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## DESCRIPTION

The engine is of the four cylinder in line type with onhead camshaft timing controlled by a drive belt, two valves per cylinder, turbine type air boosting system IHI, and indirect injection with low turbulence combustion prechamber.

The clutch - gearbox unit is connected behind the engine and forms an integral part of the engine unit. It is front mounted and set transversally at an inclination of 18°30' forwards.

It is installed on the frame by suspension type mounts and fixed by two elastic damping supports at the front and by an elastic damping fork type support at the rear.

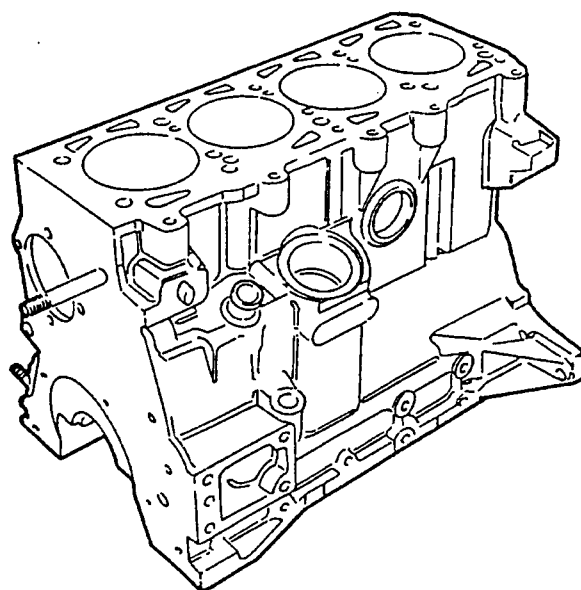
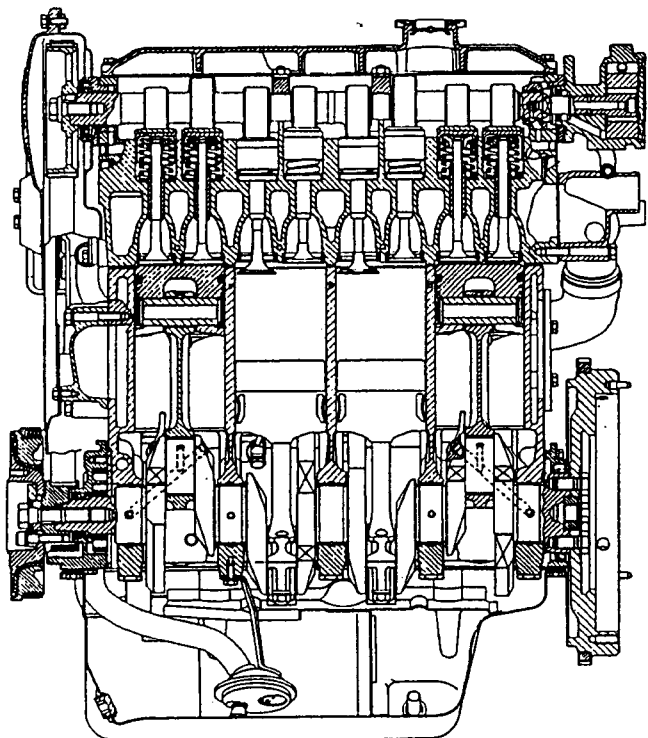
## ENGINE BLOCK

This is a single block in iron with a high mechanical resistance.

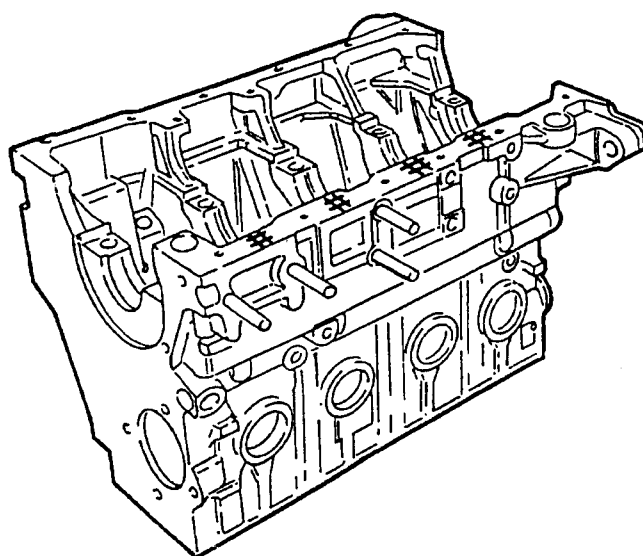
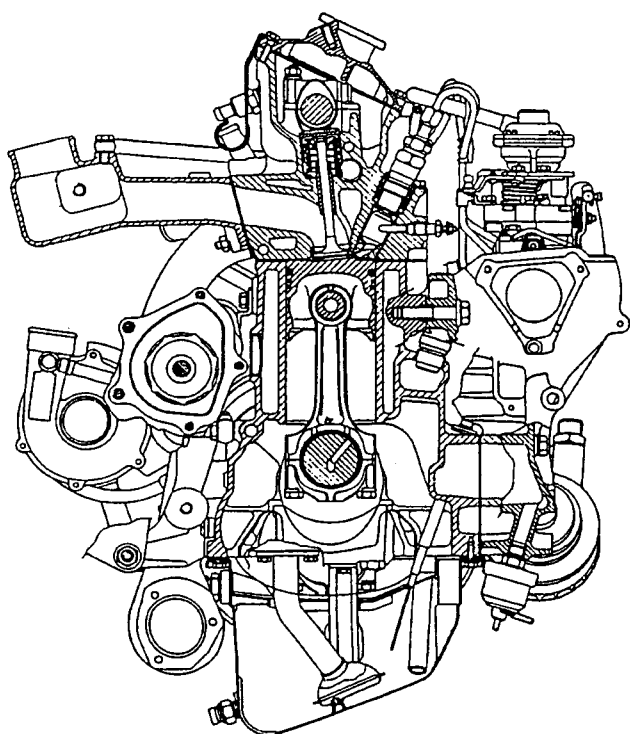
The crankshaft is supported by five main supports which also house the same number of bearing halves with thin shells.

The cylinder liners are the integral type.

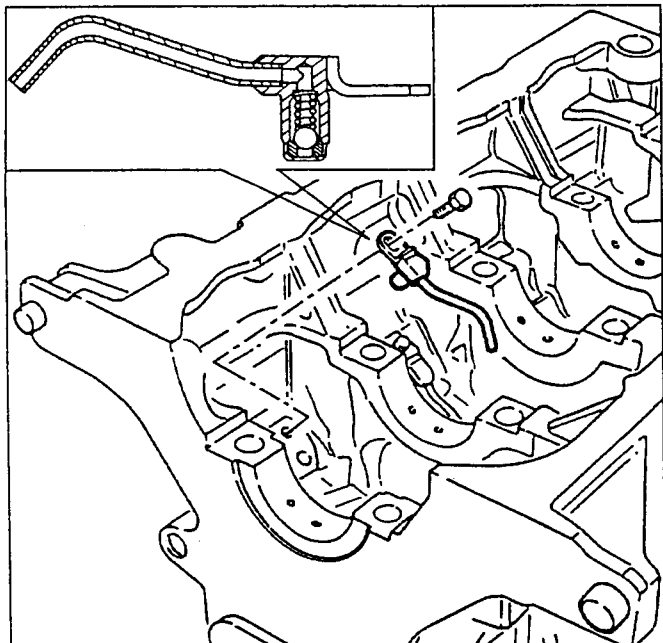
Grooving in the walls of the block allow circulation of engine coolant and lubricating oil.



The letters showing which class the cylinder liners belong to are printed on the block in the position shown in the figure below.

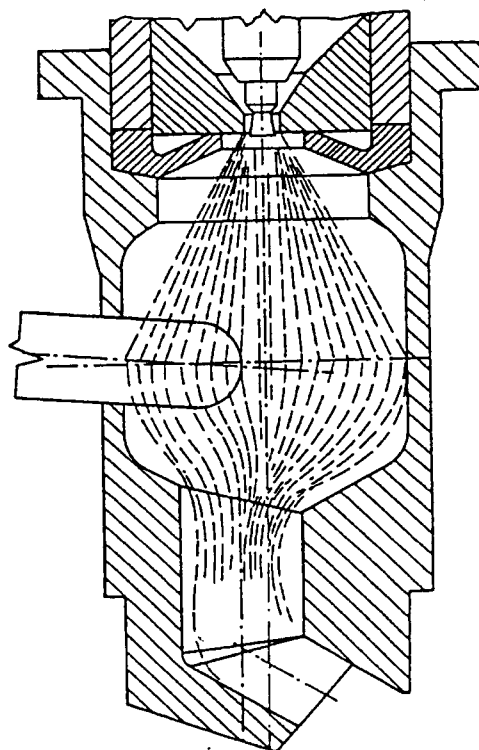


The lower part of the engine houses an oil spray jet which cools the piston skirt and lubricates the gudgeon pin.



The steel, low turbulence type precombustion chambers are positioned in suitable housings and fixed by a ring nut, within which the injector is then screwed. The seatings for the heater plugs are located in the lower part of the cylinder heads; the incandescence bulb is inserted into a suitable hole in the precombustion chamber and is consequently in direct contact with the injected fuel.

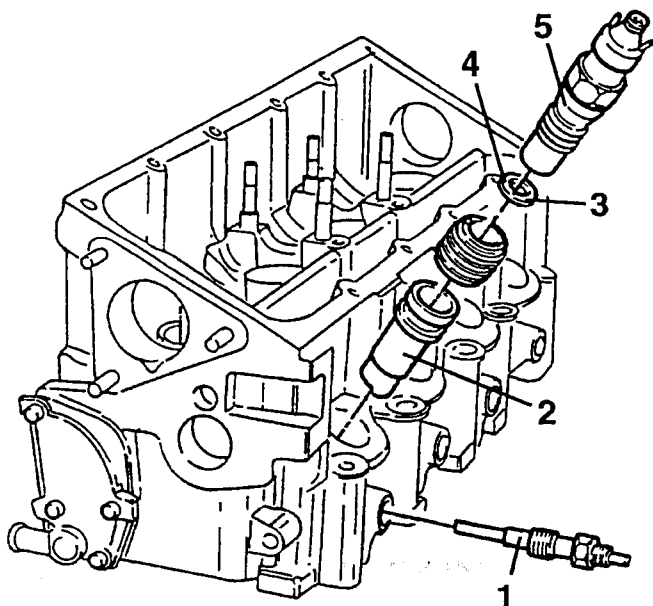
In the precombustion chamber, which is shaped like two offset cylinders, the compressed air from the piston hits the conic jet of fuel injected: the front of the flame uses up the whole amount of oxygen, and continues through the sump and flows into the cylinder. In this way, combustion is rather "slow", which is indispensable if the engine is to run softly and silently.



## CYLINDER HEADS

They are the monolith type, compact and chill cast in an aluminium and silicon alloy.

The seatings housing the precombustion chambers and the injectors are found on the cylinder heads.



1. Heater plugs
2. Precombustion chamber with washer
3. Bushing securing precombustion chamber in cylinder head
4. Engine compression elastic sealing washer
5. Injector

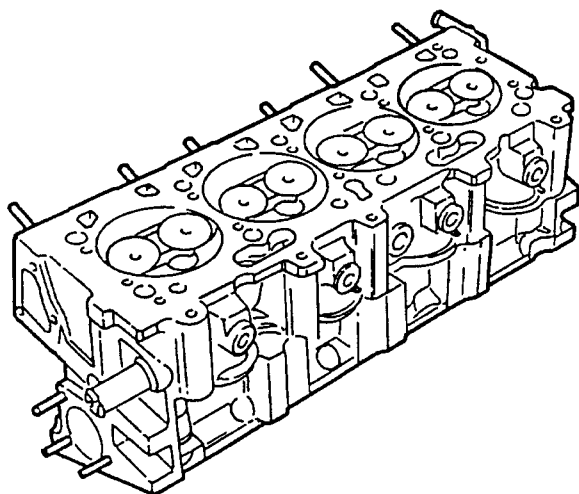
The cam shaft is supported by four supports; the front and rear ones are removable and the central ones are obtained from the cylinder heads.

The valve guides are fitted in the relative seatings of the cylinder heads with interference and the internal diameter is then perfected, after assembly, with a specific boring machine and checked by a pair of "fit-does not fit" gauges.

The seal between the cylinder heads and the engine block is the ASTADUR type.

This seal, due to the special material from which it is made, undergoes a polymerization process when the engine is running, and hardens significantly during use; adopting this type of seal, it is no longer necessary to tighten the cylinder head at the first service.

The cylinder head seal is supplied in three different thicknesses and the correct one is chosen on the basis of the average protrusion of the pistons from the upper surface of the engine block; this maintains the compression ratio within the prescribed limits.

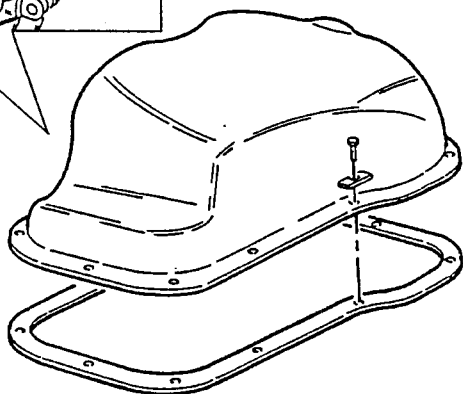
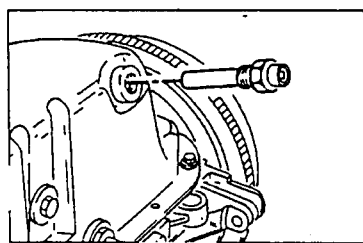


### OIL SUMP

Made from stamped plate, it is also fitted with anti-splash walls.

The oil sump also contains the seating of the engine oil temperature sensor and the oil return from turbo-charger connection is also fitted here.

A suitably positioned gasket acts as seal between the sump and the engine block.



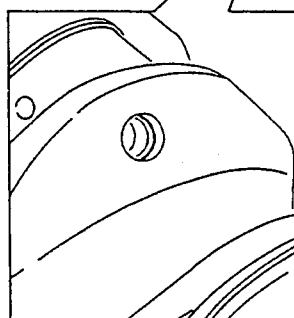
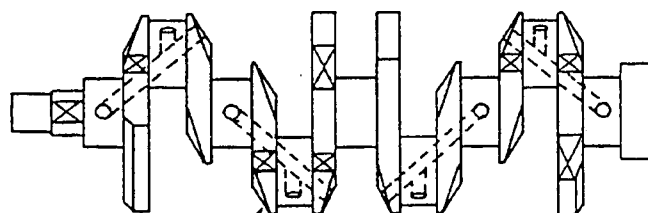
After the interventions to grind down the main and rod journals, the crankshaft should be again subjected to the nitriding treatment, to reset its initial characteristics.

After this operation, the crankshaft should be checked to ensure that the deformation falls within prescribed limits, and that it can not be straightened; otherwise it must be replaced.

The crankshaft rests on five main supports and the radial clearance is regulated by two half rings housed on the rear main support.

Eight counterweights ensure that the rotating masses are equally balanced.

A channel runs inside the shaft to lubricate the main and rod journals. The machining holes on these channels are blocked with plugs; when the engine is overhauled they should be removed and cleaned thoroughly.



### MAIN AND ROD BEARING HALVES

They are the thin shell, three metal type and are divided into two dimensional classes, they are supplied to parts in another five decrease classes.

The main bearing halves have three holes to lubricate the main journals.

### FLYWHEEL

Made from cast iron, with a ring gear in tempered steel, it is suitably balanced.

The flywheel has a precise position which must be respected during assembly; after the pistons of the first and fourth cylinders have been brought to T.D.C. the flywheel must be assembled making sure that the notch engraved on it faces upwards.

### CRANKSHAFT

This is forged in a high resistance steel alloy and hardened and tempered.

In order to improve its mechanical resistance and wear characteristics, the crankshaft is subjected to a soft nitriding treatment.

## PISTONS AND RODS

The pistons are made from an aluminium-silicium alloy and are divided into five dimensional classes. The crown of the piston has a lift which connects with the combustion chamber of the cylinder heads.

The hole of the grudgeon pin is in axis with respect to the piston axis.

Close to the second and third seal ring housings, there are two grooves. The first is a labyrinth which reduces the passage of combustion gases in the sump, so as to reduce the formation of oil vapours; the second one serves to collect the oil "scraped" from the two rings to avoid it entering the combustion chamber.

The seating of the first seal ring is made on a molybdenum coating.

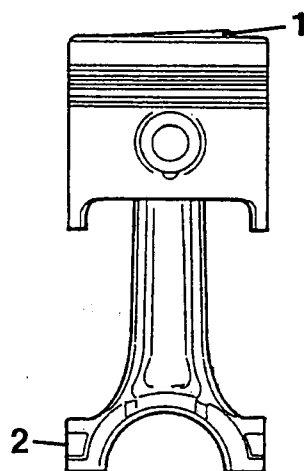
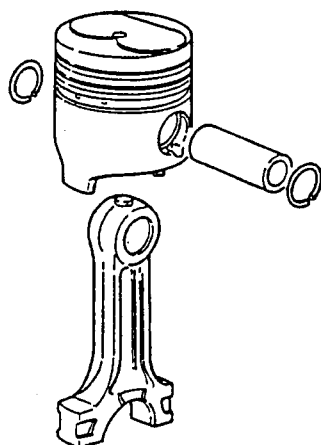
There are three seal rings: the first, seal type, is surface treated with a molybdenum coating, the second is the seal and oil scraper type, the third is the spring oil scraper type.

The visible scanco at the base of the piston skirt stops it from interfering with the oil sprayer in the engine block at B.D.C.

The rods are in tempered and hardened steel, with a copper alloy bushing fixed for connection to the piston grudgeon pin.

As the grudgeon pins are floating on both the piston hubs and the bushing fixed at the foot of the rod, they are stopped from moving laterally by two expanding elastic rings which are housed in the grooves on the hubs themselves.

The piston - rod connection must be made so that the lower part of the lift (1) on the piston is facing the same way as the number of the cylinder (2) to which the rod belongs stamped on it.

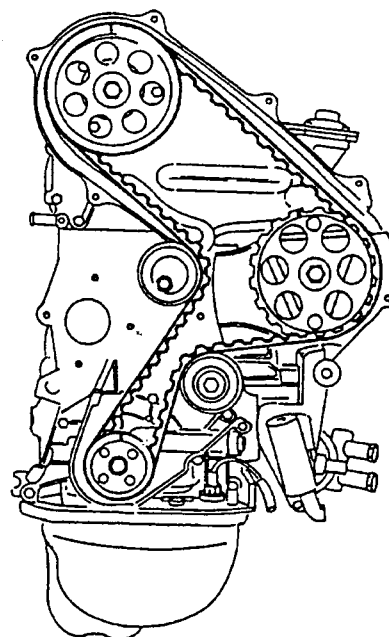


1. Lift on piston crown
2. Number of cylinder to which rod belongs.

The installation of the piston - rod assembly must be done in such a way that the numbers stamped on the rod face towards the intake-exhaust side.

## TIMING

Direct drive by drive belt, with on head cam shaft in iron with induction hardening on the cams.



The mechanical tappets are made up of a cap in casehardened and phosphor-plated steel, in contact with the cam, used to regulate the valve clearance.

The command is transmitted from the cap to the cup in carbonitrided steel which directly controls the valve. The intake and exhaust valves are made in a steel alloy and the stem is chrome-plated.

The valve seatings and valve guides are in iron.

Small rubber plugs are mounted on the top of the valve guides to catch any oil between the stem and the valve guides.

## LUBRICATION

The oil, taken from the sump using a suction device, is filtered by the net type filter which is part of the suction device itself and then reaches the oil pump. The oil pump which is the rotating lobe type is front mounted on the engine block and activated directly by the crankshaft through keying.

The oil sent under pressure by the pump, after having passed the pressure relief valve, reaches a thermostatic valve that:

- for temperatures lower than 75 °C, ensures that the oil passes directly into the cartridge filter and then to the engine;
- for temperatures greater than 90 °C, it opens allowing the oil to pass into the coolant radiator so that its temperature is lowered and a better lubrication is guaranteed.

The oil, after having been filtered by the cartridge filter (total flow with safety by-pass valve, which guarantees that the oil passes even if the cartridge becomes clogged up), makes its way towards the oil minimum pressure warning light sensor, and arrives at the main longitudinal pipe which runs around the engine block through a transversal channel.

The oil is then sent along secondary ducts to lubricate the main and rod journals.

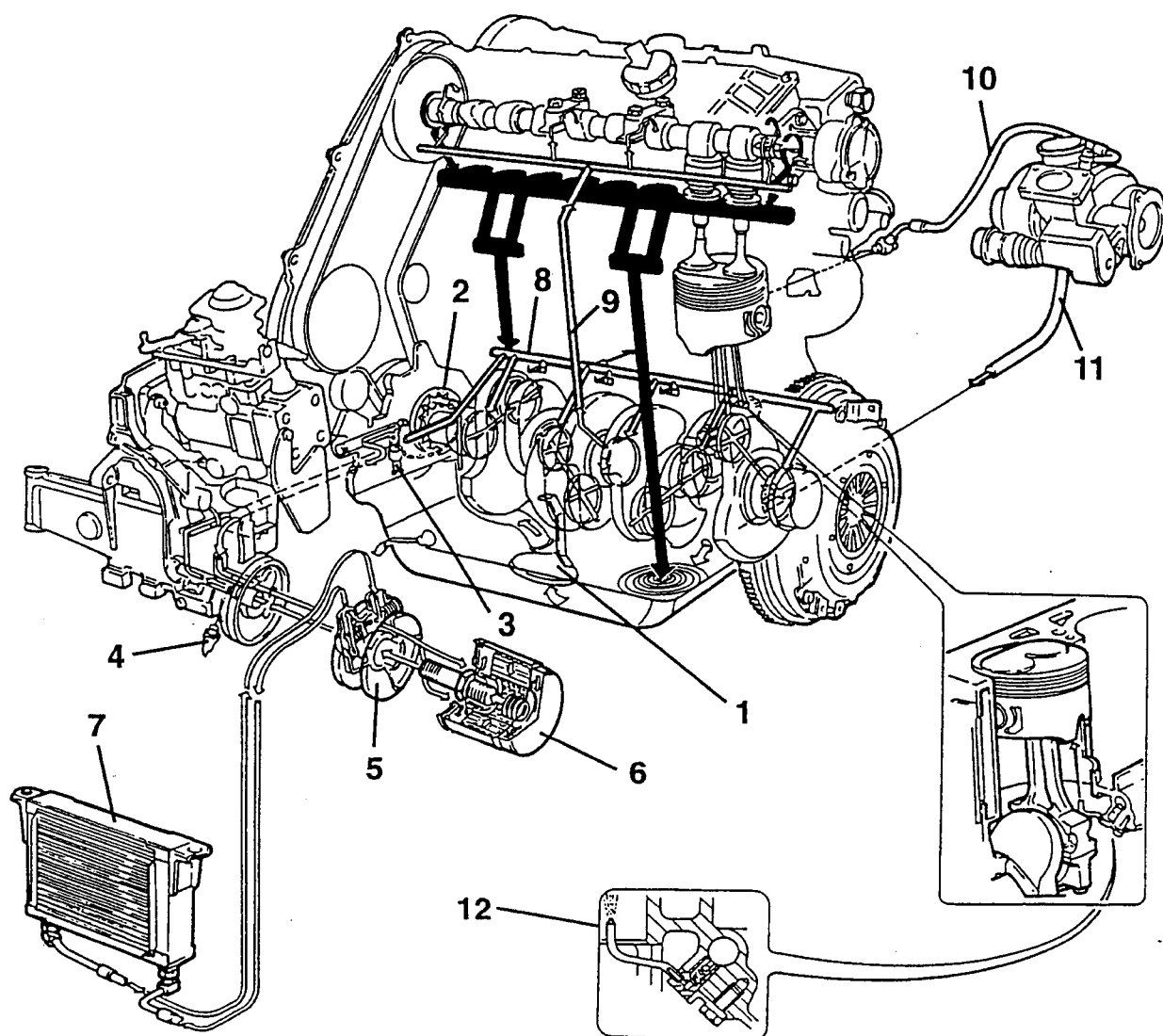
A vertical duct in the engine block and cylinder heads lubricates the cam shaft supports.

