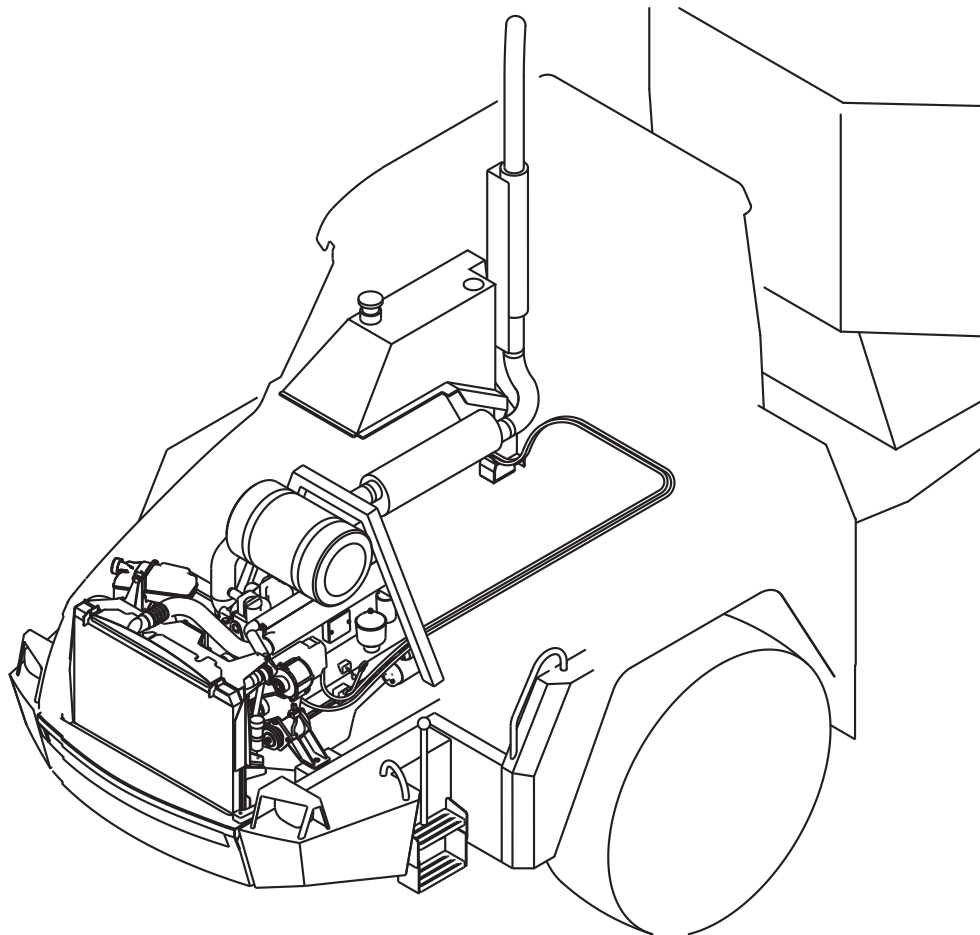


# Chapter 1

# Engine



# Chapter 1

## Engine

### Index

<b>Removal of engine assembly .....</b>	<b>5</b>
Lifting the engine.....	11
<b>Engine identification .....</b>	<b>12</b>
<b>Fuel system .....</b>	<b>13</b>
Schematic diagram of the fuel system .....	13
Overflow valve .....	13
General .....	14
FUEL .....	14
Fuel filter .....	15
Water separating prefilter .....	15
Feed pump .....	17
<b>Diagnostic procedure .....</b>	<b>18</b>
Use of diagnostic kit, machine .....	18
Measurement .....	21
Ecom standard settings code.....	24
<b>Engine control unit, ECU .....</b>	<b>27</b>
Wiring and cable duct.....	28
Throttle position sensor.....	28
Positions of sensors for ECU .....	29
Diagnostic lamp and switch.....	31
Fault codes.....	32
How to read fault codes from the ECU control unit .....	33
Flash codes tables .....	35
Overview of flash codes for coordinator .....	37
Renewing the control unit.....	39
Removing the ECU wiring.....	40
<b>Cylinder head .....</b>	<b>44</b>
Special tools.....	44
Cylinder head, parts view. ....	45
Valve mechanism .....	46
Dismantling .....	51
Renewing the valve stem seal.....	51
Replacement of valve seats .....	52
Machining the valve seats insert .....	53
Renewing the valve guides .....	55
Renewing PDE unit injector sleeves .....	56
Assembly .....	57
Fitting .....	57
<b>PDE Injectors .....</b>	<b>58</b>
Fitting the PDE injector .....	58
Adjusting unit injectors .....	62
Adjusting the valve clearance and unit injectors .....	64
Checking, adjusting the PDE32 injector rocker arms (I).....	65
<b>Turbocharger .....</b>	<b>67</b>
General .....	68
Special tools.....	69
Measuring radial clearance and axial clearance .....	70
Renewing the turbocharger.....	72

Continuation next page

<b>Pistons and cylinder liners.....</b>	<b>73</b>
Special tools.....	74
Connecting rods.....	75
Removing and dismantling connecting rods and pistons.....	76
Renewal of bearing bushing in connecting rod.....	78
Pistons.....	80
Assembling piston and connecting rod.....	82
<b>Cylinderblock.....</b>	<b>83</b>
Cylinder liner.....	83
Removing the cylinder liners.....	85
Measuring the cylinder liner height.....	86
Fitting the cylinder liners.....	87
Fitting the piston and connecting rod.....	88
<b>Flywheel and flywheel housing.....</b>	<b>90</b>
Special tools.....	91
Removing the flywheel.....	91
Renewing the rear crankshaft seal.....	93
Removing the flywheel housing.....	93
Fitting flywheel housing.....	94
Fitting the flywheel.....	96
<b>Timing gears.....</b>	<b>97</b>
Gear drive.....	97
Belt drive collant pump, generator and AC compressor.....	98
Renewing the seal in the front cover.....	99
Crankshaft damper.....	100
Timing gear, view exploded.....	101
<b>Special tools.....</b>	<b>102</b>
Crankshaft seal.....	103
Timing gear cover.....	105
Intermediate gear.....	107
Crankshaft gear.....	108
Camshaft gear.....	109
<b>Camshaft.....</b>	<b>110</b>
<b>Crankshaft.....</b>	<b>112</b>
<b>Lubrication system.....</b>	<b>114</b>
Oil pump.....	114
Lubrication oilways.....	115
Oil pressure.....	116
Oil cooler, engine.....	117
Oil cooler view.....	118
Renewing seals.....	119
Oil filter.....	120
<b>Centrifugal oil cleaner.....</b>	<b>121</b>
Dismantling and assembly.....	122
<b>Cooling fan.....</b>	<b>126</b>

Continuation next page

<b>Cooling system .....</b>	<b>127</b>
View of the cooling system.....	127
Circulation .....	128
View of the radiator system .....	128
Disassemble the cooling unit .....	129
Thermostat and thermostat housing .....	131
Thermostat.....	132
Coolant pump.....	133
External cleaning .....	137
Internal cleaning.....	137
<b>Specifications.....</b>	<b>138</b>
General information.....	138
Cylinder head.....	140
Turbocharger .....	142
Pistons and cylinder liners .....	142
Connecting rods .....	143
Flywheel and flywheel housing .....	143
Timing gear .....	144
Lubrication system .....	145
<b>Troubleshooting tables .....</b>	<b>146</b>
White smoke .....	146
White smoke, water vapour.....	146
Black smoke when running/under load .....	147
Black smoke on starting .....	148
Blue smoke .....	148
Fuel in the oil.....	148
Oil in coolant .....	149
Coolant/water in oil .....	150
Low oil pressure .....	151
High oil pressure (Engine warmed up).....	153
Abnormal wear (liner, piston rings, etc.).....	153
Vibration, no driven components engaged.....	154
Delivery pipe fractures .....	155
External corrosion on cylinder liner.....	155
Engine difficult to start.....	155
Fluid stroke.....	156
Knocking noise .....	156
High oil consumption.....	158
High fuel consumption.....	159
Low compression .....	159
Low engine output.....	159
Hot engine.....	161
Cold engine .....	162
Coolant loss .....	162
Polluted coolant.....	162
Engine heater.....	163
High oil temperature.....	163
High exhaust temperature .....	164
Low charge air pressure.....	164
Low fuel pressure .....	165
Low system voltage.....	165
High system voltage.....	165
External oil leakage.....	166
External fuel leakage .....	166
External coolant leakage.....	167
Oil pressed out via crankcase ventilation .....	167
Turbocharger breakdown .....	167



## Removal of engine assembly

### NOTE!

Place the dump truck on level ground and apply parking brake

Apply articulation lock.

Turn off main switch in battery case.

Raise the dump body and lock it with the safety support.

Raise the tiltable cab and lock it with the safety support

Drain engine coolant

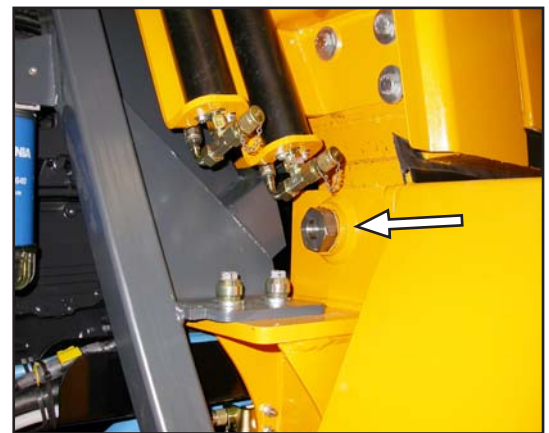
Look in **OPERATION & MAINTENANCE MANUAL** chapter 2 for instructions.



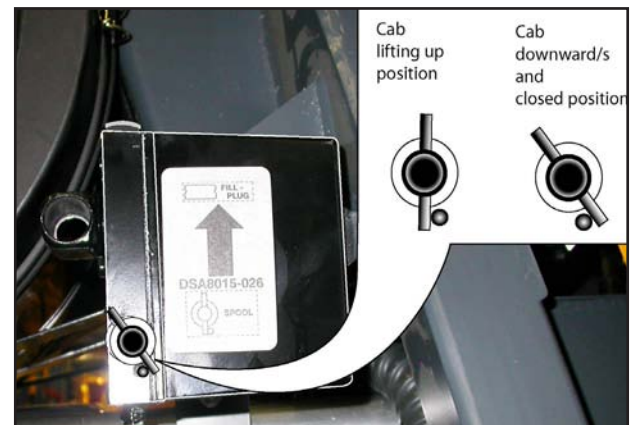
Place wheel chocks to the front wheel

Take away the cab bolt, left and right hand side.

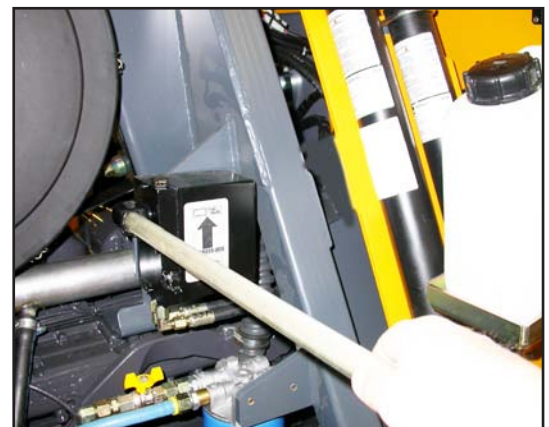
Nv 46 mm



Turn the direction valve on the pump in lifting up position.



With the handle, pump and raise the cab.



Left side:

- 1  
Disassemble the cab pump unit from the air filter stand.
- 2  
Remove the water hose from the pipe socket.
- 3  
Remove the fuel hoses (3 pcs) and
- 4  
Disassemble screws from filter stand bracket



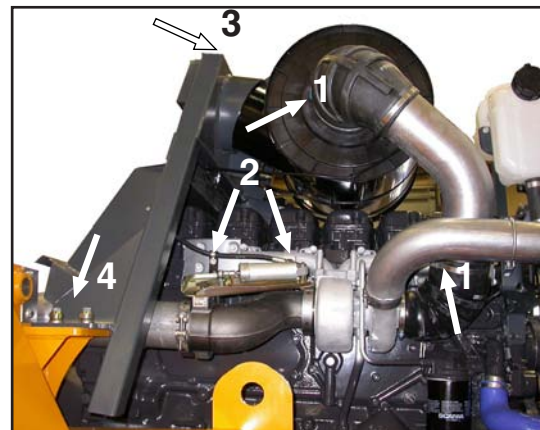
Disconnect the brake hose from the magnetic valve.

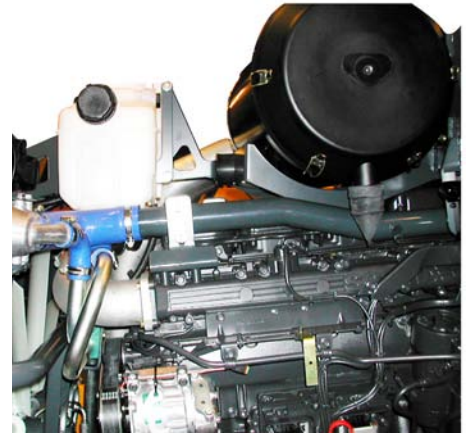
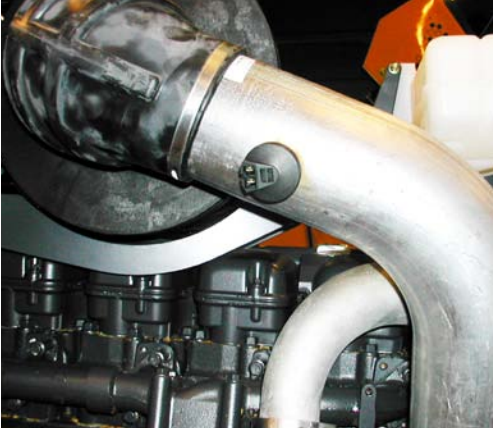
(Left side behind the cab bracket)



Right side:

- 1  
Unscrew the hose clamps and remove the pipe bend, filter - turbo
- 2  
Disconnect the oil hose from engine brake cylinder and bracket disassemble the other end at left side on the magnetic valve
- 3  
Hook up the filter stand in lifting device.
- 4  
Screw off the fastening bolt for filter stand, left and right hand side

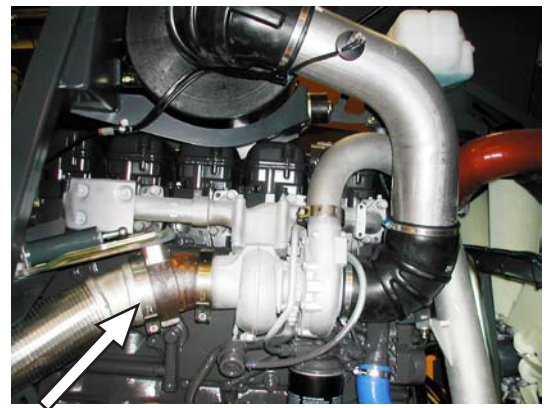




Disassemble the cable to the Air filter sensor.

Disassemble the clamps for the wiring on the filter stand

Disconnect the exhaust pipe from the turbo pipe bend.





Slack the transmission belt.

Disassemble the ground wiring.

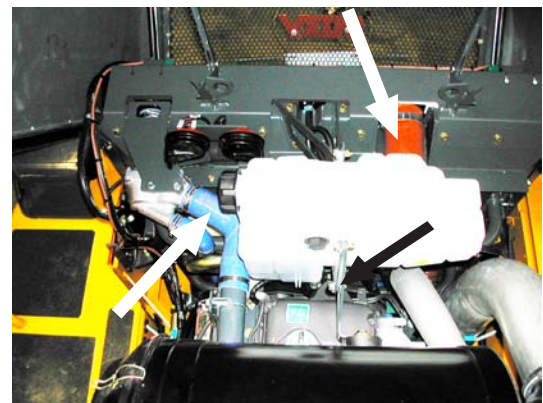
Detach the Air Cond. compressor with the hoses on, from the engine. Check that all of the clamps are undone.

Place the Air condition compressor on the left while the engine is dismount.

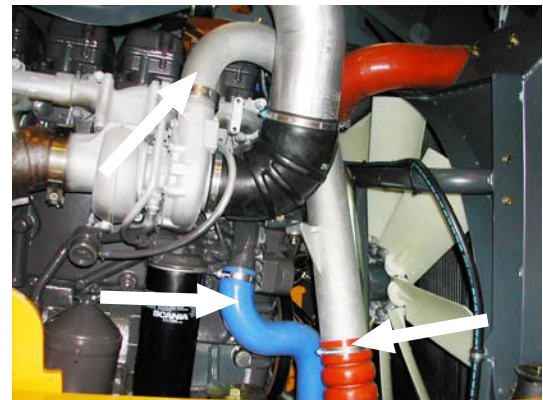


Disconnect the hose from the thermostat housing, the pipe between the air cooler and the engine air inlet.

Disconnect bracket for the air pipe and bracket between engine and fan rack



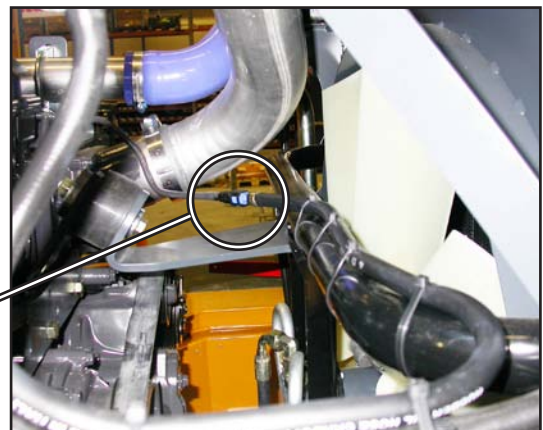
Disconnect the outlet pipe bend from turbo, and the inlet water hose from the transmission cooler.



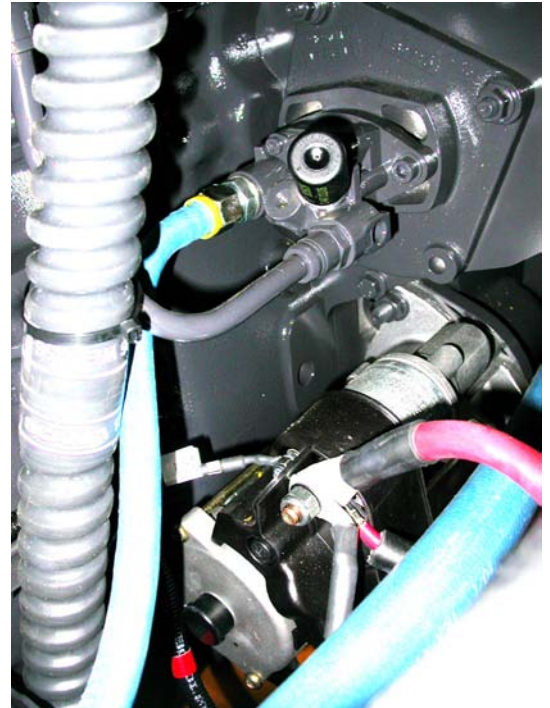
Disconnect the retur hose. (Engine - ekspansionstank)

(Quick release coupling)

(Front of the engine, view from the right hand side)



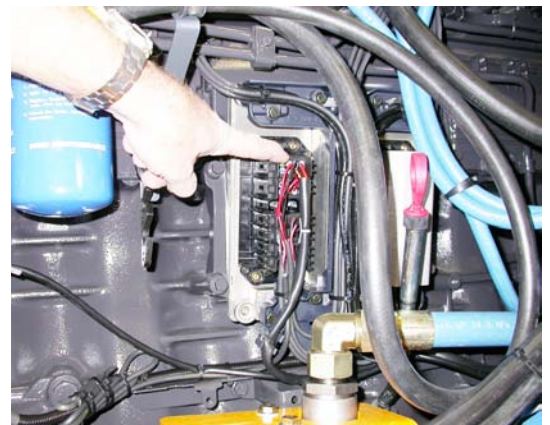
Disconnect the cables between starter motor and the frame



Disconnect the contact on the dynamo.



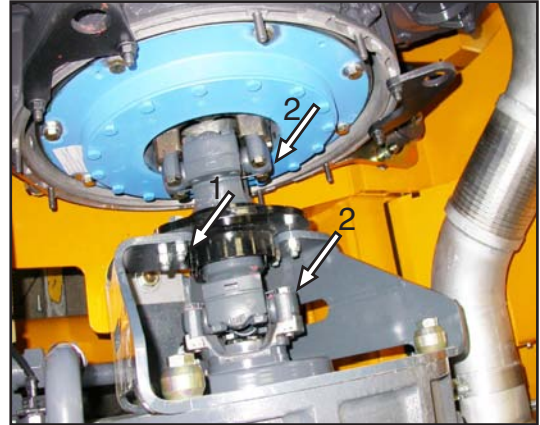
Remove the cover and disconnect the electrical contact from the engine ECU -S6 control unit



**Drive shaft**

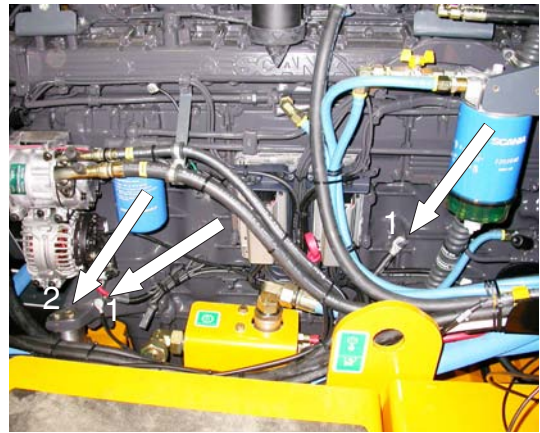
Remove safety atcher.

Remove driveshaft between transmission and engine coupling,



1  
Disassemble screw for the ground cable (2 pcs)

2  
Left and right hand side, disassemble 3 screws on the engine mounting bracket.



1  
Disassemble the hose clamp bracket.

2  
Unscrew the engine bracket bolt left and right hand side.

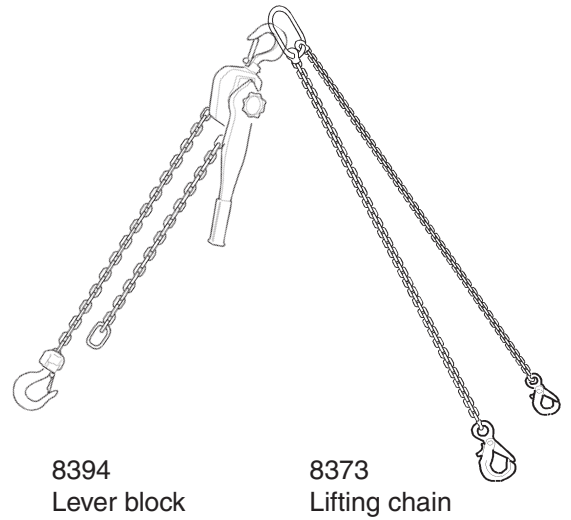




## Lifting the engine

**Note:**

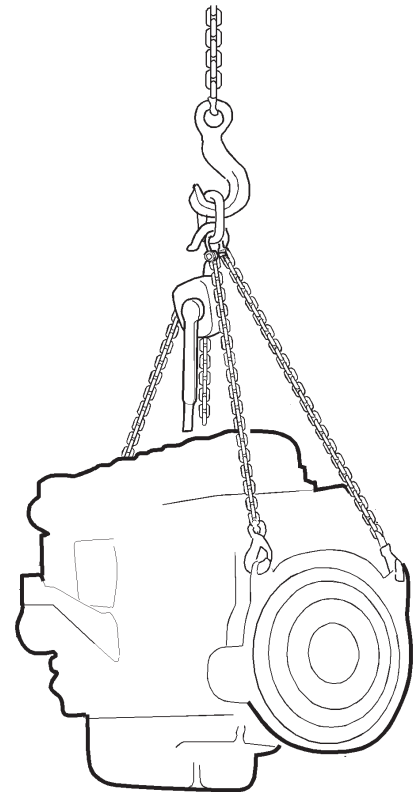
The engine lifting eyes are designed for lifting the engine only, not the engine together with its ancillary equipment (alternator, gearbox etc.) or fram



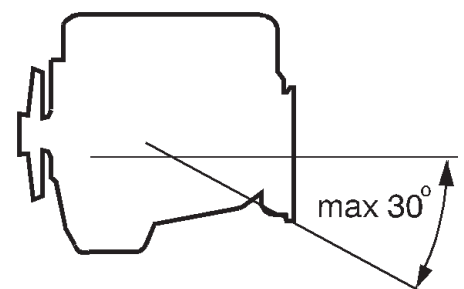
- Fasten the lifting chain 8373 to the rear lifting eyes.

- Fasten the lever block 8394 to the front lifting eye.

With attention, lift the engine out from the frame

**Note:**

The lifting eyes are sized to cope with a maximum angle of 30°.



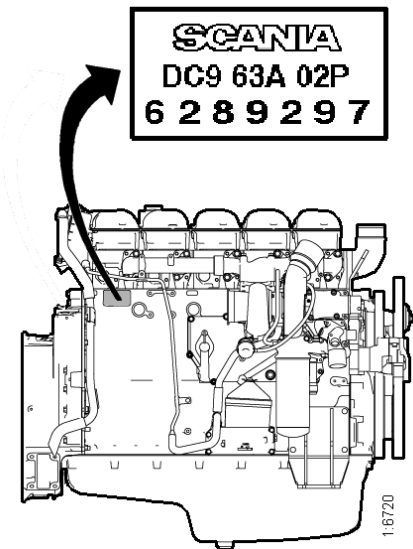
## Engine identification

The engine designation indicates, in the form of a code, the type of engine, its size and applications, etc.

The type designation and engine serial number are indicated on a type plate affixed to the right-hand side of the engine.

The engine number is also stamped on the engine block immediately above the type plate.

Refer to the illustration.



**DC 9 63 A 02 P**

### Type

DC Supercharged diesel engine with air-cooled charge air cooler.

### Displacement in whole dm<sup>3</sup>

### Performance and certification code

Indicates, together with the application code, the normal gross engine output.

The actual output setting of the engine is indicated on the engine card.

### Application

A For general industrial use

### Variant 01-99

### Type of regulator

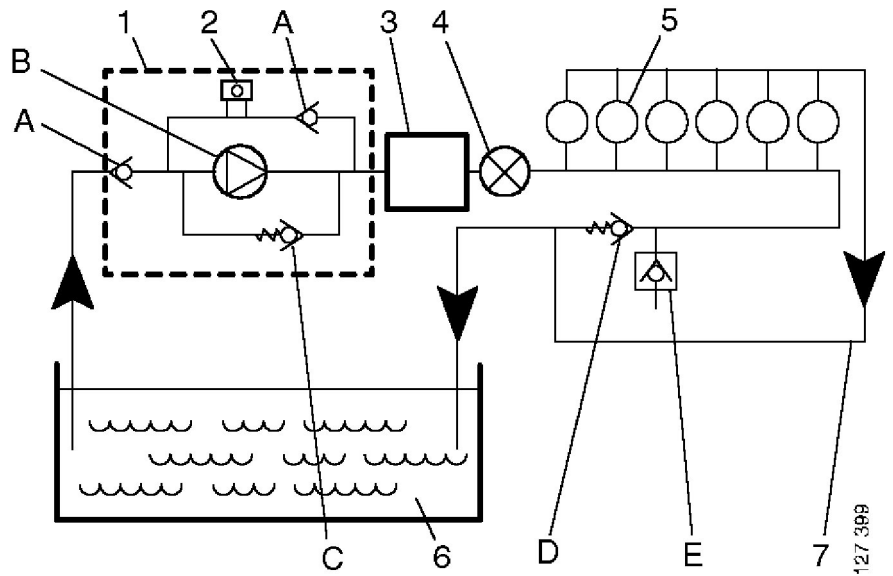
P EMS engine management system with PDE and S6



# Fuel system

## Schematic diagram of the fuel system

- 1 Feed pump
- 2 Hand pump
- 3 EMS control unit
- 4 Fuel filter
- 5 Cylinders
- 6 Fuel tank
- 7 Return line for excess fuel
- A Check valve
- B Gear pump (feed pump)
- C Safety valve
- D Pressure relief valve
- E Drain nipple

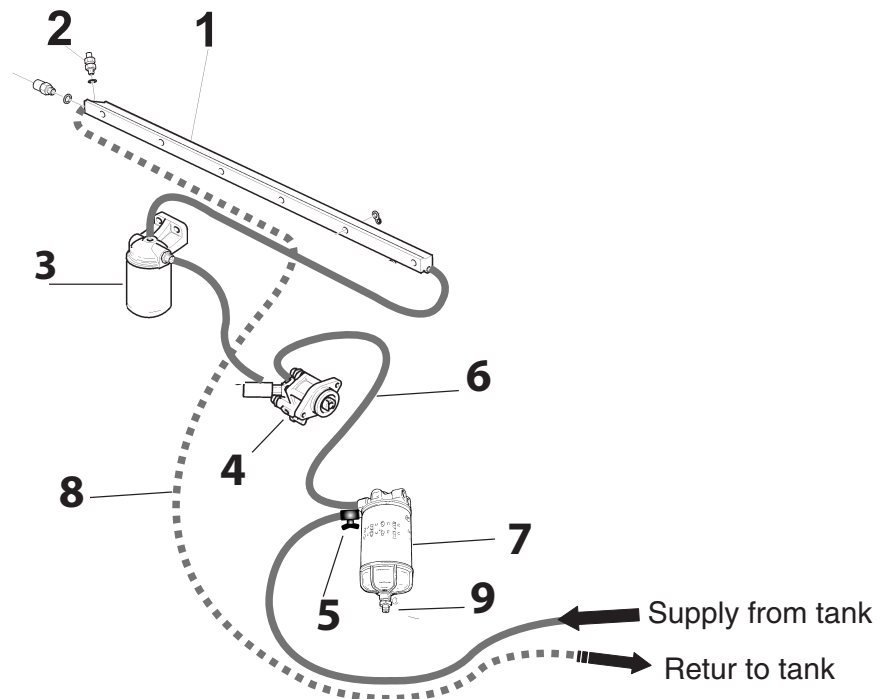


## Overflow valve

The purpose of the overflow valve is to limit the pressure in the fuel system and continuously vent it. The overflow valve ensures that the fuel circulates round the system and that there is always fuel in the injection pump for cooling, lubrication and injection.

Opening pressure is **0.6 - 0.8 bar**.  
Working pressure is approx. **1 bar**.

- 1 Fuel rail
- 2 Pressure relief valv
- 3 Fuel filter
- 4 Feed pump / hand pump
- 5 Shut-off cock
- 6 Oil hose water filter - feedpump
- 7 Water separating prefilter
- 8 Retur line
- 9 Drain valve

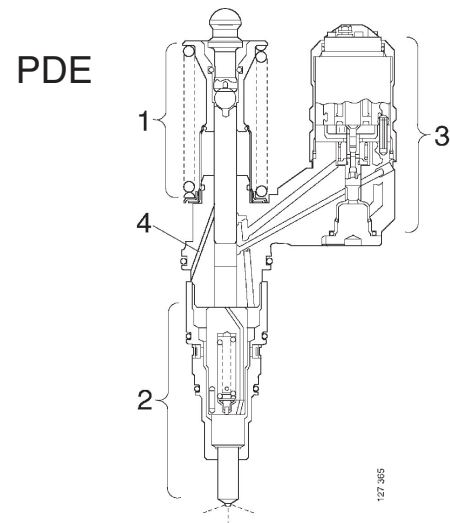


## General

Apart from fuel lines and a fuel tank, a PDE (Pumpe-Düse-Einheit) fuel system with unit injectors consists of the following items:

- a feed pump
- a hand pump
- a fuel filter
- one fuel rail.
- a pressure relief valve
- One PDE type unit injector per cylinder.

The fuel system also includes an electronic control system. The control system includes an electronic control unit, the unit injector solenoid valves and sensors.



## FUEL

### Diesel fuel oil

The composition of the diesel fuel oil has a great influence on the functioning and the service life of the engine and the injection system.

The engine output and exhaust emissions are also dependent on the fuel quality.

The diesel fuel must meet European standard EN 590.

The table below shows the requirements for some of the most important properties:

Property	Requirement
Viscosity at 40°C	2.0 - 4.5 mm <sup>2</sup> /s (cSt)
Density at 15°C	0.82 - 0.86 kg/dm <sup>3</sup>
Sulphur (concentration by mass)	max. 0.3%
Ignitability (CET rating)	min. 49
Flashpoint	56°C

### Environmentally favourable fuels (low sulphur fuels)

There are three classes of so called environmentally favourable fuels (SS15 54 35).

Class 1 is sulphur-free and class 2 is low in sulphur. Compared with class 3 (normal fuel), these fuels are less dense and this reduces engine power output.

## Fuel filter

### Design

Fuel filter are of single-mounted type. The filter screw on to a retainer which is bolted to the engine.

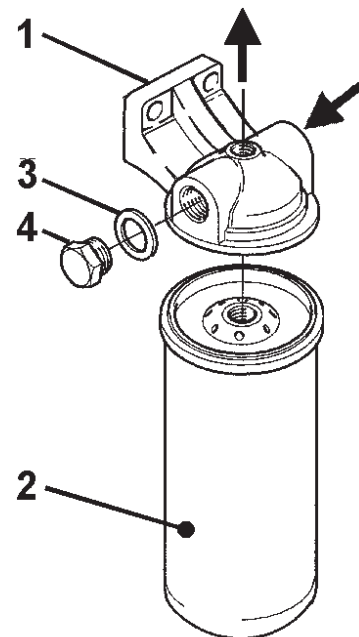
The filter consists of a metal container with a folded paper element. The filter cannot be dismantled but must be changed as a complete unit.

The fuel filter has no bleed screw and is bled by undoing plug 4 in the free inlet passage.

### Function

Fuel is pumped into the inlet by the fuel pump. It then continues through passages in the filter retainer to the upper part of the filter, down through the filter or filters and on to the outlet passage. From there, the fuel is piped to the injection pump.

1. Filter retainer
2. Filter
3. Gasket
4. Plug



Fuel filter, constituent parts

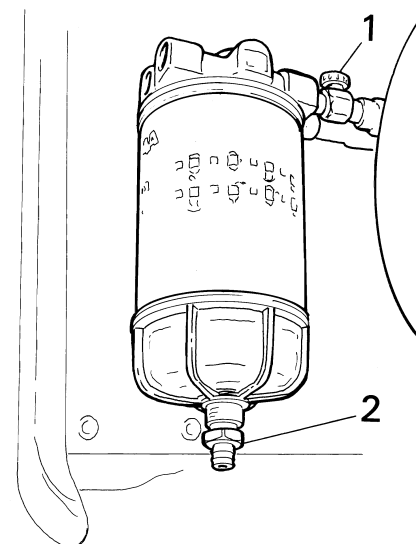
## Water separating prefilter

### Note:

**Close the shut-off cock when renewing the filter.**

The same intervals between changes apply as for those for an ordinary fuel filter.

- 1 Shut-off cock
- 2 Drain valve



## Temperature dependence of diesel fuel

At temperatures lower than those specified for the diesel fuel, paraffin wax may precipitate from the fuel and block filters and pipes. The engine can then lose power or stop. The diesel fuel is adapted for use in the specific climate of each country. If a vehicle or an engine is to be operated in a temperature zone with lower temperature than normal, first identify the temperature properties of the fuel concerned.

The properties of the fuel when cold can be improved by adopting one of the following measures before the temperature drops:

- If the fuel concerned cannot cope with the expected temperatures, and diesel fuel is not available with the correct temperature properties, we recommend that an electric fuel heater is installed **as a preventative measure**.

- The low temperature properties of diesel fuel may be improved by adding kerosene **as a preventative measure**. A maximum of 20% may be added. When refuelling, the kerosene should be added first, so that it mixes thoroughly with the diesel fuel.

### Note:

It is prohibited to use kerosene in engine fuel in some countries.

- To prevent water in the fuel from freezing and forming ice, a maximum of 0.5-2% alcohol (isopropanol) may be added.

**Drain fuel tanks and drain or change fuel filters regularly.**

## Warning

It is not permitted to mix kerosene with diesel fuel that is already adapted for the climate concerned. This can damage the PDE injectors. All use of paraffin other than kerosene is forbidden, as it causes engine damage.

## Important

It is not permissible to mix petrol with diesel fuel. In the long term, petrol may cause wear to the PDE injectors and it may also cause damage to the **engine**.

## Feed pump

The feed pump 1 draws fuel from the fuel tank and forces it through the fuel filter 3 and into the fuel rail 4.

On the feed pump there is a hand pump 2.  
The hand pump is used to vent air from the fuel system.

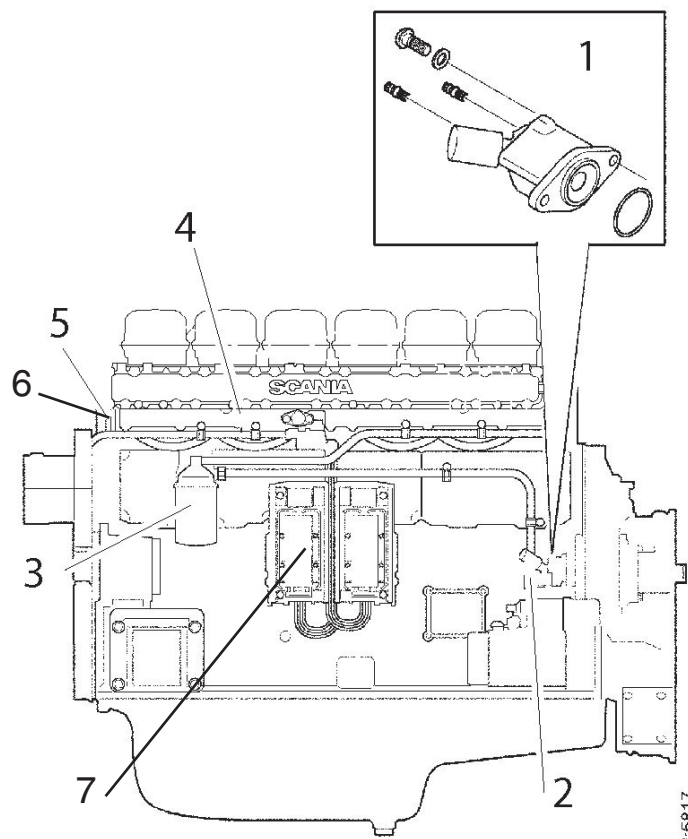
On the fuel rail there is a pressure relief valve 5.  
The pressure relief valve constantly regulates the fuel pressure. When the pressure is too high, the pressure relief valve opens, so that the excess fuel is returned to the fuel tank.

The fuel rail distributes the fuel to the unit injectors in each cylinder head.

The ECU control unit determines when the unit injectors must inject fuel into the cylinders.

## Feed pump renewal

- 1  
Clean the outside of the feed pump.  
Remove the suction and pressure lines from the feed pump.  
Fit protective plugs.
- 2  
Unscrew the bolts and remove the feed pump.
- 3  
Place a new O-ring onto the feed pump and lubricate with O-ring grease.
- 4  
Fit the feed pump.
- 5  
Connect the suction and pressure pipes.
- 6  
Bleed the fuel system; refer to *Bleeding the fuel system*.
- 7  
Start the engine and check for leaks.



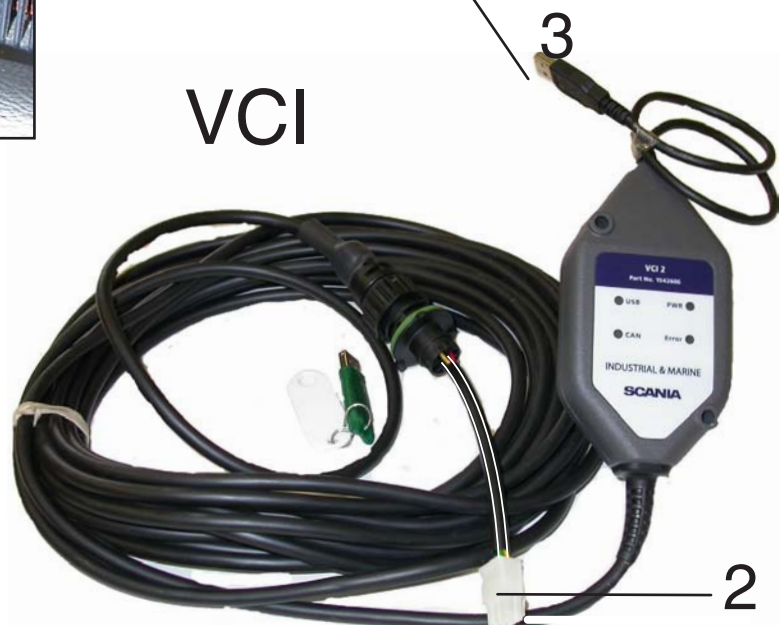
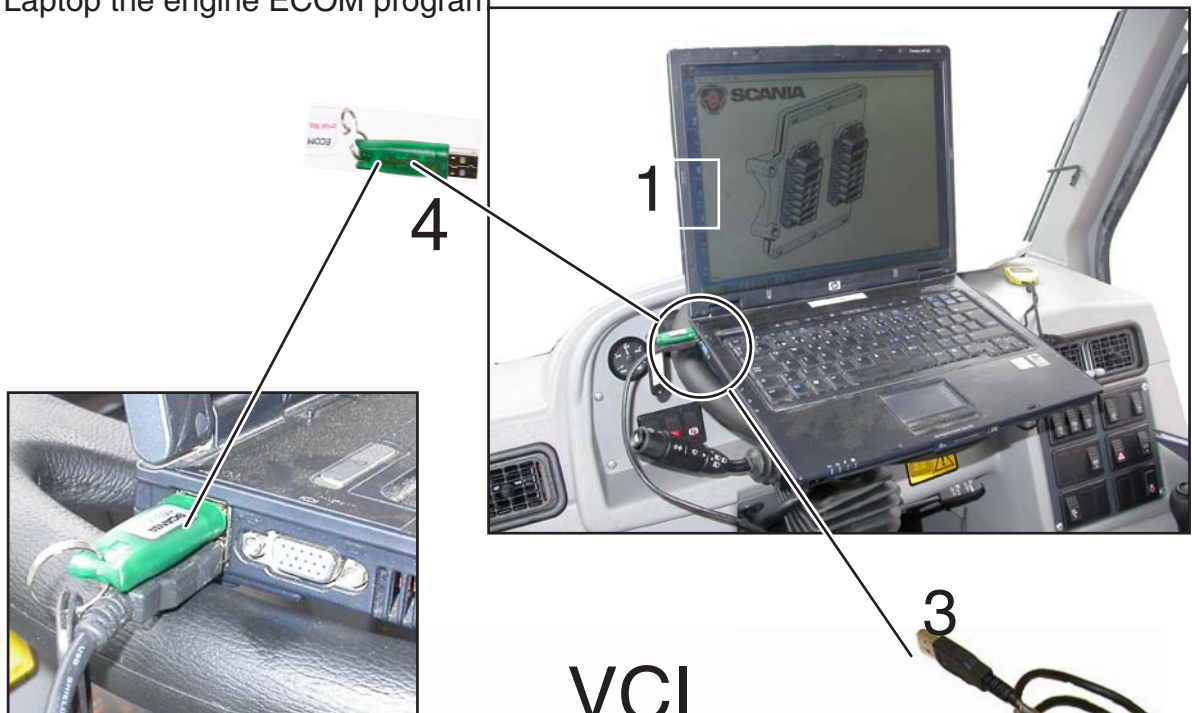
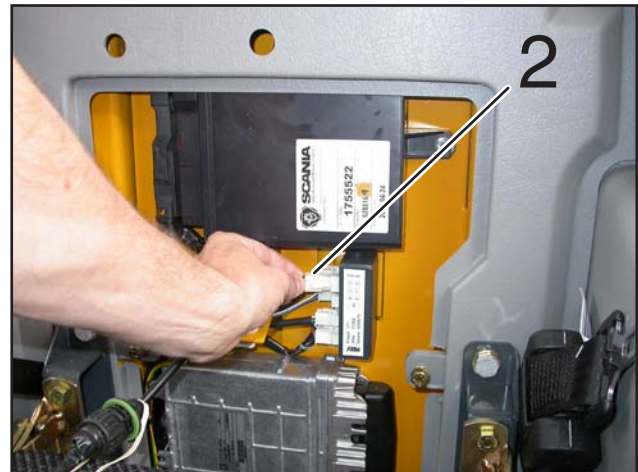
- 1 Feed pump
- 2 Hand pump
- 3 Fuel filter
- 4 Fuel rail
- 5 Pressure relief valve
- 6 Bleeder nipple
- 7 ECU control unit

## Diagnostic procedure

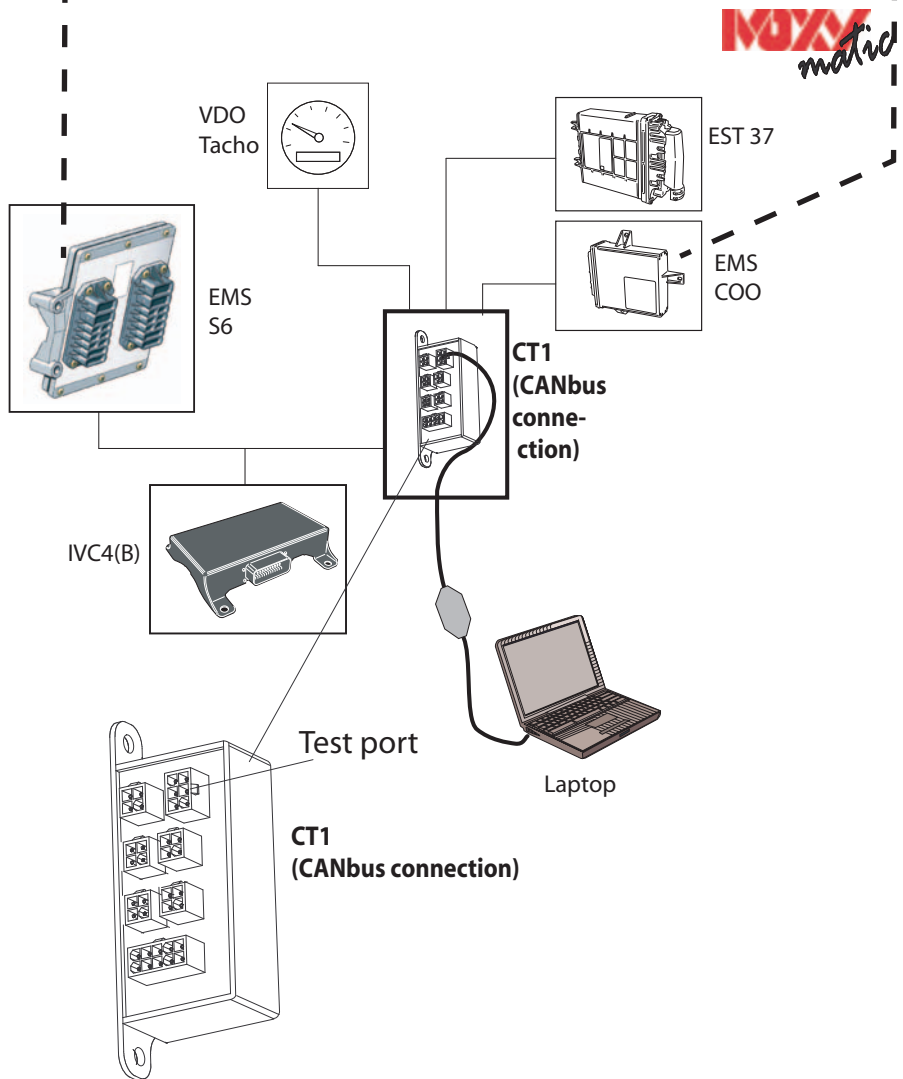
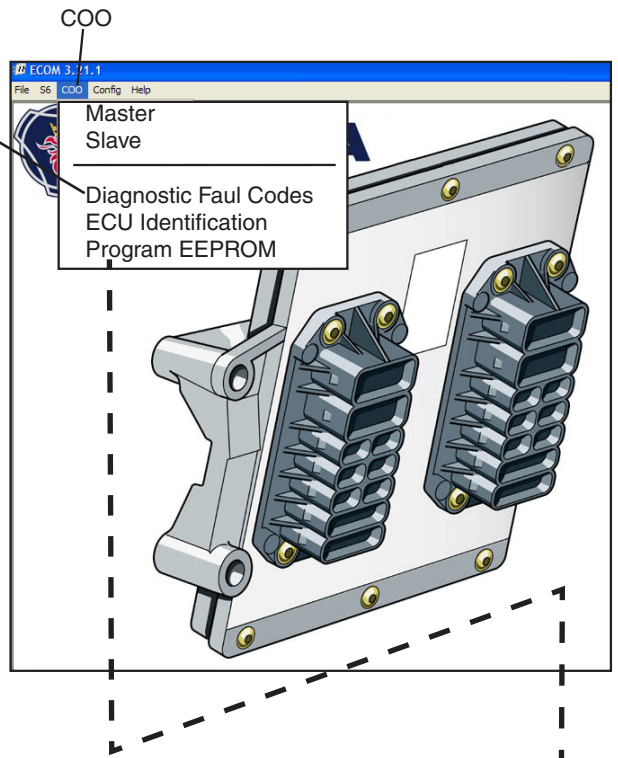
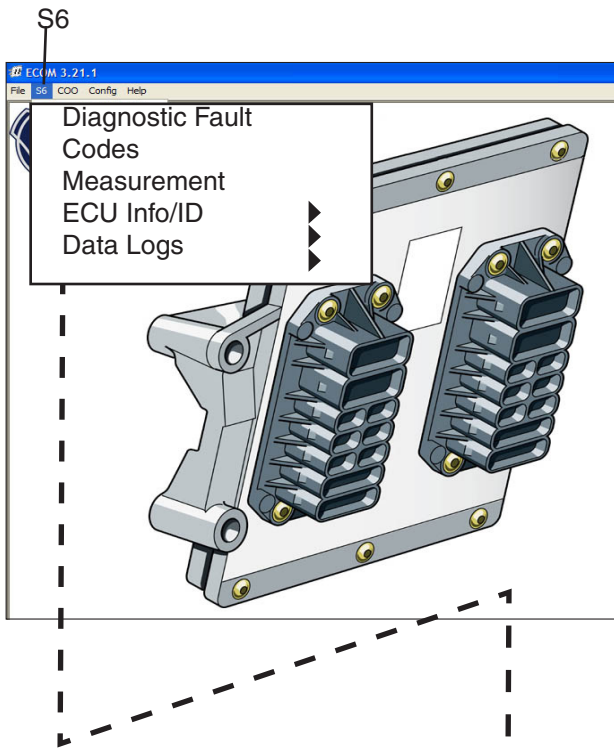
### Use of diagnostic kit, machine

