Thanks to gmctd for this!

I've edited excerpts from the manual for clarity and scope - read it if you will, ignore it if you must.....

FUEL SYSTEM
A Robert Bosch high-pressure fuel injection pump is used. The pump is attached to the back of the timing gear housing at the left /front side of the engine

DESCRIPTION
The fuel system on the 5.9L Common Rail Diesel Engine uses a rotary mechanical fuel injection pump and an Electronic Control Module (ECM) and is a drive-by-wire system, meaning there is no physical throttle cable.
The fuel delivery system consists of the:
- Accelerator pedal position-sensor module
- Air cleaner housing\element
- Fuel filter\water separator
- Fuel temperature sensor
- Fuel heater
- Fuel rail pressure relief valve
- Fuel rail pressure sensor
- Fuel injection pump
- Fuel injectors
- Fuel tank
- Fuel tank filler\vent tube assembly
- Fuel tank filler-tube cap
- Fuel tank module containing the electric lift pump, roll-over valve and a fuel gauge sending unit (fuel level sensor).
- Fuel tubing\lines\hoses
- High-pressure fuel injector lines
- Low-pressure fuel supply and return lines
- Low-pressure fuel return line

- Overflow valve
- Quantity control Fuel Control Actuator valve
- Quick-connect fittings
- Water sensor\drain module

FUEL INJECTION PUMP
The Cummins 5.9L CRD uses the Bosch CP3 injection pump, used also on the DMax 6.6L V8 CRD and the Jeep 2.8L CRD

DESCRIPTION
A radial, 3-piston pump, with a gearotor pump attached to the back, is used as the high-pressure pump for common-rail fuel pressure generation - in this system it is capable of pressures between 300-1600 bar (4351-23206 psi) .
A spring-loaded Cascade Overflow Valve regulates internal housing pressure
Regulated internal housing pressure is oem-specific
The pump shaft is driven by the timing belt at 1:1 ratio to the crankshaft.
Fuel pressure is generated independently of the injection process.
A Fuel Control Actuator solenoid valve regulates injection pressure
The pump is lubricated by the pumped Diesel fuel and is not responsible for fuel injection timing.

OPERATION

GEAROTOR PUMP

DESCRIPTION
The gearotor pump has two functions
- draws fuel from the fuel supply
- increases fuel pressure for regulation to housing pressure required for internal lubrication and supplying the high-pressure injection pump

OPERATION
This fuel system uses a gearotor supply-pump attached to the rear of the high-pressure pump. This medium-pressure fuel pump is driven by the end of the high-pressure pump shaft, and can generate 20" vacuum at the fuel inlet at high rpm.
The gearotor pump is supplied fuel from the lift pump in the fuel tank through the fuel manager\filter.

The outlet of the gearotor pump provides pressurized fuel to a branched circuit internal to the high-pressure pump flange, which supplies both the Fuel Control Actuator solenoid valve and the Cascade Overflow Valve\regulator. Because the gearotor pump increases fuel flow and pressure as engine rpm increases, the pressure and flow is regulated by the COV.

The COV and gearotor supply-pump are not serviced independently of the high-pressure pump.

CASCADE OVERFLOW VALVE

DESCRIPTION
The COV is located on the front cover of the high pressure pump.
The Cascade Overflow Valve has three functions:
- regulation of lubrication fuel to the internal moving parts of the high-pressure pump
- regulation of the fuel pressure being supplied to the Fuel Control Actuator solenoid valve
- return excess fuel to the fuel tank
This regulated internal pressure, known as housing pressure, is determined by engine displacement and power requirements - the 5.9L CRD requires 5-12.4 bar (80-180 psi)
For comparison, the 2.8L 4-cyl Jeep CRD requires 5bar maximum (73psi)

OPERATION
The COV has a spring-loaded center spool-piece that has a drilled channel with three passages: one for initial low-pressure lubrication, one for lubrication at housing-pressure , and one for overflow. The valve is operated in three stages based on the level of pressure at the inlet.

Stage 1
When the fuel pressure entering the tip of the COV is between 0 and 3 bar (43psi), pressure is too low to overcome regulator spring tension and fuel flows through the center channel, only . This passage always allows fuel flow through to the pump center-ring and lubricates the pump bearings and internal moving parts. This circuit also allows air to bleed during initial cranking and returns the air to the fuel tank.
The COV is in Stage 1 during cranking, only.

Stage 2
When the fuel entering the COV exceeds 5bar (73psi), but is less than 12.4bar (180psi), the spool-piece moves against spring tension aligning a second passage for lubrication purposes.
Stage 2 can be reached during cranking and initial start up.

