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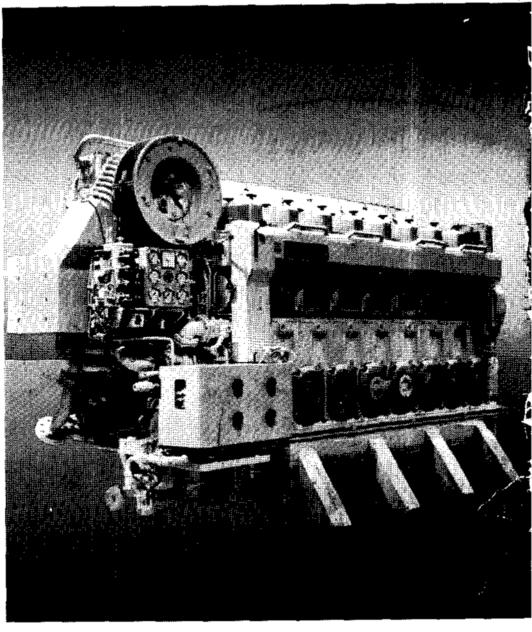
22 Wärtsilä Vasa Manual



Wärtsilä Vasa Manual

22 WÄRTSILÄ DIESEL

Tim BATCHELOR

22

This manual is for training purpose only

The only correct manual to be used for a specific installation or ship is the manual delivered with the engine

Wärtsilä Diesel takes no responsibility for eventual damages caused by incorrect information in this manual

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00. Contents, Instructions, Terminology

00. 1. Contents of the Instruction Book

1. This Instruction Book contains data and instructions for operation and maintenance of the engine. Basic general knowledge has not been entered. Consequently, it is assumed that the engine room staff is well informed of the care of diesel engines.

2. Wärtsilä reserves for itself the right to minor alterations and improvements owing to engine development without being obliged to enter the corresponding changes in this Instruction Book.

3. The diesel engines will be equipped as agreed upon in the sales documents. No claim can be made on the basis of this Instruction Book as here are described also components not included in every delivery.

4. Exact engine build-up in all details is defined by the specification number on the name plate located on the engine. **In all correspondence or when ordering spare parts, be careful to state engine type, specification number and engine number.**

5. This Instruction Book is supplemented by the Spare Part Catalogue including sectional drawings or exterior views of all components (partial assemblies).

00. 2. General rules

1. Before any steps are taken, carefully read the corresponding item in this Instruction Book.

2. Keep an **engine log book** for every engine.

3. At all maintenance work, observe the utmost cleanliness and order.

4. Before dismantling, check that all systems concerned are drained or the pressure released. After dismantling, cover immediately holes for lubricating oil, fuel oil and air with tape, plugs, clean cloth or the like.

5. When exchanging a worn-out or damaged part provided with an identification mark stating cylinder or bearing number, mark the new part with the same number on the same spot. Every exchange should be entered in the engine log and the reason should be clearly stated.

6. After reassembling, check that all screws and nuts are tightened and locked, if necessary.

00. 3. Terminology

The most important terms used in this manual are defined as follows:

Operating side. The longitudinal side of the engine where the operating devices are located (start and stop, instrument panel, speed governor).

Rear side. The longitudinal side of the engine opposite the operating side.

Driving end. The end of the engine where the flywheel is located.

Free end. The end opposite the driving end.

Designation of cylinders. According to ISO recommendation 932 and DIN 6265 the designation of cylinders begins at the driving end. In a V-engine the cylinders in the left bank, seen from the driving end, are termed A1, A2 etc. and in the right bank B1, B2 etc., see below:

Terminology

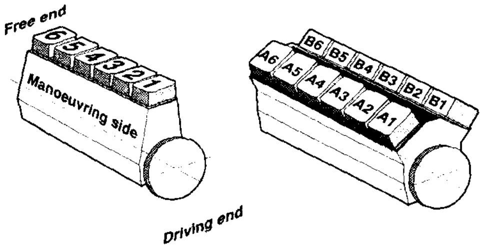

Fig 00-1 2200018932

Designation of bearings. The designation of bearings begins from the driving end. The thrust main bearing is No 1. If the engine is provided with an extra main bearing, a so-called shield bearing, this is termed 0. For the camshaft bearing the thrust bearing is No 0.

Clockwise rotating engine. When looking at the engine from the driving end the shaft rotates clockwise.

Counter-clockwise rotating engine. When looking at the engine from the driving end the shaft rotates counter-clockwise.

Bottom dead center, abbreviated **BDC**, is the bottom turning point of the piston in the cylinder.

Top dead center, abbreviated **TDC**, is the top turning point of the piston in the cylinder. TDC for every cylinder is marked on the graduation of the flywheel.

Top dead centre at firing. During a complete working cycle, comprising in a four-stroke engine two crankshaft rotations, the piston reaches TDC twice:

a) For the first time when the exhaust stroke of the previous working cycle ends and the suction stroke of the following one begins. Exhaust valves as well as inlet valves are then somewhat open and scavenging takes place. If the crankshaft is turned to and fro near this TDC, both exhaust and inlet valves will move, a fact that indicates that the crankshaft is near the position which can be named **TDC at scavenging.**

b) The second time is after the compression stroke and before the working stroke. Slightly before this TDC the fuel injection takes place (on an engine in operation) and this TDC can therefore be defined **TDC at firing.** Characteristic is that all valves are closed and do not move if the crankshaft is turned. When watching the camshaft and the injection pump it is possible to note that the pump tappet roller is on the lifting side of the fuel cam.

High temperature cooling water circuit (HT-circuit). The cooling water for the engine block, cylinder head and turbocharger.

Low temperature cooling water circuit (LT-circuit). The cooling water for the charge air cooler and the lubricating oil cooler.

01. Main Data, Operating Data and General Design

01. 1. Main data

Cylinder bore . . . . 220 mm
Stroke . . . . 240 mm
Piston displacement per cylinder . . . . 9.12 l

Firing order		
Engine type	Clockwise rotation	Counter-clockwise rotation
4R22	1-3-4-2	1-2-4-3
6R22	1-5-3-6-2-4	1-4-2-6-3-5
8R22	1-3-7-4-8-6-2-5	1-5-2-6-8-4-7-3
8V22	A1-B1-A3-B3-A4-B4-A2-B2	A1-B2-A2-B4-A4-B3-A3-B1
12V22	A1-B1-A5-B5-A3-B3-A6-B6-A2-B2-A4-B4	A1-B4-A4-B2-A2-B6-A6-B3-A3-B5-A5-B1
16V22	A1-B1-A3-B3-A7-B7-A4-B4-A8-B8-A6-B6-A2-B2-A5-B5	A1-B5-A5-B2-A2-B6-A6-B8-A8-B4-A4-B7-A7-B3-A3-B1

Normally, the engine rotates clockwise.

Lubricating oil volume in the engine						
Engine type	4R22	6R22	8R22	8V22	12V22	16V22
Oil volume c. litres	320	450	580	580	670	870
Oil volume between max. and min. marks c. litres/mm	60	100	125	100	150	195
Anticorrosive oil c. litres	65	90	110	90	130	160

Cooling water volume in the engine, c. litres						
Engine type	4R22	6R22	8R22	8V22	12V22	16V22
Engine and inverse cooling system	95	130	170	190	270	350

01. 2. Recommended operating data

Apply to normal operation at nominal speed.

	Normal values (xxx)		Alarm (stop) limits (xxx)	
	100 % load	30 % load	30-100 % l.	30 % load
Temperatures, (°C)				
Lube oil before engine	62...70	73...80	80	90
Lube oil after engine	10...18 higher	5...8 higher		
HT water after engine	90...95		105 (110)	
HT water before engine	5...8lower	2...3 lower		
HT water rise over turbocharger	8...12(15)	6...10		
LT water before engine	28...38	65...70		
Charge air in air receiver	40...60	60...70	75	-
Exhaust gas after cylinder	See test records		50 higher x)	
Preheating of HT and LT water	70			
Gauge pressures (bar)				
Lube oil before engine at a speed of 900 RPM	3.5...4.0	3	2.0 (1.5)	
1000 RPM	4.0...4.5	3.5		
1100 RPM	4.5...5.0	4.0		
1200 RPM	4.5...5.0	4.0		
LT and HTwater before pumps (=static)	0.7...1.5			
HT water before engine	2.0...4.5 xx)		xxx)	
LT water before charge air cooler	2.0...4.5 xx)		xxx)	
Fuel before engine	5...7		4	
Starting air	max. 30		18	
Charge air	See test records			
Other pressures (bar)				
Firing pressure	See test records			
Opening pressure of safety valve on lube oil pump	6...8			
Visual indicator and electronic transducer for high pressure drop over lube oil filter and fuel filter	1.2...1.8			

x) See section 20.4, 8- and 16-cylinder engines
xx) Depending on speed and installation
xxx) Alarm limit for main engine = idling pressure - 0.3 bar
xxxx) When using fuels with viscosities ≥ 380 cSt/50°C

01. 3. Reference conditions

Reference conditions according to ISO 3046/I:

Air pressure .... 100kPa (1.0 bar)
Ambient temperature .... 298K (25°C)
Relative air humidity .... 30 %
Cooling water temperature of charge air cooler ..... 298 K (25°C)

In case the engine power can be utilized under more difficult conditions than those mentioned above it will be stated in the sales documents. Otherwise, the engine manufacturer can give advice about the correct output reduction. As a guideline additional reduction may be calculated as follows:

$$(a + b + c)\ \%$$

a = 0.4 % for every °C the ambient temperature exceeds stated value in the sales document.

b = 0.8 % for every 100 m level difference above stated value in the sales document.

c = 0.3 % for every °C the cooling water of the charge air cooler exceeds stated value in the sales document.

01. 4. General engine design

The engine is a turbocharged intercooled 4-stroke diesel engine with direct fuel injection.

The engine block is cast in one piece. The main bearings are hanging. The main bearing cap is supported by two hydraulically tensioned main bearing screws and two horizontal side screws. The camshaft bearing sites are integrated. The charge air receiver is cast into the engine block as well as the cooling water header. The crankcase covers, made of light metal, seal against the engine block by means of O-rings. The lubricating oil sump is welded.

The main bearings are fully interchangeable trimetal which can be removed by lowering the main bearing cap.

The crankshaft is forged in one piece and is balanced by counterweights as required.

The connecting rods are drop forged. The big end is split diagonally and the mating faces are serrated. The small end bearing is stepped to achieve large bearing surfaces. The big end bearings are fully interchangeable trimetal or bimetal bearings.

The pistons are made of nodular iron and are cooled by oil. Cooling oil enters the cooling space through the connecting rod, gudgeon pin and bores in the piston and escapes through bores in the piston, matched to achieve optimal shaker effect. The piston skirt is pressure lubricated. The two top ring grooves are hardened.

The piston ring set consists of two chrome-plated compression rings, one combined compression and oil scraper ring and one chrome-plated, spring-loaded oil scraper ring.

The cylinder head, made of special cast iron, is fixed by four hydraulically tensioned screws.

The inlet valves are stellited and the stems are chromium-plated. The valve seat rings are made of a special cast iron alloy and are changeable.

The exhaust valves, also with stellited seats and chromium-plated stems, seal against the directly cooled valve seat rings.
The water cooler seat rings, made of a corrosion and pitting resistant material, are changeable.

The camshafts are made up from one-cylinder pieces with integrated cams. The bearing journals are separate pieces and thus it is possible to remove a camshaft piece sideways.

The injection pumps have integrated roller followers and can normally be changed without any adjustment. The pumps and piping are located in a closed space which is heat insulated for heavy fuel running.

The injection valve is completely embedded in the cylinder head. The injection pipe is connected sideways by a high pressure connection piece and therefore fuel oil can under no circumstances mix with lubricating oil.

The turbochargers are normally located at the free end of the engine but, at request, can also be located at the driving end on a V-engine.
On V12 and V16 engine there are two chargers, one for each bank.

The fuel system includes a feed pump and a duplex filter with a three-way cock.

The charge air coolers are made as removable inserts, on the V-engines two indentical ones (not 8V22).

The lubricating oil system includes gear pump, oil filter, cooler with thermostat valve, centrifugal bypass filter and an electrically driven prelubricating pump. The oil sump is dimensioned for the entire oil volume needed, and all cylinder numbers can be run in wet sump configuration. Dry sump running is also possible.

The starting system. The air supply into the cylinders is controlled by the starting air distributor run by the camshaft.
The four-cylinder engine is started by means of an air driven starting motor.

02. Fuel, Lubricating Oil, Cooling Water

02. 1. Fuel

02. 1. 1. General

The engine is designed to operate on heavy fuel (residual fuel) with a maximum viscosity of 130 cSt/80°C (approx 700 cSt/50°C, approx 7000 sec. RI/100°F) and will operate satisfactorily on blended (intermediate) fuels of lower viscosity, as well as on distillate fuel. Avoid the use of fuels having a lower viscosity than about 1.3 cSt at 40°C as such fuels may cause fuel injection pump plunger or fuel nozzle needle seizure.

The maximum limits of fuel characteristics for a certain engine are stated in the documentation delivered with the engine.

Blended fuels (residuals and distillate) with a viscosity between approx. 10 and 30 cSt/50°C (65 and 200 sec. RI/100°F) containing between 30 and 60 % distillate should, however, be avoided due to the risk of precipitation of heavy components in the blend, with filter clogging and large amount of centrifuge sludge as consequence.

When difficulties with filter clogging are experienced, fuel incompatibility can be tested by ASTM D 2781 method or similar.

02. 1. 2. Fuel treatment

1 Purification

Heavy fuel (residuals, and mixtures of residuals and distillate) must be purified in an efficient centrifuge before entering the day tank. The fuel is to be heated before centrifuging.

Recommended temperatures, depending on the fuel viscosity, are stated in the diagram, chapter 02,Fig 02-1.

Be sure that the correct gravity disc is used. Never exceed the flow rates recommended for the centrifuge for the grade of fuel in use. The lower the flow rate the better the efficiency.

