Volvo Penta MD-1

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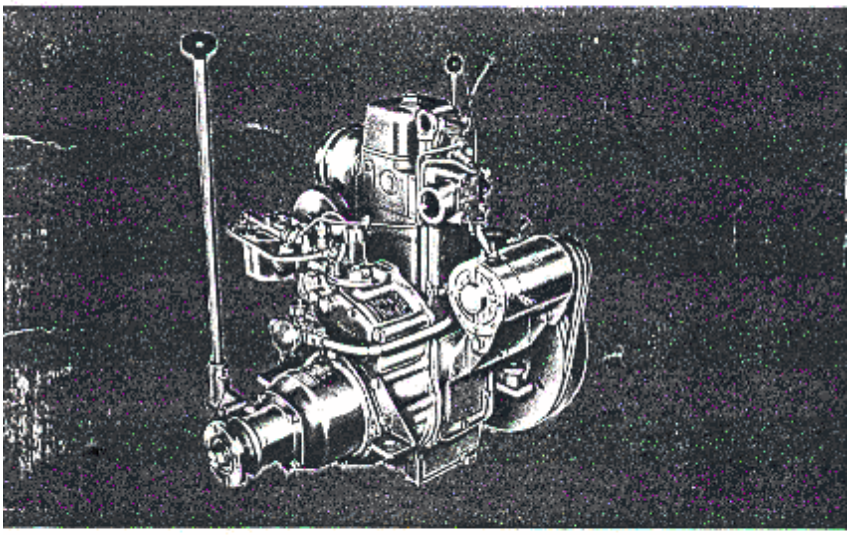
VOLVO PENTA

MD 1

MARINE DIESEL ENGINE



INSTRUCTION BOOK

Volvo Penta Service

Your Volvo Penta marine engine consists of a large number of component parts running in close co-operation with each other, and regular servicing and inspection is necessary to ensure the best running. In order to make this possible, Volvo Penta has built up an extensive service network. In all larger towns all over the world you will find modern workshops with specially-trained personnel at your service.

Volvo Penta dealers and service stations are equipped with the necessary special tools and also have comprehensive stocks of spare parts, which is your guarantee for genuine Volvo Penta spare parts.

Guarantee

Every engine is accompanied by a warranty booklet which provides the original purchaser with a guarantee against any fault in manufacture or assembly. The extent of the guarantee is set out in the warranty certificate, which we would ask you to study closely. In order for our guarantee to be valid, however, maintenance directions given in this instruction book must be complied with and in case of any doubt we would ask you to contact our authorized dealer.

In order to ensure prompt service, you should always state the engine type designation and serial number in all correspondence. The serial number is located on the transmission cover on the starboard side of the fuel injection pump.

PRESENTATION

Engine type MD 1

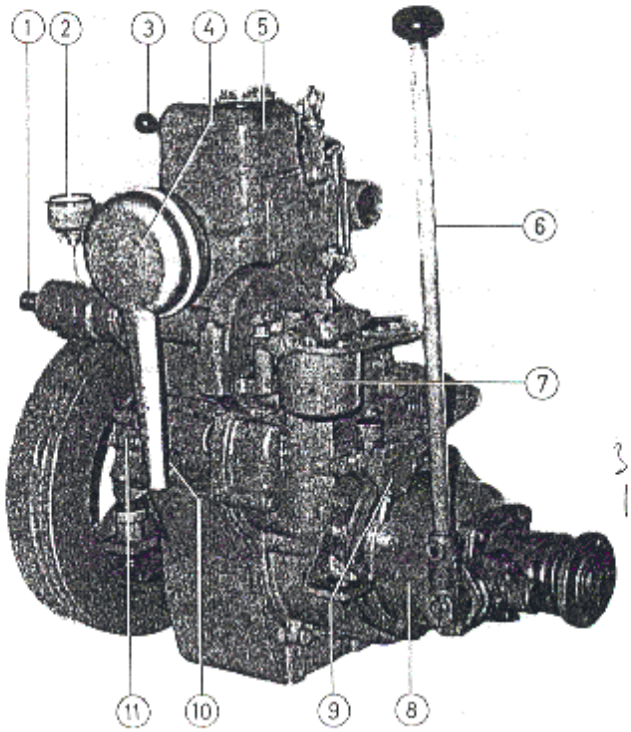


Fig. 1. Port side of engine.

1. Shaft for starting handle
2. Oil pressure gauge (not on engine with electrical equipment)
3. Decompression lever
4. Air cleaner
5. Valve cover
6. Maneuvering lever
7. Fuel filter
8. Reverse and reduction gear
9. Sea-water pump
10. Oil dipstick
11. Reducing valve

Engine type MD 1 is a 1-cylinder, 4-stroke marine diesel engine with overhead valves. The total displacement is 0.445 litres (27 cu.in.). The combustion chamber is designed for direct injection of the fuel, which means lowest possible fuel consumption, smooth vibration-free running and immediate starting.

PRESENTATION

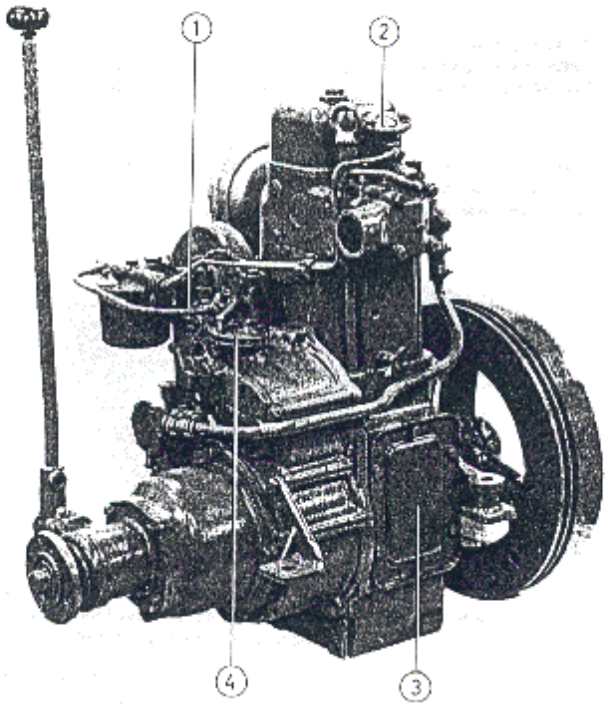


Fig. 2. Starboard side of engine.

