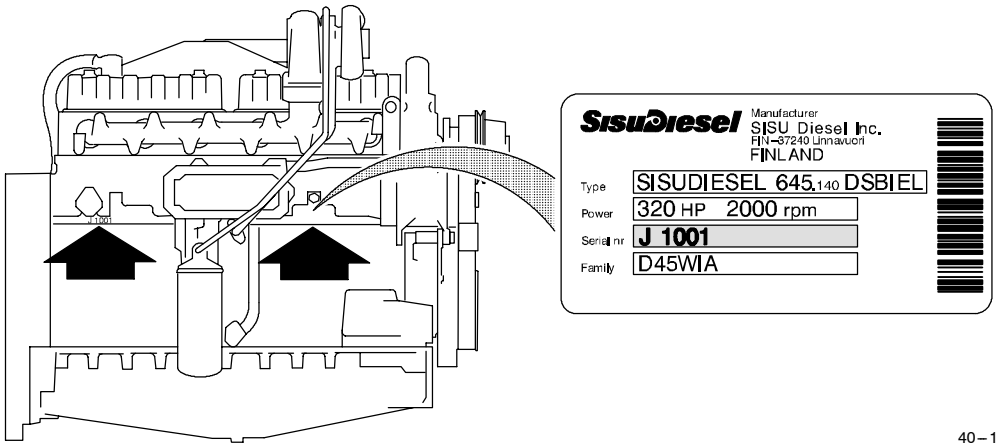
Location of the engine serial no.

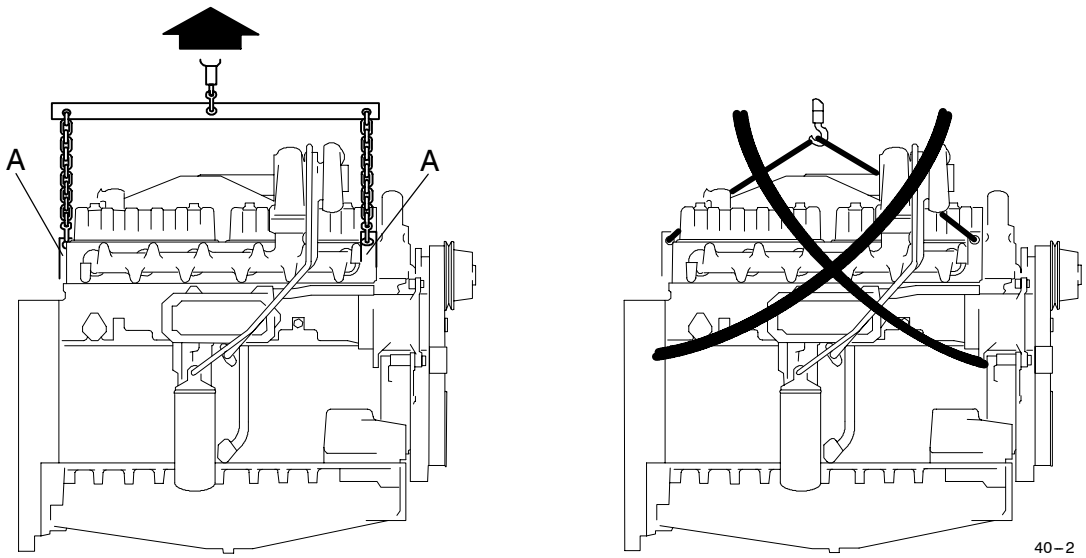


40–1

Lifting the engine

Safe lifting of the engine is done with a lifting device where the lifting force effects the lifting ears vertically.

WARNING

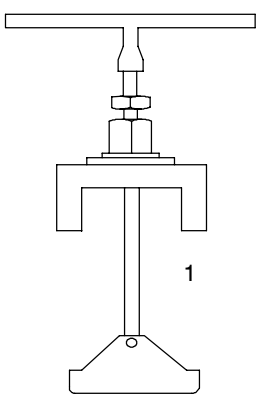


40–2

A = Engine lifting ears

Engine weight (dry, without flywheel and electrical equipment).

- self carrying and casted oil sump **826 kg**
- normal oil sump **690 kg**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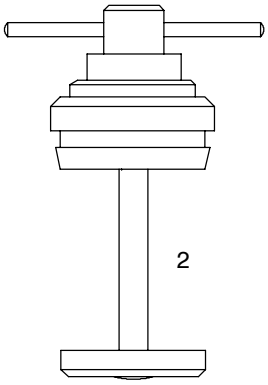
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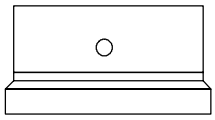
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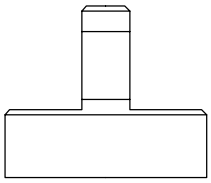
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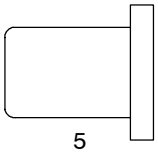
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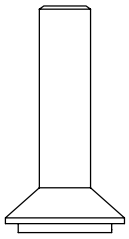
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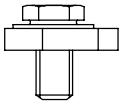
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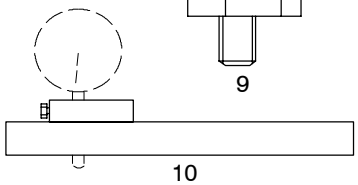
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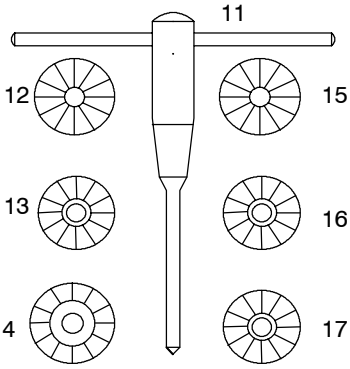
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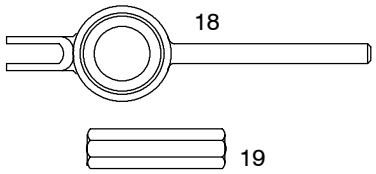
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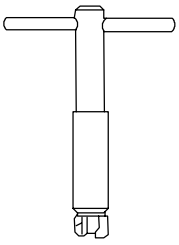
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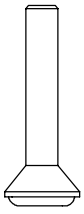
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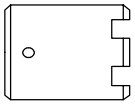
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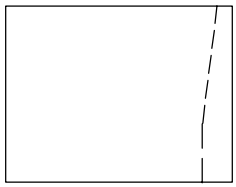
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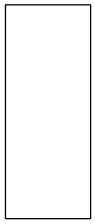
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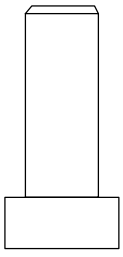
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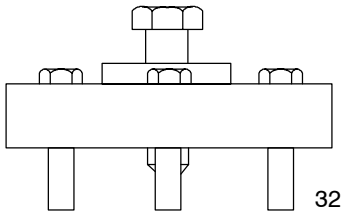
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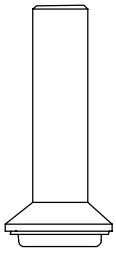
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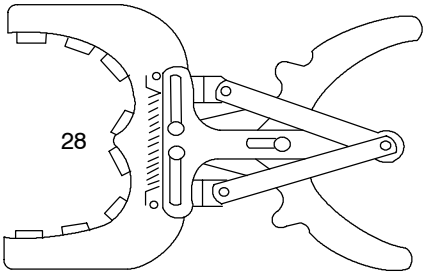
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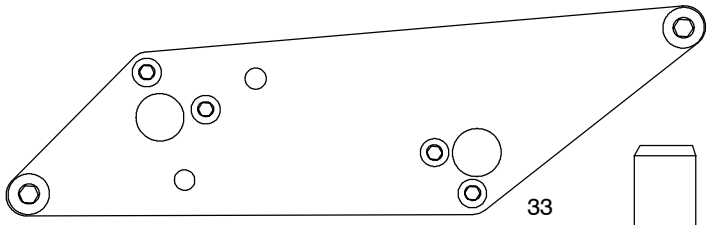
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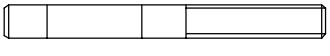
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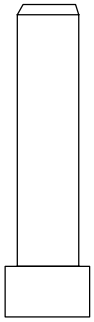
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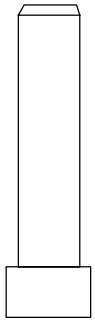
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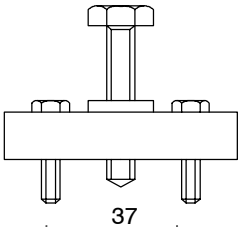
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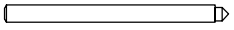
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Timing gears

Tooth backlash:

Crankshaft–idler gear	0,05...0,25 mm
Idler gear–camshaft gear	0,05...0,25 mm
Idler gear–fuel injection pump gear	0,05...0,25 mm
Max. permissible side wobble of gears	0,05 mm
Idler gear shaft, diameter	49,995...50,011 mm
Inner diameter of idler gear bearing hole	89,955...89,990 mm
Camshaft gear hole diameter	32,000...32,025 mm
Camshaft end diameter	32,043...32,059 mm

Timing marks:
Timing marks on gears are in alignment when the 1st cylinder piston is at its top dead centre between compression and power strokes.

