
Workshop Manual

Industrial Engines

TD520GE, TAD520GE, TD520VE, TAD520VE, TAD530/531/532GE, TD720GE, TAD720GE, TD720VE, TAD720VE, TAD721GE, TAD721VE, TAD722GE, TAD722VE, TAD730/731/732/733GE

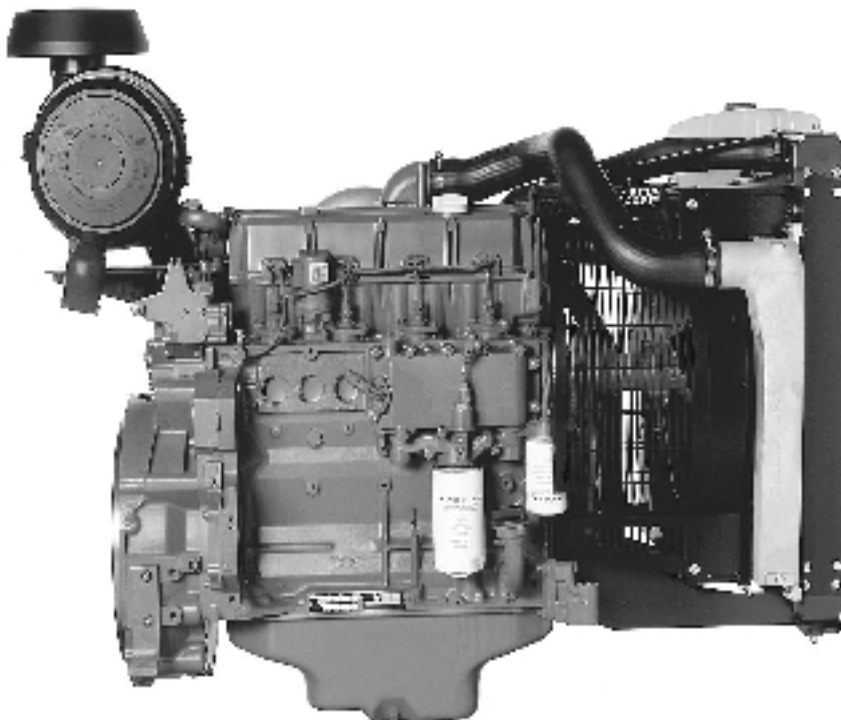
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Engine description

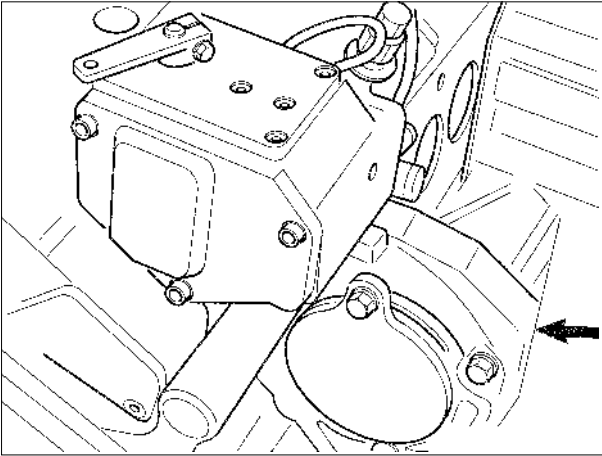
Location of the engine identification plate

Each engine is supplied with two identical identification plates, of which one is mounted on the right side of the cylinder block and the other one should be mounted in a suitable location adjacent to the engine.



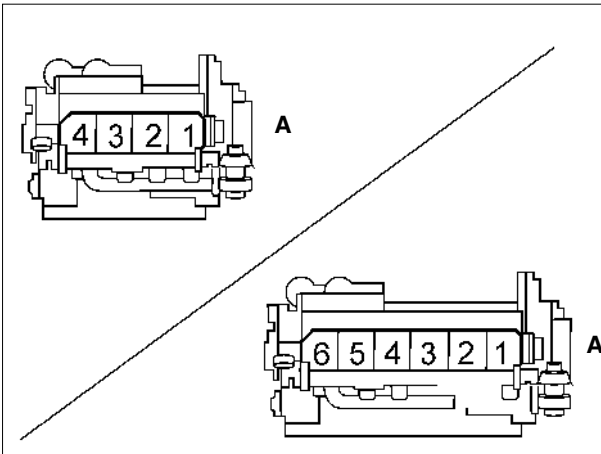
Identification plates

1. Engine model
2. Engine specific number
3. Engine serial number (10 digits)
4. Engine output without fan
5. Rated engine speed
6. Injection timing and type of camshaft
7. Manufacturers identification code
8. Indication of standard and /or regulation
9. Reference test conditions, according to ISO 3046
10. Reference test conditions, according to ISO 3046
11. Injection pump code (EP code), cylinder 1 on top
12. Piston class
13. Extra information



Engine serial number

The engine serial number is stamped into the engine block and engine identification plate. The serial number is a ten-digit number. Only the last eight digits are stamped into the engine block.

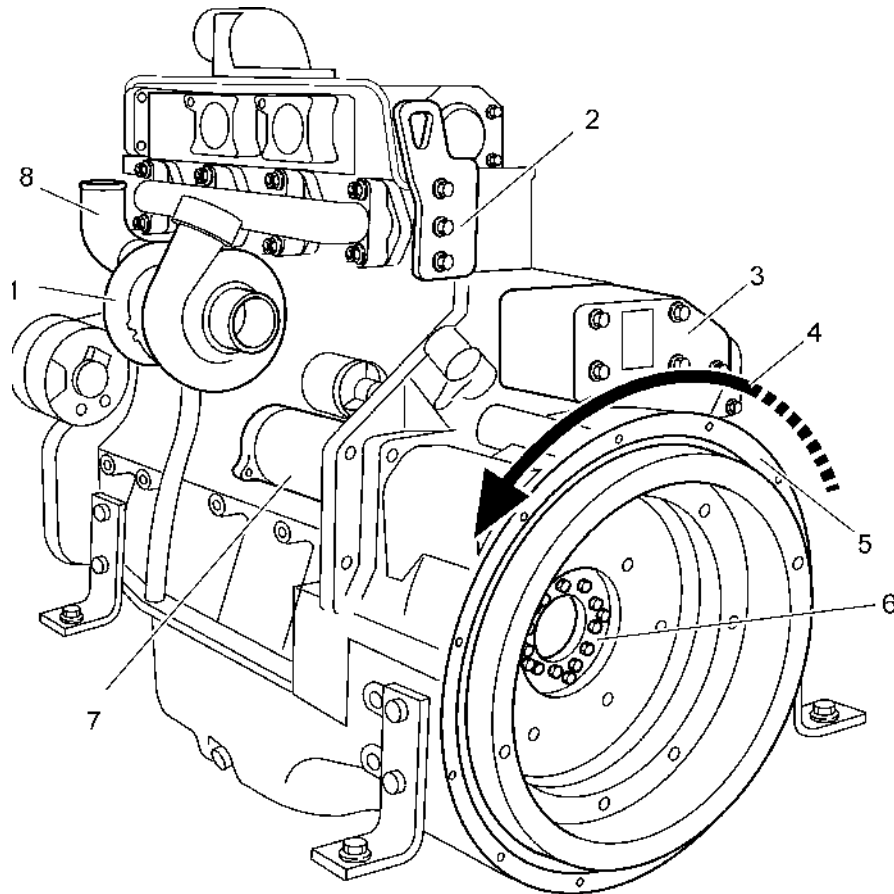


Cylinder numbering

(A = flywheel)

Engine, location of components

Starter motor side



- 1 Turbocharger
- 2 Lifting eye
- 3 Engine speed governor*
- 4 Rotation direction (counter-clockwise)
- 5 Flywheel housing
- 6 Flywheel
- 7 Starter motor
- 8 Coolant outlet pipe

* Governor (Heinzmann)

The governor for T(A)D 520, 530/532/720-722, 730-733GE/VE series engines is a mechanically variable speed governor with a Heinzmann centrifugal measuring unit.

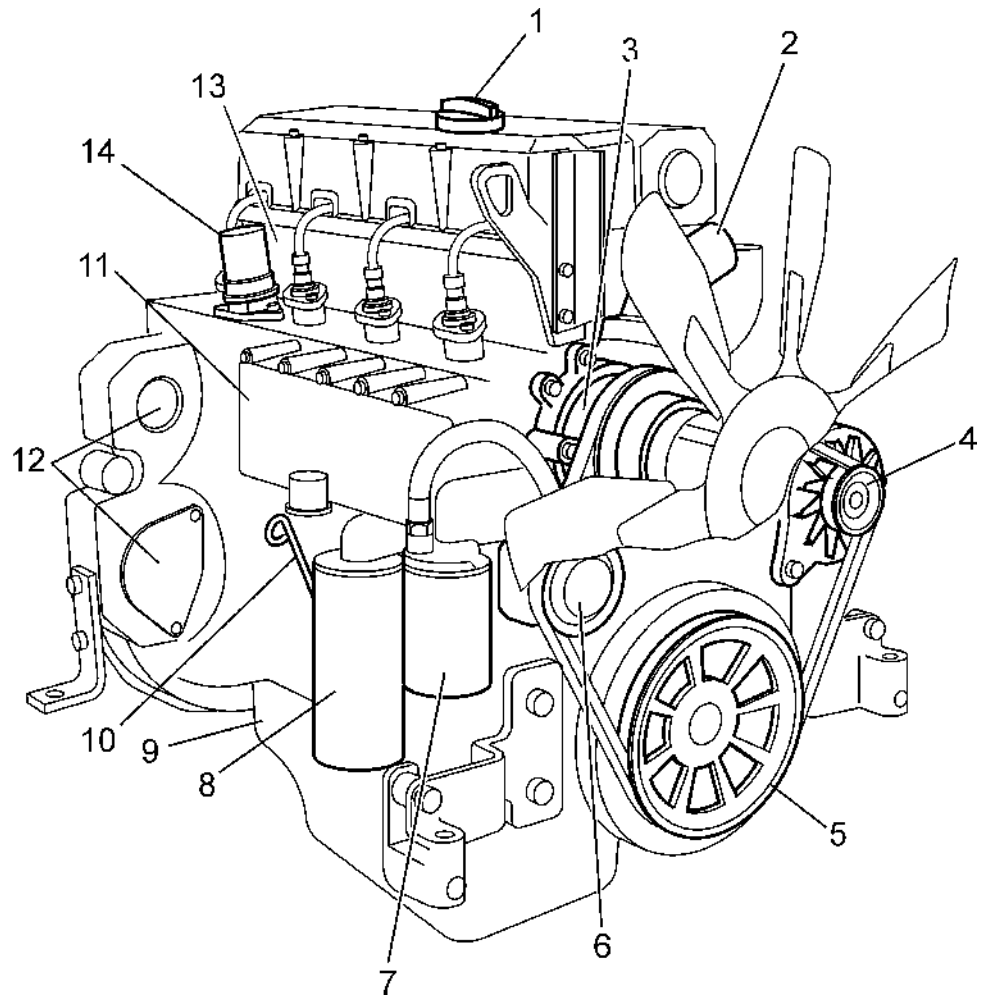
The governor for the engines above are uniquely prepared for each engine individual. This means that the governor can not be exchanged between different engines.

An incorrect adjusted governor can result in that the engine will not fulfill the regulations for emission and performance.

When ordering a governor as a spare part always state engine types serial number and rated speed (rpm).

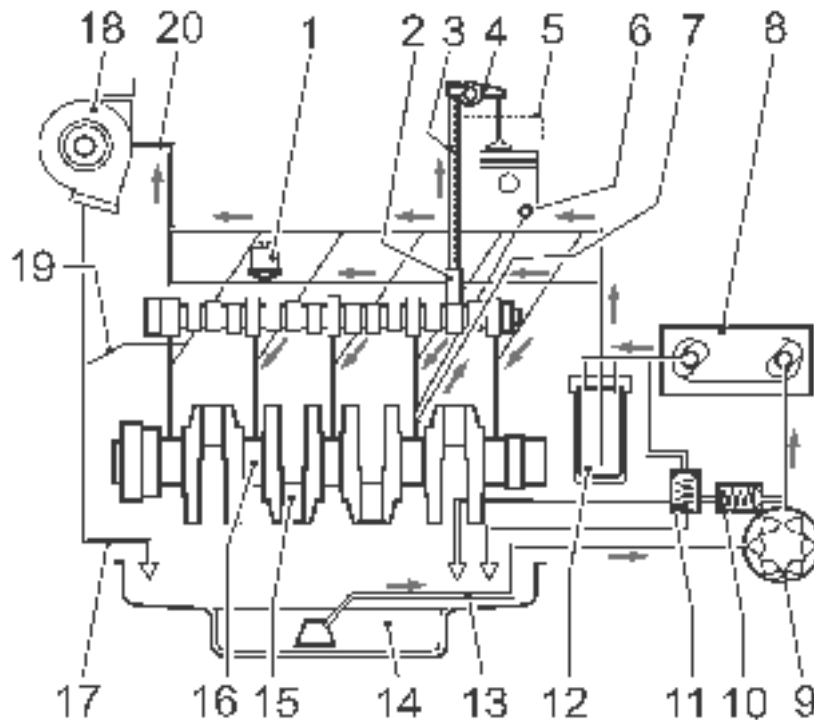
Only trained personnel should make adjustments to the governor.

Service side



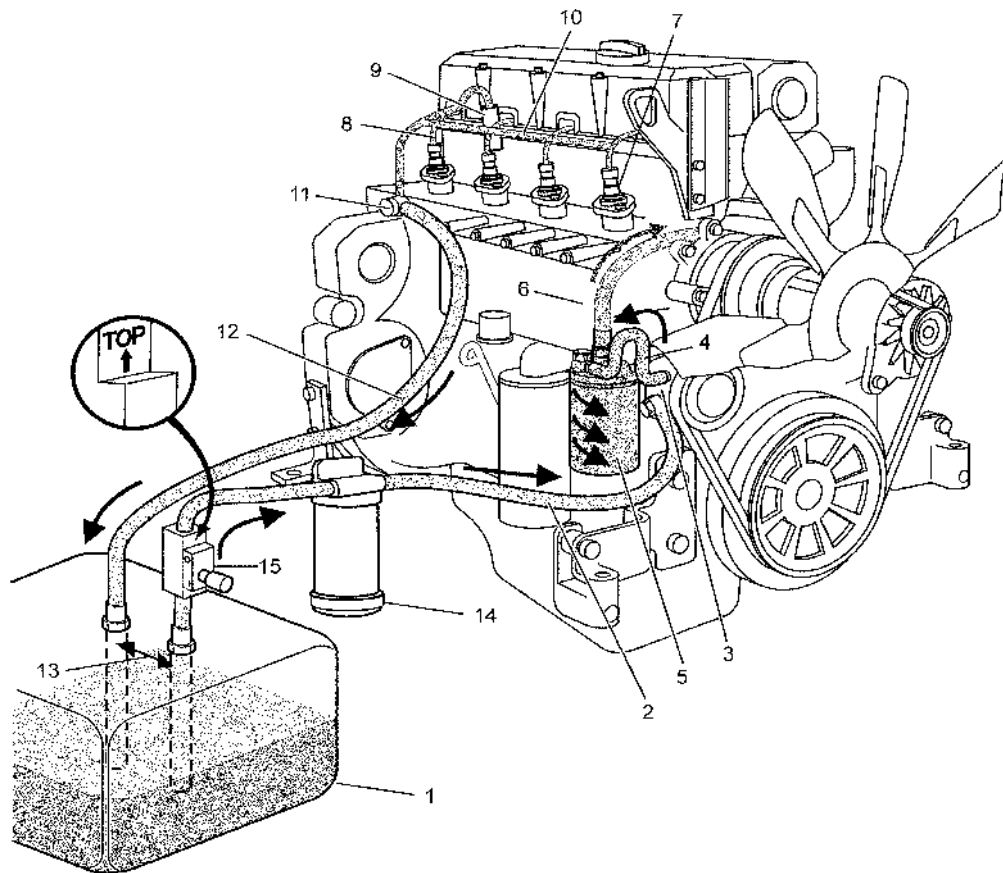
- 1 Oil filler cap
- 2 Coolant inlet pipe
- 3 Coolant pump
- 4 Alternator
- 5 Crankshaft pulley
- 6 Fuel pump
- 7 Fuel filter
- 8 Lubricating oil filter
- 9 Oil sump
- 10 Oil dipstick
- 11 Lubricating oil cooler
- 12 Power socket for hydraulic pump,
air compressor etc.
- 13 Cylinder head
- 14 Stop solenoid

Lubrication system



- 1 Oil pressure sender
- 2 Valve tappet with rocker arm lubrication
- 3 Oil suction pipe
- 4 Rocker arm
- 5 Return to oil sump
- 6 Spray nozzle for piston cooling
- 7 Oil channel to piston cooling nozzle
- 8 Lubricating oil cooler
- 9 Lubricating oil pump
- 10 Safety valve (pressure regulating valve)
- 11 Reduction valve
- 12 Lubricating oil filter
- 13 Push rod, oil feed to rocker arm lubrication
- 14 Oil sump
- 15 Connecting rod bearing
- 16 Crankshaft main bearing
- 17 Return flow from turbocharger to crankcase
- 18 Turbocharger
- 19 Return flow to oil sump
- 20 Oil line to turbocharger

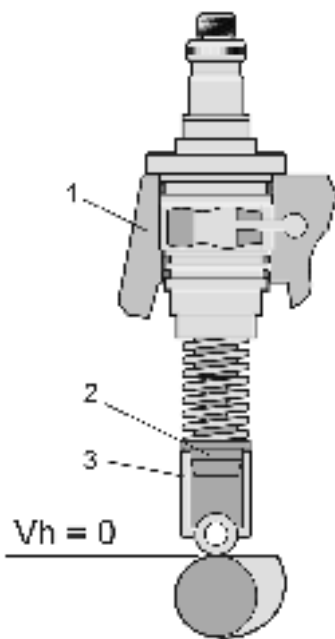
Fuel system



- 1 Fuel tank
- 2 Line to fuel pump
- 3 Fuel pump
- 4 Line to fuel filter
- 5 Fuel filter
- 6 Fuel line to fuel duct
- 7 Injection pump
- 8 Delivery pipe to injector
- 9 Injector
- 10 Fuel return line
- 11 Overflow valve with air ventilation screw
- 12 Return line to fuel tank
- 13 Fuel pipes¹
- 14 Pre-filter, water separating
- 15 Hand pump (accessory)²

¹**NOTE!** Minimum distance 300 mm.

²**NOTE!** Does not work laying down. Must be turned right (TOP).



Commencement of delivery, F_b

The engine is equipped with a separate injection pump for each cylinder. This means that the commencement of delivery, F_b , when necessary, has to be adjusted separate for each pump unit. The commencement of delivery, F_b , is adjusted with a shim, placed between lifter and injection pump.

To exchange only the injection pump, the formula $T_s = (L_0 + A/100)$ is used, according to "Calculation 1" in "Technical data"

If engine block, camshaft or roller tappet are exchanged, the corrected fitting size, E_k , and new **EP-code** must also be calculated, according to "Calculation 2 and 3" in "Technical data".

New **EP-code** must also be indicated on the identification plate, in order for calculations during future replacement of injection pump to be correct.

Delivery pipes

! **IMPORTANT!** The delivery pipes must be disposed of after disassembling.

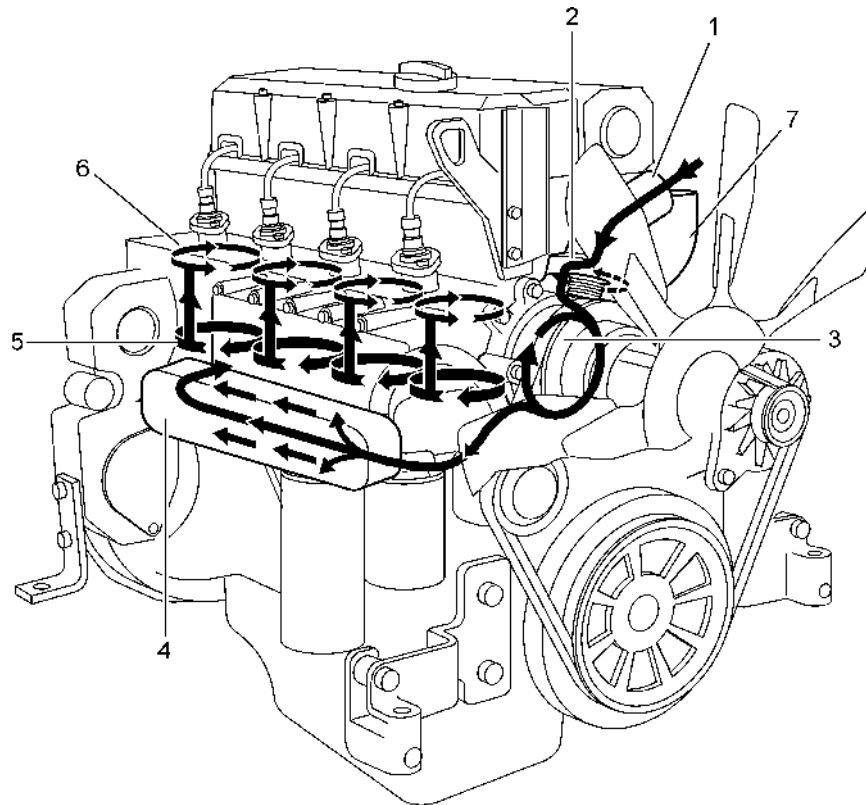
The delivery pipes are deformed when tightened and all delivery pipes must be tightened with the same tightening torque.

If they are tightened with different tightening torque, the cylinders may take different load.

Reuse of delivery pipes may mean that the engine power is not complete.

If the delivery pipes for some reason have been damaged, for example during transport, they may not be bent right, but must be replaced.

Cooling system



- 1 Coolant connection (inlet)
- 2 Thermostat housing
- 3 Coolant pump
- 4 Lubricating oil cooler
- 5 Cylinder cooling
- 6 Cylinder head cooling
- 7 Coolant connection (outlet)

Technical data

Engine

Engine	TD 520GE	TAD 520GE
Engine weight, according to DIN 70020-A	Approx. 550 kg (1212 lbs)	Approx. 575 kg (1268 lbs)
Engine displacement	4760 cm ³ (290.4 in ³)	4760 cm ³ (290.4 in ³)
Bore	108 mm (4.25")	108 mm (4.25")
Stroke	130 mm (5.12")	130 mm (5.12")
Rotation direction	Counterclockwise	Counterclockwise
Rated speed	1500/1800 rpm	1500/1800 rpm
Minimum idling speed	800-950 rpm	800-950 rpm
Operating cycle	Four stroke diesel	Four stroke diesel
Combustion system	Direct injection	Direct injection
Compression ratio	17.5:1	17.5:1
Firing order	1-3-4-2	1-3-4-2
Valve clearance, inlet exhaust	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)
Lubricating oil pressure at low idle, temperature approx. 120°C, oil SAE 15W/40	Min. 150 kPa (21.7 psi)	Min. 150 kPa (21.7 psi)
Thermostat starts to open/fully open	83°C/95°C (181°F/203°F)	83°C/95°C (181°F/203°F)

Engine	TD 520VE	TAD 520VE
Engine weight, according to DIN 70020-A	Approx. 430 kg (948 lbs)	Approx. 432 kg (952 lbs)
Engine displacement	4760 cm ³ (290.4 in ³)	4760 cm ³ (290.4 in ³)
Bore	108 mm (4.25")	108 mm (4.25")
Stroke	130 mm (5.12")	130 mm (5.12")
Rotation direction	Counterclockwise	Counterclockwise
Rated speed	1800 rpm	2000-2300 rpm
Minimum idling speed	800-950 rpm	800-950 rpm
Operating cycle	Four stroke diesel	Four stroke diesel
Combustion system	Direct injection	Direct injection
Compression ratio	18.4:1	18.1:1
Firing order	1-3-4-2	1-3-4-2
Valve clearance, inlet exhaust	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)
Lubricating oil pressure at low idle, temperature approx. 120°C, oil SAE 15W/40	Min. 150 kPa (21.7 psi)	Min. 80 kPa (11.6 psi)
Thermostat starts to open/fully open	83°C/95°C (181°F/203°F)	87°C/102°C (188°F/215°F)

Type designation	TAD530GE	TAD531GE	TAD532GE
Direction of rotation (seen from flywheel)	Anti- clockwise	Anti- clockwise	Anti- clockwise
No. of cylinders	4	4	4
Cylinder bore mm (inch)	108 (4.25")	108 (4.25")	108 (4.25")
Stroke mm (inch)	130 (5.12")	130 (5.12")	130 (5.12")
Cylinder volume liter (inch ³)	4.76 (290)	4.76 (290)	4.76 (290)
No. of valves	8	8	8
Compression ratio:			
EPA1			18.0:1
EPA2			
EU2	18.0:1	18.0:1	
Injection sequence	1-3-4-2	1-3-4-2	1-3-4-2
Engine power:			
At 1500 rpm kW (hp)	89 (139) ¹⁾	102 (139) ¹⁾	129 (139) ¹⁾
At 1800 rpm kW (hp)	95 (150) ¹⁾	110 (150) ¹⁾	136 (150) ¹⁾
Torque Nm (lbf.ft)	567 (479)	649 (479)	821 (479)
At engine speed rpm	1500	1500	1500
Torque Nm (lbf.ft)	504 (430)	584 (430)	722 (430)
At engine speed rpm	1800	1800	1800
Low idle rpm	800 – 950	800 – 950	800 – 950
Highest full load speed rpm	1500/1800 ¹⁾	1500/1800 ¹⁾	1500/1800 ¹⁾
Weight, dry (lb)	575 (1268) ^{2,3)}	575 (1268) ^{2,3)}	575 (1268) ^{2,3)}
Gross weight, dry (lb)	606 (1336) ^{2,3)}	606 (1336) ^{2,3)}	606 (1336) ^{2,3)}

¹⁾ See engine plate for specifications.

²⁾ Weight according to DIN 70020-A

³⁾ Extra weight TAD530/31/32GE SAE 2 (1800 rpm) 36 kg (80 lb)

⁴⁾ Including clutch and frame

Engine	TD720GE			TAD720GE
Engine weight, according to DIN 70020–A	ca. 750 kg (1653 lbs)			ca. 760 kg (1676 lbs)
Engine displacement	7150 cm ³ (436.3 in ³)			7150 cm ³ (436.3 in ³)
Bore	108 mm (4.25")			108 mm (4.25")
Stroke	130 mm (5.12")			130 mm (5.12")
Rotation direction	Counterclockwise			Counterclockwise
Rated speed	1500/1800 rpm			1500/1800 rpm
Minimum idling speed	800-950 rpm			800-950 rpm
Operating cycle	Four stroke diesel			Four stroke diesel
Combustion system	Direct injection			Direct injection
Compression ratio	17.1:1			17.1:1
Firing order	1-5-3-6-2-4			1-5-3-6-2-4
Valve clearance, inlet exhaust	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)			0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)
Lubricating oil pressure at low idle, temperature approx. 120°C, oil SAE 15W/40	Min. 150 kPa (21.7 psi)			Min. 150 kPa (21.7 psi)
Thermostat starts to open/fully open	83°C/95°C (181°F/203°F)			83°C/95°C (181°F/203°F)
Engine	TAD721GE			TAD722GE
Engine weight, according to DIN 70020–A	ca. 785 kg (1731 lbs)			ca. 785 kg (1731 lbs)
Engine displacement	7150 cm ³ (436.3 in ³)			7150 cm ³ (436.3 in ³)
Bore	108 mm (4.25")			108 mm (4.25")
Stroke	130 mm (5.12")			130 mm (5.12")
Rotation direction	Counterclockwise			Counterclockwise
Rated speed	1800 rpm			2000-2300 rpm
Minimum idling speed	800-950 rpm			800-950 rpm
Operating cycle	Four stroke diesel			Four stroke diesel
Combustion system	Direct injection			Direct injection
Compression ratio	18.1:1			18.1:1
Firing order	1-5-3-6-2-4			1-5-3-6-2-4
Valve clearance, inlet exhaust	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)			0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)
Lubricating oil pressure at low idle, temperature approx. 120°C, oil SAE 15W/40	Min. 80 kPa (11.6 psi)			Min. 80 kPa (11.6 psi)
Thermostat starts to open/fully open	87°C/102°C (188°F/215°F)			87°C/102°C (188°F/215°F)
Type designation	TAD730GE	TAD731GE	TAD732GE	TAD733GE
Direction of rotation (seen from flywheel)	Anti- clockwise	Anti- clockwise	Anti- clockwise	Anti- clockwise
No. of cylinders	6	6	6	6
Cylinder bore mm (inch)	108 (4.25")	108 (4.25")	108 (4.25")	108 (4.25")
Stroke mm (inch)	130 (5.12")	130 (5.12")	130 (5.12")	130 (5.12")
Cylinder volume liter (inch ³)	7.15 (436.3)	7.15 (436.3)	7,15 (436)	7,15 (436)
No. of valves	12	12	12	12
Compression ratio:				
EPA1		17.1:1		
EPA2	17.1:1	17.1:1	18,0:1	18,0:1
EU2	18.0:1			
Injection sequence	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Engine power:				
At 1500 rpm kW (hp)	129 (208) ¹⁾	153 (208) ¹⁾	201 (273) ¹⁾	201 (273) ¹⁾
At 1800 rpm kW (hp)	136 (222) ¹⁾	163 (222) ¹⁾	225 (306) ¹⁾	225 (306) ¹⁾
Torque Nm (lbf.ft)	821 (718)	974 (718)	1280 (944)	1280 (944)
At engine speed rpm	1500	1500	1500	1500
Torque Nm (lbf.ft)	722 (638)	865 (638)	1193 (880)	1193 (880)
At engine speed rpm	1800	1800	1800	1800
Low idle rpm	800 – 950	800 – 950	800 – 950	800 – 950
Highest full load speed rpm	1500/1800 ¹⁾	1500/1800 ¹⁾	1500/1800 ¹⁾	1500/1800 ¹⁾
Weight, dry (lb)	760 (1674) ²⁾	760 (1674) ²⁾	785 (1731) ²⁾	785 (1731) ²⁾
Gross weight, dry (lb)	804 (1773) ²⁾	804 (1773) ²⁾	826 (1821) ²⁾	826 (1821) ²⁾

¹⁾ See engine plate for specifications.

²⁾ Weight according to DIN 70020-A

³⁾ Extra weight TAD530/31/32GE SAE 2 (1800 rpm) 36 kg (80 lb)

⁴⁾ Including clutch and frame

Engine	TD720VE	TAD720/721/722VE
Engine weight, according to DIN 70020–A.....	ca. 570 kg (1257 lbs)	ca. 572 kg (1261 lbs)
Engine displacement	7150 cm ³ (436.3 in ³)	7150 cm ³ (436.3 in ³)
Bore	108 mm (4.25")	108 mm (4.25")
Stroke	130 mm (5.12")	130 mm (5.12")
Rotation direction	Counterclockwise	Counterclockwise
Rated speed	1800 rpm	2000-2300 rpm
Minimum idling speed	850-950 rpm	800-950 rpm
Operating cycle	Four stroke diesel	Four stroke diesel
Combustion system	Direct injection	Direct injection
Compression ratio	18.4:1	18.4:1 (stage 1), 19.0:1 (stage 2)
Firing order	1-5-3-6-2-4	1-5-3-6-2-4
Valve clearance, inlet exhaust	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)	0,35 /0,55 mm ±0,05 mm (0.014"/0.022"±0.0039)
Lubricating oil pressure at low idle, temperature approx. 120°C, oil SAE 15W/40	Min. 150 kPa (21.7 psi)	Min. 80 kPa (11.6 psi)
Thermostat starts to open/fully open	83°C/95°C (181°F/203°F)	87°C/102°C (188°F/215°F)

Coolant

Volvo Penta glycol (antifreeze) mixed 45/55 with clean water

Anti-corrosion agent

Used only in markets where there is no risk of freezing, mixed with water³⁾.

³⁾ The anti-corrosion agent must not be mixed with glycol or other types of anti-corrosion fluid as this could result in negative consequences.

Water quality specification:

To avoid the risk of clogging in the cooling system, the coolant should be mixed with pure water to ASTM D4985. If any doubt about the purity of the water, distilled water or ready-mixed coolant should always be used instead

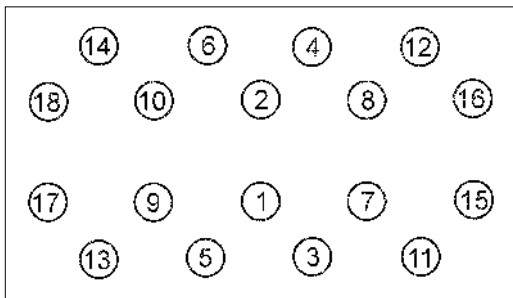
Lubrication

Engine

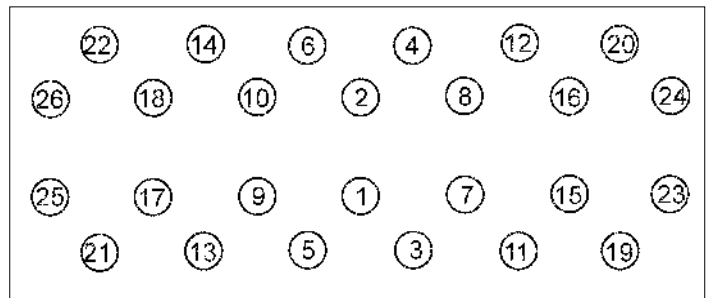
Lubrication	Forced circulation lubrication
Oil SAE	15W 40
Oil temperature in sump	Normal 80°C (176°F) Max. 125°C (257°F)
Oil pressure at rated speed:	
TAD530-532	450-480 kPa
TAD730-733	480-520 kPa
TD520GE/TAD520GE (1500 rpm)	280 kPa (40 psi)
TD520/GE/TAD720GE (1800 rpm)	330 kPa (48 psi)
TD520VE	440 kPa (64 psi)
TAD520VE	390 kPa (56 psi)
TD720GE/TAD720/721/722GE	400 kPa (58 psi)
TD720VE	450 kPa (65 psi)
TAD720VE/TAD721VE	350 kPa (51 psi)
Shut down switch setting:	
520/720/721/722 GE, 732, 733	200 kPa (29 psi)
520/720/721/722 VE, 530, 531, 730, 731, 532	50 kPa (7 psi)
Oil volume including filter:	
TD520GE/TAD520GE	10 litre (2.64 US gallon)
TD520VE/TAD520VE	13 litre (3.43 US gallon)
TD/TAD720, TAD721/722VE, TAD730/731GE	20 litre (5.28 US gallon)
TAD721/722GE, TAD732/733GE	34 litre (8.98 US gallon)

Tightening sequence for cylinder head screws

Manifold side TD/TAD 520 TAD530-532



Manifold side TD/TAD 720-722 TAD730-733



Tightening torque

Screws to cylinder head are reusable only five times.

Step 1:	50	(37 lbf.ft)
Step 2:	130	(96 lbf.ft)
Step 3:	90° angle tightening	

Tightening torque

These tightening torques apply to oiled bolts and nuts. Parts that have been degreased (washed) should be oiled before they are fitted.

Special tightening torque's

Group 21 Engine

	Nm / angle tightening	(lbf.ft)
Engine mounting	260	(192 lbf.ft)
Starter motor	70	(51.6 lbf.ft)
Gear casing	21^(±2)	(15.5 ^{±1.5} lbf.ft)

Main bearing caps

Screws to main bearing caps are reusable only three times.

Step 1	50	(37 lbf.ft)
Step 2	tighten angularly 60°	
Step 3	tighten angularly 60°	

Connecting rod big-end bearing

Use new screws every time.

Step 1	50	(22 lbf.ft)
Step 2	tighten angularly 60°	
Step 3	tighten angularly 60°	

Flywheel

A) Flywheel with screws of max 30 mm length

Step 1:	20 – 30	(15 – 22 lbf.ft)
Step 2:	tighten angularly 60°	
Step 3:	tighten angularly 30°	

B) Flywheel with screws up to 45 mm length

Step 1:	20 – 30	(15 – 22 lbf.ft)
Step 2:	tighten angularly 60°	
Step 3:	tighten angularly 60°	

C) Flywheel with a screw length between 50 – 85 mm

Step 1:	30 – 40	(22 – 30 lbf.ft)
Step 2:	tighten angularly 60°	
Step 3:	tighten angularly 60°	

Flywheel housing

M12	99^(±10)	(73 ^{±7} lbf.ft)
M16	243^(±25)	(179 ^{±18} lbf.ft)

Cylinder head

See previous page.

V-belt pulley

Screws to V-belt pulley are reusable only three times.

Step 1:	45^(±5)	(33 ±3.7 lbf.ft)
Step 2:	tighten angularly 60°	
Step 3:	tighten angularly 60°	
Vibration damper	70	
Screw, rocker cover	11^(±1)	(8 ^{±0.7} lbf.ft)
Lock nut, valve clearance adjusting screw	20^(±2)	(14.5 ^{±1.5} lbf.ft)
Screws, rocker arm fixing	21	(15.5 lbf.ft)
Screws, crankcase ventilation	9^(±1)	(6.6 ^{±0.7} lbf.ft)

Tightening torques	Nm / angle tightening	(lbf.ft)
Group 22 Oil system		
Oil cooler, screws	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Oil cooler, hollow screw		
Step 1:	80	(59 lbf.ft)
Step 2:	160	(118 lbf.ft)
Oil cooler, screw plug	80	(59 lbf.ft)
Front/oil pump housing	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Oil suction pipe	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Oil sump	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Oil pressure pipe turbo	29 ^(±3)	(21.4^{±2.2} lbf.ft)
Oil pressure pipe engine block	39 ^(±4)	(29^{±3} lbf.ft)
Screws, oil return pipe turbo		
A) with tube fitting	40 ^(±2)	(29.5^{±1.5} lbf.ft)
B) with flange fitting	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Screws, oil return pipe engine block	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Oil pressure switch	18 ^(±2)	(13^{±1.5} lbf.ft)
Group 23 Fuel system		
Screw, governor, idler gear:	21	(22.1 lbf.ft)
Screw, control rod socket	10 ^(±2)	(7^{±5} lbf.ft)
Screw, governor	17 ^(±1.5)	(12.5^{±1} lbf.ft)
Flange screws, Injection pump		
Step 1: Torque	5	(3.7 lbf.ft)
Step 2: Loosen screws for injection pump flange	60° (counterclockwise)	
Step 3: Turn injection pump to stop	Counterclockwise	
Step 4:	tighten angularly 60°	
Step 5:	7	(5 lbf.ft)
Step 6:	10	(7.4 lbf.ft)
Step 7:	30	(22 lbf.ft)
Flange screw, injector	19 ^(±2)	(14^{±1.5} lbf.ft)
Injector cap nut	40 – 50	(30 – 37 lbf.ft)
Delivery pipe		
NOTE! Use a new delivery pipe after every disassembly		
NOTE! Make sure that you use the same tightening torque for all delivery pipes		
Step 1:	5	(3.7 lbf.ft)
Step 2:	25 ^(±3.5)	(18.4^{±2.6} lbf.ft)
Screw, stop magnet	21	(15.5 lbf.ft)
Overflow valve	30	(22 lbf.ft)
Group 25 Inlet and exhaust system		
Exhaust manifold nuts	25 ^(±2.5)	(18.5^{±1.8} lbf.ft)
M8 Nuts, turbo to exhaust manifold	21 ^(±2)	(15.5^{±1.5} lbf.ft)
M10 Nuts, turbo to exhaust manifold	40 ^(±4)	(29^{±3} lbf.ft)
Screws, Inlet manifold	11 ^(±1)	(8^{±0.7} lbf.ft)
Group 26 Cooling system		
Thermostat housing	30	(22.1 lbf.ft)
Temperature sensor	21 ^(±2)	(15.5^{±1.5} lbf.ft)
Coolant pump	21 ^(±2)	(15.5^{±1.5} lbf.ft)

Determination of shim thickness when changing the injection pump.

Mathematical formula for new shim thickness: $T_s = E_k - (L_0 + A/100)$

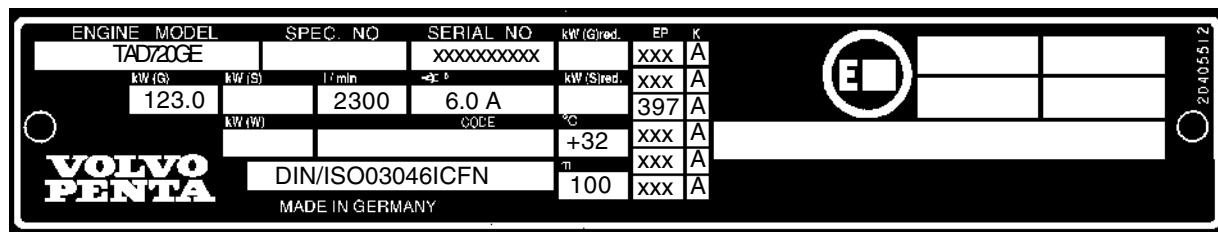
Actual shim thickness, S_s , can be found in Table 2. $S_s \rightarrow T_s$

NOTE! This formula is applicable when changing the injection pump ONLY.

Calculation 1	Explanation	Factor	Ex	TD/TAD 520/720/721/722					
				Cyl: 1	Cyl: 2	Cyl: 3	Cyl: 4	Cyl: 5	Cyl: 6
Cylinder no.		XXX							
Injection pump manufacturing number		XXX							
EP code:		EP	397						
Corrected fitting size, see table 3		E_k	146.9						
Basic meas. of inj. pump, see table 1		L_0	- 143						
Manufacturing tolerance, see inj.pump		$A/100$	- 0.63						
Theoretical shim thickness		T_s	= 3.27						
Shim thickness, see table 2		S_s	~ 3.3						

Example: Change of injection pump for cylinder 3 on a TAD 720 engine.

1. Read the EP code for cylinder 3 from the engine identification plate, in the "EP" column, e.g. 397. (Sequence from top: row 1 = cyl. 1, row 2 = cyl. 2 etc.).

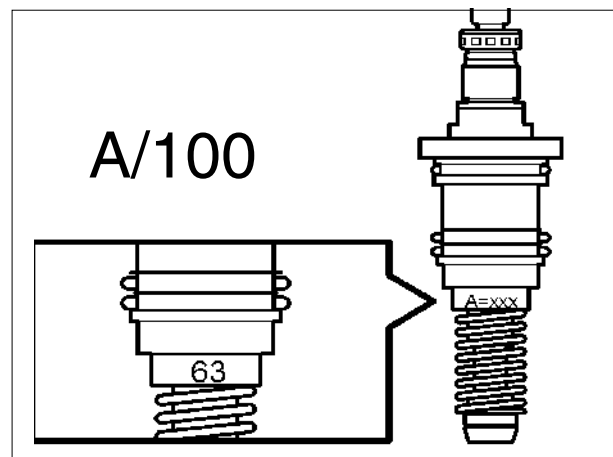


2. Using the EP code, read the corrected fitting size (E_k) for the injection pump from Table 3. Ex. EP code = 397 $\rightarrow E_k = 146.9$ mm.

3. Take the manufacturing tolerance for the injector pump length, A , from the new injector pump, Ex. 63 (see figure)

NOTE! If the value is not visible, remove possible dirt, **without** scraping.

The tolerance value A is divided by 100 in calculations.



4. Take the standard size for the injector pump, L_0 , from Table 1. Ex. 143 mm.
5. Determine the theoretical shim thickness, T_s , according to the formula: $T_s = E_k - (L_0 + A/100)$ (Also see examples in "Calculation 1")
Ex. $T_s = 146.9$ mm - (143 mm + 0.64 mm)
 $T_s = 4.54$
6. Select shim thickness, S_s , from Table 2.
Ex. $T_s = 4.54$ mm $\rightarrow S_s = 4.5$ mm

Determination of shim thickness when the injection valve opens

Performed when replacing engine block, camshaft, or roller tappet.

Mathematical formula for the new shim thickness:

$$T_s = L - [(Fb_{akt} - Fb_{nom}) \times Vh_{korr} + Vh_{nom} + L_o + A/100]$$

The actual shim thickness can be found in Table 2. $S_s \rightarrow T_s$

NOTE! After determining the shim thickness, a new EP code **MUST ALWAYS** be determined, according to "Calculation 3", in order for changing of pump to be correct at a later point in time.

Calculation 2.1	Explanation	Factor	Ex	TD/TAD 520 GE, TD/TAD 720 GE					
				Cyl. 1	Cyl. 2	Cyl. 3	Cyl. 4	Cyl. 5	Cyl. 6
	Cylinder no.	XXX	XXX						
	Injection pump manufacturing number	XXX	XXX						
	Injection angle, meas. on protractor.	Fb_{akt}	5.5						
	Injection angle, see engine id. plate \angle°	Fb_{nom}	- 6						
	Total 1 ($Fb_{akt} - Fb_{nom}$)	S1	= -0.5						
	Pre-stroke, corr.factor, see Table 1	Vh_{korr}	x 0.14						
	Total 2 ($S1 \times Vh_{korr}$)	S2	= -0.07						
	Pre-stroke, see Table 1	Vh_{nom}	+ 6.11						
	Basic meas. of inj. pump, see Table 1	L_o	+ 143						
	Manufacturing tolerance, see inj.pump	A/100	+ 0.63						
	Total 3 ($S2 + Vh_{nom} + L_o + A/100$)	S3	= 149.67						

Calculation 2.2	Explanation	Code	Ex.	Cyl. 1	Cyl. 2	Cyl. 3	Cyl. 4	Cyl. 5	Cyl. 6
	Length between block and roller tappet	L	152.18						
	Total 3 ($S2 + Vh_{nom} + L_o + A/100$)	S3	- 149.67						
	Theoretical shim thickness ($L - S3$)	T_s	= 2.55						
	Shim thickness, see Table 2	S_s	~ 2.6						

FACTOR	UNIT	EXPLANATION
Fb_{akt}	$^\circ C/A$	Injection angle, measured on protractor according to method.
Fb_{nom}	$^\circ C/A$	Injection angle, see table 1.
Vh_{korr}	mm/ $^\circ C/A$	Pre-stroke, correction factor see table 1.
Vh_{nom}	mm	Pre-stroke, nominal, see table 1.
L	mm	Measured length between block and roller tappet.
L_o	mm	Basic measurement of injection pump.
A/100	mm	Manufacturing tolerance, written on injection pump.
T_s	mm	Theoretical shim thickness.
S_s	mm	Shim thickness.
S (1, 2, 3)	xxx	Total of calculation.
EP	xxx	Code value, see table 3 or engine identification plate.
E_k	mm	Total of calculation. Only applicable when determining EP code.

Determination of the corrected fitting size, E_k , and EP code for an injection pump.

NOTE! When you change the engine block camshaft or roller tappet, you must determine the corrected fitting measurement, E_k , and change the relevant EP code on the engine identification plate.

Mathematical formula for the corrected fitting size, E_k :

$$E_k = L - [(Fb_{akt} - Fb_{nom}) \times Vh_{korr} + Vh_{nom}]$$

New EP code is found in Table 3.2 $E_k \rightarrow$ EP code

Calculation 3.1 Explanation	Factor	Ex	TD/TAD 520 GE, TD/TAD 720 GE					
			Cyl. 1	Cyl. 2	Cyl. 3	Cyl. 4	Cyl. 5	Cyl. 6
Cylinder no.	XXX	XXX						
Injection pump manufacturing number	XXX	XXX						
Injection angle, meas. on protractor.	Fb_{akt}	5.5						
Injection angle, see eng. id. plate \angle°	Fb_{nom}	- 6						
Total 1 ($Fb_{akt} - Fb_{nom}$)	S1	= -0.5						
Corr. factor, see Table 1	Vh_{korr}	x 0.14						
Total 2 ($S1 \times Vh_{korr}$)	S2	= -0.07						
Pre-stroke, see Table 1	Vh_{nom}	+ 6.11						
Total 3 ($S2 + Vh_{nom}$)	S3	= 6.04						

Calculation 3.2 Explanation	Factor	Ex	Cyl. 1	Cyl. 2	Cyl. 3	Cyl. 4	Cyl. 5	Cyl. 6
Length between block and roller tappet	L	152.22						
Total 3 ($S2 + Vh_{nom}$)	S3	- 6.04						
E_k ($L - S3 = E_k$)	E_k	= 146.18						
E_k rounded to nearest value in Table 3	E_k	~ 146.175						
EP code ($E_k \rightarrow$ Table 3 \rightarrow EP code)	EP	= 344						

(100 mm = 3.937")

Table 1

Injection angle Fb_{nom}	Camshaft type	Pre-stroke Vh_{nom}	Pre-stroke Corr. factor, Vh_{korr}	Length of pump basic measure- ment L_o (mm)
[°C/A BTDC]		[mm]	[mm/°C/A]	[mm]
5	A	6,32	0,14	143 (L_o)
6		6,11		
7		5,9		
8		5,7		
9		5,5		
10		5,31		
4	B	5,7	0,14	143 (L_o)
4,5		5,6		
5		5,5		
5,5		5,4		
6		5,31		
7		5,1		
8	4,9			

(100 mm = 3.937")

Table 2

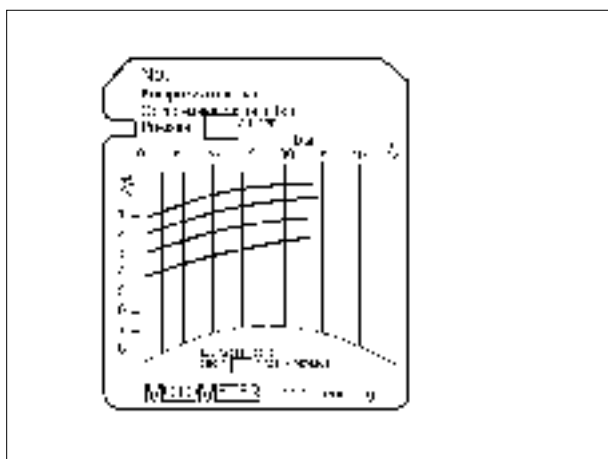
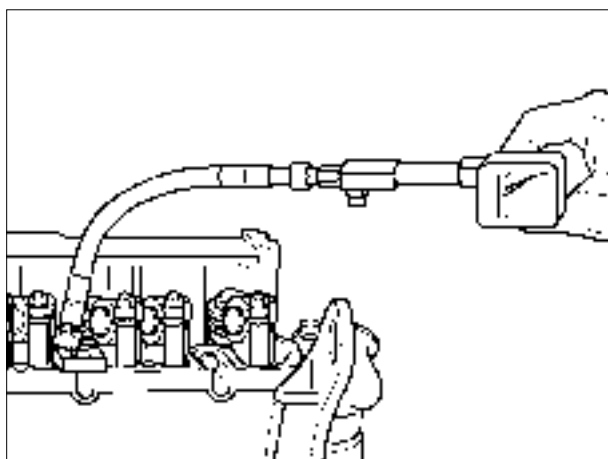
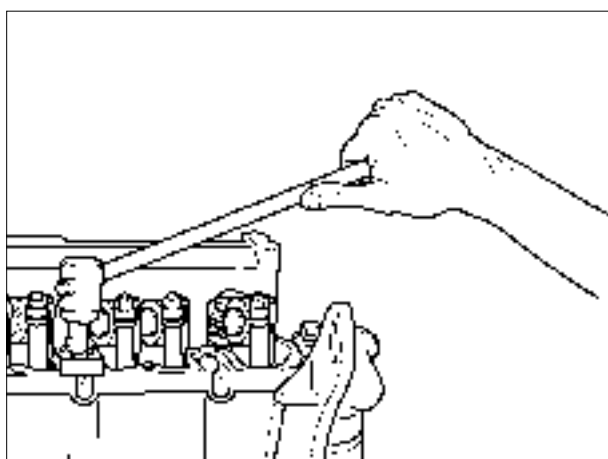
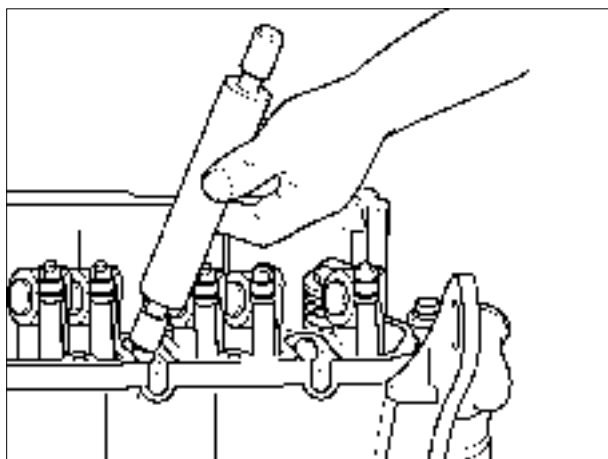
Theoretical thickness "T _s " (mm)	Shim thickness "S _s " (mm)	Theoretical thickness "T _s " (mm)	Shim thickness "S _s " (mm)
0.95–1.049	1.0	3.05–3.149	3.1
1.05–1.149	1.1	3.15–3.249	3.2
1.15–1.249	1.2	3.25–3.349	3.3
1.25–1.349	1.3	3.35–3.449	3.4
1.35–1.449	1.4	3.45–3.549	3.5
1.45–1.549	1.5	3.55–3.649	3.6
1.55–1.649	1.6	3.65–3.749	3.7
1.65–1.749	1.7	3.75–3.850	3.8
1.75–1.849	1.8	3.85–3.949	3.9
1.85–1.949	1.9	3.95–4.049	4.0
1.95–2.049	2.0	4.05–4.149	4.1
2.05–2.149	2.1	4.15–4.249	4.2
2.15–2.249	2.2	4.25–4.349	4.3
2.25–2.349	2.3	4.35–4.449	4.4
2.35–2.449	2.4	4.45–4.549	4.5
2.45–2.549	2.5	4.55–4.649	4.6
2.55–2.649	2.6	4.65–4.749	4.7
2.65–2.749	2.7	4.75–4.849	4.8
2.75–2.849	2.8	4.85–4.949	4.9
2.85–2.949	2.9	4.95–5.049	5.0
2.95–3.049	3.0		

(100 mm = 3.937")

Table 3

E _k (mm)	EP code	E _k (mm)	EP code	E _k (mm)	EP code	E _k (mm)	EP code	E _k (mm)	EP code
144.5		145.1		145.7	349	146.3	373	146.9	397
144.525		145.125		145.725	350	146.325	374	146.925	398
144.55		145.15		145.75	351	146.35	375	146.95	399
144.575		145.175		145.775	352	146.375	376	146.975	400
144.6		145.2		145.8	353	146.4	377	147.0	401
144.625		145.225		145.825	354	146.425	378	147.025	
144.65		145.25		145.85	355	146.45	379	147.05	
144.675		145.275		145.875	356	146.475	380	147.075	
144.7		145.3		145.9	357	146.5	381	147.1	
144.725		145.325		145.925	358	146.525	382	147.125	
144.75		145.35	335	145.95	359	146.55	383	147.15	
144.775		145.375	336	145.975	360	146.575	384	147.175	
144.8		145.4	337	146.0	361	146.6	385	147.2	
144.825		145.425	338	146.025	362	146.625	386	147.225	
144.85		145.45	339	146.05	363	146.65	387	147.25	
144.875		145.475	340	146.075	364	146.675	388	147.275	
144.9		145.5	341	146.1	365	146.7	389	147.3	
144.925		145.525	342	146.125	366	146.725	390	147.325	
144.95		145.55	343	146.15	367	146.75	391	147.35	
144.975		145.575	344	146.175	368	146.775	392	147.375	
145.0		145.6	345	146.2	369	146.8	393	147.4	
145.025		145.625	346	146.225	370	146.825	394	147.425	
145.05		145.65	347	146.25	371	146.85	395	147.45	
145.075		145.675	348	146.275	372	146.875	396	147.475	

(100 mm = 3.937")



Checks and adjustments

Compression test (21002)

Special tools:

Adapter for compression testing 999 8694

Compression gauge 998 8539

The injectors have been removed, the valve clearance has been checked.

