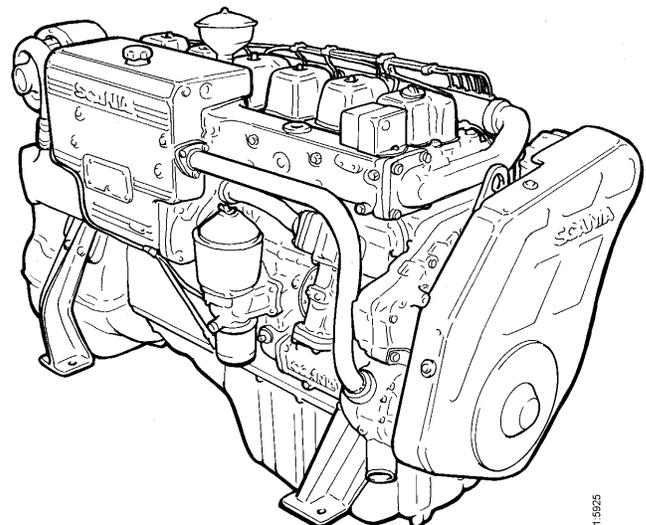
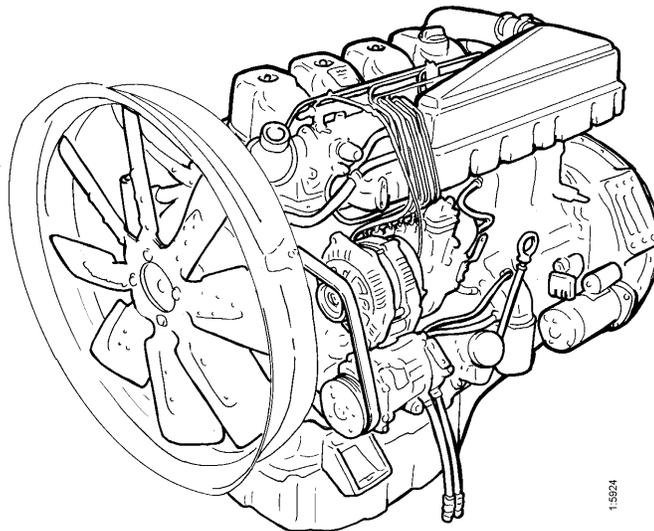
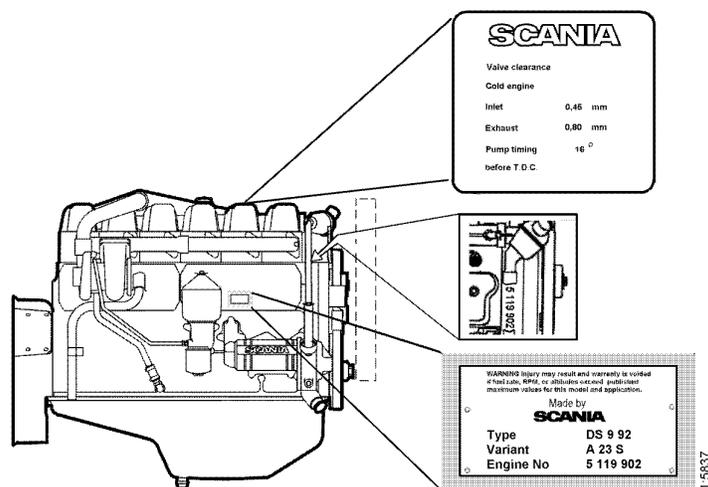


## Work Description - 9-series engine

### Industrial and Marine engines



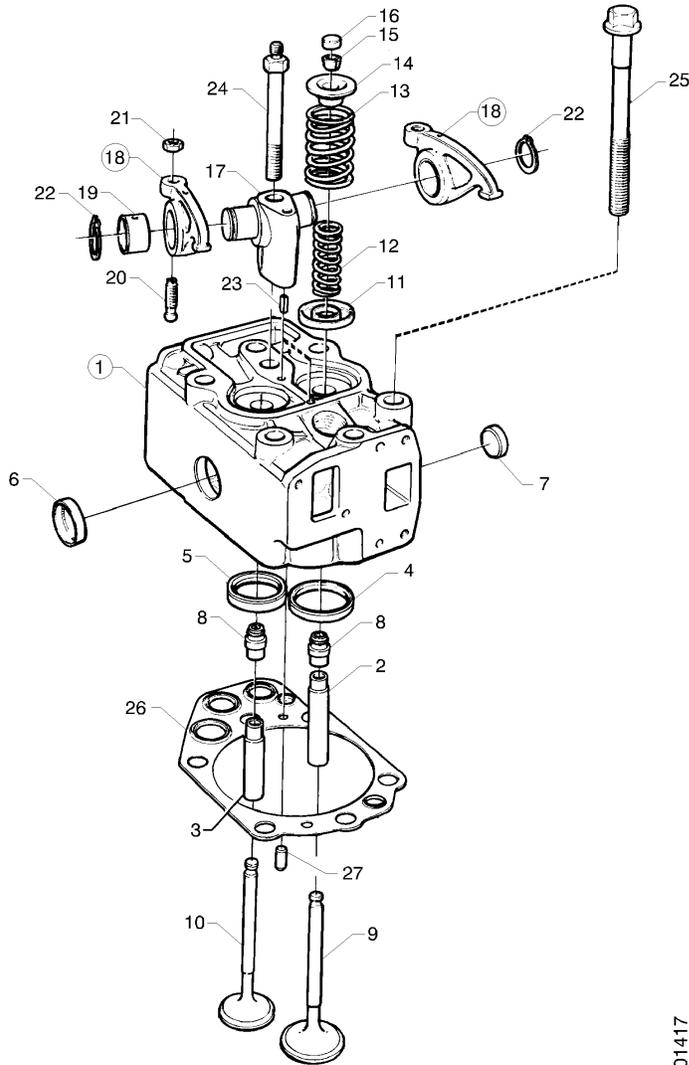
**Part No.**  
**1 588 468**



## Contents

Page	Page
Cylinder head . . . . . 3	Timing gear . . . . . 44
Valve clearance . . . . . 5	Crankshaft seal . . . . . 46
Compression . . . . . 6	Timing gear cover . . . . . 48
Removing . . . . . 8	Intermediate gear . . . . . 50
Dismantling . . . . . 9	Crankshaft gear . . . . . 51
Checking, changing and machining . . . . . 9	Camshaft gear . . . . . 52
Assembly . . . . . 17	Camshaft . . . . . 53
Fitting . . . . . 17	Crankshaft . . . . . 55
Turbocharger . . . . . 19	Lubrication system . . . . . 57
General . . . . . 20	Oil cooler . . . . . 57
Measuring radial clearance and axial clearance . . . . . 21	Oil cleaner . . . . . 59
If the turbocharger is not working . . . . . 22	Oil pump . . . . . 63
Changing the turbocharger . . . . . 23	Lifting the engine . . . . . 64
Pistons and cylinder liners . . . . . 24	Specifications . . . . . 65
Removal of loose ring in cylinder liner . . . . . 26	General information . . . . . 65
Removal and dismantling of piston and connecting rod . . . . . 26	Cylinder head . . . . . 65
Assembling piston and connecting rod . . . . . 29	Turbocharger . . . . . 67
Removing cylinder liner . . . . . 30	Pistons and cylinder liners . . . . . 67
Fitting cylinder liner . . . . . 35	Flywheel and flywheel housing . . . . . 68
Fitting piston and connecting rod . . . . . 36	Timing gear . . . . . 69
Flywheel and flywheel housing . . . . . 38	Lubrication system . . . . . 71
Removing flywheel . . . . . 40	Special tools . . . . . 73
Removing and fitting flywheel housing . . . . . 42	
Fitting flywheel . . . . . 43	

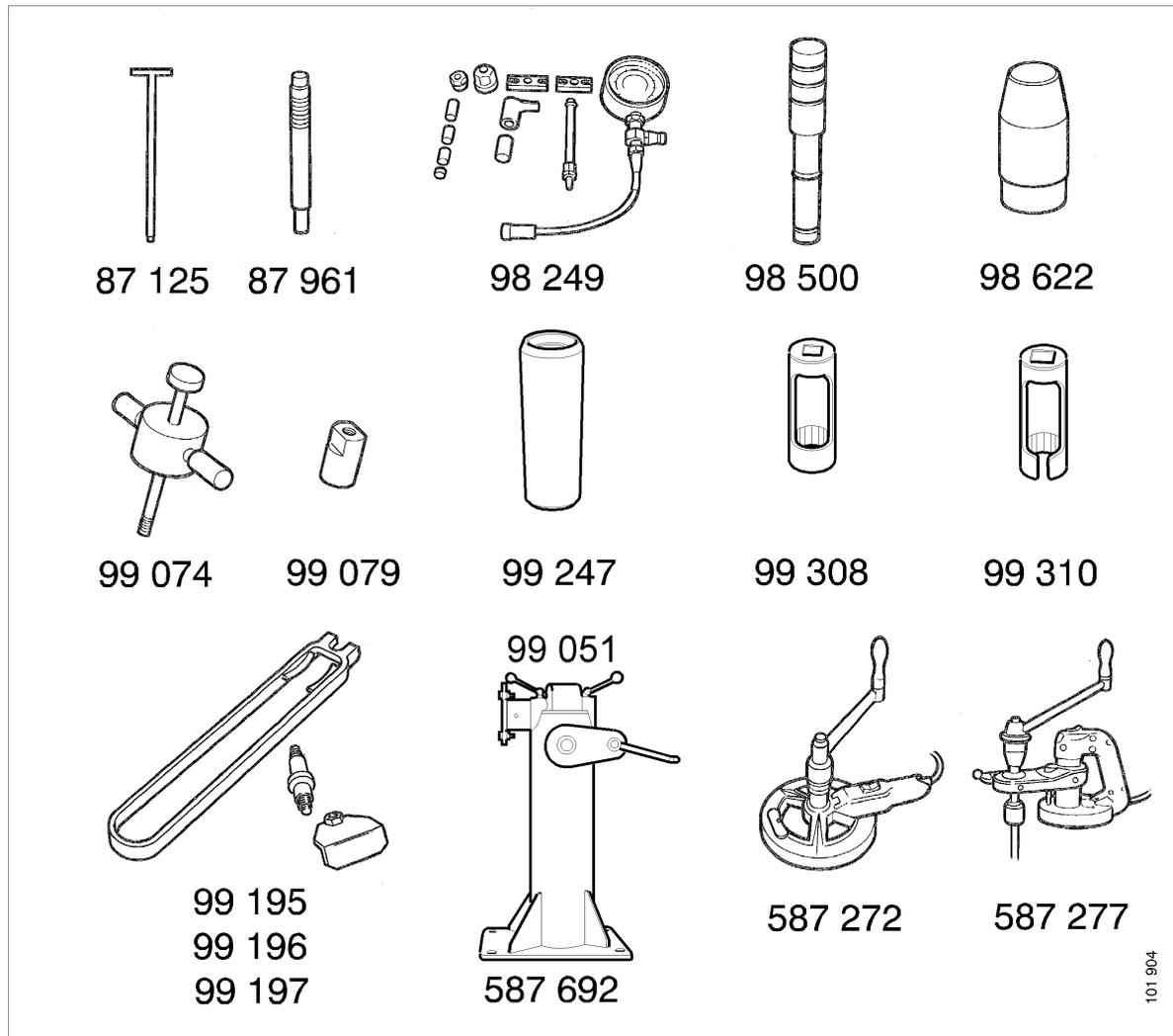
# Cylinder head



1. Cylinder head
2. Valve guide
3. Valve guide
4. Valve seat ring
5. Valve seat ring
6. Core plug
7. Core plug
8. Seal (not standard)
9. Intake valve
10. Exhaust valve
11. Valve spring collar
12. Valve spring
13. Valve spring
14. Valve spring collar
15. Collet
16. Valve stem cap
17. Bearing bracket
18. Rocker arm
19. Bushing
20. Adjusting screw
21. Hexagon nut
22. Retaining ring
23. Spiral pin
24. Bolt
25. Flange bolt
26. Cylinder head gasket
27. Pin

101417

## Special tools



87 125 *Extractor*

87 961 *Drift*

99 246 *Drift*

98 249 *Compression tester*

98 500 *Shank*

98 503 *Drift*

98 622 *Press drift*

99 051 *Fixture*

99 074 *Impact drift*

99 079 *Injector extractor*

99 247 *Assembly drift*

99 195 *Valve spring compressor, complete*

99 308 *Sleeve for injector*

99 310 *Sleeve*

587 272 *Cylinder liner cutter with grooving tool*

587 277 *Valve seat cutter*

587 692 *Engine stand*

## Valve clearance

### Checking and adjusting

Check valve clearance. The clearance for intake valves should be 0.45 mm and the clearance for exhaust valves should be 0.80 mm when the engine is cold.

Adjustment can be carried out in one of the following ways:

A. Adjust both valves in each cylinder starting with No. 1 cylinder at TDC after compression. Turn the crankshaft 1/3 turn at a time and adjust valves in injection sequence:

1-5-3-6-2-4

B. Set No. 1 cylinder at precisely TDC after compression. The following valves can now be adjusted:

*cylinder 1 intake and exhaust*

*cylinder 2 intake*

*cylinder 3 exhaust*

*cylinder 4 intake*

*cylinder 5 exhaust*

Turn the crankshaft precisely one revolution so that TDC for No. 6 cylinder is set. The remaining valves can now be adjusted:

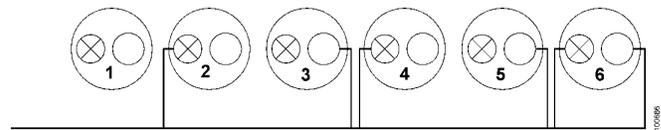
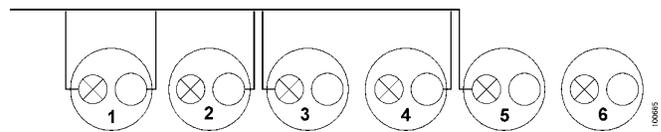
*cylinder 2 exhaust*

*cylinder 3 intake*

*cylinder 4 exhaust*

*cylinder 5 intake*

*cylinder 6 exhaust and intake*



○ Intake valve  
⊗ Exhaust valve

## Compression

### Measuring

The compression tester is used to quickly and simply check wear and damage to primarily the cylinder head valves, but also to cylinder liners and piston rings.

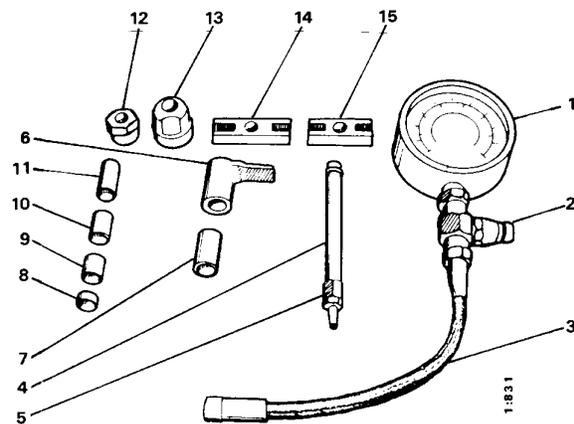
Measurements are only intended for comparison between cylinders. Lower compression in one or several cylinders is a sign of abnormal wear or damage.

By using various accessories, the compression tester can be used for several engine types.

1. Lock the stop lever in the stop position.
2. Clean around injectors. Detach delivery pipes and leak-off pipes from all injectors.

**Note** Fit protective caps on the delivery valve holders in the injection pump, on the delivery pipes and the injectors to protect them from dirt.

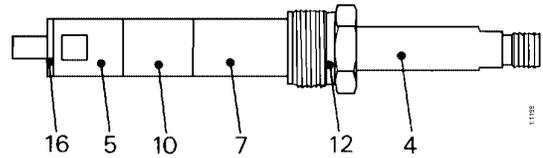
3. Undo and remove the injectors and copper washers.
4. Turn the engine over several times using the starter motor to remove any loose soot in the cylinders.



1. Pressure gauge
2. Zeroing valve
3. Flexible metal hose
4. Measuring rod, complete
5. End sleeve, diameter 21 mm
6. Spacing sleeve with guide lug
7. Spacing sleeve with collar
8. Spacing sleeve, length 6 mm
9. Spacing sleeve, length 19 mm
10. Spacing sleeve, length 25 mm
11. Spacing sleeve, length 38 mm
12. Cap nut
13. Threaded socket nut
14. Large yoke
15. Small yoke

Compression tester 98 249

5. Connect the compression tester in the injection aperture in one of the cylinders. Copper washer 16 should be used between the compression tester and the bottom of the injector aperture.
6. Turn the engine over using the starter motor and read the pressure gauge. Note the result.
7. Zero the pressure gauge by pressing zeroing button 2.
8. Move the compression tester to the next cylinder and proceed as in points 7-9.
9. Evaluate the readings and assess what further measures need to be taken on the engine.



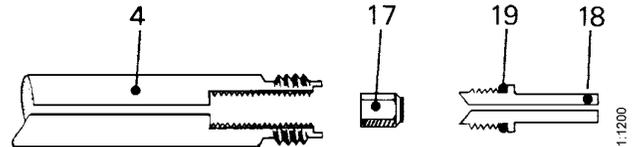
- 4 Measuring rod
- 5 End sleeve, diameter 21 mm
- 7 Spacing sleeve with collar
- 10 Spacing sleeve, L = 25 mm
- 12 Cap nut (use socket 99 308 for tightening)
- 16 Copper washer

*Measuring rod, complete*

### Cleaning the measuring rod

Measuring rod 4 has a check valve which, in the case of leakage, should be cleaned as follows:

1. Unscrew valve seat 18.
2. Remove all soot from valve 17 and valve seat 18. Do not scratch the sealing surfaces. Use compressed air to clean the inside of measuring rod 4.
3. Assemble the parts. Make sure that O-ring 19 is not damaged. Fully screw on valve seat 18 so that it seals against measuring rod 4.

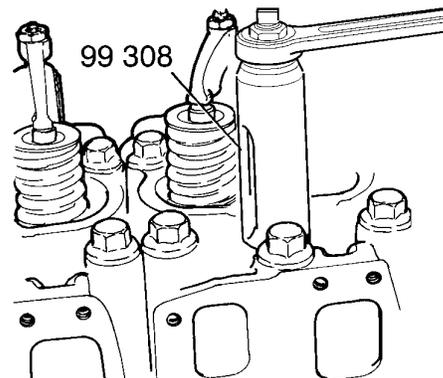


- 4 Measuring rod
- 17 Valve
- 18 Valve seat
- 19 O-ring

*Measuring rod*

## Removing

1. Remove the intake manifold, exhaust manifold and turbocharger.
2. Remove the coolant manifold.
3. Remove the delivery pipes. Protect the connections on the injection pump and injectors with plastic plugs.
4. Undo the injector nut using socket 99 308.

