6

EMISSIONS AND ENGINE CONTROL SYSTEMS

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16 Throttle actuator control module - replacement
17 Crankcase ventilation system
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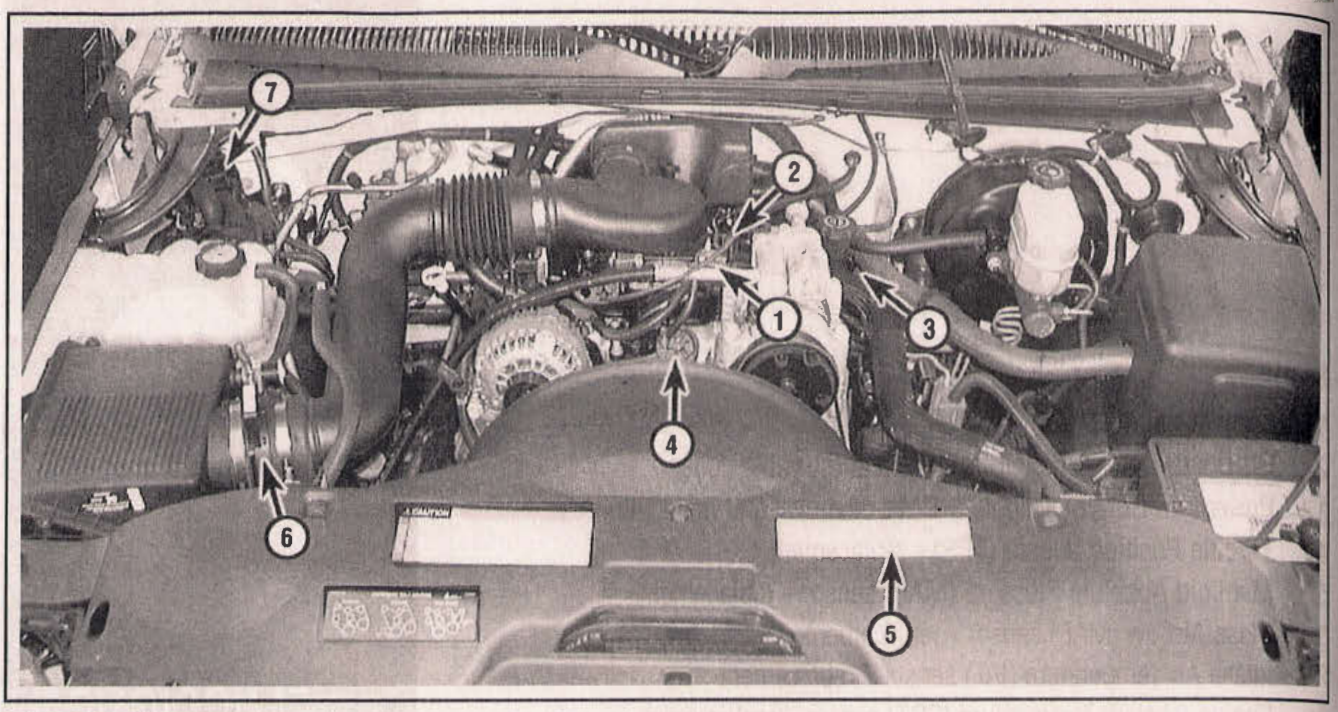
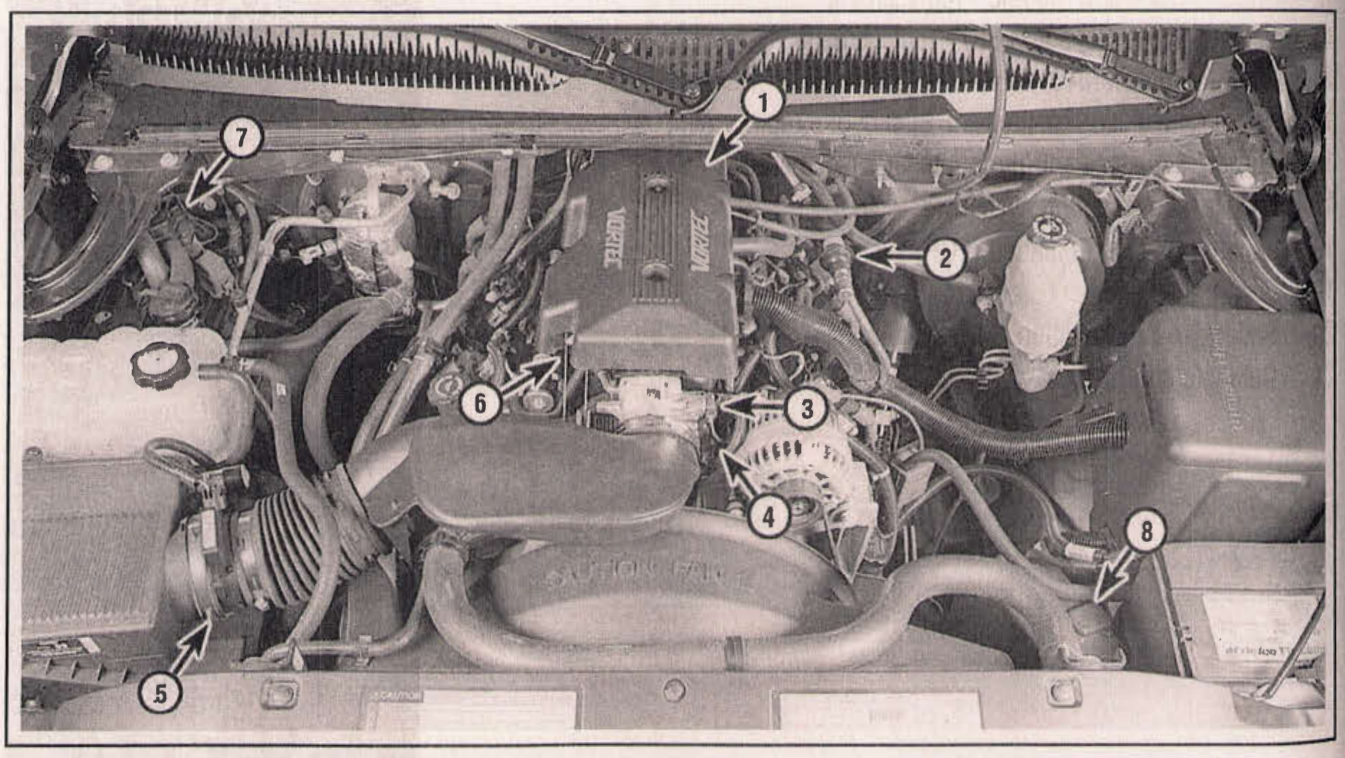
19 Evaporative emissions control (EVAP) system
20 Secondary Air Injection (AIR) system
21 Catalytic converter



1.1a Typical emission and engine control system components - V6 models

1 *Throttle Position Sensor (TPS)*
2 *Idle Air Control (IAC) valve*
3 *Positive Crankcase Ventilation (PCV) valve*
4 *Exhaust Gas Recirculation (EGR) valve*
5 *Vehicle Emissions Control Information (VECI) label*
6 *Mass Airflow (MAF) sensor/Intake Air Temperature (IAT) sensor*
7 *Secondary Air Injection (AIR) pump*



1.1b Typical emission and engine control system components - V8 models

1 *Manifold Absolute Pressure (MAP) sensor (under cover)*
2 *Secondary Air Injection (AIR) check valve*
3 *Idle Air Control (IAC) valve*
4 *Throttle Position Sensor (TPS)*
5 *Mass Airflow (MAF) sensor/Intake Air Temperature (IAT) sensor*
6 *Evaporative emissions system (EVAP) purge valve*
7 *Secondary Air Injection (AIR) pump*
8 *Powertrain Control Module (PCM)*

1 General information

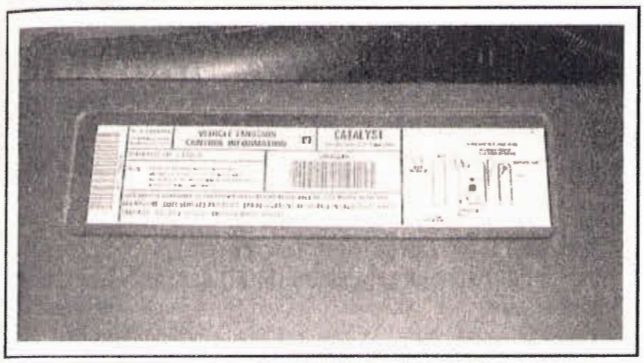
Refer to illustrations 1.1a, 1.1b and 1.6

To prevent pollution of the atmosphere from incompletely burned and evaporating gases, and to maintain good driveability and fuel economy, a number of emission control systems are incorporated (see illustrations). They include the:

Electronic engine control system
Crankcase ventilation system
Exhaust gas recirculation system
Evaporative emissions control system
Secondary air injection system
Catalytic converter

All of these systems are linked, directly or indirectly, to the emission control system.

The Sections in this Chapter include general descriptions, checking procedures within the scope of the home mechanic (when possible) and component replacement procedures for each of the systems listed above.



1.6 The Vehicle Emission Control Information (VECI) label is located in the engine compartment and contains information on the emission devices on your vehicle, vacuum line routing, etc.

Before assuming that an emissions control system is malfunctioning, check the fuel and ignition systems carefully. The diagnosis of some emission control devices requires specialized tools, equipment and training. If checking and servicing become too difficult or if a procedure is beyond your ability, consult a dealer service department or other properly equipped repair facility. Remember, the most frequent cause of emissions problems is simply a loose or broken vacuum hose or wire, so always check the hose and wiring connections first.

This doesn't mean, however, that emission control systems are particularly difficult to maintain and repair. You can quickly and easily perform many checks and do most of the regular maintenance at home with common tune-up and hand tools.

➡Note: Because of a Federally mandated warranty which covers the emission control system components, check with your dealer about warranty coverage before working on any emissions-related systems. Once the warranty has expired, you may wish to perform some of the component checks and/or replacement procedures in this Chapter to save money.

Pay close attention to any special precautions outlined in this Chapter. It should be noted that the illustrations of the various systems may not exactly match the system installed on the vehicle you're working on because of changes made by the manufacturer during production or from year-to-year.

A Vehicle Emissions Control Information (VECI) label is located in the engine compartment (see illustration). This label contains important emissions specifications and adjustment information, as well as a vacuum hose schematic with emissions components identified. When servicing the engine or emissions systems, the VECI label in your particular vehicle should always be checked for up-to-date information.

2 On-Board Diagnostic (OBD) system and trouble codes

DIAGNOSTIC TOOL INFORMATION

Refer to illustrations 2.1 and 2.2

1 A digital multimeter is necessary for checking fuel injection and emission related components (see illustration). A digital volt-ohmmeter is preferred over the older style analog multimeter for several reasons. The analog multimeter cannot display the volts-ohms or amps measurement in hundredths and thousandths increments. When working with electronic circuits which are often very low voltage, this accurate reading is most important. Another good reason for the digital multimeter is the high impedance circuit. The digital multimeter is equipped with a high resistance internal circuitry (10 million ohms). Because a voltmeter is hooked up in parallel with the circuit when testing, it is vital that none of the voltage being measured should be allowed to travel the parallel path set up by the meter itself. This dilemma does not show itself when measuring larger amounts of voltage (9 to 12 volt circuits) but if you are measuring a low voltage circuit such as the oxygen sensor signal voltage, a fraction of a volt may be a significant amount when diagnosing a problem. However, there are several exceptions where using an analog voltmeter may be necessary to test certain sensors.

2.1 Digital multimeters can be used for testing all types of circuits; because of their high impedance, they are much more accurate than analog meters for measuring low-voltage computer circuits

2 Hand-held scanners are the most powerful and versatile tools for analyzing engine management systems used on later model vehicles (see illustration). Each brand scan tool must be examined carefully to match the year, make and model of the vehicle you are working on. Often interchangeable cartridges are available to access the particular manufacturer (Ford, GM, Chrysler, etc.). Some manufacturers will specify by continent (Asia, Europe, USA, etc.).

3 With the arrival of the Federally mandated emission control system (OBD-II), a specially designed scanner has been developed. Several tool manufacturers have released OBD-II scan tools for the home mechanic.

ON-BOARD DIAGNOSTIC SYSTEM GENERAL DESCRIPTION

4 All models described in this manual are equipped with the second generation On-Board Diagnostic (OBD-II) system. The system consists of an onboard computer, known as the Powertrain Control Module (PCM), information sensors and output actuators.

5 The information sensors monitor various functions of the engine and send data to the PCM. Based on the data and the information programmed into the computer's memory, the PCM generates output signals to control various engine functions via control relays, solenoids and other output actuators. The PCM is specifically calibrated to optimize the emissions, fuel economy and driveability of the vehicle.

➡Note: On 2001 and later models, the PCM has an additional function called "torque management." With this function, The PCM reduces engine torque under certain driving conditions, such as heavy acceleration, loss of traction in one axle (4WD), or shifting under full throttle. The PCM adjusts the torque load by retarding the ignition timing and/or shutting off some fuel injectors.

6 Because of a Federally mandated warranty which covers the emissions system components and because any owner-induced damage to the PCM, the sensors and/or the control devices may void the warranty, it isn't a good idea to attempt diagnosis or replacement of the system components while the vehicle is under warranty. Take the vehicle to a dealer service department if the PCM or a system component malfunctions.

INFORMATION SENSORS

7 **Accelerator pedal position (APP) sensor** - The APP sensor is an integral component of the accelerator pedal assembly. It is used only on later V8 models that have an electronically-controlled throttle system with no cable. It provides the PCM with a variable voltage signal that is proportional to the angle of the accelerator pedal. The PCM uses this datum to control the position of the throttle plate inside the throttle body via the throttle actuator control module.

8 **Camshaft Position (CMP) sensor** - The camshaft position sensor provides information on camshaft position. The PCM uses this information, along with the crankshaft position sensor information, to control fuel injection synchronization.

9 **Crankshaft Position (CKP) sensor** - The crankshaft position sensor senses crankshaft position (TDC) during each engine revolution. The PCM uses this information to control ignition timing and fuel injection synchronization.

