Chapter 6
Emissions and engine control systems

Contents

Degrees of difficulty

Easy, suitable for novice with little experience

Fairly easy, suitable for beginner with some experience

Fairly difficult, suitable for competent DIY mechanic

Difficult, suitable for experienced DIY mechanic

Very difficult, suitable for expert DIY or professional

Specifications

EGR gas temperature sensor resistance

Temperature:	
212° F	60 to 100 k-ohms
400° F	3 to 8 k-ohms
662° F	250 to 350 ohms

Torque wrench setting	Nm	lbf ft
Crankshaft sensor bolt	27	20

1 General information

To minimise pollution of the atmosphere from incompletely burned and evaporating gases and to maintain good driveability and fuel economy, a number of emission control systems are used on these vehicles. They include the:

Air Injection Reactor (AIR) system
Crankcase Ventilation system
Exhaust Gas Recirculation (EGR) system
Electronic Fuel Injection (EFI) system
Evaporative Emission Control (EVAP) system
Three-way catalytic converter (TWC) system

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

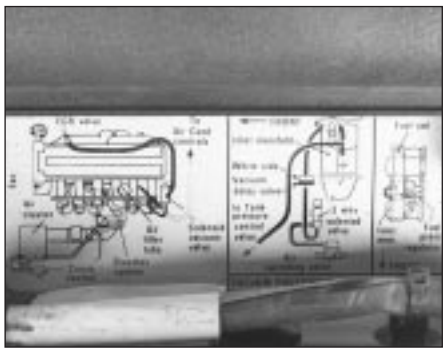
Before assuming an emissions control system is malfunctioning, check the fuel and ignition systems carefully (Chapters 4 and 5). The diagnosis of some emission control devices requires specialised tools, equipment and training. If checking and servicing become too difficult or if a procedure is beyond the scope of your skills, consult your dealer service department or other repair workshop.

This doesn't mean, however, that emission control systems are particularly difficult to maintain and repair. You can quickly and easily perform many checks and do most of the regular maintenance at home with common tune-up and hand tools. **Note:** *The most frequent cause of emission problems is simply a loose or broken electrical connector or vacuum hose, so always check the electrical connectors and vacuum hoses first.*

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

The Vehicle Emissions Control Information (VECI) label and a vacuum hose diagram are located under the bonnet **(see illustrations)**. These contain important emissions specifications and setting procedures, and a vacuum hose schematic with emissions

1.6a The Vehicle Emissions Control Information (VECI) label shows the types of emission control systems installed, engine information, etc (1992 model shown)



1.6b Typical vacuum hose routing label (1992 model shown)

components identified. When servicing the engine or emissions systems, the VECI label in your particular vehicle should always be checked for up-to-date information.

2 Electronic control system and ECU

General description

Note: *These models are susceptible to ECU damage if water is allowed to build up in the front cowl drain and overspill into the dash area near the computer. Inspect and clear the front cowl drain as a regular maintenance item to keep the water draining properly. Remove the duckbill-type rubber hose and inspect it for clogging, collapsing or deterioration.*

1 The Lucas LH Engine Management system controls the fuel injection system by means of a microcomputer known as the Electronic Control unit (ECU).

2 The ECU receives signals from various sensors which monitor changing engine operating conditions such as intake air mass, intake air temperature, coolant temperature, engine rpm, acceleration/deceleration, exhaust oxygen content, etc. These signals are utilised by the ECU to determine the correct injection duration.

3 The system is analogous to the central nervous system in the human body: The sensors (nerve endings) constantly relay signals to the ECU (brain), which processes the data and, if necessary, sends out a command to change the operating parameters of the engine (body).

4 Here's a specific example of how one portion of this system operates: An oxygen sensor, located in the exhaust manifold, constantly monitors the oxygen content of the exhaust gas. If the percentage of oxygen in the exhaust gas is incorrect, an electrical signal is sent to the ECU. The ECU takes this information, processes it and then sends a command to the fuel injection system telling it to change the air/fuel mixture. This happens in a fraction of a second and it goes on continuously when the engine is running. The end result is an air/fuel mixture ratio which is constantly maintained at a predetermined ratio, regardless of driving conditions.

5 In the event of a sensor malfunction, a backup circuit will take over to provide driveability until the problem is identified and fixed.

Precautions

6 Follow these steps:

a) Always disconnect the power by either turning off the ignition switch or disconnecting the battery terminals before removing electrical connectors.

Warning: Later models are equipped with airbags. To prevent accidental deployment of the airbag, which could cause personal injury, DO NOT work in the vicinity of the steering column or instrument panel. The manufacturer recommends that, on airbag equipped models, the following procedure should be left to a dealer service department or other repair workshop because of the special tools and techniques required to disable the airbag system.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

b) When refitting a battery, be particularly careful to avoid reversing the positive and negative battery cables. Also, make sure the ignition key is in the Off position when connecting or disconnecting the battery.

c) Do not subject EFI components, emissions-related components or the ECU to severe impact during removal or refitting.

d) Do not be careless during fault diagnosis. Even slight terminal contact can invalidate a testing procedure and damage one of the numerous transistor circuits.

e) Never attempt to work on the ECU or open the ECU cover. The ECU is protected by a government-mandated extended warranty that will be nullified if you tamper with or damage the ECU.

f) If you are inspecting electronic control system components during rainy weather, make sure that water does not enter any part. When washing the engine compartment, do not spray these parts or their electrical connectors with water.

g) These models are susceptible to ECU damage if water is allowed to build up in the front cowl drain and overspill into the dash area. Inspect and clear the front cowl drain system as a regular maintenance item to keep the water draining properly. Remove the duckbill type rubber hose and inspect it for clogging, collapsing or deterioration.

ECU removal and refitting

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

Warning: Later models are equipped with airbags. To prevent the accidental deployment of the airbag, which could cause personal injury, DO NOT work in the vicinity of the steering column or instrument panel. The manufacturer recommends that, on airbag equipped models, the following procedure should be left to a dealer service department or other repair workshop because of the special tools and techniques required to disable the airbag system.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

2.10 The ECU is located behind the passenger's side glovebox near the footrest area. Remove the mounting screws (arrowed) and carefully lower the ECU

8 Remove the lower instrument panel on the passenger side under the glove compartment (see Chapter 11).

9 Remove the glove compartment from the passenger compartment (see Chapter 11).

10 Remove the screws from the ECU bracket **(see illustration)**.

11 Lower the ECU and unplug the electrical connectors.

12 Refitting is the reverse of removal.

3 On Board Diagnosis (OBD) system - description and fault code access

Note: *1990 and 1991 models may set Code 69 erroneously. If the battery voltage drops sufficiently and the ignition key is switched quickly from OFF to START, battery voltage will be lowered and during cranking causing a delayed park/neutral signal from the decoder module to the ECU. Check all the battery connections and the condition of the battery and then check the rotary switch adjustment in Chapter 7 to remedy this code.*

General information

1 The ECU contains a built-in self-diagnosis system which detects and identifies malfunctions occurring in the network. When the ECU detects a problem, three things happen: the CHECK ENGINE light comes on, the fault is identified and a diagnostic code is recorded and stored. The ECU stores the failure code assigned to the specific problem area until the diagnosis system is cancelled.