On crankshaft gear	2 dots on tooth
On idler gear:	
– against crankshaft gear mark	1 dot on tooth
– against camshaft gear mark	1 dot on tooth
– against fuel injection pump gear mark	2 dots on notch
On camshaft gear	1 dot on notch
On injection pump gear	1 dot on notch

Connecting rod

Inside diameter of piston pin bush (with bush pressed into connecting rod)	44,025...44,040 mm
Outside diameter of piston pin bush (std)	48,080...48,120 mm
Outside diameter of piston pin bush (oversize 8363 38606)	48,580...48,620 mm
Interference fit: connecting rod small end bushing–connecting rod	0,057...0,120 mm
Connecting rod small end bore	48,000...48,025 mm
Connecting rod small end bore (oversize bush)	48,500...48,525 mm
Connecting rod big end bore	76,730...76,749 mm

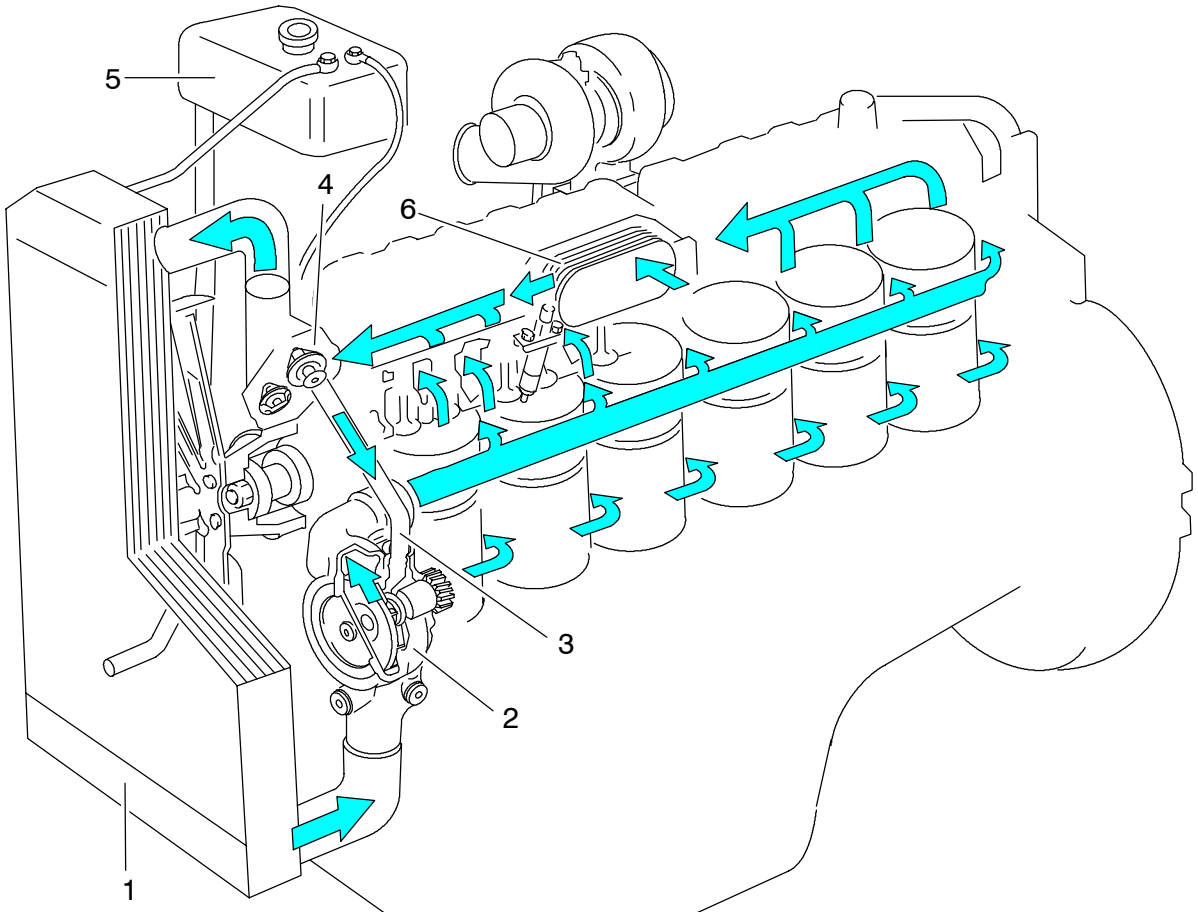
Big end bearing shell thickness:

– standard	1,833...1,842 mm
– 1st undersize 0,25 mm	1,958...1,967 mm
– 2nd undersize 0,50 mm	2,083...2,092 mm
– 3rd undersize 1,00 mm	2,333...2,342 mm
– 4th undersize 1,50 mm	2,583...2,592 mm
Big–end bearing clearance	0,046...0,102 mm
End float (side clearance) at big–end on crankshaft	0,200...0,312 mm
Piston pin bushing location perpendicular to longitudinal axis of connecting rod to be within	0,10:100
Piston pin bushing location and big–end bearing location to be parallel to within	0,05:100

Weight marking (letter) at lower end.

Max. permissible weight difference between connecting rods in the same engine	20 g

Position of connecting rod; weight marking at valve mechanism side
(away from the combustion chamber in the piston)



The cooling system

40–8

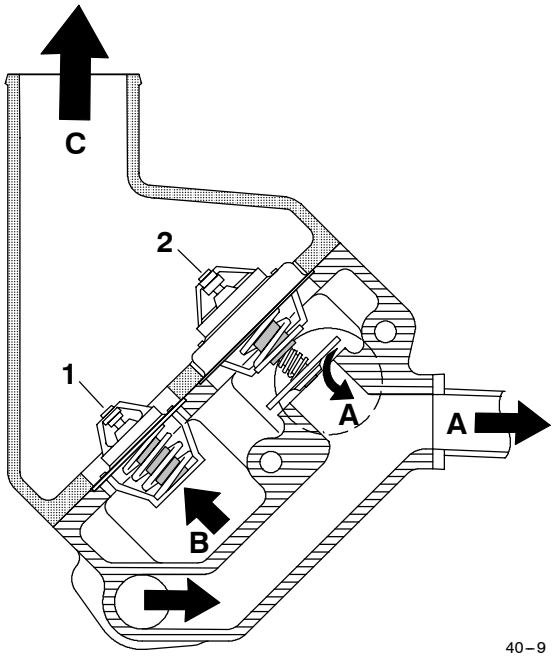
1. Radiator
2. Coolant pump
3. By–pass pipe
4. Thermostats
5. Expansion tank
6. Oil cooler

Cooling system

The gear driven coolant pump is attached to the front face of the timing gear housing. The thermostat housing is mounted on front end of the cylinder head. The system has the internal liquid circulation via the by–pass pipe. The circulation is regulated by the 2–way thermostat. This arrangement ensures a steady warming–up of the engine under all conditions.

The coolant pump has separate ball bearings.

In 645–engines there are two separate thermostats where one of them is steering the by–pass of coolant liquid. The thermostats differ in types and opening temperatures. When the coolant temperature is below the thermostat opening temperature the coolant (A) circulates through the by–pass hole into the coolant pump. The smaller, single–acting thermostat (1) opens first (at 79˚C) letting one part of the coolant (B) into the radiator. Following the load increase, also the other thermostat (2) opens (at 83˚C). This is a double–acting type which closes the by–pass hole when it opens and directs the coolant (C) into the radiator. These engine models do not have any separate winter–type thermostats.



40–9

3. CYLINDER HEAD

A. Removing cylinder head

1. Clean the engine externally and drain the coolant. Disconnect the coolant hoses from the cylinder head and the thermostat housing.

