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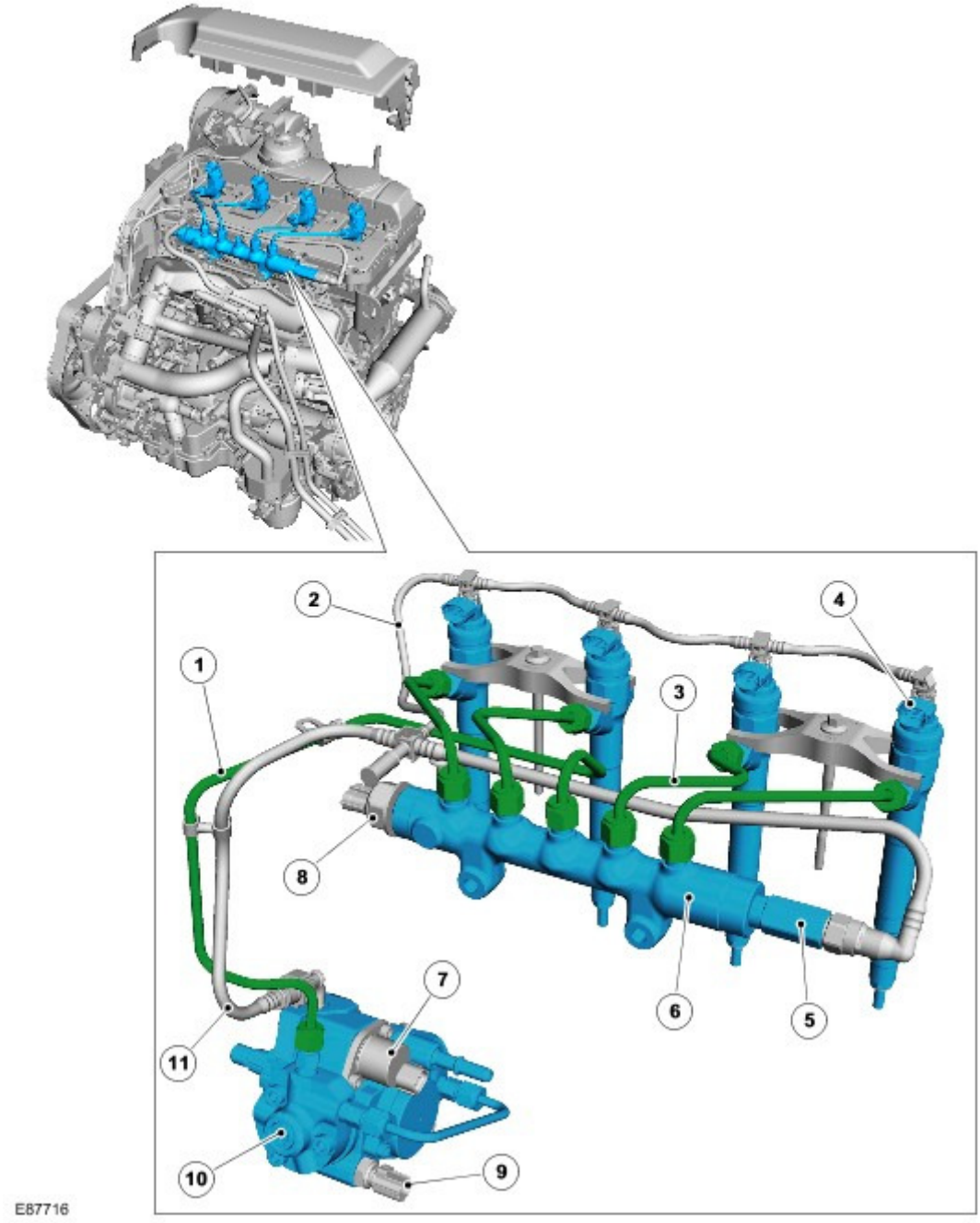
Fuel Charging and Controls

COMPONENT LOCATION



Item	Part Number	Description
1		High-pressure line
2		Leak-off pipe
3		Fuel injection line
4		Fuel injector
5		Pressure limiting valve
6		Fuel rail
7		Volume Control Valve (VCV)
8		Fuel pressure sensor

9		Fuel temperature sensor
10		High-pressure fuel pump
11		Fuel return

OVERVIEW

The 2.4 liter diesel engine is equipped with a high-pressure common rail fuel injection system. With this fuel injection process, a high-pressure fuel pump delivers a uniform level of pressure to a shared fuel rail (also known as a common rail), which serves all 4 fuel injectors. Pressure is controlled to the optimum level for smooth operation, up to a pressure of 1600 bar.