1. Fuel injection pump
2. Injector
3. Inspection cover
4. Control arm

The fuel system includes an efficient replaceable fuel filter which protects against interruptions in running.

The engine is lubricated through a pressure lubricating system where an oil pump delivers the correct amount of lubricating oil to all lubricating points at any given RPM.

The engine is equipped with hand starting. Electrical starting is optional. To facilitate starting there is a decompression device on the cylinder head.

PRESENTATION

The engine is seawater-cooled. A thermostat automatically maintains the operating temperature within the most suitable range.

The connecting rod bearing shell is accessible through the inspection door on the crankcase. Also major repairs can be carried out through this door without it being necessary to lift the engine off the bed.

The engine has an enclosed crankcase ventilation system to prevent vapor from entering the engine room. The system consists of a filter with connections and an oil trap built into the space above the tappets. Through this system the vapor in the crankcase is sucked directly into the air intake manifold and into the cylinder.

Engine and marine equipment are designed for maximum length of life and safety. During the production all parts have been subjected to a most severe inspection with highest demands on quality.

All parts subject to wear are easily replaceable and spare parts are available, machined to the exact tolerances.

The power is transmitted from the engine to the propeller shaft through a reverse gear type Volvo Penta BB with reduction 1.87:1.

Instruments

Engine with hand starting

Engines with hand starting are fitted with an oil pressure gauge (2, Fig. 1) showing the oil pressure in the engine lubricating system. When the engine is warm and idling, the pressure should be 1.5—2.5 kg/cm² (22—36 lb./sq.in.).

Engine with electrical equipment

Engines with electrical equipment have an oil pressure warning lamp, charging control lamp, key switch, starter button and switch for extra light mounted on one instrument panel. Engines with electrical equipment do not have any oil pressure gauge (2, Fig. 1).

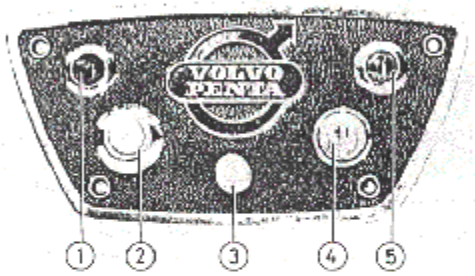


Fig. 3. Instrument panel for engine with electrical equipment.

① **Charging control lamp**
During normal running the charging control lamp should be out, which indicates that the generator is charging.

② **Starter button**
When the button is pushed in, a relay is connected and the starter-generator operates as an electrical motor and turns the engine crankshaft through V-belts.

③ **Switch**
This switch can be used for turning on and off an extra light.

④ **Key switch**
The key is used to switch on the current. It should be engaged when the engine is running — disengaged when the engine is stopped.

⑤ **Oil pressure warning lamp**
This lights up when the oil pressure is too low. When the engine is running, the warning lamp should be out, which indicates that the oil pressure in the engine is sufficient.

Running Instructions

Procedure before starting

1. Check the oil level in the engine crankcase (see "Servicing", page 32). The oil dipstick is unscrewed by turning it anti-clockwise. The oil level should be between the two marks on the dipstick and should never be allowed to go down below the lower mark. When necessary, top up with Diesel lubricating oil "Service DS" of the same make as earlier used in the engine through the filling hole on the valve cover. **Make sure that the dipstick is screwed on properly again.**

   NOTE. **The oil sump is common to engine and reverse gear and the oil level for both is checked with the same dipstick.**

2. Tighten the grease cup on the sea-water pump one turn (see "Servicing" point 2).

3. Check the fuel level in the tank and open the cock for fuel feed to the engine.

   If the engine has been out of operation for a longer period, air-vent the fuel system in accordance with the instructions given under "Servicing" point 9.

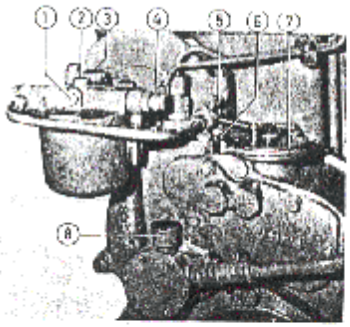


Fig. 4. Fuel injection equipment.

1. Air-vent screw
2. Center screw
3. Filler plug
4. Connection for leak-off fuel pipe
5. Air-vent screw
6. Cold starting control rod
7. Speed control arm
8. Grease cup (sea-water pump [1])

[1]) The sea-water pump is "lub.-tested for life" from engine no. 12128 and has no grease cup from this no.

4. Check that the cooling system drain cock is closed. Open the sea-cock for the cooling water intake.
5. Switch on the master switch for the electrical system, if such a switch is fitted.

Starting

1. Put the reverse gear lever in neutral position (middle position).
2. Move the speed control lever fully forwards.

3a. **Engine with electrical starting.** Switch on the main (key) switch and check that the charging control and oil pressure warning lamps light up. Press the starter button. Immediately after the engine has started, release the starter button and move the speed control lever back so that the engine will run at fast idling RPM.

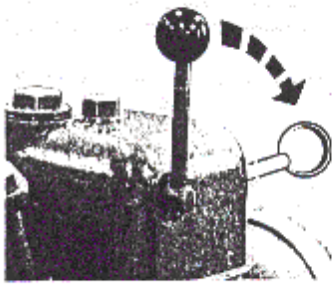


Fig. 5. Decompression lever
Lever in vertical position = Starting
Lever in horizontal position = Running

3b. **Engine with hand starting.** Put the decompression lever in vertical position (Fig. 5). Crank the engine as quickly as possible by means of the starting handle and move the decompression lever to its horizontal position during continued cranking. The starting is facilitated by using the cold starting device.

Move the throttle lever back to the position for fast idling RPM as soon as the engine has started.

NOTE.

Never race a cold engine. When the lubricating oil is cold, it is so thick that it cannot immediately penetrate into all the lubricating points in the engine so there is always risk for seizing. Run the engine warm under light loading or at rapid idling RPM.

Starting in cold weather

To facilitate starting in cold weather, the fuel injection pump is fitted with a cold starting device. This is engaged by pressing down the rod at the front end of the pump (6, Fig. 4). Before hand-starting, crank the engine slowly a few revolutions with the decompression lever in vertical position

If an engine with electrical starting does not start at the first try, make a short pause before next try to give battery and starter motor a chance to recover.