2. Remove the suction hoses between the turbocharger and the air filter and between the turbocharger and the intake manifold.

3. Disconnect the turbocharger pressure and return oil pipes.

4. Remove the pipes to the thermostart fuel reservoir.

5. Remove the injector leak–off fuel pipes and the delivery pipes. Remove the injectors. Fit blanking–off caps on all open connections.

6. Remove the intake and exhaust manifolds and the thermostat housing.

Note! It is possible to remove the cylinder head even thought these parts are attached to the head.

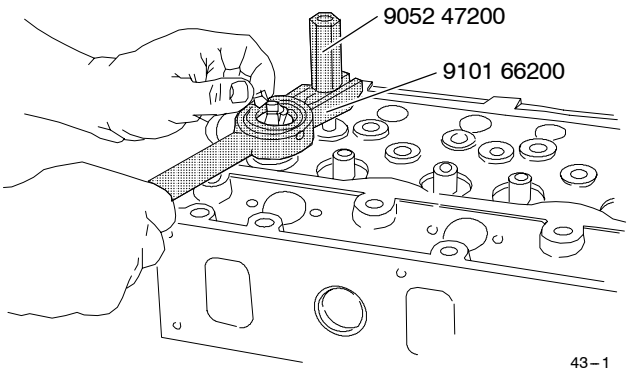
7. Remove the valve cover and the breather hose.

8. Remove the rocker arm mechanism and the push rods.

9. Loosen all the cylinder head bolts first by a 1/4 turn and then remove them. Remove the cylinder head.

B. Removing valves

Ensure that valves which are to be re–used are marked, so that they are fitted in their original locations.



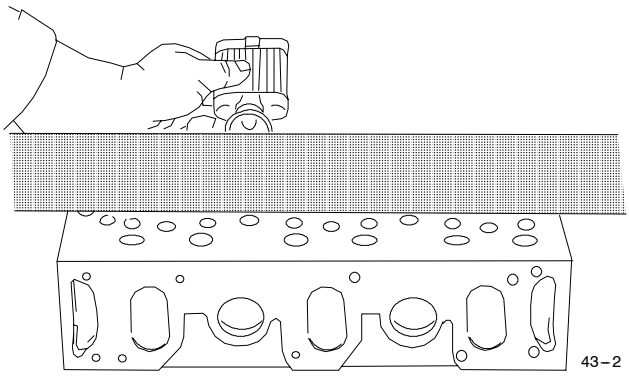
1. Install the counter screw 9052 47200 for the valve spring installing tool in the rocker arm cover bolt. For the valves in the middle, use a bolt of suitable length.

2. Compress the valve springs using lever 9101 66200. Remove the valve cotters, spring guide and spring. Remove the valves.

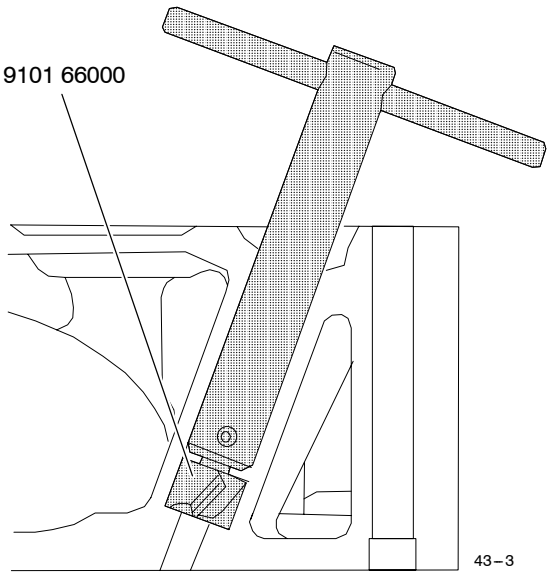
C. Checking cylinder head

1. Remove the soot from the exhaust ports, clean the sealing surfaces and wash the cylinder head.

2. Check for cracks and other damage.



3. Check the flatness of the cylinder head by using a straight edge. An uneven or warped surface should be surface ground. The height of the cylinder head, after grinding, should not be less than **104,00 mm**. The valve disc depth from the cylinder head surface should be **0,60 mm** for the exhaust valves and **0,70 mm** for the inlet valves.

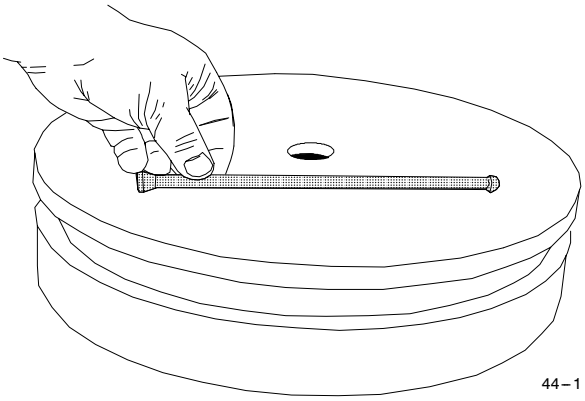


4. Straighten and clean the injector location seat in the cylinder head with cutter 9101 66000.

4. VALVE MECHANISM

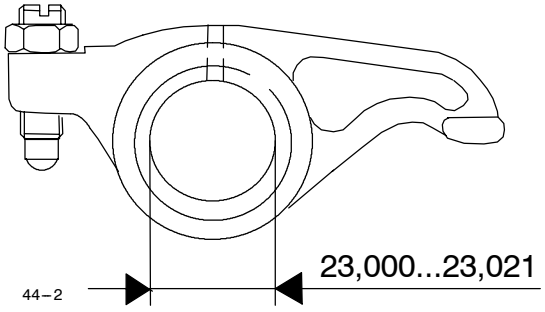
A. Reconditioning valve mechanism

1. Check the valve tappets, especially the contact surface against the camshaft. Worn or damaged tappets should be discarded.


44–1

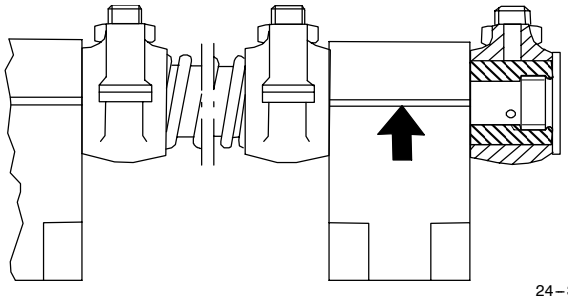
2. Check the straightness of the pushrods by rolling them on a surface table. Check also the spherical surfaces at the ends.

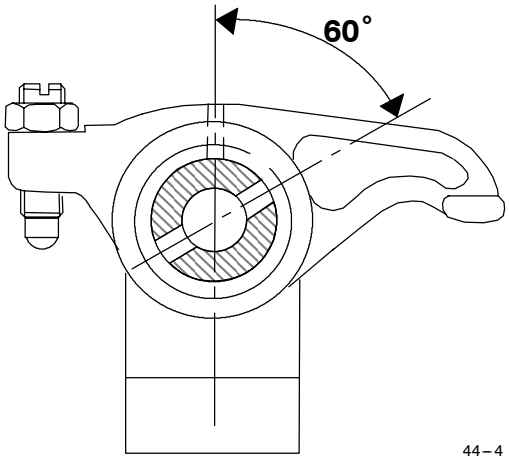
3. Dismantle and clean the rocker arm mechanism. Check the shaft for wear and that the oilways are clean.



44–2

4. Check diameter of the rocker arm bore. Change the worn or damaged rocker arm. Where necessary grind the rocker arm valve contact surface to the correct shape. Do not grind more than necessary as the hardened layer is thin.


24–3



44–4

5. Fit the plug to the other end of the rocker arm shaft. Lubricate the shaft and fit various parts in a correct order. Note the correct position of the shaft and the bearing brackets. The split side of the bracket and the shaft oil holes must be turned to the valve side (see figures above). Fit the other end plug.

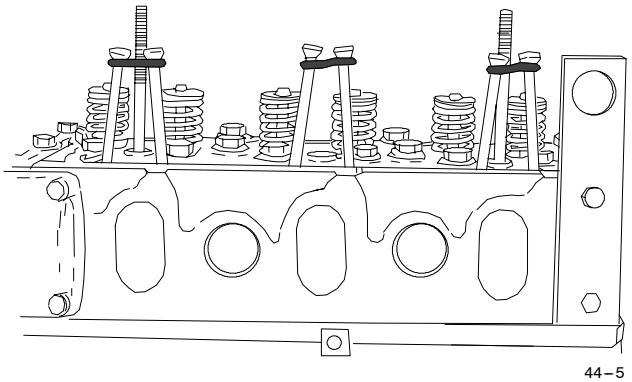
B. Changing camshaft/ camshaft gear

1. Remove the inlet pipe between the turbocharger and the intake manifold. Remove the valve cover and the breather pipe. Remove the rocker arm mechanism.

