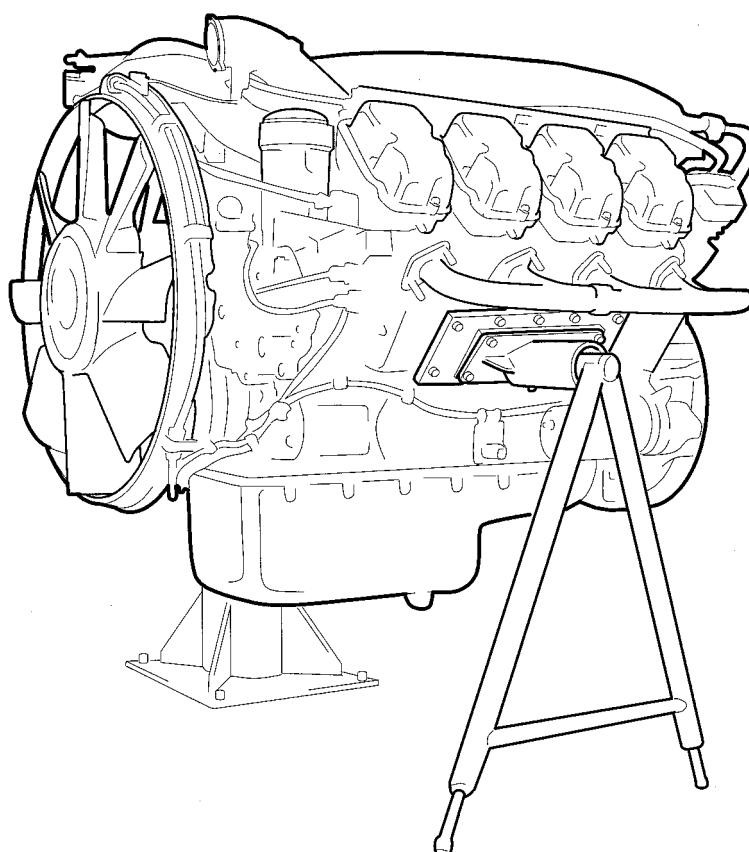




SCANIA
Scania Engines

Work description- 16-litre engine

Industrial and marine engines



114 739



***Mind the
environment!***

**Use a container to avoid spills when draining the
coolant and oil.**

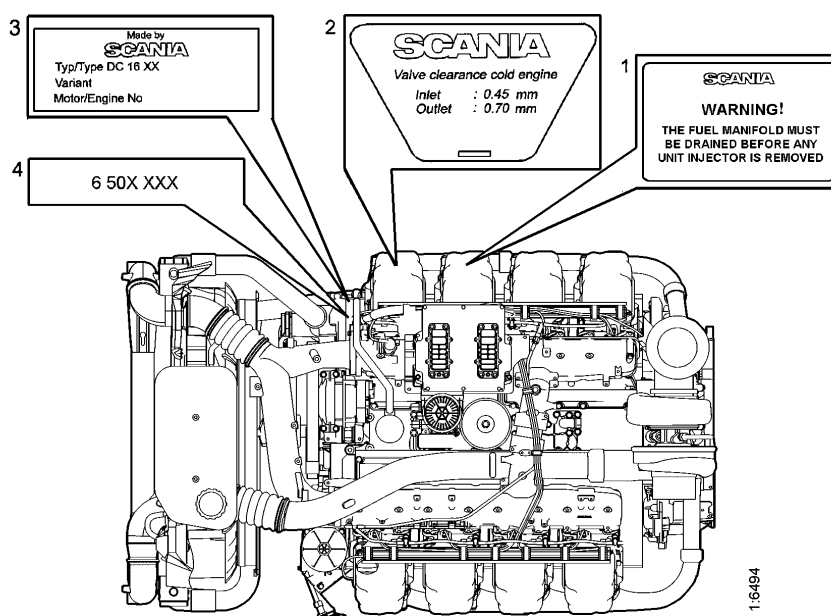
**Dispose of used coolant and oil through an
authorised waste disposal contractor.**

SCANIA

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General



- | | |
|---------------------------------------|--|
| 1. Warning plates | 3. Type plate: Engine type, Engine serial number |
| 2. Instruction plate: Valve clearance | 4. Engine serial number, stamped |

DC16 engine shown. Di 16: same location

Specifications

Cylinder bore	127.0 mm
Stroke	154.0 mm
Displacement	15.6 dm ³
No. of main bearings	5
Firing sequence	1-5-4-2-6-3-7-8
Compression ratio	18:1
Direction of rotation (engine viewed from behind)	Anticlockwise
Engine speed, low idling (all-speed)	500 rpm
Engine speed, high idling (all-speed)	2400 rpm
Oil volume	35 litre
Oil grade	see booklet 00:03-01
Weight (without oil, coolant, radiator; with fan)	1,346 kg

General tightening torques

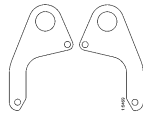
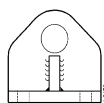
The following tightening torques apply in general unless otherwise specified:*)

Flange bolt M6	8.6 Nm
Flange bolt M8	26 Nm
Flange bolt M10	50 Nm
Flange bolt M12	92 Nm
Stud in casting M8	13 Nm
Stud in casting M10	25 Nm

*) A tolerance of +/- 15% applies to the specified tightening torques unless stated otherwise.

Removing and lifting the engine

Special tools

Number	Description	Illustration	Tool board
99 398	Lifting eyes		
1 360 442	Lifting eyes		
1 512 730	Lifting eye		
98 094	Lifting chain		
587 308	Lever block		

1. Drain the oil and coolant.

Help protect our environment! Use a suitable container. Dispose of used coolant and oil through an authorised waste disposal contractor.

DC engine:

- Remove the air filter and the inlet pipe between the turbocharger and the air filter.
- Undo the connections for coolant, charge air pipes between engine and charge air cooler, and ventilation line to the expansion tank.
- Remove the cables with cable clamp ring on the rear right-hand side.

DI engine:

- Disassemble the engine and reverse gear.
- Detach the pipe between the seawater pump and heat exchanger. Remove the seawater pump.
- Remove the turbocharger oil pipes.

2. Disconnect the negative battery cable.
3. Remove the starter motor and alternator wiring
4. Remove the wiring to the control unit.
5. Remove the fuel connection.

DC engine:

- Disconnect the filter housing for the crankcase ventilation and place to one side so that it is free from the lifting chain.
- Undo the AC compressor and move to one side.
- Screw lifting eyes 99 398 onto the engine using flange bolts M12x30 (4).

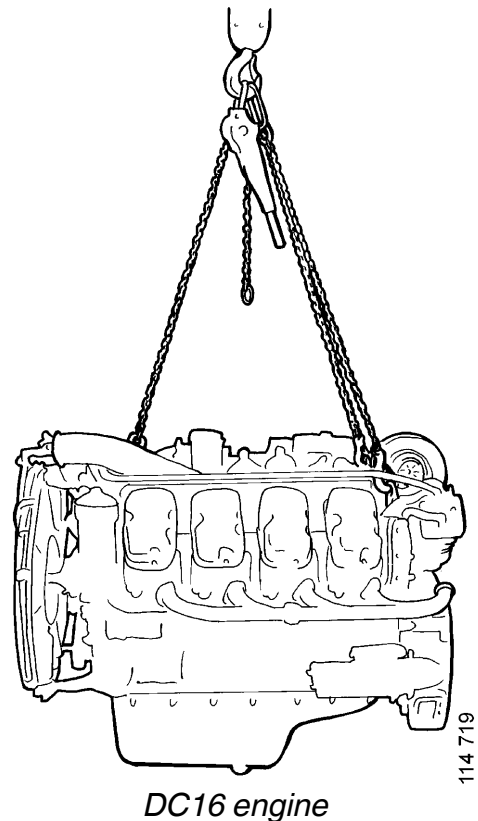
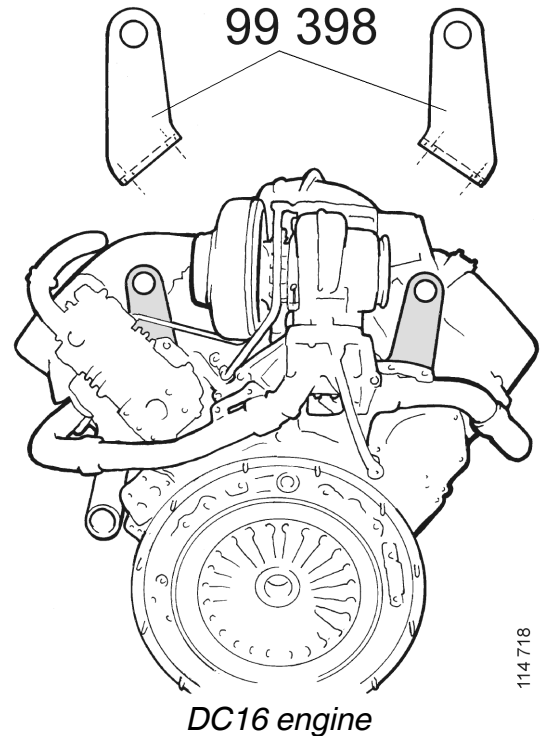
DI engine:

- Fit the front lifting eye 1512730 with two M12 x ? mm bolts through the expansion tank. Turn the lifting eye towards the centre of the engine.
 - Screw two lifting eyes 1360442 into the flywheel housing over the centre in the ten to two position.
6. Fasten the lifting chain 98 094 to the rear lifting eyes.
 7. Fasten the lever block (587 308) to the front lifting eye.

Note: The engine lifting eyes are sized for lifting the engine only, not the engine together with connected equipment (high-current generator, gearbox, reverse gear, etc.) or frame. All three lifting eyes must be used.

8. Undo the connecting pipe to the gearbox cooler or reversing gear oil cooler.
9. Undo the connection to the gearbox or reverse gear.
10. Undo all the engine brackets and lift away/out the engine.

Note: The lifting eyes are dimensioned for a maximum inclination angle of 20° when lifting the engine.



Lifting and fitting the engine

DC engine:

- Screw lifting eyes 99 398 onto the engine using flange bolts M12x30 (4).
- Disconnect the filter housing for the crankcase ventilation and place to one side so that it is free from the lifting chain.

DI engine:

- Screw two lifting eyes 1360442 into the flywheel housing over the centre in the ten to two position. The seawater pump, the heater exchanger pipe and the turbocharger oil pipes must be removed.
- Remove the closed crankcase ventilation filter.
- Fit the front lifting eye 1512730 with two M12 x ? mm bolts through the expansion tank. Turn the lifting eye towards the centre of the engine.

1. Fasten the lifting chain 98 094 to the rear lifting eyes.
2. Fasten the lever block (587 308) to the front lifting eye.
3. Lift the engine in position and bolt it to the front engine suspension.
4. *D116*: Remove the rear lifting eyes.
5. Bolt together the engine and gearbox or reverse gear.
6. Bolt the engine to the rear engine suspension.
7. Remove the lifting eyes.
8. *DC16*: Fit the filter housing for the crankcase ventilation.
9. Fit the connecting pipes to the gearbox cooler or reverse gear oil cooler.
10. Connect the wiring to the control unit and starter motor/alternator.
11. Fit the fuel pipe.

DC engine:

- Fit the coolant connections, charge air lines between the charge air cooler and the engine.
- Fit the ventilation line and static line. Fit the inlet pipe to the turbocharger and refit the air filter.

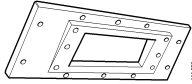
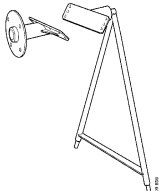
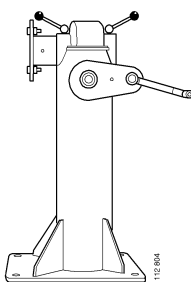
DI engine:

- Fit the turbocharger oil pipes and the seawater pump and pipe from the pump to the heat exchanger.
- Fit the closed crankcase ventilation filter.

12. Connect the negative battery cable.
13. Fill with oil and coolant as directed in booklet 00:03-01.
14. Test run the engine to check that no leakage occurs. Top up with coolant if necessary.

Mounting the engine in a universal stand

Special tools

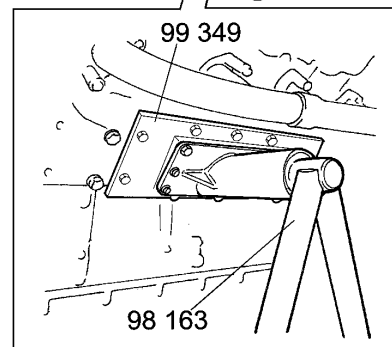
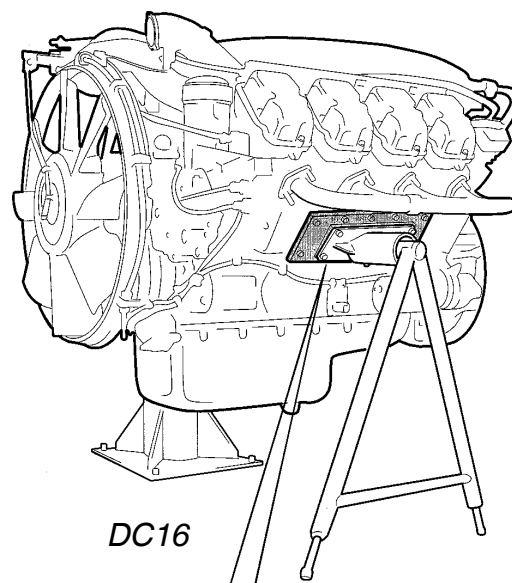
Number	Description	Illustration	Tool board
99 349	Spacer		
98 163	Fixture		
587 692	Universal stand		

DI engine:

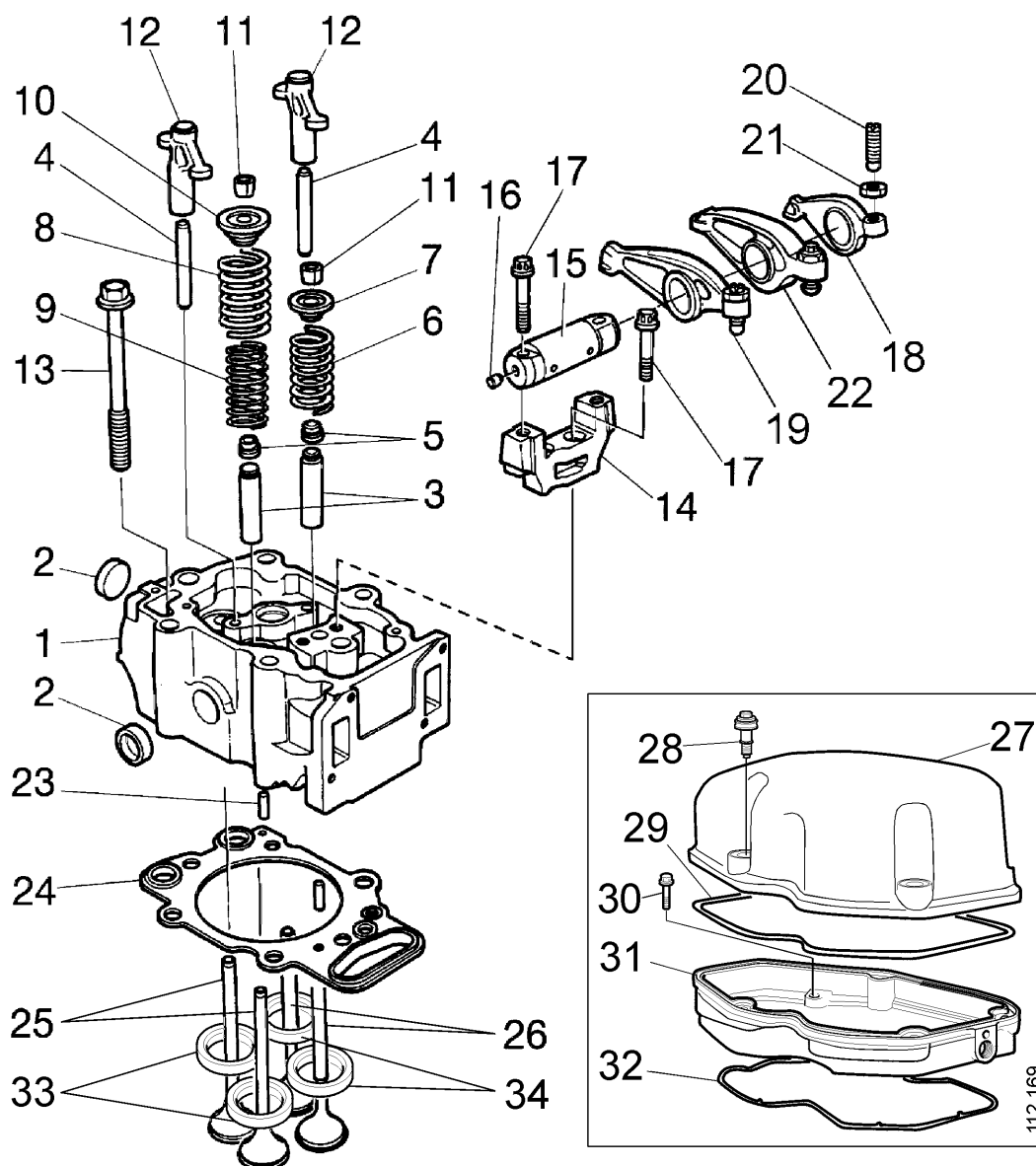
- Remove the heat exchanger pipe connections and remove the entire heat exchanger.
- Remove the exhaust manifolds.
- Remove the control unit connectors.

DC and DI engines:

1. Remove the side covers and the gaskets on the right and left-hand sides.
2. Undo the clamps on any obstructing wiring.
3. Bolt spacer 99 349 onto the right and left-hand sides. Use the bolts for the side covers.
4. Screw fixture 98 163 onto the spacers. Use M8 x 25 bolts and M8 washers.
5. Screw the fixture to the universal stand and place the fixture's support on the opposite side as illustrated.



Cylinder head



- | | | |
|--------------------------|-------------------------------|--------------------------------|
| 1. Cylinder head | 13. Bolt | 25. Exhaust valve |
| 2. Core plug | 14. Bearing bracket | 26. Intake valve |
| 3. Valve guide | 15. Rocker arm shaft | 27. Rocker cover |
| 4. Pin | 16. Rivet plug | 28. Flange bolt |
| 5. Valve stem seal | 17. Tight-fit screw | 29. Rocker cover gasket |
| 6. Valve spring, intake | 18. Rocker arm, intake | 30. Flange bolt |
| 7. Valve spring collar | 19. Rocker arm, exhaust | 31. Rocker cover |
| 8. Valve spring, exhaust | 20. Adjusting screw | 32. Rocker cover gasket |
| 9. Valve spring, exhaust | 21. Lock nut | 33. Valve seat insert, exhaust |
| 10. Valve spring collar | 22. Rocker arm, unit injector | 34. Valve seat insert, intake |
| 11. Valve collet | | |
| 12. Valve bridge | | |
| | 23. Guide pin | |
| | 24. Cylinder head gasket | |

Adjusting the valve clearance and unit injectors

Specifications

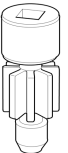
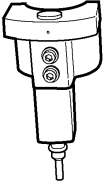
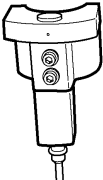
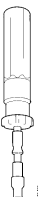
Valve clearance, intake valve (cold engine)	0.45 mm
Valve clearance, exhaust valve (cold engine)	0.70 mm
Dimension for PDE 31 unit injector (cold engine)	66.9+/-0.1 mm
Dimension for PDE 32 unit injector (cold engine)	69.9+/-0.1 mm

Tightening torques

(See page 3 for general tightening torques)

Adjusting screw lock nut on rocker arm for unit injector	39 Nm
Adjusting screw lock nut on the valve rocker arm	35 Nm
Screw for upper rocker cover	18 Nm
Bolt for lower rocker cover	26 Nm
Bearing bracket and rocker arm shaft	105 Nm
Cable connection, unit injector	2 +/-0.2 Nm

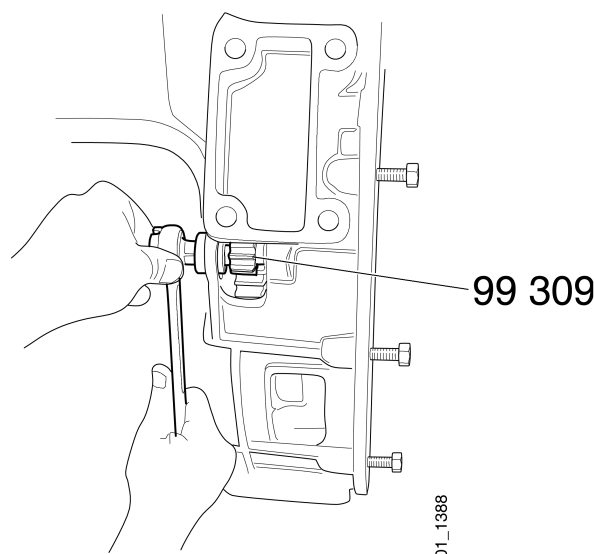
Special tools

Number	Description	Illustration	Tool board
99 309	Tool to rotate flywheel		D 5
99 414	Setting tool		Measuring tool cabinet
99 442	Setting tool		Measuring tool cabinet
588 179	Torque screwdriver		

Adjusting the valve clearance

Note: Check and adjust the valve clearance and unit injectors with the engine cold.

- Use tool 99 309 to rotate the engine.
- Check the valve clearance using a feeler gauge and use the adjusting screw on the rocker arm to set the correct clearance.
- 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.
- The intake valve clearance should be 0.45 mm and exhaust valve clearance 0.70 mm.
- See page 15 for the adjusting order.



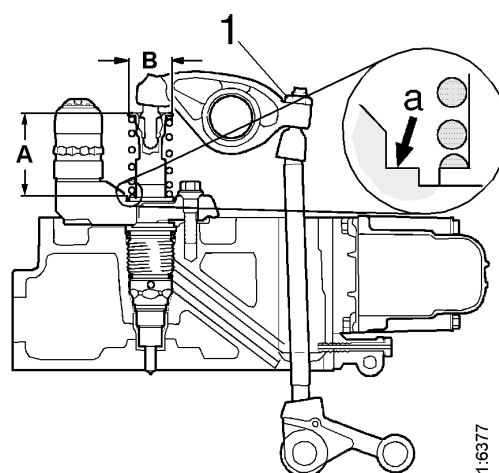
Adjusting the unit injector

Important! The PDE 31 unit injector is adjusted using setting tool 99 414 or a digital sliding caliper.

The PDE32 unit injector is adjusted using setting tool 99 442 or a digital sliding caliper.

This adjustment is essential as a fault in the position of the unit injector can result in poor performance and possible breakdown.

1. 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. The distance should be 66.9 mm for PDE31 and 69.9 for PDE32. See measurement B in the figure for identifying the injector.



**A= PDE31: 66.9 +/-0.1 mm
PDE32: 69.9 +/-0.1 mm**

**B = PDE31: 36.5 mm
PDE32: 38.8 mm**

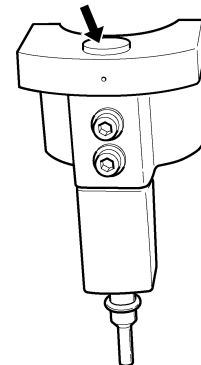
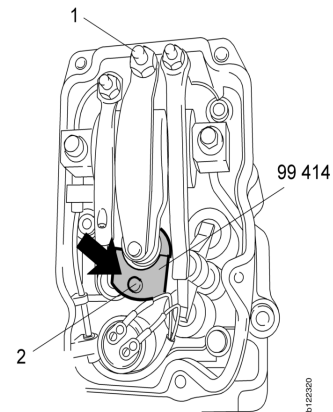
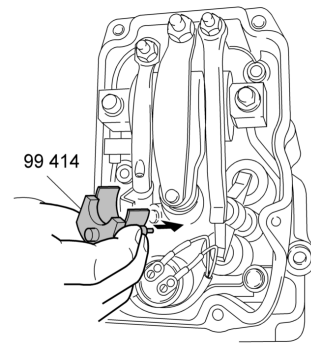


WARNING!

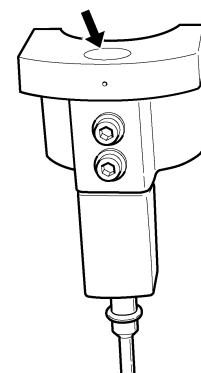
Take care when carrying out the adjustment if the dimension is well outside the adjustment dimension. The spring is pre-tensioned and can cause personal injury if it is released.

PDE31:

2. Position setting tool 99 414 with the metal plate around the injector spring.
3. 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.
4. *If tool 99 414 is not available:* Measure the distance between plane *a* and the top of the valve spring collar using a digital sliding caliper. Adjust the position of the rocker arm with the adjusting screw until the distance is 66.9 ± 0.1 mm.
5. Torque tighten the lock nut to 39 Nm.
6. The order in which the injector rockers are to be checked/adjusted is shown in the table on page 15.



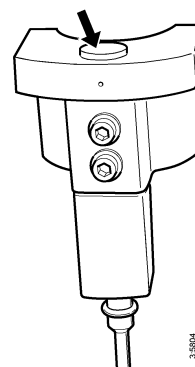
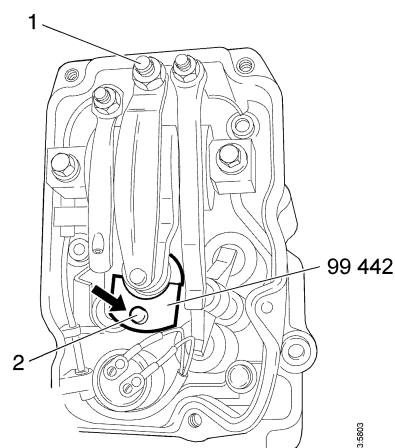
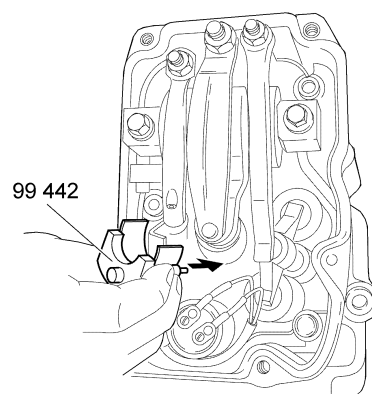
Piston above or below the flat surface. Adjustment necessary



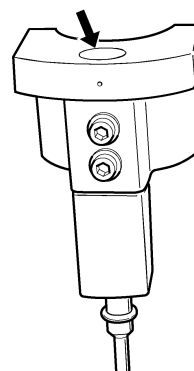
Piston level with the flat surface. The adjustment is correct

PDE32:

7. Position setting tool 99 442 with the metal plate around the injector spring.
8. 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.
9. *If tool 99 442 is not available:* Measure the distance between plane *a* and the top of the valve spring collar using a digital sliding caliper. Adjust the position of the rocker arm with the adjusting screw until the distance is 69.9+/-0.1 mm.
10. Torque tighten the lock nut to 39 Nm.
11. The order in which the injector rockers are to be checked/adjusted is shown in the table on page 15.



Piston above or below the flat surface. Adjustment necessary



Piston level with the flat surface. The adjustment is correct

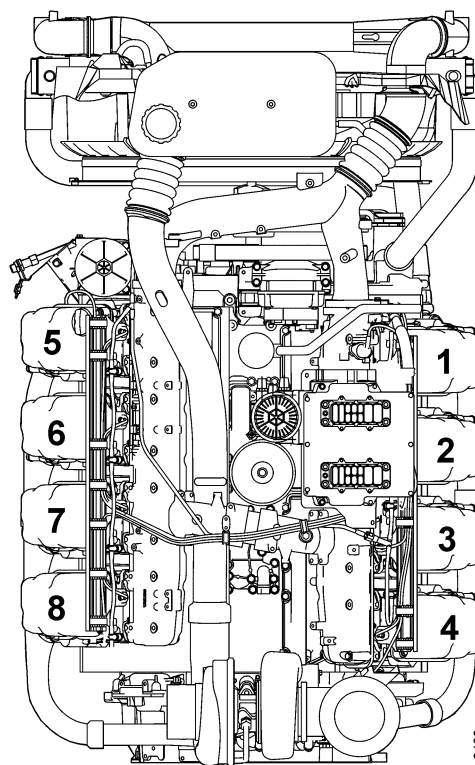
Order of adjustment

Rotate the flywheel using tool 99 309 so that the mark on the flywheel is visible in the bottom window according to the table below.

Mark on flywheel (degrees)	Valve change on cylinder	Adjust injector rocker arm on cylinder	Adjust intake valve on cylinder	Adjust exhaust valve on cylinder
TDC Down (0°)	6	4 and 5	7 and 8	4 and 5
TDC Up (180°)	7	2 and 6	1 and 5	2 and 6
TDC Down (360°)	1	3 and 7	2 and 4	3 and 7
TDC Up (540°)	4	1 and 8	3 and 6	1 and 8

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 on the rocker arm for the unit injector to 39 Nm and the lock nut for the valves to 35 Nm after adjusting.



