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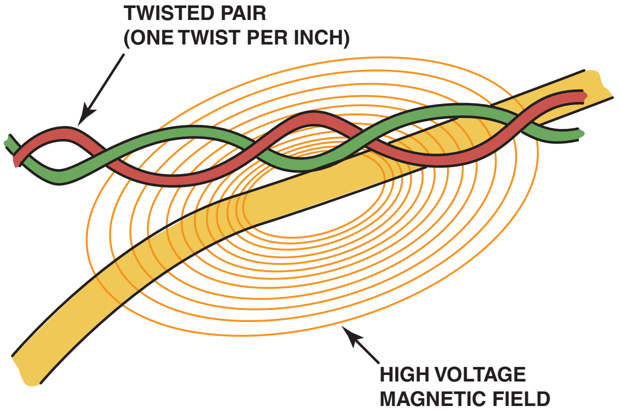

FIGURE 11 A twisted pair is used by several different network communications protocols to reduce interference that can be induced in the wiring from nearby electromagnetic sources.

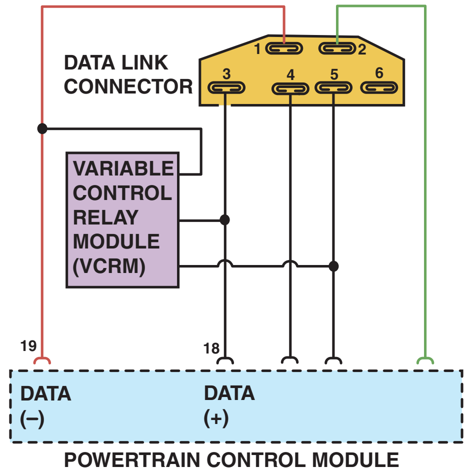

FIGURE 13 A Ford OBD-I diagnostic link connector showing that SCP communication uses terminals in cavities 1 (upper left) and 3 (lower left).

FIGURE 12 A CANDi module will flash the green LED rapidly if communication is detected.

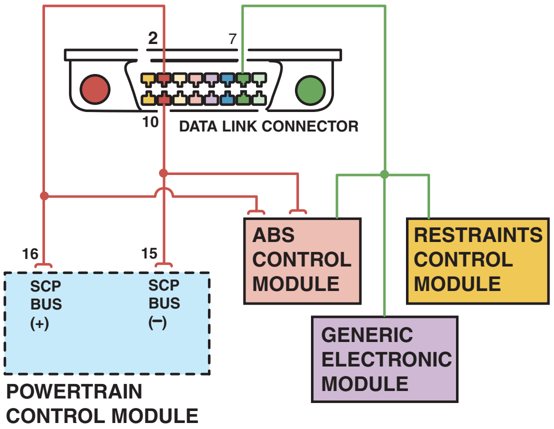

FIGURE 14 A scan tool can be used to check communications with the SCP BUS through terminals 2 and 10 and to the other modules connected to terminal 7 of the data link connector (DLC).

A CANDi (CAN diagnostic interface) module is required to be used with the Tech 2 to be able to connect a GM vehicle equipped with GMLAN. ● **SEE FIGURE 12.**

FORD NETWORK COMMUNICATIONS PROTOCOLS

STANDARD CORPORATE PROTOCOL Only a few Fords had scan tool data accessible through the OBD-I data link connector. To identify an OBD-I (1988–1995) on a Ford vehicle that is equipped with **standard corporate protocol (SCP)** and be able to communicate through a scan tool, look for terminals in cavities 1 and 3 of the DLC. ● **SEE FIGURE 13.**

SCP uses the J-1850 protocol and is active with the key on. The SCP signal is from 4 V negative to 4.3 V positive, and a scan tool does not have to be connected for the signal to be detected on the terminals. OBD-II (EECV) Ford vehicles use terminals 2 (positive) and 10 (negative) of the 16 pin data link connector (DLC) for network communication, using the SCP module communications.

UART-BASED PROTOCOL Newer Fords use the CAN for scan tool diagnosis, but still retain SCP and **UART-based protocol (UBP)** for some modules. ● **SEE FIGURES 14 AND 15.**

FREQUENTLY ASKED QUESTION

What Are U Codes?

The U diagnostic trouble codes were at first "undefined" but are now network-related codes. Use the network codes to help pinpoint the circuit or module that is not working correctly.

