

Workshop Manual

Group 21-26

A
2(0)

D1-13, D1-20, D1-30, D2-40

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00-0 General

General information

This Service Manual contains technical data, descriptions and maintenance and repair instructions for standard model Volvo Penta products. A list of these products may be found in the section **Specifications**.

The product designation and the serial number and specification is indicated on the engine decal or type plate. This information must be included in all correspondence regarding the product.

The service manual is produced primarily for the use of Volvo Penta workshops and their qualified personnel. It is assumed that any person using the Service Manual has a fundamental knowledge of the product and is able to carry out mechanical and electrical work to trade standard.

Volvo Penta continually develops its products; we therefore reserve the right to make changes. All information in this manual is based on product data which was available up to the date on which the manual was printed. New working methods and significant changes introduced to the product after this date are communicated in the form of **Service bulletins**.

Spare Parts

Spare parts for the electrical and fuel systems are subject to various national safety standards. Volvo Penta Original Spare Parts meet these standards. No damage of any kind caused by the use of spare parts not approved by Volvo Penta will be compensated by any warranty undertaking.

About this Workshop manual

Certified engines

When carrying out service and repair on emission-certified engines, it is important to be aware of the following:

Certification means that an engine type has been inspected and approved by the relevant authority. The engine manufacturer guarantees that all engines of the same type are manufactured to correspond to the certified engine.

This places special demands on service and repair work, namely:

- Maintenance and service intervals recommended by Volvo Penta must be complied with.
- Only spare parts approved by Volvo Penta may be used.
- Service on injection pumps, pump settings and injectors must always be carried out by an authorized Volvo Penta workshop.
- The engine must not be converted or modified, except with accessories and service kits which Volvo Penta has approved for the engine.
- No changes to the exhaust pipe and engine air inlet duct installations may be made.
- No warranty seals (where present on the product) may be broken by unauthorized persons.

The general instructions in the Operator's Manual concerning operation, service and maintenance apply.

IMPORTANT!

Neglected or poorly-performed care/service and the use of spare parts not approved by Volvo Penta, will mean that AB Volvo Penta no longer guarantees that the engine conforms to the certified model.

Volvo Penta accepts no responsibility for damage or costs arising as a result of failure to follow the above mentioned standards.

Introduction

The working methods described in this manual are based on a workshop scenario where the product is mounted in a holding fixture. Maintenance work is often carried out on site, in which case – if nothing else is indicated – using the same working methods as the workshop.

Warning symbols that occur in the service manual. For significance, refer to **Safety Information** .



DANGER!



WARNING!



CAUTION!

IMPORTANT!, NOTICE!

are by no means comprehensive since not everything can be foreseen as service work is carried out in the most varied of circumstances. We call attention to risks that may occur due to incorrect handling during work in a well-equipped workshop using working methods and tools tried and tested by us.

The service manual describes work operations carried out with the aid of Volvo Penta Special Tools, where such have been developed. Volvo Penta Special Tools are designed to ensure the safest and most rational working methods possible. It is therefore the responsibility of anyone using tools or working methods other than those we recommend to ensure that no risk of personal injury or mechanical damage is present, or that malfunction can result.

In some cases, special safety regulations and user instructions may be in force for the tools and chemicals mentioned in the Service Manual. These regulations must always be followed, and no special instructions regarding this are to be found in the Service Manual.

By taking these basic precautions and using common sense it will be possible to guard against most elements of risk. A clean workplace and a clean product will eliminate many risks of personal injury and malfunction.

Above all, when working on fuel systems, hydraulic systems, lubrication systems, turbochargers, inlet systems, bearings and seals, it is of the utmost importance that dirt and foreign objects are kept away, as malfunctions or shortened service intervals may otherwise result.

Repair instructions

Our mutual responsibility

Each product comprises a large number of interacting systems and components. A deviation from the technical specification may dramatically increase the environmental impact of an otherwise reliable system. It is therefore critical that the stated wear tolerances be adhered to, that systems which can be adjusted be correctly set up and that only Volvo Penta Original Parts are used. The intervals in the care and maintenance schedule must be followed.

Some systems, e.g. fuel systems, often require special expertise and test equipment. A number of components are factory-sealed, for among other things environmental reasons. Warranty-sealed components may not be worked on without authorization to perform such work.

Remember that most chemical products, incorrectly used, are harmful to the environment. Volvo Penta recommends the use of biodegradable degreasers whenever components are cleaned, unless otherwise specified in the Service Manual. When working outdoors, take especial care to ensure that oils and wash residues etc. are correctly properly for destruction.

Tightening torques

Tightening torques for vital fasteners that must be applied using a torque wrench are indicated in the Service Manual, chapter **Tightening torques** and in the Manual's work descriptions. All torque indications apply to clean threads, bolt heads and mating faces. Indicated torque data apply to lightly-oiled or dry threads. If lubricants, locking fluids or sealants are required for fasteners, the correct type will be noted in the job description.

Torque, angle tightening

When torque/angle tightening, the fastener is tightened to a specified torque, and tightening then continues through a pre-determined angle.

Example: For 90° angle tightening, the fastener is turned a further 1/4 turn in one sequence, after the specified tightening torque has been achieved.

Lock nuts

Removed locknuts may not be re-used; they must be replaced by new ones, as locking properties are impaired or lost with re-use.

In the case of lock nuts with plastic inserts the tightening torque indicated must be reduced if the nut has the same nut height as a standard, all-metal hexagonal nut.

Reduce the torque by 25% for bolt sizes of 8 mm or larger.

In the case of lock nuts with plastic inserts with a high nut-height (where the all-metal thread is as high as a standard hexagonal nut), the indicated torque applies.

Strength classes

Nuts and bolts are subdivided into different strength classes. The classification is shown by a marking on the bolt head. Markings of a higher number indicate stronger material. For example, a bolt marked 10-9 is stronger than one marked 8-8.

For this reason, it is important that when bolts are removed they are returned to their original locations on re-assembly. When replacing bolts check the applicable ***Spare parts catalogue*** to ensure the correct bolt is used.

Sealing compounds etc.

To ensure service work is correctly carried out it is important that the correct type of sealants and locking fluids are used on joints where such are required.

In each service manual section concerned, the sealants used in product manufacture are indicated. The same sealants, or sealants with equivalent properties, must be used for maintenance work.

Make sure that mating surfaces are dry and free from oil, grease, paint and anti-corrosion agent before applying sealant or locking fluid. Always follow the manufacturer's instructions regarding applicable temperatures, hardening times and such.

Two basic types of compound are used:

RTV preparations (Room Temperature Vulcanizing).

Used most often together with gaskets, e.g. sealing gasket joints, or are brushed on gaskets. RTV sealants are completely visible when the part has been removed. Old RTV sealant must be removed before the component is sealed again. Use denatured alcohol.

Anaerobic agents.

These agents cure (harden) in the absence of air. These preparations are used when two solid components, e.g. two cast components, are fitted together without a gasket. Common uses are also to lock and seal plugs, stud threads, taps, oil pressure monitors etc.

Hardened anaerobic preparations are glassy and for this reason, the preparations are colored to make them visible. Hardened anaerobic preparations are highly resistant to solvents, and old compound cannot be removed. On re-assembly, it is important to carefully degrease and wipe dry components first, before applying new sealant in accordance with the instructions.

Safety regulations for fluorocarbon rubber

Fluorocarbon rubber is a common material in sealing rings for shafts, and in O-rings, for example.

When fluorocarbon rubber is exposed to high temperatures (above 300°C/572°F), hydrofluoric acid can form. This is highly corrosive. Contact with the skin can result in severe chemical burns. Splashes in your eyes can result in chemical wounds. If you breathe in the fumes, your lungs can be permanently damaged.

WARNING!

Seals must never be cut with a torch, or be burnt afterwards in an uncontrolled manner. Risk for poisonous gases.

WARNING!

Always use chloroprene rubber gloves (gloves for chemicals handling) and goggles. Handle the removed seal in the same way as corrosive acid. All residue, including ash, can be highly corrosive. Never use compressed air to blow clean.

Put the remains in a plastic container, seal it and apply a warning label. Wash the gloves under running water before removing them.

The following seals are most probably made from fluorocarbon rubber:

Seal rings for the crankshaft, camshaft, idler shafts.

O-rings, regardless of where they are installed. O-rings for cylinder liner sealing are almost always made of fluorocarbon rubber.

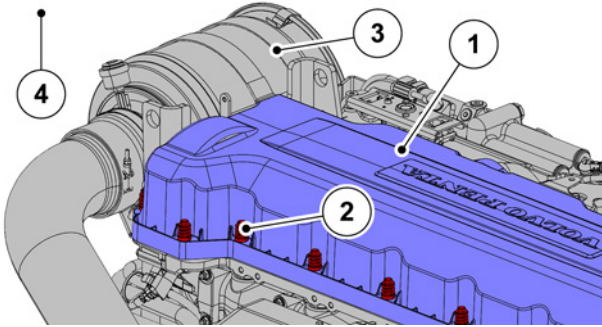
Please note that seals which have not been exposed to high temperature can be handled normally.

Illustrations

A lot of illustrations contains standardized symbols and colors. Please refer to the following information to reduce misunderstandings when working on an engine / transmission using this Workshop Manual.

Illustration colors

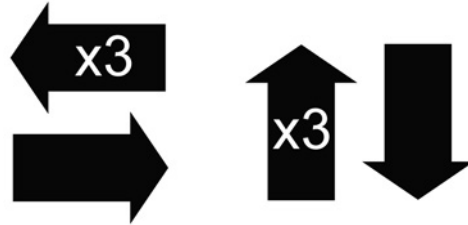
Most illustrations have a focused component (blue) which is fastened by a (red) bolt or such on a (light grey) engine / transmission body.



P0015699

- 1 Focus (blue)
- 2 Fastenings (red)
- 3 Body (light grey)
- 4 Background (white)

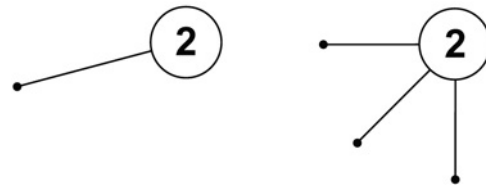
Position



P0015623

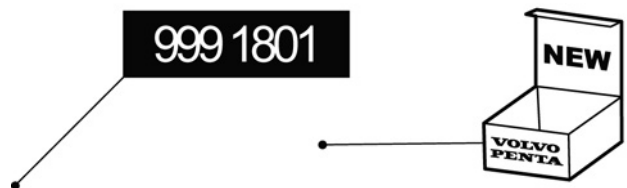
Focus arrows pointing at object. Sometimes it contains number of items, e.g. three bolts.

NOTICE! If an arrow with the text "x3" is pointing at only one item, e.g. a bolt, it still applies to the other two alike items (the two other bolts) highlighted in the illustration.



P0015627

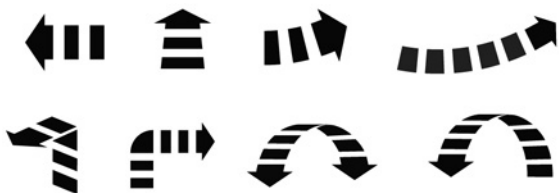
This symbol gives a positioning number to an object, e.g. 2, which is also mentioned in the supplied text information.



P0015628

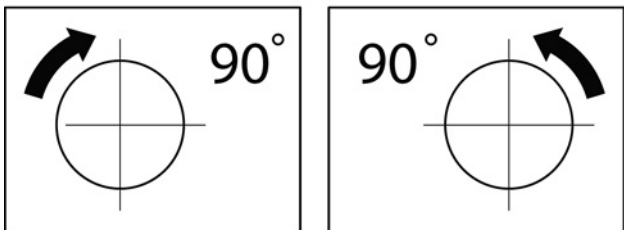
The symbol to the left shows part no. of the positioned special tool, e.g. 9991801. The symbol on the right side is used when something needs to be replaced by a new part / kit.

Movement



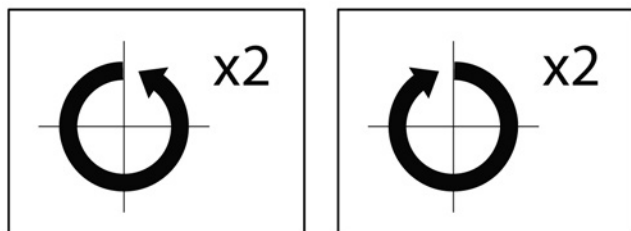
P0015622

Movement arrows are used to show which direction a component is to be moved / rotated.



P0015625

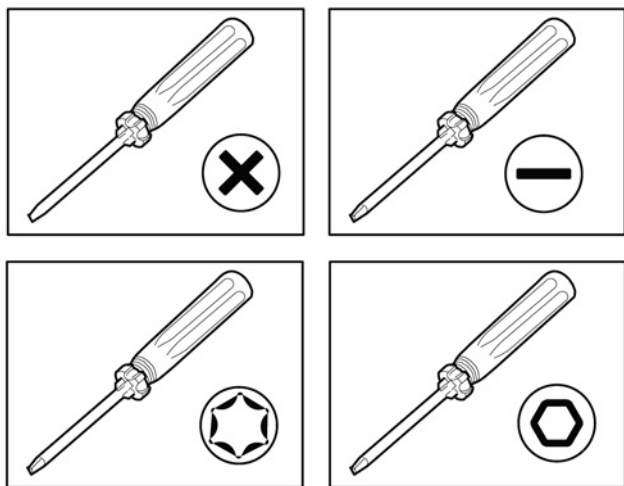
Symbol is used in a corner of the illustration to show how many degrees the object shall be turned and at which direction.



P0015626

Symbol is used to show how many revolutions the object shall be turned and at which direction.

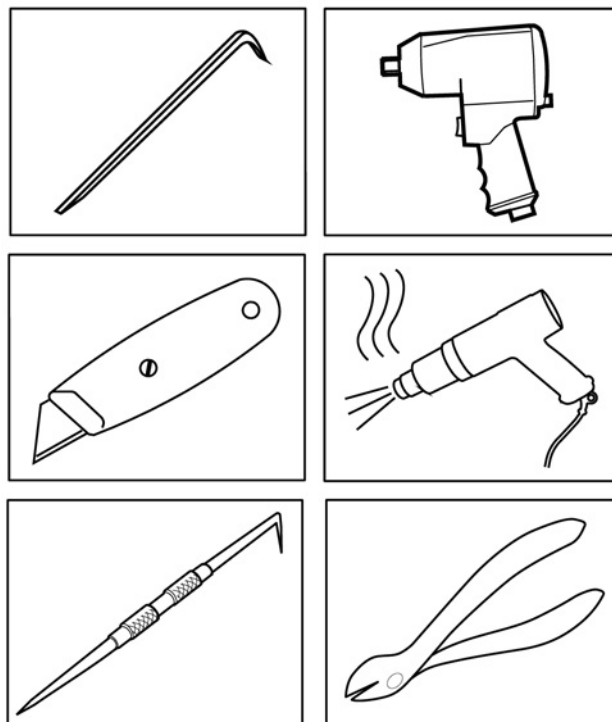
Tools



P0015629

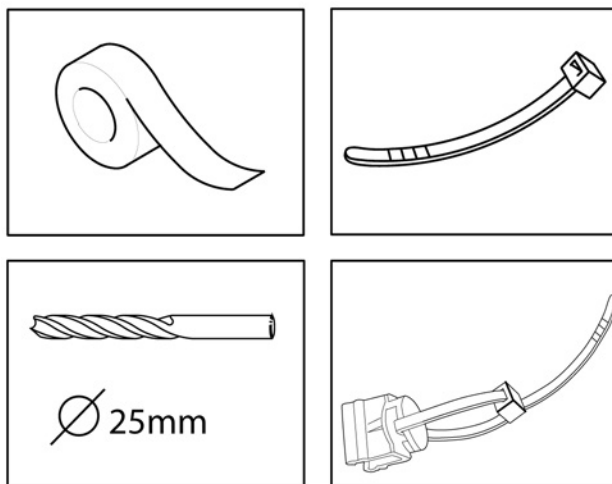
One of the following symbols is used when describing the recommended type of screwdriver.

Tools (continuence)



P0015630

A symbol of a tool in a corner of the illustration is shown when the tool is recommended to use, e.g. a knife or a crowbar.



P0015631

A drill in a specified size, duck tape and stripes may also be shown as symbols.

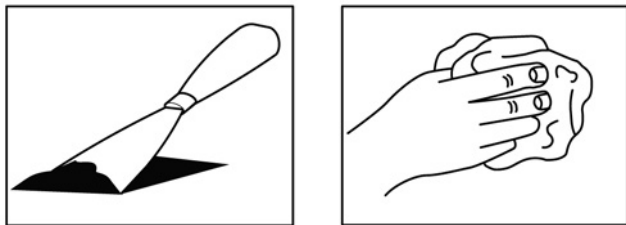
Chemicals



P0015695

Symbols can also describe when and how a chemical product is to be used.

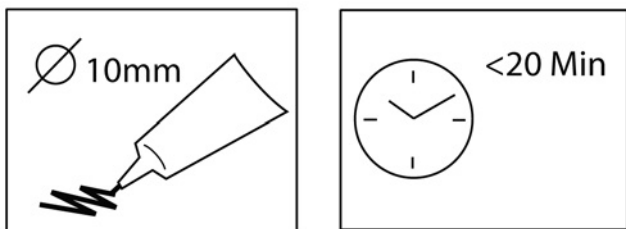
Cleanliness



P0015624

The scraper symbol suggests that a contact surface needs to be scraped from sealant etc.
The cloth symbol suggests that the mechanic should clean the contact surface thoroughly or be prepared for some oil spill or similar.

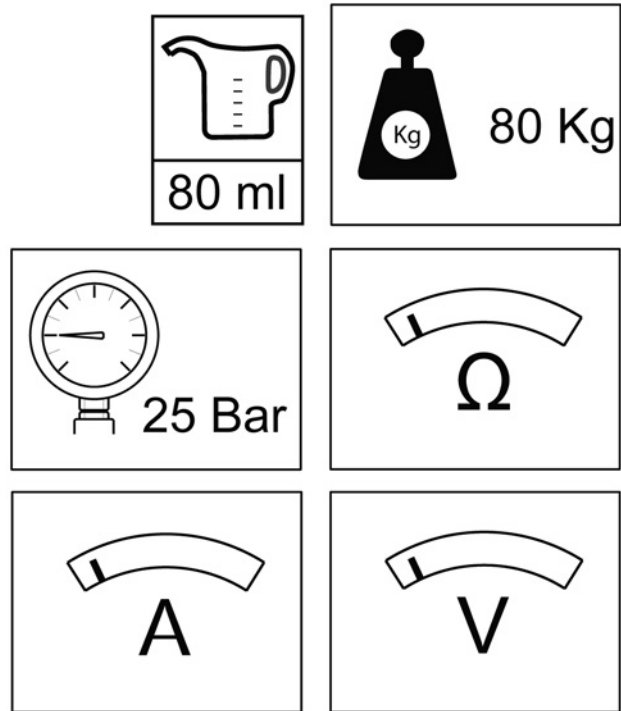
Sealant



P0015698

The tube symbol shows how thick layer of sealant to apply.
The clock symbol is used when something needs to be done within or after a certain time.

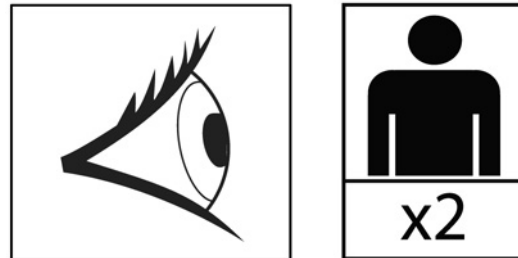
Units



P0015696

Units are mentioned in the illustration when a specific value (e.g. pressure, weight or resistance etc.) is expected.

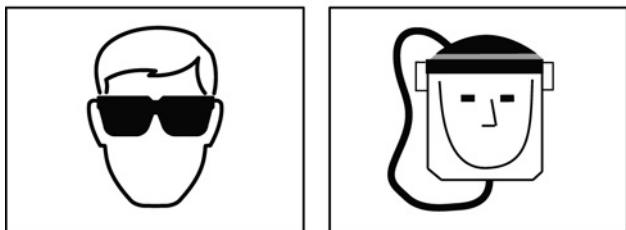
Important



P0015005

The eye symbol is used when something needs close inspection or must be performed in a certain way.
The symbol to the right is used when several mechanics are needed.

Safety



P0015697

These symbols are used when a certain safety related equipment is needed.

03-2 Specifications, Engine

Tightening torques

Cylinder head*:	
D1-13-A/B/F, D1-20-A/B/F	36.5 Nm (26.9 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	51 Nm (37.6 lbf.ft.)
Main bearings:	
D1-13-A/B/F, D1-20-A/B/F	23 Nm (17.0 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	27 Nm (19.9 lbf.ft.)
Connecting rod:	
D1-13-A/B/F, D1-20-A/B/F	23 Nm (17.0 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	32 Nm (23.6 lbf.ft.)
Front cover:	10 Nm (7.4 lbf.ft.)
Inner flywheel housing:	
D1-13-A/B/F, D1-20-A/B/F	25 Nm (18.4 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	50 Nm (36.9 lbf.ft.)
Flywheel Housing	25 Nm (18.4 lbf.ft.)
Flywheel	74 Nm (54.6 lbf.ft.)
Crankshaft belt pulley:	
D1-13-A/B/F, D1-20-A/B/F	93 Nm (68.6 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	123 Nm (90.7 lbf.ft.)
Flexible coupling	8.5–11.5 Nm (6.3–8.5 lbf.ft.)
Suction strainer, oil pump	11 Nm (8.1 lbf.ft.)
Sump	11 Nm (8.1 lbf.ft.)
Drain plug, sump	34 Nm (25.1 lbf.ft.)
Camshaft, mounting screw for retainer plate	11 Nm (8.1 lbf.ft.)
Rocker arm shaft cover:	
D1-13-A/B/F, D1-20-A/B/F	9.5 Nm (7.0 lbf.ft.)
D1-30-A/B/F, D2-40-A/B/F	23 Nm (17.0 lbf.ft.)
Valve Cover :	
Mounting screws	11 Nm (8.1 lbf.ft.)
Cap nuts	10 Nm (7.4 lbf.ft.)
Rocker arm lock nuts	14 Nm (10.3 lbf.ft.)

NOTICE! * The final tightening torque is indicated. The cylinder head must be tightened in three stages and in the correct order: refer to the tightening procedure. Lubricate the Cylinder head mounting bolts with oil on installation.

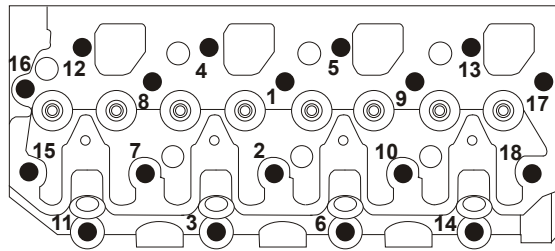
Fuel injection pump:	
Mounting nuts and bolts	6 Nm (4.4 lbf.ft.)
Supply valve retainer	42 Nm (31.0 lbf.ft.)
Delivery pipe (cylinder block - cylinder head)	12 Nm (8.9 lbf.ft.)
Injectors	64 Nm (47.2 lbf.ft.)
Feed line:	
D1-13-A/B/F, D1-20-A/B/F, D2-40-A/B/F	20 Nm (14.8 lbf.ft.)
D1-30-A/B/F	23 Nm (17.0 lbf.ft.)
Lock screw (maximum fuel volume)	13–16 Nm (9.6–11.8 lbf.ft.)
Lock screw (speed)	13–16 Nm (9.6–11.8 lbf.ft.)
Exhaust Manifold	10 Nm (7.4 lbf.ft.)
Fuel shut-off solenoid	17 Nm (12.5 lbf.ft.)
Fuel pump	
Adjuster screw	2.5 Nm (1.8 lbf.ft.)
Mounting screws	6 Nm (4.4 lbf.ft.)
Glowplugs	11.5 Nm (8.5 lbf.ft.)
Oil pressure contact and adapter	11 Nm (8.1 lbf.ft.)
Coolant temperature contact	27 Nm (19.9 lbf.ft.)
Coolant drain plug (plastic)	3 Nm (2.2 lbf.ft.)
Coolant thermostat housing	14 Nm (10.3 lbf.ft.)
Oil pressure relief valve	64 Nm (47.2 lbf.ft.)
Start motor, contacts	9.8–11.8 Nm (7.2–8.7 lbf.ft.)

General tightening torque values

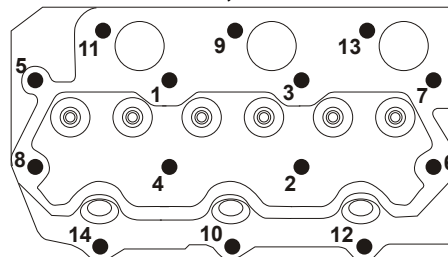
M5	5 Nm (3.7 lbf.ft.)
M6	10 Nm (7.4 lbf.ft.)
M7	17 Nm (12.5 lbf.ft.)
M8	24 Nm (17.7 lbf.ft.)
M10	50 Nm (36.9 lbf.ft.)
M12	80 Nm (59.0 lbf.ft.)
M14	130 Nm (95.9 lbf.ft.)

Tightening sequence

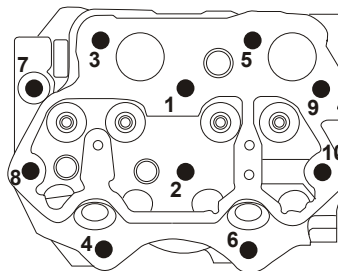
Cylinder head

D2-40

P0008160

D1-20, D1-30

P0008161

D1-13

P0008162

Conversion table

	To convert:		Multiply by	To convert:		Multiply by
	From	To		From	To	
Length	mm	inch	0,03937	inch	mm	25,40
	cm	inch	0,3937	inch	cm	2,540
	m	foot	3,2808	foot	m	0,3048
Area	mm ²	sq.in.	0,00155	sq.in.	mm ²	645,2
	m ²	sq.ft.	10,76	sq.ft.	m ²	0,093
Volume	cm ³	cu.in.	0,06102	cu.in.	cm ³	16,388
	liter, dm ³	cu.ft.	0,03531	cu.ft.	liter, dm ³	28,320
	liter, dm ³	cu.in.	61,023	cu.in.	liter, dm ³	0,01639
	liter, dm ³	imp. gallon	0,220	imp. gallon	liter, dm ³	4,545
	liter, dm ³	US gallon	0,2642	US gallon	liter, dm ³	3,785
	m ³	cu.ft.	35,315	cu.ft.	m ³	0,0283
Power	N	lbf	0,2248	lbf	N	4,448
Weight	kg	lb.	2,205	lb.	kg	0,454
Power	kW	hp (metric) ¹⁾	1,36	hp (metric) ¹⁾	kW	0,735
	kW	bhp	1,341	bhp	kW	0,7457
	kW	BTU/min	56,87	BTU/min	kW	0,0176
Torque	Nm	lbf.ft.	0,738	lbf.ft.	Nm	1,356
Pressure	Bar	PSI	14,5038	PSI	Bar	0,06895
	MPa	PSI	145,038	PSI	MPa	0,006895
	Pa	mm Wg	0,102	mm Wg	Pa	9,807
	Pa	in Wg	0,004	in Wg	Pa	249,098
	kPa	in Wg	4,0	in Wg	kPa	0,24908
	mWg	in Wg	39,37	in Wg	mWg	0,0254
Energy	kJ/kWh	BTU/hph	0,697	BTU/hph	kJ/kWh	1,435
Work	kJ/kg	BTU/lb	0,430	BTU/lb	kJ/kg	2,326
	MJ/kg	BTU/lb	430	BTU/lb	MJ/kg	0,00233
	kJ/kg	kcal/kg	0,239	kcal/kg	kJ/kg	4,184
Fuel consumption	g/kWh	g/hph	0,736	g/hph	g/kWh	1,36
	g/kWh	lb/hph	0,00162	lb/hph	g/kWh	616,78
Inertia	kgm ²	lbft ²	23,734	lbft ²	kgm ²	0,042
Flow, gas	m ³ /h	cu.ft./min.	0,5886	cu.ft./min.	m ³ /h	1,699
Flow, fluid	m ³ /h	US gal/min.	4,403	US gal/min.	m ³ /h	0,2271
Speed	m/s	ft./s	3,281	ft./s	m/s	0,3048
	mph	knot	0,869	knot	mph	1,1508
Temperature	°F=9/5 x °C+32			°C=5/9 x (°F-32)		

¹⁾ All power noted in the catalogue refers to metric horsepower.

Technical Data

Type Designation	D1-13-A/B/F	D1-20-A/B/F	D1-30-A/B/F	D2-40-A/B/F
No. of cylinders	2	3	3	4
Bore	67 mm (2.64")	67 mm (2.64")	77 mm (3.03")	77 mm (3.03")
Stroke	72 mm (2.83")	72 mm (2.83")	81 mm (3.19")	81 mm (3.19")
Cylinder volume	0.51 dm ³ (31.1 in ³)	0.76 dm ³ (46.4 in ³)	1.13 dm ³ (69.0 in ³)	1.51 dm ³ (92.1 in ³)
Power	Refer to the sales literature			
Idle rpm	850 ±25 rpm			
Rated rpm	3,200 rpm			
Compression ratio	23,5:1	23,5:1	23:1	23,5:1
Compression ratio at 250 rpm service limit	2,450 kPa (355 PSI)			
Firing sequence (highest cyl. # next to flywheel)	1-2	1-2-3	1-2-3	1-3-4-2
Direction of rotation seen from front	Clockwise			
Max. forward incline	0°			
Max. permissible rearward incline in operation	25°			
Max. lateral incline in operation	35°			
Valve clearance, idle, cold engine: inlet and exhaust	0,20 (0.008")			
Weight, dry engine	96 kg (212 lbs)	118 kg (260 lbs)	127 kg (280 lbs)	148 kg (326 lbs)
Permissible back pressure in exhaust line	20 kPa (2.9 PSI)			

Engine

Group 21: Engine

Pistons

Materials	Aluminum alloy
Diameter:	
D1-13-A/B/F, D1-20-A/B/F	66.9375–66.9525 mm (2.6353–2.6359")
D1-30-A/B/F, D2-40-A/B/F	76.932–76.947 mm (3.0288–3.0294")
Service limit, all engines	0.25 mm (0.010")
Clearance between piston and cylinder:	
D1-13-A/B/F, D1-20-A/B/F	0.048–0.082 mm (0.0019–0.0032")
D1-30-A/B/F, D2-40-A/B/F	0.0525–0.0865 mm (0.0021–0.0034")
Service limit, all engines	0.25 mm (0.010")
Front marking	The designation "SHIBAURA" on the inside of the piston must face the fuel pump on installation.

Piston rings

Compression rings, quantity	2
Oil rings, quantity	1
Upper compression ring	
Clearance between piston ring groove and ring, all engines	0.06–0.10 mm (0.0024–0.0039")
Service limit, all engines	0.25 mm (0.010")
Piston ring gap:	
D1-13-A/B/F, D1-20-A/B/F	0.13–0.25 mm (0.0051–0.0098")
D1-30-A/B/F, D2-40-A/B/F	0.15–0.27 mm (0.0059–0.0106")
Service limit, all engines	1.0 mm (0.39")
Second compression ring	
Clearance between piston ring groove and ring, all engines	0.05–0.09 mm (0.0020–0.0035")
Service limit, all engines	0.25 mm (0.010")
Piston ring gap:	
D1-13-A/B/F, D1-20-A/B/F	0.10–0.22 mm (0.0039–0.0087")
D1-30-A/B/F, D2-40-A/B/F	0.12–0.24 mm (0.0047–0.0094")
Service limit, all engines	1.0 mm (0.39")
Oil ring	
Clearance between piston ring groove and ring, all engines	0.02–0.06 mm (0.0008–0.0024")
Service limit, all engines	0.15 mm (0.0059")
Piston ring gap:	
D1-13-A/B/F, D1-20-A/B/F	0.10–0.30 mm (0.0039–0.0118")
D1-30-A/B/F, D2-40-A/B/F	0.20–0.35 mm (0.0079–0.0138")
Service limit, all engines	1.0 mm (0.39")

Piston pins

Diameter:	
D1-13-A/B/F, D1-20-A/B/F	18.998–19.002 mm (0.7480–0.7481")
Service limit	18.98 mm (0.7472")
D1-30-A/B/F, D2-40-A/B/F	20.996–21.002 mm (0.8266–0.8269")
Service limit	20.98 mm (0.826")
Clearance between hole and pin, all engines	–0.004 to +0.004 mm (–0.00016 to +0.00016")
Service limit	0.02 mm (0.0008")

Cylinder block

Bore diameter in cylinder block:	
D1-13-A/B/F, D1-20-A/B/F	67.000–67.019 mm (2.6378–2.6385")
Service limit	67.200 mm (2.6457")
D1-30-A/B/F, D2-40-A/B/F	77.000–77.019 mm (3.0310–3.0320")
Service limit	77.200 mm (3.0390")

Cylinder block flatness	Less than 0.05 mm (0.002")
Service limit	0.12 mm (0.005")

Cylinder head

Warping, cylinder head	0.00–0.05 mm (0.000–0.002")
Maximum service limit	0.12 mm (0.005")
Maximum limit for regrinding cylinder head	0.15 mm (0.006")
Selecting cylinder head gasket:	
Piston height above cylinder block upper edge	0.55–0.64 mm (0.0217–0.0252")
Select gasket thickness	1.2 mm (0.047")
Piston height above cylinder block upper edge	0.65–0.75 mm (0.0256–0.0295")
Select gasket thickness	1.3 mm (0.051")

Rocker arm shaft

Rocker arm shaft diameter:	
D1-13-A/B/F, D1-20-A/B/F	9.950–9.968 mm (0.3917–0.3924")
Service limit	9.87 mm (0.3886")
D1-30-A/B/F, D2-40-A/B/F	11.65–11.67 mm (0.4587–0.4595")
Service limit	11.57 mm (0.4555")
Rocker arm play on rocker arm shaft:	
D1-13-A/B/F, D1-20-A/B/F, minimum permissible play	0.032–0.065 mm (0.00126–0.00260")
D1-30-A/B/F, D2-40-A/B/F, minimum permissible play	0.032–0.068 mm (0.00126–0.00268")
Maximum permissible play, all engines	0.2 mm (0.008")

Crankshaft

Thrust bearings	
Standard thickness	21.85–21.95 mm (0.8602–0.8642")
Service limit	21.60 mm (0.8504")
NOTICE! The thrust bearings are pressed into the main bearing retainer.	
Crankshaft end float	0.10–0.30 mm (0.0040–0.0118")
Service limit	0.50 mm (0.0197")
Crankshaft deflection	0.30 mm (0.0011") or less
Service limit	0.06 mm (0.0023")
Front crankshaft bushing, diameter, journal	
Standard, D1-13-A/B/F and D1-20-A/B/F	42.964–42.975 mm (1.69150–1.69193")
Service limit	42.90 mm (1.6890")
Standard, D1-30-A/B/F and D2-40-A/B/F	47.965–47.975 mm (1.88830"–1.88880")
Service limit	47.90 mm (1.8858")
NOTICE! No undersize journal bushings are available.	

Main bearing journals

D1-13-A/B/F	
Diameter, standard, journal:	
#. 1	42.964–42.975 mm (1.69150–1.69193")
Service limit	42.90 mm (1.6890")
#. 2	45.948–45.959 mm (1.80897–1.80941")
Service limit	45.90 mm (1.8071")
NOTICE! No undersize journal shells are available.	
D1-20-A/B/F	
Diameter, standard, journal:	
#. 1 and 2	42.964–42.975 mm (1.69150–1.69193")
Service limit	42.90 mm (1.6890")
#. 3	45.948–45.959 mm (1.80897–1.80941")
Service limit	45.90 mm (1.8071")
NOTICE! No undersize journal shells are available.	
D1-30-A/B/F	
#. 1 and 2	47.965–47.975 mm (1.88830–1.88880")
Service limit	47.90 mm (1.8858")
#. 3	47.954–47.965 mm (1.88800–1.88830")
Service limit	47.90 mm (1.8858")
NOTICE! No undersize journal shells are available.	
D2-40-A/B/F	
#. 1, 2 and 3	47.965–47.975 mm (1.88830–1.88880")
Service limit	47.90 mm (1.8858")
#. 4	47.954–47.965 mm (1.88800–1.88830")
Service limit	47.90 mm (1.8858")
NOTICE! No undersize journal shells are available.	
Clearance between bearing shell and journal, standard play	
D1-13-A/B/F, journal #. 1	0.035–0.088 mm (0.0014–0.0035")
D1-13-A/B/F, journal #. 2	0.039–0.092 mm (0.0015–0.0036")
D1-20-A/B/F, journal #. 1 and 2	0.039–0.106 mm (0.0015–0.0042")
D1-20-A/B/F, journal #. 3	0.039–0.092 mm (0.0015–0.0036")
D1-30-A/B/F, D2-40-A/B/F	0.039–0.106 mm (0.0015–0.0042")
Service limit, all engines	0.20 mm (0.0079")

Connecting rod journals

D1-13-A/B/F, D1-20-A/B/F	
Diameter, journal:	
Standard	34.964–34.975 mm (1.3765–1.3770")
Service limit	34.90 mm (1.3740")
NOTICE! No undersize connecting rod journals are available.	
D1-30-A/B/F, D2-40-A/B/F	
Diameter, journal:	
Standard	40.964–40.975 mm (1.6128–1.6132")
Service limit	40.90 mm (1.6102")
NOTICE! No undersize connecting rod journals are available.	
Clearance between connecting rod bearing and connecting rod journal, standard play	
D1-13-A/B/F, D1-20-A/B/F	0.031–0.079 mm (0.00122–0.00311")
D1-30-A/B/F, journal #. 1 and 2	0.039–0.092 mm (0.00150–0.00360")
D1-30-A/B/F, journal #. 3	0.029–0.082 mm (0.00110–0.00320")
D2-40-A/B/F	0.039–0.092 mm (0.00150–0.00360")
Service limit, all engines	0.20 mm (0.0079")

Con rods

Piston pin bearing	
Clearance between piston pin and piston pin bearing	0.010–0.025 mm (0.00040–0.00099")
Service limit, D1-13-A/B/F, D1-20-A/B/F	0.10 mm (0.004")
Service limit, D1-30-A/B/F, D2-40-A/B/F	0.08 mm (0.0031")
Connecting rod bearings	
Clearance between connecting rod bore and connecting rod bearing	0.10–0.30 mm (0.004–0.012")
Service limit	0.70 mm (0.0276")

Camshaft

Drive	Gear wheel
Cam lobe height for inlet and exhaust valves, all engines	26.955–27.010 mm (1.0612–1.0634")
Service limit	26.5 mm (1.0430")
Cam lobe height for fuel injection pump	39.900–40.100 mm (1.5709–1.5787")
Service limit	39.8 mm (1.5669")
Cam lobe height for hand fuel pump	27.900–28.000 mm (1.0984–1.1024")
Service limit	27.0 mm (1.0630")

Valves

Inlet	
Stem diameter	6.955–6.970 mm (0.27382–0.27441")
Service limit	6.89 mm (0.271")
Valve disc	0.925–1.075 mm (0.03642–0.04232")
Service limit	0.5 mm (0.02")
Valve depth beneath cylinder head plane	0.65–0.95 mm (0.0256–0.0374")
Service limit	1.8 mm (0.071")
Clearance, valve guide	0.025–0.052 mm (0.0010–0.0020")
Service limit	0.2 mm (0.08")
Seat angle in cylinder head	45°
Seat contact surface in cylinder head	1.70–2.10 mm (0.0670–0.0830")
Service limit	2.5 mm (0.098")
Valve clearance, cold engine	0.20 mm (0.0079")

Exhaust	
Stem diameter	6.940–6.950 mm (0.27323–0.27362")
Service limit	6.84 mm (0.269")
Valve disc	0.925–1.075 mm (0.03642–0.04232")
Service limit	0.5 mm (0.02")
Valve depth beneath cylinder head plane	0.85–1.15 mm (0.0335–0.0453")
Service limit	1.8 mm (0.071")
Clearance, valve guide	0.045–0.072 mm (0.0020–0.0030")
Service limit	0.25 mm (0.0098")
Seat angle in cylinder head	45°
Seat contact surface in cylinder head	1.70–2.10 mm (0.0670–0.0830")
Service limit	2.5 mm (0.098")
Valve clearance, cold engine	0.20 mm (0.0079")

Valve springs

Length, uncompressed	35.0 mm (1.377")
Length at 79.4 Nm (58.56 lbf.ft) compression	30.4 mm (1.196")

Gear wheel group

Maximum play for all gear wheels	0.25 mm (0.0098")
Minimum play for all gear wheels	0.08 mm (0.0031")

Lubrication System

Group 22: Lubrication System

Oil pressure, hot engine at high idle	196–441 kPa (28.4–64.0 PSI)
Oil pressure, hot engine at low idle	>48 kPa (7 PSI)
Oil pressure relief valve, opening pressure:	
D1-13-A/B/F, D1-20-A/B/F	352–448 kPa (51–65 PSI)
D1-30-A/B/F, D2-40-A/B/F	304–500 kPa (44–73 PSI)
Oil pump	
Clearance between inner and outer rotors	0.01–0.15 mm (0.0004–0.0059")
Service limit	0.25 mm (0.0098")
End float between oil pump cover surface and intermediate gearwheel surface	0.01–0.15 mm (0.0004–0.0059")
Service limit	0.20 mm (0.0079")
Shims available for adjustment of end float	0.10, 0.15, 0.20, 0.50 mm (0.0039, 0.0059, 0.0079, 0.0200")
Oil grade according to API system	VDS-2 ACEA E7 API CH-4
Viscosity at –5 to +50°C (23°F to 122°F)*	SAE 15W/40 SAE 20W/50
Maximum oil volume, excl. oil filter, no engine incline:	
D1-13-A/B/F	1.9 l (0.50 US gals)
D1-20-A/B/F	2.8 l (0.74 US gals)
D1-30-A/B/F	3.5 l (0.92 US gals)
D2-40-A/B/F	6.5 l (1.72 US gals)
Oil change interval:	
D1-13-A/B/F, D1-20-A/B/F, D1-30-A/B/F	200 hours or 12 months
D2-40-A/B/F	200 hours or 12 months
NOTICE! * Temperatures at stable ambient temperature.	