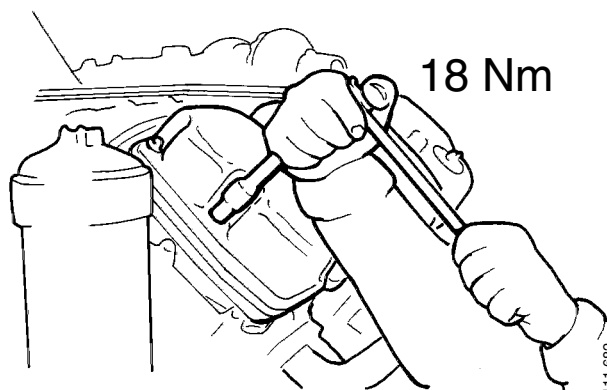
Renewing the upper rocker cover gasket

Removal

1. Clean the rocker cover and the surrounding area.
2. Remove the top part of the rocker cover.
3. Renew the rocker cover gasket.

Fitting

1. Fit the upper part of the rocker cover. Torque tighten the screws to 18 Nm.



Renewing the lower rocker cover gasket

Removal

1. Clean the rocker cover and the surrounding area.
2. Remove the top part of the rocker cover.

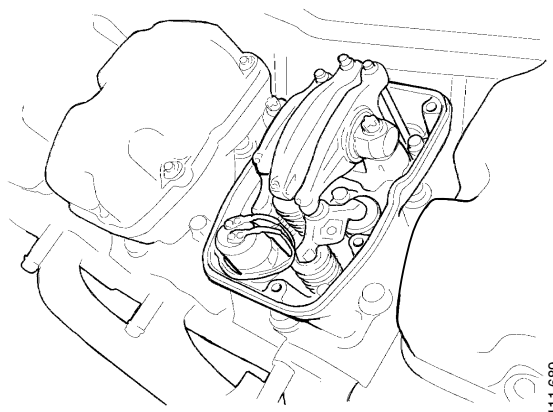
Note: All the valve mechanism components must be refitted in their original positions. Therefore, mark the parts as they are removed.

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

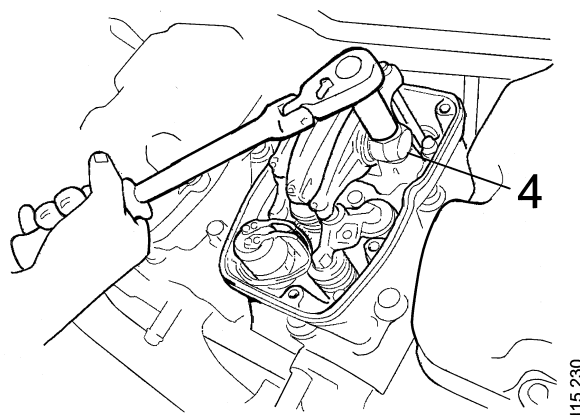


Do not lean over the engine when removing the shaft with rocker arms. The unit injector spring is pre-tensioned and can come loose, causing personal injury.

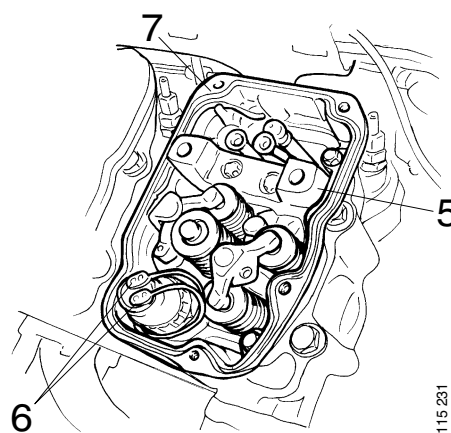
Note: If the spring comes loose from the unit injector, the unit injector must be renewed.



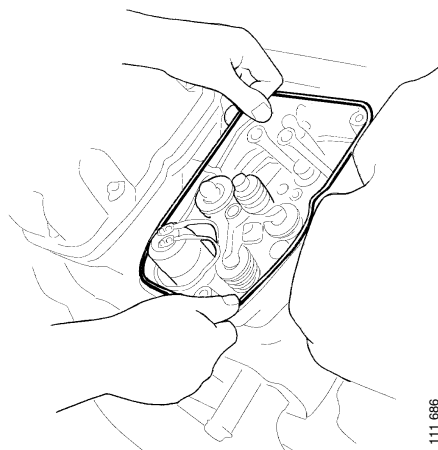
4. Remove the rocker arm shaft assembly.



5. Remove the bearing bracket.
6. Detach the cables on the unit injector. The screws cannot be removed but unscrew them as much as possible. Detach the cable grommet and remove the cable from the rocker cover.
7. Remove the lower rocker cover.



8. Renew the lower rocker cover gasket. Press in place the new gasket in the lower rocker cover.

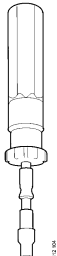


Fitting

Tightening torques

Cable connection, unit injector	2 +/-0.2 Nm
Bearing bracket and rocker arm shaft	105 Nm
Upper rocker cover	18 Nm
Lower rocker cover	26 Nm

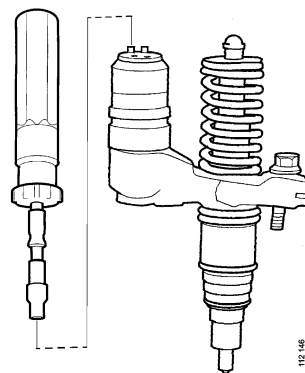
Tools

Number	Description	Illustration
588 179	Torque screwdriver	

1. Renew the gasket and fit the lower rocker cover.
Tighten the bolts to 26 Nm.

Note: If the spring has come loose from the unit injector the unit injector must be renewed.

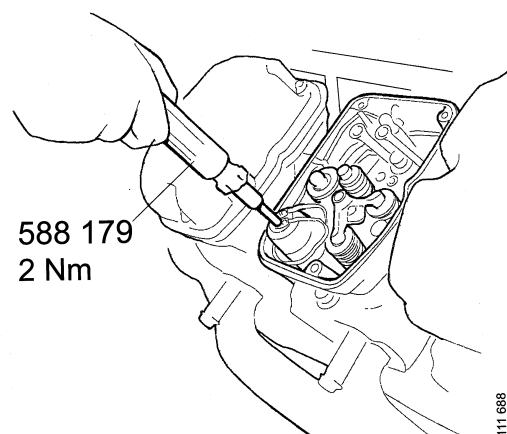
2. Screw on the cable grommet in the lower rocker cover and run the cable to the unit injector. Fit the seal to the rocker cover.



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

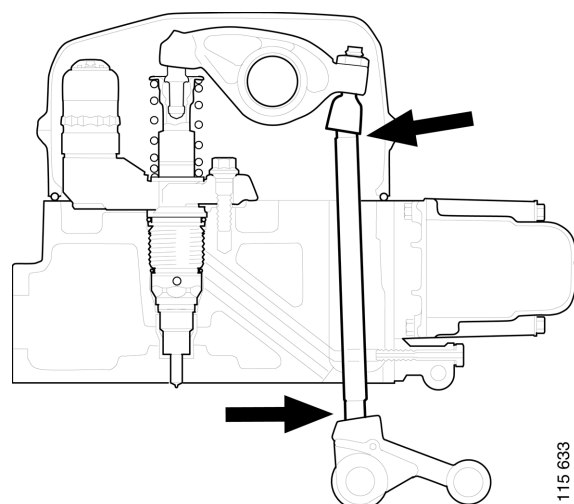
Important! *Use torque screwdriver 588 179 to avoid the risk of shearing off the screws. The entire unit injector must be renewed if the screws shear off.*

4. Fit the bearing bracket and torque tighten the bolts to 105 Nm.



Important! *Make sure the pushrods are positioned correctly. Refer to the illustration.*

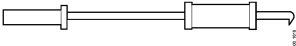
5. Refit the rocker arm shaft. Screw in the bolts alternately so that they are tightened in parallel or one of the bolts may bend. Tighten the bolts to 105 Nm.
6. Check the valve clearance and unit injector setting as described in *Adjusting the valve clearance and unit injector*.
7. Refit the upper part of the rocker cover. Tighten the bolts to 18 Nm.



Cylinder head

Removal

Special tools

Number	Description	Illustration	Tool board
87 596	Slide hammer		D 2

DC engine:

1. Open the bleed nipple on the fuel filter and empty the fuel system by opening and connecting hoses to the unions on the rear edge of the fuel manifolds and opening the unions.



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.

Help protect our environment! Use a suitable container.

2. Remove the inlet pipe between the air filter and the turbocharger.

Removing cylinder heads 1 and 2:

3. Remove the control unit with holder, cables and cable retainer, and the fuel filter.

Removing cylinder heads 3 and 4:

4. Remove the crankcase ventilation unit.

Removing cylinder head, continued:

5. Detach the intake manifold and fuel manifold from the cylinder head or cylinder heads to be removed.

If all the cylinder heads on the left-hand side, 5-8, are to be removed, remove the pipe from the turbocharger to the charge air cooler and undo the connecting pipe from the charge air cooler. Disconnect the AC compressor if fitted and place to one side. Remove the intake manifold and fuel manifold.

If all the cylinder heads on the right-hand side, 1-4, are to be removed, undo the intake pipe for the crankcase ventilation and the pipe from the charge air cooler. Remove the charge air sensor, intake manifold and fuel manifold.

DI engine:

1. Drain the fuel system by opening and connecting hoses to the unions on the rear edge of the fuel manifolds and opening the unions.

Help protect our environment! Use a suitable container.

2. Remove the connection pipe between the charge air coolers.
3. Remove the connection pipe(s) between the charge air cooler and turbocharger.
4. Remove the expansion tank and catwalk.
5. Remove the upper part of the charge air cooler and unscrew the element.
6. Detach the intake manifold and fuel manifold from the cylinder head or cylinder heads to be removed.

If all the cylinder heads on the left-hand side, 5-8, are to be removed, remove the intake manifold and fuel manifold.

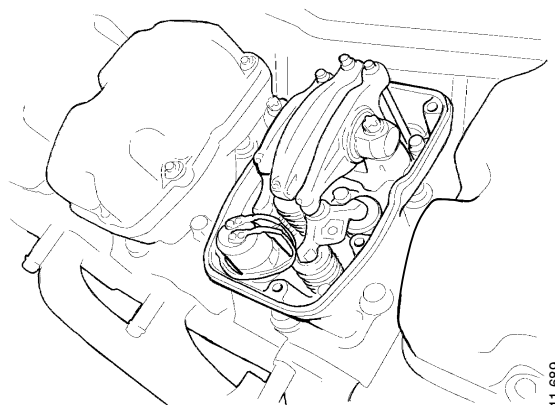
If all the cylinder heads on the right-hand side, 1-4, are to be removed, remove the charge air sensor, intake manifold and fuel manifold.

DC and DI engines:

7. Remove the cooling system ventilation pipe/pipes.
8. Remove the exhaust manifolds.
9. Remove the top part of the rocker cover.

Important! *All the valve mechanism components must be refitted in their original positions. Therefore, mark the parts as they are removed.*

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



111 689

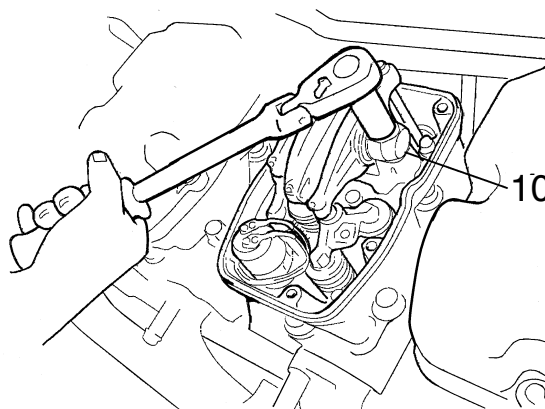


WARNING!

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.

11. Remove the rocker arm shaft assembly.



115 230

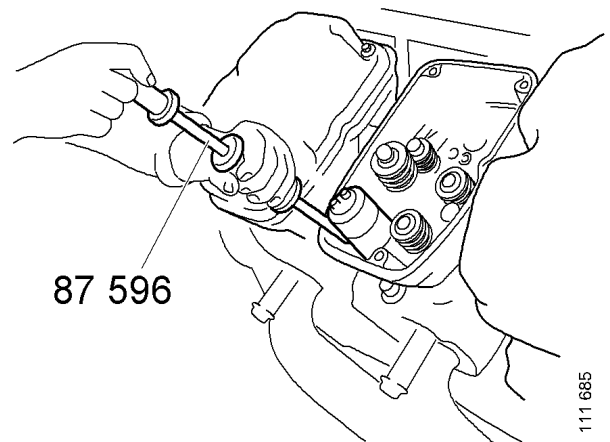
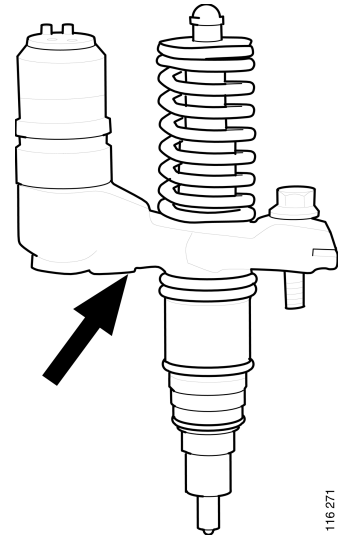
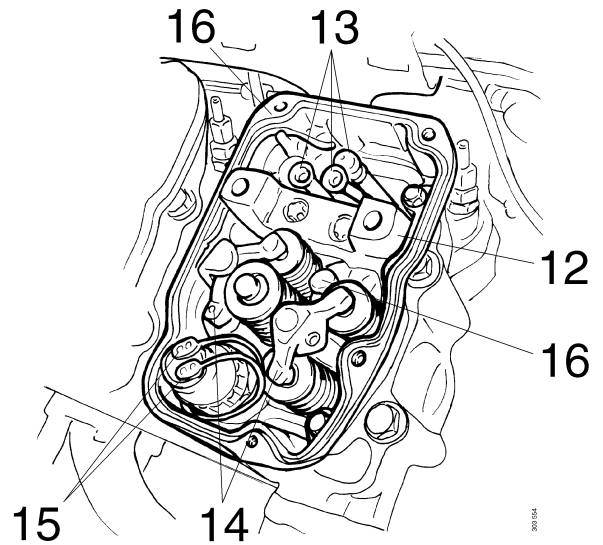
12. Remove the bearing bracket.
13. Remove the pushrods.

Note: The pushrod for the unit injector is secured with a retaining ring. Jiggle and pull carefully on the pushrod to loosen it. Check that the snap ring is still in place.

14. Remove the valve bridges.
15. Detach the cables on the unit injector. Remove the seal from the rocker cover. Detach the cable grommet from the rocker cover and remove the cable.
16. Remove the lower rocker cover.
17. Remove the screw for the fork clamp holding the unit injector in place.

Note: Do not lift the unit injector by its spring, the spring can come loose.

18. Turn the unit injectors clockwise until they stop. Place slide hammer 87 596 on the inside of the solenoid valve as illustrated.
19. Withdraw the unit injector. If the unit injector is stuck, tap carefully with a rubber mallet on the solenoid valve housing.
20. Mark the cylinder head bolt heads with a centre punch before removing them.
21. Remove the cylinder head. Mark the cylinder heads if more than one is being removed at the same time.



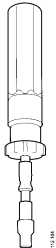
Fitting

Tightening torques

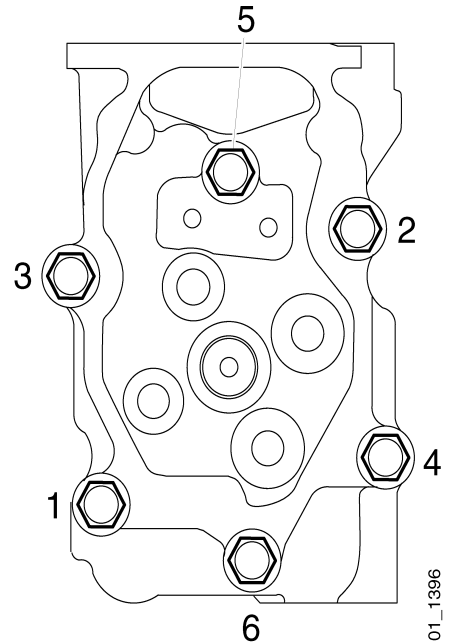
Cylinder head bolts:

First stage	60 Nm
Second stage	150 Nm
Third stage	250 Nm
Fourth stage	90°
Screws for lower rocker cover	26 Nm
Bolt for fork on unit injector.	20 Nm + 75°
Bearing bracket and rocker arm shaft	105 Nm
Screw for upper rocker cover	18 Nm
Adjusting screw lock nut on rocker arm for unit injector	39 Nm
Adjusting screw lock nut on the valve rocker arm	35 Nm
Cable connection, unit injector	2 +/-0.2 Nm
Bolt for exhaust manifold	63 Nm
Bolt for fuel manifold	26 Nm
Banjo screw for overflow line	11 Nm

Special tools

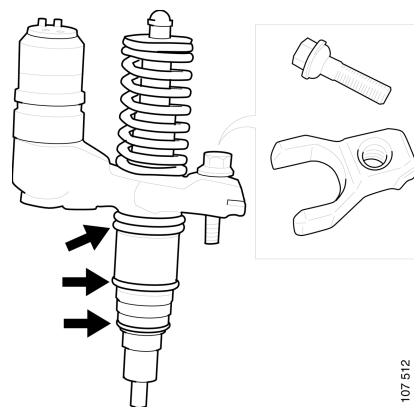
Number	Description	Illustration	Tool board
588 179	Torque screwdriver		

1. Check liner height, refer to *Pistons and cylinder liners*.
2. Fit a new cylinder head gasket.
3. 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.
4. Lubricate the threads and underneath the heads of the cylinder head bolts. Tighten them in the following four stages in the order given in the figure.
 - Torque tighten all bolts to 60 Nm.
 - Torque tighten all bolts to 150 Nm.
 - Torque tighten all bolts to 250 Nm.
 - Finally, tighten all bolts an additional 90°
 - Make a mark with a centre punch on the head of the bolt.
5. Fit the lower part of the rocker cover and torque tighten the screws to 26 Nm.

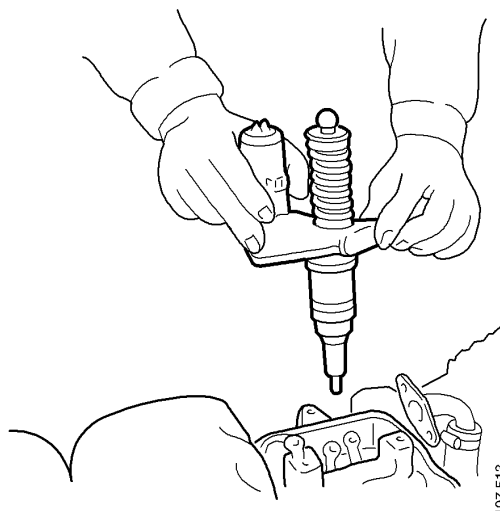


6. Make sure there is not an old sealing washer at the bottom of the injector seat. Clean the sealing surfaces in the injector seat. See the WARNING on page 20.

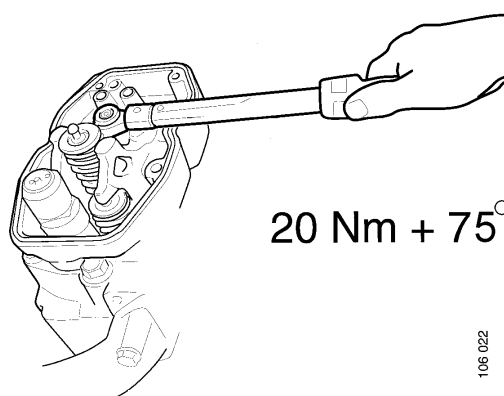
Important! *Always fit new O-rings and sealing washer to unit injectors that have been removed. Make sure all sealing surfaces are clean.*



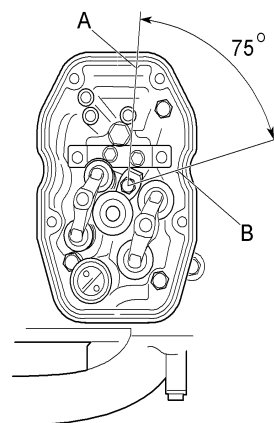
7. Lubricate the unit injector O-rings with red O-ring grease, part No. 1 402 039.
8. Fit a new sealing washer on the unit injector. A rubber insert will keep the seal in place on the unit injector.
9. Place the fork clamp with screw in position on the unit injector and insert it into the cylinder head. Press down the unit injector by hand as far as possible.



10. 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.

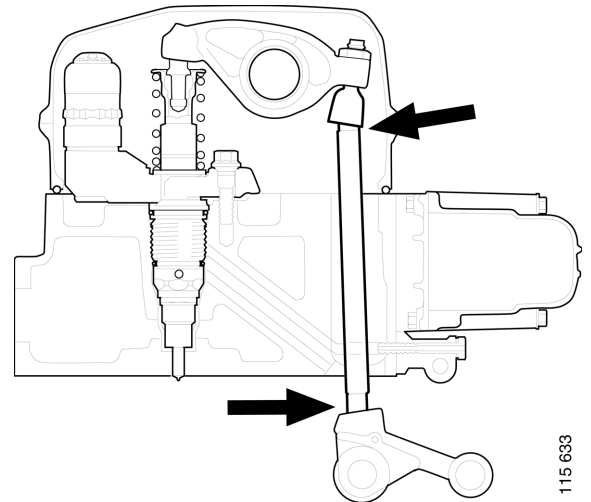


20 Nm + 75°



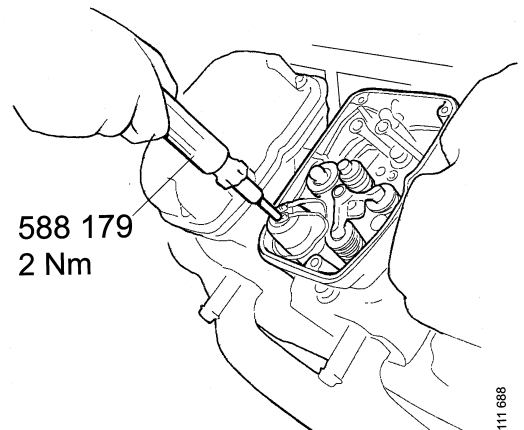
Important! *Make sure the pushrods are placed in their correct positions. Make sure the pushrod to the unit injector is firmly secured in position by the retaining ring.*

11. Fit the pushrods.
12. Fit the bearing bracket and torque tighten the bolts to 105 Nm.
13. 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.
14. Check the valve clearance and unit injector setting as described in *Adjusting the valve clearance and unit injector*.



15. Screw the cable grommet onto the lower rocker cover and run the cables to the unit injector. Fit the seal to the rocker cover.
16. 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.

Important! *Use torque screwdriver 588 179 to avoid the risk of shearing off the screws. The entire unit injector must be renewed if the screws shear off.*



17. Fit the upper part of the rocker cover and torque tighten the screws to 18 Nm.
18. Fit the exhaust manifold and tighten the bolts to 63 Nm.
19. Fit the cooling system ventilation pipes from the cylinder heads.
20. Fit the fuel manifold with overflow line. Torque tighten the screws to 26 Nm and the banjo screws on the overflow line to 11 Nm.

Important! *Make sure all the washers with rubber seals are intact.*

21. Fit the intake pipe/s.

| DC engine:

If cylinder 1-2 was removed:

- Fit the control unit with holder and the fuel filter and connect the filter.

If cylinder 3-4 was removed:

- Fit the crankcase ventilation unit.

If cylinder 5-8 was removed:

- Fit the charge air pipe between the turbocharger and the charge air cooler.
- Fit the inlet pipe to the crankcase ventilation filter.
- Screw on the connecting pipe between the intake manifolds.

On all cylinders:

- Connect the lines from the charge air cooler to the intake manifold.
- Connect the air line to the compressor.
- Connect the pipe from the crankcase ventilation.
- Fit the inlet pipe between the air filter and the turbocharger.
- Fit the charge air sensor.

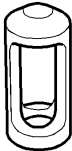
DI engine:

- Fit the intake manifold. Torque tighten the bolts to 26 Nm.
- Fit a new gasket on the intake manifold and screw on the charge air cooler element. Tighten the bolts to 26 Nm.
- Fit the upper part of the charge air cooler. Tighten the bolts to 50 Nm.
- Fit the connection pipe between the charge air coolers.
- Fit the connection pipes between the charge air cooler and the turbocharger.
- Fit the charge air sensor.
- Refit the connection pipes to and from the charge air cooler.
- Refit the closed crankcase ventilation filter.
- Refit the expansion tank and catwalk.

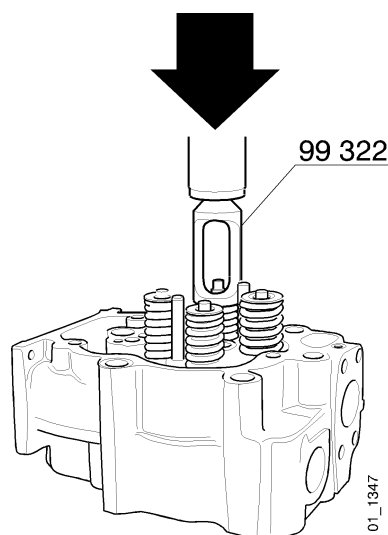
Valves

Removal

Special tools

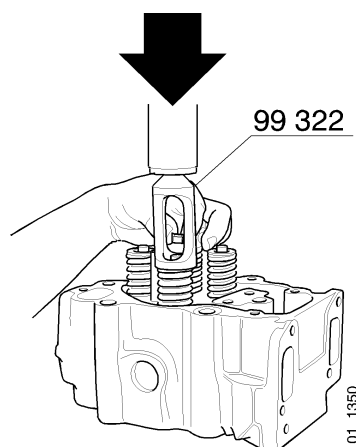
Number	Description	Illustration	Tool board
99 322	Drift		D 5

1. Press down the spring using tool 99 322 in a press so that the collets can be removed. Remove the collets, valve spring collars, springs and valves.
2. Place the valves in a stand or mark them so that they can be refitted in the same position in the cylinder head.



Fitting

1. Lubricate all parts well with engine oil before assembly.
2. Fit the valve in the guide.
3. Fit the valve springs and the valve spring collar.
4. Compress the springs in a press using tool 99 322 and fit the collets. Take care to fit the collets in the correct position.



Checking and machining

Specifications

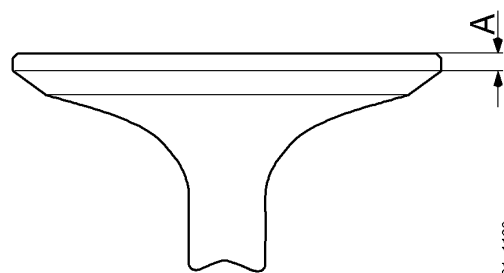
Intake valve

Head angle	19.5°
Minimum dimension A for ground valve	2.6 mm

Exhaust valve

Head angle	44.5°
Minimum dimension A for ground valve	1.8 mm

- Check dimension A on all valves.
- Grind the valves in a valve grinding machine.



Minimum dimension A for ground valve, see table.

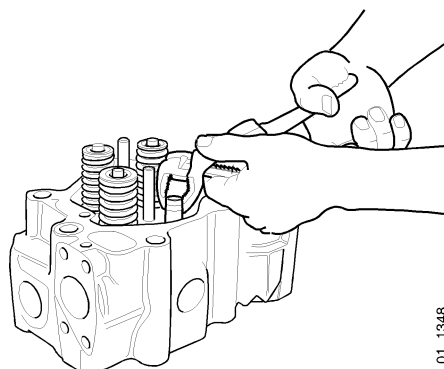
Valve stem seal

Renewal

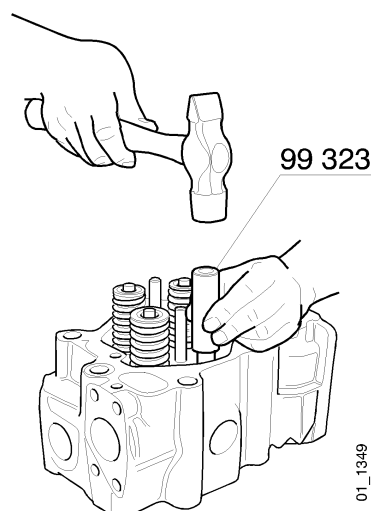
Special tools

Number	Description	Illustration	Tool board
99 323	Drift		D 5

1. Dismantle the cylinder head as described in dismantling.
2. Remove the valve stem seal with a pair of pliers.
3. Fit the valve.



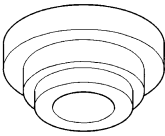
4. Tap in a new valve stem seal carefully using tool 99 323 and a hammer.



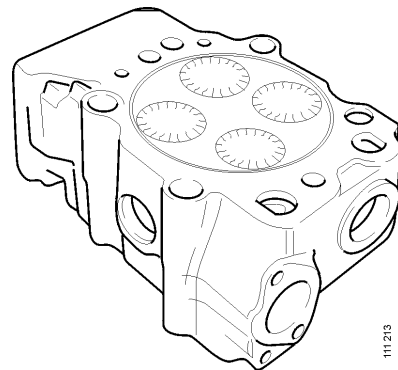
Valve seats

Renewal

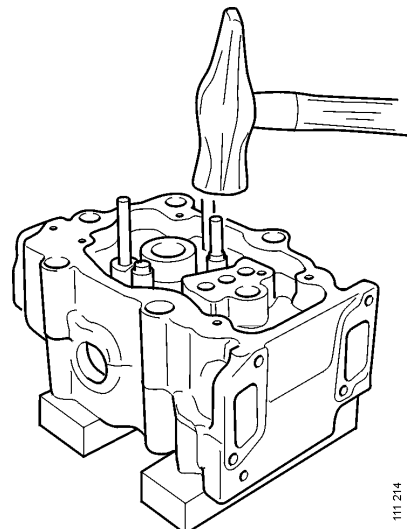
Special tools

Number	Description	Illustration	Tool board
99 384	Drift		D1-A3
99 385	Shank		D1-B1

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.