Install the VCI (ECOM programming unit)  
Moxy No.513376

1. Switch on the laptop.
2. Connect the cabel end (1) to the CT1 unit
3. Connect the USB plug (2) to the Laptop
4. Put in the USB key
5. Switch on the ignition key (If read the setting parameters)
6. Start the engine. (If controlling of the parameters)
7. Start on Laptop the engine ECOM program

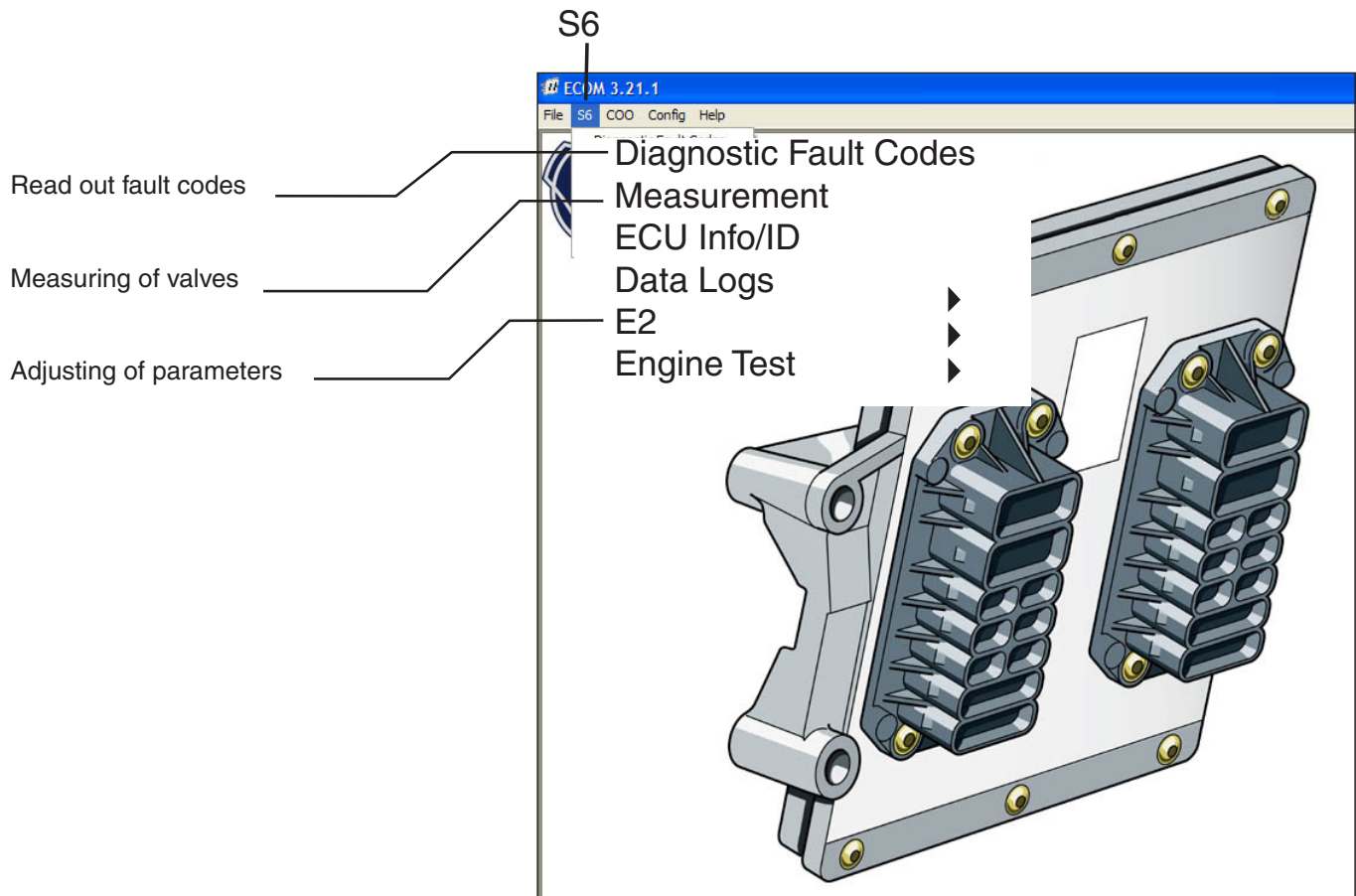






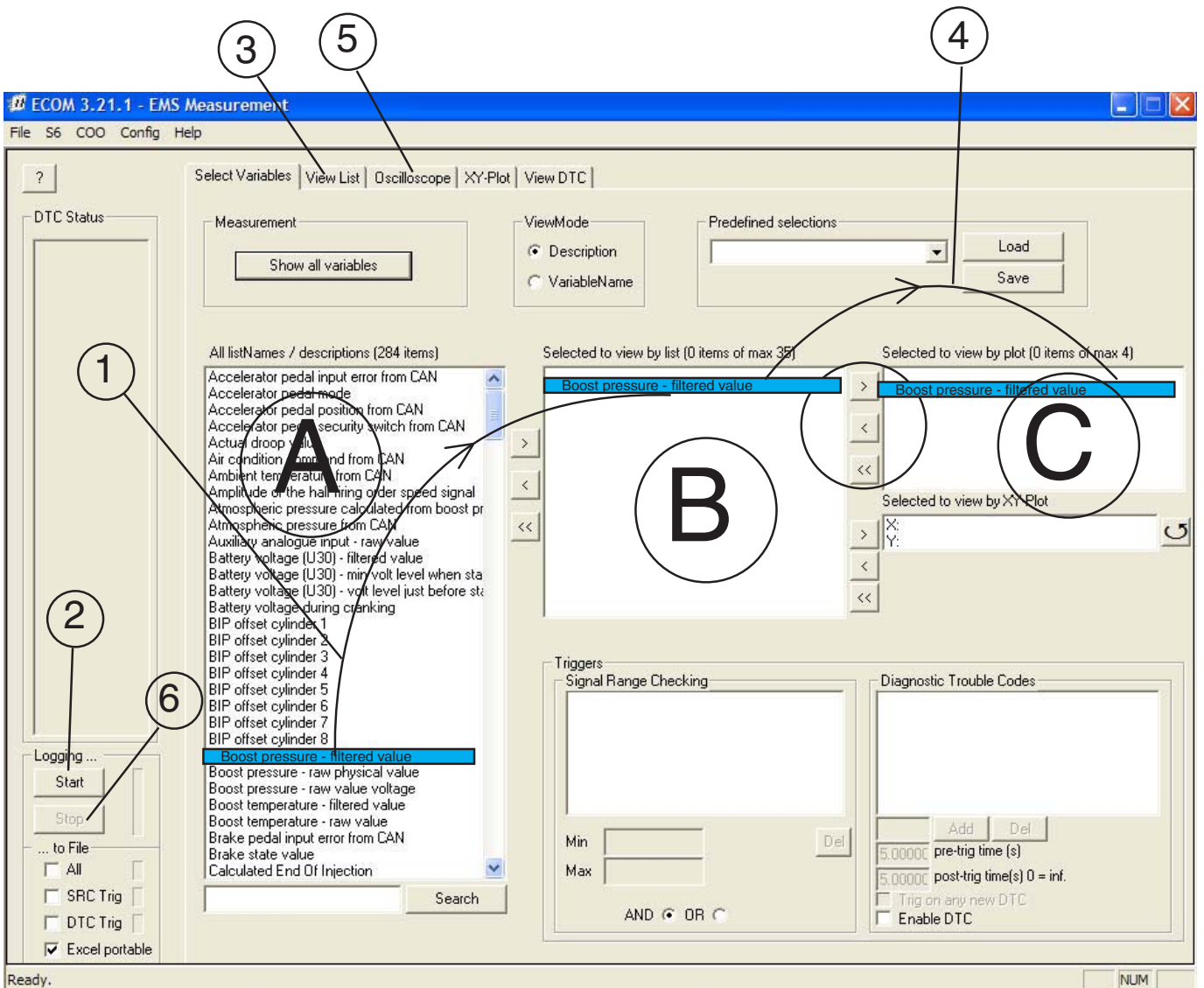
The CT1 has following functions:

- Connection point for all CANbus devices on the truck
- Contains two independent CANbus interfaces and handles data transfers between these buses
- Connection point for engine diagnosis
- Handle WDB monitoring and alarm
- Handle histogram logging (Information for service)





## Measurement



1. Move text line from the A section to B
2. Start the logging by the start button
3. Select "View the list" to watch the values or -
4. Move text line to section C
5. select the "Oscilloscope" to view the graphical diagram
6. Stop logging to select new variable

The screenshot shows the ECOM 3.21.1 - S6 DTC software interface. The window title is "ECOM 3.21.1 - S6 DTC". The menu bar includes "File", "S6", "COO", "Config", and "Help". A dropdown menu is open under "File", showing options: "Diagnostic Fault Codes", "Measurement", "ECU Info/ID", "Data Logs", "E2", and "Engine Test".

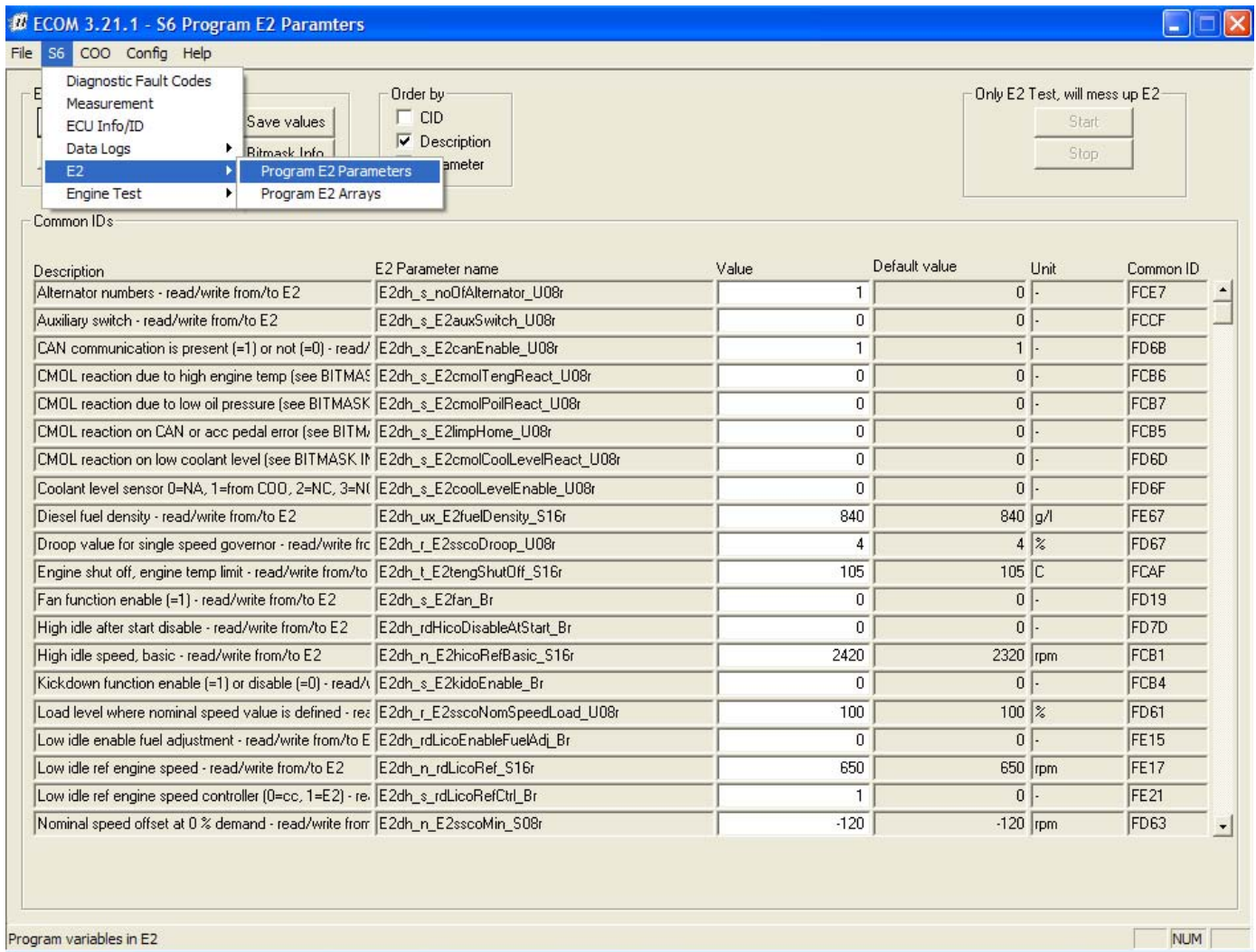
On the right side, there are several controls: "Save to file DTC and FFrames" with a "Save" button, "Load Info", "Read INTE", and a "General ECU Info" box. Below these are checkboxes for "DTC Area 1" (checked), "DTC Area 2", "DTC File", "Finished", "Ejected", "Validated", and "Selfhealed".

The main area is titled "Diagnostic Faultcodes" and contains a table with the following data:

Faultcode Area 1	DTC	Counter	Status	(YYYY-MM-DD:SS)	Description
	2000	1	Active	-001--1--1-1	Engine temp sensor, sensor signal > 4 90 VI < -40°C

Below the table, there is a section for "No Selection!" and a "Show Freeze Frame" checkbox. To the right of this section is an "Export" button and a table with columns "what", "value", and "raw".

At the bottom of the window, there is a status bar with the text "Check Diagnostic Faultcodes and Freeze Frames" and a "NUM" button.



**Example to change temp alarm and warning:**

Go to S6 ---> E2 ---> Program E2 parameter.

Read values.

Go to the column for values, find the line for engine temp and change the value.

Then go to the "button" ; write values and click on it, the value will now be change.

Confirm your choice

**Ecom standard settings code**

From Main Menu, Select:

S6

Program E2 parameters

Read values

Make changes

Write values

CID	Description	Limits	Typical Value	Unit	MT Value
FE17	Low idle, ref engine speed	0 - 3200	650	rpm	650
FE21	Low idle, ref engine speed controller.	0 - 1			1
	0 = use basic low idle, adjustable with CC-buttons				
	1 = Use FE17, not adjustable with CC-buttons				
FE65	Oil temperature sensor on EMS available	0 - 1	0/1		
	0 = Not available				
	1 = Available				
FE63	Use safety switch on accelerator pedal	0 - 1	1		1
	0 = Not available				
	1 = Available				
FE67	Diesel fuel density, used only for fuel rate calculation	0 - 2000	840	g/litre	840
FD7D	Reduced high idle after start	0 - 1			
	0 = Enable				
	1 = Disable				
FC8D	Type of governor	0 - 1	1		1
	0 = RQ				
	1 = RQV				
FCB1	High idle, ref engine speed	0 - 3200	23 - 2400	rpm	2420
FD6F	Coolant level sensor	0 - 1	0/1		
	0 = Not present				
	1 = From coordinator				
FD6D	Reaction to low coolant level	0, 1, 2, 6			
	0 = Alarm only				
	1 = Torque limitation				
	2 = Stop engine				
	6 = Stop engine with override option				

CID	Description	Limits	Typical Value	Unit	MT Value
FCB7	Reaction due to low oil pressure	0, 1, 2, 6			
	0 = Alarm only				
	1 = Torque limitation				
	2 = Stop engine				
	6 = Stop engine with override option				
FCB6	Reaction due to high coolant temperature	0, 1, 2, 3,	0/1/6		
	0 = Alarm only				
	1 = Torque limitation on low limit				
	2 = Stop engine on high limit				
	3 = Torque limitation and stop engine				
	6 = Stop engine with override option				
	7 = Torque limitation and stop engine with override option				
FCAF	Engine coolant temperature shut-off limit	0 - 150	105	°C	105
FCF3	Engine coolant temperature torque limitation limit	0 - 150	95	°C	102
FCB5	Reaction on CAN or accelrator pedal error	0, 1, 2, 3, 4, 8	0/1		
	0 = No action, low level				
	1 = Increased low idle				
	2 = CAN shut-off				
	3 = CAN shut-off and increased low idle				
	4 = AUX_AN as redundant accelrator pedal				
	8 = Always use AUX_AN accelrator pedal				
FC81	PTO mode 0, max engine speed	0 - 3200	3000	rpm	3000
FC82	PTO mode 1, max engine speed	0 - 3200	3000	rpm	3000
FC83	PTO mode 3, max engine speed	0 - 3200	3000	rpm	3000
FC80	PTO mode 3, fixed engine speed	0 - 3200	1500	rpm	1100
FD09	PTO mode 0, max torque	0 - 5100	5100	rpm	5100
FD0B	PTO mode 1, max torque	0 - 5100	5100	rpm	5100
FD0D	PTO mode 2, max torque	0 - 5100	5100	rpm	5100
FD0F	PTO mode 3, max torque	0 - 5100	5100	rpm	5100

CID	Description	Limits	Typical Value	Unit	MT Value
FCA1	PTO mode 1, accelrator pedal effective	0 - 1			1
	0 = Active				
	1 = Not active				
FD11	PTO mode 4, max torque	0 - 5100	5100	rpm	5100
FE15	Low idle to adjust fuel adjustment. Droop function on low idle	0 - 1			
FCE3	Accelrator pedal value converted to reference engine speed	0 - 3200	array x 4	rpm	480/2500/ 2500/2500
FCF9	Accelrator break point for FCE3	0 - 100	array x 4	%	0/100/ 100/100
FCE5	Droop values for different accelrator pedal values	0 - 8	array x 4	rpm/ mg/st	4,5/4,5/ 4,0/0,5
FCFB	Accelrator pedal breakpoint for FCE5	0 - 100	array x 4	%	0/20/80/ 100
FD77	Voltage breakpoints for 0% and 100% for redundant Accelrator pedal connected to input AUX_AN on EMS	100 - 4900	Array x 2		
			485/2693	mV	485/2693
FD73	Engine speed dependent friction torque. Breakpoints in flash, 500, 1000, 1500, 2200 rpm	0 - 5100	array x 4	Nm	0/0/0/0
FD75	Engine speed and temperature dependant friction torque. Breakpoints in flash, 500, 1000, 1500, 2200 rpm	0 - 5100	array x 4	Nm	0/0/0/0
FD71	Temp. breakpoints for 0% and 100% of fan friction torque of FD75	0 - 150	array x 2	°C	80/100
FD13	Torque limit 2, extra torque curves for customer use. Breakpoints for software version 2253: 1000, 1100, 1200, 1400, 1600, 1800, 1900, 2000, 2100, 2200, 2300, 2400	0 - 5100	array x 12	Nm	12 x 5100
FD15	Torque limit 3, extra torque curve for customer use. Breakpoints for software version 2253: 1000, 1100, 1200, 1400, 1600, 1800, 1900, 2000, 2100, 2200, 2300, 2400 rpm	0 - 5100	array x 12	Nm	12 x 5100



## Engine control unit, ECU

This engine has an electronic management system, ECU Engine Control Unit (also called EMS, Electronic Management System) with unit injectors (PDE) which provide each cylinder with the right amount of fuel at the right time in all operating situations.

The ECU system consists of a control unit (S6) and sensors for speed, charge air temperature and pressure, coolant temperature, oil pressure, accelerator pedal/throttle actuation which constantly emit signals to the control unit.

With the aid of this input data and the programmed control software, the correct fuel amount and correct injection time are calculated for each unit injector (PDE) under the specific operating conditions.

The ECU system sensors can also be used to emit signals to the instruments in the instrument panel. The control unit constantly checks the sensors to make sure they are operational.

The control unit contains monitoring functions to protect the engine in the event of a fault which would otherwise damage it. In the event of a fault, e.g. alarm level for low oil pressure or high coolant temperature, the S6 control unit sends a CAN message to a coordinator.

The main task of the coordinator is to pass on data by means of CAN communication from the engine control unit to other control units and signals to gauges and lamps in the instrument panel. The coordinator also has monitoring functions.

When the ECU control unit detects a fault, the control unit diagnostics lamp comes on (left-hand lamp on the instrument panel) and it stays on as long as the fault is active. At the same time, a fault code is generated which can be read off via the coordinator on the diagnostics lamp in the form of a flashing code when a separate diagnostic switch is actuated. A flashing code may consist of a number of different fault codes.

When the coordinator detects a fault, a fault code is generated which can be read off on the coordinator diagnostics lamp (the left-hand lamp on the instrument panel) in the form of a flashing code when a separate diagnostic switch is actuated.

If the torque reducing function is activated, the fuel amount is reduced to 70%, and if the engine shutoff function is actuated, the engine is shut off at programmed alarm levels.

A separate PC-based diagnostics program is used to read off the contents of the flashing codes. Reading off the fault codes, and descriptions of these, are also covered with writing in the section

### **Flash codes tables**

Only authorised personnel are allowed to carry out diagnostic procedures and program changes. The positions of the sensors which emit signals to the control unit are shown in the illustrations on next page.

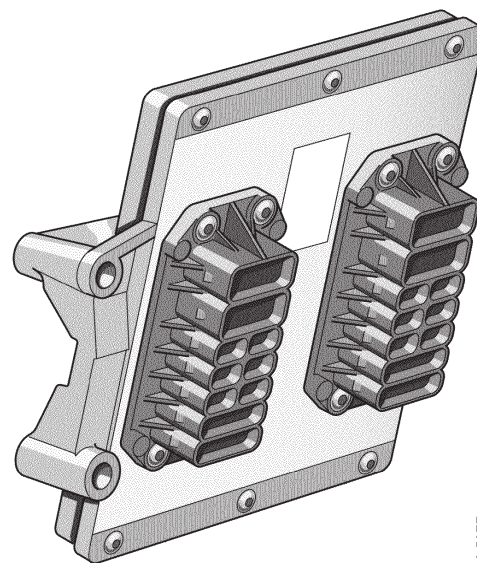
See the section

**How to read fault codes from the ECU control unit,**  
for a description of how to read off flashing codes.

See the section

### **Flash codes tables**

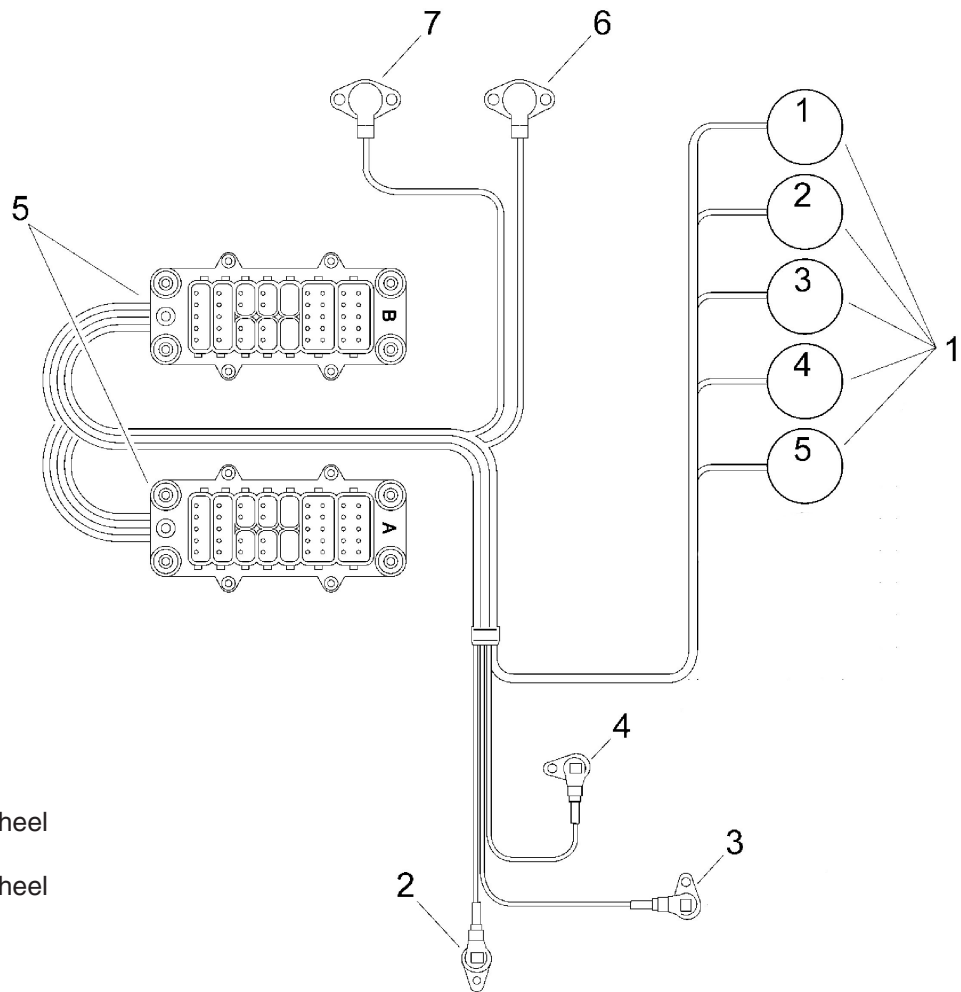
for a list of flashing codes for the control unit and



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ECU Control unit

## Wiring and cable duct



1 Cylinder 1–6

2 Coolant temperature sensor

3 Engine speed sensor 1 on flywheel

4 Engine speed sensor 2 on flywheel

5 Connector to control unit

6 Charge air pressure and temperature sensor

7 Oil pressure sensor

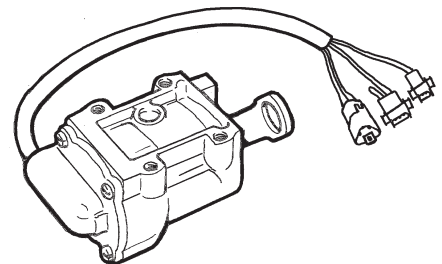
## Throttle position sensor

A throttle position sensor need to be added to the system.

The potentiometer provides the control unit with information about accelerator position.

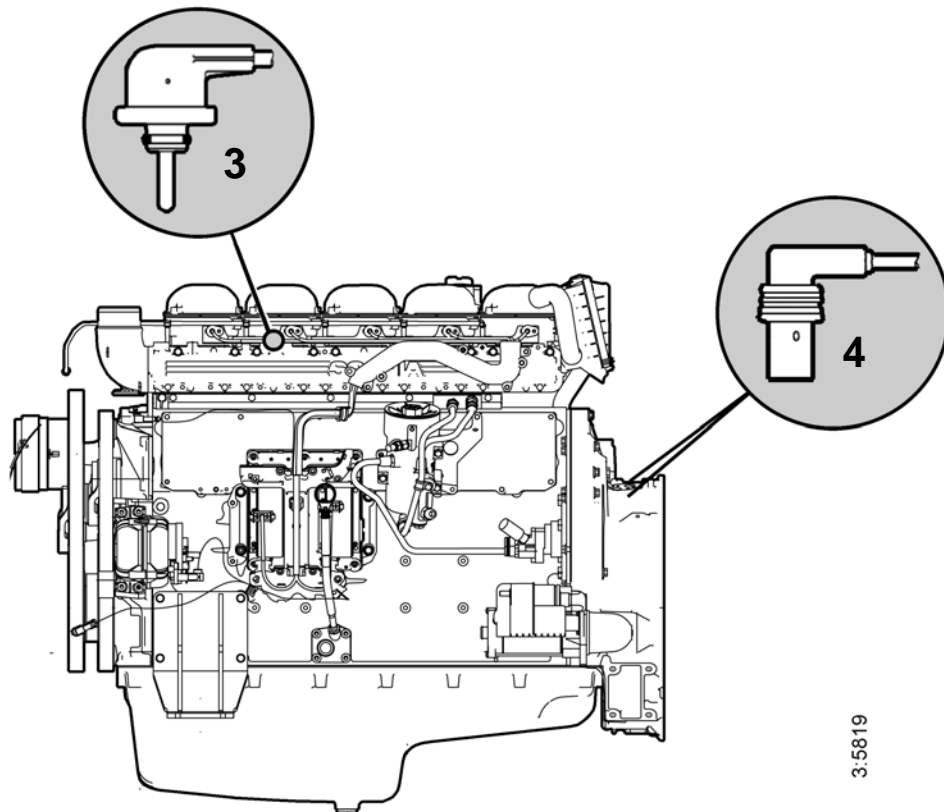
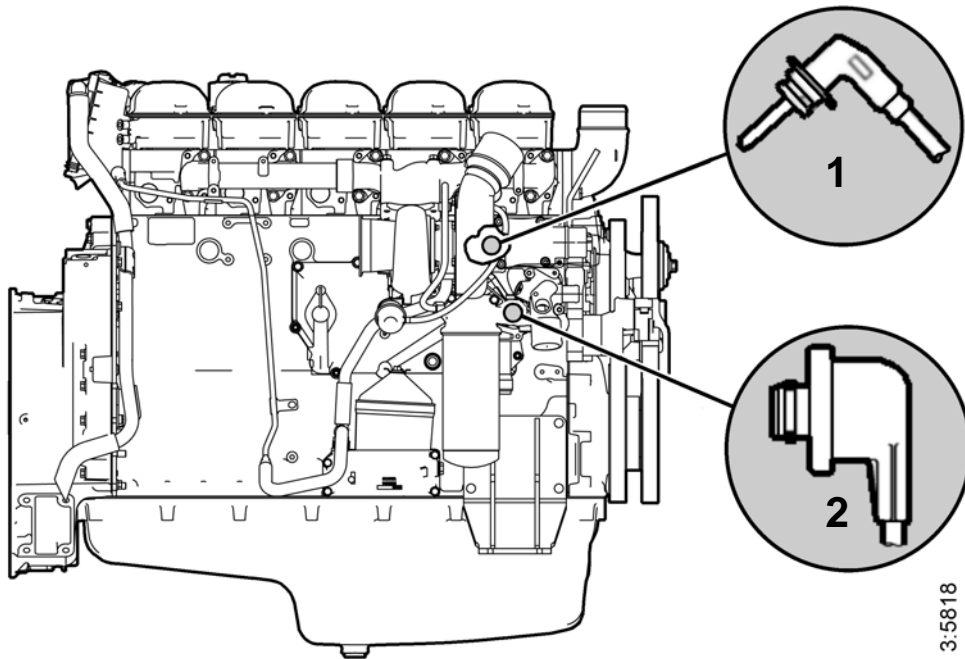
The accelerator position sensor (APS) has an integrated potentiometer and two microswitches for throttle activation (idle safety switch) and full throttle (kick down switch).

The idle safety switch tells the control unit whether the accelerator is released or activated. This is primarily a safety feature to check that the potentiometer is working as it should.





**Positions of sensors for ECU**



- 1. Oil pressure sensor
- 2. Sensor for charge air temperature and pressure
- 3. Coolant temperature sensor
- 4. Engine speed sensor (2)



### Diagnostic lamp and switch

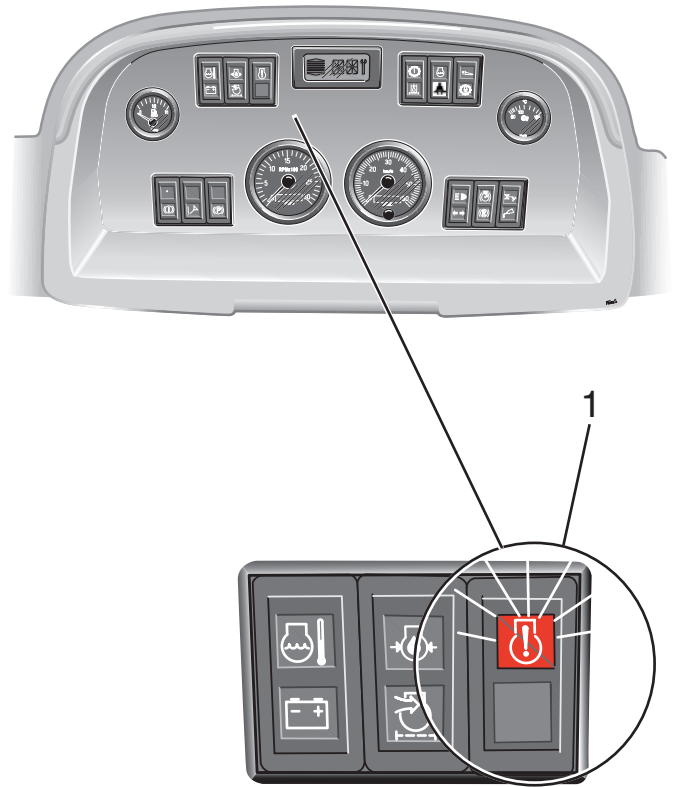
The diagnostics lamp comes on for one (1) second when the system is started. The diagnostics lamp will be lit continuously while a fault code is active.

With the aid of the diagnostics switch, the diagnostics lamps flash out any fault codes. The diagnostics lamp remains lit continuously while disconnecting, i.e. until voltage to the control unit is switched off, provided that the coordinator does not disconnect before this point.

NEW !

1  
ECU diagnostics lamp (Engine Controller Unit) and Coordinated diagnostics lamp (Coordinator) (The same lamp for both of the functions)

2  
Double Diagnostics switch

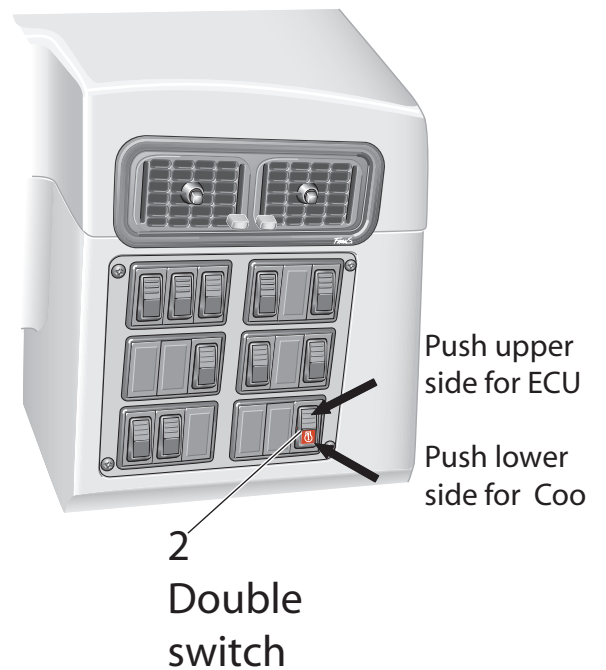


Diagnostic switch (From machine 810036)  
The diagnostics switch for the ECU or the Coordinator is located to the switch panel right hs

The diagnostics switch consists of a double switch for to select and read either the ECU or the Coordinator.

Push the upper side and read the blink code for the ECU.

Push the lower side and read the blink code for the Coordinated.



## Fault codes

### Troubleshooting using flash codes for the ECU control unit

- The diagnostics lamp for the control unit always comes on for a second when the system is powered up.
- As soon as a fault is detected by the control unit, a fault code is stored in the EEPROM and the diagnostics lamp for the control unit (the left-hand lamp on the instrument panel) lights up.
- The diagnostics lamp will remain permanently lit for as long as a fault is active. Even if the lamp has gone off and the fault is no longer active, the code can generally be read off in accordance with the instruction below.
- The diagnostics lamp for the control unit stays on during engine shutdown for as long as the control unit and coordinator are powered up.

### Checking:

- Fault symptoms
- Conditions in which the fault occurs
- How often the fault occurs
- If the diagnostics lamp lit up when the fault occurred
- If the diagnostics lamp went out by itself when the fault ceased
- If the fault codes have been erased

## How to read fault codes from the ECU control unit

### Reading fault codes for the ECU control unit:

The instructions below explain how to read fault codes in the form of flashes from the diagnostics switch.  
You can see how to interpret the flash codes on the next page.  
How to read fault codes from the diagnostics lamp

- 1 Switch on the ignition.
- 2 Press the diagnostics switch for at least one second. Diagnostic lamp will light up.
- 3 A fault code will be flashed out on the diagnostics upper lamp for the control unit.

This flash code consists of  
**long flashes** (about 1 second long)  
and  
**short flashes** (0.3 seconds long).

Long flashes are equivalent to tens and short flashes to units.

Example: long - long - short - short - short - short - short = fault code 25.

See the example on the right.  = 25

Repeat this procedure until the first flash code is repeated.  
This means that the entire fault code memory has been flashed up.  
If the fault code memory is empty, only one long flash about four (4) seconds long is given.

See the example on the right.  = 4 s

- 4 See the **flash code table** for a description and localisation of the fault.
- 5 The PC-based diagnostics tool must to be used to gain further information on the fault code.
- 6 A single, very long flash (4 s) means that there are no fault codes stored in the memory.

 = 4 s

## How to erase fault codes from the ECU control unit

The control unit memory has sufficient space to store 40 fault codes. The fault codes are stored in two different places in the control unit. Erasing with the diagnostic switch erases the fault codes that are flashed on the diagnostic lamp. However, the fault codes will remain in another memory which can only be accessed using a ECOM.

Both fault code memories are erased at the same time with ECOM. How to erase fault codes during pre-delivery inspection  
Fault codes are to be erased with ECOM during pre-delivery inspection so that both memories are empty when the engine is delivered to the customer.

## How to erase fault codes using the diagnostics switch

How to erase fault codes that are flashed on the diagnostic lamp is described below. The fault codes are still stored elsewhere in the control unit. These fault codes are erased with ECOM.

- 1 Start and switch off the engine once so that a shutdown test is carried out. Wait until the ECU warning lamp has gone out.
- 2 First press and hold the diagnostics switch, then turn the starter key to the drive position. Keep pressing the diagnostics switch for between 3 and 10 seconds. The passive fault codes will then have been cleared. When the engine is started again, the fault codes that are active will be shown again.
- 3 Start the engine and check that the diagnostics lamp goes out.
- 4 Press the diagnostics switch. The fault code memory should be empty; only one long flash should be seen.

## Flash codes tables

This is a list of the flash codes which can be read and the fault codes to which they correspond. One flash code in ECU S6 corresponds to several different fault codes.

### Flashing code list for the EMS control unit

Code	Description	Code	Description
0	No fault detected.	53	PDE in cylinder 3: The solenoid valve does not work correctly.
11	Overspeed. One or both engine speed sensors are displaying speeds in excess of 3000 r/min.	54	PDE in cylinder 4: The solenoid valve does not work correctly.
12	Engine speed sensor 1 faulty, or incorrect signal.	55	PDE in cylinder 5: The solenoid valve does not work correctly.
13	Engine speed sensor 2 faulty, or incorrect signal.	56	PDE in cylinder 6: The solenoid valve does not work correctly.
14	Coolant temperature sensor faulty, or incorrect signal.	57	PDE in cylinder 7: The solenoid valve does not work correctly.
15	Charge air temperature sensor faulty, or incorrect signal.	58	PDE in cylinder 8: The solenoid valve does not work correctly.
16	Charge air pressure sensor faulty, or incorrect signal.	59	Incorrect signal in extra analog input.
17	Oil temperature sensor faulty, or incorrect signal.	61	Incorrect control unit shutdown.
18	Oil pressure sensor faulty, or incorrect signal.	66	Shutdown due to coolant level
21	Coolant level sensor faulty.	68	Alternator charging incorrectly.
23	Fault code internally in the coordinator.	69	Starter motor function interrupted or not activated.
24	Accelerator/brake. If the accelerator and brake have been operated simultaneously.	82	Engine speed above ref. speed at start
25	Accelerator sensor/idling switch Accelerator sensor/kick-down switch	83	Fault in memory circuit (EEPROM) in control unit.
27	Engine shutdown bypassed.	84	Data transfer to the control unit memory (EEPROM) has been interrupted.
28	Shutdown due to oil pressure	85	Incorrect temperature internally in the control unit.
31	Torque limitation due to oil pressure	86	Internal fault in the control unit: Fault in hardware control.
32	Incorrect parameters for limp home function.	87	Fault in control unit RAM.
33	Battery voltage incorrect or no signal.	88	Internal control unit fault: Memory fault
37	Emergency shutdown switch activated in accordance with CAN message from coordinator.	89	Incorrect seal: Illegal editing of software.
43	CAN circuit faulty in the control unit.	93	Engine speed sensors faulty or not connected.
47	Immobiliser function. Ignition key code incorrect.	94	Shutdown due to high coolant temperature.
48	There is an incorrect CAN message or no CAN message from the coordinator.	96	Torque limitation due to high coolant temperature.
49	Incorrect CAN version in control unit or coordinator.	98	Incorrect voltage supply to one of the sensors.
51	PDE in cylinder 1: The solenoid valve does not work correctly.	99	Internal hardware fault in the processor (TPU).
52	PDE in cylinder 2: The solenoid valve does not work correctly.		

## Troubleshooting using flash codes for the coordinator

- As soon as a fault is detected by the coordinator, it is stored in the EEPROM fault code memory.  
The diagnostics lamp for the coordinator (the right-hand lamp on Scania's instrument panel) comes on when the diagnostic switch is actuated.
- The EMS lamp also lights up to indicate that there is an internal fault in the coordinator (fault code 23)
- Even if the lamp has gone off and the fault is no longer active, the code can generally be read off in accordance with the instruction below.

## How to read fault codes for the coordinator

- 1 Switch on the ignition.
- 2 Depress the diagnostic switch for at least 1 second.
- 3 A fault code will then flash on the diagnostics lamp for the coordinator (the right-hand lamp on Scania's instrument panel).  
This flash code consists of long flashes (about 1 second long) and short flashes (0.3 seconds long).  
Long flashes are equivalent to tens and short flashes to units.

Example: long - long - short - short - short - short - short = fault code 25. Refer to the illustration.



- 4 Repeat this procedure until the first flash code is repeated. This means that the entire fault code memory has been flashed up. If the fault code memory is empty, only one long flash approximately 4 seconds long will be given.

- 5 See the flash code list on page 14 for a description and localisation of the fault.

## How to erase fault codes

- 1 Turn the ignition off.
- 2 Depress the diagnostic switch while turning on the ignition.
- 3 Hold the diagnostic switch down for between 3 and 10 seconds.
- 4 This erases the passive fault codes.  
The active codes must be rectified to make them passive. They can then be erased.



## Overview of flash codes for coordinator

Code	Description of fault	Cause	Action	Note
11	Incorrect signals from the accelerator pedal sensor.	The flash code is registered when the voltage from the accelerator pedal sensor is outside the setting range.	Check the accelerator pedal sensor, connectors and cables.	See also fault codes for the ECU control unit.
12	Incorrect signals from the cruise control switches.	The flash code is registered when the voltage from the cruise control switches is not within the correct range.	Check the cruise control switches, connectors and cables.	When there are fault codes, the cruise control will perate.
13	No communication with the engine.	The flash code is registered when communication from ECU (S6) is cut off.	Check CAN connectors and cables.	When this fault occurs, the diagnostics lamp for ECU (S6) also comes on.
14	Short-circuit in the tachometer signal circuit.	The flash code is registered when there is a short circuit between the output signal and earth or supply. The flash code is registered after 10 seconds.	Check the instrument panel, connectors and cables.	
15	Faulty atmospheric pressure sensor.	The signal from the integrated sensor is outside the range.	Renew the coordinator.	See also fault codes for the ECU control unit. The signal is not always required. Check with Moxy service.
16	The signals from the brake pedal switches do not agree.	The flash code is registered after 5 minutes.	Check the brake pedal switches, connectors and cables.	See also fault codes for the ECU control unit.
17	Short circuit in the engine temperature gauge signal circuit.	The flash code is registered when there is a short circuit between the output signal and supply. The flash code is registered after 10 seconds.	Check the instrument panel, connectors and cables.	If there is a fault the gauge will display a low temperature.
18	Short-circuit in the oil pressure gauge signal circuit.	The flash code is registered when there is a short-circuit between the output signal and supply. The flash code is registered after 10 seconds.	Check the instrument panel, connectors and cables.	If there is a fault the gauge will display a high pressure.
19	Short-circuit in the oil pressure lamp signal circuit.	The flash code is registered when there is a short-circuit between the output signal and supply. The flash code is registered after 10 seconds.	Check the instrument panel, connectors and cables.	If there is a fault the lamp will not come on
21	Different versions of the communications protocol between the coordinator and EMS.	ECU does not have the same version of the communication protocol as the coordinator.	Replace the coordinator with a matching unit.	

Continued next page

Code	Description of fault	Cause	Action	Note
22	The supply voltage is too high.	The supply voltage exceeds 35 volts for more than 2 seconds.	Check the alternator.	Certain inputs and outputs become inactive. The coordinator may suffer damage.
23	The supply voltage is too low.	The supply voltage is less than 18 volts for more than 2 seconds.	Check the battery and alternator.	Certain inputs and outputs become inactive.
24	The supply voltage is too low.	The supply voltage is less than 18 volts for more than 2 seconds.	Check the battery and alternator.	Certain inputs and outputs become inactive.
25	Check value from End of line (EOL) is incorrect			
26	Road speed sensor signal missing or faulty.			
27	The signal from the RCB (remote Control Box) switches are implausible.			
28	Incorrect signals from the droop-settings switches			
29	Faulty remote start switch or short circuit			
31	No communication from the slave-coordinator or the master coordinator.			
32	Short circuit in the signal cable to the coolant temperature warning lamp			
33	Short circuit in the signal cable to the charge indicator lamp			
34	Incorrect signal from the Fixed speed switches			
35	Fault in CAN communication			

## Renewing the control unit

Tightening torques

Control unit, screws 22 Nm

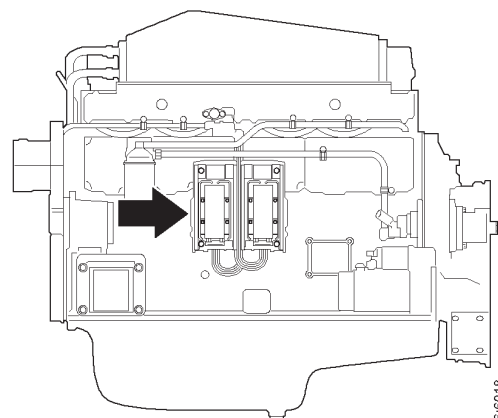
Work description

### **IMPORTANT!**

**The control unit may suffer damage if it is powered when you unplug it.**

**Before removing the control unit you must switch off the power with the starter key and wait for the EMS warning lamp to go out.**

- 1  
Remove the covers over the connectors on the control unit and then unplug the connectors.
- 2  
Remove the control unit fixing screws and lift off the control unit.
- 3  
Fit the new control unit and tighten the screws to 22 Nm.
- 4  
Plug in the connectors on the control unit.
- 5  
Do the necessary programming with ECOM. Start the engine. Check the fault codes and then delete them in accordance with the routine in troubleshooting booklet or with the PC-tool ECOM if it is available.



## Removing the ECU wiring

Drain the coolant from the engine as described in the work descriptions for the cooling system.

2

Wash clean the rocker covers and the area around them.

3

Remove the inlet pipe between the turbocharger and the air cleaner.

4

Remove the air line to the compressor. The air line is located on the left-hand cable duct.

5

Unplug the connectors from the control unit.

6

Remove the rocker covers.

On the 12-litre engine the crankcase ventilation must be removed before the rocker cover on cylinder 1 can be removed.

7

Disconnect the cables from the unit injectors.

The screws cannot be removed, but they should be unscrewed as far as possible.

8

Mark the cables with the respective cylinder numbers.

9

Remove the cable duct to which the cables are attached.

Unscrew the cable bushings in the lower rocker covers and remove the cables.

10

Remove the charge air sensor and its clamps.

11

On engines fitted with an electrically controlled fan, separate the connector on the fan ring, which is connected to the solenoid valve. Remove the cable clamps as well.