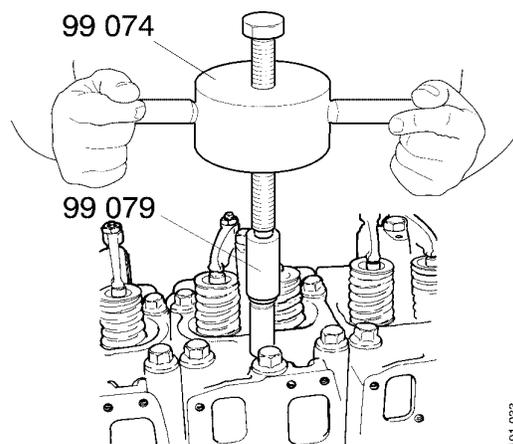


101 032

5. Extract the injectors using tools 99 079 and 99 074. Remove the copper washers using tool 87 125.
6. Insert protective plugs in the ends of the delivery pipes and fit protective caps on the injectors and injection pump.

**Note** All parts in the valve mechanism should be refitted in the same positions. For this reason, mark all parts that are removed.

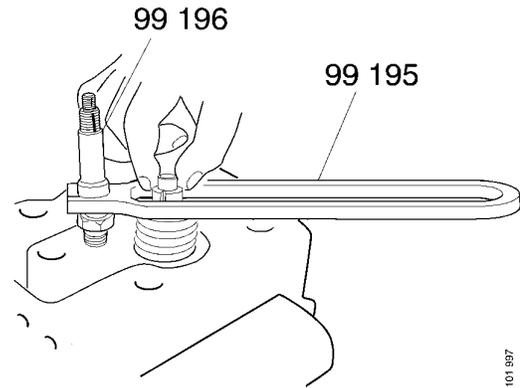
7. Unscrew the rocker arm mechanism.
8. Lift out the pushrods.
9. Remove the cylinder head bolts. Lift off the cylinder head.  
Place it on a bench on a soft surface to avoid damage to the mating surface.



101 033

## Dismantling

1. Remove the valve stem caps.
2. Extract collets, valve spring collars, springs and valves. Use tools 99 195 and 99 196 to compress the valve springs so that the collets can be removed.
3. Place the valves in a stand so that they can be refitted in the same cylinder head. Mark the cylinder heads if several are removed at the same time.



## Checking, changing and machining

### Valve stem seal (not standard)

#### Changing

1. Remove the valve stem seal.
2. Fit a new seal with tool 99 247.

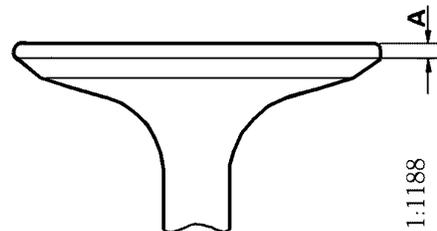
**Note** Do not hammer on the seal so hard that the valve guide is displaced.

## Valves

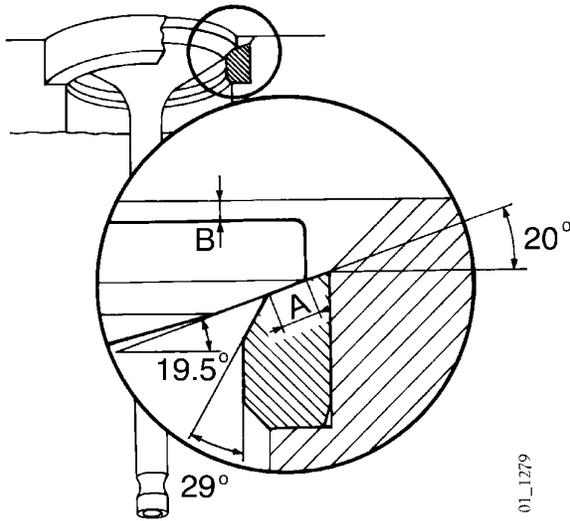
### Checking and machining

- Check dimension A on all valves.
- Machine the valves in a valve grinder.  
Intake 19.5° and exhaust 44.5°.

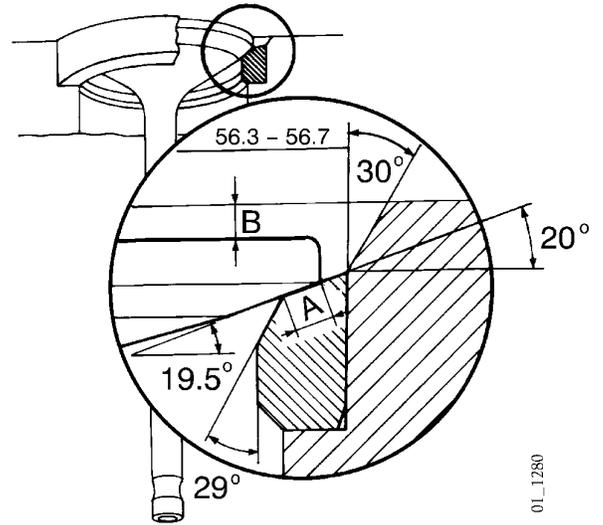
See *specifications*.



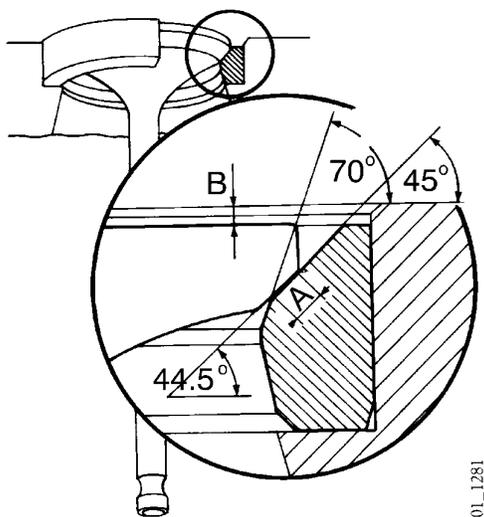
*Minimum dimension A for ground valve*  
Intake 3.0 mm  
Exhaust 1.7 mm



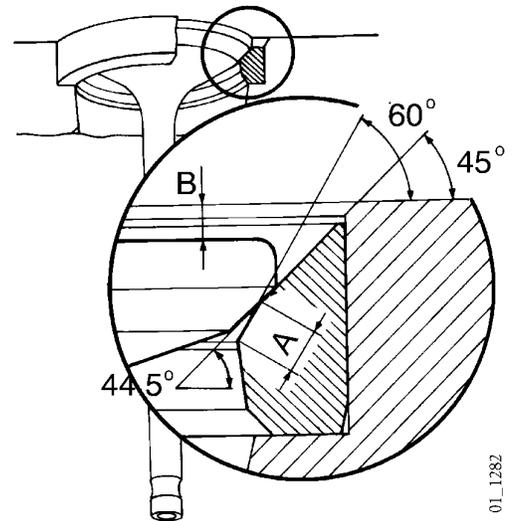
*New intake valve and new valve seat ring*



*New intake valve and valve seat ring machined to maximum*



*New exhaust valve and new valve seat ring*

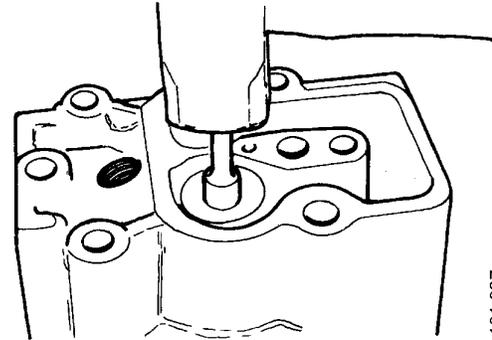
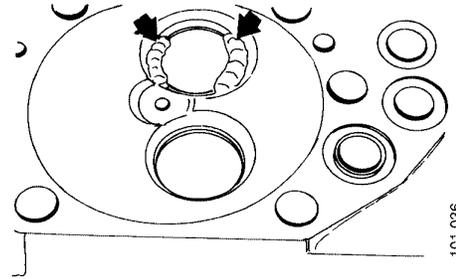


*New exhaust valve and valve seat ring machined to maximum. Surfaces at arrows aligned*

**Valve seats**

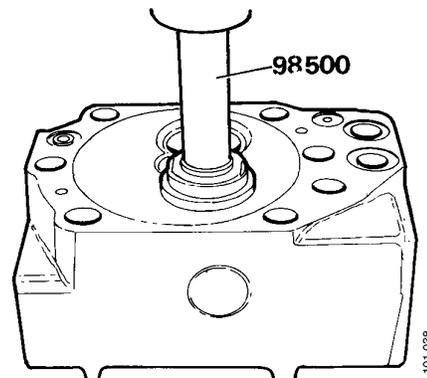
Changing

1. Remove valve seat rings. Use an old valve which has been machined so that the diameter of the head is slightly smaller than the inside diameter of the seat.
2. Place the valve in position and weld it all round using an arc welder. Cool with water. Turn the cylinder head over and tap the valve stem so that valve and seat ring fall out. Wear protective goggles!



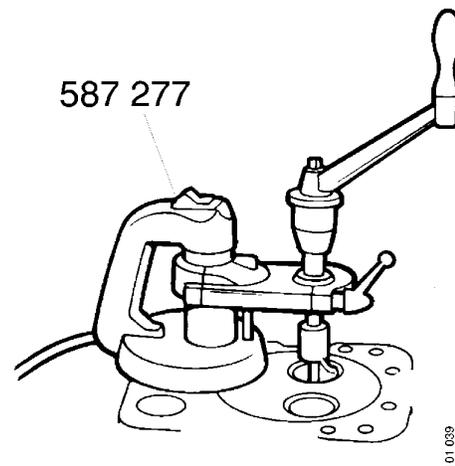
**Always turn the cylinder head with the underside down when the valve seat ring is being tapped out. Otherwise, there is a risk of loose swarf causing injury.**

3. Press in new valve seat rings. Use drift 98 503 and shank 98 500. Cool the drift and valve seat to about -80 °C in dry ice or liquid air. The rings must be pressed in very quickly.



**Take care when using the above coolants and cooled parts. Danger of frostbite.**

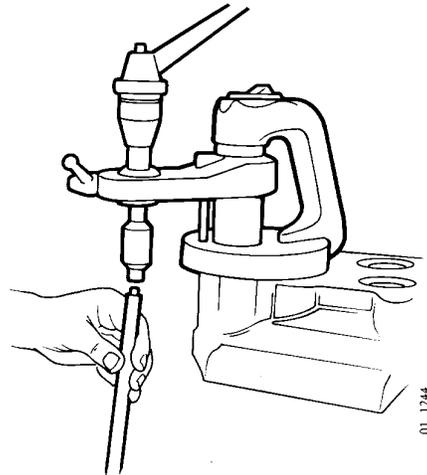
Oversize valve seat rings can be fitted if the valve seat ring position has been damaged. The seat must then be machined using tool 587 277.



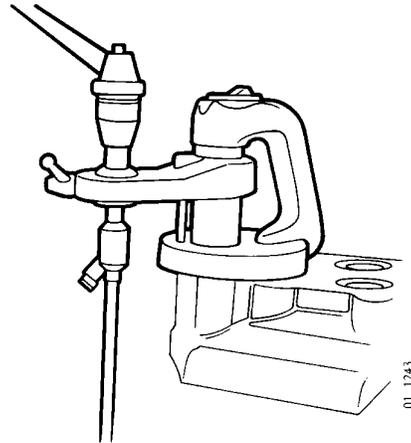
Machining

Machining dimensions and oversize valve seat rings, see *Specifications*.

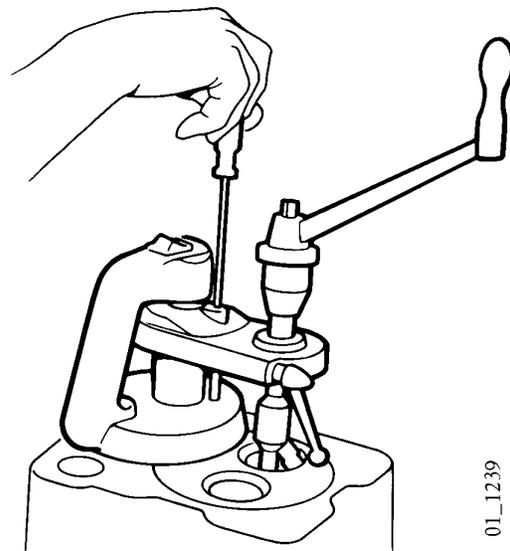
1. Check that the contact surface and magnetic foot are smooth and clean. Clean valve bushings.
2. Select the largest spindle which easily goes into the valve guide.  
Fit the guide spindle and turn the feed screw to its upper position.



3. Select and fit cutter.



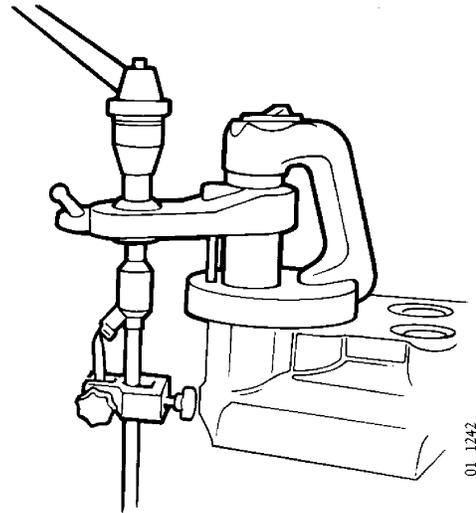
4. Undo the speed lock and move the pivot plate to the upper position using the adjusting screw.



5. Set the pointer on the cutter using a valve.

6. Set the cutter.

7. Disconnect the magnet (position 2). Insert the guide spindle in the valve bushing. Adjust the pivot plate so that the gap between the cutter and the valve seat is about 1 mm. Carefully centre the tool.

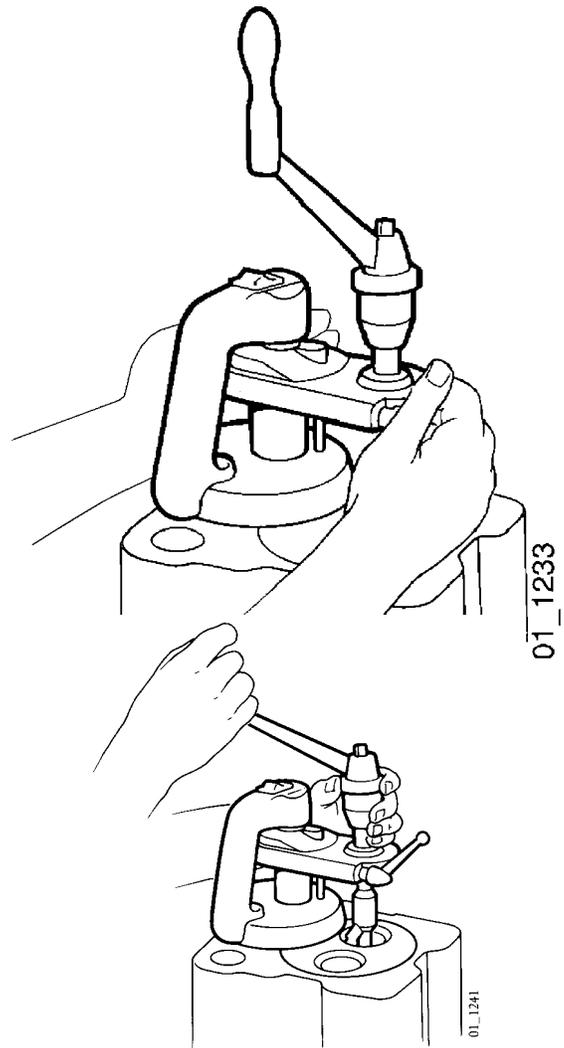


8. Connect the magnet (position 1).

9. Secure speed lock. Check that crank is easy to turn. If not, repeat centring.

10. Cut valve seat by cranking clockwise and turning the feed screw at the same time. Never crank anticlockwise. The cutter may break. Lubricate with cutting oil while working.

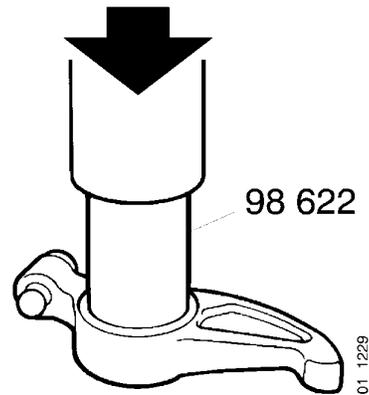
11. When the valve seat surface is finished, reduce cutting pressure by cranking 2-3 turns without feeding. Continue cranking and turn the feed screw anticlockwise. The valve seat cutter is now ready for the next valve seat.



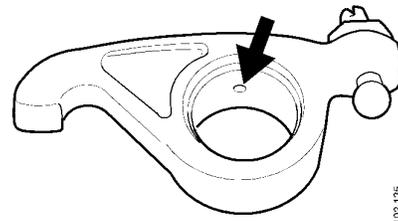
## Rocker arms

### Changing bushing

1. Remove the retaining ring.
2. Remove rocker arm from support bracket.
3. Press bushing out of rocker arm using drift 98 622.



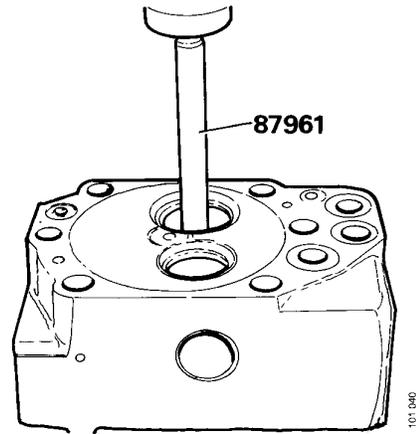
4. If wear is light, the surface of the rocker arm which presses against the valve stem cap can be adjusted using a grinding machine.
5. Turn the slit in the bushing up. Press bushing into rocker arm using drift 98 622.
6. Drill the oil hole in the bushing to the same diameter as the oil hole in the rocker arm.
7. The bushing should then be finely worked. See *specifications*.
8. Lubricate the bushing using engine oil before the rocker arm is placed on the support bracket.



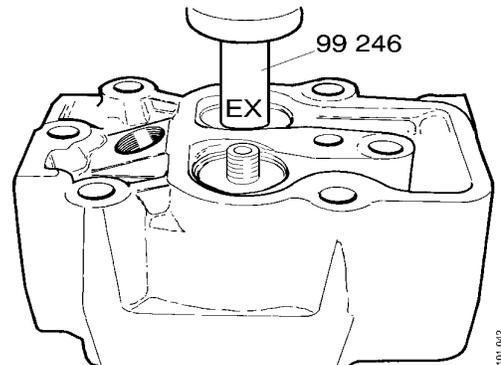
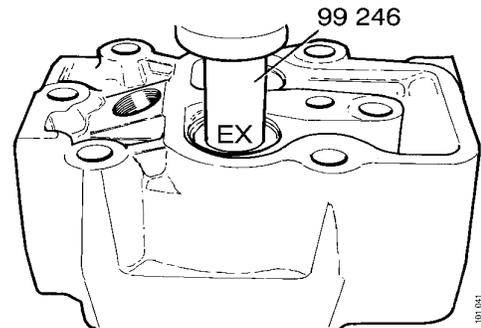
**Valve guides**

Changing

1. Press out valve guides using drift 87 961.



2. Press in new valve guides using drive 99 246 (exit). Press down the guide as far as the drift will allow, i.e. until it is against the spring seat in the cylinder head.



