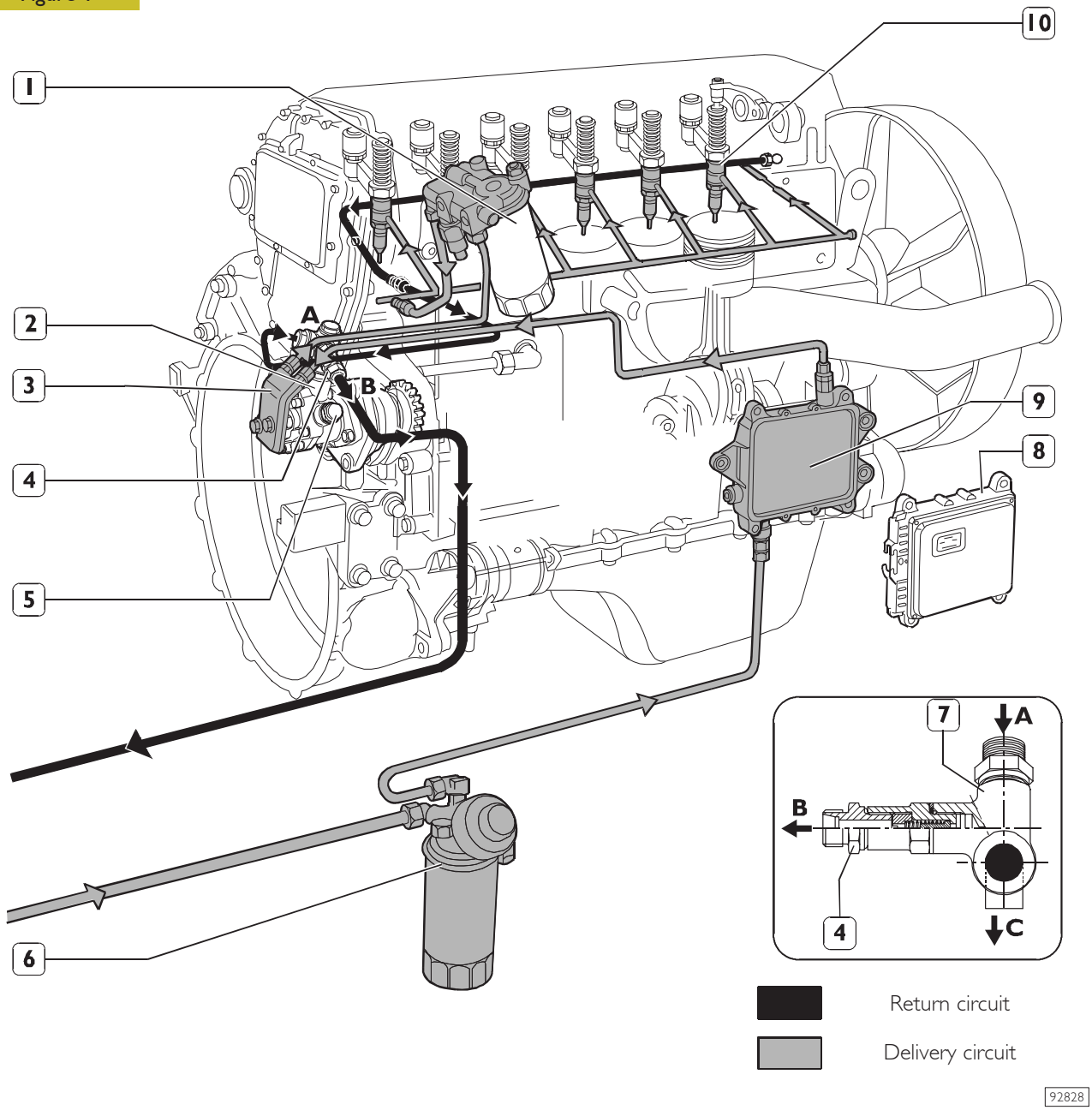
SECTION 2

Fuel

FUEL FEED

Fuel feed is obtained by means of a pump, fuel filter and pre-filter, 6 pump-injectors controlled by the camshaft by means of rockers and by the electronic control unit.