Stage 3
When fuel pressure exceeds 12.4bar (180psi), the spool-piece aligns with the overflow passage. This stage relieves the pressure into an overflow circuit that sends the fuel back to the inlet side of the gearotor pump, thus limiting maximum fuel pressure to 12.4bar (180psi).
Lubrication fuel continues to flow through all channeled passages during this stage.
Excess fuel is sent back to the fuel tank through the fuel-return circuit

Stage 3 is reached at over-pressure

FUEL CONTROL ACTUATOR

DESCRIPTION
The Fuel Control Actuator solenoid valve is located on the back of the front cover of the high-pressure pump. The solenoid is pulse-width modulated by the ECM and meters the amount of fuel that flows into the high-pressure elements inside the high-pressure pump.
The solenoid is inactive up to 30 seconds after IGNition switch is initially keyed to ON position to allow maximum fuel pressure to the fuel rail during cranking and start up. ECM assumes FCA valve control when CPS signal and rail pressure are within acceptable limits

OPERATION
The Fuel Control Actuator solenoid valve is a pulse-width modulated valve that controls the amount of fuel sent or delayed to the high-pressure pump elements inside the high-pressure pump. The ECM determines the fuel pressure set point based on engine sensor and rail-pressure inputs. If the actual fuel-rail pressure is too low, the ECM commands the solenoid to allow more fuel to flow to the high-pressure pump. This minimizes the difference between the actual fuel-rail pressure reading and the set point. The ECM will also operate the solenoid to delay fuel, reducing flow-rate, if the fuel-rail pressure becomes too high.
The FCA valve is commanded open by the ECM to allow the high-pressure pump to build maximum pressure (1600bar, 23,206psi), or closed to reduce rail pressure.
Thus, rail fuel-pressure can be increased or decreased independent of engine speed

High Pressure Pumping Plungers
The FQS valve supplies three high pressure pumping chambers. The pumping chambers have one-way inlet valves that allow fuel to flow into the chambers. The valves then close as the fuel is compressed, causing the high pressure fuel to overcome a spring-loaded ball-and-seat outlet valve.
All three pumping chambers are tied together in one circuit internal to the pump and provide high pressure fuel between 300bar (4351psi) and 1600bar (23,206psi) through a steel line to the fuel rail.
The pump is driven at 1:1 engine speed and is not responsible for injection timing.
Pump function is to provide fuel at high-pressure, while the ECM controls injection pressure and timing.

FUEL RAIL

DESCRIPTION
The fuel rail is mounted to the cylinder-head cover\intake manifold. The rail distributes regulated high-pressure fuel equally to the fuel injectors.
A pressure sensor is screwed into the rail so ECM can read and regulate system pressure.
A pressure valve is screwed into the fuel rail to allow regulated overflow return to the fuel tank.

OPERATION
The fuel rail stores the fuel for the injectors at high pressure. At the same time, the pressure oscillations which are generated due to the high-pressure pump delivery and the injection of fuel are dampened by rail volume.
The fuel rail is common to all cylinders, hence it’s name "common rail". Even when large quantities of fuel are extracted, the fuel rail maintains a constant inner pressure. This ensures that injection pressure remains constant from the instant the injector opens to the end of the injection event.

PRESSURE LIMITING VALVE

DESCRIPTION
The fuel pressure limiting valve is located on the top of the fuel rail.

OPERATION
Fuel pressure at the fuel rail is monitored by the fuel rail pressure sensor. If fuel pressure becomes excessive, the high pressure fuel overcomes a spring-loaded plunger with tapered-seat outlet valve, causing the pressure limiting valve to open and vent excess pressure into the fuel drain circuit, and back to the fuel tank.

FUEL LINES

DESCRIPTION

LOW-PRESSURE FUEL LINES
All fuel lines up to the fuel injection pump are considered low-pressure. This includes the fuel lines from the fuel tank module to the inlet of the high-pressure fuel injection pump. The fuel-return lines and the fuel-drain lines are also considered low-pressure lines.
High-pressure lines are used between the fuel injection pump and the fuel injectors

HIGH PRESSURE FUEL LINES
High-pressure fuel lines are used between the high pressure fuel injection pump and the fuel rail, and between the fuel rail and fuel injectors
All other fuel lines are considered low-pressure lines.

OPERATION - HIGH PRESSURE FUEL LINES
High-pressure fuel lines deliver fuel under extremely high pressure - between 300-1600 bar (4351-23206 psi) - from the high-pressure pump to the rail to the fuel injectors. The lines expand and contract from the high-pressure fuel pulses generated during

the injection process, which can delay the injection event - ECM compensates for that based on component specs
All high-pressure fuel lines between the rail and the injectors are of the same length and inside diameter to ensure equal-duration injection events, cylinder to cylinder.
Correct high-pressure fuel line usage and installation is critical to smooth engine operation.

FUEL MANAGER\FILTER

FUEL FILTER / WATER SEPARATOR

DESCRIPTION
The fuel filter/water separator assembly is located on left side of engine above the starter motor. The assembly also
includes the fuel heater, Water-In-Fuel (WIF) sensor and a screened banjo bolt attached at the bottom of the fuel
filter canister.

OPERATION
The fuel filter/water separator protects the fuel injection pump by removing water and contaminants from the fuel.
The construction of the filter/separator allows fuel to pass through it, but helps prevent moisture (water) from doing
so.
Moisture precipitates out and collects at the bottom of the canister.
A screened banjo-bolt is attached to the filtered outlet at the bottom of the fuel filter canister to provide additional filtering for the high pressure fuel system components.
A Water-In-Fuel (WIF) sensor is attached to the lower side of fuel filter housing.
A fuel heater is installed into the top of the filter/separator housing.