Note! The speed control lever must always be moved to the full speed position before the cold starting device is engaged. The cold starting device is automatically released when the engine has started and reached the number of revolutions which corresponds to the actual setting of the speed control lever. Do not race a cold engine. After letting the engine run warm, check that the cold starting device is disengaged.

Procedure after starting

1. **Check the oil pressure immediately after the engine has started. Under no conditions must the engine be operated with too low oil pressure.** If the engine is fitted with electrical equipment, the warning lamp goes out when the minimum pressure has been reached. If the engine is fitted with oil pressure gauge (engine with hand starting) the minimum reading should be 1.5 kg/cm² (22 lb./sq.in.).

   Normal reading is 1.5—2.5 kg/cm² (22—36 lb./sq.in.) when the engine is warm and running at idling RPM. When the engine is cold, the pressure is somewhat higher.

2. If the engine is fitted with electrical equipment, check that the charging control lamp goes out when the engine speed exceeds idling RPM. This indicates that the generator is charging. If the lamp is on at higher RPM, something is wrong.

3. Check the cooling water circulation by observing that the water is being discharged overboard.

Maneuvering

To protect the gears, all operations of the reverse and reduction gear should be carried out with the engine running at idling speed. "Ahead" is engaged by moving the maneuvering lever forwards, "Astern" by moving it backwards.

Do not let the gear slip but make sure that the lever is moved far enough to ensure positive engagement in the "Ahead" and "Astern" positions. Each operation should be carried out quickly and decisively.

Stopping

1. Let the engine run a few minutes at idling speed before it is stopped.

2. Move the speed control to "0" position or turn the lever at the fuel injection pump clockwise. This actuates the pump in such a way that the fuel feed is cut off. The engine should not be stopped by using the decompression lever.
3. If the engine is fitted with electrical equipment, switch off the current by turning the key when the engine has stopped. Otherwise the battery will be discharging. In case the engine is not to be used for any length of time, turn off also the master switch and close the fuel cock and the sea-cock.
4. When there is risk of frost the cooling system should be drained.

Running-in

When your engine is new or after it has been reconditioned, it must be run with care. The reason for this is that during this first period all vital parts in the engine wear in together. Never use full engine output for more than short periods during the first 20 hours. It is particularly important to ensure that the engine is not run at full load for longer periods. After the first 20 hours the load may be increased successively but it always pays in the long run to exercise a certain amount of care during a further period. The cylinder head nuts should be re-tightened after about 20 hours running. See "Servicing", point 5.

Always keep an eye on the instruments, particularly during the running-in period.

Before the marine engine left the factory, we made sure, through precision control procedures, that bearings and tolerances were correct. For this reason we cannot accept any responsibility for damages resulting from careless running-in.

Oil changes during the running-in period

During the running-in period the lubricating oil must be changed more often than is necessary later on. The first oil change should be carried out after 20 hours running. After that the oil should be changed every 50 hours. Never flush the engine with flushing oil. The bearing pressures in a diesel engine are too high to permit the use of this type of oil.

Precautions in case of frost

When there is risk of frost, the cooling system should be drained in accordance with the instructions given below to prevent damage to the engine block. Check that all water has been discharged by sticking a piece of wire or similar into the drain cock. This to make sure that the cock has not become clogged by dirt that prevents complete draining.

Draining the cooling system

1. Open the drain cock on the starboard side of the cylinder block (2, Fig. 6).
2. Shut the sea-cock, loosen the cover on the sea-water pump (1) and make sure that the pressure pipe for the cooling water is drained.
3. Drain the suction pipe from the sea-cock.

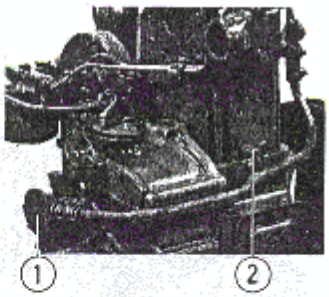


Fig. 6. Cooling water draining.

1. Cover on sea-water pump
2. Drain cock

DESCRIPTION

Engine unit

Cylinder and crankcase

The cylinder is mounted in the upper part of the crankcase. It is kept in position by the cylinder head which is tightened with long stud bolts in the crankcase. The cylinder is surrounded by a cooling jacket.

The crankcase is made of cast-iron and fitted with an inspection cover.

Cylinder head and valves

The cylinder head is made of cast-iron. In the head the water-cooled copper sleeve for the injector and the exchangeable valve guides are mounted.

The valves are of the overhead type. They are actuated by the camshaft through tappets, push rods and rocker arms.

A decompression device is built into the valve cover. When it is engaged, the exhaust valve is opened somewhat, thus making it possible to start the engine by hand.

Crankshaft and bearings

The crankshaft is drop-forged of steel and carried in two main bearings which consist of white metal lined steel bushings.

The journal is surface-hardened.

The rear main bearing is fitted with flanges and serves as a thrust bearing for the crankshaft. A rubber sealing ring is located at the flywheel and inside this there is a labyrinth packing.

Camshaft and tappets

The camshaft is forged and has surface-hardened cams. It is driven from the crankshaft through quiet-running timing gears.

The tappets are actuated directly by the camshaft. They are located in ground holes in the block above the shaft and transfer the movement to the valves through push rods and rocker arms.

Connecting rod, piston, piston rings

The connecting rod is made of drop-forged steel. The piston pin bearing consists of a finely machined bushing. The connecting rod bearing

consists of a precision made replaceable bearing shell of steel, lined with indiumplated lead-bronze.

The piston is of light-alloy, having three compression rings and two oil rings. The upper compression ring is chromed to reduce cylinder wear. The combustion chamber consists of a heart shaped recess in the piston crown.

