

Sisudiesel

645

engine

Workshop Manual

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**Sisu Diesel Inc. takes no responsibility for any damages caused
because of incorrect information in this manual**

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TO THE USER

This workshop Manual for Sisudiesel 645–diesel engines is intended to facilitate workshop operations and repair work.

645– engines are mainly the same in construction, so the same repair instructions usually apply to different engine versions. The differences between the various engine versions which affect repair work have been mentioned in technical data and repair instructions. All measurements are in millimetres and valid when the temperature of the parts is +20°C, unless otherwise stated.

Before starting the repair work read the safety instructions in the beginning of this book. Make sure that you have all necessary tools, parts and accessories at your disposal. The special tools mentioned in the work instructions are not all essential, but they speed up and facilitate the work and contribute to successful execution of work. An engine which has undergone repairs must be run in just like a new one.

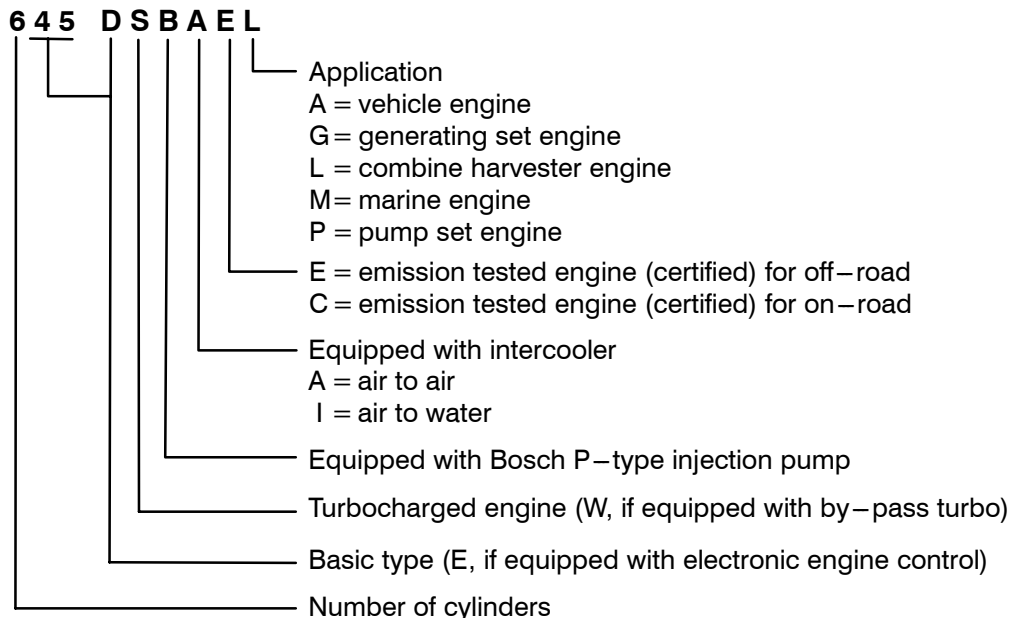
Should the engine require measures not described in this manual, please consult your local agent or the Service Department of Sisu Diesel Inc., Linnavuori, Finland. To facilitate consulting, find out the following facts about the engine before contacting us:

- engine type
- engine number
- application or equipment
- hours operated or kilometres driven.

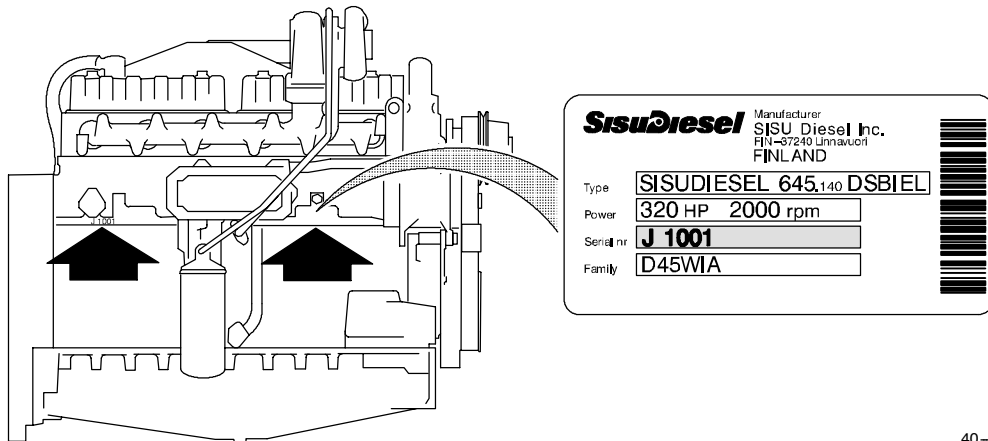
In this Workshop Manual the regular service procedure is not handled as this is explained in the 645–engines Operator's Manual.

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Engine type designations



Location of the engine serial no.



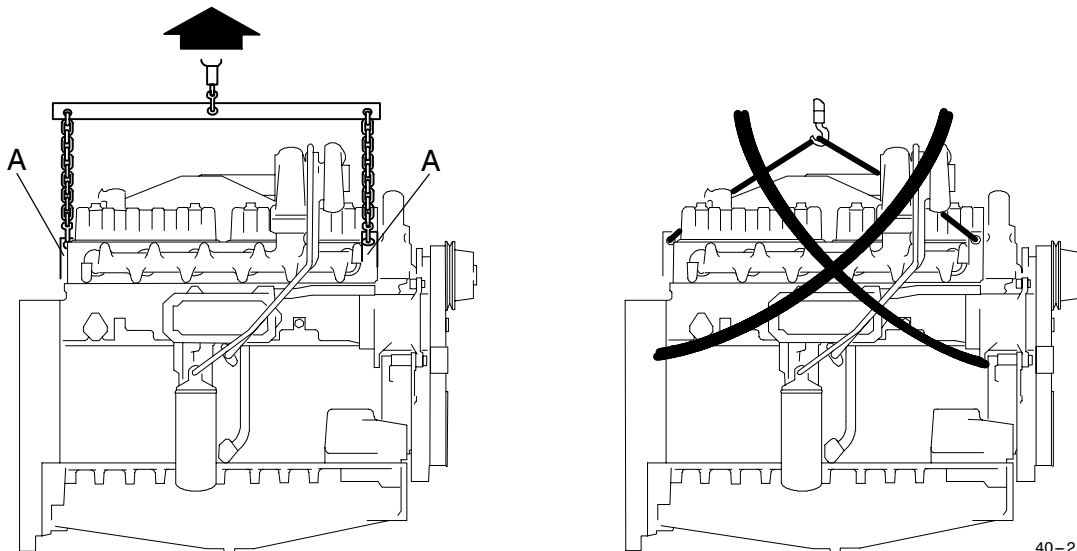
40-1

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**

SAFETY INSTRUCTIONS



In the service – and repair work of the engine there is always the possibility of injury. Before starting the work read and understand the following safety instructions and remarks!



Do not start a repair work that you do not fully handle.



Make sure that the place of the repair and the surrounding gives the possibility for safe working.



Always be sure of the cleanness and the good order of the repairing place.



Do not use faulty or otherwise useless tools.



Remove all finger rings, chains and watch before starting work.



Use up-to-date protection equipment when you work. For example eye protection as working with compressed air for cleaning, grinding, hammering or other work.



Use lifting device for lifting and transporting heavy (over 20 kg) pieces. make sure of good condition of lifting hooks and chains. The lifting ears on the engine must not be applied by side forces when lifting.



Never work under an engine that is left handling under a lifting device or lifted up by a jack. Always use strong supports before starting the work.



Use only genuine **Sisudiesel** spare parts.



Start the engine only by using the starting switch in the cabin.



Do not start an engine if the protection covers are removed. **NOTE!** The fan is difficult to see as the engine is running! Make sure that wide clothes or long hair is not caught in the rotating parts of the engine.



If you start the engine indoors, be sure you have proper ventilation.



Never use aerosol type of starting aid while operating the thermostart device (risk for explosion).



When you are operating the engine or working near it, use hearing protectors to avoid noise injuries.



Stop the engine always before service – or repair work.



Avoid touching the exhaust manifold, turbocharger and the other hot parts of the engine.



Open the radiator cap with care when the engine is hot as the cooling system is pressurised. The cooling liquid and lubrication oil of a hot engine causes injuries when touching the skin.



Open fire, smoking and sparks should not be allowed near the fuel system and batteries. (Specially when loading batteries, explosive.)



Always disconnect the minus (–) wire of the battery when doing service or repair of the electric system.



At temperatures on excess of 300°C, e.g. if the engine is burnt by a fire, the viton seals of the engine (e.g. the undermost o-ring of the oil pressure regulating valve) produce very highly corrosive hydrofluoric acid. Do not touch with bare hands, viton seals subjected to abnormally high temperatures. Always use neoprene rubber or heavy duty gloves and safety glasses when decontaminating. Wash the seals and the contaminated area with a 10% calcium hydroxide or other alkali solution. Put all removed material in sealed plastic bags and deliver them to the point stated by the Authorities concerned. **NOTE!** Never destroy viton – seals by burning!



When checking fuel injectors do not let the jet of high pressure fuel contact your skin. The fuel penetrates the skin causing severe injuries. Contact your doctor immediately!



The fuel, lubricating oil and coolant cause irritation in skin contact for long time.



Avoid unnecessary idling of the engine.



Do not let oil and other liquids drop into the soil when servicing the engine.



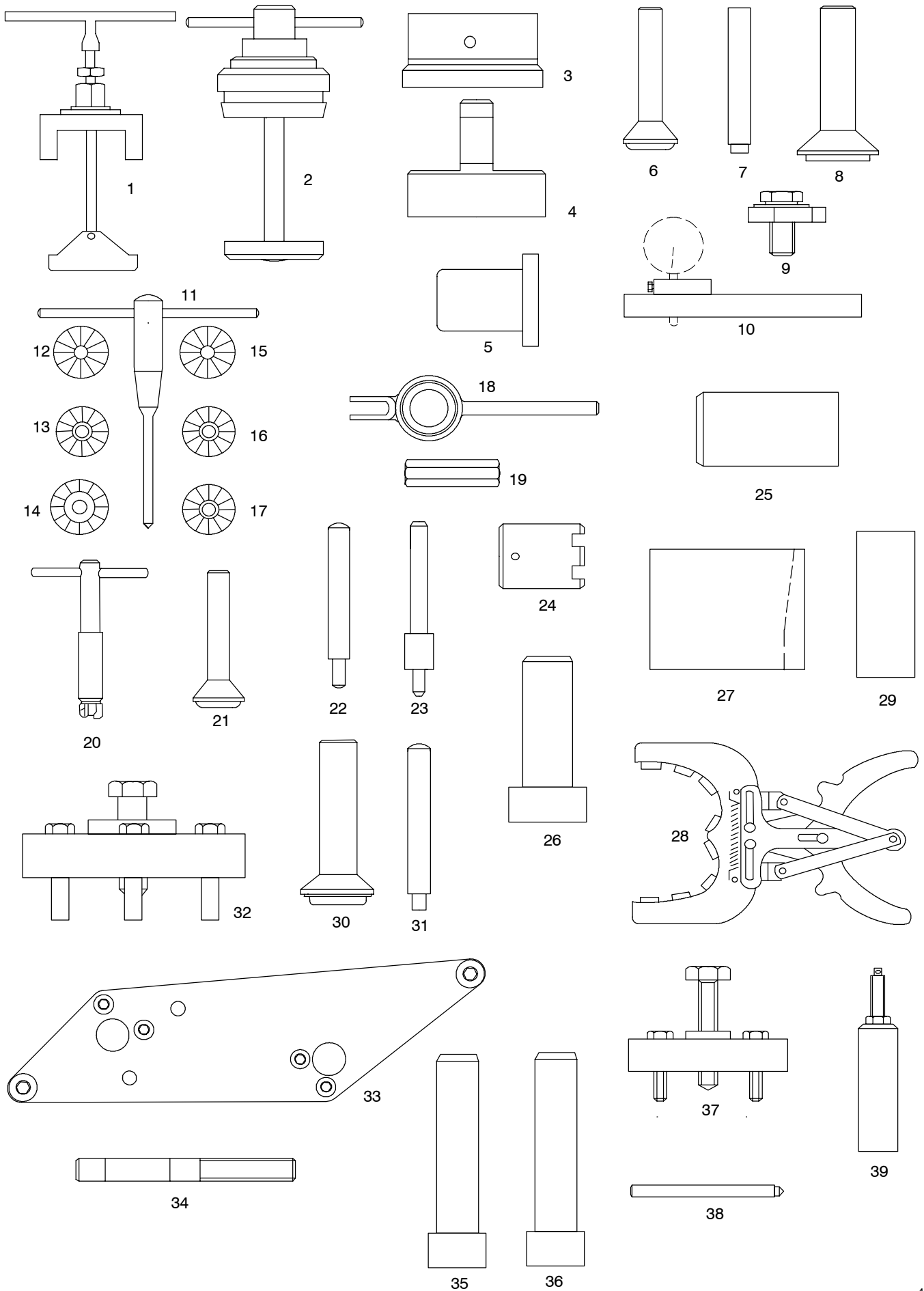
All the gaskets of the engine are of non-asbestos material.



Be careful when washing the engine with a high pressure washing machine. Do not use high pressure to wash e.g. the electric and fuel equipment or the radiator because they can easily be damaged.

SPECIAL TOOLS

	Order no	Description
1	9104 51500	Puller for cylinder liner
2	9104 52000	Milling cutter for cylinder liner seat
3	9104 52700	Centring tool for flywheel housing
4	9104 52600	Drift for fitting rear crankshaft seal
5	9103 94600	Drift for fitting front crankshaft seal
6	9052 46620	Drift for 40 mm cup plug
7	9052 46650	Drift for 16 mm cup plug
8	9025 87400	Drift for fitting camshaft cup plug
9	9101 66300	Press tool for cylinder liner
10	9025 79200	Holder for dial gauge
11	9101 66100	T-handle for valve seat milling cutter
12	9101 71100	Milling cutter for facing exhaust valve seat
13	9101 65502	Milling cutter for exhaust valve seat
14	9101 65503	Inner milling cutter for exhaust valve seat
15	9101 75800	Milling cutter for facing inlet valve seat
16	9101 65505	Milling cutter for inlet valve seat
17	9101 65506	Inner milling cutter for inlet valve seat
18	9101 66200	Lever for compressing valve spring
19	9052 47200	Counter nut for lever above
20	9101 66000	Milling tool for injector seat
21	9052 46660	Drift for 36 mm cup plug
22	9101 65800	Drift for removing valve guide
23	9101 65900	Drift for fitting valve guide
24	9024 55800	Spanner for crankshaft nut
25	9103 94700	Drift for fitting crankshaft gears
26	9103 41300	Drift for fitting coolant pump bearings
27	9105 18700	Conical sleeve for fitting pistons
28	9052 46900	Piston ring pliers
29	9103 94900	Drift for fitting oil deflector ring, crankshaft front end
30	9103 94800	Drift for 45 mm cup plug
31	9025 98700	Drift for fitting tension pins in timing gear casing and flywheel housing
32	9104 53300	Puller for crankshaft hub
33	9104 05400	Centring tool for idler gear, broad timing gear casing
34	9104 34600	Centring pin for idler gear, narrow timing gear casing
35	9103 41000	Fitting tool for coolant pump shaft seal
36	9103 41100	Fitting tool for coolant pump water seal
37	9052 48900	Extractor for injection pump gear
38	9104 52800	Injection timing check pin
39	9104 53700	Extractor for injector



ENGINE SPECIFICATIONS

PRINCIPAL DIMENSIONS AND DATA

Motor type	645
Number of cylinders	6
Displacement (ltr)	8,4
Cylinder bore (mm)	111
Stroke (mm)	145
Combustion	Direct injection
Compression ratio	16:1
Injection timing (B.T.D.C.)	Marked on the flywheel
Valve clearance, intake and exhaust (mm)	0,35 (cold or hot)
Direction of rotation from the engine front	Clockwise
Compression pressure (bar) ¹	24

¹) Minimum value at operating temperature and starting revs. Max permitted difference between cylinders 3,0 bar.

FUELSYSTEM

Injection pump	Bosch, in –line type
Fuel	Gas oil, see page 13–13
Feed pressure	
– overflow valve opening pressure	0,6–1,0 bar
– static	2,7 bar
Injection order	1–5–3–6–2–4
Injector	Four–hole nozzle
Opening pressure of the nozzle	250 bar (when checking)
Adjusting pressure of the nozzle	260 bar (when adjusting)
Fuel filter	CAV

LUBRICATION SYSTEM

Oil pressure in hot engine at running speed	2,5–5,0 bar
Oil pressure at idle speed, min.	1,0 bar
Oil capacity (ltr)	See page 10–4

COOLING SYSTEM

Numbers of thermostats	2
Opening temperature °C	Ø54 mm = 79 Ø67 mm = 83
Coolant liquid	See page 11–1

TECHNICAL DATA

Cylinder block

Holes for guide pins	13,250...13,320 mm
Main bearing housing diameter	96,000...96,025 mm
Cylinder liner location, diameter:	
– upper end	125,014...125,054 mm
– lower end	121,000...121,040 mm
Inner diameter of camshaft bushings (fitted)	50,010...50,070 mm
Height of cylinder block	468,900...469,100 mm

Cylinder liners

Protrusion of cylinder liner above cylinder block top face	0,030...0,080 mm
Max. permissible height difference between liners (under same head)	0,02 mm
Outer diameter of cylinder liner guide:	
– at upper end of liner	124,975...125,000 mm
– at lower end of liner	120,961...120,986 mm
Liner bore	111,000...111,022 mm
Height of cylinder liner flange	9,03...9,05 mm
Height of cylinder liner flange, 1st oversize, part no 8368 59581	9,08...9,10 mm
Height of cylinder liner flange, 2nd oversize, part no 8368 59582	9,13...9,15 mm
Height of cylinder liner flange, 3rd oversize, part no 8368 59583	9,23...9,25 mm
Outer diameter of cylinder liner flange	131,700...131,800 mm

Cylinder head

Height of cylinder head	104,800...105,000 mm
Height of cylinder head after repair grinding (minimum)	104,000 mm
Inside diameter of valve guide (not fitted)	9,000...9,015 mm
Outside diameter of valve guide	16,028...16,039 mm
Diameter of valve guide bore in cylinder head	16,000...16,018 mm
Position of valve guide top above cylinder head surface	21 mm
Depth of valve head face below cylinder head surface:	
– inlet valve	0,7±0,05 mm (max 1,70 mm)
– exhaust valve	0,6±0,05 mm (max 1,60 mm)
Angle of valve seat:	
– inlet valve	35° +20'
– exhaust valve	45° +20'
Width of valve seat:	
– inlet valve	2,9...3,7 mm
– exhaust valve	1,3...2,3 mm
Diameter of exhaust valve seat ring	44,070...44,132 mm
Diameter of exhaust valve seat rings recess	44,000...44,025 mm
Diameter of exhaust valve seat ring (overhaul part 8366 52269)	44,270...44,332 mm
Diameter of exhaust valve seal ring recess (overhaul part 8366 52269)	44,200...44,225 mm
Diameter of inlet valve seat ring	48,570...48,632 mm
Diameter of inlet valve seat ring recess	48,500...48,525 mm
Diameter of inlet valve seat ring (overhaul part 8368 55347)	48,770...48,832 mm
Diameter of inlet valve seat ring recess (overhaul part 8368 55347)	48,700...48,725 mm

Valves, rockers and tappets

With a valve clearance of 1,0 mm:

– inlet valve opens	$0^{\circ} \pm 2^{\circ}$ B.T.D.C
– inlet valve closes	$16^{\circ} \pm 2^{\circ}$ A.B.D.C
– exhaust valve opens	$39^{\circ} \pm 2^{\circ}$ B.B.D.C
– exhaust valve closes	$1^{\circ} \pm 2^{\circ}$ A.T.D.C

Valve clearance cold and hot:

– inlet valve	0,35 mm
– exhaust valve	0,35 mm

Angle of valve seat in cylinder head:

– inlet valve	$35^{\circ} + 20'$
– exhaust valve	$45^{\circ} + 20'$

Width of valve seat in cylinder head:

– inlet valve	2,9...3,7 mm
– exhaust valve	1,3...2,3 mm

Angle of valve face:

– inlet valve	$35^{\circ} - 20'$
– exhaust valve	$45^{\circ} - 20'$

Outside diameter of valve head:

– inlet valve	48 mm
– exhaust valve	41 mm

Max valve movement:

– inlet valve	10,9 mm
– exhaust valve	12,1 mm

Inlet valve stem diameter

8,960...8,975 mm

Exhaust valve stem diameter

8,925...8,940 mm

Inlet valve stem clearance

0,025...0,055 mm

– Reject limit

0,30 mm

Exhaust valve stem clearance

0,060...0,090 mm

– Reject limit

0,35 mm

Inside diameter of valve guide before fitting

9,000...9,015 mm

Outside diameter of valve guide

16,028...16,039 mm

Diameter of valve guide bore in cylinder head

16,000...16,018 mm

Protrusion of valve guide top above cylinder head surface

21 mm

Depth of valve face below cylinder head surface:

– inlet valve

$0,7 \pm 0,05$ mm

– exhaust valve

$0,6 \pm 0,05$ mm

Valve spring free length

69,8 mm

Spring pressure when spring compressed to a length of:

– 48,6 mm

327 ± 17 N

– 37,4 mm

500 ± 23 N

Rocker arm shaft diameter

22,970...22,990

Diameter of rocker arm bore

23,000...23,021

Max. permissible push rod deflection (when free)

0,4 mm

Free length of rocker arm spring

80 mm

Spring pressure when spring compressed to a length 58 mm

80...100 N

Outside diameter of tappet

29,939...29,960 mm

Diameter of tappet bore in cylinder block

30,000...30,043 mm

Camshaft

Diameter of camshaft bearing journal no 1

49,925...49,950 mm

Diameter of camshaft bearing journals nos 2, 3 and 4

49,865...49,890 mm

Diameter of camshaft bearing journals no 5

49,885...49,910 mm

Inside diameter of camshaft bearing bushes (when fitted in position)

50,010...50,070 mm

Camshaft clearance in bearing bush no 1

0,060...0,145 mm

Camshaft clearance in bearing bushes nos 2, 3 and 4

0,110...0,160 mm

Camshaft clearance in bearing bushes no 5

0,090...0,140 mm

Bearing bush tolerance in block (press fit)

0,025...0,080 mm

Camshaft end play with 0,5 mm gasket between cylinder block and timing gear housing and between timing gear housing and front cover	0,5...1,0 mm
Cam height (distance between back of cam and tip of cam):	
– inlet valve	41,180...41,430 mm
– exhaust valve	40,080...40,330 mm
Cam lift:	
– inlet valve	7,38 mm
– exhaust valve	8,28 mm
Camshaft max. permissible deflection (total indicator reading)	0,03 mm

Crankshaft

Crankpin diameter:	
– standard	72,981...73,000 mm
– 1. undersize 0,25 mm	72,731...72,750 mm
– 2. undersize 0,50 mm	72,481...72,500 mm
– 3. undersize 1,00 mm	71,981...72,000 mm
– 4. undersize 1,50 mm	71,481...71,500 mm
Crankpin length	40,000...40,160 mm

Main bearing journal diameter:	
– standard	89,985...90,020 mm
– 1st undersize 0,25 mm	89,735...89,770 mm
– 2nd undersize 0,50 mm	89,485...89,520 mm
– 3rd undersize 1,00 mm	88,985...89,020 mm
– 4th undersize 1,50 mm	88,485...88,520 mm
Main bearing housing diameter (in cylinder block)	96,000...96,025 mm

Main bearing shell thickness:	
– standard	2,955...2,965 mm
– 1st undersize 0,25 mm	3,080...3,090 mm
– 2nd undersize 0,50 mm	3,205...3,215 mm
– 3rd undersize 1,00 mm	3,455...3,465 mm
– 4th undersize 1,50 mm	3,705...3,715 mm

Main bearing clearance	0,050...0,127 mm
Length of thrust bearing journal (journal nearest to flywheel):	
– standard (2 standard thrust plates)	45,000...45,080 mm
– 1st oversize (one std and one 0,1 mm overthick thrust plate)	45,100...45,180 mm
– 2nd oversize (one std and one 0,2 mm overthick thrust plate)	45,200...45,280 mm
– 3rd oversize (one 0,1 mm and one 0,2 mm overthick thrust plate)	45,300...45,380 mm
– 4th oversize (two 0,2 mm overthick thrust plates)	45,400...45,480 mm

Other crankshaft journals may not be ground longer.	
Corner rounded of crankpins and journals	R4+0,5 mm
Crankshaft end float	0,100...0,380 mm
Max. permissible ovalness and other deformity of crankpins or journals	0,03 mm
Crankshaft unbalance	1,0 Ncm Max.

Flywheel

Interference fit between ring gear–flywheel	0,425...0,600 mm
Before fitting the ring gear, heat up to a temperature of	150...200 °C
Flywheel unbalance	1,0 Ncm Max
Max permissible axial wobble of flywheel clutch face, measured at inner edge of clutch face on diameter 200	0,06:ø200

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)

Piston, rings and pin

Minimum distance between piston and cylinder head (measured with a piece of lead wire through the injector location hole)	0,900...1,150 mm
Piston diameter:	
– 15 mm from lower edge	110,863...110,877 mm
Pin bore in piston	44,003...44,009 mm
Piston pin diameter	43,994...44,000 mm
Width of ring grooves:	
– 1st groove	wedge shaped ring
– 2nd groove	2,520...2,540 mm
– 3rd groove	4,040...4,060 mm
Side clearance of piston rings in their grooves:	
– 1st ring	wedge shaped ring
– 2nd ring	0,03...0,062 mm
– 3rd ring	0,05...0,082 mm
– reject limit	0,15 mm
Piston ring height (in direction of cylinder):	
– 1st ring	wedge shaped ring
– 2nd ring	2,478...2,490 mm
– 3rd ring	3,975...3,990 mm
Piston ring gap (with piston fitted in cylinder)	
– 1st ring (wedge shaped ring)	0,35...0,50 mm
– 2nd ring	0,60...0,80 mm
– 3rd ring	0,30...0,60
– reject limit 1. and 3. ring	1,0 mm
– reject limit 2. ring	1,3 mm
Max. permissible weight difference between pistons in same engine	25 g
Piston to be heated up to 100°C before fitting gudgeon pin.	
Piston position in cylinder: combustion chamber of piston to face towards injector.	

Lubricating system

Oil pressure at normal running temperature:	
– at idling speed (min.)	1,0 bar
– at running speed	2,5...5,0 bar
Free length of oil pressure valve spring	71 mm
Spring pressure when valve spring is compressed to a length of 52 mm	74+5 N
Diameter of oil pressure valve plunger	19,602...19,635 mm
Diameter of oil pressure valve cylinder	19,700...19,752 mm
Oil filter by-pass valve opens at a pressure difference of	2±0,5 bar

Oil pump

Backlash between gears when crankshaft lies firmly against the lower side of main bearings:	
– crankshaft gear–lubricating oil pump gear	0,05...0,25 mm
– between the pump gears	0,16...0,26 mm
Diameter of drive shaft at bearings for body and cover	17,966...17,984 mm
Diameter of drive shaft bearing hole on body and cover	18,000...18,018 mm
Diameter of fixed shaft at gear wheel	17,966...17,984 mm
Inner diameter of bearing for gear wheel which rotates on fixed shaft	18,000...18,018 mm
Fixed shaft in pump body, diameter	20,035...20,048 mm
Protrusion of fixed shaft end below pump body face	0,5 mm
Thickness of cover gasket	0,06...0,08 mm
Outer diameter of gear wheels	55,824...55,870 mm
Housing diameter	56,000...56,120 mm
Thickness of gears	32,000...32,027 mm
End play of gears	0,03...0,11 mm
Depth of housing	32,000...32,043 mm
Number of teeth on drive gears	46 pcs

Coolant pump

Outside diameter of bearing	52 mm
Inside diameter of bearing housing in pump body	51,970...52,000 mm
Shaft diameter at bearing	24,996...25,009 mm
Shaft diameter at impeller	15,907...15,920 mm
Impeller hole diameter	15,881...15,899 mm
Diameter of the water seal recess in the pump body	39,981...40,020 mm

Thermostat

Spare part number	Type	Opening begins at	Fully open at	Max. stroke mm
8360 15156	ø54/79°C	79° ±2°C	94°C	7,5
8363 31590	ø67/83°C	83° ±2°C	95°C	8

Turbocharger**Schwitzer S2B**

Max. axial end play	0,14 mm
Max. radial play ¹⁾	0,95 mm
Turbine housing attaching bolts	17 Nm
Nut on end of shaft	15,6 Nm

¹⁾ Measured at nut on end of shaft.

Schwitzer S300

Min. axial end play	0,05 mm
Max. axial end play	0,12 mm
Max. radial play, turbine end	0,64 mm
Max. radial play, compressor end	0,88 mm
Turbine housing attaching bolts	22 Nm
Compressor housing attaching bolts	13,5 Nm
Nut on end of shaft	20,3 Nm

TIGHTENING TORQUES

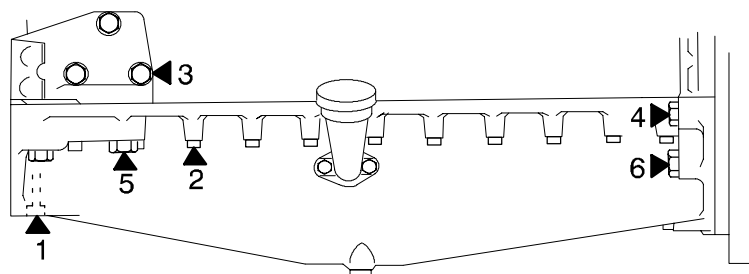
Object	Nm
Cylinder head bolts	80 Nm +90° +90° (see page 3-4)
Cylinder head studs to cylinder block	30
Main bearing bolts	200
Connecting rod bolts	40 Nm +90° +90°
Crankshaft nut	1000
Oil pump gear nut	60
Crankshaft pulley bolts	80
Flywheel bolts	200
Flywheel housing bolts:	
– outer ring M12	110
– inner ring M10	60
Belt tightener shafts bolts:	
– M10	80
– M16	200
Idler gears retaining bolts:	
– the bigger bolt (M14)	180
– the bolts for holding the bearing (M8)	22
Piston cooling valve	30
Oil pump retaining bolts	60
Coolant pump gear nut	180
Exhaust manifold nuts	50
Intake manifold bolts	30
Injection pump gear nut	200
Injector attaching nuts (on studs)	15
Injector nozzle sleeve	60

Always use the torque values listed in the following tables when specific torque values are not available.

	M8	M10
Cast iron	35±5 Nm	70±5 Nm
Aluminium	25±5 Nm	50±5 Nm

Use a washer with the aluminium parts.

The bolts of a self carrying oil sump



1	M8	25 Nm
2	M10	90 Nm
3	M12	110 Nm
4	M16	220 Nm
5	M20	600 Nm
6	M22	570 Nm

CONSTRUCTION

General

645-engine is liquid cooled, 6-cylinder, 4-stroke, in-line diesel engine with direct injection. It is designed with wet, replaceable, mid support cylinder liners, oil-cooled pistons and two separate cylinderheads.

The engines have a rigid and ribbed cylinder block. The crank mechanism is designed for supercharging. The cylinder liners are wet and supported at the middle. The cylinder head bolts are high tensile bolts.

Cylinder block

The cylinder block is the main body of the engine, to which other engine parts are attached. Wet and replaceable cylinder liners are supported at the middle which reduces vibrations and directs coolant circulation mainly to the upper part of the liners.

The seal between the cylinder liner lower part and the cylinder block is achieved by three o-rings, which are fitted in grooves in the cylinder block. The upper part is sealed by the cylinder head gasket.

The camshaft is located in the cylinder block. 645-engines have separate bearing sleeves in all camshaft bearing locations. The drilling for the camshaft rear end is covered with a plug.

