HP PUMP

So it is better to describe the HP pump operating principle, it is necessary to break down the explanation into several parts:
- Transfer pump
- High pressure pump DFP1
- High pressure pump DFP3
- IMV
- Pressure limiter

Note: *The "transfer pump"chapter is specific to the DFP1 pump in terms of diagrams: the operating principle remains identical to that for a DFP1 or DFP3 unit.*

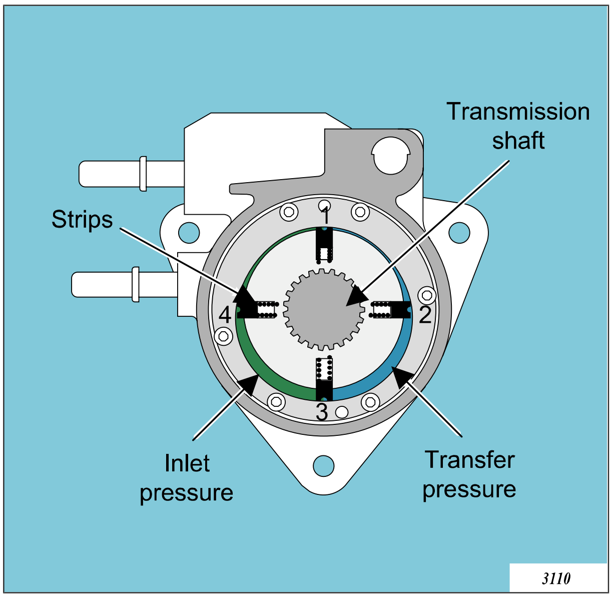
3.1 TRANSFER PUMP

3.1.1 DESCRIPTION

The first transfer pump stage draws diesel from the vehicle tank through the filter and sends it to the main pump under transfer pressure *(about 6 bar)* The blade pump technology used *(well known from our preceding products)* has the following parts:
- A rotor driven from the HP pump shaft. Torque is transferred by splined shaft.
- An eccentric liner fitted in the HP pump housing. Two off-set pins that locate the liner correctly and ensure correct assembly.
- One plate with two oblong holes: one inlet orifice and one discharge orifice.
- Four blades at 90 degrees to each other. Each blade is held against the liner by a coil spring.

3.1.2 OPERATING PRINCIPLE

Consider the space between the rotor, the liner and two successive blades.
- When the chamber is in position 1, the volume of the chamber is minimal. The volume change related to rotor angular travel is insignificant in this position.
- The rotor makes a quarter-turn anti-clockwise. The previous chamber is now in position 2. The inlet orifice is uncovered. The volume contained in the chamber quickly rises. The pressure in the chamber drops sharply. Fuel is drawn into the chamber.
- The rotor continues to rotate. It is now in position 3. Inlet and outlet orifices are now sealed off. The volume contained by the rotor, liner and the two blades is now at a maximum. Any changes in volume that depend on the rotor angle of rotation are small.

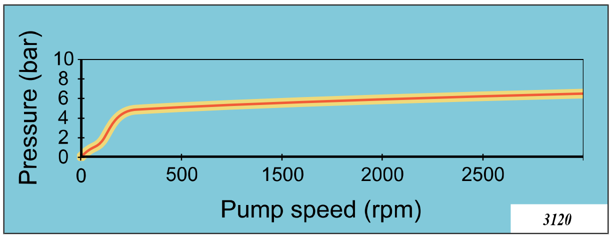


- The rotor continues to rotate. It is finally in position 4. The outlet orifice is uncovered. The volume contained by the rotor, liner and the blades diminishes rapidly. The pressure in this space increases sharply. The fuel is discharged under pressure.

HP PUMP

The vacuum generated by the transfer pump rotation is enough to draw in fuel through the filter. The transfer pump is driven by the HP pump shaft. Transfer pressure thus rises with engine speed.

A regulating valve maintains transfer pressure at a quasi constant value *(about 6 bar)* throughout the engine operating range by sending part of the fuel back to pump inlet.