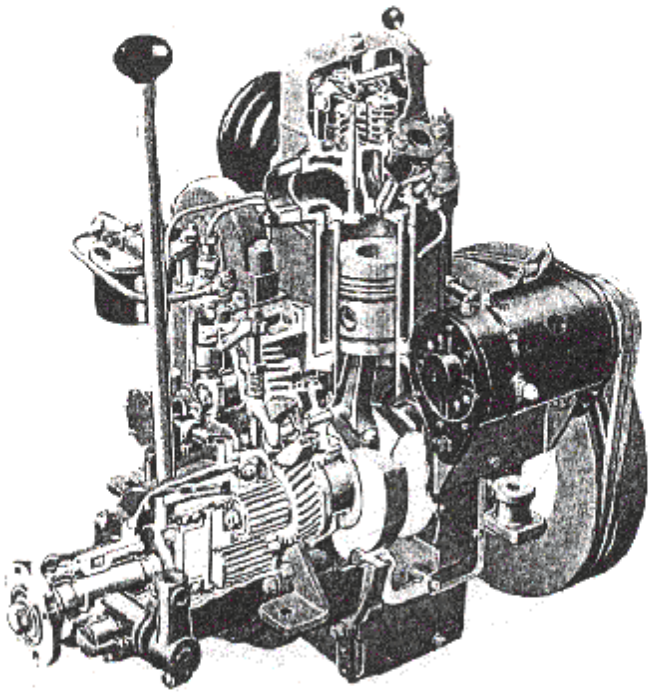


Fig. 7. Cut-away view of engine.

DESCRIPTION

Lubricating system

The engine is provided with a complete pressure lubrication system as schematically shown in Fig. 8. Pressure is produced by a so called wing pump which forces the oil through channels out to the lubricating points. The pump is driven through a coupling from the camshaft.

The oil is drawn from the sump through the oil pump strainer and then fed through a reducing valve built into the pump to prevent the oil pressure from reaching excessive values. The oil is then fed out into a channel that branches off to all main, connecting rod end camshaft bearings and up to the valve mechanism. An oil pressure sensing unit and warning lamp or an oil pressure gauge is connected to the lubricating system to provide means of checking the oil pressure.

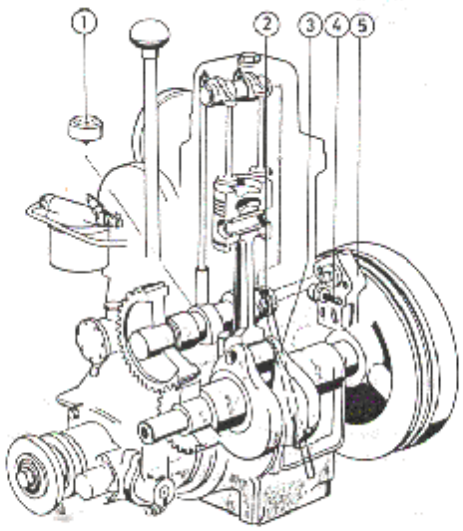


Fig. 8. Lubricating system.

1. Oil pressure gauge (engine with hand starting)
2. Oil dipstick
3. Oil strainer
4. Reducing valve
5. Oil pump

Fuel system

The fuel system consists of fuel filter, injection pump with governor, injector, pipe-lines and fuel tank.

The fuel is forced through the fuel filter to the injection pump. The injection pump then forces the fuel at high pressure to the injector and the engine cylinder.

Leak-off fuel from the injector is returned to the fuel filter through a separate line.

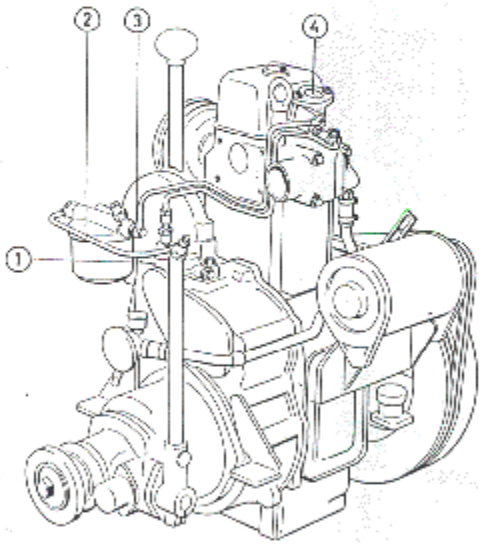


Fig. 9. Fuel system.

1. Fuel injection pump
2. Fuel filter
3. Pipe connection for leak-off oil
4. Injector

DESCRIPTION

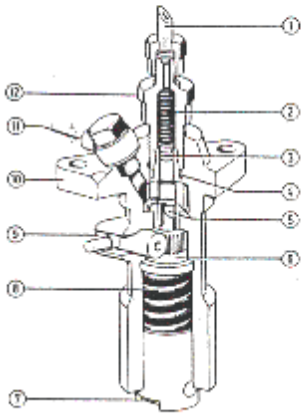


Fig. 10. Fuel injection pump.

1. Delivery pipe
2. Spring
3. Relief valve
4. Sealing ring
5. Pump element
6. Sleeve
7. Roller tappet
8. Spring
9. Link rod
10. Pump housing
11. Inlet
12. Delivery pipe connection

Fuel injection pump

The fuel injection pump is flange mounted on a housing above the rear end of the engine. It is driven through a cam mounted on the camshaft extension. The pump is of the piston-type and works with a constant stroke.

The injection pump consists of a plunger and a barrel which is closed at the top by means of a spring loaded pressure valve. From this valve the delivery pipe leads to the injector.

By means of the control arm and the link rod the pump plunger can be turned while it is operating and the amount of fuel to be injected can thus be changed.

For this purpose the bottom of the plunger is slanted and the injection will therefor end earlier or later depending on the position of the plunger.

The plunger is turned by a sleeve which actuates the lower end of the plunger. When the plunger is turned so far that the vertical groove reaches the inlet channel, the fuel injection ceases because the fuel is no longer subjected to any increase in pressure.

Centrifugal governor

The centrifugal governor is built into the housing at the injection pump and, while the engine is running, regulates the set engine speed within the engine speed range by changing the amount of fuel, in-

jected into the cylinder. The governor hub, with two centrifugal weights, is mounted on a shaft that is driven by the transmission. The centrifugal weights actuate a sleeve. When the engine RPM increases or decreases, this sleeve, in its turn, actuates the injection pump link rod through a spring-loaded lever in such a way that at decreasing speed the link rod is moved toward increased fuel injection and vice versa.

Fuel filter

The engine is fitted with a replaceable fuel filter which separates any impurities in the fuel.

On the filter there are inlet and outlet connections, an air-vent screw and a connection for the return line from the injector. The filter element consists of a spirally-wound paper filter.