Note: *1988 and 1989 models are not equipped with long term memory. It is possible to access the codes but the operator must remember to NOT turn the ignition key to the OFF position after the CHECK ENGINE light has been noticed. The codes will be lost and it will be necessary to start the engine and operate the vehicle through a complete drive cycle to allow the fault code(s) to be set once again. Instead of turning the ignition key to the OFF position, simply stop at position II (key ON but engine not running) to retain the fault codes.*

2 The CHECK ENGINE warning light, which is located on the instrument panel, comes on when the ignition switch is turned to ON and the engine is not running. When the engine is started, the warning light should go out. If the light remains on, the self-diagnosis system has detected a malfunction. **Note:** *The CHECK ENGINE light on early models is displayed on the dashboard VCM panel on the right side. Later models are equipped with a separate CHECK ENGINE light on the left side of the instrument cluster.* **Note:** *Not all the codes will cause the CHECK ENGINE light to activate. When performing any fuel or emissions systems diagnosis, always check for codes that may be stored but not indicated by the CHECK ENGINE light.*

Obtaining fault code output

3 To obtain an output of diagnostic codes, verify first that the battery voltage is above 11 volts, the throttle is fully closed, the transmission is in Park, the accessory switches are off and the engine is at normal operating temperature.

4 Turn the ignition switch to ON but don't start the engine (Position II). **Note:** *On 1988 and 1989 models, remember to turn the ignition switch to position II without turning the key to OFF.*

5 Press the VCM button on the display panel **(see illustration)** and observe the LED display on the dash for the designated codes. An asterisk next to the code indicates that there are multiple codes stored.

6 The numerical values will be displayed on the trip computer display on the dashboard.

7 If there are any malfunctions in the system, the corresponding fault codes are displayed in numerical order, lowest to highest.

Cancelling a diagnostic code

8 After the faulty component has been repaired/renewed, the fault code(s) stored in computer memory must be cancelled.

a) On 1988 to 1991 vehicles, simply drive the vehicle faster than 19 mph and the computer will automatically erase the stored fault code from memory.

3.5 To access the self-diagnosis system fault codes, locate the VCM button on the dash and with the ignition key ON (engine not running) press it to display the codes

Fault code chart for 1988 and 1989 models

Code	System affected	Probable cause
1	*Oxygen sensor*	*Open oxygen sensor circuit*
2	*Airflow sensor*	*Not in operating range*
3	*Coolant temperature sensor*	*Not in operating range*
4	*Oxygen sensor*	*System indicates full rich*
5	*Throttle potentiometer/airflow sensor*	*Low throttle potentiometer signal with high airflow sensor signal*
6	*Throttle potentiometer/airflow sensor*	*High throttle potentiometer signal with low airflow sensor signal*
7	*Throttle potentiometer*	*Idle fuel adjustment failure*
8	*Intake air temperature sensor*	*Open or shorted circuit in IAT sensor harness*

Fault code chart for 1990 to 1994 models

Code	System affected	Probable cause
11	*Idle potentiometer*	*Not in operating range*
12	*Airflow sensor*	*Not in operating range*
14	*Coolant temperature sensor*	*Not in operating range*
16	*Air temperature sensor*	*Not in operating range*
17	*Throttle potentiometer*	*Not in operating range*
18	*Throttle potentiometer/airflow sensor*	*Signal resistance low at wide open throttle*
19	*Throttle potentiometer/airflow sensor*	*Signal resistance high at idle*
22	*Heated oxygen sensor*	*Open or short circuit*
22	*Fuel pump circuit*	*Open or short circuit*
23	*Fuel supply*	*Rich exhaust Indicated*
24	*Ignition amplifier circuit*	*Open or short circuit*
26	*Oxygen sensor circuit*	*Lean exhaust/vacuum leak*
29	*ECU*	*Self check*
33	*Fuel injector circuit*	*Open or short circuit*
34	*Fuel injector circuit*	*Faulty injector indicated*
37	*EGR solenoid circuit*	*Short or open circuit*
39	*EGR circuit*	*Faulty system operation*
44	*Oxygen sensor circuit*	*Rich or lean condition*
46	*Idle speed control valve - (coil 1)*	*Open or short circuit*
47	*Idle speed control valve - (coil 2)*	*Open or short circuit*
48	*Idle speed control valve*	*Not within specification*
68	*Road speed sensor*	*Incorrect signal voltage*
69	*Neutral safety switch circuit*	*Engine cranks in Drive (adjust or renew switch)*
89	*Purge control valve circuit*	*Open or short circuit*

b) On 1992 to 1994 models, disconnect the negative battery lead for 30 seconds or more to erase the stored fault codes.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

9 A stored code can also be cancelled on early models by removing the cable from the battery negative terminal, but other items with memory (such as the clock and radio presets) will also be cancelled.

10 If the diagnosis code is not cancelled, it will be stored by the ECU and appear with any new codes in the event of future trouble.

11 Should it become necessary to work on engine components requiring removal of the battery terminal, always check to see if a diagnostic code has been recorded before disconnecting the battery.

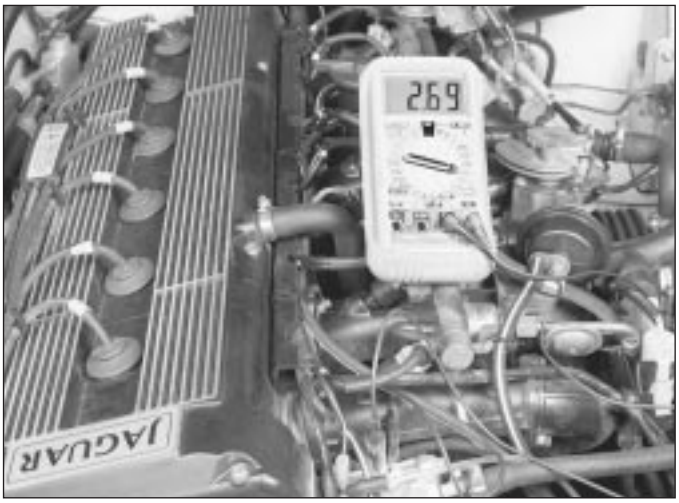
4 Information sensors

Note: *Refer to Chapters 4 and 5 for additional information on the location and the diagnostic procedures for the output actuators (ISC motor, air supplementary valve, distributor, amplifier, etc.) that are not directly covered in this section.*

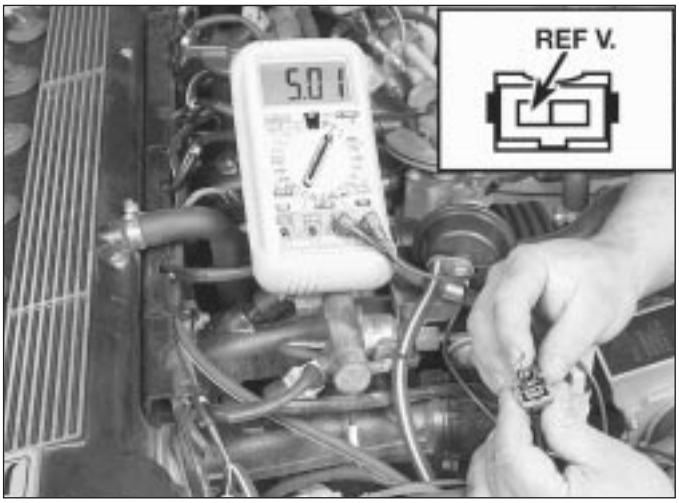
Coolant temperature sensor

General description

1 The coolant temperature sensor is a thermistor (a resistor which varies the value of its voltage output in accordance with temperature changes) which is threaded into the thermostat housing. As the sensor temperature DECREASES, the resistance values will INCREASE. As the sensor



4.2 The coolant temperature sensor is in the thermostat housing. To check the coolant temperature sensor, use an ohmmeter to measure the resistance between the two sensor terminals



4.3 Check for reference voltage to the electrical connector for the coolant sensor with the ignition key ON (engine not running). It should be approximately 5.0 volts

temperature INCREASES, the resistance values will DECREASE. A failure in this sensor circuit should set a Code 3 (1988 and 1989) or 13 (1990 to 1994). This code indicates a failure in the coolant temperature sensor circuit, so in most cases the appropriate solution to the problem will be either repair of a connector or wire, or renewal of the sensor.