1. Fit adapter 999 8694.
2. Use the existing injector yoke.
Tighten the screw to **19 ±2 Nm**
(14 ±1.5 lbf ft).

3. Connect the compression tester, 998 8539.
Turn the engine over with the starter motor. Compression: **3-3.8 MPa** (435-551 psi).

NOTE! Make sure that the fuel control rod is in the no fuel position (stop position).

The measured compression depends on the engine speed during the measuring process and the ambient air pressure.

It is difficult to give an exact limit value due to the ambient air pressure. We recommend that the compression test is to compare the cylinders of the engine. **If the pressure difference is greater than 15% the cylinder in question should be dismantled to determine the cause.**

NOTE! Refit the injector with a new copper gasket and tighten to **19 ±2 Nm** (14 ±1.5 lbf ft).

Fit the new fuel delivery pipe and tighten in two stages **5 Nm** and **25^{+3.5}₀ Nm** (19^{+2.5}₀ lbf ft).

⚠ IMPORTANT! All delivery pipes must be tightened with the same tightening torque.

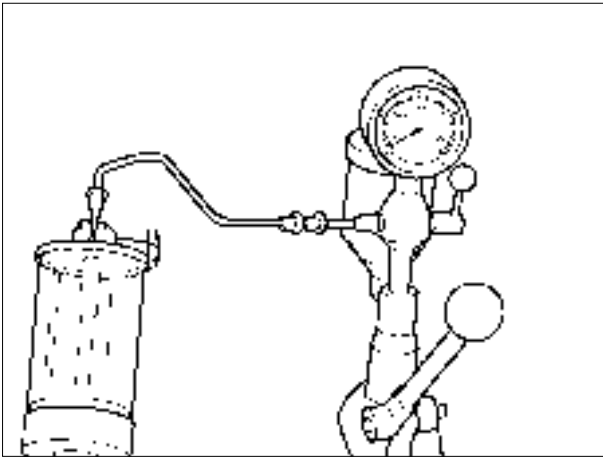
Tighten the rocker cover to **11 ±1 Nm** (6.6 ±0.7 lbf ft).

NOTE! The fuel leakage lines must always be replaced if removed.

Injectors, checking/adjusting (23712, 23713)

NOTE! You must observe the utmost cleanliness when working on the injection system. Use only clean test oil that meets ISO 4113 or clean diesel to test the injector.

NOTE! Let an authorized workshop do the tests and adjustments. The test requires equipment not sold by AB Volvo Penta.



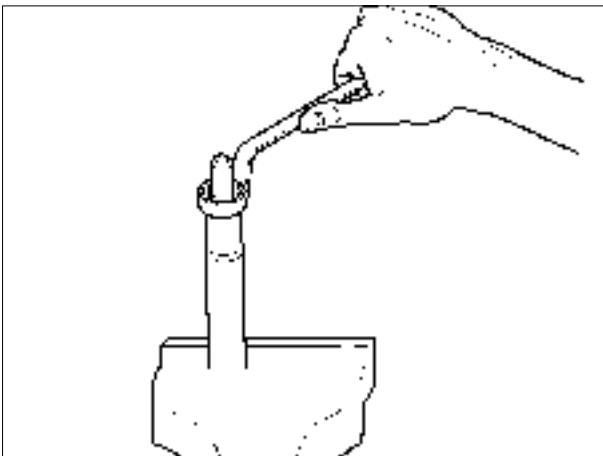
⚠ WARNING! Be very careful when working with the fuel injector nozzle. The fuel pressure jet can penetrate deep into the skin tissue and cause blood poisoning.

1. Connect the injector to the nozzle tester.
2. Check the opening pressure.
For control value for the opening pressure, see "Technical data".

NOTE! The opening pressure is different depending on if the injector or spring is new or used.

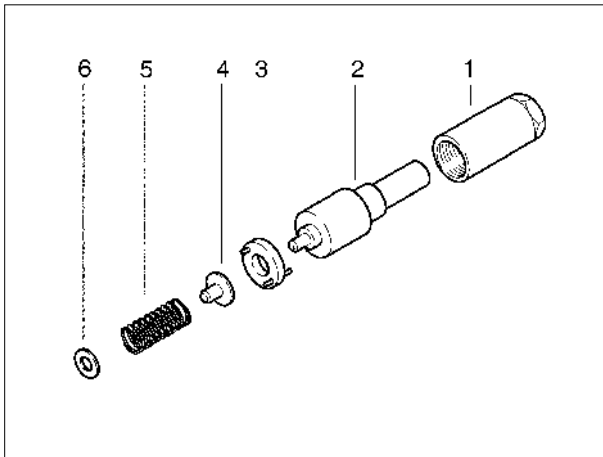
3. Check the density after the injector has opened.
The pressure may, at the most, drop to 5 MPa (725 psi) /5 sec.

By keeping the pressure constant, 2 MPa (290 psi) below opening pressure for 10 seconds, make sure that no drips occur.



Set the opening pressure for the injector

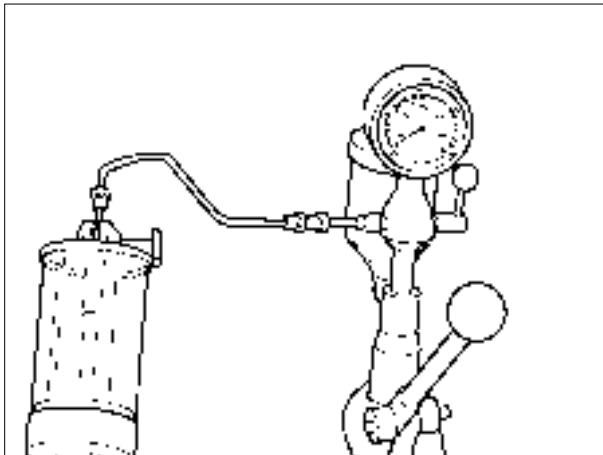
4. Take off the cap nut and remove all parts.
5. Wash the details in an ultrasonic cleaner, alternatively washing petrol or Vanolen.
6. Inspect the injector details, using an injector microscope.
7. Dip the parts in oil before assembly.



The order for removing parts is:

- 1 Cap nut
- 2 Injection nozzle
- 3 Adapter
- 4 Pressure pin
- 5 Compression spring
- 6 Shim

8. Set the pressure by selecting an appropriate shim. (A thicker shim increases the opening pressure.) Tighten the cap nut to $40 \pm 5 \text{ Nm}$ ($33 \pm 3.7 \text{ lbf ft}$). Recheck the injector in the nozzle tester.



9. Check the seal

Dry the nozzle and nozzle holder with compressed air. Press down the tester handle until you obtain a pressure of around 2.0 MPa below the previously measured opening pressure.

Example: Pressure gauge: 27.5 MPa (3988 psi)
 reading: -2.0 MPa (-290 psi)
 set to: 25.5 MPa (3698 psi)

For opening pressure, see Technical Data (1MPa = 145 psi).

10. If no leaks appear within 10 seconds the nozzle is sealed.
11. If the nozzle is leaking, dismantle and clean the injector to prevent it from leaking. If the nozzle still is leaking, replace the injector. Reuse is not permitted.
12. Chatter characteristic and spray pattern tests.

NOTE! Shut off the tester pressure gauge, for this test.

The chatter test provides an audible check of how easily the nozzle needle is moving in the nozzle body. New injectors give a different sound compared with used injectors. It worsens due to wear in the needle seat area. If an injector nozzle does not make the chatter noise despite having been cleaned, it must be replaced.

A used injector chatters clearly when the handle is moved quickly, and shows a well-distributed spray pattern. The condition of the nozzle is difficult to establish concerning spray pattern.

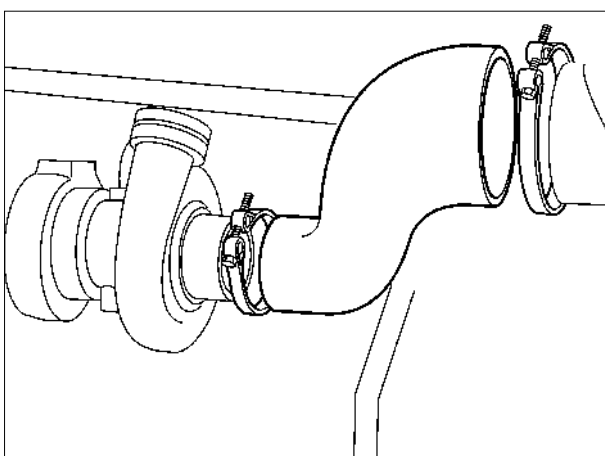
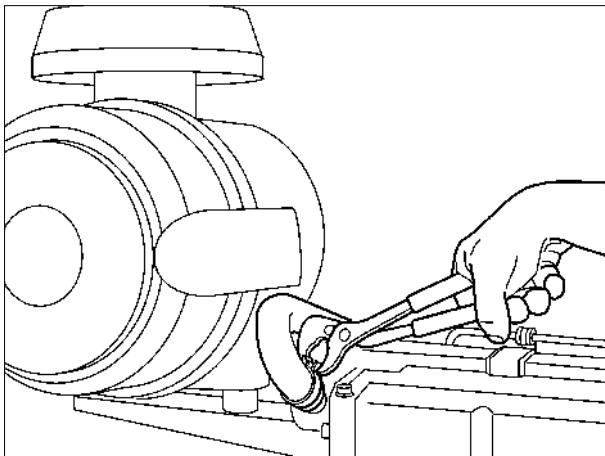
Incorrect spray pattern may cause engine damage.

Disassembly, complete engine

Special tools:

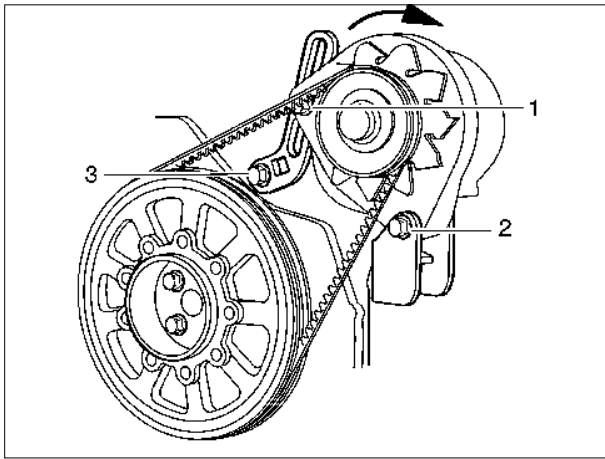
Stand for mounting engine (Unit stand)	998 6485
Engine fixture	999 8671
Puller	999 6400
Socket for injector removal	999 8007
Filter wrench	999 9179
Pressure tool (control rod)	999 8682
Filter wrench	999 9179

The repair methods that are shown in this chapter apply to the standard specification only, i.e. components in specially manufactured engines are not shown.

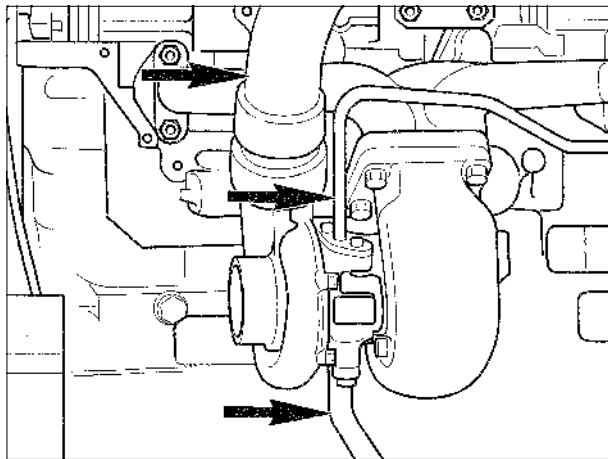


Exposure of engine

1. Mark up and loosen all cabling and terminal boxes.
Loosen the exhaust bend.
2. Drain and collect the remaining oil and coolant, and dispose of them in accordance with applicable environmental regulations.
3. Remove the air filter and crankcase ventilation hose.
4. Remove the hose between the turbocharger and the air filter.



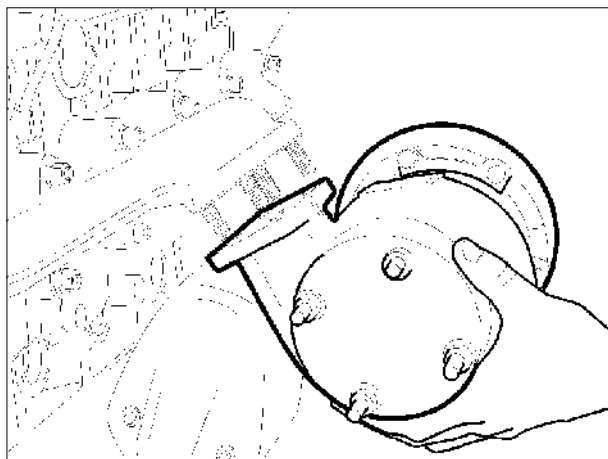
5. Remove the alternator as well as extra power sources, alternator belt and bracket, see "Drive belts, adjusting and replacing".



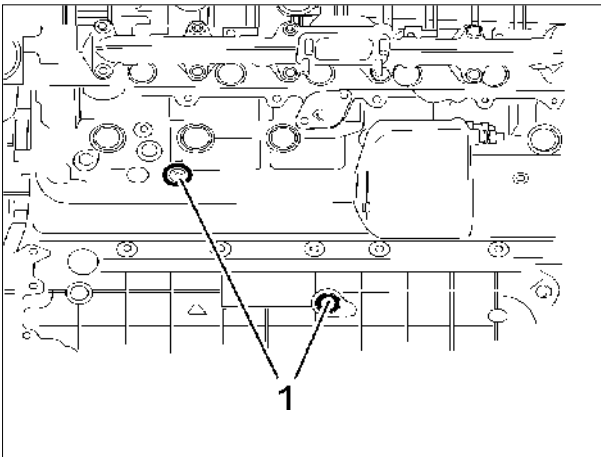
Fitting of fixture

Turbo charger, remove

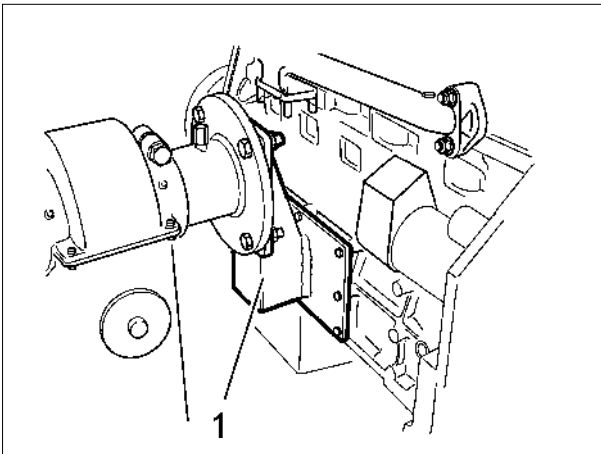
1. Remove the oil pressure pipe, oil return pipe, and charger air pipe.



2. Remove the mounting nuts and the turbo charger.



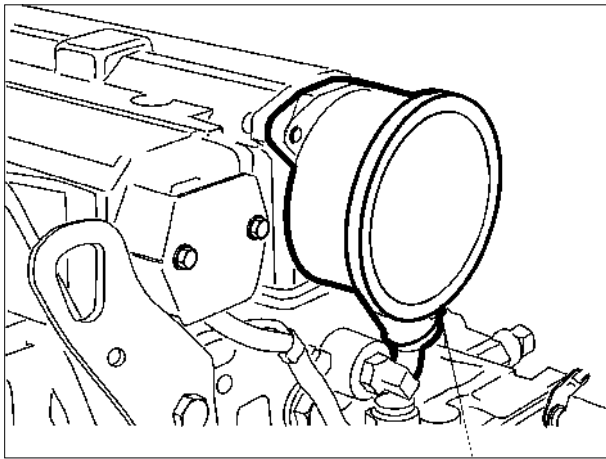
3. Plug (1) the turbo and the connections for the oil return and the oil pressure pipes in the engine block.



4. Attach the engine bracket 999 8671 (1) to the engine and tighten to **25 Nm** (18.5 lbf ft).

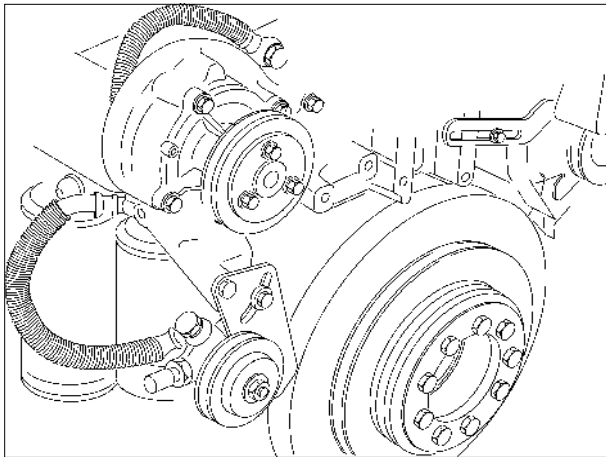
NOTE! Use the accompanying screws, since their strength is higher than that of standard screws.

5. Tighten the engine firmly in the engine repair stand 999 6845.



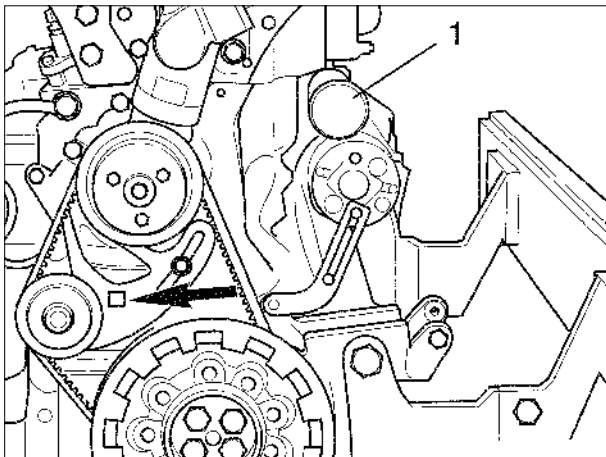
Engine, disassembly

1. Remove the oil-trap housing for the crankcase ventilation (see picture).
2. Catch any remaining oil and dispose of it in accordance with the environmental regulations.

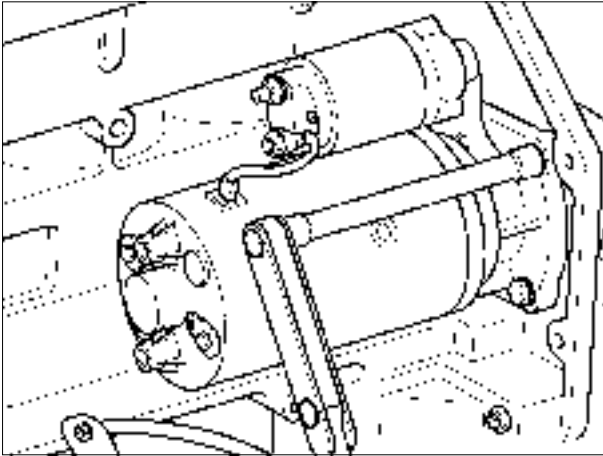


3. Loosen the fuel hose between filter and fuel pump. Remove the fuel pump, belt and bracket. Remove the fuel line between filter and fuel duct.

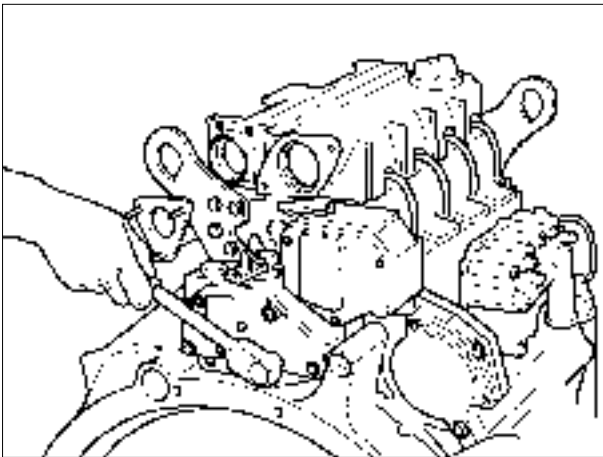
NOTE! Plug the fuel system so that dirt can not enter.



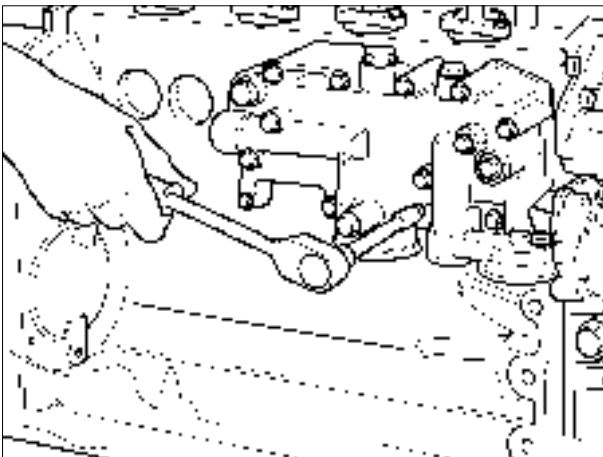
4. Remove the coolant outlet pipe (1) if required (see picture).



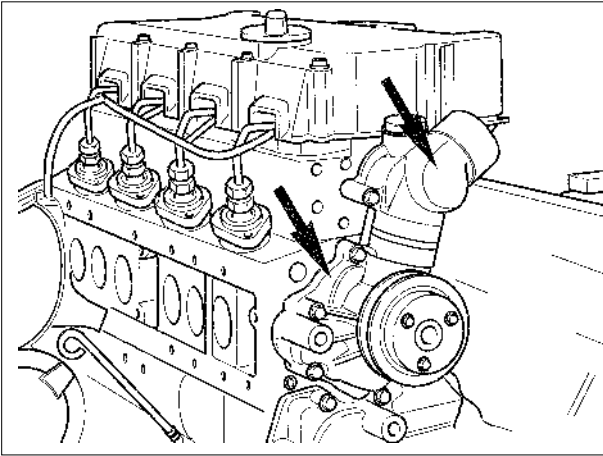
5. The starter motor can be removed at this stage, but it is easier to leave it on and remove it together with the transmission cover.



6. Remove the engine speed governor. Use a Torx socket E 10 (for electronic governors, use Allen key 6).
7. Drain the fuel from the fuel duct in the engine by removing the hollow screw at the front of the engine block and the overflow valve and fuel return vent. Remove the screw at the rear of the engine block. Remove the fuel and oil filters using tool 999 9179.

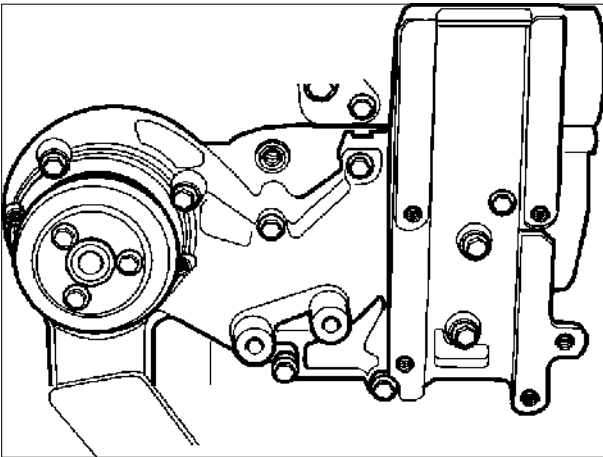


8. Remove the cooler housing.



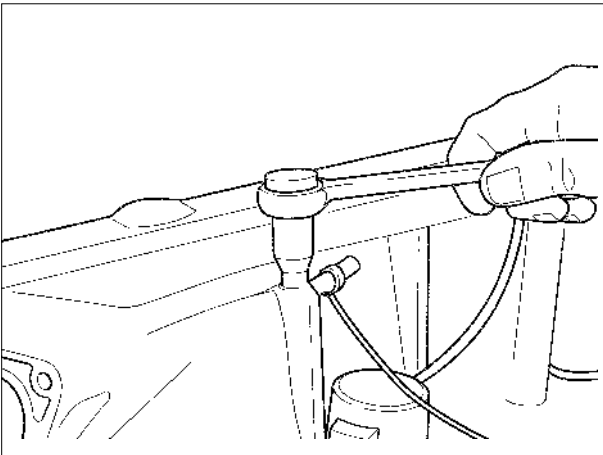
9. Remove the coolant pump and coolant housing, according to one of the pictures, depending on coolant pump model.

The lower model is removed with 7 screws. First remove the bearing bracket for the intermediate pulley.

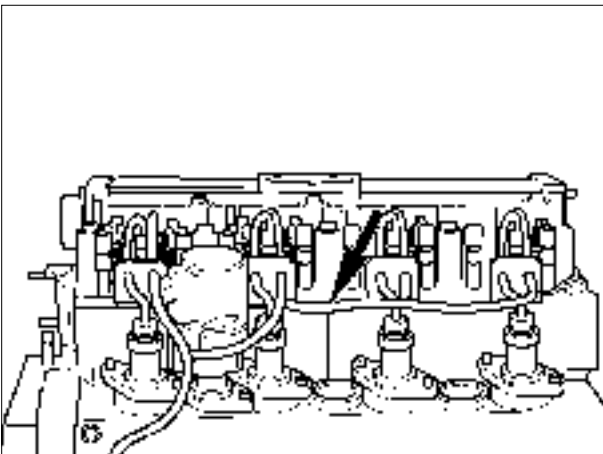


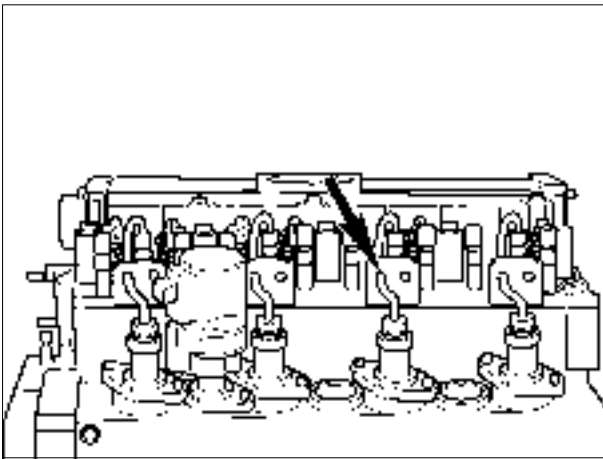
10. Loosen the screws and remove the rocker cover and the gasket.

NOTE! Make sure that dirt trapped between the inlet manifold and the rocker cover does not fall down into the engine. Clean thoroughly before removing the rocker cover.



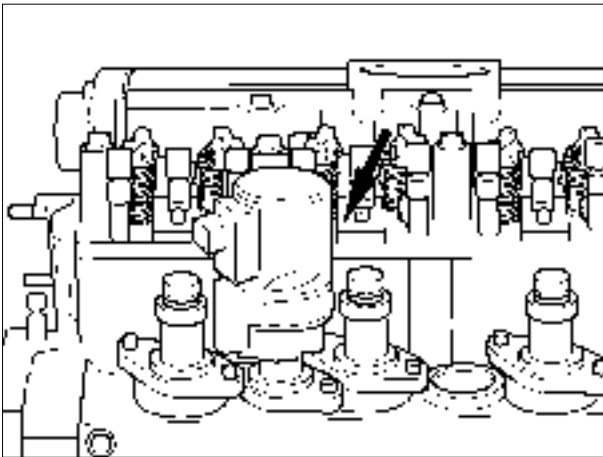
11. Remove the fuel return lines together with the overflow valve and air vent screw.





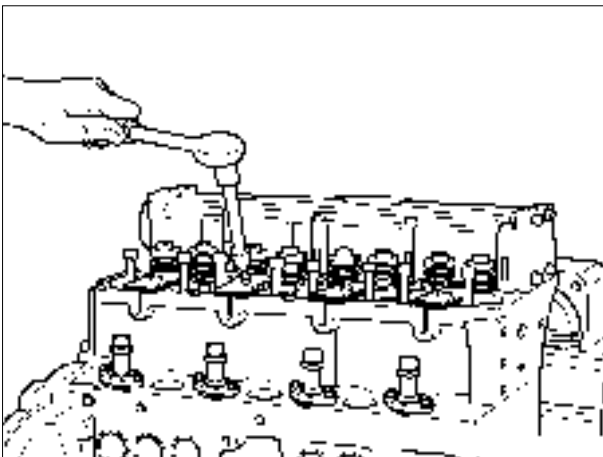
12. Remove the delivery pipes, complete with the rubber seals.

NOTE! Cover the injector and injector pump openings.



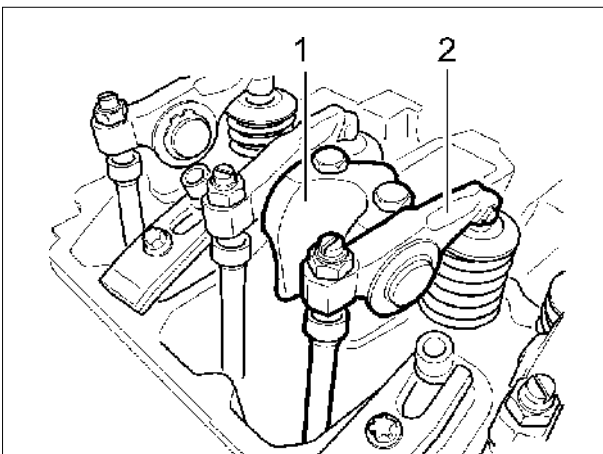
13. Remove the stop solenoid (alternatively the plug if the governor is electronic).

NOTE! Be careful not to damage the control rod. Install 999 8682 to keep the control rod in the protected "stop" position.

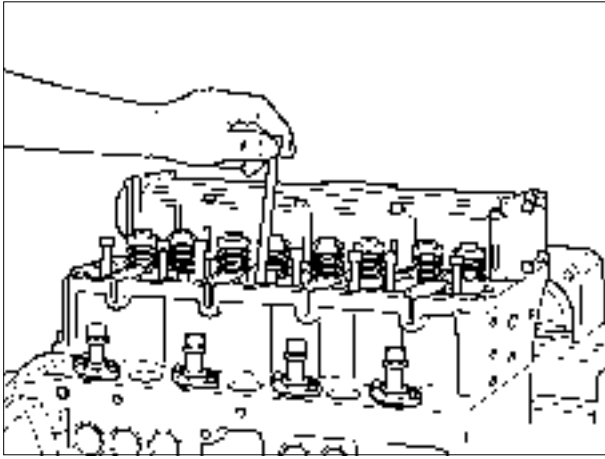


14. Remove the injectors. Use a Torx socket E 10. Use puller 999 6400 together with socket 999 8007 if any injector is stuck in the cylinder head.

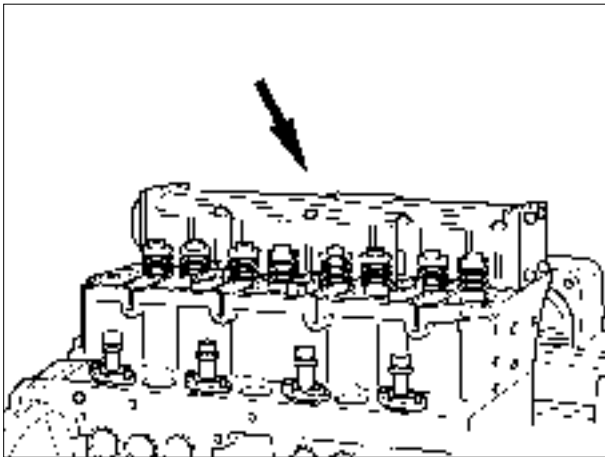
NOTE! To prevent dirt and water coming in the injector hole, make sure to clean well around the injector before removing it.



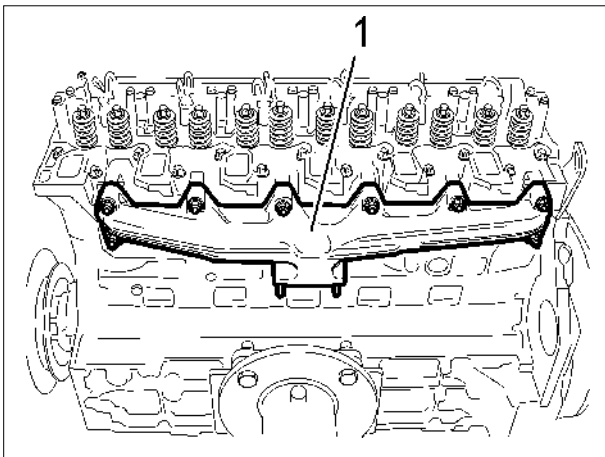
15. Mark up the rocker arm brackets (1) and remove them together with the rocker arms (2).



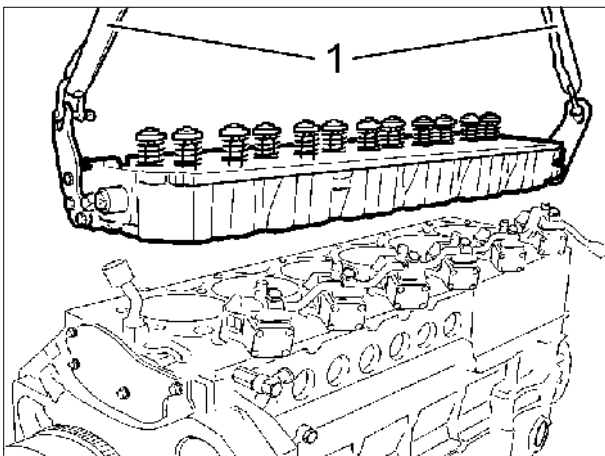
16. Remove and mark up the push rods.



17. Remove the inlet manifold and gasket.



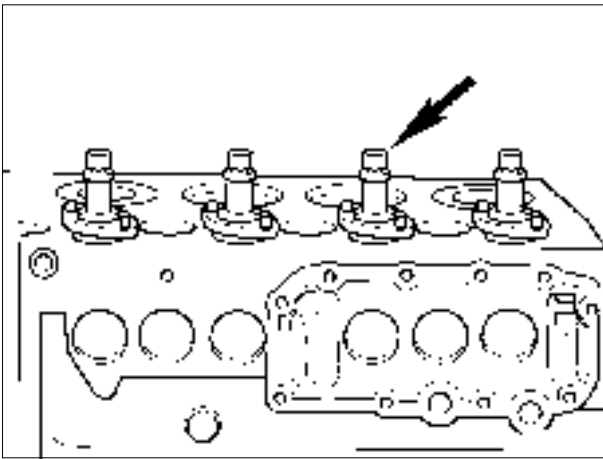
18. Remove the exhaust manifold (1).



19. Loosen the screws to the cylinder head, using the torx socket E18.

Connect lifting wires to the lifting eye bolts and remove the cylinder head.

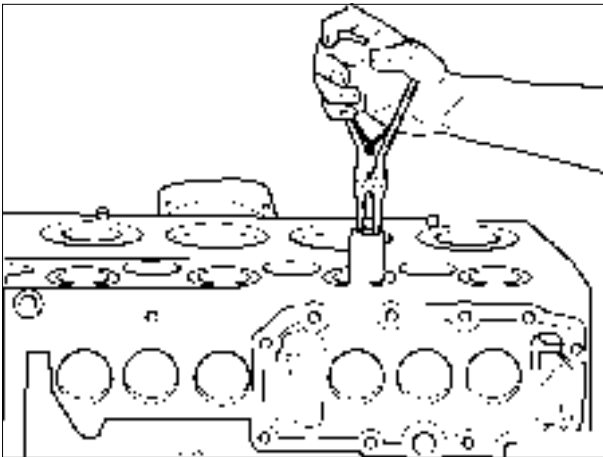
NOTE! Weight is approx. 80 kg (720-722).



NOTE! Make sure that the injection pump tappet is on the base circle when removing the pumps

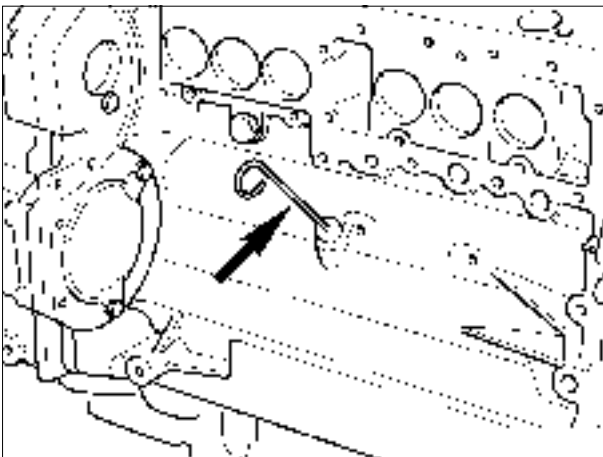
NOTE! Mark up all parts when removing to make sure the components match and will be fitted to the correct position.

20. Remove the injection pumps. Start with the screw closest to the flywheel. Put them in a stand to protect them from dirt.



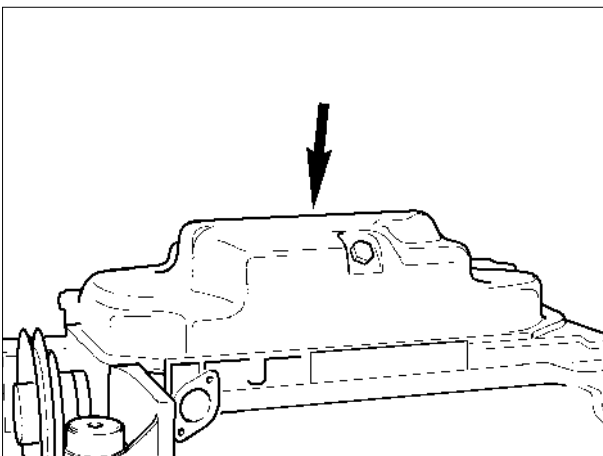
NOTE! Be careful with the loose shim.

21. Using pliers or a pen magnet, lift out and mark the roller tappets together with the shim.



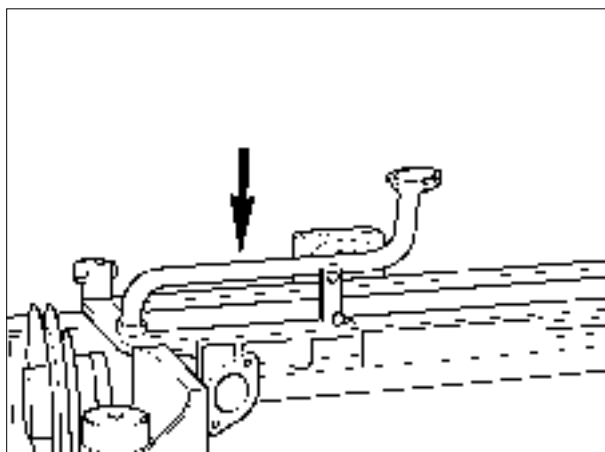
NOTE! Attach the shim firmly to its respective injection pump.

22. Pull out the dipstick.

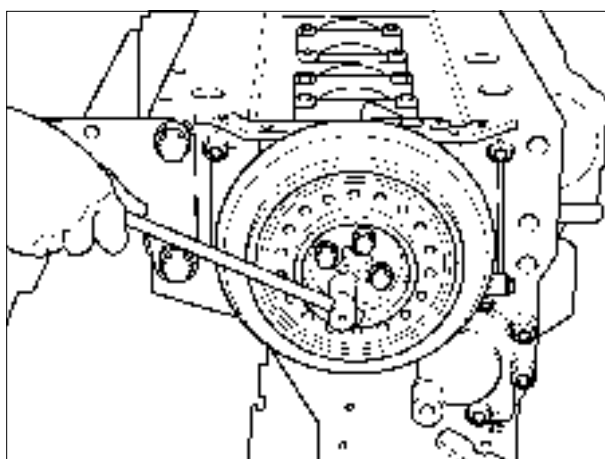


23. Remove the oil sump.

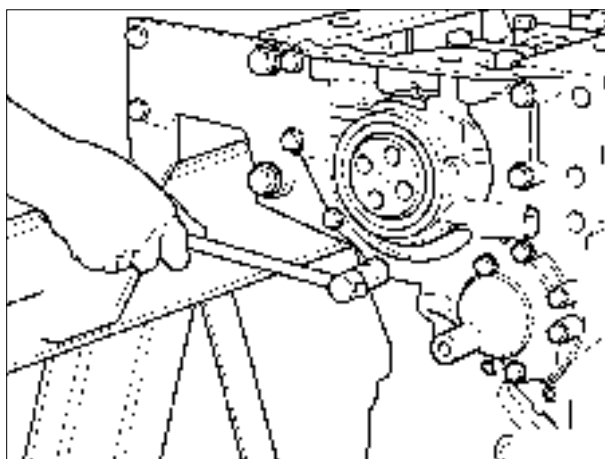
NOTE! The oil sump is mounted with a fluid gasket and may be stuck. Use a bending bar in the referring grooves.



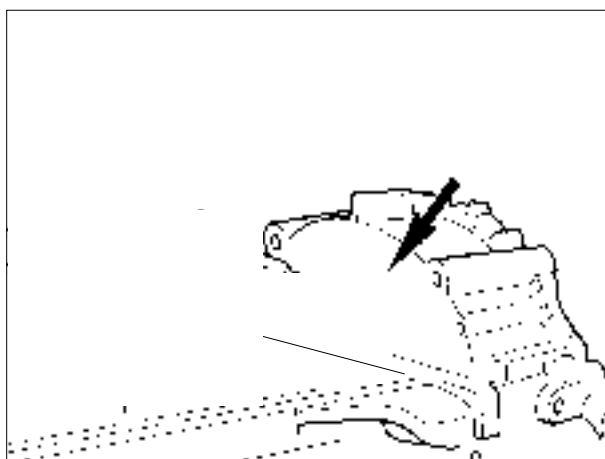
24. Remove the oil suction pipe.



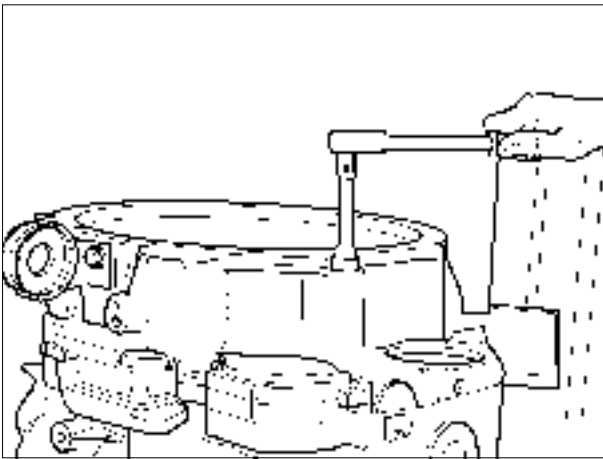
25. Remove the crankshaft pulley and damper (if installed).
Use a Torx socket E20.



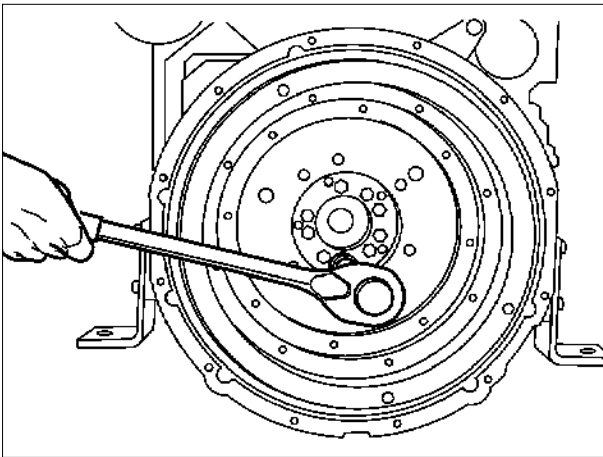
26. Remove the oil pump/front cover.



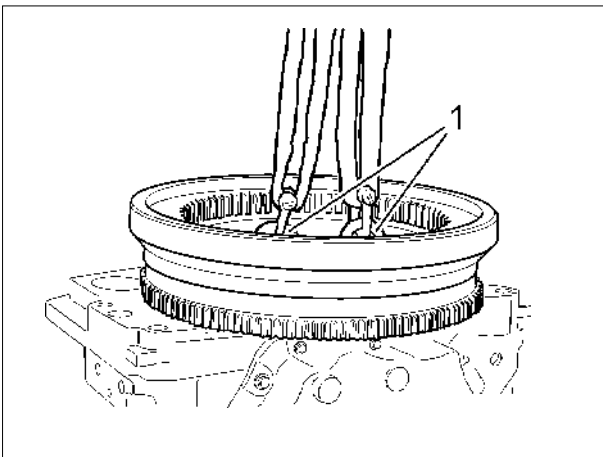
27. Remove the cover plate on the flywheel housing.



28. Remove the flywheel housing.
Use Torx sockets E20 and E14.

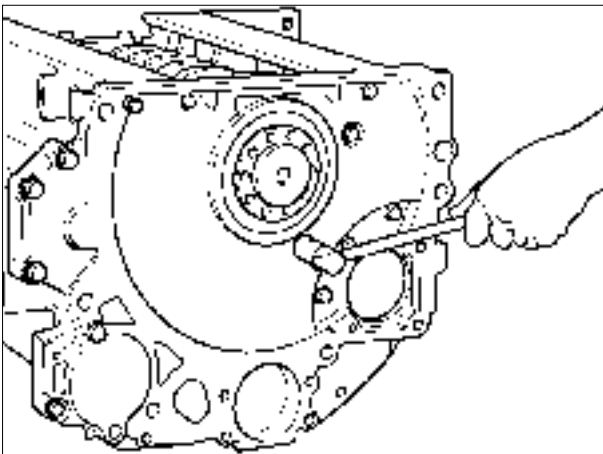


29. Turn the engine through 90°.
Remove the plastic plugs between every second screw, which are a locking device for the flywheel screws.
Loosen the screws on the flywheel, but let them stay in place.
Use 999 8681 to block the flywheel.

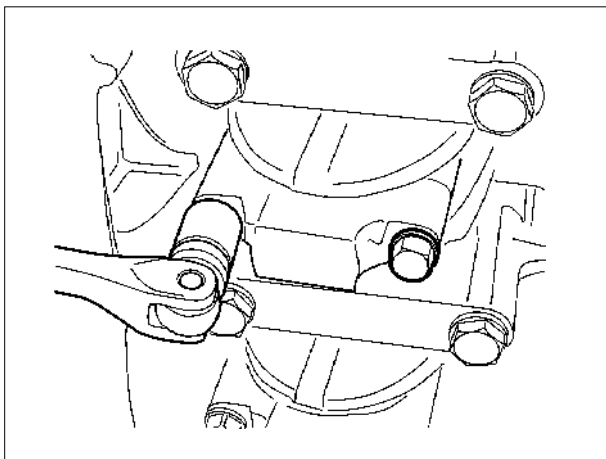


30. Connect lifting eye bolts M10 (1) and lifting wire.
Remove the flywheel.

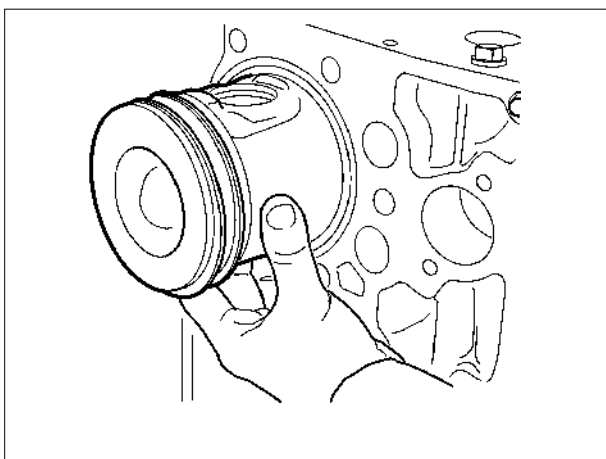
⚠ WARNING! Be careful when removing the flywheel as it is very heavy.



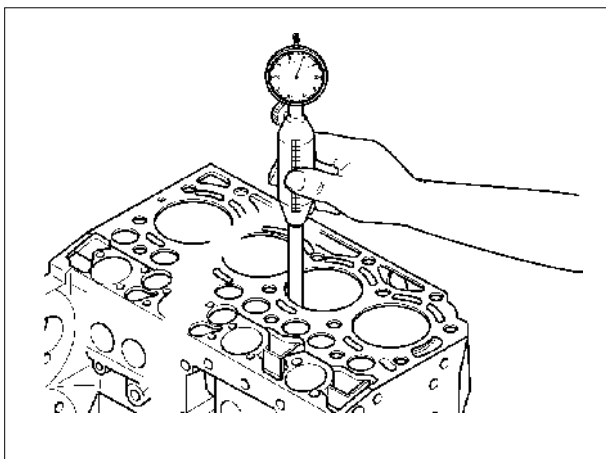
31. Remove the transmission housing if this has not been removed before.



