Chapter 6
Emissions and engine control systems

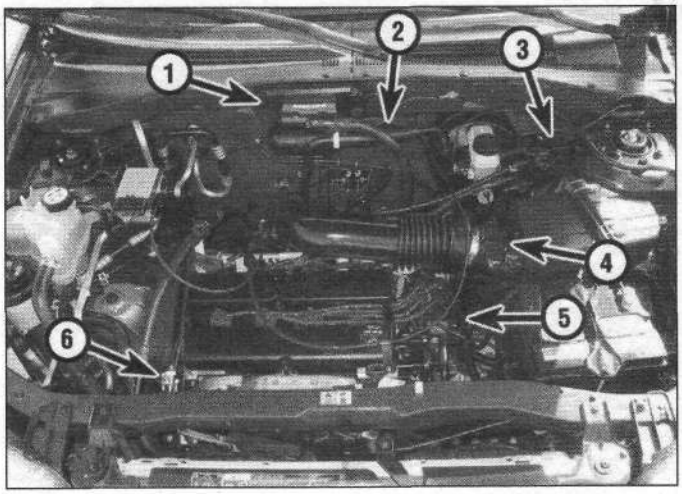
Contents

	Section
Camshaft Position (CMP) sensor - replacement	3
Catalytic converters	19
CHECK ENGINE light on	2
Clutch Pedal Position (CPP) switch - replacement	4
Crankshaft Position (CKP) sensor - replacement	5
Cylinder Head Temperature (CHT) sensor - replacement	6
Engine Coolant Temperature (ECT) sensor - replacement	7
Evaporative Emissions Control (EVAP) system - general information and component replacement	20
Exhaust Gas Recirculation (EGR) system - general information and component replacement	21
General information	1
Idle Air Control Valve (IAC) valve - replacement	18
Knock sensor - replacement	8
Mass Air Flow (MAF) sensor - replacement	9
On-board Diagnostic system and Diagnostic Trouble Codes (DTC)	2
Output Shaft Speed (OSS) sensor - replacement	10
Oxygen sensors - general information and replacement	11
Positive Crankcase Ventilation (PCV) system - general information and component replacement	22
Positive Crankcase Ventilation (PCV) valve check and replace	See Chapter 1
Power Steering Pressure (PSP) switch - replacement	12
Powertrain Control Module (PCM) - replacement	17
Throttle Position (TP) sensor - replacement	13
Transmission Range (TR) sensor - replacement and adjustment	14
Turbine Shaft Speed (TSS) sensor - replacement	15
Vehicle Speed Sensor (VSS) - replacement	16

Specifications

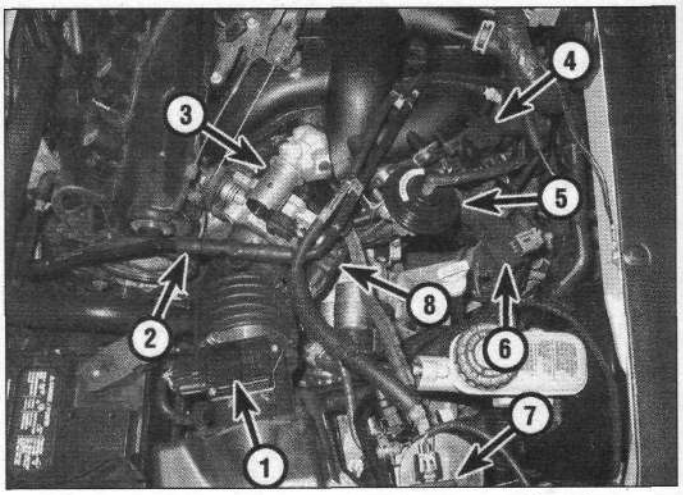
Torque specifications

	Ft-lbs (unless otherwise noted)	Nm
Camshaft Position (CMP) sensor mounting bolt		
Four-cylinder engine	180 in-lbs	20
V6 engine	89 in-lbs	10
Crankshaft Position (CKP) sensor mounting bolt		
Four-cylinder engine	62 in-lbs	7
V6 engine	89 in-lbs	10
Cylinder Head Temperature (CHT) sensor	89 in-lbs	10
Exhaust Gas Recirculation (EGR) valve mounting bolts		
Four-cylinder engine	80 in-lbs	9
V6 engine	18	25
Idle Air Control (IAC) valve mounting bolts		
2.0L four-cylinder and 3.0L V6 engines	89 in-lbs	10
2.3L four-cylinder engine	35 in-lbs	4
Knock sensor retaining nut/bolt		
Four-cylinder engine (retaining nut)	180 in-lbs	20
V6 engine (retaining bolt)	18	25
Output Shaft Speed (OSS) sensor mounting bolt	120 in-lbs	13
Oxygen sensors (all oxygen sensors, all models)	30	40
Transmission Range (TR) sensor mounting bolts	108 in-lbs	12
Turbine Shaft Speed (TSS) sensor mounting bolt	120 in-lbs	13
Vehicle Speed Sensor (VSS) (2WD and 4WD)	62 in-lbs	7



1.1a Emissions and engine control component locations (four-cylinder models)

1 *Powertrain Control Module (PCM)*
2 *EGR vacuum regulator valve*
3 *Evaporative Emissions Control (EVAP) system canister purge valve*
4 *Mass Air Flow (MAF) sensor*
5 *Differential pressure feedback EGR system sensor*
6 *Oxygen sensor electrical connectors*



1.1b Emissions and engine control component locations, left side (V6 models)

1 *Mass Air Flow (MAF) sensor*
2 *Crankcase vent tube*
3 *Idle Air Control (IAC) valve*
4 *EGR vacuum regulator valve*
5 *Exhaust Gas Recirculation (EGR) valve*
6 *Differential pressure feedback EGR system sensor*
7 *Evaporative Emissions Control (EVAP) system canister purge valve*
8 *Throttle Position (TP) sensor*

1 General information

Refer to illustrations 1.1a, 1.1b, 1.1c and 1.7

The emission control systems and components **(see illustrations)** are an integral part of the engine management system, which is called the Multiport Fuel Injection (MFI) system (see Chapter 4 for more information on the MFI system). The MFI system also includes all the government-mandated diagnostic features of the second generation of on-board diagnostics, which is known as On-Board Diagnostics II (OBD-II).

At the center of the MFI and OBD-II operations is the Powertrain Control Module (PCM), or on-board computer. The PCM controls not only engine operation but also the automatic transaxle. The PCM receives engine operating information as input signals from a number of sensors and provides output commands to actuators such as the ignition coil(s), the fuel injectors and various solenoids and relays for the engine and automatic transaxle. Other emission controls included in the overall engine control system are:

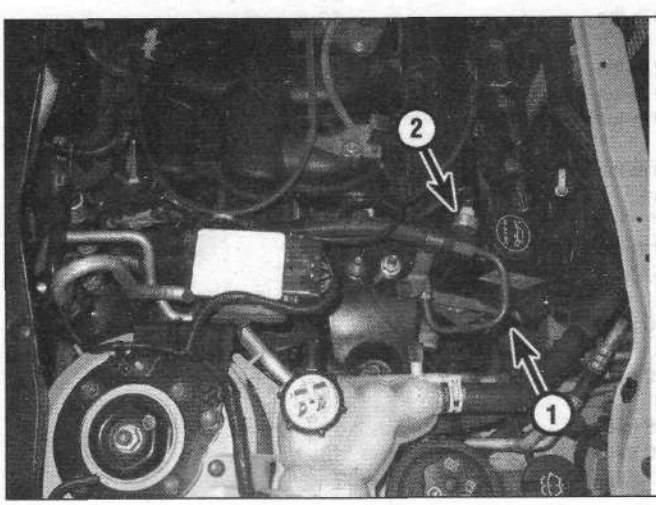
Catalytic converter(s)
Evaporative Emission Control (EVAP) system
Exhaust Gas Recirculation (EGR) system
Positive Crankcase Ventilation (PCV) system

The Sections in this Chapter include general descriptions and component replacement procedures for most of the information sensors and output actuators, as well as other components that are part of the systems listed above. Refer to Chapter 4 for more information on the air intake, fuel and exhaust systems, and to Chapter 5 for information on the ignition system. Also refer to Chapter 1 for scheduled maintenance procedures for emission-related systems and components.

The procedures in this Chapter are intended to be practical, affordable and within the capabilities of the home mechanic. The diagnosis of most engine and emission control functions and driveability problems requires specialized tools, equipment and training. When checking or servicing become too difficult or require special test equipment, consult a dealer service department or other qualified repair shop.

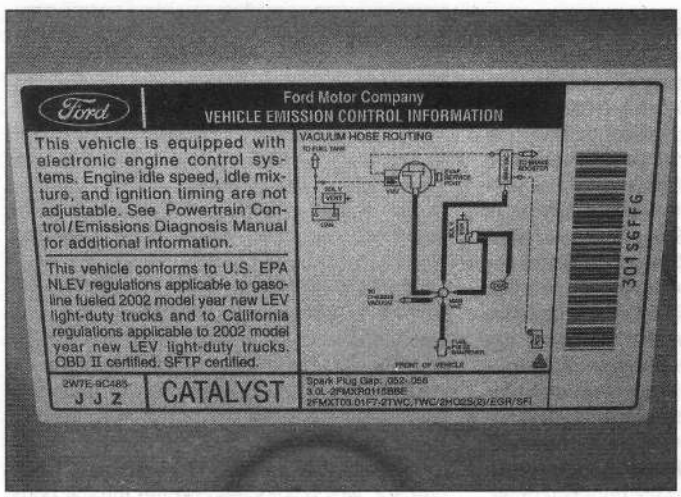
Although engine and emission control systems are very sophisticated on late-model vehicles, you can perform many checks and do most of the regular maintenance at home with common tune-up and hand tools and relatively inexpensive meters. Because of the Federally mandated warranty that covers the emission control system, check with a dealer about warranty coverage before working on any emission-related systems. After the warranty has expired, you may wish to perform some of the component replacement procedures in this Chapter to save money. Remember, the most frequent cause of emission and driveability problems is a loose electrical connector, or a broken wire or vacuum hose, so always check the electrical connections, the electrical wiring and the vacuum hoses first.

Pay close attention to any special precautions given in this Chapter. Remember that illustrations of various systems might not exactly match the system installed on the



1.1c Emission control component locations, right side (V6 models)

1 *Camshaft Position (CMP) sensor*
2 *Power Steering Pressure (PSP) switch*



1.7 The VECI label in the engine compartment identifies the emission control devices on a particular engine and includes a vacuum hose routing diagram

2.1 Scanners like these from Actron and AutoXray are powerful diagnostic aids - they can tell you just about anything you want to know about your engine management system

vehicle on which you're working because of changes made by the manufacturer during production or from year to year.

A Vehicle Emission Control Information (VECI) label **(see illustration)** is located in the engine compartment (on the underside of the hood on our project vehicle, although it might be located somewhere else, like the upper radiator crossmember, on your vehicle). This label contains emission-control and engine tune-up specifications and adjustment information. It also includes a vacuum hose routing diagram for emission-control components. When servicing the engine or emission systems, always check the VECI label in your vehicle. If any information in this manual contradicts what you read on the VECI label on your vehicle, always defer to the information on the VECI label.

2 On-Board Diagnostic (OBD) system and Diagnostic Trouble Codes (DTCs)

Scan tool information

Refer to illustrations 2.1 and 2.2

1 Hand-held scanners are the most powerful and versatile tools for analyzing engine management systems used on later model vehicles **(see illustration)**. Early model scanners handle codes and some diagnostics for many systems. 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, Toyota etc.). Some manufacturers will specify by continent (Asia, Europe, USA, etc.). **Note:** *An aftermarket generic scanner should work with any model covered by this manual. Before purchasing a generic scan tool, contact the manufacturer of the scanner you're planning to buy and verify that it will work properly with the OBD-II system you want to scan. If necessary, of course, you can always have the codes extracted by a dealer service department or an independent repair shop with a professional scan tool.*

2 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 **(see illustration)**.

OBD system general description

3 All models are equipped with the second generation OBD-II system. This system consists of an on-board computer known as the Powertrain Control Module (PCM), and information sensors, which monitor various functions of the engine and send data to the PCM. This system incorporates a series of diagnostic monitors that detect and identify fuel injection and emissions control systems faults and store the information in the computer memory. This updated system also tests sensors and output actuators, diagnoses drive cycles, freezes data and clears codes. This powerful diagnostic computer must be accessed using the new OBD-II scan tool and 16 pin Data Link Connector (DLC) located under the driver's dash area.

4 The PCM is the "brain" of the electronically controlled fuel and emissions system. It receives data from a number of sensors and other electronic components (switches, relays, etc.). Based on the information it receives, the PCM generates output signals to control various relays, solenoids (i.e. fuel injectors) and other actuators. The PCM is specifically calibrated to optimize the emissions, fuel economy and driveability of the vehicle.

5 It isn't a good idea to attempt diagnosis or replacement of the PCM or emission control components at home while the vehicle is under warranty. 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 this warranty, take the vehicle to a dealer service department if the PCM or a system component malfunctions.

Information sensors

6 **Camshaft Position (CMP) sensor** - The CMP sensor produces a signal that the PCM uses to identify the number 1 cylinder and to time the firing sequence of the fuel injectors. On four-cylinder models, the CMP sensor is located at the left rear corner of the cylinder head. On V6 models, the CMP sensor is located on the right end of the front cylinder head.

2.2 Trouble code readers like the Actron OBD-II diagnostic tester simplify the task of extracting the trouble codes

7 **Clutch Pedal Position (CPP) switch** (manual transaxle models) - The CPP switch, which is located at the top of the clutch pedal, provides a voltage input to the PCM which indicates whether the clutch pedal is depressed (no load on the engine) or not depressed (load on the engine). The PCM uses this information (along with data from other sensors) to help it determine the load on the engine so that it can alter the air/fuel mixture ratio accordingly.

8 **Crankshaft Position (CKP) sensor** - The CKP sensor produces a signal that the PCM uses to determine the position of the crankshaft. The CKP sensor is located on the right (drivebelt) end of all engines, adjacent to the crankshaft timing belt or chain sprocket.

9 **Cylinder Heat Temperature (CHT) sensor** (four-cylinder models) - The CHT sensor, which is located on the right (timing belt) end of the cylinder head, is a "thermistor," a type of variable resistor in which the resistance changes in accordance with the change in temperature. The CHT is known as a "negative temperature coefficient" (NTC) thermistor because as the temperature increases, the resistance decreases, and vice versa. The PCM uses the CHT sensor to monitor the operating temperature of the engine.

10 **Differential pressure feedback EGR system sensor** - The differential pressure feedback EGR system sensor, which is located near the firewall, to the right of the brake master cylinder reservoir, is a pressure transducer that monitors the pressure differential across a metering orifice located in the sensor. (A transducer is a device that receives a signal from one system and transfers that signal to another system, often in a different form.) The differential pressure feedback EGR system sensor outputs a voltage signal that's proportional to the pressure drop across its metering orifice. The PCM uses this data to calculate the EGR flow rate.

11 **Engine Coolant Temperature (ECT) sensor** (V6 models) - The ECT sensor is a thermistor (temperature-sensitive variable resistor) that sends a voltage signal to the PCM, which uses this data to determine the temperature of the engine coolant. The ECT sensor helps the PCM control the air/fuel mixture ratio and ignition timing, and it also helps the PCM determine when to turn the Exhaust Gas Recirculation (EGR) system on and off. The ECT sensor is located on the thermostat housing, right below the throttle body.

12 **Fuel tank pressure sensor** - The fuel tank pressure sensor, which is located above the fuel tank, near the fuel pump/fuel level sending unit module, measures the fuel tank pressure when the PCM tests the EVAP system, and it's also used to control fuel tank pressure by signaling the EVAP system to purge the tank when the pressure becomes excessive.

13 **Knock sensor** - The knock sensor is a "piezoelectric" crystal that oscillates in proportion to engine vibration. (The term *piezoelectric* refers to the property of certain crystals that produce a voltage when subjected to a mechanical stress.) The oscillation of the piezoelectric crystal produces a voltage output that is monitored by the PCM, which retards the ignition timing when the oscillation exceeds a certain threshold. When the engine is operating normally, the knock sensor oscillates consistently and its voltage signal is steady. When detonation occurs, engine vibration increases, and the oscillation of the knock sensor exceeds a design threshold. (Detonation is an uncontrolled explosion, after the spark occurs at the spark plug, which spontaneously combusts the remaining air/fuel mixture, resulting in a "pinging" or "slapping" sound.) If allowed to continue, detonation is annoying, and engine performance is diminished. On four-cylinder engines, the knock sensor is located on the right end of the rear side of the engine block. On V6 models, the knock sensor is located on the left rear side of the engine block.

14 **Mass Air Flow (MAF) sensor** - The MAF sensor is located on the air intake duct, right at the air filter housing. The MAF sensor is the principal means by which the Powertrain Control Module (PCM) monitors intake airflow. It uses a hot-wire sensing element to measure the amount of air entering the engine. The wire is maintained at a temperature of 392 degrees F (200-degrees C) above the ambient temperature by electrical current. As intake air passes through the MAF sensor and over the hot wire, it cools the wire, and the control system immediately corrects the temperature back to its constant value. The current required to maintain the constant value is used by the PCM as an indicator of airflow.

15 **Output Shaft Speed (OSS) sensor** (automatic transaxle models) - The OSS sensor, a magnetic pick-up coil which is located on the backside of the transaxle, provides the Powertrain Control Module (PCM) with information about the rotational speed of the output shaft in the transaxle. The PCM uses this information to control and diagnose powertrain behavior and to determine vehicle speed (instead of the Vehicle Speed Sensor, or VSS, which is used on manual transaxles).

16 **Oxygen sensors** - An oxygen sensor is a galvanic battery that generates a small variable voltage signal in proportion to the difference between the oxygen content in the exhaust stream and the oxygen content in the ambient air. The PCM uses the voltage signal from the upstream oxygen sensor to maintain a "stoichiometric" air/fuel ratio of 14.7:1 by constantly adjusting the "on-time" of the fuel injectors. There are *two* oxygen sensors on four-cylinder models: one *upstream* sensor (ahead of the catalytic converter) and a *downstream* oxygen sensor (after the catalyst). There are *four* oxygen sensors, one upstream and one downstream sensor for each cylinder bank, on V6 models. On these models, there are three catalysts: a smaller "fast-light-off" cat right below each exhaust manifold (the catalysts are actually an integral part of the exhaust manifolds) and another larger downstream catalyst. The oxygen sensors are located upstream and downstream in relation to the two smaller catalysts.

17 **Power Steering Pressure (PSP) switch** - The PSP sensor monitors the pressure inside the power steering system. When the front wheels are being turned at low speed there is more friction between the rubber tire treads and the road, so the pressure required to turn the wheels increases. The PCM uses the PSP sensor to determine when to increase engine idle speed during low-speed vehicle maneuvers. The PSP switch is located on the high-pressure side of the power steering system, near the right end of the front cylinder head valve cover.

18 **Throttle Position (TP) sensor** - The TP sensor, which is located on the throttle body, on the end of the throttle valve shaft, is a potentiometer that produces a variable voltage signal in accordance with the opening angle of the throttle valve. This voltage signal tells the PCM when the throttle is closed, in a cruise position, or wide open, or anywhere in between. The PCM uses this information, along with data from a number of other sensors, to calculate injector on-time.