Fuel in use						
Max. viscosity (cSt/80°C)	15	25	45	75	100	130
Approx. viscosity (cSt/50°C	40	80	180	350	460	700
Recommended centrifuge flow rate (% of rated capacity)	60	40	30	25	20	15

For marine diesel oil (max. viscosity 14 cSt at 40°C a flow rate of 80 % and a temperature of 45°C are recommended.

In case pure distillate fuel is used, centrifuging is still recommended as fuel may be contaminated in the storage tanks.

Rated capacity of the centrifuge may be used provided the fuel viscosity is less than 12 cSt at centrifuging temperature.

Marine Gas Oil viscosity is normally less than 12 cSt at 15°C.

2 Heating

See diagram, Fig 02-1. Keep the fuel temperature about 10°C above the minimum storage temperature indicated in the diagram in order to minimize the risk for wax formation and the temperature after the final heater 5 to 10°C above the recommended temperature before injection pumps to compensate for heat losses between heater and engine.

Fuel oil viscosity-temperature diagram

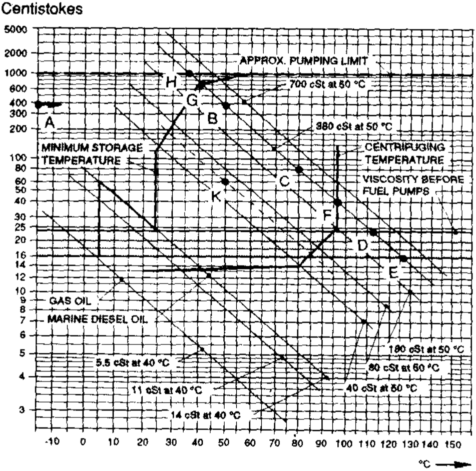

Fig 02-1 2202528936

***Example:** A fuel oil with a viscosity of 380 cSt (A) at 50 °C (B) or 80 °C (C) must be preheated to 115-130° C (D-E) before the fuel injection pumps, to 98 °C (F) at the centrifuge and to minimum 40 °C (G) in storage tanks. The fuel oil may not be pumpable below 36 °C (H).*

To obtain temperatures for intermediate viscosities, draw a line from the known viscosity / temperature point in parallel to the nearest viscosity / temperature line in diagram.

***Example:** Known viscosity 60 cSt at 50 °C (K). The following can be read along the dotted line: viscosity at 80 °C = 20 cSt, temperature at fuel injection pumps 74-87 °C, centrifuging temperature 86 °C, minimum storage tank temperature 28 °C.*

Conversion from varios current and obsolete viscosity units to centistokes can be made in the diagram, Fig 02-2. The diagram should be used only for conversion of viscosities at the same temperature. The same temperatures should then be used when entering the viscosity/temperature point into the diagram, Fig 02-1.

Viscosity conversion diagram

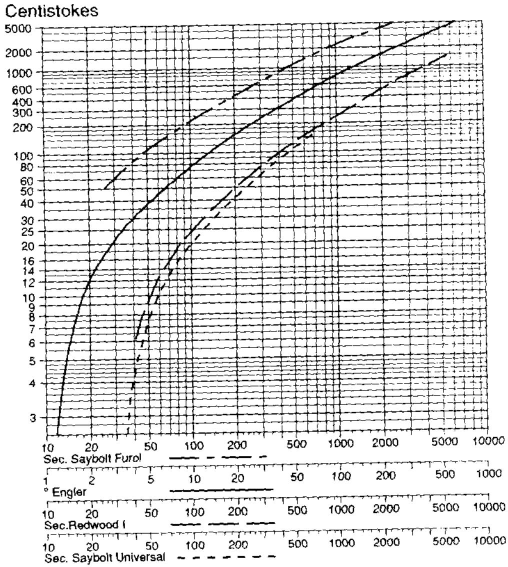

Fig 02-2 2202538935

When converting viscosities from one of the units on the abscissa to centistokes or vice-versa, keep in mind that the result obtained is valid only at one and the same temperature. When converting the viscosity in any unit at a given temperature to a viscosity at another temperature a viscosity-temperature diagram or conversion rule must be used.

3 Viscosity control
An automatic viscosity controller, or a viscosimeter, at least, should be installed in order to keep the correct viscosity of the fuel before the fuel enters the engine fuel system.

02. 1. 3. Maximum limits of fuel characteristics

The diesel engine Wärtsilä Vasa 22 is designed and developed for continuous operation, without reduction in the rated output, on fuels with the following properties:

Fuel characteristics, max. limits		Heavy fuel (HF)	Marine diesel fuel (MD)
Density	(g/ml)	1,010[1)]	
Viscosity, kinematic, at 80°C Viscosity, kinematic, at 40°C Viscosity, kinematic, at 50°C Viscosity, kinematic, at 100°F	(cSt) (cSt) (cSt) sRI	130 - 700 7000	- 14.00 11.00 70.00
Water content	(% by volume)	1.0	0.30
Water content (before engine)	(% by weight)	0.3	0.3
Sulphur content	(% by weight)	5.0	2.0
Ash content	(% by weight)	0.2	0.05
Vanadium content	(mg/kg)	600	100
Sodium content	(mg/kg)	50	50
Carbon residue, Conradson	(% by weight)	22	-
Carbon residue, Ramsbottom	(% by weight)	-	2.5
Asphaltenes	(% by weight)	14	-
Pour point, upper max.	(°C)	30	6
Aluminium content	(mg/kg)	30	30

The requirements above also correspond to the demands of:
- ISO 8217: 1987(E), ISO-F-RMH 55 and RML 55[1)]
- BS 6843: Part 1: 1987, ISO-F-RMH 55 and RML 55[1)]
- CIMAC 1986, class H 55 and K 55[1)]

[1)] Provided the fuel treatment system can remove water and solids.

02. 1. 4. Comments on fuel characteristics

1 Viscosity is no criterion of the fuel quality, but determines the complexity of the fuel heating and handling system, which should be considered when estimating installation economy.
The standard engine fuel system is laid out for max. 130 cSt/80°C (approx. 700 cSt/50°C, approx. 7000 sec. RI/100°F) fuel.

2 With a density of more than 0.991 g/ml at 15°C, water, in particular and to some extent solid matter can no longer be removed with certainty by a centrifuge. Centrifuging systems that are claimed to be able to clean fuel oils with densities up to 1.010 g/ml at 15°C are available. If such systems are installed, fuels with densities up to 1.010 g/ml at 15°C may be used.

Caution! Fuel oils having high density in combination with low viscosity may have low ignition quality.

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3 High sulphur content increases the risk for corrosion and wear, particularly at low loads, and may contribute to high-temperature deposit formation.

4 High ash content causes abrasive wear, and may cause high-temperature corrosion and contributes to deposit formation. The most harmful ash constituents are vanadium and sodium.

5 High vanadium content causes hot corrosion on exhaust valves particularly in combination with high sodium content. The corrosion increases with increased temperatures (increased engine output).

6 Sodium contributes to hot corrosion on exhaust valves when combined with high vanadium content. Fuels having sodium contents roughly 40 % of the vanadium content are considered the most aggressive. Sodium also strongly contributes to fouling of the exhaust gas turbine blading at high load.

7 High conradson carbon may cause deposit formation in combustion chamber and exhaust system, particularly at low engine output.

8 High content of asphaltenes may contribute to deposit formation in combustion chamber and exhaust systems at low loads.

Asphaltenes may under certain circumstances precipitate from the fuel and block filters and/or cause deposits in the fuel system. Precipitating asphaltenes may also cause excessive centrifuge sludge.

9 Heavy fuels may contain considerable amounts of water (up to 1 %). Water may also originate from the installation bunker tanks. To avoid difficulties in the engine fuel injection system the water content must be reduced to max. 0.2 % by centrifuging.

10 Ignition quality. Heavy fuels may have very low ignition quality at low load operation. This may cause trouble at start and low load operation particularly if the engine is not sufficiently preheated. Low ignition quality may also result in long ignition delay and as a consequence, in high firing pressure rise ratio, which may damage engine components, e.g. piston rings.

Ignition quality is not defined, nor limited, in marine residual fuel standards. The same applies to ISO-F-DMC marine destillate fuel. The ignition quality of these fuels cannot — for a variety of reasons — be determind by methods used for pure destillates, i.e. Diesel Index, Cetane Index and Cetane Number.

Shell and BP have developed equations for prediction of the ignition quality of residual fuels. Both equations provide suffecient accuracy for prediction of the ignition quality of the vast majority of fuels bunkered, although they may fail on some very unusual blends. Both equations can easily be solved with a scientific pocket calculator. Only the fuel density and viscosity need to be known.

Shell Calculated Carbon Aromaticity Index (CCAI)

$$CCAI = D - 81 - 141 \log_{10} \log_{10} (V_k + 0.85)$$

D = density (kg/m^3 at 15°C)
V_k = viscosity (cSt at 50°C)
CCAI can also be determined (but with limited accuracy) by the diagram, Fig 02-3.

Nomogram for deriving CCAI

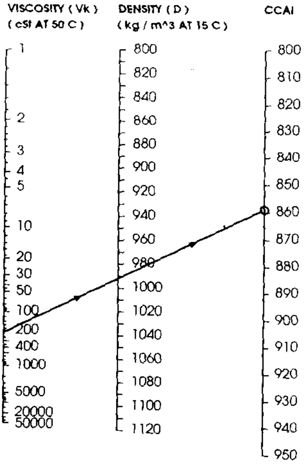

Fig 02-3

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Note! **An increased CCAI value indicates decreased ignition quality.**

BP Calculated Ignition Index (CII)

$$CII = (270.795 + 0.1038T) - 254.565\,D + 23.708 \log_{10}\log_{10}(V_t+0.7)$$

D = density (kg/l at 15°C)
V_t = viscosity in cSt measured at any temperature between 50 and 100°C
T = temperature (°C) between 50 and 100

Note! **A decreased CII value indicates decreased ignition quality**

Basically a low viscosity in combination with a high density will result in a high CCAI and a low CII, i.e. low ignition quality.

What do the values mean?

Straight run residues show CCAI values in the 770 to 840 range and are very good igniters. Cracked residues delivered as bunkers may range from 840 to — in exceptional cases — above 900. Most bunkers remain in the 850 to 870 range at present.

Normal diesel engines should digest CCAI values up to 850 with no difficulties. CCAI values between 850 and 870 may cause difficulties under unfavourable conditions: low inlet air temperatures, unsufficient pre-heating of the engine at the start, inverse cooling system not functioning properly, fuel injection system not functioning properly (in particular, badly maintained nozzles).

CCAI values between 870 and 890 are more demanding; the above mentioned systems must function perfectly in order to avoid difficulties. In severe cases it is advisable to increase the charge air temperature. CCAI value above 900 are damaging.

Symtoms of low ignition quality are:

"Diesel Knock", i.e. hard, high pitch combustion noise

Effects of diesel knock are:

Increased mechanical load on components surrounding the combustion space, increased thermal load, increased lub. oil consumption and increased lub. oil contamination.

Caution! **Although low ignition quality produces long ignition delay, advancing the ignition timing makes things only worse; fuel is injected at a lower compression temperature and this will produce even longer ignition delay**

11 Abrassive particulates. Fuel may contain highly abrassive particulates composed of aluminium and silicon oxides known as "catalytic fines" from certain refining processes. If not removed by efficient fuel treatment , considerable wear on vital engine components, like injection equipment, may be experienced.

02. 1. 5. Measures to avoid difficulties when running on heavy fuel

The engine is designed for burning heavy fuel with characteristics according to the table, chapter 02, sect. 02.1.3 under all operating conditions.

Poor fuel quality will, however, influence wear, engine part life time and maintenance intervals adversely.

In order to obtain maximum operating economy it is recommendable:

1 to limit maximum continuous output as much as operating conditions allow if fuel is known or suspected to have high vanadium content (above 200 ppm) and especially if the sodium content simultaneously is about 40 % of the vanadium content

2 to limit low load operation as much as operating conditions allow if fuel is known or suspected to have high sulphur content (above 3 %), carbon content (Conradson carbon above 12 %) and/or asphaltene content (above 8 %).

Operation below 20 % of rated output should be limited to max. 100 hours continuously, by loading the engine above 70 % of rated load for one hour before continuing the low load operation or shuting down the engine

Idling (i.e. main engine declutched, generator set disconnected) should be limited as much a possible. Warming-up of the engine at no load for more than 3 minutes before loading, as well as idling more than 3 minutes before stopping is unnecessary and should be avoided.

02. 1. 6. General advice

To avoid stability and incompatibility problems (precipitation of heavy components in the fuel), avoid if possible blending of fuels from different bunker stations, unless the fuels are known to be compatible.

If stability and compatibility problems occur, never add distillate fuel, as this will probably increase precipitation. A fuel additive with a highly powerful dispersing characteristics can be of help until a new fuel delivery takes place.

The characteristics of heavy fuels blended from residuals from modern refinery processes like catalytic cracking and visbreaking may approach at least some of the maximum limits of fuel characteristics given in the table in chapter 02, sect. 02.1.3.

Compared with "traditional" heavy fuels blended from straight run residuals the "modern" heavy fuels may have reduced ignition and combustion quality.

Fuels blended from catalytic cracking residuals may contain very abrasive catalytic fines (silicon and aluminium oxides) which, if allowed to enter the injection system, may wear down injection pumps and nozzles in a few hours.

Some of the difficulties that may occur when operating on heavy fuels blended from cracked residuals can be avoided

- by sufficient separating capacity. The best and most disturbance-free results are obtained with purifier and clarifier in series. Alternatively the main and stand-by separators may be run in parallel, but this makes heavier demands on correct gravity disc choice and constant flow and temperature control to achieve optimum results. The flow rate through the centrifuges should not exceed the maximum fuel consumption by more than 10 %.
- by sufficient heating capacity to keep centrifuging and injection temperatures at recommended levels. It is important that the temperature fluctuations are as low as possible (±2°C before centrifuge) when centrifuging high viscosity fuels with densities approaching 0.991 g/ml at 15°C.
- by sufficient preheating of the engine and the fuel systems before starting the engine

02. 2. Lubricating oil

02. 2. 1. System oil characteristics

Viscosity. Viscosity class SAE 30 or SAE 40. SAE 40 is preferred

Alkalinity. The required lubricating oil alkalinity is tied to the fuel specified for the engine. This is shown in the table "Fuel standards and lubricating oil requirements".