2. Remove the radiator, cooling fan, alternator and the ribbed V–belt.

3. Remove the belt pulley and damper. Slacken the crankshaft nut. **Do not remove it!** Remove the hub using puller 9104 53300. Take off the puller, open the nut and remove the hub.

4. Remove the timing gear casing cover (engine front cover).


44–5

5. Connect the pushrods in pairs, using o–rings or elastic bands to prevent them from falling through.

Note! Do not connect the pushrods too tightly as this might cause them to bend or snap.

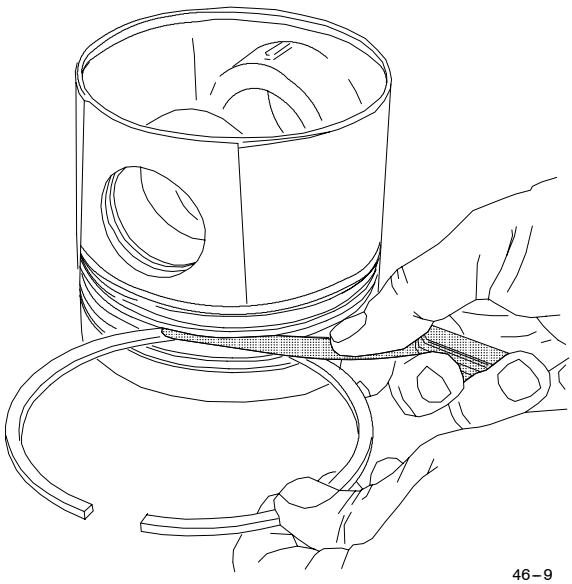
6. Crank the engine until the aligning marks on the idler gear and camshaft gear are facing each other. Extract the camshaft.

The letters show the weight classes as follows:

	Part no	Weight
C	8363 55175	2931 – 2950 g
D	8363 55176	2951 – 2970 g
E	8363 52751	2971 – 2990 g
F	8363 52752	2991 – 3010 g
G	8363 52753	3011 – 3030 g
H	8363 52754	3031 – 3050 g
I	8363 52755	3051 – 3070 g
J	8363 52756	3071 – 3090 g
K	8363 52757	3091 – 3110 g
L	8363 52758	3111 – 3130 g
M	8363 52759	3131 – 3150 g
N	8363 52760	3151 – 3170 g
0	8363 52761	3171 – 3190 g
P	8363 52762	3191 – 3210 g
R	8363 52763	3211 – 3230 g
S	8363 52764	3231 – 3250 g
T	8363 52765	3251 – 3270 g
U	8363 52766	3271 – 3290 g
V	8363 52767	3291 – 3310 g
X	8363 52768	3311 – 3330 g
Y	8363 52769	3331 – 3350 g
Z	8363 52770	3351 – 3370 g

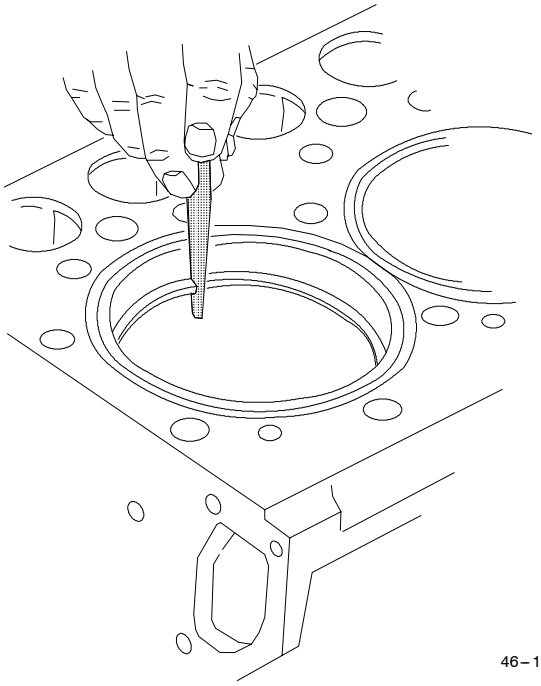
E. Changing piston rings

1. Remove the piston rings with piston ring pliers 9052 46900. Do not open the rings more than necessary. If the rings are to be used again ensure that they are fitted in the same groove.



46 – 9

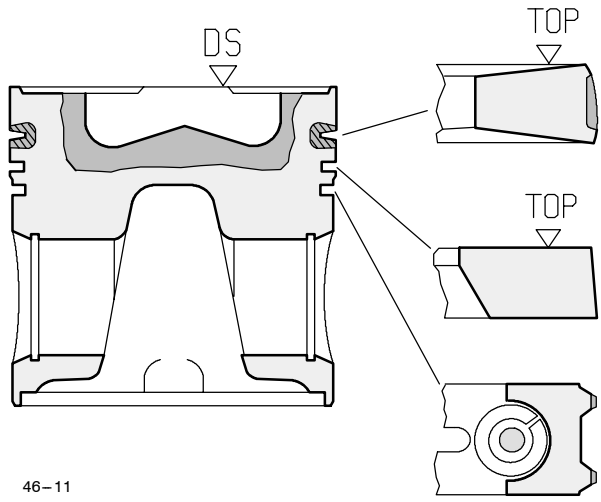
2. Clean the piston ring grooves and measure the piston ring clearance, which must not exceed **0,15 mm**. Determine whether too large a clearance is due to worn rings or a worn groove. Change worn parts.



46 – 10

3. Measure the piston ring gap by pushing one piston ring at a time into the cylinder bore. The piston ring gap must not exceed **1 mm** on 1. and 3. piston rings and **1,3 mm** on 2. piston ring.

4. Fit the piston rings on the piston using the piston ring pliers. Ensure that the rings are fitted in the correct groove and that "TOP", or the manufacturer's designation, faces upwards.

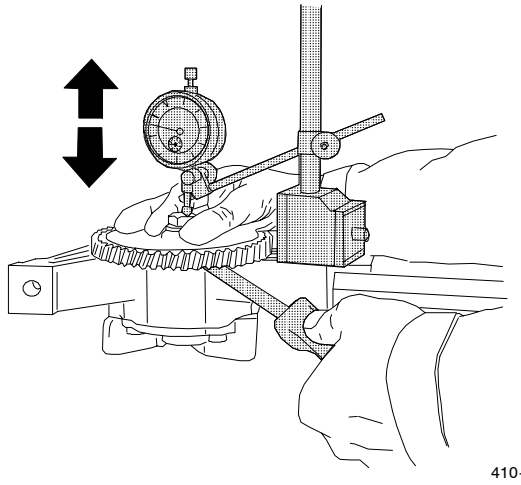


46 – 11

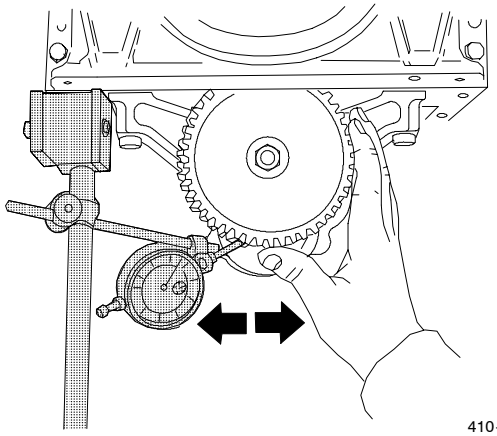
C. Assembling and fitting lubricating oil pump

1. Fit the gear wheels in the pump body. Fit the cover using a new gasket. Partly tighten the bolts. Rotate the pump shaft and tap the side of the cover lightly until the position is reached where the shaft rotates most freely. Tighten the bolts and check that the shaft still rotates freely.

2. Fit the drive gear onto the shaft. Apply Loctite 242 onto the nut threads and tighten the nut to **60 Nm**. Remember the washer under the nut.


410–4

3. Fasten the oil pump in a vice and check the end float between gear and pump housing. The clearance which should be **0,03...0,11 mm**, is adjusted by the number of gaskets between the cover and body.