Transfer pressure

3.1.3 TRANSFER PUMP CHARACTERISTICS

Regulating pressure

- 6 bar

Flow:

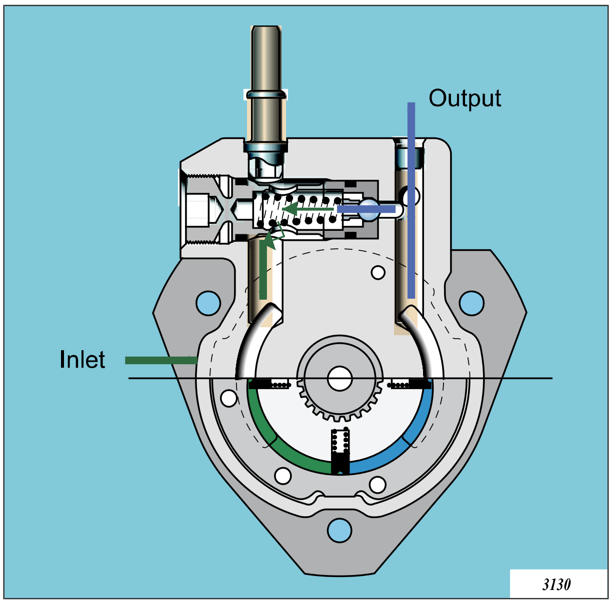
- 90 l/h at 300 rpm for pump
- 650 l/h at 2500 rpm for pump

Swept volume

- 5.6 cm^3/rev.

Intake capacity

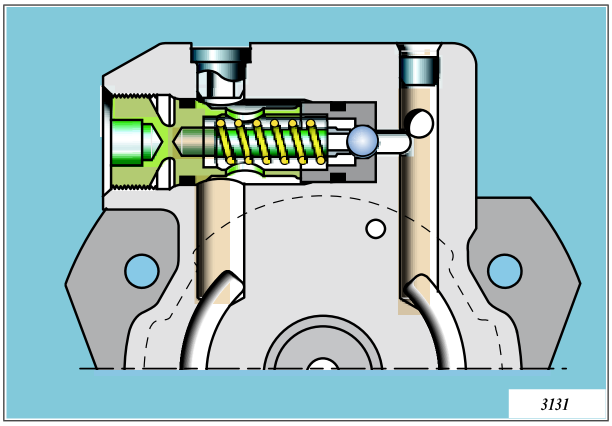
- 65 mBar at 100 rpm for pump



Transfer pump with its pressure regulator

Transfer pressure regulator mechanically controls transfer pressure using a single piston/spring arrangement to cover and uncover the fuel flow orifices.

As can be seen on the preceding diagram, the output from the regulator is recycled to the transfer pump inlet.



Close-up on transfer pressure regulator section

HP PUMP

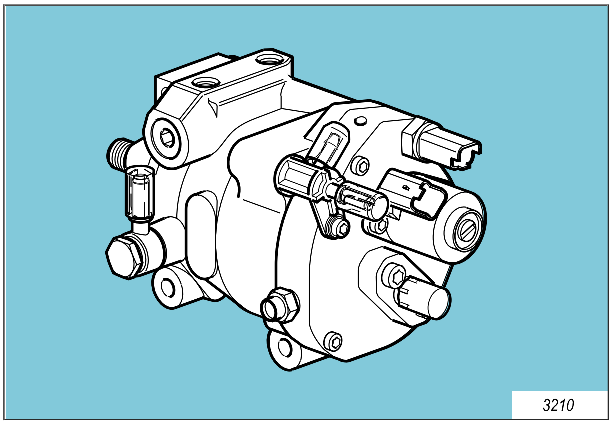
3.2 DFP1 COMMON RAIL PUMP

3.2.1 DESCRIPTION

This high pressure pump uses the cam and radial piston concept already proven on the DPC and EPIC rotating pumps. Nonetheless the transmission shaft and cam ring make up the one and same assembly. This is driven by chain or belt, rotating in the fixed hydraulic head. This design eliminates dynamic sealing problems since the high pressure is generated in the fixed part of the pump.