### Note:

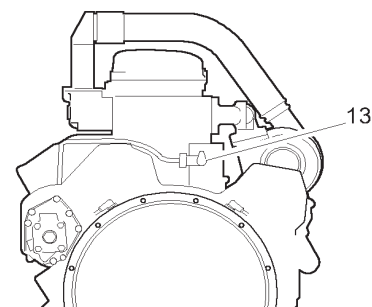
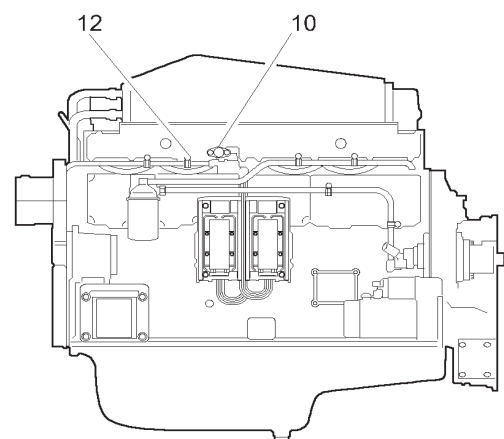
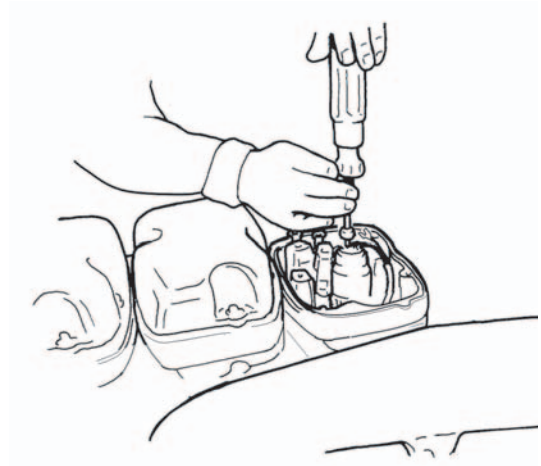
**Handle the engine speed sensors with care. They are magnetic and are sensitive to impacts.**

14

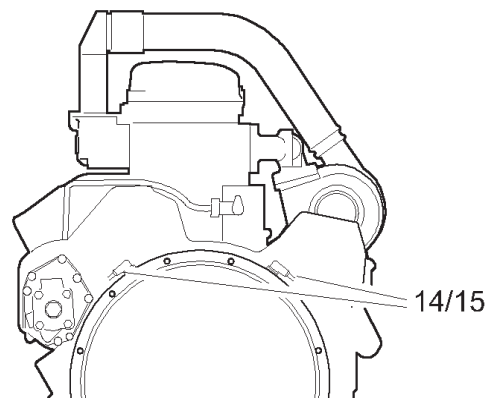
Remove engine speed sensor 1 and its clamps.

15

Remove engine speed sensor 2 and its clamps.



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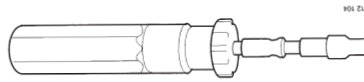
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## Fitting the wiring

### Tightening torques:

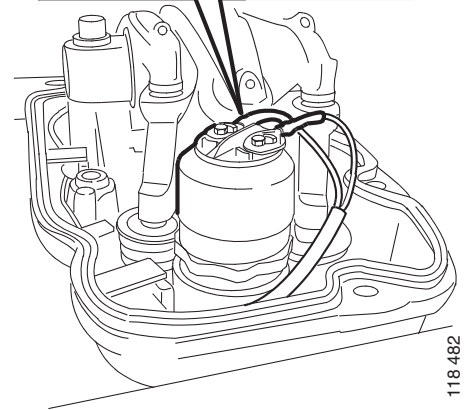
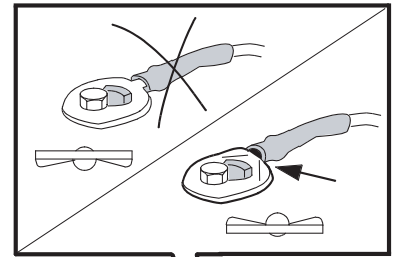
Unit injector solenoid valves, screws: 2,0 +/-0,2 Nm

512562 Torque screwdriver



### IMPORTANT!

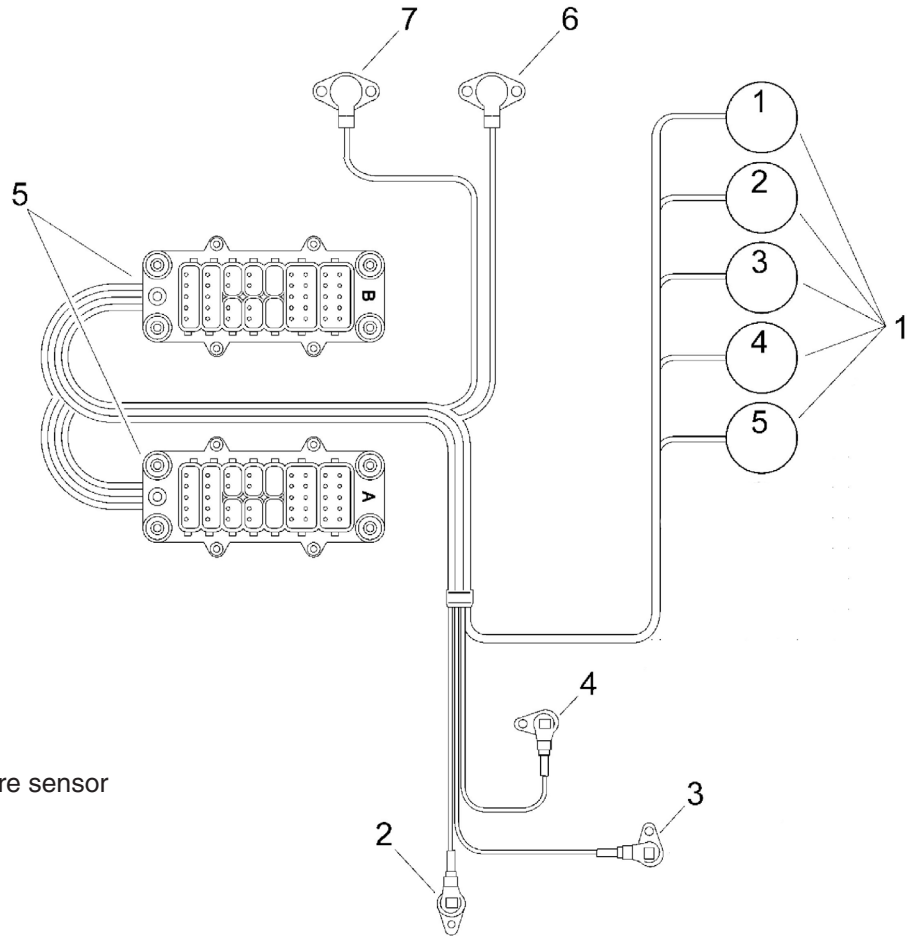
If the screws are tightened too tight, there is a risk that they may break. If this happens, the entire unit injector must be replaced.



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**Work description:**

- 1  
Make sure that the inlet pipe between the turbocharger and the air cleaner has been removed.
- 2  
Fit the cable ducts. Schematic illustrations of the location of the cable ducts and their components are shown below



- 1 Cylinder 1–6
- 2 Coolant temperature sensor
- 3 Engine speed sensor 1 on flywheel
- 4 Engine speed sensor 2 on flywheel
- 5 Connector to control unit
- 6 Charge air pressure and temperature sensor
- 7 Oil pressure sensor

- 3  
Run the cables to the unit injectors.  
Check that you have run the right cable to each unit injector by testing the cables with a multimeter as shown in the tables.

Cylinder	Connector	Pin
1	B2	1 and 6
2	B2	2 and 7
3	B2	4 and 9
4	A1	1 and 6
5	A1	2 and 7
6	A1	4 and 9



4

Press the cables into the groove in the lower rocker cover.

See the illustration about **Fitting the wiring**.

**Note:**

**Take care when tightening the cable connection screws on the unit injector. If a screw breaks, the unit injector must be replaced.**

5

Secure the cables to the unit injectors by tightening the screws. Use torque screwdriver 512562 and tighten the screws to 2.0 +/- 0.2 Nm.

(6- 7- 8- Other type of Scania engine)

9

Fit the oil pressure sensor and its clamps.

10

Fit the coolant temperature sensor and its clamps.

11

Fit the charge air sensor and its clamps.  
Note: Handle the engine speed sensors with care. They are magnetic and are sensitive to impacts.

12

Fit the auxiliary engine speed sensor and its clamps.

13

Fit the main engine speed sensor and its clamps.

14

Connect ECOM to the engine and check the unit injectors by activating them. Check also that the values from the sensors are correct.

15

Plug the connectors into the control unit.

16

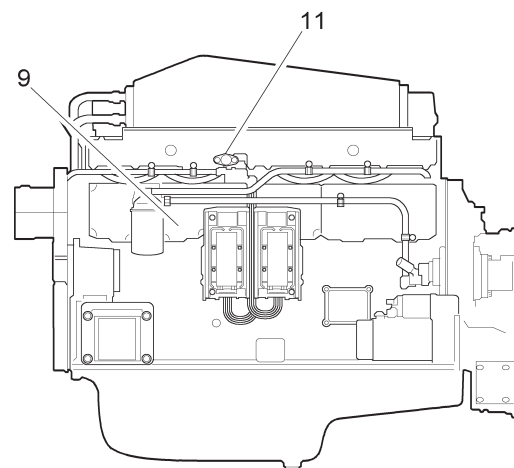
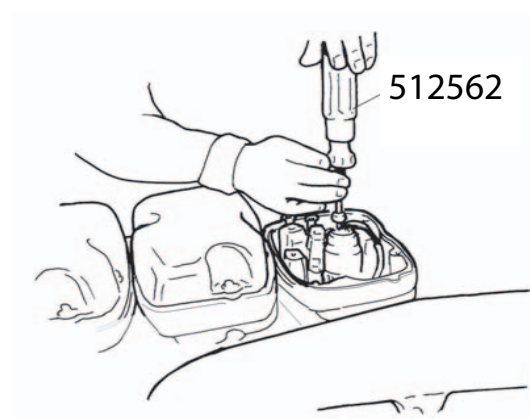
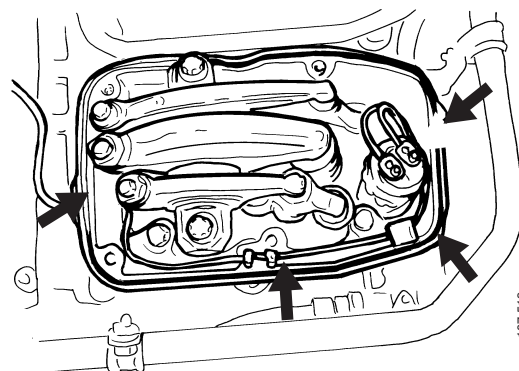
Fit the upper rocker covers and tighten the screws to 18 ± 3 Nm.

17

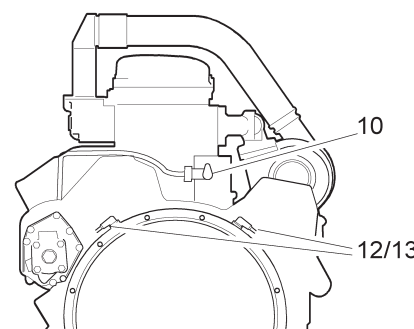
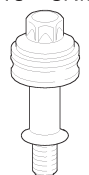
Fit the inlet pipe between the turbocharger and the air cleaner.

18

Top up with coolant in accordance with the

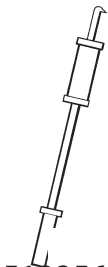
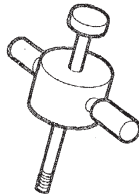

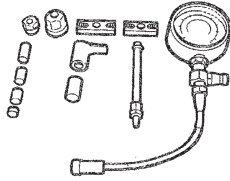
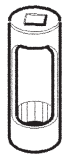
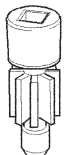
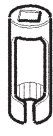
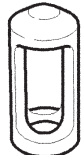




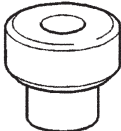
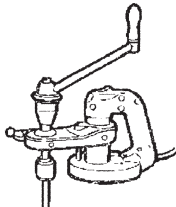
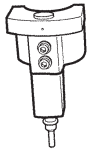
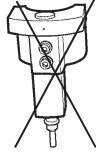


18 ± 3Nm

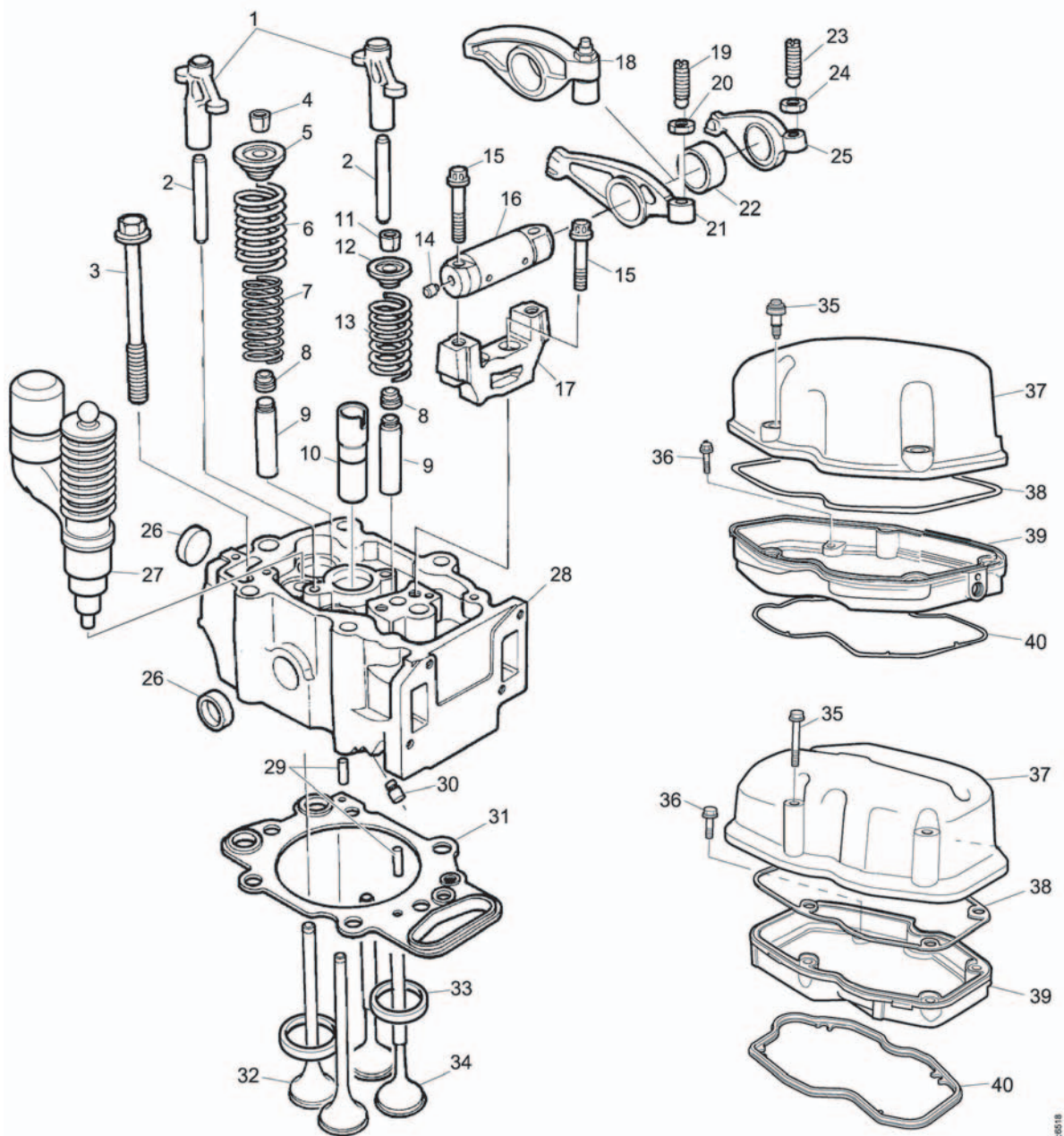


# Cylinder head

## Special tools

512256	Slide hammer		8049		8029		8019	
8049	Impact drift							
8029	Extractor for injectors							
8019	Compression tester							
8386	Sleeve for injectors		8405		8387		8406	
8405	Tool for turning flywheel							
8387	Socket							
8406	Press drift							
8407	Assembly drift							
512260	Drift		512261		512257		512266	
512261	Handle							
512257	Drift							
512266	Pilot tap							
512259	Drift							
512258	Drift							
512262	Guide		512265		512263		512264	
512265	Valve seat cutter							
512263	Setting tool							
512264	Setting tool							

**Cylinder head, parts view.**



- 1. Valve bridge
- 2. Pin
- 3. Bolt
- 4. Collet
- 5. Valve spring collar
- 6. Valve spring
- 7. Valve spring
- 8. Valve stem seal
- 9. Valve guide
- 10. Socket
- 11. Collet
- 12. Valve spring collar
- 13. Valve spring
- 14. Rivet plug
- 15. Tight-fit screw
- 16. Shaft

- 17. Bearing bracket
- 18. Rocker arm for unit injector
- 19. Adjusting screw
- 20. Hexagon nut
- 21. Rocker arm
- 22. Spacing sleeve (injection pump)
- 23. Adjusting screw
- 24. Hexagon nut
- 25. Rocker arm
- 26. Core plug
- 27. Unit injector
- 28. Cylinder head
- 29. Pin
- 30. Rivet plug

- 31. Gasket
- 32. Exhaust valve
- 33. Valve seat insert
- 34. Intake valve
- 35. Flange bolt
- 36. Flange bolt
- 37. Rocker cover, upper section
- 38. Rocker cover gasket
- 39. Rocker cover, lower section
- 40. Rocker cover gasket

## Valve mechanism

The purpose of the valve mechanism is to actuate the valves, causing them to open and close at the right times in relation to the position of the crankshaft and piston.

The camshaft is located high up and driven by the timing gears at the rear end of the engine so that it rotates at half the speed of the crankshaft.

The camshaft cams (lobes), two for each cylinder, actuate the valve tappets.

The pushrods have one end in the tappets and the other end, via the rocker arms, transfers the movement from the camshaft cam to the valves.

At one end of the rocker arm is an adjusting screw, the spherical lower end of which rests in the pushrod so that the tappet follows the camshaft at all times.

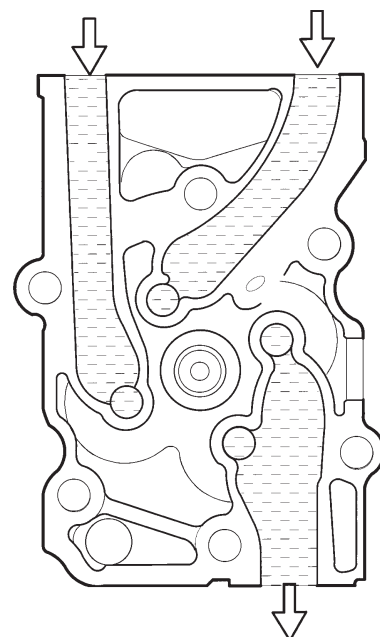
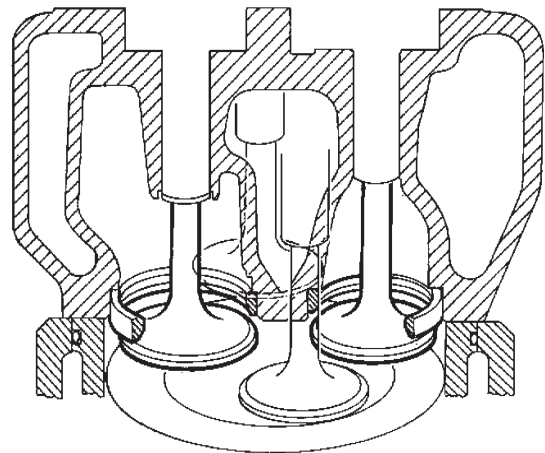
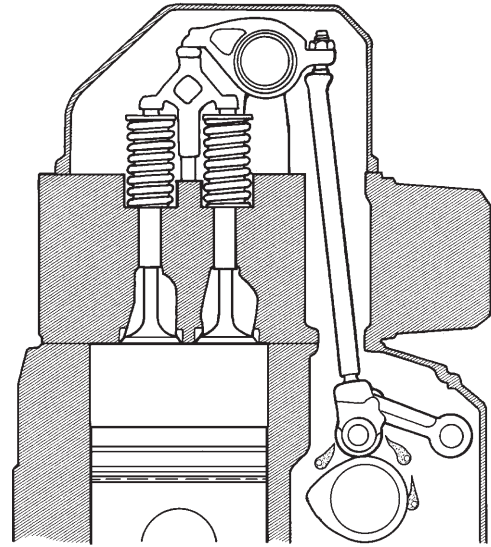
The correct clearance can be set with the adjusting screw to ensure that the valve will close properly during combustion.

The valves seal against valve seat rings which are pressed into the cylinder head to make a tight fit. The valve seat rings are made of extremely durable material to give them a long service life. Should it be necessary, they are replaceable.

With four valves per cylinder, the total valve area becomes greater, making it easier to fill the cylinder with air. At the same time, less energy is consumed in forcing out the exhaust fumes.

The effort required for gas flow is reduced and engine efficiency is improved. This in turn leads to a reduction in fuel consumption.

The injector can be located centrally, which improves combustion and results in reduced emissions and lower fuel consumption.



1. Open the bleeder nipple and drain the fuel system by undoing the banjo screw on the back of the fuel manifold.



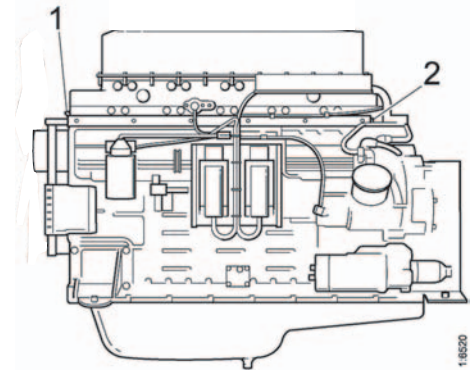
**WARNING!**

**The fuel system must be empty or 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.**

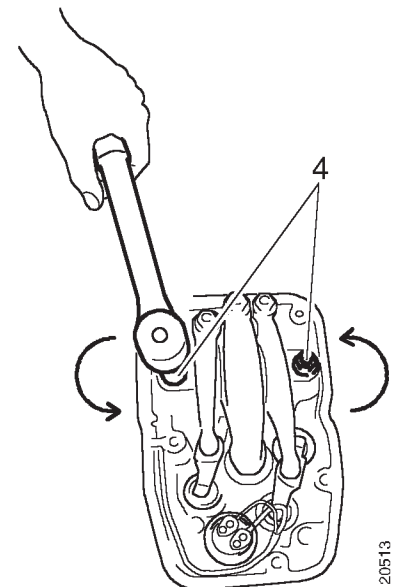
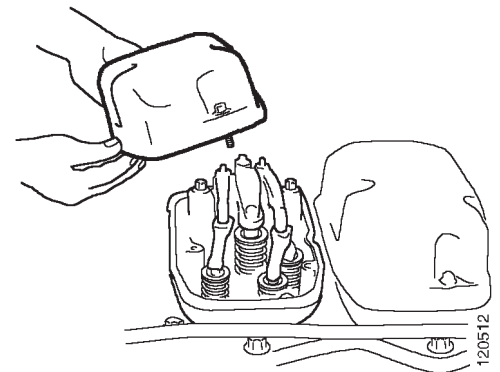
2. Clean the rocker cover and the surrounding area.

3. Remove the top part of the rocker cover.

4. Relieve the pressure on the valves by undoing the bolts on the rocker arm shaft alternately.



1. Bleeder nipple
2. Banjo screw



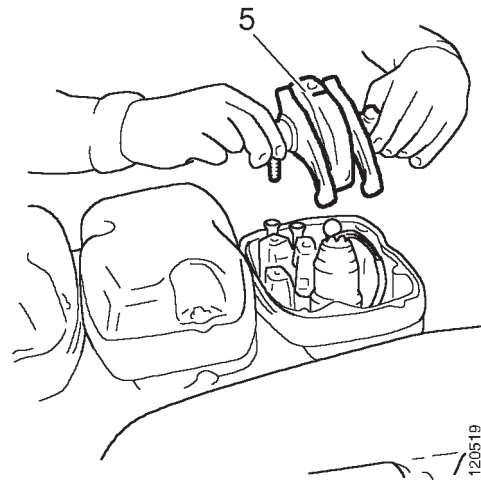


**WARNING!**

**Do not lean over the engine when removing the rocker arm shaft. The unit injector spring is pre-tensioned and can come loose, causing personal injury.**

**Note:**

**If the spring comes loose from the unit injector, the unit injector must be renewed.**



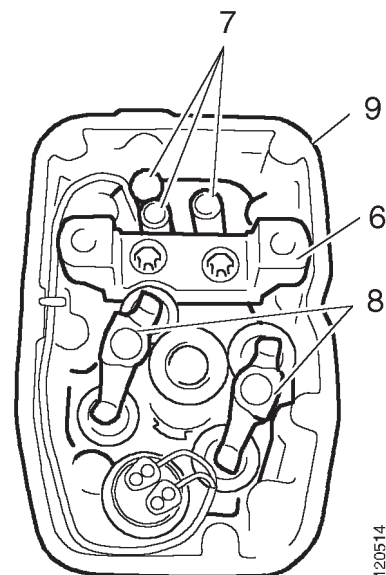
5.  
Remove the rocker arm shaft.

6.  
Remove the bearing bracket.

7.  
Remove the pushrods.  
Note: The pushrod for the unit injector is secured with a retaining ring. Jiggle and pull carefully on the pushrod to loosen it.

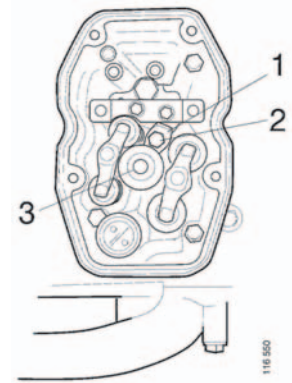
8.  
Remove the valve bridges.

9.  
Remove the lower rocker cover.



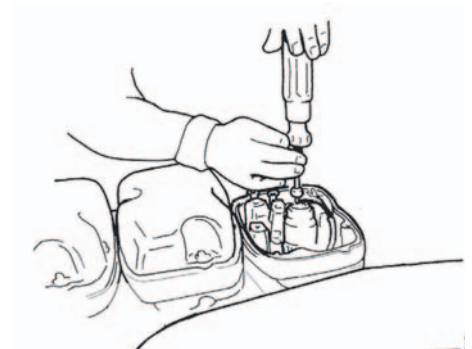


10.  
Remove the fork clamp bolt holding the unit injector in place.



1. Fork clamp  
2. Fork clamp bolt  
3. Unit injector

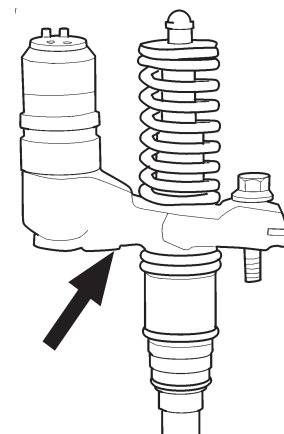
11.  
Detach the cables on the unit injector. The screws cannot be removed but undo them as far as possible.



**Note:**  
**Do not lift the unit injector by the spring.**  
**The spring can come loose.**

12.  
Turn the unit injector anti-clockwise until it stops. Place the slide hammer 87 596 between the solenoid valve and the edge of the lower rocker cover as illustrated.

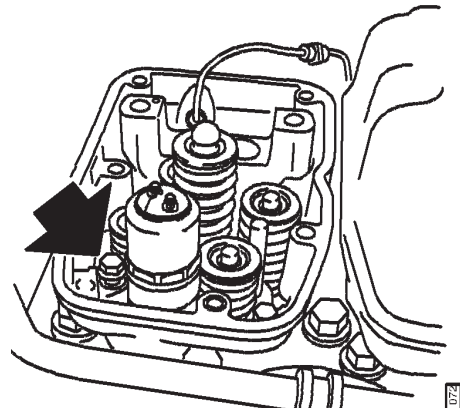
**Note:**  
**If the slide hammer is placed directly under the solenoid valve, there is a risk of breaking the solenoid valve.**



Place the slide hammer as indicated by the arrow.

13.

It is easier to position the slide hammer if one of the lower rocker cover bolts is removed.



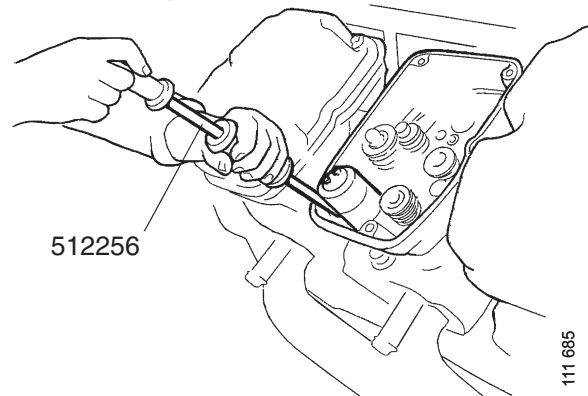
14.

Withdraw the unit injector. If the unit injector is stuck, tap carefully with a rubber mallet on the solenoid valve housing.

## Important!

**The unit injector is not to be dismantled.**

**Renew the entire unit.**



15.

Remove the sealing washer from the bottom of the injector seat, (if it was left behind when the unit injector was removed).

16.

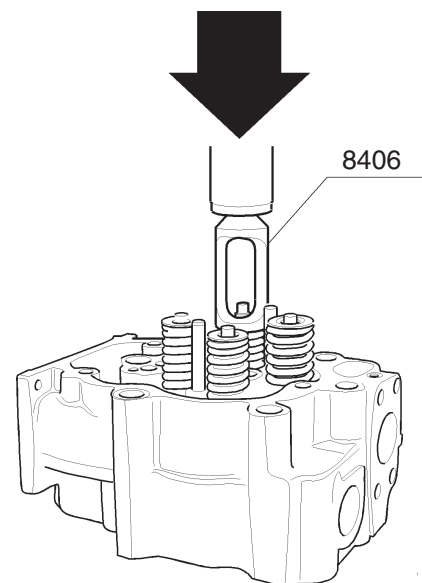
Detach the intake manifold, fuel manifold, ventilation pipe for the cooling system and the exhaust manifold.

17.

Remove the cylinder head. Mark the cylinder heads if more than one is being removed at the same time.

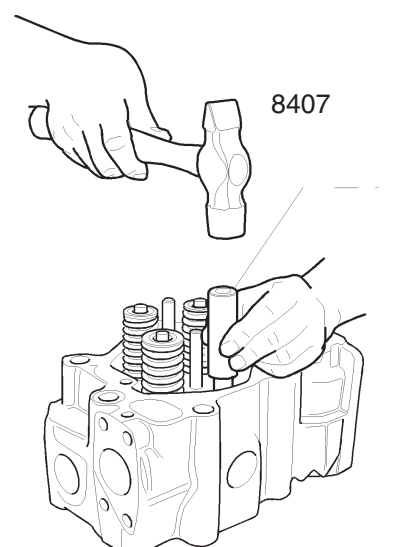
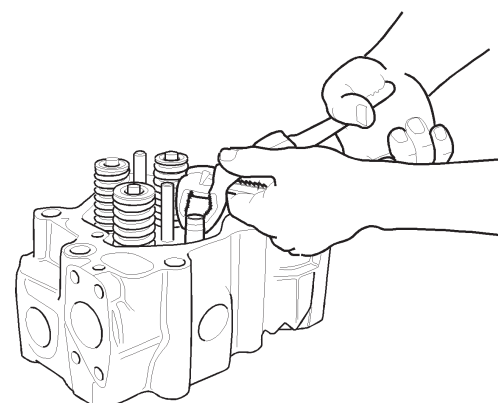
## Dismantling

1. Remove collets, valve spring collars, springs and valves. Press the spring down using tool 8406 in a press so that the collets can be removed.
2. Mark and place the valves in a rack so that they can be refitted in the same position in the cylinder head.
3. Mark the cylinder heads if more than one is removed at the same time.



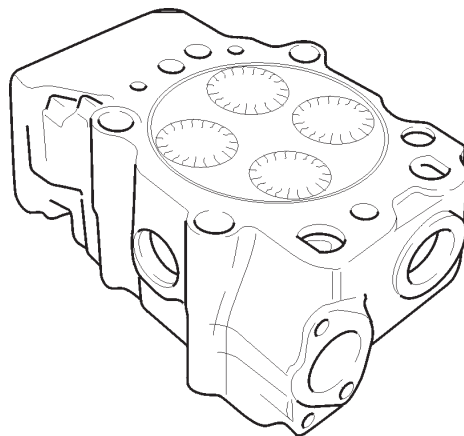
## Renewing the valve stem seal

1. Remove the valve.
2. Remove the valve stem seal with a pair of pliers.
3. Fit the valve.
4. Tap in a new valve stem seal carefully using tool 8407 and a hammer.



## Replacement of valve seats

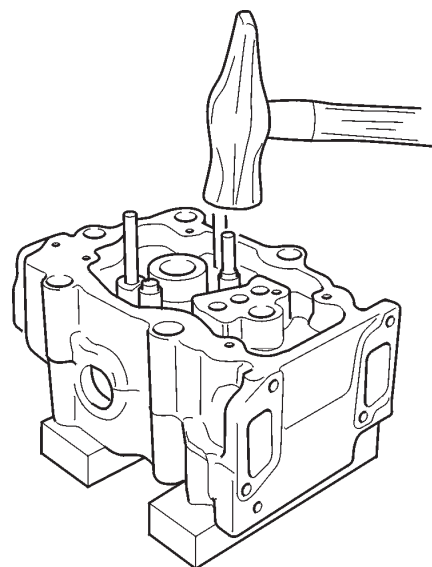
1. Remove the valve seat inserts. Use a discarded valve that has been ground so that the diameter of the disc is slightly smaller than the inside diameter of the seat.
2. Fit the valve and weld around it with an electric welder. Cool with water. Turn over the cylinder head and knock the valve stem so that the valve and seat insert fall out.



**WARNING!**

Use protective goggles. Always turn the cylinder head around with the underside downwards when tapping out the valve seat ring. Otherwise there is a risk of loose splinters causing personal injury.

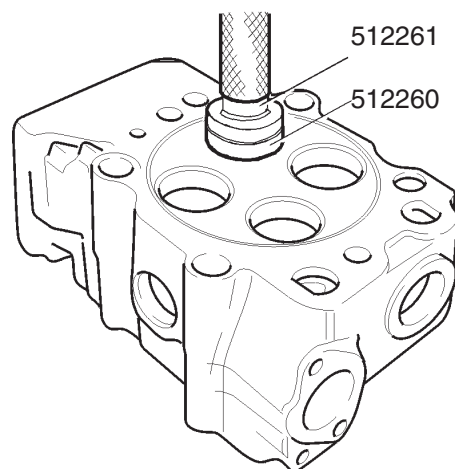
3. Press in new valve seat inserts. Use drift 512260 and handle 512261. Cool the drift and valve seat to approximately 80°C in dry ice or using liquid air. Pressing must be carried out rapidly.



**WARNING!**

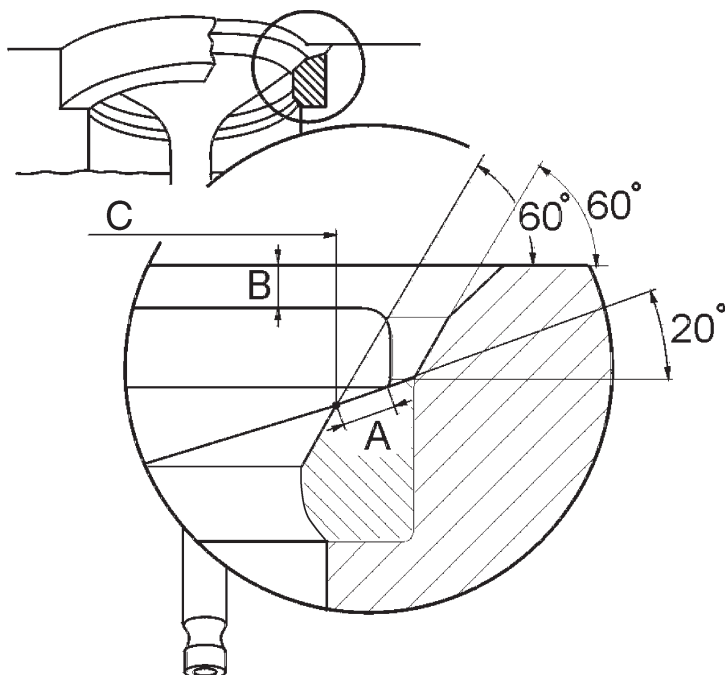
Be careful with the above-mentioned coolants and cooled components. There is a risk of frost injuries.

Oversize valve seat inserts can be fitted if the valve seat insert position has been damaged. If this is the case, the seat must be machined using valve seat cutter 512265.

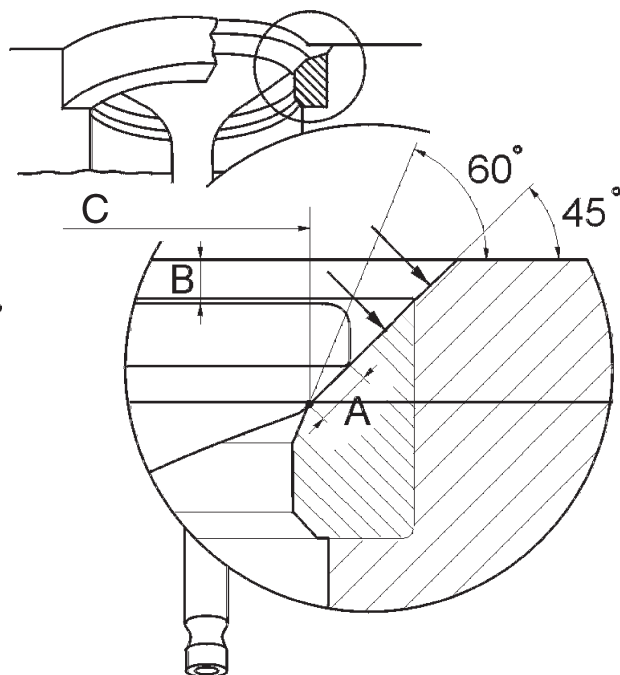


## Machining the valve seats insert

### Machining values



Inlet valve  
 A = 1,9 - 2,6 mm  
 B = 0,75 - 1,8 mm  
 C = diameter 39,8 +/- 0,5 mm  
 (setting value for machining tool)



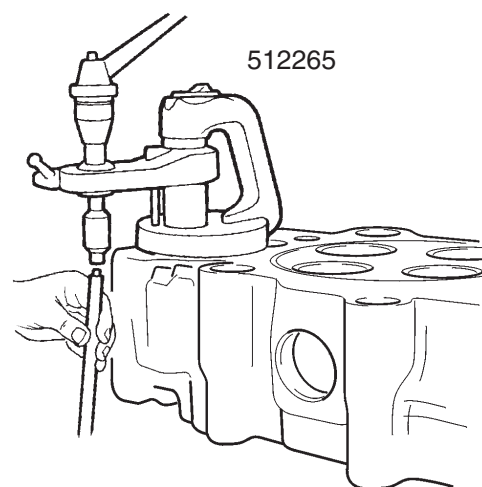
Exhaust valve  
 A = 1,8 - 2,6 mm  
 B = 0,66 - 1,8 mm  
 C = diameter 37,9 +/- 0,5 mm  
 (setting value for machining tool)

## Work description

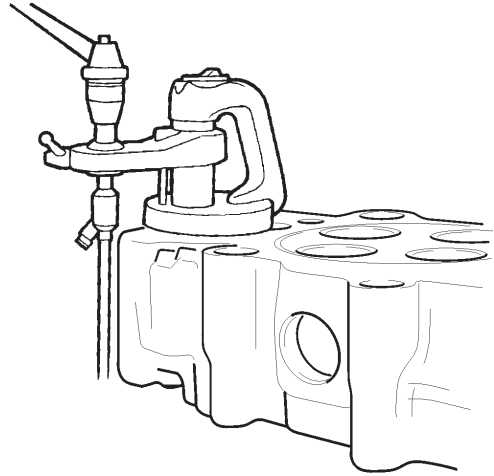
The following description applies to valve seat cutter 512265.

Machining values and over-sized valve seat inserts, see Specifications and above.

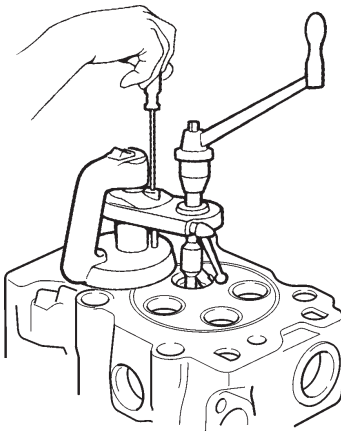
1.  
Check that the contact surface and the magnetic base are smooth and clean. Clean the valve bushings.
2.  
Select the largest spindle which slides easily into the valve guide. Insert the guide spindle and turn the feed screw to its uppermost position.



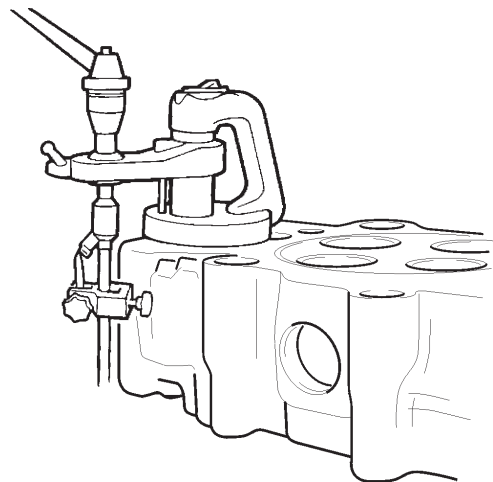
3.  
Select and fit the cutter.



4.  
Release the quick-action lock and move the pivot plate to the upper position with the adjusting screw.



5.  
Set up the dial on the cutter adjuster using a valve.

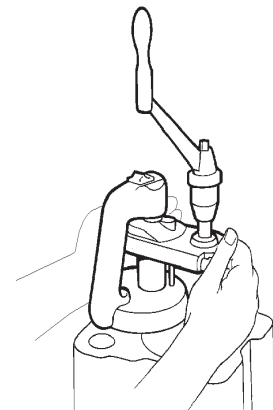


6.  
Adjust the cutter. Diameter 37.9 mm or 39.8 mm, see Machining values.

7.  
Disconnect the magnetic base (position 2). Insert the guide spindle into the valve bushing. Adjust the pivot plate so that the distance between the cutter and the valve seat is approximately 1 mm. Centre the tool precisely.

8.  
Connect the magnetic base (position 1).

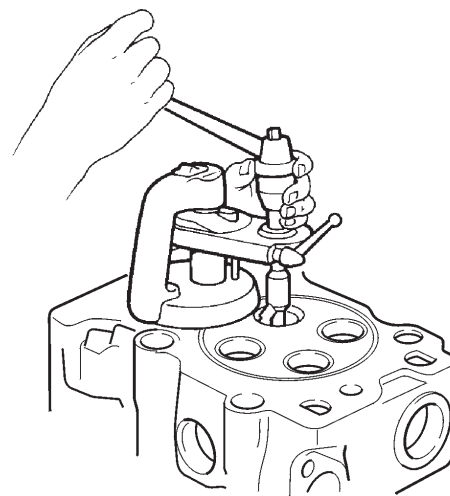
9.  
Apply the quick-action lock. Make sure the crank can be turned easily. If not, redo the centering.





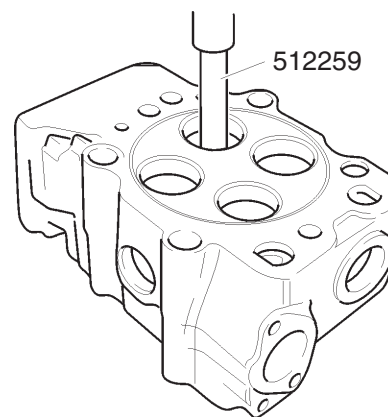
10. Machine the valve seat by cranking clockwise while turning the feed screw.  
Never crank counterclockwise, as this could damage the cutter.  
Lubricate with cutting oil during the procedure.

11. When the machining of the valve seat is completed, reduce the cutting pressure by turning the crank 23 turns without feeding.  
Then continue to turn the crank while turning the feed screw anti-clockwise. The valve seat cutter is now ready for the next valve seat.

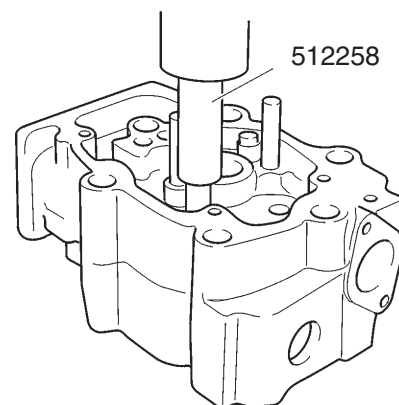


## Renewing the valve guides

1. Press out the valve guides using drift 512259.



2. Press in the new valve guides using drift 512258.  
Press the guide down as far as the drift allows, i.e. until it makes contact with the spring seat in the cylinder head.



## Renewing PDE unit injector sleeves

- The cylinder head must be removed when renewing the injector sleeve.
- The valves do not need to be removed.
- The illustration shows the cylinder head with valves removed to demonstrate clearly the work described.

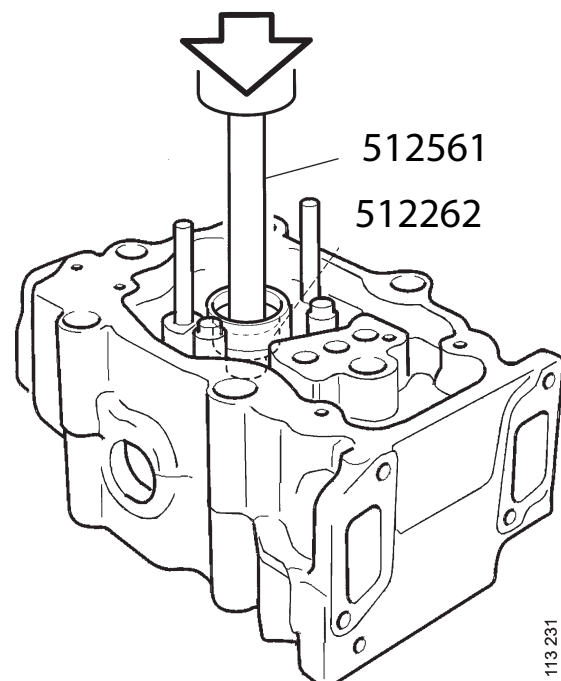
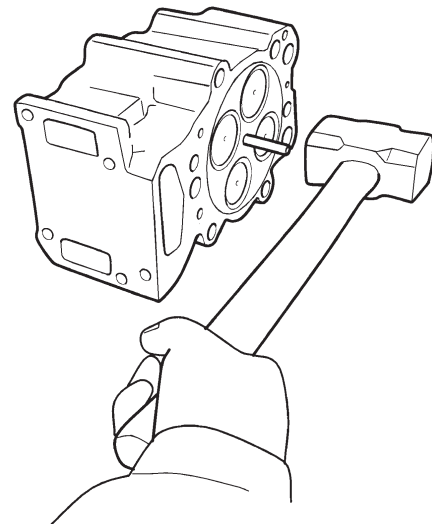
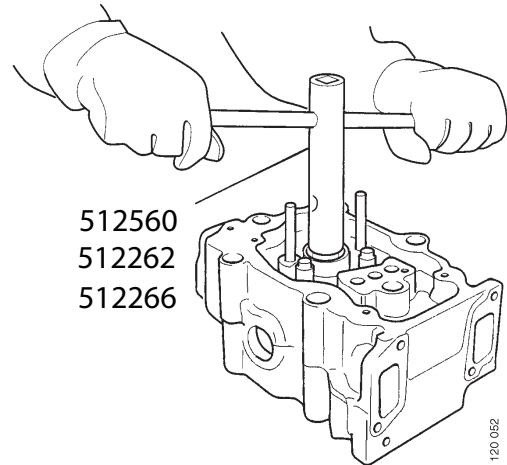
1.  
Thread the bottom part of the sleeve with pilot tap 512266 and guide 512262 512560

2.  
Knock out the pilot tap and sleeve from underneath. Use a 100 mm metal rod with a 9 mm diameter.

3.  
Degrease and check the contact surfaces of the sleeve and cylinder head. Smooth off any burrs and irregularities that may score the sleeve.

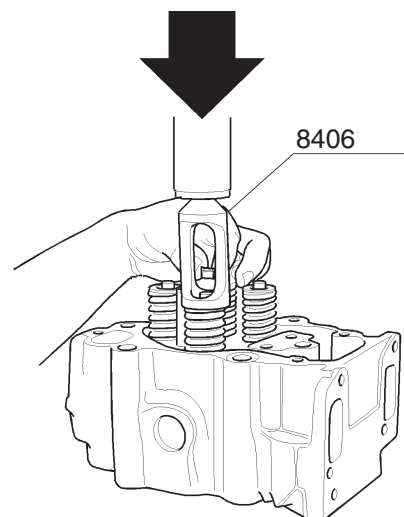
4.  
Degrease the new injector sleeve and apply a thin film of sealing agent 351161-- on the sleeve and cylinder head contact surfaces.

5.  
Press in the sleeve with drift 512561 and guide 512262



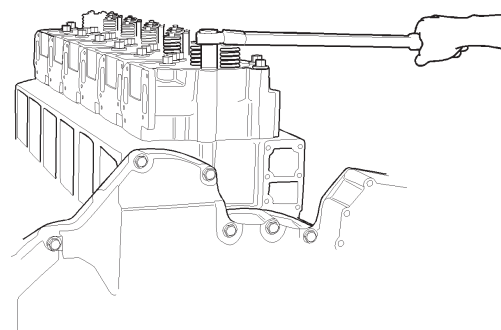
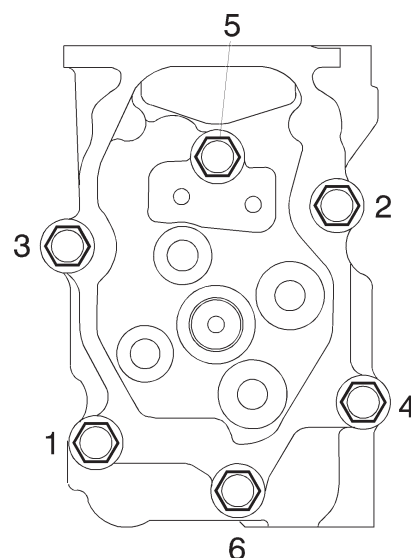
## Assembly

1. Lubricate all parts well with engine oil before assembly.
2. Fit the valves in their guides and position the cylinder head in a press.
3. Fit the valve springs and the valve spring collars.
4. Compress the springs using tool 8406 and fit the collets, making sure that they go into their correct positions.