The system supports a pre-injection (pilot) phase, which reduces combustion noise and mechanical load.

Fuel injection pressure is generated independently of engine speed and fuel injection events. The fuel injection timing and volume are calculated by the Engine Control Module (ECM), which then energizes the appropriate solenoid actuated injector.

The common rail fuel injection system has the following features:

- High fuel injection pressures of up to 1600 bar for greater atomisation of fuel (increasing performance and lowering emissions)
- Variable injection to optimise combustion in all engine operating conditions
- Low tolerances and high precision throughout the life of the system

The fuel system is divided into 2 sub systems:

- Low-pressure system
- High-pressure system

The LP system features the following components:

- Transfer pump (located in the high-pressure pump)
- Fuel filter
- Fuel cooler

The HP system features the following components:

- High-pressure fuel pump
- Fuel rail
- High-pressure fuel pipes
- Injectors

LOW-PRESSURE SYSTEM

Transfer Pump

The transfer pump is integral to the high-pressure fuel pump and is used to draw fuel from the fuel tank via the fuel filter (for more information refer to the high-pressure fuel pump section).

The suction pressure of the transfer pump is -30 to -20 Kpa.

Fuel Filter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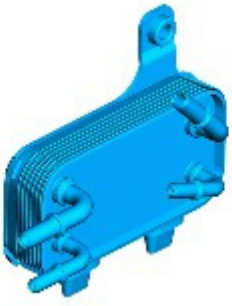
The canister type fuel filter is located forward of the Right Hand (RH) rear wheel and is protected against damage by a steel plate. For additional information, refer to Fuel Tank and Lines - 2.4L Duratorq-TDCi (Puma) Diesel (310-01 Fuel Tank and Lines)

Fuel Cooler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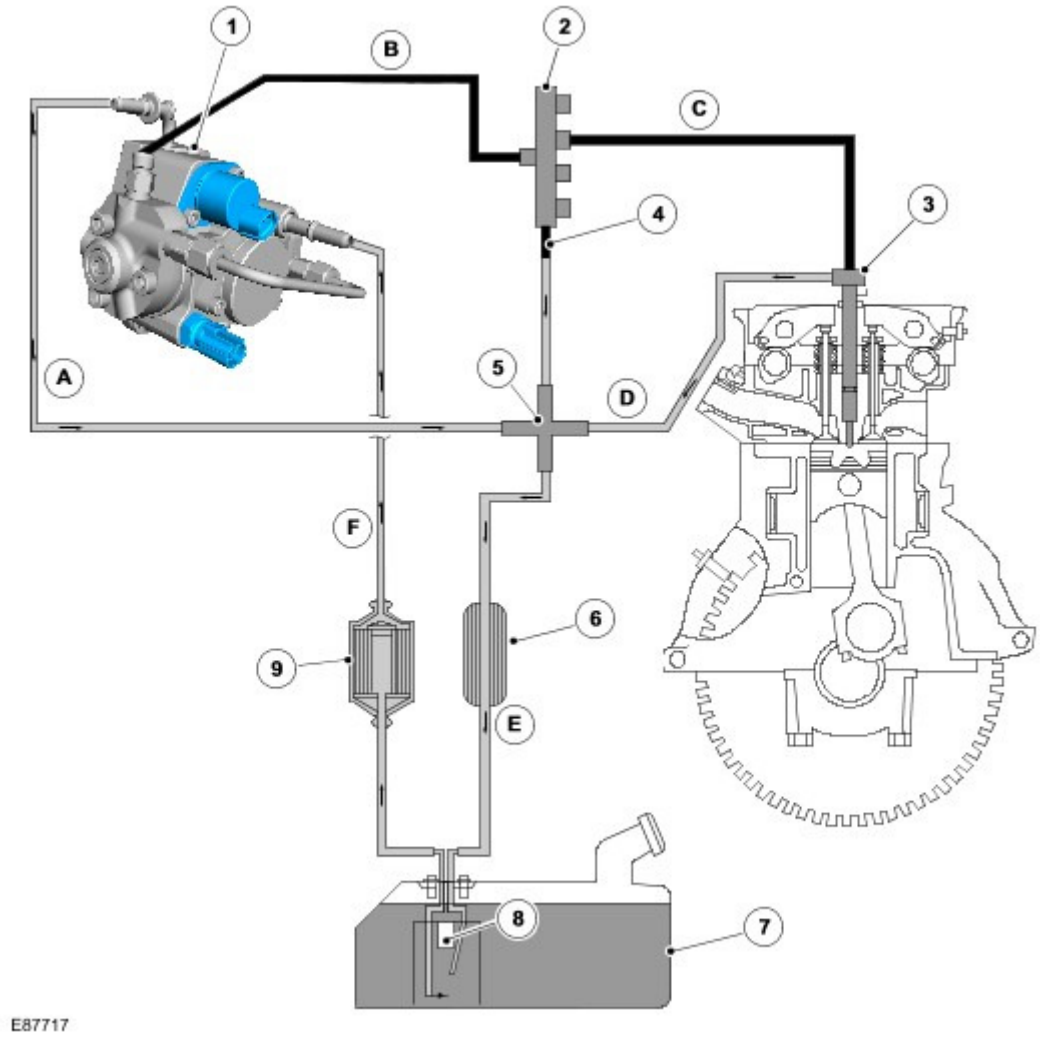
The water cooled fuel cooler is located behind the Left Hand (LH) front wheel. The cooler has a coolant system connection to aid heat transfer. For additional information, refer to Fuel Tank and Lines - 2.4L Duratorq-TDCi (Puma) Diesel (310-01 Fuel Tank and Lines)