Fuel System

Group 23: Fuel System

Feed pump maximum suction height	0.8 m (2.62 ft)
Feed pressure	15–25 kPa (2.2–3.6 PSI)

Fuel injection pump

Type	Inline horizontal pump			
	D1-13-A/B/F	D1-20-A/B/F	D1-30-A/B/F	D2-40-A/B/F
Injection start, before TDC	20° ±1°	20° ±1°	20° ±1°	22° ±1°
Pump element diameter	5 mm (0.1968")	5 mm (0.1968")	6 mm (0.2362")	5.5 mm (0.2165")
Stroke	6.5 mm (0.2559")	6.5 mm (0.2559")	6 mm (0.2362")	6 mm (0.2362")

Injectors

Opening pressure (at checks)	
D1-13-A/B/F, D1-20-A/B/F	11.96 MPa (1735 PSI)
D1-30-A/B/F	13.9 MPa (2016 PSI)
D2-40-A/B/F	14.7 MPa (2132 PSI)
Jet angle	4°

Exhaust System

Max. permissible exhaust back pressure in exhaust line at max. rpm, all engines	20 kPa (2.9 PSI)
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Cooling System

Group 26: Cooling System

Type	Positive pressure, sealed cooling system
Freshwater system volume, approx:	
D1-13 A/B/F	2.7 l (0.71 US gals)
D1-20 A/B/F	3.0 l (0.79 US gals)
D1-30 A/B/F	4.1 l (1.08 US gals)
D2-40 A/B/F	6.4 l (1.69 US gals)
Thermostat, quantity	1
Thermostat starts opening at	90° C (194° F)
fully open at	105° C (221° F)
Coolant, conc. coolant / water mixture	40/60

Water Quality

ASTM D4985:

Total solid particles	<340 ppm
Total hardness	<9,5° dH
Chloride	<40 ppm
Sulfate	<100 ppm
pH value	5.5–9
Silica (acc. ASTM D859)	<20 mg SiO ₂ /l
Iron (acc. ASTM D1068)	<0.10 ppm
Manganese (acc. ASTM D858)	<0.05 ppm
Conductivity (acc. ASTM D1125)	<500 µS/cm
Organic content, COD _{Mn} (acc. ISO8467)	<15 mg KMnO ₄ /l



P0002094

03-3 Specifications, Electrical

Electrical System

Group 30: Electrical System

System voltage	12 V
Battery capacity (starter battery)	
D1-13-A/B/F, D1-20-A/B/F, D1-30-A/B/F	70 Ah
D2-40-A/B/F	88 Ah
Glowplugs	
rated voltage	11 V
current	11 A

Alternator

Output voltage at +20°C (68°F)	
with sense	14.2 ±0.15 V
without sense	14.2 ±0.30 V
Max. current	
	115 A
Power, approx.	
	1,630 W
Suppression capacitor	
	2.2 µF

Starter motor

Power, approx.	
D1-13-A/B/F, D1-20-A/B/F	0.8 kW
D1-30-A/B/F	1.1 kW
D2-40-A/B/F	1.4 kW

05-1 Safety Instructions



P0003451

Safety Information

This Service Manual contains repair instructions, descriptions and technical data for products or product designs from Volvo Penta. Ensure that you are using the correct service manual.

Read the safety information below and the service manual section **About this Workshop manual** and **Repair instructions** carefully before repair and service work is begun.



This symbol is used in the service manual and on the product, to call attention to the fact that this is safety information. Always read such information very carefully.

Safety texts in the manual have the following order of priority:

DANGER!

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING!

Indicates a hazardous situation which, if not avoided, could result in death or serious personal injury.

CAUTION!

Indicates a hazardous situation which, if not avoided, could result in minor or moderate personal injury.

IMPORTANT!













Is used to draw your attention to something that may cause minor damage or a minor malfunction to the product or property.

NOTICE! Is used to draw your attention to important information that will facilitate the work or operation in progress.



This symbol is used on our products in certain cases and refers to important information in the instruction book. Make sure that warning and information symbols on the engine are clearly visible and legible. Replace symbols which have been damaged or painted over.

A compilation of safety precautions that must be taken and risks which must be paid attention to is presented in the following pages.

-  Immobilize the engine by turning off the power supply to the engine at the main switch (switches) and lock it (them) in the off position before starting work. Post a warning notice at the main circuit breaker.
-  Avoid opening the coolant filling cap when the engine is hot. Steam or hot coolant can spray out and system pressure will be lost. Open the filler cap slowly, and release the pressure in the cooling system if the filler cap or valve has to be opened, or if a plug or coolant hose has to be removed when the engine is hot.
-  As a rule, all service operations must be carried out with the engine stopped. However, some work, such as adjustments, will require the engine to be running. Approaching an engine which is running is a safety risk. Bear in mind that loose clothing or long hair can fasten in rotating parts and cause serious personal injury.
-  Hot oil can cause burns. Avoid skin contact with hot oil. Ensure that the lubrication system is not under pressure before any work is begun. Never start or operate the engine with the oil filler cap removed, because of the risk of oil ejection.
-  Be aware of hot surfaces (exhaust pipes, turbos, charge air pipes, starting heaters etc.) and hot fluids in pipes and hoses on an engine that is running or has just stopped. If work is done adjacent to a running engine, a careless movement or a dropped tool may in the worst case lead to personal injury.
-  Never start the engine without installing the air filter. The rotating compressor turbine in the turbocharger can cause severe injury. Foreign objects entering the intake ducts can also cause mechanical damage. Install all protective covers before the engine is started.
-  Ensure that the warning symbols or information decals on the product are always clearly visible. Replace decals which have been damaged or painted over.
-  Only start the engine in a well-ventilated space. When running in a confined space, exhaust fumes and crankcase gases must be led away from the engine bay or workshop area.
-  Avoid getting oil on your skin! Protracted or repeated exposure to oil can cause skin to become dry. Irritation, dryness, eczema and other skin problems may then result. From a health standpoint, used oil is more dangerous than new. Use protective gloves and avoid oil-soaked clothes and rags. Wash regularly, especially before eating. Use suitable barrier creams to counteract drying out of the skin and to aid dirt removal.
-  The majority of chemicals e.g. engine and transmission oils, glycol, gasoline, and diesel oil, together with chemicals for workshop use such as degreasing agents, paints and solvents, are injurious to health. Carefully read the instructions on the product packaging! Always follow a product's safety directions, e.g. use of protective mask, glasses, gloves etc. Ensure that other personnel are not exposed to substances that are injurious to health. Ensure good ventilation. Handle used and leftover chemicals in the prescribed manner.
-  Stop the engine and turn off the electrical supply at the main switch(es) before carrying out work on the electrical system.
-  Clutch adjustments must be carried out with the engine stopped.



Always use protective glasses or goggles when carrying out work where a risk of splinters, grinding sparks, splashes from acid or other chemicals is present. Your eyes are extremely sensitive; injury may cause blindness!



Never use start gas or similar products as a starting aid. They may cause an explosion in the inlet manifold. Danger of personal injury.



All fuels, as well as many chemicals, are flammable. Do not allow open flames or sparks in their vicinity. Gasoline, some thinners, and hydrogen gas from batteries are extremely flammable and explosive when mixed with air in the correct proportions. **No Smoking!** Ensure that the work area is well ventilated and take the necessary safety precautions before welding or grinding work is begun. Always ensure that there are fire extinguishers close at hand in the work area.



Batteries must never be exposed to open flames or electric sparks. Never smoke in the vicinity of the batteries; they generate hydrogen gas when charged, which is explosive when mixed with air. This gas is easily ignited and highly explosive. A spark, which can be caused by incorrect battery connection, is sufficient to cause a battery to explode and cause damage.

Do not touch the connections during start attempts. Sparking hazard! Do not lean over batteries.



Never transpose the positive (+) and negative (-) battery posts when installing batteries. Such a transposition can result in serious damage to electrical equipment. Refer to the wiring diagram.

Always use protective goggles when charging and handling the batteries. Battery electrolyte contains sulfuric acid which is highly corrosive. Should the battery electrolyte come into contact with unprotected skin, wash it off immediately using soap and copious amounts of water. If you get battery acid in your eyes, flush at once with copious amounts of water and seek medical assistance immediately.



Never start the engine with the valve cover removed. There is a risk of personal injury.



Stop the engine before working on the cooling system.

Marine engines: Close the sea cock / cooling water inlet valve before work on the cooling system is begun.




Make sure that oil, fuel-soaked rags, and used fuel and oil filters are stored in a safe manner. Rags soaked in oil can spontaneously ignite under certain circumstances. Used fuel and oil filters are environmentally hazardous waste and must be handed to an approved waste management facility for destruction, as must any used lubrication oil, contaminated fuel, paint residue, solvents, degreasers and wash residue.





Never work alone when removing heavy components, even when using lifting devices such as locking tackle lifts. When using a lifting device, two people are usually required to do the work - one to take care of the lifting device and the other to ensure that components are lifted clear and not damaged during the lifting operations.





The existing lugs on the engine should be used for lifting. Always check that the lifting equipment used is in good condition and has the load capacity to lift the engine (engine weight including gearbox or extra equipment). For safe handling and to avoid damaging components fitted to the top of the engine, the engine must be lifted with a correctly adjusted lifting boom. All chains or wires must run parallel to each other and as perpendicular to the engine as possible. If other equipment attached to the engine has altered its center of gravity, special lifting devices may be needed to obtain the correct balance for safe handling. Never perform any work on an engine that is only suspended from the lifting equipment.

 The components in the electrical and fuel systems on Volvo Penta products are designed and manufactured to minimize the risk of fire and explosion. The engine must not be run in areas where there are explosive materials.

 Only use fuels and lubricating oils recommended by Volvo Penta. Refer to the Operator's Manual for the product in question. Use of fuels that are of a lower grade may damage the engine, the injection pump and the injectors. On a diesel engine, low grade fuel can cause the control rod to bind and the engine to over-rev, with the risk of engine damage and personal injury as a result. Low fuel and oil grades may result in high service, maintenance and repair costs.

 Fuel delivery pipes must not be bent or straightened under any circumstances. Cracks may occur. Damaged pipes must be replaced.

 Exercise extreme caution when leak-detecting on the fuel system and testing the fuel injector nozzles. Use eye protection. The jet from a fuel nozzle has very high pressure and great penetration power. Fuel can force its way deep into body tissue and cause severe injury. There is a risk of blood poisoning (septicemia).

 Never use a high-pressure washer for cleaning the engine. Pay attention to the following when using a high-pressure washer on components other than the actual engine: Never direct the water jet at seals, rubber hoses or electrical components.

08-2 Special Service Tools

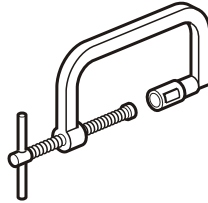


The following special tools are used when working on the engine. The tools can be ordered from AB Volvo Penta by specifying the number indicated.



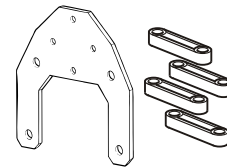
856927 Plastigauge

Used for measuring main and big end bearing clearance.



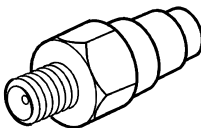
885023 Valve spring compressor

Used for compressing valve springs.



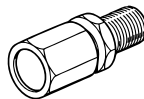
885224 Fixture

Used for installation of engine in 9992520 Stand or 9986485 Stand (with the aid of 9999737 Fixture).



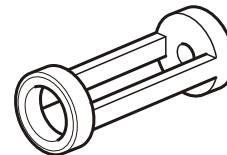
885252 Adapter

Used for compression testing.



885484 Adapter

Used for compression testing.



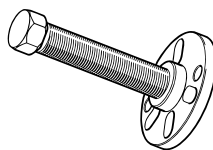
885498 Adapter

Floor lock (used together with 885023 Valve spring compressor).



885510 Plugs

protection plugs, fuel system.



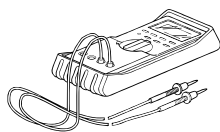
885820 Puller

Puller, for pulley.

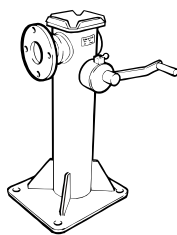


885822 Magnetic pen

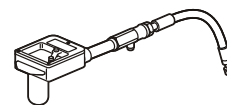
Used for removing valve lifters.

**88890074 Multimeter**

Used for measuring.

**9986485 Stand**

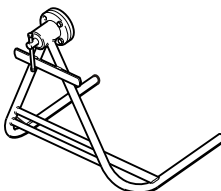
Used with 885224 Fixture and 9999737 Fixture.

**9988539 Compression meter**

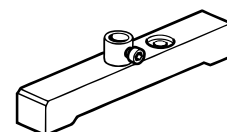
Used for compression tests.

**9989876 Dial indicator**

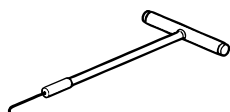
Used e.g. for checking end float.

**9992520 Stand**

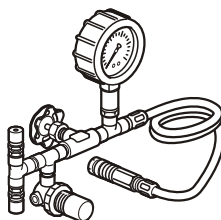
For use with 885224 Fixture.

**9995192 Gauge rod**

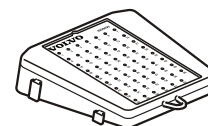
Holder for 9989876 Dial indicator.

**9995919 Extractor**

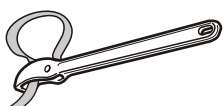
Used for seals.

**9996662 Pressure testing kit**

Used for checking pressure valve in filler cap.

**9998699 Break-out box**

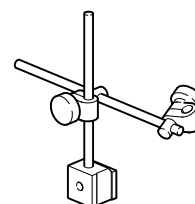
Used for measuring.

**9999179 Extractor oil filter**

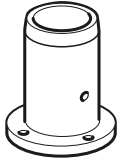
Wrench for removing fuel and oil filters.

**9999683 Dial indicator (short probe)**

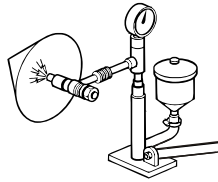
Used when checking valve guides.

**9999696 Magnetic stand**

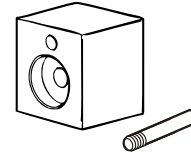
Used e.g. for checking end float.



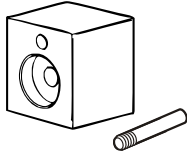
9999737 Fixture
Fixture cylinder used for
885224 Fixture to
9986485 Stand.



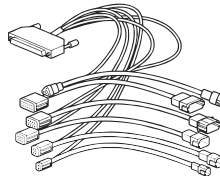
9999772 Pressure testing kit
Used for checking injectors.



3849639 Mounting tool
Used for oil pump shaft (D1-13,
D1-20).



3849640 Mounting tool
Used for oil pump shaft (D1-30,
D2-40).



88890016 Break-out cable
For use with 9998699 Break-
out box.

20-0 Engine Information, General

Design and Function

Identification Numbers

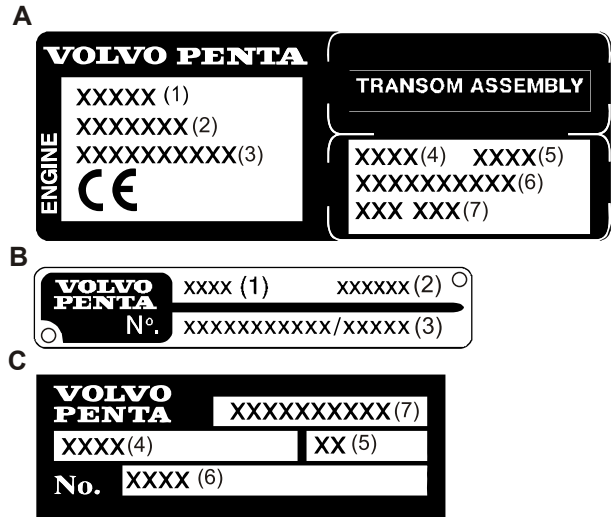
There are type plates on the engine and timing cover, marked with identification numbers. This information must always be used as a reference when spare parts are ordered. The appearance and location of the type plates is shown below. The figures in brackets refer to the location of the identification number on the type plate.

Engine

Product designation (1):
 Product number (2):
 Serial number (3):

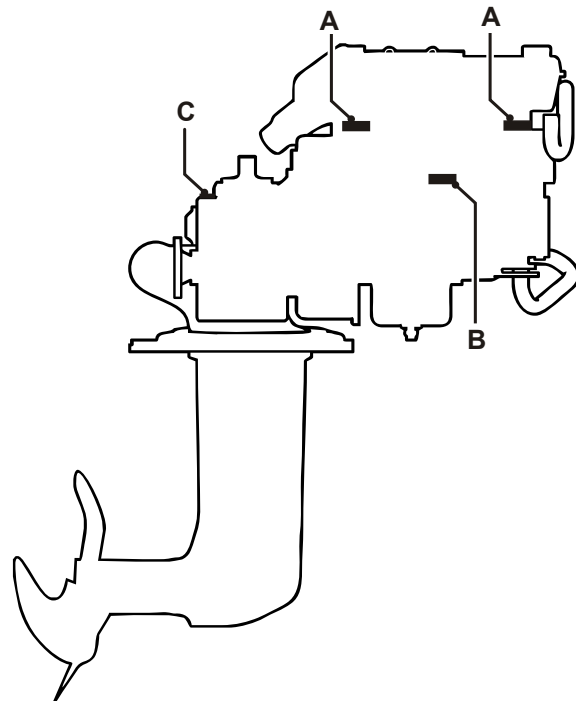
Transmission

Product designation (4):
 Gear ratio (5):
 Serial number (6):
 Product number (7):



P0007541

- A Engine and transmission decal
- B Engine plate
- C Transmission plate



p0007825

Group 21: Engine

Engine, General

The D1-13, D1-20, D1-30 and D2-40 are four cycle marine diesel propulsion engines. They all have two valves per cylinder, a high-mounted camshaft in the engine block and a mechanical injection pump.

The D1-13 is an in-line two cylinder engine with a total swept volume of 0.51 liter. The D1-20 and D1-30 are in-line three cylinder engines with total swept volumes of 0.76 and 1.13 liters respectively. The D2-40 is an in-line four cylinder engine with a total swept volume of 1.51 liter.

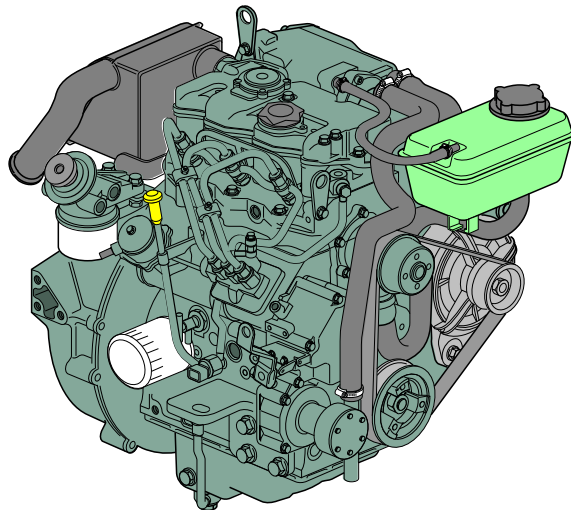
The D1-13 and D1-20 engines have identical pistons with the same dimensions. The D1-30 and D2-40 engines have different pistons, but of common dimensions.

The engines are lubricated by a pressure lubrication system, in which an oil pump supplies oil under pressure to all lubrication points.

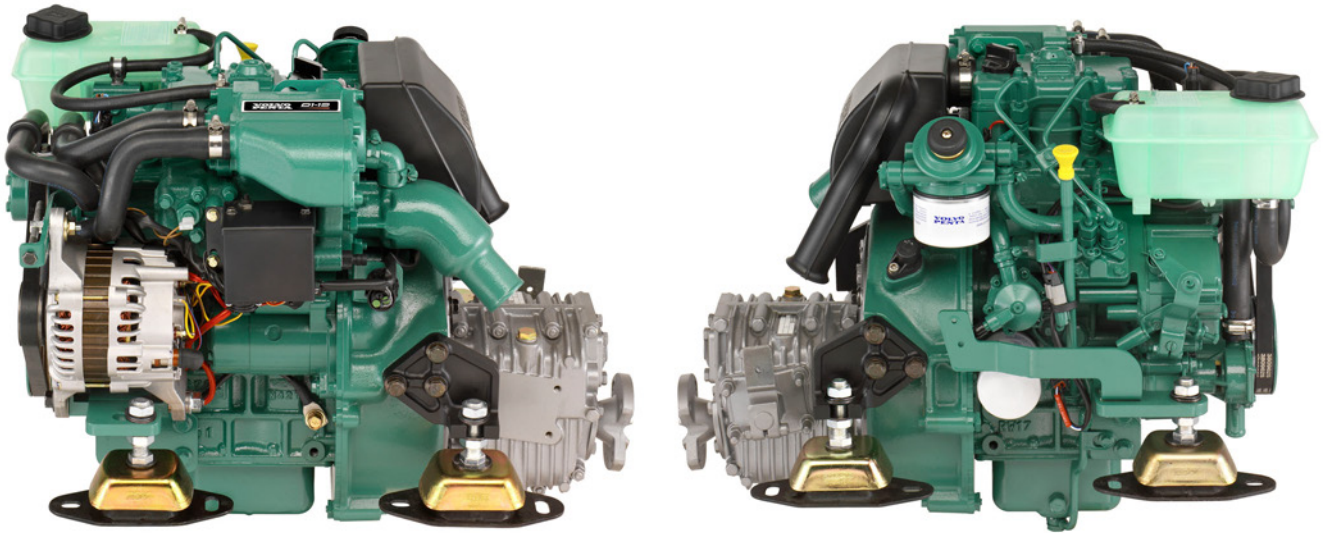
Fresh water cooling uses a thermostatically controlled raw-water cooled heat exchanger. The raw water pump is operated by a gear train.

The crankshaft operates the coolant pump and alternator via a drive belt.

D1-30 engine



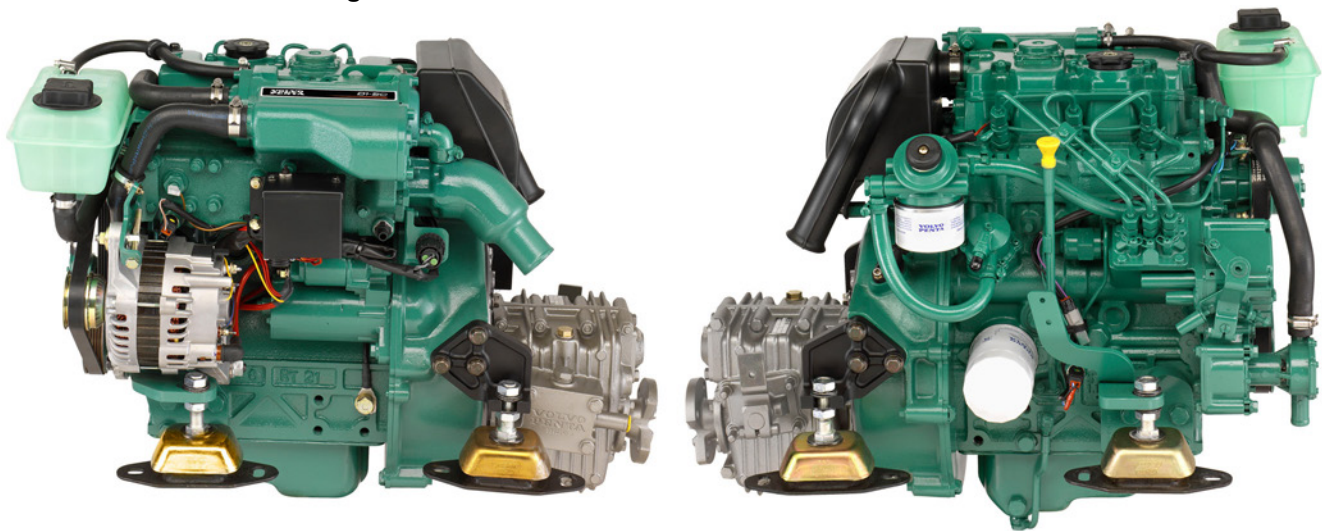
D1-13 with MS10A reverse gear



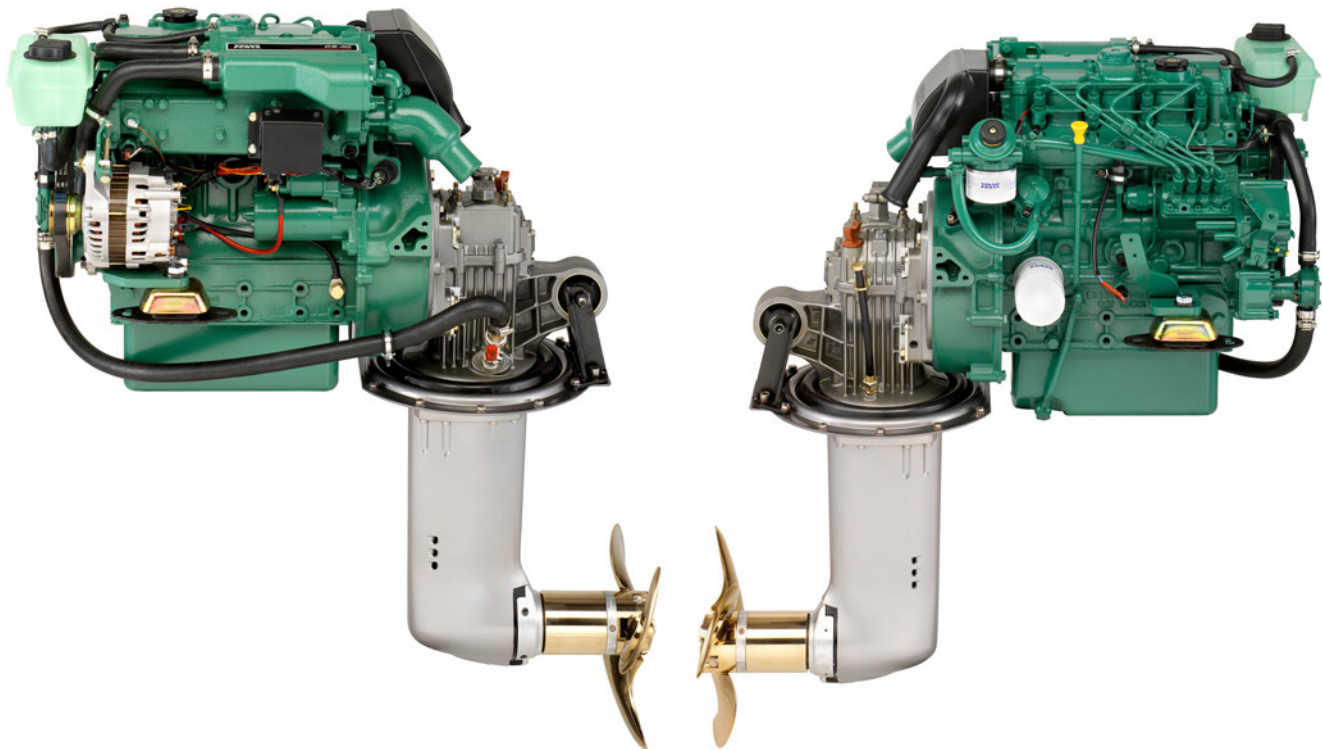
D1-20 with MS10A reverse gear

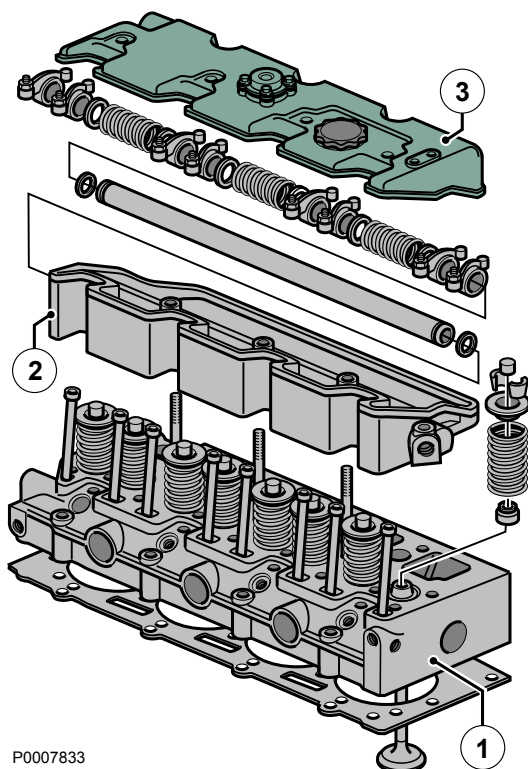
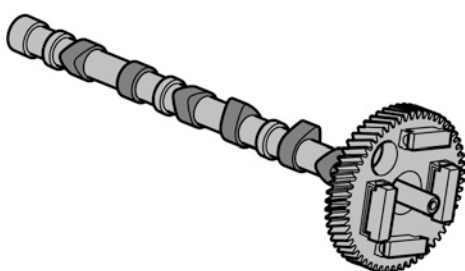
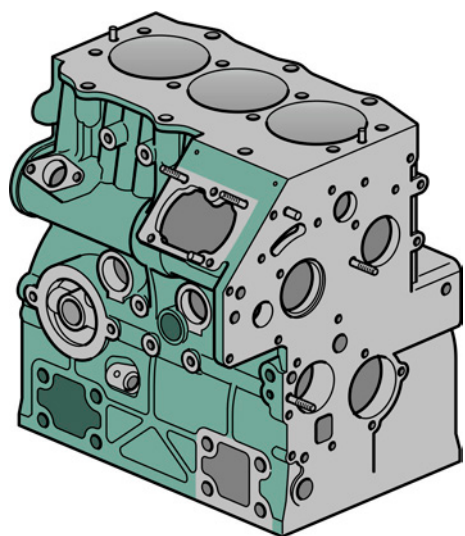


D1-30 with MS15A reverse gear



D2-40 with 130S sailboat drive





P0007833

Cylinder block

The cylinder block is cast in one piece from special cast iron alloy. The camshaft is located in the engine block.

The D1-13 engine has two cylinder bores, the D1-20 and D1-30 have three, and the D2-40 has four. The D1-13 and D1-20 engines have the same cylinder dimensions. So do the D1-30 and D2-40 engines, but larger.

All engines have cylinders machined directly in the block.

Oil pan

The oil pan is located under the cylinder block and is made from pressed sheet steel. There is an oil drain pipe installed beneath the oil pan.

Camshaft

The camshaft has lobes which operate the valves, the fuel pump and the injection pump. The camshaft is driven by a gear train.

Cylinder head

The cylinder head (1) is made from special cast iron alloy.

The cylinder head has one inlet and one exhaust valve per cylinder. These are operated by the camshaft via valve lifters and push rods. The valves have replaceable seats.

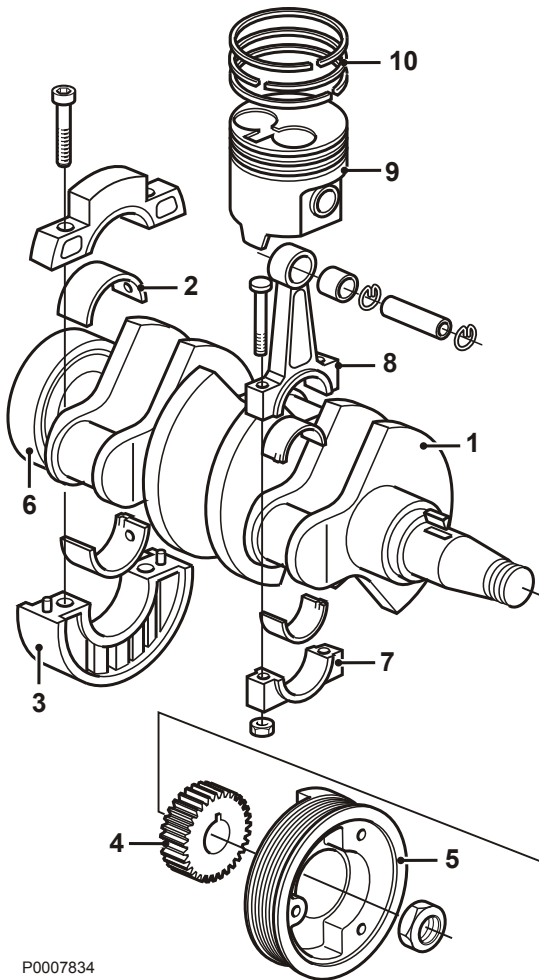
An injector is installed in the combustion chamber of each cylinder. There is one glowplug per cylinder.

Rocker arm cover

The rocker arm cover (2) is aluminum and is located above the cylinder head. The valve mechanism is installed underneath the cover. Pressurized lubrication oil passes via an external pipe to the rocker arm shaft, and then lubricates the rocker arms and valves.

Valve Cover

The valve cover (3) is made of aluminum and is located above the rocker arm cover. The valve cover has two internal sections, of which one leads inlet air down into the cylinder head via an inlet. The other section contains the crankcase ventilation valve.



P0007834

Crankshaft

The crankshaft (1) is supported by main bearings (2). The thrust bearing is integrated in the rear main bearing cap (3). The crankshaft is statically and dynamically balanced, and has induction hardened bearing surfaces. At the front end, where the gear wheel (4) for the timing gear and the pulley (5) for the alternator and coolant pump are located, the crankshaft has a groove for a Woodruff key. At the rear of the crankshaft, there is a flange (6) to which the flywheel is attached.

Main and big-end bearings

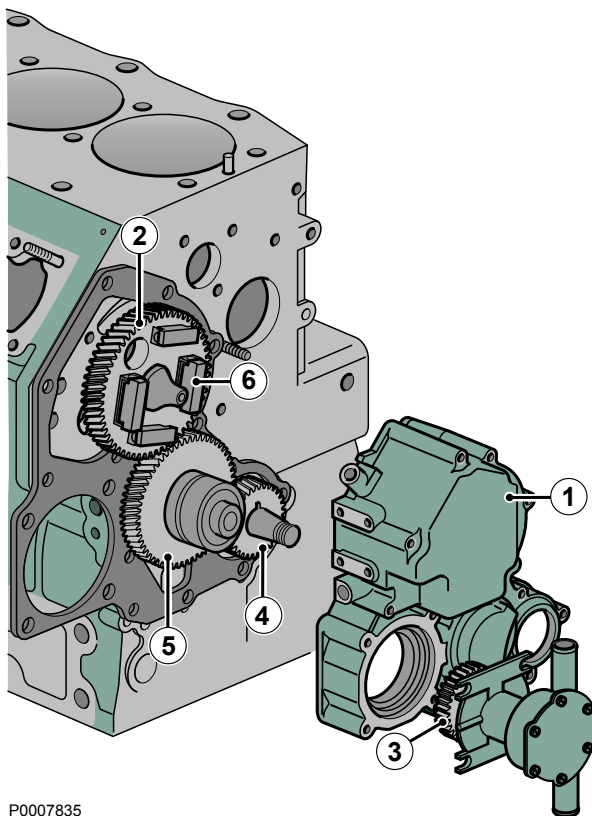
The main and big-end bearings (7) comprise steel shells lined with bearing metal. The bearings are precision made and are ready to be installed.

Con rods

The connecting rods (8) are of I-section. The small end is drilled for piston pin lubrication.

Pistons

The pistons (9) are made of light metal alloy. They have three piston rings (10). Two piston rings are compression rings and one is an oil ring.

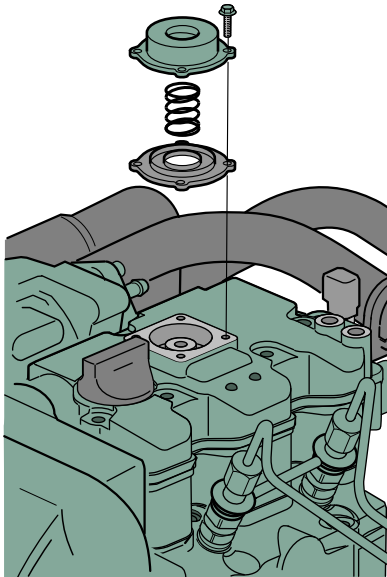


P0007835

Transmission

The timing gear comprises cylindrical gear wheels with helical cogs and is located at the front of the cylinder block. A timing gear cover (1) provides complete protection for the timing gear.

The camshaft (2) and raw water pump (3) are driven by the crankshaft gear (4), via an idler wheel (5). The engine lubrication pump is integral with the idler gear, and is driven by it. The governor weights (6) are suspended at the front of the camshaft drive and adjust the injection pump via a mechanism in the timing gear cover.