10 **Engine Coolant Temperature (ECT) sensor** - The engine coolant temperature sensor senses engine coolant temperature. The PCM uses this information to control fuel injection duration and ignition timing.

2.2 Scanners like these from Actron and AutoXray are powerful diagnostic aids - programmed with comprehensive diagnostic information, they can tell you just about anything you want to know about your engine management system

11 **Intake Air Temperature (IAT) sensor** - The intake air temperature senses the temperature of the air entering the intake manifold. The PCM uses this information to control fuel injection duration.

12 **Knock Sensor (KS)** - The knock sensor is a piezoelectric element that detects the sound of engine detonation, or "pinging". The PCM uses the input signal from the knock sensor to recognize detonation and retard spark advance to avoid engine damage.

13 **Manifold Absolute Pressure (MAP) sensor** - The manifold absolute pressure monitors intake manifold pressure and ambient barometric pressure. The PCM uses this input signal to determine engine load and adjusts fuel injection duration accordingly.

14 **Mass Airflow (MAF) sensor** - The mass airflow sensor measures the amount of air passing through the sensor body and ultimately entering the engine. The PCM uses this information to control fuel delivery.

15 **Oxygen (O2) sensor** - The oxygen sensors generate a voltage signal that varies with the varying oxygen content of the exhaust gas. The PCM uses this information to determine if the fuel system is running rich or lean and make adjustments accordingly.

16 **Throttle Position Sensor (TPS)** - The throttle position sensor senses throttle movement and position. This signal enables the PCM to determine when the throttle is closed, in a cruise position, or wide open. The PCM uses this information to control fuel delivery and ignition timing.

17 **Vehicle Speed Sensor (VSS)** - The vehicle speed sensor provides information to the PCM to indicate vehicle speed.

18 **Miscellaneous PCM inputs** - In addition to the various sensors, the PCM monitors various switches and circuits to determine vehicle operating conditions. The switches and circuits include:

a) Air conditioning system
b) Battery voltage
c) Brake On/Off switch
d) Cruise control system
e) EGR valve position
f) Engine oil level and pressure
g) EVAP system
h) Fuel level and fuel tank pressure
i) Ignition switch
j) Park/neutral position switch
k) Sensor signal and ground circuits
l) Transmission controls

OUTPUT ACTUATORS

19 **Air conditioning clutch relay** - The PCM controls the operation of the air conditioning compressor clutch with the air conditioning clutch relay.

20 **Service Engine Soon light** - The PCM will illuminate the Service Engine Soon light if a malfunction in the electronic engine control system occurs.

21 **Cruise control module** - The cruise control system operation is controlled by the PCM.

22 **Engine cooling fan relay** - The engine cooling fan is controlled by the PCM according to information received from the engine coolant temperature sensor.

23 **EGR valve** - The electronic EGR valve is controlled by the PCM. Ideal EGR flow is determined by the PCM and the EGR valve pintle position is adjusted accordingly.

24 **EVAP canister purge and vent valve solenoids** - The evaporative emission canister purge and vent valve solenoids are operated by the PCM to purge the fuel vapor canister and route fuel vapor to the intake manifold for combustion.

25 **Secondary Air Injection (AIR) pump and vacuum valve/solenoid** - The PCM operates the secondary air injection pump and opens the vacuum valve to inject fresh air into the exhaust stream, lower emission levels under certain operating conditions.

26 **Fuel injectors** - The PCM opens the fuel injectors individually in firing order sequence. The PCM also controls the time the injector is held open (pulse width). The pulse width of the injector (measured in milliseconds) determines the amount of fuel delivered. For more information on the fuel delivery system and the fuel injectors, including injector replacement, refer to Chapter 4.

27 **Fuel pump relay** - The fuel pump relay is activated by the PCM with the ignition switch in the Start or Run position. When the ignition switch is turned on, the relay is activated to supply initial line pressure to the system. For more information on fuel pump check and replacement, refer to Chapter 4.

28 **Idle Air Control valve (IAC)** - The idle air control valve controls the amount of air allowed to bypass the throttle plate when the throttle valve is closed or at idle position. The more air allowed to bypass the throttle plate, the higher the idle speed. The idle air control valve opening and the resulting idle speed is controlled by the PCM.

29 **Ignition coils/control module** - The PCM controls ignition timing through the ignition coils/control module depending on engine operation conditions. Refer to Chapter 5 for more information on the ignition coil(s) or ignition control module.

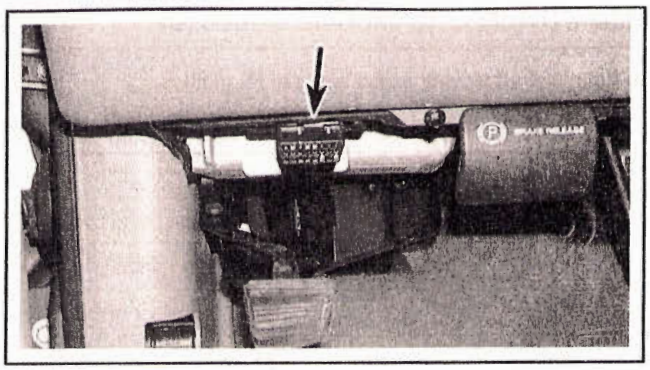
30 **Throttle actuator control module** - The throttle actuator control module receives information from the PCM and translates it into an electrical signal that is sent to the throttle body. All throttle setting from cold idle to full acceleration are governed in this way. This system is only used on later V8 models.

OBTAINING DIAGNOSTIC TROUBLE CODES

♦ Refer to illustration 2.32

➡Note: The diagnostic trouble codes on all models can only be extracted from the Powertrain Control Module (PCM) using a specialized scan tool. Have the vehicle diagnosed by a dealer service department or other qualified automotive repair facility if the proper scan tool is not available.

31 The PCM will illuminate the SERVICE ENGINE SOON light (also known as the Malfunction Indicator Lamp) on the dash if it recognizes a fault in the system. The light will remain illuminated until the problem is repaired and the code is cleared or the PCM does not detect any malfunction for several consecutive drive cycles.



2.30 The diagnostic connector is typically located under the instrument panel

32 The diagnostic codes for the On-Board Diagnostic (OBD) system can only be extracted from the PCM using a scan tool. The scan tool is programmed to interface with the OBD system by plugging into the diagnostic connector (see illustration). When used, the scan tool has the ability to diagnose in-depth driveability problems and it allows freeze frame data to be retrieved from the PCM stored memory. Freeze frame data is an OBD II PCM feature that records all related sensor and actuator activity on the PCM data stream whenever an engine control or emissions fault is detected and a trouble code is set. This ability to look at the circuit conditions and values when the malfunction occurs provides a valuable tool when trying to diagnose intermittent driveability problems. If the tool is not available and intermittent driveability problems exist, have the vehicle checked at a dealer service department or other qualified repair shop.

CLEARING DIAGNOSTIC TROUBLE CODES

33 After the system has been repaired, the codes must be cleared from the PCM memory. The preferred method is with a scan tool, but the codes can be cleared by disconnecting battery power from the PCM for a minimum of thirty seconds. Battery power can be disconnected from the PCM by removing the PCM fuse, disconnecting the PCM power connector near the positive battery terminal (if equipped) or by disconnecting the negative battery cable from the battery.

⁂ CAUTION:

On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

34 Always clear the codes from the PCM before starting the engine after a new electronic emission control component is installed onto the engine. The PCM stores the operating parameters of each sensor. The PCM may set a trouble code if a new sensor is allowed to operate before the parameters from the old sensor have been erased.

DIAGNOSTIC TROUBLE CODE IDENTIFICATION

35 The accompanying list of diagnostic trouble codes is a compilation of all the codes that may be encountered using a generic scan tool. Additional trouble codes may be obtainable with the use of the manufacturer specific scan tool. Not all codes pertain to all models and not all codes will illuminate the Service Engine Soon light when set. All models require a scan tool to access the diagnostic trouble codes.

OBD-II DIAGNOSTIC TROUBLE CODES (DTCS)

➡Note: Not all trouble codes apply to all models.

Code	Possible cause
P0030	HO2S heater control circuit bank 1 sensor 1
P0036	HO2S heater control circuit bank 1 sensor 2
P0050	HO2S heater control circuit bank 2 sensor 1
P0053	Heated O2 sensor resistance out of range (left cylinder bank, sensor 1)
P0054	Heated O2 sensor resistance out of range (left cylinder bank, sensor 2)
P0056	HO2S heater control circuit bank 2 sensor 2
P0059	Heated O2 sensor resistance out of range (right cylinder bank, sensor 2)
P0060	Heated O2 sensor resistance out of range (right cylinder bank, sensor 1)
P0068	MAF sensor circuit, difference between actual air flow and predicted speed density greater than expected
P0101	Mass Air Flow (MAF) sensor performance
P0102	Mass Air Flow (MAF) sensor circuit, low input
P0103	Mass Air Flow (MAF) sensor circuit, high input
P0106	Manifold Absolute Pressure (MAP) sensor signal out of range
P0107	Manifold Absolute Pressure (MAP) sensor circuit, voltage too low
P0108	Manifold Absolute Pressure (MAP) sensor circuit, voltage too high
P0112	Intake Air Temperature (IAT) sensor circuit, voltage too low (temperature too high)
P0113	Intake Air Temperature (IAT) sensor circuit, voltage too high (temperature too low)
P0116	Temperature difference between ECT and IAT sensors not within calibrated range
P0117	Engine Coolant Temperature (ECT) sensor circuit, voltage too low (temperature too high)
P0118	Engine Coolant Temperature (ECT) sensor circuit, voltage too high (temperature too low)
P0120	Throttle Position (TP) sensor No. 1 signal or reference voltage out of range (models with TAC)
P0121	Throttle Position (TP) sensor signal, voltage out of range
P0122	Throttle Position (TP) sensor circuit, voltage too low
P0123	Throttle Position (TP) sensor circuit, voltage too high
P0125	Engine Coolant Temperature (ECT) sensor takes too long to reach closed-loop temperature
P0128	Engine Coolant Temperature (ECT) sensor does not meet minimum thermostat regulating temperature
P0131	Upstream oxygen sensor (left cylinder bank), circuit voltage too low
P0132	Upstream oxygen sensor (left cylinder bank), circuit voltage too high
P0133	Upstream oxygen sensor (left cylinder bank), slow response
P0134	Upstream oxygen sensor (left cylinder bank) circuit, insufficient activity
P0135	Upstream oxygen sensor (left cylinder bank), heater performance
P0136	Downstream oxygen sensor (left cylinder bank) circuit, signal out of range
P0137	Downstream oxygen sensor (left cylinder bank) circuit, low voltage
P0138	Downstream oxygen sensor (left cylinder bank) circuit, high voltage
P0140	Downstream oxygen sensor (left cylinder bank) circuit, insufficient activity

Code	Possible cause
P0141	Downstream oxygen sensor (left cylinder bank) circuit, heater performance
P0143	Downstream oxygen sensor (left cylinder bank) circuit, low voltage
P0144	Downstream oxygen sensor (left cylinder bank) circuit, high voltage
P0146	Downstream oxygen sensor (left cylinder bank) circuit, insufficient activity
P0147	Downstream oxygen sensor (left cylinder bank), heater performance
P0151	Upstream oxygen sensor (right cylinder bank) circuit voltage too low
P0152	Upstream oxygen sensor (right cylinder bank), circuit voltage too high
P0153	Upstream oxygen sensor (right cylinder bank), slow response
P0154	Upstream oxygen sensor (right cylinder bank) circuit, insufficient activity
P0155	Upstream oxygen sensor (right cylinder bank), heater performance
P0156	Downstream oxygen sensor (right cylinder bank) circuit, signal out of range
P0157	Downstream oxygen sensor (right cylinder bank) circuit, low voltage
P0158	Downstream oxygen sensor (right cylinder bank) circuit, high voltage
P0160	Downstream oxygen sensor (right cylinder bank) circuit, insufficient activity
P0161	Downstream oxygen sensor (right cylinder bank), heater performance
P0169	Ambient fuel temperature high (E-85 fuel models)
P0171	Fuel trim system lean at upstream oxygen sensor (left cylinder bank)
P0172	Fuel trim system rich at upstream oxygen sensor (left cylinder bank)
P0174	Fuel trim system lean at upstream oxygen sensor (right cylinder bank)
P0175	Fuel trim system rich at upstream oxygen sensor (right cylinder bank)
P0178	Fuel Composition sensor frequency out of range (E 85 fuel models)
P0179	Fuel Composition sensor detects contaminated fuel (E 85 fuel models)
P0200	Fuel injector control circuit, incorrect voltage
P0218	Transmission fluid temperature high
P0220	Throttle Position (TP) sensor No. 2 signal or reference voltage outside normal range (models with TAC)
P0230	Fuel pump relay control circuit, commanded state of driver and actual state of control circuit don't match
P0300	Engine misfire detected
P0315	Crankshaft Position (CKP) system variation values not stored in PCM memory
P0325	Knock sensor circuit malfunction
P0327	Knock sensor signal frequency outside normal range
P0332	Knock sensor signal frequency outside normal range
P0335	No signal from Crankshaft Position (CKP) sensor for more than three seconds
P0336	Crankshaft Position (CKP) sensor signal incorrect for more than three seconds
P0337	Crankshaft Position (CKP) sensor circuit, low duty cycle
P0338	Crankshaft Position (CKP) sensor circuit, high duty cycle
P0339	Crankshaft Position (CKP) sensor circuit intermittent
P0340	Camshaft Position (CMP) sensor circuit
P0341	Camshaft Position (CMP) sensor signal not present or mismatch with CKP signal

OBD-II DIAGNOSTIC TROUBLE CODES (DTCS)

➡Note: Not all trouble codes apply to all models.

