

IGNITION SYSTEM

CONTENTS

	page		page
GENERAL INFORMATION		TESTING FOR SPARK AT COIL	7
INTRODUCTION	1	THROTTLE POSITION SENSOR	9
DESCRIPTION AND OPERATION		REMOVAL AND INSTALLATION	
AUTOMATIC SHUTDOWN (ASD) AND FUEL		IGNITION COIL—3.3L	13
PUMP RELAYS	3	AUTOMATIC SHUTDOWN RELAY	14
CAMSHAFT POSITION SENSOR	4	CAMSHAFT POSITION SENSOR—3.3L	14
CRANKSHAFT POSITION SENSOR	3	CAMSHAFT POSITION SENSOR—3.5L	15
ENGINE COOLANT TEMPERATURE SENSOR ..	4	CRANKSHAFT POSITION SENSOR	15
IGNITION COIL	3	ENGINE COOLANT TEMPERATURE SENSOR ..	15
IGNITION INTERLOCK	7	IGNITION COIL—3.5L	14
IGNITION SYSTEM	1	IGNITION INTERLOCK	19
INTAKE AIR TEMPERATURE SENSOR	6	IGNITION SWITCH	17
KNOCK SENSORS—3.5L	6	INTAKE AIR TEMPERATURE SENSOR	16
LOCK KEY CYLINDER	7	KNOCK SENSORS—3.5L	16
MANIFOLD ABSOLUTE PRESSURE (MAP)		LOCK CYLINDER HOUSING	19
SENSOR	6	LOCK KEY CYLINDER	18
POWERTRAIN CONTROL MODULE (PCM)	2	MANIFOLD ABSOLUTE PRESSURE (MAP)	
SPARK PLUG CABLES	3	SENSOR—3.3L	16
SPARK PLUGS	2	MANIFOLD ABSOLUTE PRESSURE (MAP)	
THROTTLE POSITION SENSOR (TPS)	6	SENSOR—3.5L	17
DIAGNOSIS AND TESTING		POWERTRAIN CONTROL MODULE (PCM) ...	12
CAMSHAFT POSITION SENSOR AND		SPARK PLUG CABLE—3.3L	12
CRANKSHAFT POSITION SENSOR	9	SPARK PLUG CABLE—3.5L	12
CHECK COIL TEST	8	SPARK PLUG	13
ENGINE COOLANT TEMPERATURE SENSOR ..	9	THROTTLE POSITION SENSOR	17
FAILURE TO START TEST	8	SPECIFICATIONS	
IGNITION TIMING PROCEDURE	9	CABLES RESISTANCE CHART	20
INTAKE AIR TEMPERATURE SENSOR	9	IGNITION COILS	20
MANIFOLD ABSOLUTE PRESSURE (MAP)		SPARK PLUGS	20
SENSOR TEST	9	VECI LABEL	20
SPARK PLUG CONDITION	10		

GENERAL INFORMATION

INTRODUCTION

This group describes the ignition systems for the 3.3 and 3.5L engines.

On Board Diagnostics is described in Group 25 - Emission Control Systems.

Group 0 - Lubrication and Maintenance, contains general maintenance information for ignition related items. The Owner's Manual also contains maintenance information.

DESCRIPTION AND OPERATION

IGNITION SYSTEM

NOTE: The 3.3 and 3.5L engines use a fixed ignition timing system. Basic ignition timing is not adjustable. All spark advance is determined by the Powertrain Control Module (PCM).

The distributorless ignition system used on 3.3/3.5L engines is referred to as the Direct Ignition System (DIS). **Basic ignition timing is not adjustable.** The system's three main components are the coil pack, crankshaft position sensor, and camshaft position sensor.

DESCRIPTION AND OPERATION (Continued)

The crankshaft position sensor and camshaft position sensor are hall effect devices. The camshaft position sensor and crankshaft position sensor generate pulses that are inputs to the PCM. The PCM determines crankshaft position from these sensors. The PCM calculates injector sequence and ignition timing from crankshaft position. For a description of both sensors, refer to Camshaft Position Sensor and Crankshaft Position Sensor in this section.

Basic ignition timing is not adjustable. The system's main components are the camshaft signal, crankshaft signal and ignition coil.

The crankshaft position sensor and camshaft position sensor are hall effect devices. The camshaft position sensor and crankshaft position sensor generate pulses that are inputs to the PCM. The PCM determines crankshaft position from these sensors. The PCM calculates injector sequence and ignition timing from crankshaft position. For a description of both sensors, refer to Camshaft Position Sensor and Crankshaft Position Sensor in this section.

POWERTRAIN CONTROL MODULE (PCM)

The PCM regulates the ignition system (Fig. 1). The PCM supplies battery voltage to the ignition coil through the Automatic Shutdown (ASD) Relay. The PCM also controls the ground circuit for the ignition coil. By switching the ground path for the coil on and off, the PCM adjusts ignition timing to meet changing engine operating conditions.

During the crank-start period the PCM advances ignition timing a set amount. During engine operation the following inputs determine the amount of spark advance provided by the PCM.

- Intake air temperature (3.5L engine)
- Coolant temperature
- Engine RPM
- Available manifold vacuum
- Knock sensor (3.5L Engine)

The PCM also regulates the fuel injection system. Refer to the Fuel Injection sections of Group 14.

SPARK PLUGS

The 3.3L and 3.5L engines use resistor spark plugs. They have resistance values of 6,000 to 20,000 ohms when checked with at least a 1000 volt tester. For spark plug identification and specifications, Refer to the Specifications section at the end of this group.

Remove the spark plugs and examine them for burned electrodes and fouled, cracked or broken porcelain insulators. Keep plugs arranged in the order in which they were removed from the engine. An isolated plug displaying an abnormal condition indicates that a problem exists in the corresponding cylinder. Replace spark plugs at the intervals recommended in Group 0.

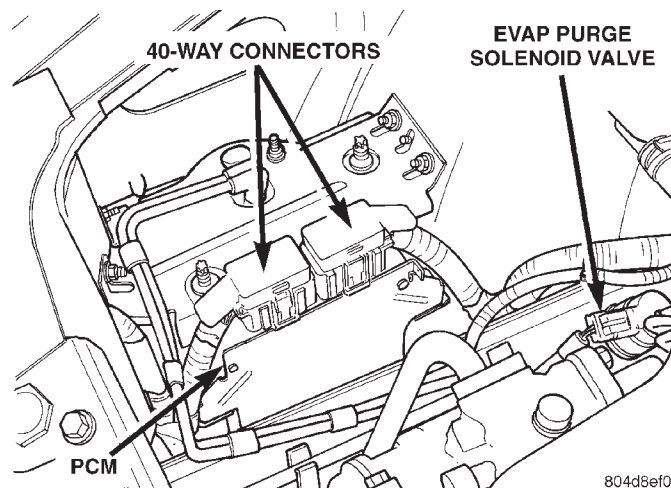
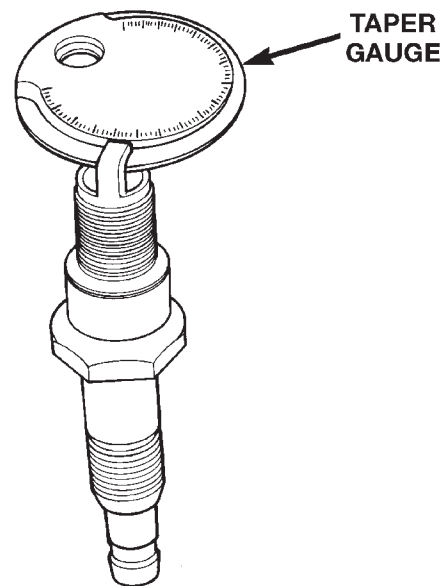


Fig. 1 Powertrain Control Module

Spark plugs that have low mileage may be cleaned and reused if not otherwise defective, carbon or oil fouled. Refer to the Spark Plug Condition section of this group. After cleaning, file the center electrode flat with a small flat point file or jewelers file. Adjust the gap between the electrodes (Fig. 2) to the dimensions specified in the chart at the end of this section.

Always tighten spark plugs to the specified torque. Over tightening can cause distortion resulting in a change in the spark plug gap. Overtightening can also damage the cylinder head. Tighten spark plugs to 28 N·m (20 ft. lbs.) torque.



803f5851

Fig. 2 Setting Spark Plug Electrode Gap

DESCRIPTION AND OPERATION (Continued)

SPARK PLUG CABLES

Spark plug cables are sometimes referred to as secondary ignition wires. The wires transfer electrical current from the distributor to individual spark plugs at each cylinder. The resistor type, nonmetallic spark plug cables provide suppression of radio frequency emissions from the ignition system.

Check the spark plug cable connections for good contact at the coil and spark plugs. Terminals should be fully seated. The nipples and spark plug covers should be in good condition. Nipples should fit tightly on the coil and spark plug cover should fit tight around spark plug insulators.

Loose cable connections can cause ignition malfunctions by permitting water to enter the towers, corroding, and increasing resistance. **To maintain proper sealing at the terminal connections, the connections should not be broken unless testing indicates high resistance, an open circuit or other damage.**

Clean high tension cables with a cloth moistened with a non-flammable solvent and wipe dry. Check for brittle or cracked insulation.

IGNITION COIL

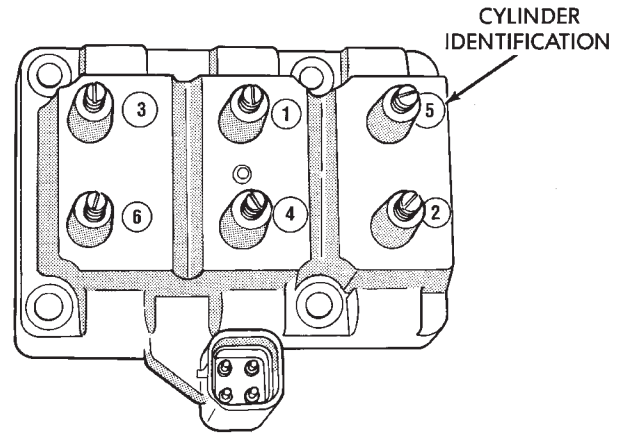
WARNING: THE DIRECT IGNITION SYSTEM GENERATES APPROXIMATELY 40,000 VOLTS. PERSONAL INJURY COULD RESULT FROM CONTACT WITH THIS SYSTEM.

The coil pack consists of 3 coils molded together (Fig. 3). High tension leads route to each cylinder from the coil. The coil fires two spark plugs every power stroke. One plug is the cylinder under compression, the other cylinder fires on the exhaust stroke. The Powertrain Control Module (PCM) determines which of the coils to charge and fire at the correct time.

The Auto Shutdown (ASD) relay provides battery voltage to the ignition coil. The PCM provides a ground contact (circuit) for energizing the coil. When the PCM breaks the contact, the energy in the coil primary transfers to the secondary causing the spark. The PCM will de-energize the ASD relay if it does not receive the crankshaft position sensor and camshaft position sensor inputs. Refer to Auto Shutdown (ASD) Relay—PCM Output, in this section for relay operation.

Coil number one fires cylinders 1 and 4, coil number two fires cylinders 2 and 5, and coil number three fires cylinders 3 and 6.

The coil's low primary resistance (0.5 - 0.7 ohm) allows the PCM to fully charge the coil for each firing.



9314-77

*Fig. 3 Coil Pack***AUTOMATIC SHUTDOWN (ASD) AND FUEL PUMP RELAYS**

The PCM operates the ASD relay and fuel pump relay through one ground path. The PCM operates them by switching on and off the ground path for the solenoid side of the relays. Both relays turn on and off at the same time.

The ASD relay connects battery voltage to the fuel injectors and ignition coil. The fuel pump relay connects battery voltage to the fuel pump.

The PCM turns the ground path off when the ignition switch is in the Off position. Both relays are off. When the ignition switch is in the On or Crank position, the PCM monitors the crankshaft position sensor and camshaft position sensor signals to determine engine speed and ignition timing (coil dwell). If the PCM does not receive a crankshaft position sensor signal and camshaft position sensor signal when the ignition switch is in the Run position, it de-energizes both relays. When the relays de-energize, battery voltage is not supplied to the fuel injectors, ignition coil and fuel pump.

The ASD relay and fuel pump relay are located in the Power Distribution Center (PDC) near the battery (Fig. 4). A decal on the underside of the PDC cover shows the locations of each relay and fuse contained in the PDC.