Wear protective goggles. Always turn the cylinder head with the underside face down while knocking out the valve seat insert. Otherwise, there is a risk that loose shivers of metal can cause personal injury.



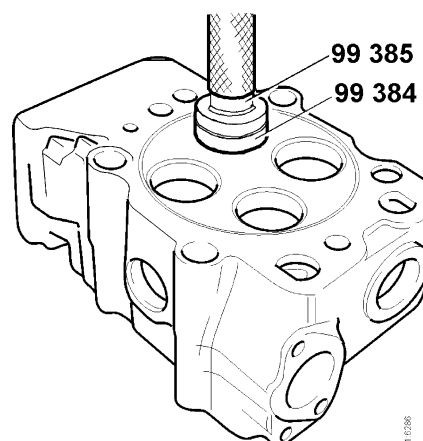
3. Press in new valve seat inserts. Use drift 99 384 and shank 99 385. Cool the drift and valve seat to about -80°C with dry ice or liquid oxygen. Pressing must be carried out rapidly.



WARNING!

Be careful when handling the cold parts and the cooling agents named above. Risk of frost injuries.

Oversize valve seat inserts can be fitted if the valve seat insert position has been damaged. The position must then be machined using tool 587 277.



Machining the cylinder head

Specifications

Cylinder head

Distance B between the cylinder head face and the valve disc:

- Intake, min. dim.	0.75 mm
- Exhaust, min. dim.	0.66 mm
- Intake, max. dim.	1.8 mm
- Exhaust, max. dim.	1.8 mm

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
Valve seat insert position, diameter	46,000 - 46.016 mm
Valve seat insert position, depth	11.25 - 11.35 mm

Oversize valve seat insert:

External diameter	46.254 - 46.265
Valve seat insert position, diameter	46.200 - 46.216
Cooling temperature when fitting valve seat insert	approx. -80°C

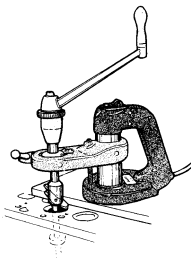
Exhaust valve seat

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
Valve seat insert position, diameter	44,000 - 44.016 mm
Valve seat insert position, depth	11.25 - 11.35 mm

Oversize valve seat insert:

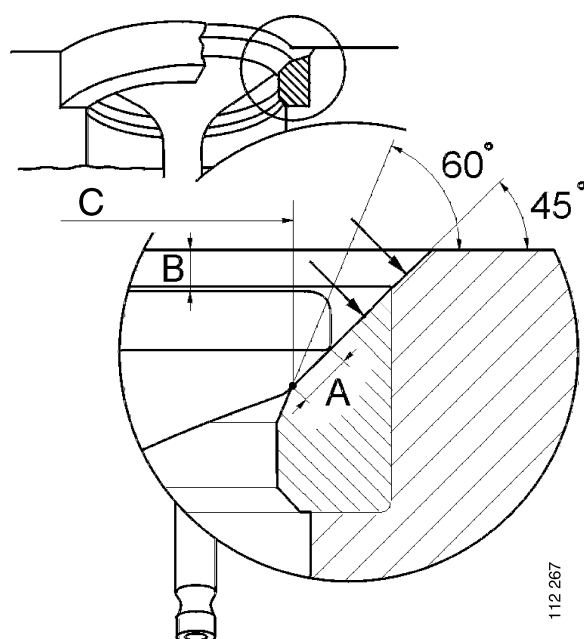
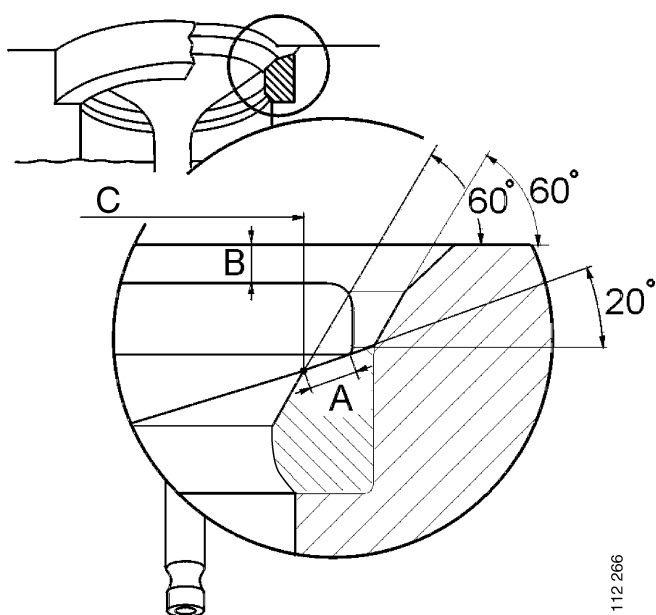
External diameter	44.281 - 44.292
Valve seat insert position, diameter	44.200 - 44.216
Cooling temperature when cooling valve seat insert	approx. -80°C

Tools

Number	Description	Illustration
587 277	Valve seat cutter	-
		
587 061	Valve seat cutter	

Two equally good alternatives for cutters are specified above.

Valve seat insert, machining measurement



Intake valve

$A = 1.9 - 2.6 \text{ mm}$

$B = 0.75 - 1.8 \text{ mm}$

$C = \text{diameter, } 39.8 \pm 0.5 \text{ mm (setting dimension for machining tool)}$

Exhaust valve

$A = 1.8 - 2.6 \text{ mm}$

$B = 0.66 - 1.8 \text{ mm}$

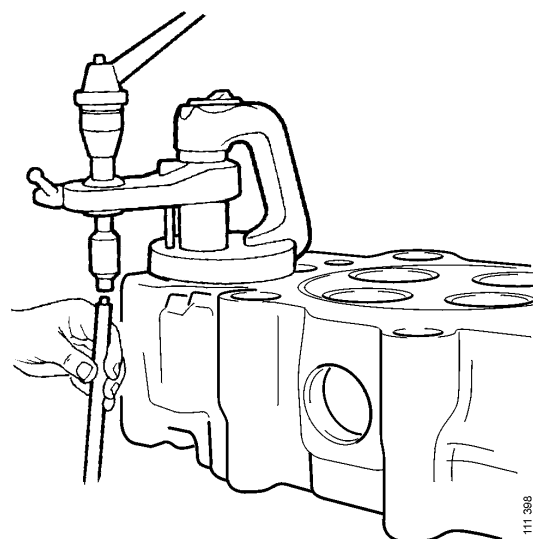
$C = \text{diameter, } 37.9 \pm 0.5 \text{ mm (setting dimension for machining tool)}$

Work description

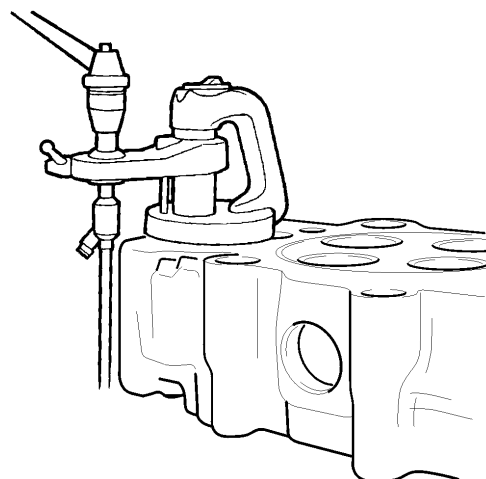
The following description applies to valve seat cutter 587 277.

For machining measurement and oversize valve seat inserts, refer to Specifications on pages 33 and 34.

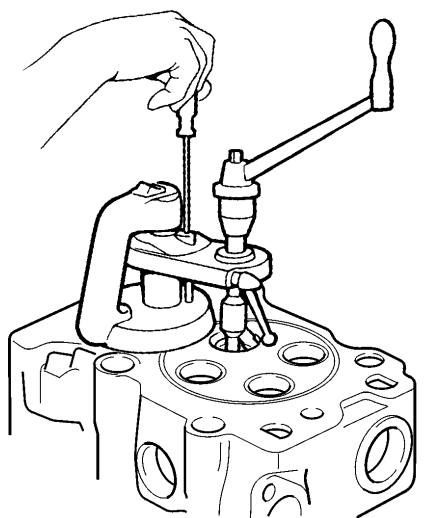
1. Make sure the contact surface and magnetic stand are level and clean. Clean the valve guides.
2. Select the largest spindle that moves easily in the valve guide. Insert the guide spindle and turn the feed screw to its uppermost position.



3. Select the cutter and fit it.

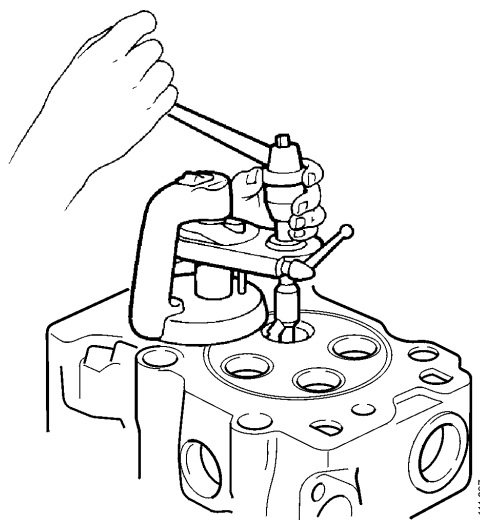
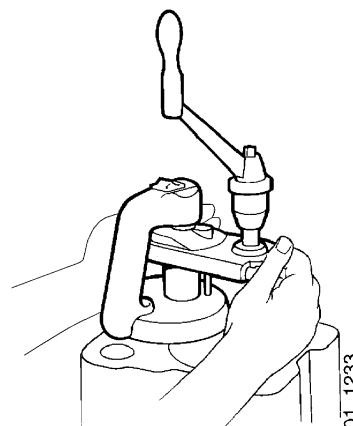
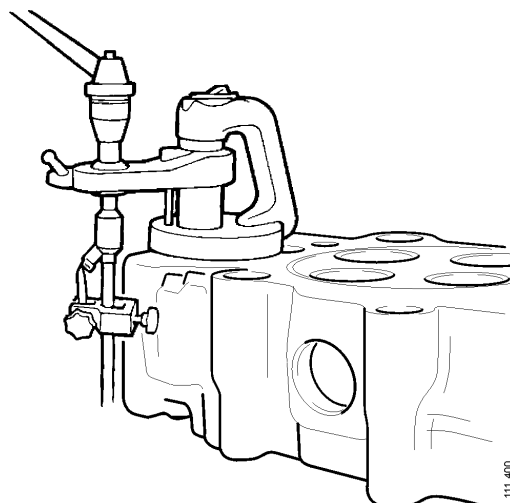


4. Release the quick-action lock and move the pivot plate to the upper position with the adjusting screw.



5. Set up the dial on the cutter adjuster using a valve.
6. Adjust the cutter. Diameter 37.9 mm and 39.8 mm respectively, refer to *machining measurement* page 34.
7. Turn off the magnet (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. Turn on the magnet (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 while machining.
11. When the surface of the valve seat has been machined, reduce the cutting pressure by turning 2-3 revolutions without any feed. Continue turning while backing off the feed screw. The valve seat cutter is now ready for the next valve seat.

The valve seats may also be machined with kit tool 587 061.



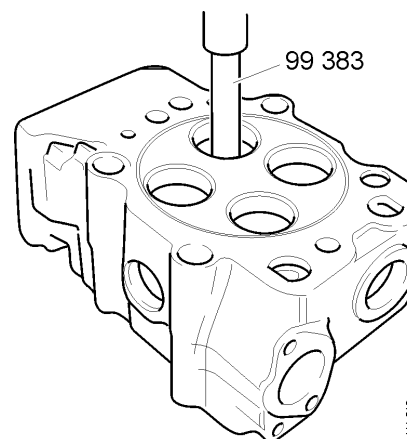
Valve guides

Renewal

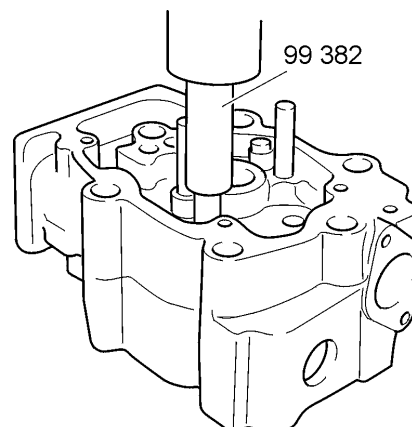
Special tools

Number	Description	Illustration	Tool board
99 382	Drift		D1-C6
99 383	Drift		D1-B1

1. Press out the valve guides using drift 99 383.



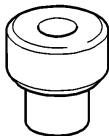
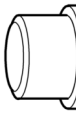
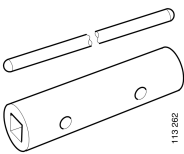
2. Press in the new valve guides using drift 99 382. Press the guide down as far as the drift allows, i.e. until it makes contact with the spring seat in the cylinder head.



Sleeves for unit injectors

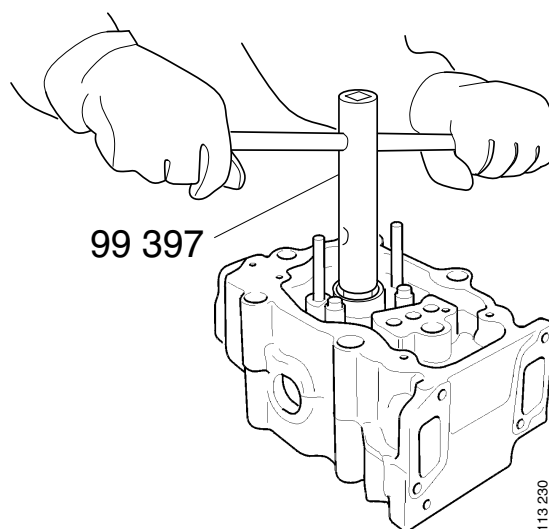
Renewal

Special tools

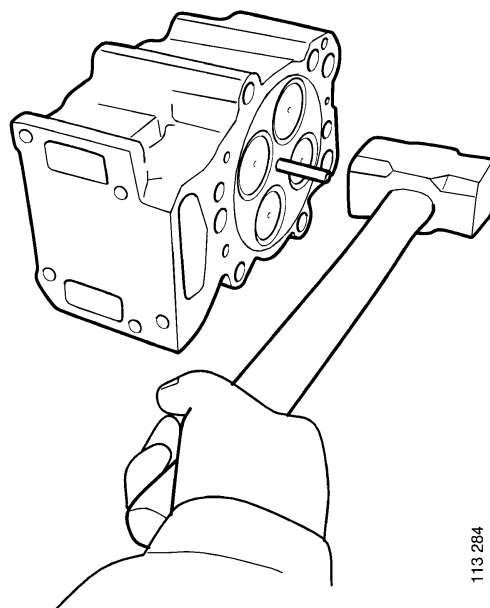
Number	Description	Illustration	Tool board
99 394	Steering		D2-A1
99 395	Drift		D2-A1
99 397	Extension piece with threader shaft		D2-C5, C6
588 221	Pilot tap		

The cylinder head must be removed when renewing the sleeve for the unit injector. The valves do not need removing. The illustrations show the cylinder head with the valves removed so that the working method can be seen more clearly.

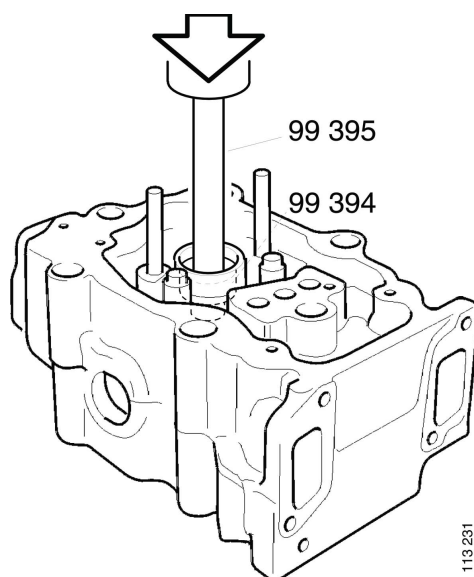
1. Thread the bottom part of the sleeve with pilot tap 588 221 and guide 99 394. Use extension piece 99 397.



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



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 561 200 on the sleeve and cylinder head contact surfaces.
5. Press in the sleeve with drift 99 395 and guide 99 394.



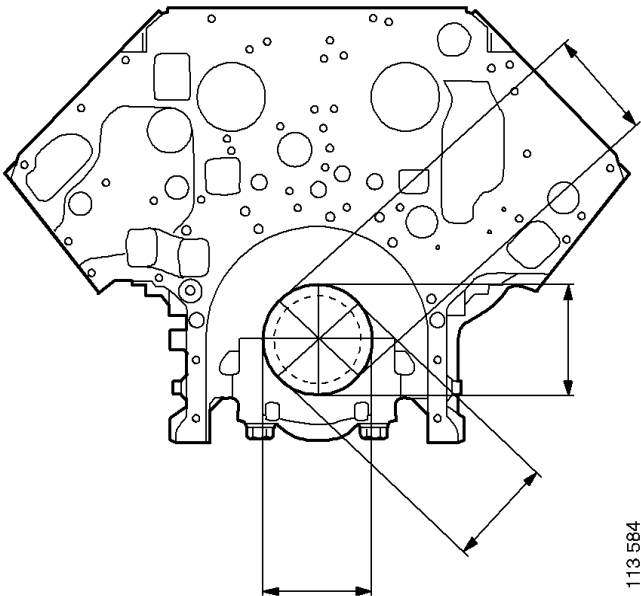
Cylinder block

Overhaul

Heat arising from the main bearings seizing and rotating in the cylinder block will change the properties of the material in the cylinder block. These cylinder blocks must be discarded.

If the main bearing seizes but does not rotate in the cylinder block, the cylinder block can be overhauled. The main bearing seats must comply with the demands on roundness given in the table. Machining out-of-round main bearing seats is something we do not recommend.

1. Measure the diameter at four different positions as illustrated. The diameter must be measured with the main bearing caps tightened and without main bearings.
2. Compare the dimensions with those in the table.



Tightening torques

Main bearing cap bolts	90 Nm+90°
Side bolts	180 Nm

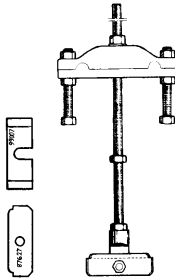
Smallest permitted diameter	Largest permitted diameter	Largest permitted difference*
112.200 mm	112.222 mm	0.016 mm

*) Maximum permitted difference between maximum and minimum diameter on same main bearing seat.

Cylinder liner

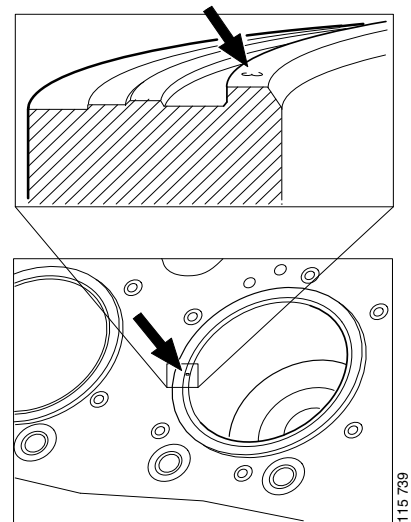
Removal

Special tools

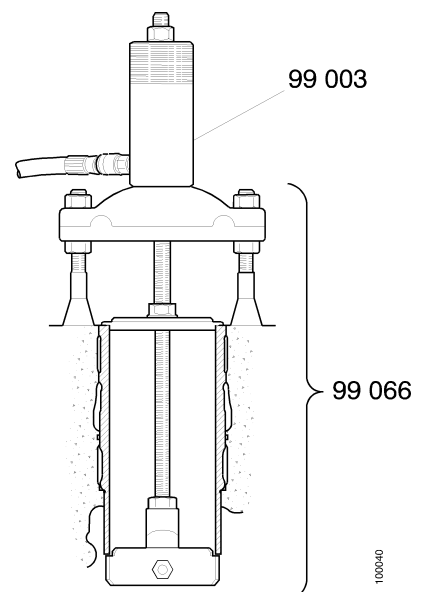
Number	Description	Illustration	Tool board
99 066	Cylinder liner puller		D2

1. Mark the cylinder liners with numbers 1-8.
The mark should face forward. 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.

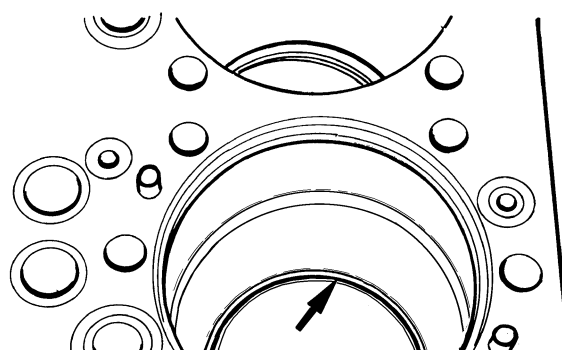


2. Remove the cylinder liner using puller 99 066.
3. Remove the sealing ring in the cylinder block.



Fitting

1. Make sure the interior of the cylinder block is clean. Clean the O-ring surfaces.
2. Carefully check the cylinder liners, both new and old, for cracks that can arise during transport or careless handling. Tap the liner carefully with a metal object. It should give a clear metallic ring if it is intact. If it is cracked, it will sound "cracked".
3. Fit the cylinder liner without O-rings and check the cylinder liner height as described in *Measuring the cylinder liner height*.
4. Remove the cylinder liner.
5. Lubricate the O-rings that seal between the cylinder liner and the engine block with glycerine or unscented soap and fit them.
6. Lubricate the lower guide surface on the cylinder liner.
7. Turn the liner with the stamped cylinder number facing forward and carefully tap it down with a rubber mallet.



1:6105

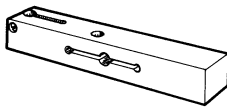
Measuring the cylinder liner height

Specifications

Cylinder liner height above cylinder block 0.20 - 0.30 mm

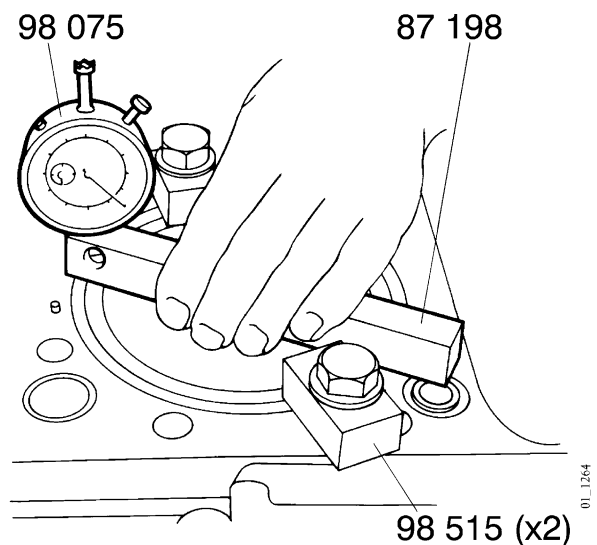
Maximum permitted difference in height between two diametrically opposite points of a cylinder liner 0.02 mm

Special tools

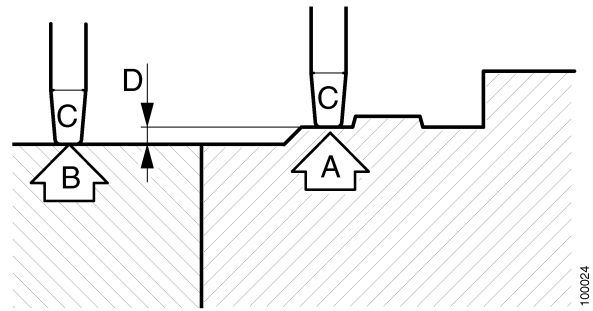
Number	Description	Illustration	Tool board
87 198	Straight edge		D2
98 075	Dial gauge		D2
98 515	Tension lug		

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 sealing rings and push down using two tension lugs 98 515. Tighten the bolts to 20 Nm.

Important *The tension lug bolts must not be tightened more than 20 Nm. Otherwise the cylinder liner may be damaged.*



3. 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. Measure each liner at two diametrically opposite points.
4. The cylinder liner must be slightly above the face of the cylinder block.
5. The height of the cylinder liner D (=A-B) above the block should be 0.20 – 0.30 mm.
6. The difference between two diametrically opposite points on the same cylinder liner may be max. 0.02 mm.



A = Area of measurement on cylinder liner

B = Area of measurement on cylinder block

C = Tip of dial gauge

D = Height of cylinder liner $D = A - B$

Machining cylinder liner height

If, during control measuring, the cylinder liner does not reach the specified value the liner seat must be machined.

Adjust the liner to the correct height using a shim. Shims are available in thicknesses of 0.20 mm, 0.30 mm and 0.40 mm.

If the cylinder liner height should be increased less than e.g. 0.20 mm, machine the bearing seat until the liner height including shim is correct.

Important *If a shim is used to adjust the liner height, the cylinder liner height must always be machined.*

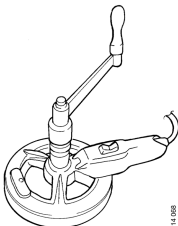
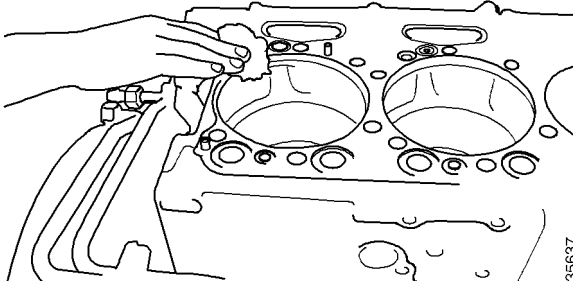
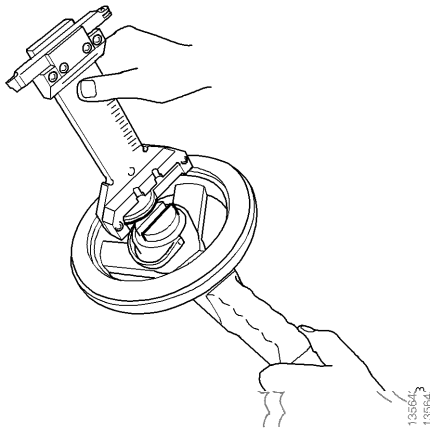
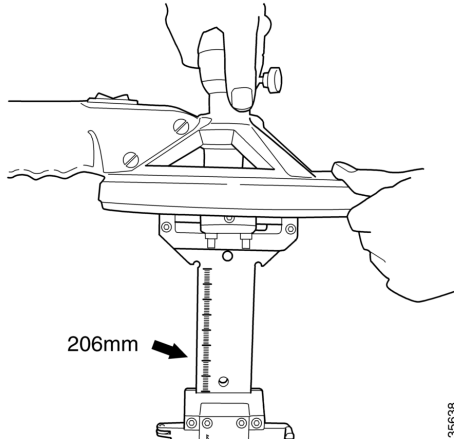
Tolerances for liner height

Lowest permissible cylinder liner height before machining	0,15 mm
Permissible cylinder liner height on engines with machined liner seats	0,20-0,30 mm
Desired measurement when machining	0,25 mm

Example of calculation of cutter depth

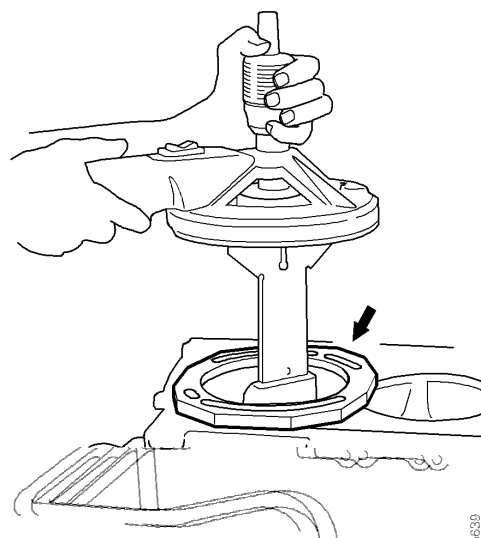
Height required	0,25 mm
Current cylinder liner height	0,14 mm
Increasing cylinder height (0.25-0.14)	0,11 mm
Shim thickness	0,2 mm
Material to be removed. (0,2-0,11)	0,09 mm

Special tools

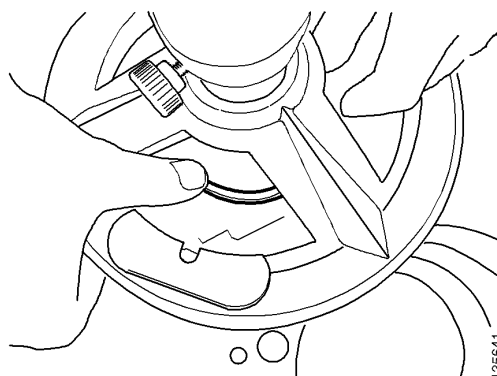
Number	Designation	Illustration	Tool board
587 512	Cylinder liner cutter		D2
588 672	Extension		D2
1. Clean the contact surface between the centering ring (which is included in the extension kit) and the top plane of the cylinder block. Note It is important for the surface to be cleaned thoroughly otherwise the cylinder liner seat may be cut to the wrong depth or may be slanted. 2. Fit extension 588 672 on the cylinder liner cutter 587 512.			
3. Set the depth of the extension to 206 mm.			

