DUCATO 2.0 JTD 8V BOSCH EDC ELECTRONICALLY-CONTROLLED FUEL SYSTEM

INTRODUCTION

New Ducato 2000 JTD vehicles are equipped with a 1997 cc 4 cylinder in-line turbodiesel engine with two valves per cylinder and one overhead camshaft, air turbocharging by means of a turbocharger and intercooler and electronic direct injection.
The fuel system ensures the engine operates correctly and may be schematically broken down into the following circuits:

- fuel supply circuit with Common Rail injection;
- air supply circuit;
- exhaust circuit;
- crankcase oil vapour recirculation circuit;
- exhaust gas recirculation circuit (EGR).

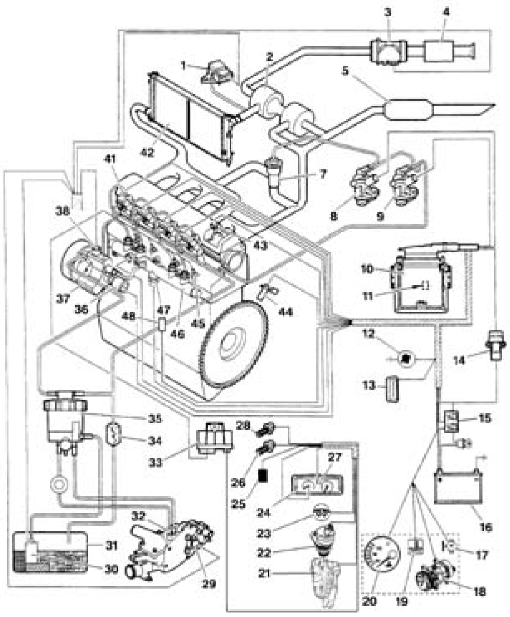
Operation of the various circuits that make up the fuel system is optimised by an electronic control system managed by a special control unit.
The main feature of the fuel system is Common Rail fuel injection. The Common Rail system is a high pressure electronic injection circuit for fast diesel engines.
The main features of the Common Rail system are as follows:

- availability of high pressure (up to 1350 bars);
- possibility of modulating these pressures (from a minimum of 150 bars to a maximum of 1350 bars) independently of engine rotation speed (rpm) and load;
- ability to work at high engine rpms (up to 6000 rpm);
- injection control precision (injection advance and duration);

The engine control unit records the following parameters (INPUT):

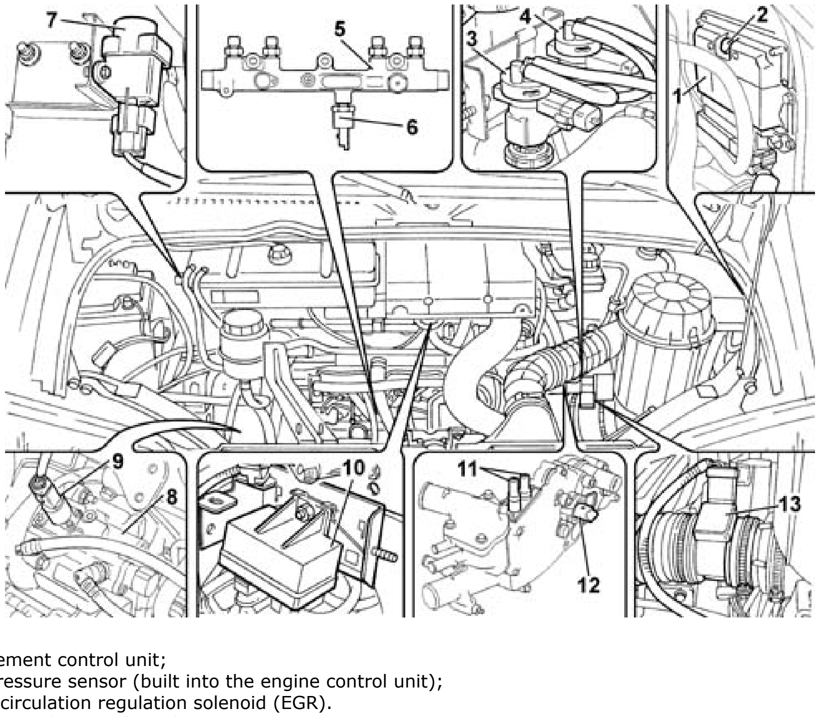
- engine speed;
- engine timing;
- intake air flow;
- coolant temperature;
- air temperature;
- fuel temperature;
- fuel pressure;
- atmospheric pressure;
- intake manifold pressure;
- accelerator pedal position;
- brake and/or clutch pedal operation.

The control unit memory contains a management program (software) that includes a set of strategies, each of which manages a specific system control function.
Each strategy uses information provided by the various sensors (input) to process a set of parameters that are based on data maps stored in the control unit. The control unit then manages system actuators (output), i.e. the devices that allow the engine to operate.



- 1 - Intake manifold pressure sensor;
- 2 - Turbocharger;
- 3 - Air flow meter with air temperature sensor;
- 4 - Air cleaner;
- 5 - Catalytic converter;
- 6 - Not connected;

- 7 - Exhaust gas recirculation valve (EGR).
- 8 - Exhaust gas recirculation regulation solenoid (EGR).
- 9 - Turbo pressure regulation solenoid;
- 10 - Engine management control unit;
- 11 - Atmospheric pressure sensor (built into the engine control unit);
- 12 - Diagnostics warning light;
- 13 - Centralised tester input;
- 14 - Inertia switch;
- 15 - Main relay;
- 16 - Battery;
- 17 - Electric fan;
- 18 - Climate control system compressor;
- 19 - Engine coolant temperature warning light;
- 20 - Engine coolant temperature gauge;
- 21 - Accelerator pedal position sensor;
- 22 - Vehicle speed sensor;
- 23 - Preheating warning light;
- 24 - Electronic rev counter;
- 25 - Engine immobiliser;
- 26 - Brake pedal switch;
- 27- On-board computer;
- 28 - Clutch pedal switch;
- 29 - Engine coolant temperature sensor;
- 30 - Filler pump (low pressure);
- 31 - Fuel tank;
- 32 - Fuel heater;
- 33 - Pre-postheating control unit;
- 34 - Fuel radiator;
- 35 - Fuel filter;
- 36 - High pressure regulator;
- 37 - High pressure pump;
- 38 - High pressure pump third piston deactivator;
- 39 - Damper;
- 40 - Not connected;
- 45 - Preheating spark plugs;
- 41 - Injectors;
- 42 - Air/air heat exchanger;
- 43 - Engine timing sensor;
- 44 - Engine speed sensor;
- 46 - Fuel manifold;
- 47 - Fuel high pressure sensor;
- 48 - Fuel temperature sensor;



- 1 - Engine management control unit;
- 2 - Atmospheric pressure sensor (built into the engine control unit);
- 3 - Exhaust gas recirculation regulation solenoid (EGR).
- 4 - Turbo pressure regulation solenoid;
- 5 - Fuel manifold;
- 6 - Fuel high pressure sensor;
- 7 - Inertia switch;
- 8 - High pressure pump;
- 9 - High pressure pump third piston deactivator;
- 10 - Pre-postheating control unit;
- 11 - Fuel heater;
- 12 - Engine coolant temperature sensor;
- 13 - Air flow meter with air temperature sensor;

The engine control unit manages the following actuators:

- injectors;
- turbo pressure regulation solenoids;
- high pressure circuit;
- exhaust gas recirculation regualation solenoid (EGR);
- pre/postheating control unit;
- high pressure pump third piston deactivator;
- rev counter;
- fuel comsumption gauge;
- compressor activation relay;
- radiator fan activation relay.

FUEL SYSTEM MANAGEMENT STRATEGIES

The main purpose of the management strategies is to calculate the exact amount of fuel to be injected into the cylinders (injection time). The associated timing (injection advance) and precision are set to ensure the best possible engine performance in terms of power, fuel consumption, fume emissions and vehicle handling.
Injection time is calculated on the basis of the following main parameters:

- amount of fuel to be injected;
- pressure available in the high pressure fuel manifold;
- engine speed.

This is also corrected using numerous other parameters in different engine situations.
The injection time may be divided into 2 stages:

- a) preinjection
- b) main injection

a) Preinjection
The preinjection takes place before the main injection.
The engine control unit decides to carry out a preinjection when engine speed is less than 3200 rpm (reduction in running noise).
The preinjection is disabled in this following case:

- engine speed greater than 3200 rpm;
- insufficient high pressure;
- degasification of high pressure fuel manifold (start-up stage);
- fuel supply lower than a minimum threshold.

b) Main injection
The injection start point and injection time vary according to whether a preinjection is present or not.
The main injection is eliminated in the following cases:

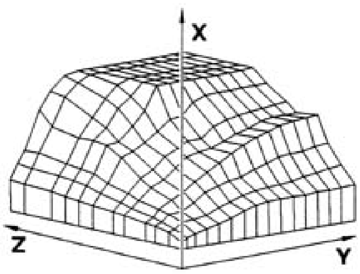
- excessive pressure in the fuel manifold (pressure greater than 1500 bars);
- insufficient pressure in the fuel manifold (pressure lower than 120 bars);
- maximum engine speed reached.

The engine control unit contains a set of maps that determine actuator operation on the basis of signals from the sensors.

- basic map;
- accelerator pedal map;
- full load curve;
- turbo pressure map;
- exhaust gas recirculation map;
- fume limitation map;
- high fuel pressure map.

Basic map
Contains the relationship between the three main system parameters, i.e.:

- X: high fuel pressure;
- Y: engine speed;
- Z: amount of fuel to be injected.



Accelerator pedal map
Function:

- to prevent great fluctuations in fuel supply (driving comfort);
- to achieve a smooth delivery curve (driving comfort).

Full load curve
Function:
allows the amount of fuel to be injected permitted by the engine not to be exceeded.
Turbo pressure map
Function:

- controls turbocharging on the basis of the amount of fuel to be injected.

Exhaust gas recirculation map
Function:

- allows the exhaust gas recirculation percentage to be calculated with extreme accuracy on the basis of the following parameters: amount of fuel to be injected, atmospheric pressure, amount of air entering the engine (measured).