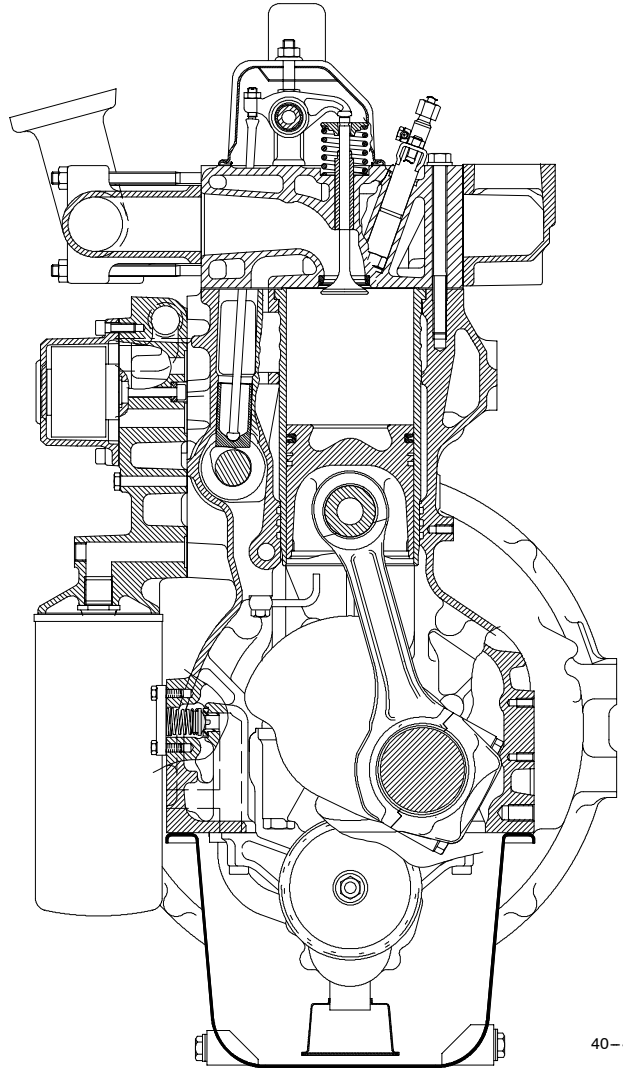
There are spaces on both sides of the rear main bearing for guide bearing shims (the crankshaft thrust bearings).

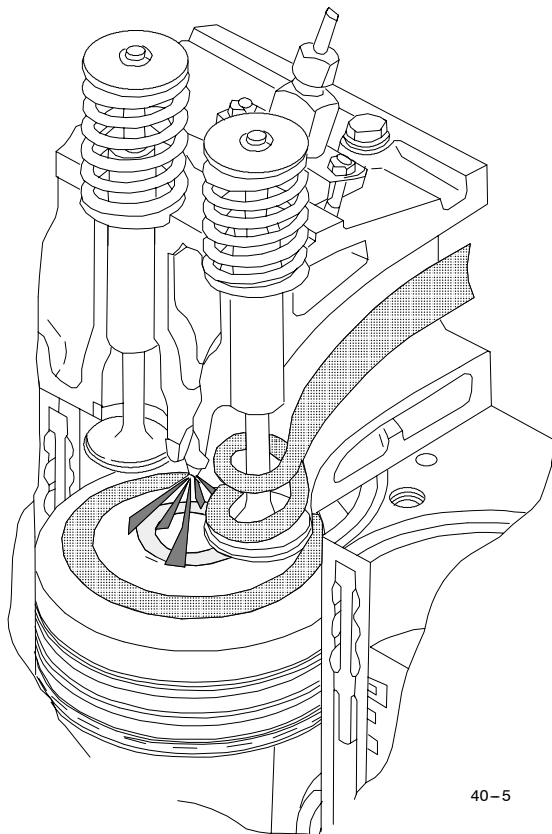
Flywheel housing

The flywheel housing is fitted at the rear end of the cylinder block. The seal for the crankshaft rear end is placed in a bore in the housing. The starter motor fixing point is fitted in the flywheel housing.

The lower face of the flywheel housing functions as a sealing surface for the oil sump gasket. This means that the lower face of the cylinder block must be level with the flywheel housing. When fitting the flywheel housing, its position is determined by tension pins.

The flywheel housing are delivered according to the requirements set, by the engine application and different flywheel housings can be mounted on all engine types.





Cylinder head

645-engines have two cylinder heads which are exchangeable with each other. Each cylinder has its own inlet and exhaust ports located on either side of the head. Between hot exhaust valves a cool inlet valve is fitted to balance the thermal load.

Cylinder head bolts are high tensile bolts which are tightened up to yield limit using angle tightening principle. Due to the large stretch the tightening forces are kept constant during the whole lifetime and retightening is unnecessary.

The injector locations are machined directly into the cylinder head. The inlet and exhaust valve guides are identical and can be interchanged. In addition, the inlet and exhaust valves are equipped with replaceable valve seat inserts.

Valve mechanism

The valve mechanism is operated by the camshaft which is located in the cylinder block. The drive is transferred with the help of tappets and pushrods. The camshaft gear wheel is fitted with a press fit and fixed with a key. Each bearing is lubricated by the force feed lubrication system through drilled oilways in the motor block.

Crank mechanism

The crankshaft is forged from chrome alloy special steel and is induction hardened at the bearing and sealing surfaces. This makes it possible to grind bearings four times without a new heat treatment. Gear wheels are located at the front end of the crankshaft. They are a press fit, and drive the idler wheel and oil pump. In addition, the front end of the crankshaft has splines for the hub of the ribbed V-belt pulley. An oil deflector ring is fitted between the hub and gear wheel.

The crankshaft is supported on the cylinder block by main bearings which are placed on both sides of each cylinder. Thus there is one main bearing more than cylinders. The crankshaft thrust washers are placed in both sides of the rear-most main bearing.

At the rear end of the crankshaft there is fitted a flywheel on which is a press-fit starter ring gear. The forged connecting rod has an I-section cross-section. The bearing location at the bottom end of the connecting rod is angle split, and the bearing cup is secured by two special elongated bolts. The upper part has a wedge-shaped bearing location, in which the piston pin bearing bushing is fitted with a press fit.

The piston is made of an eutectic aluminium alloy. In the upper face of the piston there is a combustion chamber. The shape of the chamber is intended to maximise the mixture of air and fuel. The piston has three rings. The upper molybdenum-coated ring has a wedge-shaped cross-section. The middle ring is tapered and it fits into its groove. The taper taking up the clearance. The oil control ring is spring loaded and it has a two-stage, chromed scraping edge.

The upper ring location is formed in a cast iron ring which is cast in the piston. In addition, the piston is graphite coated to ensure correct running-in.

Timing gears

There are two main types of a timing gear assemblies, so-called narrow – and broad timing gear casing.

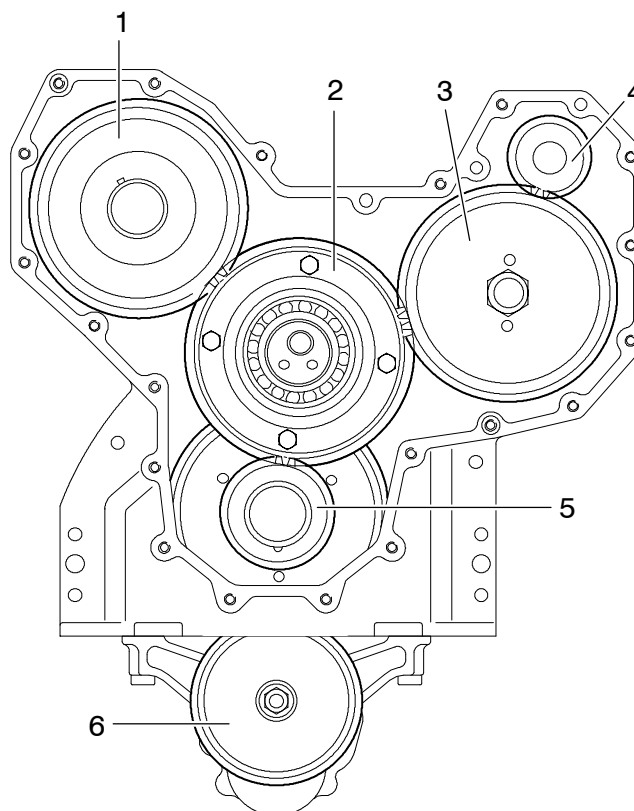
The timing gear train consists of hardened, helically cut gear wheels. The gears are encased by the timing gear casing which is fitted to the front of the engine. The timing gear drives the camshaft, fuel injection pump, oil pump and coolant pump.

If the engine is equipped with the broad timing gear casing, there is a separate drive unit for a hydraulic pump or a compressor. The drive unit is driven via a small idler gear.

The idler gear is supported with a bevelled ball bearing on the shaft on the front face of the cylinder block.

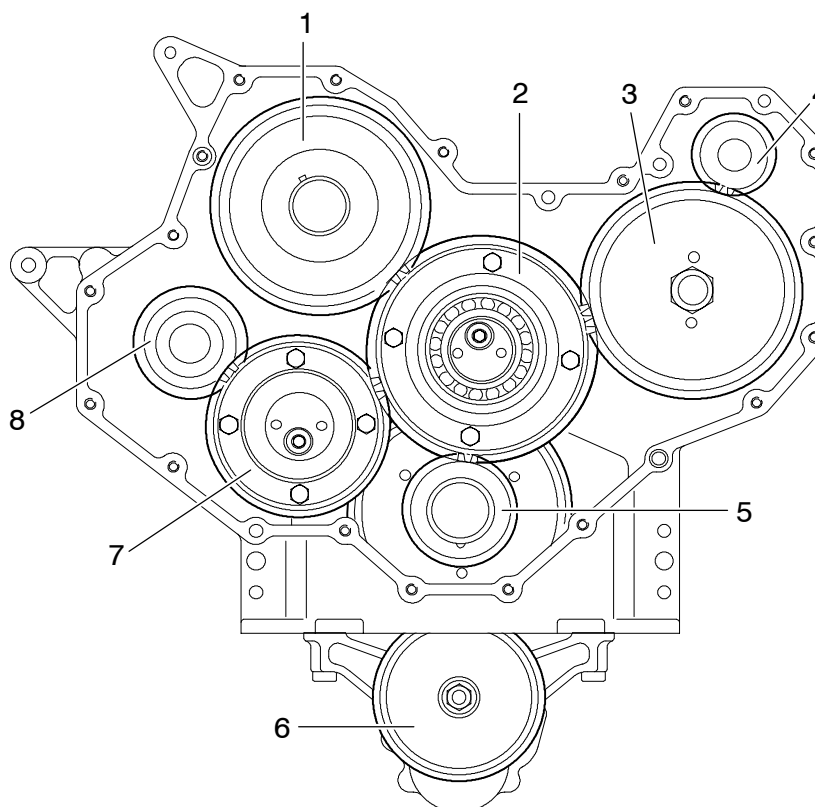
Narrow timing gear casing

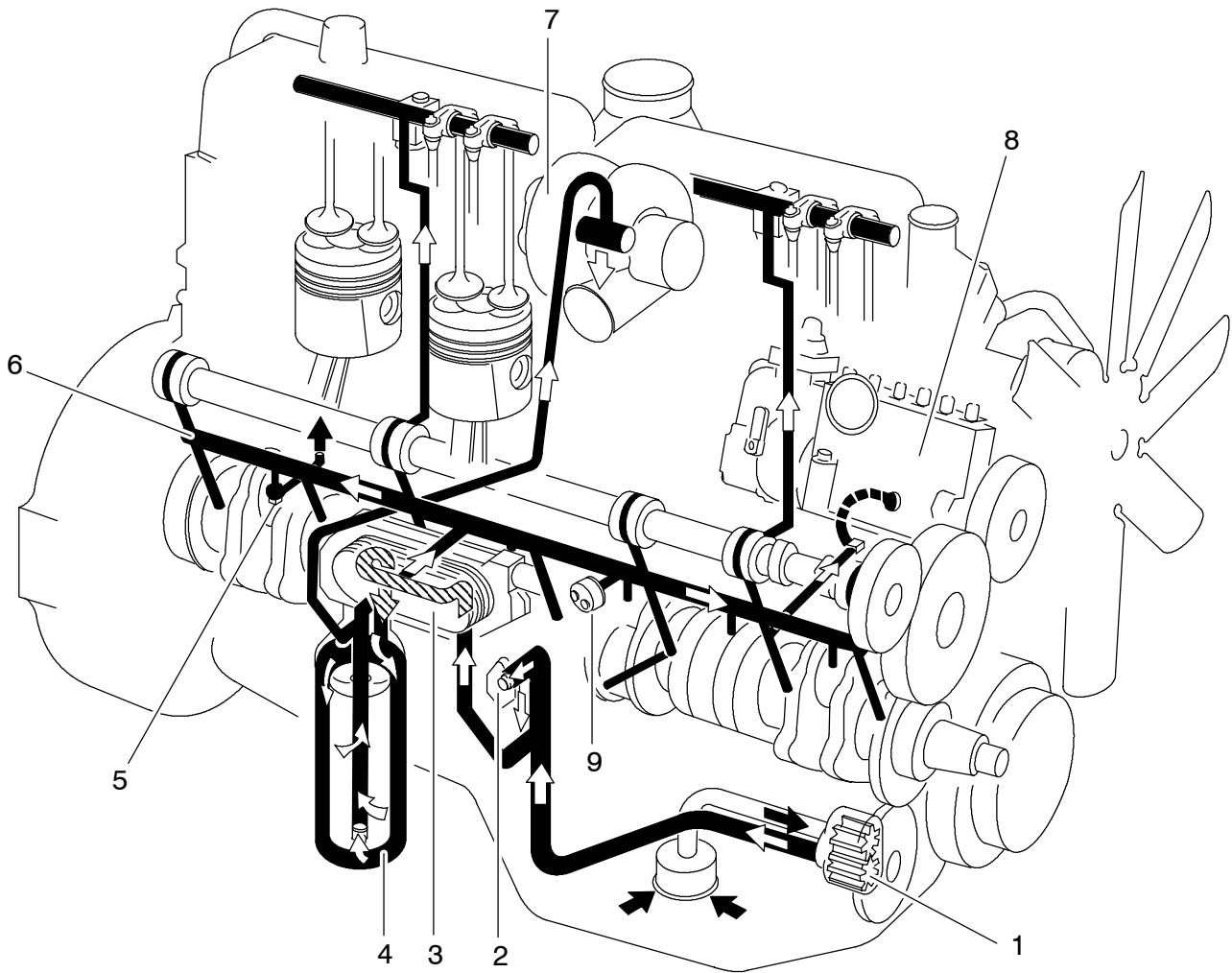
1. Camshaft gear
2. Idler gear
3. Injection pump gear
4. Coolant pump gear
5. Crankshaft gears
6. Oil pump gear



Broad timing gear casing

1. Camshaft gear
2. Idler gear
3. Injection pump gear
4. Coolant pump gear
5. Crankshaft gears
6. Oil pump gear
7. Small idler gear
8. P.T.O. gear





40-7

Lubricating system

The engine has a pressure lubricating system in which the oil pump (gear pump) is attached to the cylinder block lower face. The oil is sucked up by the pump through a suction strainer. After the pump the oil is led through an oilway to the relief valve via the oil cooler to the oil filter. After the filter, the oil is led through the main oil gallery from which oilways branch out. The oil is led through the oilways in the main bearings and through the crankshaft to the big-end bearings.

The oil is further directed from the main gallery to the injection pump, turbocharger and to a possible compressor. In addition, the camshaft bearing points and the valve mechanism get their lubrication oil via the main oil gallery.

In 645-engines is the bottom of the piston cooled with oil spray always when the oil pressure is higher than 3 bar.

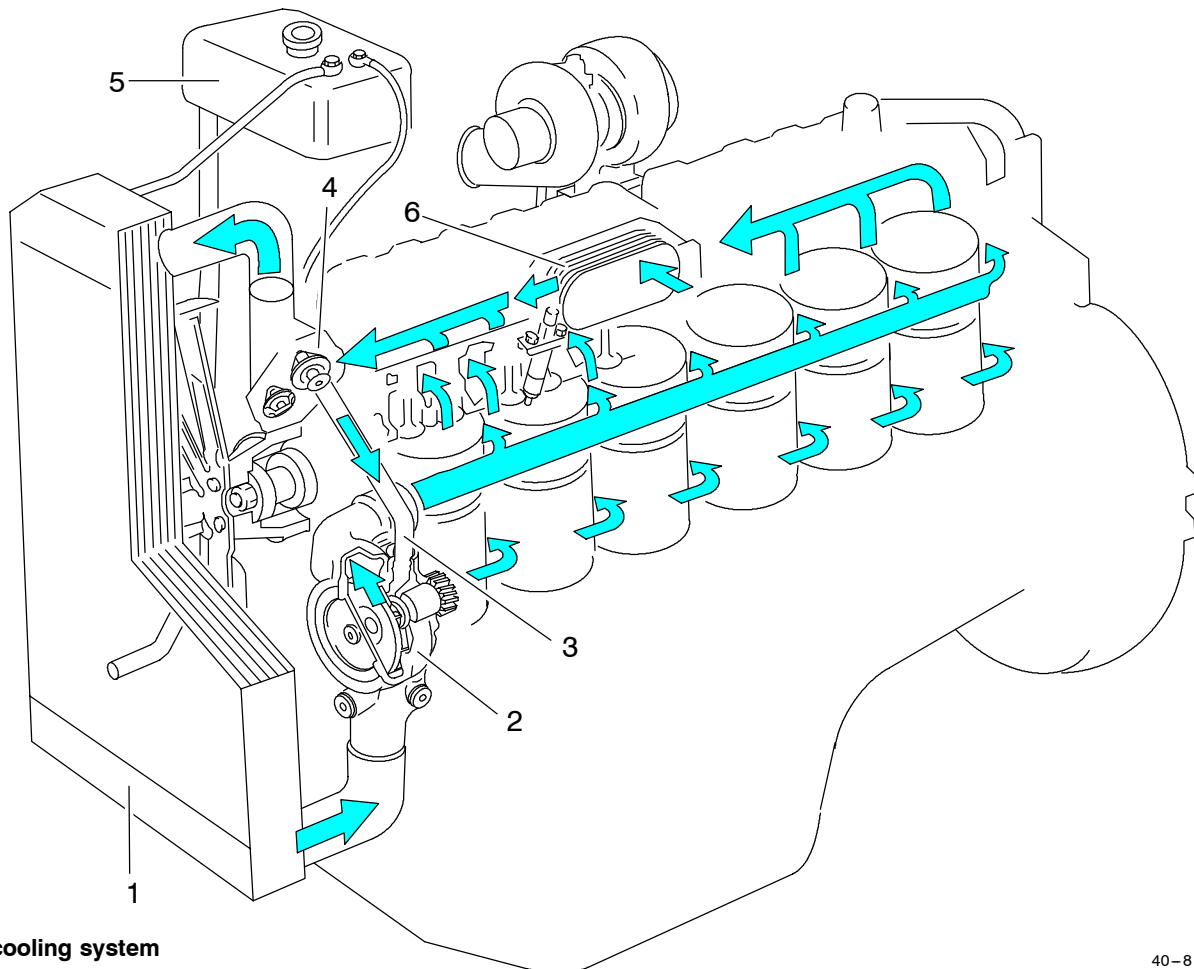
The oil pressure regulating valve is located on the right-hand side of the engine. The valve regulates the lubricating oil pressure so that it is kept constant, regardless of the engine speed. Oil pressure is about **2,5...5 bar** depending on revs, oil quality and temperature, and at engine idling speed the pressure is min **1,0 bar**.

Lubricating system

1. Oil pump
2. Oil pressure regulating valve
3. Oil cooler
4. Oil filter
5. Piston cooling nozzle
6. Main oil bore
7. Turbocharger
8. Injection pump
9. Oil pressure sensor

The oil filter is of main flow type. It has a replaceable cartridge mounted on the right side of the engine. At the bottom of the oil filter cartridge there is a by-pass valve for cold start or possible clogging of the filter.

The 645-engines are equipped with a oil cooler of plate type, that is situated on the right side of the engine above the filter. The cooler is of main flow type.

**The cooling system**

40-8

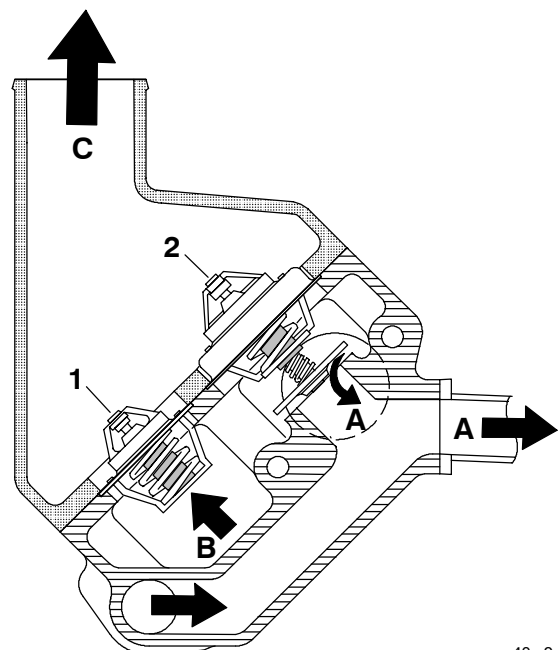
1. Radiator
2. Coolant pump
3. By-pass pipe
4. Thermostats
5. Expansion tank
6. Oil cooler

Cooling system

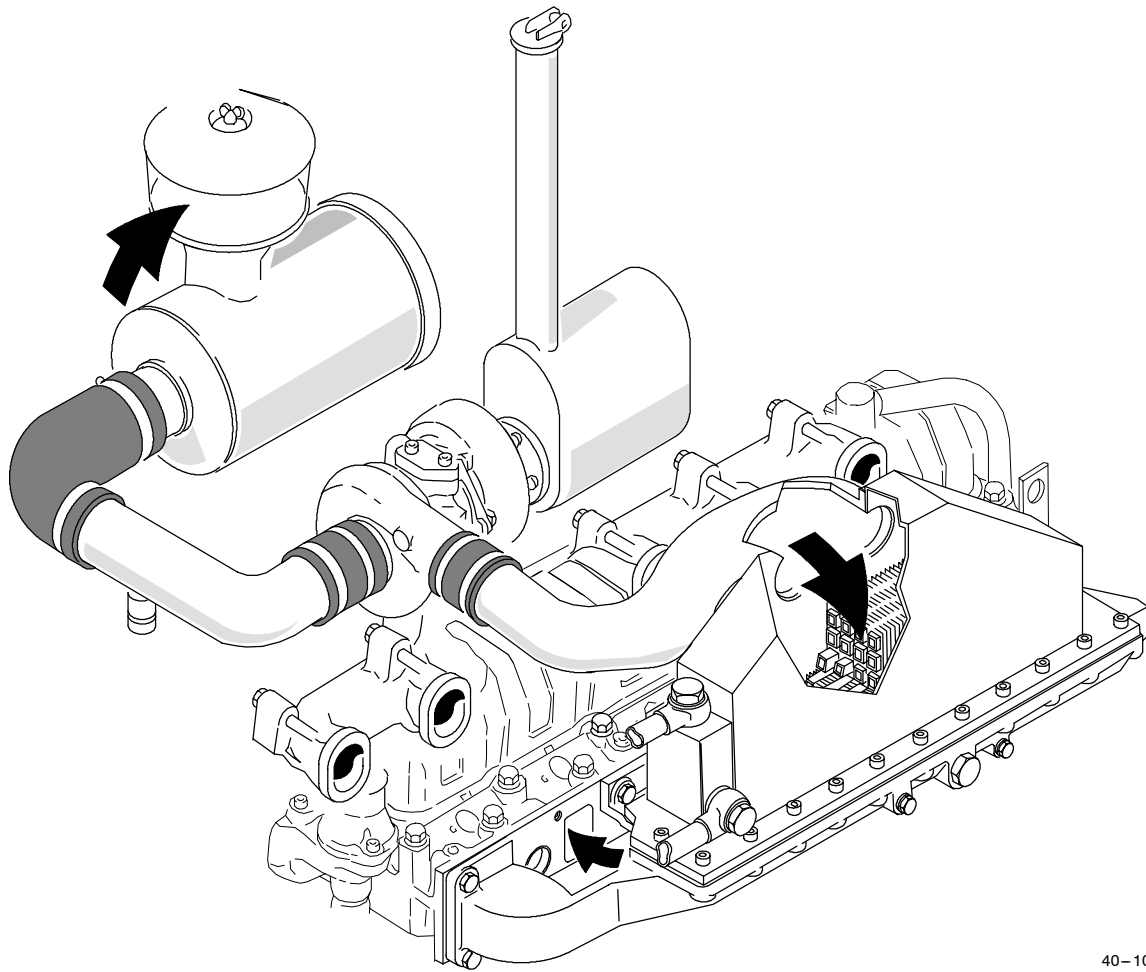
The gear driven coolant pump is attached to the front face of the timing gear housing. The thermostat housing is mounted on front end of the cylinder head. The system has the internal liquid circulation via the by-pass pipe. The circulation is regulated by the 2-way thermostat. This arrangement ensures 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



40-10

Inlet and exhaust system

The filter system for the engine inlet air comprises a cyclone type precleaner, and a paper filter which acts as the main filter. The incoming air is made to rotate in the cyclone precleaner. This causes most of the impurities to settle out and collect in the cyclone precleaner dust collector. The paper filter comprises one or two replaceable filter elements. The paper is corrugated and surrounded by a metal support.

The impurities in the air collect at the larger filter element which can be cleaned when necessary. The inner safety filter prevents impurities from entering the engine should the main filter element break, or be fitted incorrectly.

A mechanical or electrical service indicator can be mounted on the filter housing or on the inlet pipe to show when the filter cartridge is clogged. The inlet system also includes the hoses between the air cleaner and the turbocharger and the turbocharger and the intake manifold.

The exhaust manifold is attached to the cylinder head with elongated stud bolts without a separate gasket. Retightening of the manifold bolts is unnecessary.

The turbocharger is turbo-compressor driven by exhaust gas. The compact design of the turbocharger is sensitive to react even during low revolutions. The turbocharger is lubricated and cooled by the lubrication system of the engine. DW/DWI engine is equipped with a by-pass turbocharger where the highest air pressure is adjusted by so-called by-pass channel.

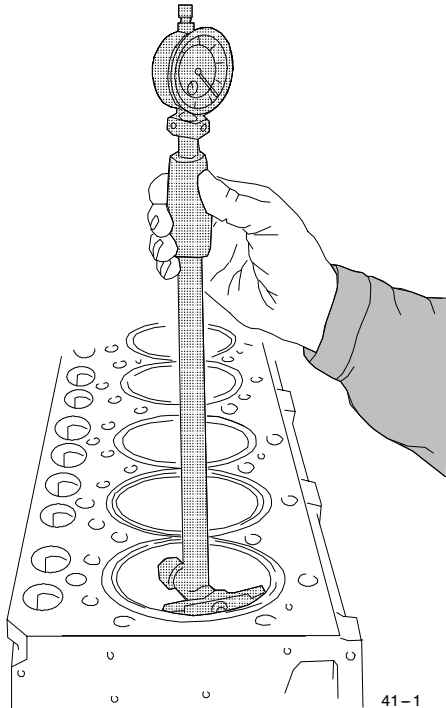
The compressed air is cooled by the air to water basis. The air coming from the turbocharger has a temperature about 150°C which is cooled by the cooling water of the engine down to about 95°C. The cooling cell is installed on the intake manifold and connected to the engine cooling system. The cooling of the compressed air stabilised the combustion, irrespective of the temperature, and minimises the thermal and mechanical load of the engine thus lowering nitric oxides (NO_x). There can be also air to air intercooler in the certain engine versions.

WORK INSTRUCTIONS

1. CYLINDER BLOCK

A. Measuring cylinder liner wear

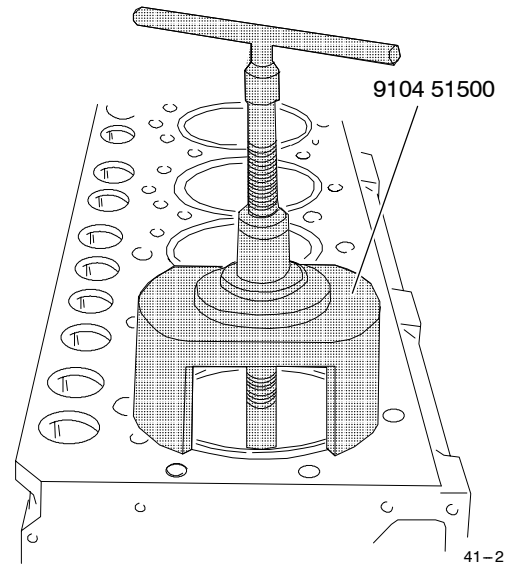
1. Using a micrometer set the dial gauge to zero using a new cylinder liner indicating the initial dimension of the bore: 111,00 mm.
2. Clean the inner surface of the cylinder liner thoroughly before measurement.



3. Perform the measurement crosswise at the liner top end, lower end and middle.
4. Check the gauge reading for maximum wear and ovalness (compare with rated).

B. Removing cylinder liner

1. If the cylinder liners are to be used again they should be marked so that they can be fitted in the same position.



2. Remove the cylinder liners using cylinder liner puller 9104 51500.

C. Checking cylinder block

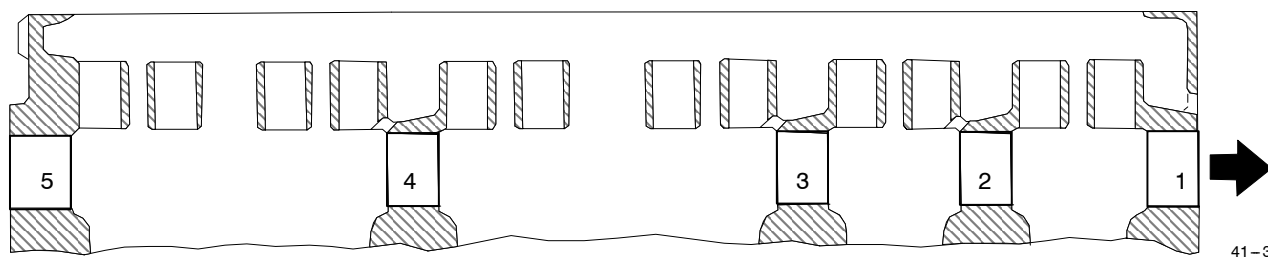
1. Clean the cylinder block and all oil ways.
2. Check the cooling channels and remove the scale and sediment to ensure engine cooling.
3. Check the tightness of the cup plugs and threaded plugs in the cylinder block as well as the condition of the cylinder block and sealing faces.
4. Measure the wear of the camshaft bearing points (compare with rated).

Note! If it is necessary to machine the upper face of the cylinder block, the pistons must be shortened by the same dimension. Observe the valve disc spaces on the piston upper face.

D. Changing camshaft bushing

On the 645-engines, all camshaft bearing points are provided with a separate bearing bushing.

1. Remove the camshaft rear end plug and tap the bushings out with a long drift. Observe the different outer diameters when removing.
2. Clean the bushings location carefully.



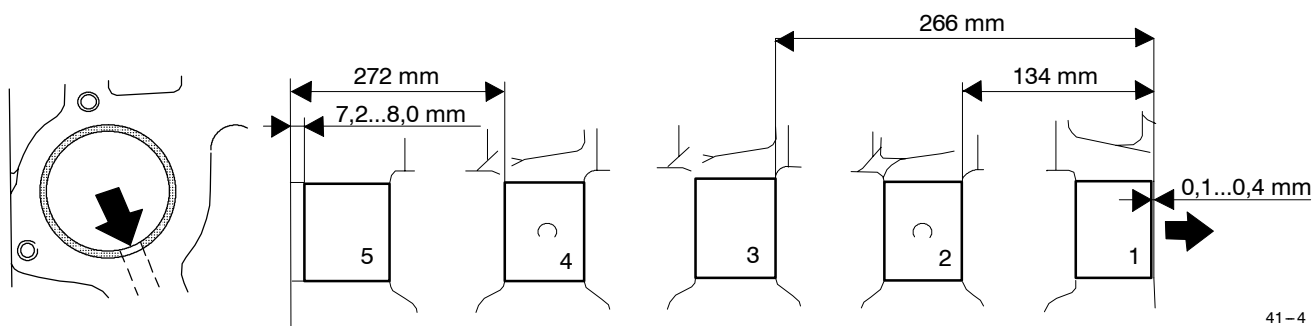
41-3

Order numbers of the camshaft bushings and hole diameters for the bushings.

Note! Numbering begins from the front end of the engine.