Fuel standards and lubricating oil requirements.

Category	Fuel standard		Lube oil TBN
A	ASTM D 975-81, BS 6843 - 1987, BS 2869 - 1983, ISO 8217: 1987(E)	GRADE ID, 2D, PROPOSED 3D CLASS DMX, DMA CLASS A1, A2 CLASS DMX, DMA	10 - 40
B	ASTM D 975-81, BS 6843 - 1987, ISO 8217(E)	GRADE 4D CLASS DMB, DMC CLASS DMB, DMC	15-40
C	ASTM D 396, BS 6843 - 1987, CIMAC 1986, ISO 8217: 1987(E)	GRADE NO 4-6 CLASS RMA10 - RML55 CLASS A10-K55 RMA 10-RML 55	25-40

Additives. The oils should contain additives that give good oxidation stability, corrosion protection, load carrying capacity, neutralization of acid combustion and oxidation residues, prevent deposit formation on internal engine parts (piston ring zone and bearing surfaces in particular).

Classification. The oil should meet the API Service CD classification.

02. 2. 2. Lubricating oil qualities

Approved system oils - all fuel categories - for Wärtsilä Vasa engines,				
Lubricating oil supplier	**Designation (brand name) of lubricating oil supplier**	**Visc.**	**TBN**	**Fuel categ.**
Agip	Cladium 350 SAE 30 Cladium 350 SAE 40	SAE 30 SAE 40	35 35	A B C A B C
BP	Energol IC HF 303 Energol IC HF 304 Energol IC HF 404	SAE 30 SAE 40 SAE 40	30 30 40	A B C A B C A B C
Caltex	RPM DELO 3000 Marine Oil 30 RPM DELO 3000 Marine oil 40	SAE 30 SAE 40	30 30	A B C A B C
Castrol	MXD 303 MXD 304 MXD 403 MXD 404	SAE 30 SAE 40 SAE 30 SAE 40	30 30 40 40	A B C A B C A B C A B C
Chevron	DELO 3000 Marine 30 DELO 3000 Marine 40 DELO 3400 Marine 30 DELO 3400 Marine 40	SAE 30 SAE 40 SAE 30 SAE 40	30 30 40 40	A B C A B C A B C A B C
Compagnie Francaise de Raffinage	Total HMA SAE 30	SAE 30	30	A B C
Esso	Exxmar 40TP 40 Exxmar 40TP 30 Exxmar 30TP 40 Exxmar 30TP 30 Exxmar 24TP 40 Exxmar 24TP 30	SAE 40 SAE 30 SAE 40 SAE 30 SAE 40 SAE 30	40 40 30 30 24 24	A B C A B C A B C A B C A B C A B C
Elf	Aurelia XT 4040 Aurelia XT 3040 Aurelia 3030 Aurelia 4030	SAE 40 SAE 30 SAE 30 SAE 40	40 40 30 30	A B C A B C A B C A B C
Mobil	Mobilgard 342 Mobilgard 442 Mobilgard 324 Mobilgard 424	SAE 30 SAE 40 SAE 30 SAE 40	40 40 30 30	A B C A B C A B C A B C
Neste	NST 30 NST 40	SAE 30 SAE 40	30 30	A B C A B C
Norol	Marine HA 303 Marine HA 304 Marine HA 404	SAE 30 SAE 40 SAE 40	30 30 40	A B C A B C A B C
Olje-Energi	Goth Oil 325	SAE 30	25	A B C
Petrofina, IMOD	Stellano 330 Stellano 430	SAE 30 SAE 40	30 30	A B C A B C
Phillips Oil Trading Ltd	Marine SR 30 Marine SR 40	SAE 30 SAE 40	30 30	A B C A B C

Approved system oils - all fuel categories - for Wärtsilä Vasa engines,				
Lubricating oil supplier	**Designation (brand name) of lubricating oil supplier**	**Visc.**	**TBN**	**Fuel categ.**
Shell	Argina T Oil 30 Argina T Oil 40 Argina X Oil 40	SAE 30 SAE 40 SAE 40	30 30 40	A B C A B C A B C
Teboil	Teboil Ward S 30T SAE 30 Teboil Ward S 30T SAE 40	SAE 30 SAE 40	30 30	A B C A B C
Texaco	Taro DP 30 Taro DP 40 Taro XL 40	SAE 30 SAE 40 SAE 40	32 32 42	A B C A B C A B C

Attention! **For use of a lubricating oil not listed in the table the engine manufacturer's permission is obligatory to maintain the engine guarantee.**

Candidate lubricating oils - distillate fuel category(A and B) - for Wärtsilä Vasa engines				
Lubricating oil supplier	**Designation (brand name) of lubricating oil supplier**	**Visc.**	**TBN**	**Fuel categ.**
Agip	Cladium 250 SAE 30 Cladium 250 SAE 40 Cladium 120 SAE 30 Cladium 120 SAE40	SAE 30 SAE 40 SAE 30 SAE 40	25 25 12 12	A B A B A A
BP	Energol DS3-153 Energol DS3-154	SAE 30 SAE 40	15 15	A B A B
Caltex	RPM DELO 2000 Marine Oil 30 RPM DELO 2000 Marine Oil 40	SAE 30 SAE 40	20 20	A B A B
Castrol	215 MXD 220 MXD Marine MLC 30 Marine MLC 40	SAE 30 SAE 40 SAE 30 SAE 40	22 22 12 12	A B A B A A
Chevron	DELO 2000 Marine 30 DELO 2000 Marine 40 DELO 1000 Marine 30 DELO 1000 Marine 40	SAE 30 SAE 40 SAE 30 SAE 40	20 20 12 12	A B A B A A
Esso	EXXMAR 12 TP 30 EXXMAR 12 TP 40	SAE 30 SAE 40	12 12	A A
Elf	Disola M 3015 Disola M 4015	SAE 30 SAE 40	15 15	A B A B
Mobil	Mobilgard 312 Mobilgard 412	SAE 30 SAE 40	15 15	A B A B
Neste	Neste Delta CD	SAE 30	10	A
Norol	Marine TMA 153 Marine TMA 154	SAE 30 SAE 40	15 15	A B A B
Pertamina	Medripal 312 Medripal 412	SAE 30 SAE 40	12 12	A A
Petrofina, IMOD	Stellano 325 Stellano 425 Caprano 312 Caprano 412	SAE 30 SAE 40 SAE 30 SAE 40	25 25 12 12	A B A B A A
Phillips Oil Trading Ltd	Super HD Motor Oil SAE 30 Super HD Motor Oil SAE 40	SAE 30 SAE 40	12 12	A A

Candidate lubricating oils - distillate fuel category(A and B) - for Wärtsilä Vasa engines				
Lubricating oil supplier	**Designation (brand name) of lubricating oil supplier**	**Visc.**	**TBN**	**Fuel categ.**
Shell	Argina S Oil 30 Argina S Oil 40 Myrina Oil 30 Myrina Oil 40 Gadinia Oil 30 Gadinia Oil 40	SAE 30 SAE 40 SAE 30 SAE 40 SAE 30 SAE 40	20 20 16 16 11 11	A B A B A B A B A A
Teboil	Teboil Ward S 10T SAE 30 Teboil Ward S 10T SAE 40	SAE 30 SAE 40	10 10	A A
Texaco	Taro XD 30 Taro XD 40	SAE 30 SAE 40	16 16	A B A B

Attention! **Permission to use candidate oils must be obtained from the engine manufacturer in particular during the guarantee period.**

Never blend different oil brands unless approved by oil supplier and, during guarantee time, by engine manufacturer.

02. 2. 3. Maintenance and control of the lubricating oil

1 **Centrifuging of the system oil** is recommended in order to separate water and insolubles from the oil. Water must not be added when centrifuging ("washing"). The oil should be preheated to 80...85°C. For efficient centrifuging, use only about 20 % of the rated flow capacity of the separator. For optimum conditions the centrifuge should be capable of passing the entire oil quantity in circulation 4-5 times every 24 hour at 20 % of rated flow. The gravity disc to be chosen acc. to oil density at 80°C (normally stated at 15°C by oil supplers).

Caution! **Defects on automatic, "self-cleaning" separators can quickly increase the water content of the oil under certain circumstances! (The water control valve fails.)**

2 During the first year of operation it is advisable to take samples of the lubricating oil after about 250, 500 and 1000 operating hours. The sample should be sent to the oil supplier for analysis. On the basis of the results it is possible to determine suitable intervals between oil changes. After that the oil can be analysed at about 500 operating hours intervals.

To be representative of the oil in circulation, the sample should be taken with the engine in operation at the sampling cock located immediately after the oil filter on the engine, in a clean container holding 0.75...1 litre. Take samples before, not after adding new oil to compensate for consumption. Before filling the container, rinse it with the oil from which sample is to be taken.

In order to make a complete assesment of the condition of the oil in service, the following details should be furnished with the sample: Installation, engine number, oil brand, engine operating hours, number of hours the oil has been in use, where in the system sample was drawn, type of fuel, any special remarks. Oil samples with no information except installation and engine number are close to valueless.

When estimating the condition of the used oil, the following properties should be observed. Compare with guidance values (type analysis) for new oil of the brand used.

Viscosity. Should not rise by more than 25 % above the guidance value at 100°C.
Maximum permissible viscosity for a SAE 30 grade oil is 140 cSt at 40°C and 15 cSt at 100°C.
Maximum permissible viscosity for a SAE 40 grade oil is 212 cSt at 40°C and 19 cSt at 100°C.
Minimum permissible viscosity is 70 cSt at 40°C and 9 cSt at 100°C.

Flash point. Should not fall by more than 50°C below the guidance value. Min. permissible flash point (open cup) 170°C. At 150°C risk of crankcase explosion.

Water content. Should not exceed 0.2 %. At 0.5 % measures must be taken; either centrifuging or oil change.

TBN. The TBN value must be at least 50% of the fresh oil nominal value. However, for lubricating oils with nominal TBN values exceeding 25, the minimum acceptable limit for used oil is TBN 15.

Insolubles. The quantity allowed depends on various factors. The oil supplier's recommendations should be followed. However, a n-Pentan insoluble value above 3 % calls for attention.

In general it can be said that the changes in the analyses give a better basis of estimation than the absolute values.

Fast and great changes may indicate abnormal operation of the engine or of a system.

3 **Compensate for oil consumption** by adding max. 10 % new oil at a time. Adding larger quantities can disturb the balance of the used oil causing, for example, precipitation of insolubles. Measure and record the quantity added. Attention to the lubricating oil consumption may give valuable information about the engine condition. A continuous increase may indicate that piston rings, pistons and cylinder liners are getting worn, a sudden increase motivates pulling the pistons, if no other reason is found.

4 **Guidance values for oil change intervals** are to be found in chapter 04, section 04.7. The intervals between changes are influenced by operating conditions, fuel quality, centrifuging efficiency and total oil consumption. Efficient centrifuging and large systems (dry sump operation) generally allow for long intervals between changes.

When changing oil the following procedure is recommended:

5 **Empty oil system** while oil is still hot. Be sure that oil filters and coolers are also emptied.

6 **Clean oil spaces,** including filters and camshaft compartment. Insert new filter cartridges.

7 **Fill a small quantity of new oil** in the oil sump and circulate with the pre-lubricating pump. Drain.

8 **Fill required quantity of oil** in the system, see chapter 01, section 01.1.

Oil samples taken at regular intervals, analysed by the oil supplier and the analysis results plotted as a function of operating hours is an efficient way of predicting oil change intervals.

Send, or ask the oil supplier to send copies of oil analyses to the engine manufacturer who will then assist in the evaluation.

02. 2. 4. Lubricating oil for the governor

See the Instruction Book for the governor (chapter 22). An oil of viscosity class SAE 30 is normally suitable and usually the same oil can be used as in the engine system, or the same oil as in the turbocharger. Oil change interval: 2000 h service.

Caution! **If turbine oil is used in the governor, take care not to mix it with engine lubricating oil. Only a small quantity may cause heavy foaming.**

02. 2. 5. Lubricating oils for BBC-VTR turbochargers with ball and roller bearings

See the Instruction Book for the turbocharger (chapter 15). A mineral oil of 52...87 cSt viscosity at 40°C should be used, turbine oils are preferred. Oil change interval is 500 h service for normal mineral oils. 1500 h service for special mineral oils and 2500 h service for synthetic lubricating oils.

Caution! **Take care that the turbine oil is not mixed with engine lubricating oil. Only a small quantity may cause heavy foaming.**

Mineral oils: oil change interval 500 h		
Manufacturer	**Brand name and ISO viscosity class (at 40°C)**	**Viscosity cSt at 50°C**
Antar	Misola H 68	38
British Petroleum	BP THB 68 BP THB 77	35 47
Castrol	Perfekto T 68 Perfekto T 100	39 51
Chevron	Turbine Oil OC 68 Turbine Oil OC 100	40 49
Gulf	Harmony Gulfcrest 68	40
Esso	Esso Tro-Mar T 68 Esso Tro-Mar T 77	39 48
Mobil	Mobil Rarus 427 Mobil DTE Oil Heavy Medium 68 Mobil DTE Oil Heavy 82	49 41 51
Shell	Turbo Oil T 68 Turbo Oil T 78 Turbo Oil T 100	39 47 58
Texaco, Caltex	Regal Oil PC 68 R & Q Regal Oil PE 100 R & Q	39 52
Total	Total Preslia 40 (68) Total Preslia 50 (68)	39 48

Special mineral oils: oil change interval 1 500 h		
Manufacturer	**Brand name and ISO viscosity class (at 40°C)**	**Viscosity cSt at 50°C**
British Petroleum	BP Energol RC 68	-
Valvoline	Valvoline Compressor oil 62	-

Synthetic lubricating oils: oil change interval 2 500h		
Manufacturer	**Brand name and ISO viscosity class (at 40°C)**	**Viscosity cSt at 50°C**
Mobil	Mobil Rarus 827 (87)	50
Nyco	Nyco Nycolube 3060	-
Esso	Exxon Synesstic 68	39

These lubricating oils are in regard of viscosity and quality according to the recommendations.