HIGH-PRESSURE SYSTEM



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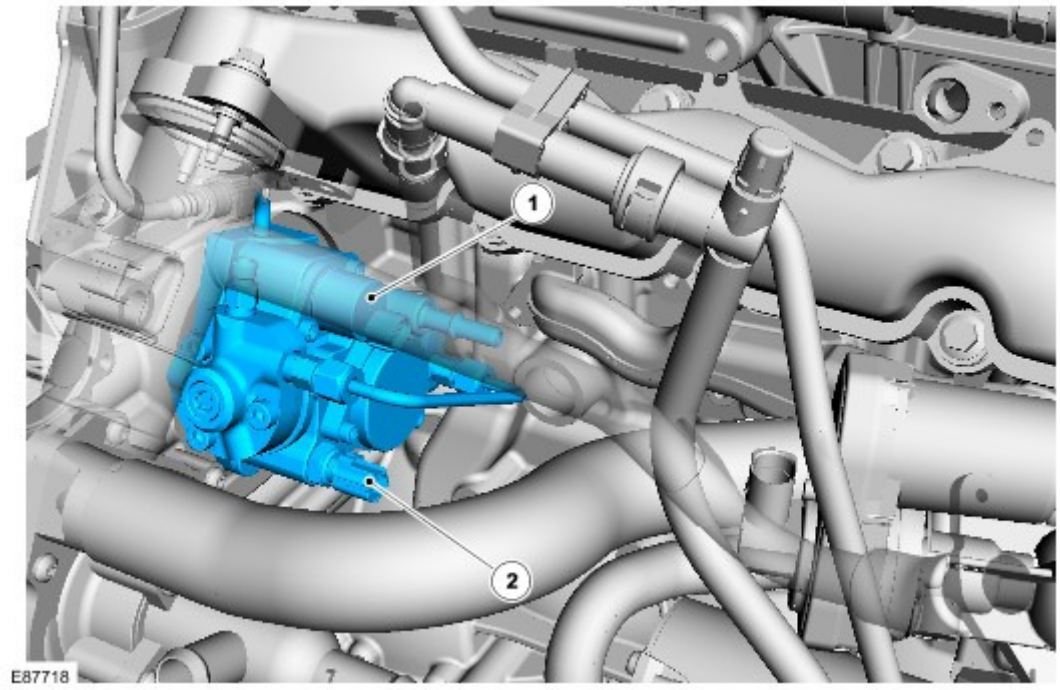
Item	Part Number	Description
A		Fuel return from high-pressure pump
B		High-pressure line
C		Fuel injection line
D		Leak-off pipe
E		Fuel return to fuel tank
F		Fuel supply
1		High-pressure pump
2		Fuel rail
3		Fuel injector
4		Pressure limiting valve
5		T-piece
6		Fuel cooler
7		Fuel tank
8		Filling level sensor unit
9		Fuel filter

The fuel is drawn from the fuel tank via the fuel filter by means of the transfer pump integrated in the high-pressure pump. The high-pressure pump pressurizes the fuel and forces it into the fuel rail. The fuel pressure required for any given situation is available for the fuel injectors for each injection process. Fuel leaking from the injectors and/or returning fuel from the high-pressure pump are fed back to the fuel tank.