Check

2 To check the sensor, measure its resistance value **(see illustration)** while it is completely cold (60 to 80° F = 1500 to 3000 ohms). Next, start the engine and warm it up until it reaches operating temperature. The resistance should be lower (180 to 200° F = 280 to 350 ohms).

3 If the resistance values of the coolant temperature sensor are correct, check the circuit for the proper signal voltage. Turn the ignition key ON (engine not running) and check for reference voltage with a high-impedance digital voltmeter **(see illustration)**. It should be approximately 5 volts.

Renewal

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

4 To remove the sensor, depress the locking tabs, unplug the electrical connector, then carefully unscrew the sensor.

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

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

6 Refitting is the reverse of removal.

Oxygen sensor

Note: *An oxygen sensor splash shield is equipped on models from VIN 664941 (mid-1990) to present. This shield prevents the self diagnosis system from setting an intermittent and erroneous code 44. Whenever replacing an oxygen sensor, make sure the splash shield is in place.*

General description

7 These models are equipped with a heated oxygen sensor system. The oxygen sensor is mounted ahead of the front catalytic converter and monitors the exhaust gases before they are changed. The electrical heating system incorporated into the oxygen sensor allows for quicker warm-up time and more efficient oxygen content monitoring. The oxygen sensor monitors the oxygen content of the exhaust gas stream. The oxygen content in the exhaust reacts with the oxygen sensor to produce a voltage output which varies from 0.1 volts (high oxygen, lean mixture) to 0.9 volts (low oxygen, rich mixture). The ECU constantly monitors this variable voltage output to determine the ratio of oxygen to fuel in the mixture. The ECU alters the air/fuel mixture ratio by controlling the pulse width (open time) of the fuel injectors. A mixture ratio of 14.7 parts air to 1 part fuel is the ideal mixture ratio for minimising exhaust emissions, thus allowing the catalytic converter to operate at maximum efficiency. This ratio of 14.7 to 1 is the one which the ECU and the oxygen sensor attempt to maintain at all times.

8 The oxygen sensor produces no voltage when it is below its normal operating temperature of about 600° F. During this initial period before warm-up, the ECU operates in open loop mode.

9 If the engine reaches normal operating temperature and/or has been running for two or more minutes, and if the oxygen sensor is producing a steady signal voltage below 0.45 volts at 1500 or more rpm, the ECU will set a Code 4 (1988 and 1989) or 26 (1990 to 1994).

10 When there is a problem with the oxygen sensor or its circuit, the ECU operates in the open loop mode - that is, it controls fuel delivery in accordance with a programmed default value instead of feedback information from the oxygen sensor.

11 The proper operation of the oxygen sensor depends on four conditions:

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

b) Outside air supply - The sensor is designed to allow air circulation to the internal portion of the sensor. Whenever the sensor is removed and installed or renewed, make sure the air passages are not restricted.

c) Proper operating temperature - The ECU will not react to the sensor signal until the sensor reaches approximately 600° F. This factor must be taken into consideration when evaluating the performance of the sensor.

d) Unleaded fuel - The use of unleaded fuel is essential for proper operation of the sensor. Make sure the fuel you are using is of this type.

12 In addition to observing the above conditions, special care must be taken whenever the sensor is serviced.

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

b) Grease, dirt and other contaminants should be kept away from the electrical connector and the louvered end of the sensor.

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

d) Do not drop or roughly handle the sensor.

4.13 To test the oxygen sensor heater, disconnect the electrical connector, and working on the sensor side, check the resistance across the two terminals. Heater resistance should be 5 to 6 ohms

4.15 Refit a pin into the backside of the oxygen sensor connector into the correct terminal and check for a millivolt output signal generated by the sensor as it warms up. The SIGNAL wire is easily recognised by the rubber sheath covering the terminal (arrowed)

e) The silicone boot must be installed in the correct position to prevent the boot from being melted and to allow the sensor to operate properly.

Check

13 Locate the oxygen sensor electrical connector and inspect the oxygen sensor heater. Disconnect the oxygen sensor electrical connector and connect an ohmmeter between the two terminals **(see illustration)**. It should be around 5 to 6 ohms.

14 Also, check for proper supply voltage to the oxygen sensor heater. Measure the voltage with the electrical connector connected. Insert a long pin into the backside of the electrical connector on the correct wire. With the ignition key ON (engine not running), check for voltage. There should be approximately 12 volts. **Note:** *Battery voltage to the heater is supplied by the main relay (1988 to 1990) or the oxygen sensor relay (1991 to 1994). Check the oxygen sensor relay and the wiring harness if battery voltage is not available to the heater. Refer to the wiring diagrams at the end of Chapter 12 and the relay locator schematics also in Chapter 12.*

15 Next, check for a millivolt signal from the oxygen sensor. Locate the oxygen sensor electrical connector and insert a long pin into the oxygen sensor signal wire terminal **(see illustration).** The SIGNAL wire is the single wire with the rubber sheath covering its terminal.

16 Monitor the voltage signal (millivolts) as the engine goes from cold to warm.

17 The oxygen sensor will produce a steady voltage signal at first (open loop) of approximately 0.1 to 0.2 volts with the engine cold. After a period of approximately two minutes, the engine will reach operating temperature and the oxygen sensor will start to fluctuate between 0.1 to 0.9 volts (closed loop). If the oxygen sensor fails to reach the closed loop mode or there is a very long period of time until it does switch into closed loop mode, or if the voltage doesn't fluctuate well (indicating a "lazy" sensor), renew the oxygen sensor with a new part.

Renewal

Note: *Because it is installed in the exhaust manifold or pipe, which contracts when cool, the oxygen sensor may be very difficult to loosen when the engine is cold. Rather than risk damage to the sensor (assuming you are planning to reuse it in another manifold or pipe), start and run the engine for a minute or two, then shut it off. Be careful not to burn yourself during the following procedure.*

18 Disconnect the cable from the negative terminal of the battery.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

19 Raise the vehicle and place it securely on axle stands.

20 Disconnect the electrical connectors from the sensor pigtail lead.

21 Unscrew the oxygen sensor from the exhaust system **(see illustration)**.

Caution: Excessive force may damage the threads.

22 Anti-seize compound must be used on the threads of the sensor to facilitate future removal. The threads of new sensors will already be coated with this compound, but if an old sensor is removed and reinstalled, recoat the threads.

