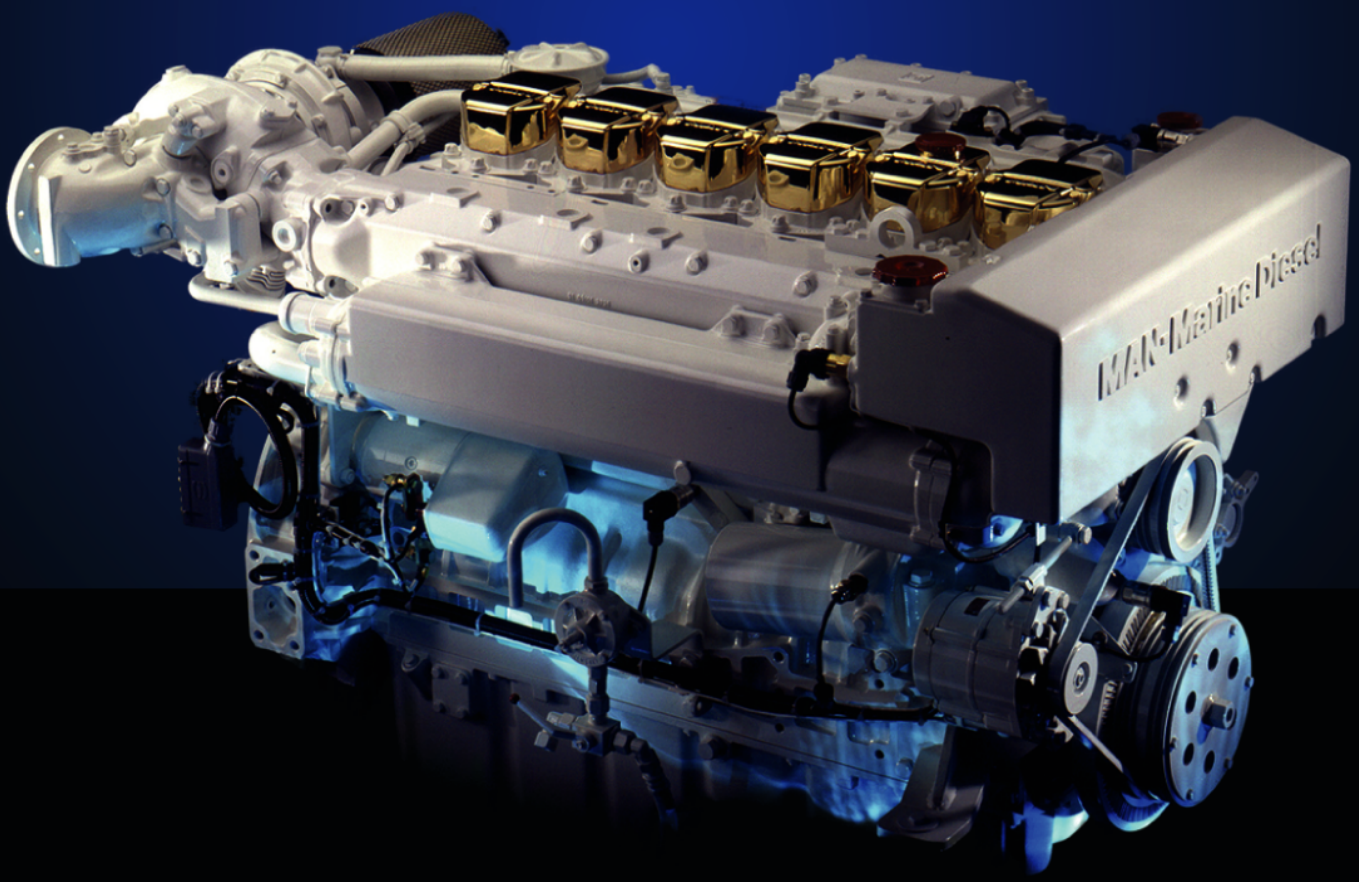
Repair Manual

MAN-Marine Diesel Engines

D 2876 LE 401 / 402 / 404 / 405



This Repair Manual is designed to facilitate repair of the engines listed in line with accepted technical principles.

In addition to this Repair Manual the following publications are available:

- Operating Instructions
- Fuels, Lubricants and Coolants for MAN Diesel Engines
- Spare-parts catalogue
- Service record book with maintenance plan

The pictures and associated descriptions show typical work that may not always be applicable to the engine in hand, which nevertheless does not mean that they are not correct.

In such cases, the repair work is to be planned and carried out in a similar way.

It is compulsory that the engine be removed before performing any of the work describe in this Repair Manual.

The expert knowledge necessary for handling Diesel engines was taken for granted when this publication was compiled.

Note:
Only use fuel, coolants and lubricants in accordance with MAN's regulations otherwise the manufacturer's warranty will not apply!
For basic information on the fuels see the publication "Fuels, Lubricants and Coolants for MAN Diesel Engines".
You can find the approved products in the internet under:
http://www.man-mn.com/ → Products & Solutions → E-Business

Any repair of components such as injection pump, alternator etc. ought to be left to our or the manufacturer's service department.

Best regards
MAN Nutzfahrzeuge Aktiengesellschaft
Nuremberg Plant

We reserve the right to make technical modifications in the course of further development.

MTDB Technical status: 07.2005 51.99598–8028

Important instructions which concern technical safety and protection of persons are emphasised as shown below.

Danger:
This refers to working and operating procedures which must be complied with in order to rule out the risk to persons.

Caution:
This refers to working and operating procedures which must be complied with in order to prevent damage to or destruction of material.

Note:
Explanatory descriptions which help in understanding the relevant work or operating procedure to be carried out.

Assembly of pipes

Danger:
No pipes may be bent.
Risk of breakage!

Fitting flat seals / gaskets

Flat seals / gaskets are often inserted with sealing agents or adhesives to make fitting them easier or to achieve better sealing. Flat seals may slip in operation due to the “sewing-machine” effect, in particular if they are used between parts with different rates of linear expansion under heat (e.g. aluminium and cast iron), and leaks may then occur.

Example:
The cap of the front crankshaft seal. If a sealing agent or an adhesive is used here the flat seal will move inwards in the course of time as a result of the different expansion rates of the materials. Oil will be lost, for which the shaft seal may be thought to be responsible.

Flat seals / gaskets can be fitted properly only if the following points are observed:

- Use only genuine MAN seals / gaskets
- The sealing faces must be undamaged and clean
- Do not use any sealing agent or adhesive – as an aid to fitting the seals a little grease can be used if necessary so that the seal will stick to the part to be fitted
- Tighten bolts evenly to the specified torque

Fitting round sealing rings

- Use only genuine MAN round sealing rings
- The sealing faces must be undamaged and clean
- Always wet round sealing rings with engine oil before fitting them

Masking of fuel and lube oil pipe connections (for classified engines only)

The unions of pressurised oil and fuel pipes are masked with a protective tape.
If this tape is removed during a repair, the unions must be masked with protective tape again afterwards.

The following pipes are affected:

- Oil supply pipe to turbochargers
- Fuel pipes between supply pump, filter and injection pump
- Injection pipes protected against leaks

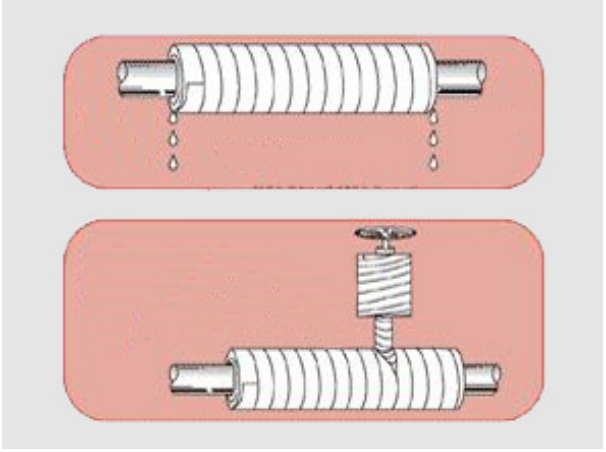


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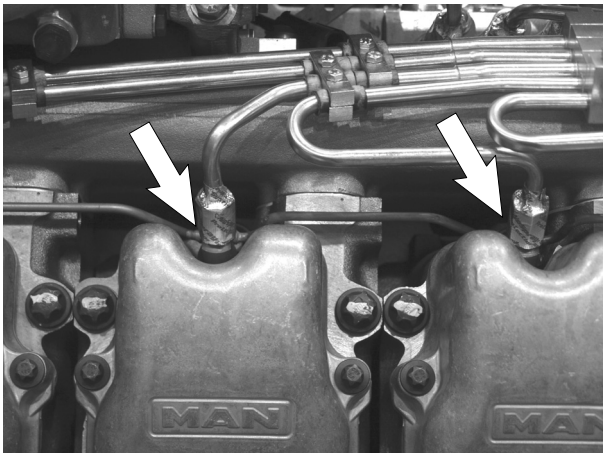
Fig. 1
A protective tape is wound around the unions. Ensure that there is 50 % overlap on every pass.



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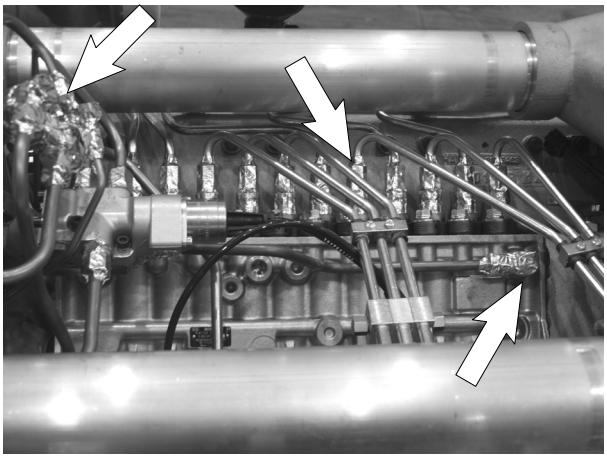
Figs. 2–4
The unions to be masked must be clean and free of oil and grease.
Do not apply the protective tape unless this is the case



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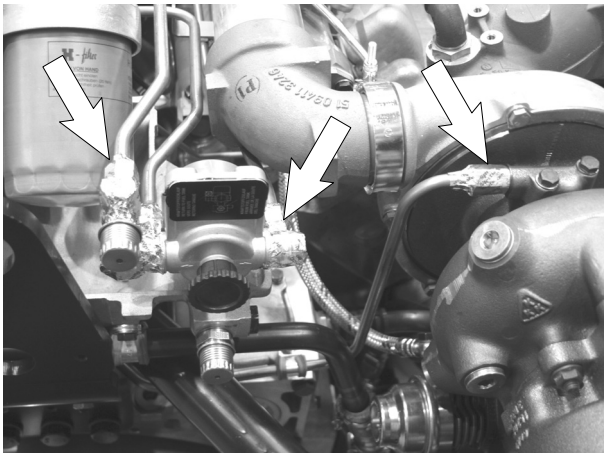

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All the engines dealt with here are related in terms of their design and make up a family.

The type classification, which is made up of a series of letters and numbers, reveals some of the features of the engine in question provided the reader is familiar with the underlying nomenclature.

The system is explained below using the model type D 2876 LE 401 as an example:

D The “D” at the start of the type classification stands for “Diesel”

28 The numbers “28” indicates that the power plant in question has a bore of 1**28** mm

7 The “7” means 166 mm stroke

6 The “6” shows that the engine has 6 cylinders**6.**

L This letter stands for **“charge–air cooling” (German: Ladeluftkühlung)**

E The “E” stands for “fitted engine” (German: Einbaumotor) and is intended to distinguish MAN vehicle engines

401/2.. This is a Works internal development number.

General notes

This quick overview summarises important regulations and arranges them according to important aspects to provide the knowledge required to avoid accidents involving personal injury, damage to property and environmental damage. Additional information can be found in the operating instructions of the engine.

Important:
Should an accident occur despite all precautionary measures, particularly one involving contact with corrosive acid, penetration of fuel under the skin, scalding by hot oil, antifreeze splashing into the eyes etc. ***you must seek medical assistance immediately.***

1. Regulations designed to prevent accidents with injury to persons

Checks, setting jobs and repair work must be carried out by authorised skilled personnel only.

- When carrying out maintenance and repair work, ensure that the engine cannot be accidentally started from the bridge by unauthorised persons.
- The engine may only be started and operated by authorised personnel.
- When the engine is running, do not get too close to rotating parts.
  Wear tight-fitting working clothes.

- Do not touch the warm engine with your bare hands: danger of burns.

- Keep the area round the engine, ladders and steps free of oil and grease.
  Accidents caused by slipping can have serious consequences.
- Only work with tools that are in perfect working order. Worn spanners / wrenches slip: danger of injury.
- Persons must not place themselves beneath an engine hanging on a crane hook.
  Keep lifting gear in order.

- Only open the coolant circuit when the engine has cooled down. If opening the coolant circuit while the engine is hot is unavoidable, observe the instructions in the chapter “Maintenance and care” in the Operator’s Manual.
- Neither pull nor open pipes and hoses that are under pressure (lubricant circuit, coolant circuit and possible downstream hydraulic oil circuit): danger of injury from outflowing fluids.

- When checking the injection nozzles, do not hold your hands in the fuel jet.
  Do not inhale fuel mist.

- When working on the electrical system, first disconnect the earth cable of the battery and reconnect this last to prevent short circuits.

- Observe the manufacturer's instructions for handling batteries.
  Caution:
  Battery acid is toxic and caustic. Battery gases are explosive.

- When performing welding work, observe the "Notes for welders".

2. Regulations designed to prevent damage to engine and premature wear

- ***Prior to repairing the engine, clean it thoroughly. Ensure that dirt, sand or foreign matter will not get into the engine during repair work.***
- If engine operation is disrupted, immediately determine the cause and have it remedied to prevent additional damage.
- Always use genuine MAN parts only. Installation of "equally" good parts from other suppliers may cause severe damage for which the workshop carrying out the work is responsible.
- Never allow the engine to run dry, i.e. without lubricant or coolant.
  Appropriate notices must be attached to engines that are not ready for operation.
- Only use operating materials (fuel, engine oil, antifreeze and anticorrosion agents) approved by MAN. Ensure that everything is kept clean. Diesel fuel must be free of water.
- ***Do not fill engine oil beyond the max. notch on the dipstick. Do not exceed the maximum permitted operating inclination of the engine.***
  Non-observance can lead to severe engine damage.
- Control and monitoring devices (charge control, oil pressure, coolant temperature) must be in perfect working order.
- Observe the instructions for operating the alternator; see chapter "Maintenance and care" in the Operator's Manual.

3. Regulations designed to prevent pollution

Engine oil and filter cartridges and elements, fuel / fuel filters

- Old oil must be passed on for recycling.
- Ensure without fail that oil and Diesel fuel will not get into the sewerage system or the ground.
  Caution:
  Danger of contaminating potable water!
- Treat used filter inserts and cartridges as hazardous waste.

Coolant

- Treat undiluted corrosion protection agents and / or antifreeze as hazardous waste.
- When disposing of used coolant, the regulations issued by the relevant local authorities must be observed.

4. Notes on safety in handling used engine oil *

Prolonged or repeated skin contact with any type of engine oil draws grease from your skin. This can lead to dryness, irritation or skin inflammation. Used engine oil also contains hazardous substances that have caused skin cancer in tests on animals. Handling old engine oil does not pose any health hazard if the basic safety and hygiene related regulations are observed.

Precautionary measures to protect your health:

- Avoid prolonged, repeated skin contact with used engine oil.
- Protect your skin with suitable skin protection cream or protective gloves.
- Clean any skin that comes into contact with engine oil.
  - Wash yourself thoroughly with soap and water. A nail brush provides effective assistance here.
  - Special hand cleaning agents facilitate cleaning soiled hands.
  - Do not use petrol, Diesel fuel, gas oil, fluxes or solvents as cleaning agents.
- After cleaning, apply skin cream containing fat.
- Change clothing and shoes that are soaked in oil.
- Do no put oily cloths in you pockets.

Ensure that used engine oil is disposed of in the appropriate manner.
– Engine oil is a substance that endangers the water supply –

For this reason, do not pour engine oil on the ground, in lakes or rivers, down plugholes or in the waste water system. Violations of this regulation are punishable offences.

Carefully collect and dispose of used engine oil. Information on collection points can be obtained from sales personnel, the supplier or the local authorities.

* Based on “Information sheet for handling used engine oil”.

The service life of an engine is influenced by very different factors. It is therefore not possible to specify certain fixed numbers of operating hours for general overhauls.

In our view, it is not necessary to open up and engine or perform a general overhaul as long as the engine has good compression values and the following operating values have not changed significantly in relation to the values measured on commissioning the engine:

- Charging pressure
- Exhaust temperature
- Coolant and lubricant temperature
- Oil pressure and oil consumption
- Smoke emissions

The following criteria greatly influence the length of the engine service life:

- Correct power output setting according to the type of application
- Expert installation in accordance with the installation instructions
- Inspection if installation by authorised personnel
- Regular maintenance as per maintenance plan in the Operator’s manual
- Choice and quality of lube oil, fuel and coolant in accordance with the publication “Fuels, Lubricants and Coolants for MAN Diesel Engines”

Pressurisation

It is extremely important for internal combustion engines (following the completion of repair work, i.e. in their dry state) to be pressurised with lube oil before being recommissioned. This procedure can also be used for ascertaining damage and its causes.

If engines are not pressurised, the risk of premature damage to bearing surfaces is very high because it takes a relatively long period of time for the lube oil drawn in from the oil pan via the oil pump to reach the individual bearings.

Such incipient damage need not necessarily lead to immediate bearing failure, but may impair the proper functioning of the bearings and reduce their service lives.

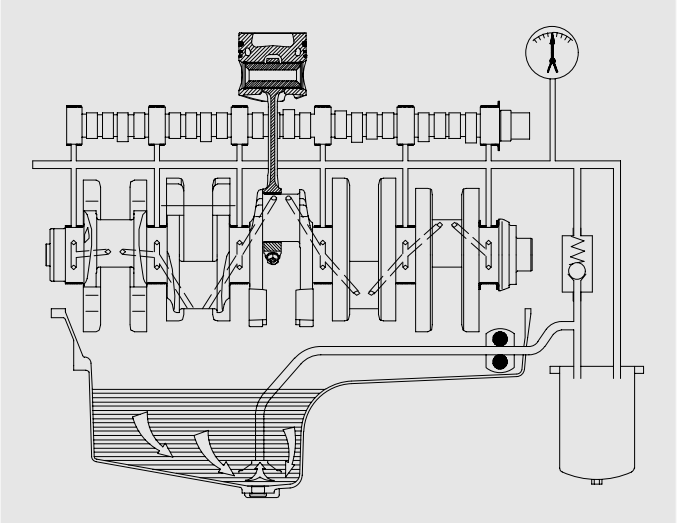
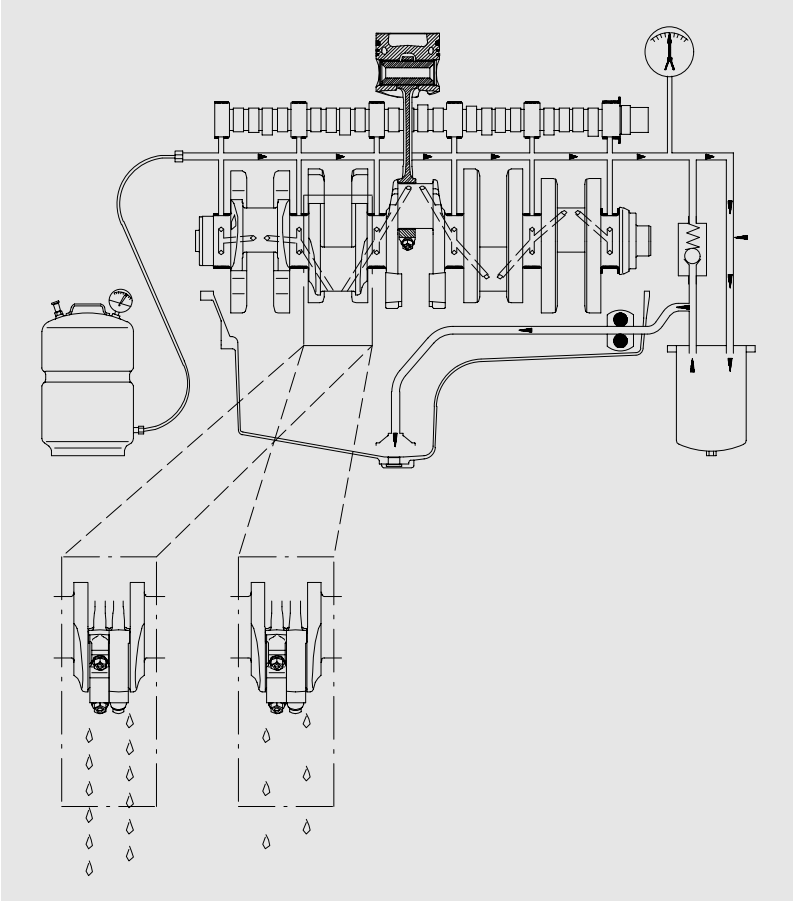


Diagram of the oil flow with unpressurised engines

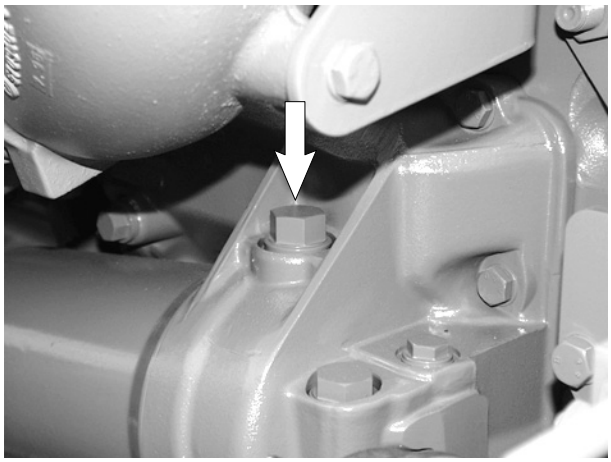
Pressurising an engine affords the following advantages:

- All engine parts are lubricated before engine startup; a lubricating film can be built up inside the bearings as early as after the first few rotations of the crankshaft, thereby preventing damage to the bearing races
- Any loss of oil, be it the result of excessively large bearing play or leaks from the crankcase or from crankcase bores which may not be plugged, can be detected immediately. For this purpose, mount the engine on an assembly dolly, remove the oil pan and install a suitable oil collector under the crankcase in such a way that the bearings are visible



Performance of pressurisation:

At least 30% of the total oil quantity is forced from the pressurisation container into the engine oil circuit. The operating pressure serves as the yardstick for the pressure to be forced in and must not be exceeded. The pressurisation container is connected up to the engine's oil circuit at the oil filter head (screw plug).



Operating faults and possible causes

We recommend

A repair is only complete when both the damage that occurred and the possible causes have been eliminated. Finding out the cause of damage is often more difficult than repairing the damage that occurred. We therefore recommend that you obtain a precise description of the operating fault before removing and dismantling components. Then use a process of elimination (questions) to pin−point the probable causes and investigate and eliminate these successively on the basis of the table ***and your own experience***. This helps to reduce repairs to the required scale and to counteract claims regarding “over−eager” replacement of parts and complaints about expensive work and down time.

Note:

The following list is conceived as an aid to memory for experts so that to causes of damage are overlooked when dealing with faults. The precondition for this, however, is that the experts are familiar with the Repair Manual for the engine as well as the accompanying Operating Instructions and the publication “Fuels, Lubricants and Coolants for MAN Diesel Engines”.

1. EDC self-diagnosis or flash code output	2. Starter turns over engine only slowly or not at all	3. Starter turns, engine does not start, engine does not start / difficult to start when cold	4. Engine stalls (dies) during operation, no longer starts (starter turns), engine does not start/starts with difficulty when hot	5. Sudden, temporary engine shutdown, engine does not reach full revs	6. Engine only runs at idle speed, no throttle response	7. Engine only runs at increased idle speed, no throttle response	8. Rated engine speed distinctly reduced (even under no load)	9. Reduced output in all ranges	10. Irregular engine operation, traction loss	11. Unstable idle speed, engine hunting, misfiring, knocking in engine	12. Engine judder	13. Unusual combustion noise	14. Excessive smoke emission: White smoke/blue smoke	15. Excessive smoke emission: Black smoke	16. Engine temperature too high (coolant loss)	17. Fuel consumption too high	18. Lubricating oil pressure too low	19. Lubricating oil pressure too high	20. Lubricating oil consumption too high	21. Engine too “loud” / mechanical noise	22. Idle speed cannot be adjusted with idle speed operating unit	**Possible causes**
x	x																					Batteries discharged, battery lead connections loose or corroded, break in power circuit
x																						Crank gear blocked / Emergency-stop switch on the terminal box activated
x	x																					Starter solenoid switch sticks (clicks) / defective, cable connection loose or damaged
x	x																					Starter/starter interlock relay defective (carbon brushes worked loose / worn, winding defective, short to ground)
	x																					Emergency-stop switch at helm / flybridge activated
x																x	x	x				Engine oil viscosity unsuitable, not suitable for ambient temperature, lubricating oil quality does not correspond to specifications
						x												x				Oil level in sump too high
																x						Oil level in sump too low, oil in sump too thin (mixed with condensate or fuel)
																x						Engine temperature too high
																x						Oil filter clogged
																x	x					Oil pressure gauge defective
																x						Safety valve in oil circuit defective (does not close, spring fatigued or broken)
																x			x			Bearing wear
																x						Oil pump gears worn
																			x			Crankshaft timing gears worn, tooth flank backlash too great
								x		x							x					Engine cold
										x												Lubricating oil entering combustion chamber (piston rings worn, piston rings broken) – valve stem guide worn – overpressure in crankcase (crankcase vent clogged)
																	x					Relief valve in oil circuit defective (does not open), oil lines / oil galleries clogged
																		x				Leaks in lubricating oil circuit, particularly at turbocharger and oil cooler
								x										x				Piston rings heavily worn, broken
								x											x			Piston pin or crankshaft bearing loose
																		x				Valve stems worn, bent
	x							x											x			Valve clearance not correct
	x							x														Valves jam
	x	x				x		x														Compression deficient, or more than 3–4 bar pressure difference between individual cylinders
	x							x					x									Valve seats leaking
o			x										x									Increased power intake due to defective secondary consumers such as hydraulic pumps, fan etc., power take-off engaged
			x			x				x		x							x			Air cleaner soiled or clogged, turbo air system leaking, air inlet / exhaust line clogged / leaking

x = Possibleo
o = Probable

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x x x x x x x x x x x	Fuel low pressure system: Fuel tank, prefilter, water trap faulty / clogged/mould/ fungal attack, fuel unsuitable / contaminated (paraffin added)
x x x x x x x x x	Fuel low pressure system: Fuel lines leaking, broken, clogged
x x x x x x x x	Fuel low pressure system: Air in system (turn on ignition when bleeding system)
x x x x x x x x x x	Fuel low pressure system: Fuel pump, overflow valve, main filter
x x x x x x x x x o x x	Fuel high pressure system: Jets defective / clogged / leaking / coked
x x x x x	Fuel high pressure system: Pressure lines – constriction, cavitation, leaking
x x o x x x x o	Fuel high pressure system: Injection pump worn / set incorrectly
o x o x	Fuel high pressure system: Injection pump constant-pressure control valve/return flow restrictor defective
x x x x o x	EHAB defective, drive faulty
o o o x o x x x	Injection pump-engine allocation: Start of delivery incorrect (basic installation), start of delivery set incorrectly
x x x x o x o	Injection pump – controller: Stiff movement – fuel delivery controller (control deviation)
x o x x o o x	Injection pump – initial stroke / start of delivery regulator: Stiffness
x x x x o	Control rod position transducer in controller: Connection lines, break, short-circuit
o o o	Control rod position transducer in controller: Set incorrectly
x x o o	Control rod position transducer in controller: Capacitance reserve of wiring harness too low (e.g. water penetrated wiring harness)
x o x o x	Injection pump: Delivery set incorrectly/uniform delivery, lower idle speed set too low
x o x x x	Delivery actuating solenoid in controller: Connection lines, break, short-circuit
x o x x o x	Feed setting magnet in the regulator: Short circuit, interruption
x x x x x o	Pedal value transmitter (throttle lever signal) defective: Connection lines, short circuit, interruption At 4–20 mA driving lever signal: – Connection line throttle lever signal 4–20 mA interrupted – Throttle lever system defective (no 4–20 mA signal available) – Wire bridges Pin 11/13, 12/14 in plug X9 missing – EDC control element 51.11615–7243 defective
x x	EDC rpm sensor defective, implausible with auxiliary rpm sensor, line defective
x x o	EDC rpm sensor, polarity reversed
x x x	Speed sensor exchanged
x x	EDC auxiliary rpm sensor defective, implausible with rpm sensor, line defective
x x x x o o o o	EDC detects incorrect engine speed (interference signal on rpm sensor line)
x x x x o	Both rpm sensors defective, line defective

x = Possible
o = Probable

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x							x					x										EDC turbo pressure sensor: Defective, incorrect, implausible with atmospheric pressure sensor, line defective
							x		x		o	x										Needle movement sensor: Too many / few pulses
x						x	x				o	o										Deviation in the control of the beginning of injection
							x		x		o	x										Exhaust turbocharger leaking or defective
																			x			Turbine and compressor rotor in turbocharger dirty (out-of-balance, irregular running)
												x										Intercooler leaking, defective
		x									x											Charge-air preheater defective
x		o					x	x			o		x									EDC coolant temperature sensor: Defective, line defective
x							x	x														EDC turbo air temperature sensor: Defective, line defective
o							x						x									Radiator dirty or failure of cooling system (temperatures too high)
													x									Coolant level too low, air in coolant circuit
													x									V-belt for water pump drive not tensioned correctly
													x						x			Incorrect V-belt tension
													x									Water pump leaking, defective / thermostat defective, does not open
													x									Coolant lines leaking, clogged or twisted
											x											Coolant entering combustion chamber (cylinder head / gasket leaking)
						x	x	x					o									Resistor bank EDC control unit pin 35
x		x	x	o				o														Power supply to EDC control unit interrupted or battery voltage too low / Relais K1 defekt
		x	x	o				o														Line terminal 15 to EDC control unit pin 47 interrupted/loose contact / Relais K2 defekt
x																				x		Operating unit for setting idle speed/resistor bank pin 44: Voltage values incorrect/implausible, operating unit switched off
x		o	o	o																		EDC control unit defective (internal fault)
		x				x	x	x		o	o		o	x								Incorrect EDC control unit (check MAN part number)
		x																				EOL programming terminated / voltage interrupt
x																						Afterrunning not completed
																				x		EOL programming: Configuration incorrect
							x					x										Thermostat defective
										x												Engine bearings worn
x						x	x															CAN system (control unit) faulty connection between EDC and MMDS → Engine operating data not displayed

x = Possibleo
o = Probable

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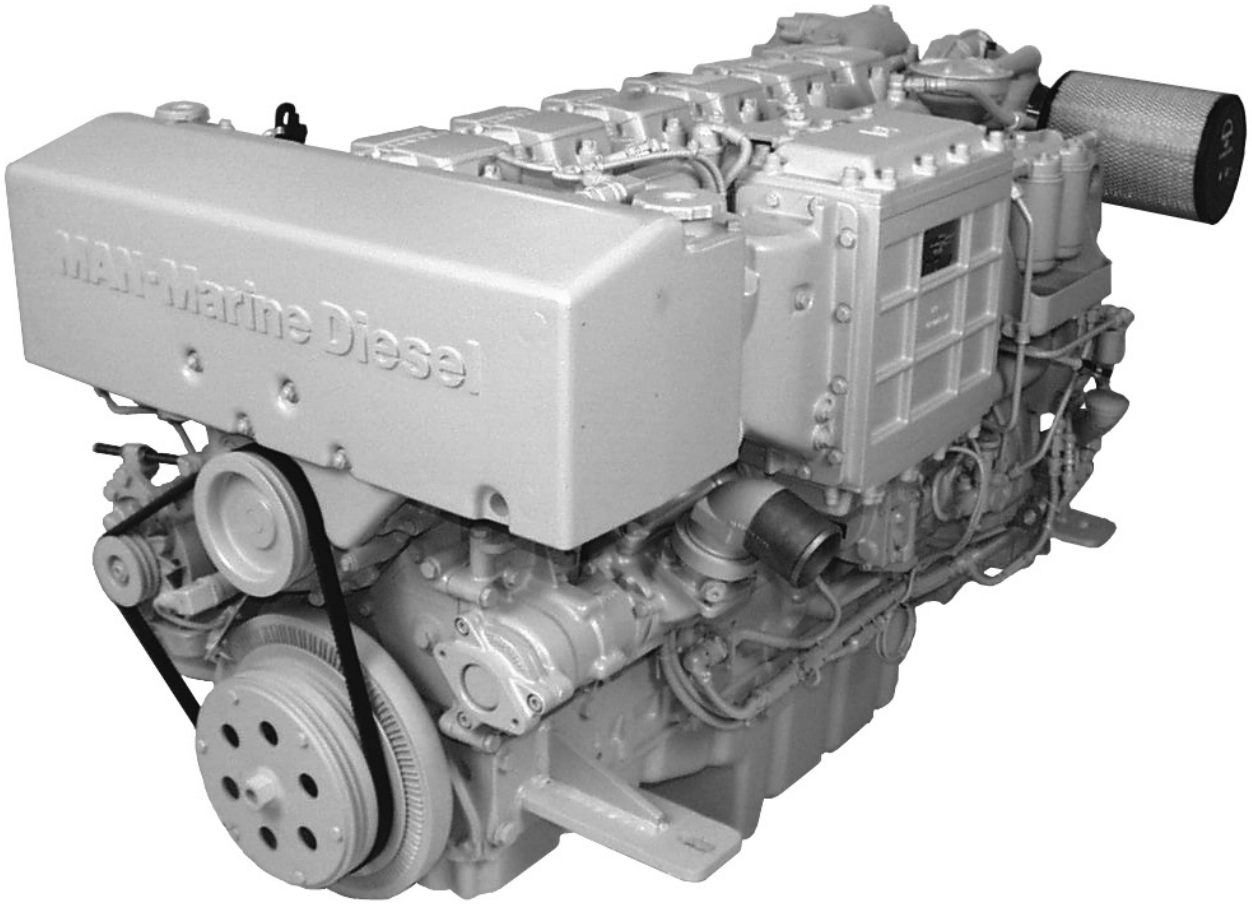
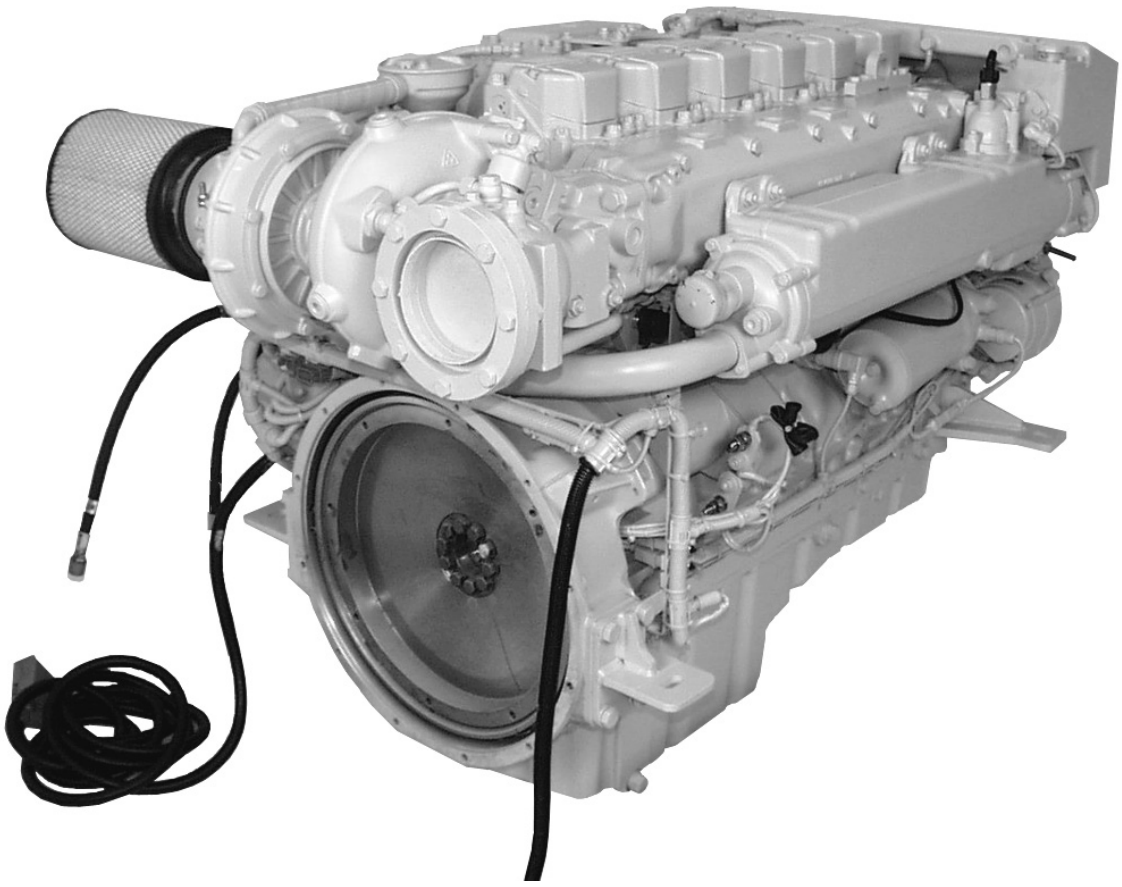
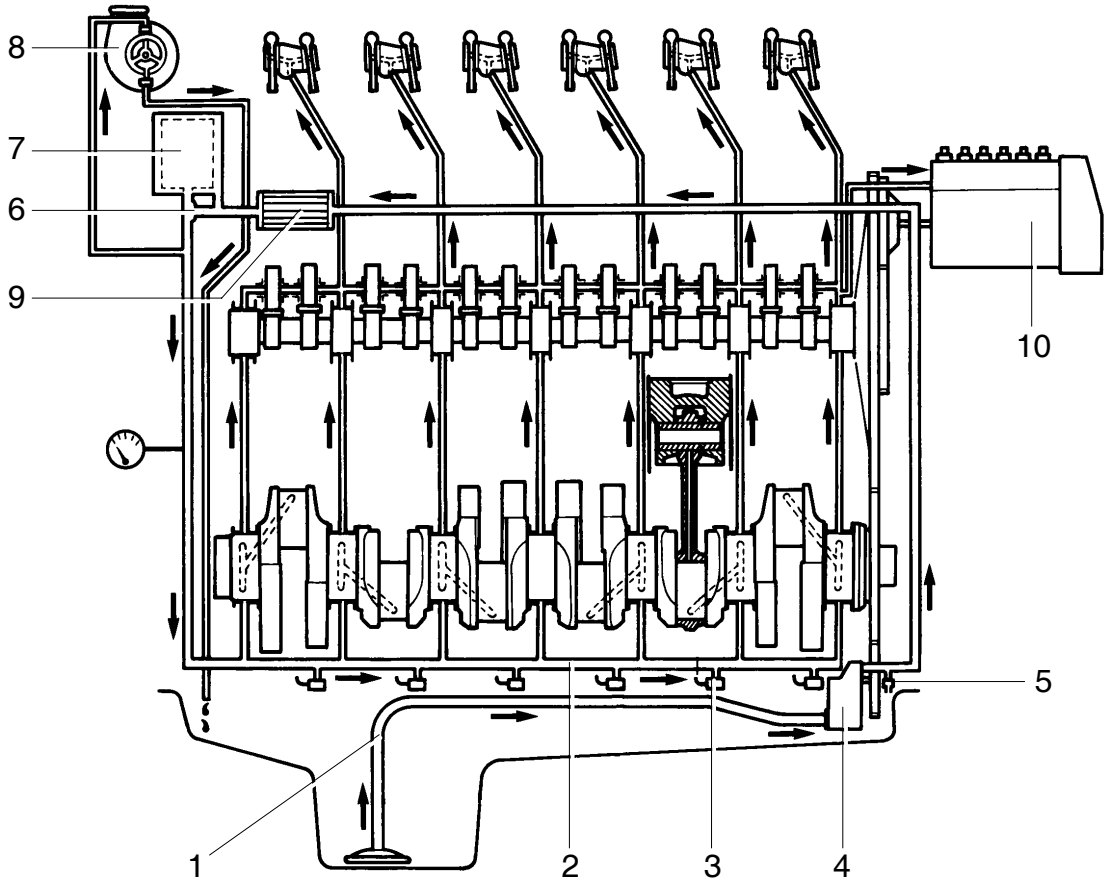
x								x	x													CAN system (TSC1–FM message) faulty connection between EDC and MMDS → MMDS system fault

x = Possible
o = Probable

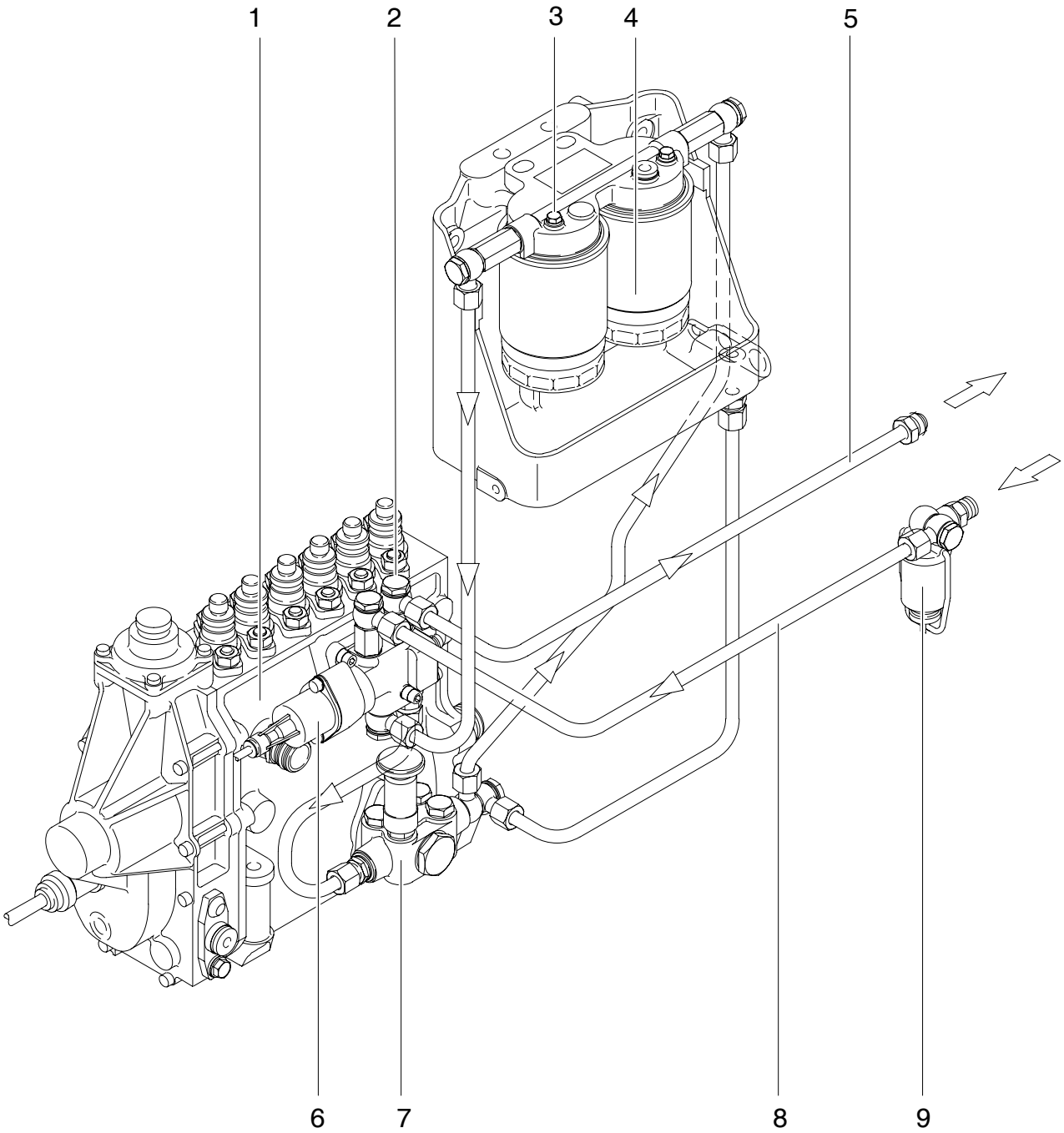

MAN-Marine Diesel


MAN-Marine Diesel

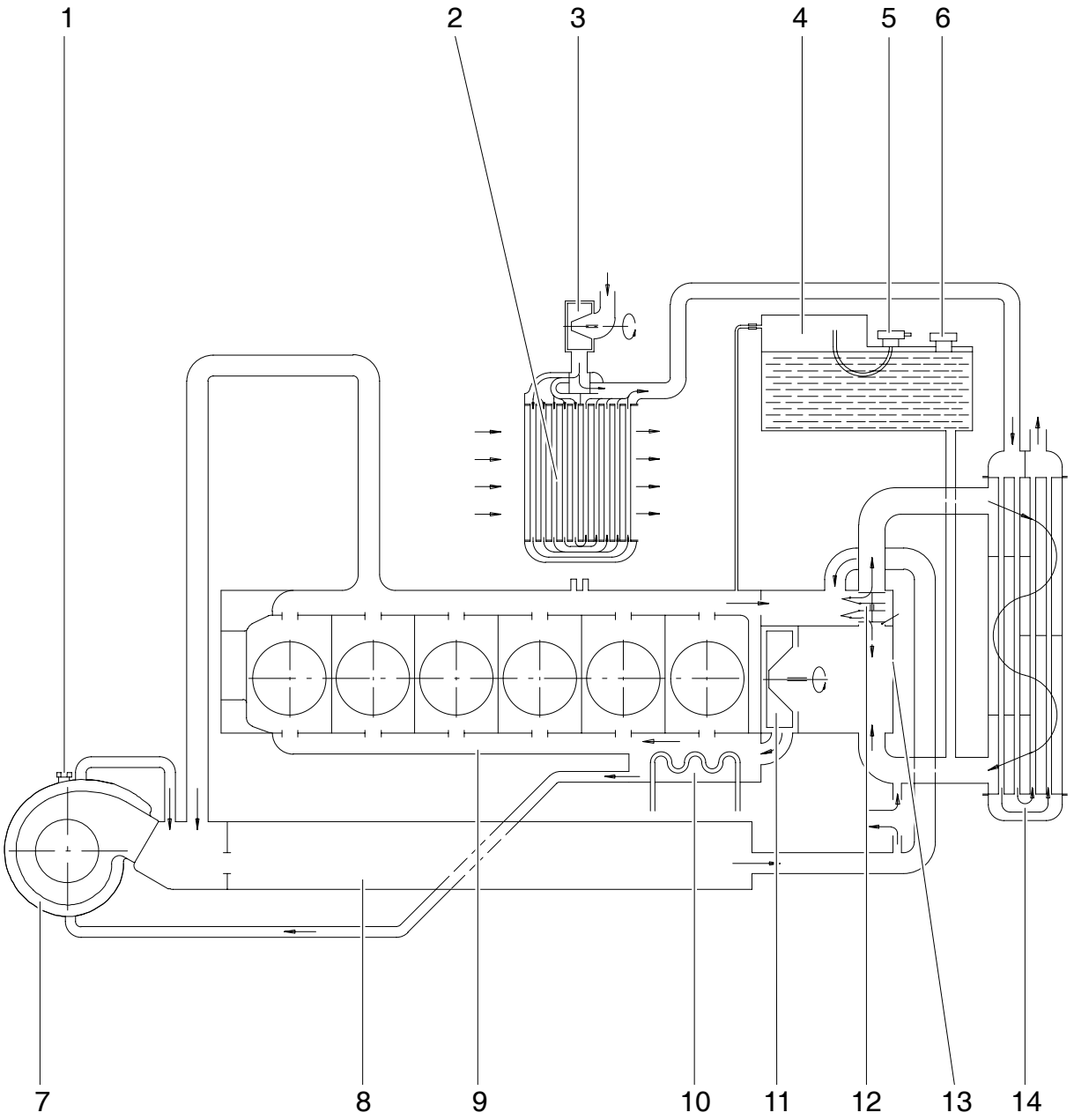




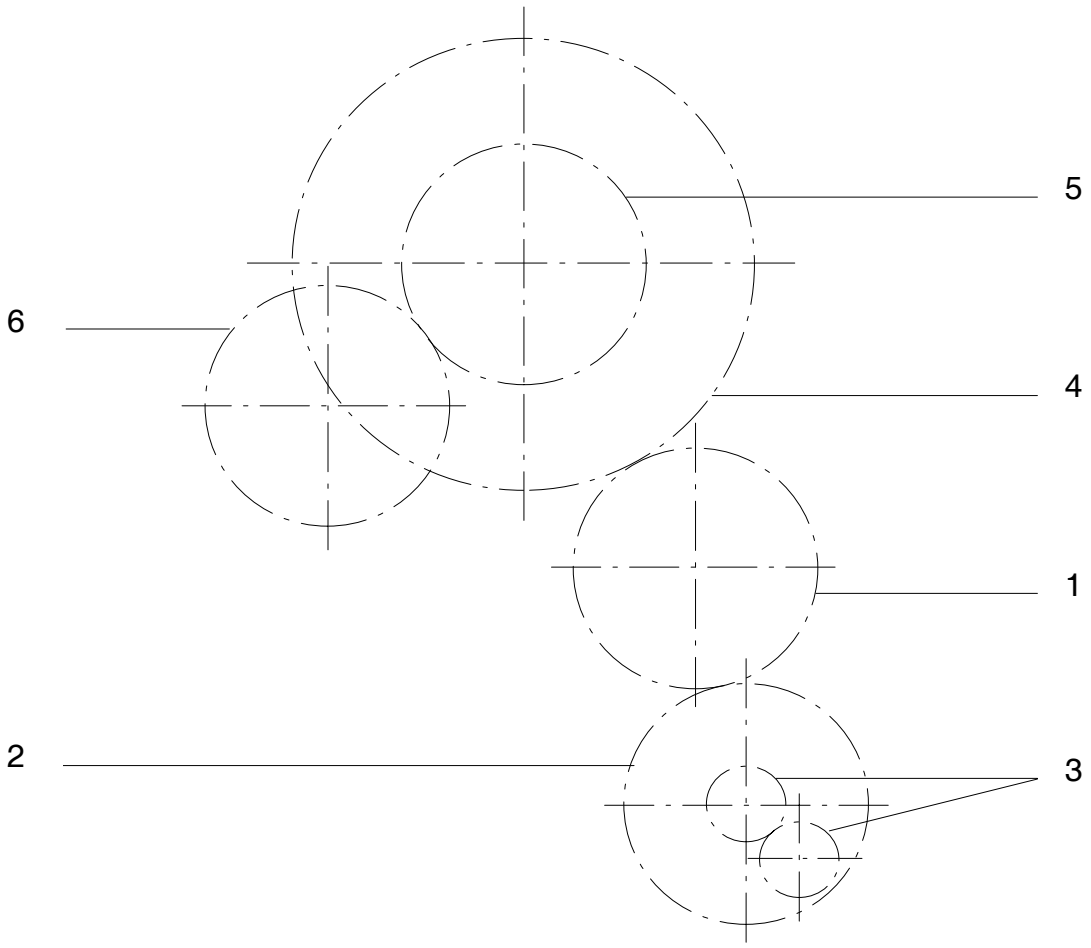
1 Oil suction pipe
2 Distributor pipe
3 Oil spray nozzle
4 Oil pump
5 Oil pressure relief valve
6 Bypass valve
7 Oil filter
8 Turbocharger
9 Oil cooler
10 Injection pump



1 Injection pump
2 Overflow valve
3 Bleed screw
4 Fuel filter
5 Fuel return to tank
6 Electro−hydraulic cutout (EHAB)
7 Delivery pump
8 Fuel supply from tank
9 Prefilter



1 Bleeder screw on turbocharger
2 Intercooler
3 Sea water pump
4 Expansion tank
5 Positive pressure / negative pressure valve
6 Coolant filler neck
7 Turbocharger, liquid−cooled
8 Exhaust manifold, liquid−cooled
9 Crankcase
10 Engine oil cooler
11 Impeller
12 Thermostat
13 Water pump housing
14 Sea water heat exchanger

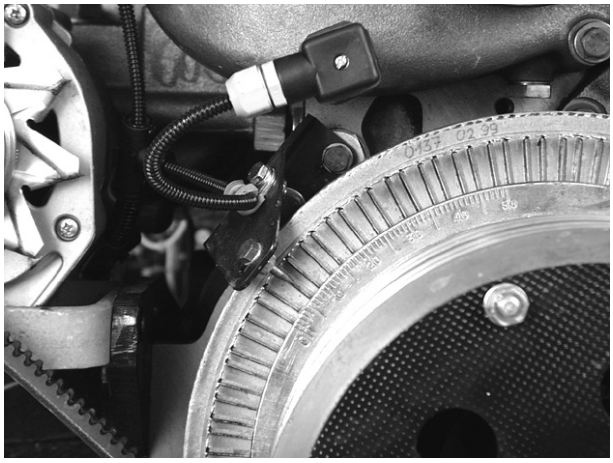


1 Crankshaft gear
2 Drive gear, oil pump
3 Oil pump supply gear
4 Drive gear, camshaft
5 Intermediate gear
6 Drive gear, injection pump

Checking start of delivery

Fig. 1

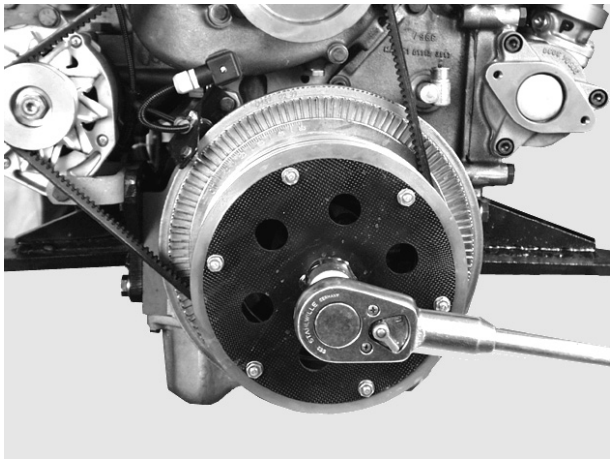
For the purpose of checking the start–of–delivery setting, an “OT” (= TDC) mark and a scale from 10...50° before TDC are engraved on a disc fitted in front of the torsional vibration damper. The scale marks are read against a pointer fitted to the crankcase.



1

Fig. 2

To turn the engine over manually during the setting work, a plate with a central hexagon bolt is located on the front side of the crankshaft pulley.



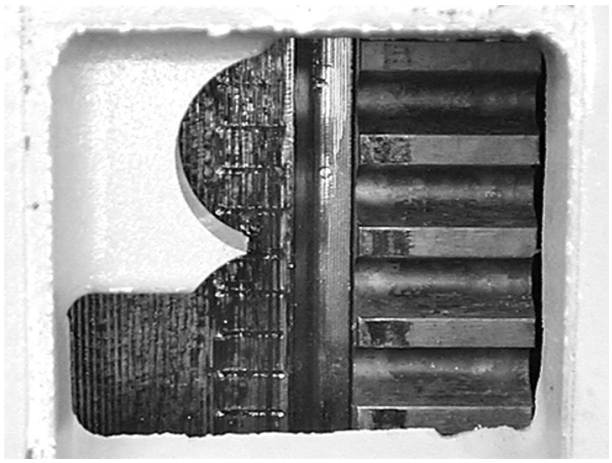
2

Fig. 3

The graduated scale on the flywheel, which is visible through the inspection hole in the flywheel housing, is often difficult to access. However it must be used to readjust the indicator after the vibration damper has been removed or replaced.

For this purpose, before the vibration damper with scale disc is installed, the engine must be set to “TDC” using the flywheel marking.

The pointer must then be aligned so that its measuring edge points exactly to the “TDC” mark on the scale disc.

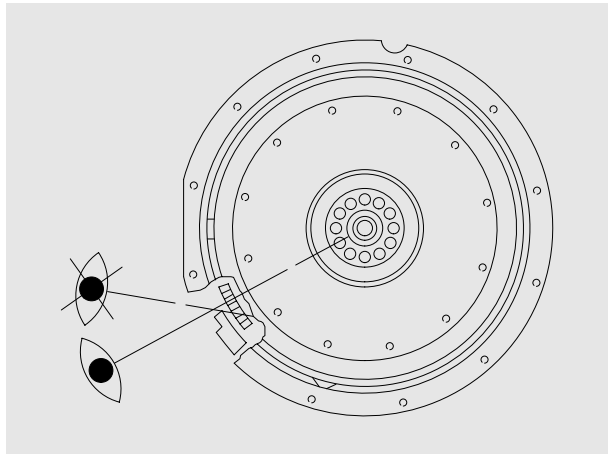


3

Fig. 4

To avoid read–off errors, always look over the notch on the flywheel housing vertically to the centre of the flywheel.

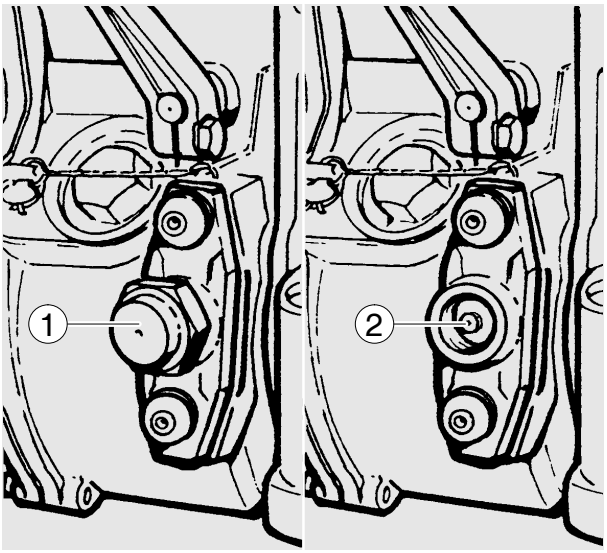
The marking on the graduated scale must be on the imaginary ”notch – flywheel centre” line.



4

Fig. 5

Remove screw plug ① on governor housing.
If fitted, take out blocking pin ②.
If the indicator is exactly in the centre of the inspection hole, the pump plunger for cylinder no. 1 is at start of delivery. However, it is only possible to determine exactly whether or not the pump is at start of delivery using the following special tools:

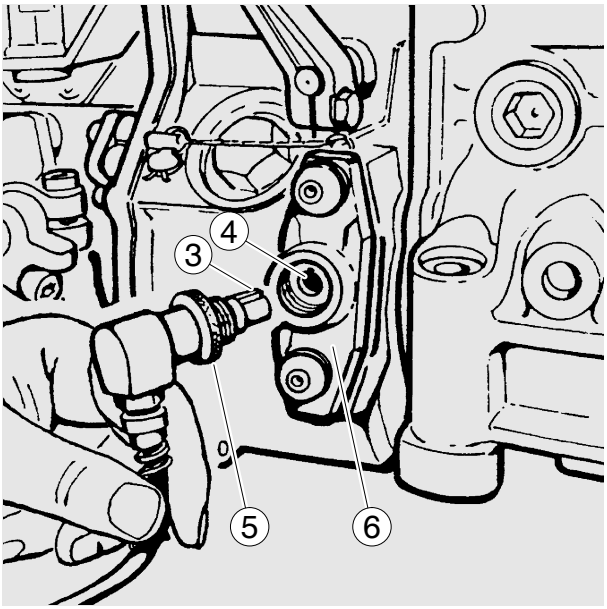


5

a. Light signal transmitter

Fig. 6

Push light signal transmitter into socket in governor housing. Make sure that guide lug ③ fits in groove ④. Tighten knurled screw ⑤ by hand.



6

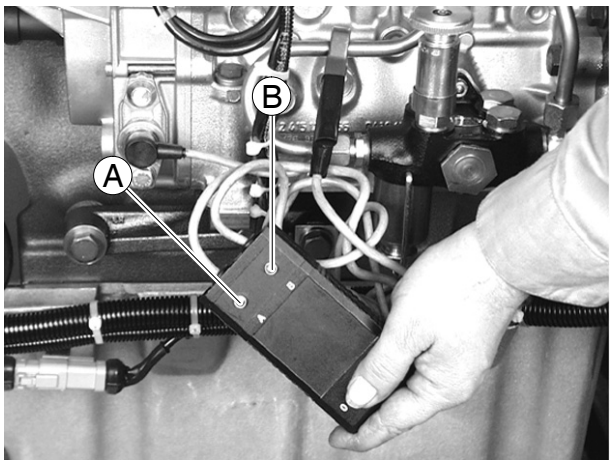
Fig. 7

Crank the engine by hand so that the piston in cylinder no. 1 comes close to the start of delivery in the compression stroke. Lamp (A) comes on shortly before start of delivery is reached.

Continue cranking the engine slowly until lamp (B) comes on as well. The injection pump is now at start of delivery.

Note:
If only lamp (B) comes on during this check, the engine has been cranked past the start of delivery. In this case, crank the engine back and repeat the procedure.

The picture shows the KDEP 1601 light signal transmitter, which is powered by its own batteries.



7

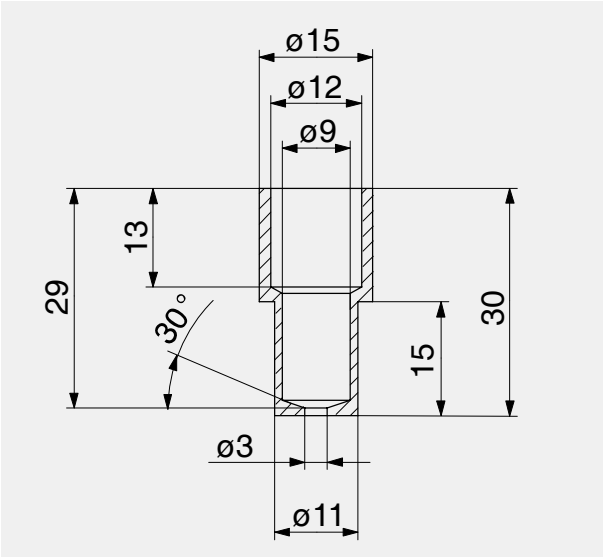
b. Plug–in sleeve

Fig. 8

If a light signal transmitter is not available, good measurement results can also be achieved with a plug–in sleeve.
The sleeve must be made from aluminium or steel following the dimensions specified in the drawing (Fig. 8).

Set the engine to start of delivery as described above. Insert the sleeve into the governor housing up to the stop.

The start of delivery is set exactly when the start–of–delivery indicator is in the centre of the 3 mm bore in the sleeve.



8

Setting start of delivery

If the check following method a) or b) reveals that the start of delivery is not correct, proceed as follows:

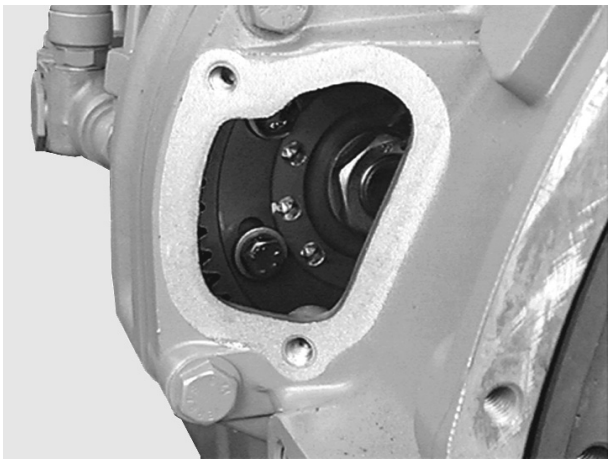
Fig. 9

Remove timing case cover.

9

Fig. 10

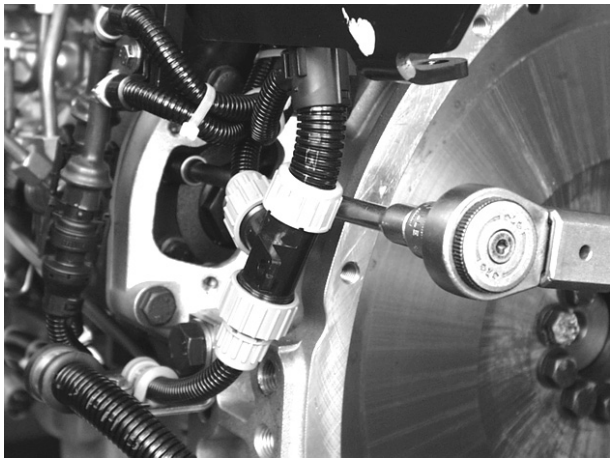
Release all bolts securing the drive gear to the injection pump hub. Two complete engine revolutions are necessary for this.