Code	Possible cause
P0342	Camshaft Position (CMP) signal constantly low
P0343	Camshaft Position (CMP) signal constantly high
P0351	Ignition Control (IC) circuit out of range (coil 1)
P0352	Ignition Control (IC) circuit out of range (coil 2)
P0353	Ignition Control (IC) circuit out of range (coil 3)
P0354	Ignition Control (IC) circuit out of range (coil 4)
P0355	Ignition Control (IC) circuit out of range (coil 5)
P0356	Ignition Control (IC) circuit out of range (coil 6)
P0357	Ignition Control (IC) circuit out of range (coil 7)
P0358	Ignition Control (IC) circuit out of range (coil 8)
P0401	Exhaust Gas Recirculation (EGR) system, insufficient flow
P0404	Exhaust Gas Recirculation (EGR) system, open position performance
P0405	Exhaust Gas Recirculation (EGR) position sensor circuit, low voltage
P0410	Secondary Air Injection (AIR) system
P0418	Secondary air injection pump relay control system
P0420	Catalyst system (left cylinder bank), low efficiency (4.3L V6)
P0420	Oxygen storage ability of catalyst (left cylinder bank) below calibrated threshold (4.8L, 5.3L or 6.0L V8)
P0430	Catalyst system (right cylinder bank), low efficiency (4.3L V6)
P0430	Oxygen storage ability of catalyst (right cylinder bank) below calibrated threshold (4.8L, 5.3L or 6.0L V8)
P0440	Evaporative Emission (EVAP) system
P0442	Evaporative Emission (EVAP) control system, small leak detected
P0443	Evaporative Emission (EVAP) canister purge solenoid valve, incorrect voltage at driver
P0446	Evaporative Emission (EVAP) vent system performance
P0449	Evaporative Emission (EVAP) canister vent solenoid valve, incorrect voltage at driver
P0451	Fuel tank pressure sensor malfunction
P0452	Fuel tank pressure sensor circuit, low voltage
P0453	Fuel tank pressure sensor circuit, high voltage
P0454	Fuel tank pressure sensor detects problem with PCM diagnosis
P0455	Evaporative Emission (EVAP) system unable to reach calibrated vacuum level
P0461	Fuel level sensor performance
P0462	Fuel level sensor circuit, voltage too low
P0463	Fuel level sensor circuit, voltage too high
P0496	Evaporative Emission (EVAP) system, excessive (intake manifold) vacuum present
P0500	Vehicle Speed Sensor (VSS) circuit
P0502	Vehicle speed sensor circuit low output

Code	Possible cause
P0503	Vehicle speed sensor signal intermittent
P0506	Idle speed performance lower than expected or out of range
P0507	Idle speed performance higher than expected or out of range
P0562	System voltage low
P0563	System voltage high
P0601	PCM failure
P0602	PCM not programmed
P0603	PCM long-term memory reset
P0604	PCM Random Access Memory (RAM)
P0605	PCM Read-Only Memory (ROM)
P0607	PCM malfunction
P0608	Vehicle speed sensor output circuit
P0641	5-volt reference circuit to TP sensor, oil pressure sensor, MAP sensor or EGR valve out of range
P0650	Incorrect voltage on the Malfunction Indicator Light (MIL) control circuit
P0651	5-volt reference circuit for Fuel Tank Pressure (FTP) sensor out of range
P0654	Tachometer control circuit
P0704	Clutch start switch circuit
P0705	Transmission range sensor (Park/Neutral position switch), circuit malfunction
P0706	Transmission range sensor (Park/Neutral position switch) performance
P0711	Transmission fluid temperature sensor circuit out-of-range
P0712	Transmission fluid temperature sensor circuit low input
P0713	Transmission fluid temperature sensor circuit high input
P0716	Input speed sensor circuit out-of-range
P0717	Input speed sensor circuit no signal
P0719	Torque converter clutch brake switch circuit low
P0724	Torque converter clutch brake switch circuit high
P0730	Incorrect gear ratio
P0740	Torque converter clutch enable solenoid circuit
P0741	Torque converter clutch system stuck off
P0742	Torque converter clutch system stuck on
P0748	Pressure control solenoid valve circuit
P0751	1-2 shift solenoid performance
P0752	1-2 shift solenoid (4L60-E)
P0753	1-2 shift solenoid circuit
P0756	2-3 shift solenoid performance
P0758	2-3 shift solenoid circuit
P0785	2-3 shift solenoid circuit

OBD-II DIAGNOSTIC TROUBLE CODES (DTCS)

➡**Note: Not all trouble codes apply to all models.**

Code	Possible cause
P1106	Manifold absolute pressure sensor circuit intermittent high voltage
P1107	Manifold absolute pressure sensor circuit intermittent low voltage
P1111	Intake air temperature sensor circuit intermittent high voltage
P1112	Intake air temperature sensor circuit intermittent low voltage
P1114	Engine coolant temperature sensor circuit intermittent low voltage
P1115	Engine coolant temperature sensor circuit intermittent high voltage
P1121	Throttle position sensor circuit intermittent high voltage
P1122	Throttle position sensor circuit intermittent low voltage
P1125	Accelerator pedal position sensor malfunction
P1133	Oxygen sensor insufficient switching (pre-converter sensor, left bank)
P1134	Oxygen sensor transition time ratio (pre-converter sensor, left bank)
P1153	Oxygen sensor insufficient switching (pre-converter sensor, right bank)
P1154	Oxygen sensor transition time ratio (pre-converter sensor, right bank)
P1220	Throttle position sensor out of range
P1221	Throttle position sensor, discrepancy between two sensors
P1258	Engine coolant over temperature
P1275	Accelerator pedal position sensor, voltage
P1276	Accelerator pedal position sensor, discrepancy between the sensors
P1280	Accelerator pedal position sensor, disagreement between sensors 1 and 2
P1281	Accelerator pedal position sensor, disagreement between sensors 1 and 2, and 2 and 3
P1285	Accelerator pedal position sensor, sensor 3 voltage out of range
P1286	Accelerator pedal position sensor, disagreement between sensors 3 and 1, and 3 and 2
P1336	Crankshaft position sensor system variation not learned
P1345	Crankshaft position sensor/Camshaft position sensor correlation
P1351	Ignition control circuit high voltage
P1361	Ignition control circuit low voltage
P1380	Electronic brake control module rough road sensing error
P1381	No serial data from electronic brake control module
P1404	EGR valve closed pintle position
P1415	Secondary air injection system malfunction, left bank
P1416	Secondary air injection system malfunction, right bank
P1441	EVAP system flow during non-purge
P1508	Idle speed too low
P1509	Idle speed too high
P1514	MAF sensor, predicted airflow different than detected
P1515	TPS, difference between actual and detected throttle position

Code	Possible cause
P1516	TPS, sensor out of range
P1517	Throttle actuator control, failed internal data test
P1518	Throttle actuator control, invalid or missing data
P1600	PCM malfunction
P1621	PCM memory performance
P1626	Serial data communication failure with vehicle theft deterent controller (no password)
P1627	PCM malfunction
P1631	Theft deterent password incorrect
P1635	5-volt reference circuit
P1637	Alternator L terminal circuit
P1639	5-volt reference circuit
P1680	PCM malfunction
P1681	PCM malfunction
P1683	PCM flash memory performance
P1810	Transmission pressure switch assembly malfunction
P1860	Torque converter clutch pulse width modulator solenoid circuit
P1870	Transmission slipping
P1875	Four-wheel drive low switch circuit
P2101	Control module throttle actuator position performance malfunction
P2108	Control module throttle actuator position performance malfunction
P2120	Accelerator pedal position sensor 1 malfunction
P2121	Accelerator pedal position sensor 1 malfunction
P2125	Accelerator pedal position sensor 2 malfunction
P2135	Throttle position sensor malfunction
P2138	Accelerator pedal position sensors 1 and 2 malfunction
P2636	Fuel pump malfunction
P2A01	HO2S performance bank 1 sensor 2
P2A04	HO2S performance bank 2 sensor 2
U0107	No communication with throttle actuator control module

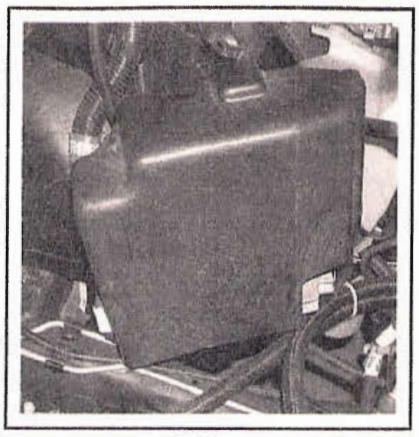
3 Powertrain Control Module (PCM) - removal and installation

Refer to illustrations 3.2, 3.3 and 3.4

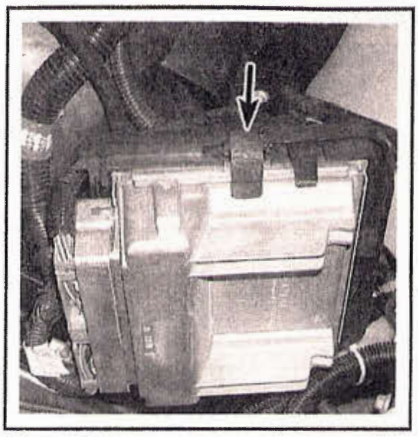
CAUTION:

Avoid static electricity damage to the Powertrain Control Module (PCM) by grounding yourself to the body of the vehicle before touching the PCM and using a special anti-static pad to store the PCM on, once it is removed.

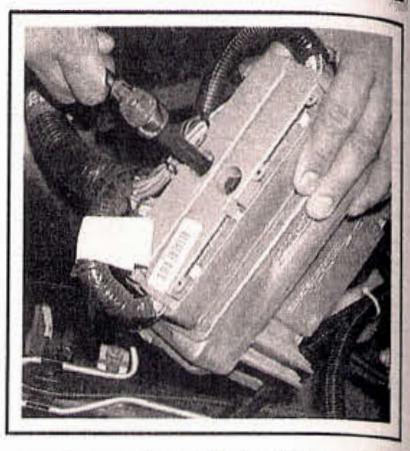
Note 1: Anytime the PCM is replaced with a new unit the PCM must be reprogrammed by a dealership service department with special equipment. A crankshaft position sensor variation relearn procedure and a vehicle anti-theft system password relearn procedure must be performed, as well. The following procedure pertains to removal and installation of the original PCM only. If the PCM must be replaced with a new unit, take the vehicle to a dealership service department.



3.2 Remove the PCM cover



3.3 Detach the latch (arrow) and remove the PCM from the mounting bracket



3.4 Loosen the retaining bolts and disconnect the electrical connectors from the PCM

➡Note 2: Anytime the battery is disconnected, stored operating parameters may be lost from the PCM causing the engine to run rough for awhile while the PCM relearns the information.

1 Disconnect the cable from the negative battery terminal.

CAUTION:

On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

2 Remove the protective cover from the PCM (see illustration).

3 Detach the PCM retainer latch and remove the PCM from the bracket (see illustration).

4 Unscrew the bolts and carefully disconnect the electrical connectors from the PCM (see illustration).

5 Installation is the reverse of removal.

4 Throttle Position Sensor (TPS) - replacement

♦ Refer to illustrations 4.1a, 4.1b and 4.4

1 The Throttle Position Sensor (TPS) is a variable potentiometer connected to the end of the throttle shaft on the throttle body (see illustrations). By monitoring the output voltage from the TPS, the PCM can determine fuel delivery based on throttle valve angle (driver demand). A broken or loose TPS can cause intermittent bursts of fuel from the injectors and an unstable idle because the PCM thinks the throttle is moving.

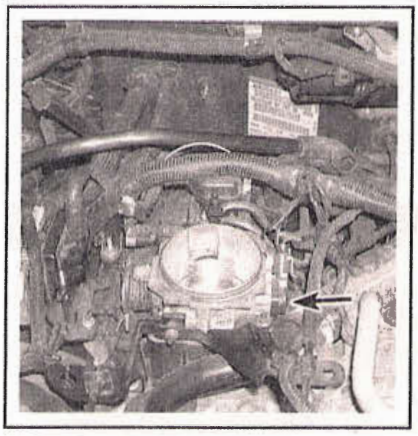
2 On V8 models, remove the alternator (see Chapter 5). On V6 models, remove the air intake duct and resonator (see Chapter 4).

3 Disconnect the electrical connector from the TPS.

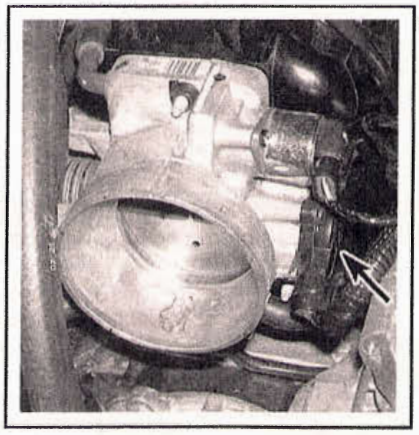
4 Remove the TPS mounting screws and remove the TPS from the throttle body (see illustration).

5 Install a new O-ring on the TPS. With the throttle in the closed position, align the TPS with the throttle shaft and install the TPS. Tighten the screws securely.

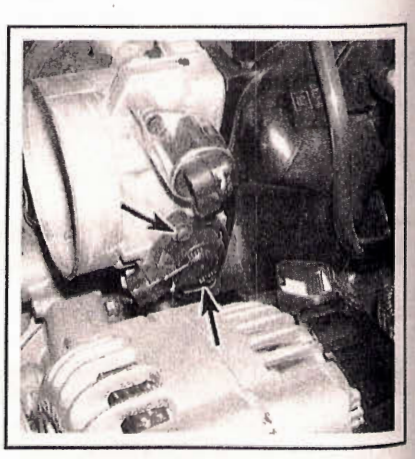
6 The remainder of installation is the reverse of removal.