CRANKSHAFT POSITION SENSOR

The crankshaft position sensor detects slots cut into the transmission driveplate extension. There are 3 sets of slots. Each set contains 4 slots, for a total of 12 slots (Fig. 5). Basic timing is set by the position of the last slot in each group. Once the Powertrain Control Module (PCM) senses the last slot, it determines crankshaft position (which piston will next be at TDC) from the camshaft position sensor input. The 4 pulses generated by the crankshaft position sensor

DESCRIPTION AND OPERATION (Continued)

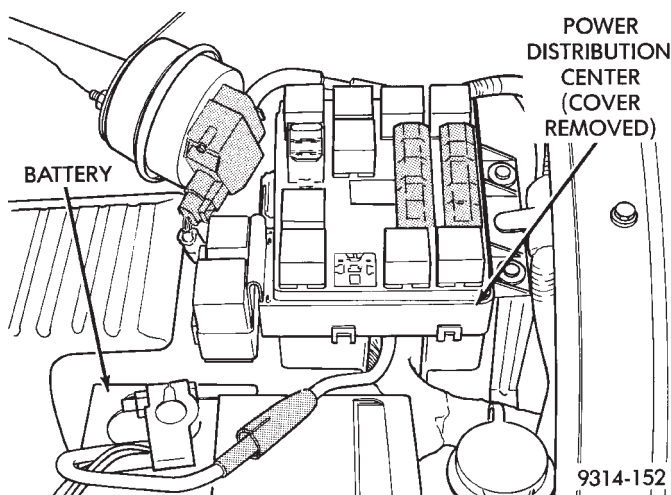


Fig. 4 Power Distribution Center

represent the 69°, 49°, 29°, and 9° BTDC marks. It may take the PCM one engine revolution to determine crankshaft position.

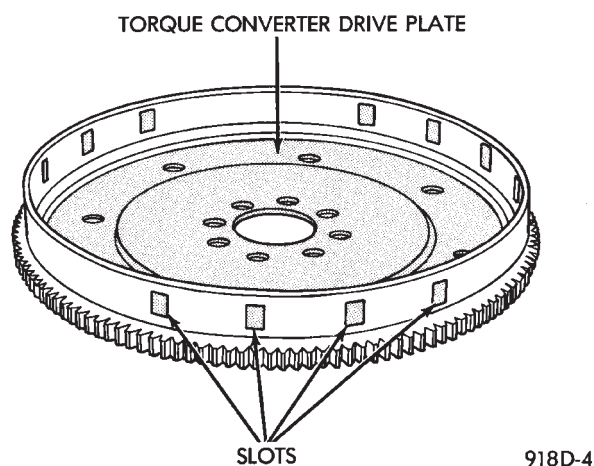


Fig. 5 Timing Slots

The PCM uses crankshaft position reference to determine injector sequence and ignition timing. Once the PCM determines crankshaft position, it begins energizing the injectors in sequence.

The crankshaft sensor is located on the passenger side of the transmission housing, above the differential housing (Fig. 6). The bottom of the sensor is positioned next to the drive plate.

CAMSHAFT POSITION SENSOR

The camshaft position sensor provides cylinder identification to the Powertrain Control Module (PCM) (Fig. 7) or (Fig. 8). The sensor generates pulses as groups of notches on the camshaft sprocket pass underneath it (Fig. 9) or (Fig. 10). The PCM keeps track of crankshaft rotation and identifies each cylinder by the pulses generated by the notches on

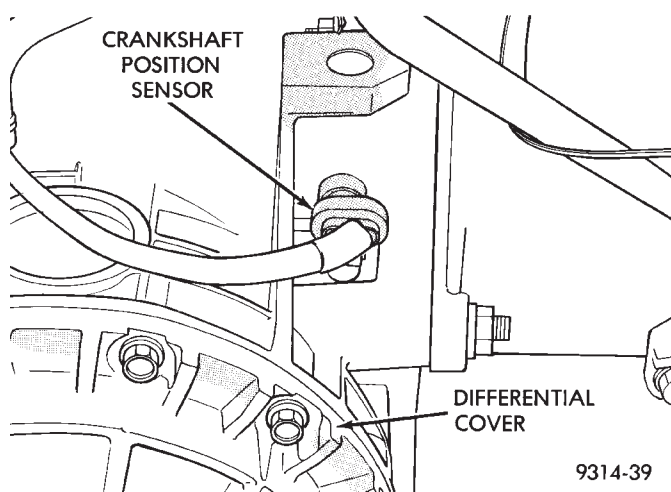


Fig. 6 Crankshaft Position Sensor Location

the camshaft sprocket. Four crankshaft pulses follow each group of camshaft pulses.

When the PCM receives two cam pulses followed by the long flat spot on the camshaft sprocket, it knows that the crankshaft timing marks for cylinder one are next (on driveplate). When the PCM receives one camshaft pulse after the long flat spot on the sprocket, cylinder number two crankshaft timing marks are next. After 3 camshaft pulses, the PCM knows cylinder four crankshaft timing marks follow. One camshaft pulse after the three pulses indicates cylinder five. The two camshaft pulses after cylinder 5 signals cylinder six (Fig. 9) or (Fig. 10). The PCM can synchronize on cylinders 1 or 4.

When metal aligns with the sensor, voltage goes low (less than 0.3 volts). When a notch aligns with the sensor, voltage spikes high (5.0 volts). As a group of notches pass under the sensor, the voltage switches from low (metal) to high (notch) then back to low. The number of notches determine the amount of pulses. If available, an oscilloscope can display the square wave patterns of each timing event.

Top dead center (TDC) does not occur when notches on the camshaft sprocket pass below the cylinder. TDC occurs after the camshaft pulse (or pulses) and after the 4 crankshaft pulses associated with the particular cylinder. The arrows and cylinder call outs on (Fig. 9) and (Fig. 10) which cylinder the flat spot and notches identify, they do not indicate TDC position.

The camshaft position sensor is mounted in the front of the timing case cover (Fig. 11) or (Fig. 12).

ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor threads into the water jacket next to thermostat housing (Fig. 13) or (Fig. 14). The sensor provides an input to the powertrain control module (PCM). As coolant

DESCRIPTION AND OPERATION (Continued)

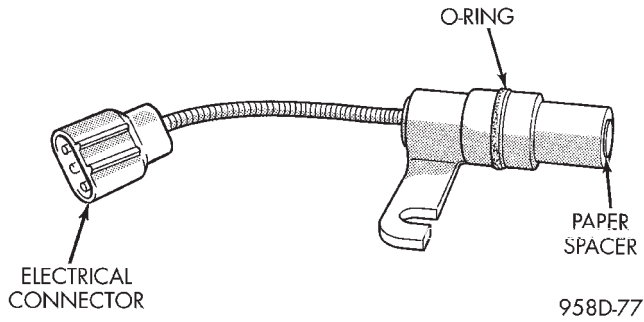


Fig. 7 Camshaft Position Sensor—3.3L Engine

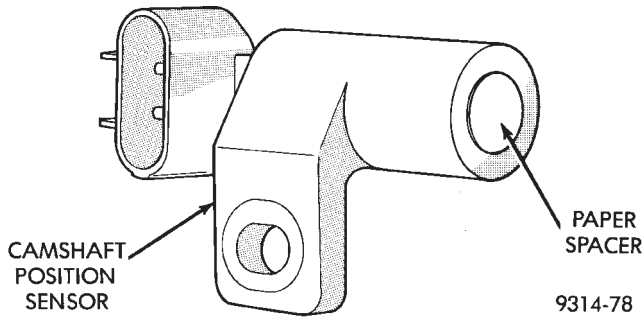


Fig. 8 Camshaft Position Sensor—3.5L Engine

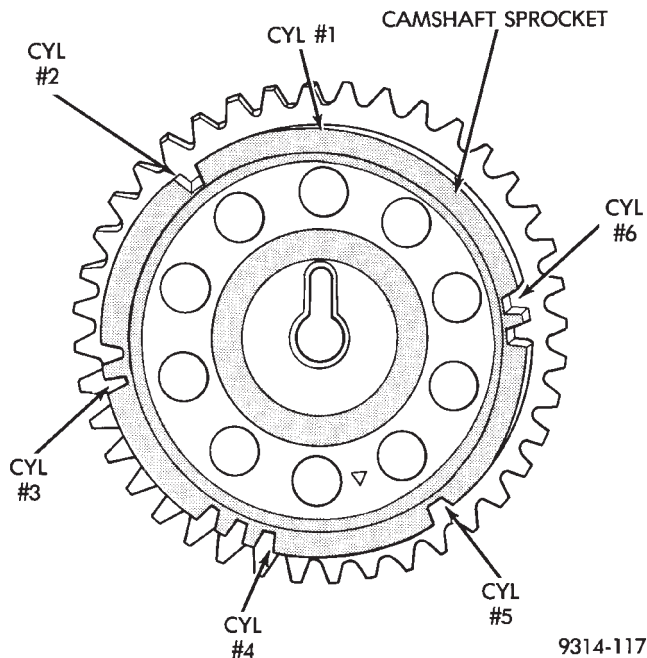


Fig. 9 Camshaft Sprocket—3.3L Engine

temperature varies, the sensor resistance changes, resulting in a different input voltage to the PCM.

The PCM contains different spark advance schedules for cold and warm engine operation. The schedules reduce engine emission and improve driveability. When the engine is cold, the PCM will demand slightly richer air-fuel mixtures and higher idle

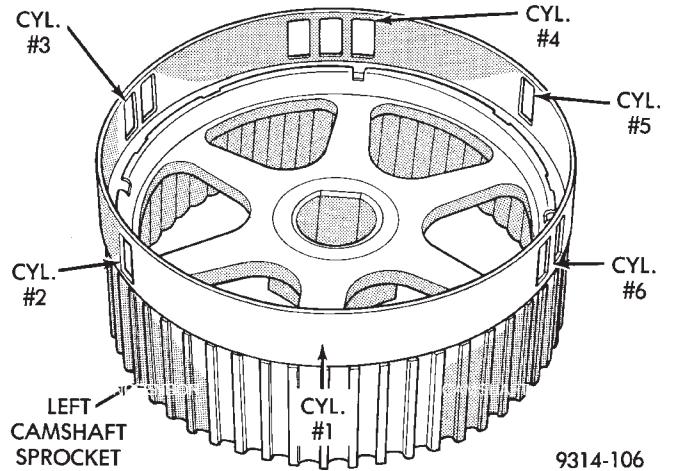


Fig. 10 Camshaft Sprocket—3.5L Engine

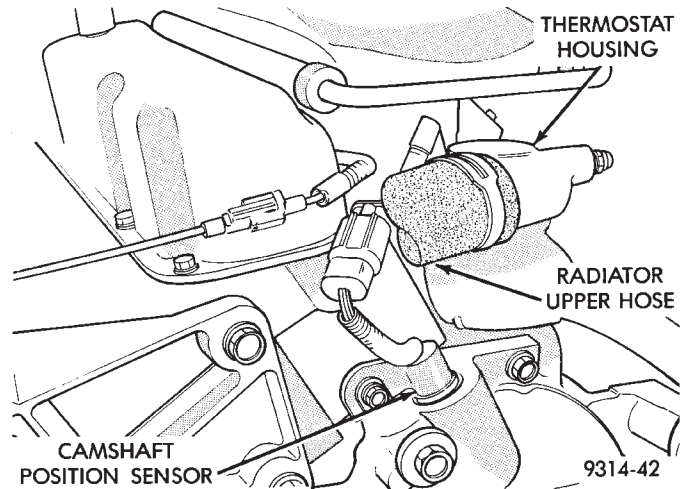


Fig. 11 Camshaft Position Sensor Location—3.3L Engine

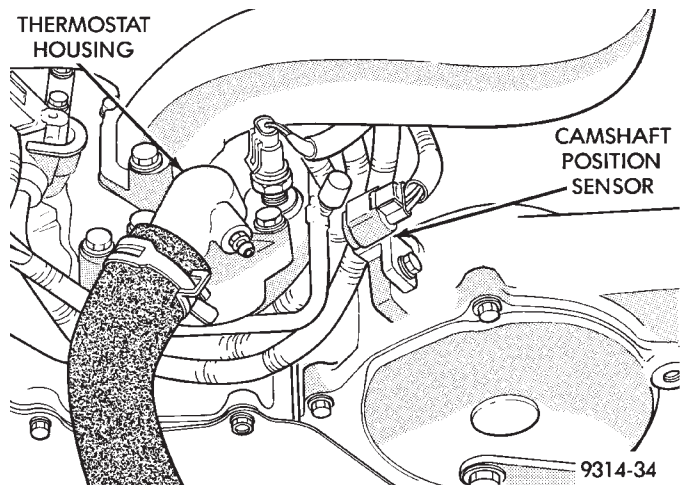


Fig. 12 Camshaft Position Sensor Location—3.5L Engine

speeds until normal operating temperatures are reached.