Fume limitation map
Function:
manages changes in fuel delivery around steady state conditions (during a gear change for example) to ensure fume emission levels remain within correct limits.
High fuel pressure map
Function:

- allows fuel high pressure value to be calculated on the basis of the amount of fuel to be injected.

The main system management strategies are as follows:

- control of amount of fuel injected;
- injetion advance control;
- injection pressure control;
- auxiliary fuel pump check;
- injection control during over-run (cut-off);
- idle speed control;
- maximum speed limit control;
- maximum torque limit control;
- fuel temperature control;
- turbo pressure control;
- control of engine cooling fan;
- control of glow plugs;
- exhaust fume control;
- exhaust gas recirculation control (E.G.R.);
- climate control system activation control;
- engine immobiliser function control;
- self-diagnostics.

CONTROL OF AMOUNT OF FUEL INJECTED

The control unit manages the fuel pressure regulator and injectors on the basis of signals from the accelerator pedal potentiometer, debimeter and rpm sensor.
Injection timing and thus injection sequence are determined upon engine start-up using signals from the engine rpm sensor and timing sensor (synchronisation stage). Injection timing is then implemented using the engine rpm sensor signal alone and considering a 1 -3 -4 -2 injection sequence.
The control unit inhibits injection in the following cases:

- Fuel pressure value greater than 1500 bar;
- Fuel pressure value lower than 120 bar;
- engine speed greater than 6000 rpm.

When the engine is warm, maximum injection duration (injector opening time) is 1500 ns. The duration may extend to 3000 s during start-up.

INJECTION ADVANCE CONTROL

The electronic control unit determines injection advance mainly on the basis of the amount of fuel to be injected.
Injection advance is then corrected on the basis of engine coolant temperature and speed in order to compensate for the increase in ignition delay due to low temperatures present in the combustion chambers during warm-up.

INJECTION PRESSURE CONTROL

This control is particularly important because injection pressure influences the following parameters:

- amount of fuel taken into the cylinders for the same injection time duration;
- nebulisation of fuel injected;
- jet penetration;

- delay between electric injector control and the effective start of fuel injection.

The above parameters influence engine behaviour crucially, particularly in terms of power supplied, exhaust emissions, noise and car handling.
The injection control unit controls the pressure regulator on the basis of engine load to achieve an optimum line pressure at all times.
When the engine is cold, injection pressure is corrected on the basis of speed and coolant temperature to meet engine requirements at different service temperatures.

AUXILIARY FUEL PUMP CHECK

The auxiliary fuel pump submerged in the tank is supplied by the injection control unit via a relay when the ignition key is turned to ON.
The pump supply is inhibited under the following circumstances:

- after the ignition key has been turned ON for a certain time but the engine is not running;
- if the inertia switch has gone off;

INJECTION CONTROL DURING OVER-RUN (CUT-OFF)

The fuel cut-off strategy is implemented when the injection control unit receives a signal to indicate that the accelerator pedal is released from the relevant potentiometer.
Under these conditions, the control unit cuts off the fuel supply to the injectors and restores it before idle speed is reached.

IDLE SPEED CONTROL

The injection control unit controls the pressure regulator and alters injector opening times on the basis of signals from the engine rpm sensor and coolant temperature sensor to keep idle speed stable.
Under certain conditions, the control unit also considers battery voltage when controlling idle speed.

MAXIMUM SPEED LIMIT CONTROL

The injection control unit limits maximum speed on the basis of rpm by means of two actions:

- as maximum speed approaches, it reduces the amount of fuel injected and reduces line pressure;
- injector operation is inhibited at speeds over 6000 rpm.

MAXIMUM TORQUE LIMIT CONTROL

The injection control unit calculates limit torque and maximum permitted fume index parameters according to rpm. The calculations are based on predefined maps stored in its memory.
The control unit then corrects the above parameters using engine coolant and vehicle speed data and uses the resulting values to modulate the amount of fuel to be injected by adjusting the pressure regulator and injectors.

FUEL TEMPERATURE CONTROL

The injection control unit is kept constantly informed on fuel temperature by a sensor in the return manifold.
If fuel temperature exceeds a certain level (about 110°C), the control unit reduces line pressure by adjusting the pressure regulator and leaving the injection times the same.

ENGINE COOLANT TEMPERATURE CONTROL

The injection control unit is constantly informed of engine coolant temperature by means of a sensor on the thermostat.
If engine coolant temperature exceeds certain levels, the control unit takes the following actions:

- reduces fuel quantity by adjusting the pressure regulator or injectors (power reduction);
- drives the engine radiator cooling fan.

HEATER PLUGS CHECK

The injection control unit controls operation of the glow plug control unit to bring temperature in the combustion chambers up levels sufficient to facilitate fuel self-ignition and thus make ignition easier.
The injection control unit controls operation of the glow plug preheating control unit for a certain time both before (preheating) and after (postheating) engine start-up and also controls activation of the relevant warning light on the control panel.
The glow plug preheating, postheating and activation times all vary on the basis of engine coolant temperature.

EXHAUST FUME CONTROL

By means of this function, the injection control unit limits any exhaust fumes that could occur during fast acceleration.
To meet this requirement, the control unit processes signals supplied by the accelerator pedal potentiometer, rpm sensor and intake air quantity sensor (debimeter) and controls the fuel pressure regulator and injectors to modulate the amount of fuel to be injected.

EXHAUST GAS RECIRCULATION CONTROL

The injection control unit computes EGR solenoid operation times on the basis of signals supplied by the rpm, intake air quantity, coolant temperature and accelerator pedal position sensors to obtain partial exhaust gas recirculation only under certain engine operation conditions.

CONTROL OF AIR CONDITIONING SYSTEM ACTIVATION

The injection control unit manages the air conditioner system compressor electromagnetic coupling in accordance with a strategy designed to avoid operating conditions that would impair engine performance.
When the compressor is activated, the engine control unit increases the amount of fuel at idle speed to adjust the engine to the higher power requirement and cut off power supply to the compressor under conditions of:

- high power demand from the engine (fast acceleration);
- engine coolant overheating.

ENGINE IMMOBILISER FUNCTION CONTROL

The system is equipped with an engine immobiliser. This function is executed by a specific control unit (Fiat CODE) able to communicate with the engine control unit and an electronic key with a transmitter that sends out a recognition code. Whenever the key is turned OFF, the Fiat CODE system fully deactivates the injection control unit.
When the key is turned ON, the following operations take place in sequence:

- 1 - the engine control unit (with the secret code in its memory) sends the Fiat CODE control unit a request to send a secret code to deactivate the function lock;
- 2 - the Fiat CODE control unit responds by sending back the secret code only once it has received, in turn, a recognition code sent by the ignition key;
- 3 - secret code recognition allows engine control unit lock deactivation and resumption of normal operation.

DIAGNOSTICS

DIAGNOSIS

The injection system can be fully tested by connecting an appropriate tester to the tester input.

FAULT DISPLAY (SELF-DIAGNOSTICS)

The engine diagnostics warning light comes on if a fault is present between the elements or the following information:

- voltage to condenser no. 1 (injector control stage in engine management control unit);
- voltage to condenser no. 2 (injector control stage in engine management control unit);
- fuel high pressure sensor;
- pressure control circuit in fuel manifold;
- accelerator pedal sensor (stage no. 1);
- accelerator pedal sensor (stage no. 2);
- turbo pressure sensor;
- air flow meter with air temperature sensor;
- supply to sensors no. 1;
- supply to sensors no. 2;
- exhaust gas recirculation function (regulation.);
- turbo pressure regulation solenoid;
- high pressure circuit;
- injector fault (1 to 4).

REDUCED OPERATING MODES (RECOVERY)

The injection system manages the following reduced modes:

- a) - operating mode with reduced fuel flow; engine rpm cannot exceed 3200 rpm under any circumstances.
- b) - a mode that stops the engine immediately.

a) Reduced fuel flow
The system switches to reduced flow mode when a fault is present in one of the following parts:

- fuel high pressure sensor;
- pressure control circuit in fuel manifold;
- accelerator pedal sensor (stage no. 1);
- accelerator pedal sensor (stage no. 2);
- intake manifold pressure sensor;
- air flow meter with air temperature sensor;
- vehicle speed sensor;
- exhaust gas recirculation function (regulation.);
- exhaust gas recirculation regualation solenoid (EGR);
- high pressure circuit;

b) Engine stop
The system stops the engine immediately when a fault is present in one of the following parts:

- EPROM in engine managment unit;
- engine speed sensor;
- engine timing sensor;
- voltage to condenser no. 1 (injector control stage in engine management control unit);
- voltage to condenser no. 2 (injector control stage in engine management control unit);
- pressure control circuit in fuel manifold;
- injector fault (1 to 4).

The following actions are already implemented:

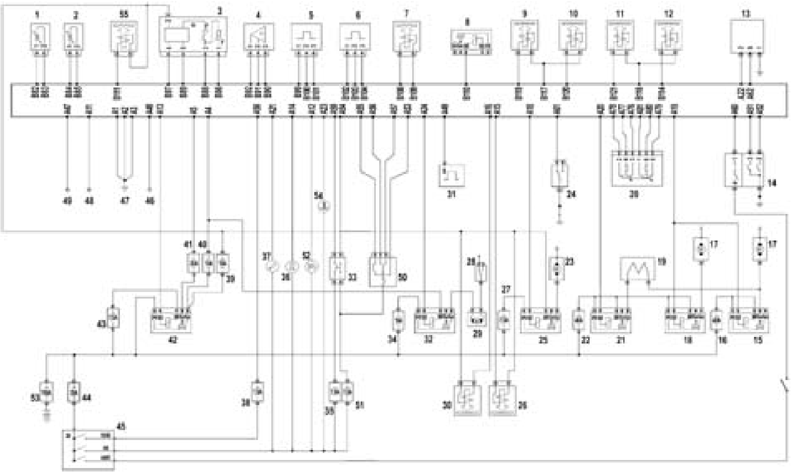
- climate control compressor cut-off, if a fault is detected in the fan control relay coils;
- deactivation of the third high pressure pump piston, if fuel pressure exceeds 106°C.