23 Refit the sensor and tighten it securely.

24 Reconnect the electrical connectors to the main engine wiring harness.

25 Lower the vehicle and reconnect the cable to the negative terminal of the battery.

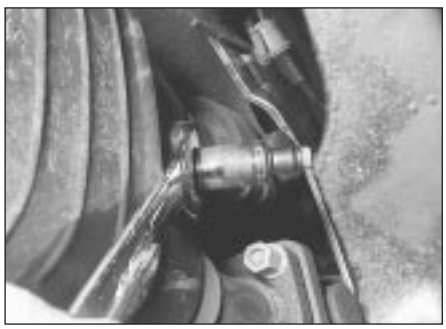
Throttle potentiometer

General description

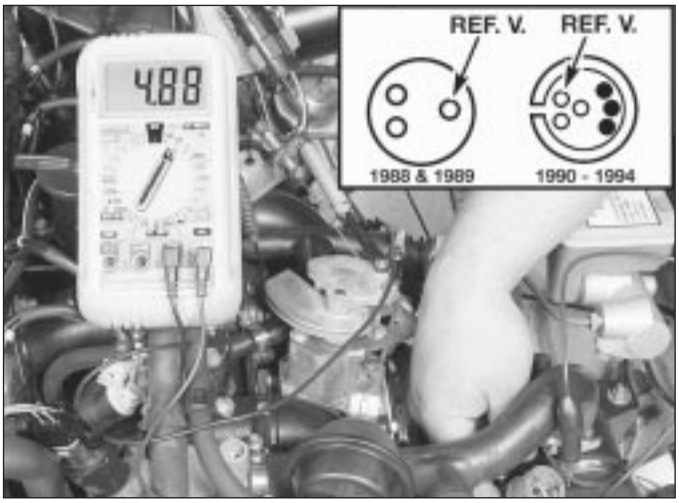
26 The throttle potentiometer is located on the end of the throttle shaft on the bottom section of the throttle body. By monitoring the output voltage from the throttle potentiometer, the ECU can alter fuel delivery based on throttle valve angle (driver demand). A broken or loose throttle potentiometer will cause bursts of fuel from the injectors and an unstable idle because the ECU thinks the throttle is moving. Throttle body removal procedures are covered in Chapter 4.

Check

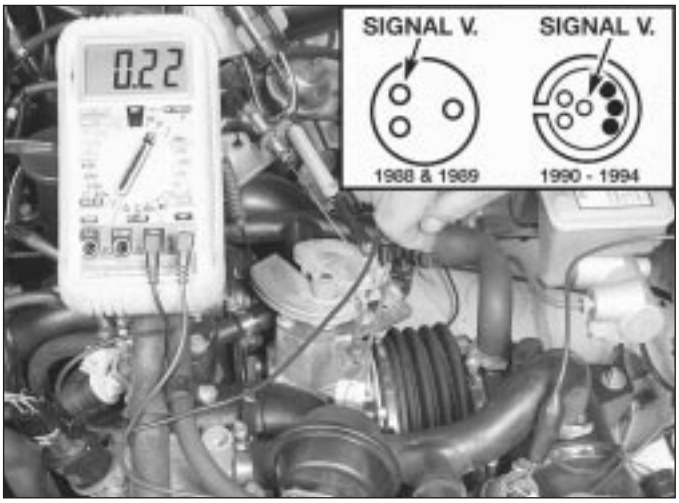
27 Check for the proper reference voltage to the throttle potentiometer. Carefully back-probe the throttle potentiometer electrical connector using a pin on the reference voltage wire and ground **(see illustration)**. With the ignition key ON (engine not running) the reference voltage should be about 5.0 volts.



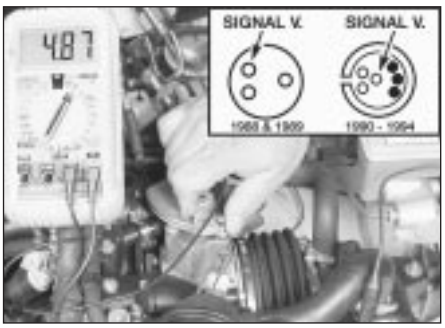
4.21 Unscrew the oxygen sensor from the exhaust system



4.27 Backprobe the throttle potentiometer electrical connector with a pin and with the ignition key ON (engine not running) there should be 5.0 volts REFERENCE available



4.28 First check the throttle potentiometer SIGNAL voltage with the throttle closed (idle). It should be 0.2 to 0.5 volts . . .



4.29 . . . then check the SIGNAL voltage with the throttle wide open. It should be between 4.5 and 5.0 volts

4.39 Check for battery voltage to the MAF sensor on terminal number 5

4.40 With the engine idling, raise the engine rpm and observe the voltage changes on terminal number 3

28 Check the signal voltage from the potentiometer. Carefully backprobe the electrical connector on the signal voltage wire (-) with the ignition key ON (engine not running) **(see illustration)**. There should be approximately 0.5 volts.

29 Next, rotate the throttle lever manually and confirm that the reference voltage increases to approximately 4.8 volts **(see illustration)**.

30 If the voltage does not increase, renew the throttle potentiometer with a new part.

Renewal

31 Remove the throttle body from the intake manifold (see Chapter 4).

32 Remove the two mounting bolts and separate the throttle potentiometer from the throttle body. **Note:** *The throttle potentiometer is difficult to reach and adjustment requires that the home mechanic tighten the bolts after the final adjustment using a mirror. Be sure to mark the mounting position of the old throttle potentiometer before refitting the new part.*

33 Refitting is the reverse of removal.

Adjustment

34 Refit the throttle body with the throttle potentiometer mounting bolts just loose enough to move the potentiometer. Be sure the bolts are tight and the potentiometer does not rotate easily.

35 Backprobe the signal wire and the ground wire (see Step 28) and with the throttle closed (idle position), rotate the potentiometer until the voltmeter reads between 0.2 and 0.5 volts. **Note:** *The throttle potentiometer is difficult to reach. Be sure to rotate the potentiometer slowly and do not interfere with the voltmeter and the electrical connectors to the gauge.*

36 Rotate the throttle lever and confirm that the voltage increases to around 4.8 volts. If the voltage range is correct, the throttle potentiometer is installed correctly.

37 Tighten the throttle potentiometer bolts. If necessary, use a small mirror to locate the bolts.

Mass airflow (MAF) sensor

General Information

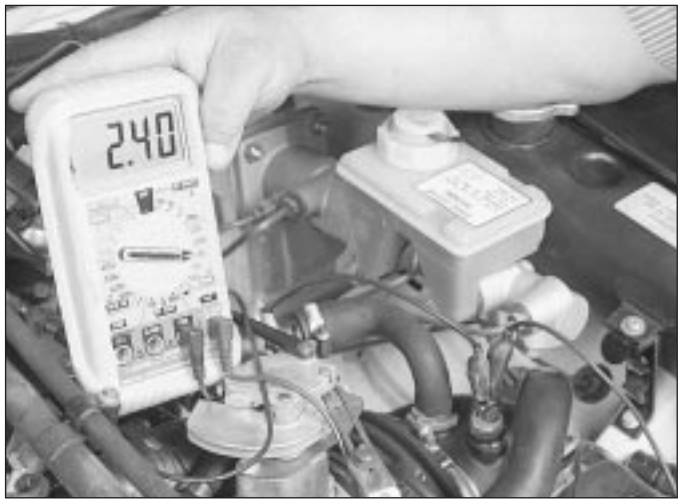
38 The mass airflow sensor (MAF) is located on the air intake duct. This sensor uses a hot wire sensing element to measure the amount of air entering the engine. The air passing over the hot wire causes it to cool. Consequently, this change in temperature can be converted into an analogue voltage signal to the ECU which in turn calculates the required fuel injector pulse width.

