Maintenance Level Training (L2)

TA

Translation of Original Instructions:

TEREX®

WORKS FOR YOU.™

Scania DC13

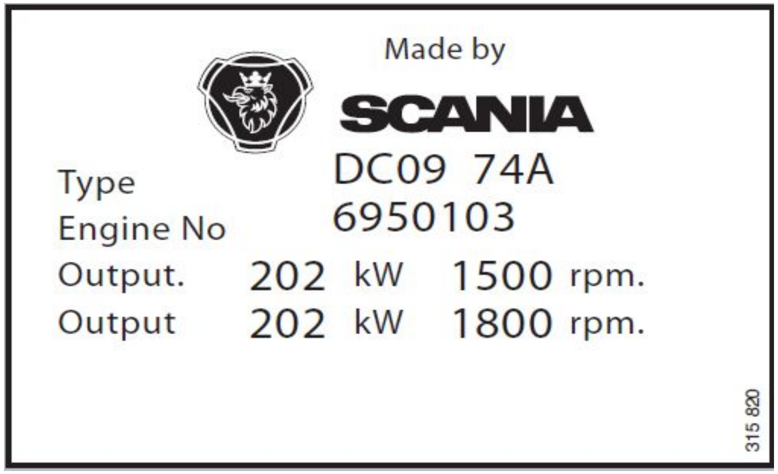
Bore x Stroke 130 x 140 mm
HP Range 401 - 550 HP
Displacement 12.7 lt.
Inline 6 Cylinder
Firing Order 1-5-3-6-2-4

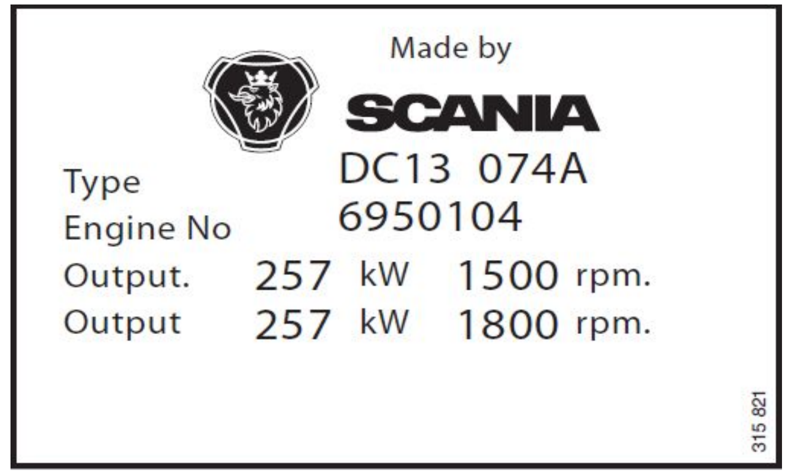
Tier 2 PDE Fuel system

Tier 4 XPI fuel system

Exhaust system
SCR (Selective Catalytic Reduction)
Reductant tank (Adblue) or (Diesel Exhaust Fluid)

Type designation
Engine plate

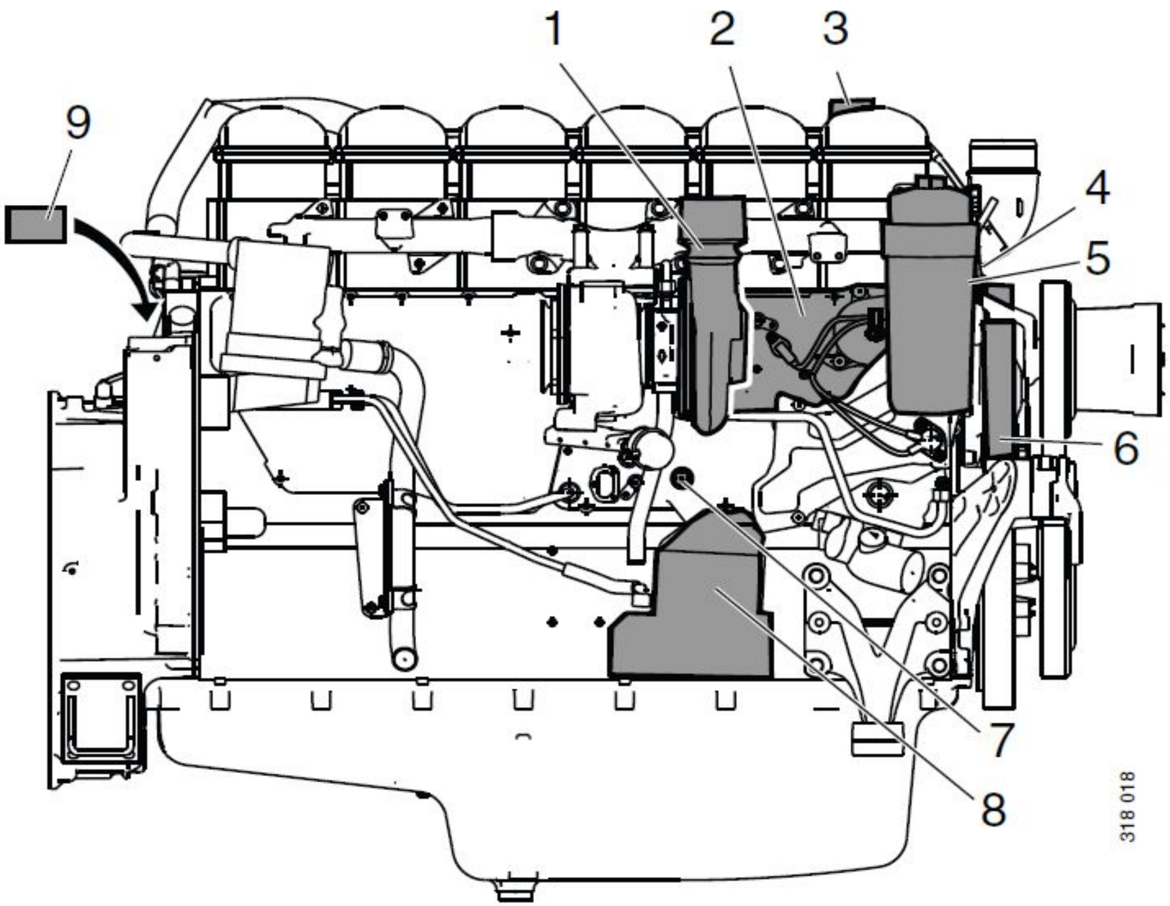




The engine type designation indicates engine type, size and applications in code form. The engine serial number is stamped onto the top of the cylinder block at the front right.
The type designation is shown on the type plate.

Example: DC09 074A
DC - Supercharged diesel engine with air-cooled charge air cooler.
13 - Displacement in whole dm3.
074 - Performance and certification code. The code indicates, together with the application code, the normal gross engine output.
A - Code for application. A means for general industrial use.

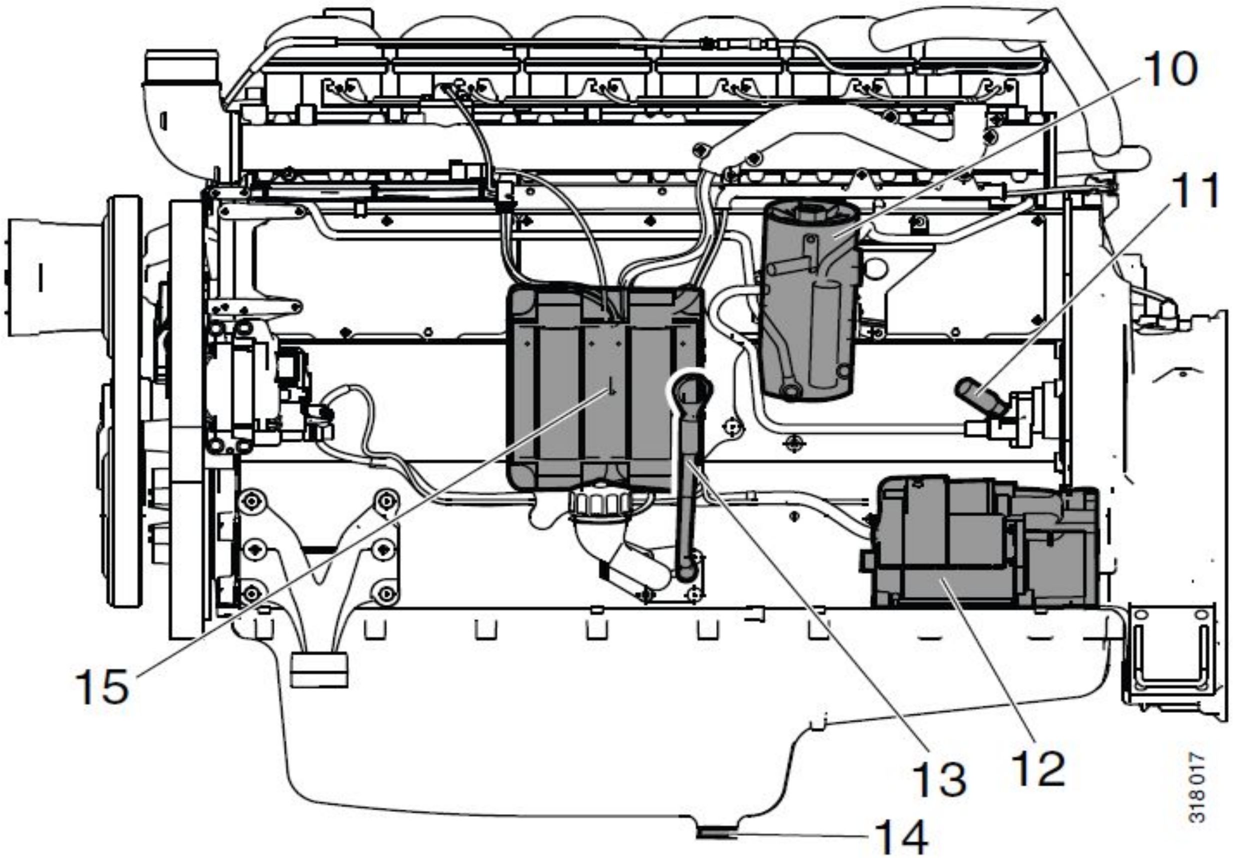
Location on engine



The illustrations show a normal version of a DC09 engine. The actual engine may have different equipment.

1. Turbocharger
2. Oil cooler
3. Oil filler
4. Engine serial number on the cylinder block
5. Oil filter
6. Coolant pump
7. Draining coolant
8. Oil filter unit
9. Type designation

Location on engine



The illustrations show a normal version of a DC13 engine.
The actual engine may have different equipment.

10. Pressure filter (fuel)
11. Hand pump (fuel)
12. Starter motor
13. Oil dipstick
14. Oil plug
15. EMS control unit

Inspection interval

Maintenance first 500 h.

- Check/Adjust valve clearance and PDE height
- Change oil and oil filter (cartridge type)
- Clean the oil centrifugal filter

Inspection interval

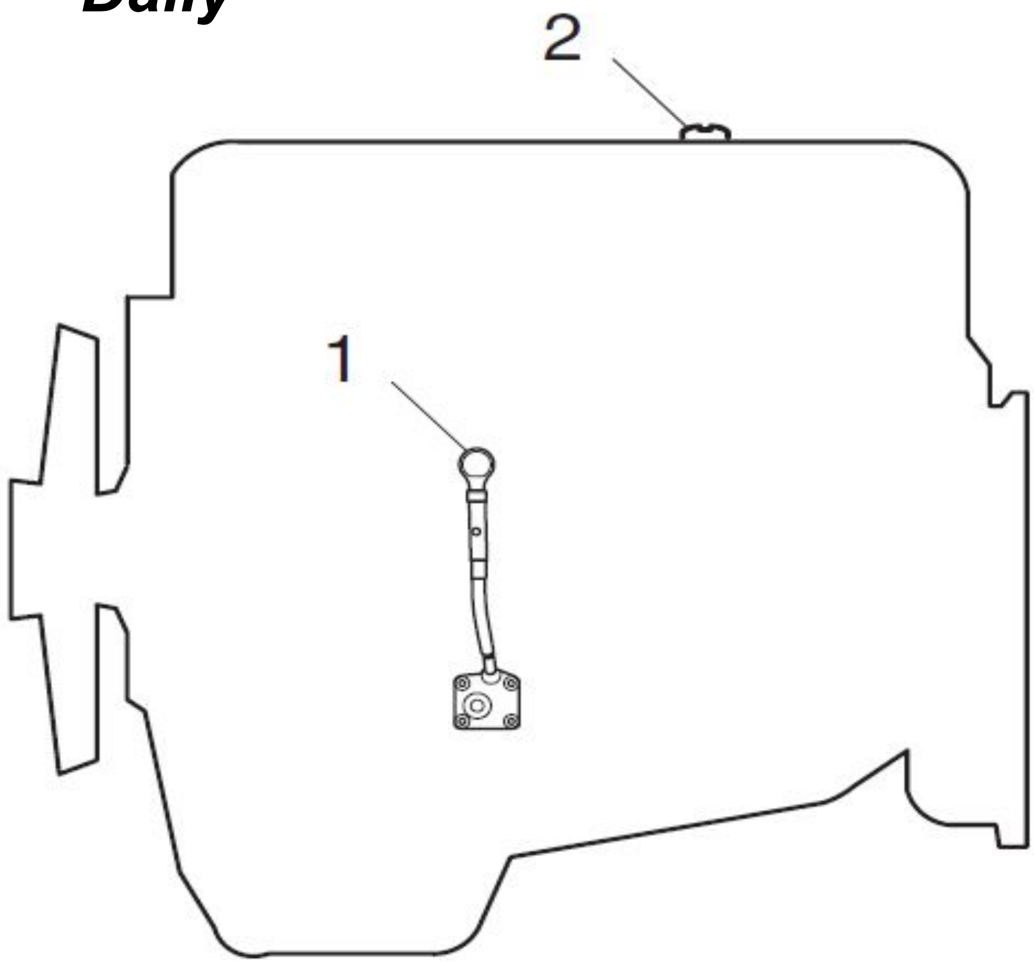
	Daily	First time at		Interval (hours)				At least	
		First start	***500***	***500***	***1000***	***2000***	***6000***	***An-nually***	***Every 5 years***
Lubrication system Checking oil level.	***X***	***X***							
Changing the oil.				***X***[1]				***X***	
Cleaning the centrifugal oil cleaner.				***X***[1]				***X***	
Renewing the oil filter.				***X***[1]				***X***	
Cooling system Checking coolant level.	***X***								
Checking coolant antifreeze or corrosion protection.		***X***				***X***		***X***	
Cleaning the cooling system and changing coolant.							***X***[1]		***X***
Air cleaner Reading the vacuum indicator.	***X***								
Cleaning or renewal of the filter element						***X***[1]			***X***
Renewing the safety cartridge.						***X***			***X***
Fuel system Checking fuel level.	***X***	***X***							
Renewing the fuel filter.					***X***[1]				***X***
Electrical system Checking the electrolyte level in batteries		***X***		***X***				***X***	
Checking state of charge.		***X***			***X***			***X***	
Cleaning the batteries.					***X***			***X***	

1 =More often if required

Checking the oil level

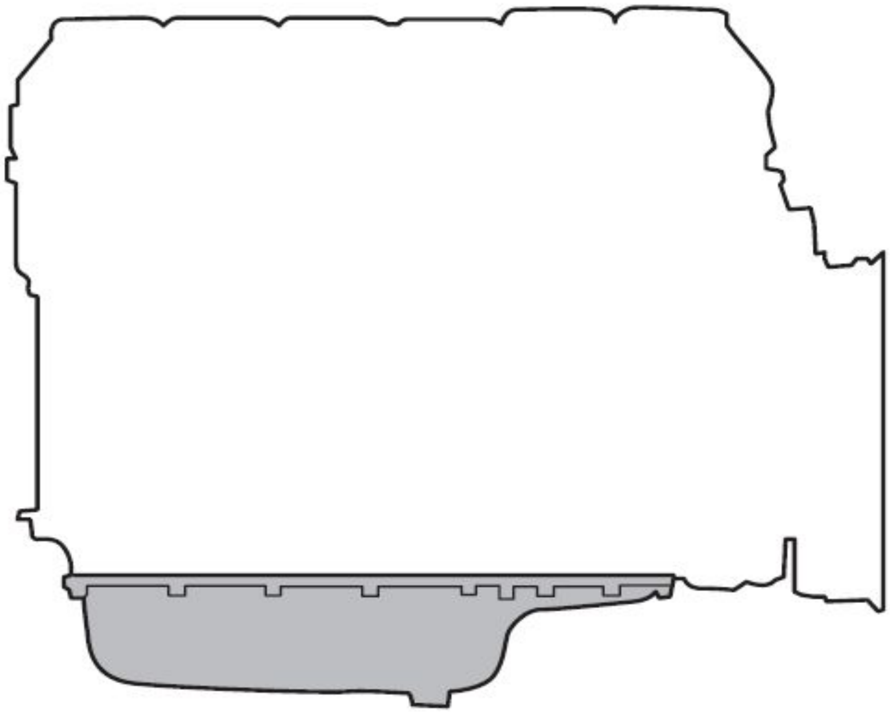
Daily

1. Oil dipstick
2. Oil filler cap



Changing the oil

Every 500 hours



Max. 45 litres (11.9 US gallons)

Min. 34 litres (9 US gallons)

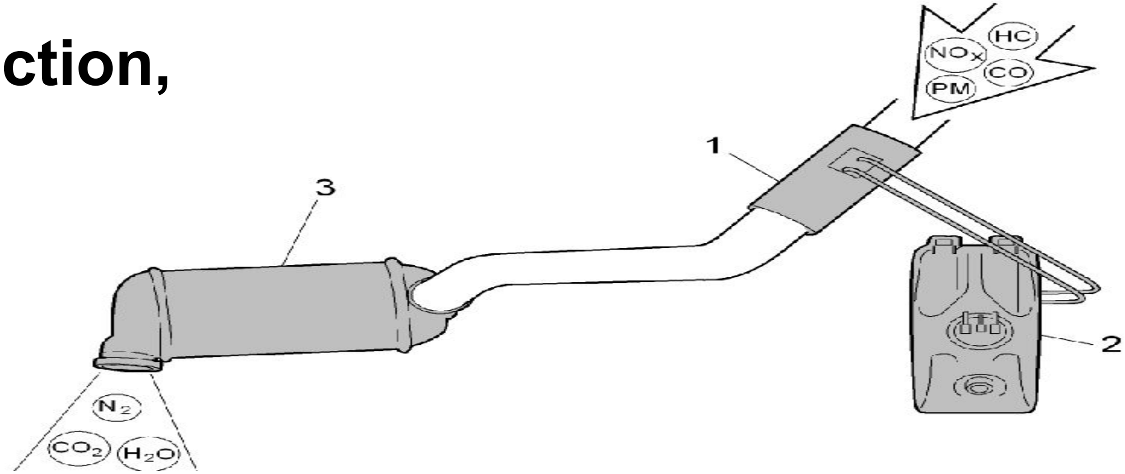
Why SCR

Low CO_2 emissions
High outputs
Response
Sulphur level in fuel
Cooling demand
Prepared for Stage 4 and Tier 4f
No particulate filter

- Regeneration not required
- Lower fuel consumption (regeneration, exhaust back pressure)
- Reduced maintenance

Selective Catalytic Reduction, SCR

Warning!
When the engine is running the exhaust system parts can reach such high temperatures that there is a risk of personal injury. Make sure that the exhaust system temperature has decreased to a suitable level before starting work

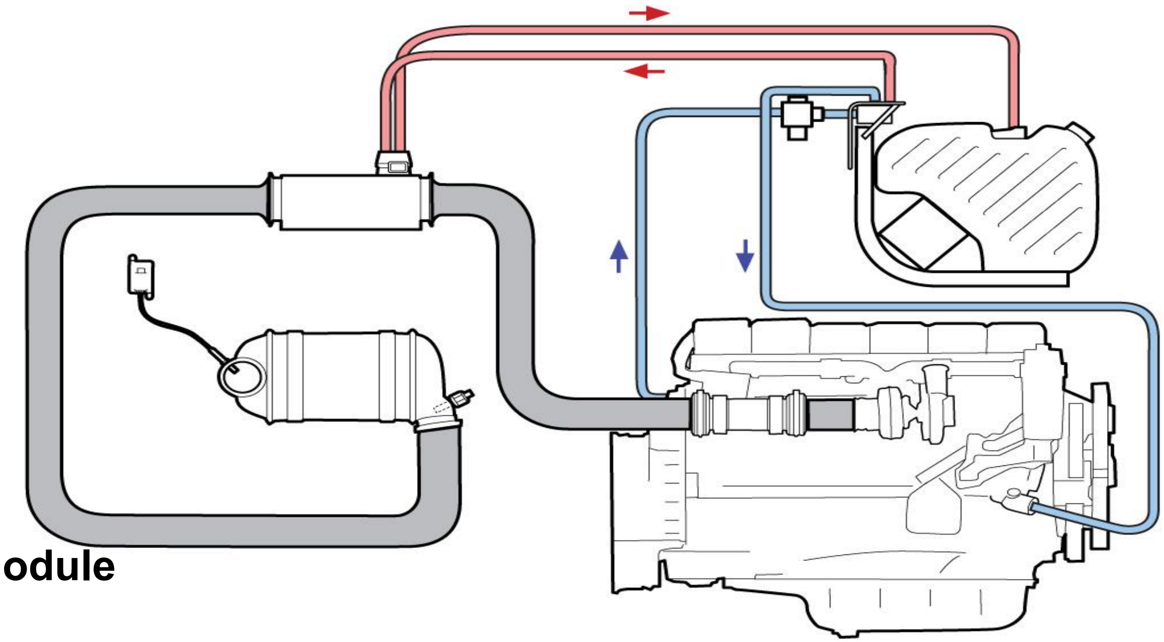


In order to reduce the concentrations of nitrogen oxide compounds (NOx) in the exhaust gases, catalytic converters are used and reductant (32.5% urea and the rest water, under the trade name AdBlue) is delivered into the exhaust gases in the hydrolysis catalytic converter. When the exhaust gases have been treated in the SCR catalytic converter water (H_2O), carbon dioxide (CO_2) and nitrogen (N_2) come out of the exhaust pipe.
The illustration is a principle drawing of the components carrying out exhaust gas aftertreatment.

1. Hydrolysis catalytic converter with reductant doser. Reductant is added, evaporated and mixed with the exhaust gases.
2. Reductant tank and reductant pump to deliver reductant to the reductant doser.
3. SCR catalytic converter that converts nitrogen oxide compounds into nitrogen and water.

The exhaust gas aftertreatment processes are monitored and activated by the exhaust gas aftertreatment control unit EEC3 which is controlled by the engine control unit EMS.

Selective Catalytic Reduction SCR



Overview of the system.

The system contains a tank with pump module

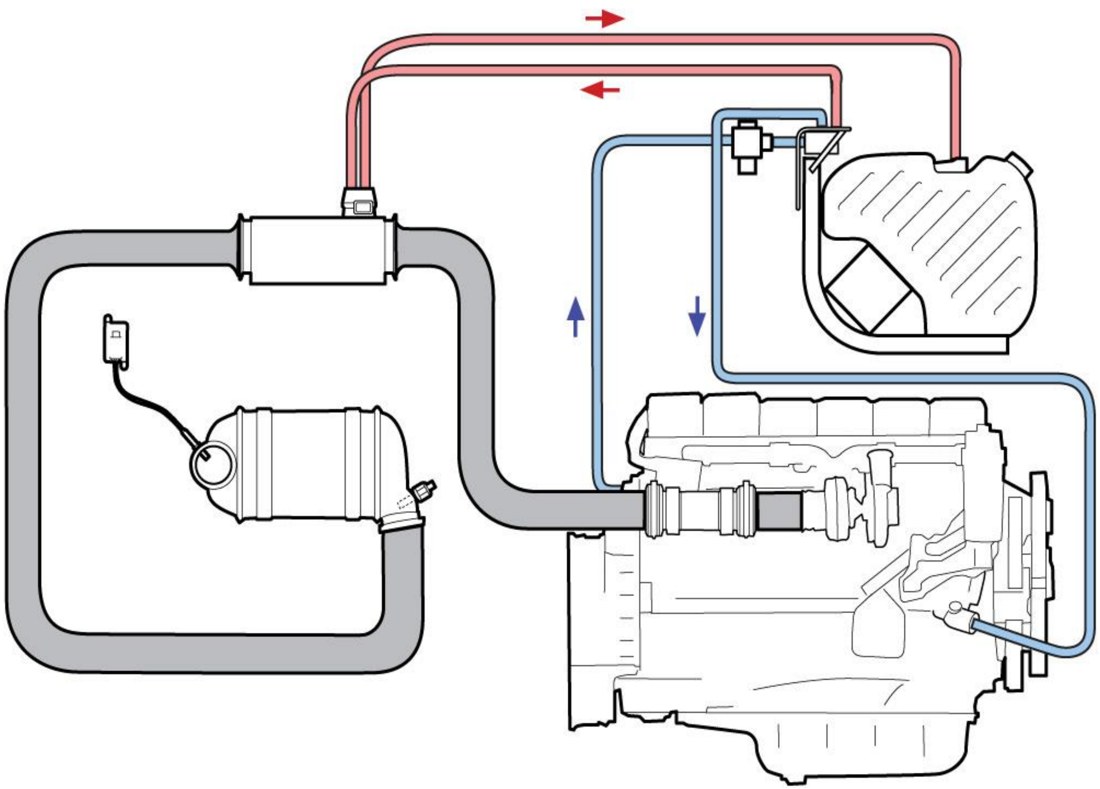
a hydrolysis catalyst with dosing unit that is mounted on the catalysts

A SCR catalyst with temperature sensor and NOx sensor

The blue hoses contain the cooling water from the engine and is used for defrosting the tank unit when risk of freezing.

The red hoses contain urea reductant and circulate to cooling the dosing unit, these are electrical heated

SCR System



Legal demand Max 10 PPM Sulfur

Technical limit 300PPM

Exhaust Emissions

Diesel exhaust gases contains (legislated emissions):

- Nitrogen Oxides, NOx
- Hydro Carbons, HC
- Carbon Monoxide, CO
- Particulate matter, PM
- Of these emissions we normally talk about

NOx and PM

What is SCR?

A way to reduce NO_X exhaust gases with a catalyst:

Nitrogen Oxide: $NO_X + NH_3{}^* \rightarrow N_2 + H_2O$

Hydro Carbons (Fuel residues): $HC + O_2 \rightarrow H_2O + CO_2$

Carbon monoxide: $CO + O_2 \rightarrow CO_2$

$^*NH_3$ = ammonia compound, from
$CO(NH_2)_2$ = Urea

What is Urea?

Pure urea is in the form of white crystals

Urea dissolved in water is non toxic

Urea is corrosive to some metals such as non-alloyed steel, copper, copper containing alloys and zinc coated steels

Commercially it's called AdBlue, DIN70070,

Urea reductant is 32.5% weight urea, 67,5% deionised water

Freezes at -11°C

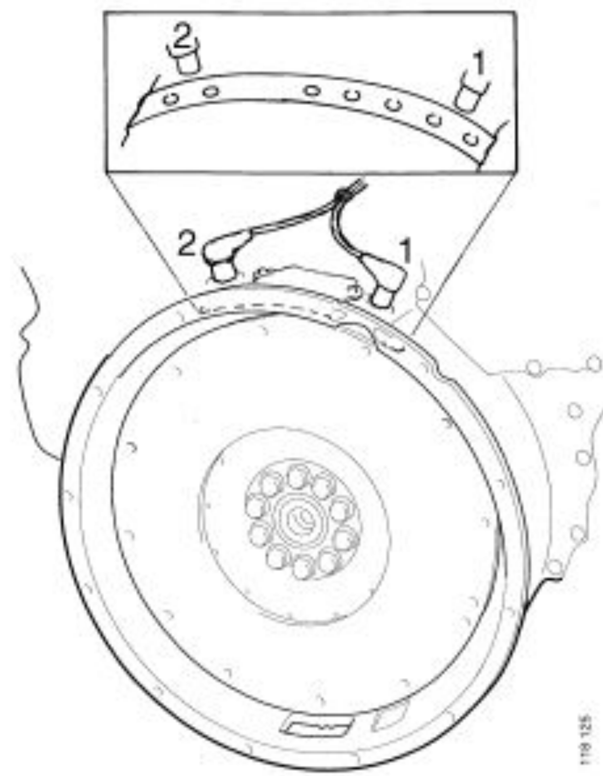
2g urea reductant → ~1g reduction of NOx

Urea reductant consumption ~5-7% of fuel consumption for reaching stage3b/ Tier 4i emission

Urea reductant crystallizes above 100°C

Locations of sensors for EMS with S6

Location of engine speed sensors on the engine with EMS S6.
The detail shows some of the holes in the flywheel that are detected by the engine speed sensors.

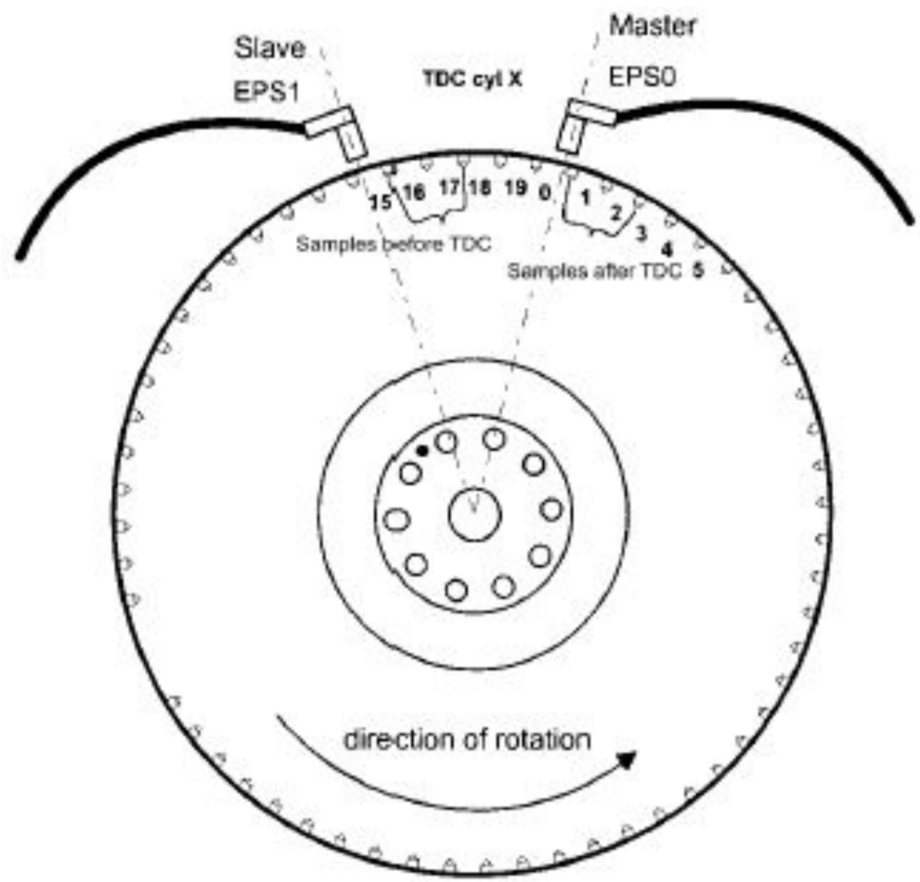


The EMS control unit receives signals from both engine speed sensors. If the control unit receives a faulty signal or no signal at all from either of the engine speed sensors, the engine torque is limited for safety reasons.
If the control unit receives a correct signal, the engine will operate normally again.
If the control unit receives a faulty signal or no signal at all from both engine speed sensors, the engine cannot be started.
If the engine is running, it will be switched off.
The control unit senses and compares the engine speed at combustion in each cylinder.
The control unit seeks to keep the engine speed constant by adjusting the fuel volume individually for each cylinder.
The interval between two of the holes is greater that that between the remaining holes.
When the control unit senses that this larger interval passes the sensor, it knows that the flywheel is
in a specific position in relation to top dead centre (TDC UP).
If the control unit detects any faults, one or more fault codes are generated.

Location on engine

There are two engine speed sensors in the EMS system, engine speed sensor 1 and engine speed sensor 2.
Both engine speed sensor 1 and engine speed sensor 2 read the position of the flywheel.
This means that the system cannot determine which of two possible revolutions the engine is at,
i.e. whether, for example, cylinder 1 or cylinder 6 is at the ignition position.
Every time the engine is stopped and the voltage cut off, the engine position is stored.
Next time the voltage is switched on, the stored position of the engine is used to determine which revolution the engine is at.
When the engine has started, a system check is performed to verify that the stored position is correct

Engine speed sensors (2x)



SCR Catalysts working temp

Exhaust temp > 200°C necessary

Good function above 250°C

Maximum function from 300°C to 500°C

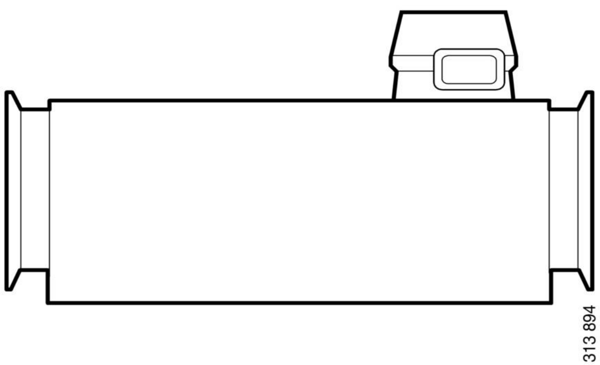
If the temperature rises above 550°C-600°C the torque will be reduced to save the catalyst.

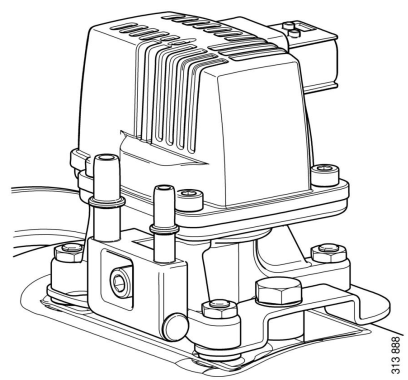
Hydrolysis catalyst

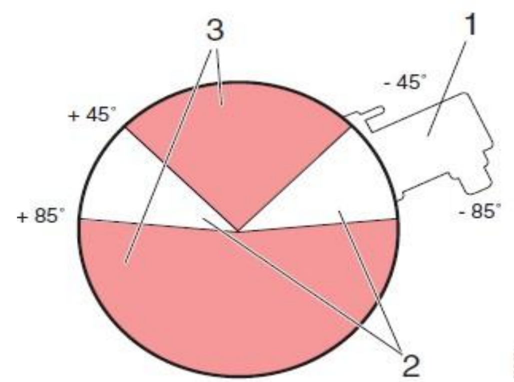
Hydrolysis catalyst with dosing unit

Dosing unit cooled by urea reductant

Injection stop when DEF level reaches approx 10% in tank due to that urea reductant is needed for cooling the dosing unit.