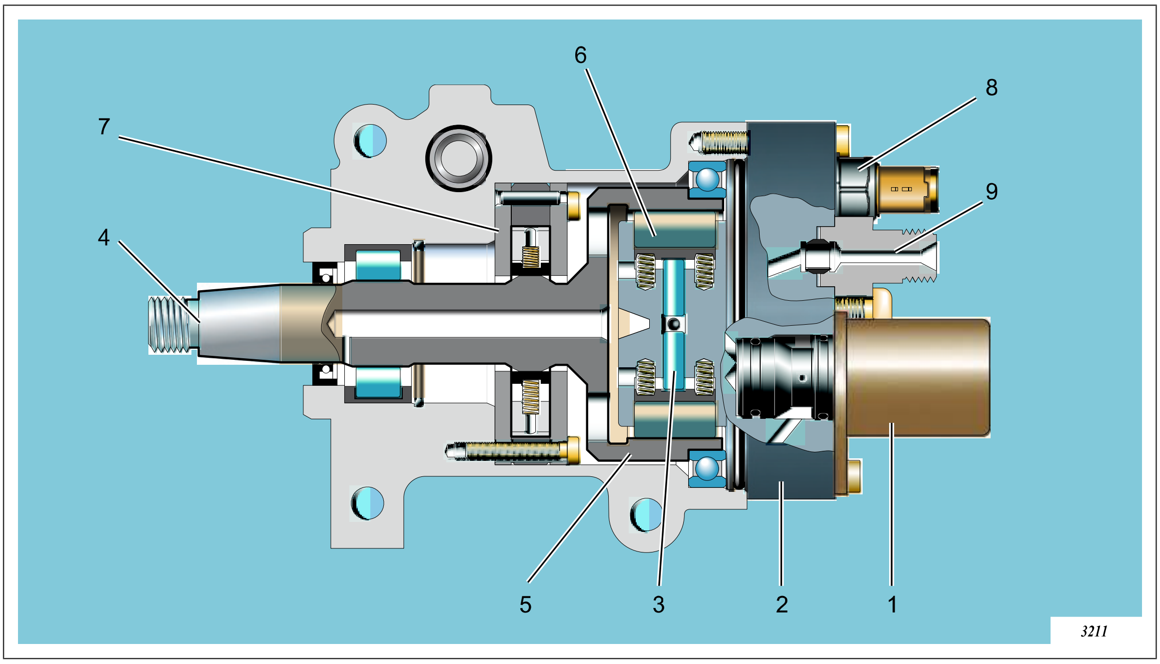
For engines needing substantial flow rates, the pump is fitted with two chambers angularly offset by 45 degrees. This offset reduces torque peaks and rail pressure variations.

The four-lobe cam is identical to that in conventional rotating pumps. However since the pump no longer determines injection procedure, it is possible to lengthen the pumping phase in order significantly to reduce driving torque, vibration and noise.



DFP1 High Pressure Pump

1	IMV	6	Roller
2	High pressure pump / Hydraulic head	7	Transfer pump
3	Plunger Piston	8	Diesel temperature sensor
4	Drive transmission shaft	9	High Pressure Exit
5	Rotary cam		