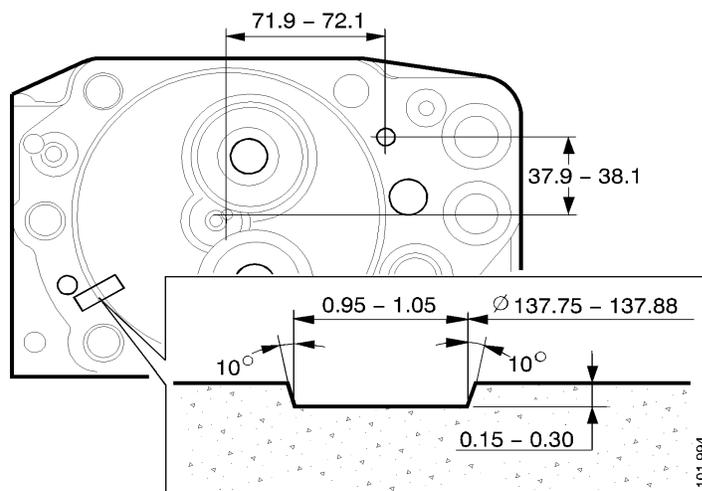
## Cylinder head

### Checking and machining the sealing surface against cylinder block.

Cylinder head is checked for cracks and other defects. The sealing surface against the cylinder block is checked against a surface plate. If the sealing surface must be machined, cylinder head height after machining must not be less than 114.4 mm.

After machine flat, new sealing grooves for the gasket must be milled.  
Use tool 587 272.

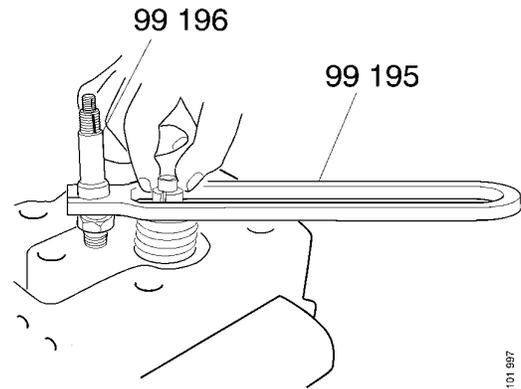
Also machine the recesses for the sealing rings.  
Depth 0.9-1.1 mm.



*Sealing groove in cylinder head*

## Assembly

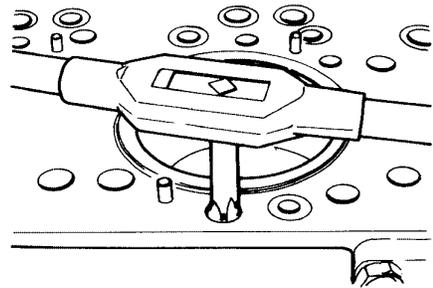
1. Thoroughly lubricate all parts before assembly.
2. Insert the valve stem in the guide. (Fit the valve stem seal, if any.)
3. Fit the lower guide washer, the two valve springs and the upper guide washer.
4. Compress springs using tools 99 195 and 99 196 and fit collets.
5. Fit valve stem caps.



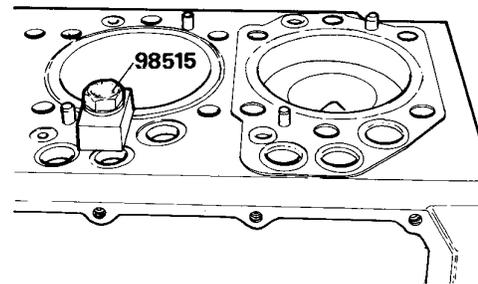
101 987

## Fitting

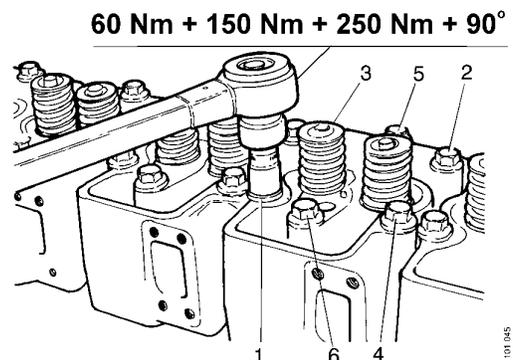
1. Clean the cylinder head bolt holes in the block using an M16 tap. Check the liner height, see *Pistons and cylinder liners*.
2. Fit a new gasket.
3. Fit the cylinder head and ensure that the guide pins fit in the holes.
4. Change bolts having three centre-punch marks on the head for new ones.
5. Lubricate the threads on the cylinder head bolts and the surface under the head.
6. Tighten the bolts in the order given in the figure and in three stages + 90 degrees as follows:
  - Tighten all bolts to 60 Nm
  - Tighten all bolts to 150 Nm
  - Tighten all bolts to 250 Nm
  - Finally tighten all bolts 90 degrees
7. Mark all bolts with a fresh centre-punch mark. (Except new bolts.)



101 943

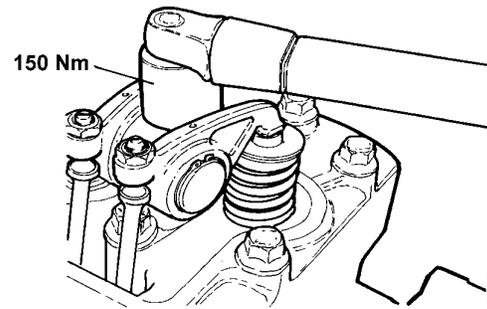


101 944

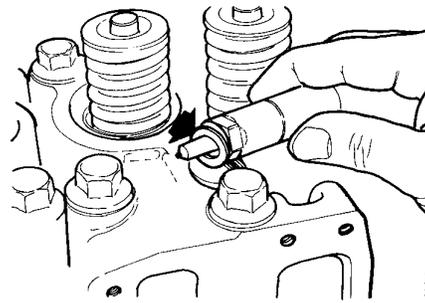


101 945

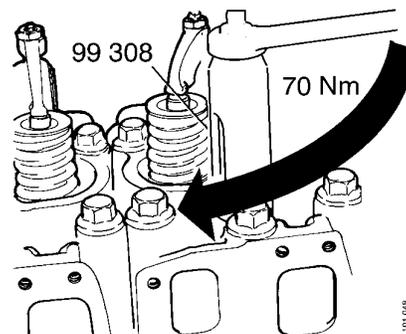
8. Fit the pushrods and rocker arm mechanism. Tighten the rocker arm mechanism bolts to 150 Nm.
9. Check valve clearance as described in *Valve clearance, checking and adjusting* on page 5.



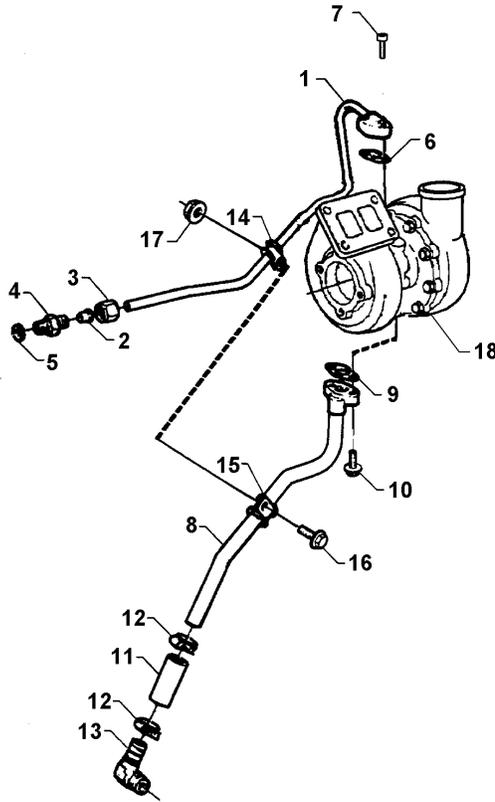
10. Check that no old seal remains in the injector hole. Fit the injectors complete with new seals.



11. Tighten the injectors to 70 Nm using tool 99 308.
12. Fit the rocker covers and tighten them to 20 Nm.
13. Fit delivery pipes and tighten to 20 Nm using socket 99 310. Fit leak-off pipes, coolant manifold, intake manifold and exhaust manifold with new gaskets and seals.
14. If the exhaust pipe has been removed and dismantled, joints should be lubricated using lubricant 561 205 when reassembling.



# Turbocharger



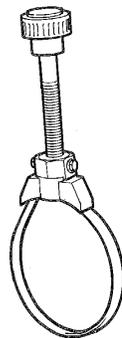
- 1. Lubrication oil pipe
- 2. Ferrule
- 3. Union nut
- 4. Straight union
- 5. Gasket
- 6. Gasket
- 7. Hexagon socket screw
- 8. Lubrication oil return pipe
- 9. Gasket
- 10. Flange bolt
- 11. Hose
- 12. Hose clip
- 13. Elbow union
- 14. Clamp
- 15. Clamp
- 16. Flange bolt
- 17. Flange bolt
- 18. Turbocharger

## Special tools



98 075

98 075 Dial gauge



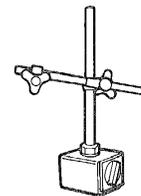
587 025

587 025 Filter wrench



587 107

587 107 Out-of-true indicator



587 250

587 250 Measuring stand

01 1274

## General

**Note** When working on the turbocharger, cleanliness is extremely important. Oil inlet and outlet connections must never be left unprotected. A foreign body in the bearing housing can quickly lead to total breakdown.

### Oil leakage

A clogged air cleaner causes vacuum in the intake line to become excessive. If this occurs there is a risk that oil mist will be drawn out from the bearing housing into the compressor and then on into the engine.

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

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

### Foreign bodies

Foreign bodies such as grains of sand or metal swarf in the turbine or compressor will destroy the impeller vanes. This leads to imbalance and bearing wear. Engine output drops and, if operation continues, there will be a risk of damage due to overheating as the air supply drops. This type of overheating cannot be observed on the coolant temperature gauge.

**Note** Never attempt to straighten a damaged vane. It will usually break when in operation and cause turbocharger breakdown and engine damage.

## Air and exhaust leakage

Even very tiny leaks in the line between air cleaner and turbocharger cause deposits of dirt on the compressor wheel. Charge pressure then drops, resulting in higher exhaust temperature and smoke. Wear on the engine also increases.

Exhaust leaks between cylinder head and turbo also result in low charge pressure.

### Charge pressure

Note that low charge pressure does not necessarily mean that the turbocharger is faulty. Low pressure may be caused by such things as a clogged air filter, leakage in the intake or exhaust lines, an incorrectly adjusted throttle control, faulty injectors, defective injection pump or faulty smoke limiter.

### Cleaning compressor wheel

Low charge pressure can be caused by a dirty compressor wheel. Remove the compressor cover. Wash the compressor wheel using white spirit and a brush. Fit the compressor cover and read the charge pressure.

**Note** The compressor wheel must not be removed from the shaft. This could cause imbalance when refitted.

## Measuring radial clearance and axial clearance

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

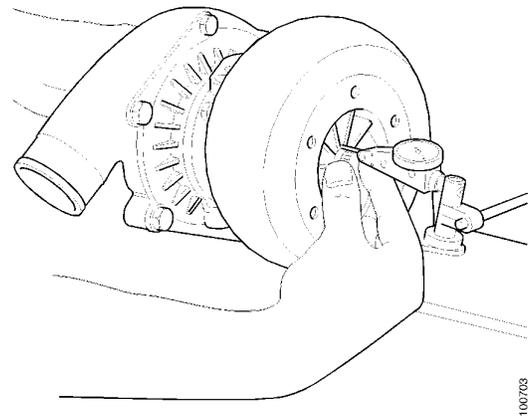
If the turbocharger appears to be functioning poorly or is making a noise, measuring charge pressure or measuring radial and axial clearance may indicate that the turbocharger is defective.

For measuring axial and radial clearance, the turbocharger can be removed and bolted to a steel plate to which the magnetic dial gauge stand can also be attached.

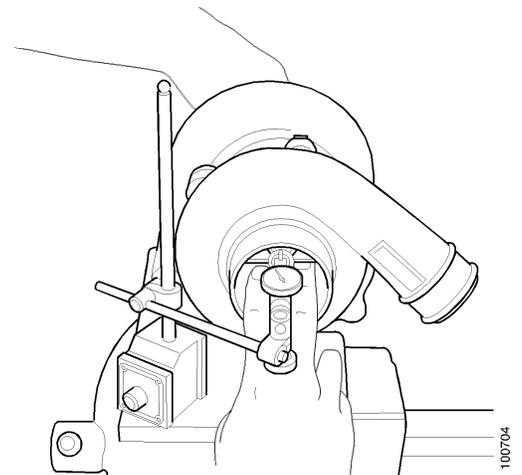
### Radial clearance

Take readings on both turbine wheel and compressor wheel.

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



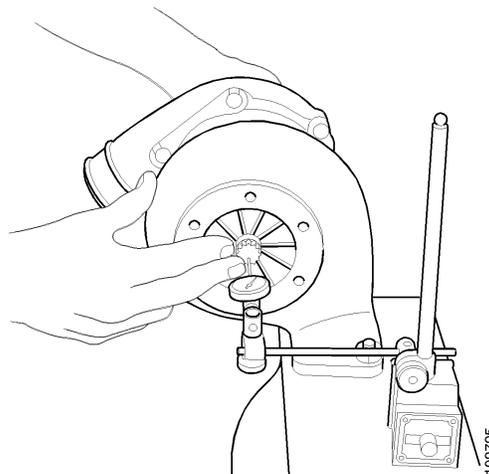
Measuring turbine wheel radial clearance.



Measuring compressor wheel radial clearance

### Axial clearance

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



### Wear limits for Holset:

Radial clearance	0.329 -0.501 mm
Axial clearance (after running-in)	0.038 -0.093 mm

### If the turbocharger is not working

1. Check that there is no leakage nor any loose objects in the line between the air cleaner and turbocharger.
2. Check that there are no loose objects in the exhaust manifold or intake manifold.  
Change the charge air cooler.
3. Check that all valves are intact.
4. Check the lubrication oil return pipe from the turbocharger for blockage or deformation.
5. Check the oil delivery pipe to the turbocharger for any blockage, deformation and leakage under pressure.
6. Check the condition and part number of the oil filter.
7. Check that the air filter is not blocked and that there are no other reasons for the abnormal increase of vacuum in the intake system.
8. Check that engine output is correct. Excessively high output reduces the life of the turbo.
9. Check that the exhaust brake, if fitted, works correctly.

## Changing the turbocharger

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

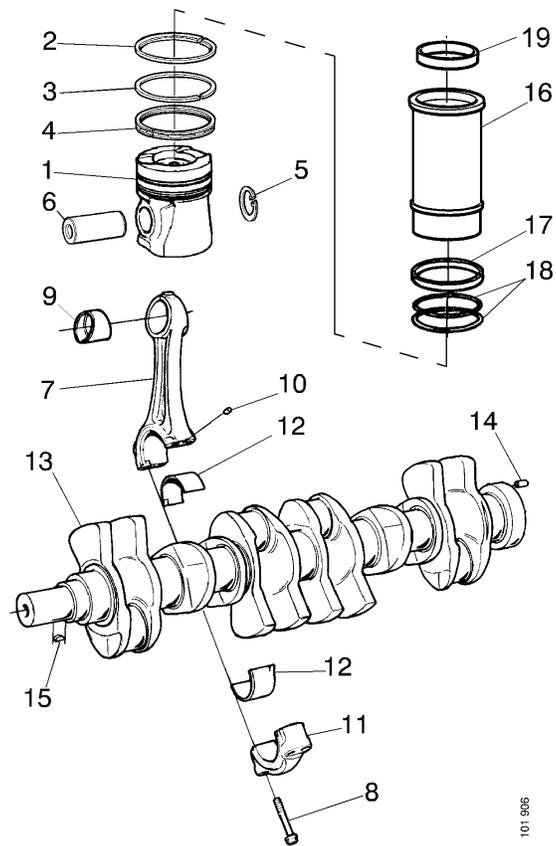
### Removing

1. Detach exhaust pipe, induction pipe and charge air cooler pipe from the turbocharger.
2. Detach then oil supply and return lines.
3. Unscrew the bolts in the turbocharger mounting and remove the turbocharger.

### Fitting

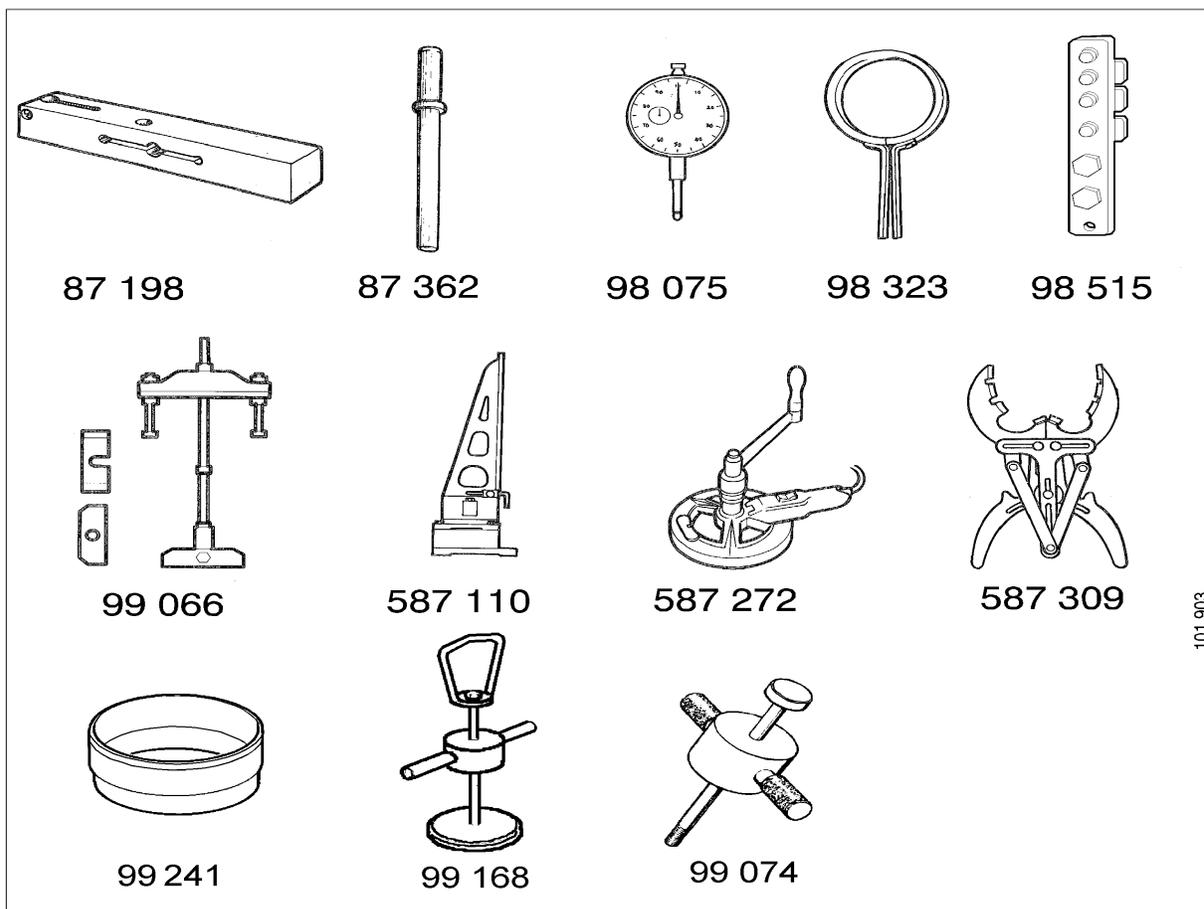
1. Check the connecting flange on the exhaust manifold to ensure that no remnants of the old gasket are still present.
2. Fit a new gasket and bolt on a new turbocharger. Lubricate the exhaust manifold bolts with temperature resistant lubricant, Part No. 561 205. Tighten to 40 Nm.
3. Connect oil supply and return lines.
4. Connect charge air pipe, induction pipe and exhaust pipe.
5. Lock the stop lever in the stop position and turn the engine over by means of the starter motor for at least 30 seconds so that the lubricating oil reaches the turbocharger. On engines with a fuel shut-off valve, this valve should be disconnected while the engine is being turned over.
6. Start the engine and check that there is no leakage.

