






Chapter 6

Engine management and emission control systems

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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	
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1 General information

To prevent pollution of the atmosphere from incomplete combustion or evaporation of the fuel, and to maintain good driveability and fuel economy, a number of emission control systems are used on these vehicles. Not all of these systems are fitted to all models, but they include the following:

Catalytic converter

Evaporative emission control (EVAP) system

Positive crankcase ventilation (PCV) system

Electronic engine management

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

Before assuming that an emissions control system is malfunctioning, check the fuel and ignition systems carefully. 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 your ability, consult a dealer service department or other specialist.

HAYNES
HINT

The most frequent cause of emission system problems is simply a leaking vacuum hose or loose wire, so always check the hose and wiring connections first.

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

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 fitted on your vehicle because of changes made by the manufacturer during production.

2 Motronic engine management system self-diagnosis - general information

The Motronic engine management system control unit (computer) has a built-in self-diagnosis system, which detects malfunctions in the system sensors and stores them as fault codes in its memory. It is not possible without dedicated test equipment to extract these fault codes from the control unit. However, the procedures given in Chapters 4 and 5 may be used to check individual components and sensors of the Motronic system. If this fails to pinpoint a fault, then the vehicle should be taken to a BMW dealer, who will have the necessary diagnostic equipment to call up the fault codes from the control unit. You will then have the option to repair the fault yourself, or alternatively have the fault repaired by the BMW dealer.

3 Electronic control unit (ECU) - removal and refitting

Removal

1 The Electronic Control Unit (ECU) is located either inside the passenger compartment under the right-hand side of the facia panel on 3-Series models, or in the engine compartment on the right-hand side on 5-Series models (see Chapter 4).

2 Disconnect the battery negative cable.

Caution: *If the radio in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery. Refer to the information on page 0-7 at the front of this manual before detaching the cable.*

Note: *If, after connecting the battery, the wrong language appears on the instrument panel display, refer to page 0-7 for the language resetting procedure.*

3 First remove the access cover on models with the ECU on the right-hand side of the engine compartment (see Chapter 4).

4 If the ECU is located inside the vehicle, remove the access cover on the right-hand side.

5 Unplug the electrical connectors from the ECU.

6 Remove the retaining bolts from the ECU bracket.

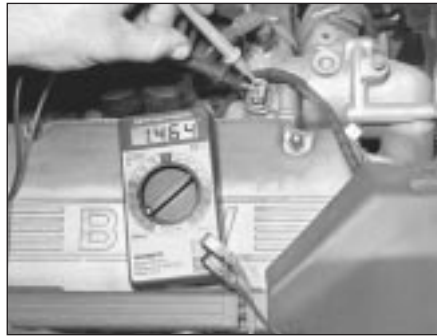
7 Carefully remove the ECU. **Note:** *Avoid static electricity damage to the ECU by wearing rubber gloves, and do not touch the connector pins.*

Refitting

8 Refitting is a reversal of removal.



4.1 The coolant temperature sensor (arrowed) is usually located next to the temperature sender unit, near the fuel pressure regulator



4.2 Check the resistance of the coolant temperature sensor at different temperatures



4.6 The oxygen sensor (arrowed) is usually located in the exhaust pipe, downstream from the exhaust manifold

4 Information sensors



Note: Refer to Chapters 4 and 5 for additional information on the location and diagnosis of the information sensors that are not covered in this Section.

Coolant temperature sensor

General description

1 The coolant temperature sensor (see illustration) is a thermistor (a resistor which varies its resistance value in accordance with temperature changes). The change in the resistance value regulates the amount of voltage that can pass through the sensor. At low temperatures, the sensor's resistance is high. As the sensor temperature increases, its resistance will decrease. Any failure in this sensor circuit will in most cases be due to a loose or shorted-out wire; if no wiring problems are evident, check the sensor as described below.

Check

2 To check the sensor, first check its resistance (see illustration) when it is completely cold (typically 2100 to 2900 ohms). Next, start the engine and warm it up until it reaches operating temperature. The resistance should be lower (typically 270 to 400 ohms).

Note: If restricted access to the coolant temperature sensor makes it difficult to attach electrical probes to the terminals, remove the sensor as described below, and perform the tests in a container of heated water to simulate the conditions.



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

Renewal

3 To remove the sensor, depress the spring lock, unplug the electrical connector, then carefully unscrew the sensor. Be prepared for some coolant spillage; to reduce this, have the new sensor ready for fitting as quickly as possible.