High-Pressure fuel Pump

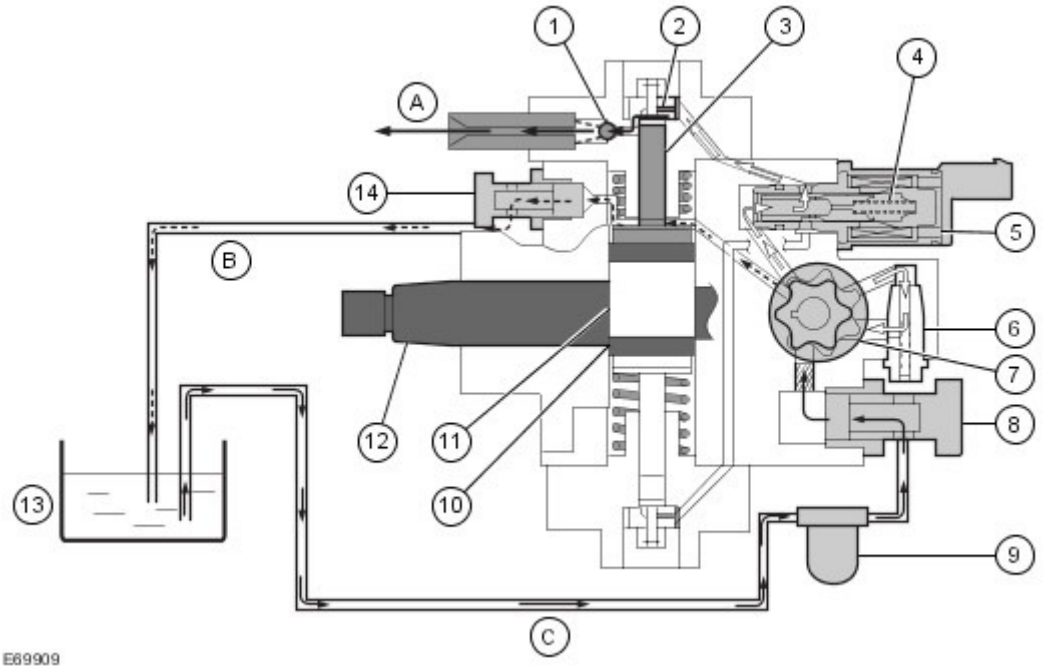


Item	Part Number	Description
1		Volume Control Valve (VCV)
2		Fuel temperature sensor

The high-pressure fuel pump provides the interface between the low and the high-pressure systems. Its function is to provide sufficient pressurized fuel under all operating conditions and for the entire service life of the vehicle.

The fuel pump is located under the intake manifold and is driven by the timing chain at the front of the engine. The pump includes a transfer pump, a high-pressure pump, a VCV and a fuel temperature sensor.

The high-pressure pump receives fuel at transfer pressure from the transfer pump and increases the fuel pressure. The high-pressure fuel is then transferred from the high-pressure pump to the fuel rail.