DFP1 High Pressure Pump section view

HP PUMP

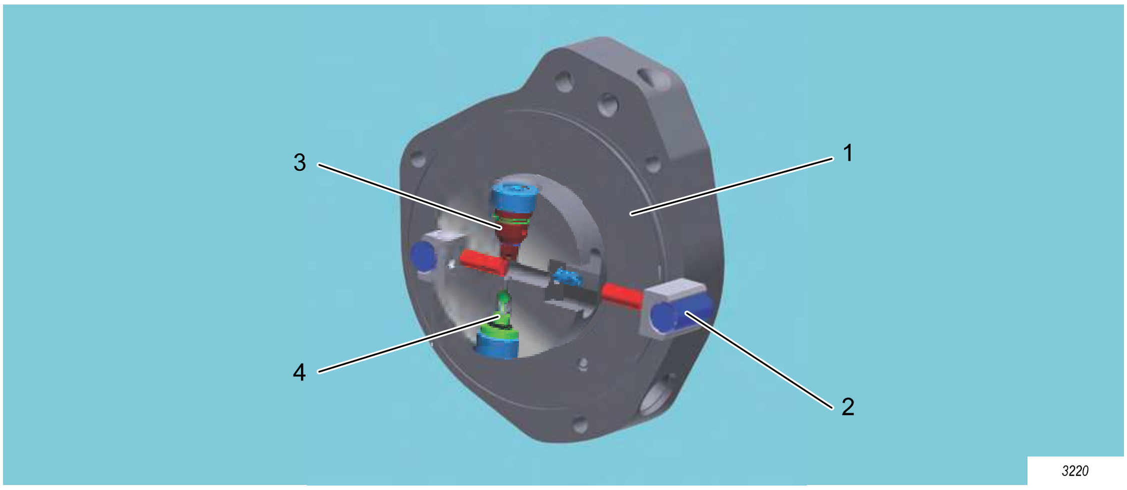
3.2.2 OPERATION

A) PUMP FEED

The transfer pump draws fuel through the filter. This delivers fuel to the HP pump entry point at a quasi-constant pressure known as the transfer pressure.

A filling actuator is fitted upstream of the HP pump. This controls the amount of fuel sent to the pumping system by adjusting the cross-section of the flow path. The ECU determines the coil current to set the flow path cross-section required to achieve the requested pressure for the engine operating conditions. When the requested pressure reduces the current increases, and vice-versa.