Check

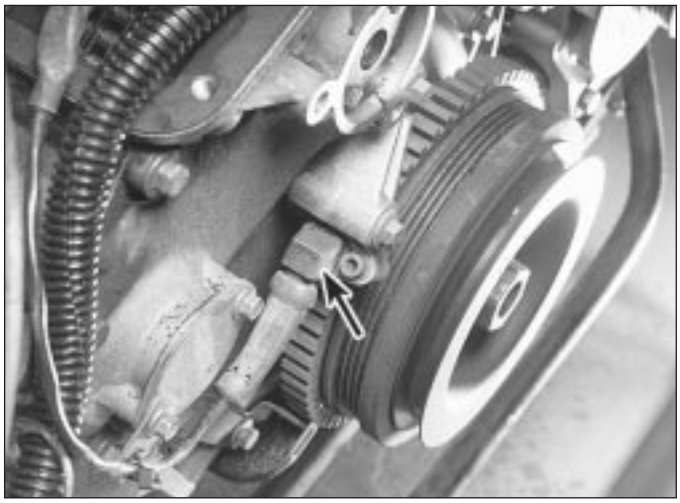
39 Check for power to the MAF sensor. Backprobe the MAF sensor electrical plug. Working on the harness side with the ignition ON (engine not running), check for battery voltage on terminal number 5 **(see illustration)**.

40 Remove the pin and backprobe the MAF sensor electrical connector terminal number 3 with the voltmeter **(see illustration)**. The voltage should be less than 1.0 volt with the ignition switch ON (engine not running). Raise the engine rpm. The signal voltage from the MAF sensor should increase to about 2.0 volts. It is impossible to simulate load conditions in the driveway but it is necessary to observe the voltmeter for a fluctuation in voltage as the engine speed is raised. The vehicle will not be under load conditions but MAF sensor voltage should vary slightly.

41 If the voltage readings are correct, check the wiring harness for open circuits or a damaged harness (see Chapter 12).



4.51 The air intake temperature sensor resistance will DECREASE when the temperature of the air INCREASES



4.57 Location of the crankshaft position sensor

42 Also, check the reference voltage to the MAF sensor from the computer. Backprobe terminal number 6 and make sure that approximately 5 volts is present.

Renewal

43 Disconnect the electrical connector from the MAF sensor.
44 Remove the air cleaner assembly (see Chapter 4).
45 Remove the four bolts and separate the MAF sensor from the air intake duct.
46 Refitting is the reverse of removal.

Intake air temperature (IAT) sensor

General description

47 The intake air temperature sensor is located inside the air intake duct. This sensor acts as a resistor which changes value according to the temperature of the air entering the engine. Low temperatures produce a high resistance value (for example, at 68° F the value is 2.0 to 2.6 k-ohms) while high temperatures produce low resistance values (at 176° F the resistance is 260 to 330 ohms. The ECU supplies around 5 volts (reference voltage) to the air temperature sensor. The voltage will change according to the temperature of the incoming air. The voltage will be high when the air temperature is cold and low when the air temperature is warm. Any problems with the air temperature sensor will usually set a code 8 (1988 and 1989) or code 16 (1990 to 1994).

Check

48 To check the air temperature sensor, disconnect the two prong electrical connector and turn the ignition key ON but do not start the engine.
49 Measure the voltage (reference voltage), which should be approximately 5 volts.
50 If the voltage signal is not correct, have the ECU diagnosed by a dealer service department or other repair workshop.
51 Measure the resistance across the air temperature sensor terminals **(see illustration)**. The resistance should be HIGH when the air temperature is LOW. Next, start the engine and let it idle. Wait awhile and let the engine reach operating temperature. Turn the ignition OFF, disconnect the air temperature sensor and measure the resistance across the terminals. The resistance should be LOW when the air temperature is HIGH. If the sensor does not exhibit this change in resistance, renew it with a new part.

EGR gas temperature sensor (1991 to 1994 models)

General description

52 The EGR gas temperature sensor is mounted in the exhaust gas transfer pipe. This sensor detects the temperature of the exhaust moving through the EGR valve. The information is sent to the ECU so the EGR on/off time is regulated precisely and efficiently.

Check

53 Disconnect the harness connector for the EGR gas temperature sensor and measure the resistance of the sensor at the various temperatures. Refer to the Specifications listed in this Chapter for a list of the temperatures and the resistance values.

Removal and refitting

54 Disconnect the harness connector for the EGR gas temperature sensor and using an open-end spanner, remove the sensor from the EGR adapter under the intake manifold.
55 Refitting is the reverse of removal.

Speed sensor

General description

56 The speed sensor is mounted on the differential housing and monitors vehicle speed by sensing the rotational speed of the rear axle. A problem with this sensor or circuit will set a code 68 and may also be the cause of an inoperative speedometer. If the speedometer doesn't work, the problem lies in the speed sensor, the instrument cluster, the ECU or the wiring in between. For further diagnosis, take the vehicle to a dealer service department or other suitably-equipped and qualified repair workshop.

Crankshaft position sensor

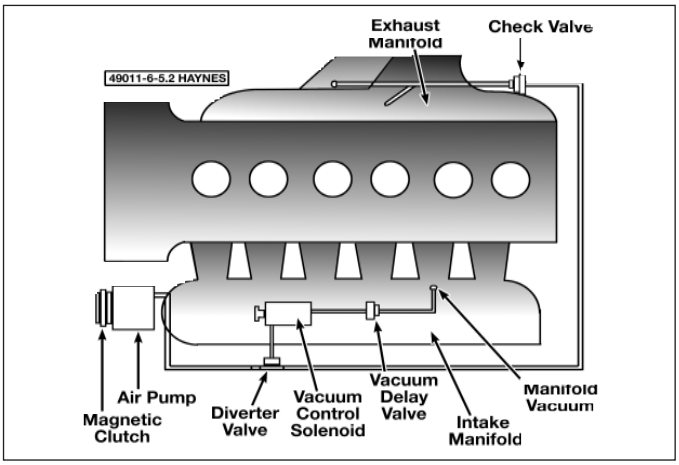
57 The crankshaft position sensor is located in the front timing cover near the crankshaft pulley **(see illustration)**. The crankshaft position sensor relays a signal to the ECU to indicate the exact position (angle) of the crankshaft.

Check

58 The crankshaft sensor cannot be diagnosed without the proper tools. The Jaguar dealer uses a diagnostic scope/computer called the JDS. Have the crankshaft sensor diagnosed by the dealer service department or other qualified repair workshop.

Renewal

59 To renew the sensor, disconnect the electrical connector and remove the bolt from the crankshaft position sensor. Refitting is the reverse of removal.
60 To renew the crankshaft sensor gear, remove the front pulley (refer to Chapter 2A).
61 Be sure there is a small gap between the crankshaft sensor and the teeth on the gear. It should be between 0.46 to 1.07 mm (0.018 to 0.042 inch).
62 Refitting is the reverse of removal. Tighten the crankshaft sensor bolt to the torque listed in this Chapter's Specifications.



5.2 Schematic of the Air Injection Reactor (AIR) system

5.5 Location of the AIR pump relay on a 1992 model

5 Air Injector Reactor (AIR) system

General information

1 The air injection reactor system reduces carbon monoxide and hydrocarbon content in the exhaust gases by injecting fresh air into the hot exhaust gases leaving the exhaust ports. When fresh air is mixed with hot exhaust gases, oxidation is increased, reducing the concentration of hydrocarbons and carbon monoxide and converting them into harmless carbon dioxide and water.