DESCRIPTION AND OPERATION (Continued)

The engine coolant sensor input also determines operation of the low and high speed cooling fans.

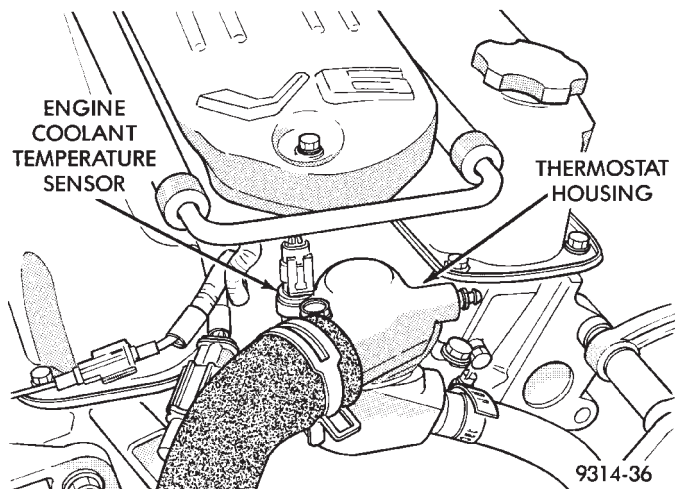


Fig. 13 Engine Coolant Temperature Sensor—3.3L

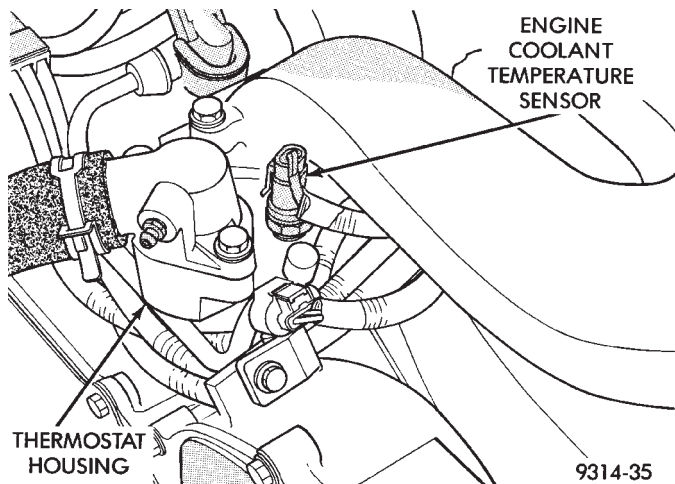


Fig. 14 Engine Coolant Temperature Sensor—3.5L

INTAKE AIR TEMPERATURE SENSOR

The Intake Air Temperature (IAT) sensor measures the temperature of the air as it enters the engine. The sensor supplies one of the inputs the PCM uses to determine injector pulse-width.

The IAT sensor threads into the intake manifold.

KNOCK SENSORS—3.5L

The 3.5L engine has two knock sensors. One sensor for the right bank of cylinders, one for the left bank. The knock sensors thread into the top of the cylinder block below the cylinder heads (Fig. 15). When a knock sensor detects a knock in one of the cylinders, it sends an input signal to the PCM. In response, the PCM retards ignition timing by a scheduled amount.

Knock sensors contain a piezoelectric material which constantly vibrates and sends an input voltage (signal) to the PCM while the engine operates. As the

intensity of the crystal's vibration increase, the knock sensor output voltage also increases.

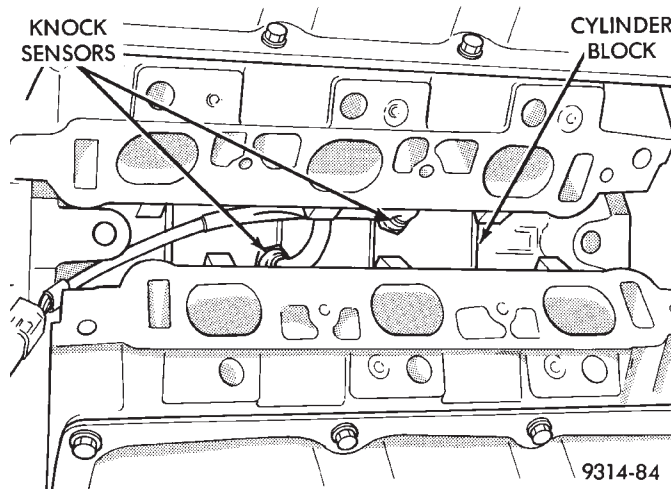


Fig. 15 Knock Sensor Locations—3.5L Engine Only

NOTE: Over or under tightening effects knock sensor performance, possibly causing improper spark control.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The Powertrain Control Module (PCM) supplies 5 volts to the Manifold Absolute Pressure (MAP) sensor. The MAP sensor converts intake manifold pressure into voltage. The PCM monitors the MAP sensor output voltage. As vacuum increases, MAP sensor voltage decreases proportionately. Also, as vacuum decreases, MAP sensor voltage increases proportionately.

During cranking, before the engine starts running, the PCM determines atmospheric air pressure from the MAP sensor voltage. While the engine operates, the PCM determines intake manifold pressure from the MAP sensor voltage. Based on MAP sensor voltage and inputs from other sensors, the PCM adjusts spark advance and the air/fuel mixture.

The MAP sensor mounts to the intake manifold.

THROTTLE POSITION SENSOR (TPS)

The TPS mounts to the side of the throttle body. The TPS connects to the throttle blade shaft. The TPS is a variable resistor that provides the Powertrain Control Module (PCM) with an input signal (voltage). The signal represents throttle blade position. As the position of the throttle blade changes, the resistance of the TPS changes.

The PCM supplies approximately 5 volts to the TPS. The TPS output voltage (input signal to the powertrain control module) represents throttle blade position. The TPS output voltage to the PCM varies from approximately 0.38 volts to 1.2 volts at mini-

DESCRIPTION AND OPERATION (Continued)

imum throttle opening (idle) to a maximum of 3.1 volts to 4.4 volts at wide open throttle.

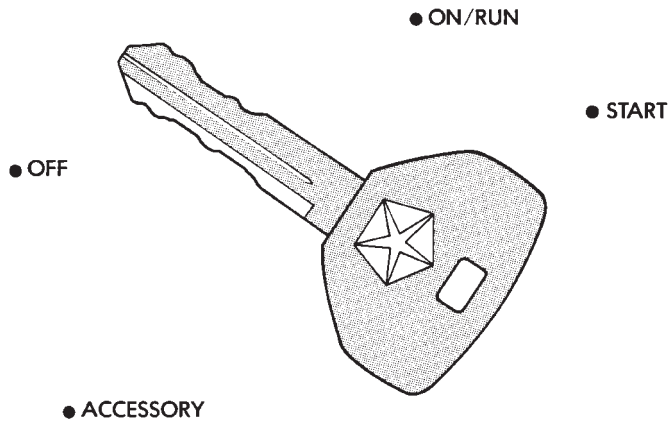
Along with inputs from other sensors, the PCM uses the TPS input to determine current engine operating conditions. The PCM also adjusts fuel injector pulse width and ignition timing based on these inputs.

LOCK KEY CYLINDER

The lock cylinder is inserted in the end of the housing opposite the ignition switch. The ignition key rotates the cylinder to 5 different detents (Fig. 16):

- Accessory
- Off (lock)
- Unlock
- On/Run
- Start

● UNLOCK



938D-22

Fig. 16 Ignition Lock Cylinder Detents

IGNITION INTERLOCK

All vehicles equipped with automatic transaxles have an interlock system. The system prevents shifting the vehicle out of Park unless the ignition lock cylinder is in the Off, Run or Start position. In addition, the operator cannot rotate the key to the lock position unless the shifter is in the park position. On vehicles equipped with floor shift refer to Group 21 - Transaxle for Automatic Transmission Shifter/Ignition Interlock.

DIAGNOSIS AND TESTING**TESTING FOR SPARK AT COIL**

WARNING: THE DIRECT IGNITION SYSTEMS GENERATES APPROXIMATELY 40,000 VOLTS. PERSONAL INJURY COULD RESULT FROM CONTACT WITH THIS SYSTEM.

The coil pack contains independent coils. Each coil must be checked individually.

CAUTION: Spark plug wire damage may occur if the spark plug is moved more than 1/4 inch away from the engine ground.

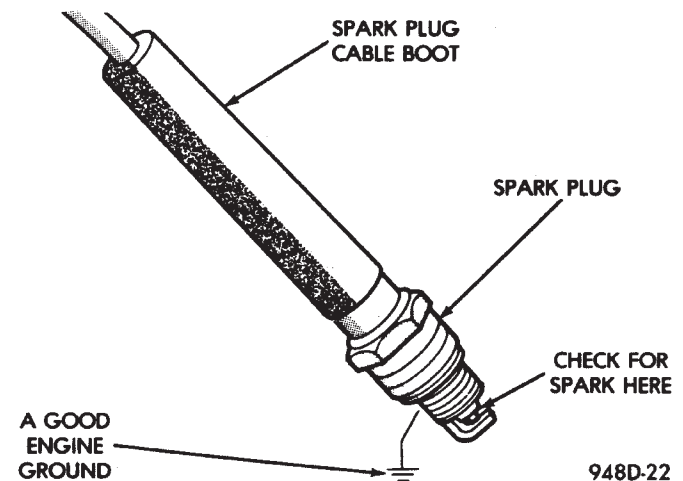
CAUTION: Do not leave any one spark plug cable disconnected any longer than 30 seconds or possible heat damage to catalytic converter will occur.

CAUTION: Test must be performed at idle and in park only with the parking brake on.

NOTE: New isolated engine valve cover may not provide adequate ground. Use engine block as engine ground.

Use a new spark plug and spark plug cable for the following test.

(1) Insert a new spark plug into the new spark plug boot. Ground the plug to the engine (Fig. 17). Do not hold with your hand.



948D-22

Fig. 17 Testing For Spark

(2) Starting with coil insulator #1, remove it from the DIS coil.

(3) Plug the test spark plug cable onto #1 coil tower. Make sure a good connection is made; there should be a click sound.

(4) Crank the engine and look for spark across the electrodes of the spark plug.

CAUTION: Always install the cable back on the coil tower after testing to avoid damage to the coil and catalytic converter.

DIAGNOSIS AND TESTING (Continued)

(5) Repeat the above test for the remaining coils. If there is no spark during all cylinder tests, proceed to the Failure To Start Test.

(6) If one or more tests indicate irregular, weak, or no spark, proceed to Check Coil Test.

CHECK COIL TEST

Coil 1 fires cylinders 1 and 4, coil 2 fires cylinders 2 and 5, and coil 3 fires cylinders 3 and 6. Each coil tower is labeled with the number of the corresponding cylinder.

(1) Disconnect the electrical connector from the coil pack.

(2) Measure the primary resistance of each coil. At the coil, connect an ohmmeter between the B+ pin and the pin corresponding to the cylinders in question (Fig. 18). Resistance on the primary side of each coil should be 0.45 - 0.65 ohm at 21° to 27°C (70° to 80°F). A coil that has not been allowed to cool off, would result in inaccurate measurement results. Replace the coil if resistance is not within tolerance.

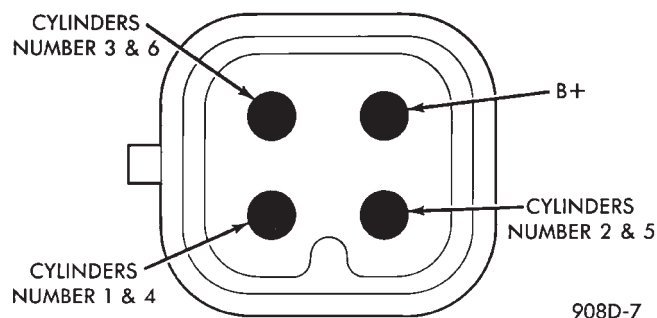


Fig. 18 Ignition Coil Terminal Identification

(3) Remove ignition cables from the secondary towers of the coil. Measure the secondary resistance of the coil between the towers of each individual coil (Fig. 19). Secondary resistance should be 7,000 to 15,800 ohms. Replace the coil if resistance is not within tolerance.

FAILURE TO START TEST

This no-start test checks the camshaft position sensor and crankshaft position sensor.