4.1a Throttle Position Sensor (TPS) location - V6 models



4.1b Throttle Position Sensor (TPS) location - V8 models



4.4 Remove the TPS mounting screws (arrows)

5 Manifold Absolute Pressure (MAP) sensor - replacement

Refer to illustration 5.1a, 5.1b and 5.4

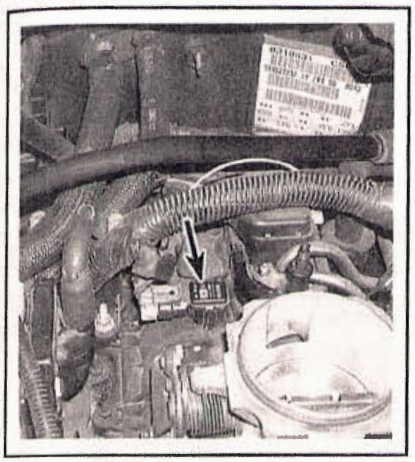
1 The Manifold Absolute Pressure (MAP) sensor monitors the intake manifold pressure changes resulting from changes in engine load and speed and converts the information into a voltage output (see illustrations). The PCM receives information as a varying voltage signal from closed throttle (high vacuum) to wide open throttle (low vacuum). The PCM uses the MAP sensor to control fuel delivery and ignition timing.

2 On V6 models, remove the intake air duct and resonator. On V8 models, remove the intake manifold cover.

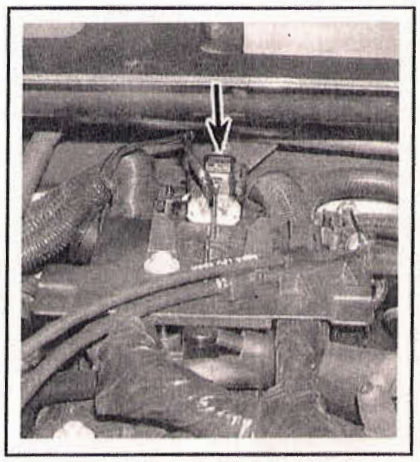
3 Disconnect the electrical connector from the MAP sensor.

4 Detach the retaining clips and withdraw the MAP sensor from the upper intake manifold (see illustration). Replace the MAP sensor seal in the upper intake manifold.

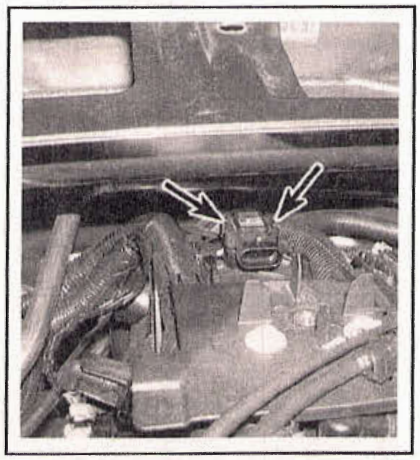
5 Installation is the reverse of removal.



5.1a MAP sensor location - V6 models



5.1b MAP sensor location - V8 models



5.4 Detach the clips (arrows) and remove the MAP sensor from the upper intake manifold

6 Mass Airflow (MAF) sensor - replacement

Refer to illustrations 6.1 and 6.4

1 The Mass Airflow Sensor (MAF) is located on the air filter housing (see illustration). The MAF sensor measures the amount of air passing through the sensor body and ultimately entering the engine through the throttle body. The PCM uses this information to control fuel delivery - the more air entering the engine (acceleration), the more fuel required.

2 Disconnect the electrical connector from the MAF sensor.

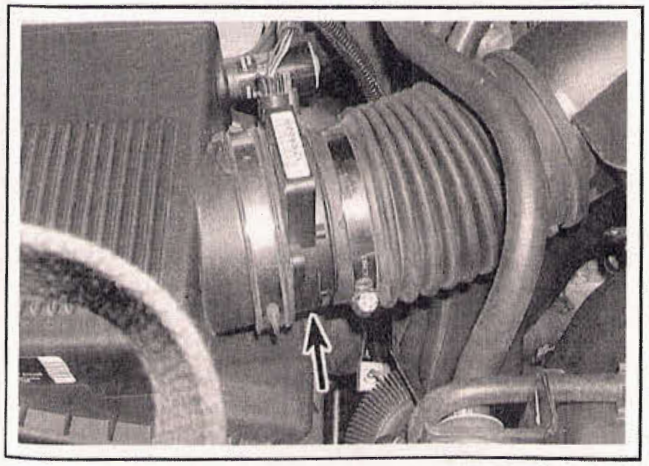
3 Loosen the hose clamp securing the air intake duct to the MAF sensor and remove the duct.

4 Loosen the hose clamp retaining the MAF sensor to the air filter cover and remove the sensor (see illustration).

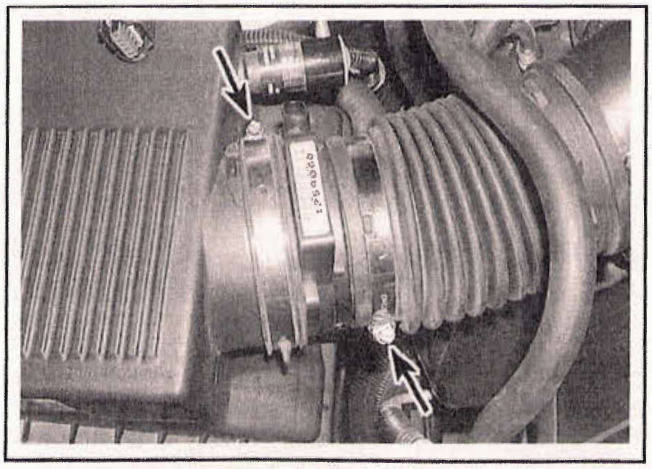
CAUTION:

Handle the MAF sensor with care. Damage to this sensor will affect the operation of the entire fuel injection system.

5 Installation is the reverse of removal.



6.1 The Mass Airflow (MAF) sensor is attached to the air filter housing



6.4 Loosen the hose clamps (arrows) and remove the Mass Airflow sensor

7 Intake Air Temperature (IAT) sensor - replacement

1 The Intake Air Temperature (IAT) sensor is a thermistor (a resistor which varies the value of its resistance in accordance with temperature changes). The change in the resistance values will directly affect the voltage signal from the sensor to the PCM. As the sensor temperature INCREASES, the resistance values will DECREASE. As the sensor temperature DECREASES, the resistance values will INCREASE.

2 The IAT is part of the MAF sensor. Replace the MAF/IAT sensor as described in Section 6.

3 Installation is the reverse of removal.

8 Engine Coolant Temperature (ECT) sensor - replacement

Refer to illustration 8.1a and 8.1b

WARNING:

Wait until the engine is completely cool before beginning this procedure.

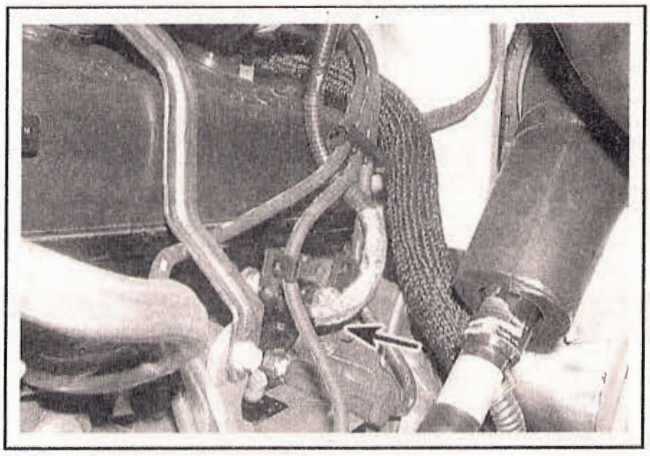
1 The Engine Coolant Temperature (ECT) sensor is a thermistor (a resistor which varies the value of its resistance in accordance with temperature changes) (see illustrations). The change in the resistance values will directly affect the voltage signal from the sensor to the PCM. As the sensor temperature INCREASES, the resistance values will DECREASE. As the sensor temperature DECREASES, the resistance values will INCREASE.

2 Drain the cooling system (see Chapter 1).

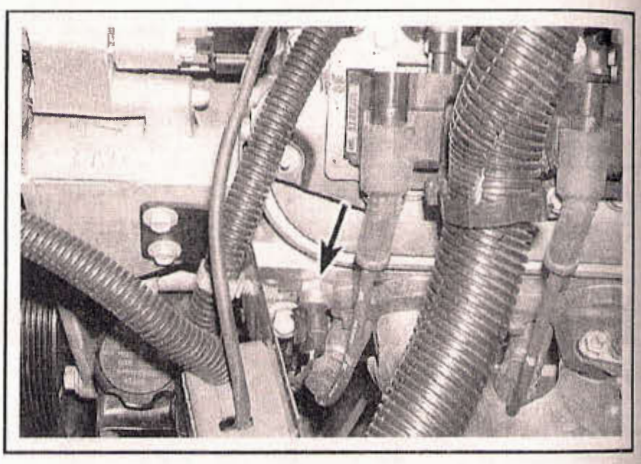
3 Disconnect the electrical connector from the sensor and carefully unscrew the sensor.

4 Before installing the new sensor, wrap the threads with Teflon sealing tape to prevent leakage and thread corrosion.

5 Installation is the reverse of removal.



8.1a Engine Coolant Temperature sensor location - V6 models



8.1b Engine Coolant Temperature sensor location - V8 models

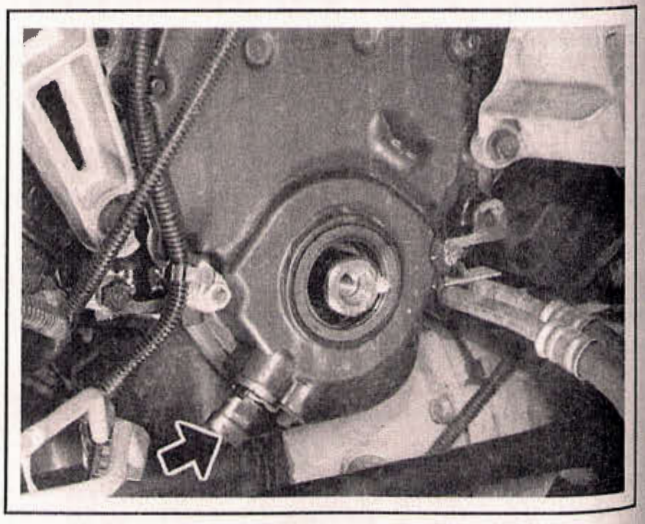
9 Crankshaft Position (CKP) sensor - replacement

Refer to illustration 9.1a, 9.1b and 9.6

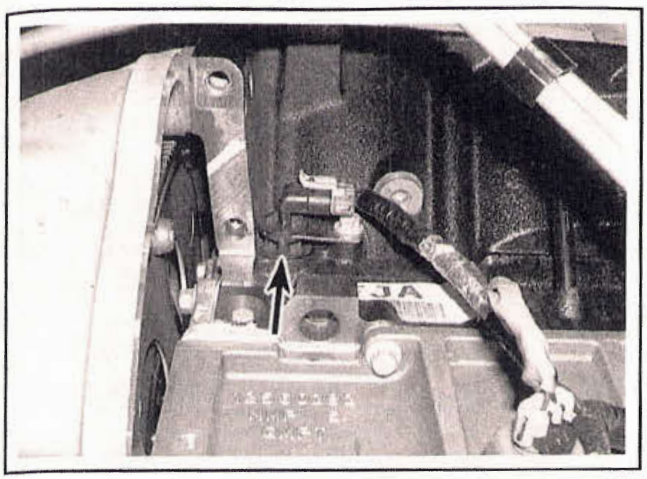
1 The Crankshaft Position (CKP) sensor provides the PCM with a crankshaft position signal (see illustrations). The PCM uses the signal to determine the spark sequence (firing order) for each cylinder. The PCM also uses the signal to precisely control ignition timing and calculate engine speed (RPM). The signal is used by the Onboard Diagnostic system for misfire detection. The crankshaft position sensor is triggered by slots cut into a reluctor ring on the crankshaft. The sensor tip is positioned approximately 0.050 inch from the reluctor ring. As the notches pass the sensor the magnetic field is altered, producing a pulsating voltage. The ignition system will not operate if the PCM does not receive a crankshaft position sensor input.

Note: Anytime a crankshaft position sensor is disturbed, A Crankshaft Position Sensor Variation Learning Procedure should be performed or a false misfire diagnostic trouble code may be set. If after replacing the sensor, a false diagnostic trouble code is set, take the vehicle to a dealership service department for the procedure.

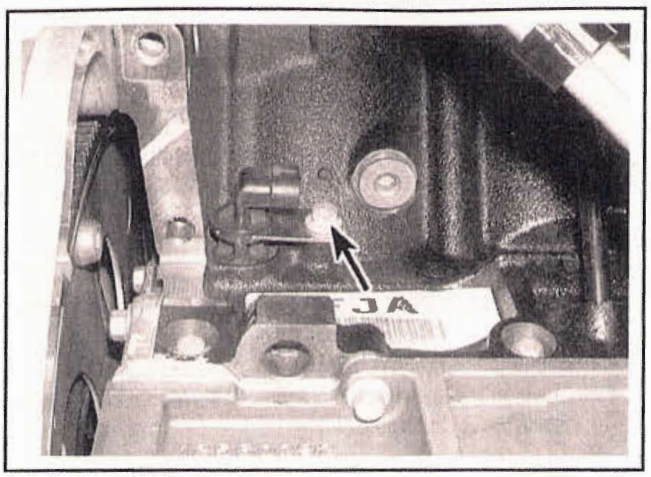
2 Disconnect the cable from the negative battery terminal.



9.1a Crankshaft Position (CKP) sensor location - V6 models



9.1b Crankshaft Position (CKP) sensor location - V8 models (starter removed for clarity)



9.6 Remove the mounting bolt (arrow) and withdraw the crankshaft position sensor

CAUTION:

On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

3 Raise the vehicle and support it securely on jackstands.

4 Remove the skid plate, if equipped. On V8 models, remove the starter (see Chapter 5).

5 Disconnect the electrical connector from the sensor.

6 Remove the crankshaft position sensor mounting bolt and remove the sensor (see illustration).

7 Installation is the reverse of removal.

10 Camshaft Position (CMP) sensor - replacement

Refer to illustrations 10.1a and 10.1b

1 The camshaft position sensor (see illustrations) is very similar in operation to the crankshaft position sensor, but it produces a signal pulse only once every two crankshaft revolutions, corresponding to cylinder number one Top Dead Center. The camshaft position sensor, in conjunction with the crankshaft position sensor, determines the timing for the fuel injection on each cylinder.