## Fitting

1. Check liner height, refer to Measuring the cylinder liner height.
2. Fit a new cylinder head gasket.
3. Fit the cylinder head and ensure that the guide pins fit into the holes.
4. The cylinder head bolts can be reused up to 3 times. Therefore, make sure the bolts have no more than 2 punch marks on top of the bolt head. If any of the bolts has 3 marks, it must be replaced with a new one.
5. Lubricate the threads on the cylinder head bolts and the surface under the head.
6. Tighten the bolts in the order given in the figure and in three stages + 90° as follows:
  - Tighten all bolts to 60 Nm
  - Tighten all bolts to 150 Nm
  - Tighten all bolts to 250 Nm
  - Finally, tighten all bolts a further 90°
  - Make a mark with a centre punch on the head of the bolt.
7. Fit the lower part of the rocker cover and tighten the bolts to 26 Nm.



## PDE Injectors

Each unit injector consists of a pump element, a solenoid valve and a nozzle. In this way, it is possible to control the fuel injection for each individual cylinder.

EMS (Engine Management System) is the electronic system that controls both how much fuel each unit injector should inject into the cylinder and also when the unit injector should inject the fuel.

This control of the injection means that we can optimise the combustion, which in turn leads to cleaner exhaust gases.

The control unit is the brain of the EMS system. The control unit processes the information both from the sensors and the components that are part of the EMS system and also from the control units in other systems.

When the control unit has processed the information, it then transmits signals to the unit injectors.

The signals control the injection of the fuel.

The EMS system makes possible such functions as for example a special cold start programme.

### Fitting the PDE injector

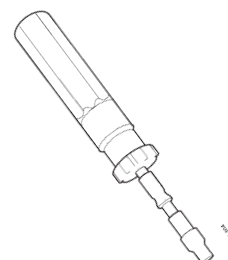
#### Specifications

Tightening torques:

Lock nut on rocker arm	39 Nm
Bolt for fork on unit injector.	20 Nm + 75°
Bearing bracket and rocker arm shaft	105 Nm
Screws for cable connections on unit injector	2 +/- 0.2 Nm

Special tools

<b>Number</b>	<b>Description</b>	<b>Illustration</b>
512562	Torque screwdriver	



**IMPORTANT!**

**Check the unit injector spring diameter before adjusting and ensure that the correct tool is used when adjusting the unit injector.**

**Note:**

All work that involves opening the fuel system must be completed in the following way:

Start the engine and check for leaks. Allow the engine to run until it is running smoothly.

Check and delete any fault codes that are registered in the control unit after the work has been completed.

1

Make sure that the old seal is not at the bottom of the injector seat. Clean the sealing surfaces in the injector seat.

**IMPORTANT!**

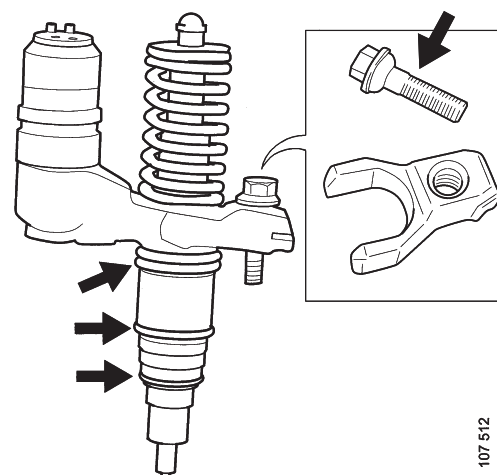
**Always renew the flange screw, O-rings and seal on unit injectors that have been removed. Make sure all sealing surfaces are clean.**

2

Lubricate the unit injector O-rings with O-ring grease, part No. 512086

3

Fit a new sealing washer on the unit injector. A rubber insert will keep the seal in place on the unit injector.



107 512



**WARNING!**

**Check that there is no fuel left in the cylinder.**

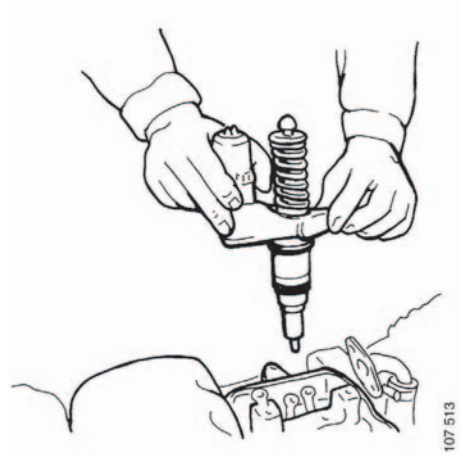
**If fuel runs into the combustion chamber, it must be removed immediately using a pump.**

**Note:**

Make sure that the fork clamp and bolt are dry and free of oil.

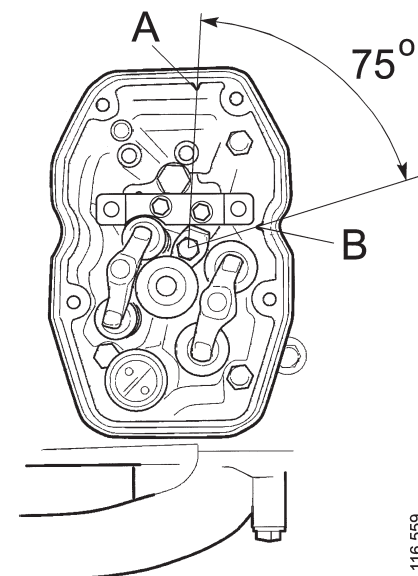
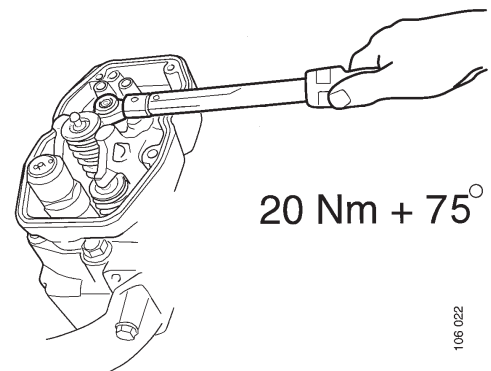
4

Place the fork clamp with screw in position on the unit injector and insert it into the cylinder head. Press down the unit injector by hand as far as possible.



5

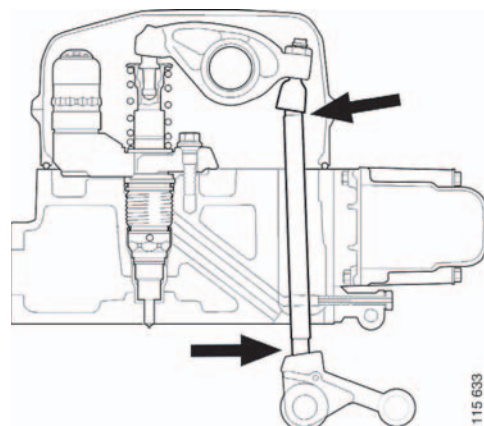
Torque tighten the bolt to 20 Nm and then a further 75°. There are two marks on the rocker cover with a 75° angle between them.





**IMPORTANT!**

Make sure the pushrods are placed in their correct positions. Make sure the pushrod to the unit injector is firmly secured in its lower position by the retaining ring.



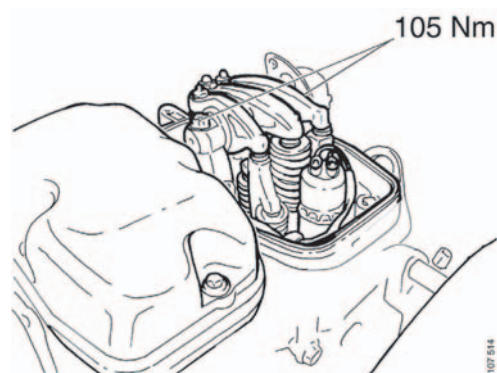
115 633

**IMPORTANT!**

If the rocker arms have been removed on more than one cylinder, the rocker arm lock bolts must be completely unscrewed before adjustment commences.

6

Refit the rocker arm shaft. Screw in the bolts alternately so that they are tightened in parallel or one of the bolts may bend. Tighten the bolts to 105 Nm.



107 514

7

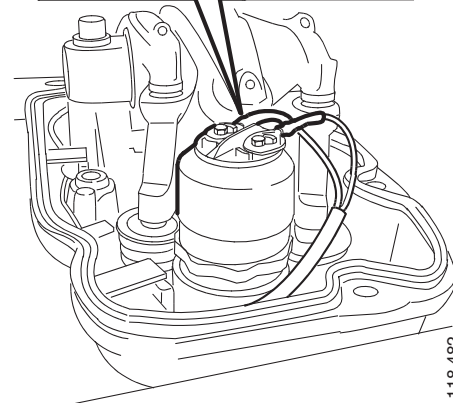
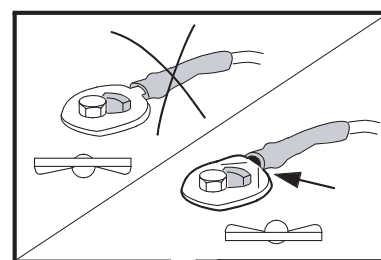
Check and adjust the unit injector as described in the section:  
Testing & Adjusting / Checking/adjusting the injector rockers.

**IMPORTANT!**

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

8

Reconnect the cables on the unit injectors. Their relative position is not important. Use torque screwdriver 588 179 to tighten the screws to 2 Nm.

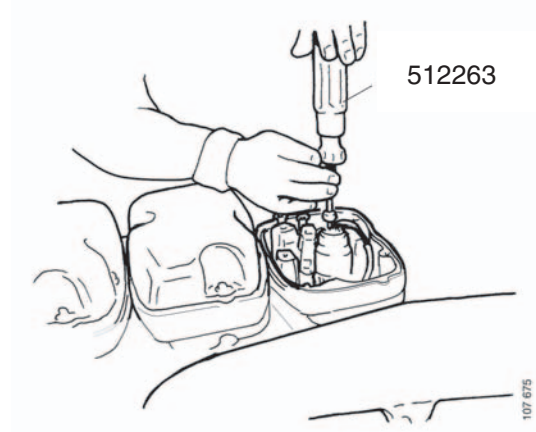


118 482

**IMPORTANT!**

Use torque screwdriver 512562 to avoid the risk of shearing off the screws.

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



9

Refit the upper rocker cover and torque tighten the bolts to 18 Nm.

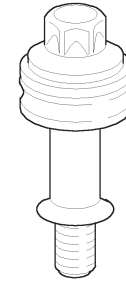
10

Close the bleed nipple and tighten the banjo screw.

11

Fill and bleed the fuel system. Refer to Bleeding the fuel system.

18 ± 3Nm

**Adjusting unit injectors**

Important! The PDE31 unit injector is adjusted using setting tool 512264 or a digital sliding caliper.

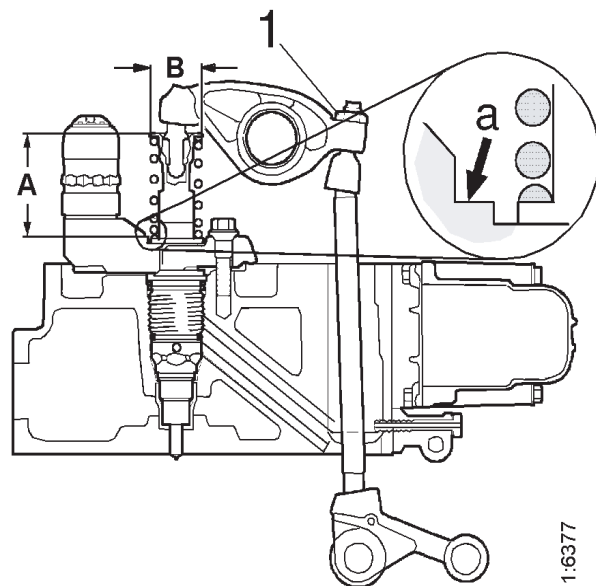
This adjustment is important because an incorrectly positioned unit injector may result in poor performance and possible breakdown.

Screw on the rocker arm adjusting screw 1 while measuring the distance between plane a and the top of the valve spring collar using a digital sliding caliper.

**NOTE !****Machine 710656 (Tier 3) - :**

Dimension A = PDE32: 69.9 +/- 0.1 mm

Dimension B = PDE32: 38,5 mm

**Tightening torques**

Lock nut on rocker arm:

39 Nm

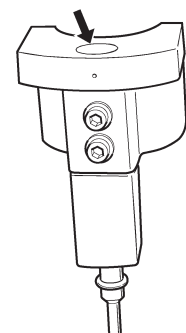
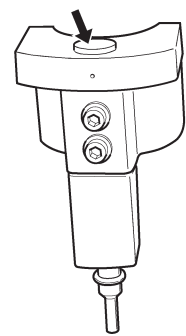
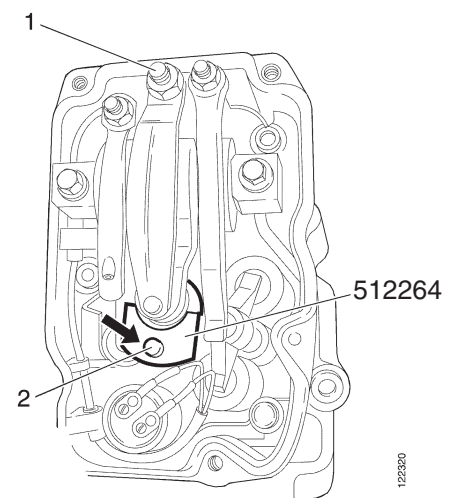
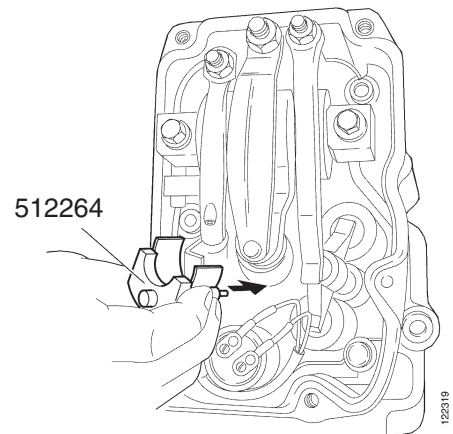


**WARNING!**

**Take care when carrying out the adjustment if the dimension is well outside the adjustment dimension. The spring is pre-tensioned and can cause personal injury if it is released.**

### PDE32

1. Position setting tool 512264 with the metal plate around the injector spring.
2. Finely adjust dimension A by simultaneously using a finger to sense that the small piston 2 is level with the flat upper surface of the tool.  
It is possible to sense differences of less than a tenth of a millimetre.
3. If tool 512264 is not available:  
Measure the distance between plane a and the top of the valve spring collar using a digital sliding caliper. Adjust the rocker position by means of the adjusting screw until the dimension is 69.9 +/- 0.1 mm.
4. Tighten the lock nut to 39 Nm.



## Adjusting the valve clearance and unit injectors

1.  
Fit the unit injector according to the section  
Fitting the PDE injector, steps 1-11.
2.  
Fit the pushrods.
3.  
Fit the bearing bracket and torque tighten the  
bolts to 115 Nm.
4.  
Fit the valve bridges.

Important!  
Lubricate the valve bridges with engine oil.

5.  
Continue according to the section:  
Fitting the PDE unit injector steps 6 - 11

### Note:

**Check and adjust the valve clearance and unit injectors at the same time and with the engine cold.**

### Checking and adjusting the valve clearance:

1.  
Turn the flywheel with tool 8405 so that the piston in cylinder  
No. 1 is at TDC after compression.
2.  
Check the valve clearance using a feeler gauge and, if necessary,  
use the adjusting screw on the rocker arm to set the correct  
clearance.

The clearance for intake valves should be      0.45 mm  
and the  
clearance for exhaust valves should be      0.70 mm  
**when the engine is cold.**

The intake valves are actuated by the short rocker arms and the  
exhaust valves by the long rocker arms. Make sure the valve  
bridge is resting correctly against the valves.

See the table next page.

### Checking, adjusting the PDE32 injector rocker arms (I)

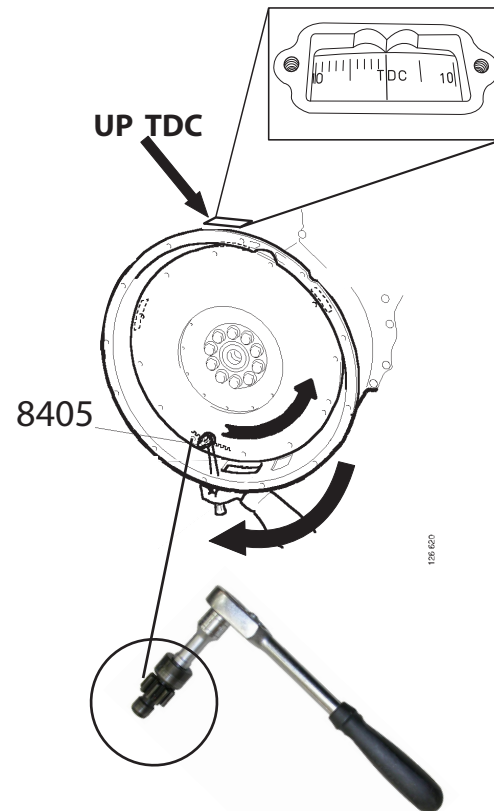
- Turn the flywheel with tool 8405 to valve overlap on cylinder 1 (which corresponds to TDC Up (0°) in the opening). Then turn the flywheel anti-clockwise 144° at a time and observe the valve overlap. Adjust the valves according to the table below.

Firing order: 1-2-4-5-3



**FLYWHEEL**

Cylinder numbering

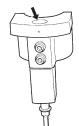
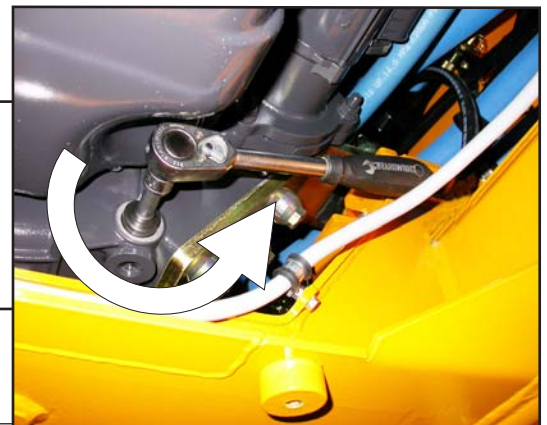


**NOTE !**

The adjustable value for the injectors are aprox ±0,2 mm. If the value is e.g. 0,8-1,0 mm, then check the position of engine.

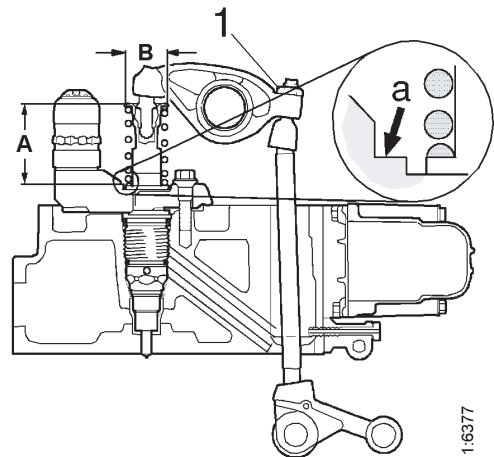
Start the adjusting prosedure again and follow the table below.

Valve overlap on cylinder		Adjust the valves on cylinder	Adjust unit injector rocker arm on cylinder
TDC Up (0°)	1	5	5
	2	3	3
	4	1	1
	5	2	2
	3	4	4

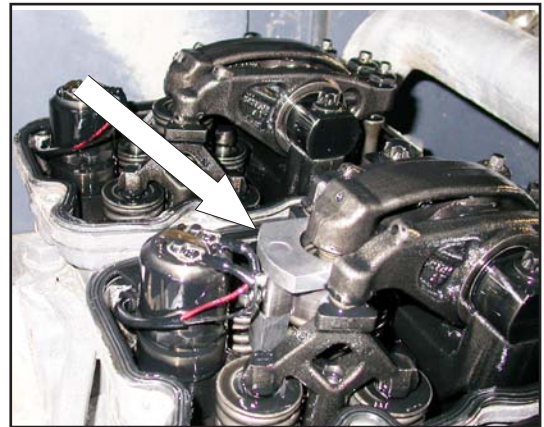


Dimension A= PDE32: 69.9±0.1 mm

Dimension B= PDE32: 38.5 mm



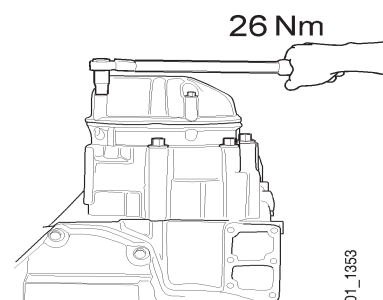
Placing of the tool 512264



Check the clearance, using a finger to sense that the small piston is level with the flat upper surface of the tool.

It is a good idea to mark the rocker arm with a pen after adjustment to keep track of what has already been adjusted.

Torque tighten the lock nut to 39 Nm after adjusting.





## Turbocharger

The purpose of the turbocharger is to increase the volume of air entering the engine's cylinders. With more air the engine can burn more fuel and so develop more power and achieve cleaner combustion than a corresponding engine without supercharging.

The turbocharger is driven by the engine's exhaust gases and consists of a turbine part and a compressor part. The compressor part compresses the engine's intake air.

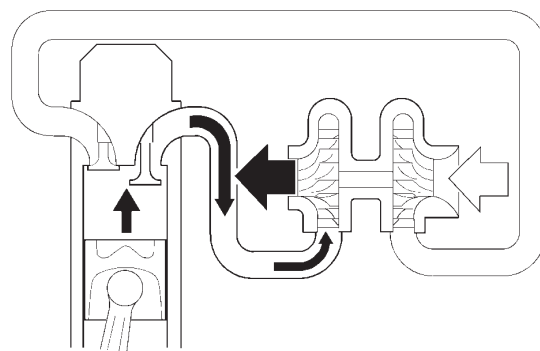
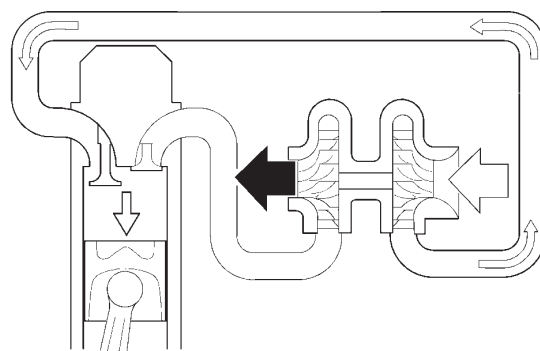
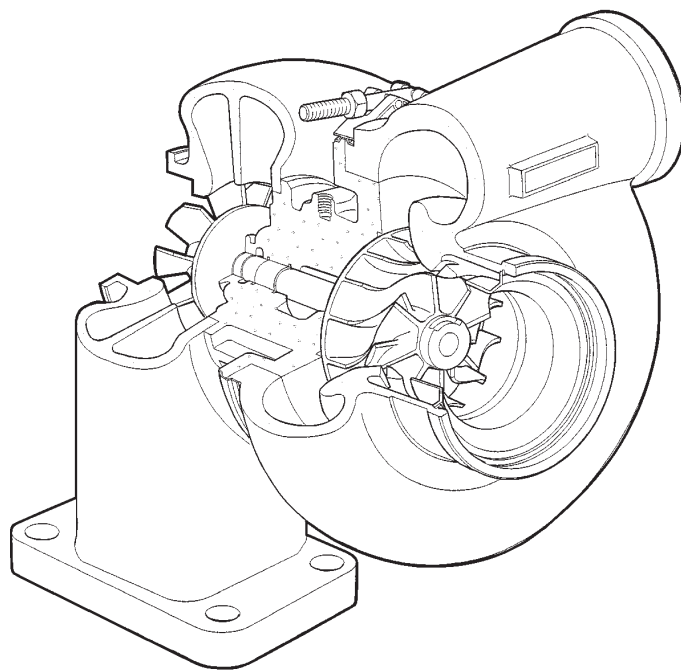
The compressor wheel is mounted on the same shaft as the turbine wheel. This shaft runs in a bearing housing between the compressor and turbine.

Higher power output from the engine gives more exhaust fumes and the increased exhaust means that the turbine wheel and therefore the compressor wheel rotate faster. In this way, the quantity of air is adapted to engine requirements without any special control devices.

The turbocharger wheel rotates extremely fast. At full power, speed is about 100,000 rpm. At the same time, the temperature on the exhaust side of the turbine wheel is above 600°C.

This makes big demands on the rotating parts in regard to balance, cooling and lubrication.

The shaft is mounted in two bushings which rotate freely in the bearing housing. The bearing housing seals for the turbine and compressor consist of seals which are similar to piston rings.





## General

### NOTE!

**Whenever working on the turbocharger, observe utmost cleanliness. The oil intake and outlet connections must never be left open. A foreign body in the bearing housing can quickly cause total breakdown.**

### Oil leakage

With a clogged air cleaner, the vacuum in the intake pipe will be excessive. There is then a risk that oil mist will be sucked out of the turbocharger's bearing housing.

If the seal on the turbine side is worn, exhaust gas is blue when idling.

If the oil outlet pipe from the turbocharger is damaged, there is a risk of oil leaking out through the seals due to lubrication oil pressure.

### Oil filter

The turbocharger rotates at high speed, sometimes above 100.000 rpm.

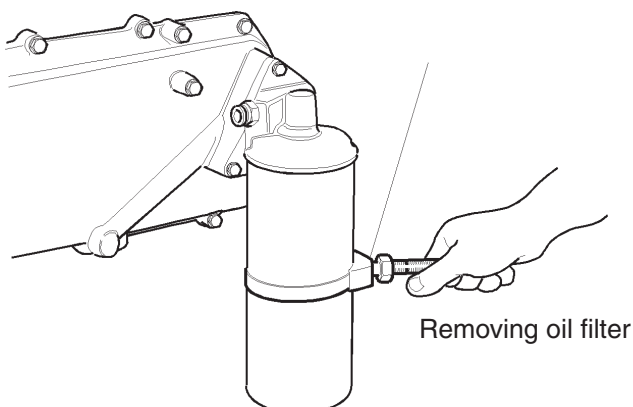
The oil lubricates and cools the turbocharger. Efficient lubrication is extremely important. There is no separate turbo filter and the oil passes through the engine oil filter. For this reason, change the oil filter and clean the oil filter assembly in accordance with our instructions.

Use filter wrench **8388** when removing the oil filter.

If the oil filter assembly is not cleaned, the oil filter will soon become clogged and its resistance to the flow of oil will increase.

A valve in the filter holder then opens and allows the oil to pass through the filter without being cleaned (filtered). Unfiltered oil is consequently supplied to the turbocharger with heavy bearing wear as a result.

The valve is designed for genuine Moxy filters and only these should be used.



### Foreign bodies

Foreign bodies, such as grains of sand or metal filings, in the turbine or compressor will damage their blades.

This leads to imbalance and bearing wear. Engine output falls off and continued operation could give rise to overheating damage on account of a decrease in the supply of air.

This type of overheating cannot be observed on the coolant temperature gauge.

### NOTE!

**Never attempt to straighten a damaged impeller. It will usually break in operation causing the turbocharger to break down and may also cause enginedamage.**

**Change the entire turbocharger.**

### Air and exhaust leakage

Even small leaks in the line between the air cleaner and turbocharger cause dirt deposits on the compressor wheel.

Charge pressure decreases with increased exhaust temperature, causing smoke. In addition, the engine is worn unnecessarily.

Exhaust leakage between cylinder head and turbocharger also results in lower charge pressure.

### Cleaning the compressor wheel

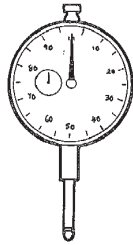
Low charge pressure can be caused by a dirty compressor wheel, for example.

- Remove the compressor housing.
- Wash the compressor wheel using white spirit and a brush.
- Fit the compressor housing and measure charge pressure again.

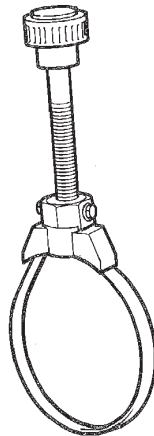
### NOTE!

**The compressor wheel must not be removed from the shaft. Imbalance may occur when it is refitted.**

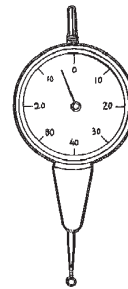
**Special tools**



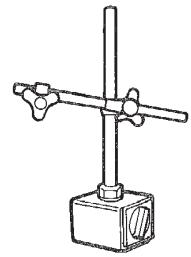
8014



8388



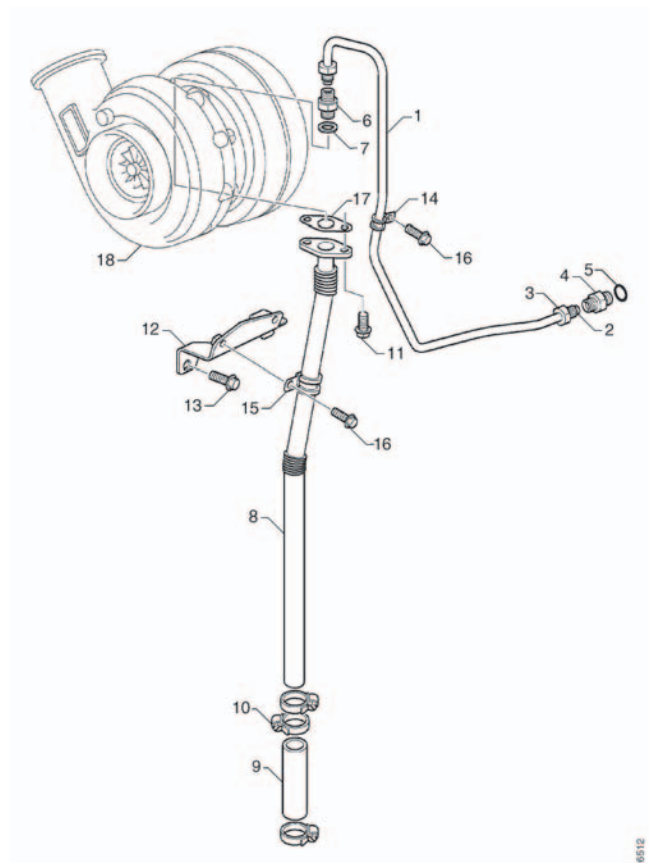
8389



8391

- 8014 Dial gauge
- 8388 Filter wrench
- 8389 Deflection gauge
- 8391 Stand

- 1. Lubrication oil pipe
- 2. Ferrule
- 3. Union nut
- 4. Straight union
- 5. Seal
- 6. Straight union
- 7. Gasket
- 8. Lubrication oil return pipe
- 9. Hose
- 10. Hose clamp
- 11. Bolt
- 12. Bracket
- 13. Bolt
- 14. Clamp
- 15. Clamp
- 16. Bolt
- 17. Gasket
- 18. Turbocharger



16512

## Measuring radial clearance and axial clearance

Measuring radial clearance and axial clearance does not usually give any indication of the remaining service life of the turbocharger.

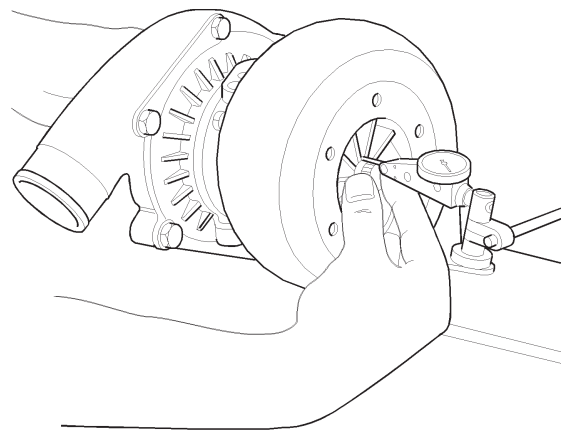
When the turbocharger is not working correctly or sounds abnormal, measuring charge pressure or measuring radial clearance or axial clearance can show that the turbocharger is defective.

To measure axial and radial clearances it is advisable to remove the turbocharger and bolt it to a steel plate, which will also serve as a base for the magnetic stand holding the dial gauge.

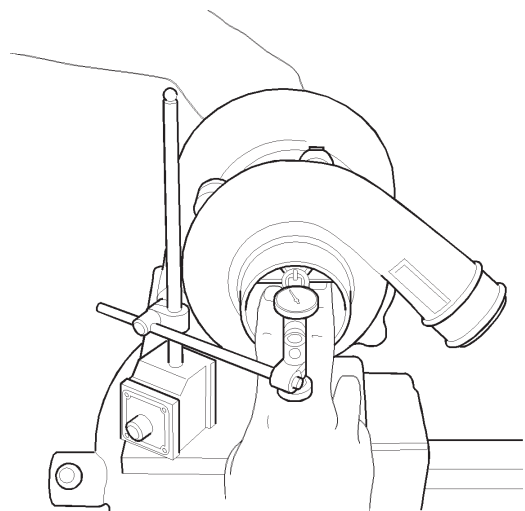
### Radial clearance

Take readings on both turbine wheel and compressor wheel.

1. Place the tip of the deflection gauge against the turbine wheel and compressor wheel.
2. Pull both ends of the shaft up. Take a reading.
3. Press both ends of the shaft down. Take a reading. The difference between readings is radial clearance.
4. Repeat measurements three times on each side.
5. If any wheel rubs against the housing, despite radial clearance being within tolerance, the turbocharger should be changed.



Measuring turbine wheel radial clearance with deflection gauge 8222 and measuring stand 8209



Measuring compressor wheel radial clearance with deflection gauge 8222 and measuring stand 8209

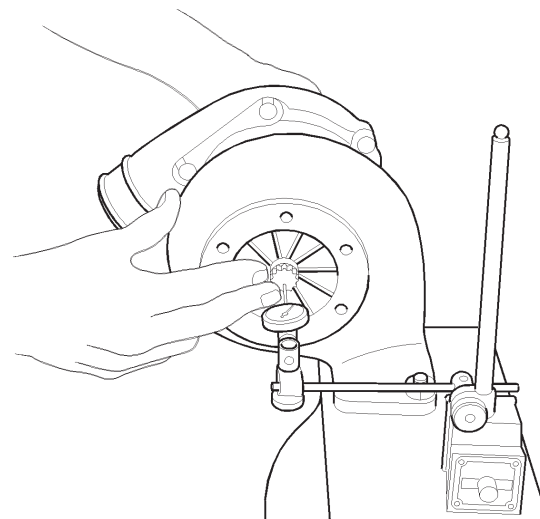
**Axial clearance**

1.  
Place the tip of the dial gauge **8014** against the end of the shaft.
2.  
Press the shaft forwards and backwards and read the dial at the end positions. The difference between readings is axial clearance.
3.  
Repeat measurements three times.

**Wear limits for Holset:**

Radial clearance            **0.198-0.564 mm**

Axial clearance  
(after running in)        **0.025-0.106 mm**



Measuring axial clearance with dial gauge 8014 and measuring stand 8391

**If the turbocharger does not work:**

1.  
Check that there is no leakage or loose objects in the line between the air cleaner and turbocharger.
2.  
Check that there are no loose particles in the exhaust manifold or intake manifold.
3.  
Check that all valves are intact.
4.  
Check the lubrication oil return pipe from the turbocharger for blockage or deformation.
5.  
Check the oil delivery pipe to the turbocharger for any blockage, deformation and leakage under pressure.
6.  
Check the condition and part number of the oil filter.
7.  
Check that the air filter is not blocked and that there are no other reasons for the abnormal increase of vacuum in the intake system.
8.  
Check that engine output is correct. Excessively high output reduces the life of the turbo.

## Renewing the turbocharger

### Note:

**When renewing the turbocharger, all gaskets and the oil filter must be changed and the centrifugal cleaner must be cleaned.**

### Removal

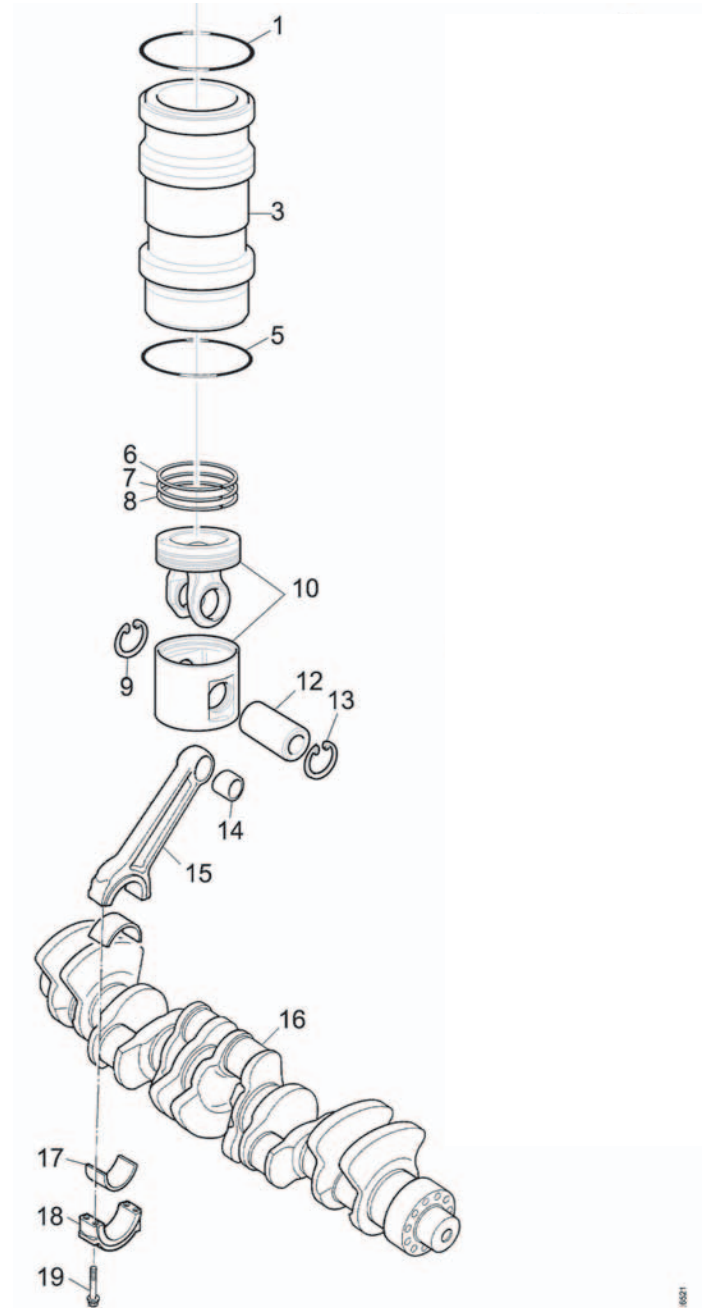
1.  
Detach the delivery and return oil lines from the turbocharger.
2.  
Detach the exhaust pipe, induction pipe and charge air cooler pipe from the turbocharger.
3.  
Undo the bolts in the turbocharger base and remove the turbocharger.

### Fitting

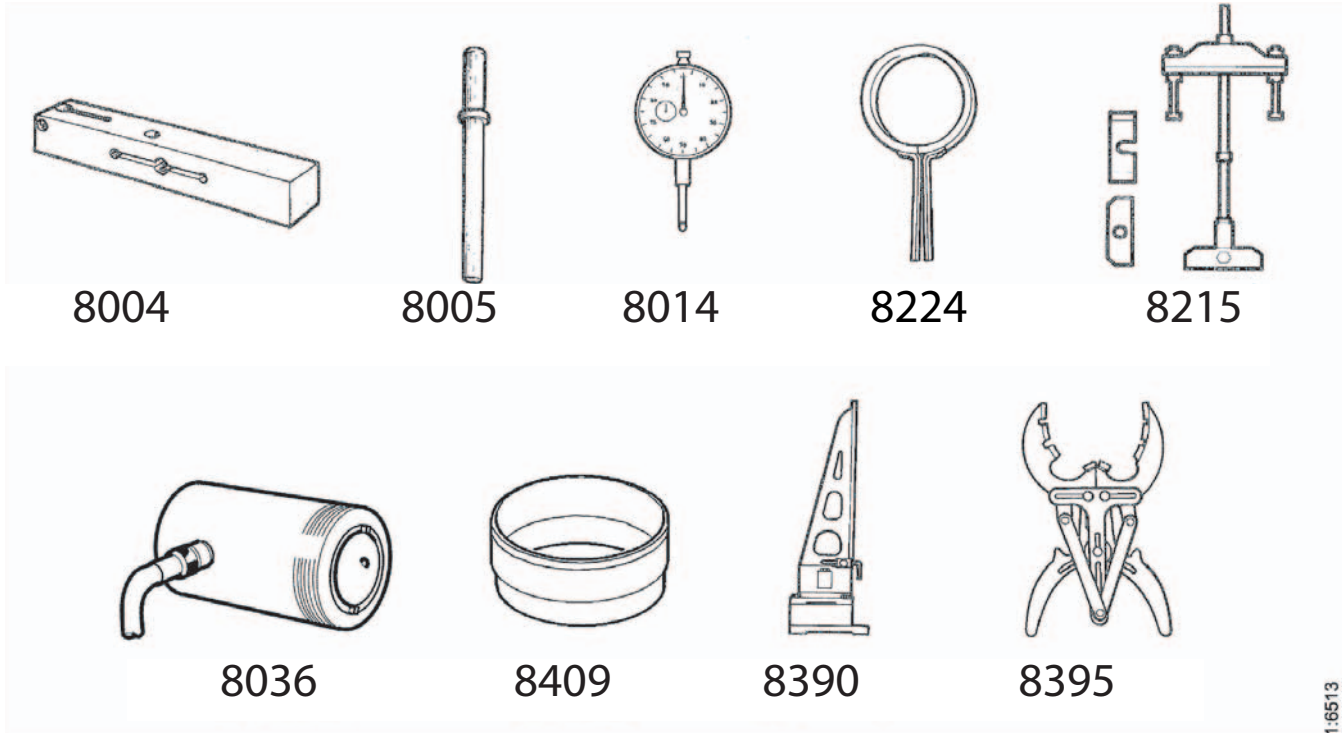
1.  
Check the connecting flange on the exhaust manifold to ensure that there are no remnants of the old gasket.
2.  
Fit a new gasket and bolt on a new turbocharger. Lubricate the exhaust manifold bolts with high-temperature resistant lubricant, part No. 561 205.  
Tighten the turbocharger to 50 Nm and the exhaust manifold to 59 Nm.
3.  
Connect the oil supply and return lines.
4.  
Connect the charge air pipe, induction pipe and exhaust pipe.
5.  
Disconnect the fuel valve's power supply (fuel shut-off) and turn the engine over with the starter motor for at least 30 seconds so that the lubricating oil will reach the turbocharger.
6.  
Start the engine and check that there is no leakage.

# Pistons and cylinder liners

1. O-ring
3. Cylinder liner for steel piston
5. O-ring
6. Compression ring
7. Compression ring
8. Oil scraper ring
9. Circlip
10. Steel piston
12. Gudgeon pin
13. Circlip
14. Bearing bushing
15. Connecting rod
16. Crankshaft
17. Bearing shell
18. Bearing cap
19. Flange bolt



## Special tools



8004	Rule for dial gauge
8005	Drift
8014	Dial gauge
8224	Piston ring compressor
8028	Pressing tool
8036	Hydraulic cylinder
8215	Puller for cylinder liner
8049	Impact drift
8401	Dismantling tool
8409	Assembly tool
8390	Test apparatus for connecting rods
8395	Piston ring expander

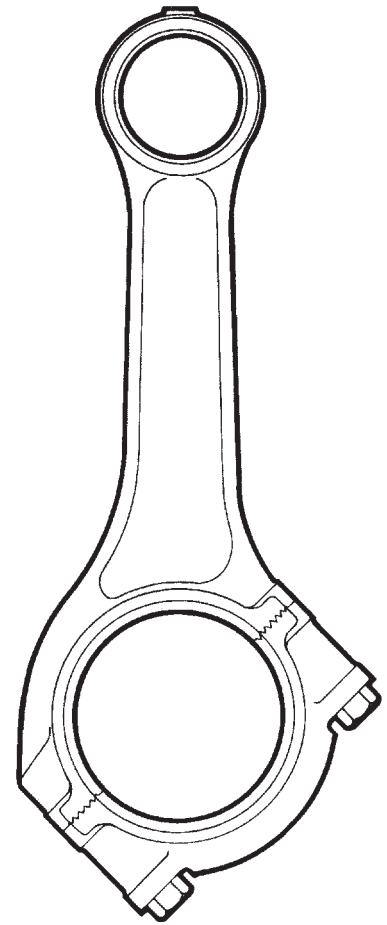
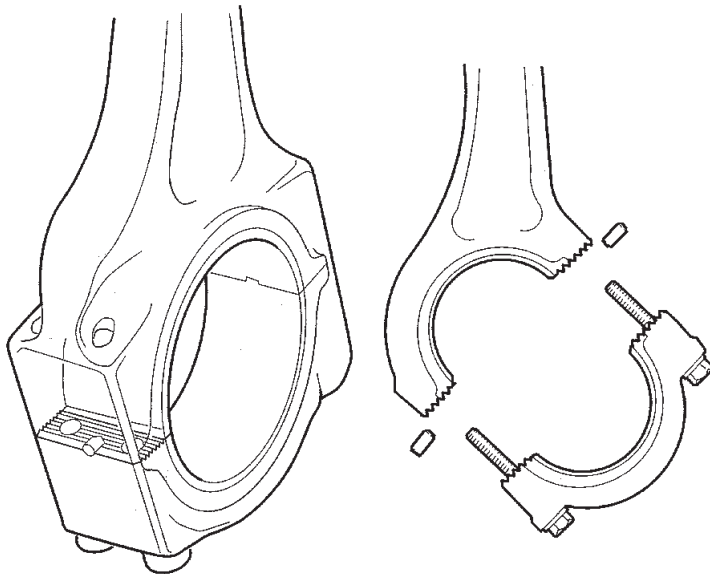


## Connecting rods

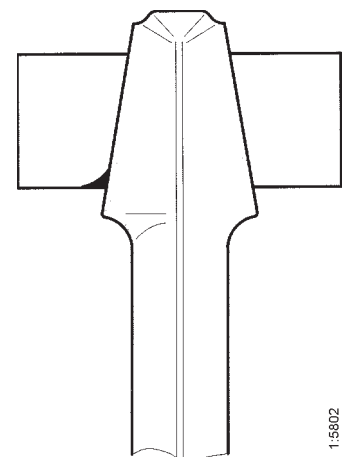
The connecting rod and big-end cap consist of a single casting which is split during the machining operation.

To prevent the big-end cap from being displaced in relation to the connecting rod, the contact surfaces are provided with grooves and guide pins. The surfaces are machined together to ensure a precise and accurate fit. The parts are also marked so that they can always be fitted in the same position.

The connecting rod and big-end cap are split obliquely, partly so that the con rod bolts will not be subjected to excessive loads and partly to enable the piston and con rod to be withdrawn through the cylinder.



The upper part of the connecting rod is wedge shaped. This allows a larger journal surface on the underside of the gudgeon pin where load is greatest during combustion.



1:5802

## Removing and dismantling connecting rods and pistons

1. Remove the cylinder head and oil sump.
2. Remove the piston cooling nozzle in the cylinder block.

### Note:

**The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be straightened. They must be renewed**

3. Remove the bearing cap and bearing shells. Protect the oil way in the crankcase using, e.g. adhesive tape, applied with the sticky side out.
4. Mark the piston and connecting rod before removing them. They must be refitted in the same place and in the same way.
5. Lift out the piston and connecting rod.

6. Place the connecting rod in a vice with soft jaws. Remove the retaining rings for the gudgeon pin.

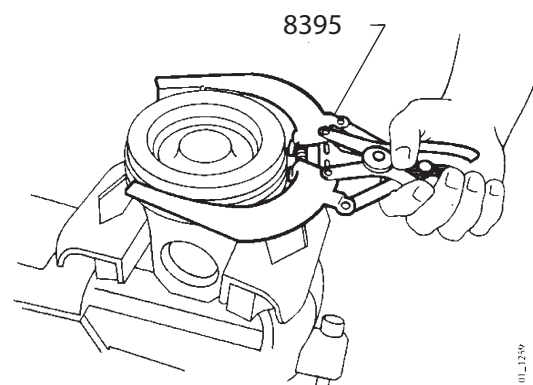
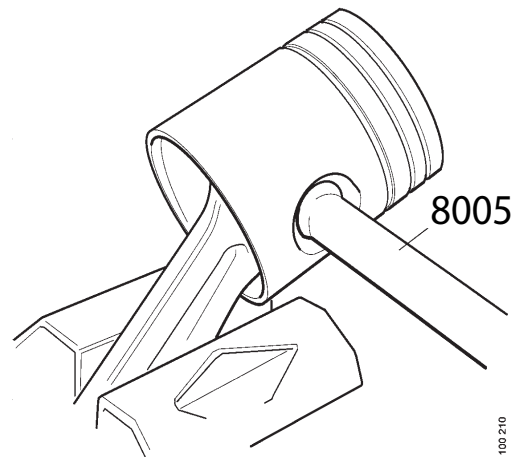
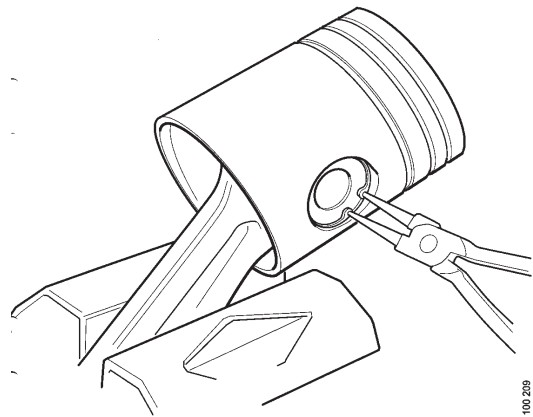
7. Push out the gudgeon pin using drift 8005.