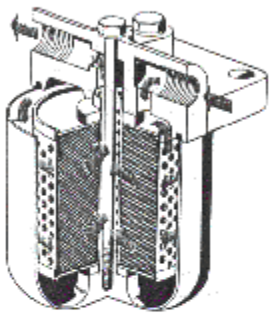


Fig. 11. Fuel filter.

Injector

The function of the injector is to atomize the fuel and feed the cylinder with the exact amount of fuel supplied by the injection pump. To ensure that the fuel is "broken up" effectively, the injection takes place under extremely high pressure.

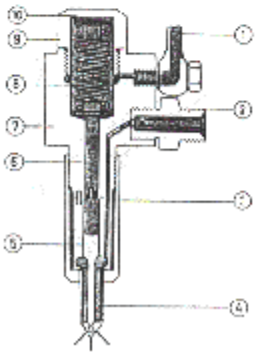


Fig. 12. Injector.

1. Return pipe for leak-off oil
2. Delivery pipe connection
3. Nozzle cap nut
4. Nozzle
5. Nozzle needle
6. Push rod
7. Injector body
8. Spring
9. Cover
10. Shim washer

DESCRIPTION

The fuel fed from the injection pump (shown in red in Fig. 12) passes a channel in the screw union and the injector body and is then forced on to the nozzle itself. The movement of the nozzle needle is regulated by the fuel pressure and a spring. When the fuel fed to the nozzle reaches a certain pressure, the needle is lifted and the fuel is injected in a finely atomized form into the combustion chamber through carefully calibrated holes in the nozzle.

Cold starting

The cold starting device is operated by means of a spring-loaded rod (6, Fig. 4). When the rod is pushed down, the screw for maximum amount of fuel is moved in such a way that the control lever turns the plunger further toward increased fuel amount. When the engine has started, the governor pulls back the lever and the rod, actuated by the spring, moves to its operating position.

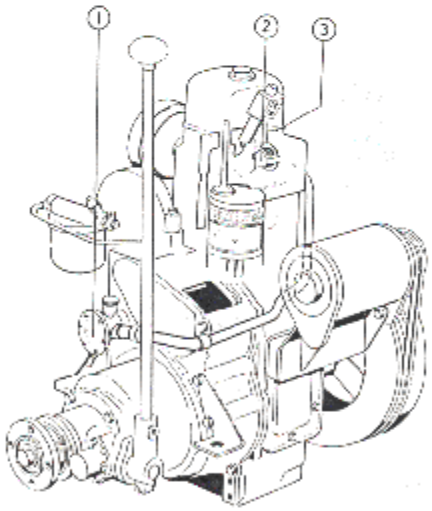


Fig. 13. Cooling system.

1. Sea-water pump
2. Thermostat
3. Distributing housing (thermostat housing)

Cooling system

The engine is sea-water cooled.

To obtain efficient cooling water circulation the engine is equipped with a sea-water pump. The pump is mounted on the transmission cover and is driven by the camshaft. The impeller is made of neoprene rubber and works against a cam. The function is shown in Fig. 14.

The pump (1, Fig. 13) sucks raw water through the outside strainer and forces it to the distributing housing (thermostat housing).

From the distributing housing there are two ways for the cooling water. When the engine is started from cold, the water flows into the engine and fills the cooling water channels. The thermostat (2) in the thermostat housing keeps the outlet from the engine closed at the same time as it keeps the pipe from the distributing housing (3) above the thermostat open. The water in the engine is therefor quickly warmed up while the water being delivered by the sea-water pump by-passes the engine above the thermostat valve.

When the engine has obtained its normal operating temperature, the thermostat opens the outlet from the engine at the same time as it chokes the by-pass pipe from the distributing housing above the thermostat. In this way the thermostat controls the cooling water circulation in the engine in such a way that the engine temperature is always kept within the most suitable range independent of the load.

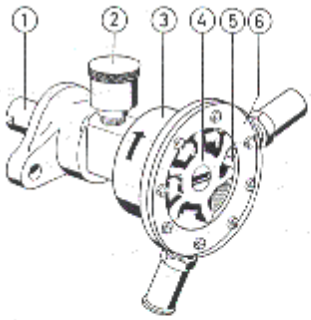


Fig. 14. Cooling water pump.

1. Shaft
2. Grease cup 1)
3. Housing
4. Impeller
5. Cam
6. Cover

1) On sea-water pump lubricated for 1-Air from engine no 12170 and has no grease cup from this no.

DESCRIPTION

Electrical system

Engines with electrical equipment 12 V are equipped with instrument panel, starter-generator and charging regulator.

The generator and the starter motor are built together as one unit. When the starting switch is engaged, a relay is actuated and the starter-generator works as motor. When the engine has started, the starting switch is disengaged and the starter-generator will function as generator.

The starter-generator is driven from the flywheel through V-belts.

CABLE DIMENSIONS		
Marked	sq.mm.	AWG or B & S number
A	2.5	13
B	25	3

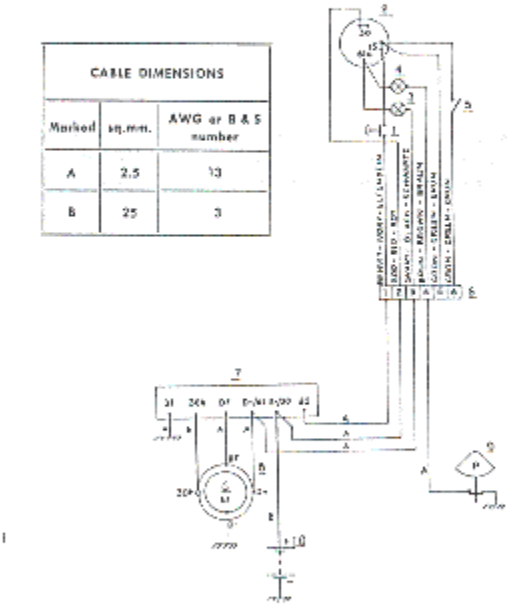


Fig. 15. Wiring diagram for engine with electrical equipment.