From the main duct the oil is sent to the turbo charger through an external tube to lubricate the control shaft and from here directly to the sump.

To improve the cooling of the piston skirts, sprayers with a small built in ball valve which opens when the pressure reaches  $1.25 + 1.75$  bar are located on the engine block; this guarantees that the main supports are sufficiently lubricated during engine start up and at idle speed.

The lubrication system is equipped with an oil vapour recirculation system which allows the vapours originating from the engine block to be recovered.

An oil temperature sensor is also fitted on the oil sump whilst the engine oil level sensor is positioned on the oil pump cover.



1. Suction device with wire gauze filter
2. Oil pump
3. Pressure relief valve
4. Minimum oil pressure warning light sensor
5. Oil filter support with thermostatic valve
6. Oil filter with safety by-pass valve

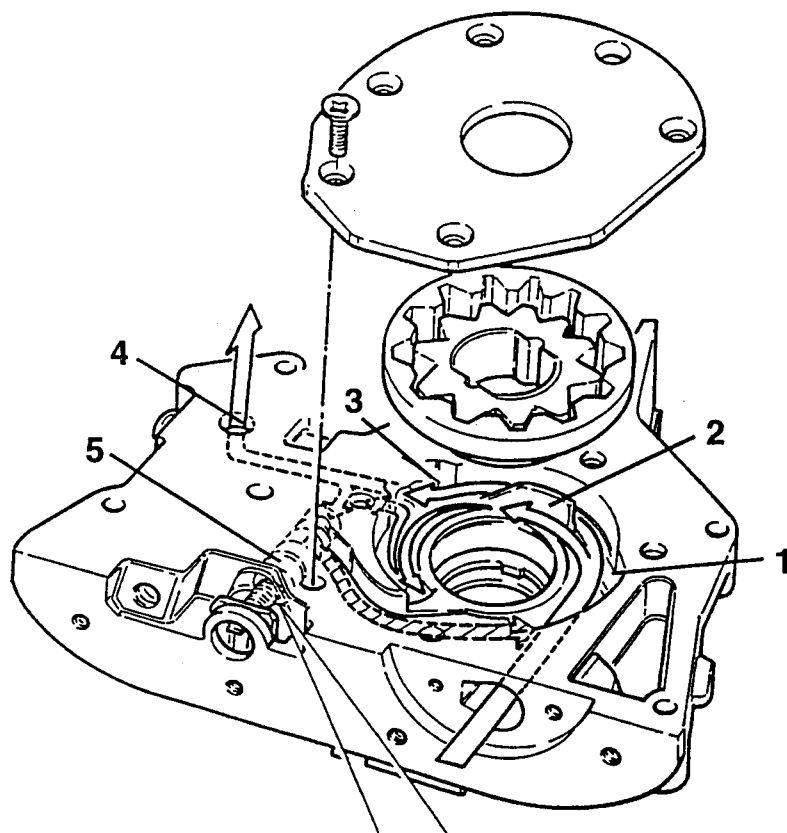
7. Engine oil cooling radiator
8. Oil delivery duct to various parts
9. Oil vertical delivery duct to cam shaft supports
10. Oil delivery tube to turbocharger
11. Oil return to sump from turbocharger tube
12. Sprayers

## OIL PUMP

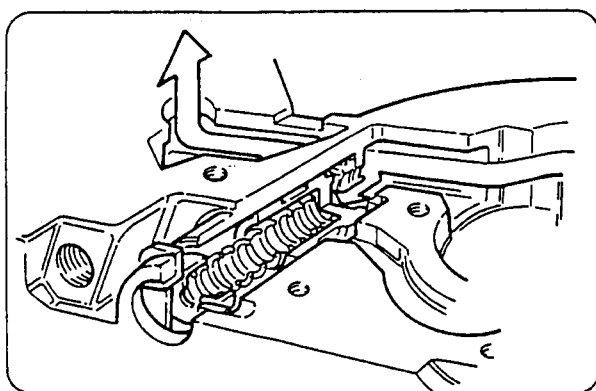
The oil is sucked from the sump through a vacuum created by the gears on the crankshaft rotating. The vacuum starts from the separating panel (2) of the gears up to the oil sump suction device.

The pressure develops from the separating panel (2), in all the engine oil delivery ducts (4).

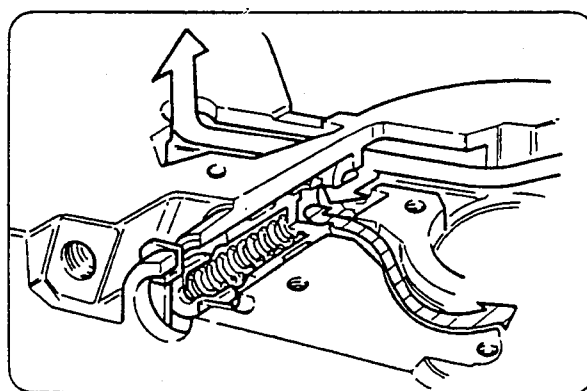
When the pressure exceeds 5 bar, the thrust exercised on the relief valve (5) causes the spring positioned below to react and moves the valve enough to open the connection duct between the pressure chamber (3) and the low pressure chamber (1), limiting the maximum pressure in the circuit.



- 1. Low pressure chamber
- 2. Separating panel
- 3. Pressure chamber
- 4. Oil delivery duct
- 5. Pressure relief valve



Closing functioning position of the engine oil pressure relief valve.



Functioning position in short circuit of the relief valve.



## INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhaul of the engine on a bench after removal from a vehicle.

The instructions are divided as follows:

- **Disassembly and reassembly of engine:**  
removal of the engine accessories and components and dis- assembly into its main component parts.
- **Disassembly and overhaul of cylinder heads:**  
complete overhaul of all the components of the cylinder heads.
- **Engine block checks and inspections:**  
complete overhaul of the components of the crank mechanisms.
- **Precautions for refitting:**  
comprising the refit operations where they significantly differ from the disassembly instructions.

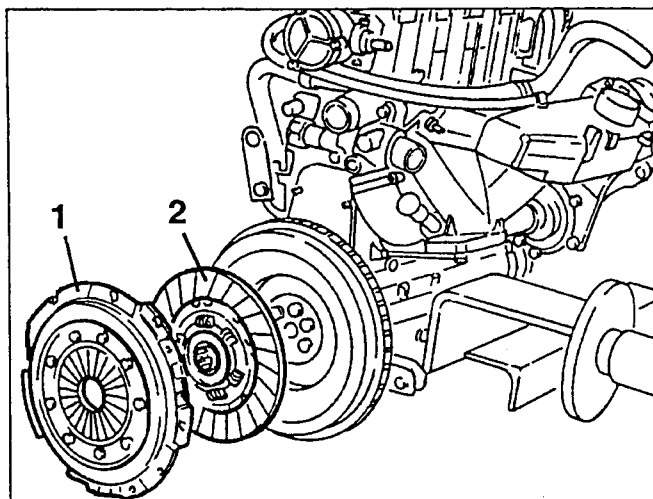
If the disassembly procedures described in the part which follows, when carried out in the reverse order, are also valid for refitting purposes unless otherwise indicated.

- **Checks and inspections of the lubrication system electrical components:**  
checks and controls of the electrical components relative to the engine lubrication system.

The procedures which follow refer to the complete overhaul of the whole engine unit; it is however possible to use individual parts of these instructions when dealing with specific components.

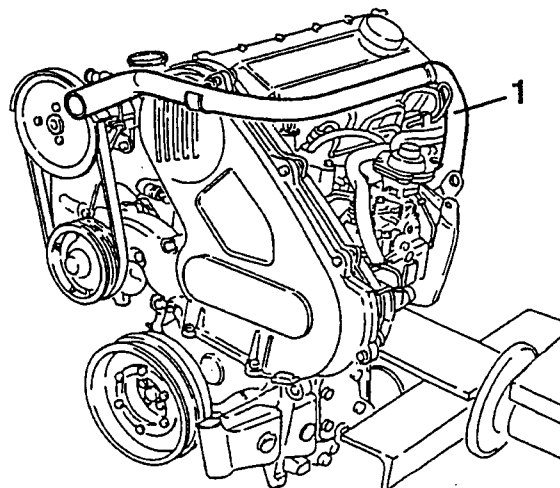
## Removal of clutch plate

1. Remove the disk pressure plate body.
2. Remove the clutch disk.

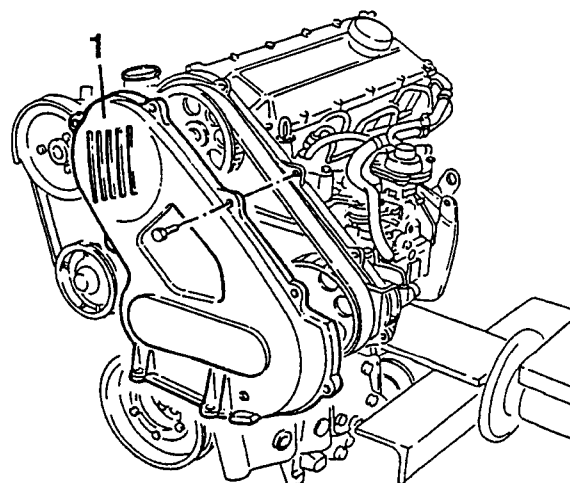


## Removal of timing belt

- Install a suitable tool on the flywheel which will allow the crankshaft to rotate.
- 1. Remove the oil vapour recirculation sleeve.



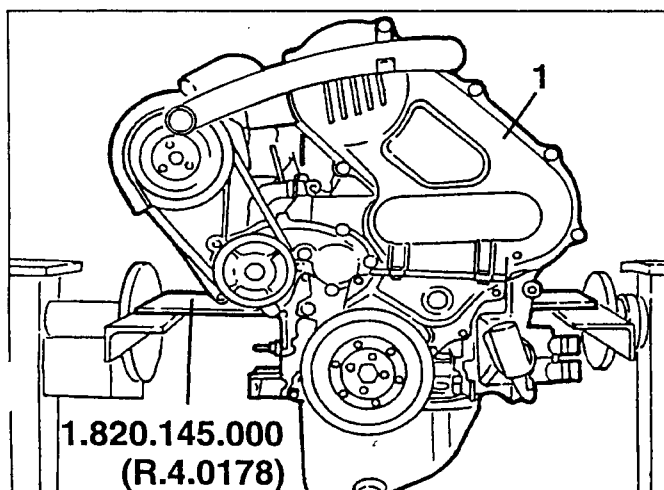
1. Remove the timing belt cover.



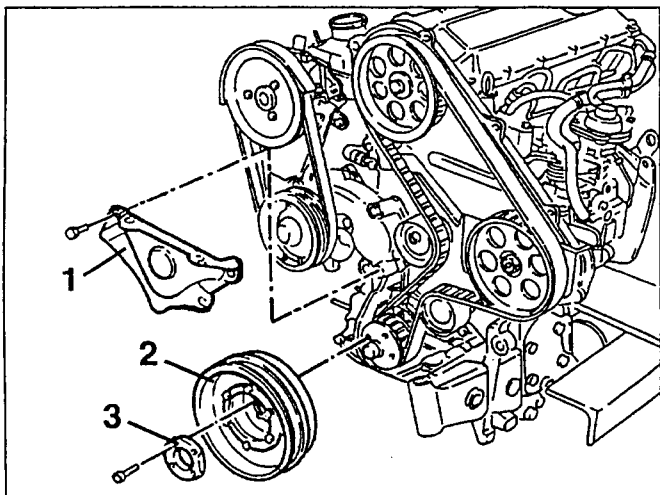
## ENGINE DIS-ASSEMBLY

### Preliminary operations

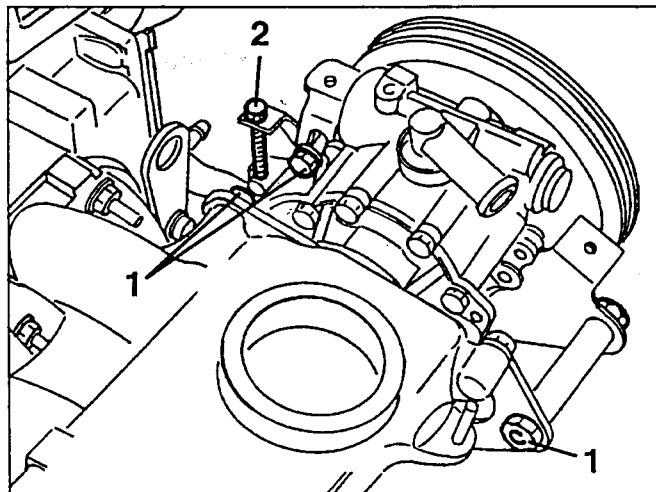
1. Set the assembly on a special overhauling stand using supports brackets N° 1.820.145.000 (R.4.0178).



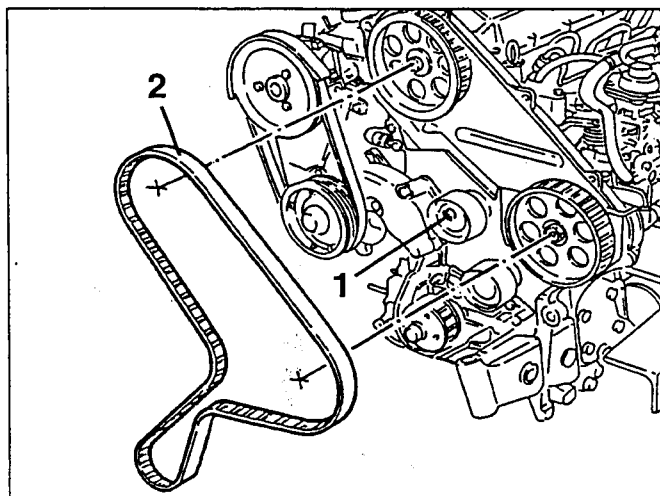
1. Remove the timing belt lower cover.
2. Remove the auxiliary parts belt control pulley.
3. Recover the spacer.



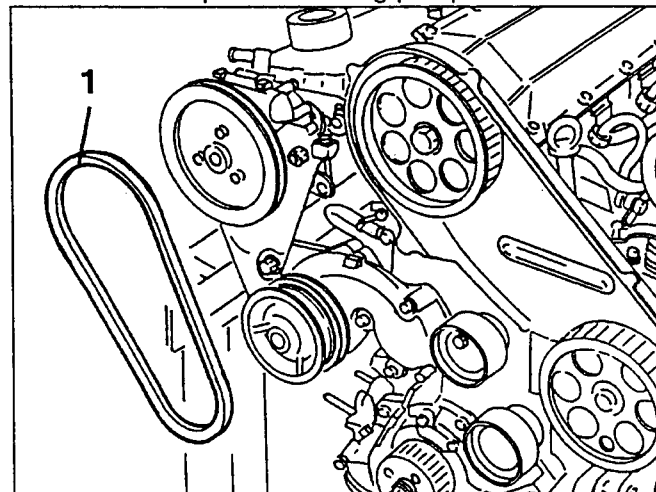
1. Loosen the fastening screws of the power steering pump indicated in the figure.
2. Decrease the tension of the power steering pump control belt by acting on the screws of the micrometric stretcher.



1. Loosen the fastening nut of the timing belt stretcher.
2. Remove the timing control belt.



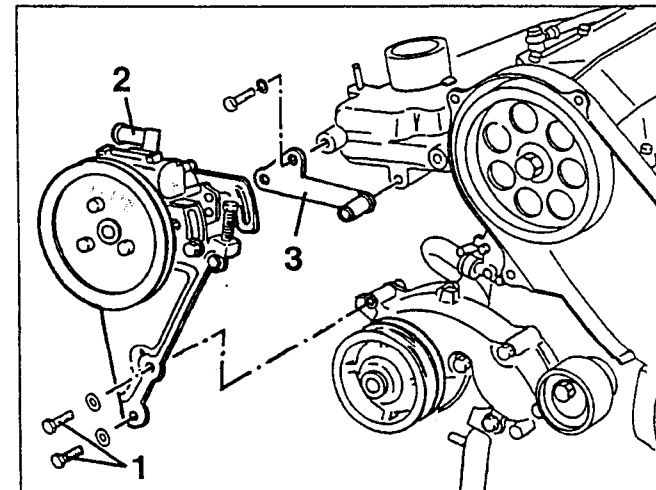
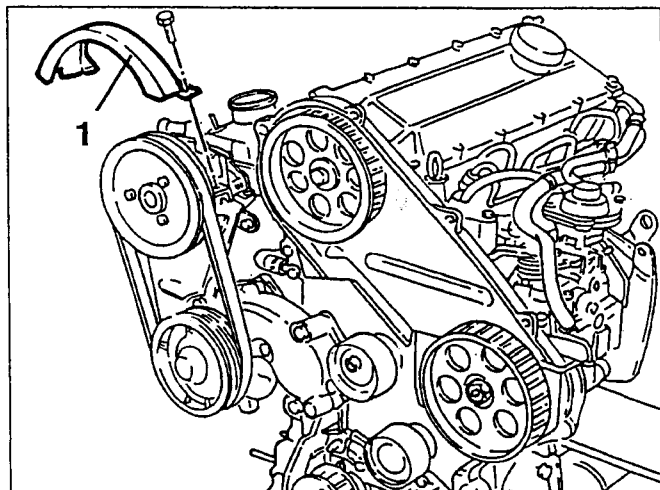
1. Remove the power steering pump control belt.



1. Unscrew completely the screws which have been loosened beforehand and the two screws indicated in the figure.
2. Remove the power steering pump complete with front bracket.
3. Remove the power steering pump front support bracket.

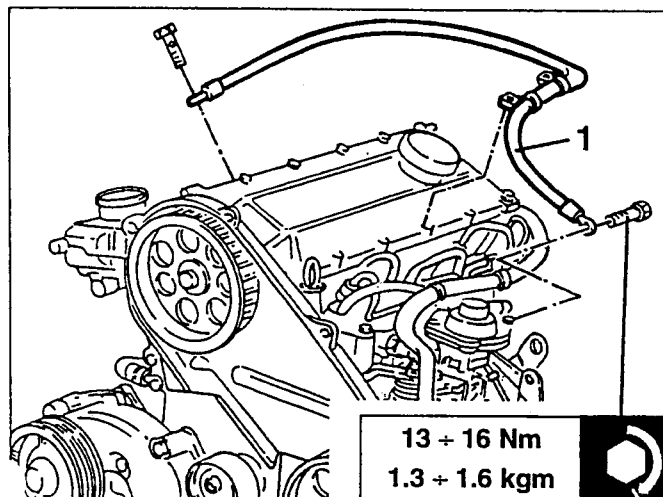
## Removal of power steering pump

1. Remove the power steering pump belt guard.

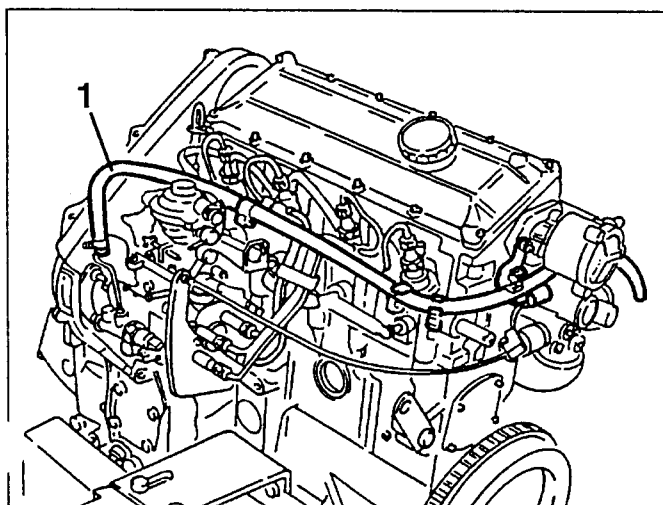


## Removal of air intake box

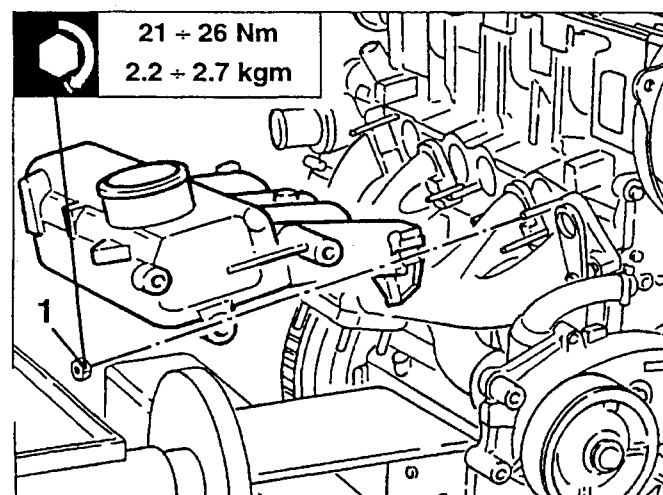
1. Remove the over pressure pipe for the flow limiter on the injection pump.