10

Fig. 11

Crank the engine to the specified angle for start of delivery.
Remove the cylinder head cover from cylinder no. 6 (flywheel end). When the valves for this cylinder overlap, the piston in cylinder no. 1 is at firing TDC.
To do this, remove the screw plug from the governor housing (see Fig. 5). The start–of–delivery indicator must be visible in the centre of the inspection hole.
Rotate the injection pump camshaft on the drive flange accordingly to the left or the right until the conditions mentioned in a) or b) (depending on the test method used) are satisfied.
Tighten the mounting bolts between the drive gear and drive flange in sequence first to 5 Nm and then to 30 Nm.
Check start of delivery again.
Install timing case cover.



11

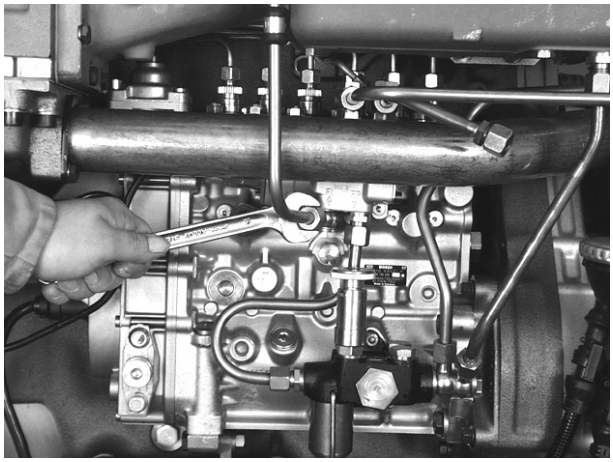
Removing injection pump

- Close shutoff valve from tank to engine.

Note:
The subsequent reinstallation of the injection pump is rendered considerably easier if before its removal the engine has been turned to start of delivery. See chapter “Adjusting start of delivery” on page 24.

Fig. 1

Remove all fuel lines from injection pump.



1

Caution:
The lines contain fuel!
Catch escaping fuel in a suitable container.

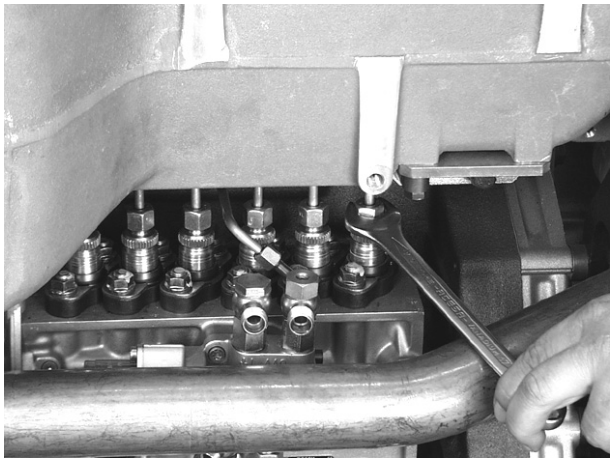
Fig. 2

Remove fuel filter with holder.

2

Fig. 3

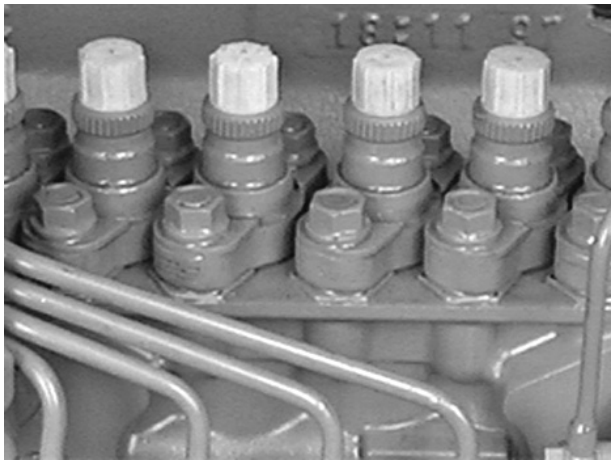
Loosen union nuts of the injection lines.



3

Fig. 4

After removal of the injection lines we recommend fitting caps to the connections on the injection pump.
This prevents dirt from getting into the injection system.

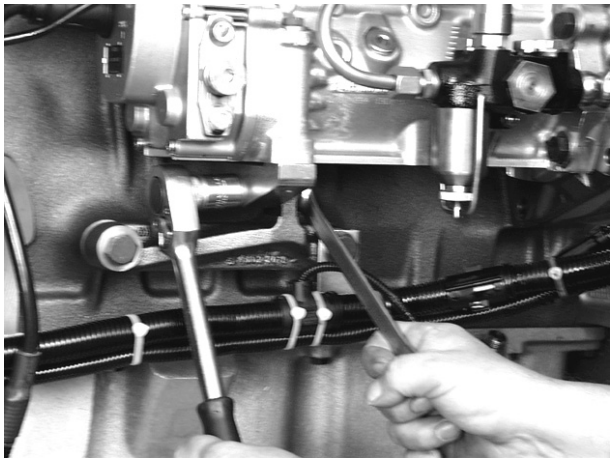


4

Caution:
Dirt in the injection system causes:
- nozzles to jam
- the injection pump drive to break

Fig. 5

Remove holders from injection pump.

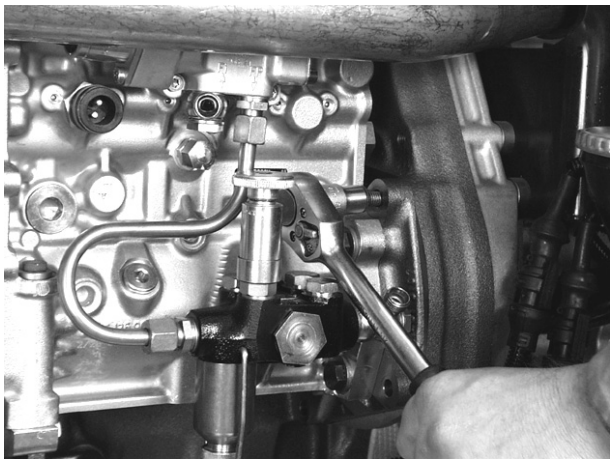


5

Fig. 6

Remove the mounting bolts from the injection pump flange.

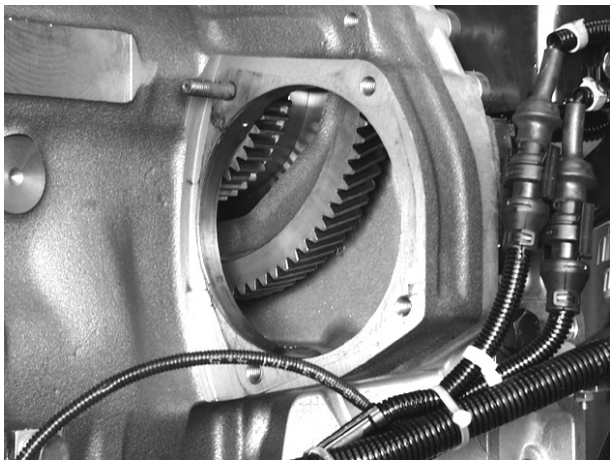
Note:
For reasons of space the mounting bolt between the injection pump and the crankcase (hexagon M10 bolt with reduced head 13 mm) can be reached only with a 3/8” socket and an extension.



6

Fig. 7

Take off injection pump.



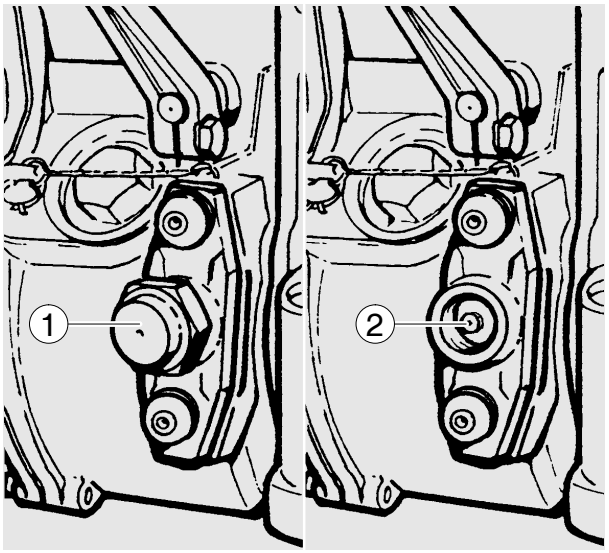
7

Installing injection pump

Fig. 8

Note:
If the injection pump is blocked, the camshaft must on no account be loaded or rotated because parts of the blocking pin may break off and drop into the governor. **Failure to comply with this instruction may result in serious damage to the injection pump!**

Remove screw plug ① on governor housing.
If fitted, take out blocking pin ②.



8

Fig. 9

Check whether the engine is at start of delivery.

The start of delivery of the individual engines is specified in the publication “Service Data”.

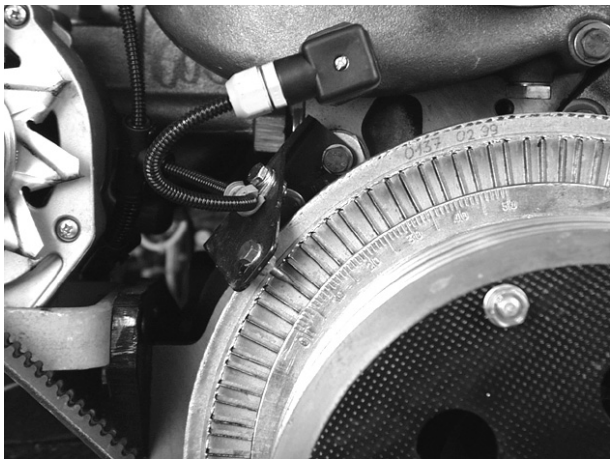

9

Fig. 10

Check whether the injection pump is at start of delivery. To do this, remove the screw plug from the governor housin (see Fig. 8). The start-of-delivery indicator must be visible in the centre of the inspection hole.

Release the mounting bolts on the injection pump drive gear so that it can be turned in the elongated holes.

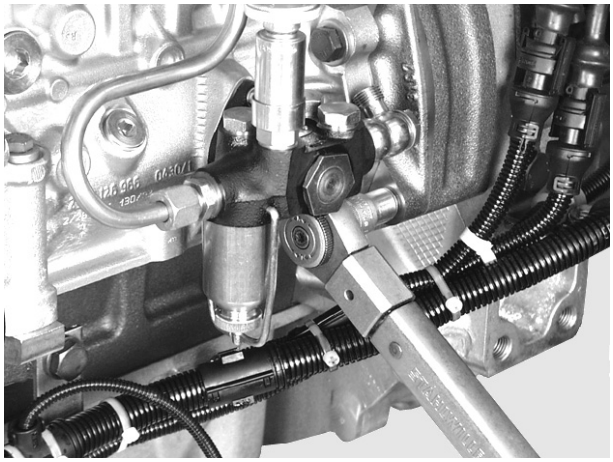
Hold the injection pump camshaft in place while turning the gear.

Fit a new O-ring (lightly oiled) on the injection pump flange.

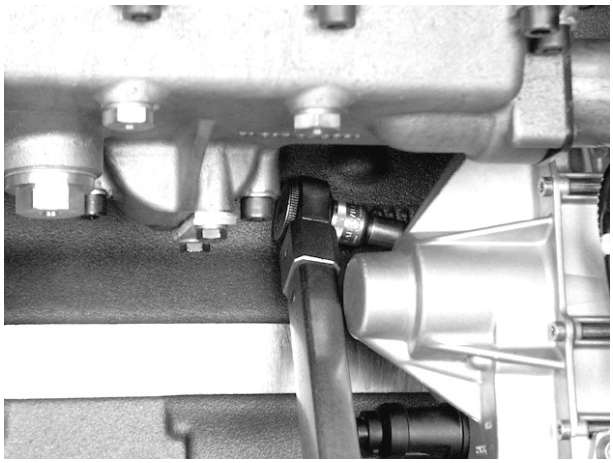

10

Figs. 11 and 12

Insert the injection pump and tighten the mounting bolts to specified torque.



11



12

Fig. 13

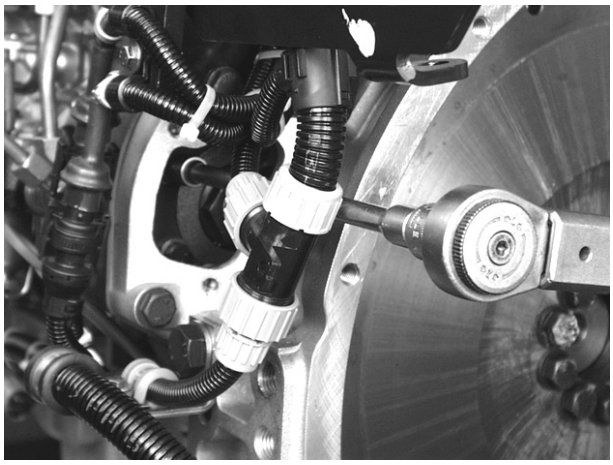
Apply an initial torque of 5 Nm to all mounting bolts on the gear through the inspection hole. Two complete engine revolutions are necessary for this.

Now tighten down all the mounting bolts to 30 Nm.

Check and if necessary set start of delivery (see page 24).

Install timing case cover.

Caution:
Comply with instructions for masking unions on pressurised oil and fuel pipes (see page 3).



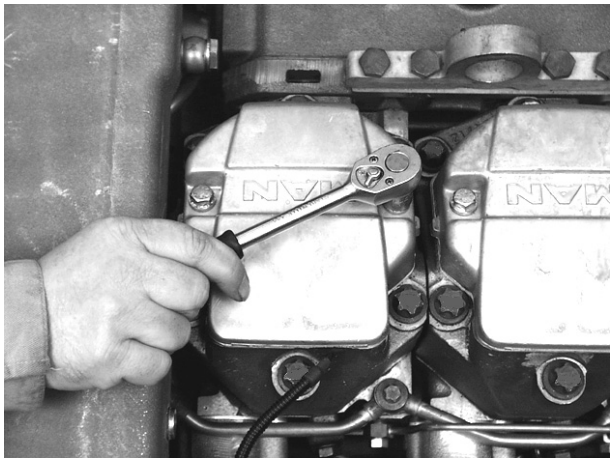
13

Removing fuel injectors

- Close shutoff valve from tank to engine.

Fig. 1

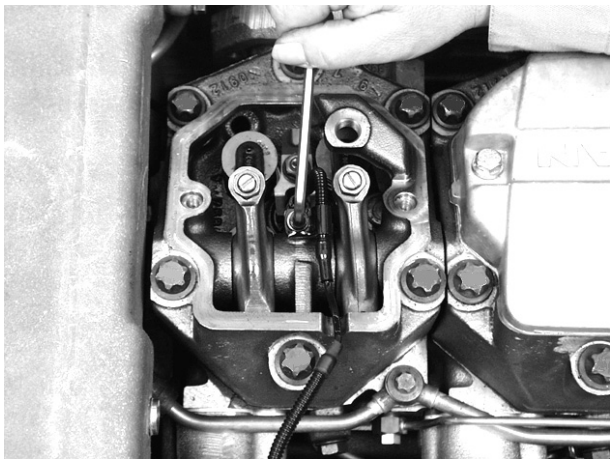
Remove the cylinder head covers.



1

Fig. 2

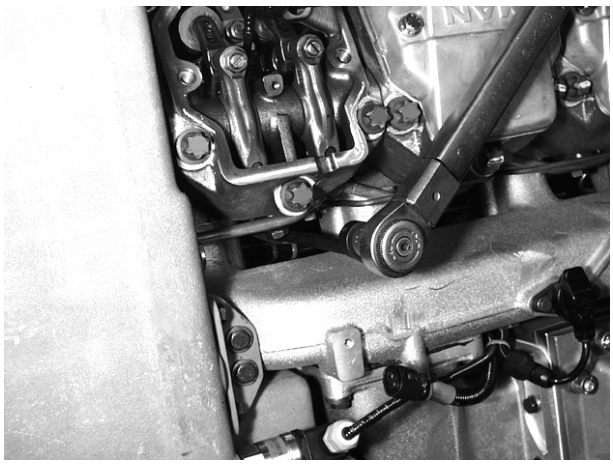
The injector nozzle of the first cylinder is equipped with a needle movement sensor.
Unscrew holder for cable.



2

Fig. 3

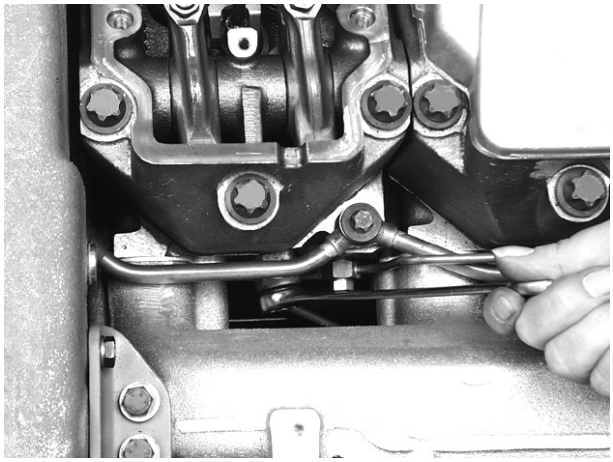
Unscrew union nut of the injection line (special tools, see item. 3, page 185).



3

Fig. 4

Unscrew mounting bolts of the connecting piece.



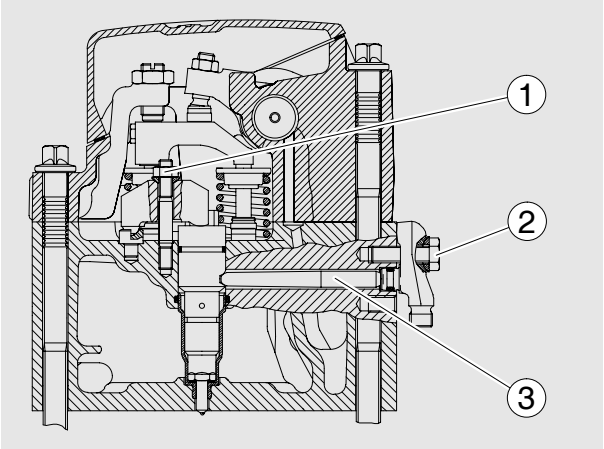
4

Fig. 5

Remove mounting bolts ② of the connecting piece.

Pull the pressure pipe ③ out of the cylinder head.

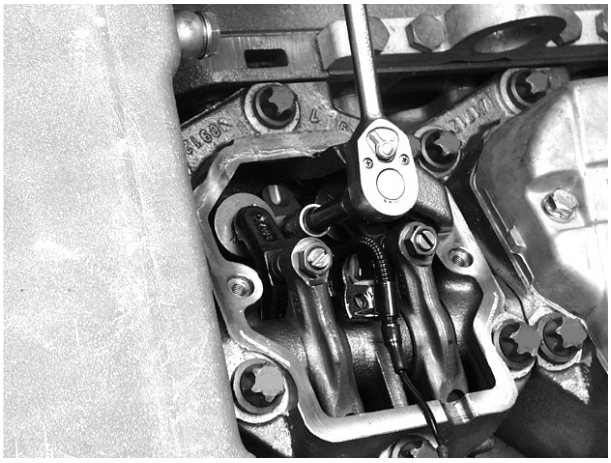
Note:
In individual cases in engines which can only be reached with difficulty the mounting bolt ② can only be unscrewed by 4. The injector nozzle should then be **carefully** pulled out of the cylinder head as described so that the pressure pipe ③ is not damaged.



5

Fig. 6

Unscrew the mounting bolt ① of the pressure flange (see item ① Fig. 5) and remove the pressure flange.

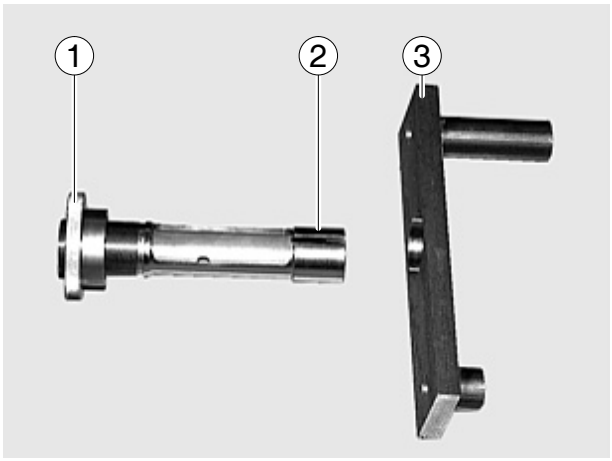


6

Fig. 7

Extractor tube for injector nozzles (special tools, see item. 15.1, page 187).

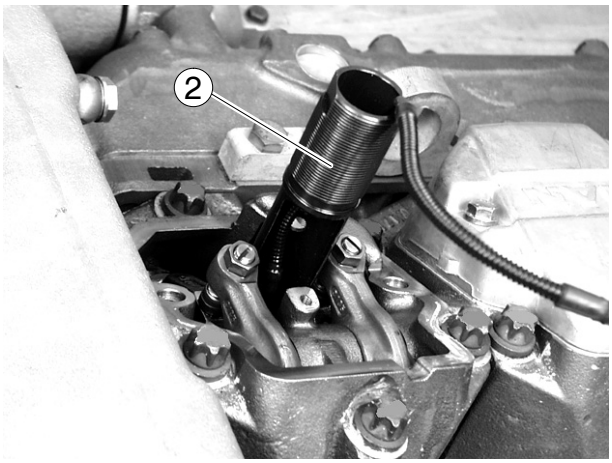
① Knurled nut
② Extractor with slit for the passage of the cable for the needle movement sensor
③ Bridge



7

Fig. 8

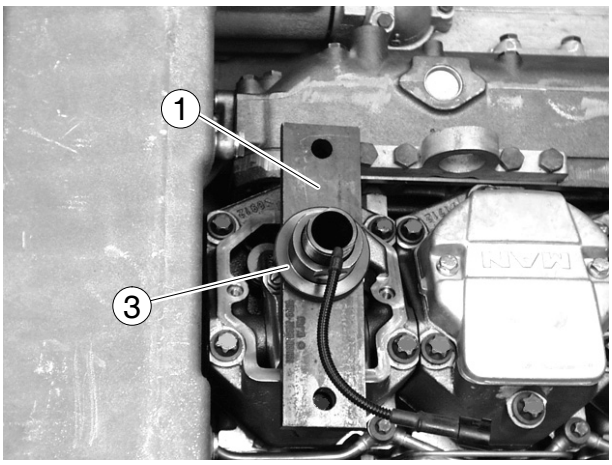
Thread the needle movement sensor through the extractor tube slit ② and up the connector up through the tube.
Screw the extractor tube onto the injection nozzle.



8

Fig. 9

Place bridge ① over the extractor tube.
The bridge rests on the cylinder head bolts.
Screw on knurled nut ③.



9

Fig. 10

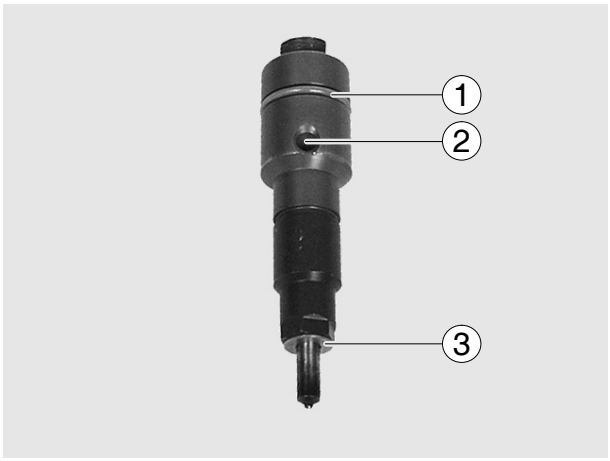
Withdraw the injection nozzle by turning the knurled nut.
Clean the nozzle seat in the nozzle bushing.

10

Installing injection nozzles

Fig. 11

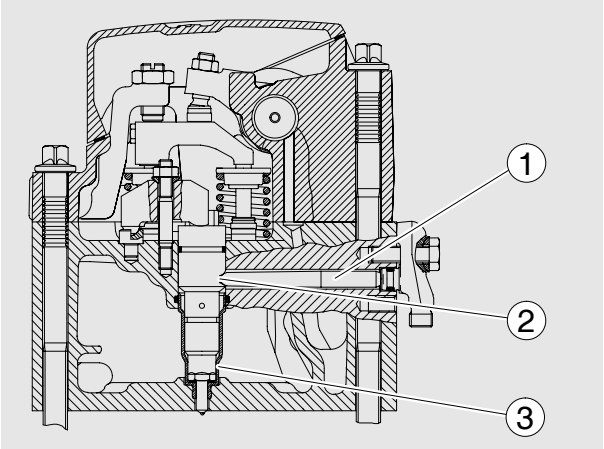
Insert new O-ring ① and new copper sealing ring ③.
Grease the O-ring.



11

Fig. 12

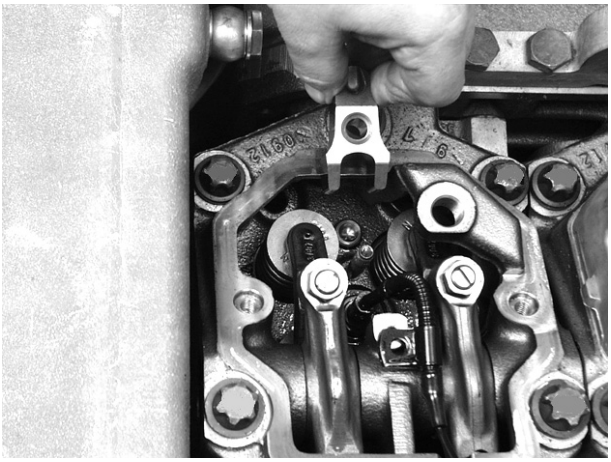
Insert the injection nozzle into nozzle bushing ③ so that inlet hole ② (see also item ② in Fig. 11) points to the hole for pressure pipe ① in the cylinder head.
Press in the injection nozzle by hand as far as it will go.



12

Fig. 13

Fit pressure flange and provisionally tighten mounting nut to 10 Nm.



13

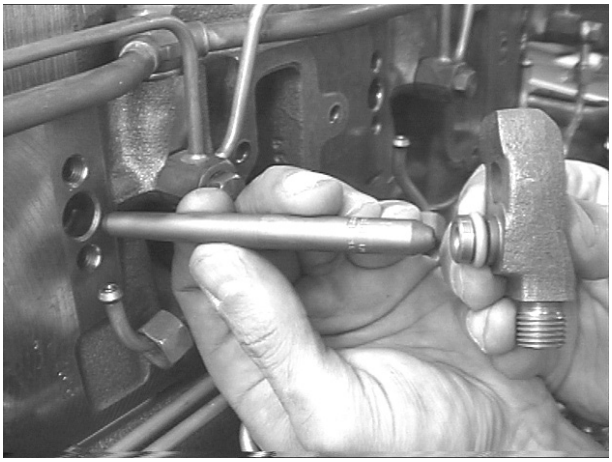
Fig. 14

Insert pressure pipe into the cylinder head.

> **Caution:**
> The thin end of the pressure pipe points towards the injection nozzle.

Replace the O-ring and apply a light coating of grease.
Insert the connection piece and align it so that the injection line can be connected without tension.

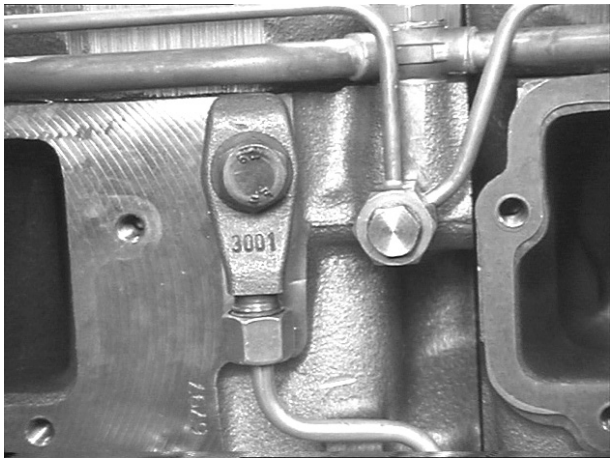
Apply initial torque of 10 Nm to injection line.



14

Fig. 15

Apply initial torque of 10 Nm to mounting bolt on connection piece.



15

Fig. 16

Tighten the mounting nut of the pressure flange (arrowed) first to 25 Nm and then to an angle of 90°.

Then tighten connection piece to 20 Nm and afterwards tighten it using a 90° torque wrench.

16

Fig. 17

Secure the injection line.

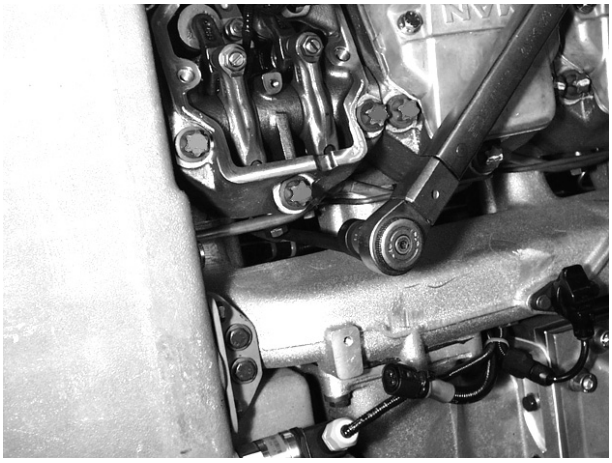
Initial installation:
Angle tightening: . . . . . 60°

Subsequent installation:
Angle tightening: . . . . . 30°

Afterwards tighten the mounting nut on the compression flange.

Angle tightening . . . . . 45°

Run engine up to normal operating temperature
Angle tightening: . . . . . 90°



17

Check tightness of nozzle holder base, pressure pipe and leak-oil line

Caution:
After the injection nozzles have been installed, always check to ensure that the nozzle holder seat, pressure pipe and leak-off oil lines do not leak.

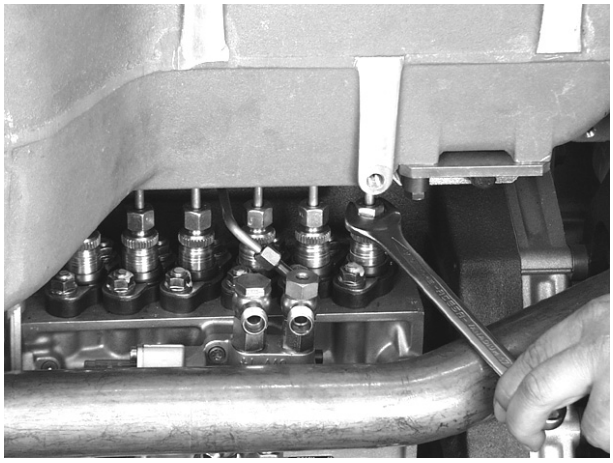
Figs. 18 and 19

Proceed as follows:

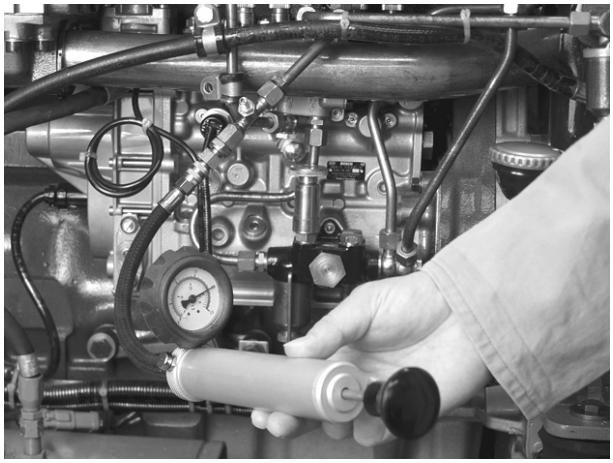
- Loosen injection lines on the connector fitting or on the injection pump
- Close fuel feed, e.g. on fuel pre-cleaner with taper plug VKA10
- Switch on the ”ignition” to open the EHAB
- Connect tester with adapter (Special tool) to the fuel return
- Pump approx. 2 bar pressure to fuel system

The pressure must not drop for a period of 3 minutes.

- Tighten up the injection lines again with the specified torque



18



19

Checking injection nozzle

Fig. 1

The nozzle tester (hand tester) is used to check the
- opening pressure (injection pressure),
- leak-tightness and
- spray pattern of each injection nozzle.

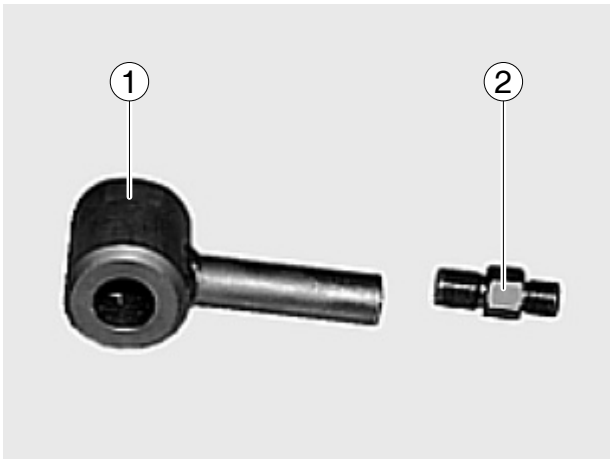
Use pure calibrating oil or pure diesel fuel for the test.
Prior to testing, clean the nozzle and check it for wear.
Check the nozzle with its nozzle holder.

1

Danger:
The high injection pressure can cause serious injury. Do not place hands under the jet spray.
Wear safety goggles.

Fig. 2

① Testing device
② Inlet connection



2

Fig. 3

Feed the needle movement sensor cable through the testing device.

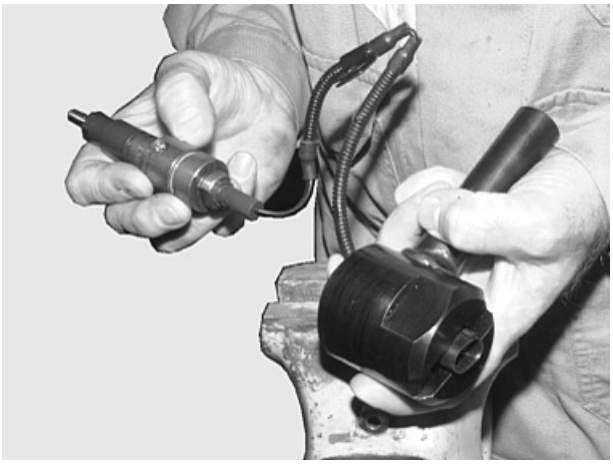
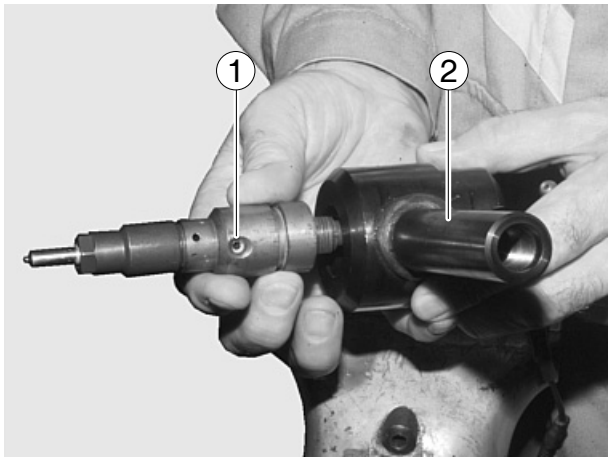

3

Fig. 4

Insert the injection nozzle with inlet hole ① towards the guide tube for pressure pipe ② in the testing device.



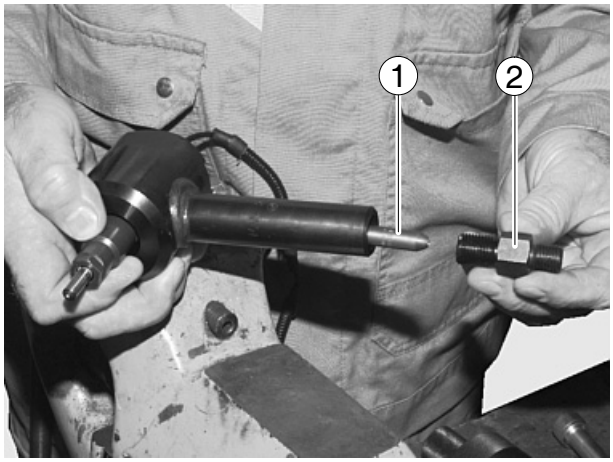
4

Fig. 5

Insert the pressure pipe with edge-type filter ① into the guide tube.

Note:
The thin end of the pressure pipe points towards the injection nozzle.

Screw inlet connection ② into the guide tube and tighten up.



5

Fig. 6

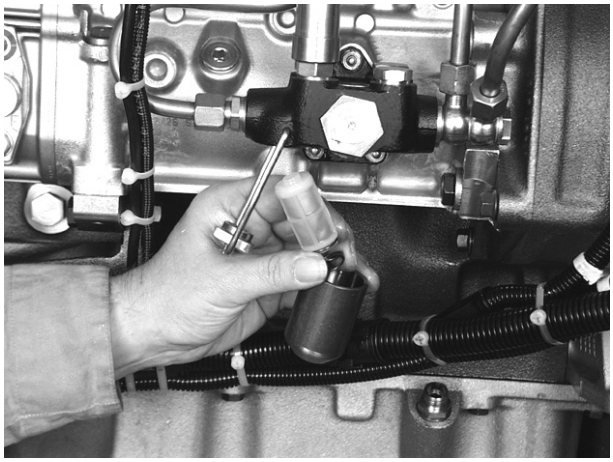
Connect the pressure line of the tester to the injection nozzle inlet connection.

6

Cleaning fuel prefilter

Fig. 1

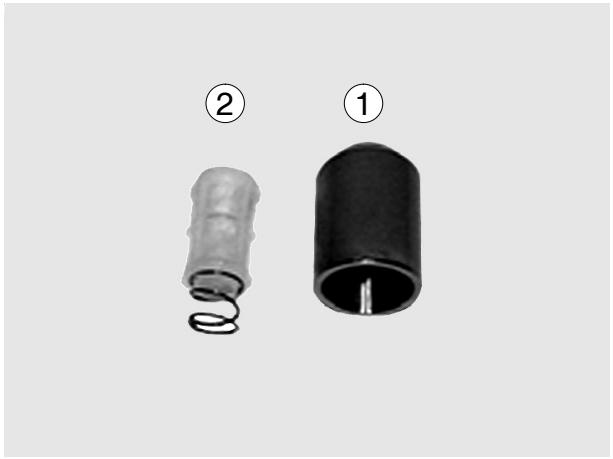
Close shut-off valve from tank to engine.
Remove round nut and take off filter housing with sieve.
Use a bowl to catch fuel that may emerge.



1

Fig. 2

Wash out filter housing ① and gauze filter ② in clean Diesel fuel and blow them out with compressed air.
Reassemble fuel prefilter using new seal.

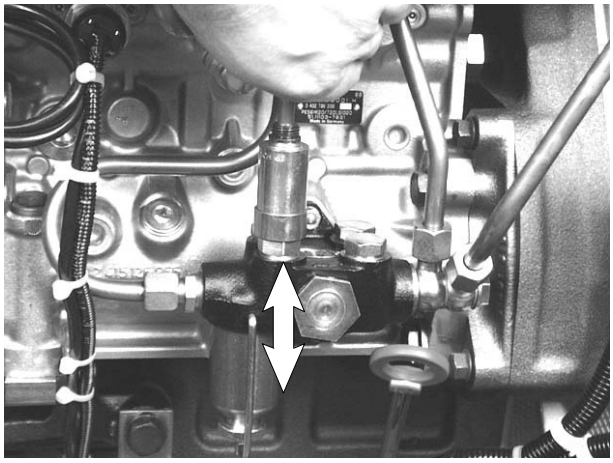


2

Fig. 3

Operate the plunger on the hand pump until the overflow valve in the injection pump can be heard to open.

Check fuel prefilter for leaks while engine is running.



3

Changing fuel filter cartridge

Parallel box fuel filter
Only when the engine is switched off.

Fig. 1

- Loosen the filter cartridge with a tape wrench, unscrew it by hand and take it off
- Moisten the seals on the new filter cartridge with fuel
- Screw on the filter cartridges and tighten them firmly by hand
- Vent the fuel system
- Check the filter for leaks

Caution:
Used fuel filters are classed as dangerous waste and must be disposed of accordingly.

1

Change-over fuel filter

Fig. 2

Where the changeover-type filter is installed, the servicing procedure is for the filter side requiring to be shut off with the engine running. During continuous operation, the selector lever should be placed in a position where both filter halves are in operation.

Caution:
Do not leave selector lever in any intermediate position because this would be liable to interfere with fuel supply. If in doubt stop the engine to change the fuel filter.

The filter cartridge is then to be exchanged as described under parallel box filter (Fig. 1).

Continuous operation (both filter halves in operation)

Right-hand filter cut out

Left-hand filter cut out

2

Venting fuel system

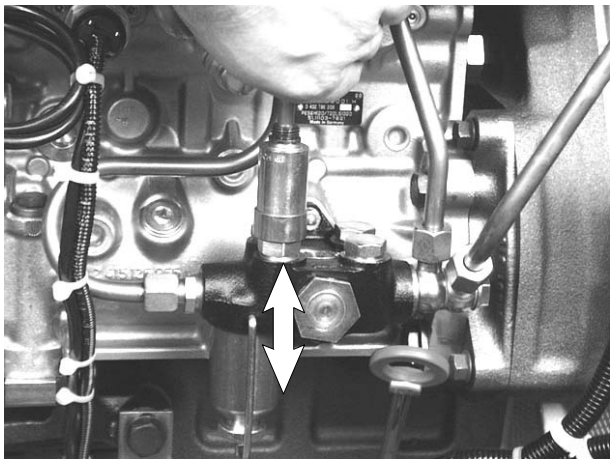
Note:
To bleed the fuel system, switch on the “ignition” so that the EHAB will be open.

Figs. 3 and 4

An arrow on the filter head indicates the direction of fuel flow.

- Unscrew the vent screw of the first filter in the direction of flow by one or two turns
- Operate the plunger on the hand pump until bubble-free fuel emerges
- Screw in and tighten the hand pump plunger
- Close the vent screw again
- Repeat this procedure at the second vent screw
- Check the fuel system for leaks

3

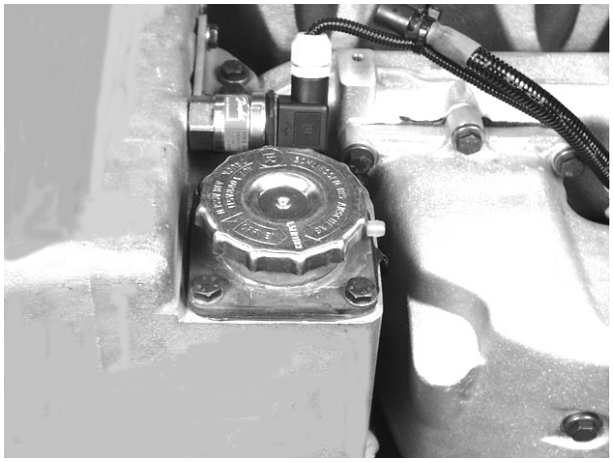

4

Draining coolant

Drain coolant when the engine **is cold** as follows:

Danger:
When draining hot coolant, there is a danger of scalding!

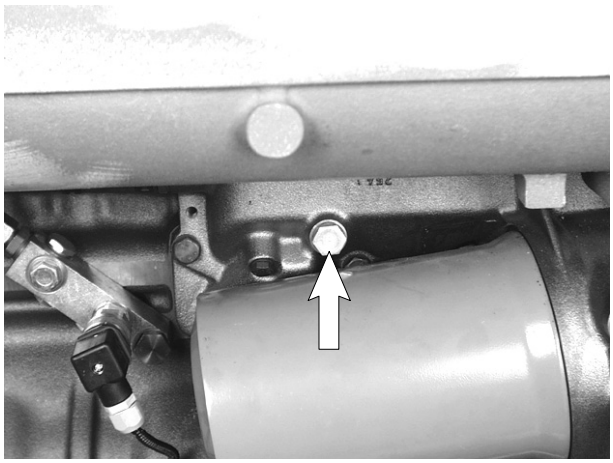
Caution:
Collect the drained coolant and dispose of it in accordance with regulations!



1

Fig. 1

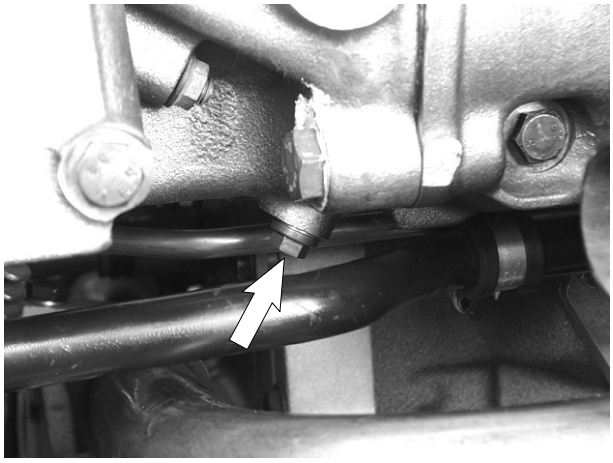
Briefly open cap on the filler neck of the expansion tank for pressure compensation.



2

Fig. 2

Open drain plug in the oil cooler housing.
Use a container to catch coolant that may emerge.



3

Fig. 3

Further drain plugs for draining the coolant are located on the exhaust-gas collector pipe (Figure) and on the intercooler.

Filling coolant

Fig. 4

The cooling system of the engine is to be filled with a mixture of drinking water from the mains and antifreeze based on ethylene glycol and / or anti-corrosion additive.
See Publication “Fuels, Lubricants and Coolants for MAN Diesel Engines”.

Coolant must be added **at the filler neck only** . Do not add cold coolant to a warm engine. Ensure that the mixing ratio “water-antifreeze” is preserved.

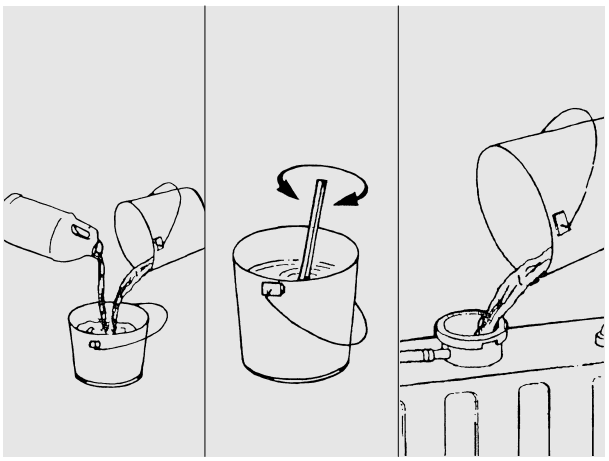
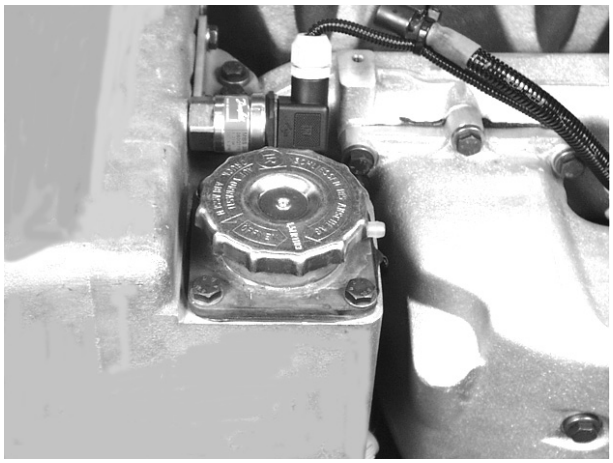
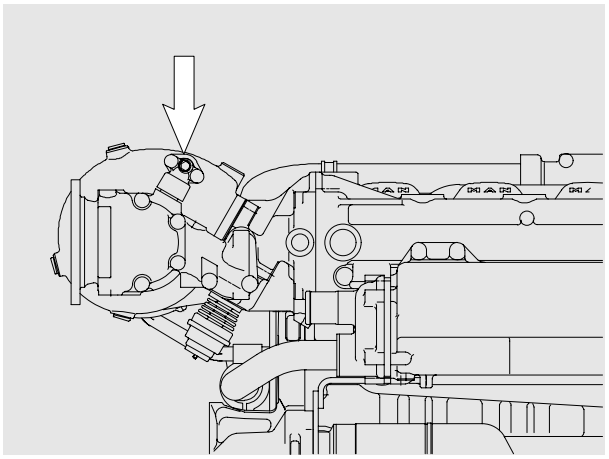

4

Fig. 5 and Fig. 6

- Remove cap (large cap)
- Set heating (if fitted) to full output, open all shut-off valves, open bleeders (if fitted)
- Unscrew bleed screw (arrow) on liquid-cooled turbocharger
- Slowly fill up with coolant via filler neck on expansion tank until fluid level has reached the lower edge of the filler neck
- Screw in bleeder screws again and refit cap
- Let engine run at a speed of 2000 rpm for approx. 5 minutes
- Switch off engine, carefully turn cap with safety valve to first detent –let off pressure– then carefully take off cap


5

Danger:
Risk of scalding and burning yourself!


6

- Before the engine is next put into operation (with the engine cold) check the coolant level and top up if necessary
- Repeat this procedure until no more coolant can be added

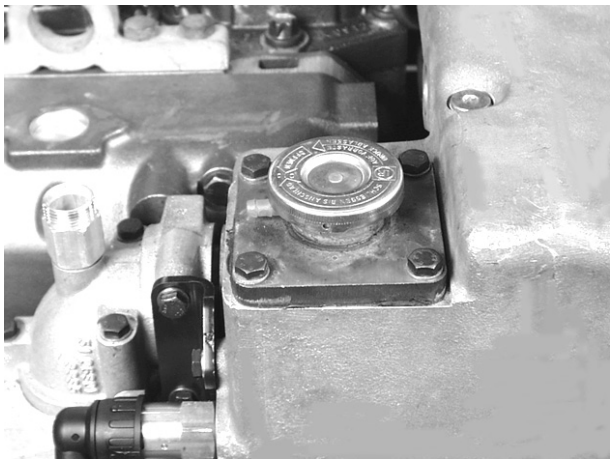
Note:
The turbochargers must not be bled while the cooling system is being topped up.

Danger:
If, in an **exceptionall** case, the coolant level has to be checked in an engine that has reached operating temperature, first carefully turn the cap ① with safety valve to the first stop, let off pressure, then open carefully.

Note:
Don't open the cooling system when the engine is at operating temperature. This causes a pressure loss in the cooling system.
If the cooling system has been opened when the engine is at operating temperature this can lead to the alarm "pressure in the expansion tank" when the engine is then put into operation and to a reduction in the engine output.
Coolant pressure in the expansion tank is only built up again when the engine has cooled down. The cooling system must therefore only be filled up when the engine is cold.

Fig. 7

Caution:
When the cover is opened with working valves, there is a danger that it is not properly sealed when closed again. The required overpressure is no longer set up in the cooling system. Premature simmering and loss of coolant result. To avoid damage to the engine, this cover should as a general rule only be opened in exceptional cases and then replaced by a new one.

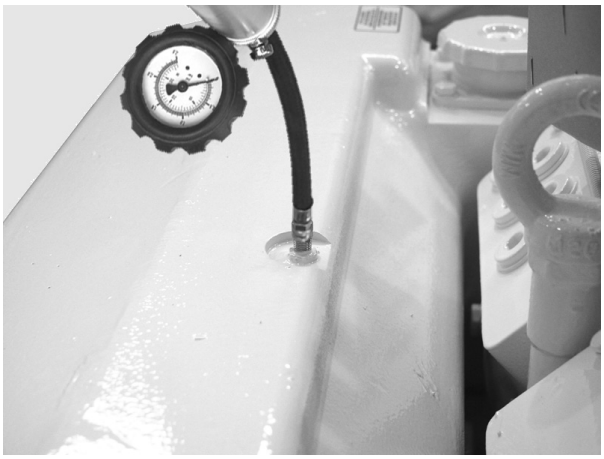


7

If the expansion tank needs to be filled up while the engine is at operating temperature, the must be obseved:

Fig. 8

- To operate the hot engine without alarm again after the end cover has been opened, a prepressure of 0.7 bar must be present in the cooling system
- To achieve this pressure a pressure valve is fitted to the expansion tank. An air pump available on the open market can be connected to this valve. The system must be pumped up to 0.7 bar using this pump.

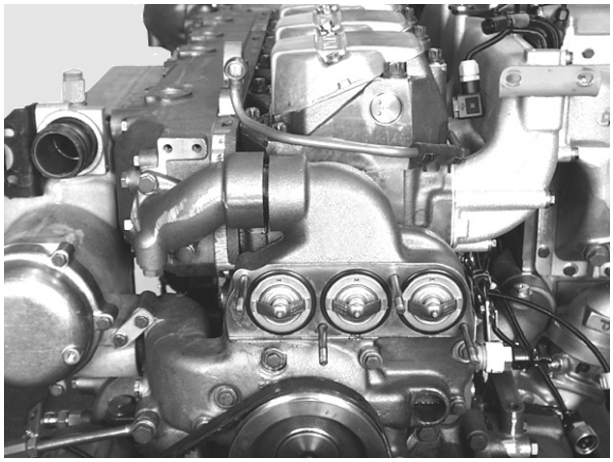


8

- Drain off coolant, see Page 43
- Remove expansion tank, see page 47

Fig. 1

Once the expansion tank has been removed the thermostats in the water pump housing are visible.



1

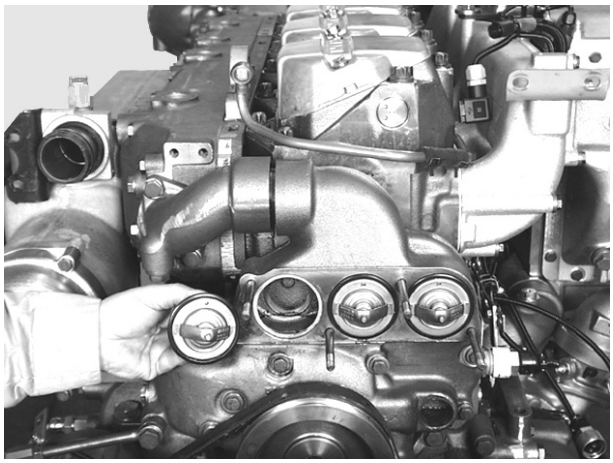
Fig. 2

Take out thermostat.

Check the function of the thermostat insert as follows.

- Suspend the thermostat in a bowl of water
- Heat up the water
- Using a suitable thermometer, ascertain the start of opening and compare it with the setpoint value in “Engineering • Data • Setting Values”
- If necessary, measure the opening stroke

Replace defective thermostats.

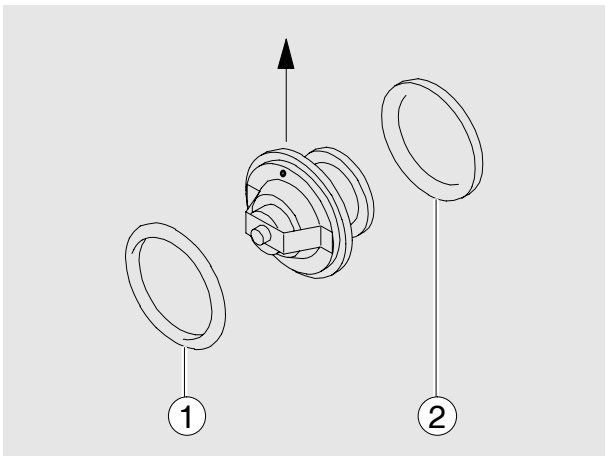


2

Fig. 3

Insert thermostat inserts (ball valve facing upwards (TOP) with new O–ring seal ① and new seal ②.

Caution:
Never operate the engine without its thermostats.



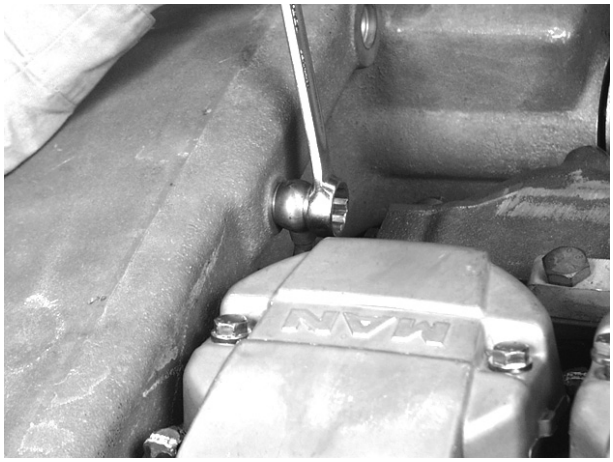
3

- Drain off coolant, see Page 43

Fig. 1

Remove hollow bolt from bleeder line.

Remove coolant level sensor.

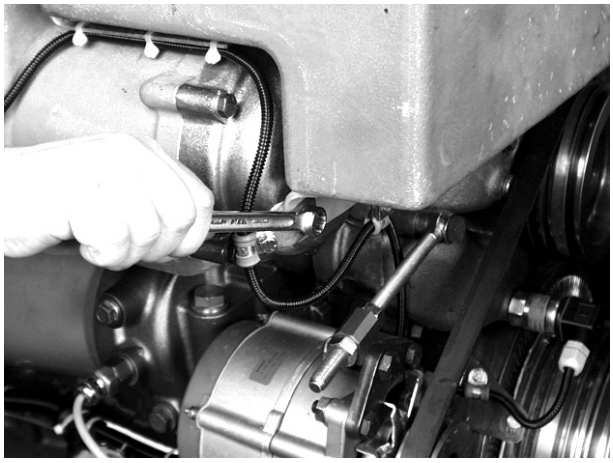


1

Figs. 2 and 3

Remove the mounting bolts from the brackets of the expansion tank.

2



3

Fig. 4

Remove nut from the front side of the expansion tank.

Take off the expansion tank.

The expansion tank is attached in reverse sequence.

4

Note:
Exchange or repair coolant pump only if it has been found to be leaky.

The design of the coolant pump mechanical cassette seal permits small amounts of coolant to pass through it. This coolant passing through results in a trace of drained coolant below the drain bore. This trace of drained coolant does not mean that the coolant pump has to be replaced.
For this reason before exchanging or repairing a coolant pump ascertain

- whether the cooling circuit shows visible and recurring signs of coolant loss; if yes
- whether the coolant loss is caused by spillage from the expansion tank (e.g. too full) or by other leakages from hoses, radiator etc.

Coolant pumps must be exchanged only if coolant drips visibly while the engine is in operation or after the engine has been switched off.

- Take off V–belt, see page 147
- Drain off coolant, see Page 43
- Remove expansion tank, see page 47
- Remove the thermostats, see page 46

Fig. 1

Unscrew coolant elbow to the exhaust gas pipe (arrow).

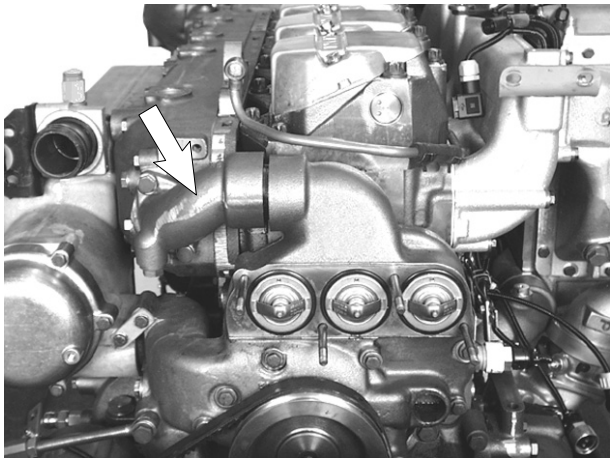
1 

Fig. 2

Release the coolant pump mounting bolts and remove the coolant pump.

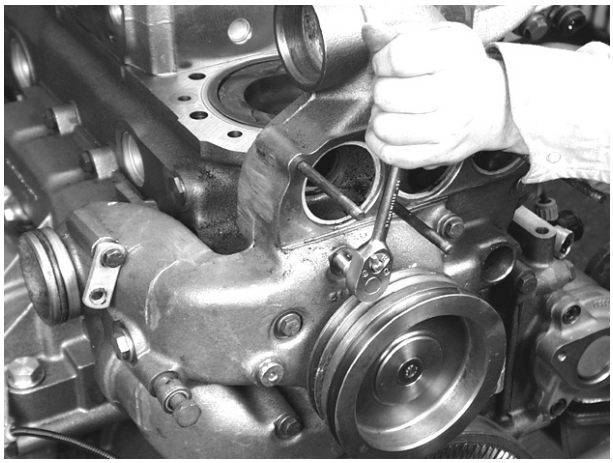
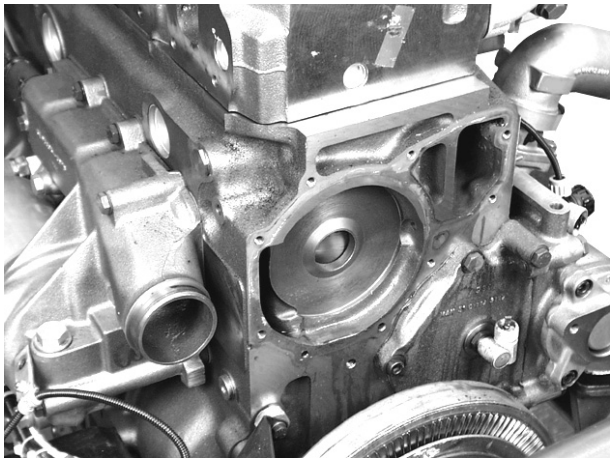
2 

Fig. 3

Clean the sealing faces on the coolant pump and crankcase with a scraper and fine abrasive paper.

Stick the new gasket for the coolant pump housing to the crankcase with grease. Fit coolant pump.

3 

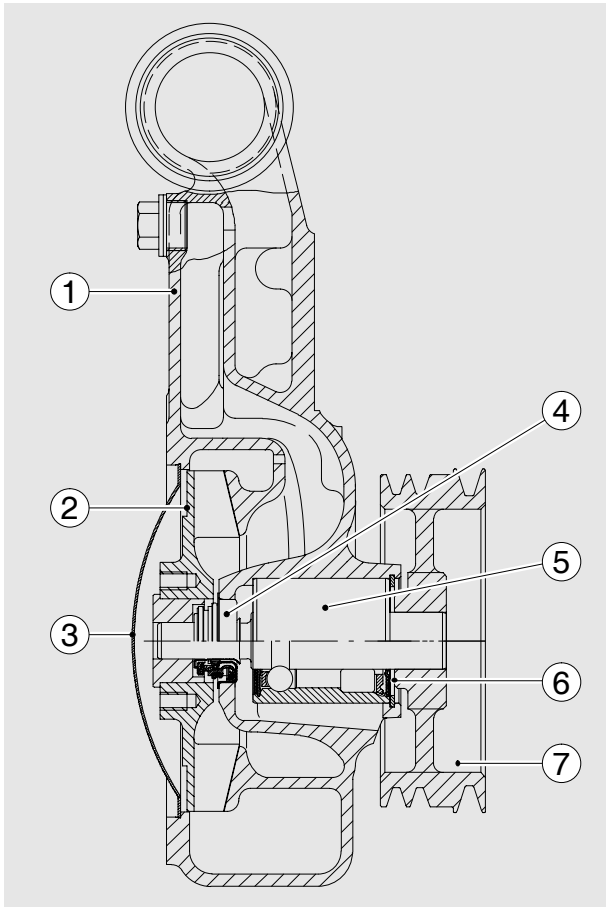
Disassembling coolant pump

The following special tool is needed to disassemble and assemble the coolant pump:

- Press
- Improvised tools, see page 194

Fig. 1

1 Coolant pump housing
2 Impeller
3 Cap
4 Mechanical seal
5 Pump bearing
6 Circlip
7 V-belt pulley



1

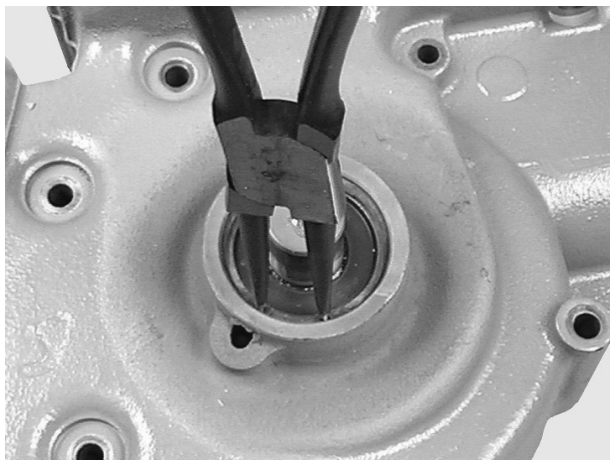
Fig. 2

Pull off V-belt pulley hub with a stable puller.