P0007836

Crankcase ventilation

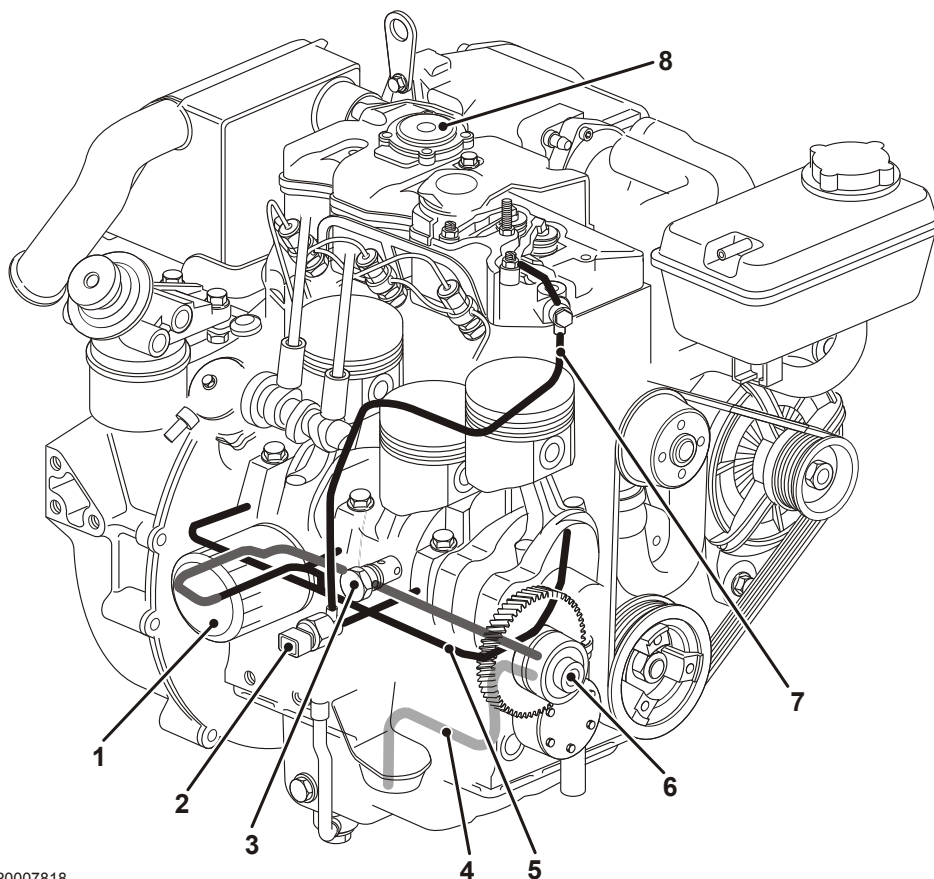
The crankcase ventilation is sealed and pressure controlled with a valve and spring located in the valve cover. When the gas pressure is higher, the valve opens and directs the crankcase gases into the inlet section, for combustion in the cylinders.

Group 22: Lubrication System

The engines are provided with a complete pressure lubrication system. The lubricating oil pump is a gear wheel pump, and is driven by the crankshaft. Lubricating oil is led through an external pipe to the valve mechanism.

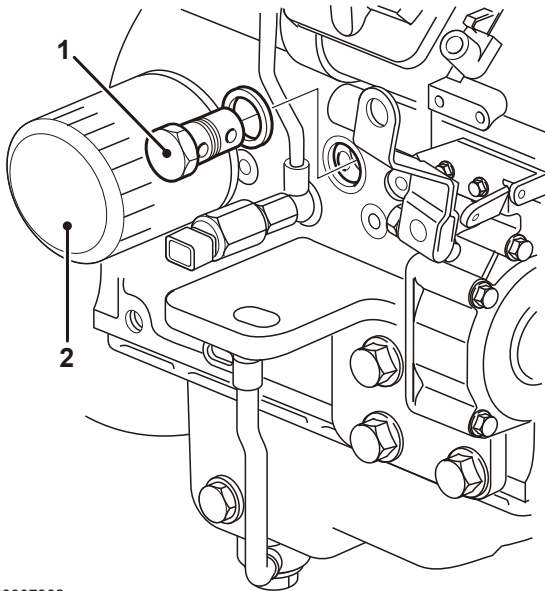
The lubrication system has a relief valve which limits the maximum oil pressure in the engine.

The oil filter is of full-flow type and is fitted with an overflow valve.



P0007818

- 1 Oil filter
- 2 Oil pressure monitor
- 3 Pressure relief valve
- 4 Inlet pipe with strainer
- 5 Main oil duct
- 6 Oil pump
- 7 Oil delivery pipe (outer) to valve mechanism
- 8 Crankcase ventilation, valve



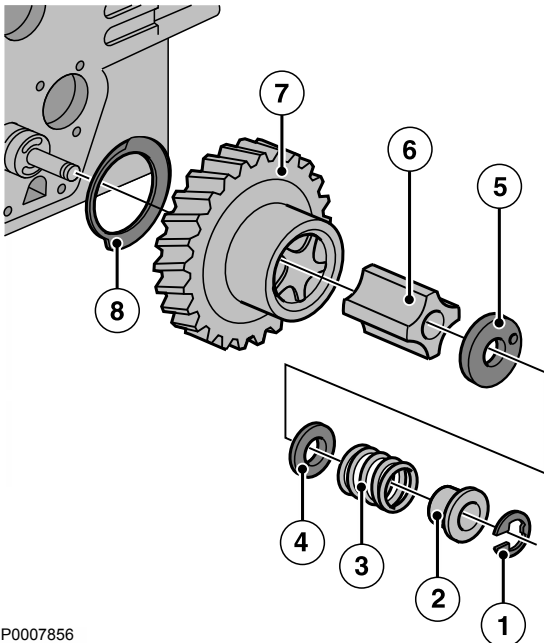
P0007862

Oil Valves

Lubrication oil pressure is limited by a relief valve (1). The valve is located in the lubrication system just before the oil filter (2). The valve opens at high pressure and allows the oil to flow back into the oil pan.

The D1-13 and D1-20 engines have a relief valve that opens in the 352-448 kPa (51-65 PSI) range. On D1-30 and D2-40 engines, the valve opens in the 304-500 kPa (44-73 PSI) range.

A bypass valve located on the oil filter opens if resistance in the filter becomes abnormally high. Oil supply to lubrication points is thus ensured even when the filter is blocked; however, the oil is no longer cleaned.



P0007856

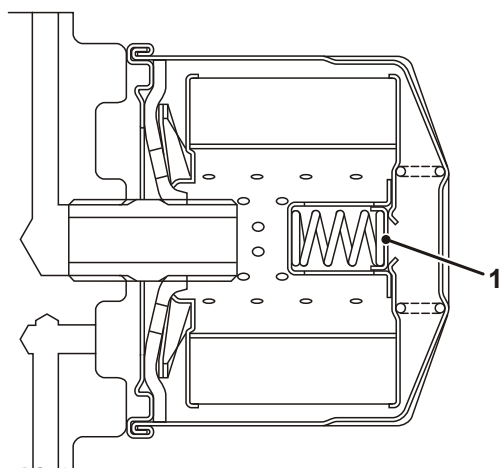
- 1 Retainer ring
- 2 Spring washer
- 3 Spring
- 4 Shim
- 5 Oil pump cover
- 6 Inner rotor
- 7 Idler wheel with outer rotor
- 8 Thrust washer

Oil pump

The lubrication pump is located within the idler gear on the timing gears, by which it is also driven.

The pump is a rotor pump with an inner rotor and an outer rotor mounted eccentrically in relation to each other. The inner rotor has one "tooth" less than the outer rotor.

Pump function results from the space between the inner and outer gear wheels increasing and decreasing. During the first part of the rotor (6) cycle volume increases, pressure drops and oil is drawn in through the inlet. After about a half revolution volume is reduced, pressure increases and oil is forced out through the outlet.



P0007860

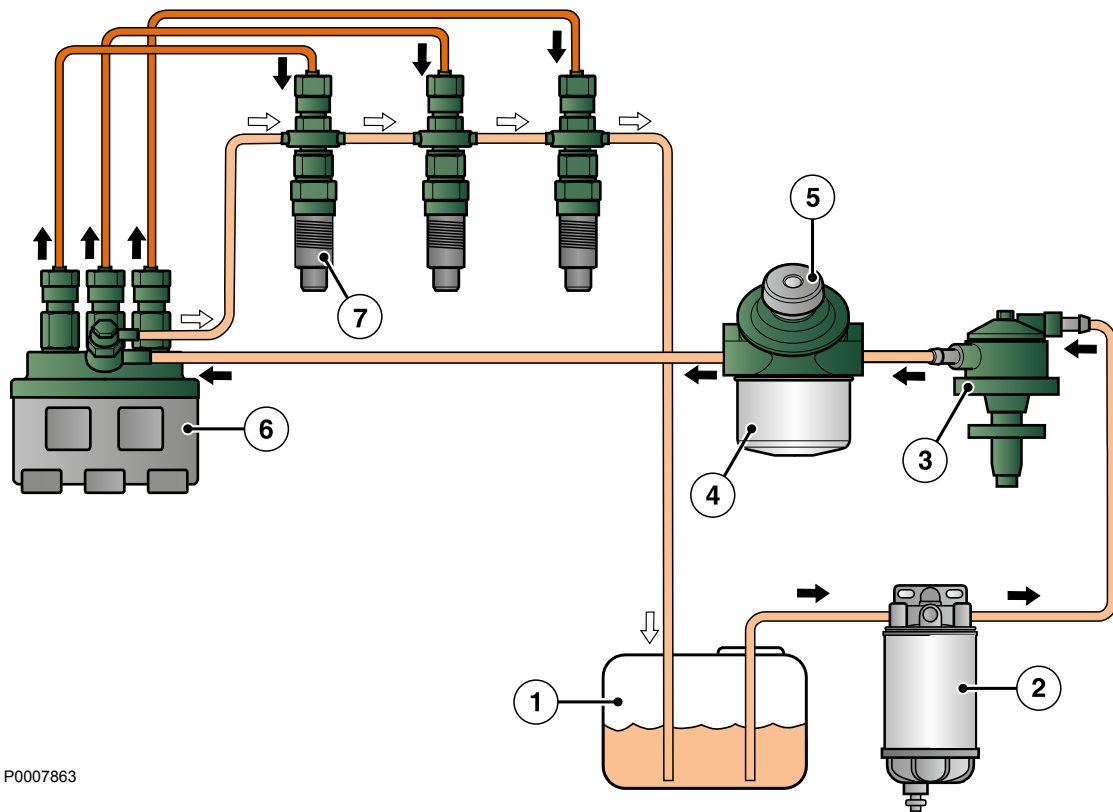
Oil filter

The purpose of the oil filter is to remove contamination from the oil. The filter is a full flow filter, which means that all the oil is filtered before it is forced out into the lubrication system.

The filter element consists of folded filter paper.

There is a bypass valve (1) at the base of the filter, which opens and allows oil to flow past the filter element if the filter insert should become blocked.

Group 23: Fuel System



P0007863

- 1 Fuel tank
- 2 Prefilter
- 3 Feed pump
- 4 Fuel filter
- 5 Hand pump
- 6 Injection pump
- 7 Injectors

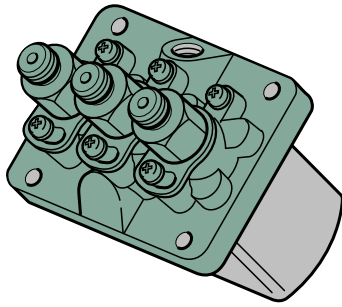
A mechanical feed pump draws fuel from the fuel tank via an optional water separation prefilter (optional equipment), and then forces fuel through a fine filter to the injection pump.

The camshaft driven injection pump then distributes the fuel in precisely timed and measured quantities to the injectors.

Fuel which returns from the injectors is returned to the base of the fuel tank. Air in the fuel system can be transported back to the fuel tank via a connection between the injection pump and the return fuel pipe.

The fuel is then forced at high pressure through the injector nozzles into a pre-combustion chamber in the cylinder head and then enters the piston combustion chamber, where an air vortex contributes to even combustion. A glowplug in the pre-combustion chamber pre-heats the fuel mixture for cold starting.

The engine fine filter removes contamination which may be left in the fuel, despite the prefilter.

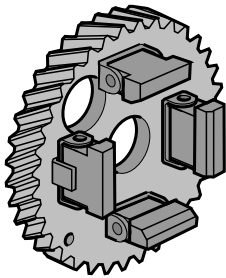


P0007864

Injection Pump

The injection pump is a flange-mounted in-line pump which is located on the engine block. The pump is driven by cams on the engine camshaft, that operate the pump chambers directly.

The injection pump has the same number of pump pistons as the engine has cylinders.

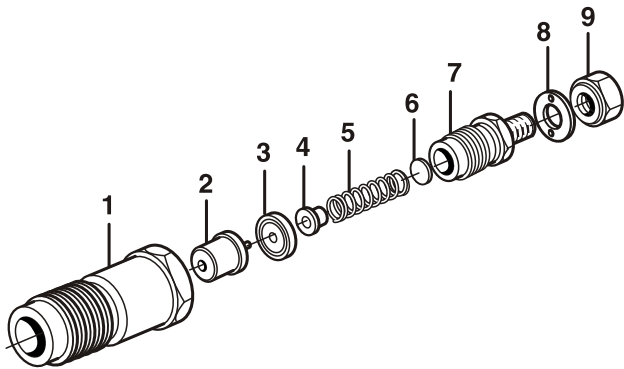


P0007851

Centrifugal Regulator

The governor is mechanical and works with speed-sensitive governor weights. It is mounted on the front of the camshaft drive.

The governor weights operate the injector pump control rod via the governor sleeve, a lever and a governor arm. Engine speed is governed throughout the entire range, from low idle to high idle (all-speed type).



P0007853

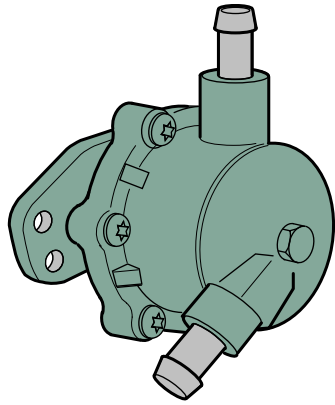
Injectors

The engine is provided with pintle-type injectors. Each injector basically consists of a nozzle retainer and a nozzle.

When the fuel pressure increases to the set value (opening pressure) the injector needle, which is held pressed against its seat by the compression spring, is lifted and atomized fuel is injected into the precombustion chamber of the engine.

Injector opening pressure is determined by the compression spring which is adjustable with shims.

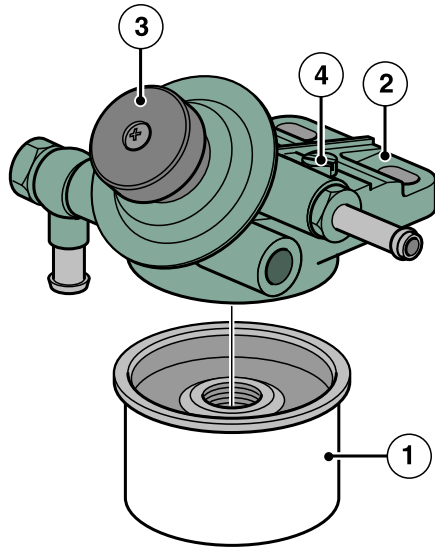
- 1 Injector nut
- 2 Injectors
- 3 Joining piece
- 4 Compression screw
- 5 Spring
- 6 Adjustment shims
- 7 Injector holder
- 8 Washer
- 9 Nut



P0007865

Feed pump

The feed pump is mounted on the outside of the engine block and is driven by an eccentric on the rear of the camshaft.



P0007866

Fuel Filter

The fuel filter (1) is of the disposable type. The filter insert is a paper filter.

The fuel filter is located in a bracket (2) together with a hand pump (3) and vent screw (4).

Group 26: Cooling System

The engine is fresh water cooled and has a sealed cooling system with expansion tank. The system is divided into two circuits.

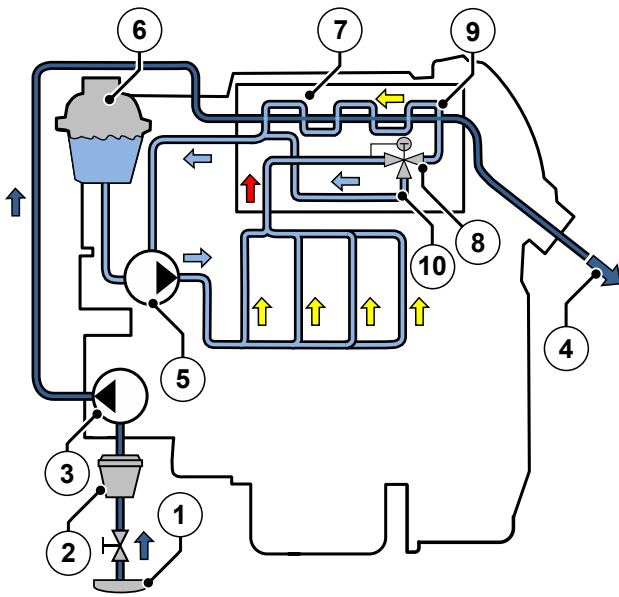
In the inner circuit, the fresh freshwater system, coolant is pumped around by a coolant pump, driven via a drive belt from the crankshaft pulley.

The fresh water system works under pressure, thus reducing the risk of boiling if the temperature becomes high. If the pressure becomes higher than normal, a pressure valve opens in the filler cap on the expansion tank.

The coolant temperature is regulated by a thermostat. When the engine is cold, a thermostat directs the coolant round an internal circuit in the engine. When operating temperature begins to be reached, the coolant is progressively directed out through the entire heat exchanger, where the surplus heat is removed.

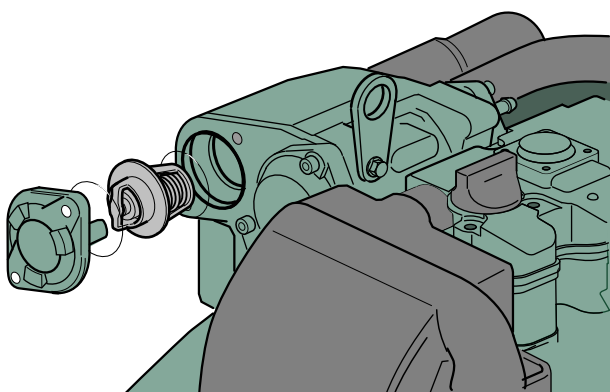
In the outer circuit - the raw water system - raw water flow is taken care of by a gear-wheel driven pump of rubber impeller type.

The raw water system cools the engine heat exchanger. Raw water is discharged together with the exhaust gas, via a connection in the exhaust bend.



P0007846

- 1 Raw water, inlet
- 2 Raw water filter
- 3 Raw water pump
- 4 Raw water, outlet
- 5 Coolant pump
- 6 Expansion tank
- 7 Heat exchanger / exhaust manifold
- 8 Thermostat
- 9 Open thermostat - circulation
- 10 Closed thermostat - circulation



P0007937

Thermostat

The engine is equipped with a thermostat whose sensor body contains wax.

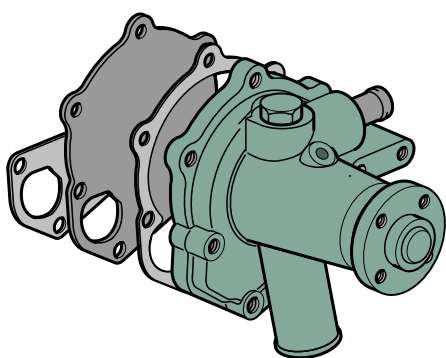
When the engine is cold the thermostat keeps the route to the heat exchanger closed. Coolant then passes through a by-pass line, directly back to the suction side of the pump. As the engine warms up, the volume of the wax increases and the thermostat progressively opens the passage to the heat exchanger, at the same time as the by-pass line is closed.

Refer to *Group 26: Cooling System page 22* for opening temperatures.

The thermostat is located in a housing which is integrated in the heat exchanger and exhaust manifold.

Coolant Pump

The coolant pump is mounted on the engine block and is driven by the crankshaft by means of a drive belt.

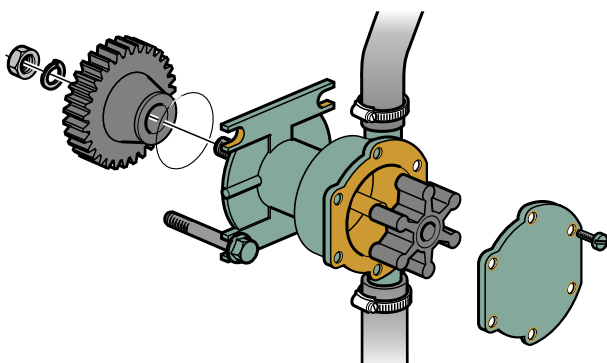


P0007938

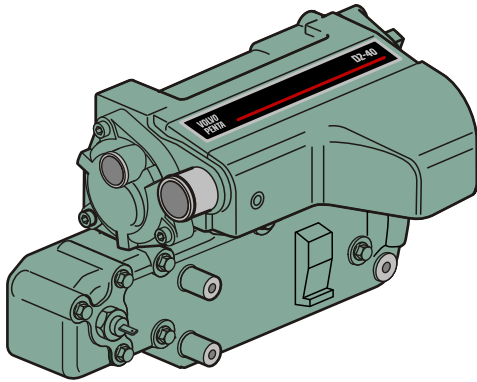
Seawater Pump

The raw water pump is a rubber impeller type pump mounted on the front of the engine. The pump is driven by the engine timing and pumps cooling water to the engine heat exchanger.

NOTICE! The impeller will be damaged if the pump is run dry.



P0007939



P0007940

Heat exchanger

The heat exchanger is located in a housing which is integrated with the exhaust manifold and thermostat.

Raw water passes through the heat exchanger matrix and transfers heat from the internal cooling circuit in the engine (fresh water system) to the outer circuit (raw water). When the thermostat is closed, coolant is led through a short, uncooled passage in the heat exchanger and back to the engine.

Test and Adjustments

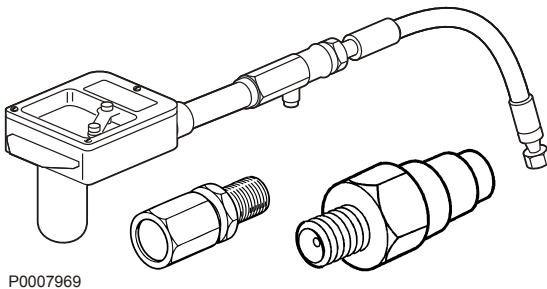
Compression Test

Tools:

885252 Adapter

885484 Adapter

9988539 Compression meter



In order to assess engine condition in a simple, reliable manner, a compression test is carried out to show cylinder and valve sealing.

- Warm the engine up, then stop it.
- Remove all the injectors and test each of the cylinders in turn.

IMPORTANT!

Observe the greatest possible cleanliness, to avoid getting dirt in the fuel system.

Plug the connections for the disassembled injectors and fuel pipes.

The compression pressure must be read at normal starter motor speed.

Low combustion pressure in all cylinders indicates worn cylinder bores and piston rings. If one cylinder has lower compression than the others, the reason can be poor valve sealing, broken piston rings or a damaged cylinder head gasket.

Place the adapters 885484 Adapter and 885252 Adapter in the injector sockets.

Place 9988539 Compression meter in the adapter and carry out the compression test.

Repair Instructions

General

If possible, a condition test should be performed before each major service activity to determine the general condition of the engine and discover any concurrent fault causes. A condition test requires the engine to be run, so it should be performed before the engine or engine components are removed.

Refer to *Compression Test* page 47.

When working with chemicals, fuel and lubricating oil

CAUTION!

Always use protective gloves for work which includes contact with oil, fuel etc.

Constant skin contact with engine oil can be very harmful.

- 1 Disconnect battery power.
- 2 Clean the outside of the engine.

NOTICE! Make sure that wash residue is collected for destruction and does not inadvertently end up in the environment.

IMPORTANT!

Remember the following when washing with a power washer: Be extremely careful when cleaning, to avoid getting water inside engine components. When a power washer is used, the water jet must never be aimed at seals, such as shaft seals, joints with gaskets, rubber hoses or electrical components.

- 3 For work that includes dismantlement of the cooling system: Close the sea cocks and drain the coolant from the raw water and fresh water systems.

IMPORTANT!

Make sure that all sea water inlets are securely closed, so that water can not find its way in during disassembly of cooling system sub-components.

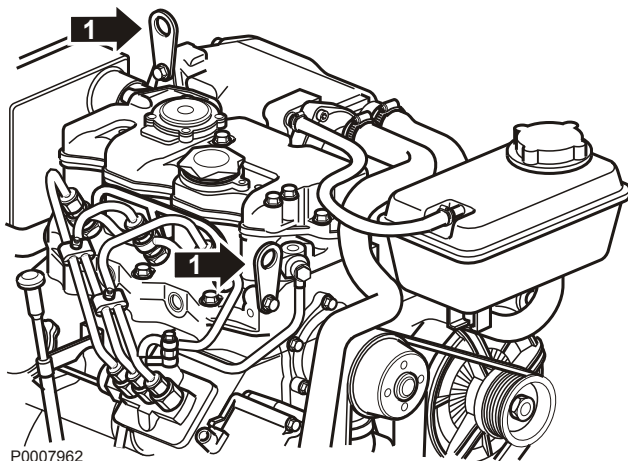
21-0 Engine Complete, General

Exposing the Engine

Before lifting the engine

Boat removed from the water

- 1 Turn the battery isolator off, and undo the battery connections on the starter motor.
- 2 Remove the harness terminal for the engine instrumentation harness.
- 3 Remove the raw water connections / keel cooling connection.
- 4 Remove the exhaust line.
- 5 Close the fuel taps. Remove the fuel connections.
- 6 Remove the throttle and gear shift cables.
- 7 Undo the propeller shaft from the reversing gear. Undo the engine mounting pads from the bed and lift the engine out. Use the lifting lugs (1) on the engine.



P0007962

Actions after lifting the engine

- 1 Clean the engine.

IMPORTANT!

Remember the following when washing with a power washer: Be extremely careful when cleaning, to avoid getting water inside engine components. When a power washer is used, the water jet must never be aimed at seals, such as shaft seals, joints with gaskets, rubber hoses or electrical components.

- 2 Drain the engine oil
- 3 Remove the reverse gear (as necessary)

Fitting the Fixture

Drained cooling system and engine oil. Engine removed. Right front engine mounting removed.

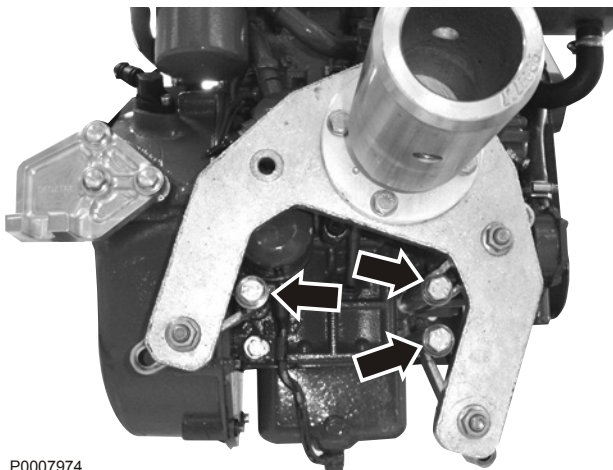
Tools:

- 885224 Fixture
- 9999737 Fixture
- 9986485 Stand
- 9992520 Stand

Use 885224 Fixture and 9999737 Fixture to secure the engine in 9986485 Stand. Only 885224 Fixture is required for securing in 9992520 Stand.

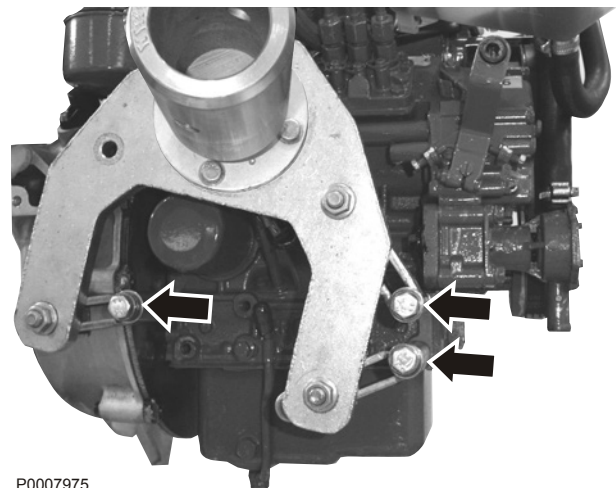
Bolt the fixture to the right side of the engine, as illustrated.

D1-13-A/B/F



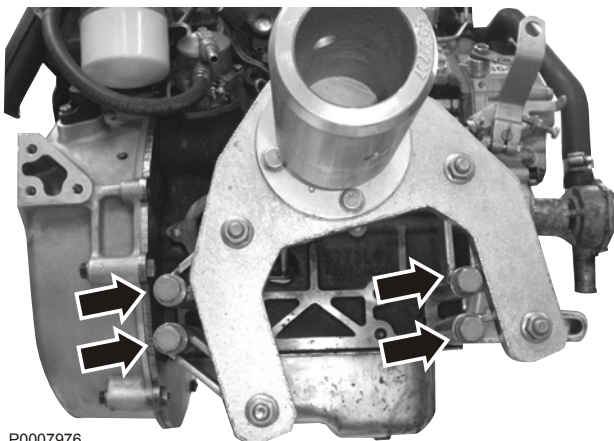
P0007974

D1-20-A/B/F



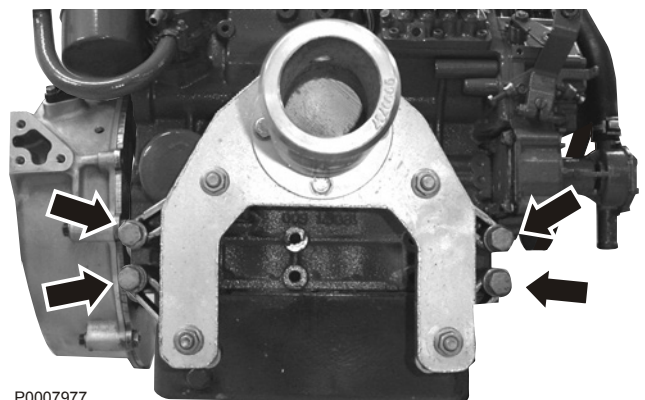
P0007975

D1-30-A/B/F



P0007976

D2-40-A/B/F



P0007977

Engine Disassembly

Tools:

885510 Plugs
885820 Puller
885822 Magnetic pen

Empty the oil and water from the engine. Lift the engine with a suitable lifting device. Install the engine fixture: Refer to *Engine with mounting and equipment* page 50.

⚠ CAUTION!

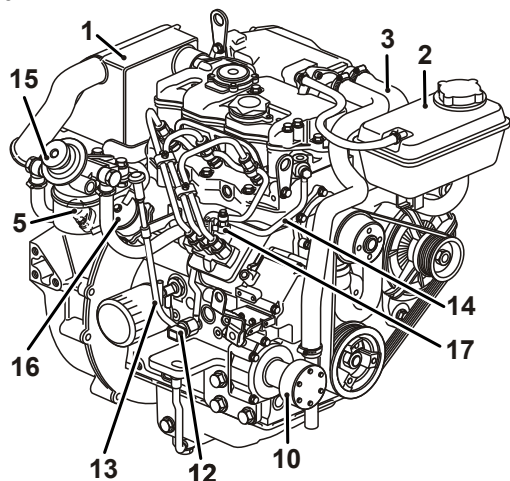
Always use protective gloves for work which includes contact with oil, fuel etc.

IMPORTANT!

Observe the greatest possible cleanliness, to avoid getting dirt in the fuel system.

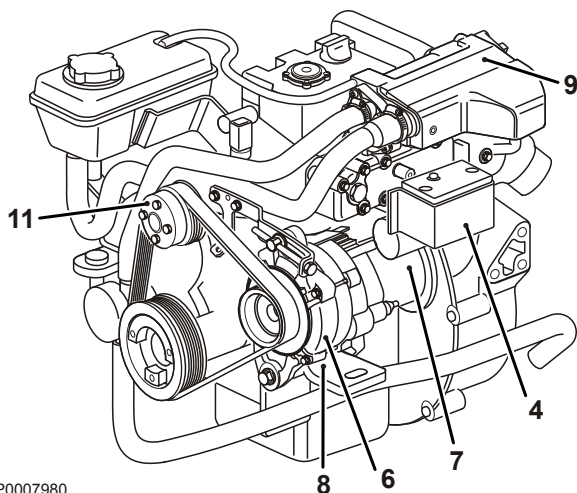
Plug the unions in the fuel system with suitable protective plugs, such as kit no. 885510 Plugs.

D1-30-A/B/F



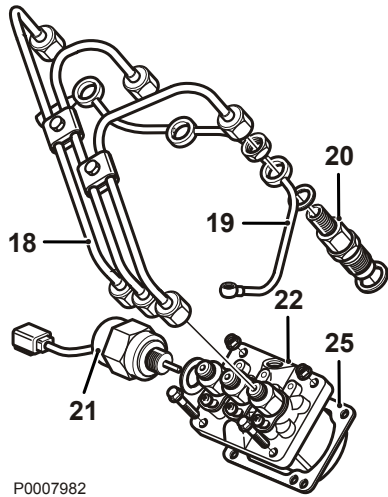
P0007981

D1-13-A/B/F



P0007980

- 1 Remove the inlet muffler (1).
 - 2 Undo the expansion tank (2) and its bracket. Remove all coolant hoses (3) with brackets.
 - 3 Remove the electronics box (4) together with the cable harness. Undo the engine rpm sensor (5).
- NOTICE!** Note the way that the cable harness is clamped before removing it.
- 4 Remove the alternator (6) with bracket, starter motor (7) and the left side engine mounting (8).
 - 5 Remove the heat exchanger/exhaust manifold (9), raw water pump (10), coolant pump (11) with spacer (D1-13).
 - 6 Remove the oil pressure monitor (12), oil dipstick (13) and the oil delivery (14) pipe to the cylinder-head.
 - 7 Remove the fuel filter bracket (15) with anchorage, feed pump (16) and feed hose by the union (17) for the injection pump. Leave the fuel hoses between the fuel filter, feed pump and union in place.



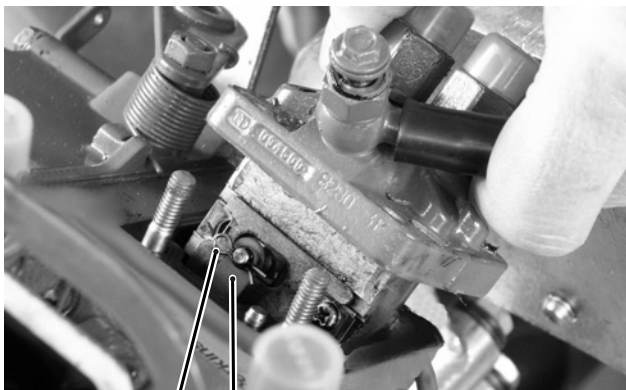
P0007982

- 8 Remove the fuel supply pipes (18) between the fuel pump and injector; use the nut underneath the fuel return pipe as a counterhold to avoid kinking the pipe. Remove the fuel supply pipes and put them on a clean, dry surface.
- 9 Remove the fuel return pipe (19) and the injectors (20).
- 10 Unscrew the stop solenoid (21). Remove the injection pump (22). Remove the pump retaining nuts and bolts. Turn the stop lever clockwise and carefully lift the pump, to make the lock clip on the regulator arm accessible. Remove the lock clip (23) and free the governor arm (24).

IMPORTANT!

Be careful when disassembling the injection pump, avoid damaging or bending its lever.

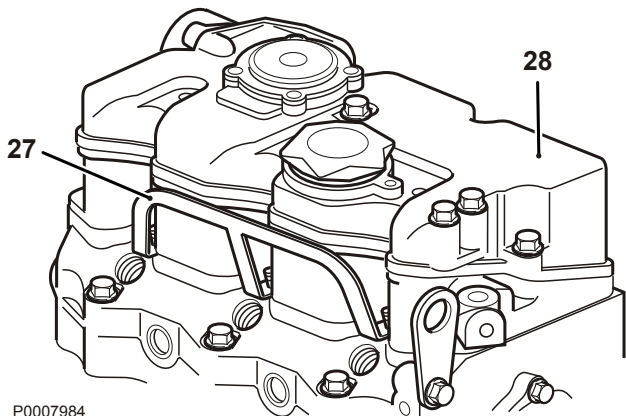
NOTICE! Retain the shim / gasket (25) located beneath the injection pump flange. Use the same thickness of shims when installing.



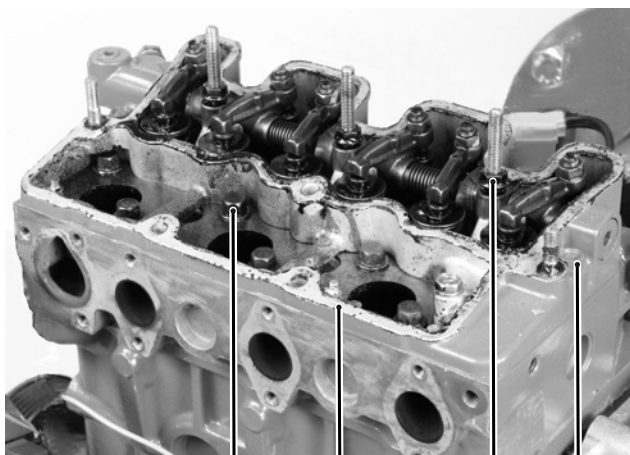
P0007983

23 24

- 11 Remove the valve cover (26), current bar (27) and the glowplugs (28).



P0007984

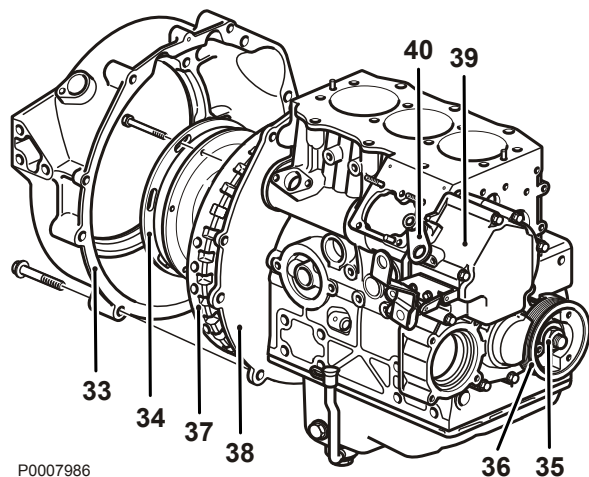


P0007985

32 29 31 30

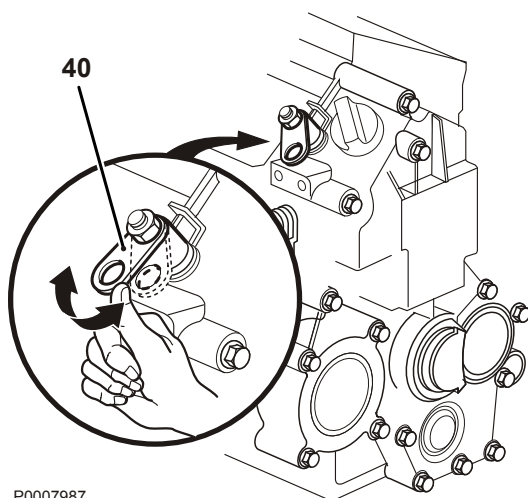
- 12 Remove the lower part of the valve cover (29) with the integrated rocker arm bridge. Start by unscrewing the two screws (30) on the edge, then undo the rocker arm bridge nuts (31) one turn at a time until the load on them has been relieved.
- 13 Prepare a stand, marked with cylinder numbers. If the valve caps, pushrods and valve lifters are to be re-used, they must be fitted in their original positions. Lift the push rods and valve caps out and put in them in number sequence in the marked stand.
- 14 Undo the bolts (32) in reverse tightening sequence; refer to *Technical Data page 13*. Remove the cylinder head.
- 15 Remove the valve lifters from the cylinder block using 885822 Magnetic pen. If the valve lifters are to be re-used they **must** be replaced in their original positions.

NOTICE! The D1-20 and D2-40 engines have certain valve lifters that are beveled.