8. Remove the piston rings using tool 8395, taking care to avoid scratching the surface of the piston skirt with the piston rings.

9. When cleaning graphited pistons in a machine, the graphiting may disappear. This does not matter after they have been in use for a while. However, new pistons should be washed carefully using white spirit or the like.

### Note:

**Always inspect the connecting rod in cylinders which have seized, been filled with water or where the valve has broken. Bent connecting rods must not be straightened.**



### Checking connecting rods

Check the connecting rods using tool 587 110.

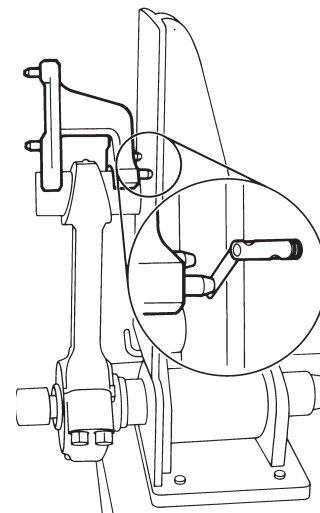
Proceed as follows:

1.

When the gudgeon pin bushing has been checked, insert the bearing cap as marked and tighten the bolts to full torque.

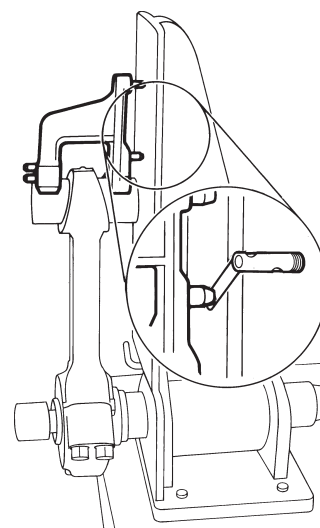
2.

Mount the connecting rod in the tool using the expander and place the gudgeon pin in its bushing. Then place indicator studs on the gudgeon pin.



Checking if connecting rod is twisted

- Check whether the connecting rod is twisted with the indicator studs horizontal.
- Check whether the connecting rod is bent with the indicator studs vertical.
- The distance between the indicator studs on the tool illustrated here is 75 mm.
- The distance between one of the indicator studs and the measuring surface must be max. 0.1 mm when measured using this tool.
- Check with a feeler gauge.

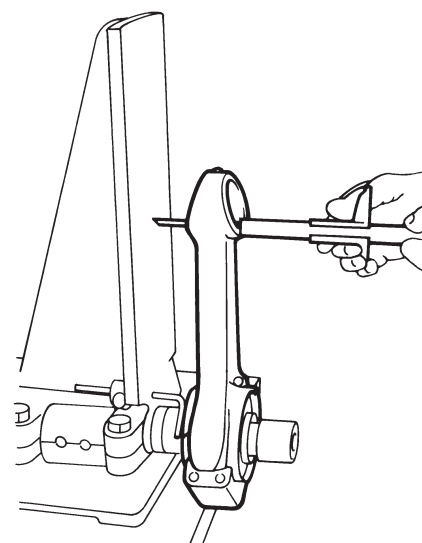


Checking if connecting rod is bent

- Also check whether the connecting rod is bent into an Sshape. This is done by measuring the distance between the outside of the connecting rod bushing and the level surface of the tool.
- Turn the connecting rod around and measure the corresponding distance.

### Important!

The difference must not exceed 0.6 mm.



Checking whether the connecting rod is bent into an S shape

## Renewal of bearing bushing in connecting rod

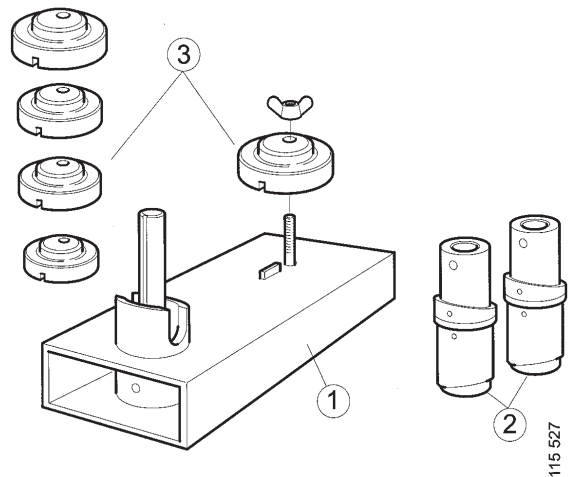
Use tool 512564 when renewing the bearing bushing.

The tool comprises three parts:

1. Pressplate with guide pin
2. Press drift
3. Supports

There are different supports, depending on the engine type.

The support marked with a D should be used for the 12engine.

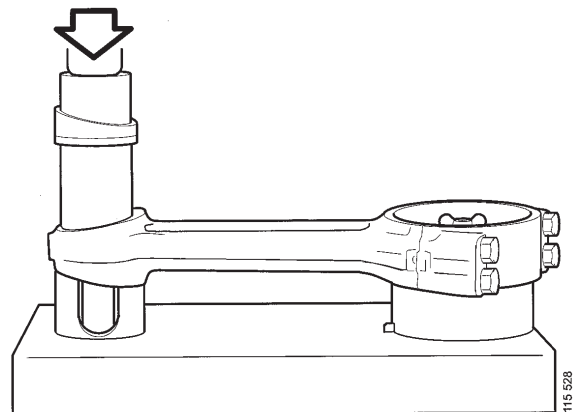


### Important!

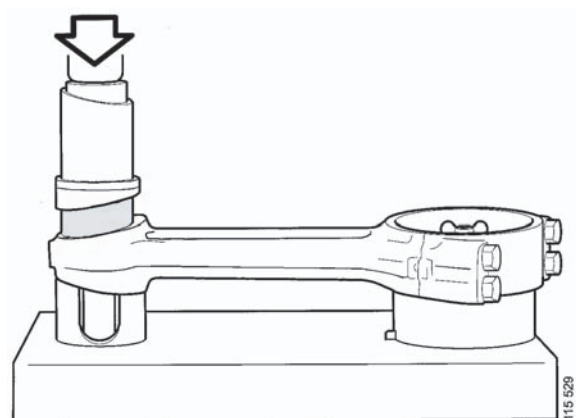
**Before carrying out this procedure, the connecting rod should be checked for straightness in accordance with Checking connecting rods**

### Work description

1.  
Fit the correct support on the pressplate and place the connecting rod so that the wide end of the connecting rod is resting against the support. Turn the press drift with the smaller diameter against the bearing bushing and press it out.

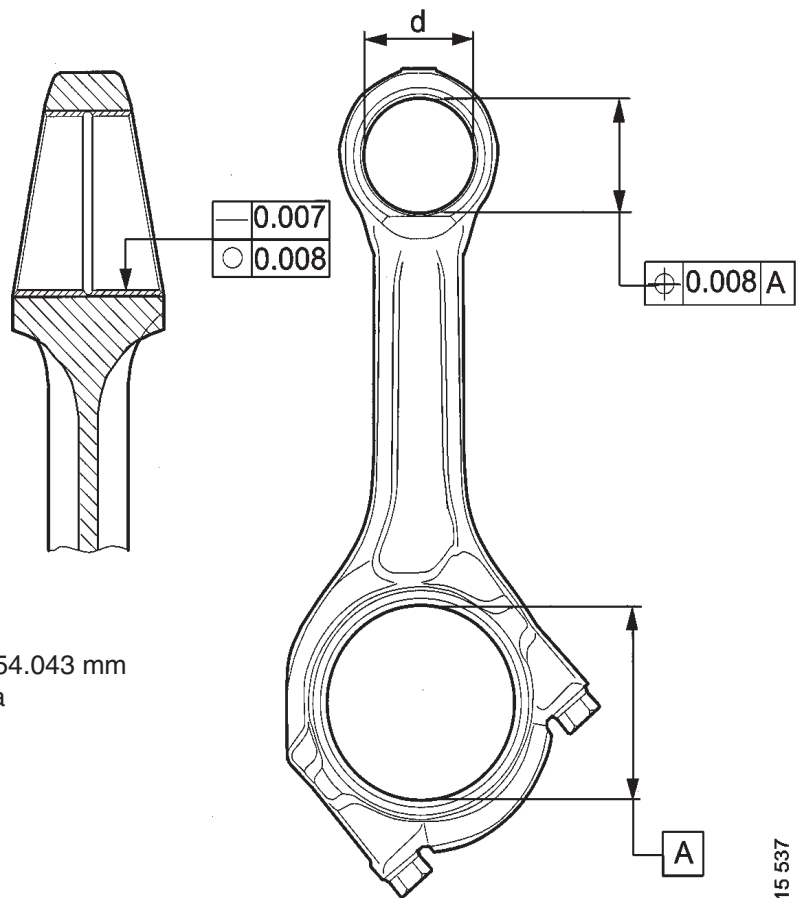


2.  
Turn over the press drift and mount a new bearing bushing onto it. Press in the bearing bushing.



3.  
After pressing in a new bearing bushing, it must be finish-turned. This requires special equipment.

Refer to illustration for the dimensions required.



Diameter,  $d = 54.030 - 54.043$  mm  
Surface quality = 0.6 Ra

115 537

## Pistons

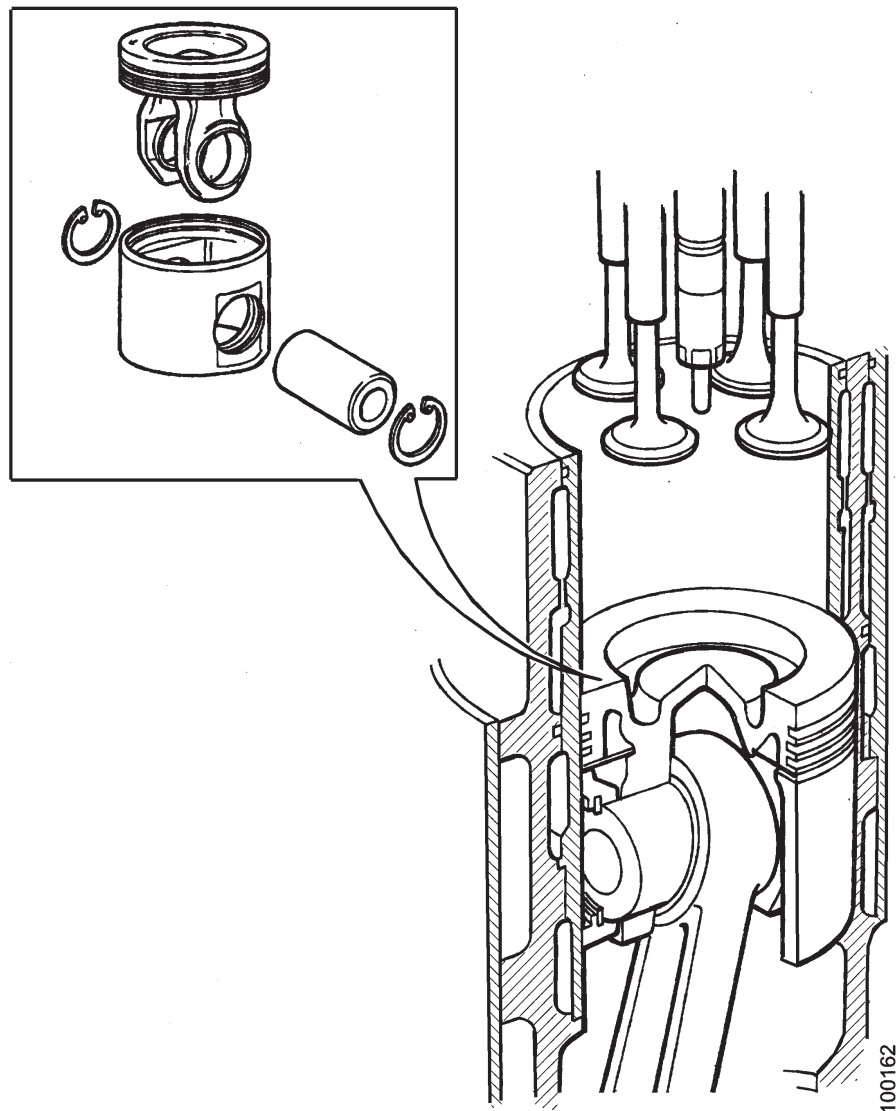
The pistons which are used in Moxy MT41 engine is of type; articulated pistons. Articulated pistons are split and have an aluminium skirt and a steel crown.

(For the aluminium piston to resist the high pressure and high temperature prevailing in the combustion chamber, the material is thicker at the piston crown and piston ring grooves than in the remainder of the piston.)

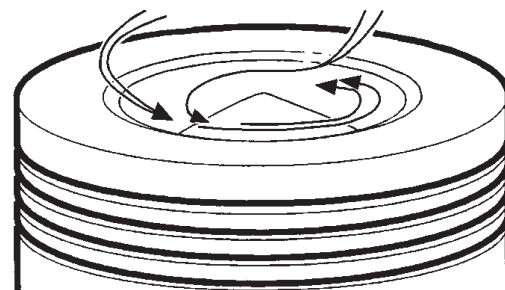
One of the advantages of articulated pistons is that they can tolerate higher loads than conventional pistons completely made of aluminium.

As the piston crown is made of steel it can withstand higher temperatures and pressure in the combustion chamber.

This enables more power to be extracted from engines with articulated pistons.



The bowl-shaped combustion chamber in the piston crown has a protuberance in the centre. The design of this protuberance ensures that the fuel injected at the end of the compression stroke is quickly mixed with the air in the combustion chamber.



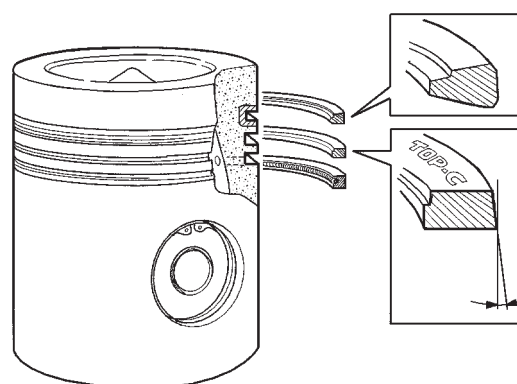
#### Piston rings

For the piston to travel freely, a gap is required between the piston and cylinder liner.

The piston therefore has two compression rings which seal this gap and conduct the heat from the piston.

The upper of these rings is exposed to higher pressure than the intermediate ring and is therefore wedge-shaped, a “keystone” ring, which increases the force pressing it against the cylinder wall.

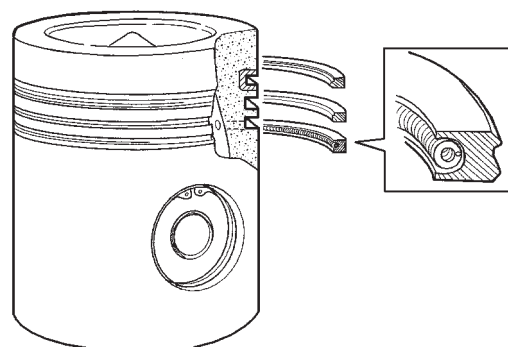
Since the greatest stress is on the upper piston ring groove, and also to reduce wear, a reinforcement of cast iron is incorporated in the piston.



The bottom piston ring, the oil scraper ring, prevents oil from the crankcase from finding its way up to the combustion chamber.

In the oil scraper ring is a coil spring which presses it against the cylinder wall.

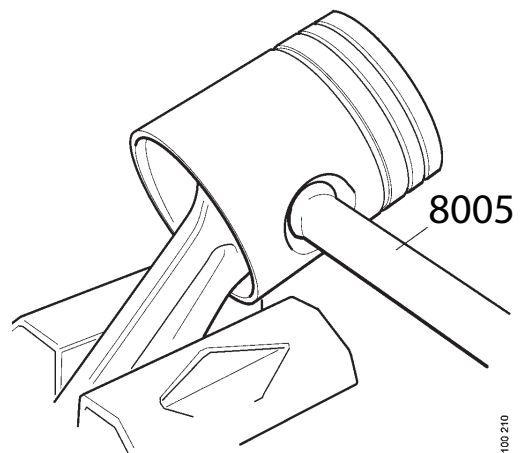
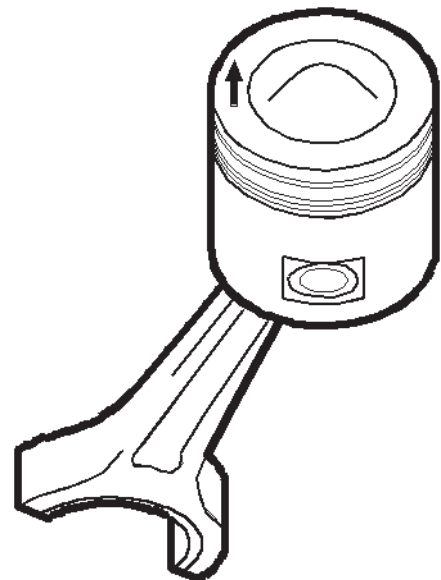
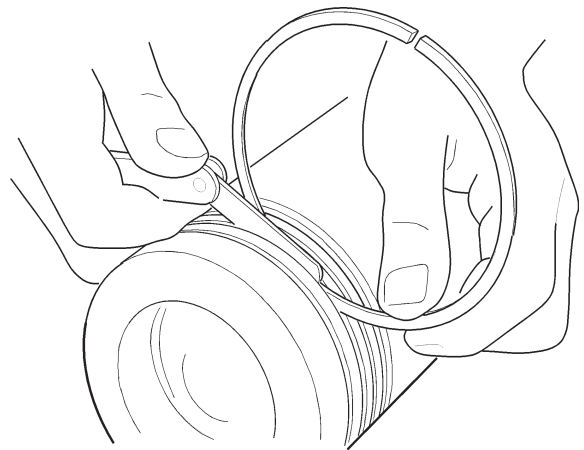
The design and quality of the pistons and piston rings are extremely important for the reliability and lubrication of the engine as well as oil and fuel consumption.





## Assembling piston and connecting rod

1. Clean the piston and its rings thoroughly without scratching the sides of the ring grooves. The oil holes in the piston should be cleaned using a suitable drill.
2. Make sure the piston ring gaps do not exceed the permitted limit.  
Place the piston rings in the cylinder liner and measure the gap using a feeler gauge. For permitted gap, see section entitled Specifications, piston rings.
3. Fit the piston rings using tool 8395. The oil scraper ring has an expander. Pistons rings marked with TOP must be turned with TOP face up.
4. Oil all the bushings, the gudgeon pin hole and the gudgeon pin before assembling.
5. Place one of the retaining rings in the piston.
6. Turn the piston and connecting rod as illustrated. The arrow mark should point forward on the engine.
7. Insert the gudgeon pin using tool 8005 and fit the second retaining ring for the gudgeon pin.

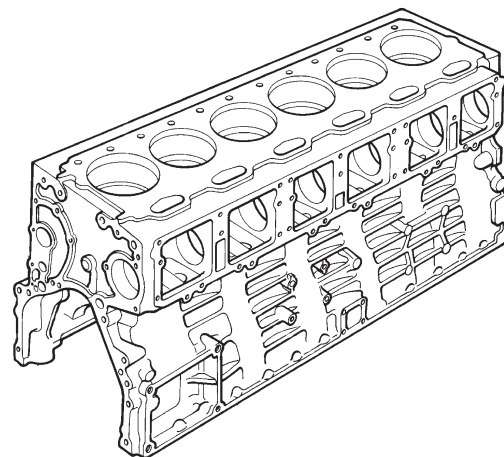


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# Cylinderblock

The cylinder block is a one-piece casting. It has 5 cylinder bores. There is a separate cylinder head for each cylinder.

The seal between cylinder block and cylinder head consists of a steel/elastomer gasket. Seals are bonded in place at the oil and coolant passages.

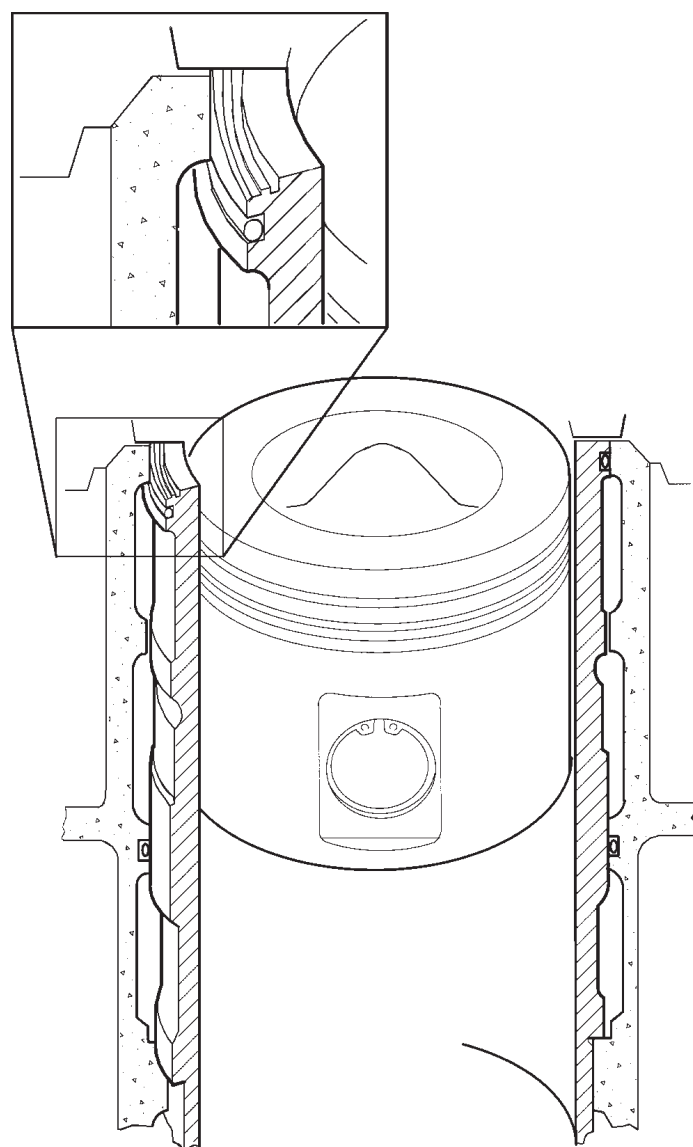


## Cylinder liner

The cylinder liners are of the “wet” type, i.e. they are surrounded by coolant.

To ensure a good seal, the edge of the cylinder liner protrudes slightly above the surface of the cylinder block.

This ensures that the cylinder head gasket is pressed against the cylinder head.

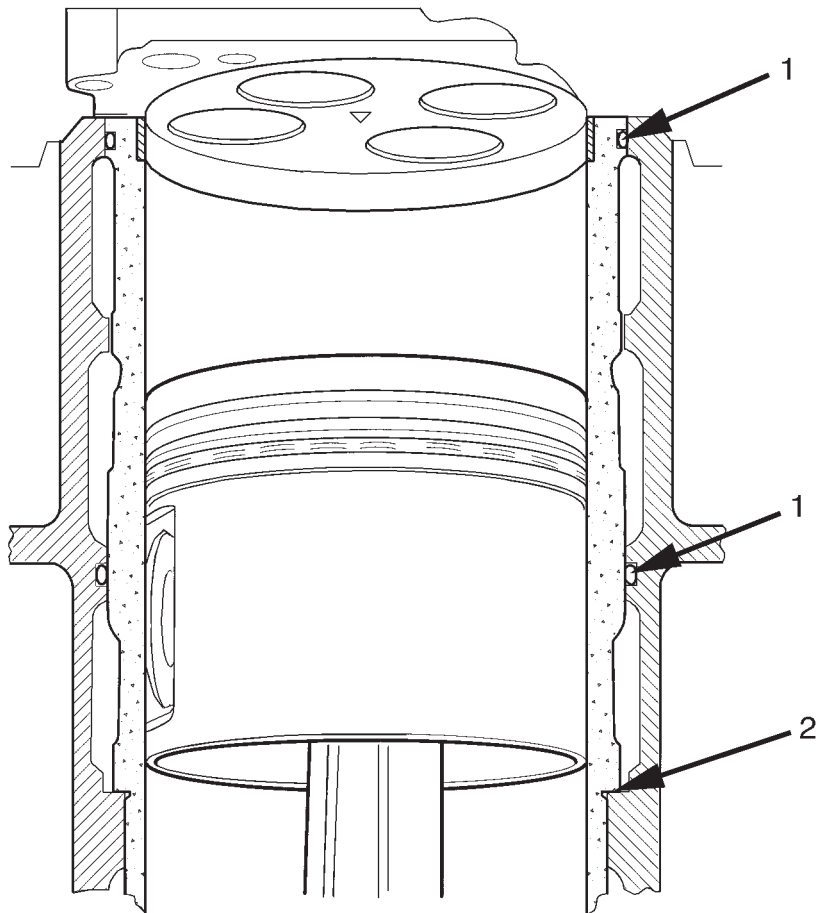


The inside of the cylinder liner is machined by what is known as plateau honing. This type of machining leaves a fine pattern of grooves which ensures that the oil needed for lubrication between piston rings and liner remains on the wall of the liner.

The design of the pattern is of major importance for ensuring low oil consumption in the engine. Two sealing rings, one in the block and one in the liner, seal off the coolant jacket. The surface of the liner in contact with the liner shelf seals off the lubricating oil.

In the space between liner shelf and sealing ring in the block is an overflow hole which discharges in the side of the cylinder block under the side covers.

Leakage at any of the sealing surfaces will result in oil or coolant coming out of the overflow hole.

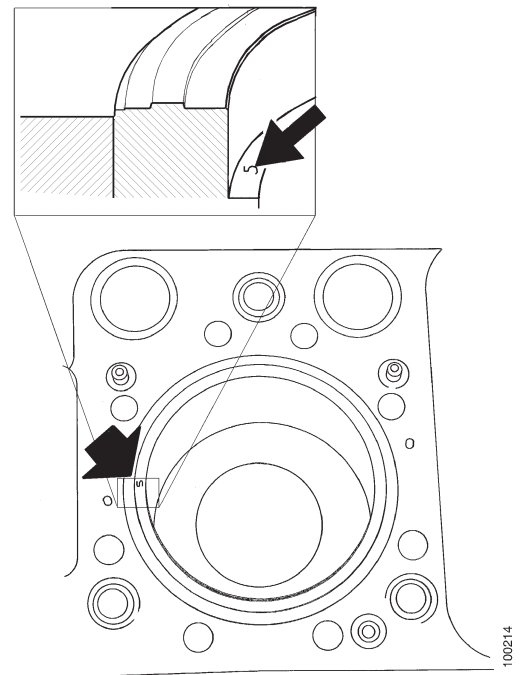


1. Seal for coolant
2. Support point for liner

## Removing the cylinder liners

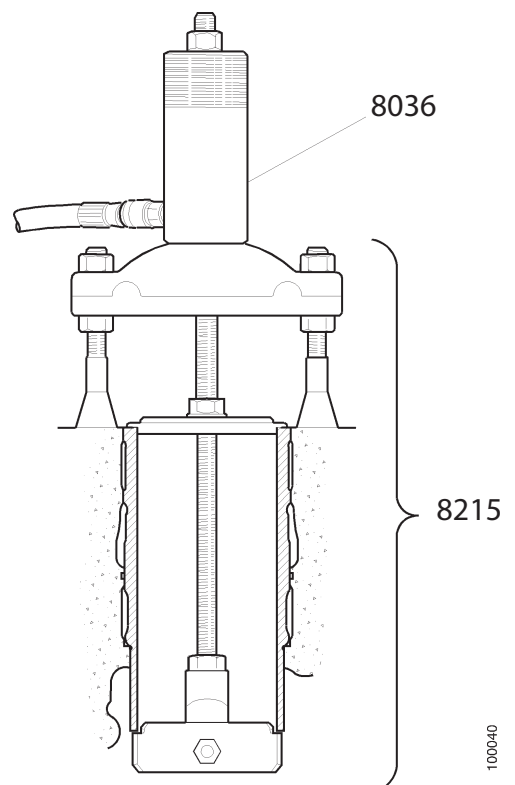
1. Mark the liners with the numbers 1-6. The mark is necessary so that the liners can be refitted in the same place and position as previously.

**Note:**  
**The mark must be made only on the surface indicated in the illustration.**  
**Other surfaces are for sealing.**



2. Withdraw the cylinder liner using puller 99 066 and hydraulic cylinder 8036. Fit spacers under the support lugs to avoid damaging the surface of the block.

3. Remove the sealing ring in the cylinder block.



Cylinder liner extractor with hydraulic cylinder

## Measuring the cylinder liner height

1. Thoroughly clean the cylinder block liner shelf, the face around the cylinder, the cylinder liner shelf and the upper face of the cylinder liner.

2. Fit the cylinder liner without O-rings and twist down by hand into position.

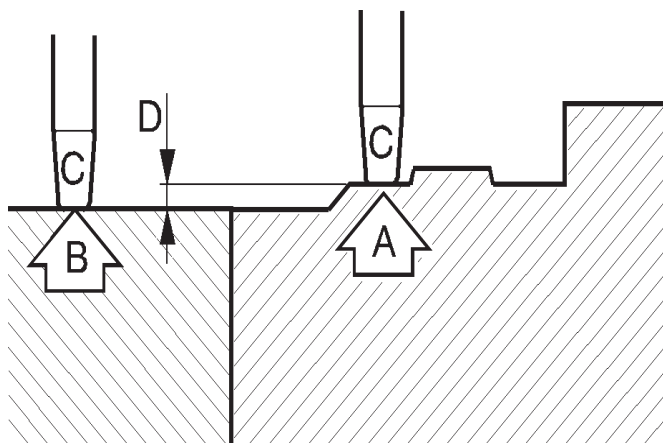
3. Lift out the liner and wipe the liner shelf in the cylinder block and the cylinder liner shelf.

4. Insert the cylinder liner without O-rings and twist it down into position again by hand.

5. Place straight edge 87 198 with dial gauge 98 075 on the liner and zero the dial gauge to the liner (A). Slide the tip of the dial gauge over to the cylinder block (B) and measure the height of the liner (A-B) as illustrated.

6. Measure each liner at two diametrically opposite points transversely across the engine.

- The cylinder liner must be slightly above the face of the cylinder block.
- The difference between the two measurements on the same liner must not exceed 0.02 mm.
- The height of the cylinder liner D (=A-B) above the block should be 0.20 – 0.30 mm.

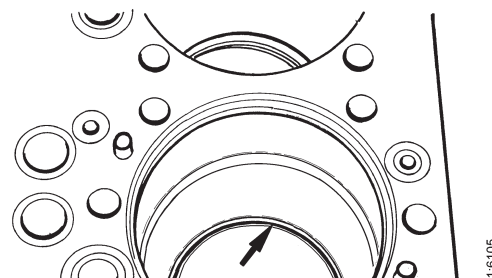


A = Measuring surface on cylinder liner  
 B = Measuring surface on cylinder block  
 C = Tip of dial gauge  
 D = Cylinder liner height  $D = A - B$

Measuring cylinder liner height

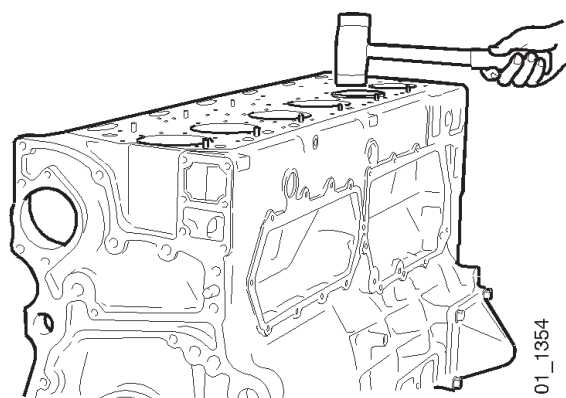
## Fitting the cylinder liners

1.  
Check cylinder liner height as described in the section entitled Measuring the cylinder liner height.
2.  
Make sure the interior of the cylinder block is clean. Clean the O-ring surfaces.
3.  
Check that the holes for coolant going to the cylinder head and cylinder liner are not clogged.
4.  
Carefully check the cylinder liners, both new and old, for cracks which might have arisen during transport or careless handling.
5.  
Tap the liner carefully with a metal object. It should give a clear metallic ring if it is intact. If it sounds cracked, renew it.



1-6105

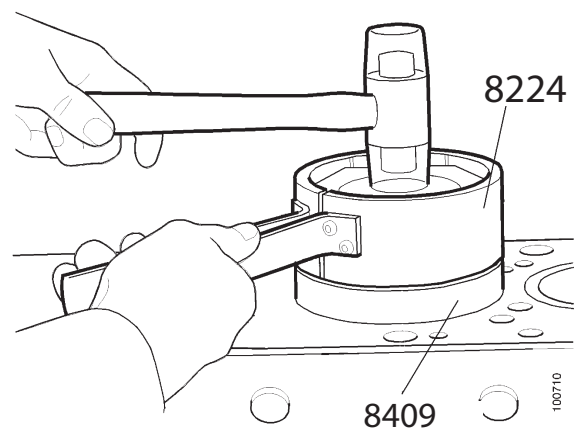
6.  
Lubricate the sealing ring to be fitted in the cylinder block with engine oil and fit it in place.
7.  
Lubricate the sealing ring to be fitted in the cylinder liner with engine oil and fit it in place.
8.  
Turn the liner with the stamped cylinder number facing forward and carefully tap it down with a rubber mallet.
9.  
Fit the scraper ring in place after the piston has been fitted.



01\_1354

## Fitting the piston and connecting rod

1.  
Lubricate the piston, piston rings, cylinder liner and piston ring compressor with engine oil.
2. Remove the protection on the connecting rod journal and lubricate the journal.
3.  
Turn the piston rings so that the ring gaps are evenly distributed round the piston.
4.  
Fit the upper connecting rod bearing shell to the connecting rod and lubricate the bearing surface.
5.  
For engines with a scraper ring in the liner:  
Fit assembly tool 8409 instead of the scraper ring in the liner.
6.  
Carefully insert the connecting rod and piston so that the arrow mark on the piston points forward.
7.  
Clamp piston ring compressor 8224 round the piston and push the piston down into the cylinder past the assembly tool.
8.  
Remove the assembly tool and press in the scraper ring. Be careful to press it in straight so that it does not tilt.
9.  
For engines without a scraper ring in the liner: Insert the connecting rod and piston.  
On aluminium pistons the arrow mark on the piston should point forward.
10.  
Clamp piston ring compressor 98 212 round the piston and push the piston down into the cylinder.





11.

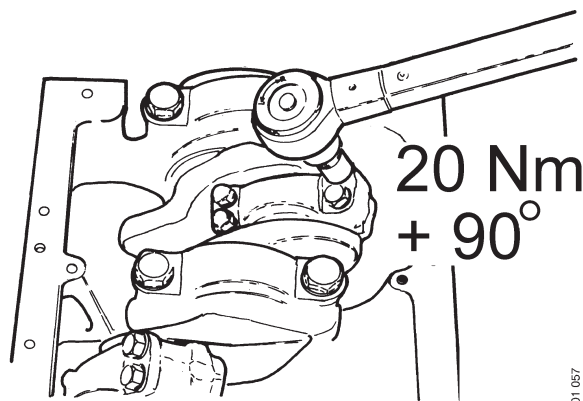
Fit the lower connecting rod bearing shell into the cap and lubricate the bearing surface. Fit the cap. Check that the connecting rod and cap have the same marking and that they are opposite each other.

12.

Lubricate the bolts, fit them and tighten to 20 Nm + 90°. Check that the piston nozzles are in perfect condition and fully open. If necessary, blow clean with compressed air.

13.

Fit the piston cooling nozzle and tighten the banjo bolts to 23 Nm.



**Note:**

**The piston cooling nozzle must not be damaged. The oil jet must hit the piston precisely. If it does not, the piston will become too warm resulting in engine breakdown. Damaged nozzles must not be re-aligned, renew them instead.**

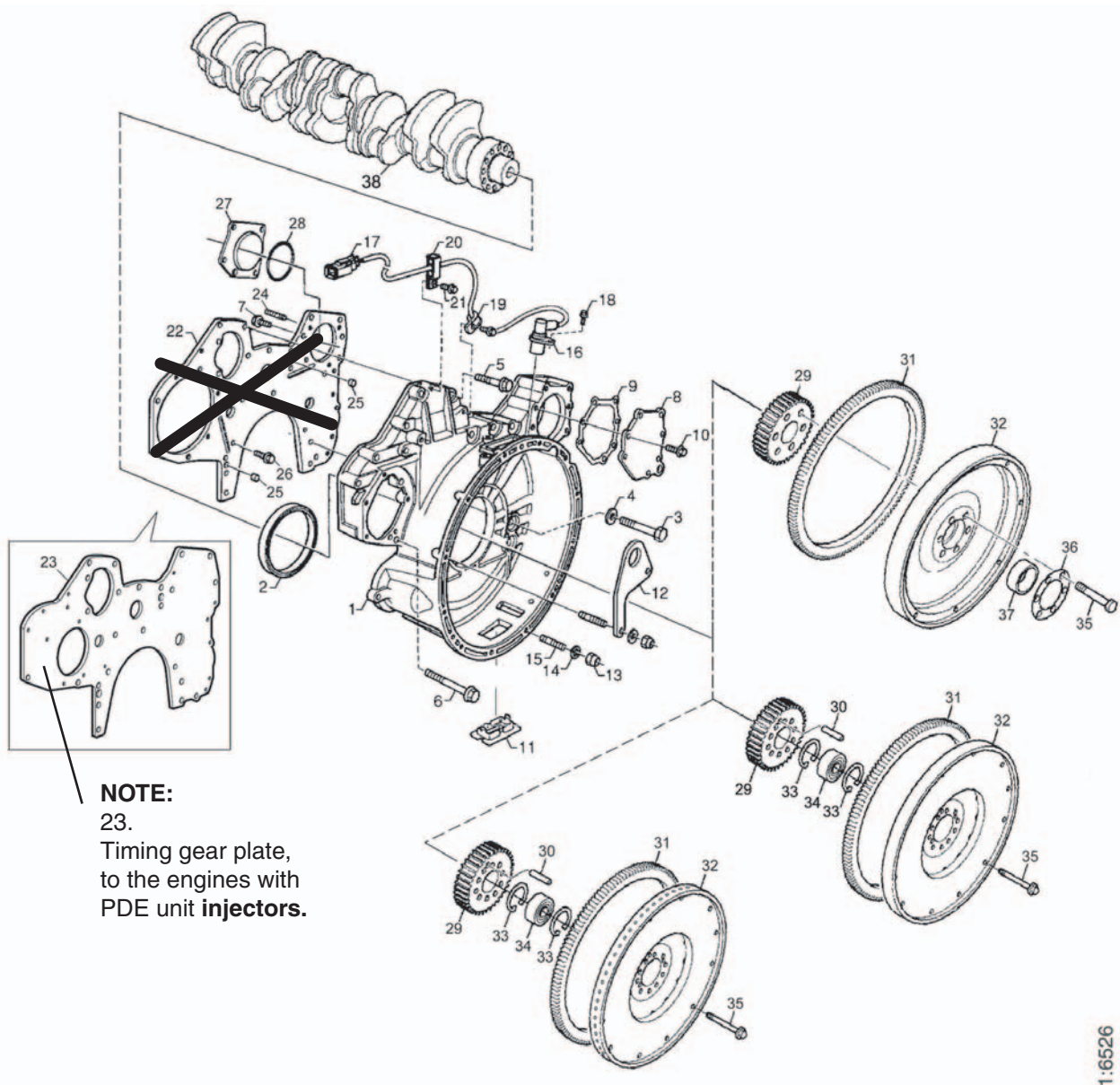
14.

Fit the oil sump and tighten the bolts to 30 Nm.

15.

Fit the cylinder head. Tighten the cylinder head bolts as described in the section Cylinder head.

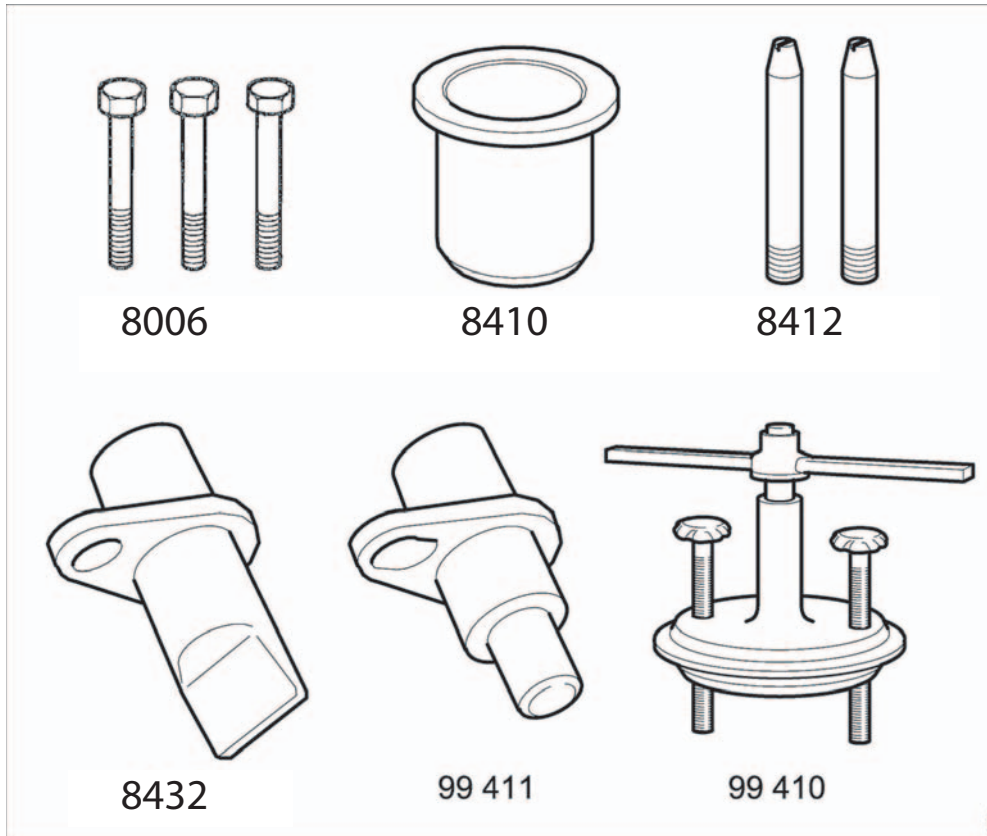
# Flywheel and flywheel housing



1:6526

- |                     |   |                        |
|---------------------|---|------------------------|
| 1. Flywheel housing | 15. Stud  | 27. Cover              |
| 2. Seal             | 16. Rotation speed sensor   | 28. O-ring             |
| 3. Bolt             | 17. Contact housing   | 29. Crankshaft gear PF |
| 4. Washer           | 18. Flange bolt   | 30. Pin                |
| 5. Flange bolt      | 19. Clamp   | 31. Ring gear          |
| 6. Flange bolt      | 20. Clamp   | 32. Flywheel           |
| 7. Flange bolt      | 21. Bolt  | 33. Circlip            |
| 8. Cover            | 22. Timing gear plate,<br>engines with injection pump             | 34. Ball bearing       |
| 9. Gasket           | <b>23. Timing gear plate,<br/>engines with PDE unit injectors</b> | 35. Bolt               |
| 10. Flange bolt     | 24. Stud  | 36. Washer             |
| 11. Cover           | 25. Pin   | 37. Guide sleeve       |
| 12. Lifting eye     | 26. Flange bolt   | 38. Crankshaft         |
| 13. Hexagon nut     |   |                        |
| 14. Washer          |   |                        |

**Special tools**



8006 Puller bolts  
 8410 Drift  
 8412 Guide pins

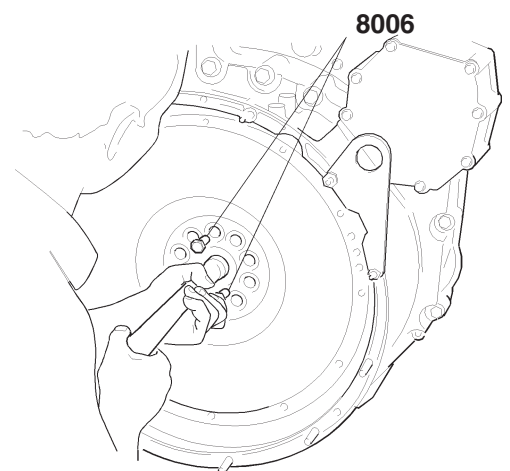
8432 Assembly tool  
 512556 Assembly tool  
 512555 Assembly tool

Not illustrated:

512559 Air powered sprayer  
 512557 Cartridge adapter  
 512558 Nozzle

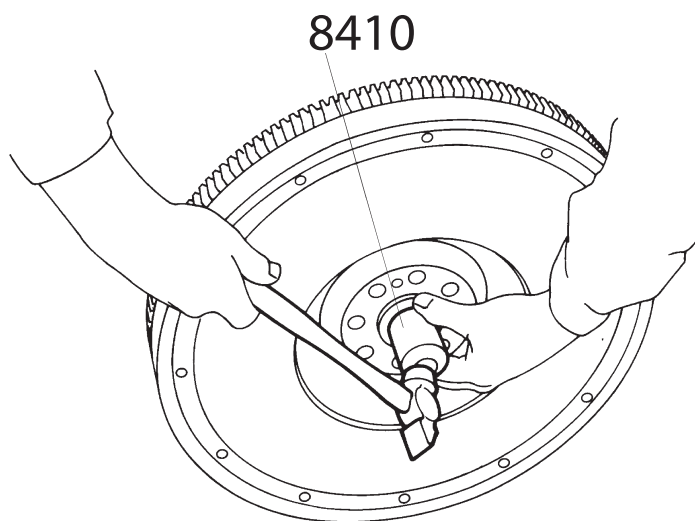
**Removing the flywheel**

1. Remove the engine speed sensor(s) in the flywheel housing.
2. Remove the bolts for the flywheel.  
 14" flywheel: Also remove the washer.
3. Pull off the flywheel from the crankshaft using puller bolts 8006



## Renewing support bearing

1.  
Remove the retaining rings on both sides of the support bearing.
2.  
Knock out the support bearing from the flywheel using drift 8410.
3.  
Fit the inner retaining ring and fit the new support bearing with drift 8410.
4.  
Fit the outer retaining ring.



## Renewing ring gear

Renew the flywheel ring gear if the gear teeth have become so worn that the starter motor pinion will not engage.

1.  
Grind a groove as deep as possible in the ring gear and crack it open with a chisel. Remove the ring gear from the flywheel.



**WARNING!**

**Use protective goggles due to the risk of metal shivers.**

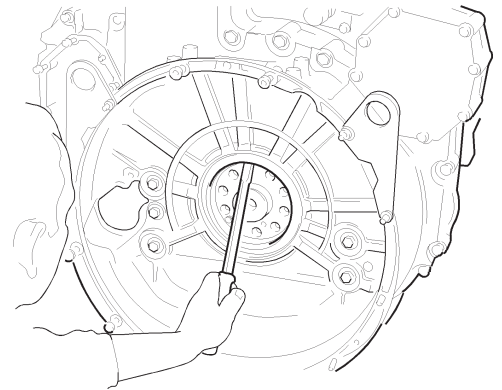
2.  
Clean the contact surfaces on the flywheel with a wire brush.
3.  
Heat the new ring gear evenly around its circumference to 100 -150°C.
4.  
Place the heated ring gear on the flywheel so that the marking with the part number is facing the engine when fitting the flywheel. Make sure the ring gear is securely against the flywheel. If necessary, knock down the ring gear with a plastic hammer.
5.  
The ring gear must not be cooled rapidly but be left to cool in the open air.

## Renewing the rear crankshaft seal

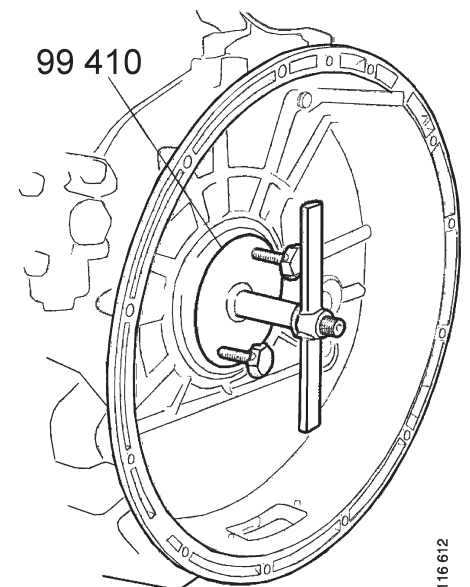
1. Remove the crankshaft seal using a screwdriver. Take care not to scratch the sealing surfaces on the crankshaft and the flywheel housing.

**Note:**

The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal should be left in place until the seal is fitted. The crankshaft should be degreased before the new seal is fitted.