410–5

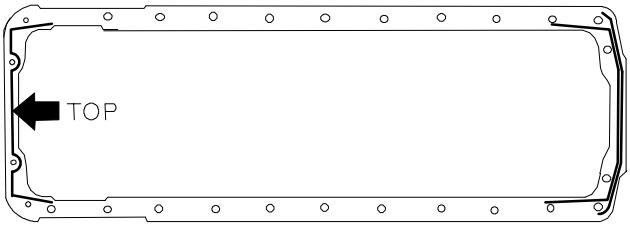
4. Fit the pump and check the tooth backlash against the crankshaft gear. The clearance, which should be **0,05...0,25 mm**, is adjusted with shims between the pump body and the cylinder block (shim 0,2 mm, order no 8360 07871). One shim increases/decreases the backlash about 0,07 mm.

Note! When measuring the tooth backlash, the engine should be the correct way up as the crankshaft bearing clearance affects the tooth backlash.

5. Connect suction and pressure pipes together with new seals. Fit the oil sump and fill in the lubrication oil.

D. Fitting oil sump gasket

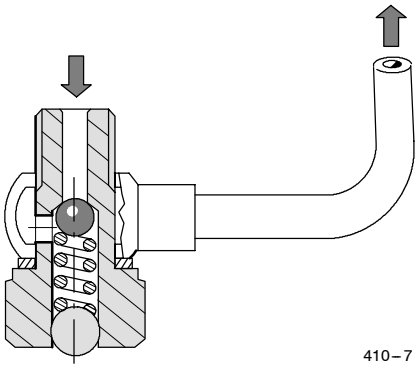
Fit the oil sump gasket with the silicone stripes against the cylinder block (self carrying and casted oil sumps).



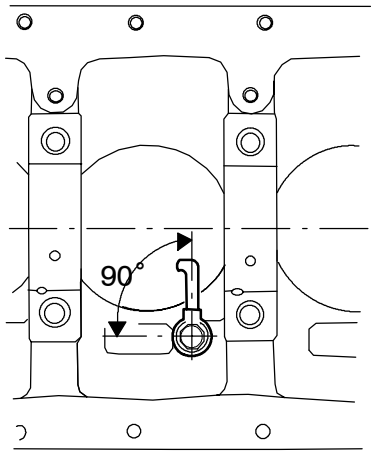
410–6

E. Piston cooling nozzles

The cooling nozzles can be removed after removing the oil sump. The nozzles have a ball valve with an opening pressure of **3±0,25 bar.**


410–7

1. Change the valve if necessary. Detach the valve from the engine and remove the nozzle pipe. Fit a new valve.

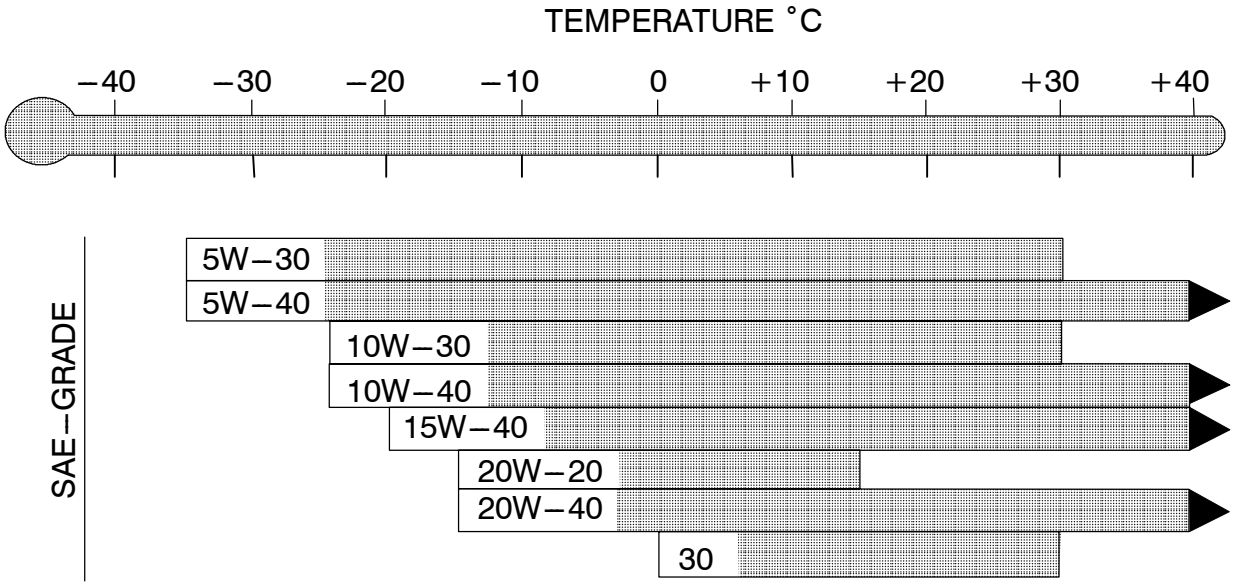


410–8

2. Fit the nozzle pipe at the angle of **90°** to the centre line of the crankshaft according to the above picture. Tighten the valve to **30 Nm**. Ensure that the pipe does not touch the pistons or connecting rods when the engine is running.

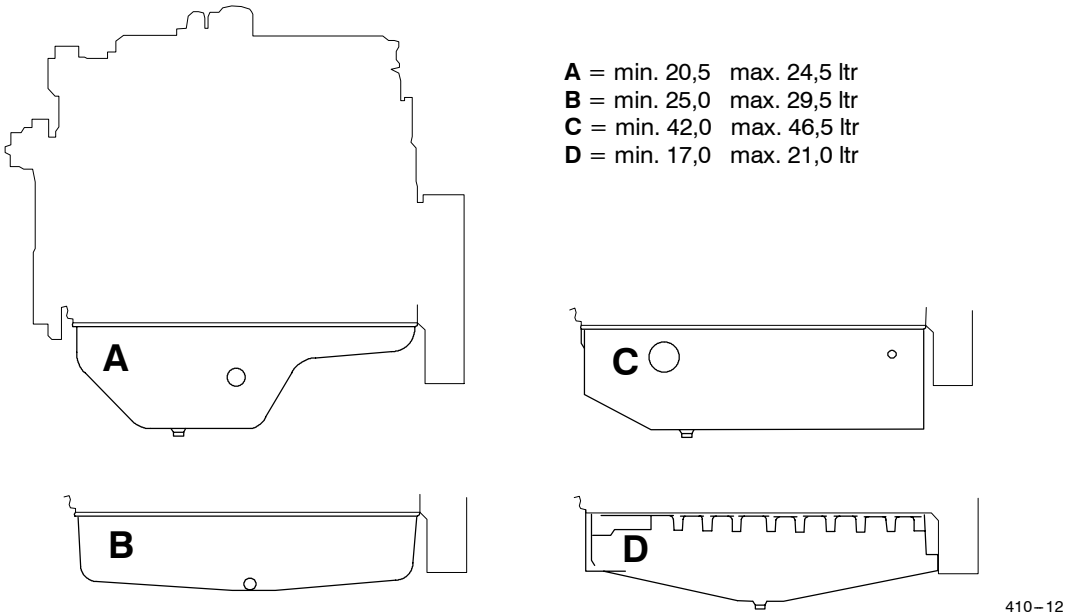
G. Lubricating oil quality requirements

– Turbocharged engines	API **CF–4, CG–4, CH–4**	ACEA **E2/E3–96, E4–98, E5–99**
– Low emission (E) engines	API **CG–4, CH–4**	ACEA **E3–96, E4–98, E5–99**