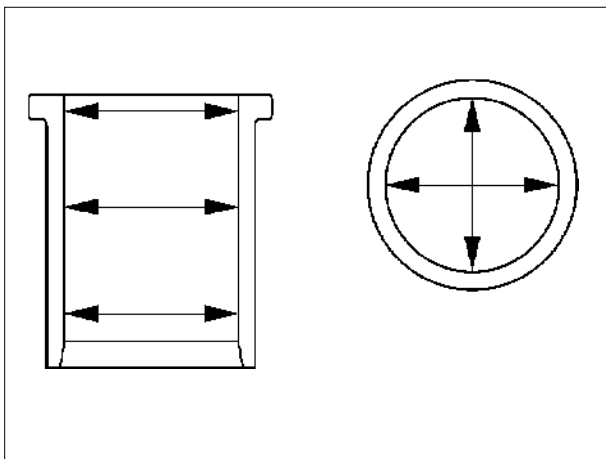
32. Turn the engine through 90°. Mark up the the bearing caps of the connecting rods and loosen the screws. Remove the bearing caps and the bearing halves. Take care of the bearing halves.



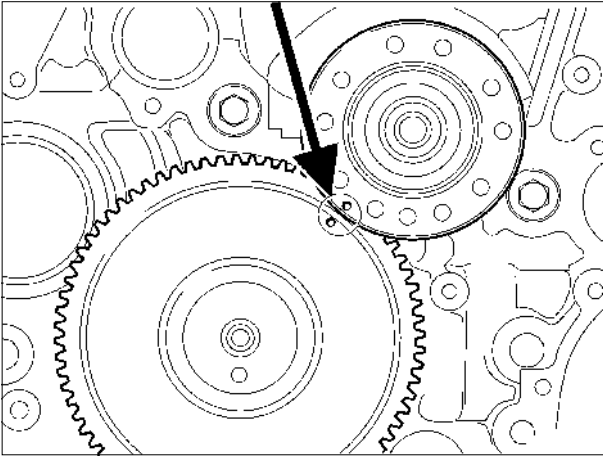
33. Remove the pistons, complete with connecting rods. Measure the liners before the main bearings are loosened.



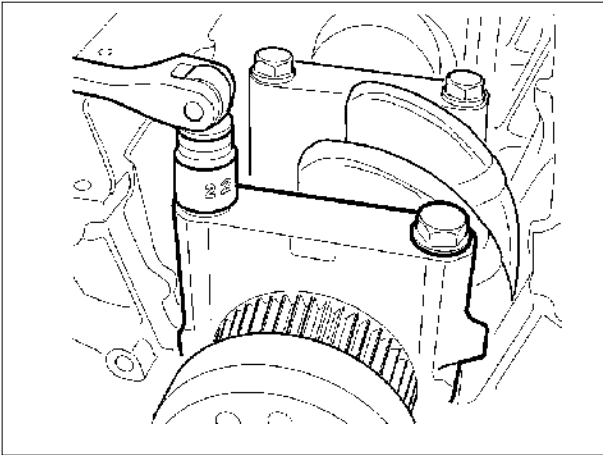
34. Turn the engine through 90°. Set the dial gauge to **108 mm** (4.25")



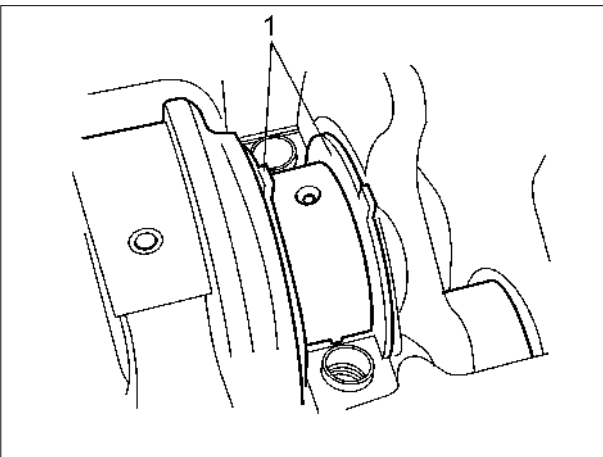
35. Make sure that the liners are not damaged or cracked. Measure the inside diameter of the cylinderliners. Measure at three different levels, according to the picture, both in the longitudinal and in the transverse axis.
 Diameter: **108^{+0.02} mm** (4.252^{+0.001"})
 Wear limit: **108.1 mm** (4.256")



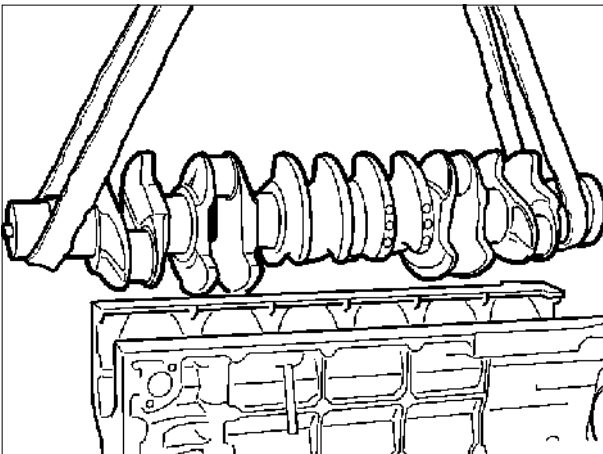
36. Turn the engine so that the crankshaft is directed upwards.
Make sure that the camshaft and crankshaft gears are marked.



37. Make sure that the crankshaft bearing caps are marked. Remove the securing screws and remove the bearing caps and the main bearing halves.

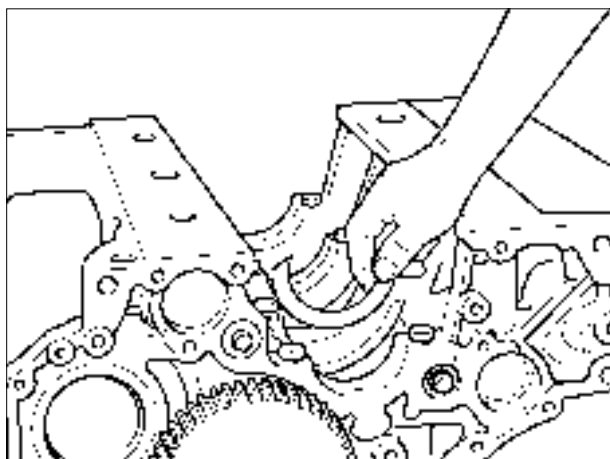


38. Remove the thrust washers (1) at main bearing cap 2 (the thrust bearing pivot).
Bearing cap 1 nearest the flywheel end.



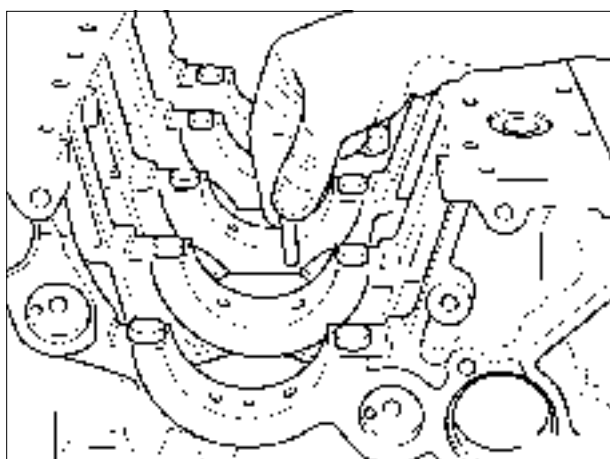
39. Lift the crankshaft out of the engine block.

NOTE! The crankshaft is heavy (approx. 75 kg, 720-722, 730-733). Use a soft strap to lift it out.

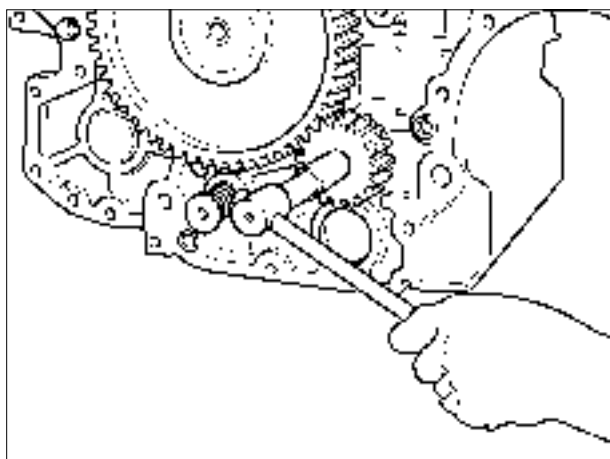


40. Remove the thrust washers and bearing shells at main bearing cap 2

NOTE! Mark up the bearing halves if they are to be used again.

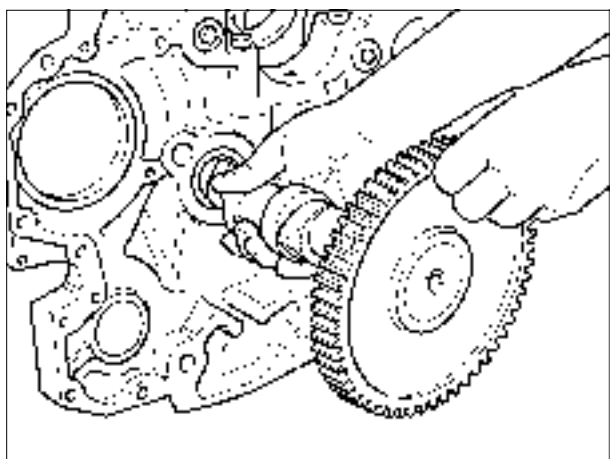


41. Press the piston cooling nozzles out.



42. Remove the idler gear.

NOTE! Does not apply to electronic governor.

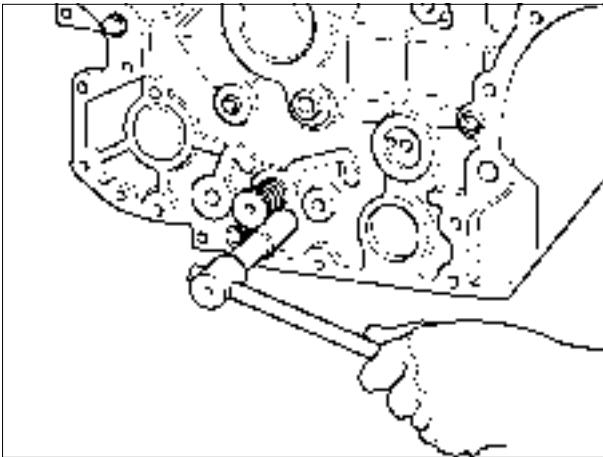


43. Pull out the camshaft.

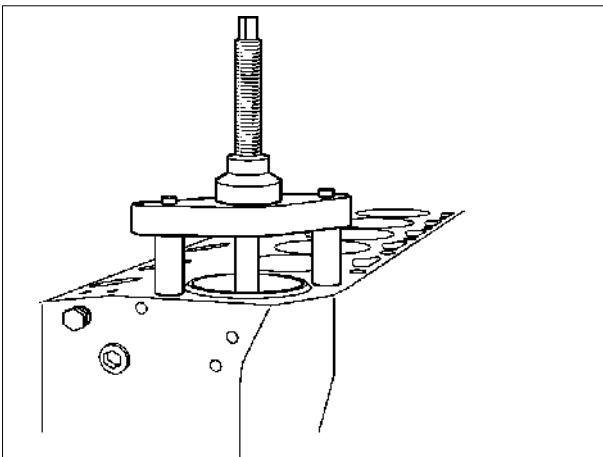
NOTE! Be careful when removing the camshaft to prevent damaging the bearings.



44. Remove the valve tappets and mark them if they are to be used again.



45. Remove the securing screw.
Pull out the control rod.



46. Remove the cylinder liners.
Use extractor plate 999 8675 together with liner extractor 999 6645 and supports 999 6395 and 999 6394.

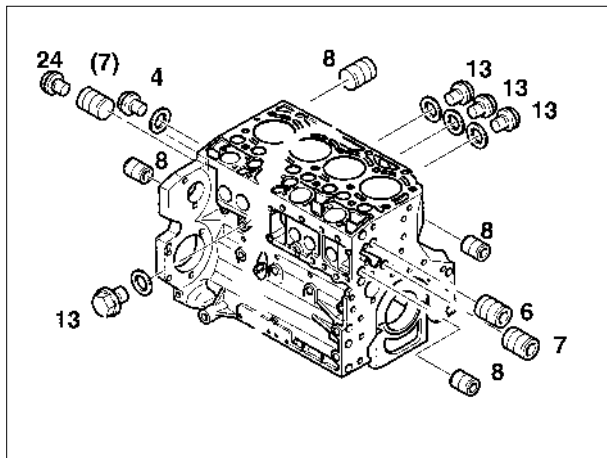
NOTE! Mark up the liners if they are to be used again.

⚠ WARNING! When fluorocarbon rubber is subjected to high temperatures highly corrosive **hydrofluoric acid** can be produced. Skin contact can cause severe burning. Be very careful and see "Safetyinstructions for fluorocarbon rubber".

Assembly, complete engine

Special tools:

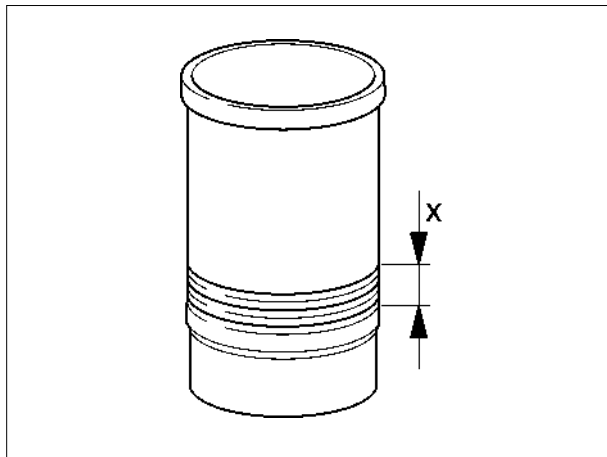
Rule depth gauge	998 5471
Engine repair stand	998 6485
Dial gauge	998 9876
Measuring/clamping instrument for control rod	999 8684
Measuring tool	999 8685
Measuring bar with spacers	999 8678
Protractor	999 8679
Cranking tool, flywheel	999 8681
Pressure tool, for locking of the control rod	999 8682
Piston ring compressor	999 8687



NOTE! Tighten the screw plugs as stated.

Use new copper seals for items 4 and 13. Insert item 24 with locking compound (part no1 161 053-2).

Item 4 =	35 ±3.5 Nm (26 ±2.6 lbf ft)
Item 6 =	95 ±9.5 Nm (70 ±7.0 lbf ft)
Item 7 =	65 ±6.5 Nm (48 ±4.8 lbf ft)
Item 8 =	35 ±3.5 Nm (26 ±2.6 lbf ft)
Item 13 =	35 ±3.5 Nm (26 ±2.6 lbf ft)
Item 24 =	10 ±2.0 Nm (7.4 ±1.5 lbf ft)

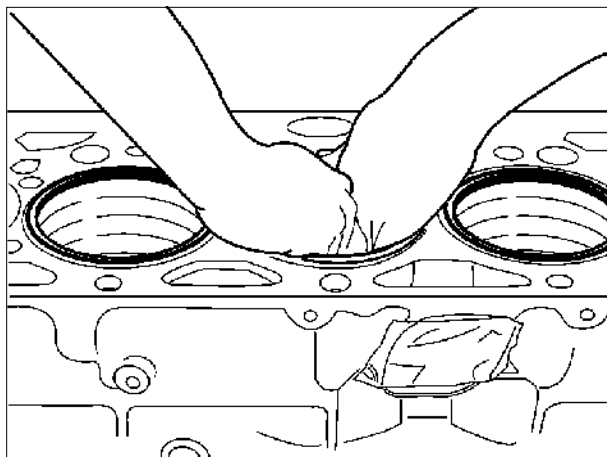


Engine, assembly Cylinder liner, installing

1. Ensure that the cylinder liner area and linersealing surfaces are completely clean.
2. Oil the engine block and cylinder liner in the areas marked X in the diagram.
Fit new O-rings.

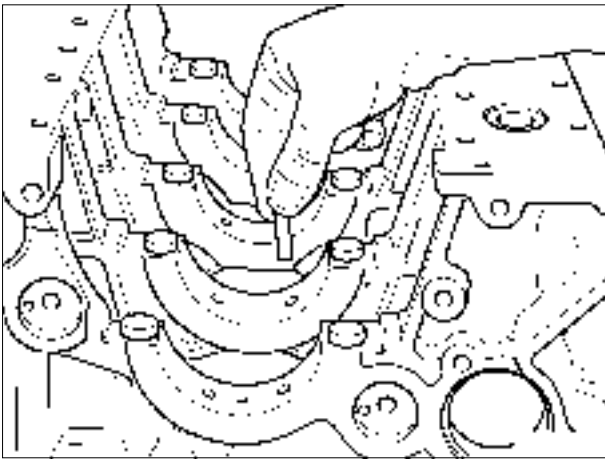
NOTE! Make sure the cylinder liner is correct mounted in the engine block, compare the liners height compare to the engine block, see "Technical data".

NOTE! Before insertion,



! IMPORTANT! Fit it without sealer, well cleaned and dry.

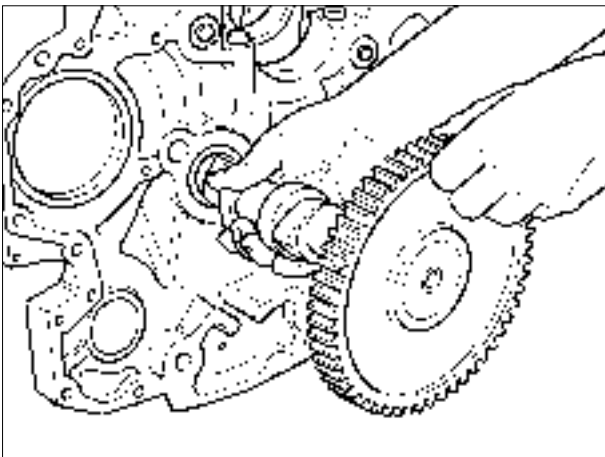
3. Fit the cylinder liner in to the correct position in the engine block. Drive it in as far as possible.

**Piston cooling nozzles**

4. Check that the oilways are not blocked. Fit the piston cooling nozzles in the correct position in the engine block. Press the piston cooling nozzles in as far as they will go.

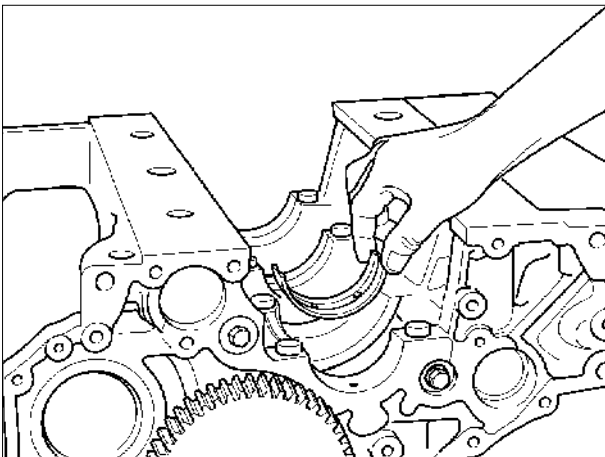
**Cams/camshaft**

5. Insert the valve tappets (lightly oiled).

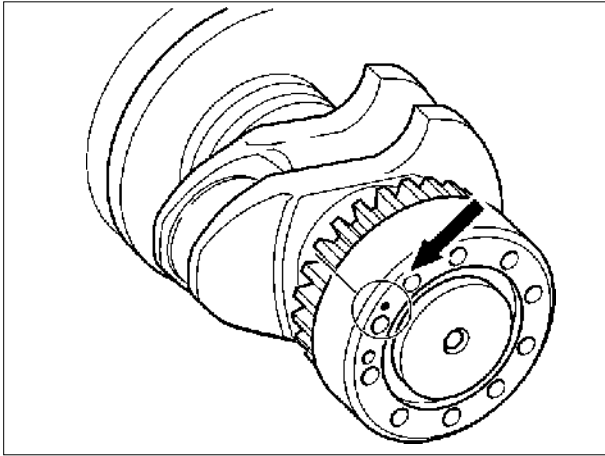


6. Fit the camshaft.

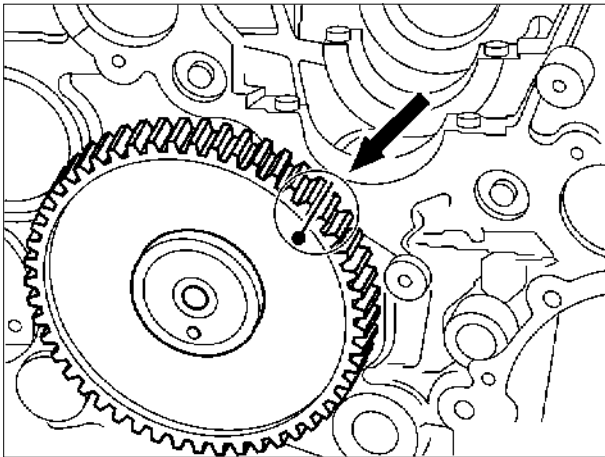
NOTE! Be careful when fitting the camshaft to prevent damaging the bearings.



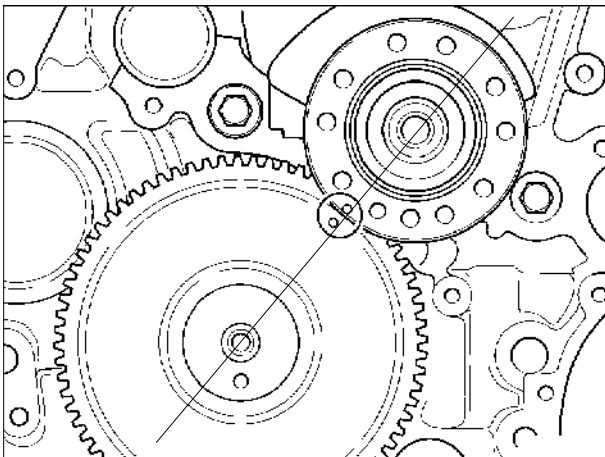
7. Fit the main bearing shells into the engine block.



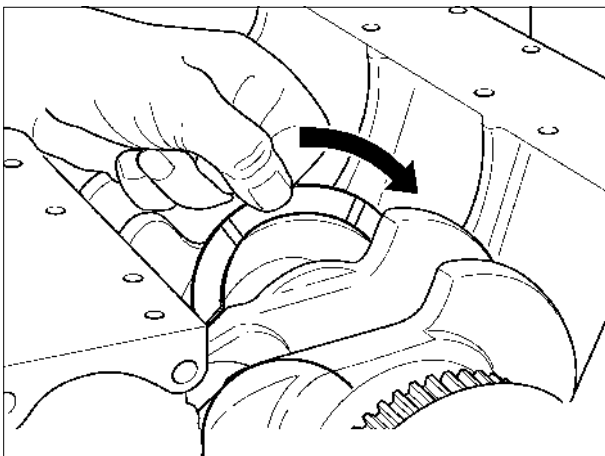
8. Mark the crankshaft if necessary (to make fitting easier).



9. Mark the camshaft, if necessary, and put it in place.

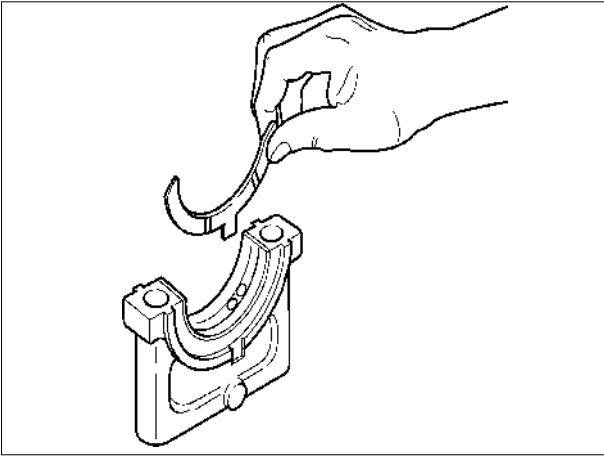


10. Insert the crankshaft. The marks must line up. Use a ruler and make sure that the marks line up through the centre of the crankshaft and camshaft.



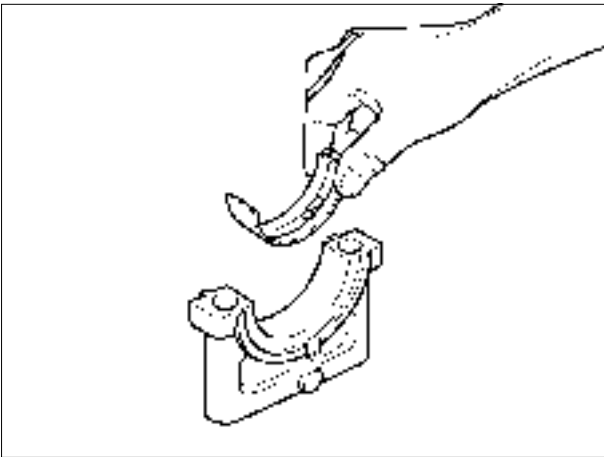
11. Insert the half thrust bearing without lug.

NOTE! The thrust bearing running face must be towards the crankshaft.

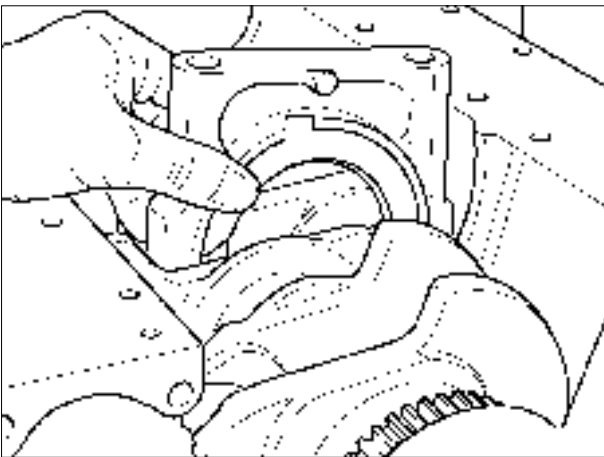


12. Fasten the half thrust bearing with lug to the thrust bearing caps (using a little grease).

NOTE! The thrust bearing running face must be towards the crankshaft.



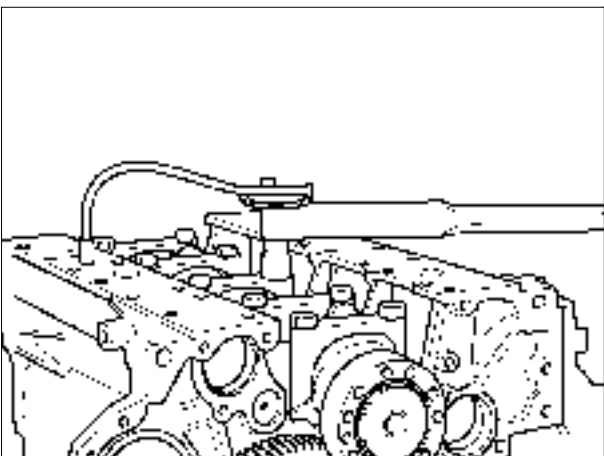
13. Fit the bearing shells into the main bearing caps and lightly oil them.



14. Oil the main bearing caps and put them in place.

NOTE! The main bearing caps are numbered 1-5 or 1-7 depending on engine type. Bearing cap 1 nearest the flywheel end.

NOTE! Make sure that the thrust washers on the bearing caps fit the washers in the block.



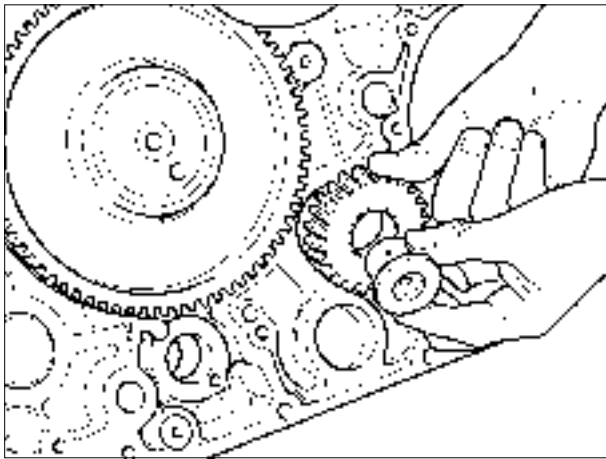
15. Tighten the main bearing cap screws as follows:

Initial torque: **50 Nm** (37 lbf ft)

1st tightening angle: **60°**

2nd tightening angle: **60°**

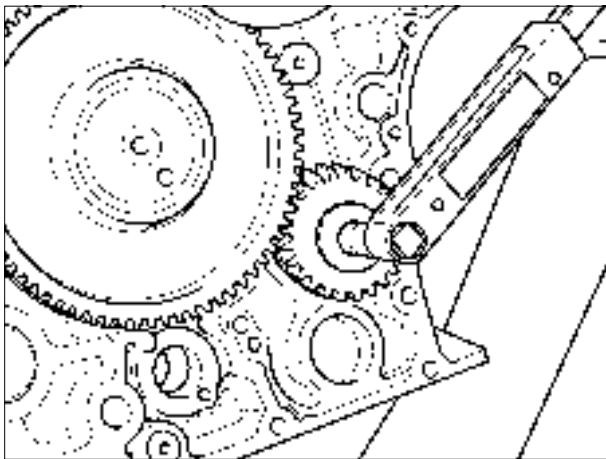
NOTE! You can use the bolts three times, if you know how many times they have been used. (Make a punch mark for each of the following usages.)



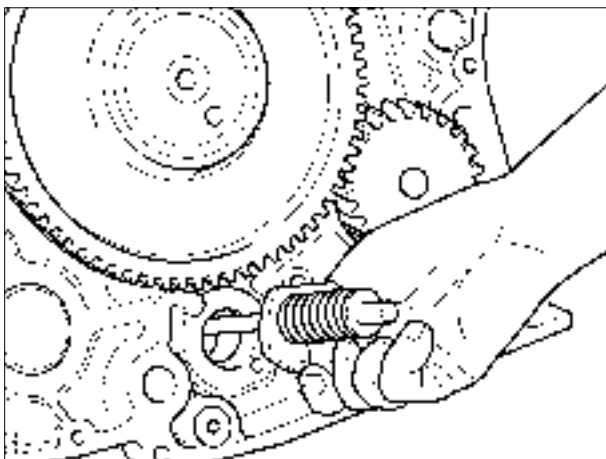
Governor idler gear (mechanical governor)

NOTE! Electronic governors do not have an idler gear.

16. Fit the governor idler, complete with bearing journal.

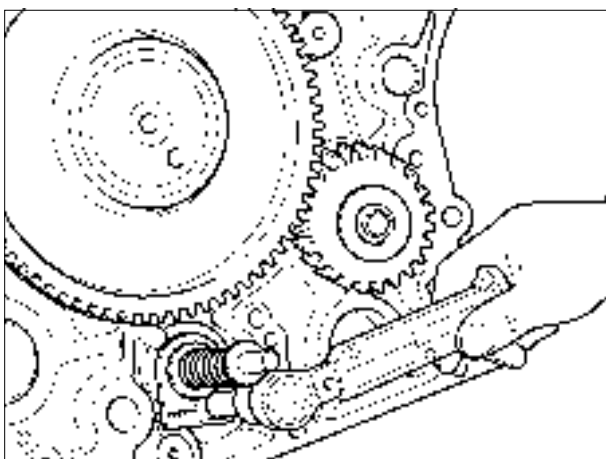


17. Using locking compound, insert the screw and tighten it, using thread sealer (1161053-2) to **21 Nm** (15 lbf ft).

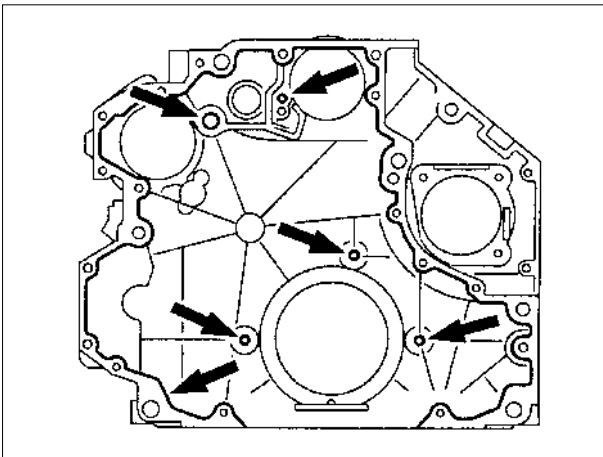


Control rod

18. Fit the control rod, complete with guide sleeve.



19. Put thread sealer (1161053-2) on the screw and tighten to **10 ⁺²₀ Nm** (7.4 ^{+1.5}₀ lbf ft).

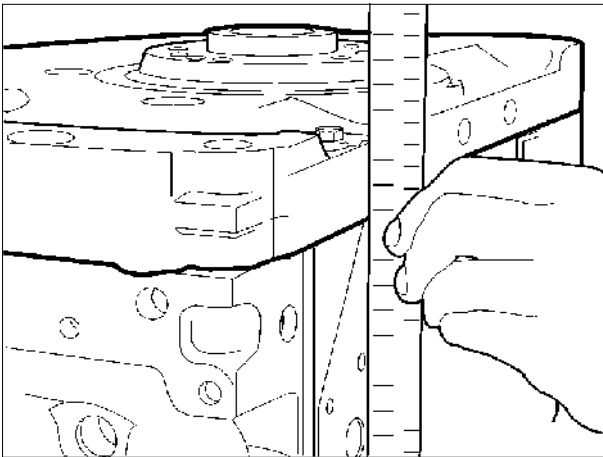


Transmission housing

NOTE! The transmission cover and starter motor can be installed together.

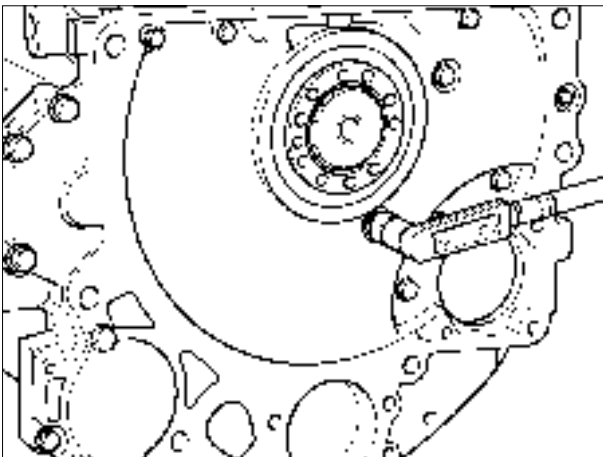
20. Apply silicon sealing compound (1161231-4) as shown in the diagram to the sealing surface for the transmission housing.

Lightly oil the crankshaft seal.

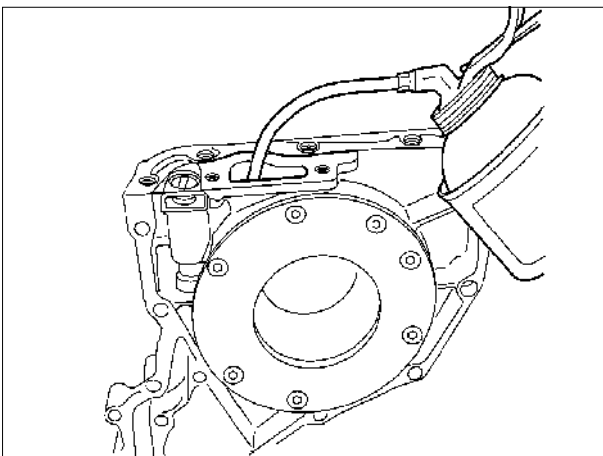


21. Fit the transmission cover, without tightening the screws.

NOTE! Line it up with the oil sump sealing surface.

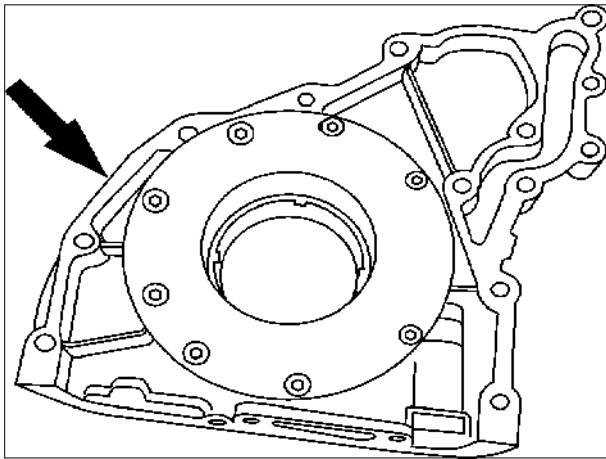


22. Tighten the screws to **21 ±2 Nm**
(15 ±1.5 lbf ft).

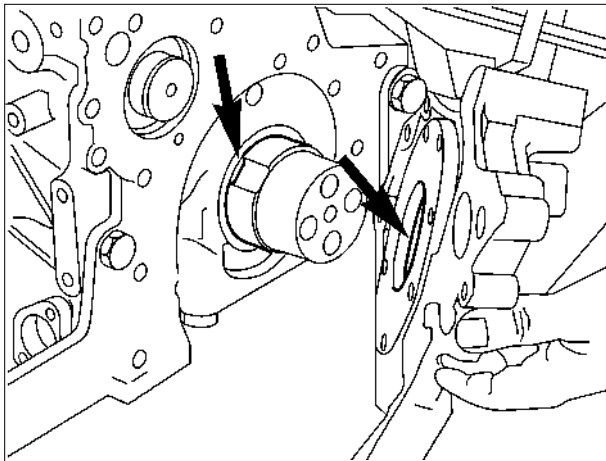


Oil pump/cover

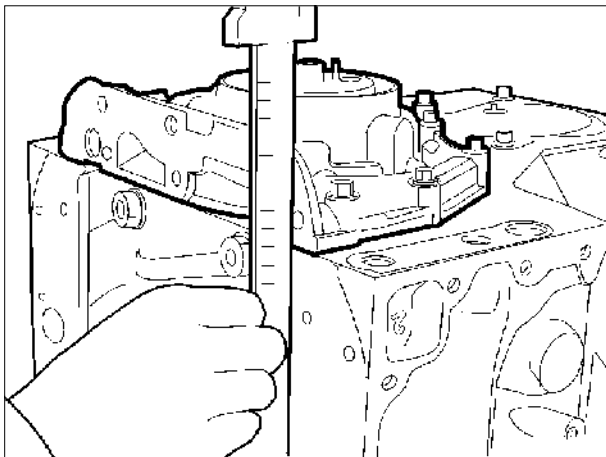
23. Lightly oil the oil pump rotor.



24. Attach the gasket to the oil pump/cover with a little grease.



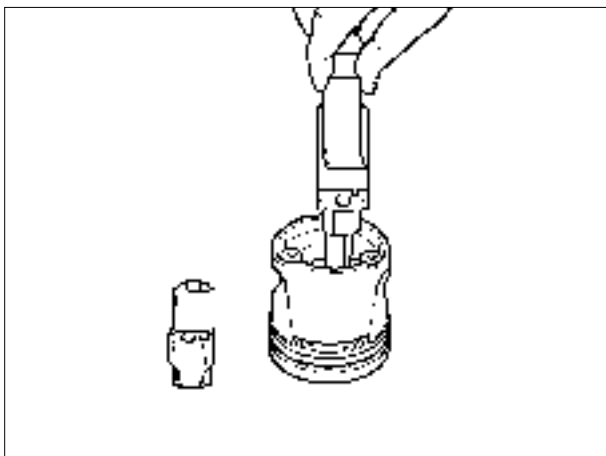
25. Fit the oil pump rotor onto the crankshaft. (It will only go in one position).



26. Fit the oil pump/cover without tightening the bolts.

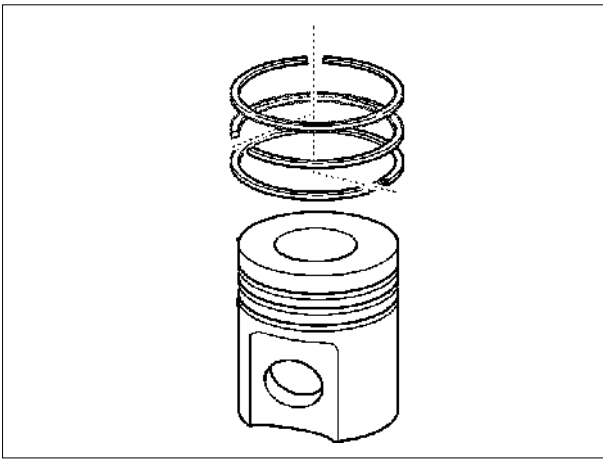
⚠ IMPORTANT! Push the cover upwards and align it with the oil sump sealing surface.

27. Tighten the oil pump/cover screws to **21 ±2 Nm** (15 ±1.5 lbf ft).

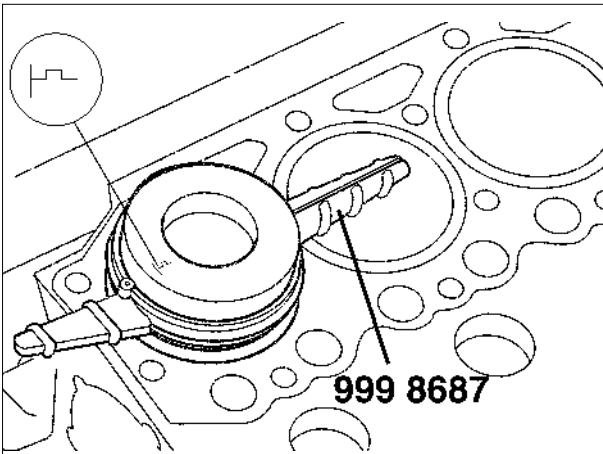


Piston complete with connecting rod

28. Fit the bearing shells into the connecting rod and cap. Lightly oil.



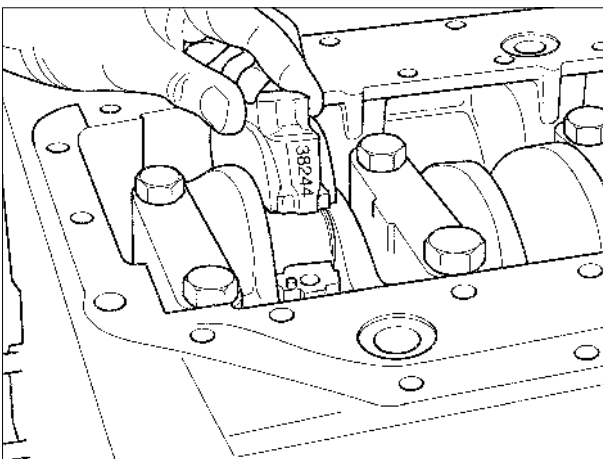
29. Position the piston ring gaps **120°** apart.



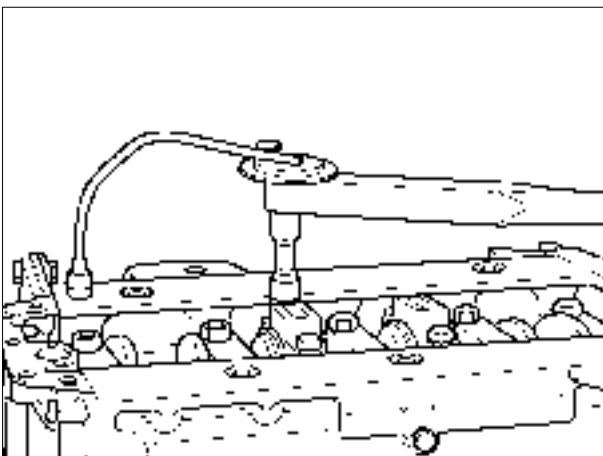
30. Use piston ring compressor 999 8687 and push the piston (complete with connecting rod) into the engine block.

⚠ IMPORTANT! Be careful, the piston rings are frail and can easily be damaged. The piston ring compressor may not be opened after the piston has been placed in the tool, since the piston rings then can be damaged. Always push out the piston before the tool is opened.

NOTE! The flywheel symbol (punched into the top of the piston and the guide pins on the connecting rod) must point towards the flywheel.



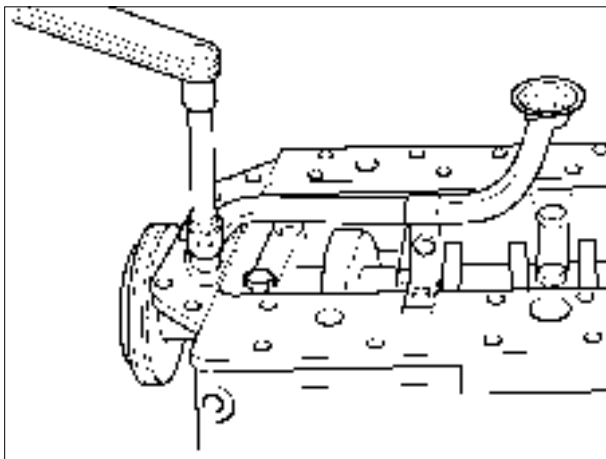
31. Lightly oil the crank pin. Press the connecting rod onto the crank pin. Fit the big end bearing cap (in accordance with the marking).



32. Tighten the new big end bearing screws as follows:
 Initial torque: **30 Nm** (22 lbf ft)
 1st tightening angle: **60°**
 2nd tightening angle: **60°**

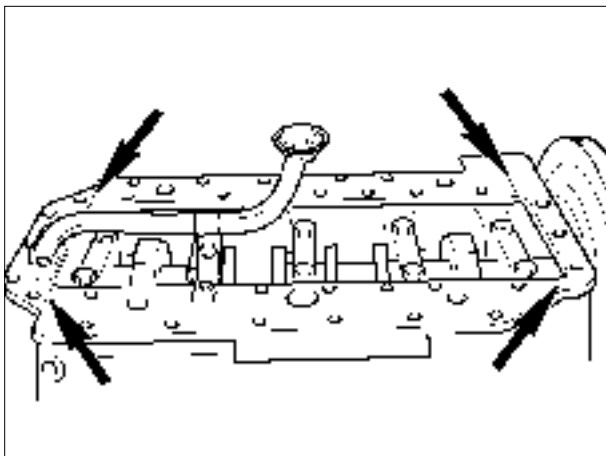
NOTE! You should renew the big end screws every time you remove them.

33. Turn the crankshaft to check that the connecting rods are running freely on the connecting crank pins.



Oil suction pipe/oil sump

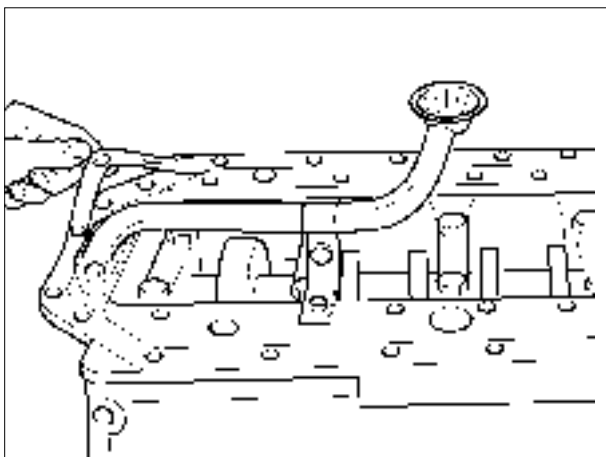
- 34. Fit the oil suction pipe with a new gasket.
- 35. Tighten the oil suction pipe to the oil pump housing. Tighten to **21 ±2 Nm** (15 ±1.5 lbf ft).



- 36. Cut off the protruding gasket.

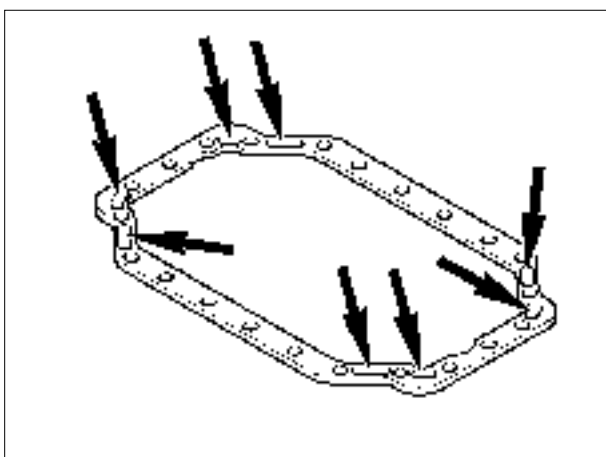
NOTE! Do not pull away protruding dried silicone.

Fill the joints in the oil sump sealing surface with silicone (part no. 1161231).

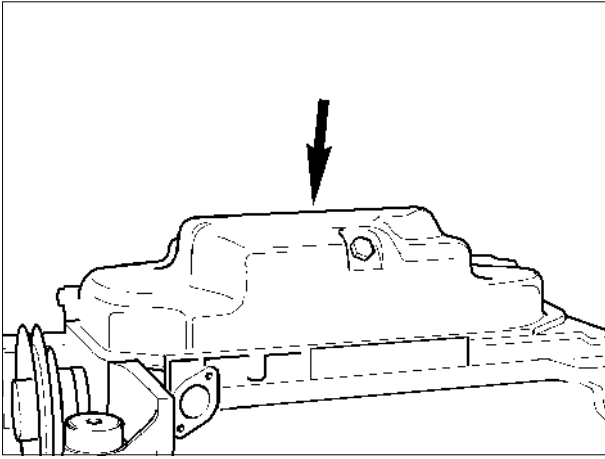


- 37. Position the new gasket on the engine block.

NOTE! The gasket consists of four parts.

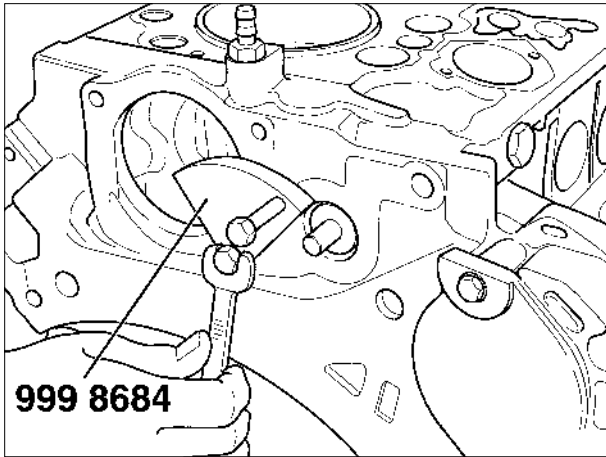


- 38. Fill the indentations in the gasket with silicon (part no. 1161231).



39. Fit the oil sump. Tighten to**21 ±2 Nm**
(15.5 ±1.5 lbf ft).

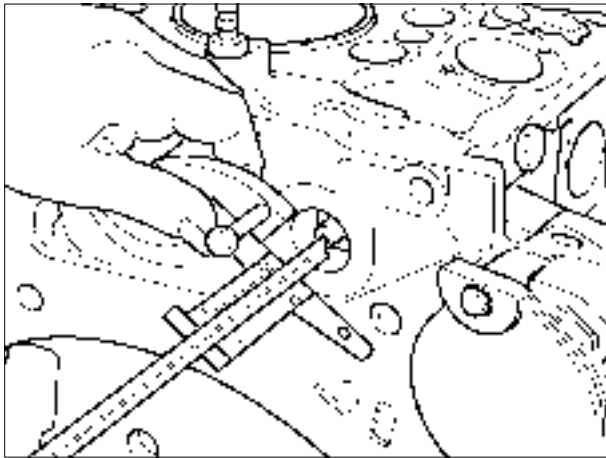
Control rod, measuring



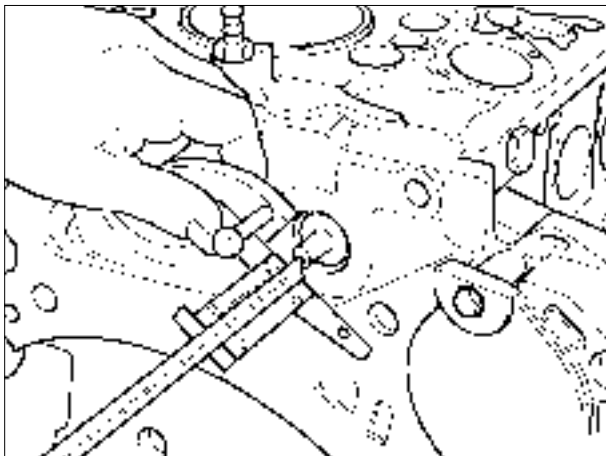
NOTE! Measure the control rod (fuel rack) travel **without** the injection pumps fitted.