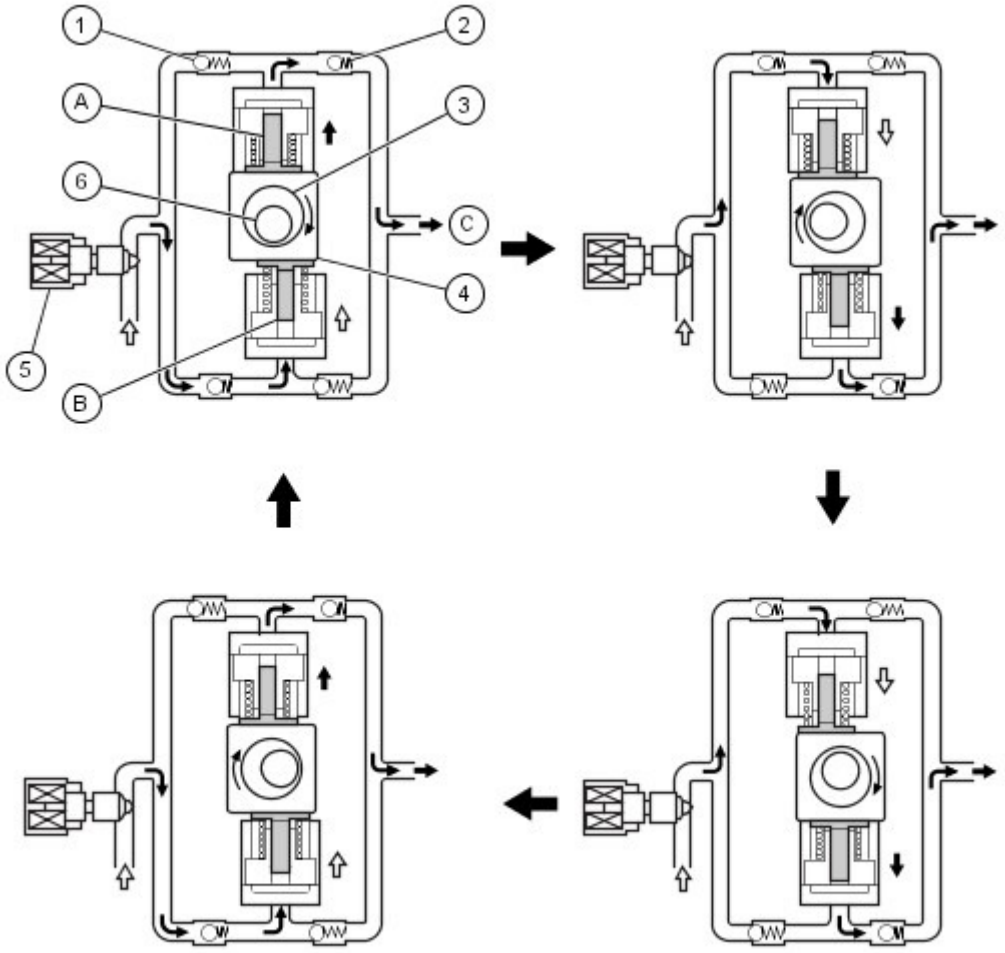
Item	Part Number	Description
A		High-pressure fuel to fuel rail
B		Fuel return

C		Fuel supply
1		High-pressure chamber outlet valve
2		High-pressure chamber inlet valve
3		Pump plunger
4		VCV return spring
5		VCV
6		Admission pressure control valve (pump internal pressure)
7		Transfer pump
8		Fuel inlet
9		Fuel filter
10		Eccentric cam ring
11		Eccentric cam
12		Drive shaft
13		Fuel tank
14		Fuel overflow valve

The transfer pump draws fuel out of the fuel tank through the fuel inlet (8). The pump internal pressure is adjusted through the admission-pressure control valve (6), ensuring that sufficient lubrication and cooling are always provided for the high-pressure pump components. The excess fuel is transferred to the inlet side of the transfer pump (7) through the admission-pressure control valve, with a portion of the fuel being transferred to the VCV (5) from the transfer pump. The fuel quantity delivered to the high-pressure chambers is determined by the opening cross-section of the VCV. The small restriction bore in the fuel overflow valve (14) provides for automatic bleeding of the high-pressure pump. The entire low-pressure system is designed to allow a defined quantity of fuel to flow back into the fuel tank through the overflow pressure regulator tube, which assists cooling of the high-pressure pump.

A total of 2 high-pressure chambers (1 and 2), each with a pump plunger (3), are used for high-pressure generation. The drive for the pump plungers is through an eccentric cam (11), which is in turn driven by the drive shaft (12). The high-pressure pump permanently generates the high system pressure for the fuel rail.

Principle of High-Pressure Generation



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Item	Part Number	Description
A		Pump plunger 1
B		Pump plunger 2
C		To fuel rail
1		Inlet valve
2		Outlet valve
3		Eccentric cam
4		Eccentric cam ring
5		Fuel metering valve
6		Drive shaft

The rotary movement of the drive shaft (6) is converted to reciprocating movement by the eccentric cam (3). The eccentric cam ring (4) transfers the reciprocating movement to the pump plungers (1 and 2).