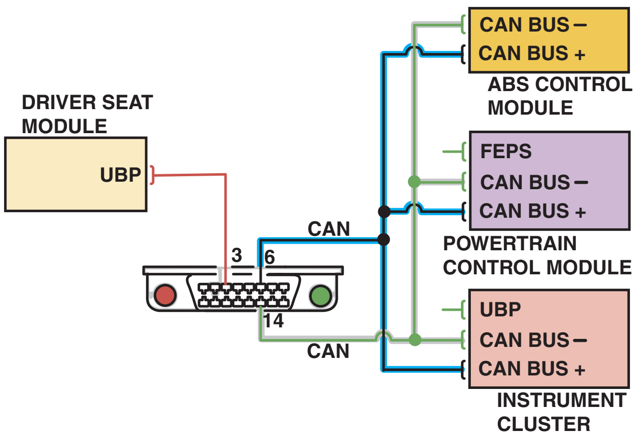

FIGURE 15 Many Fords use UBP module communications along with CAN.

CHRYSLER COMMUNICATIONS PROTOCOLS

CCD Since the late 1980s, Chrysler has used **Chrysler Collision Detection (CCD)** multiplex network for scan tool and module communications. It is a differential-type communication and uses a twisted pair of wires. The modules connected to the network apply a bias voltage on each wire. CCD signals are divided into plus and minus (CCD+ and CCD−) and the voltage difference does not exceed 0.02 V. The baud rate is 7,812.5 bps.

NOTE: The "collision" in CCD-type BUS communications refers to the program that avoids conflicts of information exchange within the BUS, and does not refer to airbags or other accident-related circuits of the vehicle.

The circuit is active without a scan tool command. ● **SEE FIGURE 16.**

The modules on the CCD BUS apply a bias voltage on each wire by using termination resistors. ● **SEE FIGURE 17.**

The difference in voltage between CCD+ and CCD− is less than 20 mV. For example, using a digital meter with the black meter lead attached to ground and the red meter lead

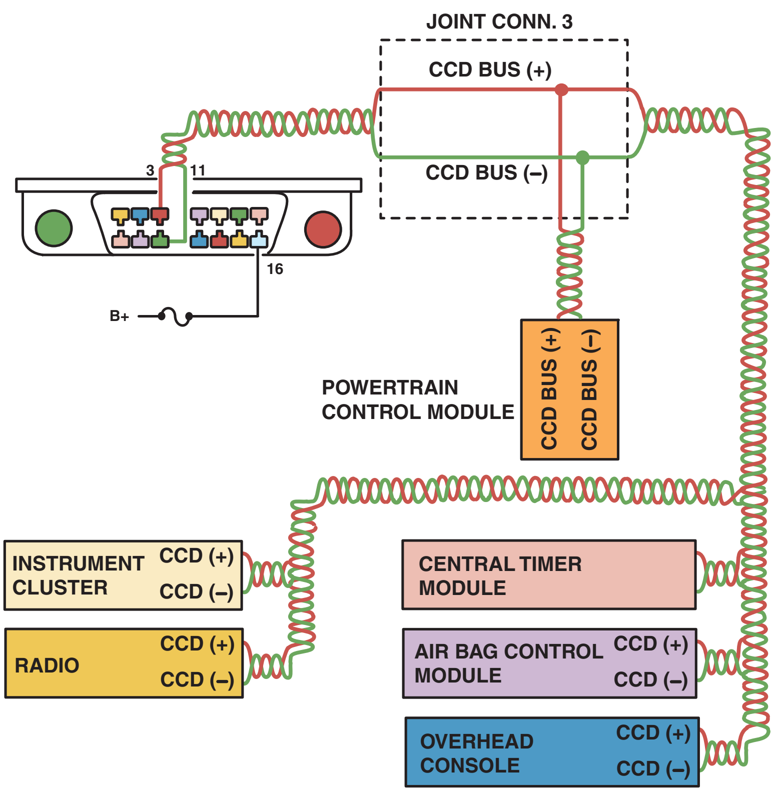

FIGURE 16 Chrysler CCD signals are labeled plus and minus and use a twisted pair of wires. Notice that terminals 3 and 11 of the data link connector are used to access the CCD BUS from a scan tool. Pin 16 is used to supply 12 volts to the scan tool.