BOSCH EDC 15C7 ENGINE CONTROL UNIT

The EDC 15C7 processes signals from the sensors by applying software algorithms and controls actuators (particularly the injectors and pressure regulator) to achieve the most effective possible engine operation.
The control unit is flash E.P.R.O.M. type and can be reprogrammed externally without the need to adjust the hardware.
The engine control unit contains a built-in atmospheric pressure sensor and is connected to the wiring by means of 2 connectors that provide a total of 121 pins.

IDENTIFICATION OF EDC 15C7 ENGINE CONTROL UNIT CONNECTIONS

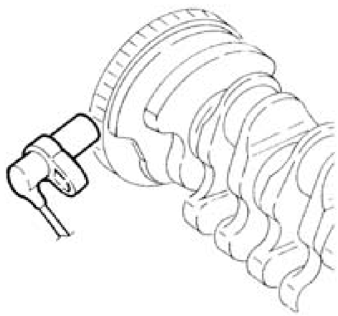
The currently available versions is: 2.3 JTD engine with EGR
Pin Out



- 1 - Fuel temperature sensor;
- 2 - Engine coolant temperature sensor;
- 3 - Air flow meter (debimeter);
- 4 - Fuel pressure sensor;
- 5 - Engine rpm sensor;
- 6 - Timing sensor;
- 7 - Fuel pressure regulator;
- 8 - Fuel filter heater relay;
- 9 - Cylinder no. 1 injector;
- 10 - Cylinder no. 2 injector;
- 11 - Cylinder no. 3 injector;
- 12 - Cylinder no. 4 injector;
- 13 - Glow plug control unit;
- 14 - 4 stage pressure switch;
- 15 - Engine cooling relay (high speed);
- 16 - 40 A fuse;
- 17 - Engine cooling fan;
- 18 - Engine cooling relay (high speed);
- 19 - Resistor;
- 20 - Potentiometer on accelerator pedal;
- 21 - Engine cooling relay (low speed;
- 22 - 40 A fuse;
- 23 - Compressor;
- 24 - Sensor on clutch pedal;
- 25 - Compressor control relay;
- 26 - Throttle solenoid;
- 27 - 7.5 A fuse;
- 28 - Inertia switch;
- 29 - Electric pump submerged in tank;
- 30 - EGR solenoid;
- 31 - Pulse generator;
- 32 - Relay controlling electric pump submerged in tank;
- 33 - Vehicle brake light control;
- 34 - 15 A fuse;
- 35 - 7.5 A fuse;
- 36 - Preheating warning light;
- 37 - Injection system failure warning light;
- 38 - 7.5 A fuse;
- 39 - 15 A fuse;
- 40 - 10 A fuse;
- 41 - 20 A fuse;
- 42 - Main relay;
- 43 - 7.5 A fuse;
- 44 - 20 A fuse;
- 45 - Ignition switch;
- 46 - Tester input;
- 47 - Chassis earth;

- 48 - Fiat CODE control unit;
- 49 - Signal for rev counter on instrument panel;
- 50 - Cruise control
- 51 - 7.5 A fuse;
- 52 - Cruise Control activation warning light;
- 53 - 150 A fuse;
- 54 - Maximum engine coolant temperature warning light;
- 55 - Shut-off solenoid+.

ENGINE SPEED SENSOR

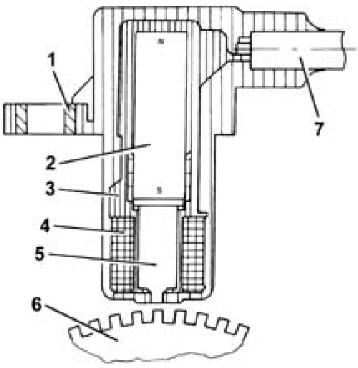


FUNCTION

The injection control unit uses a signal from the rpm sensor to determine crankshaft speed and angular position.

DESCRIPTION

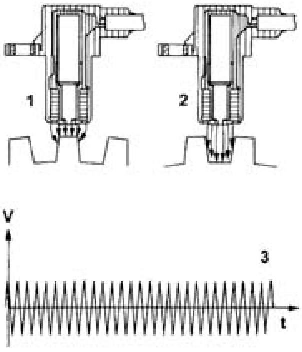
The sensor is inductive type, i.e. it uses changes in the magnetic field generated by the phonic wheel teeth (60-2 teeth) passing in front of the sensor element.
The changeover from full to empty determined by the presence or absence of a gap brings about a magnetic flux change sufficient to generate an induced alternating voltage proportional to the number of holes on the phonic wheel.
Rpm sensor peak output voltage depends, all else being equal, on the distance between the sensor and the phonic wheel teeth.



- 1 - Steel bush;
- 2 - Permanent magnet;
- 3 - Sensor case;
- 4 - Winding;
- 5 - Core;
- 6 - Phonic wheel;
- 7 - Electrical connection;

To obtain correct signals, the specified distance between phonic wheel and sensor (gap) must be between 0.8 - 1.5 mm. This distance is not adjustable. If the gap is found to be outside the tolerance limits, check the condition of the sensor and phonic wheel.

WINDING RESISTANCE



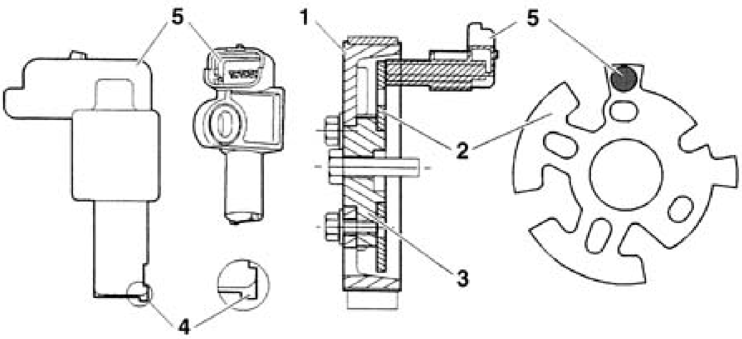
- 1 - Maximum magnetic flux;
- 2 - Minimum magnetic flux;
- 3 - Induced alternating voltage;

ENGINE TIMING SENSOR (CAMSHAFT POSITION)

FUNCTION

synchronise fuel injections in relation to piston position;
recognise top dead centres.

Plastic tooth (4) is used to adjust the gap in the factory. It is destroyed the first time the engine is started. When refitting, the specified gap must be respected: t - 1.2 (-0 +0.10) mm.



- 1 - camshaft pulley;
- 2 - phonic wheel
- 3 - camshaft hub;
- 4 - plastic pin;
- 5 - timing sensor.

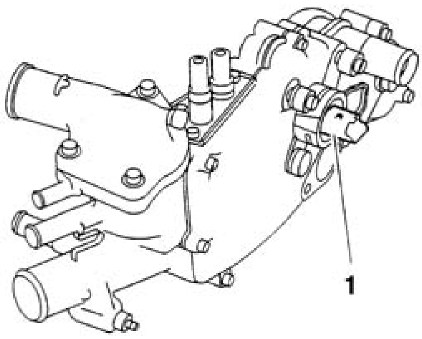
DESCRIPTION

This Hall-effect sensor is installed on the cylinder head, where it faces the camshaft hub.
A set of openings on the hub allows the timing sensor to detect engine timing position and notify the engine control unit accordingly.

OPERATION

A current-carrying semiconductor layer immersed in a normal magnetic field (force lines at right angles to current direction) generates a potential difference known as a Hall voltage at its terminals.
If current intensity remains constant, the generated voltage depends on magnetic field intensity alone. Periodic changes in magnetic field intensity are sufficient to generate a modulated electrical signal with frequency proportional to the speed of magnetic field change.
This change is achieved by making a magnetic ring (internal part of pulley) with an opening pass the sensor.
As it moves, the metal part of the ring covers the sensor to block the magnetic field and thus generate a low ouput signal. Conversely, the sensor generates a high signal when the opening is over the sensor and a magnetic field is present.

ENGINE COOLANT TEMPERATURE SENSOR



- 1 - Coolant temperature sensor

FUNCTION

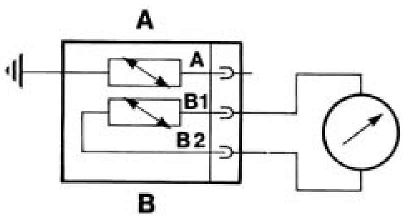
The sensor provides the control unit with information about coolant temperature.
According to the information received, the engine control unit:

- regulates preheating time;
- regulates postheating time;
- regulates the start-up flow;
- regulates idle speed;
- authorises exhaust gas recirculation circuit (EGR);
- regulates fuel flow;
- limits the injected flow if coolant temperature becomes critical (antiboil function);
- controls the fans;
- controls the instrument panel gauge and warning light.

DESCRIPTION

The sensor is installed on the thermostat. It consists of a brass case that protects the actual resistance elements, which take the form of two NTC (Negative Temperature Coefficient) thermistors - so-called because their electrical resistance falls as temperature increases).
The two thermistors are separate and provide temperature information to the instrument panel (A) and engine management unit (B) respectively.
Electrical properties:

- B1 - B2: resistance at 20°C = 6200 Ohm;
- A - earth: resistance at 30°C = 1925 Ohm;



AIR TEMPERATURE SENSOR

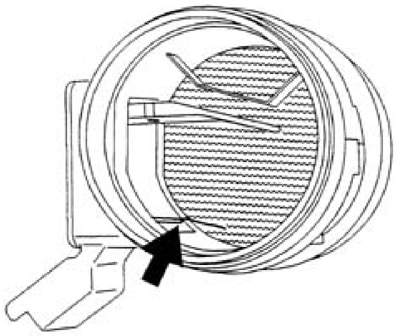
FUNCTION

The air temperature probe provides the computer with information on intake air temperature.
According to the information received, the engine control unit computes environmental air density.

DESCRIPTION

The sensor (arrowed) is built into the air flow meter.
It consists of a Negative Temperature Coefficient (NTC) resistance similar in design to the coolant temperature sensor (see).
Electrical properties:

- resistance at 25°C = 3200 Ohm;



FUEL TEMPERATURE SENSOR

FUNCTION

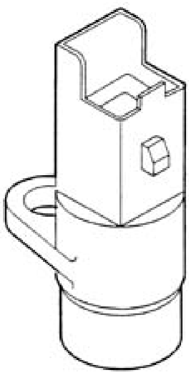
The sensor measures fuel temperature. According to the information received, the engine control unit:

- regulates fuel flow;
- computes fuel density.