Figure 1



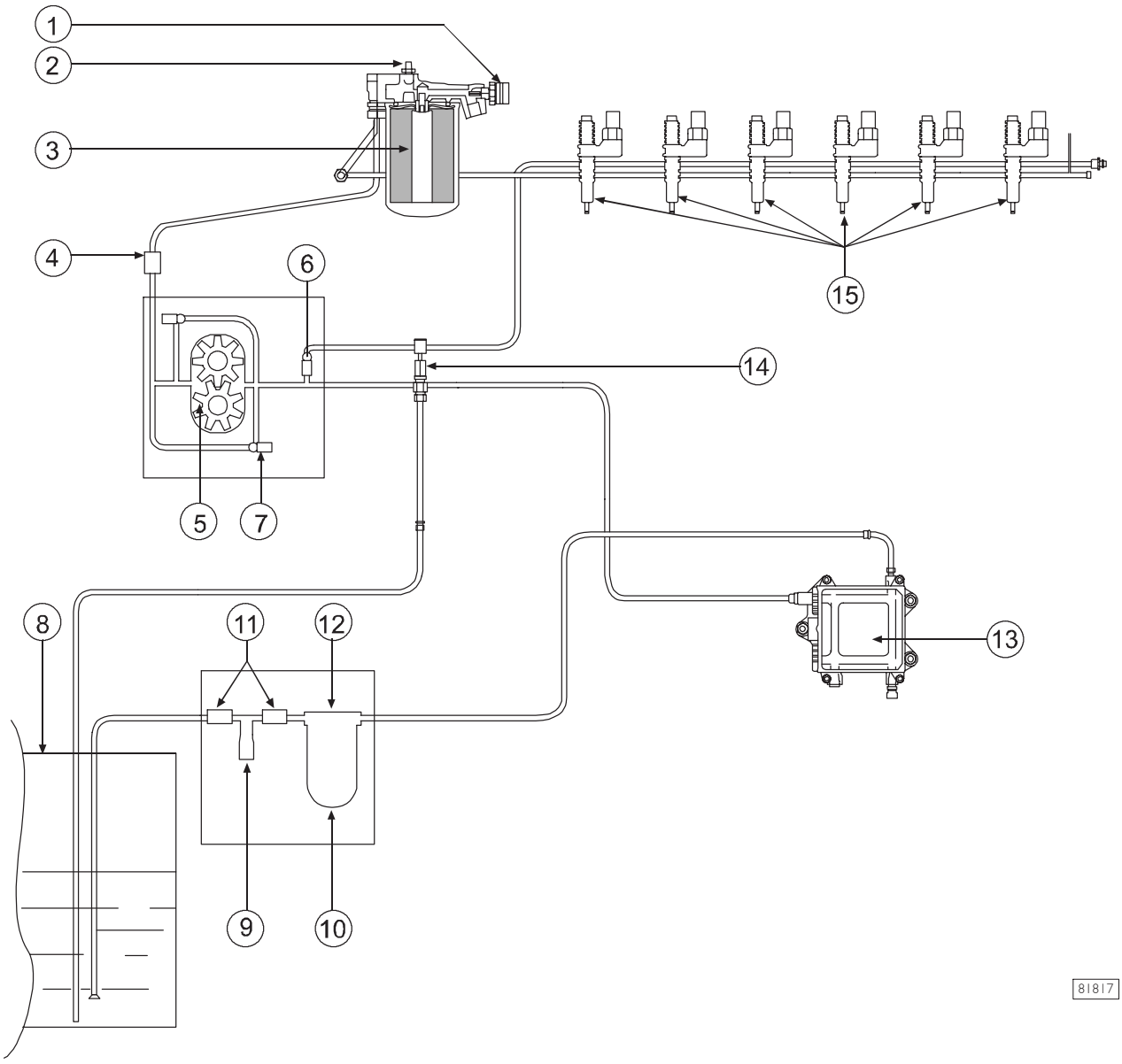
ENGINE FUEL SUPPLY DIAGRAM WITH FUEL PUMP ON THE TIMING SYSTEM CONTROL

1. Fuel filter - 2. Valve for fuel recirculation from injectors integrated in the fuel pump (start opening 3,5 bar) - 3. Fuel pump - 4. Overpressure valve for fuel return to the tank (start opening 0,2 bar) - 5. Pressure control valve (start opening 5 bar) - 6. Prefilter with priming pump - 7. Connector - 8. Gearcase - 9. Heat exchanger - 10. Pump injectors.