40. Turn the engine through 180°.

Attach the control rod (fuel rack) measuring fixture 999 8684 on the leading edge of the engine.



41. Measure from the measuring fixture to the control rod (fuel rack) stop position (see diagram). Use rule depth gauge 998 5471.



42. Measure from the measuring fixture to the control rod (fuel rack) start position. Use rule depth gauge 998 5471.

The difference between the start and stop positions is the control rod (fuel rack) travel.

Stated measurement = **17.0 mm - 17.5 mm**
(0.67" - 0.69")

Example:

Stop position = 30.7 mm (1.21")

Start position = 13.4 mm (0.53")

Control rod travel = 17.3 mm (0.68")



43. Turn the measuring fixture (see diagram). Push the control rod (fuel rack) to the stop position by hand, using the stop screw.

NOTE! Only tighten the stop screw gently by hand.

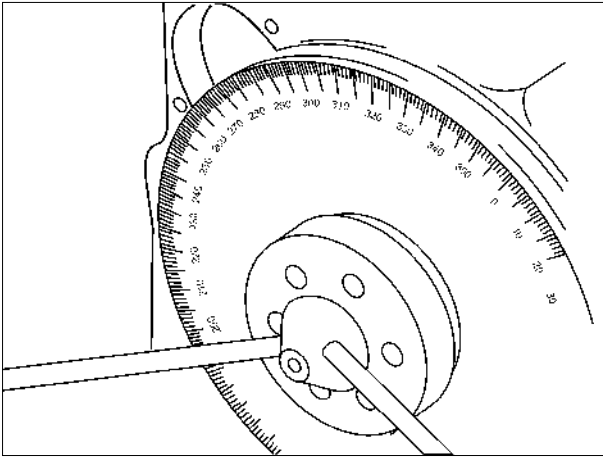
Determining the injection angle, shim thickness, and fitting of injection pumps

NOTE! The injection angle and type of camshaft is stated on the engine identification plate.

To follow the procedure described below, is only required if the engine block, camshaft or a roller tappet has been replaced.

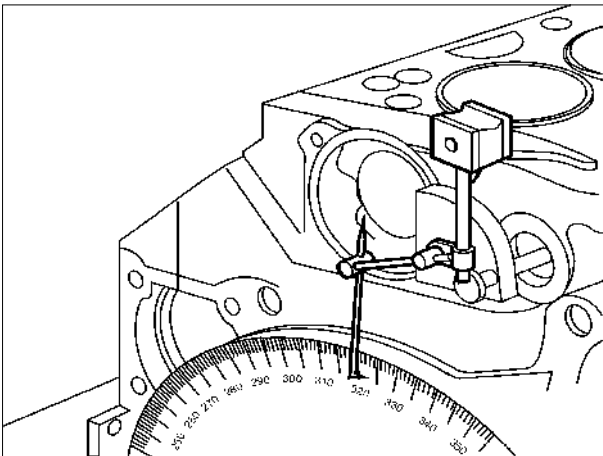
When fitting existing injection pumps see section "Injection pump installation" in this chapter.

When changing an injection pump only, see chapter "Changing injection pump".

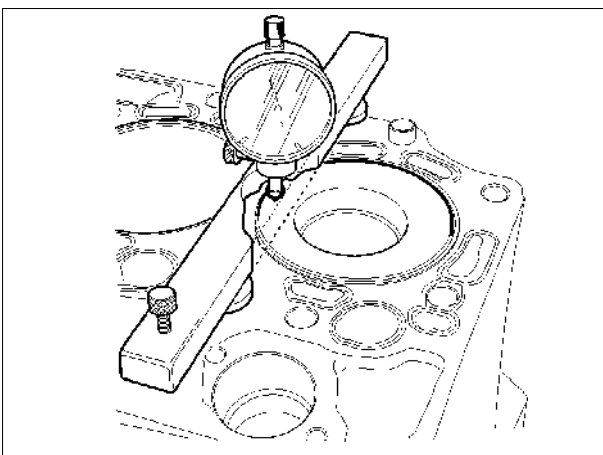


44. Fit the protractor (999 8679) to the flywheel flange on the crankshaft.

NOTE! Make sure that you tighten the screws so that there is no play.



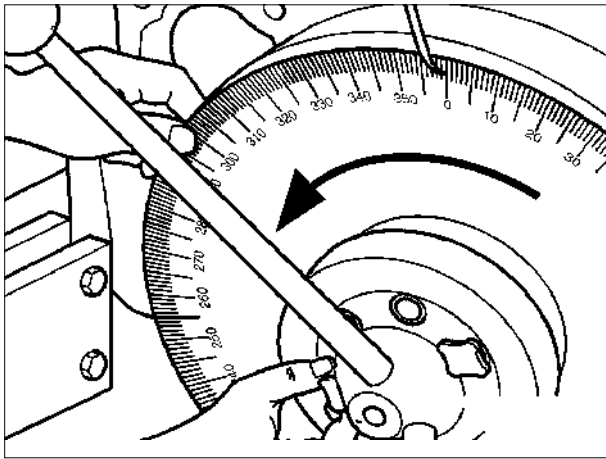
45. Attach a pointer.
Use a magnetic stand.



46. Position the measuring bar (999 8678) with spacers on the engine block over the piston belonging to the injection pump for which you are setting the timing.

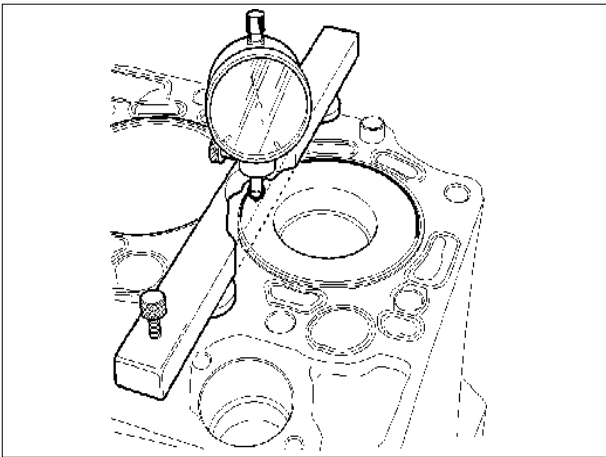
Turn the crankshaft in the direction of engine rotation until the dial gauge has reached its turning point. Set the dial gauge to "0".

⚠ IMPORTANT! The dial gauge must be placed in the center of the gudgeon pin direction.



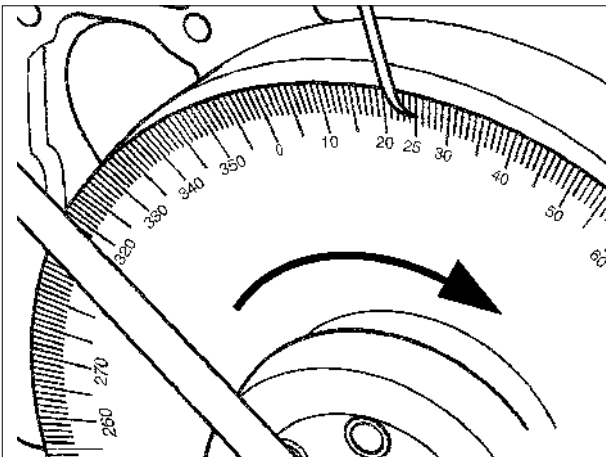
At top dead center the piston is still approx. 1°. To find the top dead center, the procedure below must be performed.

47. Turn the crankshaft through **350°** in the engine rotation direction until **8 mm (0.32")** before top dead centre (dial gauge turning point). Set the protractor to "**0**".



48. Turn the crankshaft through **350°** in the opposite engine rotation direction until **8 mm (0.32")** before top dead center (dial gauge turning point). Read the value.

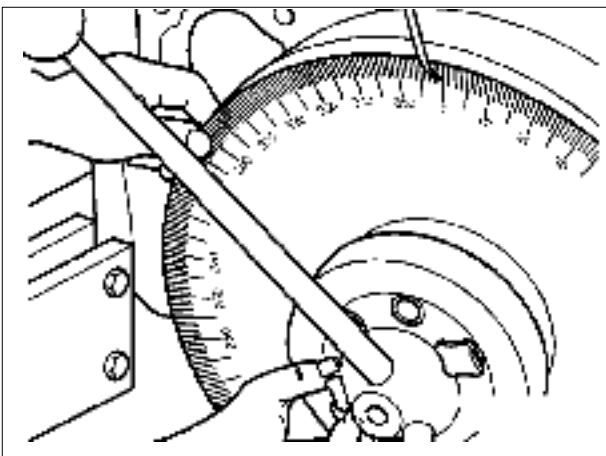
Example: 50°.



49. Turn the crankshaft until you reach half of the value you have determined on the protractor.

Example: $(0° + 50°)/2 = 25°$ ACTUAL value.

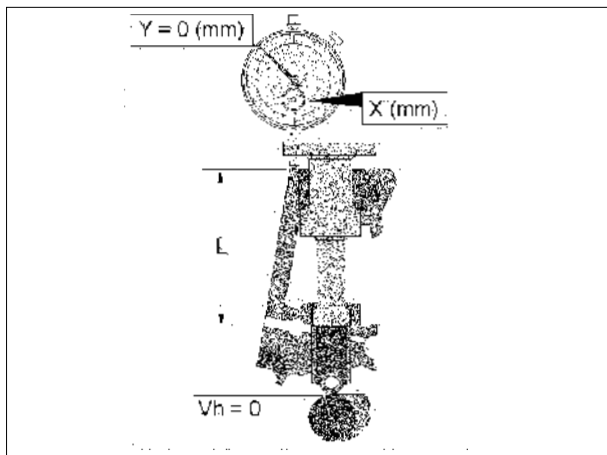
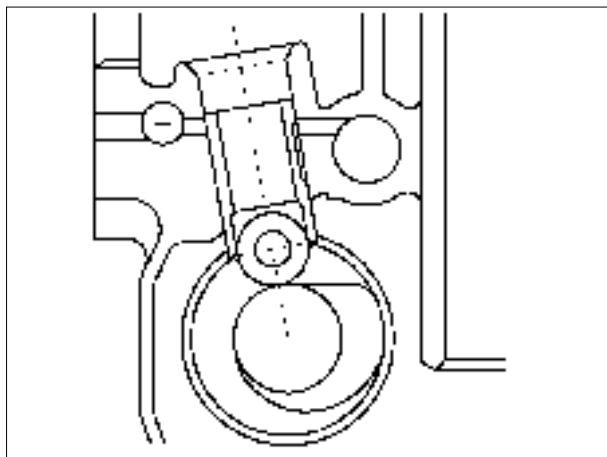
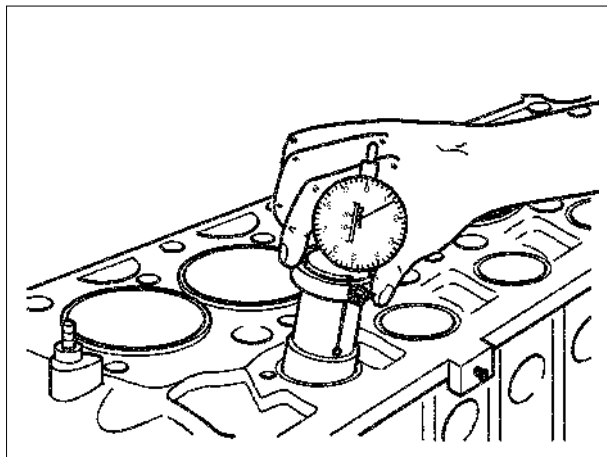
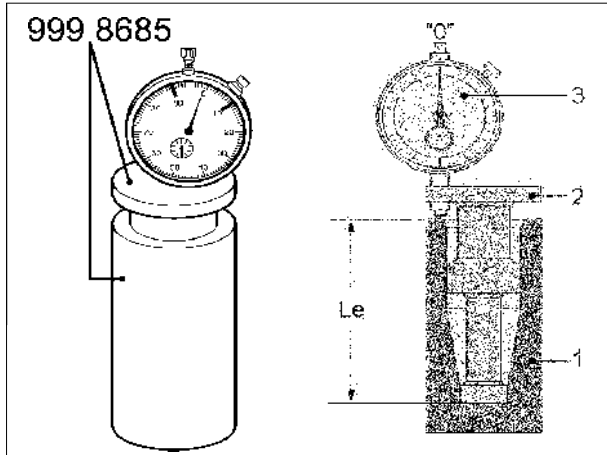
This is the same as the top dead centre and should correspond with the top dead center on the dial gauge.



50. Set the protractor to "**0**".

NOTE! Leave the protractor on for the next phase, in order to determine the injection angle.

Determining the injection angle



Measuring of permissible variation, engine block.

(We suggest that Tables 1, 2, and 3 as well as Calculations 2 and 3 from section "Technical data" in this book are photocopied.)

- 51. Install the dial gauge 998 9876 in the measuring fixture 999 8685 with a preload of **5 mm (0.2")**. Zero the dial. The set value (Le) is **150 mm (5.9")** (see figure).

1 = Gauge 999 8685

2 = Depth gauge 999 8685

3 = Dial gauge 998 9876

- 52. Position the roller tappet, without shims, for the injector pump in question on the base circle of the camshaft. Insert the depth gauge carefully in the injection pump hole.

NOTE! Make sure that the guide on the roller tappet ends up in the groove in the material.

- 53. To do this, turn the crankshaft through **180°** against the direction of rotation, until you are certain that the roller tappet is placed on the base circle.

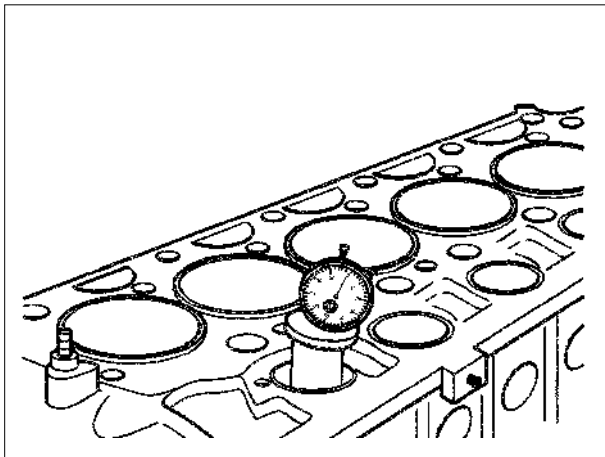
- 54. Take measurement "**L**" and enter it in "Calculation 1" in "Technical data".

Depth gauge: 150 mm (5.9")

Dial gauge (X mm): 2.18 mm (0.086")

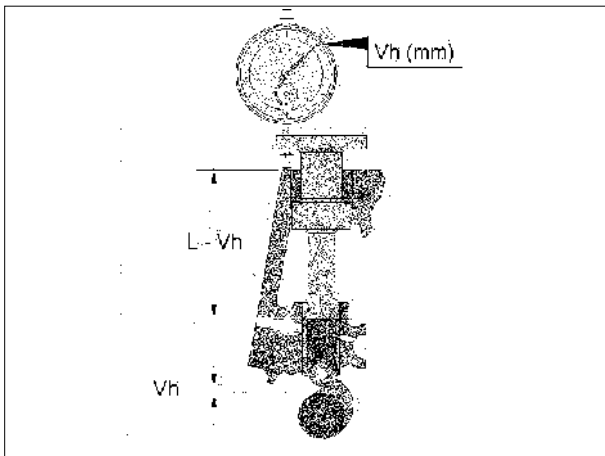
$L = 150 + 2.18 = 152.18 \text{ mm}$

$(12.75 + 0.086 = 12.83")$



Measuring of permissible variation, roller tappet and camshaft.

55. Zero the dial gauge.



56. Read the injection angle, Fb_{nom} , on the engine identification plate.

Read pre-stroke, Vh_{nom} , in Table 1 in "Technical data".

Enter both values in calculations 2.1 and 3.1 in "Technical data".

Example:

Fb_{nom} = injection angle = 6.0°

Camshaft = A

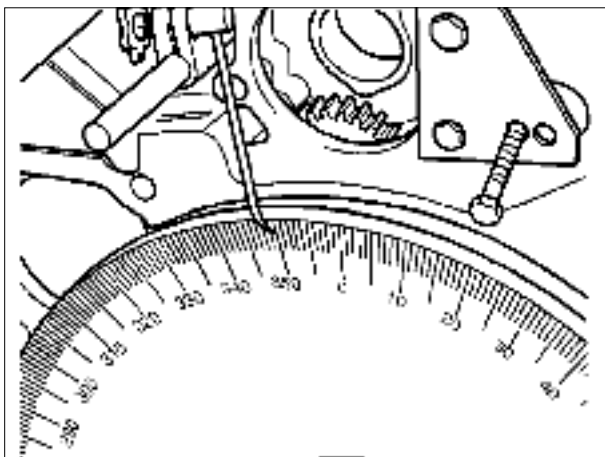
Vh_{nom} = pre-stroke = 6.11

57. Turn the crankshaft in the direction of engine rotation until the dial gauge shows (-) Vh_{nom} .

Example:

$7 - 6,11 = 0,89$

The dial gauge was zeroed at 7 mm pre-stroke and when it shows 0.89 in the example, you have reached Vh_{nom} .



58. You can now, on the protractor, read the value (eg. $354,5^\circ$) for when the injection valve should have opened.

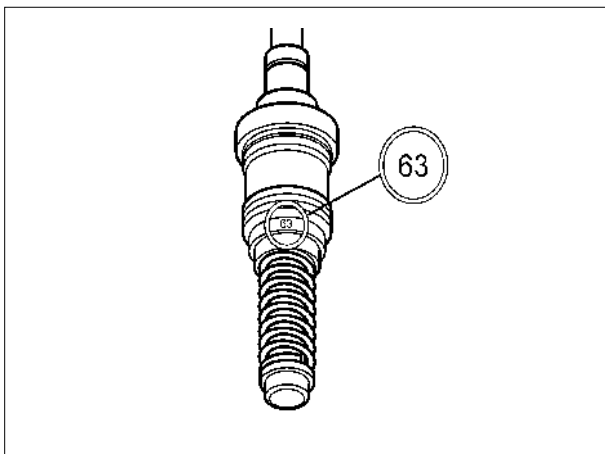
Example: $360 - 354.5 = 5.5$

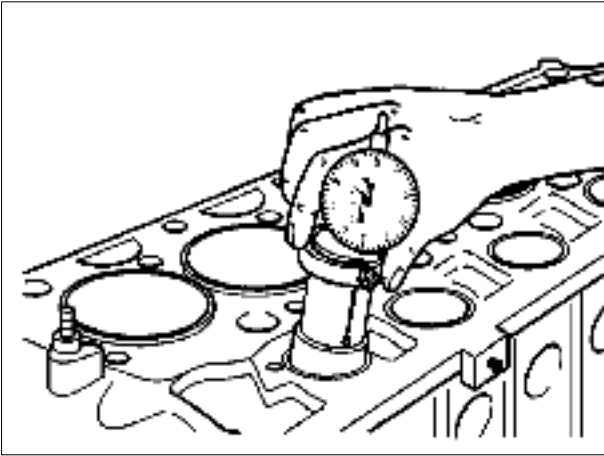
Enter it into calculations 2.1 and 3.1 in "Technical data".

Example: $F_{B akt} = 5.5^\circ$

59. Read off demension "A" = the code for the injection pump length and enter it into "Calculation 2.1" in "Technical data".

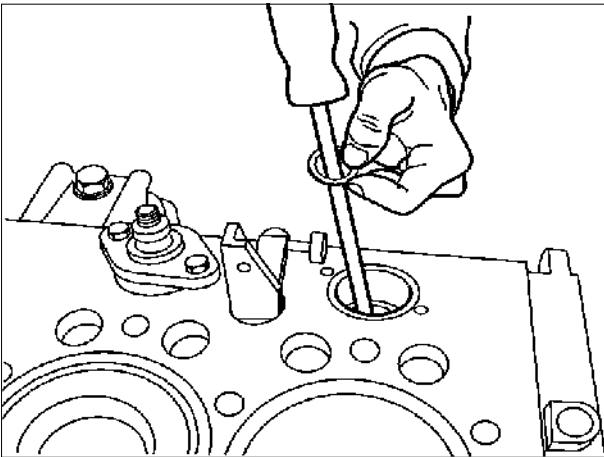
Example: $A/100 = 0.63 \text{ mm } (0.025")$





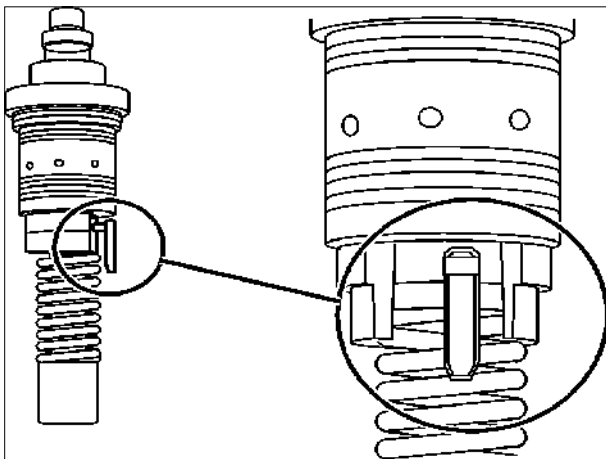
60. Remove the depth gauge with the dial gauge. Complete the calculations for shim thickness in "Calculation 2.2" in "Technical data".

NOTE! Don't forget to change the EP-code on the engine identification plate.



61. Slide the shim in place along a screwdriver into the roller tappet.

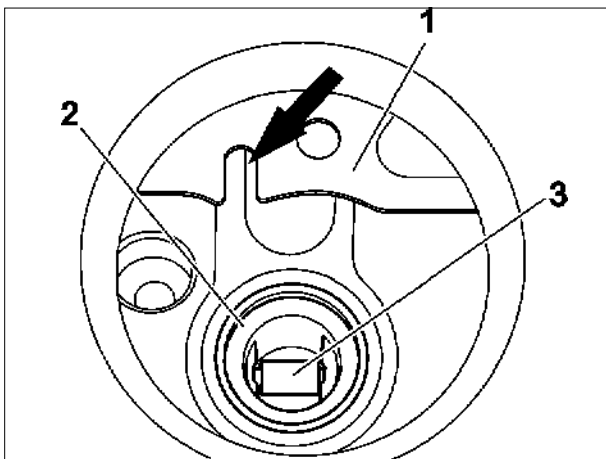
NOTE! Perform the measurement procedure in steps 51-61 above for each injection pump.



Injection pump Installation

- 62. When refitting pumps: place the existing roller tappets with their belonging shims.
- 63. **⚠ IMPORTANT!** Turn the injection pump linkage lever to middle position.
- 64. Make sure the injection pumpcam, for the cylinder in question, is on the base circle.
Turn the engine, using tool 999 8681 or protractor 999 8679.

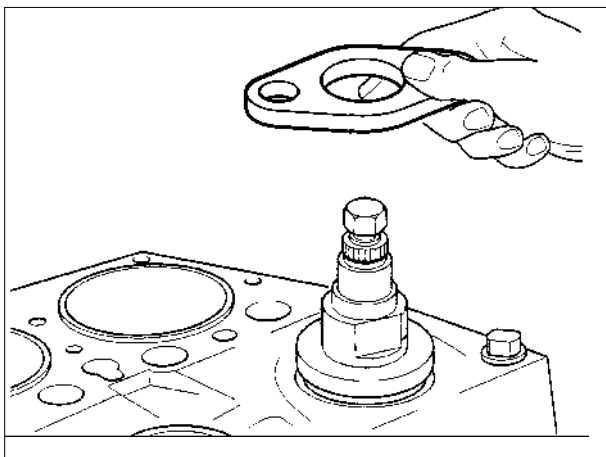
NOTE! Make sure that the control rod is still in the stop position, held in place with the tools 999 8682 or 999 8684.



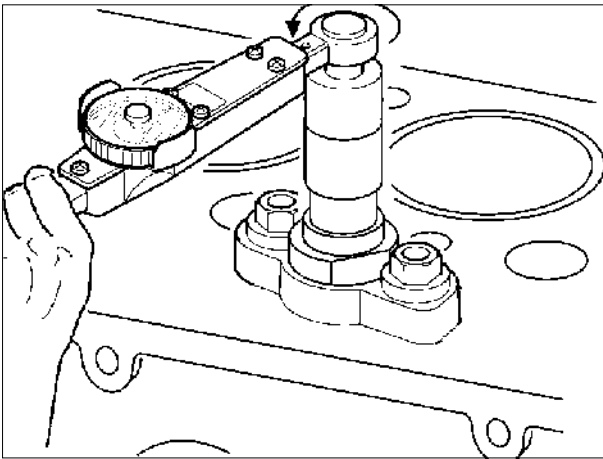
- 65. Lightly oil the O-rings, using lubricant 1141699, on the injection pump and carefully insert the pump.

⚠ IMPORTANT! Make sure that the injection pump linkage lever has entered the slot in the control rod before pushing it down.

- 1. Fuelrack
- 2. Shim for pump element
- 3. Roller tappet for pump element



- 66. Put the pump flange in place with the camfered hole side facing the pump.
Oil the screws lightly and tighten the screws evenly to 5 Nm (3.7 lbf ft).
Back she screws off 60°.



67. Turn the injection pump carefully counter-clockwise.
Use a torque wrench with gauge and 11668403.
Stop turning when the pump has reached its stop position and the torque is increased by **1Nm** (0.74 lbf ft).

Observe the torque required on the torque wrench gauge to turn the injection pump, e. g. **3.5 Nm** (2.6 lbf ft).
Example: 3.5 + 1 = 4.5 Nm

68. Tighten the screws **60° clockwise** then alternately with a torque of **7, 10 and 30 Nm** (5.2, 7.4 and 22.2 lbf ft) .

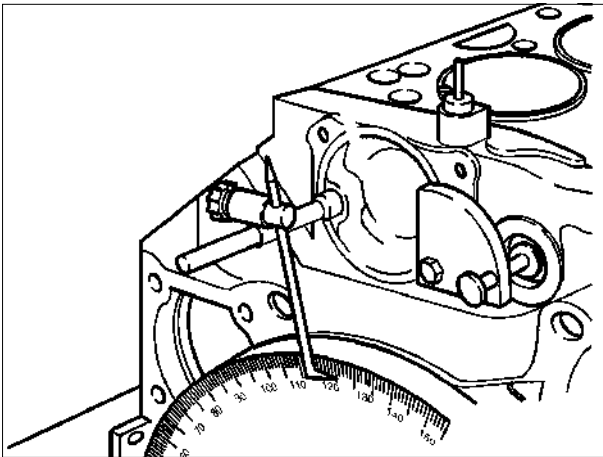
NOTE! Start with the screw furthest away from the flywheel.

NOTE! Check that the control rod (fuel rack) is moving freely after each injection pump has been installed.

Repeat the steps above for each pump.

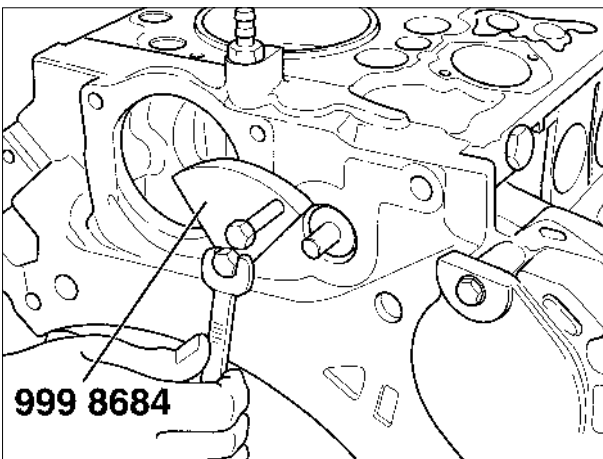
69. Remove the indicator 999 8679, if it has been fitted.

Let tool 999 8684 stay in place.



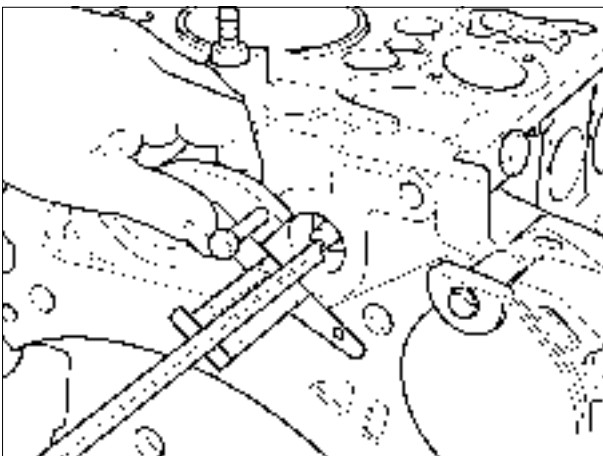
Measure the control rod (fuel rack) travel with the injection pumps installed

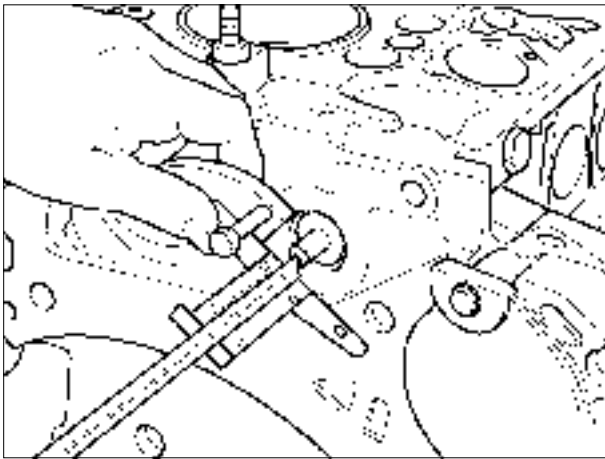
70. Loosen the measuring fixture screw and turn it from the control rod and tighten the measuring fixture screw at the measuring position.



71. Measure from the measuring fixture to the control rod stop position.

Example: 30.5 mm (1.2").





72. Measure from the measuring fixture to the control rod (fuel rack) start position.

Example: 13.6 mm (0.53").

Remove the measuring fixture.

The difference between the start and stop positions is the control rod (fuel rack) travel.

Minimum control travel is 16.8 mm (0.66")

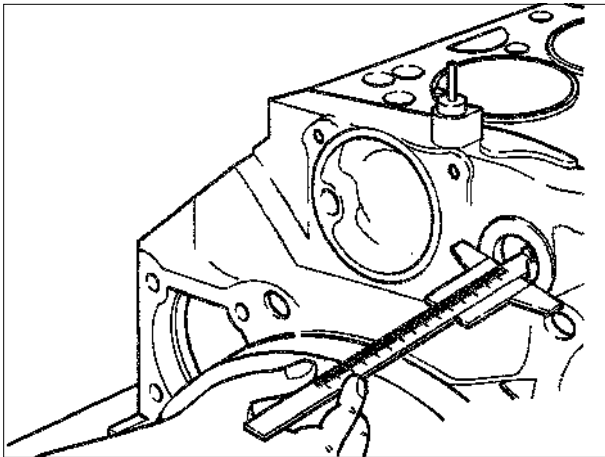
Example:

Stop position = 30.5 mm (1.2")

Start position = 13.6 mm (0.53")

Control rod (fuel rack) travel = 16.9 mm (0.67")

Measuring of the control rod's x-measurement.



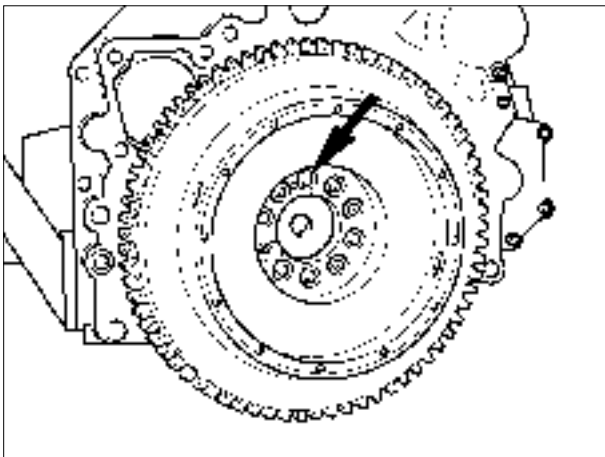
73. Measure the control rod's x-measurement from the transmission housing surface to the stop position.

NOTE! You must indicate the determined x-measurement when the engine block, control rod or gear case has been replaced.

For electronic governors (EDC 4) the x-measurement value is entered into the trigger unit.

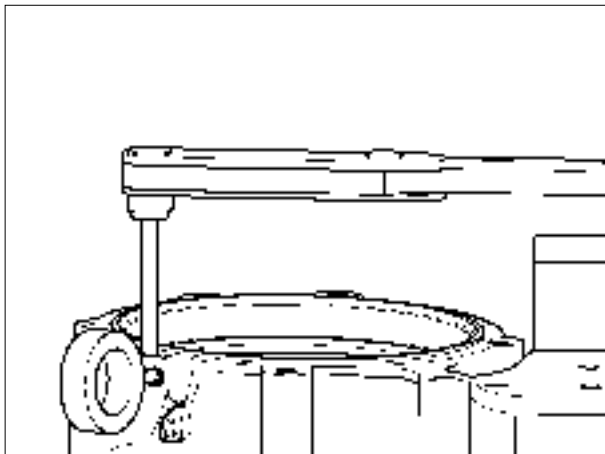
NOTE! When replacing the control rod, the governor must always be adjusted. Only trained personnel should make adjustments to the governor, using a governor test bench.

Flywheel, fitting



74. Fit the flywheel. Tighten the screws by hand.

⚠ WARNING! The flywheel is heavy, approx. 55 kg (720-722).



75. Install the flywheel housing.

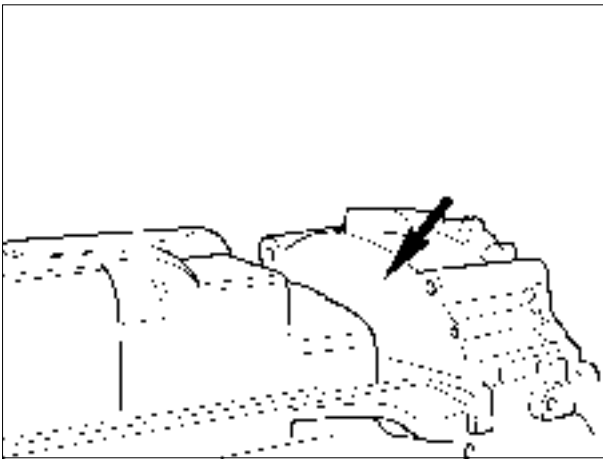
NOTE! Make sure the guiding sleeves are in place.

Tighten the screws as specified:

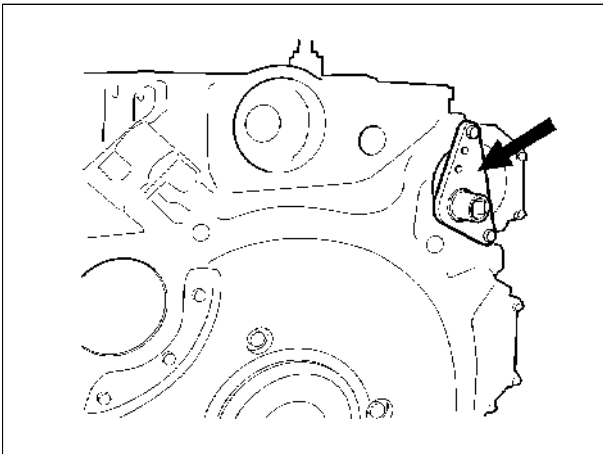
M12 screws : **99 ±10 Nm** (73.3 ±7.4 lbf ft).

M16 screws : **243 ±25 Nm** (179.9 ±18.5 lbf ft).

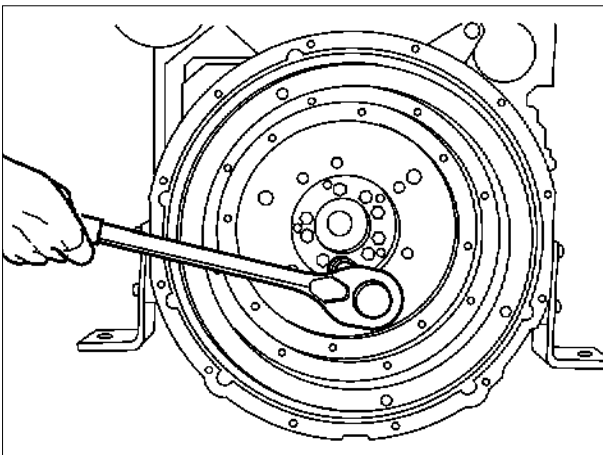
NOTE! Use Torx sockets E14 and E20.



76. Fit the cover plate on the flywheel housing.



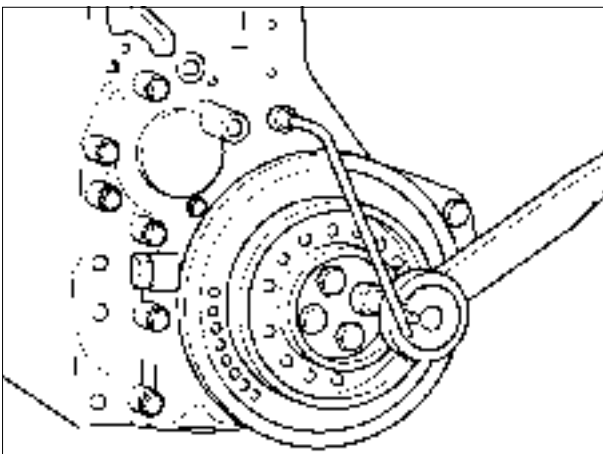
77. Fit cranking tool 999 8681 on the flywheel side.



78. Block the flywheel, using cranking tool 999 8681. Tighten the screws as specified in "Technical Data".

NOTE! There are several screw lengths. Screws may be used 5 times.

Fit the plastic plugs that are used as a locking device for the flywheel screws.



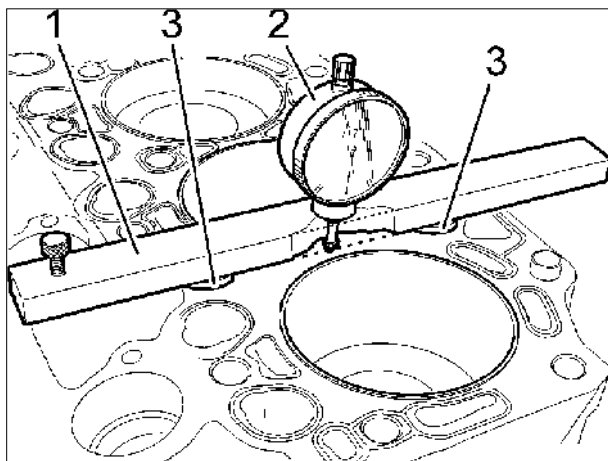
79. Fit the crankshaft pulley and vibration damper and tighten the screws as specified below:

NOTE! Use tool 999 8681 to block the flywheel.

Initial torque: **40 ±5 Nm** (33 ± 3.7 lbf ft).
 1:st tightening angle: **60°**
 2:nd tightening angle: **60°**

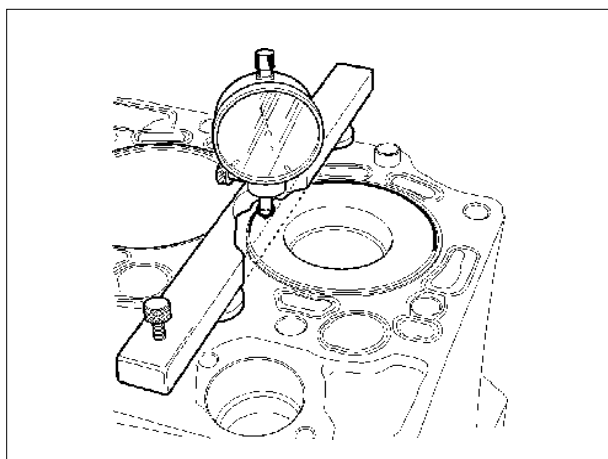
NOTE! Use Torx socket E 20.

NOTE! The screws can be used 5 times.



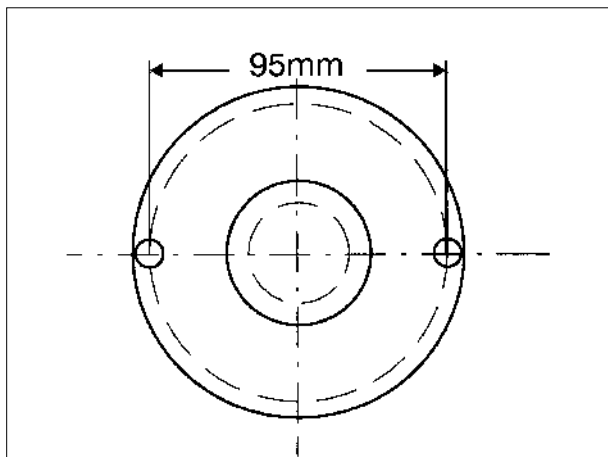
Cylinder head gasket

80. Determine the thickness of the cylinder head gasket. Put spacers (3) and measuring bar 999 8678 (1) on the sealing face of the engine block and set the dial gauge (2) to "0".

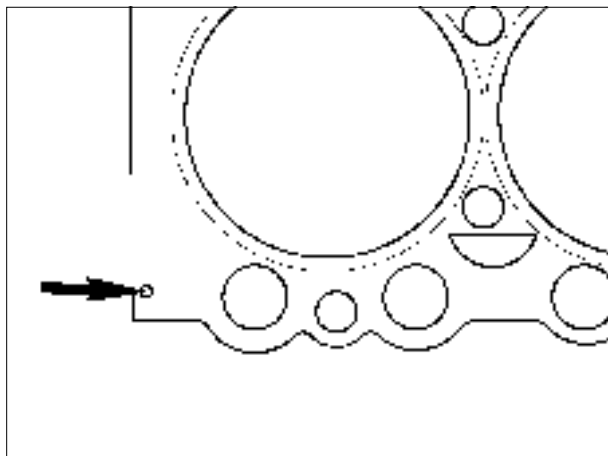


81. Put the dial gauge on the piston at the measuring points and determine the greatest piston height.

NOTE! You need to measure all pistons at T.D.C.

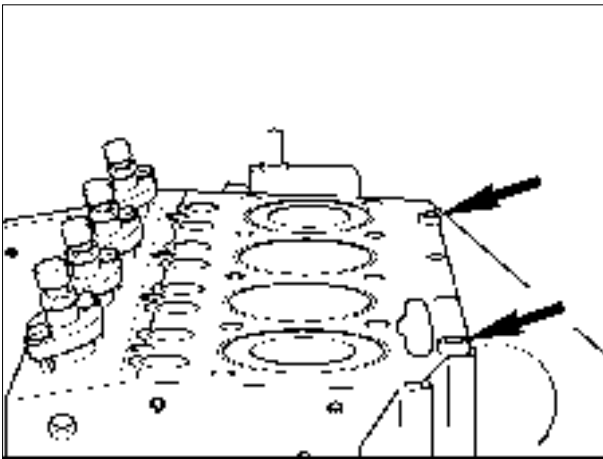


NOTE! Take note of the measuring points, since the surface of the piston is spherical. Use for example a steel ruler to find the highest point (in the direction of the gudgeon pin).



82. Compare the largest values with the table and determine a suitable cylinder head gasket.

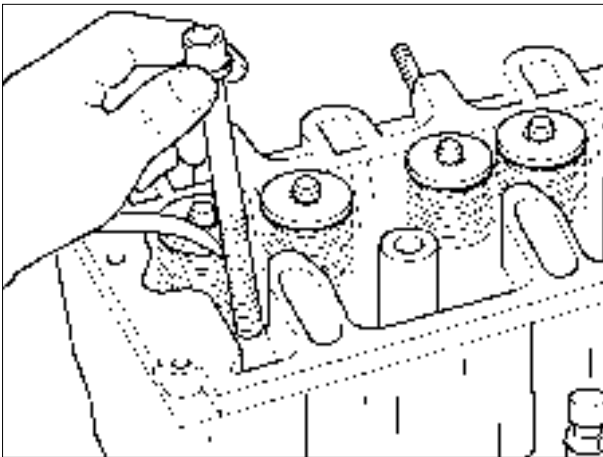
Piston height	Marking on cylinder head gasket
0.28– <0.53 mm (0.011– <0.021")	1 hole
0.54– <0.63 mm (0.021– <0.025")	2 holes
0.64–0.75 mm (0.025–0.029")	3 holes



83. Position the cylinder head gasket correctly (with the numbers facing upwards and the marking holes towards the flywheel).

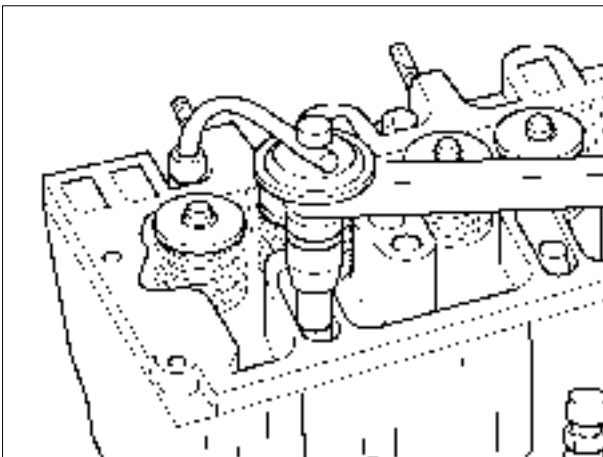
NOTE! The cylinder sealing surfaces must be clean and free of oil. Pay particular attention to the dowel sleeves.

Cylinder head with valve gear



84. Fit the cylinder head. Oil the cylinder head bolts (but let the oil drip off) and screw them in finger tight.

NOTE! You can use the cylinder head bolts up to 5 times if you know how many times they have been used. (Make a punch mark for each of the following usages.)



85. Tighten the cylinder head bolts as specified below:

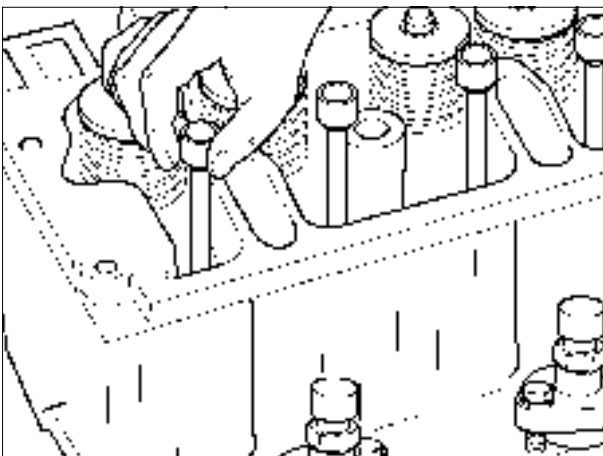
NOTE! Follow the tightening sequence for the cylinder head, see "Tightening sequence for cylinder head screws".

Tighten the bolts in three stages:

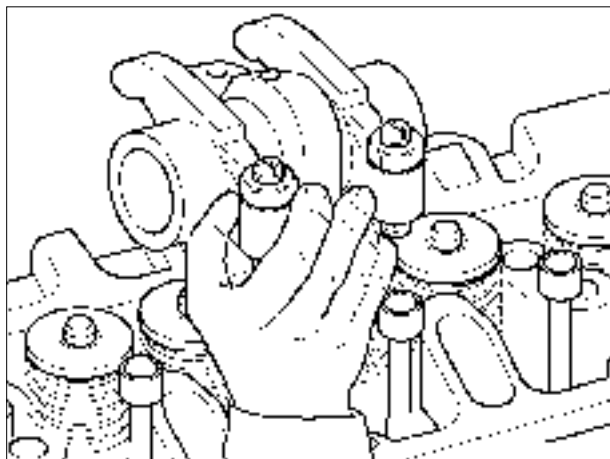
1st stage: **50 Nm** (37 lbf ft)

2nd stage: **130 Nm** (96 lbf ft)

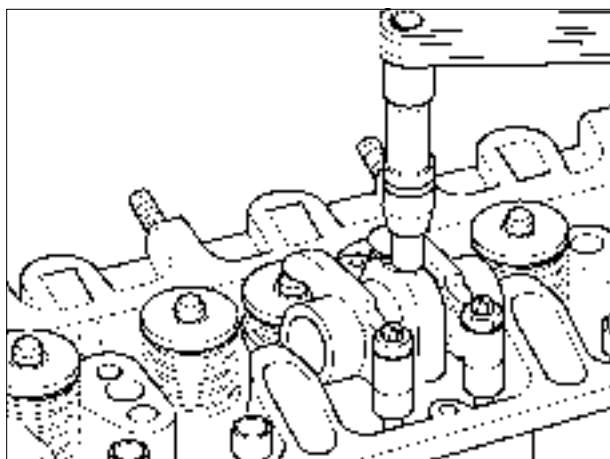
3^d stage, tightening angle: **90°**



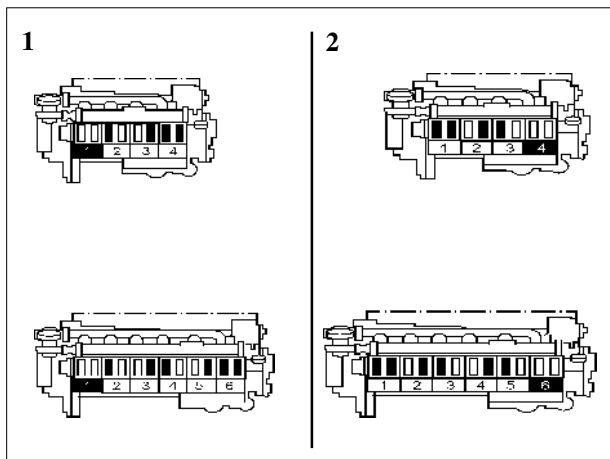
86. Insert the push rods, according to the mark up during disassembly.



87. Install the rocker arm brackets, according to the markings, and align them with the push rods/valves.



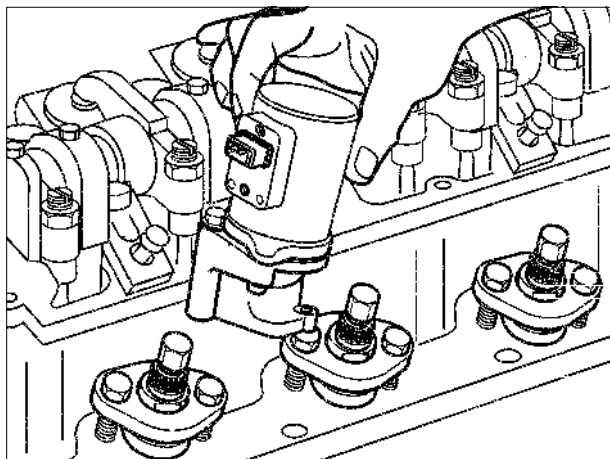
88. Tighten the screws to **21 Nm** (15 lbf ft).



89. Set the valve clearance, see “Valve clearance, adjusting” in the Repairing components chapter.

Inlet **0.35 ±0.05 mm** (0.01±0.002")
 Exhaust **0.55 ±0.05 mm** (0.02±0.002")

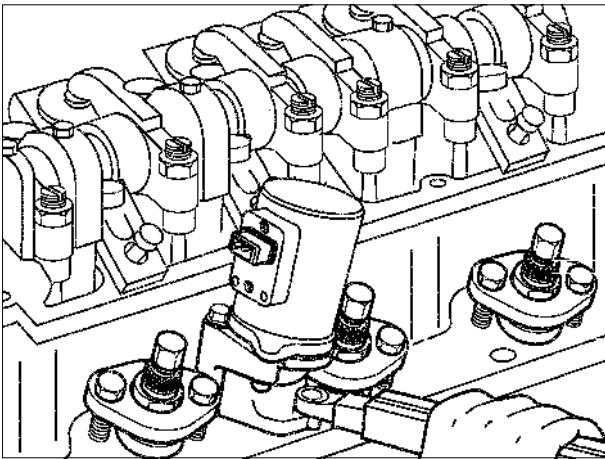
90. Remove the cranking tool.