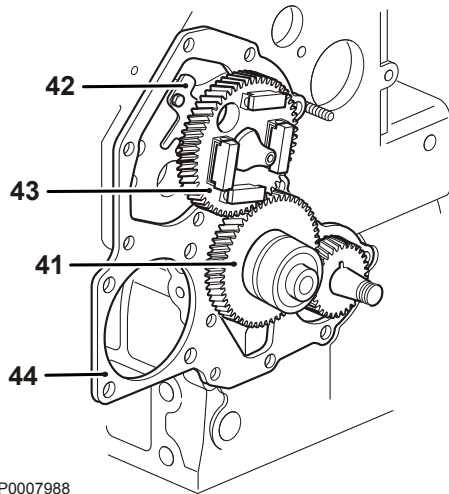


P0007986

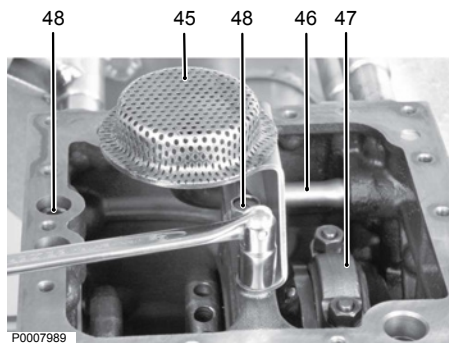
- 16 Remove the flywheel housing (33) and oscillation damper (34).
- 17 Undo the center nut (35) on the pulley. Remove the pulley (36); use special tool 885820 Puller. Use the flywheel as a counterhold. Remove the Woodruff key from the crankshaft.
- 18 Remove the flywheel (37).
- 19 Remove the inner flywheel housing (38) and rear crankshaft seal.
- 20 Remove timing gear casing (39). Load the stop arm (40) so that the springs on the inside of the housing do not come out of position or spring out.



P0007987



P0007988



P0007989

21 Remove the idler wheel (41) retainer ring. Retain the sleeve washer, spring and shims. Lift away the idler gear complete with cover and oil pump. Also remove the thrust washer behind the idler wheel.

22 Remove the locking plate (42) bolts. The bolts are accessible behind the holes in the camshaft gear. Lift out the camshaft (43), complete with gear and governor weights.

NOTICE! Be careful to avoid damaging the bearings, bearing tracks and camshaft lobes.

23 Remove the timing plate (44) with gasket.

24 Turn the engine upside down and remove the sump, together with the external oil pipe. Remove the oil strainer (45) and the oil suction pipe (46). Remove the oil relief valve.

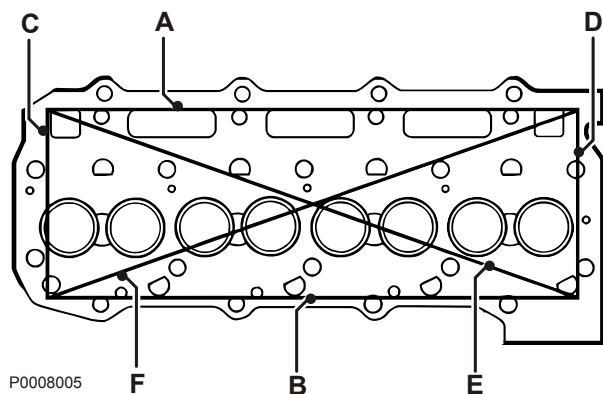
25 Scrape away the line of carbon at the top of the cylinders, to facilitate removal. Remove the big end bearing caps (47) and press the pistons out.

NOTICE! Check the markings on the big end bearing caps.

26 Remove the locking screws (48) that hold the main bearing caps. Carefully lift the crankshaft out backwards, complete with caps.

NOTICE! Tape the crankshaft gear to protect the bearing surfaces in the block during removal.

21-1 Cylinder Head



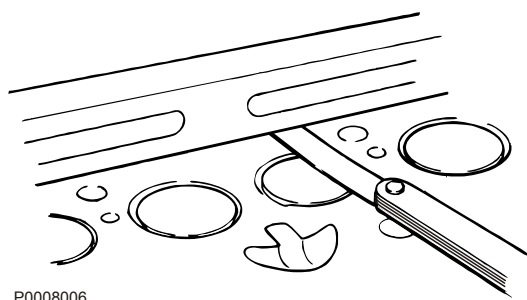
Cylinder Head, Inspection

Cylinder head warping must not exceed the value given in *Group 21: Engine page 14*. The check should be done with a feeler gauge and a straight edge. Measurement is done at six positions (A - F).

If warpage above the permissible level is found, the cylinder head must be changed. If leakage is found, or if the cylinder head has blow lines, no special measurement is needed since such a cylinder head will have to be attended to in any case.

Check the valve seats and check that the studs are firmly seated.

Inspect the cylinder head for cracks. Carefully check the areas around the valve seats and the holes for the injector nozzles.



Cylinder Head, Assembly

Measuring piston height, installing the cylinder head and other assembly

- 1 Clean the cylinder head and engine block mating planes. Remove any rust and carbon from bolt holes and from the threads on the cylinder head bolts.
- 2 Put the valve lifters in their original places.

IMPORTANT!

Refer to *Timing Gear, Installation page 80* for placement of valve lifters.

- 3 Put the new cylinder head gasket in place with the marking (1) upwards. Check that the hollow pins (2) are installed in the block.

NOTICE! The new gasket must be of the same thickness as the old one.

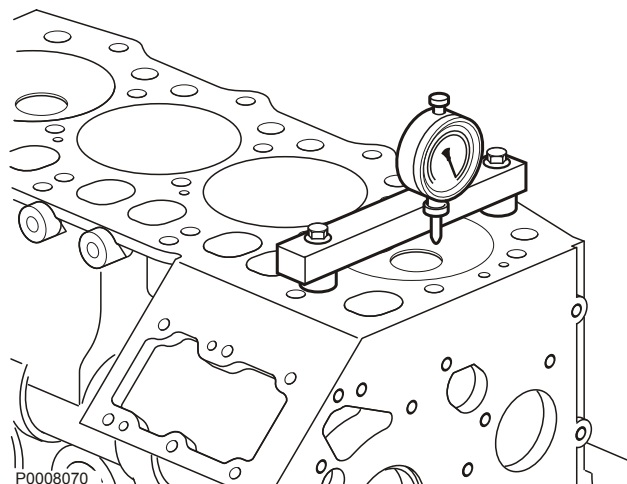
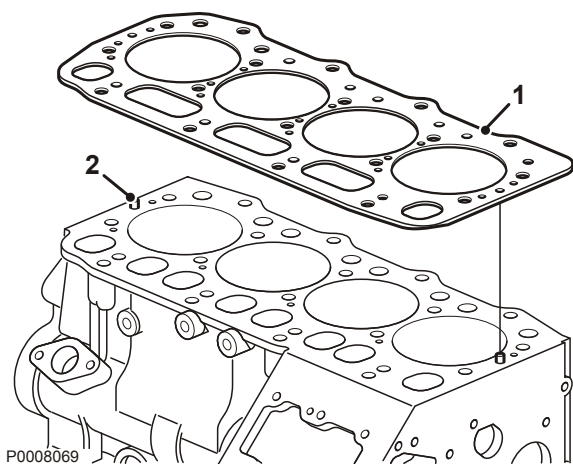
NOTICE! If a piston, connecting rod, crankshaft or engine block has been changed, new measurement must be done.

- 4 Dip the cylinder head bolts in engine oil and leave them to run off on a strainer. The bolts should have stopped dripping when they are installed (otherwise oil might well up and be regarded as leakage).

IMPORTANT!

The bolts are phosphated and must not be cleaned with a steel wire brush. If the cylinder head is painted, the contact surfaces for the cylinder head bolts must be free from paint. The clamping force in the joint could otherwise be very poor.

- 5 Put the cylinder head in place.



Difference in height between pistons and engine block plane

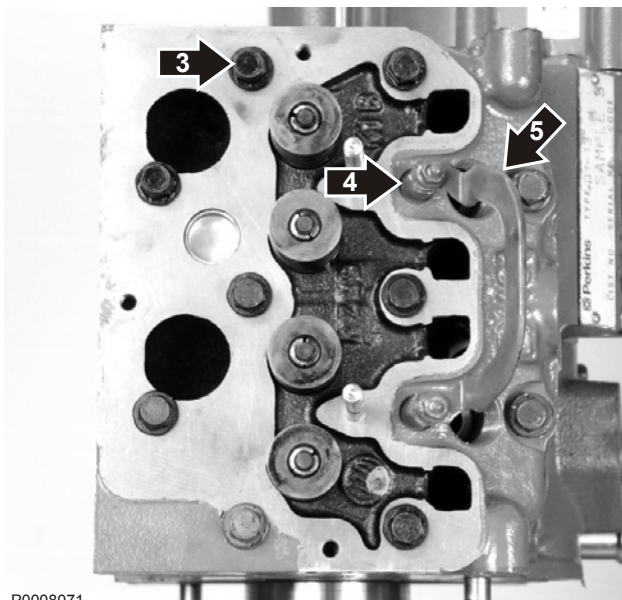
0.55 to 0.64 mm
(0.0217–0.0252")

0.65 to 0.75 mm
(0.0255–0.0295")

Gasket thickness

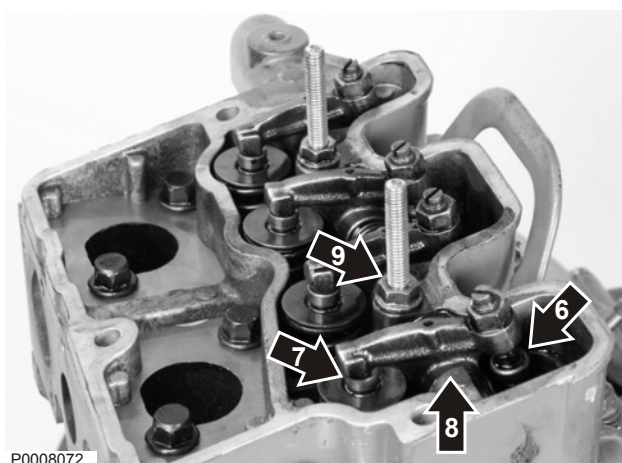
1.2 mm (0.0472")

1.3 mm (0.0512")



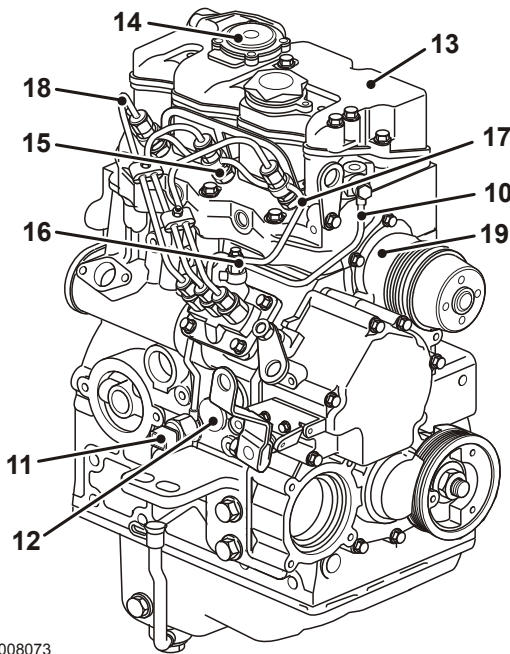
P0008071

- 6 Torque the cylinder head bolts (3) in three stages, of which the last stage must be to the stated torque. Refer to tightening sequence and torque in *Tightening torques page 9*. Re-tighten all bolts.
- 7 Install the glowplugs (4) and current bar (5).



P0008072

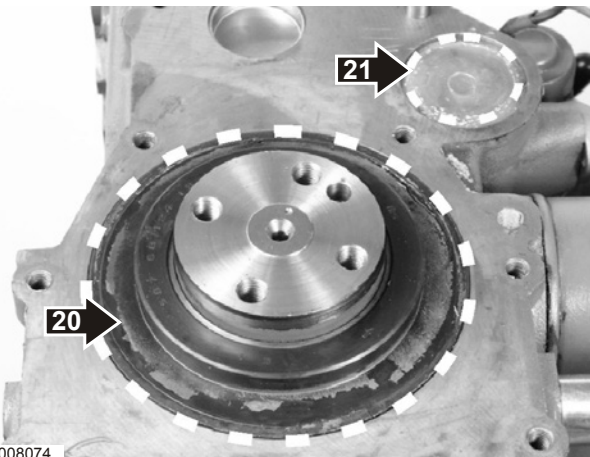
- 8 Install the push rods (6), valve caps (7) and rocker arm mechanism (8) with gasket. Torque the nuts (9); refer to *Tightening torques page 9*.



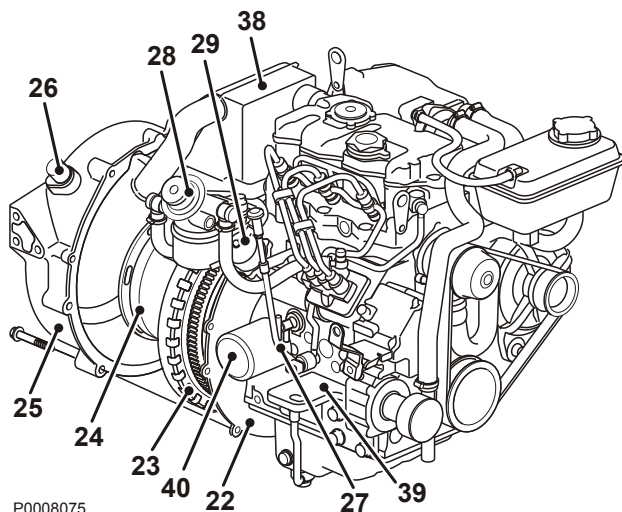
P0008073

D1-30-A/B/F

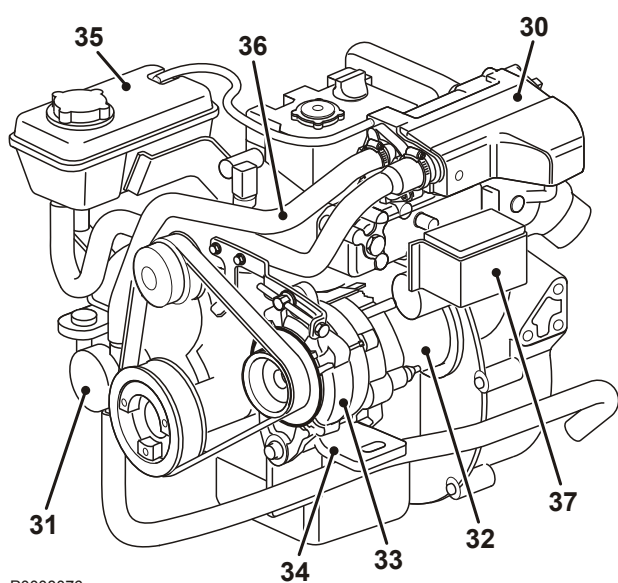
- 9 Install the oil supply pipe (10) between the block and the rocker arm mechanism, together with the oil pressure monitor (11). Install the oil pressure relief valve (12). For tightening torques, refer to *Tightening torques* page 9. Crank the crankshaft a couple of revolutions.
- 10 Adjust the valve clearance; refer to *Valves, Adjustment* page 70.
- 11 Install the valve cover (13). Check that the small ventilation hole in the crankcase ventilation cover (14) is open.
- 12 Install the copper gaskets for the injectors. Install the injectors (15). For tightening torques, refer to *Tightening torques* page 9.
- 13 Install the hollow screw (16) on the injection pump and the banjo nipple with new copper washers.
- 14 Install new copper gaskets and install the return fuel line (17). Tighten the nuts and connect the return line.
- 15 Install the delivery pipes (18). For tightening torques, refer to *Tightening torques* page 9.
- 16 Install the coolant pump (19) with spacer (D1-13-A/B/F) and a new gasket.
- 17 Clean the rear crankshaft seal seat in the engine block and the mating surface on the inner flywheel housing. Install the rear crankshaft seal (20).
- 18 Apply an even, thin sealant layer (VP no. 840 879) around the crankshaft seal and the camshaft cover (21).



P0008074



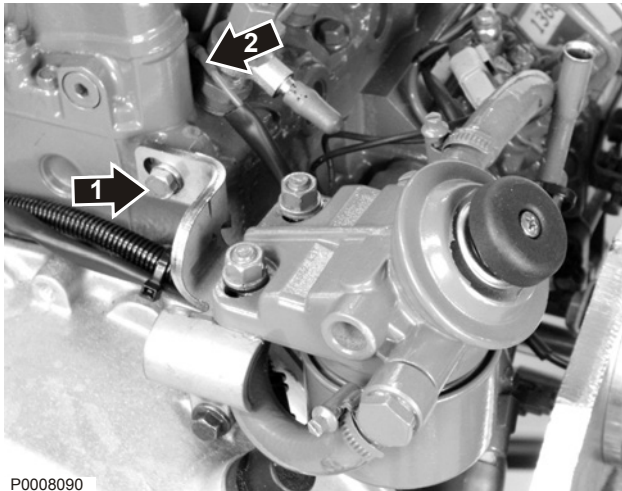
- 19 Install the inner flywheel housing (22). Install the flywheel (23) according to the marks made earlier. For tightening torques, refer to *Tightening torques page 9*. Then install the vibration damper (24) and the flywheel housing (25). Install the engine rpm sensor (26) on the flywheel housing.
- 20 Install the oil dipstick tube (27).
- 21 Install the fuel filter bracket (28) with attachment fitting, and the feed pump (29). For tightening torques, refer to *Tightening torques page 9*. Connect the fuel hoses and tighten the hose clamps.



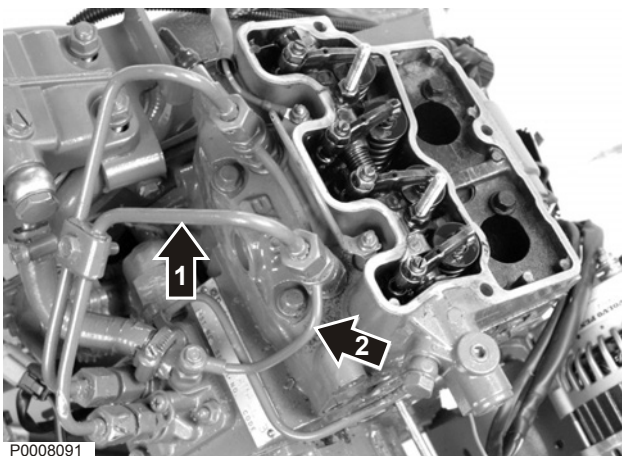
- 22 Install the heat exchanger / exhaust manifold (30) and raw water pump (31).
- 23 Install the starter motor (32) and alternator (33), together with the front engine mounting (34).
- 24 Install the expansion tank and attachment fitting (35).
- 25 Connect all coolant hoses (36). Tighten all hose clamps and brackets.
- 26 Install the electronics box (37) with cable harness; connect the connectors and other electrical connections. Clamp the cable harness as previously noted.
- 27 Install the induction silencer (38).
- 28 Remove the engine fixture and install the engine mounting (39).
- 29 Install a new oil filter (40). Add oil and coolant; refer to *Group 22: Lubrication System page 20*.
- 30 Install the engine in the boat. Connect the remaining connections and controls to the engine. Open the fuel taps and the sea cock. Start the engine and check that no leakage occurs.

Cylinder Head, Removal

Coolant drained. Air filter housing, heat exchanger and coolant pump with spacer (D1-13) removed.



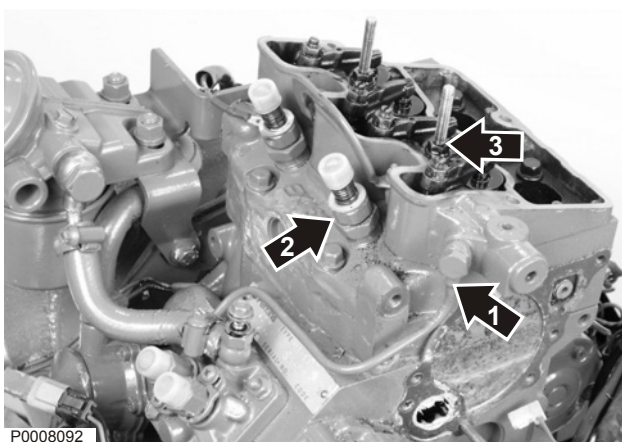
- 1 Remove the bolt (1) which holds the fuel filter bracket to the cylinder head. Remove the valve cover. Disconnect the cable (2) to the glow plugs.



- 2 Undo and remove the injector pipes (1). Undo and remove the return fuel pipe (2).

IMPORTANT!

Seal all openings in the fuel system with protective caps.



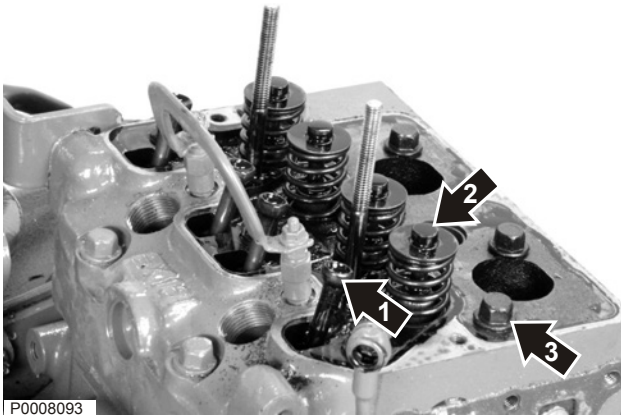
- 3 Undo the oil supply pipe (1) at the cylinder head. Unscrew the injectors (2).

IMPORTANT!

Seal all injector openings with caps.

Unscrew the nuts (3) which hold the rocker arm bridge.

The D1-20, D1-30 and D2-40 engines also have bolts that must be removed. Carefully prise the rocker arm bridge loose.



- 4 Remove the push rods (1) and valve caps (2). Mark them.
Undo the cylinder head bolts (3) in reverse tightening sequence; refer to *Tightening torques* page 9. Remove the cylinder head and gasket.

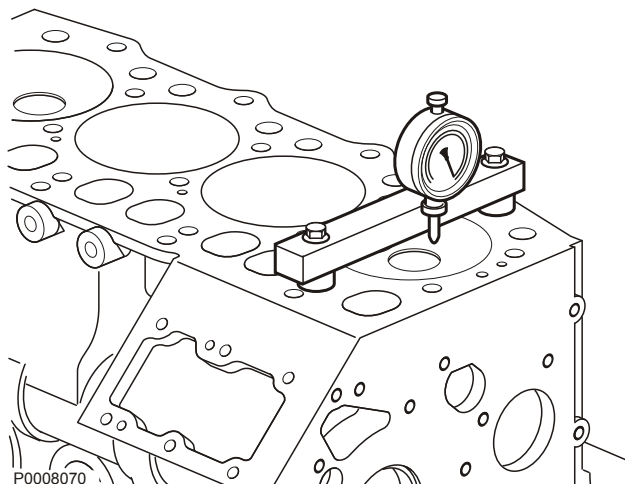
Cylinder Head, Installation

Tools:

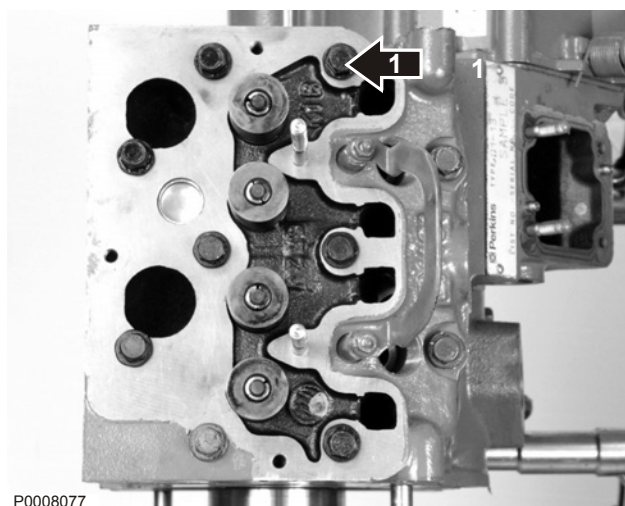
9989876 Dial indicator

9995192 Gauge rod

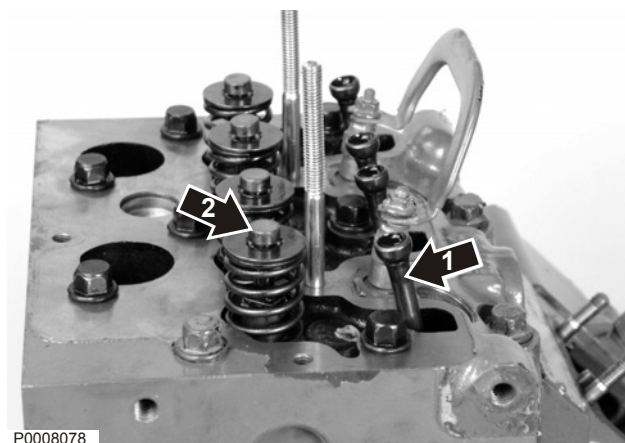
- 1 Check the piston height with tools 9989876 Dial indicator and 9995192 Gauge rod. Select a new cylinder head gasket; refer to *Group 21: Engine page 14*. Check that the valve lifters are in place.

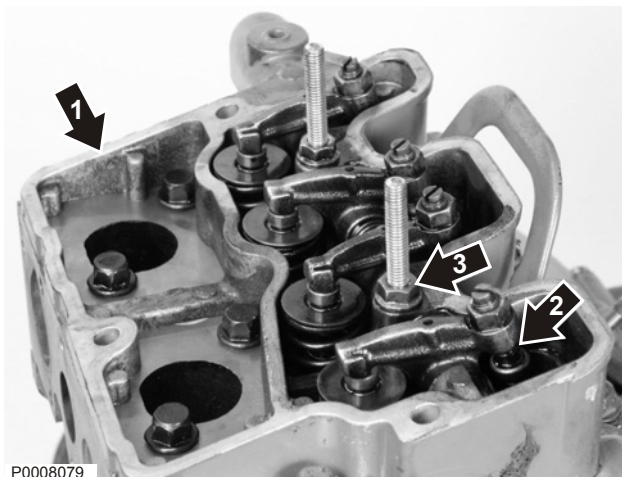


- 2 Check that the engine block guide pins for the cylinder head are in place. Install a new cylinder head gasket with the marking upwards. Put the cylinder head in place. Insert the bolts (1) and torque them according to the tightening sequence and to the specific torque; refer to *Tightening torques page 9*.



- 3 Put the push rods (1) and valve caps (2) in place.

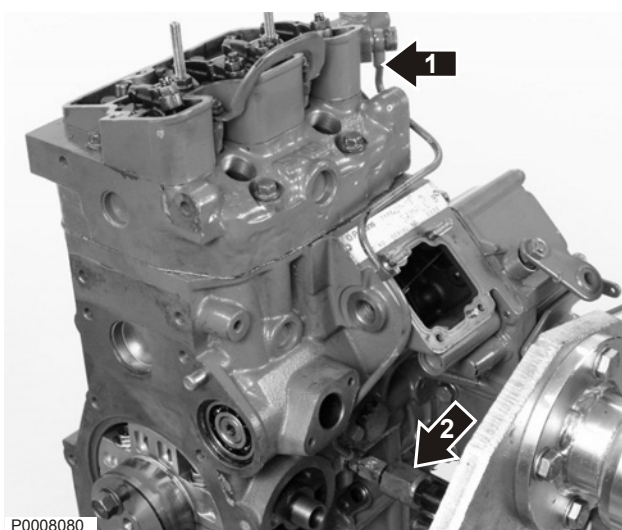




P0008079

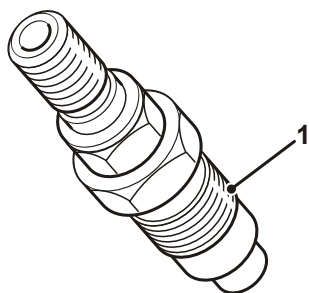
- 4 Install a new seal on the rocker arm bridge (1). Install a new rocker arm bridge. Make sure that the push rods and rocker arms (2) are correctly positioned.

Tighten the nuts (3) evenly and to the specific torque; refer to the *Tightening torques* page 9.



P0008080

- 5 Install the oil delivery pipe (1) on the cylinder head with new seals.



P0008084

- 6 Installing the injectors:

Apply sealant part no. 840879 to the two lowest threads (1).

Put new copper seals on the bottom of the cylinder head.

Install the injectors and tighten them evenly to the specified torque, refer to *Tightening torques* page 9.

21-2 Cylinder Block

Cylinder Block, Inspection

Upper block plane

Check that the upper engine block plane does not have any cracks or other damage. Also check that it is not warped (in the same way as for the cylinder head).

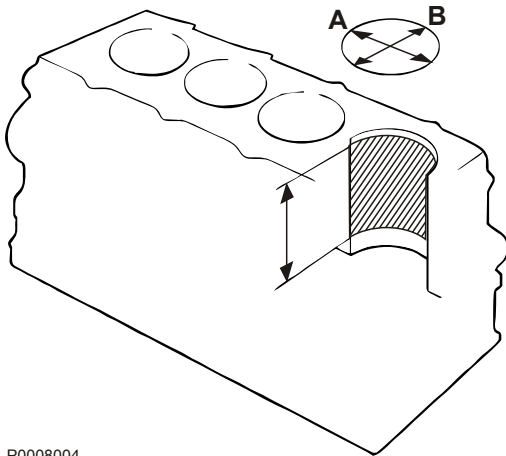
For max. warpage, refer to *Group 21: Engine page 14*. Change the engine block if it is outside the tolerances.

Cylinder bore

Check that the cylinder bores are not scored or damaged in other ways.

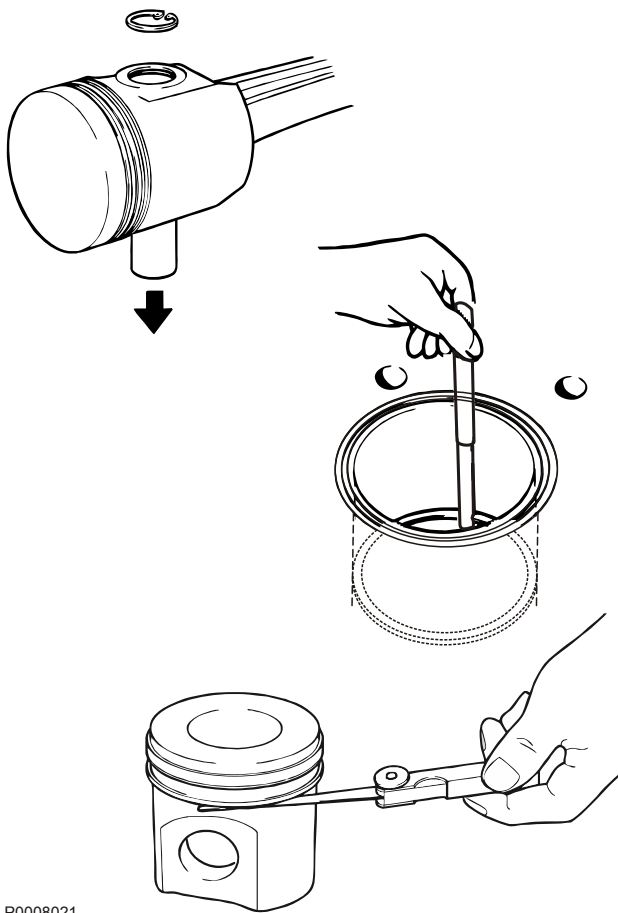
Measure the cylinder bores at the piston ring top and bottom dead center positions (approx. 10 mm (0.39") and 100 mm (3.94") below the engine block plane) and also in between. Measurement should be done with an internal dial gauge both longitudinally and transversely to the engine block (**A** and **B**).

Concerning max. permitted cylinder diameter, refer to "Wear tolerances" in *Group 21: Engine page 14*.



P0008004

21-3 Cylinder Liner, Pistons



P0008021

Piston Rings, Measurement and Inspection

- 1 Remove the piston rings with piston ring pliers.
- 2 Remove the piston pin retainer rings and remove the piston pin carefully, using a suitable mandrel.
- 3 Check that the rings do not bind in the piston ring grooves.
- 4 Check the piston ring gap. Push the ring down below bottom dead center with a piston. Change the piston ring if the gap exceeds 1.0 mm (0.04").

Also check the piston ring gap on new rings. Refer to *Group 21: Engine page 14* for measurements. In general, piston rings should be changed if there is any noticeable wear or out-of-roundness in the cylinders, since piston rings frequently do not end up in the same positions as they had before removal.

Oil consumption is also of decisive importance for the point in time when a piston ring change should be done.

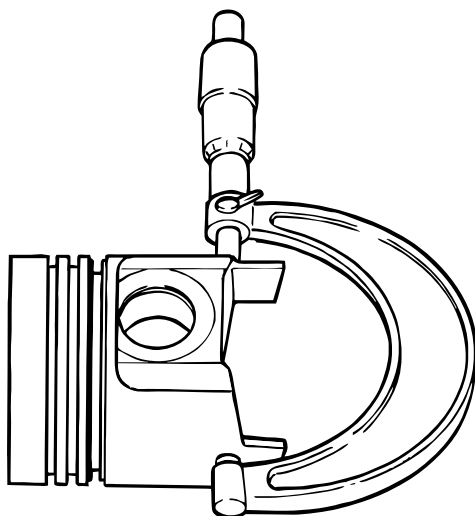
- 5 Check the clearance in the piston ring grooves. Rotate the ring in its piston groove and measure the clearance at several points with a feeler gauge. Refer to *Group 21: Engine page 14* for measurements.

Piston and Cylinder Bore, Inspection and Measurement

Check the pistons for cracks and worn piston ring grooves. Change the piston if it has deep lines in the skirt surface. Also if the piston has one or more cracks in the piston pin hole. If any such damage is found, the injection equipment must also be checked.

Measure the piston diameter with a micrometer at right angles to the piston pin hole and 10 mm (0.4") from the bottom edge of the piston. Then measure the cylinder bore and calculate the clearance between the cylinder and piston.

Replace the piston if the clearance exceeds permitted values or if the piston diameter is lower than the permitted value.

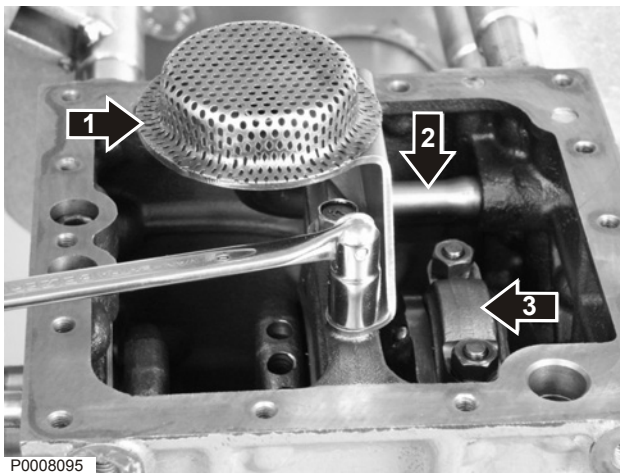
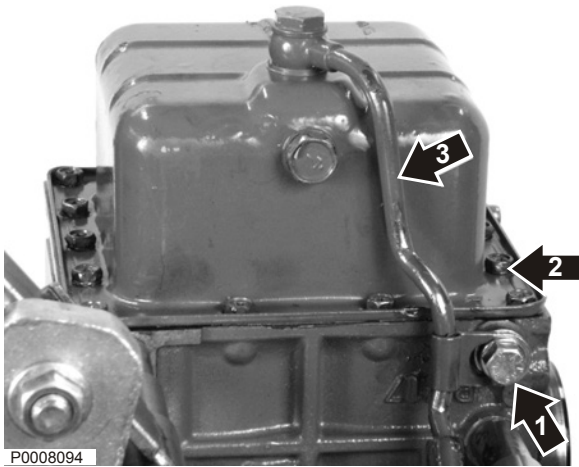


P0008022

Pistons, Removal

Engine oil drained. Cylinder head removed.

- 1 Turn the engine upside down. Undo the oil drain pipe attachment fitting (1) on the cylinder head. Unscrew the oil pan (2) and remove it together with the oil drain pipe (3).



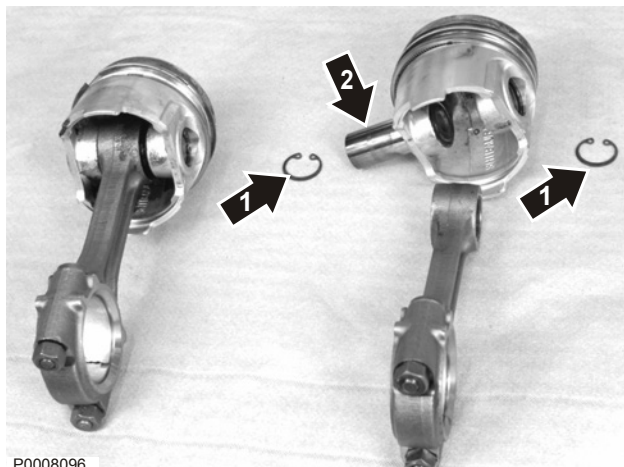
- 2 Unscrew the oil suction strainer (1). Remove the suction pipe (2) with its O-ring. Unscrew the connecting rod bearing caps (3).

IMPORTANT!

Note the markings on the bearing caps and their locations.

- 3 Press the pistons out.

NOTICE! There may be a soot deposit on the top of the cylinder bores. Remove the deposit to facilitate pressing the pistons out.



P0008096

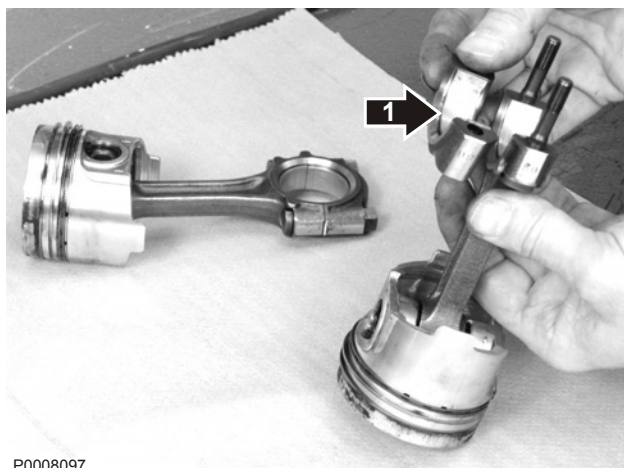
Pistons, Change

- 1 Note the positions of the pistons in relation to the crankshaft.
Remove the retainer rings (1) and press the piston pin out (2).
- 2 Clean the piston pin bushing and check it.
- 3 Install a new piston in the correct position.
Press the piston pin in.
Install the retainer rings with the lugs facing upwards.

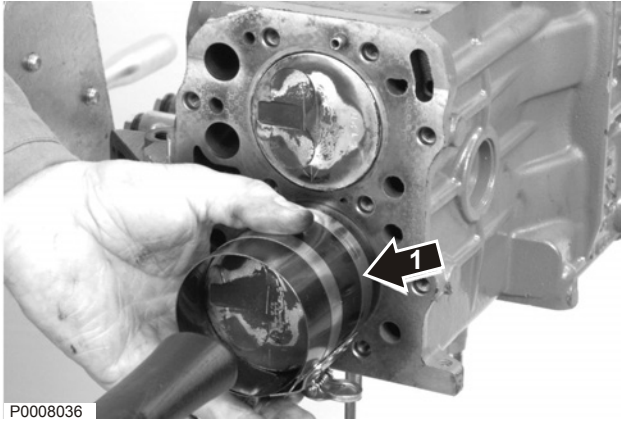
Big end bearing, change

Pistons, removed

- 1 Remove the big end bearings (1) and put the new ones in position.



P0008097



P0008036

Pistons, Installation

- 1 For piston ring positioning, refer to *Assembling Piston, Piston Rings and Con Rod* page 89. Fit a piston ring compressor on the piston. Lubricate the connecting rod bearing shells and studs with engine oil.
- 2 Crank the crankshaft so that the big end bearing is in the lowest position for the piston to be installed. Insert the piston (1) in the bore and carefully tap it down. The piston marking " SHIBAURA " must face the injection pump side.

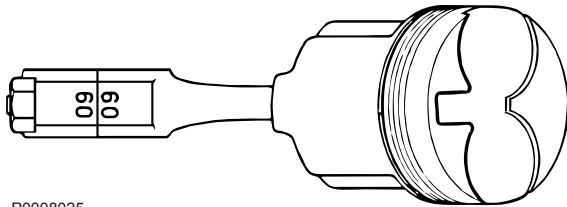
IMPORTANT!