1. Starter button
2. Key switch
3. Charging control lamp
4. Oil pressure warning lamp
5. Extra switch
6. Terminal board for instrument panel
7. Charging regulator
8. Starter-generator
9. Oil pressure sensing unit
10. Battery, 12 V, max. 60 Ah

Reverse and reduction gear

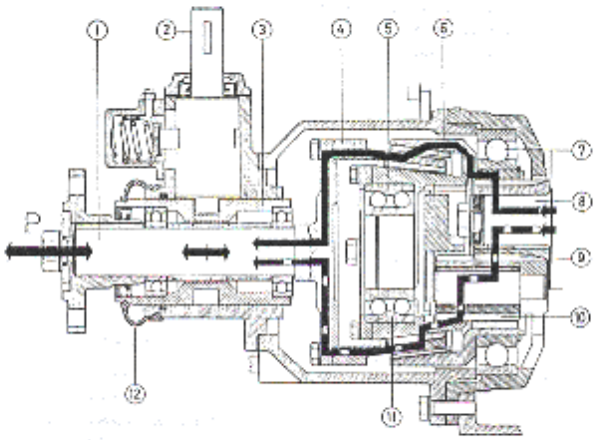


Fig. 16. Reverse and reduction gear.

"Ahead" = Thick red unbroken line
"Astern" = Thick red broken line
P = Propeller thrust

1. Output shaft
2. Manoeuvering shaft
3. Bearing sleeve
4. Cone
5. Gear with cone
6. Gear with cone
7. Ball bearing
8. Input shaft
9. Input shaft gear
10. Reverse gear
11. Ball bearing
12. Sealing

Reverse and reduction gear

Volvo Penta reverse and reduction gear type RB has a built-in reduction gear with ratio 1.87:1. "Ahead" or "Astern" is engaged through self-adjusting cones which are kept in engaged position partly by means of the propeller thrust. The oil sump is common to engine and reverse gear.

When "Ahead" is engaged, the output shaft and its cone are moved forwards and interlocks with the front cone. The power from the engine is transmitted from the gear on the crankshaft to the inner gear ring on the front cone.

When "Astern" is engaged, the output shaft is moved backwards and the rear cone is interlocked. This is driven through an intermediate gear and the rotation of the output shaft thus is reversed.

DESCRIPTION

Lubricating oils and fuels

Engine lubricating oils

Modern high-speed marine Diesel engines require high-quality Diesel lubricating oils to ensure maximum operating economy and top performance with a minimum of running interruptions. It is therefor essential that the correct grade of lubricating oil is used. For these engines only Diesel lubricating oil of grade "Service DS" in accordance with the API system must be used.

Fuels

The fuel to be used for the engine must be of a suitable composition and above all free from impurities. Therefor only use fuel oils of a well-known make.

Suitable fuels are the special Diesel fuel oils for high-speed engines which are available from all well-known oil companies. Never use fuels of inferior quality, as these contain impurities which easily cause functional disturbances in the injection pump and injectors.

Maintenance scheme

The numbers of the servicing procedures listed below refer to the detailed descriptions on the following pages. Some of these operations require special training and the use of special tools. These operations should therefor be carried out by authorized service personnel.

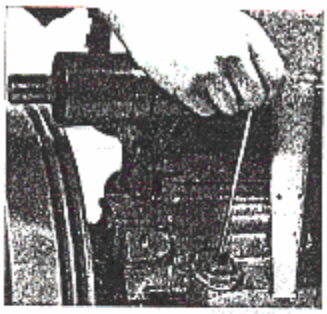
See point	Operation	To be carried out: Daily before first start	After[1] 50 hours running	After[1] 100 hours running
	Lubrication			
1	Check oil level in engine and reverse gear	●		
2	Lubricate the sea-water pump	●[6]		
3	Change oil in engine and reverse gear		●	
	Engine unit			
4	Check V-belts (engine with electrical starting)		●	
5	Re-tighten cylinder head nuts			[5]
6	Check valve clearances			●
7	Clean the air filters		●	
8	Clean the oil strainer			[5]
	Fuel system			
9	Change fuel filter element. Air-vent the fuel system			[2]
10	Check the injector			[3]
	Cooling system			
11	Check the cooling system			[3]
	Electrical system			
12	Check electrolyte level in battery	●		
13	Check the state of charge of battery			●
14	Check starter-generator			[3]
	Reverse and reduction gear			
15	Check the reverse gear			[3]
	General inspection			
16	Check and inspect the fuel injection pump			[3]
17	Compression test			[3]
18	Preparing engine for storage			[4]

[1] Or once each season if this occurs first. [2] After 300 hours or once each season.
[3] After 1000 hours or every third year. [4] When necessary. [5] When reconditioning.
[6] The sea water pump is "lubricated for life" from engine no 12178

SERVICING

Lubrication

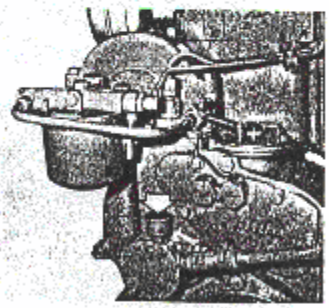
❶ Check oil level in engine and reverse gear



Check the oil level every day before starting for the first time. This is done by using the dipstick on the port side of the engine which has to be unscrewed. Before measuring, wipe the dipstick with a clean rag to avoid a faulty reading. The oil level should be between the two marks on the dipstick. Never allow the oil level to fall below the lower mark on the dipstick but do not let it rise above the upper mark either, since this will cause excessive oil consumption. When necessary, top up with Diesel lubricating oil "Service DS" through the filling hole which is located on the valve cover. Tighten the dipstick properly.

It is not necessary to check the oil level in the reverse gear, since the oil sump is common to engine and reverse gear. Thus the oil level in the reverse gear is checked at the same time as the oil is checked in the engine.

❷ Lubricate the sea-water pump 1)



The grease cup on the sea-water pump should be tightened one turn every day before the engine is started for the first time. When the cup has been screwed down as far as it goes, it has to be dismounted and filled with multipurpose grease.

❸ Change oil in engine and reverse gear

The oil must be changed after every 50 hours running or at least once a season. During the running-in period the oil should be changed more frequently (see "Running-in" page 10). The oil sump is common to engine and reverse gear.

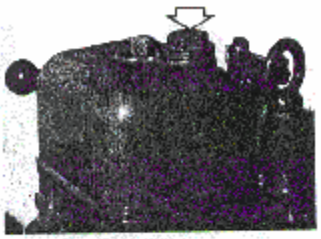
Before changing the oil, the engine must be run warm. The oil is

1) The sea-water pump is [illegible] on engines no. 12175 and has no grease cup but this nut.

drawn up from the crankcase by means of the crankcase pump which is included in the tool kit.