4. Position the centering ring over the relevant cylinder and then position the cylinder liner cutter. Energize the magnet on the cylinder liner cutter by setting the switch to position 1.

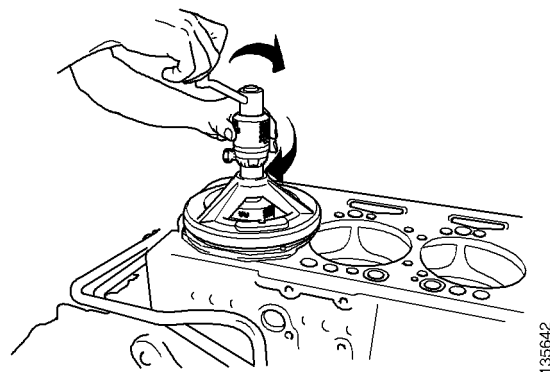
5. Check that the tool (cutter) does not touch the edge of the liner seat when the cylinder liner cutter is fitted in the centering ring. Otherwise the vertical feed screw must be wound up until the cutter is released from the liner seat.



6. Lift the rapid feeder ring and move the cutter by hand until it is positioned above the liner seat surface without including the cylinder block walls.

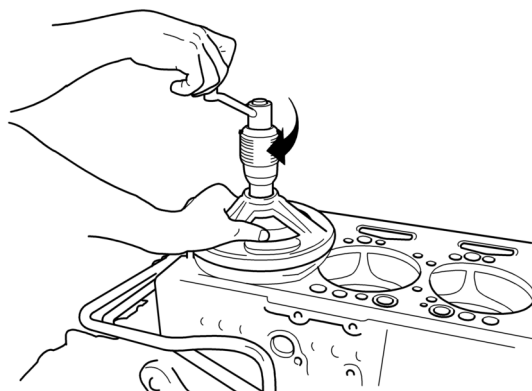


7. Wind round and at the same time turn the vertical feed screw clockwise until the cutter just touches the liner seat.
8. Lift the rapid feed ring and move the cutter back so that it is within the liner seat surface.



135642

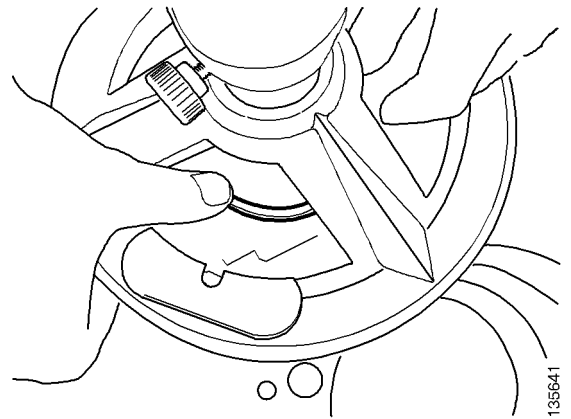
9. Adjust the vertical feed screw in order to start machining. The maximum feed per cut is 0.05 mm. If 0.05 mm is not enough, several cuts may be required until the required position is reached.
10. Wind clockwise with an even movement. Hold in the horizontal feed screw with the other hand at the same time. The cutter will be fed horizontally at 0.13 mm per turn. Wind carefully when the cutter starts to approach the outer edge of the liner seat. Release the horizontal feed screw when the cutter has gone over the edge so that feeding stops.



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Important *Never wind the cylinder liner cutter anti-clockwise, otherwise the cutter will break.*

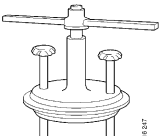
11. Move the cutter back towards the centre of the liner hole by holding down the rapid feed ring at the same time as the cutter is moved back by hand.
12. Repeat steps 9-11 if insufficient cutting depth has been attained.
13. When the required depth has been obtained, hold down the rapid feed ring and move the cutter to the middle of the cylinder hole. Change the switch on the cylinder liner cutter to position 2 and lift out the entire tool. Then remove the centering ring.
14. Clean the liner seat and the engine from grindings.
15. Put the shim in place in the liner seat. The shim should be dry.
16. Position the cylinder liner.
17. Check the measurement to ensure that the height corresponds to the height according to the measurement of the cylinder liner height.



Rear crankshaft seal

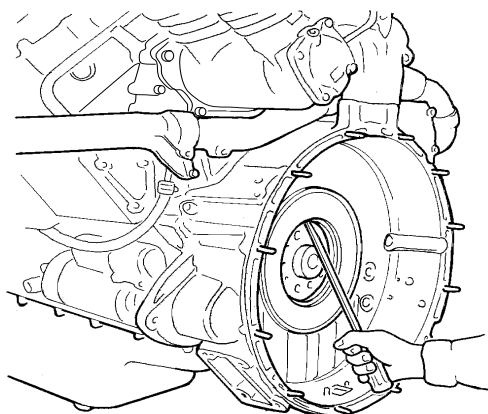
Renewal

Special tools

Number	Description	Illustration	Tool board
99 410	Assembly tool		D5

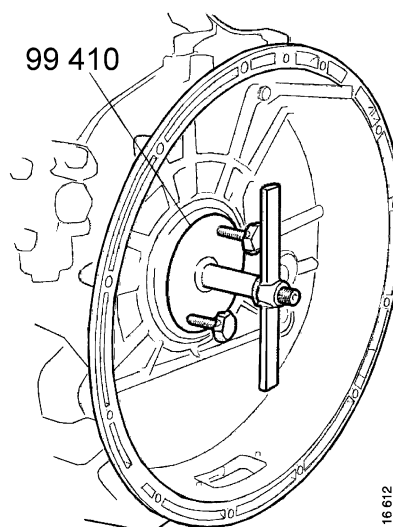
1. Remove the flywheel as described in *Flywheel, removing*.
2. Remove the crankshaft seal using a screwdriver. Take care not to scratch the sealing surfaces on the crankshaft and the flywheel housing.

Note: The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal must not be removed until just before the crankshaft seal is to be fitted on the engine.



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3. Fit the new crankshaft seal using tool 99 410. Place the crankshaft seal on the tool and fasten the tool with the bolts.
4. Turn the tool clockwise until it stops in order to attain the correct crankshaft seal position.
5. Fit the flywheel as described in *Flywheel, fitting*.



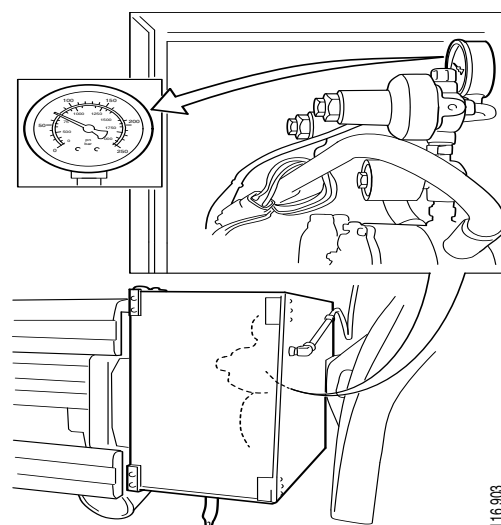
116 612

Flywheel housing

Removal

DC engine:

1. Remove the oil pipe to the turbocharger.
2. Remove the flywheel rotation speed sensors.
3. Remove the flywheel as described in *Flywheel, removing*.
4. Disconnect the negative battery cable.
5. Detach the cables to the starter motor.
6. Remove the starter motor.
7. Remove the compressor if applicable.
8. Remove the intake manifold and exhaust pipe from the turbocharger.
9. Remove the turbocharger and the turbocharger mounting with turbo manifold.
10. Remove the cover from the power take-off.
11. Remove the oil sump.
12. Remove flywheel housing.



DI engine

1. Remove the closed crankcase ventilation filter.
2. Remove the turbocharger oil pipes.
3. Remove the seawater pump with the connection pipes and connection housing.
4. Remove the flywheel as described in *Flywheel, removing*.
5. Disconnect the negative battery cable.
6. Detach the cables to the starter motor.
7. Remove the starter motor.
8. Remove the cover from the power take-off.
9. Remove the oil sump.
10. Remove flywheel housing.

Fitting

Tightening torques

Bolts for flywheel housing

Flange bolt and stud, M12 : 92 Nm

Flange bolt, M10 : 50 Nm

Nut for turbocharger manifold

92 Nm

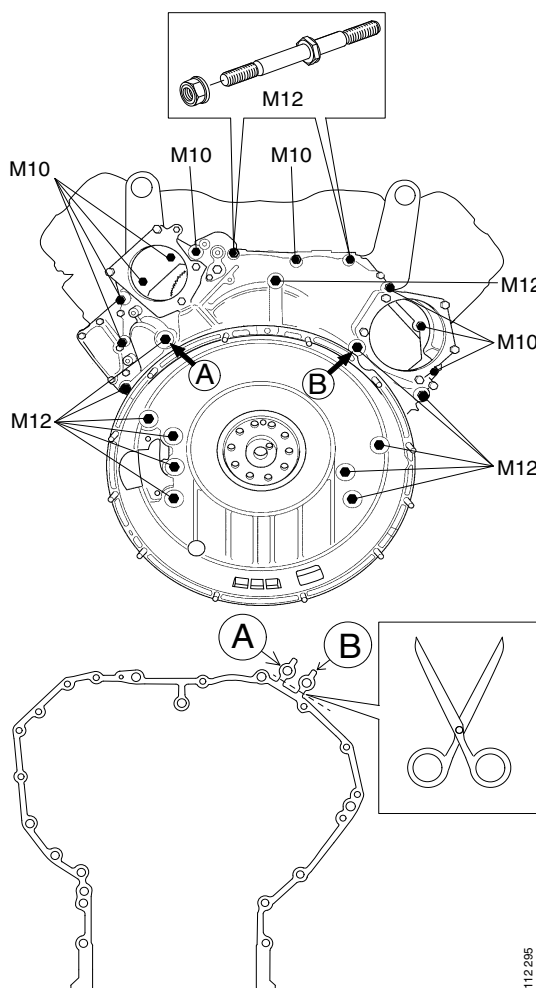
Bolts for oil sump

32 Nm

Plug for oil sump

80 Nm

1. Clean the sealing surfaces. Carefully remove any remains of the old gasket.
2. Fit the flywheel housing with a new gasket. The two appendages, A and B, are to be removed and used for bolts A and B.
3. Fit the bolts. Torque tighten the M12 bolts and studs to 92 Nm and the M10 bolts to 50 Nm.



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4. Fit the oil sump with a new gasket. Tighten the bolts to 32 Nm.
5. Fit the cover for the power take-off.

DC engine:

6. Fit the turbocharger mounting with turbo manifold.
7. Fit the turbocharger and the turbocharger manifold, torque tighten the nut to 92 Nm.
8. Fit the exhaust manifold, intake manifold and exhaust pipe from the turbocharger.
9. Fit compressor if applicable.

DI engine:

- Fit the seawater pump with the connection housing and connection lines.
 - Fit the turbocharger oil pipes.
 - Fit the closed crankcase ventilation filter.
10. Fit the starter motor and the cables to the starter motor.
 11. Fit the flywheel as described in *Flywheel, fitting*.
 12. Fit the flywheel rotation speed sensors.
 13. Fit the oil pipe to the turbocharger.

Closed crankcase ventilation

General

DC engine:

The prefilter and paper filter must be renewed as described in the maintenance instructions.

The system is fitted with a fluid trap. There must always be oil in the fluid trap. If the system has been emptied, pour approximately 1 dl oil on the bottom of the filter housing to fill the fluid trap.

DI engine:

The filter has a replaceable filter element which must be renewed as described in the maintenance instructions.

Troubleshooting

- Increased blow-by in engine

Blow-by is the flow of gases through the engine crankcase and out via the crankcase ventilation.

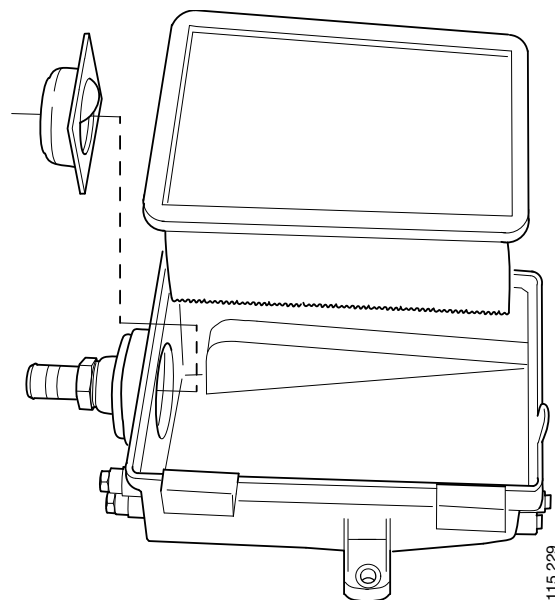
The closed crankcase ventilation system is very sensitive for changes to the blow-by in the engine. If the blow-by increases, the amount of gas passing through the crankcase ventilation will also increase.

The crankcase gases can then take with it small drops of oil from the crankcase. When the amount of oil increases, the oil separator will not be able to fulfil its task of separating the oil. Oil will then accompany the air into the charge air system.

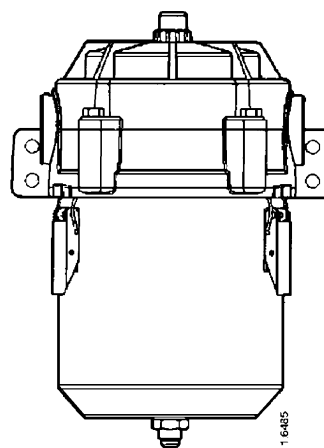
Causes of an increase in blow-by are leaking piston rings, valve guides, turbocharger or compressor.

- Too much oil in the oil sump

If the engine is filled with too much oil, the excess will splash around in the crankcase and be atomized. This means that the crankcase gases will contain a large amount of atomized oil that the crankcase ventilation will not be able to separate the oil properly. This will result in a large amount of oil from the crankcase ventilation.



DC engine: Closed crankcase ventilation



DI engine: Closed crankcase ventilation

- Air leak in the crankcase

In a well-functioning closed crankcase ventilation system, there should be a certain amount of vacuum in the crankcase. If air enters the crankcase from outside, the flow of gas from the crankcase through the crankcase ventilation will increase. This is the equivalent of increased blow-by and will lead to an increase in oil.

An air leak in the crankcase can be caused by:

- A defective diaphragm in the valve housing.
- Poorly fitted oil filler cap.
- Defective rubber plug on the oil dipstick handle.
- Worn air compressor.

- Damaged turbocharger

Oil can leak into the charge air system from a damaged turbocharger.

For checking the turbocharger, refer to *Turbocharger*.

Front timing gear casing

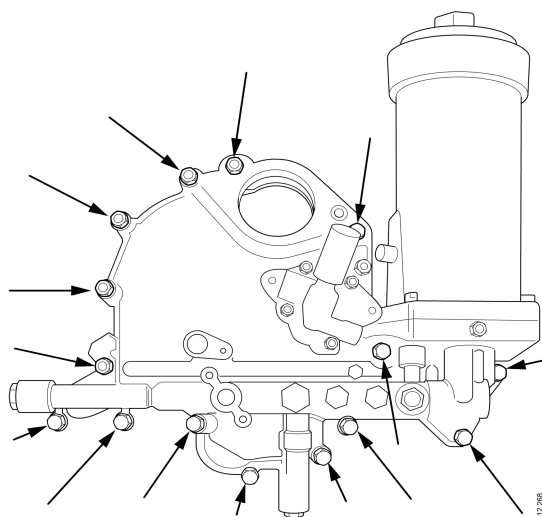
Removal

DC engine:

1. Drain the cooling system. Refer to booklet 02:01-02, *Cooling system work description*.

Help protect our environment! Use a suitable container.

2. Remove the fan and outer poly-V-belt.
3. Remove the fan drive with bracket.
4. Remove the inner poly-V-belt.
5. Disconnect the fuel connections on the feed pump and bend them to one side.
6. Remove the coolant temperature sensor and oil pressure sensor with clamp.
7. Disconnect the power steering pump if fitted and place to one side.
8. Remove the oil filter housing.
9. Remove the timing gear housing.



DI engine:

1. Drain the cooling system. Refer to booklet 02:01-02, *Cooling system work description*.
2. Remove the belt guard and poly-V-belt.
3. Disconnect the fuel connections on the feed pump and bend them to one side.
4. Remove the coolant temperature sensor and oil pressure sensor with clamp.
5. Disconnect the power steering pump if fitted and place to one side.
6. Remove the oil filter housing.
7. Remove the timing gear housing.

Fitting

DC engine:

1. Fit the timing gear housing.
2. Fit power steering pump if applicable.
3. Fit the coolant temperature sensor and oil pressure sensor with clamp.
4. Fit the fuel connections on the feed pump.
5. Fit the poly-V-belt.
6. Fit the oil filter housing.
7. Fit the fan drive with bracket.
8. Fit the outer poly-V-belt and fan.
9. Fill the cooling system. For coolant composition, refer to booklet *00:03-01*.

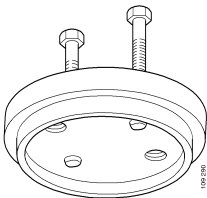
DI engine:

1. Fit the timing gear housing.
2. Fit power steering pump if applicable.
3. Fit the coolant temperature sensor and oil pressure sensor with clamp.
4. Fit the fuel connections on the feed pump.
5. Fit the poly-V-belt.
6. Fit the oil filter housing.
7. Fit the belt guard.
8. Fill the cooling system. For coolant composition, refer to booklet *00:03-01*.

Front crankshaft seal

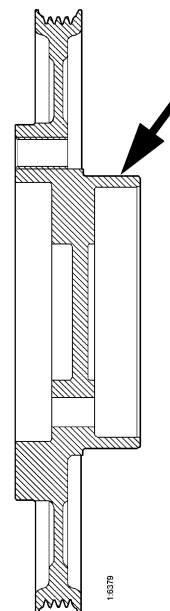
Renewal

Special tools

Number	Description	Illustration	Tool board
99 374	Press tool for crankshaft seal		D5

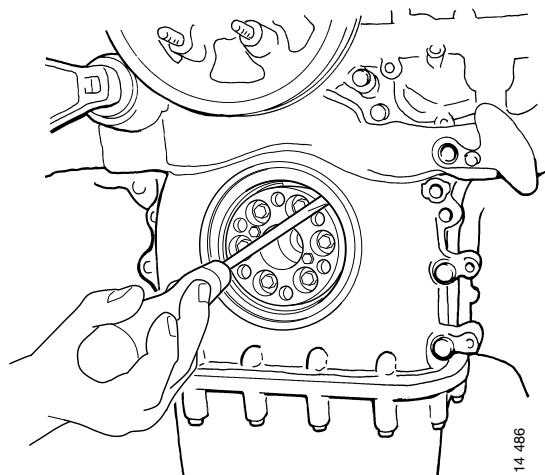
1. Remove the poly-V-belt and belt pulley/pulleys from the crankshaft.

Note: The crankshaft seal seals against the inner belt pulley. Handle the pulley with care.



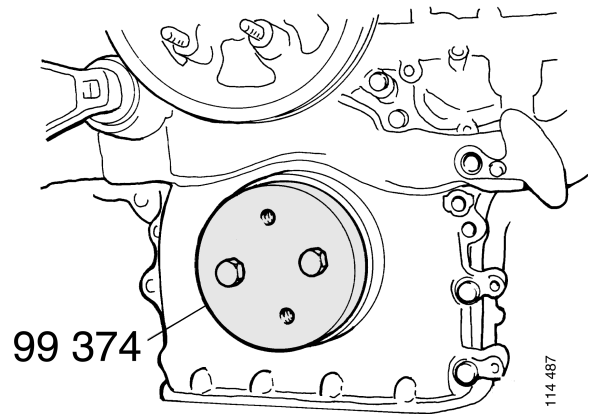
Sealing surface for crankshaft seal

2. Remove the crankshaft seal using a screwdriver. Take care not to damage the sealing surface in the housing.
3. Wipe clean the sealing ring seat in the housing.



Note: The crankshaft seal must be fitted dry and must not be lubricated. The sleeve in the seal must not be removed until just before the crankshaft seal is to be fitted on the engine.

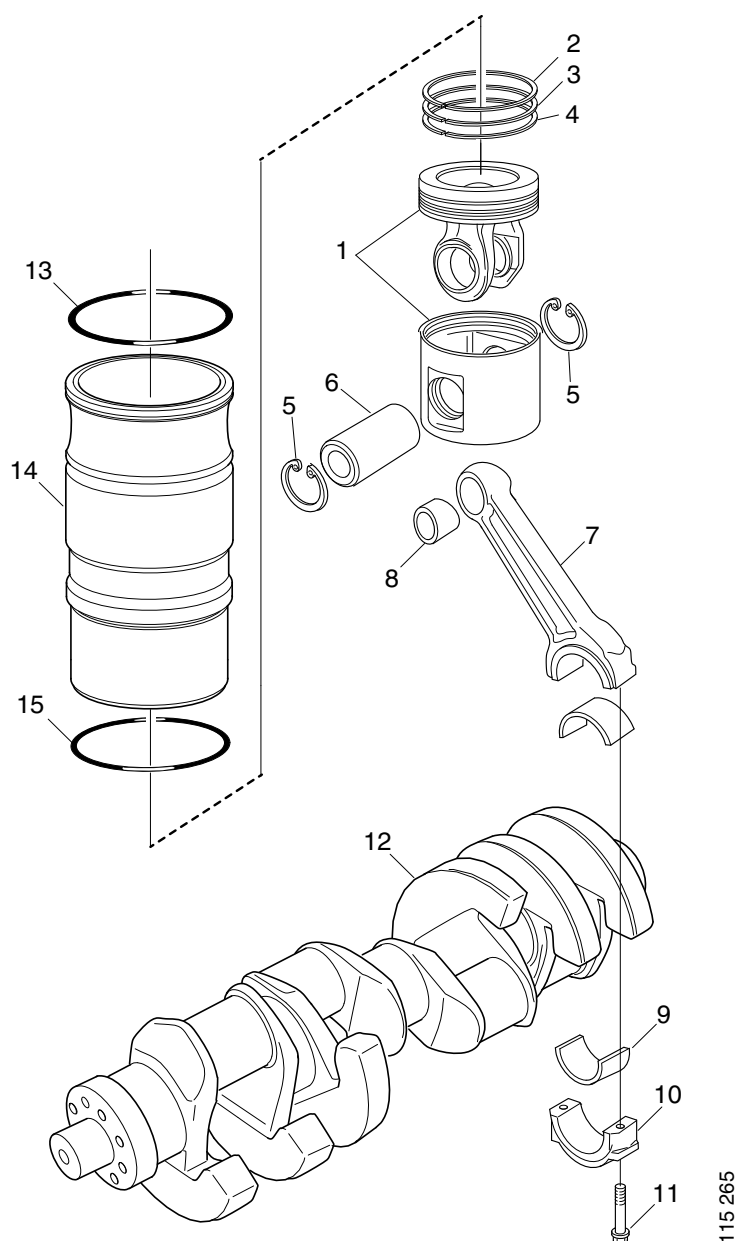
4. Place the new seal in tool 99 374 and press it in place by tightening the bolts alternately. The seal is correctly fitted when the tool bottoms.



The seal is correctly fitted when the tool bottoms

5. Remove the tool. To make removal easier, fit the bolts into the threaded holes and use as a handle.
6. Wipe clean the sealing surface on the belt pulley and fit it immediately.
7. Fit the outer belt pulley.
8. Fit the poly-V-belts.

Crank mechanism



- | | |
|---------------------|--------------------|
| 1. Piston | 9. Bearing shell |
| 2. Compression ring | 10. Bearing cap |
| 3. Compression ring | 11. Flange bolt |
| 4. Oil scraper ring | 12. Crankshaft |
| 5. Circlip | 13. O-ring |
| 6. Gudgeon pin | 14. Cylinder liner |
| 7. Connecting rod | 15. O-ring |
| 8. Bearing bushing | |

Piston and connecting rod

Removal

1. Remove the cylinder head as described in *Cylinder head, removing*.
2. Remove the oil sump.
3. Remove the piston cooling nozzle in the cylinder block.

Important! *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.*

4. Remove the bearing cap and bearing shells. Protect the oilway in the crankshaft e.g. by winding tape around it with the adhesive side out.
5. Mark the piston before removing it. The parts must be refitted in the same place and position. Lift out the piston and connecting rod.

Note: Always check the connecting rod as described in *Connecting rod, checking*, if the cylinder has seized, been filled with water or has a broken valve. Bent connecting rods must not be straightened.

Fitting

Tightening torques

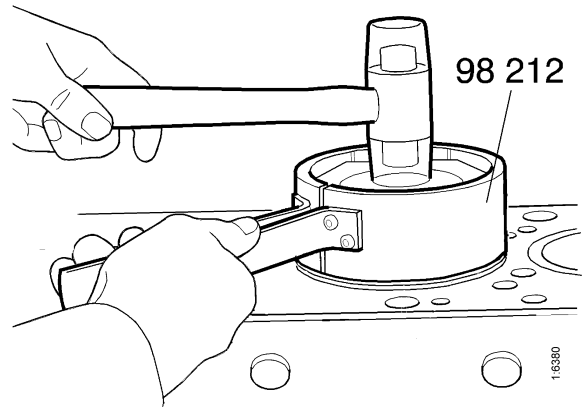
Bolts for oil sump	32 Nm
Connecting rod bolts	50 Nm +90°
Piston cooling nozzle	23 Nm

Special tools

Number	Description	Illustration	Tool board
98 212	Piston ring compressor		D3

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 gaps are distributed around the piston.
4. Fit the upper connecting rod bearing shell and lubricate the bearing surface.

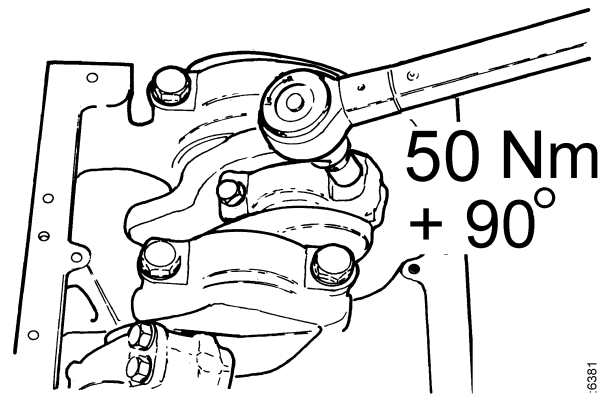
5. Fit the connecting rod and piston. Clamp the piston ring compressor 98 212 and push the piston into the cylinder.



6. Fit the connecting rod bearing shell into the cap and lubricate the bearing surface. Fit the cap. Lubricate the bolts, fit them and torque tighten to 50 Nm + 90°.
7. Fit the piston cooling nozzle. Tightening torque 23 Nm.

Important! *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.*

8. Fit the oil sump. Torque tighten the bolts to 32 Nm.
9. Fit the cylinder head. Tighten the cylinder head bolts as described in *Cylinder head, fitting*.