02. 2. 6. Lubricating grease for the fuel feed pump

For further information about the pump see chapter 17 or the separate instructions at the end of chapter 18.
Regreasing interval: see chapter 04.

Caution! The pump should be regreased after one hour of operation when the pump is new or has been overhauled.

The following grease is recommended: Klüber Unisilikon L50/2.

The pump is to be regreased only under running conditions!

02. 2. 7. Lubricating grease for the electric driven pre-lubricating pump

For further information about the pump see chapter 18 or the separate instructions at the end of the same chapter.

Regreasing interval: see chapter 04.ö

Caution! The pump should be regreased after one hour of operation when the pump is new or has been overhauled.

The following greases are recommended

- BP Energrease LS2
- Caltex Regal Starfak Premium 2
- Esso Beacon 325
- Nynäs FL3-42
- Shell Alvania 3

The pump is to be regreased only under running conditions!

02. 2. 8. Lubricating oil for the pneumatically operated starting motor (4R22 only)

For further information about the pump see chapter 21 or the separate instructions at the end of the same chapter.

Check regularly that the oil level in the lubricator is between the maximum and minimum values.

The following oil qualities are recommended:

- Gali HI 33EP
- Shell Turbo 27
- Castrol Hyspin 80
- BP Energol HP46
- Mobil Deterrgent Light

02. 3. Cooling water

02. 3. 1. General

In order to prevent corrosion, scale deposits or other deposits in closed circulating water systems, the water must be treated with additives.

Before treatment, the water must be limpid and have a hardness as low as possible (max. 10 d°H), a chloride content of less than 80 mg/l and a pH-value above 7. The best result will be achieved by using totally desalinated (distilled) water, for instance from a fresh water generator, and additives.

Caution! **Distilled water without additives absorbs carbon dioxide from the air, which involves great risk of corrosion.**

Sea water will cause severe corrosion, and deposit formation, even if supplied to the system in small amounts.

Rain water has a high oxygen and carbon dioxide content: great risk of corrosion; unsuitable as cooling water.

02. 3. 2. Additives

As additives, use products from well-known and reliable suppliers with vast distribution nets. Follow thoroughly the instructions of the supplier.

Attention! **The use of emulsion oils, phosphates and borates (sole) is not recommended.**

From the table in chapter 02, section 02.3.4 appear the qualities of some usual cooling water additives.

Some commercially available water treatment products are listed as examples in 02.3.5 in chapter 02.

In an emergency, if compounded additives are not available, treat the cooling water with sodium nitrite ($NaNO_2$) in portions of 5 kg/m^3. To obtain a pH-value of 9, add caustic soda (NaOH), if necessary.

Attention! Sodium nitrite is toxic.

02. 3. 3. Treatment

When changing the additive or when entering additive into a system where untreated water has been used the complete system must be cleaned (chemically) and rinsed before fresh treated water is poured into the system. If, against our recommendations, an emulsion oil has been used, the complete system must be absolutely cleaned from oil and greasy deposits.

Evaporated water should be compensated by untreated water; if treated water is used the content of additives may gradually become too high. To compensate for leakage or other losses, add treated water.

In connection with maintenance work calling for drainage of the water system, take care of and reuse the treated water.

02.0.4. Summary of the most common cooling water additives			
Additive	**Advantages**	**Disadvantages**	**Suitability**
Sodium nitrite	- *good efficiency* - small active quantities 0.5 % by mass - cheap	- determination of the concentration can be done only with special equipment	- suitable as additive except in *air cooled* heat exchangers with large soft solder surfaces
Nitrite + borate	- no increased risk of corrosion at over or under-doses - innocuous for the skin - allowed for use in fresh water generators intended for house-keeping purposes	- tendency to attack zinc coverings and soft solderings - **toxic**: lethal dosage 3...4 g solid nitrite	
Sodium chromate or potassium chromate	- good efficiency - small active quantities. 0.5 %by mass - *reasonable price* - simple determination of concentration (comparison of colour with test solution) - available anywhere	- increased risk of corrosion *when too low concen-*tration: spot corrosion - injurious for the skin - **toxic**: lethal dosage 1 g - prohibited for use in fresh water generators *intended* for house keeping purposes	- suitable as additive for purposes where the toxic effect can be tolerated. ***Caution at use and thorough control are necessary***
Sodium silicate	- not toxic - *harmless to handle*	- not active when water velocity exeeds 2m/s - commercial products very expensive - increased risk of corrosion when too low concent-ration: *spot corrosion*	- limited suitability

Examples of commercially available cooling water treatment products	
Supplier	**Product designation**
Burmah-Castrol Marine Burmah House Pipers Way Wiltshire N3 1RE, England	Castrol Solvex WT2
Duolite International Dia-Prosim Water Conditioning La Tour de Lyon 185 Rue de Berly 75579 Paris Cedex 12	RD11M
Drew Chemical Corp., Marine Division 522 Fifth Avenue New York, N.Y. 10036, USA	Maxigard Drew Ameroid DEWT-NC powder
Gamlen Chemical Company (UK) Ltd Wallingford Road Uxbridge Middlesex, England	Gamlen Gamcor NB
Houseman Hegro Ltd The Priory, Burham Slough SL 1 7LS, England	Cooltreat101 Cooltreat 102
Magnus Maritec International Inc. 150 Roosevelt Place, P.O.Box 150 Palisades Park, New Jersey 07650, USA	NLC Diesel Water treatment
Nalfloc Ltd, Marine Department P.O.Box 11, Northwich, Cheshire CW 8 4DX, UK	Nalfeet 9-121 powder Nalfleet 9-131C liquid
Nalco Chemical Co, Marine Department 100 Morris Avenue, Springfield New Jersey 07081, USA	Nalco 39 powder Nalco 9-L liquid
Rochem Ships Equipment A/S, P.O.Box 2645, St Haunshaugen, Oslo 1, Norway	Rochem Rocor NB Rochem Rocor NB liquid

Attention! **Ask the supplier of the treatment product for instructions about treatment procedure,, dosage and concentration control.**

Most suppliers will provide a test kit for the concentration control.

03. Start, Stop and Operation

03. 1. Start

Before starting the engine, check that

- the lubricating oil level is correct,
- the fuel system is in running order (correct preheating, correct pressure, sufficient precirculation to heat the fuel injection pumps),
- the circulating system and raw water system are in running order (correct pressures, circulating water preheated and precirculated sufficiently to heat the engine),
- the oil level in the governor and turbocharger(s) is correct,
- the starting air pressure exceeds 15 bar,
- the starting air system is drained of condensate,
- voltage to DESPEMES to ensure alarm functions.

03. 1. 1. Manual start

1 Start the prelubricating oil pump to obtain a lubricating oil pressure, abt. 0.5 bar.

2 Turn the crankshaft two revolutions or run the engine on starting air for some revolutions keeping the **stop lever in stop position** and the indicator valves open. In doing so the risk of waterlocks is eliminated.

3 Disengage the turning gear from the flywheel.

4 Check that the automatic alarm and stop devices are set in start position (chapter 23).

5 Check that the stop lever is in work position, open the starting air valve, shut the blow-off valve when there is no more condensate.

6 Push the start button until the engine starts firing. If the engine does not start after 2...3 s. the reason should be checked.

7 On engines equipped with pneumatic starting motors, never make a second starting attempt before the flywheel has stopped.

8 Check after start that the pressure and temperature values are normal.

9 Check that the automatic alarm and stop devices are set in work position.

03. 1. 2. Remote and automatic start

If the engine has been out of operation for more than a week the first start is to be carried out manually according to point 1.

Engines with automatic starting must be tested once a week.

1 When starting the engine remotely, start the lubricating oil priming pump at first. Usually, the operation of the pump is indicated by a signal lamp. The engine can be started when the lube oil pressure gauge shows an oil pressure of abt. 0.5 bar.
In automatically starting engines the priming pump operates continuously thus keeping the engine ready for start. At least every second day, make sure that the pump is running.

2 Press the remote start button of the remotely controlled engine. The solenoid valve located on the engine will then be energized and allow starting air to the engine. Press the start button long enough (1...2 s) to make the engine start. The start will be indicated by the remote tachometer or bya signal lamp showing when the engine is running. In some cases the remote control is automated so that, when pressing the button, the priming pump starts and after an increase of the oil pressure (to about 0.5 bar) the engine starts automatically as described in point 3.

3 In engines with automatic starting the solenoid valve is controlled by a program relay. The normal program is as follows: As soon as the program relay gets a starting impulse the solenoid valve is energized for 2...4 s and opens, then starting the engine. If the engine fails to start, a new starting attempt takes place after 20 s, whereby the solenoid valve will be energized for10 s. If this attempt fails, too, the program relay will connect the alarm circuit. On engines equipped with pneumatic starting motors the period between the starting attemps should be long enough to guarantee that the flywheel has stopped.

4 When the engine has reached a predeterminated speed, an auxiliary relay energized by the remoted tacho transmitter cuts off the starting circuit, and the starting air solenoid valve closes. At the same time the current to the priming pump will be disconnected thus preventing the pump from operating when the engine is running. On certain installations the priming pump will continue to operate at low engine speed to assist the engine driven lubricating oil pump to maintain the oil pressure. After a fixed time (10...30 s) the system for alarm, stop and speed remote control will be automatically connected.

03. 2. Stop

03. 2. 1. Manual stop

1 Engines with built-on circulating water pump: Idle the engine 3...5 min before stopping. **Engines with separate circulating water pump:** 2...3 min will be enough, but the water pump should run for some 5 min more.

2 Stop the engine by moving the stop lever into stop position.The time of slowing down offers a good opportunity to detect possible disturbing sounds.

03. 2. 2. Remote stop

1 Point 03.2.1.1 above is valid.

2 Press the remote control stop button. The shut-down solenoid, built on the governor, will then be energized for a fixed time and the control racks of the injection pumps move into stop position. The time for the solenoid to be energized is set so (20...50 s.) that the solenoid operates until the engine stops. During this time the engine cannot be restarted. After a predeterminated time the shut-down solenoid will return to its initial position.

3 When the engine stops and the speed decreases below a certain limit, the system for alarm, stop and speed remote control will be disconnected and the signal lamp indicating that the engine is running goes out. In engines equipped with automatic lubricating oil priming pumps, the pump will be started at the same time.

03. 2. 3. Automatic stop

When the shut-down solenoid is energized from the automatic shut-down system due to some disturbance, the engine will stop as in remote stop. Before this an alarm device will normally initiate an alarm signal indicating the reason for the shut-down.

When the engine stops because of overspeed, the mechanical overspeed trip device and the electro-pneumatic overspeed trip device may have tripped.

03. 2. 4. General

The engine can always be stopped manually (with the stop lever) independent of the remote control or automation system.
When overhauling the engine, make absolutely sure that the automatic start and the priming pump are disconnected. Close

the starting air shut-off valve located before the solenoid valve.
Move the stop lever into STOP position.
If the engine is to be stopped for a lengthy time, close the indicator valves. It is also advisable to cover the exhaust pipe opening.

The lubricating oil system on a stopped engine should be filled with oil every second day by priming the engine. At the same time, turn the crankshaft into a new position. This reduces the risk of FRETTING CORROSION on journals and bearings when the engine is exposed to vibrations.

Blow the engine with open indicator valves and start the engine once a week to check that everything is in order.

03. 3. Normal operation supervision

03. 3. 1. Every second day or after every 50 running hours

1 Read all thermometers and pressure gauges and, the load of the engine. Compare the values read, with those at corresponding load and speed in the Acceptance Test Records and curves. **Guidance values are stated in chapter 01.**

- If the difference between exhaust gas temperatures of various cylinders is larger than 80°C at loads higher than 25% the reason for this should be looked for.
- The charge air temperature should, in principle, be as low as possible at loads higher than 60 %, however, not so low that condensation occurs. See chapter 03, Fig 03-1. At loads lower than *40 % it is favourable to have a charge air temperature as high as* possible.

2 Check the indicator for pressure drop over fuel filters.
When the pressure drop over the filters increases, the pressure in the system decreases. Very low pressure (less than 0.5 bar) reduces the engine performance and may cause uneven load distribution between the cylinders (risk of breakdown!). Too high pressure drop may also result in deformation of filter cartridges (risk of injection pump seizure).

3 Check the indicator for pressure drop over the lubricating oil filters. Too large pressure drop indicates clogged filter cartridges, which results in reduced oil filtration when the by-pass valve is open. Reduced oil filtration results in increased wear. Vent filters and, if no improvement, change the cartridges.

4 Check the oil level in the oil sump/oil tank. Estimate the appearance and consistence of the oil. A simple control of the water content: A drop of oil on a hot surface (about 150°C), e.g. a hot-plate. If the drop keeps "quiet", it does not contain water; if it "frizzles" it contains water. Compensate for oil consumption by adding max. 10 % fresh oil at a time.

5 Check that the ventilation (de-aerating) of the engine circulating water system (the expansion tank) is working. Check that the leakage from the gossip hole of the circulating water pump and the raw water pump is normal (slight).

Condensation in charge air coolers

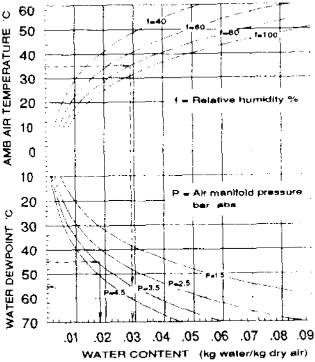


Fig 03-1 2203528945

Example: *If the ambient air temperature is 35 °C and the relative humidity is 80% the water content in air can be read from the diagram (0.029 kg water/kg dry air). If the air manifold pressure (receiver pressure) under these conditions is 2.5 bar, i.e. absolut air pressure in the air manifold is abt. 3.5 bar (ambient pressure + air manifold pressure), the dewpoint will be 55 °C (from diag.). If the air temperature in the air manifold is only 45 °C, the air can only contain 0.018 kg/kg (from diag.). The difference, 0.011 kg/kg (0.029-0.018) will appear as condensed water.*

6 **Check the quantity of leak-fuel** from the draining pipes.