1. Remove the fuel arrival from filter to injection pump pipe.

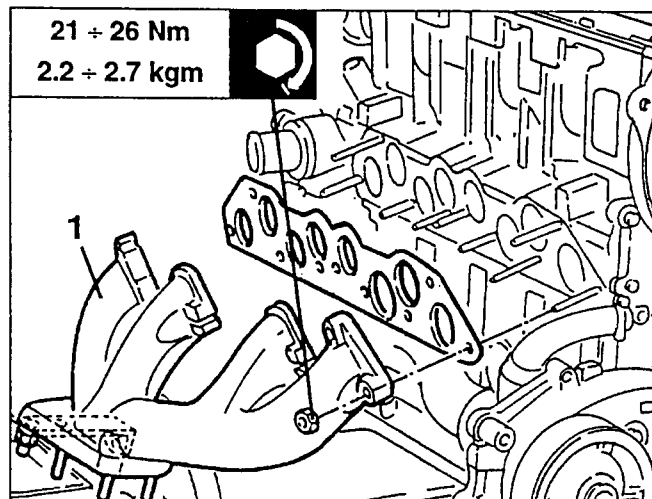


1. Unscrew the fastening screws and remove the air intake box.



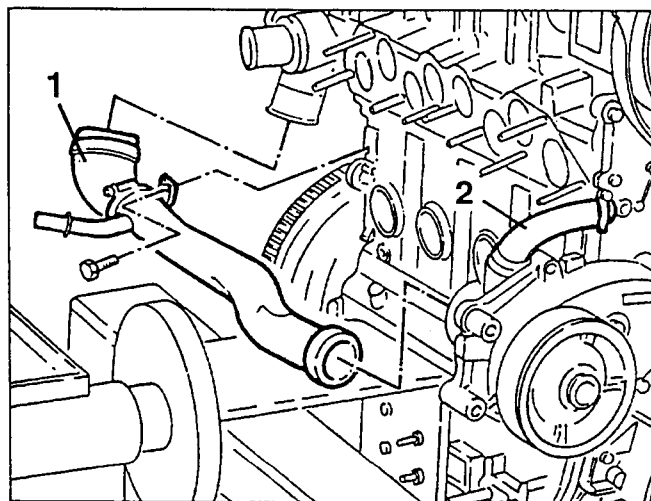
## Removal of exhaust manifold

1. Unscrew the fastening screws and remove the exhaust manifold.

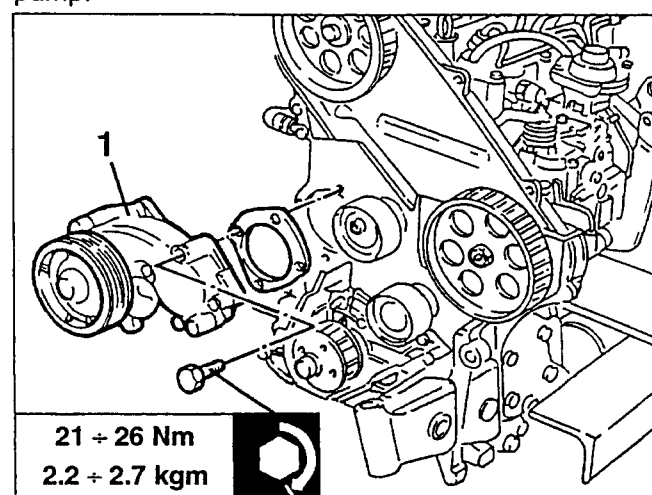


## Removal of water pump

1. Remove the engine coolant to pump return manifold.
2. Disconnect the engine coolant to pump return pipe from the cylinder heads.

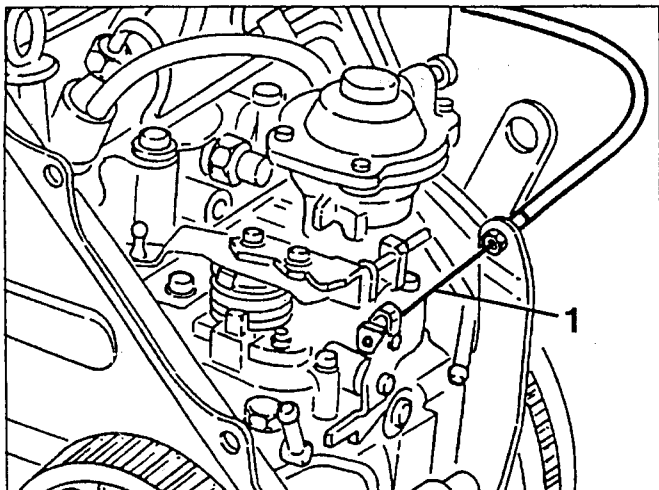


1. Unscrew fastening screws and remove water pump.

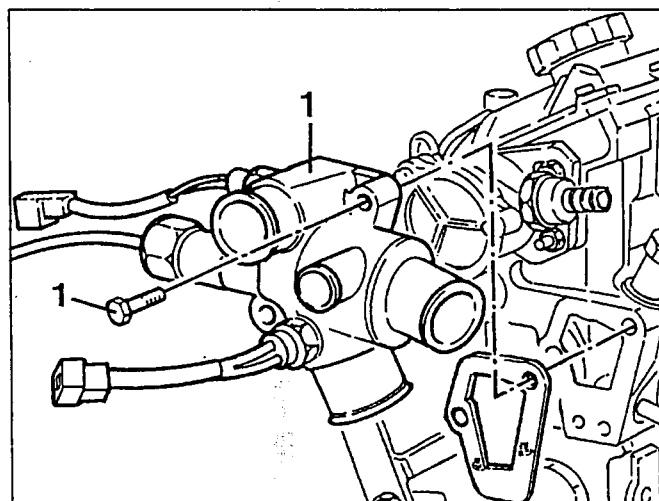


## Removal of thermostatic cup

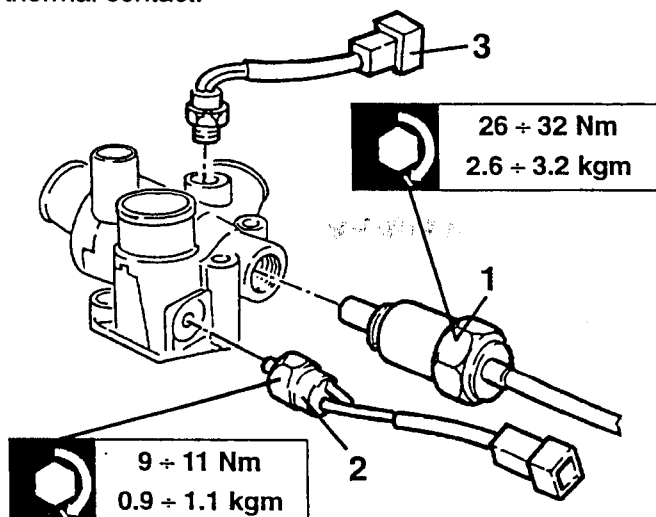
1. Disconnect the cable of the idle speed automatic control device.



1. Unscrew the screws and remove the complete thermostatic cup.

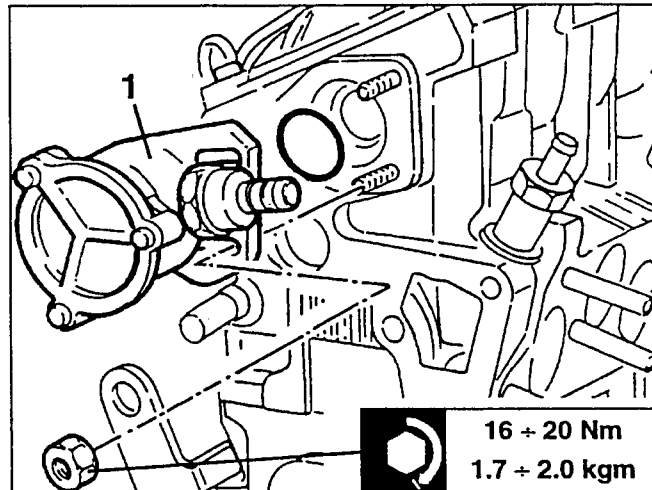


1. Remove the thermostatic sensor of the idle speed automatic device.
2. Remove the KSB consensus thermoswitch.
3. Remove the air conditioning compressor cut-off thermal contact.



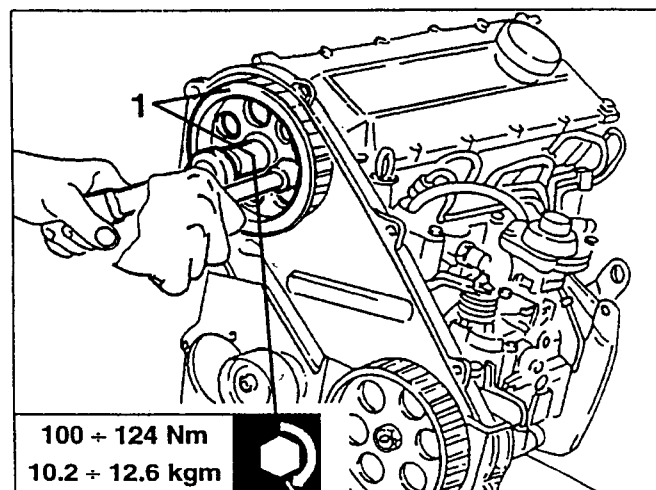
## Removal of servobrake vacuum pump

1. Unscrew the fastening screws and remove the vacuum pump for the servo brake.

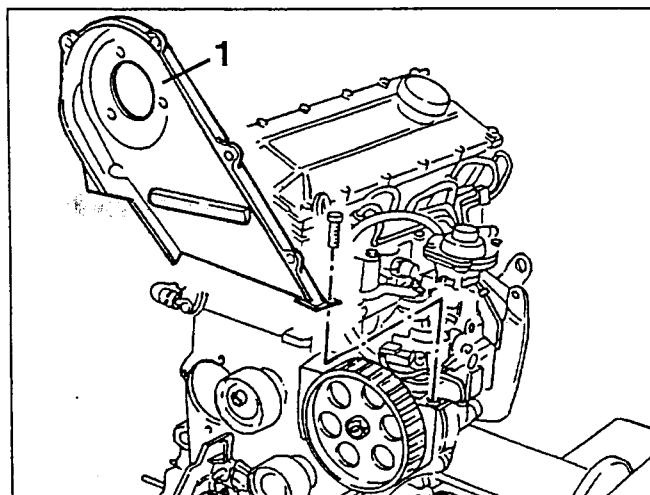


## Removal of injection pump

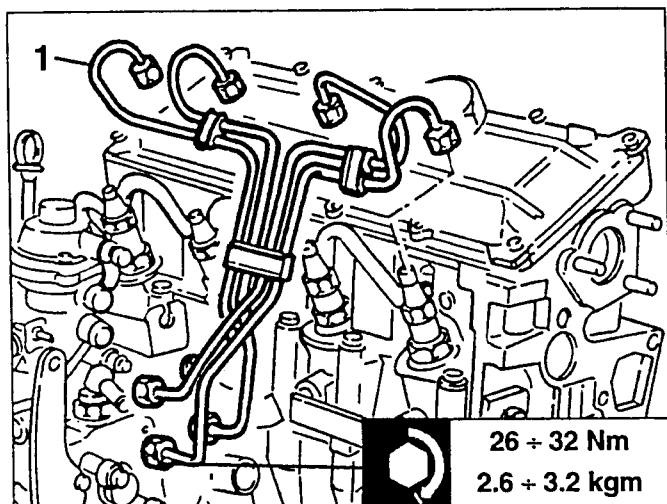
1. Using a 13 mm spanner as a counter rotation tool loosen the screw and remove the timing command pulley.



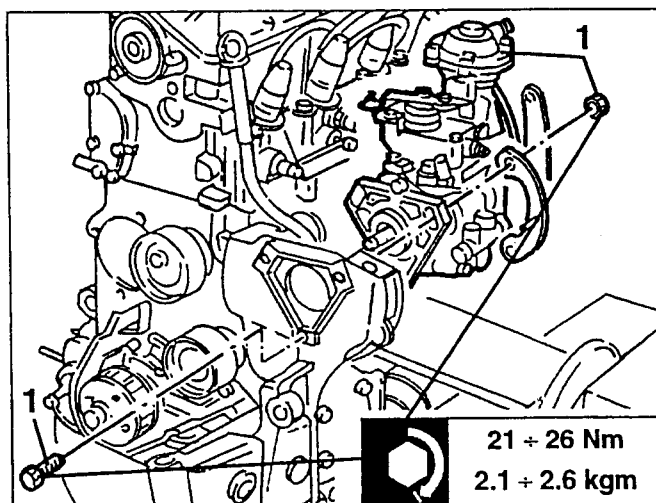
1. Remove the timing belt rear cover.



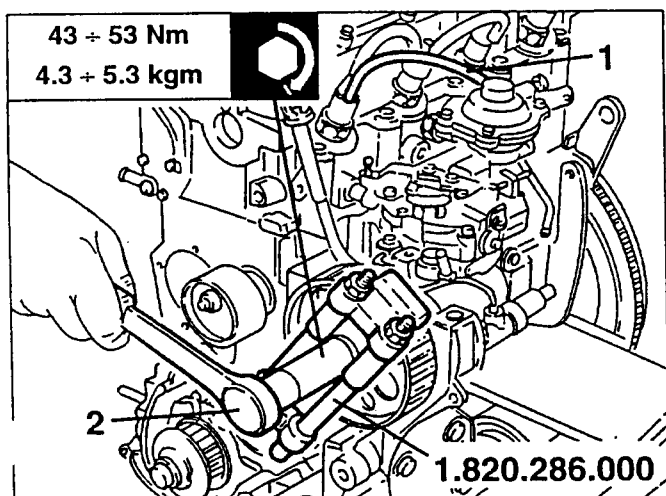
Remove the fuel from injection pump to electroinjectors delivery pipe.



1. Unscrew the fastening screws and nuts and remove the injection pump.

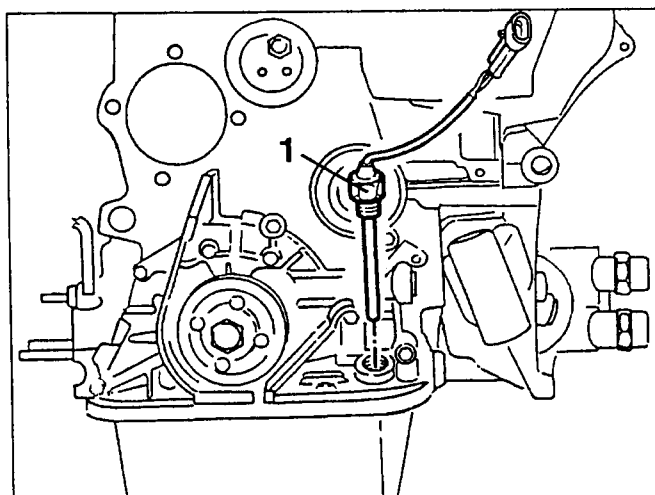


1. Disconnect the fuel to injection pump return pipe from injector.
2. Using tool N° 1.820.286.000 unscrew the fastening nut of the injection pump control pulley.

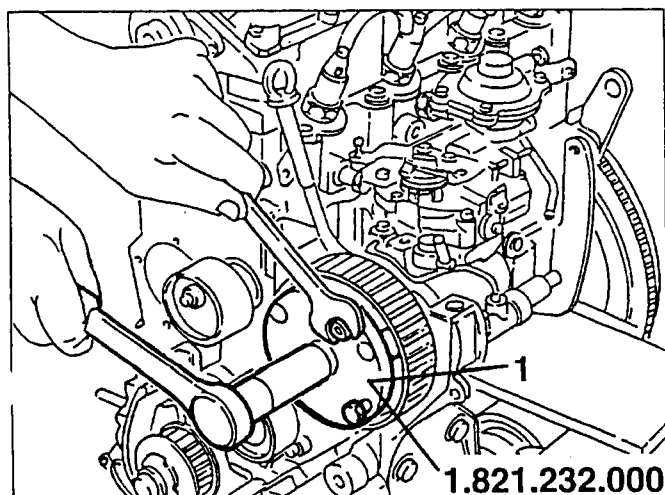


### Removal of oil filter support bracket and injection pump

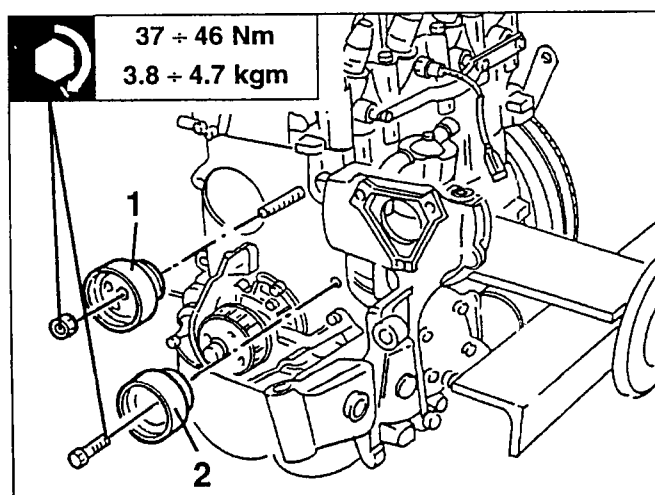
- Remove the guide and engine oil dipstick.
1. Remove engine oil level sensor.



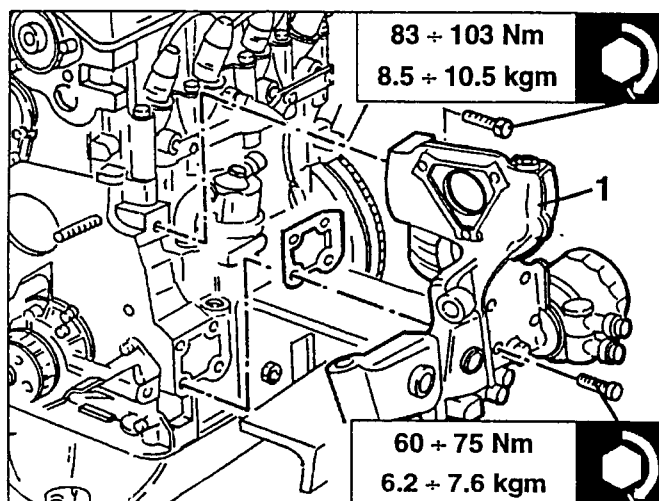
1. Using tool N° 1.821.232.000 remove the injection pump control pulley.



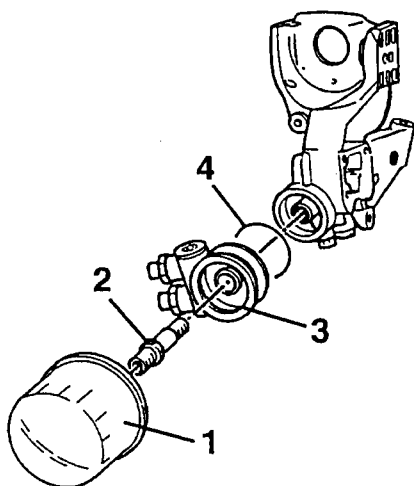
1. Remove the timing belt stretcher.
2. Remove the timing belt jockey pulley.



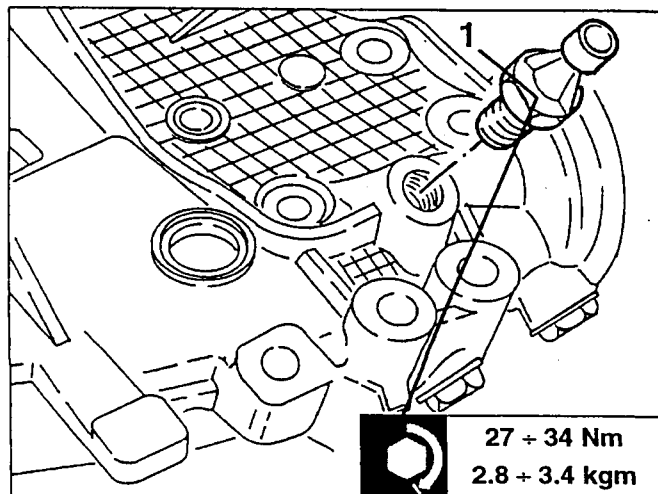
1. Unscrew the fastening screws and remove the oil filter support bracket and the injection pump.



1. At the bench remove the oil filter from the support bracket.
2. Remove fastening journal.
3. Remove oil filter support.
4. Remove O-Ring.

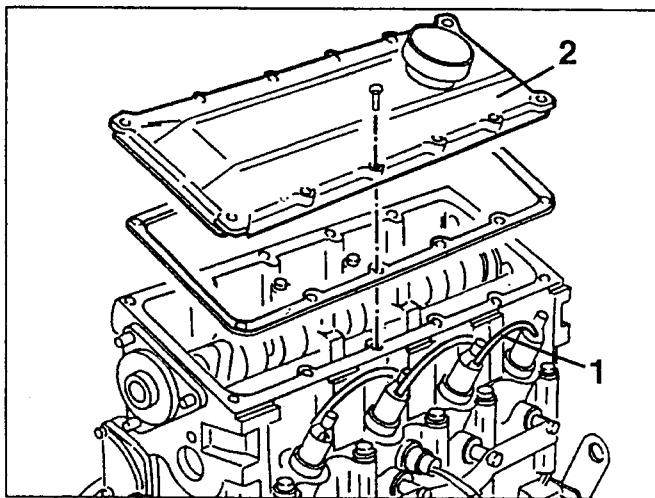


1. Remove the engine oil minimum pressure sensor from the bracket.

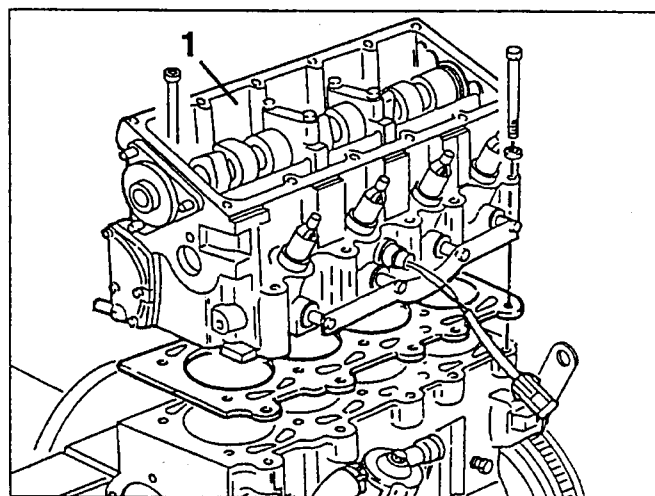


## Removal of cylinder heads

1. Remove the fuel to injection pump return pipe from the injectors.
2. Unscrew the fastening screws and remove the timing cover.