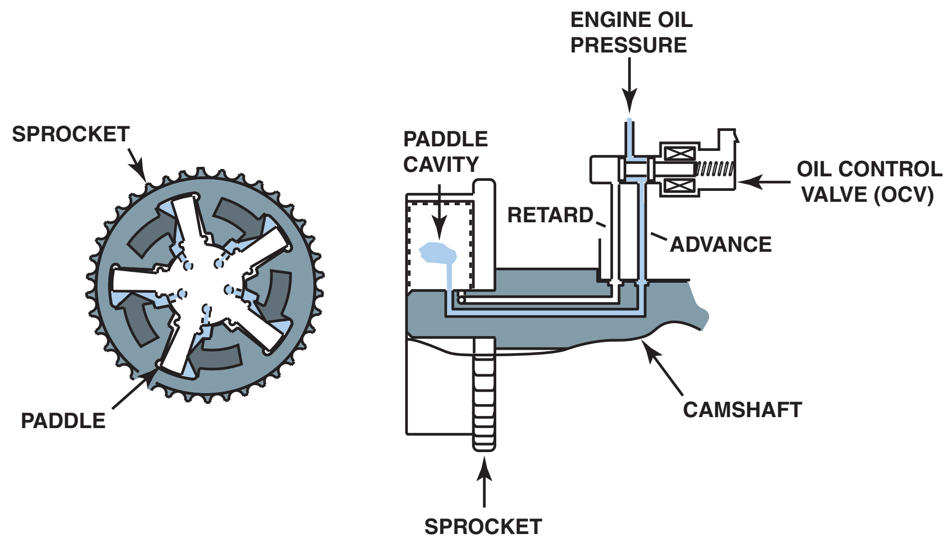

FIGURE 6 A vane phaser is used to move the camshaft using changes of oil pressure from the oil control valve.

OHV VARIABLE TIMING (CONTINUED)

NOTE: A unique cam-within-a-cam is used on the 2008+ Viper V-10 OHV engine. This design allows the exhaust lobes to be moved by up to 36 degrees to improve idle quality and reduction of exhaust emissions.

VANE PHASER SYSTEM ON AN OVERHEAD CAMSHAFT ENGINE The vane phaser system used on overhead camshaft (OHC) engines uses a camshaft piston (CMP) sensor on each camshaft. Each camshaft has its own actuator and its own oil control valve (OCV). Instead of using a piston along a helical spline, the vane phaser uses a rotor with four vanes, which is connected to the end of the camshaft. The rotor is located inside the stator, which is bolted to the cam sprocket. The stator and rotor are not connected. Oil pressure is controlled on both sides of the vanes of the rotor, which creates a hydraulic link between the two parts. The oil control valve varies the balance of pressure on either side of the vanes and thereby controls the position of the camshaft. A return spring is used under the reluctor of the phaser to help return it to the home or zero degrees position. ● **SEE FIGURE 6**.

MAGNETICALLY CONTROLLED VANE PHASER A magnetically controlled vane phaser is controlled by the ECM by using a 12-volt pulse-width-modulated (PWM) signal to an electromagnet, which operates the oil control valve (OCV). A magnetically controlled vane phaser is used on many General Motors engines that use overhead camshafts on both the intake and exhaust. The OCV directs pressurized engine oil to either advance or retard chambers of the camshaft actuator to change the camshaft position in relation to the crankshaft position. ● **SEE FIGURE 7**.

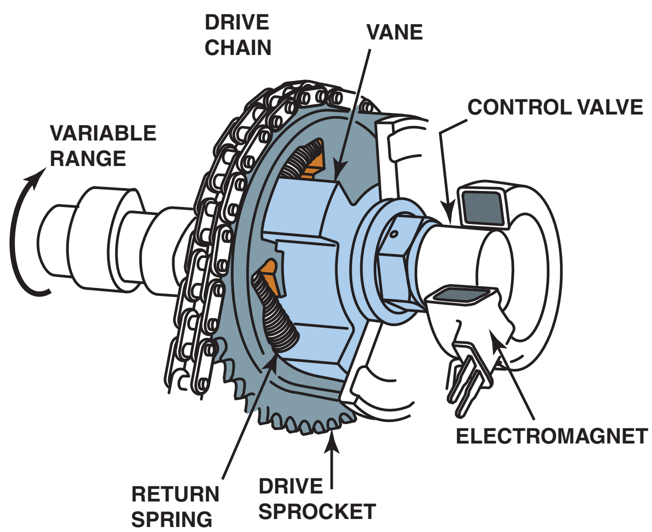

FIGURE 7 A magnetically controlled vane phaser.