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

Note: It may be necessary to drain a small amount of coolant from the radiator before removing the sensor.

4 Before the sensor is fitted, ensure its threads are clean, and apply a little sealant to them.

5 Refitting is the reverse of removal.

Oxygen sensor

General description

Note: Oxygen sensors are normally only fitted to those vehicles equipped with a catalytic converter. Most oxygen sensors are located in the exhaust pipe, downstream from the exhaust manifold. On 535 models, the oxygen sensor is mounted in the catalytic converter. The sensor's electrical connector is located near the bulkhead (left side) for easy access.

6 The oxygen sensor, which is located in the exhaust system (see illustration), monitors the oxygen content of the exhaust gas. 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. It is this ratio of 14.7 to 1 which the ECU and the oxygen sensor attempt to maintain at all times.

7 The oxygen sensor produces no voltage when it is below its normal operating temperature of about 320° C. During this initial period before warm-up, the ECU operates in "open-loop" mode (ie without the information from the sensor).

8 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 rpm or greater, the ECU fault code memory will be activated.

9 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 with feedback information from the oxygen sensor.

10 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 disturbed, 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 320° C. 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.

11 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 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.*
- e) *The silicone boot must be fitted in the correct position, to prevent the boot from being melted and to allow the sensor to operate properly.*



4.12a The oxygen sensor, once it is warmed up (320° C), puts out a very small voltage signal. To verify it is working, check for voltage with a digital voltmeter (the voltage signals usually range from 0.1 to 1.0 volt)

Check

12 Warm up the engine, and let it run at idle. Disconnect the oxygen sensor electrical connector, and connect the positive probe of a voltmeter to the oxygen sensor output connector terminal (refer to the following table) and the negative probe to earth (see illustrations).

Note: Most oxygen sensor electrical connectors are located at the rear of the engine, near the bulkhead. Look for a large rubber boot attached to a thick wire harness. On early 535i models, the connector for the oxygen sensor heater circuit is under the vehicle. Look for a small protective cover. These models should have the updated oxygen sensor fitted, to make access similar to other models. Consult your dealer service department for additional information.

13 Increase and then decrease the engine speed, and monitor the voltage.

14 When the speed is increased, the voltage should increase to 0.5 to 1.0 volts. When the speed is decreased, the voltage should fall to about 0 to 0.4 volts.

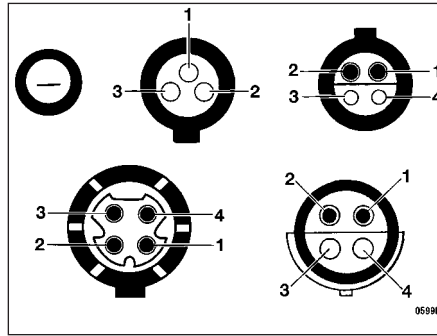
15 Also where applicable, inspect the oxygen sensor heater (models with multi-wire sensors). With the ignition on, disconnect the oxygen sensor electrical connector, and connect a voltmeter across the terminals designated in the chart (see below). There should be battery voltage (approximately 12 volts).

16 If the reading is not correct, check the oxygen sensor heater relay (see Chapter 12). If the information is not available, check the owner's handbook for the exact location of the oxygen sensor heater relay. The relay should receive battery voltage.

17 If the oxygen sensor fails any of these tests, renew it.

Renewal

Note: Because it is fitted in the exhaust manifold, converter 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



4.12b These oxygen sensor terminal designations are for the harness side only. Use the corresponding terminals on the sensor side for the testing procedures (there are three different four-wire oxygen sensor connectors available - don't get them mixed up)

(assuming you are planning to re-use it in another manifold or pipe), start and run the engine for a minute or two, then switch it off. Be careful not to burn yourself during the following procedure.

18 Disconnect the battery negative cable.



Caution: If the radio in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code

before disconnecting the battery. Refer to the information on page 0-7 at the front of this manual before detaching the cable.

Note: If, after connecting the battery, the wrong language appears on the instrument panel display, refer to page 0-7 for the language resetting procedure.

19 Raise and support the vehicle.

20 Disconnect the electrical connector from the sensor.

21 Carefully unscrew the sensor.



Caution: Excessive force may damage the threads.