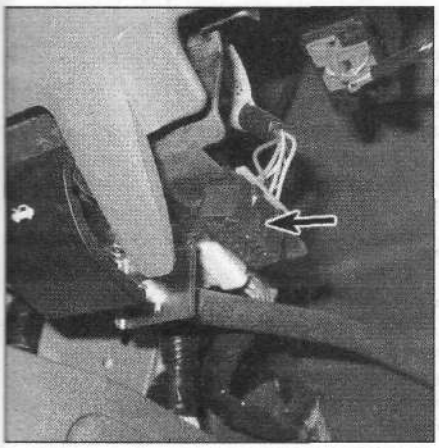
19 **Transmission Range (TR) sensor** - The TR sensor, which is located at the manual lever on top of the automatic transaxle, functions like a conventional Park/Neutral Position (PNP) switch: it prevents the engine from starting in any gear other than Park or Neutral, and it closes the circuit for the back-up lights when the shift lever is moved to Reverse. The PCM also sends a voltage signal to the TR sensor, which uses a series of step-down resistors that act as a voltage divider. The PCM monitors the TR sensor's voltage output, which corresponds to the position of the manual lever. Thus the PCM is able to determine the gear selected and is able to determine the correct pressure for the electronic pressure control system of the transaxle.

20 **Turbine Shaft Speed (TSS) sensor** (automatic transaxle models) - The TSS sensor, a magnetic pick-up coil which is located on the left side of the transaxle, provides the Powertrain Control Module (PCM) with information about the rotational speed of the turbine (input) shaft. The PCM uses this information to determine control strategies for the Torque Converter Clutch (TCC) and to determine the static Electronic Pressure Control (EPC) pressure setting during shifts.

21 **Vehicle Speed Sensor (VSS)** - The VSS, which is located on the transaxle, provides information to the PCM to indicate vehicle speed. Manual transaxles are equipped with one VSS. Automatics are equipped with an input and an output VSS (the PCM compares the difference, if any, between the two signals to predict transaxle failure).

Output actuators

22 **EVAP canister purge valve** - The EVAP canister purge valve, which is located in the



2.30 Location of the 16-pin Data Link Connector (DLC)

engine compartment, near the master cylinder, is normally closed. But when ordered to do so by the PCM, it allows fuel vapors from the EVAP canister to be drawn into the intake manifold for combustion under certain operating conditions. The PCM-controlled EVAP canister purge valve also controls this vapor flow.

23 **EVAP canister vent solenoid** - The EVAP canister vent solenoid, which is located underneath the vehicle, near the EVAP canister, seals the EVAP system for inspection and maintenance tests and for OBD-II leak and pressure tests.

24 **Exhaust Gas Recirculation (EGR) vacuum regulator valve** - When the engine is put under a load (hard acceleration, passing, going up a steep hill, pulling a trailer, etc.), combustion chamber temperatures increase. When combustion chamber temperature exceeds 2500 degrees, excessive amounts of oxides of nitrogen (NOx) are produced. NOx is a precursor of photochemical smog. When combined with hydrocarbons (HC), other "reactive organic compounds" (ROCs) and sunlight, it forms ozone, nitrogen dioxide and nitrogen nitrate and other nasty stuff. The vacuum-controlled EGR valve allows exhaust gases to be recirculated back to the intake manifold where they dilute the incoming air/fuel mixture, which lowers the combustion chamber temperature and decreases the amount of NOx produced during high-load conditions. The amount of exhaust gases recirculated to the intake is determined by the strength of the vacuum signal delivered to the EGR valve. The PCM-controlled EGR vacuum regulator valve is the electromagnetic device that regulates the supply of vacuum to the EGR valve. The EGR vacuum regulator valve is located near the EGR valve.

25 **Fuel injectors** - The fuel injectors, which spray a fine mist of fuel into the intake ports, where it is mixed with incoming air, are inductive coils under PCM control. For more information about the injectors, see Chapter 4.

26 **Idle Air Control (IAC) valve** - The IAC valve controls the amount of air allowed to bypass the throttle valve when the throttle valve is at its (nearly closed) idle position. The IAC valve is controlled by the PCM. When the engine is placed under an additional load at idle (low-speed maneuvers or the air conditioning compressor, for example), the engine can run roughly, stumble and even stall. To prevent this from happening, the PCM opens the IAC valve to increase the idle speed enough to overcome the extra load imposed on the engine. The IAC valve is mounted on the intake manifold, near the throttle body.

27 **Ignition coil(s)** - The ignition coil(s) is/are under the control of the Powertrain Control Module (PCM). There is no ignition control module. Instead, "coil drivers" inside the PCM turn the primary side of the coil(s) on and off. For more information about the ignition coil(s), see Chapter 5.

Obtaining and clearing Diagnostic Trouble Codes (DTCs)

28 All models covered by this manual are equipped with on-board diagnostics. When the PCM recognizes a malfunction in a monitored emission control system, component or circuit, it turns on the CHECK ENGINE light, also known as the Malfunction Indicator Light (MIL), on the dash. The PCM will continue to display the MIL until the problem is fixed and the Diagnostic Trouble Code (DTC) is cleared from the PCM's memory. You'll need a scan tool to access any DTCs stored in the PCM.

29 Before outputting any DTCs stored in the PCM, thoroughly inspect ALL electrical connectors and hoses. Make sure that all electrical connections are tight, clean and free of corrosion. And make sure that all hoses are correctly connected, fit tightly and are in good condition (no cracks or tears). Also, make sure that the engine is tuned up. A poorly running engine is probably one of the biggest causes of emission-related malfunctions. Often, simply giving the engine a good tune-up will correct the problem.

Accessing the DTCs

Refer to illustration 2.30

30 On these models, all of which are equipped with On-Board Diagnostic II (OBD-II) systems, the Diagnostic Trouble Codes (DTCs) can only be accessed with a scan tool. Simply plug the connector of the scan tool into the diagnostic connector **(see illustration)**, which is located under the left side of the dash, then follow the instructions included with the scan tool to extract the DTCs.

31 Once you have outputted all of the stored DTCs, look them up on the accompanying DTC chart.

32 After troubleshooting the source of each DTC, make any necessary repairs or replace the defective component(s).

Clearing the DTCs

33 Clear the DTCs with the scan tool in accordance with the instructions provided by the scan tool's manufacturer.

Diagnostic Trouble Codes

34 The accompanying tables are a list of the Diagnostic Trouble Codes (DTCs) that can be accessed by a do-it-yourselfer working at home (there are many, many more DTCs available to dealerships with proprietary scan tools and software, but those codes cannot be accessed by a generic scan tool). If, after you have checked and repaired the connectors, wire harness and vacuum hoses (if applicable) for an emission-related system, component or circuit, the problem persists, have the vehicle checked by a dealer service department or a qualified repair shop.

OBD-II trouble codes

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

Code	Probable cause
P0040	Upstream oxygen sensors swapped (crossed wiring harnesses)
P0041	Downstream oxygen sensors swapped (crossed wiring harnesses)
P0068	Throttle Position (TP) sensor inconsistent with Mass Air Flow sensor
P0102	Mass Air Flow (MAF) sensor circuit, low input
P0103	Mass Air Flow (MAF) sensor circuit, high input

Code	Probable cause
P0106	Barometric (BARO) pressure sensor circuit, performance problem
P0107	Barometric (BARO) pressure sensor/MAP sensor circuit, low voltage
P0108	Barometric (BARO) pressure sensor/MAP sensor circuit, high voltage
P0109	BARO/MAP sensor circuit intermittent
P0112	Intake Air Temperature (IAT) sensor circuit, low input
P0113	Intake Air Temperature (IAT) sensor circuit, high input
P0116	Engine Coolant Temperature (ECT) circuit range/performance problem
P0117	Engine Coolant Temperature (ECT) sensor circuit, low input
P0118	Engine Coolant Temperature (ECT) sensor circuit, high input
P0121	Throttle Position (TP) circuit out of range or performance problem
P0122	Throttle Position (TP) sensor circuit, low input
P0123	Throttle Position (TP) sensor circuit, high input
P0125	Insufficient coolant temperature for closed loop fuel control
P0128	Coolant temperature below thermostat regulated temperature
P0131	Upstream oxygen sensor circuit problem (rear cylinder bank on V6)
P0132	Upstream oxygen sensor circuit, high voltage (rear cylinder bank on V6)
P0133	Upstream oxygen sensor circuit, slow response (rear cylinder bank on V6)
P0135	Upstream oxygen sensor heater circuit problem (rear cylinder bank on V6)
P0136	Downstream oxygen sensor circuit problem (rear cylinder bank on V6)
P0138	Downstream oxygen sensor circuit, high voltage (rear cylinder bank on V6)
P0141	Downstream oxygen sensor heater circuit problem (rear cylinder bank on V6)
P0148	Fuel delivery error
P0151	Upstream oxygen sensor circuit, low voltage (front cylinder bank on V6)
P0152	Upstream oxygen sensor circuit, high voltage (front cylinder bank on V6)
P0153	Upstream oxygen sensor circuit, slow response (front cylinder bank on V6)
P0155	Upstream oxygen sensor heater circuit problem (front cylinder bank on V6)
P0156	Downstream oxygen sensor circuit problem (front cylinder bank on V6)
P0158	Downstream oxygen sensor circuit, high voltage (front cylinder bank on V6)
P0161	Downstream oxygen sensor heater circuit problem (front cylinder bank on V6)
P0171	System too lean (rear cylinder bank on V6)
P0172	System too rich (rear cylinder bank on V6)
P0174	System too lean (front cylinder bank on V6)
P0175	System too rich (front cylinder bank on V6)
P0176	Flexible Fuel (FF) sensor circuit malfunction
P0180	Engine Fuel Temperature (EFT) sensor A circuit, low input

Code	Probable cause
P0181	Engine Fuel Temperature (EFT) sensor A circuit, range/performance
P0183	Engine Fuel Temperature (EFT) sensor circuit, high input
P0190	Fuel Rail Pressure (FRP) sensor circuit malfunction
P0191	Fuel Rail Pressure (FRP) sensor circuit performance
P0192	Fuel Rail Pressure (FRP) sensor circuit, low input
P0193	Fuel Rail Pressure (FRP) sensor circuit, high input
P0196	Engine Oil Temperature sensor circuit range/performance problem
P0197	Engine Oil Temperature sensor circuit, low input
P0198	Engine Oil Temperature sensor circuit, high input
P0201	Injector no. 1 circuit malfunction
P0202	Injector no. 2 circuit malfunction
P0203	Injector no. 3 circuit malfunction
P0204	Injector no. 4 circuit malfunction
P0205	Injector no. 5 circuit malfunction
P0206	Injector no. 6 circuit malfunction
P0219	Engine overspeed condition
P0221	Throttle Position (TP) sensor B circuit range/performance problem
P0222	Throttle Position (TP) sensor B circuit, low input
P0223	Throttle Position (TP) sensor B circuit, high input
P0230	Fuel pump primary circuit malfunction
P0231	Fuel pump secondary circuit low
P0232	Fuel pump secondary circuit high
P0297	Vehicle overspeed condition
P0298	Engine oil over temperature condition
P0300	Random misfire detected
P0301	Cylinder no. 1 misfire detected
P0302	Cylinder no. 2 misfire detected
P0303	Cylinder no. 3 misfire detected
P0304	Cylinder no. 4 misfire detected
P0305	Cylinder no. 5 misfire detected
P0306	Cylinder no. 6 misfire detected
P0315	PCM unable to learn crankshaft pulse wheel tooth spacing
P0316	Misfire occurred during first 1000 engine revolutions
P0320	Ignition engine speed input circuit malfunction
P0325	Knock sensor 1 circuit malfunction

Code	Probable cause
P0326	Knock sensor 1 circuit range/performance
P0330	Knock sensor 2 circuit malfunction
P0331	Knock sensor 2 circuit range/performance
P0340	Camshaft Position (CMP) sensor circuit malfunction
P0345	Camshaft Position (CMP) sensor circuit malfunction
P0350	Ignition coil primary or secondary circuit malfunction (four-cylinder)
P0351	Ignition coil A primary or secondary circuit malfunction (V6 engine)
P0352	Ignition coil B primary or secondary circuit malfunction (V6 engine)
P0353	Ignition coil C primary or secondary circuit malfunction (V6 engine)
P0354	Ignition coil D primary or secondary circuit malfunction (V6 engine)
P0355	Ignition coil E primary or secondary circuit malfunction (V6 engine)
P0356	Ignition coil F primary or secondary circuit malfunction (V6 engine)
P0400	EGR flow failure (outside the minimum or maximum limits)
P0401	Exhaust Gas Recirculation (EGR) valve, insufficient flow detected
P0402	Exhaust Gas Recirculation (EGR) valve, excessive flow detected
P0403	EEGR electric motor windings or circuits to PCM shorted or open
P0405	DPF EGR sensor circuit, low voltage detected
P0406	DPF EGR sensor circuit, high voltage detected
P0411	Secondary Air Injection (AIR) system, upstream flow
P0412	Secondary Air Injection (AIR) system, circuit malfunction
P0420	Catalyst system efficiency below threshold (rear catalyst on V6)
P0430	Catalyst system efficiency below threshold (front catalyst on V6)
P0442	EVAP control system, small leak detected
P0443	EVAP control system, canister purge valve circuit malfunction
P0446	EVAP control system canister vent solenoid circuit malfunction
P0451	Fuel tank pressure sensor circuit out of range or performance problem
P0452	Fuel tank pressure sensor circuit, low input
P0453	Fuel tank pressure sensor circuit, high input
P0455	EVAP control system, big leak detected
P0456	EVAP control system, very small leak detected
P0457	EVAP control system, leak detected (fuel filler neck cap loose or off)
P0460	Fuel level sensor circuit malfunction
P0462	Fuel level sensor circuit, low input
P0463	Fuel level sensor circuit, high input
P0480	Visctronic Drive Fan (VDF) primary circuit malfunction

Code	Probable cause
P0481	High Fan Control (HFC) primary circuit failure
P0500	Vehicle Speed Sensor (VSS) malfunction
P0501	Vehicle Speed Sensor (VSS) range/performance problem
P0503	Vehicle Speed Sensor (VSS), intermittent malfunction
P0505	Idle Air Control (IAC) system malfunction
P0506	Idle Air Control (IAC) rpm lower than expected
P0507	Idle Air Control (IAC) rpm higher than expected
P0511	Idle Air Control (IAC) circuit malfunction
P0528	Visctronic Drive Fan (VDF) speed sensor circuit malfunction
P0534	Low air conditioning cycling period
P0537	Air conditioning evaporator temperature circuit, low input
P0538	Air conditioning evaporator temperature circuit, high input
P0552	Power Steering Pressure (PSP) sensor circuit malfunction
P0553	Power Steering Pressure (PSP) sensor circuit malfunction
P0602	Control module programming error
P0603	Powertrain Control Module (PCM) Keep-Alive-Memory (KAM) test error
P0605	Powertrain Control Module (PCM) Read-Only-Memory (ROM) error
P0606	Powertrain Control Module (PCM) internal communication error
P0703	Brake switch circuit input malfunction
P0704	Clutch pedal position switch malfunction
P0720	Insufficient input from Output Shaft Speed (OSS) sensor
P0721	Noise interference on Output Shaft Speed (OSS) sensor signal
P0722	No signal from Output Shaft Speed (OSS) sensor
P0723	Output Shaft Speed (OSS) sensor circuit, intermittent failure
P0812	Reverse Switch (RS) input circuit malfunction

3 Camshaft Position (CMP) sensor - replacement

Four-cylinder models

Refer to illustrations 3.3 and 3.5

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

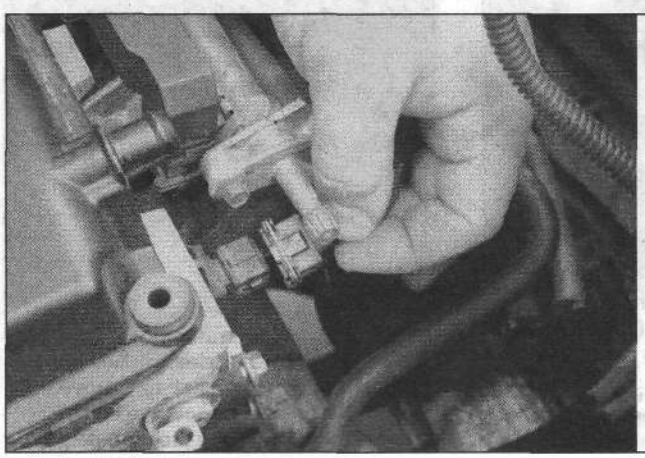
2 Locate the CMP sensor at the left rear corner of the cylinder head.

3 Disconnect the electrical connector from the CMP sensor **(see illustration)**.

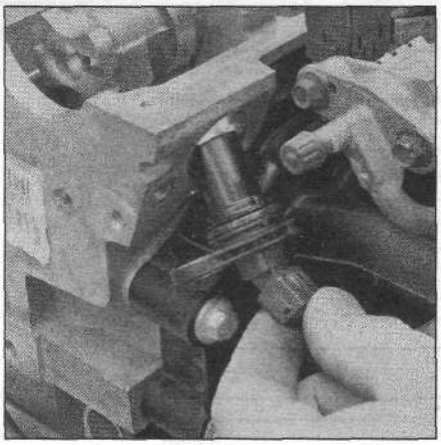
4 Remove the CMP sensor retaining bolt.

5 Remove the CMP sensor **(see illustration)**.

6 Installation is the reverse of removal. Be



3.3 Disconnect the electrical connector from the CMP sensor (four-cylinder models)



3.5 Remove the CMP sensor retaining bolt, then remove the CMP sensor from the cylinder head (four-cylinder models)

sure to tighten the CMP sensor bolt to the torque listed in this Chapter's Specifications.

7 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

V6 models

Refer to illustration 3.9

8 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

9 Locate the CMP sensor at the right end of the front cylinder head **(see illustration)**.

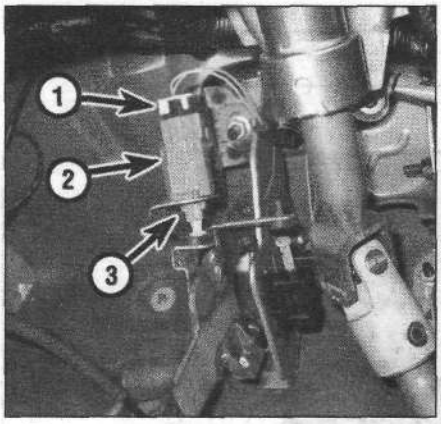
10 Disconnect the electrical connector from the CMP sensor.

11 Remove the CMP sensor retaining bolt.

12 Remove the CMP sensor.

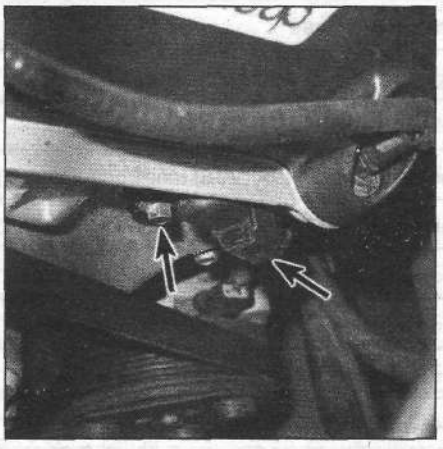
13 Installation is the reverse of removal. Be sure to tighten the CMP sensor bolt to the torque listed in this Chapter's Specifications.

14 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



4.2 On models with a manual transaxle, the Clutch Pedal Position (CPP) switch is located at the top of the clutch pedal

1 Electrical connector
2 Clutch Pedal Position (CPP) switch
3 Locknut



3.9 On V6 models, the CMP sensor is located at the right end of the front cylinder head; to remove the CMP sensor, disconnect the electrical connector and remove the retaining bolt

4 Clutch Pedal Position (CPP) switch - replacement

Refer to illustration 4.2

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

2 Locate the CPP switch at the top of the clutch pedal **(see illustration)**.

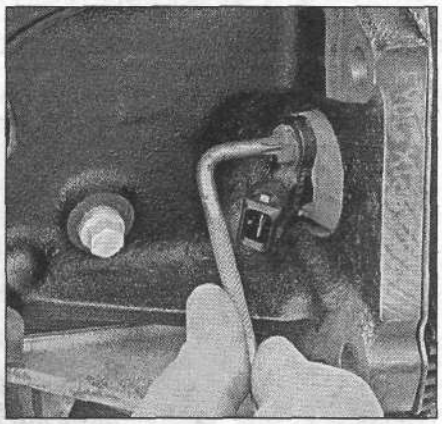
3 Disconnect the electrical connector from the CPP switch.