The following occurs when the pulse width is changed:

- **0% pulse width—**The oil is directed to the advance chamber of the exhaust camshaft actuator and the retard chamber of the intake camshaft activator.
- **50% pulse width—**The PCM is holding the cam in the calculated position based on engine RPM and load. At 50% pulse width, the oil flow through the phaser drops to zero. ● **SEE FIGURE 8**.
- **100% pulse width—**The oil is directed to the retard chamber of the exhaust camshaft actuator and the advance chamber of the intake camshaft actuator.

The cam phasing is continuously variable with a range from 40 degrees for the intake camshaft and 50 degrees for the

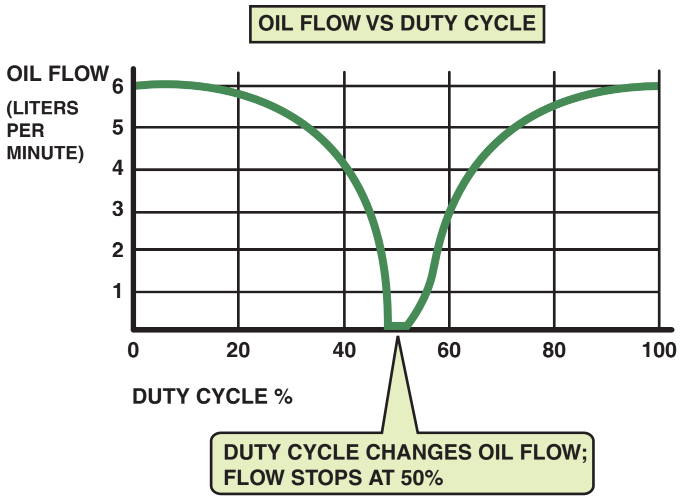

FIGURE 8 When the PCM commands 50% duty cycle, the oil flow through the phaser drops to zero.

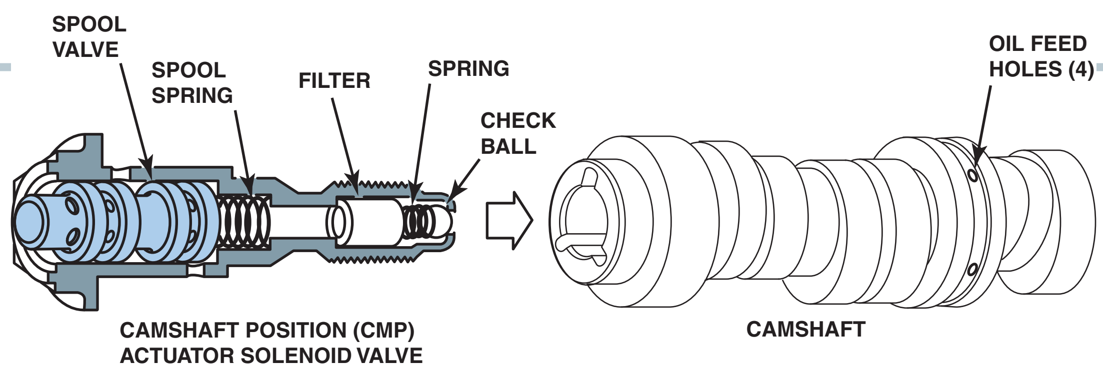

FIGURE 9 A camshaft position actuator used in a cam-in-block engine.

exhaust camshaft. The PCM uses the following sensors to determine the best position of the camshaft for maximum power and lowest possible exhaust emissions:

- Engine speed (RPM)
- MAP sensor
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor
- Barometric pressure (BARO) sensor

CAM-IN-BLOCK ENGINE CAM PHASER Overhead valve engines that use a cam-in-block design use a magnetically controlled cam phaser to vary the camshaft in relation to the crankshaft. This type of phaser is not capable of changing the duration of valve opening or valve lift.

Inside the camshaft actuator is a rotor with vanes that are attached to the camshaft. Oil pressure is supplied to the vanes, which causes the camshaft to rotate in relation to the crankshaft. The camshaft actuator solenoid valve directs the flow of oil to either the advance or retard side vanes of the actuator. **SEE FIGURE 9**.

The ECM sends a **pulse-width-modulated (PWM)** signal to the camshaft actuator magnet. The movement of the pintle is used to direct oil flow to the actuator. The higher the duty cycle is, the greater the movement in the valve position and change in camshaft timing.

FREQUENTLY ASKED QUESTION

What Happens When the Engine Stops?

When the engine stops, the oil pressure drops to zero and a spring-loaded locking pin is used to keep the camshaft locked to prevent noise at engine start. When the engine starts, oil pressure releases the locking pin.