2

Fig. 3

Unclip the circlip from the coolant pump housing.



3

Fig. 4

Knock out cap by driving a suitable mandrel under the cap at the notch.

4

Fig. 5

Press impeller off the shaft, using a suitable mandrel. For this purpose align coolant pump housing horizontally on a stable support (eg support ring, special tool, see page 194).

Use suitable mandrel to press the coolant pump shaft with bearing out of the housing.
Shaft and bearing are encapsulated and replaced as a single unit only.

Take off axial face seal.

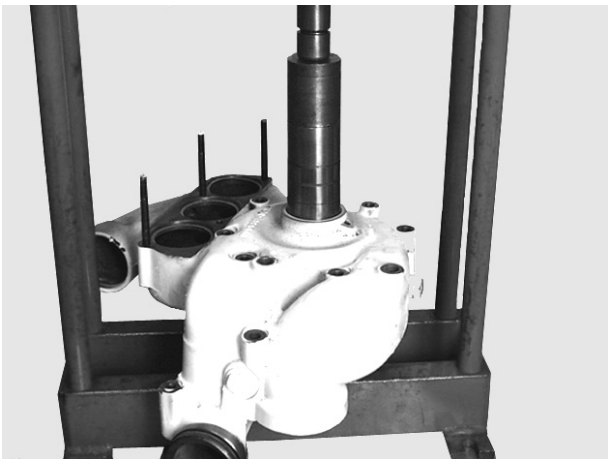
5

Reassembling coolant pump

Fig. 6 and Fig. 7

Press in coolant pump bearing.
Use hollow mandrel to press on the outer bearing ring and not on the bearing shaft.
For this purpose align coolant pump housing horizontally on a stable support (eg support ring, special tool, see page 194).
Fit the circlip.

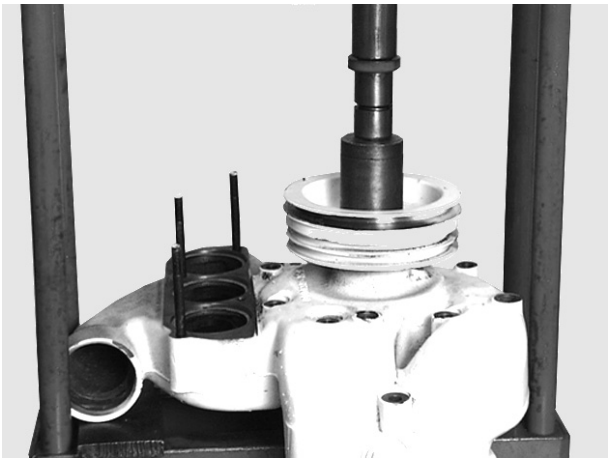
6



7

Fig. 8

Press the V-belt pulley on to the bearing shaft so that it fits flush.Use the other shaft end as support.



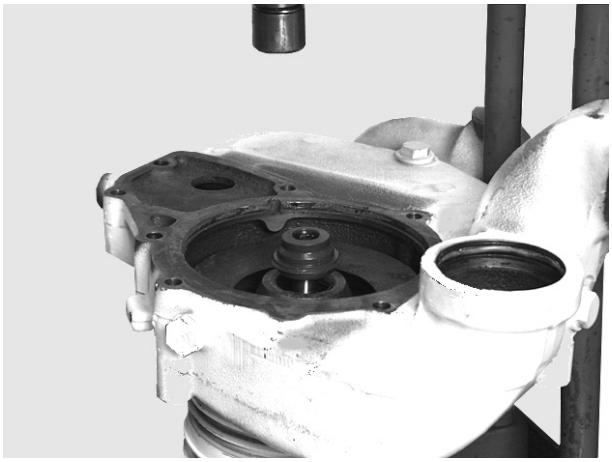
8

Figs. 9 and 10

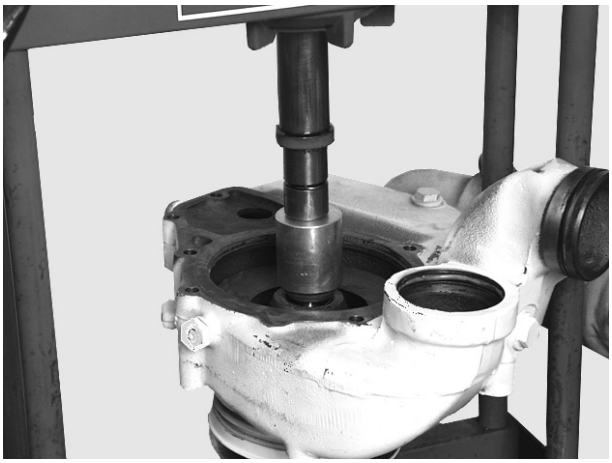
Turn coolant pump housing over.

Press in new mechanical seal with press-fitting sleeve (special tool, page 185, page 10) until it stops.
Observe installation note for seal on page 54.

Note:
The seal can be exchanged even without removing the coolant pump shaft.



9



10

Fig. 11

Degrease impeller and coolant pump shaft with degreasing spray.

11

Fig. 12

Seal impeller with “Loctite 648”.

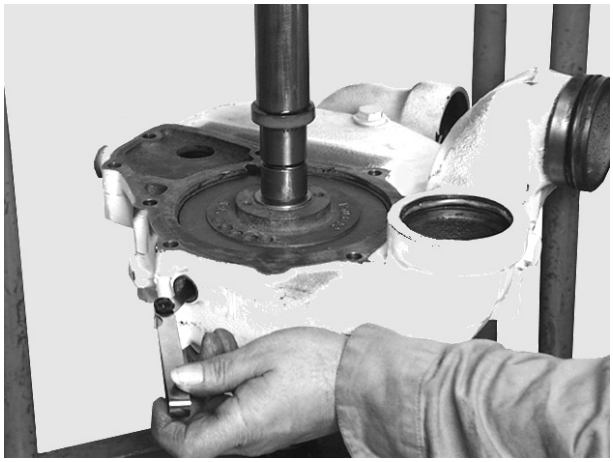
12

Figs. 13 and 14

Press impeller slowly on to bearing shaft to ensure correct gap.

For this purpose an inspection hole closed up with a screw plug (M16x1.5) is provided on the bottom of the coolant pump housing.

① Impeller
② Coolant pump housing



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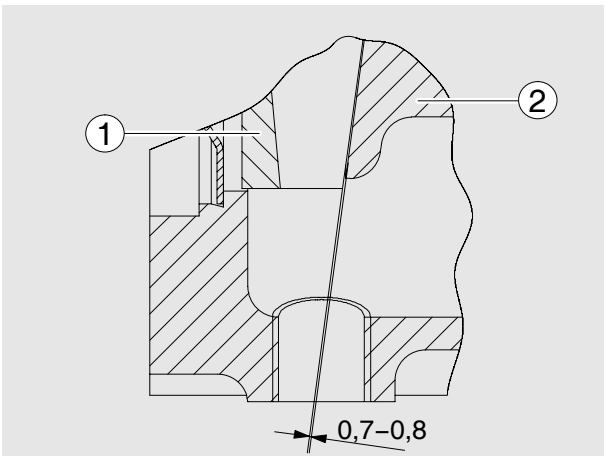
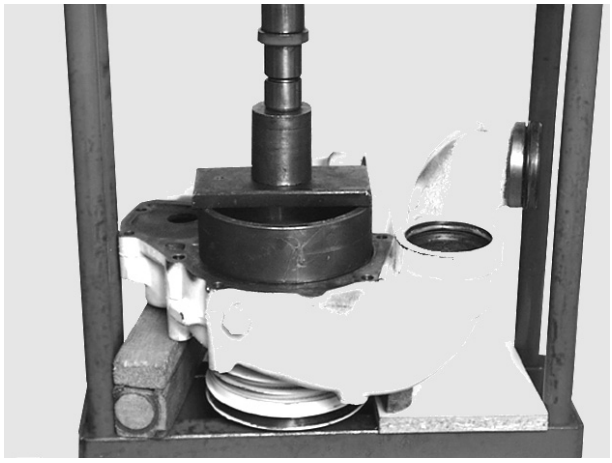


14

Fig. 15

Place on the new pump cover and use a suitable pressing die to press the cover into the housing.

Fit coolant pump with new seal,
see page 48.

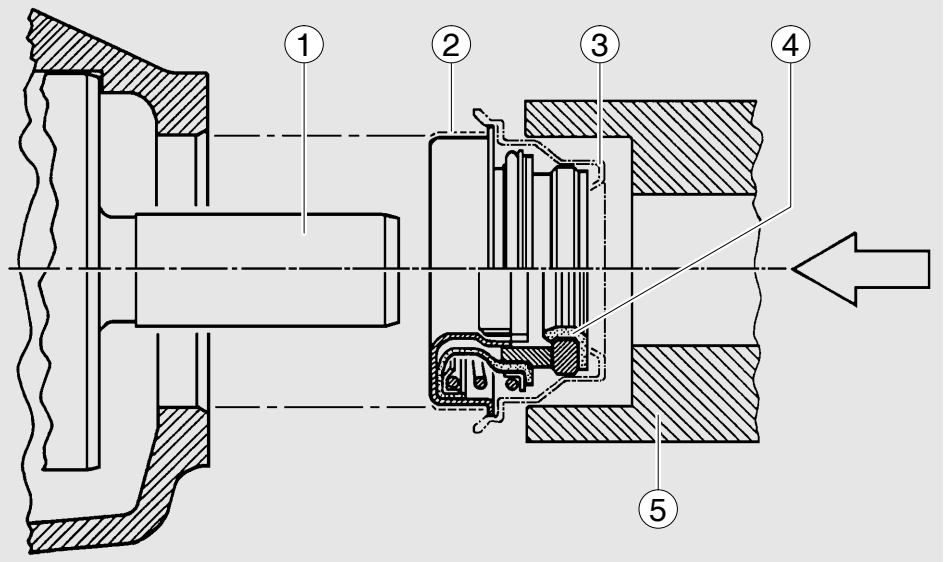


15

Installation note for mechanical seal:

Fit the mechanical seal ”wet”, i.e. when fitting, coat holding sleeve ④ and coolant pump shaft ① with a mixture of 50% water and 50% cleaning spirit or 40% to 50% antifreeze as per MAN 324 and water.
Other anti-skid agents must not be used.

Because the seal on collar ② is coated with sealing paint, no sealing paint needs to be applied if the locating bore in the coolant pump housing is in perfect condition. If the bore shows even the slightest scoring or other minor damage, a sealing bead of Dirko-Transparent, Part No. , must be applied to collar ②.
Fit the seal with a plastic transportation cap onto shaft ① and use installation tool ⑤ to press it in until the tool contacts the housing. Remove the plastic cap.



Note:
Tests have shown that most cases of damage to the coolant pump can be attributed to the use of unsuitable coolants.
Only those anticorrosion and antifreeze agents expressly approved by MAN Nutzfahrzeuge AG as per the MAN 324 standard (see brochure “Fuels, Lubricants and Coolants for MAN Diesel Engines”) will guarantee fault-free operation.

Cleaning inside of cooling system

Tests have shown that in many cases the poor condition of the coolant and / or the cooling system accounts for damage to the coolant pump seal. The poor condition of the cooling system is normally due to the use of unsuitable or no antifreeze or corrosion inhibitor or to defective caps for filler necks and service valves which are not punctually replaced.

If the coolant pump of an engine develops leaks twice in short succession or the coolant is heavily contaminated (cloudy, brown, mechanically contaminated, grey or black signs of leakage on the coolant pump housing, after the defect on the oil cooler), clean the cooling system **prior** to removing the faulty coolant pump as follows:

a) Drain coolant
b) Open the thermostats positively (use bypass inserts) so that the entire cooling circuit is flushed immediately during the cleaning operation
c) Fill coolant circuit with a mixture of hot water (min. 50°C) and Henkel P 3 neutrasel 5265 detergent (1.5% by volume) (5266, 5225, Kluthe Hakopur 316), refer to Publication “Fuels, Lubricants ...”
d) Warm up the engine under load. After a temperature of 60°C is reached, run the engine for a further 15 minutes
e) Drain cleaning fluid
f) Repeat steps c) and d)
g) Flush the cooling circuit; to this effect
h) Replace the drain plug with a drain plug with an 8 mm dia. bore
i) Fill the cooling circuit with hot water
k) Run the engine at idle for 30 minutes. At the same time continuously replenish the water emerging for the bore in the drain plug by adding fresh water at the filler neck

Only now should the coolant pump be repaired. On completion of repairs, fill the cooling system with coolant, refer to publication “Fuels, Lubricants ...”.

Note:
Only sediments and suspended particles can be removed by this cleaning method. If rust and lime deposits are detected, proceed following the instructions set out in the section below:

Removing lime deposits in cooling system

Proceed as follows:

- Drain coolant
- Fill the system with undiluted original pickling fluid (Engine pickling fluid RB-06). Keep the engine running for approx. 8 hours with this fluid in the system (also in normal operation)
- Drain the pickling fluid and flush the system thoroughly with tap water
- If necessary, refill the system with fresh pickling fluid and pickle the system for a further 8 hours
- Drain the pickling fluid, fill the system with tap water, and run the engine at idle for 5 minutes to flush out all fluid; then drain the water
- Fill the system with soda solution (1%). Drain the soda solution after running the engine at idle for 5 minutes, and flush with tap water until the discharging water runs clear
- Fill cooling circuit with a mixture of potable tap water and anti–freeze with at least 40% by volume, refer to Publication “Fuels, Lubricants ...”

Filler caps and service valves of cooling system

The rubber seals on the filler caps and service valves (negative pressure and positive pressure valves) of the cooling system are subject to natural ageing.
To prevent leakages in the cooling system together with the associated loss of pressure and its consequences through to serious engine damage, replace the filler caps and service valves at the same time as changing the coolant (every two years at the latest).

Waste water treatment

Drained and spent cleaning and pickling fluid should be brought up to a pH value of 7.5 to 8.5 with the aid of caustic soda. Once the precipitation has settled to the bottom of the container, the clear fluid above can be tipped into the sewer system. To be sure, it is advisable to consult the local authorities for more information on waste water rules and restrictions. The sludge at the bottom must be taken to a special waste dump.

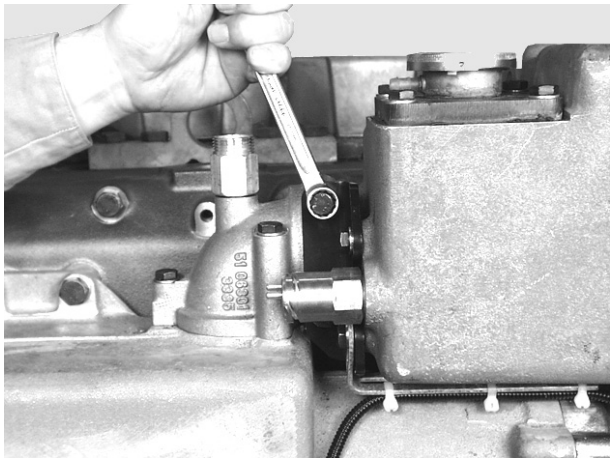
Sources of supply for pickling fluids

Motor pickling fluid RB-06
Reincolor-Chemie GmbH
Werkstr. 21
D–90518 Altdorf
Tel.: (0 91 87) 97 03 0

- Drain off coolant, see Page 43

Fig. 1

Remove mounting bolts from the coolant elbow between expansion tank and seawater heat exchange.

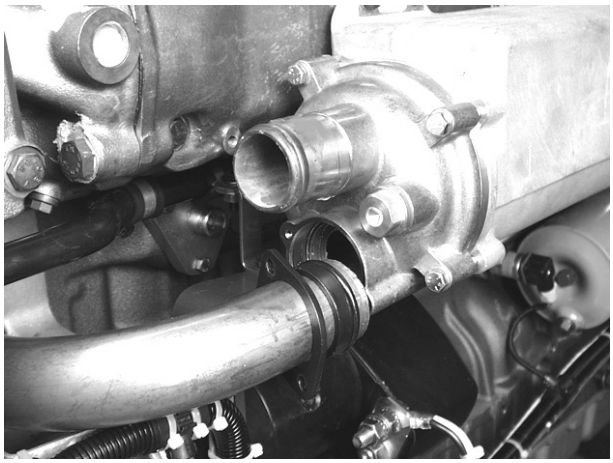


1

Fig. 2

The seawater connecting pipe from the intercooler is fastened to the heat exchanger by means of a plug connection. To remove them, unscrew pressure flange.

Remove pipe clamps from the seawater pipe and pull out pipe plug connection.



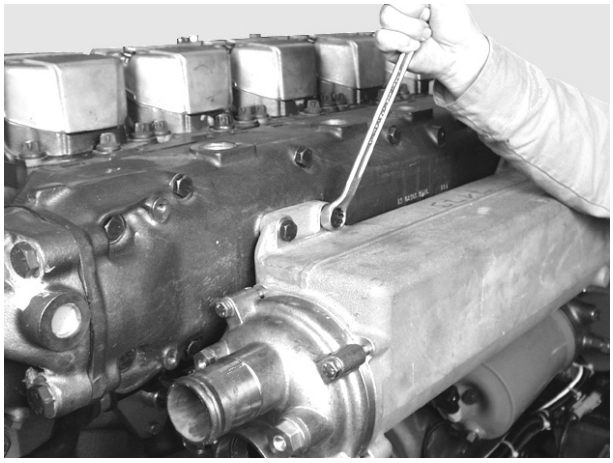
2

Fig. 3

Remove mounting bolts from the heat exchanger brackets.
Take off heat exchanger.

The heat exchanger is attached in reverse sequence.

When assembling, fit new O-rings at the plug connection.

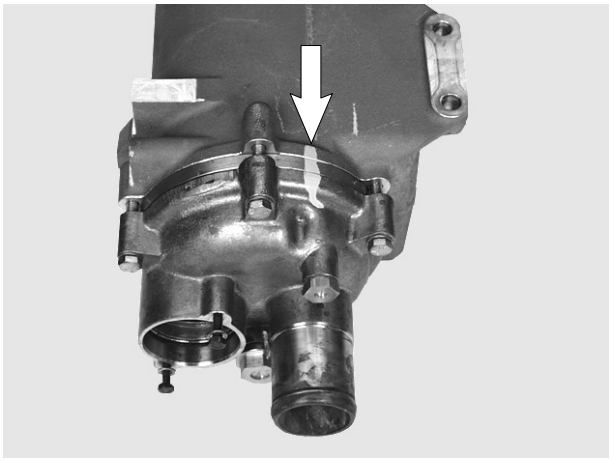


3

- Remove heat exchanger, see page 57

Fig. 1

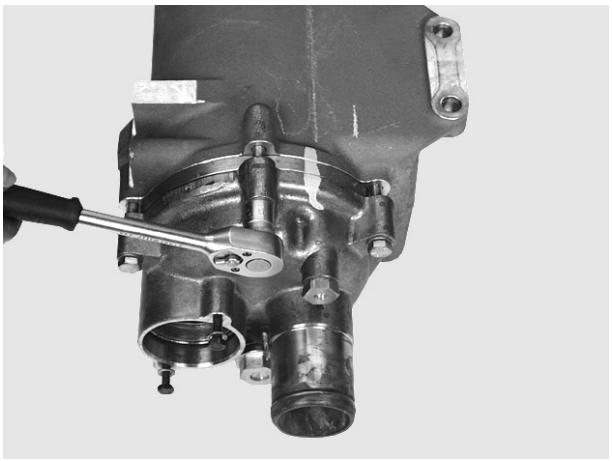
Match-mark the position of the covers relative to the heat-exchanger housing (arrow).



1

Fig. 2

Remove both covers.



2

Fig. 3

Unfastening the pipe cluster:

- Remove cap nuts
- Remove setscrews

3

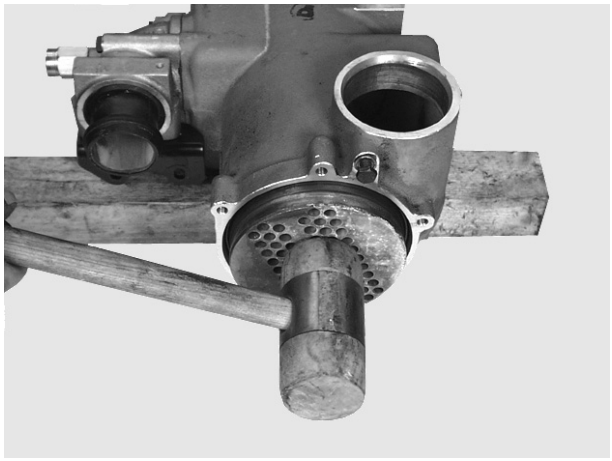
Fig. 4

At the flywheel end of the heat exchanger the collar of the pipe cluster (arrow) is visible.

4

Fig. 5

Carefully knock out pipe cluster from the opposite end using a hammer of wood.



5

Fig. 6

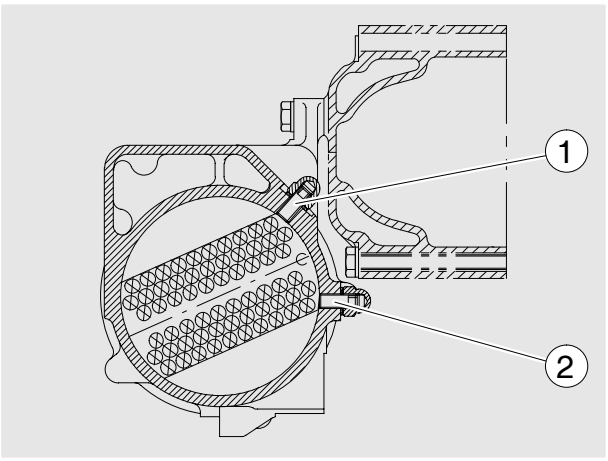
Pull out pipe cluster.

6

Fig. 7

The pipe cluster is installed in reverse order.

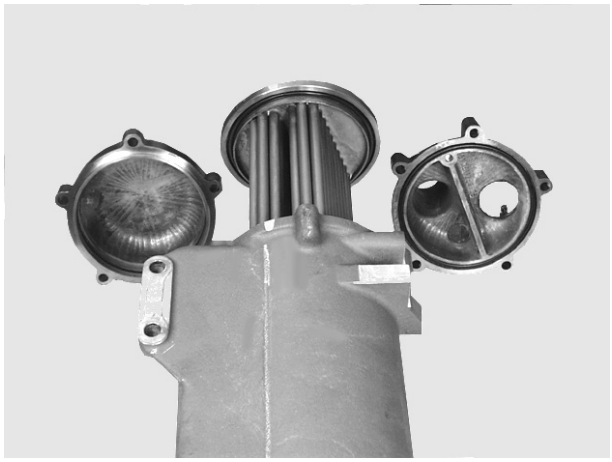
Insert setscrews for fixing the pipe cluster (use “Loctite 242” bolt securing agent).
First tighten the lower setscrew ② then the upper setscrew ①, both to 30 Nm.



7

Fig. 8

When installing the pipe cluster, use new O-rings and check the heat exchanger for leaks.



8

Internal cleaning of the pipe cluster in seawater heat exchangers

Deposits may form on the seawater side of the pipe cluster in the heat exchanger, impairing the heat transition to such an extent that the coolant heat can no longer be sufficiently conducted away. This is bound to cause an increase in the coolant temperature.

In the event of an increase in coolant temperature, check all other components of the cooling system first.

- Seawater filter contaminated
- Seawater inlet clogged up
- Flow rate of seawater sufficient
- Impeller of seawater pump worn

If all components of the cooling system are in order, but the coolant temperature remains nevertheless high, cleaning the pipe cluster may eliminate the fault.

Proceed as follows:

- Lay or stand removed pipe cluster in a suitable container made of synthetic material such as PE, PP, PVC, GRP etc.
- Fill container with undiluted genuine pickling liquid at room temperature (Lithsolventsäure or engine pickling fluid RB–06) until the pipe cluster is completely submerged
- Allow pickling fluid to soak in for approx. 10 hours. If this period of time is not sufficient, allow another 5 hours
- The pickling period can be shortened by heating up the pickling fluid up to a maximum of 50°C and by moving the pipe cluster from time to time
- After the pickling the pipe cluster is to be intensively rinsed with tap water and again installed in the heat exchanger
- Use new seals (O-ring seals) for the caps
- Install pipe set and check heat exchanger for leaks

Waste water treatment

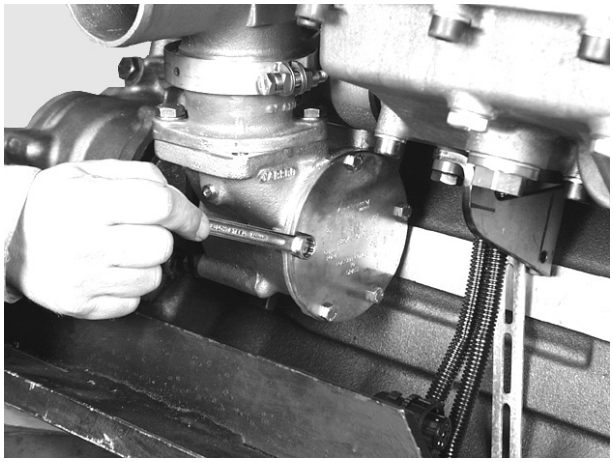
Drained and spent cleaning and pickling fluid should be brought up to a pH value of 7.5 to 8.5 with the aid of caustic soda. Once the precipitation has settled to the bottom of the container, the clear fluid above can be tipped into the sewer system. The sludge at the bottom must be taken to a special waste dump.

Changing impeller

Figs. 1 and 2

Replace worn or damaged impeller together with wearing plate and seal (repair kit).

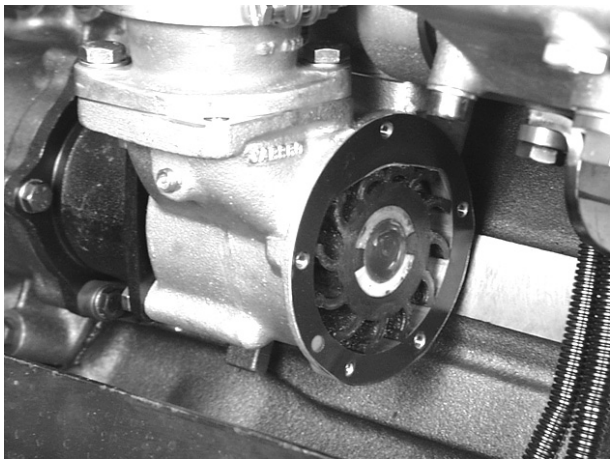
To do so, unscrew the lid.



1

Fig. 2

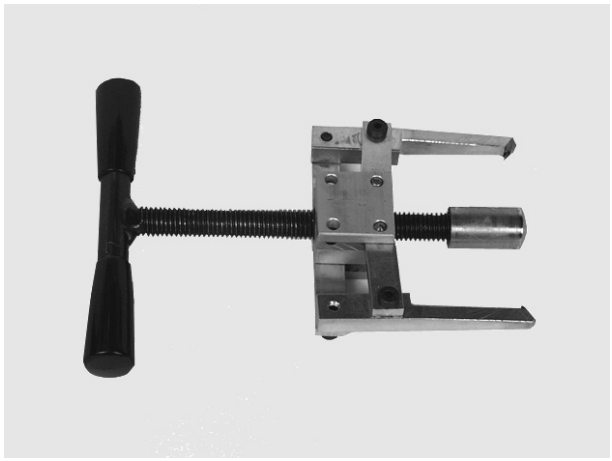
Unscrew oval-head bolt between intake and pressure pipes of the seawater pump.
This bolt holds the eccentric (see also Fig. 5, page 62).



2

Fig. 3

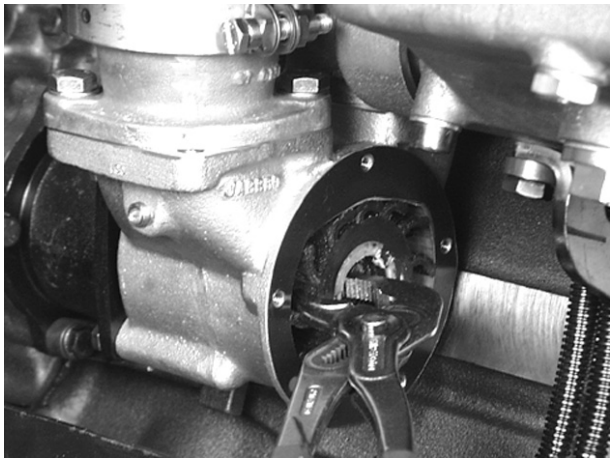
Pull out impeller together with the cam, using a suitable extracto (available from the manufacturer of the seawater pump).



3

Fig. 4

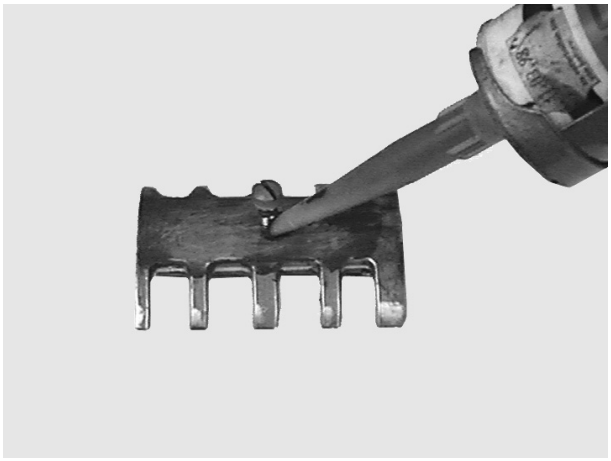
If no extractor is available, pull out impeller together with the eccentric, using a pair of pliers.



4

Fig. 5

Install the impeller in reverse order.
Apply sealant to cam before installing it.
Lightly coat new impeller with Vaseline prior to its installation.
Dry running will destroy the impeller. Fill pump with water prior to operation.
Check for leaks.



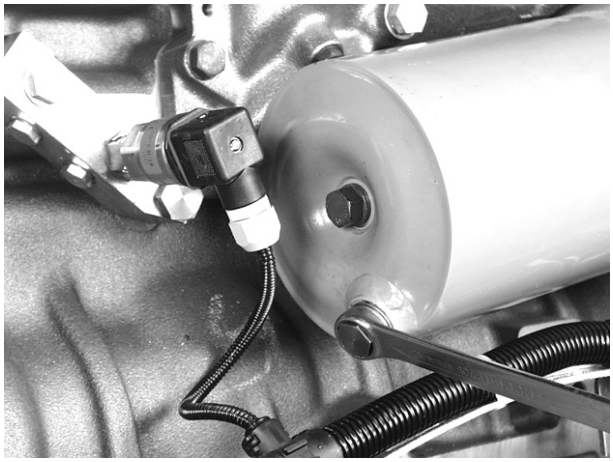
5

Caution:
Old oil and used oil filters are hazardous waste.
Observe safety instructions for the prevention of environmental damage.

Figs. 1 and 2

Open the oil drain plug on the oil filter casing and catch emerging oil in a suitable container. Reinsert oil drain plug with new gasket.

Danger:
The oil filter casing and filter insert are filled with hot oil; danger of burns and scalding!

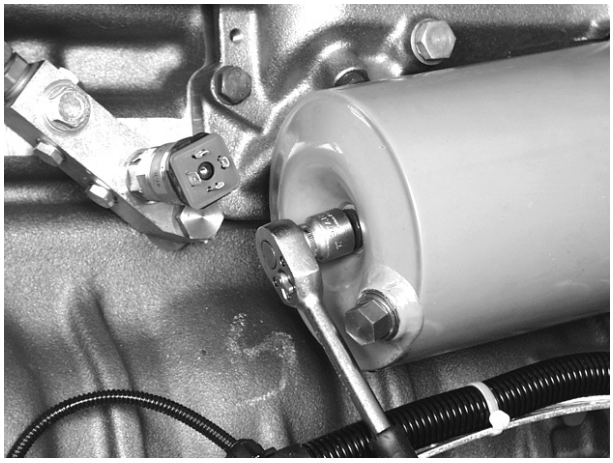


1

2

Fig. 3

Loosen the securing bolt of the filter cup.
Remove filter cup and clean inside.



3

Fig. 4

Insert a new filter cartridge and reinstall the filter casing with new seals.

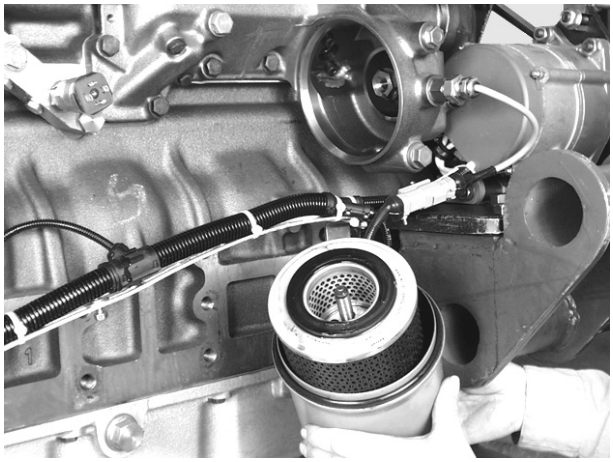
Reinsert oil drain plug with new gasket.

Note:
To avoid twisting the gasket, hold the filter cup while tightening the tensioning screw.

Observe tightening torque for mounting bolt (see “Engineering • Data • Setting values”).

Note:
The pictures show the standard oil filter. Classifiable engines have a filter with a changeover feature.
However, the oil filter cartridges are changed analogously.

Fill engine oil and check for leaks after a short engine run
Check oil level.



4

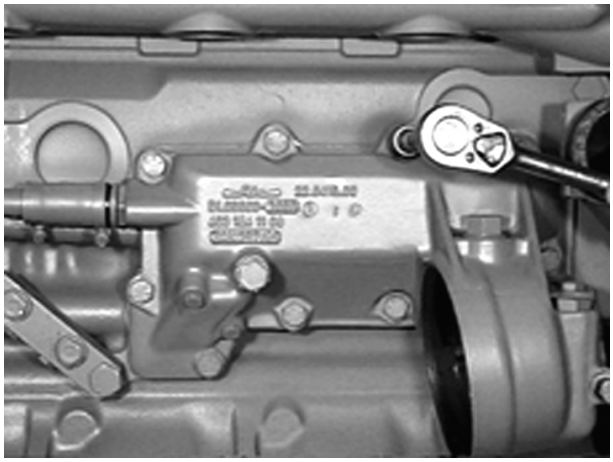
- Drain engine oil, see page 63
- Drain off coolant, see Page 43
- Remove oil filter, see Page 63

Fig. 1

Remove hose clamp on the coolant outlet pipe leading from the oil cooler housing.

Unscrew the mounting bolts from the oil cooler housing.

Note:
Do not remove the four 13 mm mounting bolts. They keep the oil cooler in place.

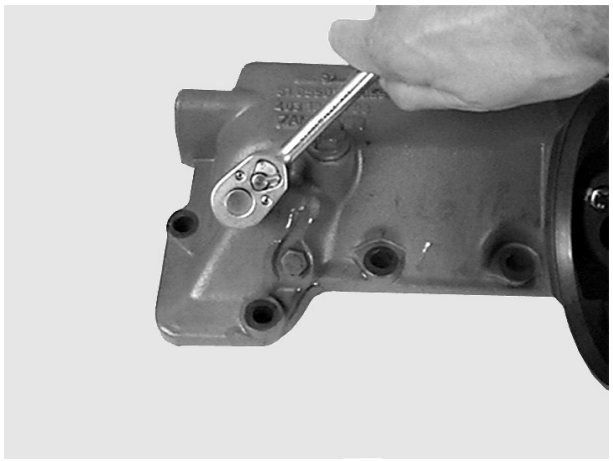


1

Figs. 2 and 3

Remove the oil cooler housing together with the oil cooler.

Remove the oil cooler from the housing.



2

3

Fig. 4

Inspect the oil cooler for damage and replace if necessary. Fit oil cooler with new seals.

Fit the oil filter with a new seal.
Fill up with engine oil and coolant.

4

Removing the oil pump

Fig. 1

Drain engine oil from the oil pan and from the oil filters.
Use a vessel of sufficient size to ensure that the oil does not overflow.

Danger:
The oil is hot– risk of scalding. Do not touch the oil drain plug with bare fingers. Oil is an environmental hazard. Handle it with care!

Caution:
Old oil is hazardous waste.
Observe safety instructions for the prevention of environmental damage.


1

Fig. 2

Remove oil pan.

Note:
Various oil pan variants are possible. The picture shows a deep oil pan.

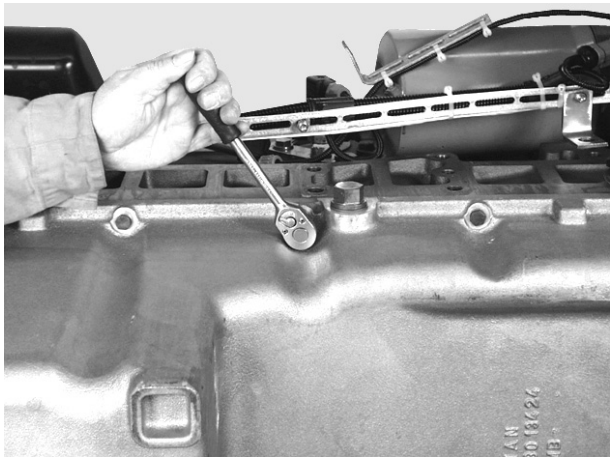

2

Fig. 3

Unscrew the oil intake pipe.

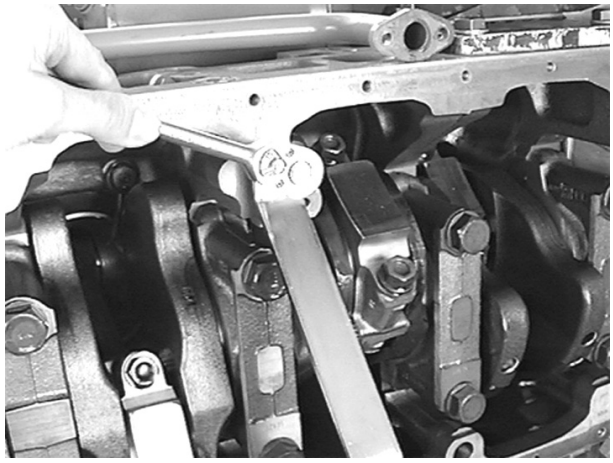
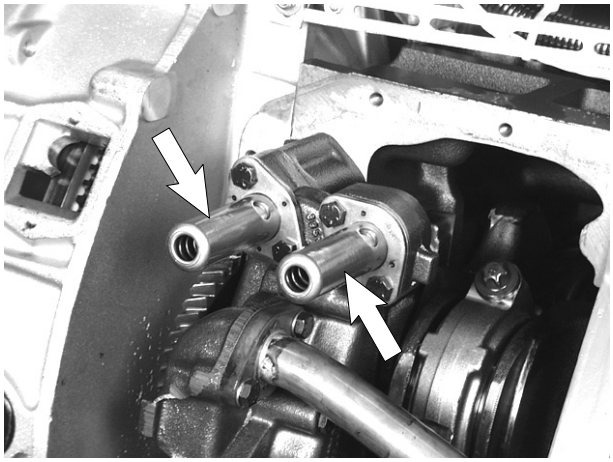

3

Fig. 4

Remove mounting bolts of pressure relief valve and the oil pump.
The overpressure valve is encapsulated.
Opening pressure, see “Service Data”.

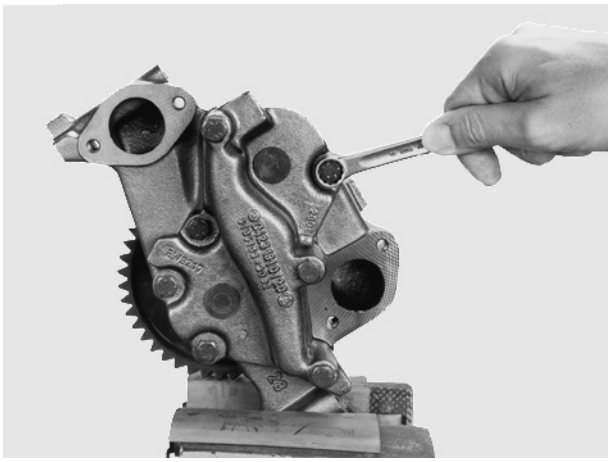
Remove oil pump.


4

Servicing the oil pump

Fig. 5

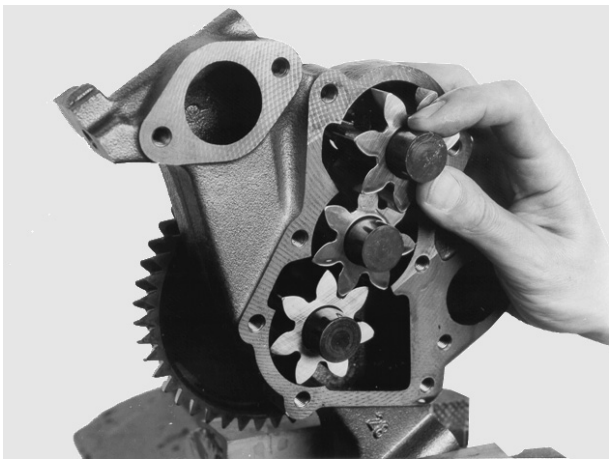
Clamp the oil pump in a vice (use protective jaws).
Remove the oil pump cover.



5

Fig. 6

Pull the driven oil pump wheel from the casing.
Check the toothed wheels and pump casing for wear (see “Service Data”).



6

Fig. 7

Remove the oil pump drive gear.
To do this, lay the pump on a suitable surface and press off the drive gear with a mandrel.
To install, place the drive gear on the shaft, supporting the opposite shaft end in the process.
Press on the drive wheel, observing the prescribed gap (see “Service Data”).

7

Fig. 8

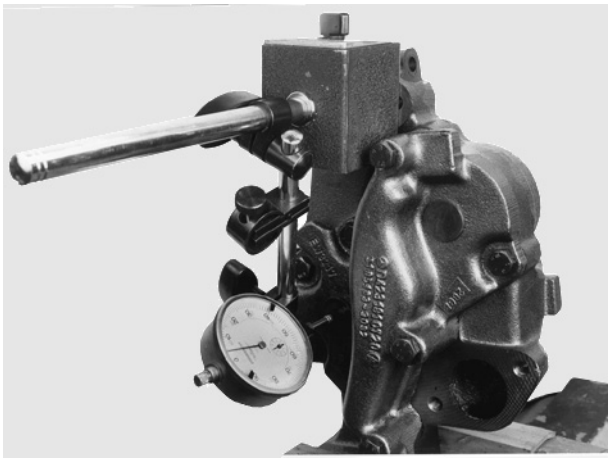
Fit the cover.
Tighten the mounting bolts with the prescribed torque.
Grind or exchange covers if they are severely worn.

8

Checking the axial clearance of the pump wheels

Fig. 9

Attach a dial gauge, push the shaft in one direction up to the stop and set the dial gauge to “0”.
Press the shaft in the opposite direction and read off the reaction of the dial gauge.
Axial clearance of pump gears in new condition see “Service Data”.



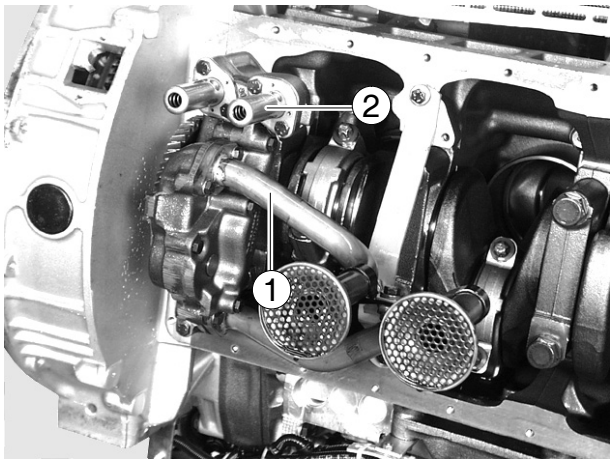
9

Fitting the oil pump

Fig. 10

before fitting, check that the oil pump is running smoothly.

Fit the oil intake line ① with seal. Screw on the pressure-relief valve ② without seal.
Before installing the oil pan, crank the engine to check whether the crank gear and the oil pumps run unimpeded and smoothly.
Stick new oil-pan gasket on to oil pan using grease and then bolt oil pan into place.



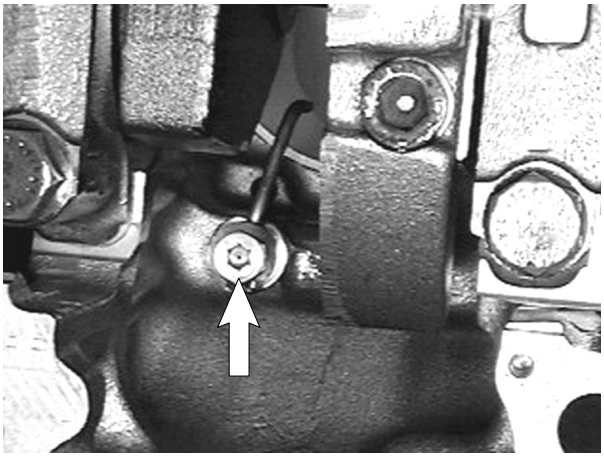
10

Removing oil spray nozzle

- Drain off oil, see page 63
- Removing the oil pan, see page 65

Fig. 1

Unscrew the oil spray nozzle valve (arrowed) and remove with the oil spray nozzle.

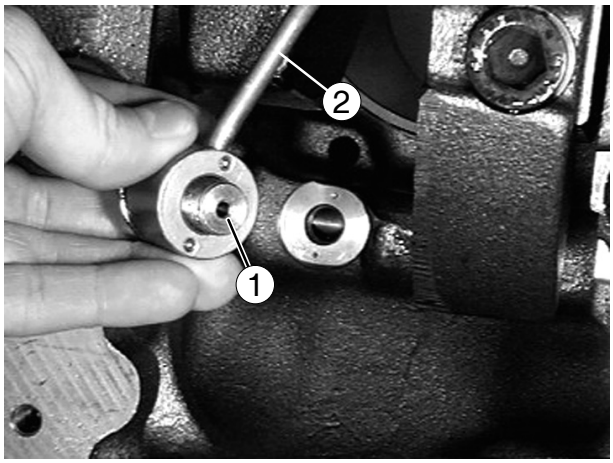


1

Fig. 2

1 Oil spray nozzle valve
2 Oil spray nozzle

Note:
The oil spray nozzles are provided with balls. When the oil spray nozzle valve is tightened at the factory, the balls are pressed into the crankcase where they make impressions which are used as marker points for installing the nozzle in the event of repairs.

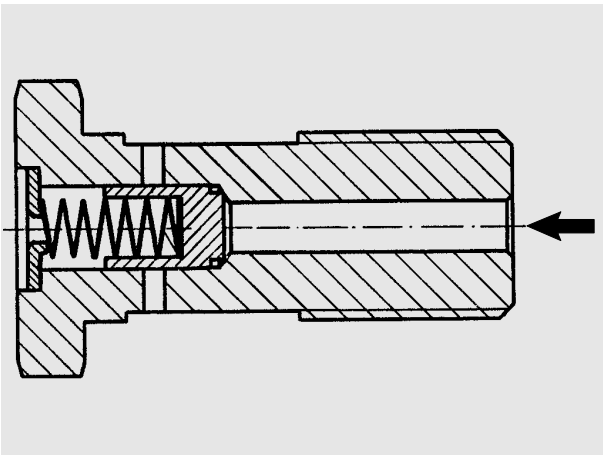


2

Checking oil spray nozzle valve

Fig. 3

Use a piece of wire to check whether the valve piston is easy to move.
Opening pressure, see “Service Data”.



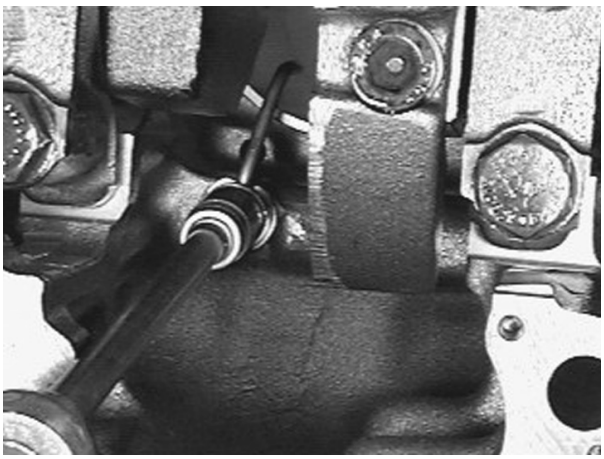
3

Installing the oil injection nozzle

Fig. 4

Screw in the oil spray nozzle together with its valve.
The balls of the oil spray nozzle must be located in the impressions designated for this purpose in the crankcase. This ensures that the nozzle is secured in the correct installation position.
Turn the engine. The crankshaft drive or pistons must not collide with the oil injection nozzle.

Tighten the mounting bolts with the prescribed torque.
Tightening torque . . . . . 70 Nm



4

Removing vibration damper

- Crank the engine to TDC. This ensures that it is easier to fit the graduated disc during subsequent assembly work.
- Relieve tension on the V-belt and remove the belt.

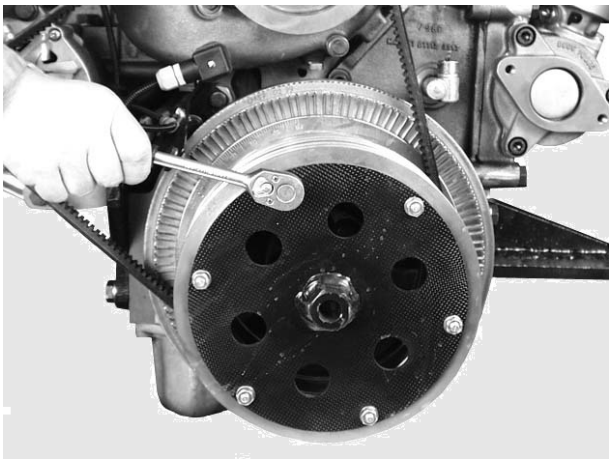
Fig. 1

Block the crank gear.
The picture shows a special tool that is to be fitted to the inspection hole in the flywheel housing.

1

Fig. 2

Remove the barring device and the delivery start pointer.

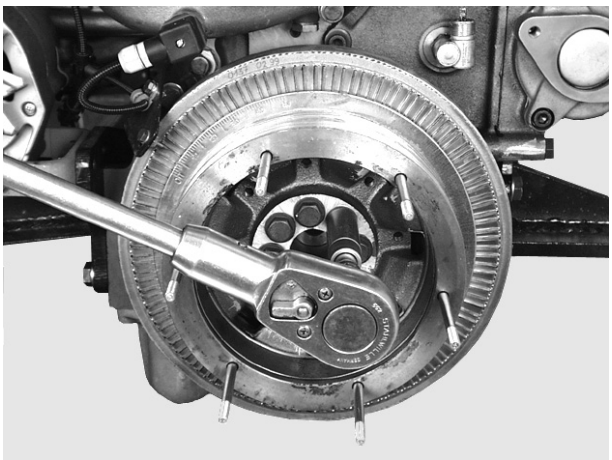


2

Fig. 3

Loosen the mounting bolts of the vibration damper.

Note:
Prior to removal mark the position of the vibration damper relative to the crankshaft. This will ensure that in the subsequent reassembly the graduated disc is in correct position.



3

Fig. 4

Remove vibration damper carefully.

Caution:
The vibration damper is sensitive to impacts.

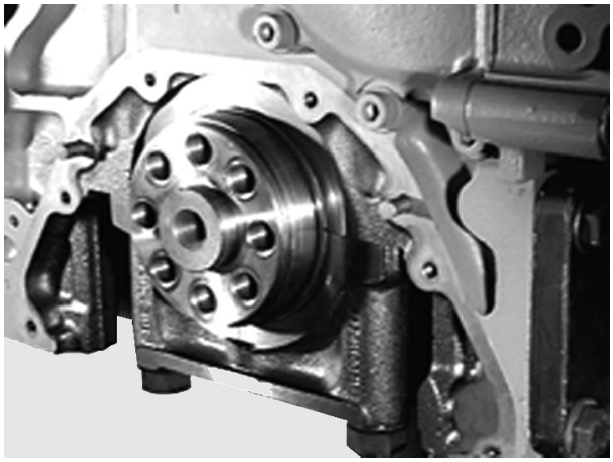
4

Replacing the front crankshaft gasket

Fig. 5

Remove cover.

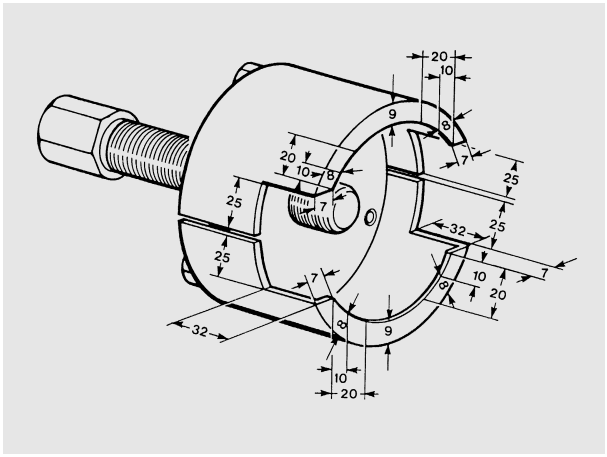
Only replace the front crankshaft gasket as a complete unit, i.e. replace the bearing race and the radial shaft sealing ring.



5

Fig. 6

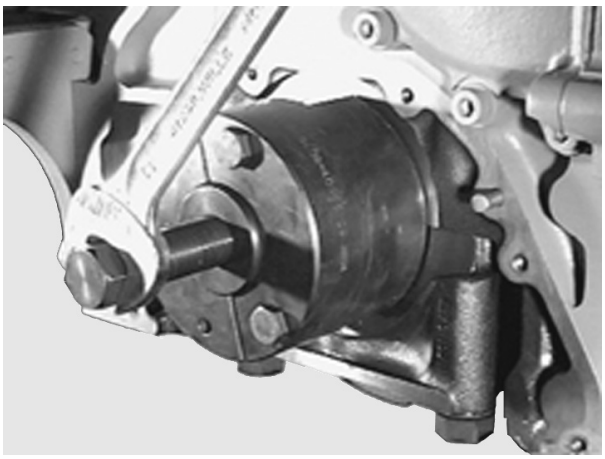
To remove the race, a puller (special tool, see page 185, item 13) is necessary.



6

Fig. 7

Pull off the bearing race.



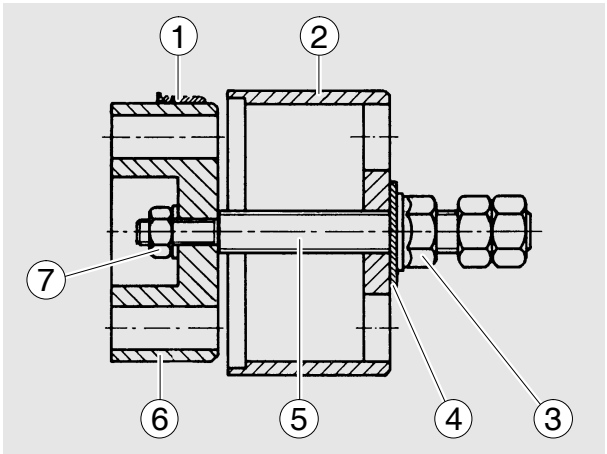
7

Fig. 8

A special too is required to fit the bearing race.

Clean the inside of the bearing race and tail shaft. Coat the tail shaft with sealing compound “Antipor 46”.

- Push race ⑦ and pressing sleeve ⑧ onto adapter ③ .
- Tighten spindle ① in adapter ③ with nut ④ .
- Screw adapter ⑥ securely onto the crankshaft.



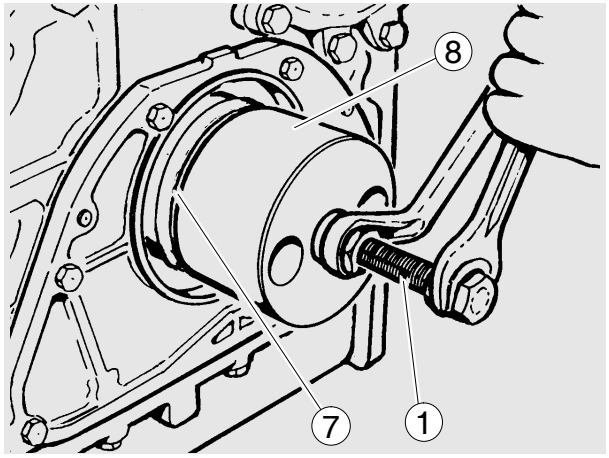
8

Fig. 9

The adapter must lie free of clearance on the crankshaft so that the right press-in depth of the bearing race is ensured.

Pull the bearing race as far as it will go into the press-in sleeve ② on the adapter with collar nut and thrust washer (③ and ④ in Fig. 8).

Note:
The bearing race can also be mounted when the cover is fitted.



9

Fig. 10

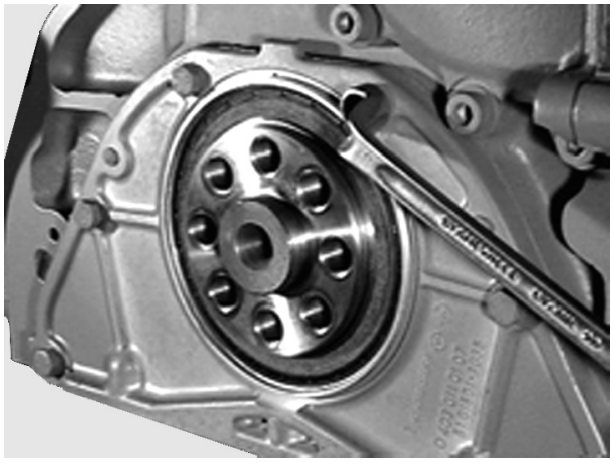
As spare parts the cover and shaft seal are delivered only as a complete assembly in order to ensure correct installation.

So that it remains possible to mount the shaft sealing ring, it must stay on the transport and installation sleeve until assembly.

10

Fig. 11

Fit the cover with a new seal.



11

Installing vibration damper

Fig. 12

Place vibration damper on two guide pins (M16x1.5). Ensure that the position of the graduated disc relative to the crankshaft is correct.

Tighten the mounting bolts with the prescribed torque.

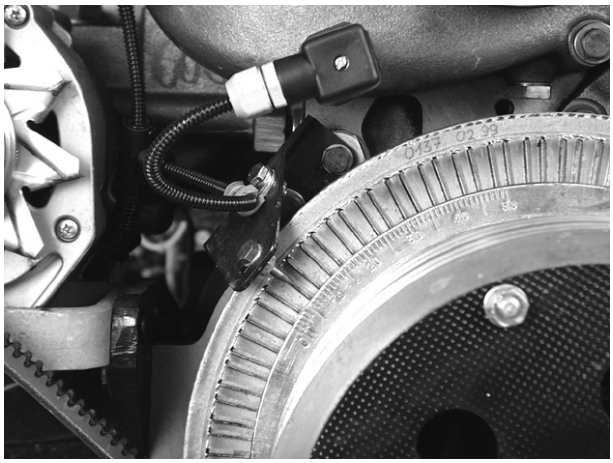
Tightening torque . . . . . 260 Nm

12

Fig. 13

Screw on delivery start indicator and V–belt pulleys.

Refit and tension V-belt (see page 147).

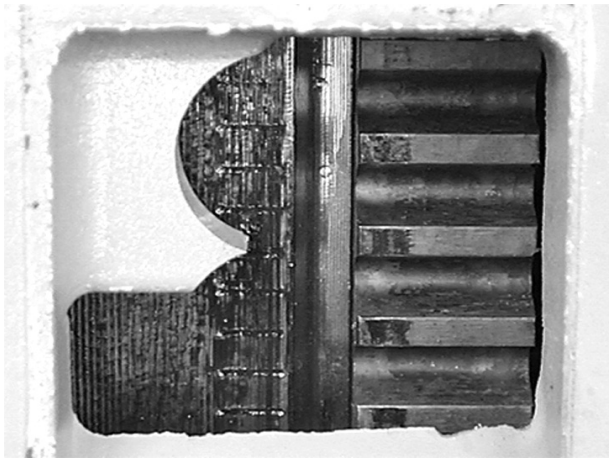


13

Fig. 14

Therefore check whether the scale of degrees on the inspection hole cover of the flywheel housing and on the vibration damper indicate the same values.

If necessary readjust delivery start indicator.



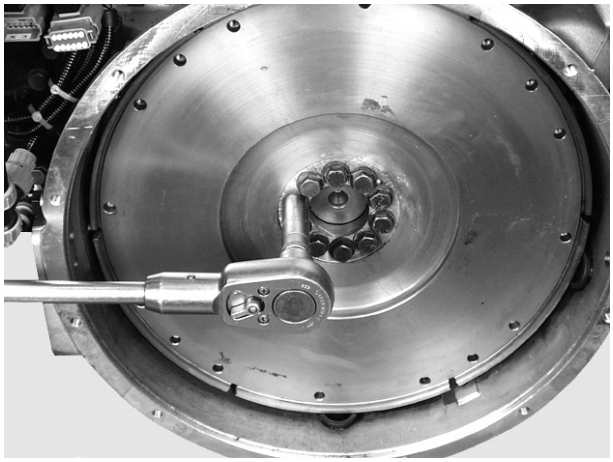
14

Removing flywheel

- Remove rpm sensor

Fig. 1

Release the mounting bolts, securing the engine against rotating if necessary.



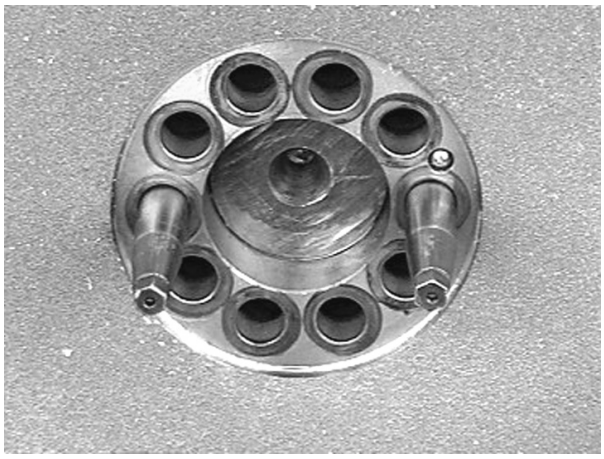
1

Fig. 2

Remove two bolts facing each other and replace them by two guide pins (special tool, item 22, see page 189).

Remove all the bolts.
Pull off the flywheel with suitable lifting gear.

Danger:
The flywheel is heavy!
Use lifting gear.



2

Fitting the flywheel

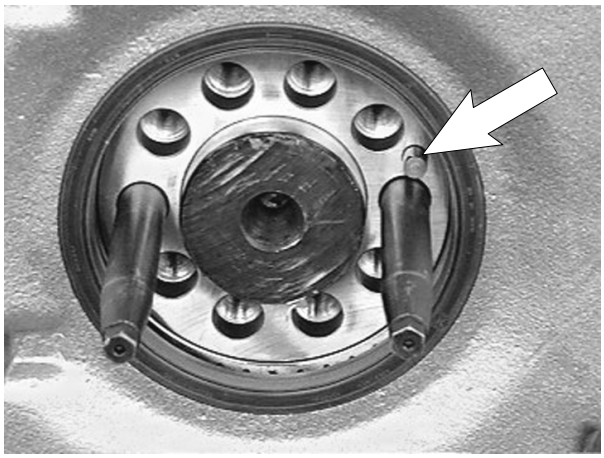
Fig. 3

Insert the guide pins.

Coat the sealing face on the inside of the flywheel with “Antipor 46” sealing compound.

Place guide mandrels on the flywheel; ensuring that the centering mandrel (arrow) fits correctly into the bore in the flywheel.

Push the flywheel on as far as it will go.