4 Unscrew the CPP switch locknut.

5 Remove the CPP switch.

6 Installation is the reverse of removal.

7 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



5.5 On 2.0L four-cylinder models, the CKP sensor is located on the front side of the block, near the flywheel; to remove the CKP sensor, disconnect the electrical connector and remove the mounting bolt

5 Crankshaft Position (CKP) sensor - replacement

2.0L four-cylinder models

Refer to illustrations 5.5 and 5.6

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

2 Remove the exhaust manifold (see Chapter 2A).

3 Locate the CKP sensor on the front of the engine near the flywheel end of the block.

4 Disconnect the electrical connector from the CKP sensor.

5 Unscrew the CKP sensor mounting bolt **(see illustration)**.

6 Remove the CKP sensor **(see illustration)**.

7 Installation is the reverse of removal. Be sure to tighten the CKP sensor mounting bolt to the torque listed in this Chapter's Specifications.

8 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

V6 models

Refer to illustration 5.12

9 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

10 Loosen the right front wheel lug nuts. Raise the front of the vehicle and place it securely on jackstands. Remove the right front wheel.

11 Remove the lower right splash shield **(see illustration 10.13 in Chapter 5)**.

12 Locate the CKP sensor **(see illustration)** next to the crankshaft pulley.

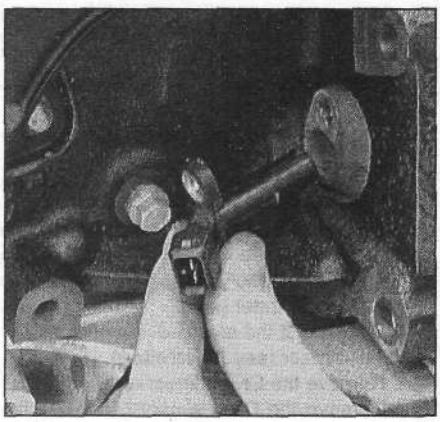
13 Disconnect the electrical connector from the CKP sensor.

14 Remove the CKP sensor mounting bolt.

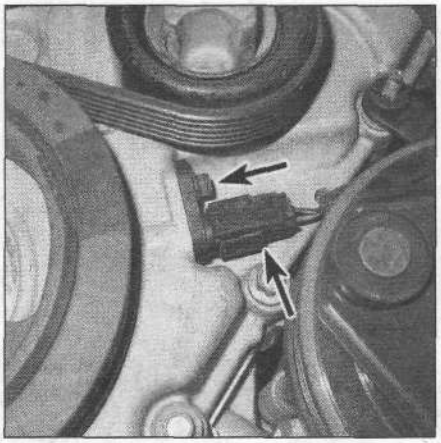
15 Remove the CKP sensor.

16 Installation is the reverse of removal. Be sure to tighten the CKP sensor mounting bolt to the torque listed in this Chapter's Specifications.

17 After you've reconnected the battery, the Powertrain Control Module (PCM) must



5.6 Remove the CKP sensor (four-cylinder models)



5.12 On V6 models, the CKP sensor is located near the crankshaft pulley; to remove the CKP sensor, disconnect the electrical connector and remove the sensor mounting bolt

relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

2.3L four-cylinder engine

Note: *The CKP sensor for this engine must be replaced with a new one whenever it is removed because there is a special alignment tool that must be used to install the sensor that can only be obtained with the purchase of a new sensor - the tool is not sold separately.*

18 Disconnect the cable from the negative battery terminal (see Chapter 5).

19 The CKP sensor is mounted right next to the crankshaft pulley.

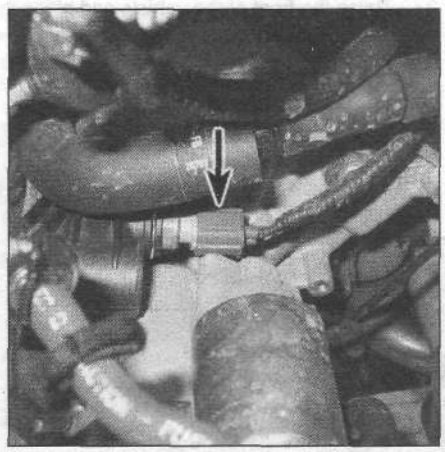
20 Disconnect the electrical connector to the CKP sensor.

21 Set the engine at TDC (see Chapter 2B).

22 With the special timing pin and crankshaft pulley alignment tool in place, remove the mounting bolts for the CKP sensor.

23 To install the CKP sensor, install the mounting bolts - but do not tighten them.

24 Adjust the CKP sensor by using the CKP sensor alignment tool, then tighten the mounting bolts securely.



7.4 On V6 models, the ECT sensor is located on the thermostat housing (four-cylinder models don't use an ECT sensor; they use a CHT sensor); to remove the ECT sensor, disconnect the electrical connector and remove the retaining clip, then pull out the sensor

6 Cylinder Head Temperature (CHT) sensor - replacement

Refer to illustration 6.4

Note: *This procedure applies to four-cylinder models only.*

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

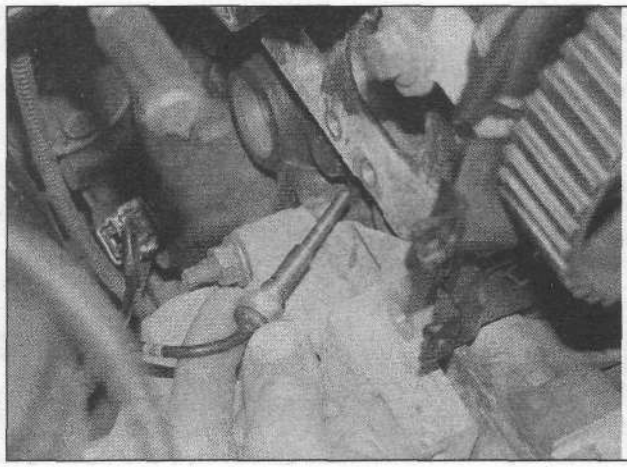
2 If you're working on a 2.0L four-cylinder engine, remove the alternator (see Chapter 5).

3 Disconnect the CHT sensor electrical connector.

4 Unscrew and remove the CHT sensor **(see illustration)**.

5 Installation is the reverse of removal. Be sure to tighten the CHT sensor to the torque listed in this Chapter's Specifications.

6 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



6.4 To remove the CHT sensor from a 2.0L four-cylinder engine, disconnect the electrical connector, then unscrew the sensor. On 2.3L four-cylinder engines, the sensor is located between the number 2 and number 3 spark plugs. (V6 engines do not use a CHT sensor, they use an ECT sensor)

7 Engine Coolant Temperature (ECT) sensor - replacement

Refer to illustrations 7.4, 7.6 and 7.8

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

Note: *This procedure applies to V6 models only.*

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

2 Drain the cooling system (see Chapter 1).

3 Remove the air intake duct (see Chapter 4).

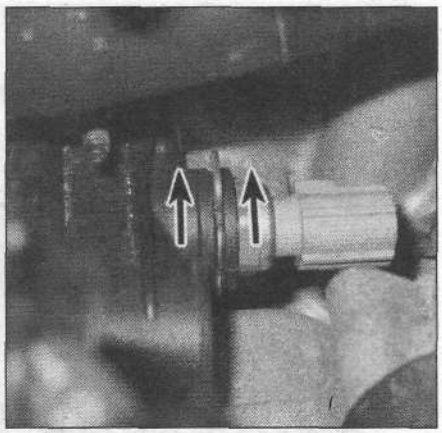
4 Locate the ECT sensor on the thermostat housing **(see illustration)**.

5 Disconnect the electrical connector from the ECT sensor.

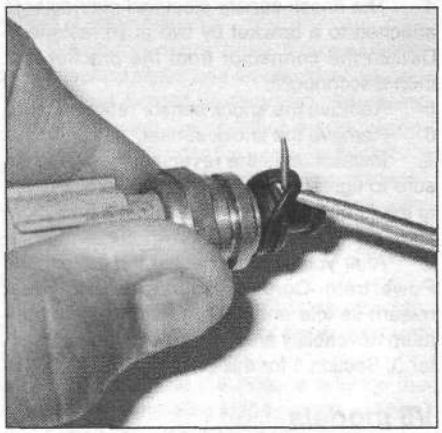
6 Remove the ECT sensor retaining clip **(see illustration)** by pulling it straight up.

7 Remove the ECT sensor.

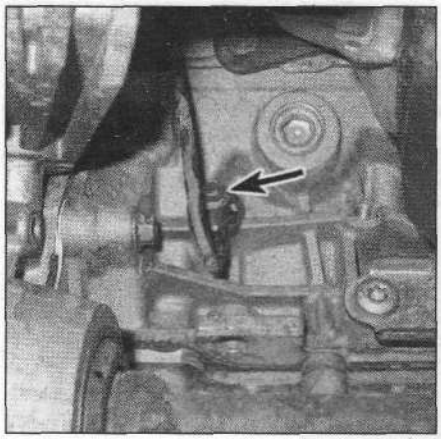
8 Remove the ECT sensor O-ring **(see illustration)** and discard it. Always use a new O-ring when installing the ECT sensor, even if you're planning to reuse the old ECT sensor.



7.6 To remove the ECT sensor retaining clip, pull it straight up



7.8 Remove and discard the old ECT sensor O-ring; always use a new O-ring when installing the ECT sensor, even if you plan to reuse the old sensor



8.11 On V6 models, the knock sensor is located on the rear side of the block, near the transaxle; to detach the knock sensor from the block, trace the electrical lead up to the connector (see next illustration) and disconnect it, then remove the knock sensor retaining bolt and remove the sensor

9 Installation is the reverse of removal.
10 Refill the cooling system (see Chapter 1).
11 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

8 Knock sensor - replacement

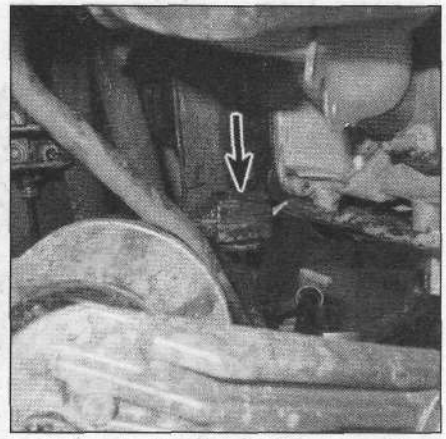
Four-cylinder models

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
2 Raise the front of the vehicle and place it securely on jackstands.
3 Locate the knock sensor on the back side of the block, near the alternator. If you're working on a 2.3L four-cylinder model, remove the intake manifold (see Chapter 2A).
4 The knock sensor electrical connector is attached to a bracket by two push fasteners. Detach the connector from the bracket and then disconnect it.
5 Remove the knock sensor retaining nut.
6 Remove the knock sensor.
7 Installation is the reverse of removal. Be sure to tighten the knock sensor retaining nut to the torque listed in this Chapter's Specifications.
8 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

V6 models

Refer to illustrations 8.11 and 8.12

9 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
10 Raise the front of the vehicle and place it



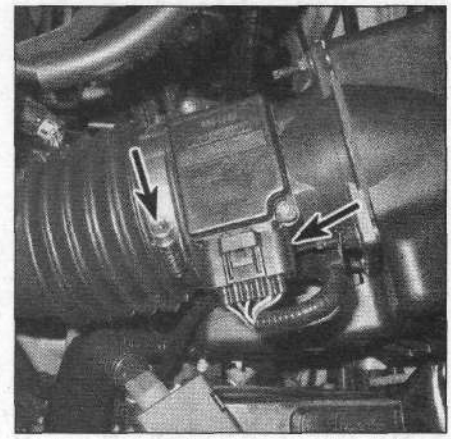
8.12 Trace the electrical lead from the knock sensor up to the sensor electrical connector and disconnect it

securely on jackstands.
11 Locate the knock sensor on the rear side of the block **(see illustration)**.
12 Disconnect the knock sensor electrical connector **(see illustration)**.
13 Remove the knock sensor retaining bolt.
14 Remove the knock sensor.
15 Installation is the reverse of removal. Be sure to tighten the knock sensor retaining bolt to the torque listed in this Chapter's Specifications.
16 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

9 Mass Air Flow (MAF) sensor - replacement

Refer to illustrations 9.2 and 9.5

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
2 Remove the air intake duct **(see illustration)**.
3 Disconnect the electrical connector from the MAF sensor **(see illustration 9.2)**.
4 Remove the half of the air filter housing that includes the MAF sensor (see Section 8 in Chapter 4).



9.2 Loosen the air intake duct hose clamp screw and pull off the duct, then disconnect the electrical connector from the MAF sensor (V6 model shown, four-cylinder models similar)

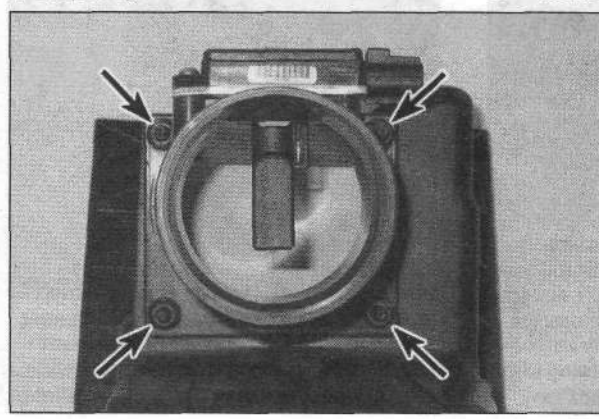
5 Remove the four MAF sensor retaining nuts **(see illustration)** and remove the MAF sensor.
6 Installation is the reverse of removal. Be sure to tighten the MAF sensor retaining nuts securely.
7 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

10 Output Shaft Speed (OSS) sensor - replacement

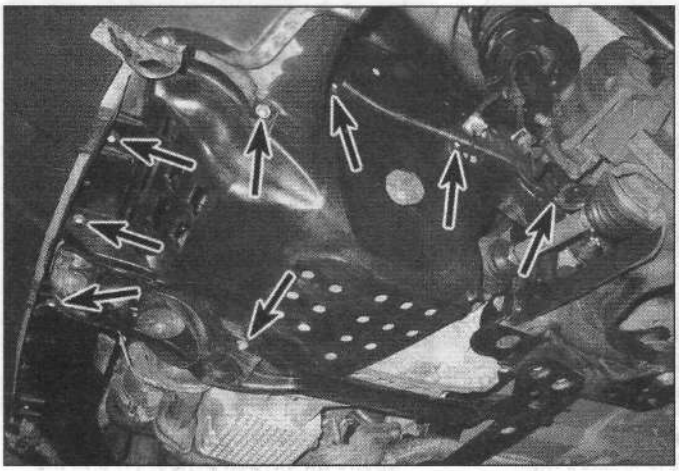
Refer to illustrations 10.3, 10.4, 10.6 and 10.7

Note: *This sensor is used only on models with an automatic transaxle.*

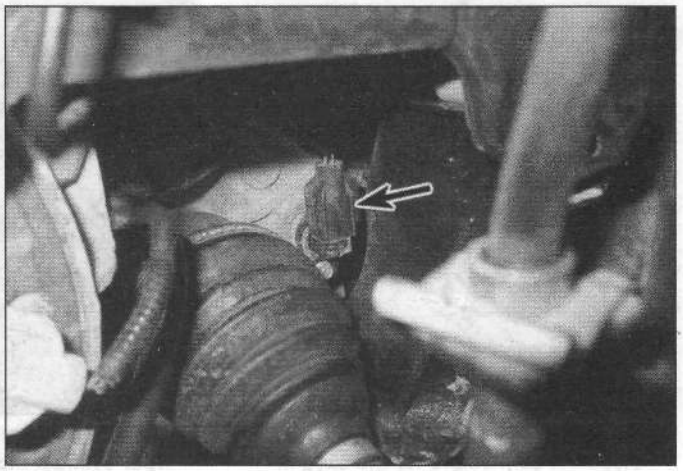
1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
2 Raise the front of the vehicle and place it securely on jackstands.
3 Remove the lower left splash shield **(see illustration)**.
4 Locate the OSS sensor on the left side of the transaxle **(see illustration)**.
5 Disconnect the electrical connector from the OSS sensor **(see illustration 10.4)**.
6 Remove the OSS sensor retaining bolt



9.5 To detach the MAF sensor from the air filter housing cover, remove these nuts (V6 model shown, four-cylinder models similar)



10.3 To detach the lower left splash shield, remove these fasteners



10.4 The OSS sensor is located on the left side of the automatic transaxle

(see illustration) and remove the OSS sensor.

7 Remove the old O-ring from the OSS sensor **(see illustration)** and discard it. Be sure to use a new O-ring when installing the OSS sensor (even if you're planning to reuse the old OSS sensor).

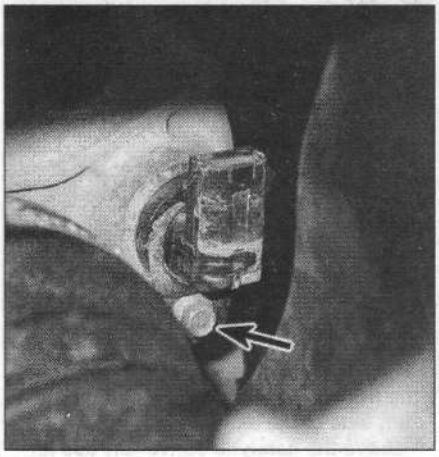
8 Installation is the reverse of removal. Be sure to tighten the OSS sensor retaining bolt to the torque listed in this Chapter's Specifications.

9 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

11 Oxygen sensors - general information and replacement

General information

1 An oxygen sensor is a galvanic battery that produces a very small voltage output in response to the amount of oxygen in the exhaust gases. This voltage signal is the "input" side of the feedback loop between the oxygen sensor and the Powertrain Control Module (PCM). Without it, the PCM would be unable to correct the injector on-time (which determines the air/fuel ratio) to maintain the "perfect" (known as *stoichiometric)* air/fuel ratio of 14.7:1 that the catalyst needs for optimal operation.



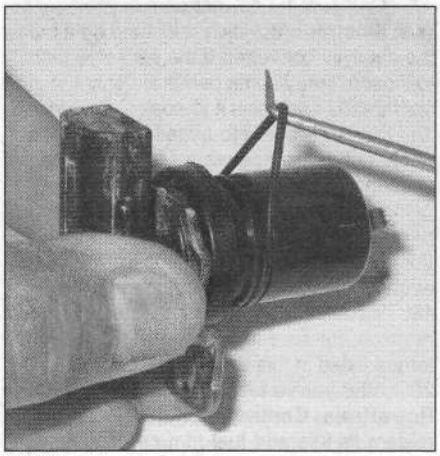
10.6 To detach the OSS sensor from the transaxle, remove this bolt

On-Board Diagnostics II (OBD-II)

2 All vehicles covered by this manual have On-Board Diagnostics II (OBD-II) engine management systems, which means they have the ability to verify the accuracy of the basic feedback loop between the oxygen sensor and the PCM. They accomplish this by using an oxygen sensor *ahead of* the catalytic converter and another oxygen sensor *behind* the catalytic converter. By comparing the amount of oxygen in the post-catalyst exhaust gas to the oxygen content of the exhaust gas before it enters the catalyst, the PCM can determine the efficiency of the converter.

Four-cylinder models

3 All four-cylinder vehicles covered by this manual have *two* heated oxygen sensors: one *upstream* sensor (ahead of the catalytic converter) and a *downstream* oxygen sensor (after the catalyst).