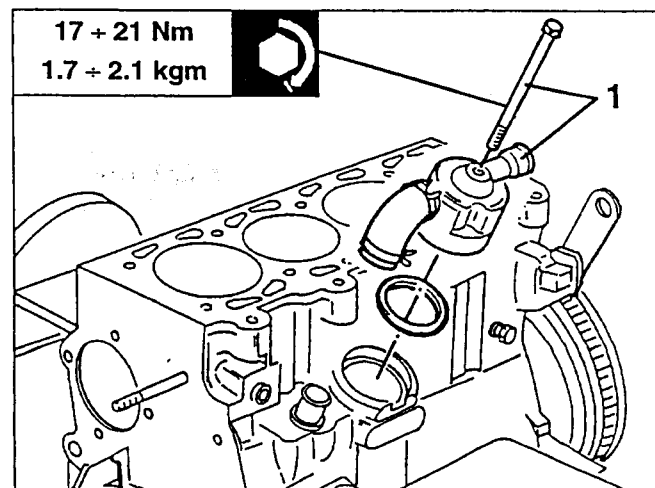


1. Unscrew the fastening screws and remove the cylinder heads.

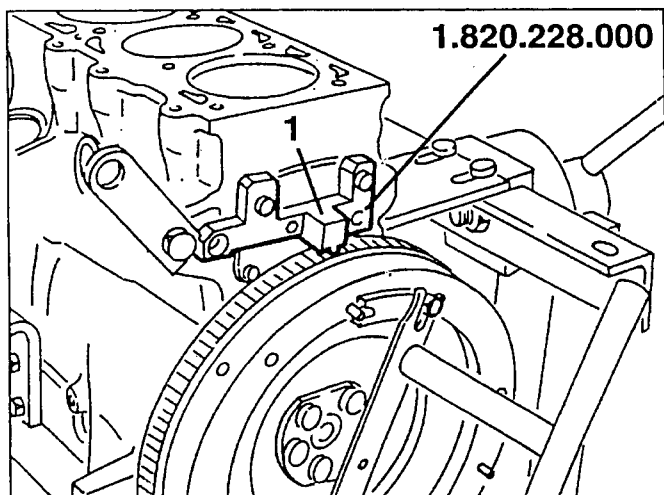


## Removal of oil sump

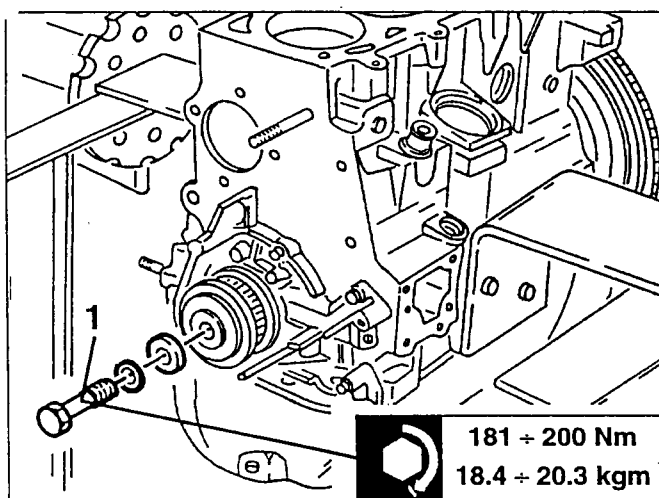
1. Remove the oil vapour separator from engine block.



Install flywheel stop tool N° 1.820.228.000.

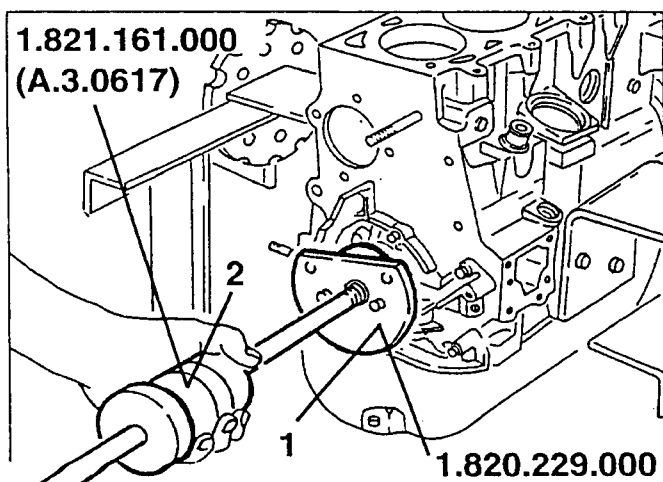


1. Unscrew the fastening screws of the timing control belt pulley.



Install tool N° 1.820.229.000 on the timing control pulley.

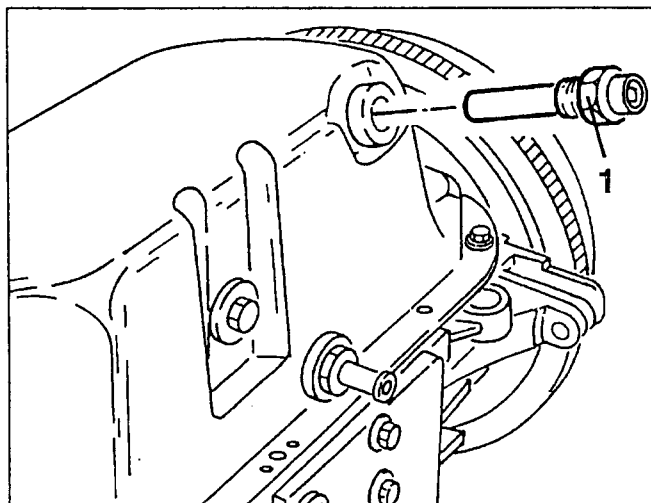
2. Using ram N° 1.821.161.000 (A.3.0617), remove the timing control pulley.



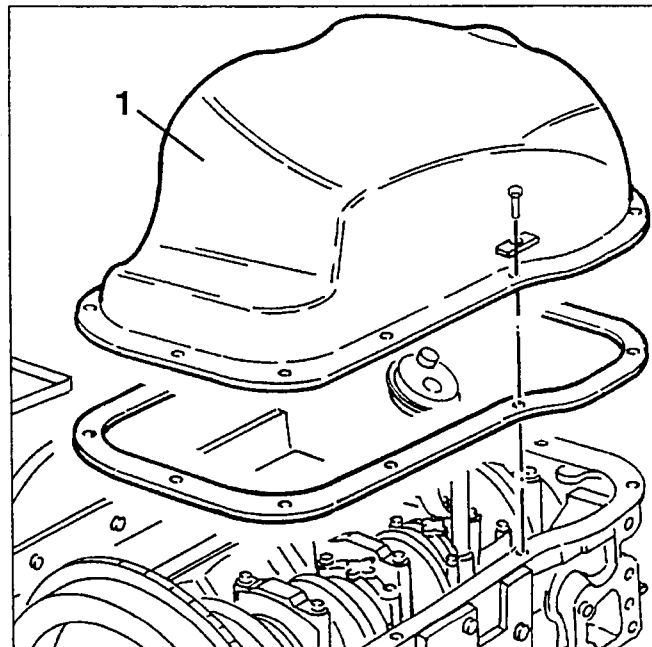
- Remove flywheel stop tool N° 1.820.228.000 installed previously.

- Rotate the engine block 180° on the rotating overhaul stand.

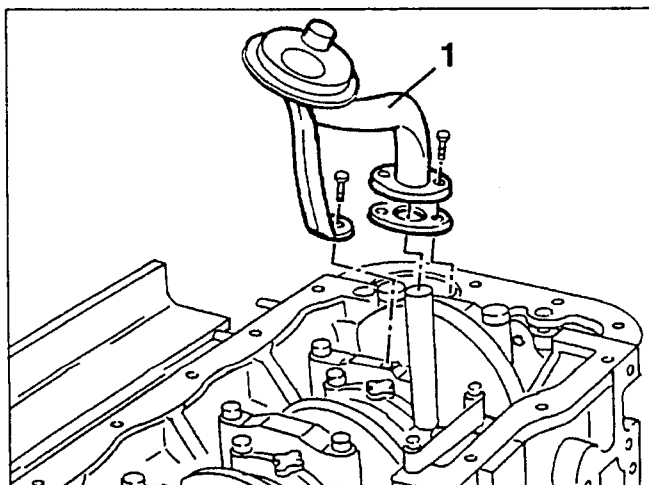
1. Remove the engine oil temperature sensor from the oil sump.



1. Unscrew the fastening screws and remove the oil sump.

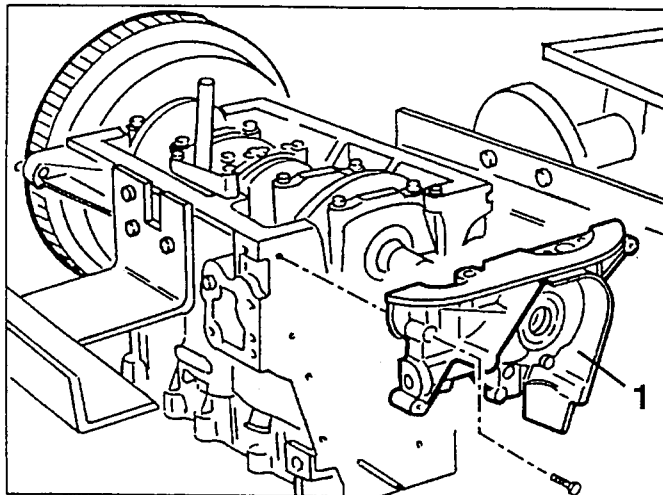


1. Remove the suction device for the engine oil pump.

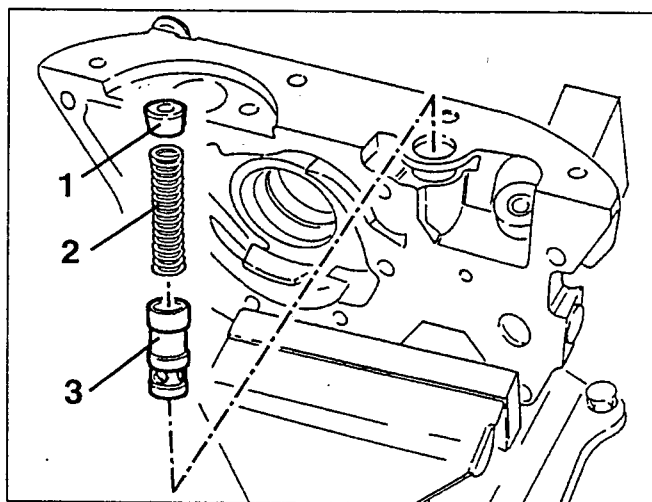


## Removal of engine block front cover

1. Remove the engine block front cover with built-in oil pump.

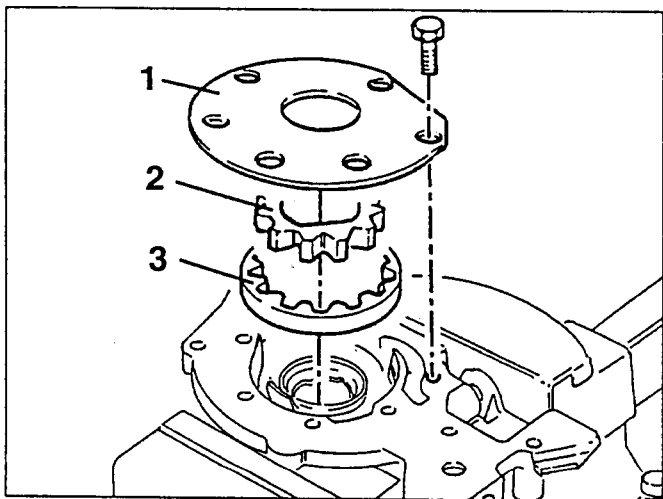


1. Remove the spring stop.
2. Remove the spring.
3. Remove the valve box.

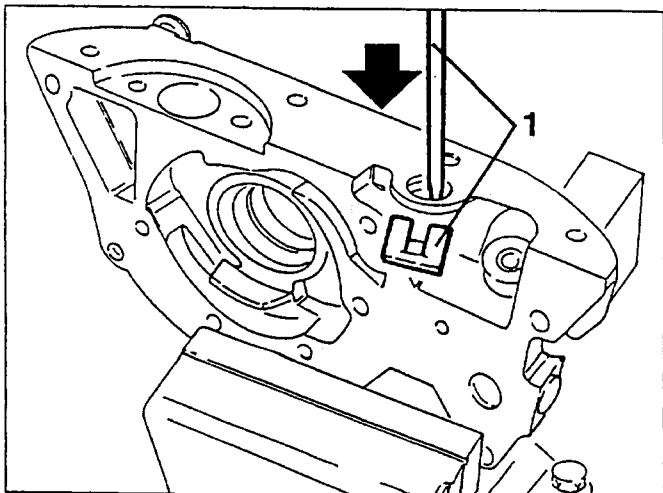


## Disassembly of oil pump

1. Unscrew fastening screws and remove cover.
2. Remove driving gear.
3. Remove driven gear.

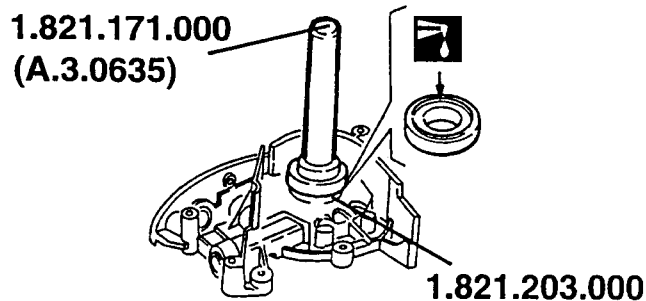


1. With a suitable punch press the oil pressure relief valve and extract the stop plate.



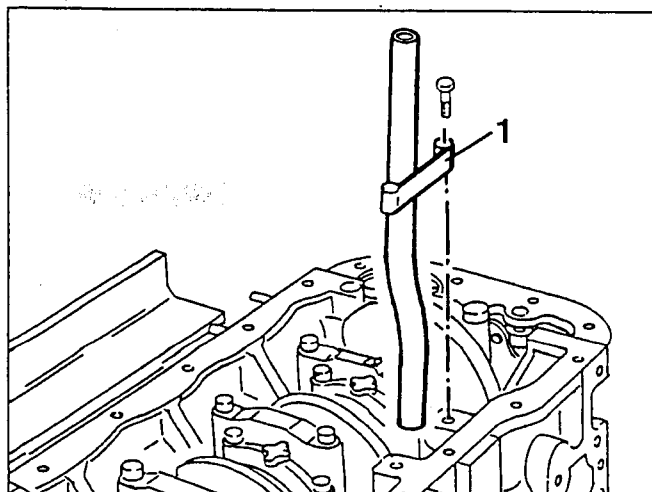
- Remove the oil seal ring from the engine block front cover.

During reassembly fit the oil seal ring on the engine block front cover using tools N° 1.821.171.000 (A.3.0635) and N° 1.821.203.000.



## Removal of pistons and rods

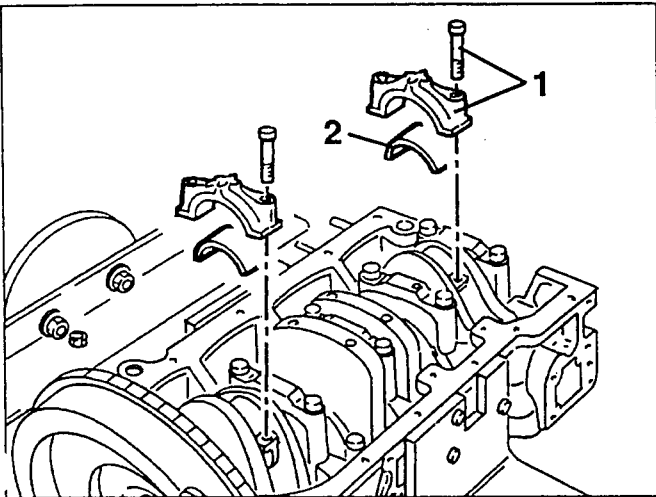
- Remove the flywheel stop tool installed previously.
1. Remove the engine oil dipstick.





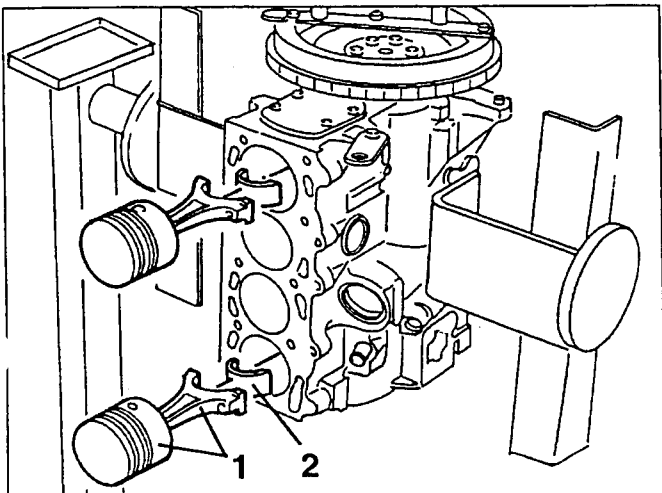
• Rotate the crankshaft so that the first and fourth piston is at B.D.C.

1. Unscrew the fastening screws and remove the first and fourth cylinder rod caps.
2. Recover the rod bearing halves.



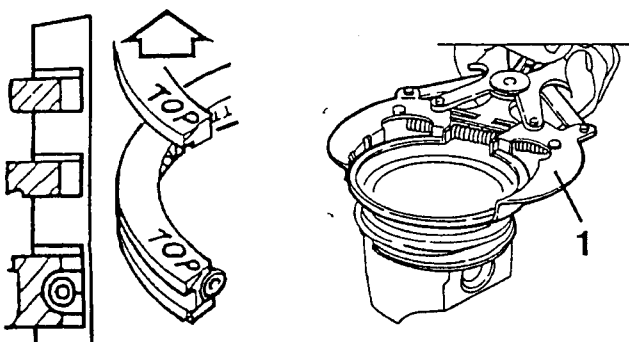
- Rotate the engine block by 90° on the overhauling stand.

1. Remove the piston-rod assembly of the first and fourth cylinders.
2. Recover the rod bearing halves.



- Rotate the engine block and repeat the procedure for the second and third cylinders.

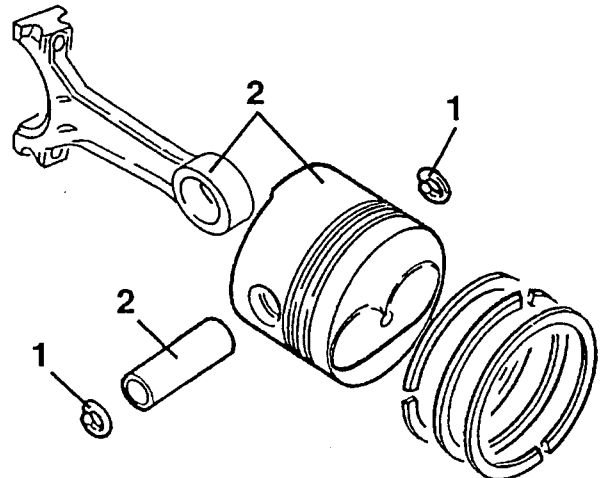
1. Using a suitable tool extract the seal rings and oil scraper ring from the piston.



During refitting rotate the seal rings so that the wording "TOP", stamped on the rings themselves, faces upwards.

1. Extract the two elastic rings which block the grudgeon pin.
2. Extract the grudgeon pin and separate the piston from the rod.

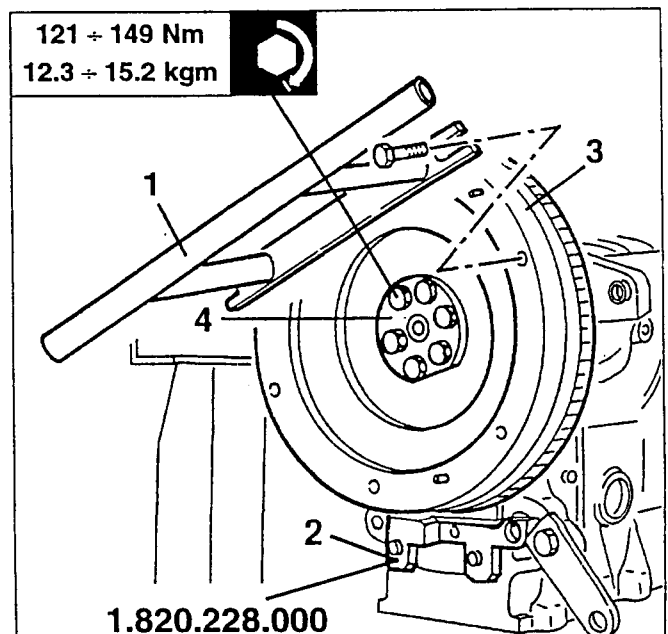
During refitting, follow the precautions contained in the relative paragraph.



## Removal of engine flywheel

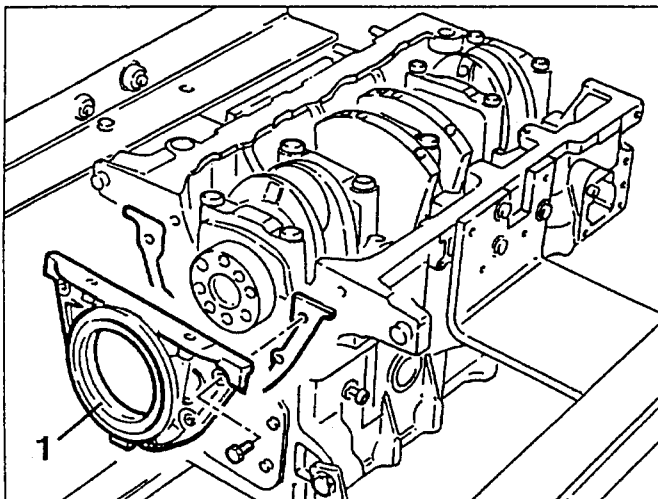
1. Remove the tool used to rotate the crankshaft, installed previously, from the flywheel.
  2. Install the flywheel stop tool N° 1.820.228.000.
  3. Unscrew the fastening screws and remove the engine flywheel.
  4. Recover the safety washer.
- Remove the flywheel stop tool.

During reassembly, bring the first and fourth cylinders to the T.D.C., install the flywheel ensuring that the notch faces upwards.



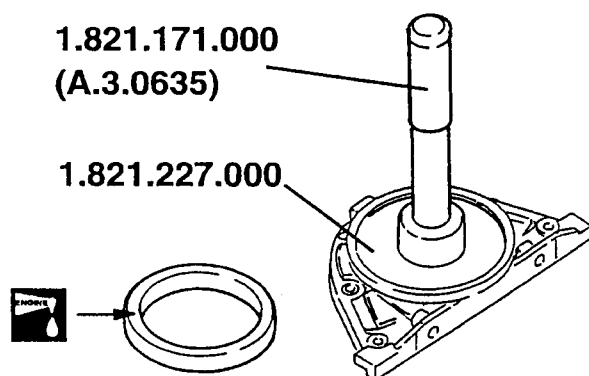
## Removal of crankshaft

1. Remove the engine rear cover.

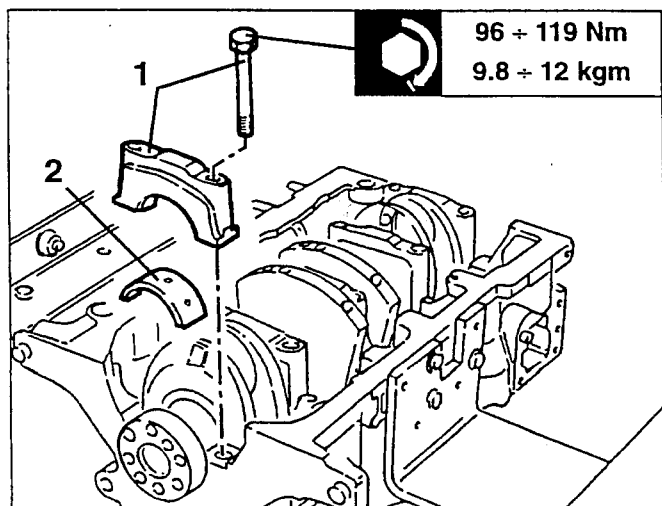


- Remove the oil seal ring from the engine rear cover.