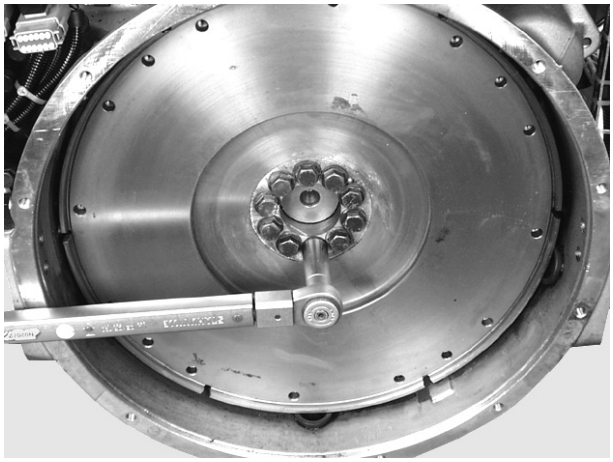
3

Fig. 4

Lightly oil the new mounting bolts (stress bolts), screw them in and tighten in diagonal sequence to specified torque.

Tightening torque:
Initial torque . . . . . 100 –110 Nm
1st angle tightening . . . . . 90–100°
2st angle tightening . . . . . 90–100°

- Install rpm sensor



4

Replacing starter ring gear

Fig. 5

Remove the flywheel.
Drill the starter motor toothed wheel and break with a chisel.

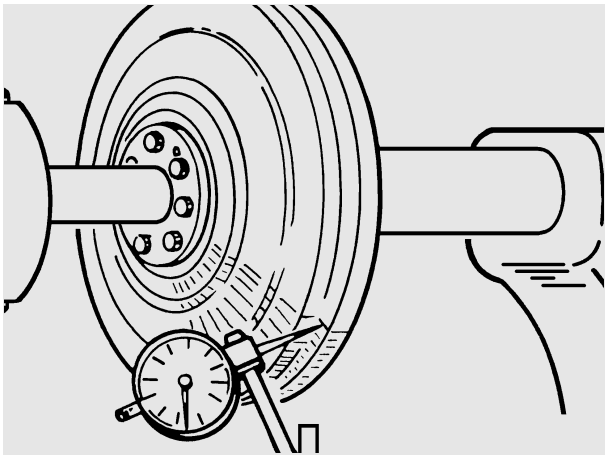
Caution:
In doing so, do not damage the flywheel.

5

Fig. 6

Note:
As the maximum axial run-out of the starter motor toothed wheel must not be exceeded, the axial run-out of the flywheel should be measured on the contact surface of the starter motor toothed wheel prior to shrinking on the starter motor toothed wheel.
If the required value is exceeded, replace the flywheel.

Engage the flywheel at the hub.
Apply the dial gauge to the contact surface of the toothed wheel.
Turn the flywheel a few revolutions by hand and observe the reaction of the dial gauge.



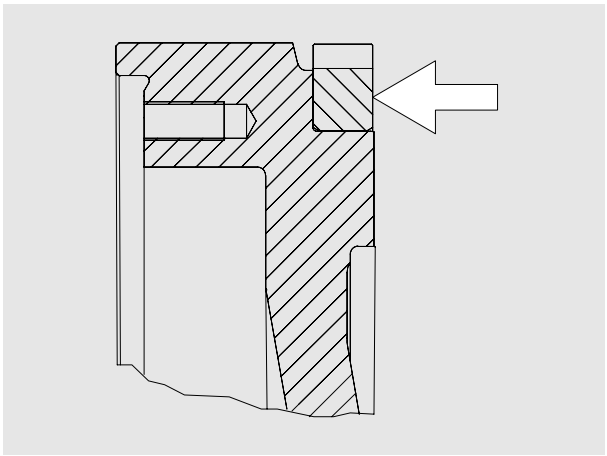
6

Fig. 7

Heat the new starter ring gear to approx. 200°C to 230°C and press on as far as it will go.

Danger:
The parts are hot! Risk of burns!
Wear protective gloves.

Check the axial runout and compare with the max. permissible value.



7

Removing shaft sealing ring

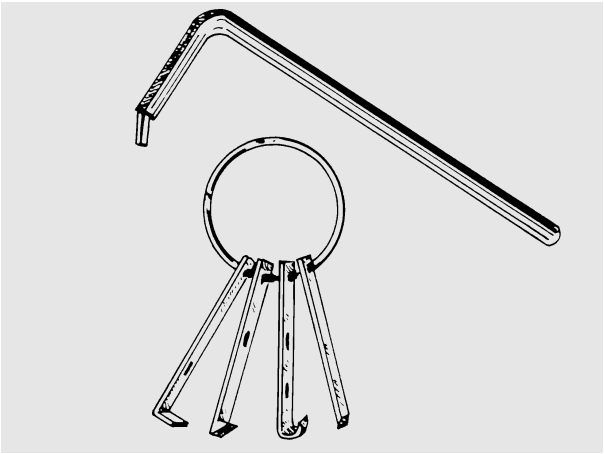
Fig. 1

Remove flywheel, see page 73.
Prise out the seal using the special tool (Fig. 2) or a screwdriver.

1

Fig. 2

Special tool for levering out the crankshaft seal.



2

Fit shaft sealing ring

Fig. 3

When fitting a new shaft sealing ring, you must also replace the flywheel bearing race.
Insert the new shaft sealing ring into the flywheel housing.
Use mandrel (special tools, item 12, see page 185) to drive in sealing ring until flush.
Refer to the comments and assembly instructions on page 77.

3

Replacing the bearing race

- Removing flywheel, see page 73

Fig. 1

If the shaft sealing ring on flywheel side is replaced, it is also recommended to replace the bearing race of the flywheel.

Pull off the bearing race to be exchanged using a puller (special tool).

1

Fig. 2

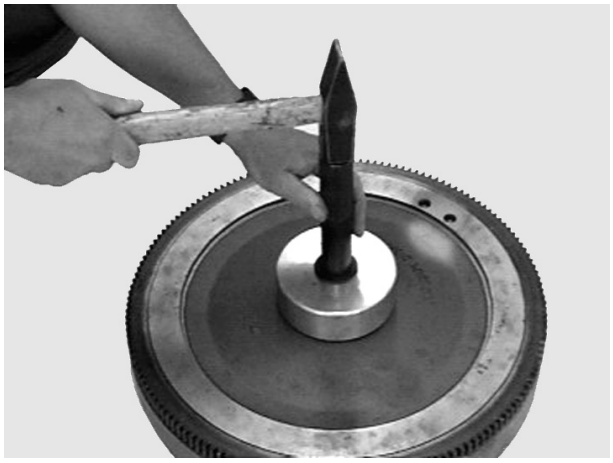
Insert the new bearing race in the drift (special tool) in such a way that the inner bevelled side faces the flywheel when fitted later.

Carefully warm up the drift with bearing race. The installation temperature of the bearing race is approx. 150°C.

2

Fig. 3

Press in the bearing race as far as it will go.



3

Fig. 4

Seal the gap between flywheel and bearing race with “Antipor 46”.

4

General information on crankshaft seals

As a general principle, the radial shaft sealing rings are made of polytetrafluorothylene (PTFE), otherwise known as Teflon.

PTFE sealing rings differ from the elastomer sealing rings that used to be common in that they have a much wider, flat sealing lip that is not pretensioned by a coiled spring expander.

The relatively large pretension of the sealing lip itself means that it curves inwards. This is why the PTFE sealing ring is delivered on a transport sleeve. So that it remains possible to mount the sealing ring, it must stay on this sleeve until assembly. This applies also because the sealing lip is very sensitive and the smallest damage causes leaks.

The sealing lip and the bearing race of the flywheel must not be coated with oil or other lubricants.

On fitting the new sealing ring, always replace the bearing race alongside it.

Assembly instructions for crankshaft seals

- The PTFE sealing ring must be fitted absolutely free of oil and grease. Even the slightest traces of oil on the bearing race or sealing ring will cause leakage
- Remove oil, grease and corrosion inhibitor from the bearing race before assembly. All standard cleaning agents can be used here
- If the PTFE sealing ring is fouled with oil or grease, it is rendered unusable. Cleaning is not permitted in this instance
- The PTFE sealing ring must never be stored without the supplied transport sleeve. Even after it has been stored for a period of only 30 minutes without the transport sleeve, it will lose it pretension and thus be rendered unusable

- Draining off coolant, see page 43
- Remove intercooler, see page 88

Note:
When carrying out work on the intake system, ensure meticulous cleanliness to prevent dirt and foreign matter from penetrating into the system.

Removing intake pipe

Fig. 1

Remove hose connection from waste gate.

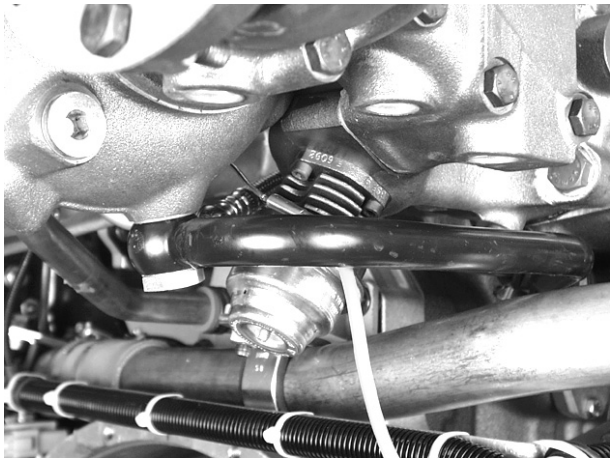
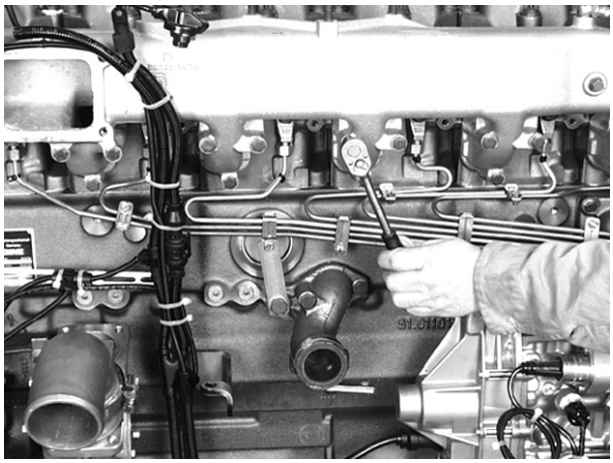

1

Fig. 2

Remove the mounting bolts from the intake manifold.

Remove the intake pipe.


2

Installing intake pipe

Fig. 3

Place intake manifold with new seals in position.

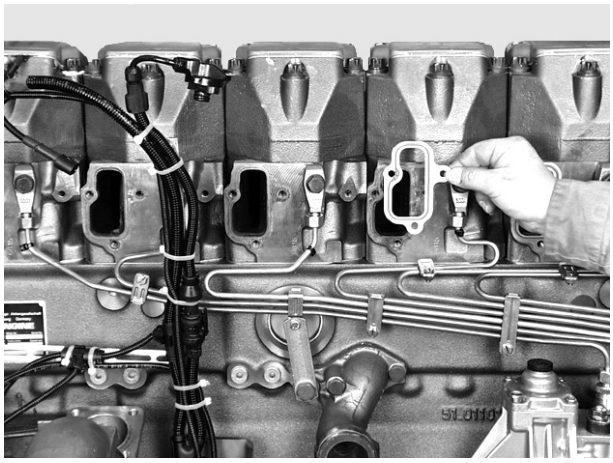
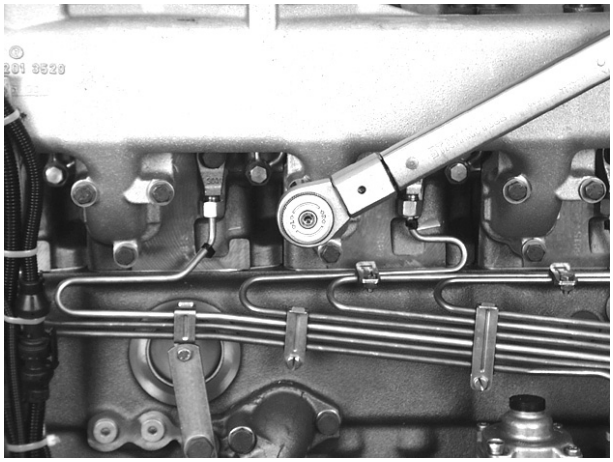

3

Fig. 4

Tighten the mounting bolts with the prescribed torque.
Ensure that the seals are correctly seated.


4

- Draining off coolant, see page 43
- Remove turbocharger, see page 84
- Remove heat exchanger, see page 57

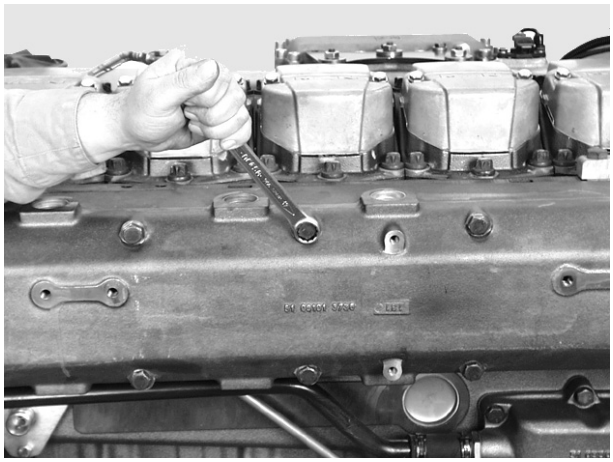
Removing exhaust manifold

Fig. 1

Loosen the mounting bolts of the liquid–cooled exhaust manifold.

Pull exhaust manifold to flywheel and remove.

Danger:
The exhaust manifold is heavy!

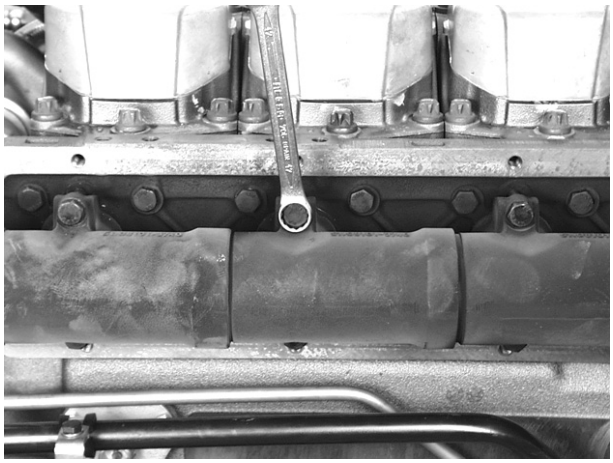


1

Fig. 2

The exhaust pipes are not secured directly on the cylinder heads, rather are bolted onto an intermediate plate and joined without seals.

Note:
Sealing on the exhaust side is ensured by the liquid-cooled exhaust manifold.

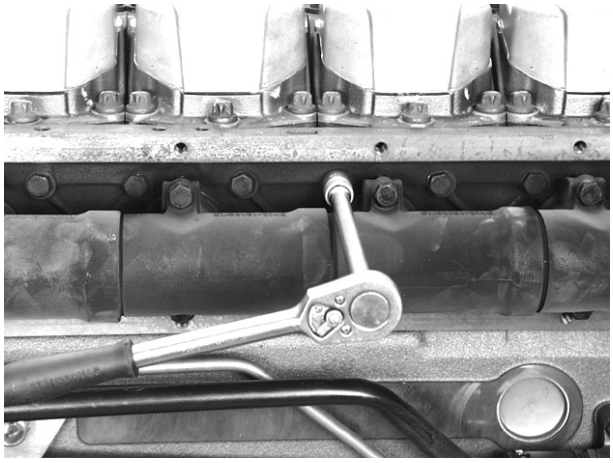


2

Fig. 3

Loosen the mounting bolts of the intermediate plate and remove plate.

Note:
The intermediate plate can be removed together with the exhaust pipes.

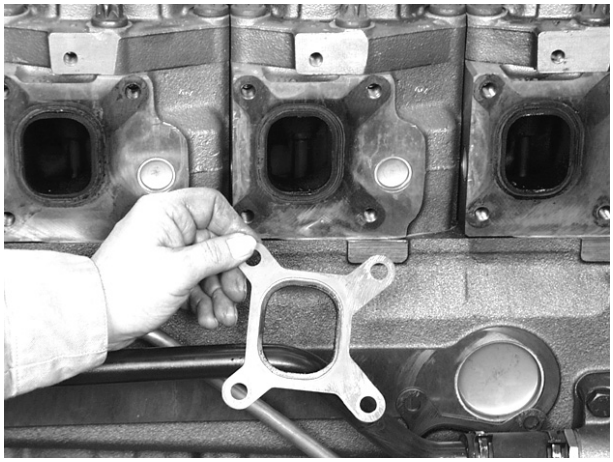


3

Installing exhaust pipe

Fig. 4

Position the exhaust manifold with new gaskets.



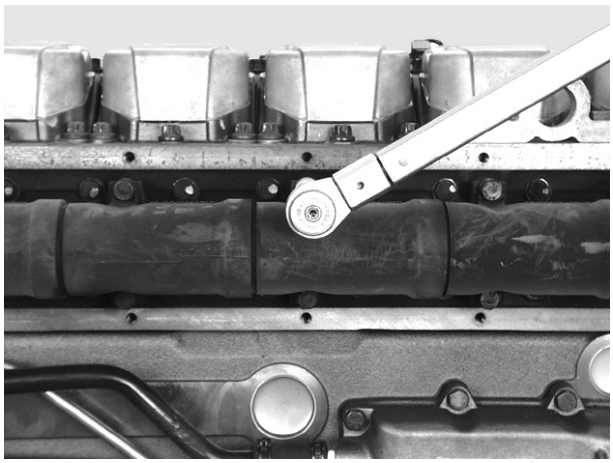
4

Fig. 5

Tighten mounting bolts of the intermediate plate and the exhaust pipes to specified torque (see “Service Data”).

Tightening torque:
Intermediate plate:
Initial torque . . . . . 60 Nm
Angle tightening . . . . . 90°

Exhaust manifold to intermediate plate:
M10 . . . . . 45 Nm
M8 . . . . . 22 Nm

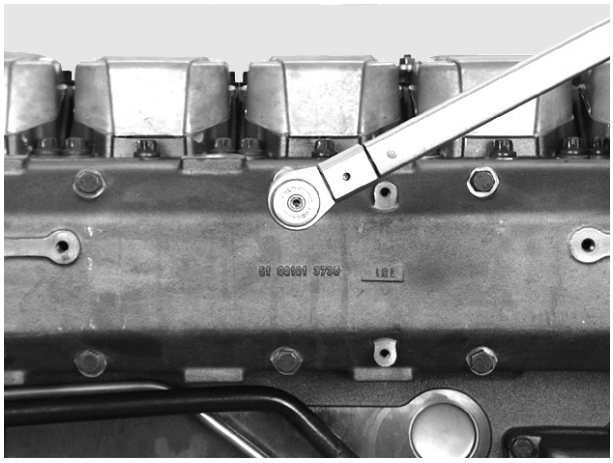


5

Fig. 6

Tighten the mounting bolts of the exhaust manifold to the specified torque(see “Service Data”).

Tightening torque . . . . . 22 Nm



6

Before replacing the turbocharger, carry out the following checks

Turbochargers are frequently replaced if engine oil consumption is too high, power output too low or intake or exhaust gas noises appear to be abnormal.
Subsequent inspections by the manufacturer of the supposedly defective parts frequently prove the turbochargers to be in working order.
To ensure that only defective turbochargers are replaced in future, the following checks must be carried out beforehand:

If oil consumption is too high

- Check the air filter for contamination,
- Ensure adequate engine room ventilation,
- Check the intake pipework for restricted cross-section (caused e.g. by damage, contamination).

These causes give rise to increased oil consumption on account of the increased vacuum pressure at the compressor inlet.

- Check the outside of turbocharger for traces of oil.

Oil consumption caused by the turbocharger is dependent on bearing wear and results in relatively early mechanical damage.

If engine power output is unsatisfactory

Ensure correct adjustment of

- start of fuel delivery,
- valve clearance,
- speed adjustment (pedal value)

Also check the following:

- the compression,
- the charge-air pressure,
- the pressure in the inlet chamber of the injection pump,
- the exhaust back pressure.

If the above checks fail to establish a possible cause, check the turbocharger for:

- coking in the turbine area, which impairs the movement of the wheel assembly (can be eliminated by axial movement)
- dirt in the compressor area
- damage caused by foreign objects

If a significant amount of dirt has accumulated, clean the compressor end and check the bearing clearance.

Caution:
Do not damage the light alloy compressor wheel.

If there are abnormal intake or exhaust gas noises

- Check the intake and exhaust system in the area of the charger group.
  Defective seals can lead you to think the turbocharger is defective and must therefore be replaced.
- If there are still unusual noises, check the bearing clearance.
  Turbochargers in good working order do not make any excessive noise.

If oil accumulates in charge-air pipes and intercooler

The very design of the engine causes a small amount of oil to collect in the charge-air system in the form of oil mist - this is perfectly natural and desired.
The oil mist is required to lubricate the intake valve seats.

If more oil accumulates than is normal, i.e. to the extent that oil pockets develop e.g. in the lower air box of the intercooler, this can lead to oil disintegration or uncontrolled engine racing when the oil is separated. Eliminate the cause in such cases.

Possible causes:

- The engine is overfilled with oil.

Check whether the correct dipstick and guide tube combination is fitted.

- The engine oil used is unsuitable (see publication ”Fuels, Lubricants, Coolants for MAN Diesel Engines”).
- The engine is being run on impermissibly steep inclines.
- The crankcase pressure is to high. This may be caused by a defective oil separator valve (crankcare breather) or piston ring wear.

Compressor coking

This can occur when the charge-air temperature is permanently high, for example when the engine is constantly run at full load.

Coking lowers the boost pressure but does not negatively affect power output or acceleration performance. Coking can increase exhaust gas opacity.

In the event of compressor coking:

- Remove the compressor housing without tilting it If it gets jammed, the compressor wheel blades may get damaged or bent, and the resultant imbalance can ruin the turbocharger
- Remove carbonisation in the compressor housing with a suitable cleaning agent

Danger:
Do not under any circumstances spray in cleaning agent while the engine is running
- Ineffective
- Risk of accident!

- In problem cases, use oil types that are less likely to lead to compressor carbonisation (see publication Fuels, Lubricants, Coolants for MAN Diesel Engines”)

Checking charging pressure

Sufficient boost pressure is essential to ensuring full power output and clean combustion.

Checking the charge-air pressure helps detect damage to the turbocharger, operating faults in the wastegate and leaks in the intercooler and in the charge-air pipes.

Extreme operating conditions (full-load operation and high air temperature) and the use of unsuitable engine oils (see also publication “Fuels, Lubricants and Coolants for MAN Diesel Engines”) may give rise to deposits on the compressor and in the intercooler, resulting in a reduction in boost pressure.

Preconditions for measurement

The start of fuel delivery and valve clearance must be set as specified and the engine must be at normal operating temperature.

Charge-air pressure

A general set-point value for the charge-air pressure cannot be given. Values ascertained on the test bed ought not to be used for comparison, as the respective installation conditions are decisive.
The value which was ascertained when the ship was commissioned and was noted in the commissioning report is to be used as the set-point value.

When carrying out the measurement, observe the following

Based on various atmospheric reference conditions during the measurements and on tolerances of the pressure gauges used, deviations of max. ±100 hPa (±100 mbar) are permitted.

Fig. 1

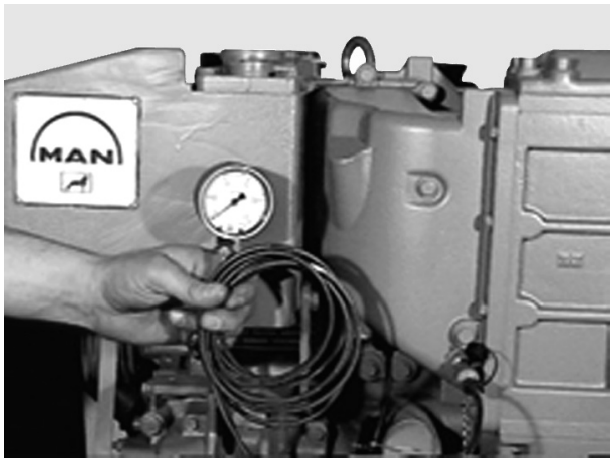
Two measuring connections for checking the charge-air pressure and the charge-air temperature are located in the charge-air elbow behind the intercooler.

Remove the screw plug and connect up the pressure gauge (M14x1,5 and M12x1,5).

1

Fig. 2

Measure the boost pressure downstream of the intercooler at rated engine speed and full load.



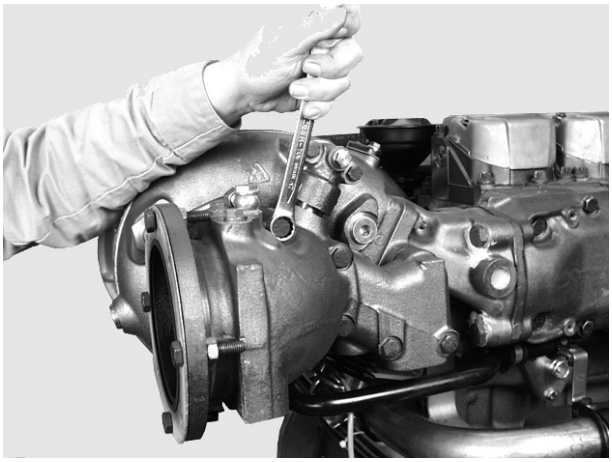
2

Removing turbocharger

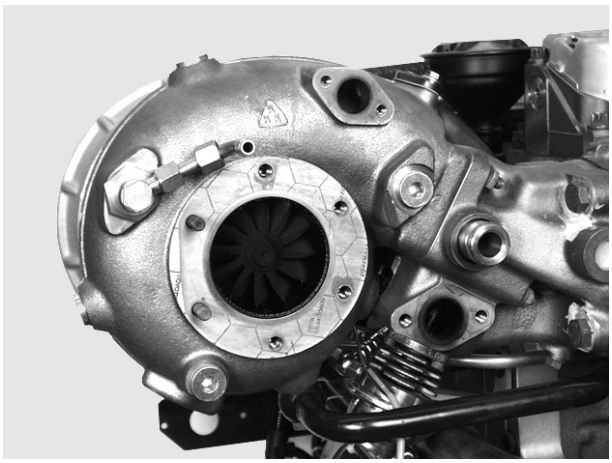
- Draining off coolant, see page 43
- Remove the air filter.
- Remove the hose from the crankcase breather

Figs. 1 and 2

Loosen mounting bolts of the exhaust manifold and remove exhaust manifold.



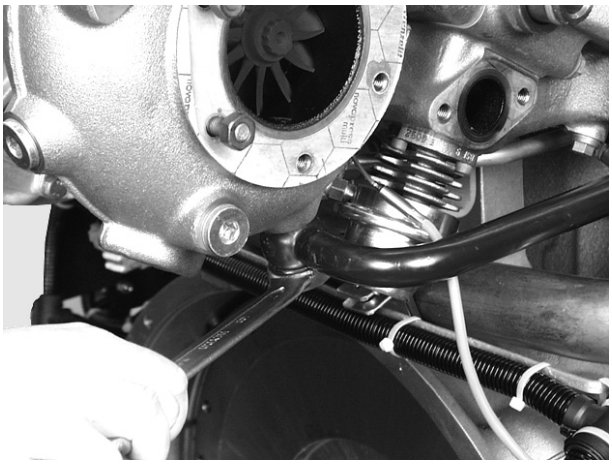
1



2

Fig. 3

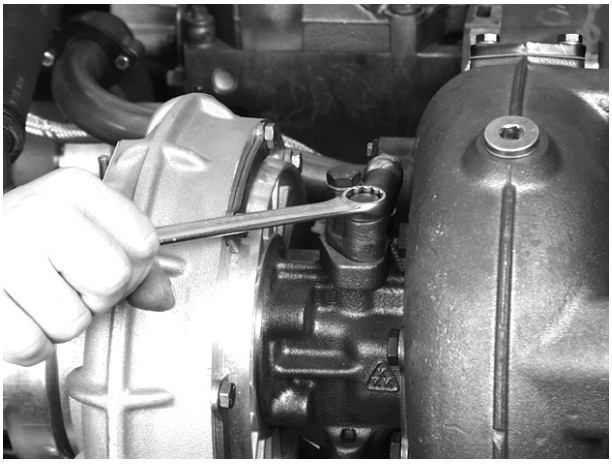
Remove the coolant supply line from the turbocharger.



3

Fig. 4

Remove oil supply and return lines.



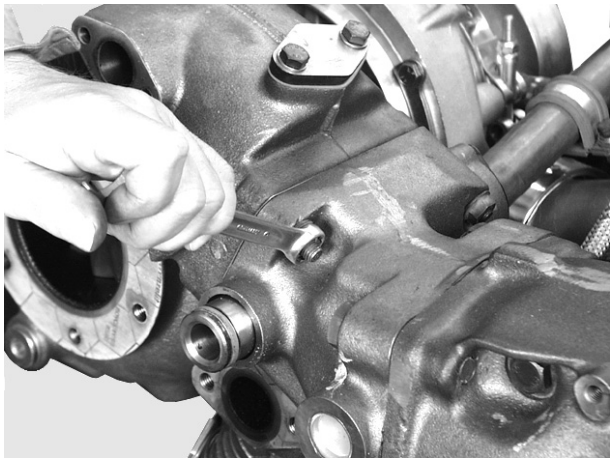
4

Fig. 5

Remove the four (self-locking) nuts from the turbocharger flange.

Take off turbocharger.

Note:
When placing the turbocharger to one side, ensure extreme cleanliness to prevent penetration of dirt and foreign bodies.



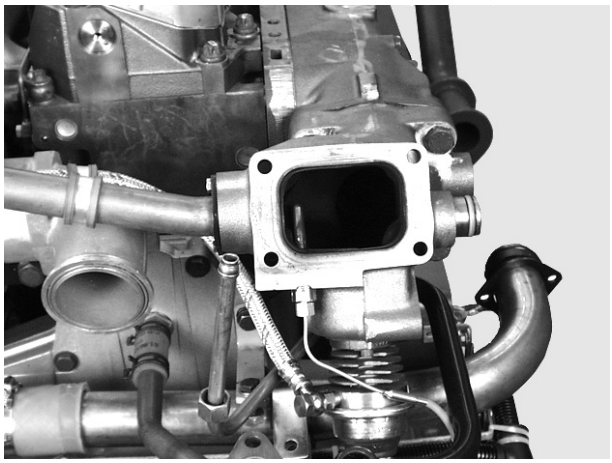
5

Installing turbocharger

Fig. 6

The turbocharger is fitted in reverse order.
On assembly, new seals and new self-locking nuts are to be used.
Before connecting the oil supply line, fill the bearing housing with fresh engine oil.
Check all the connections for leaks and to ensure they are not subjected to strain.

Caution:
Comply with instructions for masking unions on pressurised oil and fuel pipes (see page 3).

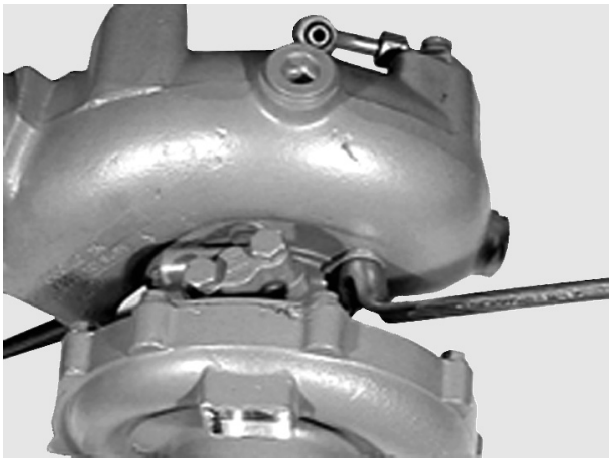


6

- Remove turbocharger, see page 84

Fig. 1

Mark the turbine housing relative to the bearing housing and remove the turbine housing.



1

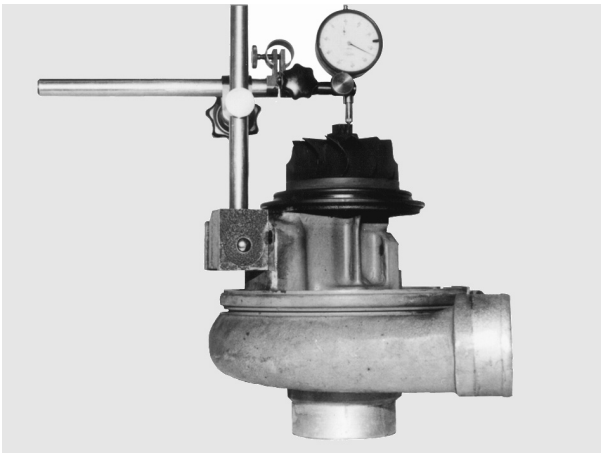
Axial clearance

Fig. 2

Arrange the dial gauge bracket with magnetic foot and dial gauge as shown in the illustration. Apply the dial gauge with initial tension on the face of the shaft end of the turbine wheel.

Press the rotor shaft against the dial gauge, read off and note the value. Press the rotor shaft in the opposite direction, read off and note the value.

The difference between the values obtained is the axial clearance. Replace the turbocharger if this clearance is exceeded.



2

Radial clearance

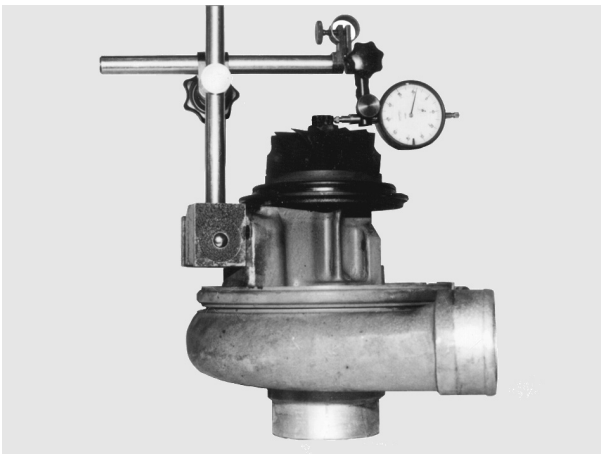
Fig. 3

The radial clearance is measured only on the turbine side with a dial gauge or feeler gauge.

Place the measuring tip of the dial gauge to the side of the hub, press the turbine wheel to the dial gauge, read off and note the value.

Press the turbine wheel in the opposite direction, read off and note the value. The difference between the values obtained is the radial clearance.

Place turbine housing in position, observe markings and screw on turbine housing.

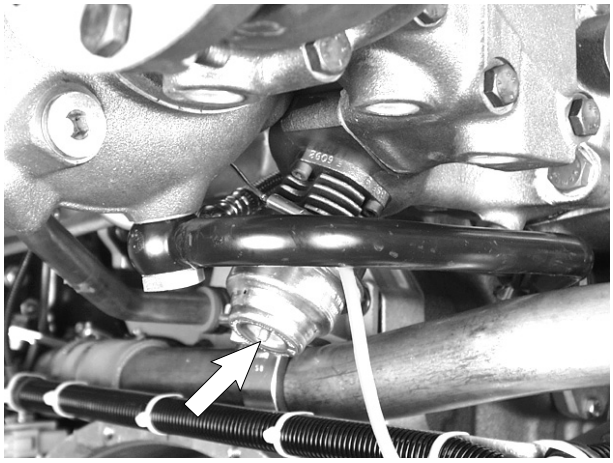


3

Fig. 1

The engines D 2876 LE4.. are equipped with waste gates (arrow). Their task is to limit the charge–air pressure to a precisely defined value.

Manipulation or modification of the setting is not permitted.

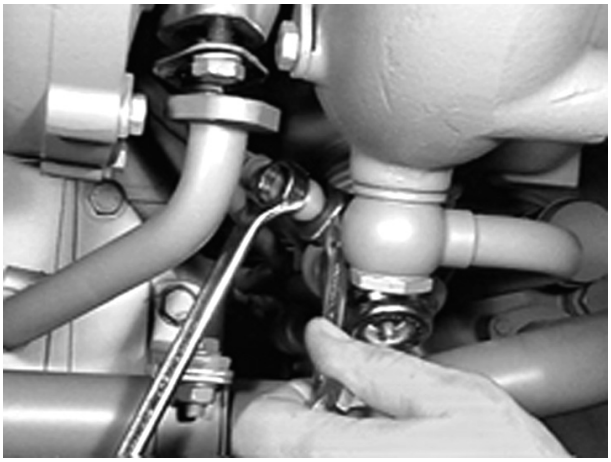


1

Fig. 2

The waste gates are maintenance-free.

For replacement, unscrew the air hose and loosen the mounting bolts. Use a new sealing ring.

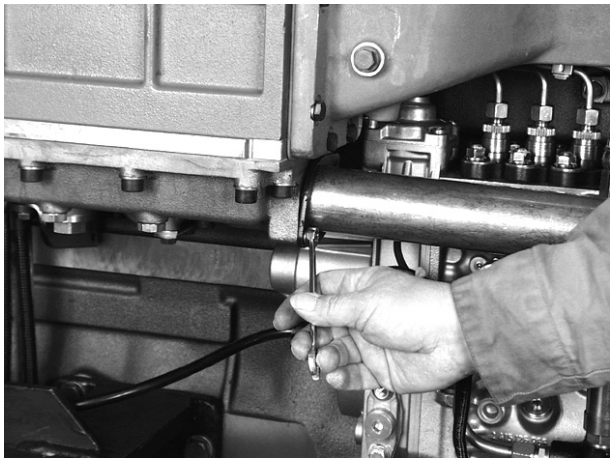


2

- Drain coolant from crankcase and intercooler, see page 43
- Loosen piping of the fuel filter and remove fuel filter

Fig. 1

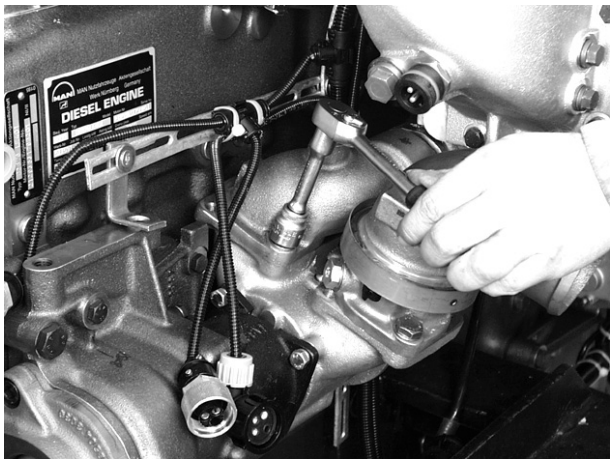
The coolant lines are fastened by means of plug connections. To remove them, unscrew pressure flange.



1

Fig. 2

Remove neck from the seawater pump.

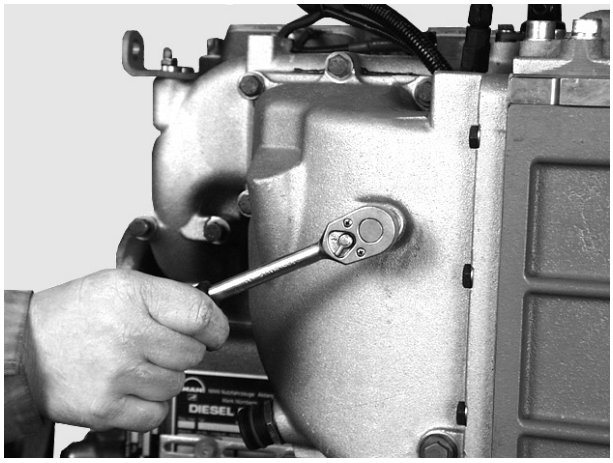


2

Fig. 3

Remove the five bolts from the intercooler connecting elbow leading to the intake pipe.

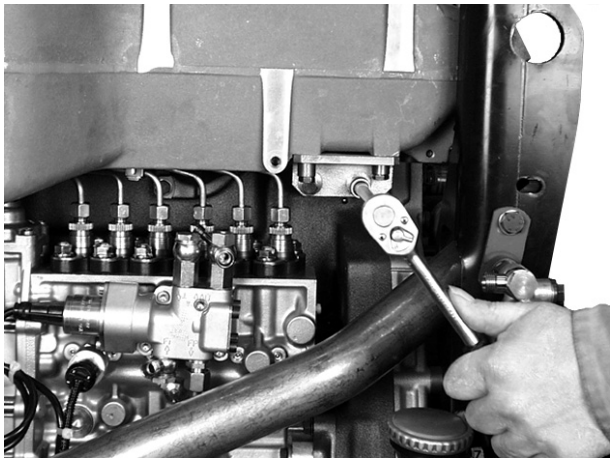
> **Note:**
> For reasons of space, one bolt between the expansion tank and the elbow can be reached only with a 1/4” socket and an extension.



3

Fig. 4

Take the brackets off the charge-air pipe leading from the compressor to the intercooler.

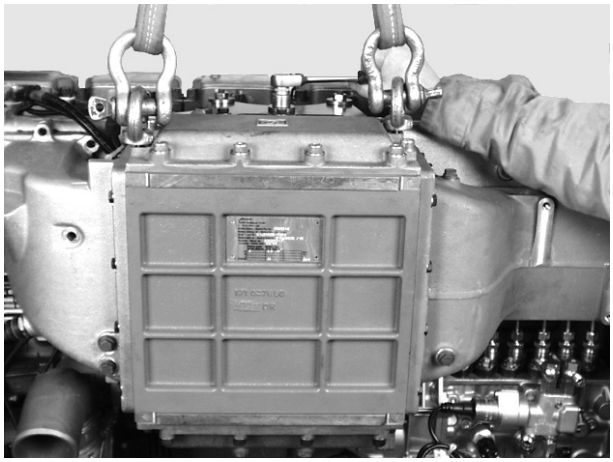


4

Fig. 5 and Fig. 6

Take off intercooler. Shake the intercooler to open the lower plug connection from the coolant intake neck.

Danger:
The intercooler is heavy.
Use lifting gear or work with a helper.



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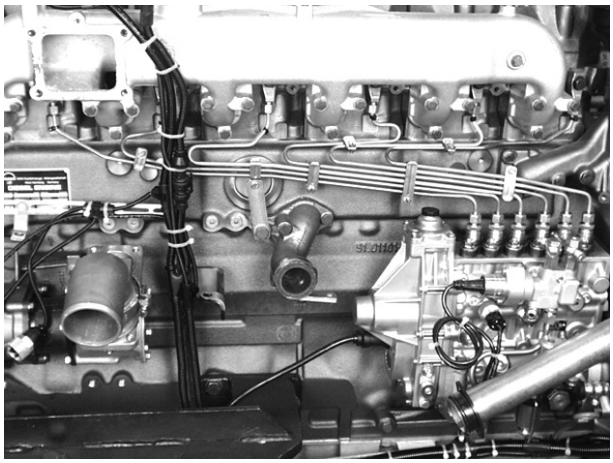
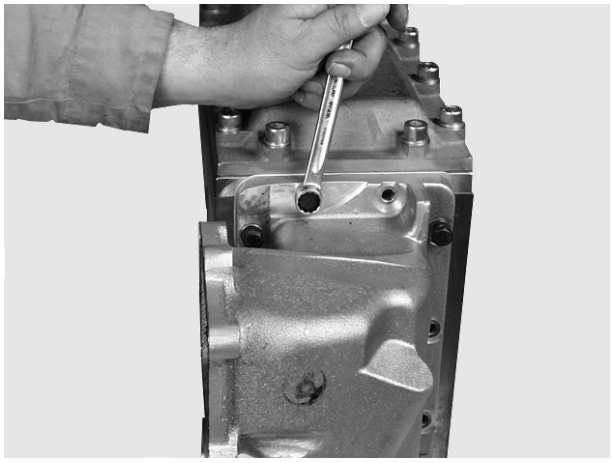


6

Disassembling and cleaning intercooler

Fig. 7

Remove charge-air elbow.

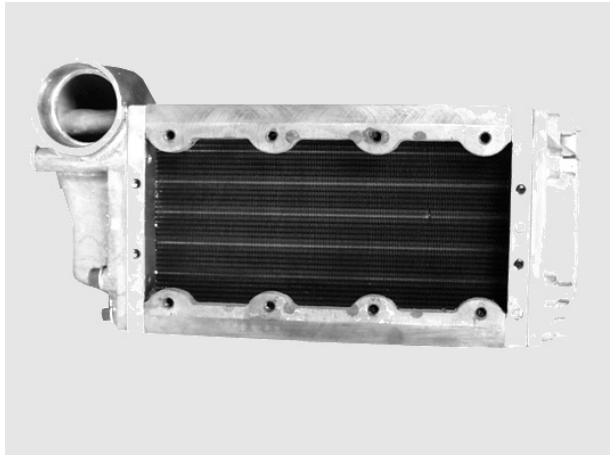


7

Fig. 8

Clean the fins on the intercooler of oil and residues, using a steam jet cleaner.

Do not damage the fins.



8

New cylinder head seal and modified cylinder bush from March 2003

From March 2003 the cylinder bush, the upper seal on the cylinder bush, the cylinder head seal and the torque regulations on various series D 2876 four valve engineswithout Common Rail have been modified as standard.

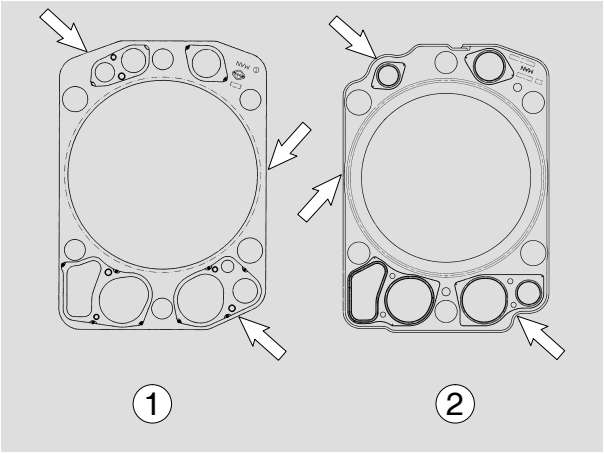
Note:
To aid recognition, these engines do not have the sticker “First retightening of cylinder-head bolts completed” on one of the valve caps.

Fig. 1

1 Version until 28.02.2003

2 Version since 01.03.2003

The differences between old ① and new ② cylinder head gaskets are marked by arrows.



1

Caution:
A mixture of old and new versions in the same engine is not permitted!
Conversion is possible only if the cylinder head gasket, the cylinder liners and the cylinder liner seal are changed to the new version in all cylinders!

Note:
The modifications to the cylinder liners and the cylinder liner seal can be seen the the section “Changing cylinder liners”, page 140.

Removing the cylinder head

- Draining off coolant, see page 43
- Remove expansion tank, see page 47
- Remove heat exchanger, see page 57
- Remove intercooler, see page 88
- Remove liquid-cooled exhaust manifold, see page 79
- Remove injection nozzles, see page 32

Fig. 1

Detach fuel leak-off oil line.
Remove the coolant bleed pipe.
Remove the cylinder head covers.

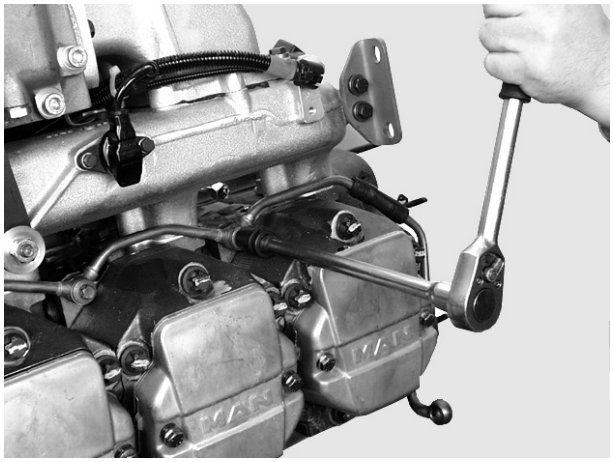

1

Fig. 2

Back off the valve adjusting screws.
Release and remove the cylinder head bolts in reverse order of tightening.

Note:
Use a reinforced screwdriving machine to loosen and tighten the cylinder-head bolts.

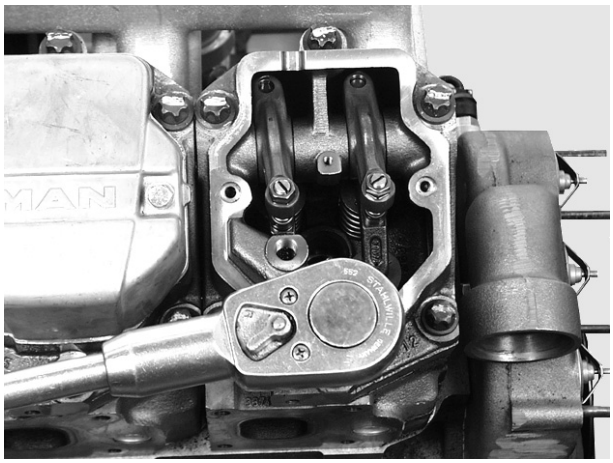

2

Fig. 3

Remove the rocker arm bearing housing.

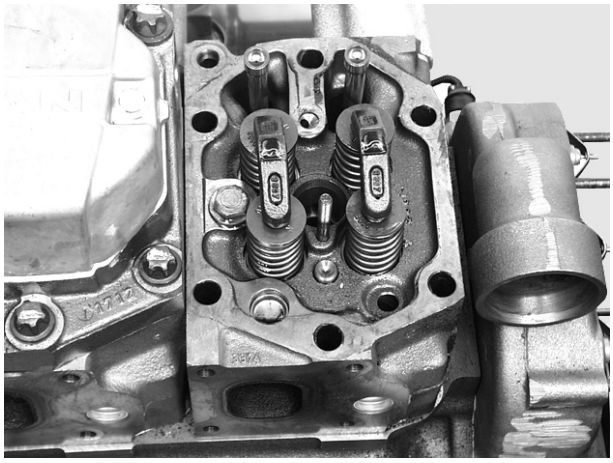

3

Fig. 4

Remove the valve bridges.
Take out the push rods.

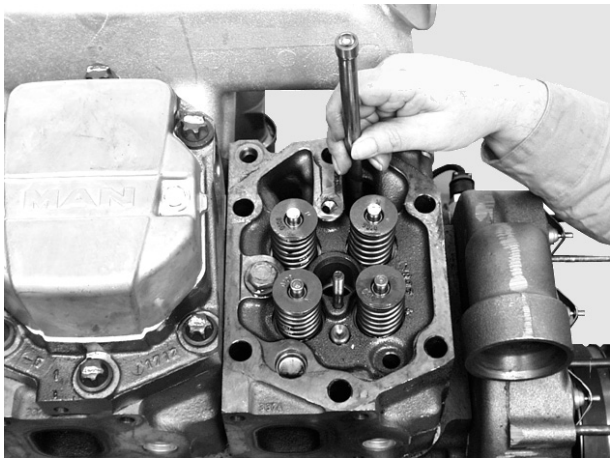
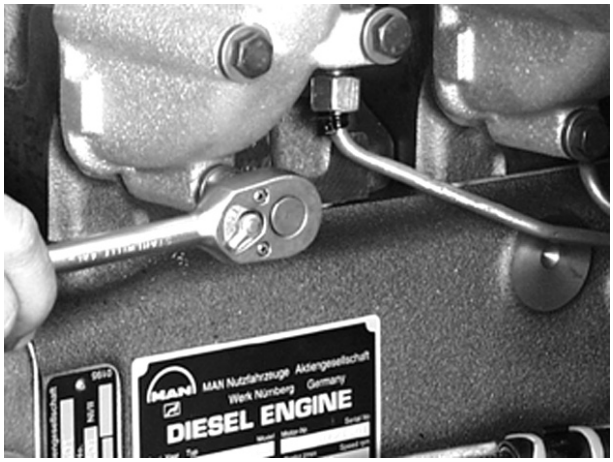

4

Fig. 5

Remove the mounting bolts from the intake and exhaust pipes for the respective cylinder head.

Loosen all bolts of intake manifold and intermediate plate.

This will reduce the tension on the cylinder head, and the head can be taken off more easily.



5

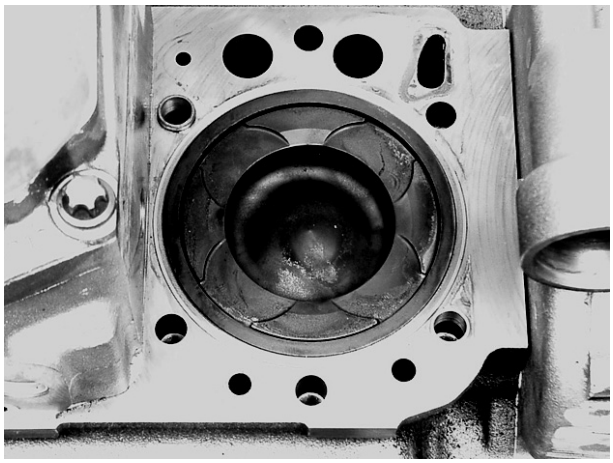
Fig. 6

Remove the cylinder head and cylinder head seal.

Check whether the cylinder head sealing face and cylinder block are flat using a straightedge.

Caution:
The cylinder head sealing face must **not** be reworked.

Note specified nozzle projection and valve recess (see “Service Data”).



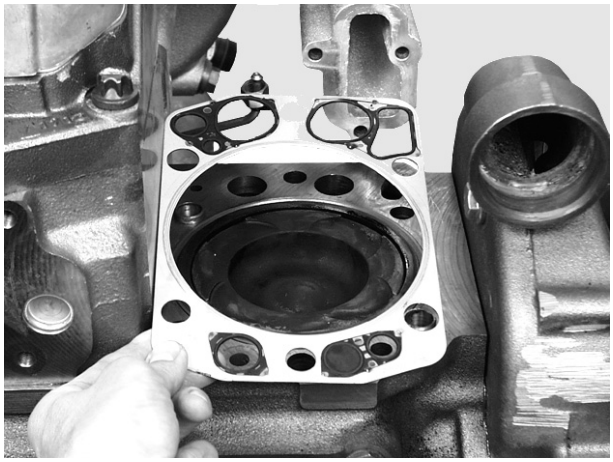
6

Fitting the cylinder head

Fig. 7

Before fitting, clean and blow out the threaded holes in the crankcase. Clean the sealing surfaces on the cylinder head and on the crankcase.

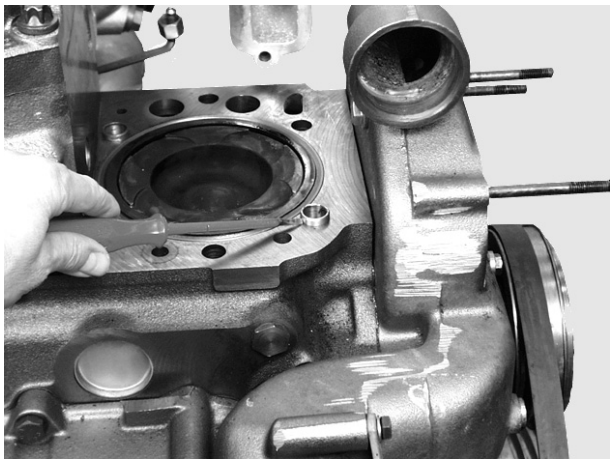
Lay the new cylinder head seal in place, ensuring that the hole patterns match up, and place the cylinder head on top.



7

Fig. 8

Each cylinder head is fixed in position with 2 fitting sleeves.

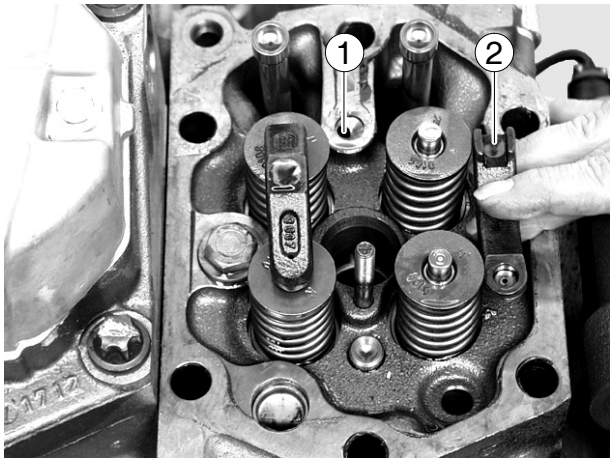


8

Fig. 9

Check the tappet push rod for deformation. When inserting the tappet push rods, ensure that they fit in the socket of the valve tappet.

Insert the valve bridges with the cut-through sides ② facing the push rods.

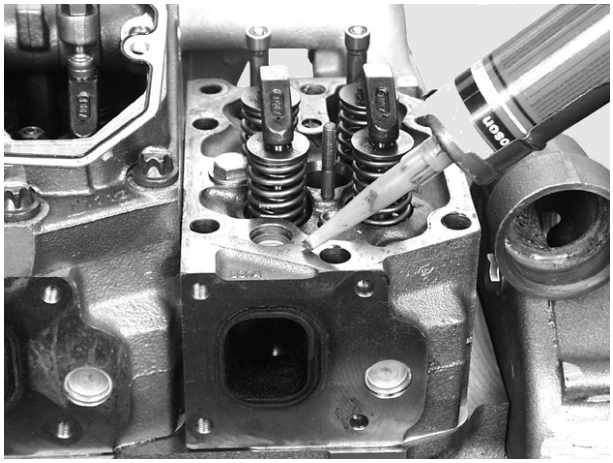


9

Fig. 10

Apply a thin bead of “Loctite 5900” sealing compound to seal the rocker arm bearing housing.

Caution:
The bore hole (① in Fig. 9) must be kept clear for the oil supply!



10

Fig. 11

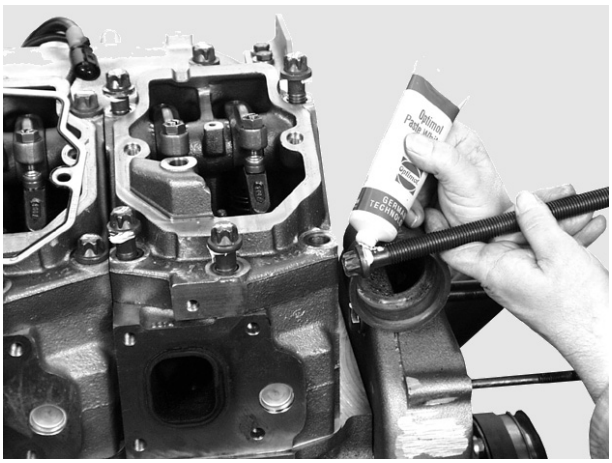
Fit the rocker arm bearing housing, inserting the rocker arm ball pins into the tappet ball sockets.

11

Fig. 12

Check that the cylinder head bolts do not exceed the max. permitted length (see “Service Data”). Removed bolts can be reused if the max. permitted length is not exceeded.

Before inserting the cylinder-head bolts, apply engine oil to the thread and coat the seating surface of the bolt head with installation paste “Optimoly White T”.



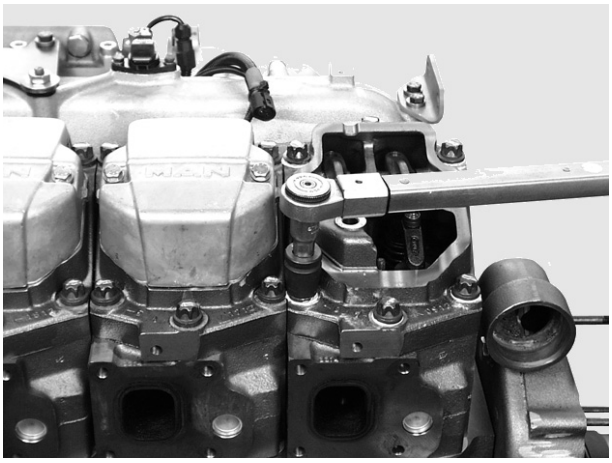
12

Fig. 13

Tighten the bolts according to the rotation angle method. Observe the tightening sequence, specified tightening method, information and instructions on the cylinder head bolts in the publication “Service Data”.

Note:
To avoid any distortion between the cylinder heads and exhaust pipes, we recommend proceeding as follows:

- Fit the cylinder head gaskets and cylinder heads.
- Turn the head bolts a few thread turns.
- Secure steel ruler (special tool) with ground face on the exhaust side; tightening torque for mounting bolts 20 Nm.
  If a steel ruler is not available, mount exhaust manifold and tighten to 20 Nm.
- Tighten the cylinder-head bolts as prescribed.
- Unscrew the straightedge.
- Tighten the exhaust pipe and intake manifold with the prescribed torque.

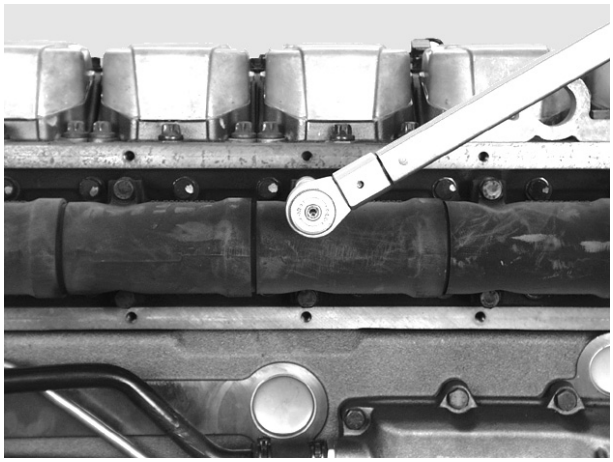


13

Fig. 14

Fit new seals between the cylinder head and intake pipe or intermediate plate.

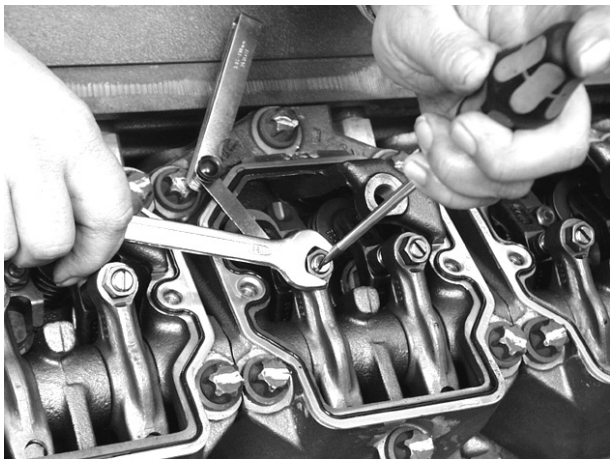
Tighten the mounting bolts of the intake pipe and intermediate plate to the specified torque (see “Service Data”).



14

Fig. 15

Set valve clearance, see Page 97. Fit injection nozzle.
Fit the cylinder head cover with a new gasket.
Fit coolant bleed line with new seals.
Fill up with coolant, see Page 44.



15

General notes

The sealing effect of the cylinder head seal depends mainly on whether the required initial tension of the cylinder-head bolt is actually achieved and retained.

To tighten the cylinder-head bolts, use a calibrated torque wrench. The specified final torque must be maintained for at least 5 seconds when it is applied. When using snap-type torque wrenches, tighten the bolts gradually as otherwise the torque selected will not be fully transferred to the bolts.

Observe notes on usability of cylinder head bolts, tightening sequence and specified tightening method in the publication “Engineering • Data • Setting Values”.

Tightening

“Tightening” is the initial tightening of the newly fitted bolts that have not yet been tightened following a repair - e.g. after replacement of the cylinder head seal. Tighten the cylinder-head bolts with the engine cold, i.e. the crankcase is hand-warm or colder.

Before inserting the cylinder-head bolts, apply engine oil to the thread (not the threaded hole) and coat the seating surface of the bolt head with installation paste “Optimoly White T”.
Do not use oils or oil additives containing MoS_2.
In the case of unoiled bolts, a significant portion of the tightening torque is converted into friction and is thus lost for the bolt pretensioning.

- To secure the cylinder heads, tighten the cylinder head bolts only slightly
- Align the cylinder heads by screwing on the straightedge (special tool).
  If a steel ruler is not available, use exhaust or intake manifold.
- Tighten step by step in the right order and with the prescribed tightening torque and / or angle of rotation

Caution:
If individual bolts are tightened too much during preliminary tightening, the cylinder head is distorted. The distortion can no longer be removed with continued tightening in accordance with regulations!

Fig. 1

Remove the cylinder head covers.

Fig. 2

Use barring device to turn engine so that the piston in the cylinder to be set is at TDC and the all valves are closed. At this point both inlet and exhaust valves will be open i.e. valves overlap.