1	Hydraulic head body	3	Inlet valve
2	Roller shoe	4	Discharge valve

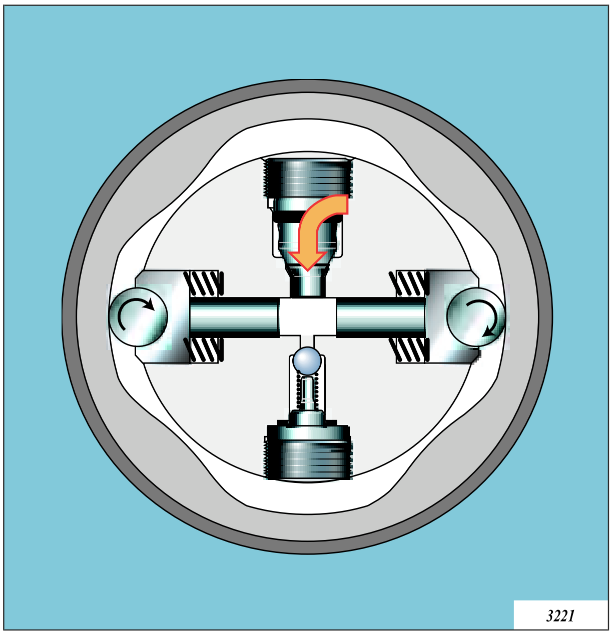


HP PUMP

B) PUMPING PRINCIPLE

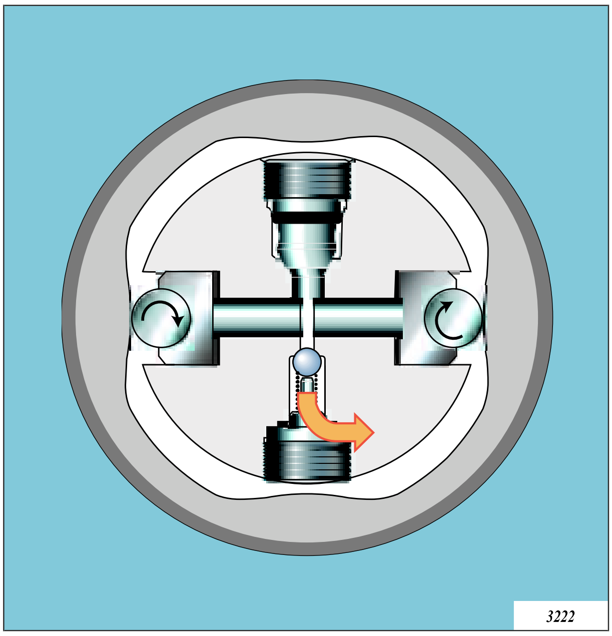
During the filling phase, two helical springs - one on each piston - keep the cam rollers in contact with the cam. The transfer pressure is sufficient to open the inlet valve and to move the plunger pistons apart. In this way the dead space between the two plunger pistons fills with fuel.

When the diametrically opposite rollers simultaneously move over the cam raise profile, the pistons are pushed together. Pressure rapidly increases in the space between the two plunger pistons.



Intake phase

When the pressure rises above transfer pressure the inlet valve closes. When pressure goes above rail pressure the discharge valve opens. The fluid under pressure is then delivered to the rail.

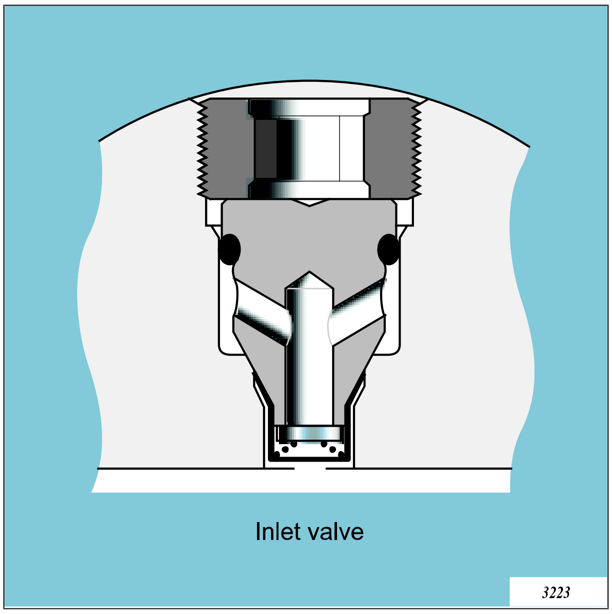


Discharge phase

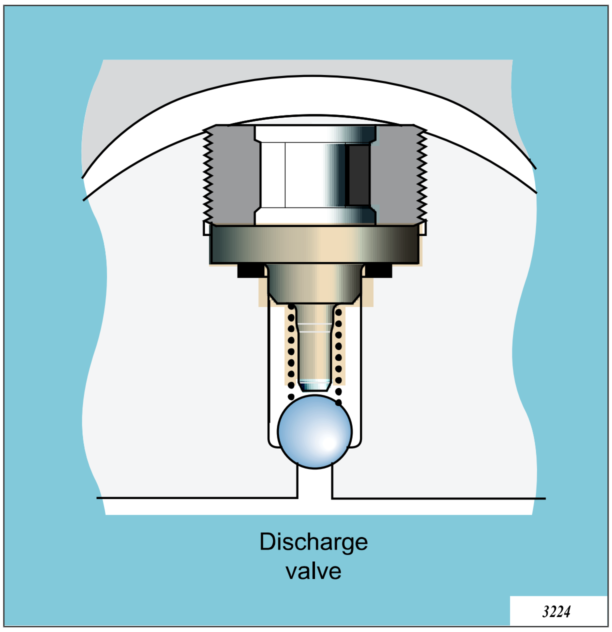
HP PUMP

C) INLET AND DISCHARGE VALVES

In the intake phase, the transfer pressure closes the valve. Fluid enters the body of the pump element. Under the effect of the transfer pressure, the plunger pistons move apart. When the rollers simultaneously meet the cam raise profile, pressure suddenly increases in the pump element body. The valve closes when the pump element body pressure becomes greater than the transfer pressure.