Make sure that the connecting rod studs do not strike the crankshaft when tapping down the piston.

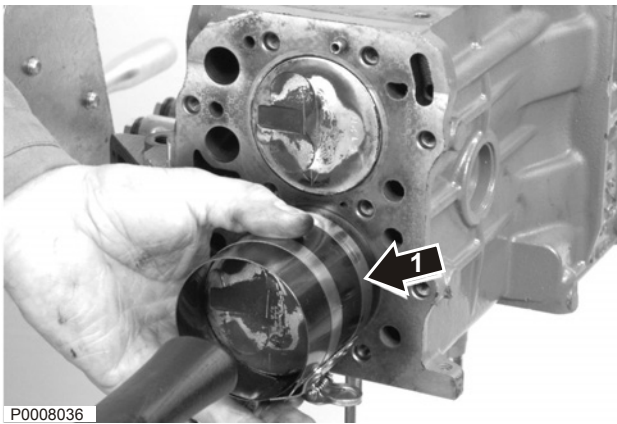
- 3 Install the big end bearing cap according to the mark. Tighten with 23 Nm of torque (17.0 lbf.ft) (D1-13, D1-20), or 32 Nm (23.6 lbf.ft) (D1-30, D2-40). Check the movement of the big end bearing. Repeat the procedure to install the remaining pistons.

Pistons in Cylinders, Installation

NOTICE! After replacing the crankshaft, piston or piston pin, the weight difference between connecting rods with piston and piston rings must not exceed 10 g (0.0022 lbs) between cylinders. Also refer to *Pistons, Installation* page 68 and *Assembling Piston, Piston Rings and Con Rod* page 89.



P0008025



P0008036

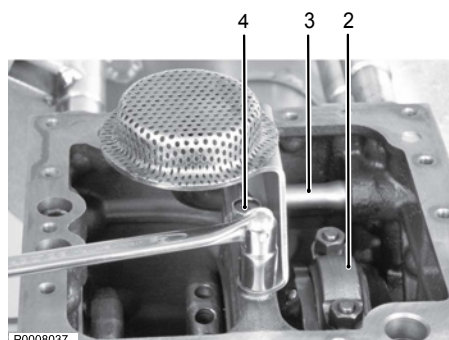
- 1 Lubricate the pistons and piston rings with engine oil and rotate the rings so that the oil finds its way into the piston ring grooves. Rotate the piston rings so that the ring gaps are staggered 90° from each other.
Make sure that no piston ring gap is placed in line with the piston pin.
- 2 Put the bearing shells in their places in the connecting rods and caps. Oil the bearing journals with engine oil.
- 3 Check that the markings on the piston crown or inside the piston tally with those on the connecting rod.
Use a piston ring compressor (1) and install the piston with connecting rod in its cylinder, starting with cylinder no. 1 (front).

IMPORTANT!

Make sure that the connecting rod studs do not strike the crankshaft when tapping down the piston.

The connecting rod with the **lowest number** must be installed at the front (in cyl. no. 1) and the connecting rod with the highest number closest to the flywheel.

The connecting rods must be turned so that the mark (number / color mark) is facing towards the injection pump (camshaft side).



P0008037

- 4 Install the bearing caps (2) and tighten the con rod bolts. For tightening torques, refer to *Tightening torques* page 9. Big end bearing caps must be installed so that the number markings / paint marks on the connecting rod and cap tally. Undamaged connecting rod bolts do not need to be changed, but may be reinstalled.
- 5 Install the oil suction pipe (3) and oil strainer (4). For tightening torques, refer to *Tightening torques* page 9. Use a **new** O-ring.

IMPORTANT!

Do not press the oil suction pipe down to the bottom of the hole. There is a risk that an oil duct could be blocked.

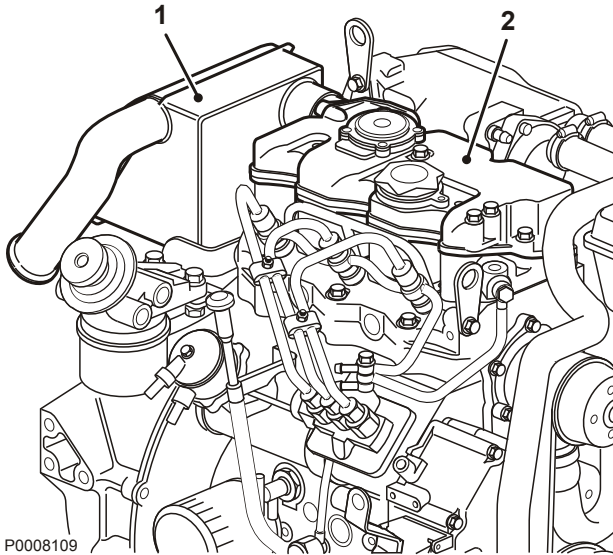
- 6 Install the oil pan together with a new gasket. For tightening torques, refer to *Tightening torques* page 9.

21-4 Valve Mechanism

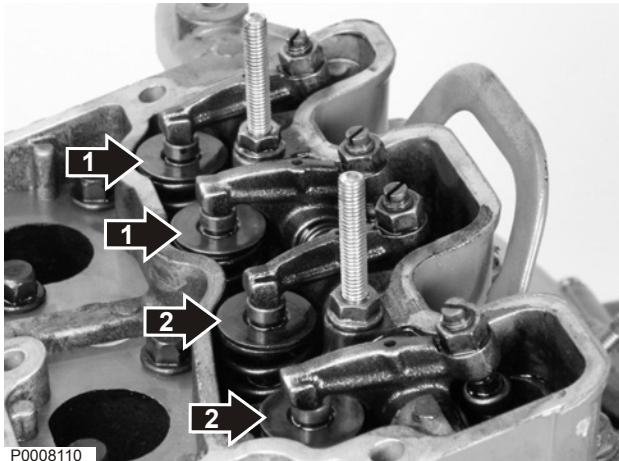
Valves, Adjustment

Stopped engine and cold engine

- 1 Remove the air filter housing (1) and valve cover (2).

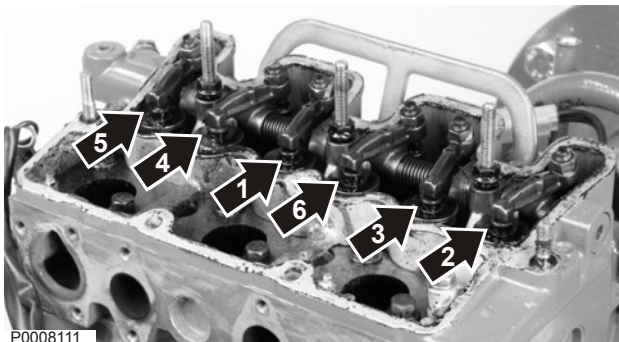


P0008109



P0008110

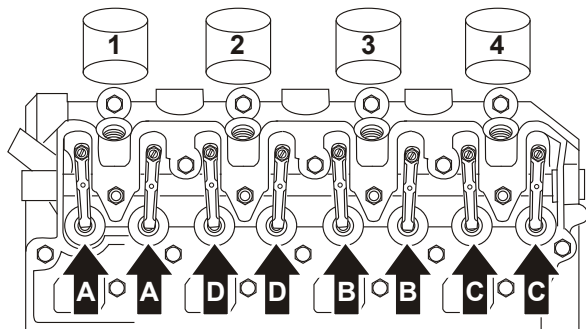
- 2 **D1-13**
Crank the engine clockwise until the valves (1) for no. 1 cylinder overlap. Then crank the engine exactly one more turn. You can now adjust the valves for no. 1 cylinder. Refer to item 3 for the adjustment procedure.
Crank the engine clockwise until the valves (2) for no. 2 cylinder overlap. Then crank the engine exactly one more turn. Adjust the valves for no. 2 cylinder.



P0008111

D1-20, D1-30

Crank the engine clockwise until the valves for no. 1 cylinder overlap. Adjust no. 2 inlet valve (1) and no. 3 exhaust valve (2). Refer to item 3 for the adjustment procedure. Crank the engine clockwise until the valves for no. 2 cylinder overlap. Adjust no. 3 inlet valve (3) and no. 1 exhaust valve (4). Crank the engine clockwise until the valves for no. 3 cylinder overlap. Adjust no. 1 inlet valve (5) and no. 2 exhaust valve (6).



P0008112

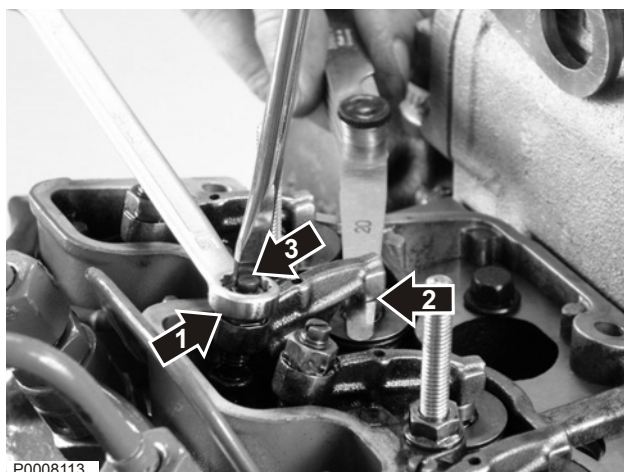
D2-40

Crank the engine clockwise until the valves for no. 4 cylinder overlap. Adjust no. 1 inlet and exhaust valve (A). Refer to item 3 for the adjustment procedure.

Crank the engine clockwise until the valves for no. 2 cylinder overlap. Adjust no. 3 inlet and exhaust valve (B).

Crank the engine clockwise until the valves for no. 1 cylinder overlap. Adjust no. 4 inlet and exhaust valve (C).

Crank the engine clockwise until the valves for no. 3 cylinder overlap. Adjust no. 2 inlet and exhaust valve (D).



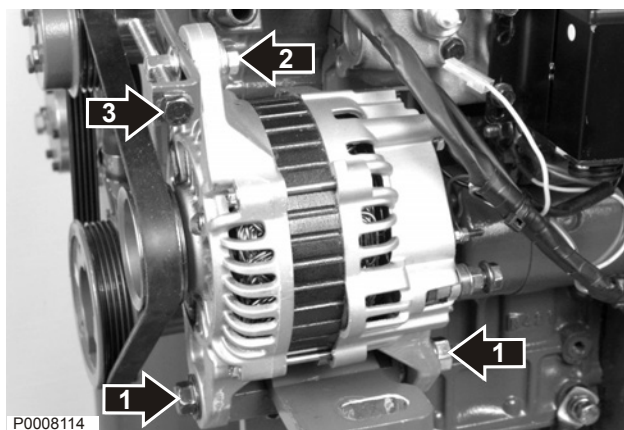
P0008113

3 Adjustment

Undo the locknut (1) with a ring wrench. Measure the valve clearance (2) with a feeler gauge. Adjust the valve clearance with the adjustment screw (3).

The correct valve clearance for all valves and engines is 0.2 mm (0.0079").

When the correct valve clearance has been reached, tighten the locknut (1).



P0008114

- 4 Install the valve cover with a new seal. Install the air filter housing. Test run the engine and check that no oil leakage occurs.

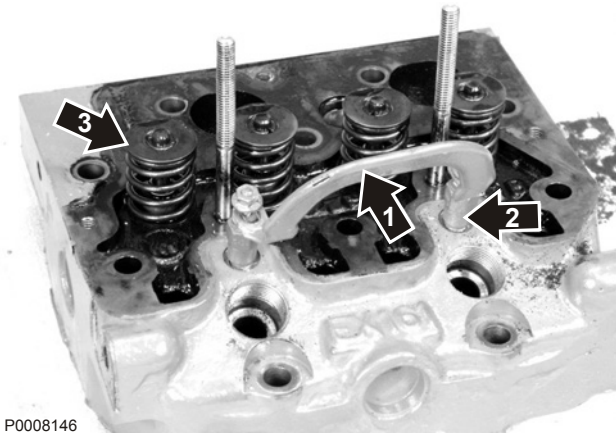
Valves, Removal

Cylinder head removed

Tools:

885023 Valve spring compressor
885498 Adapter

- 1 Remove the busbar (1) and glow plugs (2). Remove the valves (3) with the aid of 885023 Valve spring compressor and 885498 Adapter. Mark the valves. Remove the valve seals.



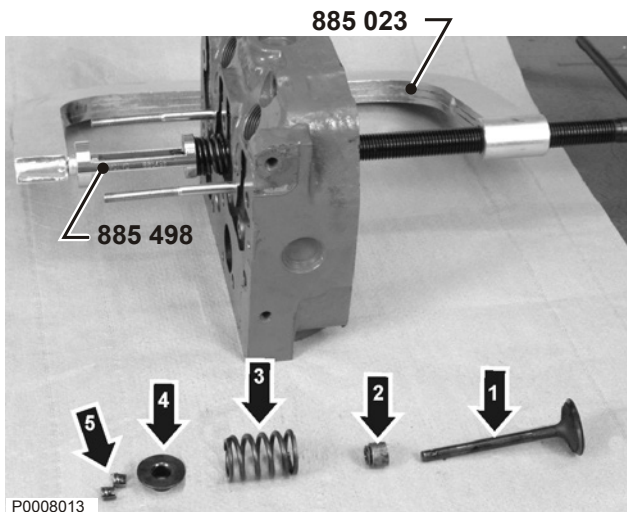
P0008146

Valves, Installation

Tools:

885023 Valve spring compressor
885498 Adapter

- 1 Install the valve (1) in the cylinder head as marked. Install a new valve seal (2), spring (3) and valve spring washer (4). Compress the valve spring with the spring clamp and install the collets (5).
- 2 Install the glowplugs and tighten to the specified torque: refer to *Tightening torques page 9*. Install the busbar.



P0008013

Valve Guides, Inspection

Tools:

9999683 Dial indicator (short probe)

9999696 Magnetic stand

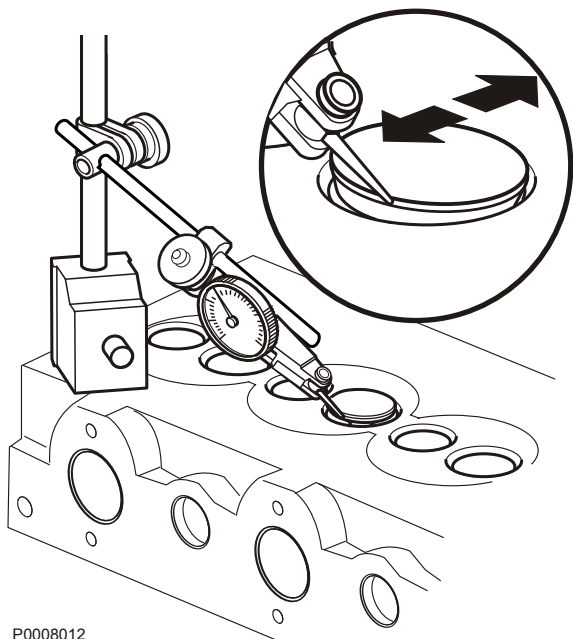
- 1 Put the cylinder head on the bench, and put the valves in the valve guides.
- 2 Measure the wear with 9999683 Dial indicator (short probe) and 9999696 Magnetic stand. Lift each valve about 2 mm (0.08") from its seat, put the measurement tip on the valve seat rim and check the wear.

Permissible clearance between valve and valve guide:

Inlet valve, max clearance 0.20 mm (0.008")

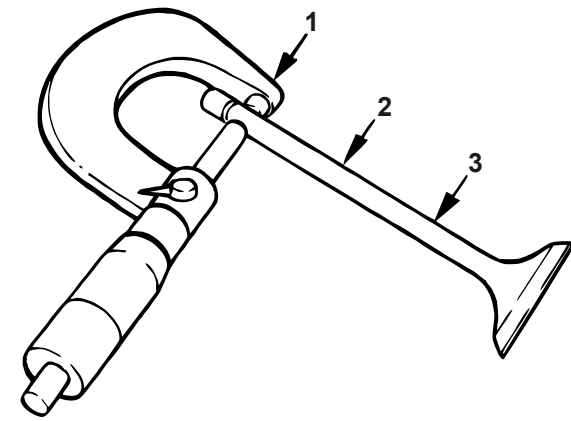
Exhaust valve, max clearance 0.25 mm (0.010")

NOTICE! Since the valve guides are machined directly in the cylinder head, the cylinder head must be changed when the clearance is too great, even when the valve is new.

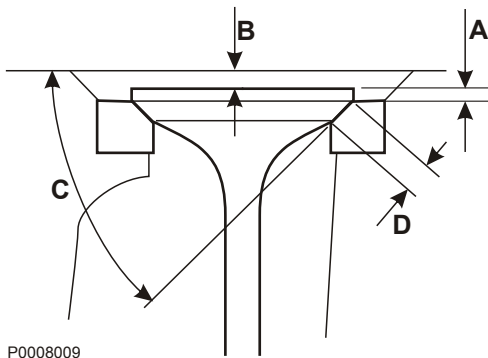


P0008012

Valve Seats and Valve, Grinding



P0008008



P0008009

- 1 Check valve stem wear. Measure the diameter with a micrometer at points I, II and III.
Diameter, min. inlet: 6.89 mm (0.271")
Diameter, min. exhaust: 6.84 mm (0.269")
- 2 Grind the valves in a valve grinding machine. Grind the sealing surface as little as possible, but just enough to "clean" it up. If the valve disc edge (A) after grinding is less than 0.5 mm (0.020"), scrap the valve. Equally, any valve with a bent valve stem must be scrapped.
- 3 Check valve guide wear (please refer to *Valve Guides, Inspection page 73*) before the valve seats are machined.

- 4 Mill the valve guides. When machined, only remove enough material to give the valve seat the correct shape and a good mating surface.

NOTICE! Do not grind so much that the valve depth exceeds the permissible value. Please refer to *Valve Seat, Change page 75*.

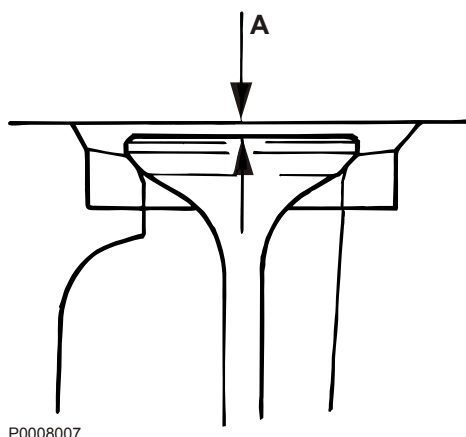
Mill new seats down so far that the distance between the cylinder head plane and the valve disc surface (B) is between 0.65-0.95 mm (0.026–0.037") for the inlet and 0.85-1.15 mm (0.020–0.045") for the exhaust.

The mating face (C) must be 45 degrees and the contact surface (D) must be 1.70-2.10 mm (0.067–0.083").

- 5 Grind the valves in with grinding paste, and check contact with marker dye.

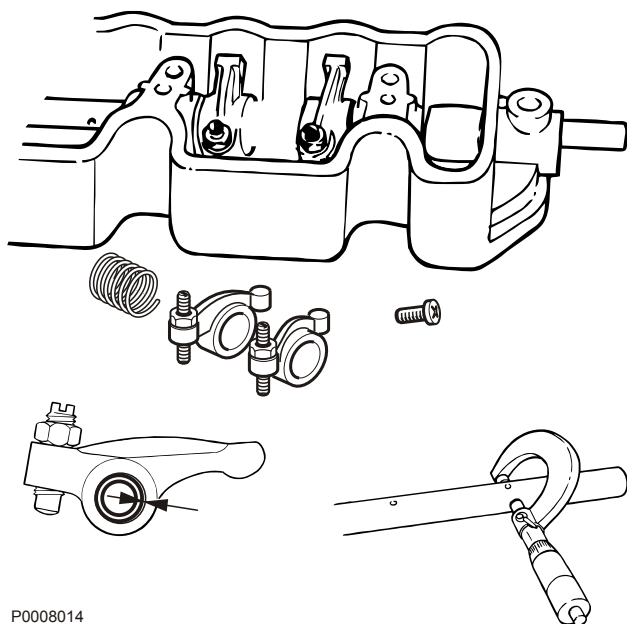
Valve Seat, Change

The valve seats should be changed when distance "A", measured with a new valve exceeds 1.8 mm (0.071").



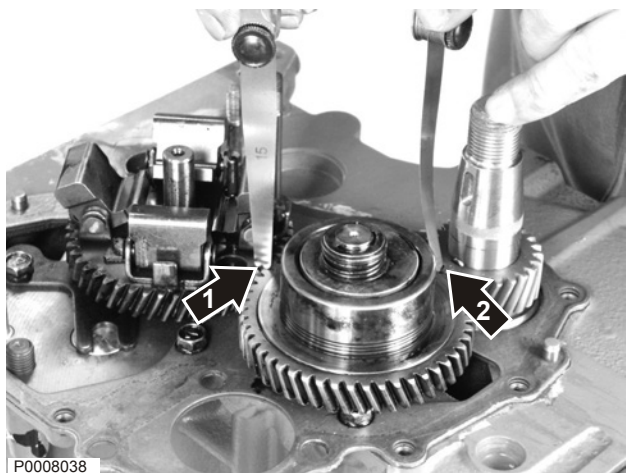
- 1 Remove the old valve seat by heating it with a gas torch between 600–700 °C (1112– 1292 °F) diagonally across the seat.
Let the cylinder heat cool for 3-5 min in the air. Then carefully tap the seat out with a mandrel (check that the cylinder head is not damaged).
The valve seat can also be milled out (check that the cylinder head is not damaged).
- 2 Carefully clean the valve seat bed in the cylinder head. Check the cylinder head for cracks.
- 3 Cool the new valve seat with carbon dioxide snow etc. to minus 60–70 °C (140–158 °F) and possibly heat the cylinder head to 60–100 °C (140–212 °F).
- 4 Seat the seat into the cylinder head. Use a hydraulic press and a suitable mandrel.
- 5 Machine the seats to the correct angle and width.

Rocker Arm Mechanism, Overhaul



- 1 Remove the plug at the front of the rocker arm shaft. If the shaft has a stop screw, it must be removed before the shaft is pulled out.
- 2 Disassemble the rocker arm mechanism. Remove the rocker arms, springs and washers.
- 3 Clean the components. Be especially careful with the rocker arm shaft oil channels and the oil holes in the rocker arms.
- 4 Check the wear of the rocker arm shaft with a micrometer.
- 5 Check that the rocker arm bearing surfaces are not worn oval. Check the clearance between rocker arm and shaft. Check that the spherical part of the adjustment screw is not deformed or worn. The threads on the pin and lock nut must be undamaged. The lock nut must be in good condition.
- 6 Oil the rocker arm shaft and disassemble the other components.

21-5 Timing Gears and Shaft



Flank Clearance, Checking

Use a feeler gauge to measure the flank clearance (1) between the oil pump gear and the camshaft gear.

Use a feeler gauge to measure the flank clearance (2) between the oil pump gear and the crankshaft gear.

Refer to *Group 21: Engine page 14* for min. and max. values.

Timing Gear, Removal

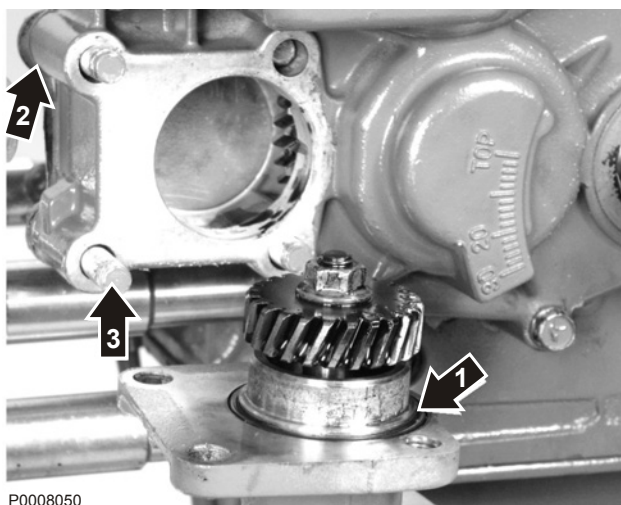
Cylinder head removed

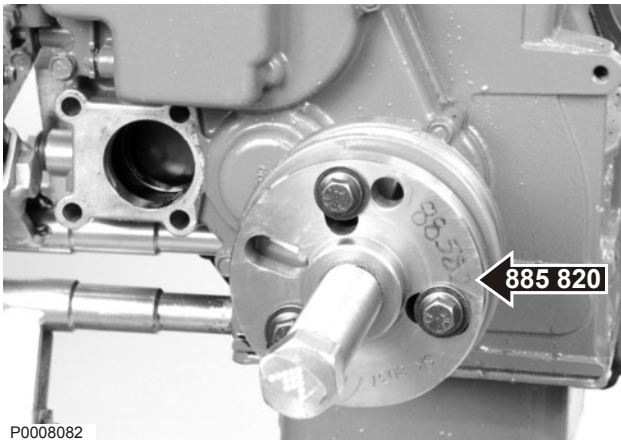
Tools:

885820 Puller

885822 Magnetic pen

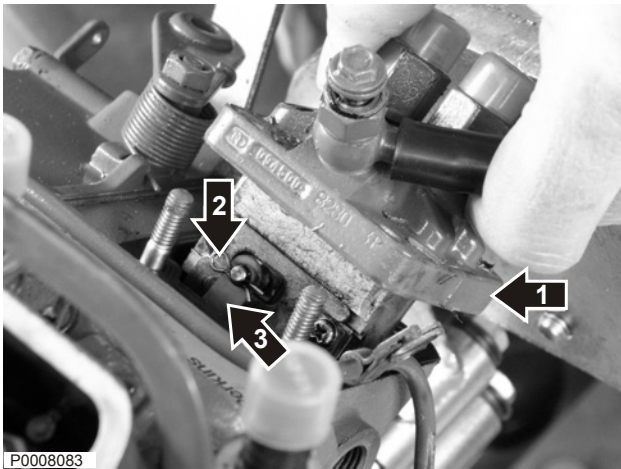
- 1 Remove the raw water pump (1). Remove the end panel (2) and the bolts (3).





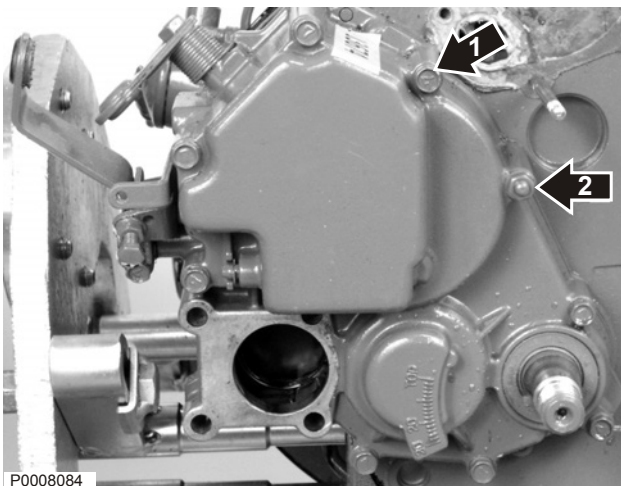
P0008082

- 2 Unscrew the center nut from the pulley. Place tool 885820 Puller on the pulley and remove it. Remove the key from the groove in the shaft



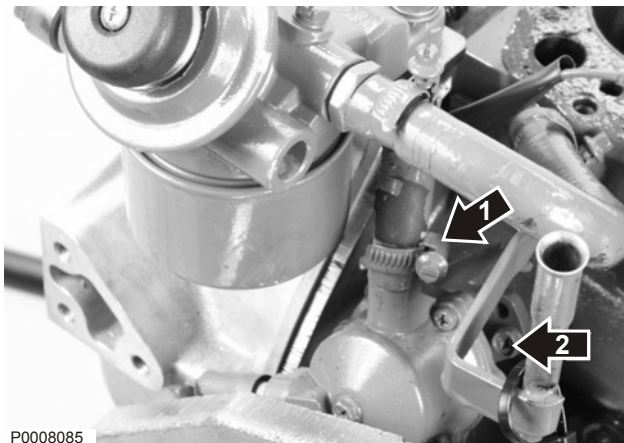
P0008083

- 3 Unbolt the injection pump (1). Lift it up until the lock clip (2) is accessible. Undo the clip and release the control rod (3).



P0008084

- 4 Undo the timing gear cover bolts (1) and nut (2). Remove the cover.



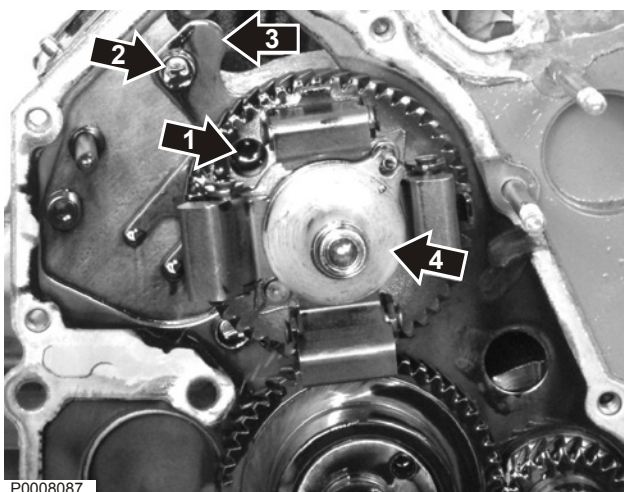
- 5 Undo the fuel pipe from the fuel filter (1). Undo the fuel feed pump screws (2). Wipe dry the fuel that runs out.



- 6 Remove the valve lifters with tool 885822 Magnetic pen.

IMPORTANT!

Mark the valve lifters so that they are put back in the same positions. The D1-20 and D2-40 engines have certain valve lifters that are beveled.



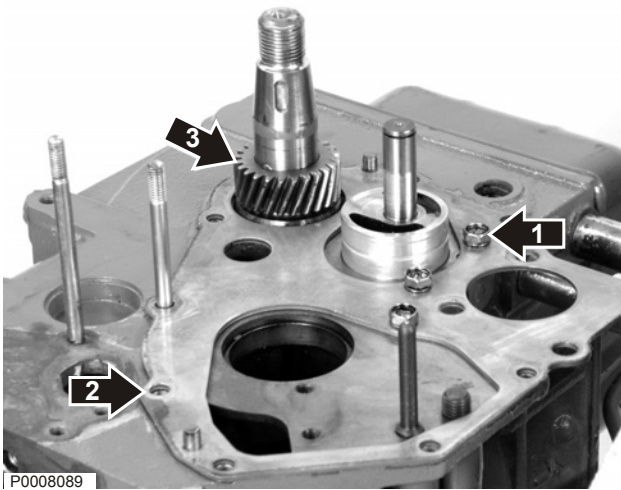
- 7 Rotate the camshaft until the socket cap screw (1) is visible in the hole in the camshaft drive gear. Unscrew the socket cap screw and hex head bolt (2). Remove the lock plate (3). Remove the camshaft regulator sleeve (4). Pull the camshaft out carefully.

IMPORTANT!

There is a risk of damaging the inner camshaft bearing with a camshaft lobe if the camshaft is pulled out with force.



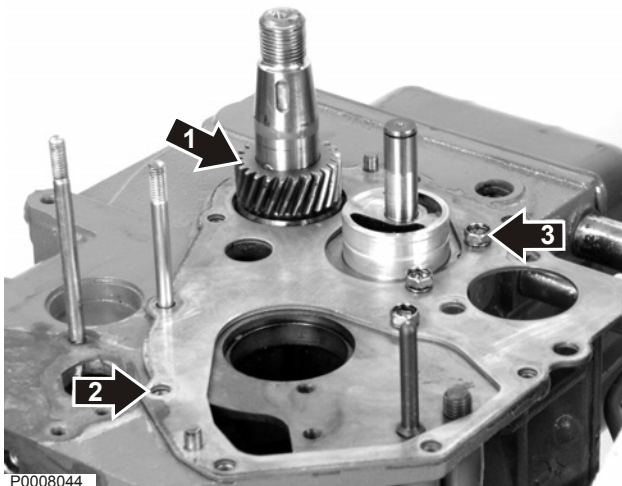
- 8 Remove the retainer ring (1) on the oil pump shaft. Remove all oil pump components. Note the spacer washer (2) inside the oil pump gear.



- 9 Undo the remaining bolts (1). Remove the timing gear plate (2). Remove the crankshaft gear (3) with a puller. Remove the gear wheel and its Woodruff key.

Timing Gear, Installation

- 1 Place the gear wheel (1) and its key on the crankshaft. Tap the gear wheel on. Position the timing gear plate (2) and a new gasket. Fasten the timing gear plate inner bolts (3).

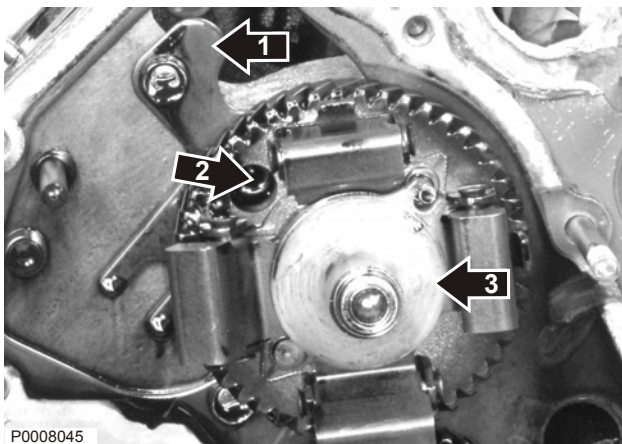


P0008044

- 2 Carefully insert the camshaft.

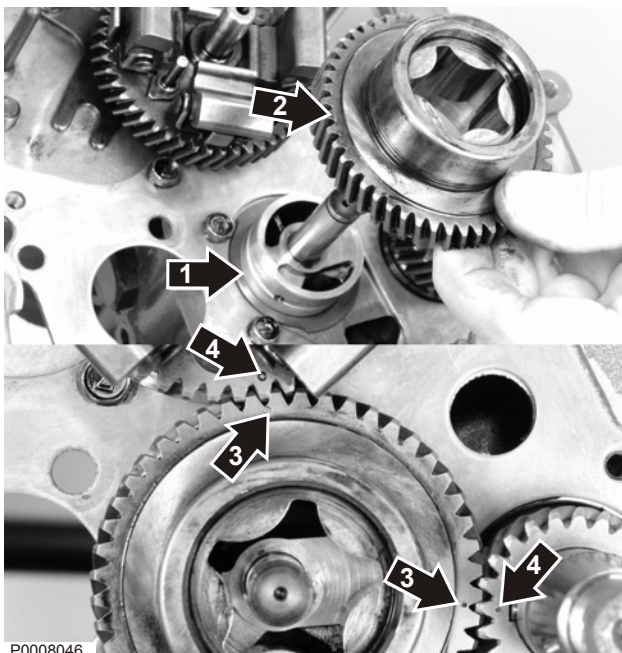
IMPORTANT!

If the camshaft is forced in, there is a risk that one of the cam lobes will damage an internal bearing. Place the lock plate (1) in position. Rotate the camshaft until the screw hole for the socket cap screw (2) becomes visible in the hole in the camshaft drive gear. Fasten the lock plate. Place the camshaft regulator sleeve (3) in position.

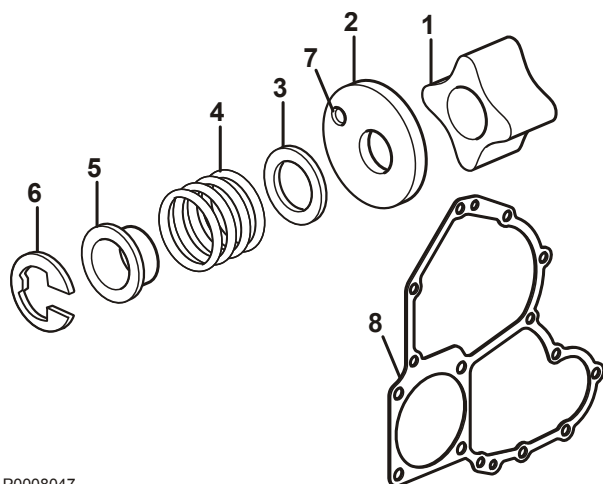


P0008045

- 3 Fit the thrust washing (1) in place. Put on the oil pump gear wheel (2). Make sure that the markings (3) on the gear wheel line up with the markings (4) on the other gear wheels. Check the gear flank play; refer to *Flank Clearance, Checking* page 76.



P0008046



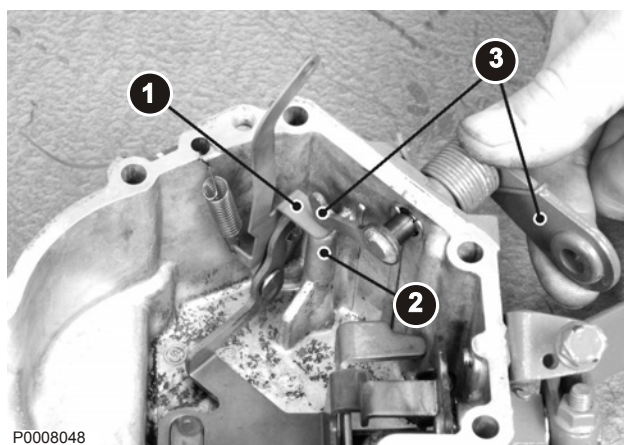
P0008047

- 4 Install the pump rotor (1), end washer (2), shim (3), spring (4) and bush (5) in the oil pump gear wheel. Install the retainer ring (6) on the shaft.

NOTICE! Note that the end washer (2) has a hole (7) that must mate up with the guide pin in the timing gear cover.

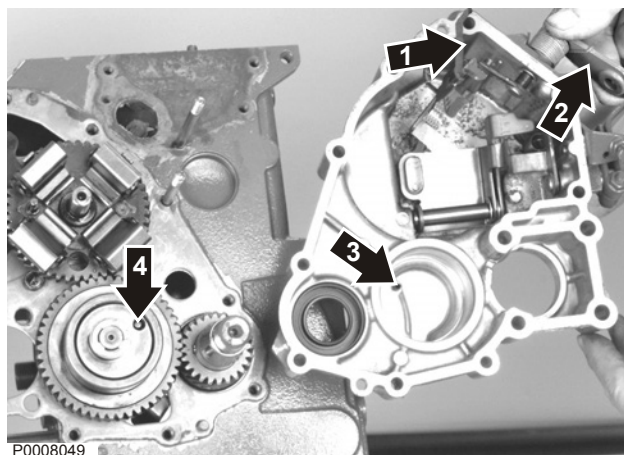
Install a new gasket on the timing cover.

NOTICE! If the gasket has a center section (8), this must be cut away.



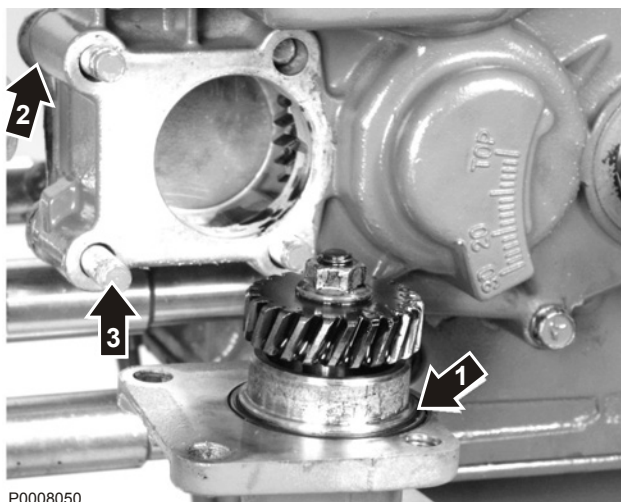
P0008048

- 5 Put the control rod (1) on the heel (2) in the timing gear cover. Turn the stop arm (3) round so that the control rod is held against the heel.



P0008049

- 6 Install the timing gear cover at the same time as the control rod (1) is held fast by the stop arm (2). Put the timing gear cover in place. Make sure that the control rod ends up in the correct position and that the pin (3) engages in the hole (4) in the oil pump end washer. Bolt on the timing gear cover.