DESCRIPTION

The sensor is positioned on the fuel return circuit in the tank.
It consists of a Negative Temperature Coefficient (NTC) resistance similar in design to the coolant temperature sensor (see).
Electrical properties:

- resistance at 25°C = 2400Ohm;
- resistance at 80°C = 270 Ohm;



FUEL HIGH PRESSURE SENSOR

FUNCTION

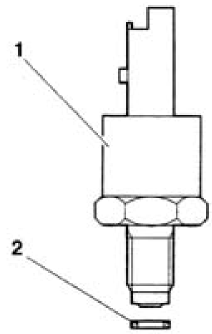
The sensor measures the high pressure value in the fuel manifold. According to the information received, the engine control unit:

- determines the amount of fuel to be injected;
- regulates high fuel pressure in the fuel manifold.

DESCRIPTION

The sensor is located on the fuel manifold and is piezoelectric type. It supplies a voltage proportional to the pressure of fuel in the fuel manifold.
Electrical properties:

- pressure of 100 bars: voltage = 0.5 Volts;
- pressure of 300 bars: voltage = 1.3 Volts;



- 1 - Fuel high pressure sensor;
- 2 - Steel gasket.

VEHICLE SPEED SENSOR

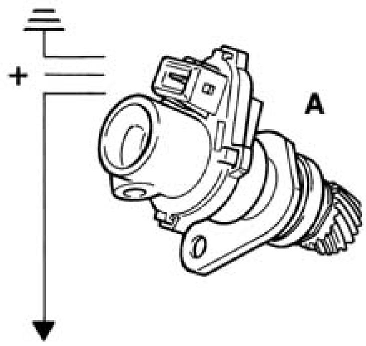
FUNCTION

The sensor provides the engine management unit with information on vehicle speed. According to the information received, the engine control unit:

- calculates vehicle speed (vehicle at a standstill or moving);
- determines the gear ratio engaged;
- improves idle speed with the vehicle in motion.

DESCRIPTION

The sensor is installed on the gearbox. It is Hall effect type and similar in design to the engine timing sensor (see).



ATMOSPHERIC PRESSURE SENSOR

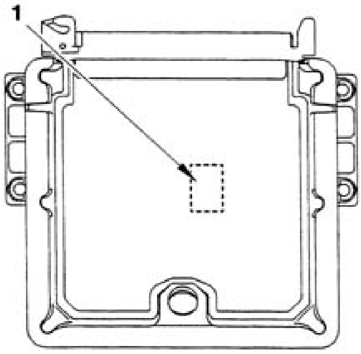
FUNCTION

The sensor measures atmospheric pressure. According to the information received, the engine control unit:

- determines air density;
- turns off recirculation when the vehicle is at high altitude.

DESCRIPTION

Atmospheric pressure sensor (1) is built into the engine control unit.
It is piezoelectric type and supplies a voltage proportional to atmospheric pressure.



INTAKE MANIFOLD PRESSURE SENSOR

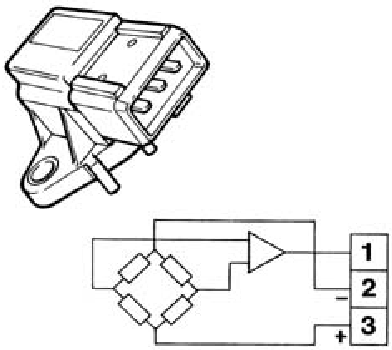
FUNCTION

The sensor is used to determine air pressure in the intake manifold. According to the information received, the engine control unit:

- modulates turbo pressure;
- modulates fuel pressure;
- regulates fuel flow.

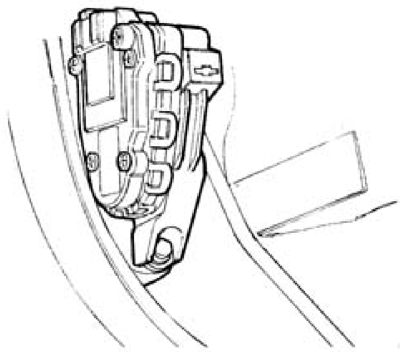
DESCRIPTION

The sensor is connected to the intake air circuit at the level of the air/air heat exchanger.
It is piezoelectric type and supplies a voltage proportional to air pressure in the intake manifold.

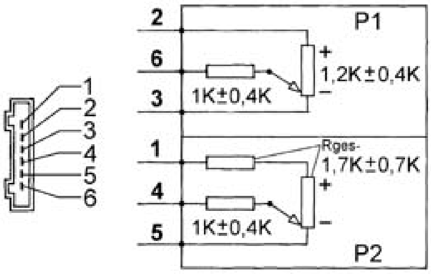


ACCELERATOR PEDAL POTENTIOMETER

Accelerator pedal position is converted into an electrical voltage signal and sent to the engine control unit by a potentiometer on the pedal unit assembly.



The accelerator pedal position sensor is used, together with rpm level, to establish injection times and relative fuel pressure.



- 1 - 5V positive;
- 2 - 5V positive;
- 3 - Negative;
- 4 - Analogue signal;
- 5 - Negative;
- 6 - Analogue signal.

ACCELERATOR PEDAL OPERATION CHECK

Connector the tester station (EXAMINER or SDC) to the input in the passenger compartment (facia junction unit).
Move the accelerator pedal to the end of its travel (fully depressed).
Record the accelerator pedal potentiometer output voltage.
If the value measured is not within the range of 3.5 - 4.4 Volts, replace the pedal complete with potentiometer.
Disconnect the tester station jack from the input in the passenger compartment (facia junction unit).

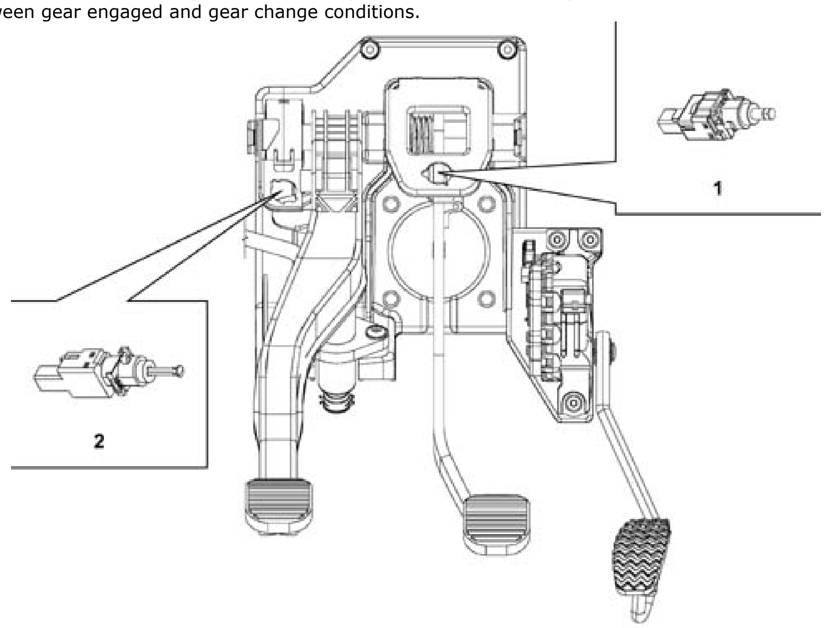
BRAKE PEDAL SWITCH

Switch (1) on the brake pedal controls the vehicle brake lights. The same switch sends a signal to pin A59 of the engine control unit. The control unit uses the "brake pedal depressed" signal to:

- detect a situation of deceleration;
- check the veracity of the accelerator potentiometer output signal.

CLUTCH PEDAL SWITCH

Switch (2) on the clutch pedal is connected to pin A61 of the engine control unit. The engine control unit uses the "clutch pedal operated" signal to distinguish between gear engaged and gear change conditions.

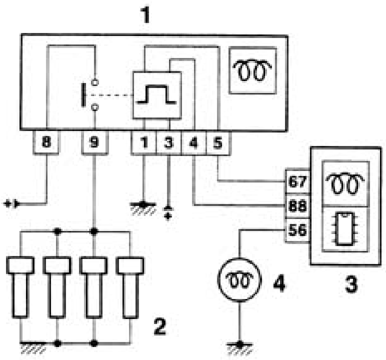


PRE-POSTHEATING CONTROL UNIT

FUNCTION

The control unit supplies electrical power to the glow plugs when controlled by the engine management unit.

 When the warning light goes off without start-up taking place, the glow plugs remain active for 10 seconds.



- 1 - pre-postheating control unit;
- 2 - glow plugs;
- 3 - engine management control unit;
- 4 - preheating warning light;

The control unit determines preheating and postheating times on the basis of engine coolant temperature.
Preheating

Engine coolant temperature (°C)	Pre-heating time (seconds)
-30°	16 seconds
-10°	5 seconds
0°	0.5 seconds
10°	0.25 seconds
18°	0 seconds
40°	0 seconds

During start-up, the glow plugs are supplied with power in the following cases:

- coolant temperature less than 20°C;
- engine running at more than 700 rpm for more than 0.2 seconds.

HEATER PLUGS

FUNCTION

The glow plugs allow temperature in the combustion chambers to increase quickly during start-up.

DESCRIPTION

The glow plugs consist of an electrical coil covered by a protective metal case.

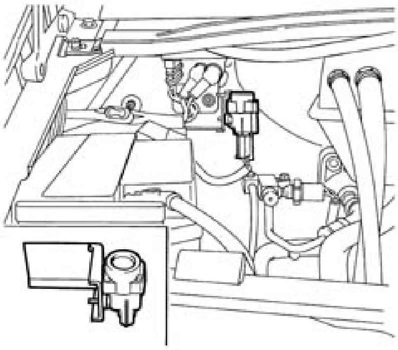
Postheating
Postheating allows glow plug operation to be extended following the start-up stage.
Postheating allows pollutant emissions to be reduced during the moments following start-up.