The Powertrain Control Module (PCM) supplies 8 volts to the camshaft position sensor and crankshaft position sensor through one circuit. If the 8 volt supply circuit shorts to ground, neither sensor will produce a signal (output voltage to the PCM).

When the ignition key is turned and left in the On position, the PCM automatically energizes the Auto Shutdown (ASD) relay. However, the controller de-energizes the relay within one second because it has not received a camshaft position sensor signal indicating engine rotation.

During cranking, the ASD relay will not energize until the PCM receives a camshaft position sensor

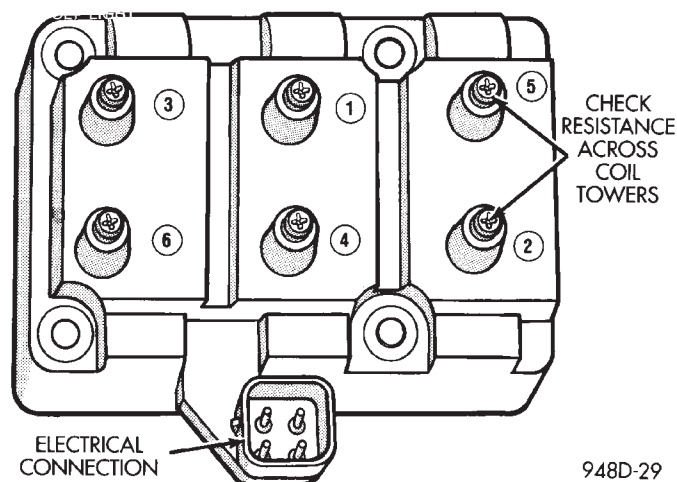


Fig. 19 Checking Ignition Coil Secondary Resistance

signal. Secondly, the ASD relay remains energized only if the controller senses a crankshaft position sensor signal immediately after detecting the camshaft position sensor signal.

(1) Check battery voltage. Voltage should be approximately 12.66 volts or higher to perform failure to start test.

(2) Disconnect the harness connector from the coil pack.

(3) Connect a test light to the B+ (battery voltage) terminal of the coil electrical connector and ground as shown in (Fig. 20). The B+ wire for the DIS coil is dark green with an orange tracer. **Do not spread the terminal with the test light probe.**

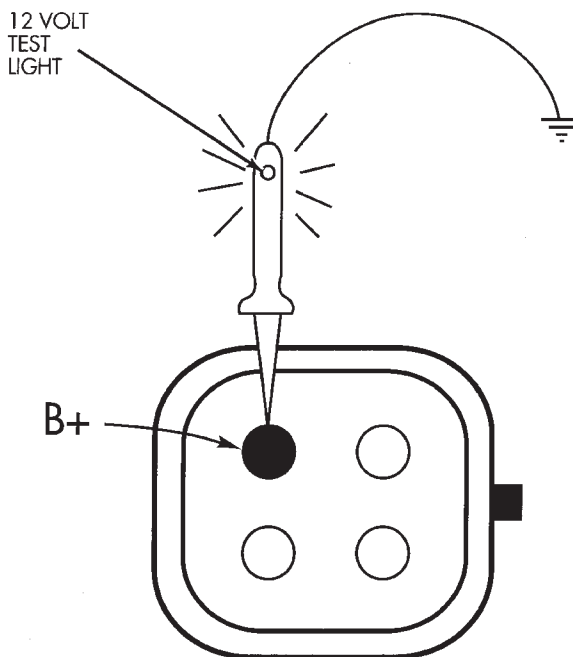


Fig. 20 Ignition Coil Engine Harness Connector

DIAGNOSIS AND TESTING (Continued)

(4) Turn the ignition key to the **ON position**. The test light should flash On and then Off. **Do not turn the Key to off position, leave it in the On position**.

(a) If the test light flashes momentarily, the PCM grounded the Auto Shutdown (ASD) relay. Proceed to step 5.

(b) If the test light did not flash, the ASD relay did not energize. The cause is either the relay or one of the relay circuits. Use the DRB scan tool to test the ASD relay and circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

(5) Crank the engine. (If the key was placed in the off position after step 4, place the key in the On position before cranking. Wait for the test light to flash once, then crank the engine.)

(6) If the test light momentarily flashes during cranking, the PCM is not receiving a crankshaft position sensor signal. Use the DRB scan tool to test the crankshaft position sensor and sensor circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

(7) If the test light did not flash during cranking, unplug the crankshaft position sensor connector. Turn the ignition key to the off position. Turn the key to the On position, wait for the test light to momentarily flash once, then crank the engine. If the test light momentarily flashes, the crankshaft position sensor is shorted and must be replaced. If the light did not flash, the cause of the no-start is in either the crankshaft position sensor/camshaft position sensor 8 volt supply circuit, or the camshaft position sensor output or ground circuits. Use the DRB scan tool to test the camshaft position sensor and the sensor circuits. Refer to the appropriate Powertrain Diagnostics Procedure Manual. Refer to the wiring diagrams section for circuit information.

IGNITION TIMING PROCEDURE

The engines for this vehicle, use a fixed ignition system. The PCM regulates ignition timing. Basic ignition timing is not adjustable.

CAMSHAFT POSITION SENSOR AND CRANKSHAFT POSITION SENSOR

The output voltage of a properly operating camshaft position sensor or crankshaft position sensor

switches from high (5.0 volts) to low (0.3 volts). By connecting an Mopar Diagnostic System (MDS) and engine analyzer to the vehicle, technicians can view the square wave pattern.

ENGINE COOLANT TEMPERATURE SENSOR

Refer to Group 14, Fuel System for Diagnosis and Testing.

INTAKE AIR TEMPERATURE SENSOR

Refer to Group 14, Fuel System, for Diagnosis and Testing.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR TEST

Refer to Group 14, Fuel System for Diagnosis and Testing.

THROTTLE POSITION SENSOR

To perform a complete test of the this sensor and its circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the throttle position sensor only, refer to the following:

The Throttle Position Sensor (TPS) can be tested with a digital voltmeter (DVM). The center terminal of the sensor is the output terminal. One of the other terminals is a 5 volt supply and the remaining terminal is ground.

Connect the DVM between the center and sensor ground terminal. Refer to Group 8W - Wiring Diagrams for correct pinout.

With the ignition switch in the ON position, check the output voltage at the center terminal wire of the connector. Check the output voltage at idle and at Wide-Open-Throttle (WOT). At idle, TPS output voltage should be approximately 0.38 volts to 1.2 volts. At wide open throttle, TPS output voltage should be approximately 3.1 volts to 4.4 volts. The output voltage should gradually increase as the throttle plate moves slowly from idle to WOT.

Check for spread terminals at the sensor and PCM connections before replacing the TPS.

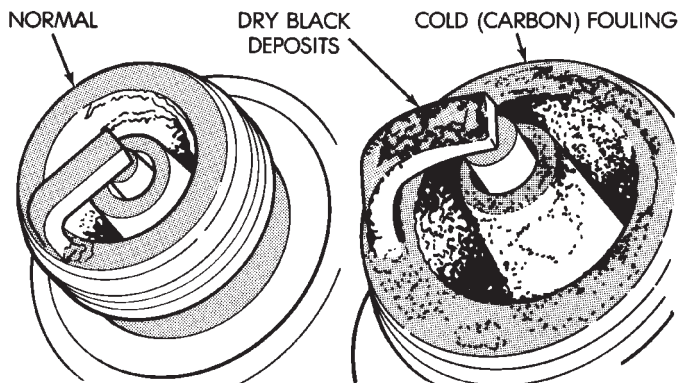
DIAGNOSIS AND TESTING (Continued)

SPARK PLUG CONDITION

NORMAL OPERATING CONDITIONS

The few deposits present will be probably light tan or slightly gray in color with most grades of commercial gasoline (Fig. 21). There will not be evidence of electrode burning. Gap growth will not average more than approximately 0.025 mm (.001 in) per 1600 km (1000 miles) of operation for non platinum spark plugs. Non-platinum spark plugs that have normal wear can usually be cleaned, have the electrodes filed and reinstalled.

CAUTION: Never attempt to file the electrodes or use a wire brush for cleaning platinum spark plugs. This would damage the platinum pads which would shorten spark plug life.



J908D-15

Fig. 21 Normal Operation and Cold (Carbon) Fouling

Some fuel refiners in several areas of the United States have introduced a manganese additive (MMT) for unleaded fuel. During combustion, fuel with MMT may coat the entire tip of the spark plug with a rust colored deposit. The rust color deposits can be misdiagnosed as being caused by coolant in the combustion chamber. Spark plug performance is not affected by MMT deposits.

COLD FOULING (CARBON FOULING)

Cold fouling is sometimes referred to as carbon fouling because the deposits that cause cold fouling are basically carbon (Fig. 21). A dry, black deposit on one or two plugs in a set may be caused by sticking valves or misfire conditions. Cold (carbon) fouling of the entire set may be caused by a clogged air cleaner.

Cold fouling is normal after short operating periods. The spark plugs do not reach a high enough operating temperature during short operating periods. **Replace carbon fouled plugs with new spark plugs.**

FUEL FOULING

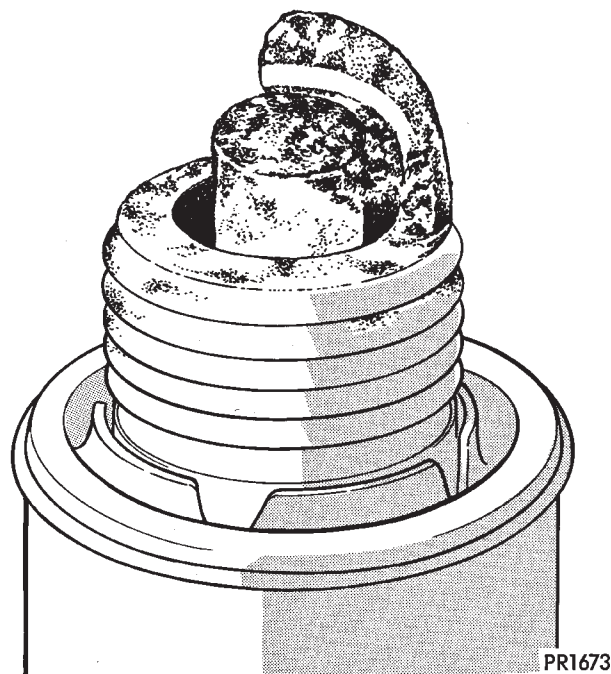
A spark plug that is coated with excessive wet fuel is called fuel fouled. This condition is normally observed during hard start periods. **Clean fuel fouled spark plugs with compressed air and reinstall them in the engine.**

OIL FOULING

A spark plug that is coated with excessive wet oil is oil fouled. In older engines, wet fouling can be caused by worn rings or excessive cylinder wear. Break-in fouling of new engines may occur before normal oil control is achieved. **Replace oil fouled spark plugs with new ones.**

OIL OR ASH ENCRUSTED

If one or more plugs are oil or ash encrusted, evaluate the engine for the cause of oil entering the combustion chambers (Fig. 22). Sometimes fuel additives can cause ash encrustation on an entire set of spark plugs. **Ash encrusted spark plugs can be cleaned and reused.**



PR1673

Fig. 22 Oil or Ash Encrusted

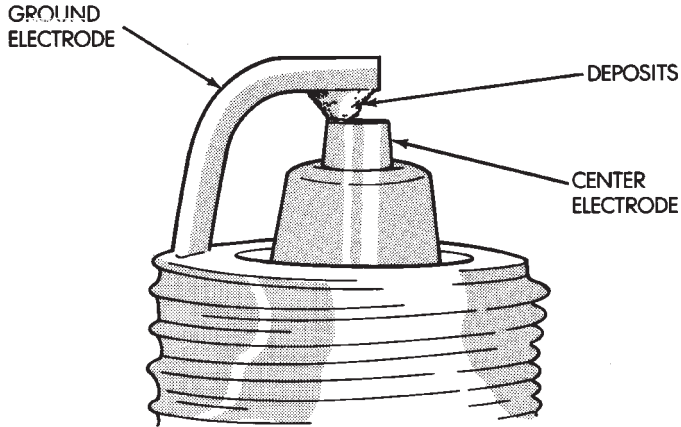
HIGH SPEED MISS

When replacing spark plugs because of a high speed miss condition; **wide open throttle operation should be avoided for approximately 80 km (50 miles) after installation of new plugs.** This will allow deposit shifting in the combustion chamber to take place gradually and avoid plug destroying splash fouling shortly after the plug change.