P0008050

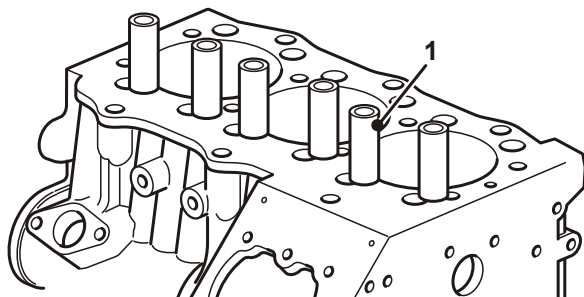
- 7 Place a new O-ring (1) in the groove in the raw water pump.
Install the rear end piece (2) with a new gasket and its four bolts (3).

NOTICE! The longest bolts must be placed on the outside (D1-13, D1-20).

Install the raw water pump and bolt it secure.

- 8 Install the belt pulley key on the crankshaft.
Install the pulley and tighten it to the specified torque with the center nut; refer to *Tightening torques* page 9.

D1-20



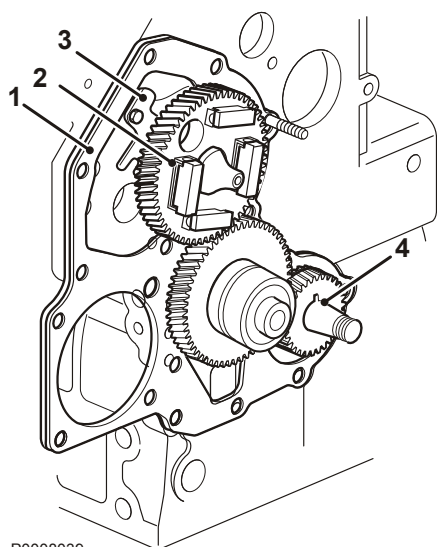
P0007999

- 9 Put the valve lifters in place as marked.

IMPORTANT!

All valve lifters must be put back in their previous places. Note that on D1-20 engines, valve lifter no. 2 for cylinder 1 has a chamfer (1). Note that on D2-40 engines, both valve lifters for cylinder 1 have a chamfer.

Installing the timing gear and injection pump



P0008039

- 1 Install the timing gear plate (1) with new gasket.
- 2 Oil the camshaft bearing surfaces and carefully insert the camshaft (2) into place, complete with drive gear and regulator weights.

NOTICE! Be careful to avoid damaging the bearings, bearing races and camshaft lobes.

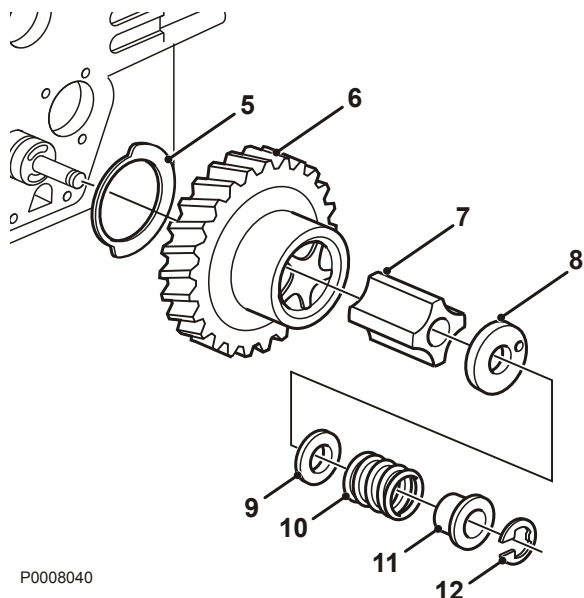
- 3 Install the camshaft lock plate (3) in the correct position and tighten it.
- 4 Fit the key into the crankshaft and install the crankshaft gear (4).

IMPORTANT!

The components must be oiled before installation.

IMPORTANT!

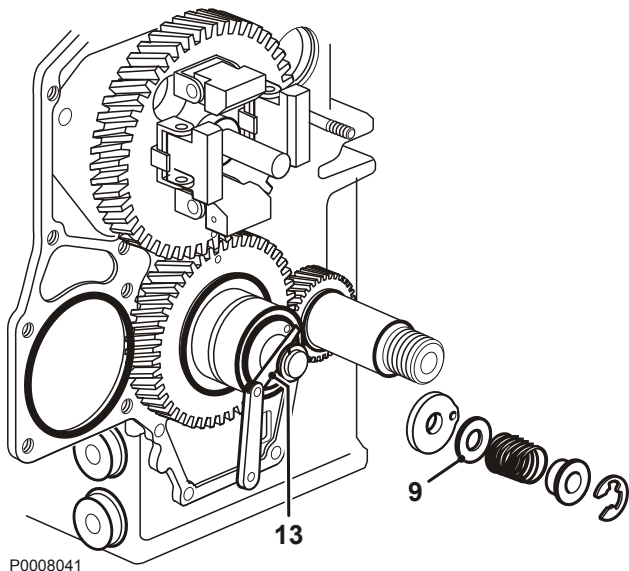
Make sure that the gear wheel markings coincide.



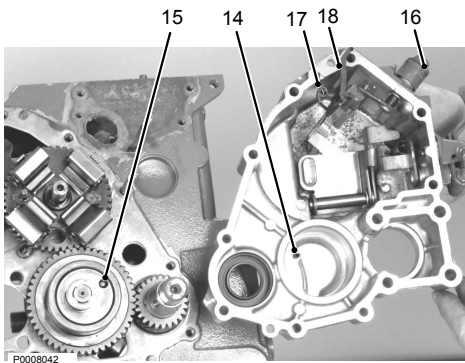
P0008040

- 5 Install the thrust washer (5) on the idler wheel shaft stub. Install the idler wheel (6) in accordance with the markings.

NOTICE! Do not turn the crankshaft before the timing gear cover has been installed.



- 6 Install the inner rotor (7) and the oil pump cover (8). Install the shim (9), spring (10), spring washer (11) and lock washer (12).
- 7 Adjust the oil pump end float (13) to 0.10 - 0.15 mm (0.0039–0.0059"). Shims are available in thicknesses 0.10, 0.15, 0.20 and 0.50 mm (0.0039, 0.0059, 0.0079, 0.0197").



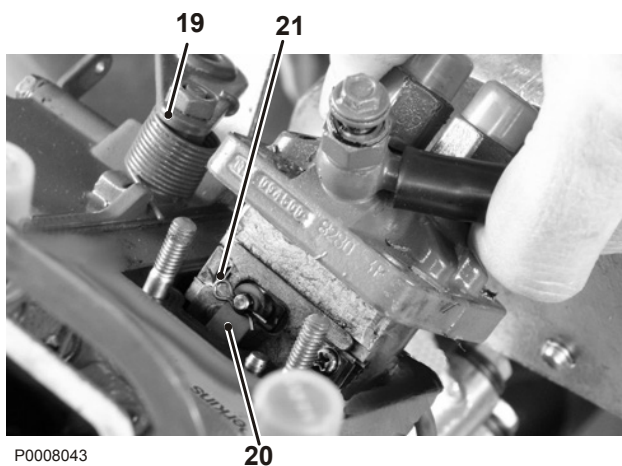
- 8 Install a new, and if necessary adjusted, gasket for the timing cover. Center the cover in front of the oil pump.

NOTICE! Check that the tubular pin (14) in the timing cover engages in the hole (15) in the oil pump cover. Turn the cover backwards and forwards, and center it in the mid position. The stop arm (16) must be turned and held in place when the timing cover is installed.

- 9 Check that the starter spring (17) is correctly located in the timing cover, and is connected to the regulator arm (18). Put the timing gear cover in place. Insert the regulator arm through the hole in the cylinder block. Bolt on the timing gear cover.

- 10 Turn the stop arm (19) clockwise and connect the arm (20) to the injection pump. Install the clip (21).

NOTICE! Carefully ensure that the shim / gasket which was placed underneath the injection pump flange is put back, before the pump is placed in the block (applies when the pump has been removed).



- 11 Bolt on the injection pump; for tightening torque refer to *Tightening torques* page 9.
- 12 Install a new front crankshaft seal; refer to *Crankshaft Seal, Change (front)* page 97. Fit the key into the crankshaft and install the crankshaft pulley. For tightening torque, refer to *Tightening torques* page 9.

Camshaft, Inspection

Camshafts and valve lifters, inspection

Using a steel ruler, check that valve lifter (1) contact surfaces facing the camshaft are convex or flat. If the surface is concave, change the valve lifter.

If the valve lifter is worn right across the lifting surface, the valve lifter must be scrapped. The "depression" shows that the lifter has not been turning.

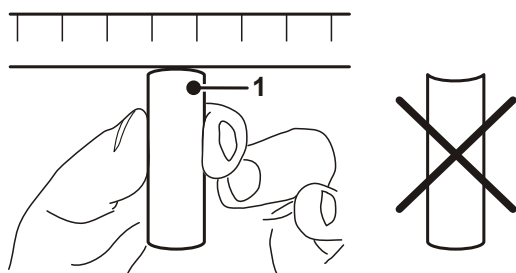
On the other hand, a dark line outermost on the valve lifter shows that the surface is not worn. It is valve lifter condition that determines whether it is necessary to check for camshaft wear.

Check that the lifting surfaces on the camshaft and valve lifters do not have large pitting defects. Pitting defects can occur for various reasons. The defects are caused when small pieces of metal loosen from the hardened surface. Lifters and camshafts with minor pitting defects may be used. Pitting defects seldom becomes worse.

Check that the camshaft bearing surfaces and cam curves are not abnormally worn.

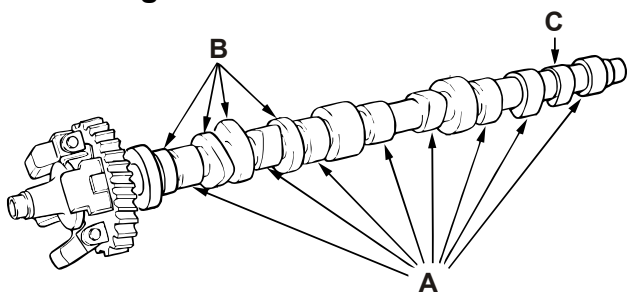
Change the camshaft if major damage or wear is evident.

NOTICE! When the camshaft is changed, all the valve lifters must also be changed.



P0008142

Measuring the camshaft



P0008028

Cam height A (inlet and exhaust)	26.5 mm (1.04")
Cam height B (for injection pump)	41.8 mm (1.65")
Cam height C (for feed pump)	27.0 mm (1.06")

Change the camshaft if the wear limits have been exceeded.

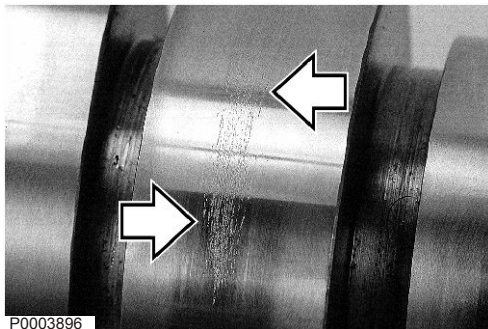
Guidelines for replacement

In normal conditions, unevenness may occur on the surface of engine camshaft lobes. This does not mean that the camshaft has to be changed. These marks do not have any negative influence on either engine performance or the durability of the engine and its components.

Examples of acceptable wear and **unacceptable** wear are shown below.

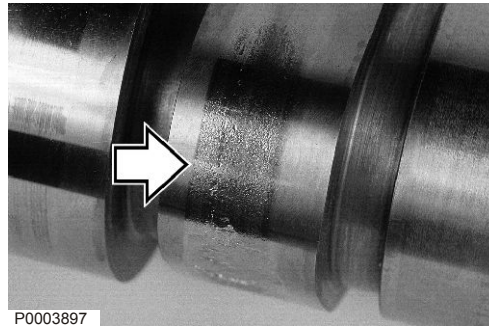
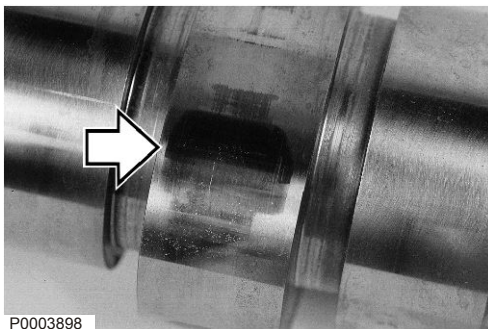
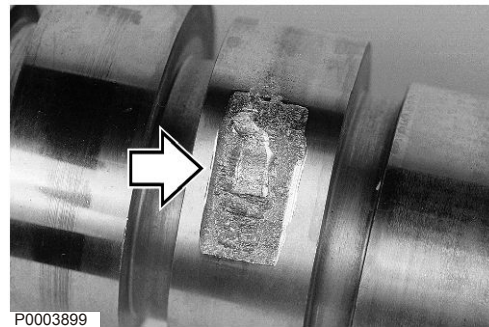
Acceptable wear

The camshaft does not need to be changed.

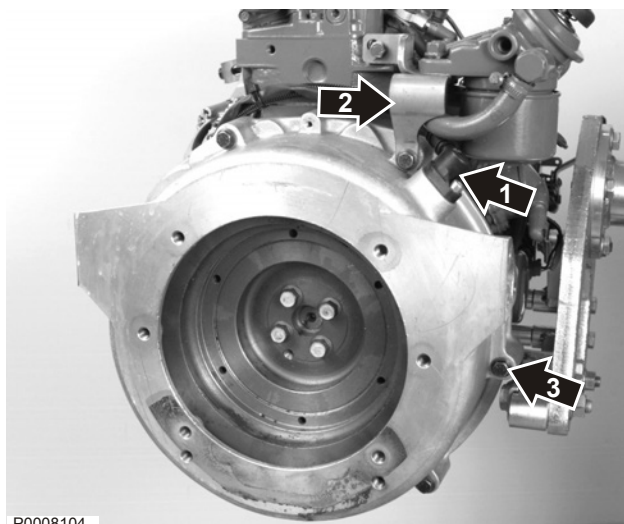


Unacceptable wear

NOTICE! The camshaft and associated rocker arms must be changed.

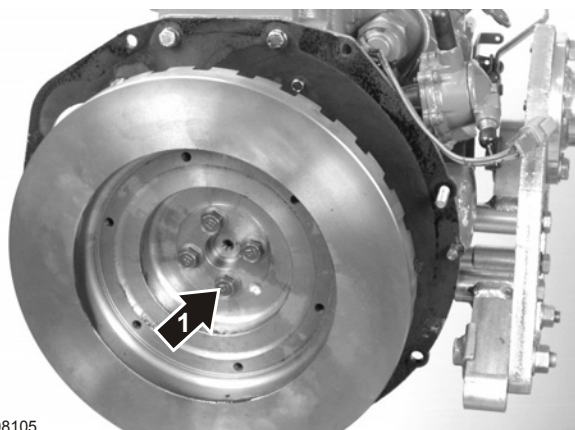


Flywheel, Change



P0008104

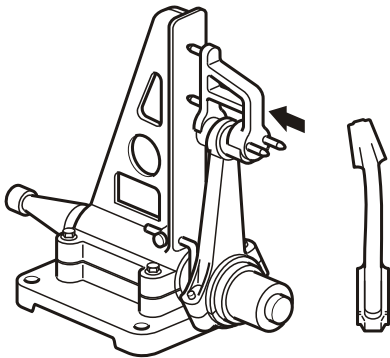
- 1 Remove the engine rpm sensor (1) and filter housing bracket (2). Remove the flywheel cover (3) and flexible coupling.



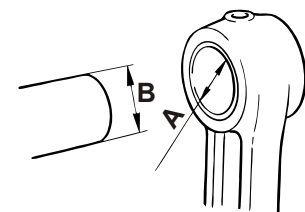
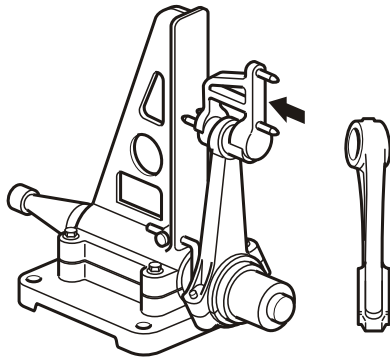
P0008105

- 2 Unbolt the flywheel (1) and remove it. Clean and check the crankshaft seal.
- 3 Carefully clean the crankshaft and flywheel. Install the new flywheel and tighten it to the specified torque; refer to *Tightening torques* page 9. Install the flexible coupling, flywheel housing, filter housing bracket and engine rpm sensor.

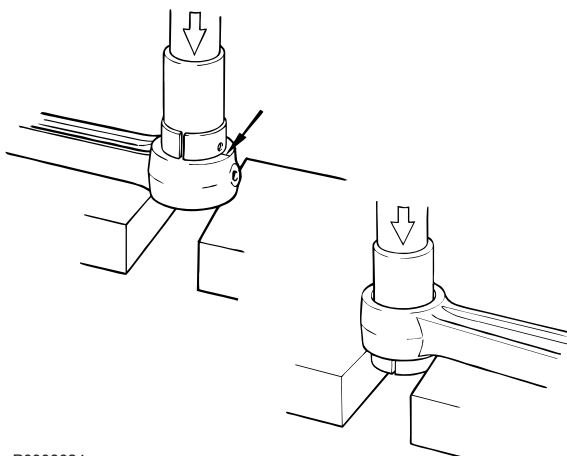
21-6 Crank Mechanism



P0008163



P0008023



P0008024

Con Rods, Inspection

- 1 Check the connecting rods for cracking, straightness and twist before any piston pin bush replacement.

Scrap the connecting rod if it is cracked, bent or twisted.

Check the wear in the "small end" with a piston pin. When the clearance is correct, an oiled piston pin should slowly slide through the bush under its own weight.

- 2 Use a new piston pin and measure connecting rod straightness in a fixture. Max. deviation: 0.15 mm (0.0059") per 100 mm (3.9") measured length.
- 3 Measure connecting rod twist. Max. deviation: 0.20 mm (0.0079") per 100 mm (3.9") measured length.

- 4 Check the end float between the connecting rod and crankshaft. Change the connecting rod if the end float exceeds 0.035 - 0.085 mm (0.0014 - 0.0033").

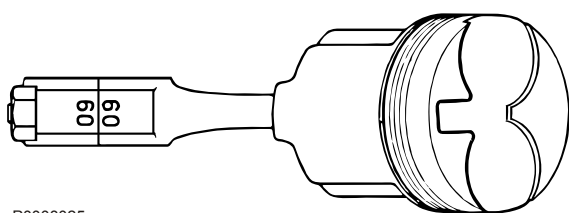
Also check the connecting rod bushes. For permissible clearance between the piston pin (A) and the connecting rod bush (B), refer to *Group 21: Engine page 14*.

Changing the piston pin bushing

- 1 Press the old bush out.
- 2 Press the new bush in.

NOTICE! Make sure that the oil hole in the bush lines up with the drilling in the connecting rod. Using a felt tip pen, draw a line across the hole in the connecting rod and the bush. Check that the oil duct is open after pressing in the new bush.

- 3 Ream the bush and measure the connecting rod with an internal dial gauge.



P0008025

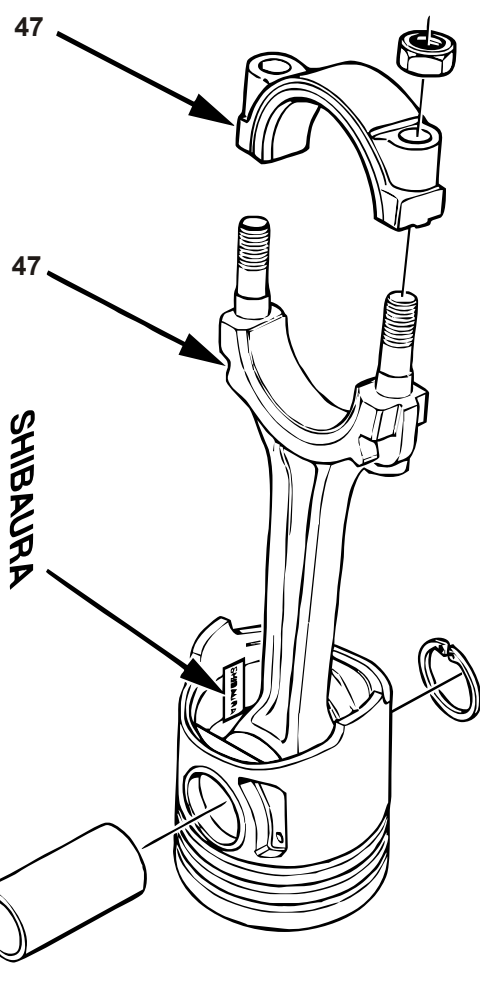
Assembling Piston, Piston Rings and Con Rod

- 1 Install one of the retainer rings in the piston.
- 2 Oil the piston pin and connecting rod bush.
- 3 Heat the piston to approx. 100°C (212 °F). Position the piston and connecting rod so that the markings line up.

The marking on the connecting rod and the "SHIBAURA" marking inside the piston must face the same direction.

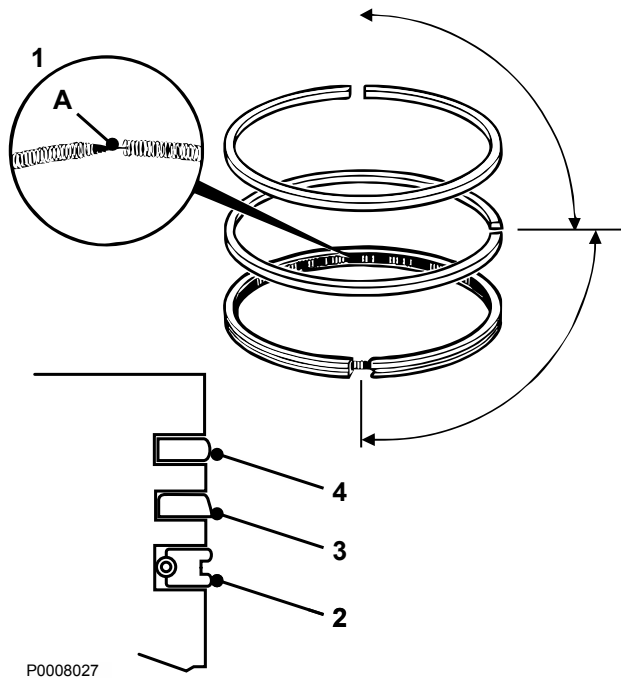
Slide the piston pin in.

NOTICE! It should be possible to press the piston pin in easily. It must not be driven in.



P0008026

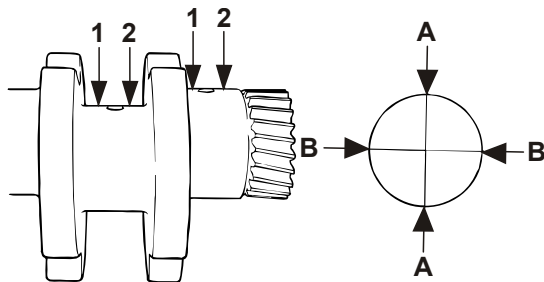
- 4 Install the other retainer ring.
- 5 Check that the connecting rod is not tight on the piston pin bearing.
- 6 Check the big end bearing clearances. Refer to *Crankshaft and Bearings, Inspection page 90*.
- 7 Check the piston ring gap in the cylinder bore and that the rings do not bind in the piston ring grooves.



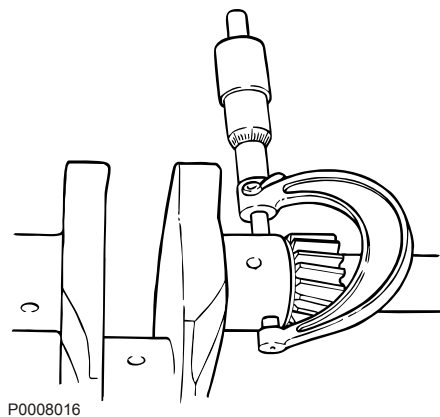
- 8 Install the piston rings on the pistons, using piston ring pliers. Letters or markings on ring surfaces must always be turned so that the marking faces upwards.
Install the oil scraper ring first. Put the expansion spring (1) for the oil scraper ring in the lower piston ring groove, with the guide pin (A) inside both ends of the spring. Check that the ends of the spring do not overlap. Install the oil scraper ring (2) above the expansion spring. Check that the ring gap is staggered 180° (356 °F) from the guide pin.
Install the ring with the tapered surface (3) in the center piston ring groove so that the marking faces the piston crown.
Install the upper ring (4) with the marking upwards.
Check that the ring openings are staggered 90° (194 °F) from each other.

Crankshaft and Bearings, Inspection

Clean the crankshaft carefully in all channels after disassembly and inspect the crankshaft thoroughly to determine if overhaul is really necessary.



- 1 Check wear and ovality with a micrometer. Measure the diameters **A-A** and **B-B** at points 1 and 2. Max. permissible taper and ovality in the main and big-end journals is 0.05 mm (0.002"). Change the crankshaft if these values are exceeded.
- 2 Measure longitudinal crankshaft crookedness (runout). Lay the crankshaft on a pair of V-blocks placed under the front and rear main bearing journals. Alternatively, the crankshaft can be suspended between centers. Measurements shall be done on the center main bearing journal(s).
For max lengthwise crookedness (runout), refer to *Group 21: Engine page 14*. If these values are exceeded, the crankshaft must be changed.
- 3 Check that the crankshaft seal mating surfaces on the crankshaft are not worn or damaged.



Inspection of the crankshaft bushing and crankshaft journal

Check the bearing clearance between the crankshaft journal and the crankshaft bushing. Use both internal and external micrometers.

- 1 Measure the inner diameter of the bushing at points **1** and **2**. Measure in two directions (**A** and **B**) at each point.
- 2 Measure the bearing journal outer diameter and calculate the bearing play (difference between previous measurement and max. diameter of the bearing journal).

For max. bearing play, refer to *Group 21: Engine page 14*.

Change the bush if the clearance exceeds the permissible value.

Inspection of main and big end bearings

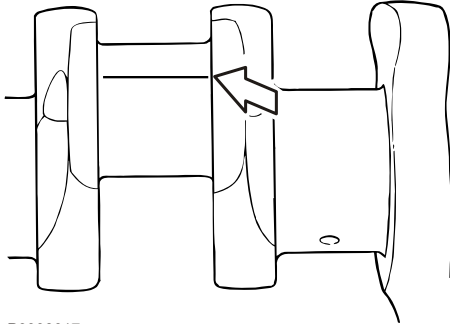
Check the main and big end bearing shells, and the front main bearing bushing. Change worn bearing shells, or any with damaged bearing surfaces.

Big End Bearing Clearance, Check

Tools:

856927 Plastigauge

Big-end bearing radial play can be checked with the aid of 856927 Plastigauge as follows:

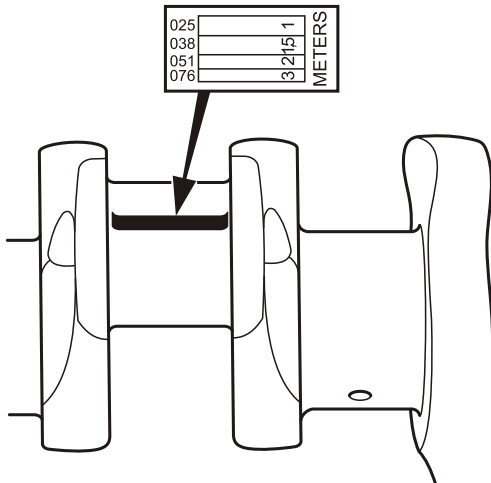


P0008017

- 1 Wipe off any oil from the big end bearing and big end journal. Apply a piece of plastigauge the same length as the width of the bearing along the big-end journal. Avoid the oil hole.
- 2 Install the connecting rod and bearing cap (observe the markings) and tighten the connecting rod bolts.
For tightening torques, refer to *Tightening torques page 9*.

NOTICE! Do not rotate the connecting rod or crankshaft during measurement, as this will destroy the measurement strip.

- 3 Remove the big end cap and measure the width of the compressed plastigauge at the widest point. Use the scale supplied with the plastigauge.



P0008018

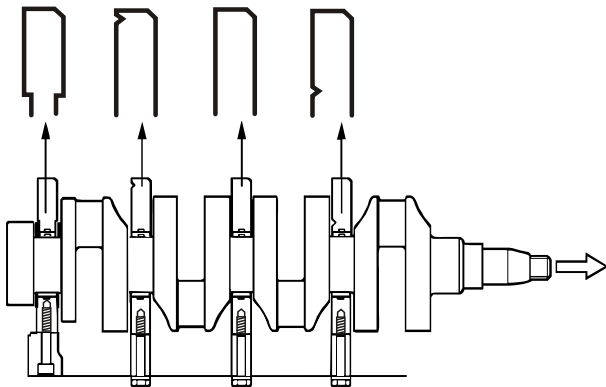
For max. permissible big-end bearing play, refer to *Group 21: Engine page 14*.

Change the big-end bearing if bearing clearance exceeds the permissible value.

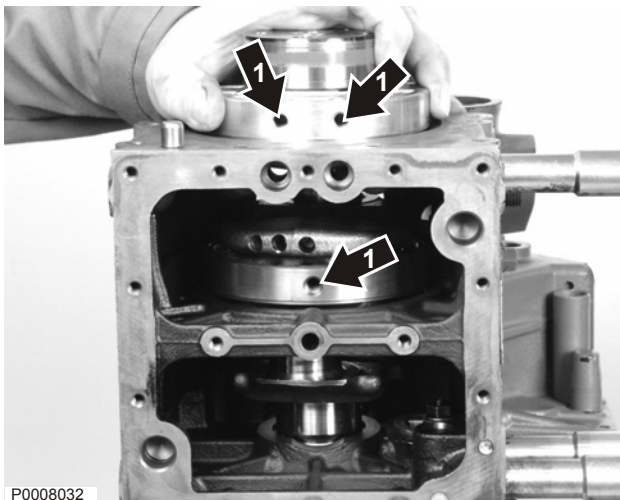
Crankshaft, Installation

Tools:

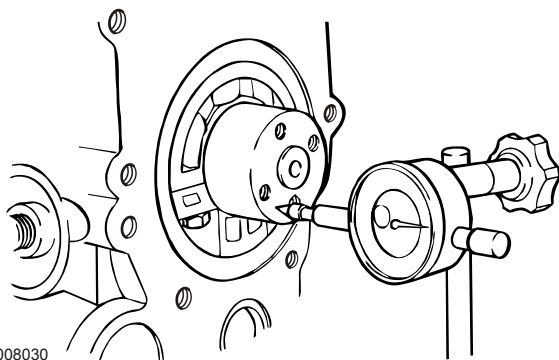
9989876 Dial indicator
9999696 Magnetic stand



P0008029



P0008032



P0008030

- 1 Check the cleanliness of the crankshaft ducts, bearing surfaces, engine block and bearing caps. Check that the bearing shells and their beds do not have any burrs or deformities.
- 2 Place the main bearing shell in position in the bearing cap. The bearing shells equipped with oil grooves must be placed in the **upper** bearing caps.
- 3 Oil the bearings and main bearing journals and install the bearing caps in their respective positions. The chamfered edges must face forwards on all bearing caps; refer to the illustration to ascertain bearing cap locations.
- 4 Bolt the bearing caps together; for tightening torque refer to *Tightening torques page 9*.
- 5 Carefully lift the crankshaft into place in the cylinder block. Align the main bearing holder bolt holes (1) before the crankshaft is pressed into place.

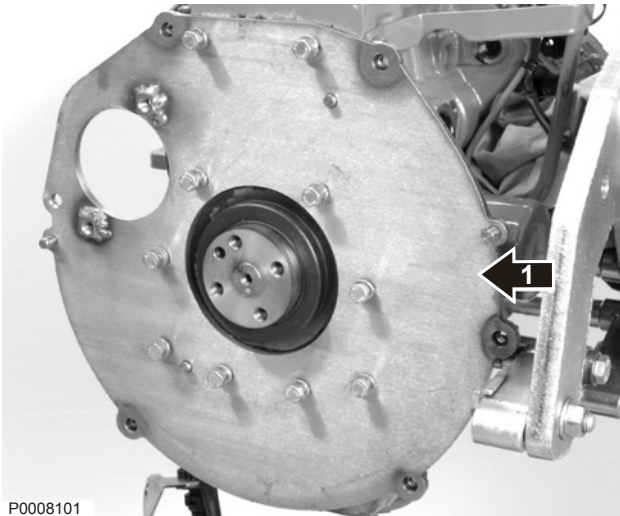
NOTICE! Tape the crankshaft gear before lifting the crankshaft into place, to prevent the gear teeth from damaging the front bearing seat.

- 6 If necessary, carefully tap the crankshaft into place and bolt fast the main bearing holders. Torque the main bearing caps in the engine block. For tightening torque, refer to *Tightening torques page 9*.
- 7 Using special tools 9999696 Magnetic stand and 9989876 Dial indicator, check that end float does not exceed 0.5 mm (0.020").
- 8 Install the oil pressure relief valve with a new seal. Torque to 64 Nm (47.2 lbf.ft). Install a the rear crankshaft seal; refer to *Crankshaft Seal, Change (rear) page 98*.

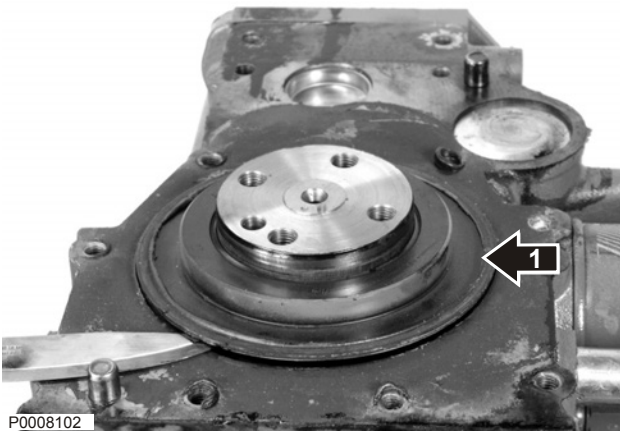
Crankshaft, Removal

Removed pistons, flywheel and timing gear

- 1 Unbolt the inner timing gear plate (1).

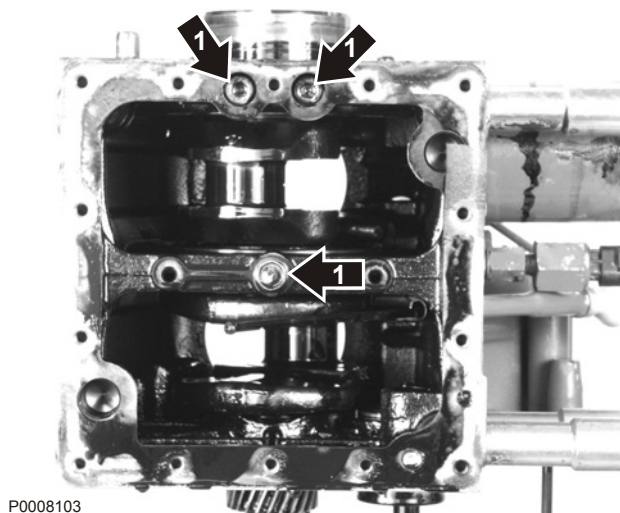


- 2 Remove the rear crankshaft seal (1).
- 3 Unscrew the oil pressure relief valve.



- 4 Undo the bolts (1) that hold the main bearing caps. Lift the crankshaft out.

NOTICE! Tape the crankshaft gear teeth to protect the bearing when the shaft is pulled out.



Main bearings, replacing

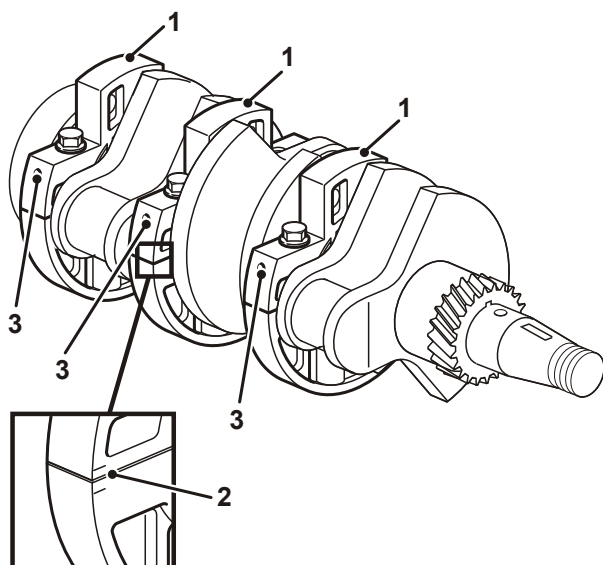
Crankshaft, removed

- 1 Unbolt the main bearing holders (1) and remove them from the crankshaft.

IMPORTANT!

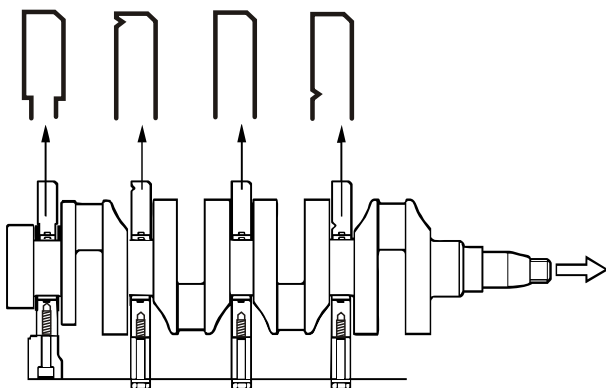
The marking (2) on all main bearing holders on D1-20, D1-30 and D2-40 engines must be carefully noted to avoid faulty replacement. Also note the oil holes (3) in the bearing caps.

D1-20, D1-30

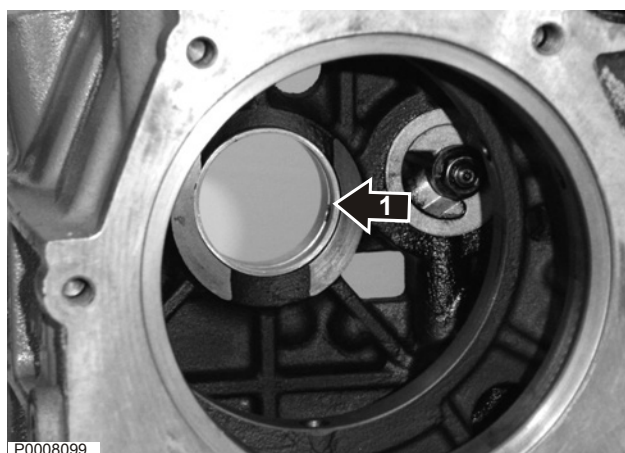


P0008098

D2-40

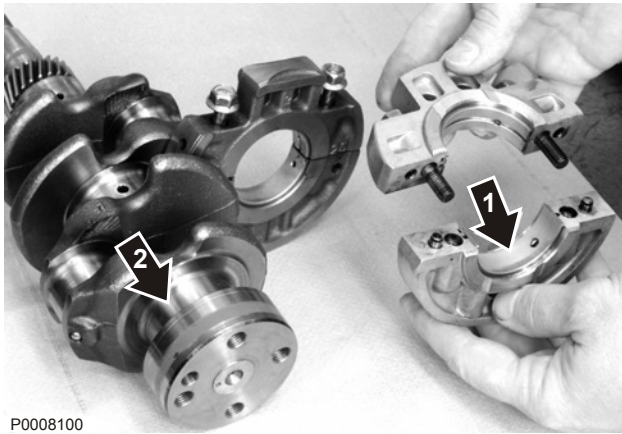


P0008029

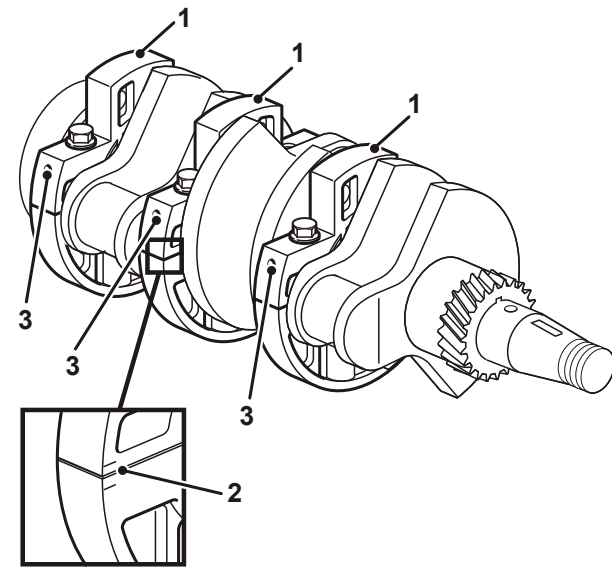


P0008099

- 2 Drive out the main bearing bush (1) located in the engine block. Use a suitable mandrel and tap the bush out from inside the crankcase.