A. Fuel arrival from injectors - B. Fuel return to the tank - C. Fuel inlet from injectors in the fuel filter

FUEL SUPPLY DIAGRAM (ALL TYPES)

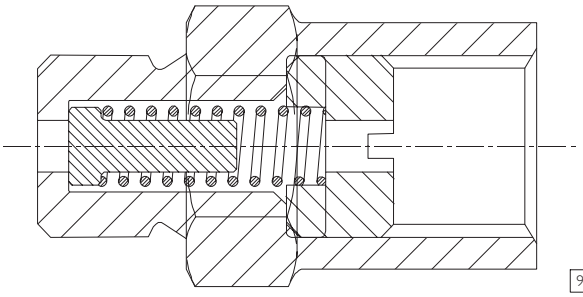
Figure 2



1. Temperature sensor - 2. Bleed valve - 3. Secondary fuel filter - 4. By-pass valve (0.3 ÷ 0.4 bar) - 5. Fuel supply pump - 6. Integrated valve (3.5 bar) - 7. Pressure relief valve (5 bar) - 8. Fuel tank - 9. Priming pump - 10. Primary fuel filter - 11. Check valve (opening 0.1 bar) - 12. Heater - 13. Electronic control unit - 14. Fuel return union with valve built in (0.2 bar) - 15. Pump-injectors.

Overpressure valve

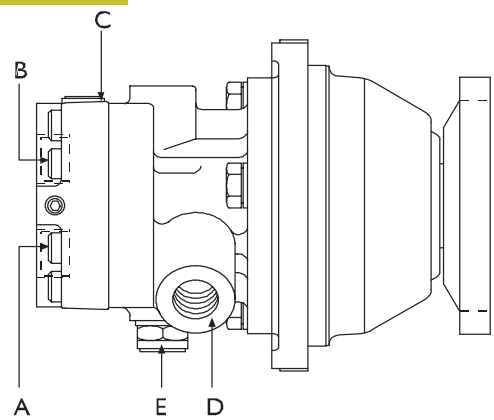
Figure 3



An overpressure valve is a single-acting valve, calibrated to 0.2 ÷ 0.3 bar, placed on the piping that returns fuel to tank. The overpressure valve prevents fuel duct in cylinder head from emptying with engine stopped.

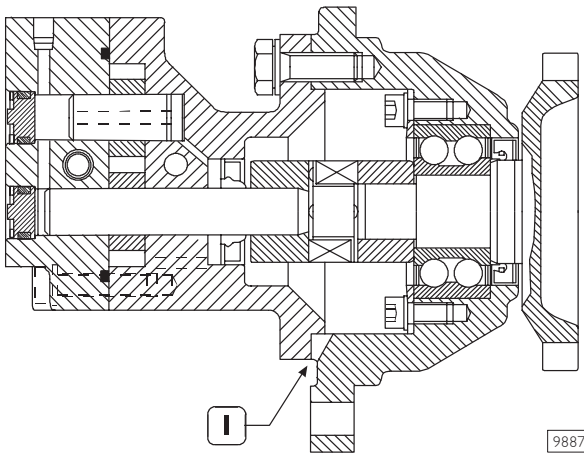
Fuel pump

Figure 4



Fuel pump mounted on timing system
A. Fuel inlet – B. Fuel delivery – C. By-pass nut – D. Fuel return from the pump-injectors – E. Pressure relief valve – Opening pressure: 5-8 bars.

Figure 5



CROSS-SECTION OF THE FUEL PUMP
1. Oil and fuel leakage indicator.