22 A high-temperature 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 refitted, recoat the threads.

- 23 Refit the sensor and tighten it securely.
- 24 Reconnect the electrical connector of the pigtail lead to the main engine wiring harness.
- 25 Lower the vehicle, and reconnect the battery.

Oxygen sensor type	Sensor output signal	Heated power supply (12V)
Unheated (single-wire)	black wire (+)	Not applicable
Heated (three-wire)	terminal 1 (+)	terminals 3 (+) and 2 (-)
Heated (four-wire)	terminal 2 (+)	terminals 4 (+) and 3 (-)

Throttle Position Sensor (TPS)

General description

26 The Throttle Position Sensor (TPS) is located on the end of the throttle shaft on the throttle body. By monitoring the output voltage from the TPS, the ECU can determine fuel delivery based on throttle valve angle (driver demand). In this system, the TPS acts as a switch rather than a potentiometer. One set of throttle valve switch contacts is closed (continuity) only at idle. A second set of contacts closes as the engine approaches full-throttle. Both sets of contacts are open (no continuity) between these positions. A broken or loose TPS can cause intermittent bursts of fuel from the injector and an unstable idle, because the ECU thinks the throttle is moving.

27 All models (except for early 535i models with automatic transmission) combine the idle and full-throttle switch; a separate idle position switch indicates the closed-throttle position, while the TPS is used for the full-throttle position. On 535i models with automatic transmission, the TPS is connected directly to the automatic transmission control unit. With the throttle fully open, the transmission control unit sends the full-throttle signal to the Motronic control unit.

All models except early 535i with automatic transmission

Check

28 Remove the electrical connector from the TPS, and connect an ohmmeter to terminals 2 and 18 (see illustrations). Open the throttle



4.28a The TPS on L-Jetronic systems is located under the intake manifold (terminals arrowed)



4.28b First check for continuity between terminals 2 and 18 with the throttle closed (later Motronic system shown) . . .



4.28c ... then check for continuity between terminals 3 and 18 as the throttle is opened

slightly by hand. Release the throttle slowly until it reaches 0.2 to 0.6 mm from the throttle stop. There should be continuity.

29 Check the resistance between terminals 3 and 18 as the throttle is opened. There should be continuity when the throttle switch is within 8 to 12 degrees of fully-open. If the readings are incorrect, adjust the TPS.

30 If all the resistance readings are correct and the TPS is properly adjusted, check for power (5 volts) at the sensor, and if necessary trace any wiring circuit problems between the sensor and ECU (see Chapter 12).

Adjustment

31 If the adjustment is not as specified (paragraphs 28 to 30), loosen the screws on the TPS, and rotate the sensor into the correct adjustment. Follow the procedure for checking the TPS given above, and tighten the screws when the setting is correct.

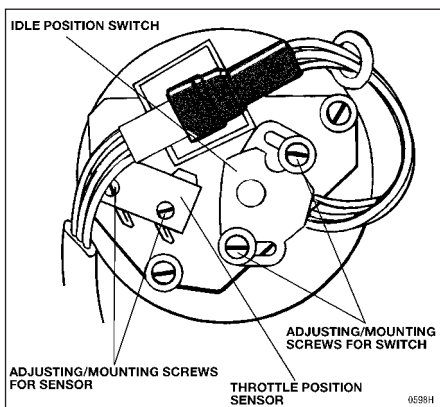
32 Recheck the TPS once more; if the readings are correct, reconnect the TPS harness connector.

Early 535i models with automatic transmission

Check

33 First test the continuity of the TPS. Follow paragraphs 28 to 30 and check for continuity.

34 Next, test the idle position switch (see illustration). Unplug the electrical connector in the idle position switch harness, and



4.34 Idle position switch and TPS on early 535i models with automatic transmission

connect an ohmmeter to terminals 1 and 2. There should be continuity. Open the throttle slightly, and measure the resistance. There should now be no continuity.

35 Check for the correct voltage signals from the TPS, with the throttle closed and the ignition on. Probe the back of the TPS connector with a voltmeter, and check for voltage at terminal 3 (black wire) and earth. There should be 5 volts present. Also, probe terminal 3 (black wire) and terminal 1 (brown wire). There should be 5 volts present here also.