10.7 Be sure to replace the OSS sensor O-ring (even if you're planning to reuse the same OSS sensor)

V6 models

4 There are *four* heated oxygen sensors, one upstream and one downstream sensor for each cylinder head, on V6 models. On these models, there are three catalysts: a smaller "fast-light-off" cat right below each exhaust manifold (the catalysts are actually an integral part of the exhaust manifolds) and another larger downstream catalyst. The oxygen sensors are located upstream and downstream in relation to the two smaller catalysts.

All models

5 The upstream and downstream oxygen sensors on all models are heated to speed up the warm-up time during which the sensors are unable to produce an accurate voltage signal. The circuit for each oxygen sensor heater is controlled by the PCM, which opens the ground side of the circuit to shut off the heater as soon as the sensor reaches its normal operating temperature.

6 Special care must be taken whenever a sensor is serviced.

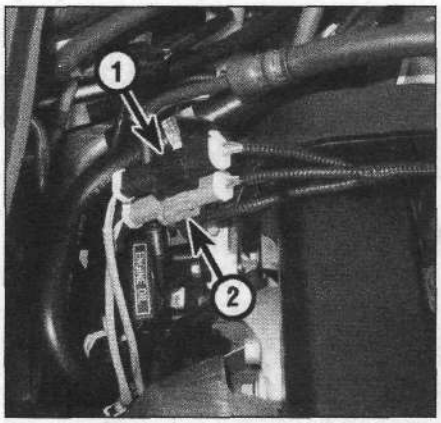
a) *Oxygen sensors have a permanently attached pigtail and an electrical connector that cannot be removed. Damaging or removing the pigtail or electrical connector will render the sensor useless.*

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 an oxygen sensor.*

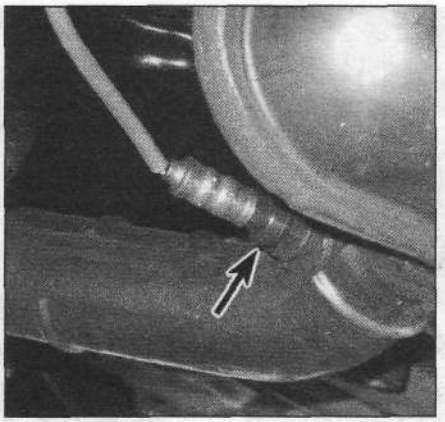
d) *Oxygen sensors are extremely delicate. Do not drop a sensor or throw it around or handle it roughly.*

e) *Make sure that the silicone boot on the sensor is installed in the correct position. Otherwise, the boot might melt and it might prevent the sensor from operating correctly.*

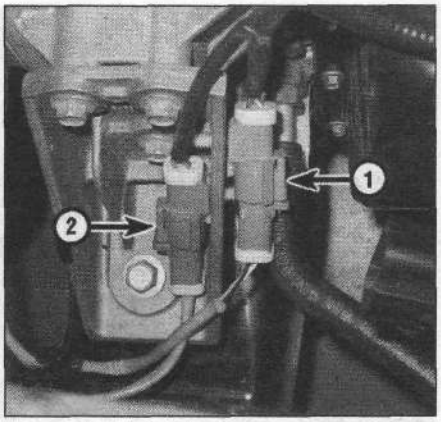


11.9 On four-cylinder models, the electrical connectors for the oxygen sensors are located at the right front corner of the valve cover

1 *Electrical connector for upstream oxygen sensor*
2 *Electrical connector for downstream oxygen sensor*



11.17 The downstream oxygen sensor on four-cylinder models is located right below the catalytic converter



11.22 The electrical connectors for the upstream oxygen sensor (1) and the downstream sensor (2) for the front cylinder bank are located at the front engine mount (water pump removed for clarity, but you can disconnect either connector without removing the pump) (V6 models)

Replacement

Note: *Because it is installed in the exhaust manifold or pipe, both of which contract when cool, an oxygen sensor might be very difficult to loosen when the engine is cold. Rather than risk damage to the sensor or its mounting threads, start and run the engine for a minute or two, then shut it off. Be careful not to burn yourself during the following procedure.*

Four-cylinder models

Upstream oxygen sensor

Refer to illustration 11.9

7 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

8 Remove the exhaust manifold heat shield (see Chapter 2A).

9 Disconnect the upstream oxygen sensor electrical connector **(see illustration)**, which is located near the right front corner of the valve cover. There are two oxygen sensor connectors at this location: one is for the upstream oxygen sensor and the other connector is for the downstream sensor. Trace the electrical harness from the upstream oxygen sensor back to its connector to ensure that you're unplugging the correct connector.

10 Using an oxygen sensor socket (available at most automotive retailers), unscrew the upstream oxygen sensor. If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in for awhile.

11 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

12 Installation is otherwise the reverse of removal. Be sure to tighten the sensor to the torque listed in this Chapter's Specifications.

13 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

Downstream oxygen sensor

Refer to illustration 11.17

14 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

15 Disconnect the oxygen sensor electrical connector **(see illustration 11.9)**, which is located near the right front corner of the valve cover. There are two identical oxygen sensor connectors at this location: one is for the upstream oxygen sensor and the other connector is for the downstream sensor. Trace the electrical harness from the upstream oxygen sensor back to its connector (with the vehicle still on the ground, it's easier to trace the harness from the upstream sensor) and then disconnect the *other* connector, which is the connector for the *downstream* sensor.

16 Raise the front of the vehicle and place it securely on jackstands.

17 Unscrew the downstream oxygen sensor **(see illustration)**, which is located right below the catalytic converter. If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in for awhile.

18 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

19 Installation is otherwise the reverse of removal. Be sure to tighten the sensor to the torque listed in this Chapter's Specifications.

20 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

V6 models

Upstream oxygen sensor (front cylinder bank)

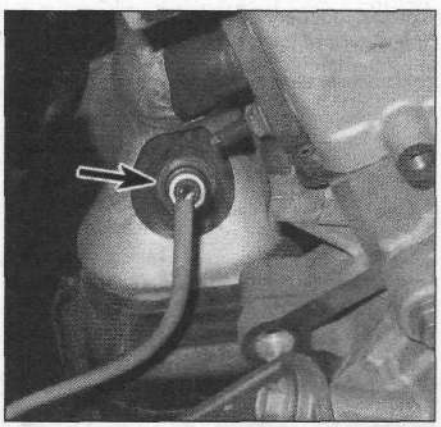
Refer to illustrations 11.22 and 11.23

21 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

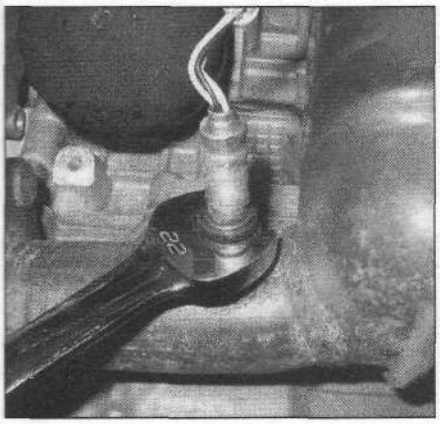
22 Disconnect the upstream oxygen sensor electrical connector **(see illustration)**.

23 Locate the upstream oxygen sensor for the front cylinder bank **(see illustration)**. Using an oxygen sensor socket (available at most automotive retailers), unscrew the upstream oxygen sensor. If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in for awhile.

24 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not



11.23 The upstream oxygen sensor for the front cylinder bank is located on the left side of the exhaust manifold, right above the catalytic converter; use an oxygen sensor socket to remove it (V6 models)



11.30 The downstream oxygen sensor for the front cylinder bank is located between the catalytic converter and the exhaust pipe flange; it's not necessary to use an oxygen sensor socket on to remove this sensor because there's enough room to put a wrench on it (V6 models)

necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

25 Installation is otherwise the reverse of removal. Be sure to tighten the sensor to the torque listed in this Chapter's Specifications.

26 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

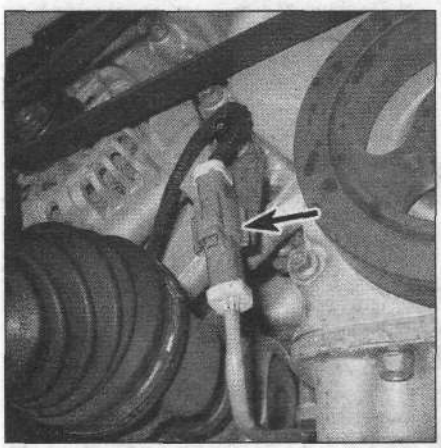
Downstream oxygen sensor (front cylinder bank)

Refer to illustration 11.30

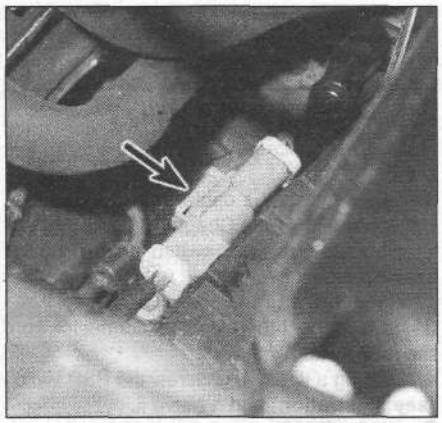
27 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

28 Disconnect the downstream oxygen sensor electrical connector **(see illustration 11.22)**.

29 Raise the front of the vehicle and place it securely on jackstands.



11.45 The electrical connector for the downstream oxygen sensor for the rear cylinder bank is located near the crankshaft pulley



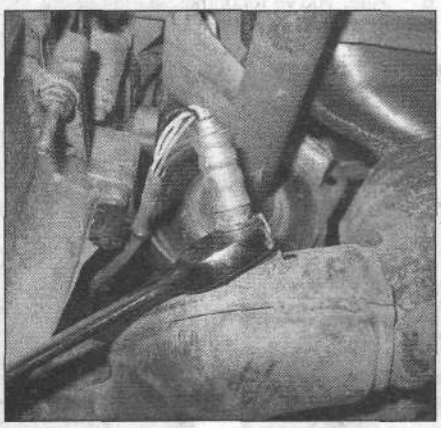
11.35 The electrical connector for the upstream oxygen sensor for the rear cylinder bank is located behind the rear cylinder head, near the heater hoses; if you find it difficult to unplug the connector, detach it from the plastic wiring harness protector, then unplug it (V6 models)

30 Locate the downstream oxygen sensor for the front cylinder bank **(see illustration)**, then unscrew the downstream oxygen sensor. If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in for awhile.

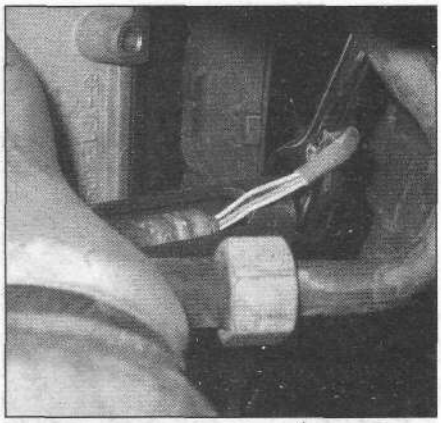
31 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

32 Installation is otherwise the reverse of removal. Be sure to tighten the sensor to the torque listed in this Chapter's Specifications.

33 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



11.46 You should be able to remove the downstream oxygen sensor for the rear cylinder bank with a regular wrench (alternator removed for clarity) (V6 models)



11.38 Use an oxygen sensor socket to unscrew the upstream oxygen sensor for the rear cylinder bank (V6 models)

Upstream oxygen sensor (rear cylinder bank)

Refer to illustrations 11.35 and 11.38

34 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

35 Disconnect the upstream oxygen sensor electrical connector **(see illustration)**, which is located behind the rear cylinder head, near the heater hoses.

36 Raise the front of the vehicle and place it securely on jackstands.

37 Locate the upstream oxygen sensor on the rear cylinder head exhaust manifold, right above the EGR pipe.

38 Using an oxygen sensor socket, unscrew the oxygen sensor **(see illustration)**. If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in awhile.

39 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

40 Installation is otherwise the reverse of removal. Be sure to tighten the sensor to the torque listed in this Chapter's Specifications.

41 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

Downstream oxygen sensor (rear cylinder bank)

Refer to illustrations 11.45 and 11.46

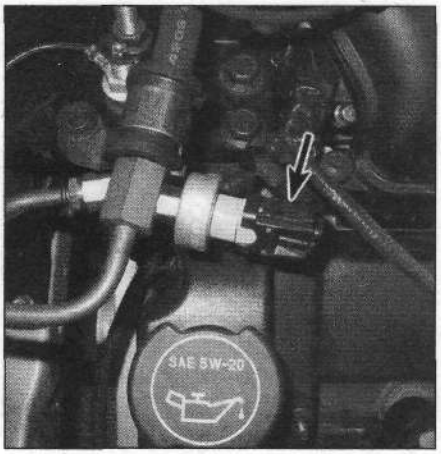
42 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

43 Loosen the right front wheel lug nuts. Raise the vehicle and place it securely on jackstands. Remove the right front wheel.

44 Remove the right lower engine splash shield **(see illustration 10.13 in Chapter 5)**.

45 Disconnect the downstream oxygen sensor electrical connector **(see illustration)**.

46 Using a wrench, unscrew and remove the downstream oxygen sensor **(see illustration)**.



12.2 The PSP switch is located on the power steering pressure line, near the oil filler cap (V6 models)

If the sensor is difficult to loosen, spray some penetrant onto the sensor threads and allow it to soak in for awhile. **Note:** *In the accompanying photo, the alternator has been removed for clarity. You shouldn't have to actually remove the alternator to remove the downstream sensor, but it is a very tight fit, so if the sensor proves difficult to remove, you might have to remove the alternator* (see Chapter 5) *to give yourself more room to work.*

47 If you're going to install the old sensor, apply anti-seize compound to the threads of the sensor to facilitate future removal. If you're going to install a new oxygen sensor, it's not necessary to apply anti-seize compound to the threads. The threads on new sensors already have anti-seize compound on them.

48 Installation is otherwise the reverse of removal. Be sure to tighten the downstream oxygen sensor to the torque listed in this Chapter's Specifications.

49 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

12 Power Steering Pressure (PSP) switch - replacement

Refer to illustrations 12.2 and 12.4

Note: *This procedure applies to V6 models only.*

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

2 Locate the PSP switch on the power steering pressure line, right behind the oil filler cap **(see illustration)**.

3 Disconnect the electrical connector from the PSP switch.

4 Using a wrench, unscrew the PSP switch **(see illustration)** and remove it.

5 Installation is the reverse of removal.

6 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

13 Throttle Position (TP) sensor - replacement

Refer to illustrations 13.2 and 13.3

Note: *This procedure applies to all V6 models and to 2003 four-cylinder models (the TP sensor is not removable on 2001 and 2002 2.0L models; it's part of the throttle body).*

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).

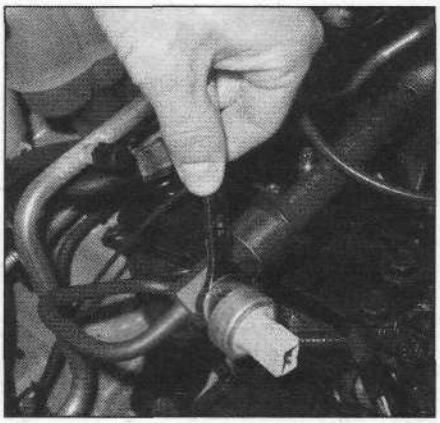
2 On V6 models, remove the engine cover **(see illustration)**.

3 Disconnect the TP sensor electrical connector **(see illustration)**.

4 Remove the TP sensor mounting screws **(see illustration 13.3)** and remove the TP sensor.

5 When installing the TP sensor screws on a 2003 four-cylinder model, be sure to hand start the screws. They're self-threading, so failure to hand-start them could damage the throttle body. Installation is otherwise the reverse of removal.

6 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



12.4 Unscrew the PSP switch with a wrench

14 Transmission Range (TR) sensor - replacement

Refer to illustration 14.6

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

Note 1: *This procedure applies to V6 models only.*

Note 2: *A special tool (Ford tool no. 307-351, or equivalent) is required for this procedure - without it, chances are you won't be able to adjust the sensor properly, and a trouble code will then be set (along with driveability problems). If you don't have access to the special tool, have this procedure performed at a dealer service department or other qualified repair shop.*

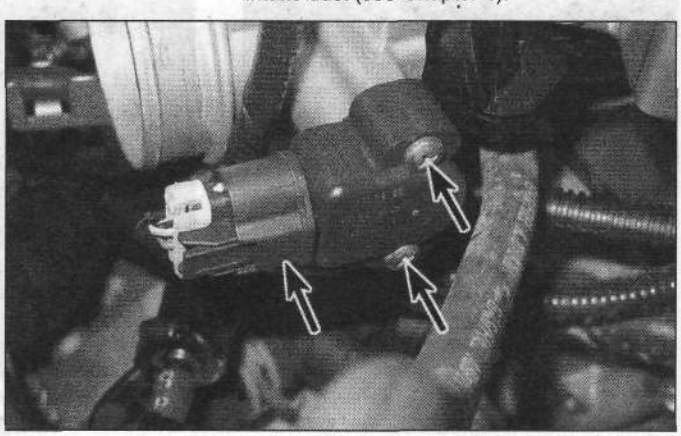
Removal

1 Set the parking brake, then place the shift lever in Neutral.

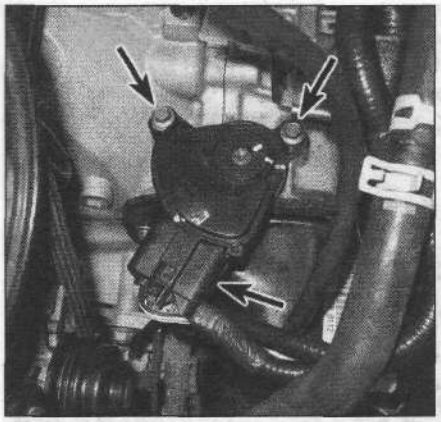
2 Remove the battery and the battery tray (see Chapter 5).

3 Remove the air filter housing and air intake duct (see Chapter 4).

13.2 To detach the engine cover from a V6 engine, remove these fasteners



13.3 To remove the TP sensor, disconnect the electrical connector and remove the TP sensor mounting screws (V6 model shown, 2003 four-cylinder TP sensor similar)



14.6 Disconnect the electrical connector from the TR sensor, then remove the mounting bolts

4 Drain the engine coolant (see Chapter 1).
5 Remove the thermostat housing (see Chapter 3).
6 *Disconnect the electrical connector from* the TR sensor **(see illustration)**.
7 Unscrew the bolts and remove the sensor.