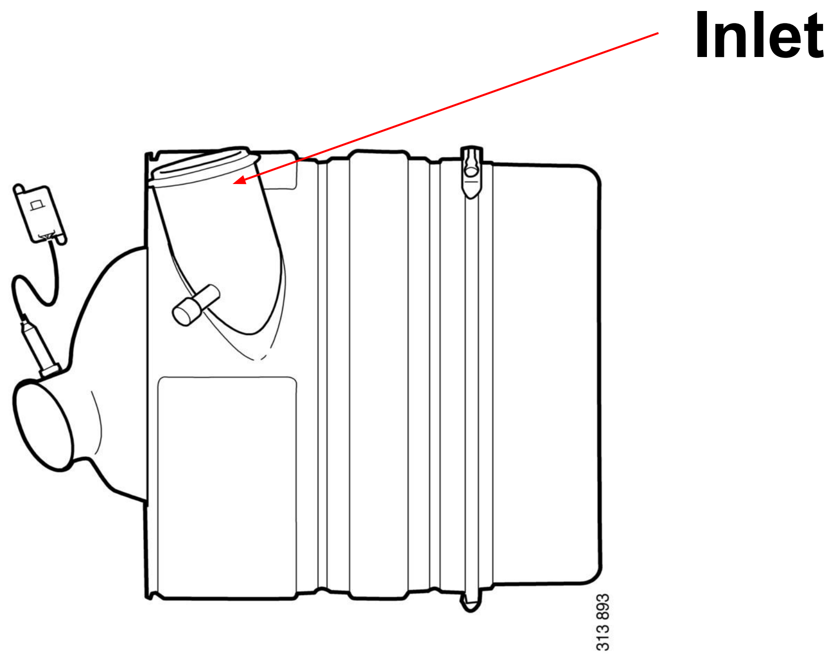




Make sure to install the dosing module at correct angle 1

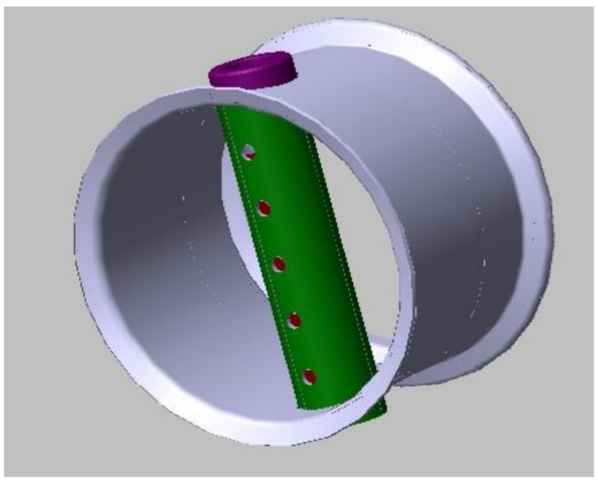
SCR catalyst with Silencer

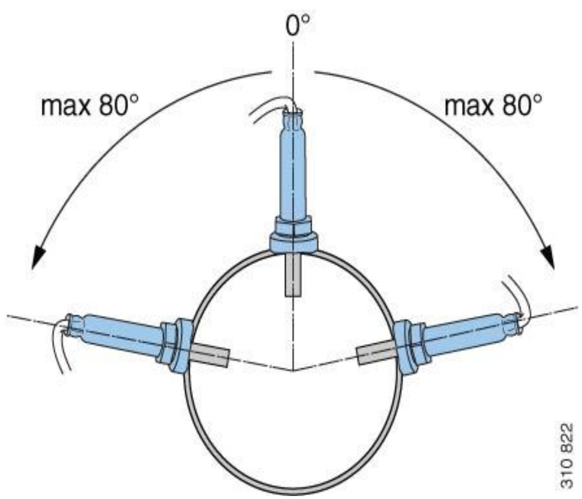
Damping approx 20 dB(A)
Only for DC9 and DC13
Outlet can be rotated



NOx flange

- NOx flange is mandatory
- The flange is needed to uniform the exhaust flow for accurate measurement of Nox gasses remaining after the catalytic conversion.
- Fitted on the SCR catalyst outlet flange.
- **Ensure the sensor is fitted at correct angle**





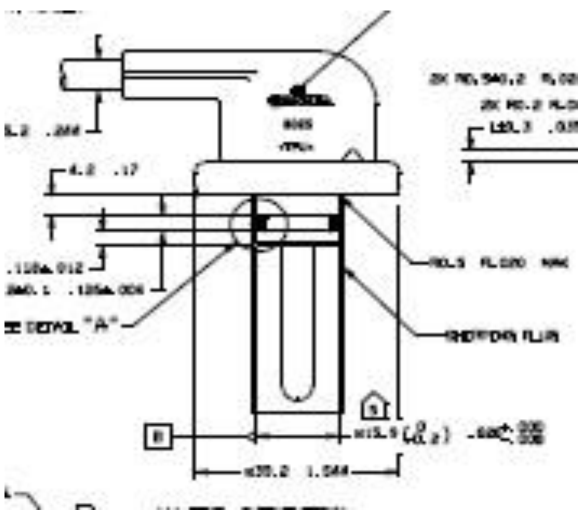
Ambient condition sensor

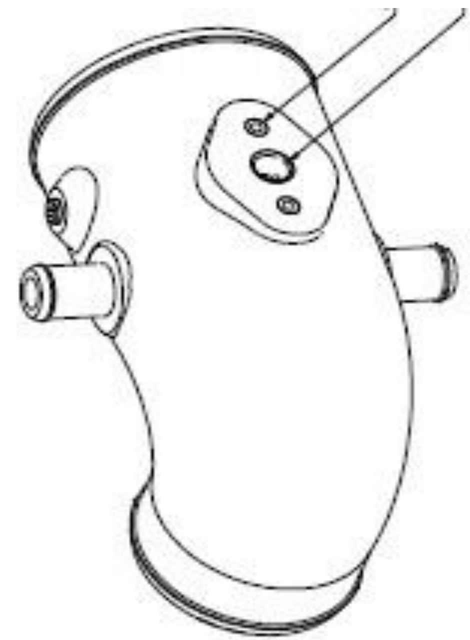
Needed as a reference sensor to EMS

Only valid for SCR engines

Fitted between air filter and turbocharger

Measuring pressure and temperature



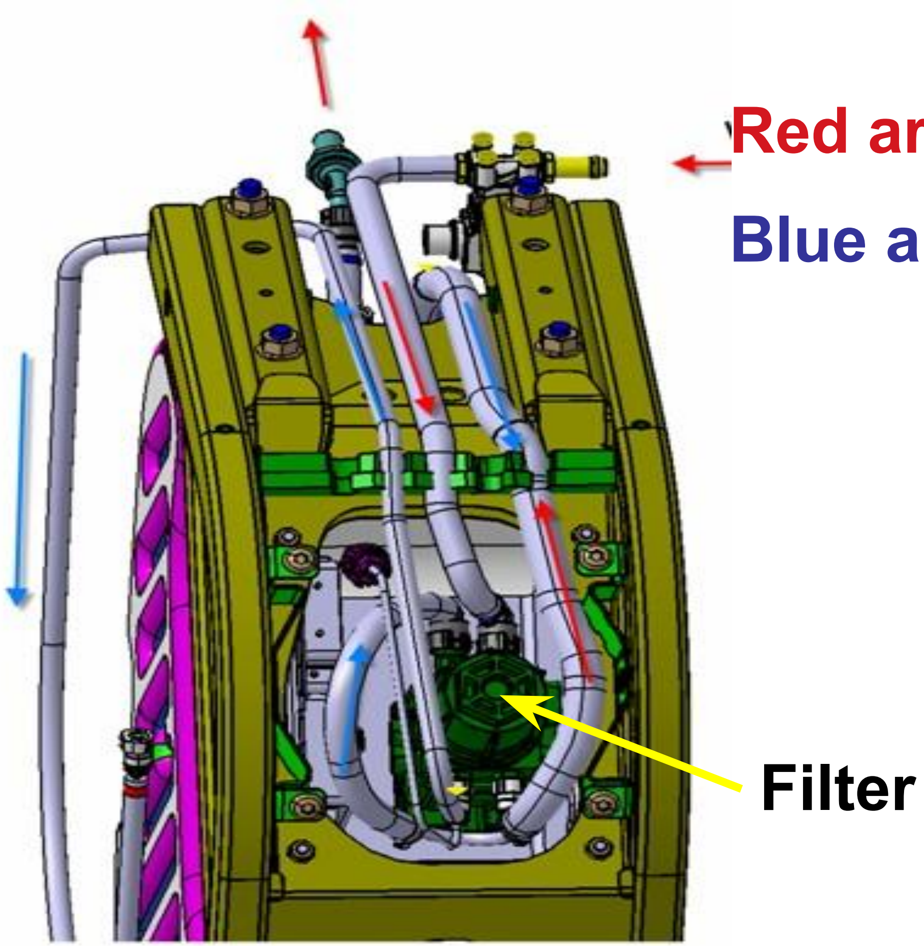


DEF tank

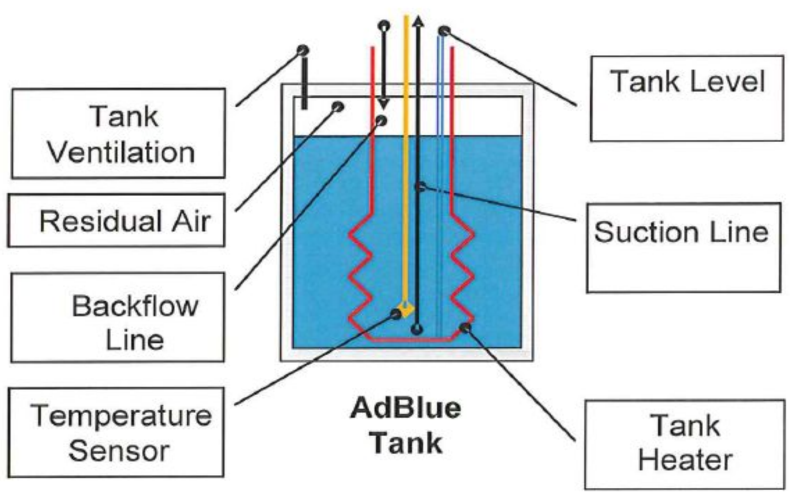
Maximum constant
temperature of urea 50°C

Do not fit filler neck expansion room needed in tank

SCR tank module flow

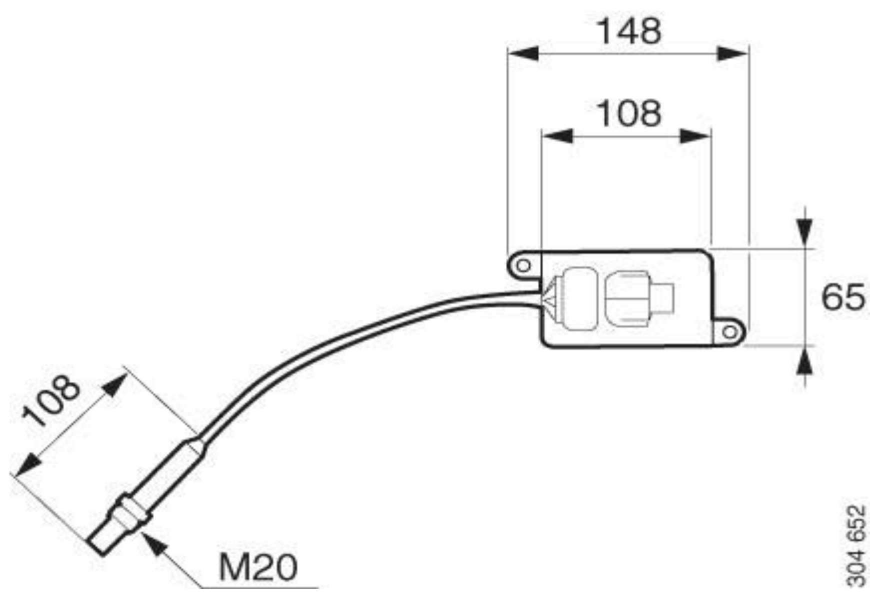


SCR pick up unit



Fitting of the NOx control unit on exhaust cradle

Electrical cable length between sensor and control unit 600mm

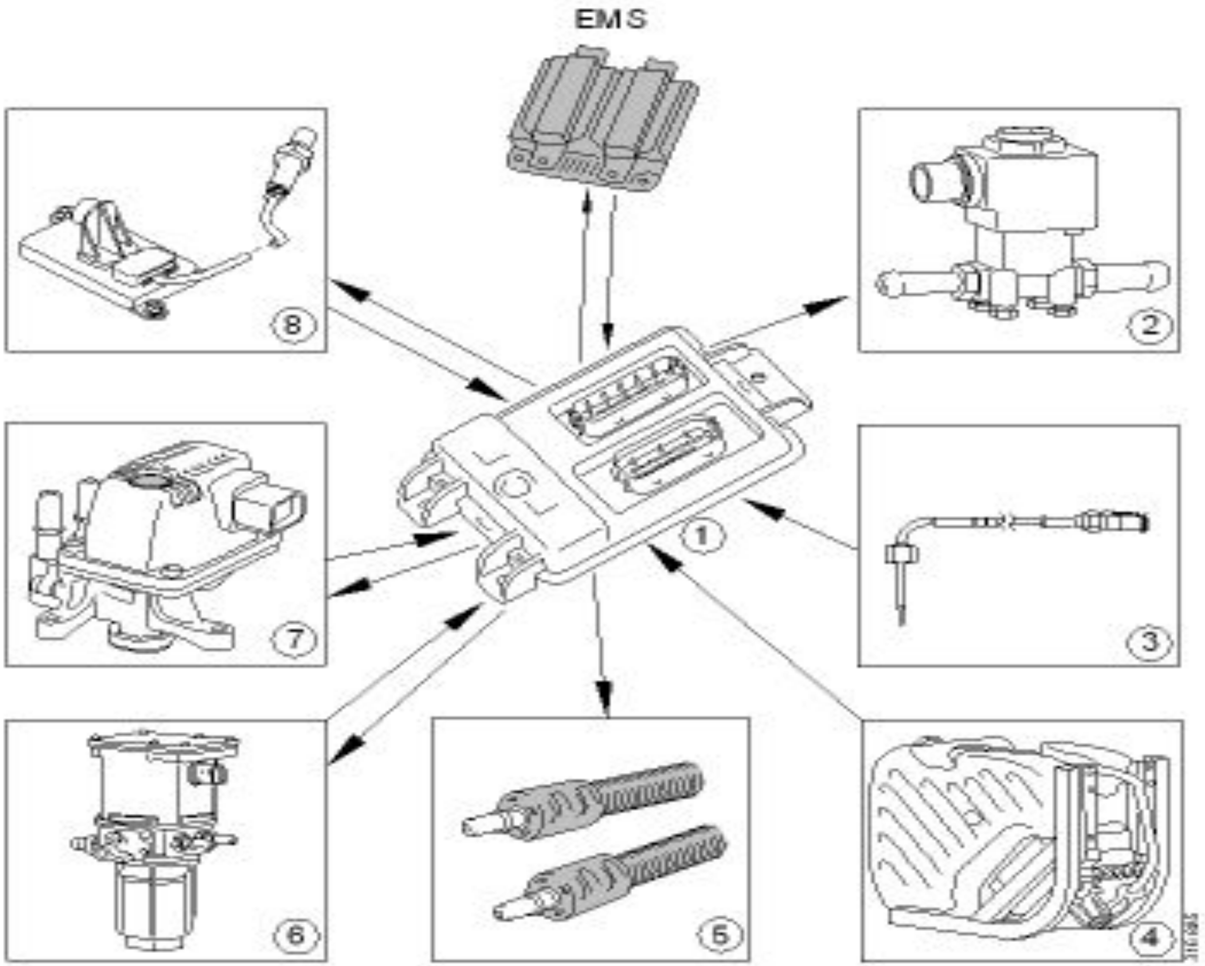


When working with the SCR-system

Important

Make sure that you always clean the area when working on the SCR system to prevent any spilt reductant from drying and forming crystals which may get into the system.
Always fit new O-rings and clean thoroughly so that the sealing surface is clean and free from crystals.

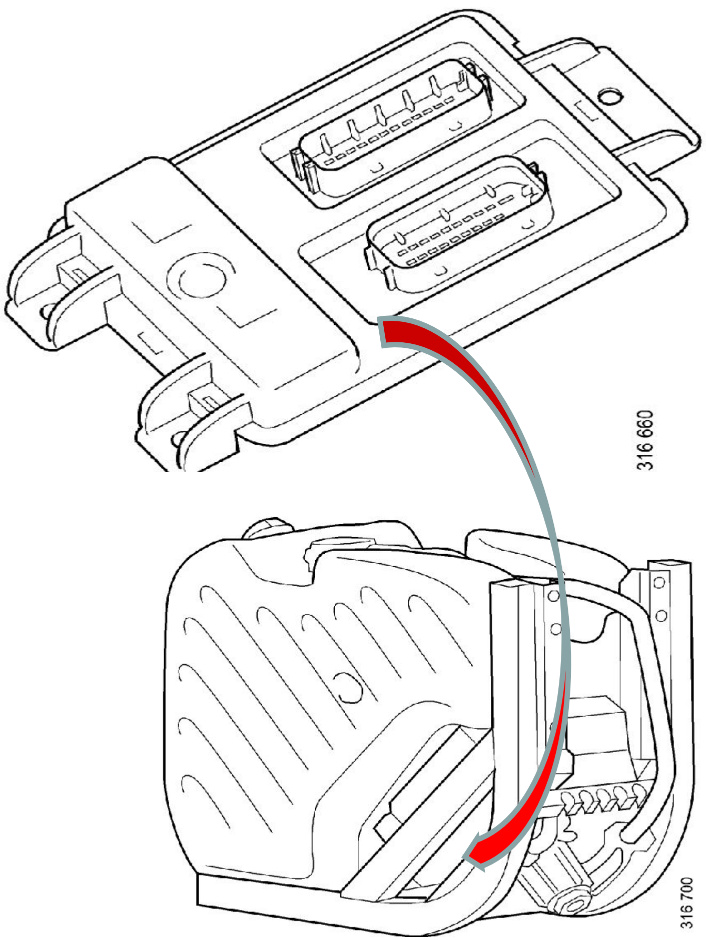
Components in the SCR-system



1. Control unit EEC3 EEC (Exhaust Emission Control system),

2.Coolant valve
3.Temperature sensor
4.Level and temperature sensor in reductant tank
5.Electrically heated hoses for reductant
6.Reductant pump
7.Reductant doser
8.NOx sensor

Control unit EEC3 (E67)

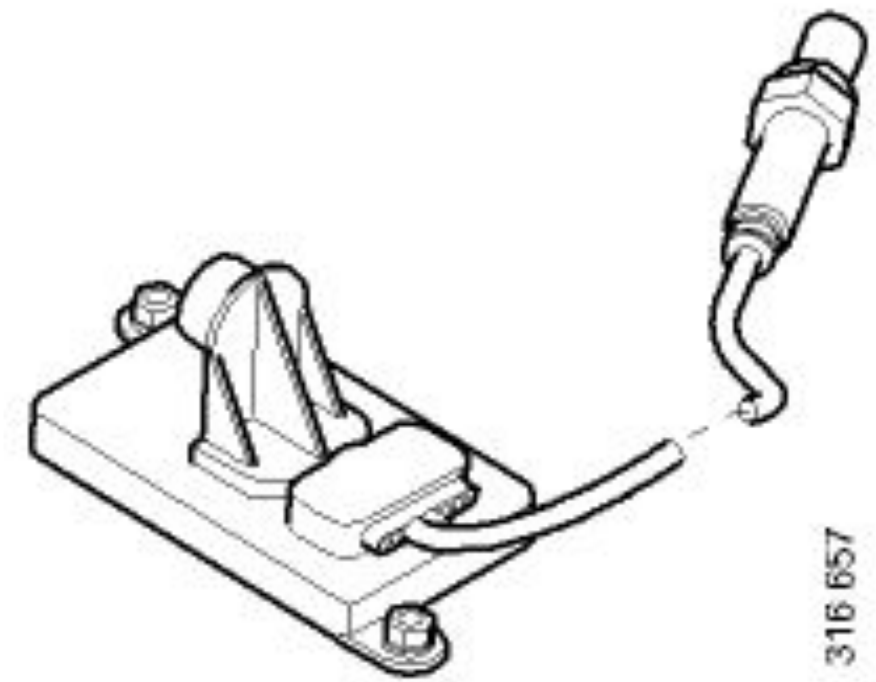


The EEC3 control unit retrieves data from the system's sensors and components.

EEC3 communicates with the engine control unit EMS. EMS decides on what measures are to be executed, e.g. what quantity of reductant is to be metered to the exhaust gases, and notifies EEC3.

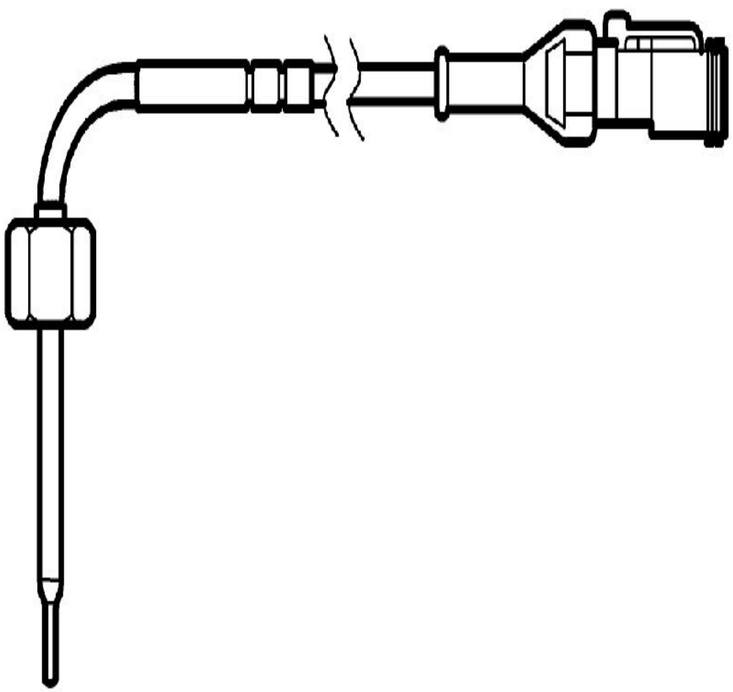
The EEC3 control unit is independently responsible for the functions which supply reductant to the exhaust gases. The EEC3 control unit is located on the reductant tank bracket underneath the reductant tan**k.**

NOx sensor (T115)



NOx sensor (T115)
There is a NOx sensor in the system.
It is used to measure the content of nitrogen oxide compounds in the exhaust gases after exhaust gas aftertreatment.
This sensor reports to EEC3, which notifies EMS. The sensor is electrically heated by EEC3.
The NOx sensor is located on the SCR catalytic converter's exhaust outlet.

Exhaust temperature sensor before catalytic converter (T113)

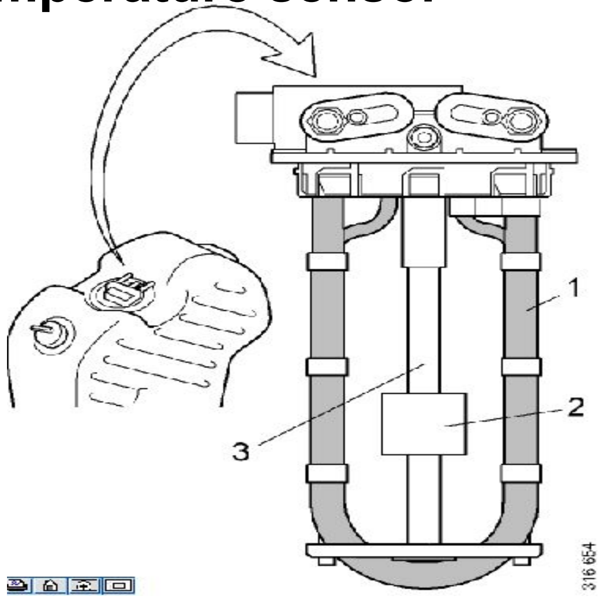


Temperature sensor (T113)
There is a temperature sensor for measuring the exhaust gas temperature at the intake to the SCR catalytic converter. This sensor reports to EEC3, which notifies EMS. The sensor is located on the SCR catalytic converter at the exhaust intake.

The exhaust temperature sensor detects the temperature of the exhaust gases before the SCR catalytic converter. The sensor informs the engine control unit of the exhaust gas temperature. The engine control unit uses, for example, the exhaust temperature to determine how much reductant should be injected into the exhaust gases in order to obtain the required emission level.

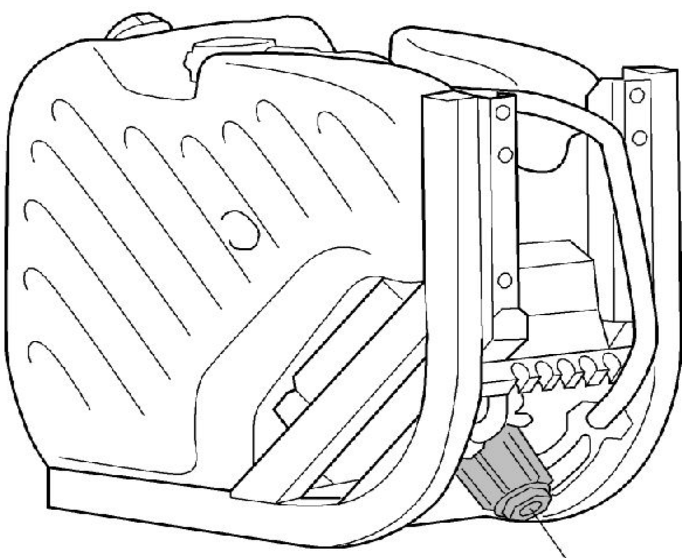
Level sensor and temperature sensor (T116)

1. Pipe for coolant
2. Level sensor
3. Temperature sensor



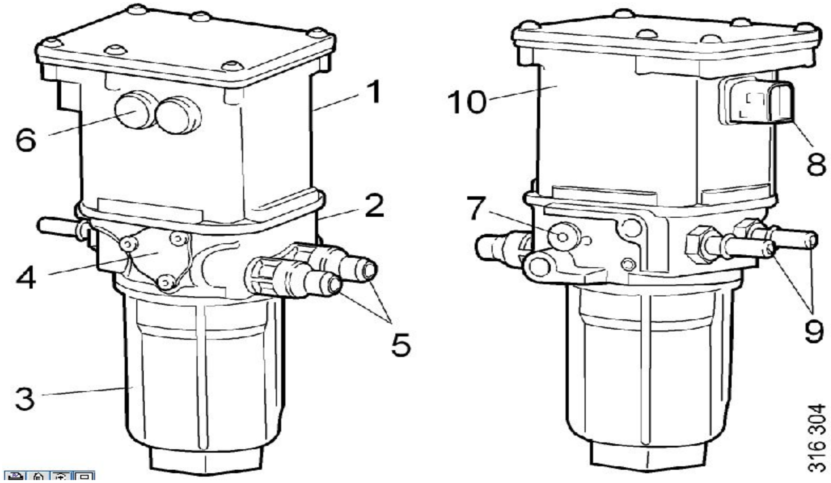
Level sensor and temperature sensor (T116)
There is a level and temperature sensor in the reductant tank which measures the fluid level and fluid temperature. This sensor reports to EEC3. The sensor is located in the reductant tank.

Reductant pump (V183)



Reductant pump (V183)
To achieve the right reductant pressure prior to metering in the exhaust system, there is an electrically operated reductant pump with variable speed control in the system which is monitored and activated by EEC3. The reductant pump reports pump speed to EEC3. The reductant pump is heated by the engine's coolant at low outdoor temperatures. The reductant pump is located on the reductant tank bracket underneath the reductant tank

Reductant pump (V183)



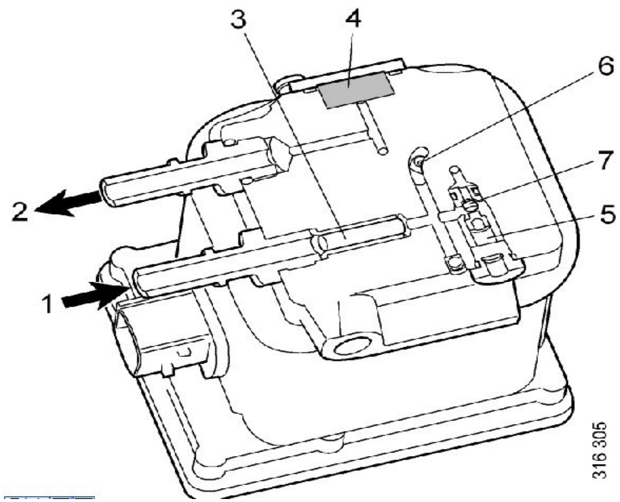
1. **Pump unit**
2. **Valve block**
3. **Reductant filter**
4. **Cover**
5. **Connections for coolant**
6. **Ventilation**
7. **Internal hexagon bolt**
8. **Connection for electrical connector**
9. **Connections for reductant**
10. **Electric motor for diaphragm pump**

To ensure that the correct quantity of reductant is metered to the exhaust gases, there is an electrically operated reductant doser in the system which is monitored and activated by EEC3. The reductant doser reports the pressure and temperature of the reductant to EEC3. The reductant doser is electrically heated and located on the hydrolysis catalytic converter.

The reductant pump sucks reductant from the reductant tank, filters and builds up pressure for the reductant which is then fed to the reductant doser.

The reductant pump is an electrically driven diaphragm pump with a filter for cleaning the reductant. The reductant pump is heated using the engine's coolant at low outdoor temperatures in order to thaw frozen reductant or prevent it freezing.

Reductant pump (V183)



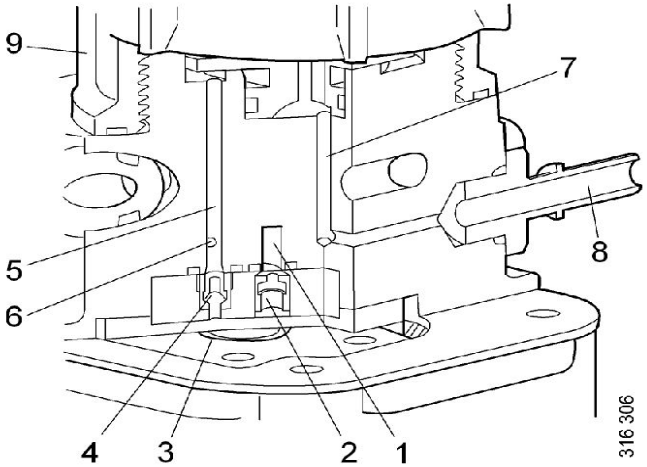
1. Intake, reductant
2. Outlet, reductant
3. Prefilter, reductant
4. Antifreeze
5. Overflow valve
6. Port to pump chamber
7. Check valve

The illustration shows a section through the valve block viewed from below.

Reductant is sucked through the intake (1) and prefilter (3) and then through a port (6) to the pump chamber, where reductant pressure is built up. If the reductant pressure exceeds 13 bar in the pump, the overflow valve (5) and check valve (7) open, reducing the reductant pressure in the pump. The amount of reductant pumped to the reductant doser can be varied by regulating the speed of the electric motor between 800 and 3500 revolutions per minute.

If the reductant freezes at low outdoor temperatures in the pump when it is non-operational, which takes place at approx. -11°C, there is antifreeze (4) for the valve block, which is a cavity filled with a soft material which can be compressed.

Reductant pump (V183)

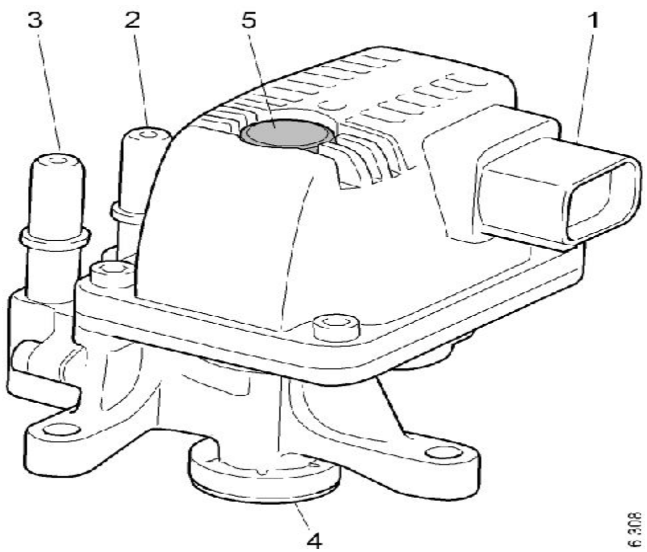


1. **Port from prefilter**
2. **Intake valve**
3. **Pump diaphragm**
4. **Outlet valve**
5. **Port to reductant filter**
6. **Port to overflow valve**
7. **Port from reductant filter**
8. **Connection, outlet for reductant**
9. **Holder for reductant filter**

The illustration below shows a section through the valve block viewed from the side. The reductant pump is shown with the reductant filter facing upwards.

Reductant is sucked in through the intake port (1) and via an intake valve (2) to the pump chamber, where reductant pressure is built up by means of the diaphragm (3). Pressurized reductant passed through the outlet valve (4) and via the port (5) to the reductant filter. If the pressure exceeds 13 bar, the overflow valve opens via the port (6). Once the reductant has passed the reductant filter, it is pumped out via the port (7) and outlet (8). The reductant pressure has been reduced and is approx. 10 bar.