2 The air injection system is composed of an air pump, diverter valve (bypass), check valve, air injection manifold, vacuum delay valve, vacuum control solenoid, air pump magnetic clutch, air pump clutch relay and hoses **(see illustration)**. The air pump is driven by a belt from the crankshaft and supplies compressed air to the exhaust manifold(s). The check valve prevents the reverse flow of exhaust gases into the system. The vacuum-operated (early models) or electrically-operated (later models) air cut-off valve prevents air from being drawn into the exhaust when the air pump is switched off. System vacuum to the air cut-off valve is controlled by the solenoid vacuum valve in parallel circuit with the air pump. A delay valve prevents vacuum loss to the solenoid valve during wide open throttle operation.

3 Injected air is controlled by the computer, the air pump clutch and the air pump clutch relay. The AIR system is used during warm-up (58 to 83° F) to control emissions while the engine is running rich. The oxygen sensor feedback system cannot function while the AIR system is operating. The computer controls both systems during warm-up and operating temperatures. If problems occur with the AIR system relay or circuit, the on-board diagnosis system will set a code 66.

Check

4 Check the condition of the air pump drivebelt, the injection hoses and the injection manifold. Make sure that all components are intact and there are no leaks.

5 Check the operation of the air pump clutch relay **(see illustration)** and the air pump clutch. First remove the relay and check for battery voltage to the relay. Also, check the relay itself. Refer to the relay checking procedure in Chapter 12. Extract codes from the self-diagnosis system (see Section 3) and check for a code 66, AIR relay malfunction.

6 Make sure the electrical connector is securely fastened to the diverter valve **(see illustration)**. If everything appears OK but a fault code still sets, have the system diagnosed by a dealer service department or other qualified repair workshop.

Air pump renewal

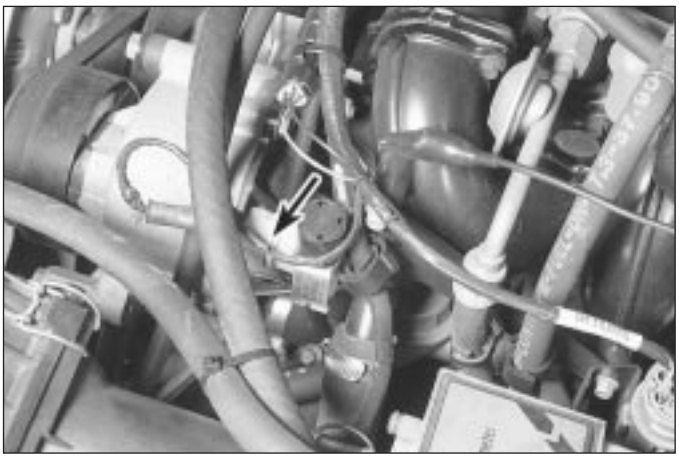
7 Disconnect the cable from the negative terminal of the battery.

Caution: If the stereo in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.

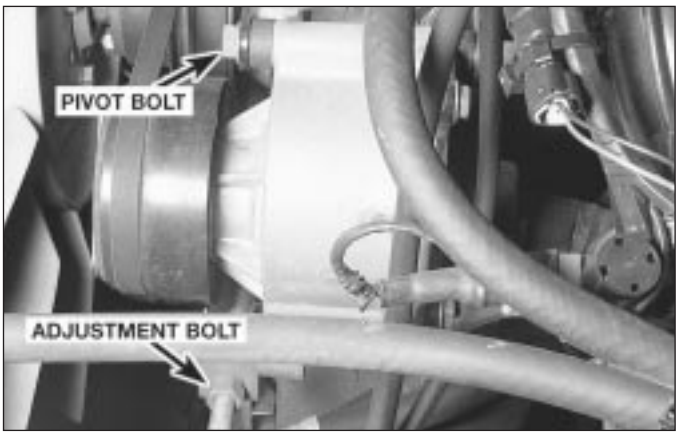
8 Disconnect the electrical connector from the air pump clutch.

9 Loosen the clips from the air inlet and outlet hose and separate them from the air injection pump.

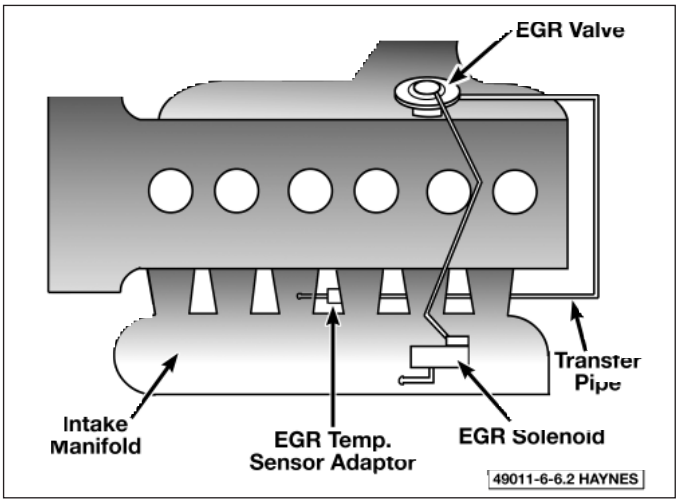
10 Loosen the adjuster and pivot bolts **(see illustration)** and nuts but do not remove them from the air injection pump brackets.



5.6 Location of the AIR diverter valve on a 1992 model - check the hoses for cracking and the electrical connector for security



5.10 Loosen the pivot bolt and then the adjustment nut to remove the drivebelt from the air pump. The adjustment nut has a lock bolt that must be loosened before the pump will move down the adjuster



6.2 Schematic of the EGR system

6.4 Apply vacuum to the EGR valve and confirm that the valve opens and allows exhaust gases to circulate. Once it is activated, the EGR valve should hold steady (no loss in vacuum)

11 Swing the pump toward the engine and remove the drivebelt from the pump.
12 Remove the link arm through-bolt.
13 Remove the pivot bolt and front spacer, rear cone and air injection pump from the engine compartment.
14 Remove the nut securing the front pulley on the air injection pump.
15 Remove the clutch snap-ring and the clutch.
16 Refitting is the reverse of removal.

6 Exhaust Gas Recirculation (EGR) system

Note 1: *Some 1990 models have the EGR vacuum hose routed incorrectly through the bulkhead securing straps, thereby restricting the vacuum signal to the EGR valve. Remove the EGR vacuum hose from the bulkhead harness and refit a new hose. Secure it to the engine compartment using tie-wraps and do not allow any restrictions in the hose.*

Note 2: *Some models have copper sealing washers that soften and leak around the EGR valve causing engine performance and starting problems. Refit steel washers and pipe adapters into the EGR system. Contact a Jaguar dealer for the VIN numbers and years of the models that are affected by this defect.*
1 To reduce oxides of nitrogen emissions, some of the exhaust gases are recirculated through the EGR valve to the intake manifold to lower combustion temperatures.
2 The EGR system consists of the EGR valve, an EGR solenoid, an EGR gas temperature sensor and the transfer pipe **(see illustration)**.