Installation

8 Fit the special tool onto the sensor, engaging the two prongs on the tool with the two notches in the rotating ring of the sensor. The large tang on the other end of the tool fits into the notch in the sensor housing.
9 Place the sensor onto the transaxle, making sure the projections on the rotating ring of the sensor align with the slots in the shaft.
10 Install the sensor mounting bolts and tighten them to the torque listed in this Chapter's Specifications. Remove the special tool, then reconnect the electrical connector.
11 The remainder of installation is the reverse of the removal procedure.
12 Refill the cooling system (see Chapter 1).
13 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

15 Turbine Shaft Speed (TSS) sensor - replacement

Refer to illustrations 15.4 and 15.7

Note: *This procedure applies to models with an automatic transaxle.*

1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
2 Loosen the left front wheel lug nuts. Raise the vehicle and place it securely on jackstands. Remove the left front wheel.
3 Remove the lower left splash shield **(see illustration 10.3)**.
4 Locate the TSS sensor on the left side of the transaxle **(see illustration)**.
5 *Disconnect the TSS sensor electrical* connector.
6 Put a drain pan under the TSS sensor to catch any spilled automatic transmission fluid. Then remove the TSS sensor mounting bolt and remove the sensor.
7 Remove the old TSS sensor O-ring **(see illustration)** and discard it. Be sure to use a new O-ring when installing the TSS sensor (whether you're reusing the old sensor or installing a new one).
8 Installation is the reverse of removal. Be sure to tighten the TSS sensor mounting bolt to the torque listed in this Chapter's Specifications. Tighten the wheel lug nuts to the torque listed in the Chapter 1 Specifications.
9 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

16 Vehicle Speed Sensor (VSS) - replacement

Note: *This procedure applies to models with a manual transaxle.*

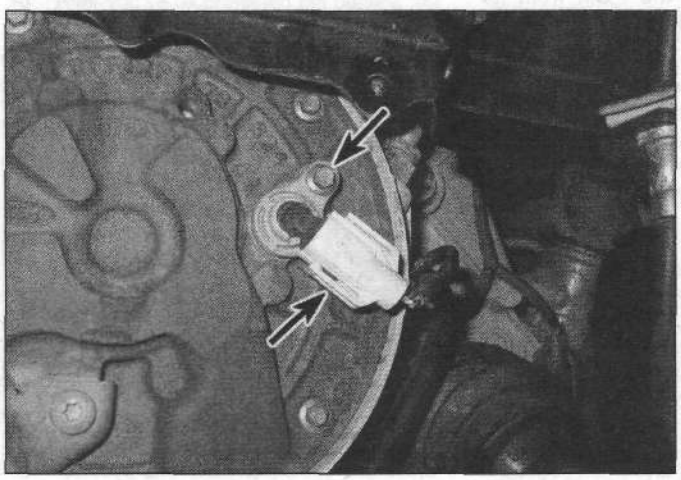
1 Disconnect the cable from the negative battery terminal (see Chapter 5, Section 1).
2 On 2002 4WD models, raise the vehicle and place it securely on jackstands. (The VSS is accessed from underneath the vehicle on these models.)
3 Locate the VSS on top of the rear part of the transaxle, near the inner CV joints.
4 Disconnect the VSS electrical connector.
5 Remove the VSS hold-down bolt.
6 Remove the VSS.
7 Installation is the reverse of removal. Be sure to tighten the VSS hold-down bolt to the torque listed in this Chapter's Specifications.
8 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

17 Powertrain Control Module (PCM) - replacement

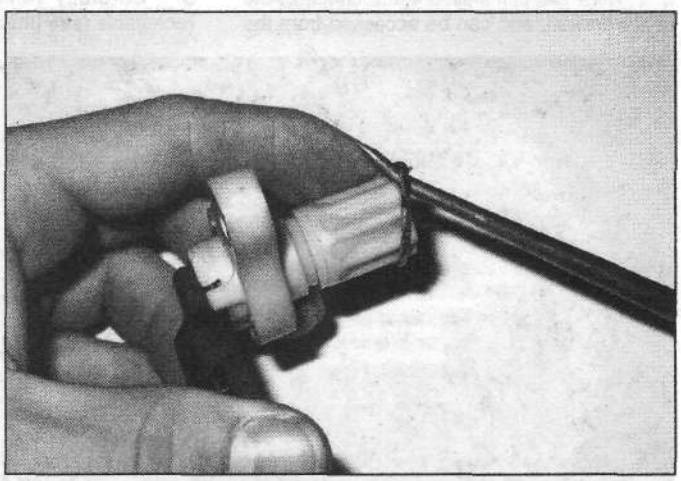
Refer to illustration 17.3a, 17.3b, 17.4a, 17.4b and 17.5

Caution: *To avoid electrostatic discharge damage to the PCM, handle the PCM only by its case. Do not touch the electrical terminals during removal and installation. If available, ground yourself to the vehicle with an anti-static ground strap, available at computer supply stores.*

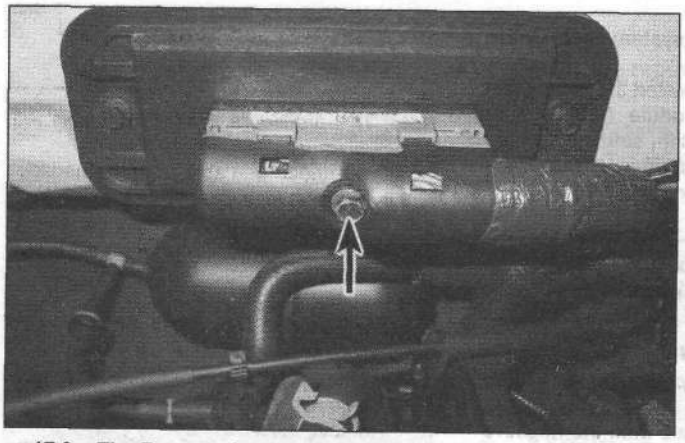
Note: *The PCM is a highly reliable component and rarely requires replacement. Because the PCM is the most expensive part of the engine management system, you should be absolutely positive that it has failed before replacing it. If in doubt, have the system tested by*



15.4 The TSS sensor is located on the left side of the automatic transaxle; to remove the TSS sensor, disconnect the electrical connector and remove the sensor mounting bolt (models with an automatic transaxle)

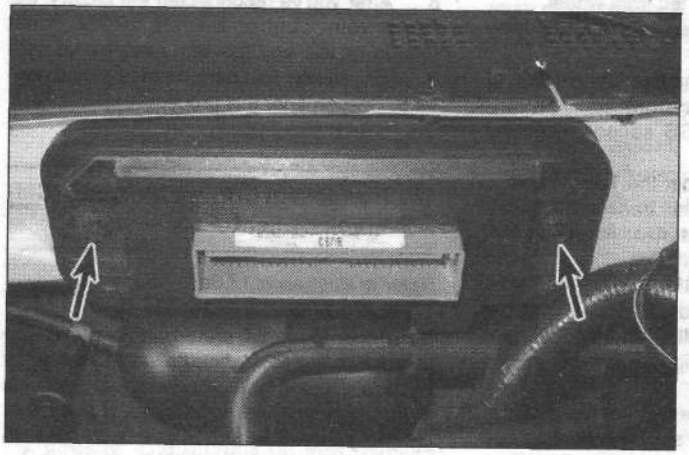


15.7 Be sure to remove and discard the old TSS sensor O-ring; always use a new O-ring when installing the TSS sensor whether you're reusing the old sensor or installing a new one (models with an automatic transaxle)

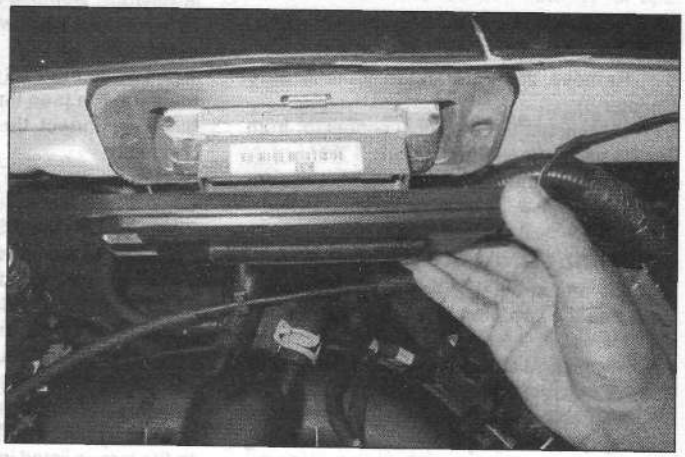


17.3a The Powertrain Control Module (PCM) is located in the firewall, on the engine compartment side; to disconnect the electrical connector, remove this bolt . . .

17.3b . . . then pull the connector straight out



17.4a To remove the PCM cover, remove these two nuts . . .



17.4b . . . and remove the cover

an experienced driveability technician at a dealer service department or other qualified repair shop.

1 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

2 The PCM is installed in the center of the upper firewall, and can be accessed from the engine compartment side.

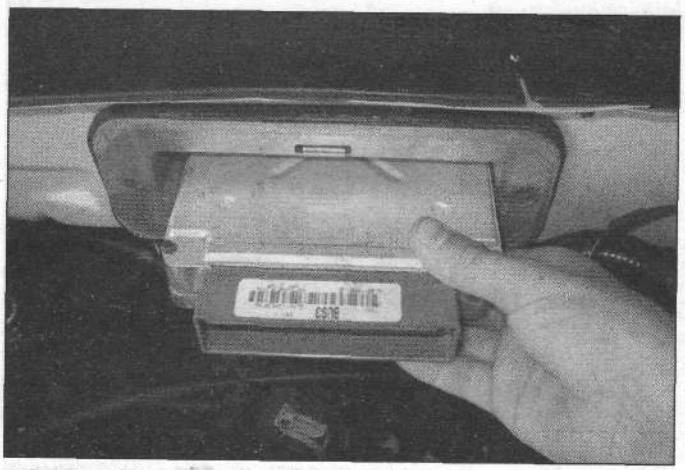
3 Disconnect the electrical connector retaining bolt, then disconnect the electrical connector from the PCM **(see illustrations)**.

4 Remove the PCM cover nuts and remove the cover **(see illustrations)**.

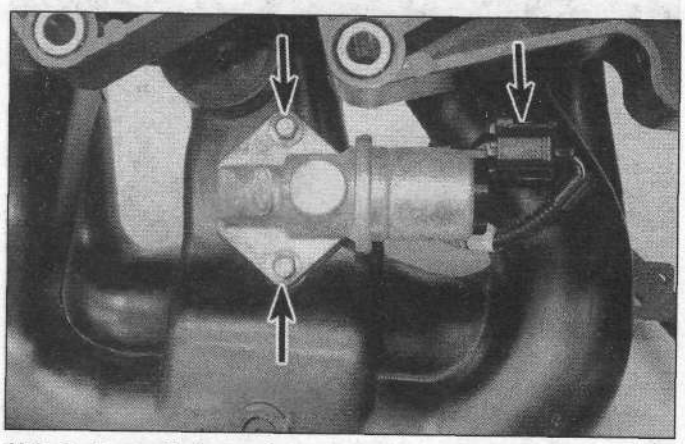
5 Carefully remove the PCM from its receptacle **(see illustration)**.

6 Installation is the reverse of removal.

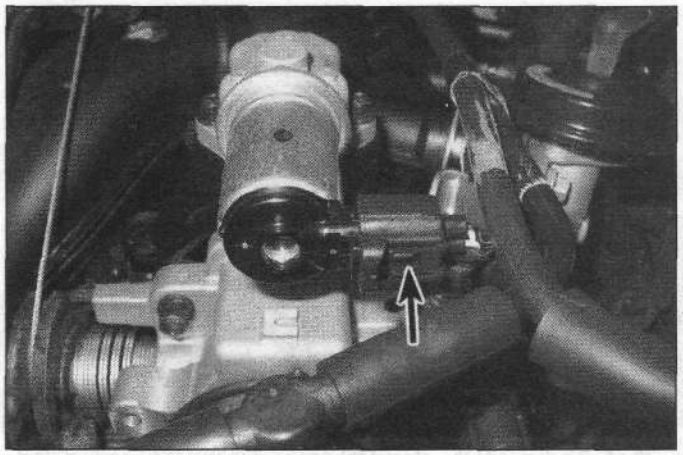
7 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



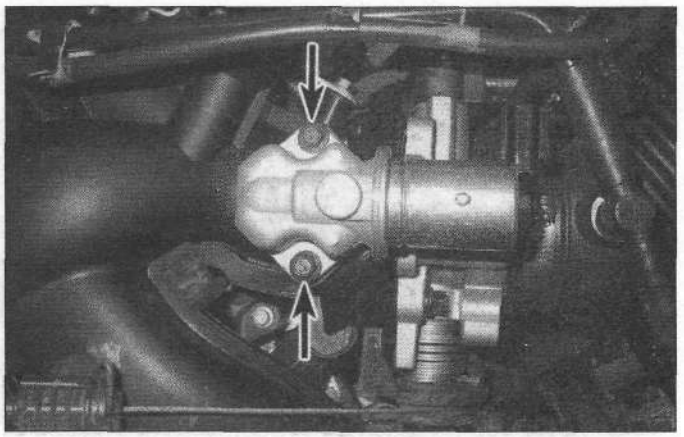
17.5 Carefully remove the PCM from its receptacle in the firewall



18.3 On four-cylinder models, the IAC valve is located underneath the intake manifold (manifold removed for clarity); to detach the IAC valve from the manifold, disconnect the electrical connector and remove the two mounting bolts



18.13 Disconnect the IAC valve electrical connector (V6 models)



18.14 To detach the IAC valve from the intake manifold, remove these two bolts

18 Idle Air Control (IAC) valve - replacement

Four-cylinder models

Refer to illustration 18.3

1 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

2 Raise the front of the vehicle and place it securely on jackstands.

3 Locate the IAC valve on the underside of the intake manifold **(see illustration)**.

4 Disconnect the electrical connector from the IAC valve.

5 Remove the IAC mounting bolts.

6 Remove the IAC valve and discard the old gasket.

7 Using a new gasket, install the IAC valve and tighten the bolts to the torque listed in this Chapter's Specifications.

8 Reconnect the IAC valve electrical connector.

9 Lower the vehicle and reconnect the cable to the negative battery terminal.

10 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

V6 models

Refer to illustrations 18.13, 18.14 and 18.16

11 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

12 The IAC valve is located on top of the intake manifold, near the throttle body.

13 Disconnect the electrical connector **(see illustration)** from the IAC valve.

14 Remove the IAC valve mounting bolts **(see illustration)**.

15 Remove the IAC valve.

16 Remove and discard the old IAC valve gasket **(see illustration)**

17 Install a new IAC valve gasket. Make sure that the gasket is fully seated in its groove before installing the IAC valve.

18 Install the IAC valve. Be sure to tighten the IAC valve mounting bolts to the torque listed in this Chapter's Specifications.

19 The remainder of installation is the reverse of removal. Reconnect the cable to the negative battery terminal.

20 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

19 Catalytic converters

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

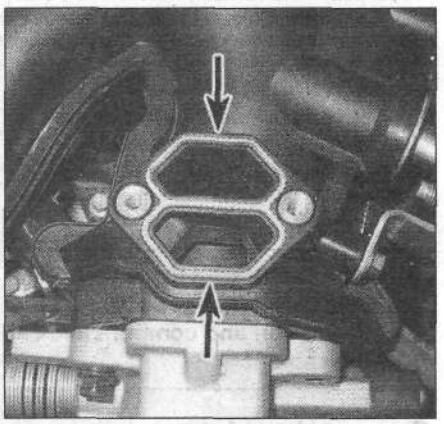
General description

1 A catalytic converter (or catalyst) is an emission control device in the exhaust system that reduces certain pollutants in the exhaust gas stream. There are two types of converters. An oxidation catalyst reduces hydrocarbons (HC) and carbon monoxide (CO). A reduction catalyst reduces oxides of nitrogen (NOx). Catalysts that can reduce *all three pollutants* are known as "three-way catalysts." The models covered by this manual are equipped with three-way catalysts.

Check

2 The test equipment for a catalytic converter (a "loaded-mode" dynamometer and a 5-gas analyzer) is expensive. If you suspect that the converter on your vehicle is malfunctioning, take it to a dealer or authorized emission inspection facility for diagnosis and repair.

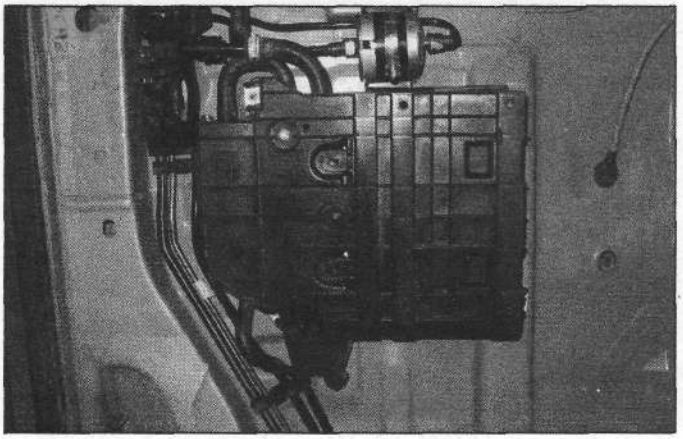
3 Whenever you raise the vehicle to service underbody components, inspect the converter for leaks, corrosion, dents and other damage. Carefully inspect the welds and/or flange bolts and nuts that attach the front and rear ends of the converter to the exhaust system. If you note any damage, replace the converter.



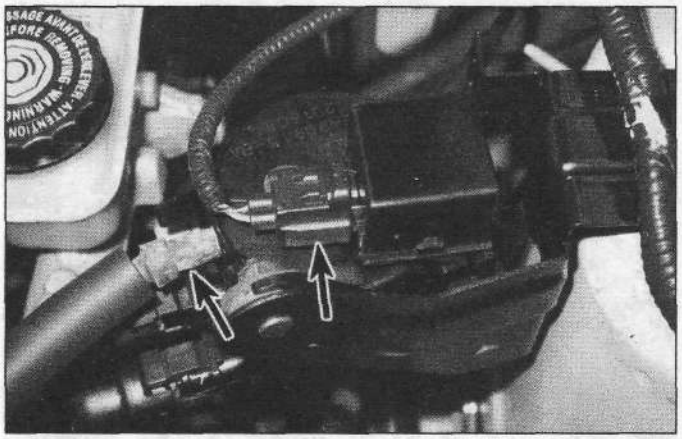
18.16 Be sure to remove the old IAC valve gasket and install a new one before reinstalling the IAC valve

4 Although catalytic converters don't break too often, they can become clogged or even plugged up. 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* (see Chapter 2).
b) *Warm the engine to operating temperature, place the transaxle in Park (automatic models) or Neutral (manual models) and apply the parking brake.*
c) *Note the vacuum reading at idle and jot it down.*
d) *Quickly open the throttle to near its wide-open position and then quickly get off the throttle and allow it to close. Note the vacuum reading and jot it down.*
e) *Do this test three more times, recording your measurement after each test.*
f) *If your fourth reading is more than one in-Hg lower than the reading that you noted at idle, the exhaust system might be restricted (the catalytic converter could be plugged, OR an exhaust pipe or muffler could be restricted).*



20.2 The EVAP canister, check valve, dust separator and canister vent solenoid, and the hoses connecting them, are located underneath the vehicle, near the left side; to replace any of these components, you must first remove the entire assembly



20.15 Disconnect the electrical connector and the vacuum line from the EVAP canister purge valve; be sure to cap the vacuum line to prevent dirt and moisture from entering the line while it's disconnected (V6 model shown, four-cylinder models similar)

Replacement

5 See "Exhaust system servicing - general information" in Chapter 4 for the catalytic converter replacement procedures for both four-cylinder and V6 models.

20 Evaporative emissions control (EVAP) system - general information and component replacement

General description

Refer to illustration 20.2

1 The **Evaporative Emissions Control (EVAP) system** prevents fuel system vapors (which contain unburned hydrocarbons) from escaping into the atmosphere. On warm days, vapors trapped inside the fuel tank expand until the pressure reaches a certain threshold, at which point the fuel vapors are routed from the fuel tank through the fuel vapor vent valve and the fuel vapor control valve to the EVAP canister, where they're stored temporarily, until they can be consumed by the engine during normal operation. When the conditions are right (engine warmed up, vehicle up to speed, moderate or heavy load on the engine, etc.) the Powertrain Control Module (PCM) opens the canister purge valve, which allows the fuel vapors to be drawn from the canister into the intake manifold, where they mix with the air/fuel mixture before being consumed in the combustion chambers. This system is complex and virtually impossible to troubleshoot without the right tools and training. However, the following description should give you a good idea of how it works:

2 The **EVAP canister (see illustration)** is located under the vehicle, near the left side of the vehicle. The EVAP canister, which contains activated carbon, is the repository for storing the fuel vapors. You'll have to raise the vehicle to inspect or replace the canister or any other part of the EVAP system except for the canister purge valve (which is located in the engine compartment) but the canister is designed to be maintenance-free and should last the life of the vehicle. There are several other important components located near the EVAP canister: the check valve, the dust separator and the canister vent solenoid.