Note:
As far as possible turn engine only in direction of rotation (anti–clockwise as seen when looking at the flywheel) in order to prevent the direction of rotation of the sea water pump impeller being reversed.

Fig. 3

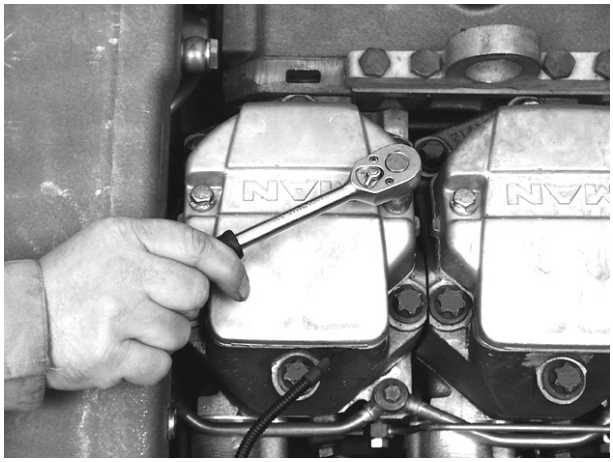
Valves are in crossover in cylinder:

1	5	3	6	2	4
6	2	4	1	5	3

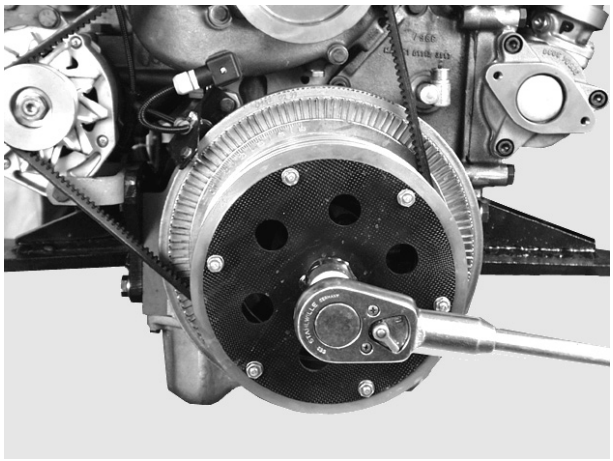
Set valves on cylinder:

Arrangement of cylinders and valves

I Engine front end
II Flywheel side
A Exhaust valve
E Inlet valve



1



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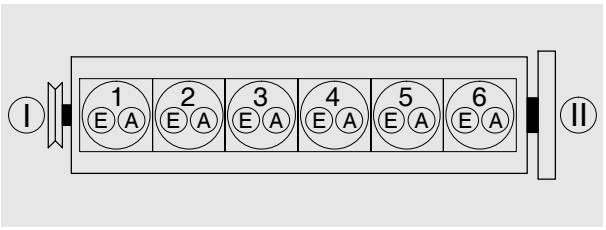


3

Fig. 4

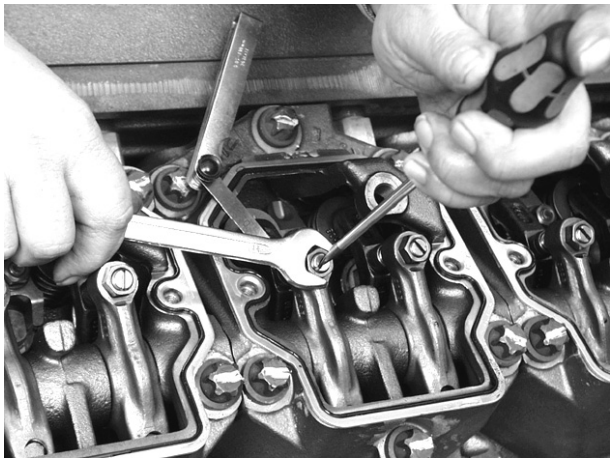
Push feeler gauge between valve connection and rocker arm. Loosen the locknut and turn the adjustment screw until the feeler gauge can be moved with slight resistance

Valve clearance:

Intake: 0.5 mm
Exhaust: 0.6 mm

Tighten the lock nut to specified torque using the screwdriver to prevent the adjusting screw from turning.
Tightening torque . . . . . 22 Nm
Check clearance again.

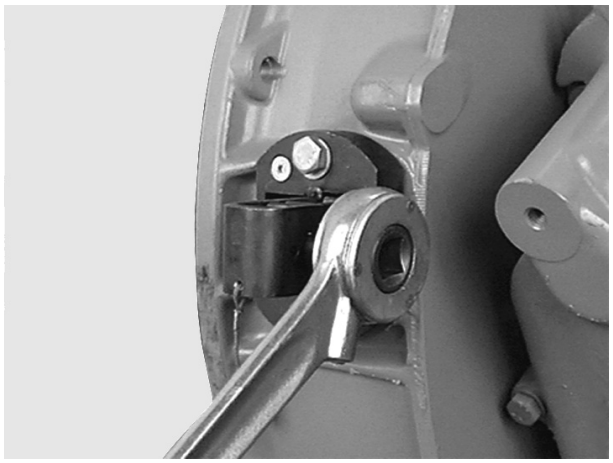
Refit cylinder head covers.



4

Fig. 5

An engine cranking device (special tool) may be mounted also at the inspection hole of the flywheel housing.



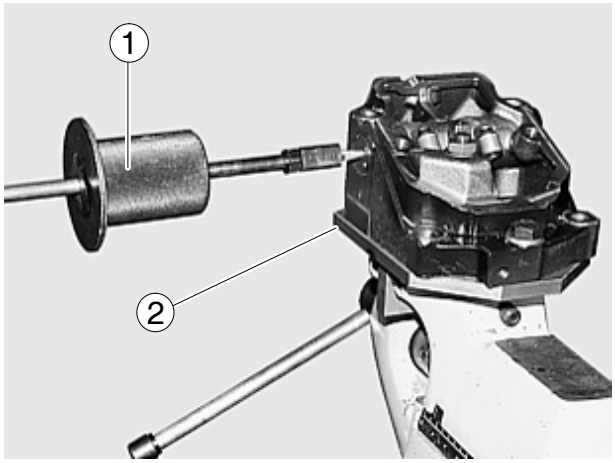
5

Disassembling rocker arm mechanism

- Remove cylinder head, see page 91

Fig. 1

Clamp the assembly plate ② (special tools, see page 185, item. 8) in a vice and bolt the rocker arm bearing housing to the assembly plate.
The exhaust valve rocker arm shaft has a tapped hole.
Screw adapter and impact puller ① into this tapped hole.



1

Fig. 2

Pull out the exhaust valve rocker arm shaft and remove the rocker arm.

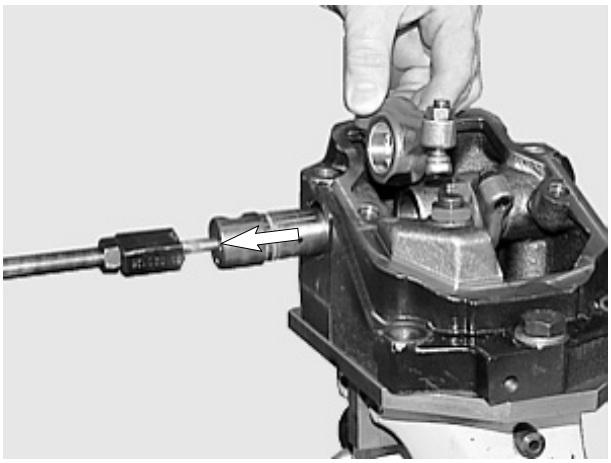

2

Fig. 3

Drive out the intake valve rocker arm shaft with a suitable plastic mandrel.

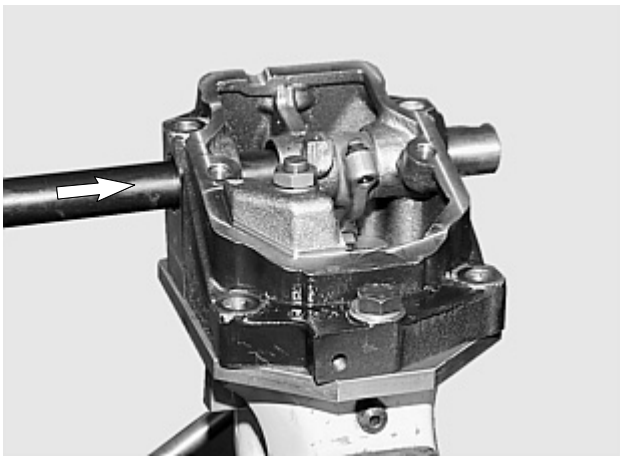

3

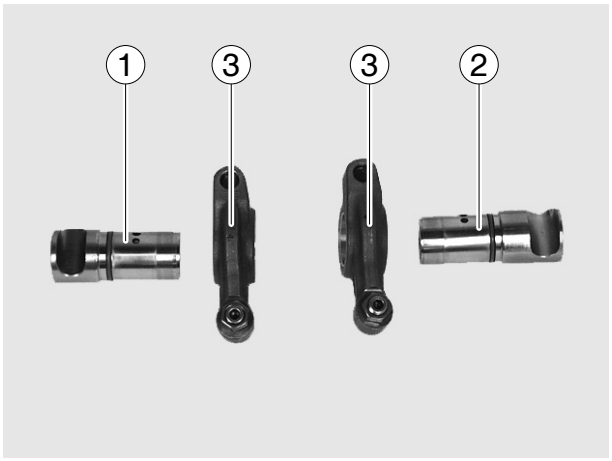
Fig. 4

Remove the rocker arm shaft and rocker arm.


4

Fig. 5

① Rocker arm shaft for exhaust valves
② Rocker arm shaft for inlet valves
③ Rocker arm



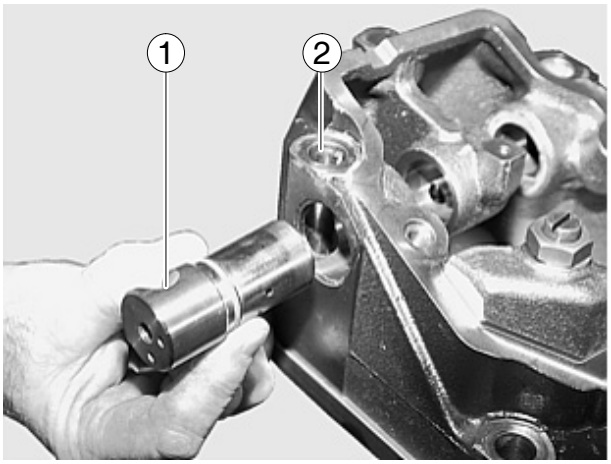
5

Assembling rocker arm mechanism

Fig. 6 and Fig. 7

Recesses ① in the rocker arm shafts serve to accommodate the cylinder head bolts ②.

Align the rocker arm shafts so that the holes for the cylinder head bolts are kept free.



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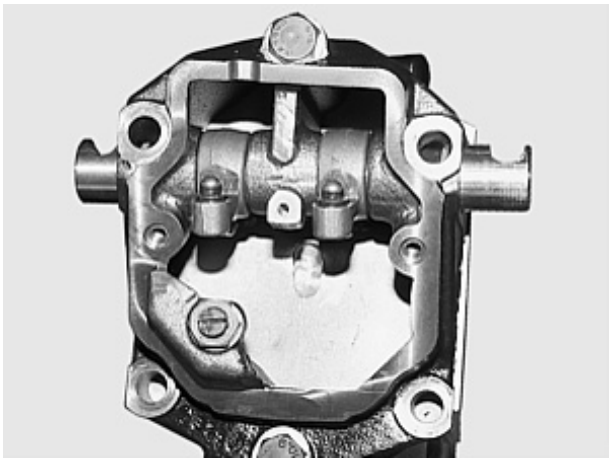
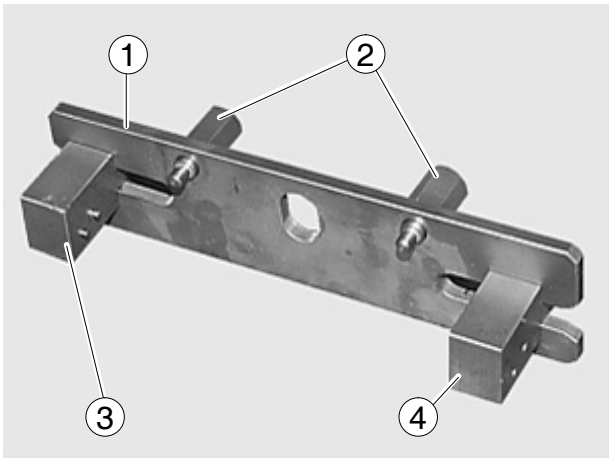


7

Fig. 8

Press-in device for the rocker arm shafts (special tools, item. 15.3, see page 187).

① Guide plate
② Mounting bolts
③ Press-in part “A” for exhaust-side shaft
④ Press-in part “B” for intake-side shaft



8

Fig. 9

Bolt the guide plate onto the rocker arm bearing shaft – with “TOP” facing the intake side.

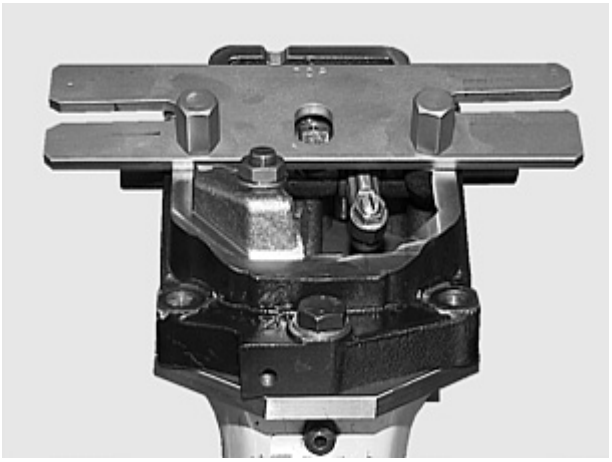


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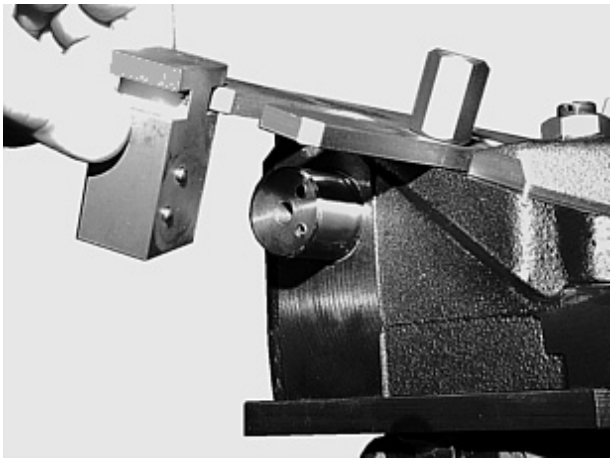
Fig. 10

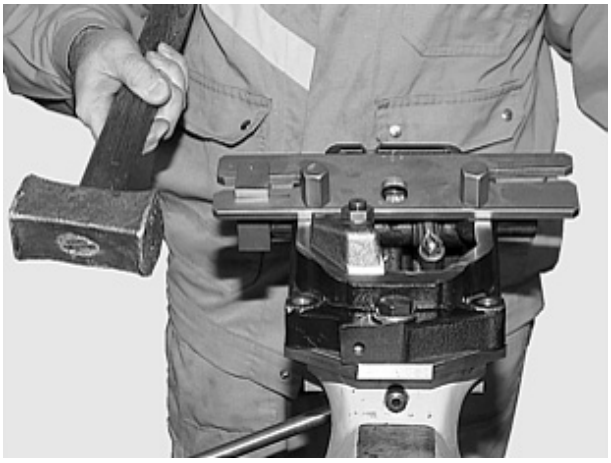
Insert press-in part “A” for the exhaust-side shaft into the guide plate, ensuring that the alignment pins fit into the shaft bores.



10

Fig. 11

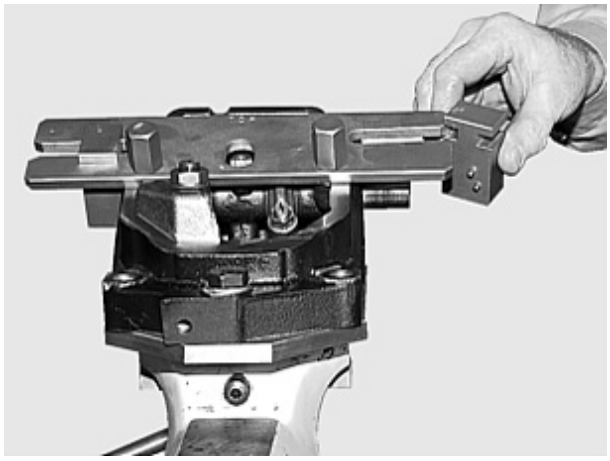
Drive the rocker arm shaft fully home into the bearing housing.



11

Fig. 12

Insert press-in part “B” for the intake-side shaft into the guide plate, ensuring that the alignment pins fit into the shaft bores.
Drive the rocker arm shaft fully home into the bearing housing.



12

Fig. 13

Remove the press-in tool.
Check the rocker arms for ease of movement and axial play.

13

Removing valves

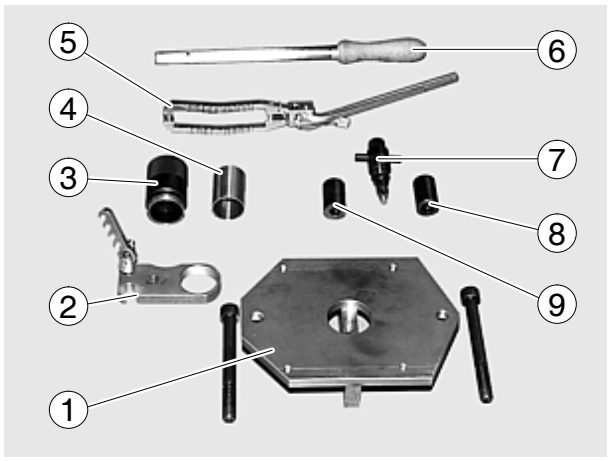
- Remove cylinder head, see page 91

Fig. 1

Special tools for removing and installing the valve springs:

① Assembly plate for cylinder head and rocker arm bearing housing (not in tool case)
② Anchor plate with grid part
③ Guide sleeve
④ Additional guide sleeve for 4-valve cylinder head
⑤ Pressure fork
⑥ Extension for pressure fork
⑦ Assembly cartridge for retaining wedges
⑧ Sleeve with large diameter for 2-valve cylinder head
⑨ Sleeve with small diameter for 4-valve cylinder head

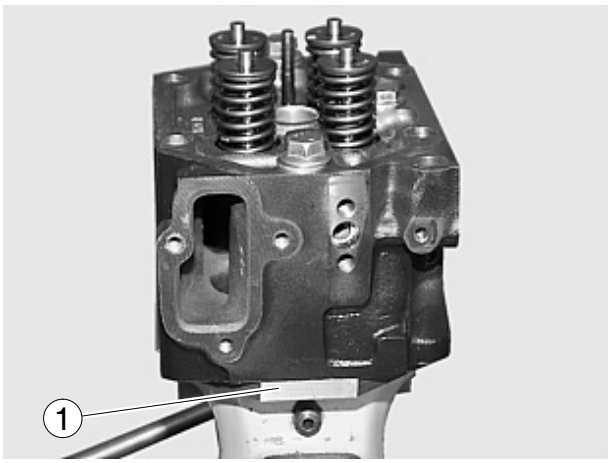
Depending on the cylinder head, the sleeves are bolted onto the mounting cartridge.



1

Fig. 2

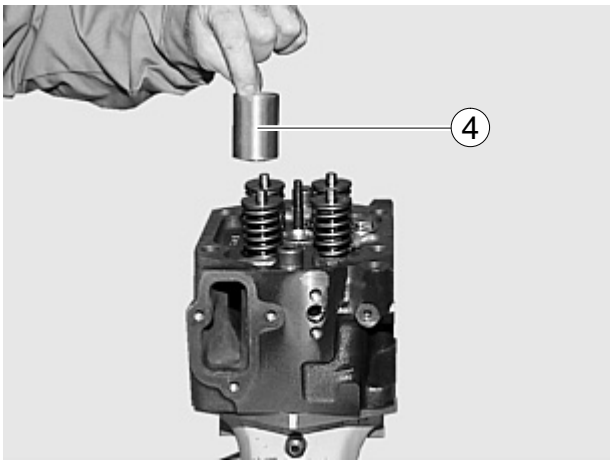
Secure the cylinder head on mounting plate ①.



2

Fig. 3

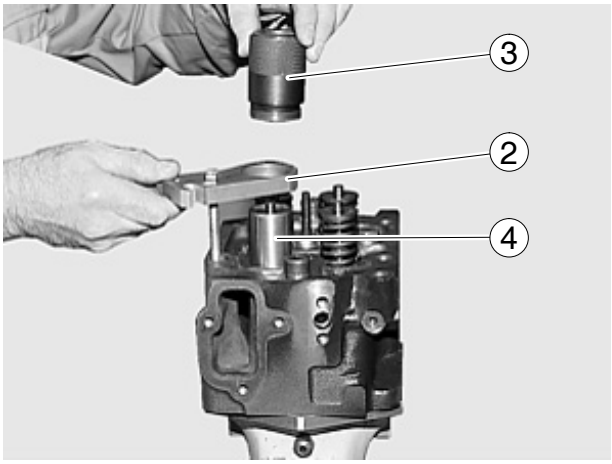
Fit guide sleeve ④ over the valve spring for centring.



3

Fig. 4

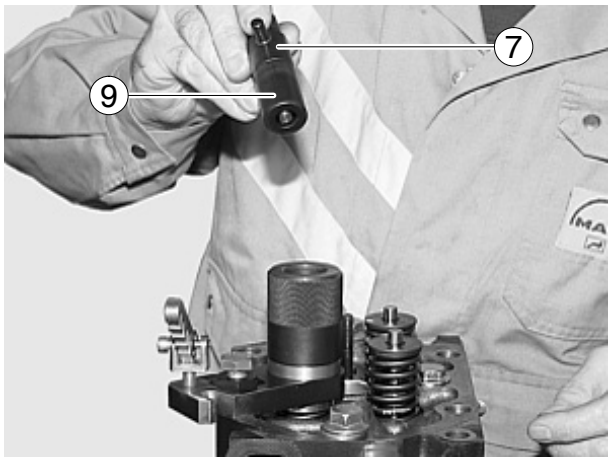
Screw guide sleeve ③ into anchor plate ② and push both parts over guide sleeve ④ onto the cylinder head.
Bolt down the anchor plate.



4

Fig. 5

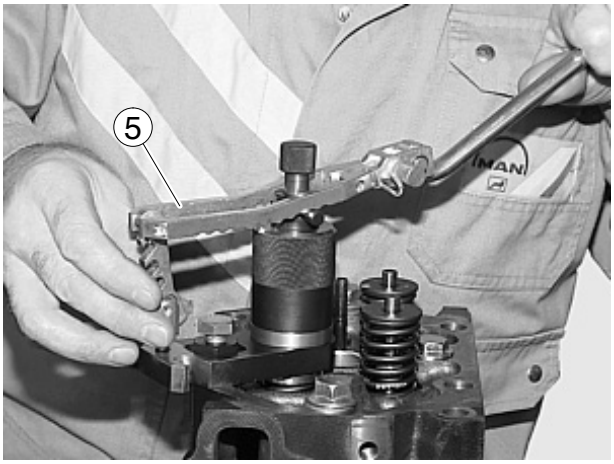
Feed mounting cartridge ⑦ with sleeve ⑨ (small dia.) into the guide sleeve and using the knurled grip insert the holder into the joint between the retaining wedges.



5

Fig. 6

Attach pressure fork ⑤ and press down as far as possible with the mounting cartridge.
Press the knurled grip (arrow) down, turning a little if necessary.



6

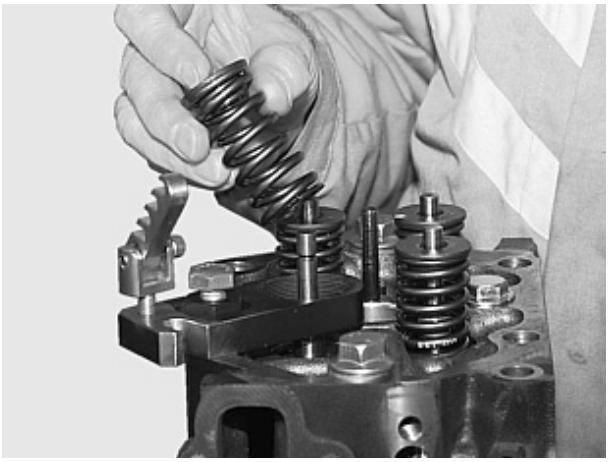
Fig. 7

Release the pressure fork slowly. The retaining wedges must now be in the mounting cartridge.

7

Fig. 8

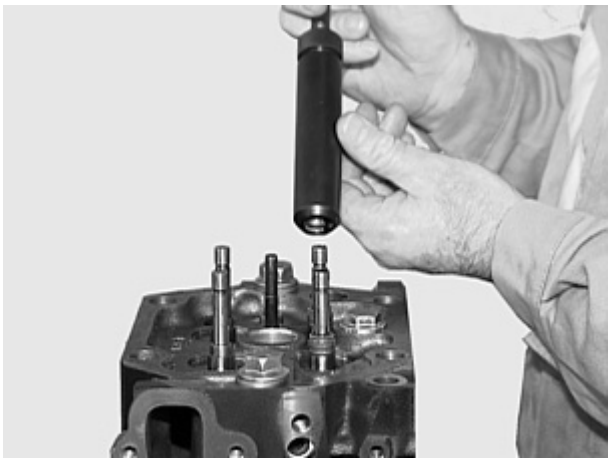
Remove the guide sleeves and the valve spring. Remove the anchor plate and attach it for removal of the next valve spring.



8

Fig. 9

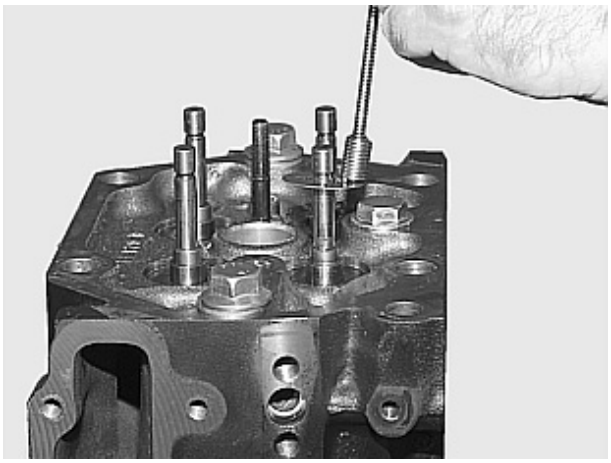
Remove the valve stem seals with a quick gripper (if available).



9

Fig. 10

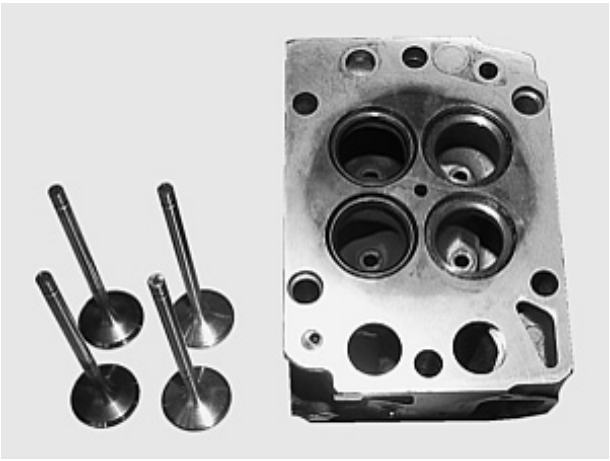
Remove the washers for the valve springs.



10

Fig. 11

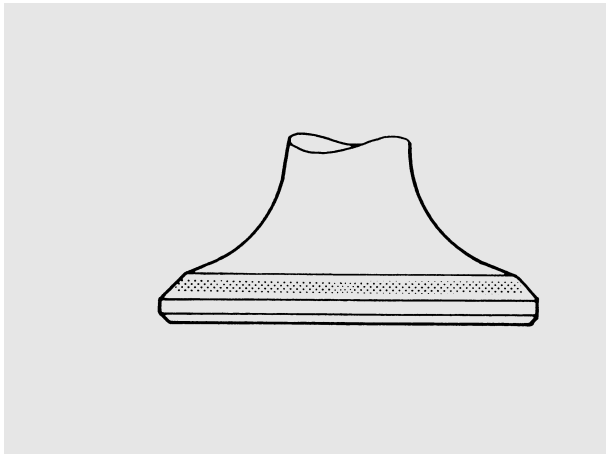
Turn the cylinder head over and remove the valves.
Clean parts.
Inspect the valve stem for pitting and wear.
Inspect the valve guides for wear; if necessary, measure internal diameter (see “Service Data”) with a plug gauge.
Inspect the valve seat inserts for burnt-out spots.



11

Fig. 12

Inspect the valve seat for heavy notching and burnt-out spots; if necessary, regrind the valves, paying attention to the valve recess (see “Service Data”) while doing so.

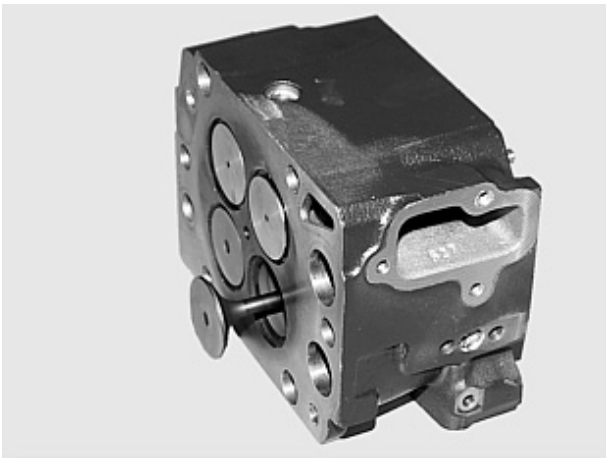


12

Installing valves

Fig. 13

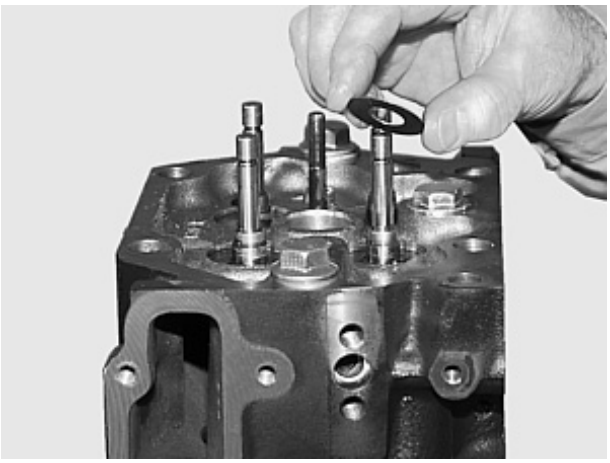
Lubricate the valves at the stems and insert in the correct valve guides.



13

Fig. 14

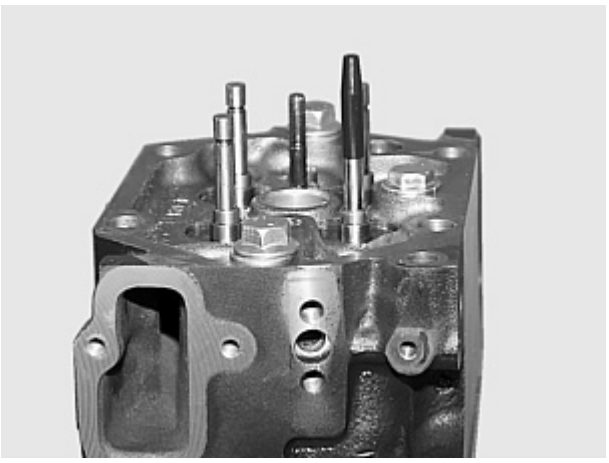
Turn the cylinder head over and secure to the mounting plate.
Insert the washers for the valve springs.



14

Fig. 15

Mount the insertion sleeve for the valve stem seals (Special tools, see item 15.10 page 187) on the relevant exhaust valve.

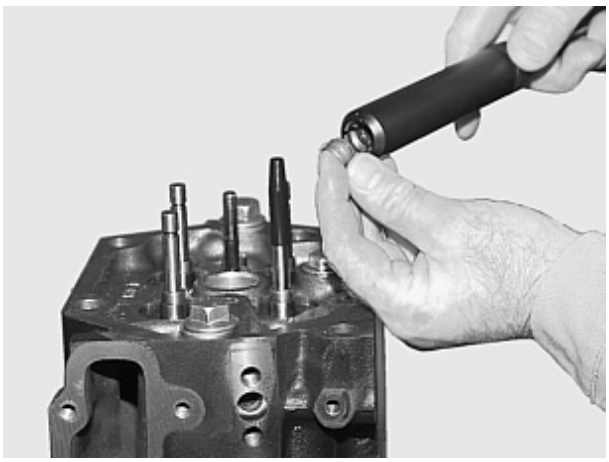


15

Fig. 16

Place the valve stem seal in the quick gripper so that after installation the spiral-type expander is at the top.

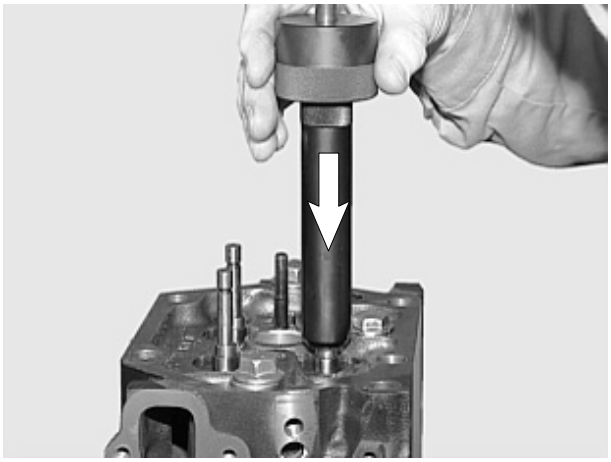
Note:
Use only new valve stem seals.



16

Fig. 17

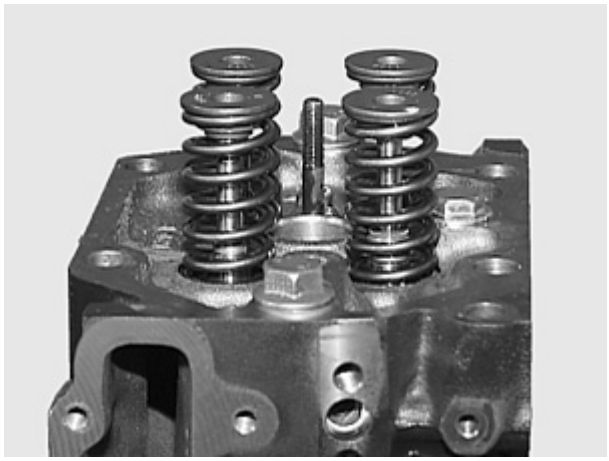
Press in the valve stem seal as far as it will go.
Remove the guide sleeve.



17

Fig. 18

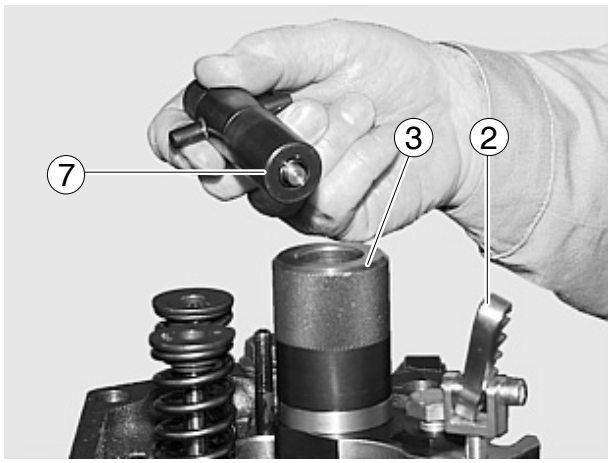
Mount the valve springs and spring seats.



18

Fig. 19

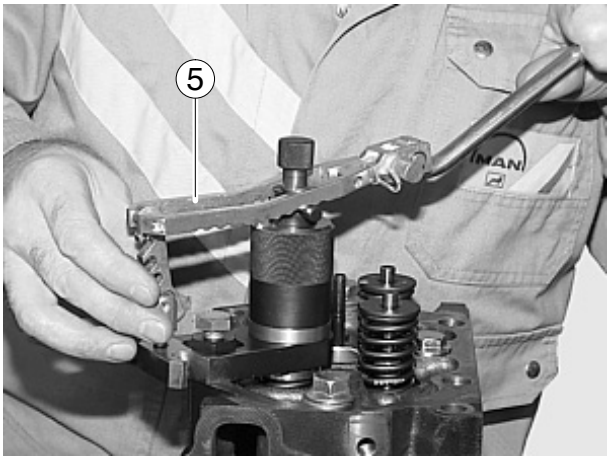
Fit guide sleeve ④ over the valve spring for centring.
Mount anchor plate ② and guide sleeve ③ from the special tool kit.
Insert the retaining wedges in mounting cartridge ⑦.



19

Fig. 20

Insert the mounting cartridge in the guide sleeve and press down with pressure fork ⑤ as far as it will go.
Release the pressure fork and remove the mounting cartridge.

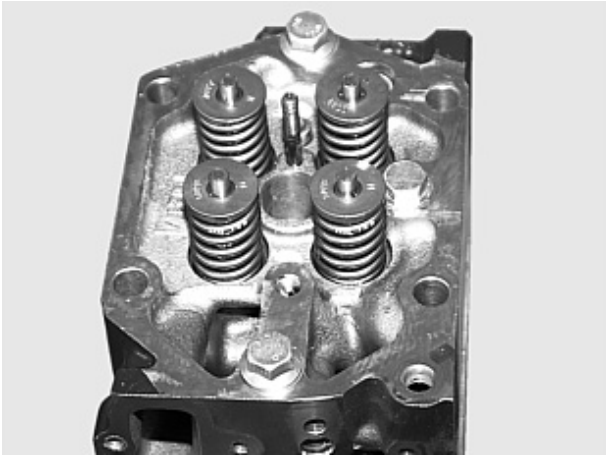


20

Fig. 21

The valve tapers must snap reliably into place when the pressure fork is released.

Caution:
Make sure the valve tapers are correctly seated as tapers which spring out may cause serious engine damage.



21

Measuring valve recess

Fig. 22

Position the dial gauge with its holder on the cylinder head. Set the tip of the dial gauge on the cylinder head and set the gauge to “0”, swivel to the valve plate and read off the recess. Replace the valve and valve seat insert if necessary.

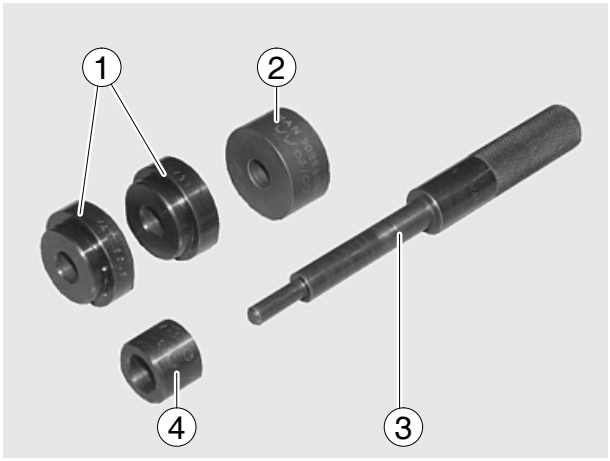
22

- Removing and attaching cylinder head, see page 91
- Remove and install valves, see page 103

Fig. 1

Special tool for removing and installing the valve guides and valve seats:

① Press-in plates for valve seat inserts
② Spacer ring for ①
③ Extraction and press-in punch for valve guides and valve seats
④ Press-in sleeve for valve guides



1

Fig. 2

Press out the valve guide from the combustion chamber side with press-in punch ③.

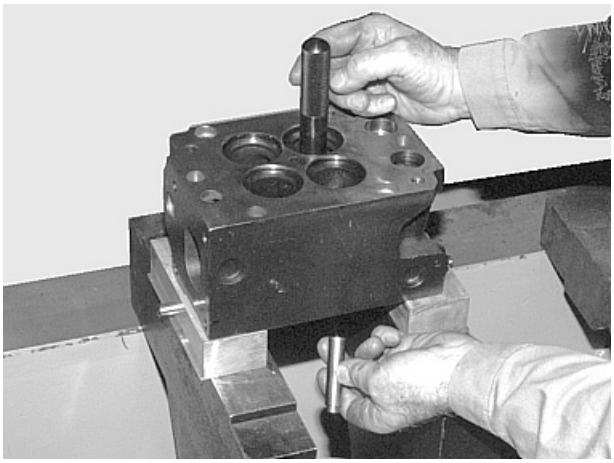

2

Fig. 3

Lubricate the new valve guide and press in with the press-in punch and press-in sleeve from the rocker arm side.
Press-in depth (see publication “Service Data”).

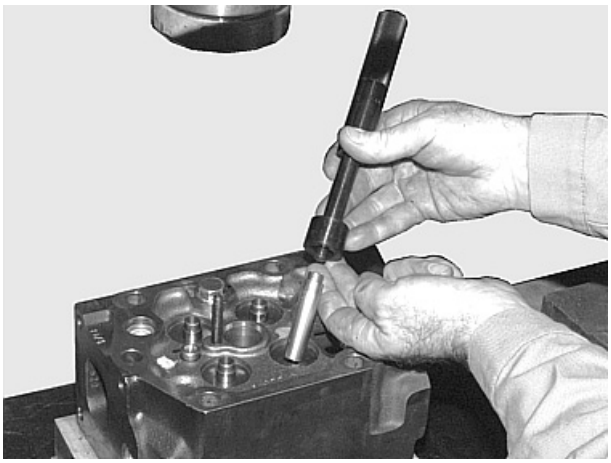
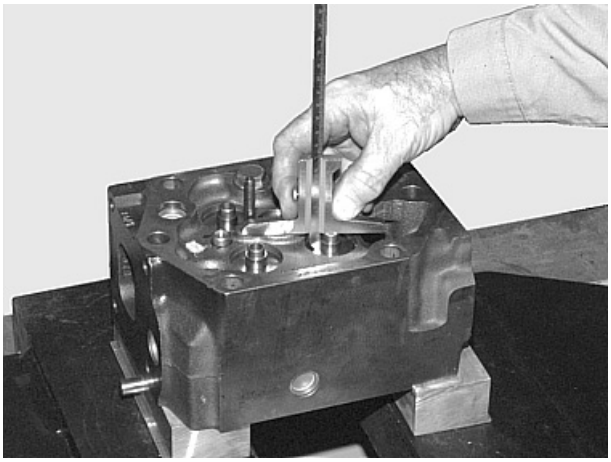

3

Fig. 4

The press-in depth of the valve guides is determined by the press-in sleeve.

Note:
When the valve guides have been replaced, the valve seats must also be reconditioned (refer to technical data and manufacturer’s instructions of the valve seat turning equipment available in the machine shops).


4

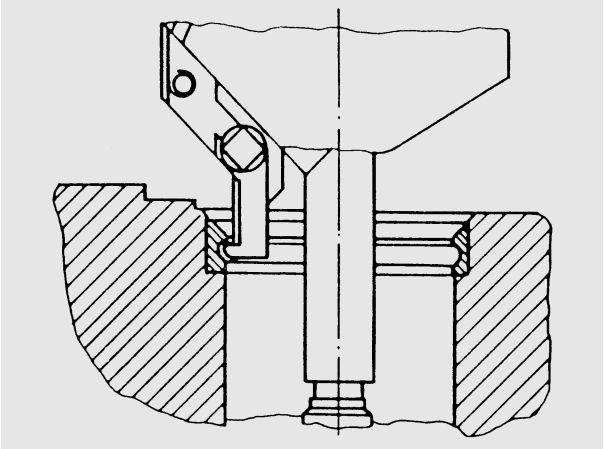
Removing valve seat insert

Note:
If the valve seat inserts are replaced, the valve guides must be replaced at the same time as otherwise exact refacing of the valve seat inserts cannot be guaranteed.
For the above-mentioned reasons, the tool for removing and installing the valve guides and valve seat inserts have been designed in such a way that, when this tool is used, the valve guides and the valve seat inserts can be replaced only together or only the valve guides alone can be replaced.

Fig. 1

Use a valve seat machining tool (valve seat turning tool) to cut a groove approx. 3–4 mm wide in the valve seat insert.

Insert an internal puller into the cut groove and tighten.



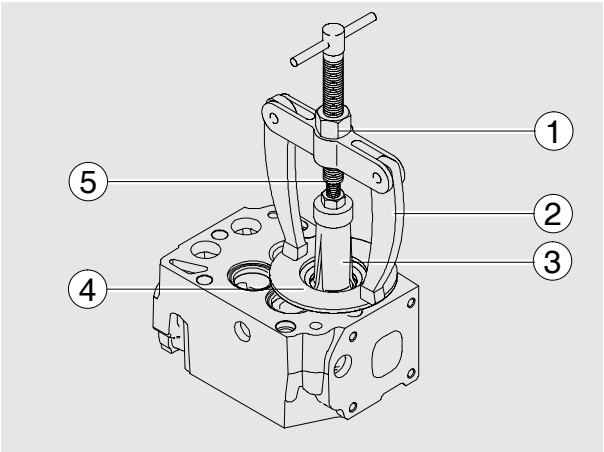
1

Fig. 2

Note:
To avoid damaging the cylinder head sealing face, lay disc ② or similar item under arms ③ of the support.

Screw threaded spindle ⑤ into internal puller ③, align arms ② of the support and pull out the valve seat insert by turning nut ①.

Clean the contact face of the seat insert in the cylinder head.

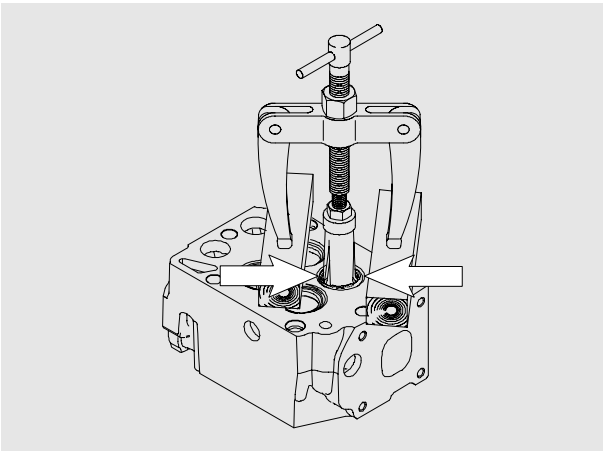


2

Fig. 3

If a valve seat machining tool is not available, the following procedure may be adopted:

- Apply two short welding beads on the valve seat (arrow) using an arc welding set
- Pull out the valve seat insert
- Clean the contact face of the seat insert in the cylinder head



3

Installing valve seat insert

Fig. 4

Chill the new valve seat insert down to approx. –200°C and insert in the cylinder head (approx. 20°C room temperature).
Carry out a check by driving it in as far as it will go using a pressing tool.
Install the valve guides.

Note:
When the valve seat inserts are replaced, the valve seats must also be refaced.

4

Note:

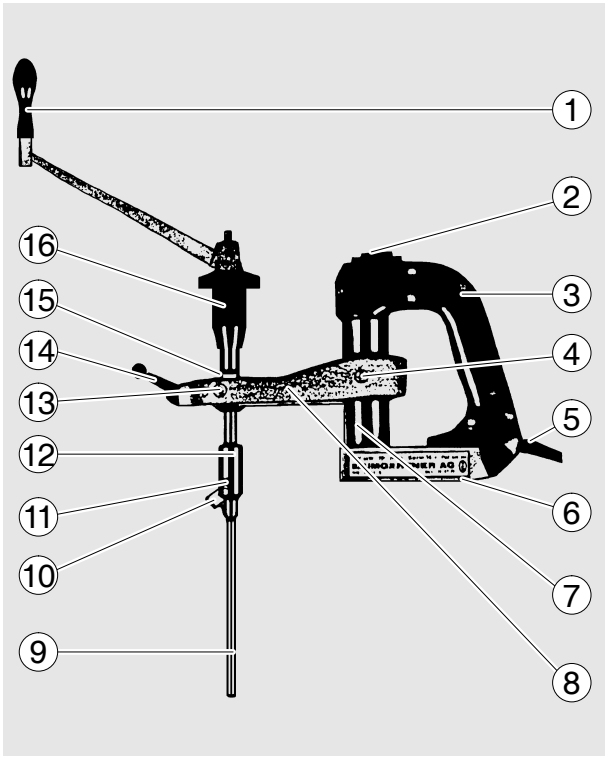
- After temperature equalisation: machine the valve seats
- After machining: clean the cylinder head and check for leaks with a leak testing device.
- If the cylinder head is excessively heated (above +200°C), the core hole covers (end covers) lose their tightness and must be replaced
- To do this, clean the core holes, blow out the channels and press in new core hold covers with “LOCTITE 648” and press–in mandrel

Reworking valve seat

(with Mira precision valve seat machining tool)

Fig. 1

① Driving crank
② Toggle switch
③ Handle
④ Lubricating nipple
⑤ Mains connection
⑥ Magnetic flange with coil
⑦ Guide pipe
⑧ Slewing arm
⑨ Guide mandrel
⑩ Tool
⑪ Hex socket screw
⑫ Rotary head
⑬ Lubricating nipple
⑭ Jaccard lever
⑮ Guide ball
⑯ Feed nut with mm scale



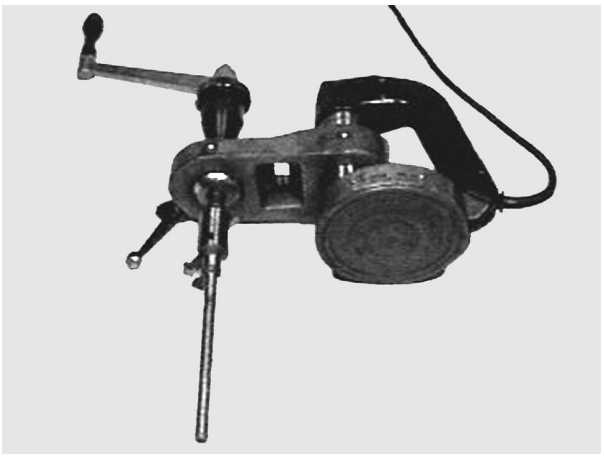
1

Fig. 2

Select a suitable guide mandrel, screw it in and tighten with a fork wrench.

Note:
For extreme precision work, the guide mandrel must fit snugly.

Select and insert a forming cutter with the corresponding seat width and corresponding seat angle.

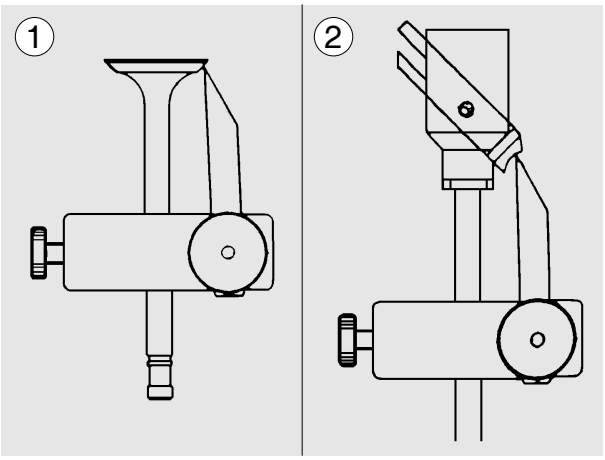


2

Fig. 3

Adjust the forming cutter with a setting gauge and tighten with the hexagon socket screw.

Insert the tool complete with guide mandrel in the valve guide.



3

Fig. 4

Release the Jaccard lever, set the magnetic flange down flat on the clamping plate and adjust the height so that the forming cutter does not contact the valve seat.

Set the toggle switch to position 1.

Tighten the Jaccard lever.

4

Fig. 5

Machine the valve seat by turning the driving crank steadily in a clockwise direction and simultaneously operating the feed nut.

Caution:
During the machining process, turn the crank vigorously and steadily but under no circumstances against the direction of turning as this may cause the carbide cutting edge to break off.

5

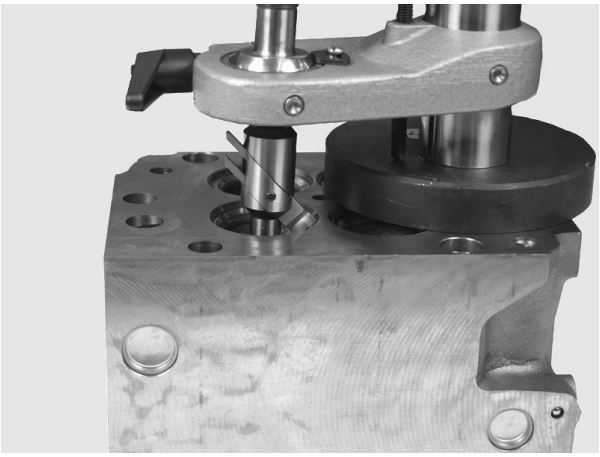
Fig. 6

Once the valve seat has been cleanly machined, reduce the working pressure of the forming cutter by 2–3 turns without feed motion.
During these turns, turn the feed nut back 2–3 turns.

Press the toggle switch briefly to position 2 to lift the magnetic field.

Now move the entire Mira tool upwards and insert it in the next valve guide, repeating the centring operation.

Use the same cutter settings for all the intake and exhaust valve seats.

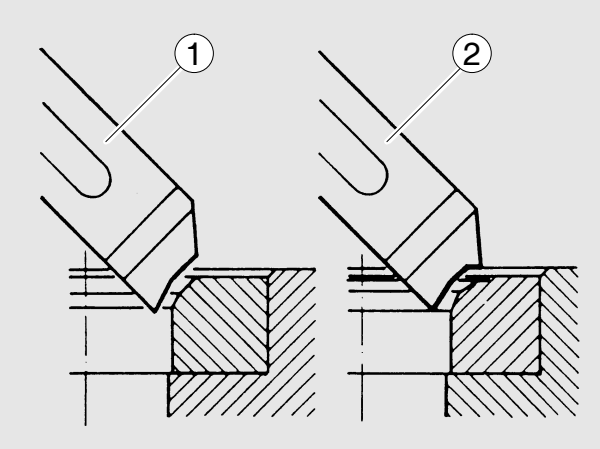


6

Fig. 7

Observe the specified seat angle.

① Exhaust
② Intake

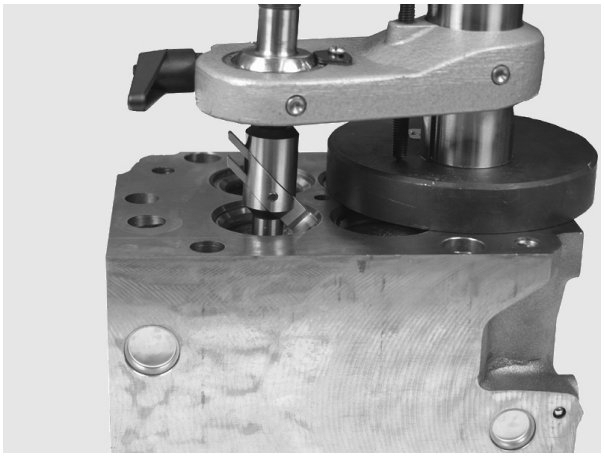


7

Fig. 8

When reworking the valve seat inserts, remove as little material as possible from the seat face.

The valve recess serves as the reference value.

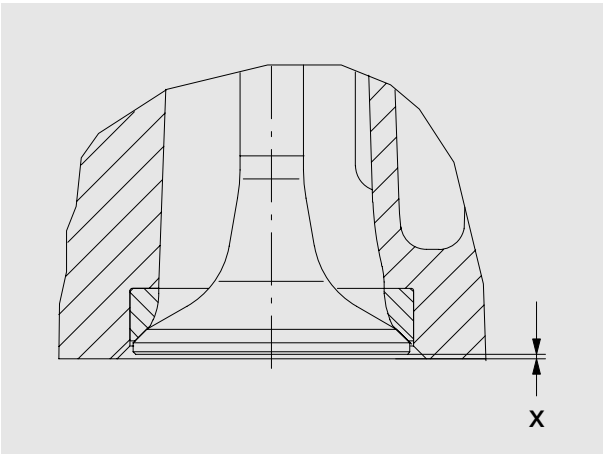


8

Fig. 9

The valve seat insert must be changed if the theoretical valve seat is too deep in the cylinder head or if the seat face has become too wide.

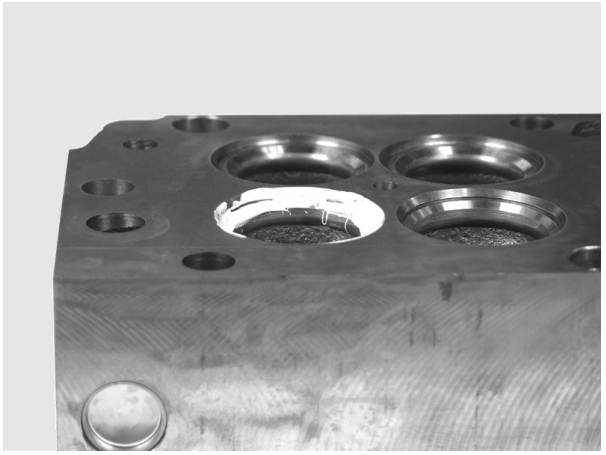
Ensure that the valve recess (X) is correct, see “Service Data”.



9

Fig. 1

Apply abrasive paste to the tapered area of the valve seat.
Lubricate the valve guide and insert the valve.

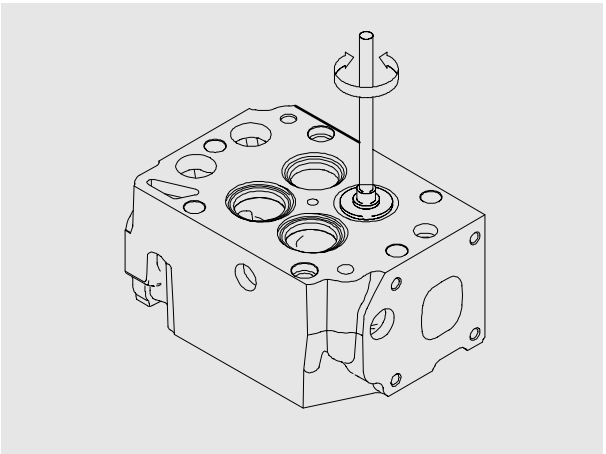


1

Fig. 2

Use a valve grinder to reface the valve seat by applying moderate axial pressure and describing a turning motion.

Note:
Keep the valve stem and the valve guide free of abrasive paste.

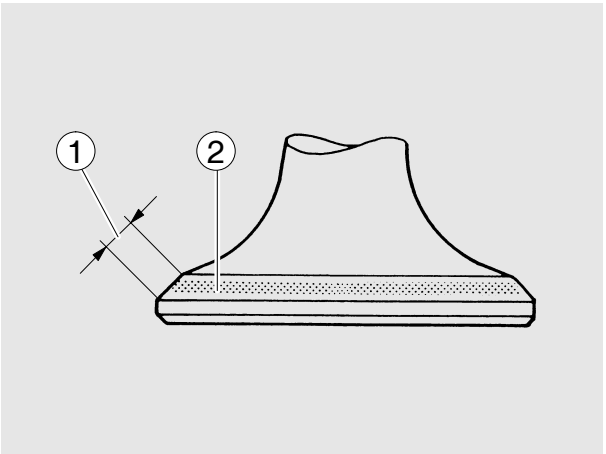


2

Fig. 3

The valve seat must have a faultless, contained grinding pattern.
The grinding pattern width is correct if the valve seat insert is in order.

① Valve tapered area
② Valve seat



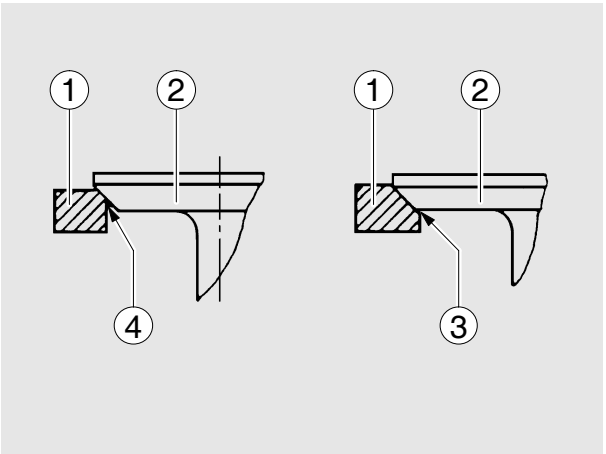
3

Fig. 4

① Valve seat insert
② Valve
③ Valve seat too wide
④ Valve seat good

Note:
Valve seats which are too wide tend to accumulate coking residues,
– valves start to leak –

Valve seats which are to narrow prevent rapid dissipation of heat from the valve plate to the cylinder head,
– valves burn –



4

- Checking and/or setting valve clearance, see page 97
- Run engine up to normal operating temperature
- Remove all fuel injectors, see page 32
- For compression guideline values, see publication “Service Data”

Fig. 1

Starting at cylinder no. 1 (cooling pump side), fit a new sealing ring and tighten down the compression recorder test connection with a pressure flange.

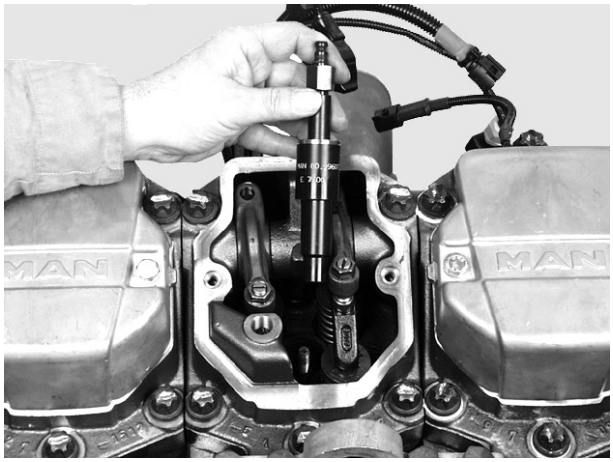

1

Fig. 2

Insert a test chart in the compression recorder for diesel engines. Screw the compression recorder onto the test connection.

Turn the engine over with the starter motor until there is no longer any needle deflection shown by the compression recorder.

In doing so, switch off the power supply of the electro-hydraulic shutoff valve (EHAB).

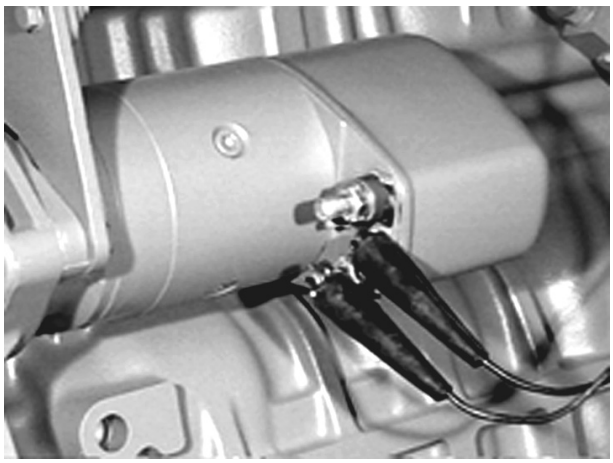
Connect the compression recorder together with the test connection to the next cylinder and check all the cylinders as described above.


2

Fig. 3

Depending on the configuration of the compression recording device, the engine can also be turned directly from the compression recording device. Here, the electrical connections must be established at the starter motor solenoid switch (terminals 50 and 30).

Compare the recorded values and remove the compression recorder and test connection.
Screw in fuel injectors with nozzle and new seal, see page 35.
Connect the injection and leak−off oil lines.

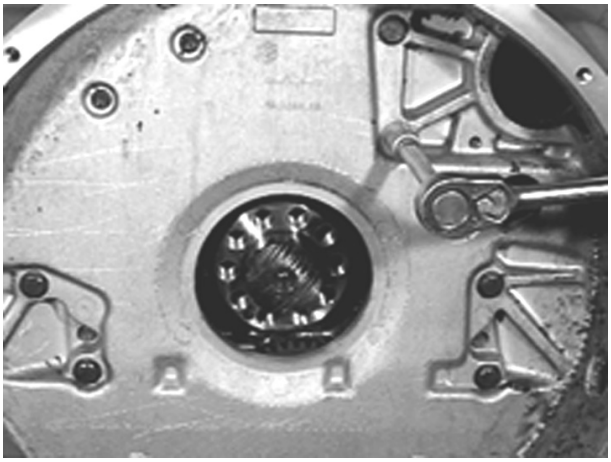

3

- Removing the starter motor, see page 148
- Remove rpm sensor
- Removing flywheel, see page 73

Fig. 1

Release the mounting bolts.