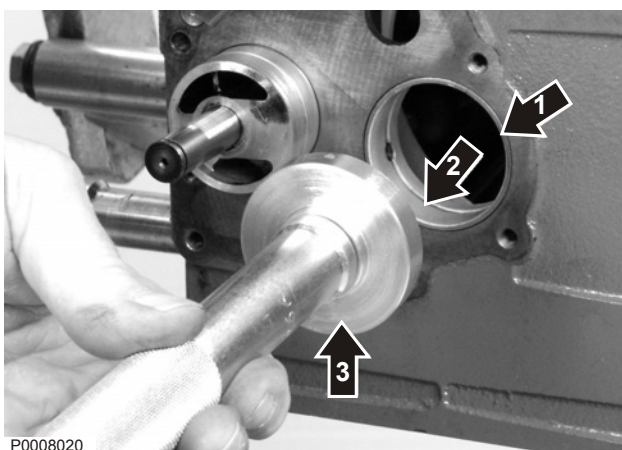
- 3 Inspect all main bearings (1). Remove them from their holders. Measure the crankshaft bearing surfaces (2); refer to *Crankshaft and Bearings, Inspection* page 90.



- 4 Install the new main bearings and lubricate them with engine oil. Install the main bearing holders (1) on the crankshaft according to the markings (2). Torque the bolts to 23 Nm (17 lbf.ft).

IMPORTANT!

Install the main bearing holders in their original places. The oil holes (3) must face the corresponding holes in the engine block.



- 5 Install the main bearing bush (1) in the cylinder block.

IMPORTANT!

Position the bush so that its oil hole is correctly aligned in the cylinder block. The oil groove (2) in the bush must be furthest in.

Tap the bush in with a suitable mandrel (3) until it lines up with the cylinder block.

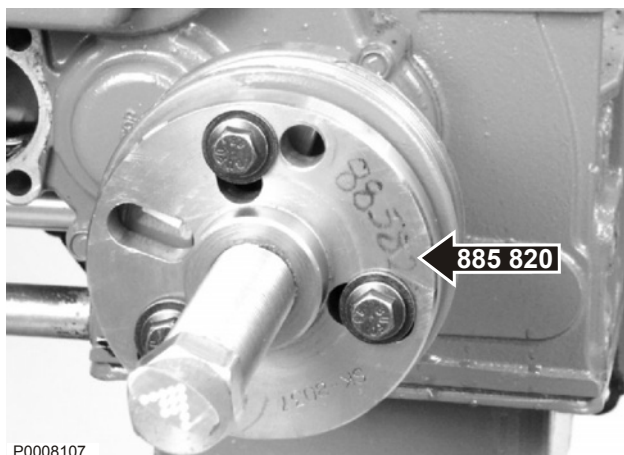
Check that the oil duct is open after pressing in the new bush. Also check the internal diameter of the bush. For dimensions, refer to *Group 21: Engine* page 14.

Crankshaft Seal, Change (front)

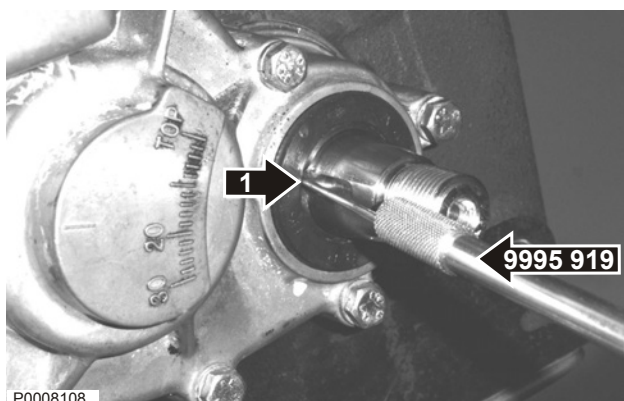
Tools:

885820 Puller

9995919 Extractor



P0008107



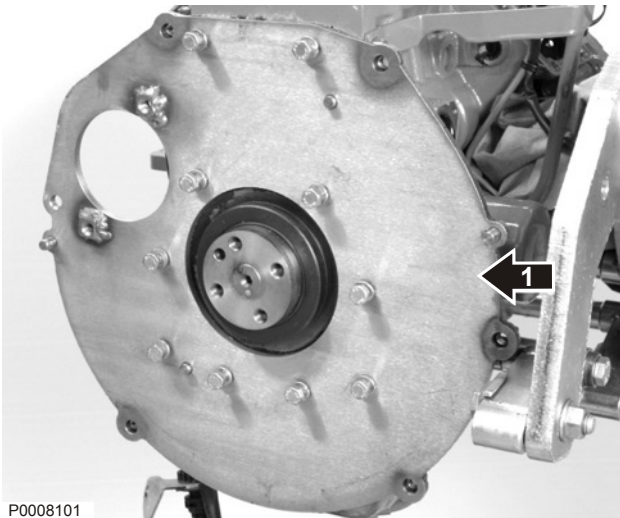
P0008108

- 1 Undo the drive belt.
Unscrew the center nut from the crankshaft pulley. Install tool 885820 Puller on the belt pulley and pull off the pulley.
Remove the key from the groove in the shaft.
- 2 Insert tool 9995919 Extractor inside the crankshaft seal lip (1) and pull the seal out.
Clean the crankshaft and seal surfaces. Tape over the key groove on the crankshaft to avoid damaging the new seal during installation.
- 3 Lubricate the new crankshaft seal with engine oil and put it on the crankshaft. Drive the seal into place with a suitable mandrel.
Remove the tape.
- 4 Install the belt pulley key on the crankshaft.
Install the belt pulley and tighten it to the fasten it with the center nut to the specified torque; refer to *Tightening torques page 9*.
Install and adjust the drive belt.

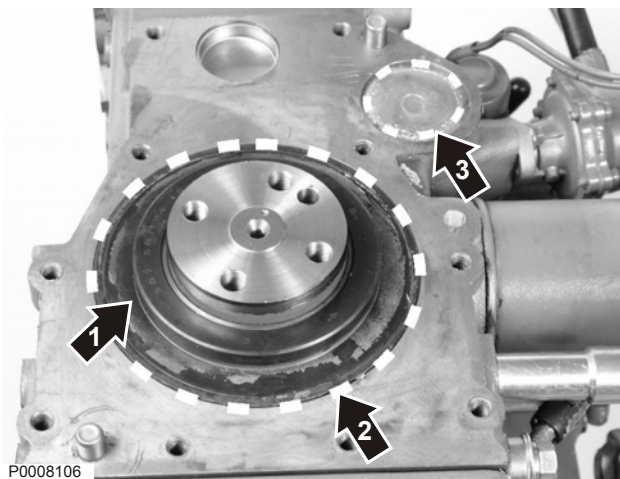
Crankshaft Seal, Change (rear)

Flywheel removed

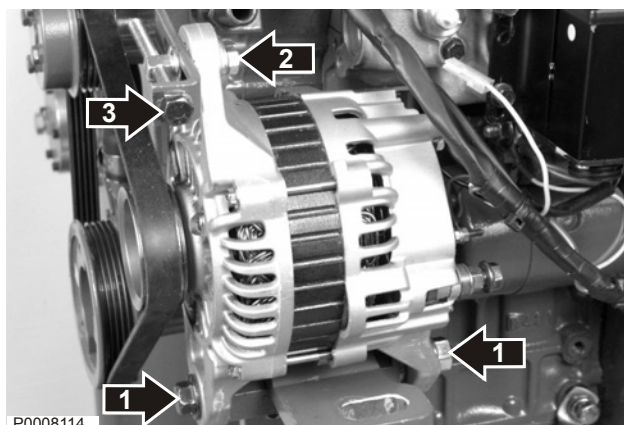
- 1 Unbolt the inner timing gear plate (1).



- 2 Remove the rear crankshaft seal (1). Check that the area for the crankshaft seal on the engine block, the crankshaft and the inner flywheel housing are cleaned. Lubricate the new crankshaft seal lip with engine oil and put the seal in place. Apply sealant part no. 840879 all round the crankshaft seal (2) and the camshaft cover (3). Fix the inner flywheel plate.



21-9 Miscellaneous



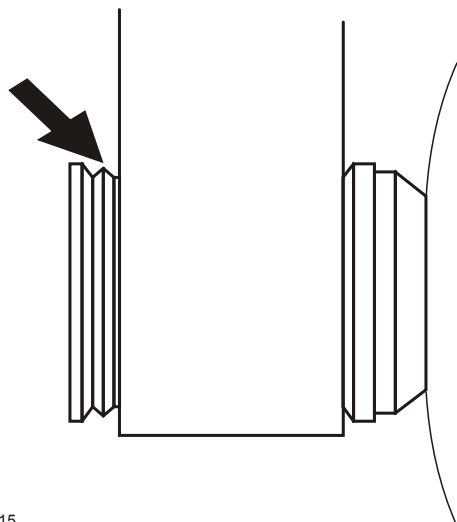
P0008114

Drive Belt, Change

- 1 Lightly loosen the lower retaining bolts (1) on the alternator. Loosen the upper retaining nut (2). Loosen the tension bolt (3) and slacken the drive belt. Remove the drive belt.

- 2 Install a new drive belt. Tension the belt with the tensioner bolt. Check the tension. Tighten the alternator retaining nut and retaining bolts.

WARNING! D1-30, D2-40: Ensure that the alternator belt is placed in the groove closest to the alternator.



P0008115

D1-30, D2-40

22-1 Oil pump and Line

Oil Pump Bearing, Change

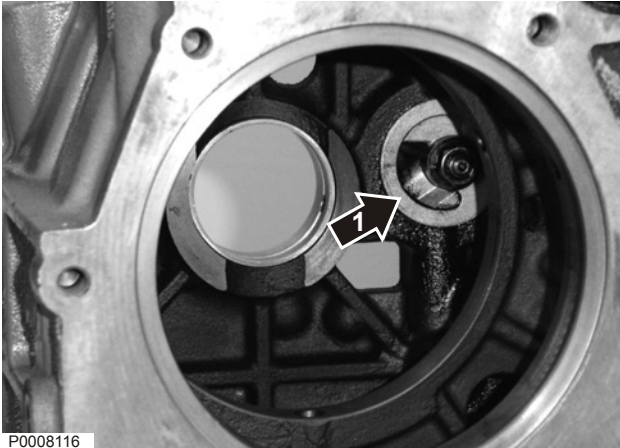
Timing gear and crankshaft removed

Tools:

3849639 Mounting tool

3849640 Mounting tool

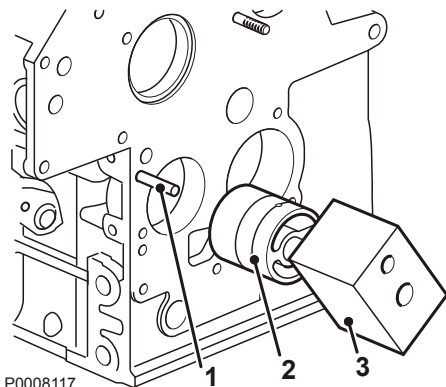
- 1 Drive out the oil pump bearing section (1) located in the cylinder block. Tap it out from inside the crankcase.



P0008116

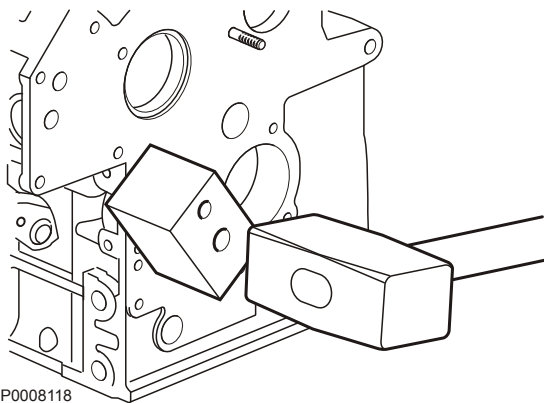
- 2 Use special tool 3849639 Mounting tool for D1-13 and D1-20 engines, and 3849640 Mounting tool for D1-30 and D2-40. First screw the guide pin (1) for the tool into the cylinder block. Then put the new oil pump bearing (2) into the tool block (3).

NOTICE! It is important that the engine block surface touching the tool is clean and smooth. The tool block must be oiled.



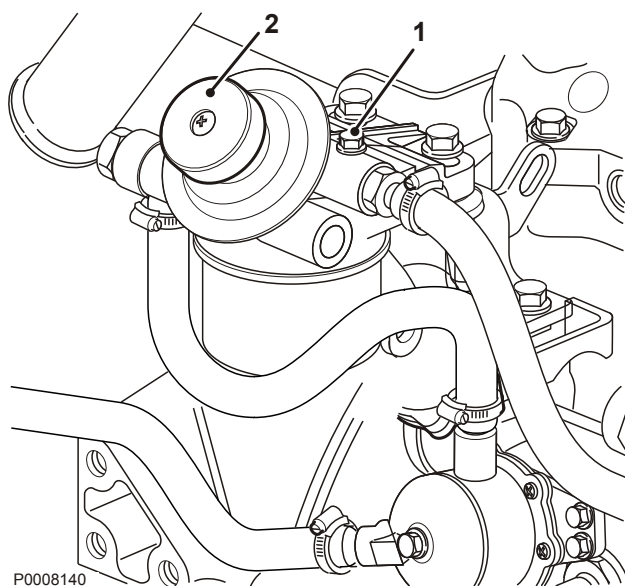
P0008117

- 3 Position the tool block with the bearing in place, using the guide pin. Tap the bearing into place until the tool bottoms on the cylinder head.



P0008118

23-0 Fuel System, General



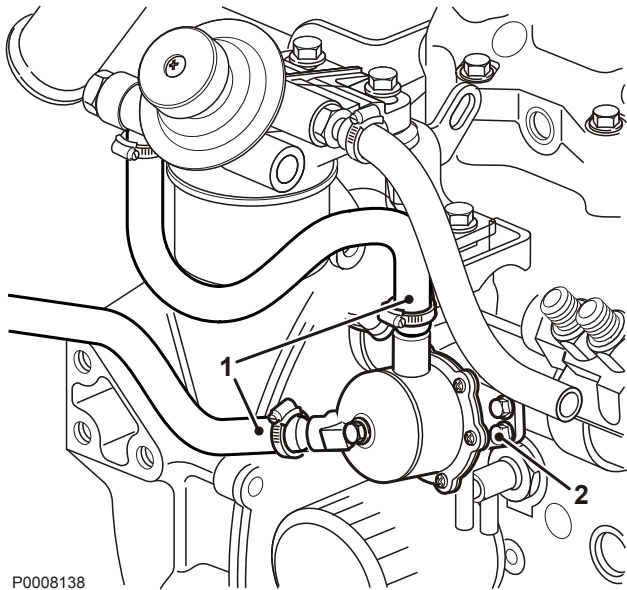
Fuel system, bleeding

- 1 Open the bleed screw (1) located above the fuel filter bracket.

NOTICE! Check whether the copper washer on the bleed screw needs to be changed.

- 2 Operate the hand pump (2) located on the fuel filter bracket until fuel with no air bubbles comes out of the bleed screw. Keep pumping at the same time as the bleed screw is closed. Pump another 10 strokes.
- 3 Wipe dry the fuel that runs out. Start the engine and check sealing.

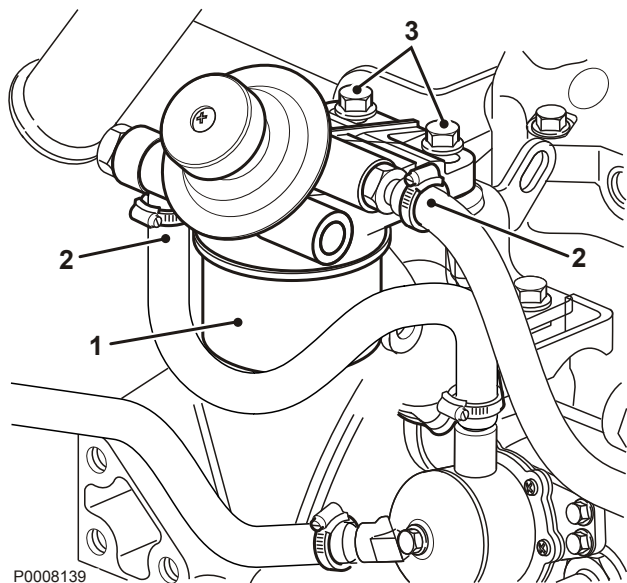
23-3 Fuel Feed Pump and Filter



P0008138

Fuel Feed Pump, Change

- 1 Put a rag under the feed pump to collect spilled fuel.
Undo the feed pump unions (1).
Remove the feed pump (2).
- 2 Place a **new** O-ring on the feed pump.
Install the feed pump and screw it in place.
Install the fuel unions on the feed pump.

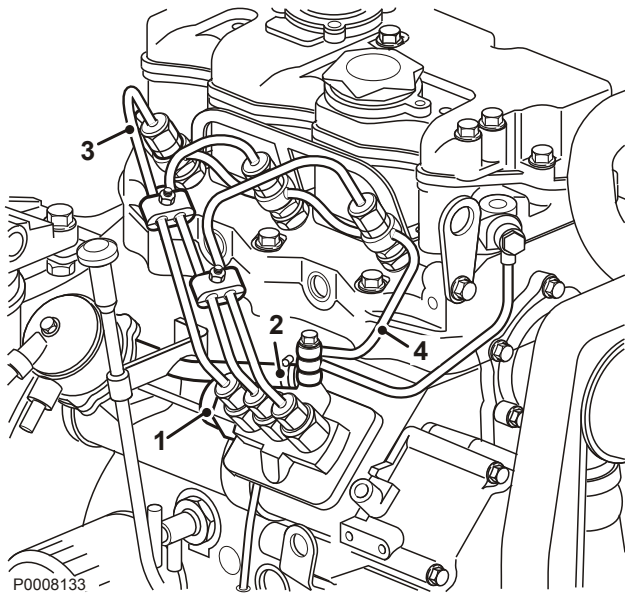


P0008139

Hand Pump, Change

- 1 Put a rag under the filter housing bracket to collect spilled fuel. Undo the fine filter (1); it must be sorted as environmentally hazardous waste.
Undo the fuel unions (2).
Unbolt the hand pump (3) and remove it.
- 2 Put a new fine filter in the new hand pump.
Install the hand pump on the bracket.
Fasten the fuel unions.
Bleed the fuel system; refer to *Fuel system, bleeding page 101*.

23-6 Injection Pump, Regulator

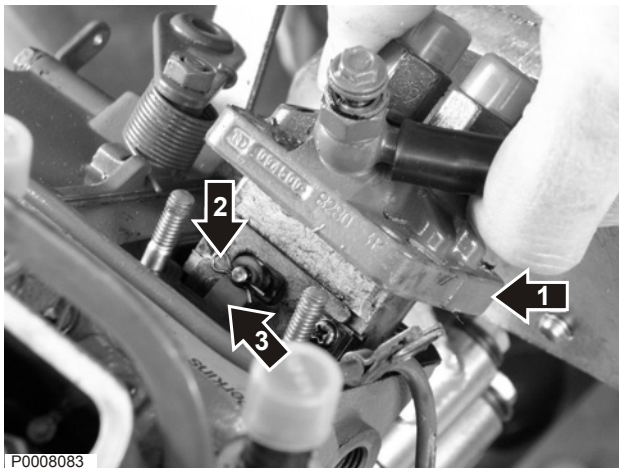


Injection Pump, Change

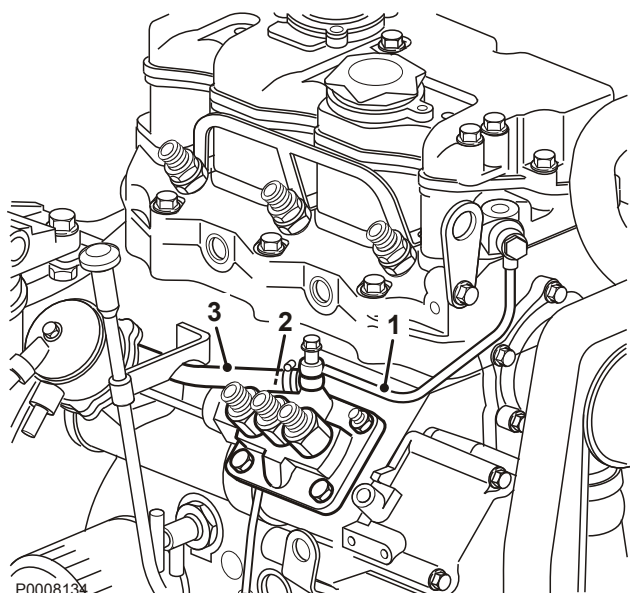
- 1 Unscrew the stop solenoid (1).
Undo the feed line (2) to the injection pump.
Undo the delivery pipes (3) and return fuel pipe (4).

IMPORTANT!

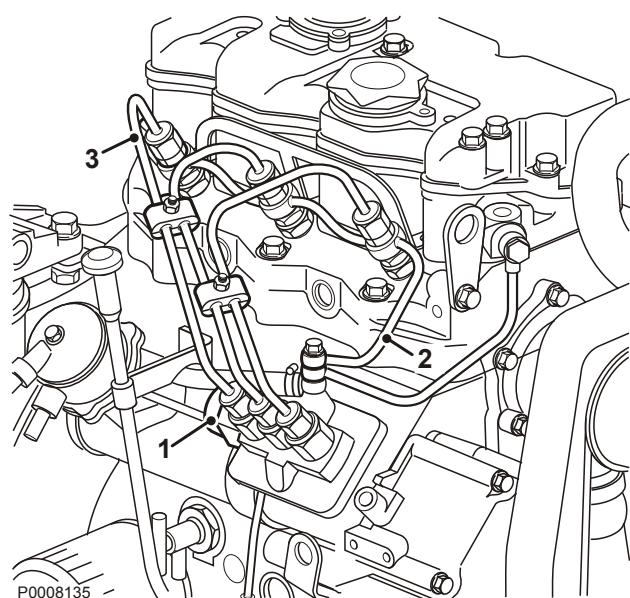
Seal all openings in the fuel system with protective caps.



- 2 Unbolt the injection pump (1). Lift it up until the lock clip (2) is accessible. Undo the clip and release the control rod (3).
Lift the injection pump out and remove the shim.

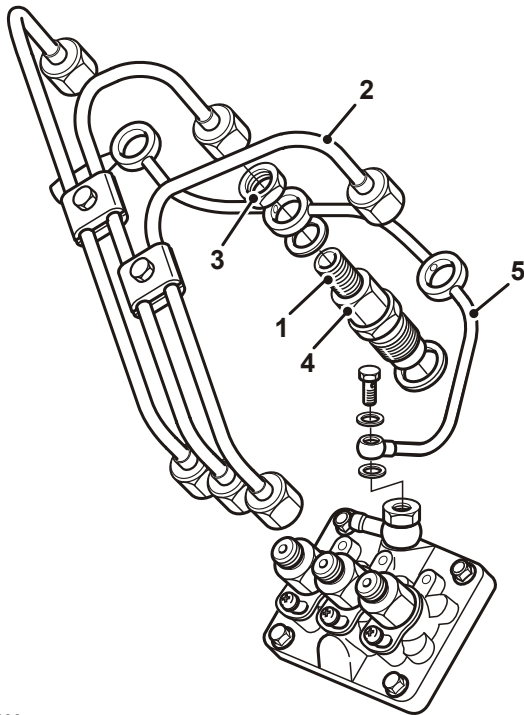


- 3 Put a new shim of the same thickness in place on the pump housing. Insert the new injection pump into the housing and fasten the control rod with the lock clip. Attach the oil supply pipe (1) to one of the studs (2). Tighten the injection pump to the specified torque; refer to *Tightening torques* page 9. Install the feed line (3).

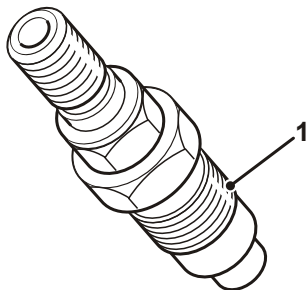


- 4 Install the stop solenoid (1) with a new seal. Install the fuel return pipe (2). Install the delivery pipes (3) and tighten to the specified torque; refer to *Tightening torques* page 9.

23-7 Injectors and Delivery Pipes



P0008136



P0008084

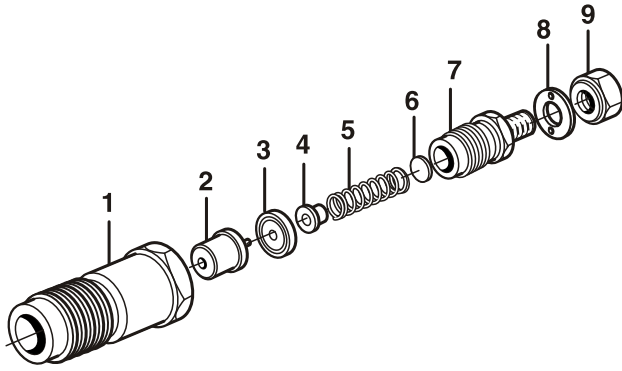
Injector, Change

- 1 Clean round the injectors (1). Undo the fuel delivery pipes (2) at the injection pump and the injectors. Lift the fuel delivery pipes away together. Remove the nut (3) at the top of each injector, use the nut (4) underneath the fuel return pipe (5) as a counterhold to avoid kinking the pipe. Lift the return fuel pipe away. Unscrew the injectors. Remove the copper seals under the injectors.

IMPORTANT!

Seal all openings in the fuel system with protective caps.

- 2 Install the new injectors with new copper seals. Apply sealant part no. 840879 to the two lowest threads (1). For tightening torques, refer to *Tightening torques page 9*. Install the return fuel pipe, use the nut underneath the fuel return pipe as a counterhold to avoid kinking the pipe. Install the fuel delivery pipes. Check that they do not come out of alignment, and tighten the nuts. For tightening torque, refer to *Tightening torques page 9*.
- 3 Start the engine and check for leaks.



P0007853

- 1 Injector nut
- 2 Injectors
- 3 Joining piece
- 4 Compression screw
- 5 Spring
- 6 Adjustment shims
- 7 Injector holder
- 8 Washer
- 9 Nut

Overhauling injectors

- 1 Clean the outside of the injector.
- 2 Fix the injector (holder) in a vise. Unscrew the injector nut and disassemble the injector.

NOTICE! Be careful that the injector nozzle does not fall out during disassembly.

- 3 Pull the injector nozzle out of the injector sleeve and put the components in white benzene.

NOTICE! Make sure that the injector needles and injector sleeves which belong with each other, and fit together, are not mixed up if several injectors are cleaned at the same time. To avoid mix-ups, the injectors should be put in an injector stand or in different compartments.

- 4 Check each injector carefully with an illuminated magnifier or an injector microscope. Also check the other components.
- 5 When installing a **new nozzle** it is important that the conserving oil is cleaned off the injector needle and sleeve before the injector is assembled (avoid skin contact with the needle's sliding surface).
Clean the components in chemically pure white benzene. Check that the needle slides in the sleeve with no tendency to bind.
- 6 Dip the injector components in pure Diesel or testing oil, and fit the components together. Use the original thickness of adjustment washer(s) to set the opening pressure.
- 7 Check the opening pressure, jet pattern and sealing in an injector tester.

Testing injectors

Testing is done in an injector tester. During the test, opening pressure and sealing are most important. The spray pattern is more difficult to evaluate and does not fully indicate the condition of the nozzle.

WARNING!

Be careful when testing injectors, avoid getting the fuel jet from an injector on un-protected parts of your body. The jet has such powerful penetration ability that it can force its way in under your skin and cause blood poisoning (septicemia).

Opening pressure

With the pressure gauge connected, press the injector tester lever down slowly until the injector opens and releases fuel. Read off the opening pressure at the opening instant.

If the value noted does not coincide with the prescribed value, the setting must be changed. This is done with washers.

NOTICE! The opening pressure increases or decreases by about 1 MPa (145 psi) with a change of shim thickness of 0.1 mm (0.0039").

Checking injectors

Spray pattern

Tools:

9999772 Pressure testing kit

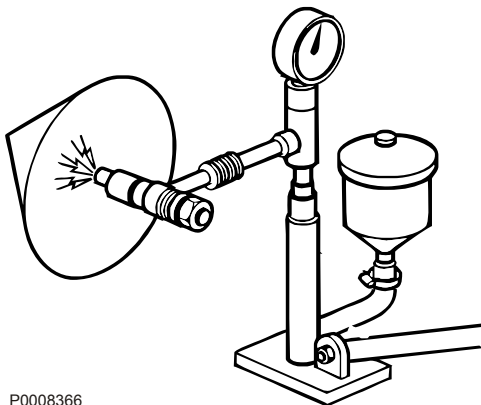
- 1 Pump the injector tester, special tool 9999772 Pressure testing kit, and check the injector spray pattern. The fuel spray should be cone shaped and aligned with the injector center line. Fuel drops must not occur in the spray.
- 2 Check that the fuel jet has a circular cross section.

Sealing

When sealing is checked, investigate any fuel leakage that may occur between the injector nozzle seat and the tapered sealing surface in the injector sleeve.

- 1 Wipe the injector nozzle tip dry.
- 2 Pump the pressure up to about 2 MPa (290 psi) below the injector opening pressure (refer to *Group 23: Fuel System page 21*). Keep the pressure constant for about 10 sec. and check that no fuel drips out from the tip of the injector. Damp injectors may be approved.

Fit protective plugs to the injector pipe connections and over the injector nozzles if the injectors are not to be installed immediately.



P0008366

Setting engine rpm

Check that the accelerator control functions normally, i.e. the actuator arm (1) is pressed against the low idle stop (2) when the accelerator control is at idle, and is pressed against the full throttle screw (3) when the accelerator control is at full throttle. Adjust the control as necessary. Also check that the air filter is not blocked, and that the air inlet is not blocked.

IMPORTANT!

The engine's fuel volume and speed are set at the factory to give highest power and least environmental impact. These settings must not be disturbed.

NOTICE! Seals on injection equipment may only be broken by authorized personnel. Seals which have been broken must be re-sealed.

Low idle

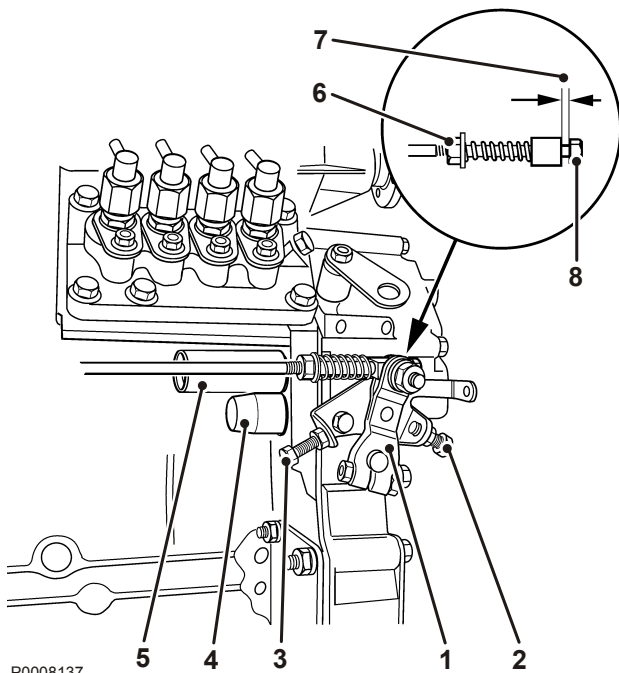
- 1 Check that the gap (7) is about 3 mm (0.1181") when the accelerator is in the idle position. If necessary: Undo locknut (6) and adjust screw (8) to give the correct gap.
- 2 Warm the engine up and check the idling speed with a tachometer (refer to *Group 23: Fuel System page 21* for correct idling speed)
- 3 Use adjustment screw (2) as necessary to give the correct idling speed.
- 4 Check the gap (3) again as in item 1.

Race revolutions (high idle)

Warm the engine up and check the race revolutions with a workshop tachometer when the engine is unloaded at full throttle (refer to *Group 23: Fuel System page 21* for correct race revolutions).

Adjust the following as necessary

- 1 Loosen the stop screw (3) so that it does not limit the movement of the actuator arm (1).
- 2 Run the engine without load at full throttle and adjust the race revolutions to the correct value with adjustment screw (4); reseal the screw.
- 3 Adjust stop screw (3) to give a clearance of 0.1 mm (0.0039") between the stop screw (3) and the actuator arm (1) when the throttle control is in the full throttle position.



P0008137

- 1 Actuator arm
- 2 Adjustment screw, low idle
- 3 Stop screw, full throttle
- 4 Adjustment screw, race revolutions
- 5 Adjustment screw, max. fuel volume
- 6 Lock nut

26-0 Cooling System, General

The engine's internal cooling system makes sure the engine works at the right temperature. It is a closed system that must always be filled with a mixture of concentrated coolant and water in order to protect the engine against internal corrosion, cavitation and bursts due to freezing.

IMPORTANT!

Coolant of a suitable chemical composition must be used all year round. This also applies in areas where there is never any risk of freezing, to provide the engine with full corrosion protection.

The corrosion protection additives become less effective over time, which means that the coolant must be changed at regular intervals; refer to the *Maintenance Schedule*. The cooling system must be flushed whenever the coolant is changed; refer to the *Cooling System, Cleaning* section.

Volvo Penta engines are delivered with either "Volvo Penta Coolant" (green) or "Volvo Penta Coolant VCS" (yellow); both are available as concentrates and "Ready Mixed".

Volvo Penta coolants have been prepared to work best with Volvo Penta engines and offer excellent protection against corrosion, cavitation damage, and bursts due to freezing. Only coolants of this quality are adapted to, and approved by, Volvo Penta.

We recommend that the coolant supplied with the engine on delivery be used. Future warranty claims related to engine and accessories may be declined if an unsuitable coolant has been used, or if the instructions for coolant mixture have not been followed. The use of anti-corrosion agents alone is not permitted in Volvo Penta engines. Never use water alone as a substitute for coolant.



P0013077

IMPORTANT!

- The two types of Volvo Penta coolant may **never** be mixed with each other as this will affect the anti-corrosion properties.
- Coolant filters may not be used together with Volvo Penta Coolant VCS.
- Engines using yellow Volvo Penta Coolant VCS must have a yellow decal with the text VOLVO COOLANT VCS on the expansion tank.

Ready Mixed

Ready mixed coolant contains 40% Volvo Penta Coolant / Volvo Penta Coolant VCS and 60% water. This mixture protects the engine against internal corrosion, cavitation and bursts due to freezing down to -28°C (-18°F).

Coolant, Mixing

The concentrated coolant must be mixed with pure water (distilled or de-ionized water) according to specifications; refer to *Water Quality*.

WARNING!

All coolant is hazardous and harmful to the environment. Do not consume. Coolant is flammable.

IMPORTANT!

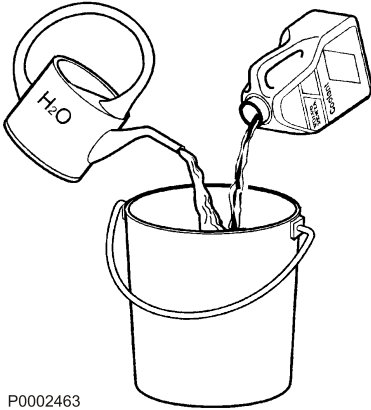
Different kinds of coolant must not be mixed with each other!

Mix: 40% concentrated coolant and 60% water

This mixture protects against internal corrosion, cavitation and bursts due to freezing down to -28°C (-18°F). A 60% glycol admix lowers the freezing point to -54°C (-65°F).

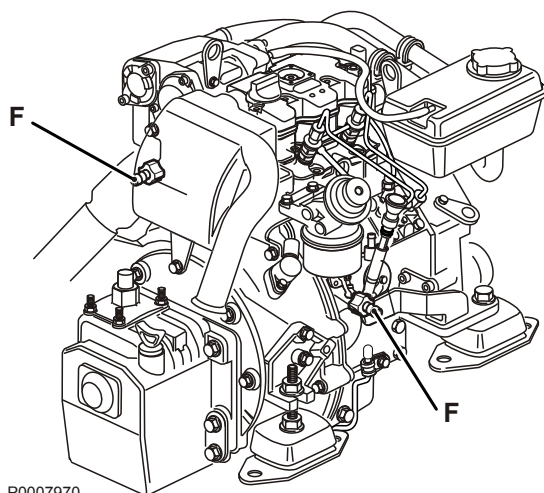
Never mix more than 60% concentrate in the coolant. A greater concentration provides reduced cooling effect with the risk for overheating and reduced anti-freeze protection.

It is extremely important that the system be filled with the correct coolant concentration. Mix in a separate clean vessel before filling the cooling system. Make sure that the liquids mix.



P0002463

D1-13



P0007970

F = Fresh water, drain tap

Coolant, Draining

NOTICE! Remove the expansion tank filler cap and close the hull fitting before draining the cooling system.

⚠ WARNING!

Burn hazard. Steam and hot fluid may spray out. Stop the engine and allow it to cool before opening the filler cap.

- 1 Connect drain hoses to the taps on the fresh water system. Open all drain points. The raw water system is drained by undoing hoses at the lowest points of the system.
- 2 Check that all water drains out. Check whether the installation has any further taps or plugs at the lowest points of the cooling water and exhaust lines.
- 3 Close the taps.
- 4 Pump the bilges out as necessary. Check that no leakage occurs.

Coolant Level, Checking and Topping Up

⚠ WARNING!

Stop the engine and let it cool before starting work on the cooling system. Hot fluids and hot surfaces can cause burns.

Filling

Flush the cooling system clean before new coolant is added.

Close all drain points and fill up with coolant to the correct level.

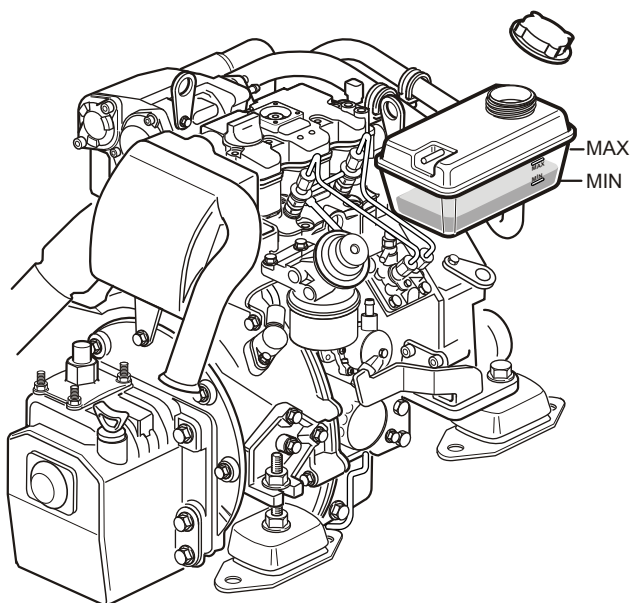
The engine must be stopped when the cooling system is filled, and must not be started until the system is vented and completely filled. If a heating installation is connected to the engine cooling system, the heat control valve must be fully open and the installation vented during filling.

Check the hoses and joints and rectify any leaks.