Order no**Hole diameter**

1. 8363 22610	55,62...55,65
2. 8368 52460	55,42...55,45
3. 8368 52459	55,22...55,25
4. 8368 52460	55,42...55,45
5. 8368 52461	55,64...55,67

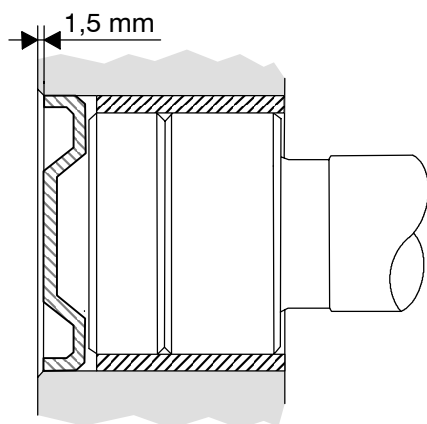


41-4

3. Press in a new bushings. Observe the different outer diameters. Note the position of the oil hole. It is unnecessary to ream the bushing because it has a correct inner diameter when it is fitted in place.

E. Fitting plug at camshaft rear end

1. Clean the seat for the plug.
2. Apply sealing compound to the contact surface of the plug



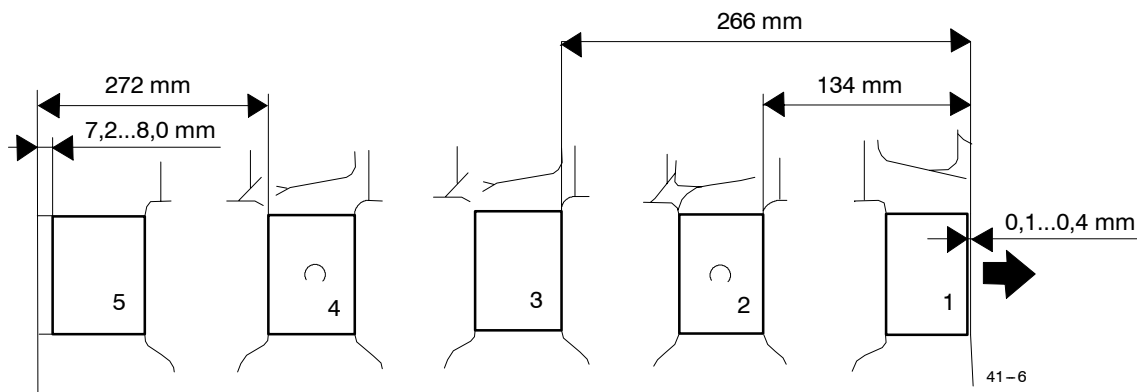
41-5

3. Drive in the plug with fitting drift 9025 87400.

Note! Do not drive in the plug too far because it will affect the camshaft end float.

F. Oversize bushings for camshaft

If the location of the camshaft bushing is damaged, a bushing with a **0,2 / 0,4 mm** oversize outer diameter can be fitted.

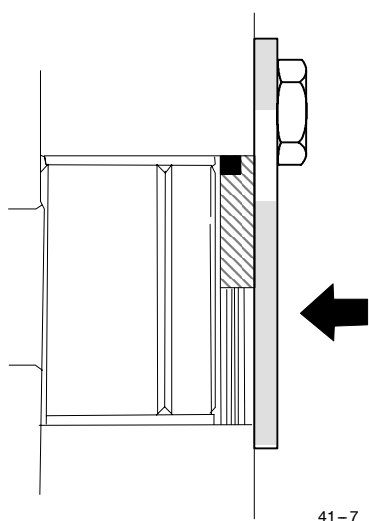


Camshaft oversize bearing bushings. Numbering begins from the front end of the engine.

Order no	Hole diameter
1. 8363 24661	56,02...56,05
2. 8368 52466	55,62...55,65
3. 8368 52460	55,42...55,45
4. 8368 52466	55,62...55,65
5. 8368 52467	55,84...55,87

Press in a new bushings. Observe the different outer diameters. Note the position of the oil hole. It is unnecessary to ream the bushing because it has a correct inner diameter when it is fitted in place.

G. Fitting plug at camshaft rear end (oversize bearing bushings)

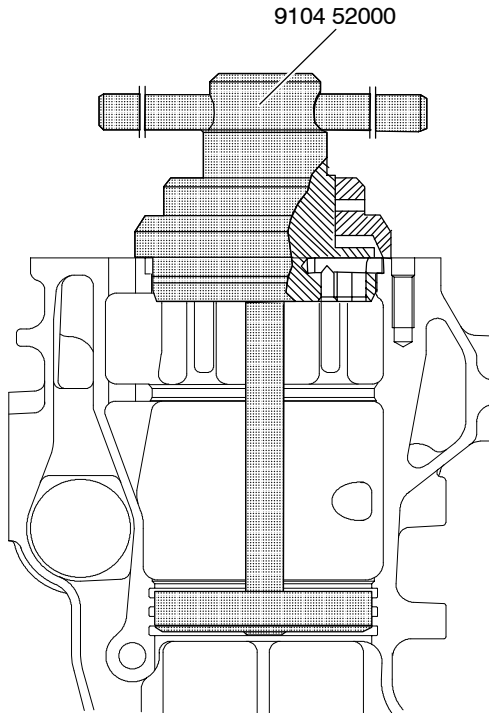


The camshaft rear end plug is replaced with plug 8363 24391 and o-ring 6146 05125 after machining. Use plate 8361 24210 in those engines where the flywheel housing is not covering the blocking plug.

H. Fitting cylinder liner

1. Clean the cylinder liner and its recess in the cylinder block. Without o-rings the liner should rotate easily in its recess.

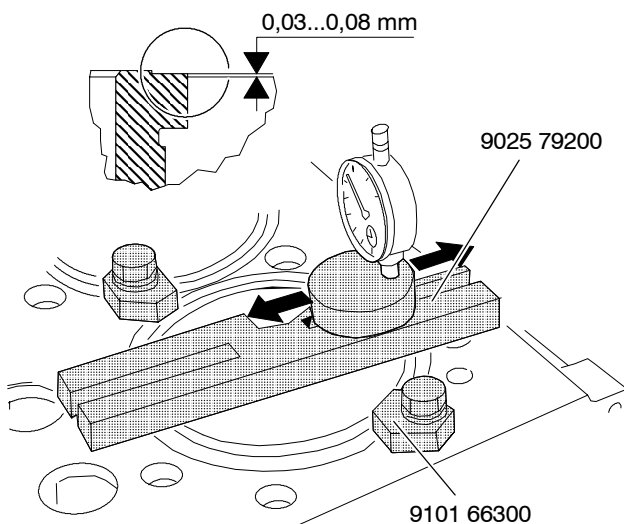
2. Apply a thin layer of marking paint on the underside of the cylinder liner flange. Fit the cylinder liner without o-rings and turn it forwards and backwards. Lift out the liner and check that paint has been deposited on the whole contact surface.



41-8

3. If the recess is damaged, or the cylinder liner height (see point 5) needs to be adjusted, use milling cutter 9104 52000. If necessary, a light lapping can be executed after milling with the help of the cylinder liner. Apply lapping paste to the underside of the cylinder liner flange, and twist the liner with twisting tool. Lapping is not suitable for adjusting the cylinder liner height.

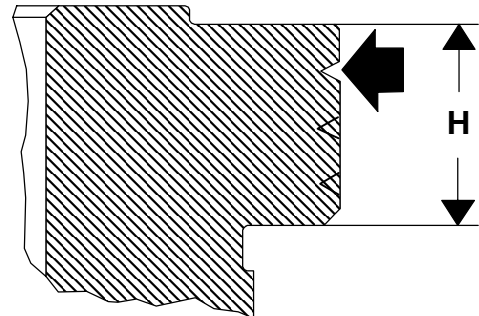
4. Clean the contact surfaces.



41-9

5. Fit the cylinder liners and fix each liner with two press tools 910166300. Measure the cylinder liner height with a dial gauge and holder 9025 79200. Zero the dial gauge against a flat surface, for example, the cylinder block face. Measure each liner in four places. The height of the liner above the cylinder block face should be **0,03...0,08 mm**. The height difference between cylinder liners under the same cylinder head must not exceed **0,02 mm**, nor must an intermediate cylinder liner lie lower than an outer one.

6. If the cylinder liner height is too low, a liner with a higher flange is fitted.



41-10

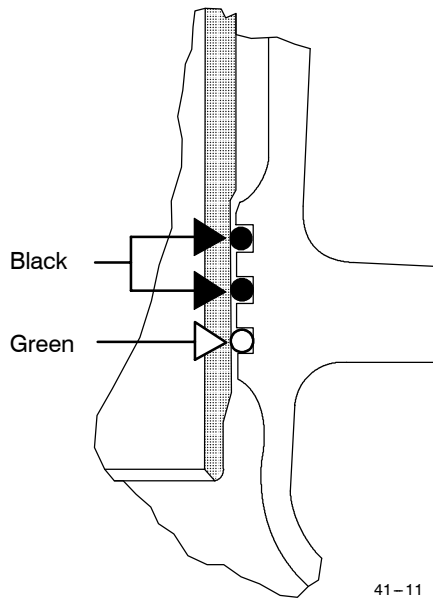
Order no	H	Marking grooves pcs
8368 55445	9,03 ^{+0,02}	— (std.)
8368 59581	9,08 ^{+0,02}	1
8368 59582	9,13 ^{+0,02}	2
8368 59583	9,23 ^{+0,02}	3

Cylinder liners with oversize flanges (higher flanges) are marked with grooves on the outer circumference as follows:

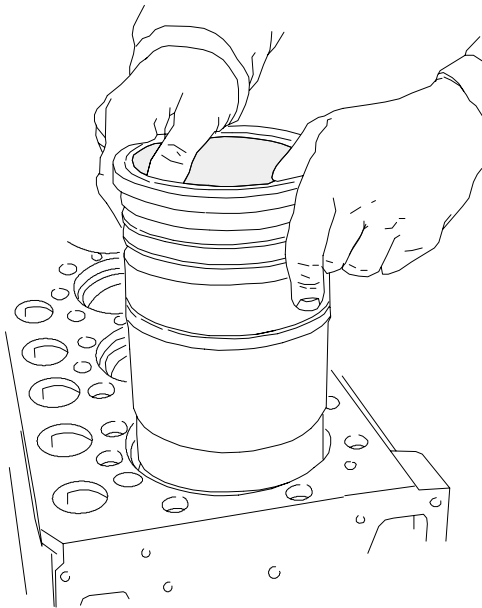
1st oversize, 0,05 mm = 1 marking groove
 2nd oversize, 0,10 mm = 2 marking grooves
 3rd oversize, 0,20 mm = 3 marking grooves

Note! Recess depth is adjusted with a cylinder liner recess cutter 9104 52000.

7. If the liner height of a cylinder liner is not the same all the way round, the cylinder liner flange and the cylinder block recess depth should be checked. Cylinder liners with warped flanges should be discarded.



8. Fit the o-rings into the grooves in the cylinder block and lubricate them with a liquid soap (not with engine oil).



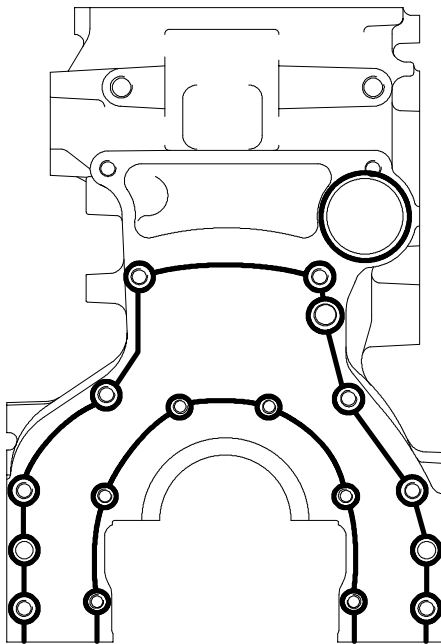
9. Press the cylinder liners into the cylinder block. It should be easy to press them fully home. Make sure that the liners do not rise up after fitting.

2. FLYWHEEL HOUSING

A. Fitting flywheel housing

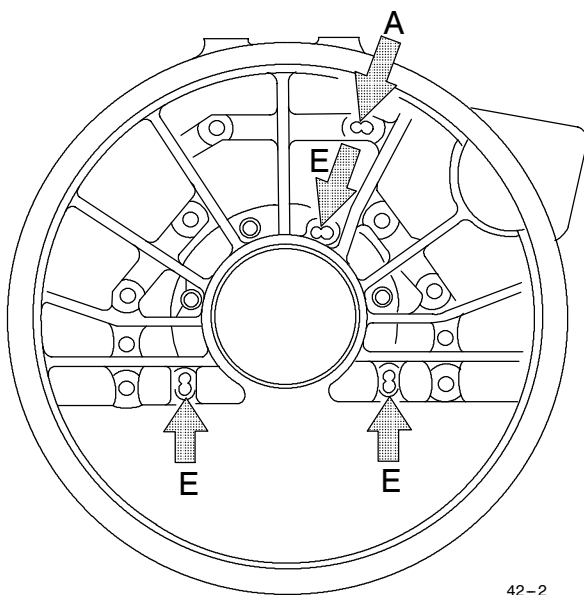
The flywheel housing is centred on the cylinder block by two tension pins. Even the flywheel housings which are delivered as spare parts have ready-made holes for the pins.

1. Clean the sealing surfaces between the cylinder block and the flywheel housing.



42-1

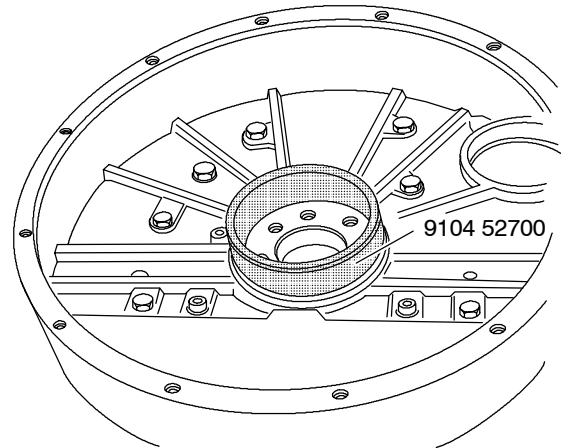
2. Apply silicone sealing as shown in figure above.



42-2

3. Lift the flywheel housing into place and fit all the bolts.

Note! Use a spring washers under the bolts in the holes **A** and **E** !



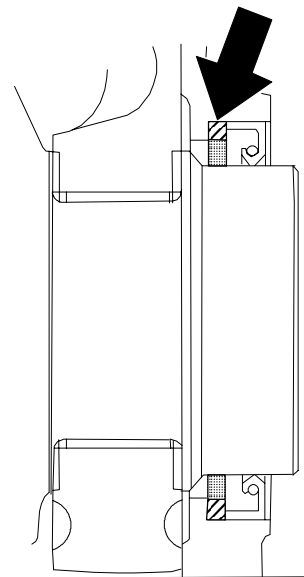
42-3

4. Centre the housing with centring tool 9104 52700 (**Note!** This is important of the engines with a turbine clutch). Fit the tension pins with drift 9025 98700.

5. Tighten the fixing bolts, the inner ring socket head bolts to **60 Nm** and outer ring hexagonal bolts to **110 Nm**.

B. Changing crankshaft rear oil seal

1. Lift out the engine. Remove the clutch assembly (and possible turbine clutch).
2. Remove the flywheel.
3. Remove the oil seal. Do not damage the crankshaft.
4. Clean the seal location and grind off any burrs.

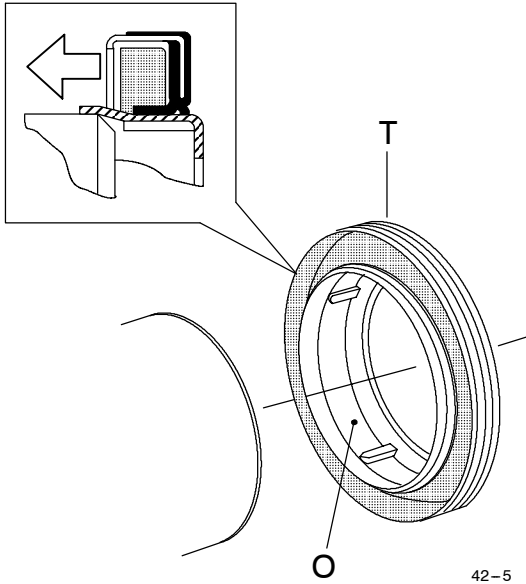


42-4

Note! If the crankshaft is worn at the sealing location, a 2 mm spacer ring, part no 8360 20054, can be fitted in front of the crankshaft rear oil seal.

5. Fit the seal as follows:

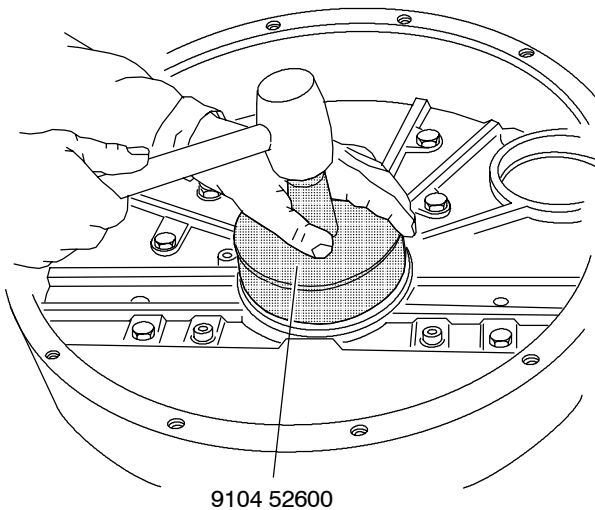
- Do not remove the plastic sleeve in before hand.
- **NOTE! FIT THE SEAL DRY, NOT OILED**



O = Sleeve

T = Seal

- Put the sleeve against the crankshaft rear end so that the sleeve is on the shaft bevelling.
- Push the seal over the sleeve on the shaft and further against the flywheel housing.



9104 52600

42-6

- Remove the sleeve and hit the seal into position with the fitting tool 9104 52600.

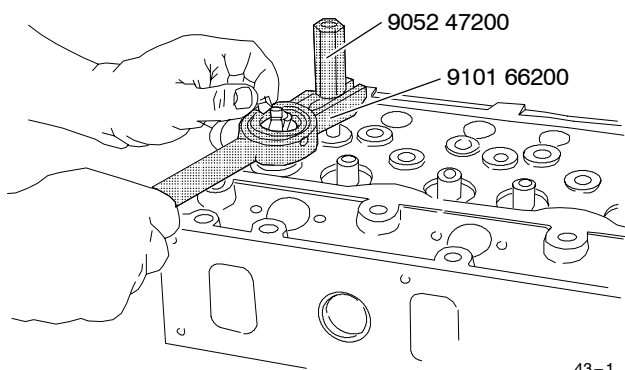
3. CYLINDER HEAD

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 thermostat 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 though 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

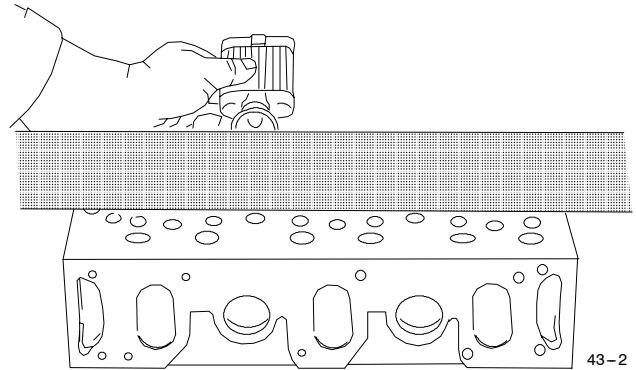
Ensure that valves which are to be re-used are marked, so that they are fitted in their original locations.



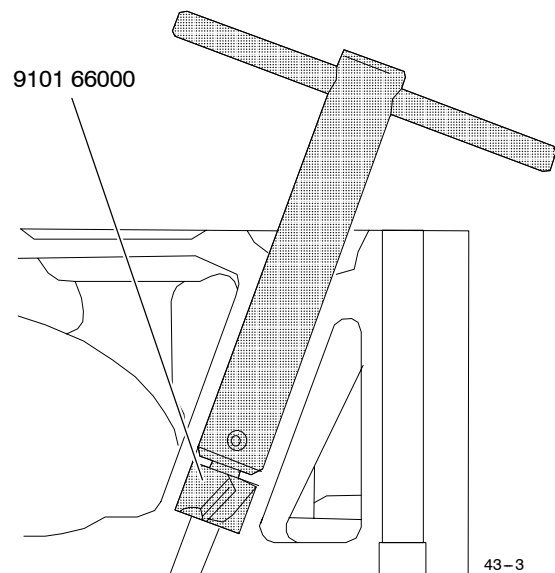
1. Install the counter screw 9052 47200 for the valve spring installing tool in the rocker arm cover bolt. For the valves in the middle, use a bolt of suitable length.
2. Compress the valve springs using lever 9101 66200. Remove the valve cotters, spring guide and spring. Remove the valves.

C. Checking cylinder head

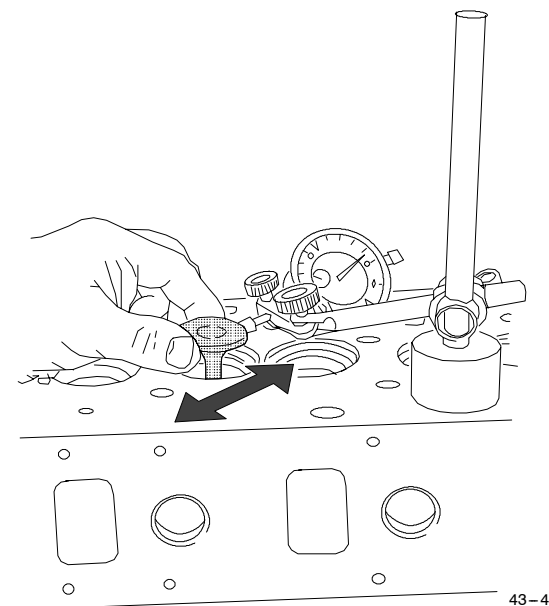
1. Remove the soot from the exhaust ports, clean the sealing surfaces and wash the cylinder head.
2. Check for cracks and other damage.



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.

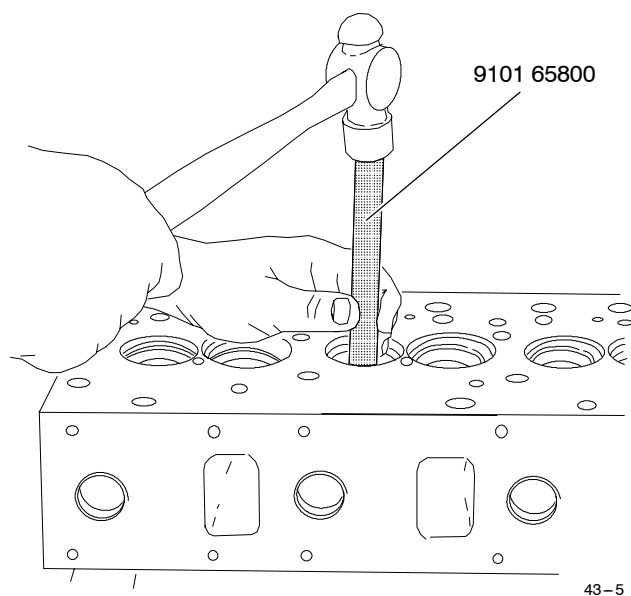


4. Straighten and clean the injector location seat in the cylinder head with cutter 9101 66000.



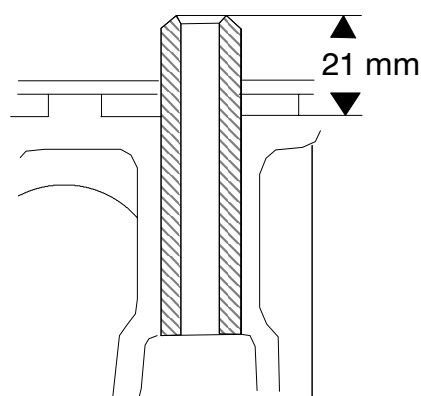
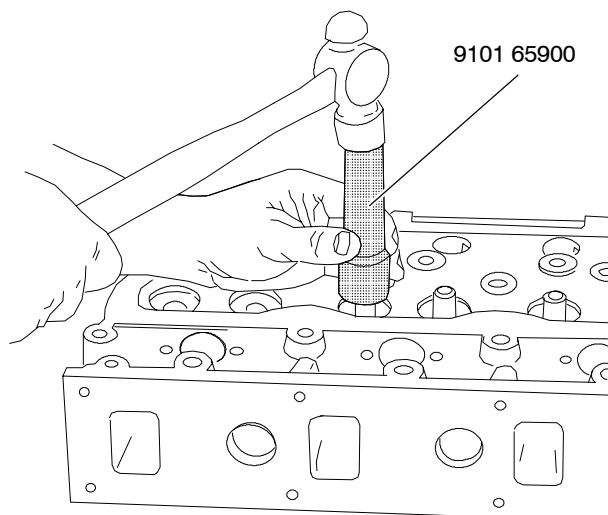
5. Measure the clearance between the valve stem and the valve guide with a dial gauge. Lift the valve so that the valve head is **15 mm** from the face of the cylinder head, and measure the clearance. It must not be greater than **0,30 mm** for the inlet valves and **0,35 mm** for the exhaust valves. In order to establish the valve guide wear, a new valve should be used when measuring.

D. Changing valve guides



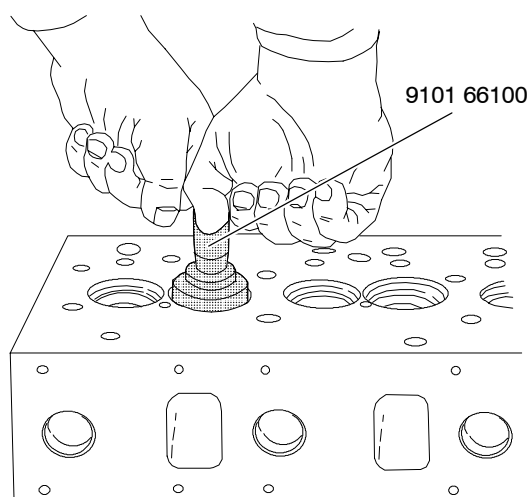
1. Press or knock out the old guides using drift 9101 65800. Clean the valve guide locations.

2. Lubricate the outside of the new guides and fit them using drift 9101 65900, which ensures the correct fitting height (**21 mm** over the spring face).



3. The guides are the same for the inlet and exhaust valves. Ensure that the steepest chamfer on the guide, faces the valve head. Check that the valves do not bind in the guides.

E. Machining valve seat



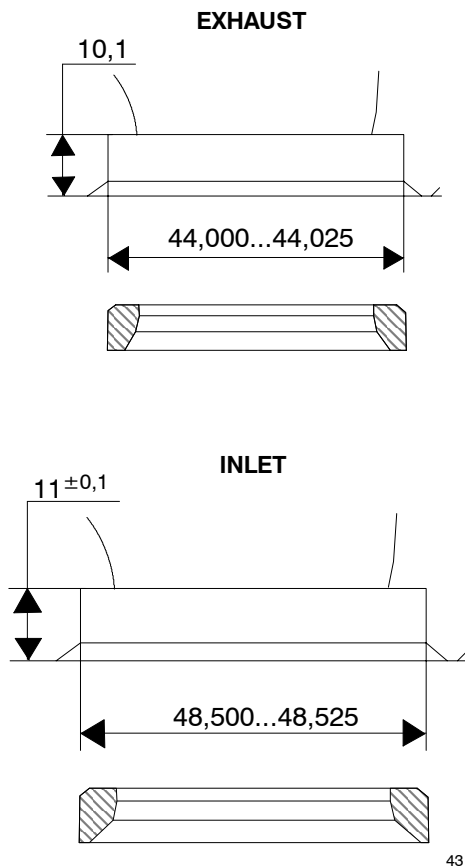
Machine the damaged valve seat with milling cutter. If the width of the seat exceeds **2,3 mm** in exhaust and **3,7 mm** in intake, it should be reduced primarily at the outer edge.

The valve seat angle is **45° +20'** for exhaust valve and **35° +20'** for inlet valve.

F. Changing valve seat rings

Exhaust and inlet valves are fitted with separate valve seat rings. If the sealing surface is damaged so badly that it cannot be repaired with machining, the seat ring should be changed.

1. Grind the valve head on a discarded valve so that it sits down in the valve seat. Fit the valve and weld it in place in the seat. Cool with water.
2. Turn the cylinder head over and knock out the valve and seat.



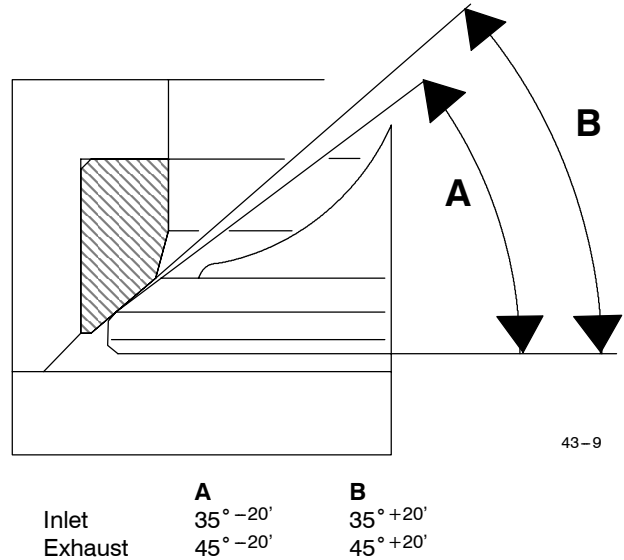
3. Clean the valve seat location and check dimensions. Cool the new seat ring in liquid nitrogen until it stops bubbling, or alternatively place it in dry ice.

4. Fit the seat with a suitable drift. Machine the seat.

Note! Where necessary, standard size seats can be replaced by inserts with a larger outer diameter. See technical data, point **cylinder head**.

G. Grinding valves

In order to ensure that there is a proper seal around the valves, there is a difference in the sealing surface angles. Thus there is a very narrow sealing surface which seals effectively even after prolonged running.



1. Grind the damaged valve disc with a valve refacer. Adjust angles to **45° -20'** for exhaust valves and **35° -20'** for inlet valves.

2. If the edge of the valve head is less than **1,5 mm** after it has been ground, or if the valve stem is bent, the valve should be discarded.

3. If necessary, grind the end of the valve stem.

4. Lap the valves with lapping paste and check the contact surface with marking paint.

5. Clean the cylinder head and valves of any remaining lapping paste.

H. Fitting valves

1. Check the valve springs for straightness, length and tension using a spring tester. Compare with specifications.

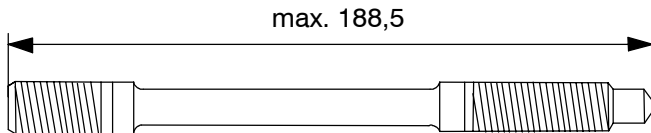
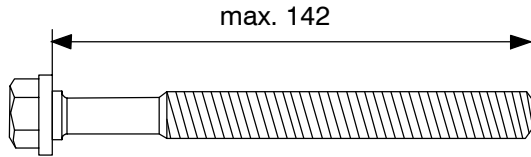
2. Lubricate the valve stems and fit the valves in the correct order in the cylinder.

3. Fit the springs, spring guides and valve keepers with the aid of a lever for compressing valve springs, 9101 66200.

4. Tap the end of the valve stems lightly after fitting the valve in order to ensure that they are secure.

I. Fitting cylinder head

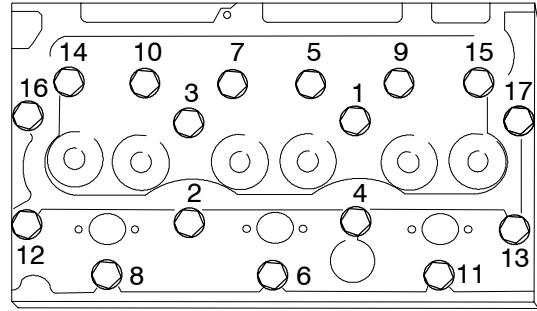
1. Measure the length of the cylinder head bolts. Compare with dimensions shown in figure below. Change too long bolts.



43-10

2. Screw the cylinder head stud bolts in to the cylinder block to a torque of **30 Nm**. Fit the valve tappets if removed.

3. Check that the sealing surfaces are clean and fit the cylinder head gaskets and the cylinder heads. Ensure that both cylinder heads are parallel by fastening lightly the exhaust manifold before tightening the cylinder head bolts (the exhaust manifold can damage, if the heads are not parallel). Clean and lubricate and fit the bolts.