3 The **fuel tank pressure sensor**, which is located near the in-tank fuel pump/fuel level sending unit module on top of the fuel tank, monitors the pressure inside the tank, and transmits its measurement to the PCM during an OBD-II leak test.

4 The **fuel vapor vent (FVV) valve**, which is mounted on top of the fuel tank, controls the flow of fuel vapors entering the EVAP system. On vehicles with composite fuel tanks, the FVV valve cannot be removed or repaired.

5 The **fuel vapor control valve** (V6 models only) prevents liquid fuel from entering the EVAP canister or the canister purge valve during refueling. It also prevents liquid fuel from flooding the fuel vapor hoses if the fuel tank is overfilled.

6 The **canister vent solenoid**, which is mounted on the EVAP canister, is normally open. But it seals off the EVAP system for inspection and maintenance (I/M 240) testing and for OBD-II leak and pressure tests.

7 The **evaporative emission (EVAP) check valve**, which is mounted on the EVAP canister mounting bracket, is normally closed. But it opens during refueling, which allows the air inside the fuel tank to vent to the atmosphere through a more direct and lower-resistance path as it's displaced by the rising fuel level in the tank.

8 The **evaporative emission (EVAP) canister purge valve**, which is under the control of the Powertrain Control Module (PCM), regulates the flow of vapors being purged from the EVAP canister into the intake manifold. The canister purge valve is normally closed. It opens only when directed to do so by the PCM, which uses the availability of intake manifold vacuum and data from various information sensor inputs to determine when and how long to open the valve. The interval of time during which the purge valve is opened by the PCM is known as its "duty cycle." The purge valve is located in the engine compartment, on a bracket near the brake master cylinder.

9 The **evaporative emission (EVAP) dust separator**, which is attached to the EVAP canister mounting bracket, prevents dust and dirt particles suspended in the atmosphere from entering the EVAP system.

General system checks

10 The most common symptom of a faulty EVAP system is a strong fuel odor (particularly during hot weather). If you smell fuel while driving or (more likely) right after you park the vehicle and turn off the engine, check the fuel filler cap first. Make sure that it's screwed onto the fuel filler neck all the way. If the odor persists, inspect all EVAP hose connections, both in the engine compartment and under the vehicle. You'll have to raise the vehicle and place it securely on jackstands to inspect most of the EVAP system, since it's located under the vehicle. Be sure to inspect each hose attached to the canister for damage and leakage along its entire length. Repair or replace as necessary. Inspect the canister for damage and look for fuel leaking from the bottom. If fuel is leaking or the canister is otherwise damaged, replace it.

11 Poor idle, stalling, and poor driveability can be caused by a defective fuel vapor vent valve or canister purge valve, a damaged canister, cracked hoses, or hoses connected to the wrong tubes. Fuel loss or fuel odor can be caused by fuel leaking from fuel lines or hoses, a cracked or damaged canister, or a defective vapor valve.

12 To check for excessive fuel vapor pressure in the fuel tank, remove the gas cap and listen for the sound of pressure release. If the fuel tank emits a "whooshing" sound when you open the filler cap, fuel tank vapor pressure is excessive. Inspect the canister vapor

hoses and the canister inlet port for blockage or collapsed hoses. Also inspect the vapor vent valve. A complete test can only be done with a proprietary OBD-II scan tool (see Section 2), which will run a series of checks using the fuel tank pressure sensor and other output actuators to detect excessive pressure. You'll have to take the vehicle to a dealer service department to have the EVAP system professionally diagnosed.

Component replacement

EVAP canister purge valve

Refer to illustrations 20.15, 20.17a, 20.17b and 20.18

Note: *The EVAP canister purge valve depicted in the accompanying photos shows the purge valve on a V6 model, but the purge valve on four-cylinder models is identical in location and design to the unit you see here.*

13 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

14 The EVAP canister purge valve is located in the engine compartment, on a bracket near the master cylinder.

15 Disconnect the purge valve electrical connector **(see illustration)**.

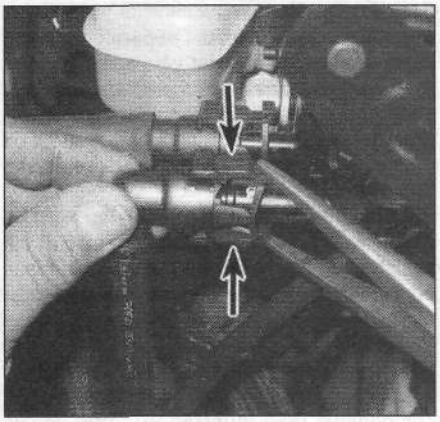
16 Disconnect the vacuum line from the purge valve **(see illustration 20.15)**. Cap the vacuum line to prevent dirt or moisture from entering it while it's disconnected.

17 Disconnect the EVAP canister return line and outlet line **(see illustrations)**. Cap the tubes to prevent dirt, dust and moisture from entering the EVAP system while the lines are open. (It's not really necessary to mark the two lines because the lines and the fittings are different diameters.)

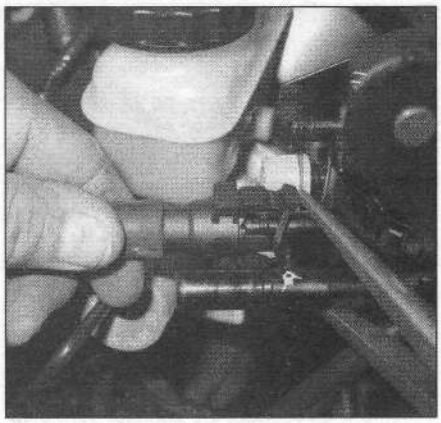
18 Remove the two purge valve mounting nuts **(see illustration)** and remove the purge valve from its mounting bracket (it's not necessary to remove the bracket).

19 Installation is the reverse of removal.

20 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



20.17a To disconnect the EVAP canister return line, squeeze the two tabs on the fitting together and pull off the line (V6 model shown, four-cylinder models similar)



20.17b Disconnect the EVAP canister outlet line the same way (V6 model shown, four-cylinder models similar)

Fuel tank pressure sensor

Refer to illustrations 20.24, 20.25a and 20.25b

21 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

22 Remove the rear seat cushion (see Chapter 11).

23 Pull back the carpeting and remove the fuel pump/fuel level sending unit module access cover **(see illustrations 5.4a and 5.4b in Chapter 4)**.

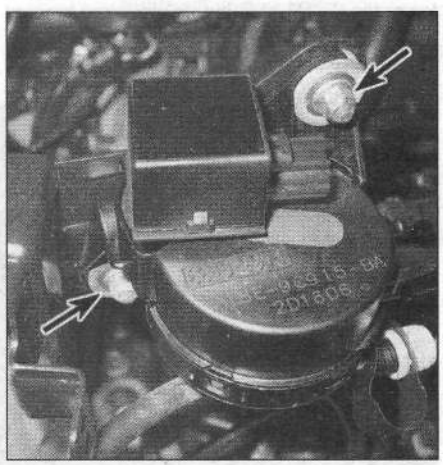
24 Disconnect the electrical connector from the fuel tank pressure sensor **(see illustration)**.

25 Pull the fuel tank pressure sensor out from under the floorpan and cut the two crimped hose clamps **(see illustrations)**.

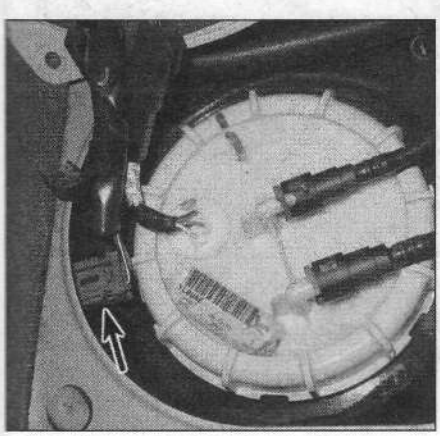
26 Note which way the fuel tank pressure sensor is oriented before disconnecting the inlet and outlet hoses.

27 Installation is the reverse of removal. Be sure to secure the hoses to the sensor with new hose clamps (it's not necessary to use crimp-style clamps).

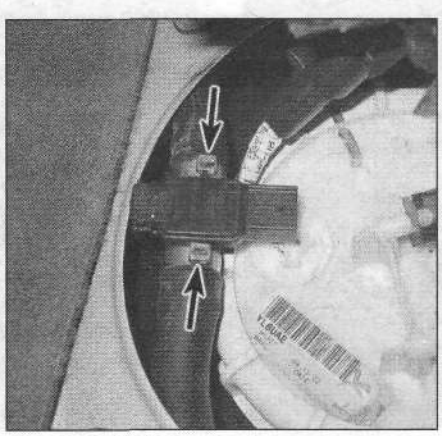
28 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



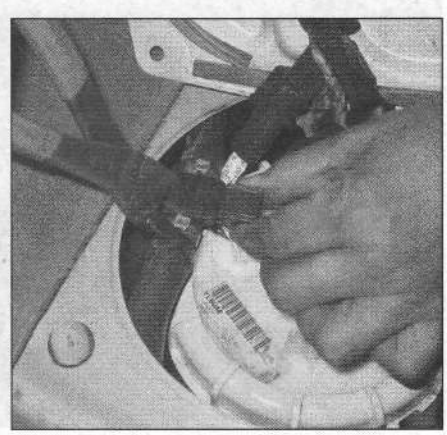
20.18 To detach the EVAP canister purge valve from its mounting bracket, remove these two nuts (V6 model shown, four-cylinder models similar)



20.24 Disconnect the electrical connector from the fuel tank pressure sensor



20.25a Pull the fuel tank pressure sensor out from under the floorpan and cut the two crimped hose clamps . . .



20.25b . . . with a pair of diagonal cutters

EVAP canister, check valve, dust separator and canister vent solenoid

Refer to illustrations 20.31, 20.32, 20.33a, 20.33b, 20.33c, 20.34a, 20.34b, 20.34c, 20.35a, 20.35b, 20.36a and 20.36b

29 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

30 Raise the vehicle and place it securely on jackstands.

31 On the back side of the EVAP canister assembly, disconnect the EVAP canister outlet hose **(see illustration)**.

32 On the front side of the EVAP canister assembly, disconnect the canister vent solenoid electrical connector and the canister vent hose **(see illustration)**.

33 Remove the EVAP canister mounting bracket nuts and bolts **(see illustrations)** and lower the EVAP canister, its mounting bracket and the rest of the EVAP components as a single assembly **(see illustration)**.

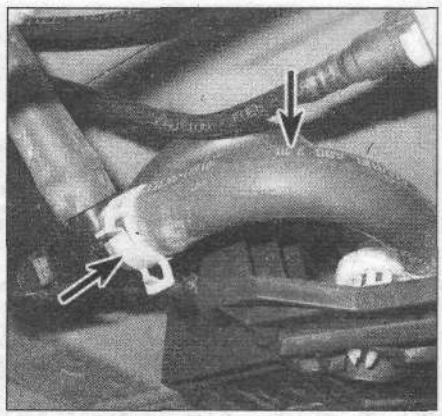
34 Remove the remote canister vent hoses, the check valve, the dust separator and the dust separator-to-canister vent solenoid hose **(see illustrations)**. To disengage the dust separator from the EVAP canister mounting bracket, simply pull it straight up to slide it off the retaining tab on the mounting bracket **(see illustration)**.

35 To detach the EVAP canister from its mounting bracket, pry up the right side of the canister and then slide the two mounting tabs on the left side of the canister out from their slots in the mounting bracket **(see illustrations)**.

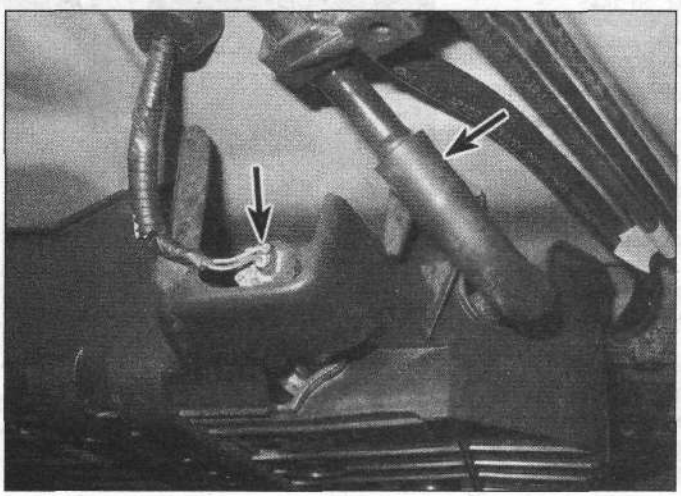
36 If you're replacing the EVAP canister or the canister vent solenoid, separate the two components **(see illustration)**. After you've separated the canister and the vent solenoid, inspect the solenoid O-ring and replace it if it's damaged or worn **(see illustration)**.

37 Installation is the reverse of removal.

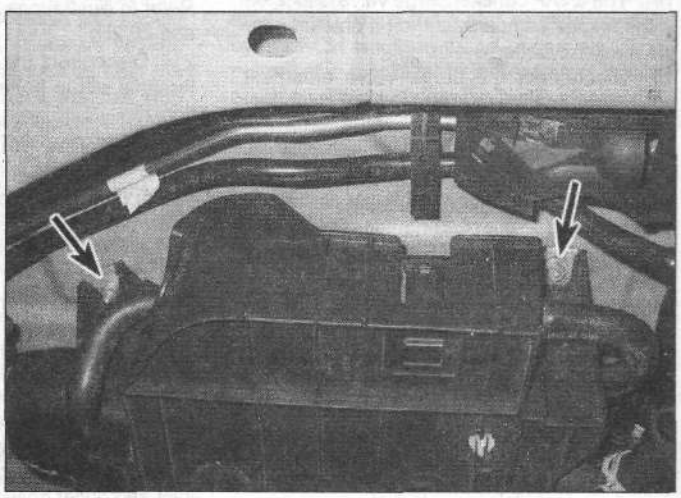
38 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).



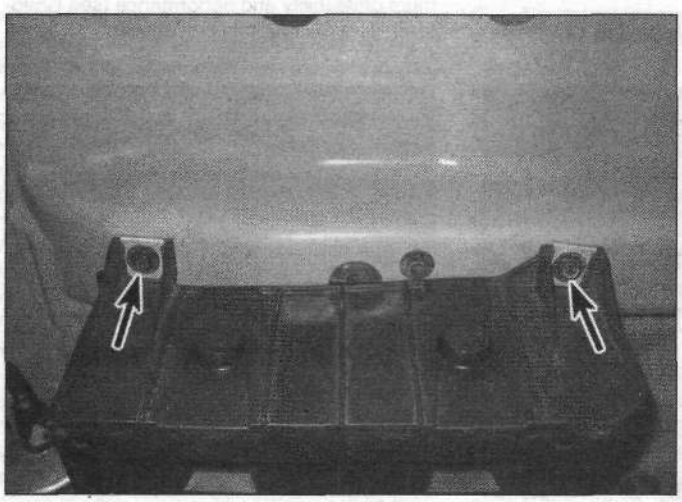
20.31 To disconnect the EVAP canister outlet hose, loosen this hose clamp, slide it back and pull off the hose



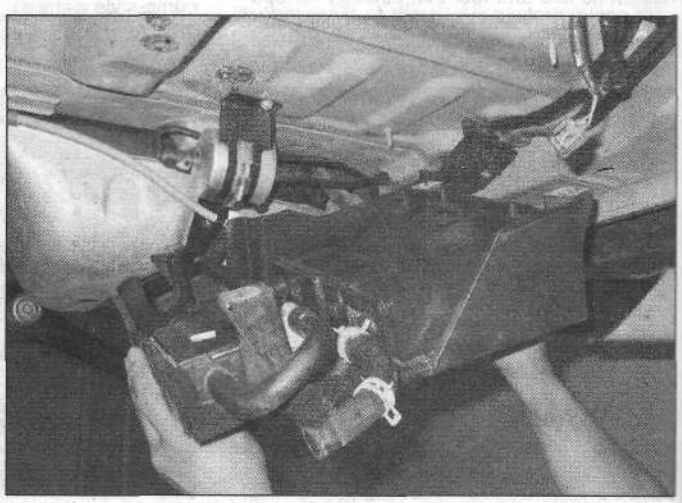
20.32 Disconnect the canister vent solenoid electrical connector and the canister vent hose



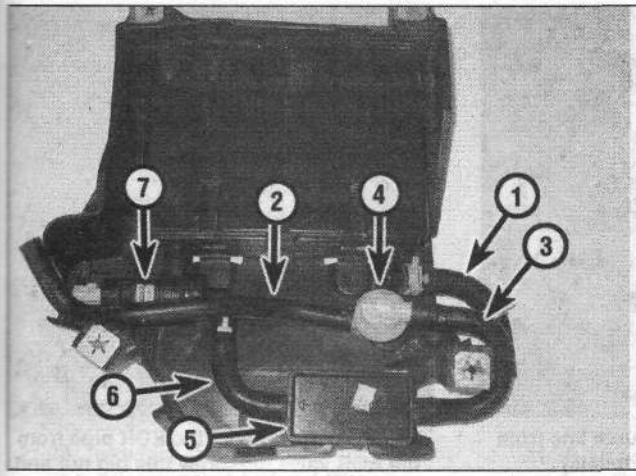
20.33a To detach the EVAP canister mounting bracket from the underside of the vehicle, remove these two nuts from the left side . . .



20.33b . . . remove these two bolts from the right side . . .

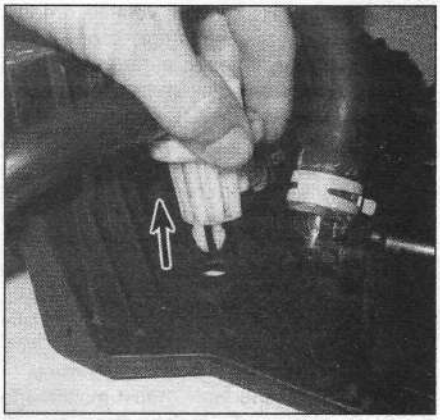


20.33c . . . and then lower the EVAP canister, the mounting bracket and the rest of the EVAP system components as a single assembly



20.34a EVAP canister and related EVAP components

1 *EVAP canister outlet hose*
2 *Remote canister vent hose*
3 *Remote canister vent hose*
4 *EVAP check valve*
5 *Dust separator*
6 *Dust separator-to-canister vent solenoid hose*
7 *Canister vent solenoid*



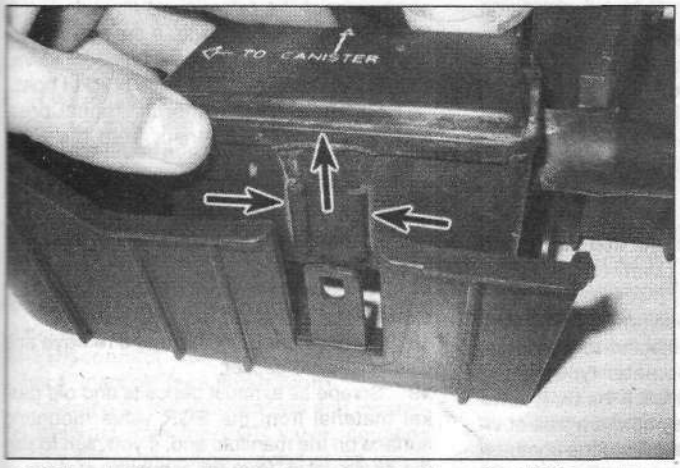
20.34b To detach the check valve from the EVAP canister mounting bracket, disengage the check valve mounting tangs from the hole in the bracket by pulling it straight up

21 Exhaust Gas Recirculation (EGR) system - general information and component replacement

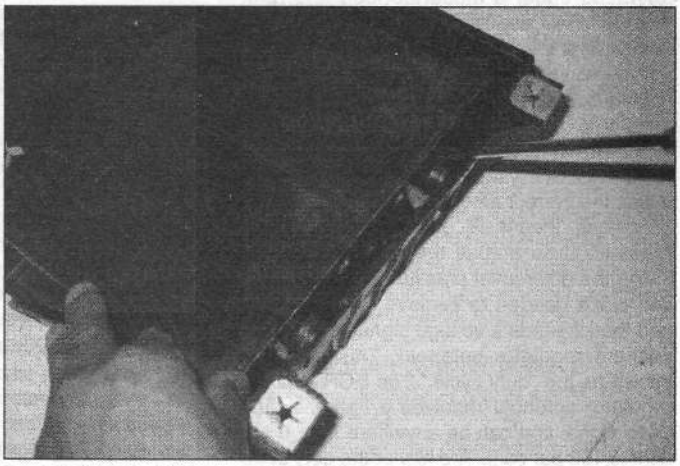
General description

1 Exhaust gas recirculation (EGR) systems on late-model vehicles have two equally important functions: they reduce oxides of nitrogen (NOx) emissions and they reduce engine detonation, or pinging. Recirculating a small amount of exhaust back to the intake system reduces combustion temperatures because exhaust is a mixture of inert gases and does not contribute to the combustion process. Because high combustion temperature is a major factor in both NOx emissions and detonation, EGR effectively reduces both.