7 **Check that the drain pipes** of the air coolers are open.

8 **Check that the gossip holes** of the oil coolers and the circulating water coolers are open.

9 **Clean the compressor side** of the turbocharger by injecting water. See the instruction manual of the turbocharger.

10 **Drain the fuel day tank** of water and sediments, if any, and drain the starting air receiver of water.

11 **Marine engines** (propulsion and auxiliary engines): On a stopped engine, prime the engine and **turn the crankshaft into a new position.** This reduces the risk of crankshaft and bearing damage due to vibrations.

03. 3. 2. Every second week or after every 250 running hours

1 **Clean the centrifugal lubricating oil filters.** If the deposits are thicker than 20 mm, reduce the cleaning interval to retain filtering efficiency. Maximum deposit capacity is 40 mm.

2 **Keep the injection pump racks clean** (free from sticky deposits), check that the parts of the fuel control shaft system move easily. Is to be done on a stopped engine.

3 **Clean the turbine side of the turbocharger** by injecting water. See chapter 15 and the instruction book of the turbocharger.

03. 3. 3. Once a month or after every 500 running hours

1 **Check content of additives** in the circulating water.

2 **Check the cylinder pressures.** At the same time, note the load of the engine (the position of the load indicator or the injection pump racks offers an accurate measure of the engine load).

Note! **Measurement of cylinder pressures without simultaneous notation of the engine load is practically worthless.**

3 **Check the function** of the load dependent "inverse" cooling system with engine loaded below 39% of rated output.

03. 3. 4. In connection with maintenance work

1 **Record the following steps** and the running hours in the engine log:

- lubricating oil sampling (record also operating time of oil). Lubricating oil analyses without statement of operating time is of limited value ("go - no go" only).
- lubricating oil changes
- cleaning of centrifugal lubricating oil filters
- change of lubricating and fuel oil filter cartridges
- change of parts in connection with maintenance according to chapter 04.

03. 3. 5. General

1 **There is no automatic supervision** or control arrangement that can replace an experienced engineer's observations. LOOK at and LISTEN to the engine!

2 **Forms,** "Operating data" and "Service Report", are delivered with every installation. Use them!

3 **Strong gas blow-by** past the pistons is one of the most dangerous things that can occur in a diesel engine. If gas blow-by is suspected (e.g. because of a sudden increase of the lubricating oil consumption) check the crankcase pressure. If the pressure exceeds 30 mm H_2O, check the crankcase venting system, if in order, pull the pistons!

4 **Operation at loads below 20 %** of rated output should be limited to maximum 100 hours continuously when operating on heavy fuel by loading the engine above 70 % of rated load for one hour before continuing the low load operation or shuting down the engine. Continous operation on marine diesel fuel at loads below 10% of rated output should be limited to max. 100 hours by loading the engine by more than 70% of rated output for one hour before continuing the low load operation or shuting down the engine.

Idling (i.e. main engine declutched, generator set disconnected) should be limited as much as possible. Warming-up of the engine for more than 3...5 minutes before loading, as well as idling more than 1 minute before stopping is unnecessary and should be avoided.

03. 4. Start after a prolonged stop (more than 8 h)

03. 4. 1. Manual start

1 Check

- the lubricating oil level
- the circulating water level in the expansion tank
- the raw water supply
- the fuel oil level in the day tank (troublesome and time consuming job to vent the fuel system if the feed pump has sucked air!)
- the starting air pressure - min. 15 bar
- that the control shaft system and the injection pump racks move freely. Otherwise **risk of overspeed**.

2 Observe all points in chapter 03 pos. 03.1.1. **Point 2 grows more important the longer the engine has been stopped.**

3 After starting, check that the starting air distributing pipe is not heated at any cylinder (leakage from the starting valve).

4 Vent fuel and lubricating oil filters.

03. 5. Start after overhaul

1 Check that the connection between the speed governor, overspeed trip and injection pumps is set correctly (especially the injection pump rack position) and does not jam, and that all connections are properly locked and the injection pump racks move freely in the pumps.

2 The speed governor control lever being in max. position and the stop lever in work position, release the overspeed trip manually. Check that all injection pump racks move to a value less than 4 mm.

3 If the injection pumps, camshaft or its driving mechanism have been touched, check the injection timing. If the camshaft or its driving mechanism have been touched, check the valve timing of one cylinder, at least (on each cylinder bank in a V-engine).

4 Check the cooling water system for leakage, especially:

- the lower part of the cylinder liners
- the oil cooler
- the charge air cooler

5 Check/adjust the valve clearances. Guidance values, see chapter 06.

6 Vent the fuel oil system if it was opened.

7 Start the priming pump. Vent the lubricating oil filters. Check that lubricating oil appears from all bearings and lubricating nozzles, from the piston cooling oil outlet and from the valve mechanism. Check that there is no leakage from the pipe connections inside or outside the engine.

8 Rags or tools left in the crankcase, untensioned or unlocked screws or nuts (those which are to be locked), worn-out self-locking nuts, MAY CAUSE total breakdown.

Well cleaned oil spaces (oil sump and camshaft spaces) save the oil pump and oil filter.

9 See the instructions in chapter 03 pos. 03.1 and 03.4 when starting.

03. 6. Operation supervision after overhaul

1 At the first start, listen carefully for possible jarring sounds. If anything suspected, stop the engine immediately, otherwise stop the engine after 5 minutes' idling at normal speed. Check at least the temperatures of the main and big end bearing and of all other bearings which have been opened.

If everything is in order, restart.

2 Check that there is no leakage of gas, water, fuel, heating oil or lubricating oil. Especially observe the fuel lines, injection pumps and injection valves. Watch the quantities emerging from the leak oil pipes!

3 Check that the starting air distributing pipe is not heated at any cylinder (leaky starting valve). May cause **explosion!**

4 After overhauling, the following instructions are especially important:

- Check pressure and temperature gauges.
- Check the automatic alarm and stop devices.
- Check the pressure drop over the fuel filter and lubricating oil filter.
- Check the oil level in the oil sump/oil tank. Estimate the condition of the oil
- Check the ventilation (de-aerating) of the engine circulating water system
- Check the quantity of leak fuel
- Check the gossip holes of the coolers
- Check the content of additives in the circulating water
- Check the cylinder pressures
- Listen for jarring sounds
- Check the crankcase pressure

- Check the starting air pipes
- Vent the filters

03. 7. Running-in

1 After piston overhaul, follow program A in Fig 03-2, as closely as possible. The piston rings have slided into new positions and need time to refit. If the program cannot be followed, **do not load the engine fully for 4 h, at least.**

2 After changing piston rings, pistons or cylinder liners, after honing of cylinder liners, follow program B in Fig 03-2, as closely as possible.

If the program cannot be followed, **do not load the engine fully for 10 h, at least.**

Avoid "running-in" at continuous and constant low load!

The important thing is to vary the load several times. The ring groove will have a different tilting angle at each load stage, and consequently the piston ring a different contact line to the cylinder liner.

The running-in may be performed either on distillate or heavy fuel, using the normal lubricating oil specified for the engine.

Running-in program

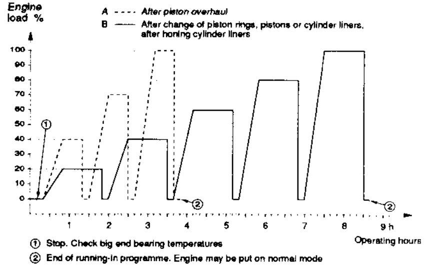


Fig 03-2 2203518935

04. Maintenance Schedule

04. 1. General

The maintenance necessary for the engine depends on the operating conditions in the main. The periods stated in this schedule are guidance values, only, but must not be exceeded during the guarantee period. When using diesel oil or intermediate fuels of comparatively good quality as fuel oil it may be possible to lengthen the stated maintenance intervals considerably depending on the engine load. See also the instruction books of the turbocharger and the governor, separate instructions for additional equipment and chapter 03.

04.2 Interval: Every second day, irrespective of the engine being in operation or not		
Part	Work	Instr. in chapt, sect.
Automatic prelubrication	Check operation	03.2, 23.1
Crankshaft	Marine engine: in a stopped engine, turn the crankshaft into a new position.	03.3.1.

04.3 Interval: Once a week irrespective of the engine being in operation or not		
Part	Work	Instr. in chapt., sect.
Start process	Test start (if the engine on stand-by).	03.1

04.4 Interval: 50 operating hours		
Part	Work	Instr. in chapt., sect.
Turbocharger	Clean the compressor by injecting water	15.3
Temperature and pressure gauges, load indicators etc.	Read, record	03.3.1
Fuel and lubricating oil filters	Check pressure drop indicators.	17, 18, 23
Lubricating oil sump, governor, turbocharger(s)	Check oil level, compensate for consumption.	02.2.3, 02.2.4, 02.2.5, 15, 22, 18
Circulation water system	Check the level in the expansion tank	19
Injection and fuel system	Check the quantity of leak fuel from the pumps and nozzles.	17
Air coolers	Check that the draining pipe is open, check if any leakage.	15.4, fig.15-51 pos. 6 15.3
Fuel day tank	Drain possible water and sediment.	17
Valve mechanism	Check the valve clearances after 50 hours' running in new and overhauled engines.	06.1, 12.4
Screws and nuts	Check the tightening of the connecting rod screws, main bearing screws after the first 50 operating hours on a new engine and after overhaul, those of the above mentioned screws that have been opened.	07, 10.4 11.6

04.5 Interval: 250 operating hours		
Part	Work	Instr. in chapt., sect.
Centrifugal filter	Clean, more often if necessary. Remember opening the valve before the filter after cleaning.	18
Lubricating oil	In a new installation or after change to use of a new lubricating oil brand, take samples for analysing.	02.2.3
Control mechanism	Check for free movement, clean, lubricate.	22
Turbocharger	*Clean the turbine by injecting water; more often if necessary.*	15

04.6 Interval: 500 operating hours		
Part	Work	Instr. in chapt., sect.
Circulating water	Check content of additives.	02.3.4
Lubricating oil	In a new installation or after change to use of a new lubricating oil brand, take samples for analysing.	02.2.3
Cylinder pressure	Check.	12
Cooling system	Check the funktion of the load dependent cooling system with the engine loaded below 30% of rated output.	19 03.3.3
Turbocharger	Change lubricating oil	02.2.5, 15.2

04.7 Interval: 1000 operating hours		
Part	Work	Instr. in chapt., sect.
Lubricating oil filter	Replace the filter cartridges. (The cartridges are to be replaced when the pressure difference indicator shows too high pressure drop.) Clean the wire gauze and filter housing. Drain the filter housings. *)	18.7
Lubricating oil	In a new installation or after change to a new oil brand, take samples for analysing.	02.2.3
Fuel filter	Replace filter cartridges.(The cartridges are to be replaced when the pressure difference indicator shows too high pressure drop). Clean the wire gauze and filter housing. *)	17.1, 17.2, 17.7
Electrically operated *lubricating oil pump*	Regrease the pump under running condition	18
Electrically operated fuel feed pump	Regrease the pump under running condition	17
Automation	Check function of the alarm and automatic stop devices.	23
Air filter	Clean (more often, if necessary)	15.2
Valves	Check that the inlet and exhaust valves move freely in their guides. This should preferably be done when the engine has been out of operation for a couple of hours. Check valve clearances. Check cylinder tightness (valves, piston rings), pneumatic test.	06.1 12.4

***) Note!** **It is important that the air is vented out of the filter housing after change of filter cartridges.**

04.8 Interval: 2000 operating hours		
Part	Work	Instr. in chapt., sect.
Injection valves	Test the opening pressure. Dismantle and clean the nozzles. Check the effective needle lift. Check the springs. Replase the O-rings. Check the nozzle condition in a test pump. Note: It is very difficult to estimate the nozzle condition by test pumping when the engine has been stopped on heavy fuel unless the injection valve is dismantled and all parts are thoroughly cleaned in diesel oil. Recommendation: Replace the complete injection valves by new or reconditioned ones.	16.8 16.11
Charge air coolers	Check and, the first time, possibly clean the **waterside.** If in good condition and deposits unsignificant: future intervals 4000 running hours.	15.
Measuring instruments	Check pressure and temperature gauges. Replace faulty ones.	23
Governor	Change lubricating oil.	02.2.4, 22.
Overspeed trip device	Check function and tripping speed	22

04.9 Interval: 4000 operating hours		
Part	Work	Instr. in chapt., sect.
Crankshaft	Check the alignment. Check the axial clearance	11 06.2
Camshaft	Check the contact faces of the cams and tappet rollers. Check that the rollers rotate.	14
Turbocharger	Inspect the cooling water ducts for possible deposits and clean if the deposits are thicker than 1 mm.	15
Coolers	Clean the lubricating oil and charge air coolers. Look carefully for corrosion.	15
Cylinder liners	Pull one cylinder liner and inspect the water side. If the deposits are thicker than 1 mm, clean all liners, improve the cooling water treatment.	10.6 02.3
Control mechanism	Check for wear in all connecting links between the governor and all injection pumps.	22
Starting fuel limiter	Check the function	22.3.5, 22.7
Exhaust manifold	Check the nuts of the flange connections as well as the nuts of the vertical studs inside the insulating box.	