43-11

4. Picture above show the correct tightening order of the cylinder head bolts. The order has also been marked on the cylinder heads.

5. Tighten the cylinder head bolts progressively as follows:

1. First tightening to **80 Nm**.
2. Tightening of **90°**.
3. Tightening again of **90°**.

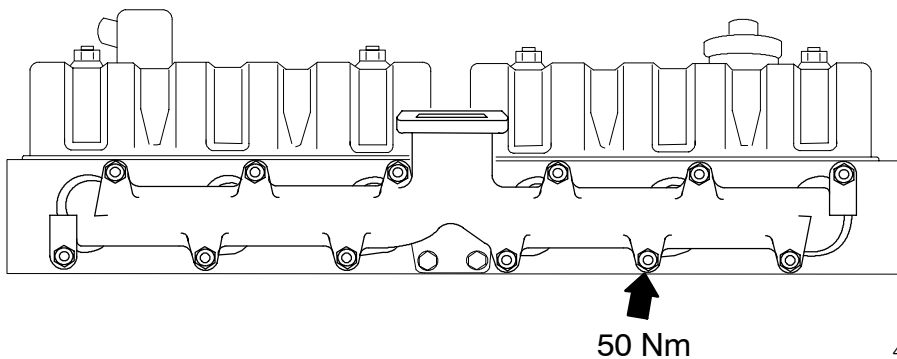
6. Adjust the valve clearances (see instruction **4 C**).

7. Run the engine with a light load to the normal running temperature ($\sim 75^{\circ}\text{C}$).

8. Tighten the bolts **60°** and adjust the valve clearances.

Note! After this the cylinder head does not need retightening.

Tighten the exhaust manifold nuts to **50 Nm**. **DO NOT OVER TIGHTEN THE NUTS!**

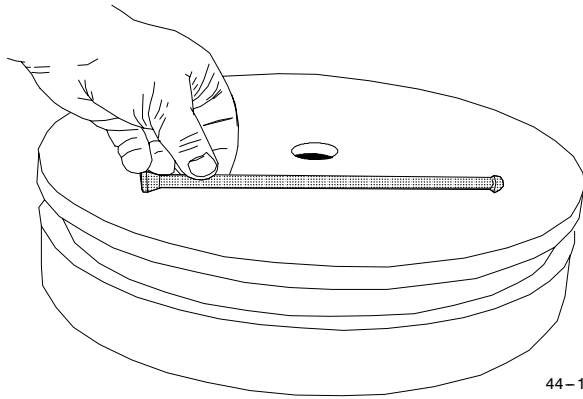


43-12

4. VALVE MECHANISM

A. Reconditioning valve mechanism

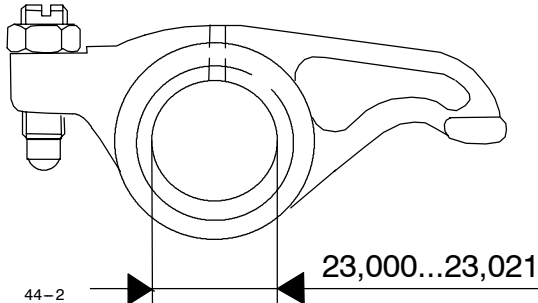
1. Check the valve tappets, especially the contact surface against the camshaft. Worn or damaged tappets should be discarded.



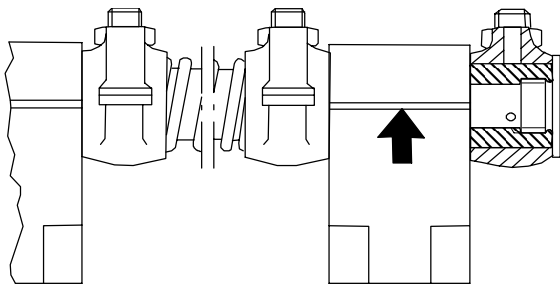
44-1

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

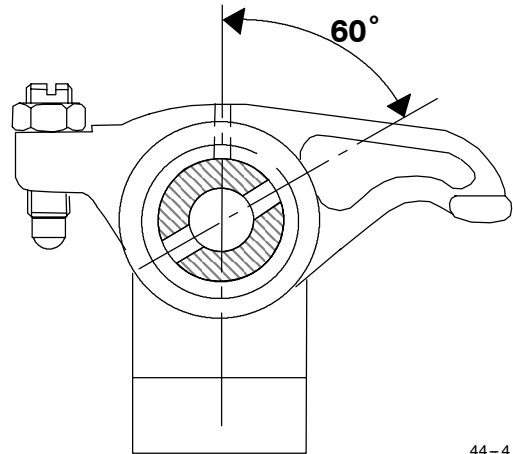
3. Dismantle and clean the rocker arm mechanism. Check the shaft for wear and that the oilways are clean.



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.

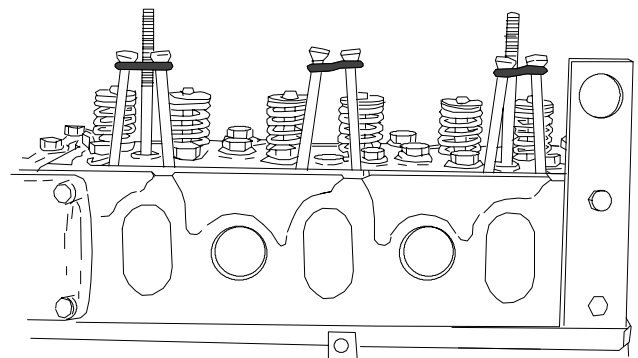
B. Changing camshaft/ camshaft gear

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.

7. Separate the camshaft from the gear wheel using a press or suitable drift.

8. Clean the parts which are to be refitted.

9. Fit the key in its groove. Heat the camshaft gear to **200 °C** in an oven and fit it on the shaft.

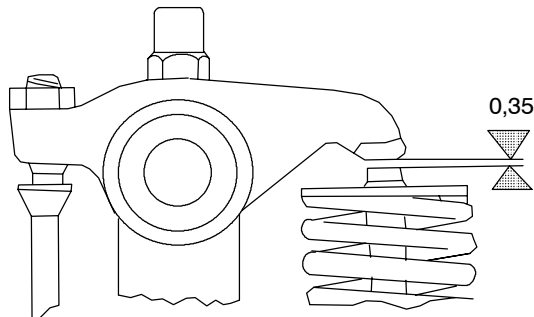
10. Lubricate bearing surfaces and lobes and insert the shaft in the cylinder block. Ensure that the aligning marks on the gears agree.

11. Fit the timing gear casing cover, the hub, damper and crankshaft V-belt pulley.

12. Free the pushrods and fit the rocker arm mechanism. Adjust the valves. Fit the valve cover and the breather pipe and the inlet pipe between the turbocharger and the intake manifold.

13. Fit the other removed parts.

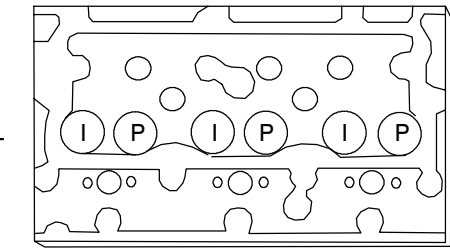
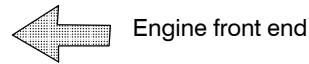
C. Adjusting valves



44-6

The valve clearance, which can be adjusted on a hot or cold engine, is **0,35 mm** for both inlet and exhaust valves. The clearance is adjusted when the respective piston is at T.D.C. in the compression stroke. The valves for the different cylinders are adjusted in the same sequence as the order of injection.

- Slacken the lock nut of the adjusting screw.
- Measure clearance with a feeler gauge. The clearance is correct when a **0,35 mm** feeler gauge is slightly tight-fitted between the rocker arm and the valve stem end. Adjust clearance by rotating the adjusting screw.
- Tighten the locking nut and check the clearance.



44-7

ⓘ INLET
Ⓟ EXHAUST

Adjusting

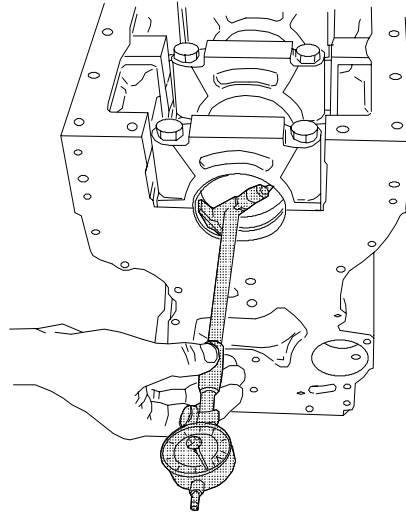
- Rotate the crankshaft in the running direction until the valves in the 6th cylinder are rocking (exhaust closes, inlet opens). Check the valve clearance of the 1st cylinder.
- Rotate the crankshaft by 1/3 of a turn in the running direction so that valves in the 2nd cylinder are rocking. Check valves in the 5th cylinder.
- Continue according to the order of injection:

Injection order	1 5 3 6 2 4
Valves rock in cyl. no	6 2 4 1 5 3

5. CRANKSHAFT

A. Removing crankshaft

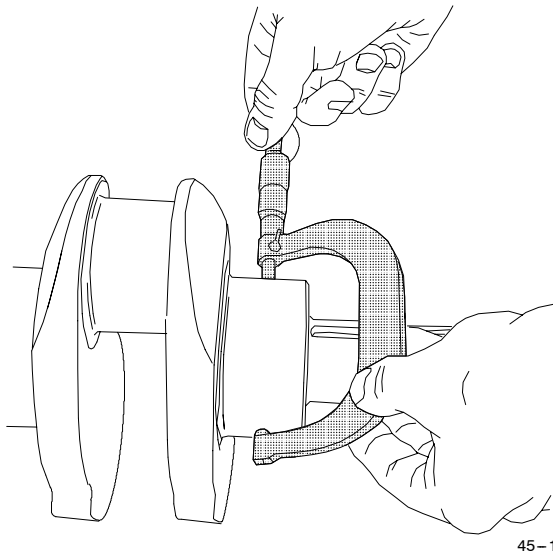
1. Remove the oil sump.
2. Unscrew the lubricating oil pump pressure pipe fixing screws from the cylinder block. Remove the oil pump and the suction and pressure pipes.
3. Remove the flywheel and the flywheel housing.
4. Detach the belt pulley and vibration damper from the crankshaft front end. Pull off crankshaft hub and remove timing gear housing (see instruction **8 A**).
5. Remove the connecting rod bearing caps and push the connecting rods out of the way of the crankshaft.
6. Remove the main bearing caps and lift out the crankshaft.



45-2

B. Checking crankshaft

1. Clean the crankshaft. Do not forget the oilways.



45-1

2. Measure the journal wear in several points. Out-of-round, taper or other wear must not exceed **0,03 mm**.

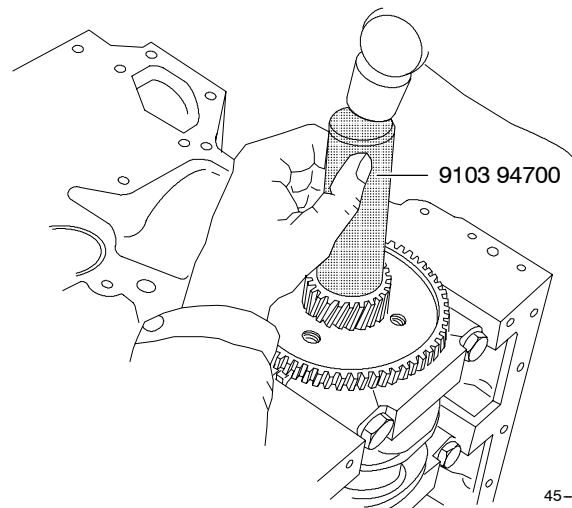
3. Refit the bearing caps with new bearing shells and tighten them to the correct torque. Measure the I.D. with a dial gauge which has been zeroed to the dimensions obtained in point 2. With this method the indicator shows the actual bearing clearance. Measure in several points in case the worn bearing housing is not round.

4. If the bearing clearance exceeds **0,18 mm** for main bearings or **0,14 mm** for connecting rod big-end bearings with new bearing shells, the bearing journals on the crankshaft should be ground. Refer to the specifications for the relevant correct undersize and the corresponding bearings, see technical data, point **crankshaft**. **When grinding note that the journal edges must remain round.**

C. Changing crankshaft gears

1. Break the crankshaft gears using e.g. a grinder. Grind the gears enough. Hit the gears apart with a chisel. Do not damage the crankshaft!

2. Clean the seat on the crankshaft with, for example, a wire brush.

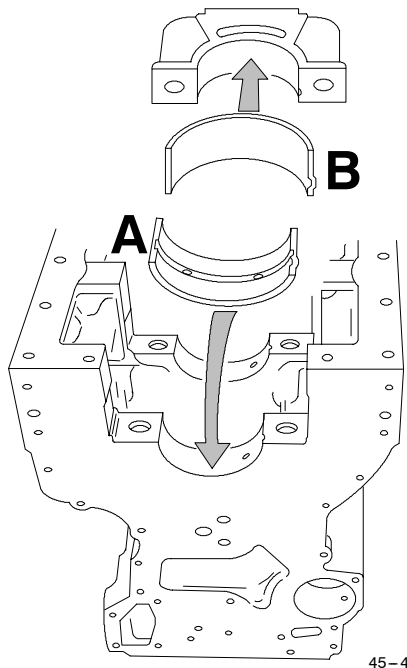


45-3

3. Heat the new gears to **220...250° C**. Tap them onto the shaft with drift 9103 94700. Note the position of the key and ensure that the aligning marks on the front gear are visible. Leave it to cool.

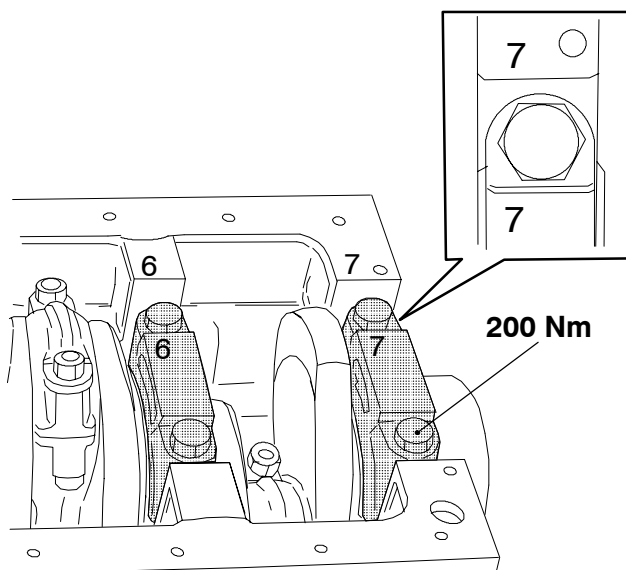
D. Fitting crankshaft

1. Clean the oilways, bearing shells and bearing locations. Check that the crankshaft is clean.

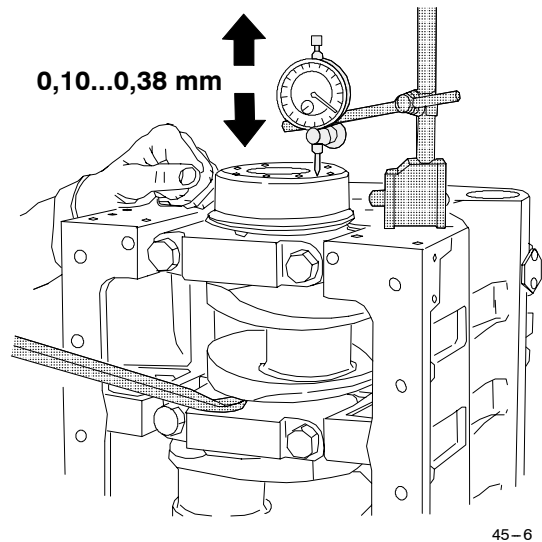


2. Assembly the bearing with oilholes/groove (A) to the cylinder block and the bearing with no hole (B) to the bearing cap. Ensure that the bearing shell clamping claws fit into their notches and that the shells to be fitted in the cylinder block have a hole coinciding with the oil port.

3. Lubricate the bearing surfaces and fit the crankshaft. Fit the crankshaft thrust bearings with the lubricating grooves facing the crankshaft.



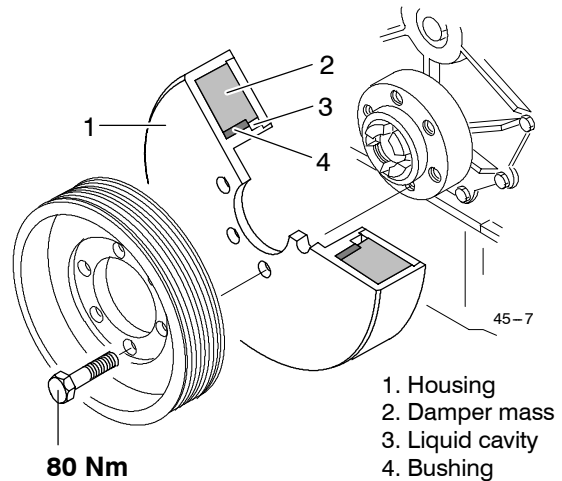
4. Fit the main bearing caps according to their numbering, the rear with thrust bearings provided with guide lugs. Lubricate the bolts and tighten them to **200 Nm**.



5. Check that the crankshaft can rotate without binding. Check the end float using a dial gauge. The correct end float is **0,10... 0,38 mm**. If the end float is too large, oversize thrust bearings should be fitted.

Note! Bearing shells should never be reamed or machined in any other way, nor should the sides of the bearing caps be filed

E. Checking vibration damper



In the 645-engines the crankshaft front end incorporates a torsional vibration damper. The vibration damper consists of a sealed housing in which there is a mass of steel. This mass (the damper ring) is carried in the centre on a bushing and is surrounded on all sides by a viscous silicone fluid.

Do not remove the damper by turning forcibly and be careful not to damage it when it is loose. Even a small dent makes the damper inoperative. If you detect a dent on the outer surface, do not install the damper back in the engine.

Note! (645-engines with timing mark on the damper) Vibration dampers delivered as spare parts do not have injection timing mark. Make the marking on the new damper with an electrical pen, **do not tap!**
Piston distance from top dead centre vs. crank angle, see instruction 7 B.

6. CONNECTING RODS AND PISTONS

A. Removing pistons together with connecting rods

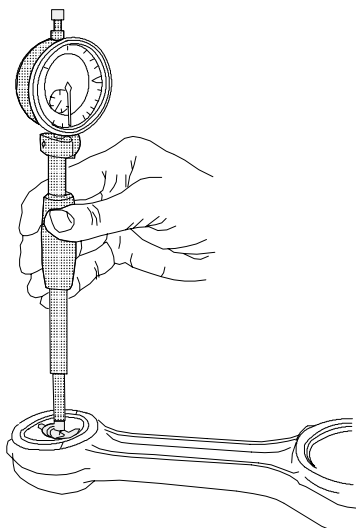
1. Remove the oil sump and the oil inlet and pressure pipes.
2. Remove the cylinder head.
3. Scrape off the possible soot in the cylinder liner. If the turning edge is clearly marked, smooth it down carefully with a scraper.
4. Remove the big end bearing caps and bearing shells. Place the shells in order if they are to be re-used.
5. Push up the piston and connecting rod with the shaft of a hammer or similar wooden tool.
6. Remove the piston pin snap rings. Push out the pin.

Note! If the piston pin does not move under thumb pressure the piston should be heated to **100°C**.

B. Changing connecting rod bearings

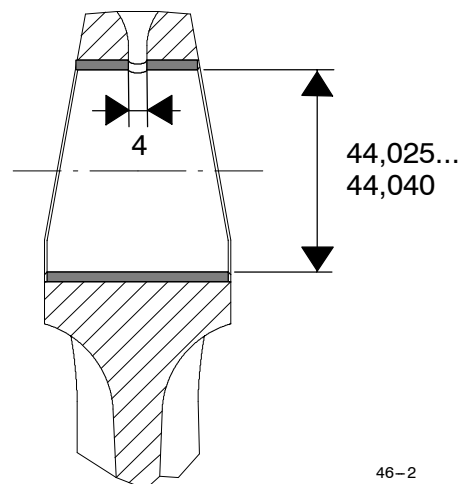
Piston pin bushing

1. Clean the connecting rod and bearing shells.



46-1

2. Measure the I.D. of the piston pin bushing using a cylinder gauge.
3. If the piston pin bushing is worn, it should be driven out using a suitable drift.



46-2

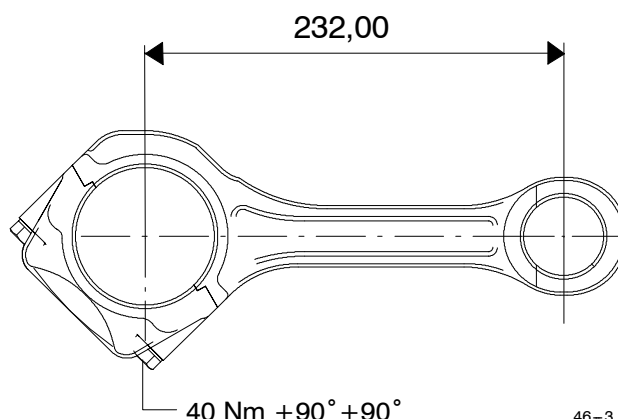
4. Press the new bush in its place. Ensure that the oil hole in the bush coincides with the respective hole in the connecting rod. After fitting drill $\varnothing 4 \text{ mm}$ oil hole and ream the bush to attain its correct diameter.

Big end bearing

1. Fit the bearing shells together and tighten the bolts to **40 Nm +90° +90°**.
2. Measure the I.D. using a cylinder gauge which has been zeroed to the diameter of the respective bearing journal. If the clearance exceeds **0,14 mm** with new bearing shells, the big end journals require grinding. Refer to the specifications for the correct undersize and the corresponding bearing. Ensure that the radii at the end of the bearing journals is not altered when grinding.

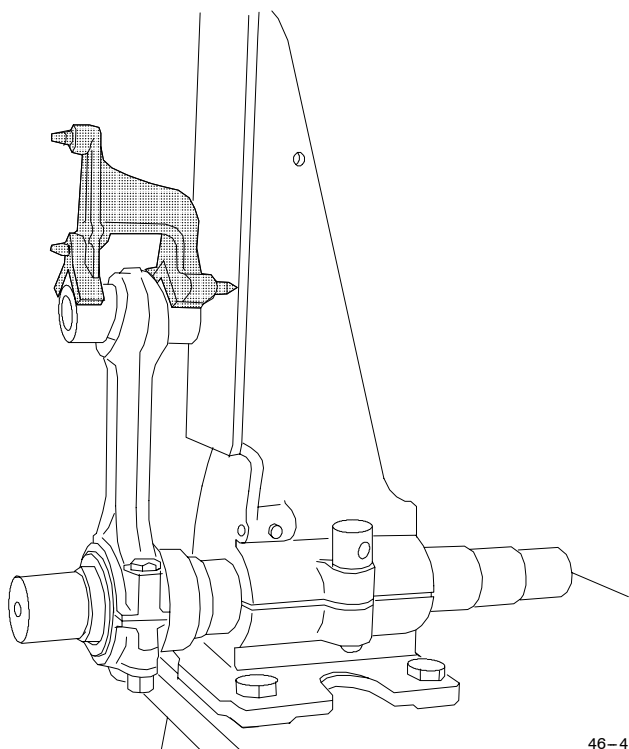
C. Checking connecting rod

The connecting rod is checked in a special fixture, intended for the purpose (e.g. Carl Larsson).



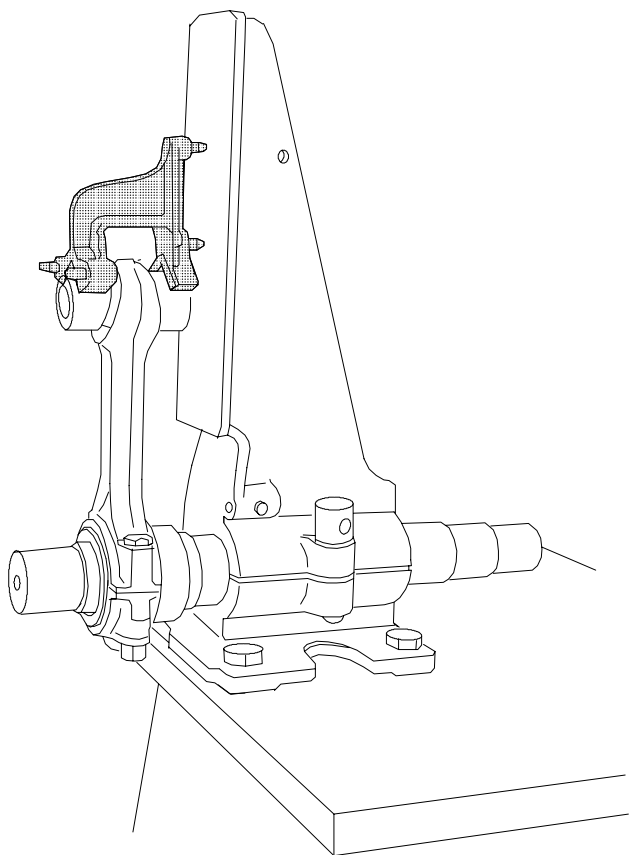
46-3

1. Fit the big end bearing caps and tighten the bolts to **40 Nm +90° +90°**.
2. Fit the connecting rod in the fixture and fit the piston pin which corresponds to that connecting rod.



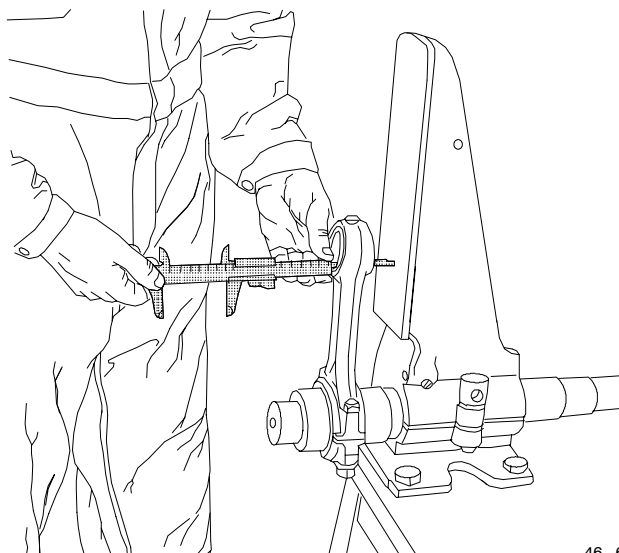
46-4

3. Check that the connecting rod is not twisted by positioning the measuring tool with the horizontally placed measuring points against the face of the fixture.



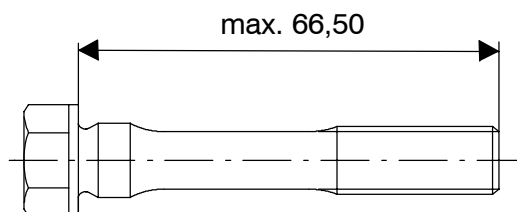
46-5

4. Turn the measuring tool round with the vertically placed measuring points against the face, and check the straightness of the connecting rod.



46-6

5. Also check the S-bending of the connecting rod by using sliding callipers to measure the distance between the edge of the small-end bearing bushing and the face of the fixture. turn the connecting rod round so that the other side of the connecting rod faces the fixture. Then measure the same distance. The accepted deviation is **0,6 mm**.

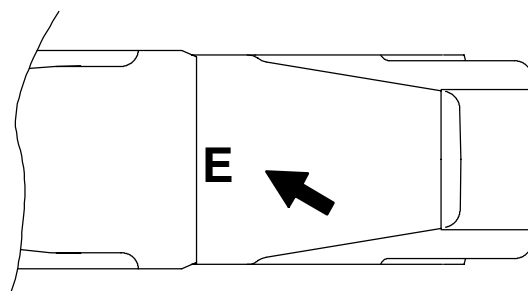


46-7

6. Measure the length of the connecting rod bolts. The length should be max **66,50 mm**. If the bolt is longer, change it with a new one. It is recommended that the bolts are always changed when they are unscrewed.

D. Connecting rod weight classes

The connecting rods are divided into weight classes with intervals of **20 g**. The weight class (a letter) is stamped on the side face of the connecting rod. All the connecting rods in one engine should be of the same weight class, that is to say the greatest permissible weight difference is **20 g**.



46-8

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
O 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

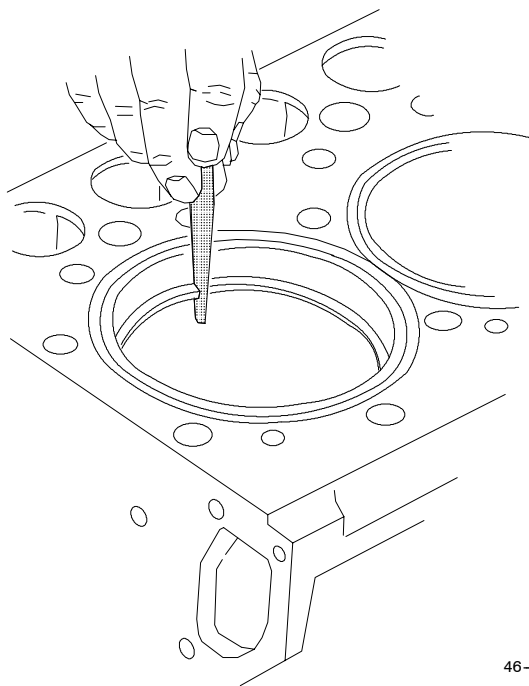
E. Changing piston rings

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

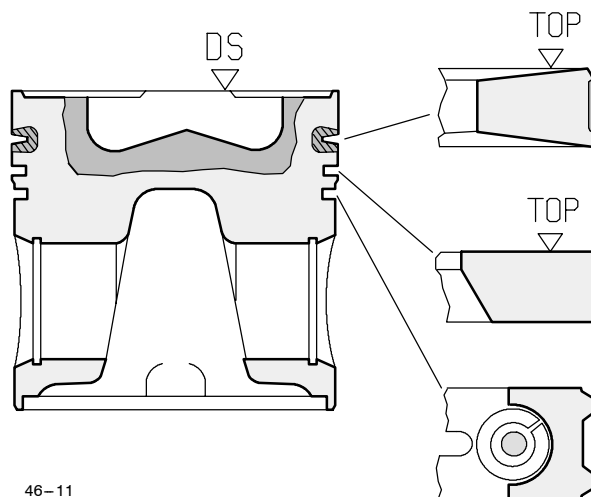
2. Clean the piston ring grooves and measure the piston ring clearance, which must not exceed **0,15 mm**. Determine whether too large a clearance is due to worn rings or a worn groove. Change worn parts.



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.

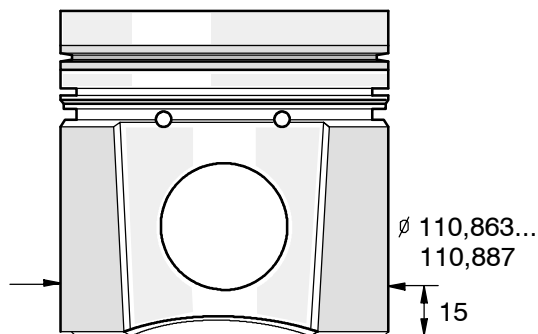
4. Fit the piston rings on the piston using the piston ring pliers. Ensure that the rings are fitted in the correct groove and that "TOP", or the manufacturer's designation, faces upwards.