DIAGNOSIS AND TESTING (Continued)

ELECTRODE GAP BRIDGING

Loose deposits in the combustion chamber can cause electrode gap bridging. The deposits accumulate on the spark plugs during continuous stop-and-go driving. When the engine is suddenly subjected to a high torque load, the deposits partially liquefy and bridge the gap between the electrodes (Fig. 23). This short circuits the electrodes. **Spark plugs with electrode gap bridging can be cleaned and reused.**

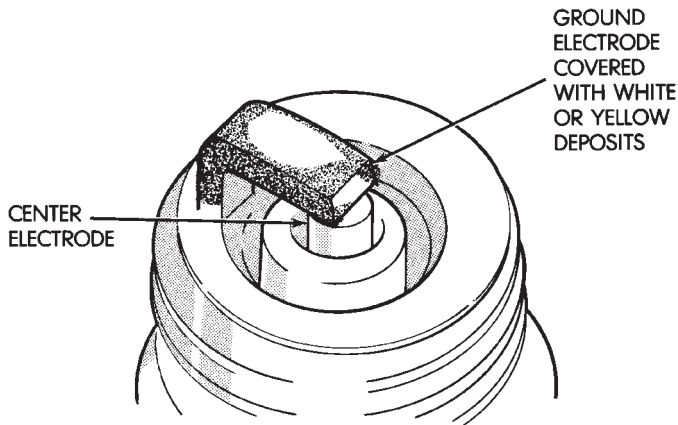


J908D-11

Fig. 23 Electrode Gap Bridging

SCAVENGER DEPOSITS

Fuel scavenger deposits may be either white or yellow (Fig. 24). They may appear to be harmful, but are a normal condition caused by chemical additives in certain fuels. These additives are designed to change the chemical nature of deposits and decrease spark plug misfire tendencies. Notice that accumulation on the ground electrode and shell area may be heavy but the deposits are easily removed. **Spark plugs with scavenger deposits can be considered normal in condition, cleaned and reused.**

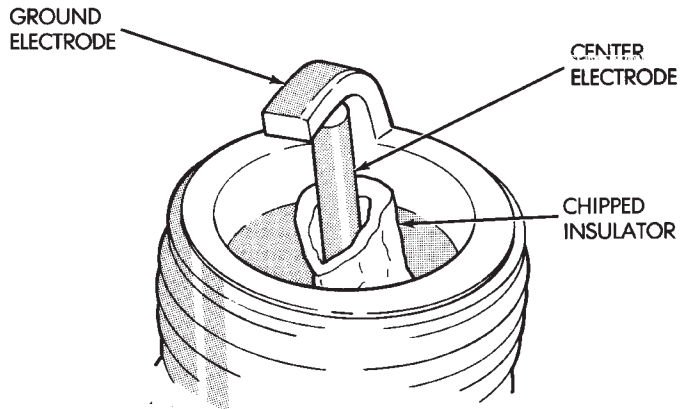


J908D-12

Fig. 24 Scavenger Deposits

CHIPPED ELECTRODE INSULATOR

A chipped electrode insulator usually results from bending the center electrode while adjusting the spark plug electrode gap. Under certain conditions, severe detonation also can separate the insulator from the center electrode (Fig. 25). **Spark plugs with chipped electrode insulators must be replaced.**

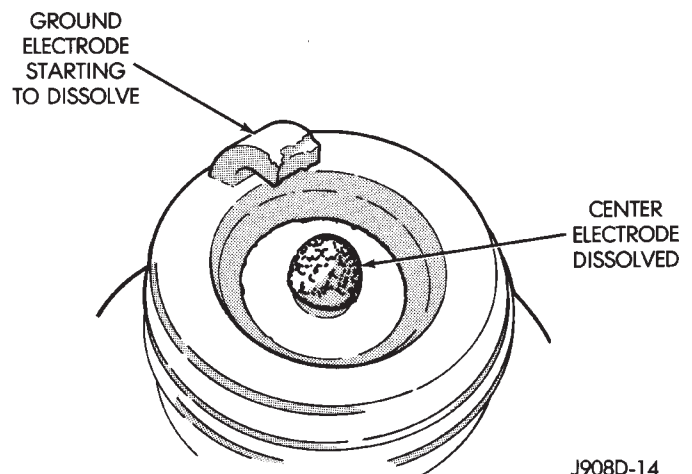


J908D-13

Fig. 25 Chipped Electrode Insulator

PREIGNITION DAMAGE

Excessive combustion chamber temperature can cause preignition damage. First, the center electrode dissolves and the ground electrode dissolves somewhat later (Fig. 26). Insulators appear relatively deposit free. Determine if the spark plugs are the correct type, as specified on the VECI label, or if other operating conditions are causing engine overheating.



J908D-14

Fig. 26 Preignition Damage

SPARK PLUG OVERHEATING

Overheating is indicated by a white or gray center electrode insulator that also appears blistered (Fig. 27). The increase in electrode gap will be consider-

DIAGNOSIS AND TESTING (Continued)

ably in excess of 0.001 in per 1000 miles of operation. This suggests that a plug with a cooler heat range rating should be used. Over advanced ignition timing, detonation and cooling system malfunctions also can cause spark plug overheating.

BLISTERED
WHITE OR
GRAY
COLORED
INSULATOR



J908D-16

Fig. 27 Spark Plug Overheating

REMOVAL AND INSTALLATION

POWERTRAIN CONTROL MODULE (PCM)

The PCM engine control strategy prevents reduced idle speeds until after the engine operates for 320 km (200 miles). If the PCM is replaced after 320 km (200 miles) of usage, update the mileage in the new PCM. Use the DRB scan tool to change the mileage in the PCM. Refer to the appropriate Powertrain Diagnostic Manual and the DRB scan tool.

REMOVAL

- (1) Remove air cleaner.
- (2) Disconnect PCM 2 40-way connector (Fig. 28)
- (3) Remove 2 bolts from PCM bracket.
- (4) Remove PCM.

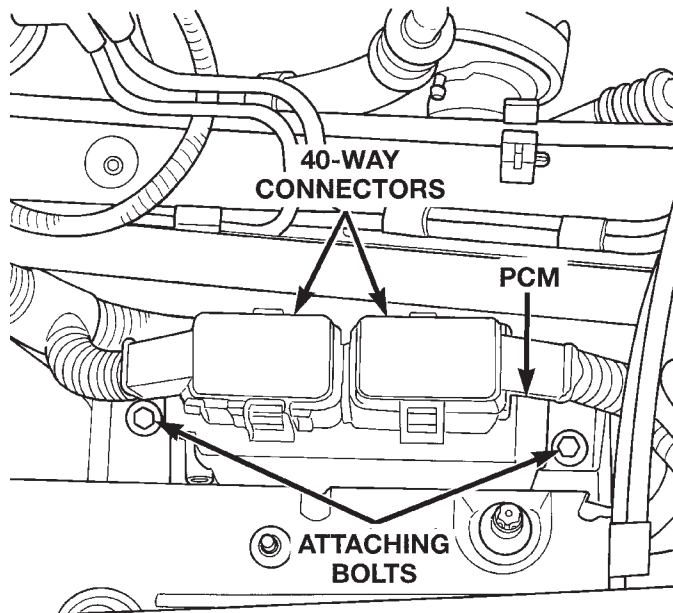
INSTALLATION

- (1) Install PCM. Tighten bolt to 4 N·m (35 in. lbs.) torque.
- (2) Attach 2 40-way connector to PCM.
- (3) Install air cleaner.
- (4) Using DRB scan tool, program mileage into PCM. Refer to the DRB scan tool and the appropriate Powertrain Diagnostic Manual.

SPARK PLUG CABLE—3.3L

REMOVAL

Remove the cable from the retaining bracket. Grasp the terminal as close as possible to the spark plug. Rotate the cover (boot) slightly and pull straight back. **Do not use pliers and do not pull the cable at an angle.** Doing so will damage the



8066007e

Fig. 28 PCM Location

insulation, cable terminal or the spark plug insulator. **Wipe spark plug insulator clean before installing cable and cover.**

INSTALLATION

When replacing the spark plug and coil cables, route the cables correctly and secure them in the appropriate retainers. Failure to route the cables properly can cause the radio to reproduce ignition noise, cross ignition of the spark plugs or short circuit the cables to ground.

SPARK PLUG CABLE—3.5L

The cables insulate the spark plugs and seal the top of the spark plug tube. A grooved tray routes the cables from the coil to each cylinder. The cables for the even number cylinders run along the bottom of the tray (Fig. 29). Cables for the odd number cylinders run along the top of the tray. Access the cables through the openings between the runners of the intake manifold plenum.

REMOVAL

To remove the cables, lightly grasp the top of the boot with pliers. Rotate the cable slightly and pull straight up. To replace the cables, disconnect the cable from the ignition coil. Remove the cable from the tray and route the coil end under the center of the intake manifold plenum.

INSTALLATION

To install the cables, run the coil end under the plenum and through the cable tray. Route the cables

REMOVAL AND INSTALLATION (Continued)

for the left side of the engine under the front of the fuel rail and then down the side of the rail (Fig. 30). Connect the cable to the coil. Slide the insulator into the tubes and over the spark plug. Ensure the insulator fully seats to the top of the spark plug tube.

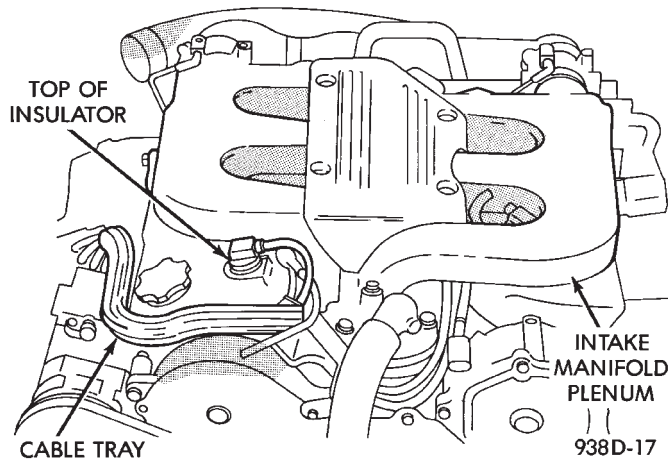


Fig. 29 Spark Plug Cables—3.5L Engine

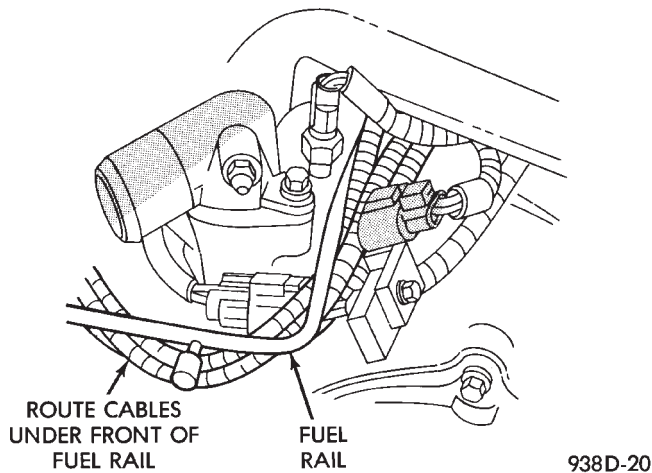


Fig. 30 Fuel Rail—3.5L Engine

SPARK PLUG

Always remove the spark plug cable by grasping at the spark plug boot, turning the boot 1/2 turn and pulling straight back in a steady motion.

REMOVAL

- (1) Prior to removing the spark plug, spray compressed air around the spark plug hole and the area around the spark plug.
- (2) Remove the spark plug using a quality socket with a rubber or foam insert.
- (3) Inspect the spark plug condition. Refer to Spark Plug Condition in this section.

INSTALLATION

- (1) To avoid cross threading, start the spark plug into the cylinder head by hand.

- (2) Tighten spark plugs to 28 N·m (20 ft. lbs.) torque.

- (3) Install spark plug cables over spark plugs. On 3.5L engines, ensure the top of the spark plug insulator seals the upper end of the spark plug tube.

IGNITION COIL—3.3L

The electronic ignition coil pack attaches to a bracket mounted on the left cylinder head (Fig. 31).