During reassembly fit a new oil seal ring on the rear engine cover using tools N° 1.821.171.000 (A.3.0635) and N° 1.821.227.000.



1. Unscrew the fastening screws and remove the main journals.
2. Remove the main bearing halves from the caps.

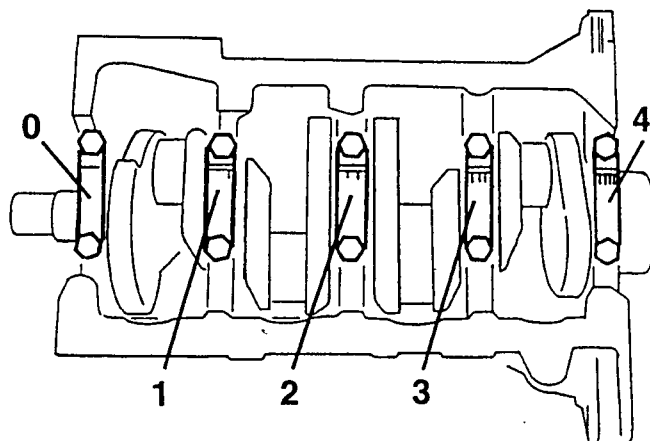


**NOTE:** Highlight the position of the various components should they be re-used during assembly.

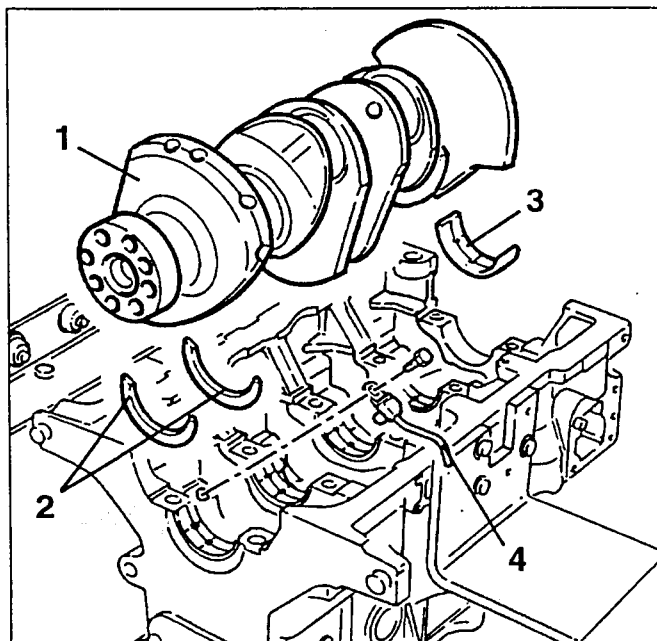


### CAUTION:

The position of each cap is dictated by a series of notches (from zero to four starting from the front side of the engine) engraved on the caps themselves.



1. Remove the crankshaft.
2. Recover the thrust half rings.
3. Recover the main bearing halves from the supports.
4. Remove the engine oil sprayers used to lubricate and cool the pistons from the engine block.

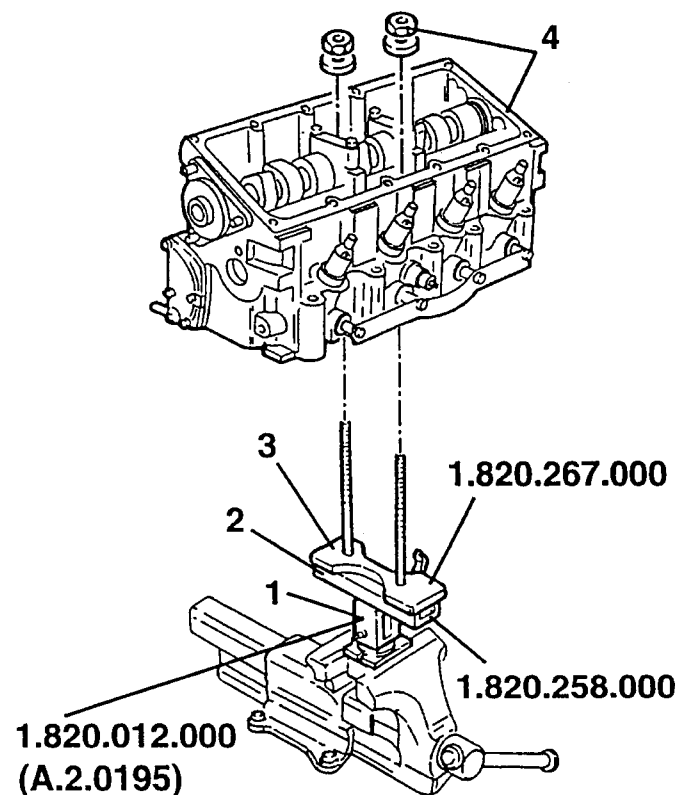


During crankshaft reassembly check that the axial play falls within prescribed limits (see "Precautions for reassembly").

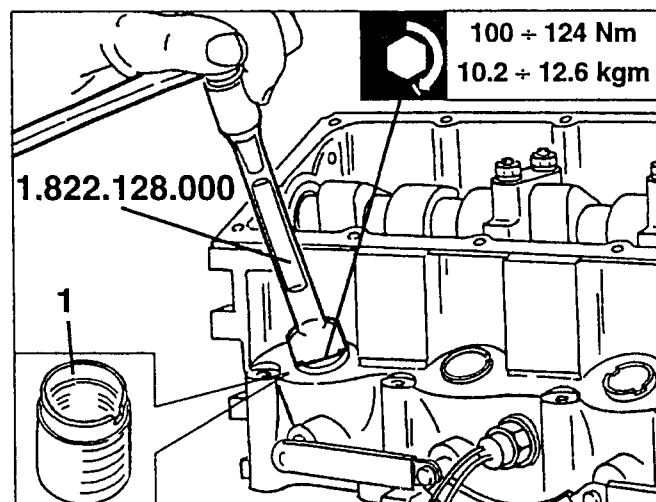
## DISASSEMBLY OF CYLINDER HEADS

### Preliminary operations

1. Clamp the moveable support N° 1.820.012.000 (A.2.0195) into a vice.
2. Install cylinder head support fork N° 1.820.258.000 and lock it to the support.
3. Insert tool N° 1.820.267.000 for the disassembly of the valves into the fork.
4. Insert the cylinder heads into the studs of the forks and lock them there.

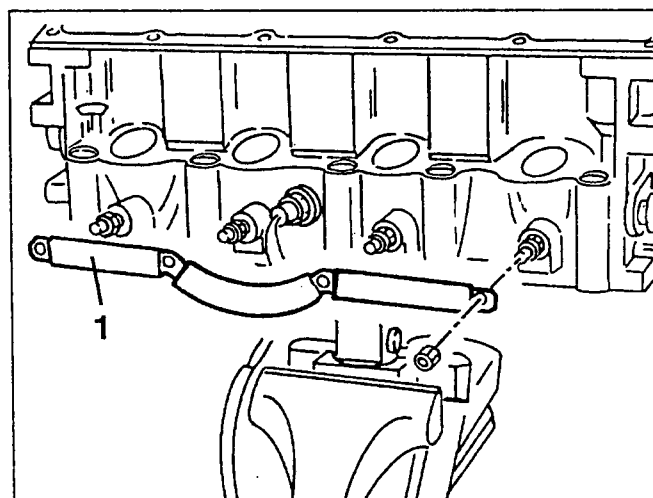


1. Using tool N° 1.822.128.000 remove the combustion prechamber fixing bushing.

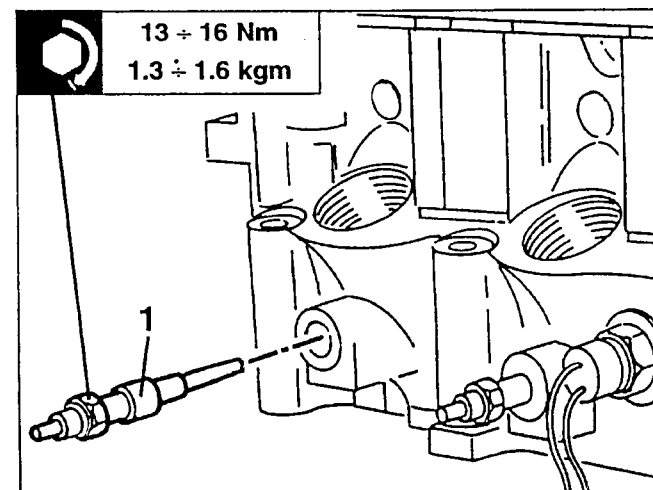


### Removal of heater plugs

1. Remove the heater plugs supply connecting strip.

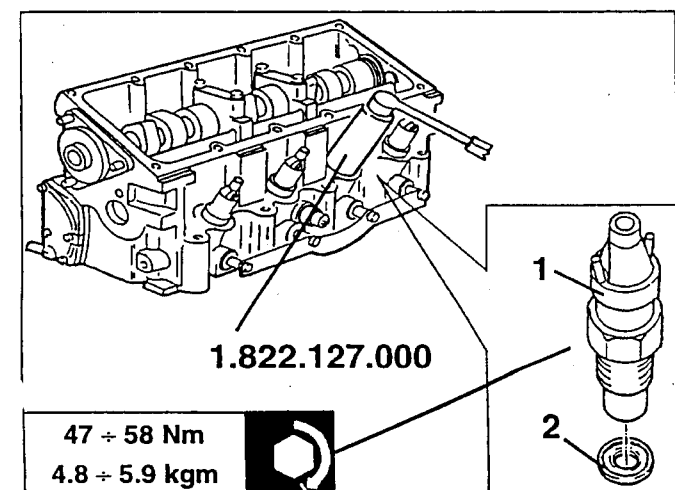


1. Remove the heater plugs.



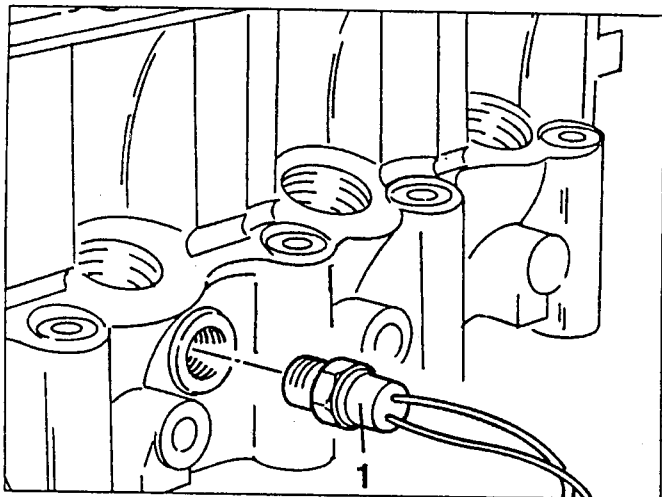
### Removal of injectors

1. Using tool N° 1.822.127.000 remove the injectors.
2. Recover the engine compression seal elastic washer.



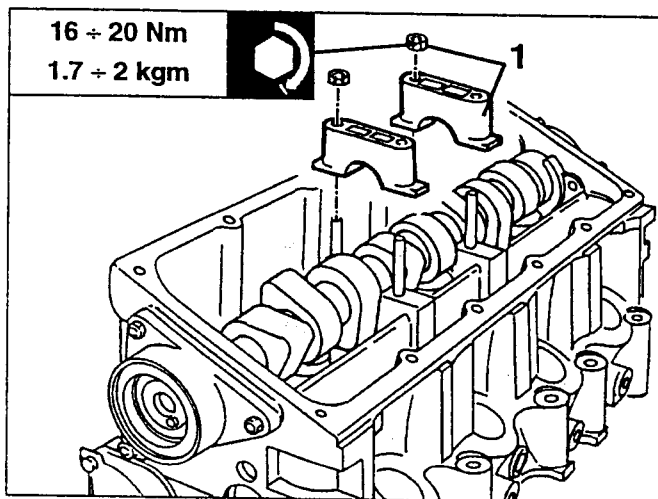
## Removal of coolant temperature sensor

1. Remove the engine coolant temperature indicator transmitter and the max. temperature warning light contact.

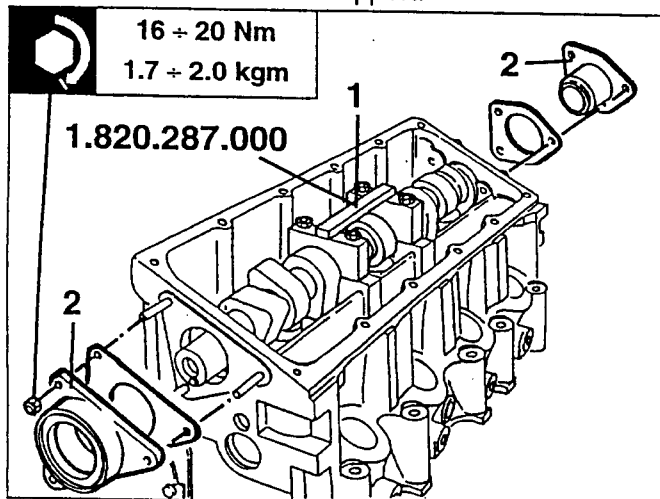


## Removal of cam shaft

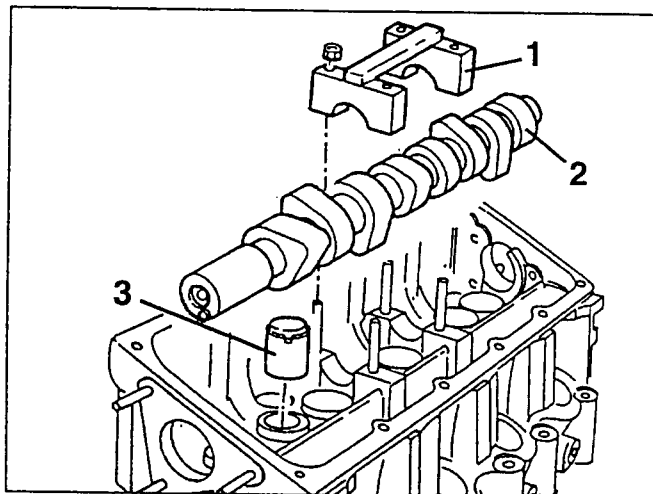
1. Unscrew the fastening nuts and remove the cam shaft caps.



1. Install tool N° 1.820.287.000.
2. Remove the camshaft support.

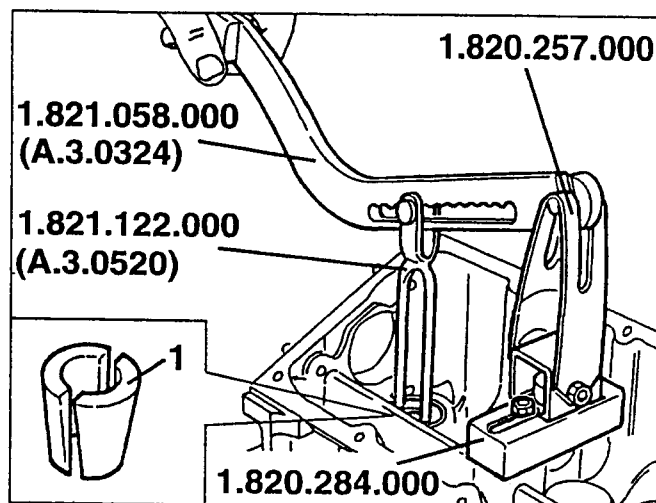


1. Remove tool installed previously.
2. Extract the camshaft.
3. Remove the valve cups complete with valve clearance adjusting plates.

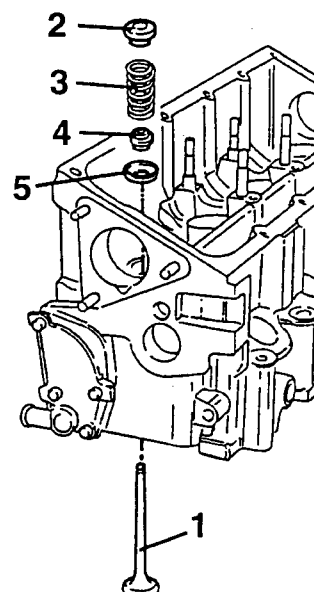


- Operate on each valve as follows.

1. Using the equipment indicated in figure, remove the cotters.

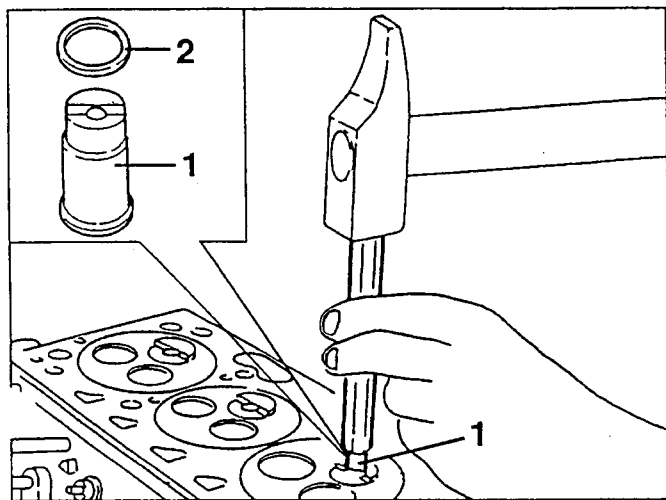


1. Extract the valve.
2. Remove the upper cap.
3. Recover the spring.
4. Using tool N° 1.821.208.000 remove the small rubber oil seal.
5. Remove the lower cap.

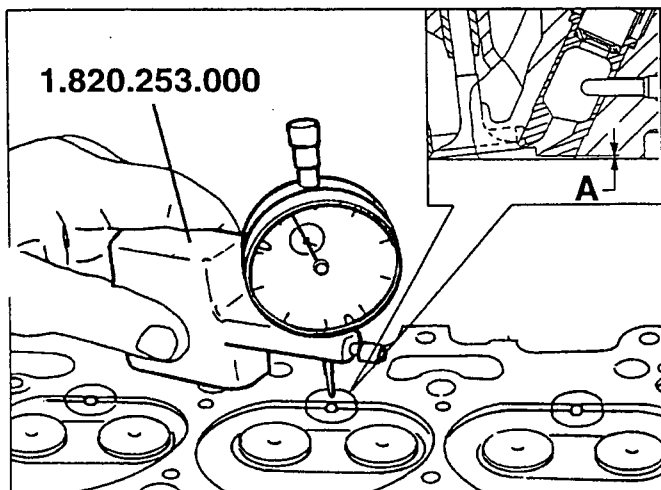


To reassemble the small rubber oil seal, use inserting tool N° 1.821.206.000.

- Remove the cylinder heads from the support tools.
1. Using a suitable punch, force the combustion pre-chamber from its seating.
  2. Remove seal ring.



During reassembly of the combustion prechamber, check that it does not protrude from plane of the cylinder heads more than the prescribed limits using tool N° 1.820.253.000.



Distance "A" that precombustion chamber protrudes from plane of cylinder heads

- 0.765 + + 0.055

## CYLINDER HEAD CHECKS AND INSPECTIONS

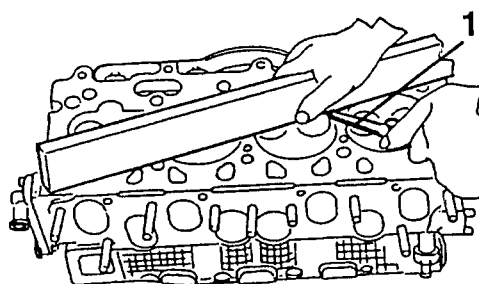
### Checking lower plane of cylinder heads

1. Check that the lower plane is level and, if necessary, reface.



Maximum head lower plane error

0.1 mm



1. After resurfacing, check that the height of the cylinder heads exceeds the minimum value.



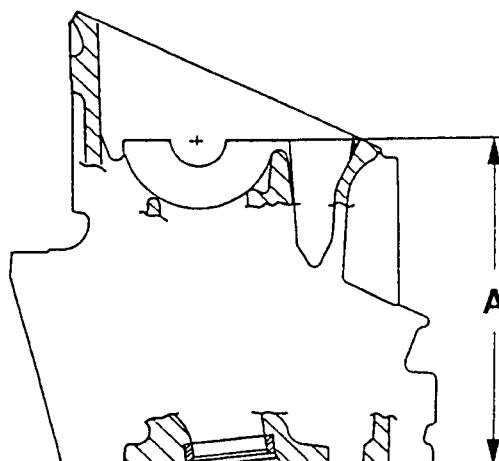
#### CAUTION:

do not exceed the minimum value as this could cause serious engine malfunction.



Minimum height "A" of head after facing


144.85 mm

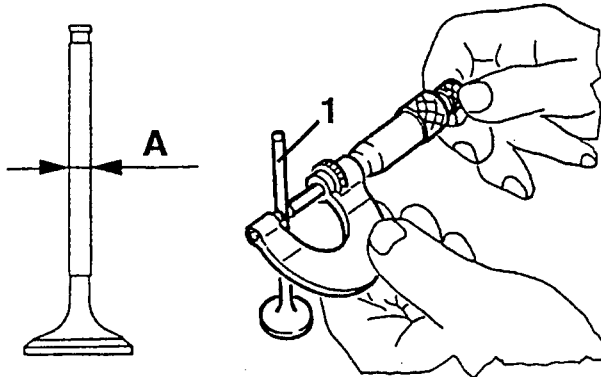


- Check that the surfacing of the lower plane of the head is of the required quality.