46-11

F. Checking pistons

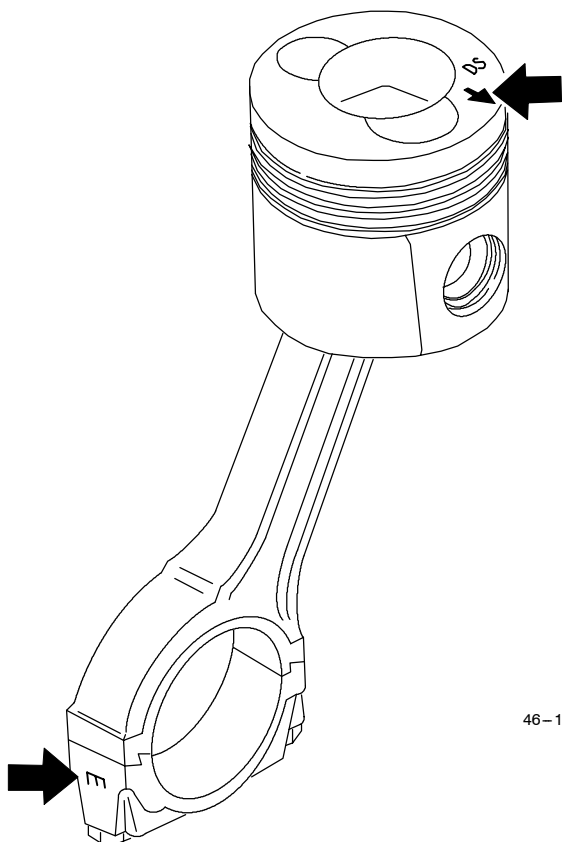
Check the condition of the pistons and piston pins. Pay special attention to possible cracks on the edge of the combustion chamber and on the upper edge of the piston pin hole. Measure the diameter of the piston at the point shown in the figure below. Renew a piston if needed.



46-12

G. Fitting piston pin

1. Place the connecting rod inside the piston and push the piston pin into place.



46-13

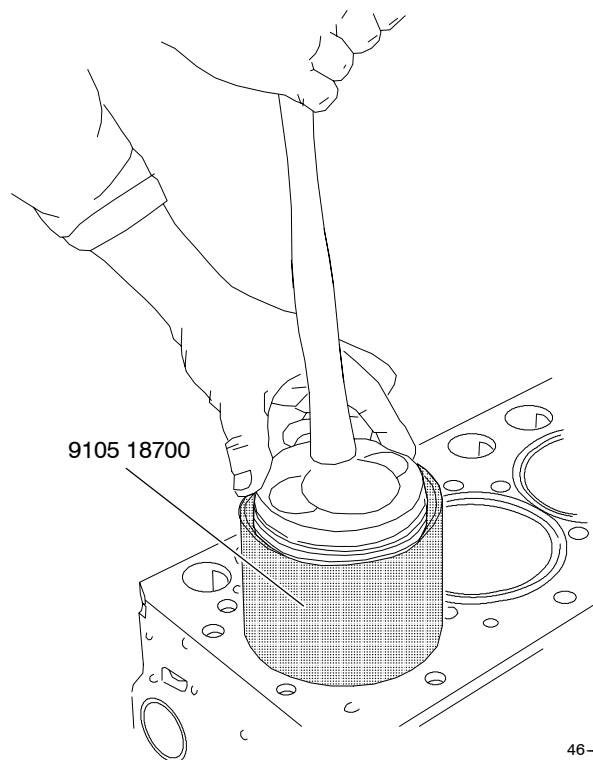
Note! The combustion chamber and the weight class letter should be on opposite sides!

2. Fit the piston pin circlips. Ensure that the circlips are pressed correctly into the grooves. The circlip ends must point upwards.

H. Fitting piston together with connecting rod.

1. Check that the bearing locations are clean and place the bearing shells in the connecting rod and bearing cap. Note the position of the bearing shells.

2. Lubricate piston, rings and cylinder bore. Ensure that the piston ring gaps are spread around the piston.



46-14

3. Use a piston ring strap or preferably a fitting tool (9105 18700). Fit the piston with the marking on the connecting rod (weight class) facing the camshaft (an arrow on the piston must point forward).

4. Lubricate the big end bearing journal and bearing shells, and push the piston down. Fit the bearing cap so that the notches for the guide lugs are in the same side. Tighten the connecting rod bolts to **40 Nm +90° +90°**.

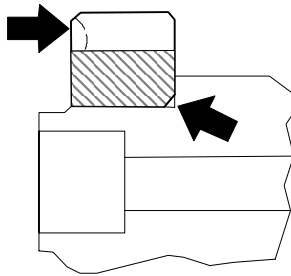
5. Check that the connecting rod has sufficient end float on the big end bearing journal.

7. FLYWHEEL

A. Changing starter ring gear on flywheel

If the ring gear is worn, change it with a new one. The ring gear cannot be turned around because its teeth are chamfered and hardened on the starter motor side.

1. Remove the old starter ring by tapping it at various points with a drift. Clean the flywheel contact face with a steel-wire brush.



47-1

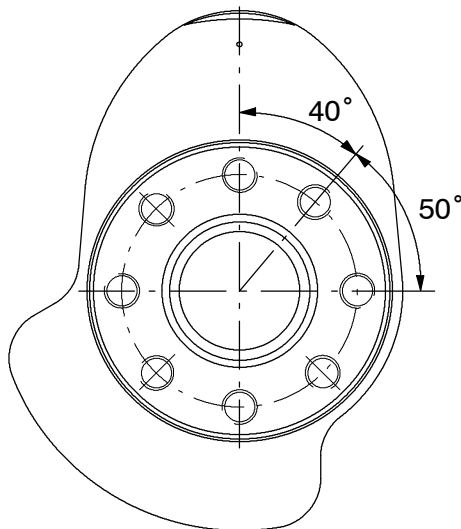
2. Warm the ring gear to the temperature of **150...200°C**. Fit the ring gear with the inner diameter chamfering turned against the flywheel and the teeth chamfering against the starter motor.

3. Allow the ring gear to cool freely without using any coolant.

B. Fitting flywheel

1. Clean the contact surfaces on the crankshaft rear flange and on the flywheel.

2. Fasten the flywheel to the crankshaft rear end. As a guide pins can be used studs (M14, 2 pcs) which are screwed in to the flywheel fixing bolt holes.



47-2

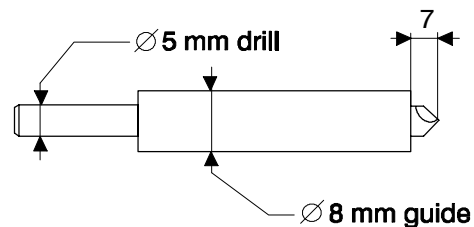
Note! The flywheel fixing bolt holes are unsymmetrical.

3. Tighten the flywheel retaining screws evenly to a torque of **200 Nm**.

Note! Flywheel delivered as spare parts do not have injection timing mark. Make the marking on the new flywheel in connection with installation.

4. Rotate the crankshaft until the piston of the 1st cylinder reaches its top dead centre. Drop cyl. no 1 inlet valve down against the piston head. Set the dial gauge on top of the valve stem end and zero it at the piston top dead centre. Then rotate the crankshaft opposite to running direction until dial gauge shows about ten (10) mm below TDC. After that rotate the crankshaft slowly to running direction until the dial gauge shows the figure corresponding injection timing (see table below).

5. Bore the injection timing mark hole by a drill (see picture below) to the flywheel.



Piston distance from top dead centre vs. crank angle

Grad	mm	Grad	mm
1°	0,014	16°	3,671
2°	0,058	17°	4,138
3°	0,130	18°	4,633
4°	0,232	19°	5,154
5°	0,362	20°	5,701
6°	0,521	21°	6,275
7°	0,709	22°	6,874
8°	0,925	23°	7,499
9°	1,170	24°	8,150
10°	1,443	25°	8,825
11°	1,745	26°	9,525
12°	2,075	27°	10,249
13°	2,432	28°	10,997
14°	2,818	29°	11,768
15°	3,230	30°	12,563

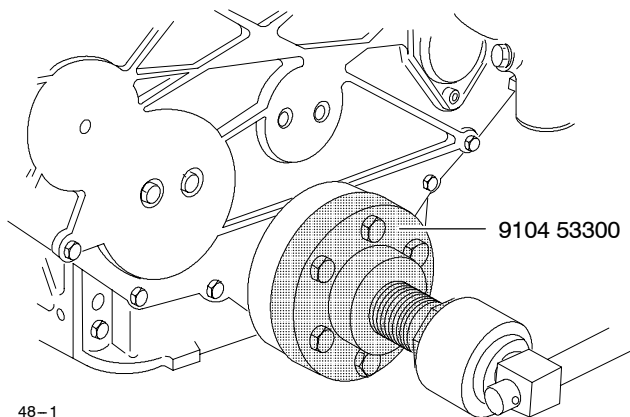
8. TIMING GEAR ASSEMBLY

A. Removing timing gear casing

As the timing gear casing bottom face forms a part of the mating face for the oil sump gasket, the casing cannot be removed without first removing the oil sump.

1. Remove the oil sump.
2. Remove the radiator, fan, belt, alternator and belt tensioner assy. If the engine is equipped with a air compressor or air conditioner, it has to be removed.
3. Remove the crankshaft belt pulley and the vibration damper.

Note! When removing the hub piece from the crankshaft front end mark the correct position of the hub. (Engines with the timing mark on the vibration damper.)



4. Loosen the crankshaft nut about two turns (special tool 9024 55800). Fit extractor 9104 53300 and extract the crankshaft hub. Take off the extractor, open the nut and remove the hub.

Do not remove the nut completely first. The hub will be dashed dangerously when it is loosen.



WARNING

5. Remove the cooling pump, observe the retaining screws on the injection pump side. Remove the timing gear casing cover.

6. Remove the injection pump.

Note! If the timing gear casing is not to be changed, the injection pump can remain in place. In which case disconnect all leads and pipes from the pump and loosen bottom mounting from the pump.

7. Unscrew the idler gear bolts and remove the idler gear (broad timing gear casing).

8. Extract the camshaft.

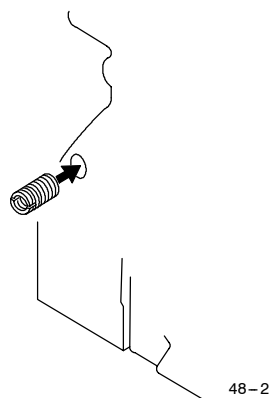
Note! If the cylinder head and valve mechanism have not been removed, the tappets must be prevented from falling down, see instruction point 4 B.

9. Remove the timing gear casing. Ensure that no sealing surfaces are damaged.

10. Remove the crankshaft front seal ring from the front casing cover and clean all parts removed.

B. Fitting timing gear casing

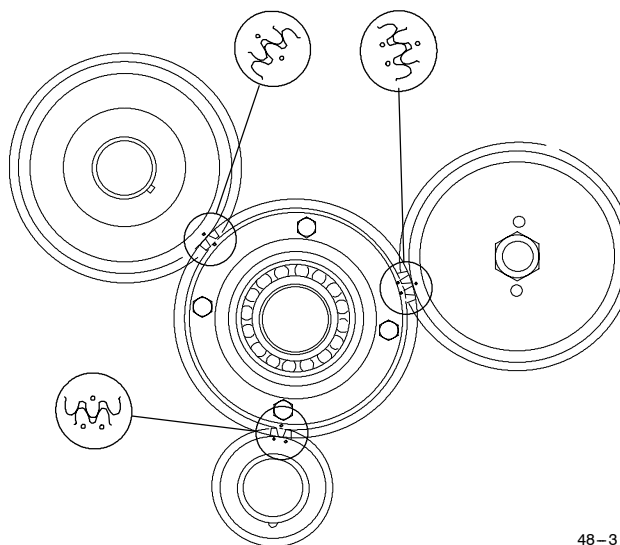
The position of the timing gear casing and cover is determined by two tension pins. Therefore centring should not be undertaken in connection with fitting. However, the backlash between the different gears should be checked. Casing and covers that are delivered as spare parts also have holes for the tension pins already machined.



1. Screw in the thread piece M14/M8 to the cylinder block (narrow timing gear casing). Fit the casing with a new gasket against the cylinder block. Hit in the tension pins with drift 9025 98700. Tighten bolts and nuts.

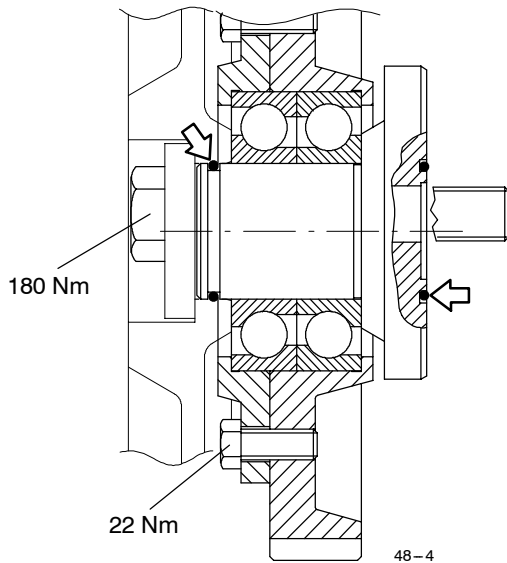
2. Fit the injection pump and its gear wheel (if removed).

3. Lubricate the camshaft bearings and insert the shaft in the cylinder block. Release the pushrods and tappets if they have been suspended.

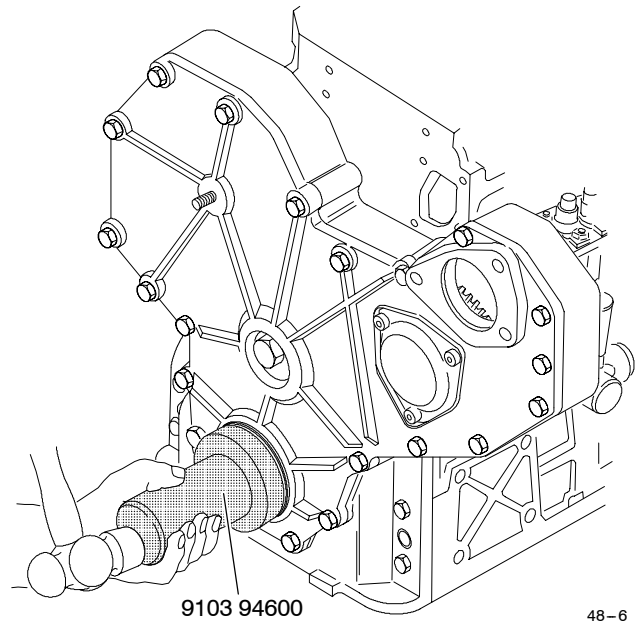


Timing gear position

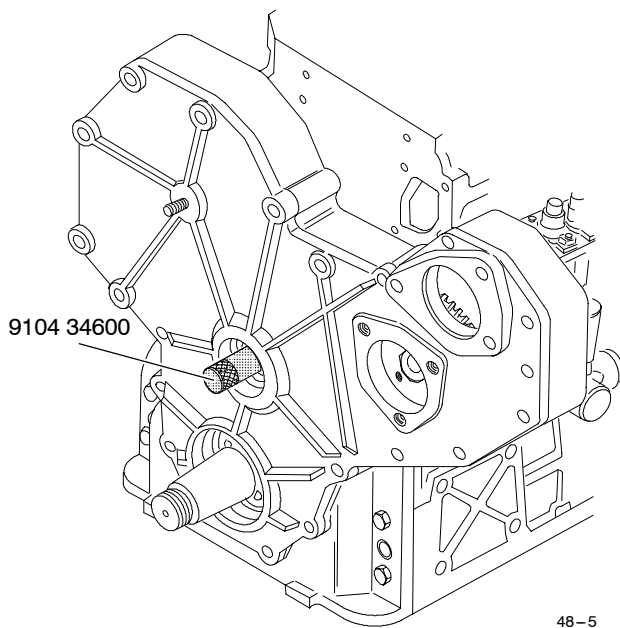
Narrow timing gear casing



4. Assemble the idler gear as in picture. Place the o- ring between the shaft and the cylinder block and fit the idler gear in its place. Note the correct position of the timing marks. Place an o- ring also in the shaft front end.



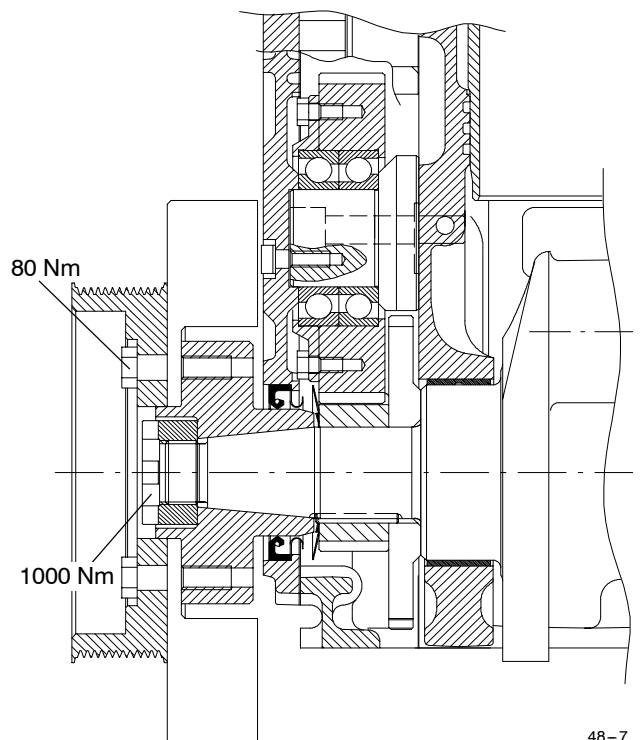
7. Fit the protective plate into the bottom of the seal position and fit the crankshaft front seal with special tool 9103 94600.



5. Fit the guide pin 9104 34600 instead of the idler gear bolt. Fit the camshaft axial controller in the cover (apply sealing compound to the thread) and fit the cover. Hit in the tension pins.

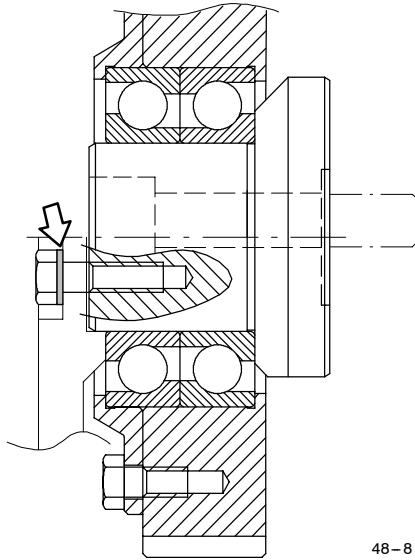
Note! If the crankshaft oil throwing ring is removed, fit it (drift 9103 94900) before fitting the cover.

6. Tighten the cover bolts. Remove the guide pin, fit the idler gear shim and tighten the bolt **180 Nm**.

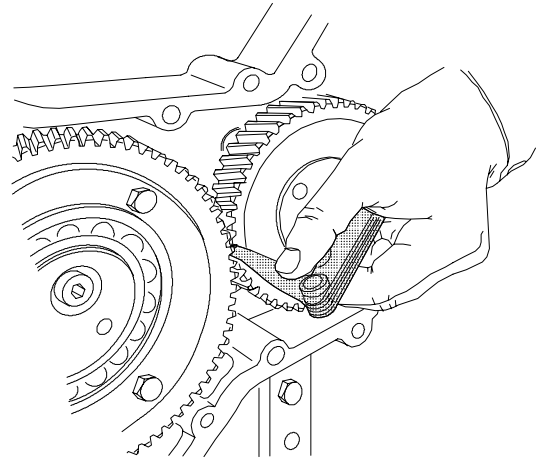


8. Lubricate both the seal and sealing surfaces and fit the crankshaft hub. Lubricate the crankshaft nut threads and tighten the nut to **1000 Nm**.

9. Fit the other removed parts.

Broad timing gear casing

4. Assemble the idler gears as in picture. Fit the big idler gear in its position. Note the position of the timing marks. Fit also the small idler gear.

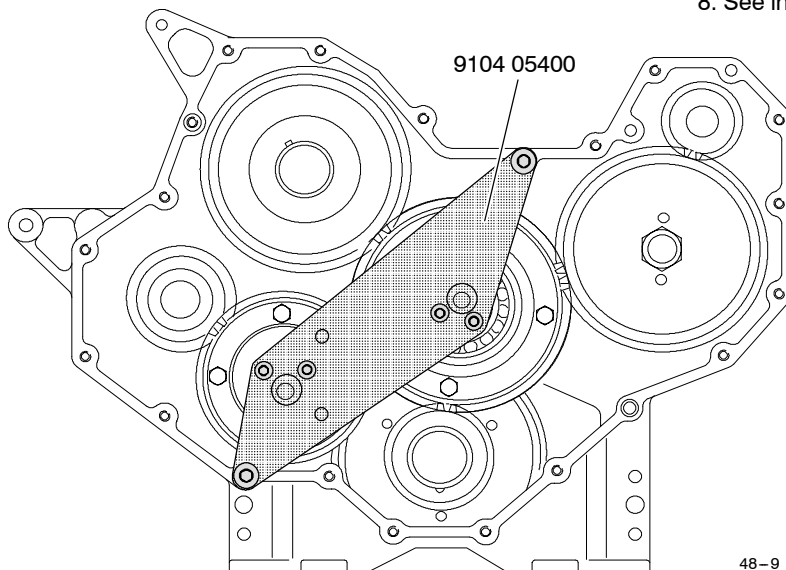


6. Check the tooth backlash, which should be **0,05...0,25 mm**.

7. Fit the drive unit shaft and camshaft axial controller in the front cover (apply sealing compound to the thread). Fit the cover and hit in the tension pins. Observe the idler gear shaft bolt seals. Fit the drive unit rear bearing and cover.

Note! If the crankshaft oil throwing ring is removed, fit it (drift 9103 94900) before fitting the cover.

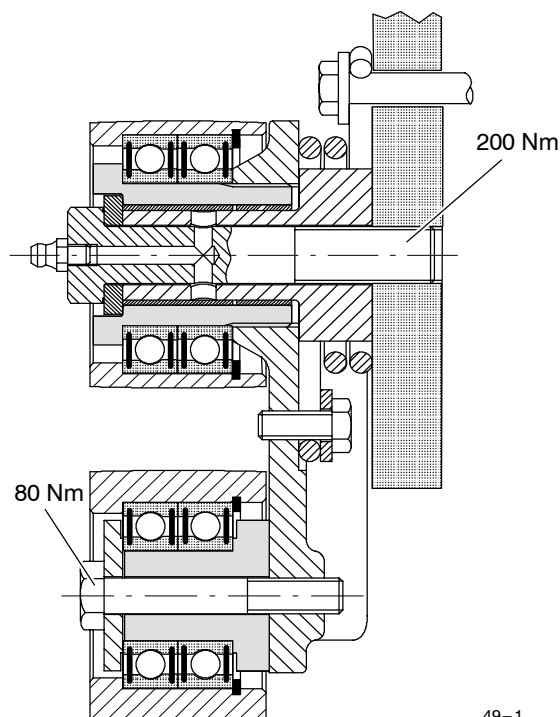
8. See instruction **7...9** / Narrow timing gear casing.



5. Tighten the guide bolts in the guide unit frame and position the unit on the idler gears as in picture (guide bolts in the idler gear shaft holes and housing holes). Tighten the idler gear bolts through the guide unit holes, tighten **180 Nm**. Remove the guide unit.

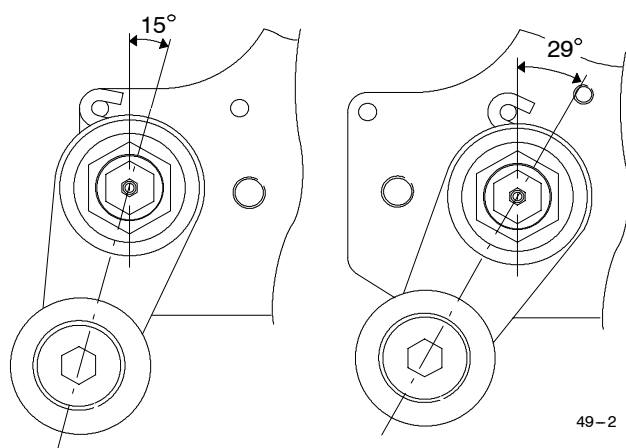
9. TENSIONING DEVICE

A. Tensioning device for ribbed belt



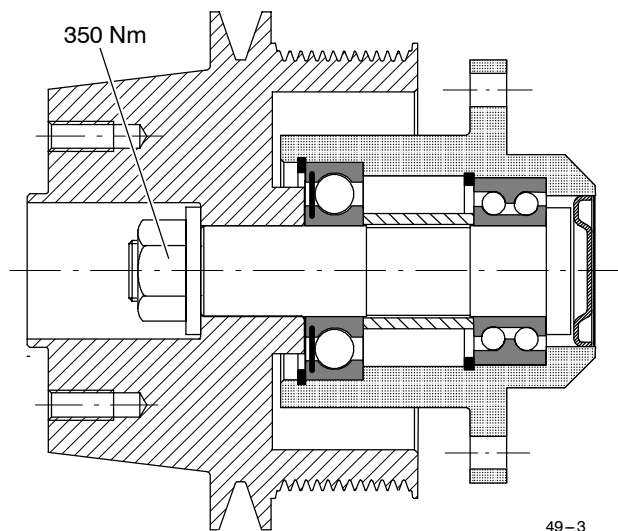
1. Assemble the tensioning device, as the picture shows. The bearing bushes of the upper shaft do not have to be broached after fitting.

2. Fasten the tensioner to the mounting plate. Lubricate the grease nipple of the upper shaft of the tensioner. Use heat resistant grease, e.g. ISOFLEX TOPAS NB52 (NLGI 2).



3. Note, when tightening a new ribbed belt, that the starting position of the tensioner is determined by the mounting hole place.

B. Fan drive device



1. Assemble the drive device as the picture shows. Fit inner bearing and circlip. Fill the bearing housing partially with heat resistant ball bearing grease (NLGI 2). Fit the intermediate sleeve, outer bearing and circlip. Note the position of the outer bearing as assembling.

2. Press the shaft into its position so that the pressing force is not transmitted by the bearing balls.

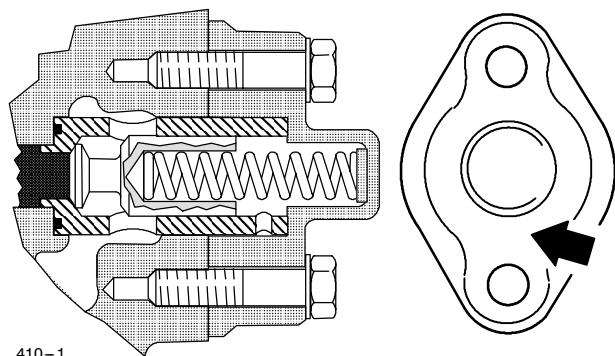
3. Tap the blocking plug (if mounted) in its place with fitting drift 9025 87400.

4. Fit the belt pulley, washer and nut. Tighten the nut to **350 Nm**.

10. LUBRICATION SYSTEM

A. Reconditioning of oil relief valve for lubricating oil pressure

If the engine lubricating oil pressure is insufficient or if it varies, the relief valve should be checked after first checking the oil level.



410-1

1. Remove the cover over the valve and spring. Take care of the washer between the cover and spring. Remove the valve insert together with the valve cone and ensure that the o-ring is also removed.

2. Clean the parts and check that the valve cone slides freely in the insert and that the sealing surface is undamaged. Minor damage can be adjusted, but in general, damaged parts should be changed. Scrape off any remains of the gasket.

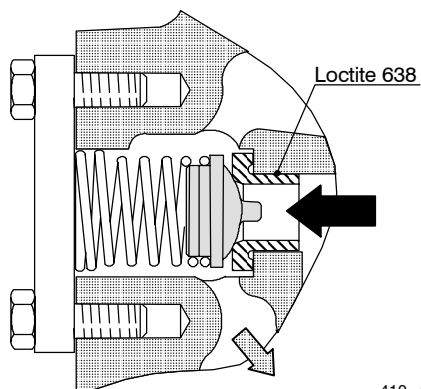
3. Assemble the valve with a new o-ring and insert it in the cylinder block. Place the washer and spring in the cover and fit it with a new gasket.

4. Note that the relief valve cover is not symmetrical. The greater distance between the spring housing and bolt should be turned downwards.

Note!

From engine no J 14016

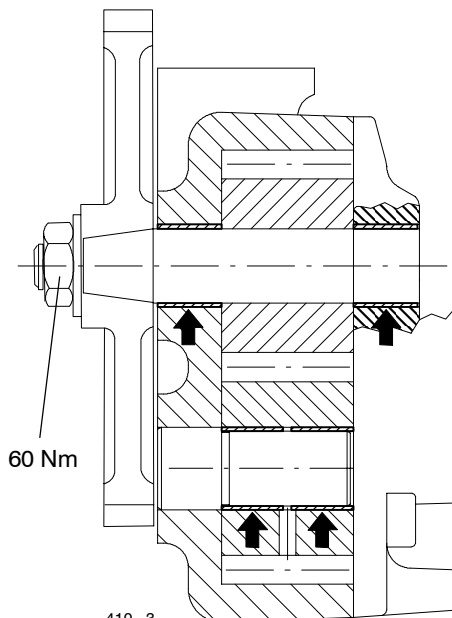
The engines are equipped a new type of oil pressure valve. In the construction of the new valve the hydraulic vibrations are damped, it is more reliable and it gives the best, optimised pressure level.



410-2

B. Removing and dismantling lubricating oil pump

1. Drain the engine oil and remove the oil sump.
2. Remove the oil pump suction and pressure pipe.
3. Remove the oil pump together with any shims between the pump and the cylinder block.
4. Remove the pump cover and the gasket. Remove the gear on the dead axle.
5. Clamp the pump gear across the teeth in a vice fitted with soft jaws, and loosen the drive gear nut. Knock the gear wheel off by hitting the end of the shaft with a soft hammer. Pull out the drive shaft-gear wheel.
6. Clean the parts and check for wear and other damage. Compare with the specifications. Change damaged parts and all seals.



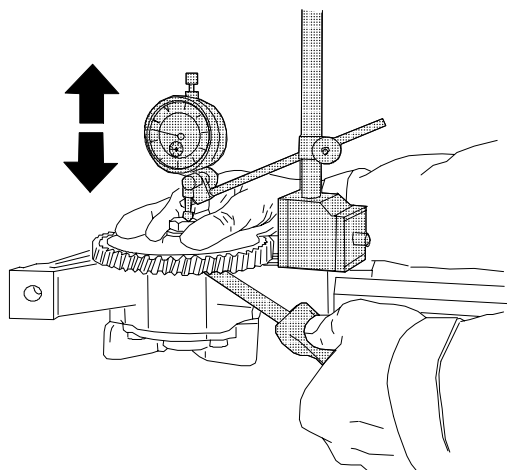
410-3

7. On 645-engines the bearing points are provided with separate bearing bushings. If you change the bushings, machine them to dimension of **18,000...18,018** after fitting.

C. Assembling and fitting lubricating oil pump

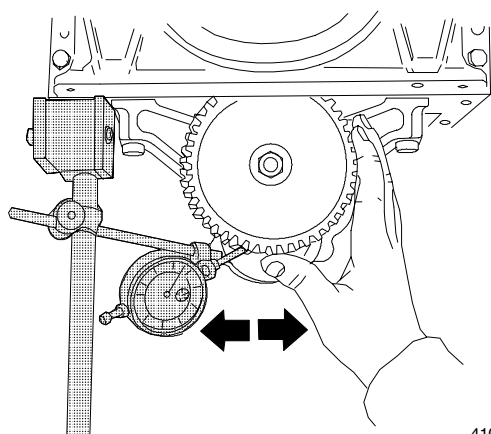
1. Fit the gear wheels in the pump body. Fit the cover using a new gasket. Partly tighten the bolts. Rotate the pump shaft and tap the side of the cover lightly until the position is reached where the shaft rotates most freely. Tighten the bolts and check that the shaft still rotates freely.

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

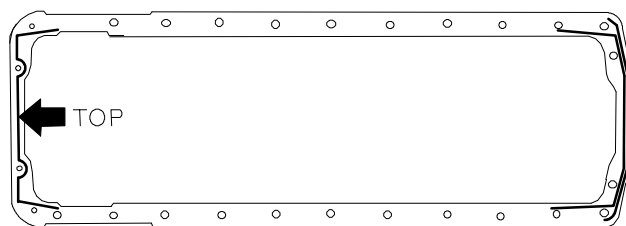
4. Fit the pump and check the tooth backlash against the crankshaft gear. The clearance, which should be **0,05...0,25 mm**, is adjusted with shims between the pump body and the cylinder block (shim 0,2 mm, order no 8360 07871). One shim increases/decreases the backlash about 0,07 mm.