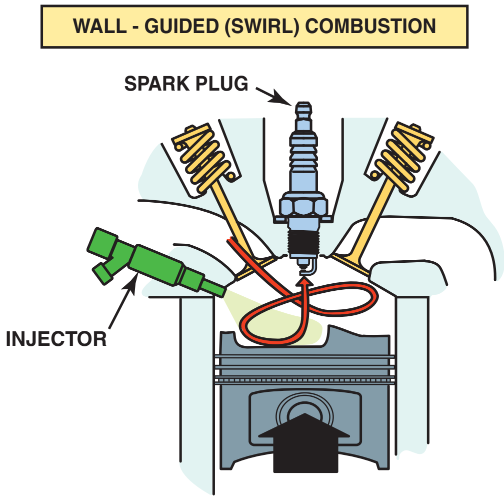

FIGURE 7 The side injector combines with the shape of the piston to create a swirl as the piston moves up on the compression stroke.

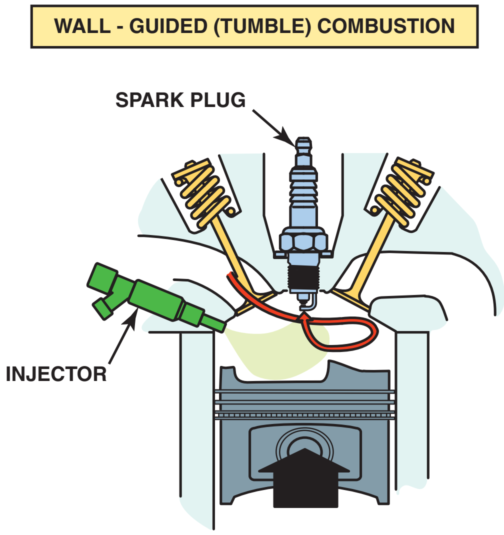

FIGURE 8 The piston creates a tumbling force as the piston moves upward.

LEXUS PORT- AND DIRECT-INJECTION SYSTEMS

OVERVIEW Many Lexus vehicles use gasoline direct injection (GDI) and in some engines, they also use a conventional port fuel-injection system. The Lexus D-4S system combines direct-injection injectors located in the combustion chamber with port fuel-injectors in the intake manifold near the intake valve. The two injection systems work together to supply the fuel needed by the engine. ● **SEE FIGURE 9** for how the two systems are used throughout the various stages of engine operation.

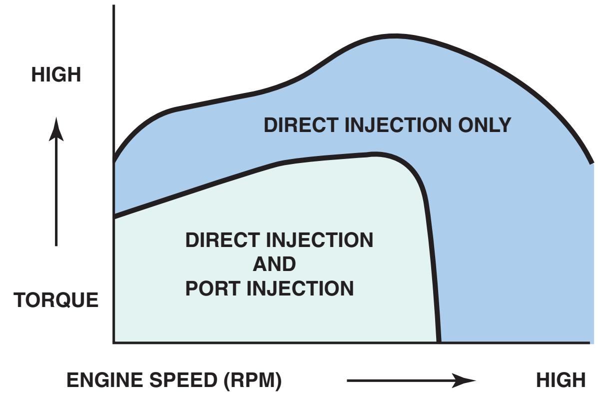

FIGURE 9 Notice that there are conditions when the port fuel-injector located in the intake manifold, and the gasoline direct injector, located in the cylinder both operate to provide the proper air–fuel mixture.

COLD-START WARM-UP To help reduce exhaust emissions after a cold start, the fuel system uses a stratified change mode. This results in a richer air–fuel mixture near the spark plug and allows for the spark to be retarded to increase the temperature of the exhaust. As a result of the increased exhaust temperature, the catalytic converter rapidly reaches operating temperature, which reduces exhaust emissions.

ENGINE START SYSTEM

An engine equipped with gasoline direct injection could use the system to start the engine. This is most useful during idle stop mode when the engine is stopped while the vehicle is at a traffic light to save fuel. The steps used in the Mitsubishi start-stop system, called the *smart idle stop system (SISS)*, allow the engine to be started without a starter motor and include the following steps:

STEP 1 The engine is stopped. The normal stopping position of an engine when it stops is 70 degrees before top dead center, plus or minus 20 degrees. This is because the engine stops with one cylinder on the compression stroke and the PCM can determine the cylinder position, using the crankshaft and camshaft position sensors.

STEP 2 When a command is made to start the engine by the PCM, fuel is injected into the cylinder that is on the compression stroke and ignited by the spark plug.