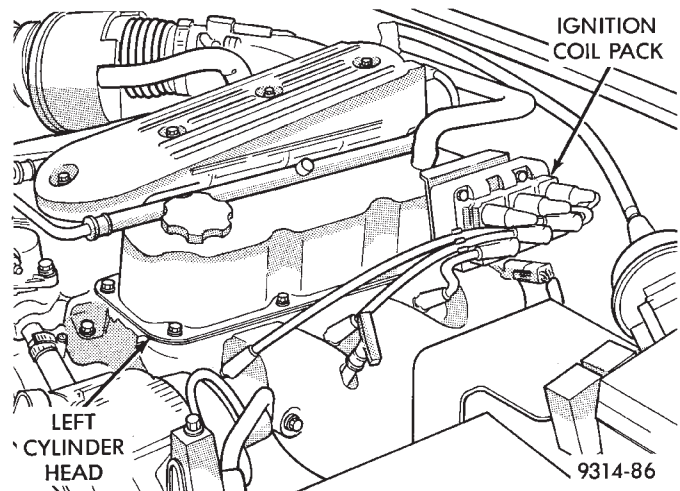


Fig. 31 Ignition Coil—3.3L

REMOVAL

- (1) Disconnect electrical connector from coil pack.
- (2) Remove coil pack mounting screws.
- (3) Remove coil. The spark plug cables are numbered for cylinder identification.
- (4) Transfer spark plug cables to new coil pack. The coil pack towers are numbered with the cylinder identification (Fig. 32).

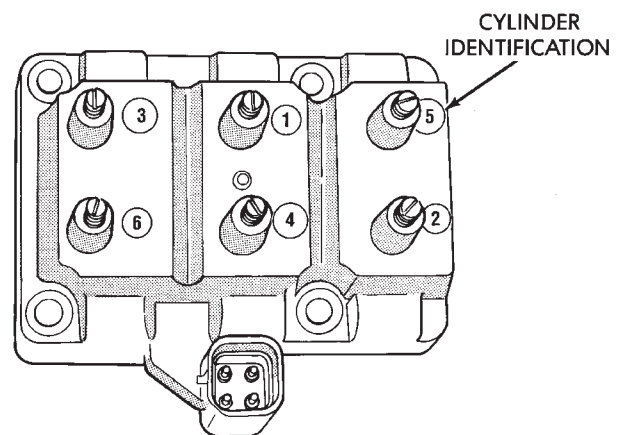


Fig. 32 Cylinder Identification

INSTALLATION

- (1) Reverse procedure for installation.

REMOVAL AND INSTALLATION (Continued)

IGNITION COIL—3.5L

The ignition coil pack attaches to the right cylinder head (Fig. 33).

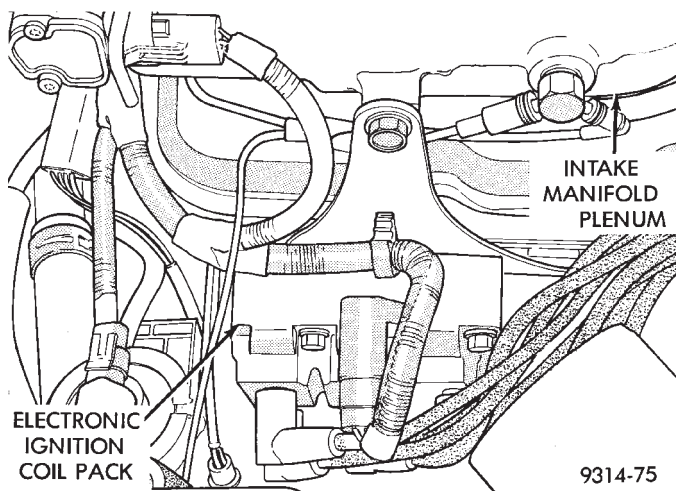


Fig. 33 Ignition Coil —3.5L Engine

REMOVAL

- (1) Remove air cleaner hose.
- (2) Disconnect electrical connector from coil pack.
- (3) Remove coil pack mounting screws.
- (4) Remove coil. The spark plug cables are numbered for cylinder identification (Fig. 34).

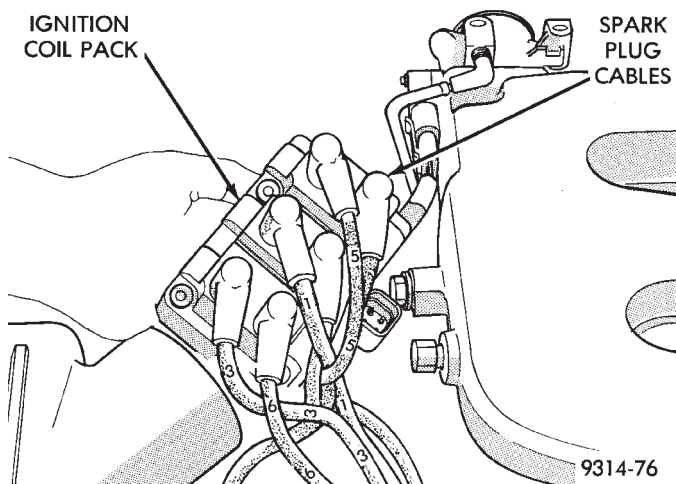


Fig. 34 Spark Plug Cable Identification

- (5) Transfer spark plug cables to new coil pack. The coil pack towers are numbered with the cylinder identification (Fig. 32).

INSTALLATION

- (1) Reverse procedure for installation.

AUTOMATIC SHUTDOWN RELAY

The relay is located in the Power Distribution Center (PDC) (Fig. 35). The PDC is located next to the battery in the engine compartment. For the location

of the relay within the PDC, refer to the PDC cover for location. Check electrical terminals for corrosion and repair as necessary.

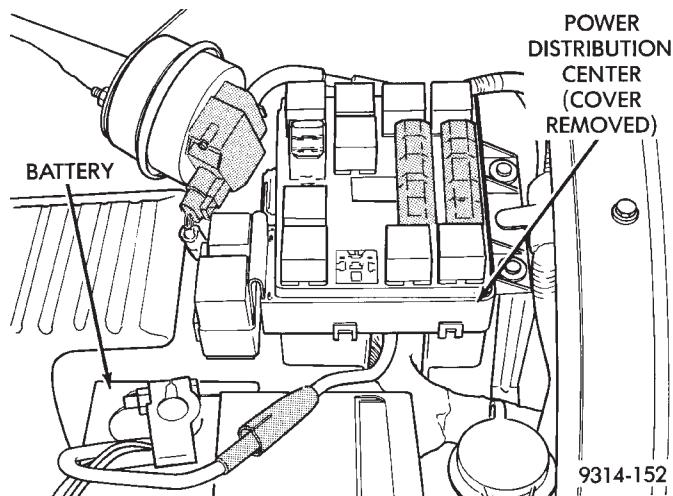


Fig. 35 Power Distribution Center (PDC)

CAMSHAFT POSITION SENSOR—3.3L

The camshaft position sensor is mounted in the front of the timing case cover (Fig. 36).

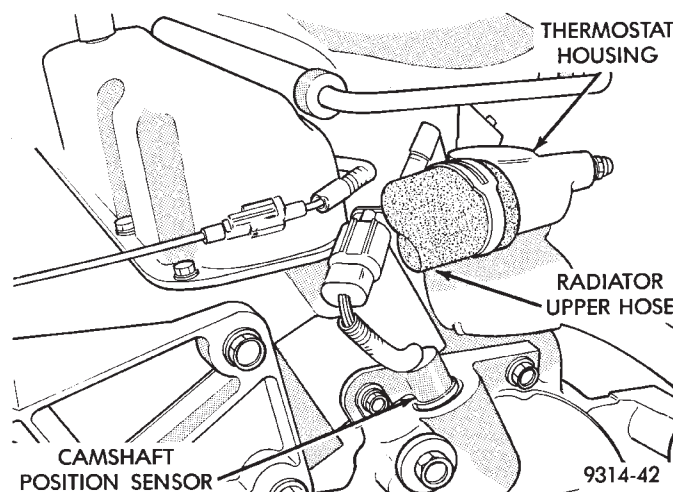


Fig. 36 Camshaft Position Sensor Location

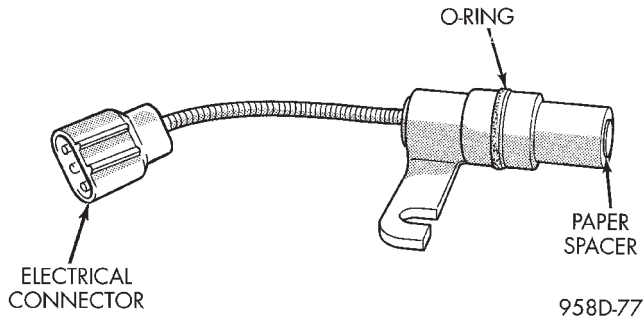
REMOVAL

- (1) Disconnect electrical connector from sensor.
- (2) Loosen camshaft position sensor screw.
- (3) Without pulling on the connector wires, pull the sensor up out of the chain case cover.

INSTALLATION

If the removed sensor is reinstalled, clean off the old spacer on the sensor face. Attach a NEW SPACER to the face of the sensor before installation. If installing a new sensor, confirm that the paper spacer is attached to the face and O-ring is positioned in groove (Fig. 37).

REMOVAL AND INSTALLATION (Continued)

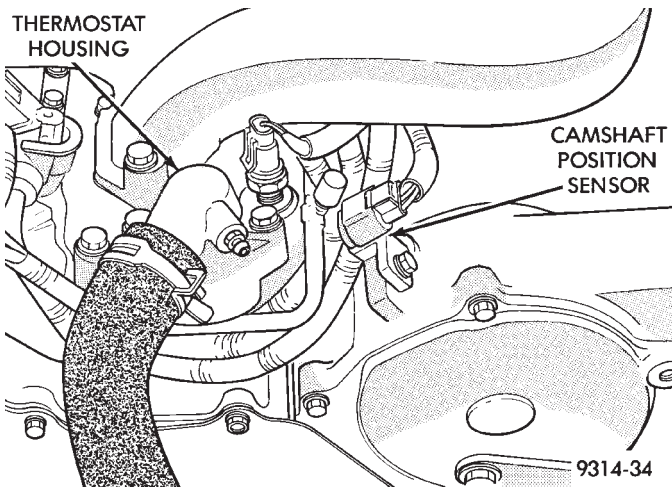
**Fig. 37 Paper Spacer—3.3L Engine**

(1) Install sensor in the chain case cover and push sensor down until contact is made with the camshaft sprocket. While holding the sensor in this position, install and tighten the retaining bolt to 12 N·m (105 in. lbs.) torque.

(2) Attach electrical connector to sensor.

CAMSHAFT POSITION SENSOR—3.5L

The camshaft position sensor is installed in the timing belt housing cover above the left camshaft sprocket (Fig. 38).

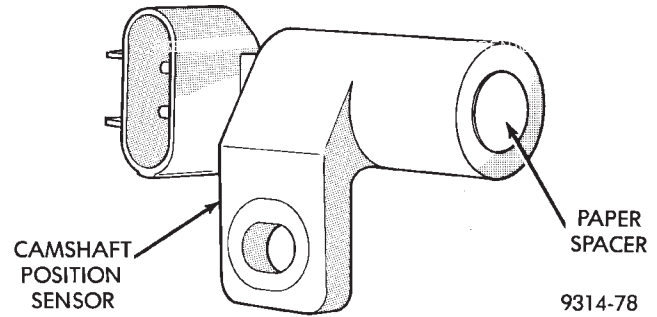
**Fig. 38 Camshaft Position Sensor—3.5L****REMOVAL**

- (1) Disconnect electrical connector from sensor.
- (2) Remove camshaft position sensor screw.
- (3) Pull sensor up out of the chain case cover.

INSTALLATION

If the removed sensor is reinstalled, clean off the old spacer on the sensor face. Attach a NEW SPACER to the face of the sensor before installation. If installing a new sensor, confirm that the paper spacer is attached to the face (Fig. 39).

(1) Install sensor in the timing belt housing and push sensor down until contact is made with the camshaft sprocket. While holding the sensor in this

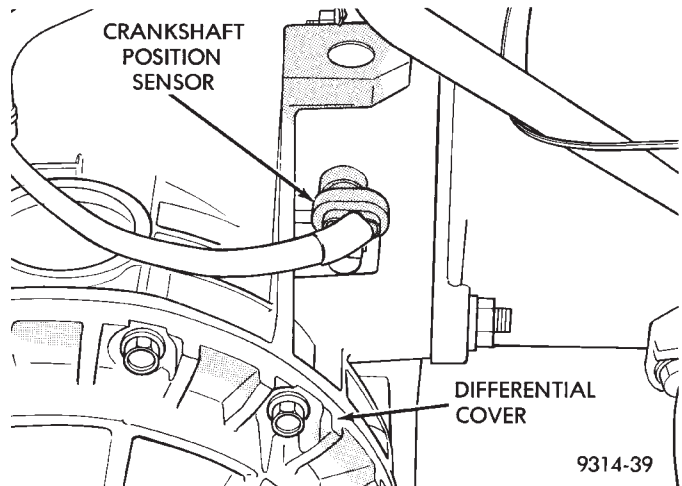
**Fig. 39 Paper Spacer—3.5L Engine**

position, install and tighten the retaining bolt to 12 N·m (105 in. lbs.) torque.