## Pistons and cylinder liners



- |                     |                     |
|---------------------|---------------------|
| 1. Piston           | 11. Bearing cap     |
| 2. Compression ring | 12. Big-end bearing |
| 3. Compression ring | 13. Crankshaft      |
| 4. Oil scraper ring | 14. Pin             |
| 5. Retaining ring   | 15. Key             |
| 6. Gudgeon pin      | 16. Cylinder liner  |
| 7. Connecting rod   | 17. Seal            |
| 8. Flange bolt      | 18. O-ring          |
| 9. Bushing          | 19. Loose ring      |
| 10. Pin             |                     |

## Special tools



87 198 Straight edge for dial gauge

87 362 Drift

98 075 Dial gauge

98 323 Piston ring compressor

98 515 Pressing tool

99 066 Puller for cylinder liner

99 074 Impact drift

99 241 Assembly tool

99 168 Dismantling tool

587 110 Connecting rod tester

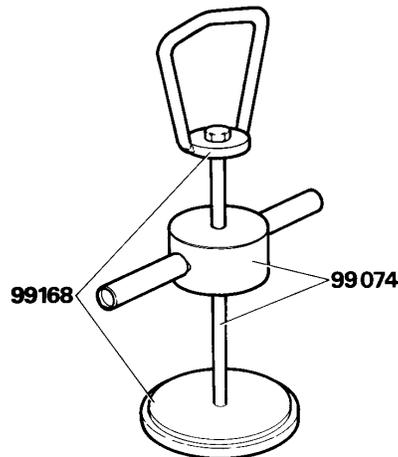
587 272 Cylinder liner cutter

587 309 Piston ring expander

## Removal of loose ring in cylinder liner

If the loose ring is so firmly in place that it cannot be removed by hand, proceed as follows:

1. Remove cylinder head and oil sump.
2. Rotate the crankshaft until the piston is at BDC.
3. Fit tension lugs 98 515 to the edge of the cylinder liner so that the liner cannot be pulled out of position.
4. Place plate 99 168 on the piston crown.
5. Press a piston ring into the liner until it is below the loose ring.
6. Fit handle 99 168 on impact drift 99 074. If it proves difficult to fit the bolt in the handle, the bolt head can be ground down slightly but without weakening the bolt.
7. Screw the bolt into the plate.
8. Pull up the plate so that it abuts against the pressed-in piston ring.
9. Drive out the loose ring using the impact drift.

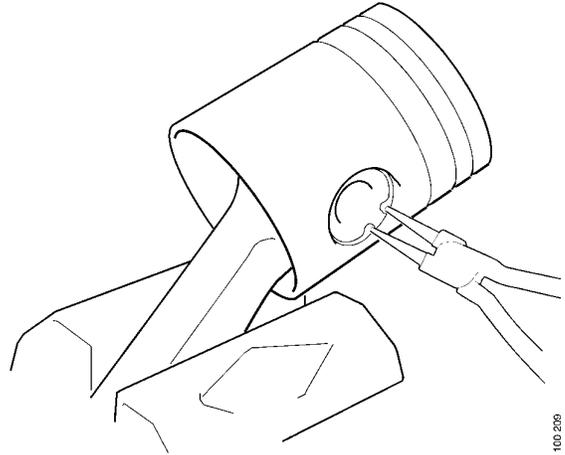


## Removing and dismantling piston and connecting rod

1. Remove the piston cooling nozzles in the cylinder block.

**Note** The piston cooling nozzle must not be damaged. If the jet of oil does not strike the piston in the right place, there could be a danger of engine breakdown. Damaged nozzles *must* be changed.

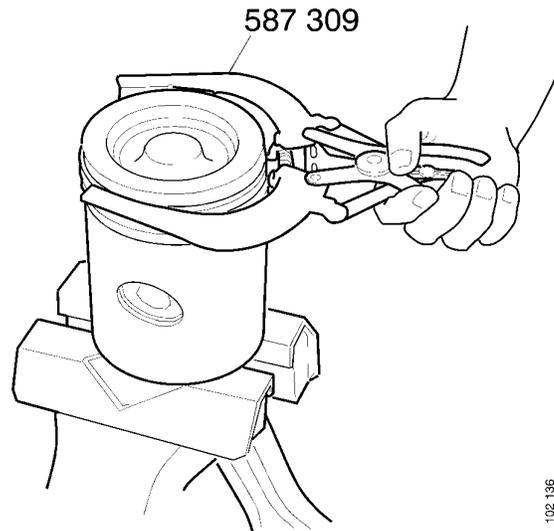
2. Remove the bearing cap and bearing halves. Protect the oilway in the crankshaft using tape, for instance, wound with the adhesive side out.
3. Drive out piston and connecting rod.
4. Place the connecting rod in a vice with soft jaws. Remove the gudgeon pin retaining rings.



100 206

5. Remove the piston rings using tool 587 309. Be careful not to scratch the piston skirt with the piston rings.

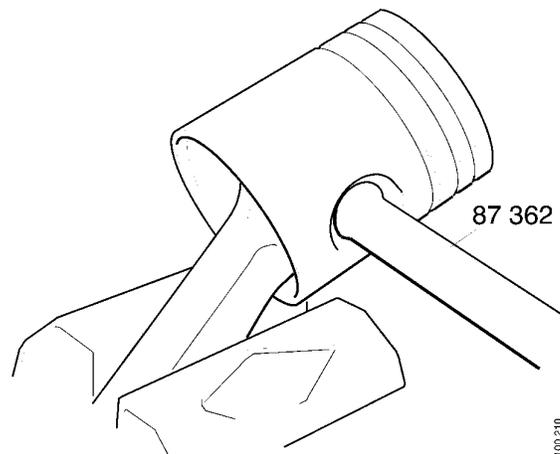
When cleaning graphited pistons in a machine, the graphiting may disappear. This does not matter when they have been used for some time. However, new pistons should be washed carefully using white spirit, for instance.



102 136

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

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

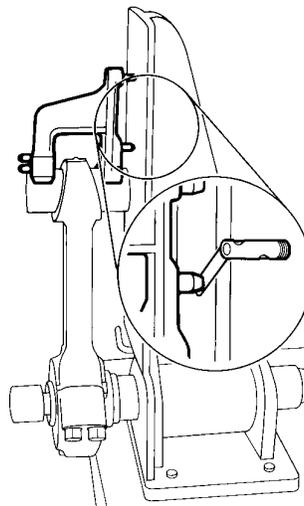


100 210

## Checking connecting rods

Check connecting rods using tool 587 110. Proceed as follows:

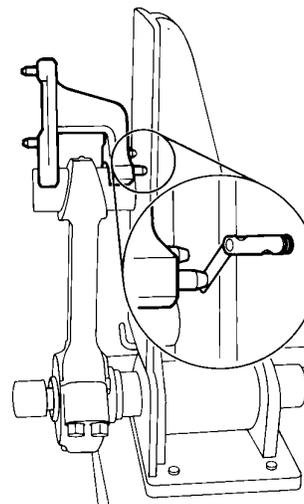
1. When the gudgeon pin bushing has been checked, insert the bearing cap as marked and tighten the bolts with full torque.
2. Mount the connecting rod in the tool using the expander and place the gudgeon pin in its bushing. Then place indicator studs on the gudgeon pin.
3. Check whether the connecting rod is twisted, with the indicator studs horizontal.



*Checking whether the connecting rod is twisted*

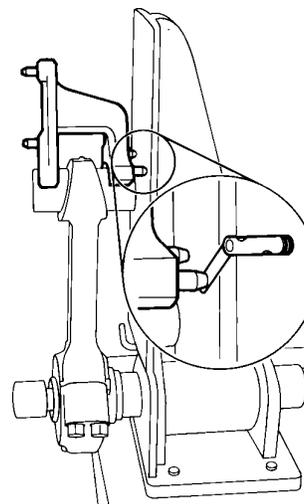
4. Check whether the connecting rod is bent, with the indicator studs vertical.

- The distance between the indicator studs on the tool shown here is 75 mm
- The distance between one of the indicator studs and the surface being measured must not be more than 0.1 mm, measured using this tool.
- Check with a feeler gauge.



*Checking whether the connecting rod is bent*

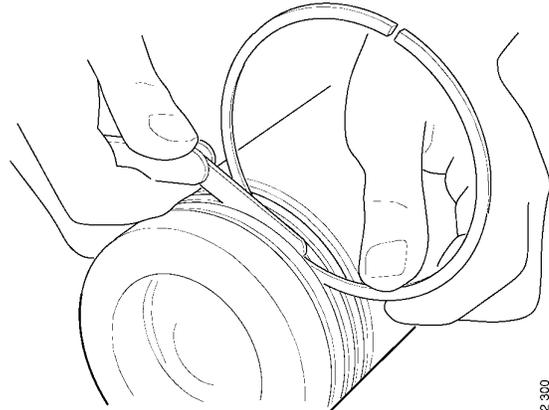
- Also check whether the connecting rod is bent into an S shape. Do this by measuring the distance between the outer side of the connecting rod bushing and the flat surface on the tool.
- Turn the connecting rod round and measure the corresponding dimension.
- The difference should be no more than 0.6 mm.



*Checking whether the connecting rod is bent into an S shape*

## Assembling piston and connecting rod

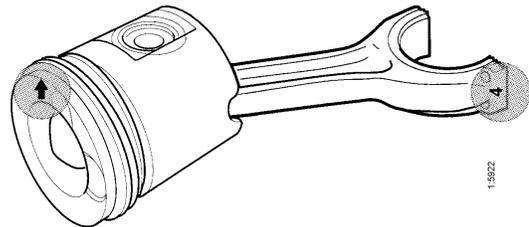
1. Clean the piston and its ring grooves carefully without scratching the sides of the ring grooves. The oil holes in the piston should be cleaned using a suitable drill.
2. Check that the axial clearance of the other piston ring does not exceed the permitted value (0.25 mm).  
*See specifications.*



102 300

3. Fit the piston rings using tool 587 309. The oil scraper ring has an expander. Piston rings marked TOP should be turned with TOP up.
4. Oil all bushings and the gudgeon pin before assembly.

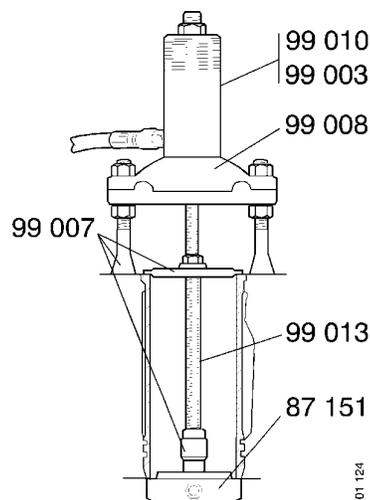
5. Clamp the connecting rod in a vice with soft jaws. Turn it so that the cylinder number marking faces outwards.
6. Fit one of the retaining rings in the piston. Heat the piston to 100 °C and place it on the connecting rod with the arrow pointing as shown in the figure.
7. Push in the gudgeon pin using drift 87 362.
8. Fit the second retaining ring.



1:5922

## Removing cylinder liner

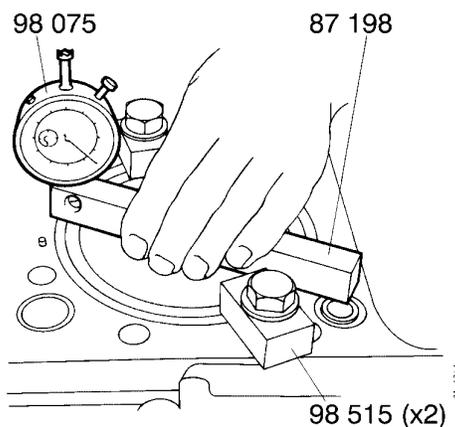
1. Mark the liners with the numbers 1-6. Marking is essential to make it possible to fit the liners in the same place and same position as previously.
2. Extract the cylinder liner using puller 99 066 and support plate 99 007 with or without hydraulic tool.
3. Remove seals from cylinder block.



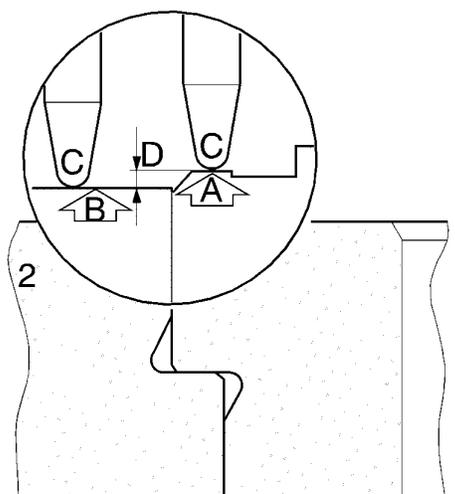
Puller for cylinder liner with hydraulic hole cylinder

## Measuring cylinder liner height

- Insert the liner without seals and press it down using two tension lugs 98 515. Tighten bolts to 50 Nm.
- The cylinder liner and mating surfaces in the block must be carefully cleaned before taking measurements. Use a wire brush and carefully scrape of carbon deposits.



- Place straight edge 87 198 with dial gauge 98 075 on the liner and reset the dial gauge against the liner (A).
- Slide the tip of the dial gauge across to the block (B) and measure the height of the liner (A-B) as shown in the figure.
- Measure each liner at two diametrically opposite points.



- A Measuring surface on cylinder liner
- B Measuring surface on cylinder block
- C Measuring tip
- D Cylinder liner height  $D = A - B$

- The cylinder liner should be slightly above the surface of the cylinder block.
- The difference between the two measurements on the same liner may be up to a maximum of 0.035 mm.
- Cylinder liner height  $D (=A-B)$  above the block should be 0.27-0.33 mm.

### Adjusting cylinder liner height

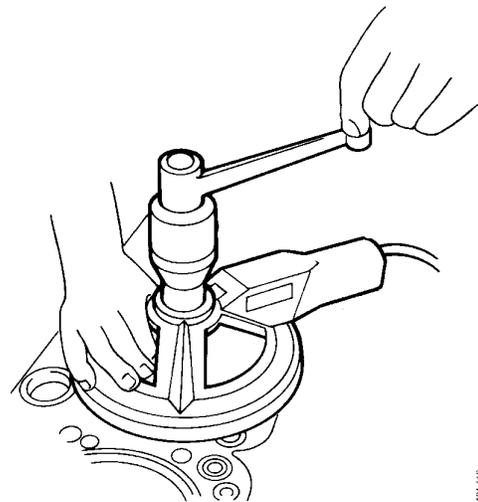
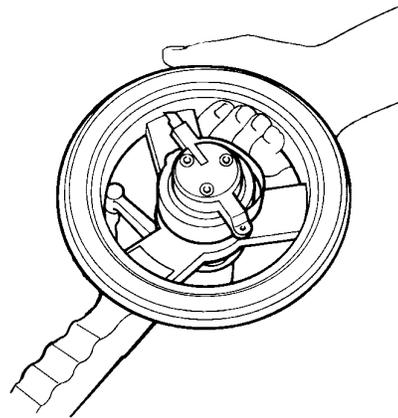
- Check and, if necessary, adjust the entire cylinder bank at the same time.
- The liner mating surface in the block must be clean and in perfect condition. Affix tape (adhesive side out) over the oilway holes in the crankshaft. Place a cloth in the cylinder block to collect swarf.
- If the surface is damaged it must be machined using tool 587 272.
- After the liner's mating surface in the block has been machined, a shim must be fitted to provide correct liner height.
- Try to aim for the least possible amount of machining so that the thinnest possible shim can be used. Shims are available in the following thicknesses: 0.20, 0.25, 0.30, 0.40, 0.50 and 0.75 mm.
- Remove any burrs and measure the thickness of the shims using a micrometer. Only use one shim, i.e. a thick shim, instead of several thin ones.
- Try to set liner height close to the upper limit of 0.33 mm.

## Machining cylinder liner to desired height

1. Calculate the difference between the thickness of the shim and how much you wish to raise the cylinder liner. This difference is the thickness of the layer which must be removed with the cutter.

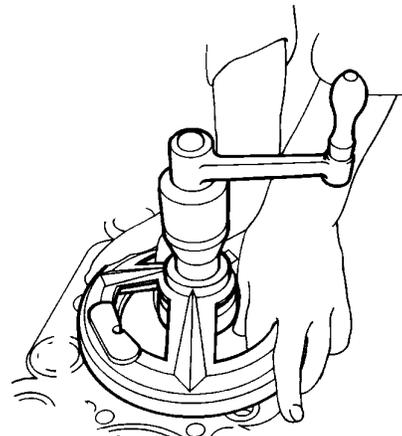
Example for calculating necessary cutting depth:

Desired height	0.33 mm
Measured cylinder liner	0.25 mm
Raising cylinder liner, $0.33 - 0.25 =$	0.08 mm
Closest thickness of shim	0.20 mm
Layer to be removed, $0.20 - 0.08 =$	0.12 mm

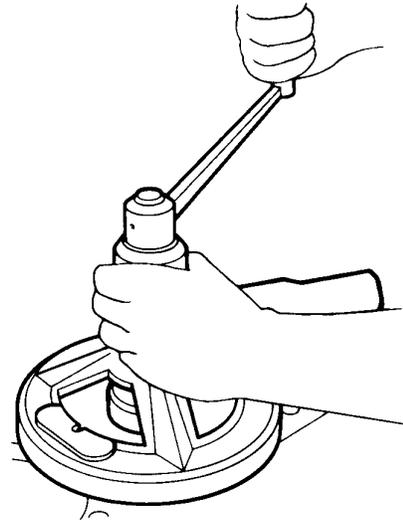


2. Clean contact surfaces between tool and block surface. Fit cutter in cutting head by lifting the speed feed ring.

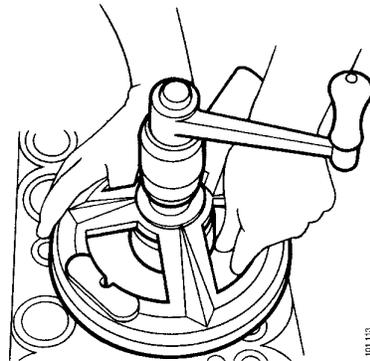
3. Centre the tool with the centre roller.  
Connect the magnet (position 1).