Pump performances					
Pump rotation speed (rpm)		4100	900	250	140
Minimum flow rate (l/h)		310	45	12	6
Test conditions	Negative pressure on aspiration (bar)	0.5	0.3	0.3	0.3
	Pressure on delivery (bar)	5	3	0,3	0.3
	Test liquid temperature (°C)	30	30	30	20
	Test liquid	ISO 4113			

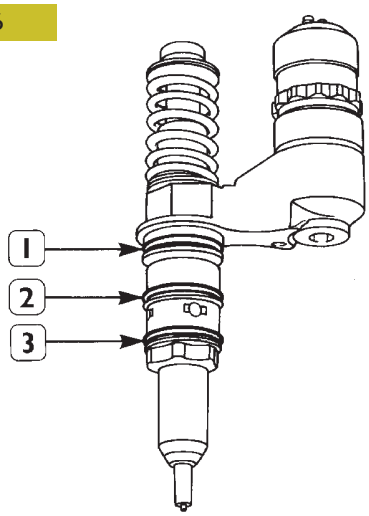
Field of use	
Pump rotation speed (rpm)	2600
Overrunning rotation speed (max 5 min) (rpm)	4100 max
Diesel oil temperature (°C)	-25/+80
Filtering rate on aspiration (micron)	30
Negative pressure on aspiration (bar)	0.5 max

Pressure control valve	
Valve calibration	5 ÷ 5.8

Injectors return valve	
Valve calibration	3.2 ÷ 3.8

Injector-pump

Figure 6



1. Fuel/oil seal – 2. Fuel/diesel seal – 3. Fuel/exhaust gas seal.

The injector-pump is composed of: pumping element, nozzle, solenoid valve.

Pumping element

The pumping element is operated by a rocker arm governed directly by the cam of the camshaft.
The pumping element is able to ensure a high delivery pressure. The return stroke is made by means of a return spring.

Nozzle

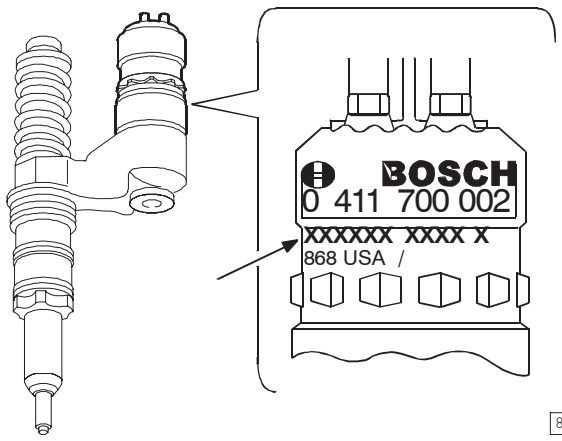
Garages are authorized to perform fault diagnosis solely on the entire injection system and may not work inside the injector-pump, which must only be replaced.

A specific fault-diagnosis program, included in the control unit, is able to check the operation of each injector (it deactivates one at a time and checks the delivery of the other five).
Fault diagnosis makes it possible to distinguish errors of an electrical origin from ones of a mechanical/hydraulic origin.
It indicates broken pump-injectors.
It is therefore necessary to interpret all the control unit error messages correctly.
Any defects in the injectors are to be resolved by replacing them.

Solenoid valve

The solenoid, which is energized at each active phase of the cycle, via a signal from the control unit, controls a slide valve that shuts off the pumping element delivery pipe.
When the solenoid is not energized, the valve is open, the fuel is pumped but it flows back into the return pipe with the normal transfer pressure of approximately 5 bars.
When the solenoid is energized, the valve shuts and the fuel, not being able to flow back into the return pipe, is pumped into the nozzle at high pressure, causing the needle to lift.
The amount of fuel injected depends on the length of time the slide valve is closed and therefore on the time for which the solenoid is energized.
The solenoid valve is joined to the injector body and cannot be removed.
On the top there are two screws securing the electrical wiring from the control unit.
To ensure signal transmission, tighten the screws with a torque wrench to a torque of 1.36 – 1.92 Nm (0.136 – 0.192 kgm).