V6 MODELS

Refer to illustration 10.5

2 Disconnect the cable from the negative battery terminal.

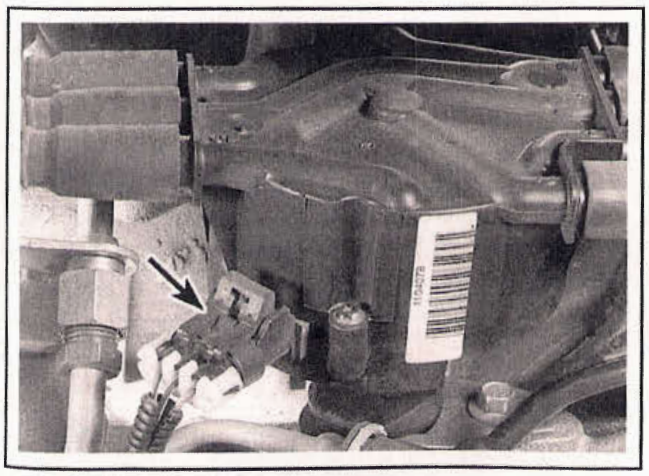
CAUTION:

On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

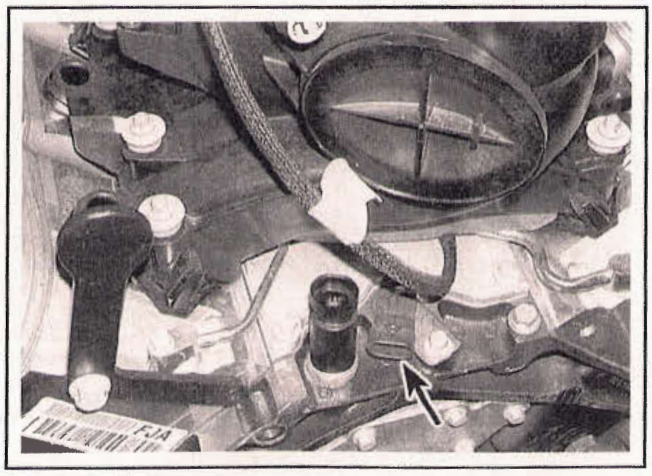
3 Remove the distributor cap and rotor (see Chapter 1).

4 Disconnect the electrical connector from the camshaft position sensor.

5 Using a breaker bar and socket on the crankshaft pulley bolt, rotate the engine until the square slot in the reluctor aligns with the



10.1a Camshaft position sensor location - V6 models



10.1b Camshaft position sensor location - V8 models

camshaft position sensor (see illustration).

6 Remove the camshaft position sensor mounting screws and remove the sensor from the distributor.

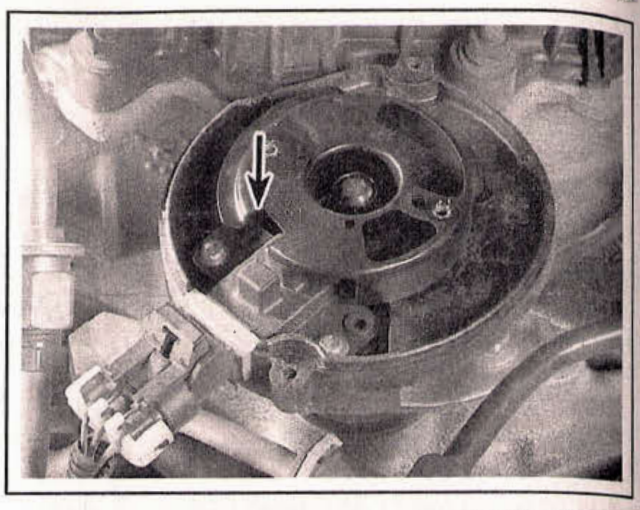
7 Installation is the reverse of removal. Apply thread locking compound to the camshaft position sensor, rotor and distributor cap screws before installing them.

V8 MODELS

8 Disconnect the electrical connector from the sensor (see illustration 10.1b).

9 Remove the camshaft position sensor mounting bolt and withdraw the sensor from the engine block.

10 Installation is the reverse of removal.



10.5 To remove the camshaft position sensor on V6 models, rotate the crankshaft until the square slot in the reluctor (arrow) aligns with the camshaft position sensor

11 Oxygen sensor - replacement

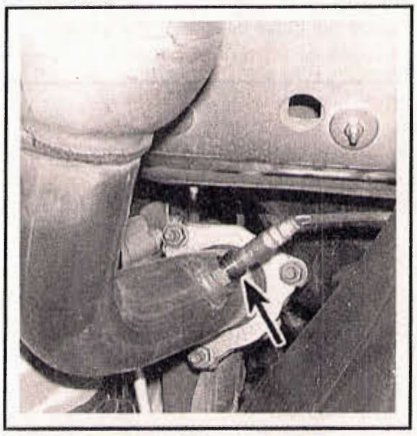
Refer to illustration 11.1, 11.2 and 11.9

Note: All models are equipped with four oxygen sensors; two pre-converter oxygen sensors and two post-converter oxygen sensors.

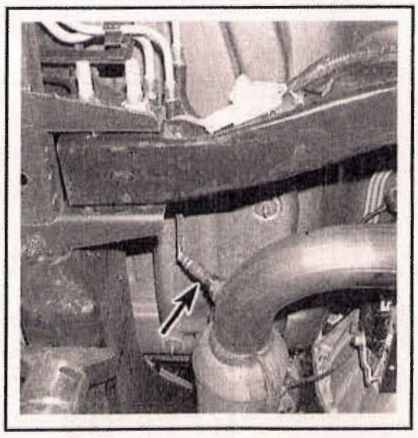
1 An oxygen sensor, in effect, measures the oxygen remaining in the exhaust gas after the combustion process. The leftover oxygen in the exhaust reacts with the elements inside the oxygen sensor to produce a voltage output that varies from 0.1 volt (high oxygen, lean mixture) to 0.9 volt (low oxygen, rich mixture). The pre-converter oxygen sensor is mounted in the exhaust system before the catalytic converter. The PCM monitors the varying voltage signal from the pre-converter oxygen sensor continuously to determine the required fuel injector pulse width, controlling the engine air/fuel ratio (see illustration). A mixture ratio of 14.7 parts air to 1 part fuel is the ideal ratio for gasoline fuel to minimize exhaust emissions, as well as the best combination of fuel economy and engine performance. Based on oxygen sensor signals, the PCM tries to maintain this air/fuel ratio of 14.7:1 at all times.

2 The post-converter oxygen sensor (mounted in the exhaust system after the catalytic converter) has no effect on PCM control of the air/fuel ratio (see illustration). However, the post-converter sensor is identical to the pre-converter sensor and operates in the same way. The PCM uses the post-converter signal to monitor the efficiency of the catalytic converter. A post-converter oxygen sensor will produce a slower fluctuating voltage signal that reflects the lower oxygen content in the post-catalyst exhaust.

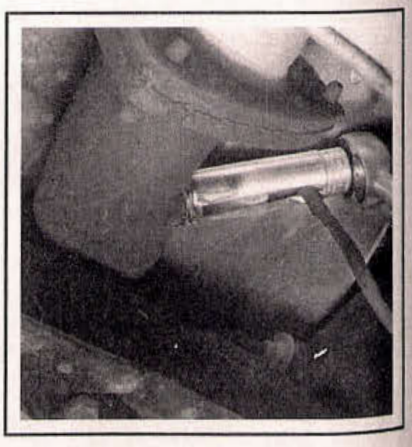
3 An oxygen sensor produces no voltage when it is below its normal operating temperature of about 600-degrees F. During this warm-up period, the PCM operates in an open-loop fuel control mode. It does not use the oxygen sensor signal as a feedback indication of residual oxygen in the exhaust. Instead, the PCM controls fuel metering based on the inputs of other sensors and its own programs. All oxygen



11.1 The pre-converter oxygen sensor is located in the exhaust pipe before the catalytic converter



11.2 The post-converter oxygen sensor is located in the exhaust pipe after the catalytic converter



11.9 A special slotted socket, allowing clearance for the wiring harness, may be required for oxygen sensor removal (the tool is available at most auto parts stores)

sensors are equipped with a heating element, powered by fused ignition voltage, to heat the oxygen sensor to operating range as quickly as possible.

4 Proper operation of an oxygen sensor depends on four conditions:

a) Electrical - The low voltages generated by the sensor require good, clean connections which should be checked whenever a sensor problem is suspected or indicated.

b) Outside air supply - The sensor needs air circulation to the internal portion of the sensor. Whenever the sensor is installed, make sure the air passages are not restricted.

c) Proper operating temperature - The PCM will not react to the sensor signal until the sensor reaches approximately 600-degrees F. This factor must be considered when evaluating the performance of the sensor.

d) Unleaded fuel - Unleaded fuel is essential for proper operation of the sensor.

5 The PCM can detect several different oxygen sensor problems and set diagnostic trouble codes to indicate the specific fault (see Section 2). When an oxygen sensor fault occurs, the PCM will disregard the oxygen sensor signal voltage and revert to open-loop fuel control as described previously.

6 The exhaust pipe contracts when cool, and the oxygen sensor may be hard to loosen when the engine is cold. To make sensor removal easier, start and run the engine for a minute or two; then shut it off. Be careful not to burn yourself during the following procedure. Also observe these guidelines when replacing an oxygen sensor.

a) The sensor has a permanently attached pigtail and electrical connector which should not be removed from the sensor. Damage or removal of the pigtail or electrical connector can harm operation of the sensor.

b) Keep grease, dirt and other contaminants away from the electrical connector and the louvered end of the sensor.

c) Do not use cleaning solvents of any kind on the oxygen sensor.

d) Do not drop or roughly handle the sensor.

7 If replacing the post-converter oxygen sensor, raise the vehicle and place it securely on jackstands.

8 Disconnect the electrical connector from the sensor.

9 Using a suitable wrench or specialized oxygen sensor socket, unscrew the sensor from the exhaust pipe (see illustration).

10 Anti-seize compound must be used on the threads of the sensor to aid future removal. The threads of most new sensors will be coated with this compound. If not, be sure to apply anti-seize compound before installing the sensor.

11 Install the sensor and tighten it securely.

12 Reconnect the electrical connector to the sensor and lower the vehicle.

12 Knock sensor and module - replacement

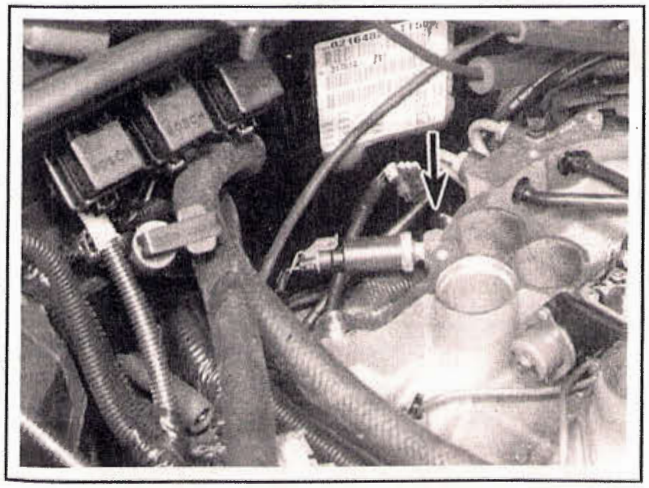
Refer to illustration 12.1a and 12.1b

WARNING:

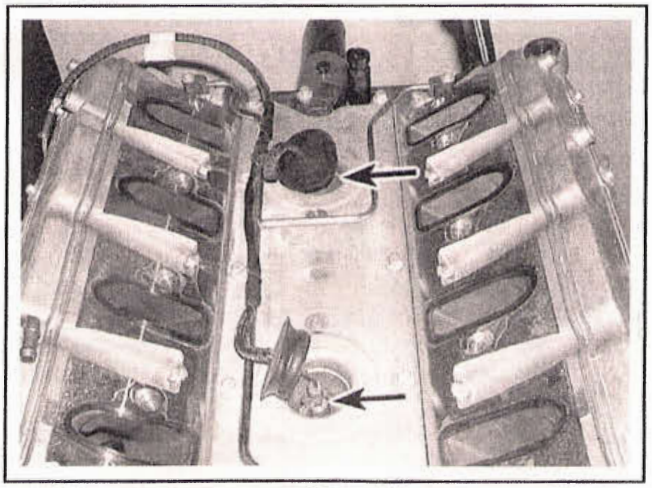
The engine must be completely cool before beginning this procedure.

1 The knock sensor detects abnormal vibration (spark knock or pinging) in the engine (see illustration). The knock control system is designed to reduce spark knock during periods of heavy detonation. This allows the engine to use maximum spark advance to improve driveability. Knock sensors produce AC output voltage which increases with the severity of the knock. The signal is fed into the PCM and the timing is retarded to compensate for the severe detonation. V6 models are equipped with a replaceable knock sensor module in the PCM.

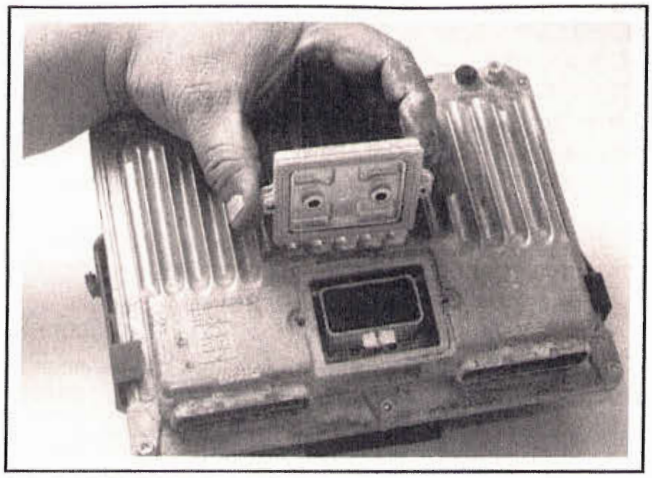
2 Disconnect the cable from the negative battery terminal.