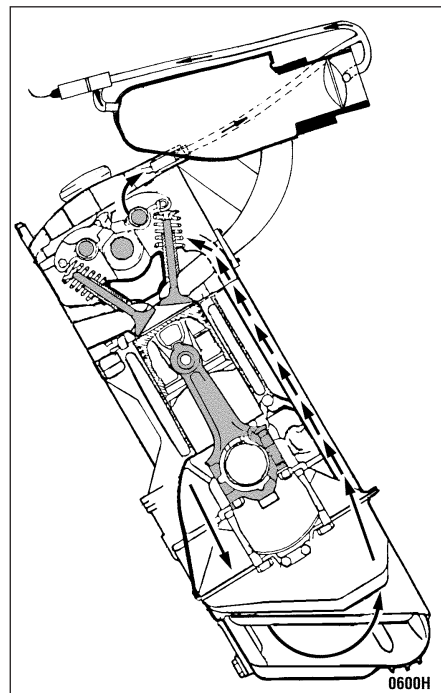
36 Check for voltage at terminal 2 (yellow wire) and terminal 1 (brown wire), and slowly open the throttle. The voltage should increase steadily from 0.7 volts (throttle closed) to 4.8 volts (throttle fully-open).

Adjustment

37 First measure the stabilised voltage. With the ignition on and the throttle closed, measure the voltage between terminal 3 (black wire) and terminal 1 (brown wire). It should be about 5 volts.

38 Next, loosen the sensor mounting screws, and connect the voltmeter to terminal 2 (yellow wire) and terminal 3 (black wire). With the throttle fully open, rotate the switch until there is 0.20 to 0.24 volts less than the stabilised voltage. **Note:** You will need a digital voltmeter to measure these small changes in voltage.

39 Recheck the TPS once more; if the readings are correct, reconnect the TPS electrical connector. It is a good idea to lock the TPS screws with paint or thread-locking compound.



5.1 Diagram of the PCV system on the M20 engine (others similar)

Airflow meter

General description

40 The airflow meter is located on the air intake duct. The airflow meter measures the amount of air entering the engine. The ECU uses this information to control fuel delivery. A large volume of air indicates acceleration, while a small volume of air indicates deceleration or idle. Refer to Chapter 4 for all the diagnostic checks and renewal procedures for the airflow meter.

Ignition timing sensors

41 Ignition timing is electronically-controlled on Motronic systems, and is not adjustable. During starting, a crankshaft position sensor relays the crankshaft position to the ECU, and an initial baseline ignition point is determined. Once the engine is running, the ignition point is continually changing based on the various input signals to the ECU. Engine speed is signalled by a speed sensor. Early Motronic systems have the reference sensor and the speed sensor mounted on the bellhousing over the flywheel. Later Motronic systems have a single sensor (pulse sensor) mounted over the crankshaft pulley. This sensor functions as a speed sensor as well as a position sensor. Refer to Chapter 5 for more information. **Note:** Some models are equipped with a TDC sensor mounted on the front of the engine. This sensor is strictly for the BMW service test unit, and it is not part of the Motronic ignition system.

5 Positive crankcase ventilation (PCV) system

1 The Positive Crankcase Ventilation (PCV) system (see illustration) reduces hydrocarbon emissions by scavenging crankcase vapours. It does this by circulating blow-by gases and then re-routing them to the intake manifold by way of the air cleaner.

2 This PCV system is a sealed system. The crankcase blow-by vapours are routed directly to the air cleaner or air collector with crankcase pressure behind them. The vapour is not purged with fresh air on most models or



5.2 PCV hose being removed from the valve cover



5.3 It's a good idea to check for excess residue from the crankcase vapours circulating in the hoses and ports - this can eventually clog the system, and cause a pressure increase in the engine block

filtered with a flame trap like most conventional systems. There are no conventional PCV valves fitted on these systems - just a hose (see illustration).

3 The main components of the PCV system are the hoses that connect the valve cover to the throttle body or air cleaner. If abnormal operating conditions (such as piston ring problems) arise, the system is designed to allow excessive amounts of blow-by gases to flow back through the crankcase vent tube into the intake system, to be consumed by normal combustion. **Note:** Since these models don't use a filtering element, it's a good idea to check the PCV system passageways for clogging from sludge and combustion residue (see illustration).