(2) Attach electrical connector to sensor.

CRANKSHAFT POSITION SENSOR

The crankshaft sensor is located on the passengers side of the transmission housing, above the differential housing (Fig. 40). The bottom of the sensor sits above the drive plate.

**Fig. 40****REMOVAL**

- (1) Disconnect electrical connector from crankshaft position sensor.
- (2) Remove sensor mounting screw. Remove sensor.

INSTALLATION

- (1) Reverse procedure for installation.

ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant sensor is located next to the thermostat housing (Fig. 41) or (Fig. 42).

REMOVAL

- (1) With the engine cold, disconnect coolant sensor electrical connector.
- (2) Remove coolant sensor.

REMOVAL AND INSTALLATION (Continued)

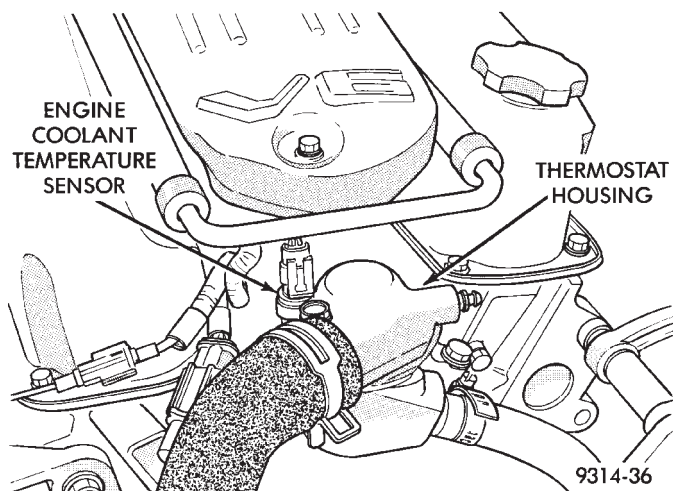


Fig. 41 Engine Coolant Temperature Sensor—3.3L

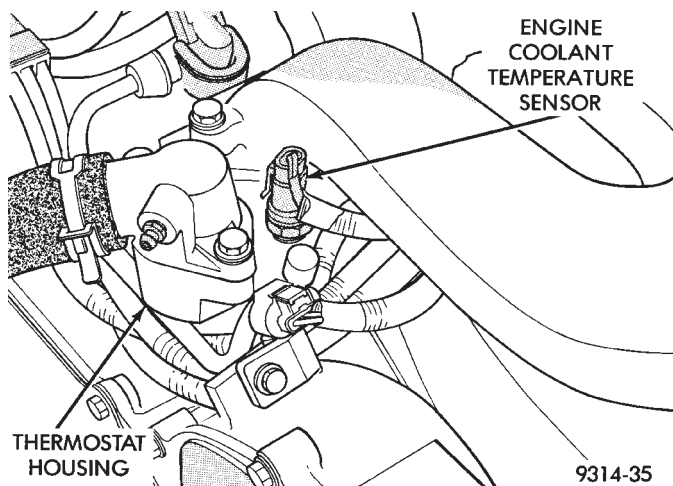


Fig. 42 Engine Coolant Temperature Sensor—3.5L

INSTALLATION

- (1) Install coolant sensor. Tighten sensor to 28 N·m (20 ft. lbs.) torque.
- (2) Attach electrical connector to sensor.

KNOCK SENSORS—3.5L

The 3.5L engine uses two knock sensors. The sensors thread into the cylinder block, directly below the intake manifold.

REMOVAL

- (1) Remove intake manifold plenum. Refer to Intake Manifold Plenum in Group 11.
- (2) Remove intake manifold. Refer to Group 11.
- (3) Disconnect electrical connector from knock sensor(s) (Fig. 43).
- (4) Use a crows foot socket to remove the knock sensors.

INSTALLATION

- (1) Install knock sensor. Tighten knock sensor to 10 N·m (7 ft. lbs.) torque. **Over or under tighten-**

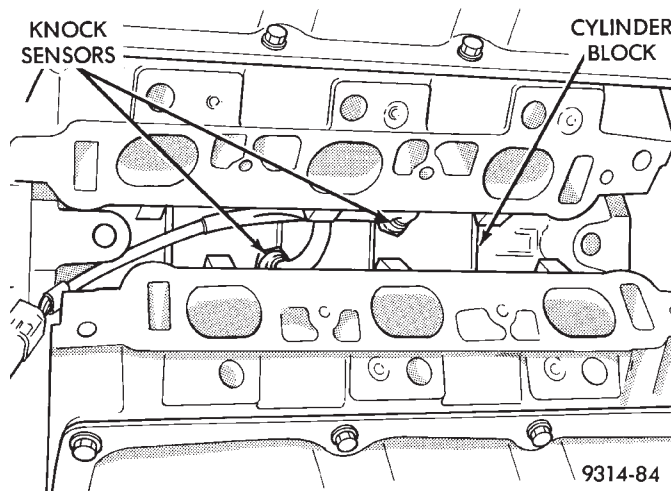


Fig. 43 Knock Sensor—3.5L Engine

ing effects knock sensor performance, possibly causing improper spark control.

- (2) Attach electrical connector to knock sensor.
- (3) Install intake manifold. Refer to Group 11.
- (4) Install intake manifold plenum. Refer to Intake Manifold Plenum in Group 11.

INTAKE AIR TEMPERATURE SENSOR

For removal and installation of sensors refer to Group 14, Fuel Systems.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—3.3L

On 3.3L engines, the MAP sensor mounts onto the rear of the intake manifold plenum (Fig. 44).

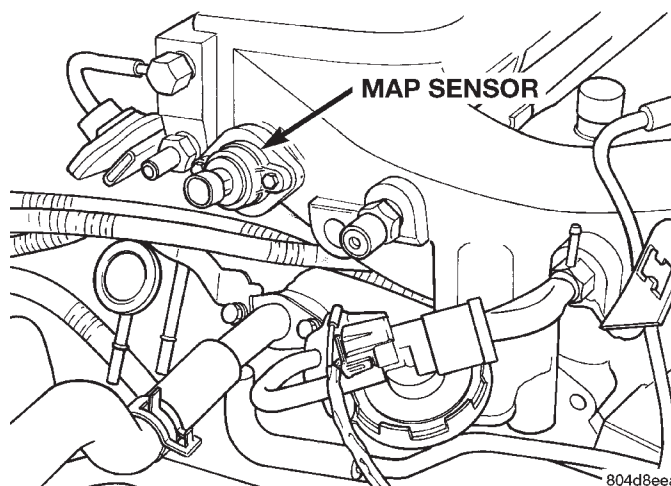


Fig. 44 MAP Sensor—3.3L Engine

REMOVAL

- (1) Disconnect the electrical connector from the MAP sensor.
- (2) Remove sensor.

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

- (1) The sensor mounts onto intake manifold plenum. Tighten screws to 2 N·m (20 in. lbs.) torque.
- (2) Attach electrical connector to sensor.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—3.5L

On 3.5L engines, the MAP sensor threads into the left side of the intake manifold plenum (Fig. 45).

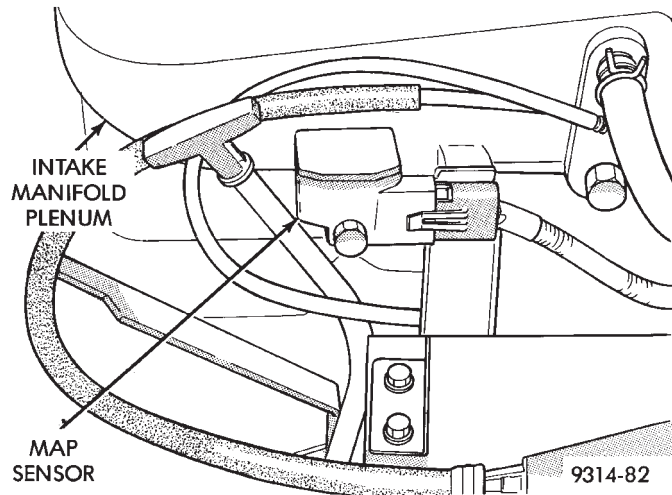


Fig. 45 MAP Sensor—3.5L Engine

REMOVAL

- (1) Disconnect the electrical connector from the MAP sensor.
- (2) Remove sensor.

INSTALLATION

- (1) Thread sensor into intake manifold plenum. Tighten sensor to 10 N·m (90 in. lbs.) torque and then rotate it to horizontal position.
- (2) Attach electrical connector to sensor.

THROTTLE POSITION SENSOR

Refer to Group 14, Fuel Injection Section, for Removal/Installation.

IGNITION SWITCH

The ignition switch attaches to the lock cylinder housing on the end opposite the lock cylinder (Fig. 46). For ignition switch terminal and circuit identification, refer to Group 8W, Wiring Diagrams.

REMOVAL

- (1) Disconnect negative cable from battery.
- (2) Remove tilt lever attaching screw. Remove lever.
- (3) Remove upper and lower cover from steering column.
- (4) Remove multi-function switch.

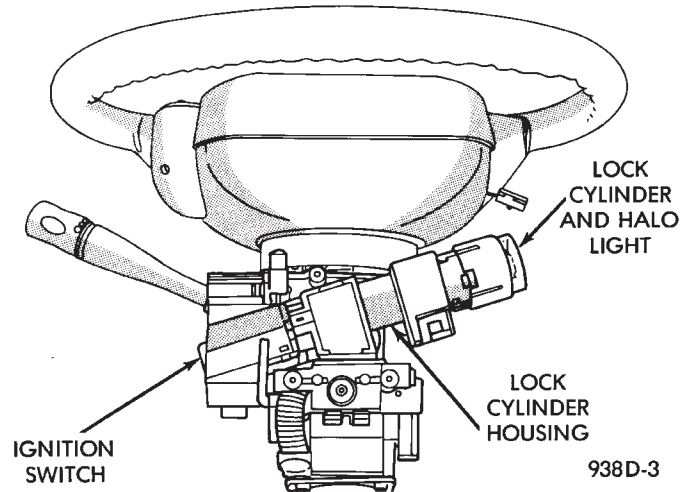


Fig. 46 Ignition Switch

- (5) Disconnect electrical connector from ignition switch (Fig. 47).
- (6) Remove Ignition switch mounting screws. Remove switch.

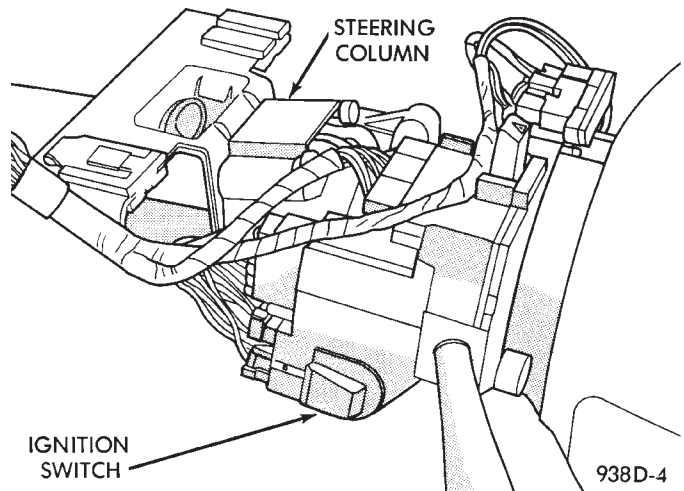


Fig. 47 Ignition Switch Removal/Installation

INSTALLATION

- (1) A tab on the ignition switch indexes to a notch in the lock cylinder housing (Fig. 48). Also, a slot in the end of the ignition switch fits over the shaft in the end of the lock cylinder housing. Use the ignition key to rotate the lock cylinder to align the ignition switch with lock cylinder housing.
- (2) Install and tighten ignition switch mounting screws.
- (3) Attach electrical connector to ignition switch.
- (4) Install multi-function switch.
- (5) Install upper and lower cover on steering column.
- (6) Install tilt lever.
- (7) Connect negative cable to battery.