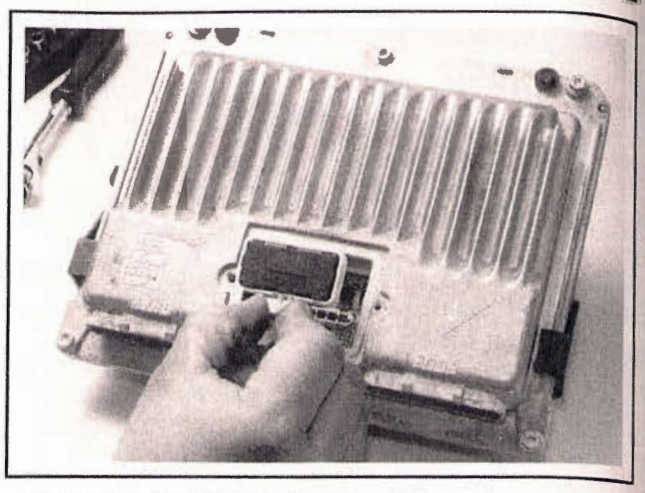
12.1a On V6 models, the knock sensor is threaded into the transmission mounting flange portion of the engine block below the oil pressure sending unit



12.1b Knock sensor locations - V8 models



12.12 Remove the screws and the cover to access the knock sensor module



12.13 Pinch the tabs together and pull the knock sensor module straight up

CAUTION:

On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

KNOCK SENSOR

V6 models

3 Remove the distributor (see Chapter 5).
4 Remove the oil pressure sending unit.
5 Disconnect the electrical connector and remove the knock sensor from the engine block.
6 Installation is the reverse of removal. Be sure to install the distributor in exactly the same position as originally installed (see Chapter 5).

V8 models

7 Remove the intake manifold (see Chapter 2B).
8 Detach the grommets from the valley cover, pull the grommets up and disconnect the electrical connectors from the knock sensors. Remove the wiring harness.
9 Remove the knock sensors from the engine block.
10 Installation is the reverse of removal.

KNOCK SENSOR MODULE (V6 MODELS)

Refer to illustrations 12.12 and 12.13

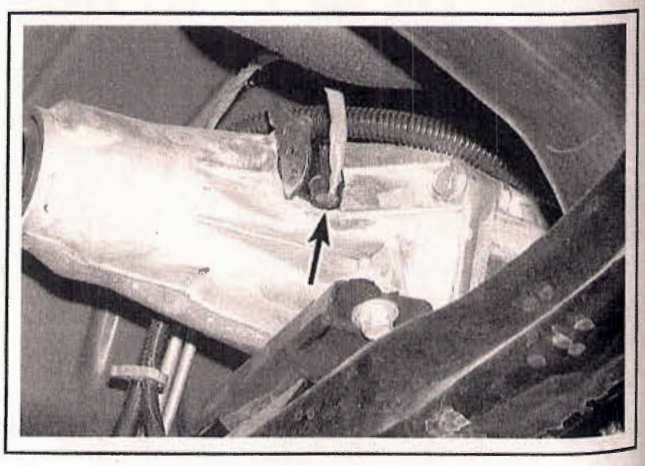
Note: The knock sensor module may be replaced in the original PCM. If a new PCM is being installed, it must be programmed at a dealer service department (see Section 3).

11 Remove the PCM (see Section 3).
12 Remove the knock sensor module cover (see illustration).
13 Carefully pinch the retaining tabs and pull the knock sensor straight up (see illustration).
14 To install the knock sensor module, align the tabs on the module with the notches on the socket.
15 Press down on the ends of the knock sensor module until the module is seated in the socket and the retaining tabs click into place.
16 Install the knock sensor module cover.
17 Install the PCM.

13 Vehicle Speed Sensor (VSS) - replacement

Refer to illustration 13.1

1 The Vehicle Speed Sensor (VSS) is a permanent magnet generator mounted on the transmission (see illustration). The sensor is triggered by a toothed rotor on the transmission output shaft. As the output shaft rotates, the sensor produces an AC voltage, the frequency of which is proportional to vehicle speed. The PCM uses the sensor input signal for several different engine and transmission control functions. The VSS signal also drives the speedometer on the instrument panel. A defective VSS can cause various driveability and transmission problems.
2 Raise the vehicle and support it securely on jackstands.
3 Disconnect the electrical connector from the VSS.
4 Remove mounting bolt and withdraw the VSS from the transmission case.
5 Replace the sensor O-ring.
6 Installation is the reverse of removal.



13.1 Vehicle speed sensor location

14 Idle Air Control (IAC) valve - replacement

Refer to illustrations 14.1a, 14.1b, 14.3 and 14.5

Note: This actuator is only used on early V8 and all V6 models.

1 The idle speed is controlled by the Idle Air Control (IAC) valve (see illustrations). The IAC valve regulates the air bypassing the throttle plate by moving the pintle in or out of the air passage. The IAC valve is controlled by the PCM, adjusting the idle speed depending upon the running conditions of the engine (air conditioning system, power steering, cold and warm running etc.). The engine idle speed is not adjustable on these models.

2 On V6 models, remove the air intake duct and resonator (see Chapter 4).

3 Disconnect the electrical connector from the IAC valve. Remove the two mounting screws from the valve and withdraw it from the throttle body (see illustration).

4 Inspect the IAC valve pintle and the air passage and valve seat in the throttle body for heavy carbon deposits. Clean the IAC valve with aerosol carburetor cleaner, a shop towel and a soft brush, if necessary. Do not submerge the IAC valve in any liquid cleaner. If the air passage requires further cleaning, remove the throttle body and clean it thoroughly.

5 If installing a new IAC valve, measure the distance from the tip of the IAC valve pintle to the mounting flange (see illustration). If the distance is greater than 1-1/8 inch, press the pintle in by hand, as necessary.

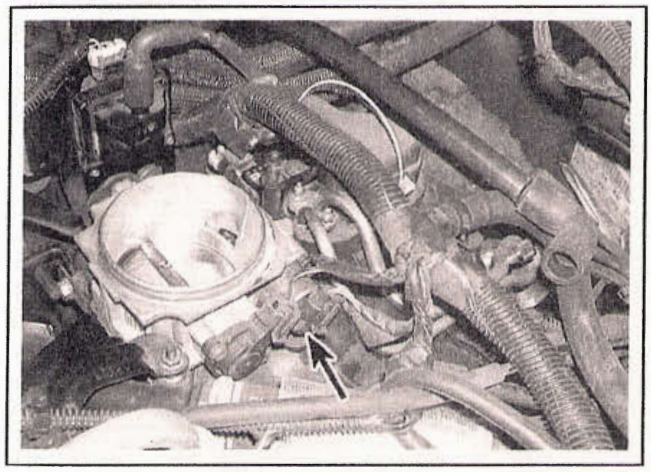
CAUTION:

Do not attempt to press the pintle in on a used IAC valve. The force required to move a pintle shaft with carbon build-up may damage the valve.

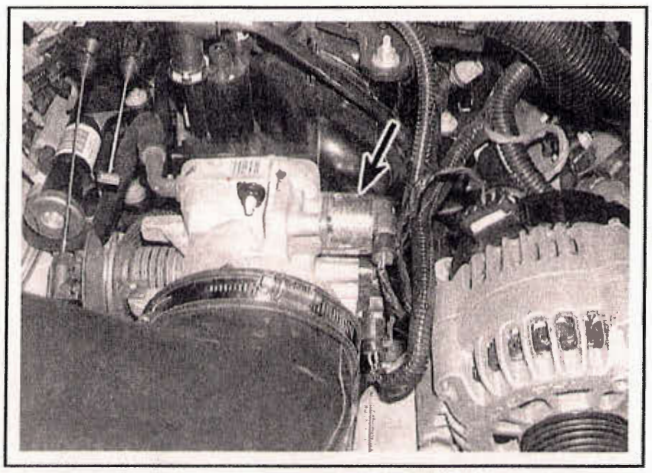
6 Install a new O-ring and lubricate it with clean engine oil.

7 Install the IAC valve and tighten the screws securely. Connect the electrical connector.

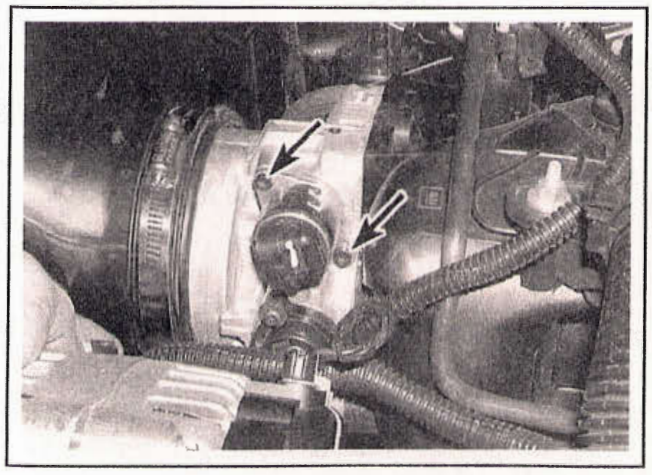
8 Cycle the ignition key On for ten seconds, then Off for ten seconds to reset the valve. Start the engine, allow it to idle for five minutes, turn the engine off for thirty seconds, then start the engine again and check the idle operation.



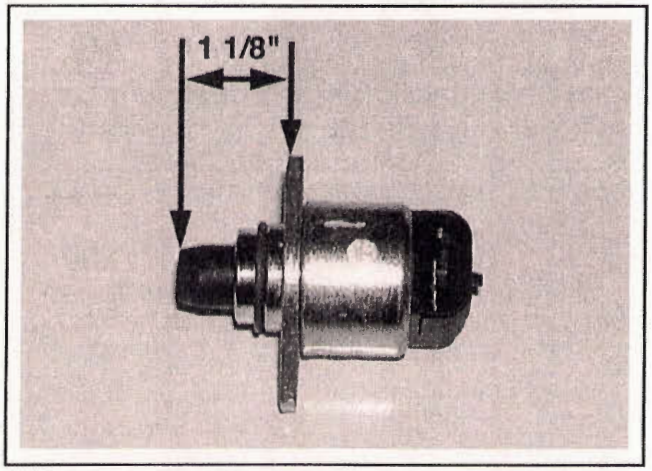
14.1a IAC valve location - V6 models



14.1b IAC valve location - early V8 models



14.3 Remove the screws (arrows) and withdraw the IAC valve from the throttle body



14.5 Before installing a new IAC valve, measure the distance from the tip of the pintle to the mounting flange - press the pintle in until the distance is less than 1-1/8 inch

15 Accelerator Pedal Position (APP) sensor - replacement

➡Note: This sensor is only used on later V8 models with electronically-controlled throttles.

1 The sensor is part of the accelerator pedal assembly.

2 Release the wiring safety clip and disconnect the electrical harness from the sensor.

3 Remove the two bolts and carefully lift the pedal assembly out.

4 Installation is the reverse of removal.

5 The proper operation of the pedal sensor can be checked by a dealer or other qualified repair shop using a diagnostic scan tool. This will verify correct closed-throttle and wide-open settings.

16 Throttle actuator control module - replacement

➡Note: This sensor is only used on later V8 models with electronically-controlled throttles.

1 This module is located on the upper left portion of the firewall.

2 Release the wiring safety clips and disconnect both wiring harnesses from the module.

3 Remove the three retaining nuts and carefully lift the module out.

4 Installation is the reverse of removal.

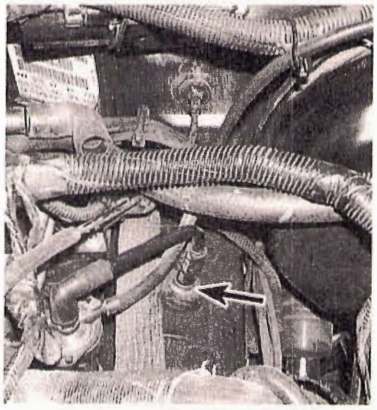
17 Crankcase ventilation system

◗ Refer to illustrations 17.2a, 17.2b and 17.2c

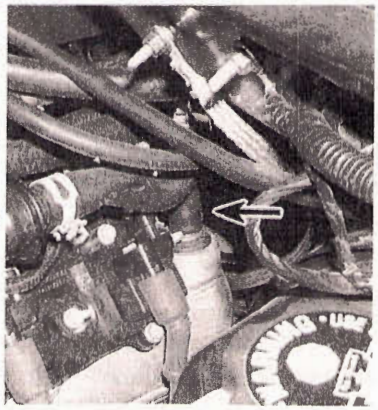
1 When the engine is running, a certain amount of the gasses produced during combustion escape past the piston rings into the crankcase as blow-by gasses. The crankcase ventilation system is designed to reduce the resulting hydrocarbon emissions (HC) by routing the gasses and vapors from the crankcase into the intake manifold and combustion chambers, where they are consumed during engine operation.

2 All models use a Positive Crankcase Ventilation (PCV) system. The main component of the Positive Crankcase Ventilation (PCV) system is the PCV valve (see illustrations). Fresh air flows from the air intake duct through a vent tube into the engine. Crankcase vapors are drawn from the crankcase by the PCV valve. To maintain idle quality and good driveability, the PCV valve restricts the flow when the intake manifold vacuum is high. When intake manifold vacuum is lower, maximum vapor flow is allowed through the valve (see illustration).