## Clearance between valve guides and valve stems

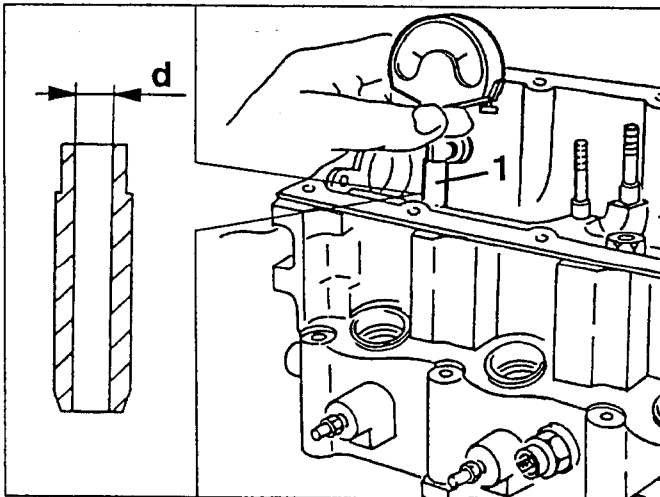
1. Measure the diameter of the valve stems and check that it falls within the prescribed limits:

	<b>Diameter of valve stems "A"</b>	
	intake and exhaust	7.974 ÷ 7.992 mm




1. Measure the inner diameter of the valve guides and check that it falls within prescribed limits.

	<b>Inner diameter of valve guides "d"</b>	
	intake and exhaust	8.022 ÷ 8.040 mm

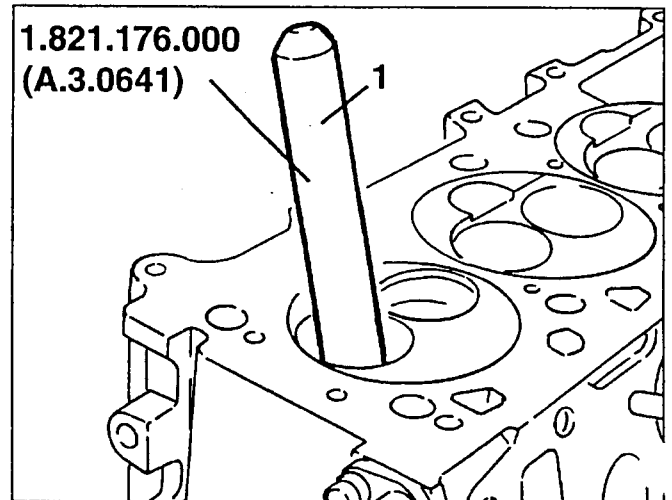


- Calculate the clearance between the guide valves and valve stems and check that it falls within the prescribed limits, if this is not the case replace the worn parts.

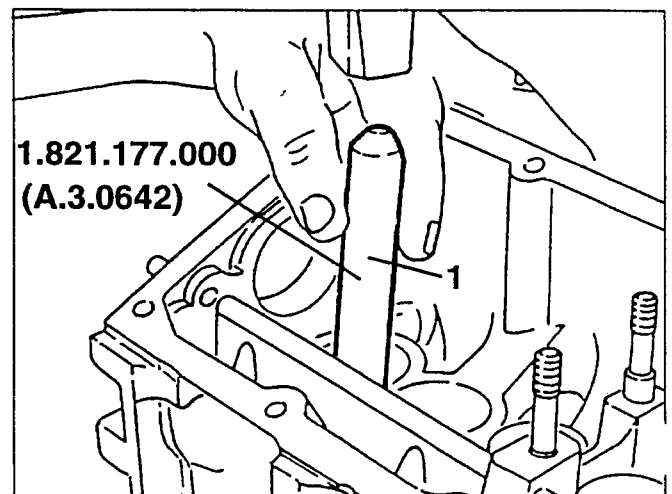
	<b>Radial clearance between valve guides and valve stems</b>	
	intake and exhaust	0.030 ÷ 0.066 mm

## Replacement of valve guides


1. Extract the worn valve guides using extractor N° 1.821.176.000 (A.3.0641).

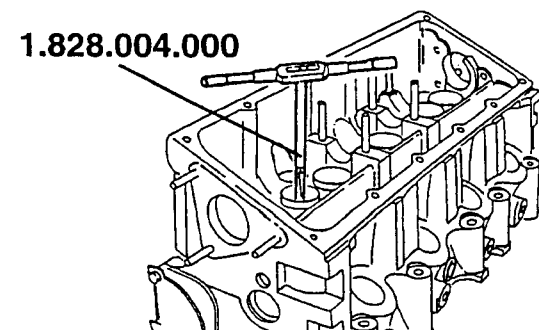


1. Insert the new valve guides using inserting tool N° 1.821.177.000 (A.3.0642).



1. Using tool N° 1.828.004.000, bore the valve guides to gauge the holes to the prescribed diameter.

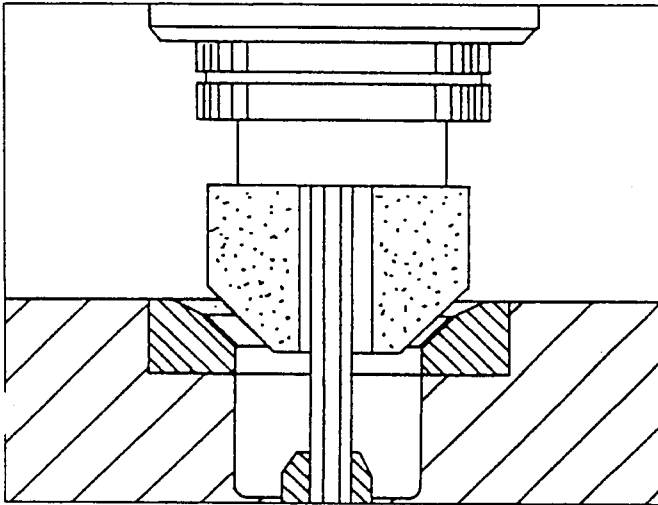
	<b>Inner diameter of valve guides "d"</b>	
	intake and exhaust	8.022 ÷ 8.040 mm



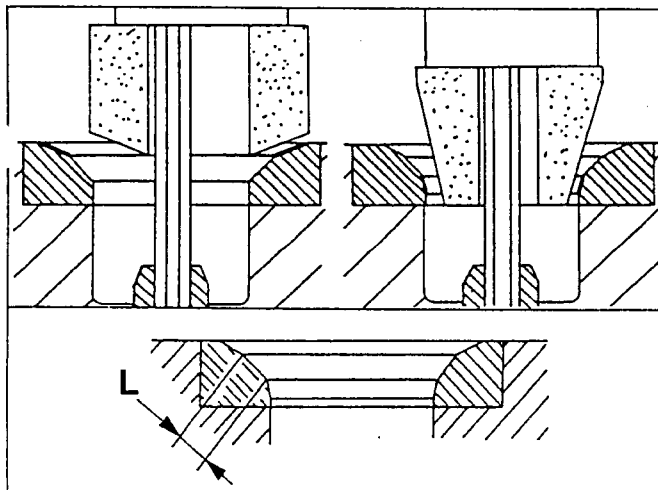
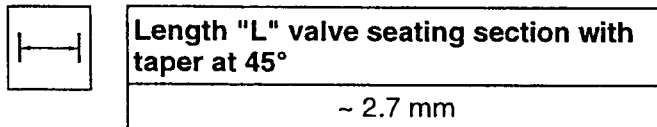
## Turning of valve seatings

- If necessary, turn the valve seating using a suitable tool as follows:

- turn valve seatings with grinder at a  $44^{\circ} 30'$ .



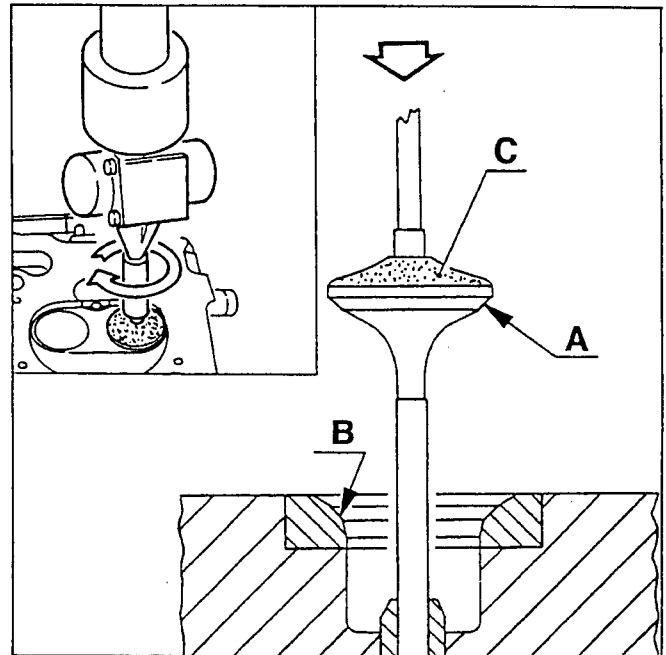
- turn valve seatings with grinder at  $20^{\circ}$  and at  $75^{\circ}$  as indicated in the figure until the prescribed value "L" is obtained.



- After turning, grind each valve in its seating as follows:

- spread the stop limit surfaces "A" and "B" of the valves and seatings with abrasive paste (SIPAL A-REXONS Carbosilicium for valve).
- lubricate the valve stem with engine oil.
- Fix the lower surface of the valve head to the suction cup "C" of a pneumatic lap.
- insert the valve into the respective guide and grind.

- after grinding, clean both the valves and their seatings thoroughly.

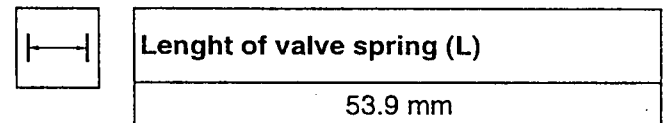


## Valve springs

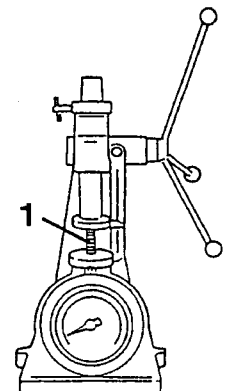
- Check that the "free" length of the valve springs falls within prescribed limits.

### NOTE:

The planes must be parallel to each other and perpendicular to the axis of the spring with a maximum error of  $2^{\circ}$ .



1. Using a dynamometer, check that the spring's characteristics fall within prescribed limits.

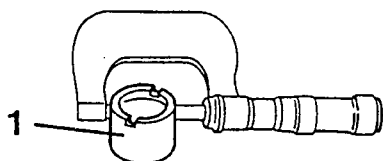


	Length of spring mm	Control load daN (kg)
Valve closed	36	36.7 ÷ 39.6 (37.4 ÷ 40.4)
Valve open	26.5	55.9 ÷ 60.8 (57 ÷ 62)

## Clearance between valve cups and relative seatings

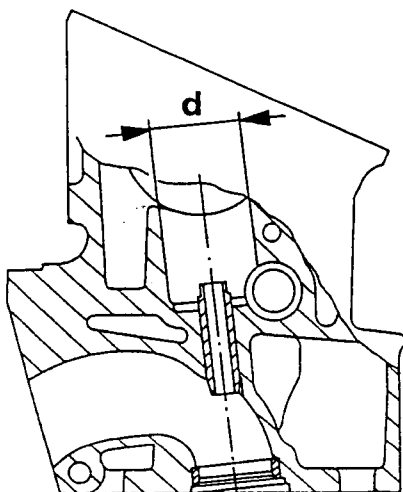
1. Measure the external diameter of the valve cups and check that it falls within the prescribed limits.

Diameter of valve cups	
intake and exhaust	36.975 + 36.995 mm



- Measure the diameter of the valve cup seatings on the cylinder heads and check that it falls within prescribed limits.

Diameter of valve cup seatings "d"	
intake and exhaust	37.000 + 37.025 mm



- Calculate the clearance between valve cups and relative seatings to check that it falls within prescribed limits, if not replace the worn parts.

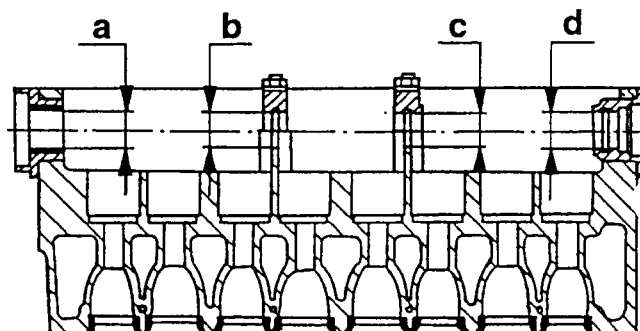
Clearance between cups and relative seatings
0.005 + 0.050 mm

## Check camshaft radial clearance

- Install the lateral supports and camshaft central caps and tighten the relative nuts to the prescribed torque.  
- Measure the diameter of the camshaft supports and check that they fall within the prescribed values.



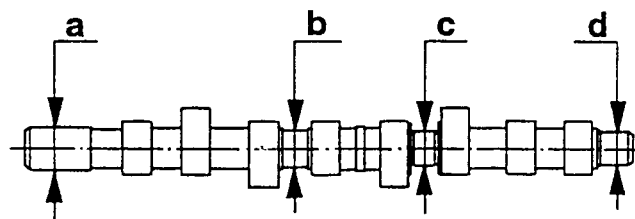
Diameter of camshaft supports	
First support (a)	29.990 + 30.015 mm
Second support (b)	25.545 + 25.570 mm
Third support (c)	24.045 + 24.070 mm
Fourth support (d)	23.990 + 24.015 mm



- Measure the diameter of the camshaft journals and check that they fall within the prescribed values.



Diameter of camshaft journals	
First journal (a)	29.945 + 29.960 mm
Second journal (b)	25.500 + 25.515 mm
Third journal (c)	24.000 + 24.015 mm
Fourth journal (d)	23.945 + 23.960 mm



- Calculate the radial clearance between the camshaft journals and the relative supports and check that they fall within the prescribed limits, if not replace the worn parts.



Camshaft radial clearance
0.03 + 0.07 mm



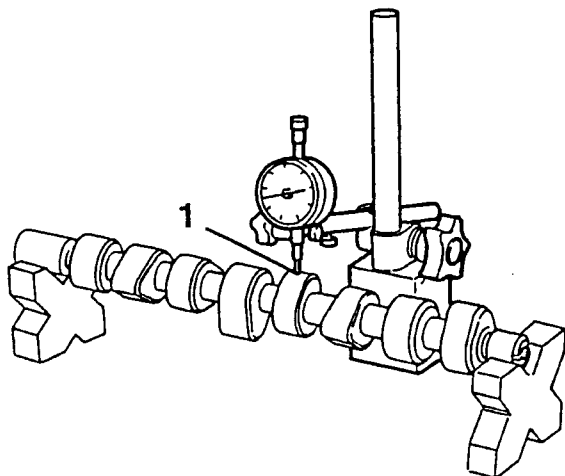
## Check height of cams

1. Measure the height of the camshaft cams and check that they fall within prescribed limits.



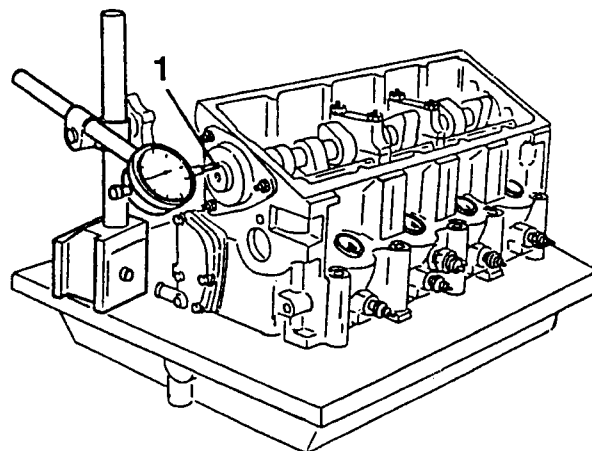
### Minimum cam height

intake and exhaust	8.5 mm
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### Camshaft axial clearance

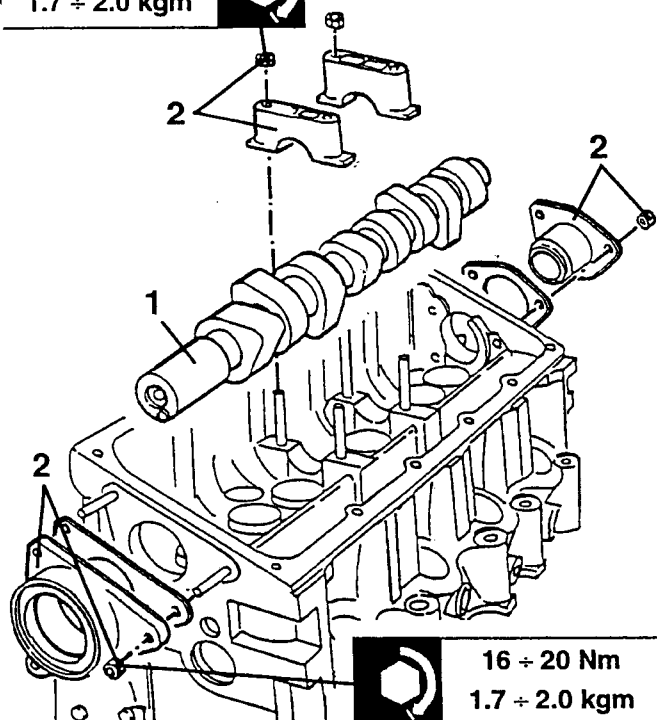
0.1 mm



## Check camshaft axial clearance

1. Position the camshaft on the cylinder heads.
2. Install the central caps and the lateral supports and tighten the relative nuts to the prescribed torque.

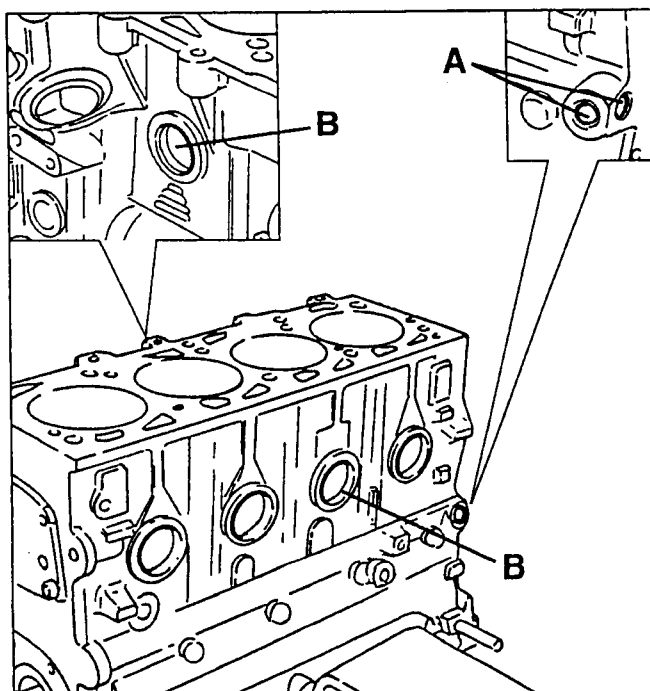
16 ÷ 20 Nm  
1.7 ÷ 2.0 kgm



16 ÷ 20 Nm  
1.7 ÷ 2.0 kgm

## ENGINE BLOCK CHECKS AND INSPECTIONS

- Visibly check the engine block for cracks and signs of excessive wear; check the integrity of the threading.
- Remove the plugs from the lubricating and cooling ducts "A" and "B" and clean the ducts with a suitable detergent, then dry with a jet of air and replace the plugs.
- Thoroughly Clean off any fragments of gasket from the engine block plane.

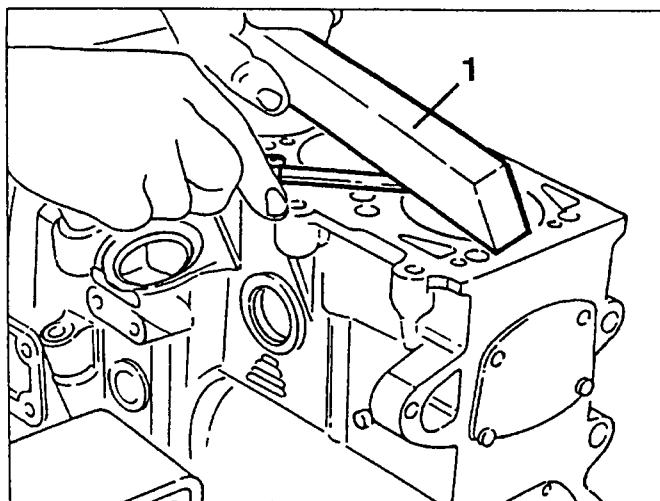


1. Check the planarity of the cylinder head plane and check that it falls within prescribed values, and if necessary, reface.



**Maximum planarity error of cylinder head plane**

0.1 mm



1. After refacing, check that the engine block height "A" exceeds the minimum value.

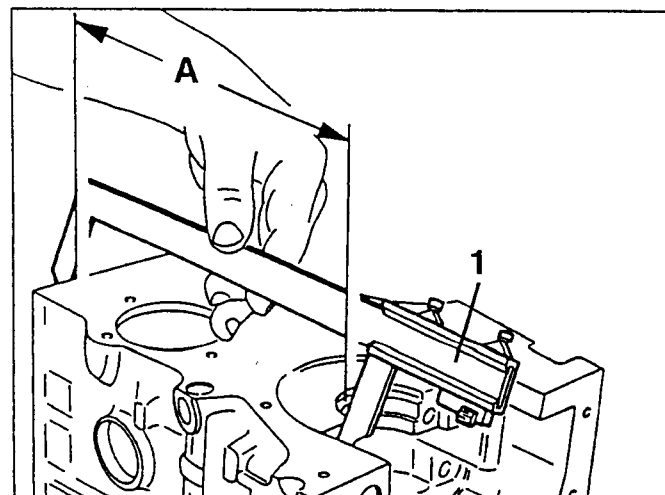


**CAUTION:**  
do not exceed minimum value otherwise engine may seriously malfunction.



**Minimum height "A" of engine block after facing**

231.93 ÷ 232.07 mm



## Check clearance between liners and pistons

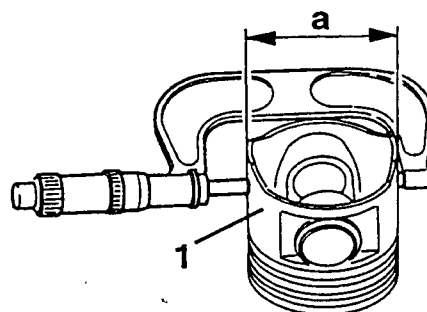
1. Measure the external diameter of the pistons and check that it falls within the prescribed values.



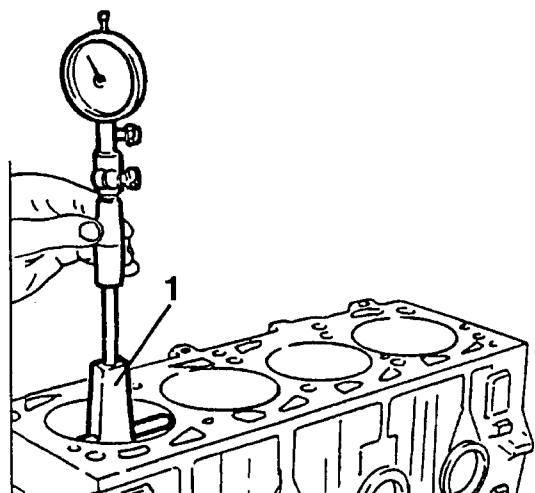
**External diameter "a" (1)**

Class A	82.530 ÷ 82.540 mm
Class B	82.540 ÷ 82.550 mm
Class C	82.550 ÷ 82.560 mm
Class D	82.560 ÷ 82.570 mm
Class E	82.570 ÷ 82.580 mm

(1) The external diameter of the piston must be measured perpendicularly to the hole of the gudgeon pin and at a distance of 15mm from the lower edge of the skirt.