91. Fit the stop solenoid with a **new** O-ring. With the control rod (fuel rack) in stop position, put the stop solenoid into place.

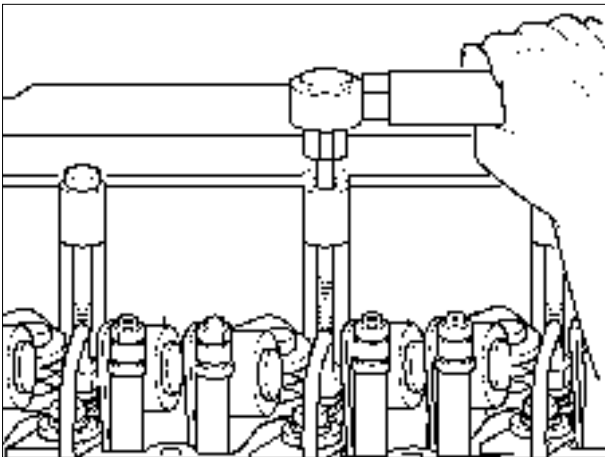
NOTE! For engines with electronic governor, fit the plug with a **new** O-ring.

NOTE! Lightly oil the O-ring.



92. Tighten the screws to **21 Nm**
(15 lbf ft).

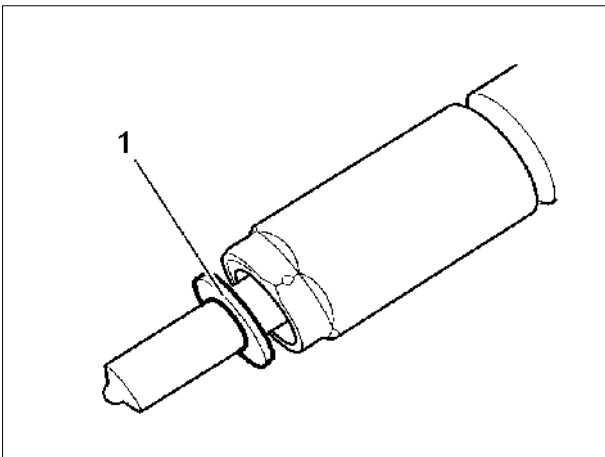
NOTE! This does not apply to EDC 4 (electronic governor).



Inlet pipes

93. Fit the inlet pipe with a new gasket.

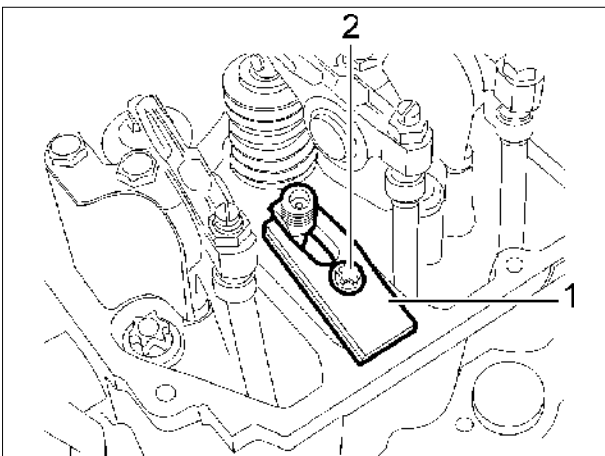
Tighten the screws to **11 ±1 Nm**
(8.1 ±0.7 lbf ft).



Fitting of injectors / delivery pipes

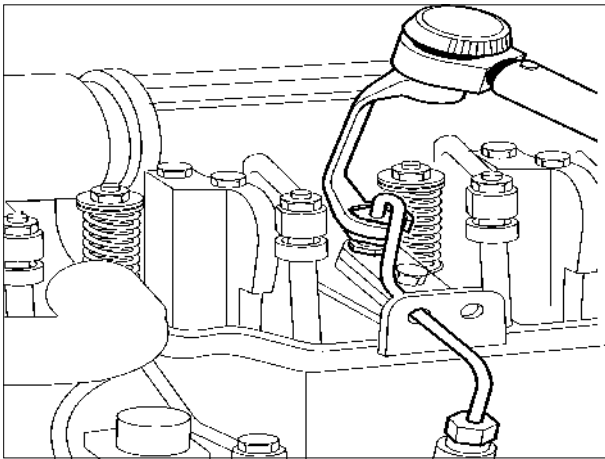
94. Using a little high temperature paste (1161035), fit a **new** copper gasket (1) on the injector and fit the injector.

NOTE! The connection for the fuel return line must be towards the exhaust side.



95. Put the injector yokes (1) in place and tighten the screws lightly.

Use Torx socket E10 (2).



96. Fit a new delivery pipe and rubber seal. Use tool 885490. Tighten the nuts by hand.

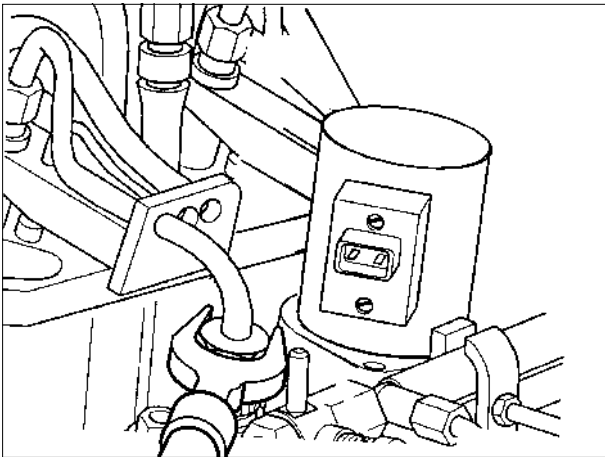
NOTE! When you install the delivery pipes, the sealing cones must fit exactly in the pump and injector.

⚠ WARNING! Do not bend the pressure pipes. The pressure pipes can be used only once.

NOTE! The delivery pipes are deformed when tightened and all delivery pipes must be tightened with the same tightening torque.

If they are tightened with different tightening torque, the cylinders may take different load.

Reuse of delivery pipes may mean that the engine power is not complete.



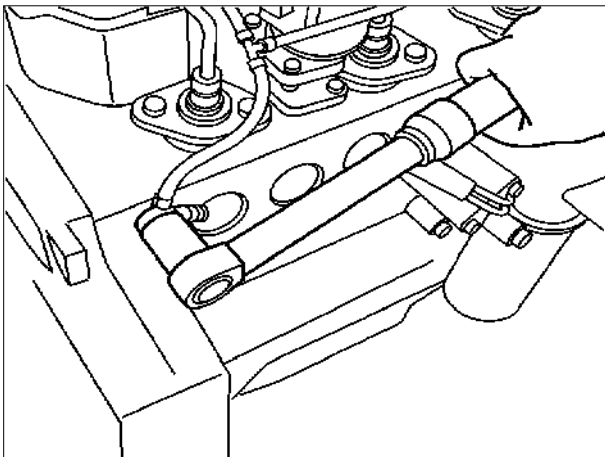
97. Tighten the screws for the injector yokes to **19 ±2 Nm** (14 ±1.5 lbf ft).

98. Pre-tension the delivery pipe nuts in two stages:
 1. Tighten to **5 Nm** (3.7 lbf ft)
 2. Tighten to **25 ±3.5 Nm** (22 ±2.6 lbf ft)

99. Fit the fuel leakage line and push it through the rubber seal.

NOTE! Always replace the leakage line.

100. Fit the overflow valve with new copper gaskets. Tighten to **30 Nm** (22.2lbf ft).

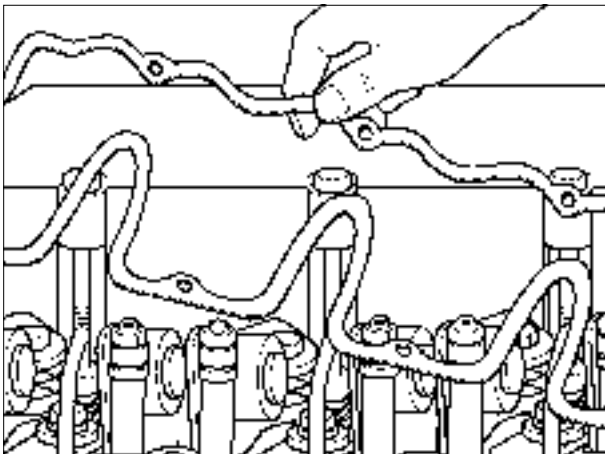


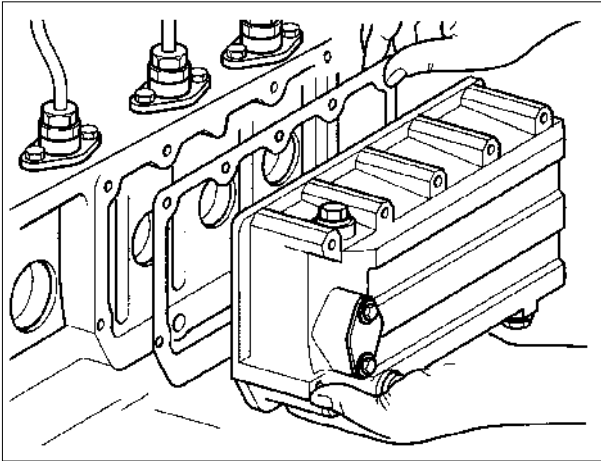
Rocker cover

101. Fit the rocker cover with a new gasket.

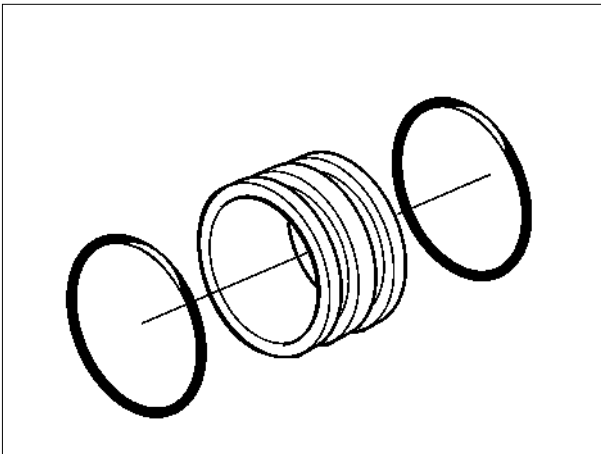
NOTE! Make sure that the gasket is placed correctly in the grooves of the rocker cover.

102. Fit the rocker cover. Tighten the screws to **11 ±1 Nm** (8 ±0.7 lbf ft).



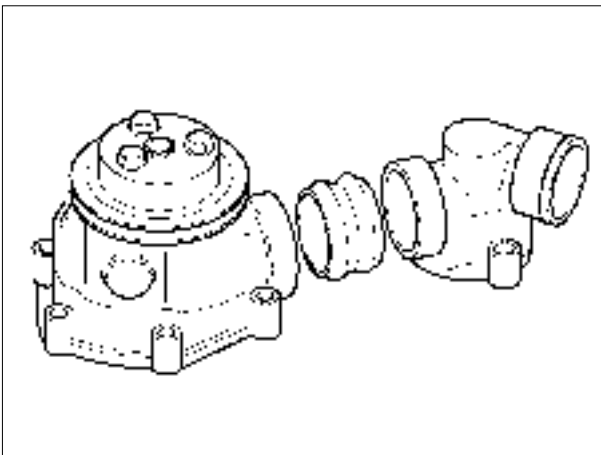
**Oil cooler**

103. Fit the oil cooler with a new gasket.
Tighten the screws to **21 ±2 Nm**
(15.5 ±1.5 lbf ft).

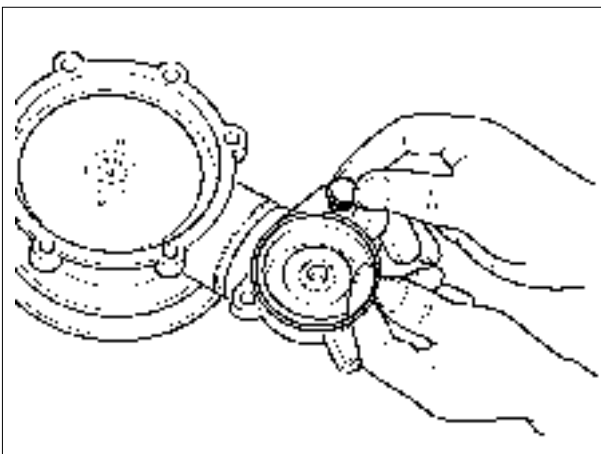
**Coolant pump**

104. Fit the O-rings to the intermediate pipe.

NOTE! To make it easier to fit, put some lubricant (part no 1 141 699) on the O-rings.



105. Press the intermediate pipe into the thermostat housing and coolant pump.

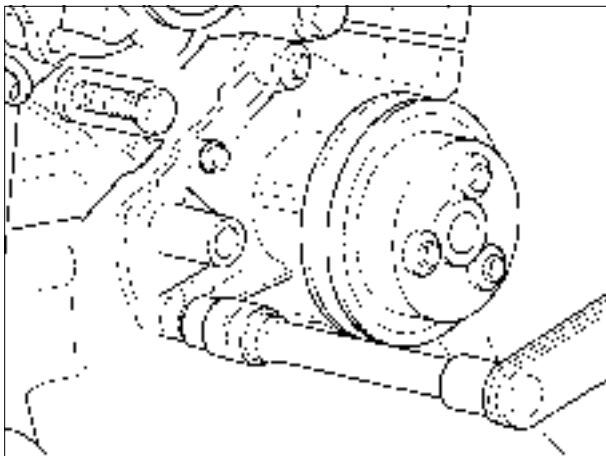


106. Fit the O-ring into the thermostat housing.

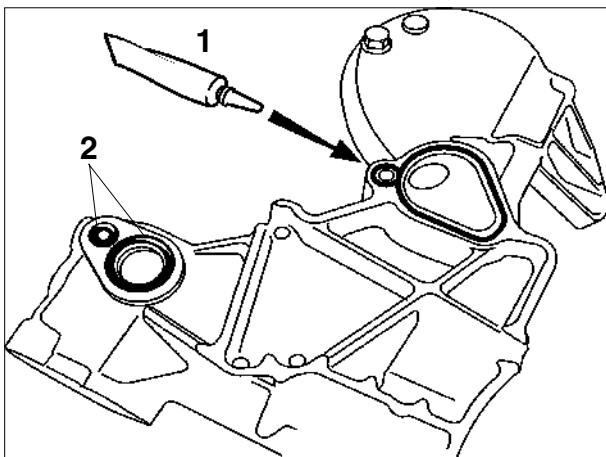
NOTE! To make it easier to fit, put some lubricant (part no 1 141 699) on the O-rings.



107. Fit the coolant pump with thermostat housing and use a **new** gasket.

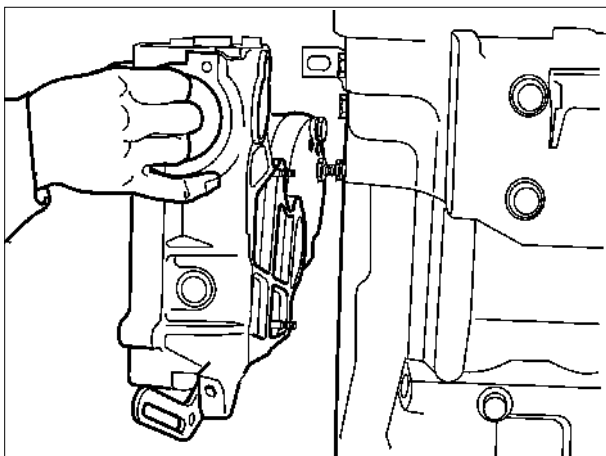


108. Tighten the screws alternately to: **21 ±2 Nm** (15 +1.5 lbf ft).

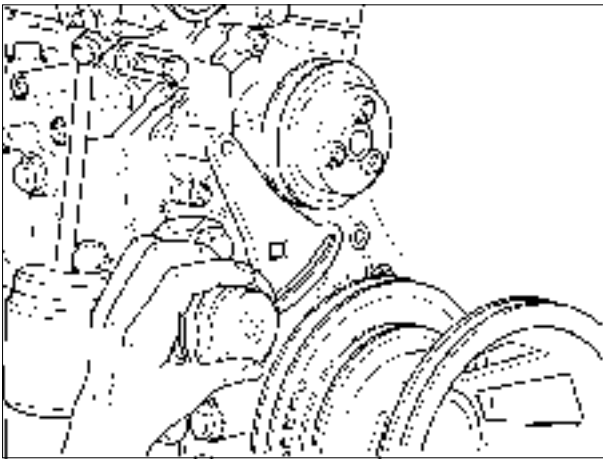


Alternative assembly (depending on coolant pump model):

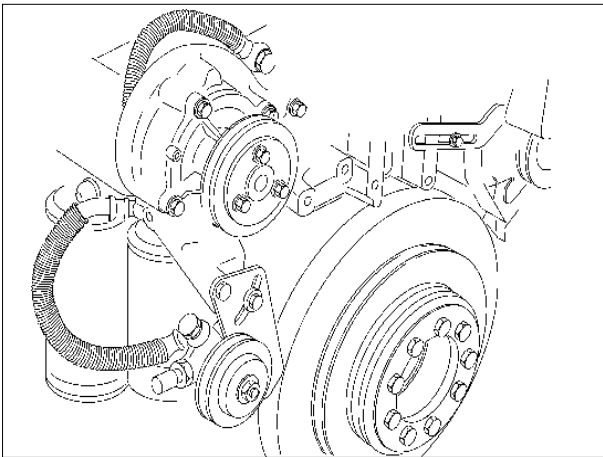
109. Fit the plug for the control rod.
Apply sealing compound (1), 1161277 or 1161231, and **new** O-rings (2) on the cooling pump house.



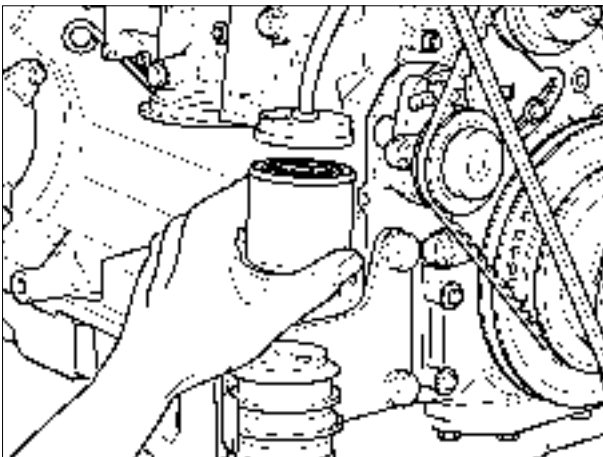
110. Fit the coolant housing with the coolant pump.
Tighten the screws to **21 ±2 Nm** (15 +1.5 lbf ft).

**Fuel pump**

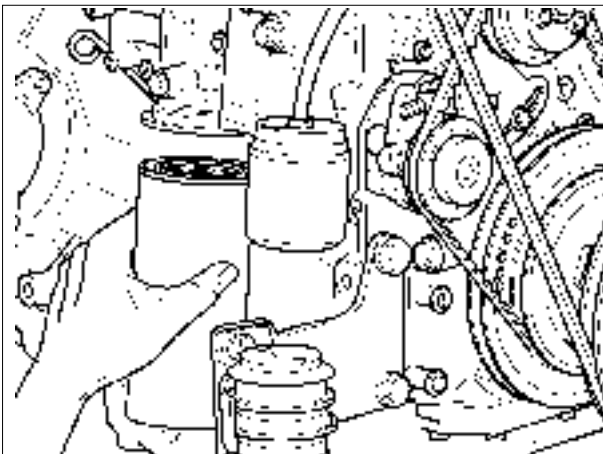
111. Fit the fuel pump.



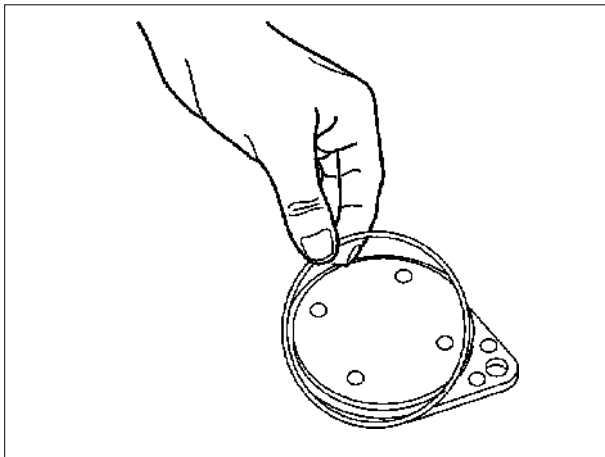
112. Fit the fuel lines. Tighten the hollow screws to **34 Nm** (25 lbf ft).



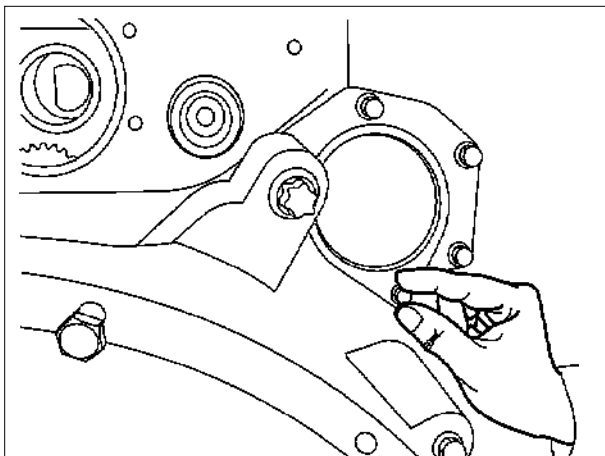
113. Lightly oil the fuel filter gasket. Tighten the fuel filter by hand until it touches the contact surface. Turn another half a turn, no more.



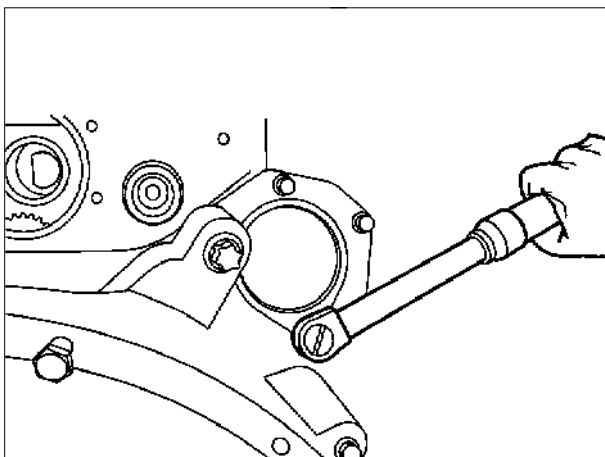
114. Lightly oil the oil filter gasket. Tighten the oil filter by hand until it touches the contact surface. Turn another half a turn, no more.



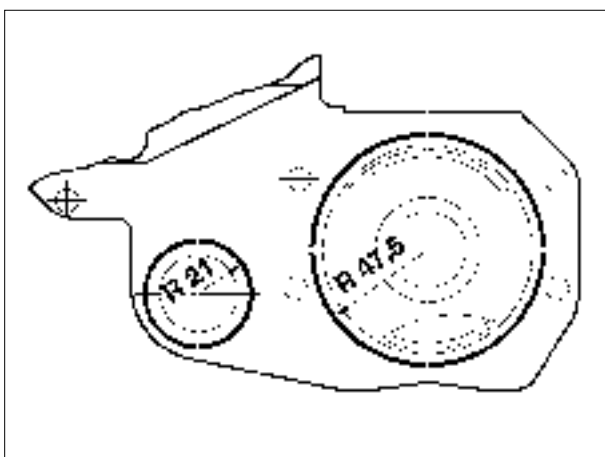
115. Fit a **new** O-ring to the cover and lightly oil it.



116. Fit the cover.



117. Tighten the screw to **21 ± 2 Nm**
(15 ± 1.5 lbf ft).

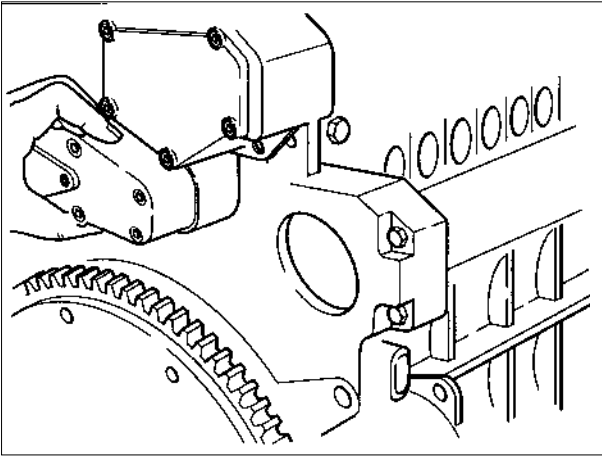


Speed governor

118. Apply silicone sealing compound (1161231) to the governor.

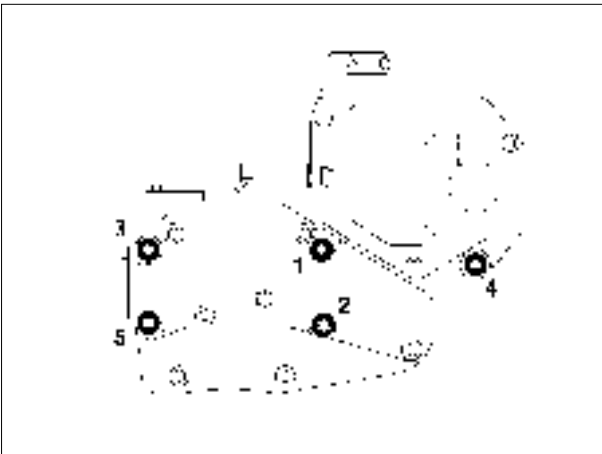
Sealant bead diameter $\text{Ø } 1.5^{+0.5}_0 \text{ mm}$
($0.06^{+0.02}{}_0$ ”).

NOTE! The sealing surface must be free from oil and grease.



119. Install the speed governor.

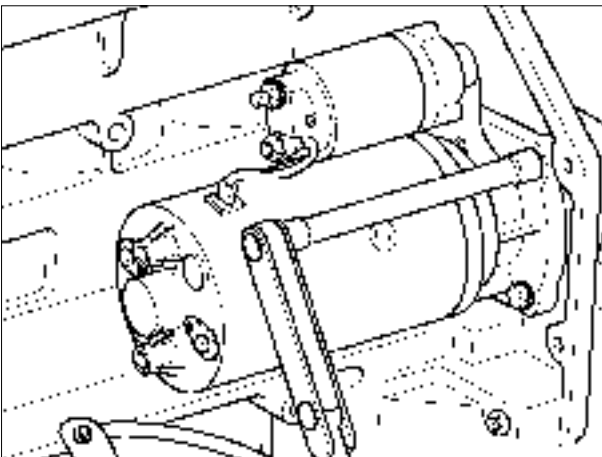
⚠ IMPORTANT! The governor is uniquely prepared for each engine. This means that the governor can not be exchanged between different engines.
 An incorrect adjusted governor can result in that the engine will not fulfill the regulations for emission and performance.
 When ordering a governor as a spare part always state engine type's serial number, rated speed (rpm), and x-measurement.



120. Tighten the torx screw in the sequence 1-2-3-4-5 using torx socket E 10. Tighten to .. **17 ±1.5 Nm** (12 ±1 lbf ft).

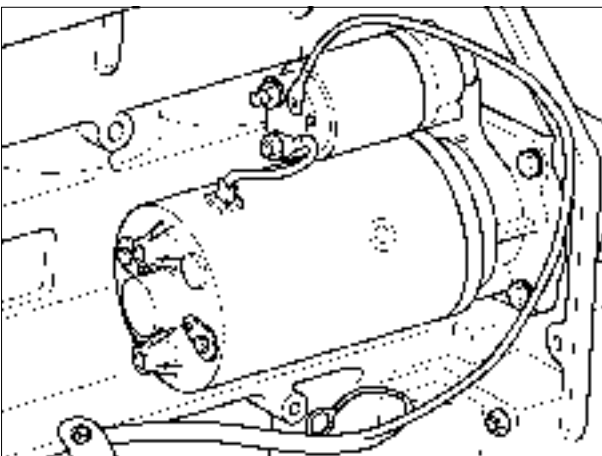
NOTE! For electronic governors the x-measurement is entered as a value into the trigger unit. An electronic governor is not unique with a calibrated x-measurement.

121. For electronic governors, the following applies for the 5 M8 screws:
 1-2 = 70 mm
 3-5 = 55 mm
 Tighten the screws to **24 Nm**

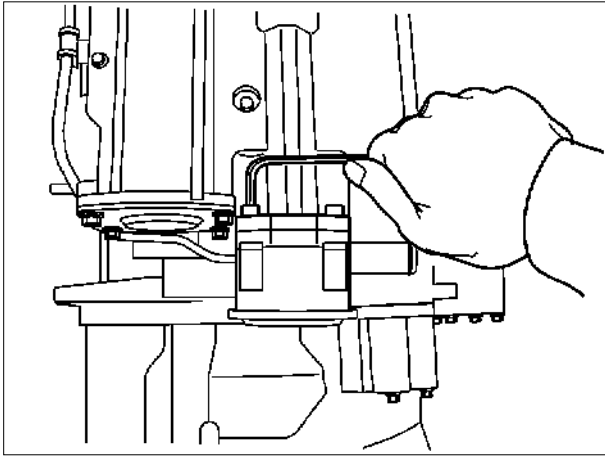


Starter motor

122. Fit the starter motor, if it has not been fitted together with the transmission housing.
 Tighten the screws to **70 Nm** (52 lbf ft).

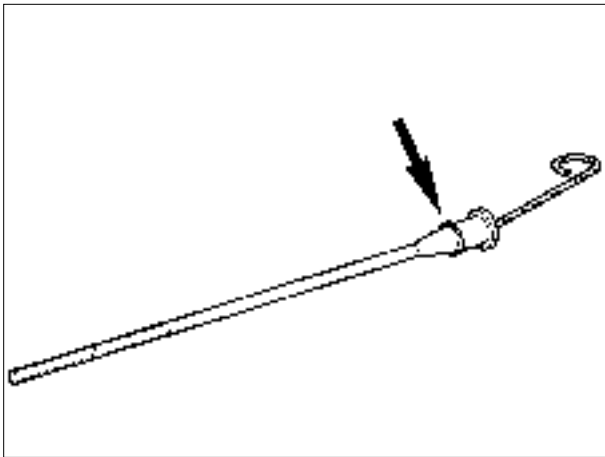


123. Fit the cable and fixing clips.



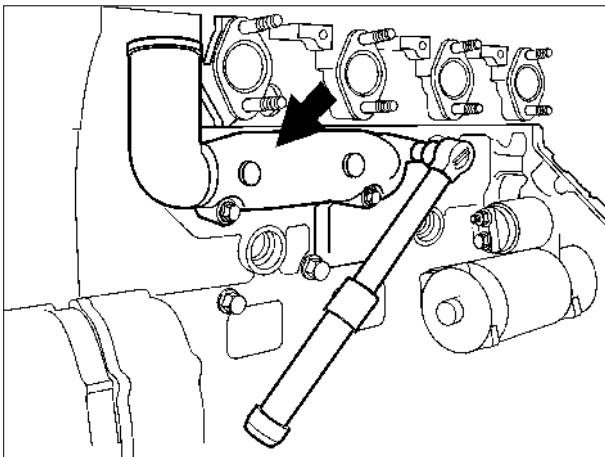
124. Fit the crankcase vent.

NOTE! Use an 5 mm Allen key.

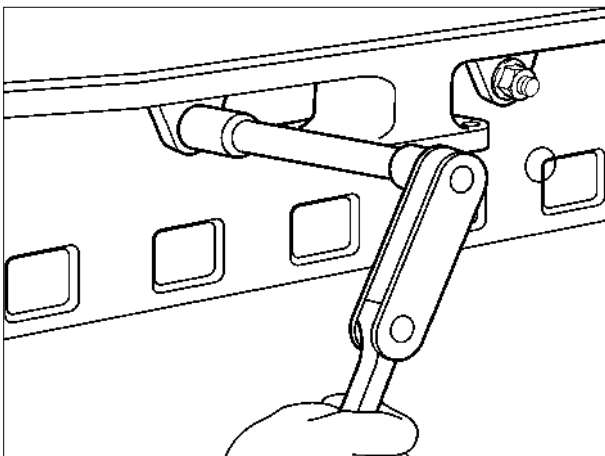


Oil dipstick

125. Slide on the **new** O-ring.



126. Fit the outlet coolant pipe with a **new** gasket and sealant. Tighten the screws to **21 ±2 Nm** (15.5 ±1.5 lbf ft).



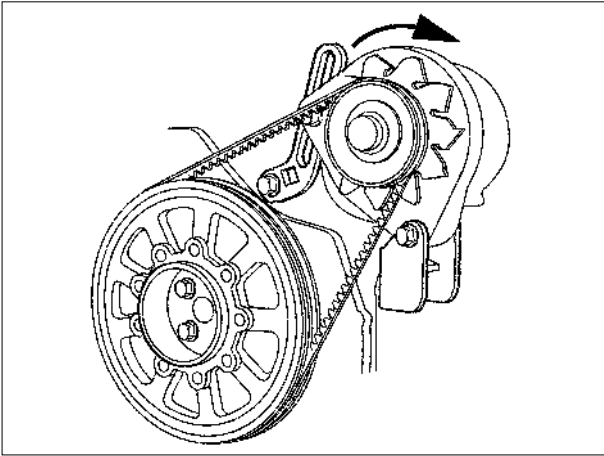
Exhaust manifold

127. Fit the exhaust manifold with **new** gaskets.

The gasket flange should be directed towards the cylinder head.

Tighten the exhaust manifold nuts with a torque to **25 ±2.5 Nm** (18 ±1.8 lbf ft).

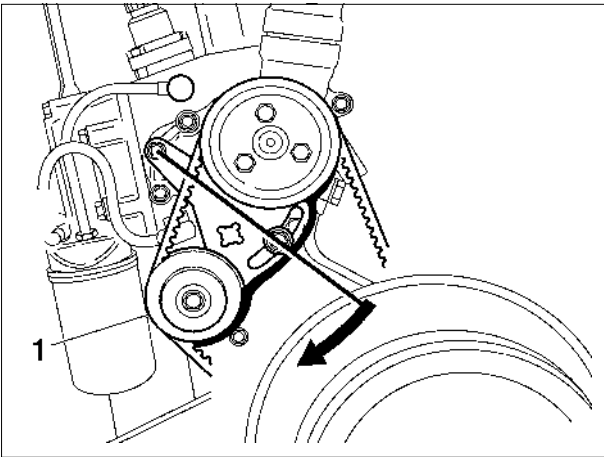
NOTE! Use high temperature paste (1161035) on the screws.



Alternator

128. Fit the alternator bracket and alternator.
 Fit the V-belt.
 Adjust the position of the alternator by pushing it in the direction of the arrow until you obtain the correct belt tension.
 Tighten the screws to **30 Nm** (22 lbf ft).

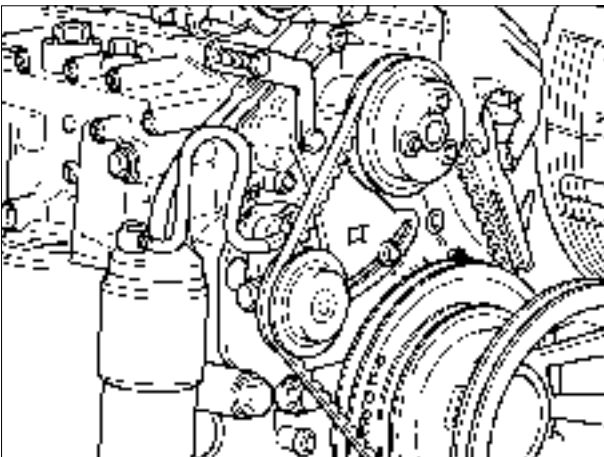
NOTE! The belt is correctly tensioned when you can press it down 10 mm (0.4") between the pulleys.



129. Fit the belt and tension it.

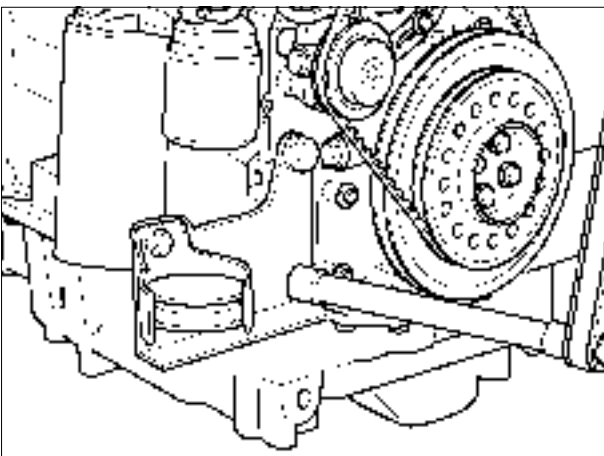
1. Push the fuel pump (1) in the direction of the arrow until you obtain the correct belt tension.*
2. Tighten the screws to **21 ±2 Nm** (15.5 ±1.5 lbf ft).

***NOTE!** The belt tension is correct when you can press them down 10 mm (0.4") midway between the pulleys.



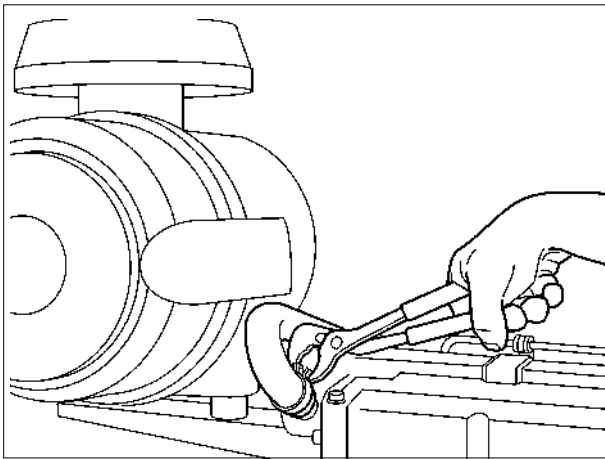
Check the belt tension, coolant/fuel pump

130. The belt is correctly tensioned when you can press it down **10 mm** (0.4") between the pulleys.

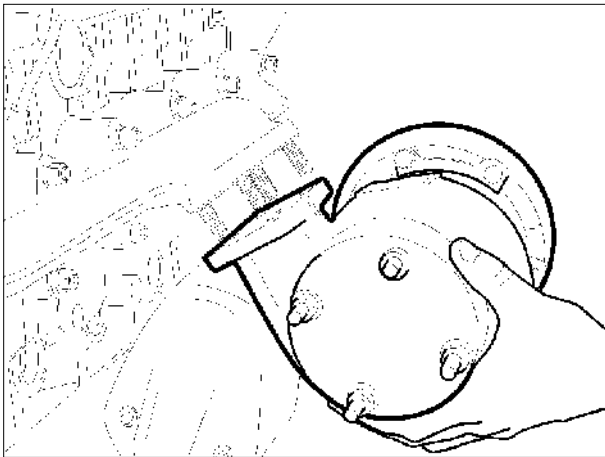


Engine mounting

131. Fit the engine mounting. Tighten to **260 Nm** (192 lbf ft).

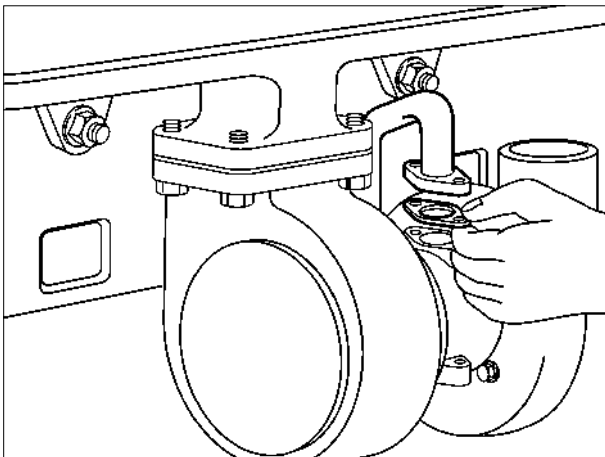


132. Re-install air filter bracket, air filter and crankcase ventilation hose.



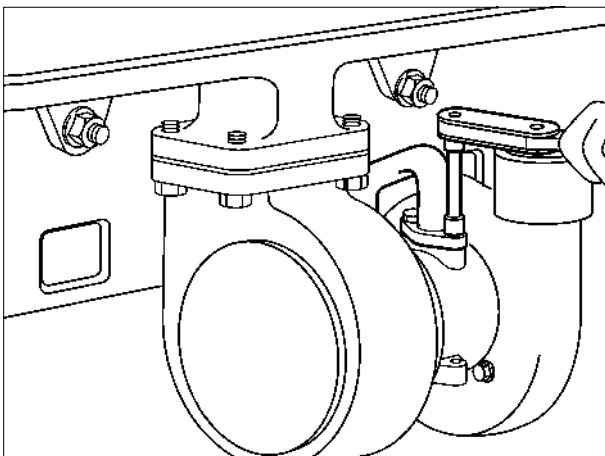
133. Remove the engine from the engine repair stand, then loosen the engine fixture.

134. Install the turbo.

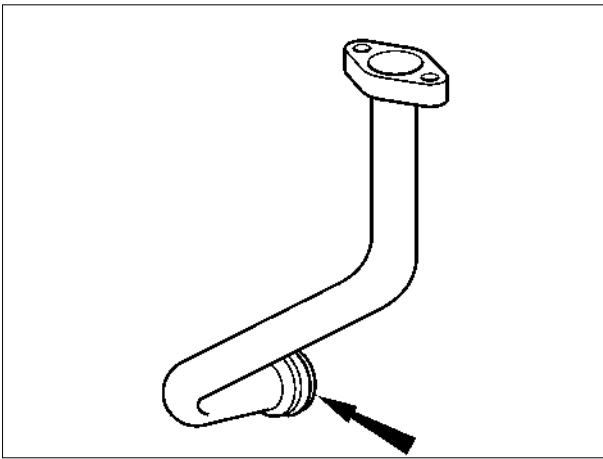


Oil pressure pipe/oil return pipe

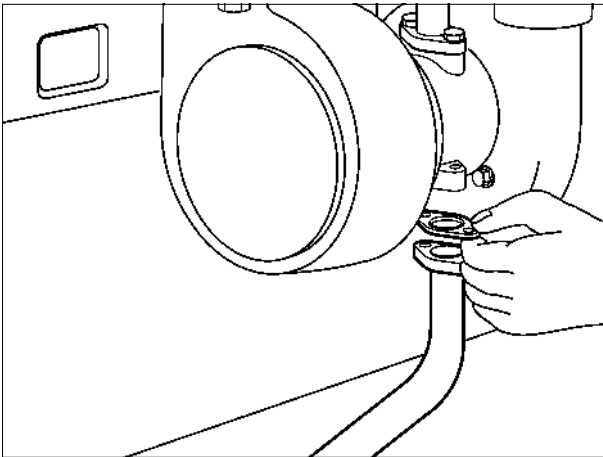
135. Fit the oil pressure pipe with a **new** gasket



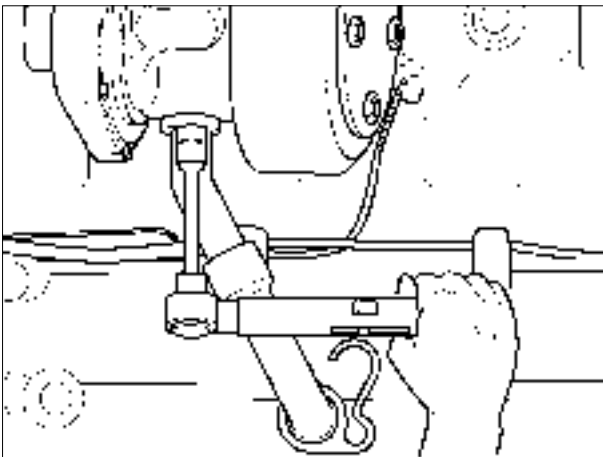
136. Tighten the screws to **21 ±2 Nm**
515.5 ±1.5 lbf ft).



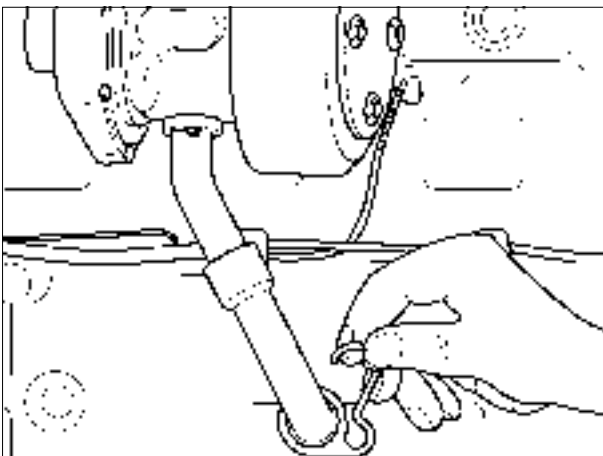
137. Fit a **new** O-ring to the return pipe. Oil lightly.



138. Fit the oil return pipe with a **new** gasket.



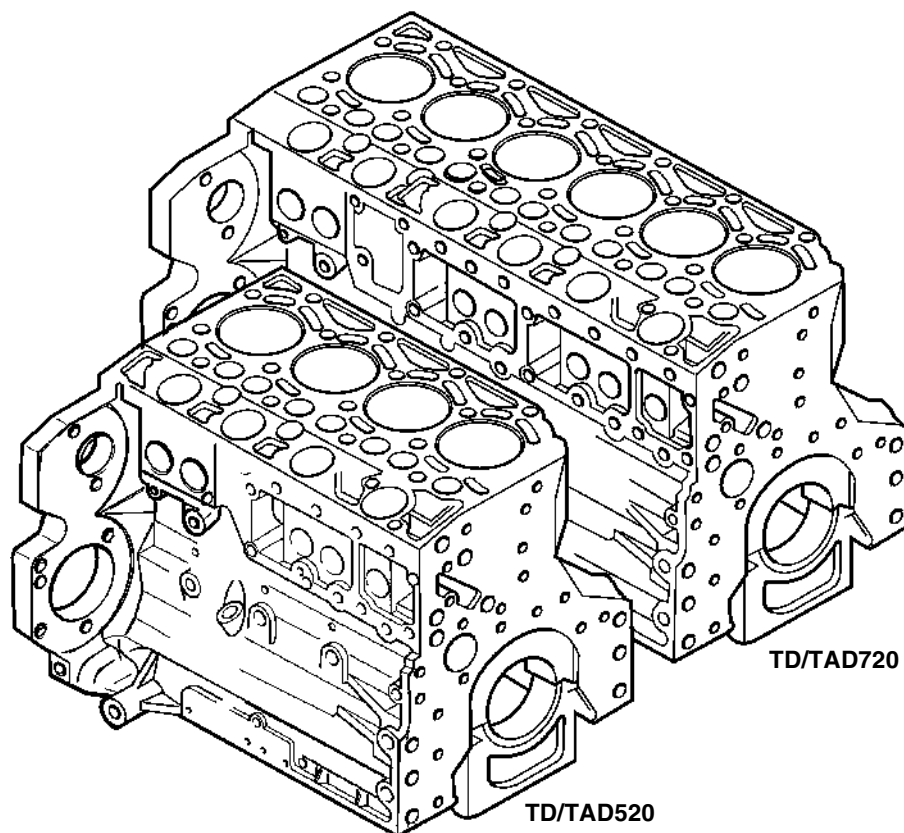
139. Tighten the screws to**21 + 2 Nm**
(15.5 +1.5 lbf ft).



140. Fit the clamping yoke.

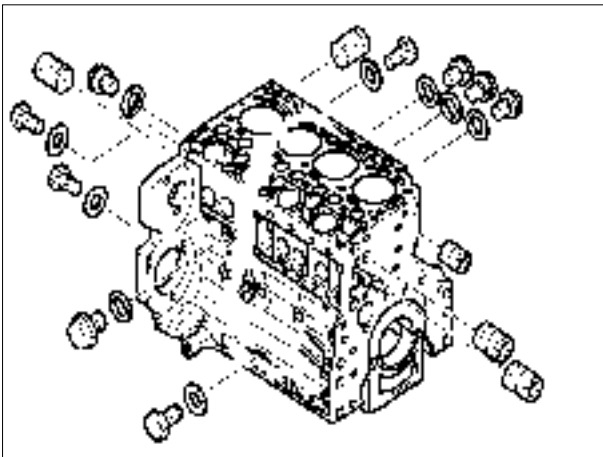
Checks and adjustments

Engine block

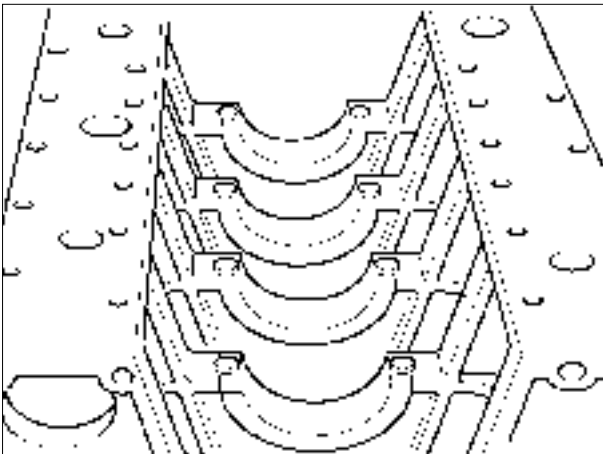


Special tools:

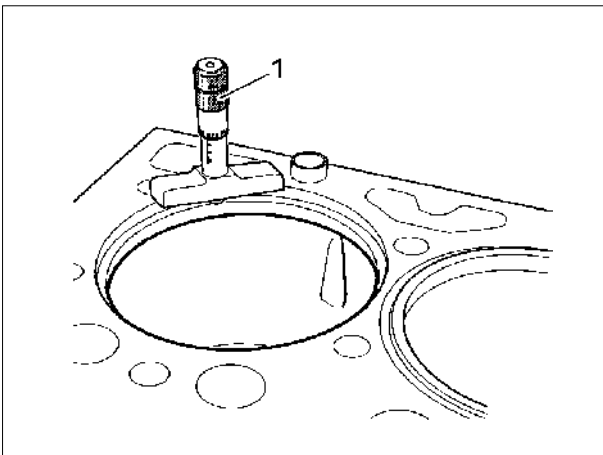
Cylinder liner extractor with support	999 6645, 999 6395
Fitting tool for camshaft bearings	999 8695
Fitting tool for control rod sleeves	999 8696
Cylinder extractor plate	999 8675
Standard shaft	999 2000



1. Remove the screw plugs. Check that the oil channels are free.

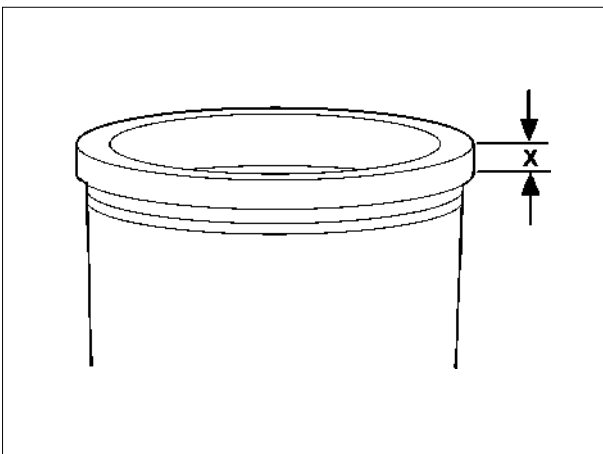


2. Clean the engine block and check that it has no damages.



3. Using a depth micrometer, measure the distance between the liner collar seat and sealing surface in the engine block. Measure in several places at each cylinder.
 Max. depth: $8.92^{+0.03}_0$ mm ($0.35^{+0.002''}_0$)

NOTE! Liner collar height or collar seat depth can not be re-machined. Replace liner and engine block if required.