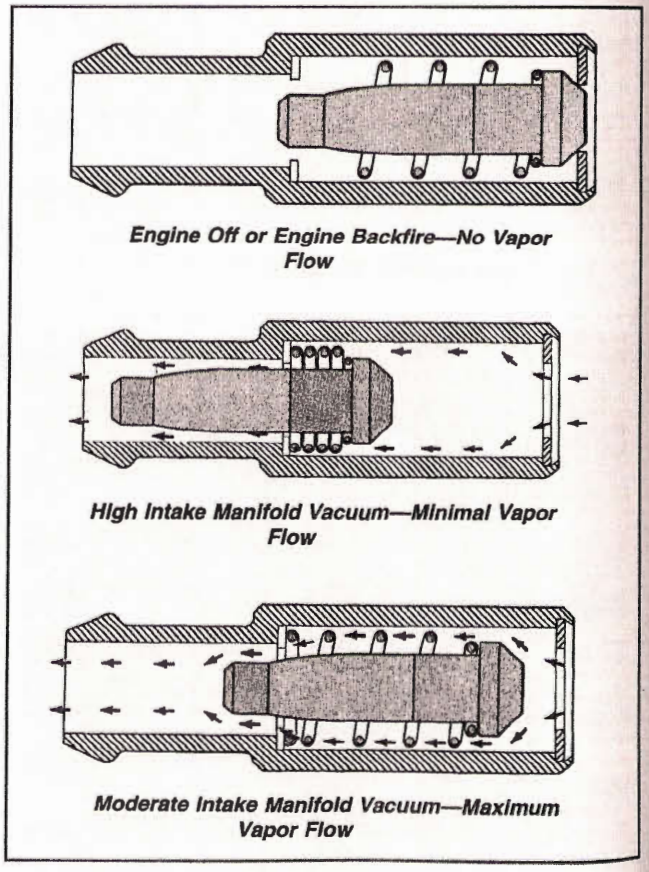
3 Checking and replacement of the PCV valve is covered in Chapter 1.



17.2a PCV valve location - V6 models



17.2b PCV valve location - V8 models through 2001 - on later models the PCV valve is in the left side of the intake manifold, not the valve cover



17.2c Typical PCV valve operation

18 Exhaust Gas Recirculation (EGR) system

Refer to illustrations 18.1a and 18.1b

1 The Exhaust Gas Recirculation (EGR) system is used to lower NOx (oxides of nitrogen) emission levels caused by high combustion temperatures. The EGR valve (see illustrations) recirculates a small amount of exhaust gases into the intake manifold. The additional mixture lowers the temperature of combustion thereby reducing the formation of NOx compounds.

2 The EGR system consists of an electronic EGR valve and the PCM. The PCM controls the EGR flow rate by energizing the EGR valve solenoid coil, opening or closing the EGR passage in small increments. The PCM monitors the EGR valve pintle position with an EGR position sensor built into the EGR valve. This system allows for precise control of EGR flow, achieving optimum EGR flow depending on engine operating conditions.

REPLACEMENT

Refer to illustrations 18.5, 18.13a and 18.13b

EGR valve

3 On V6 models, remove the air intake duct and resonator from the throttle body (see Chapter 4).

4 Disconnect the electrical connector from the EGR valve.

5 Remove the EGR valve mounting bolts (see illustration). Remove the EGR valve and gaskets. Discard the gaskets.

6 Using a gasket scraper, clean the EGR valve gasket surfaces.

7 Installation is the reverse of removal.

EGR pipe

V6 models

8 Remove the EGR pipe bracket bolt.

9 Loosen the fittings at each end of the pipe and remove the pipe.

10 Install the pipe and start the fittings, but do not fully tighten them. Loosely install the bracket bolt.

11 Align the pipe with the adapters and tighten the exhaust manifold fitting, followed by the intake manifold fitting. Tighten the bracket bolt.

V8 models

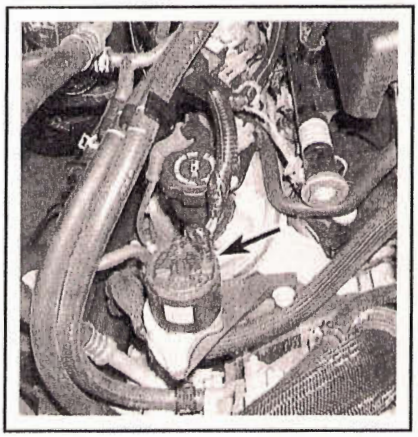
12 Remove the EGR valve.

13 Remove the EGR pipe-to-intake manifold bolts, followed by the EGR pipe-to exhaust manifold bolts (see illustrations).

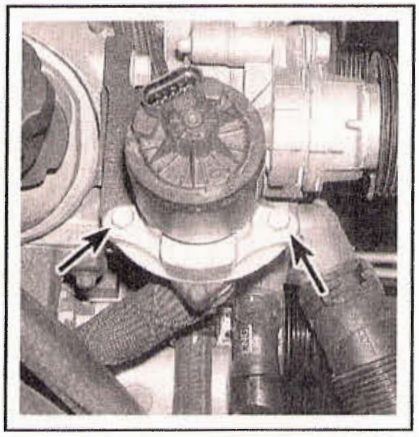
14 Remove the EGR pipe-to cylinder head bolt and remove the pipe.

15 Installation is the reverse of removal.

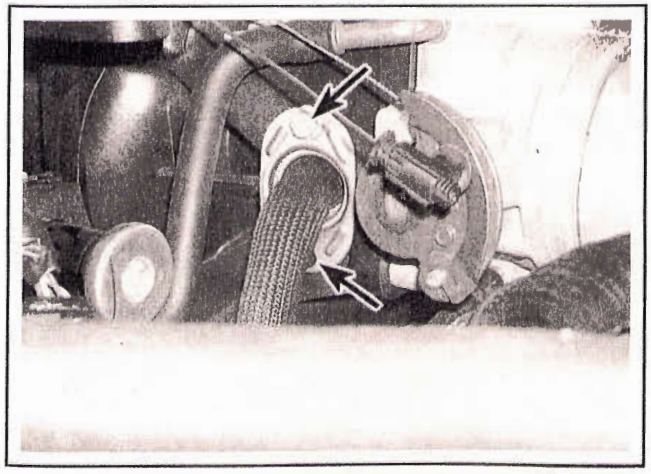
18.1a EGR valve location - V6 models



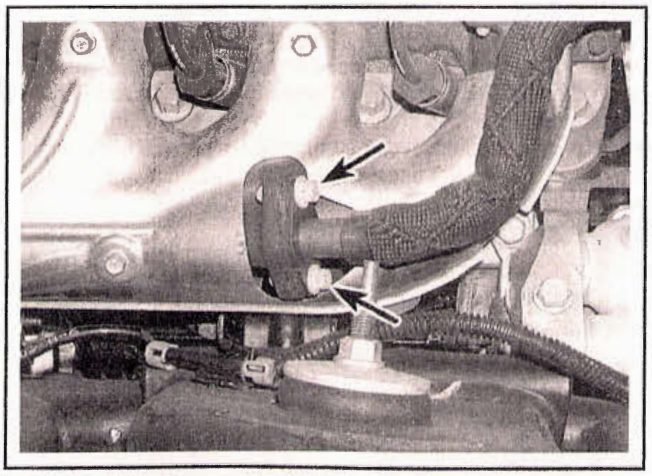
18.1b EGR valve location - V8 models



18.5 Remove the EGR valve mounting bolts (arrows)



18.13a Remove the EGR pipe-to-intake manifold bolts . . .



18.13b . . . and the EGR pipe-to-exhaust manifold bolts

19 Evaporative emissions control system

1 The fuel evaporative emissions control (EVAP) system absorbs fuel vapors from the fuel tank and, during engine operation, releases them into the engine intake system where they mix with the incoming air/fuel mixture. The main components of the evaporative emissions system are the canister (filled with activated charcoal to absorb fuel vapors), the purge valve, the vent valve, the fuel tank pressure sensor, the fuel tank and the vapor and purge lines.

2 After passing through a check valve, fuel tank vapor is carried through the vapor hose to the charcoal canister. The activated charcoal in the canister absorbs and stores the vapors. When a programmed set of conditions are met (engine running, warmed to a pre-set temperature, etc.), the PCM opens the purge valve and the vent valve. Fuel vapors from the canister are then drawn through the purge hose by intake manifold vacuum into the intake manifold and combustion chamber where they are consumed during normal engine operation.

3 The PCM regulates the rate of vapor flow from the canister to the intake manifold by controlling the duty cycle of the EVAP purge valve control solenoid. During cold running conditions and hot start time delay, the PCM does not energize the solenoid. After the engine has warmed up to the correct operating temperature, the PCM purges the vapors into the intake manifold according to the running conditions of the engine. The PCM will cycle (ON then OFF) the purge valve control solenoid about 5 to 10 times per second. The flow rate will be controlled by the pulse width, or length of time, the solenoid is allowed to be energized.

4 The system performs a self-diagnostic check when the engine is started cold. When the programmed conditions are met, the PCM opens the EVAP canister purge valve, leaving the vent valve closed. This action allows the engine to draw a vacuum on the entire EVAP system. Once the proper vacuum level is reached, the PCM closes the purge valve, sealing the system. The PCM then monitors the fuel tank pressure sensor voltage and sets a diagnostic code if a leak is detected.

5 The fuel tank pressure sensor operation is similar to the MAP sensor. The PCM supplies a 5-volt reference voltage and ground circuit to the sensor. The sensor returns a signal voltage to the PCM which varies according to the air pressure inside the fuel tank. When the air pressure inside the tank is equal to the outside air pressure (as with the fuel filler cap removed), the sensor output voltage is approximately 1.5 volts. With 14 in-Hg vacuum inside the tank the sensor output voltage is 4.5 volts.

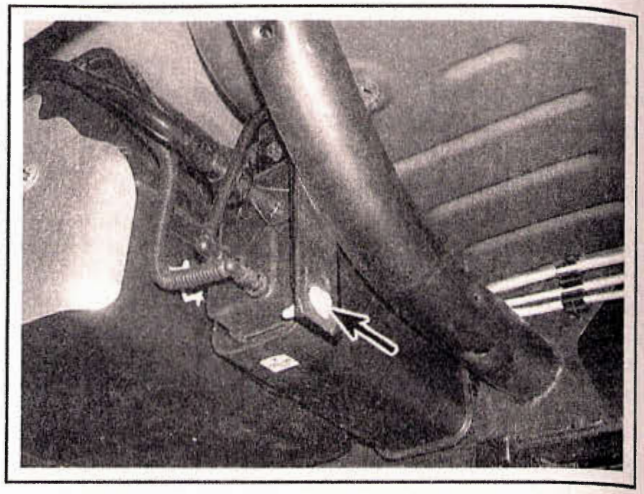
CHECK

➡Note: The evaporative control system, like all emission control systems, is protected by a Federally-mandated warranty (5 years or 50,000 miles at the time this manual was written). The EVAP system probably won't fail during the service life of the vehicle; however, if it does, the hoses or charcoal canister are usually to blame.

6 Always check the hoses first. A disconnected, damaged or missing hose is the most likely cause of a malfunctioning EVAP system. Refer to the *Vacuum Hose Routing Diagram* (attached to the radiator support) to determine whether the hoses are correctly routed and attached. Repair any damaged hoses or replace any missing hoses as necessary.

7 Check the related fuses and wiring to the purge and vent valves. Refer to the wiring diagrams at the end of Chapter 12, if necessary. The purge and vent valves are normally closed - no vapors will pass through the ports. When the PCM energizes the solenoid (by completing the circuit to ground), the valve opens and vapors flow through.

8 A scan tool is required to thoroughly check the system. If the above checks fail to identify the problem area, have the system diagnosed by a dealer service department or other qualified repair shop.



19.12 Remove the EVAP canister bracket mounting bolt (arrow)

COMPONENT REPLACEMENT

➧ Refer to illustrations 19.12, 19.14a, 19.14b, 19.18 and 19.26

9 All EVAP system hoses are equipped with quick-connect fittings. Before disconnecting a fitting, clean around the fitting and twist the fitting back-and-forth to loosen the seal. To disconnect a large hose fitting, squeeze the retainer tabs together and pull the fitting off the pipe. To disconnect a small hose fitting, push the locking tab in and pull the fitting off the pipe.

EVAP canister

10 The EVAP canister is attached to a bracket near the fuel tank.

11 Raise the vehicle and support it securely on jackstands.

12 Disconnect the hoses from the canister (see Step 9). Remove the bracket mounting bolt and remove the canister (see illustration).

13 Installation is the reverse of removal.

Purge valve

14 The purge valve is mounted on the intake manifold (see illustrations). On V8 models, remove the intake manifold cover.

15 Disconnect the electrical connector. Depress the locking tab and remove the hose from the purge valve (see Step 9).

16 Remove the mounting nuts/bolt. On V6 models, remove the wiring harness retainer from the mounting stud. Remove the purge valve.

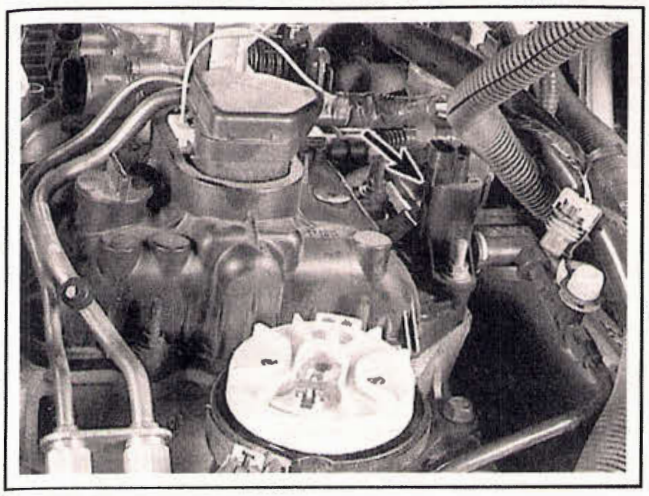
17 Installation is the reverse of removal.