1. Measure the diameter of the cylinder liners and check that it falls within the prescribed values.



**Inner diameter "d"**

Class A	82.600 ÷ 82.610 mm
Class B	82.610 ÷ 82.620 mm
Class C	82.620 ÷ 82.630 mm
Class D	82.630 ÷ 82.640 mm
Class E	82.640 ÷ 82.650 mm

Check that the taper and the ovalization of the liners falls within the prescribed values.



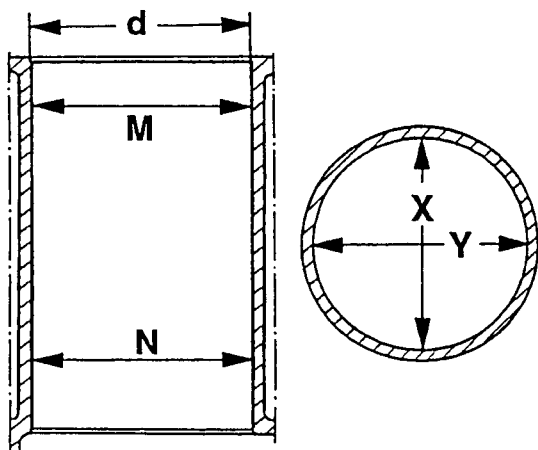
**Maximum taper**

$$M - N = 0.005 \text{ mm}$$



**Maximum ovalization**

$$X - Y = 0.05 \text{ mm}$$



- Calculate the clearance between the liners and the pistons and check that it falls within prescribed limits.

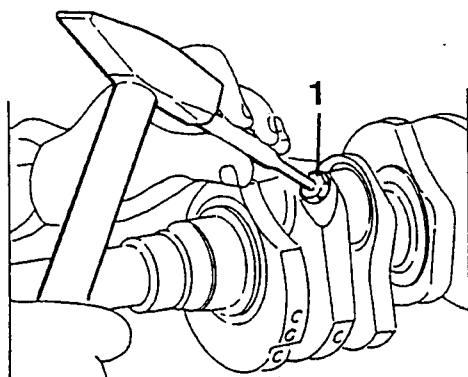


**Clearance between liners and pistons**

$$0.060 + 0.080 \text{ mm}$$

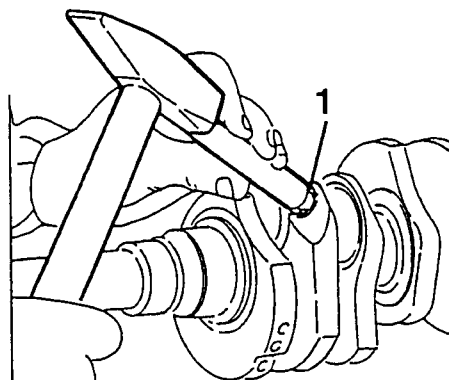
### Cleaning of crankshaft lubrication ducts

1. Punch a hole in the crankshaft lubrication duct plugs, then extract them and remove any shavings created by the calking operation.

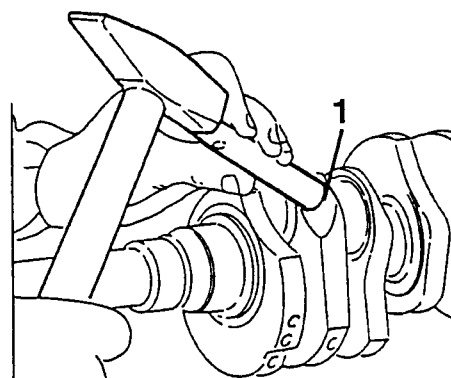


- Thoroughly clean the lubrication ducts using a suitable detergent, then dry with a jet of compressed air.

1. Apply the prescribed sealant on the new plugs and insert them, using a suitable tool, into the holes of the lubrication duct.



1. Calk the plugs using a suitable tool.

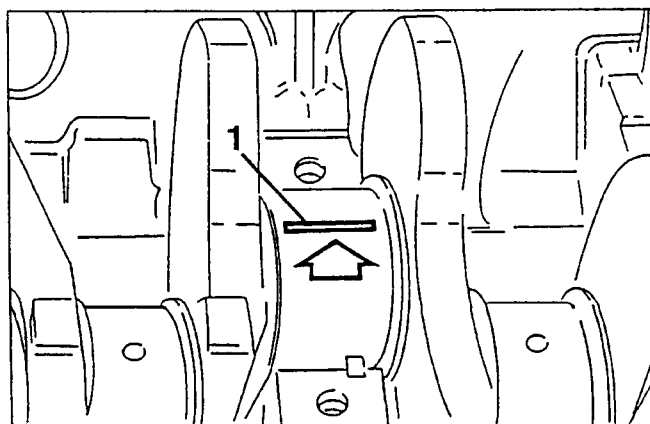


**Measure the assembly clearance between the main journals and relative bearings halves using a gauged wire (plastigage)**

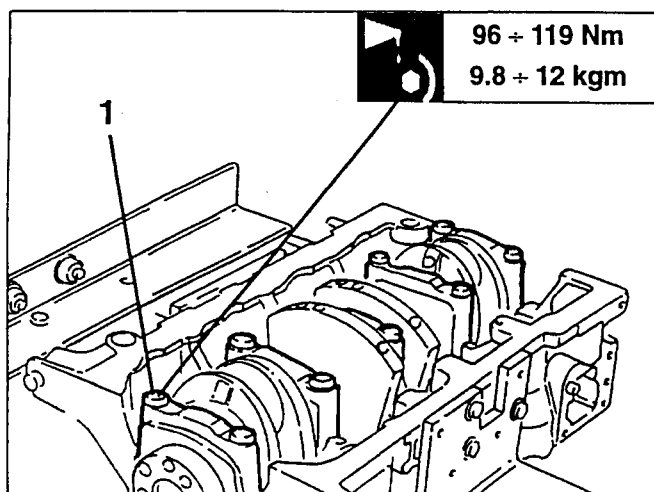
**NOTE:** Check each journal without removing the crankshaft during the checking operation.

The bearing halves must be housed in their respective seatings.

1. Rest a piece of calibrated wire across the whole width of the main journal being checked, paying particular attention that it does not correspond with the lubrication hole.



1. Tighten the lubricated main cap fastening screws to the prescribed torque.



1. Remove the main cap and compare the width of the gauged wire pressed with the scale indicated on the sachet.

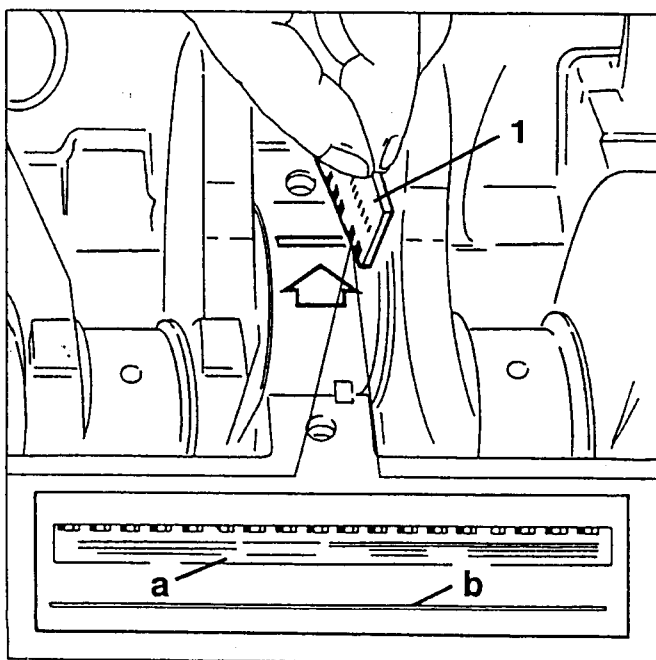
From the comparison between the width of the pressed wire and the scale, it is possible to determine the clearance between the journals and the relative bearing halves.

- Proceed in the same way for the other main journals.



#### Radial clearance between main journals and bearing halves

Class A (red)	$0.027 \pm 0.066$ mm
Class B (blue)	$0.024 \pm 0.063$ mm



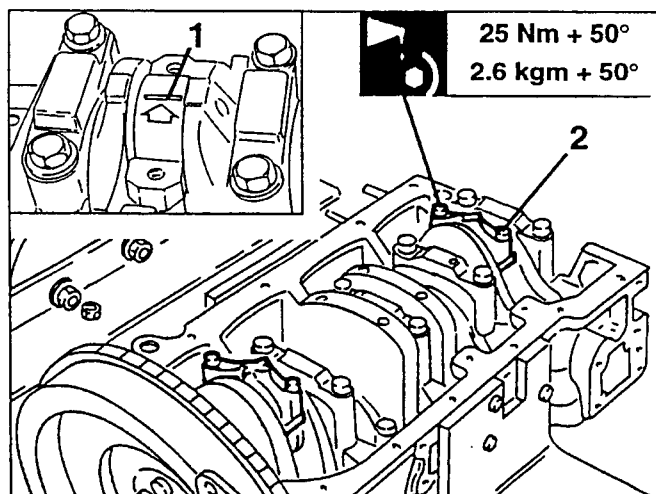
- a. Sachet with comparison scale  
b. Gauged wire

### Measure assembly clearance between rod journals and relative bearing halves using a gauged wire (plastigage)

1. Rest a piece of gauged wire across the whole width of the rod journal paying particular attention that it does not correspond with the lubrication holes.

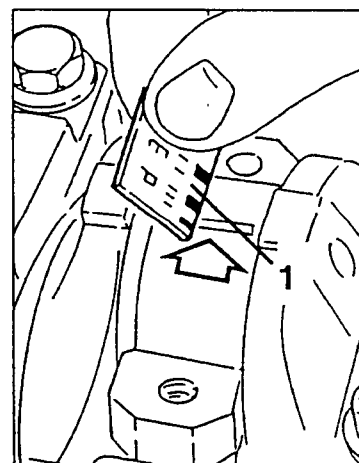
**NOTE:** The bearing halves must be housed in their respective seatings.

2. Tighten the lubricated rod cap fastening screws to the prescribed torque.



1. Remove the rod cap and compare the width of the pressed gauged wire with the scale indicated on the sachet.

- From the comparison between the width of the pressed wire and the scale, it is possible to determine the clearance between the bearings halves and the rod journals.



- Proceed in the same way for the other rod journals.



#### Radial clearance between the rod journals and bearing halves

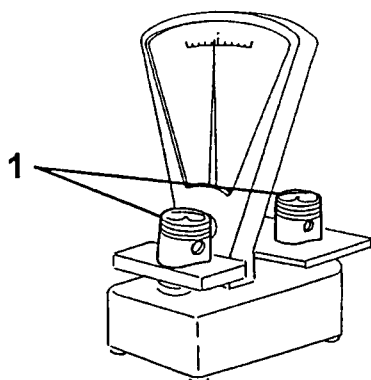
Class A (red)	$0.026 \pm 0.063$ mm
Class B (blue)	$0.023 \pm 0.060$ mm

## Checking and differences in weight between single pistons and single connecting rods

1. Weigh the pistons complete with seal rings, scraper ring, gudgeon pin and check that the difference in weight is within the specified limit.



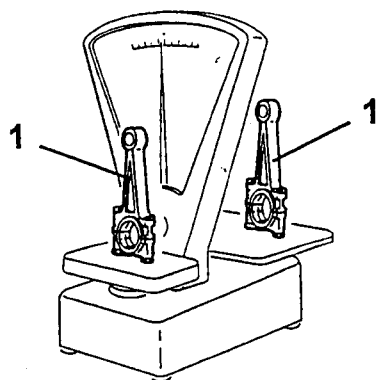
Difference in weight between pistons
$\pm 5 \text{ g}$



1. In the same way, check that the difference in weight between the connecting rods, complete with half bearings, caps and screws, is within the specified limit.



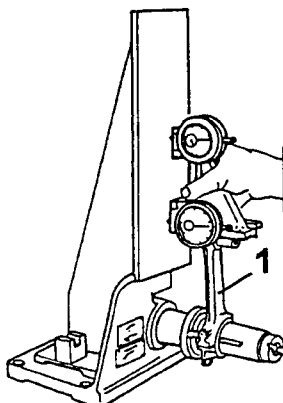
Difference in weight between connecting rods
$\pm 2.5 \text{ g}$



## Checking connecting rod squareness

1. Check the squareness of the connecting rods using a reference plane.

If imperfect squaring is noted, it is necessary to replace the connecting rod to avoid abnormal stresses, which would result in uneven wear of the piston and of the connecting rod itself.

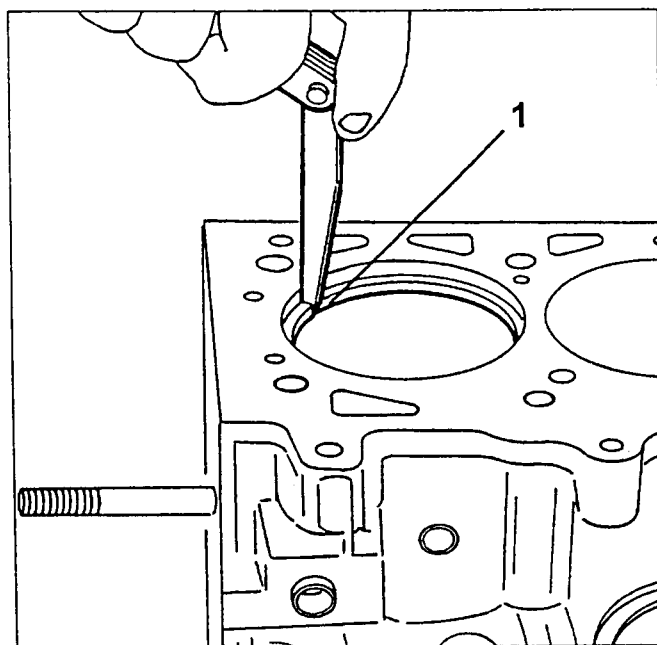


## Checking the seal ring gap

1. Insert the seal rings in the cylinder liner and use a thickness gauge to check that the gap is within the specified limits.



Ring gap	
First ring	$0.20 \div 0.35 \text{ mm}$
Second ring	$0.30 \div 0.50 \text{ mm}$
Oil scraper ring	$0.25 \div 0.50 \text{ mm}$

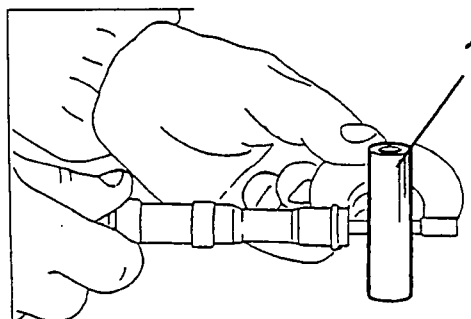


## Checking the clearance between gudgeon pin and seat on piston

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



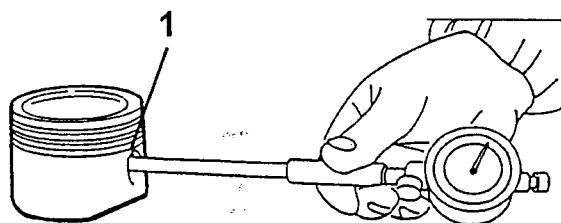
Gudgeon pin outside diameter		
Version before change	Class 1	$25.987 \div 25.990 \text{ mm}$
	Class 2	$25.990 \div 25.993 \text{ mm}$
Version after change		$25.987 \div 25.991 \text{ mm}$



1. Measure the diameter of the hole on the piston paired with the gudgeon pins and check that it is within the specified limits.



Gudgeon pin hole diameter in pistons		
Version before change	Class 1	25.993 ÷ 25.996 mm
	Class 2	25.996 ÷ 25.999 mm
Version after change		25.994 ÷ 25.999 mm



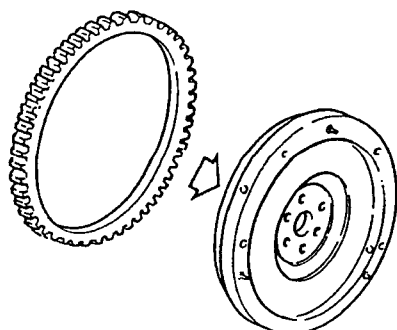
- Calculate the clearance between the gudgeon pins and their seats on the pistons and check that it is within the specified limits.



Clearance between gudgeon pins and seats on pistons	
Version before change	0.003 ÷ 0.009 mm
Version after change	0.003 ÷ 0.012 mm

## Changing the flywheel ring gear

- Check that the flywheel ring gear is intact and, if necessary, replace it proceeding as follows:
  - remove the old ring gear using a hydraulic press.
  - carefully clean the contact surfaces of the new ring gear and of the flywheel.
  - evenly heat the new ring gear to a temperature of 80 °C and fit it on the flywheel.
  - allow to cool in a natural environment; do not force cool.

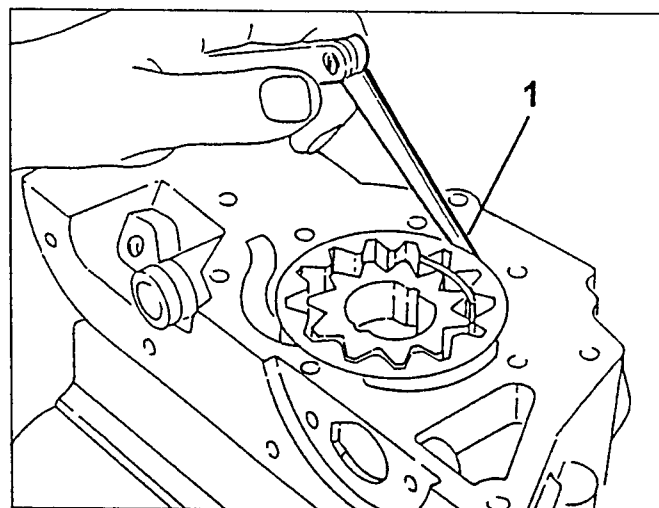


## Inspecting and checking the oil pump

1. Check that the clearance between the pump casing housing and the driven gear is within the specified limit.



Clearance between pump casing housing and driven gear
0.080 ÷ 0.186 mm



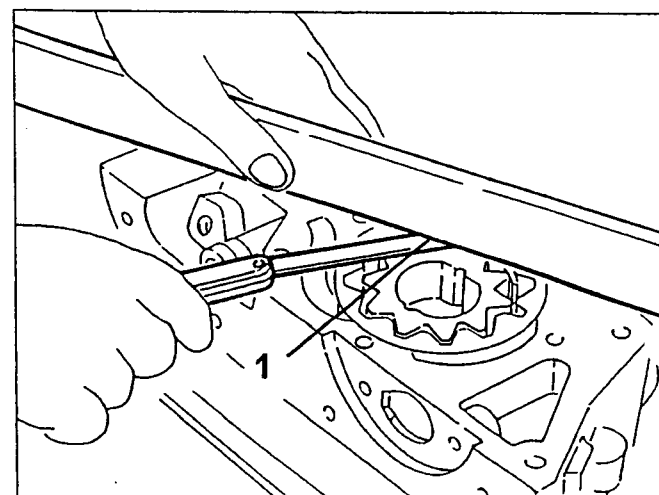
1. Check that the clearance between the resting surface of the pump cover and the upper side of the gears is within the specified limit.



**WARNING:**  
If the clearances are not within the specified limits, change the front cover with incorporated oil pump.



Clearance between pump cover resting surface and upper side of gear
0.025 ÷ 0.056 mm



## INSTRUCTIONS FOR REASSEMBLY

For reassembly operations, reverse the sequence followed for disassembly, unless otherwise specified below.

### Checking and adjusting valve clearance

- After refitting the camshaft measure the valve clearance as follows:

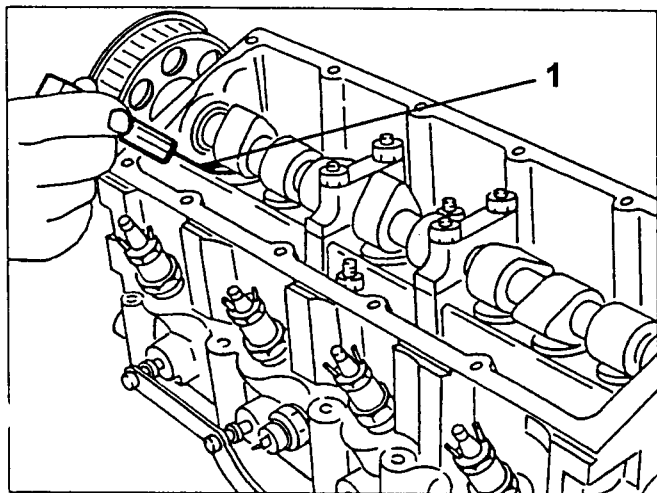
- Turn the camshaft to take the intake and exhaust valves to the closed position.

1. Check that the clearance between the lowered radius of the cam and the corresponding tappet is within the specified limits.



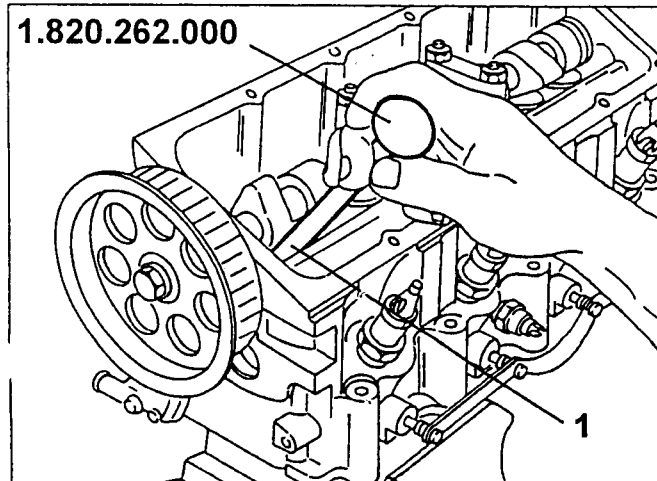
#### Valve operating clearance (with engine cold)

Intake	$0.30 \pm 0.05$ mm
Exhaust	$0.35 \pm 0.05$ mm

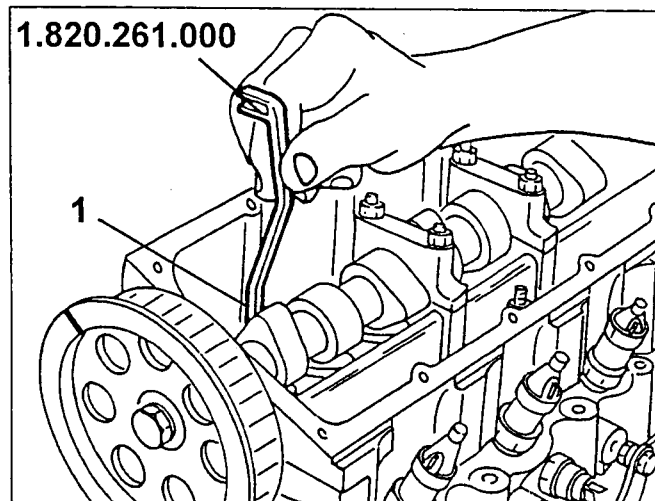


- If the clearance is not within the specified limits, proceed as follows:

1. Using the pressure lever no. 1.820.262.000 lower the tappet.

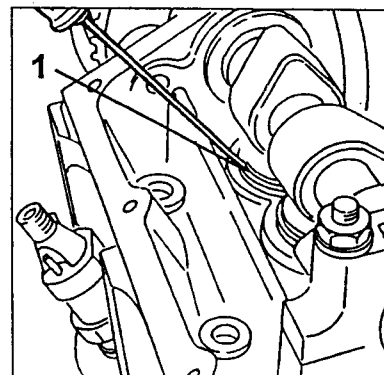


1. Position tool no. 1.820.261.000 directing the notches on the edge of the tappets to facilitate removal of the plate.



1. Prise and remove the tappet adjustment plate.

- Replace the removed plate by another one of suitable thickness to restore the correct valve clearance.