Figure 7

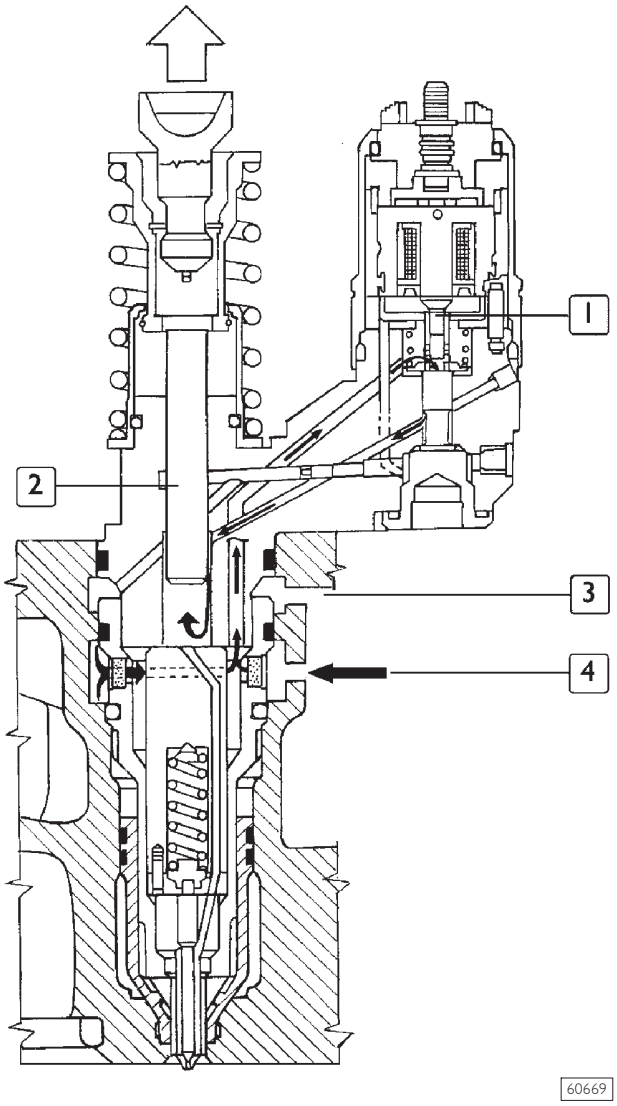


For each replaced injector you shall connect with the diagnosis device and when it is required by the program you shall insert the printed code on the injector (→) to program the gearcase again.

NOTE When checking the clearance of the rocker arms, it is important to check the injector-pump pre-load.