The oil filling is done through the hole on the valve cover as shown by the arrow on the picture. Never use flushing oil.

Use Diesel lubricating oil "Service DS" in accordance with the API system.

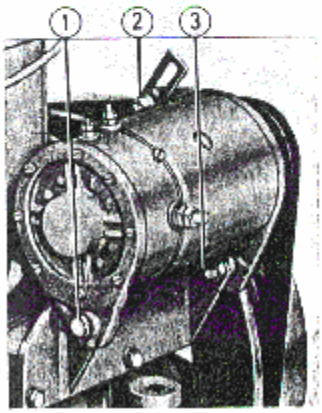


OIL GRADE	VISCOSITY between −10° C (14° F) and +20° C (68° F)	VISCOSITY above +20° C (68° F)	OIL CAPACITY excluding oil cleaner
Service DS	SAE 10W	SAE 20	1.5 litres (1.7 Imp. qts.) (1.4 US qts.)

Engine unit

❹ Check V-belts (Engine with electrical starting)

The V-belts should be checked after every 50 hours running. Wear or dirt may cause the belts to start slipping. Check the belt tension by pressing down the belts midway between the starter-generator and the flywheel. It should be possible to press down the belts about 3—4 mm (⅛") with normal thumb pressure. If the tension is too low, loosen the adjusting bolt (2) and the bolts (1 and 3) at the attaching points of the starter-generator. Pull the starter-generator outwards and tighten the bolts.

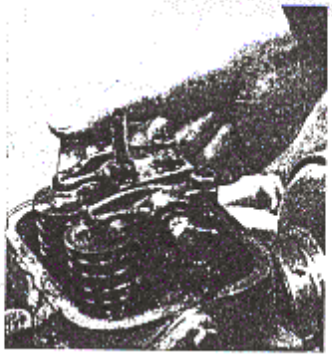


❻ Re-tighten cylinder head nuts

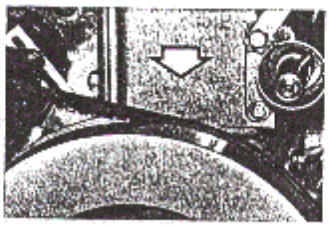
When the engine is new or if the cylinder head has been removed, the cylinder head nuts have to be re-tightened after about 20 hours running. This should be done when the engine is warm. The nuts should also be re-tightened once every season. A torque wrench should be used both when tightening for the first time and re-tightening the cylinder head. Regarding torque figures, see "Technical Data". The valve clearances should always be adjusted after the cylinder head nuts have been tightened.

❻ Check valve clearances

The valve clearances should be checked after every 100 hours running or once every season. Too small valve clearances can easily cause burned valve seats. When adjusting the valves, the engine should be warm. The clearance should be 0.30 mm (0.012") for the inlet valve and 0.35 mm (0.014") for the exhaust valve. The valves must not be adjusted when the engine is running.



Watch the valves while cranking the engine by means of the starting handle. When the inlet valve begins to open and the exhaust valve closes, the "0" mark on the flywheel is in its highest position as shown in the picture. Then crank the engine one more turn. Check and, if necessary, adjust the valves for the cylinder.

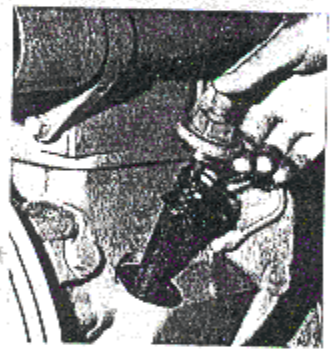


❼ Clean the air filter

The air cleaner should be removed and cleaned after every 50 hours running.

1. Loosen the clamp with a screwdriver and remove the cleaner.
2. Wash the air cleaner in fuel oil. Soak it in engine oil.
3. Allow the engine oil to run off and fit the cleaner.

❽ Clean the oil strainer



The oil strainer should be removed and cleaned when recondition of the engine is done.

1. Loosen the square nut for the strainer. Remove the strainer.
2. Wash the strainer in fuel oil and put it back. Tighten the nut properly.

Fuel system

❾ Change fuel filter element

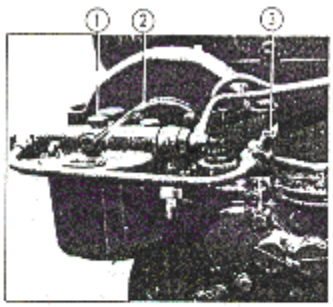
The fuel filter element should be changed after every 300 hours running or at least once every season. The element must never be cleaned but has to be replaced by a new element.

1. Clean the filter housing and cover carefully on the outside. Unscrew the center bolt (1) on the upper side of the filter housing and remove this.
2. Remove the element and wash the housing with clean Diesel fuel oil.
3. Fit a new element and washers and tighten the center bolt. Air-vent the system as follows.

SERVICING

Air-venting

1. Open the air-vent screw on the fuel filter (2).
2. Allow about 0.5 litre (about 1 pint) of fuel to pass out. Close the air-vent screw.
3. Open the air-vent screw (3) on the injection pump and let the fuel pass out through this air-vent screw until it is free from air-bubbles. Close the air-vent screw.



⑩ Check the injectors

The injector should be removed at regular intervals and taken to a Diesel workshop for cleaning and a check on opening pressure, leakage and spray pattern. We recommend an interval of about 300 hours of operation between these inspections.

Removing

1. Clean the injector, delivery pipe and cylinder head around the injector.
2. Unscrew the delivery pipe and leak-off line from the injector. Fit protective caps.
3. Loosen the two nuts over the yoke holding the injector to the cylinder head and lift up the injector.

Fitting

1. Check that the contact surfaces on the injector and the copper sleeve are clean.
2. Push down the injector into position and fit the yoke but do not tighten the nuts.
3. Connect the delivery pipe. Make sure that the pipe flange is in correct position. Do not forget to fit the clamp in position, otherwise the life of the delivery pipe will be shortened.
4. Tighten the retaining nuts on the yoke. The tightening torque should be 2 kgm (15 lb.ft.). Connect the return line.