Reductant doser (V182)

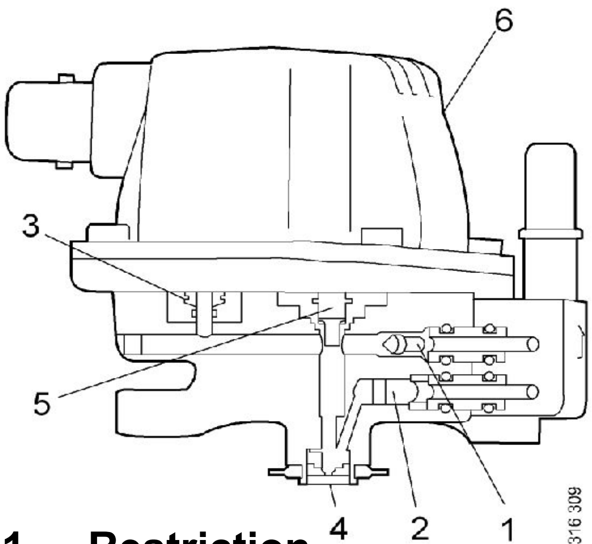


1. **Connection for electrical connector**
2. **Reductant inlet**
3. **Reductant outlet**
4. **Metering nozzle**
5. **Ventilation**

There is an electrically controlled water valve for the coolant flow from the engine's cooling system to the reductant tank. The coolant heats the reductant in the reductant tank and the reductant pump at low outdoor temperatures. The position of the water valve varies according to the engine installation.

The reductant doser meters out the quantity of reductant, which the engine control unit indicates, to the evaporator in the silencer. On industrial and marine engines the reductant is metered out to the hydrolysis catalytic converter

Reductant doser (V182)

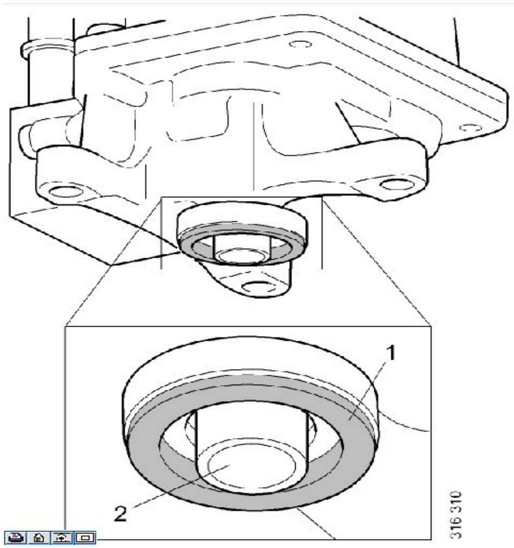


1. **Restriction**
2. **Prefilter**
3. **Pressure and temperature sensor**
4. **Metering nozzle**
5. **Solenoid valve**
6. **Heater element**

Important!
Do not switch off the main switch until cooling of the reductant doser has finished. The reductant doser can be damaged by too high a temperature

The reductant flows from the inlet at a pressure of about 9–10 bar and first passes the prefilter (2), fills the ducts after which the sensor (3) reads the pressure and temperature.
The dosage quantity is determined by the opening time of the solenoid valve (5). It opens once per second and the amount of time that the solenoid valve is open during that second determines the dosage quantity. The opening time can vary from 5–95% of 1 second. The reductant is metered to the exhaust gases via the metering nozzle (4).
After the engine has been switched off, the reductant pump continues to pump reductant to the reductant doser to cool it, otherwise the reductant doser can be damaged by the heat in the silencer. No metering takes place but the reductant flows out to the reductant tank via the restriction (1) and the outlet. Cooling stops when the temperature is not critical in the reductant doser

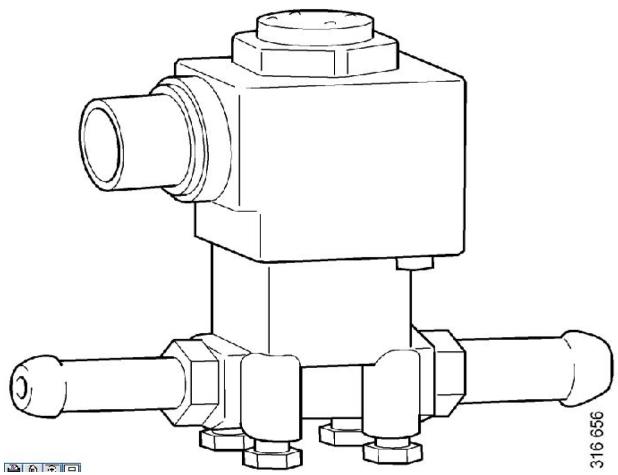
Reductant doser (V182)



1. **Graphite gasket**
2. **Metering nozzle**

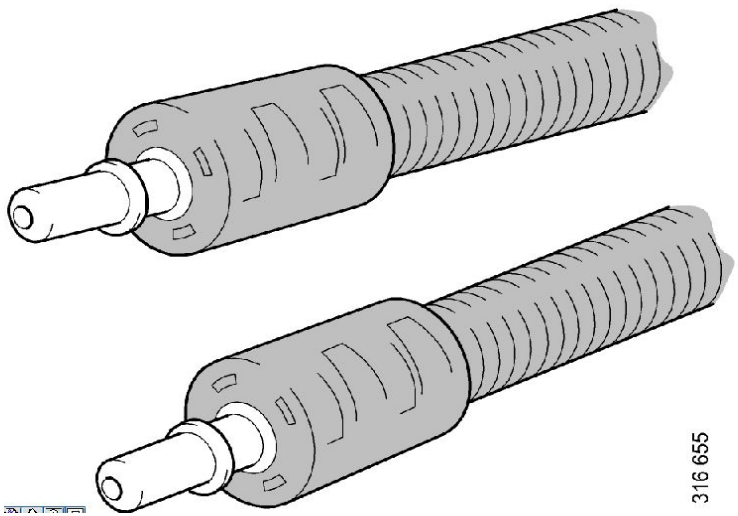
A graphite gasket (1) is fitted on the reductant doser which seals against the evaporator in the silencer (against the hydrolysis catalytic converter in industrial and marine applications).
It should be renewed if the reductant doser has been removed from the evaporator in the silencer or the hydrolysis catalytic converter.
Also check the metering nozzle (2).

Coolant valve (V118)



Coolant valve (V118)
There is an electrically controlled water valve for the coolant flow from the engine's cooling system to the reductant tank. The coolant heats the reductant in the reductant tank and the reductant pump at low outdoor temperatures. The position of the water valve varies according to the engine installation.

Electrically heated hoses for reductant (H25, H26,)

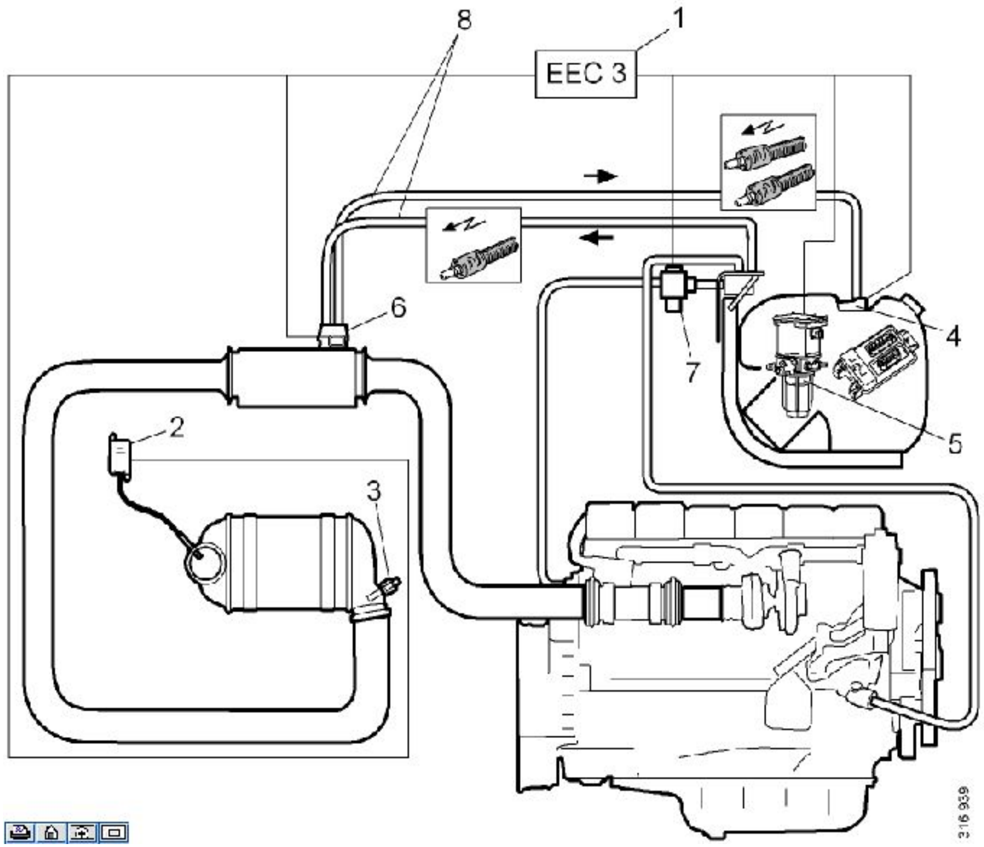


The hoses designed for reductant are electrically heated in order to prevent ice formation at low outdoor temperatures.

Electrical heating of the hoses is activated by EEC3.

The hoses run between the connections on the top of the reductant tank to the reductant pump and on to the reductant doser.

System overview for electrics

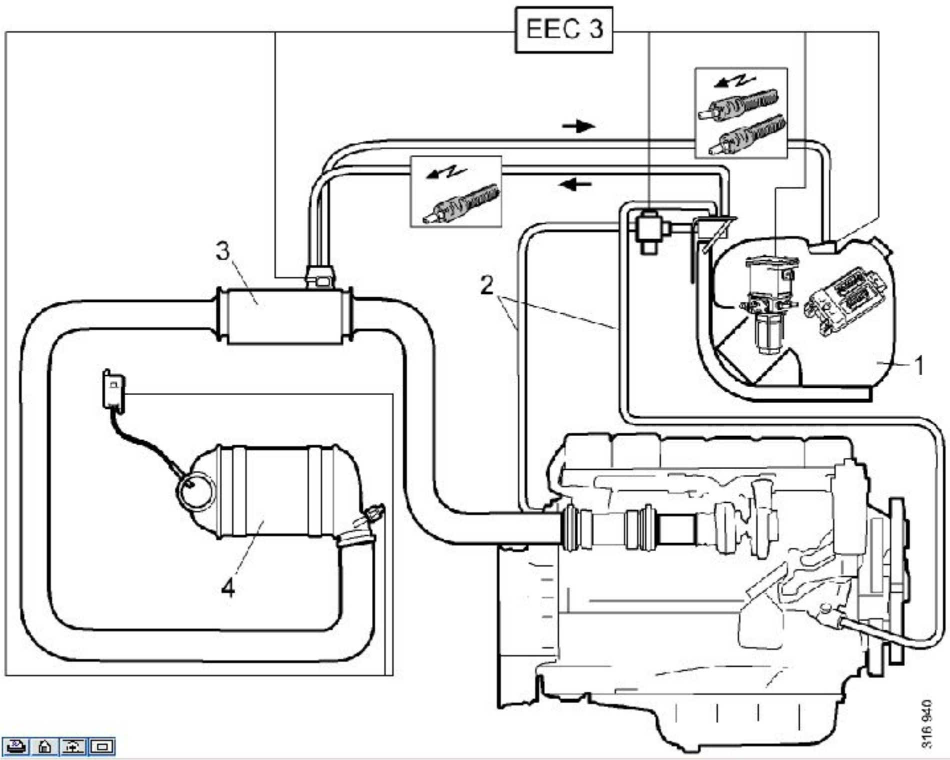


The locations of components vary depending on the engine version and installation. For information on detailed locations,

see the overview for the component in question.

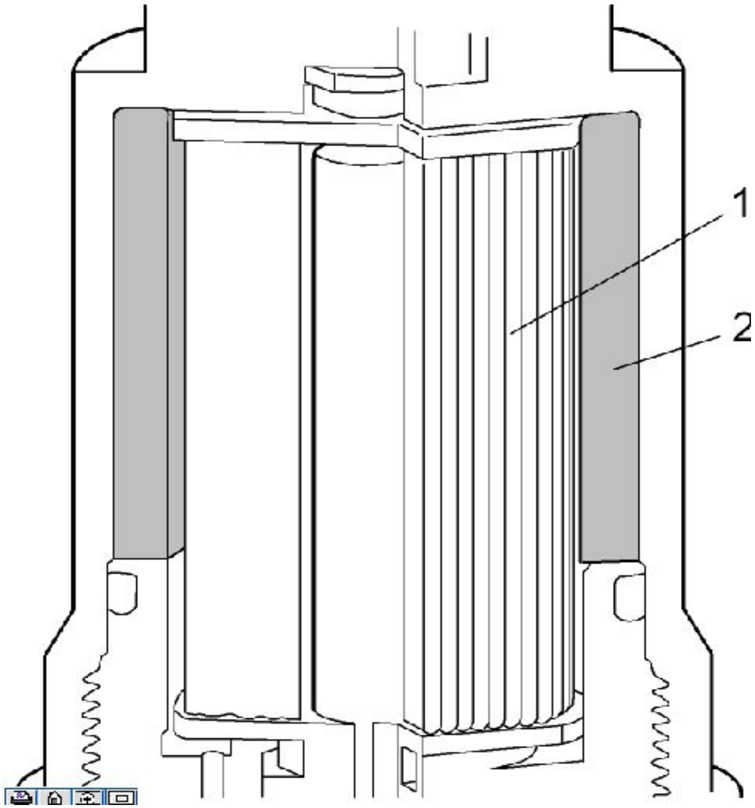
1. Control unit EEC3
2. NOx sensor
3. Temperature sensor
4. Level and temperature sensor
5. Reductant pump
6. Reductant doser
7. Coolant valve
8. Electrically heated hoses for reductant

System overview for mechanics



1. Reductant Tank
2. Coolant hoses Engine
3. Hydrolysis Catalyst
4. SCR Catalyst

Reductant filter



1. Reductant filter
2. Antifreeze

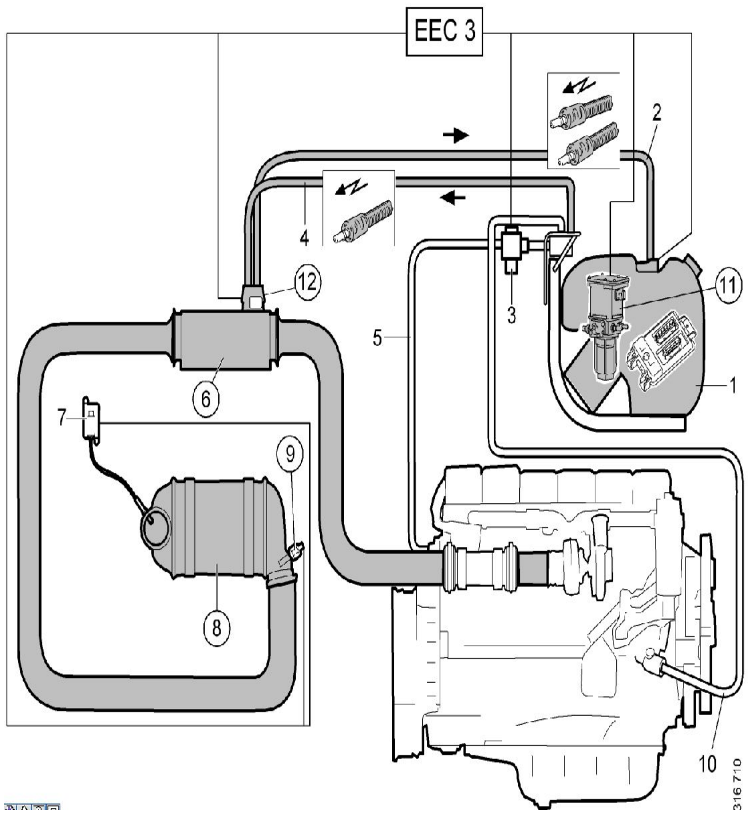
The illustration shows the reductant filter (1) facing upwards.

The reductant filter must be renewed according to the specified inspection interval.

If the reductant freezes at low outdoor temperatures when the reductant pump is non-operational, which takes place at approx. -11°C, there is antifreeze (2) for the valve block, which is a cavity filled with a soft material which can be compressed.

Scania

Exhaust gas aftertreatment function and working principle



Start

The reductant pump starts when the following has taken place: The engine has started, the EEC3 control unit has carried out a system check, the catalytic converters are starting to warm up and have reached the correct operating temperature (200–250°C), and any reductant heating is complete. The reductant pressure is built up to 9–10 bar to then be injected into the hydrolysis catalytic converter by the reductant doser.

The EEC3 control unit monitors the values and functions of all sensors

The engine is started.

The reductant pump (11) starts and builds up the reductant pressure to 9–10 bar.

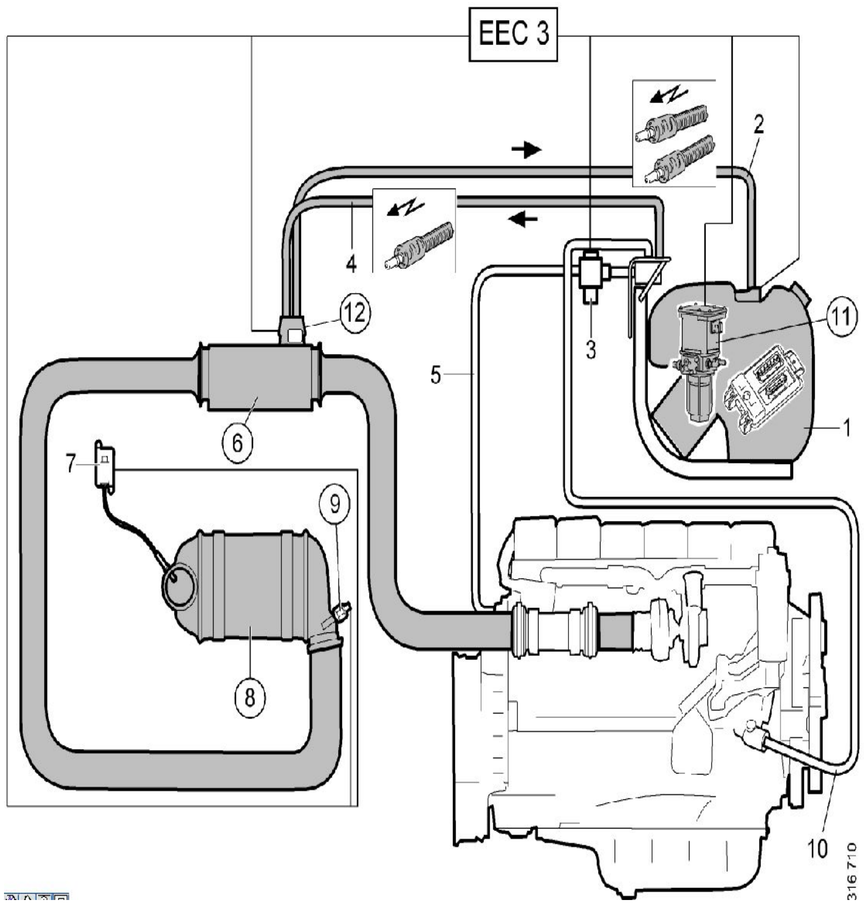
When the temperature sensor (9) indicates that the temperature of the exhaust gases has reached 200–250°C, the EEC3 control unit activates the reductant doser (12), which starts injecting reductant to the hydrolysis catalytic converter (6). The dose is determined by the engine control unit EMS on the basis of the combustion control in the engine which is currently being operated by the engine control unit.

The SCR catalytic converter's (8) reduction process starts.

(*-match):>Starting at cold outdoor temperatures, below -11°C<

Operation and reductant metering

The exhaust gases are treated in a number of steps before being released via the tailpipe. These steps are based on the combustion control mode of the engine control unit. First, the exhaust gases are mixed with reductant when they pass the hydrolysis catalytic converter (6).
The process of hydrocarbon reduction begins in the hydrolysis catalytic converter (6) and ends in the SCR catalytic converter (8).
Once the exhaust gases have passed the hydrolysis catalytic converter (6), the exhaust gas temperature is measured using the temperature sensor (9). The value is read off by the EEC3 control unit and transmitted to the engine control unit. The values from the temperature sensor (9) are used by the engine control unit to control the exhaust gas temperature, which should be between 200 and 250°C. This can be done with the exhaust brake, if fitted, the injection system XPI or a combination of the two.
The exhaust gases then pass through the SCR catalytic converter (8) where most reduction of hydrocarbons takes place by means of reductant injected in previously. NOx is converted into water, carbon dioxide and ammonia.
The volume of reductant mixed with the exhaust gases in the hydrolysis catalytic converter (6) is determined by the engine control unit, activated by the EEC3 control unit and carried out by the reductant doser (12). The dose is determined by the engine control unit on the basis of the values from the NOx sensor (7), temperature sensor (9) and the combustion control mode of the engine control unit.
The EEC3 control unit activates injection of reductant to the hydrolysis catalytic converter (6) from the reductant tank (1) by means of the reductant pump (11) and the reductant doser (12).



Shutdown

When the engine is switched off, the reductant pump continues for a specific period to supply the reductant doser with reductant. However, reductant is not injected into the hydrolysis catalytic converter but is returned to the reductant tank and has the purpose of cooling the reductant doser. Otherwise it may be damaged by the heat from the hydrolysis catalytic converter

XPI Fuel System

XPI = Extra high Pressure Injection

Scania XPI is a new generation Common Rail (CR) system

Developed by Scania in cooperation with Cummins

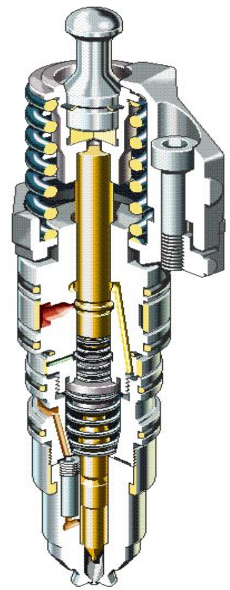
Average pressure 1800 bar
Max pressure 2400 bar

SCANIA

Historical overwiew

PDE

HPI



XPI

Unit injector systems = high pressure generated in each injector

Injection pressure is a function of engine speed and injected fuel amount

Common rail system = separate high pressure pump

Injection pressure independent of speed and injected fuel amount

Benefits from Scania XPI

Injection timing or duration independent of camshaft position

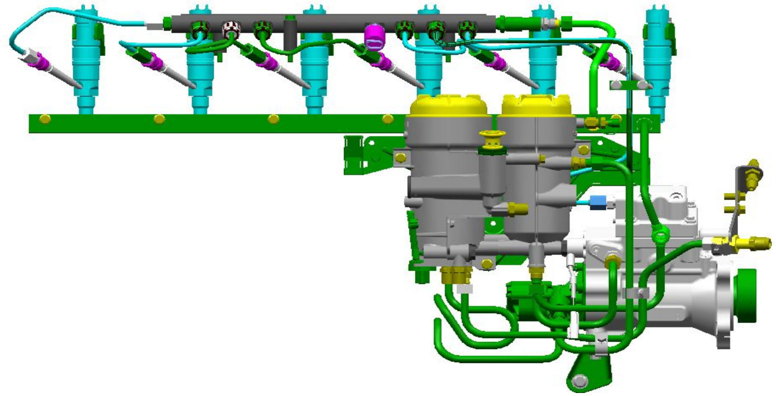
Higher average injection pressure compared to unit injector and inline pump systems

Injection pressure can be regulated independently of engine speed and amount of fuel injected

Simplified valve train since the pushrods for unit injectors are no longer needed

Multiple injections are possible

Scania XPI common-rail fuel system
All speed engine Stage 3B/Tier 4i



Scania XPI common-rail fuel system

The new engine range is equipped with Scania XPI fuel injection (extra high pressure injection), developed by Scania in cooperation with Cummins.

This is a new generation common-rail (CR) system, providing extra high injection pressure with a high degree of efficiency.

Maximum average injection pressure is 1800 bar. Maximum peak pressure is 2400 bar.

Benefits from common-rail technology are:

Injection timing or duration independent of camshaft position.

Higher average injection pressure compared to unit injector and inline pump systems.

Injection pressure can be regulated independently of engine speed and amount of fuel injected.

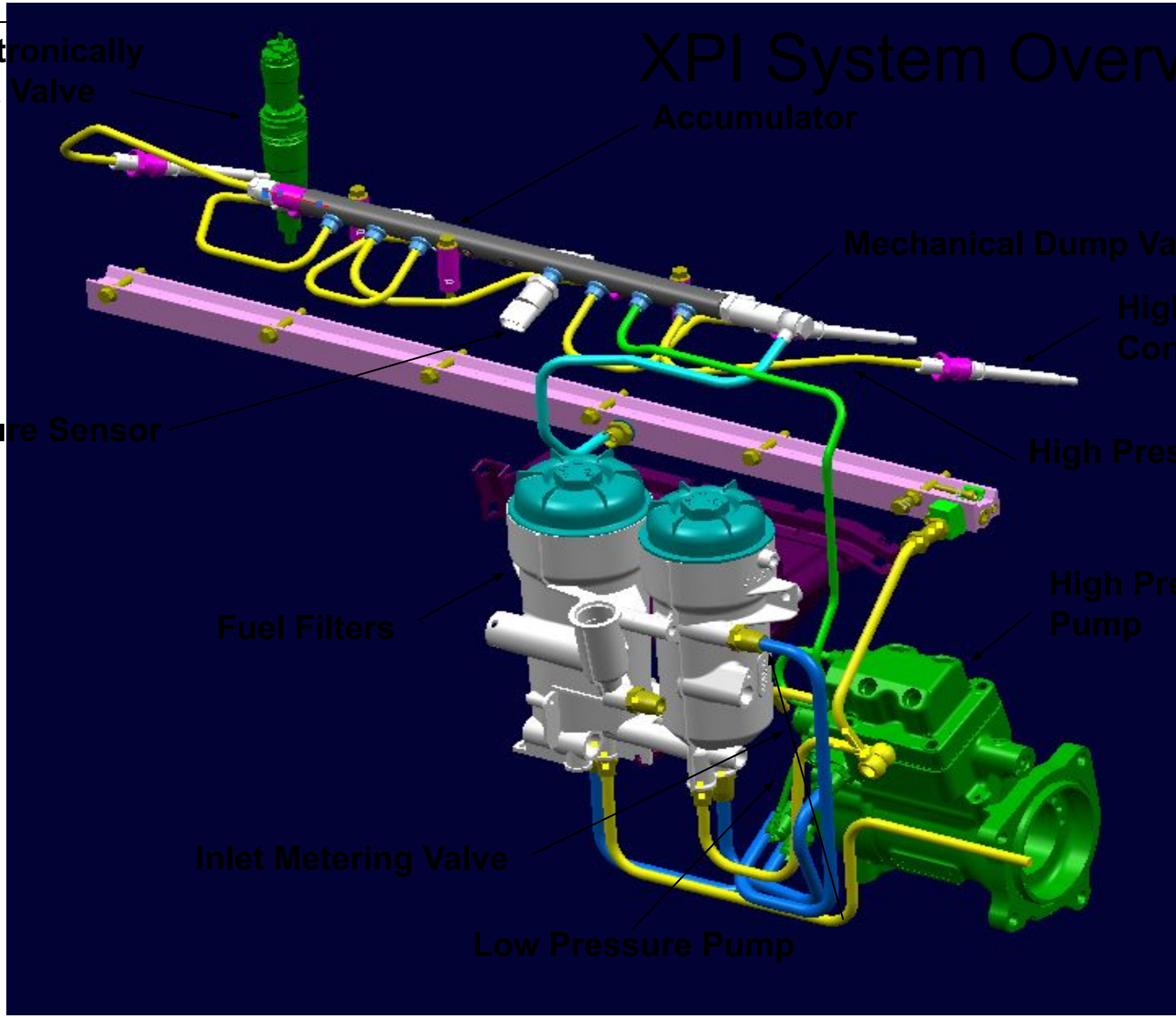
Multiple injections are possible.

Simplified valve train since the pushrods for unit injectors are no longer needed.

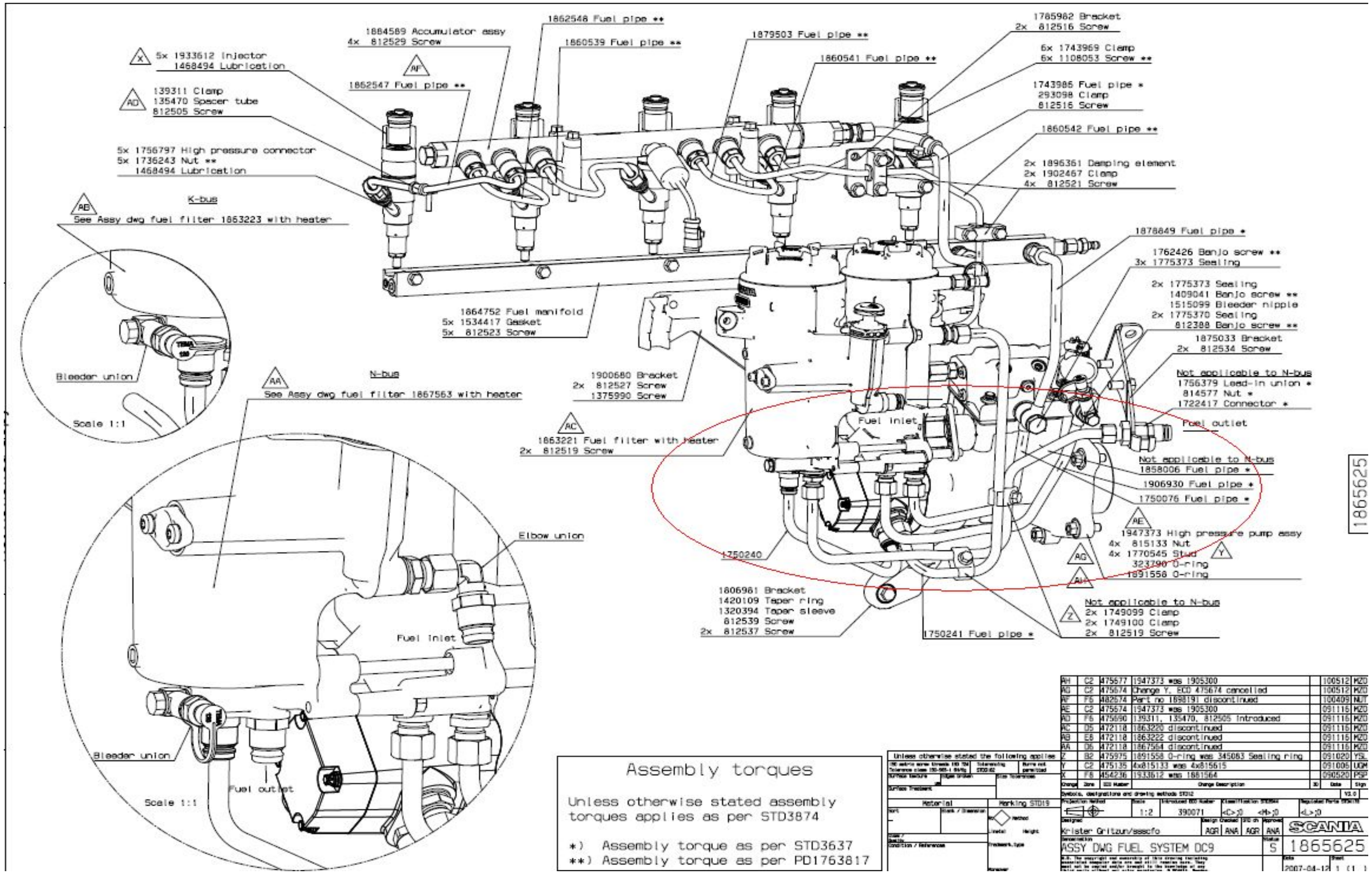
The possibility to have multiple injection pulses means better control possibilities.

For example, an early pilot-injection can control noise and emissions, and late post-injections can control the exhaust gas temperature for after treatment.