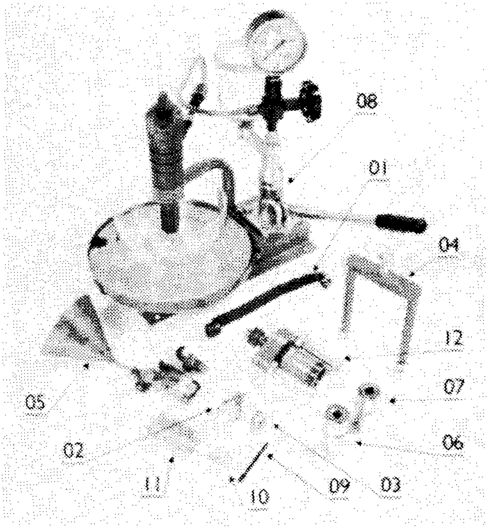
04.10 Interval: 8000 - 12000 operating hours		
Part	Work	Instr. in chapt., sect.
Cylinder heads	Dismantle and clean the underside, the inlet and exhaust ports, the inlet and exhaust valves. Inspect the cooling spaces and clean, if necessary. Grind the valves (often lapping by hand is enough). Replace the O-rings in the valve guides. Check the starting valves.	12
Piston, piston rings, gudgeon pin	Pull, inspect and clean. Check the height of the ring grooves (the height clearance of the rings). Check the retainer rings of the gudgeon pins. Renew the complete set of piston rings. **Note!** The running-in program, chapter 03 section 03.7.	11

04.10 Interval: 8000 - 12000 operating hours		
Water pumps	Dismantle and check.	19.3
Cylinder liners	Pull one cylinder liner, on V-engines one per cylinder bank, inspect the water side. If the deposits are thicker than 1 mm, clean all liners and the engine block water space. Replace the O-rings in the bottom part by new ones at every overhaul. *Measure the bore.* Hone the liners.	10
Connecting rods	Inspect the big end bearing and mating surface serrations. Measure the big end bore.	11
Main bearings	Inspect the bearing shells.	10
Gears	Inspect all gears.	11, 13
Lubricating oil pump	Inspect	18
Thermostat valves	Clean and check the *thermostatic element*, valve cone - casing,,the function of the pneumatic cylinder, the indicator pin and the sealings.	19.5 or 19.6, 18.6, 17.4, 6.2.19
Turbocharger	Change bearings in the VTR-chargers	15
Fuel system	Drain the fuel day tank.	
Cooling water system	Replace the O-rings of the circulating water discharge pipe by new ones.	

04.11 Interval: 16000 operating hours		
Part	Work	Instr. in chapt., sect.
Connecting rods	Inspect the small end bearings.	11
Valve mechanism	Check the bearing clearances in the tappets and rocker arms.	12, 14
Injection pumps	Overhaul.	16
Camshaft	Check the bearings.	10
Governor drive	Check the governor driving shaft bearing clearance in situ.	22
'Geislinger' vibration damper	Dismantle and check.	11
Viscous vibration damper	Take a sample of the oil for analysing.	11
Crankshaft	Check the condition of the main bearing.	10, 11

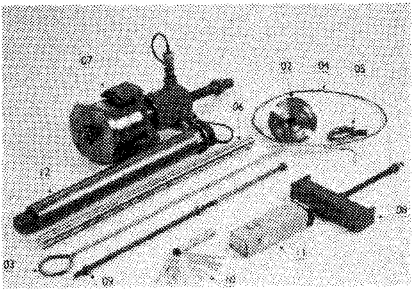
04.12 Interval: 24000 operating hours		
Part	Work	Instr. in chapt., sect.
Centrifugal filter for lubricating oil	Generral overhaul	18.8

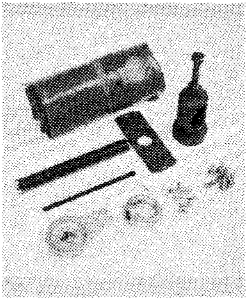
04.14 Interval: 64000 operating hours		
Part	Work	*Instr. in chapt., sect.*
The whole engine	*General overhaul.*	



25 Injection Equipment

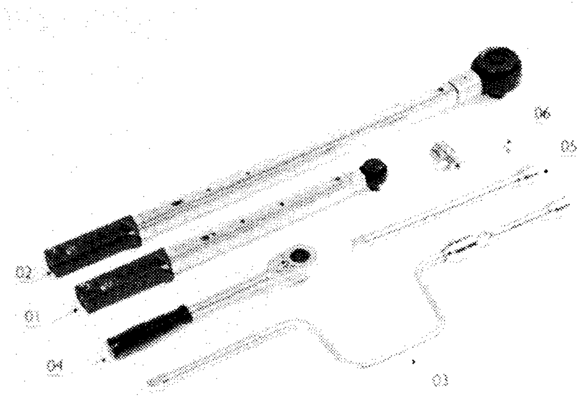
Item 25	Code	Description	Drawing No.
*01	806005	Special socket wrench 19 for flange nuts	3V80G22
*02	806009	Crow foot wrench 27 for injection pipes	4V80L02-1
03	806010	Adapter A10 X 12,5	DIN 3123
04	846008	Mounting tool for injection pump tappet	22.84G02
05	862007	Checking dev. for fuel injection timing	22.86C01
06	807010	Socket wrench 30 for nozzle nut 30X12,5L	DIN 3124
07	807004	Socket wrench 22 for conn. piece	DIN 3124
*08	864011	Testing dev. for injection valve	22.86E02
09	845006	Shaft for nozzle needles	4V84L15-1
10	845006	Nozzle needles 0,36 ,50 pack	4V84L13-1
11	845006	Brass wire brush	4V84L14-1
12	837017	Extractor for injection valve	3V83H98





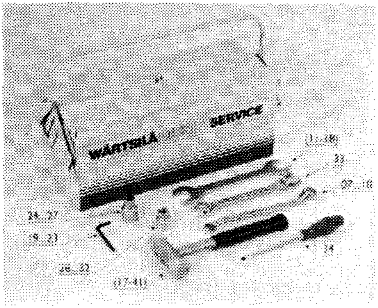
27 Miscellaneous Tools

Item 27	Code	Description	Drawing No.
01	809001	Tool chest	22.80L01
02	837012	Extractor for gear wheels etc.	22.83H02
03	845003	Brushes for cleaning charge air cooler	4V84F07
04	845004	Brushes for cleanig oil & circ water coolers	4V84F06
05	832004	Eye bolt for charge air cooler insert	M12 DIN 580
06	844001	Lever	4V84E03
07	834001	Mounting & removing device for cam. bear.bush	2 2.83E01
08	837013	Dismantling device for centrifugal filter rotor	4V83L01-1
09	837015	Mounting tool for overspeed trip device	4V83H73
*10	848001	Feeler gauge	C DIN 2275
11	841018	Molykote	
12	846011	Mounting screw for plate cooler	2284G06
13	865001	Maintenance tools: 8R22, 16V22	
14	865001	Maintenance tools: 6R22,8R22,12V22,16V22	
15	865001	Maintenance tools: 4R22	
16	865001	Maintenance tools: 6R22,8R22,12V22,16V22	
18	865002	Blanking device for turbocharger	



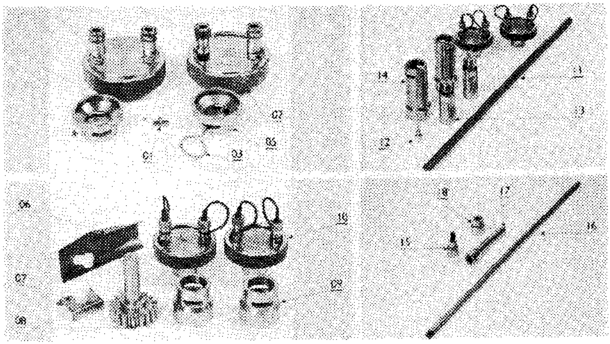
26 Tightening Tools

Item 26	Code	Description	Drawing No.
01	820008	Torque wrench max 100 Nm	4V92K207-1
02	820009	Torque wrench max 400 Nm	4V92K207-2
03	808002	Speed brace with 1/2 in square B12,5X500	DIN 3122
04	808003	Ratchet handle with 1/2 in square	DIN 3122
05	808005	Extencion bar with 1/2 in square B12,5X125	DIN 3123
06	806006	Spec. key for hex. socket scr. KW 8 for camsh. fl.	4V80G21



26 Handtools

Item 26	Code	Description	Drawing No.
07	801004	Ring wrench 10-12	DIN 897
08	801003	Ring wrench 13-17	DIN 897
09	801002	Ring wrench 19-22	DIN 897
10	801001	Ring wrench 24-27	DIN 897
11	800008	Double head open end wrench 10-12	DIN 895
12	800007	Double head open end wrench 13-17	DIN 895
13	800006	Double head open end wrench 14-17	DIN 895
14	800005	Double head open end wrench 19-22	DIN 895
15	800004	Double head open end wrench 24-27	DIN 895
16	800003	Double head open end wrench 30-32	DIN 895
17	800002	Double head open end wrench 32-36	DIN 895
18	800001	Double head open end wrench 41-46	DIN 895
19	803006	Hexagon socket screw key 5	DIN 911
20	803005	Hexagon socket screw key 6	DIN 911
21	803004	Hexagon socket screw key 8	DIN 911
22	803003	Hexagon socket screw key 10	DIN 911
23	803002	Hexagon socket screw key 12	DIN 911
24	803007	Hex s. scr. bit with 1/2 # square drive 6	
25	803008	Hex s. scr. bit with 1/2 # square drive 10	
26	803009	Hex s. scr. bit with 1/2 # square drive 14	
27	803010	Hex s. scr. bit with 1/2 # square drive 17	
28	807005	Socket wrench 13	DIN 3124
29	807006	Socket wrench 17	DIN 3124
30	807007	Socket wrench 19	DIN 3124
31	807008	Socket wrench 24	DIN 3124
32	807011	Socket wrench 27	DIN 3124
33	801005	Open ring spanner 30-32	DIN 3118
34	808006	Screw driver	4V84L19-1



28 Additional Tools

Engines With Shield Bearing

Item 28	Code	Description	Drawing No.
*01	851004	Turning tool for shield bearing shell	4V85B10
*02	861030	Tool for hydr tightening of shield bearing	22.86B08
*03	861025	Pin for hydraulic tightening device	4V86B34
04	820010	Change key for torque wrench, 24 mm	4V92K208-1
*05	861031	Distance sleeve, V-engines only	4V86B65
06	853003	Protecting sleeve for connecting rod, upper	2V83F71
07	835004	Protecting sleeve for connecting rod, lower	3V83F68
*08	483001	Turning device	3V48D38
*09	861026	Distance sleeve	4V86B141
*10	861027	Hydraulic tightening device	22.86B06

R-engines Only

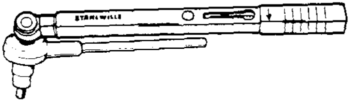
Item 28	Code	Description	Drawing No.
*11	844002	Barring lever	4V84E01
12	803012	Wrench combination for dismantling electric motor	4V80D16
*13	861032	Distance piece	3V86B71
*14	861033	Distance sleeve	3V86B142

4R22 and 8V22

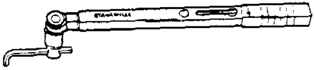
Item 28	Code	Description	Drawing No.
15	803013	Bit14 hex socket scr. w3/4 square drive stahwille	4V80L01-5
16	332001	Guide pin for mounting of pump cover	4V33C28
17	808008	Extension lever	4V80K12
18	807012	Socket wrench 30 x 20	DIN 3124

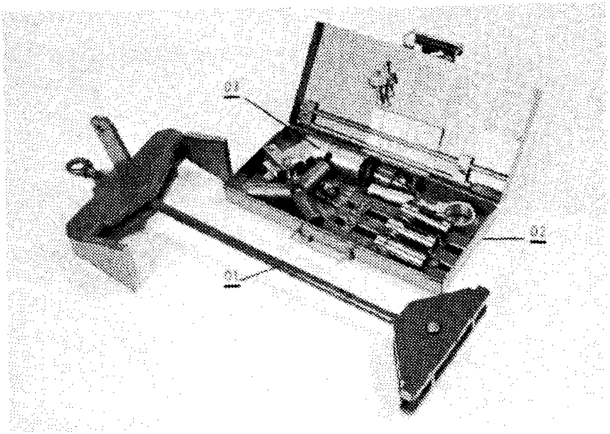
Tool combinations 05-15

A Lateral tie bolt



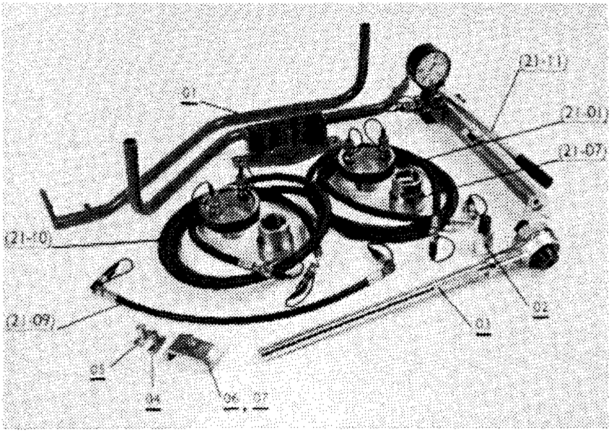
B Camshaft screws





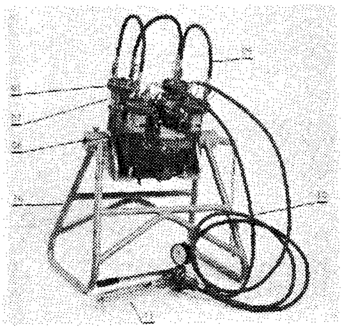
24 Cylinder Liner

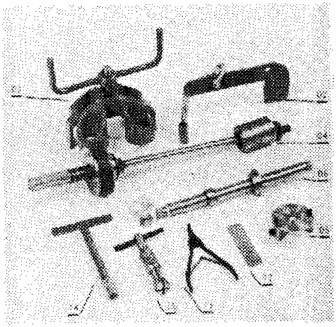
Item 24	Code	Description	Drawing No.
*01	836001	Extracting and lifting tool for cyl. liner	22.83G02
*02	841009	Honing tool for cyl. liner	1V-T22088
03	841010	Drilling machine for honing tool	4V84B136-1