The pump plungers are offset by 180 degrees. This means that during a reciprocating movement, pump plunger 1 performs exactly the opposite movement to pump plunger 2.

When the eccentric cam produces an upward stroke, pump plunger 1 moves in the direction of Top Dead Center (TDC), thus compressing the fuel and delivering it to the fuel rail via the outlet valve (2). The inlet valve (1) is pressed into its seat by the delivery pressure. Pump plunger 2 is moved by the tension spring force in the direction of Bottom Dead Center (BDC). Due to the high pressure in the fuel rail, the outlet valve is pressed into its seat. The pump internal pressure opens th inlet valve and fuel flows into the high-pressure chamber.

When the eccentric cam produces a downward stroke, the process is reversed.

The VCV is located on the high-pressure fuel pump. The valve regulates the fuel supply (and hence the quantity of fuel) from the transfer pump to the high-pressure fuel pump elements, depending on the fuel pressure in the rail. This makes it possible to match the delivery of the high-pressure fuel pump to the requirements of the engine from the

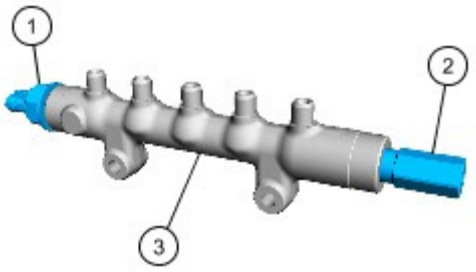
low-pressure side. The quantity of fuel flowing back to the main fuel supply line is kept to a minimum. In addition, this adjustment reduces the power consumption of the high-pressure fuel pump, improving the efficiency of the engine. For additional information, refer to Electronic Engine Controls - 2.4L Duratorq-TDCi (Puma) Diesel (303-14 Electronic Engine Controls)

After replacing the high-pressure pump and/or the ECM, the VCV must be calibrated with the aid of approved Land Rover diagnostic equipment.

The fuel temperature sensor is also located on the high-pressure fuel pump. The ECM monitors the fuel temperature constantly so it can respond correctly to changes in fuel density in relation to fuel temperature. For additional information, refer to Electronic Engine Controls - 2.4L Duratorq-TDCi (Puma) Diesel (303-14 Electronic Engine Controls)

If the fuel temperature sensor is disconnected the engine will operate at reduced power and a DTC will be triggered.

Fuel Rail



E69911

Item	Part Number	Description
1		Fuel pressure sensor
2		Pressure limiting valve
3		Fuel rail

The fuel rail performs the following functions:

- Stores fuel under high pressure
- Minimizes pressure fluctuations

Pressure fluctuations are induced in the high-pressure fuel system by operating movements in the high-pressure chambers of the fuel pump and the opening and closing of the solenoid valves on the fuel injectors. Consequently, the fuel rail is designed in such a way that it has sufficient volume to minimize pressure fluctuations, but low enough volume to be able to build up the fuel pressure required for a quick start in the shortest time possible.

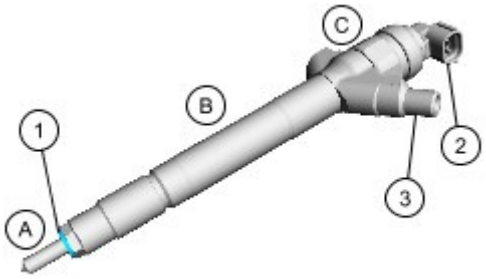
The fuel supplied by the high-pressure pump passes through a high-pressure line to the high-pressure accumulator. The fuel is then sent to the individual fuel injectors via the 4 injector tubes, which are all the same length. When fuel is taken from the fuel rail for an injection process, the pressure in the fuel rail is kept almost constant.

The pressure limiting valve opens at a fuel pressure of approximatly 2000 bar. It serves as a safety device in the case of malfunctions in the high-pressure system, preventing damage due to excessive pressure. The valve operates as a disposable unit and must be replaced after a single trigger, as the valve can no longer be guaranteed leak-free. Triggering of the pressure limiting valve is detected by the ECM, whereupon a corresponding Diagnostic Trouble Code (DTC) is set and the Malfunction Indicator Lamp (MIL) is actuated.