Renewing a piston

Specifications

Piston rings

Number of compression rings 2 off

Gap:

1st ring 0.35 - 0.60 mm

2nd ring 0.45 - 0.65 mm

Maximum play in groove, 2nd ring 0.25 mm

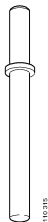
Number of oil scraper rings 1 off

Gap 0.40 - 0.65 mm

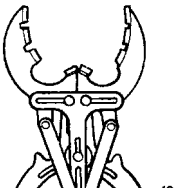
Maximum play in groove 0.25 mm

Important! *Turn the rings marked "TOP" with the mark face up.*

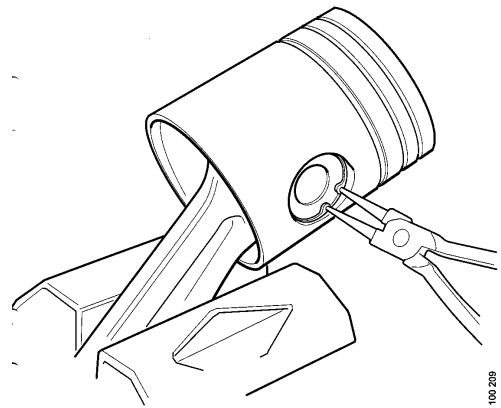
Special tools

Number	Description	Illustration	Tool board
87 362	Drift		D3

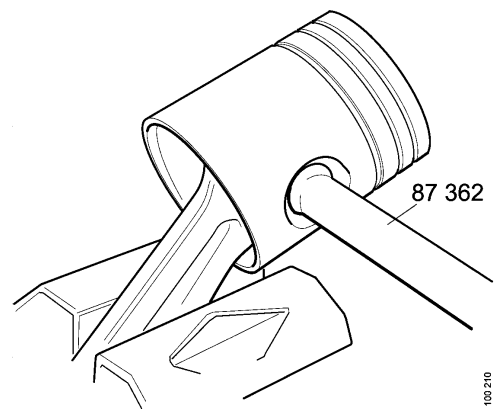
Other tools

Number	Description	Illustration	Tool board
587 309	Piston ring expander		D3

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

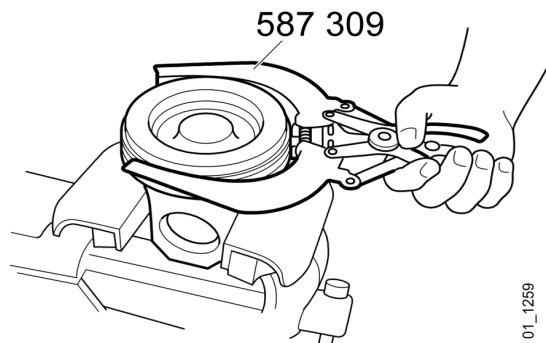


2. Push out the gudgeon pin using drift 87 362.



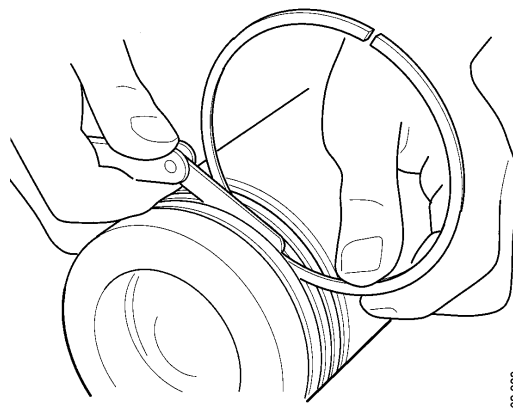
3. Place the piston crown in a vice and remove the piston rings using tool 587 309. Take care not to scratch the surface of the piston crown with the piston rings.

Note: Always check the connecting rod in a cylinder that has seized, been water filled or has a broken valve. Bent connecting rods must not be straightened.



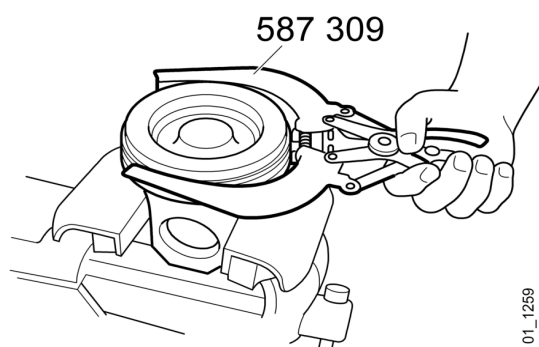
4. Clean the piston crown and its ring grooves thoroughly without scratching the sides of the ring grooves. Clean the oil holes in the piston using a suitable drill bit.

5. Make sure the piston ring gaps do not exceed the permitted limit. Place the piston rings inside the cylinder liner and measure the gap with a feeler gauge. Measure also the play in the groove for the 2nd compression ring and the oil scraper ring. Refer to *Specifications* for permitted gap.



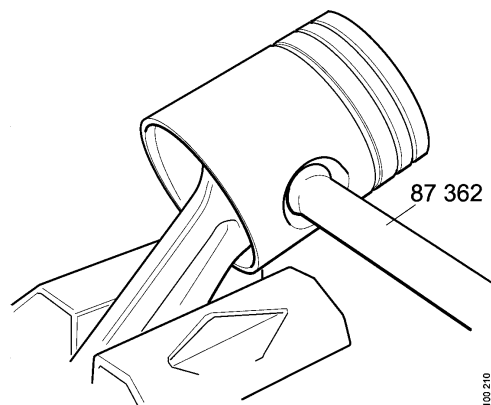
102 300

6. Fit the piston rings using tool 587 309. The oil ring is fitted with an expander. Pistons rings marked with TOP must be turned with TOP face up.



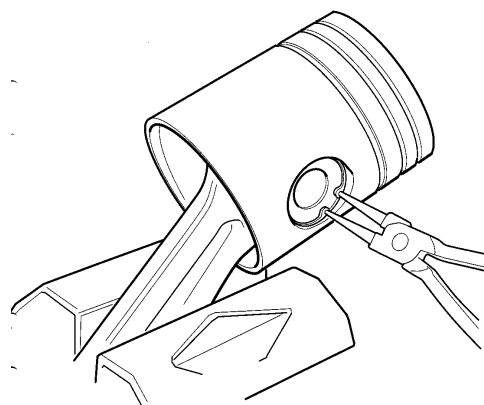
01_1259

7. Oil all the bushings, the gudgeon pin hole and the gudgeon pin before assembling.
8. Fit the piston skirt to the piston crown and fit one of the gudgeon pin retaining rings.
9. Fit the piston to the connecting rod and press in the gudgeon pin with drift 87 362.



100 210

10. Fit the second retaining ring.

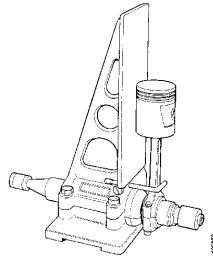


100 209

Connecting rod

Checking

Tools

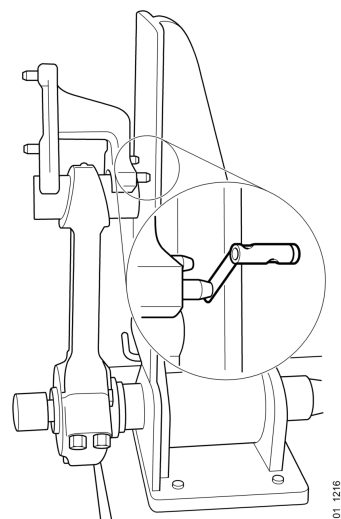
Number	Description	Illustration	Tool board
587 110	Control device		-

- Connecting rod and bearing cap are marked *1* to *8*.
- Check the connecting rods using tool 587 110.

Make sure the gudgeon pin bushing is not damaged and then proceed as below:

1. Fit the bearing cap as marked and torque tighten the bolts to 50 Nm +90°.
2. Fit the connecting rod in the tool using the expander and put the corresponding gudgeon pin in the gudgeon pin bushing.
3. Then apply the indicator to the gudgeon pin.

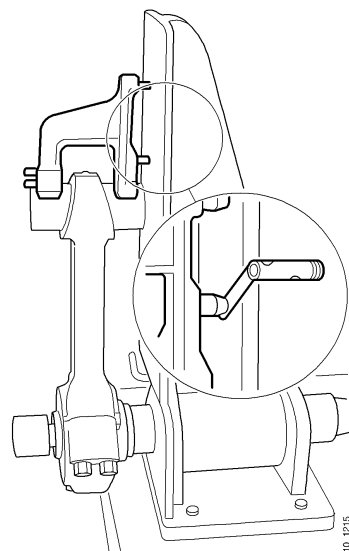
- Check whether the connecting rod is twisted with the indicator studs horizontal.



Checking for twisted connecting rod.

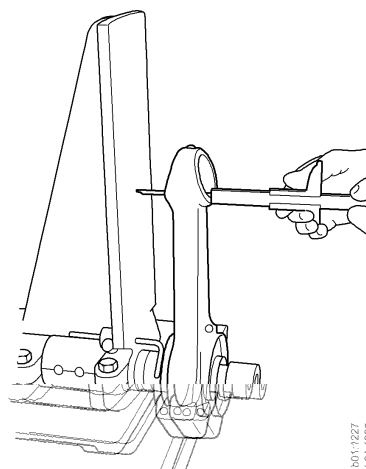
- Check whether the connecting rod is bent with the indicator studs vertical.

Note: Bent connecting rods must not be straightened.



Checking for crooked connecting rod.

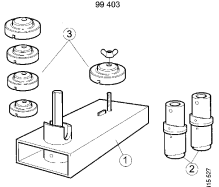
- The distance between the indicator studs on the tool illustrated here is 75 mm.
- The distance between one of the indicator studs and the measuring surface must be maximum 0.05 mm when measured using this tool. Check with a feeler gauge.
- Check also whether the connecting rod is bent in an S-shape. 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. The difference between the two measurements should be between 3.3-4.5 mm.



Checking whether the connecting rod is bent in an S-shape

Renewal of bearing bushing in connecting rod

Special tools

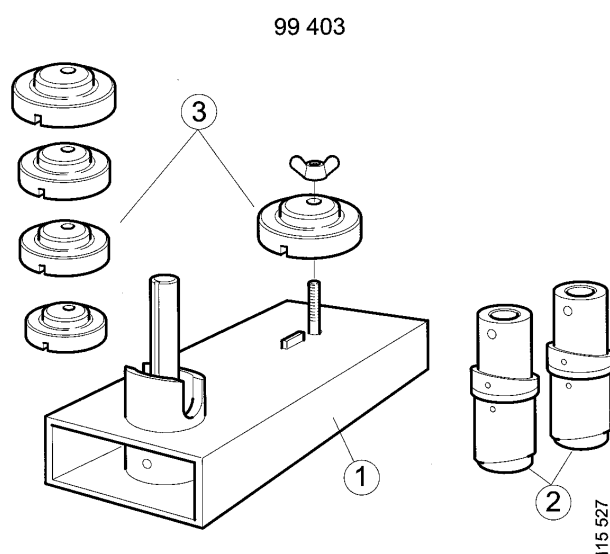
Number	Description	Illustration
99 403	Tool for renewing bearing bushing	

Use tool 99 403 when renewing the bearing bushing.

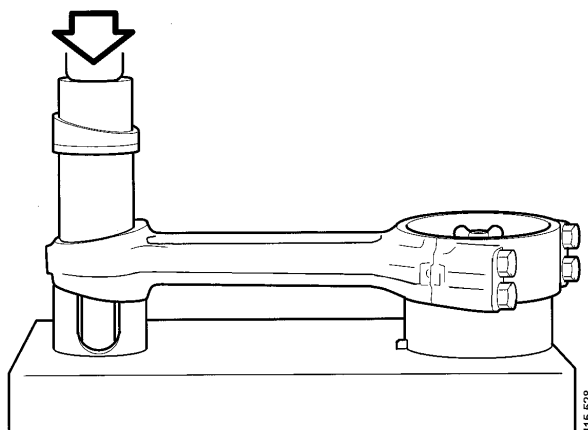
The tool comprises three parts:

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

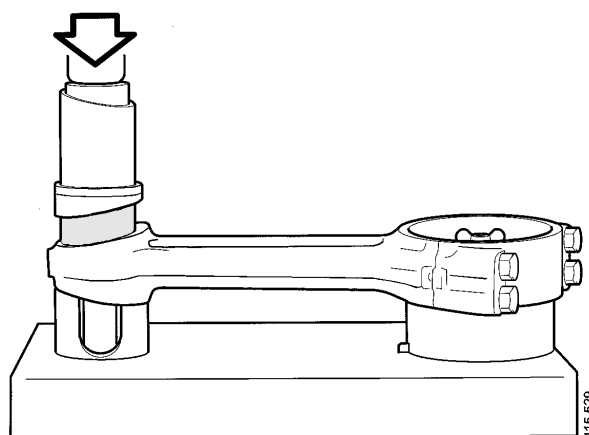
There are different supports, depending on the engine type. The support marked E is for 16 litre engines.



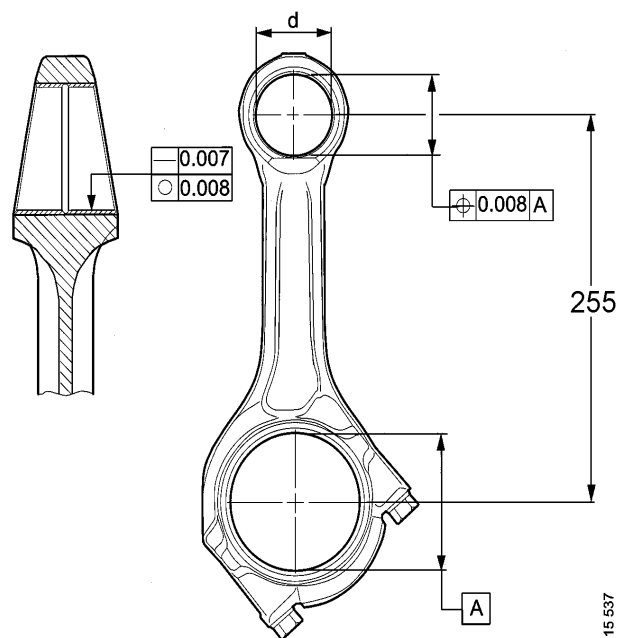
1. Place the connecting rod on the pressplate so that the wide end of the connecting rod is resting against support E. Turn the pressplate so that the smaller diameter faces the bearing bushing and press out the bearing bushing.



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. Measurements as illustrated.

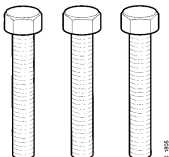


Diameter, $d = 54.030 - 54.043 \text{ mm}$
Surface quality = 0.6 Ra

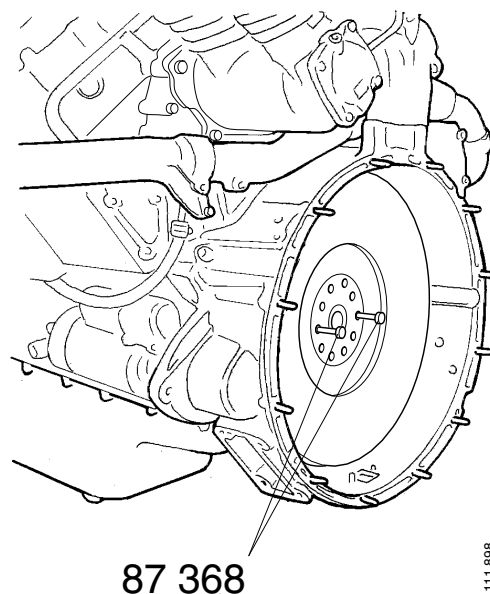
Flywheel

Removal

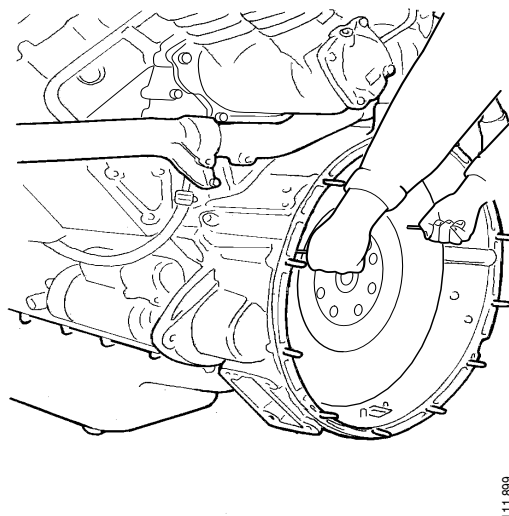
Special tools

Number	Description	Illustration	Tool board
87 368	Puller bolt		AM1, D3, B1, AD1

1. Remove the rotation speed sensors from the flywheel housing.
2. Remove the bolts for the flywheel.
3. Pull off the flywheel from the crankshaft using puller bolts 87 368.



4. The flywheel can be lifted using two M10x100 bolts that have been partially threaded into the holes.



Fitting

Specifications

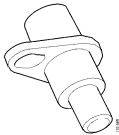
Flywheel

Maximum machining allowance for disc pressure surface	Refer to group 4, clutch
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Tightening torques

Flywheel bolts	130 Nm+90°
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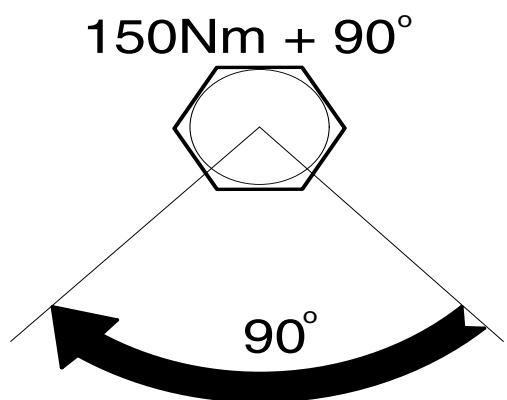
Special tools

Number	Description	Illustration	Tool board
99 324	Guide pins		D5
99 411	Tool for locking flywheel		D5

1. Fit two guide pins 99 324 in the crankshaft flange.
2. Fit the flywheel on the crankshaft.

Important! Always use new bolts.

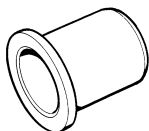
3. Torque tighten the bolts alternately to 130 Nm and then a further 90°. Use tool 99 411 to lock the flywheel.
4. Fit the engine speed sensors.



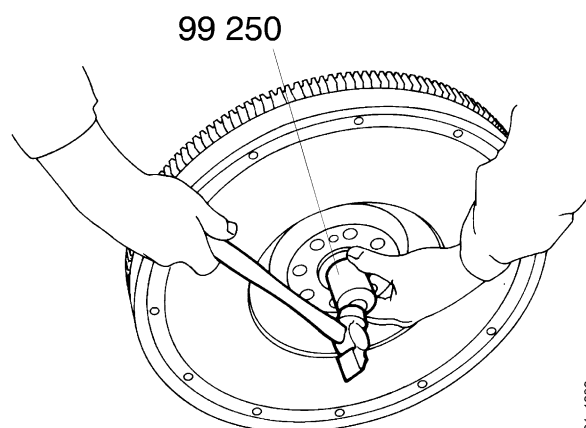
Support bearing

Renewal

Special tools

Number	Description	Illustration	Tool board
99 250	Drift		D3, C4

1. Remove the retaining rings on both sides of the support bearing.
2. Knock out the support bearing from the fly-wheel using drift 99 250.
3. Fit the inner retaining ring and a new support bearing using drift 99 250.
4. Fit the outer retaining ring.



01_1392

Ring gear

Renewal

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.

Crankshaft

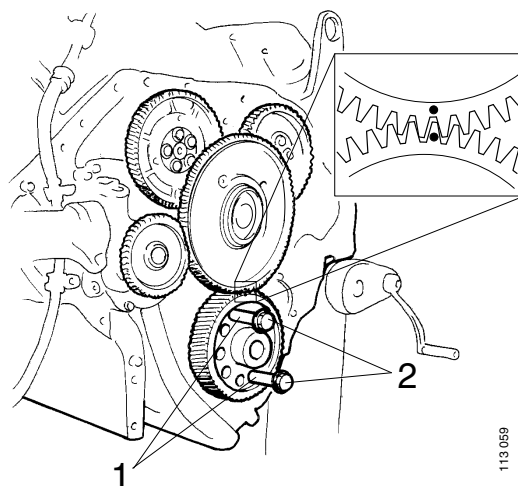
Removal

The crankshaft must be removed while the engine is suspended in the universal stand. Refer to *Mounting the engine in a universal stand*.

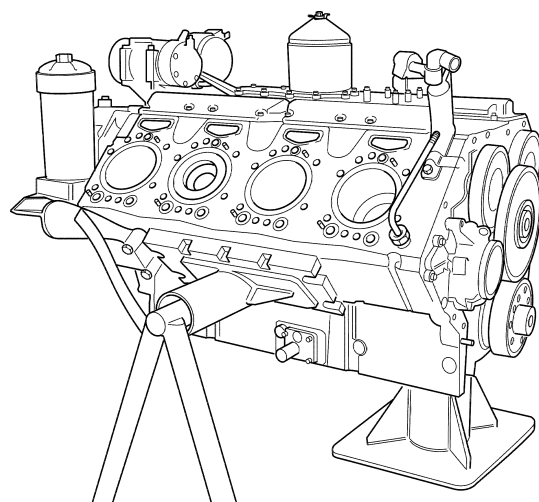
1. Remove the oil sump.
2. Remove the flywheel as described in *Flywheel, removing*.
3. Remove the flywheel housing as described in *Flywheel housing, removing*.
4. Remove the oil strainer and the suction pipe.
5. Remove the poly-V-belts.
6. Remove the fan ring and the fan.
7. Remove the cylinder heads as described in *Cylinder head, removing*.
8. Remove the belt pulleys on the front of the crankshaft.
9. Remove the front housing.
10. Remove the crankshaft damper with spacer sleeve.
11. Remove the piston cooling nozzles.

Important! *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.*

12. Turn the engine so that it is vertical.
13. Lift out the pistons and connecting rods. Turn the crankshaft so that the piston to be removed is at TDC. To be able to rotate the crankshaft, the crankshaft gear must be secured with two flywheel bolts and two 50 mm spacers.



1. 50 mm
2. Flywheel bolts

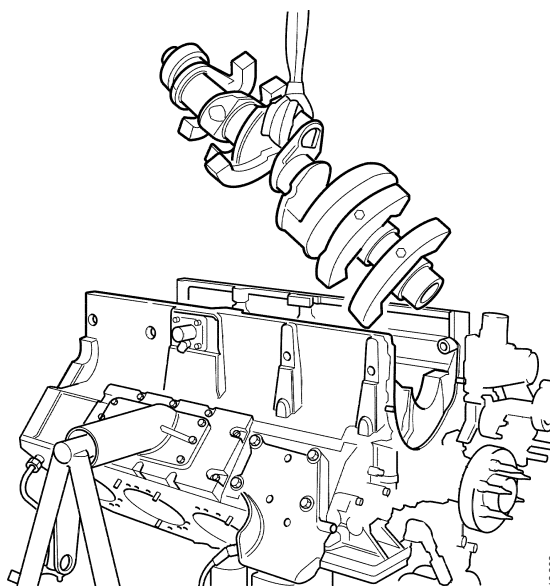


Engine after removal according to items 1 - 13

14. Turn the engine upside down.
15. Remove the crankshaft gear.
16. Remove the main bearing caps. Protect the oilway in the crankshaft e.g. by winding tape around it with the adhesive side out.

Note: The main bearing caps are marked and must be refitted in the same place.

17. Remove the lower and upper thrust washers.
18. Lift out the crankshaft.



Fitting

Tightening torques

Main bearing cap bolts	90 Nm+90°
Side bolts	180 Nm
Connecting rod cap bolts	50 Nm+90°
Bolts to crankshaft damper	135 Nm
Bolts to inner belt pulley on crankshaft	92 Nm

Important! *All parts must be cleaned before fitting.*

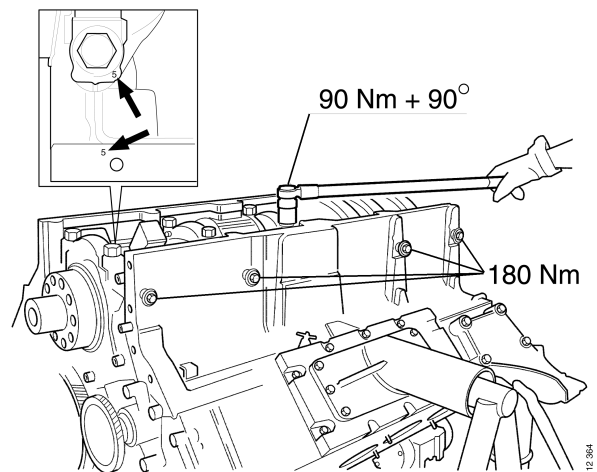
1. Place the bearing shells in the main bearing seats in the engine block and then lubricate the bearing surface with engine oil.

Note: The outside of the bearing shells must not be lubricated.

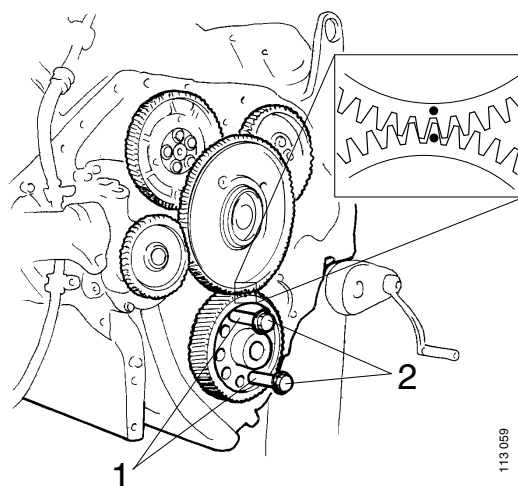
2. Lift in the crankshaft.
3. Fit the thrust bearing washers.
4. Place the main bearings in the main bearing caps and fit them. Torque tighten the cap bolts to 90 Nm +90°.

Note: The main bearing caps are marked and must be refitted according to the marks on the block.

5. Torque tighten the side bolts to 180 Nm.

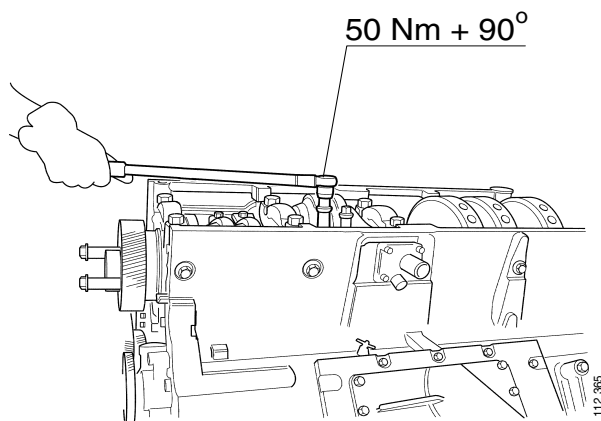


6. Fit the crankshaft gear so that the marks on the crankshaft gear and the intermediate gear are pointing at each other. Secure the gear with two flywheel bolts and two 50 mm long spacers.

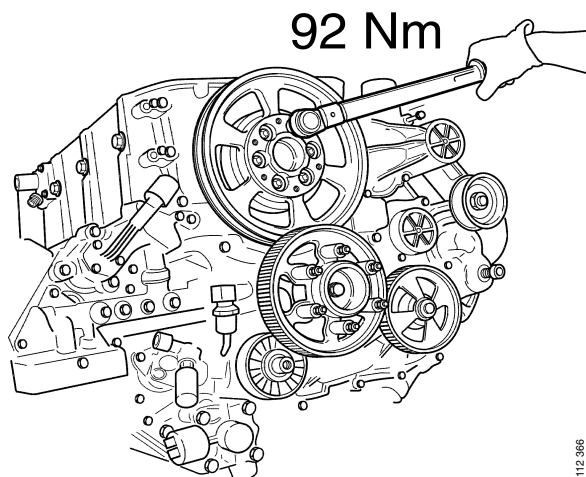


1. 50 mm long spacers
2. Flywheel bolts

7. Turn the engine so that it is vertical.
8. Fit the piston and connecting rod as described in *Fitting the piston and connecting rod*.
9. Fit the connecting rod bearing into the connecting rod cap and lubricate the bearing surface. Fit the cap. Lubricate the bolts and tighten them to 50 Nm +90°.
10. Clean the cylinder heads and fit them as described in *Cylinder head, fitting*.
11. Fit the crankshaft damper and spacing sleeve. Torque tighten the bolts to 135 Nm.



12. Clean and fit the gaskets for the front housing. Fit the front housing.
13. Fit the belt pulleys on the crankshaft. Torque tighten the bolts on the inner belt pulley to 92 Nm.
14. Fit the oil strainer and suction pipe.
15. Fit the flywheel housing as described in *Flywheel housing, fitting*.
16. Fit the flywheel as described in *Flywheel, fitting*.
17. *DC16*: Fit the fan, the fan ring and the poly-V-belts.
18. *D116*: Fit the poly-V-belt.
19. Fit the oil sump.

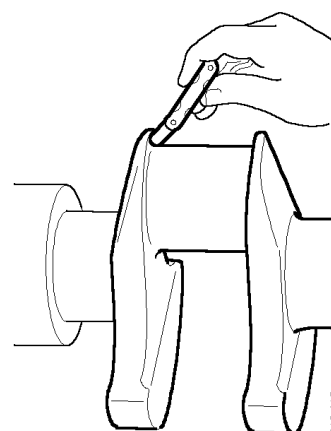
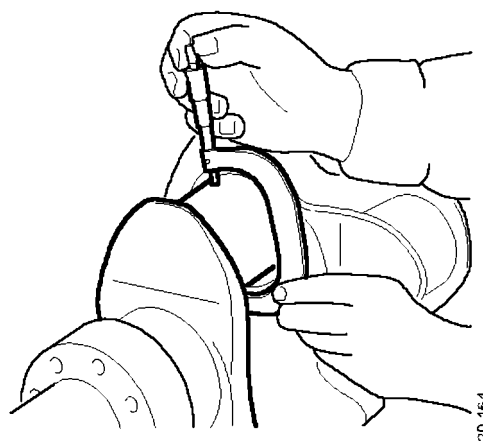


112 366

Checking and machining the crankshaft

Important *Grinding of a crankshaft can and should only be carried out by workshops that have machine equipment for such jobs.*

- Measure the crankshaft journals. Use a micrometer to measure two diameters at right angles to each other.
- If either of these diameters is lower than the minimum indicated limit, regrinding of the crankshaft should be considered.
- Consideration must also be given to oil pressure, which is in turn affected by such things as main bearing and crankshaft bearing wear.
- When regrinding, stated undersizes must be complied with. Suitable bearings are available for these sizes.
- Refer to the next page for the diameters required for different undersizes.
- It is important that the fillet radius of the journals is correct.
- After grinding the journals, the oil hole connections to the bearing surfaces should be rounded off and polished.