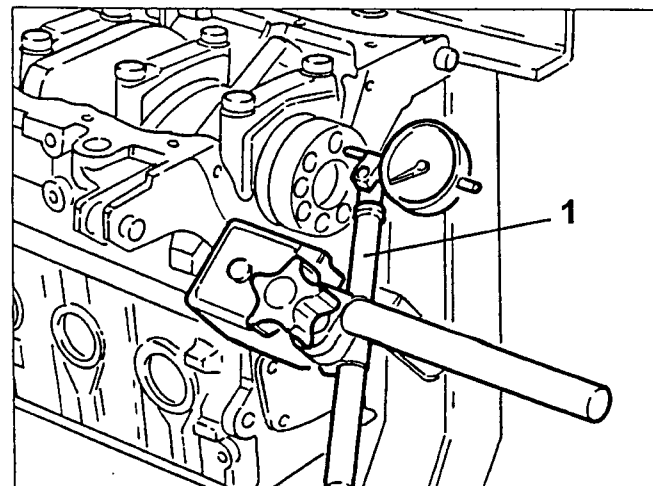
### Checking the crankshaft end float

1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.



#### Crankshaft end float

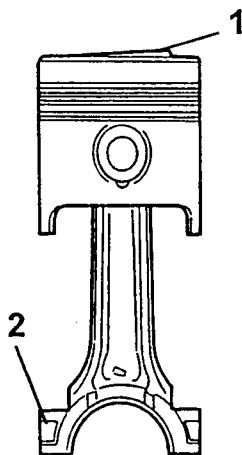
$0.049 \div 0.211$  mm



## Refitting pistons and connecting rods

- Turn the crankshaft until the connecting rod pins of the 1st and 4th cylinder reach the position corresponding to the B.D.C.
- Assemble the pistons - connecting rods in the sequence illustrated below.

1. Protrusion on piston crown
2. Number of cylinder to which connecting rod belongs



- House the corresponding half bearings on the connecting rod big ends.

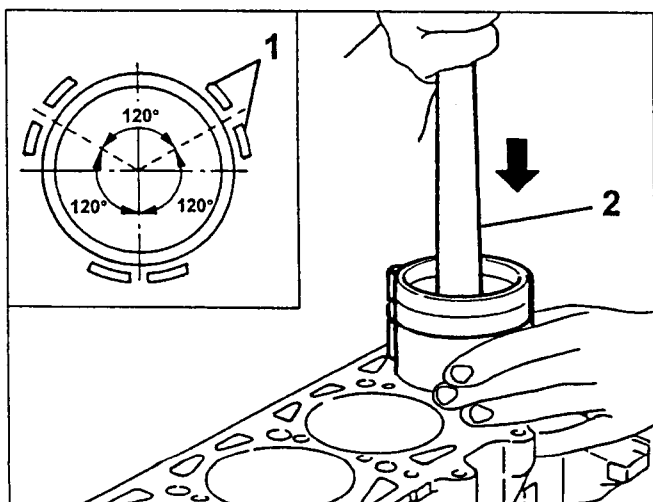


Carefully clean the outer surfaces of the half bearings and their seats.

1. Place the rings in the pistons with the notches offset by 120°.
2. Using a suitable tool, insert the pistons and connecting rods in the 1st and 4th cylinder.



Assemble the connecting rod-piston sets directing the number of the cylinder stamped on the connecting rod small end towards the intake - exhaust side.



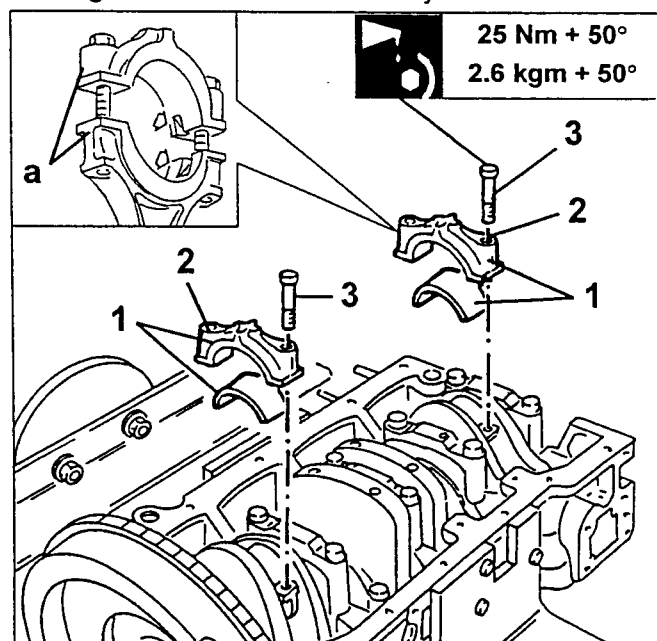
- Turn the crankcase 180°.
- 1. House the corresponding half bearings on the connecting rod caps.

2. Assemble the connecting rod caps of the first and fourth cylinder with the safety notch on the same side as the one on the connecting rod.



On the side, the connecting rod caps have the number of the cylinder to which they belong; during reassembly this number should be on the same side as the one stamped on the connecting rod big end.

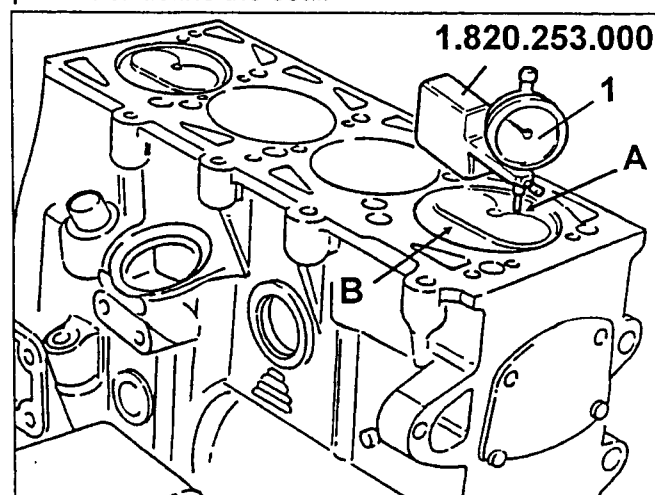
3. Tighten the connecting rod cap fastening screws to the specified torque in oil.
- In the same way reassemble the pistons and connecting rods of the 2nd and 3rd cylinder.



a. Stamped number of corresponding cylinder

## Cylinder head refitting

1. Using tool no. 1.820.253.000 fitted with dial gauge, find for each cylinder in points A and B the protrusion/recess of the piston; calculate the average of the values and consider the highest average among the pistons to define the seal.





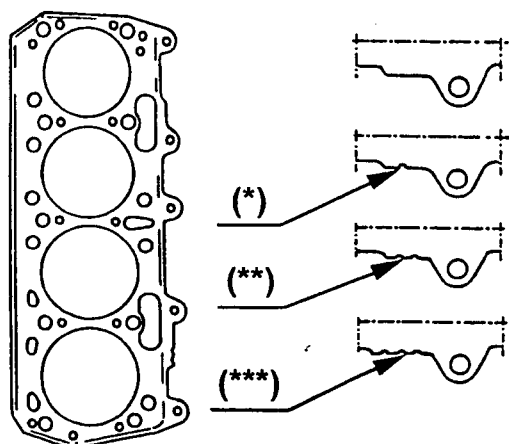
- Choose the cylinder head seal of suitable thickness according to the table given below.

Average piston protrusion		Thickness of cylinder head seal
up to engine no. 1762797	from engine no. 1762798	
< 0.7 mm	< 1.05 mm	1.67 mm
0.7 ÷ 0.8 mm	1.05 ÷ 1.15 mm	1.75 mm (*)
0.8 ÷ 0.9 mm	1.15 ÷ 1.25 mm	1.85 mm (**)
> 0.9 mm	> 1.25 mm	1.93 mm (***)

(\*) marked by 1 notch on the outer edge

(\*\*) marked by 2 notches on the outer edge

(\*\*\*) marked by 3 notches on the outer edge



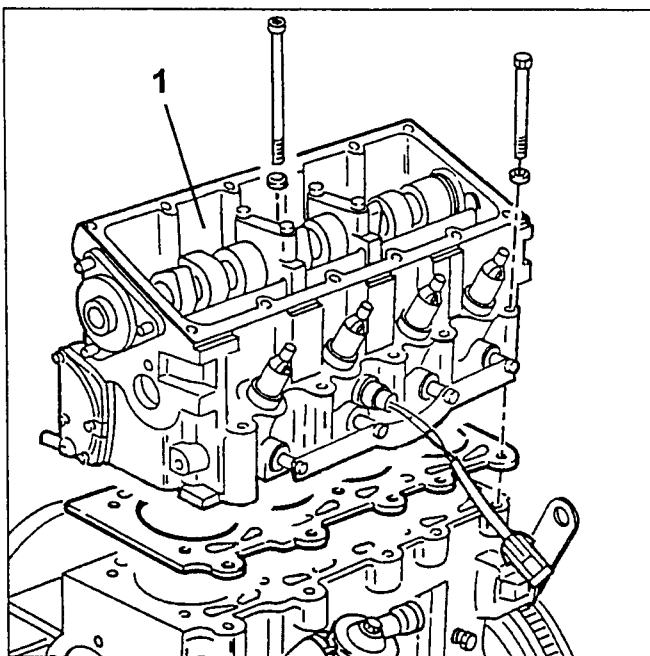
The cylinder head seal is of the ASTADUR type. Due to the special material with which it is made, this seal polymerises when the engine is running therefore it hardens considerably.

#### CYLINDER HEAD SEAL ASSEMBLY

For the cylinder head seal to polymerise, it is necessary:

- to keep the seal in its original package;
- take the wrapper off shortly before assembly;
- not to lubricate or soil the seal with oil;
- during assembly, carefully clean the surfaces of the cylinder and crankcase.

1. Assemble the cylinder head on the crankcase.

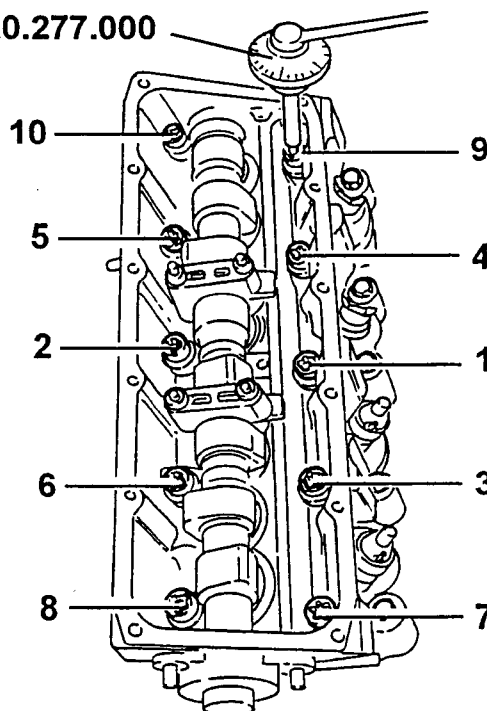


- Tighten the **inner screws** fastening the cylinder head as described below, bearing in mind that, for each step, the tightening sequence is the one shown below.

- Tighten the **inner screws** to a torque of 100 Nm (10.2 kgm).

- Angle tighten by 90° + 90° the **inner screws** using graduated disk no. 1.820.277.000.

1.820.277.000



- Tighten the **outer screws** fastening the cylinder head to the crankcase to a torque of 26 ÷ 32 Nm (2.6 ÷ 3.2 kgm).

**NOTE:** For tightening the cylinder head outer screws no particular sequence is required.



**WARNING:**

ASTADUR seals are paired with cylinder head fastening screws of the type with tightening to the yield point.

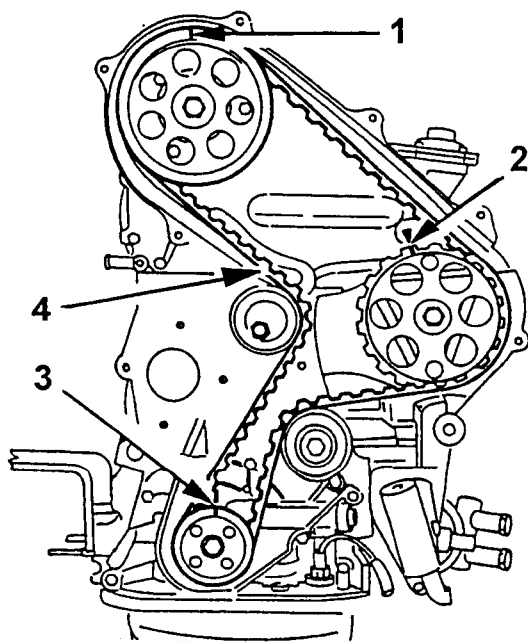
With the adoption of ASTADUR seals it is no longer necessary to tighten the cylinder head fastening screws at the first service coupon.

### Camshaft drive belt assembly and checking valve gear timing

- Refit the camshaft toothed pulleys, the pulley guide and the belt tensioner.

1. Direct the camshaft drive pulley so that the notch on it corresponds with the hole on the camshaft belt rear cover.
2. Direct the injection pump drive pulley so that the notch on it corresponds with the relief on the camshaft belt rear cover.
3. Turn the crankshaft until the reference notch of the camshaft belt drive pulley is aligned with the relief on the engine front cover.
4. Assemble the toothed belt, checking correct mating of the teeth on all the toothed pulleys.

When assembling the toothed belt, to avoid damaging the structure of the fibres that form it, never cause sharp bends.



- On tool no. 1.824.016.000 (C.2.0129) assemble support no. 1.824.017.000 (C.2.0130), then position the weight, with the knurled piece, at a distance of 120 mm on the millimetre rod and lock it.

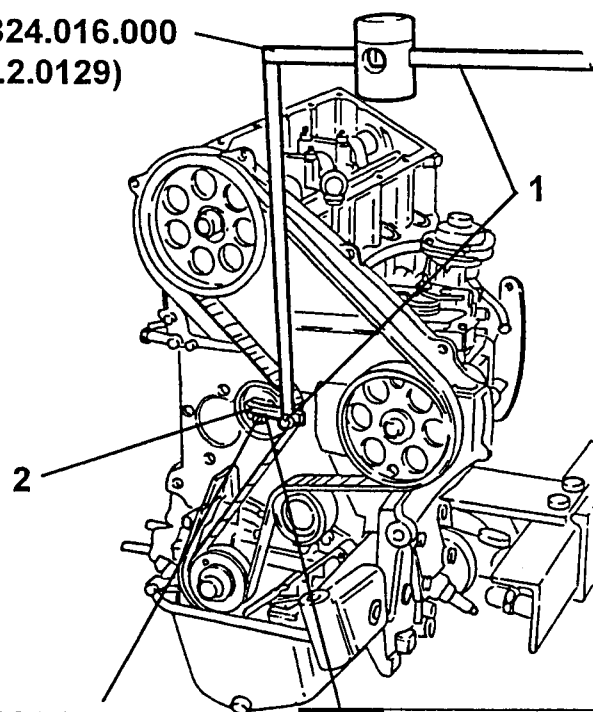
1. Apply the tool assembled in this way on the belt tensioner, as illustrated. Working on the joint, direct the millimetre rod so that it is horizontal.

- Settle the toothed belt turning the crankshaft twice in its normal direction of rotation.

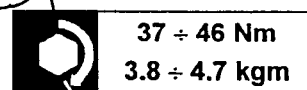
2. Tighten the belt tensioner fastening nut to the specified torque.

During this phase, the millimetre rod may move from its horizontal position; in this case it is necessary to work on the belt tensioner again to restore the original position of the millimetre rod and repeat the operation.

1.824.016.000  
(C.2.0129)

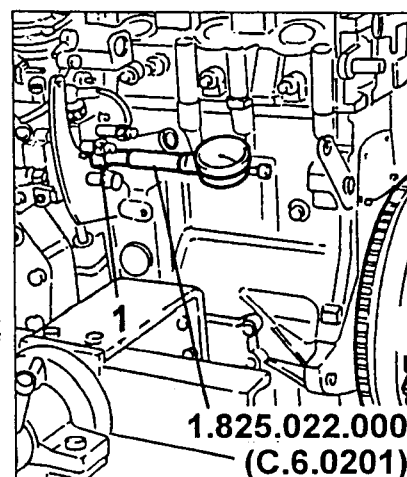


1.824.017.000  
(C.2.0130)



### Injection pump timing

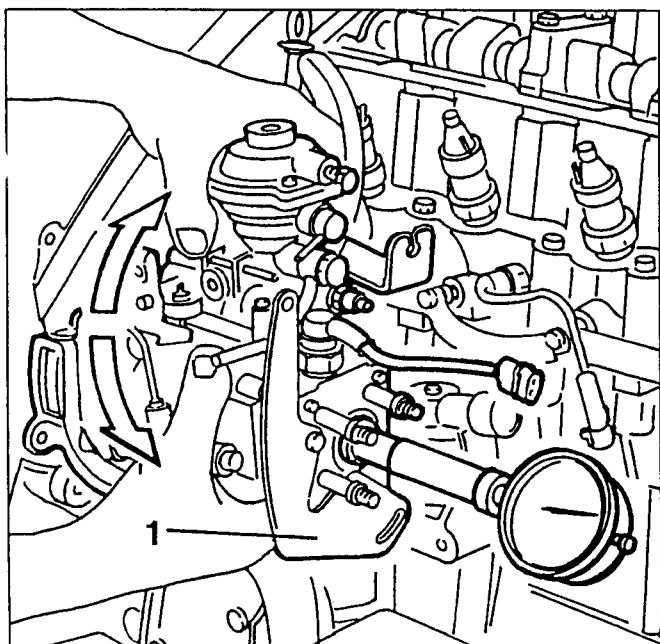
1. Remove the plug on the pump cover and in its place screw on tool no. 1.825.022.000 (C.6.0201) complete with dial gauge with the feeler in contact with the crown of the distributor piston.



- Using a suitable tool, rotate the engine in the opposite direction to the normal rotating direction until the timing piston of the pump reaches the B.D.C. indicated by the comparator; when in this position set the latter to zero.

- Rotate the engine in the normal rotating direction until the piston of cylinder N° 1 is at the T.D.C. In this position the piston will have carried out a 0.8 mm stroke as indicated on the comparator.

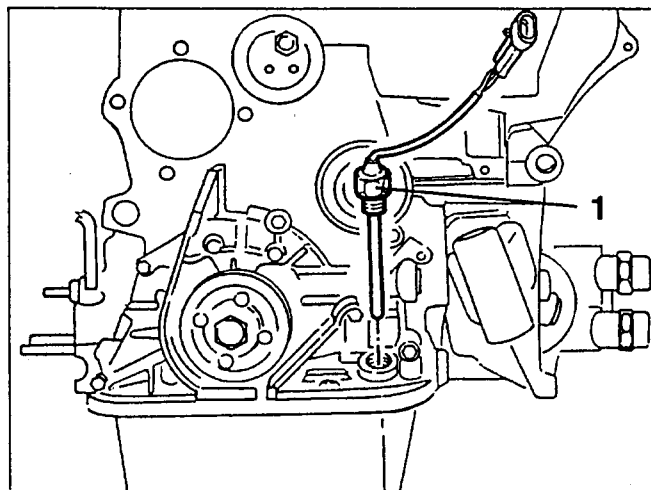
1. If this stroke is not indicated, the pump body must be rotated in its slot until the correct value, as indicated on the comparator, is obtained then tighten the screws fastening the pump to the support.



### Engine oil level sensor

1. Check the setting of the engine oil level sensor; If the prescribed values are not found, replace the sensor.

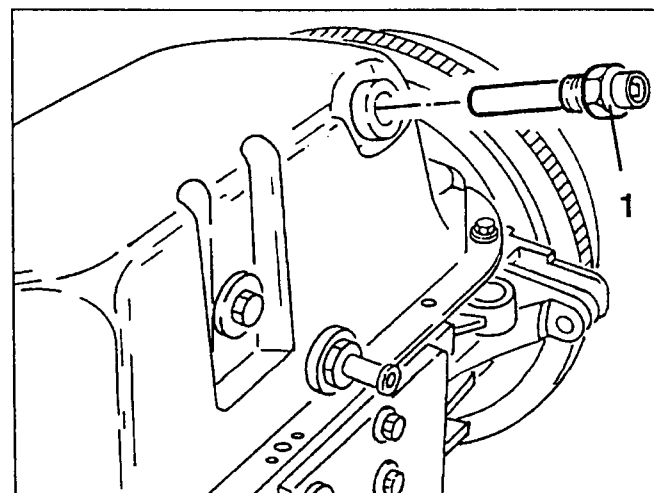
Circuit resistance	$12\Omega \pm 5\%$
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### Oil temperature sensor

1. Check the setting of the engine oil temperature sensor; If the prescribed values are not found, replace the sensor.

Temperature °C	Resistance $\Omega$
$60 \pm 0.5$	$525 \div 605$
$90 \pm 0.5$	$195 \div 215$
$120 \pm 0.5$	$82 \div 94$
$140 \pm 0.5$	$49 \div 55$



**WHEN REASSEMBLY IS COMPLETED** carry out all the checks and inspections required by ordinary maintenance (see GROUP 00) and the checks regarding the supply system (see GROUP 04) and the cooling system (see GROUP 07).

## INSPECTION OF LUBRICATION CIRCUIT ELECTRICAL COMPONENTS

- Engine oil level sensor.
- Engine oil temperature sensor.
- Engine oil minimum pressure warning light.

As regards the other sensors and electrical components located in the engine compartment, refer to the specific groups where they are described in detail.

## Engine oil minimum pressure warning light sensor

1. Check the setting of the engine oil minimum pressure warning light sensor; if the prescribed value is not found, replace the sensor.



**Contact  
opening/closing  
pressure**

0.2 ÷ 0.5 bar