The fuel rail pressure sensor is located in the end of the fuel rail. The sensor measures the pressure of the fuel in the fuel rail. This input is then used by the ECM to control the amount of fuel delivered to the fuel rail. For additional information, refer to Electronic Engine Controls - 2.4L Duratorq-TDCi (Puma) Diesel (303-14 Electronic Engine Controls)

If the pressure sensor is disconnected the engine will operate at reduced power and a DTC will be triggered. The sensor is not serviceable, and will come as part of a new rail with the limitting valve.

Fuel Injectors



E69912

Item	Part Number	Description
A		Fuel injector nozzle
B		Hydraulic servo system
C		Solenoid valve
1		Combustion chamber seal
2		Electrical connection - solenoid valve
3		High-pressure fuel line connection

The 4 fuel injectors are located in the cylinder head, between the 4 valves in each cylinder. Each injector is sealed into the cylinder head with a copper washer. Each injector has an electrical connector for power supply and connections to the ECM. The fuel injectors are operated directly by the ECM for fuel metering (start of injection and quantity of fuel injected). The top of each injector is fitted with a fuel return pipe, which allows fuel used in the operation of the injector to return to the tank.

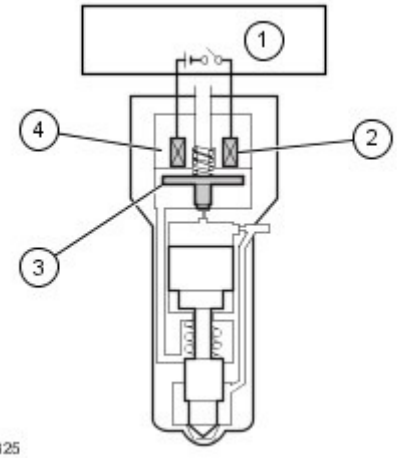
NOTE:

The copper washers that seal the injectors in the cylinder head must not be re-used.

Each electronic injector has a solenoid valve, which when energised, allows a ball valve to lift off its seat. This allows pressurised fuel to lift a needle valve in the injector nozzle and spray a finely atomised jet of fuel into the cylinder. Fuel that spills past the ball valve is directed into a return line, which is connected to the fuel return from the high-pressure fuel pump.

Each injector solenoid is controlled separately by the ECM, which provides an earth path to open the injector nozzle at the correct time and for a calculated period to provide a metered injection of fuel into the cylinder. The ECM uses signals from other sensors and a programmed fuelling strategy to ensure that the precise amount of fuel is injected at the correct timing for maximum fuel efficiency and minimum emissions.

Fuel Injector Solenoid Valve



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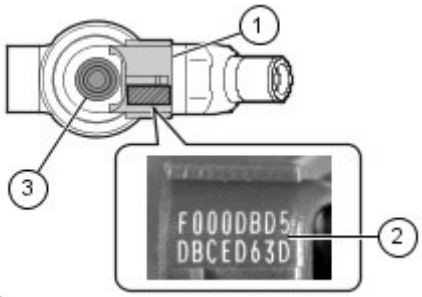
Item	Part Number	Description
1		ECM
2		Coil
3		Solenoid armature
4		Solenoid valve

The ECM applies current to the injector solenoid valves in 3 stages:

- 1. 18 amps
- 2. 8 amps
- 3. 4 amps

At the beginning of an injection process, the solenoid valve is actuated with a higher pick-up current so that it opens quickly. After a short period of time, the pick-up current is reduced to a low holding current.

To ensure optimum fuel metering, the ECM must be informed of a change of injector through the input of a 16-digit identification number. Inside the hydraulic servo system there are various restrictions with extremely small diameters, which have specific manufacturing tolerances. These manufacturing tolerances are given as part of the identification number, which is located on the housing of the fuel injector.



E69913

Item	Part Number	Description
1		Solenoid valve
2		16-digit identification number
3		Connection for leak-off pipe

NOTE:

If the identification numbers are not entered correctly with the approved Land Rover diagnostic equipment, the following faults may occur:

- Increased black smoke formation
- Irregular idling
- Increased combustion noise

Furthermore, once new ECM software has been loaded with the approved Land Rover diagnostic equipment, the fuel injectors must also be configured.

The ECM detects injector faults based on the power consumption of the solenoid valves. In the event of a fuel injector failure, any of the following symptoms may be observed:

- Engine misfire
- Idle faults
- Reduced engine performance
- Reduced fuel economy
- Difficult cold start
- Difficult hot start
- Increased smoke emissions