Dimensions when regrinding

Main bearing journals

Standard, diameter	107.978-108.000 mm
Undersize 1, diameter	107.728-107.750 mm
Undersize 2, diameter	107.428-107.450 mm
Undersize 3, diameter	107.228-107.250 mm
Undersize 4, diameter	106.978-107.000 mm
Hole recess radius	4.75-4.85 mm
Surface quality	0.25 Ra

Connecting rod journals

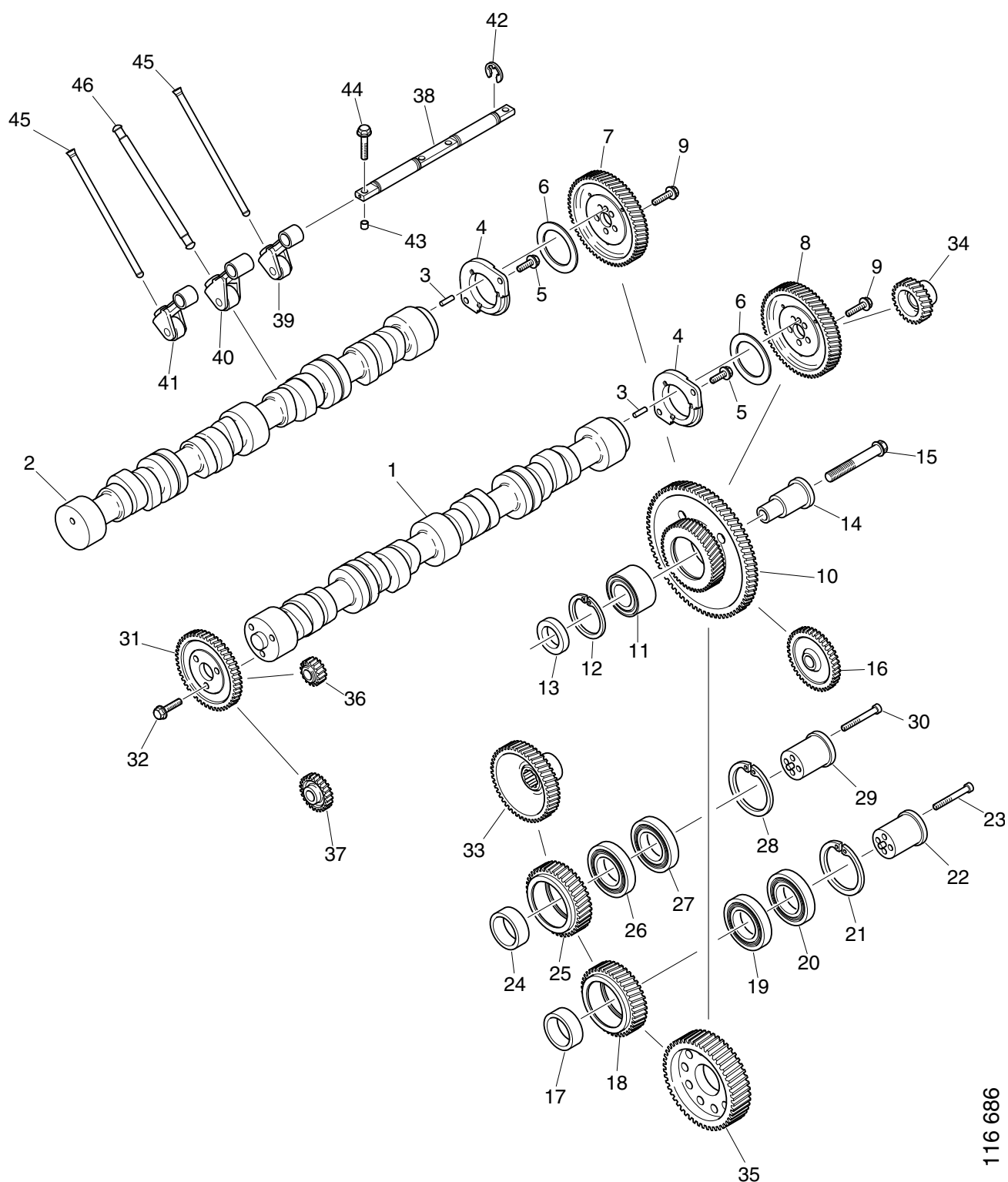
Standard, diameter	92.978-93.000 mm
Undersize 1, diameter	92.728-92.750 mm
Undersize 2, diameter	92.478-92.500 mm
Undersize 3, diameter	92.228-92.250 mm
Undersize 4, diameter	91.978-92.000 mm
Hole recess radius	4.8-5.2 mm
Surface quality	0.25 Ra
Width, max.	56.05
Radial clearance	0.051-0.114 mm

Thrust washers

Standard, thickness	3.370-3.430 mm
Oversize 1, thickness	3.450-3.510 mm
Oversize 2, thickness	3.500-3.560 mm
Oversize 3, thickness	3.630-3.690 mm
Oversize 4, thickness	3.880-3.940 mm
Axial clearance	0.138-0.380 mm

Timing gear

Gear drive



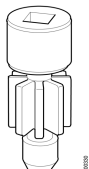
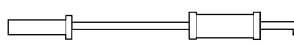
116 686

- | | | |
|------------------------------|------------------------------|--------------------------------------|
| 1. <i>Camshaft</i> | 17. <i>Spacing sleeve</i> | 33. <i>Power take-off drive gear</i> |
| 2. <i>Camshaft</i> | 18. <i>Intermediate gear</i> | 34. <i>Compressor gear</i> |
| 3. <i>Pin</i> | 19. <i>Ball bearing</i> | 35. <i>Crankshaft gear</i> |
| 4. <i>Guide flange</i> | 20. <i>Ball bearing</i> | 36. <i>Hydraulic pump gear</i> |
| 5. <i>Flange bolt</i> | 21. <i>Retaining ring</i> | 37. <i>Feed pump gear</i> |
| 6. <i>Thrust washer</i> | 22. <i>Shaft journal</i> | 38. <i>Shaft</i> |
| 7. <i>Camshaft gear</i> | 23. <i>Bolt</i> | 39. <i>Roller tappet</i> |
| 8. <i>Camshaft gear</i> | 24. <i>Spacing sleeve</i> | 40. <i>Roller tappet</i> |
| 9. <i>Flange bolt</i> | 25. <i>Intermediate gear</i> | 41. <i>Roller tappet</i> |
| 10. <i>Intermediate gear</i> | 26. <i>Ball bearing</i> | 42. <i>Retaining ring</i> |
| 11. <i>Ball bearing</i> | 27. <i>Ball bearing</i> | 43. <i>Guide sleeve</i> |
| 12. <i>Retaining ring</i> | 28. <i>Retaining ring</i> | 44. <i>Flange bolt</i> |
| 13. <i>Spacing sleeve</i> | 29. <i>Shaft journal</i> | 45. <i>Pushrod</i> |
| 14. <i>Shaft</i> | 30. <i>Bolt</i> | 46. <i>Pushrod</i> |
| 15. <i>Bolt</i> | 31. <i>Camshaft gear</i> | 47. <i>Pushrod</i> |
| 16. <i>Oil pump gear</i> | 32. <i>Flange bolt</i> | |

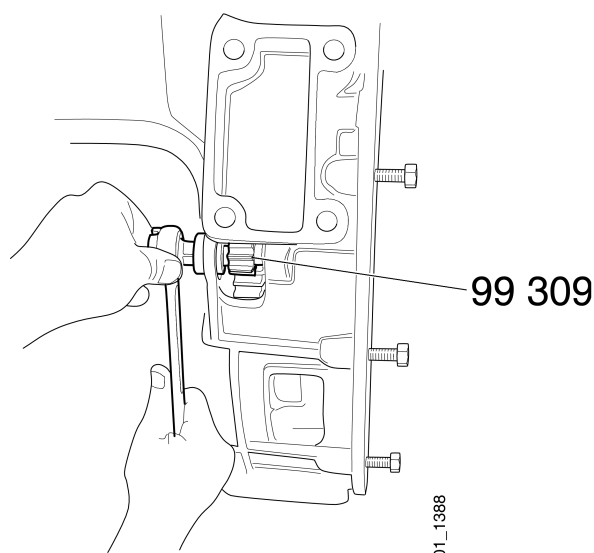
Intermediate gear

Removal

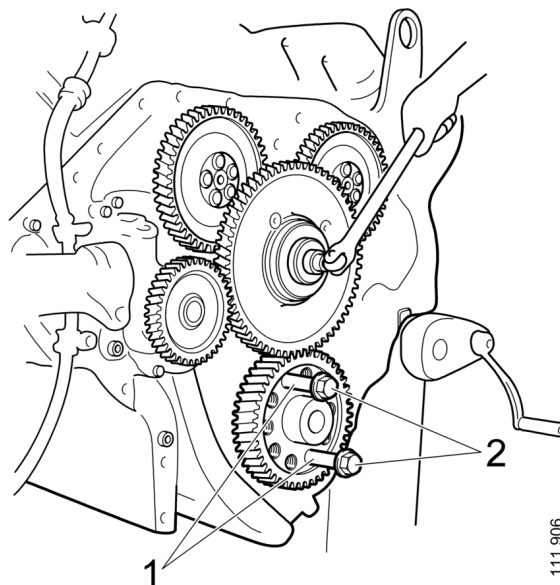
Special tools

Number	Description	Illustration	Tool board
99 309	Turning tool		D5
87 596	Slide hammer		D2

1. Position the engine so that cylinder 6 changes direction, the crankshaft is turned to 0°, the text "down TDC" is visible in the lower window on the flywheel. Use tool 99 309 to rotate the engine.
2. Remove the flywheel as described in *Flywheel, removing*.
3. Remove the flywheel housing as described in *Flywheel housing, removing*.



4. Secure the crankshaft gear to prevent it from being moved out of position on the crankshaft. Use two flywheel bolts and two 50 mm long spacers.

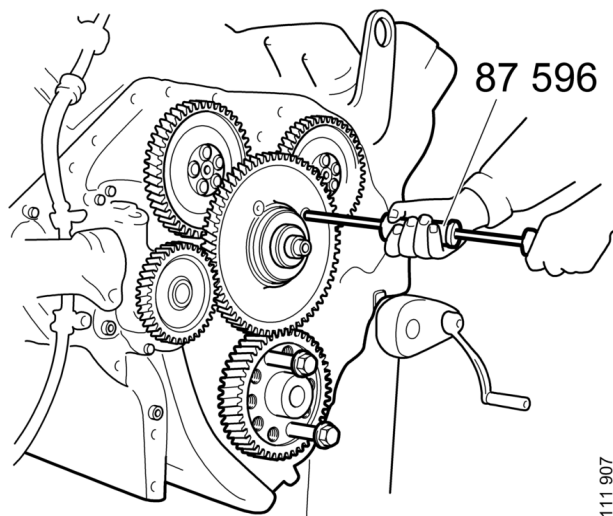


1. 50 mm long spacers
2. Flywheel bolts

5. Loosen the centre bolt on the intermediate gear.

Important! The camshaft and crankshaft must not be rotated once the intermediate gear has been removed. Pistons and valves can collide and be damaged.

6. Remove the intermediate gear with slide hammer 87 596. Fit the slide hammer alternately in the two timing holes.



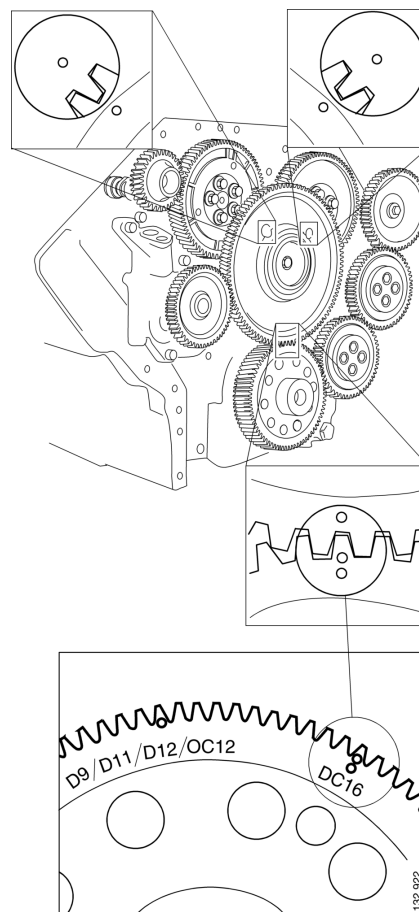
Fitting

Tightening torques

Screws to intermediate gear

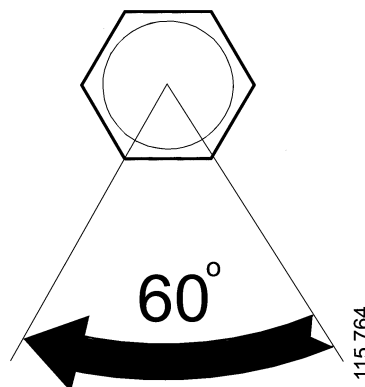
50 Nm + 60°

1. Secure the crankshaft gear to prevent it from being moved out of position on the crankshaft. Use two flywheel bolts and two 50 mm long spacers.
2. Fit the intermediate gear. Make sure the marks on the intermediate gear correspond with the relevant marks on the crankshaft and camshaft gears. Torque tighten the bolt to 50 Nm + 60°.



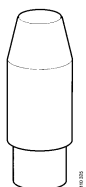
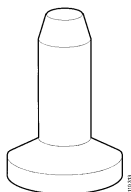
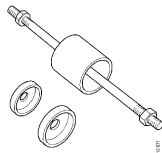
50 Nm + 60°

3. Fit the flywheel housing as described in *Flywheel housing, fitting*.
4. Fit the flywheel as described in *Flywheel, fitting*.



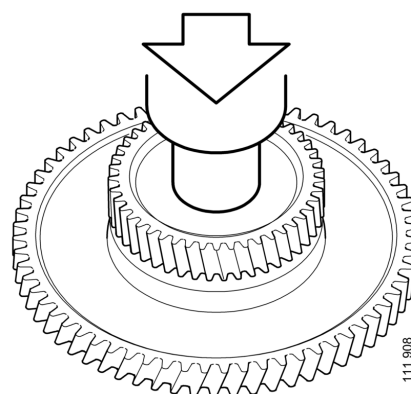
Bearing in intermediate gear

Renewal

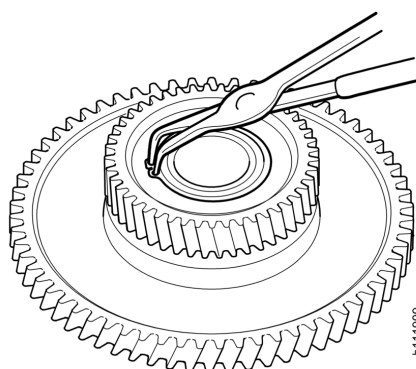
Number	Description	Illustration	Tool board
87 505	Drift		AM1
87 294	Drift		AD/AS3, G3
99 009	Drift		AD/AS3
98 743	Assembly tool, tube section only used.		C1
99 250	Drift		D3, C4

Removal

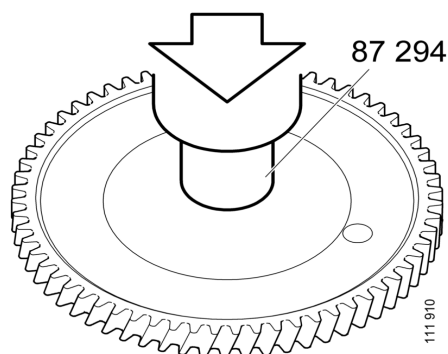
1. Press in the shaft journal until it is level with the small gear.



2. Remove the spacing sleeve and snap ring.



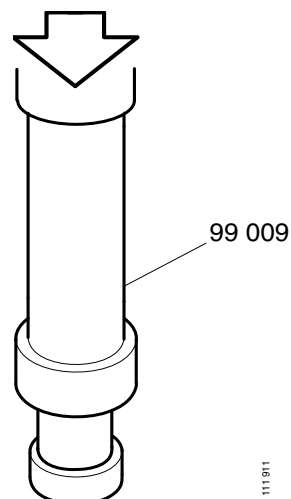
3. Turn the gear. Press out the bearing and shaft from the gear. Use tool 87 294.



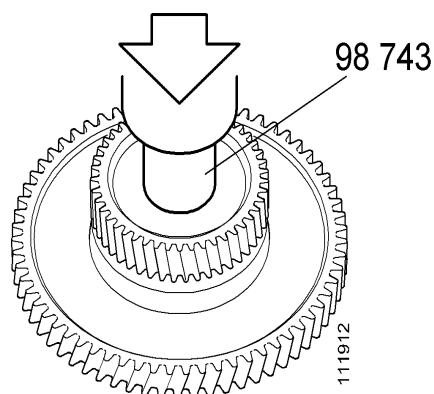
4. Press the bearing off the shaft. Use tool 87 505.

Fitting

1. Press a new bearing onto the shaft. Use tool 99 009.



2. Press the bearing and shaft into the gear. Press on the outer bearing race using the tube section of tool 98 743 until it stops.



3. Fit the retaining ring.
4. Press the spacer ring towards the bearing using tool 99 250.

Camshaft gear

Removal

1. Remove the intermediate gear as described in *Intermediate gear, removing*.
2. Undo the bolts and remove the camshaft gears by hand. Note that the camshaft gears are different.

Fitting

Tightening torques

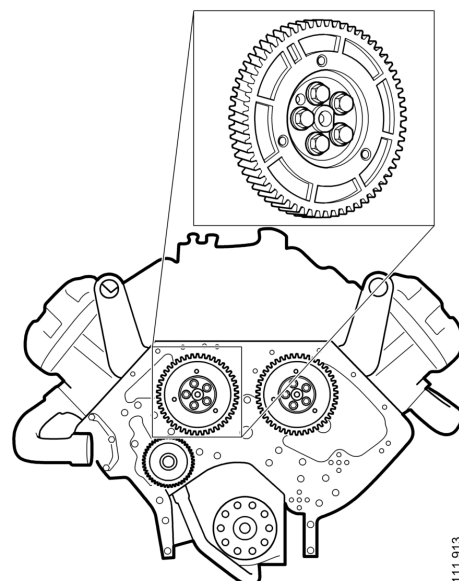
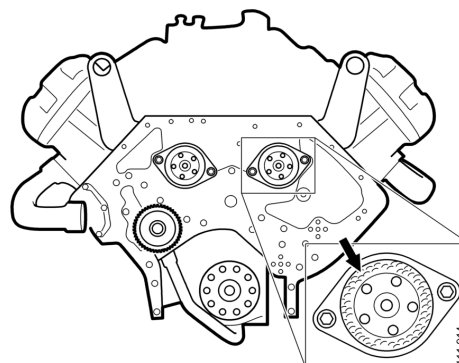
Bolts to camshaft gears

63 Nm

1. Fit the camshaft flanges and thrust bearings.

Note: The camshaft gears are not identical. Gear for engine speed indication on left. Refer to the illustration.

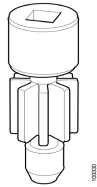
2. Fit the gear wheels and tighten the bolts to 63 Nm



Crankshaft gear

Removal

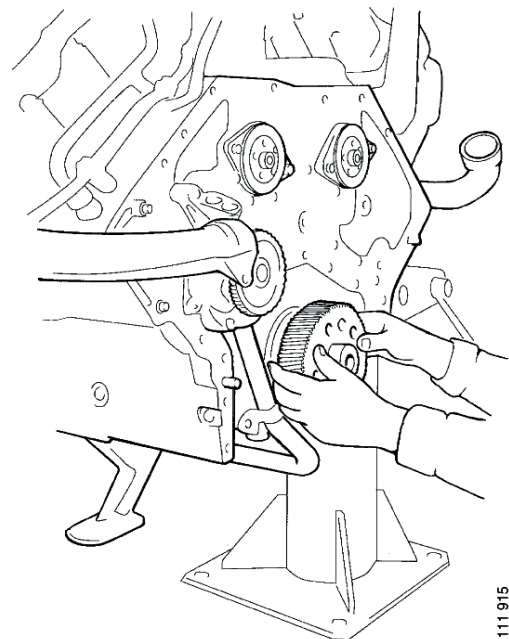
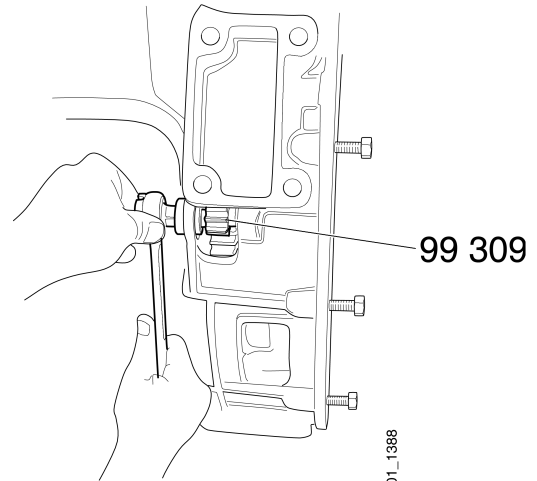
Special tools

Number	Designation	Illustration	Tool board
99 309	Tool to rotate flywheel		D5

1. Position the engine so that cylinder 6 changes direction, the crankshaft is turned to 0°, the text "down TDC" is visible on the flywheel. Use tool 99 309 to rotate the engine.
2. Remove the flywheel as described in *Flywheel, removing*.
3. Remove the flywheel housing as described in *Flywheel housing, removing*.
4. Remove the intermediate gear as described in *Intermediate gear, removing*.

Important! The camshaft and crankshaft must not be rotated once the intermediate gear has been removed. Pistons and valves can collide and be damaged.

5. Remove the crankshaft gear.



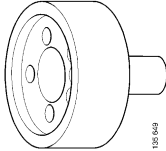
Fitting

1. Fit the crankshaft gear.
2. Fit the intermediate gear as described in *Intermediate gear, fitting*.
3. Fit the flywheel housing as described in *Flywheel housing, fitting*.
4. Fit the flywheel as described in *Flywheel, fitting*.

Camshaft

Removal

Special tool

Number	Designation	Illustration	Tool board
99 522	Holder		-

If there is bodywork preventing you from lifting out the camshafts, there are three alternative methods available.

- Lift out the engine.
- Lower the back of the engine and push out the camshafts under the bodywork.
- The left-hand camshaft can be lifted forward if the radiator assembly is removed.

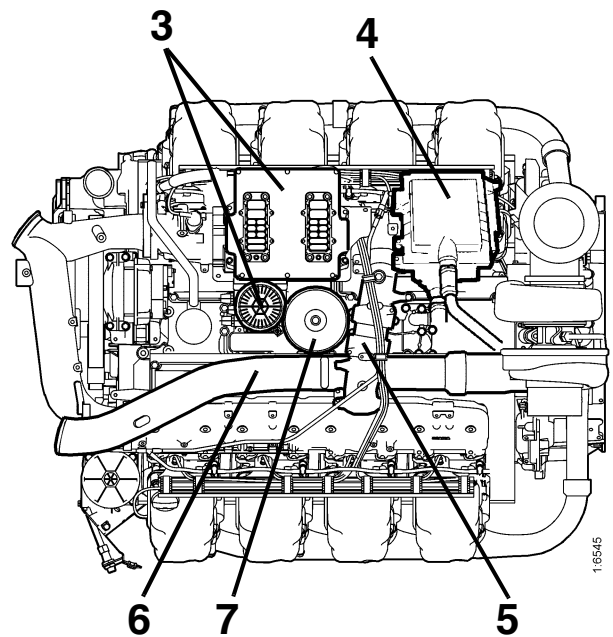
The numbering in the illustrations correspond with the numbering of the work operations.

1. Drain the cooling system. Refer to booklet *Cooling system, work description*.

Help protect our environment! Use a suitable container. Dispose of used coolant through an authorised waste disposal contractor.

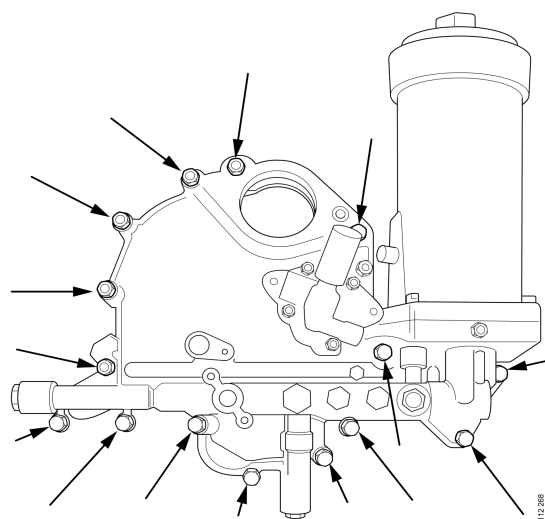
DC engine:

2. Remove the inlet pipe between the air filter and the turbocharger.
3. Remove the control unit with holder and the fuel filter.
4. Remove the crankcase ventilation unit.
5. Disconnect the connection pipe between the intake manifolds on the left-hand side.
6. Remove the charge air pipe between the turbocharger and the charge air cooler.



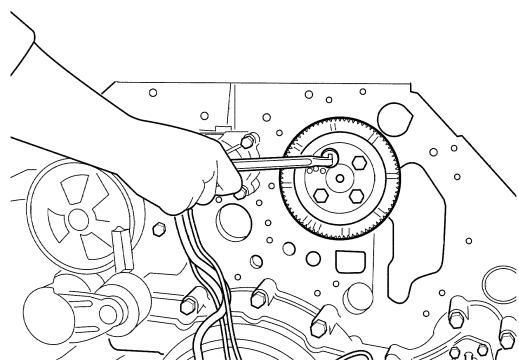
DI engine:

- Remove the catwalk and the pipe between the charge air coolers.
- Remove the expansion tank and belt guard.
- Remove the pipe to the closed crankcase ventilation.
- 7. Remove the oil cleaner.
- 8. Remove the poly-V-belts.
- 9. Remove the alternator.
- 10. Disconnect the AC compressor on engines with AC and place it to one side. Remove the bracket.
- 11. Remove the front timing gear housing as described in *Front timing gear housing, removing*.



The front timing gear casing is screwed on with 15 bolts

- 12. Remove the front camshaft gear.



- 13. Remove the flywheel as described in *Flywheel, removing*.
- 14. Remove the flywheel housing as described in *Flywheel housing, removing*.
- 15. Remove the intermediate gear as described in *Intermediate gear, removing*.
- 16. Remove the camshaft gear as described in *Camshaft gear, removing*.
- 17. Disconnect the banjo connections on the front and rear edges of the fuel manifolds.
- 18. Disconnect the banjo connections to and from the fuel filter.

19. Remove the fuel manifolds.

Note Note that the fuel manifolds are different. Mark the fuel manifolds so that they can be refitted in the same positions

Help protect our environment! Use a container to avoid spillage.

20. Remove the upper rocker covers.

Important Mark the rocker arms, pushrods, tappet shafts and valve bridges because they must be refitted in the same positions.

21. Remove the rocker arm shafts and pushrods.

22. Remove the camshaft covers.

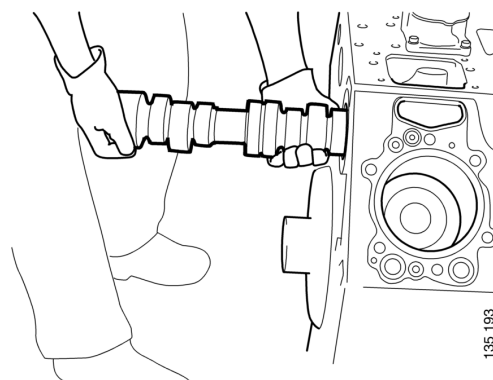
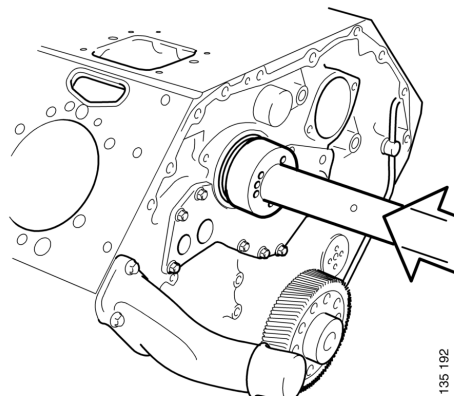
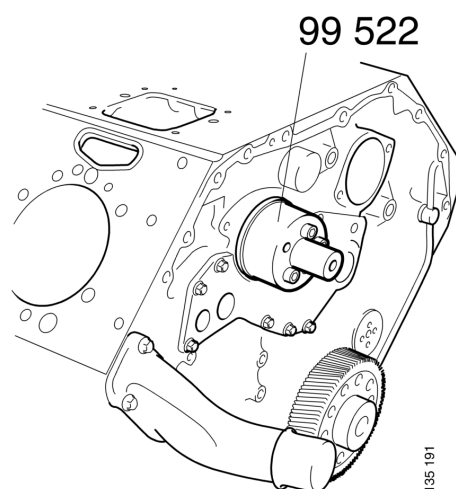
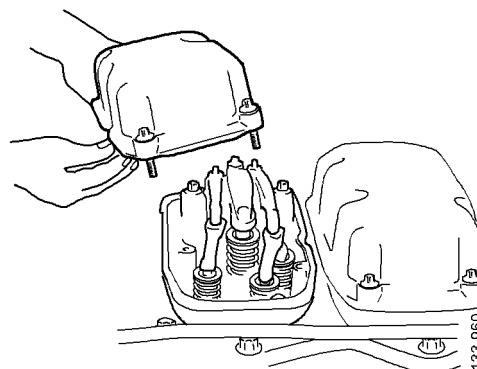
23. Remove the roller tappet shaft assemblies.