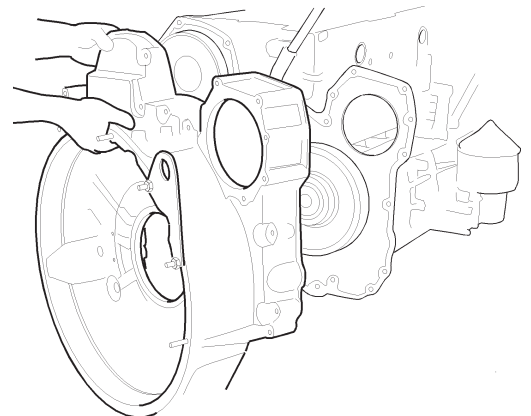


2. Fit the new crankshaft seal using tool 512555. Place the crankshaft seal on the tool and fasten the tool with the bolts.
3. Turn the tool clockwise until it stops in order to attain the correct crankshaft seal position.



## Removing the flywheel housing

1. Remove the starter motor.
3. Remove flywheel housing.

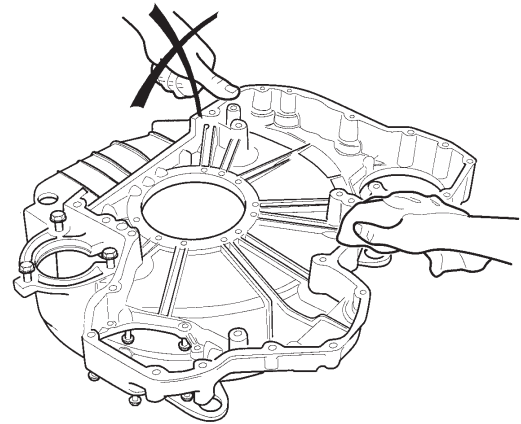


## Fitting flywheel housing

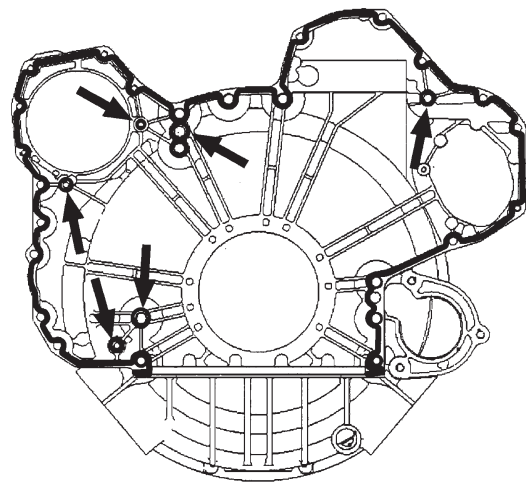
1. Remove all old sealing compound on the sealing surfaces of the timing gear casing and timing gear plate. Clean off any oil and grease using an alcohol based cleaning agent.

### Note:

The sealing surfaces must be absolutely clean and free from grease. Do not touch the surfaces after degreasing.



2. Apply the sealing agent (512565) on the timing gear housing with the air powered sprayer (512559), cartridge adapter (512565) and nozzle (512558). The width of the bead should be between 0.8 and 1.2 mm. Follow the pattern as illustrated.



### Important!

Ensure that you apply sealing agent inside the screwholes, but without allowing sealing agent into the crankcase. The sealing agent may block channels and nozzles. This is particularly important to bear in mind around oil ways, where the flow of oil to the air compressor or injection pump can be blocked.

### Important!

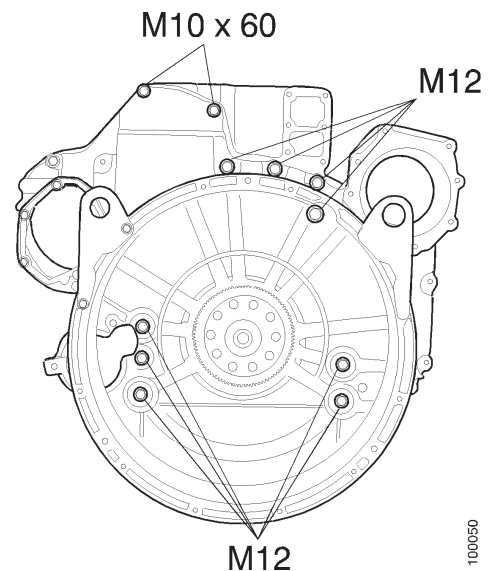
Assembly must be completed within 25 minutes of starting to apply the sealing agent.

### Note:

The bolts are of various sizes and lengths. Ensure that they are fitted in the correct places. See also the illustrations on the next page.

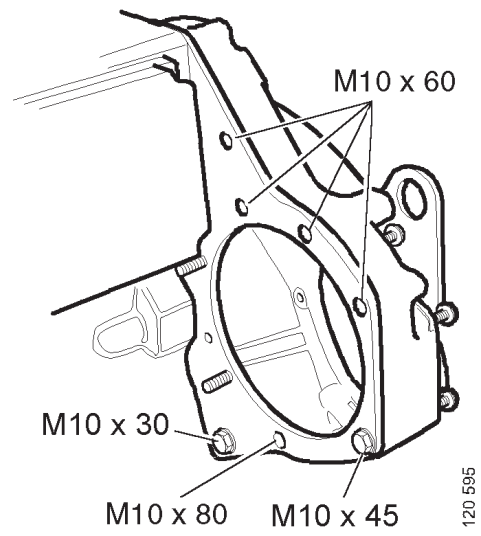
3. Torque tighten the M12 bolts to 90 Nm and the M10 bolts to 50 Nm.

4. Fit the starter motor



Apply the sealing agent on the timing gear housing side against the transmission plate. Apply the sealing agent around the screw holes marked with arrows.

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120 595

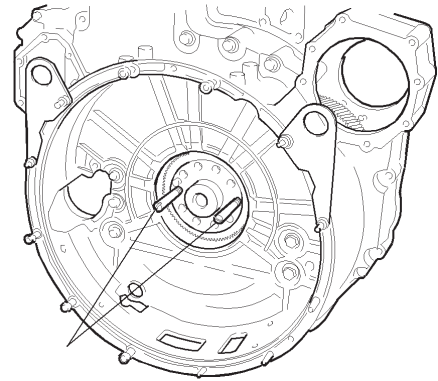


## Fitting the flywheel

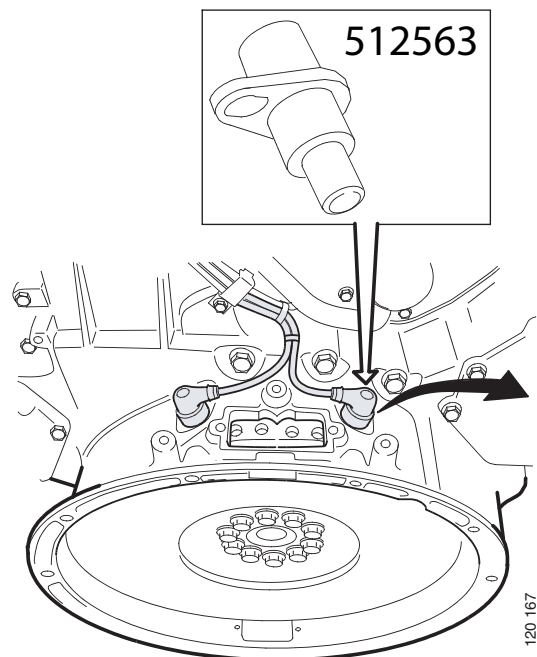
1.  
Fit two guide pins **8412** in the crankshaft flange.
2.  
Fit the flywheel on the crankshaft.

### NOTE!

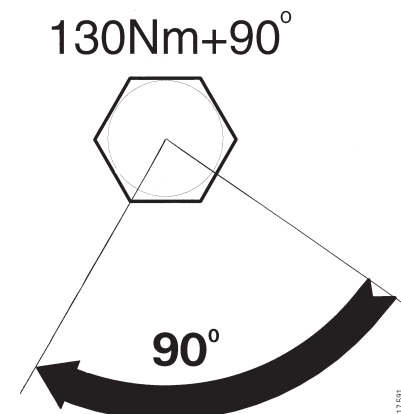
Always use new bolts and washer .



3.  
Lock the flywheel using tool:  
- 512563 for engines with unit injector.



4.  
Torque tighten the bolts alternately to  
130 Nm and then a further 90°.
5.  
Fit the engine speed sensors).



## Timing gears

### Gear drive

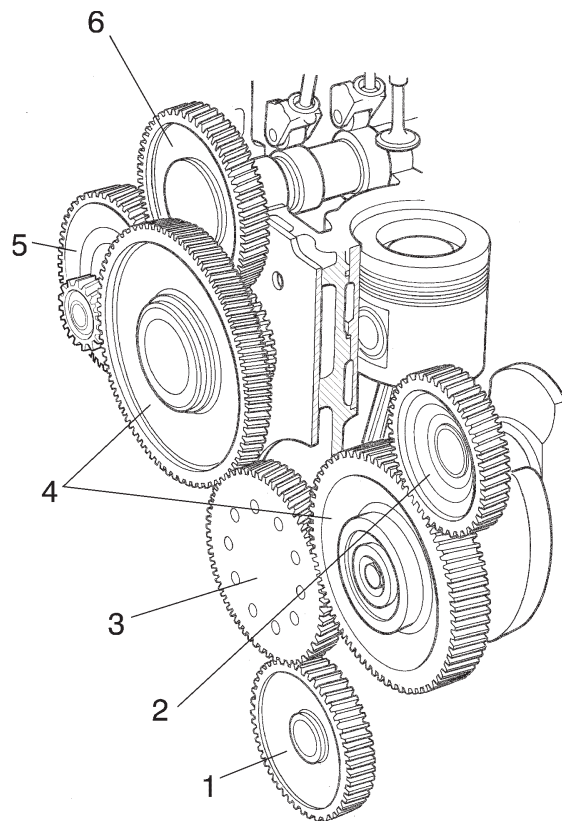
On the engine, the gear drive is located at the rear end of the engine.

Important components like the injection pump and valve mechanism require precise operation and are therefore attached to the rear end of the crankshaft, close to the flywheel, where crankshaft rotation is smoothest.

The gear on the crankshaft drives two intermediate gears and the oil pump gear.

One of the intermediate gears drives the camshaft. The camshaft gear in its turn drives the injection pump gear.

The other intermediate gear meshes with the gear for the air compressor

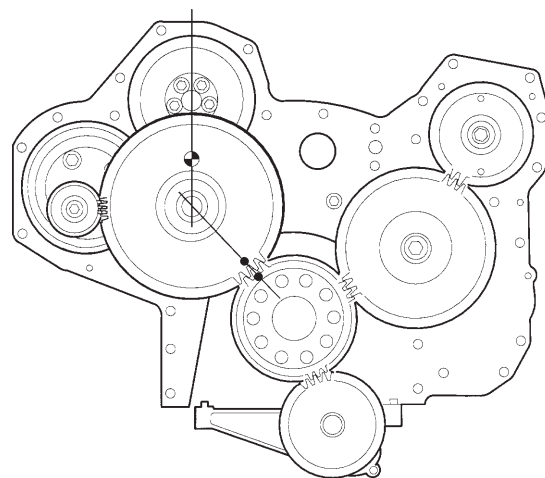


1. Oil pump gear
2. Air compressor gear
3. Crankshaft gear
4. Intermediate gear
5. Injection pump gear
6. Camshaft gear

The camshaft and injection pump rotate at half the speed of the crankshaft.

To facilitate correct assembly of the timing gears, the gears are marked on a tooth or in the space between two teeth.

The injection pump gear has an oval hole for setting the injection timing (the  $\alpha$  angle).



## Belt drive collant pump, generator and AC compressor

The coolant pump and alternator are driven by the belt drive, as also is the A/C compressor.

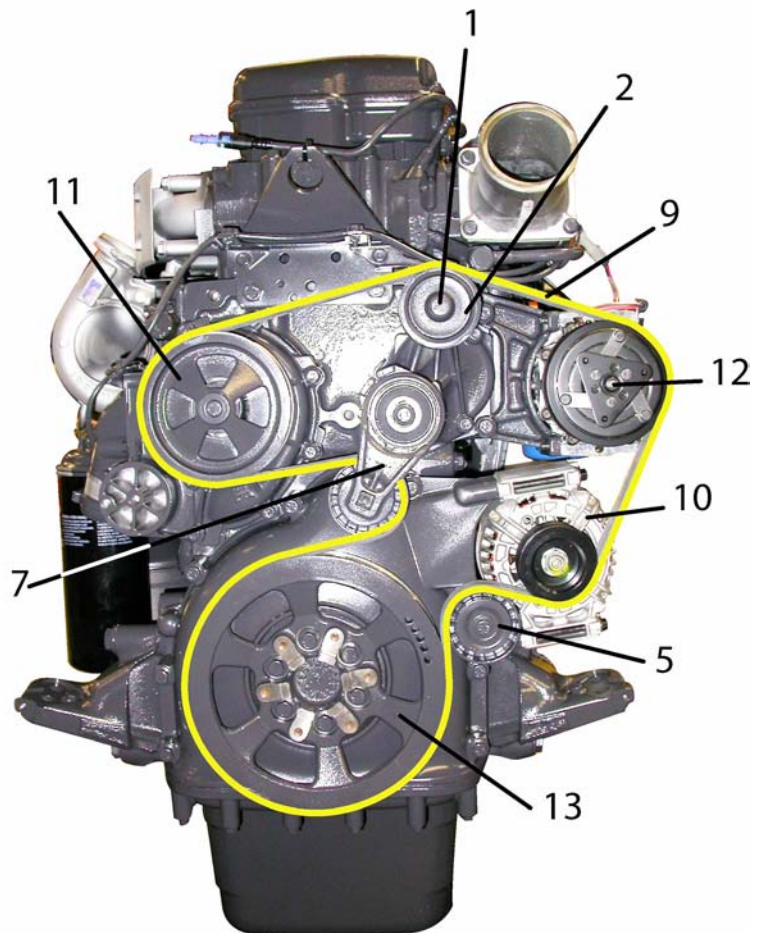
(The fan is mounted on a special bracket and is driven by the hydraulic system. See in chapter 5 Hydraulic system)

The drive belt is a "Multigroove V-belt", i.e. the belt has numerous V-shaped grooves on the drive side. The pulleys are of corresponding design and the belt therefore has an extremely large contact surface for its width. A large contact surface reduces the risk of belt slippage.

Included in the belt circuit are also jockey pulleys, the purpose of which is to give the belt a good arc of contact round the pulleys.

An automatic belt tensioner is used to obtain the correct belt tension.

- 1 Spacing sleeve
- 2 Roller
- 5 Roller
- 7 Belt tensioner
- 9 Poly V belt
- 10 Alternator
- 11 Coolant pump
- 12 A/C compressor
- 13 Pulley



## Renewing the seal in the front cover

1.  
Remove the fan ring and the fan.  
Thermostatic fan: Store it upright (vertical).
2.  
Remove the belt(s), crankshaft damper and belt pulley.
3.  
Remove the driver bolts and withdraw the driver. Mind the sealing surface.
4.  
Pull or prise off the seal in the cover.  
Take care to avoid damaging the sealing surface in the cover.
5.  
Wipe the sealing surface in the cover clean.

Note: The crankshaft seal must be fitted dry and must not be lubricated.  
The sleeve in the seal should be left in place until the seal is fitted.

6.  
Place the new seal on tool 8421 and press it in place by tightening the diametrically opposite bolts alternately.  
The seal is correctly fitted when the tool comes up against the cover.

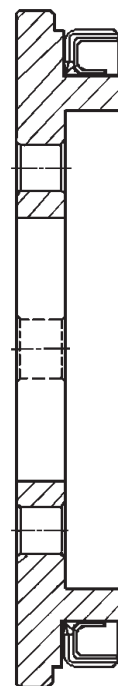
7.  
Remove the tool by screwing the bolts into the threaded holes.

8.  
Wipe the driver sealing surface clean. Fit a new seal on the end surface of the driver and push the driver onto the spacing sleeve on the end of the crankshaft.

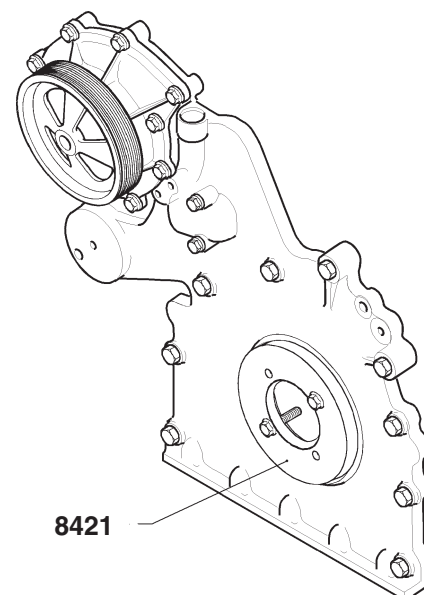
9.  
Bolt the driver to the crankshaft flange and tighten the flange bolts to 135 Nm.

10.  
Bolt the crankshaft damper and possibly the belt pulley to the hub and tighten to 110 Nm.

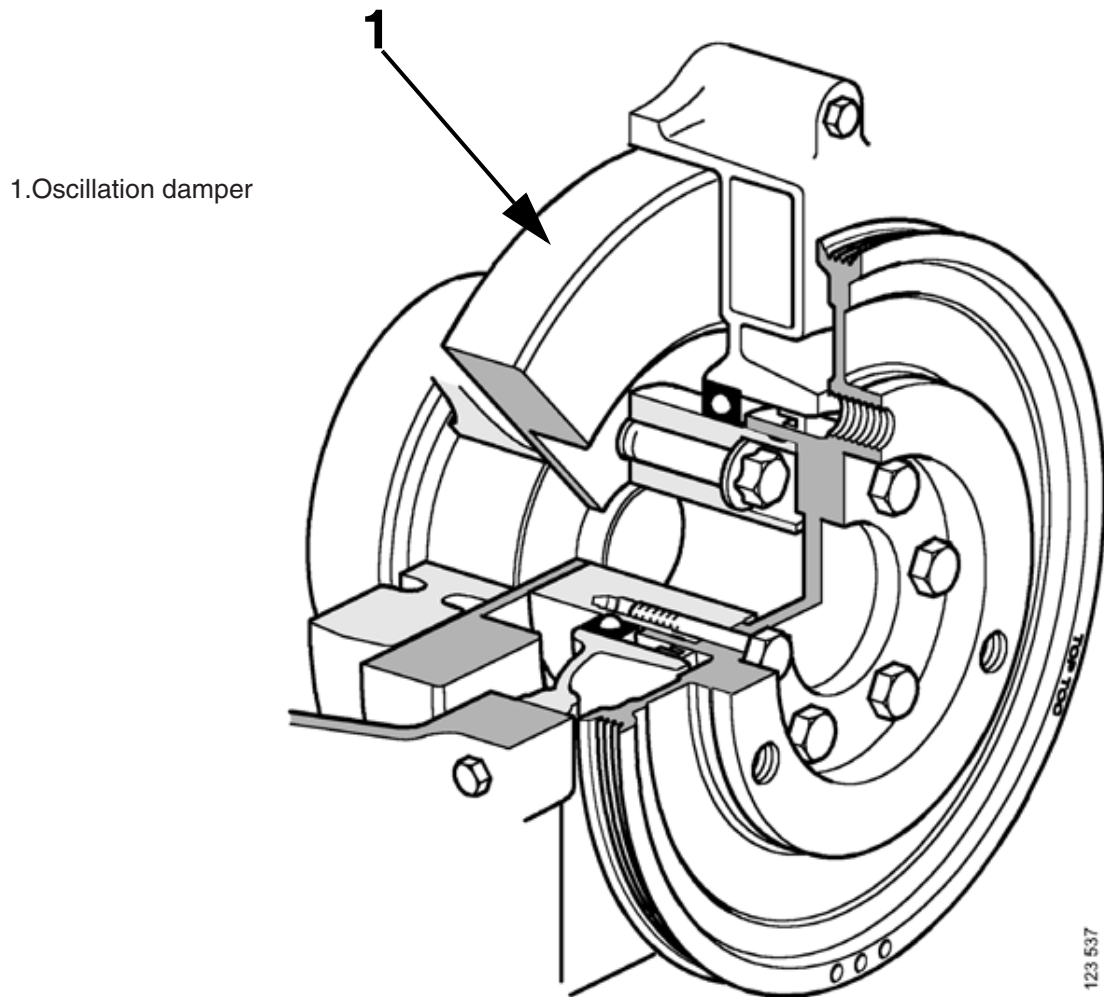
11.  
Fit the belt(s), fan ring and fan.



Tool 8421 with crankshaft seal



## Crankshaft damper



### Crankshaft damper

The power impulses from the connecting raise torsional oscillations in the crankshaft. These oscillations are severest at certain engine speeds which vary with the design of the engine, how it is loaded, etc.

Torsional oscillation is characterised as follows:

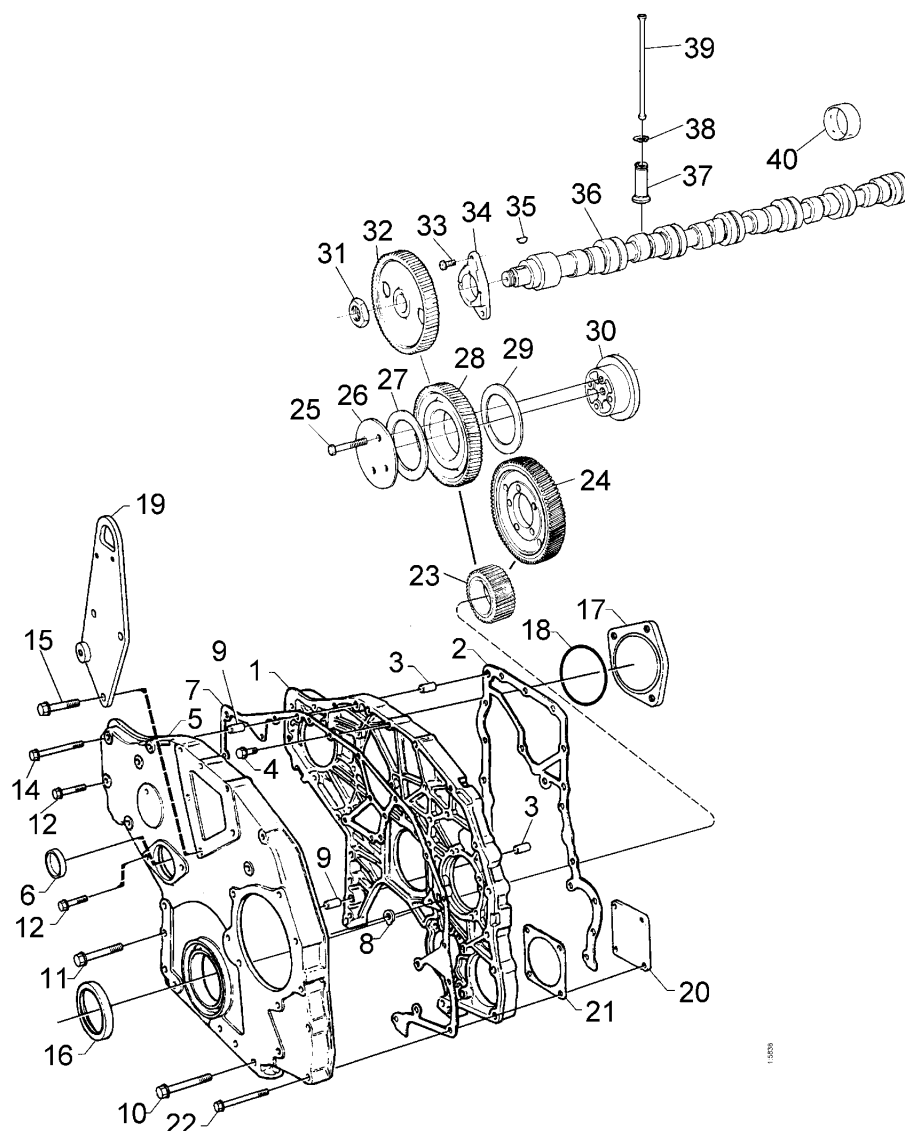
The flywheel (at the "rear" end of the crankshaft) rotates at an almost constant speed throughout each revolution of the crankshaft. In relation to the constant speed of the flywheel, the rotational speed of the front end of the crankshaft will increase and decrease several times during each rotation.

To reduce the amplitude of the oscillation, a crankshaft damper is attached to the front end of the crankshaft underneath a cover.

A ring of steel is incorporated in the circular and completely enclosed housing of the crankshaft damper. The housing is bolted onto the crankshaft.

There is a heavy oil between the housing and ring which damps the relative movement between the two. The oscillation at the front of the crankshaft is damped by the ring striving to rotate with even speed. 1

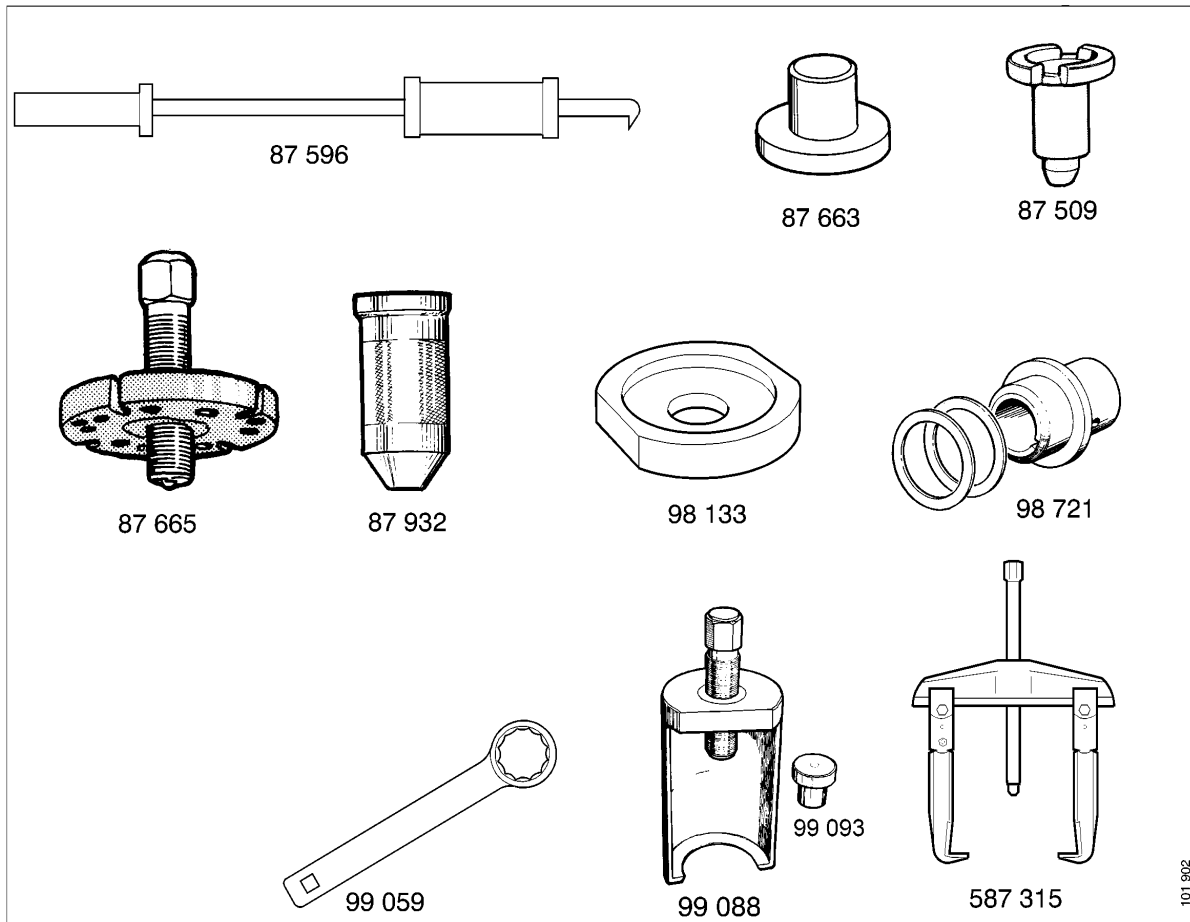
## Timing gear, view exploded



- |                        |                         |                       |
|------------------------|-------------------------|-----------------------|
| 1. Timing gear housing | 14. Flange bolt         | 27. Thrust bearing    |
| 2. Gasket              | 15. Flange bolt         | 28. Intermediate gear |
| 3. Pin                 | 16. Crankshaft seal     | 29. Thrust bearing    |
| 4. Flange bolt         | 17. Cover               | 30. Shaft journal     |
| 5. Timing gear cover   | 18. O-ring              | 31. Nut               |
| 6. Core plug           | 19. Lifting eye         | 32. Camshaft gear     |
| 7. Gasket              | 20. Cover               | 33. Flange bolt       |
| 8. Gasket              | 21. Gasket              | 34. Guide flange      |
| 9. Pin                 | 22. Flange bolt         | 35. Key               |
| 10. Flange bolt        | 23. Crankshaft gear     | 36. Camshaft          |
| 11. Flange bolt        | 24. Injection pump gear | 37. Tappet            |
| 12. Flange bolt        | 25. Bolt                | 38. Retaining ring    |
| 13. Flange bolt        | 26. Washer              | 39. Pushrod           |
|                        |                         | 40. Bushing           |

# Special tools

## Special tools, gear



87 509 Drift

87 596 Slide hammer

87 663 Support drift

87 665 Puller

87 932 Drift

98 133 Washer

98 721 Assembly tool

99 059 Slogging wrench

99 088 Puller

99 093 Support drift

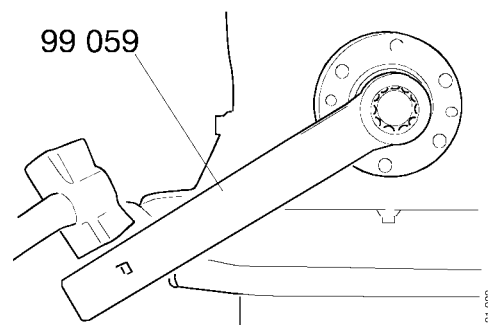
587 315 Puller



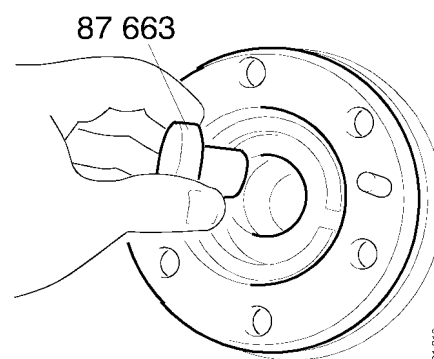
## Crankshaft seal

### Removing

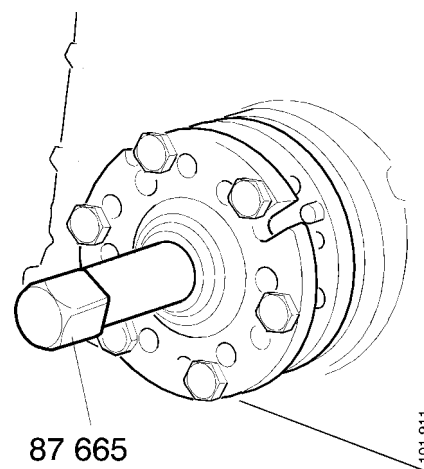
1. Remove components that are in the way: radiator, fan ring, fan or belt guard.
2. Undo the crankshaft damper bolts and those for the belt pulley, if fitted. Remove the crankshaft damper and belt pulley, if fitted. Take care to avoid damaging the crankshaft damper.
3. Remove the crankshaft bolt in front of the damper hub. Use slogging wrench 99 059.



4. Fit support drift 87 663 in the end of the crankshaft.



5. Screw on puller 87 665 with all six bolts. Pull the hub out 2-5 mm. Then unscrew the bolt a few turns and tap the hub in to loosen the cone.



6. Pull the hub off altogether.
7. Remove the seal using slide hammer 87 596. Protect the end of the crankshaft against scratches.

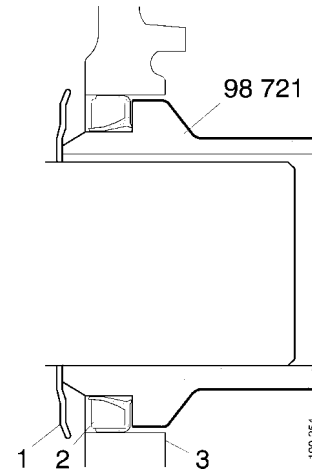
## Fitting

1. Wipe clean the seal seat in the housing.

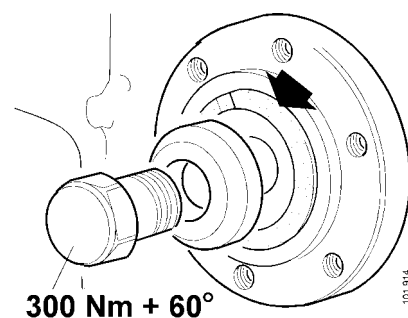
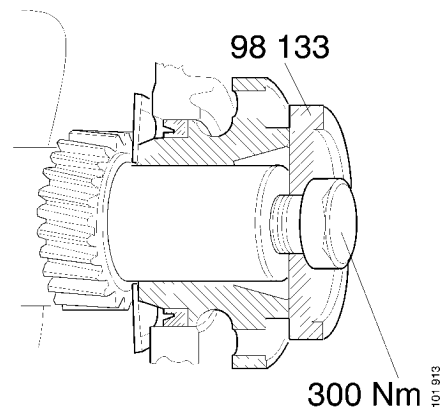
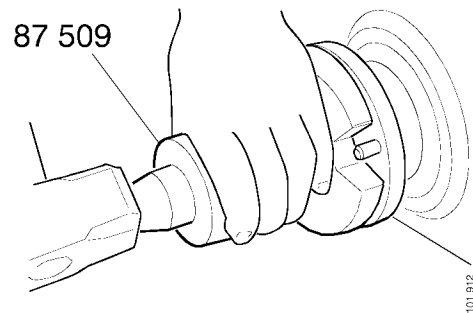
**Note** The crankshaft seal should be fitted dry and must not be lubricated. The sleeve inside the seal must not be removed until immediately before the seal is fitted in the engine.

2. Use assembly tool 98 721 to press in the seal. This tool is tapped in using a copper hammer.
3. Degrease the surface of the oscillation damper hub in contact with the seal and drive on the hub using drift 87 509.
4. Fit the crankshaft bolt with washer 98 133 but without the cone in the hub. Tighten the crankshaft bolt to 300 Nm.

5. Remove the crankshaft bolt and washer 98 133 and fit the cone. Screw in the crankshaft bolt with attendant washer. Tighten first to 300 Nm and then a further sixth of a turn (60°) using slogging wrench 99 059.
6. Fit the oscillation damper and, if fitted, the belt pulley. Tighten the bolts to 110 Nm.
7. Refit the components that were removed earlier because they were in the way.



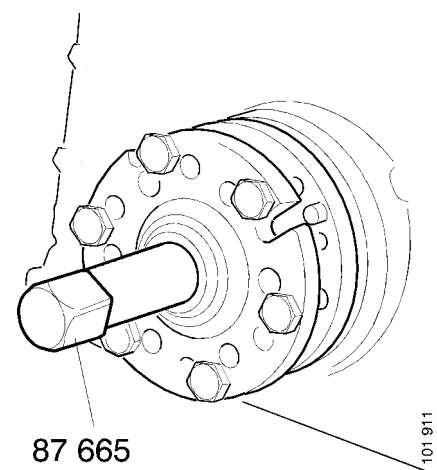
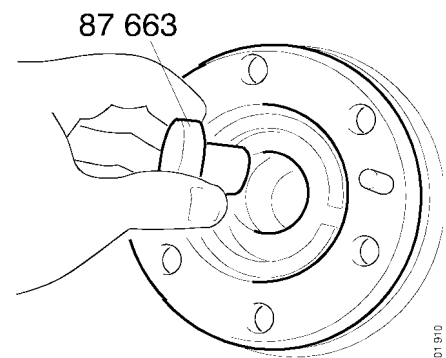
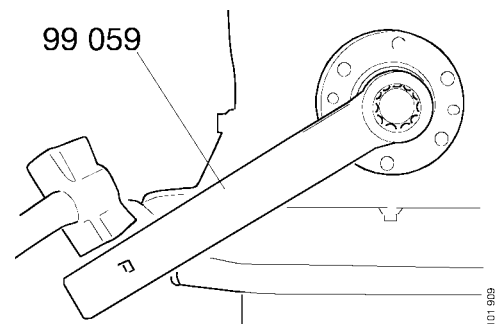
1. Oil deflector
2. Seal
3. Timing gear cover



## Timing gear cover

### Removing

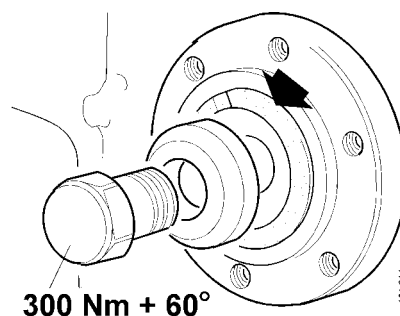
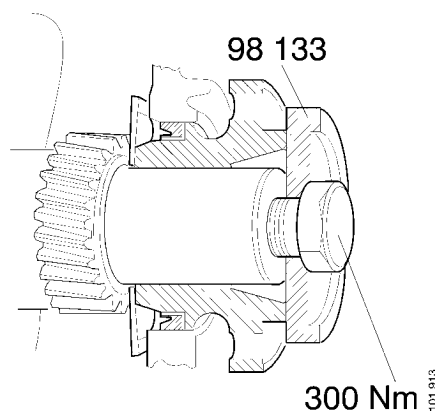
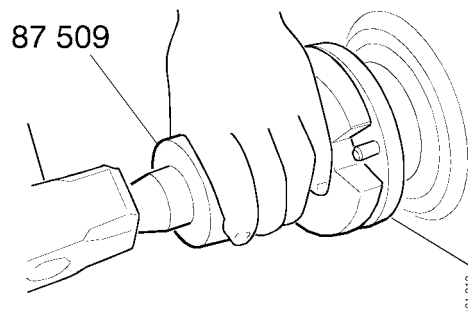
1. Remove components that are in the way: radiator, fan ring, fan, belt guard, alternator, V-belt, belt tensioner, tensioning rollers, fan drive, alternator bracket.
2. Turn the engine over to the ignition position.
3. Undo the crankshaft damper bolts and those for the belt pulley, if fitted. Remove the crankshaft damper and belt pulley, if fitted. Take care to avoid damaging the crankshaft damper.
4. Remove the crankshaft bolt in front of the damper hub.  
Use slogging wrench 99 059.
5. Fit support drift 87 663 in the end of the crankshaft.
6. Screw on puller 87 665 with all six bolts. Pull the hub out 2-5 mm. Then unscrew the bolt a few turns and tap the hub in to loosen the cone.
7. Pull the hub off altogether.
8. Remove the seal using slide hammer 87 596. Protect the end of the crankshaft against scratches.
9. Engine equipped with compressor:  
Remove the coolant manifold between the coolant pump and compressor.
10. Undo the three compressor retaining bolts in the timing gear housing. Extract the compressor and gear.



11. Check that the engine is in the ignition position.
12. Remove the oil sump.
13. Remove the timing gear housing.

## Fitting

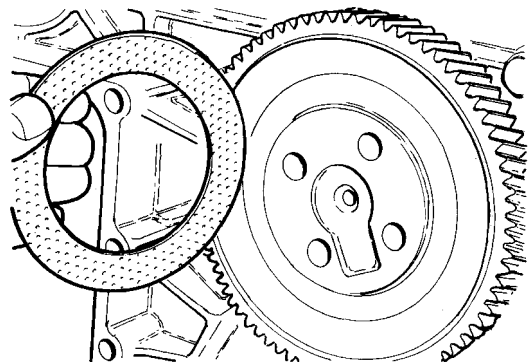
1. Clean the mating surfaces and fit a new gasket.
2. Fit the timing gear housing in place and tighten the bolts to a torque of 39 Nm.
3. Fit a new crankshaft seal.  
See Crankshaft seal: Fitting.
4. Drive on the oscillation damper hub using drift 87 509.
5. Fit the crankshaft bolt with washer 98 133 but without the cone in the hub. Tighten the crankshaft bolt to 300 Nm.
6. Remove the crankshaft bolt and washer 98 133 and fit the cone. Screw in the crankshaft bolt with attendant washer. Tighten first to 300 Nm and then a further sixth of a turn (60°) using slogging wrench 99 059.
7. Fit the oil sump with a new gasket.
8. Refit the components that were removed earlier because they were in the way.



## Intermediate gear

### Removing

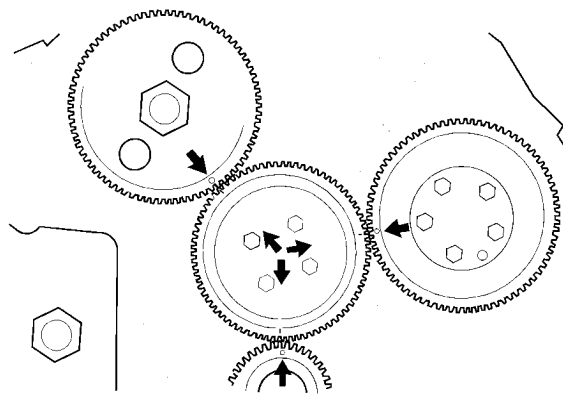
1. Remove the timing gear cover.  
See Timing gear cover: Removing.
2. Remove oil catcher from end of crankshaft.
3. Turn the crankshaft so that the marks on the camshaft gear and crankshaft gear point towards the centre of the intermediate gear.
4. Remove the intermediate gear.



**Note** After the intermediate gear has been removed, the camshaft and crankshaft must not be moved. Pistons and valves could then strike each other and sustain damage.

### Fitting

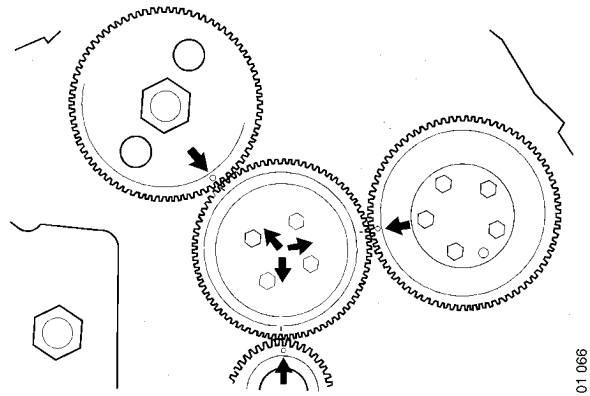
1. Lubricate the bearing surfaces and fit the intermediate gear and thrust bearings so that all marks are in the correct positions.
2. Fit the washer and tighten the bolts to a torque of 39 Nm.
3. Fit the oil catcher on the end of the crankshaft.
4. Fit the timing gear cover.  
See Timing gear cover: Fitting.



## Crankshaft gear

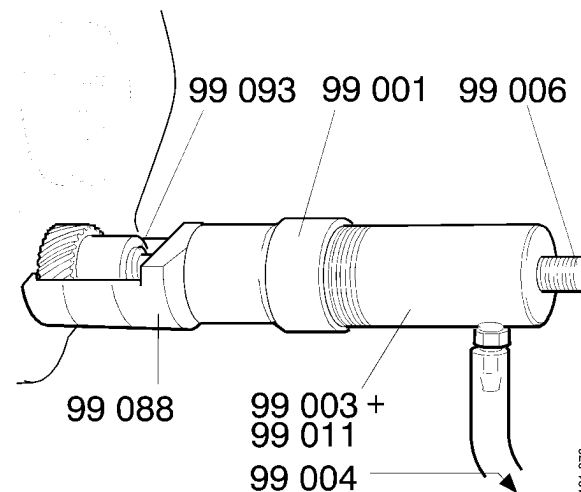
### Removing

1. Remove the timing gear cover.  
See Timing gear cover: Removing.
2. Remove oil catcher from the end of the crankshaft. Remove oil pump.
3. Turn the crankshaft so that the marks on the camshaft gear and crankshaft gear point towards the centre of the intermediate gear.
4. Remove the intermediate gear. If necessary, also remove the oil pump gear.
5. Pull off the crankshaft gear using puller 99 088 and support drift 99 093, with or without the aid of the hydraulic tool as shown in the figure.



101 066

**Note** After the intermediate gear has been removed, the camshaft and crankshaft must not be moved. Pistons and valves could then strike each other and sustain damage.



101 070

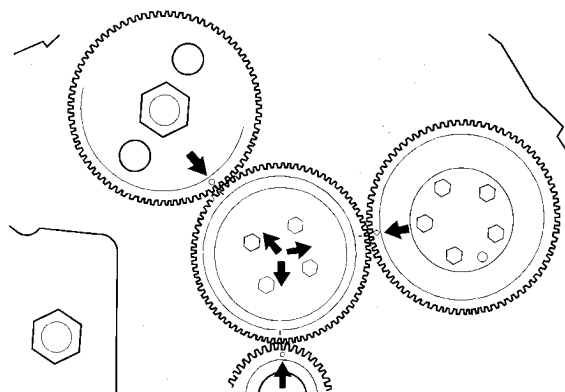
### Fitting

1. Lubricate the end of the crankshaft using engine oil.
2. Heat the gear to 130 °C and fit it onto the shaft with the marking facing outwards. Make sure that the key is fitted in place. Use drift 87 932 and tap the gear fully home.
3. Fit the intermediate gear.  
See Intermediate gear: Fitting, points 1-2.
4. Fit the oil pump.
5. Fit oil catcher on end of crankshaft.
6. Fit the timing gear cover.  
See Timing gear cover: Fitting.

## Camshaft gear

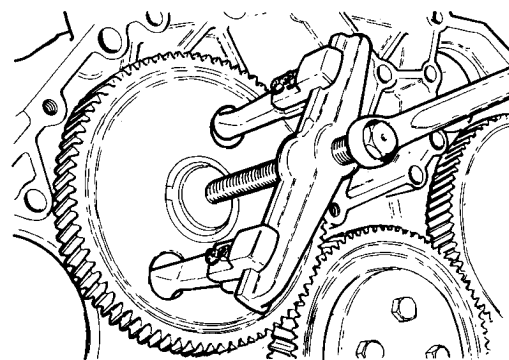
### Removing

1. Remove the timing gear cover.  
See Timing gear cover: Removing.
2. Remove oil catcher from end of crankshaft.
3. Turn the crankshaft so that the marks on the camshaft gear and crankshaft gear point towards the centre of the intermediate gear.
4. Remove the intermediate gear.
5. Pull off the camshaft gear using puller 587 315.



101 066

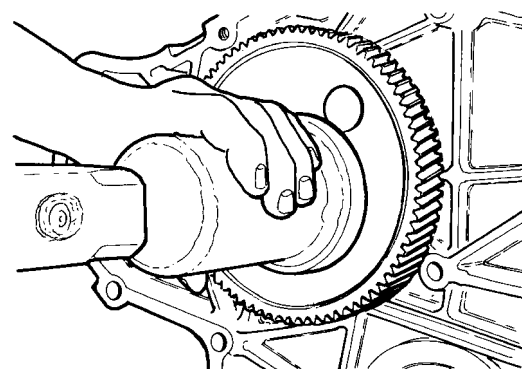
**Note** After the intermediate gear has been removed, the camshaft and crankshaft must not be moved. Pistons and valves could then strike each other and sustain damage.



101 066

### Fitting

1. Lubricate the end of the camshaft using engine oil.
2. Heat the gear to 100 °C and drive it onto the shaft with the marking facing outwards. Make sure that the key is fitted in place.
3. Fit the intermediate gear.  
See Intermediate gear: Fitting, points 1-2.
4. Check that the gear has cooled down. Secure the flywheel. Tighten the camshaft nut to a torque of 600 Nm.
5. Fit oil catcher on end of crankshaft.
6. Fit the timing gear cover.  
See Timing gear cover: Fitting.



101 066



# Camshaft

## Removing

- It is assumed that the timing gear housing has already been removed.
- 1. Remove rocker arms and pushrods.
- 2. Turn crankshaft around until the tooth marked "O" on the crankshaft gear and camshaft gear point towards the centre of the intermediate gear. In this position, the camshaft guide flange bolts can be accessed through the holes in the camshaft gear.
- 3. Remove the side covers with valve tappets.
- 4. Undo the camshaft gear retaining nut. The camshaft gear can now be pulled off the camshaft using puller 587 315 or can be left in place when the camshaft is extracted.
- 5. Remove the intermediate gear and the guide flange bolts.
- 6. Extract the camshaft from the front. Take care to avoid damaging cams and bearings.

## Fitting

1. Lubricate and push in the camshaft. Be careful not to damage cams and bearings.
2. Fit the guide flange bolts.
3. Fit the intermediate gear, see Intermediate gear: Fitting, points 1-2.
4. Fit the camshaft gear, see Camshaft gear: Fitting, points 1-4.
5. Lubricate the camshaft cams. Fit the side covers with a new gasket.
6. Lubricate pushrods and rocker arms with motor oil and fit them in place.

### Changing valve tappets

1. Clamp the side cover in a vice. Remove the retaining ring and valve tappet.
2. Fit a new valve tappet. Fit the retaining ring, using a screwdriver.

### Camshaft bearings

- There is very little wear on the camshaft and camshaft bearings and these components rarely need any work to be done on them.
- However, when reconditioning the engine, check that the bearing surfaces and cams are not abnormally worn.
- Fit new bearings so that the lubricating holes are opposite the oilways in the block.