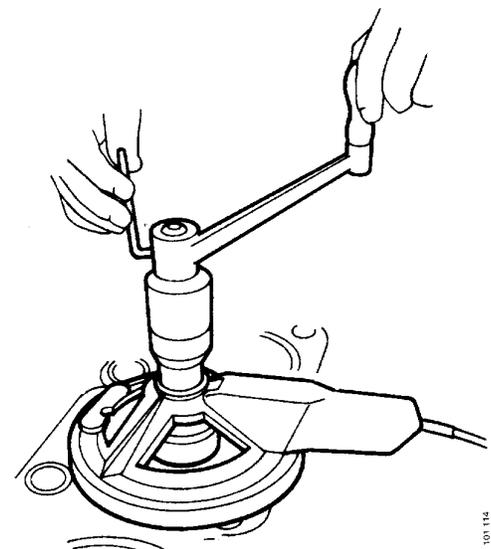
4. Raise the speed feed ring and move the cutter forward so that the carbide tip is above the liner seat level without touching the outer edge.



5. Crank and, at the same time, turn the vertical feed screw clockwise until the cutter just comes into contact with the liner seat surface.



6. Lift the speed feed ring and withdraw the bit until the point is just inside the liner seat surface.



7. Set the vertical feed screw to required depth. See point 1.

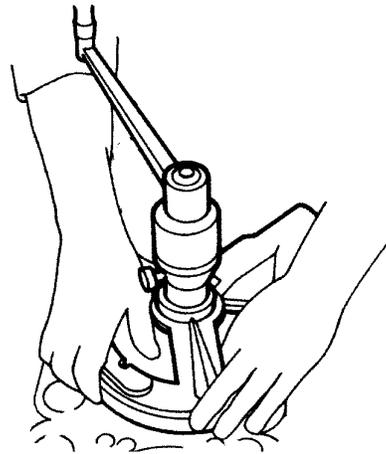
8. Crank clockwise with an even movement, holding the horizontal feed screw with your other hand at the same time. The bit is then fed horizontally 0.13 mm per revolution.
9. Crank more carefully as the bit approaches the outer edge of the cylinder liner and allow the horizontal feed ring to slide round in your fingers.
10. Release the ring fully as soon as the bit has reached the outer edge so that feed ceases. Do not move the vertical feed screw during the machining process.



01.115

11. Move the bit back to the centre so that neither bit nor engine block is damaged when the tool is placed over the next liner seat.

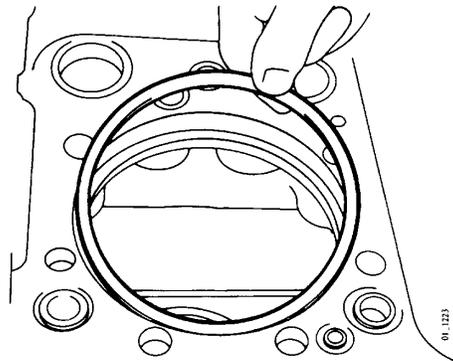
Lift away the tool and place it over the next liner seat.



01.116

12. Measure the thickness of the shim with the tool's micrometer.

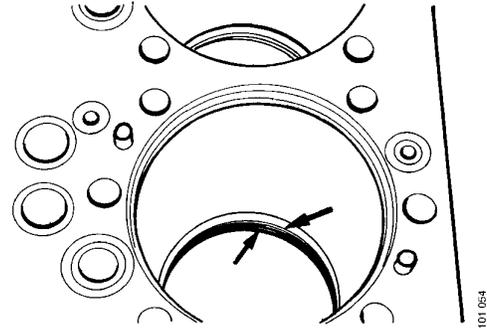
13. Fit shim and cylinder liner.
14. Press down the cylinder liner with tension lugs and check cylinder liner height as per instructions.



01.122

## Fitting cylinder liner

1. Check that the inside of the cylinder block is clean.
2. Carefully check the cylinder liners, both new and old, for cracks which may have arisen during transport or as a result of careless handling.
3. Gently tap the liner with a metal object. It should make a clean metallic ringing sound if it is intact. If it sounds cracked it should be changed.



4. Lubricate with glycerine the two seals which are to be placed in the cylinder block and then fit them in the cylinder block.
5. Fit the wide seal on the cylinder liner with the text "out" facing outwards.

**Note This seal is not oil resistance and therefore must *not* be lubricated.**

6. Lubricate the lower guide surface on the cylinder liner with glycerine.



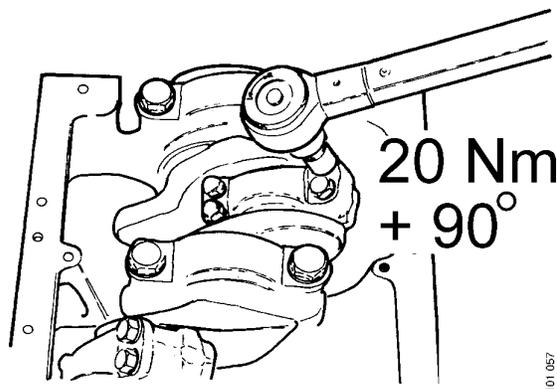
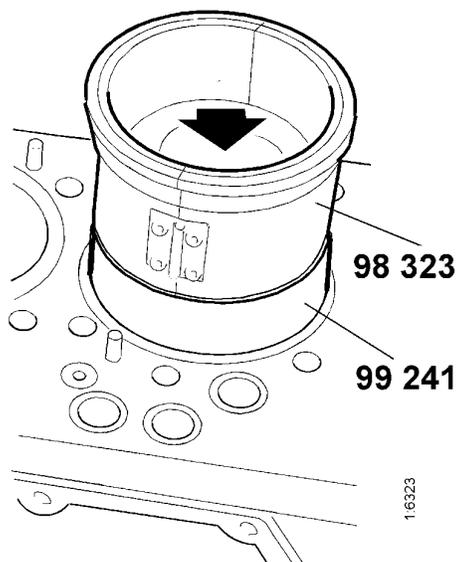
*Lubricate the lower part of the cylinder liner before fitting it in place.*

7. Turn the liner with the punched-in cylinder numbering to the same position it was in before removal and carefully tap it down using a rubber mallet. Check that the O-rings are intact.

8. Check and adjust cylinder liner height as described in *Measuring cylinder liner height* and *Adjusting cylinder liner height*

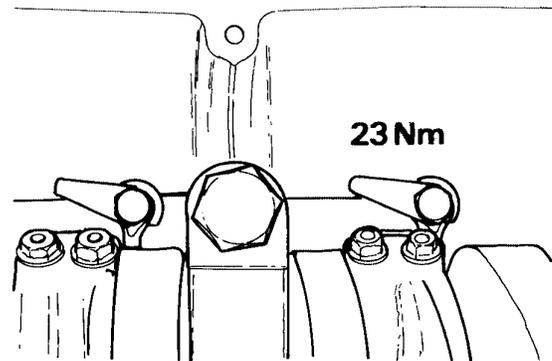
## Fitting piston and connecting rod

1. Check that the inside of the cylinder block is clean.
2. Remove the cover from the big-end bearing journal and lubricate the journal.
3. Turn the piston rings so that the ring gaps are evenly distributed round the piston.
4. Fit assembly tool 99 241 instead of the loose ring in the liner.
5. Carefully insert the connecting rod with piston so that the arrow mark on the piston points forward.
6. Lubricate piston ring compressor 98 323 and fit it round the piston.
7. Press the piston down into the cylinder past the assembly tool.
8. Remove the assembly tool and press in the loose ring. Take care to press the ring straight down so that it does not enter at an angle or become skewed.
9. Place the big-end bearing halves in the caps and lubricate the bearing surfaces. Fit the caps. Check that connecting rod and cap have the same marking and that they are opposite each other.
10. Lubricate the bolts, fit them and tighten alternately in two stages. Stage 1: 50 Nm, stage 2: 110 Nm.



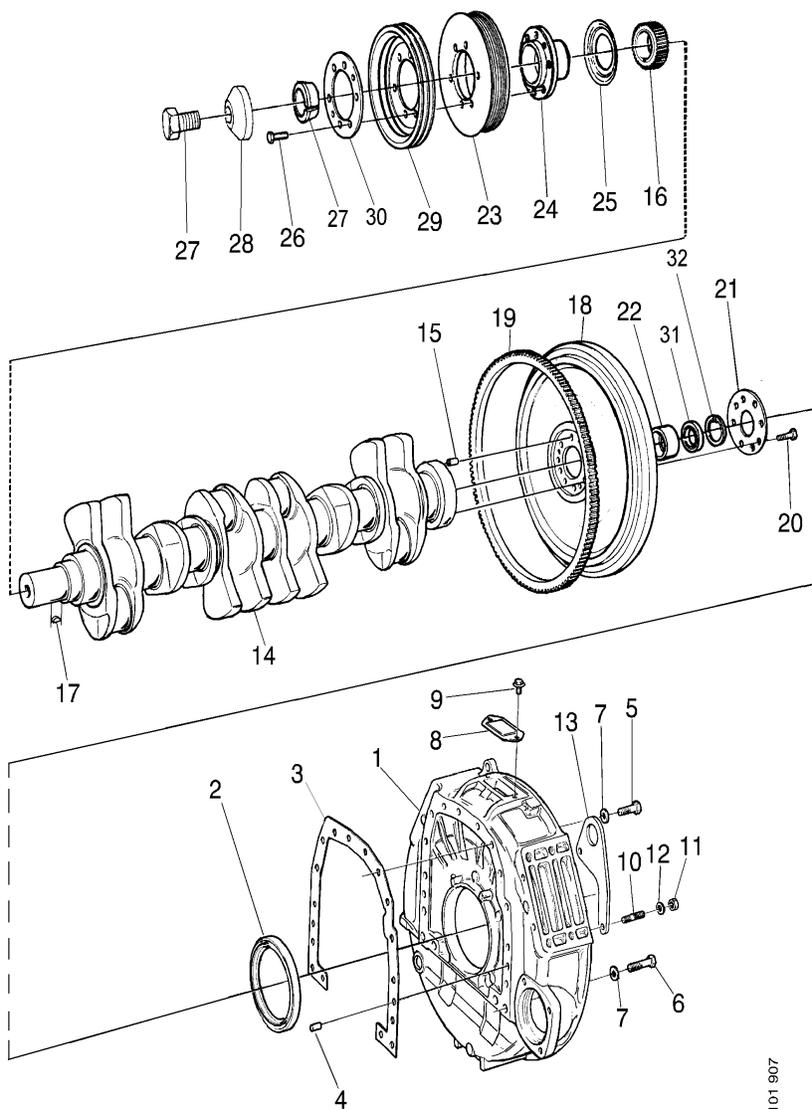
11. Check that the piston cooling nozzles are in good condition and fully open. Blow clean with compressed air, if necessary.
12. Fit the piston cooling nozzle and tighten the banjo bolt to 23 Nm.

**Note** The piston cooling nozzle must not be damaged.  
If the jet of oil does not strike the piston in the right place, there could be a danger of engine breakdown.  
Damaged nozzles *must* be changed.



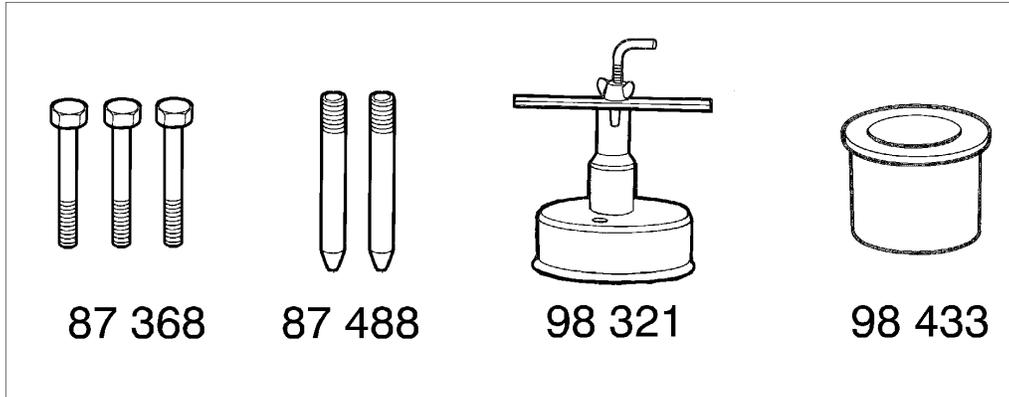
13. Fit the oil sump.
14. Fit the cylinder head.  
Tighten the cylinder head bolts as described in the *Cylinder head section*.

## Flywheel and flywheel housing



- |                     |                                 |                                   |
|---------------------|---------------------------------|-----------------------------------|
| 1. Flywheel housing | 13. Lifting eye                 | 24. Hub                           |
| 2. Shaft seal       | 14. Crankshaft                  | 25. Oil deflector                 |
| 3. Gasket           | 15. Pin                         | 26. Bolt                          |
| 4. Pin              | 16. Crankshaft gear             | 27. Taper ring                    |
| 5. Hexagon bolt     | 17. Key                         | 28. Washer                        |
| 6. Hexagon bolt     | 18. Flywheel                    | 29. Pulley (not standard)         |
| 7. Washer           | 19. Ring gear                   | 30. Washer                        |
| 8. Cover            | 20. Hexagon bolt                | 31. Ball bearing (not standard)   |
| 9. Tapping screw    | 21. Washer                      | 32. Retaining ring (not standard) |
| 10. Stud            | 22. Guide sleeve (not standard) |                                   |
| 11. Locknut         | 23. Oscillation damper          |                                   |
| 12. Washer          |                                 |                                   |

Special tools



87 368

87 488

98 321

98 433

87 368 Puller bolts

87 488 Guide pins

98 321 Assembly tool

98 433 Drift

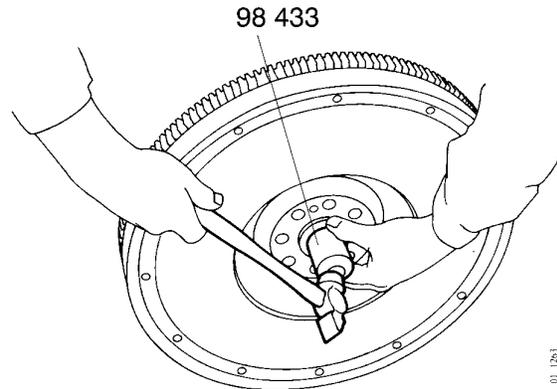
01\_1278

## Removing flywheel

1. Remove the bolts and washer.
2. Pull the flywheel off the crankshaft using puller bolts 87 368.

## Changing the support bearing, if fitted

1. Tap the support bearing out of the flywheel using a drift.
2. Fit a new support bearing using drift 98 433.



01\_1263

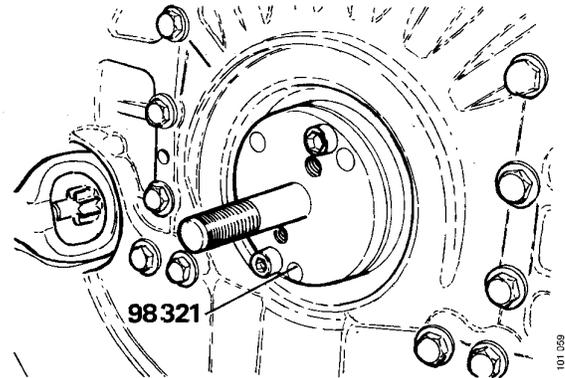
## Changing the ring gear

- Change the flywheel ring gear if the teeth have become so worn that the starter motor drive does not engage.
1. Grind as deep a groove as possible in the ring gear and split it using a cold chisel. Remove the ring gear from the flywheel.
  2. Clean contact surfaces on the flywheel using a wire brush.
  3. Heat the new ring gear so that it is at an even temperature of about 100-150 °C.

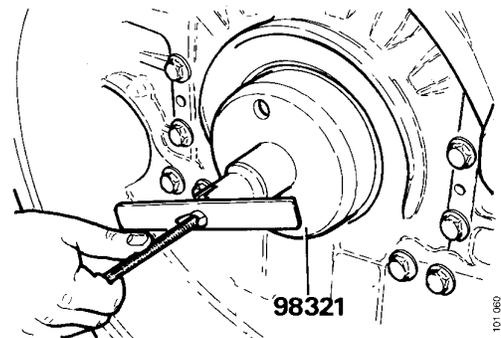
4. Place the heated ring gear on the flywheel so that the chamfer on the teeth faces the starter motor. Make sure that the ring gear abuts firmly against the flywheel.
5. If necessary, tap the ring gear in place using a plastic mallet.
6. The ring gear must not be cooled rapidly but must cool down in the open air.

### Changing crankshaft seal

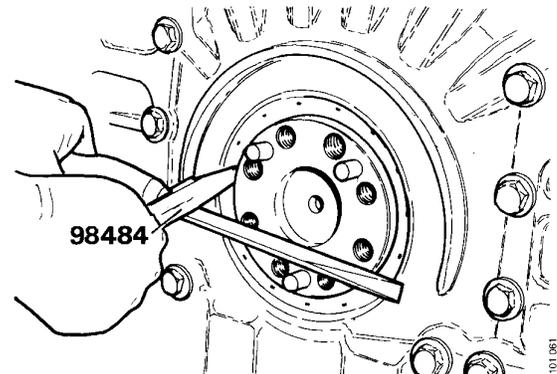
1. Bolt the inner part of assembly tool 98 321 to the crankshaft flange.



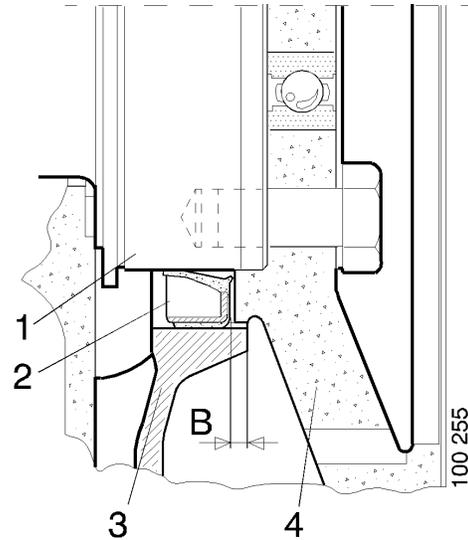
2. Fit the outer part of assembly tool 98 321 and screw it in until it abuts against the seal. Then screw in the set screw against the inner part and lock the wing nut.