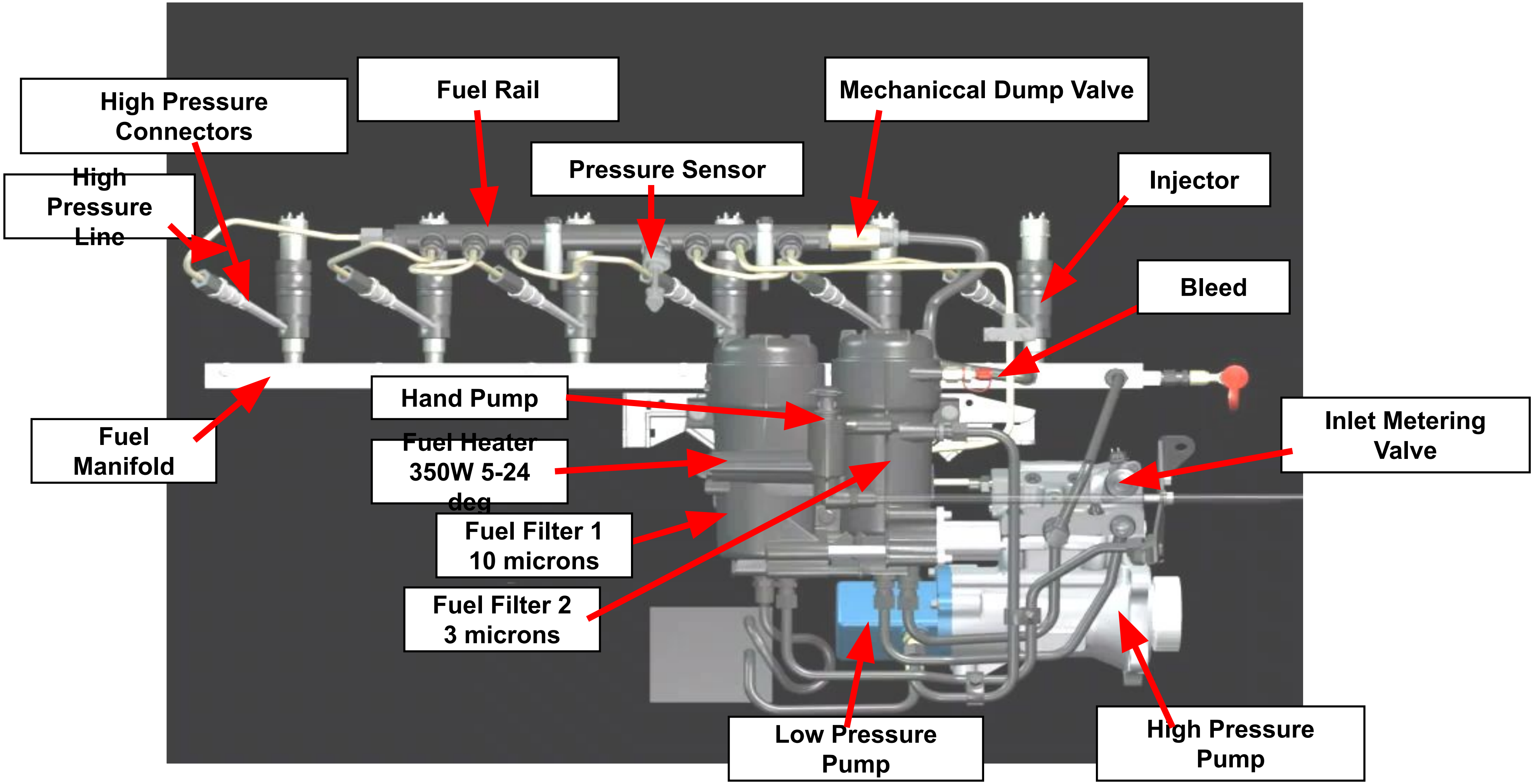
Scania


XPI System Overview
Injector w/ Electronically Controlled Pilot Valve
(Only 1 Shown)
Accumulator
Mechanical Dump Valve
High Pressure Connectors
Rail Pressure Sensor
High Pressure Line
High Pressure Pump
Fuel Filters
Inlet Metering Valve
Low Pressure Pump

Fuel Connections XPI



Scania XPI


High Pressure Connectors
Fuel Rail
Mechaniccal Dump Valve
Pressure Sensor
Injector
High Pressure Line
Bleed
Fuel Manifold
Hand Pump
Fuel Heater 350W 5-24 deg
Inlet Metering Valve
Fuel Filter 1 10 microns
Fuel Filter 2 3 microns
Low Pressure Pump
High Pressure Pump

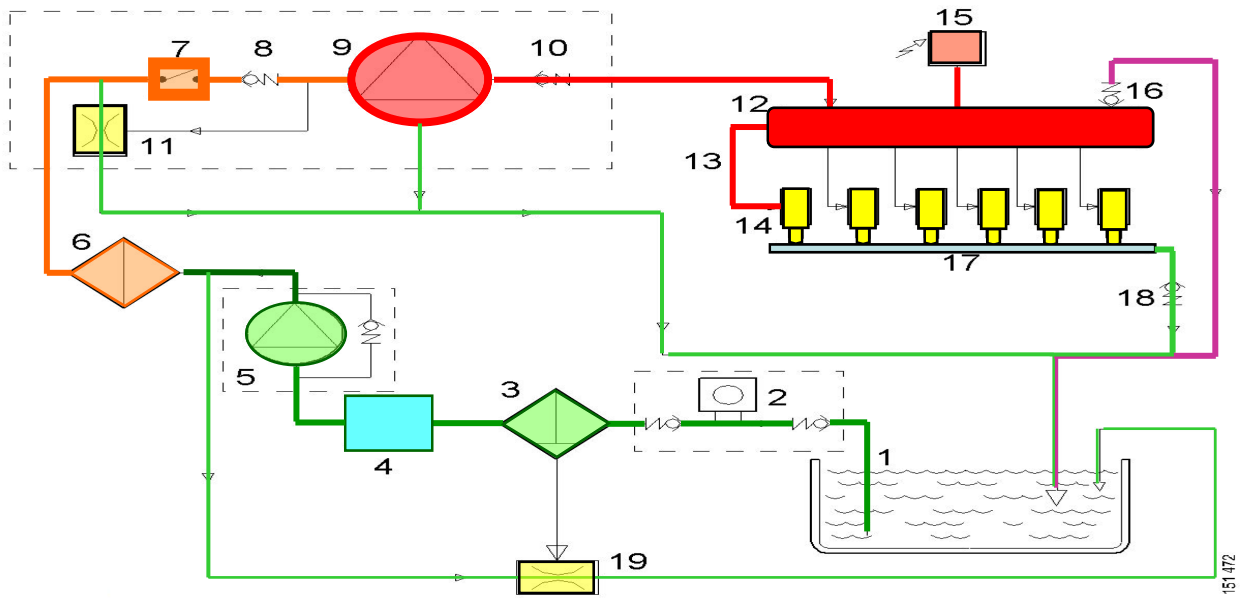
Scania XPI

The new system allows a high degree of freedom in terms of injection timing and pressure. With common-rail, injection timing and duration are independent of the camshaft. High injection pressures are available at any time, irrespective of engine speed. It also opens the possibility to use several injection pulses, see below.

Control of the fuel injection system is all-electronic. This means that there are no lobes on the camshaft to actuate the fuel injectors, nor are there any tappets, pushrods or rocker arms for this purpose.

Fuel under high pressure is constantly available in the rail, giving the possibility of injecting fuel at any time, independent of camshaft position.

1. Fuel tank
2. Hand pump with check valves
3. Fuel filter, water separating suction filter
4. Control unit cooler
5. Feed pump
6. Fuel filter, pressure filter
7. Fuel metering valve
8. Check valve
9. High pressure pump
10. Check valve
11. Restriction
12. Accumulator
13. High pressure connection
14. Injectors
15. Fuel pressure sensor
16. Safety valve
17. Fuel manifold for return fuel
18. Return line with check valve
19. Draining the water

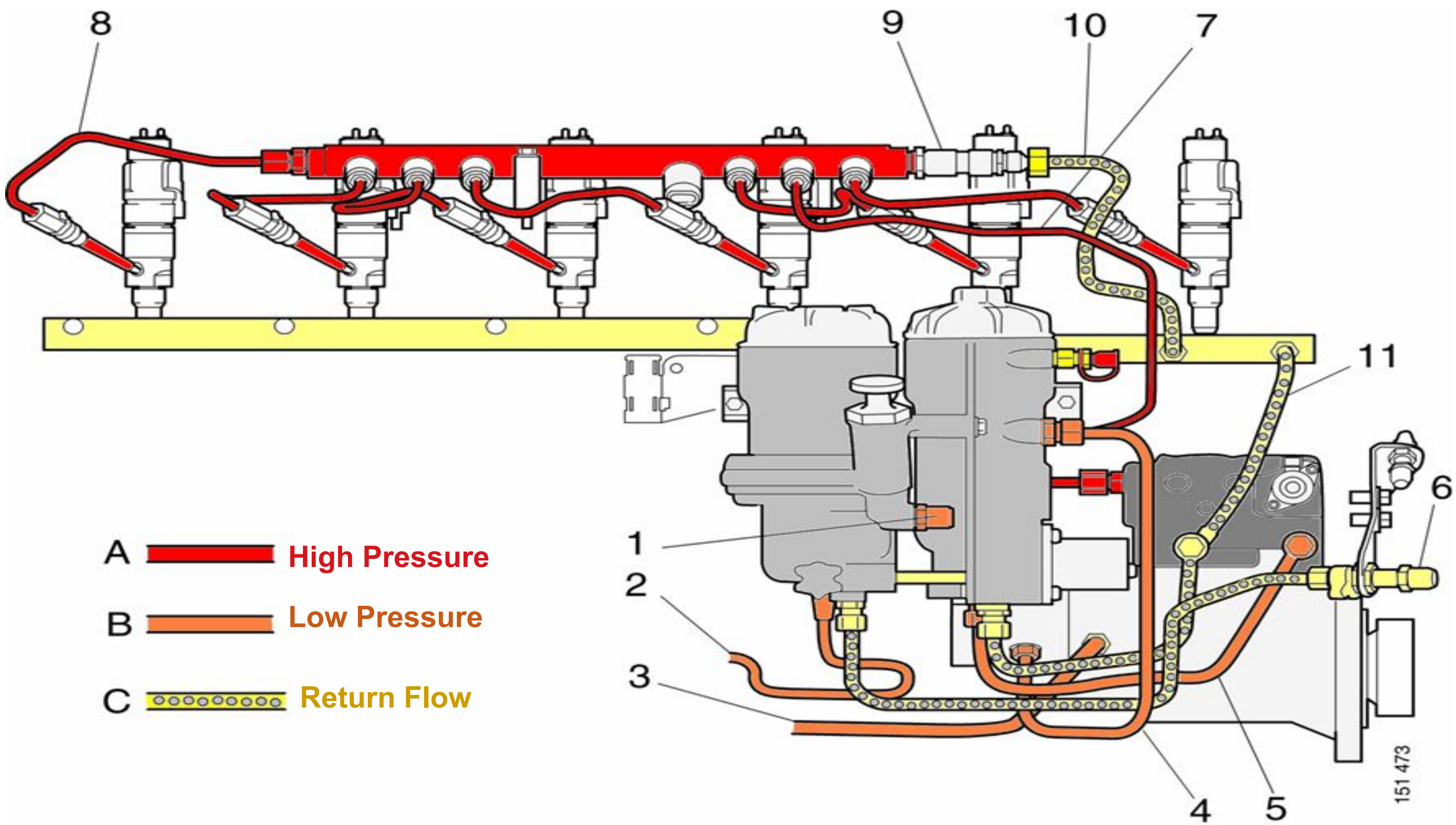


Scania XPI

Working principle of Scania XPI

Fuel is sucked from the tank by the low-pressure pump via a prefilter with a water separator via the cooling circuit for the engine management system to the main fuel filters. Water in the fuel is automatically drained back to the tank via a venturi device.
The low-pressure pump supplies fuel via the inlet metering valve to the high-pressure fuel pump. The pumps, which are integrated into one unit together with the fuel metering valve, are driven by the timing gears of the engine.
The high-pressure pump supplies fuel under operating pressure to the rail, i.e. the accumulator running the length of the engine on the cool side.
The operating pressure is regulated by the amount of fuel admitted by the inlet metering valve, ranging from an idling pressure of around 500 bar to a peak pressure of 2400 bar. The average working pressure is around 1800 bar.
The inlet metering valve is controlled electronically by the engine management system via a closed loop from a pressure sensor in the rail. A mechanical dump valve on the rail prevents excess pressure build-up by sending fuel back to the tank via the return rail.
The fuel injector for each cylinder is constantly fed with high-pressure fuel from the rail. Injection pulses are controlled electronically via a servo valve in the injector. The injector remains open as long as current is supplied from the ECU.
The amount of fuel injected depends on the opening time and the pressure in the rail. The starting time of the pulse determines the start of injection.
Fuel is injected into the combustion chamber through the injector nozzle.

Scania

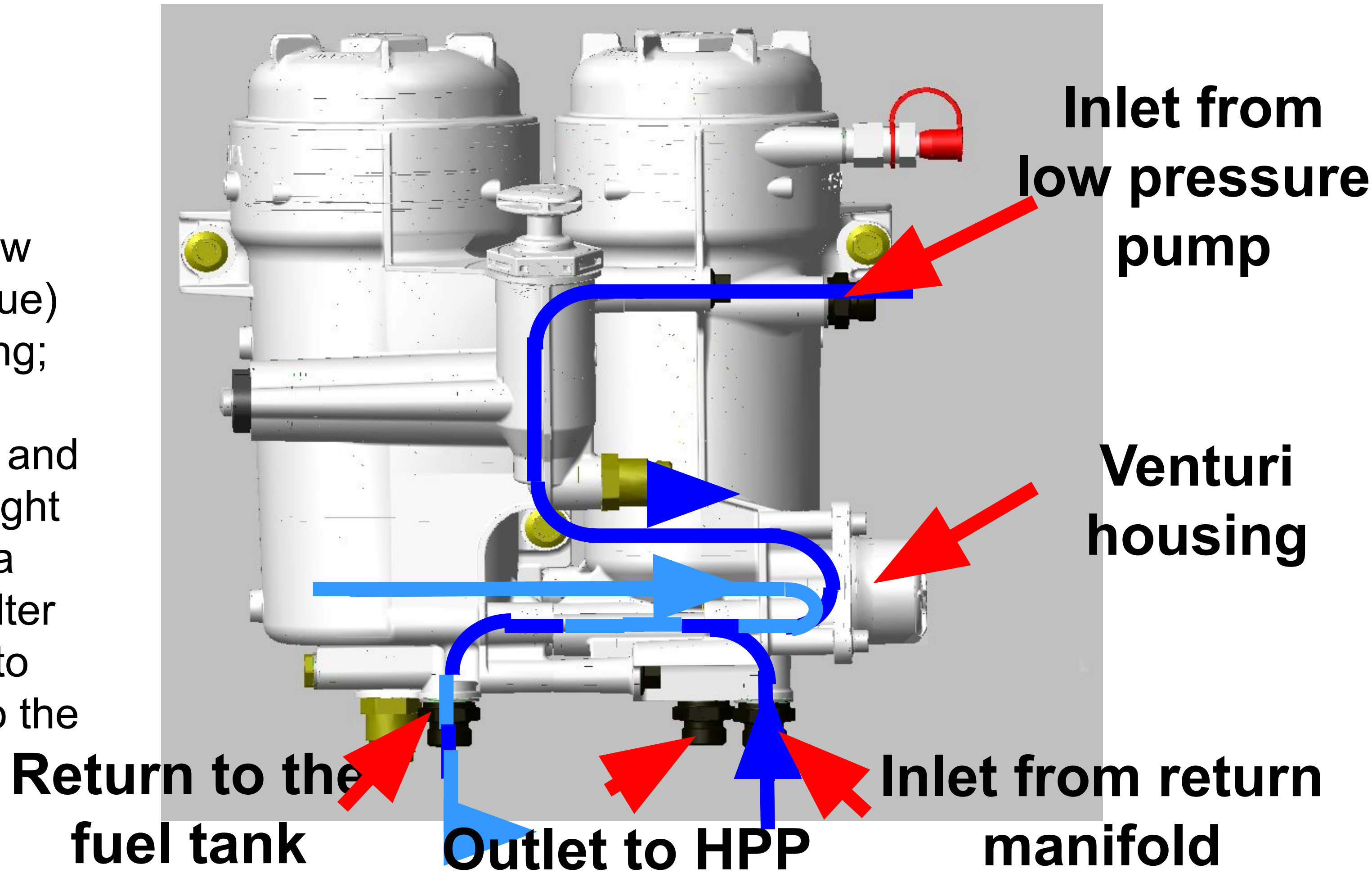


8
9
10
7
11
6
1
2
3
4
5
151 473
A
High Pressure
B
Low Pressure
C
Return Flow

Scania

This is how Venturi device works

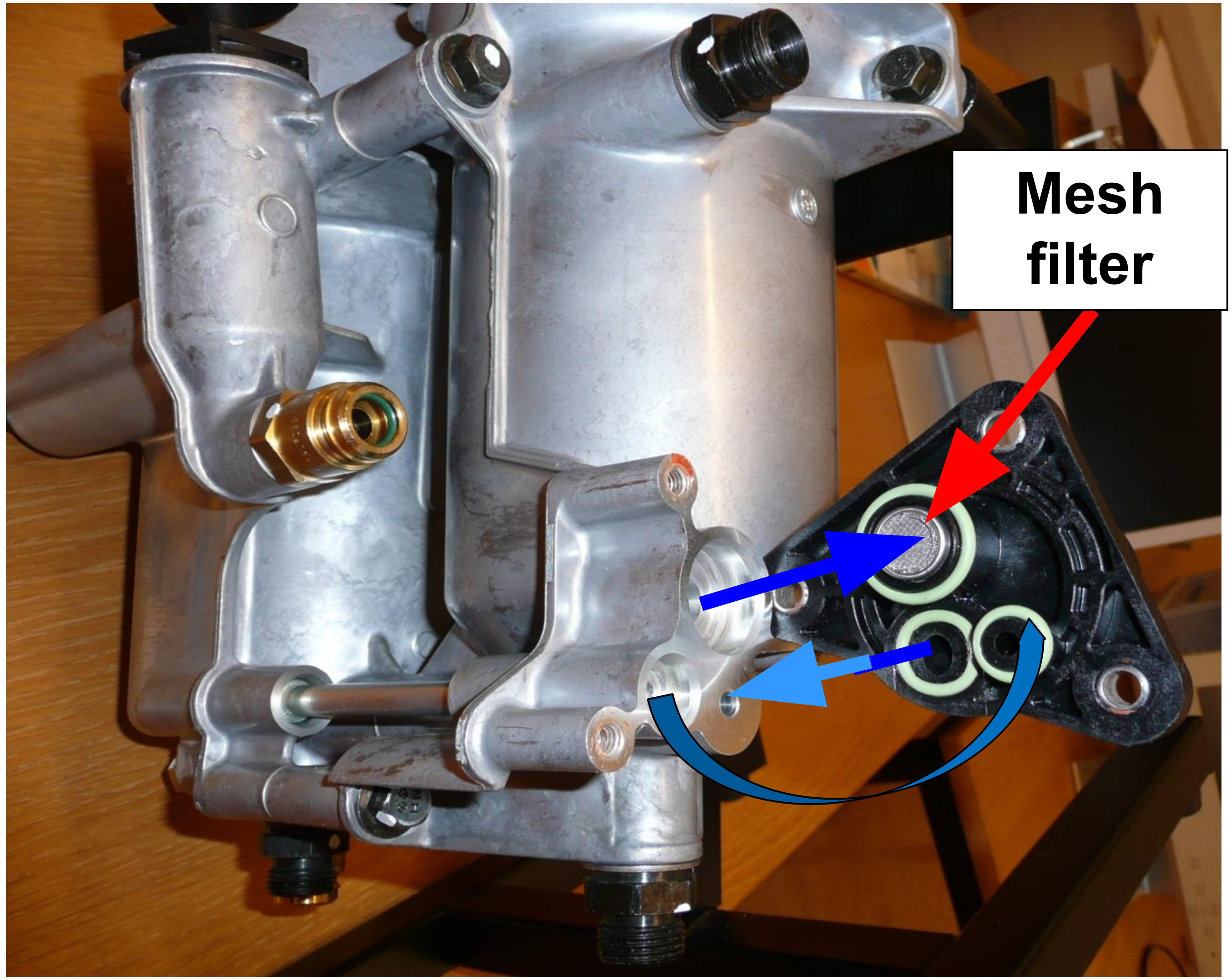
A small quantity of the pressurized fuel from low pressure pump (dark blue) goes into Venturi housing; due to Venturi effect a suction force is created and fuel mixed with water (light blue) is drawn through a pipe between the fuel filter housings and push it into the normal return line to the fuel tank.



Scania XPI

Venturi System

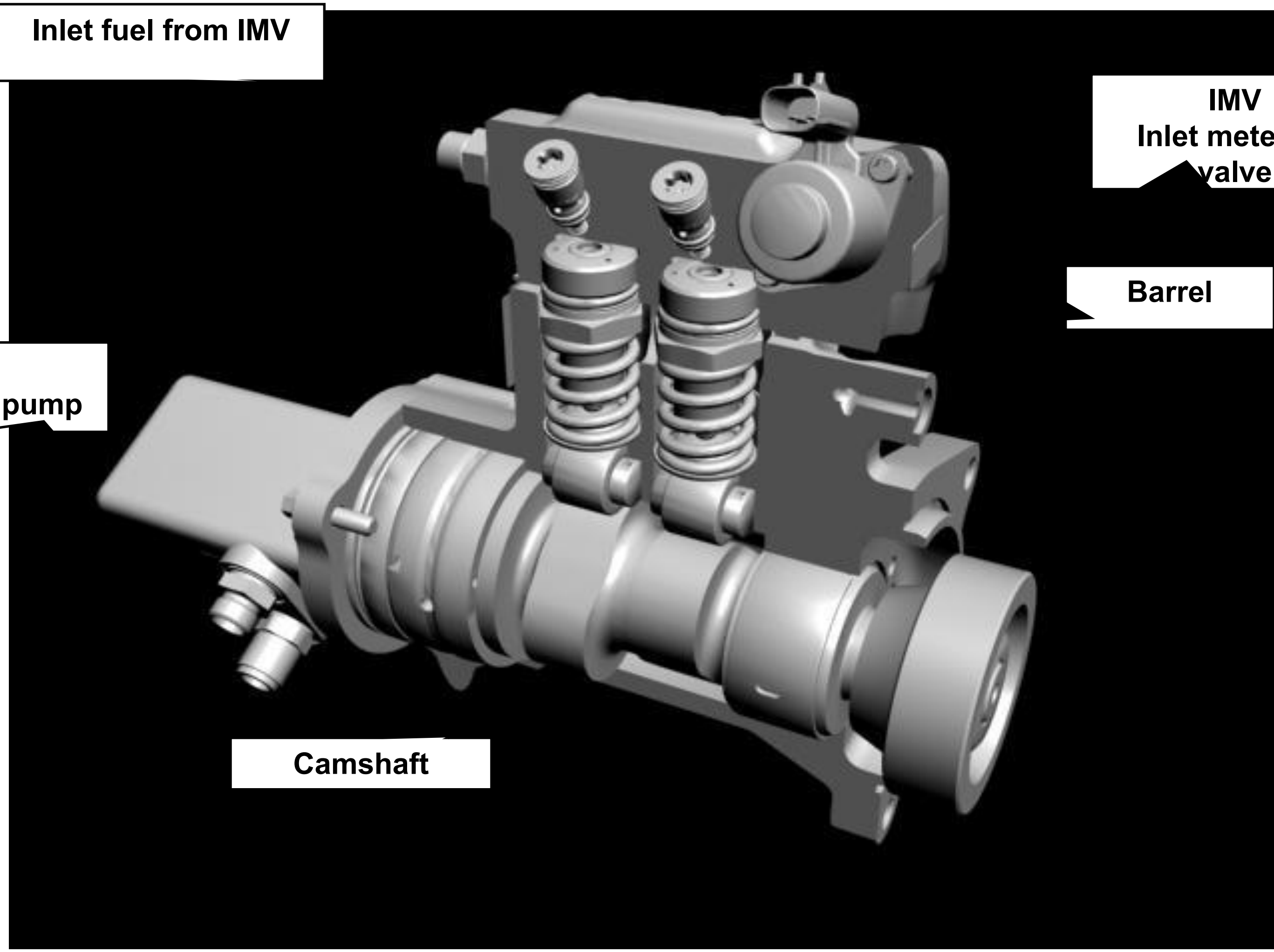
The pressurized inlet to the Venturi housing is protected by a wire mesh filter. If the suction filter (coarse filter) from the water separator housing fails, contaminated fuel with dirt could clog the wire mesh and functions of the Venturi device will be reduce; if this happen water will accumulate into the water separator housing and eventually damaging the XPI high pressure components. If the fine filter is clogged always check, and clean if necessary, the wire mesh filter.



Scania

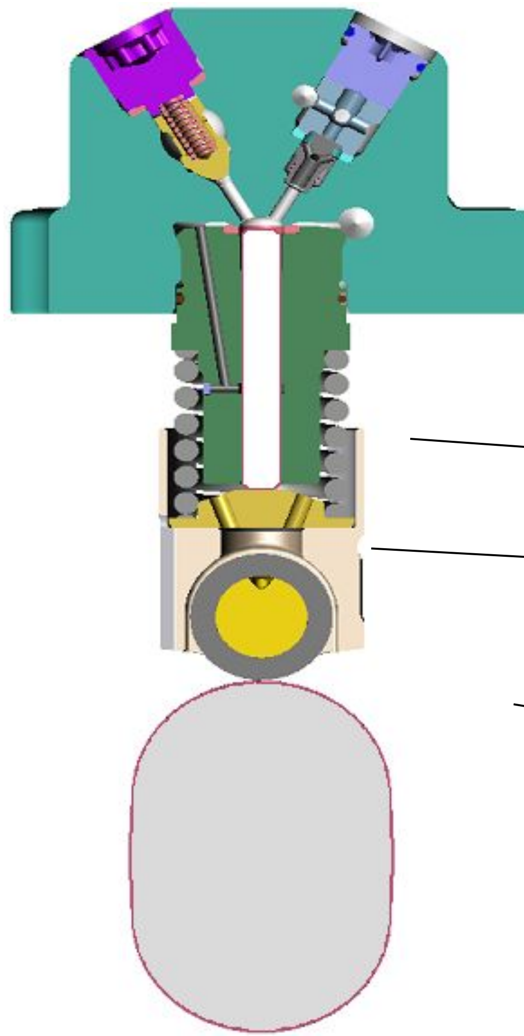
XPI HPP, Cut away view

Variable displacement pump. Pistons stroke only as big as necessary



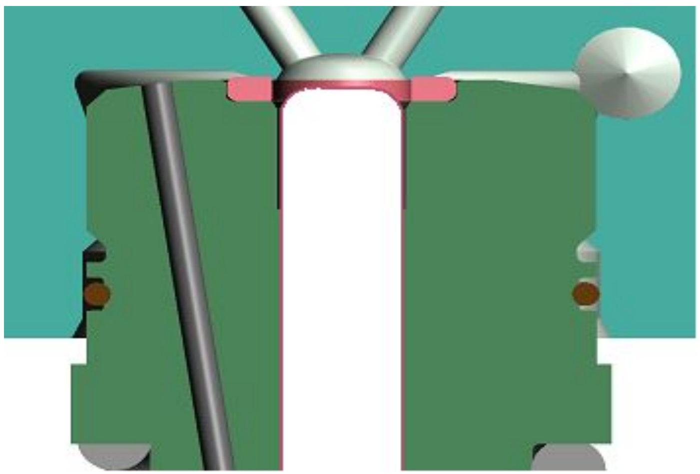
Internal pressure relief valve in feed pump 9-13 bar

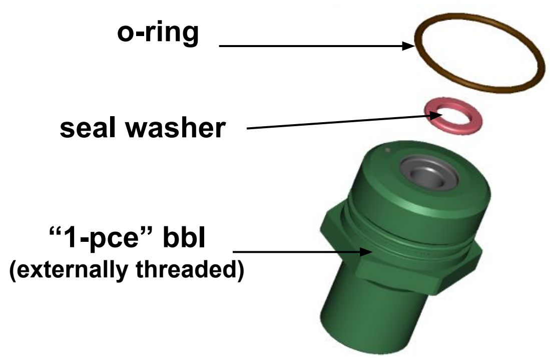
XPI HPP Head Assembly

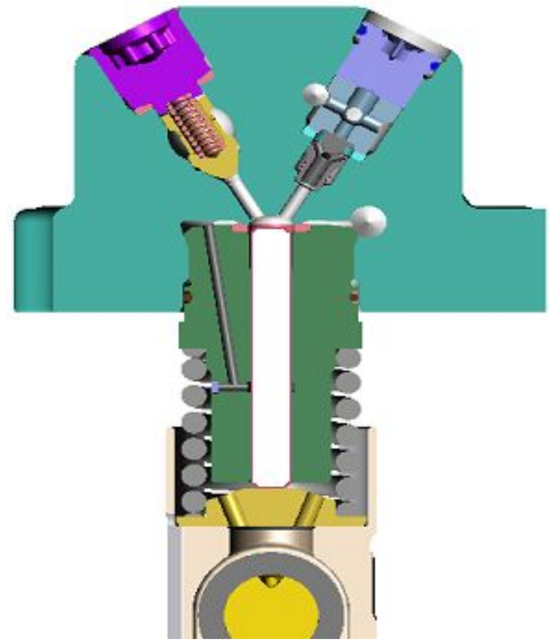


Ceramic plunger has a 3 micron clearance.

XPI Barrel Design







Rail Pressure Sensor

- General Description
  - Pressure range of 0-2850bar
  - +5Vdc power supply
  - 0.5-4.5V output
  - -40 to 125ºC overall operating range

Rail Pressure Sensor

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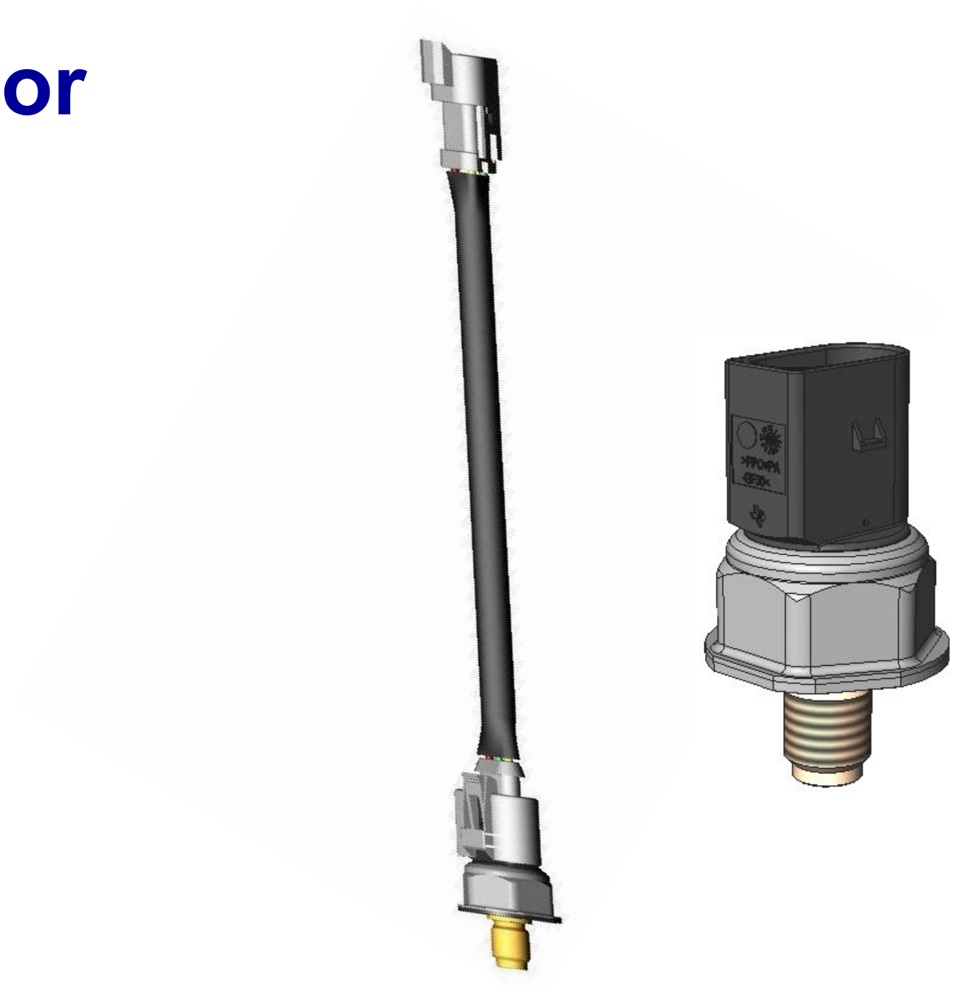
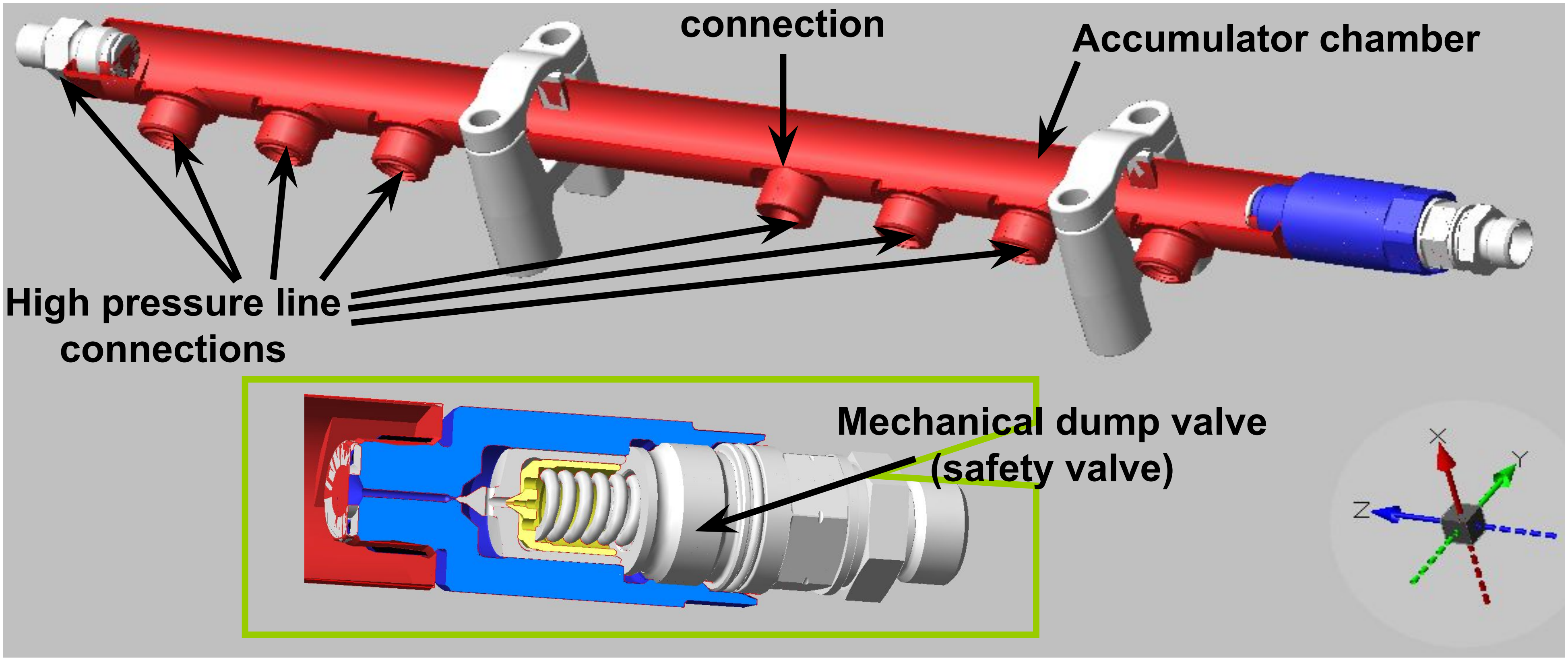
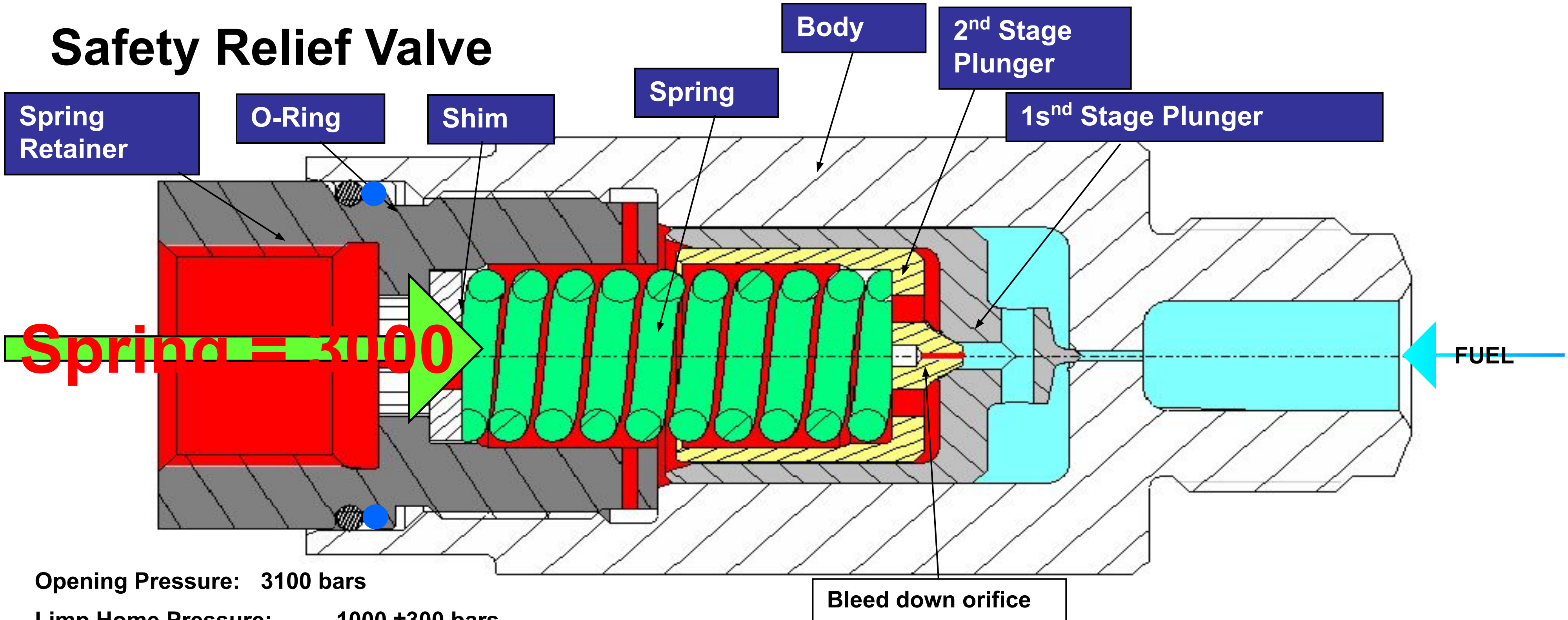


Accumulator



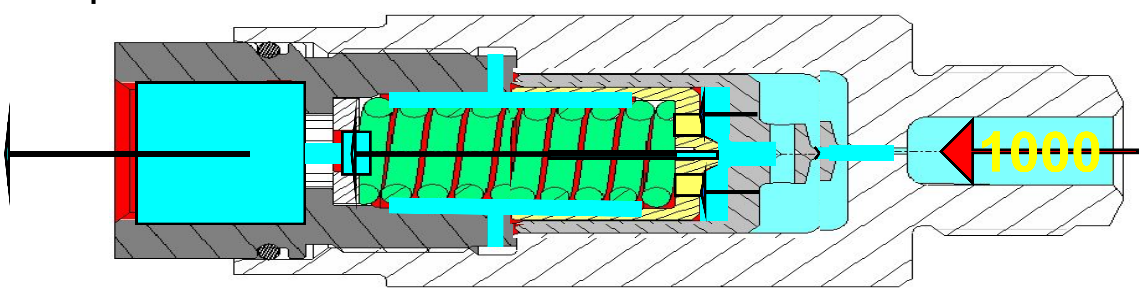
The common rail system uses a type of accumulation chamber called a rail to store pressurized fuel, and injectors that contain electronically controlled solenoid valves to inject the pressurized fuel into the cylinders. When the fuel pressure becomes higher than normal a mechanical dump valve (also named safety valve) dumps the overpressure to return manifold.