6 Evaporative emissions control (EVAP) system

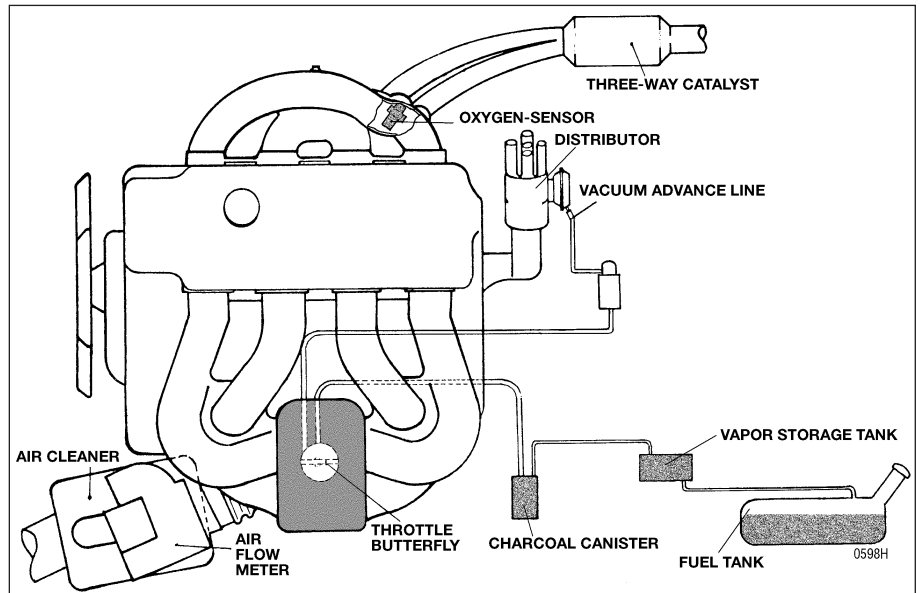


General description

Note: This system is normally only fitted to those vehicles equipped with a catalytic converter.

1 When the engine isn't running, the fuel in the fuel tank evaporates to some extent, creating fuel vapour. The evaporative emissions control system (see illustration) stores these fuel vapours in a charcoal canister. When the engine is cruising, the purge control valve is opened slightly, and a small amount of fuel vapour is drawn into the intake manifold and burned. When the engine is starting cold or idling, the purge valve prevents any vapours from entering the intake manifold and causing excessively-rich fuel mixture.

2 Two types of purge valve are used; electrically-operated or vacuum-operated. To find out which type is on your vehicle, follow the hose from the charcoal canister until you locate the purge valve. Some are located on the intake manifold, and others near the charcoal canister. Look for either an electrical connector, or vacuum lines, to the purge valve.



6.1 Diagram of the EVAP system on the M10 engine (others similar)

3 A faulty EVAP system will only affect engine driveability when the engine is warm. The EVAP system is not usually the cause of difficult cold starting or any other cold-running problems.

Check

Vacuum-operated purge valve

4 Remove the vacuum lines from the purge valve, and blow into the larger valve port. It should be closed, and not pass any air. **Note:** Some models have a thermo-vacuum valve that delays canister purging until the coolant temperature reaches approximately 46° C. Check this valve to make sure that vacuum is controlled at the proper temperatures. The valve is usually located in the intake manifold, near the thermo-time switch and the coolant temperature sensor.

5 Disconnect the small vacuum hose from the purge valve, and apply vacuum with a hand-held vacuum pump. The purge valve should be open, and air should be able to pass through.



6.8 When the ignition is switched on, there should be a distinct "click" from the purge valve

6 If the test results are unsatisfactory, renew the purge valve.

Electrically-operated purge valve

7 Disconnect any lines from the purge valve, and (without disconnecting the electrical connector) place it in a convenient spot for testing.

8 Check that the valve makes a "click" sound as the ignition is switched on (see illustration).

9 If the valve does not "click", disconnect the valve connector, and check for power to the valve using a test light or a voltmeter (see illustration).

10 If battery voltage is present, but the valve does not work, renew it. If there is no voltage present, check the Motronic control unit and the wiring.

Canister

11 Mark all the hoses for position, then detach them from the canister.

12 Slide the canister out of its mounting clip.



6.9 Check for battery voltage at the electrical connector to the purge valve



6.12 EVAP system charcoal canister viewed from under the vehicle (316i model)

On some models, it will be necessary to release the retaining clip (see illustration).

13 Visually examine the canister for leakage or damage.

14 Renew the canister if you find evidence of damage or leakage.

7 Catalytic converter



General description

1 To reduce emissions of unburnt hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx), the later vehicles covered by this manual are equipped with a catalytic converter (see illustration). The converter contains a ceramic honeycomb coated with precious metals, which speed up the reaction between the pollutants listed previously and the oxygen in the exhaust gas. The pollutants are oxidised to produce water (H₂O), nitrogen and carbon dioxide (CO₂).