WATER IN FUEL SENSOR

DESCRIPTION
The Water-In-Fuel (WIF) sensor is located on the side of the fuel filter/water separator canister.

OPERATION
The sensor varies an input to the Engine Control Module (ECM) when it senses water in the fuel filter/water separator.
As the water level in the filter/separator increases, the resistance across the WIF sensor decreases. This decrease in resistance is sent as a signal to the ECM and compared to a standard reference value. Once the value
drops to 30 to 40 kilohms, the ECM will activate the water-in-fuel warning lamp through CCD bus circuits. This all
takes place when the ignition key is initially put in the ON position. The ECM continues to monitor the input while the engine is running.

FUEL HEATER

DESCRIPTION
The fuel heater assembly is located on the side of the fuel filter housing and internal to the fuel filter housing .
The heater/element assembly is equipped with a temperature sensor (thermostat) that senses fuel temperature. This
sensor is attached to the fuel heater/element assembly.

OPERATION
The fuel heater is used to prevent diesel fuel from waxing during cold weather operation.
When the fuel temperature is below 45° ±8 F (7°C), the temperature sensor allows current to flow to the heater
element warming the fuel. When the fuel temperature is above 75° ±8 F (24°C), the sensor stops current

flow to the
heater element.
Battery voltage to operate the fuel heater element is supplied from the ignition switch and through a solid state
device in the IPM.
There is no Fuel Heater Relay - fuel heater element and solid-state device in IPM are not ECM controlled.
The heater element operates on 12 volts, 300 watts at 0° F (-18° C).
The fuel heater is used to prevent diesel fuel from waxing during cold weather operation.
A malfunctioning fuel heater can cause a wax build-up in the fuel filter/water separator. Wax build-up in the filter/ separator can cause engine starting problems and prevent the engine from revving up. It can also cause blue or white fog-like exhaust. If the heater is not operating in cold temperatures, the engine may not operate due to fuel waxing.

The fuel heater assembly is located on the side of fuel filter housing and internal to the fuel filter housing.
The heater assembly is equipped with a built-in fuel temperature sensor (thermostat) that senses fuel temperature.
When fuel temperature drops below 45° ± 8° F (7° C), the sensor allows current to flow to built-in heater element to warm fuel. When fuel temperature rises above 75 °± 8° F (24° C), the sensor stops current flow to heater element (circuit is open).
Voltage to operate fuel heater element is supplied from ignition switch, through the solid-state device in IPM, to fuel temperature sensor and on to fuel heater element.

The heater element operates on 12 volts, 300 watts at 0 °F (-18° C). As temperature increases, power requirements decrease.
A minimum of 7 volts is required to operate the fuel heater. The resistance value of the heater element is less than

1 ohm (cold) and up to 1000 ohms warm

FUEL TRANSFER PUMP

ELECTRIC FUEL LIFT PUMP
'03-'04 trucks have a Carter sliding-vane type lift pump attached to the fuel manager head on the engine, supplying ~15psi pressure, internally bypassed, with an internal pre-filter screen
'05^ trucks have a rotary-vane type lift pump in the fuel module in the tank, supplying ~ 9psi, externally bypassed, returning excess fuel to the tank, with a pre-filter screen

DESCRIPTION
The '05^ fuel transfer pump (fuel lift pump) is part of the fuel pump module .
The fuel pump module is located in the fuel tank.
The 12–volt electric pump is operated and controlled by the Engine Control Module (ECM).
The ECM controls a relay in the Intelligent Power Module (IPM) for transfer pump operation.

OPERATION
The purpose of the fuel transfer pump is to supply (transfer) a low-pressure fuel source from the fuel tank through
the fuel filter/water separator to the high-pressure fuel injection pump.
Check valves within the pump control direction of fuel flow and prevent fuel bleed-back during engine shut down.
Operating pressure is 9psi @ 50gph, maximum current flow to the pump is 5 amperes @100 percent duty-cycle..
The transfer pump is self-priming: when the key is first turned on (without cranking engine), the pump will operate
for approximately 2 seconds and then shut off (Note: When ambient temperatures are cold enough to cause the
intake air heaters to operate, the fuel lift pump will operate during the entire intake air pre-heat cycle). The pump will
also operate for up to 25 seconds after the starter is engaged, and then stop if the engine is not running.
A safety feature ensures the pump will shut off immediately if the key is on and the engine stops running.
The fuel volume of the transfer pump will always provide more fuel than the fuel injection pump requires. Excess
fuel is returned from the injection pump through the COV overflow valve back to the fuel tank.

The oem lift pump is of the flow-thru-when-failed type - the internal gearotor lift pump in the CP3 will pump 20" vacuum, and is designed to pull fuel from the tank thru a filter head - if the replacement aftermarket remote lift pump is not flow-thru, the engine will stop when the lift pump fails.

Always be sure the replacement LP is flow-thru type