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

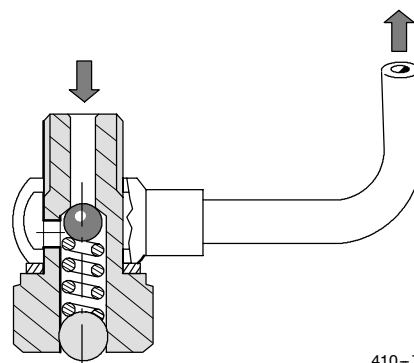
Fit the oil sump gasket with the silicone stripes against the cylinder block (self carrying and casted oil sumps).



410-6

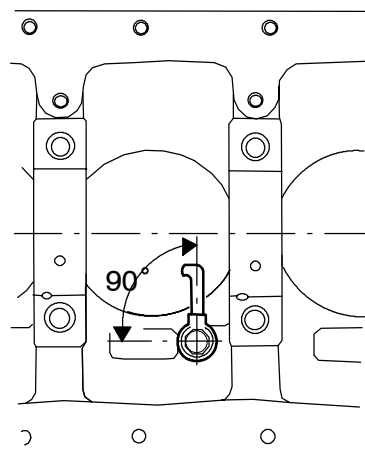
E. Piston cooling nozzles

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.

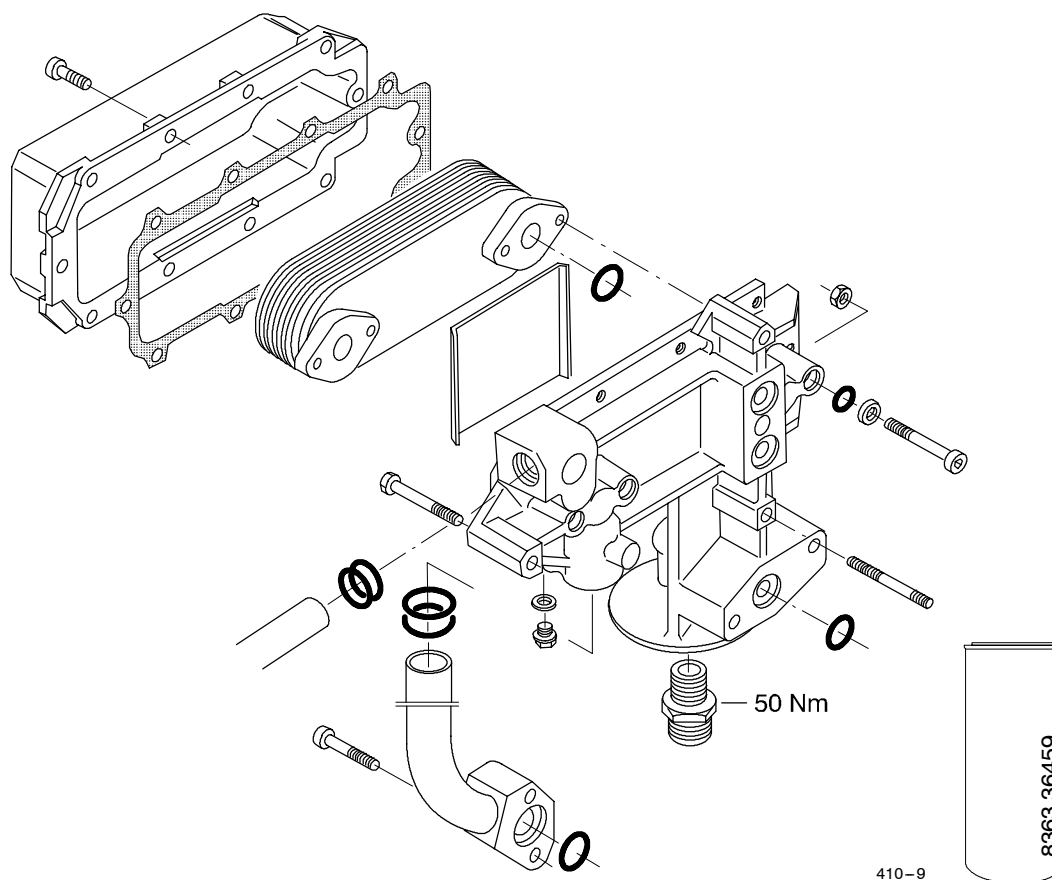


410-8

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.

F. Oil cooler

Practically there are two different oil coolers, the difference being position of the oil filter, see picture.

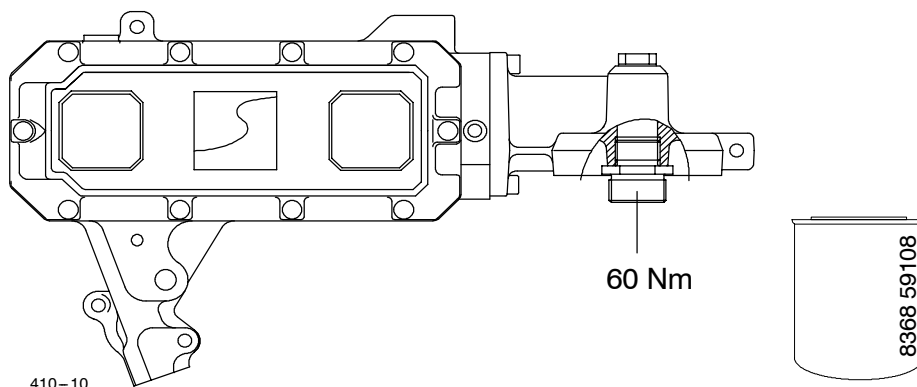


To remove

1. Open the coolant drain plug under the oil cooler and drain the coolant into a suitable container. Remove the pipe going into the thermostat housing.
2. Remove the turbo oil pipes and the oil pressure pipe from the cylinder block. Remove the oil filter. Drain the oil into a container.
3. Remove the oil cooler from the engine. Open the cooler housing and remove the guide plate. Unscrew the cell bolts and remove cell from the body. Clean the all parts.

Fitting oil cooler

1. Assemble the oil cooler using new gaskets. Fit the cell to the body. The oil side can be pressure tested before fitting the housing. Test pressure is 5^{+1} bar.
2. Push the guide plate between the cell and the body and fit the housing. If needed now can the water side be pressure tested, test pressure 5 bar.
3. Assemble the oil cooler to the engine and assemble oil- and coolant pipes. Replace the oil filter.
4. Fill the coolant system. Start the engine and check for leak-ages.

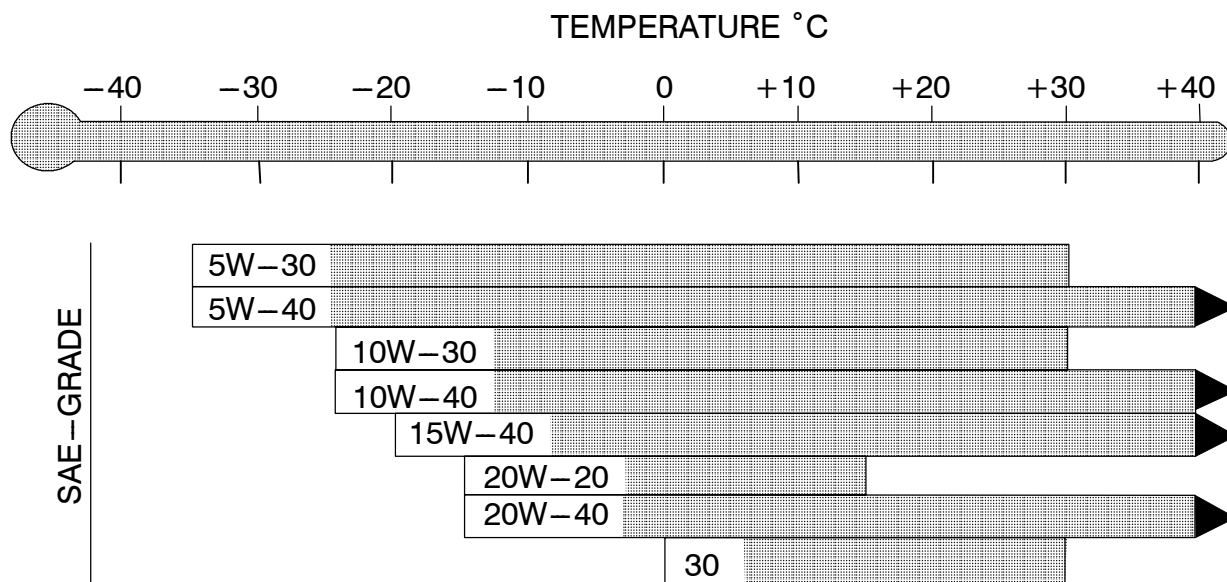


G. Lubricating oil quality requirements

- Turbocharged engines
- Low emission (E) engines

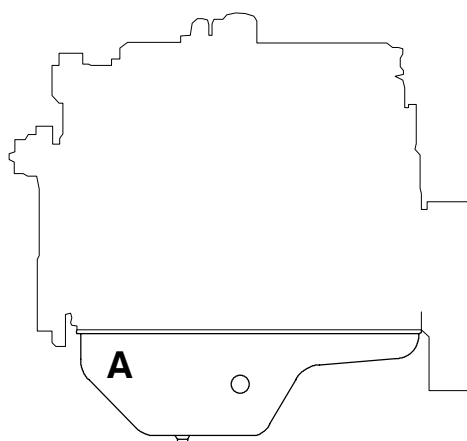
API CF-4, CG-4, CH-4
API CG-4, CH-4

ACEA E2/E3-96, E4-98, E5-99
ACEA E3-96, E4-98, E5-99

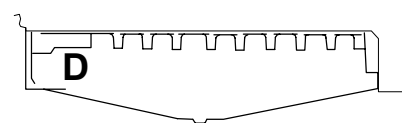
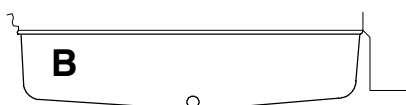
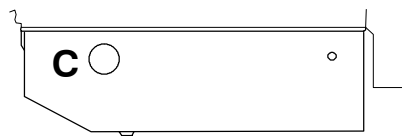


410-11

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

11. COOLING SYSTEM

A. Quality requirements of coolant

The coolant used must meet the standards ASTM D 3306 or BS 6580:1992.

- Mixing proportion should be 40–60 % of ethylene/propylene–glycol based coolant and the rest water. The best ratio is 50/50 %.

- In warm climates the 30 % mixture ratio gives enough good protection against corrosion.

- Water used should be clean and soft water i.e. that it does not include metals and their salts.

- Check the coolant frost resistance every now and then. Change the coolant every other year.

Note! Never use only water as coolant!

B. Thermostat

645–engines have two separate thermostats. The smaller, single–acting thermostat opens at 79°C and the other, double–acting type, at 83°C. In 645–engines there are no separate winter thermostats.

To remove

1. Drain the cooling system so that the coolant level is below the thermostats position and disconnect the top hose from the water outlet cover.

2. Remove the outlet cover and the thermostats. Clean the sealing surfaces.

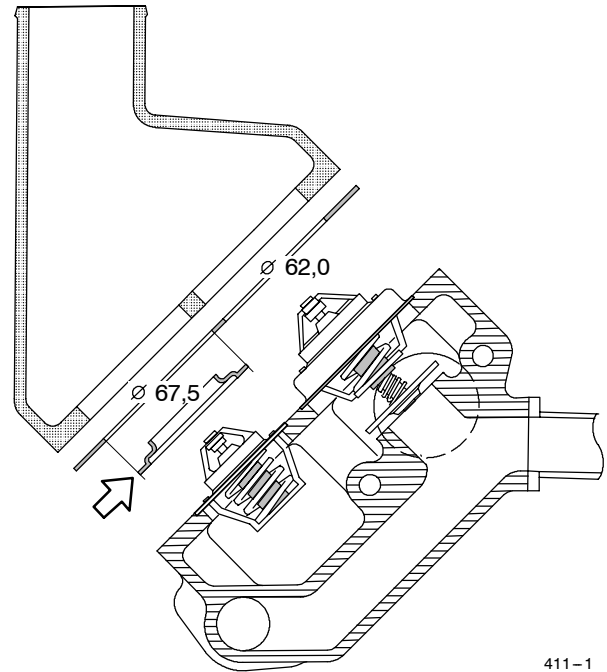
Check the function of the thermostat as follows:

- Lower the thermostat into a vessel of boiling water so that the thermostat does not touch the sides or bottom.

- Opening must begin under 20 seconds.

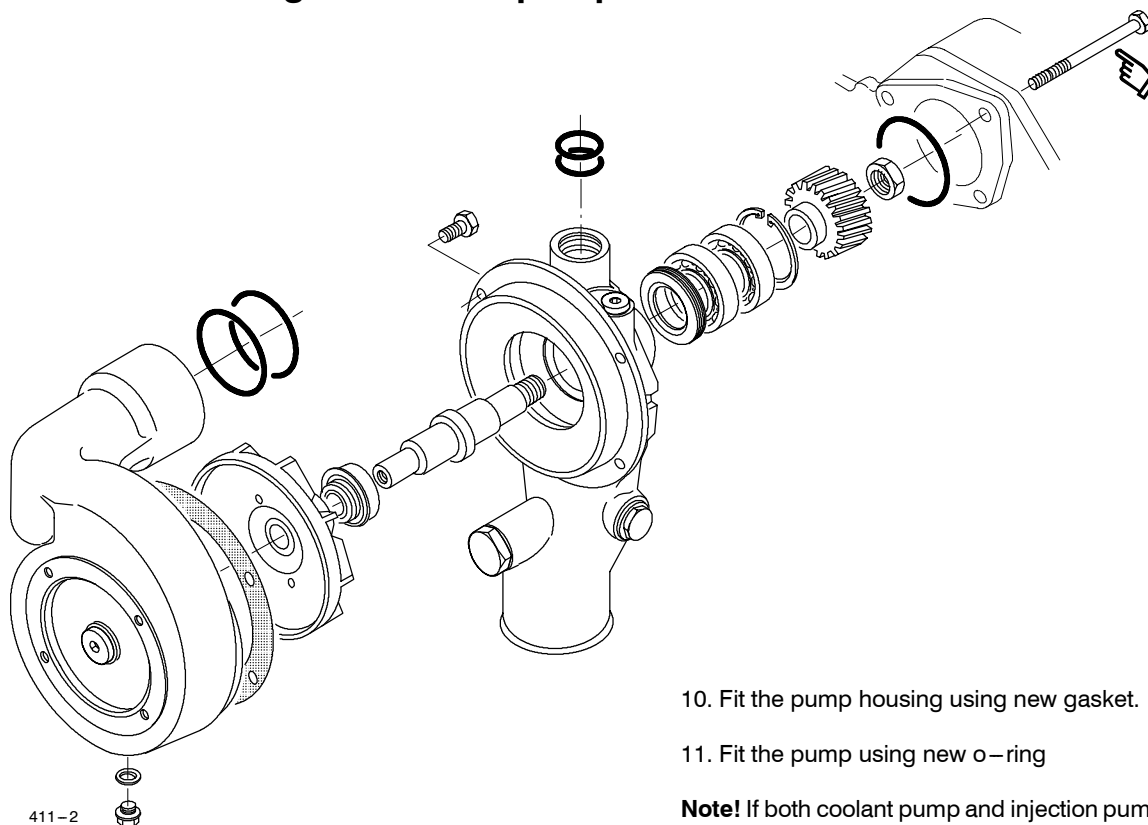
- The thermostat must be fully open under 50 seconds. Stroke, see specifications.

To replace



- 1 Put the thermostats in position in the housing. Fit a new gasket and the outlet cover. For guiding you can use M8 studs (2 pcs). Observe the plate (if mounted) that comes on top of the smaller thermostat. Fit the gasket so that the bigger hole is on the same side as the plate.

2. Connect the top hose and fill the cooling system.

C. Reconditioning the coolant pump

1. Drain the coolant. Disconnect the hose at the inlet connection of the coolant pump. Loosen the coolant pipes from the coolant pump.

2. Release the three screws which retain the coolant pump to the cover of the timing case—from the rear. Remove the coolant pump.

3. Unscrew the gear fixing nut and remove the gear. Remove the pump housing from the pump body. In the double coolant pump first remove the smaller coolant pump (for intercooler) with impeller.

4. Remove the circlip in the pump body. Press the shaft together with bearings in the direction of the gear.

5. Tap out the water seal and shaft seal using a drift. Remove o-ring seals and clean the parts and inspect their condition. Replace faulty or worn parts with new ones.

Note! If the pump bearings have to be changed, use a pump repair kit. This kit also contains all seals (see Parts Catalogue).

6. Tap the new shaft seal in the body using a drift 9103 41000. Grease bearings with heat resistant ball bearing grease (NLGI 2). Press in the bearings and fit the circlip.

7. Fit the shaft in such a way that the pressing force is not transmitted by the bearing balls.

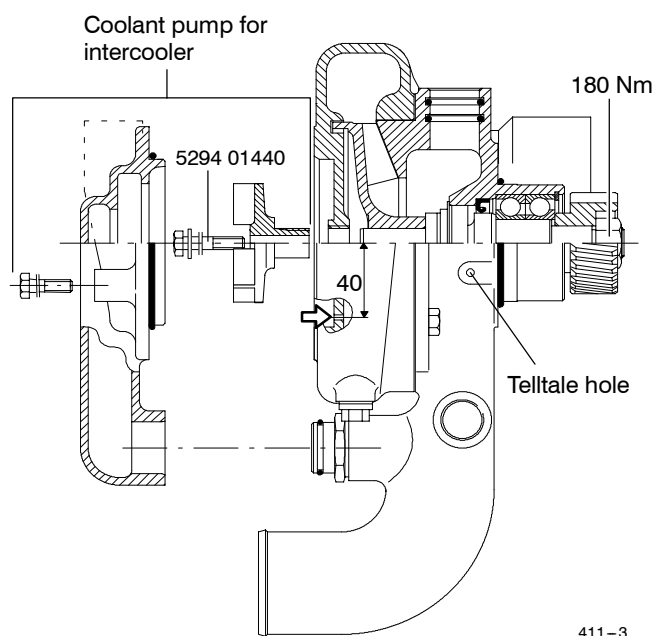
8. Hit the water seal into its position with tool 9103 41100. Press the impeller to its position (towards the shaft shoulder) supporting the shaft from the other end. Make sure that the shaft can rotate freely.

9. Fit the gear on the shaft and tighten the nut to **180 Nm**.

10. Fit the pump housing using new gasket.

11. Fit the pump using new o-ring

Note! If both coolant pump and injection pump are removed, fit the coolant pump first (one fitting screw can not be fitted as injection pump is in position).

Double coolant pump

Note when assembling the smaller water pump the following:

– If you change the pump housing, drill a $\varnothing 3$ mm hole in the back side as picture shows.

– Use in tightening the small impeller always a rust proof screw (order no 5294 01440).

12. INLET AND EXHAUST SYSTEM

An engine that is equipped with a turbocharger is a great deal more sensitive to disturbances and impurities in the inlet and exhaust systems than a naturally aspirated engine. Therefore special attention must be given to the whole inlet and exhaust system.

A. Checking air cleaner

The engine performance and length of service life depend to a great extent on the state of the air cleaner. A defective air cleaner allows impurities to pass through, which in time damage the turbocharger and the engine. A blocked air cleaner lowers the engine output and also causes oil leakage through the sealing ring on the turbocharger shaft.

Note! The safety filter inside the main filter should not be removed unnecessarily, for checking or cleaning. The safety filter must not be cleaned, but should be changed once a year or when necessary (see Operator's Manual).

B. Checking inlet and exhaust pipes

Important! Leaks in the inlet or exhaust system markedly lower the effect of the turbocharger. Because of the pressure, even small leaks in the manifold or in the turbine inlet contact flange quickly increase in size. For this reason all leaks must be dealt with immediately.

1. Inspect the pipes and sealing surfaces between the air cleaner and the turbocharger, as well as between the turbocharger and the intake manifold. If the intake manifold is dusty on the inside, there is a leak in either the air cleaner or the induction pipes. Remedy the leak.

2. Clean the intake manifold sealing surface. Check that the sealing surface is flat using a straight ruler. If the surface is not flat or it has scratches, machine or renew the intake manifold. Ensure that the cylinder heads are parallel.

3. Fit a new gasket and fasten the intake manifold. Tighten the manifold fixing screws to a torque of **30 Nm**. Fasten the air pipes carefully.

4. Check that the exhaust manifold is air tight. Tighten the nuts to **50 Nm** and inspect for any damage (cracks, deformation, corrosion etc.). Check also the connection between the turbocharger and the exhaust manifold.

5. Remove the manifold if necessary. Clean the sealing surfaces and remove any carbon deposits. Check that the sealing surfaces are flat. If the fastening flanges are twisted or there are scratches on the sealing surfaces, machine the flanges or renew the exhaust manifold.

6. Ensure that no loose objects or impurities have entered the exhaust pipe or the silencer. Any such loose objects or impurities can increase the back pressure for the exhaust gases from the turbine wheel.

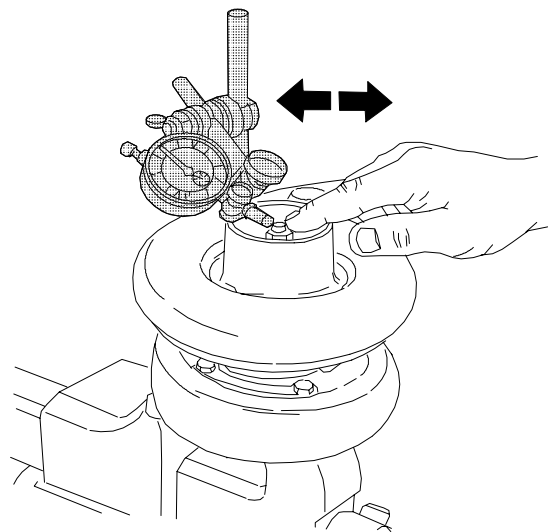
C. Checking turbocharger

If a fault is suspected in the turbocharger it can be located in the following way:

1. Visually inspect the turbine and compressor wheels. The vanes must not show any signs of damage, deformation or wear caused by foreign objects.

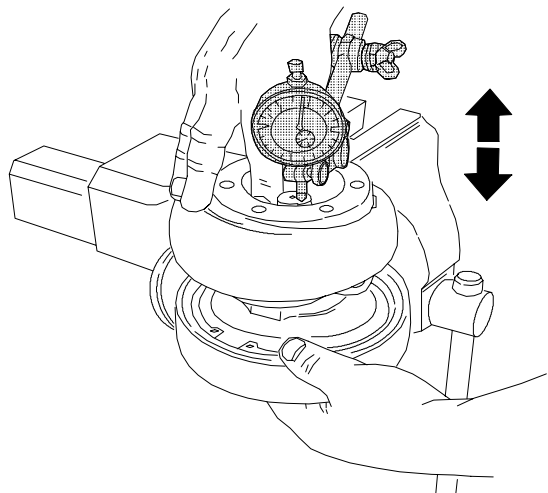
2. Investigate any oil leaks through the sealing rings on the shaft in the turbine and compressor housing.

Note! At low idling there is always a certain amount of oil leakage on the compressor side. However, this should not cause too much concern unless the oil consumption is too great.



412-1

3. Check the turbine shaft running clearance. Place the stylus of a dial gauge against the shaft and move the shaft side-ways. Refer to the clearance given in the specifications on page **0-12**.



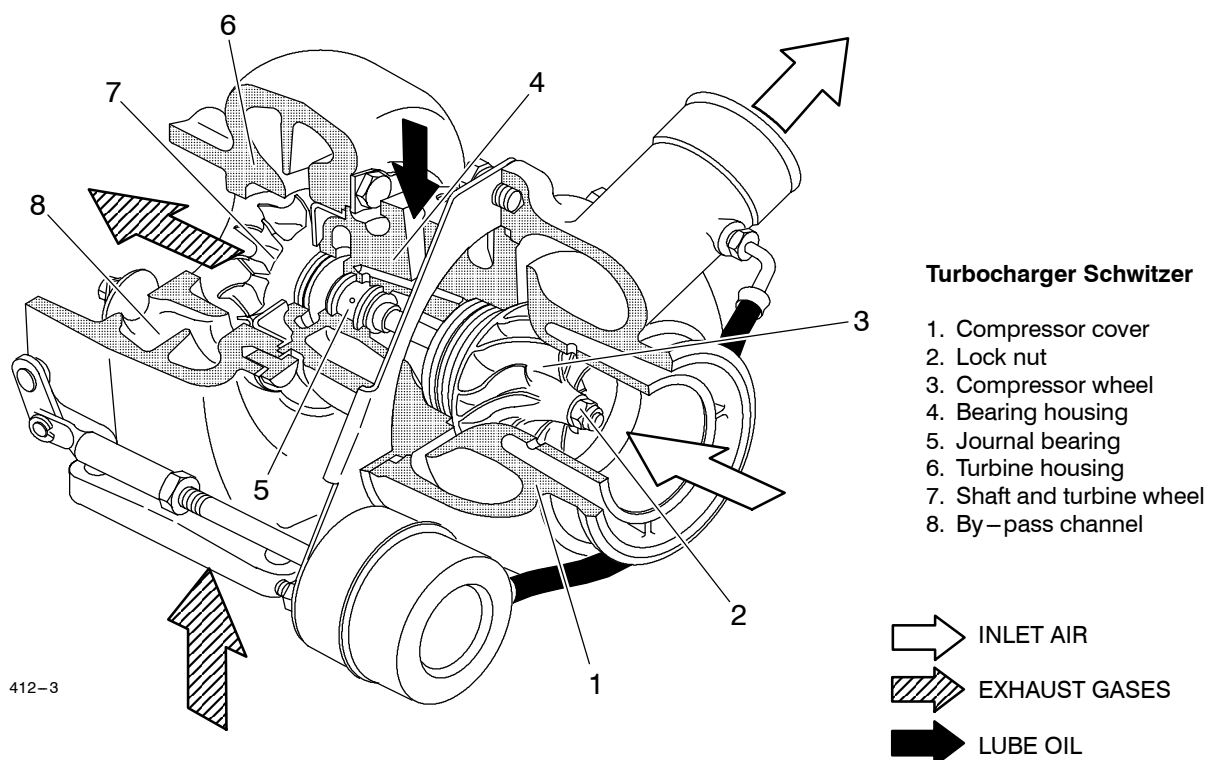
412-2

4. Check the shaft end float. Place the stylus of the dial gauge against the end of the shaft and move the shaft axially. Refer to the clearance given in the specifications on page **0-12**.

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.



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.

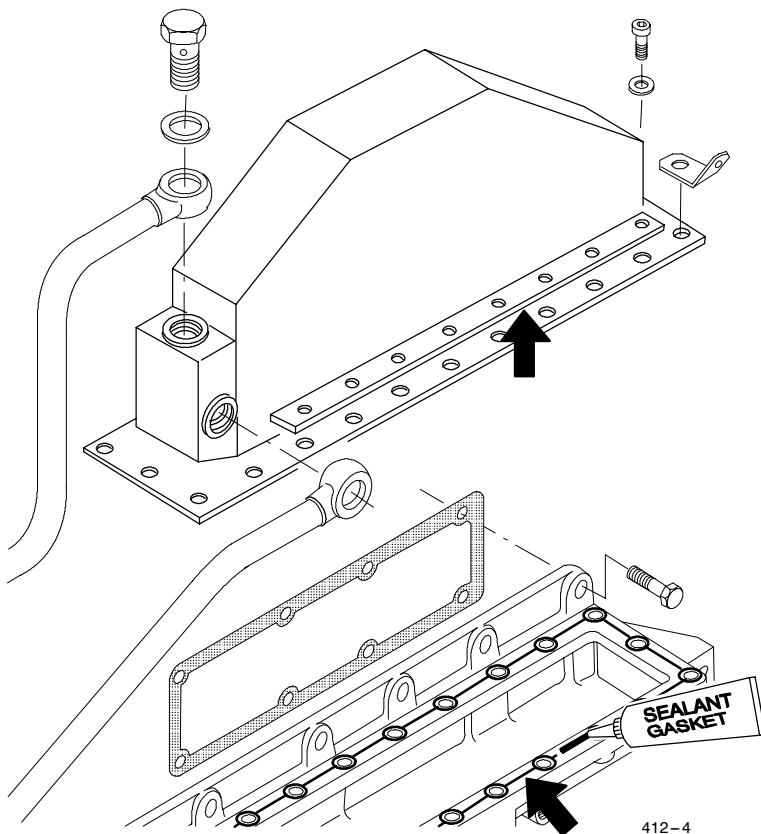
3. Connect the inlet pipe and the exhaust pipe on the turbo.

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.

E. Fitting intercooler



412-4

1. Using a new gaskets, fit the intake manifold to the cylinder head.

2. Fit the cooler with thrust plates to the intake manifold.

Note! A conventional gasket is not used but apply a continuous bead of silicone sealing to the sealing surface.

Leak test pressure for the cooler:

- Water side **2,9 bar**
- Air side **3,5 bar**

3. Attach the boost air pipe to the cooler housing and coolant pipes to the cooler. Fill the cooling system.

13. FUEL SYSTEM

Note! This manual gives only general instructions for repair and service measures related to the fuel system. This applies particularly to the injection pump which can be repaired only by a specially trained person who has the necessary special tools and gauges. All service and repair work related to the fuel system requires special care and cleanliness!

TECHNICAL DATA

Injection pump Bosch "P"

Type (pump/governor)	Bosch PES6P/RSV
Injection order	1–5–3–6–2–4
Direction of rotation	clockwise
Diameter of pump piston	
– 3000–series	12 mm
– 7100–series	12 mm
Stroke	
– 3000–series	11 mm
– 7100–series	12 mm
Injection advance	see injection pump adjusting values

Fuel feed pump

Type	Bosch FP/KG24P307
Construction	piston pump, separate hand pump
Fuel feed pressure (overflow valve opening pressure)	0,6–1,0 bar
Pressure from fuel feed pump (without overflow valve)	2,7 bar

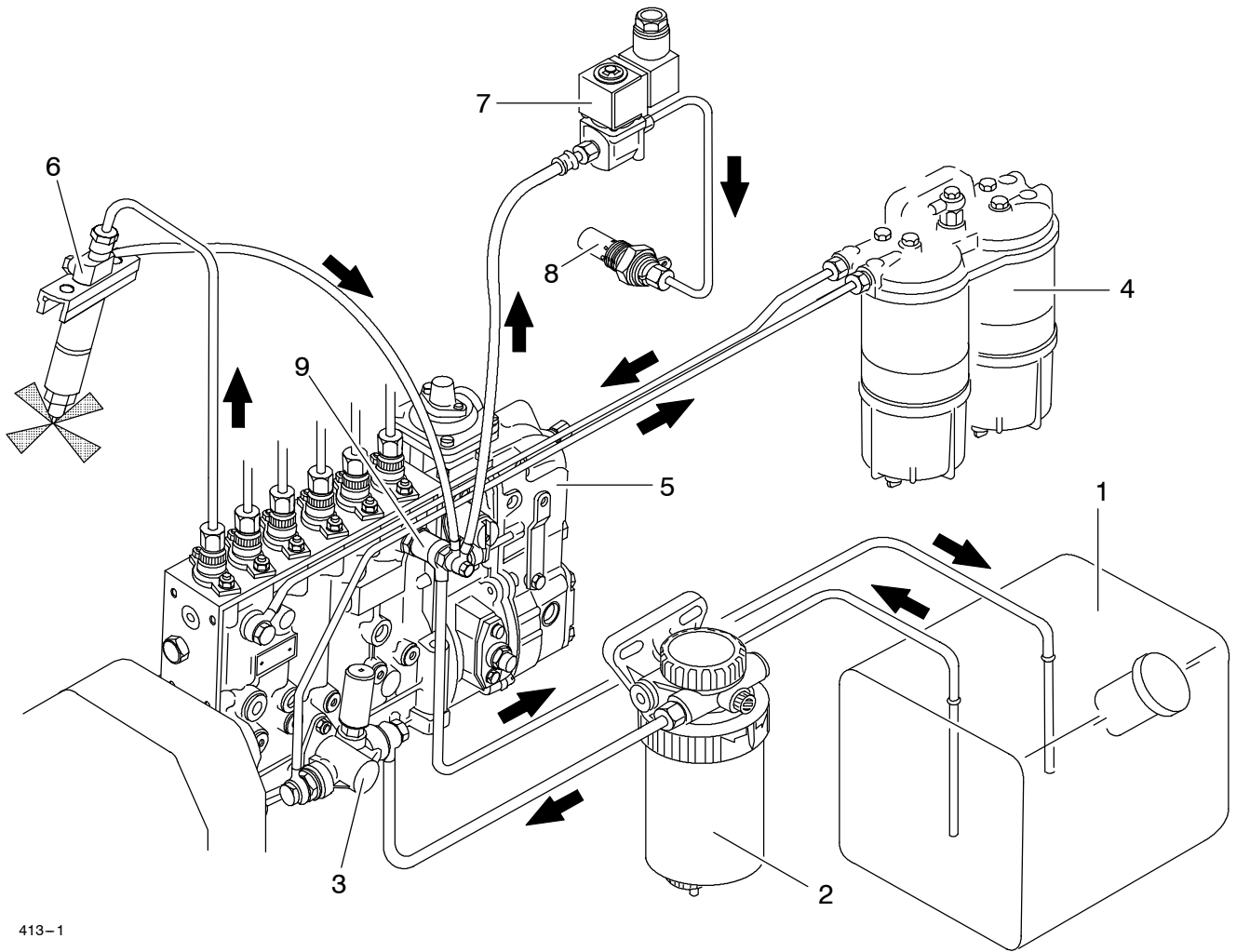
Injectors

Type	four–hole nozzle
Opening pressure	250 bar
Setting pressure ¹⁾	260 bar
Sealing ring	8999 01495

¹⁾ Value to be used when adjusting the opening pressure of a new or used injector.