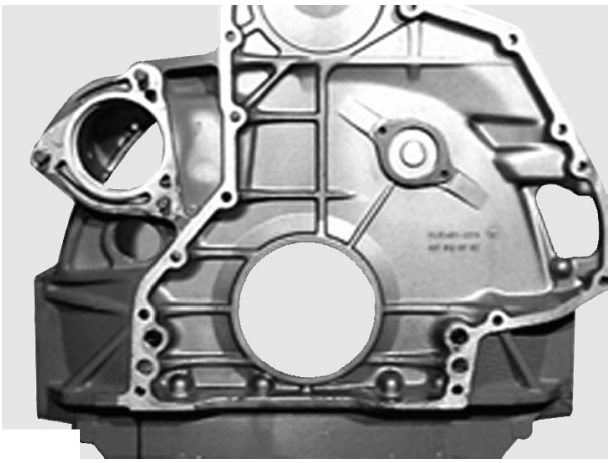
The bottom of the timing case is bolted to the oil pan!



1

Fig. 2

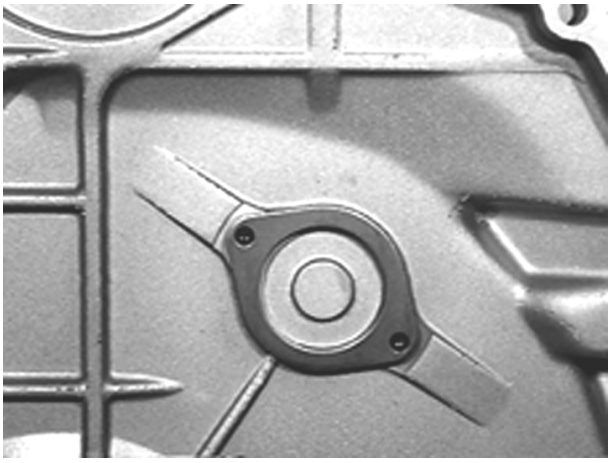
Remove the timing case. Take the gasket off the timing case and fit a new one.



2

Fig. 3

Check the contact washer on the camshaft for wear, in necessary fitting a new one.



3

Fig. 4

Stick the new seal on with a little grease.

Fit flywheel housing. In doing so, examine the oil pan gasket; replace if necessary.

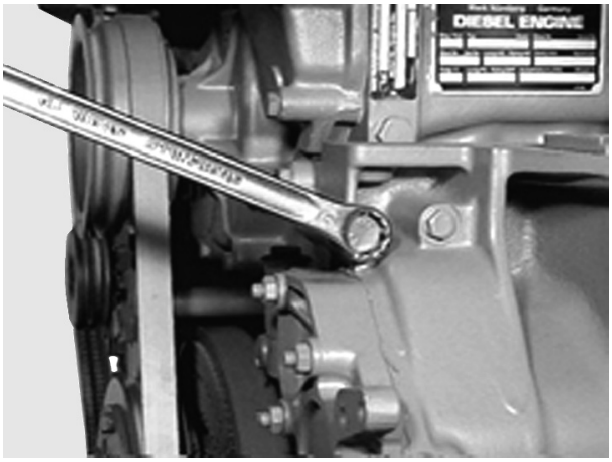
Lightly oil the threads and contact faces of the mounting bolts and tighten to specified torque (see “Engineering • Data • Setting values”).

4

Removing the camshaft

- Draining off coolant, see page 43
- Removing the oil pan, see page 65
- Removing the starter motor, see page 148
- Removing the flywheel and timing case, see page 117
- Removing cylinder heads, see page 91
- Remove vibration damper, see page 69

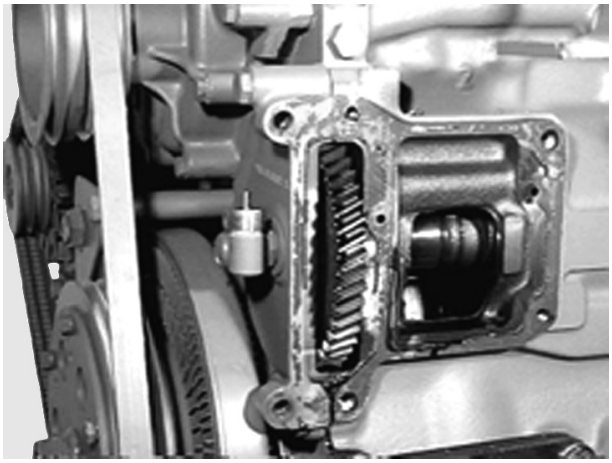
Note:
The engine must be turned through 180° in order to remove the camshaft. To do so, the engine must be placed on assembly truck.



1

Fig. 1

Remove seawater pump with drive system.



2

Fig. 2

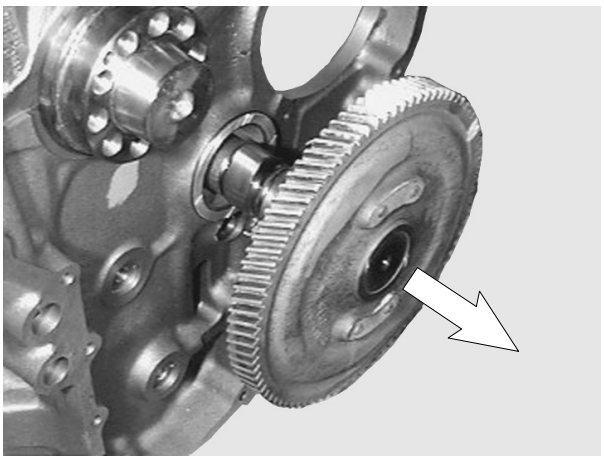
Remove angle drive, cover and seawater–pump drive gear from the camshaft.

Fig. 3

Turn the engine upside down so that the valve tappets do not obstruct removal of the camshaft.

Fit insert mandrel (special tool) to camshaft.

Withdraw the camshaft. Take care not to damage the camshaft bearings. Check the camshaft for wear and damage.
In the case of damage to the camshaft or drive toothed gear, the entire unit (camshaft - toothed gear) must be replaced.

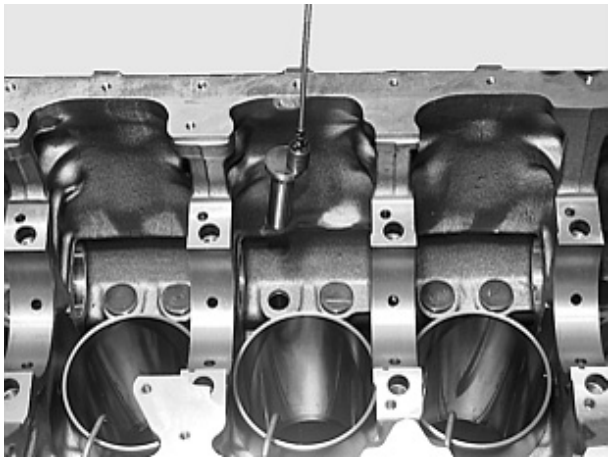


3

Fig. 4

Pull out the valve tappets with a magnet, check for wear and replace if necessary.

Valve tappets can only be removed when the camshaft has been removed.



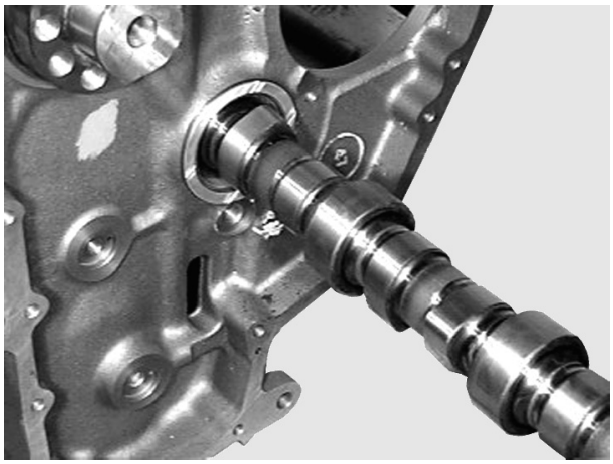
4

Fitting the camshaft

Fig. 5

Fit insert mandrel (special tool) to camshaft.

Oil the camshaft and insert carefully.



5

Fig. 6

In doing so, note the marking of the crankshaft and camshaft toothed gear.

6

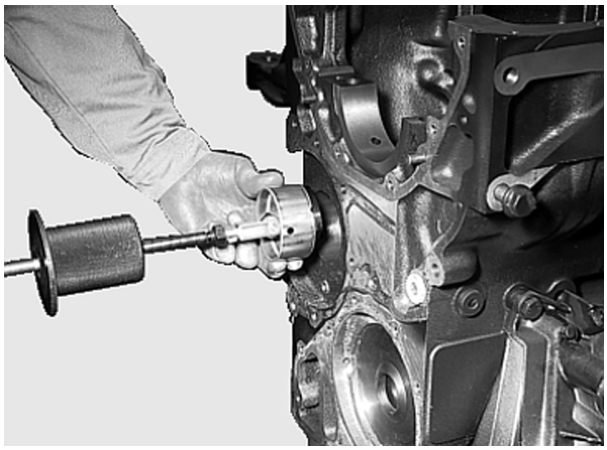
Removing the camshaft bearing bushes

Note:
The engine is equipped with 7 camshaft bearings. Bearing no. 1 is located on the counter-flywheel side.

Press out the camshaft bearing bush, bearing 1

Fig. 1

Use the impact extractor (special tool) to pull out the bearing bush of bearing 1 from the counter-flywheel side.

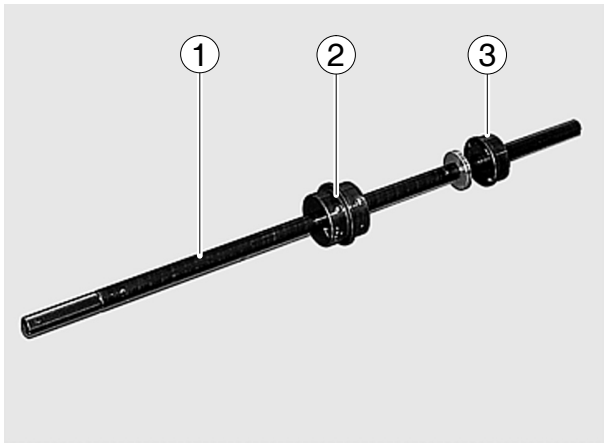


1

Fig. 2

Special tool for pressing out bearing bushes 2 to 6 from the mounting too.

① Shaft with groove and fixed stop
② Double-sided guide bush
③ Press-out plate



2

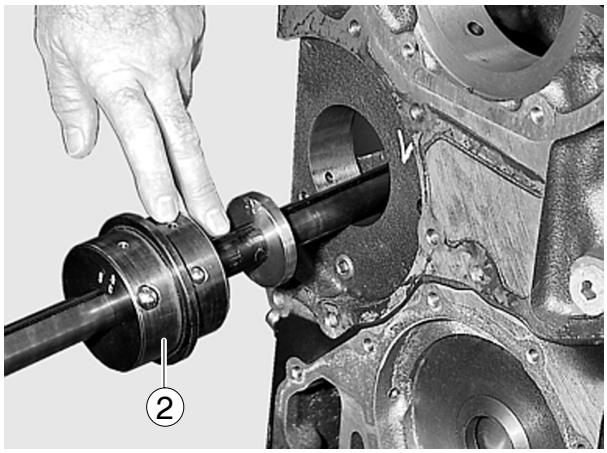
Press out camshaft bearing bush of bearings 2, 3 and 4

Fig. 3

Use the special tool, see Fig. 2, to pull out bearings 2, 3 and 4 from the counter-flywheel side.

Place the guide bush ② on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

The spring-loaded balls lock into the oil holes.



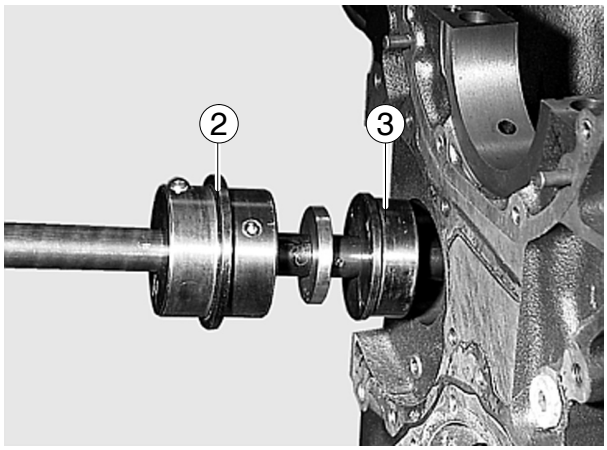
3

Fig. 4

Place the press-out plate ③ from the other side of the stop onto the shaft and insert in bearing bush 2.

Here, insert the guide bush ② with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.

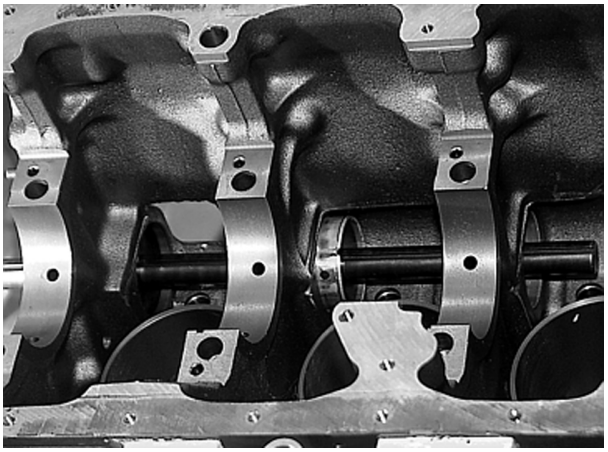
The groove of the shaft must face upwards.



4

Fig. 5

Use a soft hammer (plastic or copper) to knock out camshaft bearing bushes 2, 3 and 4 in succession.

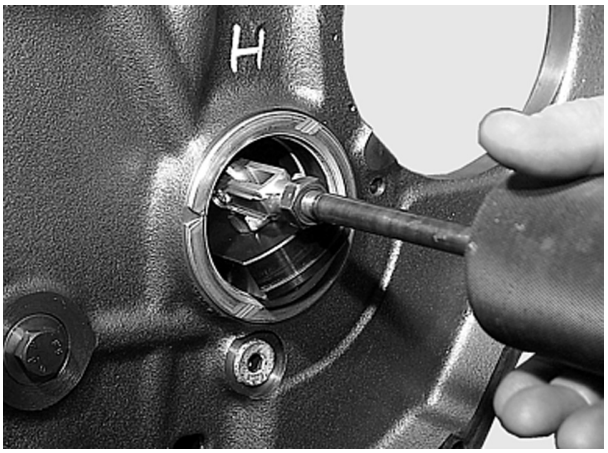


5

Press out the camshaft bearing bush, bearing 7

Fig. 6

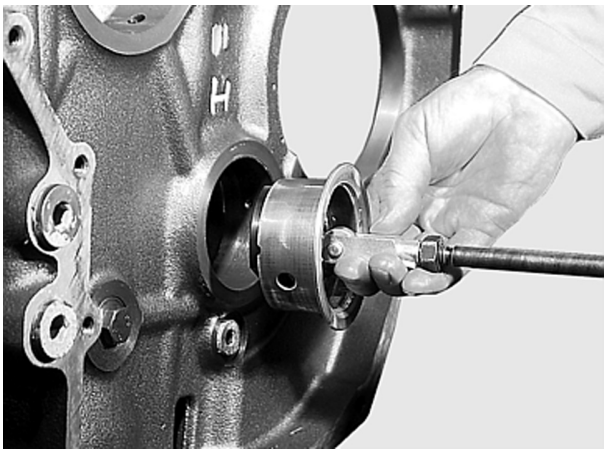
Use the impact extractor (special tool) to pull out the cam bearing bush of bearing 7 from the fly-wheel side.



6

Fig. 7

Pull out the bearing bush.



7

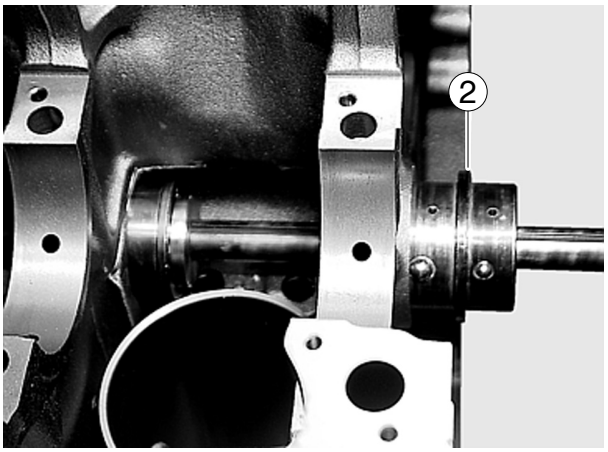
Press out camshaft bearing bushes of bearings 5 and 6

Fig. 8

Press out the bearing bushes of bearings 5 and 6 from the flywheel side.

Place the guide bush ② on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

The spring-loaded balls lock into the oil holes.

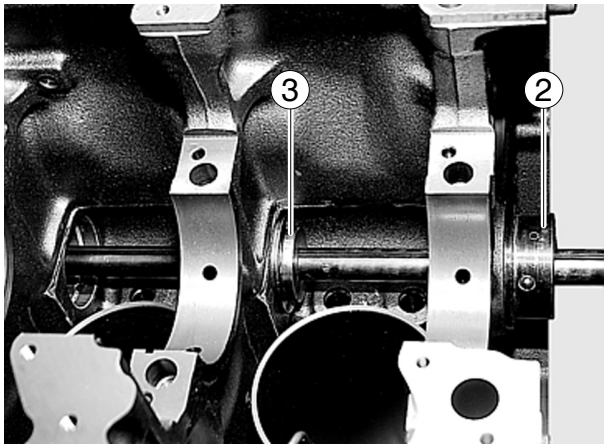


8

Fig. 9

Place the press-out plate ③ from the other side of the stop onto the shaft and insert in bearing bush 6.

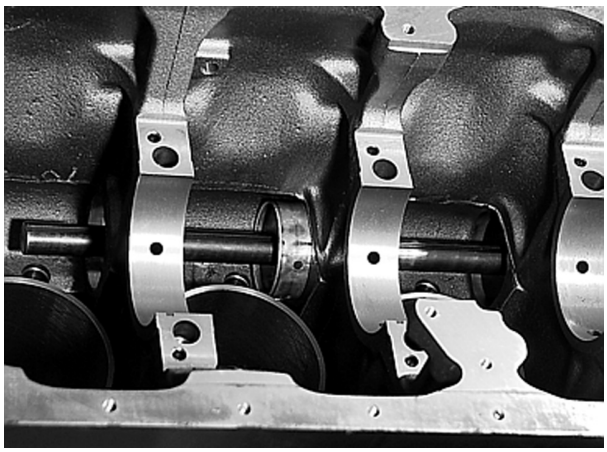
Here, insert the guide bush ② with the larger diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.
The groove of the shaft must then face upwards.



9

Fig. 10

Use a soft hammer (plastic or copper) to knock out bearing bushes 6 and 5 in succession.

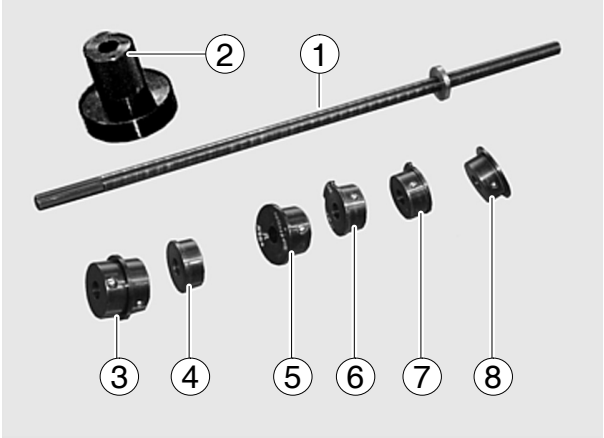

10

Fitting the camshaft bearing bushes

Fig. 11

Depending on the number of the camshaft bearing, there are various press-in plates (special too) for pressing in the bearing bushes

① Shaft with groove and fixed stop
② Striking weight for ①
③ Double-sided guide bush
④ Press-out plate for bearing bushes 2 to 6
⑤ Press-in plate for bearing bush 1
⑥ Press-in plate for bearing bushes 2 to 4
⑦ Press-in plate for bearing bushes 5 and 6
⑧ Press-in plate for bearing bush 7



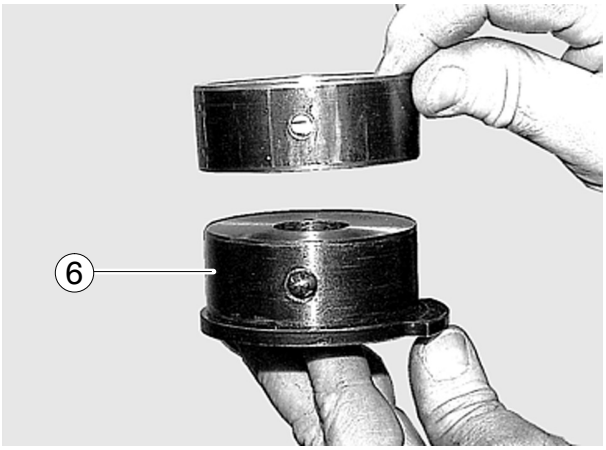
11

Press in the camshaft bearing bush, bearing 2

Figs. 12 and 13

Place the bearing bush on the press-in plate ⑥.

Caution:
- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate



12

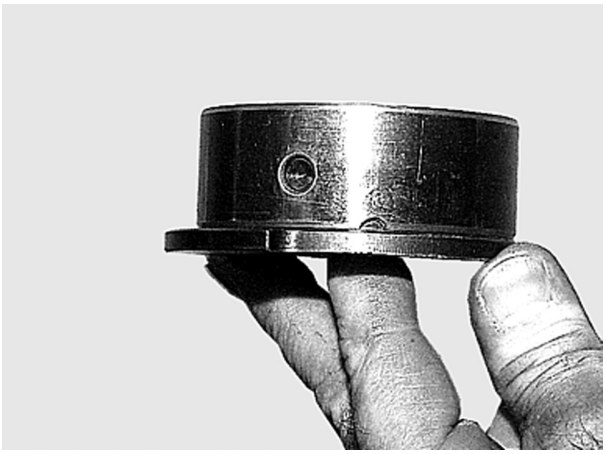
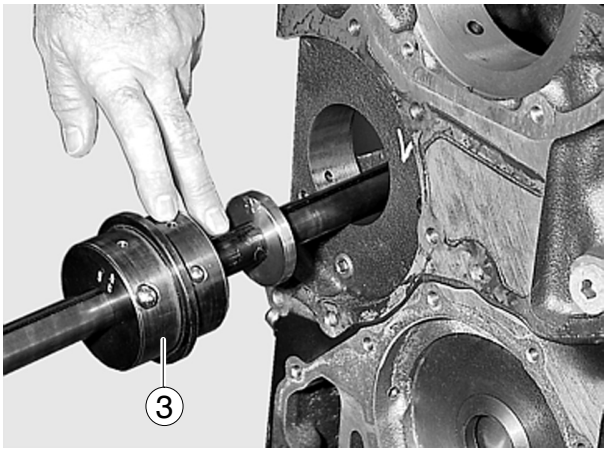

13

Fig. 14

Place the guide bush ③ on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

When the shaft is put in place, the groove must face upwards so that the guide bush is fixed in place by the correct oil holes.

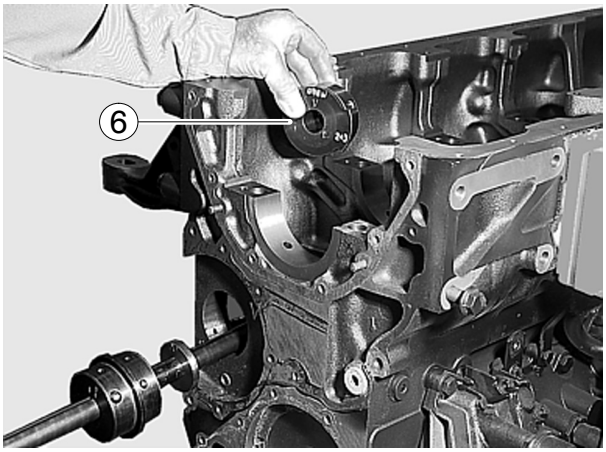


14

Fig. 15

Place the press-in plate ⑥ with fitted bearing bush on the shaft.

The press-in plate is fixed in place by the groove so that the oil holes line up after pressing in.

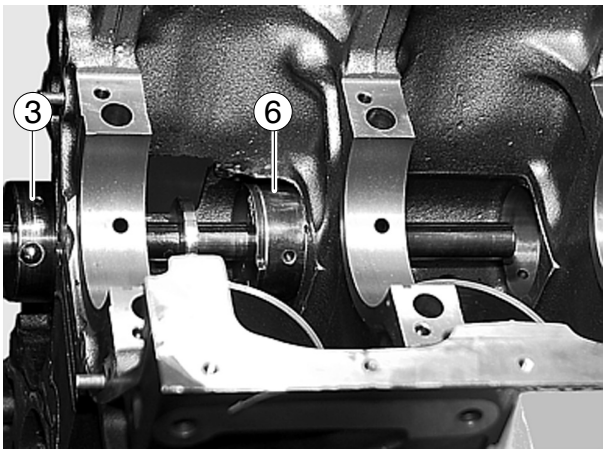


15

Fig. 16

Here, insert the guide bush ③ with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.

The groove of the shaft must then face upwards. Apply the press-in plate ⑥ with fitted bearing bush.



16

Fig. 17

Use a soft hammer (plastic or copper) to drive camshaft bearing bush 2 in as far as it will go.

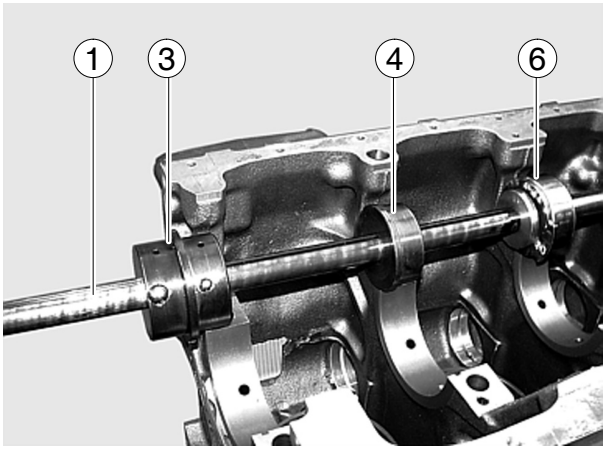
17

Press in camshaft bearing bushes, bearings 3 and 4

Fig. 18

Arrangement of special tools:

① Shaft with groove and fixed stop
③ Double-sided guide bush
④ Press-out plate as additional guide
⑥ Press-in plate



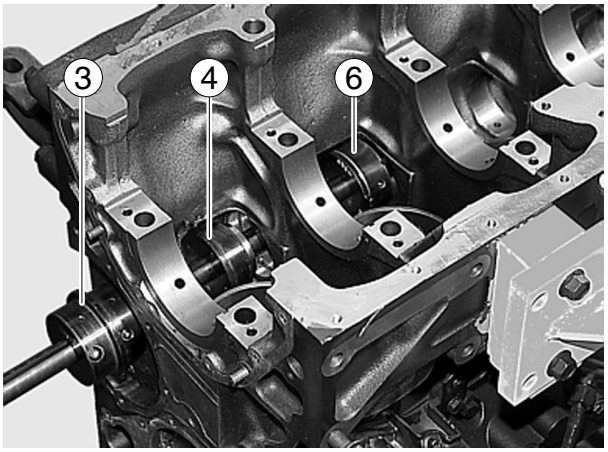
18

Fig. 19

From the counter-flywheel side, insert the press-out plate ④ in bearing 2.
Insert the shaft with guide bush ③ through bearing 1, then through the press-out plate ④ (bearing 2).

Here, insert the guide bush ③ with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.
The groove of the shaft must then face upwards.

Place the press-in plate ⑥ with fitted bearing bush on the shaft.
The press-in plate is fixed in place by the groove so that the oil holes line up after pressing in.

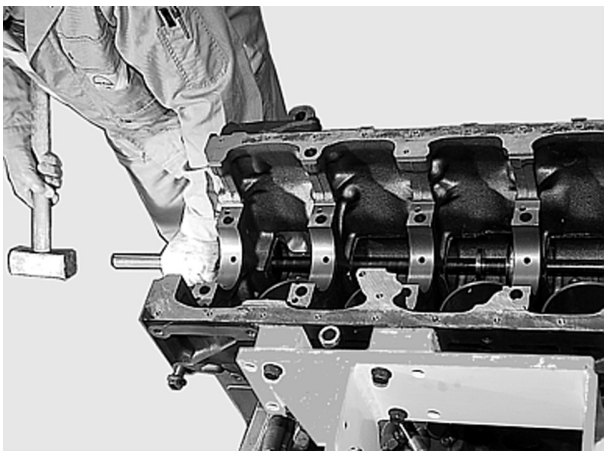


19

Fig. 20

Use a soft hammer (plastic or copper) to drive the bearing bush into bearing 3 as far as it will go.

To fit bearing 4, proceed in the same manner.


20

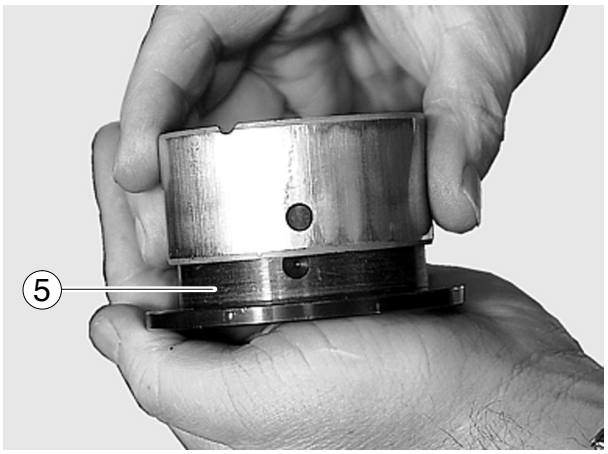
Press in the camshaft bearing bush, bearing 1

Figs. 21 and 22

Place the bearing bush on the press-in plate.

Note:
The bearing bush and press-in plate ⑤ for bearing 1 are wider than for bearings 2 to 6.

Caution:
- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate



21


22

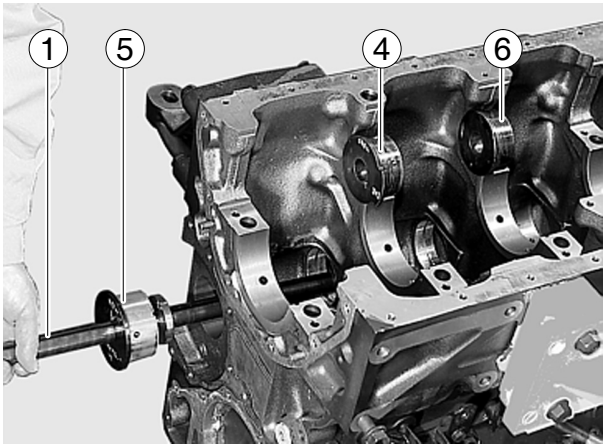
Figs. 23 and 24

Arrangement of special tools:

① Shaft with groove and fixed stop
④ Press-out plate for bearing bushes 2 to 6 as additional guide
⑤ Press-in plate for bearing bush 1
⑥ Press-in plate for bearing bushes 2 to 4 as additional guide

From the counter-flywheel side,insert the press-out plate as guide in camshaft bearing 2.

Insert the press-in plate ⑥ in bearing 3 , letting the spring-loaded ball for fixing the position of the shaft ① lock into the oil hole.



23

Insert the shaft up to the stop into the press-in plate (bearing 2) and press-out plate (bearing 3).

Caution:
Do not twist the fixing from the groove.
The groove must face upwards.

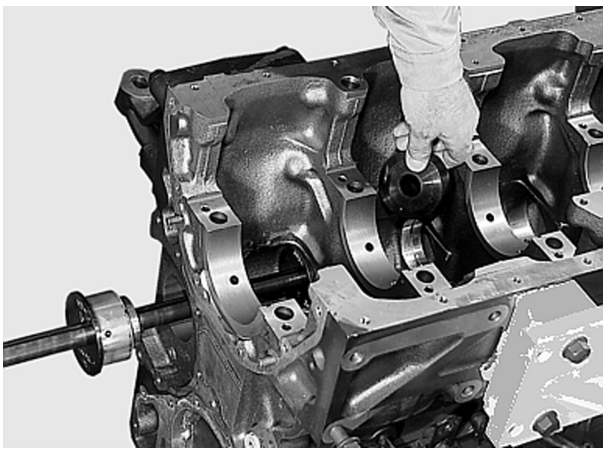
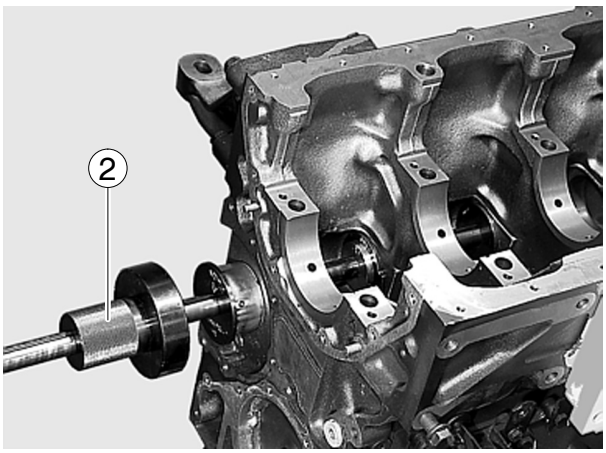

24

Fig. 25

Place the press-in plate with fitted bearing bush on the shaft.

The oil holes are covered in that the press-in plate is fixed in position by the groove of the shaft.
Drive in the bearing bush with striking weight ②.



25

Fig. 26

Check all the pressed-in bearing bushes for seating and free access to the oil holes.

Caution:
Check that the bearing hole matches up to the oil hole in the housing.
Minimum cross section with mandrel ∅ = 2.5 mm.

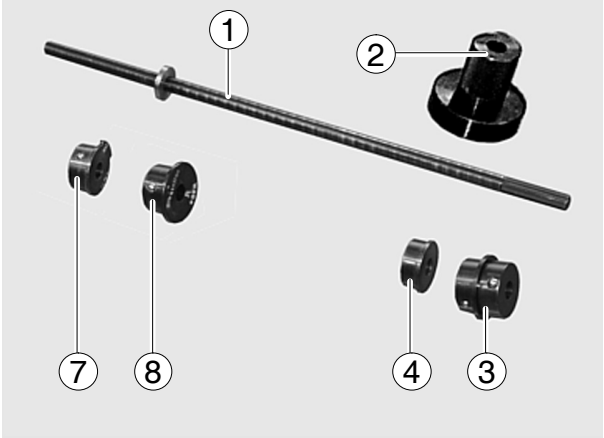

26

Fitting camshaft bearing bushes, bearings 3 and 4

Fig. 27

Special tool for pressing out bearing bushes 5, 6 and 7 from the mounting tool:

① Shaft with groove and fixed stop
② Striking weight for ①
③ Double-sided guide bush
④ Press-out plate as additional guide
⑦ Press-in plate for bearing bushes 5 and 6
⑧ Press-in plate for bearing bush 7

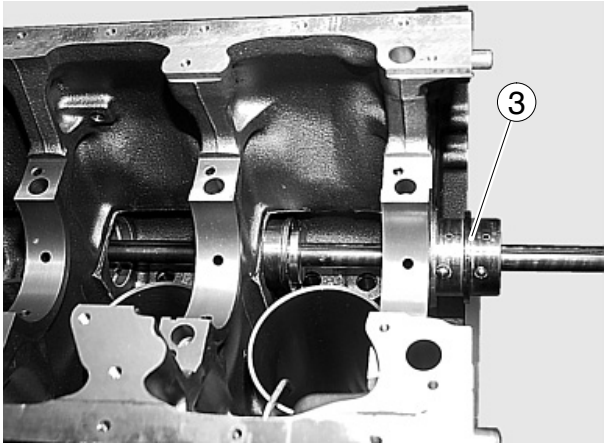


27

Fig. 28

From the counter-flywheel side, press in bearing bushes 5 and 6 as described for bearing bushes 2, 3, and 4.

Insert the guide bush ③ with large diameter in bearing 7.
The groove of the shaft must then face upwards.

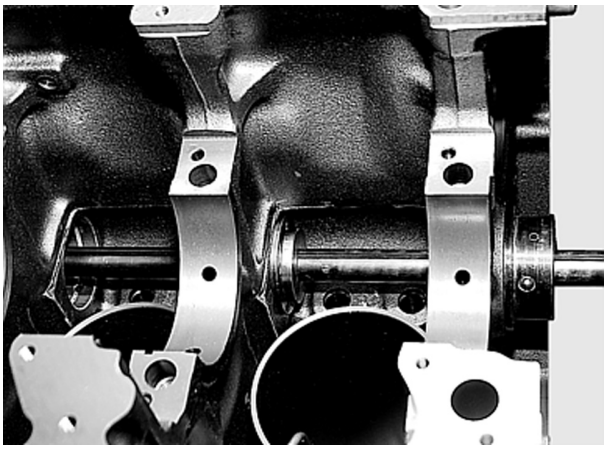


28

Fig. 29

Use a soft hammer (plastic or copper) to drive bearing bush 6 in as far as it will go.

To fit bearing 5, proceed in the same manner.


29

Press in the camshaft bearing bush, bearing 7

Fig. 30

From the flywheel side,insert the press-out plate as guide in bearing 5.

Insert the press-in plate as guide in bearing 6, letting the spring-loaded ball for fixing the position of the shaft lock into the oil hole.

Insert the shaft up to the stop into the press-in plate (bearing 6) and press-out plate (bearing 5).

Caution:
Do not twist the fixing from the groove.
The groove must face upwards.

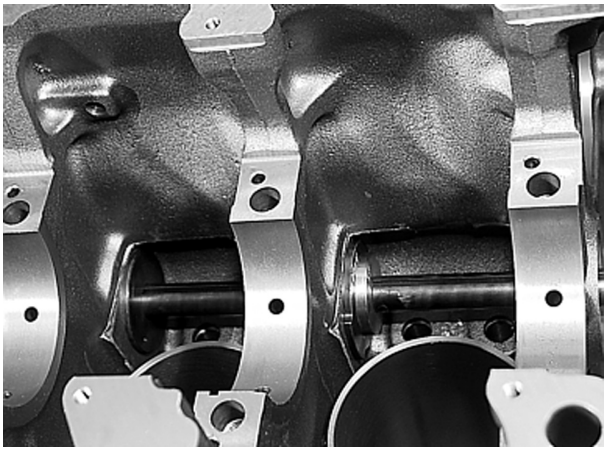
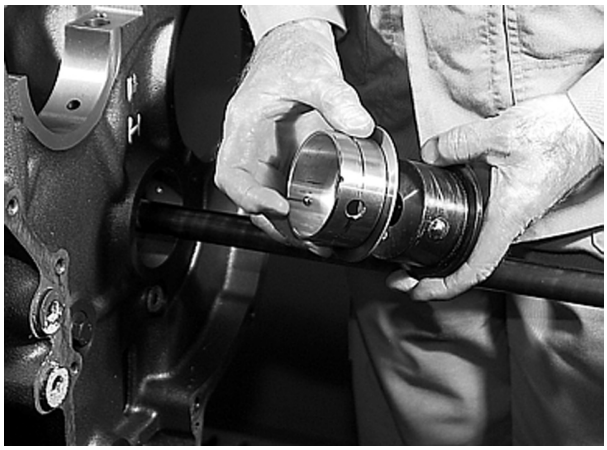

30

Fig.31

Place the bearing bush with edge on the press-in plate.

Caution:
- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate

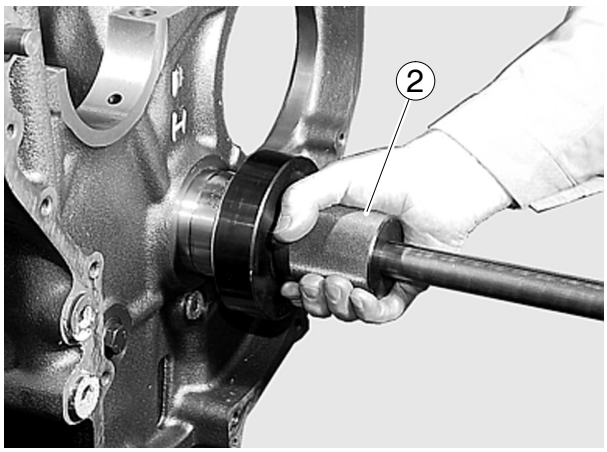


31

Fig. 32

The oil holes are covered in that the press-in plate is fixed in position by the groove of the shaft.

Drive in the bearing bush with striking weight ②.

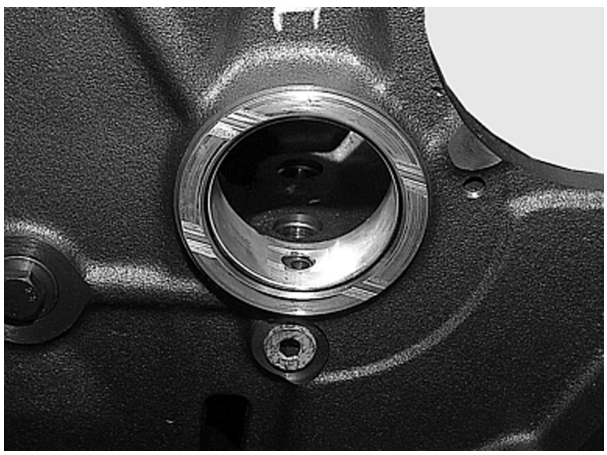


32

Fig. 33

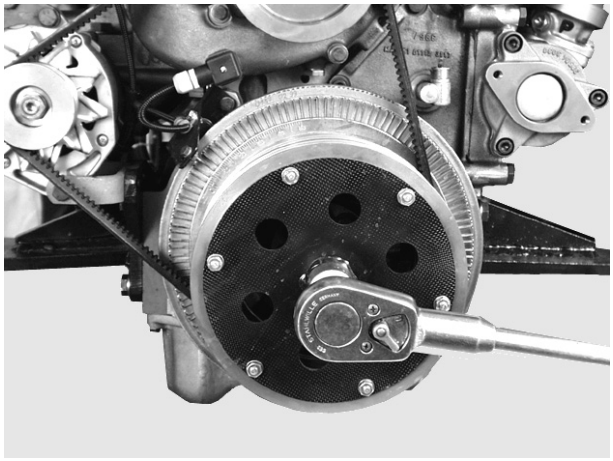
Check all the pressed-in bearing bushes for seating and free access to the oil holes.

Caution:
Check that the bearing hole matches up to the oil hole in the housing.
Minimum cross section with mandrel
∅ = 2.5 mm.



33

Note:
Unsynchronised valve timing can cause severe engine damage.
For this reason, following engine faults that can cause twisting of the shrunk-on camshaft toothed wheel, the correct seating must be checked by checking the valve timing.
This check is also recommended after the camshaft is fitted.



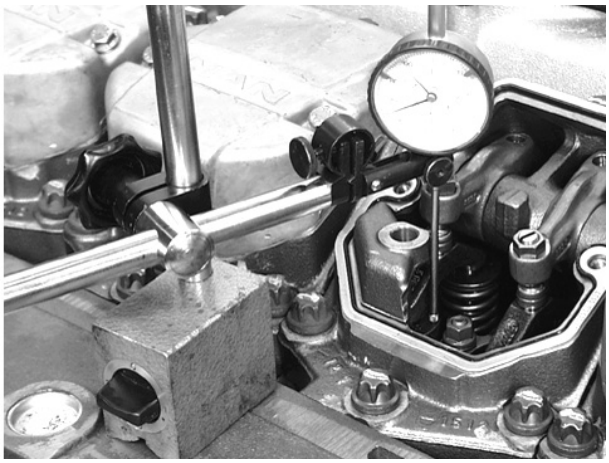
1

Fig. 1

Remove the cylinder head cover from the 1st cylinder.
Set the valve clearance of the 1st cylinder correctly. Turn the engine using the barring gear until the valves of the 1st cylinder overlap.

Turn the engine back to approx. 50° before “TDC”, then turn forwards to 30° bevore “TDC” again.

– Note the degree marking on the flywheel –



2

Fig. 2

Place the dial gauge with approx. 2 mm initial tension on the valve spring retainer of the exhaust valve on cylinder no. 1 and set to “0”.

Turn the engine in the running direction by 180° – The outlet valve is then fully closed –.

Read the stroke of the valve on the dial gauge.

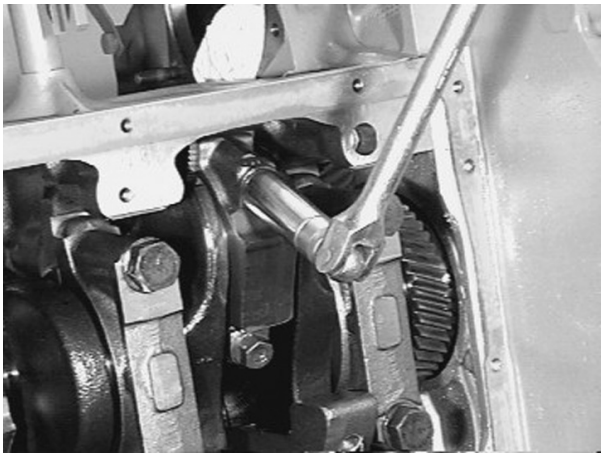
The valve stroke must lie between 4.8 and 5.7 mm.

Removing the crankshaft

- Remove oil pan (see page 65) and oil pump (see page 65)
- Remove timing case, see page 117
- Remove the front cover for sealing the crankshaft and the cylinder heads

Fig. 1

Remove the bolts from the conrod bearing caps, take out the conrods with pistons and set them down in order of installation.

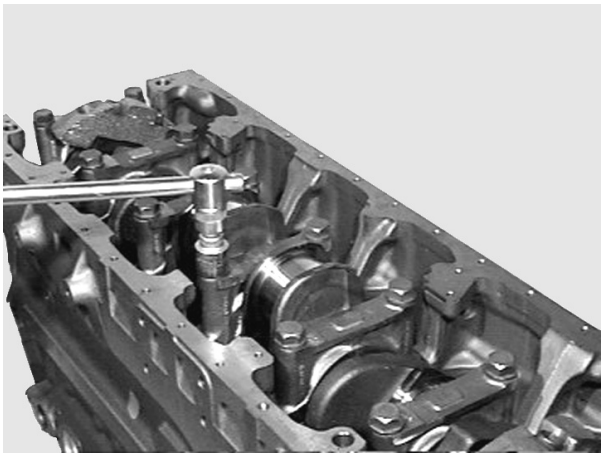


1

Fig. 2

Release the mounting bolts from the crankshaft bearing caps in stages from the inside outwards and remove.
Remove the bearing caps and place to one side in the order of installation.

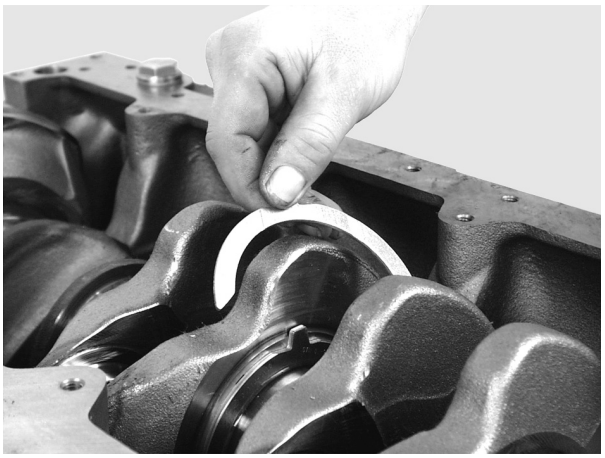
Remove the bearing shell halves from the bearing caps and place to one side assigned to the bearing caps.



2

Fig. 3

Remove the lower half of the contact washers.



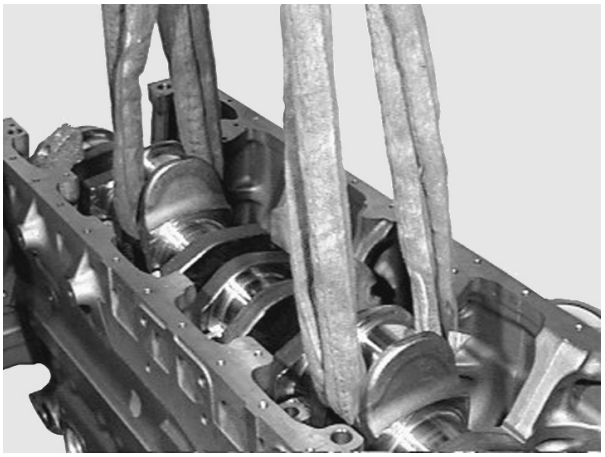
3

Fig. 4

Lift the crankshaft out of the crankcase with hemp rope or a leather belt.

Caution:
If a steel cable is used, the contact surfaces of the crankshaft bearing journals could be destroyed.

Remove the bearing shells and the upper halves of the contact washers from the crankcase. If they have not yet been marked, mark the bearing shell halves for the bearing caps.
Clean the parts and check for wear; replace if necessary.



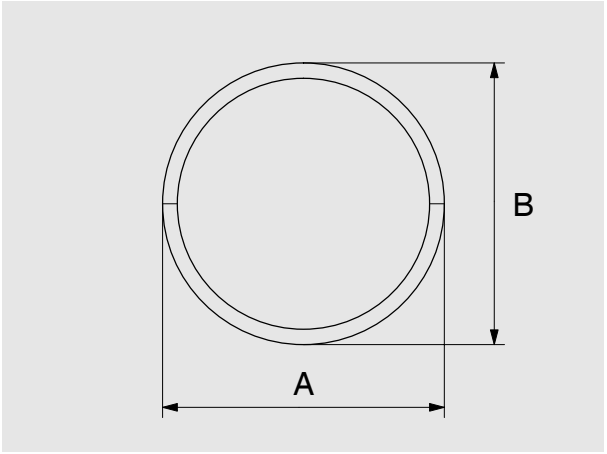
4

Check the spread of the bearing bushes

Fig. 5

Place the bearing shells together on a level surface. Measure and note down dimensions **“A”** and **“B”**.

Spread dimension = A–B



5

Install the crankshaft

Fig. 6

Clean the oilways in the crankcase and in the crankshaft with dry compressed air.
Thoroughly clean the bearing shells and journals.

Insert the bearing bushes in the crankcase, observing the numbering.
Tack the upper halves of the contact washer to the crankcase with a little grease.

Caution:
If new bearing shells are used, pay attention to the corresponding repair stage.


6

Fig. 7

Oil the contact surfaces of the bearing shells and insert the crankshaft.

In doing so, note the markings of the crankshaft and camshaft gears.


7

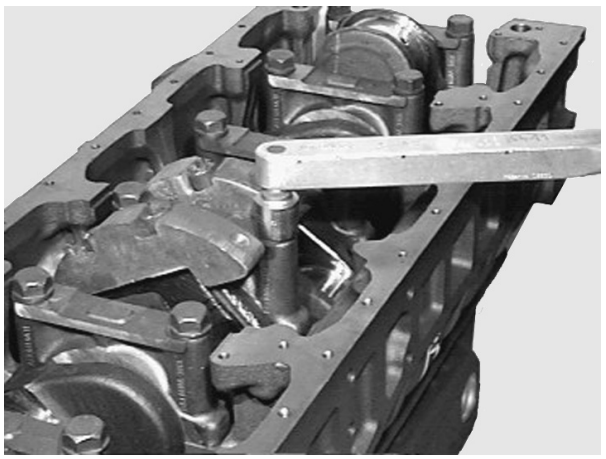
Fig. 8

Assemble the bearing caps with the associated bearing shells in accordance with the installations sequence.
Oil the contact surfaces of the bearing shells and fit the bearing caps.
Insert the bearing cap bolts and tighten to specified torque in stages from the inside outwards.

Tightening torque
Initial torque . . . . . 300 –330 Nm
Angle tightening . . . . . 90–100°

Final tightening according to rotation angle method.
Check that the crankshaft runs smoothly.

Caution:
Damaged bearing caps cannot be replaced on an individual basis.

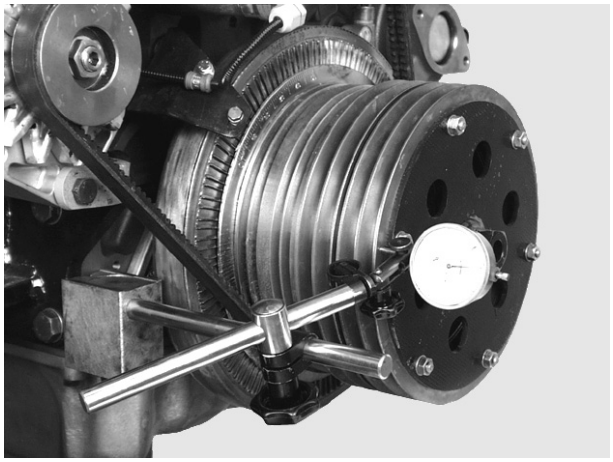

8

Checking axial clearance

Fig. 9

Note:
The crankshaft axial clearance is determined by the centre crankshaft bearing (thrust bearing).

- Fit the dial gauge holder with dial gauge to the crankcase
- Apply the tip of the dial gauge to the crankshaft
- Move the crankshaft back and forth in axial direction and read off the clearance from the dial gauge
- If the permitted axial clearance is exceeded, replace the main bearing shells completely



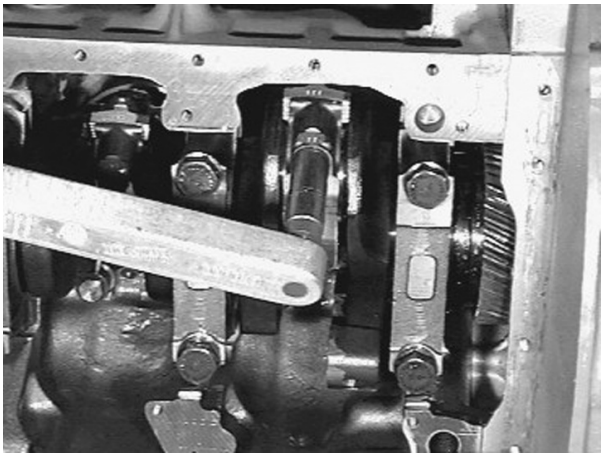
9

Fig. 10

Measure the conrod bearings, insert the pistons with conrods. Coat the conrod bearing shells with oil and pull the conrods to the journals.

Fit the conrod bearing caps with bearing shells (observe marking - numbers must be on the same side).

Screw in the mounting bolts and tighten them in stages to specified torque.



10

Final tightening according to rotation angle method.
(For tightening torques and reusability of bolts, see “Service Data”).

Tightening torque
Initial torque . . . . . 100 –110 Nm
Angle tightening . . . . . 90–100°

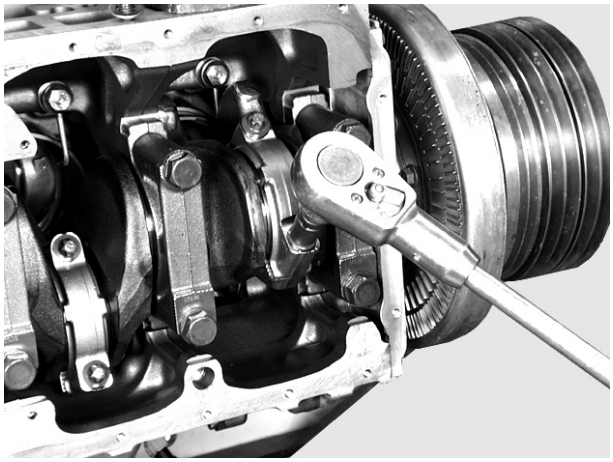
Fit oil pan and other detachable components.

Removing pistons with conrods

- Remove oil pan and oil suction pipe, see Page 65
- Removing cylinder heads, see page 91

Fig. 1

Loosen and remove conrod bearing cover bolts.

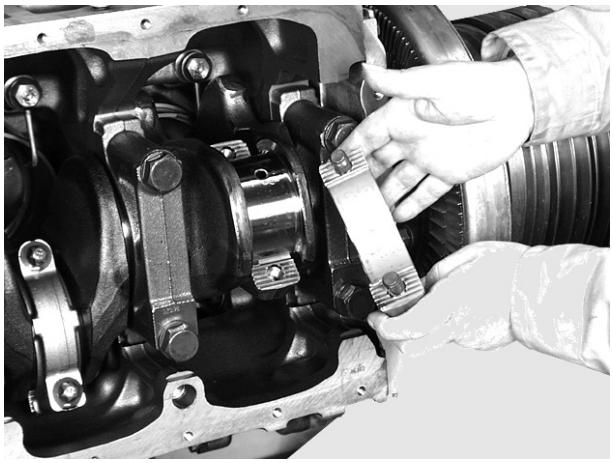


1

Fig. 2

Take off connecting rod bearingcaps with bearing shells; expediting the procedure by means of light strokes with a synthetic hammer if necessary.

Note:
The conrod bearing covers are numbered at the conrod foot; arrage them in corresponding order.



2

Fig. 3

Remove combustion residues (oil carbon) from top cylinder edge using a piece of hard wood.

Caution:
Do not damage the cylinder liners!

Press out the conrod with piston upwards.

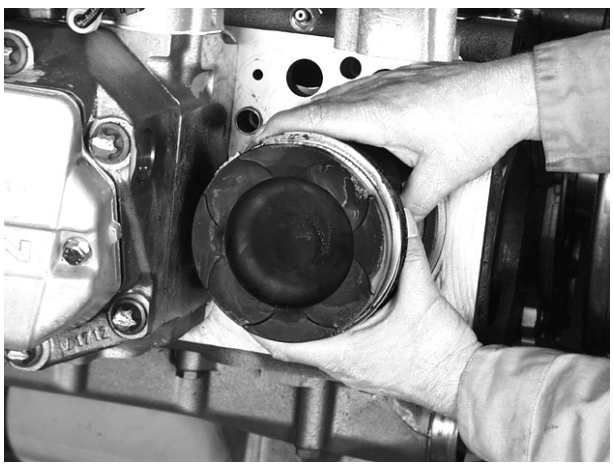
Caution:
Do not damage the oil injection nozzles!

3

Fig. 4

Lay pistons with connecting rods and associated caps aside; use deposit rack if available.
Perform visual check of piston and piston rings.

Note:
For reconditioned crankcase sealing faces, repair pistons with undersizes of 0.2, 0.4 and 0.6 mm in the compression height are available (see “Service Data”).

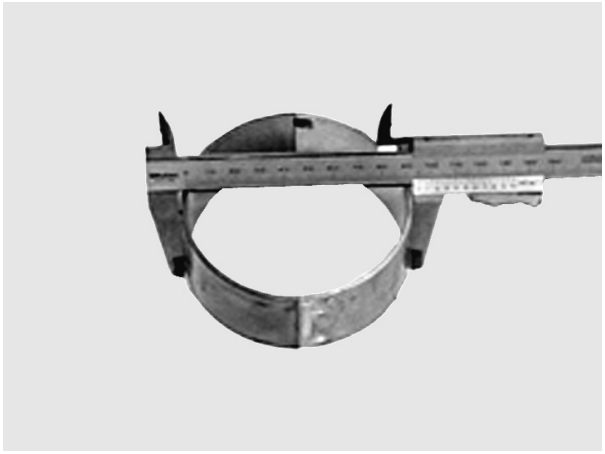


4

Installing pistons with conrods

Note:
If the pistons have to be replaced, it must be determined whether oversize pistons were fitted by measuring the pistons or reading off the dimension on the piston crown.
If this is the case, oversize pistons are to be used.

Fig. 5



5

Check bearing bushes for wear and damage.
Measure spread as in the case of main bearing bushes.
If required, fit new bearing bushes.
In the case of repairs to the conrod journals, use bearing bush of the corresponding repair level.

Fig. 6

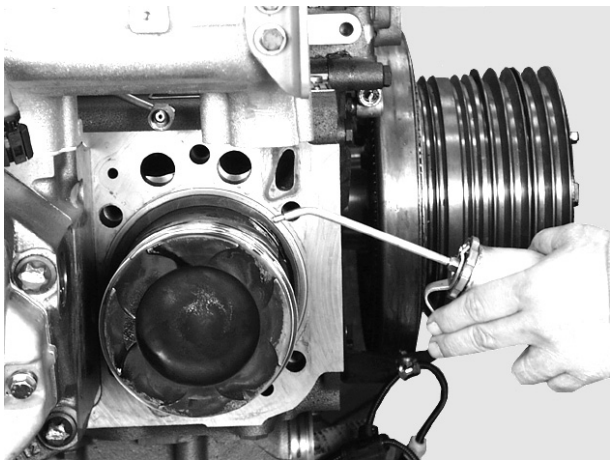
6

Insert the bearing bushes in the conrod or conrod bearing cover.

Caution:
The rod shell has a red or yellow mark on the side.

The running surface must not be damaged!
Apply a thin coat of oil to the conrod bushes.

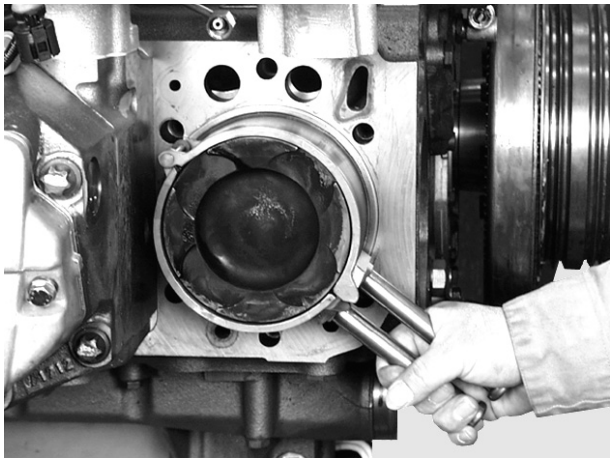
Fig. 7



7

Apply a thin coat of oil to the cylinder walls and pistons.
Adjust the piston ring joints by approx. 120° each.
Slide on the piston ring scuff band and tension the piston rings.

Fig. 8



8

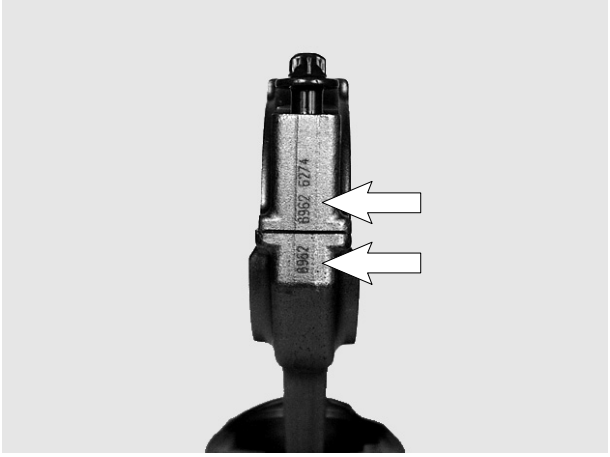
Insert the piston so that the recess on the piston skirt points to the oil spray nozzle.
Guide the conrod and push the piston on until it contacts the conrod foot on the conrod journal.

Caution:
Do not damage the oil injection nozzles!

Fig. 9

Place the conrod bearing cap in position.

Caution:
The numbers on the conrod bearing cap and the conrod big end must be on one side.



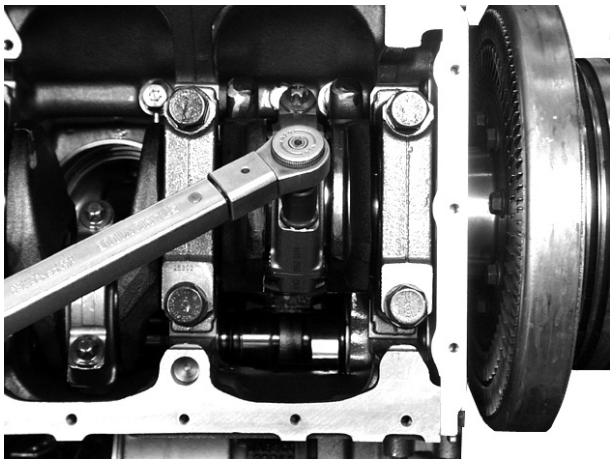
9

Fig. 10

Screw in the conrod bolts and tighten them in stages to the prescribed value.