### Checking camshaft setting

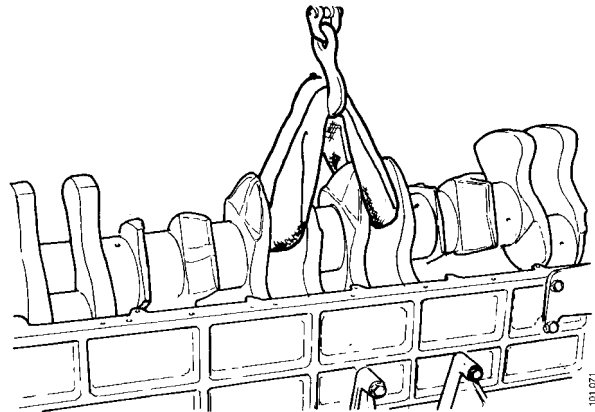
1. Set the crankshaft at TDC for No. 1 cylinder's compression stroke (valves closed).
2. Set up two dial gauges against the valve spring thrust washers.
3. Adjust the rocker arms so that there is no clearance and then an additional 0.1 mm (see that both valves are open 0.1 mm).
4. Zeroize both dial gauges.
5. Turn the crankshaft one revolution in its direction of rotation until the TDC position is reached again.
6. Read the two dial gauges and compare the results with the values given below:

Intake valve lifting height	0.55-1.65 mm
Exhaust valve lifting height	0.50-1.50 mm

# Crankshaft

## Removing

1. Remove the cylinder heads and pushrods.
2. Remove the flywheel and flywheel housing.
3. Remove the fan, fan bearing, oil sump, timing gear housing and intermediate gear.
4. Remove the oil pump and all pistons and connecting rods.
5. Remove all main bearing caps and carefully lift out the crankshaft using a lifting strap or the like which will not damage the shaft journals.
6. Remove all main bearing halves and thrust washers on the 7th main bearing.



## Checking and grinding

1. Measure the crankshaft pivot pins. Use a micrometer to take measurements at two points 90 degrees apart.

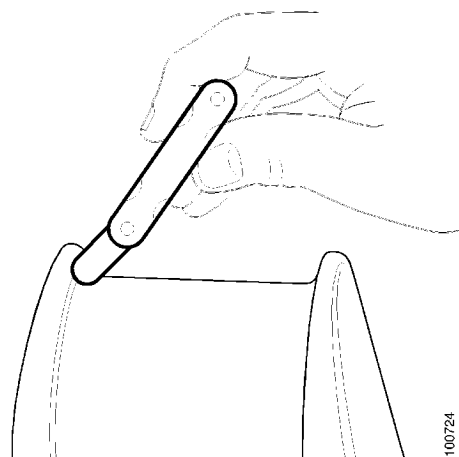
If either of these diameters is below the specified lower limit, regrinding of the crankshaft or the fitting of a replacement crankshaft should be considered.

The oil pressure should also be taken into account, which is in turn also affected by wear in the main and big-end bearings.

2. When regrinding, stated undersizes must be complied with. There are bearings adapted to these dimensions.

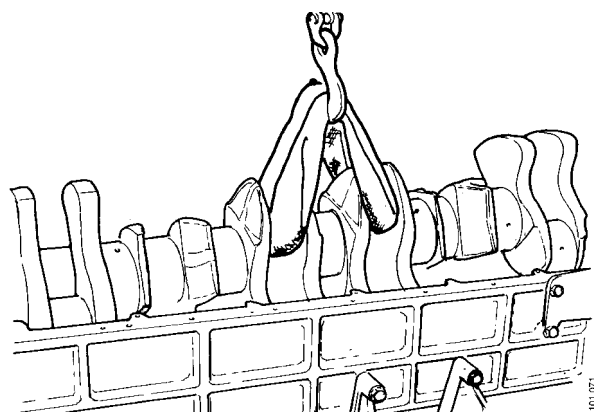
It is important that the fillet radius of the pivot pins is correct.

After grinding the pivot pins, the oil hole orifices at the bearing surfaces should be rounded and polished.

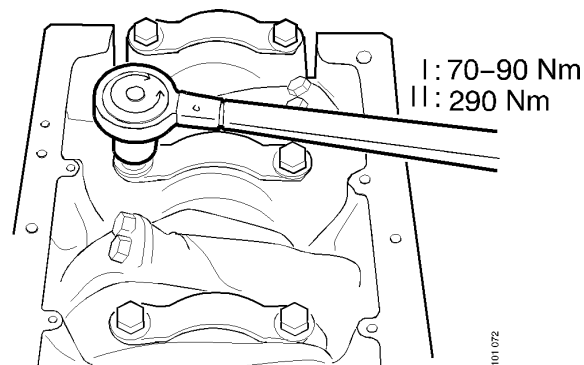


## Fitting

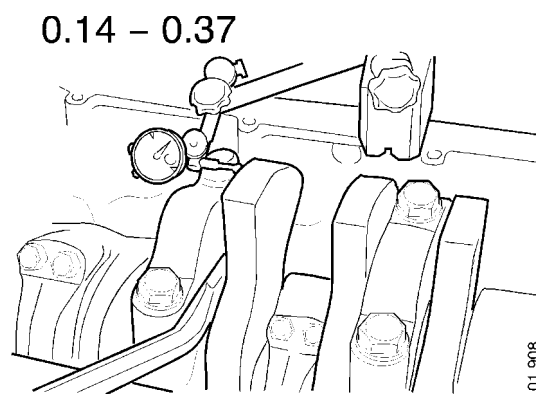
1. Be particularly careful to clean all oilways in the crankshaft, pivot pins and contact surfaces for bearings and caps.
2. Check that the dimensions of bearings and thrust washers are correct. Fit the bearing halves in block and cap. Generously lubricate bearings and pivot pins.
3. Carefully lift in the crankshaft. Fit the thrust washers and place the caps as marked.



4. Lubricate the bolt threads and start by tightening the cap bolts to 90 Nm. Then tighten the bolts to 290 Nm. Check that the crankshaft rotates easily.



5. Check crankshaft axial clearance. It should be 0.14-0.37 mm. The clearance can be adjusted by changing the thrust bearing washers.
6. Fit pistons, connecting rods and oil pump.
7. Fit the fan bearing and fan, oil sump, timing gear housing and intermediate gear.
8. Fit the flywheel and flywheel housing.
9. Fit the cylinder heads and pushrods.



# Lubrication system

## Oil pump

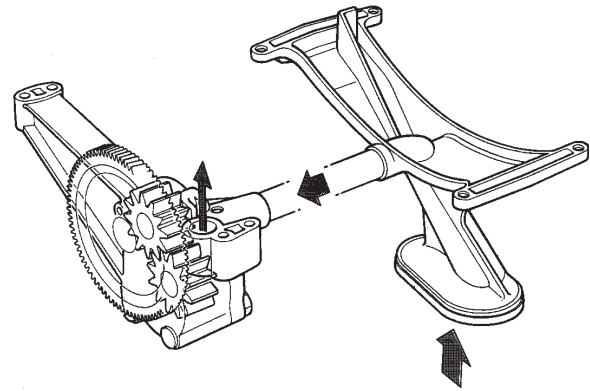
An oil pump, driven by the crankshaft gear, generates the circulation required to provide lubrication oil to all lubrication points so that it flows through the oil cleaner and oil cooler.

The lubricating oil is sucked from the sump through a strainer in the oil pump.

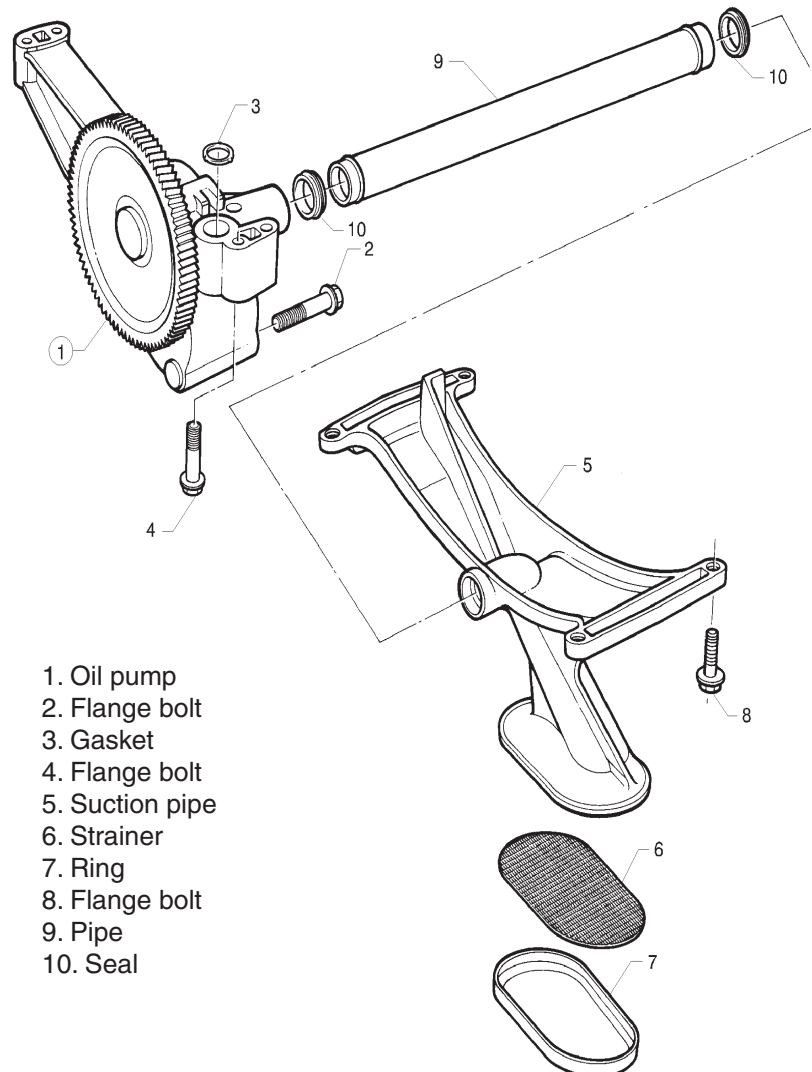
The oil pressure must be so high as to ensure that each lubrication point receives the amount of oil needed for its lubrication and cooling.

Too high oil pressure could cause excessive stress to components in the lubrication system.

Particularly when the oil is cold there is a risk that the pressure will be high and for this reason a safety valve is incorporated in the oil pump. If the pressure is too high the oil pressure valve will allow oil to escape (and run back to the sump) so that the pressure will not be so high as to cause any damage.



1. Oil pump



1. Oil pump
2. Flange bolt
3. Gasket
4. Flange bolt
5. Suction pipe
6. Strainer
7. Ring
8. Flange bolt
9. Pipe
10. Seal

### NOTE!

**In the case of leakage or fault in the oil pump, it should not be reconditioned but should be renewed as a unit.**

## Lubrication oilways

The lubrication oil passes through channels in the cylinder block to reach the camshaft bearings and the crankshaft main bearing.

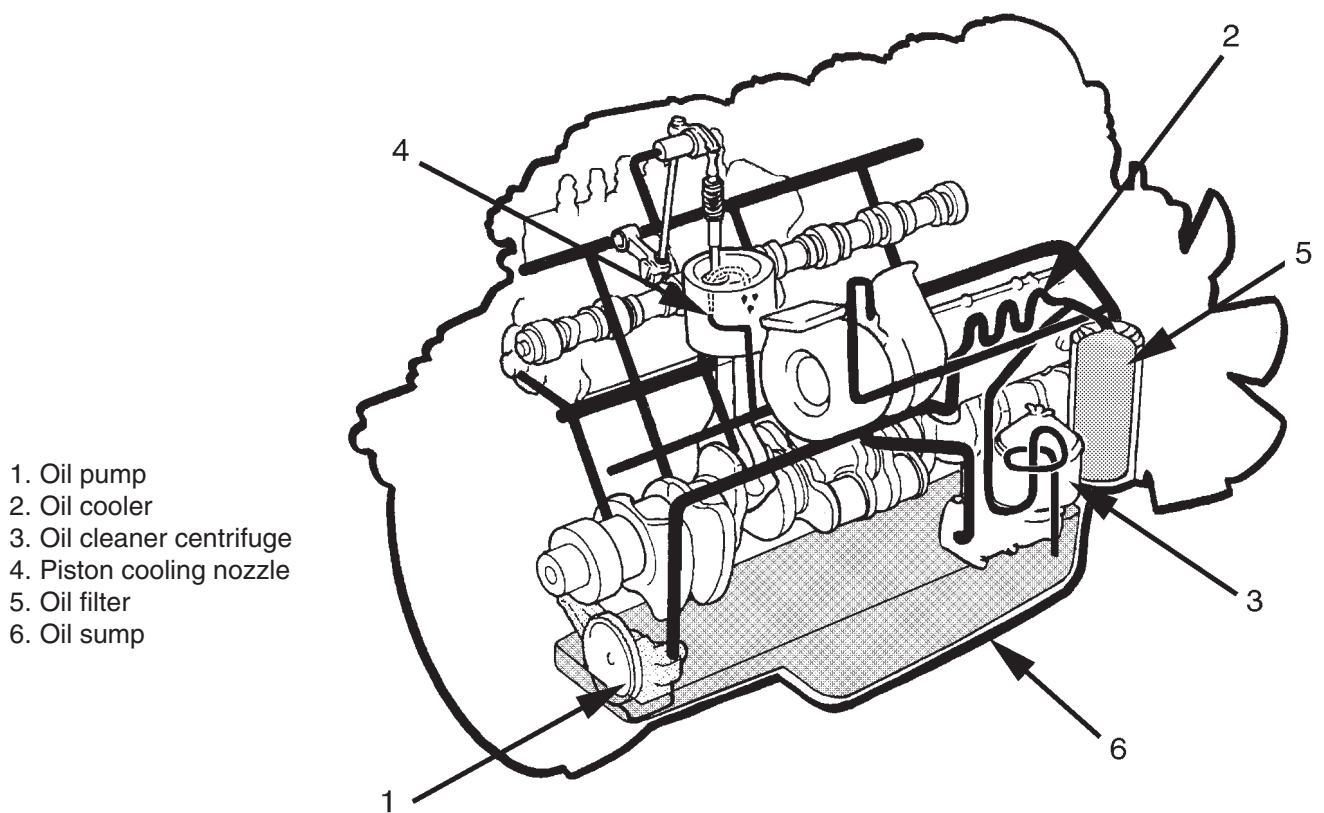
Channels in the crankshaft feed the oil on to the connecting rod bearings.

Lubrication oil for the rocker arms is led via a direct channel from the main oilway.

The channel is constantly pressurised.

The oil is led to the roller tappet shafts via grooves in the camshaft bearing.

The roller tappet shafts have drilled channels to lubricate the roller tappets.



## Oil pressure

### Max. oil pressure:

Warm engine running at a speed above 800 rpm 6 bar

### Normal oil pressure:

Warm engine running at an operating speed of 3 - 6 bar

### Min. oil pressure:

warm engine running at a speed of 1000 rpm 1.0 bar

The control system has the following alarm levels:

- at a speed of less than 1000 rpm and an oil pressure of less than 1.0 bar
- at a speed of more than 1000 rpm and an oil pressure of less than 2.3 bar for longer than 5 seconds.

The following functions are available if there is an alarm:

- Alarm which only switches on the warning lamp and diagnostics lamp.

A fault code is generated in the control unit.

After an alarm, approved values should be registered for more than 1 second to reset the alarm.

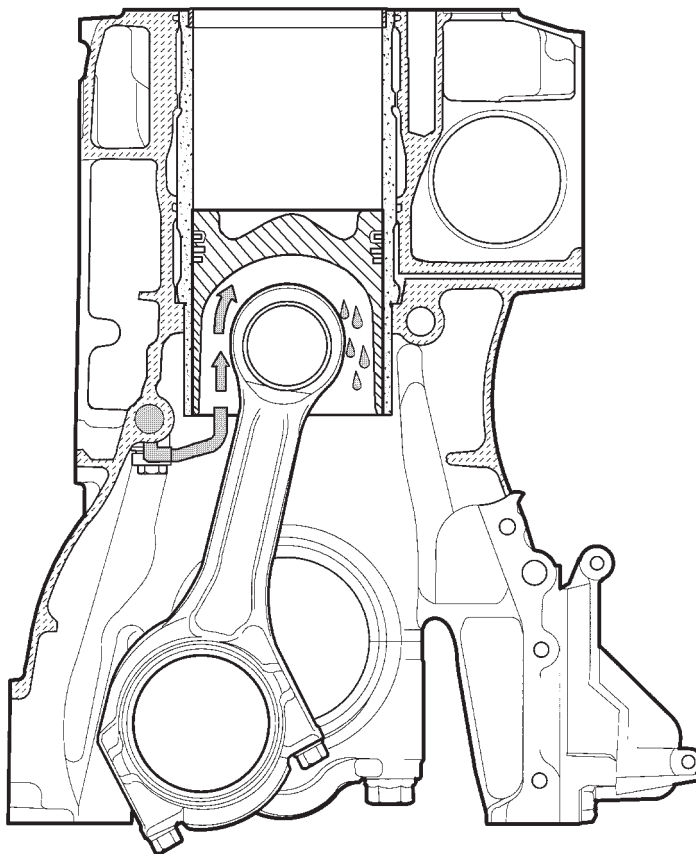
**High lubricating oil pressure (above 6 bar) is normal when starting a cold engine.**

The pistons are cooled by the lubrication oil.

Oil is sprayed up under the piston crown through special nozzles, one for each cylinder.

Since piston cooling is not needed at low engine rpm, an oil pressure valve in the oil cooler housing opens at 3 bar.

See the next page.





## Oil cooler, engine

From the oil pump, the lubricating oil flows via passages in the block to the oil cooler located inside the front side cover on the right-hand side of the block.

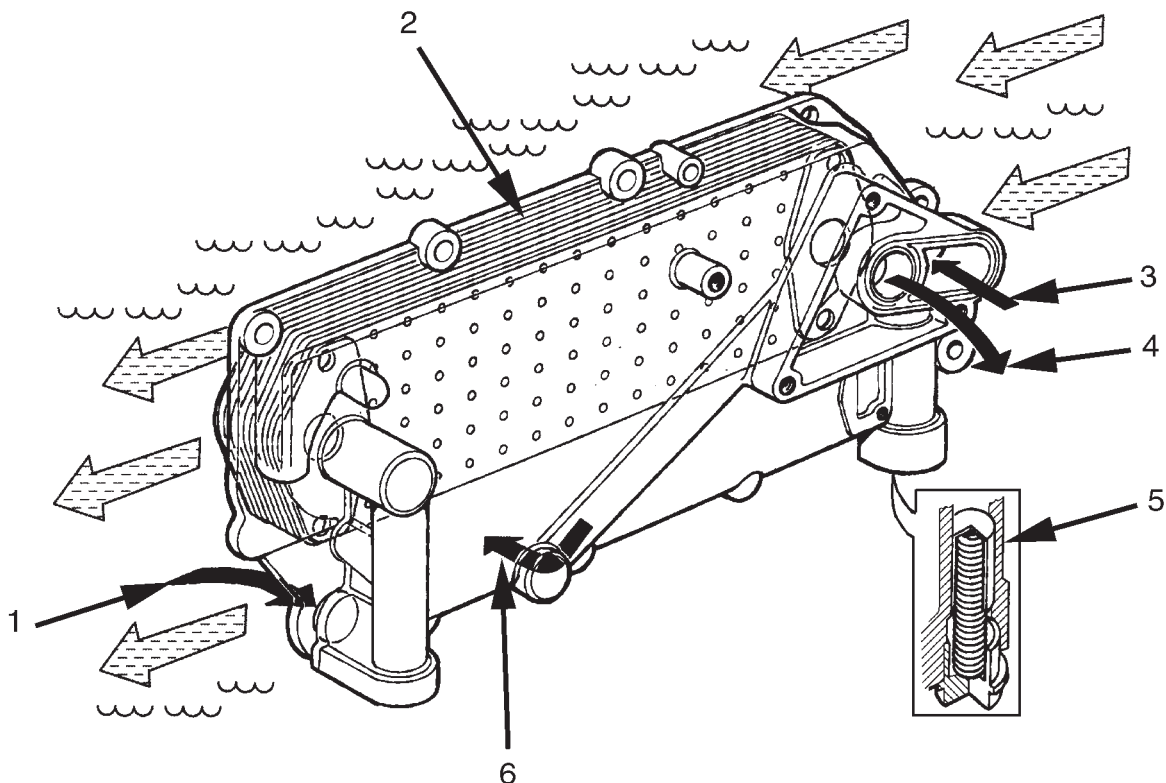
The oil cooler is a plate heat exchanger.

All the oil flows through the cooler where it is cooled by the coolant from the cooling system.

An oil pressure valve (5) is located in the coil cooler housing for cooling the pistons.

It has an opening pressure of 3 bar. No piston cooling therefore takes place at low engine speeds (idling).

See also under **Lubrication oilways**.

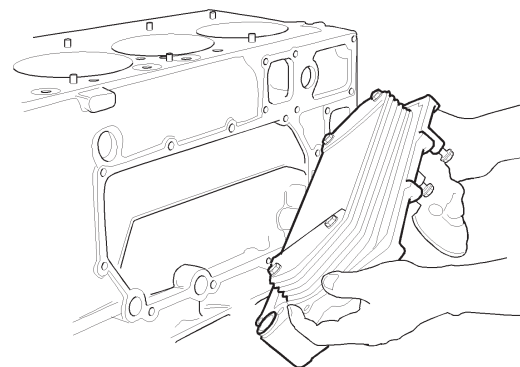


1. Oil from oil pump
2. Heat exchanger assembly
3. Oil from filter into engine
4. Cooled oil to paper filter
5. Delivery valve for piston cooling
6. Partial flow to centrifugal cleaner

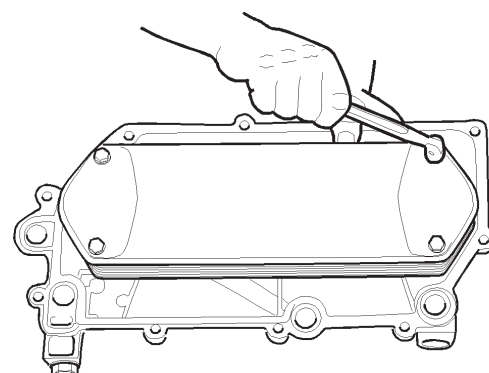


## Renewing seals

1.  
Remove the side cover and oil cooler from the block.



2.  
Remove the 4 bolts securing the oil cooler to the side cover.

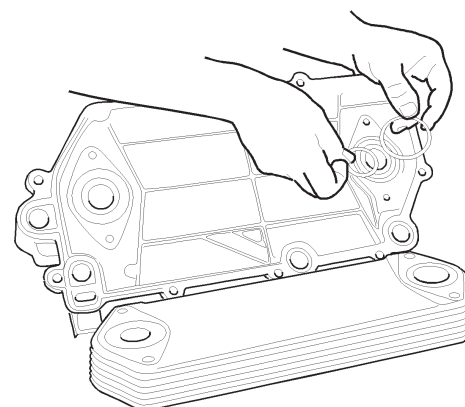


3.  
Remove the oil cooler.

4.  
Renew the 4 O-rings.

5.  
Fit the oil cooler insert and bolt securely to the side cover using 26 Nm torque.

6.  
Bolt the side cover to the block.



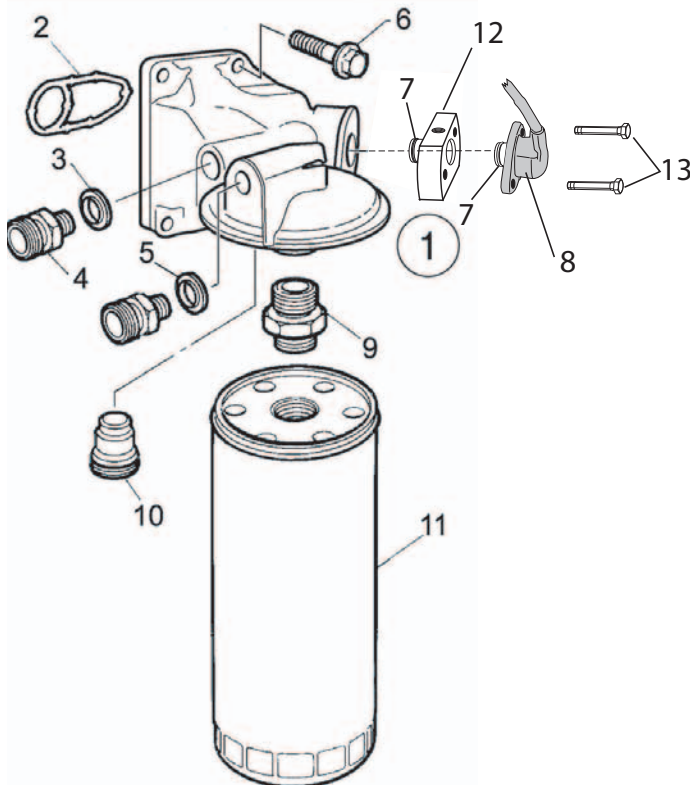
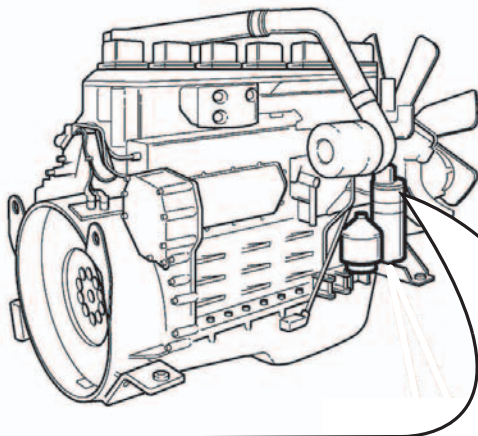
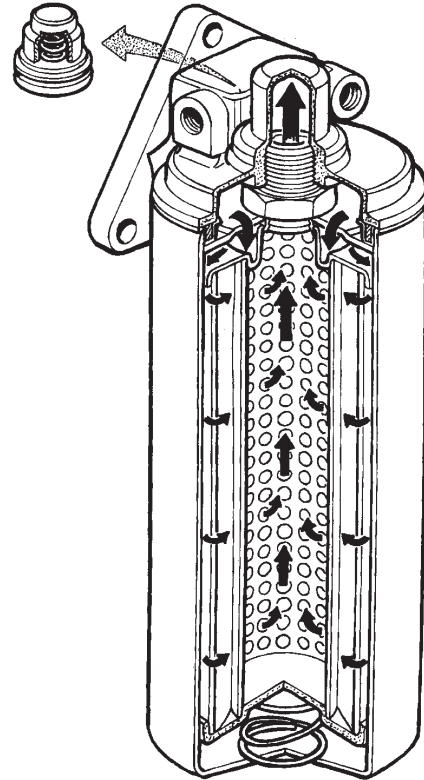
## Oil filter

From the oil cooler, the oil passes through a large-capacity full-flow filter of paper.

This filter also cleans the oil to the turbocharger.

The oil filter has an overflow valve which opens if the filter becomes clogged. Unfiltered oil then continues to the engine and only some of the oil is cleaned in the centrifugal cleaner.

It is therefore especially important to change the filter at the intervals recommended in the **Operating & Maintenance Manual**.



1. Filter head
2. Gasket
3. Seal
4. Straight union
5. Gasket
6. Flange bolt
7. O-ring
8. Pressure sensor
9. Union
10. Overflow valve
11. Oil filter
12. Adapter
13. Screw

# Centrifugal oil cleaner

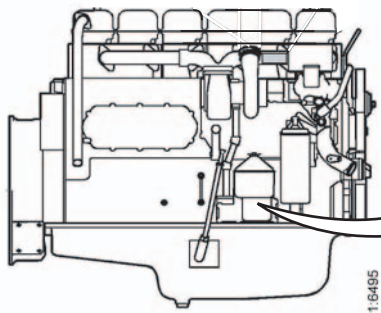
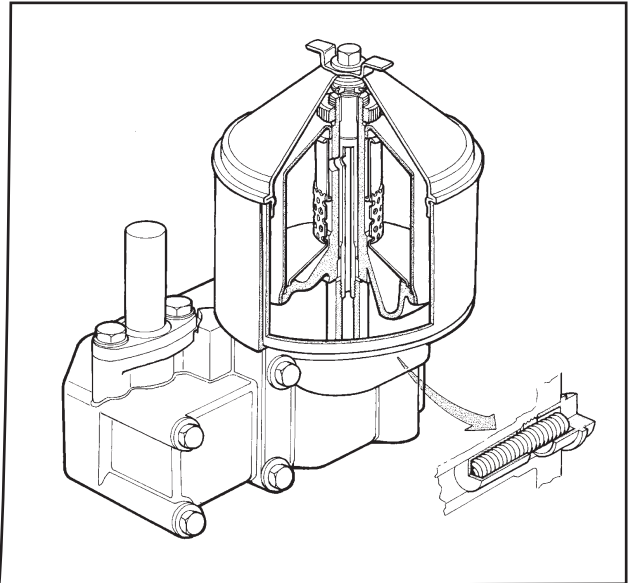
Some of the oil passes from the main passage in the oil cooler cover to the centrifugal cleaner and then, after cleaning, flows back to the sump.

Surplus oil is drained back to the sump via an overflow valve. This ensures that the pressure in the oil system is not too high.

The centrifugal cleaner's rotor is caused to spin by the force of the oil which squirts out through two nozzles at the bottom of the rotor.

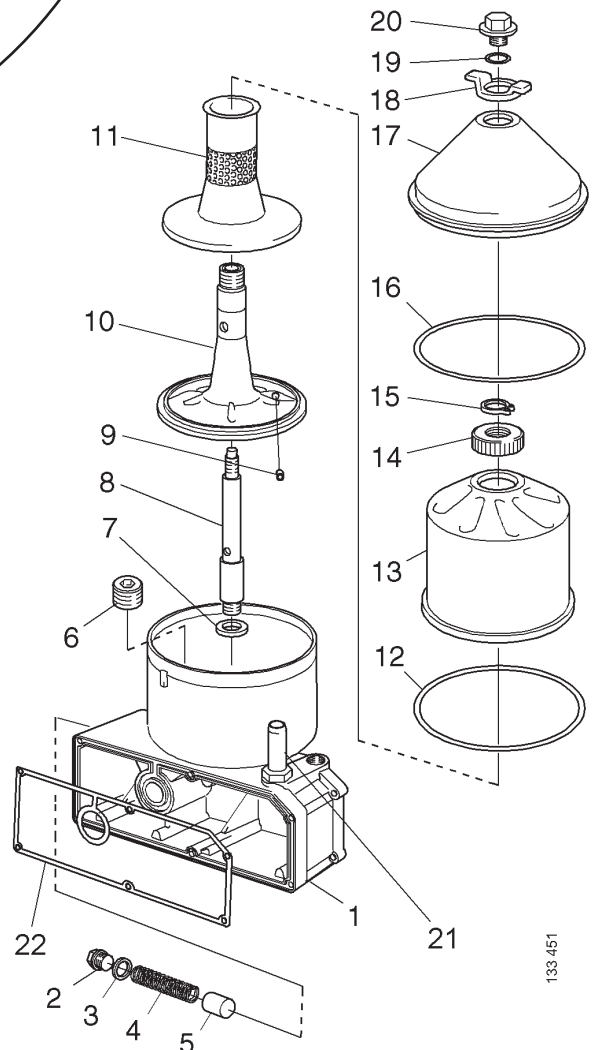
Dirt particles are slung against the wall of the rotor by centrifugal force and fasten there as a coating.

The rotor should be dismantled and cleaned at definite intervals according to the inspection programme included in the operator's manual.



1.6495

1. Housing
2. Plug
3. Gasket
4. Spring
5. Piston
6. Plug
7. Washer
8. Shaft
9. Nozzle
10. Rotor
11. Strainer
12. O-ring (change when cleaning)
13. Rotorbowl
14. Nut
15. Snap ring
16. O-ring (change when cleaning)
17. Cover
18. Lifting eye
19. O-ring
20. Lock nut
21. Nipple
22. Gasket



133 451

## Dismantling and assembly

- During routine cleaning of the oil cleaner, there should be a certain amount of dirt deposits in the rotor bowl.

- If this is not the case, it indicates that the rotor is not spinning. The cause of this must be immediately investigated.

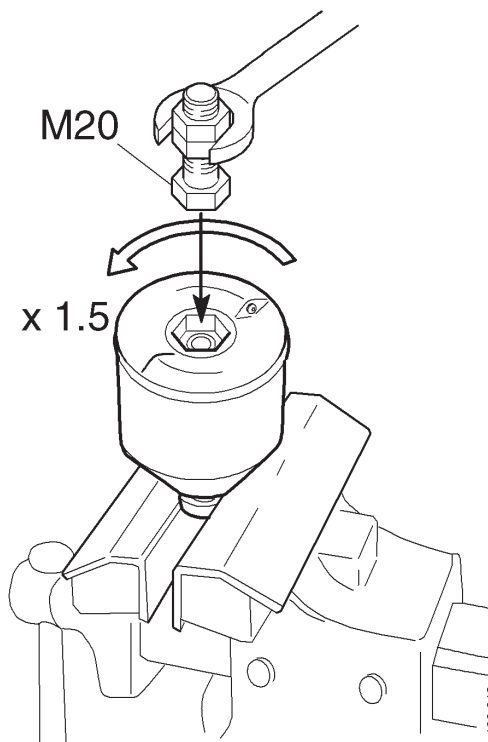
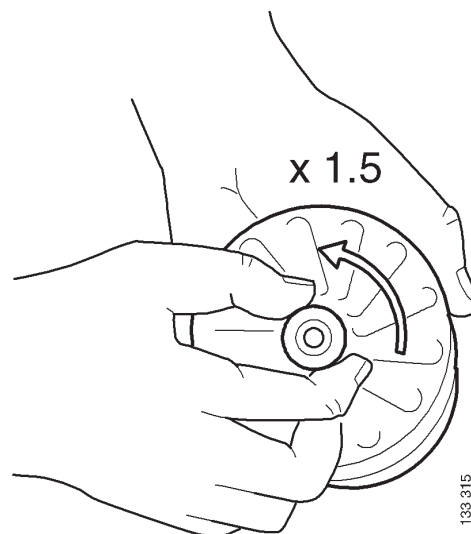
- If the dirt deposit exceeds 28 mm at the recommended intervals, the rotor bowl should be cleaned more often.

1. Undo the nut holding the outer cover and remove the nut.
2. Drain out the oil from the rotor
3. Lift out the rotor. Wipe off the outside. Undo the rotor nut and unscrew it about three turns to protect the bearing.

### Note:

**The rotor must not be put in a vice. Never strike the rotor bowl. This may cause damage resulting in imbalance.**

4. If the rotor nut is difficult to get loose, turn the rotor upside down and fasten the rotor nut in a vice.
5. Turn the rotor counterclockwise 1,5 turns by hand, or if this does not help, use M20 screw and nut as shown at the figure

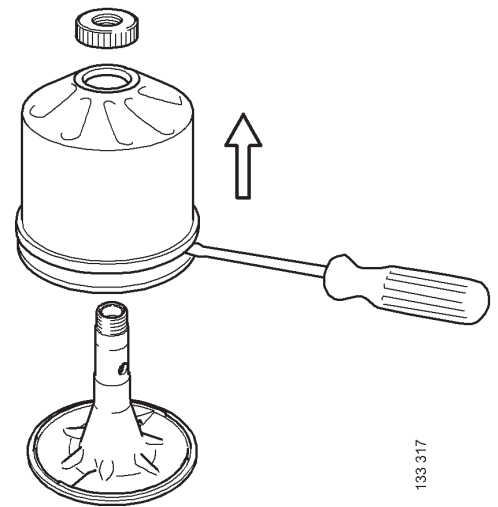




6.  
Grasp the rotor bowl and tap lightly with your hand or carefully use a screwdriver between the rotor bowl and the strainer so that the rotor bowl comes loose from the rotor.

**Note:**  
**Never strike on the rotor directly as this may damage its bearings.**

6.  
Remove the rotor nut and bowl from the rotor.



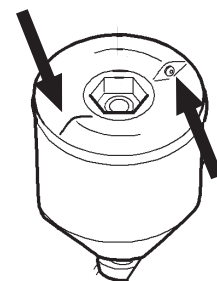
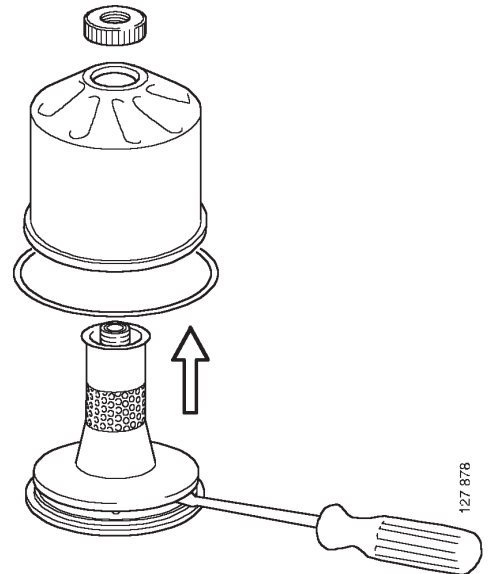
7.  
Remove the strainer located on the rotor. If the strainer has fastened, prise carefully with a knife or screwdriver at the bottom between the rotor and the strainer.

8.  
Scrape away the deposits inside the bowl with a knife.

9.  
Wash the parts.

10.  
Inspect the two nozzles on the rotor. Make sure they are not blocked or damaged.  
**Renew with new rotor if any damaged on the nozzles.**

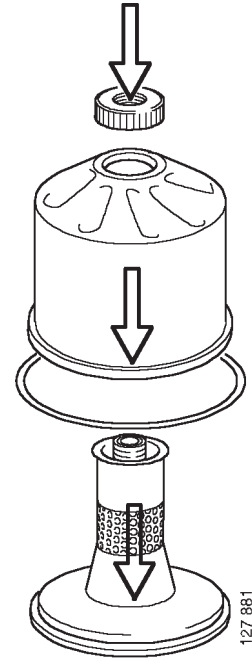
11.  
Make sure the bearings are not damaged.  
**Renew with new rotor if any damaged on the bearing**





12.  
Position the O-ring in the lid. Renew the O-ring if it is at all damaged.

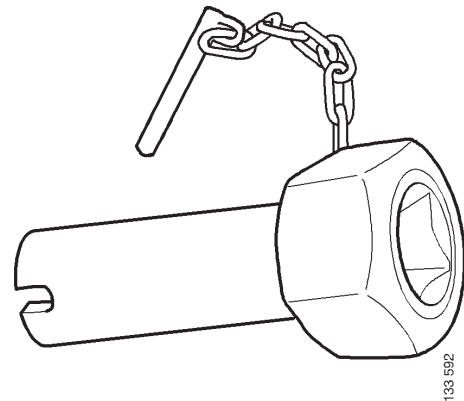
13.  
Assemble the parts and tighten the rotor nut by hand.



14.  
When tighten the rotor axle (point 15) its necessary to modified the Socket spanner 8023 with to weld nut M20 without threads, on the square end.  
See the figure.

The socket spanner 8023 is still usable for the old type of the centrifugal filter after this modification

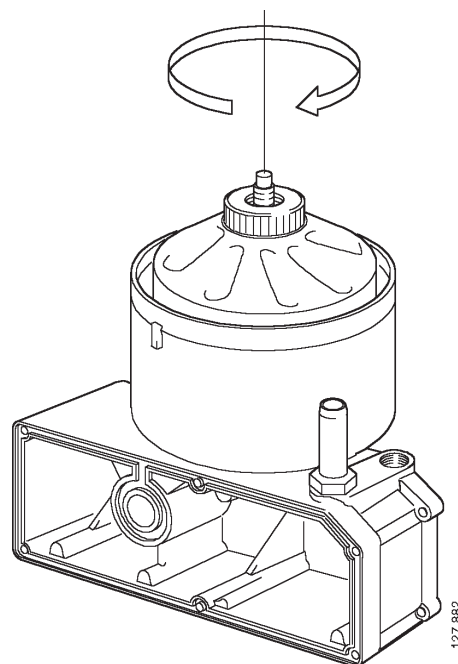
14. För att kunna dra fast rotoraxeln vid punkt 15 i detta Ti behöver hylsnyckeln 98 421 modifieras med en mutter:  
-Borra ur gängorna i en M20-mutter så att den passar på hylsnyckelns fyrkantsfäste.  
-Svetsa fast muttern.  
Obs! Hylsnyckeln passar fortfarande för den gamla centrifugaloljerenaren efter ombearbetningen.



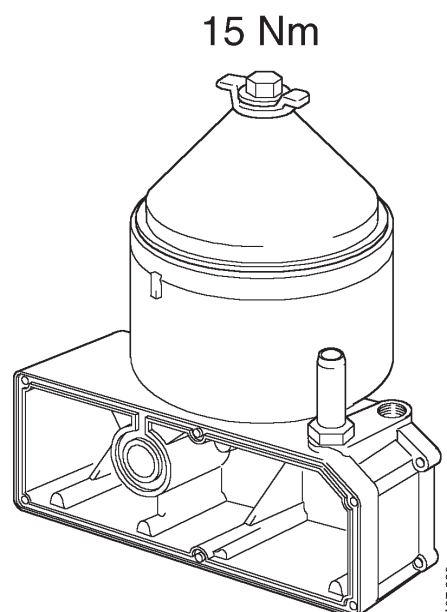
14.  
Make sure the shaft is not loose. If it is, it can be locked using screw locking compound. First clean thoroughly using a suitable solvent.

15.  
Tighten the rotor shaft using socket 8023. Tightening torque 34 Nm.

16  
Refit the rotor and spin it by hand to make sure it rotates easily.



17.  
Inspect the O-ring on the cleaner housing cover and fit it with a lock nut. Tighten the lock nut to 15 Nm.



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## Cooling fan

The fan is driven by the hydraulic system and is moved to the hydraulic chapter.

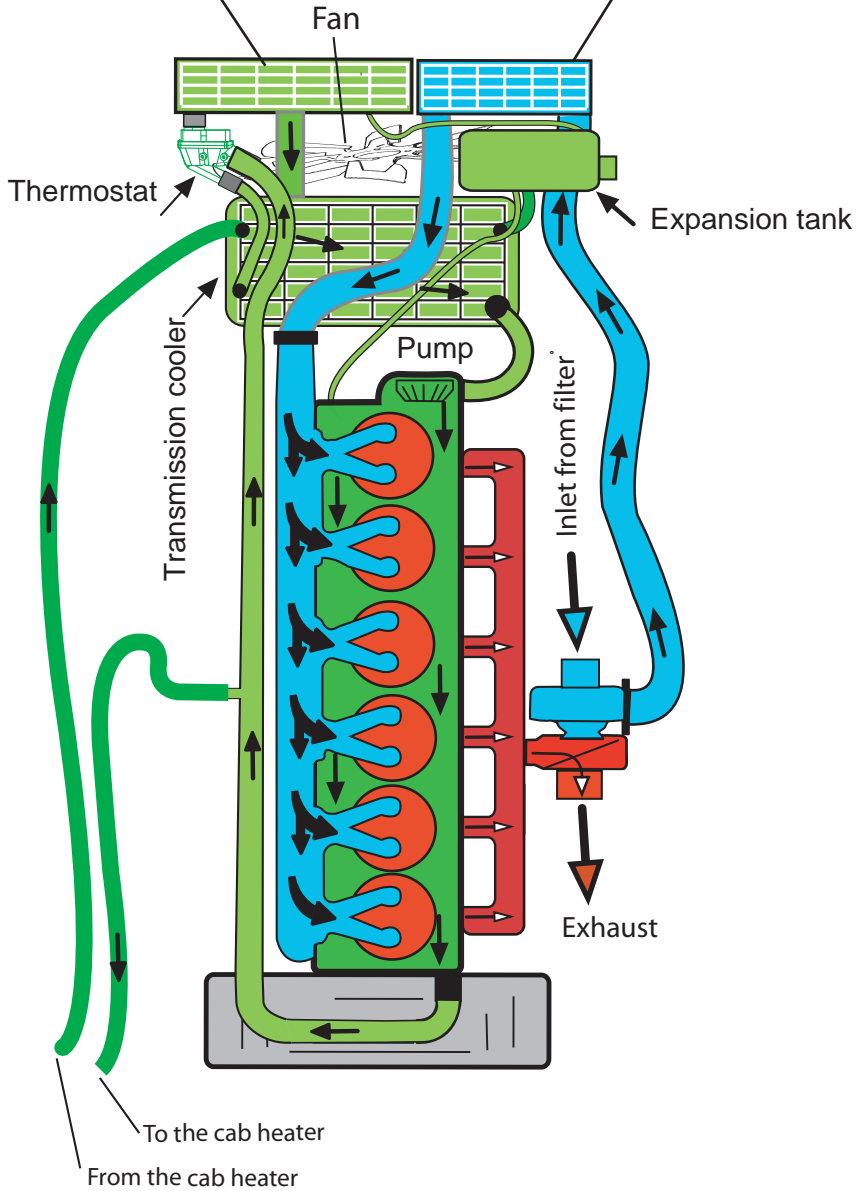
Look in the chapter 5.

# Cooling system

## View of the cooling system

Cooling water circulates in the engine cooling system

Charge air cooler



## Circulation

From the pump, the coolant is carried into the cylinder block's longitudinal distribution ducting and then through holes in the cylinder block, washes round the cylinder liners and flows up to the cylinder heads.

The coolant is also forced directly up into the cylinder heads from the distribution ducting via passages which leads to the injectors and exhaust valves.

From the engine's rear cylinder head the coolant flows forward through the pipe directly into the thermostat housing, which is located on the left-hand side of the radiator shield.

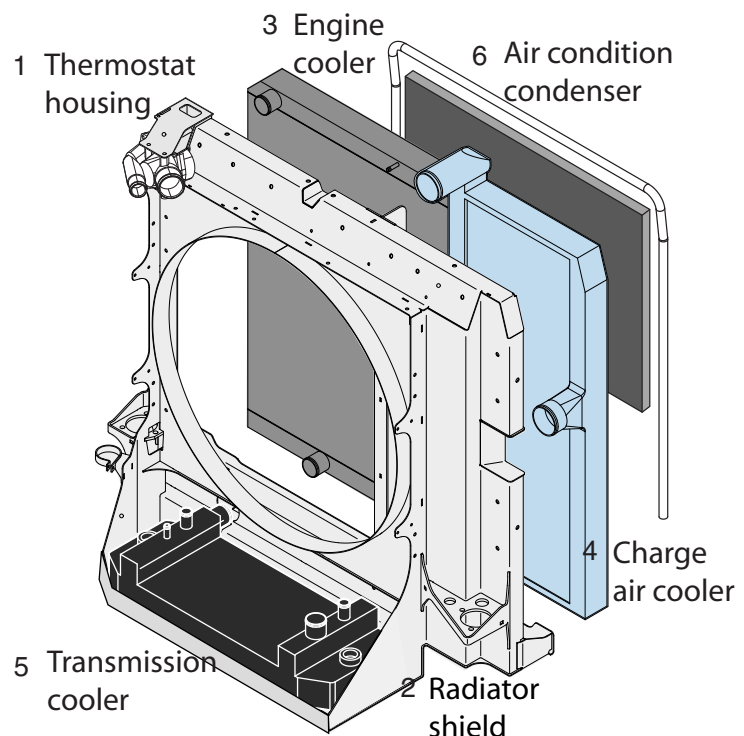
The by pass in the thermostat housing forwards the coolant which is under the temperature limit for the thermostat, back to the engine through the transmission cooler. The coolant which needs to be cooled, are going through the open thermostat and to the radiator cooler system, through the transmission cooler and back to the engine, where the coolant pump is circulating the coolant in the system.

The cab heater takes the heat coolant from the pipe line on the left-hand side of the engine, and after heating the cab, the returned coolant is going to the transmission cooler.

The inlet air to the engine, is by the turbo compressor forced through the charge air cooler. The hydraulic driven fan are also feeding the air through the air charge cooler and cools the air from the turbo compressor.

The pressure of the air, in the air charge system, to the cylinders is approx 1 - 2 bar, depend on the engine's rpm.

## View of the radiator system



## Disassemble the cooling unit

1

Drain the coolant and transmission oil.

First, remove both cover on the underside front frame left and right side.

On left side of the transmission cooler unscrew the plug (Nv 13 mm) and drain the coolant from the engine and radiator.

On the right side under the transmission cooler unscrew the plug (Nv 13mm) and drain the transmission oil from the system.

### NOTE !

**Use a clean drum or similar if the cooling water shall be reused.**

**Its recommend to supply with new oil when refilling oil to the transmission.**

2

Disassemble the horn unit, remove the fastening wiring strips and clamps from the brackets.

3

Disconnect the cooling hoses from the thermostat housing and the outlet hose from the transmission oil cooler.

4

Disassemble the hose on the charge air cooler

5

Disconnect hoses between the expansion tank and the engine.