3. Remove the tool and prise out the seal using tool 98 484 and a screwdriver.



**Note** The crankshaft seal should be fitted dry and must not be lubricated. The sleeve inside the seal must not be removed until immediately before the seal is fitted in place. The crankshaft must be degreased before assembly of the new seal.

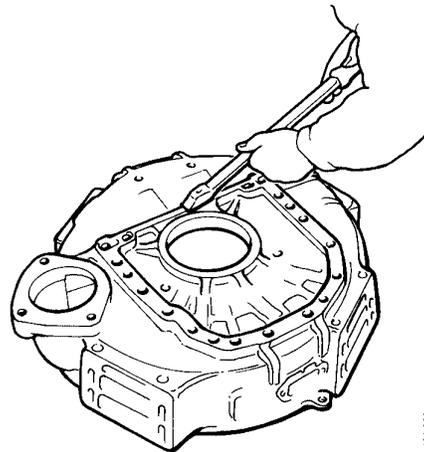


4. Fit a new crankshaft seal.
5. Fit the inner part of 98 321 again. Screw in the outer part of 98 321 until the set screw abuts against the inner part.

## Removing and fitting flywheel housing

### Changing gasket behind flywheel housing

1. Remove the starter motor.
2. Remove the 16 bolts securing the flywheel housing. Remove flywheel housing.
3. Clean the sealing surface on the flywheel housing and engine.

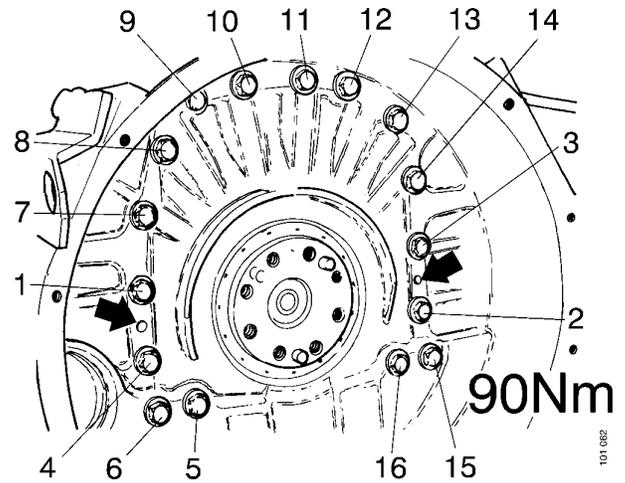


101 063

4. Fit a new gasket and mount the flywheel housing on the guide pins. Tighten the bolts to 90 Nm in the order shown in the illustration.
5. Fit a new crankshaft seal.  
(See *Changing crankshaft seal*).

**Note** The seal must always be changed when the flywheel housing has been removed.

6. Fit the starter motor.

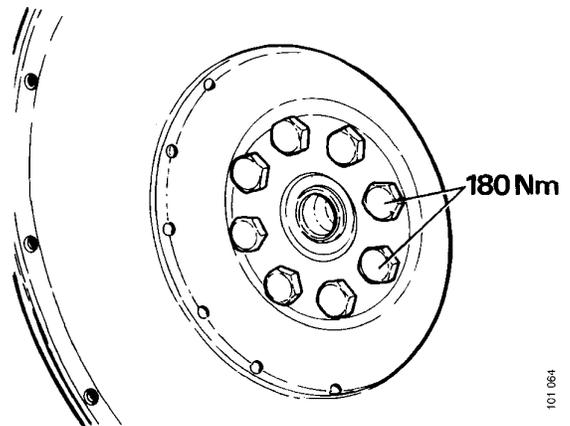


### Fitting flywheel

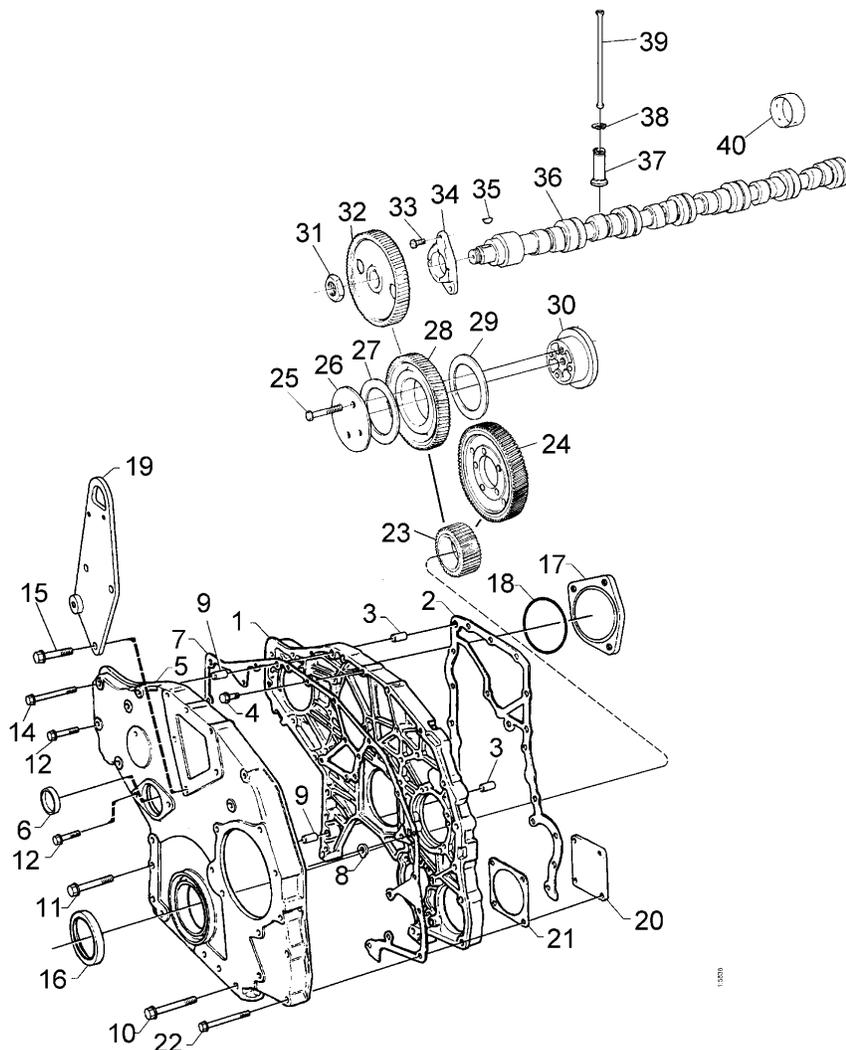
1. Fit two guide pins 87 488 in the end of the crankshaft.
2. Fit the flywheel on the crankshaft.

**Note** Always use new bolts.

3. Fit the washer and tighten the bolts to 180 Nm.

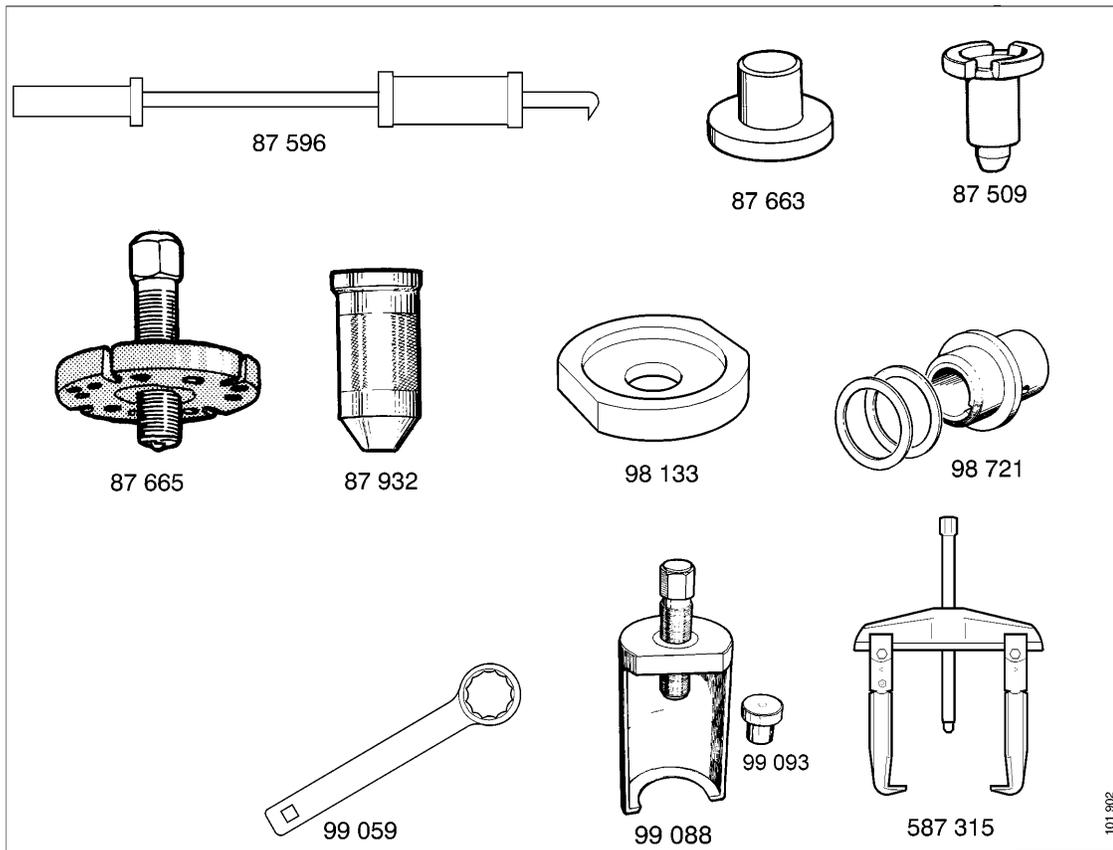


## Timing gear



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

Special tools

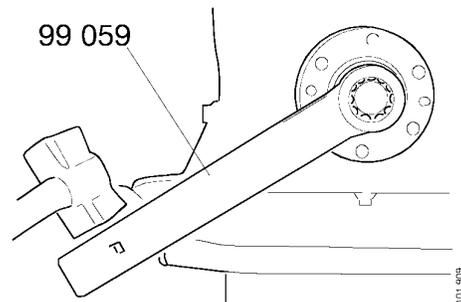


- |        |               |         |                 |
|--------|---------------|---------|-----------------|
| 87 509 | Drift         | 98 721  | Assembly tool   |
| 87 596 | Slide hammer  | 99 059  | Slogging wrench |
| 87 663 | Support drift | 99 088  | Puller          |
| 87 665 | Puller        | 99 093  | Support drift   |
| 87 932 | Drift         | 587 315 | Puller          |
| 98 133 | Washer        |         |                 |

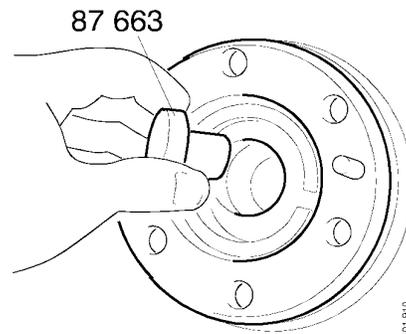
## Crankshaft seal

### Removing

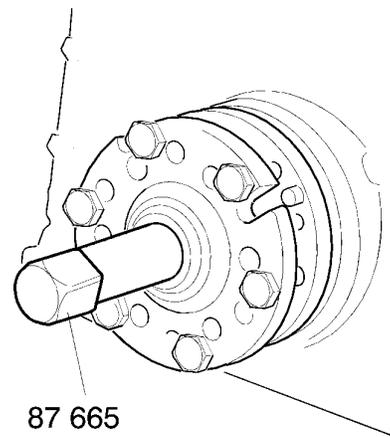
1. Remove components that are in the way: radiator, fan ring, fan or belt guard.
2. Undo the crankshaft damper bolts and those for the belt pulley, if fitted. Remove the crankshaft damper and belt pulley, if fitted.  
**Take care to avoid damaging the crankshaft damper.**
3. Remove the crankshaft bolt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



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



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

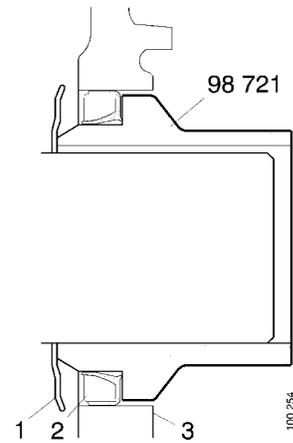


6. Pull the hub off altogether.
7. Remove the seal using slide hammer 87 596.  
Protect the end of the crankshaft against scratches.

**Fitting**

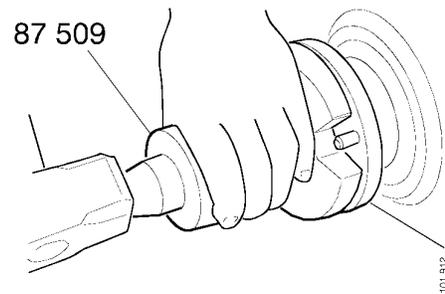
1. Wipe clean the seal seat in the housing.

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

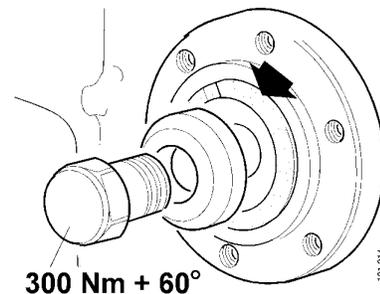
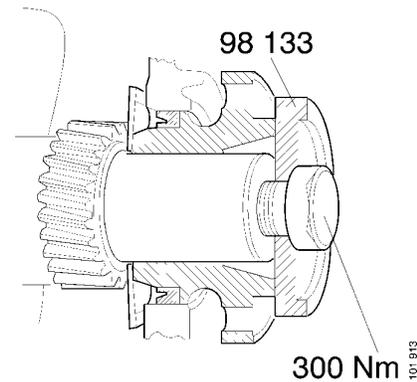


1. Oil deflector
2. Seal
3. Timing gear cover

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



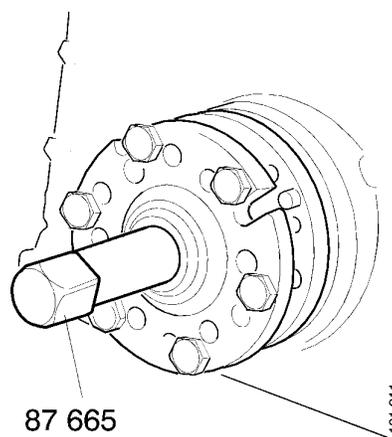
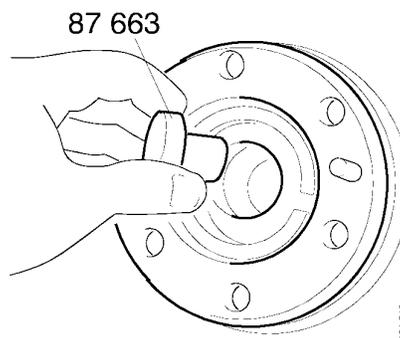
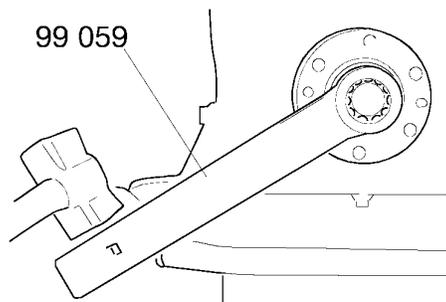
5. Remove the crankshaft bolt and washer 98 133 and fit the cone. Screw in the crankshaft bolt with attendant washer. Tighten first to 300 Nm and then a further sixth of a turn (60°) using slogging wrench 99 059.
6. Fit the oscillation damper and, if fitted, the belt pulley. Tighten the bolts to 110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



## Timing gear cover

### Removing

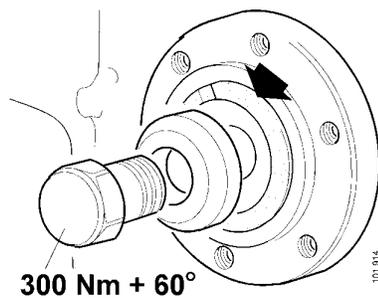
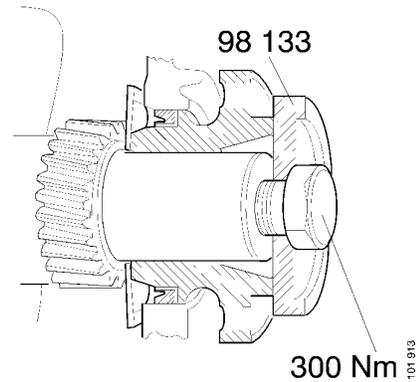
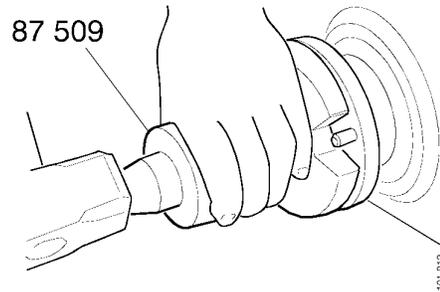
1. Remove components that are in the way: radiator, fan ring, fan, belt guard, alternator, V-belt, belt tensioner, tensioning rollers, fan drive, alternator bracket.
2. Turn the engine over to the ignition position.
3. Undo the crankshaft damper bolts and those for the belt pulley, if fitted. Remove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



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

**Fitting**

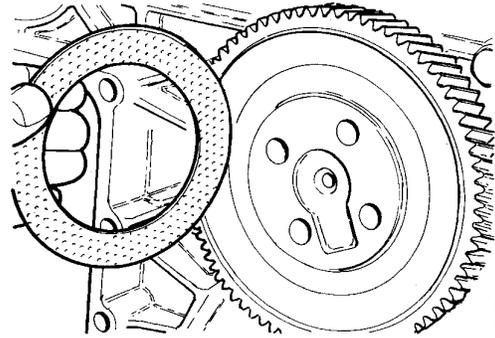
1. Clean the mating surfaces and fit a new gasket.
2. Fit the timing gear housing in place and tighten the bolts to a torque of 39 Nm.
3. Fit a new crankshaft seal.  
See *Crankshaft seal: Fitting*.
4. Drive on the oscillation damper hub using drift 87 509.
5. Fit the crankshaft bolt with washer 98 133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