Cooling system

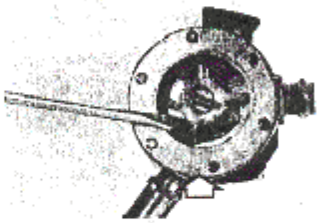
⓫ Check the cooling system

The cooling system should be checked after every 300 hours running or at least once every season for leakage, blockage etc.

Changing impeller in the sea-water pump

When the impeller has to be replaced, proceed as follows.

Unscrew the slotted screws on the cover and remove this. Insert two screwdrivers and force out the impeller by exerting leverage on the pump housing (see Fig.). Remove any pieces of the impeller that may be left in the housing.



Press in the new impeller. Fit the gasket and cover. Make sure that there is always a spare impeller on board.

Electrical system

⓬ Check electrolyte level in battery

If the battery is to operate without trouble, the electrolyte level has to be checked at regular intervals. The electrolyte level should be 5—10 mm (3/16—3/8") above the cell plates.

Add distilled water when necessary. Never add too much, since this can cause the electrolyte to splash over and cause damage. **Never check the level by using a lighted match, as the gas formed in the cells is explosive.**

⓭ Check state of charge of battery

The state of charge of the battery should be checked after every 100 hours running. This should be done by using a hydrometer showing the specific gravity of the electrolyte which varies with the state of charge (see under "Technical Data").

If the specific gravity has fallen to the lowest value stated, the battery must be re-charged at a charging station.

During the winter it is particularly important to ensure that the batteries do not become discharged. The electrolyte in a discharged battery freezes at about –20° C (–4° F), which means that the battery will be ruined. When examining the state of charge, also check that the terminal posts and cable ends are well-tightened and coated with grease or vaseline. If necessary, they should be wiped with a piece of rag or brushed with a wire brush and then a fresh coating of grease or vaseline should be applied.

Only use the starter motor for short periods when starting. High and prolonged loading will shorten the life of the batteries considerably.

⓮ Check starter-generator

Once every third year, or after about 1000 hours running, the starter-generator should be taken to an authorized workshop for general inspection.

Reverse and reduction gear

⓯ Check the reverse gear

The reverse gear is self-adjusting. In other words, no adjustments are necessary to compensate for wear.

The reverse gear should be checked regularly for oil leakage, abnormal noise level or excessive operating temperature. Once every third year, or after about 1000 hours running, the reverse gear should be inspected by an authorized workshop.

General inspection

⓰ Check and inspect the fuel injection pump

The function of the engine depends to a great extent on whether the fuel injection settings are correct. Since running conditions vary considerably, it is difficult to state any definite intervals but, as a rule, the pump should be removed and checked by personnel from an authorized Diesel workshop after every 1000 hours running or every third year.

NOTE. Repairs which necessitate disassembly of the internal parts of the pump and which may change the settings may only be carried out by authorized Diesel workshops with the necessary tools and test devices at their disposal. Any guarantee made becomes null and void if the seals are broken.

⑰ Compression test

A simple and reliable way to determine the condition of the engine is to carry out a compression test which indicates the degree of sealing in the cylinder. The test should be carried out when the engine is warm. The injector is removed and the compression pressure is tested. During the test the speed control should be in "0" position while the engine is turned round by the starter motor. The battery must be in good condition to ensure that the starter motor is capable of turning the engine with sufficient speed. With hand starting, proceed in the same way with the exception that the engine has to be cranked by hand as rapidly as possible.

The compression pressure, which is the same for engine with hand starting and engine with electrical starting, is shown under "Technical Data".

⑱ Preparing engine for storage

Even insignificant rust attacks on the precision-manufactured parts of the engine and marine equipment can mean serious impairment of their general condition.

If the engine is not to be used for less than a month, it should be started after 14 days and run warm.

If the engine is not to be used for more than a month, inhibiting in accordance with the following points is recommended.

Inhibiting

1. Run the engine warm after which it is stopped and the lubricating oil in the engine is pumped out with the help of the crankcase pump. The oil sump is common to engine and reverse gear.
2. Fill up the engine with inhibiting oil to the lowest mark on the dipstick. Suitable inhibiting oils are Esso Rust Ban 623, Shell Ensis Oil 20 or corresponding oils of another make.
3. Drain off the fuel oil in the fuel filter and replace the flexible fuel line from the tank by a hose. Place the hose in a can containing 1/3rd Esso Rust Ban 623 and 2/3rds fuel oil. Place the can so that there is a gravity feed to the filter connection.

SERVICING

4. Air-vent the fuel system and start the engine. Run the engine at rapid idling until about 1/4 litre (about 1/2 pint) has been used up from the can.
5. Stop the engine, pump out the inhibiting oil from the engine and then re-connect the fuel line.
6. Remove the injector and inject about 10 c.c. (1/3 fl.oz.) of inhibiting oil into the cylinder. Then crank the engine a few turns and fit the injector without final tightening.
7. Drain the cooling water in accordance with "Precautions in case of frost", see page 11. Remove all rubber hoses in the cooling system and plug the holes. Fill the cooling water channels of the engine with anti-rust oil Shell Donax C or similar through the thermostat housing after the thermostat has been removed.

   The engine must not then be cranked before being taken into use again. Attach a label which clearly indicates that the oil and cooling water have been drained and also the date on which it was inhibited.
8. Clean the engine externally and touch up any scraped-off spots with paint. Coat the engine with anti-rust oil.
9. Remove the battery from the boat and hand it in to a charging station. It must be maintained in a good state of charge in order not to be ruined.
10. Coat the metal parts of the maneuvering controls and cable connections with anti-rust oil.

Preparing engine for use again

1. Fit a new fuel filter. Fill the engine with lubricating oil (see "Servicing" point 3).
2. Take the battery on board and connect the battery cables. Coat the battery terminals with vaseline after tightening.
3. Remove the injector and turn the engine round with the starter motor so that any residual inhibiting oil on the piston top is blown out. Clean, inspect and fit the injector.
4. Check-tighten all bolts on the engine.
5. Fill up with fuel and carefully inspect the tank and lines to make absolutely sure that there is no leakage. Remove the plugs from the cooling water connections and connect the hoses. Fit the thermostat. Wipe up any spilled fuel and "air" the engine compartment.

6. Start the engine and check cooling water, oil pressure etc. Check the maneuvering and steering controls.
7. Check the supply of spare parts on board. Make sure that there is always a spare impeller for the sea-water pump on board.