Check

EGR valve

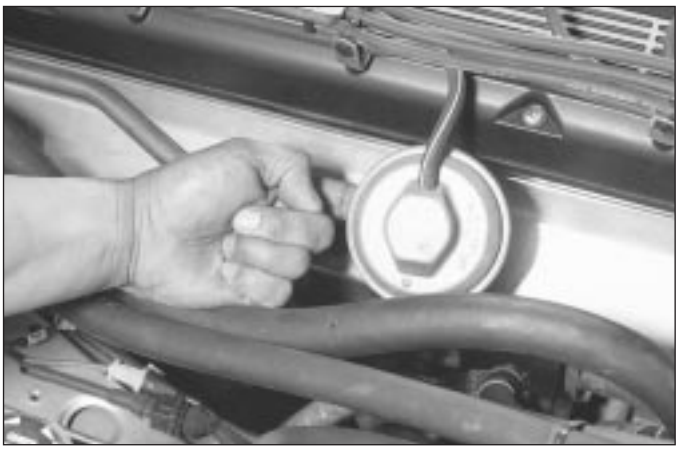
3 Start the engine and allow it to idle.
4 Detach the vacuum hose from the EGR valve and attach a hand vacuum pump in its place **(see illustration).**
5 Apply vacuum to the EGR valve. Vacuum should remain steady and the engine should run poorly. **Note:** *This action will raise the pintle and allow exhaust gases to recirculate into the intake system and cause rough running condition at idle.* Double-check the movement of the pintle by checking the diaphragm using the tip of your finger **(see illustration)**. If the EGR diaphragm moves smoothly and holds steady when vacuum is applied, the EGR valve is working properly.

Warning: Don't burn yourself. If the EGR valve is hot, wear a glove or wait until it cools.

a) If the vacuum doesn't remain steady and the engine doesn't run poorly, renew the EGR valve and recheck it.
b) If the vacuum remains steady but the engine doesn't run poorly, remove the EGR valve and check the valve and the intake manifold for blockage. Clean or renew parts as necessary and recheck.

EGR system

6 Disconnect the hose from the EGR valve, refit a vacuum gauge and check for vacuum to the EGR valve. There should be vacuum present with the engine warmed to operating temperature (above 140° F) and between 1000 and 4000 rpm **(see illustration).**



6.5 Use a fingertip to move the diaphragm inside the EGR valve

6.6 Check for vacuum to the EGR valve from the throttle body

6.8 Check for battery voltage to the EGR control solenoid

7 Start the engine and observe the vacuum gauge. At idle, there should be no vacuum present. Raise the engine rpm and observe the vacuum increase. This is a ported vacuum source and therefore it should only register vacuum when throttled.

8 Check the operation of the EGR control solenoid. Check for battery voltage to the EGR control solenoid harness **(see illustration)**. If battery voltage is not available, check the harness. Refer to the wiring diagrams at the end of Chapter 12.

9 If battery voltage is available to the EGR control solenoid, have the EGR system diagnosed by a dealer service department or other qualified repair workshop.

EGR valve renewal

10 Detach the vacuum hose, disconnect the fitting that attaches the EGR pipe to the EGR valve and remove the EGR valve from the exhaust manifold and check it for sticking and heavy carbon deposits. If the valve is sticking or clogged with deposits, clean or renew it.

11 Refitting is the reverse of removal.

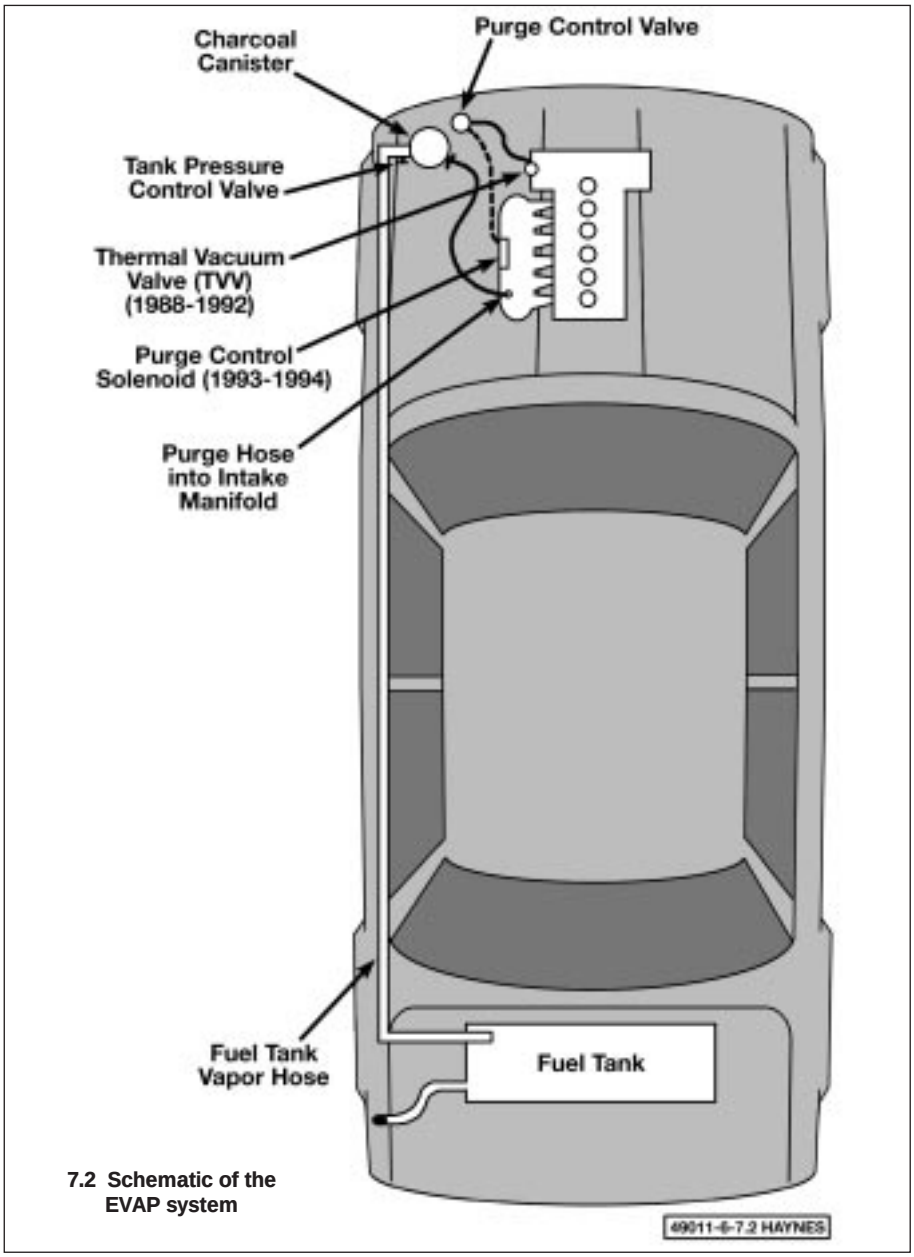
7 Evaporative Emission Control (EVAP) system

Note: *Some models may have charcoal canister vent plugs installed in the canister from the factory. These blanking plugs must be removed to allow proper pressure and release within the EVAP system. Check the charcoal canister for these additional plugs and remove them. With the blanking plugs installed, the fuel tank will collapse causing rough running and hesitation and loss of power under load.*

General description

1 This system is designed to trap and store fuel that evaporates from the fuel tank, throttle body and intake manifold that would normally enter the atmosphere in the form of hydrocarbon (HC) emissions.

2 The Evaporative Emission Control (EVAP) system consists of a charcoal-filled canister, the lines connecting the canister to the fuel tank, tank pressure control valve, purge control valve and thermal vacuum valve (TVV) **(see illustration)**. **Note:** *1993 and 1994 models have a purge control solenoid that is controlled by the ECU. This solenoid switches vacuum to the purge control valve.*



7.2 Schematic of the EVAP system

3 Fuel vapours are transferred from the fuel tank and throttle body to a canister where they're stored when the engine isn't running. When the engine is running, the fuel vapours are purged from the canister by intake airflow and consumed in the normal combustion process. **Note:** *The ECU will set a code 89 if the purge control valve is defective or the circuit has shorted.*

4 The fuel tank is equipped with a pressure control valve. This valve opens and closes according to the pressure increase and decrease in the fuel tank.