Vent valve

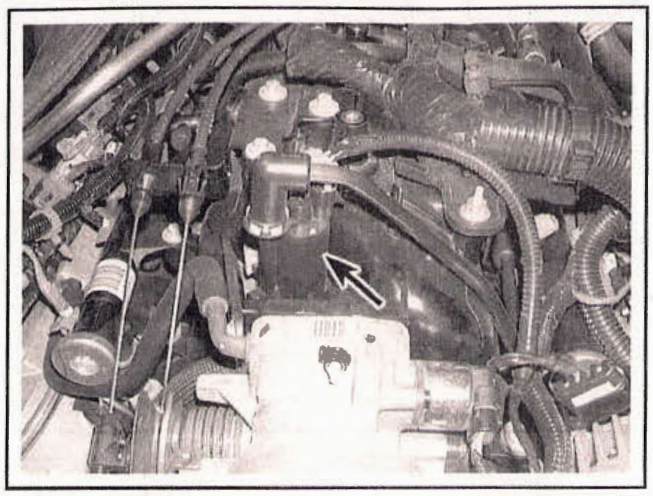
18 The vent valve is mounted on a bracket near the fuel tank (see illustration).

19 Raise the vehicle and support it securely on jackstands.

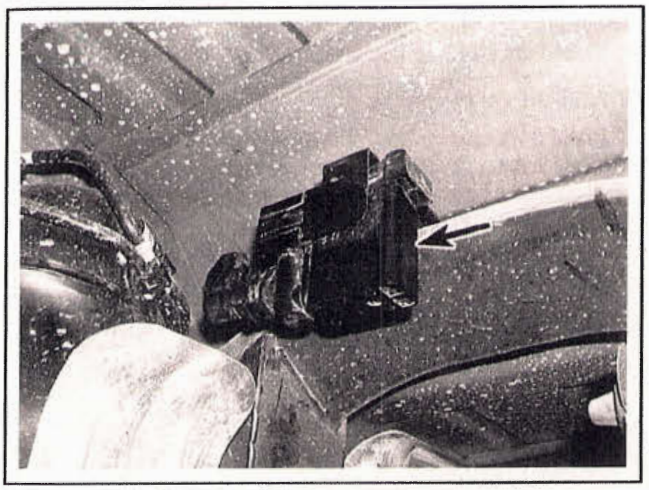
20 Disconnect the electrical connector. Remove the hose from the



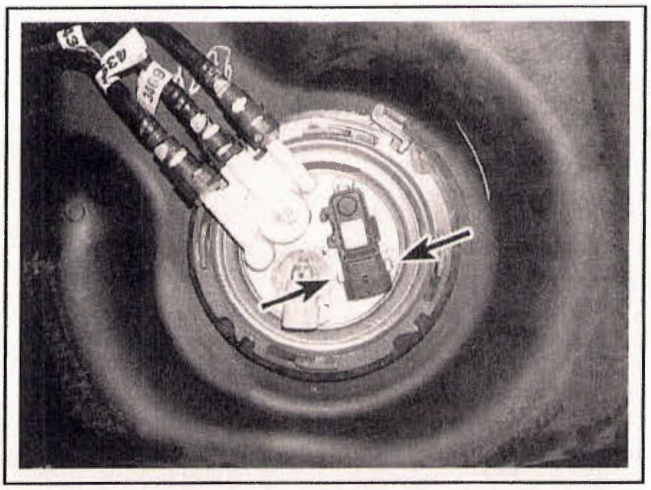
19.14a EVAP purge valve/control solenoid location - V6 models



19.14b EVAP purge valve/control solenoid location - V8 models



19.18 EVAP vent valve/control solenoid location



19.26 Pry the retaining clips out (arrows) and withdraw the fuel tank pressure sensor from the fuel pump module

vent valve (see Step 9).

20 Release the retainers and remove the vent valve from the bracket.

21 Installation is the reverse of removal.

Fuel tank pressure sensor

23 The fuel tank pressure sensor is located on the fuel pump module.

24 Remove the fuel tank (see Chapter 4).

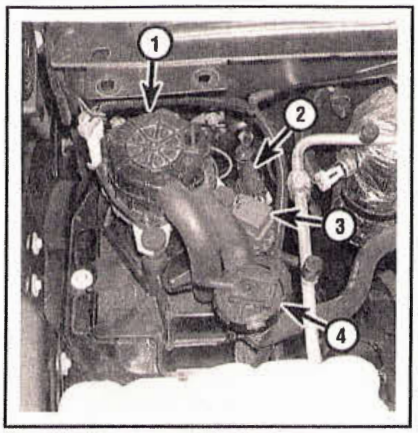
25 Disconnect the electrical connector from the fuel tank pressure sensor.

26 Release the retaining clip and remove the sensor from the top of the fuel pump module (see illustration).

27 Installation is the reverse of removal.

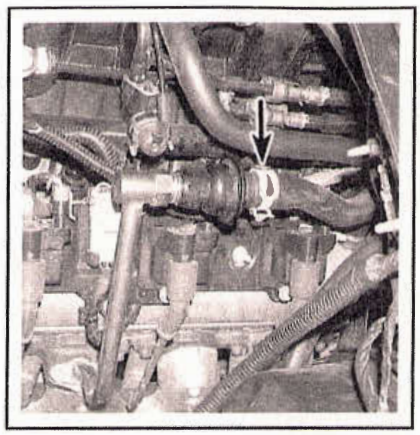
20 Secondary Air Injection (AIR) system

1 Some models are equipped with a secondary air injection (AIR) system. The secondary air injection system is used to reduce tailpipe emissions on initial engine start-up. The system uses an electric motor/pump assembly, relay, vacuum valve/solenoid, air shut-off valve, check valves and tubing to inject fresh air directly into the exhaust manifolds. The fresh air (oxygen) reacts with the exhaust gas in the catalytic converter to reduce HC and CO levels. The air pump and solenoid are controlled by the PCM through the AIR relay. During initial start-up, the PCM energizes the AIR relay, the relay supplies battery voltage to the air pump and the vacuum valve/solenoid, engine vacuum is applied to the air shut-off valve which opens and allows air to flow through the tubing into the exhaust manifolds. The PCM will operate the air pump until closed loop operation is reached (or four minutes, maximum). During normal operation, the check valves prevent exhaust backflow into the system.

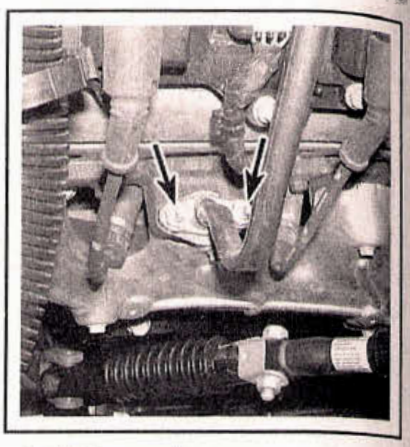


20.2 Secondary air injection component locations

1 *Air pump*
2 *Vacuum valve/solenoid*
3 *Air pump/solenoid relay*
4 *Air shut-off valve*



20.21 Using hose clamp pliers, squeeze the clamp tangs together, slide the clamp down the hose and remove the hose from the check valve



20.23 Remove the mounting nuts (arrows) and remove the check valve and pipe assembly

CHECK

Refer to illustration 20.2

2 Check the air pump hoses and the vacuum hoses (see illustration). Repair any damaged hoses or replace any missing hoses as necessary. Check the vacuum source to the vacuum valve/solenoid. Intake manifold vacuum should be present with the engine running.

3 Check the related fuses, the relay and the wiring to the air pump and vacuum valve/solenoid. Refer to Chapter 12 for the relay check and refer to the wiring diagrams at the end of Chapter 12, if necessary. The vacuum valve/solenoid is normally closed - no vacuum is applied to the air shut-off valve. When the PCM energizes the relay (by completing the circuit to ground), the air pump operates, the vacuum valve opens, vacuum is applied to the air shut-off valve, the shut-off valve opens and air flows through the tubing into the exhaust manifolds.

4 A scan tool is required to thoroughly check the system. If the above checks fail to identify the problem area, have the system diagnosed by a dealer service department or other qualified repair shop.

COMPONENT REPLACEMENT

Refer to illustrations 20.21 and 20.23

Air pump

5 Remove the bolts and the fender-to-cowl brace.

6 Disconnect the electrical connector from the air pump motor. Detach the hoses from the air pump.

7 Detach the air pump from the rubber mounting posts and remove the air pump assembly.

8 Installation is the reverse of removal.

Vacuum valve/solenoid

9 Disconnect the electrical connector from the valve/solenoid.

10 Label and disconnect the vacuum hoses from the valve/solenoid.

11 Remove the mounting screw and remove the vacuum valve/solenoid.

12 Installation is the reverse of removal.

Air shut-off valve

13 Detach the vacuum hose from the shut-off valve.

14 Detach the clamp from the assembly base.

15 Loosen the hose clamp and detach the air outlet hose from the shut-off valve.

16 Detach the shut-off valve from the air inlet hose and remove the valve.

17 Installation is the reverse of removal.

Air pump/solenoid relay

18 Disconnect the electrical connector from the relay.

19 Release the retaining tab and remove the relay from the bracket.

20 Installation is the reverse of removal.

Check valve and pipe

WARNING:

The engine must be completely cool before beginning this procedure or serious burns may result.

21 Loosen the clamp and remove the air hose from the check valve (see illustration).

22 On V6 models, remove the air pipe-to-exhaust manifold bracket bolt.

23 Remove the mounting bolts/nuts and remove the check valve and pipe assembly (see illustration).

24 To remove the check valve from the pipe, clamp the large nut on the pipe in a vise and remove the check valve with an open-end wrench.

25 Clean the carbon deposits from the pipe flange and the exhaust manifold mounting surface. Remove the carbon deposits from the hole in the manifold, if necessary.

26 Install the check valve on the pipe and install the assembly onto the exhaust manifold with a new gasket. Tighten the fasteners securely.

27 The remainder of installation is the reverse of removal.

21 Catalytic converter

➡Note: Because of a Federally mandated warranty which covers emissions-related components such as the catalytic converter, check with a dealer service department before replacing the converter at your own expense.

1 The catalytic converter is an emission control device added to the exhaust system to reduce pollutants from the exhaust gas stream. A three-way (reduction) catalyst design is used. The catalytic coating on the three-way catalyst contains platinum and rhodium, which lowers the levels of oxides of nitrogen (NOx) as well as hydrocarbons (HC) and carbon monoxide (CO).

2 The test equipment for a catalytic converter is expensive and highly sophisticated. If you suspect that the converter on your vehicle is malfunctioning, take it to a dealer or authorized emissions inspection facility for diagnosis and repair.

CHECK

3 Whenever the vehicle is raised for servicing of underbody components, check the converter for leaks, corrosion, dents and other damage. Check the flange bolts that attach the front and rear ends of the converter to the exhaust system. If damage is discovered, the converter should be replaced.

4 A catalytic converter may become plugged. The easiest way to check for a restricted converter is to use a vacuum gauge to diagnose the effect of a blocked exhaust on intake vacuum.

a) Connect a vacuum gauge to an intake manifold vacuum source.
b) Warm the engine to operating temperature, place the transmission in Park and apply the parking brake.
c) Note and record the vacuum reading at idle.
d) Open the throttle until the engine speed is about 2000 rpm.
e) Release the throttle quickly and record the vacuum reading.
f) Perform the test three more times, recording the reading after each test.
g) If the reading after the fourth test is more than one in-Hg lower than the reading recorded at idle, the catalytic converter, muffler or exhaust pipes may be plugged or restricted.

REPLACEMENT

♦ Refer to illustrations 21.7a and 21.7b

➡Note: Refer to the exhaust system servicing section in Chapter 4 for additional information.

5 Raise the vehicle and support it securely on jackstands.

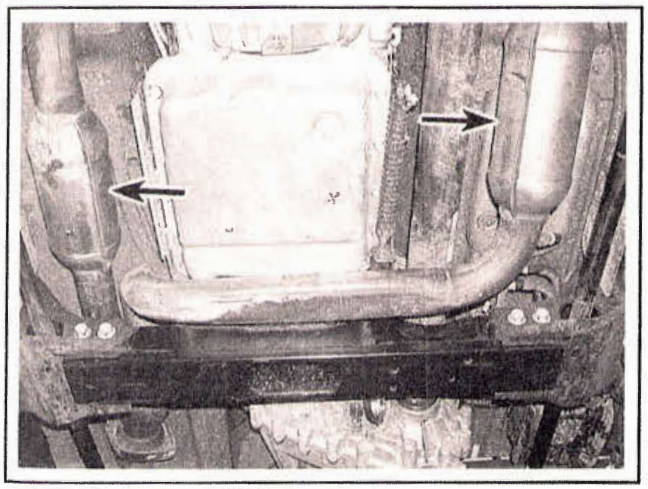
6 Disconnect the electrical connectors from the oxygen sensors.

7 Remove the catalytic converter-to-exhaust pipe flange bolts and separate the exhaust pipe from the catalytic converter (see illustrations). Support the exhaust pipe.

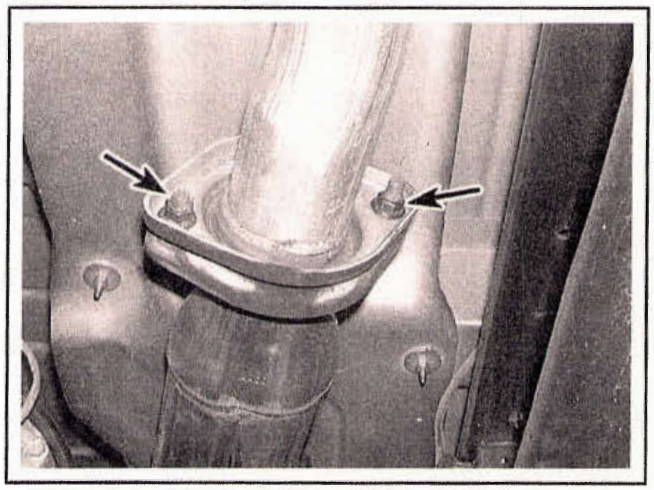
8 Remove the bolts and detach the catalytic converter header pipe from the exhaust manifold (see Chapter 2A or 2B). Remove the catalytic converter and pipe assembly.

9 Clean the carbon deposits from the mounting flanges and install new gaskets.

10 Installation is the reverse of removal.



21.7a Catalytic converter locations



21.7b Remove the catalytic converter-to-exhaust pipe flange bolts (arrows)