Tightening torques

Injection pump gear nut	200 Nm
Overflow valve	30 Nm
Injector nozzle sleeve	60 Nm
Injector attaching nuts (on studs)	15 Nm



413-1

Fuel system

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

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:

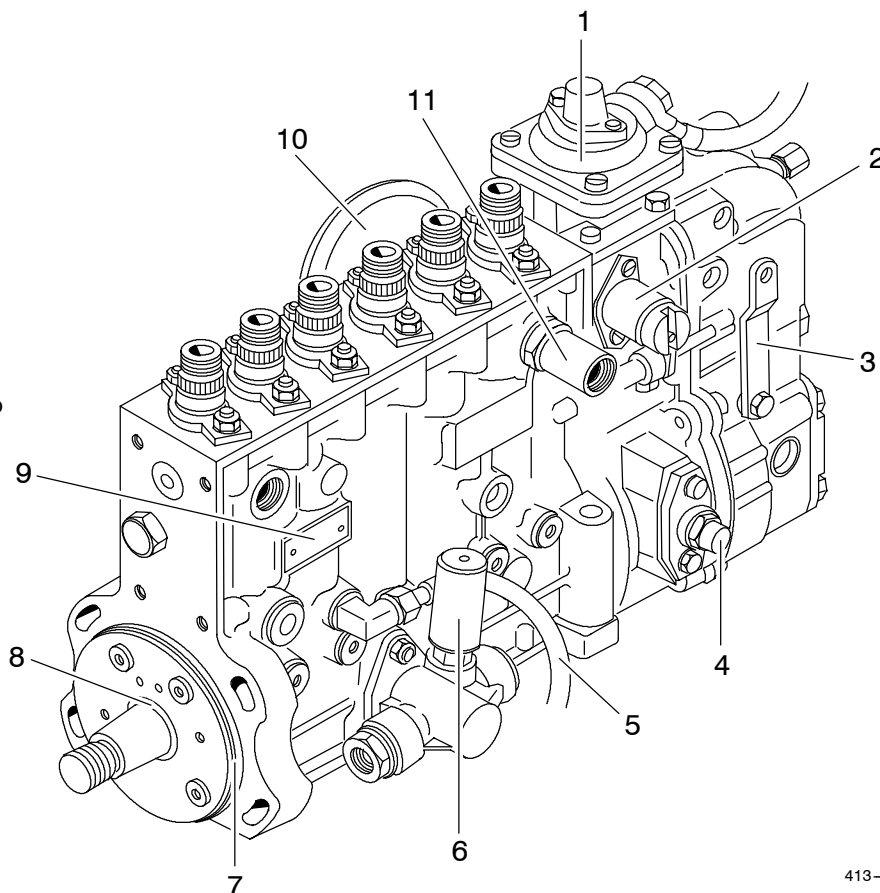
– Knocking is an indication that one of the injectors is faulty. When a cold engine ticks over a certain amount of knocking is unavoidable. If the engine knocks after it has reached normal operating temperature, it is very likely that one of the injectors is faulty. Air in the fuel system can also cause 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).

Bosch-P injection pump**Injection pump**

1. Boost control
2. Cold start solenoid
3. Speed lever
4. Injection timing indicator
5. Lube oil into the injection pump
6. Hand pump
7. O-ring seal
8. Return of lube oil to engine
9. Identification plate
10. Pressure equalizer
11. Overflow valve



413-2

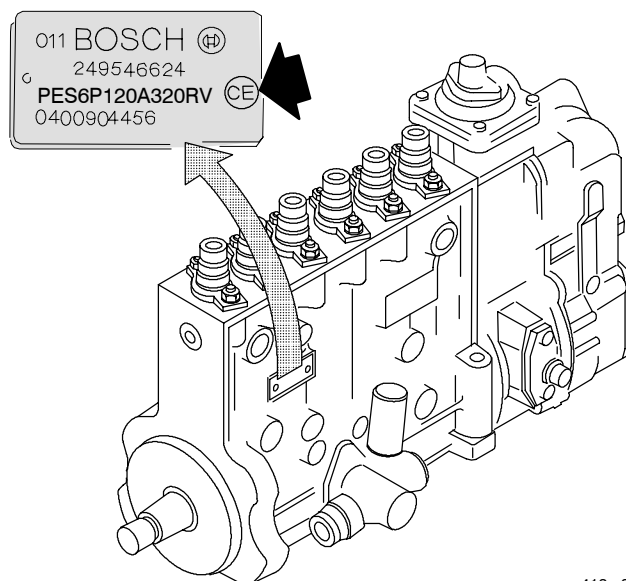
The fuel injection pump is flange/bottom mounted and sealed by one o-ring in the timing gear housing. The injection pump is driven from the crankshaft through an idler gear. The injection pump is connected to the engine force-feed lubrication system through an external pipe. Lubricating oil returns to the engine via the hole at the front end of the injection pump.

The fuel feed pressure which fills the high pressure pump elements with fuel is created by a piston pump which is attached to the side of the fuel injection pump. The piston pump is driven from an eccentric on the camshaft of the injection pump. The fuel feed pump supplies more fuel than the injection pump needs. The excess fuel flows through the overflow valve back to the fuel tank. The fuel cools the injection pump and also takes any air bubbles with it back to the tank.

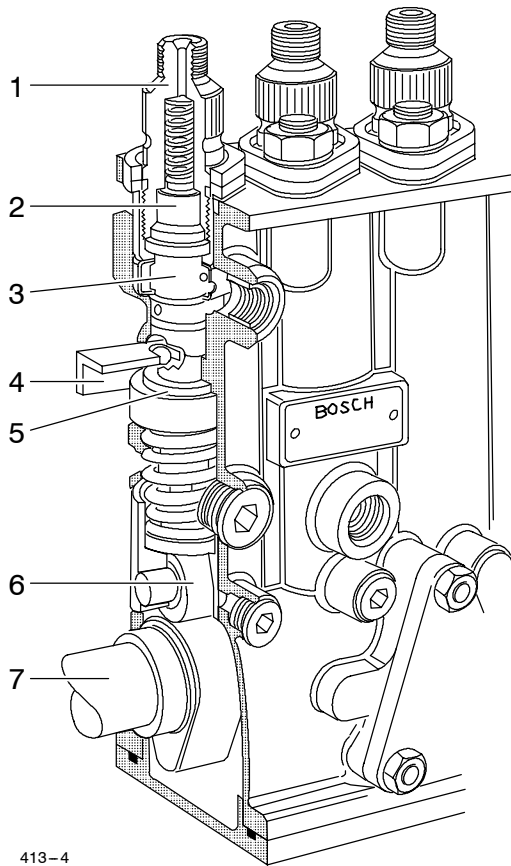
The injection pump is equipped with a boost control and an electrical excessfuel feed device. The beginning of the injection is positioned with a lock pin in the regulator housing.

Fuel injection pump type plate

The injection pump type plate shows one particular letter indicating the user application, see figure below. This letter should always be quoted when ordering a replacement pump or when looking for setting values.



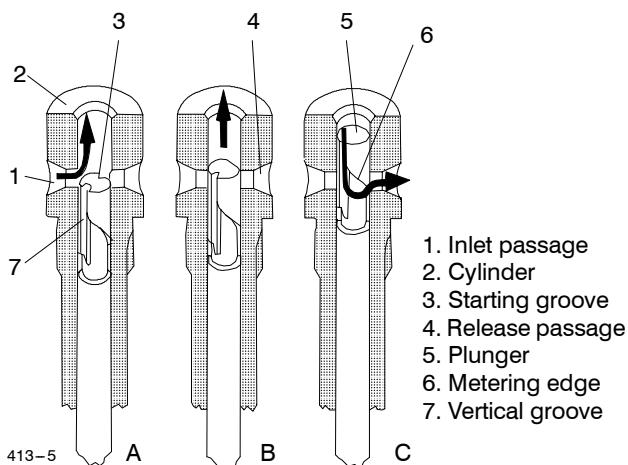
413-3



413-4

1. Pressure valve holder
2. Pressure valve
3. Pump element
4. Control rod
5. Control tag
6. Roller tappet
7. Camshaft

The purpose of the fuel injection pump is to meter out fuel to the combustion chamber at the correct time. Pump element (3) which is driven by the pump camshaft (7) via roller tappet (6) forces the fuel through pressure valve (2) and further through the delivery pipe to the injector.



413-5

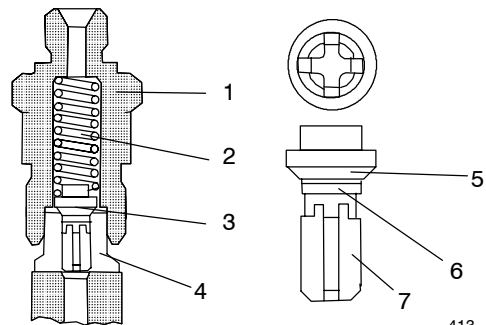
Two-hole pump element (maximum feed)

- A. Bottom dead centre
- B. Fuel injection begins
- C. Fuel injection ends

The pump element consists of one plunger and one cylinder which are a matched pair and because of the fine tolerances the whole element should be changed as a complete unit.

The cylinder has two passages: inlet passage and release passage. Both passages allow fuel to enter the pressure space. The side of the plunger has one vertical groove and one metering edge which are used for adjusting the amount of fuel injected into the combustion chamber of the engine.

The top of the plunger is provided with a starting groove (delay groove) which delays the injection timing by approx. 8° . (This should be borne in mind when checking the fuel injection timing). This groove improves the cold starting properties of the engine. It works fully automatically. When the engine has stopped the control rod in the injection pump turns the plungers so that the starting groove faces towards the release passage. When the engine has started and when the injection pump has reached a certain speed, the governor pulls the control rod back into running position.



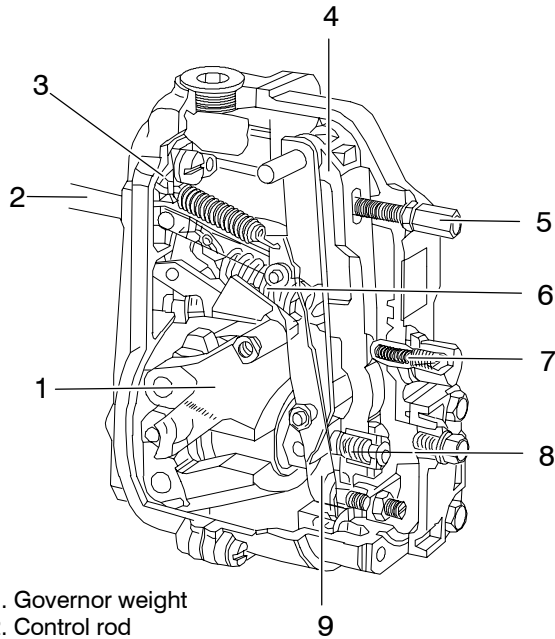
413-6

Pressure valve

1. Holder for pressure valve
2. Valve spring
3. Valve cone
4. Valve guide
5. Valve head
6. Pressure-reducing piston
7. Vertical grooves

The pressure valve is fitted on top of the pump element and its purpose is to close the connection between the pump element and the delivery pipe. This happens when the metering edge of the plunger passes the lower edge of the release passage, thus reducing the pressure in the space above the plunger. Its second purpose is to reduce the pressure in the delivery pipe. This is important as it enables the nozzle valve (needle) to close more quickly.

Pressure valve cone contains a pressure-reducing piston which, when the valve closes, is first lowered into the guide and then closes the connection between the delivery pipe and the pump element. The valve head is then pressed against its seat and the fuel in the delivery pipe is given the same space as the displacement of the pressure-reducing piston.

Governor

1. Governor weight
2. Control rod
3. Starting spring
4. Main lever
5. Idler screw
6. Governor spring
7. Additional spring, idling
8. Spring for equaliser
9. Governor control arm

413-7

The governor is of the centrifugal type and is fitted at the rear end of the injection pump. The governor controls the rotational speed of the engine throughout the whole speed range, and identifies the rotational speed by means of the governor weights. The position of the governor control and of the governor weights is transferred through the governor lever linkage to the control rod. The governor has one governor spring. Starter spring, which is attached to the upper end of the control lever, it pulls the control rod to the starting position when the engine stops. This means that the amount of fuel injected when the engine is started automatically becomes greater.

Manifold pressure compensator

The boost control unit on the governor housing has been connected via a hose to the engine intake manifold. At low revs the boost pressure is low and engine tends to smoke. The boost control limits amount of injected fuel at low revs, lowering exhaust gas emissions. This adjustment starts at a certain, adjusted, boost pressure.

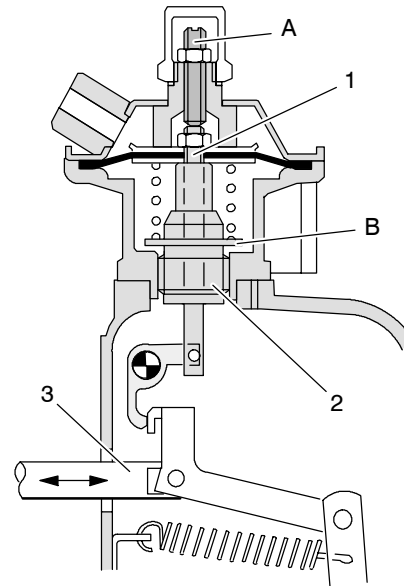
The boost control unit membrane is pre-tightened and air tight. A spring in the unit affects the lower surface of the membrane; the other end of the spring rests against the threaded guide sleeve (2). The spring tension can thus be changed in certain limits (adjusted in factory).

With thread equipped pin (1) is attached to the membrane. The lower end of the pin transmits movement of the membrane via an angle piece to the injection pump control rod (3).

When increased boost pressure presses the membrane downwards, also the pin moves downwards against the spring force and allows the control rod to move towards the greater fuel amount, which is injected into the combustion

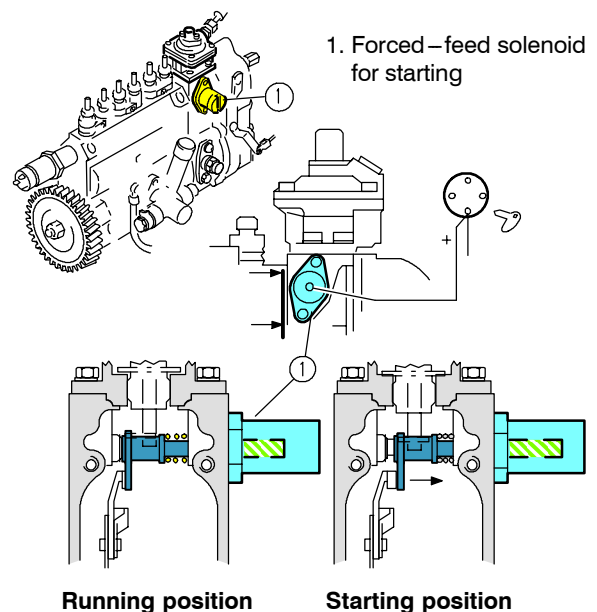
chambers. When the boost pressure decreases, the control rod moves towards the smaller amount of injected fuel.

Important! The boost control unit has been adjusted in the factory, and adjustments afterwards are not necessary.

**Boost control**

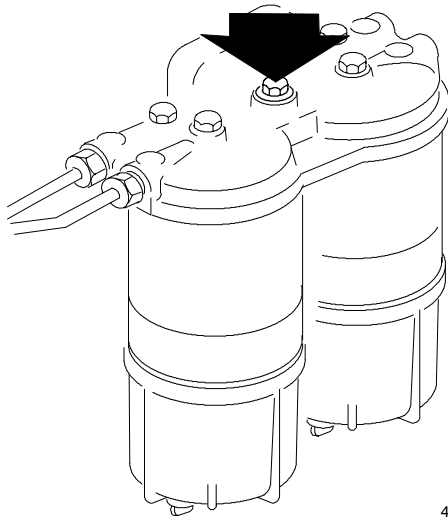
A. Adjustment screw with which is adjusted fuel amount, which the injection pump injects at low boost pressure.

B. The operating pressure wheel.

Cold start solenoid

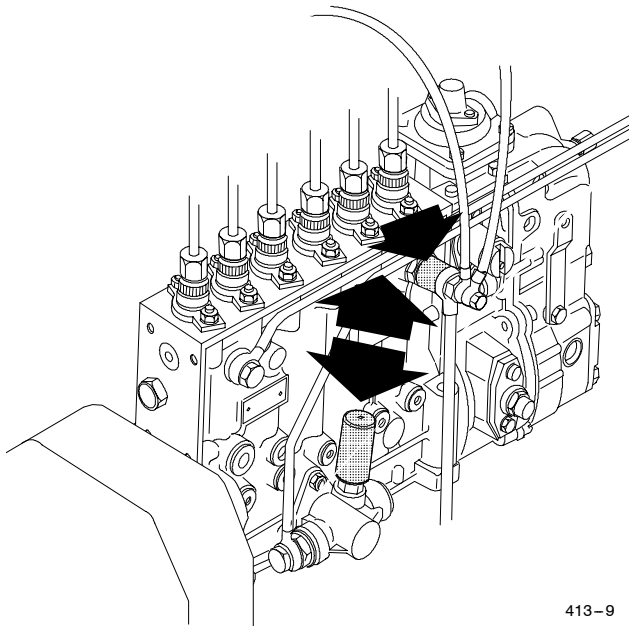
When the engine is started, the control rod must move to the starting position. This can be done by moving the boost control lever in the direction of the axle, so that the lever cannot affect any more the injection pump control rod. The mechanism functions with aid of solenoid and a cross shaft.

The solenoid is energised, when the ignition switch is turned in a starting position. The solenoid is energised as long as the starter motor is on. In the starting position, the solenoid is magnetic. When the solenoid moves to the starting position, a click sound can be heard from the injection pump.

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.



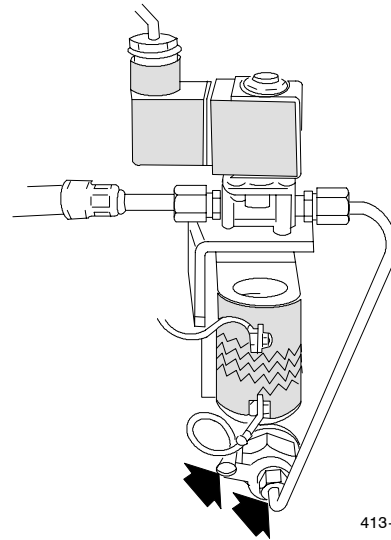
413-9

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.

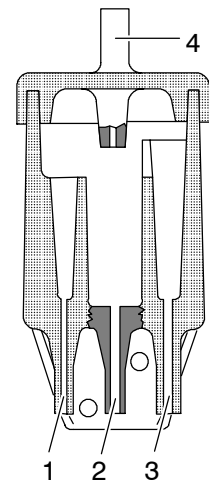
System with the magnetic valve

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

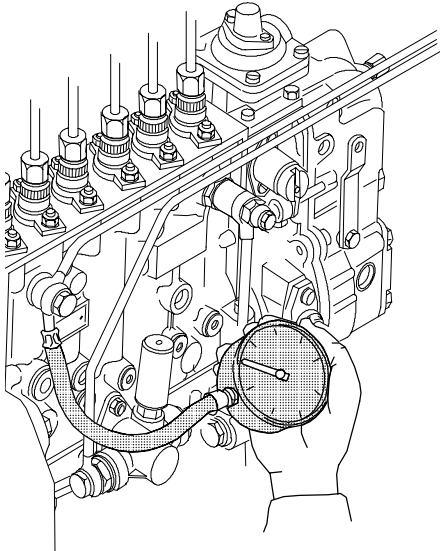
1. Reservoir filling
2. To the glow plug
3. Return the fuel tank
4. Breather

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.

C. Measuring fuel feed pressure

1. Clean the fuel injection pump and the filter and the pipes between them.



413-11

2. Fit the gauge at the banjo connection on the pump, as shown above (between filter and injection pump).
3. Run the engine at low idling for a while and compare the gauge reading with the prescribed value (**0,6...1,0 bar**).

Note! If the measured pressure is below the prescribed value, this may be caused by:

- faulty overflow valve
- blocked fuel filter
- faulty fuel feed pump
- blocked or leaking fuel pipes or unions

D. Checking overflow valve

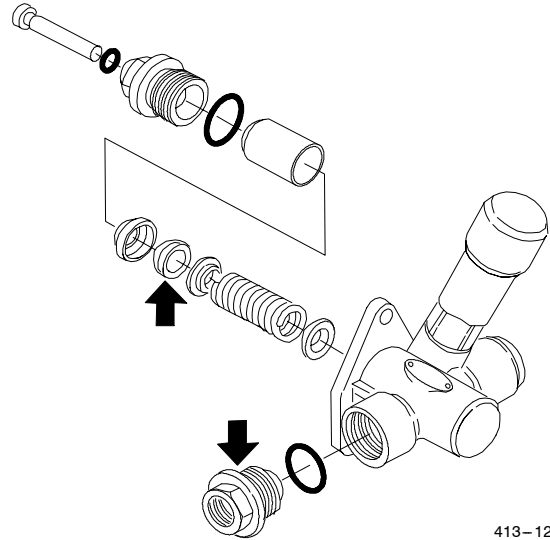
If the fuel feed pressure deviates from the prescribed value, check the opening pressure of the overflow valve.

1. Connect a pressure gauge to the banjo union in the same way as in previous instruction **13 C**.
2. Pump with the hand pump until the overflow valve opens. Compare the reading on the gauge at the moment the valve opens with the prescribed value (**0,6...1,0 bar**).
3. If the recorded opening pressure deviates from the prescribed value, the overflow valve should be changed.

Note! If the recorded pressure is considerably lower than the prescribed value, there may be a fault in the hand pump or the fuel feed pump valves.

E. Changing fuel feed pump valves

1. Clean the feed pump. Disconnect fuel pipes to the feed pump. Remove the feed pump.



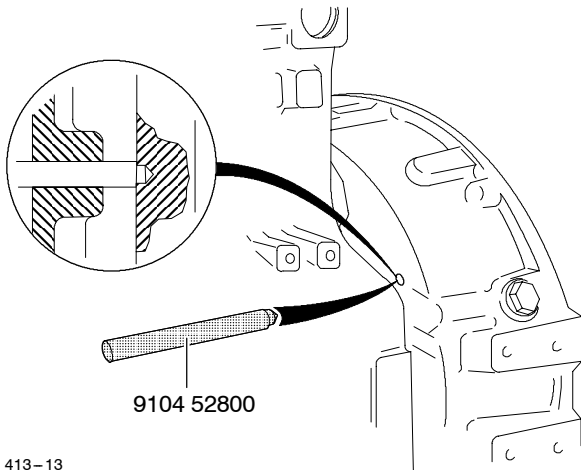
413-12

2. Secure the pump in a vice provided with soft jaws. Loosen the tappet body from the pump and remove the piston, seal rings, suction valve and the spring.
3. Detach from the pump body the outlet side threaded connector, in which is placed the pressure valve.
4. Rinse the valves with clean fuel and check the function and possible wear.
5. Change the valve if needed and assemble the pump using new o-rings and gasket.

F. Checking injection timing

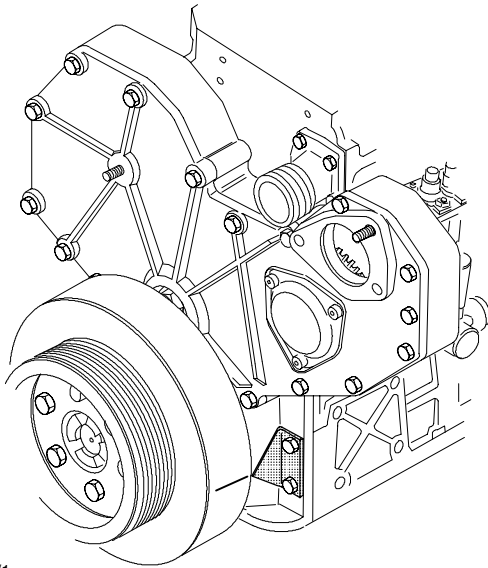
The injection starting point in the 1st cylinder has been positioned with aid of an indicator pin in the pump governor housing and with a locator/mark hole on the flywheel. In some engines the injection timing for cylinder no. 1 is marked on the vibration damper. The timing indicator is on the left side of the vibration damper.

1. Clean the injection pump and its surroundings carefully.
2. Turn the crankshaft to a position where the 1st cylinder piston reaches its compression stroke top dead centre. Then turn the crankshaft backwards until the mark hole on the flywheel (mark on the vibration damper) passes the locator hole on the front face of the flywheel housing (timing indicator). After that rotate the crankshaft slowly to running direction until the mark hole on the flywheel (mark on the vibration damper) is at the point of the locator hole (timing indicator).



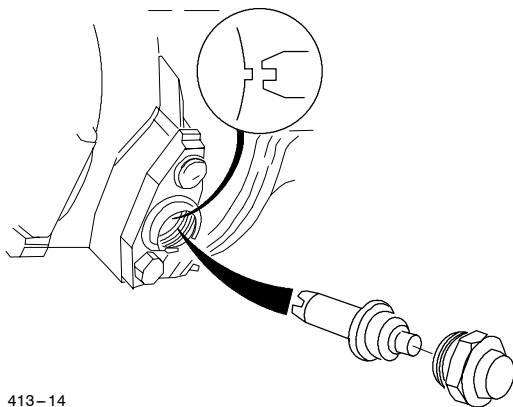
413-13

3. Push the locator 9104 52800 into the holes on the flywheel housing and on the flywheel.



413-13/1

Or check, that the mark on the vibration damper is at the point of the timing indicator.



413-14

4. Unscrew the plug on the side of the injection pump. Take out the indicator pin.

5. Turn the indicator pin and push it into the hole so that the groove at the end of the pin points towards the pump.

6. If the pin groove fits on the boss on the governor weight assembly, the injection timing is correct. Repeat the check procedure. If the injection pump needs to be adjusted, follow the instructions under heading **13 G**.

Note! Do not rotate the crankshaft when the groove end of the pin is inside the pump, since the pin end damages easily and plastic pieces remain in the governor housing.

7. When the adjustment is correct, turn the indicator pin so that the groove points outwards (running position) and push the pin into the hole. Refit the plug.

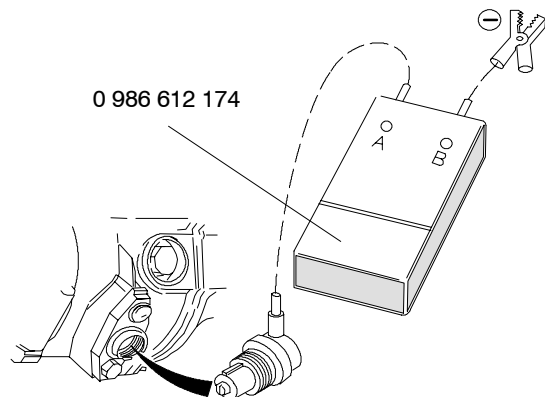
8. Take out the locator from the flywheel hole.

Usage of the electrical inspection device (Bosch KDEP 1601 0 986 612 174)

Also in electrical device can be used to check the timing.

1. Turn the crankshaft to a position where the 1st cylinder piston reaches its compression stroke top dead centre. Then turn the crankshaft backwards until the mark hole on the flywheel passes the locator hole on the front face of the flywheel housing.

2. Unscrew the plug on the side of the injection pump. Take out the indicator pin.



413-15

3. Connect the inspection device sensor into the governor housing. Note the position of the sensor! Connect the - wire into earth.

4. Rotate the crankshaft in running direction until light **A** is on.

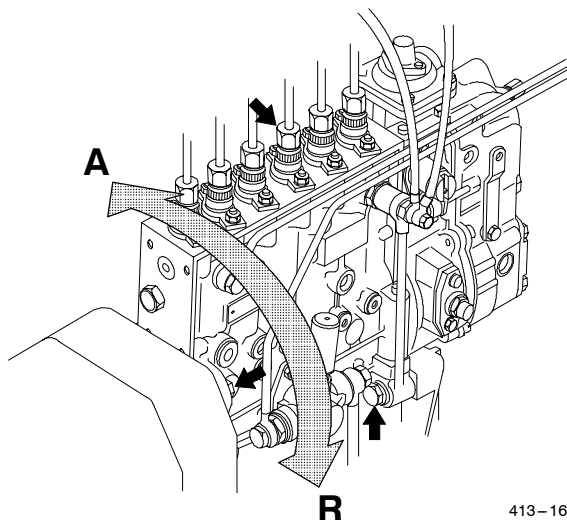
5. Continue rotating the crankshaft in running direction very slowly until light **B** is on.

6. Push the locator 9025 99100 into the hole on the flywheel housing. If the mark hole on the flywheel is at the point of the locator hole, the injection timing is correct. If the holes are not at the point, perform the adjustment according to instruction **13 G**.

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.



413–16

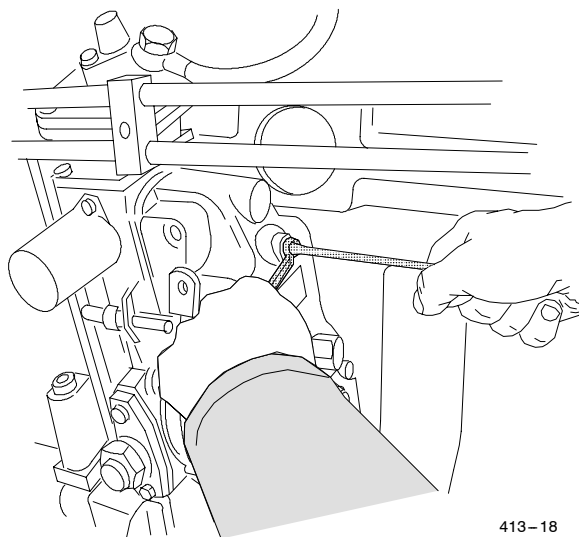
2. If the injection timing is retarded, turn the injection pump anti-clockwise (viewed from the front end of the pump). If the timing is advanced, turn the pump clockwise.

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.

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.



413–18

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.

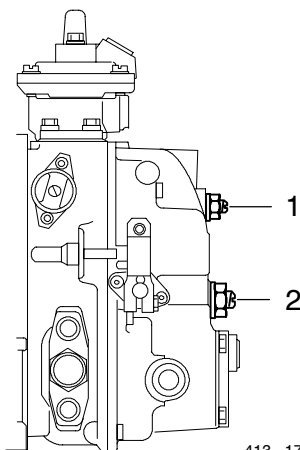
6. Tighten the adjusting screw of the additional spring until the idling speed rises to the rated value. Lock the adjusting screw in this position.

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.

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:



413–17

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

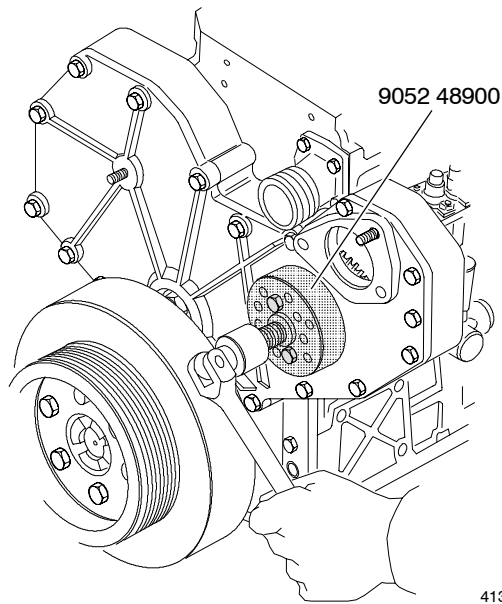
I. Removing fuel injection pump

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.