5

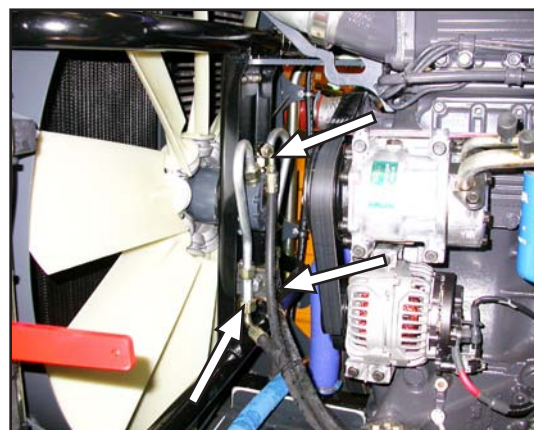
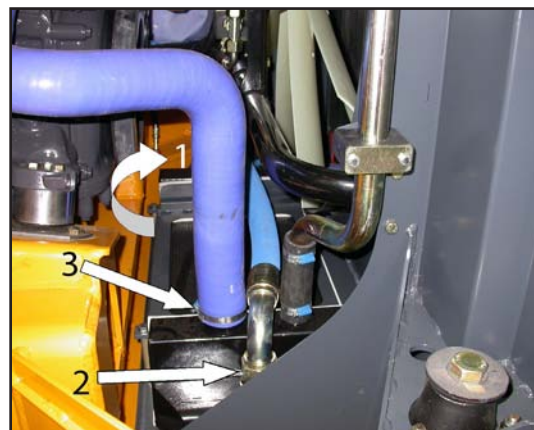
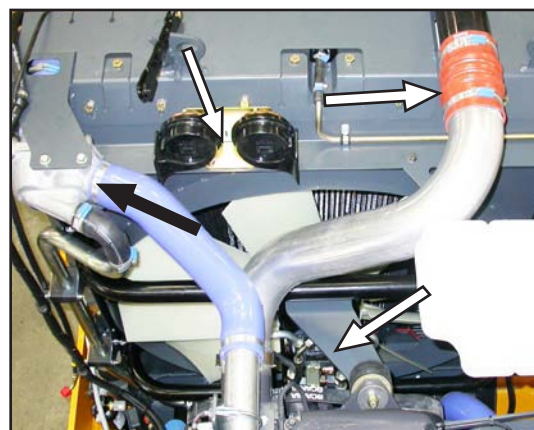
Disassemble oil hoses from the transmission oil cooler

and the fan motor.

### NOTE !

#### Oil under hydraulic pressure !

The oil system for the fan motor is in the same oil system as the brake, therefore it is recommended when disassemble hoses or units from this system, always to eliminate pressure in the accumulator, locate in front of the cab. (2 on left and side 2 on the right side). this can be doing with to operate the brake pedal several times. (Approx 15-20 times)



6

Disassemble the Air Condition condenser and the fastening clamps from the fastening brackets.  
Place the condenser on the left side of the engine.

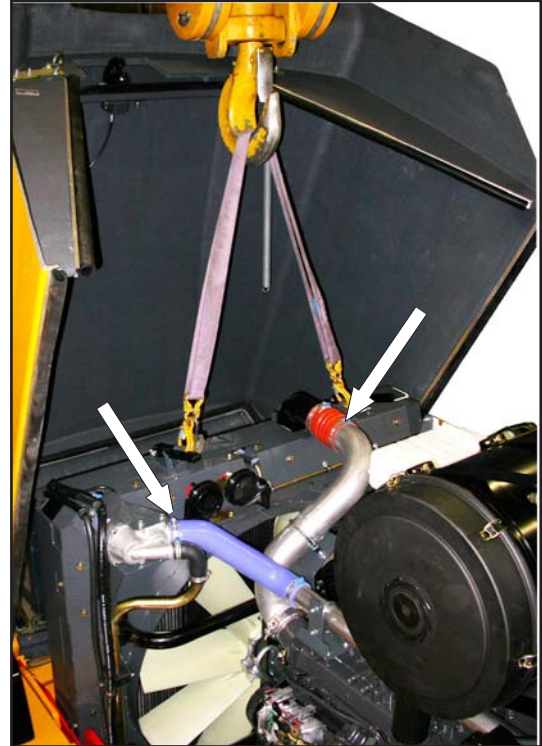
**NOTE !**

**Do not disassemble the Air Condition hoses from the condenser filter or the compressor.**

7

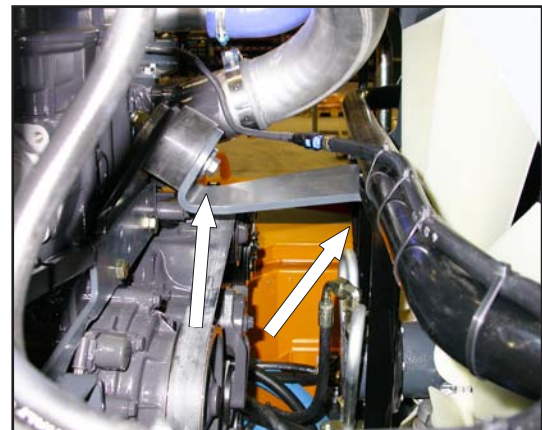
Fastening the lifting device to the radiator unit.

Check that all cooling pipes and hoses are disassembled



8

Disassemble the upper bracket between engine and fan bracket, (3 screws).



9

Disassemble lower fastening 2 screws (left and right hand side)

10

Carefully lift the cooler unit out from the frame.





### Thermostat and thermostat housing

The engine have a double thermostat.

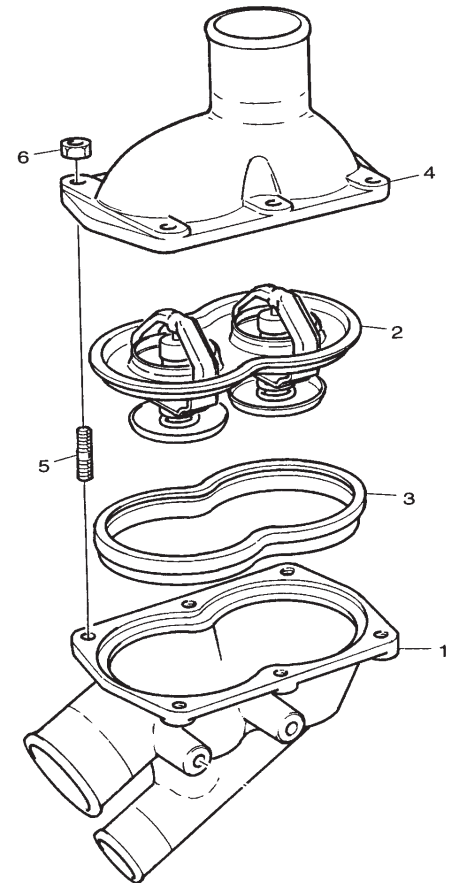
When a double thermostat are used they have the same opening temperature as standard.

The thermostats use wax as the temperature-sensitive medium.

At coolant temperatures below the opening temperature of the thermostats, nearly all the coolant circulates between the engine's coolant passages and the coolant pump without passing through the radiator.

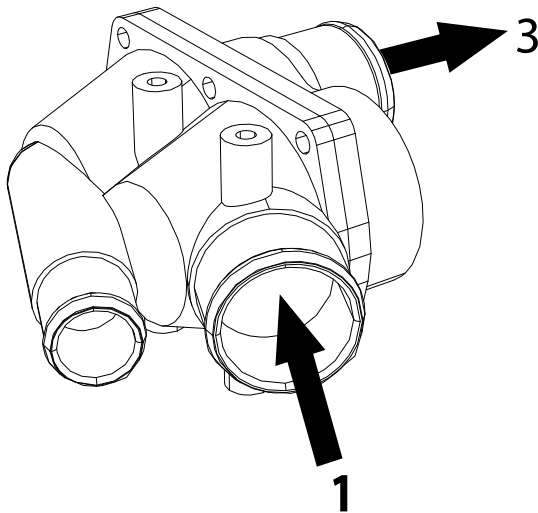
When the coolant temperature in the engine is higher than the temperature for fully open thermostat, the by-pass channel is closed and all coolant flows through the thermostats and on to the radiator.

If temperature equilibrium occurs within the operating range of the thermostats, i.e. between the temperature limits for fully closed and fully open thermostat, the thermostat valves will assume a corresponding intermediate position. Some of the coolant will then be directed to the coolant pump without being cooled and the remainder directed to the radiator.

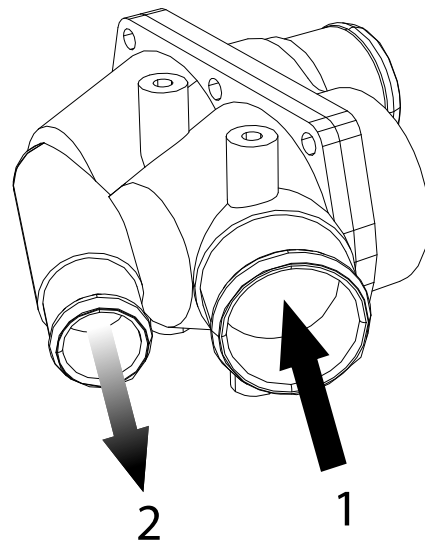


- 1. Thermostat housing
- 2. Thermostat
- 3. Gasket
- 4. Cover
- 5. Stud
- 6. Flange nut

Open thermostat - full flow to radiator



Closed thermostat - return to coolant pump trough by-pass channel



- 1. Coolant from the engine
- 2. By-pass channel (back to the coolant pump)
- 3. Outlet to the radiator

## Thermostat

### Removing

1. Remove the expansion tank filler cap.

Drain a sufficient amount of coolant from the system.

2. Remove the hose from the thermostat housing cover.

Detach the thermostat housing cover and remove the thermostat (double thermostat).



### Fitting

1. Clean the thermostat housing and check that nothing obstructs the function of the thermostat.
2. Insert the thermostat in the housing. Fit new gaskets and screw the thermostat housing together.
3. Fill the system with coolant.  
See **OPERATING & MAINTENANCE MANUAL** chapter 7 for the composition of the coolant.
4. Start the engine and check that there are no leaks. Check the coolant level and top up as necessary.

Apply Loctite No. 510  
Part No. 516204

Assemble cover;  
Screw No. 051735 M8 x 38 - 8.8  
Nut No. 502975 M8

Torque with 24 Nm



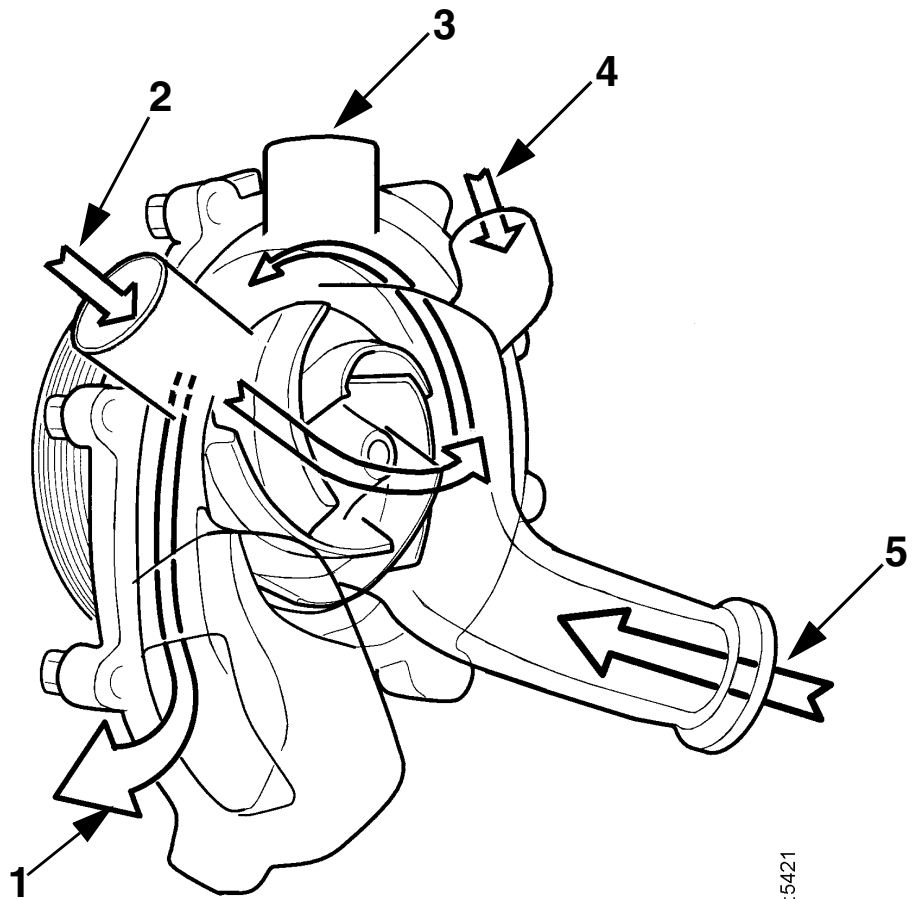
## Coolant pump

The coolant pump is located at the front side of the front cover on the right-hand side of the engine.

The coolant pump is driven by a multigroove belt directly from the crankshaft damper.

The pump is of centrifugal type and consists of a spiral shaped pump housing with an impeller directly mounted on the driveshaft. The shaft is mounted in the housing and by means of two permanently lubricated ball bearings.

The pump shaft bearing is sealed against the ingress of coolant by an elastic axial seal.



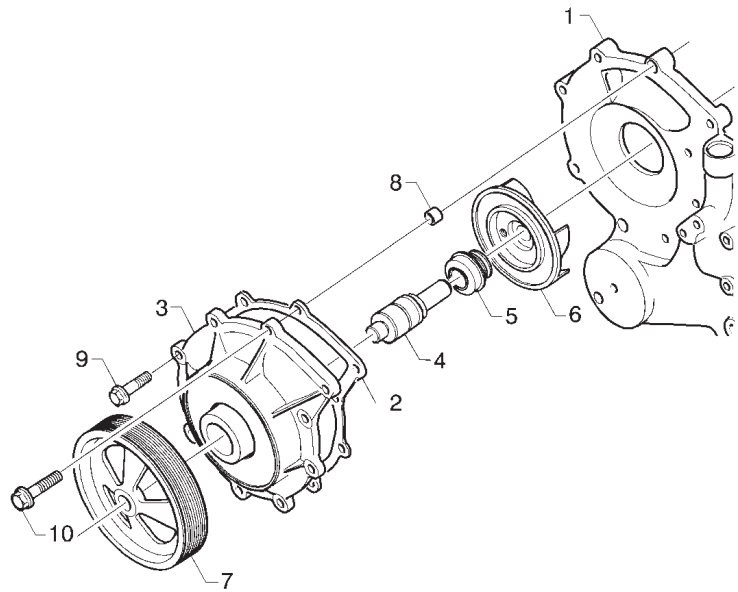
2:5421

Circulation through coolant pump

1. Outlet to engine
2. By-pass channel
3. Static line
4. Return from charge air cooler
5. Coolant from radiator

## Removing

1. Drain the cooling system through the drain taps in the block and in the pipe from the outlet on the radiator.
2. Remove any protection meshes and fan ring with sealing ring to gain access to the fan.
3. Remove the fan.
4. Turn the automatic belt tensioner and prise the poly-V-belt off the coolant pump pulley.
5. Remove the coolant pump assembly.  
Fitting the pump



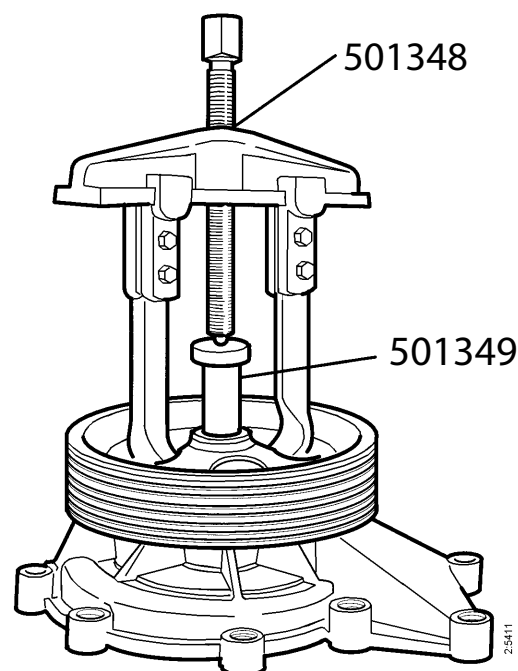
1. Clean old gasket debris from the sealing surfaces.
2. Fit the pump without damaging the seal(s).
3. Fit the automatic belt tensioner.
4. Fit the (poly-V) drive belt and any protection mesh and fan ring with sealing ring.
5. Fit the fan.
6. Fill the cooling system. See booklet 00:03-01 for the composition of the coolant.

7. Start the engine and check that no leakage occurs. Check the level of the coolant and top up as necessary.

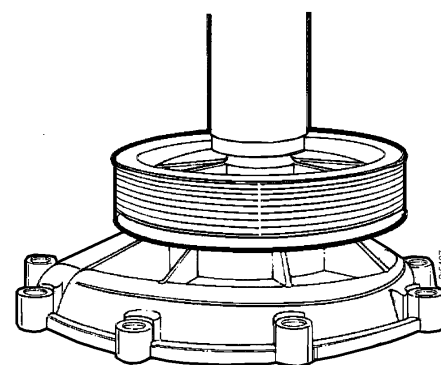
1. Front cover
2. Gasket
3. Pump cover
4. Shaft with bearing
5. Sealing ring
6. Impeller
7. Pulley
8. Guide sleeve
9. Flange screw
10. Flange screw

## Changing the pulley

1.  
Remove the pulley using puller 501348 and drift 501349.
2.  
Press the pulley on until it is flush with the shaft end face.



The pulley is removed

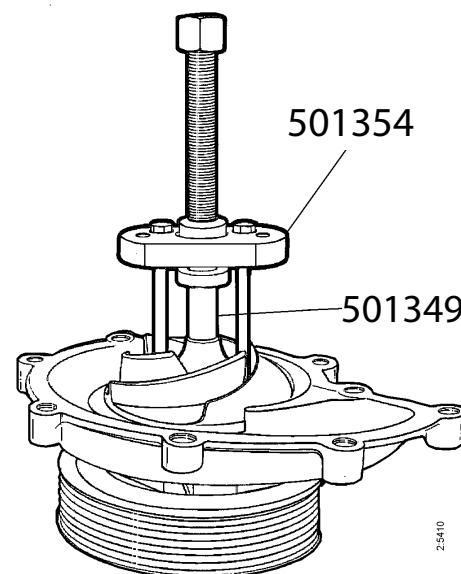


The pulley is pressed on

## Changing the sealing ring

If coolant has leaked out inside the housing behind the pulley, the sealing ring can be changed.

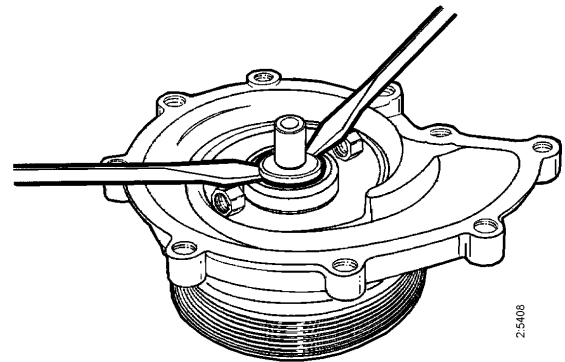
1.  
Place the pump with pulley on a flat and level surface.
2.  
Fit puller 501354 using two M 8 x 65 mm bolts and drift 501349. Pull off the impeller.
3.  
Split the carbon ring on the seal and remove the debris.



The impeller is removed

4. Prise off the seal using two screwdrivers and separator plates.

**Note:**  
Do not damage the pump housing gasket surface.

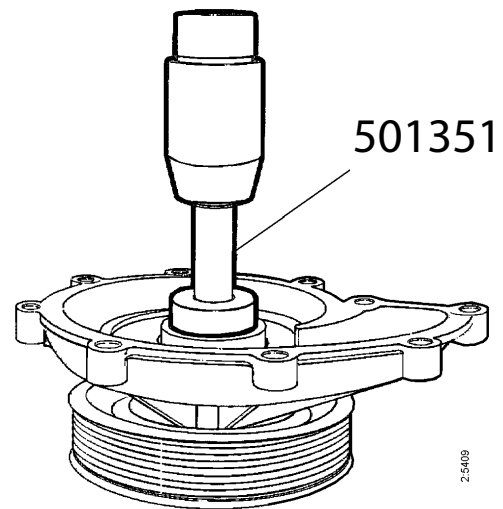


The seal ring is removed

5. Apply sealing agent (501350) to the inside and outside (brass sleeve) of the sealing ring. Make sure that no sealing agent gets onto other sealing surfaces.

**Important!**  
Sealing agent (501350) should be used sparingly. There is a risk of the sliding surfaces being glued together.

6. Press in the new sealing ring with drift 501351 until the edge of the brass sleeve abuts against the pump housing. Keep it under pressure for about 10 seconds.

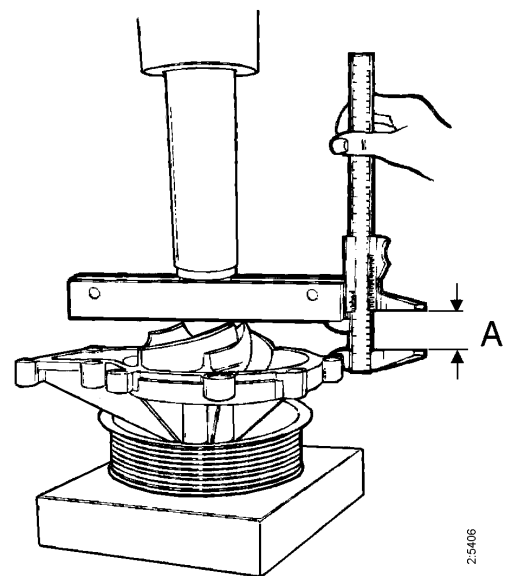


The new seal ring is pressed in

**Note:**  
It is very important that tool 501351 is used. It is designed to correctly preload the spring which holds the seal.

7. Press on the impeller using drift 501351 until the clearance between the gasket surface of the pump housing and the end of the impeller shaft is 13.3 - 13.7 mm.

**Important!**  
The shaft must not change position in the pump housing as there is a danger that the sealing ring would then also change its position.



A = 13,3 - 13,7 mm  
The clearance is measured

Puller for pulley	501348
Drift for pulley	501349
Puller for impeller	501354
Drift for pressing in sealing ring and for impeller	501351

## External cleaning

### Radiator

- Check that the radiator is not clogged on the air side and that the cooling fins are not damaged.
- Carefully scrape the deposit off the radiator's cooling fins. If necessary, a paraffin-based engine cleaner can be used.
- Bent fins can be straightened using a wire brush, for example, and exercising care.

## Internal cleaning

### Removing oil and grease

- If possible, run the engine until it has reached the operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with liquid dishwasher detergent intended for household use. Concentration 1% (0.1/10 l).
- Run the engine until warm for about 20-30 minutes. Do not forget the cab heating system (if fitted).
- Drain the cooling system.
- Fill the system again using clean, hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant according to the specification on page 33.



**WARNING**  
Handling cleaning agents  
for the cooling system:  
Read the warning label on  
the container.

### Removing deposits

- If possible, run the engine until it has reached operating temperature and then drain the cooling system.
- Remove the thermostat.
- Fill the system with clean, hot water mixed with a commercially available radiator cleaner based on sulphamic acid and containing dispersing agents. Follow the manufacturer's instructions for mixing proportions and cleaning times.
- Run the engine for the specified time and then drain the cooling system.
- Refill the system with hot water and run the engine for approximately 20-30 minutes.
- Drain the water from the system.
- Refit the thermostat.
- Fill up with new coolant according to the specification on page 33.



Always collect fluid in a  
suitable container to avoid  
spillage when draining  
coolant.  
Dispose of used coolant  
through an authorized  
waste disposal contractor.



# Specifications

## General information

<b>GENERAL</b>		<b>DC9 EMS</b>
Number of cylinders		5 in line
Cylinder diameter	mm	127
Stroke	mm	140
Displacement	dm <sup>3</sup> (litres)	8.87
No. of main bearings		6
Firing order		1 - 2 - 4 - 5 - 3
Compression ratio		18:1
Engine direction of rotation viewed from rear		Anticlockwise
Fan direction of rotation viewed from front		Clockwise
Cooling		Liquid
Valve clearances, cold engine		
intake valve	mm	0.45
exhaust valve	mm	0.70
Weight, without coolant or oil	kg	887
*With charge air cooler, radiator, expansion tank and pipes		
<b>LUBRICATION SYSTEM</b>		
Max. oil pressure		
hot engine at engine speeds		6
above 1000 r/min	bar (kp/cm <sup>2</sup> )	
Normal oil pressure:		
hot engine at operating speed	bar (kp/cm <sup>2</sup> )	3 - 6
Min. oil pressure:		
hot engine under 1000 rpm	bar (kp/cm <sup>2</sup> )	0.7
hot engine above 1000 rpm		2.3
Oil volume, see page 27		
Crankcase pressure with closed crankcase ventilation	mm VP	-55 - +20

<b>FUEL SYSTEM</b>		<b>DC9 EMS</b>
Low idle speed	rpm	700 (adjustable 500-800)
Maximum full load speed		See engine card
Fuel		Diesel fuel oil <sup>1</sup>
<sup>1</sup> see page 55		
<b>COOLING SYSTEM</b>		
Number of thermostats		1 (dual thermostat)
Thermostat, opening temperature	°C	8 3
Coolant temperature: system at atmospheric pressure	°C	83 - 95
system at overpressure	°C	83 - approx. 100
Volume, including radiator, engine and expansion tank with 1.0 m <sup>2</sup> radiator	dm <sup>3</sup> (litres)	57
<b>ELECTRICAL SYSTEM</b>		
System voltage	V	24
Alternator, current	A	80 or 100
Starter motor output	kW (hp)	5.5 (7.5)
Monitors, threshold values: oil pressure monitor	bar (kp/cm <sup>2</sup> )	1,0 0,15
temperature monitor	°C	Programmed in S6

## Cylinder head

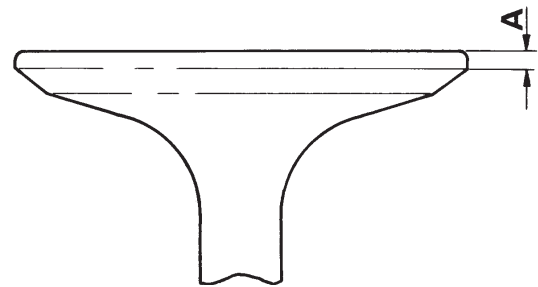
### Intake valve

Valve head angle ..... 19.5  
 Minimum dimension A for ground valve ..... 2.6 mm  
 Distance between the surface of the cylinder head and the valve head . 0.75-1.8 mm

### Exhaust valve

Valve head angle ..... 44.5  
 Minimum dimension A for ground valve ..... 1.8 mm  
 Distance between the surface of the cylinder head and the valve head . 0.66-1.8 mm

- Check dimension A for each valve.
- Grind the valves in a valve grinding machine



Minimum dimension A for ground valve

### Intake valve seat

Seat angle ..... 20.0°-20.5°  
 Width of contact surface A ..... 1.9 - 2.6 mm  
 Valve seat insert, outer diameter ..... 46.054 - 46.065 mm  
 Seat for valve seat insert, diameter ..... 46.000 - 46.016 mm  
 Seat for valve seat insert, depth ..... 11.25 - 11.35 mm

### Oversized valve seat insert:

Outer diameter ..... 46.254 - 46.265 mm  
 Seat for valve seat insert, diameter ..... 46.200 - 46.216 mm  
 Cooling temperature when fitting valve seat insert ..... approx. -80°C

## Exhaust valve seat

Seat angle .....	45.0°-45.5°
Width of contact surface A .....	1.8 - 2.6 mm
Valve seat insert, outer diameter .....	44.081 - 44.092 mm
Seat for valve seat insert, diameter .....	44.000 - 44.016 mm
Seat for valve seat insert, depth .....	11.25 - 11.35 mm

## Oversized valve seat insert:

Outer diameter .....	44.281 - 44.292 mm
Seat for valve seat insert, diameter .....	44.200 - 44.216 mm
Cooling temperature when fitting valve seat insert .....	approx. -80°C

## Tightening torques

Cylinder head bolts:	
First tightening .....	60 Nm
Second tightening .....	150 Nm
Third tightening .....	250 Nm + 90°
Nut for injector .....	70 Nm
Bolts for rocker arm bracket .....	115 Nm
Nut for adjusting screw on rocker arm .....	40 Nm
Bolt for rocker cover .....	26 Nm
Bolts for exhaust manifold .....	50 ± 5 Nm +60°
Bolts for turbocharger .....	50 Nm

## Valve clearances and unit injectors

Valve clearance, intake valve (cold engine) .....	0.45 mm
Valve clearance, exhaust valve (cold engine) .....	0.70 mm
Dimension for PDE31 unit injector (cold engine) .....	66.9 +/- 0.1 mm
Dimension for PDE32 unit injector (cold engine) .....	69.9 +/- 0.1 mm

## Tightening torques

Adjusting screw lock nut on rocker arm for unit injector .....	39 Nm
Adjusting screw lock nut on rocker arm for valves .....	35 Nm
Bolt for upper rocker cover .....	18 Nm
Bolt for lower rocker cover .....	26 Nm
Support bracket and rocker arm shaft .....	105 Nm
Cable connection, unit injector .....	2 +/- 0,2 Nm

## Cooling system

Number of thermostat .....	1 (dual thermostat)
Thermostat opening temperature .....	80°C
By pass closed at .....	87°C
Fully open at .....	95°C

## Turbocharger

### Wear limits

Shaft radial clearance.....	0.198-0.564 mm
Shaft axial clearance (after running in) .....	0.025-0.106 mm

### Tightening torques

Bolts, turbocharger - exhaust manifold .....	63 Nm
Bolts in turbine housing (exhaust pipe) .....	24 Nm
V-clamps, exhaust and intake .....	6-10 Nm

## Pistons and cylinder liners

### Cylinder liner

Shims for cylinder liner, thickness.....	0.20, 0.25, 0.30, ..... 0.40, 0.50, 0.75 mm
Height of cylinder liner above cylinder block .....	0.20 - 0.30 mm
Maximum permitted height difference on one liner between dimensions measured at two diametrically opposite points.....	0.02 mm

### Pistons

Fitted with arrow on piston crown facing forward.

### Piston rings

Number of compression rings .....	2
Gap: 1st ring .....	0.35 - 0.60 mm
2nd ring.....	0.45 - 0.65 mm
Maximum clearance in groove, 2nd ring .....	0.25 mm

Rings marked "TOP" should be turned with the marking up.

Number of oil scraper rings .....	1
Gap .....	0.40 - 0.65 mm
Max. clearance in groove.....	0.25 mm



**Timing gear****Camshaft gear**

Backlash against intermediate gear ..... 0.03 - 0.15 mm

**Injection pump gear**

Backlash against intermediate gear ..... 0.03 - 0.15 mm

**Intermediate gear**

Max. axial clearance ..... 0.238 mm

**Camshaft**

Axial clearance ..... 0.10 - 0.25 mm

**Tightening torques**

Bolts for camshaft gear .....	63 Nm
Bolts for intermediate gears .....	50 Nm + 60°
Bolts for compressor gear .....	105 Nm
Connecting rod bolts .....	20 Nm + 90°
Main bearing bolts .....	50 Nm + 90°
Bolts for driver .....	135 Nm
Bolts for crankshaft damper and pulley .....	110 Nm
Flange bolts and banjo bolts for valve tappets .....	32 Nm
Bolts for timing gear plate .....	63 Nm



## Lubrication system

### Oil cleaner

Permitted thickness of deposits on wall of cover ..... max. 20 mm

### Oil pressure valve (Note: not safety valve)

Oil pressure:

Idle ..... 1.6 bar  
With warm engine running at 1000 rpm ..... 2.5 bar  
With warm engine running at 2,000 rpm ..... 4.5 - 6.0 bar  
Free spring length ..... 61.4 mm

### Oil filter

Only use original MOXY filters.

### Tightening torques:

#### Oil pump:

Bolts for oil pump cover ..... 26 Nm  
Bolts, oil pump - cylinder block ..... 26 Nm

#### Oil cleaner:

Lock nut for oil cleaner housing cover ..... 15 Nm  
Nut for rotor bowl ..... Tightened by hand  
Rotor shaft ..... 34 Nm

#### Oil nozzle for piston cooling:

Banjo bolt ..... 23 Nm

#### Oil cooler:

Bolts for oil cooler insert ..... 26 Nm

## Troubleshooting tables

### White smoke

Effect	Cause	Troubleshooting	Action
Incompletely burnt fuel	Cold engine	The white smoke starts to turn blue and disappears when the engine is warmed up	If possible: reduce engine speed or put the engine under load Install a white smoke limiting device (exhaust brake) Install flame heater Install an engine heater
Too much fuel in relation to air at low combustion temperatures.	Injection timing too late		
	Inlet valve does not open properly. Valve adjustment disturbed.		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound.  <b>WARNING!</b> <b>Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury</b>	
	Leaky injector, dripping		

### White smoke, water vapour

Effect	Cause	Troubleshooting	Action
Water in the combustion chamber	Leaky charge air cooler	Test pressure (air 0.5 bar, liquid 4 bar)	
	Leaky cylinder head gasket	The fault is also present when the engine is hot	
	Cracked cylinder head (not cracks between valve seats)	<b>If the fault is hard to trace:</b> Change all cylinder heads for exchange cylinder heads. (Or test pressurizing all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Crack in cylinder liner		

**Black smoke when running/under load**

Effect	Cause	Troubleshooting	Action
Too much fuel in relation to air at high combustion temperatures	“Adjusted” injection pump, attempt to boost	Check the lead seal	Test in test bench
	Injection timing too late		
	Inlet valve does not open properly. Valve adjustment disturbed		
	Broken delivery valve spring, uncontrolled injection	Disconnect one delivery pipe at a time and listen for changes in the engine sound.  <b>WARNING!</b> <i>Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury</i>	
	Leaky injector, dripping?		
	Nozzle tip jams		
	More than 1 washer under injector		
	Fault in turbo	Check charge air pressure	
	Clogged air filter		
	High exhaust counter-pressure	See page 48	
Worn intake valves			
Clogged intake port			

**Black smoke on starting**

Effect	Cause	Troubleshooting	Action
Engine difficult to start	Binding control rack	Open the cover on the actuator solenoid and check with a finger on the control rod that it goes to the maximum stop bracket.	Take the pump to a Bosch workshop for repair

**Blue smoke**

Effect	Cause	Troubleshooting	Action
	Oil coating past piston rings		
	Oil leakage in turbo-charger		
	Damaged piston cooling nozzles		Change damaged nozzles
	Petrol in diesel oil		

**Fuel in the oil**

Effect	Cause	Troubleshooting	Action
Dilution of oil in sump	Unburnt fuel passes the piston		Normally about 1% of fuel in the lubricating oil per 200 h
	Defective injector		
	Internal leakage in injection pump (worn pump element or crack in pump housing)		
	Worn/broken O-ring at feed pump pushrod	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Frequent cold starts		
	Worn engine		
	Intake valve not opening		

## Oil in coolant

Effect	Cause	Troubleshooting	Action
	Oil cooler leaks when engine is running	Test pressurize the oil cooler Note: classed oil cooler, test pressurized: 10 bar oil on the oil side, 0.5 bar air on the water side, immersed in water 25 - 27 °C	
	Defective cylinder head gasket		
	Crack in cylinder head (not cracks between valve seats).	<b>If the fault is hard to trace:</b> Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	

**Coolant/water in oil**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Dilution of oil in sump	Oil cooler leaks when engine is not running	Test pressurize the oil cooler, see above	
	Leaky O-rings at cylinder liner	Leakage in telltale hole?	Change liner seals
Dilution of oil in sump	Water is condensed in crankcase ventilation and runs down into the sump	<p>Run the engine until warm. Remove the oil sump and all side covers. Test pressurize the cooling system. If coolant seeps out behind side covers or at the camshaft bearing there is probably a crack in one of the cylinder heads. As a rule it is possible to see which cylinder head or heads are leaking.</p>	<p>Change the cylinder head for a exchange cylinder head. If no leakage can be found, change <u>all</u> cylinder heads for exchange cylinder heads.</p>
	Crack in cylinder head		
	Crack in water jacket on cylinder block/cylinder head. (Coolant runs down through the pushrod hole.)		
	Crack in water jacket on cylinder head. (Coolant runs down via the oil duct for rocker arm lubrication.)		
	Leakage in charge air cooler core	Test pressure (air 0.5 bar, liquid 4 bar)	

### Low oil pressure

Effect	Cause	Troubleshooting	Action
Gauge shows low pressure	Crankshaft bearing/ main bearing of wrong size has been fitted on reground crankshaft	Max. oil pressure 2 bar also when engine cold	Change to bearings of the correct size. Check the bearing seats be- fore assembly
	Excessive play in big- end and main bearings		
	Seizing in camshaft bearings	If the bushing slides all the way out of the bearing seat, the oil pressure warning lamp will come on. The engine throws out oil through the crank- case ventilation	
	Piston cooling nozzle has come loose		
	Suction pipe to oil pump has come loose, the pump sucks air		
	Extremely low lubricat- ing oil viscosity  Worn bushings or loose shaft in oil cleaner		Choose a viscosity that is suitable for the ambi- ent temperature  Change rotor if bushing is worn oval Change worn/damaged shaft
	Broken O-ring on cy- clone part of oil cleaner		
	Defective oil pump drive		
	Internal leakage in oil cleaner  Defective sensor/instru- ment	Check that the oil cleaner is correctly as- sembled  Take a reading of the oil pressure on warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min.	
	Incorrectly adjusted oil relief valve		1 shim = 0.2 bar
	Broken spring in oil relief valve	Max. oil pressure 2 bar at 2000 r/min	Check/remedy relief valve
	The piston in the oil re- lief valve has jammed in open position		

Continue next page



Effect	Cause	Troubleshooting	Action
Gauge shows low pressure	Loosened guide plates in the oil cooler prevent passage of the oil		
	Worn/damaged oil pump		
	Clogged oil cooler		
	Loose screws in timing gear's intermediate gear		
Gauge indicates low pressure at maximum speed but not at idling speed	The main oil duct (to piston cooling nozzles) plug in the rear of the engine has come loose	Oil pressure at idling/ low engine speed is not affected since the delivery valve closes at 3 bar	

**High oil pressure (Engine warmed up)**

Effect	Cause	Troubleshooting	Action
Gauge indicates high pressure	Defective sensor/ instrument	Take a reading of the oil pressure on the warmed-up engine using a mechanical pressure gauge directly on the engine: Minimum 1 bar at 800 r/min. Maximum 6 bar > 800 r/min.	
	Oil viscosity too high		Choose a viscosity that is suitable for the ambient temperature
Gauge indicates high pressure	Incorrectly adjusted oil relief valve		1 shim = 0.2 bar
	Piston in oil relief valve jammed in closed position		
	Valve in oil duct to piston cooling nozzles is binding		

**Abnormal wear (liner, piston rings, etc.)**

Effect	Cause	Troubleshooting	Action
Short service life	Unclean intake air due to leakage in intake piping		
	Wrong grade of oil, polishing damage		
	Changing of filters and oil has been neglected		
	Low coolant temperature (cold engine)		
	Excessive sulphur content in fuel		Change the fuel Change to oil with a higher base number. Shorter oil change intervals
	Defective injector (causes oil film to be washed off)		

**Vibration, no driven components engaged**

Effect	Cause	Troubleshooting	Action
	Wrong injection timing		
	Broken delivery valve spring	Disconnect one delivery pipe at a time and listen for changes in the engine sound.  <b>WARNING!</b> <b>Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury</b>	
	Individual injectors not operating		
	Fan imbalance		
	Flywheel has come loose		
	Crankshaft hub loosened		
	Abnormally worn main bearings		
Vibration or unusual noise at 1500 - 1700 r/min	Defective vibration damper		
Drive belts run off pulleys			
Only when compressed air compressor is charging, worst at about 1000 r/min, see also page xx	Compressor operates with excessive counter-pressure (e.g. clogged piping/air dryer) or excessively high safety valve opening pressure		
	Alignment fault		

**Delivery pipe fractures**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	No clamping		
	Carelessly handled delivery pipe		

**External corrosion on cylinder liner**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Unsuitable corrosion protection agent, glycol or water in coolant		Clean the cooling system and fill up with coolant as described in the maintenance instructions

**Engine difficult to start**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Air in fuel system	Leakage in suction pipe		
	Leaky overflow valve		
	Low battery voltage		
	Ambient temperature too low		Starting aids are not normally needed at temperatures above -15 °C
	Oil viscosity too high		
	Paraffin precipitation in the fuel		
	Blocked intake or exhaust system		
	No fuel		
	Wrong injection timing		
Faulty injector			

**Fluid stroke**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Starter motor not powerful enough to pull the piston over the compression stroke (if the engine fires a connecting rod could be bent)	Leaky charge air cooler	Test pressure (air 0.5 bar, liquid 4 bar)	
	Leaky cylinder head gasket		
	Crack in cylinder head	<b>If the fault is hard to trace:</b> Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Crack in cylinder liner		
	Water has entered the engine via the exhaust/intake system		
	Crack in water-cooled exhaust manifold		
	Injector open		

**Knocking noise**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Exhaust valves close too late and strike the piston crowns	Timing gears incorrectly meshed	Check the valve timing.	
	The crankshaft gear has come loose		
	Valve mechanism not operating		
Rapidly increasing valve clearances	Disturbances in the supply of lubricant for the rocker arms		
The piston strikes the cylinder head	Loosened big end cap (wrong tightening torque after repair)		Tighten to the torque specified in the Shop manual
	Foreign objects in the piston crown		

Continue next page

Effect	Cause	Troubleshooting	Action		
	Piston seizure (may be caused by clogged piston cooling nozzles)				
	Wrong injection timing				
	Worn collets on exhaust valves				
Broken upper piston rings	Incorrectly adjusted injection pump	Disconnect one delivery pipe at a time and listen for changes in the engine sound.  <b>WARNING!</b> Be careful when disconnecting the delivery pipes as the pressure is extremely high and could cause injury			
	Broken delivery valve spring (after-injection)				
	Connecting rod bearing seizure				
	Faulty injector (seized, worn, incorrect or cracked tip, fatigued spring)			Incorrectly adjusted injector	
				More than 1 washer under injector	
				Fuel leakage in flame start	Check whether it leaks. (Take out the flame start and run the engine with fuel pipe connected)
		Loosened big end cap			
Melting damage on piston crown		Check the injection timing			
	Incorrectly adjusted injector				

**High oil consumption**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Blue smoke under load	Piston ring seizure		
		Combustion temperature too high?	
	Cylinder seizure		
	Liner wear	Unclean intake air?	
	Carbon polishing (in patches)	Poor grade of oil?	
	Piston ring wear		
	Piston rings stuck		
	Tapered piston rings fitted wrong way		
	Broken piston rings	Individual piston rings broken = incorrectly fitted Several upper rings broken = start spray used wrongly, wrong injection timing (too early) Several intermediate rings broken = worn rings or grooves	
	Worn valve guides	Check the clearance between valve and guide. High exhaust temperature? Poor grade of oil?	
	Oil level too high?		
	Defective shaft seals in turbocharger	Check whether oil is present in the compressor or intake manifold	
	Clogged air filter		
	Excessive vacuum in the air intake before the turbocharger	Measure the vacuum (max. 500 mm wc) Check the air filter	
Oil viscosity too low			
Deformed/incorrectly directed piston cooling nozzles			

**High fuel consumption**

Effect	Cause	Troubleshooting	Action
	Faulty injector		
	Low charge air pressure		
	Adjusted injection pump	Check in a pump test bench that the amount (Q-mm <sup>3</sup> /stroke) corresponds to specification	
	Manner of driving, operating/load conditions		

**Low compression**

Effect	Cause	Troubleshooting	Action
Effect	Worn engine	Troubleshooting Check the compression	
	Broken piston rings		
	Incorrectly adjusted/defective valves		
	Hydrostatic lock/bent connecting rod		

**Low engine output**

Effect	Cause	Troubleshooting	Action
	Low fuel supply pressure (below 0.3 bar)	Check the feed pump and overflow valve for leakage as described in the workshop manual Look for leakage in the suction pipe between tank and feed pump Clogged fuel filter/Paraffin precipitation in fuel	
	Faulty injector		

Continue next page



Effect	Cause	Troubleshooting	Action
	Fuel too hot		
	Incorrect fuel specification	Check density and viscosity	
	Low charge air pressure	Check charge air pressure	
	Abnormal pressure drop in intake piping	Check the vacuum before the turbocharger, max. 500 mm wc. Check the air filter	
	Worn engine	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Worn crankcase ventilation: -50 - +20 mm wc	
	Leaky valves	Take compression readings and compare those of the different cylinders	
	Wrong injection timing		
	Intake air temperature too high	Check the temperature of the air before the engine. Above +25 °C reduces engine power	
	Exhaust counterpressure too high	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc	
	Intake counterpressure too high	See "Low charge air pressure", page 48	
	Incorrectly adjusted injection pump	Check in a pump test bench	
	Blocked fuel consumption gauge		
	Binding injector	Injector's nozzle nut tightened too hard	
	Exhaust brake/white smoke limiter throttle in closed position		

**Hot engine**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Instrument shows high temperature	Defective sensor/instrument	Check that sensor and instrument suit each other (120 and 150 °C) Check with a separate instrument	
	Low coolant level		
	Clogged cooling system		Clean the cooling system internally and externally
	Pressure cap not operating	Test pressurize	
	Impeller on coolant pump worn or damaged		
	Cooling capacity too low	Take a reading of the cooling capacity	
	Gas leakage (causes loss of coolant)		
	Defective thermostats	Check opening temperature of thermostats	
Drive belts slip or pump wheel loose on pump shaft			
Air pockets in engine's outer cooling circuit		Vent at the cooling system's highest point Check that the ventilation piping to the expansion tank is not clogged	
Reduced coolant flow	Excessive pressure drop in the external cooling system	Check with forcibly opened thermostats	
	Clogged radiator		
	Circulation of cooling air	Check by taking temperature readings	
	Cavitation damaged impeller in coolant pump		
	Leakage in charge air cooler		

**Cold engine**

Effect	Cause	Troubleshooting	Action
Instrument indicates low temperature	Defective sensor/instrument	Check that sensor and instrument match each other (120 and 150 °C) Check with a separate instrument	
	Thermostat jammed in open position	Check operation of thermostat	

**Coolant loss**

Effect	Cause	Troubleshooting	Action
	Defective cylinder head gasket (external leakage)		
	External leakage		
Coolant pressed out of radiator on DSI engines	Turbocharging pressure enters cooling system via leaking charge air element	Test pressure (air 0.5 bar, liquid 4 bar)	
	Crack in cylinder head (not cracks between valve seats)	<b>If the fault is hard to trace:</b> Change all cylinder heads for exchange cylinder heads. (Or test pressurize all cylinder heads. Heat the cylinder heads before pressurizing them.)	
	Cracked cylinder liner	Grey oil = Coolant in oil Locate the leak by removing the oil sump and pressurizing the cooling system while turning the engine over by hand	

**Polluted coolant**

Effect	Cause	Troubleshooting	Action
	Faulty inhibitor		Clean the cooling system and fill it with coolant as described in the maintenance instructions
	Overdosed corrosion inhibitor		

**Engine heater**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Boiler scale on engine heater	Incorrect mixture or type of glycol and/or corrosion inhibitor Anti-freeze with phosphate-based inhibitor must not be used		Clean the cooling system and fill it with coolant as described in the maintenance instructions
Short service life	The heater is not designed for continuous engagement. Suitable temperature for thermostat control = 40 - 60 °C		

**High oil temperature**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Instrument indicates too high temperature	Defective sensor/instrument	Check with separate instrument	
	Poor water flow in oil cooler		

**High exhaust temperature**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Adjusted injection pump	Check the lead seal, check CRO if necessary	Test in test bench
	Wrong injection timing	Check the injection timing	
	Nozzle drips	Check type, opening pressure and general condition	
	High exhaust counterpressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High inlet air temperature		
	Low charge air pressure		
	Clogged air filter		

**Low charge air pressure**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Dirty/damaged turbine/compressor wheel in turbocharger		Check/clean
	Leakage between turbocharger and cylinder head		Check/change gaskets
	Bearing seizure in turbocharger	Check bearing play	Recondition/change turbocharger
	Clogged air filter	Check the vacuum before the turbocharger, max. 500 mm wc	
	High exhaust counterpressure	Take a reading, recommended counterpressure: 500 mm wc, max. 1000 mm wc Check silencer, spark arrester, length and inside diameter of exhaust pipe	
	High fuel temperature		

**Low fuel pressure**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Clogged fuel filter		
	Defective overflow valve		
	Defective feed pump		
	Air leakage in suction pipe		
	High pressure drop in suction pipe		

**Low system voltage**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Normal charging voltage: 27 - 28 V	Broken alternator drive belt		
	Slipping alternator drive belt		
	Batteries in poor condition		
	Alternator fault		
	Voltage regulator fault		
	Battery charger fault		

**High system voltage**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Normal charging voltage: 27 - 28 V	Voltage regulator fault		
	Battery charger fault		

**External oil leakage**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Crankcase pressure too high	Check "blow-by" in crankcase Correct value for new engine: 0 - +10 mm wc (flow rate 60 - 100 l/min.) Closed crankcase ventilation: -50 - +20 mm wc	
	Leaky crankshaft seal		
	Leakage at liner seal via overflow hole in cylinder block		
	Defective cylinder head gasket		
Leakage in manifold joint	Low load		

**External fuel leakage**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Damaged injector and injection pump connections/gaskets		
	Defective pulsation damper		
	Blocked overflow valve	Leakage at high engine speed and low power output	

**External coolant leakage**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>	
	Leakage in cylinder liner seal			
	Cold leakage			Change to original hoses
	Defective cylinder head gasket			Check at the water pump housing's telltale hole
	Water pump leakage  Leakage at charge air cooler connection			

**Oil pressed out via crankcase ventilation**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
	Hole in piston crown	Increases when white smoke limiting device is engaged or exhaust brake applied	
	Bearing seizure in turbocharger		
	Oil seepage via pistons - liner		
	Oil seepage in air compressor		

**Turbocharger breakdown**

<b>Effect</b>	<b>Cause</b>	<b>Troubleshooting</b>	<b>Action</b>
Loss of power	Excessive bearing play in turbocharger		Check the connections
	Lubrication piping between turbocharger and filter incorrectly connected		