REMOVAL AND INSTALLATION (Continued)

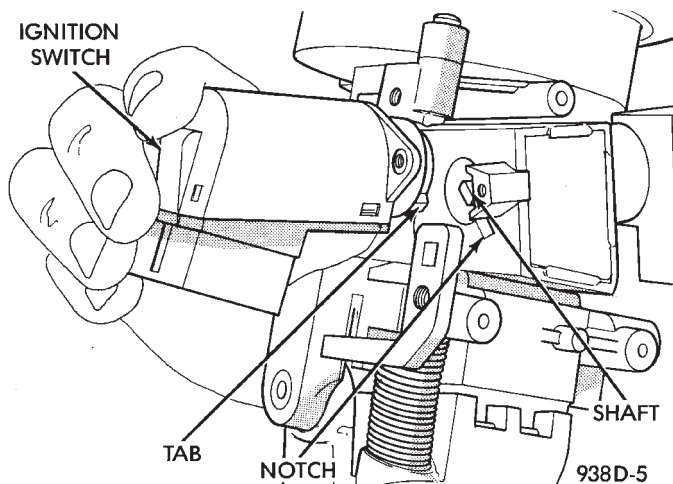


Fig. 48 Ignition Switch Alignment

LOCK KEY CYLINDER

The lock cylinder is inserted in the end of the housing opposite the ignition switch. The ignition key rotates the cylinder to 5 different detentes (Fig. 49):

- Accessory
- Off (lock)
- Unlock
- On/Run
- Start

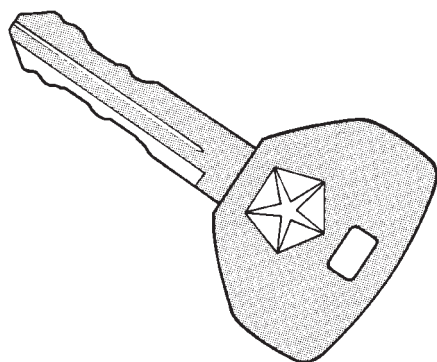
● UNLOCK

● ON/RUN

● START

● OFF

● ACCESSORY



938D-22

Fig. 49 Ignition Lock Cylinder Detentes

When replacing the lock cylinder, if the vehicle has a column shifter, install a new interlock cassette. If the vehicle has a floor shift, adjust the interlock cable at the floor shifter when the lock cylinder is replaced. Refer to Floor Shift Interlock Adjustment in Group 21.

REMOVAL

- (1) Disconnect negative cable from battery.
- (2) Remove the tilt lever attaching screw. Remove lever.

(3) Remove the upper and lower covers from the steering column.

(4) Turn the ignition key to the run position. When ignition switch is in the run position, the lock cylinder retaining tab will depress.

(5) Depress tab and slide lock cylinder out of housing (Fig. 50).

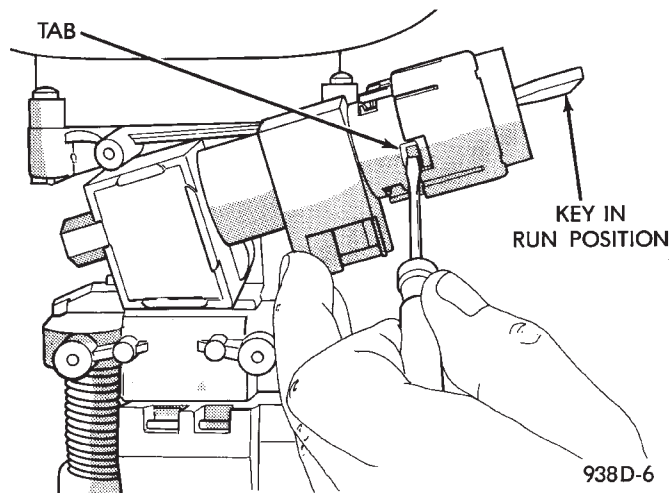


Fig. 50 Lock Cylinder Removal

INSTALLATION

(1) Install key in lock cylinder. Turn key to run position (retaining tab on lock cylinder can be depressed).

(2) The shaft at the end of the lock cylinder aligns with the socket in the end of the housing. To align the socket with the lock cylinder, ensure the socket is in the Run position (Fig. 51).

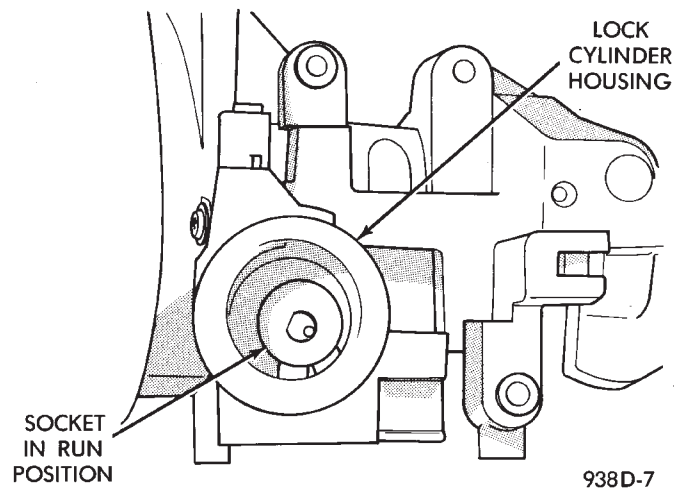
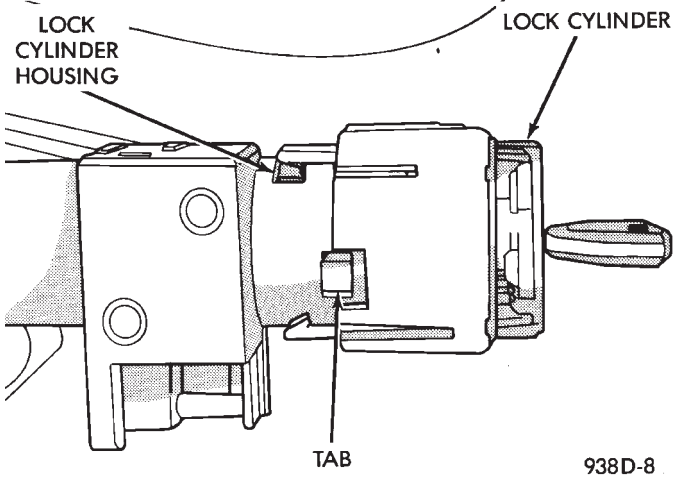


Fig. 51 Socket in Lock Cylinder Housing

(3) Align the lock cylinder with the grooves in the housing. Slide the lock cylinder into the housing until the tab sticks through the opening in the housing (Fig. 52).

(4) Turn key to Off position. Remove key.

REMOVAL AND INSTALLATION (Continued)**Fig. 52 Lock Cylinder Installation**

(5) If the vehicle has column shift and a new lock cylinder was used, install and adjust a new interlock cassette. Refer to Ignition Interlock in this section. If the vehicle has a floor shift, adjust the interlock cable when the lock cylinder is replaced. Refer to the Floor Shift Interlock Adjustment procedure in this section.

(6) Install upper and lower cover on steering column.

(7) Install tilt lever.

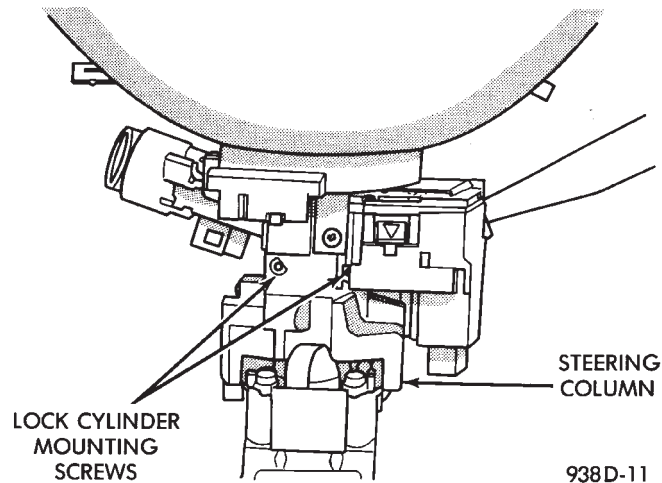
(8) Connect negative cable to battery.

IGNITION INTERLOCK

Refer to Group 21, Transaxle for Shifter/Ignition Interlock Service.

LOCK CYLINDER HOUSING

The lock cylinder housing attaches to the steering column with tamper-proof screws and hardened washers (Fig. 53) (Fig. 10).

**Fig. 53 Lock Cylinder Housing Mounting Screws****REMOVAL**

(1) Remove the tilt lever attaching screw. Remove lever.

(2) Remove the upper and lower covers from the steering column.

(3) If the vehicle has floor shift, remove the interlock cable. If the vehicle has column shift, remove and discard the column shift interlock cassette.

(4) Remove the multi-function switch and ignition switch. Refer to Ignition Switch in this section.

(5) Center punch the tamper-proof screws.

(6) Using a 6 mm (1/4 inch) drill bit, drill out the screw heads. Drill until the bit contacts the hardened washer under the screw head.

(7) Remove the lock cylinder housing from the steering column.

(8) Use a pair of pliers to remove the bolts from the steering column lock.

INSTALLATION

The heads of the tamper-proof mounting screws shear off when tightened.

(1) Position lock cylinder housing on steering column.

(2) Tighten new mounting screws until the heads of the tamper-proof screws shear off.

(3) Install ignition switch and multi-function switch.

(4) If the vehicle has column shift, install a new column shift interlock cassette. If the vehicle has a floor shift, reconnect and adjust the shift cable.

(5) Install upper and lower covers on steering column.

(6) Install tilt lever

SPECIFICATIONS

VECI LABEL

If anything differs between the specifications found on the Vehicle Emission Control Information (VECI) label and the following specifications, use specifications on VECI label. The VECI label is located in the engine compartment.

DescriptionTorque

- 3.3/3.5L Camshaft Position Sensor
- Screw 12 N·m (105 in. lbs.)
- 3.3/3.5L Engine Coolant Sensor . 28 N·m (20 ft. lbs.)
- 3.3/3.5L Crankshaft Position
- Sensor Screw 12 N·m (105 in. lbs.)
- 3.3/3.5L Ignition Coil 12 N·m (105 in. lbs.)
- 3.5L Knock Sensor 10 N·m (7 ft. lbs.)
- 3.3L Map Sensor 2 N·m (20 in. lbs.)
- 3.5L Map Sensor 10 N·m (90 in. lbs.)
- Spark Plugs 28 N·m (20 ft. lbs.)

CABLES RESISTANCE CHART

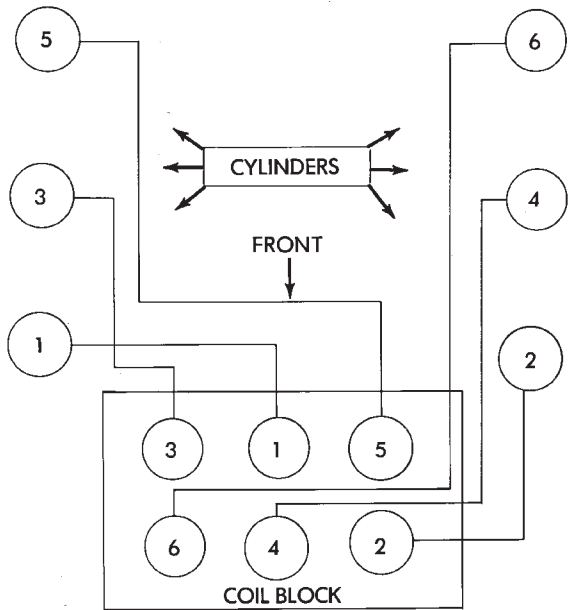
MINIMUM	MAXIMUM
250 Ohms Per Inch	1000 Ohms Per Inch
3000 Ohms Per Foot	12,000 Ohms Per Foot

SPARK PLUGS

Engine	Spark Plug	Gap	Thread Size
3.3L	RN14MC5	0.048 TO 0.053 in.	14 mm (3/4 in.) reach
3.5L	RC12LYC	0.033 TO 0.038 in.	14 mm (3/4 in.) reach

IGNITION COILS

Coil Manufacturer	Primary Resistance at 21°C–27°C (70°F–80°F)	Secondary Resistance at 21°C–27°C (70°F–80°F)
Diamond (brass towers)	0.45 to 0.65 Ohms	7,000 to 15,800 Ohms
Toyodenso (aluminum towers)	0.45 to 0.65 Ohms	7,000 to 15,800 Ohms



938D-18

FIRING ORDER—3.3/3.5L

948D-24