Final tightening according to rotation angle method.

(For tightening torques and reusability of bolts, see “Service Data”).

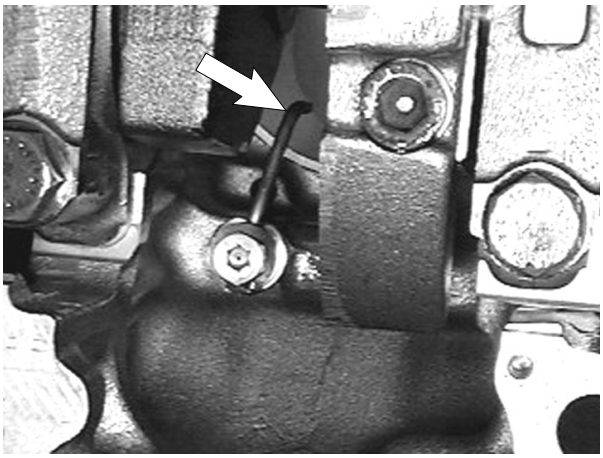


10

Fig. 11

Turn the engine slowly.
The conrods and oil injection nozzles (arrow) must not collide or scuff.

Note:
As far as possible turn engine only in direction of rotation (anti-clockwise as seen when looking at the flywheel) in order to prevent the direction of rotation of the sea water pump impeller being reversed.



11

Removing pistons from conrod and fitting

Fig. 1

Remove pistons with conrods.
Clamp the conrod in a vice using protective jaws.
Disengage piston pin fastening.

1

Fig. 2

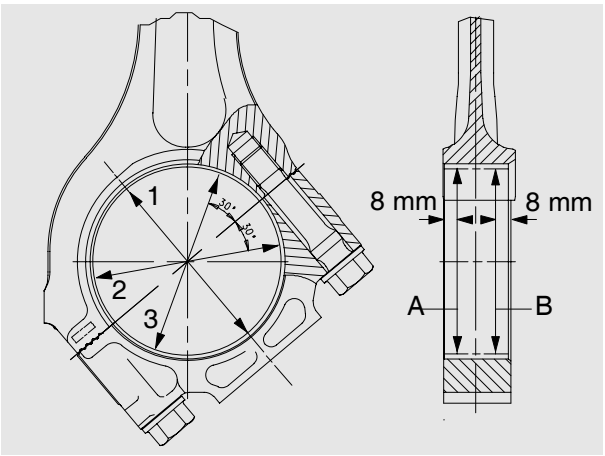
Push out gudgeon pin, holding piston in place. Remove piston and place to one side.

2

Measure conrod foot bore (base hole)

Fig. 3

Insert the new conrod bearing and fit the cap.
Tighten bolts according to regulation.
Measure the bearing bore with an inside micrometer in measuring directions 1, 2 and 3 and in planes a and b.
For max. permitted values, see “Service Data”. In the case of deviations beyond the tolerance range, replace conrod.



3

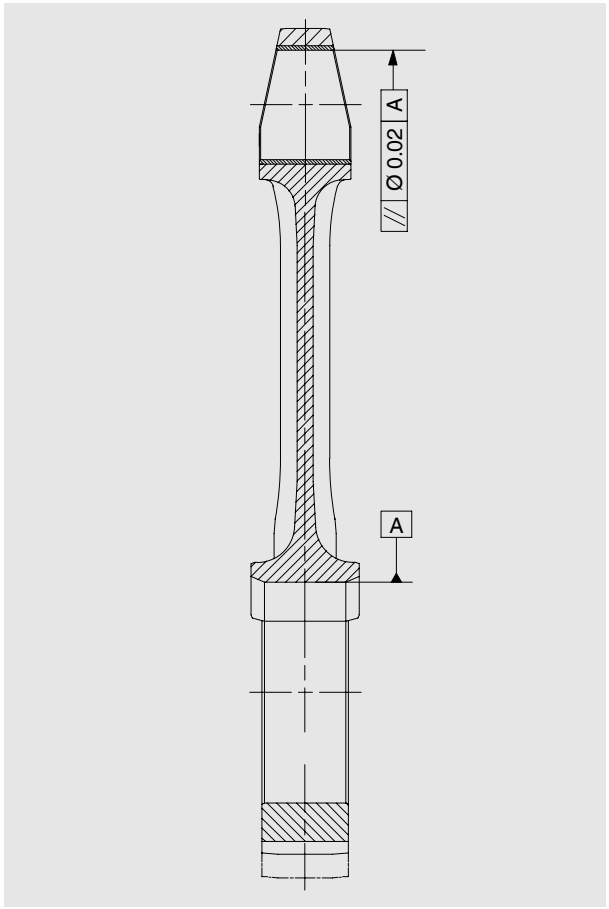
Fig. 4

Piston pin sockets are not available. In the case of worn sockets, fit exchange conrods.

4

Fig. 5

Clean conrod. Inspect for external damage, replace damaged conrods if necessary.
Check parallel location of conrod and twisting of piston pin eye to bearing bush bore hole. In the case of deviations beyond the tolerance range, replace conrod.



5

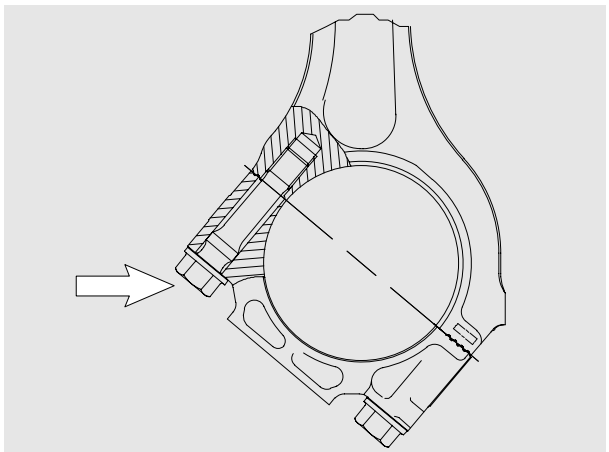
Fig. 6 and Fig. 7

Place piston on the conrod.

Caution:
The recess for the oil injection nozzle in the piston shaft (arrow) must lie on the side of the short conrod foot.

Insert piston pin. Engage fastenings.
Fitting pistons, see page 134.

6

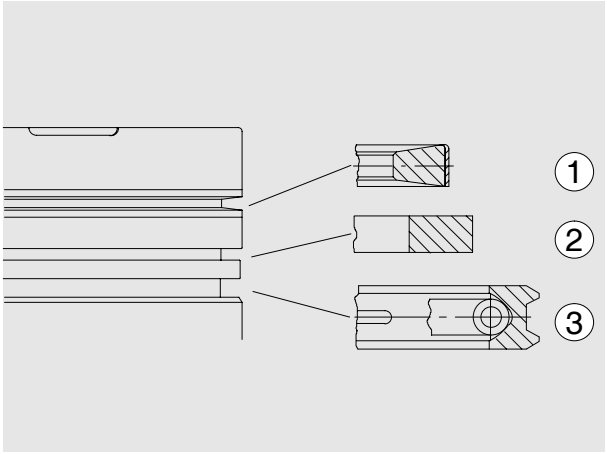


7

Piston ring arrangement

Fig. 1

1 Compression ring (double-sided keystone ring)
2 Compression ring (tapered compression ring)
3 Oil scraper ring (bevelled-edge ring)



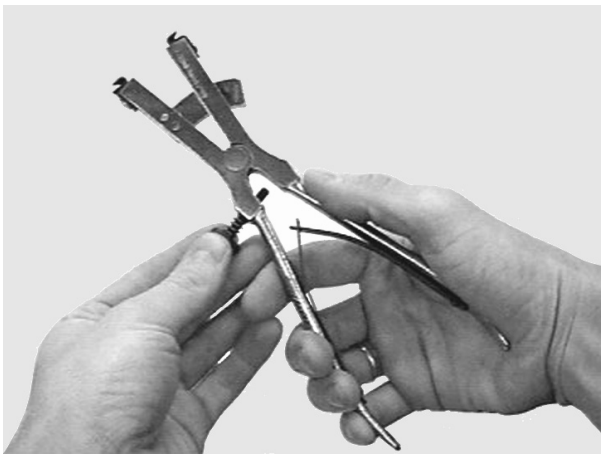
1

Removing piston rings

Fig. 2

Remove pistons with conrods.
Fit conrod in a vice, use protective jaws.

Set piston ring wrench to piston diameter.



2

Fig. 3

Apply piston ring wrench to piston ring joint and disengage the piston ring from the piston ring grooves.

Note:
The coiled spring expanders mean that the oil scraper ring has greater tangential tension.

Carefully clean the piston ring grooves using sawdust. Do not damage the piston ring grooves.

3

Checking ring end clearance

Fig. 4

Insert the piston rings individually in the cylinders and use a feeler gauge to determine the ring end clearance.

If the ring end clearance is too great, replace the piston rings.

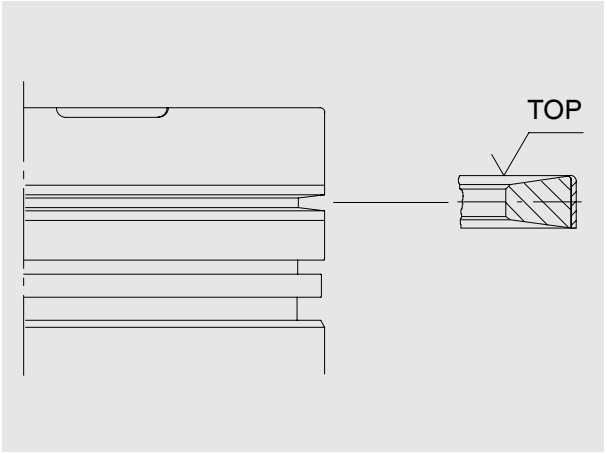
For ring end clearance, see “Service Data”.

4

Installing piston rings

Fig. 5 and Fig. 6

Use the piston ring wrench to engage the piston rings in the relevant piston ring groove (TOP facing upwards).



5

6

Checking piston ring axial clearance

Fig. 7

Determine the piston ring clearance in each piston ring groove at various points using a feeler gauge.

To do so, press the piston ring fully into the piston ring groove at the point to be measured.

If the clearance determined is too great, replace the pistons and piston rings.

For piston ring axial clearance, see “Service Data”.

7

New cylinder liners and modified cylinder head gasket since March 2003

From March 2003 the cylinder bush, the upper seal on the cylinder bush, the cylinder head seal and the torque regulations on various series D 2876 four valve engines without Common Rail have been modified as standard.

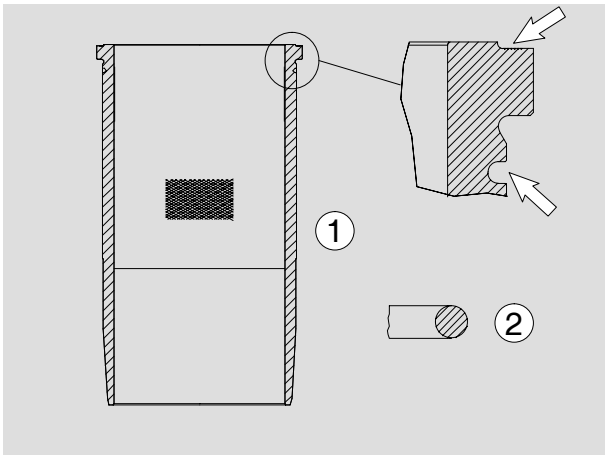
Note:
To aid recognition, these engines do not have the sticker “First retightening of cylinder-head bolts completed” on one of the valve caps.

Fig. 1

Version until 28.02.2003

Cylinder liner ① with seal ② (2 toric seals per cylinder liner).

For differences see arrows.



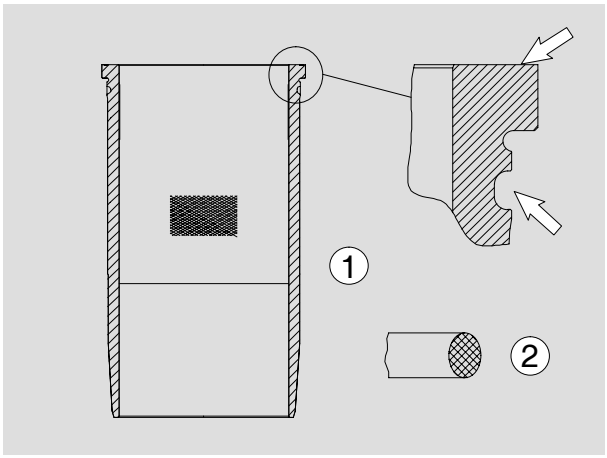
1

Fig. 2

Version since 01.03.2003

Cylinder liner ① with seal ② (1 profiled seal per cylinder liner).

For differences see arrows.



2

Caution:
A mixture of old and new versions in the same engine is not permitted!
Conversion is possible only if the cylinder head gasket, the cylinder liners and the cylinder liner seal are changed to the new version in all cylinders!

Note:
For modifications to cylinder head gasket see chapter “Removing / installing cylinder head”, page 90.

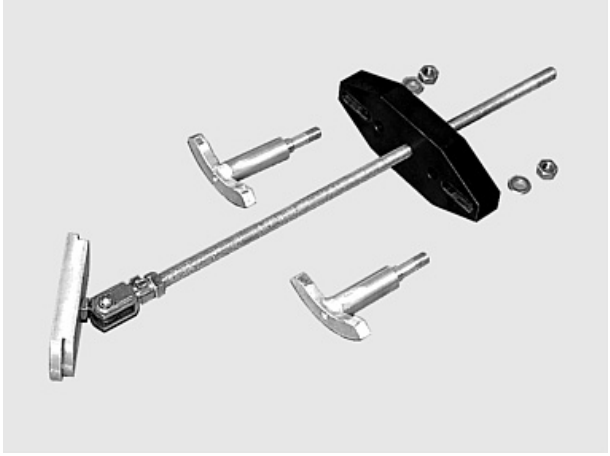
Removing cylinder liners

Note:
Observe oversizes for cylinder liner outside diameters and collar heights (see “Service Data”).

- Remove cylinder head, see page 91
- Remove piston, see page 133

Fig. 1

Observe oversizes for cylinder liner outer diameters and collar heights (see page 191, item 32).



1

Fig. 2

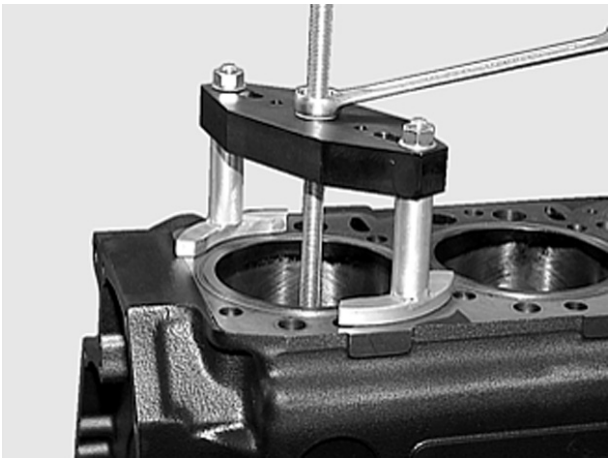
Mark the cylinder liner position relative to the engine so that it can be reinstalled if reused.

Insert the cylinder liner extractor apparatus into the cylinder liner, taking care not to damage the oil spray nozzle.

2

Fig. 3

Fit the support on the extractor spindle and screw on the nut.
Hold the extractor spindle in place and extract the cylinder liner by turning the nut.



3

Fig. 4

Remove the extractor apparatus and take out the cylinder liner.

4

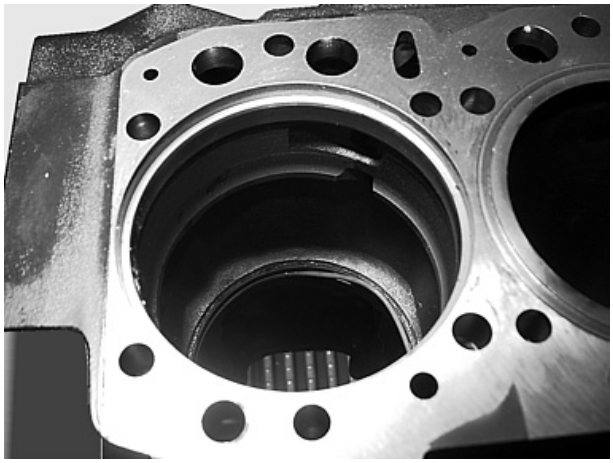
Fig. 5

Set the cylinder liner down in an upright position.
Number cylinder liners in order of installation.
Remove the O-rings.

5

Fig. 6

Remove the O-rings from the crankcase.
Clean the seat for the cylinder liners in the crankcase.

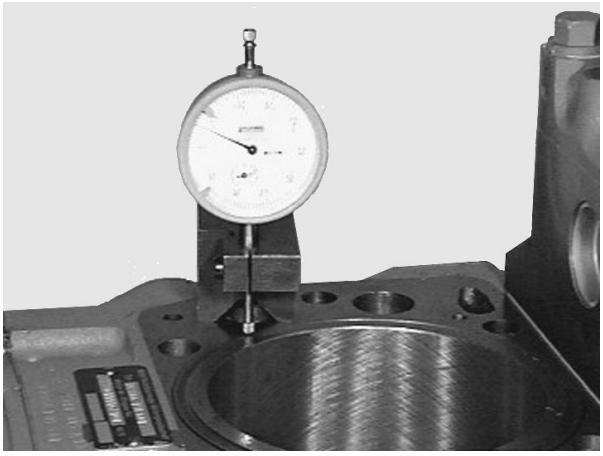


6

Checking cylinder liner protrusion

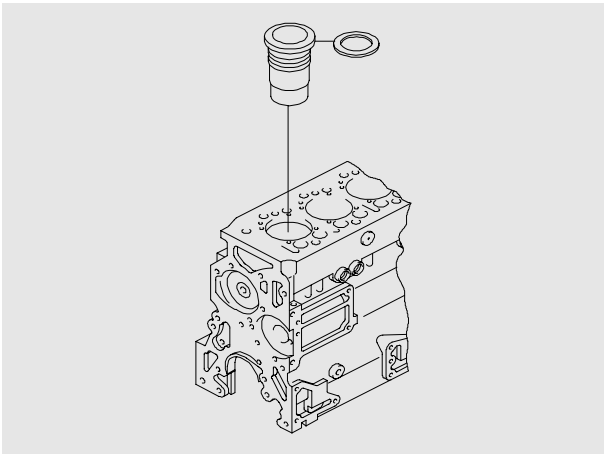
Fig. 7

Clean the basic bore and the cylinder liner.
Insert the cylinder liner without O-rings into the crankcase, observing the marking (ensure that it is identical to the position prior to removal).
Using the dial gauge and its holder, measure the cylinder liner protrusion at no less than 4 different points.
For specified values, see “Service Data”.



7

Note:
To verify that the O-rings are correctly seated after the cylinder liners are fitted, check the liner protrusion with special tool, as follows:
Position the press-on measuring plate with turned collar facing the liner, using 2 fitting sleeves to centre the plate.
Tighten 4 boltsimprovised: collar bolt 51.90020–0270, length shortened to 90 mm) n the press-on measuring plate in stages and crosswise to 40 Nm.
Set the dial gauge combination to “0” over the measuring plate under preload relative to the crankcase.
Measure the liner protrusion at no less than 4 different points.



8

Fig. 8

Fit a shim if the protrusion is below the minimum level, even at only a single point.
The shim is placed under the cylinder liner collar.
However, it may only be used if after installation the upper tolerance limit is not exceeded.

Installing cylinder liners

Fig. 9

Insert new O-rings for the lower seal (144x4) dry into the crankcase.
Insert new O-rings for the upper seal (138x2) into the cylinder liner grooves.
Do not overstretch the O-rings.

Note:
Do not use grease or sealing compounds of any type to install the cylinder liners and O-rings.

9

Figs. 10 and 11

Apply a thin coat of engine oil to the cylinder liner in the upper and lower O-ring areas.
Apply a thin coat of engine oil to the lower O-rings in the crankcase.

Insert the liners into the crankcase and press them in with both hands.
Then place a clean metal plate on the liner and exert uniform and downward pressure until the liner is seated in the crankcase recess.

If noticeable resistance can be felt during this procedure, the O-rings are no longer in their proper position.
Reposition the O-rings and insert the liner again.

10

11

Measuring piston protrusion

Fig. 1

Remove the cylinder heads.
Turn the piston to be measured to TDC.

Apply the dial gauge bracket with dial gauge to the crankcase gasket surface.
Set the dial gauge to “0”.

1

Fig. 2

Carefully swing the dial gauge bracket around while raising the tip of the dial gauge.

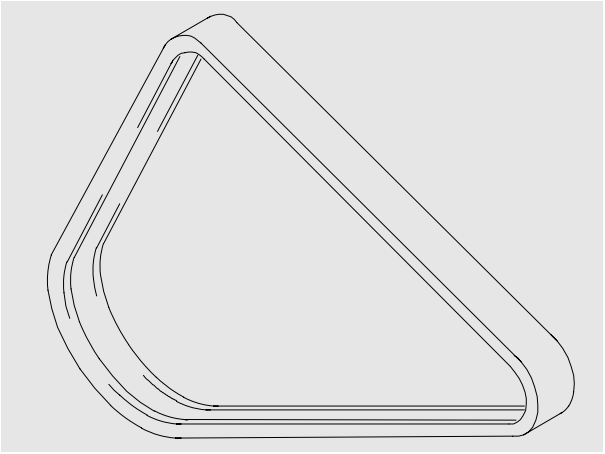
Lower the tip of the dial gauge to the piston crown and read off the excess piston projection.

2

Checking condition

Fig. 1

- Check V-belts for cracks, oiling, overheating and wear
- Change damaged V-belts



1

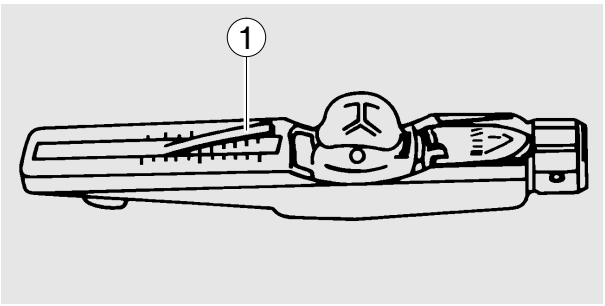
Checking tension

Figs. 2 and 3

Use belt tension indicator to check V-belt tension.

- Lower the gauge arm ① in the scale.
- Position the tension indicator in the centre of the belt between the two pulleys so that the edge of the stop face ② locates against the side of the belt.
- Slowly depress the pressure pad ③ vertically downwards until the spring disengages with an audible click; the gauge arm moves upwards.

A false reading will be obtained if you continue to apply pressure after the spring has disengaged.



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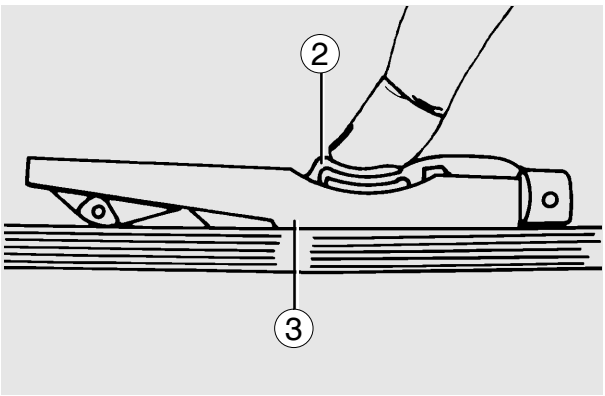


3

Fig. 4

Taking tension reading

- The tension is shown where the top of the gauge arm (① in picture 2) intersects the kg scale.
- Ensure that the gauge arm does not move before you take the reading.

If the reading does not correspond with the specified value, the V-belt tension must be corrected.

Drive belt width	Tensioning forces according to the kg graduation on the tester		
	New installation		When servicing after long running time
	Installation	After 10 min. running time	
2/3VX	90–100	70–80	60

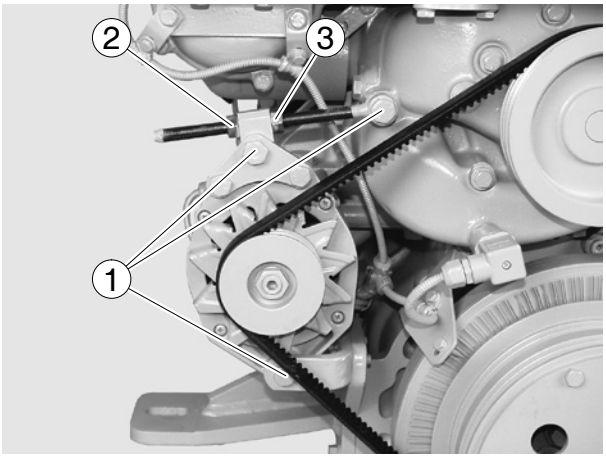
4

Tensioning and changing V-belts

Fig. 5

- Loosen mounting bolts ①
- Loosen lock nut ②
- Turn adjusting ③ nut until the V-belt is correctly tensioned
- Retighten lock nut and mounting bolts

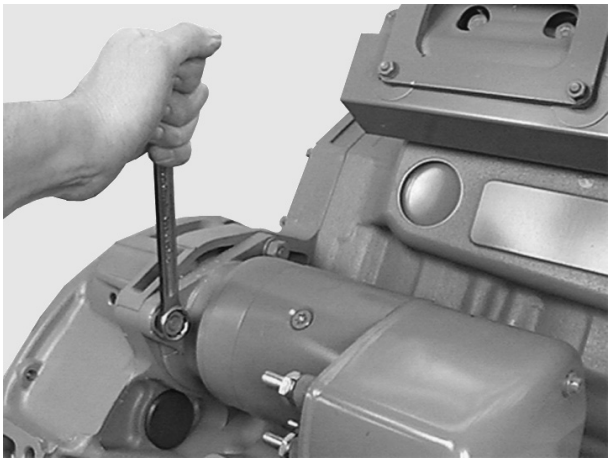
To change the V-belts, turn adjusting nut back and swing alternator inwards.



5

Fig. 1

Disconnect the negative lead from the battery or, if fitted, switch off the battery master switch.
Disconnect the connecting cable at terminal 31 (negative terminal, thick cable), connecting cable at terminal 30 (positive terminal, thick cable) and at terminal 50 from the starter motor.
Remove mounting nuts.



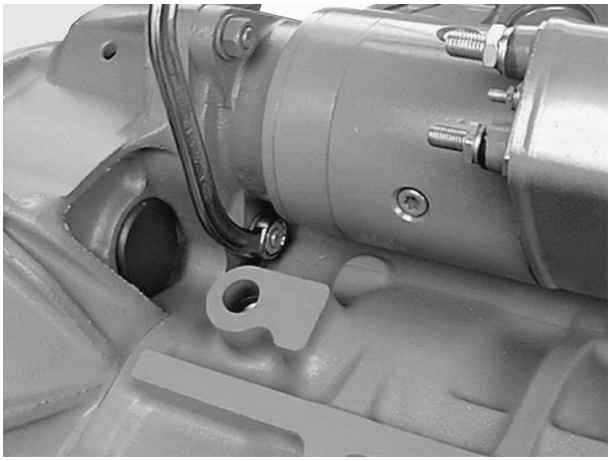
1

Fig. 2

A curved wrench is advantageous for the inner bolts.

Remove the starter motor.

Check the starter pinion for wear and whether it can move freely. If necessary, clean piston using a brush dipped in fuel and regrease it.



2

Check the flywheel ring gear for wear and damage.
Turn over engine by hand once, paying particular attention to the positions at which the engine finally stops; i. e. when the engine is switched off it always stops in certain positions.
The starter pinion engages in these positions when the engine is started.

Replacing the starter ring gear, see page 74.

The starter motor is installed in reverse order to its removal; when doing so, connect the cables correctly and tighten the bolts as specified.

Connect the battery or turn on the battery master switch.
Check the function of the starter motor after installation.

Monitoring the coolant level

All engines are equipped with either one or two coolant level probes for monitoring the coolant level in the coolant expansion tank. This probe is of the capacitative type. The sensor and the evaluating electronics form a unit.

If the coolant falls below the level monitored a minus potential is sent to the signal output “S”. With this a check lamp or a relay can be triggered.

Checking the coolant level probe

The probe features an integrated checking function. As soon as voltage is applied to the probe the signal appears for approx. 2 seconds to signalise that the probe is ready for operation.

If this signal does not appear, the probe must be checked.

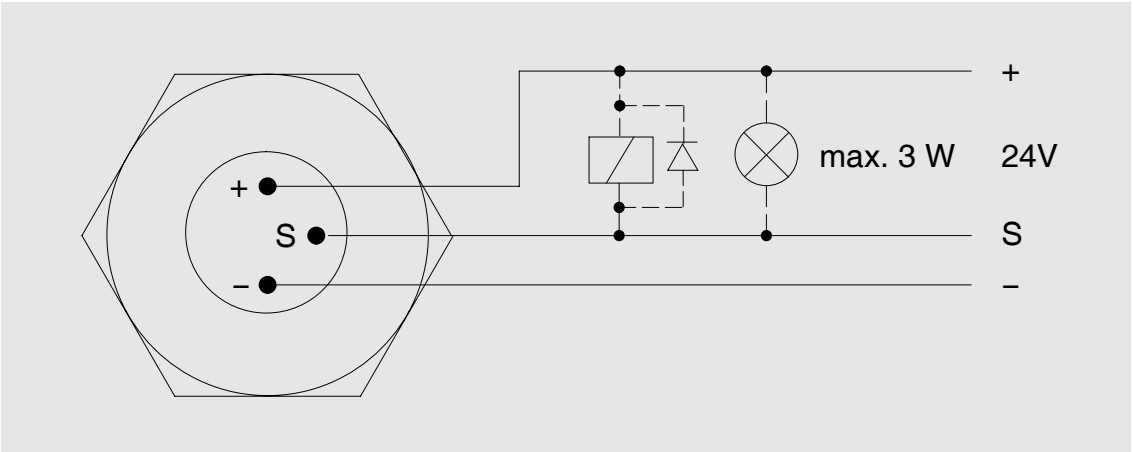
It is not possible to carry out a functional check by measuring the resistance (ohmmeter) because of the internal transistors.

The check can be carried out with a water tank and a small test bulb (< 3 watt).

Dip the probe into the water and apply a supply voltage of 24 V to the plus and minus leads. The output “S” is to be connected to the plus lead via the test lamp. The test lamp does not come on.

If the probe is taken out of the water, the test lamp must come on after approx. 7 seconds.

If the lamp does not come on the probe is defective and must be changed.



Service Data

Engine models D 2876 LE 401 / 402 / 404 / 405

Design	in-line
Cycle	4–stroke Diesel with turbocharger and intercooler
Number of cylinders	6
Compression ratio	
D 2876 LE 401 / 404	15 : 1
D 2876 LE 402 / 405	15,5 : 1
Bore	128 mm
Stroke	166 mm
Engine capacity	12 816 cm^3
Direction of rotation viewed from flywheel	anti clockwise
Firing sequence	1–5–3–6–2–4
Firing interval	120°
Max. engine output	
D 2876 LE 401	515 kW / 700 hp at 2200 rpm
D 2876 LE 402	412 kW / 560 hp at 2100 rpm
D 2876 LE 404	463 kW / 630 hp at 2200 rpm
D 2876 LE 405	537 kW / 730 hp at 2200 rpm
Lubrication	Pressure circulation
by	gear oil pump
Cooling	Fluid cooling
by	impeller pump
Coolant temperature	
before start of full load	60°C
normal	90°C
temporarily	95°C

Valve train

The checking values are valid for all engines listed in this publication

Valve clearance:

(when engine is cold)

Inlet	0.50 mm
Exhaust	0.60 mm

Valve clearance:

The individual valve train components expand slightly as they warm up. Valve clearance ensures that the valves close reliably and that an effective seal is formed even when the engine is warm.

Valve clearance too small:

The valves do not sit correctly on the valve seat inserts when closed and are therefore no longer able to conduct the heat to the cylinder head. In this situation the exhaust valves in particular are prone to burning because of the high thermal stress to which they are exposed as a result of the hot combustion gases which are constantly flowing past them.

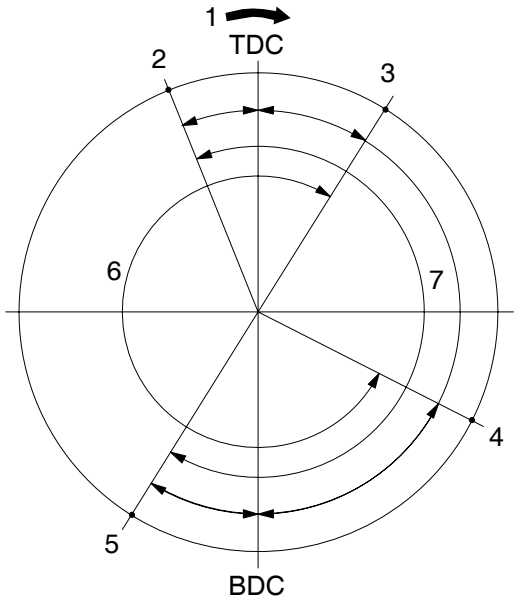
Valve clearance too large:

The valve opening cross–sections are reduced and cylinder charging is impaired. Valve train wear and valve noise is greatly increased.

Valve timing

1 = direction of engine rotation
2 = intake valve opens 23° before TDC
3 = exhaust valve closes 30° after TDC
4 = exhaust valve opens 60° before BDC
5 = intake valve closes 37° after BDC
6 = exhaust valve open for 270°
7 = intake valve open for 240°

The degrees specified refer to the crankshaft angle



Compression pressures

(Engine was run before measurement, warm to the touch)

good	bar	over 28
permissible	bar	25–28
in need of repair	bar	under 24
pressure difference (between the individual cylinders)	bar	max. 4

Fuel system

Delivery rate of fuel supply pump:		
n= 2.200 rpm	l/h	280
Opening pressure of overflow valve:		
at injection pump	bar	2.0–2.5

Lubricating system

Oil pump delivery rate:

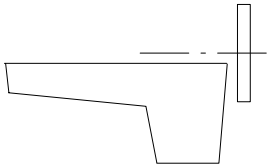
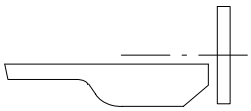
The speeds are pump speeds.
Oil pump speed: Engine speed x 0.977 (i = 1.023).
Delivery rates with SAE 20 oil at 90°C and 6 bar oil pressure.

n = 585 rpm	l / min	42
n = 2.150 rpm	l / min	195

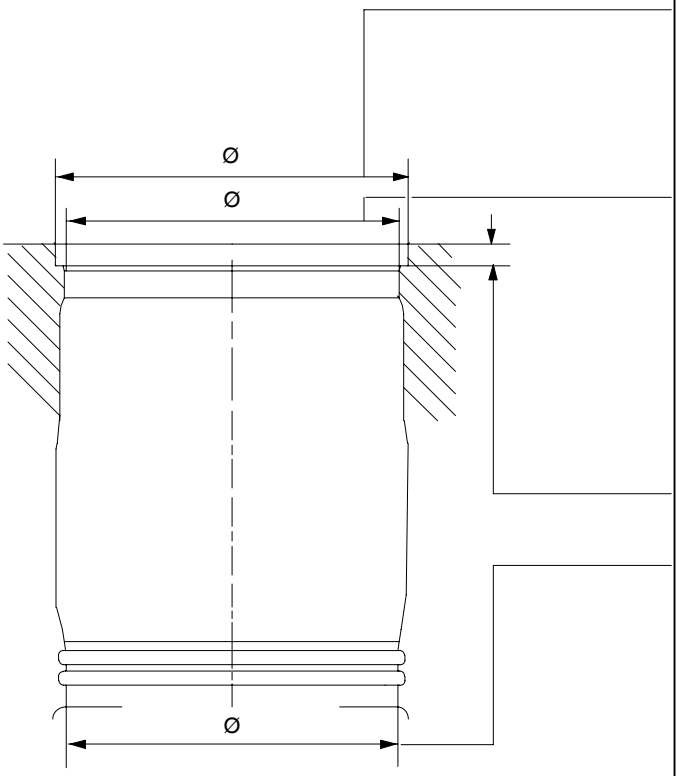
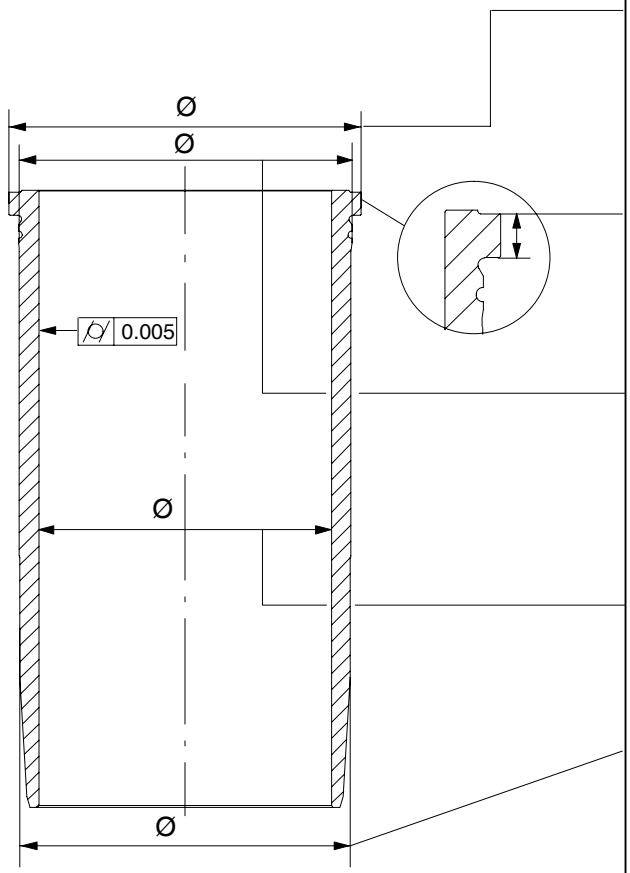
Valve opening pressures in lubricating oil circuit:

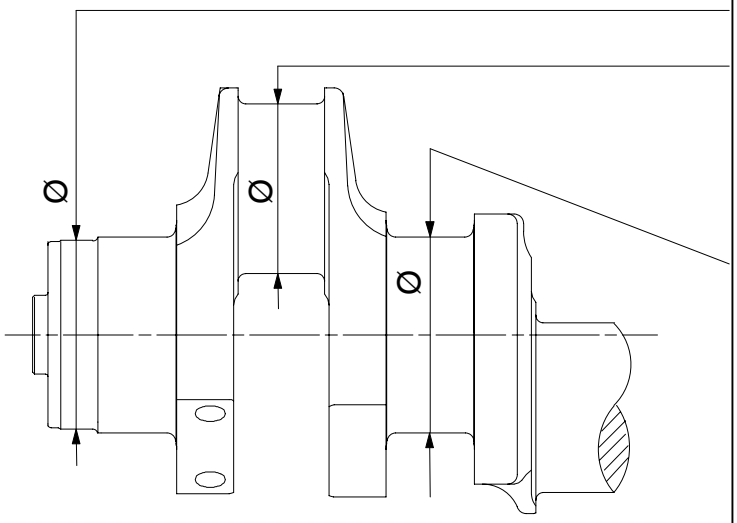
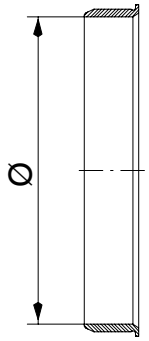
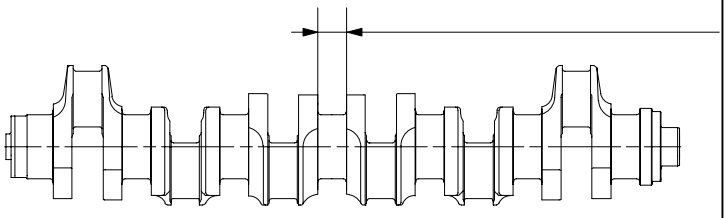
Bypass valve for oil filter		
Opening pressure	bar	2
Pressure at maximum opening	bar	4
Relief valve on oil pump	bar	9–10
Pressure valve of the oil injection nozzles		
Opening pressure	bar	1.9–2.1
Pressure at maximum opening	bar	1.4–1.6

Oil filling capacities

Model	Oil pan	Min. capacity	Max. capacity
D 2876 L..	deep Sump FW* 	26 l	30 l
D 2876 L..	flat 	29 l	34 l

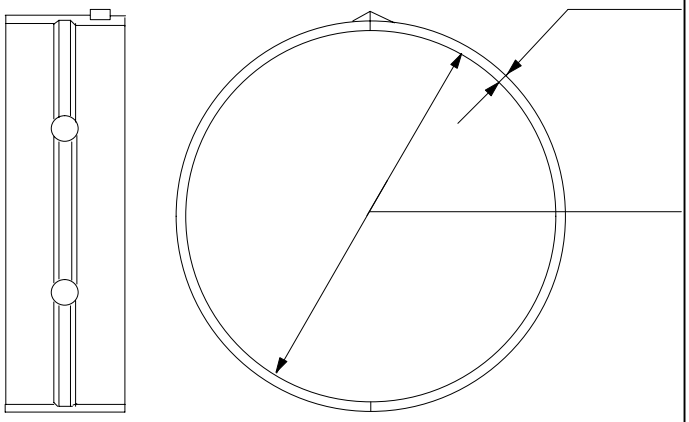
*FW = adjacent to flywheel

Service data	Dimensions Limit values
Crankcase  	Standard size: 153.90–153.94 mm for cylinder liners with 0.5 and 1.0 mm larger outside Ø: 154.40–154.44 mm standard size: 145.80–145.84 mm for cylinder liners with 0.5 mm larger outside diameter: 146.30–146.34 mm for cylinder liners with 1.0 mm larger outside diameter: 146.80–146.84 mm 9.955–10.025 mm Standard size: 144.50–144.54 mm for cylinder liners with 0.5 mm larger outside diameter: 145.00–145.04 mm for cylinder liners with 1.0 mm larger outside diameter: 145.50–145.54 mm
Cylinder liner  	Standard size: 153.694–153.757 mm with 0.5 and 1.0 mm larger outside diameter: 154.194–154.257 mm Standard size: 10.05–10.07 mm with 0.5 mm more flange height: 10.55–10.57 mm Liner protrusion above upper deck of crankcase: 0.03–0.08 mm Standard size: 145.761–145.786 mm with 0.5 mm larger outside diameter: 146.261–146.286 mm with 1.0 mm larger outside diameter: 146.761–146.786 mm 127.990–128.010 Max. wear limit: 0.15 mm below base dimension Standard size: 144.432–144.457 mm with 0.5 mm larger outside diameter: 144.932–144.957 mm with 1.0 mm larger outside diameter: 145.432–145.457 mm

Service data	Dimensions Limit values
Crankshaft	
Crankshaft front end (opposite end to flywheel)  	99.985–100.020 mm Standard size: 89.98–90.00 mm undersize –0.25: 89.73–89.75 mm undersize –0.50: 89.48–89.50 mm undersize –0.75: 89.23–89.25 mm undersize –1.00: 88.98–89.00 mm Standard size: 103.98–104.00 mm undersize –0.25: 103.73–103.75 mm undersize –0.50: 103.48–103.50 mm undersize –0.75: 103.23–103.25 mm undersize –1.00: 102.98–103.00 mm
Bearing race for crankshaft, front end  	Inner diameter: 99.907–99.942 mm
Thrust bearing journal 	Standard size: 46.000–46.062 mm undersize: –0.25 and –0.50: 46.500–46.562 mm –0.75 and –1.00: 47.000–47.062 mm

Service data	Dimensions Limit values

Main bearing

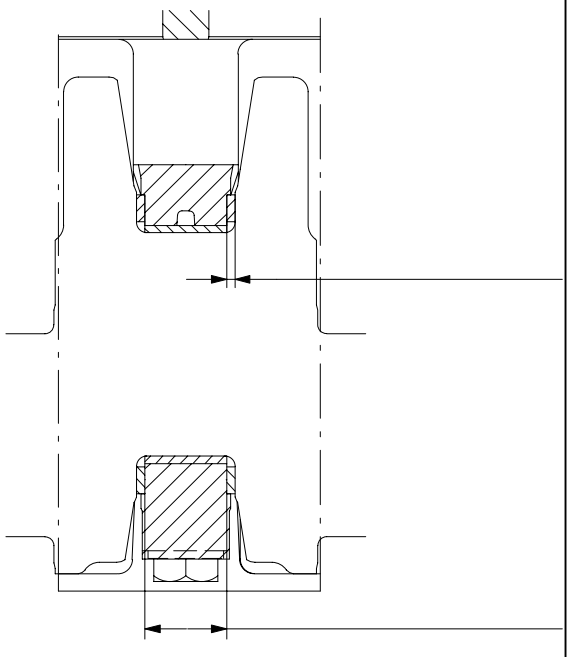


Standard size: 3.466–3.478 mm
undersize –0.25: 3.591–3.603 mm
undersize –0.50: 3.716–3.728 mm
undersize –0.75: 3.841–3.853 mm
undersize –1.00: 3.966–3.978 mm

Internal bearing Ø when fitted:
Standard size: 104.060–104.106 mm
undersize –0.25: 103.810–103.856 mm
undersize –0.50: 103.560–103.606 mm
undersize –0.75: 103.310–103.356 mm
undersize –1.00: 103.060–103.106 mm

Spread: 0.3–1.2 mm

Marking: top / bottom
standard: 0005 / 0006
undersize –0.25: 0011 / 0012
undersize –0.50: 0013 / 0014
undersize –0.75: 0015 / 0016
undersize –1.00: 0017 / 0018

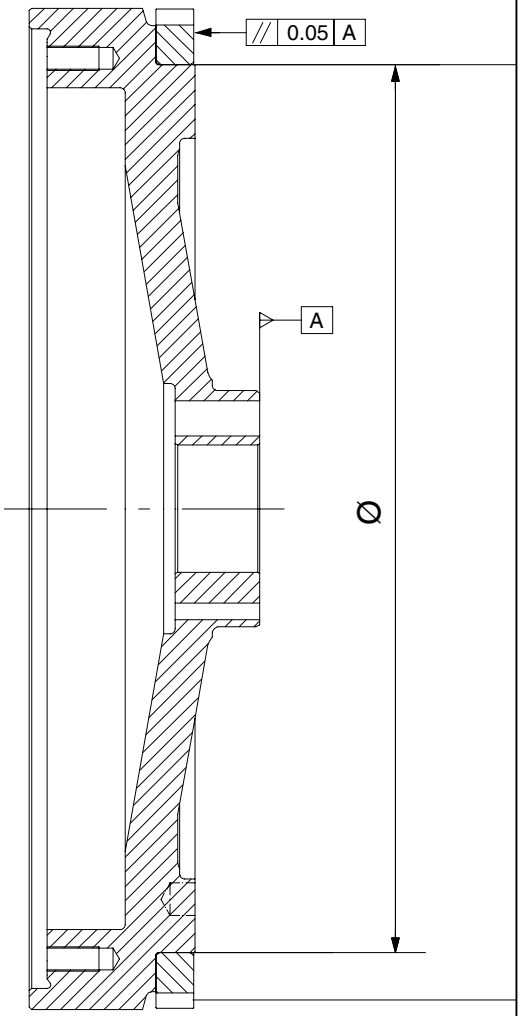


Permissible axial clearance of crankshaft:
0.200–0.401 mm

Thrust bearing width (thrust washer):
Standard size: 3.350–3.400 mm
Repair stage 1: 3.600–3.650 mm
Repair stage 2: 3.850–3.900 mm

38.961–39.000 mm

Flywheel



Ø Flywheel:
432.490–432.645 mm

Internal gear ring Ø:
432.000–432.155 mm

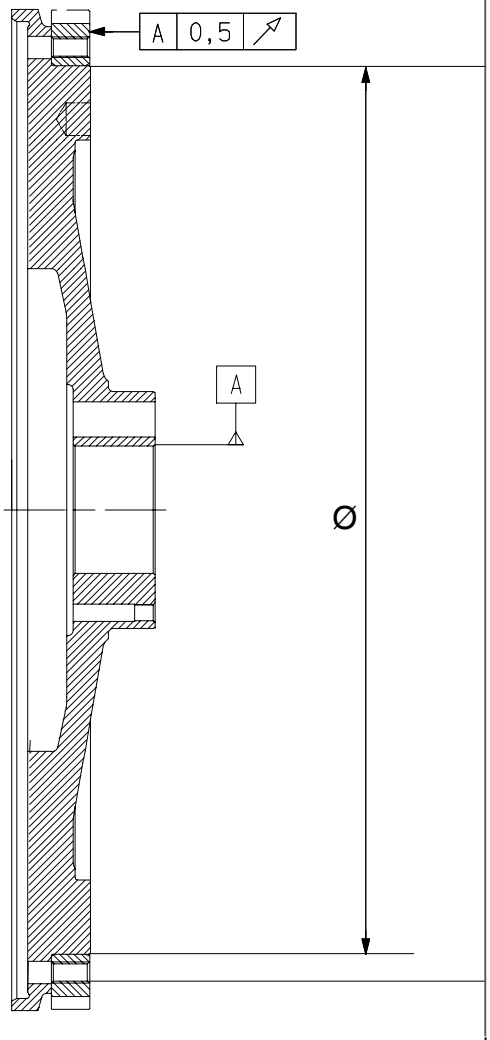
Interference: 0.335–0.645 mm
Installation temperature: 200–230°C

m = 52.3 kg (with gear ring)
J = 1.975 kgm^2

Number of teeth: Z = 160, module 3
Matching gear: Starter pinion (Z = 9)

Backlash: 0.6–0.9 mm

Flywheel



Ø Flywheel:
432.490–432.645 mm

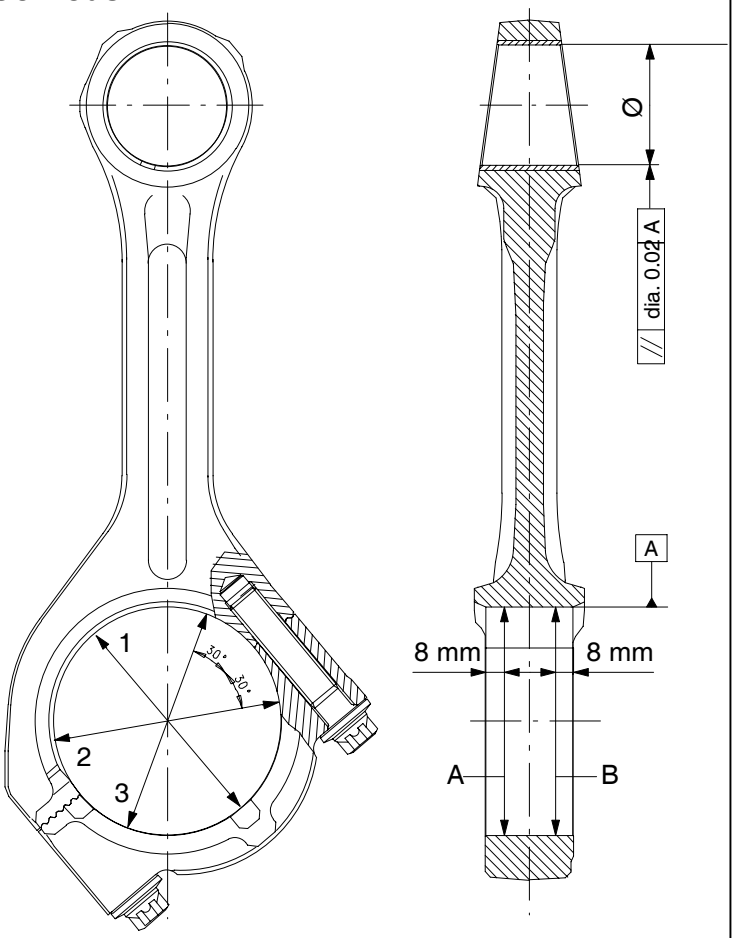
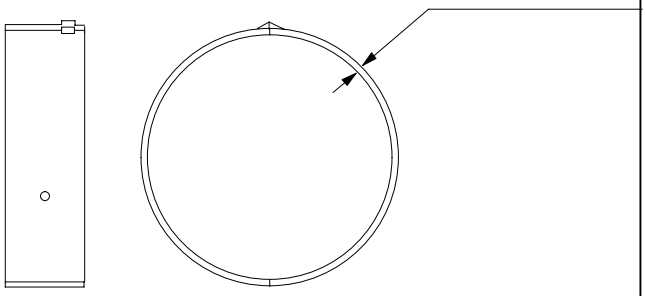
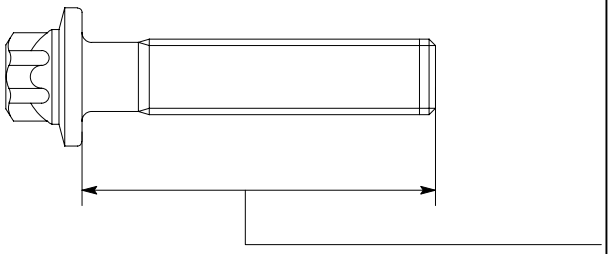
Internal gear ring Ø:
432.000–432.155 mm

Interference: 0.335–0.645 mm
Installation temperature: 200–230°C

m = 32.5 kg (with gear ring)
J = 1.10 kgm^2

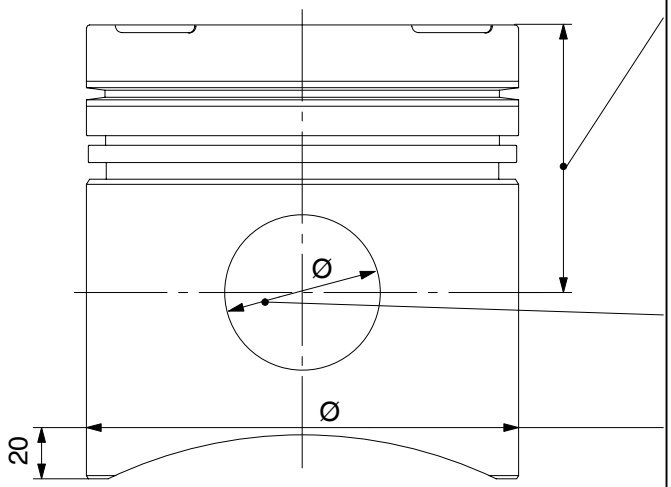
Number of teeth: Z = 160, module 3
Matching gear: Starter pinion (Z = 9)

Backlash: 0.6–0.9 mm

Service data	Dimensions Limit values
Conrods 	50.055–50.065 mm Conrods which are discoloured at the big end must not be re-installed. Bearing bore in measuring directions 1, 2 and 3 and in measuring planes a and b: 90.044–90.086 mm Edge condition: New conrod bearing in place, conrod assembled
Conrod bearings 	Standard size: 2.468–2.478 mm undersize –0.25: 2.593–2.603 mm undersize –0.50: 2.718–2.728 mm undersize –0.75: 2.843–2.853 mm undersize –1.00: 2.968–2.978 mm Spread: 0.6–1.5 mm If signs of wear are present (scores, anti–wear coating damaged), replace both bearing shells. Important: Note installation position (upper half bearing shell has red mark on the side)
Connecting rod bolts 	Length With each tightening, the bolts are deliberately stressed beyond the stretch limit and each tightening thus extends their length permanently. Torx bolt M14x1.5

Service data	Dimensions Limit values

Pistons



Compression height: 79.20–79.25 mm
with undersize:
0.2 mm 79.00–79.05 mm
0.4 mm: 78.80–78.85 mm
0.6 mm: 78.60–78.65 mm

Piston protrusion above crankcase top:
0.013–0.331 mm

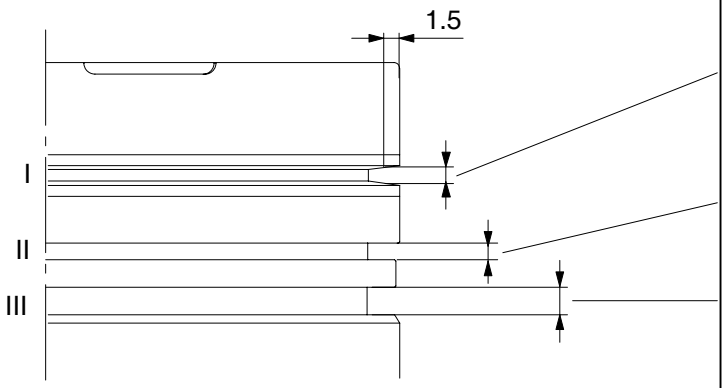
50.01–50.018 mm

Piston pin diameter:
49.994–50.0 mm

127.855–127.895 mm

Max. difference in weight per engine piston set: 100g

Piston ring grooves

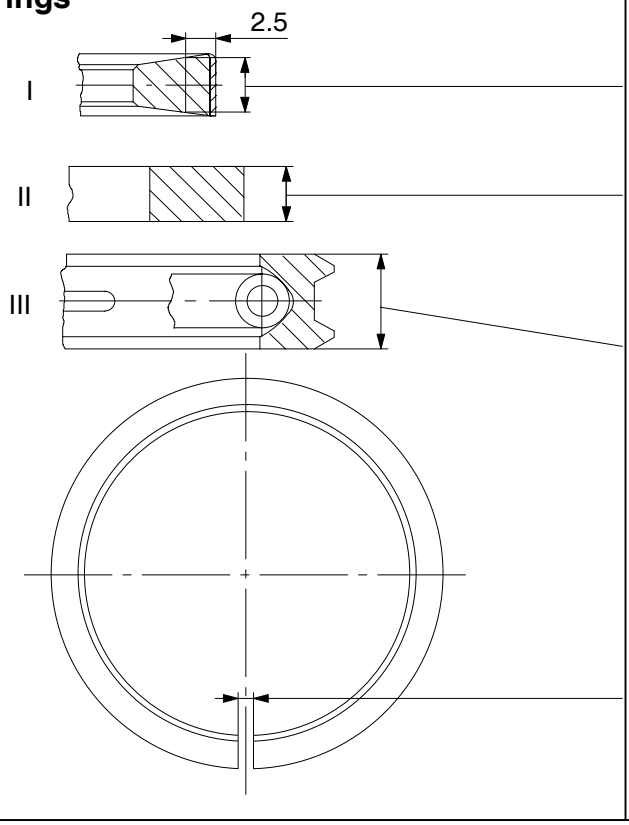


3.47–3.50 mm

3.05–3.07 mm

4.02–4.04 mm

Piston rings

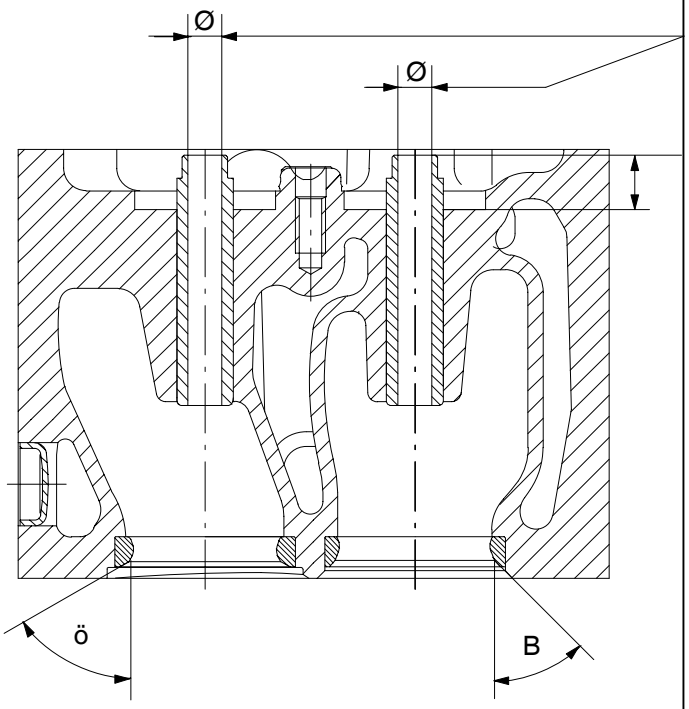
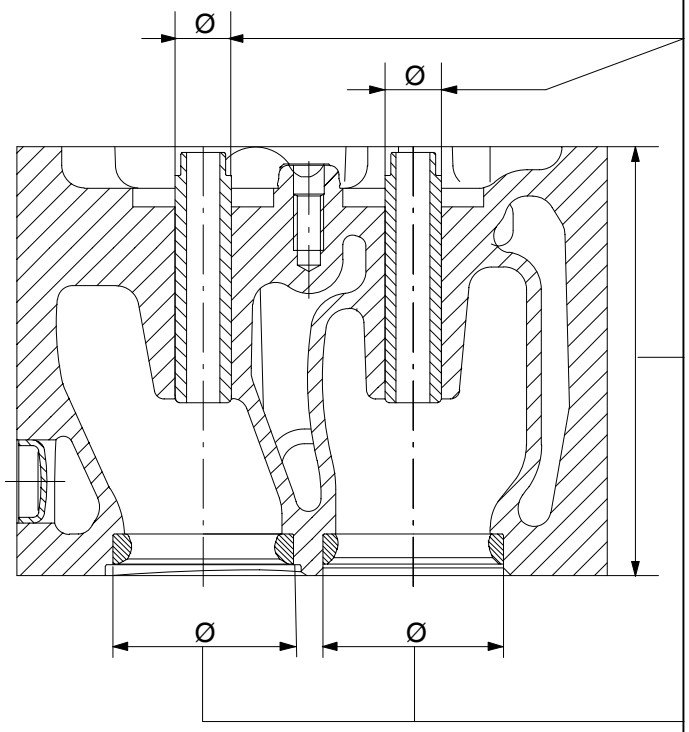


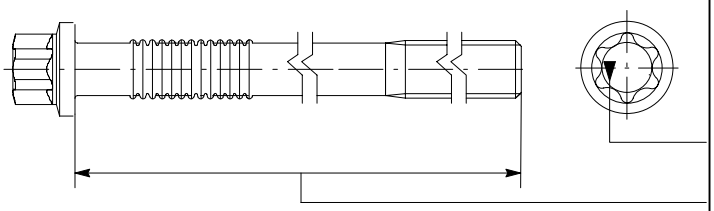
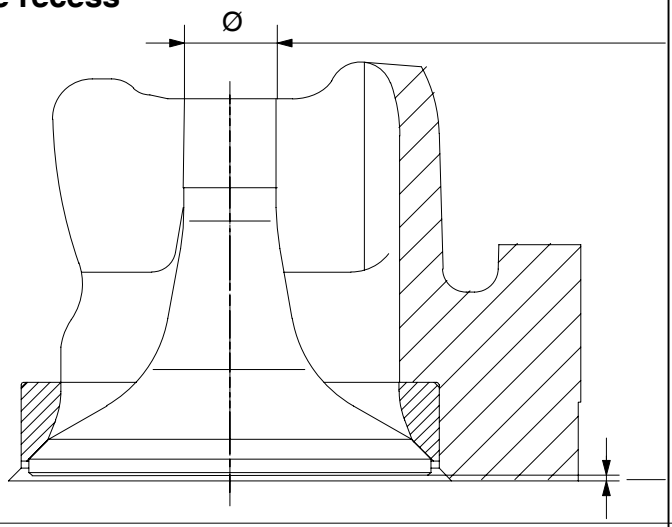
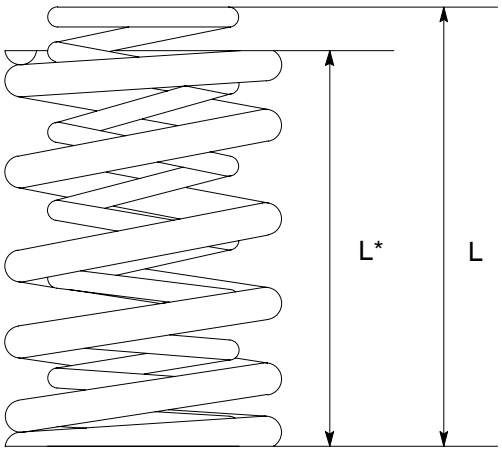
1st ring – keystone ring
Height: 3.296–3.330 mm