24. Remove the guide flanges.

25. Mount holder 99 522 on the rear of the camshaft.

26. Fit a pipe with the inner diameter 22-24 mm over the pin on the holder.

27. Push the camshaft out forwards by pushing it with the pipe. When the part of the camshaft has come out, it is easier to pull it out by hand.



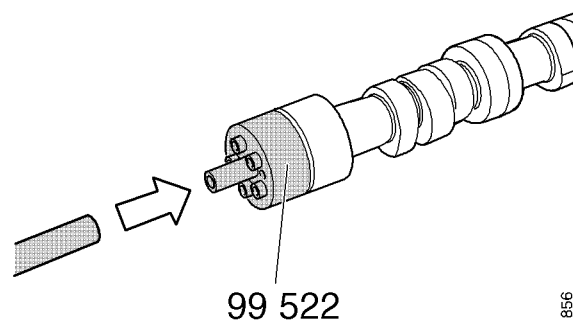
Fitting

Tightening torques

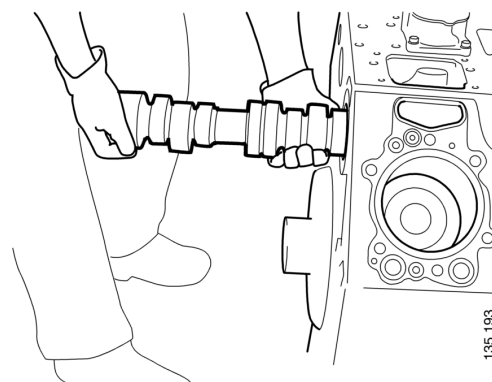
Bolt for camshaft gear	63 Nm
Screw for upper rocker cover	18 Nm
Bolt for fuel manifold	26 Nm

Note: Check that the camshafts are located correctly; camshaft with bolt holes for gear wheels in both ends on the left. Check also that the left-hand camshaft is turned the right way. End with 5 bolt holes must be facing rear.

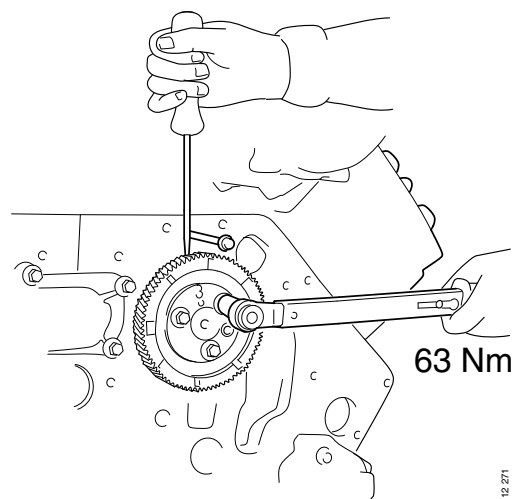
1. Fit holder 99 522 on the camshaft to be fitted.



2. Oil the bearing races and pull in the camshaft from the front using the cab tilt pipe. The camshaft is pressed in from the front by hand at the same time as guiding it correctly onto the bearings from the rear using the bar. Be careful not to damage cams and bearings when pushing in the camshaft. Remove holder 99 522 from the camshaft.



3. Fit the front camshaft gear. Hold tight with a screwdriver as illustrated and torque tighten the bolts to 63 Nm.
4. Fit the guide flanges at the rear.



5. Fit the camshaft gears at the back as described in *Camshaft gear, fitting*.
6. Fit the intermediate gear as described in *Intermediate gear, fitting*.
7. Fit the front timing gear housing.
8. Fit the coolant pump.
9. Fit the oil pressure sensor in the front timing gear housing.
10. Fit the fuel connections on the feed pump.
11. Fit power steering pump if applicable.
12. Fit the valve tappets.

13. Fit all the pushrods and rocker arm housings.

Important! *Check that none of the snap rings for the injector pushrods come loose and fall into the engine.*

14. Adjust the valve clearance and the unit injector (PDE) as described in *Adjusting the valve clearance and unit injector*.
15. Fit the rocker covers. Torque tighten the bolts to 18 Nm.
16. Fit the camshaft apertures. Make sure the sealing surfaces are clean and free from damage.
17. Fit the fuel manifolds and torque tighten the bolts to 26 Nm. Grease the O-rings, making sure they stay in their positions.

Note **The fuel manifolds are different. Make sure that they are fitted in the correct location.**

18. Fit the banjo screws on the front and rear edges of the fuel manifolds.

DC engine:

19. Fit the fan bracket and fan.
20. Fit the bracket with the AC compressor and the alternator.
21. Fit the poly-V-belts.
22. Fit the oil cleaner, bracket with control unit and fuel filter.
23. Fit the charge air pipe between the turbo-charger and the charge air cooler.
24. Screw on the connecting pipe between the intake manifolds.
25. Fit the crankcase ventilation unit.
26. Fit the inlet pipe between the air filter and the turbocharger.
27. Fit the flywheel housing as described in *Fly-wheel housing, fitting*.
28. Fit the flywheel as described in *Flywheel, fitting*.

DI16:

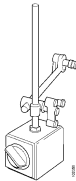
16. Fit the alternator.
17. Fit the poly-V-belt.
18. Fit the oil cleaner.
19. Fit the pipe between the charge air coolers, the catwalk, expansion tank and belt guard.
20. Fit the flywheel housing as described in *Fly-wheel housing, fitting*.
21. Fit the flywheel as described in *Flywheel, fitting*.

Checking camshaft setting

Specifications

Injector lifting height 4.5-5.1 mm

Special tools

Number	Description	Illustration	Tool board
587 250	Indicator stand		
98 075	Dial gauge		

Right-hand camshaft

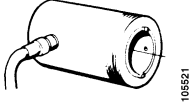
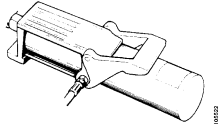
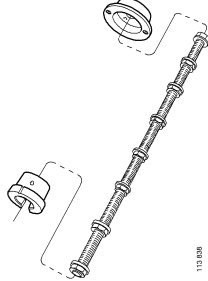
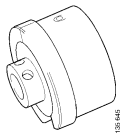
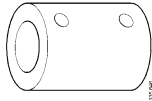
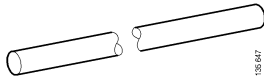
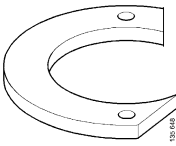
1. Adjust the unit injector on cylinder 1 as described in *Adjusting the unit injector*. The engine position is such that TDC Up (540°) is visible in the lower window of the flywheel.
2. Zero the dial gauge against the valve spring collar on the unit injector.
3. Turn the flywheel 180° in the direction of rotation using tool 99 309 so that TDC Down (0°) is visible in the lower window on the flywheel.
4. Take a reading from the dial gauge, it should be between 4.5-5.1 mm.

Left-hand camshaft

1. Adjust the unit injector on cylinder 6 as described in *Adjusting the unit injector*. The engine position is such that TDC Up (180°) is visible in the lower window of the flywheel.
2. Zero the dial gauge against the valve spring collar on the unit injector.
3. Turn the flywheel 180° in the direction of rotation using tool 99 309 so that TDC Down (360°) is visible in the lower window on the flywheel.
4. Take a reading from the dial gauge, it should be between 4.5-5.1 mm.

Removing the camshaft bearing

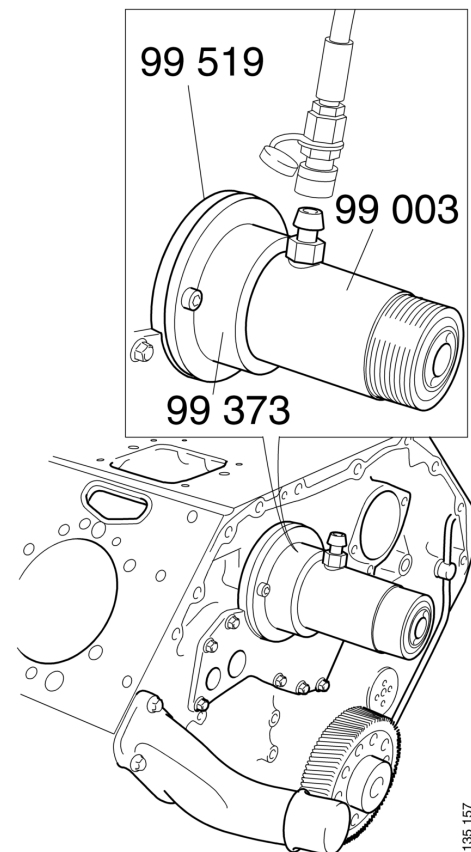
Special tools

Number	Designation	Illustration	Tool board
99 003	Hydraulic cylinder		H1
99 004	Air-operated hydraulic pump		H1
99 373	Tool for renewing camshaft bearing (only the holder (3) should be used)		D5
99 516	Drift for pressing camshaft bearings in and out		D1
99 517	Socket		D1
99 518	Bar for pressing camshaft bearings in and out		D1
99 519	Spacer		D1

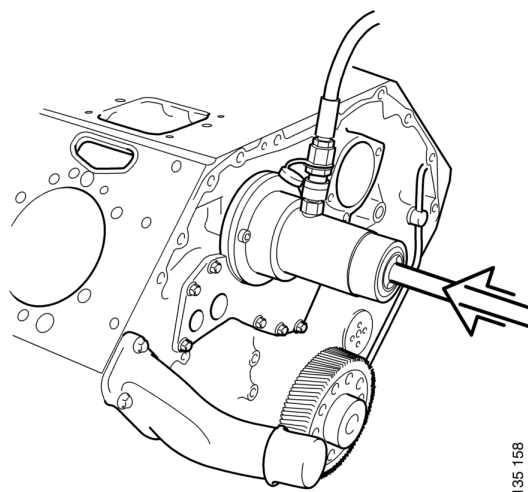
1. Remove the camshafts as described in this booklet.

Note Wipe around the edges and the bearing seat surfaces around the old bearings to avoid damaging the contact surfaces when fitting the new bearings.

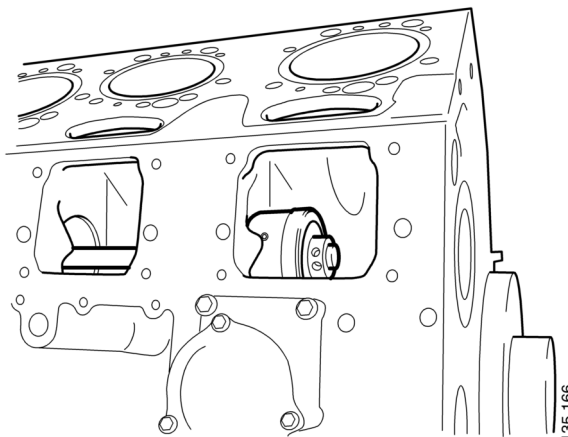
2. Clean the camshaft seats.
3. Screw together hydraulic cylinder 99 003 and flange 99 373. Align spacer 99 519 and screw the flange onto the cylinder block.



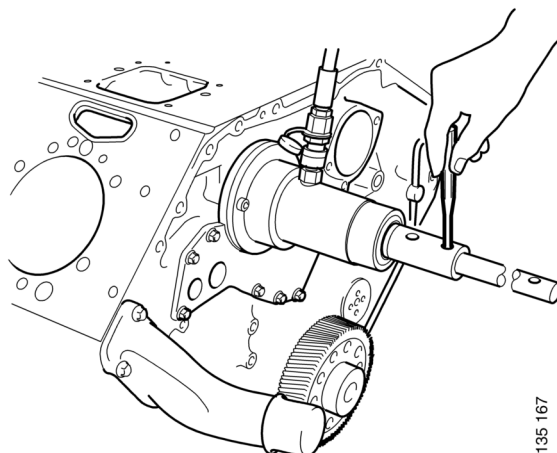
4. Insert the bar through the hydraulic cylinder so that the outer hole on the bar is behind the bearing to be renewed.



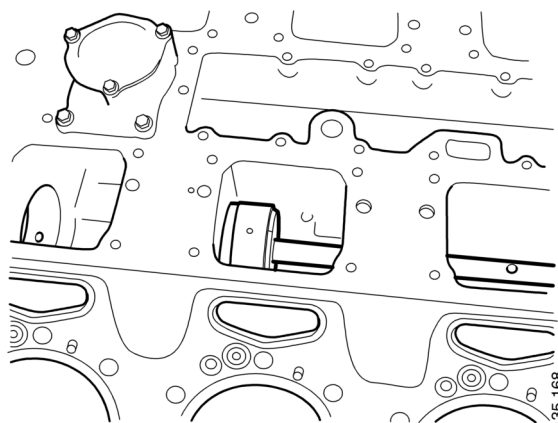
5. Secure drift 99 516 in the outer hole on the bar using a 12.9 M8 screw.



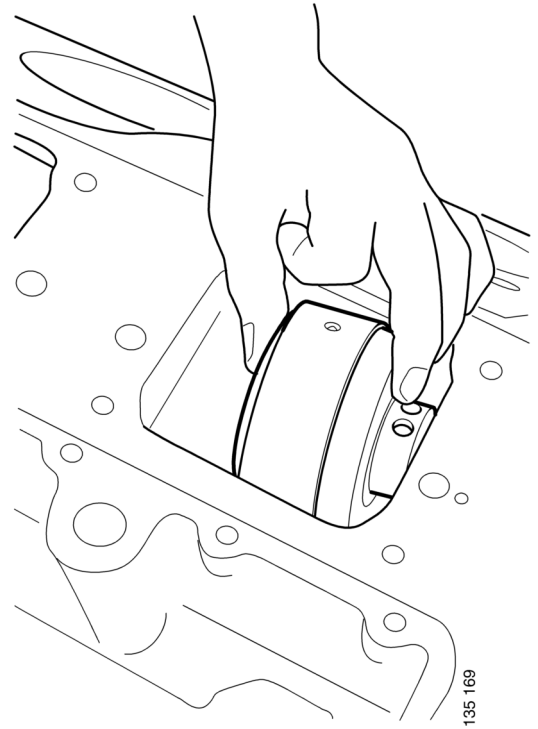
6. Pull the bar until the drift is locked in the bearing. Attach the socket next to the hydraulic cylinder using an 8 mm impact drift.



7. Connect the hydraulic cylinder to the hydraulic pump. Start the hydraulic pump and run it until the bearing has become completely detached from the bearing seat.

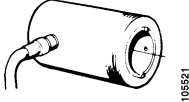
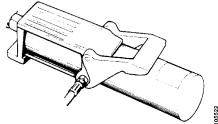
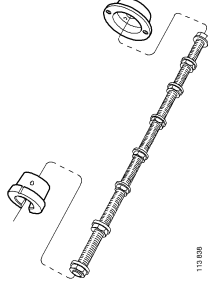
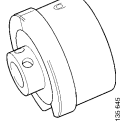
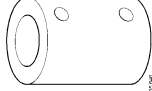
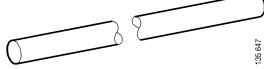
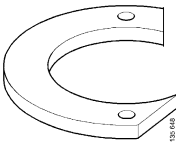


8. Detach the drift from the bar. Remove the bearing.
9. Release the remaining bearings in the same way.

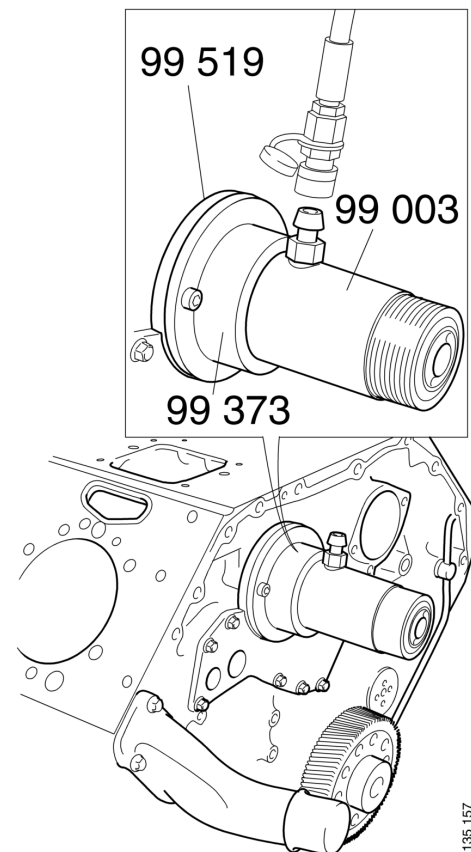


Fitting the camshaft bearing

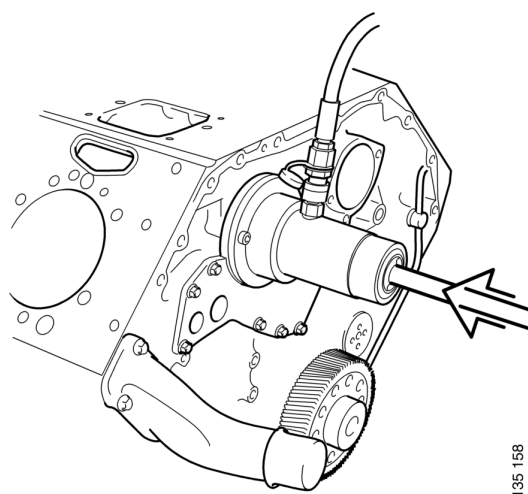
Special tools

Number	Designation	Illustration	Tool board
99 003	Hydraulic cylinder		H1
99 004	Air-operated hydraulic pump		H1
99 373	Tool for renewing camshaft bearing (only the holder (3) should be used)		D5
99 516	Drift for pressing camshaft bearings in and out		D1
99 517	Socket		D1
99 518	Bar for pressing camshaft bearings in and out		D1
99 519	Spacer		D1

1. Clean the bearing seats thoroughly and check that there is no damage to any of them.
2. Screw together hydraulic cylinder 99 003 and flange 99 373. Align spacer 99 519 and screw the flange into the cylinder block.

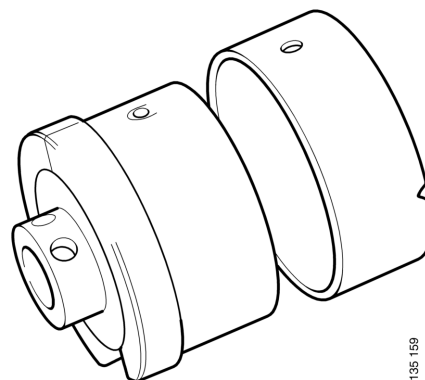


3. Insert the bar 99 518 through the hydraulic cylinder 99 003 so that the outer hole on the bar 99 518 is behind the bearing seat the bearing should be fitted to.

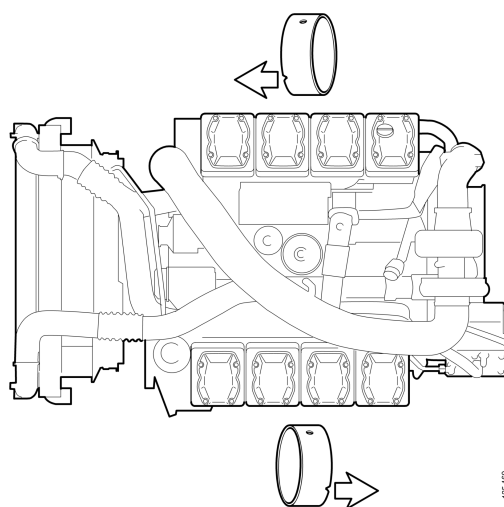


4. Put a new bearing on drift 99 516. Make sure that the ball on drift 99 516 fits the round bearing lubrication hole correctly. The bearing must be fitted in the right direction. On the right camshaft, the recess on the bearing must be turned forwards in the direction of the water pump. On the left camshaft, the bearings should be turned so that the recesses are turned towards the flywheel. Lubricate the bearings externally so that they slide in more easily.

Important *Make sure the bearings are facing the right direction so that the lubrication holes in the bearing correspond to the lubrication holes in the cylinder block.*

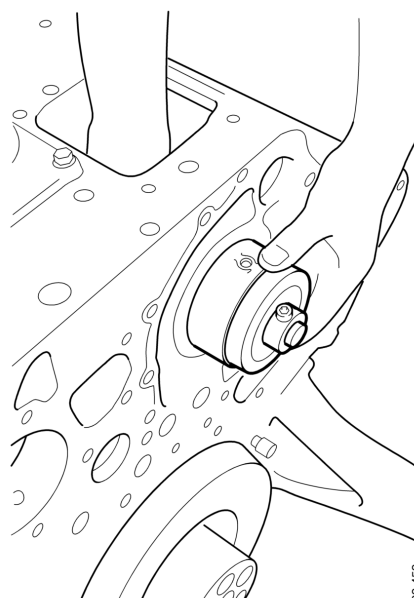


135 159



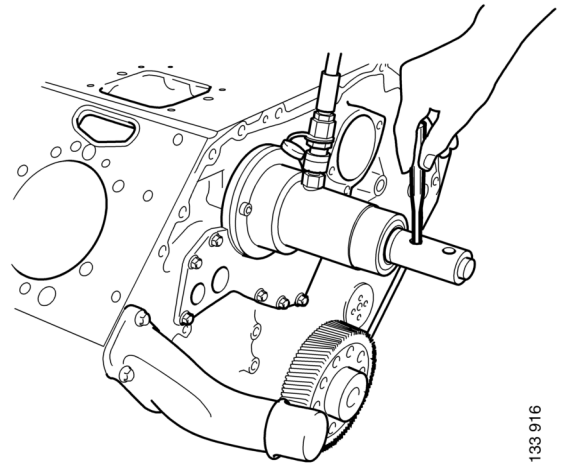
135 160

5. Fasten drift 99 516 in the outer hole on the bar with the lubrication hole facing upwards. Fasten with a 12.9 M8 bolt.



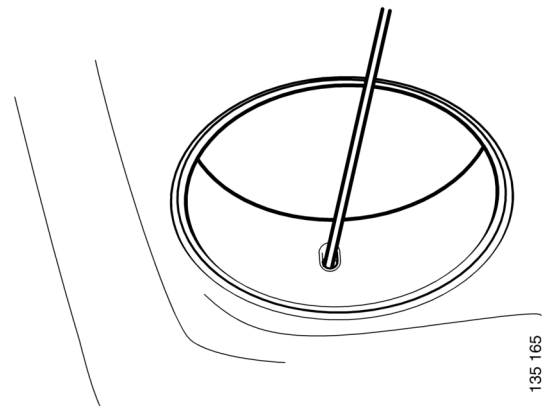
133 453

6. Pull out the bar through the hydraulic cylinder so that socket 99 517 can be locked in it using an 8 mm impact drift. The impact drift should point vertically so that the lubrication ducts are correctly located.
7. Connect the hydraulic cylinder 99 003 to the hydraulic pump 99 004. Run it until the bearing is correctly located according to the measurements on the next page. Check that the drift is still vertical when the bearing is in position.



8. Check that the lubrication hole is open. This can be done by looking down the hole and for example by sticking a scribing needle into it.

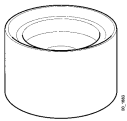
Camshaft bearing number	Distance (mm)
1	-13
2	196
3	400
4	603
5	811



The values in the table should be interpreted as follows. The bearing is in the correct position when the distance between the cylinder block and the front edge of drift 99 516 corresponds to the value in the table. -13 mm therefore means that the drift protrudes 13 mm from the front edge of the cylinder block.

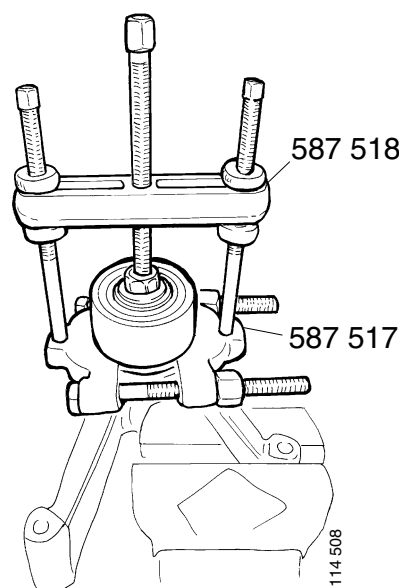
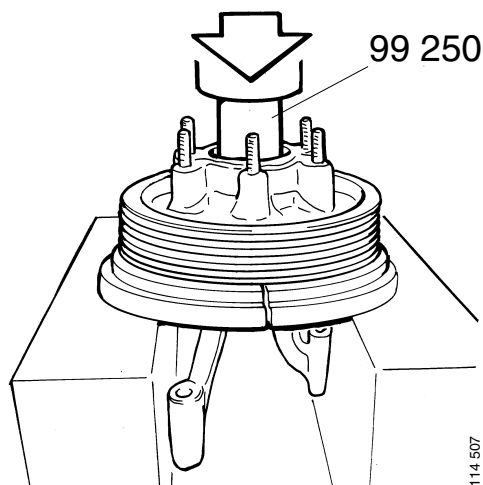
Fan drive

Special tools

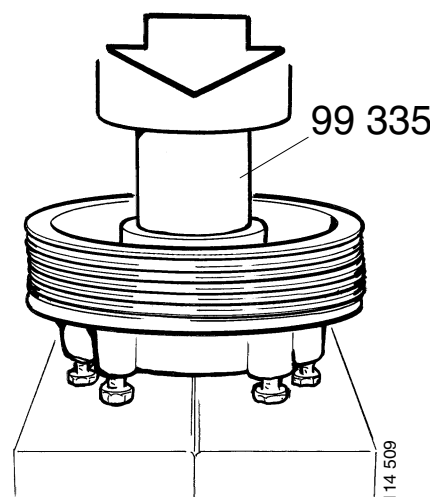
Number	Description	Illustration	Tool board
99 250	Drift		D3,C4
99 335	Drift		AD4-A2
587 517	Puller plate		XA1
587 518	Puller		XA2

DC16 all-speed: Renewal of belt pulley bearing

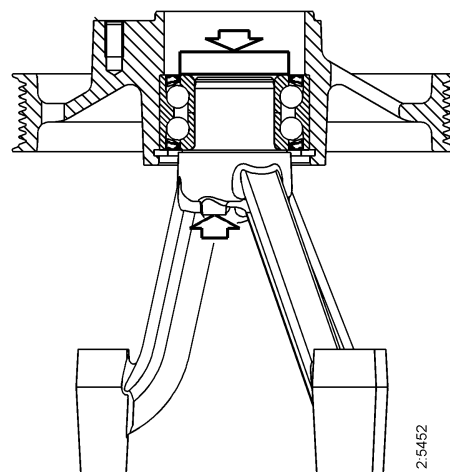
1. Remove the fan drive poly-V-belt.
2. Disconnect the fan and place it in the fan cowl.
3. Remove the fan bracket with belt pulley.
4. Remove the snap ring behind the bearing.
5. Clamp the bracket in a vice and remove the centre bolt in the shaft journal and washer.
6. Place the fan bracket with belt pulley between parallel pieces in a press and press out the bearing with fan bracket. Use a suitable drift with diameter 60-62 mm (99 250).
7. Check the that the bearing surface in the belt pulley is not damaged.
8. Pull the bearing off the bracket using a universal puller or 587 517 and 587 518. See illustration.



9. Screw nuts onto the studs and place the belt pulley in a press with the nuts as support.
10. Press in place a new bearing. Use a drift with diameter 66-68 mm (99 335) and press on the outer race until it stops.
11. Fit the retaining ring.

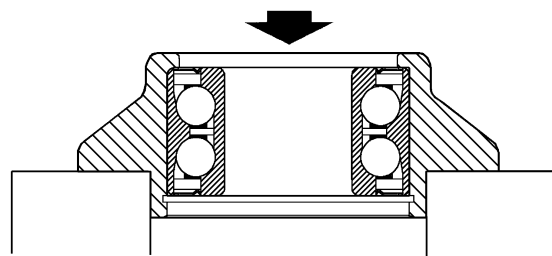


12. Place the fan bracket in a press so that it rests on the three specific support surfaces.
13. Press the belt pulley onto the bracket shaft journal. Use a suitable drift and press on the bearing inner ring with the washer as a separator plate.
14. Fit the fan bearing with belt pulley onto the engine.
15. Fit the washer and centre bolt. Torque tighten the bolt to 149 Nm.
16. Fit the fan drive poly-V-belt, fan retainer and fan.



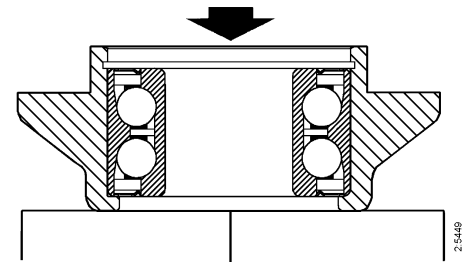
DC16 single-speed: Renewal of hub bearing

1. Remove the fan drive poly-V-belt.
2. Disconnect the fan and place it in the fan cowling.
3. Remove the fan bracket with belt pulley.
4. Remove the pulley from the hub.
5. Remove the snap ring in front of the bearing.
6. Clamp the bracket in a vice and remove the centre bolt in the shaft journal and washer.
7. Press out the shaft journal from the hub using a universal puller that grips around the centre of the hub.
8. Place the hub in a press between parallel pieces and press out the bearing. Use a suitable drift with diameter 70-72 mm.
9. Check the that the bearing surface in the hub is undamaged.