STEP 3 The piston on the compression stroke is forced downward forcing the crankshaft to rotate counterclockwise or in the opposite direction to normal operation.

STEP 4 The rotation of the crankshaft then forces the companion cylinder toward the top of the cylinder.

STEP 5 Fuel is injected and the spark plug is fired, forcing the piston down, causing the crankshaft to rotate in the normal (clockwise) direction. Normal combustion events continue allowing the engine to keep running.

GASOLINE DIRECT-INJECTION SERVICE

NOISE ISSUES Gasoline direct injection (GDI) systems operate at high pressure and the injectors can often be heard with the engine running and the hood open. This noise can be a customer concern because the clicking sound is similar to noisy valves. If a noise issue is the customer concern, check the following:

- Check a similar vehicle to determine if the sound is louder or more noticeable than normal.
- Check that nothing under the hood is touching the fuel rail. If another line or hose is in contact with the fuel rail, the sound of the injectors clicking can be transmitted throughout the engine, making the sound more noticeable.
- Check for any technical service bulletins (TSBs) that may include new clips or sound insulators to help reduce the noise.

CARBON ISSUES Carbon is often an issue in engines equipped with gasoline direct-injection systems. Carbon can affect engine operation by accumulating in two places:

- **On the injector itself.** Because the injector tip is in the combustion chamber, fuel residue can accumulate on the injector, reducing its ability to provide the proper spray pattern and amount of fuel. Some injector designs are more likely to be affected by carbon than others. For example, if the injector uses small holes, these tend to become clogged more often than an injector that uses a single slit opening where the fuel being sprayed out tends to blast away any carbon. ● **SEE FIGURE 10.**

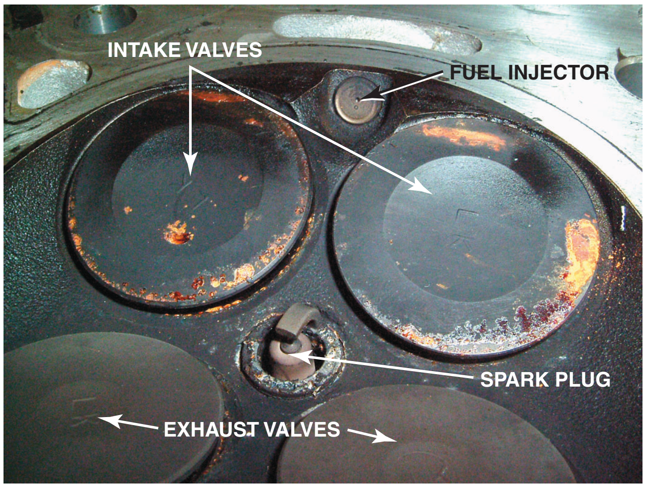

FIGURE 10 There may become a driveability issue because the gasoline direct-injection injector is exposed to combustion carbon and fuel residue.

- **The backside of the intake valve.** This is a common place for fuel residue and carbon to accumulate on engines equipped with gasoline direct injection. The accumulation of carbon on the intake valve can become so severe that the engine will start and idle, but lack power to accelerate the vehicle. The carbon deposits restrict the airflow into the cylinder enough to decrease engine power.

NOTE: Lexus engines that use both port and gasoline direct-injection injectors do not show intake valve deposits. It is thought that the fuel being sprayed onto the intake valve from the port injector helps keep the intake valve clean.

CARBON CLEANING. Most experts recommend the use of Techron®, a fuel system dispersant, to help keep carbon from accumulating. The use of a dispersant every six months or every 6,000 miles has proven to help prevent injector and intake valve deposits.

If the lack of power is discovered and there are no stored diagnostic trouble codes, a conventional carbon cleaning procedure will likely restore power if the intake valves are coated.

SUMMARY

1. A gasoline direct-injection system uses a fuel injector that delivers a short squirt of fuel directly into the combustion chamber rather than in the intake manifold, near the intake valve on a port fuel-injection system.
2. The advantages of using gasoline direct injection instead of port fuel-injection include:
   - Improved fuel economy
   - Reduced exhaust emissions
   - Greater engine power
3. Some of the disadvantages of gasoline direct-injection systems compared with a port fuel-injection system include:
   - Higher cost
   - The need for NO_x storage catalyst in some applications
   - More components
4. The operating pressure can vary from as low as 500 PSI during some low-demand conditions to as high as 2,900 PSI.
5. The fuel injectors are open for a very short period of time and are pulsed using a 50 to 90 V pulse from a capacitor circuit.