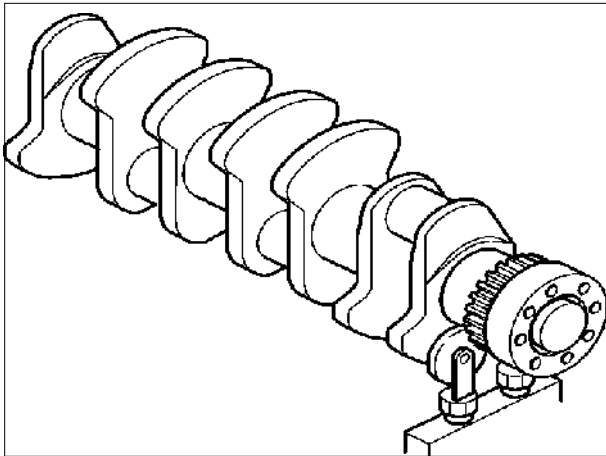


4. Inspect the liner collar and measure the height of the collar in several spots on the circumference.
NOTE! Min. collar height : $9^{-0.02}$ mm ($0.354^{-0.001''}$)

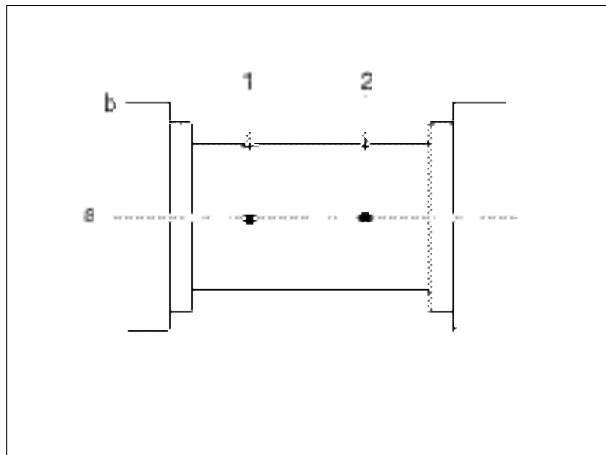
Crankshaft, measuring

Special tool:

Dial gauge 998 9876



1. Place the crankshaft on the support stand.



2. Procedure for measuring the main bearing journals at planes "1" and "2" in points "a" and "b".

Bearing main diameter: **85.00**^{-0.02} mm
(3.35^{-0.008}")

Undersize:

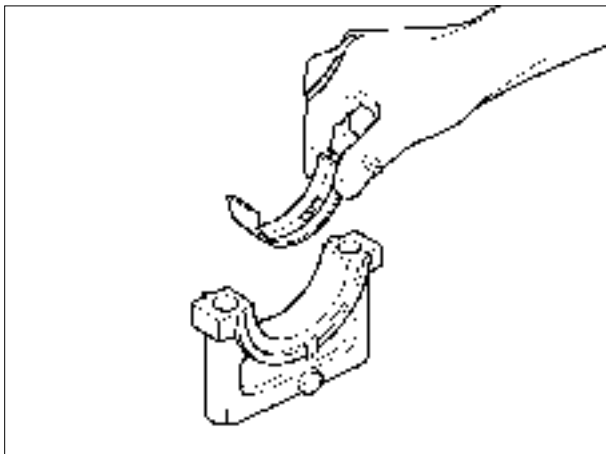
0.25 mm **84.75**^{-0.02} mm
(3.337^{-0.001}")

0.50 mm **84.50**^{-0.02} mm
(3.327^{-0.001}")

Wear limit:

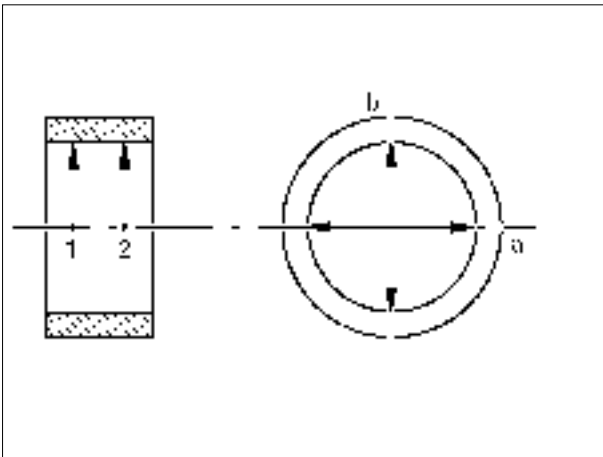
Bearing journal oval: **0.01 mm**
(0.0004")

Conicity: **0.01 mm**
(0.0004")



Main bearing caps

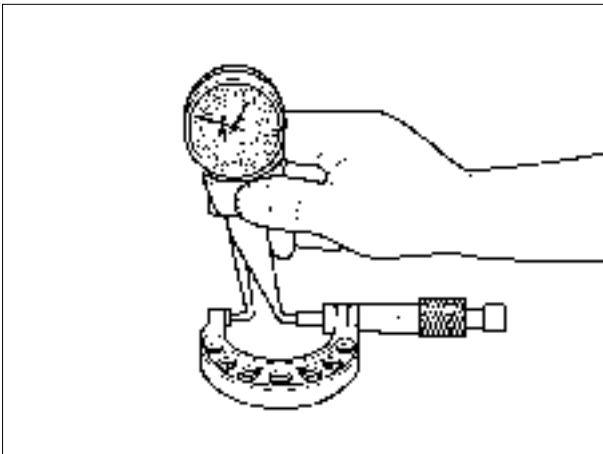
3. Fit the bearing shells into the main bearing caps and fit the main bearing caps in the engine block.



4. Measure the main bearing diameter at points "1" and "2" in planes "a" and "b".
 Inner diameter, Ø **85,03^{+0.036} mm (3.347^{+0.001"})**

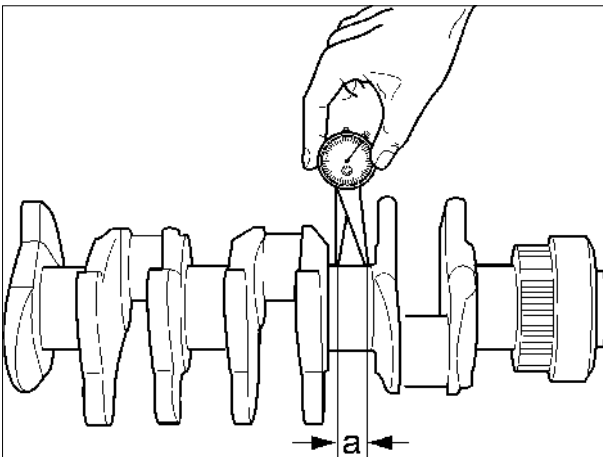
Oversize:

- 0.25 mm** **84,78^{+0.036} mm (3.338^{+0.001"})**
0.50 mm **84,53^{+0.036} mm (3.328^{+0.001"})**



Crankshaft bearings

5. Set the dial gauge to **38 mm (1.5")**.



6. **NOTE!** Before working on the crankshaft, measure the width of the new crankshaft bearings, see step 8.

Measure the width of the thrust bearing journal (use an internal dial gauge).

Bearing journal width: **38.00^{+0.06} mm (1.5^{+0.002"})**

Oversize:

0.40 mm **38.40^{+0.06} mm (1.512^{+0.002"})**

7. Measure the width of the crankshaft thrust bearing journal and note of measurement "a".

Example:

Measurement "a" = 38.02

8. Locate the half thrust bearings on the main bearing cap. Measure and note the width, measurement "b".

9. Determine the axial clearance.

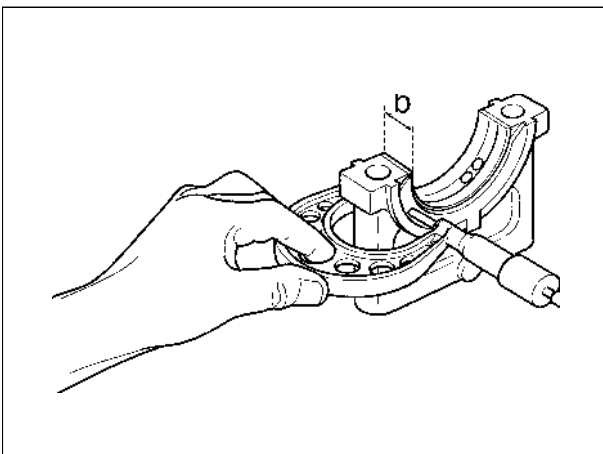
Example:

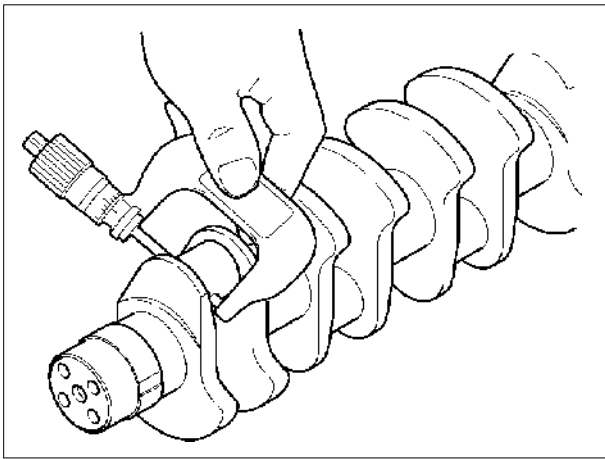
Measurement "a" = **38.02 mm (1.5")**

Measurement "b" = **37.90 mm (1.49")**

"a" - "b" = axial clearance = **0.12 mm (0.005")**

Permitted axial clearance = **0.10 - 0.30 mm (0.004" - 0.018")**



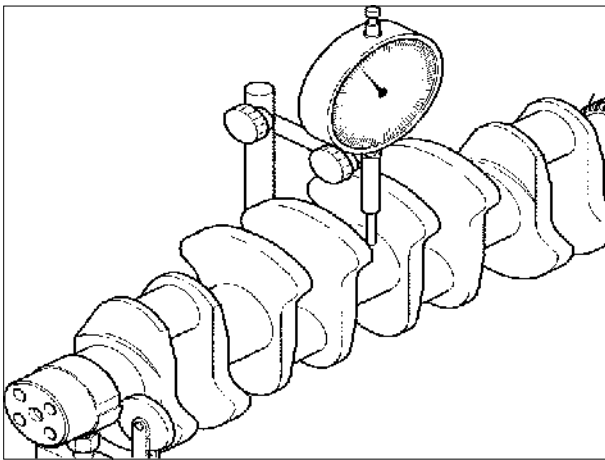


Crankshaft journals

10. Measure the big-end bearing journals.

Crankshaft journal
 diameter: **68.00^{-0.02} mm** (2.68^{-0.001"})
 Undersize:
0.25 mm **67.75^{-0.02} mm** (2.67^{-0.001"})
0.50 mm **67.50^{-0.02} mm**(2.66^{-0.001"})

Wear limit:
 Crankshaft journal
 oval **0.01 mm** (0.0004")
 Conicity **0.01 mm** (0.0004")



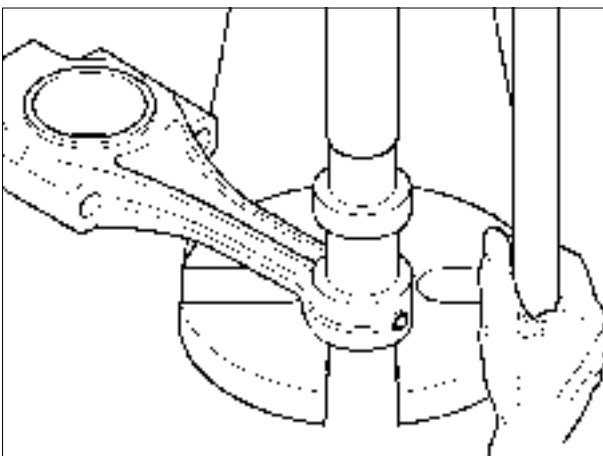
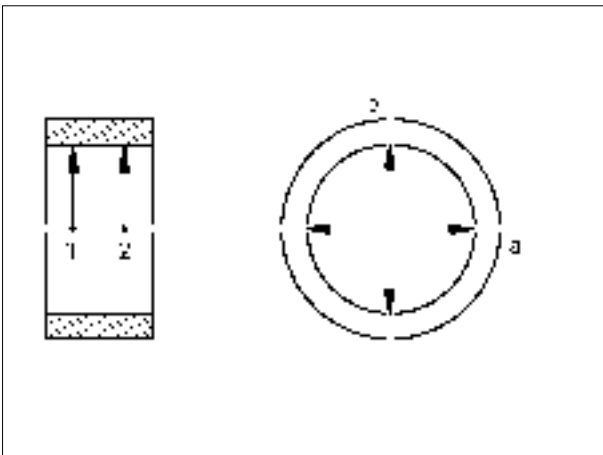
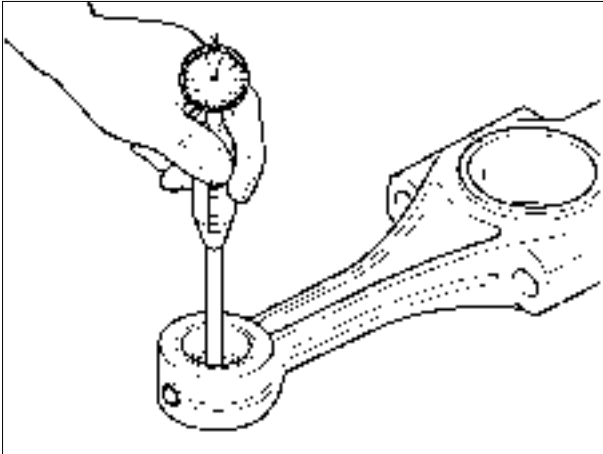
11. Check that the crankshaft runs evenly (use a dial gauge).

Max. deviation:
520: **0.07 mm** (0.0027")
720/721/722: **0.10 mm** (0.0039")

Connecting rods, measuring

Special tools:

Dial gauge 998 9876
 Fitting tool crankshaft bushing 999 8692



Crankshaft bushing

1. Set the dial gauge to **42 mm** (1.65")

2. Measure the bushing in the upper connecting rod end at planes "1" and "2" in points "a" and "b."
3. The bushing in the upper connecting rod end, pressed in

Specified value: **42.04^{+0.01} mm** (1.65^{0.002"})

Wear limit:

Play for bushing in upper connecting rod end: **42.12 mm** (1.66")

4. Change the bushing in the upper connecting rod end if necessary.

Hole diameter for the bushing in the upper connecting rod end: **45.50^{+0.02} mm** (1.79^{+0.001"})

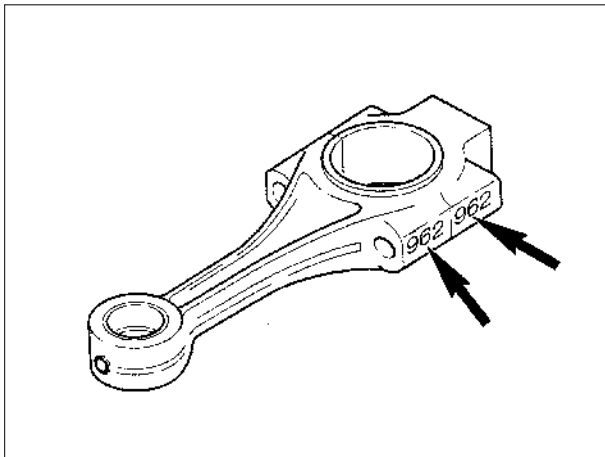
Outside diameter for the bushing in the upper connecting rod end: **45.50^{+0.04} mm** (1.79^{+0.002"})

5. Press the bushing into the upper connecting rod end so that it is level with the surface.

Use tool: 999 8692.

NOTE! The lubricating oil holes in the bushing and the connecting rod must be aligned with one another.

6. After you have pressed the bushing in, ream it to the exact size: **42.04^{+0.01} mm** (1.65^{+0.0004"})



Crankshaft journals

- Check that the big-end bearing cap matches the connecting rod so that the number markings are turned towards each other and are identical.

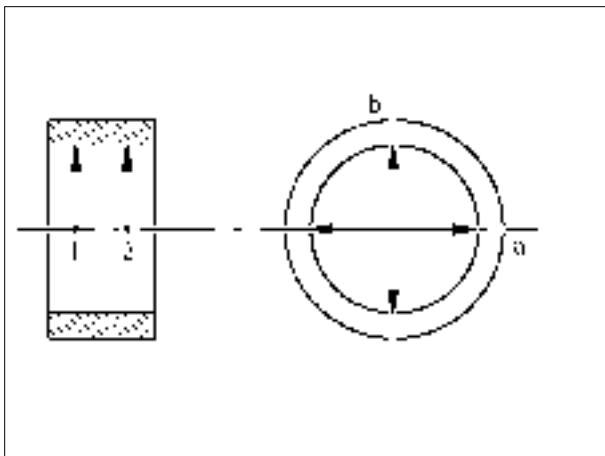
NOTE! Make sure the locating pegs are in place.

- Fit the big-end bearing cap. Tighten the screws according to specification.

Initial torque: **30 Nm** (22 lb ft)

NOTE! Only when measuring.

- Set the dial gauge to **72.5 mm** (2.85").



- Procedure for measuring the big-end bearing diameter at planes "1" and "2" in points "a" and "b".

Big-end bearing diameter: **72.5^{+0.02}** (2.854^{+0.002"})

NOTE! If the measured values are just a little out, take additional measurements when new bearing shells have been fitted.

- Remove the bearing cap and fit new bearing shells. Replace the bearing cap. Tighten the screws according to specification.

Initial torque: **30 Nm** (22 lb ft)

NOTE! Only when measuring.

- Set the dial gauge. Measure the bearing shells at planes "1" and "2" in points "a" and "b".

Big-end bearing shells

Inside diameter: **68.03^{+0.04} mm** (2.68^{+0.002"})

Oversize:

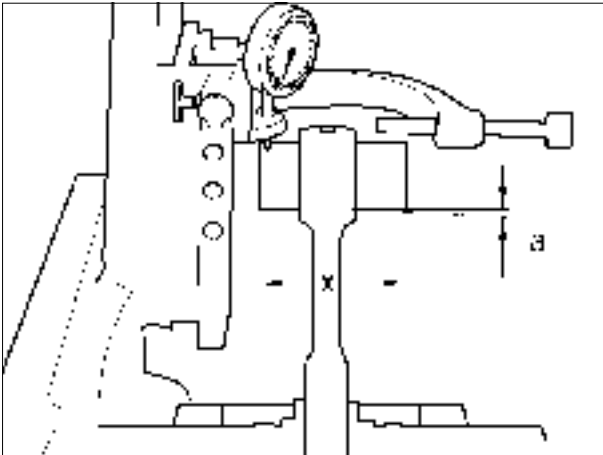
0.25 mm **67.78^{+0.04} mm** (2.67^{+0.002"})

0.50 mm **67.53^{+0.04} mm** (2.66^{+0.002"})

Wear limit:

Radial play for big-end bearings: **0.12mm** (0.005")

NOTE! If the wear does not exceed the bearing tolerances by more than **0.015 mm** (0.0006"), you can still use the connecting rod. If the limit value is exceeded, change the connecting rod.

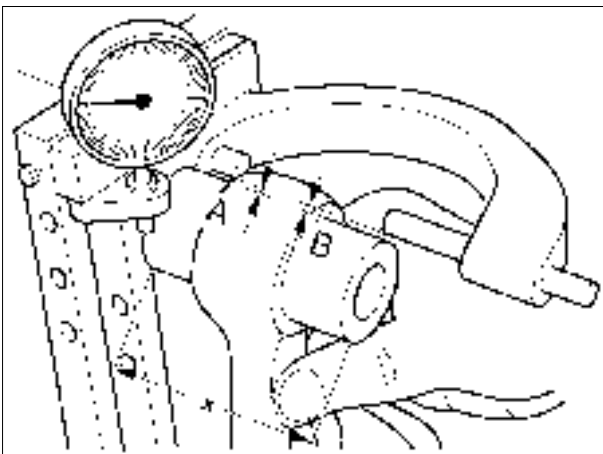


If there is any reason to suspect a bent or twisted connecting rod, they should be checked on the connecting rod tester.

NOTE! Check the connecting rods without bearing shells.

12. Use a gudgeon pin to measure the connecting rod for straightness.

Max. deviation $a = 0.05 \text{ mm}$ (0.002") over a distance (x) of 100 mm (3.9").

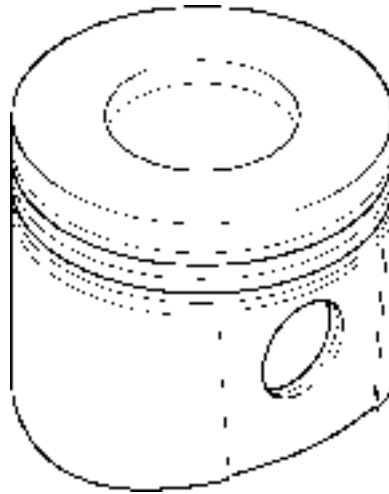


13. Use a gudgeon pin to measure the connecting rod for torsion.

Max. deviation $a = 0.05 \text{ mm}$ (0.002") over a distance (x) of 100 mm (3.9").

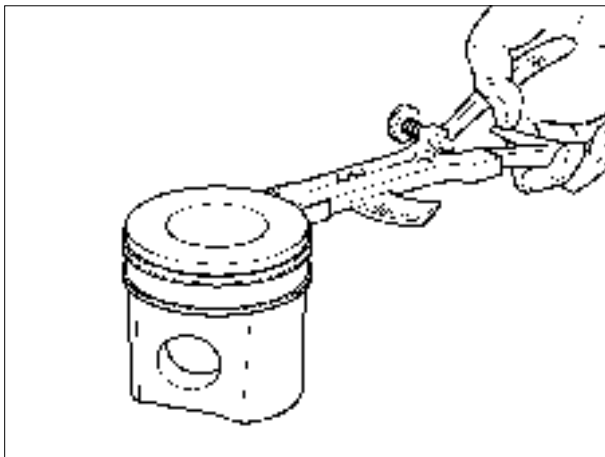


Pistons



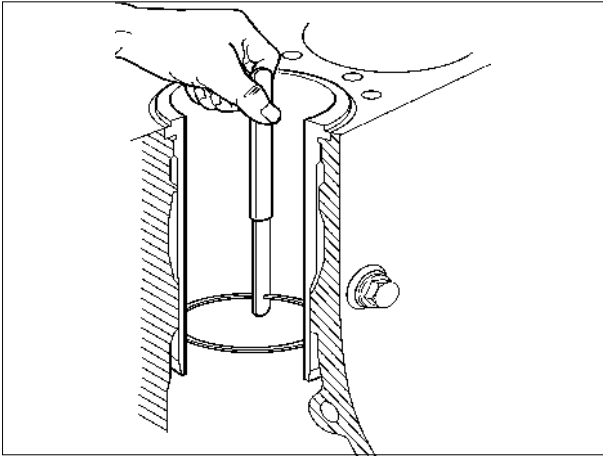
Special tool:

Piston ring pliers 998 5423



1. Remove the circlip. Remove the gudgeon pin.
2. Remove the piston rings using the piston ring pliers 998 5423.

NOTE! Clean and inspect piston and ring grooves.

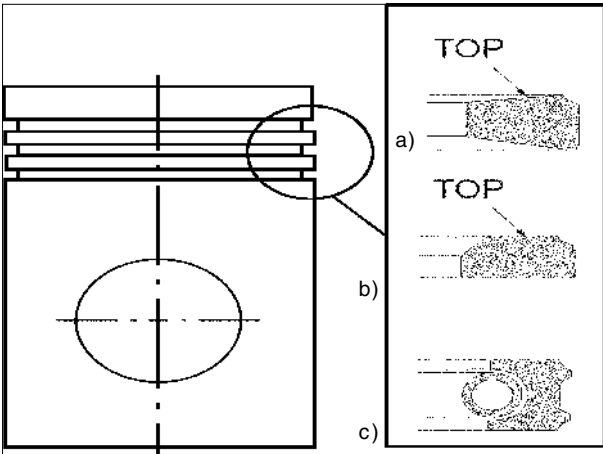


3. Check the piston ring gap (see diagram). When taking the measurement, use a piston to push the ring down **below** the lower dead center position. Measure the ring gap with a feeler gauge.

Wear limits:

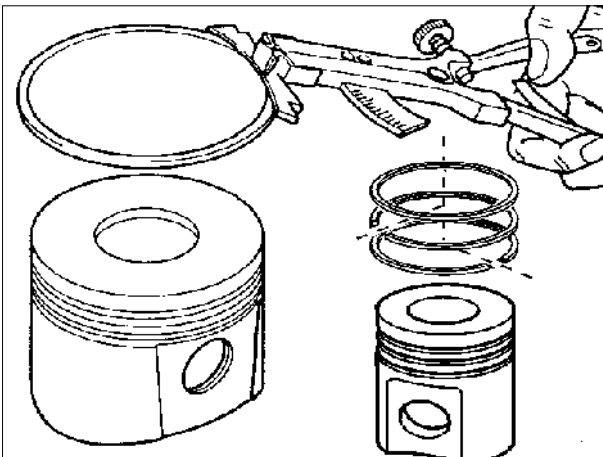
- 1st ring gap **0.8 mm** (0.03")
- 2nd ring gap **2.5 mm** (0.1")
- 3rd ring gap **1.15 mm** (0.045")

4. Clean and check the piston and the piston's ring-shaped grooves.



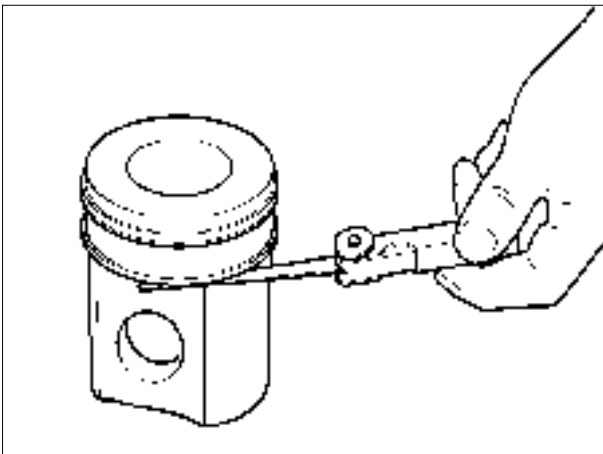
Order and positions for the piston rings:

5. Fit the oil control ring (c).
6. Fit the tapered compression ring (b) with text "Top" towards combustion chamber.
7. Fit the conical compression ring (a) with text "Top" towards combustion chamber.



8. Fit the piston rings as the instructions in step 5 shows and then make sure that the ring gap is 120° between them.

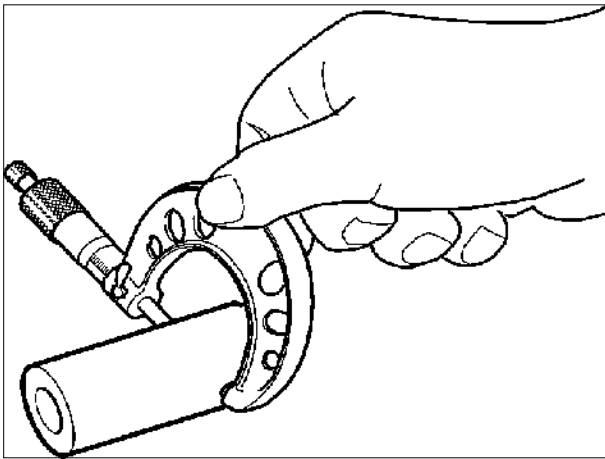
NOTE! The joint of the inside spring of the oil control rings should be moved 180° in relation to the ring gap.



9. Measure the clearance of grooves with a feeler gauge.

Wear limits:

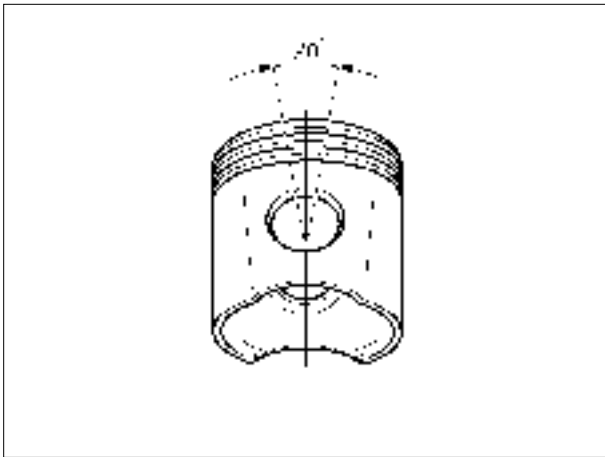
- axial play 1st ring "keystone" ring (conical compression ring)
- axial play 2nd ring 0.17 mm (0.007")
- axial play 3rd ring 0.10 mm (0.004")



10. Check the gudgeon pin for wear.

Gudgeon pin

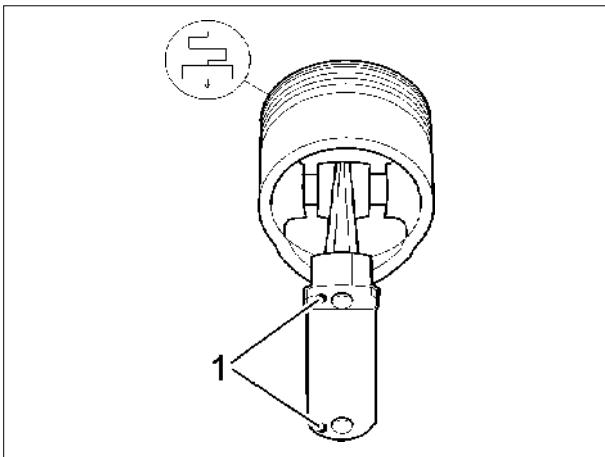
diameter: $42^{-0.006}$ mm ($1.654^{-0.002}$)



Joining the connecting rod and piston

NOTE! The gap in the ring must be facing the top of the piston.

11. Insert one of the circlips.



12. Put the piston onto the connecting rod. The fly-wheel symbol on the piston and the cylindrical pegs on the connecting rod (1) must be on the same side.

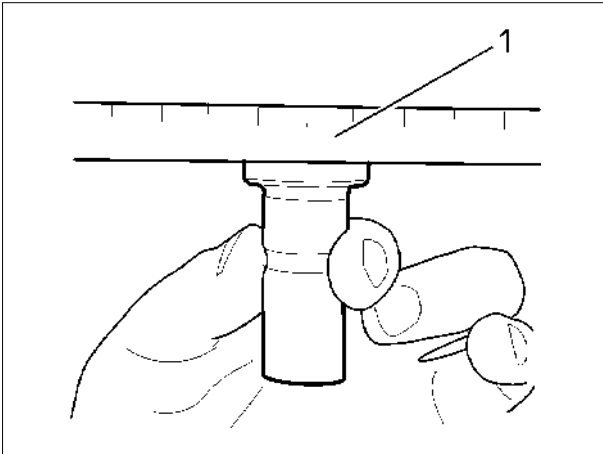
13. Insert the other circlip in the right position.

Camshaft

Special tools:

Dial gauge 998 9876

Fitting tool, camshaft bearings 999 8695



Camshaft and valve tappets, checking

Using a steel ruler (1), make sure that the contact surface between the valve tappets and the camshaft is convex or level. If the surface is concave, replace the valve tappets.

If the valve tappet is worn across the lifting surface, the tappet should be disposed of. "The ditch" shows that the tappet has not rotated.

A dark stripe farthest out on the lifting surface, however, shows that the surface is not worn. The condition of the valve tappets determines whether the camshaft should be checked for wear or not.

Make sure that the lifting surfaces on the camshaft and the valve tappets do not have great pitting damage. Pitting damage can appear for different reasons. The damage consists of small metal pieces being broken off the hardened surface. Tappets and camshaft with minor pitting damages can be used. Pitting damages are rarely worsened.

Make sure that the bearing race and cam curves of the camshaft are not abnormally worn. For example the camshaft lifters may be obliquely worn axially. This can, in mild cases, be adjusted by honing.

If there are greater damages and wear, replace the camshaft.

NOTE! If the camshaft is replaced, all valve tappets must also be replaced.

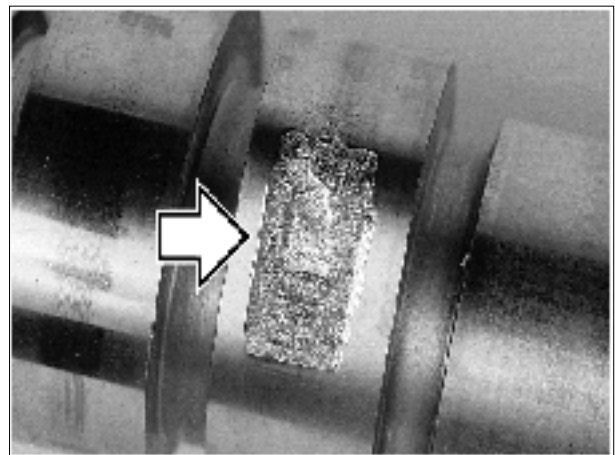
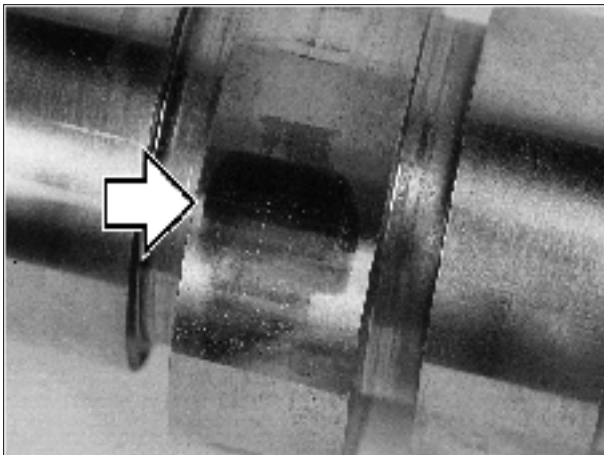
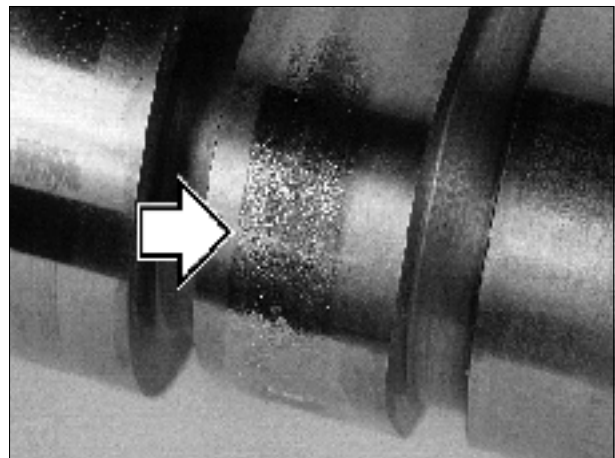
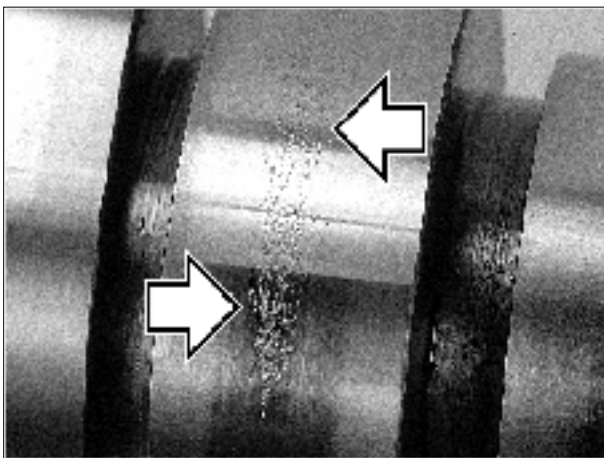
Guiding principles for replacement

Under normal circumstances there may be unevennesses on the surface of the camshaft ridges. This means that the camshaft must be replaced. These markings have no negative effect neither on the engine prestanda nor on the strength of the engine or its components.

Below, you can see examples of acceptable wear and unacceptable wear.

Acceptable wear

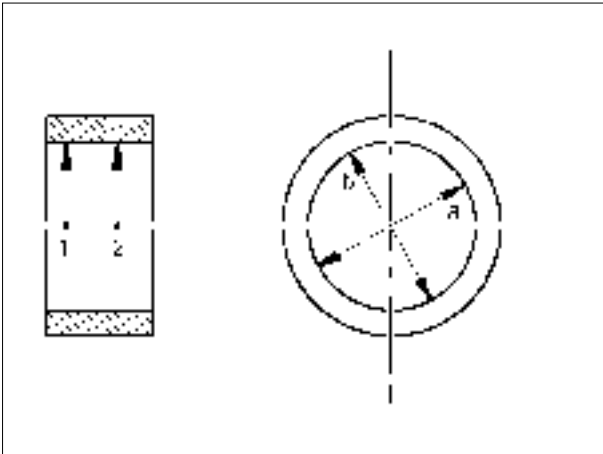
The camshaft does not need to be replaced.



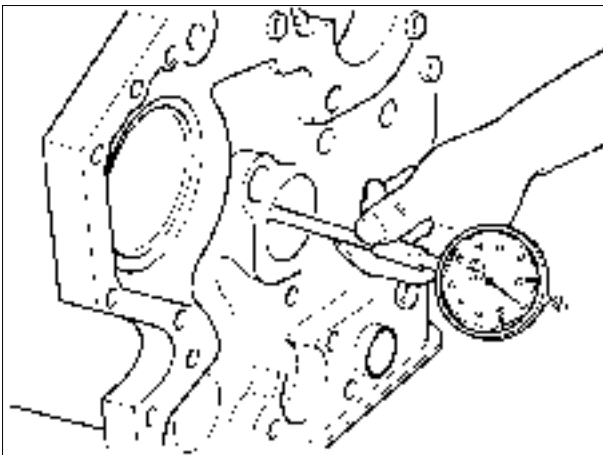
Camshaft bearings

Special tools:

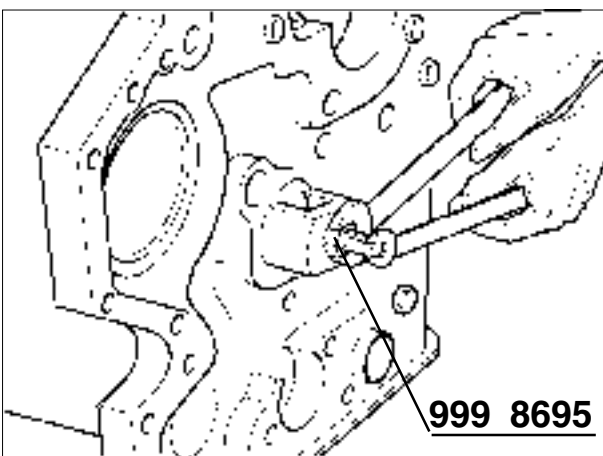
- Dial gauge 998 9876
- Fitting tool, camshaft bearings 999 8695



1. Set the internal dial gauge to **65 mm** (2.56").
2. Procedure for measuring the bushes at planes **1** and **2** in points "a" and "b" (see figure).

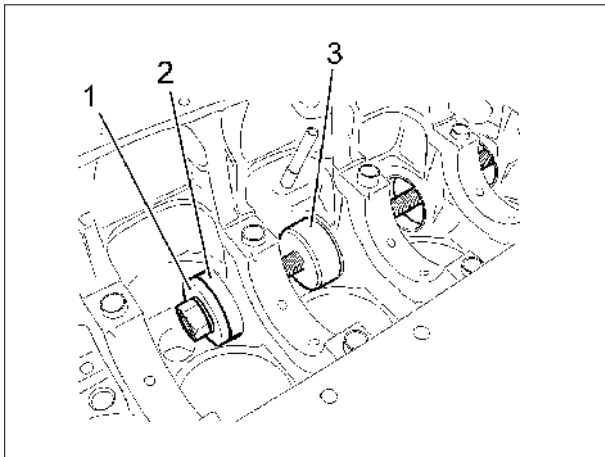


3. Measure the bushes, replace if necessary.
 Inside diameter: **65.00** ^{+0.054} mm (2.56 ^{+0.002}")
 Wear limit: **65.08** mm (2.562")

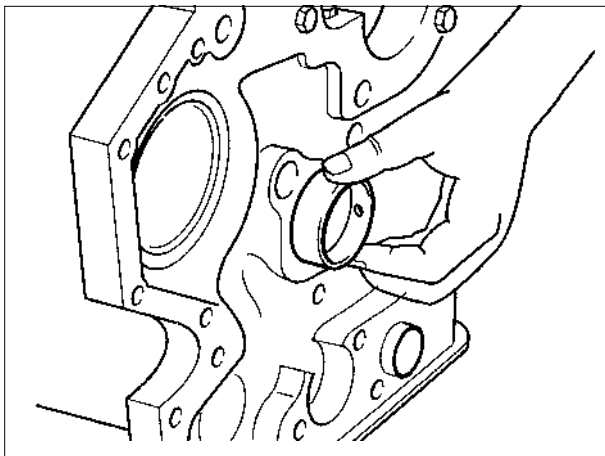


Bearings, replacing

4. Remove the bearings. They can be removed in both directions.
 Use tool 999 8695.

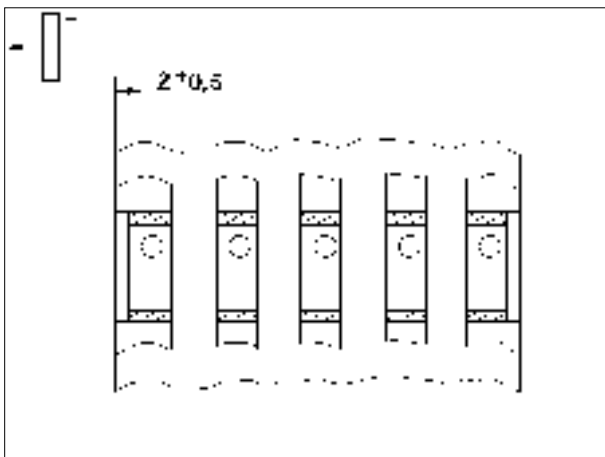


- 1) Styryhlysa
- 2) Lagerbussning
- 3) Presshlysa

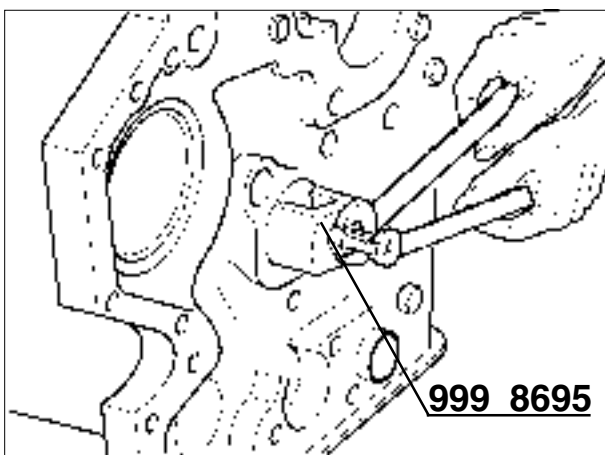


5. Position the new bearing.

NOTE! The widest bearing, 27 mm (1.06"), should be palced at the flywheel end.



NOTE! The lubrication holes must fit the oil duct in the bearing positions.

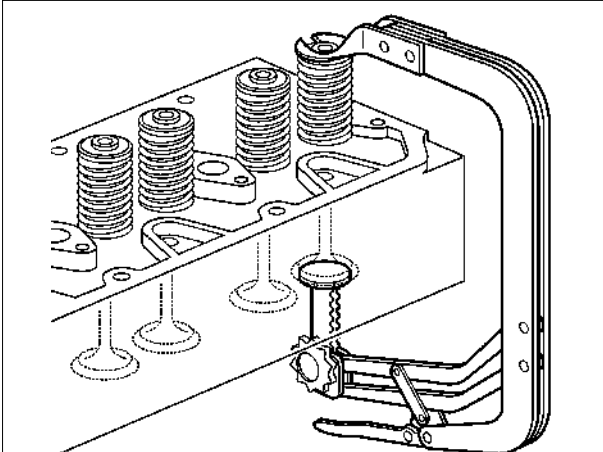


6. Fit the bearings.
Use tool 999 8695.

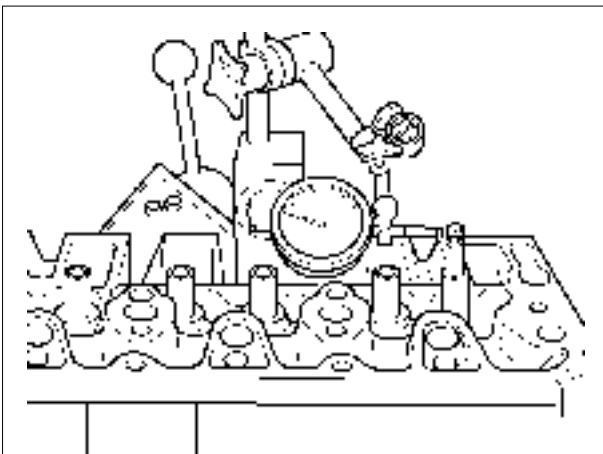
Cylinder head

Special tool:

Valve spring compressor 998 5468



1. Put the cylinder head in a vice.
2. Remove valve retainers, valve discs, valve springs and valves, using valve spring compressor 998 5468.



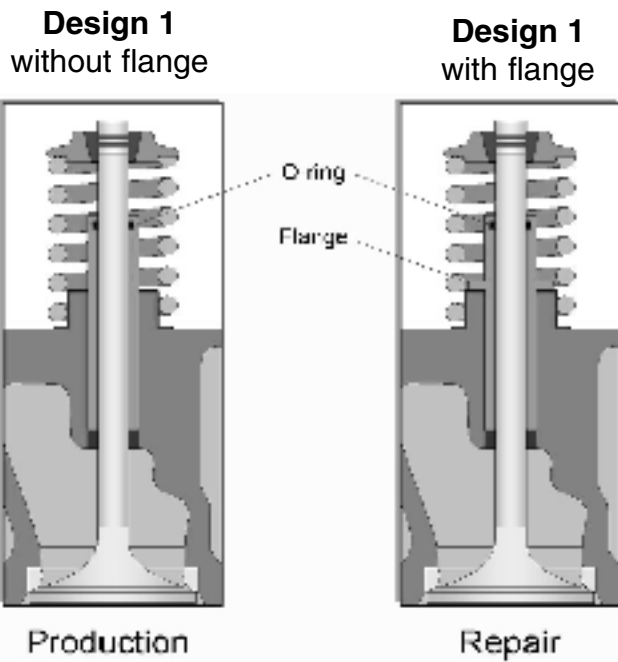
3. Remove the valve stem seals.
4. Clean the cylinder head and check it to ensure there is no damage.
5. Move the valve down a bit so that it is not positioned in the seat.
6. Measure the valve stem clearance in the valve guide.

Wear limits:

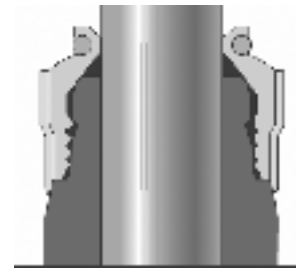
Inlet valve: **0.10 mm** (0.004")

Exhaust valve: **0.13 mm** (0.005")

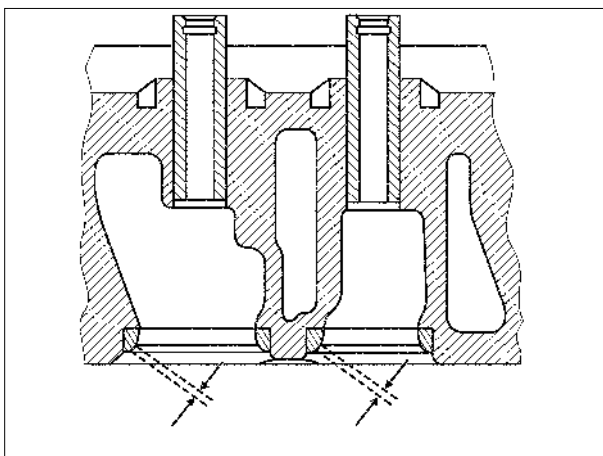
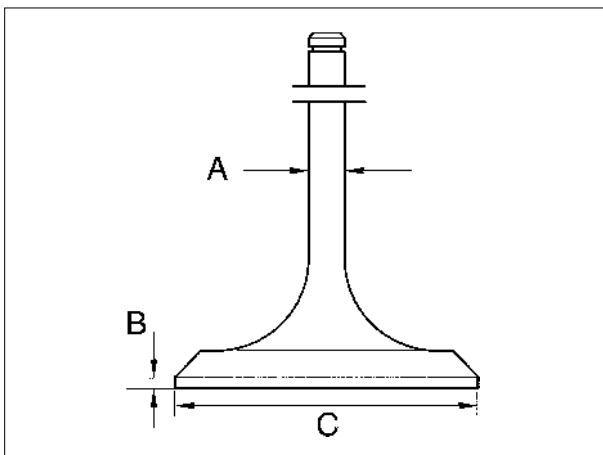
NOTE! Measured with a new valve. Replace valve guide if worn. The valve guides are different as a spare part, compared to the production part. See fig.



Design 2



On later designs, the o-ring is exchanged for a valve rod seal, according to the picture for design 2.



7. Check and measure the valves.

A. – Valve stem diameter: standard

Inlet valve: **8.98^{-0.015} mm**
(0.3535"-0.0006")

Exhaust valve: **8.96^{-0.015} mm**
(0.3528"-0.0006")

B. – Valve edge thickness

Wear limits:

Inlet valve: **2.1 mm (0.08")**

Exhaust valve: **1.8 mm (0.07")**

C. – Valve head diameter:

Inlet valve: **48.0 ±0.1 mm**
(1.89 ±0.004")

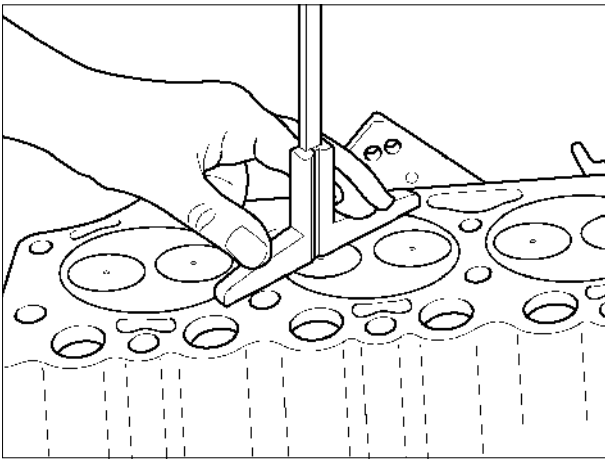
Exhaust valve: **42.0 ±0.1 mm**
(1.65 ±0.004")

8. Check the valve seats rings and wear limits.

Wear limit for valve seat width.

Inlet valve: **2.8 mm (0.11")**

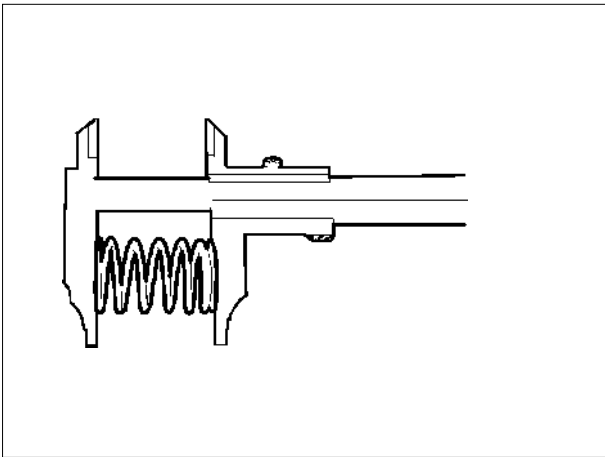
Exhaust valve: **2.2 mm (0.09")**



9. Measure the distance between the center of the valve head and the cylinder head mating surface.
 Depth of valve in cylinder head:
 Measurement between valve disc and cylinder head face:
 Inlet/Exhaust Max **1.5 mm** (0.06")

10. Measure the length of the valve spring using a sliding caliper and with the spring unloaded.

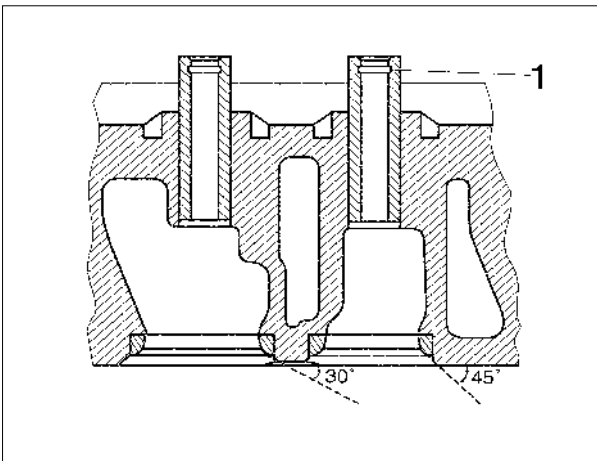
Unloaded length, standard
64.70 ±1.3 mm (2.55" ±0.05")



11. Use the grinding tool to grind the valves into their seats and correct the seat angle.

Valve seat angle	Inlet	Exhaust
	30°	45°
Valve seat width, maximum	Inlet	Exhaust
	2.8 mm (0.11")	2.2 mm (0.09")

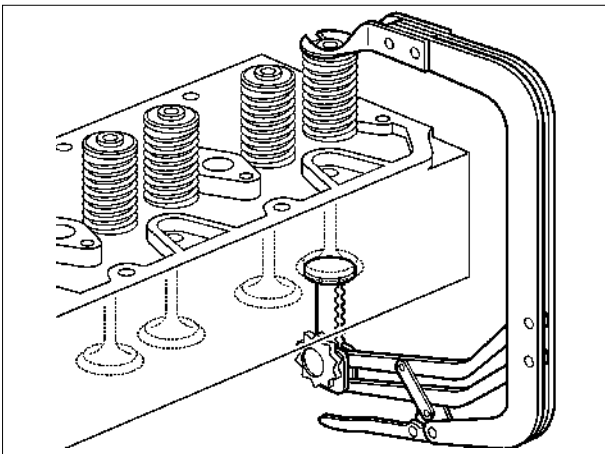
NOTE! Measure the depth of the valve in the cylinder-head again after you have ground in the valves.