23 Main Bearings

Item 23	Code	Description	Drawing No.
01	832003	Lifting device for bearing cap	22.83C02
02	803001	Bit 22 hex. socket screws, 1 in sq.drive	4V80L01-6
03	822001	Torgue multiplier X-4	4V82L01-1
*04	851001	Turning tool for main bearing shell R22	4V85B07
*05	851002	Turning tool for main bearing shell V22	4V85B12
*06	851005	Turning tool for thrust washers & bearing sh. R22	3V85B08
*07	851006	Turning tool for thrust washers & bearing sh. V22	3V85B17

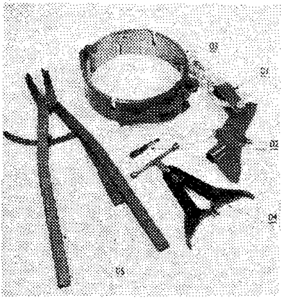


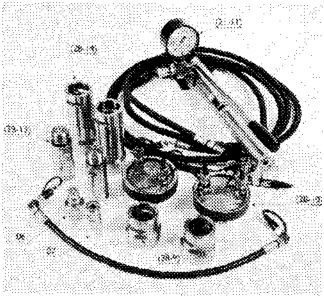


21 Cylinder Head

Item 21	Code	Description	Drawing No.
*01	861020	Hydraulic tightening device	22.86B09
*02	832005	Lifting tool for cylinder head	2V83C82
*03	846010	Dismantling device for valve springs	22.84G04
04	834002	Fitting tool for exhaust. valve seat ring	22.83E02
*05	841001	Grinding device for valves	22.84B02
06	841008	Grinding tool for injection sleeve bottom	22.84B03
*07	861031	Distance sleeve	3V86B67
*08	861025	Pin	4V86B11
*09	861035	Hose, short	4V86A13-1
*10	861036	Hose, long	4V86A30
*11	861000	Hydraulic hand pump	4V86A38
12	848003	Valve clearance feeler gauge	4V84K47
13	843001	Circlip pliers	B19 DIN 5254
14	808001	T-wrench for indicator valve	4V80K06
15	837016	Extractor for push rod *protection pipe*	3V83H97
16	832006	Service trestle for cylinder head	4V84G154

Note: *Items* marked with (*) are normally supplied with the engine. Some of the tools are applicable for certain cylinder numbers and with certain engine mounted equipment.





22 Piston

Item 22	Code	Description	Drawing No.
*01	832002	Lifting tool	3V83C64
02	845001	Tap M12	DIN 352
*03	843002	Clamp device for piston rings	2V84D10
04	843003	Piston ring pliers	4V84L18-1
*05	843004	Circlip pliers	4V84L16-1

Connecting Rod

Item 22	Code	Description	Drawing No.
*06	803011	Stud remover M30x2	4V80D18
07	807011	Socket wrench with square drive 27	DIN3124

See also item 21 and 28

06. Adjustments, Clearances and Wear Limits

06. 1. Adjustments

Valve timing:

Inlet valves open .... 50° before TDC, closes 20° after BDC

Exhaust valves open .... 50° before BDC, closes 50° after TDC

Valve clearances, cold engine:

Inlet valves .... 0.4 mm

Exhaust valves .... 0.8 mm

Start of delivery .... acc. to techn. spec.

Fuel rack position, heavy fuel .... see test records

Opening pressure of fuel injection valve .... 280 bar

Tripping speed of electro-pneumatic and mechanical overspeed trip devices:

Nominal engine speed	Tripping speed of mechanical overspeed trip device	Tripping speed of electro-pneumatic overspeed trip device
16.7 r/s (1000 rpm)	19.67 r/s (1180 rpm)	19.17 r/s (1150 rpm)

06. 2. Clearances and wear limits (at 20°C)

Pos	Part, measuring point	Drawing dimension (mm)	Normal clearance (mm)	Wear limit (mm)
10	Main bearing clearance (also flywheel bearing)		0.18...0.27	
	Journal diameter	200	+0...-0.029	
	Journal circularity	0.015		
	Journal taper	0.015/100		
	Main bearing shell thickness	7.440	+0...-0.015	7.38
	Bore of main bearing housing	215	+0.029...-0	
	Assembled bearing bore	200	+0.239...+0.180	

Pos	Part, measuring point	Drawing dimension (mm)	Normal clearance (mm)	Wear limit (mm)
	Main thrust bearing, axial clearance		0.12...0.25	0.5
	Main thrust bearing width	100 -0.160...-0.210		
	Corresponding crankshaft widht	100 +0.035...-0		
	Camshaft bearing clearance (also thrust)		0.10...0.18	
	Camshaft diameter	120 +0...-0.022		
	Camshaft bearing shell, thickness	4.950 +0...-0.015		4.90
	Camshaft bearing housing, bore	130 +0.025...-0		
	Camshaft bearing diameter	120 +0.102...+0.157		
	Camshaft diameter at thrust bearing	75 +0...-0.019		
	Camshaft thrust bearing housing, bore	90 +0...+0.022		
	Camshaft thrust bearing diameter, in situ	75 +0.056...+0.108		
	Camshaft thrust bearing axial clearance		0.14...0.31	
	Camshaft thrust bearing, widht	70 -0.24...-0.37		
	Cylinder liner, diameter	220.00 +0.046...-0		top:220.45 bottom:220.25
	Cylinder liner cylindricity	0.02		0.20
	Big end bearing clearance		0.14...0.23	
	Crank pin, diameter	180 +0...-0.025		179, 825
	Crank pin circularity	0.015		0.05
	Crank pin, taper	0.015/100		
	Big end bearing shell, thickness	4.940 +0...-0.015		
	Connecting rod bore, lower	190 +0.029...-0		
	Big end bearing assembled diameter	180 +0.203...+0.144		
	Gudgeon pin bearing clearance		0.09...0.15	
	Gudgeon pin diameter	95 +0...-0.010		
	Gudgeon pin circularity	0.0025		
	Gudgeon pin taper	0.005		
	Connecting rod bore, upper	115 +0.022...-0		
	Gudgeon pin bearing diameter, in situ	95 +0.142...+0.090		95.18
	Connecting rod axial clearance in piston		0.55...0.80	
	V22: Clearance between connecting rods		0.18...1.94	
	Clearance gudgeon pin – piston		0.005...0.025	
	Bore diameter in piston	95 +0.015...+0.005		
	Piston ring gap (clamped ø220) Compression rings Oil scraper rings		 0.81...1.11 0.96...1.21	2.05
	Piston ring height clearance: Compression ring 1 Compression ring 2 Compression ring 3 oil scraper ring		 0.12...0.15 0.07...0.10 0.07...0.10 0.04...0.07	 0.40 0.35 0.35 0.35

Pos	Part, measuring point	Drawing dimension (mm)	Normal clearance (mm)	Wear limit (mm)
	Piston ring groove height Groove I *Groove II* Groove III Groove IV	4.11 +0.02...-0 4.06 +0.02...-0 4.06 +0.02...-0 6.03 +0.02...-0		
	Piston clearance at bottom in cross direction of engine		0.14...0.22	
	Corresponding piston diameter	219.87 ± 0.02		
	Crankshaft oil slinger(driving end) Axial clearance: radial clearance around crankshaft flange:		0.39...1.03 0.62...0.93	
12	Valve guide diameter	16 +0.095...+0.075		
	Valve stem diameter	16 +0...-0.018		15.97
	Valve stem clearance		0.06...0.11	0.20
	Valve seat deviation relative guide (max. value)	0.10		
	Inlet valve seat bore in cylinder head	78 +0.019...0		
	Exhaust valve seat bore in cylinder head: outer bore inner bore	85+0.022...0 75+0.019...0		
13	Intermediate gear of camshaft drive bearing clearance axial clearance		0.03...0.09 0.15...0.35	0.20 0.50
	Bearing diameter in situ	60 +0.03...-0		
	Bearing journaldiameter	60 -0.03...-0.06		
	Camshaft driving gear backlash:			
	Crankshaft gear - intermediate gear		0.10...0.45	
	Intermediate gear -camshaft gear		0.10...0.45	
	Base tangent length:			
	- crankshaft gear	99.75 ±0.024		
	- large intermediate gear	146.003 ±0.027		
	- small intermediate gear	92.842 ±0.024		
	- camshaft gear	130.694 ±0.024		
14	Valve tappet, diameter	55 -0.03...-0.06		
	Guide diameter	55 +0.03...-0		
	Diameter clearance		0.03...0.09	0.15
	Tappet roller bore diameter	30 +0.021...-0		
	Bush diameter, outer	30 -0.020...-0.033		
	Bush diameter, bore	22 +0.041...+0.020		
	Tappet pin diameter	22 -0.007...-0.020		21.95
	Bearing clearance roller-bush bush-tappet pin		0.02...0.05 0.03...0.06	0.10 0.13
	Rocker arm bearing diameter	*50 +0.050...+0.025*		
	Bearing journal diameter	50 +0...-0.016		49.95
	Bearing clearance		*0.03...0.07*	0.25
	Yoke pin diameter	20 -0.040...-0.053		
	Yoke bore diameter	20 +0.033...-0		
	Diameter clearance		0.04...0.09	0.15

Pos	Part, measuring point	Drawing dimension (mm)	Normal clearance (mm)	Wear limit (mm)
16	Nozzle needle lift	0.4		0.5
	Injection pump tappet:			
	Tappet roller bore diameter	36 +0.025...0		
	Bush diameter, outer	36 -0.050...-0.089		
	Bush diameter, bore	28 +0.065...+0.098		
	Tappet pin diameter	28 -0.020...-0.053		
	Bearing clearance roller-bush bush-tappet pin		0.05...0.114 0.085...0.153	0.15 0.20
17	Fuel feed pump, engine driven			
	Shaft diameter	20 +0.009...-0.004		
	Bush diameter, bore	20 +0.061...+0.040		
	Bearing clearance		0.03-0.07	0.15
	Axial clearance		0.02-0.10	
	Backlash for driving gear		0.55...0.68	
	Base tangent length for pump gear	53.68 ±0.022		
	Crankshaft gear for pump operation	115.348 ±0.024 115.159 ±0.024		
	Base tangent length, standard design z = 70 fast transm. ratio z = 73			
18	Lubricating oil pump for V22			
	Shaft diameter	50 -0.080...-0.105		
	Bush diameter, bore	50 +0.039...-0		
	Bearing clearance		0.08...0.15	0.22
	Axial clearance		0.27...0.36	
	Backlash for driving gear		0.36...0.49	
	Base tangent length, driving gear standard design i = 70/48 fast transm. ratio i = 73/45 pump gear	 84.404 ±0.024 84.489 ±0.024 42.95 ±0.030		
	Lubricating oil pump for R22			
	Shaft diameter	32 -0.07...-0.10		
	Bush diameter, bore	32 +0.039...-0		
	Bearing clearance		0.07--0.14	
	Axial clearance		0.18...0.25	
	Backlash for driving gear		0.36...0.49	
	Base tangent length, driving gear standard design i = 70/48 fast transm. ratio i = 73/45 pump gear	 84.404 ±0.024 84.489 ±0.024 28.53 ±0.030		
19	Water pump backlash for driving gear		0.55...0.68	
	Base tangent lengthfor driving gear standard design i = 70/30 fast transm. ratio i = 73/27	 53.515 ±0.021 53.735 ±0.021		
22	Driving shaft for governor	20 +0...-0.021		
	Bearing for driving shaft	20 +0.053...+0.020		
	Bearing clearance		0.020...0.07	0.15
	Axial clearance		0.10...0.15	
	Backlash for driving gear		0.10...0.20	0.30

Pos	Part, measuring point	Drawing dimension (mm)	Normal clearance (mm)	Wear limit (mm)
23A 4R	Backlash, balancing shaft gears			
	Crankshaft gear – Intermediate gear		0.1...0.6	
	Intermediate gear – balancing shaft gear		0.1...0.5	
	Balancing shaft gear		0.1...0.35	
23B 8V	Backlash, balancing arrangement gears			
	Balancing shaft driving gear – water pump driving gear		0.175...0.55	
	Balancing shaft driving gear – intermediate gear		0.175...0.55	
	Shaft diameter	60 -0.030...-0.060		
	Bush diameter (assembled)	60 +0.090...+0.030		
	Bearing clearance		0.060...0.139	
	Axial clearance		0.15...0.045	

07. Tightening Torques and Instructions for Screw Connections

07. 1. Tightening torques for Screws and Nuts

The position numbers refer to fig. 07-51. Threads and contact faces of nuts and screw heads should be oiled with lubricating oil if otherwise not stated. Notee that locking fluid and special lubricant (Molykote) are used in certain cases.

Misused Molykote may cause the screws to break.