410–11

H. Oil capacities



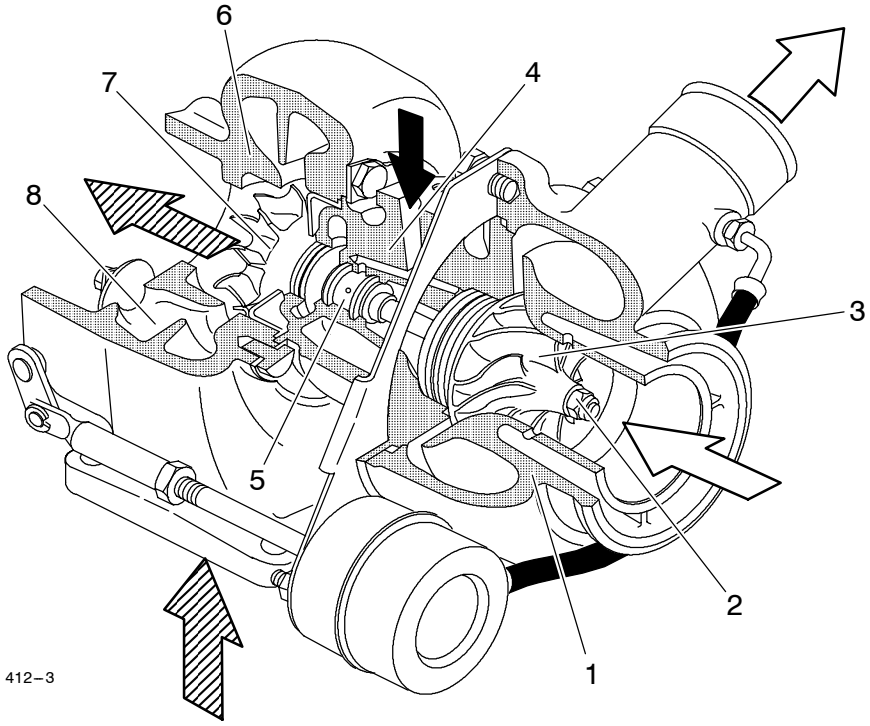
A = min. 20,5 max. 24,5 ltr
B = min. 25,0 max. 29,5 ltr
C = min. 42,0 max. 46,5 ltr
D = min. 17,0 max. 21,0 ltr

410–12

If any defects or wear are confirmed, the turbocharger should be reconditioned.

If the engine does not work correctly and the turbocharger is not defective or too worn, the fault could be traced to one of the following items:

– Blocked air filter.
– Leakage in the inlet or exhaust systems. Leaking flange seal.
– Defective or wrongly adjusted injection pump.
– Wrongly adjusted throttle linkage.
– Defective or wrongly adjusted injectors.
– Low fuel pressure (e.g. blocked fuel filter).
– Low compression, wrong valve clearance.



Turbocharger Schwitzer

1. Compressor cover
2. Lock nut
3. Compressor wheel
4. Bearing housing
5. Journal bearing
6. Turbine housing
7. Shaft and turbine wheel
8. By–pass channel

INLET AIR
EXHAUST GASES
LUBE OIL

D. Fitting turbocharger

Locate the cause of the defects on the turbocharger. Remedy the fault before fitting the new turbocharger.

In order for the turbocharger to work satisfactorily, it is important that the engine oil is in good condition. Likewise the oil should be to the correct quality specification. The air filter and oil filter should be serviced according to the handbook specification.

The setting of the injection pump critically affects the function of the turbocharger. The injection pump should be adjusted according to the manufacturers instructions.

1. Check the tightness of the intake and exhaust manifolds, and that they are securely fastened. Ensure that there are no loose carbon or rust particles, or other foreign objects in the manifolds.

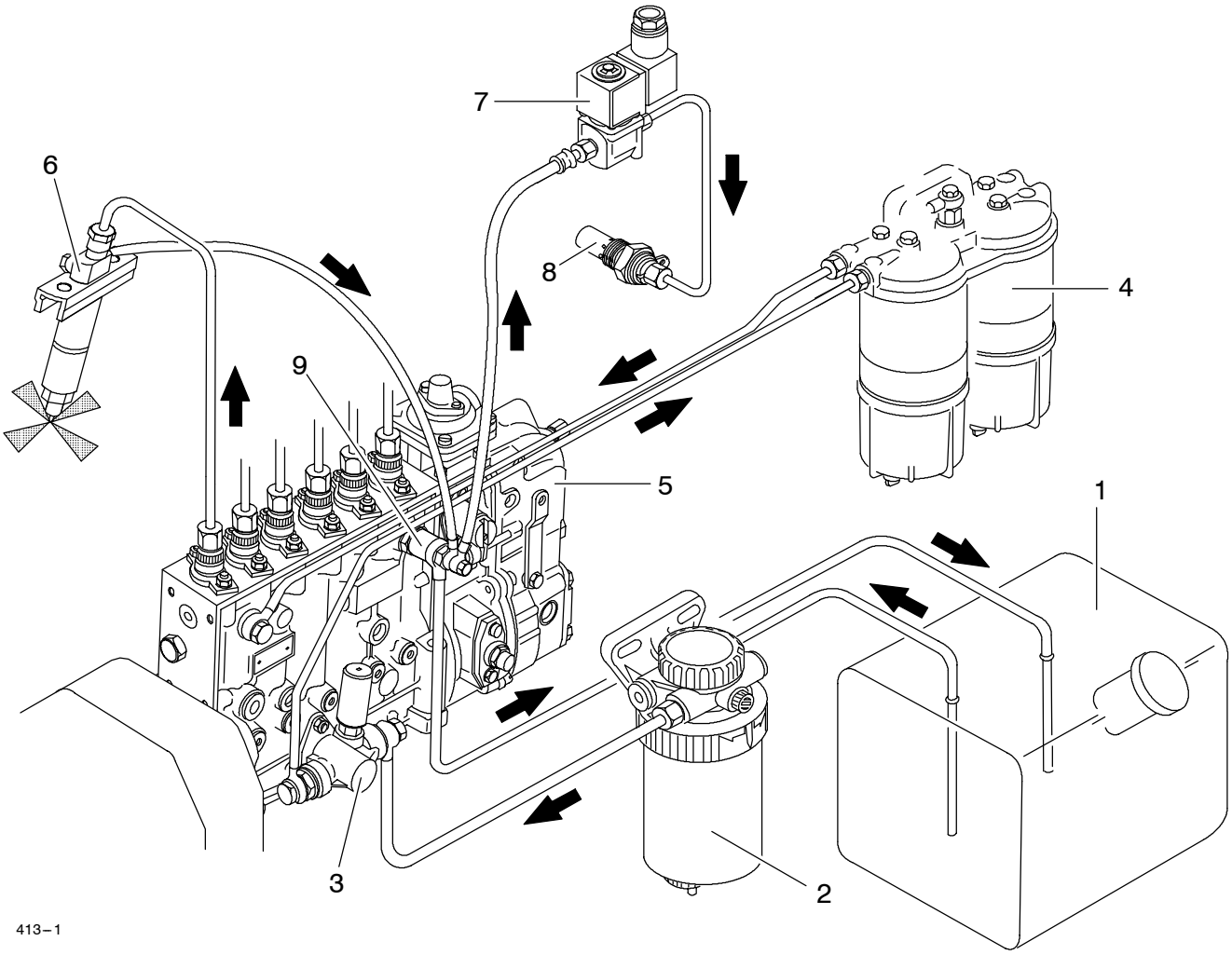
2. Connect the turbocharger to the exhaust manifold and tighten down using a new gasket.

3. Connect the inlet pipe and the exhaust pipe on the turbo.

4. Pour clean engine oil into the bearing housing through the inlet oilway. This is very important in order to ensure that the turbocharger is lubricated at the time of starting.

5. Connect the pressure and return oil pipes. Use a new seal. Check that there are no tensions in the pipes when tightening.

6. Before starting, pull out the stop control and crank the engine over with the starter motor so that the oil pressure rises. Start the engine and check that there are no leaks.



Fuel system

1. Fuel tank
2. Prefilter
3. Feed pump
4. Fuel filters
5. Injection pump
6. Injector
7. Solenoid valve
8. Glow plug
9. Overflow valve

Fuel system, description

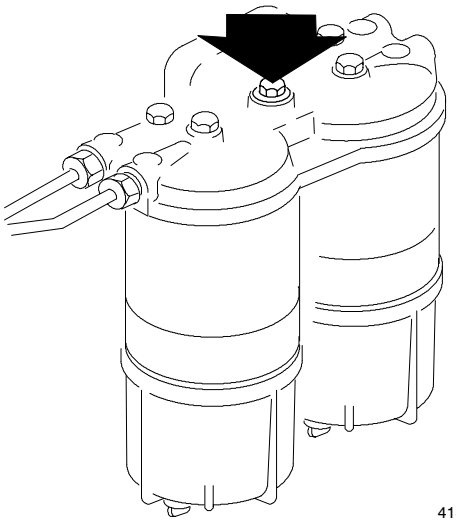
Fuel feed pump (3) draws fuel from tank (1) through prefilter (2) and forces it through filters (4) to fuel injection pump (5). The fuel injection pump pumps fuel at high pressure through the delivery pipes to injectors (6) which inject the fuel in the form of a fine mist into the combustion chamber.
Excess fuel lubricates the nozzle valve (needle) and flows on to the fuel tank
Excess fuel returns from the fuel injection pump through overflow valve (9) to the fuel tank.
The fuel system is often equipped with the thermostart device to be used in cold conditions. The glow plug (8) receives fuel from a separate reservoir of the thermostart device or from the overflow valve of the injection pump regulated by the magnetic valve (7).