Engine coolant temperature (°C)	Pre-heating time (seconds)
-30°	180
-10°	180

0°	60
10°	60
18°	30
40°	0

SAFETY INERTIA SWITCH

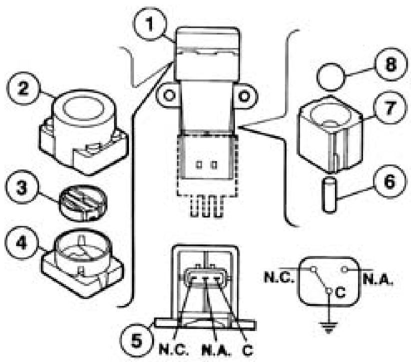
The vehicle is fitted with an inertia switch located in the engine bay to increase the degree of vehicle occupant safety in the case of impact.



The sensor reduces the possibility of fire (due to emerging fuel) by deactivating the auxiliary pump that feeds the fuel circuit.
The inertia switch consists of a steel ball fitted in a housing (tapered seat) and maintained in position by the attractive force of a permanent magnet.
In the case of violent vehicle impact, the ball is released from the magnetic detent and opens the normally closed (N.C.) electrical circuit to break the auxiliary fuel pump earth connection and hence the power supply to the injection system.
Simply press the switch until it clicks home to restore the auxiliary pump earth connection.

⚠ if a smell of fuel or fuel system leaks are noted after even an apparently slight impact, do not reset the inertia switch but find and repair the fault to prevent the risk of fire.

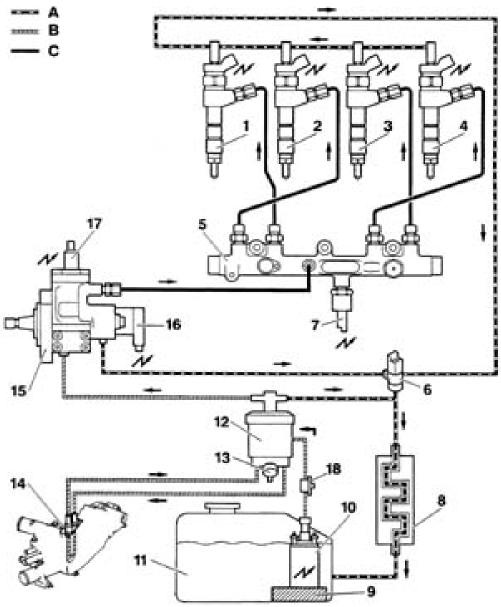
Inertia switch components



- 1 - Inertia sensor assembly;
- 2 - Sheath;
- 3 - Button;
- 4 - Upper side;
- 5 - Engagement side;
- 6 - Permanent magnet;
- 7 - Permanent magnet seat;
- 8 - Steel ball;
- C - Shared terminal;
- N.C. - Normally closed contact;
- N.O. - Normally open contact;

FUEL FEED CIRCUIT

In operational terms, the fuel supply circuit is divided into a low pressure circuit and a high pressure circuit.
The low pressure circuit consists of the tank, multifunction valve, auxiliary electric pump submerged in the tank and a return manifold.
The high pressure circuit consists of a high pressure pump, outlet manifold and injectors.

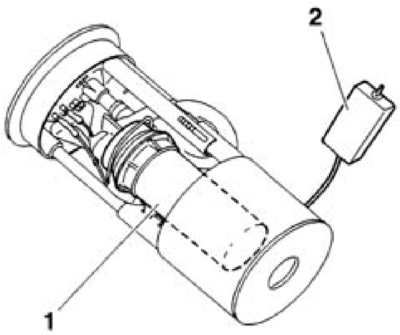


- A - return circuit to tank;
- B - low fuel pressure circuit;
- C - high fuel pressure sensor;
- 1 - Injector;
- 2 - Injector;
- 3 - Injector;
- 4 - Injector;
- 5 - high fuel pressure manifold;
- 6 - fuel temperature sensor;
- 7 - high fuel pressure sensor;
- 8 - fuel radiator;
- 9 - fuel prefilter;
- 10 - filler pump (low pressure);
- 11 - fuel tank;
- 12 - fuel filter + water decanter + low pressure circuit pressure regulator;
- 13 - water bleed screw;
- 14 - fuel heater;
- 15 - high fuel pressure pump;
- 16 - high fuel pressure regulator on high pressure pump;
- 17 - high pressure pump third piston deactivator;
- 18 - damper.

CRADLE ASSEMBLY WITH SUBMERGED PUMP (FILLER)

The assembly consists mainly of:

- a roller-type fuel pump;
- a fuel level gauge;
- a built-in fuel filter.

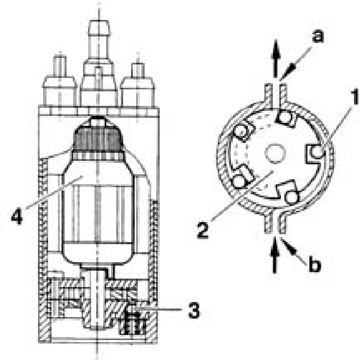


- 1 - filler pump (low pressure) with filter;
- 2 - fuel level gauge float.

FUNCTION

The filler pump:

- supplies the high pressure pump with fuel;
- provides the necessary pressure to the low pressure circuit.



- a - fuel outlet;
- b - fuel inlet;
- 1 - rollers;
- 2 - impeller;
- 3 - safety valve;
- 4 - direct current motor.

DESCRIPTION

The electric pump submerged in the fuel is volumetric roller type with brush motor and permanent magnet excitation.
Impeller (2) is turned by the electric motor to create volumes that migrate from intake port (b) to outlet port (a).
These volumes are delimited by rollers (1) that adhere to pump outer race (6) during motor rotation.
The electric pump is fitted with two valves:

- a check valve to prevent the fuel circuit emptying (with the pump off);
- a second pressure relief valve (3) to bypass the outlet to the inlet when the pressure exceeds 7 bars.

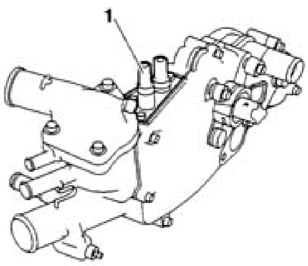
The pump is supplied at 12 V by the main relay in the following cases:

- due to contact activation for a period of 2 to 3 seconds;
- with the engine running.

FUEL HEATER

FUNCTION

The fuel heater heats the fuel to service temperature.



DESCRIPTION

The fuel heater heats fuel directed from the thermostat element (fuel filter).
It takes the form of pipe (1) in contact with the coolant and is located in the thermostat casing.

FUEL FILTER AND THERMOSTAT ELEMENT

This consists of three built-in elements:

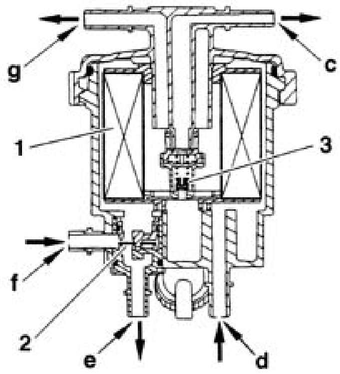
- fuel filter;
- low pressure regulator;
- thermostat element.

FUNCTION

fuel filtering (filter threshold 5 microns);
water decanting;
control of fuel heating (thermostat element);

control of low pressure fuel circuit (low pressure regulator built-in).

After fuel filter replacement, the high and low pressure circuits are bled automatically.



- 1 - filter element;
- 2 - thermostat element;
- 3 - low pressure regulator;
- c - fuel return to tank;
- d - heated fuel return from thermostat;
- e - fuel outlet to thermostat;
- f - fuel inlet;
- g - fuel outlet to high pressure pump.

Fuel filter:

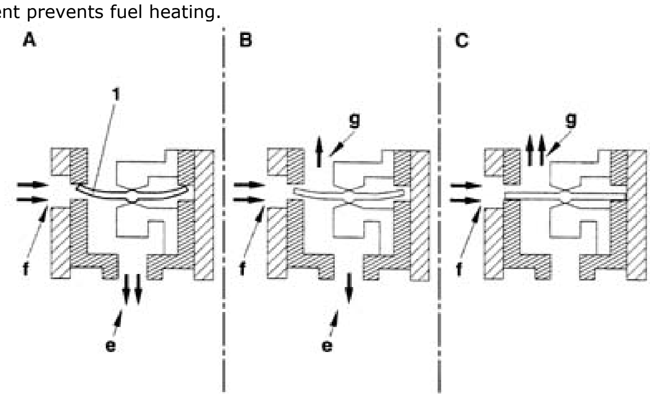
- replacement frequency: every 60,000 Km;
- bleed: every 20,000 Km;

DESCRIPTION OF LOW PRESSURE REGULATOR

The low pressure regulator controls fuel pressure in the low pressure circuit.
Circuit pressure: = 2.5 bar.

THERMOSTAT ELEMENT DESCRIPTION

When cold, the thermostat element directs part of the fuel toward the fuel heater.
When warm, the thermostat element prevents fuel heating.



- e - fuel outlet (to coolant outlet casing);
- f - fuel inlet;
- g - fuel outlet (to filter element);
- 1 - thermostat element.

The thermostat element takes the form of a double strip that bends according to fuel temperature.
A Fuel temperature lower than 15°C:

- the thermostat element is raised from its seat;
- the direct passage to the filter is closed;
- fuel is heated by contact with the water outlet casing.

B Fuel temperature between 15 and 25°C:

- the thermostat element is partly raised from its seat;
- part of the fuel is heated;

C Fuel temperature higher than 25°C:

- the thermostat element rests on its seat;

- fuel flows directly toward the filter element.

FUEL RADIATOR

FUNCTION

The high pressure pump compresses fuel from the filler pump to increase the fuel temperature.
The fuel radiator cools the fuel as it returns to the tank.

DESCRIPTION

The fuel radiator is secured beneath the body. It consists of a steel coil that promotes heat exchange between fuel and air.