Safety Relief Valve



Opening Pressure: 3100 bars

Limp Home Pressure: 1000 ±300 bars



Dual-Stage Safety valve:

Cone-on-Cone on 1st Stage

Cone-on-Cone on 2nd Stage

XPI Injector

Injector Scania XPI

Function

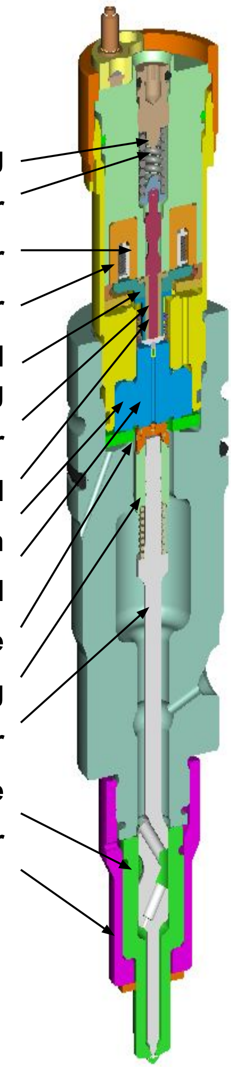
There is one injector for each cylinder. The injector is controlled electrically by the engine control unit.

The injector operates in two phases. One phase is when no power is supplied to the injector and it is closed. The other phase is when power is supplied to the injector and it is open.

The injector consists of a piston, nozzle needle, spring and an electromagnetically controlled fuel valve.

The fuel enters the injector via the high pressure connection. The injector is continuously pressurised to a maximum of 2400 bar. When the solenoid valve is supplied with power and opens, fuel is injected into the cylinder.

Injection timing and the amount of fuel to be injected is determined by the engine control unit. Injection duration and the fuel pressure in the accumulator determine the amount of fuel which is injected into the cylinder.



Phase 1, no power to the solenoid valve in the injector

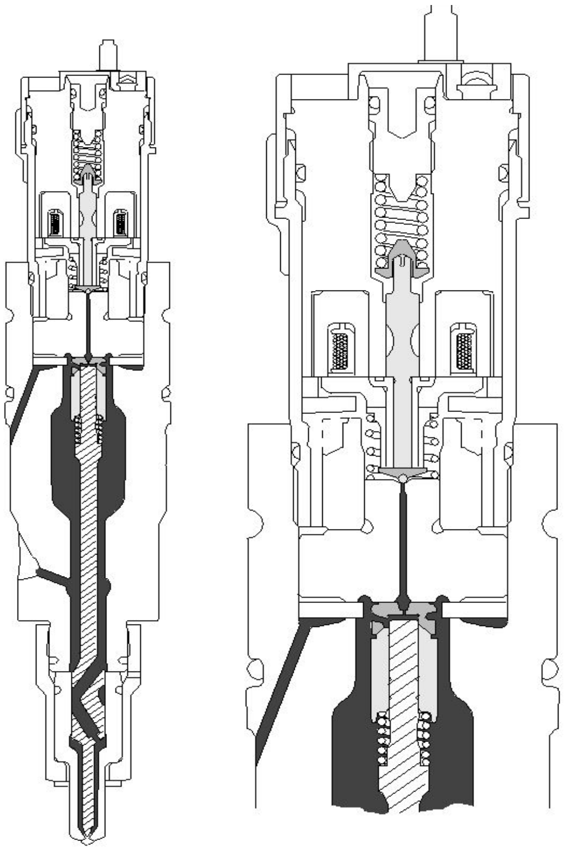
No power is supplied to the injector solenoid valve and the injector is closed. There is a fuel pressure of between 350 and a maximum of 2400 bar in the injector.

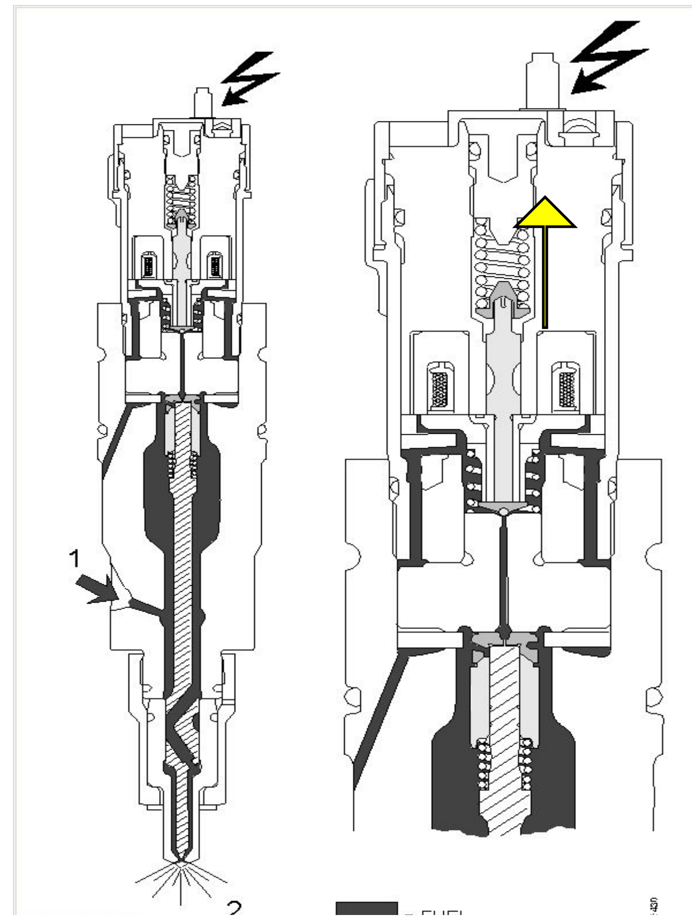
Phase 2, power to the solenoid valve in the injector

Power is supplied to the injector solenoid valve which then opens, so that the fuel flows up into the valve part. The pressure difference which arises in the injector means that the piston is drawn upwards and fuel is injected into the cylinders.

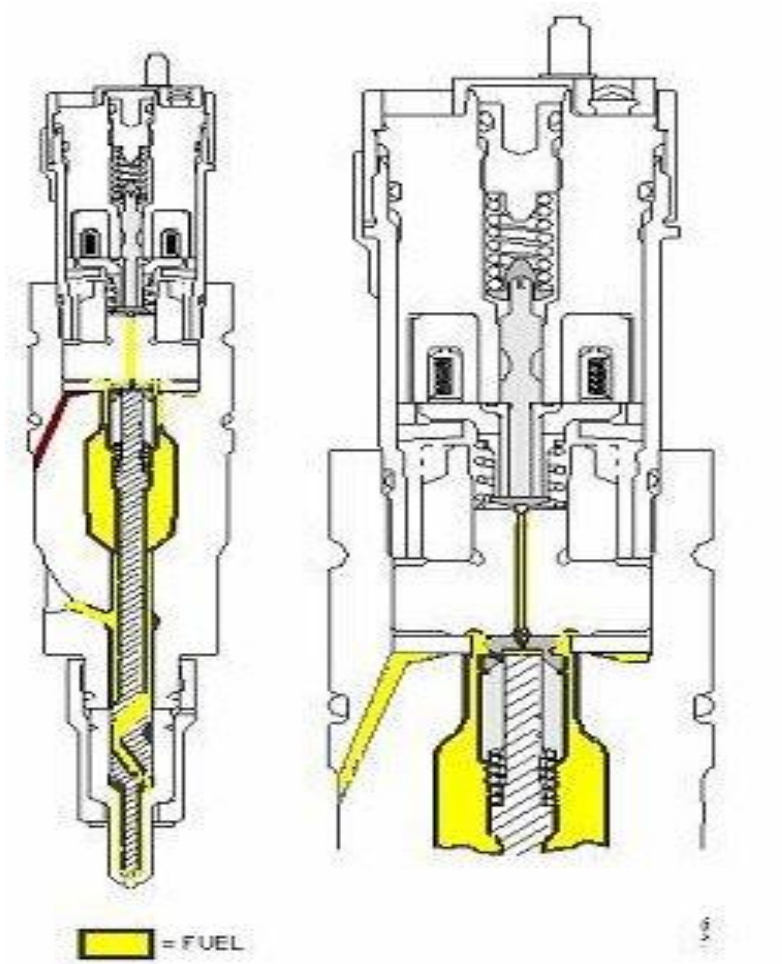
When power is again switched off to the solenoid valve, the fuel pressure in the injector pushes the piston downwards and closes the injector

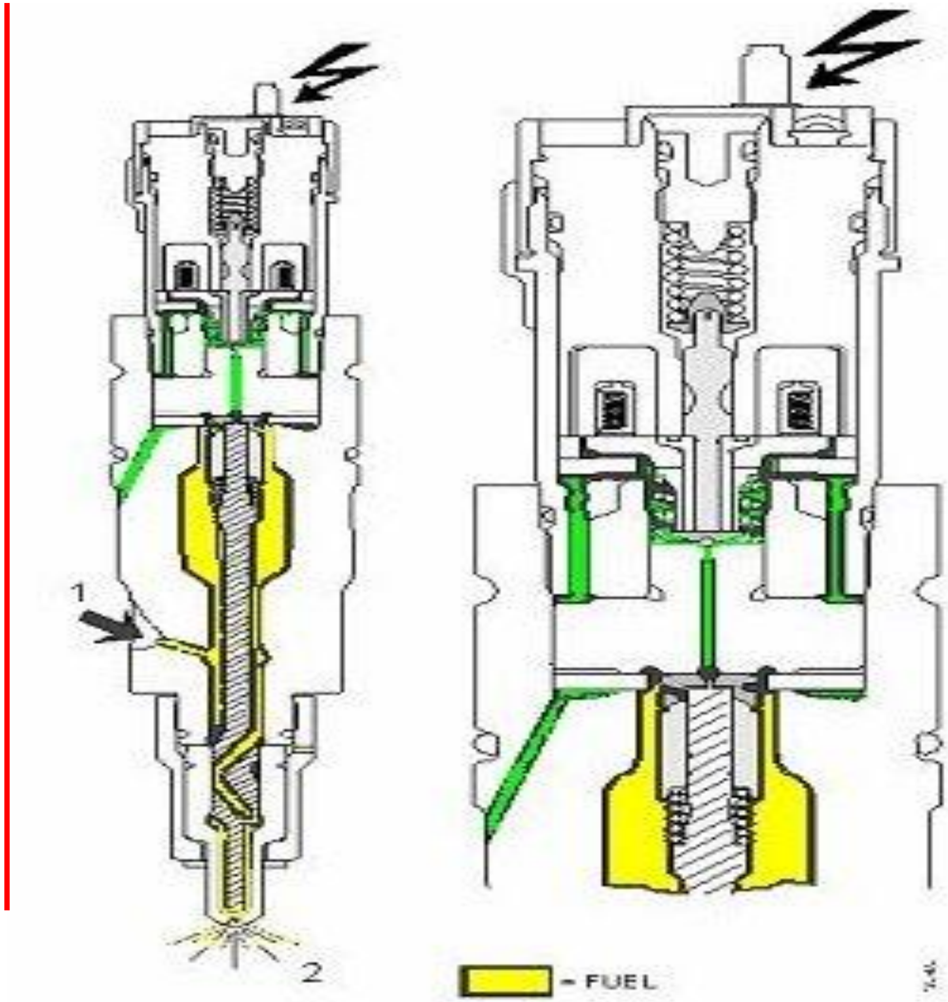
Phase 1 & 2 of Injection





Scania





= High pressure Fuel

= Return Fuel

Injectors: Individual adjustment code

Each injector has an individual adjustment code. This code has to be entered into the ECU each time an injector is exchanged.This operation has to be performed with SDP 3.

The purpose of the individual adjustment code is to reduce variation between injectors. The result is an engine that runs smoother and delivers the correct power output.

After changing the injectors you need to, CLEAR fuel data

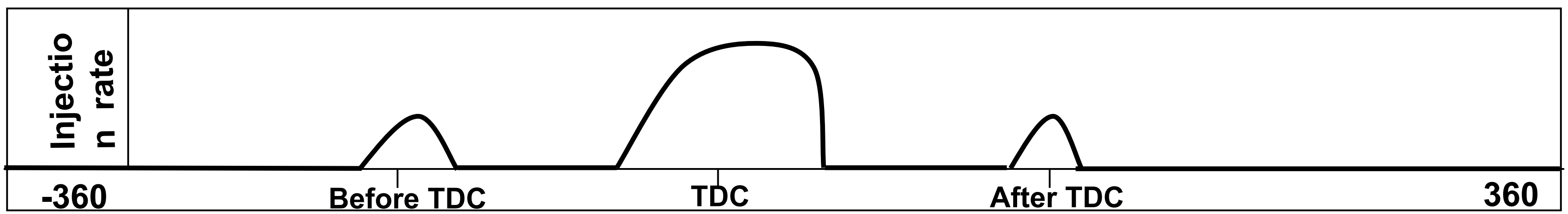
Multiple injections

Multiple injections are possible with this electronically controlled injection system.

(A small amount of fuel (pilot injection) can be injected slightly before the main injection to reduce noise and prepare the combustion chamber for lower emissions.)

Pilot injectionMain injectionPost injection

A small post-injection shortly after the main injection reduces soot and NOx. It can also be used to control exhaust temperature to suit some future aftertreatment systems.



Pilot injection

Reduce noise

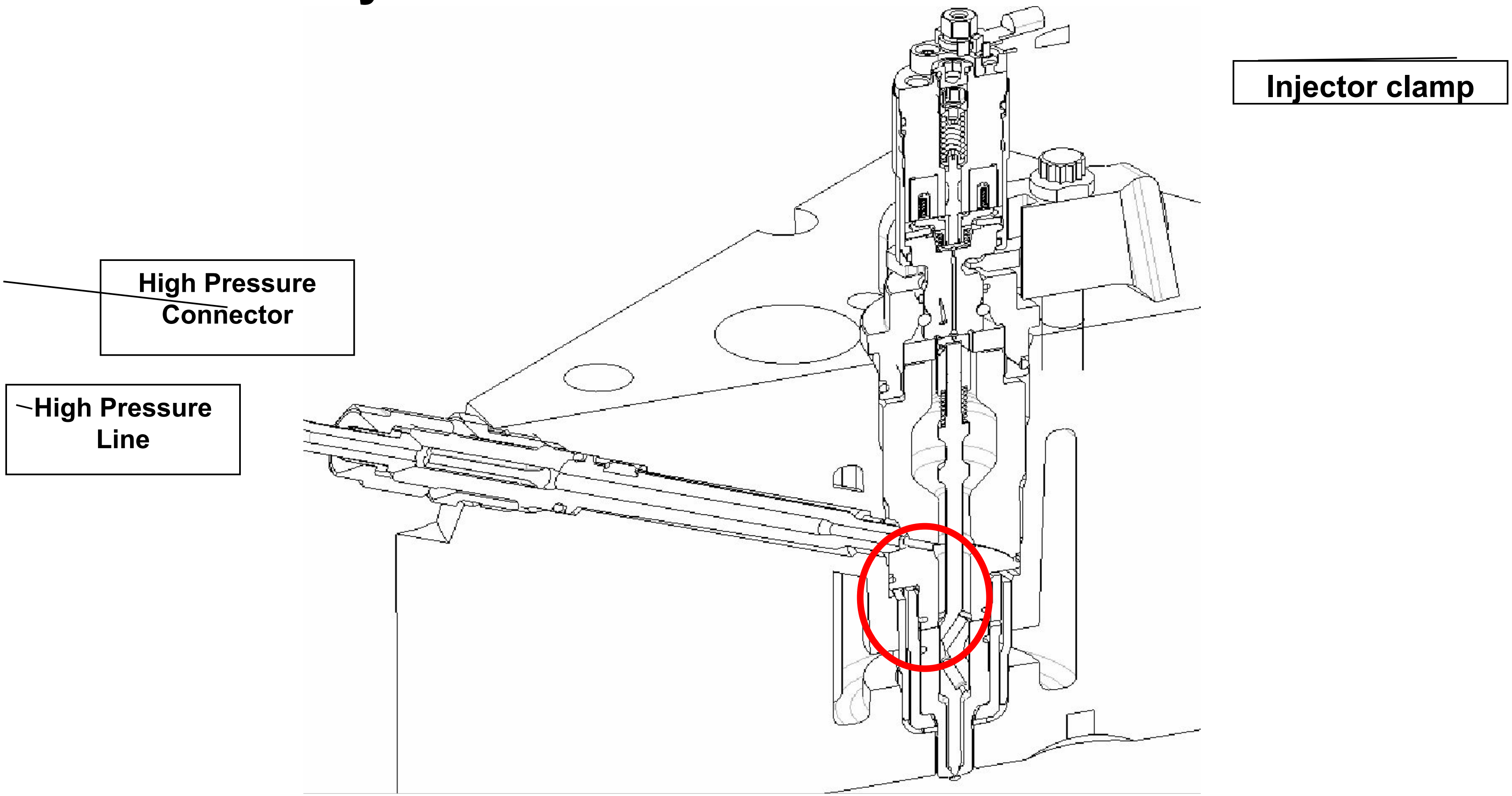
One main injection

Control combustion

(Post injection)

Reduce exhaust emissions

Injector assembly



Scania

Cleanliness requirement

Many internal parts in the system are sensitive to dirt and water droplets. This is due to that the dimensions are very small, the surface finish requirements are high, and the pressures are extremely high. Examples of sensitive parts are:

- Pilot valve (injector)
- Needle seal with floating sleeve (injector)
- Plungers / barrels (HPP)
- Inlet and outlet checkvalves (HPP)

This means that cleanliness is more important than ever when working on fuel system components.

Regulations

Warning!

The fuel system has a very high fuel pressure of up to 3000 bars.

The fuel system must be depressurised before any work is started.

Use SDP3 to minimise the high pressure in the fuel system.

A jet of fuel at high pressure can cut through the skin.

The system should always be treated as pressurised, even when the engine is switched off.

Wear protective gloves and goggles.

Cleanliness requirement: Pilot valve

The thickness of a human hair is 85 µm. The pilot valve stroke is 47 µm!

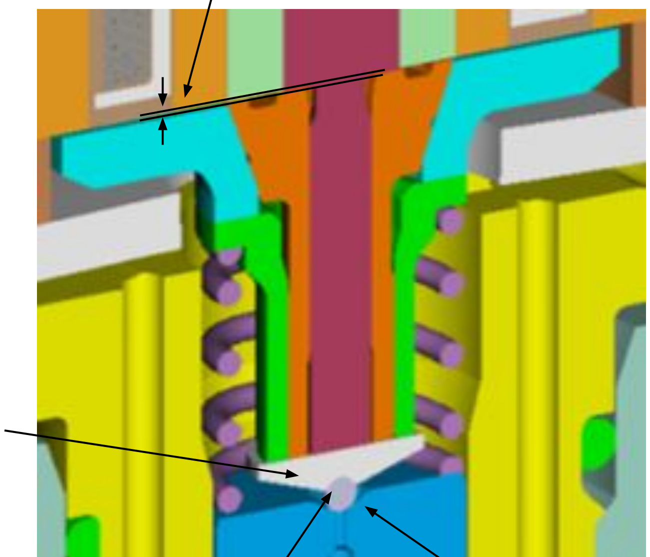
Pilot valve seat

1000 µm = 1mm

Human hair =85µm

Stroke = 47 µm

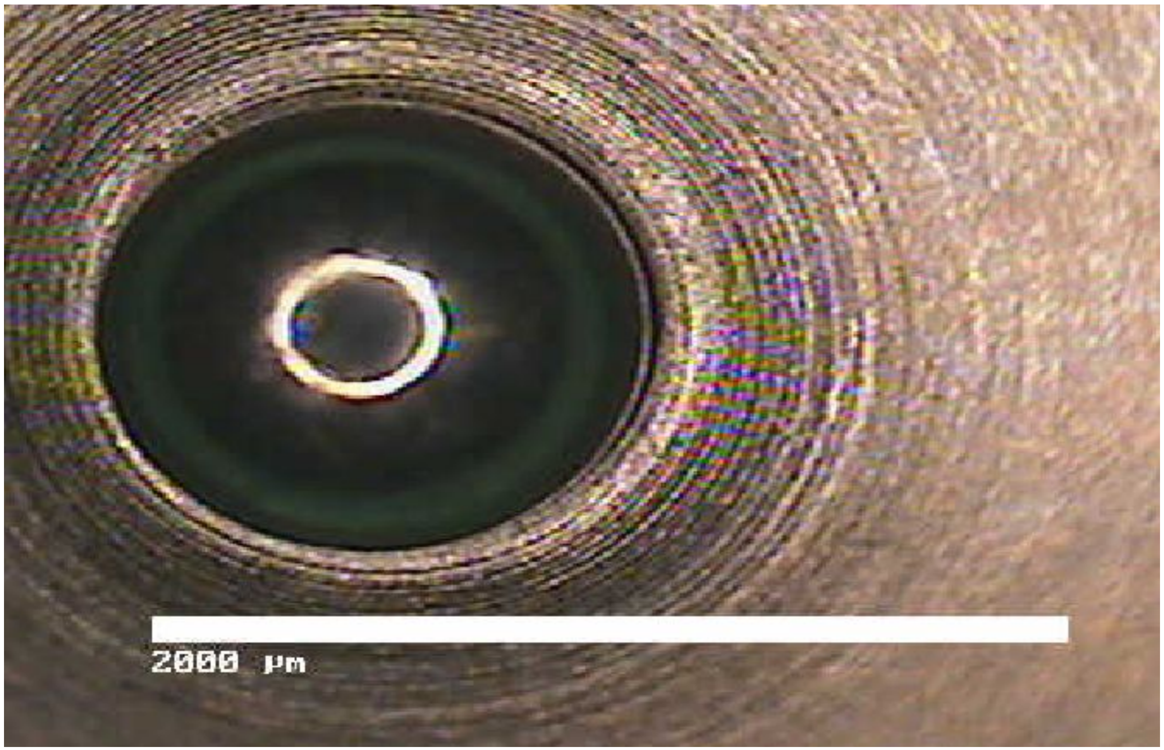
Ball Retainer



Ball

Seat

Cleanliness requirements: Pilot valve ball



The size of the ball is around 1 mm. This ball is exposed to a pressure of 2200 bar. Debris between ball and seat = leakage and uncontrolled fueling

Cleanliness requirement: General

- Do not use compressed air for cleaning purposes.
- Use only non-fluffy cleaning cloths on the fuel system
- When removing and fitting components, do not use materials like fluffy cloths, cardboard or wood.
- Use undamaged tools (not with split chrome surfaces)
- Do not remove parts from their original enclosure until immediately before assembly.
- If you need to send the part somewhere: use a new plastic bag and seal it properly. If possible, use the original packing of the new part.

Service: Safety

Due to the high fuel pressure, leakage can cause jets of fuel that penetrates through the skin!

Always consider the high pressure part of the system (accumulator and high pressure lines) as pressurized. The pressure could be as high as 2400 bar. This applies also to an engine that is not running!

Before working on any of the fuel system components: De-pressurize the system by use of SDP3 and then untightening the cylinder high pressure line nut at the accumulator of the cylinder you are going to work on. Cover the nut with a cloth during the operation. Use safety glasses and gloves.

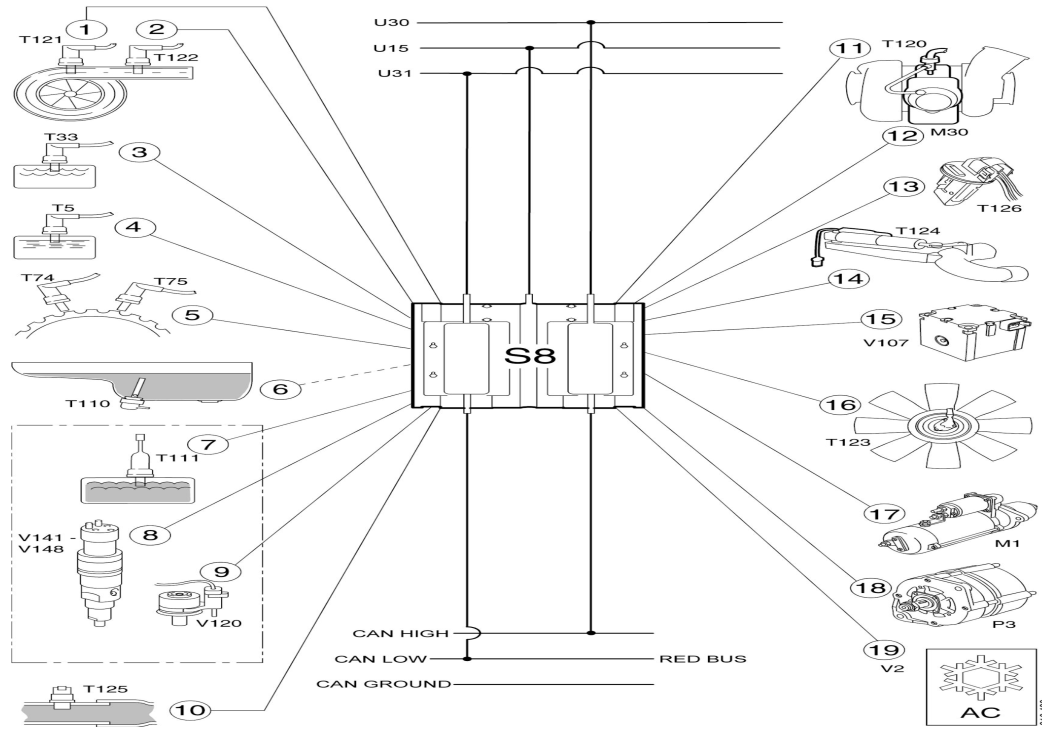
Avoid standing closer than 1 m to a running engine. Fuel jets will diverge within this distance from the source and become less harmful.

Scania

S8 Engine Management System (EMS)

1. T21, charge air temperature sensor
2. T22, charge air pressure sensor
3. T33, coolant temperature sensor
4. T5, oil pressure sensor
5. T74, T75, engine speed sensors
6. T110, oil level sensor, available as an option
7. T111, fuel pressure sensor
8. V141-V148, XPI injectors
9. V120, fuel inlet metering valve
10. T125, exhaust back pressure sensor
11. T120, turbo speed sensor
12. M30, electric motor for adjustable turbocharger
13. T126, intake air temperature and flow sensor
14. T124, position sensor for the EGR valve
15. V107, valve block with a proportional valve for the EGR valve and exhaust brake
16. T123, rotation speed sensor and fan solenoid valve
17. M1, starter motor
18. P3, alternator
19. V2, coupling coil for AC compressor

- **The S8 EMS is introduced with improved memory addressing, and is prepared future demands.**
- **Input from gearbox temperature sensor, additional NOx sensor etc**
- **New architecture for calculations**



Troubleshooting: Tools

To apply the methods described here you need the pressure sensor + amplifier included in Scania pressure measurment kit (P/N 99362) or another suitable sensor. You also need a multimeter.

<u>Note:</u> Pressure is displayed in Mpa.

0,1 MPa = 1 bar

Pressure sensor + amplifier

Multimeter

Troubleshooting: Feed pressure

If engine is not firing at all: Start with checking the feedpressure from the LPP.

Connect the pressure sensor to the air bleed fitting on the main filter housing. Open the fitting.

At cranking the pressure shall be at least 1,5 bar (0,15 on the multimeter display)

At idling the pressure shall be at least 9 bar (0,9 on the multimeter display).

If the pressure is too low: check all fittings on the suction side of the pump to ensure that there is no suction leakage.

If all fittings are OK and the presssure still too low: exchange the LPP

Troubleshooting: Fuel manifold pressure

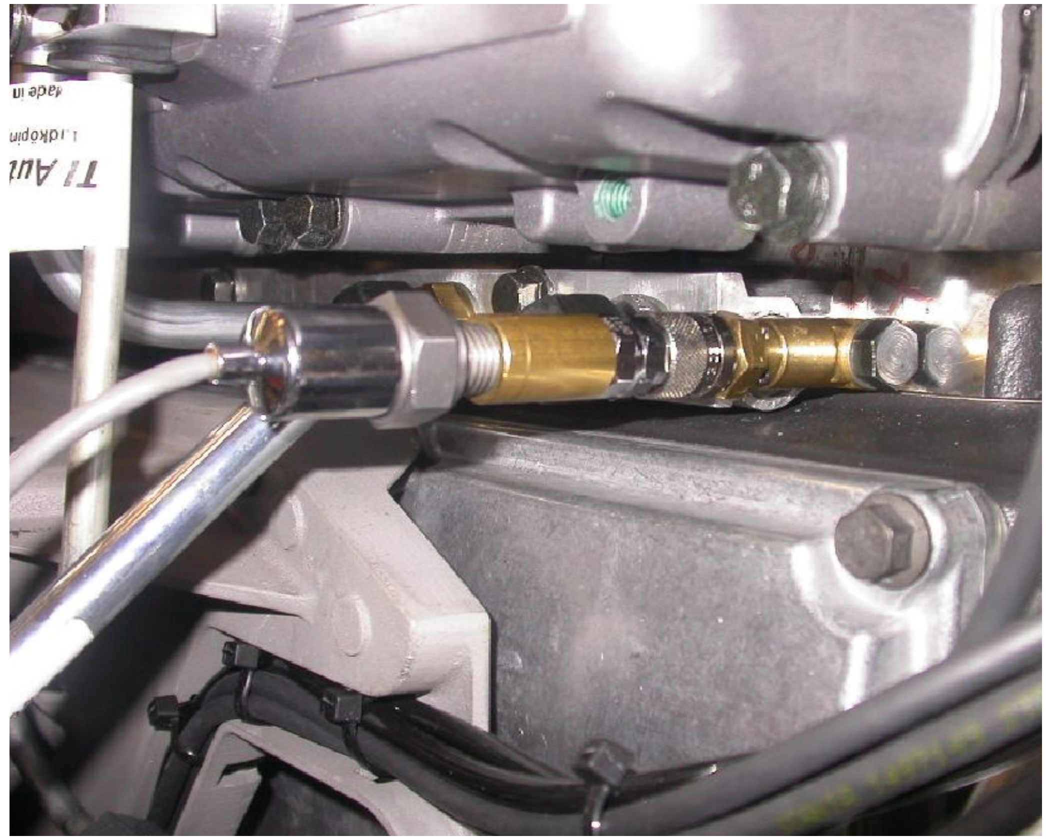
If the railpressure is too low (fault code for low railpressure triggered): Begin with checking all High Pressure Line fittings for external leakage.

If fittings are OK: Connect the pressure sensor to the fitting on the return side of the fuel manifold. Open the fitting.