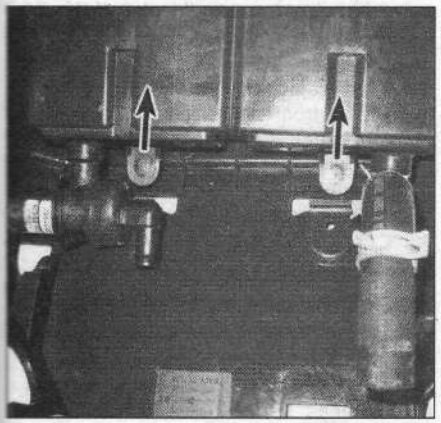
2 When the combustion chambers reach about 2500-degrees F, they begin to produce excessive quantities of oxides of nitrogen (NOx). NOx, when combined with unburned



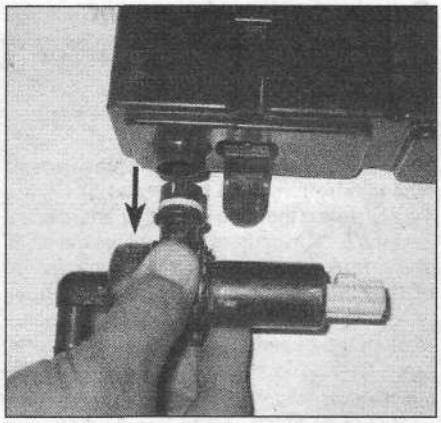
20.34c To disengage the dust separator from the EVAP canister mounting bracket, slide it straight up and off the retaining tab on the mounting bracket



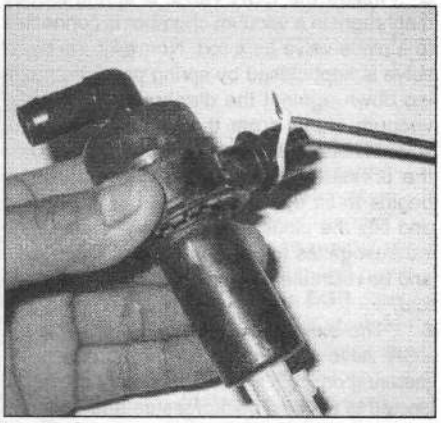
20.35a To disengage the EVAP canister from its mounting bracket, pry up the right side of the canister . . .



20.35b . . . and then slide the two mounting tabs on the left side of the canister out of their slots in the mounting bracket



20.36a To separate the vent solenoid from the EVAP canister, simply pull the solenoid straight out



20.36b Always inspect the vent solenoid O-ring for cracks, tears and deterioration; if it's damaged or worn, replace it

hydrocarbons (HC), other volatile organic compounds and sunlight, forms ozone, nitrogen dioxide and nitrogen nitrate, otherwise known as photochemical smog. The Exhaust Gas Recirculation (EGR) system reduces (NOx) by recirculating exhaust gases from the exhaust ports through the EGR valve and back into the intake manifold, from which they're recycled back through the combustion chambers, which lowers the temperature during the combustion process.

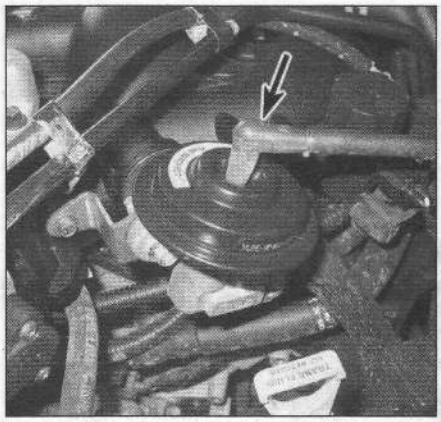
3 The EGR system on the vehicles covered by this manual is known as a "differential pressure feedback" EGR system. The differential pressure feedback system consists of the pipe connecting the exhaust manifold to the EGR valve, the EGR valve itself, the differential pressure feedback EGR system sensor and the EGR vacuum regulator valve (or solenoid), as well as the Powertrain Control Module (PCM) and several information sensors, including the Crankshaft Position (CKP) sensor, the Engine Coolant Temperature (ECT) sensor, the Intake Air Temperature (IAT) sensor, the Mass Air Flow (MAF) sensor and the Throttle Position (TP) sensor. Before the PCM will activate the EGR system, the engine must be fully warmed up, stable and operating under a moderate load and rpm. The PCM will deactivate the EGR when the engine is at idle, during extended wide-open-throttle conditions and whenever it detects a malfunction in the EGR system or in one of its monitored components or circuits.

4 Here's how the differential pressure feedback EGR system works: The PCM determines the correct amount of EGR flow for the conditions, then it calculates the appropriate pressure drop across the metering orifice, inside the differential pressure feedback sensor, that's needed to achieve that flow rate, and then it sends a voltage signal to the EGR vacuum regulator solenoid. This signal is known as the "duty cycle." The EGR vacuum regulator solenoid receives a variable duty cycle signal that can be anywhere from 0 per cent to 100 per cent. The higher the duty cycle percentage, the stronger the vacuum signal diverted by the vacuum regulator solenoid to the EGR valve.

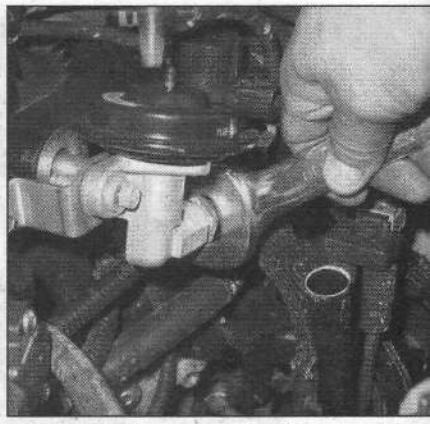
5 Inside the EGR valve, a spring-loaded diaphragm in a vacuum chamber is connected to a pintle valve by a rod. Normally, the pintle valve is kept closed by spring pressure pushing down against the diaphragm. When the vacuum signal from the vacuum regulator solenoid becomes strong enough to overcome the pressure of the spring, the diaphragm begins to lift upward, which pulls up the rod and lifts the pintle valve off its seat, allowing exhaust gases to flow through the EGR valve and be recirculated back into the intake manifold.

6 The exhaust gases flowing through the EGR valve must first pass through the EGR metering orifice. One side of the orifice is connected to exhaust backpressure and the other side leads to the intake manifold. Whenever there is EGR flow, it creates a pressure drop across the orifice. When the EGR valve closes, EGR flow through the orifice ceases, and the pressure on both sides of the orifice is equal. The PCM tries to maintain a pressure drop across the orifice that's appropriate to the operating conditions. The differential pressure feedback sensor measures the actual pressure drop across the metering orifice and sends a voltage signal (between 0 and 5 volts) to the PCM that's proportional to the measured pressure drop. This feedback signal from the differential pressure feedback sensor is used by the PCM to make constant corrections to the EGR flow rate.

7 Typically, EGR systems are trouble-free. If the EGR valve ever fails, it will do so while it's either closed or open. If the EGR valve is closed when it fails the EGR system will no longer work, but there will be no obvious symptom, other than the fact that the engine might detonate (or "ping"), or run a little hotter, under a load on a hot day (acceleration, passing, going up a hill or pulling a trailer). And when your vehicle is subjected to a biennial "loaded-mode" (dynamometer-type) smog test, the EGR system will fail. If the EGR valve is open when it fails, the symptom will be obvious. Exhaust gases metered into the combustion chambers during idle will cause the engine to run roughly and might even cause it to run so roughly that it stalls.



21.26 Disconnect the vacuum line from the EGR valve (V6 models)



21.27 To disconnect the EGR pipe from the EGR valve, unscrew this big nut and then carefully pull out the pipe just enough to clear the valve (V6 models)

Component replacement

EGR valve and pipe

2.0L four-cylinder models

8 Raise the vehicle and place it securely on jackstands.

9 Remove the right lower splash shield **(see illustration 10.13 in Chapter 5)**.

10 Unscrew the tube nut fitting and disconnect the EGR pipe from the exhaust manifold. This fitting might be difficult to loosen because of the intense heat to which it has been repeatedly subjected. If so, spray some penetrant on the threads of the fitting and then try again later. (The penetrant manufacturer will specify *how long* you should wait for the penetrant to loosen things up.)

11 In the engine compartment, remove the air intake duct (see Chapter 4).

12 Unscrew the big nut at the upper end o the EGR pipe and disconnect the pipe fron the EGR valve. **Caution:** *The manufacture says that anytime you disconnect the EGF pipe from the EGR valve, you MUST replac the old EGR pipe. Do NOT reuse the old EGF pipe! The manufacturer also says that yo must inspect the (aluminum) threads inside the EGR valve for damage. If the threads ar damaged, you MUST replace the EGR valve.*

13 Remove the two EGR pipe bracket bolts.

14 Carefully remove the differential pres sure feedback EGR sensor from the EGF pipe.

15 Remove the EGR pipe and discard i (see **Caution** in Step 12).

16 Disconnect the vacuum line from th EGR valve.

17 Remove the two EGR valve mountin bolts.

18 Remove the EGR valve and remove an discard the old gasket.

19 Scrape all exhaust deposits and old gas ket material from the EGR valve mountin surface on the manifold and, if you plan to us the same valve, from the mounting surface o the valve. Carefully remove carbon deposit from the valve port and pintle with a smal screwdriver. **Caution:** *Do not try to wash th valve in solvent or sandblast it.* If the EGF passage contains excessive deposits, clean i out with a small scraper and a vacuum. Mak sure that all loose particles are removed t keep them from clogging the EGR valve o from being drawn into the engine.

20 Installation is the reverse of removal. Be sure to tighten the EGR valve mounting bolt to the torque listed in this Chapter's Specifica tions. And don't forget to use a new EGR pip and tighten the EGR pipe fittings securely.

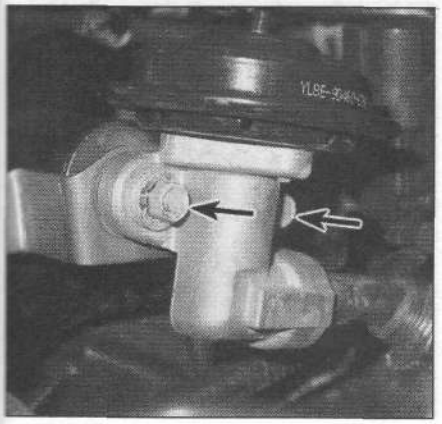
2.3L four-cylinder models

Warning: *Wait until the engine is completel cool before beginning this procedure.*

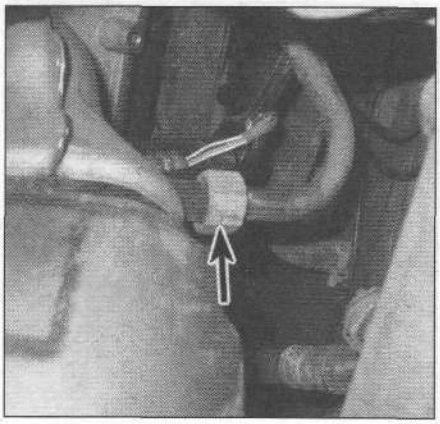
21 The EGR is located on the left side of th cylinder head. Engine coolant passes through the valve.

22 Drain the engine coolant.

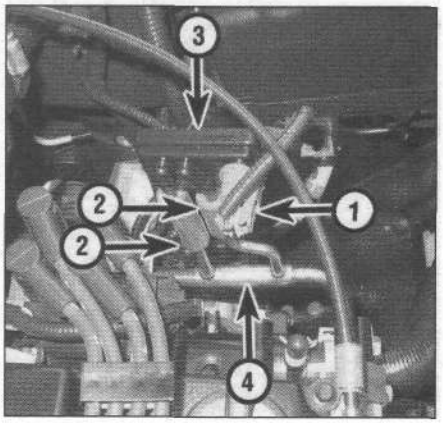
23 Remove the upper radiator hose fron



21.28 To detach the EGR valve from its mounting bracket, remove these two bolts (V6 models)



21.30 To disconnect the EGR pipe from the exhaust manifold, unscrew this big nut



21.34a On four-cylinder models, the differential pressure feedback EGR system sensor is located at the left end of the cylinder head, near the ignition coil

1 Electrical connector
2 Rubber hoses
3 Differential pressure feedback EGR system sensor
4 EGR pipe

the thermostat outlet, then remove the coolant hose from the EGR valve.

24 Remove the two EGR mounting bolts and remove the valve. Discard the old gasket.

25 Installation is the reverse of removal.

V6 models

Refer to illustrations 21.26, 21.27, 21.28 and 21.30

26 Disconnect the vacuum line from the EGR valve **(see illustration)**.

27 Disconnect the EGR pipe from the EGR valve **(see illustration)**.

28 Remove the bolts securing the EGR valve to its mounting bracket on the intake manifold **(see illustration)** and remove the EGR valve. Remove and discard the old gasket.

29 Remove the differential pressure feedback EGR sensor from the EGR pipe (see Step 28).

30 Disconnect the EGR pipe from the exhaust manifold **(see illustration)**.

31 Scrape all exhaust deposits and old gasket material from the EGR valve mounting surface on the mounting bracket at the intake manifold and, if you plan to use the same valve, from the mounting surface of the valve. Carefully remove carbon deposits from the valve port and pintle with a small screwdriver. **Caution:** *Do not try to wash the valve in solvent or sandblast it.* If the EGR passage contains excessive deposits, clean it out with a small scraper and a vacuum. Make sure that all loose particles are removed to keep them from clogging the EGR valve or from being drawn into the engine.

32 Installation is the reverse of removal. Attach the EGR pipe nuts loosely at the valve and at the exhaust manifold until the EGR valve is tightened on the intake manifold. Tighten the pipe fittings securely. Be sure to tighten the EGR valve mounting bolts to the torque listed in this Chapter's Specifications.

Differential pressure feedback EGR system sensor

Refer to illustrations 21.34a, 21.34b and 21.35

33 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

34 Disconnect the electrical connector from the differential pressure feedback EGR system sensor **(see illustrations)**.

35 Carefully disconnect the differential pressure feedback EGR system sensor from the two hoses that connect it to the two small metal pipes welded to the EGR pipe **(four-cylinder models, see illustration 21.34a; V6 models, see accompanying illustration)**.

36 While the differential pressure feedback EGR system sensor is removed, inspect the condition of the two small hoses. Look for cracks, tears and deterioration. If the hoses are worn or damaged, replace them.

37 Installation is the reverse of removal.

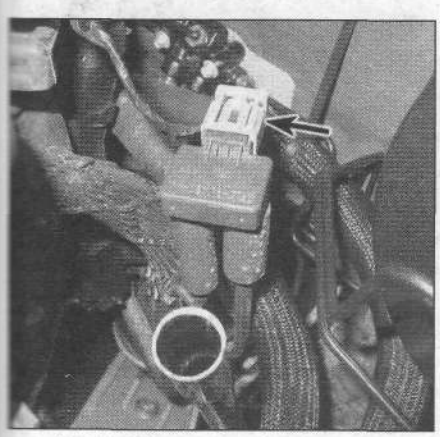
38 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

EGR vacuum regulator valve

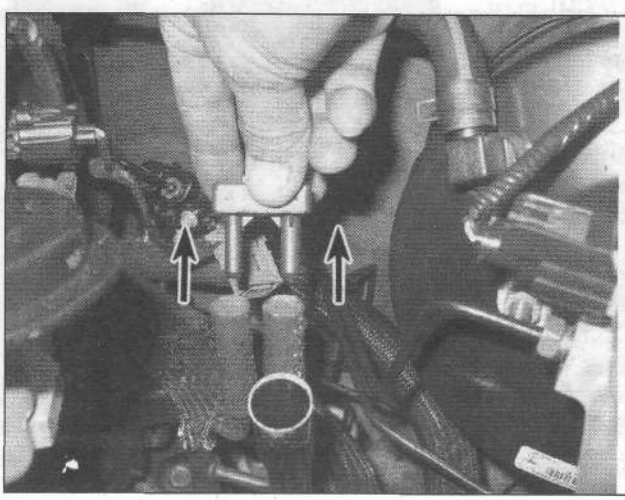
Refer to illustrations 21.40, 21.41, 21.42, 21.43 and 21.44

39 Disconnect the cable from the negative terminal of the battery (see Chapter 5, Section 1).

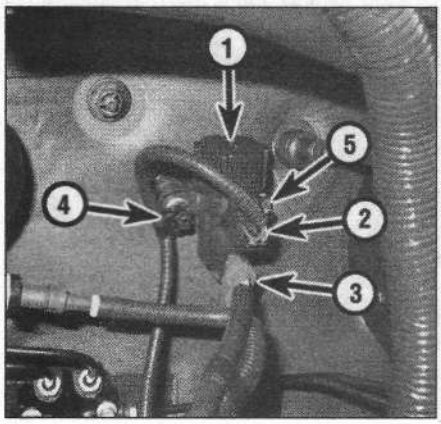
40 On four-cylinder models, locate the EGR vacuum regulator valve on the firewall **(see**



21.34b Disconnect the electrical connector from the differential pressure feedback EGR system sensor (V6 models)

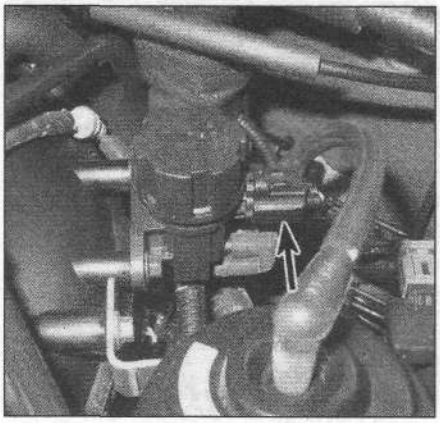


21.35 To disconnect the differential pressure feedback EGR system sensor from the two hoses that connect it to the two small metal pipes welded to the EGR pipe, carefully pull it straight up; be sure to inspect the hoses before installing the sensor (V6 model shown, four-cylinder models similar)

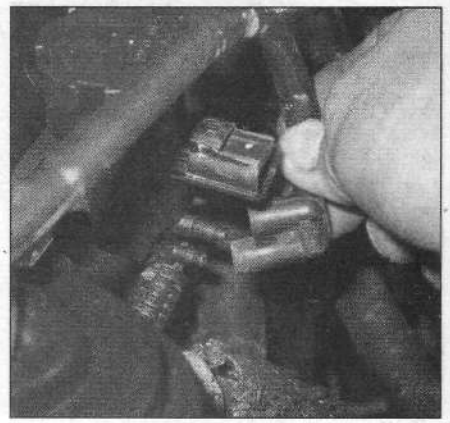


21.40 EGR vacuum regulator valve (four-cylinder models)

1 EGR vacuum regulator valve
2 Electrical connector
3 Vacuum hose connector
4 Right mounting nut (remove harness clip from stud first, then remove nut)
5 Left mounting nut



21.41 Disconnect the electrical connector from the EGR vacuum regulator valve (V6 model shown, four-cylinder models similar)



21.42 Disconnect the vacuum lines from the EGR vacuum regulator valve (V6 model shown, four-cylinder models similar)

illustration), to the right of the brake master cylinder. On V6 models, it's on the intake manifold.