FUEL HIGH PRESSURE PUMP

FUNCTION

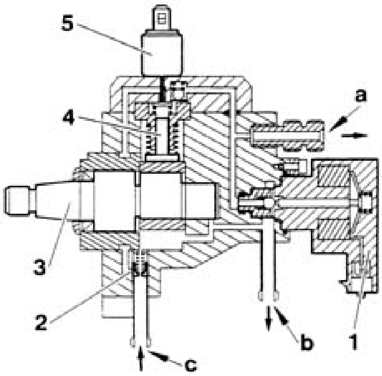
the high pressure pump:

- provides high fuel pressure;
- supplies the injectors via the fuel manifold.

DESCRIPTION

The high pressure pump receives fuel at low pressure from the filler pump and is driven by the timing belt (operating ratio 1:0.5).

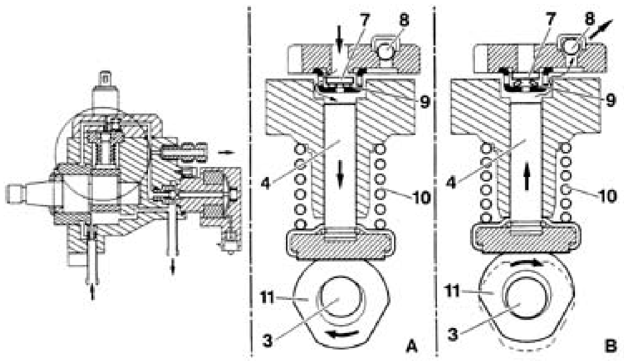
Fuel high pressure ranges from 200 to 1350 bar. The high presure pump is not a distribution pump and does not require timing adjustment.



- a - high pressure outlet (to fuel manifold);
- b - fuel return to tank;
- c - fuel inlet (from filler pump);
- 1 - high pressure regulator;
- 2 - lubrication valve;
- 3 - pump camshaft;
- 4 - piston;
- 5 - high pressure pump third piston deactivator.

HIGH PRESSURE GENERATION

The high pressure pump shaft is fitted with a cam. The pistons are suppiled with fuel via a low pressure circuit inside the high pressure pump. Fuel is taken up by the piston during the intake stage. It is then compressed by the piston and directed via a delivery valve to the fuel manifold at a pressure level modulated by by the pressure regulator.



- 3 - Pump camshaft;
- 4 - High pressure piston;
- 7 - Fuel intake valve;

- 8 - Ball delivery valve;
- 9 - Intake valve return spring;
- 10 - High pressure piston return spring;
- 11 - Drive cam.

A intake stage:

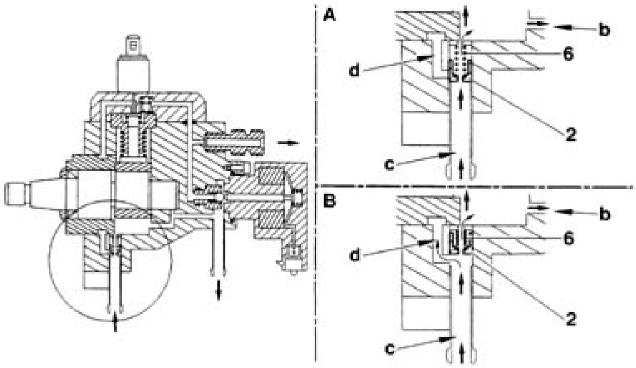
- the filler pump supplies fuel via intake valve (7);
- the return spring pushes the piston against the cam;
- the piston creates a vacuum in the chamber.

B delivery stage:

- after bottom dead centre;
- the fuel pressure drop brings about intake valve closure (about 1 bar);
- fuel is blocked inside the chamber;
- the high pressure pump cam pushes the piston;
- fuel pressure increases;
- fuel is directed to the delivery valve;
- delivery valve (8) opens;
- After top dead centre, the delivery valve closes due to the pressure drop.

LUBRICATION VALVE DESCRIPTION

Lubrication valve (2) ensures high pressure pump lubrication if turbo pressure is too low. It takes up different positions according to the difference between filling pressure and pressure in the return circuit to the fuel tank.



- A - Pressure below 0.8 bar;
- B - pressure greater than 0.8 bar;
- b - fuel return to tank;
- e - fuel inlet (from filler pump);
- d - to high pressure stage;
- 2 - lubrication valve;
- 6 - return springs.

A. pressure difference less than 0.8 bars:

- the fuel pressure is insufficient to press valve (2);
- fuel flows through the valve via a calibrated hole;
- the fuel allows lubrication and cooling of the high pressure pump.

B difference in pressure greater than 0.8 bar

- the fuel pushes valve (2);
- part of the fuel flows into the valve through the calibrated hole;
- most of the fuel is directed to the high pressure stage of the high pressure pump.

HIGH PRESSURE PUMP THIRD PISTON DEACTIVATOR

FUNCTION

The high pressure pump third piston deactivator:

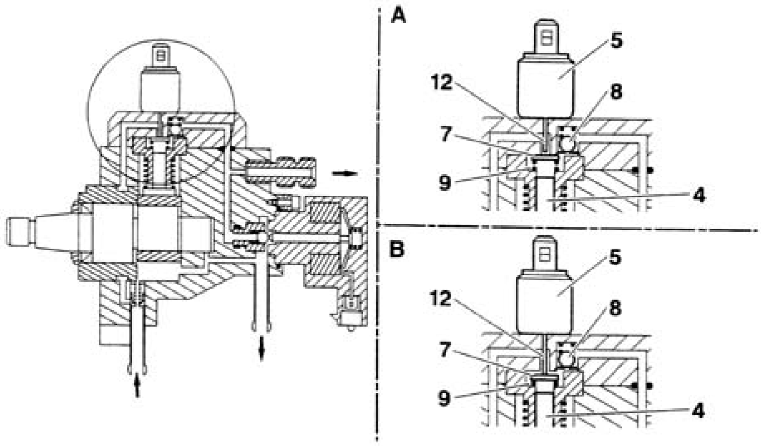
- decreases power uptake by the high pressure pump if the engine is used at low load;
- quickly lowers the high pressure in the case of a fault.

DESCRIPTION

Components of the high pressure pump third piston deactivator:

- an electromagnet;
- a push-rod that moves under the action of the magnetic field set up by the electromagnet.

The deactivator is controlled by the engine control unit by closing the relevant electrical supply circuit to earth.



- 4 - high pressure piston;
- 5 - high pressure pump third piston deactivator;
- 7 - fuel intake valve;
- 8 - ball delivery valve;
- 9 - intake valve return spring;
- 12 - push-rod.

A third piston deactivator not supplied:

- fuel intake valve (7) is locked in its seat by spring (9);
- the cylinder is closed;
- the pump shaft cam action sets up pressure;
- the fuel pressure allows delivery valve (8) to rise;
- the fuel is directed toward the pump high pressure outlet.

B the third piston deactivator is supplied with power:

- push-rod (12) lifts intake valve (7) from its seat;
- the cylinder is open: no pressure set up;
- fuel is directed toward the low pressure section of the high pressure pump.

OPERATING STRATEGY:

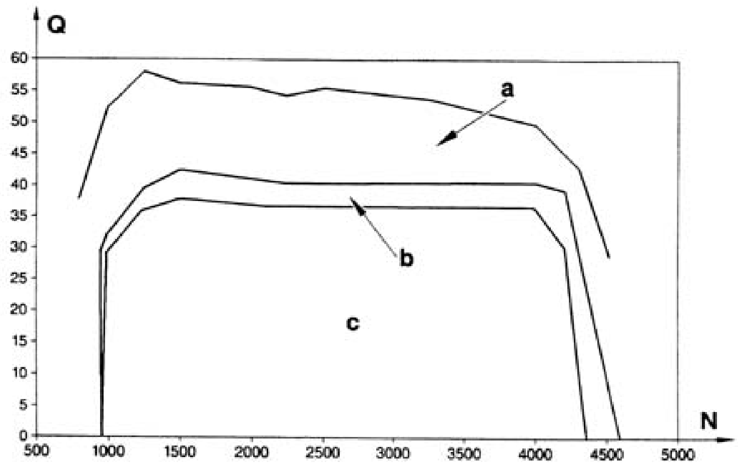
The pump works using 3 pistons:

- at idle speed:
- from 2/3 of fuel load to full load

The pump works using 2 pistons:

- outside idle speed
- below 2/3 of full engine load.

If fuel temperature exceeds 106°C, the high pressure pump works using only 2 pistons (third piston deactivator supplied).



- a - use of 3 pistons;
- b - use of 2 or 3 pistons (hysteresis);

- c - use of 2 pistons;
- N - engine speed (rpm);
- Q - injected fuel flow (litres).

HIGH PRESSURE REGULATOR

FUNCTION

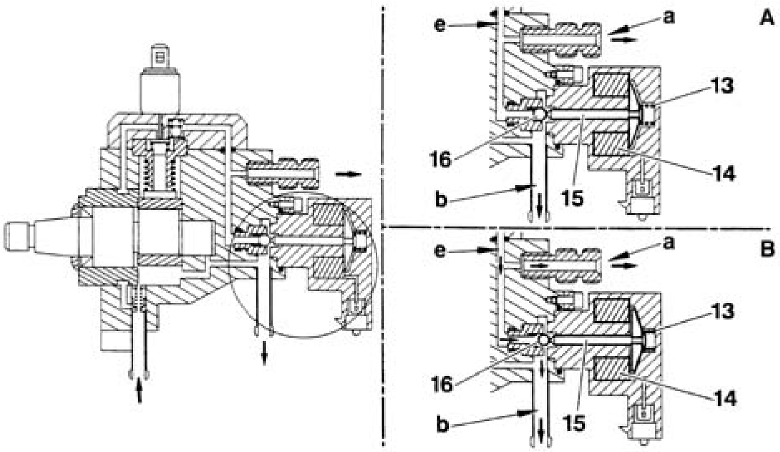
The high pressure regulator modulates fuel pressure at the high pressure pump outlet.

DESCRIPTION

The high pressure regulator includes 2 pressure control circuits:

- an electric circuit that acts directly on the high fuel pressure that controls the high pressure regulator electromagnet (engine management control unit);
- a mechanical circuit that ensures a minimum pressure and damps pressure pulses;

After turning off the engine, wait 30 seconds before beginning work. No residual pressure is left in the fuel high pressure circuit when the engine has been turned off for 30 seconds.