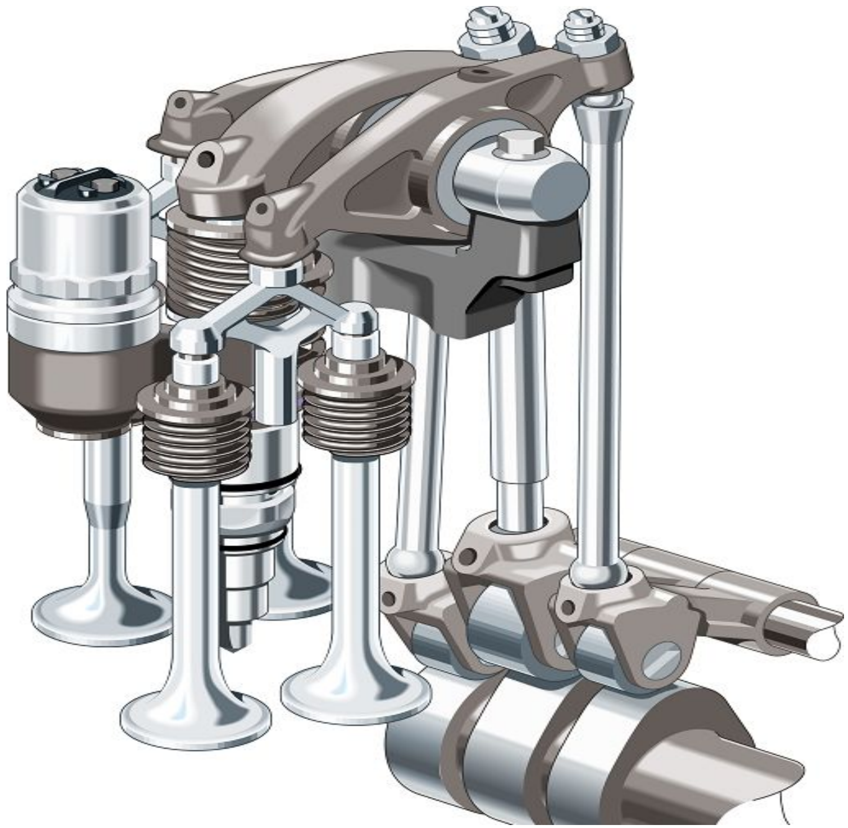
The pressure shall not exceed 1 bar at 500 rpm idle (hot engine).

A too high pressure indicates too high return line flow, which indicates one or more of the following faults:

- Pilot Valve leakage
- Cracked injector
- Worn out HPP
- Leaking HPC



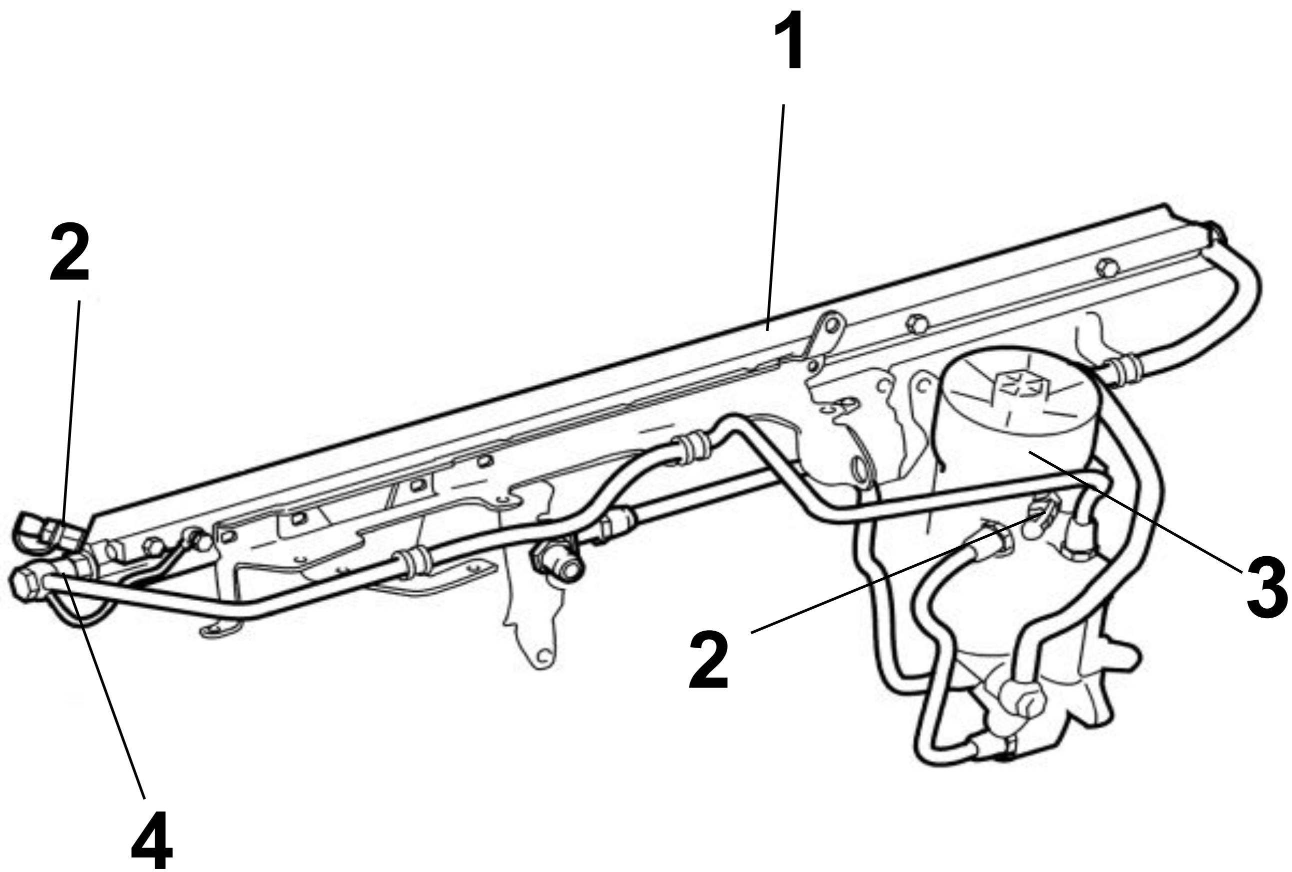
Fuel system, PDE
(Pumpe-Düse-Einheit)



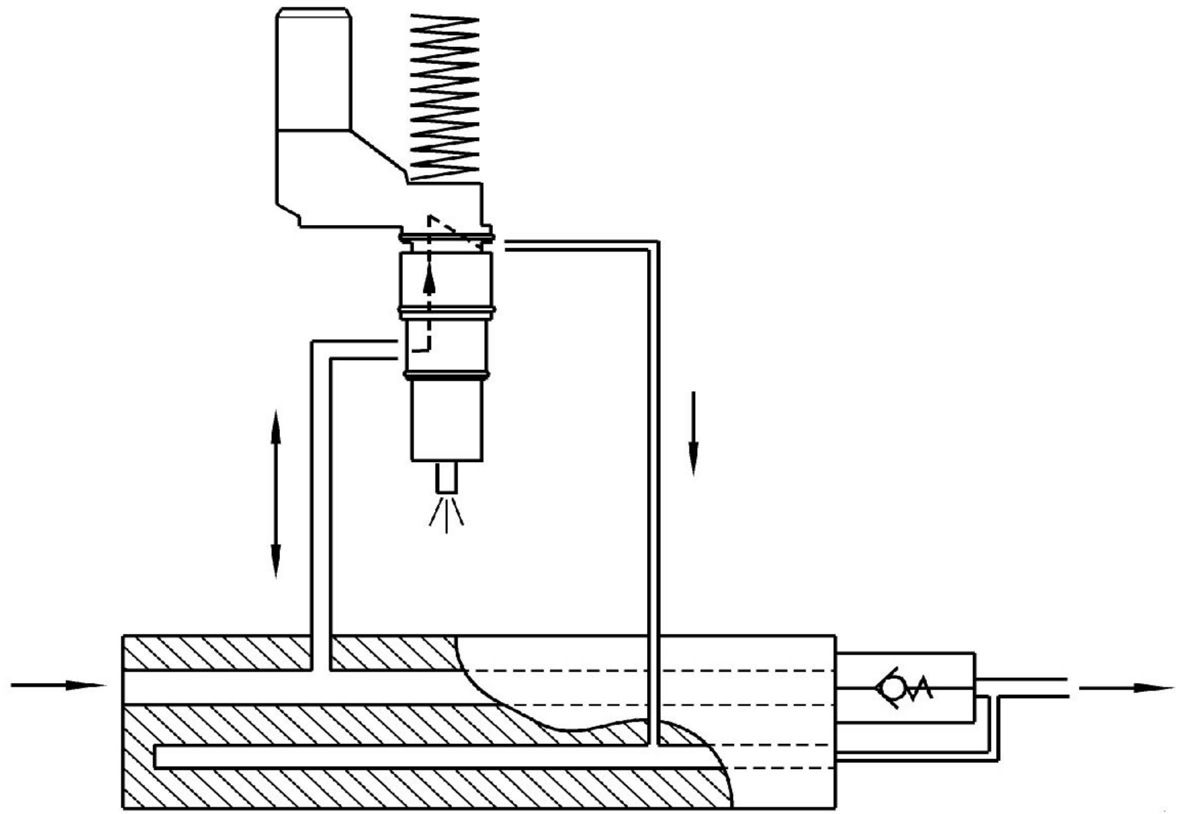
Fuel system

Fuel rail

1. Fuel rail
2. Drain nipple (for bleeding)
3. Fuel filter
4. Overflow valve



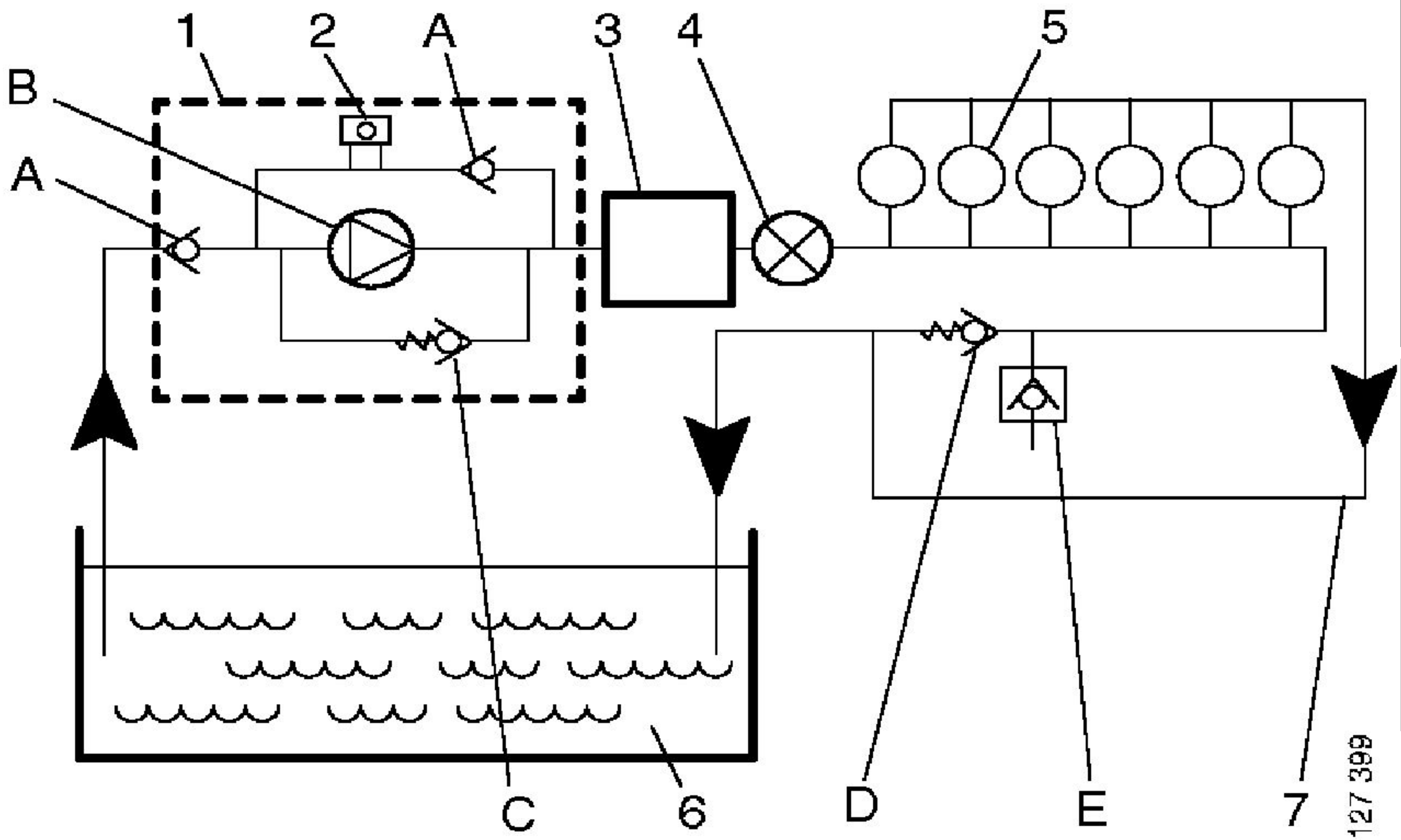
Fuel system



Fuel flow, Monorail

Fuel system

Skeleton diagram of the fuel system



1. Feed pump
2. Hand pump
3. Control unit
4. Fuel filter
5. Cylinders
6. Fuel tank
7. Return pipe

A. Check valve
B. Feed pump (gear driven)
C. Safety valve
D. Overflow valve
E. Drain nipple

Fuel system

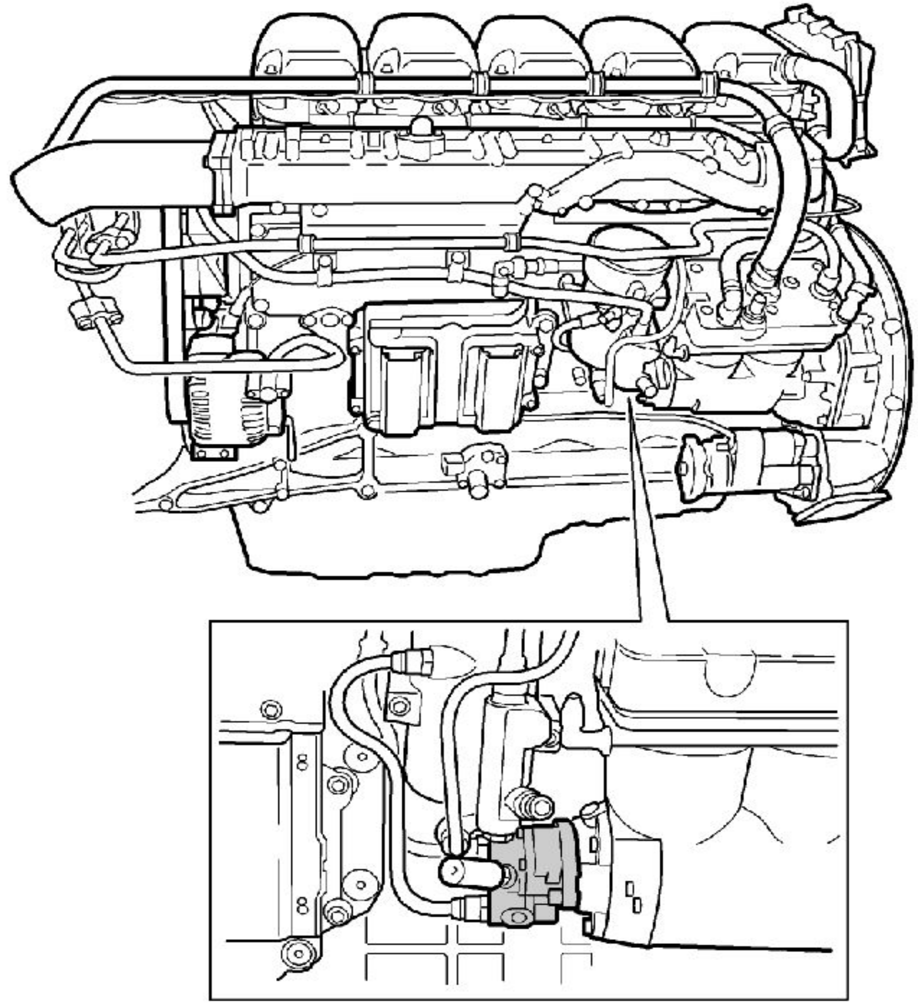
Feed pump

Gear type

Operation pressure 4,5-7 bars

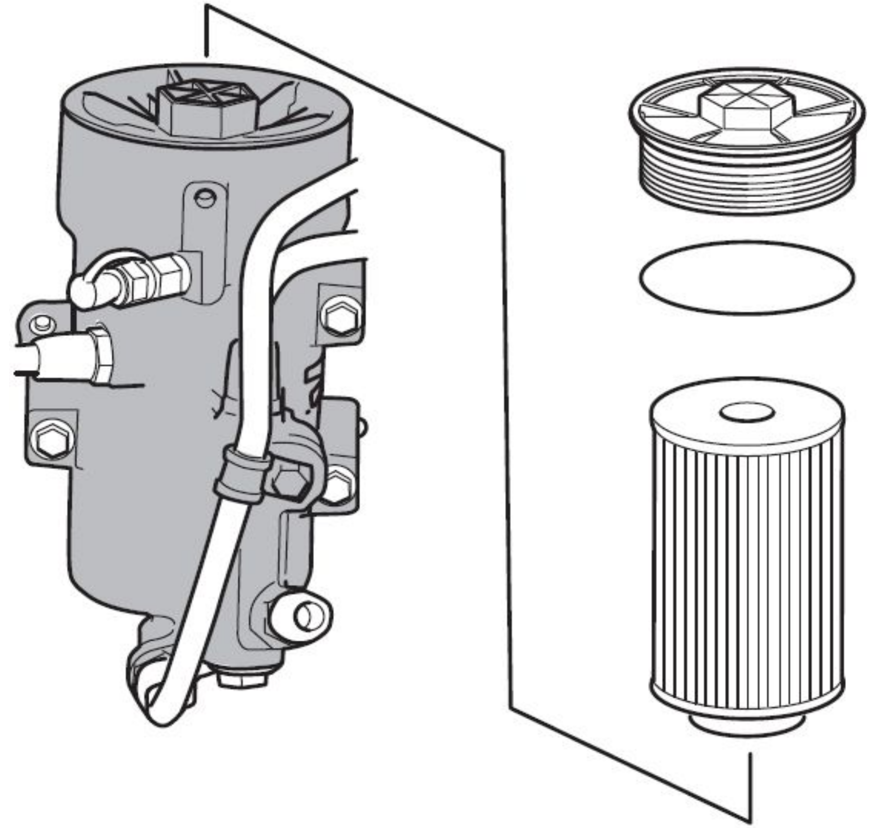
Max. suction height is 2 meters

Double action hand pump for bleeding



Fuel system

Renewing fuel filter 1000 h.



Water separating filter "pre-filter"

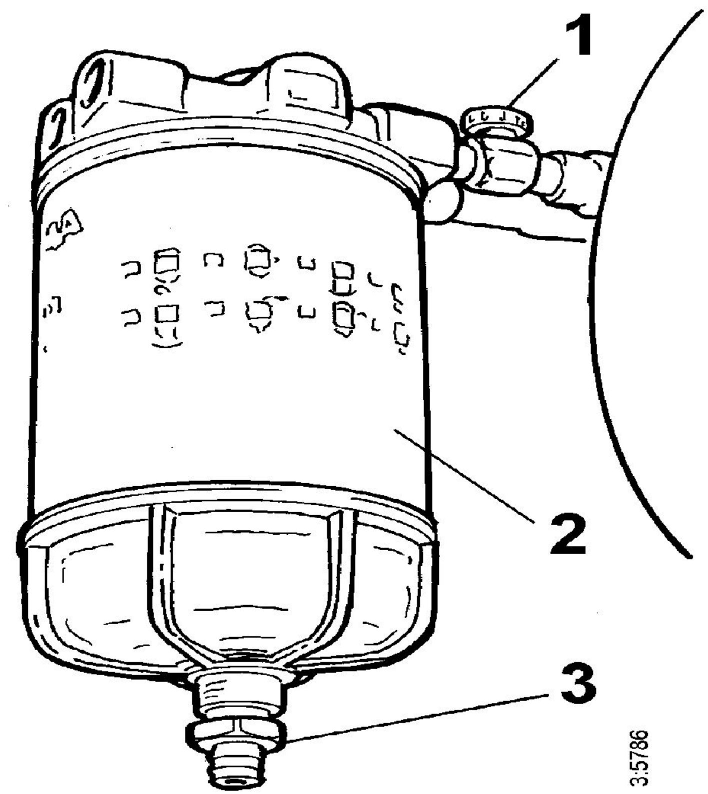
- **Drainage must be carried out when filling fuel.**
- **The filter must be changed at the same replacement interval as the main filter.**

Important !
Fit the filter elements in the filter covers before placing them in the fuel filter housings or the filter elements may be damaged.

Fuel system   Renewing fuel filter 1000 h.

Water separating filter
"pre-filter"

- **Drainage must be carried out when filling fuel.**
- **The filter must be changed at the same replacement interval as the main filter.**



Fuel system

Unit injector, PDE

(Pumpe-Düse-Einheit)

Operated by the EMS-system

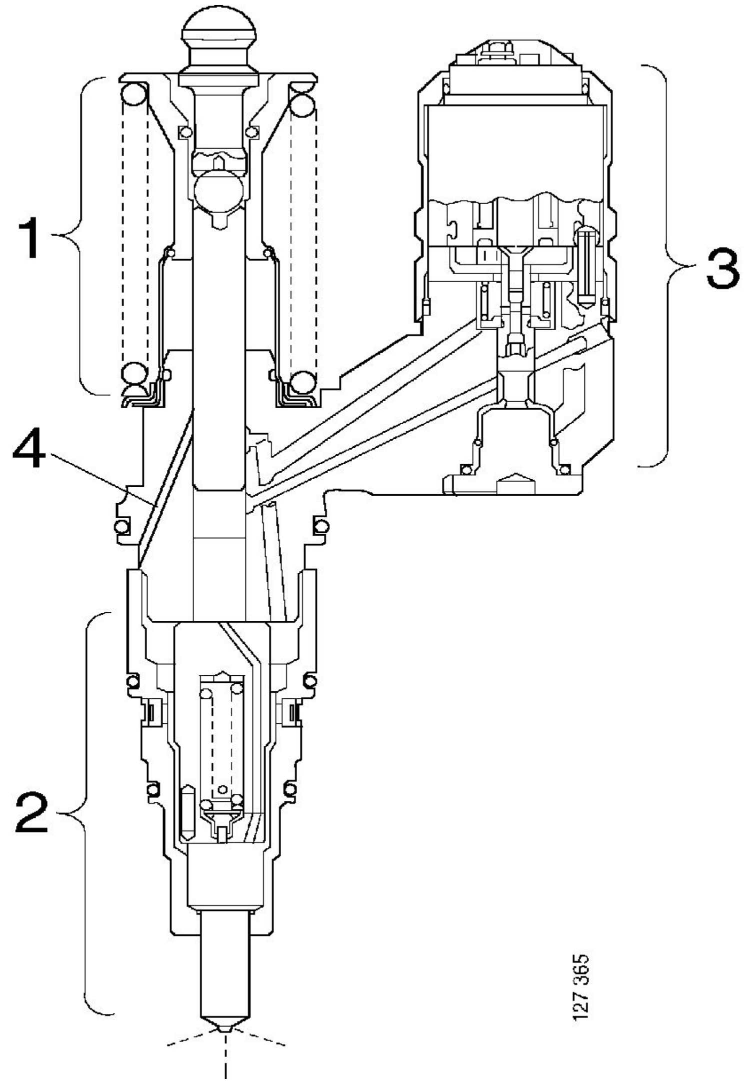
Engine-Management-System

1 **Pump part**

2 **Injector section**

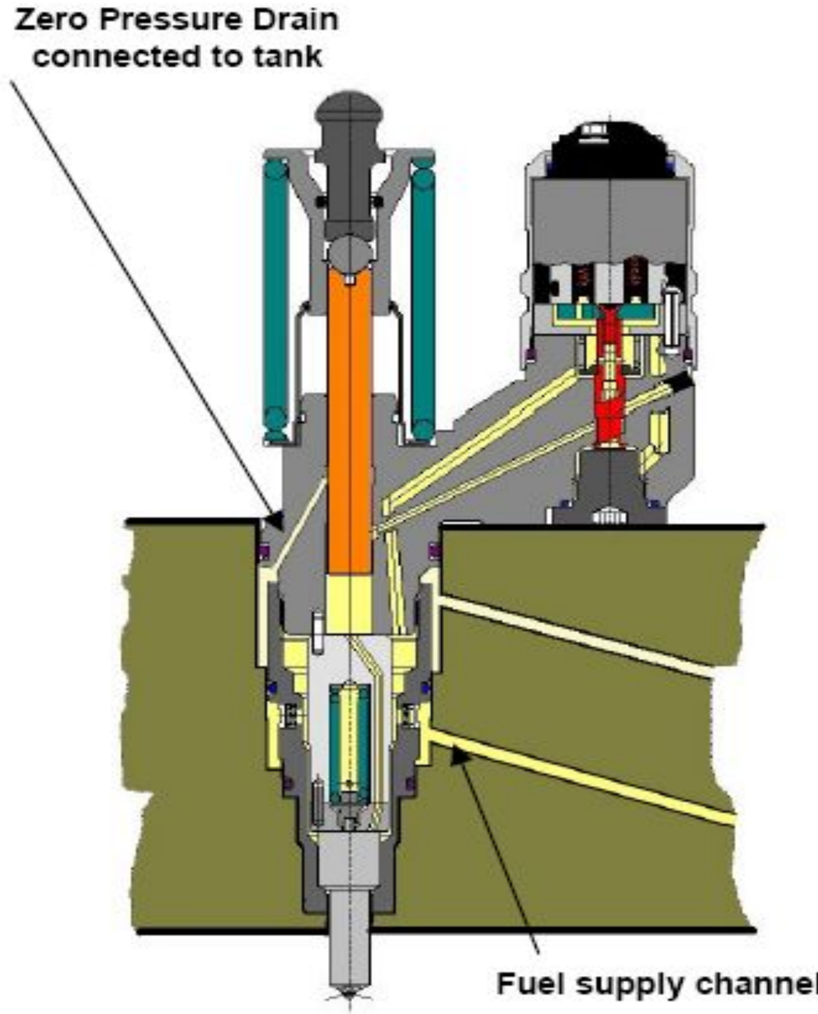
3 **Valve housing**
Electrical operated

4 **Zero pressure return**



Fuel system

Zero pressure drain in the PDE

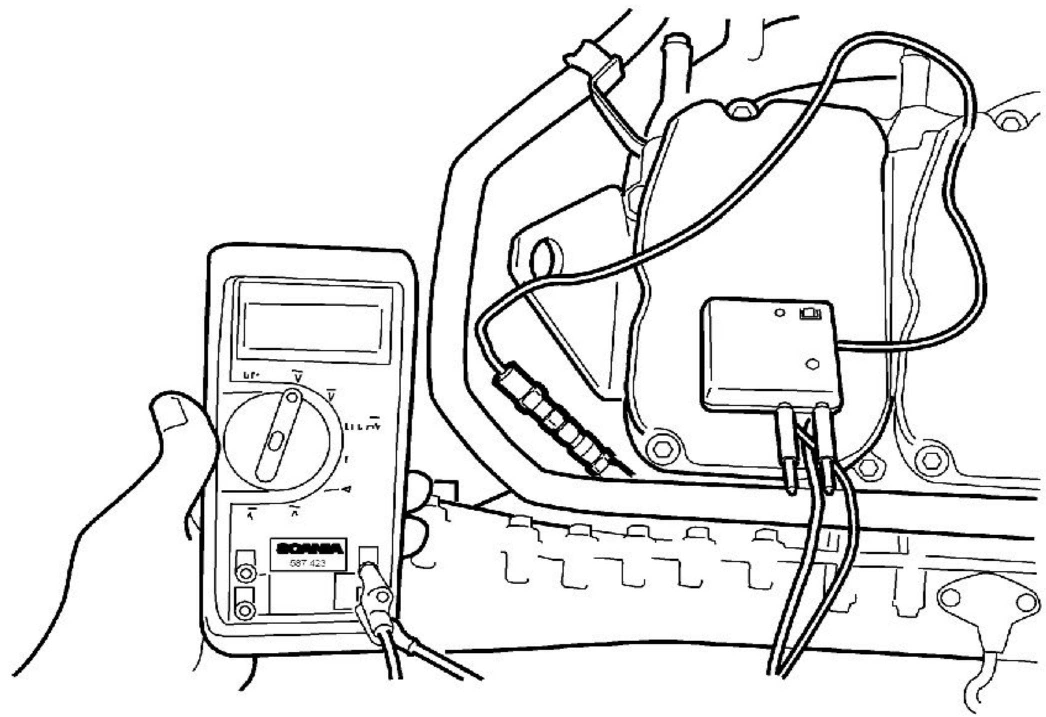


Measuring feed pump pressure

Pressure between:
4,5 – 7 Bar

Pressure gauge
Mechanical
98 113

Pressure gauge
Electronically
99 362

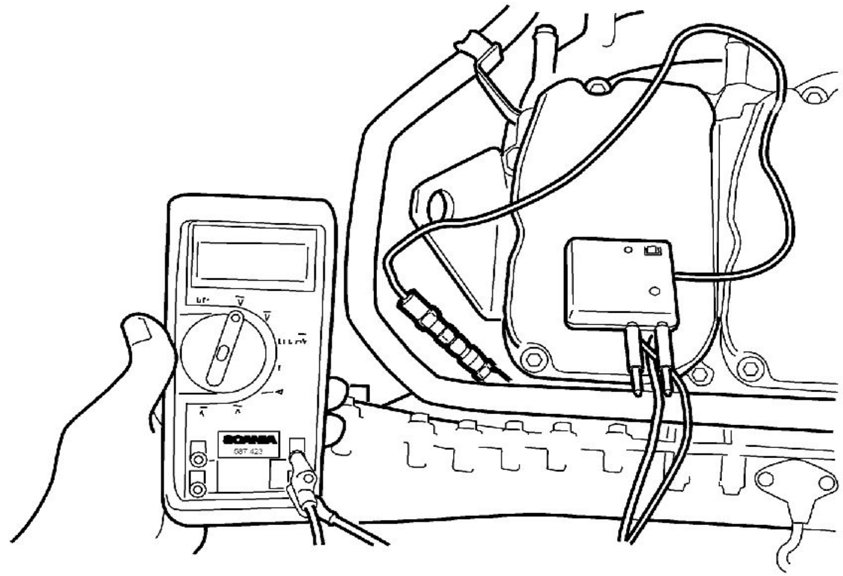


Checking to overflow valve

Pressure between:

4,5 – 7 Bar

1. **Connect pressure gauge 99 362 to the bleeder nipple on the fuel manifold.**
2. **Turn the starter key to the drive position without starting the engine**
3. **Pump with the hand pump until the overflow valv opens (*A hissing sound should be heard.)* and read the pressure gauge. If the overflow valv opens at a lower pressure, it is faulty and must be renewed.**
4. **Start the engine *(The engine should be easy to start.)* and rev it up to 1500 rpm. If the pressure then exceeds 7.5 bar, the overflow valve is blocked and must be cleaned or renewed.**



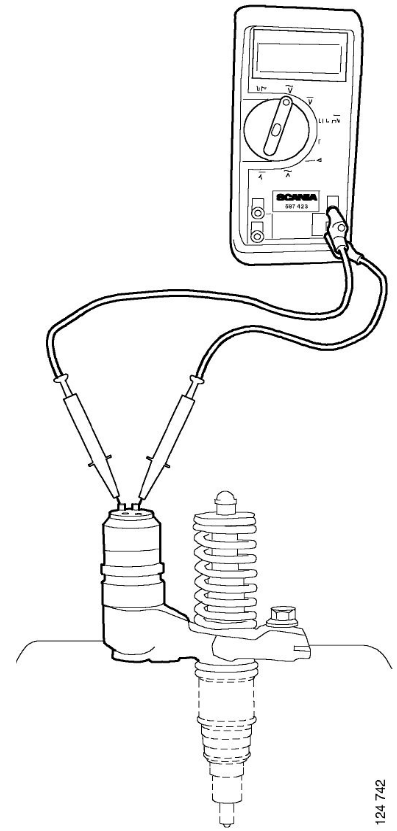
Note!

Do not forget to open the bleeder nipple when the pressure gauge is connected.

Trouble shooting the unit injector (PDE)

Measure the resistance between the two poles on the solenoid valve for 20 sec. for stable value.
The resistance should be 0.3 - 1.5 Ohms at room temperature and with the engine cold.

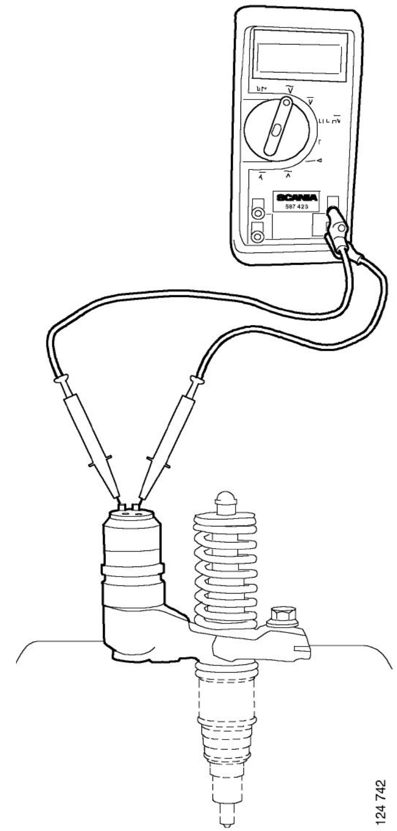
Measure also the resistance between the contact surface on the solenoid valve and the valve's metal casing to check that there is no short circuit. Take measurements on both screws.