Symptoms of dirty or faulty injectors are:

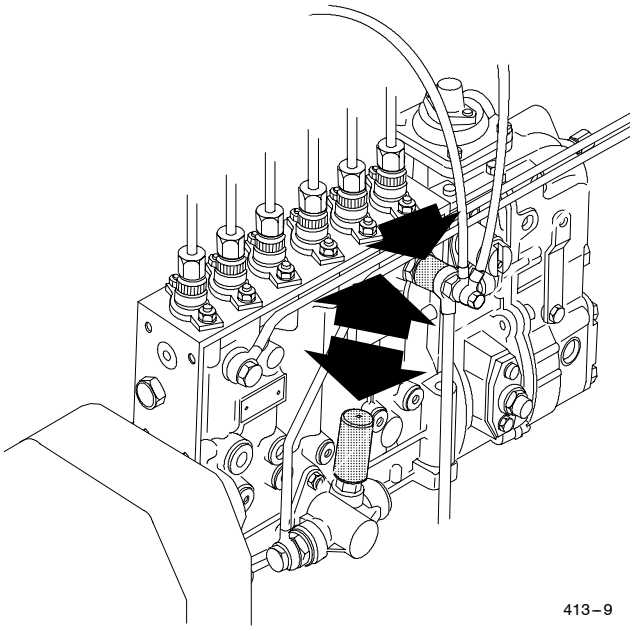
– Knocking is an indication that one of the injectors is faulty. When a cold engine ticks over a certain amount of knocking is unavoidable. If the engine knocks after it has reached normal operating temperature, it is very likely that one of the injectors is faulty. Air in the fuel system can also cause knocking (which should disappear after the system has been bled of air).
– Smoky exhaust gases may indicate impaired performance of the injectors. However, this can also be caused by other faults such as a blocked air cleaner.

The fuel system should always be bled when the fuel system has been emptied (e.g. the fuel tank has been emptied during driving, in connection with maintenance or repair work or after a long idle period).

A. Bleeding fuel system


413–8

1. Slacken the bleeder screw on the filter head. Pump with the hand pump until the fuel flowing out at the bleeder screw is free from air bubbles. Then tighten the bleeder screw.


413–9

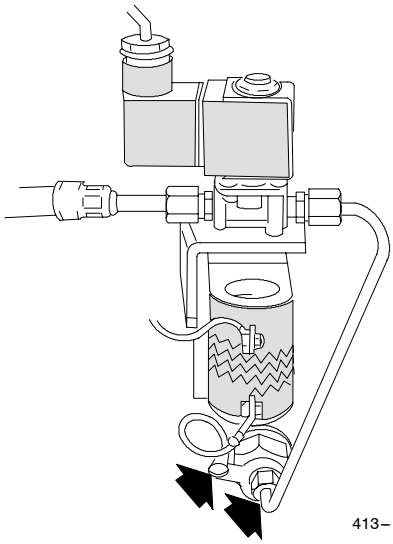
3. Slacken the injection pump overflow valve. Pump with the hand pump until the fuel flowing out is free from air bubbles. Tighten the overflow.

4. Wipe off any fuel from the engine.

B. Bleeding thermostart system

Always remove air from the glow plug fuel pipe when the pipe or reservoir has been emptied during repair work etc. This prevents damages to the glow plug caused by lack of fuel during starting.

System with the magnetic valve


413–10

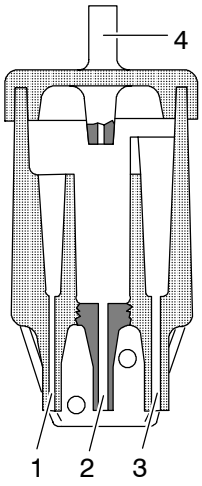
1. Disconnect the electrical wire from the glow plug and the fuel pipe.

2. Connect electricity to the magnetic valve and rotate the engine until fuel comes out from the fuel pipe connection.

3. Tighten the pipe connection and connect the electrical wire.

System with the fuel reservoir

1. Reservoir filling
2. To the glow plug
3. Return the fuel tank
4. Breather



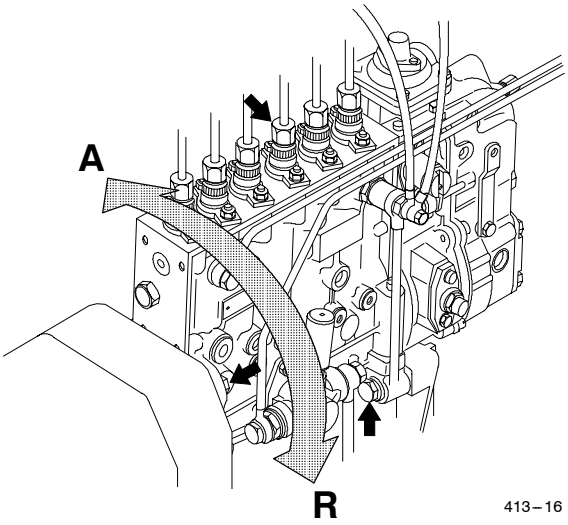
1. If the tank is empty fill it first e.g. through the breather.

2. Open the fuel pipe connection to the glow plug and let the fuel come out. Tighten the pipe.

G. Adjusting fuel injection timing

If the timing is incorrect, adjust as follows:

1. Loosen the retaining nuts and screw of the injection pump and the connection nuts of the injection pipes.



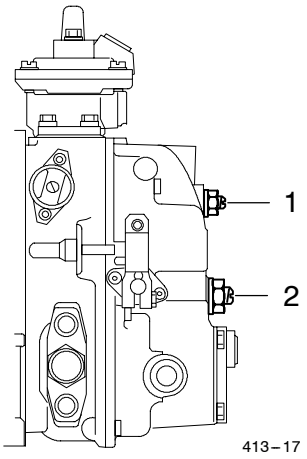
2. If the injection timing is retarded, turn the injection pump anti–clockwise (viewed from the front end of the pump). If the timing is advanced, turn the pump clockwise.

3. Check the injection timing and turn the pump again, if necessary.

4. When the injection timing is correct tighten the retaining nuts and screw of the pump and the connecting nuts of the injection pipes.

H. Adjusting idling speed

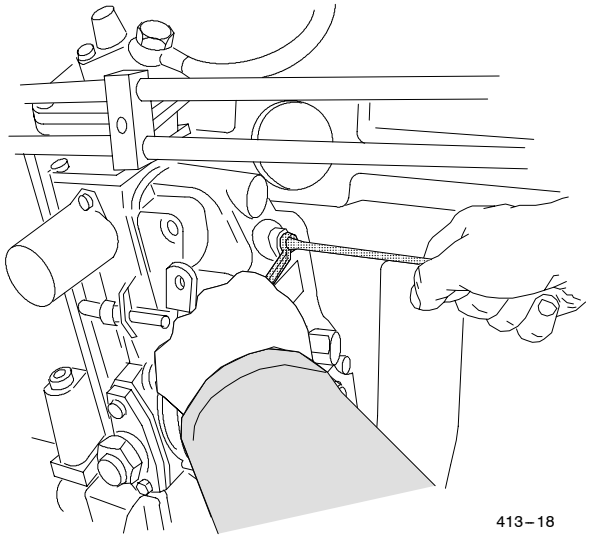
If the idling speed of the engine deviates from the value given in the specifications or if the engine revs vary at the idling speed, adjust the idling speed as follows:



1. Unscrew the idling speed adjusting nut cap (1) and the cap (2) on the idling speed additional spring adjusting screw.

2. Ensure that the throttle lever is in the idling position and that the engine is at normal operating temperature.

3. Start the engine and loosen the adjusting screw of the additional spring so that it does not affect the idling speed.



4. Adjust the idling speed using the adjusting screw to about **20...30 rpm** below rated speed and lock the adjusting screw.

5. Run the engine a few times and ensure that the idling speed remains as set.

6. Tighten the adjusting screw of the additional spring until the idling speed rises to the rated value. Lock the adjusting screw in this position.