41 Disconnect the electrical connector from the EGR vacuum regulator valve **(2.0L four-cylinder models, see illustration 21.40; V6 models, see accompanying illustration)**.

42 Disconnect the vacuum hoses from the EGR vacuum regulator valve **(2.0L four-cylinder models, see illustration 21.40; V6 models, see accompanying illustration)**.

43 On V6 models, detach the PCM wiring harness bracket **(see illustration)** and set it aside.

44 Remove the EGR vacuum regulator valve mounting nuts **(2.0L four-cylinder models, see illustration 21.40)** or bolts **(V6 models, see accompanying illustration)** and remove the valve from the firewall (four-cylinder models) or from the intake manifold (V6 models).

45 Installation is the reverse of removal. Be sure to tighten the vacuum regulator valve mounting nuts or bolts securely.

46 After you've reconnected the battery, the Powertrain Control Module (PCM) must relearn its idle and fuel trim strategy for optimum driveability and performance (see Chapter 5, Section 1 for this procedure).

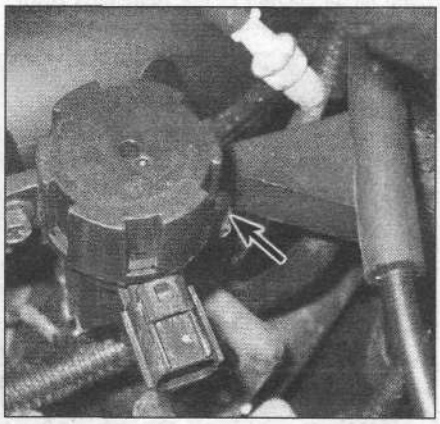
22 Positive Crankcase Ventilation (PCV) system - general information and component replacement

General description

Note: *Refer to Chapter 1 for scheduled maintenance on the PCV system for four-cylinder models. (The only scheduled maintenance for the PCV valve on V6 models is replacement every 100,000 miles).*

1 The Positive Crankcase Ventilation (PCV) system reduces hydrocarbon emissions by scavenging crankcase vapors. It does this by circulating fresh air from the air cleaner through the crankcase, where it mixes with blow-by gases and is then rerouted through a PCV valve to the intake manifold. The PCV system uses intake manifold vacuum to draw crankcase vapors from the crankcase into the intake manifold. The PCV valve varies the amount of blow-by gases that can be returned to the intake manifold in proportion to the amount of intake manifold vacuum available, but in the event of a backfire it prevents the entry of combustion gases into the manifold. To maintain idle quality, the PCV valve restricts the flow when intake manifold vacuum is high.

2 The PCV system consists of a fresh-air inlet hose between the air intake duct and the crankcase **(see illustration)**, the PCV valve itself and the PCV hose (also referred to as the crankcase ventilation hose), which connects the PCV valve to the intake manifold. Both the four-cylinder engine and the V6 also use a crankcase vent oil separator to which the PCV valve is attached. The crankcase vent oil separator acts as a baffle to prevent oil in the crankcase from entering the PCV valve.



21.43 On V6 models, remove this nut, detach the PCM wiring harness bracket from the stud and push the harness out of the way

3 Inspect the fresh-air inlet hose and the PCV valve hose (crankcase ventilation hose) for cracks, leaks and other damage. Disconnect the hose from the crankcase vent oil separator and the intake manifold and check the inside for obstructions. If a hose is clogged, replace it. If the PCV valve is clogged or otherwise not working properly, replace it, do not try to clean it.

Component replacement

Four-cylinder models

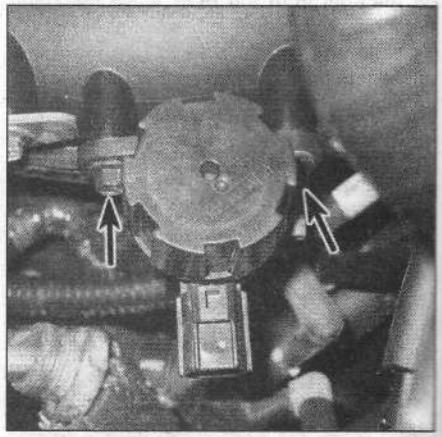
Fresh air inlet hose

Refer to illustration 22.4

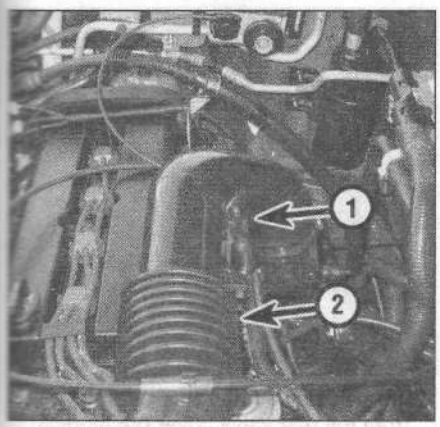
4 Disconnect the fresh air inlet hose from the air intake duct **(see illustration)**.

5 Remove the air intake duct (see Chapter 4).

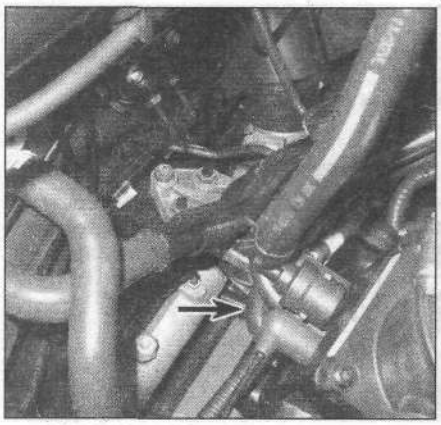
6 Disconnect the fresh air inlet hose from



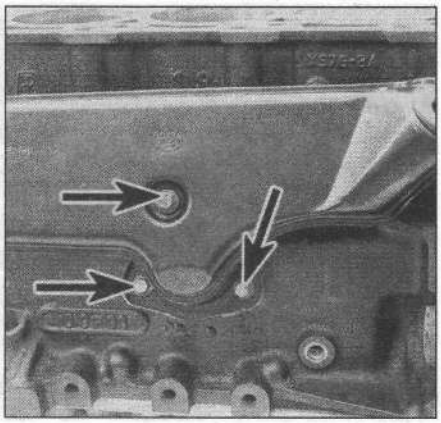
21.44 To detach the EGR vacuum regulator valve, remove these two bolts; be careful not to damage the threads on the stud (on the right bolt) that secures the PCM wiring harness bracket (V6 model shown, four-cylinder models similar, except that there's no stud on either bolt)



22.4 The fresh-air inlet hose on four-cylinder models connects the air intake duct (1) to the crankcase via a pipe on the valve cover (2) (valve cover pipe not visible in this photo; it's below the accordion pleats in the air intake duct)



22.10 The PCV hose, or crankcase ventilation hose, begins at the PCV valve (which is located on the left end of the crankcase vent oil separator) and ends here at the intake manifold, downstream from the throttle plate in the throttle body, so that the pressure differential caused by intake manifold vacuum will pull the crankcase vapors into the manifold (four-cylinder models)



22.16a To detach the crankcase vent oil separator from the engine block on a four-cylinder model, remove these three bolts . . .

the pipe at the left rear corner of the valve cover.

7 Thoroughly clean the fresh air inlet hose and inspect the condition of the hose. Look for cracks, tears and other deterioration. If it's damaged or worn, replace it. Also inspect the grommet at the air intake duct. Make sure that it's not cracked or torn. If it's worn or damaged, replace it. A leaking fresh air inlet hose or grommet will result in an unmetered air leak ("false air") that will lean out the air/fuel mixture ratio, which will cause a lean misfire and other driveability problems.

8 Installation is the reverse of removal.

PCV hose (crankcase ventilation hose)

Refer to illustration 22.10

9 Disconnect the PCV hose from the PCV valve, which is located at the upper left corner of the crankcase vent oil separator, which in turn is located on the front side of the engine block, behind the exhaust manifold and the crankcase vent oil separator.

10 Disconnect the PCV hose from the intake manifold **(see illustration)**.

11 Thoroughly clean the PCV hose and inspect the condition of the hose. Look for cracks, tears and other deterioration. If it's damaged or worn, replace it. Also inspect the grommet at the air intake duct. Make sure that it's not cracked or torn. If it's worn or damaged, replace it. A leaking PCV hose result in an unmetered air leak ("false air") that will lean out the air/fuel mixture ratio, which will cause a lean misfire and other driveability problems.

12 Installation is the reverse of removal.

PCV valve

13 See Chapter 1.

Crankcase vent oil separator

Refer to illustrations 22.16a, 22.16b and 22.18

Note: *The PCV valve and oil separator on the 2.3L four-cylinder engine is located under the intake manifold, requiring its removal (see Chapter 2A).*

14 The crankcase vent oil separator is located on the front side of the engine block, behind the exhaust manifold and the catalytic converter. To access the separator, remove the catalytic converter (see "Exhaust system - inspection and component replacement" in Chapter 4) and remove the exhaust manifold (see Chapter 2A).

15 Disconnect the PCV hose from the PCV valve or remove the PCV valve from the crankcase vent oil separator (see Chapter 1).

16 Remove the crankcase vent oil separator mounting bolts and remove the separator (see illustrations). Remove and discard the old oil separator gasket.

17 Remove the PCV valve from the oil separator if you haven't already done so. Then wash out the oil separator with a suitable solvent. Blow it out with compressed air (be sure to wear safety goggles during this procedure!) and make sure that the passages are clear.

18 Install a new crankcase vent oil separator gasket (see illustration).

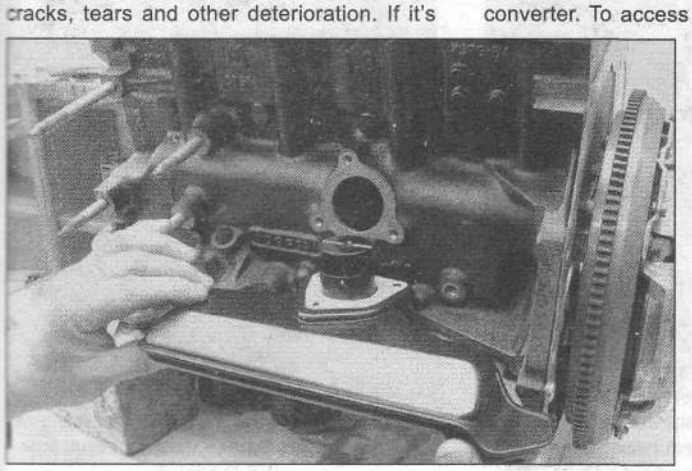
19 Installation is otherwise the reverse of removal. Be sure to tighten the oil separator mounting bolts to the torque listed in this Chapter's Specifications.

V6 models

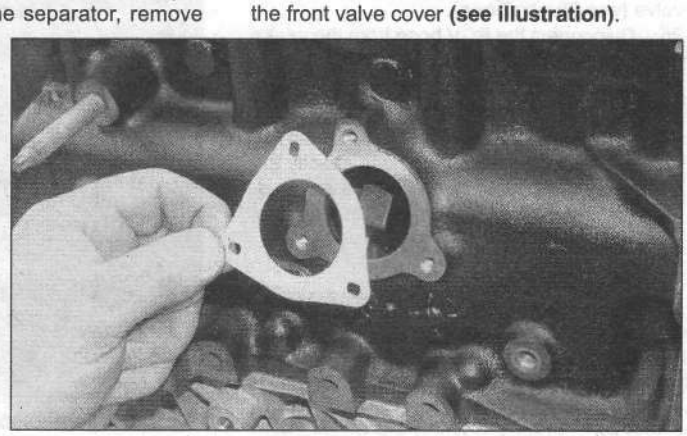
Fresh air inlet hose

Refer to illustrations 22.20 and 22.22

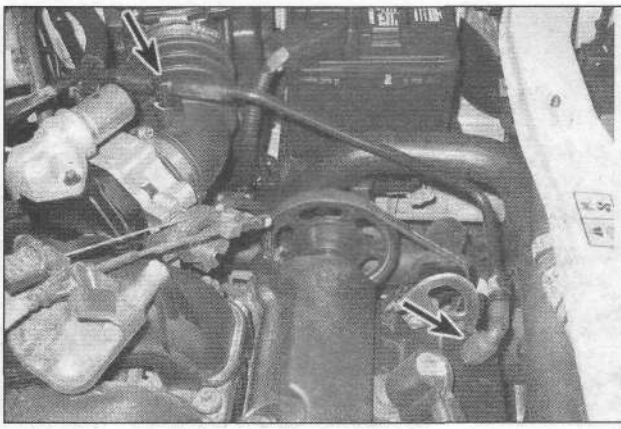
20 Disconnect the fresh air inlet hose from the front valve cover **(see illustration)**.



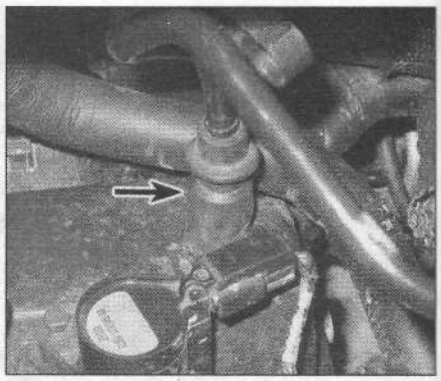
22.16b . . . and pull off the separator and the old gasket



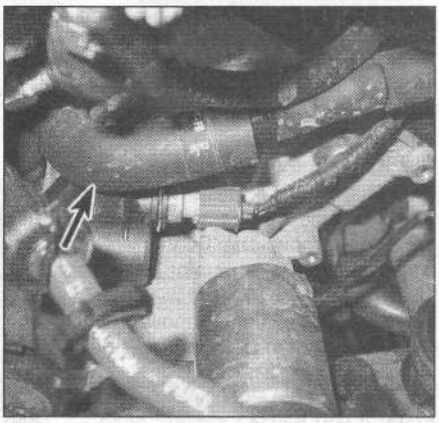
22.18 Before installing the crankcase vent oil separator on a four-cylinder model, be sure to install a new gasket



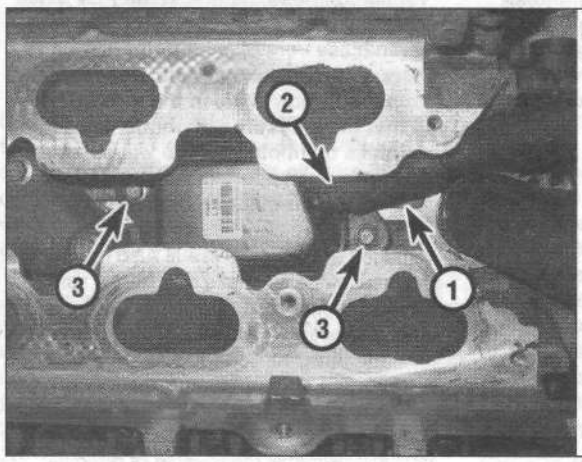
22.20 Disconnect the fresh air inlet hose from the front valve cover and from the air intake duct (V6 models)



22.22 Disconnect the fresh air inlet hose from the rear valve cover (V6 models)



22.24a Disconnect the PCV hose from the PCV valve, which is located in the left end of the valley between the cylinder heads (V6 models)



22.24b PCV hose, PCV valve and crankcase vent oil separator installation details (intake manifold removed for clarity) (V6 models)

1 *PCV hose*
2 *PCV valve*
3 *Crankcase vent oil separator mounting bolts*

21 Disconnect the fresh air inlet hose from the air intake duct **(see illustration 22.20)**.
22 Disconnect the fresh air inlet hose from the rear valve cover **(see illustration)**.
23 Installation is the reverse of removal.

PCV hose (crankcase ventilation hose)

Refer to illustrations 22.24a, 22.24b and 22.25

24 Disconnect the PCV hose from the PCV valve **(see illustrations)**.
25 Disconnect the PCV hose from the intake manifold **(see illustration)**.
26 Carefully note the routing the PCV hose and then pull it out and remove it.
27 Installation is the reverse of removal. Make sure that you route the hose exactly the same way that it was routed before removal. Make sure that there are no kinks in the hose.

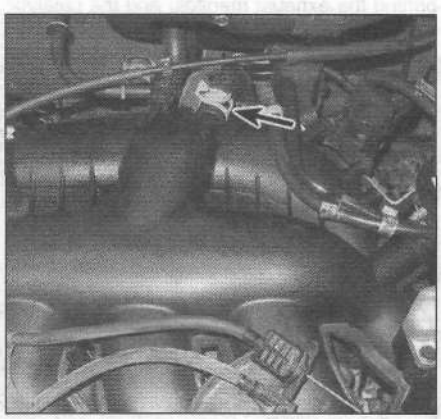
PCV valve

Refer to illustration 22.29

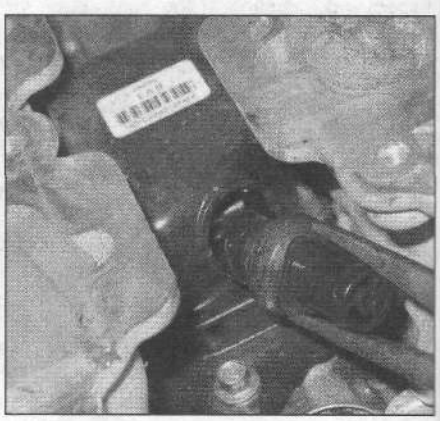
28 Disconnect the PCV hose from the PCV valve **(see illustrations 22.24a and 22.24b)**.
29 Disconnect the PCV valve from the crankcase vent oil separator **(see illustration)**. *Unscrew* the PCV valve - don't try to just pull it out.
30 Inspect the PCV valve (see Chapter 1).
31 Installation is the reverse of removal.

Crankcase vent oil separator

32 Remove the intake manifold (see Chapter 2B)
33 Disconnect the PCV hose from the PCV valve **(see illustration 22.24b)**.
34 Remove the PCV valve **(see illustration 22.29)**.
35 Remove the front cylinder head (see Chapter 2B). (You can't remove the crankcase vent oil separator without removing the front cylinder head.)
36 Remove the crankcase vent oil separator mounting bolts **(see illustration 22.24b)**.
37 Remove the crankcase vent oil separator. Remove the old oil separator gasket.
38 Wash out the oil separator with a suitable solvent. Blow it out with compressed air (be sure to wear safety goggles during this procedure!) and make sure that the passages are clear.
39 Installation is the reverse of removal. Be sure to use a new gasket and tighten the crankcase vent oil separator bolts to the torque listed in this Chapter's Specifications.



22.25 To disconnect the PCV hose (crankcase ventilation hose) from the intake manifold, loosen this hose clamp, slide it back and pull off the hose



22.29 Unscrew the PCV valve to remove it from the crankcase vent oil separator (V6 models)