## Intermediate gear

### Removing

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

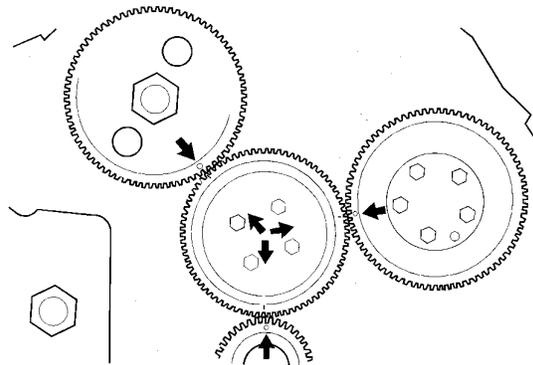


101 067

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

### Fitting

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

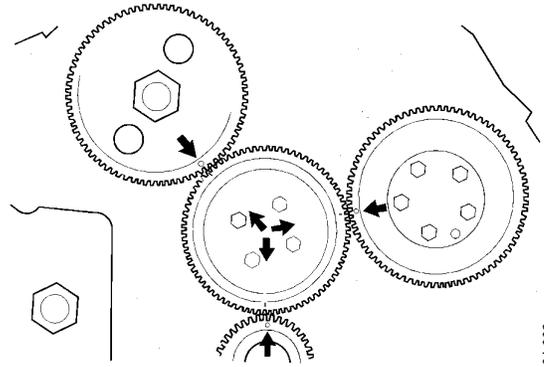


101 066

## Crankshaft gear

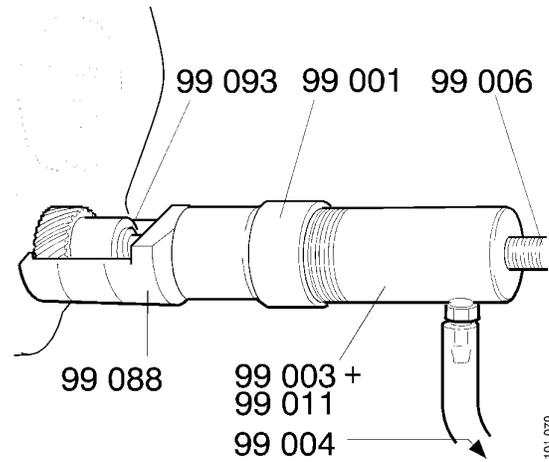
### Removing

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



101 066

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



101 070

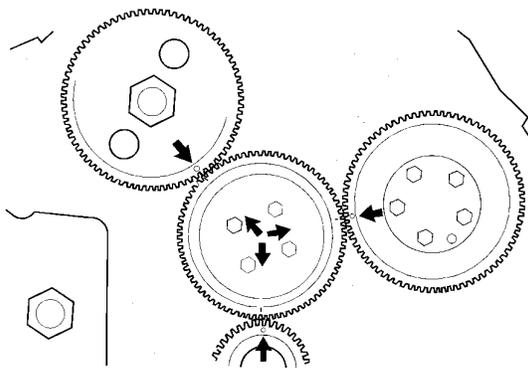
### Fitting

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

## Camshaft gear

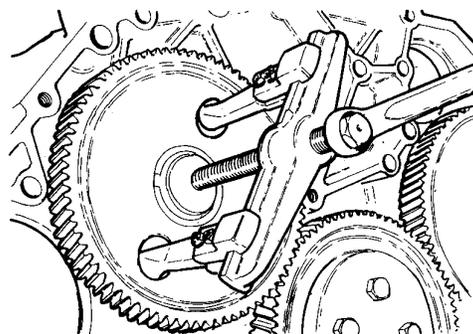
### Removing

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



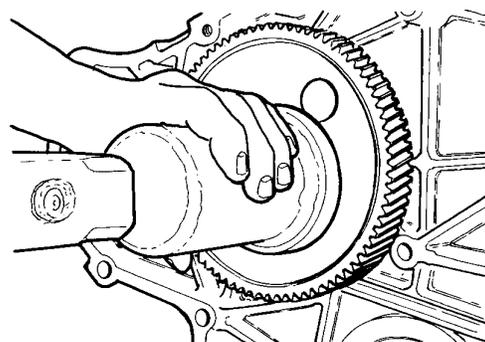
101 066

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



### Fitting

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



101 066

## Camshaft

### Removing

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

### Fitting

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

## Changing valve tappets

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

## Camshaft bearings

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

## Checking camshaft setting

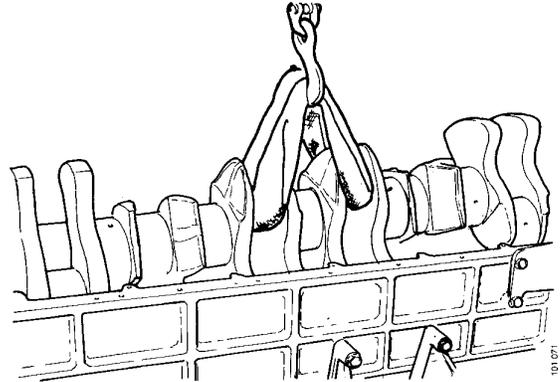
1. Set the crankshaft at TDC for No. 1 cylinder's compression stroke (valves closed).
2. Set up two dial gauges against the valve spring thrust washers.
3. Adjust the rocker arms so that there is no clearance and then an additional 0.1 mm (see that both valves are open 0.1 mm).
4. Zeroize both dial gauges.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

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

## Crankshaft

### Removing

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



### Checking and grinding

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

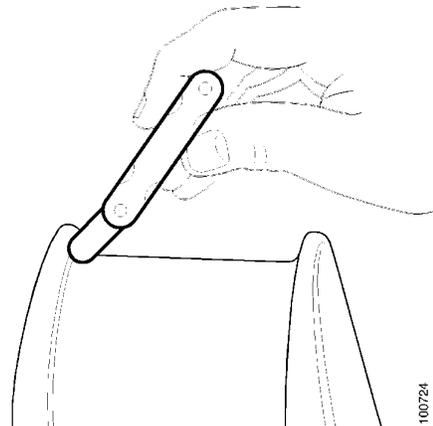
If either of these diameters is below the specified lower limit, regrinding of the crankshaft or the fitting of a replacement crankshaft should be considered.

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

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

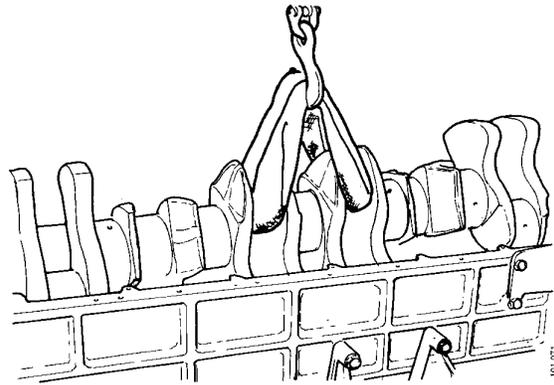
It is important that the fillet radius of the pivot pins is correct.

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

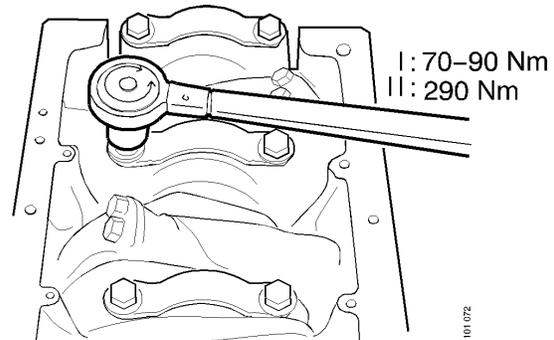


## Fitting

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

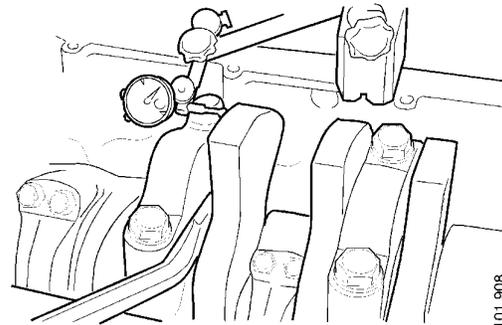


4. Lubricate the bolt threads and start by tightening the cap bolts to 90 Nm. Then tighten the bolts to 290 Nm. Check that the crankshaft rotates easily.



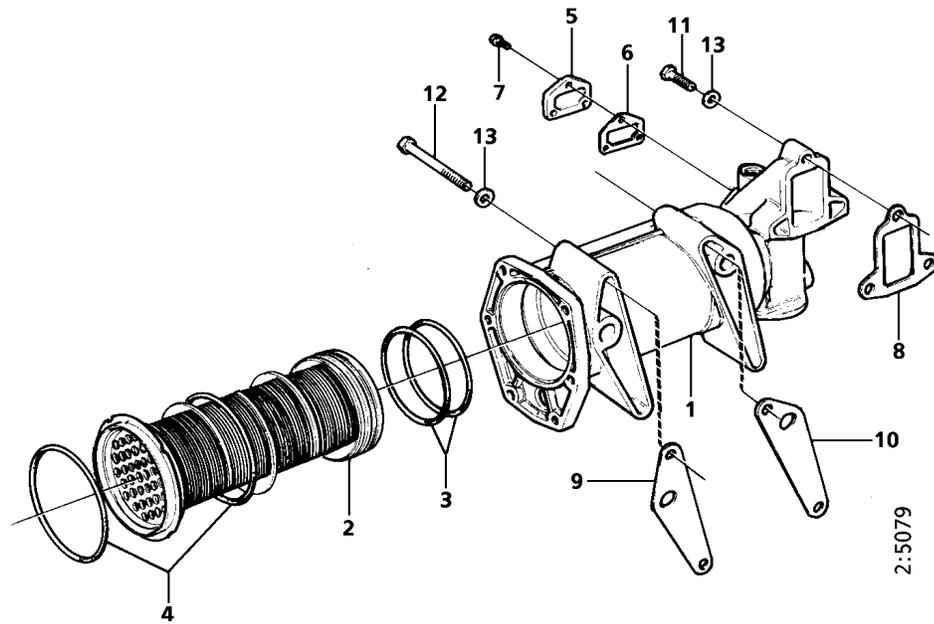
5. Check crankshaft axial clearance. It should be 0.14-0.37 mm. The clearance can be adjusted by changing the thrust bearing washers.
6. Fit pistons, connecting rods and oil pump.
7. Fit the fan bearing and fan, oil sump, timing gear housing and intermediate gear.
8. Fit the flywheel and flywheel housing.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

0.14 – 0.37



## Lubrication system

### Oil cooler

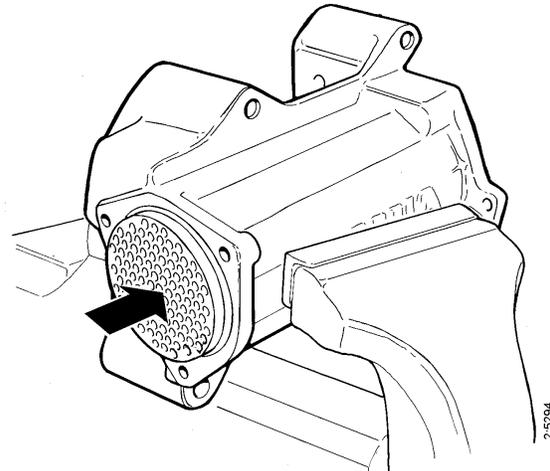


- |                       |                |                 |
|-----------------------|----------------|-----------------|
| 1. Housing            | 6. Plug        | 11. Gasket      |
| 2. Cooling element    | 7. Cover       | 12. Gasket      |
| 3. Seal               | 8. Gasket      | 13. Flange bolt |
| 4. Connection housing | 9. Flange bolt | 14. Flange bolt |
| 5. Bolt               | 10. Gasket     | 15. Flange      |

### Changing seals and oil cooler element

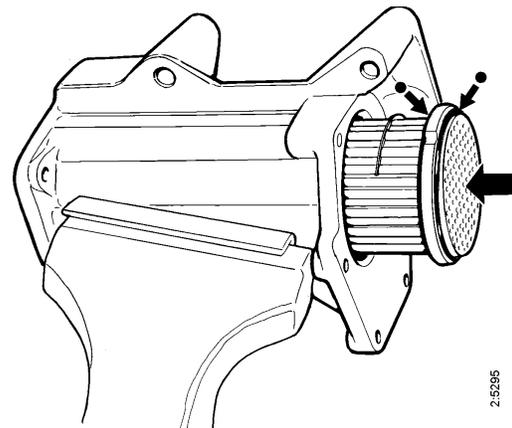
1. Remove the drive belt.
2. Drain the cooling system.
3. Remove pipes and hoses connected to the coolant pump and oil cooler.
4. Detach the oil cooler and coolant pump from the engine.
5. Unscrew the coolant pump retaining bolts and remove pump and pump housing.

6. Clamp the oil cooler in a vice fitted with soft jaws. **Do not clamp the jaws on the oil cooler's sealing surfaces.** Remove cover 7 on connection housing 4 and unscrew the connection housing.
7. Remove the O-ring and loose flange 15 and press out element 2.
8. Fit new greased O-rings on both sides of the element's flange and insert the element into the housing from the pump side.
9. Fit a new greased O-ring on the opposite side of the element and press it into the oil cooler housing.
10. Fit the loose flange and turn it to the right position.



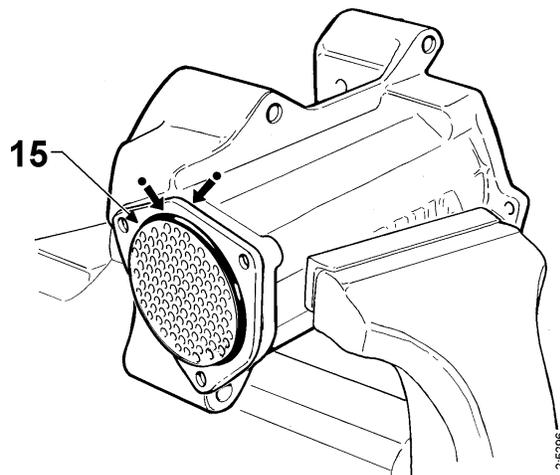
Pressing out the cooling element

11. Fit another greased O-ring outside the loose flange. Press on the connection housing and screw it in place to a tightening torque of 20 Nm. Fit the cover on the connection housing.



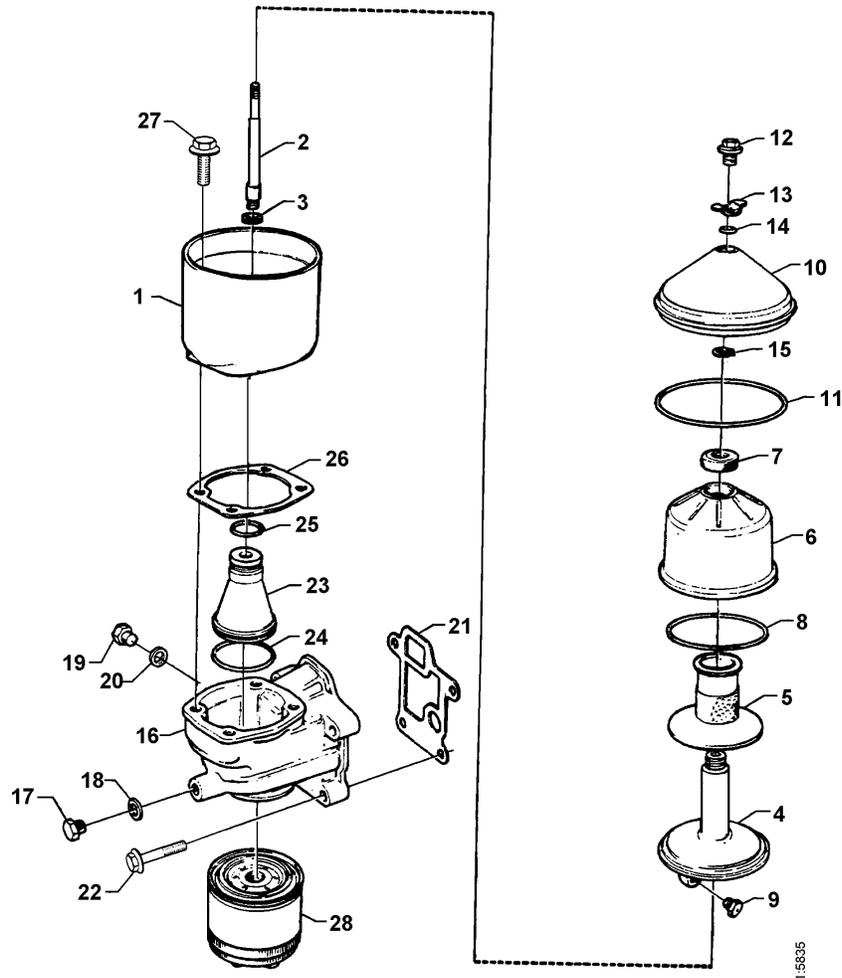
Inserting the element into the housing with new O-rings

12. Turn the element to the right position and screw on the pump housing and coolant pump with a new gasket in between. Tighten the flange bolts to 42 Nm.
13. Attach the oil cooler unit to the engine. Use new gaskets. Tighten the flange bolts to 42 Nm.
14. Connect the pipes and hoses that were previously detached.
15. Fit the drive belt.
16. Fill the cooling system with coolant. See *Oils, lubricants, liquids*, section 0 for the composition of the coolant.



Fitting new O-rings and the loose flange

# Oil cleaner

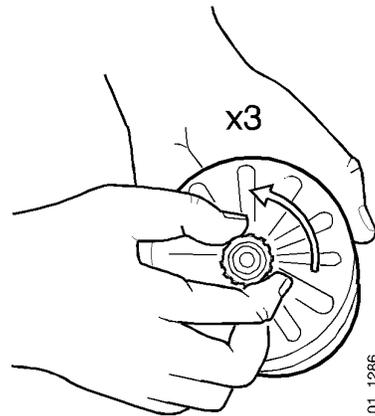


- |                  |                     |                 |
|------------------|---------------------|-----------------|
| 1. Rotor housing | 11. O-ring          | 21. Gasket      |
| 2. Shaft         | 12. Locking screw   | 22. Flange bolt |
| 3. Washer        | 13. Washer          | 23. Cyclone     |
| 4. Rotor         | 14. O-ring          | 24. O-ring      |
| 5. Strainer      | 15. Retaining ring  | 25. O-ring      |
| 6. Rotor bowl    | 16. Cyclone housing | 26. Gasket      |
| 7. Nut           | 17. Plug            | 27. Flange bolt |
| 8. O-ring        | 18. Gasket          | 28. Oil filter  |
| 9. Nozzle        | 19. Plug            |                 |
| 10. Cover        | 20. Gasket          |                 |

## Dismantling and assembly

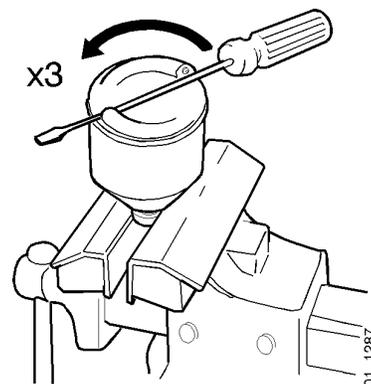
- During routine cleaning of the oil cleaner, it should be found that a certain amount of dirt has been deposited in the rotor bowl.
- If this is not the case, it indicates that the rotor is not turning. The cause of this must be investigated immediately.
- If it is found at the recommended cleaning intervals that the dirt deposits exceed 20 mm, the rotor bowl should be cleaned more often.