Check

2 Visually examine the converter(s) for cracks or damage. Make sure all nuts and bolts are tight.

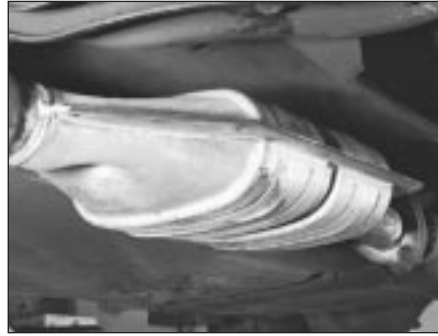
3 Inspect the insulation cover (if applicable) welded onto the converter - it should not be loose.



Caution: If an insulation cover is dented so that it touches the converter housing inside, excessive heat may be transferred to the floor.

4 Start the engine and run it at idle speed.

5 Check for exhaust gas leakage from the converter flanges. Check the body of each converter for holes.



7.1 Typical catalytic converter (M10 engine type shown, others similar)

Component renewal

6 See Chapter 4 for removal and refitting procedures.

Precautions

7 The catalytic converter is a reliable and simple device, which needs no maintenance in itself, but there are some facts of which an owner should be aware, if the converter is to function properly for its full service life.

- (a) *DO NOT use leaded (eg UK "4-star") petrol in a car equipped with a catalytic converter - the lead will coat the precious metals, reducing their converting efficiency, and will eventually destroy the converter.*
- (b) *Always keep the ignition and fuel systems well-maintained in accordance with the manufacturer's schedule, as given in Chapter 1. In particular, ensure that the air cleaner filter element, the fuel filter (where fitted) and the spark plugs are renewed at the correct interval. If the intake air/fuel mixture is allowed to become too rich due to neglect, unburned fuel will enter the catalytic converter, overheating the element and eventually destroying the converter.*
- (c) *If the engine develops a misfire, do not drive the car at all (or at least as little as possible) until the fault is cured - the misfire will allow unburned fuel to enter the converter, which will result in its overheating, as noted above.*
- (d) *DO NOT push- or tow-start the car - this will soak the catalytic converter in unburned fuel, causing it to overheat when the engine does start - see (b) or (c) above.*
- (e) *DO NOT switch off the ignition at high engine speeds - ie do not "blip" the throttle immediately before switching off*

the engine. If the ignition is switched off at anything above idle speed, unburned fuel will enter the (very hot) catalytic converter, with the possible risk of its igniting on the element and damaging the converter.

- (f) *DO NOT use fuel or engine oil additives - these may contain substances harmful to the catalytic converter.*
- (g) *DO NOT continue to use the car if the engine burns oil to the extent of leaving a visible trail of blue smoke - the unburned carbon deposits will clog the converter passages, and reduce its efficiency; in severe cases, the element will overheat.*
- (h) *Remember that the catalytic converter operates at very high temperatures - hence the heat shields on the car's underbody - and the casing will become hot enough to ignite combustible materials which brush against it. DO NOT, therefore, park the car in dry undergrowth, or over long grass or piles of dead leaves.*
- (i) *Remember that the catalytic converter is FRAGILE - do not strike it with tools during servicing work, and take great care when working on the exhaust system. Ensure that the converter is well clear of any jacks or other lifting gear used to raise the car, and do not drive the car over rough ground, road humps, etc, in such a way as to "ground" the exhaust system.*
- (j) *In some cases, particularly when the car is new and/or is used for stop/start driving, a sulphurous smell (like that of rotten eggs) may be noticed from the exhaust. This is common to many catalytic converter-equipped cars, and seems to be due to the small amount of sulphur found in some petrols reacting with hydrogen in the exhaust, to produce hydrogen sulphide (H₂S) gas; while this gas is toxic, it is not produced in sufficient amounts to be a problem. Once the car has covered a few thousand miles, the problem should disappear - in the meanwhile, a change of driving style, or of the brand of petrol used, may effect a solution.*
- (k) *The catalytic converter, used on a well-maintained and well-driven car, should last for 50 000 to 100 000 miles - from this point on, the CO level should be carefully checked regularly, to ensure that the converter is still operating efficiently. If the converter is no longer effective, it must be renewed.*