Fill the system slowly! Filling must not be done so fast that air locks are formed in the system. Air must be allowed to flow out through the filler opening. Check the coolant level after the engine has been run for about an hour. Top up with coolant as necessary.

NOTICE! It is okay to lift off and heighten the expansion tank to ease the filling.

Check and top up as necessary after the engine has been running warm (open thermostat).



P0007524

Checking

WARNING!

Do not open the coolant filler cap when the engine is warm, except in emergencies, this could cause serious personal injury. Steam or hot fluid could spray out.

Turn the filler cap to the first stop and allow any excess pressure to hiss out before removing the cap completely. Top the coolant up as necessary. The level must be between the MAX and MIN markings.

Fault cause

Coolant temperature too low

Low coolant temperature can be caused by:

- Faulty thermostat
- Faulty temperature sensor or gauge
- Low engine loading

Excessive coolant temperature

Excessive coolant temperature (warning lamp lights up) can be caused by:

- Blocked raw water inlet or raw water filter
- Defective impeller in the raw water pump
- Too low coolant level; air in the fresh water system
- Slipping or broken coolant pump vee belt
- Faulty thermostat, temperature sensor or gauge
- Blocked cooling system
- Incorrectly set injection advance in the injection pump
- Filler cap gasket does not seal

Coolant losses

There are two types of coolant losses

- Coolant losses during operation
- Coolant losses after stopping a hot engine

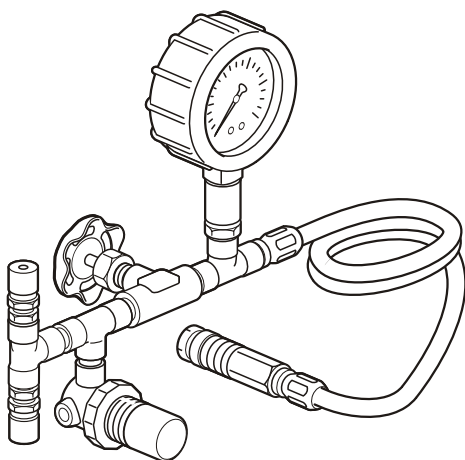
Coolant losses during operation can be due to a leaking cooling system or air or combustion gases being forced into the cooling system.

Pressure Valve in Filler Cap, Check

Tools:

9996662 Pressure testing kit

- 1 Drain some of the coolant and connect 9996662 Pressure testing kit to a nipple or other plugged hole in the cooling system.
- 2 Extend the drain hose from the filler pipe with a hose that discharges into a water-filled vessel.
- 3 Increase the pressure and read the pressure gauge when the valve opens (water bubbles into the vessel with the drain hose). The valve should open at 75 kPa (10.9 PSI).
- 4 Remove the test equipment. Install the plug and fill the engine with coolant.



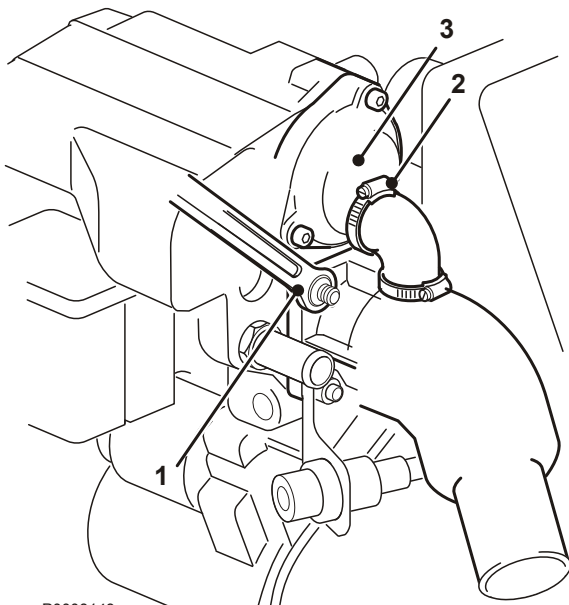
P0002790

26-1 Radiator, Heat Exchanger

Heat Exchanger, Cleaning

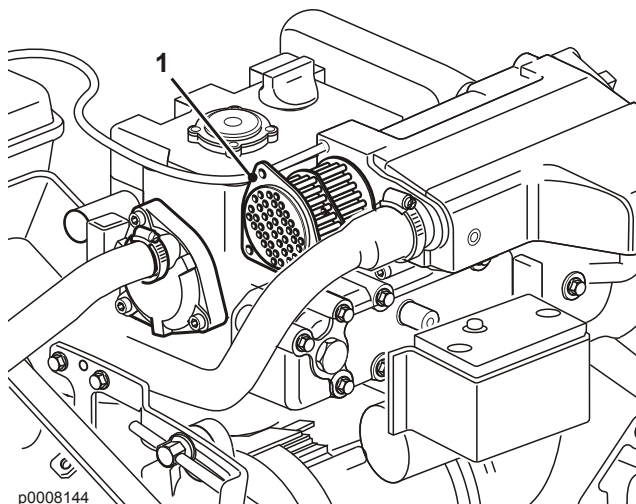
Drained cooling system and raw water. Air filter housing removed. Removed expansion tank and attachment fitting (D1-30 and D2-40)

- 1 Undo the heat exchanger end plate on the alternator side.
Remove the exhaust elbow (1) and hose clamp (2) from the heat exchanger end plate. Remove the exhaust elbow.
Undo the other heat exchanger end plate (3).

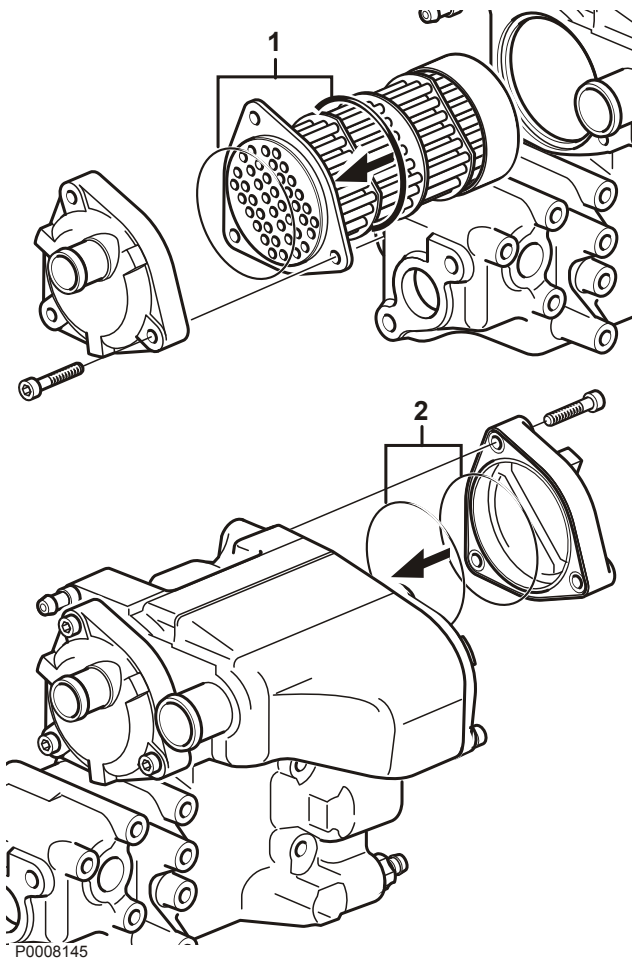


P0008143

- 2 Remove the insert (1) and clean it.



p0008144

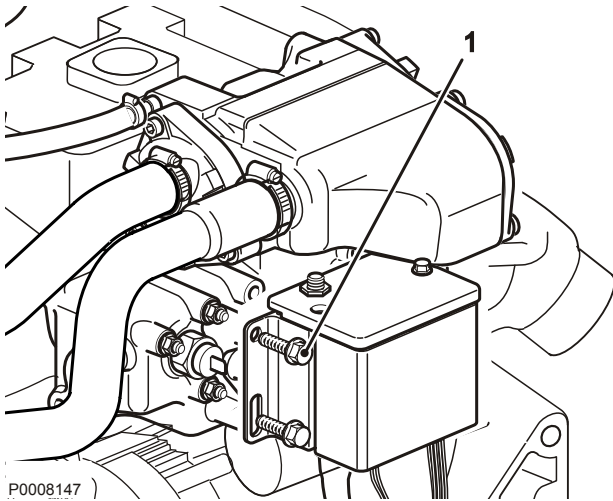


- 3 Install new O-rings (1) on the insert end plate. Slide the insert in from the alternator side. Bolt the end plate onto the heat exchanger.
- 4 Install new O-rings (2) on the insert and end plate. Bolt the end plate onto the heat exchanger. Install the exhaust elbow.
- 5 Fill up with coolant. Check the level and sealing after warming up.

Heat Exchanger/Exhaust Manifold, Change

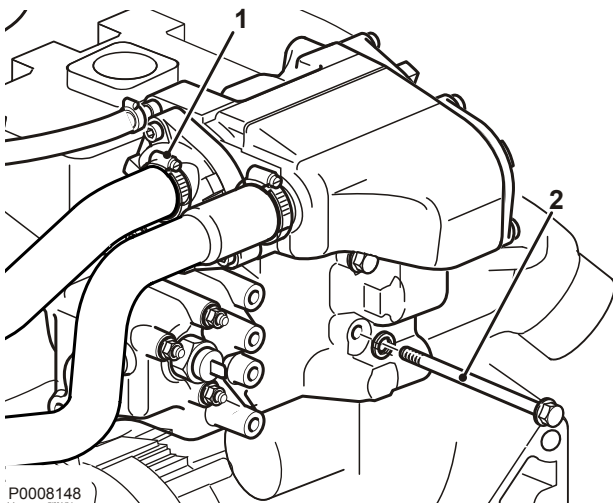
Current cut off by the main switches. Drained cooling system and raw water. Removed expansion tank and attachment fitting (D1-30, D2-40).

- 1 Undo the hose union on the exhaust elbow. Unscrew the distribution box (1) and move it to one side.



P0008147

- 2 Undo the hose connections (1). Undo the screws (2) and carefully pry the heat exchanger / exhaust manifold away. Remove the gasket.
- 3 Clean the sealing surfaces of the cylinder head. Transfer the exhaust elbow to the new heat exchanger/exhaust manifold. Install the new heat exchanger / exhaust manifold and gasket. Start to tighten the screws from the center and then outwards. Torque to 10 Nm (7.4 lbf.ft). Install the distribution box on the exhaust manifold.
- 4 Install the hose unions and junction to the exhaust elbow. Fill up with coolant. Warm up the engine and check the sealing and coolant level.



P0008148

26-2 Coolant Pump, Thermostat

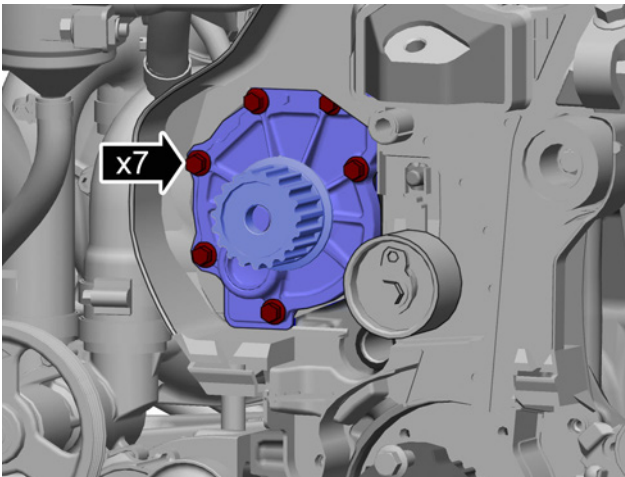
Coolant Pump, Change

D2-40A, D2-40B, D2-40F

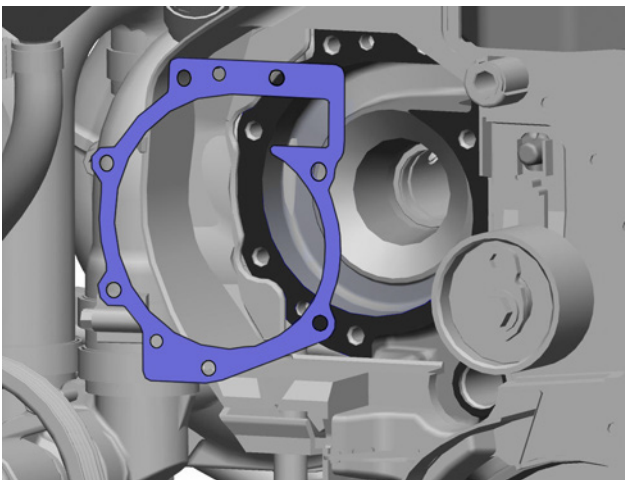
Removal

Drain the coolant according to *26-0, Coolant, Change*.
Remove the camshaft belt according to *21-5, Camshaft Belt, Change*.

- 1 Remove the coolant pump.
Tightening torque: M6, 10 Nm (7.4 lbf.ft.)



P0010727



P0010728

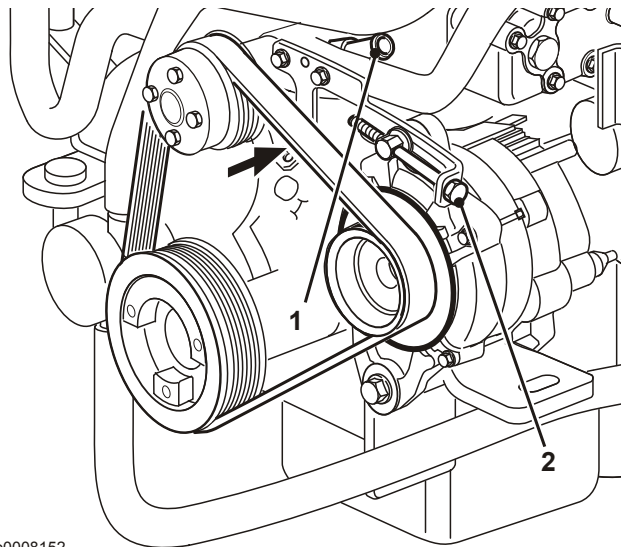
- 2 **NOTICE!** Make sure the surface is clean before application.

Remove and discard the gasket.

Installation

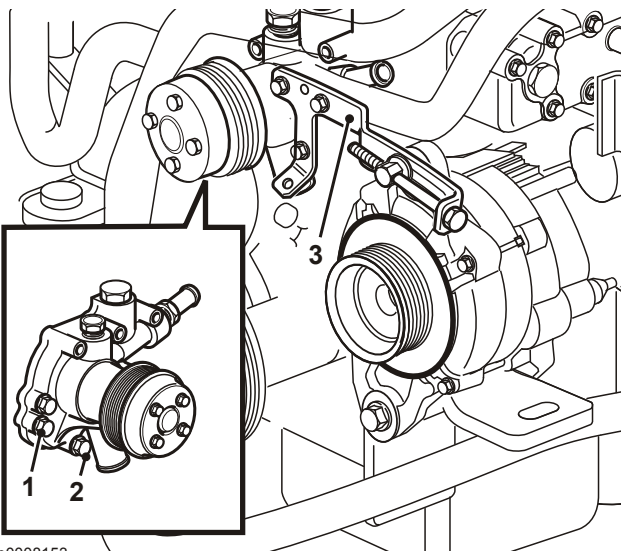
Install in reverse order.

Coolant Pump, Change



p0008152

- 1 Drain the coolant.
Undo the hose connections (1) for the coolant pump.
Loosen the tension (2) on the drive belt and remove it.



p0008153

- 2 **D1-13-A and D1-20-A**
Undo the temperature sensor connector.

Alla motorer

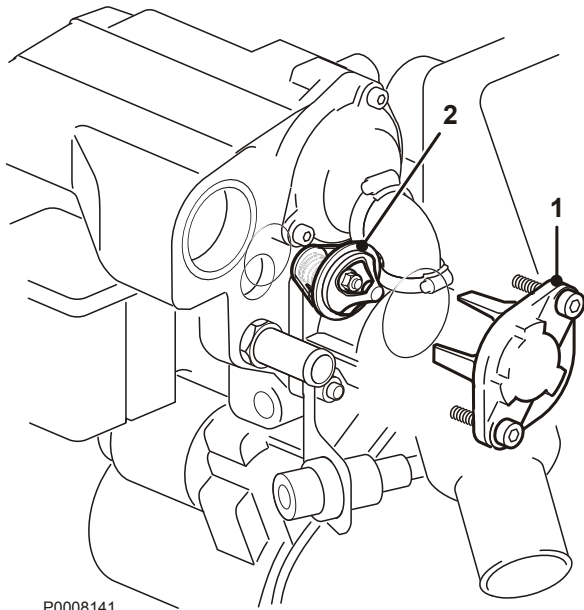
Loosen the screws (1) and nut (2) which hold the coolant pump and alternator stay (3).
Remove the coolant pump and alternator stay.

D1-13:

Also remove the spacer which is located between the coolant pump and engine block.

- 3 Clean the sealing surfaces. Transfer the temperature sensor, hose union and pulley to the new coolant pump.
- 4 Install the new coolant pump with new seals, spacer (D1-13) and alternator stay. Install and tension the drive belt. Install the hose connections.
- 5 Fill up with coolant. Warm up, and check the sealing and coolant level.

Thermostat, Change



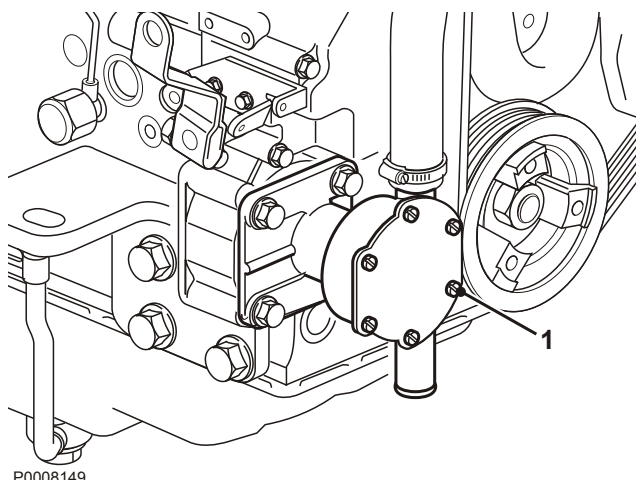
- 1 Drain the coolant.
Remove the thermostat housing cover (1).
Remove the O-ring from the cap.
Remove the thermostat (2) and seal.
- 2 Install a new thermostat and seal.
Install the thermostat housing cover with a new O-ring. Tighten the screws to the specified torque, refer to *Group 26: Cooling System page 22*.
- 3 Fill up with coolant.
Warm up the engine and check the sealing and coolant level.

26-6 Sea Water System, Sea Water Pump

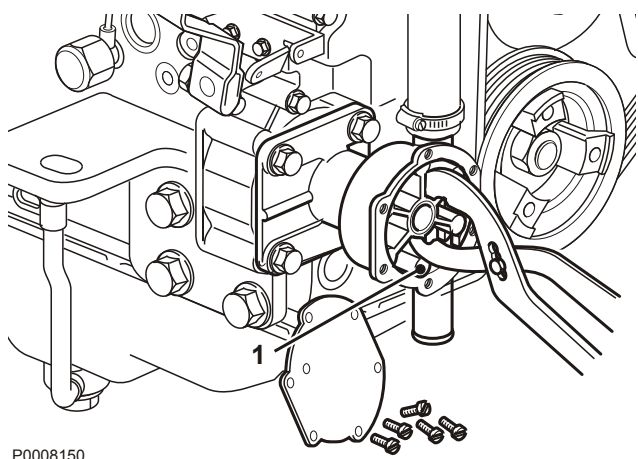
Seawater Pump, Impeller, Change

Closed sea cock

- 1 Unscrew all screws on the cover (1).



- 2 Remove the impeller (1) with the aid of pliers.
- 3 Clean the pump housing and sealing surfaces.
- 4 Lubricate the impeller and housing with glycerin. Place the impeller and a new gasket in the housing. Screw the cover down. Open the sea cock and start the engine. Check the sealing.



IMPORTANT!

Only glycerin may be used as an impeller lubricant.

Seawater Pump, Change

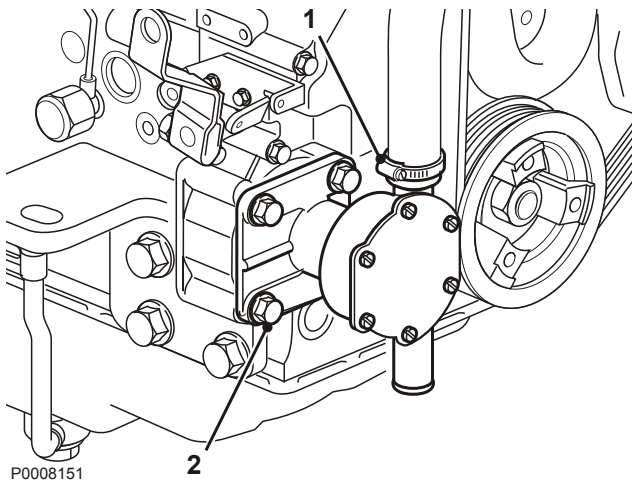
Closed sea cock

- 1 Undo the hose connections (1) to the raw water pump.
Undo the four bolts (2) that retain the raw water pump.

- 2 Remove the raw water pump and the O-ring.
Check the mating surfaces.

NOTICE! Check the raw water pump gear wheel.
If the gear wheel is damaged, the idler gear must be inspected as well.

- 3 Install a new raw water pump and O-ring.
Install the bolts and connect the hoses.
Open the sea cock and run the engine. Check the sealing.

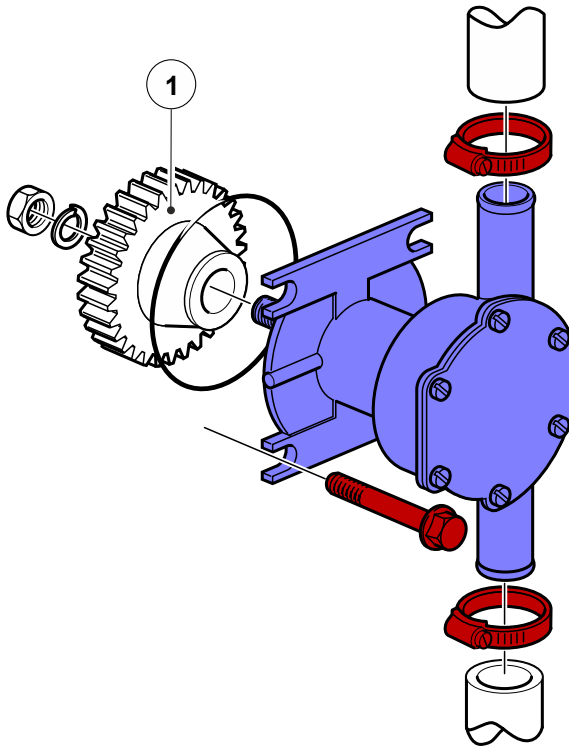


Seawater Pump, Overhaul

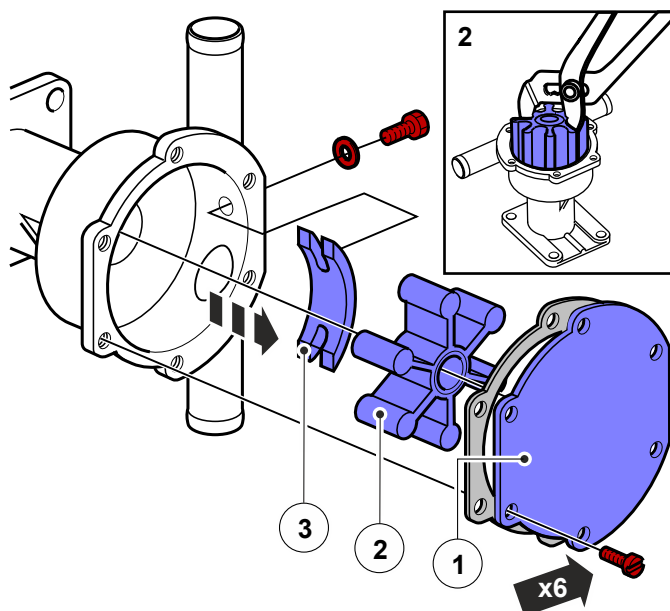
NOTICE! Close the sea cock or the valve on the S-drive before working on the cooling system.

Disassemble

- 1 Remove the seawater pump.
Remove the gearwheel (1) from the seawater pump shaft. Use a puller.

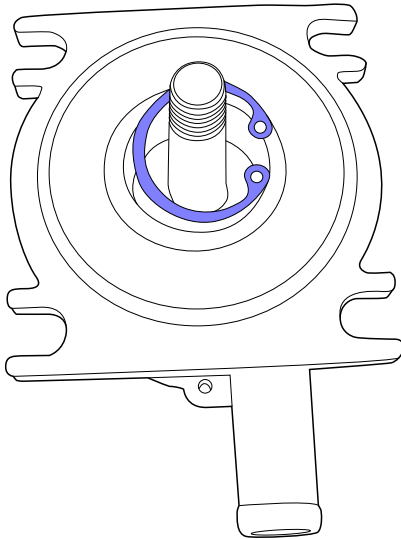
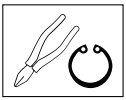


P0018119



- 2 Remove the impeller cover (1) and gasket.
Pull out the impeller (2) with the aid of polygrip pliers.
Remove the wear washer (3).

P0018120

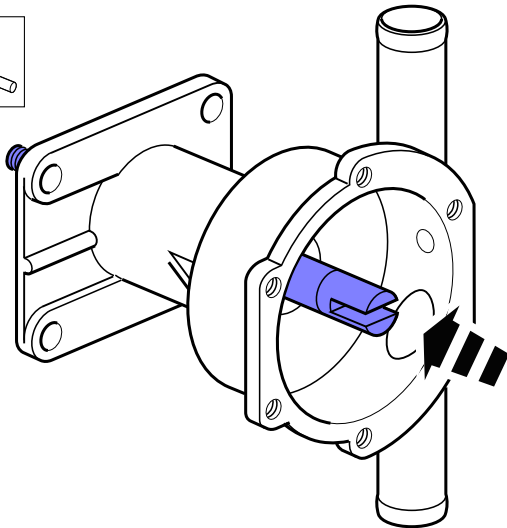
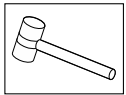


P0018121

- 3 Remove the retainer ring.

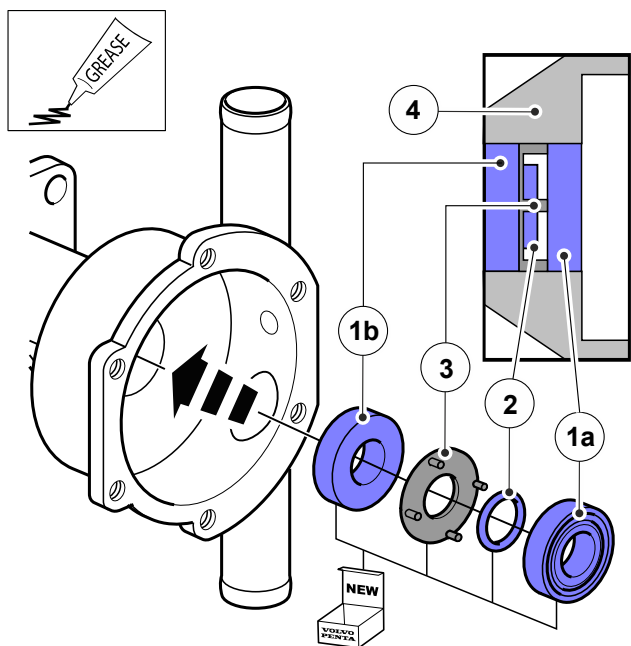
⚠ CAUTION!

Risk of eye injury. Eye protection required.



P0018122

- 4 Carefully tap out the shaft.

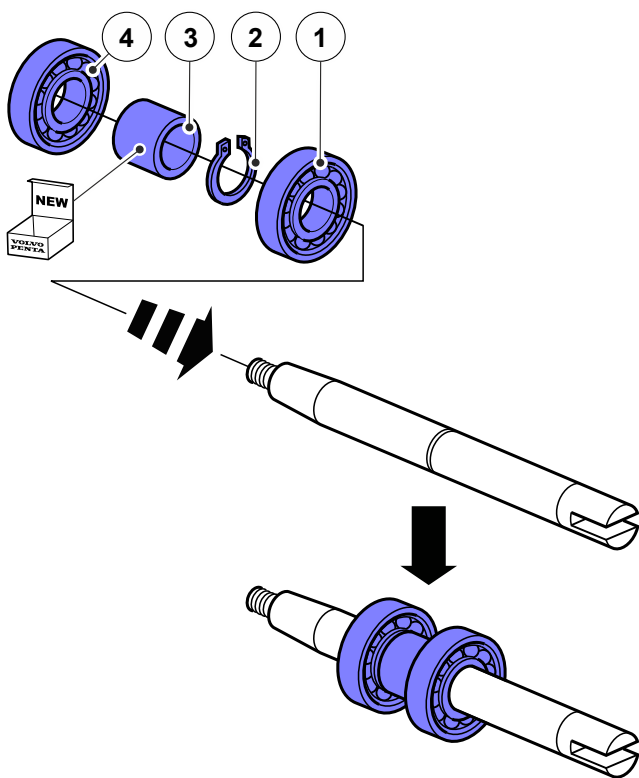


P0018146

Reassemble

- 5 Apply 828250 Grease on the seal rings (1a, 1b). Install seal rings, O-ring (2) and spacer washer (3) according to the illustration.

NOTICE! The last seal ring (1a) shall align with the surface of the pump housing (4).



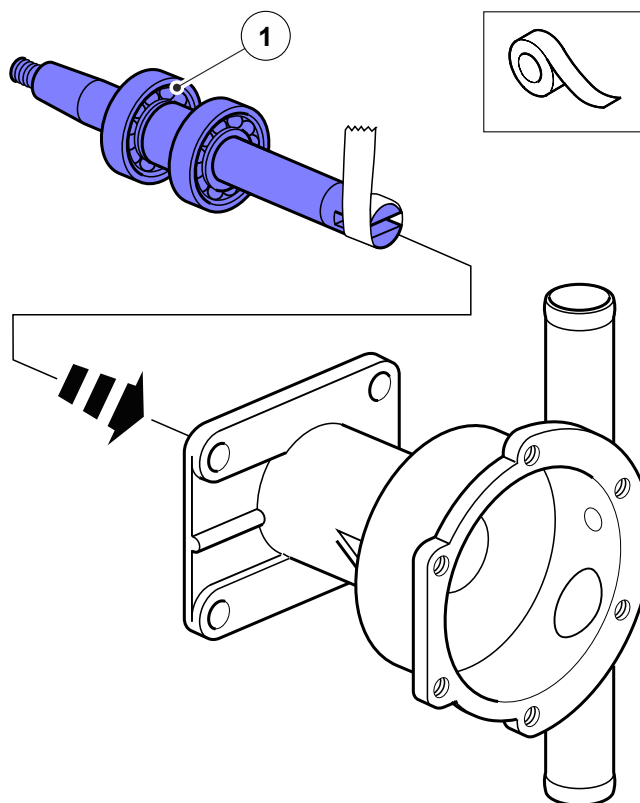
P0018147

- 6 Carefully press on the first ball bearing (1) behind the groove for the retainer ring. Install the retainer ring (2) and spacer sleeve (3).

CAUTION!

Risk of eye injury. Eye protection required.

Carefully press on the second ball bearing (4). Press the first ball bearing back until it is abut the retainer ring.



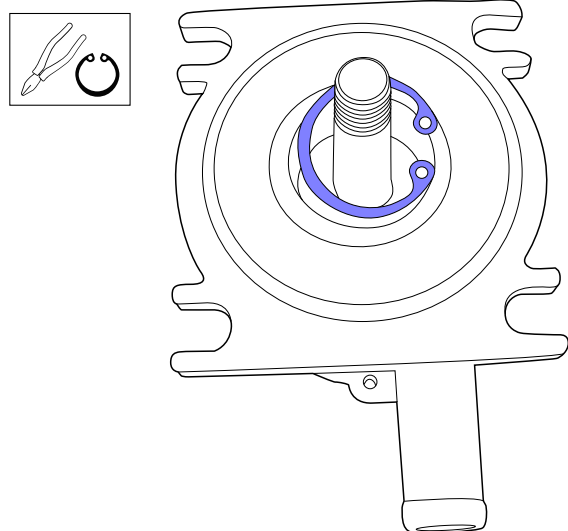
7 **IMPORTANT!**
Tape around the top of the shaft to protect the seal rings.

Press the shaft onto the seawater pump housing, preferably with the aid of a vise.

IMPORTANT!
Make sure that the shaft is mounted on the O-ring correctly and that the seal rings are held in place. Try rotating the shaft when it is mounted.

NOTICE! Preferably use a sleeve to press on the lower ball bearing (1) until the retainer ring groove in the pump housing is visible.

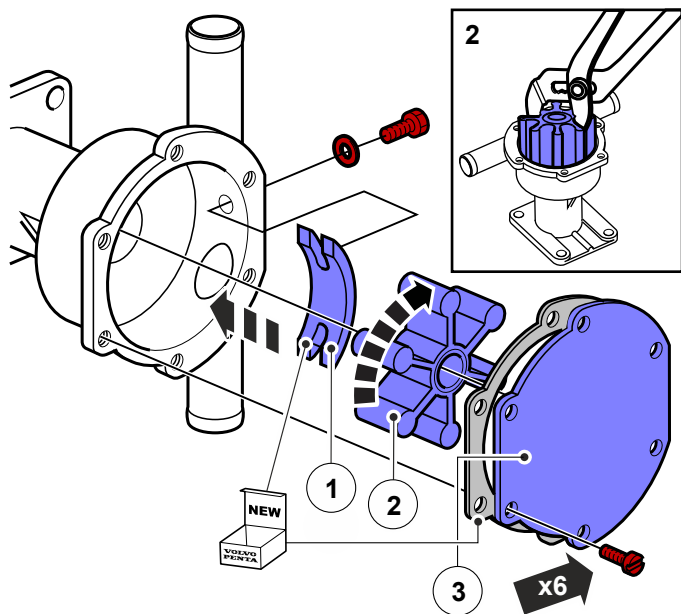
P0018158



8 Fit the retainer ring into the groove in the seawater pump housing.

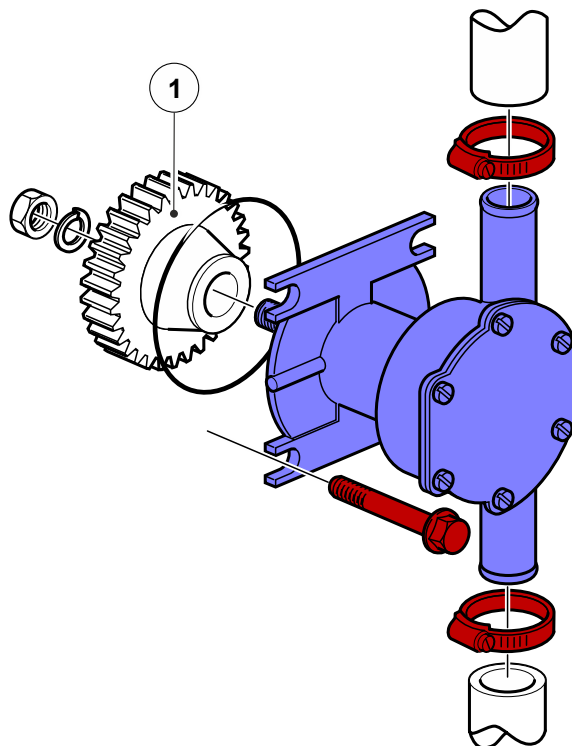
CAUTION!
Risk of eye injury. Eye protection required.

P0018121



- 9 Install the wear washer (1).
Press in the impeller (2) with a rotating movement (clockwise).
Install the impeller cover (3) and gasket.

P0018159



- 10 Fit a new O-ring and the gearwheel (1) with a washer and nut on the seawater pump shaft.
Install the seawater pump.

P0018119

Finishing off

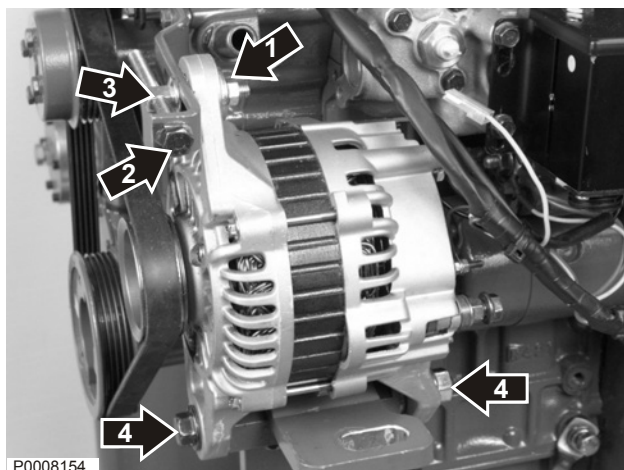
- 11 Open the sea cock, or S-drive valve.
Start the engine and check that no leakage occurs.

32-1 Alternator

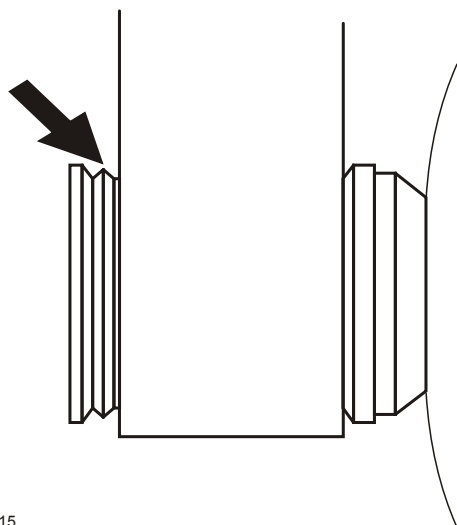
Alternator, Change

Current cut off at the main switches

- 1 Mark and undo all electrical connections to the alternator.
- 2 Loosen the upper retaining nut (1). Undo the tension bolt (2) to release the upper retaining bolt (3) for the alternator. Unscrew the lower retaining bolt (4) and remove the alternator.



P0008154



P0008115

- 3 Put the new alternator in position and tighten the lower retaining bolt. Tighten it loosely. Put the upper retaining bolt in position and lightly tighten the upper fixing nut. Screw the tension bolt into the retaining bolt. Put the drive belt in place and tension it with the tension bolt.

IMPORTANT!

D1-30, D2-40: Ensure that the alternator belt is placed in the groove closest to the alternator.

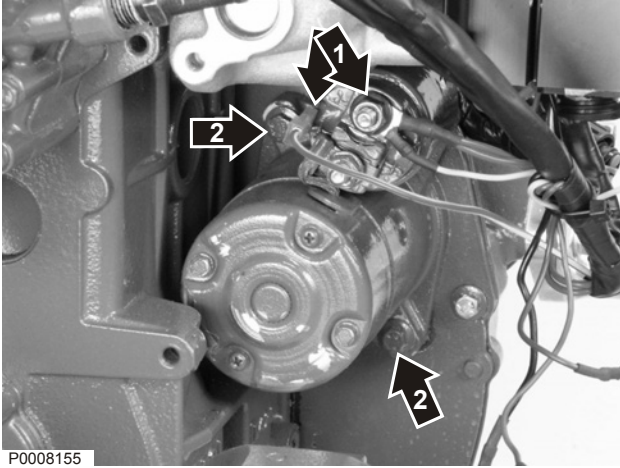
- 4 After checking the drive belt tension, tighten the lower retaining bolt and upper retaining nut. Install the electrical connections on the alternator.

33-1 Starter Motor

Starter Motor, Change

Current cut off by the main switches. Alternator removed (D1-13).

- 1 Undo all electrical connections (1) to the start solenoid.
- 2 Undo the starter motor retaining bolts (2). Lift the starter motor out.
- 3 Put the new starter motor in position and fasten it with the bolts. Install the electrical connections on the starter motor.
- 4 Switch the current on and check the starter motor function.



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