- A - high pressure regulator not supplied with power;
- B - high pressure regulator supplied with power;
- a - high pressure fuel outlet (to fuel manifold);
- b - fuel return to tank;
- e - high fuel pressure circuit;
- 13 - spring;
- 14 - electrical coil;
- 15 - magnetic core;
- 16 - ball.

MECHANICAL CONTROL

The high pressure circuit undergoes pressure changes.
Fuel pressure increases when a pump piston is pressed and decreases when an injector is opened.
The ball moves to damp pressure changes.

ELECTRICAL CONTROL

1 When the high pressure regulator is not supplied with power:

- the high fuel pressure counters the mechanical action of spring (13);
- the regulator opens for a high pressure greater than spring load (= 100 bars);
- fuel released by the high pressure regulator returns to the tank through the outlet.

2 Pressure increase control stages:

- the engine management unit supplies the high pressure regulator with a duty-cycle;
- the high pressure regulator coil drives the magnetic core (magnetic force);
- the effort applied to the ball is the sum of the force of spring (13) and the magnetic force of the core;
- the high pressure regulator setting increases.

3 Pressure reduction control stages:

- the engine management unit reduces the duty-cycle that supplies the high pressure regulator coil;
- the high pressure regulator coil drives the magnetic core (magnetic force);
- the effort applied to the ball decreases;
- the high pressure regulator setting decreases.

ELECTRICAL PROPERTIES

Variable DC (Duty Cycle) voltage control:

- maximum voltage (maximum DC) = maximum pressure;
- minimum voltage (minimum DC) = minimum pressure.

When the high pressure regulator is not supplied with power pressure is limited to = 100 bar.

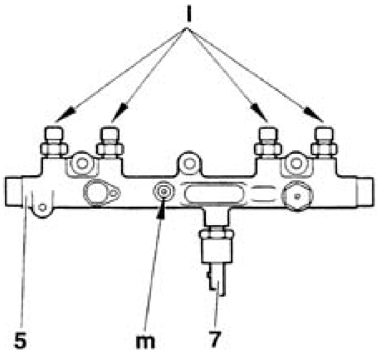
FUEL MANIFOLD (RAIL)

The fuel manifold is made out of tooled steel and located between the high pressure pump and injectors on the cylinder head.

FUNCTION

The fuel manifold (rail):

- joins the components of the high pressure circuit;
- stores the amount of fuel required for engine operation;
- decreases pulses determined by injections.



- 5 - high fuel pressure manifold;
- 7 - high pressure sensor;
- 1 - output to injectors;
- m - high pressure supply.

INJECTORS

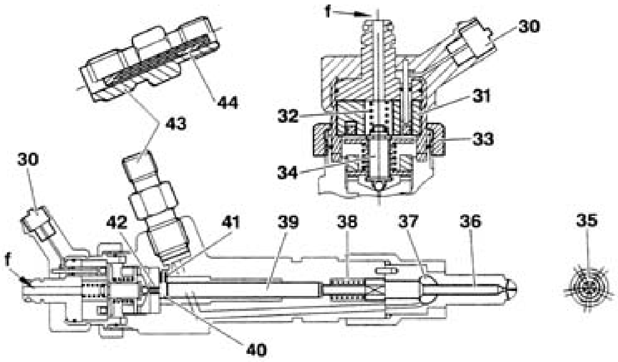
FUNCTION

The injectors inject the amount of fuel required to operate the engine.

DESCRIPTION

From a mechanical viewpoint, the injector does not differ essentially from the conventional injectors used in mechanical injection diesel engines.
The control solenoid is located in the upper part of the injector and secured to the injector case by nut (33).
The injectors incorporate 5 holes that improve the air/fuel mixture.
The amount of fuel injected depends on the following parameters:

- electrical command duration;
- injector opening speed;
- injector hydraulic output (hole number and diameter);
- fuel pressure in the fuel manifold (rail).



- f - fuel return to tank;
- 30 - electrical connector;
- 31 - electrical control solenoid;
- 32 - control solenoid spring;
- 33 - nut;
- 34 - control solenoid pintle;
- 35 - injector tip;
- 36 - injector pintle (5-hole nozzle);
- 37 - pressure chamber;
- 38 - injector spring;
- 39 - control piston;
- 40 - control chamber;
- 41 - supply nozzle;
- 42 - fuel return circuit nozzle;
- 43 - high pressure input connector;
- 44 - multilayer filter built into connector (43).

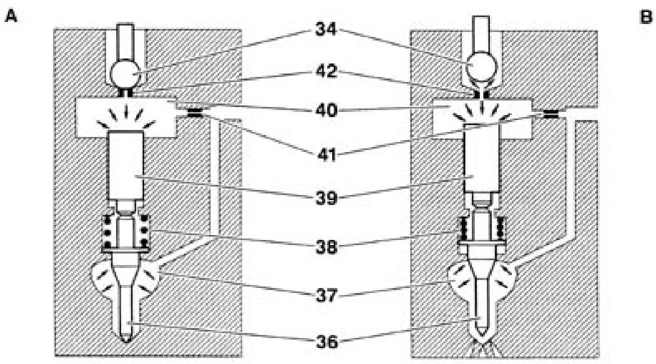
PRINCIPLE OF INJECTOR OPERATION

The fuel pressures used in the direct injection system obviate direct electrical control of the injectors. Injector opening is therefore achieved by exploiting the pressure difference between control chamber (40) and pressure chamber (37).
Injector pintle (36) is locked in its seat by spring (38) and surmounted by control piston (39) (the control piston is free to move in its bore).
The control piston head emerges into control chamber (40).
The control chamber is connected to the following circuits:

- fuel high pressure circuit via nozzle (41);
- return circuit to fuel tank via nozzle (42).

Control chamber (40) is insulated from the fuel reurn circuit by means of solenoid pintle (34).
Injector pintle (36) is locked in its seat by spring (32).
Fuel is distributed identically between chambers (40) and (37).
Nozzle (42) is bigger than nozzle (41).

 Miximum lift of control soleonid pintle: = 0.06 mm.



- With injector closed;
- B opening of one injector;
- 34 - control solenoid pintle;
- 36 - injector pintle;
- 37 - pressure chamber;
- 38 - injector spring;
- 39 - control piston;
- 40 - control chamber;
- 41 - feed nozzle;
- 42 - fuel return circuit nozzle.

A With injector closed.
The effort exercised by the high pressure is identical between control chamber (40) and pressure chamber (37).
The control piston is immobile (locked against the injector pintle).
The pressure increase in the high fuel pressure common injection ramp promotes injector closure.
B opening of one injector.
The engine control unit supplies the control solenoid.
Operating stage from lifting of solenoid pintle (34) under the action of the control solenoid (magnetic field):

- fuel is lost via nozzle (42);
- fuel entering through nozzle (41) does not compensate for the loss through nozzle (42);
- the balance between the pressure in chambers (40) and (37) is lost;
- the pressure in pressure chamber (37) lifts the injector pintle;
- the control piston rises;
- fuel is sent to the piston head.

C Closure of an injector.
Operating stage from the time when the injection motor control unit cuts off power to the injector solenoid:

- the solenoid spring locks the solenoid pintle in its seat to block nozzle (42);

- fuel loss toward the return circuit is cut off;
- the pressure increase in control chamber (40) brings about injector closure;
- the balance of pressures between chambers (40) and (37) is re-established;
- the injector is ready for a new cycle.

ELECTRICAL PROPERTIES

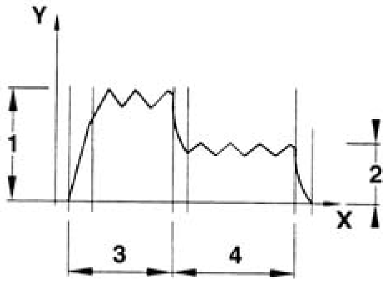
The electrical supply to a solenoid is broken down into 2 stages.
a) Return stage.
The return stage brings about rapid lifting of the solenoid pintle. This is limited to a few tenths of a millisecond (0.3 ms).
The injector solenoid is supplied with:

- a voltage of 80 Volts;
- a current of 20 A.

b) Maintenance stage.
The maintenance stage allows the solenoid power supply to be continued while limiting electrical power uptake.
The injector solenoid is supplied with:

- a voltage of 50 Volts;
- a current of 12 A.

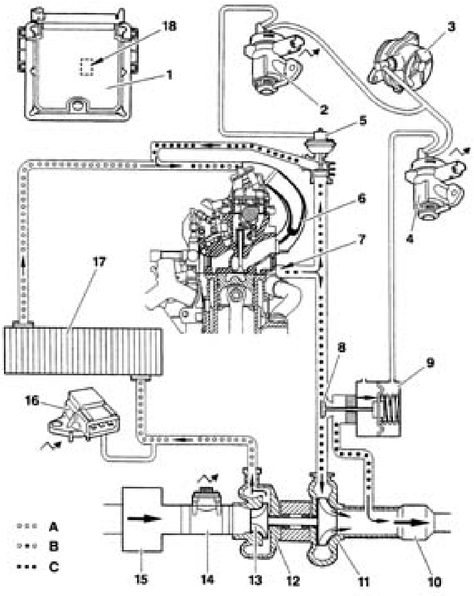
- It is not possible to supply an injector with 12 Volts (solenoid would be destroyed).



- Y - current (A);
- X - duration (ms);
- 1 - return current;
- 2 - maintenance current;
- 3 - return stage;
- 4 - maintenance stage.

AIR SUPPLY CIRCUIT AND EXHAUST GAS RECIRCULATION CIRCUIT

Air supply circuit and exhaust gas recirculation circuit.



- A - air;
- B - exhaust gas + air;

- C - exhaust gas;
- 1 - Engine management control unit;
- 2 - Exhaust gas recirculation regulation solenoid (EGR).
- 3 - Vacuum pump;
- 4 - Turbo pressure regulation solenoid;
- 5 - Exhaust gas recirculation valve (EGR);
- 6 - Intake manifold;
- 7 - Exhaust manifold;
- 8 - Wastegate;
- 9 - Wastegate pnematic control capsule (on turbocharger);
- 10 - Catalytic converter;
- 11 - Exhaust turbine;
- 12 - Turbo unit;
- 13 - Air compressor;
- 14 - Air flow meter + air temperature sensor;
- 15 - Air cleaner;
- 16 - Intake manifold pressure sensor;
- 17 - Air/air heat exchanger (intercooler);
- 18 - Atmospheric pressure sensor (built into the engine control unit).