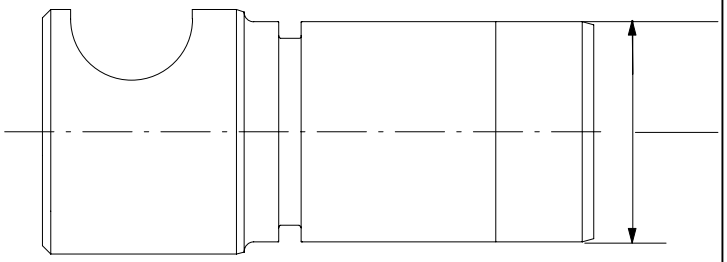
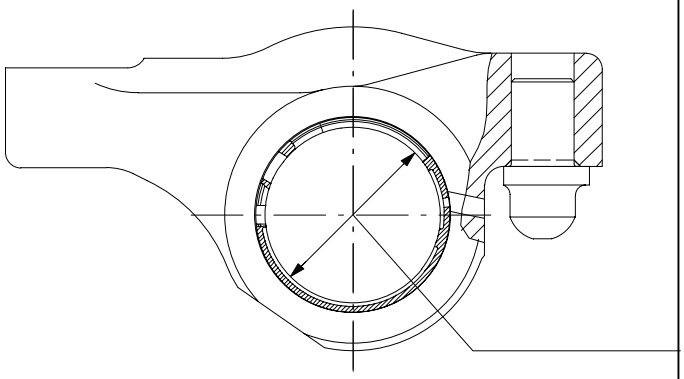
2nd ring – Minute ring:
Height: 2.97–3.0 mm
Axial clearance: 0.05–0.10 mm

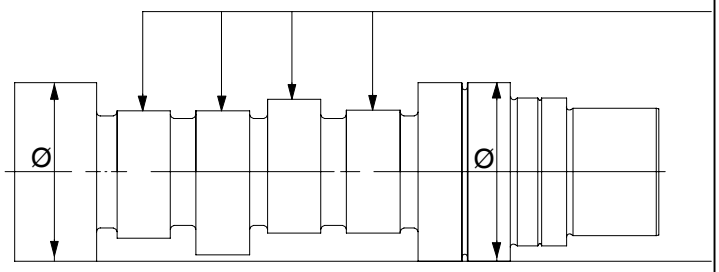
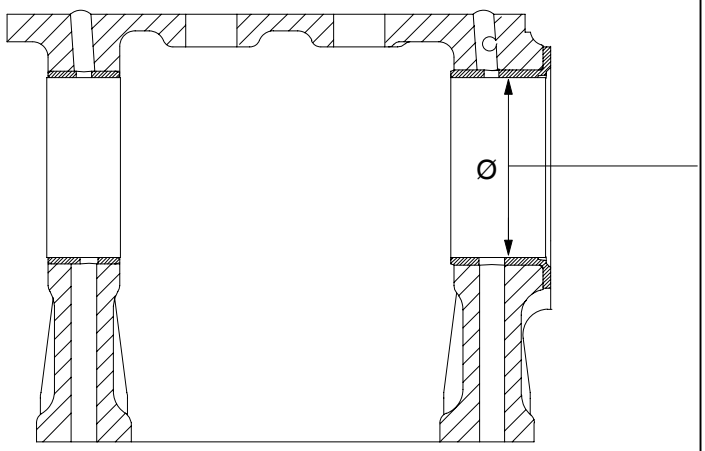
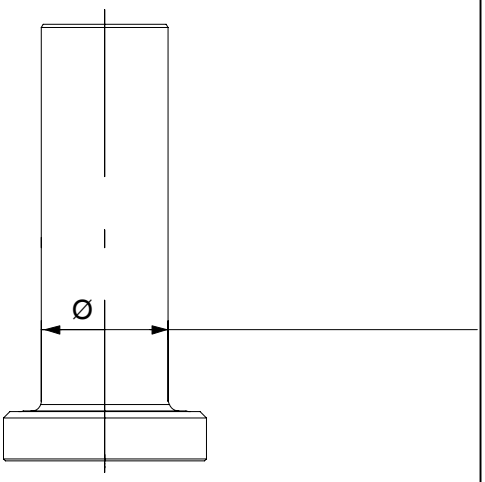
3rd ring – bevelled ring
Height: 3.975–3.990 mm
Axial clearance: 0.03–0.065 mm

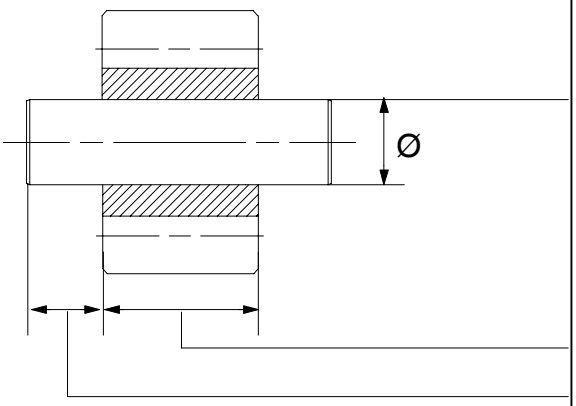
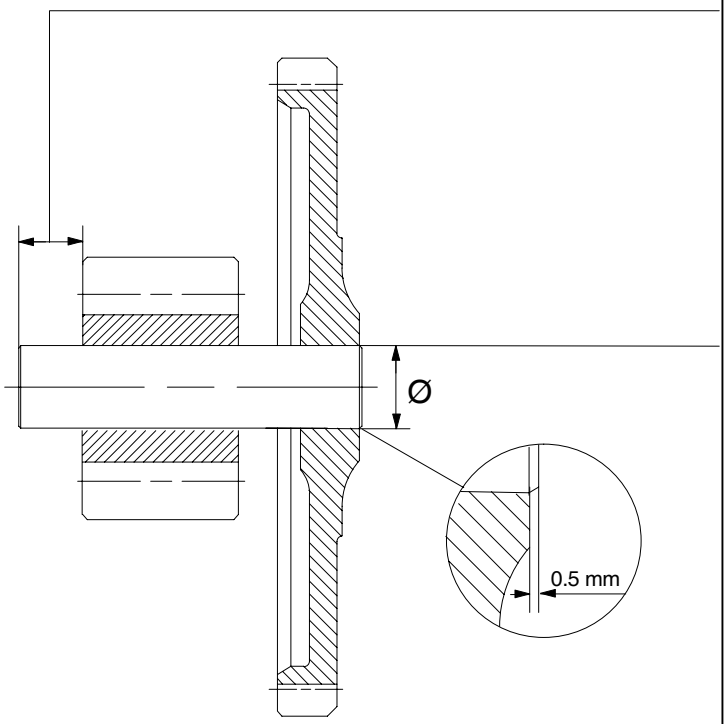
Ring gap:
1st ring: 0.5–0.7 mm
2nd ring: 0.7–0.9 mm
3rd ring: 0.25–0.55 mm

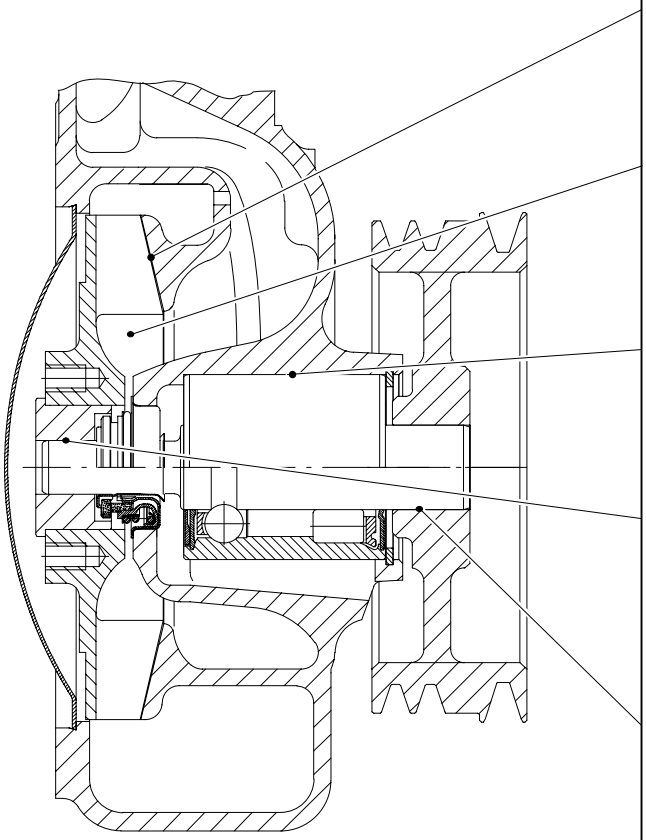
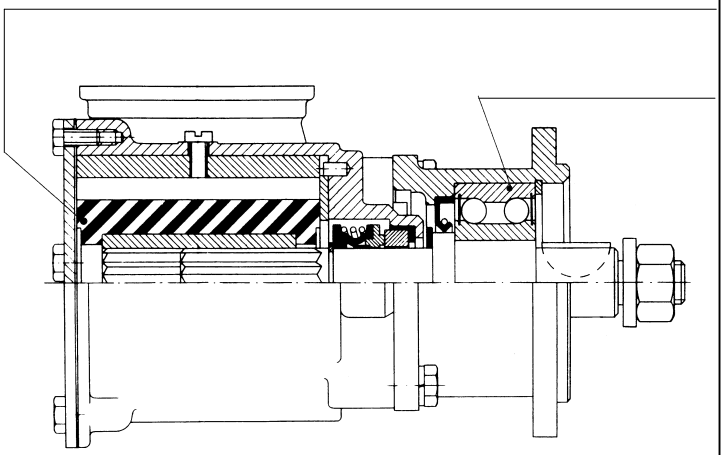
Service data	Dimensions Limit values
Cylinder head	
	9.000–9.015 mm 14.1–14.5 mm Intake valve φ = 60° Exhaust valve β = 45°
	Bore in cylinder head for valve guide: 15.000–15.018 mm External diameter of valve guide: 15.028–15.046 mm Standard size: 114–114.2 mm (observe specified dimensions for injector projection and valve recess) Bore in cylinder head: 48.00–48.025 mm External diameter of valve seat ring: 48.10–48.11 mm

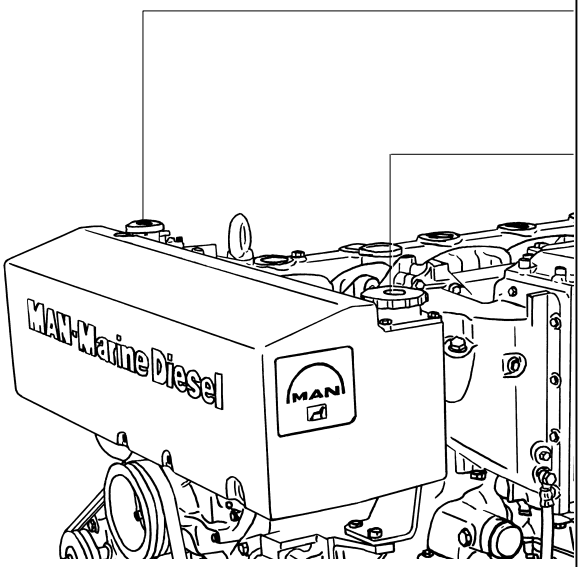
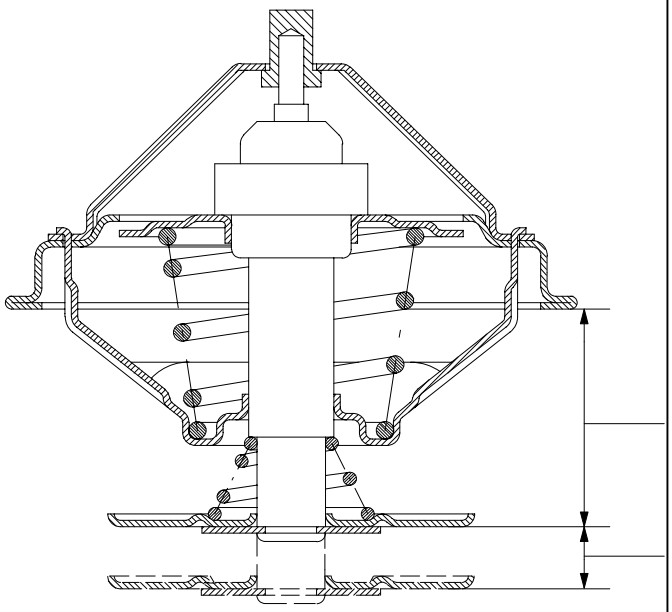
Service data	Dimensions Limit values
Cylinder head bolts 	Length With each tightening, the bolts are deliberately stressed beyond the stretch limit and each tightening thus extends their length permanently. When the bolt has reached its maximum length, it must not be re-used. Angle of rotation symbol 51.90490–0041 / 0070: new: 259–259.5 mm, max. 261.5 mm 51.90490–0042 / 0071: new: 197.5–198 mm, max. 200 mm
Valve recess 	Intake valve: 8.963–8.977 mm Exhaust valve: 8.95–8.964 mm Valve recess: 0.80 mm
Valve springs 	Inner spring: Free length (L), approx. 64.8 mm Spring force at L = 38 mm: 142–158 N Spring force at L = 26 mm: 213–239 N Outer spring: Free length (L*), approx. 63.3 mm Spring force at L* = 45 mm: 410–470 N Spring force at L* = 33 mm: 714–790 N The lowest spring force is at the same time the wear limit value.

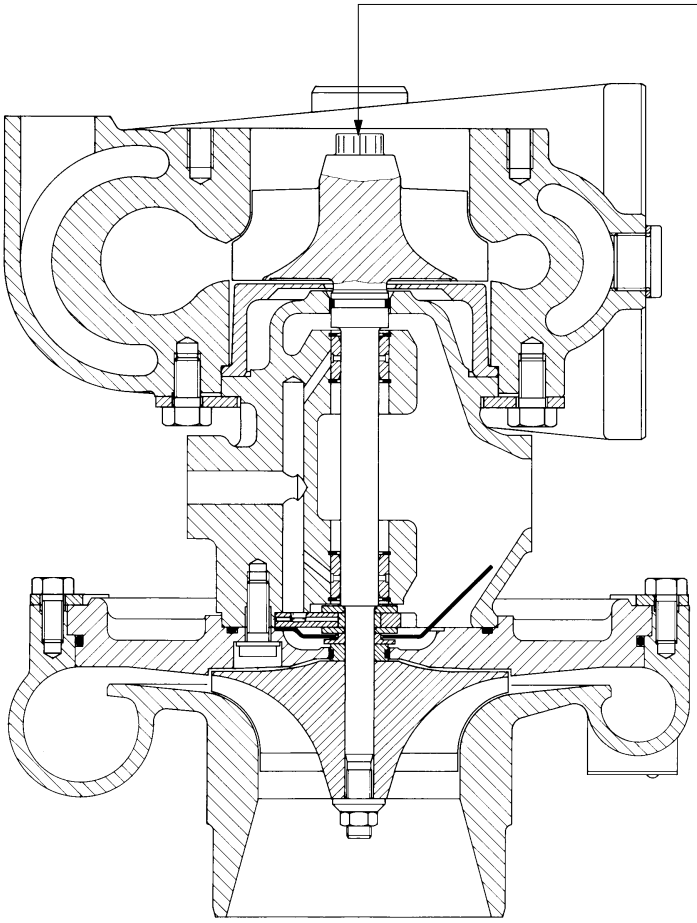
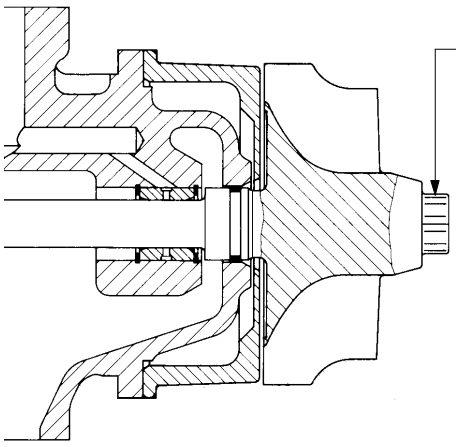
Service data	Dimensions Limit values
Valve gear	
Rocker arm shaft 	27.961–27.97 mm
Rocker arm 	28.005–28.021 mm Rocker arm radial clearance: 0.035–0.06 mm

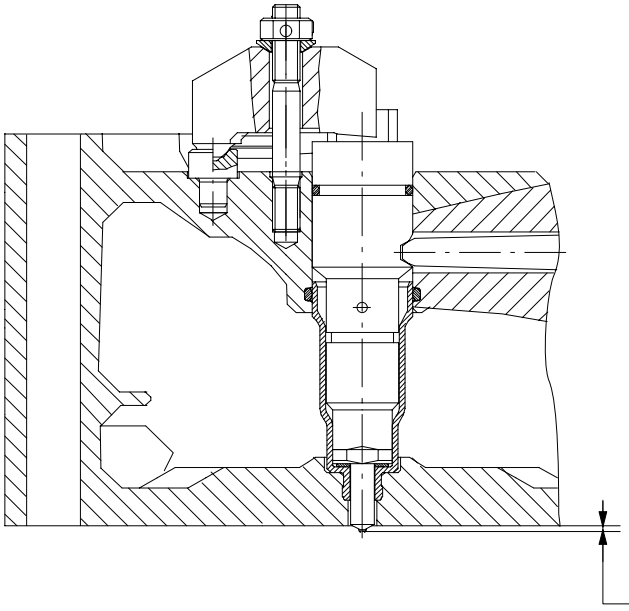
Service data	Dimensions Limit values
Camshaft  	Replace if signs of wear are present Camshaft axial clearance: 0.20–0.90 mm Wear limit: 1.5 mm 69.910–69.940 mm Backlash: Crankshaft gear and camshaft gear: 0.128 mm–0.252 mm
Camshaft bearing  	70.000–70.030 mm
Valve tappet  	Matching bore in crankcase: 20.000–20.021 mm 19.944–19.965 mm

Service data	Dimensions Limit values
Oil pump	
Oil pump gear 	Shaft: 21.930–21.940 mm Bore in housing lid: 22.000–22.021 mm Radial clearance: 0.060–0.091 mm Housing depth: 28.000–28.033 mm Gear axial clearance: 0.040–0.106 mm 27.927–27.960 mm 14.5–14.7 mm
Drive wheel with oil pump gear 	14.5–14.7 mm Shaft: 21.930–21.940 mm Bore in drive gear: 21.870–21.885 mm Press on force: 12.000 N Backlash: Drive wheel and crankshaft wheel: 0.099–0.451 mm

Service data	Dimensions Limit values
Cooling system	
Coolant pump 	Gap: 0.7–0.8 mm Ø impeller: 149.5–150 mm Bearing seat in housing: 54.940–54.970 mm Ø of bearing: 54.981–54.994 mm Interference: 0.011–0.054 mm Bore for bearing shaft in impeller: 16. 008–16.010 mm Ø of bearing shaft: 16.043–16.056 mm Interference: 0.033–0.048 mm Hub bore: 25.007–25.020 mm Ø of bearing shaft : 25.048–25.061 mm Interference: 0.028–0.054 mm
Raw water pump 51.06500-7026 	If impeller is worn, replace it together with seals (repair kit) If wear in the bearing can be felt (air in bearing), replace the bearing Speed of raw water pump: 1.53 x engine speed (i=0.65)

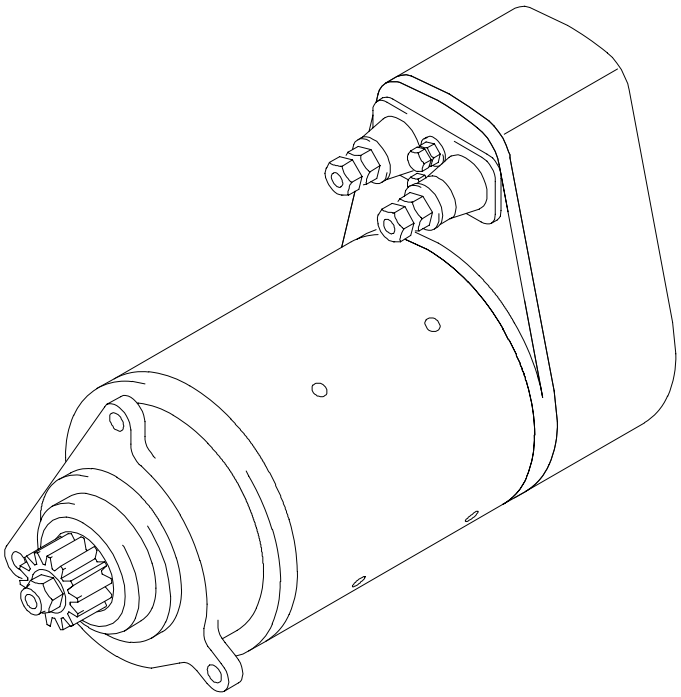
Service data	Dimensions Limit values
Cover for heat exchanger 	Working valve opens at 0.85–1.15 bar overpressure 0.02–0.08 bar negative pressure Valve cap: Safety valve opens at 1.3–1.7 bar overpressure (pressure: 1.5 LR1103) Warning: When opening the cap with the working valve there is a risk that it may remain non–tight after it has been closed again. The overpressure required in the cooling system no longer builds up. Premature boiling occurs and coolant is lost. To prevent damage to the engine, this cap should only be opened in exceptional circumstances and then replaced with a new one.
Thermostat 	Opening begins at: 83°C (±2°) Fully open: 95°C (The temperature for the start of opening is printed on the thermostat) 24.5–25.8 mm Lift at least 8 mm at 95°C

Service data	Dimensions Limit values
Turbocharger	
Axial clearance 	Axial clearance max. 0.16 mm for turbochargers KKK K36 and all engines D 2876 LE 4..
Radial clearance 	Radial clearance max. 0.58 mm for turbochargers KKK K36 and all engines D 2876 LE 4..

Service data	Dimensions Limit values
Fuel system **Injection nozzles**	
Manufacturer	Bosch
Type of injector	DLLA 154 P 945
Number of holes	6
Opening pressure of injector New nozzle holder: Used nozzle holder:	320+8 bar
Projection above cylinder head contact surfaces	
	2.12–3.13 mm
Injection pump	Bosch control-slide pump RP 39 Governor Bosch-EDC MS 5
Start of delivery	
Model	Crank angle before TDC
D 2876 LE 401 up to engine no ... 9838 999	7.5°±0.5°
D 2876 LE 401 engine no. and up ... 9839 001	8°±0.5°
D 2876 LE 402	6°±0.5°
D 2876 LE 404 / 405	8°±0.5°

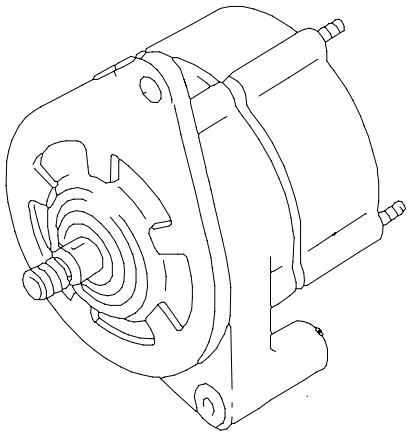
Service data	Dimensions Limit values

Starter motor



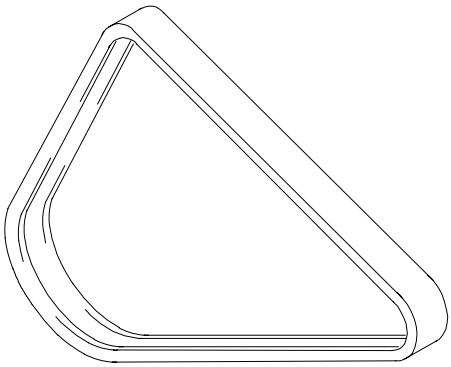
Manufacturer:	Bosch
Type:	KB
Operating method:	splined shaft
Starter motor pinion:	
Number of teeth:	Z = 9
Module:	3
Nominal power:	5.4 kW
Nominal voltage:	24 V

Alternator



Manufacturer:	Bosch
Type:	N1
Type:	2–pole, insulated
Operation method:	Threephase current
Voltage:	28 V
Max. current:	55 A

V–belts / Powerband



Replace damaged V–belts (cracks, wear, oil)

Measuring tension withtension tester

Belt width	Tensioning forces according to the kg graduation on the tester		
	New installation		When servicing after long running time
	Installa-tion	After 10 min. run-ning time	
2/3VX	90-100	70-80	60

Note:
All screw connections, the purpose of which is not stated in the following table, are to be tightened in accordance with the guide values in our company standard M 3059 (see page 176). Fit the bolts slightly oiled!

Screw plugs

DIN 908	
M14x1.5, M16x1.5	80 Nm
M18x1.5, M22x1.5	100 Nm
M24x1.5, M26x1.5	120 Nm
M30x1.5	150 Nm
DIN 7604	
AM10x1, M12x1.5	50 Nm
AM14x1.5	80 Nm

Crankcase, crankshaft drive

Gear case to crankcase M14, 12.9	225 Nm
Gear case to crankcase M10, 12.9	75 Nm
Inspection port cover to gear case M8, 12.9	40 Nm
Inspection port cover to gear case M8, 8.8	10 Nm
Crankshaft bearing caps to crankcase M18x2	
Initial torque	300–330 Nm
Angle tightening	90–100°
Vibration damper to crankshaft M16x1.5, 12.9	260 Nm
Flywheel to crankshaft M16x1.5	
Initial torque	100–110 Nm
1st angle tightening	90–100°
2nd angle tightening	90–100°
Connecting rod bearing caps M14x1.5	
Initial torque	100–110 Nm
Angle tightening	90 to 100°

Cylinder head

Tightening / retightening the cylinder-head bolts, see page 177

Lubrication system

Oil pump to crankcase M8, 8.8	22 Nm
Cover oil pump M8, 8.8	22 Nm
Oil cooler to oil filter head M8, 8.8	22 Nm
Filter box to oil filter head M8, 10.9	50 Nm
Oil pan to crankcase	22 Nm
Oil drain plug to oil pan M26x1.5	80 Nm
Oil jet flange to crankcase M14x1.5	70 Nm

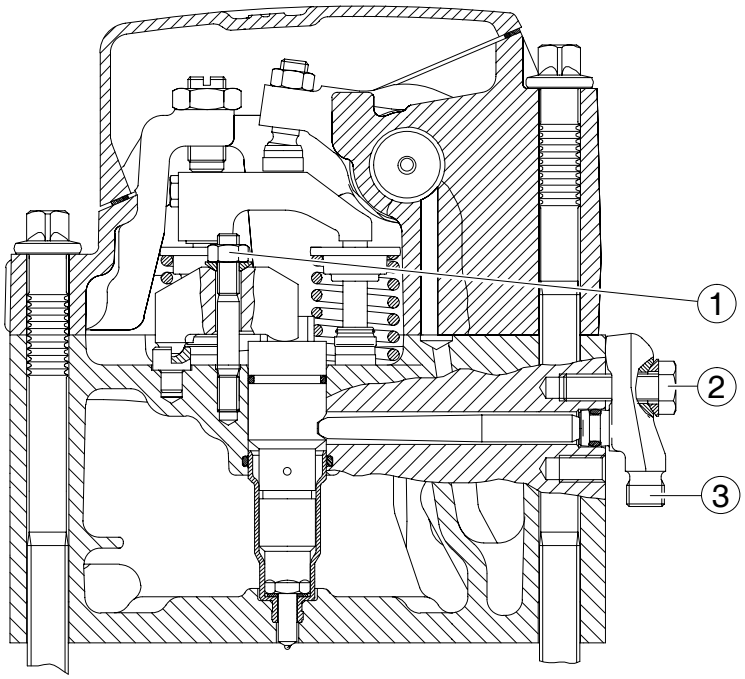
Exhaust / intake manifold

Exhaust manifold to intermediate plate M10	45 Nm
Exhaust manifold to intermediate plate M8	22 Nm
Intermediate plate to cylinder head M10	
Initial torque	60 Nm
Angle tightening	90°
Intake pipe to cylinder head M8, 8.8	22 Nm

Fuel system

Assembly sequence for injector and injection line:

1. Collar nut for injector retainer ①, initial torque ..... 10 Nm
2. Injection line ③, initial torque ..... 10 Nm
3. Mounting bolt for connector to injection line ②, initial torque ..... 10 Nm
4. Collar nut for injector retainer ①
   - Initial torque ..... 25 Nm
   - Rotation angle ..... 90°
5. Mounting bolt for connector to injection line ②
   - Final torque ..... 20 Nm
   - Rotation angle ..... 90°
6. Injection line ③
   - Rotation angle for first installation ..... 60°
   - Rotation angle for assembly sequence ..... 30°
7. Collar nut for injector retainer ①
   - Rotation angle ..... 45°
   - Let engine warm up
   - Rotation angle ..... 90°



Starter / alternator

Starter to crankcase M12x1,5 ..... 80 Nm
V–belt pulley on alternator ..... 40–50 Nm

Installation tightening torques according to company standard M 3059

Bolts / nuts with external or internal hexagon, head without collar or flange

Thread size x pitch	Grades / tightening torques in Nm		
	for **8.8 / 8**	for **10.9 / 10**	for **12.9 / 12**
M4	2.5	4.0	4.5
M5	5.0	7.5	9.0
M6	9.0	13.0	15.0
M7	14.0	20.0	25.0
M8	22.0	30.0	35.0
M8x1	23.0	35.0	40.0
M10	45.0	65.0	75.0
M10x1.25	45.0	65.0	75.0
M10x1	50.0	70.0	85.0
M12	75.0	105.0	125.0
M12x1.5	75.0	110.0	130.0
M12x1.25	80.0	115.0	135.0
M14	115.0	170.0	200.0
M14x1.5	125.0	185.0	215.0
M16	180.0	260.0	310.0
M16x1.5	190.0	280.0	330.0
M18	260.0	370.0	430.0
M18x2	270.0	290.0	450.0
M18x1.5	290.0	410.0	480.0
M20	360.0	520.0	600.0
M20x2	380.0	540.0	630.0
M20x1.5	400.0	570.0	670.0
M22	490.0	700.0	820.0
M22x2	510.0	730.0	860.0
M22x1.5	540.0	770.0	900.0
M24	620.0	890.0	1040.0
M24x2	680.0	960.0	1130.0
M24x1.5	740.0	1030.0	1220.0

New cylinder head seal and modified cylinder bush from March 2003

From March 2003 the cylinder bush, the upper seal on the cylinder bush, the cylinder head seal and the torque regulations on various series D 2876 four valve engineswithout Common Rail have been modified as standard.

Note:
To aid recognition, these engines do not have the sticker “First retightening of cylinder–head bolts completed” on one of the valve caps.

Retightening of the cylinder head bolts on engines up to 28.02.2003

(Engine cold or warm)

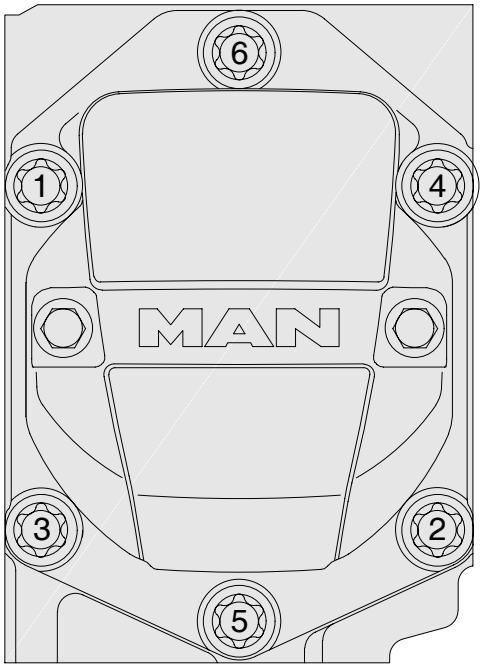
Erster Nachzug der Zylinder-kopfschrauben erledigt

First retightening of cylinder-head-bolts completed

Spare part no. 51.97801–0211

The cylinder heads are fitted with cylinder–head bolts for rotation angle tightening. On new engines, the cylinder-head bolts are retightened at the factory after running in and marked by the sticker **“First retightening of cylinder-head bolts ...”** on a cylinder head cover.

Intake side



Exhaust side

Tightening schedule

After the first 400 hours of operation, tighten the cylinder-head bolts 1–6 in the order specified in tightening schedule by 90° (1/4 turn).

Note:
The cylinder-head bolts to be retightened must not be loosened; they are to be tightened further from their current position by 90° (1/4 turn).

Zweiter Nachzug der Zylinder-kopfschrauben erledigt

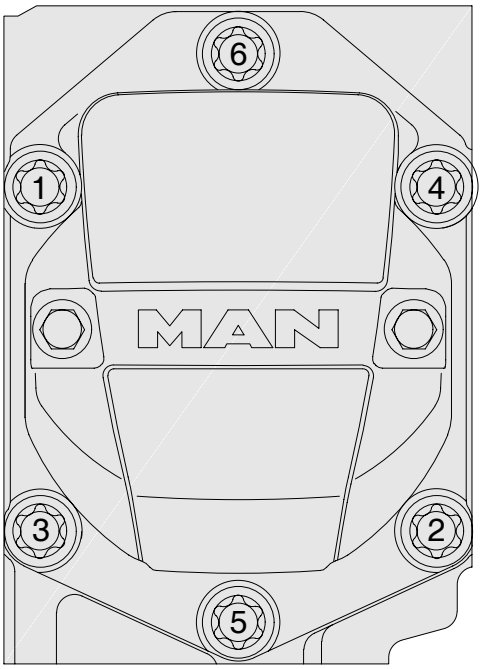
Second retightening of cylinder-head-bolts completed

Spare part no. 51.97801–0212

Remove the sticker “**First retightening of the cylinder-head bolts ...**” and attach the sticker **“Second retightening of the cylinder-head bolts ...”** to verify the second retightening.

Tightening the cylinder-head bolts following a repair
(engine cold)

Intake side



Exhaust side

Tightening schedule

Before inserting the cylinder head bolts, apply engine oil to the threads (not the tapped holes) and “Optimoly White T” installation past to the bolt head contact faces. Do not use oils or oil additives containing MoS_2. The bolts are to be tightened using the rotation angle method according to tightening schedule as follows.

- 1st pretightening = to 10 Nm
- 2nd pretightening = to 80 Nm
- 3rd pretightening = to 150 Nm
- 4th pretightening = 90°
- Final tightening = 90°

Set the valve clearance.

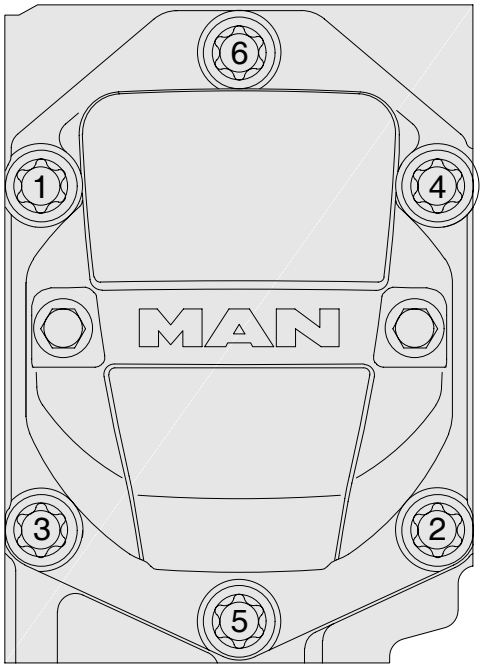
Note:
When the head has been removed, the cylinder head gasket must always be replaced.

Retightening the cylinder-head bolts following a repair
(Engine cold or warm)

After the first 10 to 20 hours of operation, following a repair, retighten the cylinder-head bolts in the order specified in tightening schedule by 90° (1/4 turn).
The cylinder-head bolts to be retightened must not be loosened; they are to be tightened further from their current position by 90° (1/4 turn).
Attach the sticker **“First retightening of cylinder-head bolts ...”** (remove sticker that might already be attached).
After the first 400 hours of operation, following a repair, tighten cylinder-head bolts 1 to 6 in the order specified in tightening schedule by another 90° (1/4 turn).
Attach sticker **“Second retightening of cylinder-head bolts ...”**.

Retightening of new and rebuilt engines from 01.03.2003

Intake side



Exhaust side

On engines which have modified cylinder liners, the cylinder-head bolts are no longer retightened at the factory.

Therefore the “First retightening of cylinder-head bolts completed” sticker is omitted

After 400 hours of operation, retighten the cylinder-head bolts by 90° (1/4 turn) in accordance with the tightening schedule on the left without loosening them first.

Nachzug der Zylinder-kopfschrauben erledigt

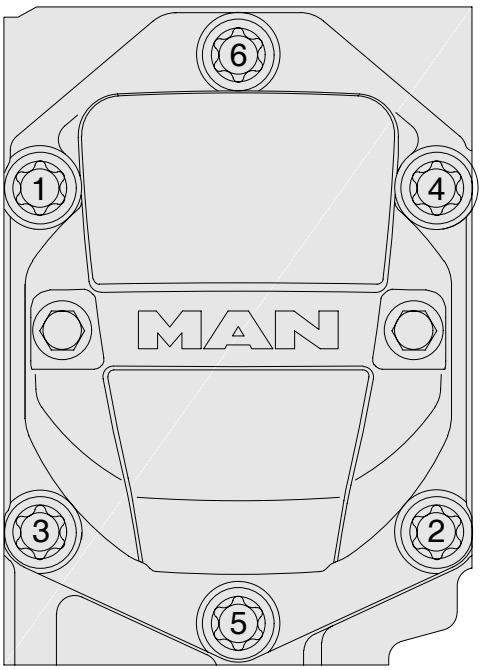
Retightening of cylinder-head-bolts completed

Spare part no. 51.97801–0315

Following successful tightening, attach the **“Re-tightening of cylinder-head bolts completed”** sticker to one of the valve caps.

Tightening the cylinder-head bolts following a repair
(engine cold)

Intake side



Exhaust side

Before inserting the cylinder head bolts, apply engine oil to the threads (not the tapped holes) and “Optimoly White T” installation past to the bolt head contact faces. Do not use oils or oil additives containing MoS_2. The bolts must be tightened using the torque angle method according to the tightening sequence on the left.

- 1st pretightening = to 10 Nm
- 2nd pretightening = to 80 Nm
- 3rd pretightening = to 150 Nm
- 4th pretightening = 90°
- Final tightening = 90°

Set the valve clearance.

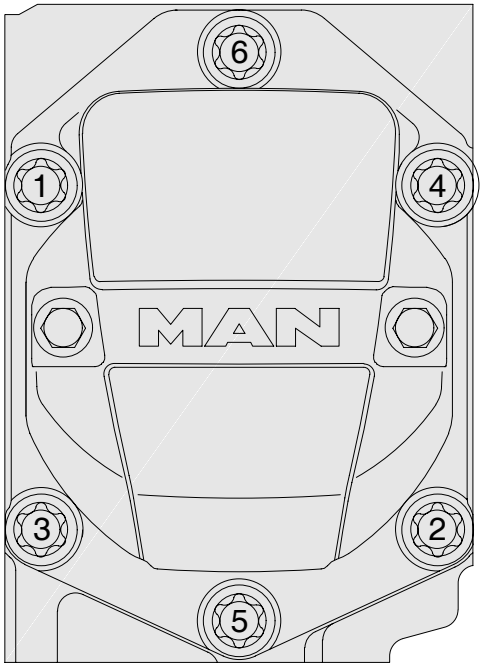
Following successful first tightening during a repair, remove the existing sticker from the valve cap.

Note:
When the head has been removed, the cylinder head gasket must always be replaced.

Retightening the cylinder-head bolts following a repair
(Engine cold or warm)

Following successful repair, retighten with cylinder head bolts **once** using the angle-of-rotation method.

Intake side



Exhaust side

After 400 hours of operation, tighten the cylinder–head bolts without unscrewing them by 90° (1/4 turn) in accordance with the tightening schedule on the left.

Nachzug der Zylinder-kopfschrauben erledigt

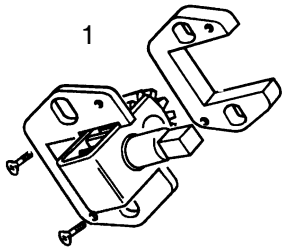
Retightening of cylinder-head-bolts completed

Spare part no. 51.97801–0315

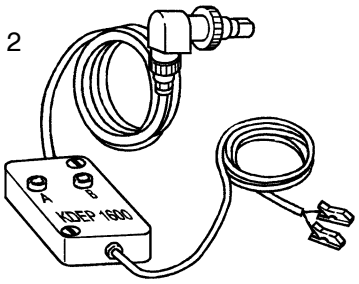
Following successful tightening, attach the **"Re-tightening of cylinder-head bolts completed"** sticker to one of the valve caps.

Special tools

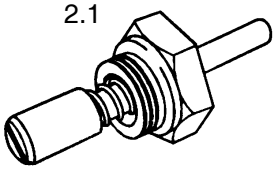
1



2



2.1



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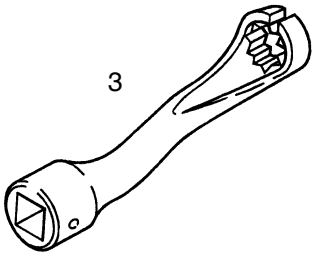

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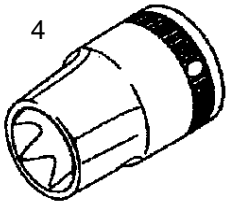

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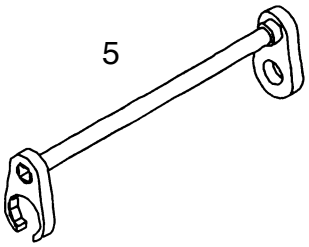

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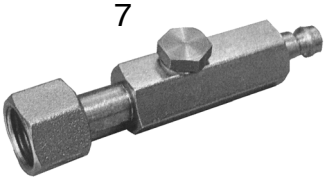

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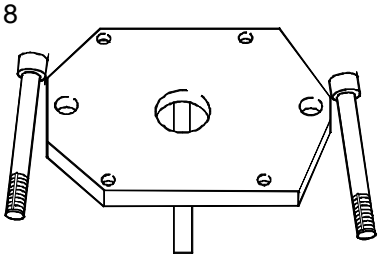

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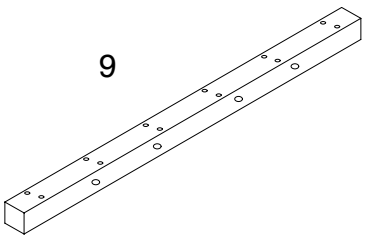
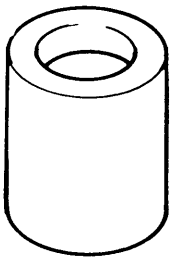
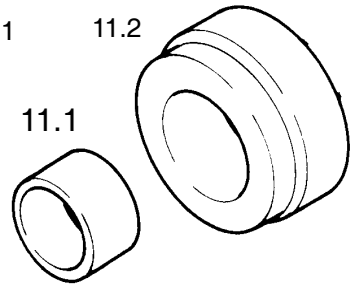


10



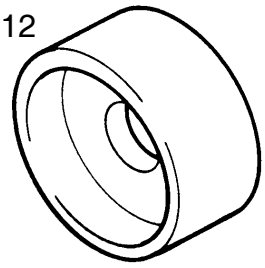
11

11.1

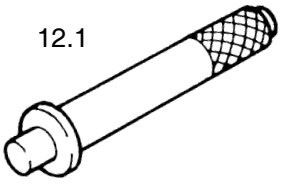


11.2

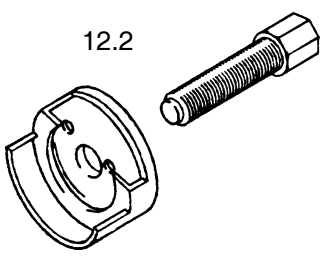
12



12.1



12.2



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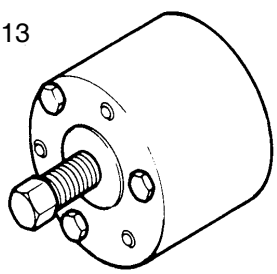

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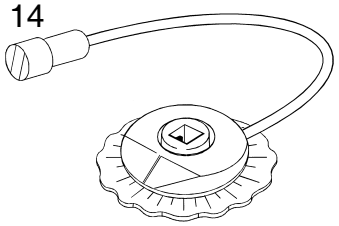
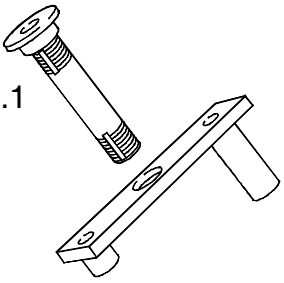


Fig. no.	Designation	Item number
1	Engine cranking device	80.99626–6008
	with standard ratchet	80.99627–0001
2	Light signal sensor for start of delivery setting	80.99605–6002
2.1	Blocking device for start of delivery setting in the case of injection pumps with start of delivery sensor in conjunction with light signal sensor 2	80.99605–0217
3	Special spanner (WAF 17) for injection pressure lines	80.99603–0025
4	Wrench socket for cylinder head bolts (Torx)	08.06143–0215
5	Socket spanner for injection line on the cylinder head	80.99603–6019
6	Tester for checking for leaks at nozzle holder seat, pressure pipe and leakage oil duct	80.99620–0029
7	Adapter	80.99620–0033
	with air connection	81.98130–0614
	in conjunction with tester 6	
	with the following reducing bolted connection:	
	2x reducing connection D8134A-RED15/10-PLA3C	82.98130–0174
	2x reducing connection D8134A-RED22/15-PLA3C	82.98130–0194
	1x screw plug D813A-VKA 10A3C	82.90310–0023
8	Mounting plate for cylinder head and rocker arm bearing housing	80.99606–6089
9	Straightedge for cylinder heads	80.99605–0175
10	Pressing mandrel for cassette seal in conjunction with handle 12.1	80.99617–0191
11	Driving mandrel for seal in timing case	
	comprising:	
11.1	Guide sleeve	80.99604–0068
11.2	Pressing plate in conjunction with handle 12.1	80.99604–0069
12	Driving mandrel for race on flywheel in conjunction with handle 12.1	80.99617–0017
12.1	Attachment handle for all press-in plates	80.99617–0129
12.2	Puller for bearing race on the flywheel	80.99601–6017
13	Puller for front crankshaft bearing race	80.99601–0076
14	Rotation angle measuring device	80.99607–0134

15

15.1



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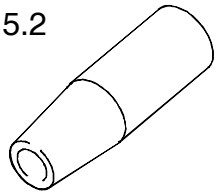

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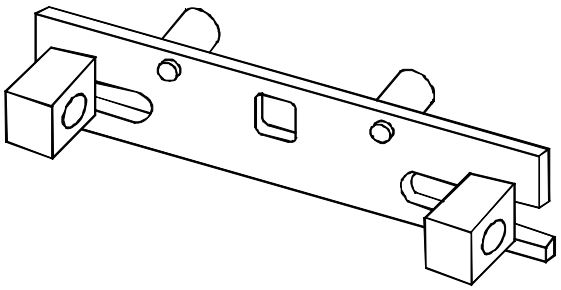

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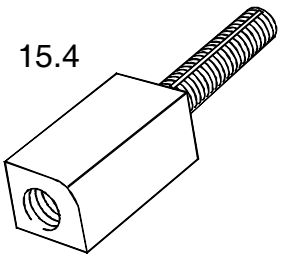

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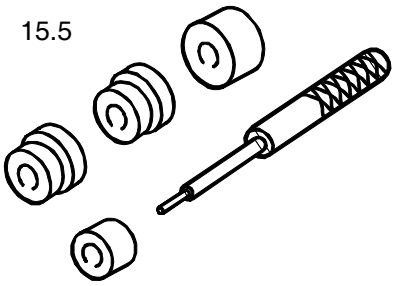

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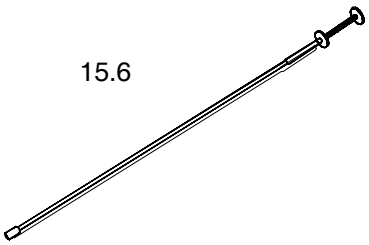

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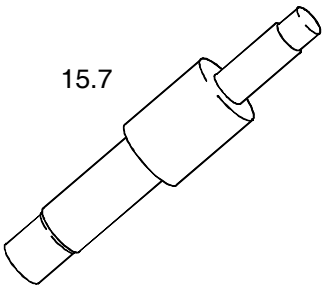

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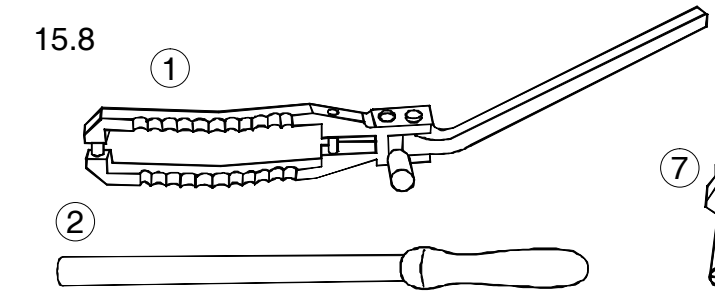

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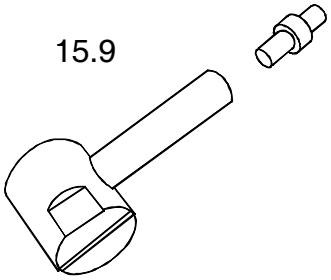

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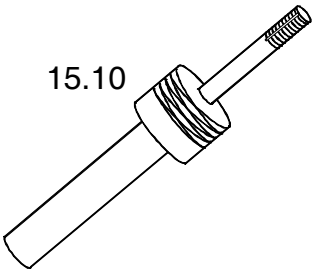

Fig. no.	Designation	Item number
15	Tool case complete with special tools for cylinder heads	80.99606–6096
	Contents:	
15.1	Extractor for injection nozzles	80.99602–6005
15.2	Mounting sleeve for valve stem seals	80.99606–0516
15.3	Centring and press-in tool for rocker arm shafts	80.99606–6090
15.4	Adapter for impact puller for pulling out rocker arm shafts	80.99602–0140
15.5	Press-in tool for valve guides and valve seats	80.99604–6024
15.6	Magnetic lifter for pressure pipe fittings	80.99639–0009
15.7	Connecting piece for compression recorder	80.99607–0158
15.8	Mounting tool for valve springs and tapers (set)	80.99606–6087
	① Mounting tool	80.99606–6093
	② Extension	80.99606–6094
	③ Centring plate	80.99606–0512
	④ Mounting tool	80.99606–6092
	⑤ Mounting cartridge	80.99606–6120
	⑥ Guide sleeve	80.99606–0587
	⑦ Hexagon bolt M10x25 – 8.8	06.01283–5215
	Hexagon bolt M8x140 – 8.8	06.01013–3129
15.9	Adapter for ejecting injection nozzles	80.99607–6018
15.10	Mounting tool for valve stem seals	80.99606–6088

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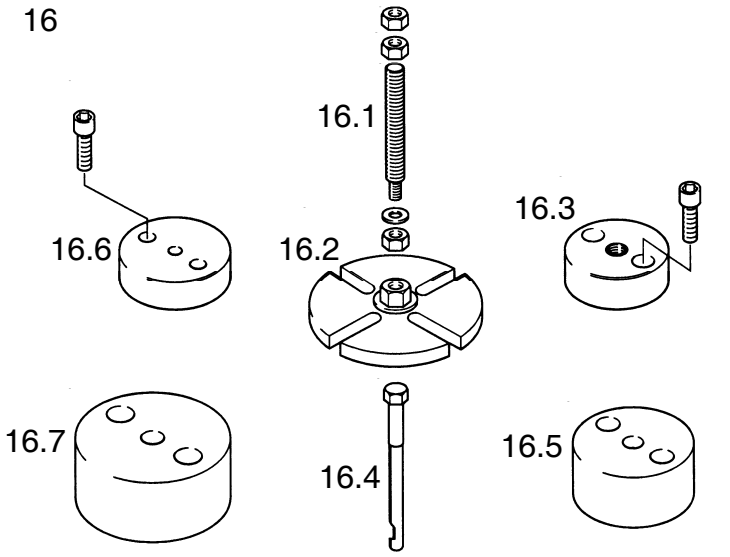

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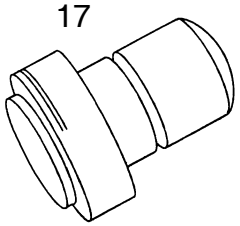

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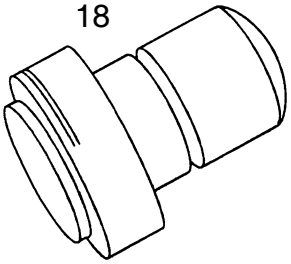

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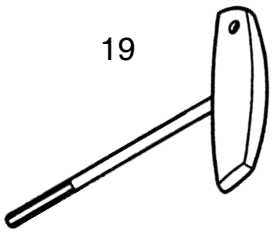

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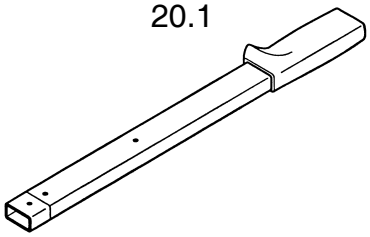

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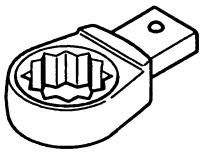

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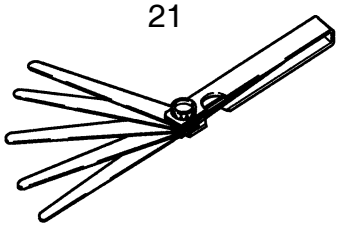

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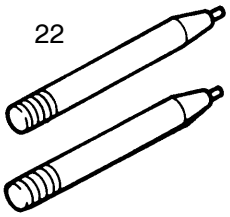

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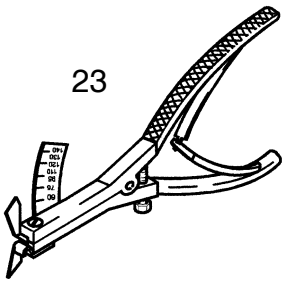

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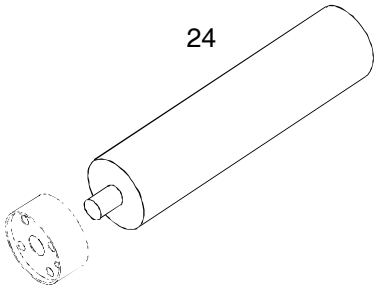

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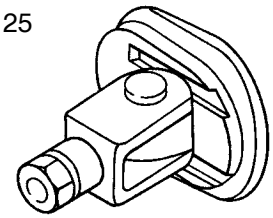

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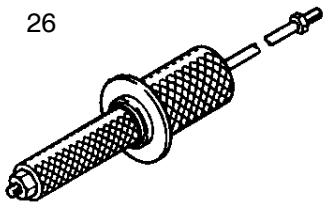

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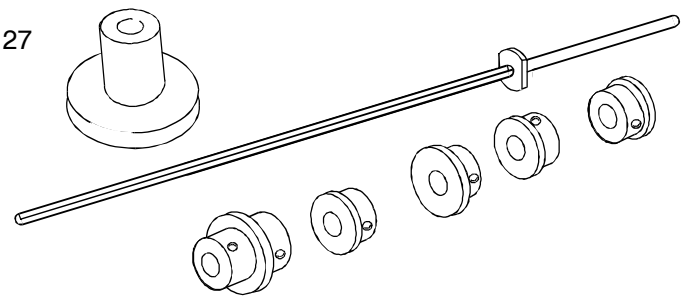

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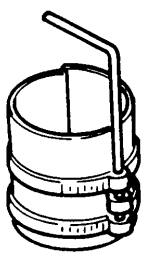
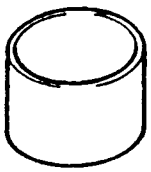


Fig. no.	Designation	Item number
16	Special tool for front crankshaft seal	80.99606–6011
	Component parts:	
16.1	Spindle	80.99606–0229
16.2	Extractor apparatus	80.99606–0298
16.3	Adapter	80.99606–0264
16.4	Extractor hook	80.99606–6013
16.5	Press-in sleeve	80.99606–0300
16.6	Adapter	80.99606–0302
16.7	Fitting sleeve	80.99606–0301
17	Press-in mandrel for cap, dia. 50.2 mm	51.91606–0053
18	Press-in mandrel for cap, dia. 62.2 mm	51.91606–0045
19	Hexagon bolt wrench 5 with transverse handle for valve clearance setting	08.06125–9035
20.1	Torque wrench 6–50 Nm for valve clearance setting	08.06450–0006
20.2	Ring socket tool for valve clearance setting in conjunction with 20.1	08.06460–0003
21	Valve gauge for valve setting	80.99607–6019
22	Guide pins for flywheel	80.99617–0020
23	Piston ring pliers	83.09144–6090
24	Guide mandrel for camshaft	80.99617–6007
25	Pulling tool for front and rear camshaft bearing bushes	80.99606–6103
	in conjunction with:	
26	Impact puller	80.99602–0016
27	Fitting tool for camshaft bearing bushes	80.99606–6099
28	Piston ring scuff band	80.99613–0035

29



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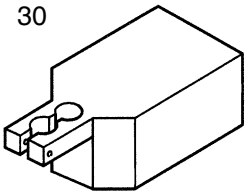

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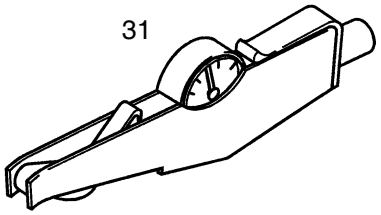

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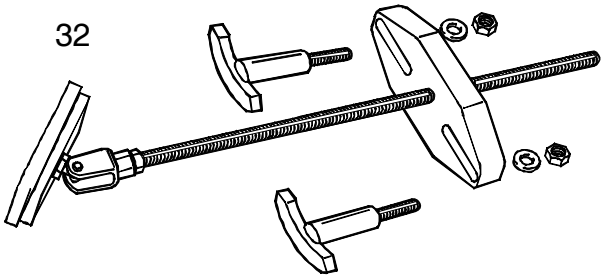

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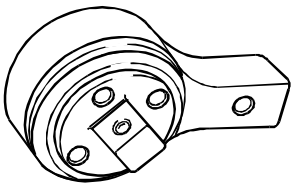

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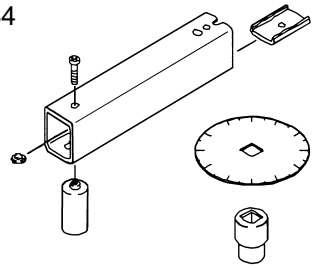

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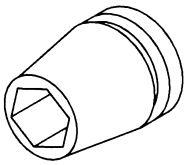

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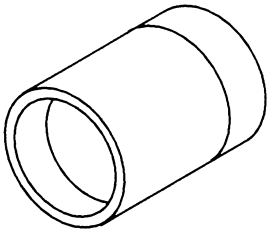

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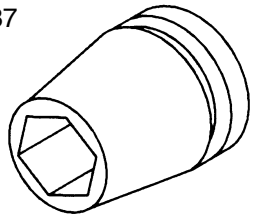

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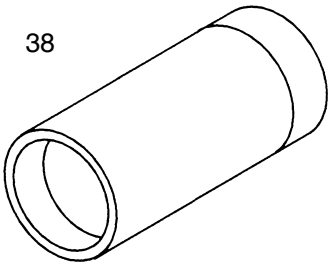

Fig. no.	Designation	Item number
29	Piston ring tensioning sleeve	83.09144–0187
30	Dial gauge holder	80.99605–0172
31	V-belt tension tester	80.99605–0279
32	Extractor apparatus for cylinder liners	80.99601–6018
33	Power amplifier 1:3.3 / 242.5–800 Nm	80.99619–0006
34	Tool for fitting cylinder head bolts	80.99606–6100
35	19 mm socket for flywheel bolts in conjunction with pos. 33, 36	80.99603–0311
36	Brace in conjunction with pos. 33, 35	80.99606–0585
37	27 mm socket for main bearing bolts in conjunction with pos. 33, 38	80.99603–0312
38	Brace in conjunction with pos. 33, 37	80.99606–0584

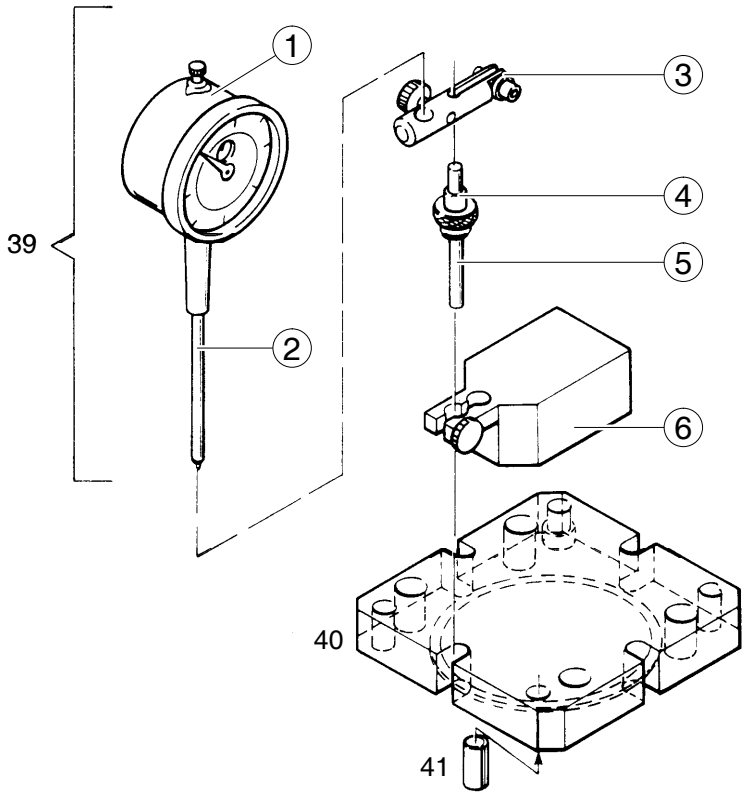
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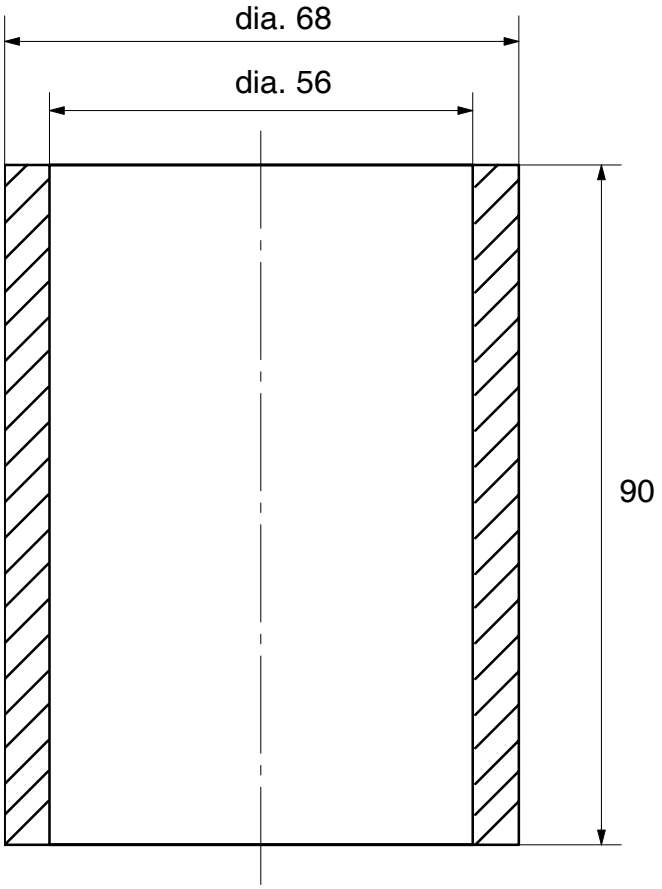
Fig. no.	Designation	Item number
39	Measuring combination for measuring the cylinder liner protrusion comprising:	
	① Dial gauge	08.71000–1205
	② Tracer pin for dial gauge	80.99605–0197
	③ Dial gauge bracket	80.99605–0179
	④ Support pin	80.99605–0180
	⑤ Dial gauge bracket	80.99605–6006
	⑥ Dial gauge bracket	80.99605–0172
40	Press-on measuring plate	80.99605–0195
41	Fitting sleeves	51.91701–0247

Note:
There is a complete catalogue of “MAN special tools”.
This catalogue contains all of the special tools for maintenance and servicing MAN trucks, omnibuses and engines available from MAN.
Available from the central spare parts warehouse.

Special tools for coolant pump repair for improvised manufacture

(Material: steel as available)

Support ring for pressing out coolant pump bearing



MAN Nutzfahrzeuge AG
Business Unit Engines
Vogelweiherstraße 33
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