Check

5 Poor idle, stalling and poor driveability can all be caused by an inoperative pressure relief valve, split or cracked hoses or hoses connected to the wrong fittings. Check the fuel tank filler cap for a damaged or deformed gasket.

6 Evidence of fuel loss or fuel odour can be caused by liquid fuel leaking from fuel lines, a cracked or damaged canister, an inoperative fuel tank control valve, disconnected, misrouted, kinked, deteriorated or damaged vapour or control hoses.

7 Inspect each hose attached to the canister for kinks, leaks and cracks along its entire length. Repair or renew as necessary.

8 Look for fuel leaking from the bottom of the

7.11a Check for vacuum to the thermal vacuum valve (TVV)

7.11b Check for vacuum from the TVV before and after the engine has reached normal operating temperature

7.12 Remove the front spoiler to gain access to the purge control valve (see Chapter 11). Apply vacuum to the valve and make sure the valve holds vacuum

7.14 Remove the bolts (arrowed) and lower the charcoal canister from the wing

canister. If fuel is leaking, renew the canister and check the hoses and hose routing.

9 Inspect the canister. If it's cracked or damaged, renew it.

10 Check for a clogged filter or a damaged pressure relief valve. Using low pressure compressed air (such as from a tyre pump), blow into the canister tank pipe. Air should flow freely from the other pipes. If a problem is found, renew the canister.

11 Check the operation of the thermal vacuum valve (TVV). With the engine cold and idling, check for ported vacuum to the temperature vacuum switch. Vacuum should be present **(see illustration)**. Now warm the engine to operating temperature (above 115°F/43°C) and confirm that ported vacuum passes through the TVV **(see illustration)**. Renew the valve if the test results are incorrect.

12 Check the operation of the purge control valve. Apply vacuum to the purge control valve using a hand-held vacuum pump and observe that the valve holds vacuum steadily **(see illustration)**. If the valve holds vacuum and the valve is opening, it is working properly.

Charcoal canister renewal

13 Clearly label, then detach the vacuum hoses from the canister.

14 Remove the mounting clamp bolts **(see illustration)**, lower the canister with the bracket, disconnect the hoses from the check valve and remove it from the vehicle.

15 Refitting is the reverse of removal.

8 Crankcase ventilation system

General information

1 The crankcase ventilation system reduces hydrocarbon emissions by scavenging crankcase vapours. It does this by circulating fresh air from the air cleaner through the crankcase, where it mixes with blow-by gases and is then re-routed through a heating element to the intake manifold **(see illustration).**

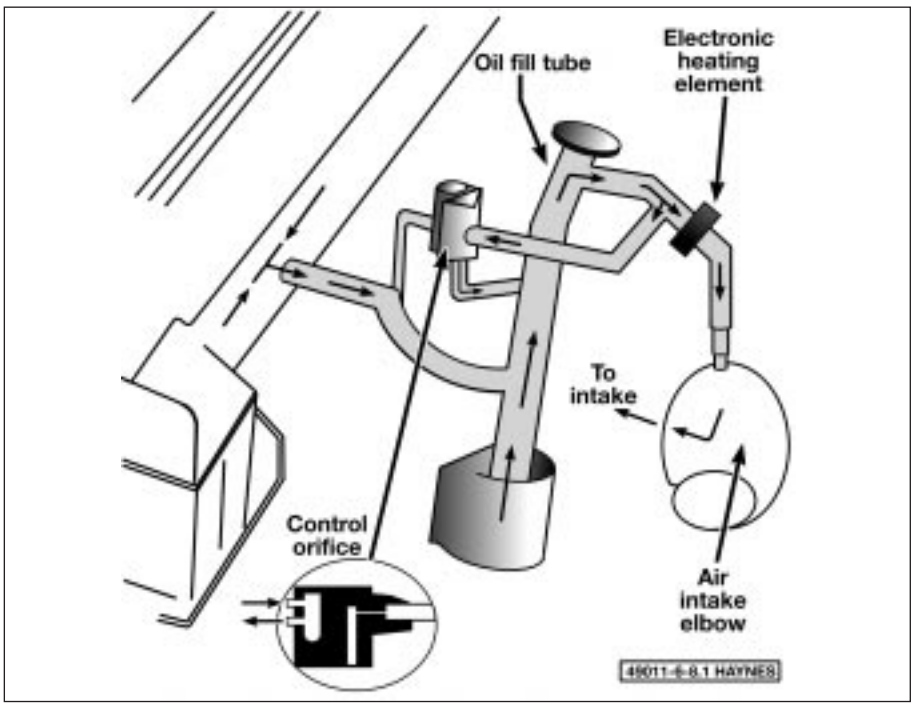
2 The main components of the crankcase ventilation system are the control orifice, a heating element and the vacuum hoses connecting these components with the engine.

3 Piston blow-by gasses are collected from the crankcase and the camshaft housing via the oil filler tube. These gasses are fed into the intake manifold at part throttle through the part throttle orifice and when the engine is at full throttle, the gasses are fed through the air intake elbow.

4 To prevent possible icing-up during cold weather operation, the control orifice and the hose to the intake system is electronically heated. The heater element is energised by a relay signal from the windscreen washer jet temperature sensor.

Check

5 Remove the tubes and elbows that connect the crankcase ventilation system and inspect them for obstructions, oil deposits or clogging. Make sure the ventilation system is free of all



8.1 Schematic of the crankcase ventilation system

8.7 Disconnect the electrical connector from the electronic heating element

obstructions to ensure complete recirculation of gasses from the crankcase back into the intake manifold. In the event of clogging, the pressure will increase causing blow-by and oil leaks through seals and gaskets.

6 Check the operation of the heating element. Check for battery voltage to the element while the engine is cold. If no voltage is available to the heating element, check the circuit from the windscreen washer jet temperature sensor.

Renewal

7 Disconnect the electrical connector from the heating element **(see illustration)**.

8 Remove the clamps from the hoses and separate the heating element from the engine.

9 Remove the hoses from the intake manifold. These crankcase ventilation hoses are specially formed and must be replaced with special factory parts from Jaguar.

10 Refitting is the reverse of removal.

9 Catalytic converter

General description

1 To reduce hydrocarbon, carbon monoxide and oxides of nitrogen emissions, all vehicles are equipped with a three-way catalyst system which oxidises and reduces these chemicals, converting them into harmless nitrogen, carbon dioxide and water.

2 The catalytic converter fits into the exhaust system much like a silencer. **Note:** *The exhaust system configuration changes with later model updates. Older models (1988 and 1989) are equipped with a pre-catalytic converter near the exhaust manifold incorporating a single exhaust pipe to the silencer. Later models are equipped with dual exhaust pipes, dual catalytic converters and dual silencers.*

Check

3 Periodically inspect the catalytic converter-to-exhaust pipe mating flanges and bolts. Make sure that there are no loose bolts and no leaks between the flanges.

4 Look for dents in or damage to the catalytic converter protector. If any part of the protector is damaged or dented enough to touch the converter, repair or renew it.

5 Inspect the heat insulator for damage. Make sure there is enough clearance between the heat insulator and the catalytic converter.

Renewal

6 To renew the catalytic converter, refer to Chapter 4. It is recommended that catalytic converters be renewed at a qualified silencer workshop because of the numerous tack welds on the exhaust pipes.