TURBO UNIT

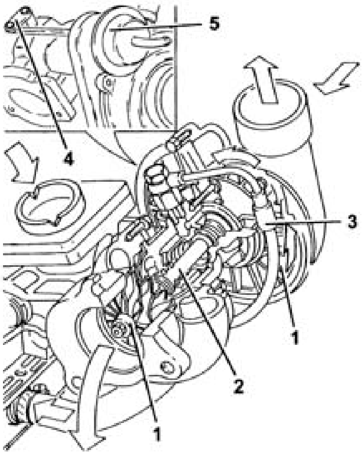
FUNCTION

The turbo unit turbocharges the engine.

DESCRIPTION

The turbocharger consists essentially of two impellers (1) fitted to the same shaft (2). It turns on floating bearings that are lubricated by a branch (3) of the engine lubrication circuit.
The exhaust-gas operated turbine turns the compressor to compress the intake air.
The turbocharger is fitted with wastegate (4) controlled by pneumatic actuator (5) that cuts off part of the exhaust gas flow to the turbine on the basis of engine torque requirements.

The high speed of the mobile parts and high temperatures to be dissipated require thorough lubrication. The pressurised oil required for this operation is taken from the engine oil circuit. Reduce engine speed to idling before turning off. if this requirement is not observed, the turbocharger will eventually be destroyed due to lack of lubrication.



- 1 - Impellers;
- 2 - Shaft;
- 3 - Lubrication;
- 4 - Wastegate;
- 5 - Actuator.

AIR/AIR HEAT EXCHANGER (INTERCOOLER)

FUNCTION

The air/air heat exchanger cools air taken into the cylinders to increase air density inside.
This increase in air density allows an increase in engine performance.

VACUUM PUMP

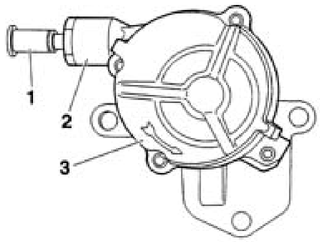
FUNCTION

The vacuum pump provides the vacuum required to control the following components:

- exhaust gas recirculation valve (E.G.R.);
- exhaust gas recirculation valve pneumatic control capsule;
- brake servo.

DESCRIPTION

The vane-type vacuum pump is driven directly by the camshaft.
A safety valve built into the pump insulates the brake servo circuit with engine off. The safety valve makes it possible to maintain enough reserve vacuum in the brake servo for several braking manoeuvres.



- 1 - outlet connection;
- 2 - safety valve;
- 3 - vacuum pump.

TURBO PRESSURE CONTROL SOLENOID

FUNCTION

The regulation solenoid controls the turbo pressure regulation valve with the aim of:

- modulating turbo pressure;
- limiting turbo pressure.

DESCRIPTION

The solenoid is connected to the following elements:

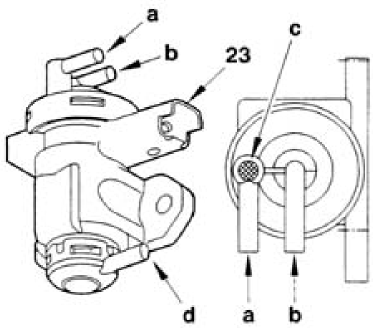
- atmospheric pressure;
- vacuum supplied by the vacuum pump.

The pressure supplied by the solenoid lies between atmospheric pressure and vacuum pump vacuum level.

ELECTRICAL PROPERTIES

The solenoid control is variable DC (Duty Cycle) voltage type:

- maximum supply voltage (maximum DC) = maximum vacuum;
- no supply (minimum DC) - no vacuum (atmospheric pressure).

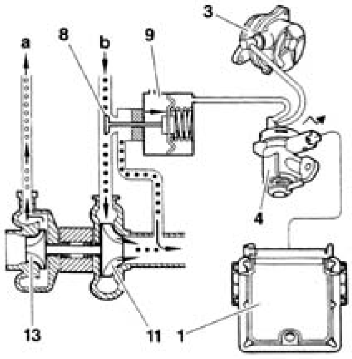


- a - user outlet;
- b - vacuum pump vacuum intake;
- c - white marking;
- d - atmospheric pressure input.

WASTEGATE CONTROL CIRCUIT OPERATION

Turbo pressure is governed by solenoid (4) controlled by engine control unit (1).

The wastegate is open when not controlled pneumatically (vacuum). Pressure in the intake manifold is increased by wastegate closure.



- a - to intake distributor;
- b - gas from exhaust manifold;
- 1 - engine management control unit;
- 3 - vacuum pump;
- 4 - turbo pressure regulation solenoid;
- 8 - wastegate;
- 9 - Wastegate pnematic control capsule;
- 11 - exhaust turbine;
- 13 - air compressor;

EXHAUST GAS RECIRCULATION VALVE (EGR)

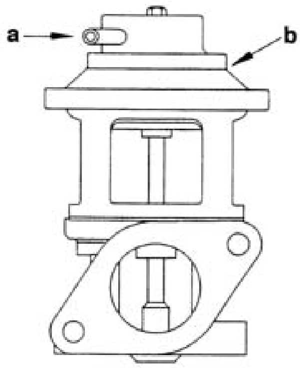
FUNCTION

The exhaust gas recirculation valve controls the amount of exhaust gas recycled.
The exhaust gas recirculation device (EGR) brings about a reduction in the amount of nitrogen oxice (NOx) released at the exhaust by taking a proportion of the exhaust gases back into the cylinders.

DESCRIPTION

The recirculation valve is located on the exhaust manifold.
Operating stages:

- when the pneumatic control capsule is not controlled pneumatically, the recirculation valve closes;
- when the pneumatic control capsule is controlled pneumatically, the recirculation valve opens;

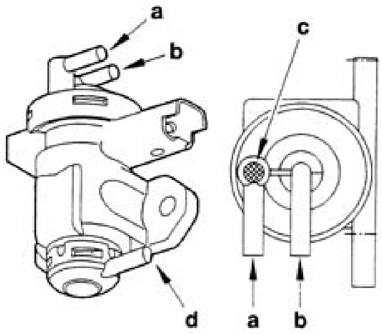


- a - vacuum intake (gas recirculation regulation soleonid);
- b - exhaust gas recirculation valve pneumatic control capsule.

EXHAUST GAS RECIRCULATION SOLENOID

FUNCTION

The solenoid brings the vacuum pump into communication with the exhaust gas recirculation valve capsule.



- a - outlet;
- b - vacuum pump vacuum intake;
- c - white marking;
- d - atmospheric pressure input.

AIR FLOW METER

FUNCTION

The flow meter measures the air mass taken in by the engine. According to the information received, the engine control unit:

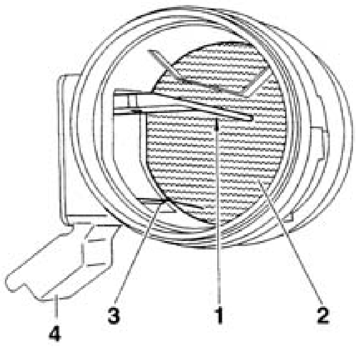
- determines the exhaust gas recirculation rate;
- limits black fume generation during transitory stages (acceleration, deceleration) by correcting fuel deliver.

DESCRIPTION

The flow meter is located between the air cleaner and turbocharger. It consists of the following components:

- metal plate (hot film);
- air temperature sensor;

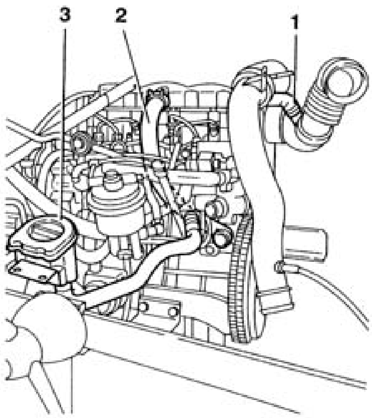
The very fine metal plate consists of a heating resistance and a measurement resistance.
The engine management control unit supplies the heating resistance to keep the metal plate at constant temperature. Air that passes into the meter cools the metal plate to alter the measurement resistance. The engine management unit associates the measurement resistance value to an air mass.



- 1 - metal plate (hot film);
- 2 - protective grid;
- 3 - air temperature sensor;
- 4 - electrical connector.

OIL VAPOUR RECIRCULATION SYSTEM (BLOW-BY)

Oil vapour emissions are controlled by an cylinder head intake pipe (1) downstream of the air cleaner.
A proportion of the vapours condenses and returns to the sump through pipe (2), connected in turn to filler fitting (3).



- 1 - cylinder head vapour intake pipe;
- 2 - oil return pipe to sump;
- 3 - oil filler fitting.

OXIDISING CATALYTIC CONVERTER

The catalytic converter is a simple, effective post-treatment device that oxidises most of the CO, HC and particulate to create carbon dioxide and steam.
Initially, exhaust gases pass through the cells to heat the catalytic converter to trigger pollutant conversion: because the conversion is strongly exothermic (combustion), the catalytic converter is then able to maintain the high internal temperature required to ensure efficient conversion.
Conversion efficiency is estimated to be as follows: CO 50%; HC 50%; particulate: 30
The catalytic converter service temperature range (within which conversion efficiency is maximum) is between 200°C and 350°C.
If the catalytic converter is the correct size, temperature can be controlled and sulphur compound oxidation can be limited.

Partculate is made up of partly-condensed diesel combustion residues and consists of: 1. Carbon (fly ash), 2. saturated hydrocarbons 3. aromatic compounds, 4. Metals, 5. Water and 6. Sulphur compounds (see figure). The only substances oxidised by the catalytic converter are the hydrocarbons, while the remainder are expelled through the exhaust.

The sulphur in the fuel is oxidised to produce sulphur dioxide and sulphur trioxide, which are converted into sulphurous and sulphuric acid when they come into contact with steam.