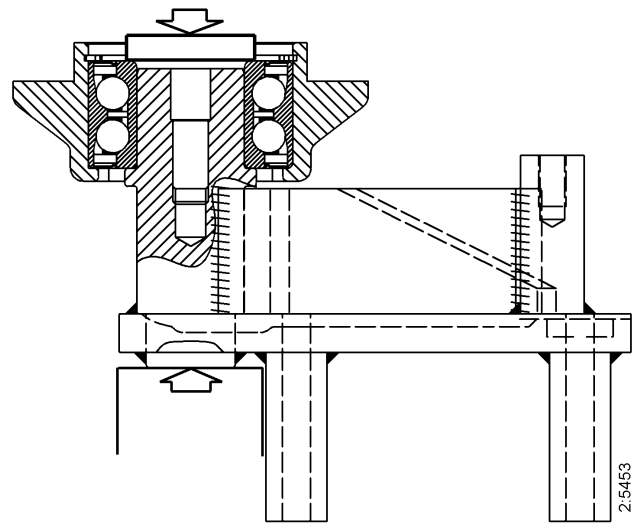


Press the bearing out of the hub

10. Place the hub in a press and press in place the new bearing. Use a drift with diameter 78-80 mm and press on the outer race until it stops.
11. Fit the retaining ring.
12. Mount the bracket in a press with support under the opposite end of the shaft journal.
13. Press the hub with bearing onto the shaft journal until it stops. Use a drift with diameter 50-55 mm and a spacer washer between the drift and the inner race.
14. Fit the pulley onto the hub.
15. Fit the fan bearing on the engine.
16. Fit the washer and centre bolt.
Torque tighten the bolt to 135 Nm.
17. Fit the poly-V-belt for the fan drive.
18. Fit the fan.



Press the bearing into the hub



Press the hub with bearing onto the shaft journal

Lubrication system

Specifications

Oil pressure

Idle speed	min 1.4 bar
With warm engine running at 1000 rpm	min 3.0 bar
With warm engine running at 2000 rpm	4.5 +/-1 bar

Oil filter

Renewing the oil filter

Tightening torques

Filter housing lid	25 Nm
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Special tools

Number	Description	Illustration	Location
587 637	Sleeve		Maintenance cabinet

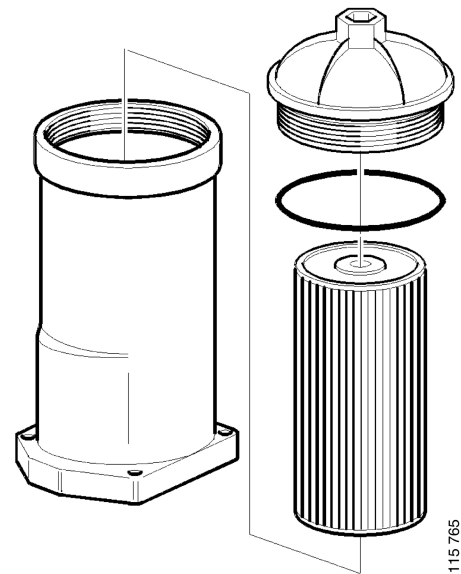
Note: The oil cleaner must be cleaned when renewing the filter. Refer to *Operator's manual* for change intervals.

1. Unscrew the filter lid with a closed tool with hexagon driver, e.g. socket 587 637.

Note: Do not use an adjustable spanner or other open tool as there is a risk of damaging the filter lid.

2. Lift out the filter housing lid with filter element. The filter housing will drain automatically once the filter has been removed.
3. Undo the old filter from the lid by carefully bending it to one side.
4. Fit a new O-ring on the lid. Lubricate the O-ring with engine oil.
5. Press a new filter element into the snap fastener in the lid.
6. Make sure the oil filter drain has emptied the oil from the filter housing. Screw on the filter lid with a closed tool with hexagon driver, e.g. socket 587 637. Tightening torque 25 Nm.
7. Start the engine and inspect the filter housing for leaks.

Note: The engine must not be run without a filter element in the oil filter. This would risk damaging the engine due to particles and low oil pressure.



Oil cooler

Changing seals

The numbering in the illustrations correspond with the numbering of the work operations.

1. Drain the cooling system. Refer to booklet *Cooling system, work description*.

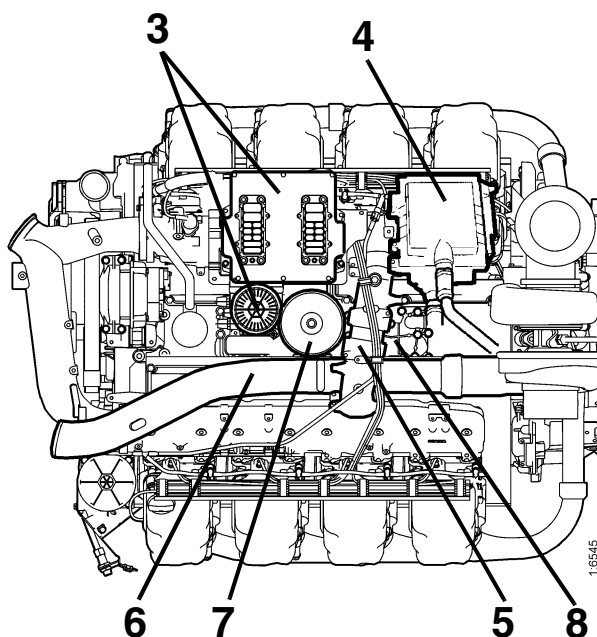
Help protect our environment! Use a suitable container. Dispose of used coolant through an authorised waste disposal contractor.

DC engine:

2. Remove the inlet pipe between the air filter and the turbocharger.
3. Undo the control unit with bracket and fuel filter and place to one side.
4. Remove the crankcase ventilation with pipe.
5. Disconnect the connecting pipe between the intake manifolds.
6. Remove the charge air pipe between the turbocharger and the charge air cooler.

DI engine:

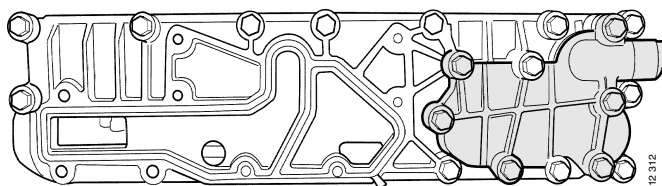
- Remove the catwalk and the pipe between the charge air coolers.
- Remove the connection pipe to the closed crankcase ventilation.



7. Remove the oil cleaner.

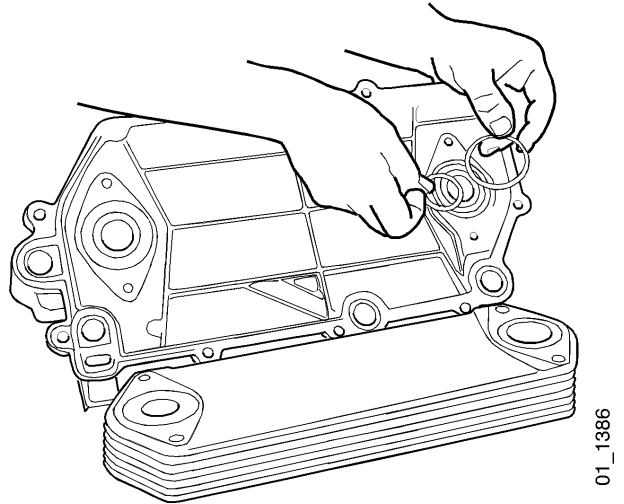
Note: Lift the oil cooler vertically so that no oil leaks into the cooling system.

8. Remove the oil cooler lid with the oil cooler.



The small cover need not be detached

9. Remove the four bolts securing the oil cooler to the side cover.
10. Remove the oil cooler.
11. Renew the four O-rings.



Fitting

1. Screw on the oil cooler to the oil cooler lid.
2. Fit the oil cooler lid with the oil cooler.

Note: Lower the oil cooler as vertically as possible so that oil does not leak into the cooling system.

3. Clean the oil cleaner as described in *Oil cleaner, dismantling and cleaning* and fit it.

DC engine:

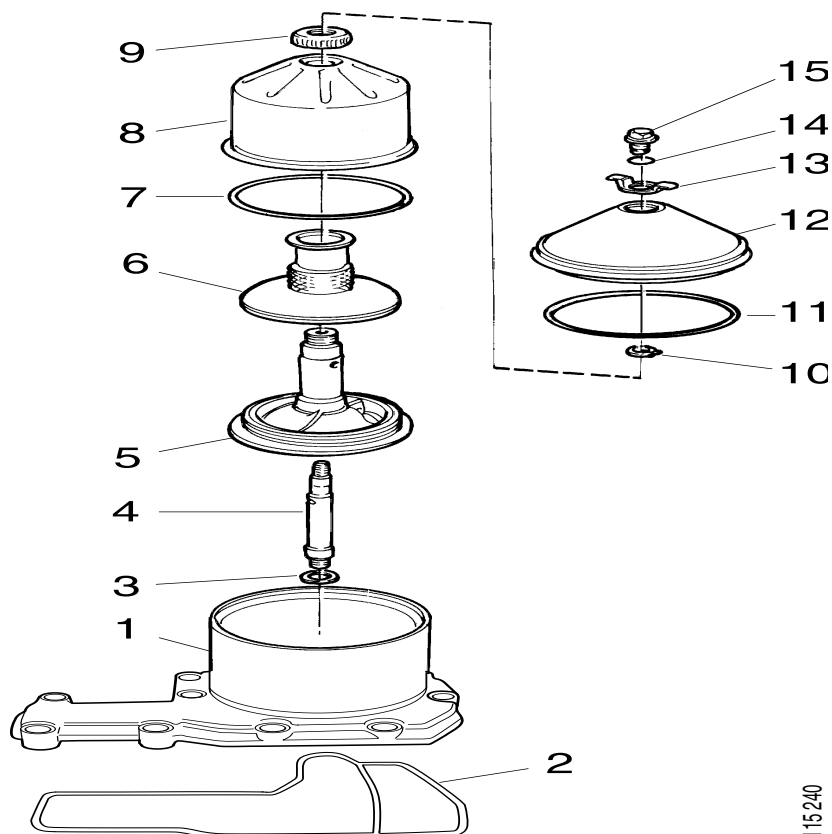
4. Screw into place the control unit with bracket and fuel filter.
5. Fit the charge air pipe between the turbo-charger and the charge air cooler.
6. Screw on the connecting pipe between the intake manifolds.
7. Fit the water pipe to the air compressor.
8. Fit the crankcase ventilation with pipe.

DI engine:

- Fit the pipe between the charge air coolers. Fit the catwalk.
 - Connect the pipe to the closed crankcase ventilation.
9. Fill the engine with coolant. Refer to *Operator's manual* or booklet 00:03-1 for composition.

Oil cleaner

1. Housing
2. Gasket
3. Washer
4. Shaft
5. Rotor
6. Strainer
7. O-ring
8. Rotor bowl
9. Nut
10. Retaining ring
11. O-ring
12. Cover
13. Lifting eye
14. O-ring
15. Lock nut



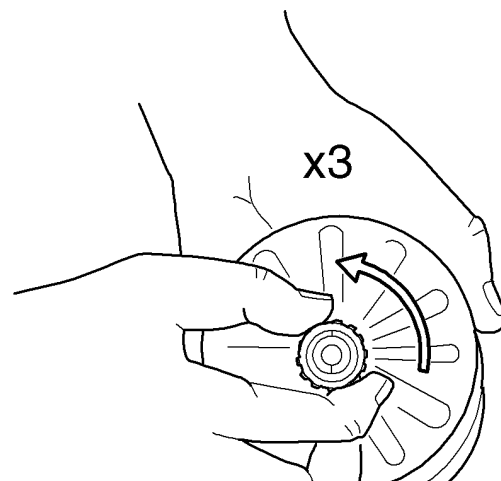
Dismantling and cleaning

Specifications

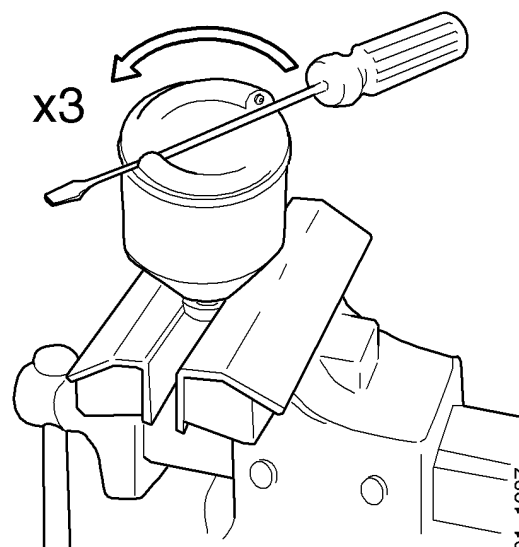
Permitted thickness of deposits on walls of bowl 20 mm

Important! *There should be a certain amount of deposited dirt apparent in the rotor bowl during routine cleaning of the oil cleaner. If this is not the case, the rotor may not be revolving. The cause must be established immediately. If the dirt deposit exceeds 20 mm with the recommended intervals, the rotor bowl must be cleaned more often.*

1. Undo the nut securing the outer lid.
2. Lift out the rotor. Wipe off the outside. Undo the rotor nut and screw it about three turns to protect the bearing.

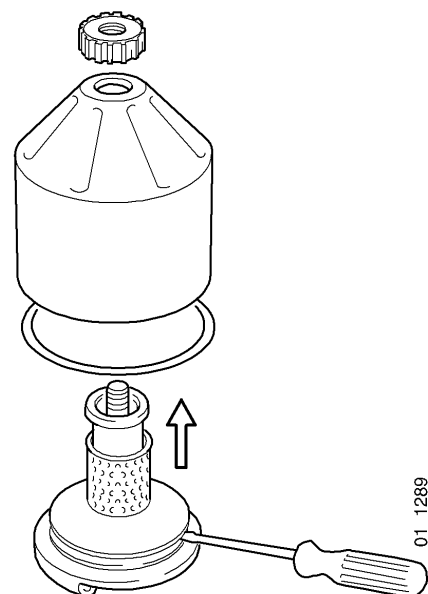


3. If the rotor nut is difficult to get loose, turn the rotor upside down and fasten the rotor nut in a vice. Turn the rotor counterclockwise three turns by hand or if this does not help, place a screwdriver between the outlet holes.

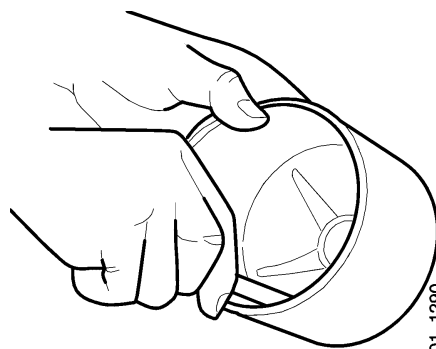


Important! *The rotor must not be put in a vice. Never strike the rotor bowl. This may cause damage resulting in imbalance.*

4. Grasp the rotor bowl and tap lightly with your hand or a plastic mallet on the rotor nut so that the rotor bowl comes loose from the rotor. Never strike on the rotor directly as this may damage its bearings.
5. Remove the rotor nut and bowl from the rotor.
6. Remove the strainer located on the rotor. If the strainer has fastened, prise carefully with a knife at the bottom between the rotor and the strainer.



7. Scrape away the deposits inside the bowl with a knife.
8. Wash the parts.
9. Inspect the two nozzles on the rotor. Make sure they are not blocked or damaged. Renew damaged nozzles.
10. Make sure the bearings are not damaged.



Assembly

Specifications

Tightening torques

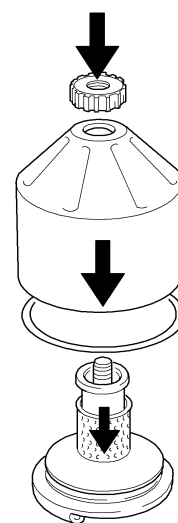
Lock nut for oil cleaner housing lid	15 Nm
Nut for rotor bowl	Tighten by hand
Rotor shaft	34 Nm
Locking compound	561 200

1. Position the O-ring in the lid. Renew the O-ring if it is at all damaged.
2. Assemble the parts and tighten the rotor nut by hand.

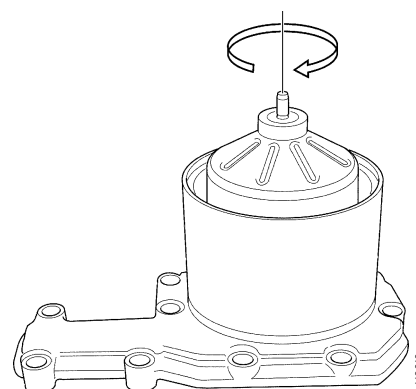
3. Make sure the shaft is not loose. If it is, it can be locked using locking compound 561 200. First clean thoroughly using a suitable solvent. Tighten the rotor shaft using socket 98 421. Tightening torque 34 Nm.

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

5. Inspect the O-ring on the cleaner housing lid and fit it. Torque tighten the lock nut to 15 Nm.

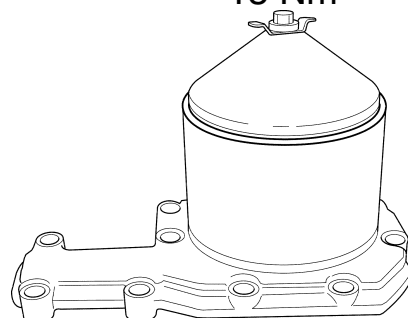


01_1293



112313

15 Nm



112314

Oil pump

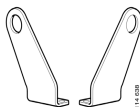
**In case of leak or oil pump malfunction:
Change the whole pump!**

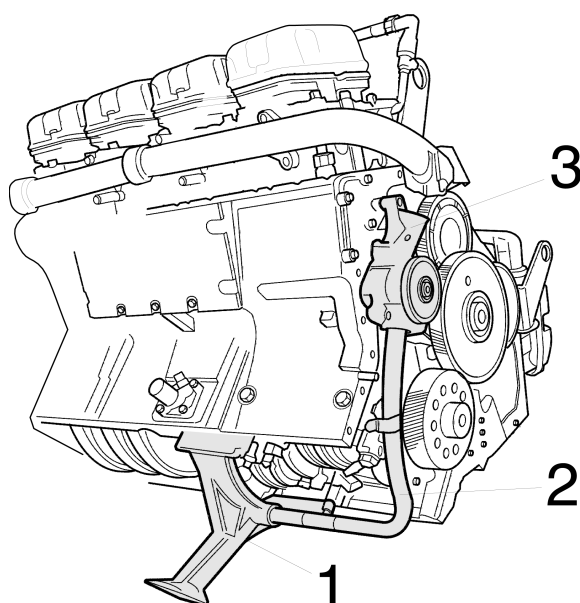
Renewing the oil pump

Tightening torques

Plug for oil sump	80 Nm
Bolts for exhaust manifold	63 Nm
Bolts for oil sump	32 Nm

Special tools

Description	Number	Illustration	Tool board
Engine support	99 318		
Lifting eyes	99 398		



1. Strainer
2. Suction pipe
3. Oil pump

Removal

1. Drain the engine oil from the oil sump. Clean the magnetic plug and torque tighten to 80 Nm.

Help protect our environment! Use a suitable container. Dispose of used oil through an authorised waste disposal contractor.

2. Remove the oil sump.
3. Support the engine using tool 99 318.
4. Remove the flywheel as described in *Flywheel, removing*.
5. *DC16*: Remove the rear exhaust manifold and compressor, if fitted.
6. Remove the flywheel housing as described in *Flywheel housing, removing*.
7. Remove the strainer and the suction pipe.
8. Remove the oil pump.

Fitting

1. Renew the O-ring and fit a new oil pump.
2. Renew the O-rings and refit the strainer and suction pipe.
3. Fit the flywheel housing as described in *Flywheel housing, fitting*.
4. *DC16*: Refit the exhaust manifold and air compressor, if fitted. Torque tighten the exhaust manifold to 63 Nm.
5. Fit the flywheel as described in *Flywheel, fitting*.
6. Fit the oil sump and torque tighten the bolts to 32 Nm.
7. Fill with oil and check the oil level in the engine using the dipstick. Refer to *Operator's manual* for oil grade.

Exhaust manifold

Renewing gaskets

Tightening torques

Bolts for exhaust manifold

63 Nm

DC16:

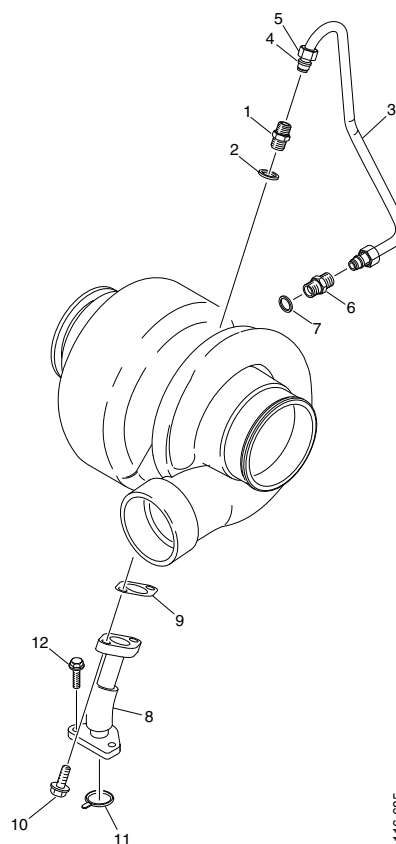
1. Undo the bolts and remove the front exhaust manifold.
2. Undo the bolts and remove the rear exhaust manifold.
3. Scrape away the gaskets from the exhaust manifolds and cylinder head.
4. Lubricate the joints with heat-resistant grease and fit new gaskets.
5. Fit the rear exhaust manifold and junction pipe.
6. Fit the front exhaust manifold.
7. Torque tighten all bolts to 63 Nm.

DI16:

1. Remove the bolts between the exhaust manifold and the turbocharger connection pipe.
2. Unscrew the bolts and remove the exhaust manifold.
3. Scrape away the gaskets from the exhaust manifolds and cylinder head.
4. Lubricate the joints with heat-resistant grease and fit new gaskets.
5. Fit new O-rings in the water seals.
6. Fit the water-cooled exhaust manifold. Tighten the bolts to 63 Nm.
7. Fit new O-rings and a new seal and connect the pipe from the turbocharger. Tighten the bolts to 63 Nm.

Turbocharger

1. Straight union
2. Gasket
3. Lubrication oil pipe
4. Ferrule
5. Nut
6. Straight union
7. Gasket
8. Lubrication oil return pipe
9. Gasket
10. Flange bolt
11. Gasket
12. Flange bolt



116 685

Important information

Observe strict cleanliness at all times when working on the turbocharger. Never leave connections for oil inlets or outlets unprotected. Foreign bodies in the bearing housing will soon lead to total breakdown.

Oil leaks

A blocked air filter creates excess vacuum in the inlet line. There is then a risk of oil mist being drawn from the bearing housing.

If the sealing ring on the turbine side is worn, the exhaust gases will be blue when idling.

If the oil outlet pipe from the turbocharger is damaged, there is risk of oil leaking out.

Foreign bodies

Foreign bodies in the turbine or compressor, e.g. a grain of sand or metal shavings, will ruin the vanes. This will lead to imbalance and bearing wear. Engine power will drop.

Important! *Never attempt to straighten a damaged vane. It may break off when running and the turbocharger may break down completely, causing serious damage to the engine.*

Air and exhaust leaks

Even small leaks in the line between the air filter and the turbocharger will cause dirt to be deposited on the compressor wheel. The charge pressure will be reduced, resulting in increased exhaust temperature and smoke, which will reduce the service life of the engine.

Leaks in the exhaust line between the cylinder head and the turbocharger will also result in loss of charging pressure.

Measuring the charging pressure

The charging pressure can be measured using the ECOM diagnostic tool.

Cleaning

Low charging pressure can sometimes be due to dirt in the compressor housing.

- Disassemble the compressor housing and clean with white spirit and a brush.
- Renew the O-ring if it is damaged. Assemble the compressor housing and measure the charging pressure again.

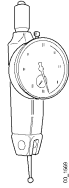
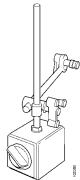
Measuring radial and axial play

Specifications

Wear limits

Turbine shaft play	max. 0.611 mm
Turbine shaft axial play	max. 0.102 mm

Special tools

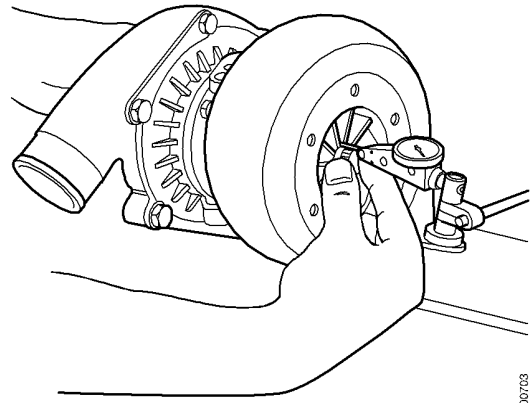
Number	Description	Illustration	Tool board
98 075	Dial gauge		D2
587 107	Rocker indicator		
587 250	Indicator stand		M1

In general, measuring the radial and axial clearance gives no indication of the remaining service life of the turbocharger.

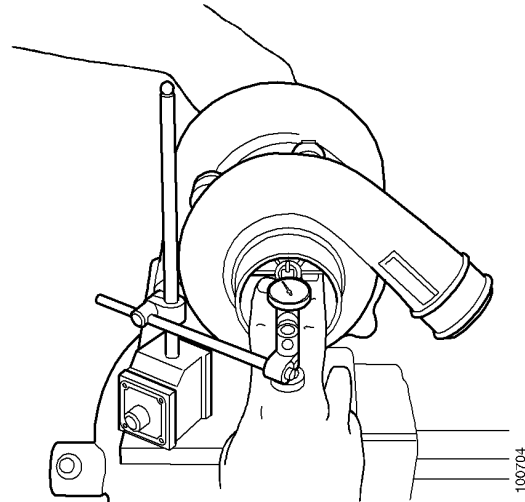
When the turbocharger seems to be functioning poorly or noisily, measuring the charging pressure or radial and axial clearance can indicate whether the turbocharger is at fault.

Radial play:

1. Measure the clearance at the turbine wheel as well as at the compressor wheel.
2. Place the tip of the dial gauge against the turbine or compressor wheel.



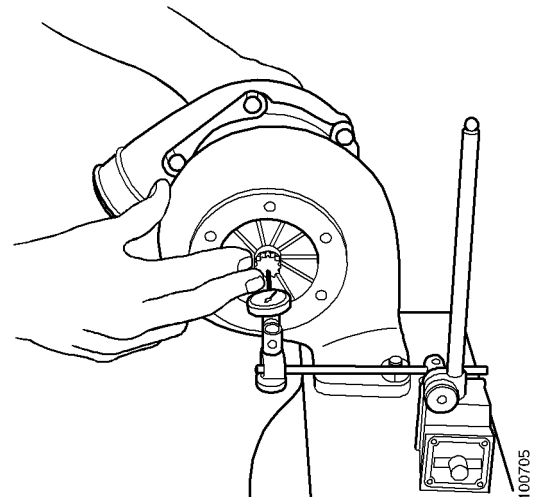
3. Pull up both ends of the shaft. Take a reading.
4. Press down both ends of the shaft. Take a reading. The difference between the two readings is the radial play.



5. Repeat the test three times on each side.
6. If any of the wheels makes contact with the housing despite the radial clearance being within tolerances, the turbocharger must be renewed.

Axial clearance:

1. Place the tip of the dial gauge against the end of the shaft.
2. Press the shaft longitudinally to and fro and take a reading at the end positions. The difference between the readings is the axial clearance.
3. Repeat the test three times.



Renewal of turbocharger

Tightening torques

Bolts, turbocharger – exhaust pipe	63 Nm
V-clamps, M6	8 Nm
V-clamps, M8	20 Nm

Removal

Important! *Observe strict cleanliness at all times when working on the turbocharger. Never leave connections for the oil inlet or outlet unprotected. Foreign bodies in the bearing housing will soon lead to total breakdown.*

1. Detach the inlet and return lines for the oil from the turbocharger.
2. Undo 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.

Check in case of turbocharger breakdown

- Make sure leaks or loose particles do not occur in the line between the air filter and the turbocharger.
- Check that there are no loose particles in the exhaust or intake manifolds. Renew the charge air cooler.
- Make sure all valves are intact.
- Check that the oil return pipe from the turbocharger is not blocked or deformed.
- Check that the oil delivery pipe to the turbocharger is not blocked or deformed.
- Renew the oil filter and clean the lubrication system.

Fitting

1. Check the connecting flange on the exhaust manifold for any remains of the old gasket.
2. Fit a new gasket and screw on the turbocharger. Lubricate the bolts with high-temperature resistant lubricant, part no. 561 205. Tighten to 63 Nm.
3. Connect the inlet and return line for the oil.
4. Connect the charge air pipe, induction pipe and exhaust pipe.
5. Crank the engine with the starter motor for at least 30 seconds so that the lubrication oil reaches the turbocharger.
6. Start the engine and check for leaks.