1. Unscrew the locknut securing the outer cover and remove the cover.
2. Lift out the rotor. Wipe the outside clean. Slacken the rotor nut and unscrew it about three turns to protect the bearing.



**Note** Never clamp the rotor in a vice.  
 Never strike the rotor bowl.  
 This could give rise to consequential damage which might cause imbalance.

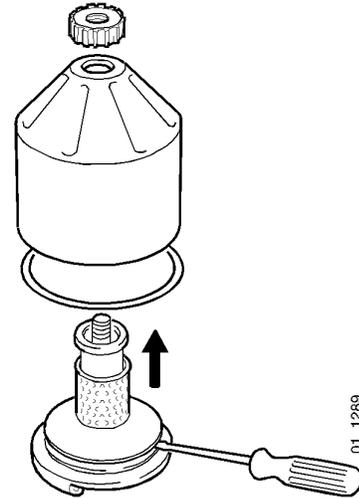
3. If it is difficult to loosen the rotor nut, turn the rotor upside down and clamp the rotor nut in a vice.
4. Turn the rotor anticlockwise three turns by hand or, if this does not succeed, by placing a screwdriver between the outlet holes.



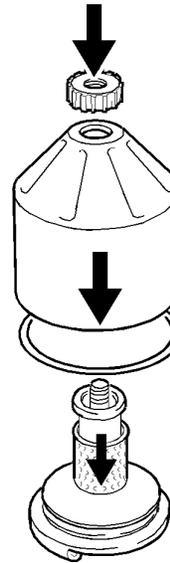
5. Hold the rotor bowl and tap the rotor nut lightly with your hand or with a plastic mallet until the rotor bowl comes away from the rotor.

**Note Never hit the rotor directly as this could damage its bearings.**

6. Remove the rotor nut and bowl from the rotor.
7. Remove the rotor insert from inside the rotor. If the strainer is stuck, carefully prise it loose using a knife inserted at the bottom between rotor and strainer.
8. Scrape the deposits off the inside of the bowl using a knife.
9. Wash the parts.
10. Check the two nozzles on the rotor. Make sure that they are not blocked or damaged. Change damaged nozzles.
11. Check that the bearings are not damaged.
12. Place the O-ring in position in the bowl. Change the O-ring if it is even slightly damaged.

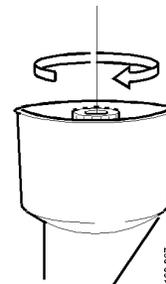


13. Assemble the parts and tighten the rotor nut hard by hand.
14. Check that the shaft is not loose. If it is, it should be locked using locking compound 561 200. First clean it thoroughly with a suitable solvent.
15. Tighten the rotor shaft using socket wrench 98 421. Tightening torque 34 Nm.



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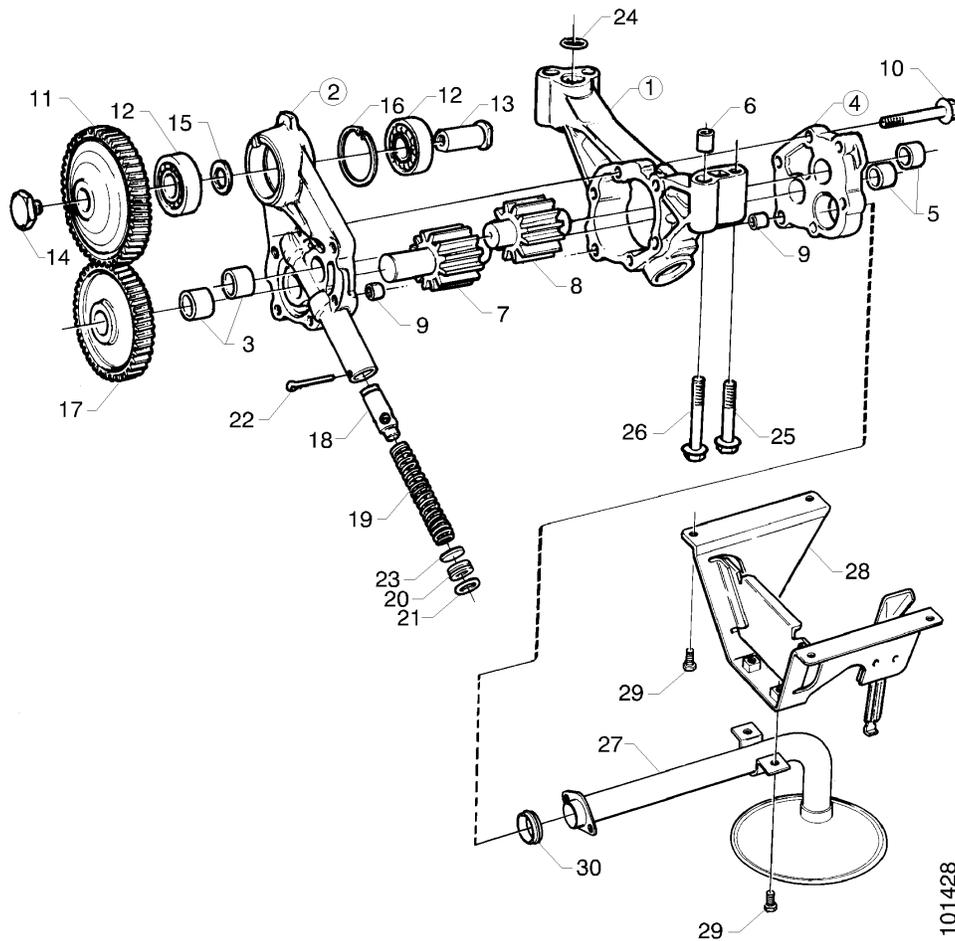
16. Refit the rotor and spin it by hand to make sure that it turns easily.
17. Check the O-ring on the cleaner housing cover and fit the cover, securing it with the locknut. Tighten the locknut to 10 Nm.



100 237

## Oil pump

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



- |                     |                        |                  |
|---------------------|------------------------|------------------|
| 1. Oil pump housing | 11. Oil pump gearwheel | 21. O-ring       |
| 2. Oil pump cover   | 12. Ball bearing       | 22. Split pin    |
| 3. Bushing          | 13. Shaft              | 23. Shim         |
| 4. Oil pump cover   | 14. Bolt               | 24. O-ring       |
| 5. Bushing          | 15. Spacing ring       | 25. Flange bolt  |
| 6. Guide sleeve     | 16. Retaining ring     | 26. Flange bolt  |
| 7. Pump wheel       | 17. Oil pump gearwheel | 27. Suction pipe |
| 8. Pump wheel       | 18. Piston             | 28. Bracket      |
| 9. Guide sleeve     | 19. Spring             | 29. Flange bolt  |
| 10. Flange bolt     | 20. Plug               | 30. Seal         |

101428

## Lifting the engine

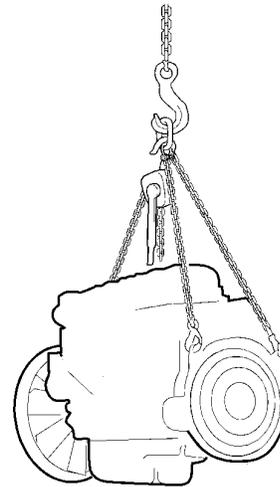
### Special tools

**Note** The engine lifting eyes are sized for lifting the engine only, not the engine together with connected equipment (alternator, gearbox, etc.) or frame.

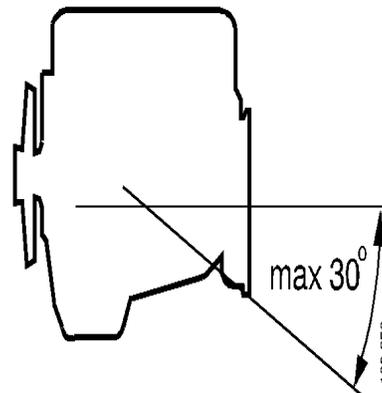


98 094 Lifting chain  
587 308 Lever block

- Fasten lifting chain 98 094 in the rear lifting eyes.
- Fasten lever block 587 308 in the front lifting eyes.



**Important** The lifting eyes are sized for a maximum lifting angle of 30°.



# Specifications

## General information

Cylinder configuration.....	In-line engine
Number of cylinders .....	6
Cylinder bore .....	115 mm
Stroke .....	144 mm
Swept volume .....	8.97 dm <sup>3</sup>
Number of main bearings .....	7
Firing order .....	1-5-3-6-2-4
Injection.....	Direct
Operation.....	4 stroke
Cooling .....	Liquid
Approx. weight, incl. alternator.....	805 kg
Direction of rotation (engine viewed from rear).....	anticlockwise

Compression ratio	} See Operator's Manual.
Output	
Engine speed	
Torque	
Oil capacity	
Oil grade	

## Locking compound, lubricants, sealing compounds

T Activator for faster curing of locking compound 561 200.....	561 045
Locking compound.....	561 200
Lubricant for exhaust pipe bolts and joints.....	561 205
Sealant for cylinder liner.....	584 010
Thread-locking adhesive.....	561 019

## Cylinder head

Minimum cylinder head height after machining, page 17.....	114.4 mm
Distance "B" between cylinder head surface and valve head, page 11	
With new parts, min.....	0.78 mm
With machined parts, max.....	1.80 mm

## Intake valve

Clearance (cold engine).....	0.45 mm
Head angle.....	19.4°-19.6°
Minimum dimension A for machined valve, page 10.....	3.0 mm

**Exhaust valve**

Clearance (cold engine) .....	0.80 mm
Head angle .....	44.4°-44.6°
Minimum dimension A for machined valve, page 10 .....	1.7 mm

**Intake valve seat**

Seat angle .....	20.0°
Contact surface width A, page 11 .....	2.3 - 2.8 mm
Valve seat ring OD .....	53.066 - 53.079 mm
Position for valve seat ring, diameter .....	53.000 - 53.019 mm
Position for valve seat ring, depth .....	11.25 - 11.35 mm

**Exhaust valve seat**

Seat angle .....	45.0°
Contact surface width A, page 11 .....	1.9 - 2.6 mm
Valve seat ring OD .....	49.081 - 49.092 mm
Position for valve seat ring, diameter .....	49.000 - 49.016 mm
Position for valve seat ring, depth .....	11.25 - 11.35 mm

**Valve guides**

Length, intake .....	68.2 mm
exhaust .....	68.2 mm
Height above surface for valve guide:	
intake .....	16.7 mm
exhaust .....	16.7 mm

**Rocker arm mechanism**

Rocker arm bushing, ID (pressed in and machined) .....	30.007 - 30.028 mm
Surface quality .....	0.8 Ra
Oil hole diameter drilled to same diameter as in rocker arm.	

## Tightening torques

Cylinder head bolts:	
First tightening . . . . .	60 Nm
Second tightening . . . . .	150 Nm
Third tightening . . . . .	250 Nm + 90°
Injector nut . . . . .	70 Nm
Nut for adjusting screw on rocker arm . . . . .	40 Nm
Rocker cover bolt . . . . .	20 Nm
Exhaust manifold bolts . . . . .	50 Nm
Rocker arm mechanism bolts . . . . .	150 Nm

## Turbocharger

### Wear limits

Radial shaft clearance . . . . .	0.329-0.501 mm
Axial shaft clearance (after running in) . . . . .	0.038-0.093 mm

### Tightening torques

Bolts, turbocharger - exhaust pipe . . . . .	40 Nm
Hose clip, exhaust . . . . .	5 Nm

## Pistons and cylinder liners

### Cylinder liner

Shims for cylinder liner, thickness . . . . .	0.20, 0.25, 0.30, 0.40, 0.50, 0.75 mm
Cylinder liner height above cylinder block . . . . .	0.27 - 0.33 mm
Maximum permitted height difference on individual liner between measurements read at two diametrically opposite points across the engine . . . . .	0.035 mm

## Pistons

Fitted with arrow on piston crown facing forwards.

## Piston rings

Number of compression rings . . . . .	2
Gap: 1st ring . . . . .	0.4 - 0.75 mm
2nd ring . . . . .	0.3 - 0.6 mm
Clearance in groove max 2nd ring . . . . .	0.25 mm

Rings marked "TOP" should be turned with the marking facing upwards.

Number of oil scraper rings . . . . .	1
Gap . . . . .	0.3 - 0.55 mm
Clearance in groove max. . . . .	0.25 mm

## Connecting rods

Connecting rods and caps marked 1 to 6.

Fitted with marking facing inwards.

## Tightening torques

Bolts for tension lugs when pressing down cylinder liner . . . . .	50 Nm
Oil sump bolts . . . . .	20 Nm
Connecting rod bolts (oiled threads). . . . .	20 Nm + 90°

## Flywheel and flywheel housing

### Flywheel

Maximum machining of contact surface for plate: See group 4, Clutch

### Ring gear

Heated to 100 - 150 °C before fitting.

## Flywheel housing

Seal in flywheel housing: Dimension B, page 43 . . . . . 7 mm

## Tightening torques

Flywheel bolts . . . . . 180 Nm

Bolts for flywheel housing . . . . . 90 Nm

## Timing gear

### Camshaft gear

Heated to 100 °C before fitting.

Backlash against intermediate gear . . . . . 0.03 - 0.18 mm

### Injection pump gear

Backlash against intermediate gear . . . . . 0.03 - 0.16 mm

### Intermediate gear

Axial clearance max . . . . . 0.23 mm

### Power take-off gear

Backlash against intermediate gear . . . . . 0.03 - 0.18 mm

### Camshaft

Axial clearance . . . . . 0.15 - 0.30 mm

**Crankshaft**

Main bearing races . . . . .	Diameter:	
	Standard	95.000 - 94.978 mm
	Undersize 1	94.750 - 94.728 mm
	Undersize 2	94.500 - 94.478 mm
	Undersize 3	94.250 - 94.228 mm
	Undersize 4	94.000 - 93.978 mm
	Undersize 5	93.750 - 93.728 mm
	Undersize 6	93.500 - 93.228 mm
	Fillet radius	4.75 - 4.85 mm
	Surface quality	0.25 Ra
	Width, max	46.78 mm
	Bearing clearance	0.054 - 0.116 mm

Big-end bearing journals . . . . .	Diameter:	
	Standard	80.000 - 79.981 mm
	Undersize 1	79.750 - 79.731 mm
	Undersize 2	79.500 - 79.481 mm
	Undersize 3	79.250 - 79.231 mm
	Undersize 4	79.000 - 79.981 mm
	Undersize 5	78.750 - 78.731 mm
	Undersize 6	78.500 - 78.481 mm
	Fillet radius	4.8 - 5.2 mm
	Surface quality	0.25 Ra
	Width, max	53.10 mm
	Bearing clearance	0.050 - 0.112 mm

Thrust bearing . . . . .	Thickness:	
	Standard	3.38 - 3.43 mm
	Oversize 1	3.46 - 3.51 mm
	Oversize 2	3.51 - 3.56 mm
	Oversize 3	3.64 - 3.69 mm
	Oversize 4	3.89 - 3.94 mm
	Oversize 5	4.27 - 4.32 mm
	Axial clearance	0.14 - 0.37 mm

## Tightening torques

### Tightening torques

Nut for camshaft gear .....	600 Nm
Nut for compressor gear .....	200 Nm
Bolts for intermediate gear shaft journal.....	49 Nm
Main bearing bolts:	
Stage I .....	70-90 Nm
Stage II .....	290 Nm
Flywheel bolts .....	180 Nm
Crankshaft bolt .....	300 Nm+60°
Fan.....	30 Nm

## Lubrication system

### Oil pump

#### Backlash:

Crankshaft gear - intermediate gear on oil pump .....	0.03 - 0.36 mm
Intermediate gear - crankshaft gear .....	0.03 - 0.16 mm

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

#### Oil pressure:

With hot engine at 2000 rpm.....	4-6 bar
With hot engine at 800 rpm.....	min. 1.5 bar

Free spring length .....	98 mm
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### Oil cleaner

Permitted thickness of deposits on wall of bowl.....	20 mm
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### Oil filter

Use only genuine Scania filters (screwed on by hand).

**Tightening torques****Oil pump:**

Bolts for oil pump cover . . . . .	22 Nm
Bolts, oil pump - cylinder block . . . . .	42 Nm
Lock bolt (left-hand thread) for intermediate gear . . . . .	40 Nm

**Oil cleaner:**

Locknut for oil cleaner housing cover . . . . .	10 Nm
Nut for rotor bowl . . . . .	Tighten by hand
Rotor shaft. . . . .	34 Nm

**Oil nozzle for piston cooling:**

Banjo bolt . . . . .	23 Nm
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## Special tools

Part number	Designation	Shown on page
87 125	Puller	4, 8
87 198	Straight-edge for dial gauge	25, 30
87 362	Drift	25, 29
87 368	Puller bolt	40
87 488	Guide pins	43
87 509	Drift	45, 47, 49
87 596	Slide hammer	45, 46, 48
87 663	Support drift	45, 46, 48
87 665	Puller	45, 46, 48
87 932	Drift	45, 51
87 961	Drift	4, 15
98 075	Dial gauge	25, 30
98 094	Lifting chain	64
98 133	Washer	45, 47, 49
98 323	Piston ring compressor	25, 36
98 249	Compression tester	4, 6
98 321	Assembly tool	39, 41
98 421	Socket wrench	62
98 433	Drift	39, 40
98 500	Shank	4, 11
98 503	Drift	11
98 515	Pressing tool	28, 33
98 622	Press drift	4, 14
98 721	Assembly tool	45, 47

<b>Part number</b>	<b>Designation</b>	<b>Shown on page</b>
99 003	Hydraulic hole cylinder	30
99 007	Support plate	30
99 059	Slogging spanner	45, 46, 48
99 066	Puller for cylinder liner	25, 30
99 074	Impact drift	4, 8
99 079	Extractor for injectors	4, 8
99 088	Puller	45, 51
99 093	Drift	45, 51
99 195	Valve spring compressor	4, 9, 17
99 196	Valve spring compressor	4, 9, 17
99 241	Assembly tool	36
99 246	Drift	15
99 247	Assembly drift	4, 9
99 308	Socket for injectors	4, 8, 18
99 310	Sleeve	4, 18
587 025	Filter wrench	19
587 107	Out-of-true indicator	21, 22
587 110	Test device for connecting rods	25, 28
587 250	Measuring stand	19, 21, 22
587 272	Cylinder liner cutter with grooving tool	25, 31, 32, 33, 34
587 277	Valve seat cutter	4, 11, 1
587 308	Lever block	64
587 309	Piston ring pliers	25,27
587 315	Puller	45, 52, 53
587 692	Engine stand	4