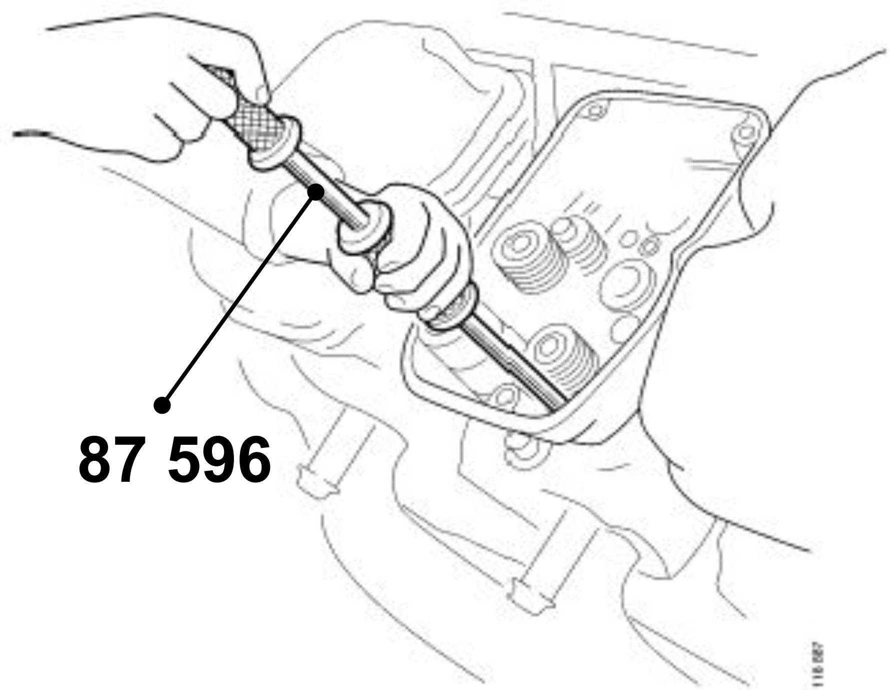
Trouble shooting the unit injector (PDE)

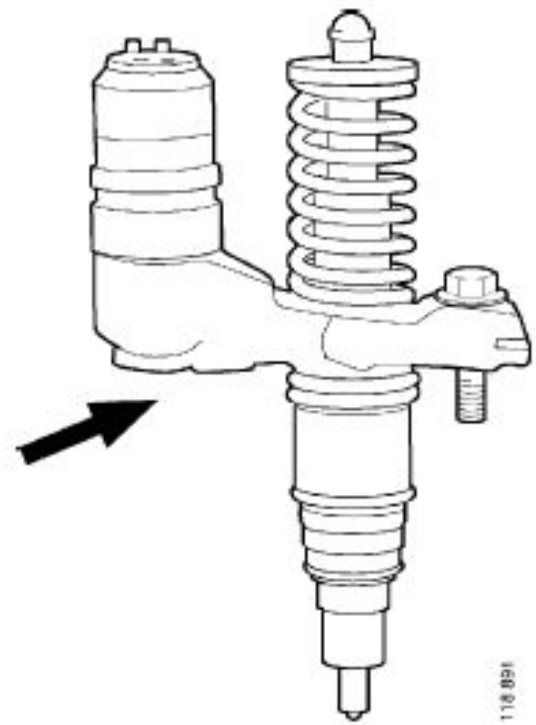
One of the unit injectors may be short circuited to earth via the chassis.

This means that the EMS control unit will not work and not provide and fault codes.
If this is the case, each unit injector must be tested.

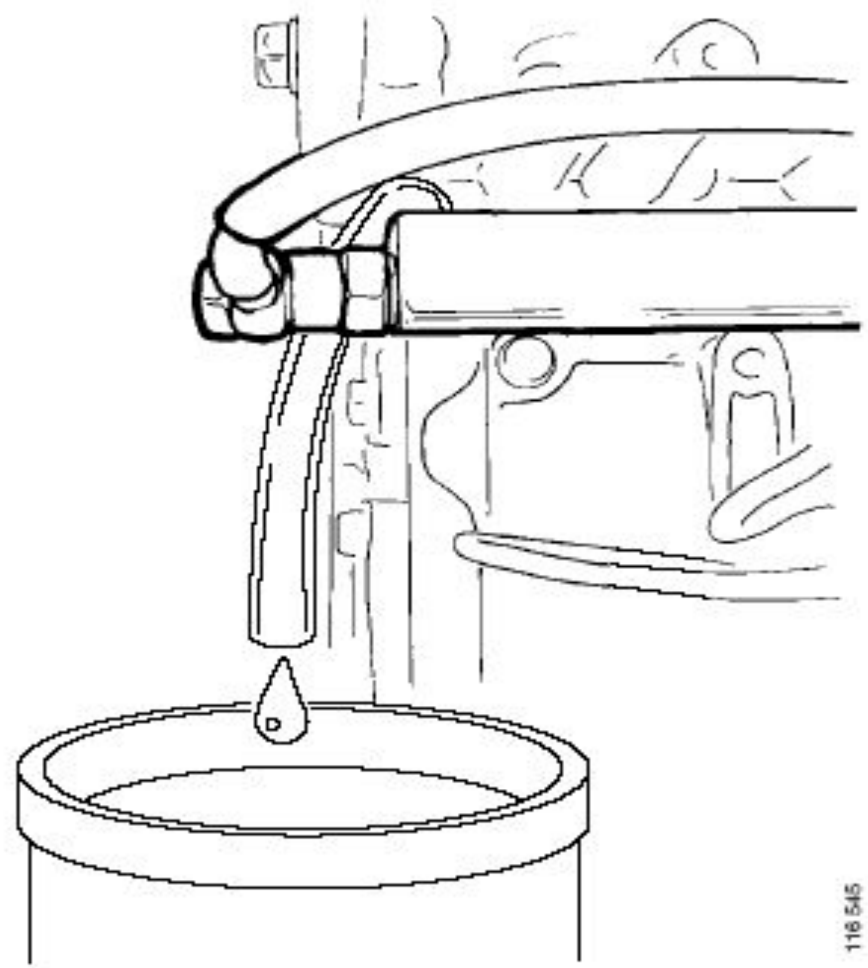


Dismantling the PDE





Dismantling the PDE

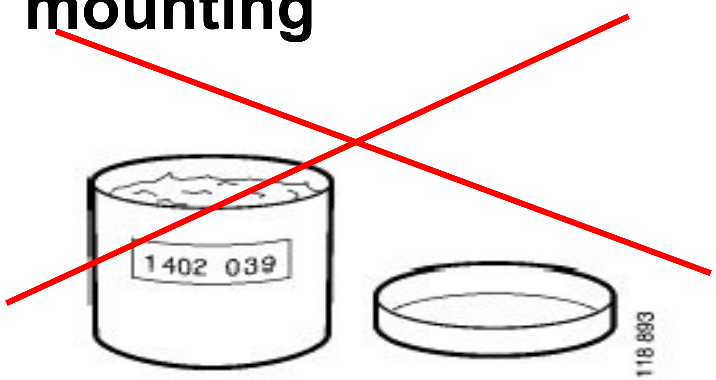


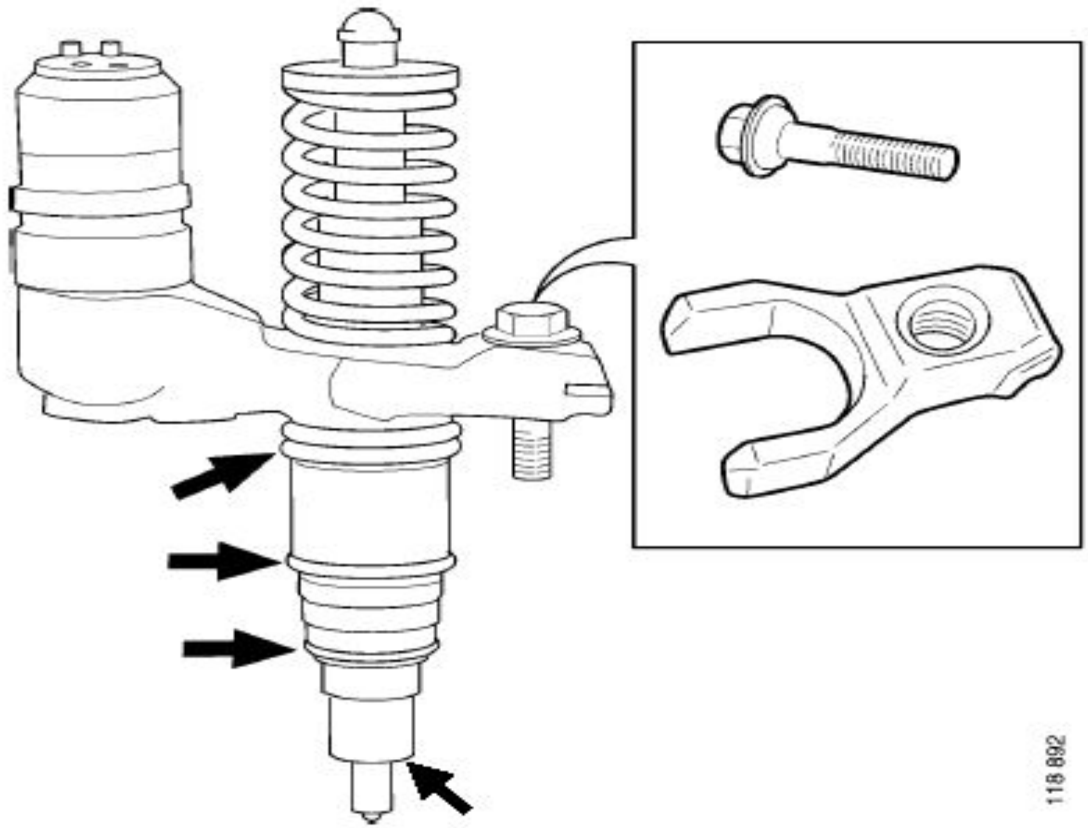
WARNING!

The fuel system must be empty before dismantling the unit injector otherwise fuel may run down into the cylinders, which will result in a great risk of liquid hammering.
If fuel runs into the combustion chamber, it must be removed immediately using a pump.

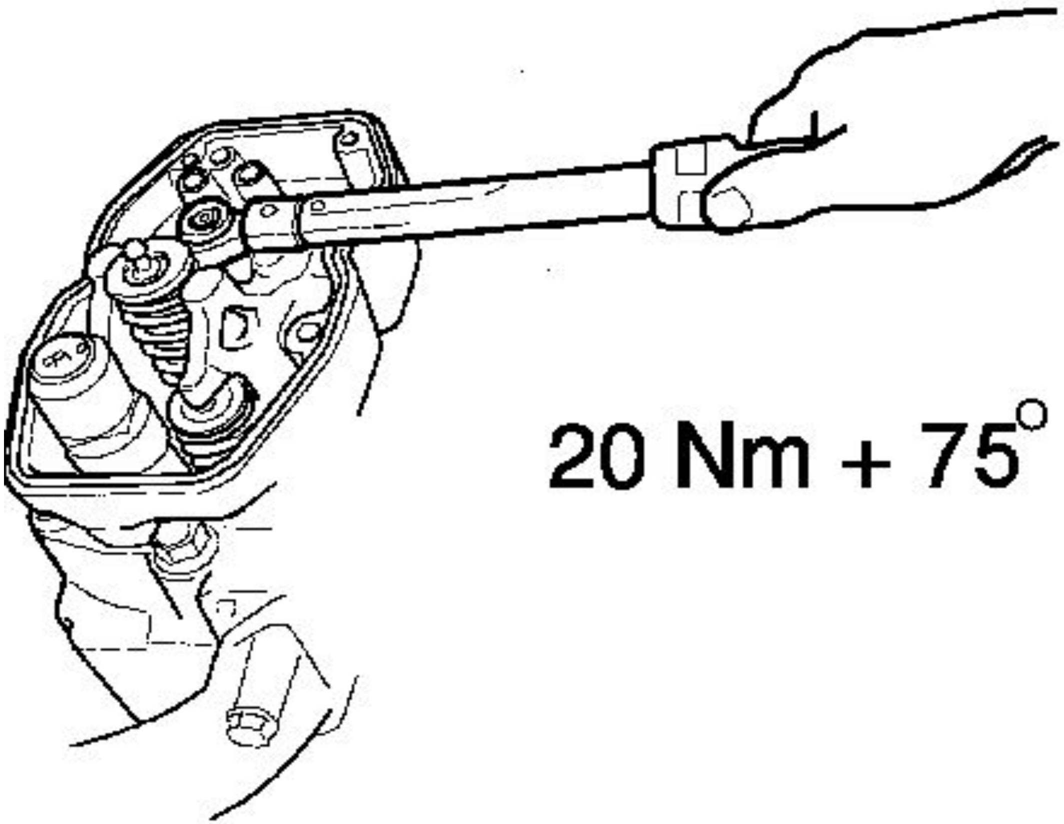
Mounting the PDE

Engine oil should be used to lubricate O-rings when mounting

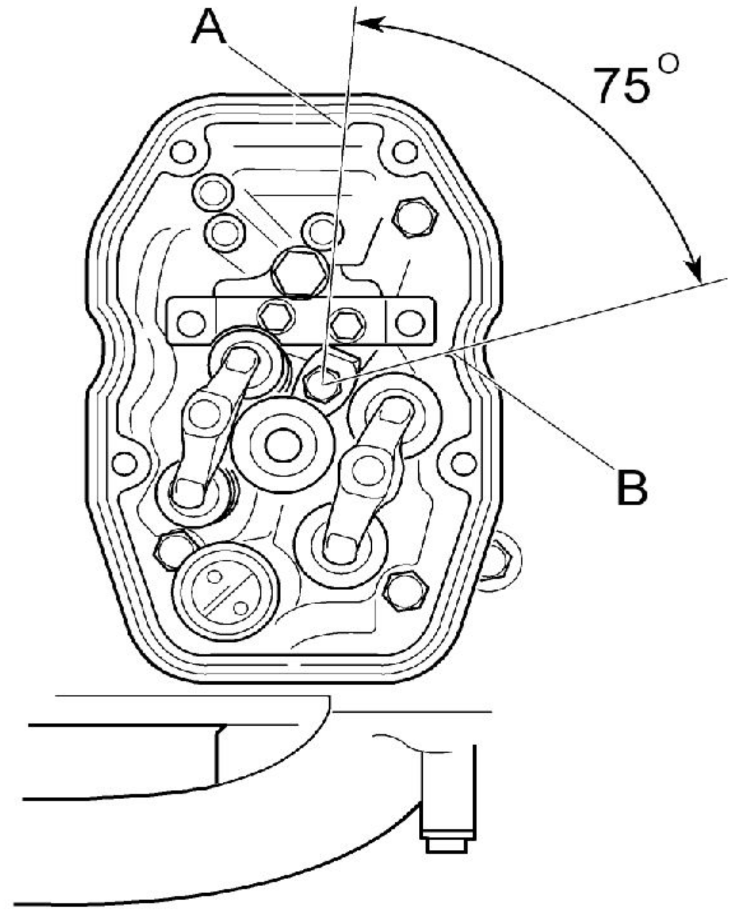




Mounting the PDE



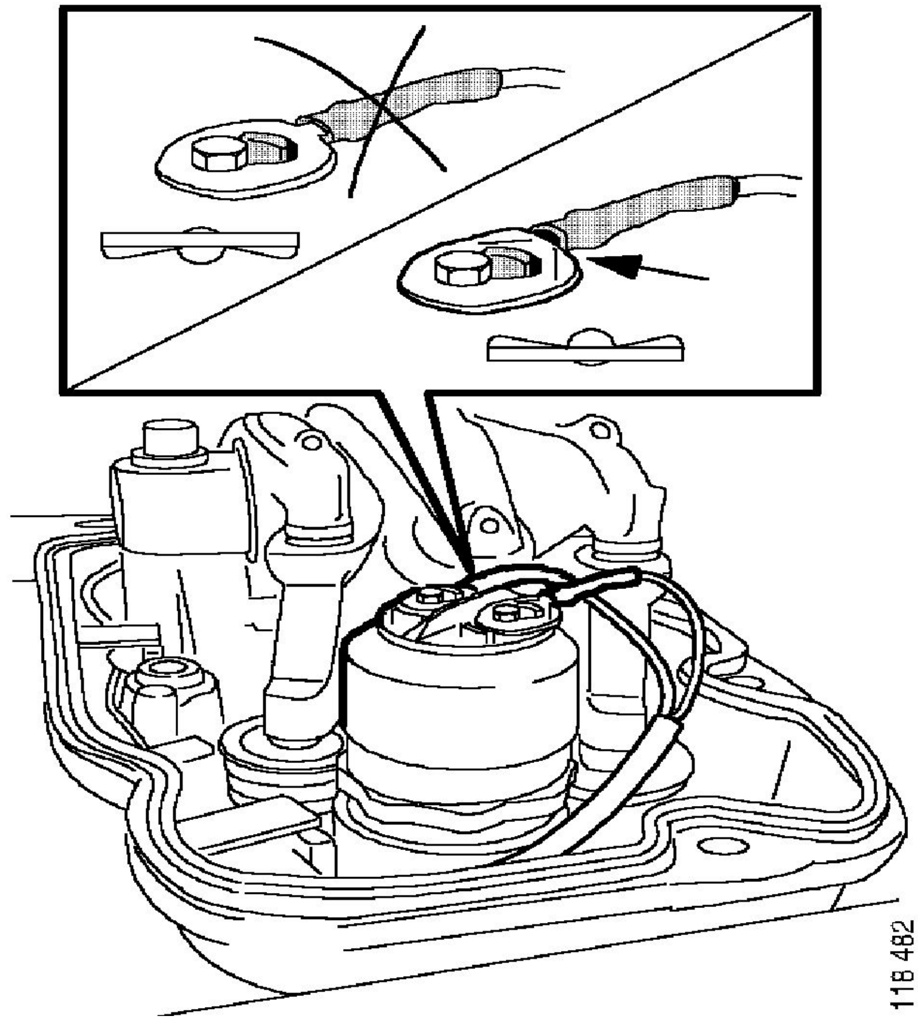
20 Nm + 75°



Mounting the PDE

IMPORTANT! Make sure that the cable terminals are the right way round when fitting the cables to the unit injector.

Their relative position is not important. Use torque screwdriver 588 179 to tighten the screws to 2 Nm.

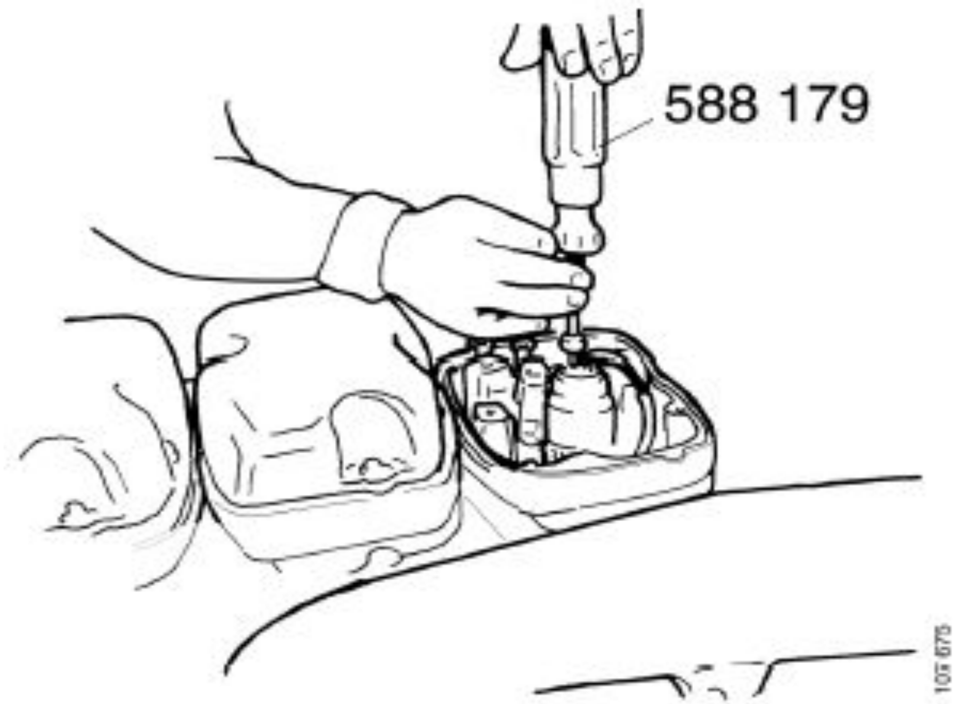


Mounting the PDE

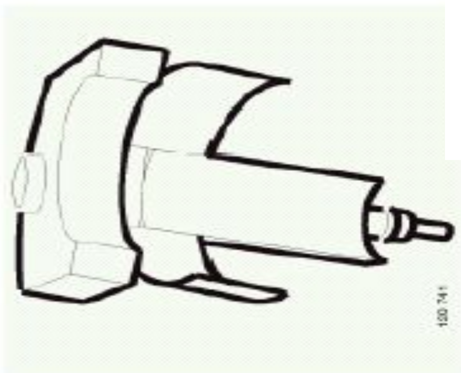
Tightening torque 2 +/- 0.2 Nm

IMPORTANT!
Use torque screwdriver 588179 to avoid the risk of shearing off the screw.

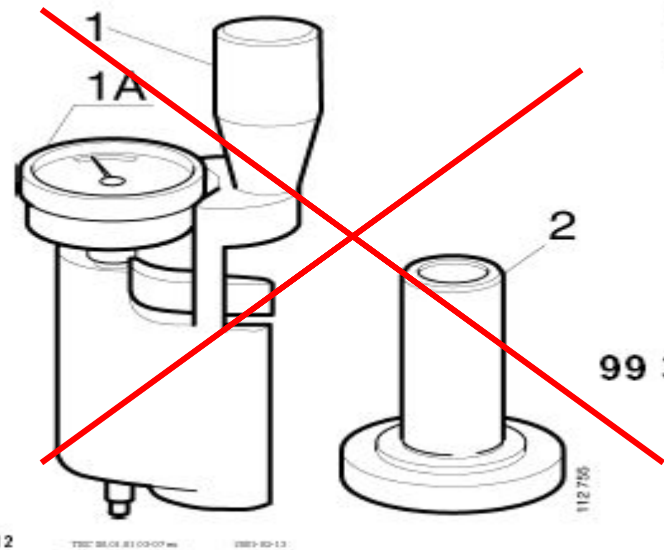
The entire unit injector must be renewed if the screws shear off.



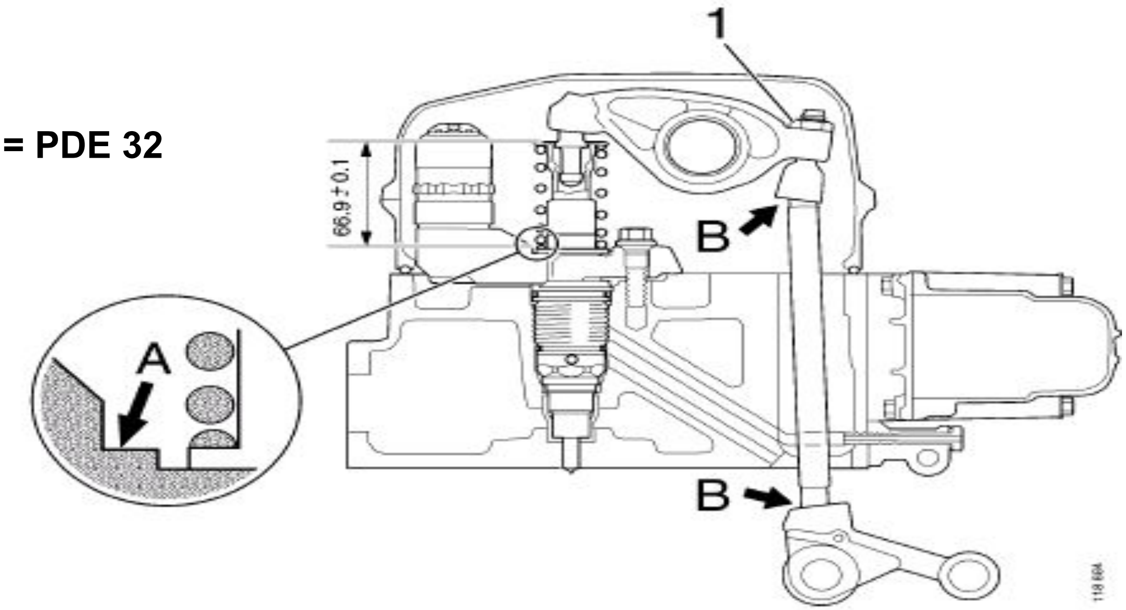
Tools for adjusting PDE



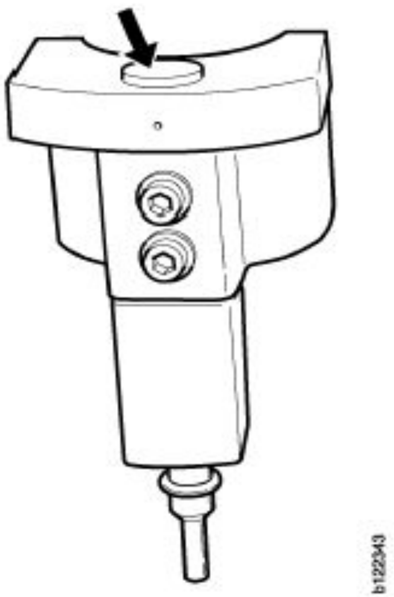
99 442 = PDE 32



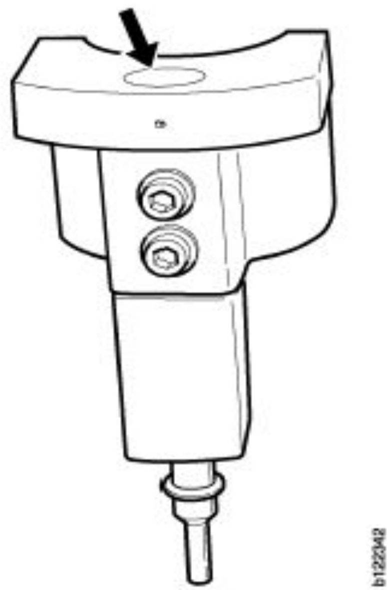
99 365



Tools for adjusting PDE



Piston above or below the flat surface of the setting tool. Adjustment necessary.

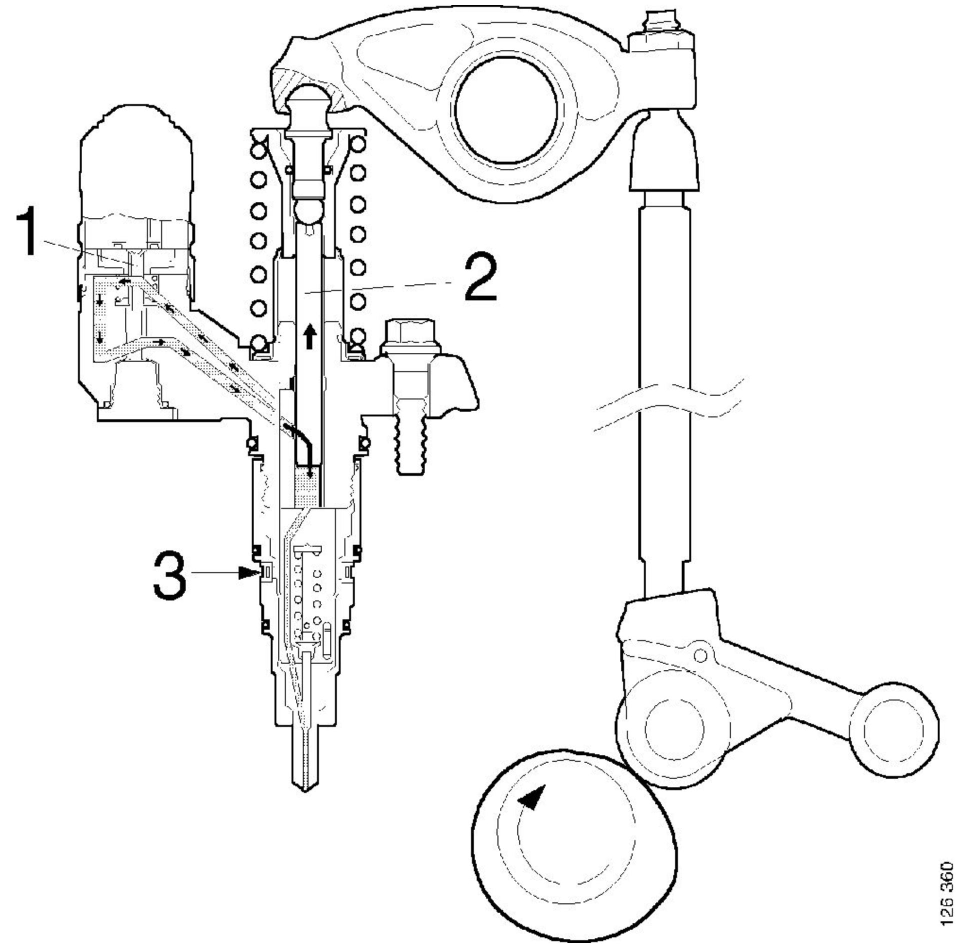


Piston level with the flat surface of setting tool. Adjustment is correct.

Filling phase

During the filling phase, pump plunger (2) moves up to it's highest position.

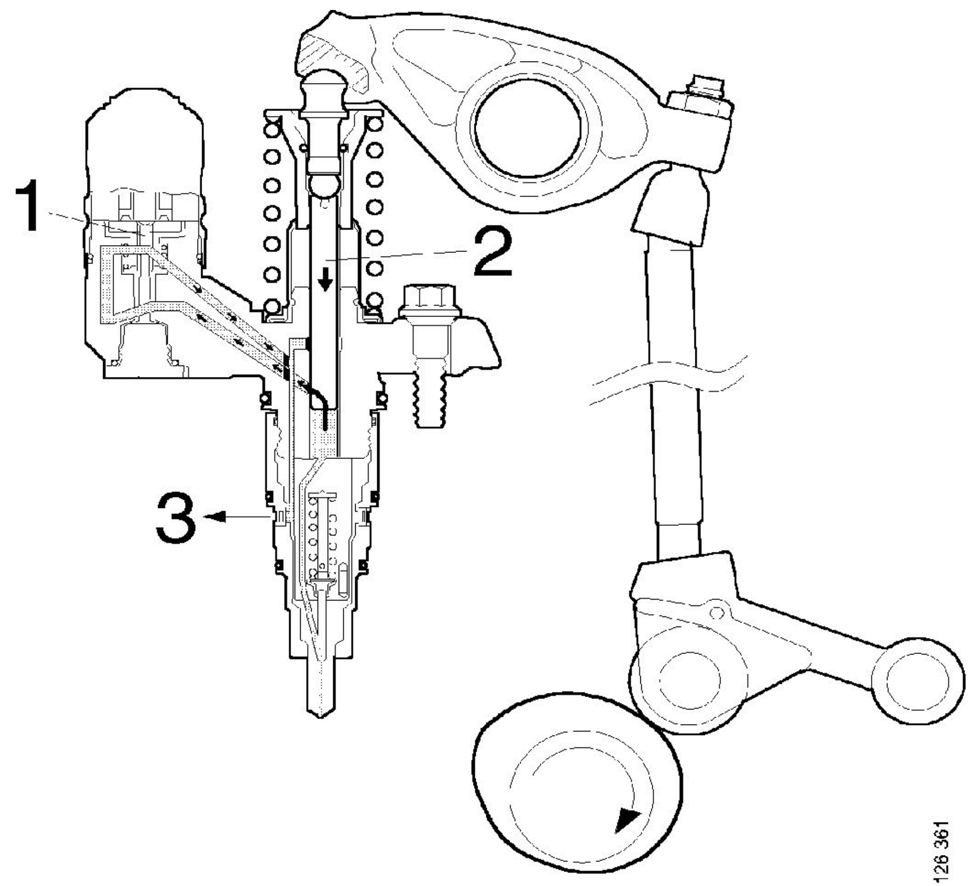
Fuel valve (1) is in it's open position and fuel can flow in to the barrel from the fuel duct, (3)



Spill phase

The spill phase begins when the camshaft starts to press pump plunger (2).

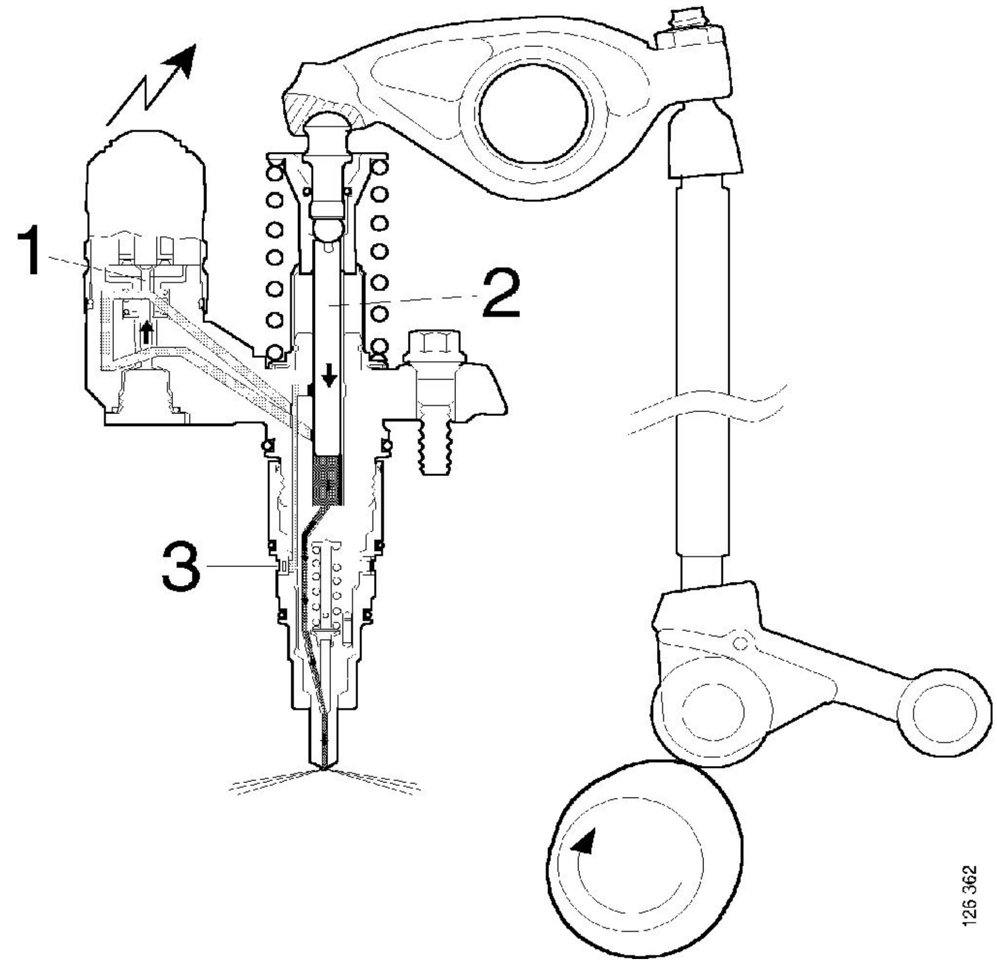
The fuel can flow through fuel valve (1) through the hole in the unit injector and out through fuel duct (3).



Injection phase

The injection phase begins when the fuel valve (1) closes. The fuel valve closes when voltage is applied to the solenoid valve.