12. Insert the valve steam seal (1)

13. Fit the valves, valve springs and spring discs.

NOTE! Oil the stems of the inlet and exhaust valves. Push the valves in gently, with a slight twisting motion. The o-ring (1) is very thin and can easily be damaged.

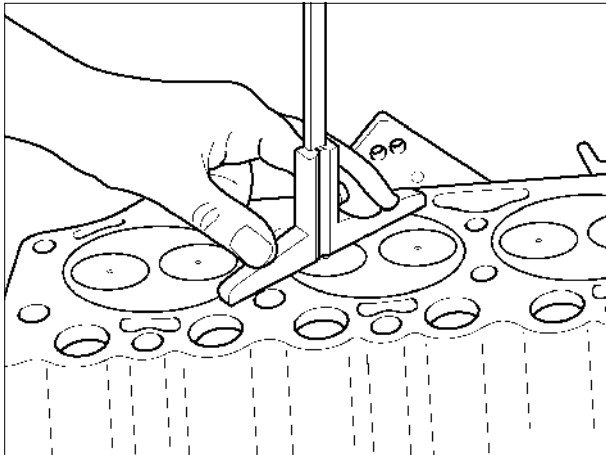


14. Use valve spring compressor 998 5468 for the valve springs. Insert the valve retainers.

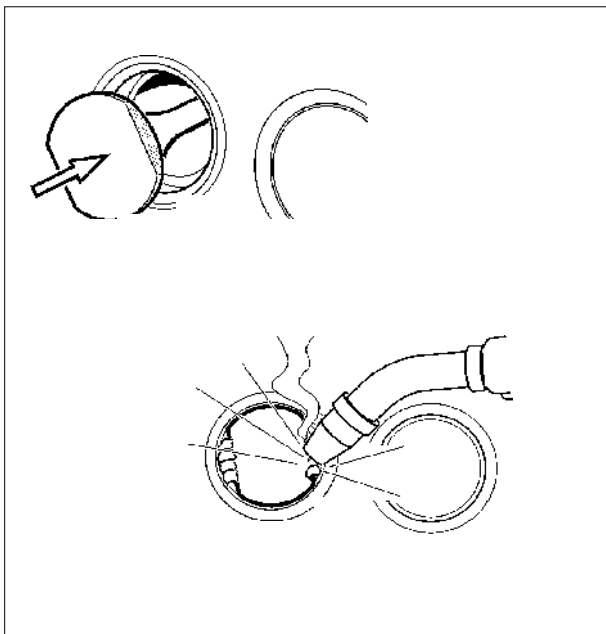
Valve seat, changing

(21405, 21406)

Cylinder head removed



1. The valve seats shall be changed when the measurement between the valve disc and cylinder head face exceeds the value given in the specification or when the tightness is not satisfactory. Max. 1.5 mm.

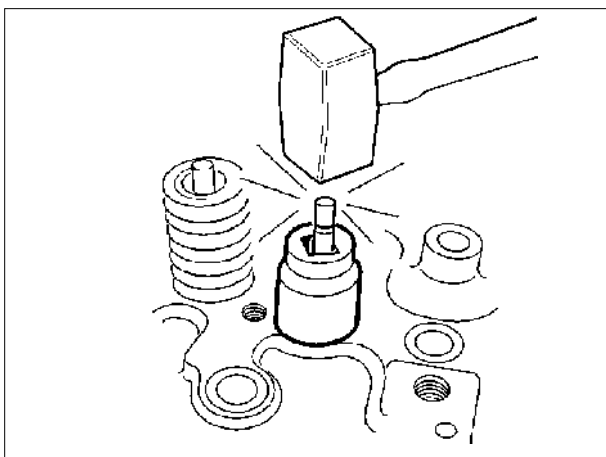


2. Cut off the face of an old valve and weld it to the valve disc. Use a MAG-weld or alternatively a conventional arc welder (with a stainless welding electrode).

⚠ IMPORTANT! Carefully cover other surfaces on the cylinder head so that possible welding sparks can not stick.

3. Place a suitable socket over the valve/valve guide and **carefully** knock out the valve seat.

NOTE! Be careful so that the cylinder head is not damaged.

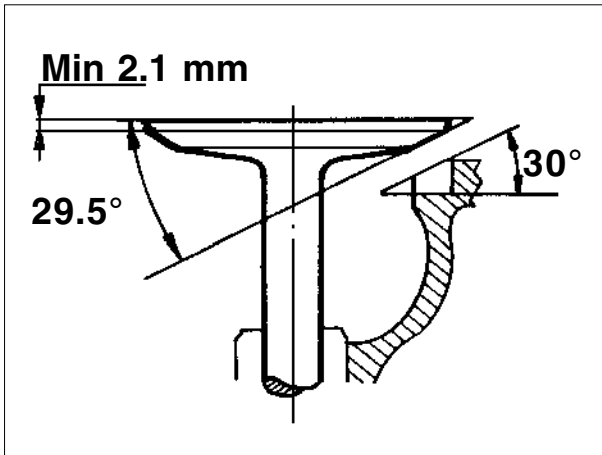


4. Clean the location of the seat carefully and check the cylinder head for cracks.
5. Measure the diameter of the valve seat location. Check whether a seat of standard size or an oversize seat should be used. Perform possible work to the location of the valve seat, see "Technical Data".
6. Cool the seat, using carbon dioxide snow, to between -60°C (-76°F) and -70°C (-94°F) and heat the cylinder head, for example by running hot water over it.
Using a drift, press in the valve seat.

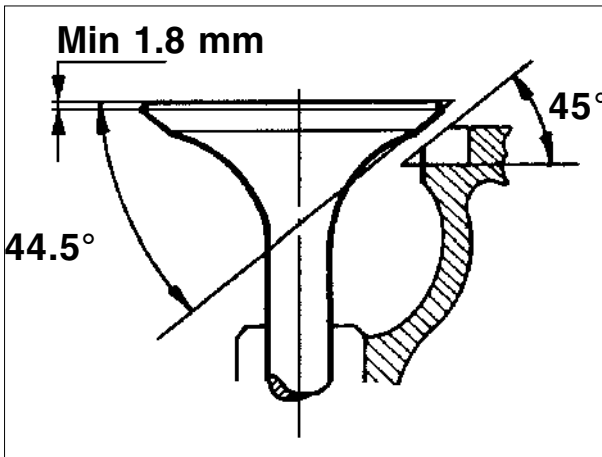
NOTE! Turn the seat so that the seat angle faces the tool.

Valve seat, grinding

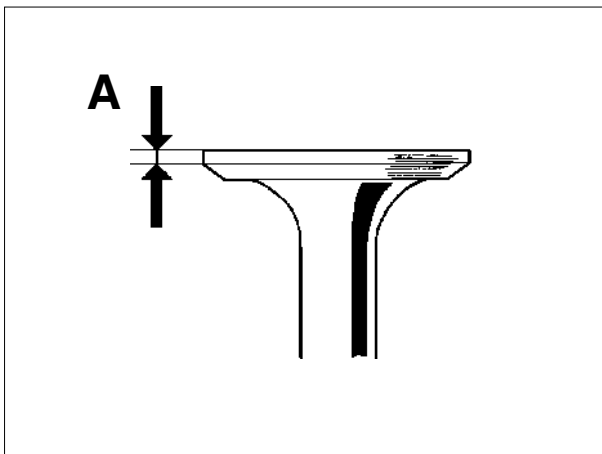
(21405, 21406)



Inlet valve



Exhaust valve



NOTE! As a spare part the valve seats are finish-machined and should not need further grinding.

1. Before grinding the valve seats, the valve guides should be checked and replaced, if the permissible variation of wear is exceeded.
2. When grinding the valve seats, make sure that not too much material is removed; only so much material that the valve seat gets the right shape and that the valve disc gets a good contact surface.
3. The valve seat is grinded down so that the measurement between the cylinder head face and the valve disc is according to specification.
4. The valve seat angle is checked, using a valve seat gauge, when the seat surface has been coated with a thin layer of indelible ink.

Valves, grinding

(21401, 21402)

For valve tightening angles, see "Technical data".

NOTE! As a spare part the valves are finish-machined and should not need further grinding.

1. The faying surface should be grinded as little as possible, however so much that all the damages are removed.
2. Check the measurement (**A**) on the edge of the valve disc. If the measurement is smaller than the permissible variation of wear, according to the specification, the valve should be replaced. See "Technical Data".

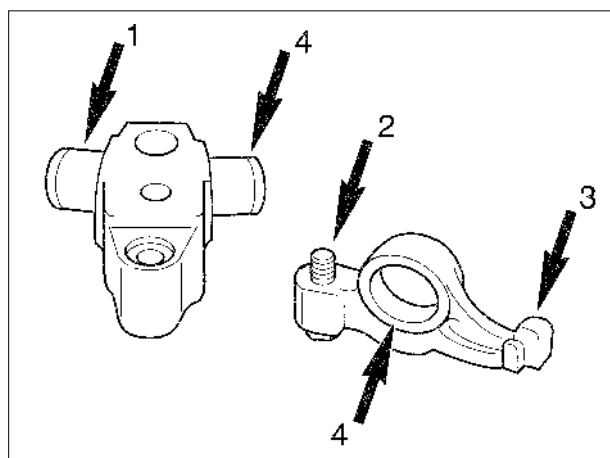
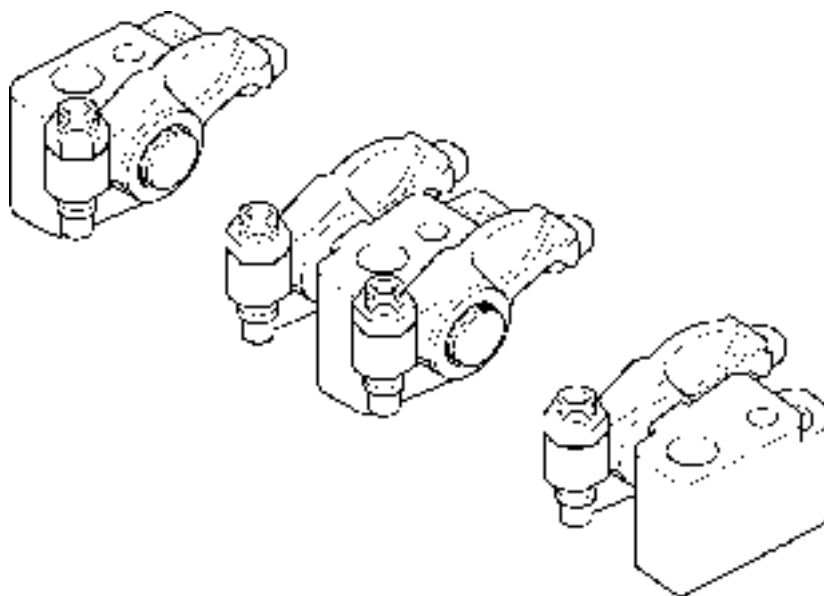
Always replace a valve with a crooked valve spindle.

3. Check the tightness of the valves, using indelible ink.

If there's a leakage, yet another grinding of the valve seat is done, however not on the valve. After this, yet another check is performed. When the grinding result is satisfactory, the valve and seat can be "lapped" together, using a fine grinding paste.

Rocker arm bracket

(21451, 21452)



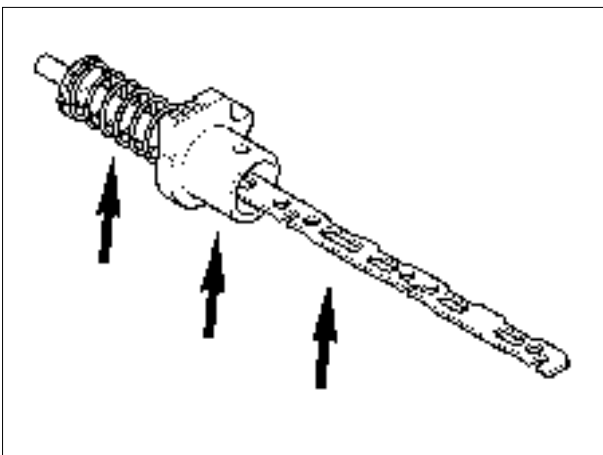
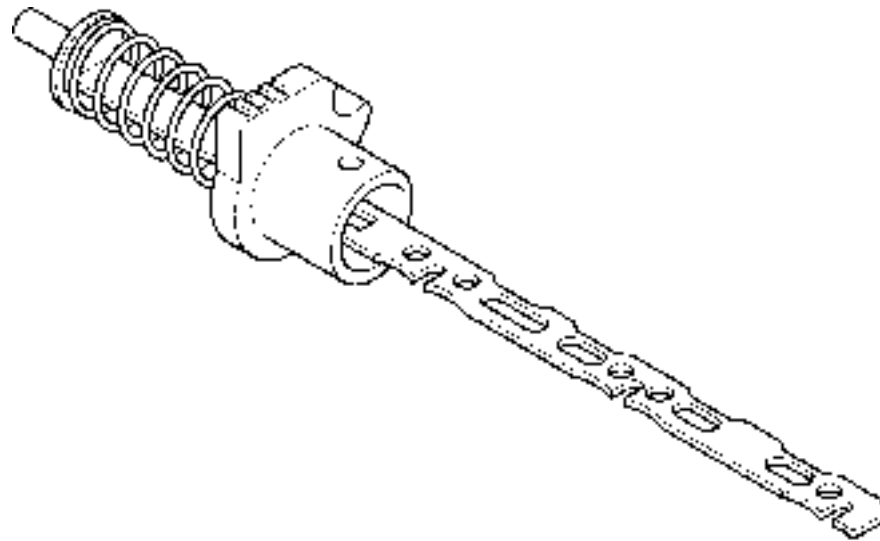
Rocker arm bracket, disassembly/checking/assembly

1. Disassemble the rocker arm and rocker arm bracket.
2. Check for wear.
 - (1) Shaft pivots
 - (2) Adjusting screw
 - (3) Rocker arm contact surfaces
 - (4) Diameter

Replace if the wear is abnormal.

3. Check that the oilways are clear.
4. Assemble the rocker arm and rocker arm bracket. Fit the circlips.

Control rod

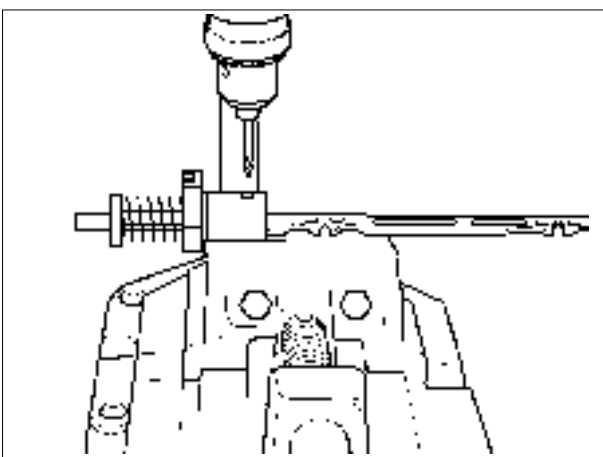


Check the control rod

1. Check the control rod and replace any damaged parts.

NOTE! The governor must always be re-set when you have changed the control rod. A trained specialist should perform the setting, on a governor test bench.

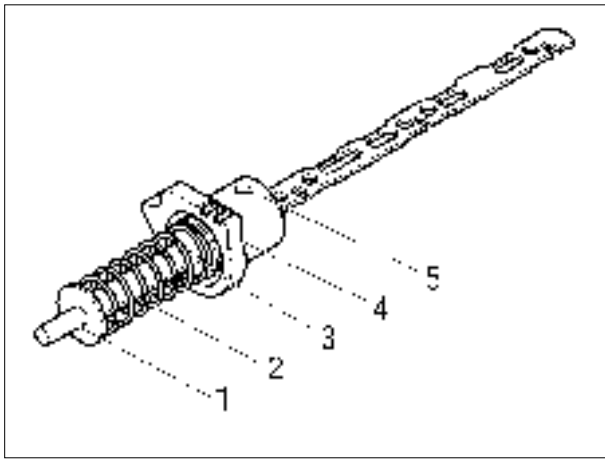
NOTE! With an electronic governor, the new x-measurement must be entered into the trigger unit.



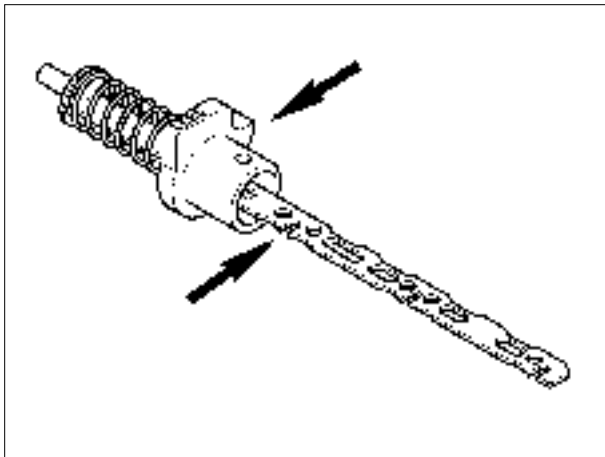
Dismantling

2. Drill out the tension pin on the guide sleeve and remove it.

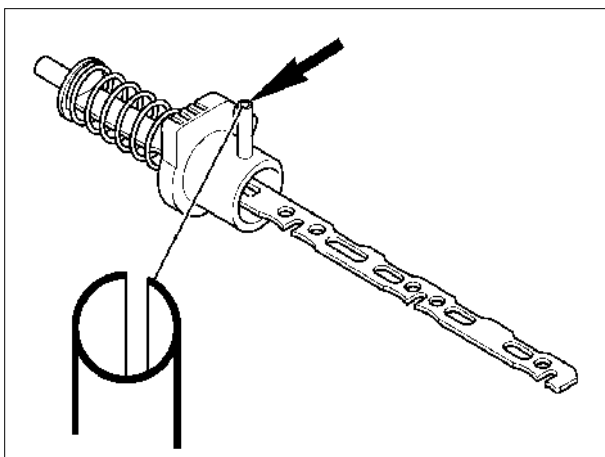
NOTE! Always renew the guide sleeve and the tension pin when you dismantle the control rod.

**3. Assembly sequence:**

1. Control rod
2. Compression spring
3. Washer
4. Guide sleeve
5. Tension pin

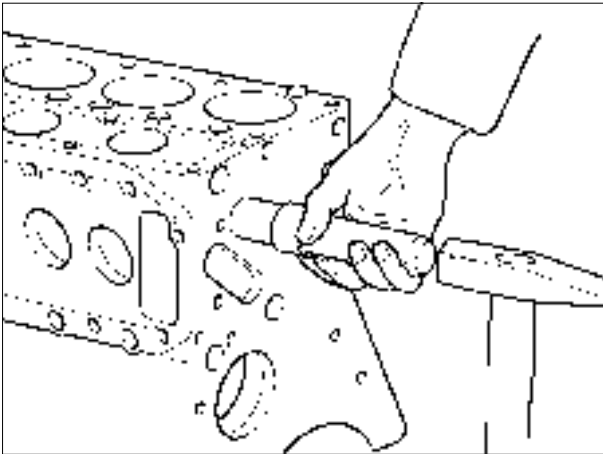


4. Pay attention to the alignment of the control rod in relation to the guide sleeve.



5. Insert the tension pin according to fig.
6. Press the tension pin in as far as it will go.

Control rod guide sleeves

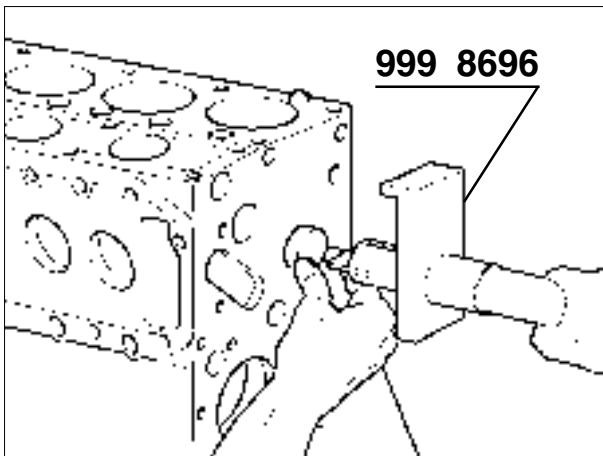


Special tools:

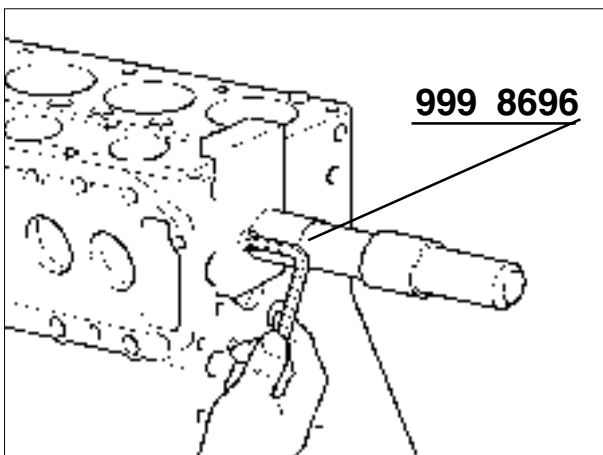
Fitting tool, control rod sleeves 999 8696

Standard shaft, drifts 999 2000

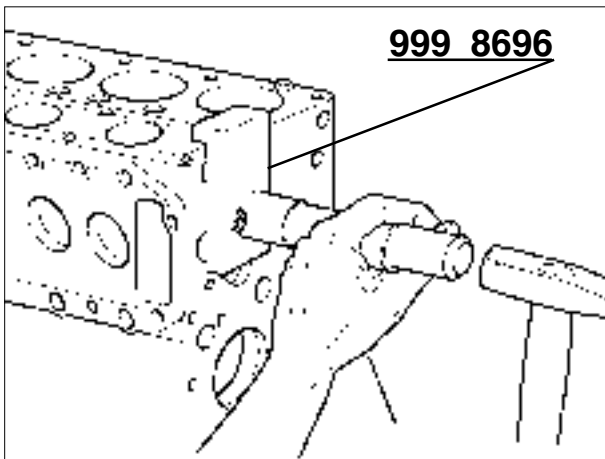
1. For engines 520/720/721/722, remove the plug, then drive out the guide sleeve at the front end. On engines 720/721/722 also drive out the guide sleeve at the flywheel end.



2. Position the guide sleeve on the drift with the chamfer towards the crankcase.



3. Put the fitting tool 999 8696 and the drift against the engine block and lock it in place with a screw.

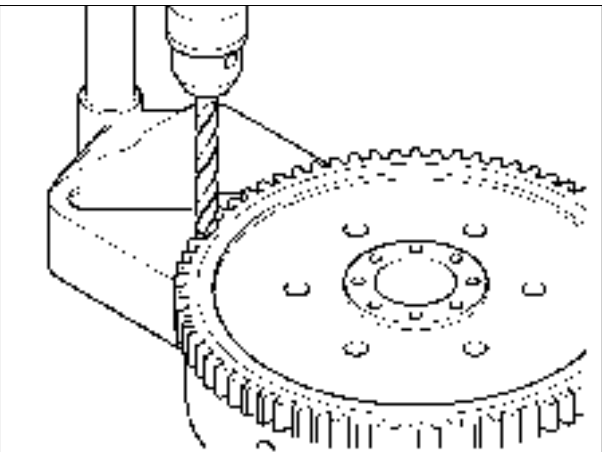
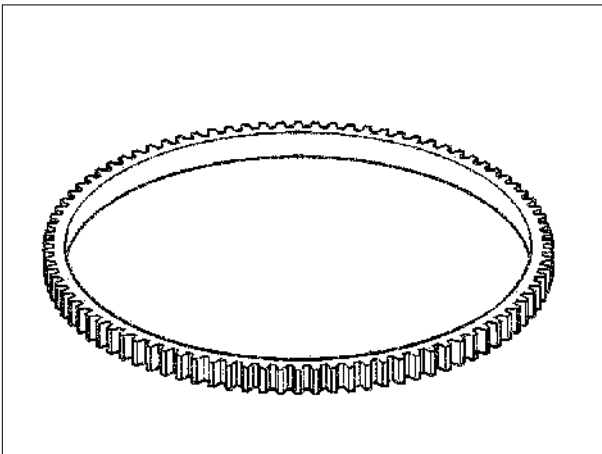
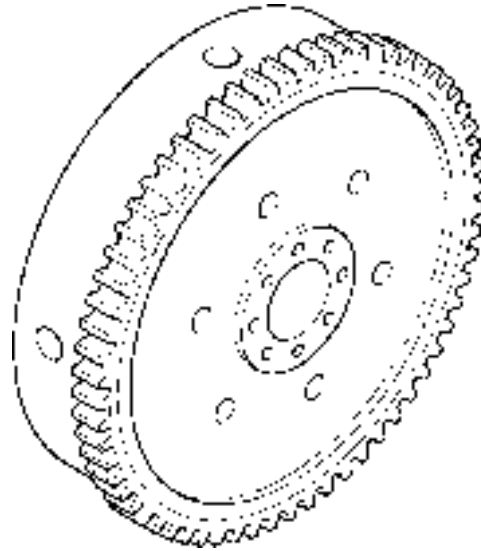


4. Drive in the guide sleeve until the drift 999 8696 bottoms in the socket.
5. For engines 720, 721, 722, drive in guide sleeve from flywheel end. Repeat the procedure as above. Use the longer drift.

Repairing components

Group 21 Engine

Flywheel ring gear, changing (21687)



1. **Heat the new ring gear to Max 210°C (410°F)**

Use an oven or gas torch.

If you use an oven, put in the new ring gear in advance.

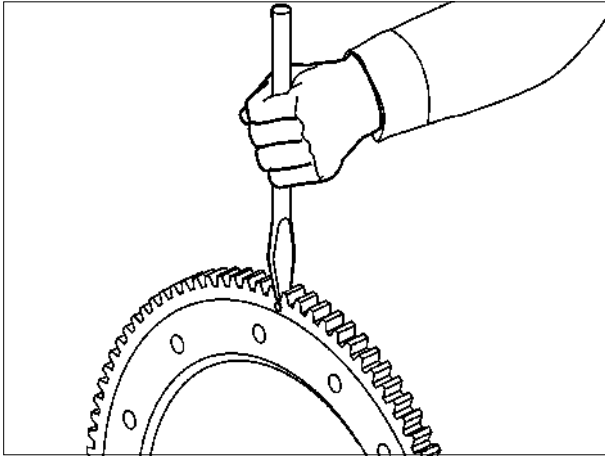
If you use a gas torch, heat the ring gear immediately before you install it.

2. **Drill a hole between two teeth.**

Use a **10 mm** (0.4") drill.

Drill a **9 mm** (0.35") deep hole.

⚠ IMPORTANT! Be careful not to drill on the fly-wheel, if you do it will loose its balance.

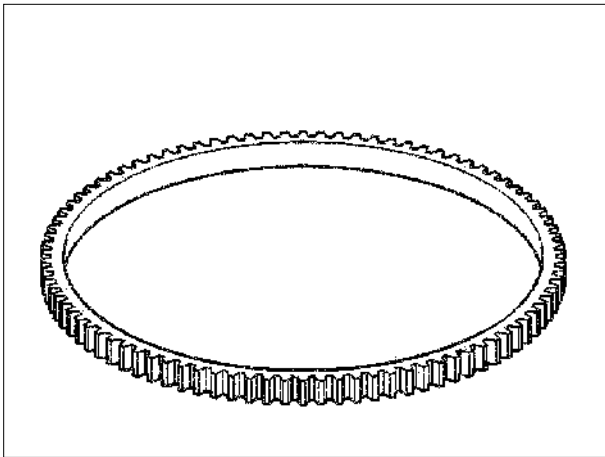


3. **Remove the flywheel ring gear**

Hold the ring gear firmly in a soft-faced vice.

Pry off the ring gear using a screwdriver. If necessary, split the ring gear at the drilled hole.

Clean the contact surfaces of the flywheel.



4. **Fit the new ring gear**

Check the temperature.

Position the ring gear so that it meets the flywheel flange.

If necessary tap the ring gear down to the bottom. Use a brass drift.

Let the ring gear cool.

Valve clearance, checking/adjusting

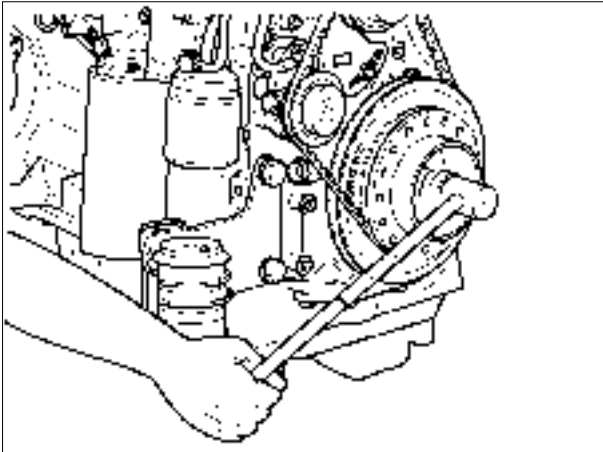
(21403)

Special tools:

Rotating tool, crankshaft 999 8676

Cranking tool, flywheel 999 8681

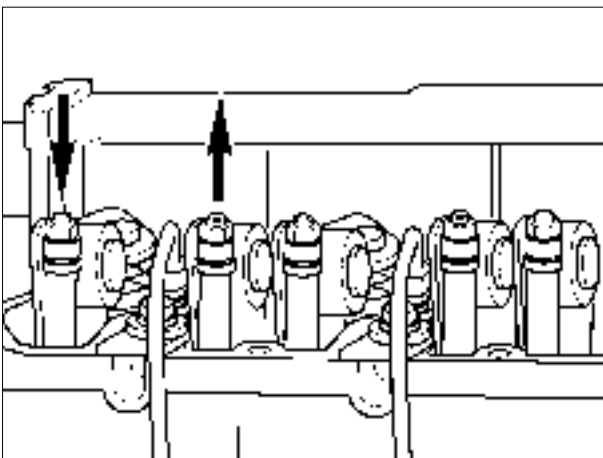
NOTE! The normal valve clearance is set when the engine is cold or has cooled down for at least half an hour.
Oil temperature $\leq 80^{\circ}\text{C}$ (176°F .)



NOTE! The valve clearance should be at the highest permissible variation when the cylinder head gasket is changed and at the lowest permissible variation after 50 hours running.

1. Rotate the crankshaft until the valves for no. 1 cylinder overlap.

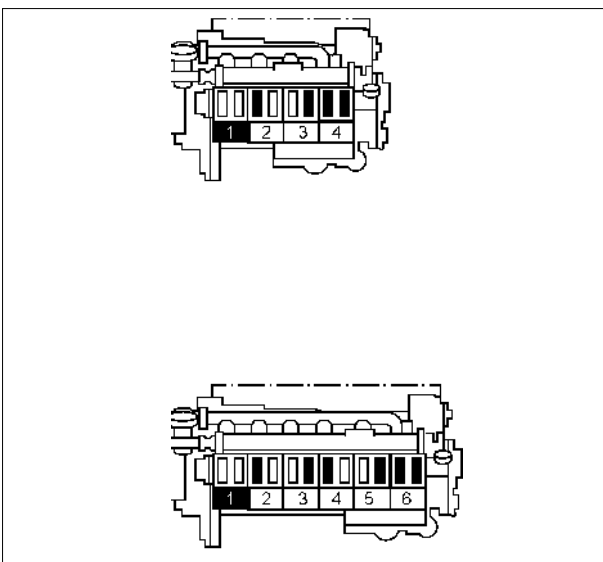
NOTE! The valves overlapping means: The exhaust valve is closing. The inlet valve is opening. Neither of the push rods can be turned in this position. (Number 1 cylinder is nearest the flywheel).

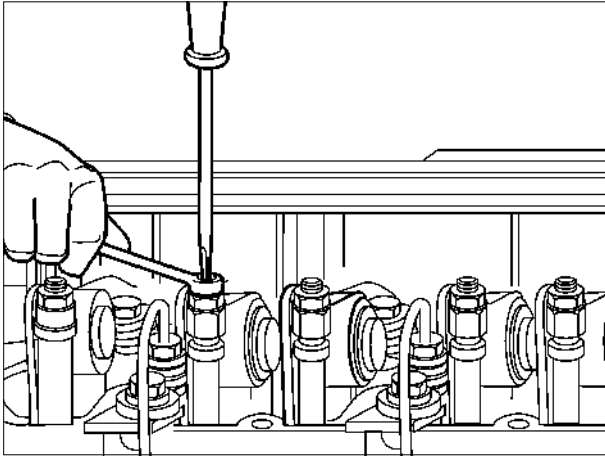


2. Set the valve clearance for each cylinder using a feeler gauge, according to the **black markings**.
Mark up the rocker arm on each set cylinder, using a chalk.

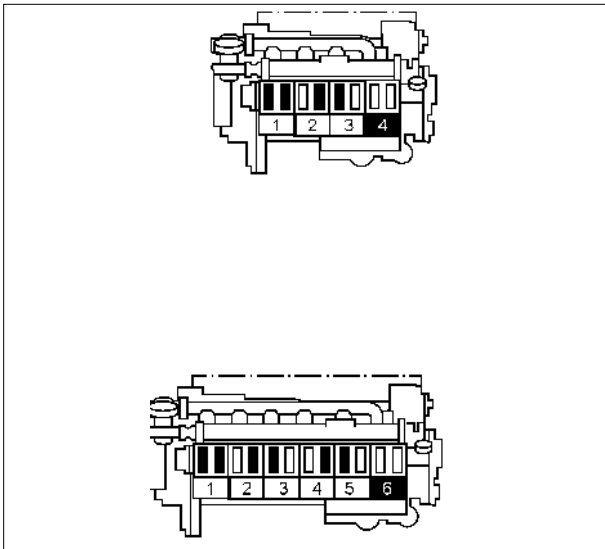
Inlet valve clearance: **0.35 ±0.05 mm**
(0.01±0.002")

Exhaust valve clearance: **0.55 ±0.05 mm**
(0.02±0.002")





3. Tighten the locknut to **20 ±2 Nm** (15 lbf ft).
Recheck the setting with the feeler gauge.



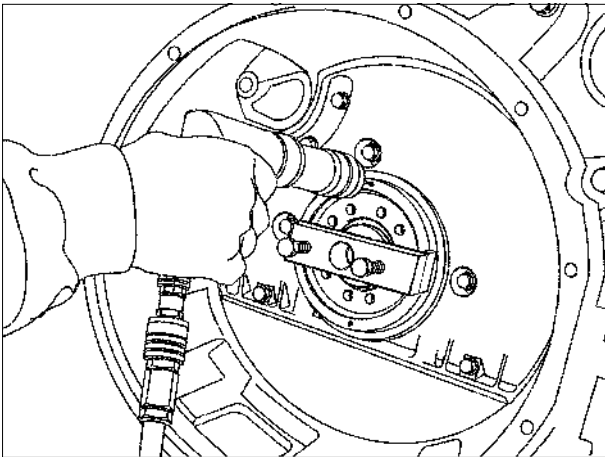
4. Rotate the crankshaft another revolution (360°).
Set the valve clearance for each cylinder using a feeler gauge, according to the **black markings**.
Mark up the rocker arm on each set cylinder, using a chalk.
5. Tighten the locknut to **20 ±2 Nm** (15 lbf ft).
Recheck the setting with the feeler gauge.
6. Fit a **new** rocker cover gasket.

Crankshaft seals, changing (complete engine)

Special tools:

- Standard shaft, drifts 999 2000
 - Fitting/Removal tool, rear 999 8672
 - Fitting tool/Removal, front 999 8673
- (Transmission housing, flywheel end)

Rear crankshaft seal, changing (21671)



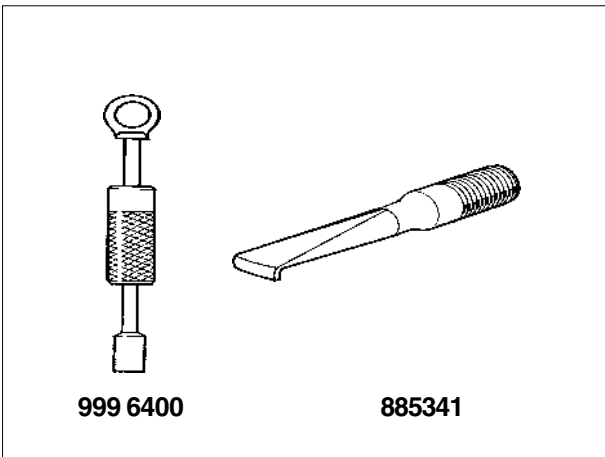
1. Remove the flywheel.

NOTE! The flywheel is very heavy.

2. Remove the crankshaft seal from the transmission housing using tool 999 8672.

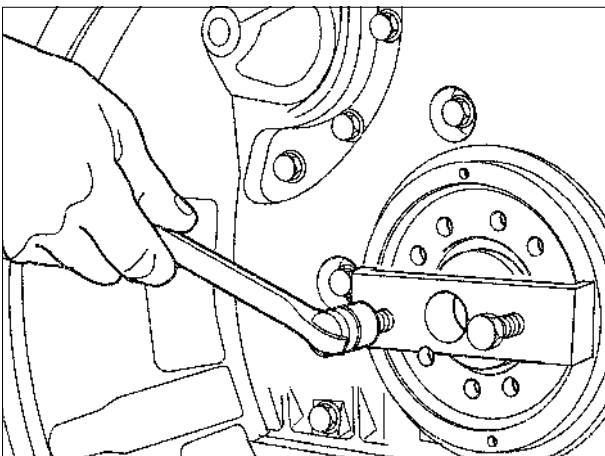
3. Drill two **3.5 mm** (0.14") holes in the seal, through the pre-drilled holes in the tool.

NOTE! Max. depth **8 mm** (0.31")



Alternatively:

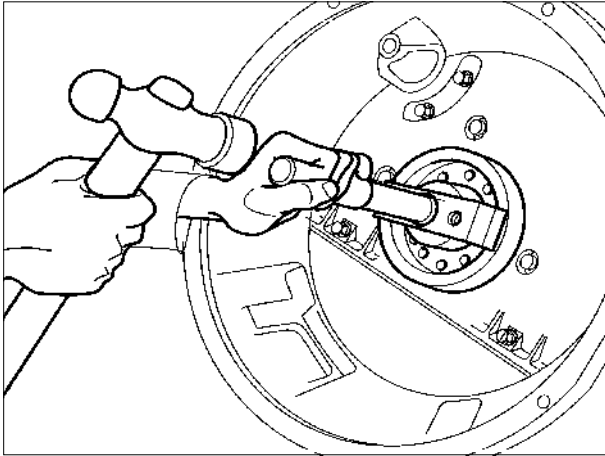
Use extractor 885341 together with slide hammer 999 6400.



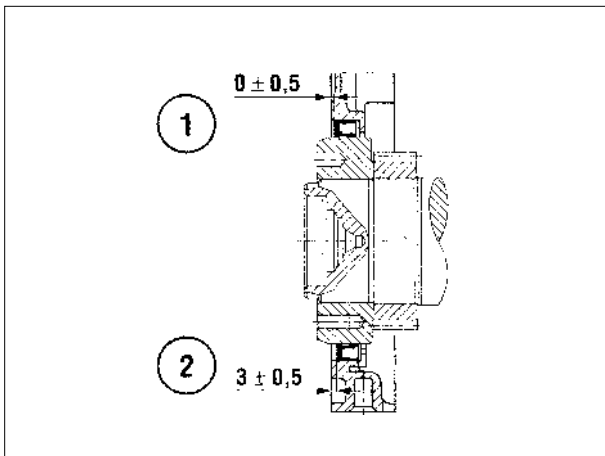
4. Screw two self-tapping screws in the drilled holes.

NOTE! Max. screw length **40 mm** (1.6").

5. Pull out the seal using the screws in the tool.



6. Lightly oil the sealing lip on the new seal and put it on the tool 999 6872, with the lip facing the crankshaft.

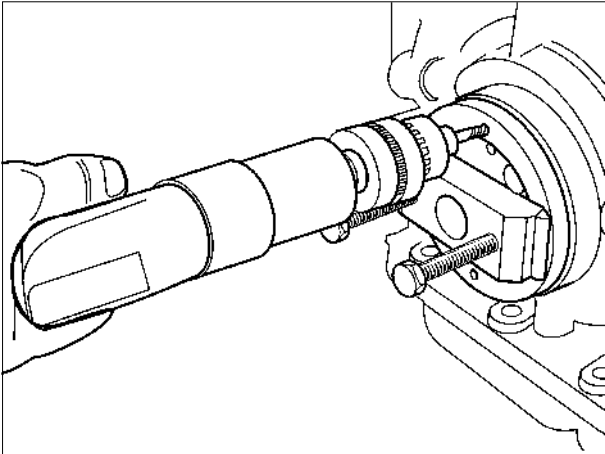


NOTE! The seal is originally installed in position (1), see fig.

The tool's installation position (2) is when the crankshaft has a measurable wear, in position (1).

Use a drift and gently knock the seal into required position.

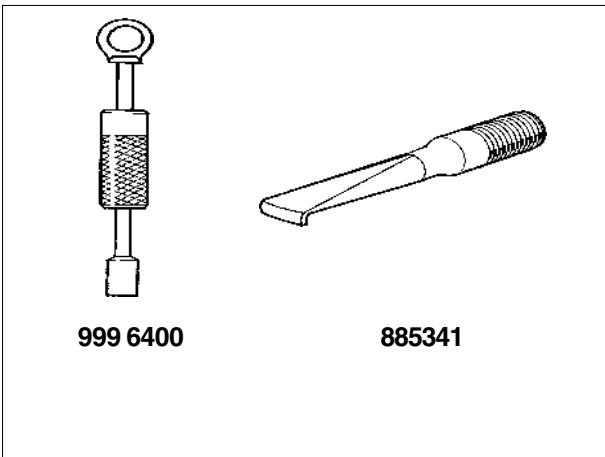
Front crankshaft seal, changing (Front housing) (21672)



1. Remove the crankshaft pulley and vibration damper if fitted.
2. Remove the crankshaft seal from the front housing using tool 999 8673.

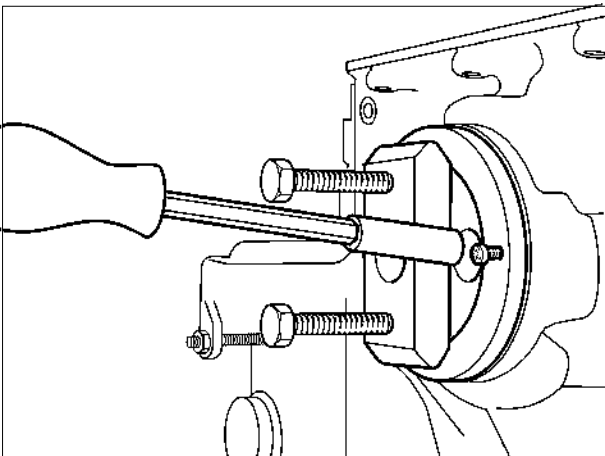
Drill two **3.5 mm** (0.14") holes in the seal, through the predrilled holes in the tool.

NOTE! Max. depth 7.5 mm (0.3").



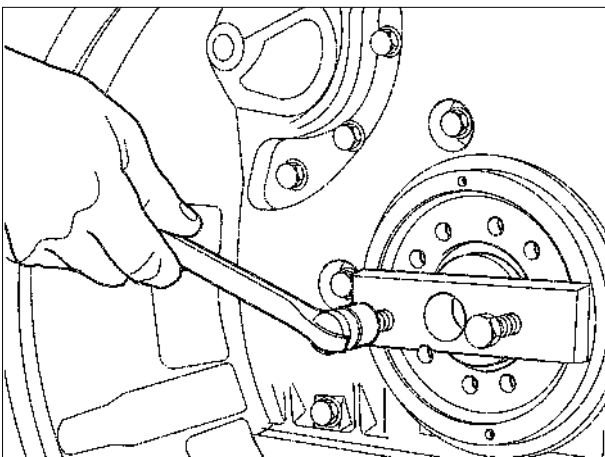
Alternatively:

Use extractor 885341 together with slide hammer 999 6400.

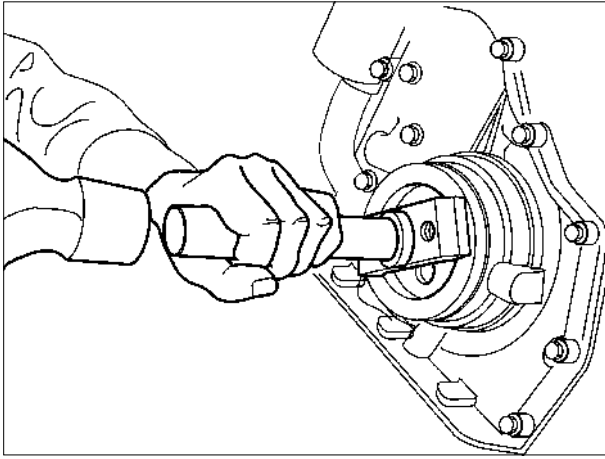


3. Screw two self-tapping screws in the drilled holes.

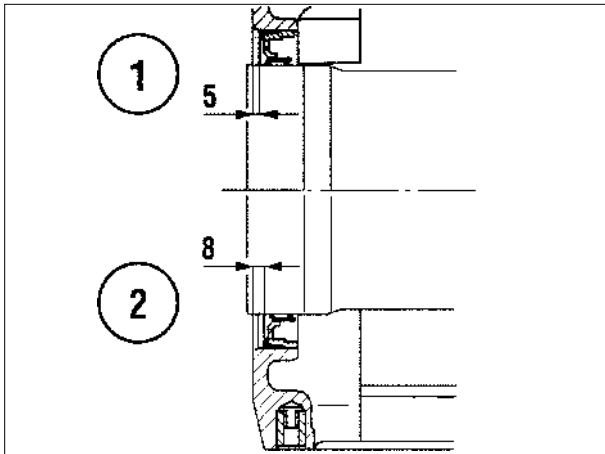
NOTE! Max. length of screws 32 mm (1.28").



4. Pull out the seal using the screws in the tool.



5. Lightly oil the sealing lip of the new crankshaft seal and put it on the tool 999 8673. The sealing lip to face the crankshaft. Use standard shaft 999 2000, and carefully knock the seal in place.



NOTE! The seal is originally installed in position (1), see fig.

The tool's installation position (2) is when the crankshaft has a measurable wear, in position (1).

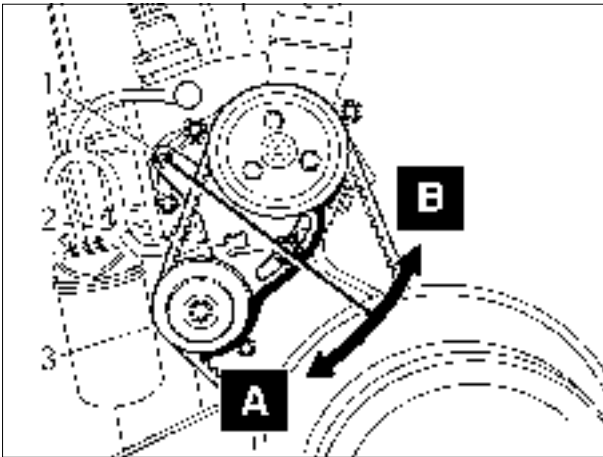
Use a drift and gently knock the seal into required position.

Drive belts, adjusting and replacing (26341)

⚠ IMPORTANT! Only check/tension or change the drive belt when the engine is stopped. Replace the drive belt guard.

NOTE! Replace drive belts that are oily, worn or damaged in some other way.

NOTE! The belt tension is correct when you can press them down **10 mm** (0.4") between the pulleys.



Coolant / fuel pump

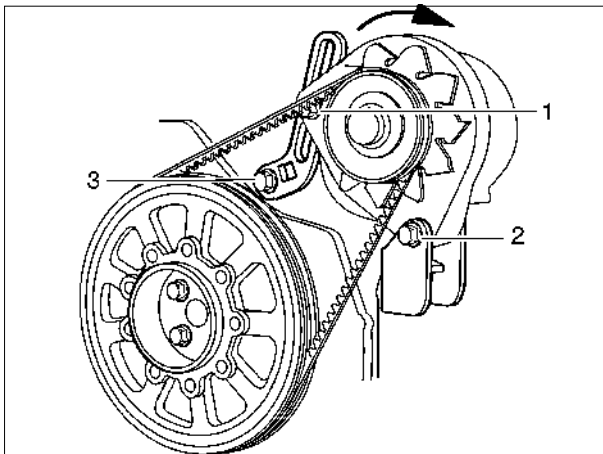
Drive belts, adjusting

1. Loosen the screws (1 and 2).
2. Push the fuel pump (3) in the direction (A) of the arrow until you obtain the correct* belt tension.
3. Retighten the screws (1 and 2).

Drive belts, replacing

1. Remove the alternator drive belt, see "Alternator".
2. Loosen the screws (1 and 2).
3. Push the fuel pump (3) in the direction of the arrow (B).
4. Remove the old belt, clean and check the belt pulleys for wear.
5. Fit the new belt.
6. Push the fuel pump in the opposite direction to the arrow (A) until you obtain the correct* belt tension.
7. Retighten the screws (1 and 2).

⚠ IMPORTANT! Do not over-tighten the belt, as it might damage the bearing in the fuel pump.



Alternator

Drive belts, adjusting

1. Loosen the screws (1, 2 and 3).
2. Push the alternator in the direction of the arrow until you obtain the correct belt tension.
3. Retighten the screws (1, 2 and 3).

Drive belts, replacing

1. Loosen the screws (1, 2 and 3).
2. Remove the old drive belt.
3. Fit the new belt.
4. Adjust the alternator until you obtain the correct* belt tension.
5. Retighten the screws (1, 2 and 3).