413–19

5. Use puller 9052 48900 and loosen the gear from the injection pump camshaft front end.

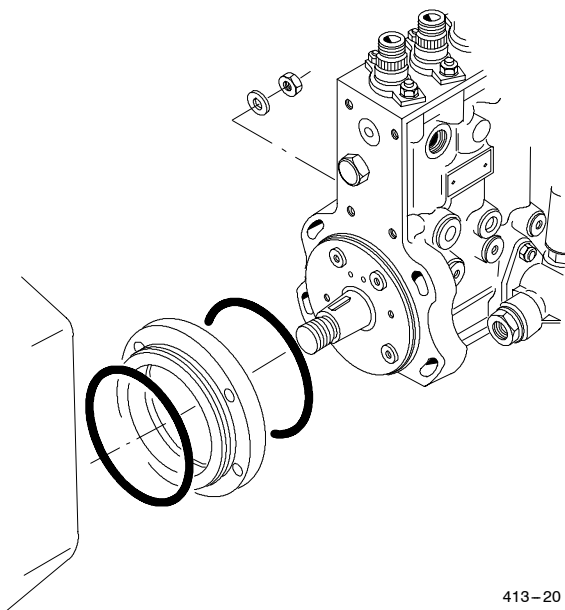
6. Open the retaining nuts and bottom mounting screws and remove the injection pump.

7. Take off the fit ring and clean the sealing surfaces.

Note! The injection pump gearing remains in contact with the idler gear, so you don't have to mark their position when removing the pump.

J. Fitting fuel injection pump

1. Check the condition of the o-rings between the pump and the timing gear casing. Change the o-rings if necessary.



413–20

2. Lubricate the o-ring and put the fit ring to the timing gear casing.

3. Lubricate the o-ring and place the injection pump so that the key on the pump shaft aligns with the key slot inside the gear. Tighten the gear nut to **200 Nm** and fit the cover.

4. Adjust the injection timing, see instruction **13 G**.

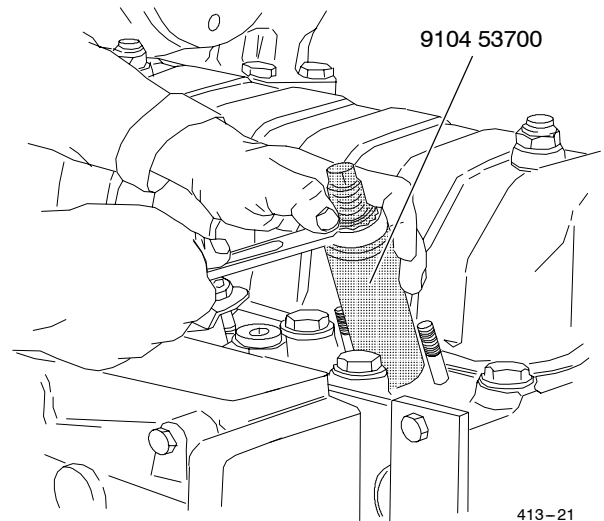
5. Connect the supply and return fuel lines. Connect the lubricating oil line. Use new sealing washers. Fit the delivery pipes.

6. Bleed the fuel system, see instruction **13 A**.

7. Fit the coolant pump and fill the cooling system.

K. Removing injectors

1. Clean the injectors and the area around them. Disconnect the delivery pipes and the leak-off pipes.



413–21

2. Remove the injector attaching nuts and remove the injector from the cylinder head. Fit protective plugs to all connections. If the injector does not rise by hand, use puller 9104 53700.

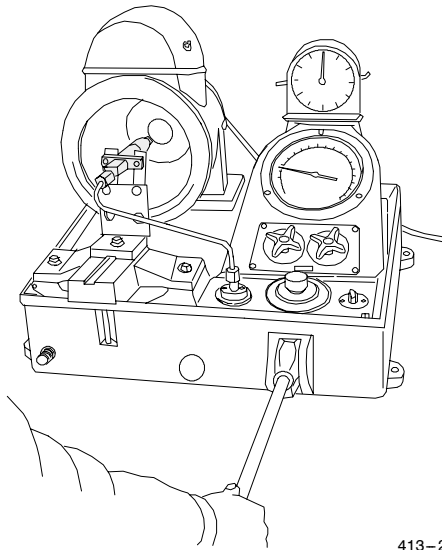
3. Remove the sealing washers from the bottom of the injector location in the cylinder head if they do not come out with the injector.

L. Inspecting injectors



Note! When pressure testing the injectors, it is important to avoid the nozzle end as the fuel jetting out easily penetrates the skin. Also bear in mind that the fuel "mist" is dangerous to inhale.

1. Clean the injector with cleaning fluid and a soft brush. The carbon deposits must not be knocked off or removed in any other way which may damage the nozzle.



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.

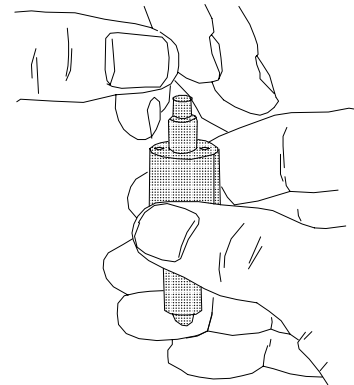
However, with a rapid pumping on the tester handle, it should be possible to hear the chattering (creaking) sound or/and see a mist of the fuel jetting out.

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:

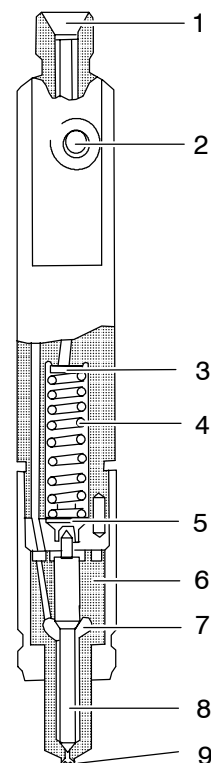


413–23

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

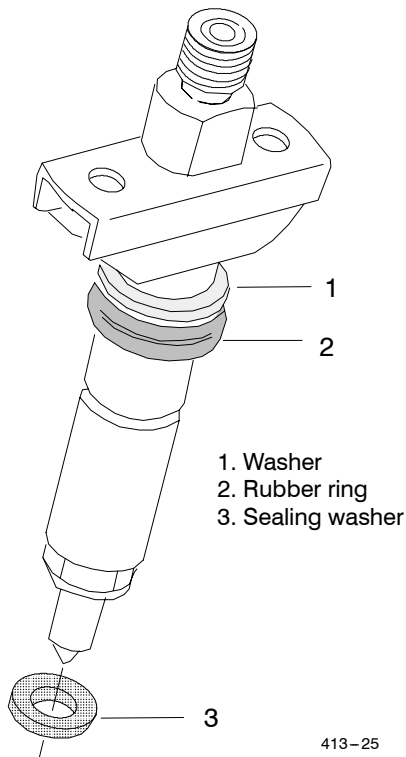
6. Before assembling, all parts should be carefully cleaned in clean fuel or testing fluid.

7. Put the same thickness of shim back as were fitted earlier. Note possible adjustment of the opening pressure. Assemble the rest of the injector. Note the position of the spring guide and the valve stop spacer.

8. Tighten the nozzle cap nut by hand and then to **60 Nm**.

N. Fitting injector in engine

1. Clean the injector sealing surface in the cylinder head. If necessary use a reamer 9101 66000.



2. Fit the injector in the cylinder head using a new sealing washer.

Note! The spray pattern from the injector is not symmetrical on purpose. It is therefore important that the injector is fitted correctly in the cylinder head. The connection for the leak-off line should be facing the valve mechanism.

3. Fit the attaching clamp and tighten the nuts evenly to **15 Nm**.

4. Connect the leak-off line together with new sealing washers and connect the delivery pipes.

Note! The screw studs in the cylinder head for the injectors should only be finger tight. If tools have to be used the studs should be tightened only lightly.

Note! Make sure, that the injector is of a correct type. Wrong injectors cause malfunctions and can damage the engine.

O. Fitting delivery pipes

1. Check the state of the pipes. If there are kinks, damage by chafing, or if the tapered sealing end is damaged, the pipes should be changed.

2. Fit the pipes without tension and check that they are at right angles to the union.

3. Fit the clamps for the pipes.

Fuel quality requirement

	Requirement	Test method
Density, +15 °C	0,82...0,86 kg/dm ³	ASTM D 4052, EN ISO 12185
Viscosity, +40 °C	1,2...4,5 mm ² /s	ASTM D 445, ISO 3104
Sulphur content	max. 0,2 % m/m	ASTM D 4294, ISO 8754
Cetane index	min. 45	ASTM D 4737
Water content	max. 200 mg/kg	ASTM D 1744

The fuel should be according to norm EN 590.

Engine output depending on fuel quality

Different fuel qualities like temperature, density and viscosity affect the actual output of the engine. Our output rates use fuel with a density of 0.84 kg/dm³ and specific heat rate of 42,7 MJ/kg at a fuel temperature of +15 °C.

The correction in % caused by the change of fuel qualities is seen in the attached figures.

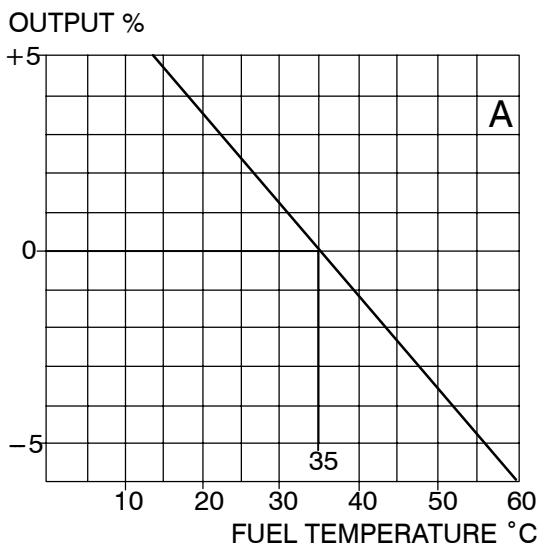


FIG. A. Engine output dependence on fuel temperature. +35 °C is the reference temp (correction 0 %).

The fuel temperature is not only a function of ambient conditions but also varies according to the fuel system of the application (tank size and location, return flow etc.).

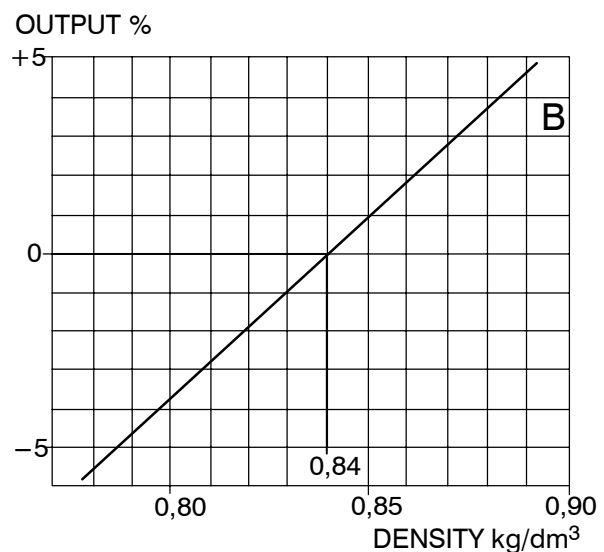


FIG. B. Engine output dependence on fuel density. Normal value is 0,84 kg/dm³ at +15 °C.

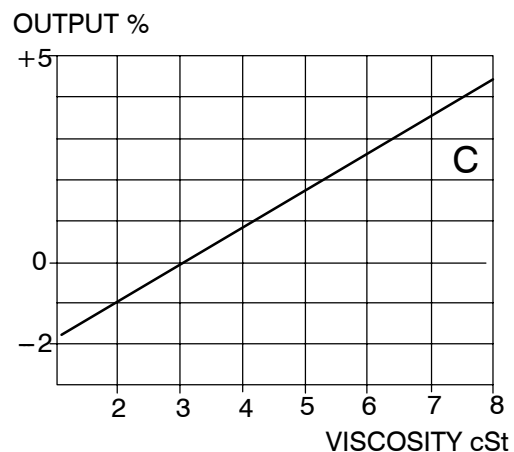


FIG. C. Engine output dependence on fuel viscosity. Normal value is 3 cSt at +20 °C.

Note fig. B and C only if the fuel quality is changed. In fig. A there are all the quality dependencies caused by the change of the temperature. The fuel density and viscosity can be seen in the produce declaration given by the manufacturer.

The output correction is made as follows: Correction percentages from figures A, B and C are summed up. The given rated power is then corrected with the resulting percentage.

**FUEL SYSTEM
EQUIPMENT AND FEEDING TABLE****645**

Test equipment ISO 4008
Fluid ISO 4113
Pipes $\varnothing 6 \times 1,5 \times 600$ ISO 4093

Nozzle ISO 7440 207 bar
0,60 orifice plate

Engine	Application	Pump spare part no Fuel adjustment card	Pump Governor	Injection advance ° Max. output r/min Idling r/min Output kW	Boost control press. bar	rpm	Feed rate mm ³ /stroke	RW mm	Control rod min. -1 mm rpm	Control rod position 4 mm rpm	Element Pressure valve Covernor spring
645 DSB AEL	MF 7276	8368 54748 8.000	PES 6P 120A	12	2,0	1000	242-244	14,1...14,5	1020	1065-1085	-
			320RS 7437	2000	2,0	500		14,1...14,5			-
			/-	1100		LDA					-
			RSV 550-1000	263	1,5	500	150-152	14,2			
			P1A 678		0,0	500	12-14	10,7			
					0,0	550		3,8...4,2			
645 DSB IE	MF 8280 MF 8180	8363 54708 8.002	PES 6P 120A	14	1,2	1100	172-174	11,8...12,2	1120	1180-1200	8363 54638
			320RS 3382	2200	1,2	950	180-182	12,2...12,6			8363 30239
			/-	950	1,2	750	181-183	12,2...12,6			-
			RSV	200	0,75-0,80	LDA					
					0,0	500	110-113	11,9			
					0,0	500	7-10	8,7...9,1			
					0,0	475		5,5			
645 DSB IE	MF 8170 MF 8270 Allis 9775	8363 54740 8.003	PES 6P 120B	14	1,2	1100	157-159	10,5...10,9	1120	1180-1200	8363 54638
			320RS 3382	2200	1,2	950	166-168				8363 30239
			/A	950	1,2	750	167-169				-
			RSV	181	0,60-0,65	LDA					
					0,0	500	110-113	10,6			
					0,0	500	7-10	8,7...9,1			
					0,0	475		5,5			
645 DSB IEL	MF 7272 LAN	8363 54800 8.007	PES 6P 120A	14	1,5	1000	176-178	11,5...11,9	1025	1065-1075	8363 54638
			320RS 3382	2000	1,5	500	184-185	12,0...12,4			8363 30239
			/F	1100		LDA					-
			RSV 425-1100	205	1,1	500	100-102	11,6			
			P0A 669		0,0	500	7-10	8,7...9,1			
					0,0	550		5,5			

**FUEL SYSTEM
EQUIPMENT AND FEEDING TABLE****645**

Test equipment ISO 4008
Fluid ISO 4113
Pipes $\varnothing$ 6 x 1,5 x 600 ISO 4093

Nozzle ISO 7440 207 bar
0,60 orifice plate

Engine	Application	Pump spare part no Fuel adjustment card	Pump Governor	Injection advance° Max. output r/min Idling r/min Output kW	Boost control press. bar	rpm	Feed rate mm ³ /stroke	RW mm	Control rod min. - 1 mm rpm	Control rod position 4 mm rpm	Element Pressure valve Governor spring
645 DSBIE	MF 7274	8368 54811 8.009	PES 6P 120A 320RS 7437 /A RSV 550 - 1000 P1A 678	12	2,0	1000	230 - 232	13,2...13,6	1020	1065 - 1085	-
				2000	2,0	500	222 - 224	13,2...13,6			-
				1100		LDA					-
				234	1,2	500	212 - 214	13,3			
					0,0	500	150 - 152	10,7			
645 DSIM	BONI	8368 54775 8.005	PES 6P 120A 320RS 7437 /C RSV		0,0	550	12 - 14	3,8...4,2			
				12	1,8	1000	242 - 244	14,1...14,5	1010	1080 - 1100	-
				2000	1,8	800		14,0...14,4			-
				850		LDA					-
				295	1,2	500	212 - 214	13,0			
645 DSBIE	Vammas RG 281	8363 54839 8.010	PES 6P 120A 320RS 3382 /M RSV		0,0	500	150 - 152	10,7			
					0,0	425	12 - 14				
				14	1,2	1000	170 - 172	11,8...12,2	1020	1090 - 1110	8363 54638
				2000	1,2	500		12,1...12,5			8363 30239
				850		LDA					-
				200	0,76	500		10,8...11,2			
					0,0	800	100 - 102	8,9...9,3			
					0,0	425	10 - 13	5,5			

15. ELECTRICAL SYSTEM

A. Alternators

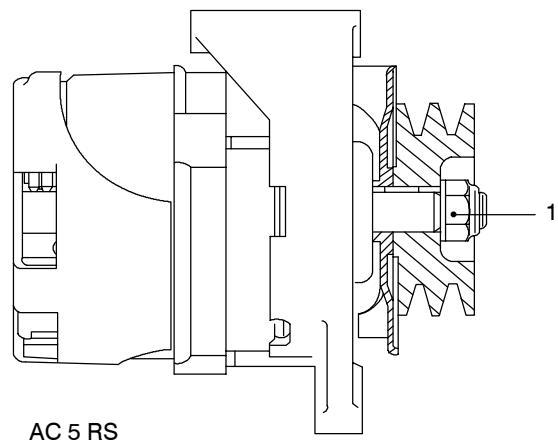
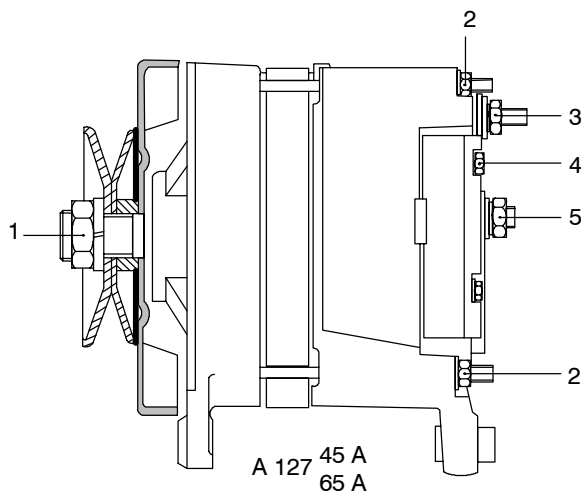
Magneti Marelli A 127 45 A/65 A

(Lucas)

(Sisu Diesel no. 8366 40127 45 A)

(Sisu Diesel no. 8366 40128 65 A)

Nominal voltage	12 V
Max. voltage 6000 r/min	A 127 45 A 45 A
	A 127 65 A 65 A
Earthing	(-) minus
Max. allowed speed	15 000 r/min
Brush length when new	17 mm
Min. brush length	5 mm
Brush spring tension	1,3...2,7 N
Number of stator poles	12
Number of stator phases	3
Stator resistance	A 127 45 A 0,25 ohm
	A 127 65 A 0,18 ohm
Rotor resistance	2,9 ohm
Regulating voltage	13,6...14,4 V
Tightening torques:	
1. Shaft nut	60 Nm
2. Assembling screws	5,5 Nm
3. Phase connection (M5)	4,0 Nm
4. Regulator screws	2,5 Nm
5. Main connection	4,0 Nm



415-1

CAV AC 5 RS 24 V 55 A

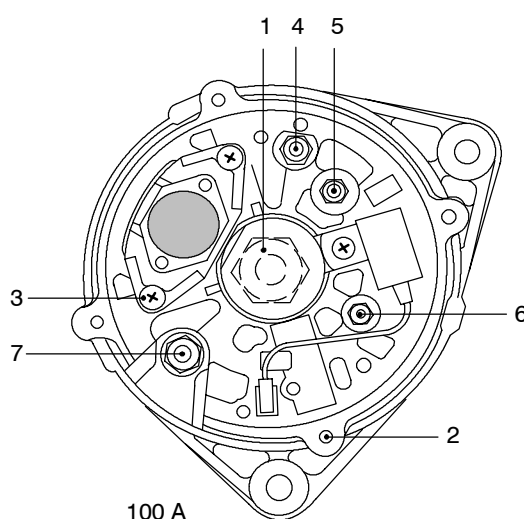
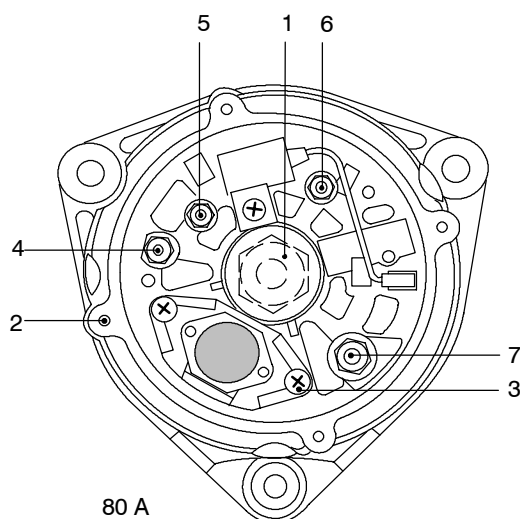
(Sisu Diesel no. 8353 39422)

Nominal voltage	24 V
Output	
2000 r/min	27 A
3000 r/min	42,5 A
4000 r/min	49 A
Charge begins	1250 r/min
Max. allowed speed	10 000 r/min
Min. slip ring diameter	32 mm
Min. brush length	8 mm
Brush spring tension	2,23 N
Rotor resistance	8,0...8,3 ohm
Stator resistance	0,09 ohm
Tightening torques:	
1. Shaft nut	55 Nm

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



415-2

Bosch N1-28 V 0/100 A

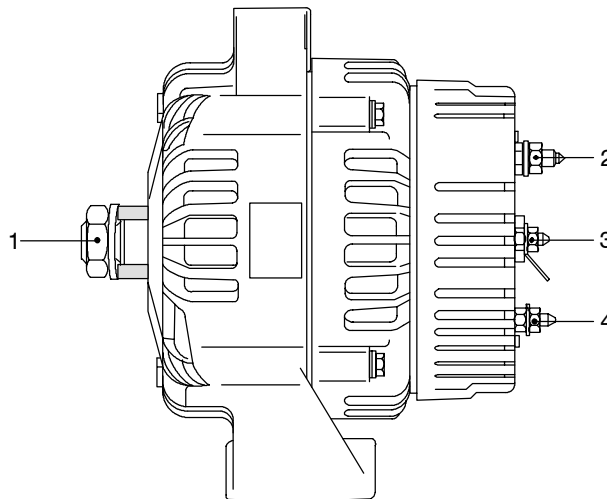
(Sisu Diesel no. 8353 40374)

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

Iskra AAK 5118 14 V 95 A

(Sisu Diesel no. 8366 40927)

Nominal voltage	12 V
Output (testing voltage 13 V)	
2000 r/min	≥50 A
4000 r/min	≥84 A
6000 r/min	≥94 A
Charge begins	1100 r/min
Max. allowed speed	15 000 r/min
Min. slip ring diameter	15,3 mm
Min. brush length	5 mm
Rotor resistance	2,7...2,97 ohm
Stator resistance	0,33...036 ohm
Tightening torques (see figure below):	
1. Shaft nut	50...70 Nm
2. Joint B+ (M6)	4,2...6,0 Nm
3. Joint D+ (M5)	2,7...3,8 Nm
4. Joint W (M 5)	2,7...3,8 Nm



415-3

Bosch NC 14 V 70-120 A

(Sisu Diesel no. 8368 40939)

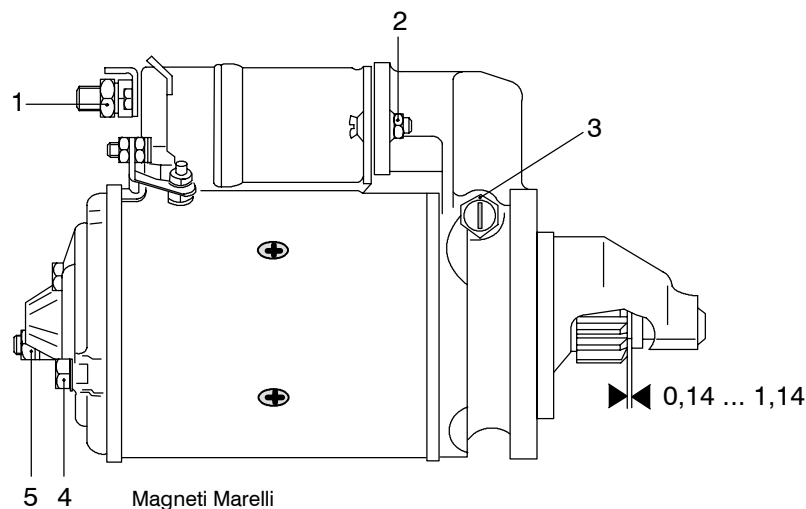
Nominal voltage	12 V
Output (13,5 V)	
2000 r/min	79 A
4000 r/min	111 A
6000 r/min	120 A
Charge begins	1200 r/min
Max. allowed speed	12 000 r/min
Tightening torques (see figure above):	
1. Shaft nut	75...85 Nm
2. Joint B+ (M8)	Max. 18 Nm
3. Joint D+ (M5)	Max. 5 Nm

B. Starters

Magneti Marelli M 127/2,8 12 V
(Lucas)

(Sisu Diesel no. 8353 31592)

Values, unloaded	
Running speed	5500...8000 r/min (max.)
Amperage	115 A
Voltage	11 V
Values, under loading	
Running speed	1000 r/min (max.)
Amperage	670 A
Voltage	8,0 V
Torque	20,8 Nm
Values, locked	
Running speed	0 r/min (max.)
Amperage	1160 A
Voltage	5,0 V
Torque	45,4 Nm
Brush spring tension	11,6...15,5 N
Min. brush length	8 mm
Min. commutator diameter	38 mm
Tightening torques:	
1. Solenoid battery jointing	12 Nm
2. Solenoid retaining screws	6 Nm
3. Fork link nut	20 Nm
4. Assembling screws	11 Nm
5. Earth joint	8 Nm



415-4

Bosch JF (R) 24 V 4kW

(Sisu Diesel no. 8353 30965)

Bosch JF (R) 24 V 4 kW, 2-pole

(Sisu Diesel no. 8361 30388)

Values, unloaded	
Running speed	>7000 r/min
Amperage	<85 A
Voltage	23 V
Values with armature locked	
Running speed	0 r/min (max.)
Amperage	900...1050 A
Voltage	13,5 V
Torque	>65 Nm
Solenoid engaging voltage min.	18 V
Min. brush length	8,5 mm
Min. commutator diameter	42,5 mm
End play of armature	0,1...0,3 mm

Iskra AZJ3234 12 V 3,1 kW

(Sisu Diesel no. 8366 40949)

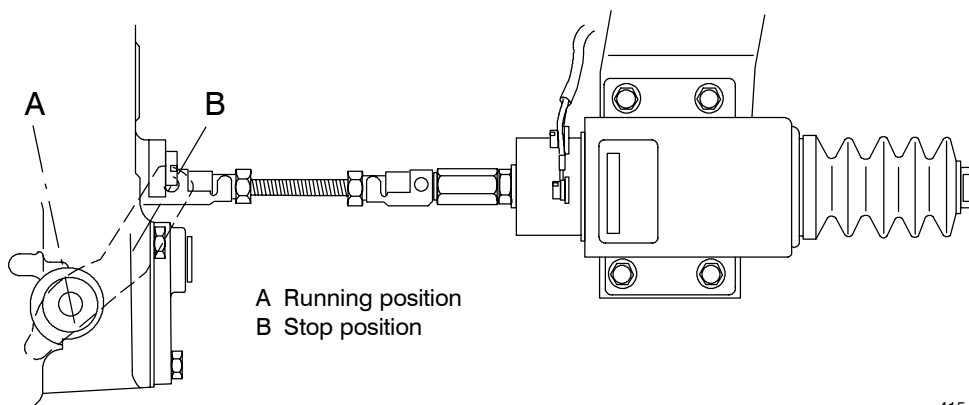
Values, unloaded	
Running speed	≤1000 r/min
Amperage	≤140 A
Voltage	11 V
Values with armature locked	
Running speed	0 r/min (max.)
Amperage	≤1660 A
Voltage	5,6 V
Torque	≥45 Nm
Brush length (new)	23 mm
Min. brush length	13 mm
Brush spring tension	40...48 N
Min. commutator diameter	43,5 mm
Tightening torques:	
Studs (M6)	5,8 Nm
Screws on solenoid (M5)	3,2 Nm
Screws on solenoid (M6)	6,0 Nm
Pole shoes (M10)	37 Nm
Brush holder	3,2 Nm
Lever pin on engagement lever	12 Nm
Contact screws on solenoid switch (M8)	8,5 Nm
Contact screws on solenoid switch (M10)	13 Nm

Iskra AZJ3247 12 V 3,6 kW

(Sisu Diesel no. 8366 40940)

Values, unloaded	
Running speed	≤1000 r/min
Amperage	≤140 A
Voltage	11 V
Values with armature locked	
Running speed	0 r/min (max.)
Amperage	≤1756 A
Voltage	5,3 V
Torque	≥47 Nm
Brush length (new)	23 mm
Min. brush length	13 mm
Brush spring tension	40...48 N
Min. commutator diameter	43,5 mm
Tightening torques:	
Studs (M6)	5,8 Nm
Screws on solenoid (M5)	3,2 Nm
Screws on solenoid (M6)	6,0 Nm
Pole shoes (M10)	37 Nm
Brush holder	3,2 Nm
Lever pin on engagement lever	12 Nm
Contact screws on solenoid switch (M8)	8,5 Nm
Contact screws on solenoid switch (M10)	13 Nm

C. Fitting stop solenoid



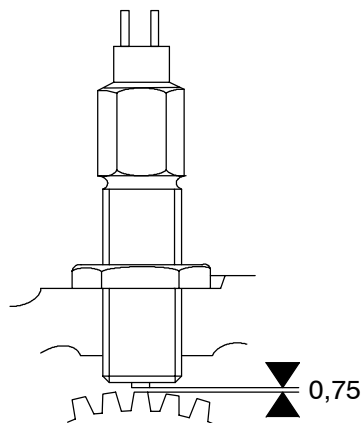
For a correct use of the dual coil solenoid (pull coil and hold coil) the plunger should reach the end of its magnetic stroke at each pulse. In this way, it will press the internal switch which connects the continuous operation second hold coil working without over-heating and with a minimum power absorption.

1. Fit the solenoid energized and adjust the leverage in such a way that the stop lever will reach its position or running position (stop solenoid energized during running).

Note! Energize the solenoid through a battery with suitable voltage and keep it energized during installation.

D. Installation of magnetic pick up

1. Rotate the flywheel to a position so that one of the flywheel ring gears teeth are in front of the pick up installation hole.

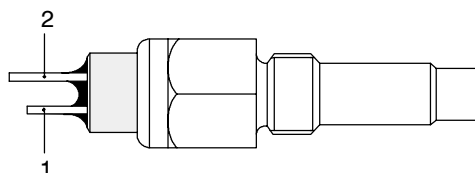


2. Turn the pick up in, until it comes in contact with the tooth.

3. Turn the pick up out $\frac{1}{2}$ turn and tighten the lock nut. This way the pick up end is **0,75 mm** from the tooth.

Note! Clean the pick up end from dirt in the yearly service.

E. Temperature sensor



1. Connection for warning light
2. Connection for temperature gauge

Alarming temperature $98 \pm 3^\circ\text{C}$.

Gauge monitoring resistances:

60°C	$134 \pm 13,5 \text{ ohm}$
90°C	$51,2 \pm 4,3 \text{ ohm}$
100°C	$38,5 \pm 3,0 \text{ ohm}$

Part no.	Alarming temperature
6542 71208	$98 \pm 3^\circ\text{C}$
8366 40772	$106 \pm 3^\circ\text{C}$
8366 64017	$110 \pm 3^\circ\text{C}$