In the intake phase, the discharge valve ball comes under rail pressure on its external face and under transfer pressure on its internal face. The ball thus remains in its seating thus ensuring pump element body sealing. When the two diametrically opposite rollers simultaneously meet the cam raise profiles, the plunger pistons move towards each other and the pump element body pressure rapidly increases. When the pressure in this element becomes greater than rail pressure, the ball is in disequilibriuim and consquently opens *(the spring loading is negligible in relation to the pressure loading)* Fuel thus flows into the rail under high pressure.



D) PUMP LUBRICATION AND COOLING

The fuel in circulation keeps the pump lubricated and cooled. The mininim flow needed for pump operation is 50 litres/hour.

HP PUMP

E) PUMP PHASING

Conventional injection pumps distribute fuel under pressure to the various injectors. It is thus essential to phase the pump so that injection takes place at the required point in the cycle. The Common Rail system HP pump no longer distributes the fuel so it is essential to phase the pump with the engine. Nonetheless phasing the pump has two advantages:

- Variations in torque from the camshaft and the pump can be synchronised to limit stress in the distribution belt.
- Pressure control can be improved by synchronising pump-produced pressure peaks with the falls in pressure generated by each injection. This phasing improves pressure stability, which helps reduce the difference in flow between cylinders *(line to line)*.

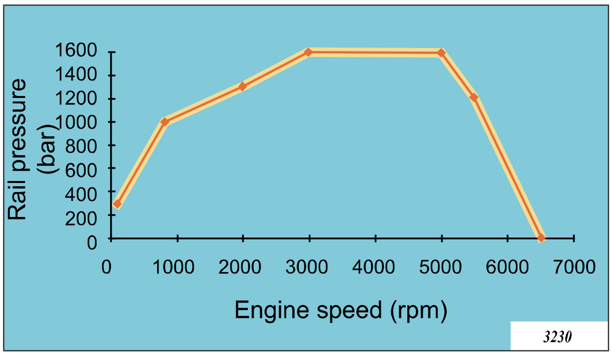
Phasing the pump will be done using a pin inserted in the pump drive shaft.

Note: *However phasing is obligatory on DFP1 pumps fitted on Renault applications for, unlike the practice with other car builders, the phase sensor is not positioned on the camshaft but on the pump pinion. It is therefore essential to phase the pump on Renault applications to avoid any problem with engine synchronisation.*

3.2.3 CHARACTERISTICS

A) DFP1 MAX PRESSURE GRAPH

The time needed to achieve sufficient rail pressure to start depends on the injection system volume *(rail dimensions, tubing length, etc)*. The object is to achieve a 200 bar pressure in 1.5 revs *((3rd compression)*.



HP PUMP

B) CHARACTERISTICS

Applicatio ns	Capacity (cm^3/rev)	No. of plungers	Rack	Ratio	Max Pump Speed	Max Rail pump Speed	Drives
Renault K9	0.6	2	1	1/2	3000 rpm @ 1000bar	1000 - 2500 rpm @ 1600bar	Belt
PSA DV4TED4	0.67	3	1	2/3	3500 rpm @ 1200bar	1170 - 3000 rpm @ 1600bar	Belt
Ford Puma Transit	1.2	4	2	1/2	3000 rpm @ 1000bar	1000 - 2500 rpm @ 1600bar	Chain
Ford Lynx/ Puma	0.9	4	2	1/2	3000 rpm @ 1000bar	1000 - 2500 rpm @ 1600bar	Chain
Kia	0.9	4	2	1/2	2800 rpm @ 1000bar	1250 - 2100 rpm @ 1400bar	Belt
SsangYong	0.9	4	2	5/8	3000 rpm @1000bar	1000 - 2500 rpm @ 1400bar	Chain