***NOTE!** The belt tension is correct when you can press them down **10 mm** (0.4") between the pulleys.

Group 22 Oil System

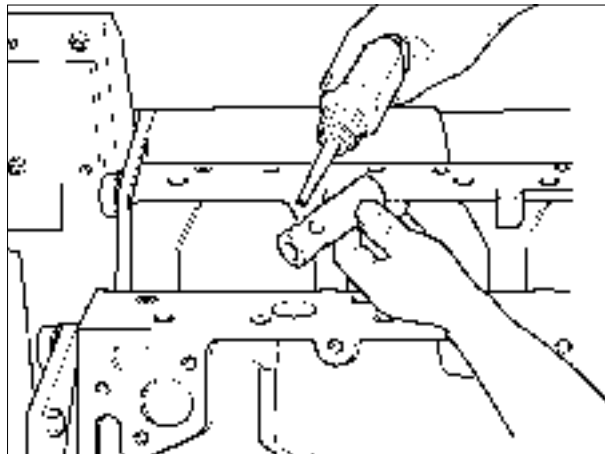
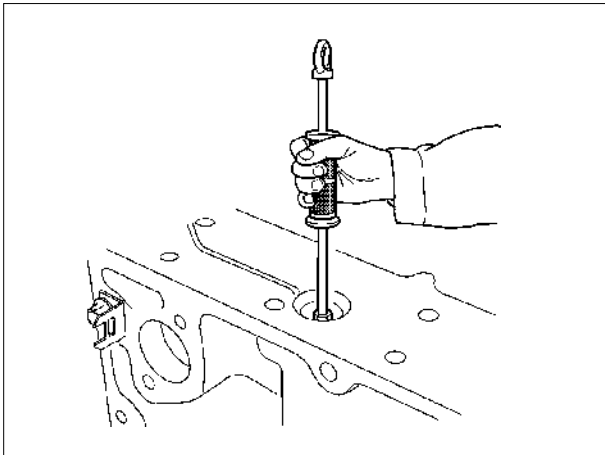
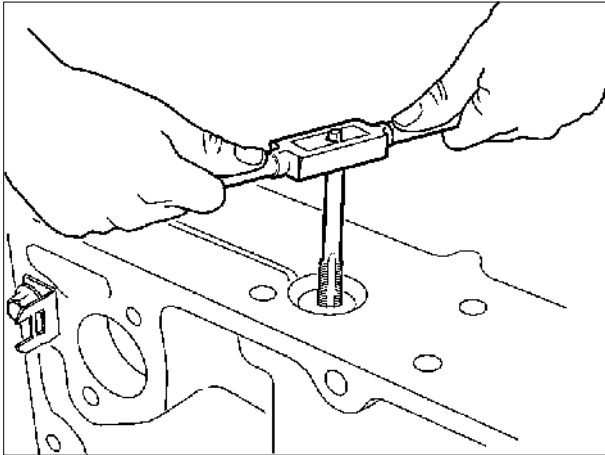
(22020)

Reduction valve

Special tools:

Adapter, oil pressure valve 999 8674

Slide hammer 999 6400



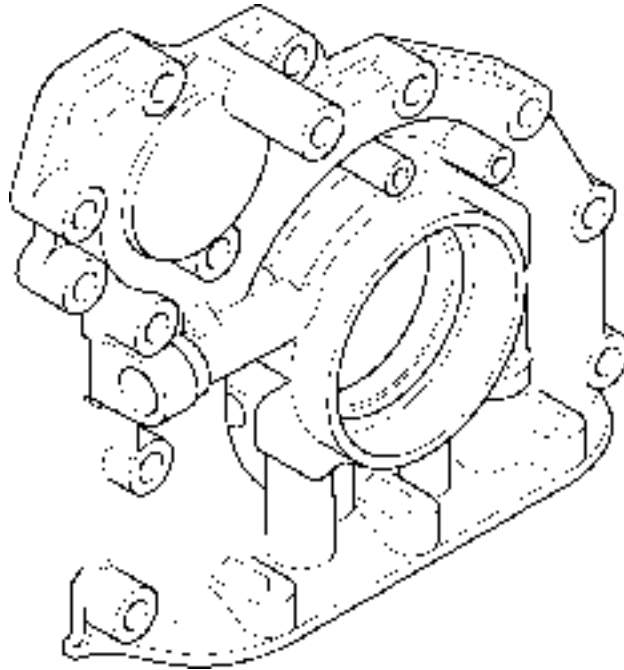
Removing

1. Drill a $\text{\O} 6.7 \text{ mm}$ hole (early engines), and tap an M8 thread in the reduction valve.
2. Use tool 999 6400 together with adapter 999 8674. Pull out the reduction valve.

Inserting

3. Apply locking compound (part no. 1161351-0) to the new reduction valve.
4. Drive in the reduction valve using a brass drift $\approx \text{\O} 20 \text{ mm}$ (0.8")

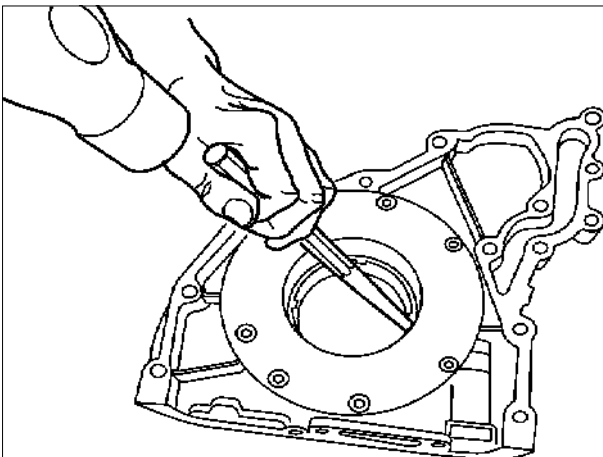
Front housing, oil pump (22111)



Special tools:

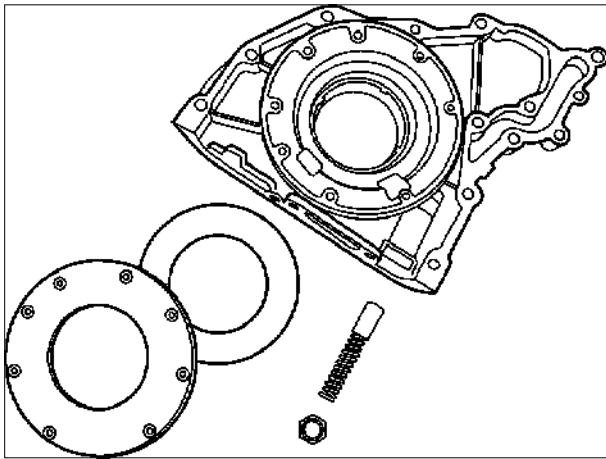
Standard shaft, drifts 999 2000

Fitting/removal tool, front crankshaft seal ... 999 8673



Removing

1. Use a drift to drive out the crankshaft seal.

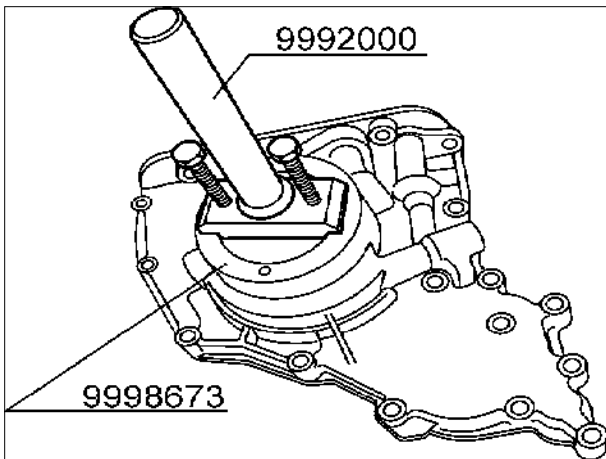


2. When cleaning the front cover remove the oil pump and reduction valve first.
3. Press down the compression spring and remove the retaining washer. Remove the spring and valve for inspection. Also inspect the valve seat in the housing.

NOTE! Be careful, as the spring load of this valve is very high. A good quality spring compressor is required.

4. Take out the gear assembly and check for abnormal wear. Fit a new gear assembly if necessary and oil lightly.

Tighten the screws to: **8-9 Nm**
(6-6.6 lb.)



Fitting

5. Insert the reduction valve and spring.
6. Press down the compression spring and insert the spring retaining washer.

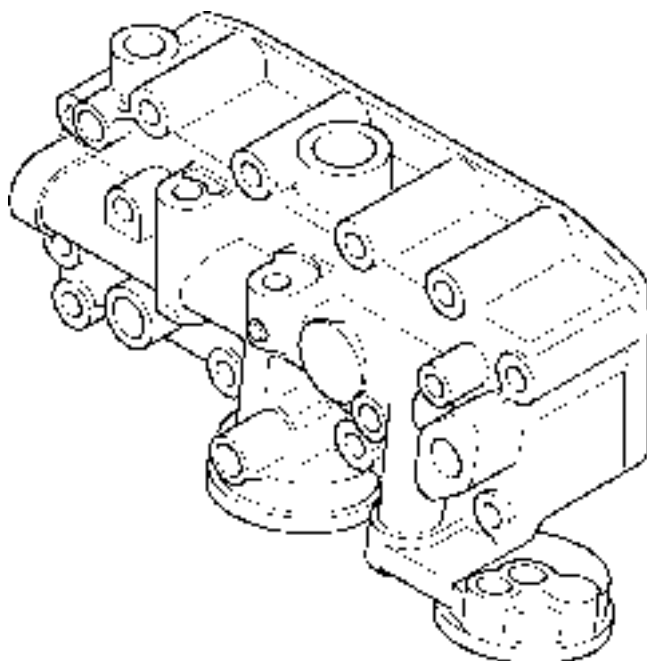
NOTE! Make sure the retaining washer is firmly in place.

Lubricate with a thin coating of oil before fitting.

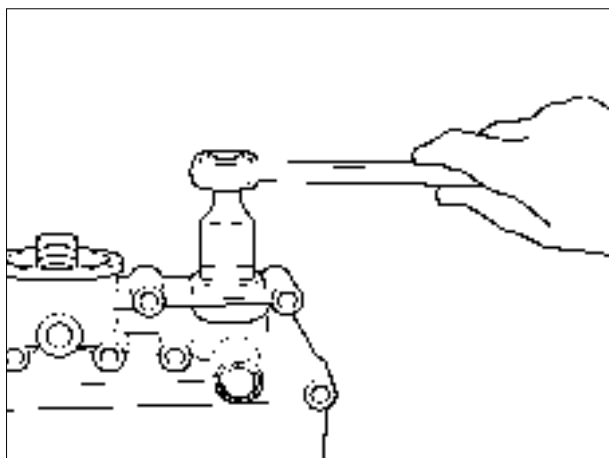
7. Insert the crankshaft seal using fitting tool 999 8673 and 999 2000.

⚠ WARNING! Make sure the correct oilpump is used for the engine in question. The pumps are different between the 520 and the 720/721/722 engines.
See "Parts catalogue".

Engine oil cooler

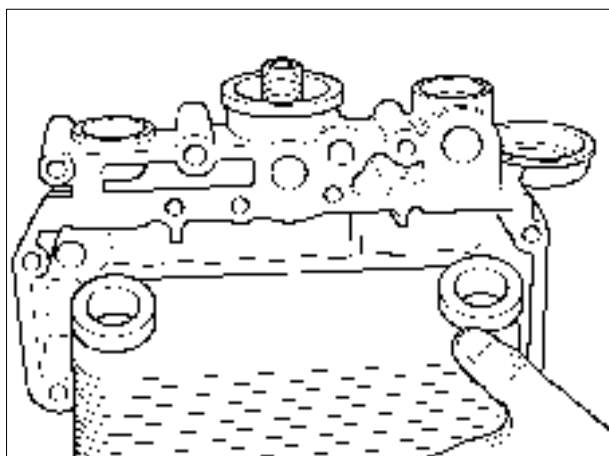


Oil cooler, check (replace) (22311)



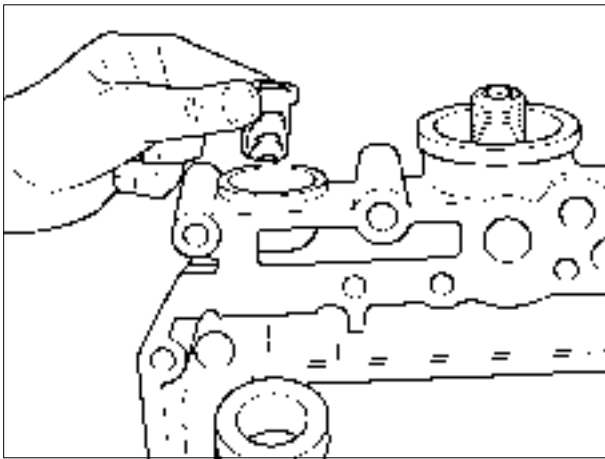
Check

1. Remove the Allen key plugs (17 mm).
2. Remove the hollow Allen key screws (17 mm) that hold the oil cooler.
3. Check all individual parts. If you suspect a leak, pressure-test the oil cooler and change if necessary.



Replace

4. Put the oil cooler into the oil cooler housing.



5. Fit a **new** aluminium washer on the hollow Allen key screw. Use thread-sealing compound (1161053-2) for the threads.
6. Tighten the hollow screw in two steps.
Initial torque: **80 Nm** (66.6 lbf ft)
Final torque: **160 Nm** (118.4 lbf ft)
7. Fit a **new** O-ring on the Allen key plug and oil lightly.
8. Tighten the plug to: **80 Nm** (66.6 lbf ft)
9. Fit the oil cooler with a **new** gasket.

**Oil cooler, leakage check
(22312)**

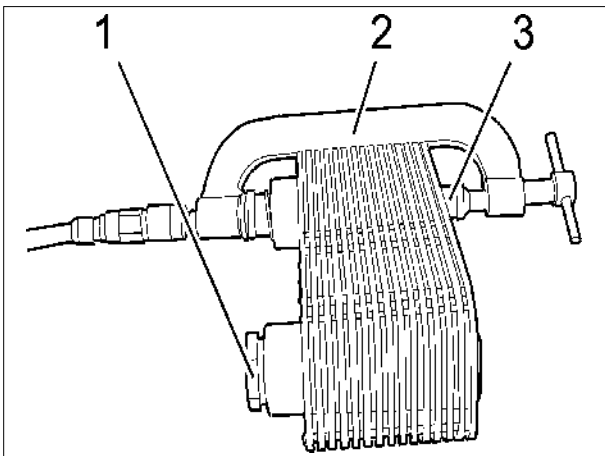
Special tools:

- Pressure-testing equipment 999 6662
- Clamp for cooler 999 6685
- Plug M26x1.5 part no. 942352
- Spacer 30 mm (eg. socket 10 mm)

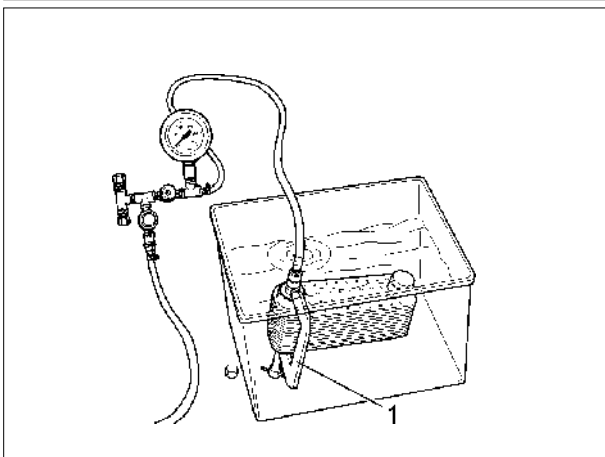
NOTE! During the check, the oil cooler should be as dry as possible within, since remaining water may have a sealing effect on a possible crack. Also, water may not seep into the oil cooler during the check.

NOTE! Avoid starting or stopping the ventilation system or letting air in or out of the premises during the check. This would change the air pressure in the premises, which may be misinterpreted as leakage.

NOTE! The oil cooler should, during the check, have the same temperature as the surroundings. It may not be repaired.



1. Place a clamp (2) on the oil cooler (3), as shown in the picture. Make sure that it is properly tightened.
2. Plug the other connection (1).



3. Connect the pressure-testing equipment.
4. Place the oil cooler in a tub of water.
5. Set the air pressure to 100 kPa (14.5 psi).
Check if there are air bubbles coming from the oil cooler.
6. Increase the pressure to 500 kPa (72.5 psi).
Hold the pressure for 1 minute.
The pressure may not drop.

NOTE! If the pressure drops during the check, there is a leakage and the oil cooler must be replaced.

Lubricating oil pressure (22002)

Special tools:

Manometer 999 6398

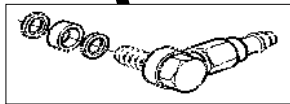
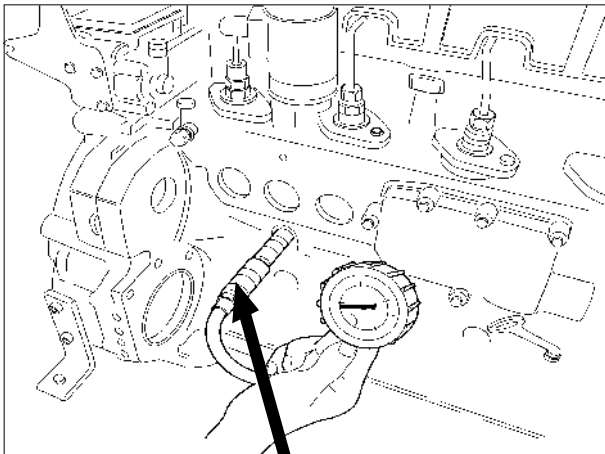
Nipple 999 6066

Spacer art.nr. 1678297

Alternately:

Electrical pressure gauge 999 8496

together with hose 999 8493



1. Measure the lubricating oil pressure on the start motor side of the engine, as in picture, using the manometer together with nipple and spacer.

Minimum oil pressure at operation temperature and idle speed:

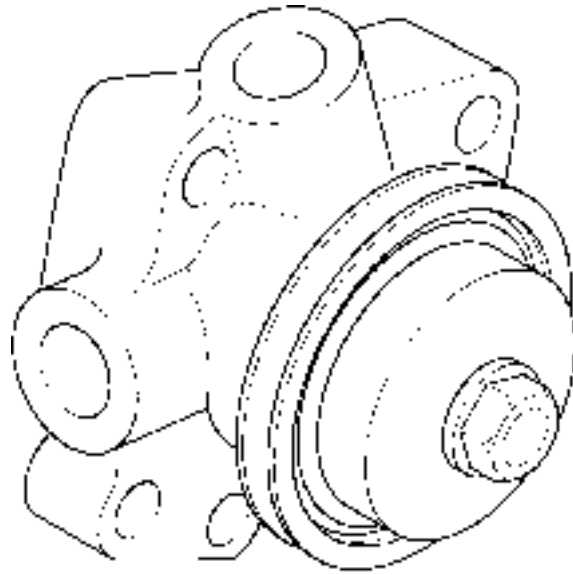
520, 530-532: **90 kPa** (13.1 psi)

720, 721,722, 730-733: **80 kPa** (11.6 psi)

At rated speed, se Technical Data.

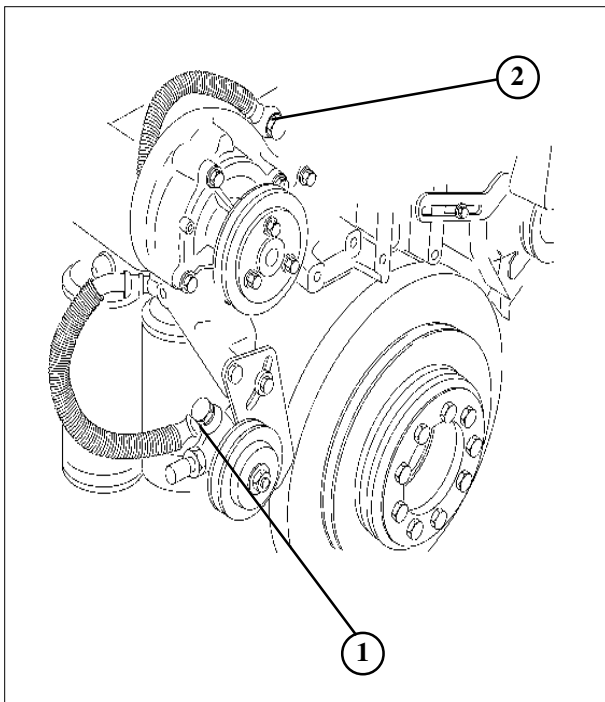
Group 23 Fuel System

Fuel pump



Special tools:

Nipple	999 6066
Manometer	999 6398
Hollow screw	art. no. 180211
Copper washer	art. no. 969011
Alternatively:	
Electrical pressure gauge	999 8496
Hose	999 8493



Fuel supply pressure, checking. (23315)

⚠ IMPORTANT! Clean the nipple and hose thoroughly before connecting them to the fuel system. The injectors are sensitive and may easily be damaged by contamination.

1. Check the fuel pump and replace if necessary.
2. Measure the supply pressure before (1) and after (2) the fuel filter.
Use manometer 999 6398, nipple 999 6066 with a long hollow screw (art. no. 180211) and new copper washers (969011).

Supply pressure:

1) after pump: **0.5 MPa / 5 bar**

2) after filter:

at 1500 rpm **0.28 MPa / 2.8 bar**

Changing injection pump

(23611)

Before installing the new injection pump: See chapter "Injection pump installation"

NOTE! Before replacing the injection pump, make sure that the reason for the power loss is due to an injection pump and not due to a damaged delivery pipe. Check the inner diameter of the pipe. It should be **1.8 mm (0.07")** for all 520/720/721/722 engines.

When installing a new injection pump, the shim thickness under the pump must be calculated to give the correct injection timing.

Follow the procedure below:

1. Clean the engine thoroughly before removing the rocker cover. A lot of dirt is usually trapped between the inlet manifold and the rocker cover.
2. Remove the plug and install tool 999 8684.
3. Adjust the control rod to stop position.
4. Make sure that the roller tappet for the pump is on the camshaft base circle.
Loosen the screws holding the pump (a couple of turns) and tap the pump gently to see if it is popping up.

NOTE! The pump is spring-loaded and if the tappet is not on the base circle, the force from the pump spring can damage the threads in the engine block when removing the screws.

5. Remove the shim in the roller tappet. Cover up the hole to protect from any dirt getting into the engine.
6. Read the **EP-code** on the engine name plate for the cylinder in question. Enter the value in "Calculation 1, Technical data".
7. Read off the corresponding corrected dimension, **E_k**, from Table 3. Enter the value in "Calculation 1, Technical data".
8. Read off the length of the pump, **L₀**, from Table 1. Enter the value in "Calculation 1, Technical data".
9. Read off the manufacturing tolerance, **A**, on the injection pump. Enter the value **A/100** in "Calculation 1, Technical data".
10. Calculate the theoretical shim thickness, **T_s**, according to the formula **T_s = E_k - (L₀ + A/100)**. See "Calculation 1, Technical data".
11. Read the actual shim thickness, **S_s**, from Table 2.

12. Slide the shim along e. g. a screwdriver into place.

NOTE! Only one shim should be used.

13. Make sure the roller tappet for the pump in question is on the camshaft base circle.
14. Turn the pump linkage lever into middle position, oil the O-rings on the pump and insert the pump.

NOTE! make sure the pump linkage lever is introduced properly in the slot of the control rod before pushing the pump down.

15. Install the pump flange with the chamfered hole side facing the pump and pre-load the screws to **5 Nm (3.7 lbf ft)**. Thereafter slacken the screws **60°**.
16. Use socket 11668403 and a torque wrench with gauge to turn the injection pump CCW slowly and gently while observing the torque on the gauge, required to turn the injection pump, e. g. **3.5 Nm (2.6 lbf ft)**. Stop turning when the pump has reached its stop position and the reading on the gauge has gone up **1 Nm (0.7 lbf ft)**
Example: 3.5 + 1 = 4.5 Nm (2.6 + 0.7 = 3.3 lbf ft).
17. Tighten the screw on the pump flange **60°**. Then tighten them alternately, start with the screw remote of the flywheel with **7 Nm - 10 Nm - 30 Nm (5.2 - 7.4 - 22.2 lbf ft)**.
18. After installation of the pump, remove the special tool 999 8684 and check that the fuel tack is moving freely.
19. Pre-tension the delivery pipe in two stages:
1 **5 Nm (3.7 lbf ft)**
2 **25 ± 3.5 Nm (18.5 ± 2.6 lbf ft)**.

NOTE! A delivery pipe which has been removed, should be replaced with a new one.

20. Fit a new rocker cover gasket and the rocker cover.
Tighten the screws to **11 ± 1 Nm (8.1 ± 0.7 lbf ft)**.

Group 25 Inlet and exhaust system

Boost pressure

(25502)

Special tools:

Manometer 999 6398

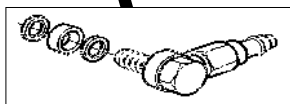
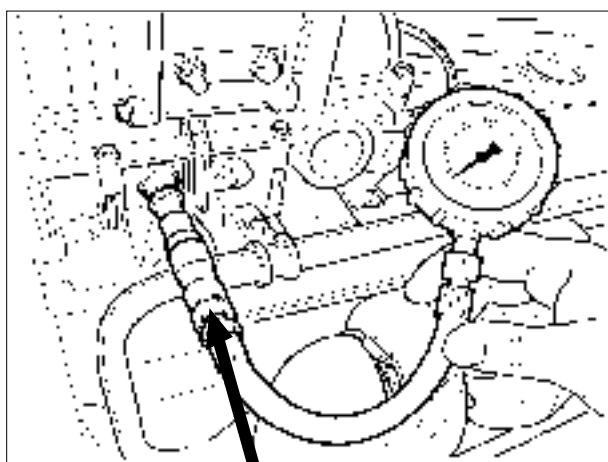
Nipple 999 6066

Spacer art.nr. 1678297

Alternately:

Electrical pressure gauge 999 8496

together with hose 999 8493

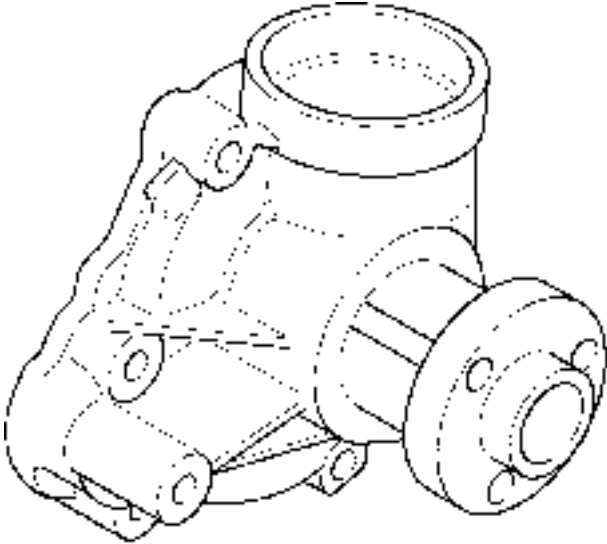


1. Measure the turbocharger boost pressure, as in picture, using the manometer together with nipple and spacer.

For boost pressure, see "Technical Data".

Group 26 Cooling System

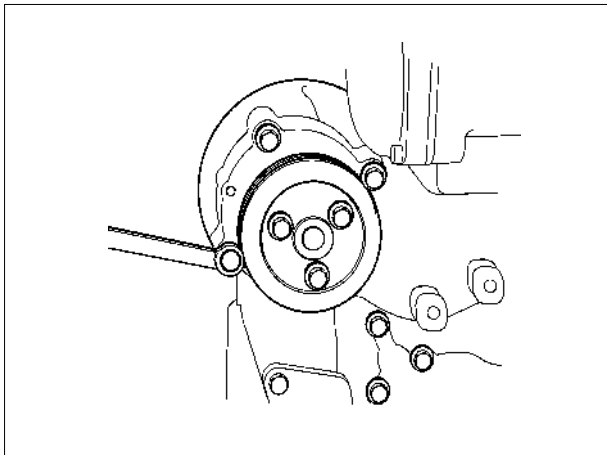
Coolant pump, check / replace (26211)



Depending on which coolant pump model that is installed, follow one of the procedures below.

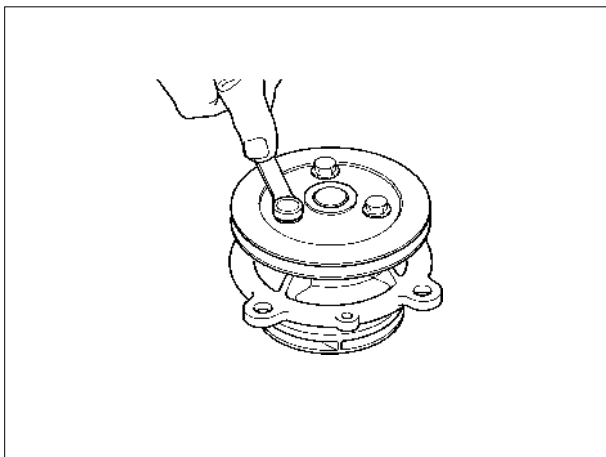
Modell 1:

1. Remove the coolant pump from the housing.
2. Remove the V-belt pulley.
3. Check coolant pump and sealing for leaks, replace the coolant pump if necessary.
4. Fit the V-belt pulley.
Tighten the bolts to..... **21 Nm** (15 lbf ft).
5. Fit the coolant pump in the housing with a new gasket.

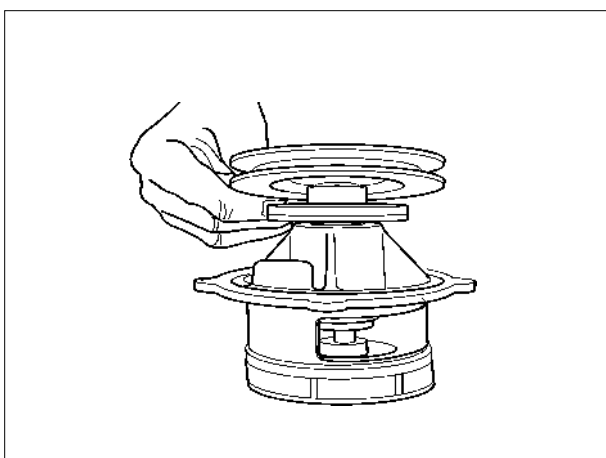


Modell 2:

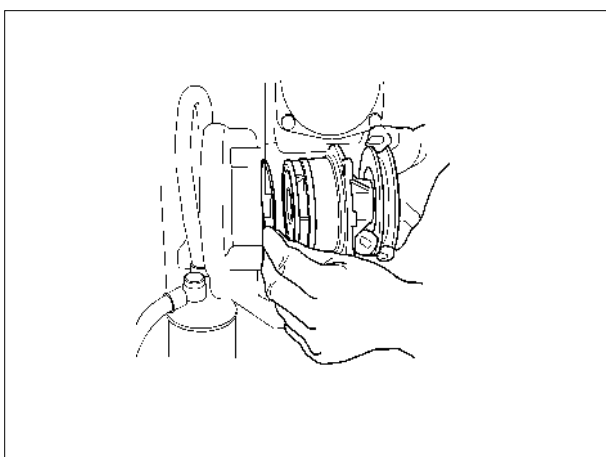
1. Loosen the coolant pump from the house.



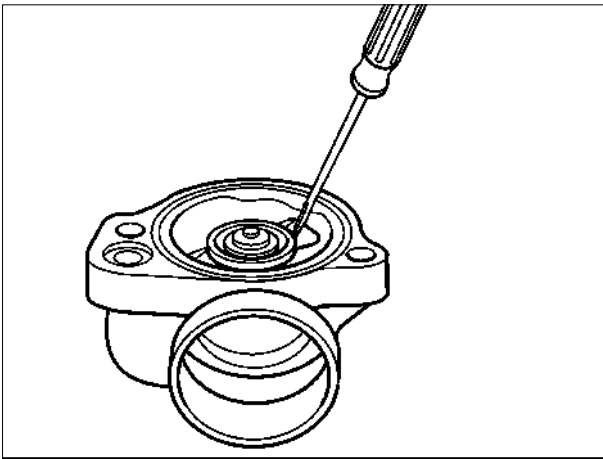
2. Remove the V-belt pulley.
3. Check coolant pump and sealing for leaks, replace the coolant pump if necessary. Make sure that the overflow hole for the spindle seal is not filled up.



4. Fit the V-belt pulley. Tighten the bolts to..... **21 Nm** (15 lbf ft).



5. Fit the coolant pump in the housing with a **new** gasket.



Thermostat

(26273)

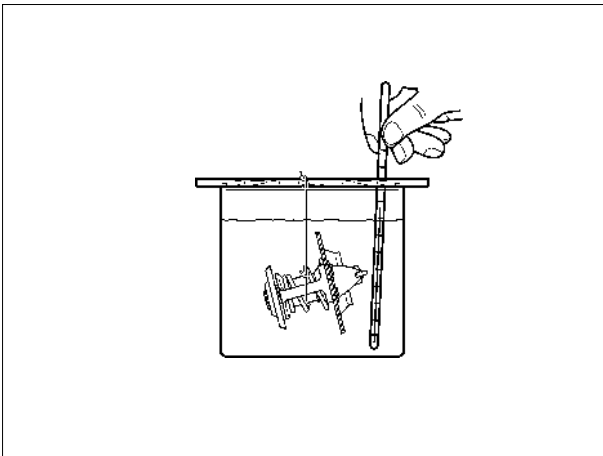
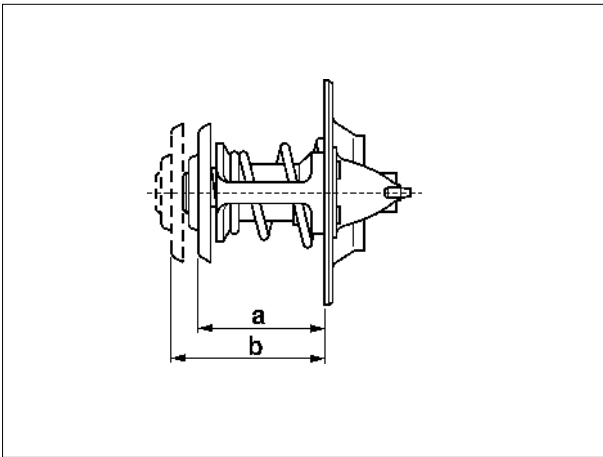
Thermostat, checking

1. Push the thermostat down, then turn it and take it out of the thermostat housing.
2. Test the thermostat function and replace if necessary.
3. Push the thermostat down into the thermostat housing and turn it.

NOTE! The securing yoke must engage with the thermostat housing.

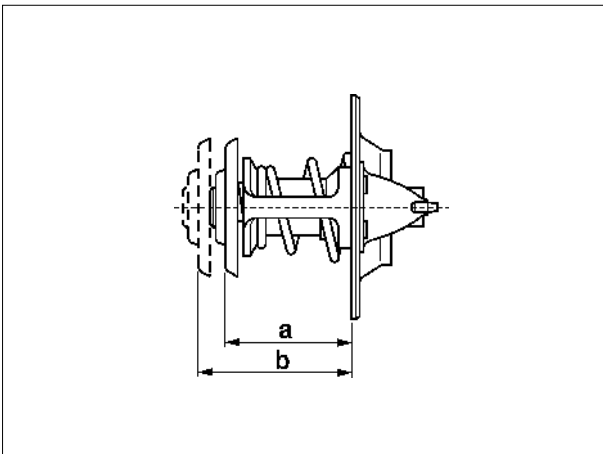
Thermostat, function check

1. Measure the measurement "a" on the thermostat.
 "a" = the thermostat starts to open **83°C**
 "b" = the thermostat is completely open **93°C**



2. Heaten the thermostat in a water bath.

NOTE! To get the exact opening temperature, measure as close to the thermostat as possible without touching it. Stir the water unceasingly to get an even temperature distribution. The temperature should not rise more than 1°C/min, or the time of opening is delayed.



3. Measure the measurement "b" on the thermostat.

When the thermostat is completely open, 95°C, the difference between "a" and "b" should be at least 8 mm.

"a"- "b" = **min 8 mm.**

Wiring diagrams

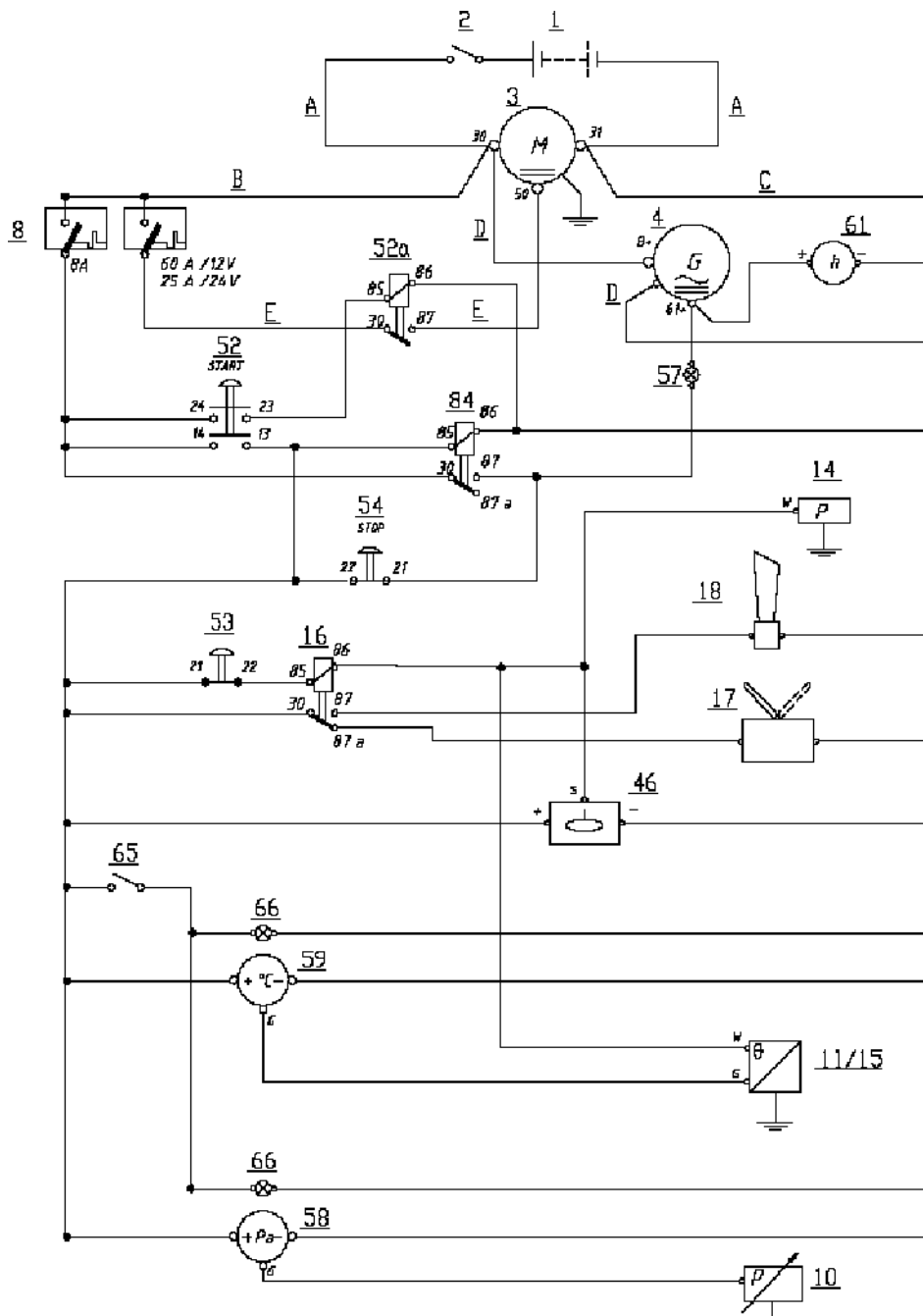
NOTE! The wiring diagrams on this and the following pages are examples of wiring diagrams. The engines are **not** fitted with an electrical system in the factory.

Wiring diagram (TD/TAD 520, 720, 721, 722 GE stage 1 engines)

- 1. Battery
- 2. Main switch
- 3. Starter motor
- 4. Alternator
- 8. Fuse
- 10. Oil pressure sender
- 11. Temperature sender/engine connector
- 14. Oil pressure connector
- 15. Temperature sender/engine connector
- 16. Relay
- 17. Stop solenoid

- 18. Horn
- 46. Water level connector (720 models)
- 52. Start connector
- 52a. Start relay
- 53. Interlock button
- 54. Stop button
- 57. Charge warning lamp
- 58. Oil pressure gauge
- 59. Water temperature gauge
- 61. Hour counter
- 65. Instrument illumination connector
- 66. Instrument illumination
- 84. Holding relay

Conductor area	
12V	24V
A. 90 mm ² (0.140 in ²)	70 mm ² (0.109 in ²)
B. 10 mm ² (0.016 in ²)	2.5 mm ² (0.004 in ²)
C. 2.5 mm ² (0.004 in ²)	2.5 mm ² (0.004 in ²)
D. 10 mm ² (0.016 in ²)	6 mm ² (0.009 in ²)
E. 6 mm ² (0.009 in ²)	2.5 mm ² (0.004 in ²)
Unspecified area 1 mm ² (0.002 in ²)	



Wiring diagram (TD/TAD520, 720, 721, 722 VE stage 1 engines with start/ stop button activation)

1. Battery
2. Main switch
3. Starter motor
4. Generator
5. Hourmeter
6. Fuse
7. Start button
8. Start relay
9. Holding current relay
10. Charging control lamp 3W
11. Stop button
12. Switch for instrument light
13. Revolution counter
14. Instrument light
15. Preheating time control unit
16. Glow plugs
17. Tachometer (sender)

18. Preheater lamp
19. Temp switch excessfuel solenoid
20. Excessfuel solenoid
21. Stop solenoid
22. Signal horn
23. Water temperature gauge
24. Temp sender/switch engine
25. Alarm lamp cool water
26. Oil pressure gauge
27. Oil pressure sender/switch
28. Alarm lamp oil pressure
29. Alarm lamp water level
30. Water level switch
31. Relay
32. Diode
33. Supply button

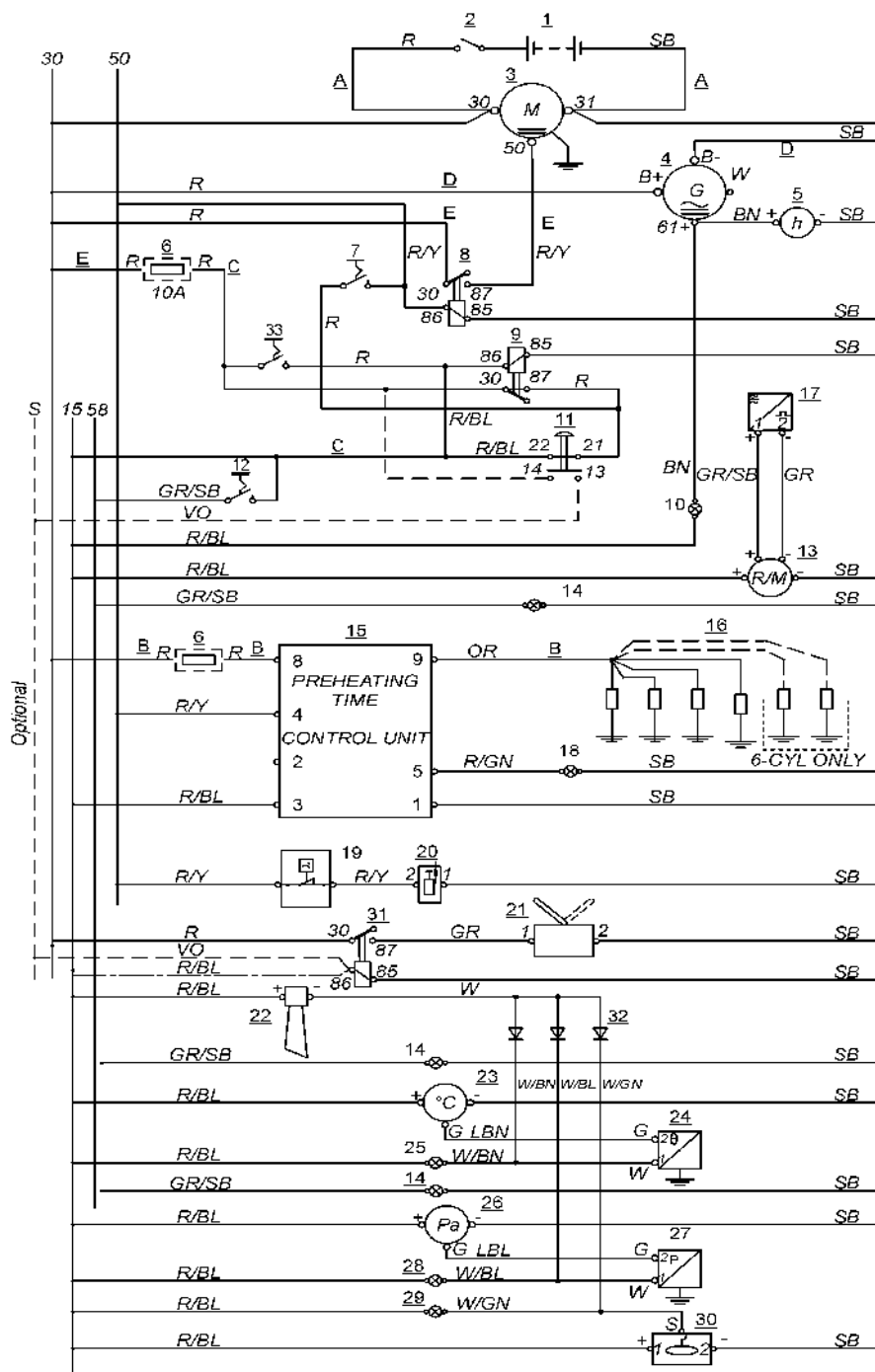
Conductor area

12V		24V	
A.	90 mm ² (0.140 in ²)	70 mm ² (0.109 in ²)	
B.	10 ¹ mm ² (0.016 in ²)	6 ² mm ² (0.009 in ²)	
C.	25 mm ² (0.04 in ²)	25 mm ² (0.04 in ²)	
D.	50 mm ² (0.08 in ²)	25 mm ² (0.04 in ²)	
E.	6 mm ² (0.009 in ²)	25 mm ² (0.04 in ²)	

Unspecified area 15 mm² (0.023 in²)

¹ For 6-cylinder = 16 mm² (0.025 in²)

² For 6-cylinder = 10 mm² (0.016 in²)

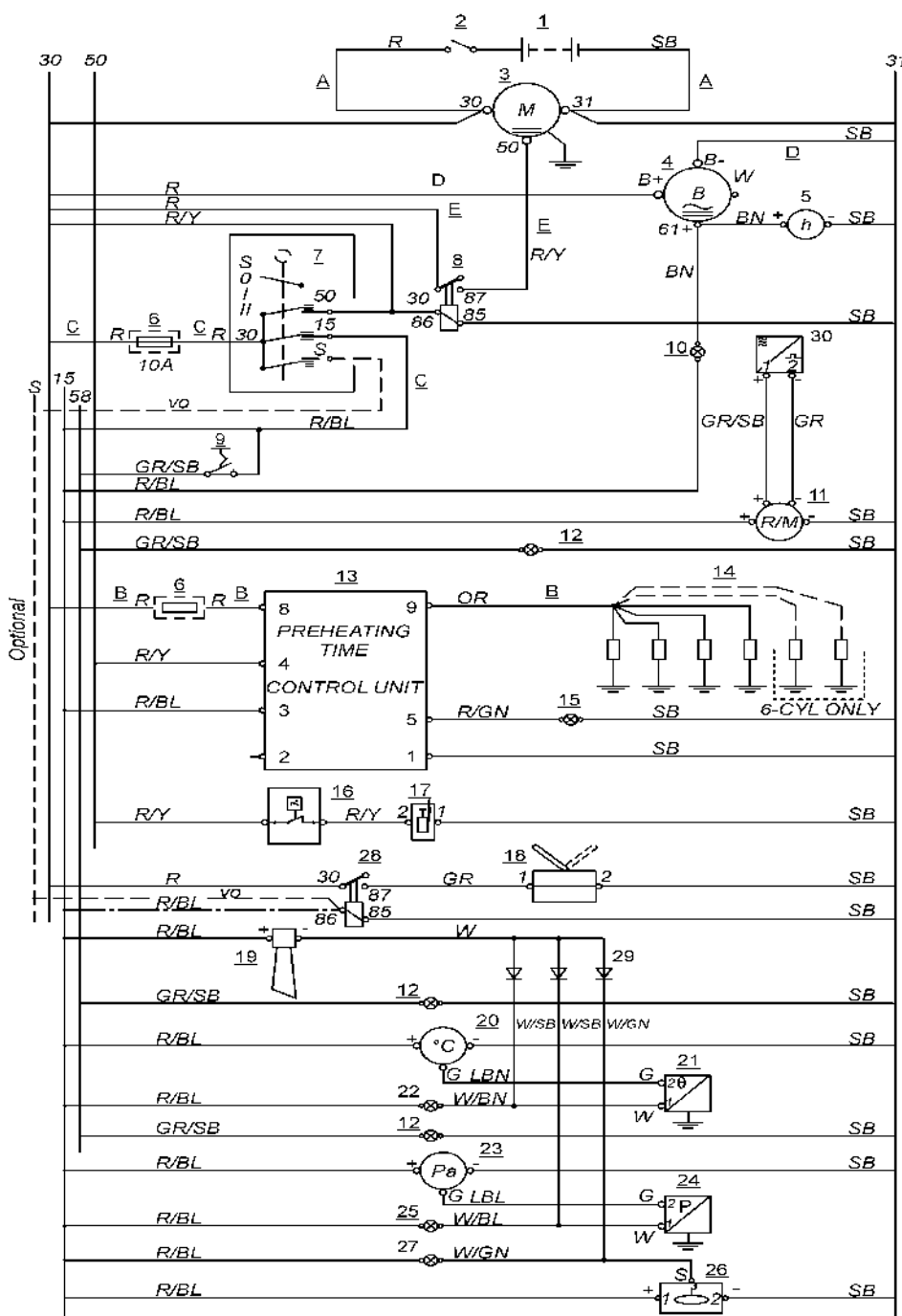


Wiring diagram (TD/TAD520, 720, 721, 722 VE stage 1 engine with key activation)

- | | |
|-------------------------------------|--------------------------------|
| 1. Battery | 17. Excessfuel solenoid |
| 2. Main switch | 18. Stop solenoid |
| 3. Starter motor | 19. Signal horn |
| 4. Generator | 20. Water temperature gauge |
| 5. Hourmeter | 21. Temp sender/switch engine |
| 6. Fuse | 22. Alarm lamp cool water |
| 7. Key switch | 23. Oil pressure gauge |
| 8. Start relay | 24. Oil pressure sender/switch |
| 9. Switch for instrument light | 25. Alarm lamp oil pressure |
| 10. Charging control lamp 3W | 26. Water level switch |
| 11. Revolution counter | 27. Alarm lamp water level |
| 12. Instrument light | 28. Relay |
| 13. Preheating time control unit | 29. Diode |
| 14. Glow plugs | 30. Tachometer (sender) |
| 15. Preheater lamp | |
| 16. Temp switch excessfuel solenoid | |

Conductor area

	12V	24V
A.	90 mm ² (0.140 in ²)	70 mm ² (0.109 in ²)
B.	10 ¹⁾ mm ² (0.016 in ²)	6 ²⁾ mm ² (0.009 in ²)
C.	25 mm ² (0.04 in ²)	25 mm ² (0.04 in ²)
D.	50 mm ² (0.08 in ²)	25 mm ² (0.04 in ²)
E.	6 mm ² (0.009 in ²)	25 mm ² (0.04 in ²)
Unspecified area 15 mm ² (0.023 in ²)		
¹⁾ For 6-cylinder = 16 mm ² (0.025 in ²)		
²⁾ For 6-cylinder = 10 mm ² (0.016 in ²)		



Wiring diagram (TD/TAD520, 720, 721, 722 VE stage 2 engines key activation)

1. Battery
2. Main switch
3. Starter motor
4. Generator
5. Hourmeter
6. Fuse
7. Key switch
8. Start relay
9. Switch for instrument light
10. Charging control lamp 3W
11. Revolution counter
12. Instrument light
13. Power relay
14. Heating flange
15. Control unit air preheater
16. Preheater lamp
17. Resistor NTC

18. Temp switch excessfuel solenoid
19. Excessfuel solenoid
20. Stop solenoid
21. Signal horn
22. Water temperature gauge
23. Temp sender/switch engine
24. Alarm lamp cool water
25. Oil pressure gauge
26. Alarm lamp oil pressure
27. Oil pressure sender/switch
28. Water level switch
29. Alarm lamp water level
30. Relay
31. Preheating button
32. Diode

Conductor area

12V		24V	
A.	90 mm ² (0.140 in ²)	70 mm ² (0.109 in ²)	
B.	16 mm ² (0.025 in ²)	16 mm ² (0.025 in ²)	
C.	25 mm ² (0.04 in ²)	25 mm ² (0.04 in ²)	
D.	50 mm ² (0.08 in ²)	25 mm ² (0.04 in ²)	
E.	6 mm ² (0.009 in ²)	25 mm ² (0.04 in ²)	
Unspecified area 15 mm ² (0.023 in ²)			