Injector Phases

Figure 8

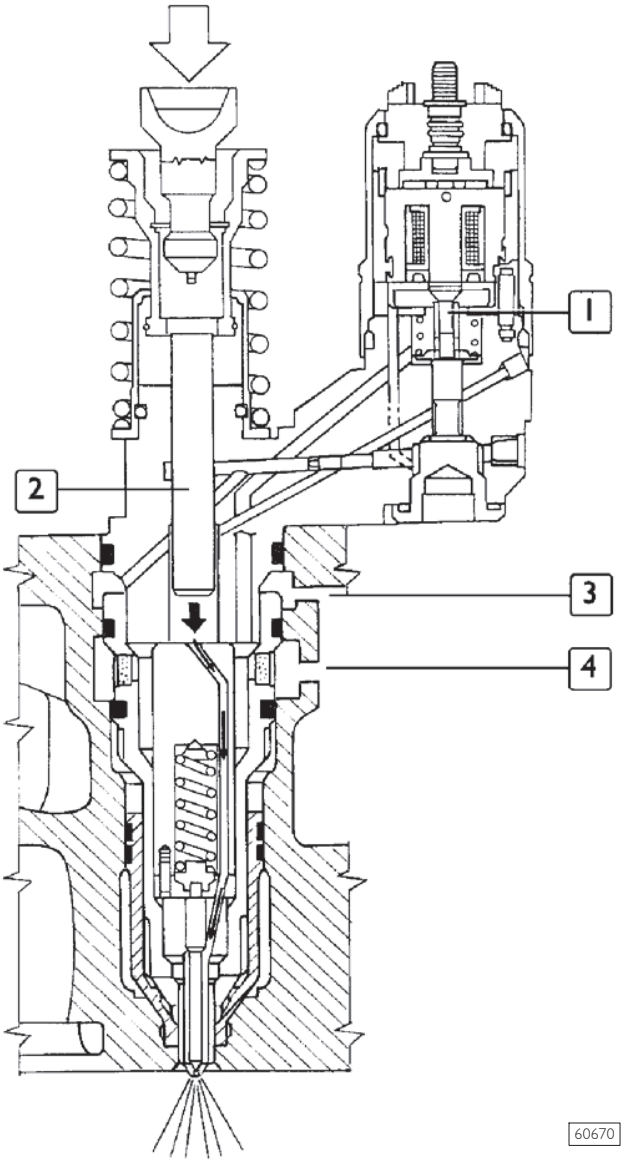


1. Fuel valve - 2. Pumping element - 3. Fuel outlet - 4. Filling and backflow passage.

Filling phase

During the filling phase the pumping element (2) runs up to the top position.
After passing the highest point of the cam, the rocker arm roller comes near the base ring of the cam.
The fuel valve (1) is open and fuel can flow into the injector via the bottom passage (4) of the cylinder head.
Filling continues until the pumping element reaches its top limit.

Figure 9



1. Fuel valve - 2. Pumping element - 3. Fuel outlet - 4. Filling and backflow passage.

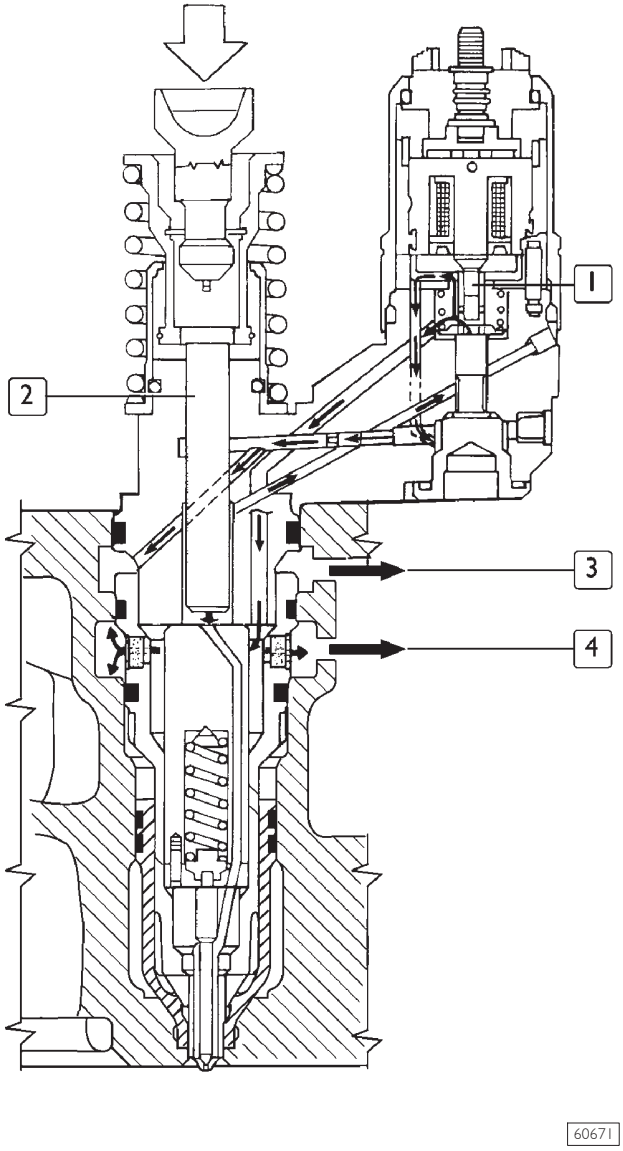
Injection phase

The injection phase begins when, at a certain point in the down phase of the pumping element, the solenoid valve gets energized and the fuel valve (1) shuts.

The moment delivery begins, appropriately calculated by the electronic control unit, depends on the working conditions of the engine.

The cam continues with the rocker arm to push the pumping element (2) and the injection phase continues as long as the fuel valve (1) stays shut.

Figure 10



1. Fuel valve - 2. Pumping element - 3. Fuel outlet - 4. Filling and backflow passage.

Pressure Reduction phase

Injection ceases when the fuel valve (1) opens, at a certain point in the down stroke of the pumping element, after the solenoid valve gets de-energized.

The fuel flows back through the open valve (1), the injector holes and the passage (4) into the cylinder head.

The time for which the solenoid valve stays energized, appropriately calculated by the electronic control unit, is the duration of injection (delivery) and it depends on the working conditions of the engine.