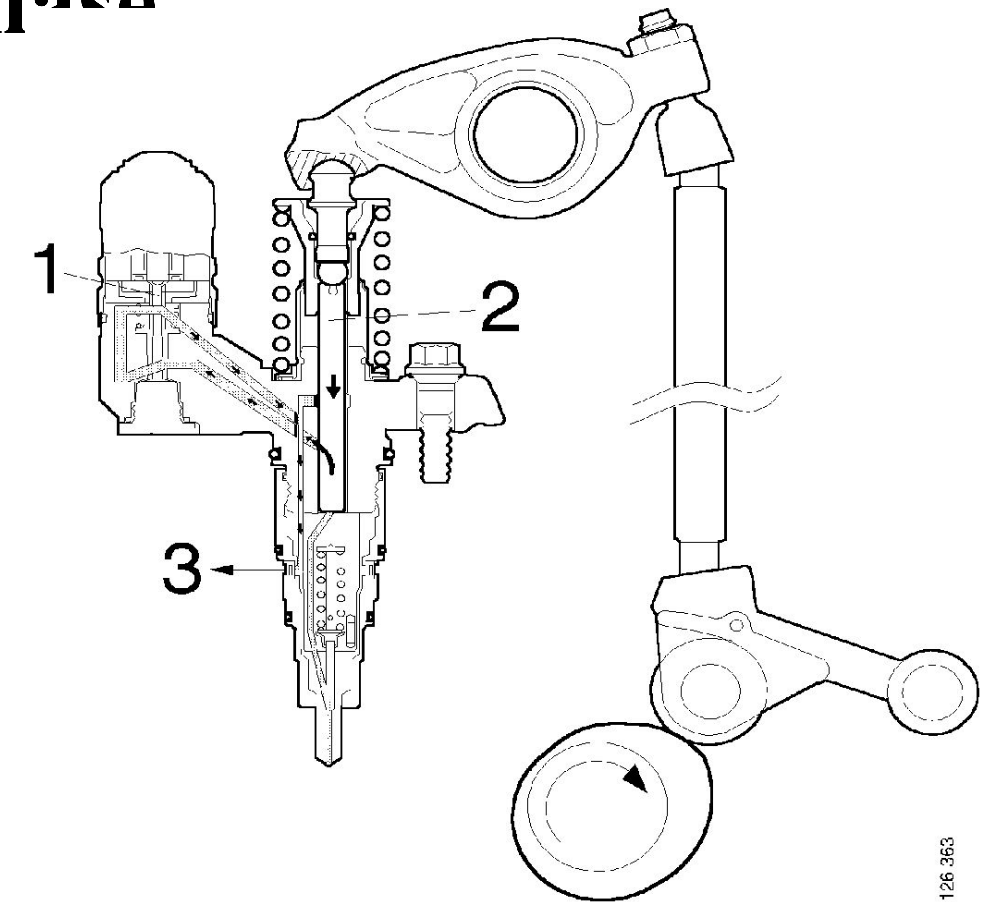
The injection phase continues as long as fuel valve (1) is remains closed.



Pressure reduction phase

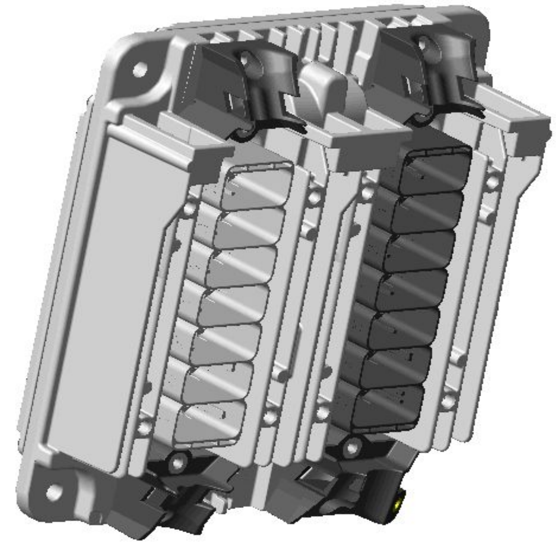
Injection stops when the fuel valve (1) opens and the pressure in the unit injector drops below the nozzle's opening pressure.

It's the closed or open position of the fuel valve which determines when injection should begin and end.

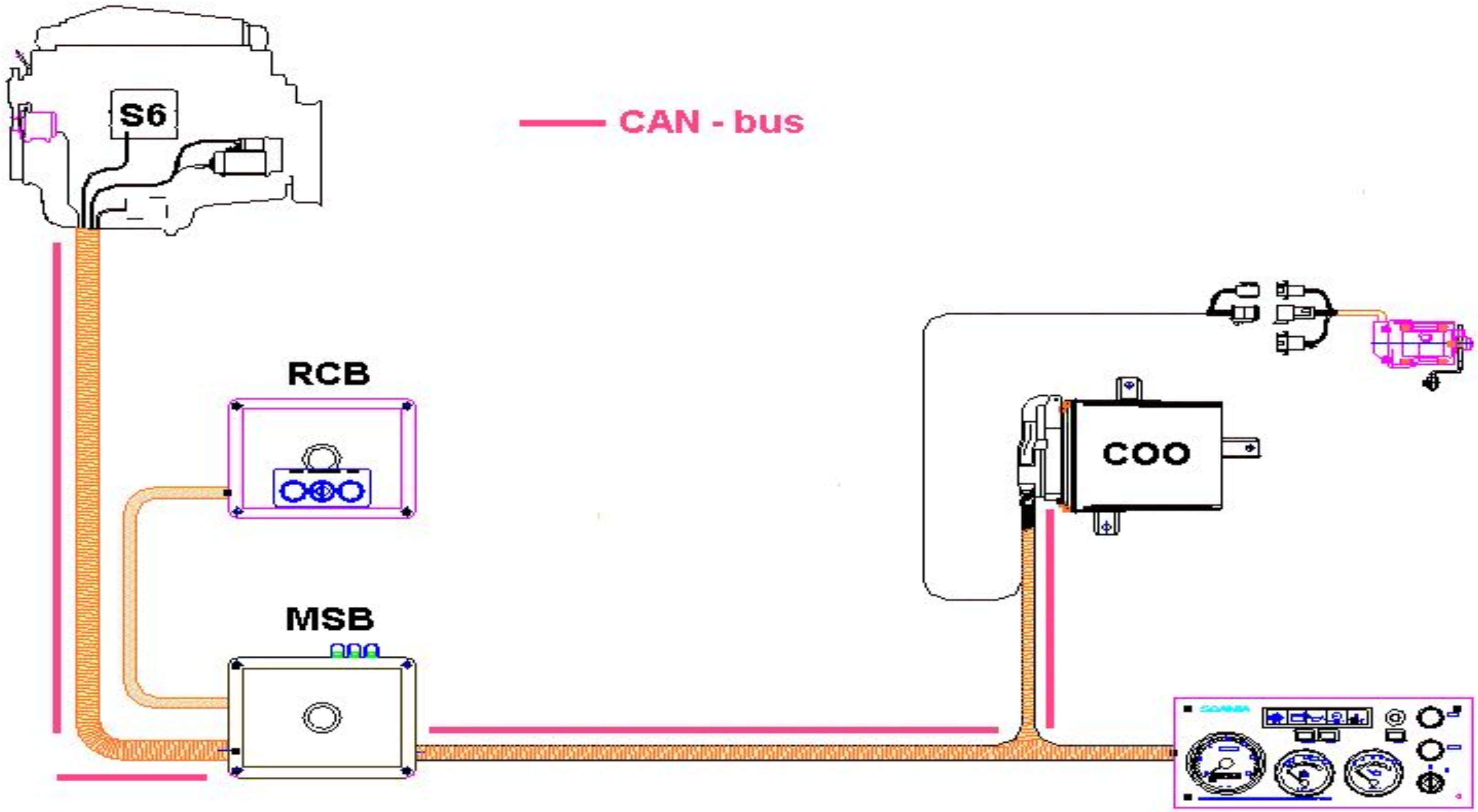


S8 Engine Management System (EMS)

- Manufactured by Continental in Germany
- Designed to be mounted on the engine block with cooling
- Scania designed connector concept
- Included in the system are:
  - Sensors for speed (2 pc's)
  - Oil pressure/Oil temp. (for marine)
  - Boost pressure & Boost temp and
  - Coolant temperature



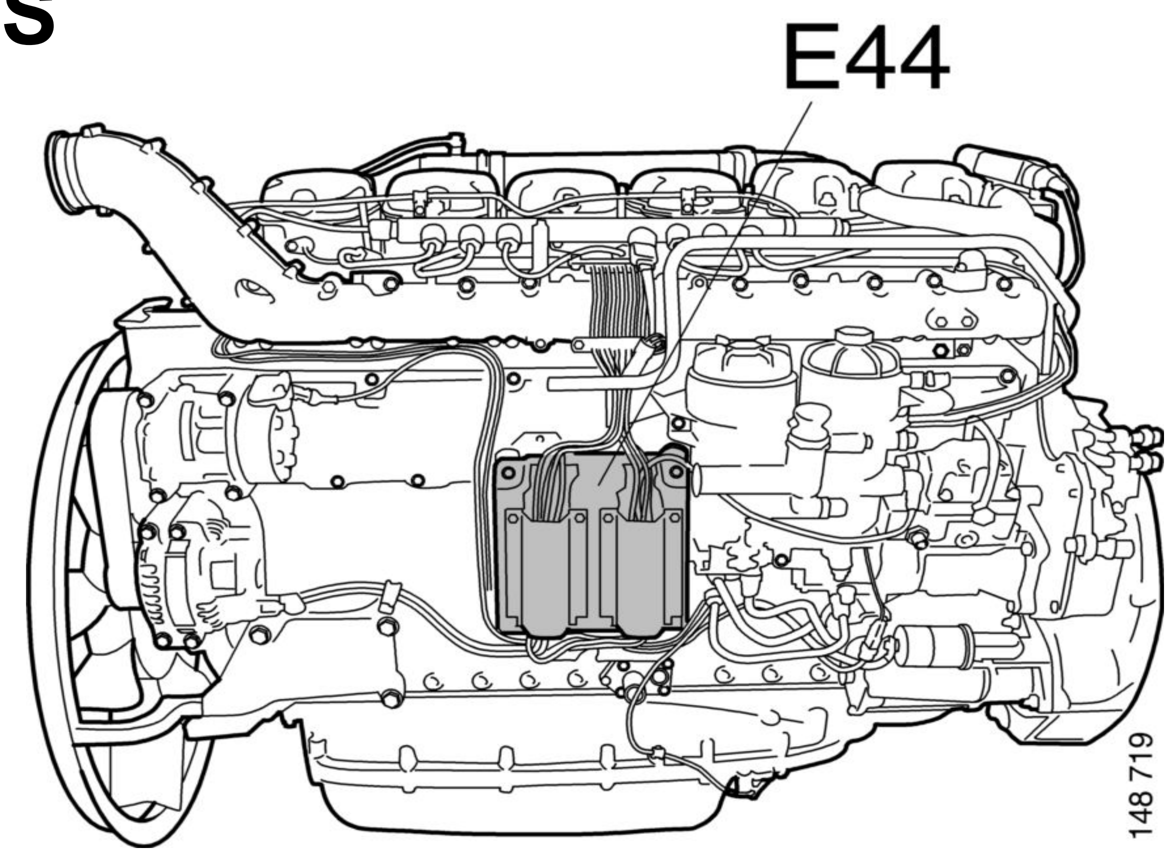
CAN communication



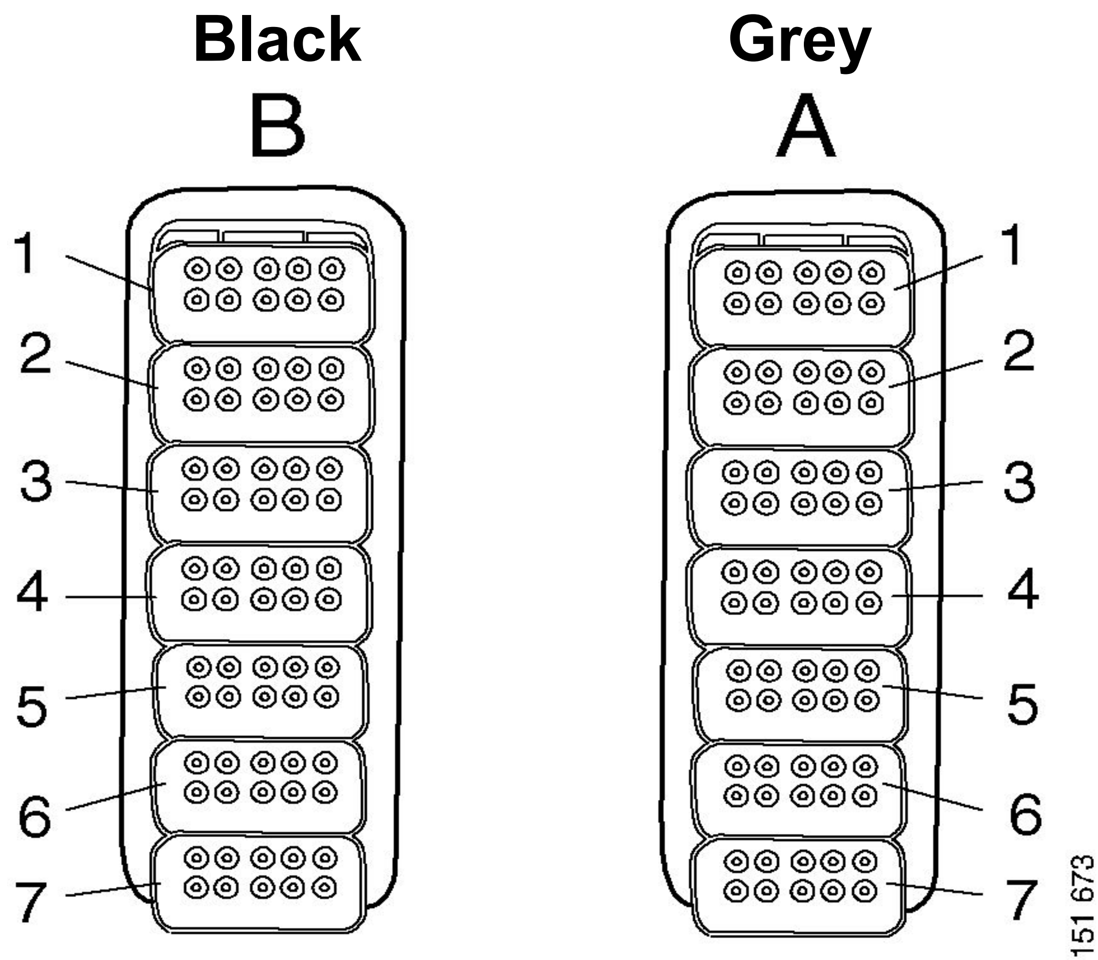
Electrical system, Designations

Code	Description
B	Brake and make switches (mechanical operated)
C	Connections
D	Diodes, resistors and potentiometers
E	Electronic control units
F	Fuses
G	Ground connections
H	Heated devices
K	Diagnostic connections
L	Lamps
M	Electric motors
N	Audio
O	Instruments
P	Power supply
R	Relays
S	Switches, (possible to push by hand or foot)
T	Sensors and Monitors
U	Antennas
V	Solenoid valves
W	Warning lamps

Electrical system, EMS

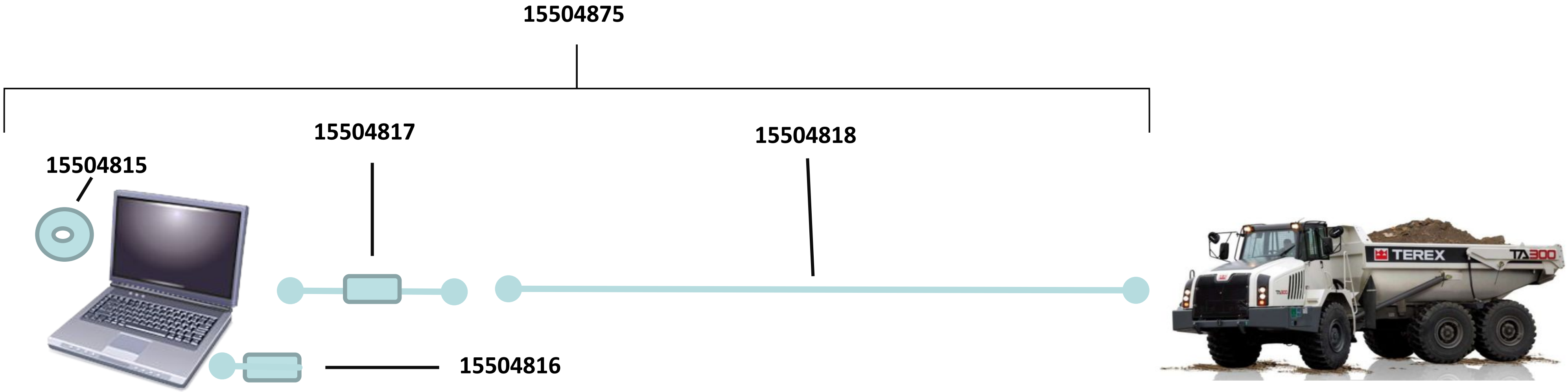


Electrical system, EMS



Scania

SDP3 Engine Diagnostic



Software: SDP3

Source: Terex, Part No: 15504815

Cost: £????

USB Key: 15504816

Cost: £???? Annual Subscription

Library Files: N/A

SDP3

Possible settings all speed:

- Customer adapted output curves
- Speed droop (Standard, (approx 10%) Stiff (approx 4% droop)
- Four different PTO mode
- Low idling speed
- Increased idling at cold engine (discontinued)
- Alarm levels
- Reaction at alarm (only alarm, reduced power or engine stop)
- Possible to override alarm (via CAN)
- Redundant throttle (connected in S8)
- “Limp home”

Generic Cable Colours

BK	black	YE	yellow
BN	brown	RD	red
OG	orange	GN	green
BU	blue	VT	violet
GY	grey	WH	white
PK	pink		

There are also cables marked with two colours, e.g. YE/WH. The above table provides all possible combinations.

Cylinder output test

- Mainly used to detect faulty injectors.

- Engine must run at no load and be internally synchronized.

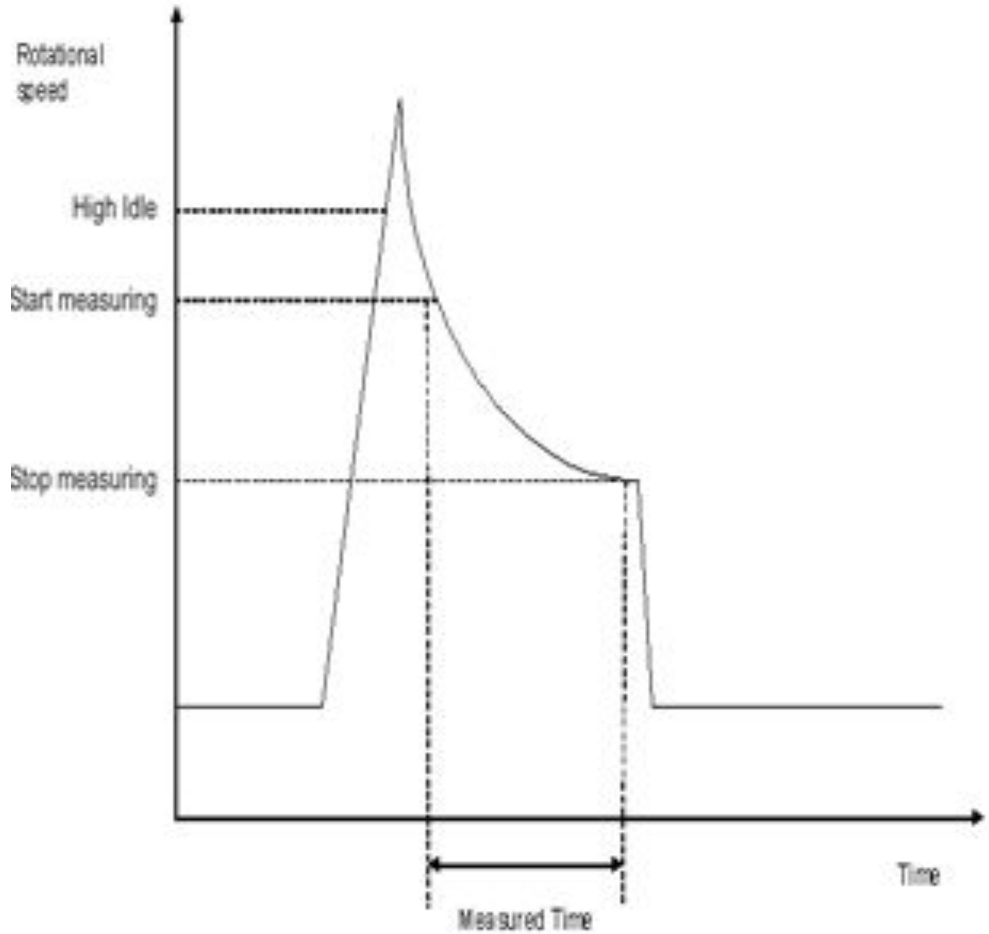
- Engine temperature should be >50^{o}C

Cylinder output test

The engine revs up to a fixed (1800) RPM with a fixed fuel amount.

- All cylinders except one are cut off.
- RPM drops, and time is measured between two fixed RPMs.
- The test is repeated for all cylinders a number of times.
- The result is time. (look for the most prominent)

Cylinder output test



Cylinder output test

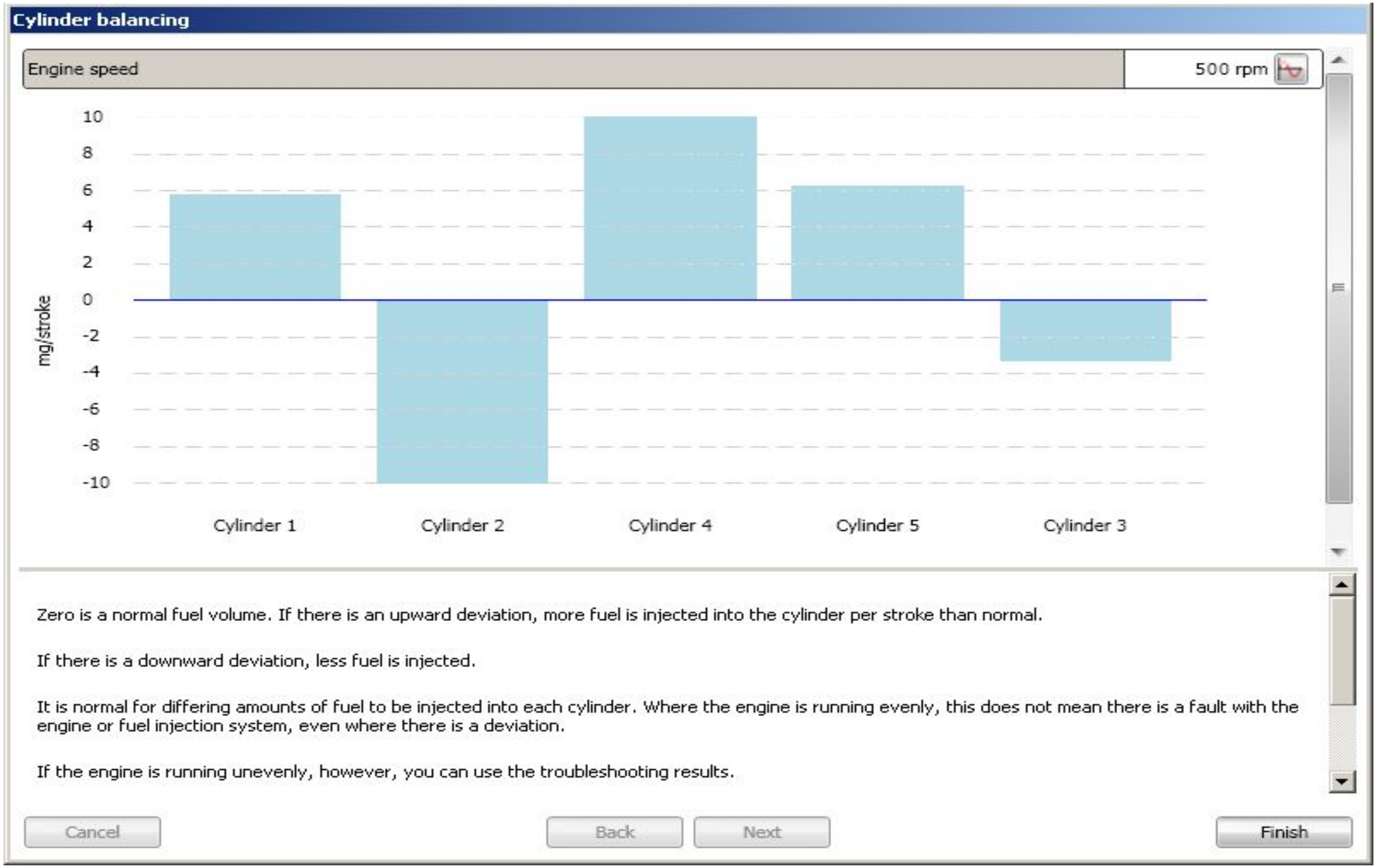
Short time could indicate:

- Bad injector.

- Low compression

- Seized piston

SDP3


Cylinder balancing
Engine speed
500 rpm
10
8
6
4
2
0
-2
-4
-6
-8
-10
mg/stroke
Cylinder 1
Cylinder 2
Cylinder 4
Cylinder 5
Cylinder 3
Zero is a normal fuel volume. If there is an upward deviation, more fuel is injected into the cylinder per stroke than normal.
If there is a downward deviation, less fuel is injected.
It is normal for differing amounts of fuel to be injected into each cylinder. Where the engine is running evenly, this does not mean there is a fault with the engine or fuel injection system, even where there is a deviation.
If the engine is running unevenly, however, you can use the troubleshooting results.
Cancel
Back
Next
Finish

Compression test

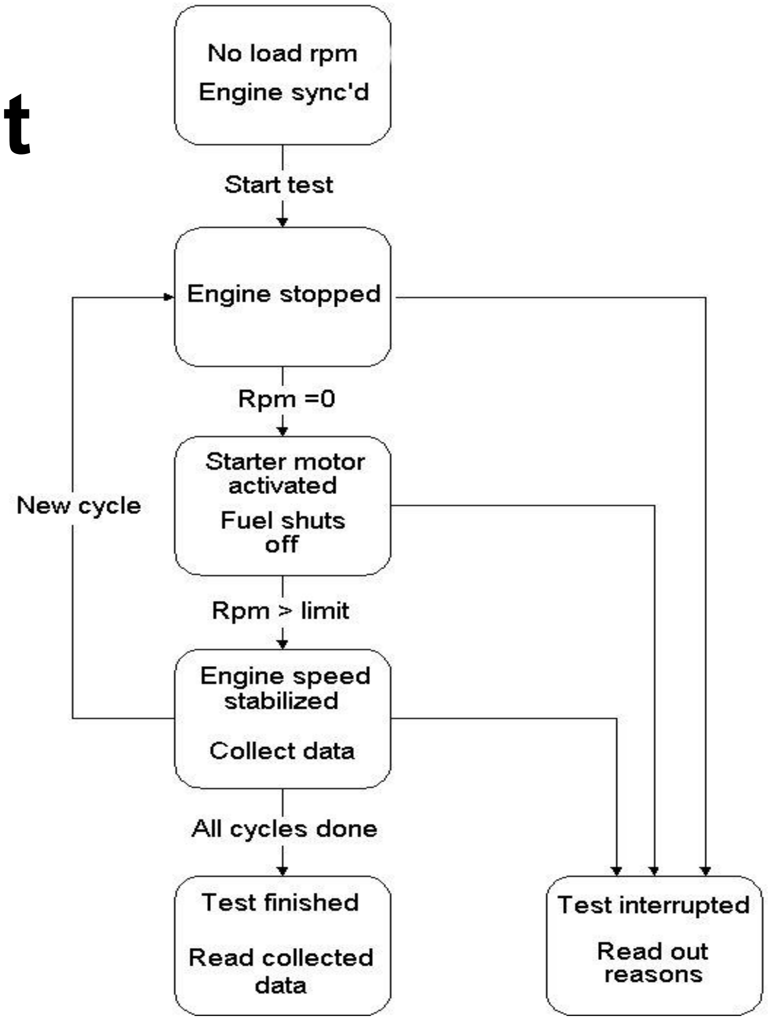
Engine must run at no load and be internally synchronized.

- Engine temperature should be >50 ºC

- U15 must be ”ON” during the test. (gen-sets might need a by-pass)

- Starter motor must be controlled by EMS and CAN-start activated.

Compression test



Compression test

The result is speed. (look for the most prominent)

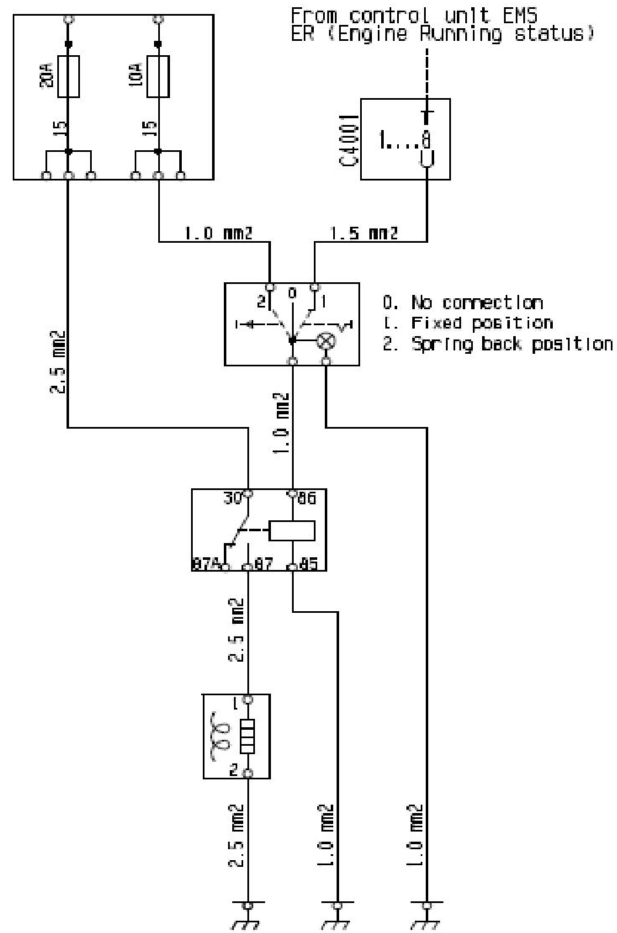
- High speed could indicate low compression.

- Low speed could indicate seized piston.

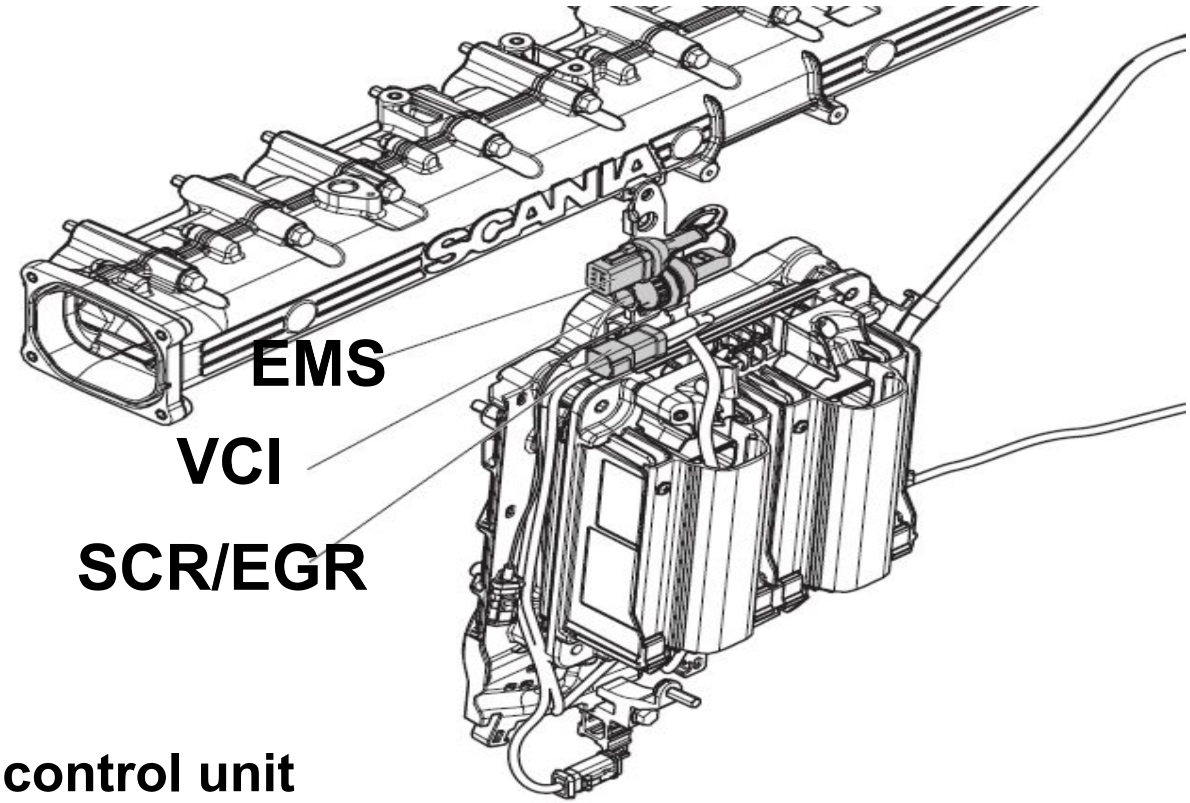
- Main reason for failed test is weak batteries.

Fuel heater XPI

- Deutsch contact DTP04-2P
- Max 350W
- Thermostat with working range 5° C - 24°C



Customer interface

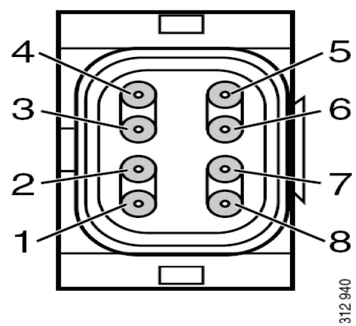


1. C4001 EMS control unit
2. C4000 Diagnostics
3. C4002 SCR or EGR system

Scania

EMS contact C4001

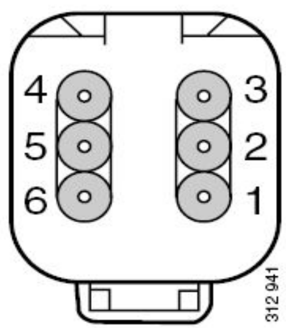
4. Supply U30
3. Ignition U15
2. Ground U31
1. Supply U30



5. Ground U31
6. CAN high
7. CAN low
8. Engine running status

SCR contact C4002

4. **Tank level lamp (GND)**
5. **SCR error lamp (+24V)**
6. **SCR error lamp (GND)**



3. **Tank level lamp (+24V)**
2. **Not used**
1. **Ignition U15**

EMS parameter settings

Altitude power reduction