7. Fix the safety caps of the adjusting screws.

Note! Other adjustments (output and max. speed) of the injection pump can only be performed by a specially trained person who has the necessary special tools and gauges available.

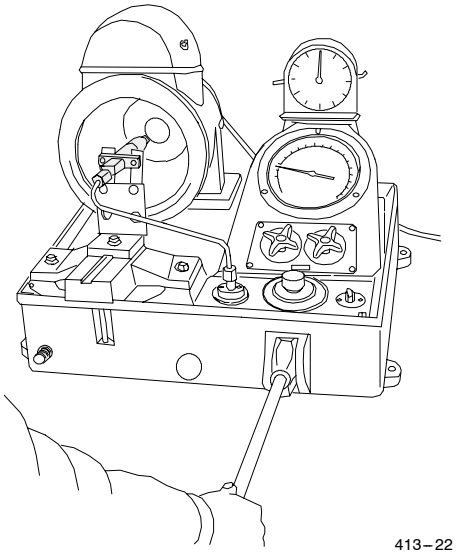
I. Removing fuel injection pump

1. Clean the injection pump and surrounding engine parts and the pipes and connectors on the injection pump.

2. Disconnect the delivery pipes and the banjo bolts at the supply and return fuel connections. Disconnect the lubricating oil line. Plug all connections.

3. Drain the cooling system and remove the cooling pump.

4. Detach the cover from the front cover. Unscrew the pump drive gear nut.



413–22

2. Secure the injector in a test bench and check the following:

- injector opening pressure
- the properties of the chattering (creaking) sound and the form of the spray pattern
- sealing of nozzle valve against its seat

Opening pressure

Pump a few times to fill the injector. Increase the pressure in the injector until the chattering (creaking) sound becomes audible. Read off the opening pressure of the injector. If the opening pressure deviates from the given value (**230±5 bar**), the injector should be taken apart and checked.

Adjustment is achieved by changing the shim. The thickness of the shims varies from 1,00...1,90 mm and they are available in increments of 0,05 mm. A thicker shim will raise the opening pressure while a thinner one lowers it. A difference in shim thickness of 0,05 mm changes the opening pressure by approx. 5,0 bar. As the opening pressure of the injector drops slightly after adjustment, the opening pressure should be set to approximately 10 bar above the value given in the specifications. This value applies both to new and used injector.

Chattering sound properties

Testing with a hand powered pump does not create the same circumstances as when the injector is fitted in the engine. Only with new nozzles are the test results reliable. With used nozzles, there is no chattering (creaking) sound when the tester is pumped at a certain rate. This has to do with the design of the nozzles.

However, with a rapid pumping on the tester handle, it should be possible to hear the chattering (creaking) sound or/and see a mist of the fuel jetting out.

Tightness of nozzle

Press down the tester pump lever until the pressure rises to approx. 20 bar below the adjusting value. Maintain this pressure for approximately 10 seconds and check whether drops of fuel are formed on the point of the nozzle. If the injector leaks, it should be cleaned or the nozzle should be changed.

M. Reconditioning injectors

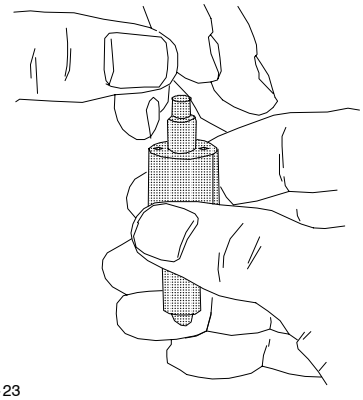
1. Secure the injector in a suitable way.

2. Unscrew the nozzle cap nut. Remove the nozzle and the parts inside the holder.

3. Clean the nozzle in cleaning fluid both inside and outside.

4. Clean the nozzle holes with a needle (including in cleaning set 8360 83288).

5. Test the movement of the nozzle valve as follows:

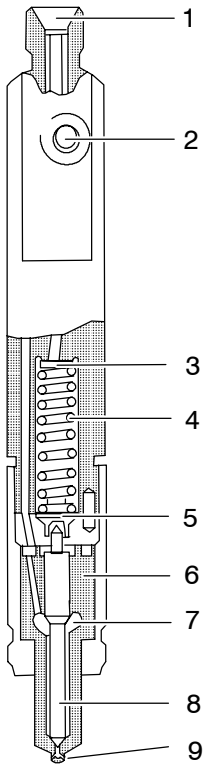


413–23

Rinse the parts thoroughly in fuel or testing fluid. Pull the valve out of the nozzle body to 1/3rd of its length. If the fit is correct, the valve should be able to slide down in the nozzle body under its own weight. Turn the valve slightly and repeat the test. Should the nozzle valve bind slightly, it should be changed.

Injector

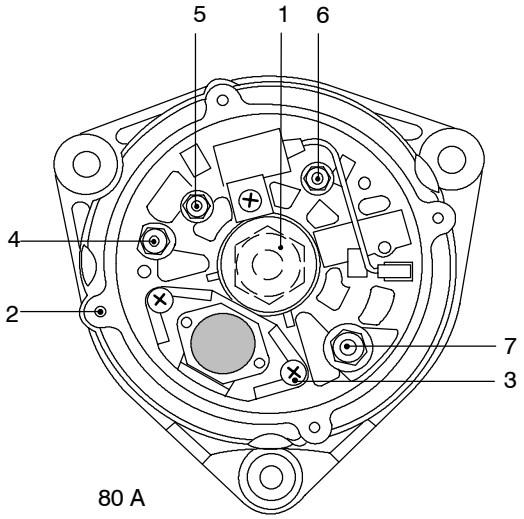
1. Fuel inlet
2. Leak–off fuel
3. Shim
4. Pressure spring
5. Valve stop spacer
6. Nozzle body
7. Pressure chamber
8. Nozzle valve
9. Nozzle hole



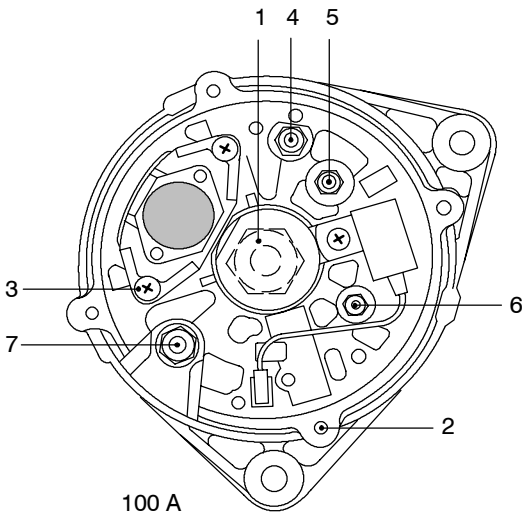
413–24

Bosch N1–28 V 10/80 A (Sisu Diesel no. 8353 39751)

Nominal voltage	24 V
Output	
1500 r/min	≥16 A
2700 r/min	≥53,5 A
6000 r/min	≥79 A
Min. slip ring diameter	26,8 mm
Brush length when new	19 mm
Min. brush length	5 mm
Rotor resistance	7,5...8,2 ohm
Stator resistance	0,057...0,062 ohm
Regulating voltage	28 V
Tightening torques:	
1. Shaft nut	55 Nm
2. Assembling screws	4,1...5,5 Nm
3. Regulator screws	1,6...2,3 Nm
4. Joint B– (M6)	4,8...6,8 Nm
5. Joint W (M5)	2,7...3,8 Nm
6. Joint D+ (M4)	1,6...2,3 Nm
7. Joint B+ (M8)	7,5...8,0 Nm



80 A



100 A

415–2

Bosch N1–28 V 0/100 A (Sisu Diesel no. 8353 40374)

Nominal voltage	24 V
Output (warm generator, testing voltage 26 V)	
2000 r/min	≥26 A
3500 r/min	≥72 A
7000 r/min	≥94 A
Min. slip ring diameter	26,8 mm
Brush length when new	19 mm
Min. brush length	5 mm
Rotor resistance	7,5...8,2 ohm
Stator resistance	0,038...0,041 ohm
Regulating voltage	28,5 V
Tightening torques:	
1. Shaft nut	70 Nm
2. Assembling screws	4,1...5,5 Nm
3. Regulator screws	1,6...2,3 Nm
4. Joint B– (M6)	4,8...6,8 Nm
5. Joint W (M5)	2,7...3,8 Nm
6. Joint D+ (M4)	1,6...2,3 Nm
7. Joint B+ (M8)	7,5...8,0 Nm