1 Nm = 0.102 kpm

Pos	Screw connections	Torque Nm	Scale setting
1	Main bearing side screws. Use tool combination acc. to 05-15A.	1200±20	30 kpm
2	Shild bering fixing. **Apply Loctite 242 on threads.**	210±10	21 kpm
3	Connecting rod screw (not hydraulically tightened srews). After tightening the screws are locked in pairs with steel wire ø 2 mm. **Apply Molykote G-n Plus under the screw head, on the scrwe guiding and the threads.**	260±10	
4A	Counerweight pressure screw (connections with one fastening screw). Lubricate the pressure face, i.e. the end of the screw, with Molykote Paste G. Apply lubricating oil on the threads.	500±10	
4B	Counterweight screws (connections with two fastening screws). Apply lubricating oil on the screws. Use tool combination acc. to 05-15A.	1320±20	33 kpm
5A	Crankshaft flange screws (connection without nuts), 20 pcs. Lubricate the washers with Molykote G-n Plus, the threads with oil. Use the torque multiplier X-4.	1160±20	29 kpm
5B	Crankshaft flange screws (fitted bolts) 10 pcs. Lubricate the contact faces of the screws and holes with Molykote G-n Plus. Use the torque multiplier X-4.	640±20	16 kpm
6	Extension shaft flange at free end. Use the torque multiplier X-4.	600±20	15 kpm
7	Screws of pump driving gear at free end. Use the torque multiplier X-4.	600±20	15 kpm
8	Split gear on crankshaft: gear to crankshaft - screws. **Apply Loctite 242 on the threads. See section 07.2.**	120±5	12 kpm
9	Split gear on crankshaft: Screws of gear half to gear half. **Apply Loctite 242 on the threads. See section 07.2.**	140±5	14 kpm
10	Camshaft flange screws. The screws are treated with locking compound and can be used three times the locking effect being intact; then replace. Use tool combination 05-15B. **Do not wash the screw threads but keep them clean and dry.**	80±5	7 kpm
10A	Screws of intermediate gear bearing journal. **Apply loctite 242 on the threads. See section 07.2.**	400±10	
11	Screws of overspeed trip device to the camshaft.	45±5	4.5 kpm
12	Screw for dog at overspeed trip device.	85±5	8.5 kpm
13	Nuts for valve tappet guide block.	85±5	8.5 kpm
14	Nuts for injection pump flange.	85±5	8.5 kpm

Pos	Screw connections	Torque Nm	Scale setting
15	Injection pump head piece (L'Orange), fastening screws M10.	65±3 (0-30-50-65)	6.5 kpm
16A	Injection pump element (L'Orange), fastening screws M12.	100±5 (0-50-80-100)	10 kpm
16B	Injection pump cover (Bosch), fastening screws.	45±5 (0-20-35-45)	4.5 kpm
17	Injection pipe connection nozzle holder.	65±5	6.5 kpm
18	Injection pipe cap nuts.	50±5	5 kpm
19	Injection valve fastening nuts (M12).	50±3	5 kpm
20	Injection nozzle cap nut.	110±5	11 kpm
21	Nuts of rocker arm bearing bracket. Apply Loctite 270 on the stud threads in cylinder head.	85±5	8.5 kpm
22	Starting valve: fastening screws	40±4 (0-20-40)	4 kpm
	Stem nut	14±2	1.4 kpm
23	Fastening screws for driving gear of the lubricating oil, circulating water and raw water pumps (connections with one fastening screw per pump). **Apply Loctite 242 on the threads.**	85±5	8.5 kpm
23A	Fastening screws for water pump driving gear (connection with three Inbus Plus fastening screws).	23±3	2.3 kpm
23B	Fastening screws for lubricating oil pump driving gear 6R, 8R, V22 (connection with four Inbus Plus fastening screws).	75±5	7.5 kpm
23C	Fastening nut for lubricating oil pump driving gear 4R22HF.	210±10	21 kpm
24	Fastening of gear for fuel feed pump. (Not for electrically driven pumps.) Apply lubricating oil on the shaft thread and the contact face of the nut. Clean and degrease the conical part of the screwed joint. Do not apply any lubricant.	135±5	13.5 kpm
25	Impeller nut for circulating and raw water pumps.	150±5	15 kpm
26	For balancing mechanism of four cylinder engines:		
1	bearing cap screws	250±10	25 kpm
2	fastening screws for gears	120±5	12 kpm
3	fastening screw for intermediate gear	250±10	25 kpm
4	screws for intermediate gear bearing	290±10	29 kpm
5	screw connection: intermediate shaft - balancing shaft	120±5	12 kpm
6	fastening screws (M16): oil sump - engine block	250±10	25 kpm

We recommend the use of torque measuring tools alsa when tightening other screws and nuts. The following torques apply to screws of the strenght class 8.8:

Screw dimension	Width across flats of hexagon screws	Key width of hexagon socket head screws	Torque/Nm	kpm
M8	13	6	25	2.5
M10	17	8	50	5.0
M12	19	10	85	8.5
M16	24	14	200	20

07. 2. Use of Locking Fluid

When using locking fluid (Loctite), clean parts carefully in a decreasing fluid and let dry completely before applying locking fluid.

07. 3. Hydraulically Tightened Connections

07. 3. 1. Tightening Pressures for Hydraulically tightened Connections

The position numbers refer to fig 07-51.

Pos.	Screw connection	Hydraulic pressure when tightening	Tightening torques of studs Nm	Max. hydr. pressure when opening	Hydraulic cylinder number
27	Main bearingscrew M42	540 bar	200	560 bar	861020
28	Cylinder headscrew M42	500 bar	200	520 bar	861020
29A V22	Connecting rodscrew M30x2	555 bar	85	565 bar	861027
29B R22	Connecting rodscrew M30x2	555 bar	85	565 bar	861020
30	Shield bearingscrew M24	285 bar	50	295 bar	861030

07. 3. 2. Filling, venting and control of the hydraulic tool set

(Fig. 07 - 52)

1 Connect the hydraulic pump and cylinder acc. to scheme 07-52B. Fill the filling bottle (delivered with the pump) with oil, viscosity about 2°E.

2 Open the release valve (3) and press the pistons of the cylinders (4) to expel oil possibly occurring in the cylinders back to the pump container.

3 Lift the pump above the cylinders and keep it in the position where the palstic plug (2) is topmost. Remove the plug and filling screw located inside the plug.

4 Press the spout of the filling bottle into the filling hole and squeeze the bottle to make the oil enter. Let air flow into the bottle, and fill the pump container completely with oil.

5 Replace the filling screw and plastic plug.

6 Vent the complete hydraulic set by closing the valve (3), open the air vent screw (7) and pump until airvoid oil flows out. Close the screw (7).

7 If a large oil amount escapes when venting, refill the container.
The system is provided with bayonet couplings including non-return valves which means that venting is necessary when filling the container, only.

The non-return valves are opened by the pins located in teh centre of teh male and female parts. If these pins get worn, replace the couplings. Risk of blocking system.

If, exceptionally, it is necessary to operate the with couplings not completely intact, it is advisable to open the air vent screw to assure that the passage is open to all cylinders before tightening the connection.

07. 3. 3. Dismantling hydraulically tightened screw connections

1 Attach distance sleeves and hydraulic cylinders according to fig. 07-52A. Screw on cylinders by hand.

2 Connect the hoses to the pump and cylinders according to scheme 07-52B. Open the release valve (2) and screw cylinders in clockwise direction to expel possible oil.

3 Screw the cylinders in counter-clockwise direction about half a revolution (180°).

4 Close the release valve and pump pressure to the stated value.

5 **Screw the nut** in counter-clockwise direction about half a revolution.

6 **Open the release valve** and remove the hydraulic tool set.

07. 3. 4. Reassembling hydraulically tightened screw connections

1 **Screw on nuts** and attach distance sleeves. Screw on cylinders by hand.

2 **Connect the hoses** to the pump and cylinders. Check that the release valve is open and screw the cylinders in clockwise direction to expel possible oil.

3 **Close the release valve** and pump pressure to the stated value.

4 **Screw the nuts** in clockwise direction until close contact to face. Keep pressure constant at the stated value.

5 **Open the release valve** and remove the hydraulic tool set.

Hydraulic cylinder 07-52

08. Operating Troubles, Emergency Operation

Preventive measures, see chapter 03 and 04. Some possible operating troubles require prompt action. Operators should acquire knowledge of this chapter for immediate action when needed.

		See chapter, section
1.	**Crankshaft does not rotate at starting attempt**	
a)	V-engines: The turning device is connected. In-line engines: The cover on flywheel protection is open. **NOTE!** Engine cannot be started when turning device is connected. However, before starting, always check that turning device is removed.	11.1, 21.1
b)	Starting air pressure too low, shut-off valve on starting air inlet pipe closed	21.1, 21.5
c)	Jamming of starting valve in cylinder head	21.4
d)	Jamming of starting air distributor piston	21.3
e)	Starting air solenoid valve faulty	21.2
f)	Inlet or exhaust valve jamming when open. 'Negative' valve clearance (strong blowing noise).	12
g)	Starting automation outside engine faulty	03.1.2, 23.
h)	4R22: Starting motor faulty	21.6
2.	**Crankshaft rotates but engine fails to fire**	
a)	Too low speed (1b).	
b)	Automatic shut-down device is not in start position.	23
c)	Load limit of control shaft or of governor is set at too low a value	22
d)	Overspeed trip device has tripped	22.5, 22.6
e)	Starting fuel limiter wrongly adjusted	22.3.5, 22.7
f)	Some part of fuel control mechanism jamming and prevents fuel admission	22
g)	Fuel and injection system not vented, pipe connections between injection pumps and valves not tightened	17.3
h)	Fuel filter clogged	17.7, 17.1
i)	Three-way cock of fuel filter wrongly set, valve in fuel inlet pipe closed, fuel day tank empty, fuel feed pump not started or faulty	17.7, 17.1
k)	Very low air and engine temperatures (preheat circulating water!)in connection with fuel of low ignition quality	02.1.4k
l)	Fuel insufficiently preheated or precirculated	02.1.2b, 02 fig. 02-1
m)	Too low compression pressure (1f)	
3.	**Engine fires irregularly, some cylinders do not fire at all**	
a)	Jamming valves, inadequate fuel supply, too low temperatures	1f, 2f,g,h,k,l, 4d
b)	Injection pump control rack wrongly adjusted	22.3
c)	Injection pump control sleeve does not mesh properly with rack(may cause overspeed if set in direction towards increased fuel quantity)	16.5
d)	Injection pump faulty (plunger or tappet sticking; delivery valve spring broken, delivery valve sticking)	16
e)	Injection valve faulty; nozzle holes clogged	16
f)	Piston rings ruined; too low compression pressure	11.6.2

g) 8...16-cylinder engines. It may be troublesome to make these fire on all cylinders when idling, due to the small quantity of fuel required. **In normal operation this is acceptable.** In special cases, in engines which have to idle continuosly for longer periods (several hours), for some reason, it is advisable to adjust the rack positions carefully (reduce rack position somewhat on those cylinders having the highest exhaust gas temperatures, increase somewhat on those cylinders not firing). This adjustment should be done in small steps and the difference between rack positions of various cylinders should not exceed 1 mm.	
4. Engine speed not stable	
a) Governor adjustment faulty (normally too low compensation)	22
b) See point 2f	
c) Fuel feed pressure too low	01.2.2
d) Water in preheated fuel (vapor lock in injection pumps)	
e) Loading automation (e.g. controllable pitch propeller) outside engine faulty	23
5. Knocks or detonations occur in engine (if reason cannot be found immediately, stop the engine!)	
a) Big end bearing clearance too large (loose screws !)	06.2. pos. 11, 07.3.1 pos.35, 11.7
b) Valve spring or injection pump tappet spring broken	12, 16
c) Inlet or exhaust valve jamming when open	
d) Too large valve clearances	06.1, 12.4
e) One or more cylinders badly overloaded (3b, c)	
f) Injection pump or valve tappet guide block loose	16.3, 14.4, 07.1.9, 07.1.10
g) Initial phase of piston seizure	
h) Insufficient preheating of engine in combination with fuel of low ignition quality	
j) Fuel injection timing wrong	
6. Dark exhaust gases	
a) Late injection (wrongly set camshaft drive)	06.1, 16.4, 13.3
b) See points 3b,c,d,e	
c) Unsufficient charge air pressure - air intake clogged - turbocharger compressor dirty - charge air cooler clogged on air side - turbocharger turbine badly fouled **NOTE!** Engines starting on heavy fuel may smoke if left idling.	Test Records 15.2 15.2, 04.4 15.6 04.5
7. Engine exhaust gases blue-whitish or gray witish	
a) Excessive lubricating oil consumption due to: gas blow-by past piston rings; worn or broken oil scraper rings or worn cylinder liners; sticking compression rings; compression rings turned upside-down; ring scuffing (burning marks on sliding surfaces)	03.3.5, 11.6
b) Blue-whitish exhaust gases may occasionally occur when engine has been idling for a lengthy time or at low ambient temperature, or for a short time after starting	
c) Gray witish exhaust gases due to water leakage from exhaust boiler, turbocharger	

8. Exhaust gas temperature of all cylinders abnormally high	
a) Engine badly overloaded (check injection pump rack positions)	Test Records
b) See point 6d	
c) Charge air temperature too high - charge air cooler clogged on water side or dirty on air side - water temperature to air cooler too high, water quantity unsufficient - engine room temperature abnormally high	Test Rec., 01.2 15.5, 15.6 01.3 01.3
d) Excessive deposits in cylinder head inlet or exhaust ports	
e) Exhaust pipe pressure after turbine high	04.4, 04.5, 15.3
9. Exhaust gas temperature of one cylinder above normal	Test Records
a) Faulty exhaust gas thermometer	23, 03.3.1a
b) Exhaust valve - jamming when open - 'negative' valve clearance - sealing surface blown by (burned)	
c) Faulty injection valve - opening pressure much too low - sticking of nozzle needle when open - broken spring - nozzle cracked	06.1 16.11
d) Late injection	06.1, 16.4
e) Fuel supply insuficient (filter clogged)	
f) Injection pump faulty , fuel rack sticking in high	
10. Exhaust gas temperature of one cylinder below normal	
a) Faulty exhaust gas thermometer	23, 03.3.1
b) See points 2f,h, 3b,c,d,e	
c) Leaky injection pipe or pipe fittings	16.7
d) When idling, see point 3g	3.3.1
11. Exhaust gas temperatures very unequal	
a) See points 9a,c,e	
b) Too low fuel feed pressure: too small flow through injection pumps (see points 2h,,i). May cause great load differences between cylinders although injection pump rack positions are the same. **Dangerous!** Causes high thermal overload in individual cylinders.	01.2.2
c) See points 1f, 6b	
d) When idling, see point 3g	
e) Exhaust pipe or turbine nozzle ring partly clogged	
f) Apply to 8- and 16-cylinder engines. The difference in exhaust gas temperatures of the two cylinders next to the turbocharger is normally 50-120°C.	
12. Lubricating oil pressure lacking or too low	01.2.2
a) Faulty pressure gauge, gauge pipe clogged	23.1.1
b) Lubricating oil level in oil sump too low	01.1, 18.2
c) Lubricating oil pressure control valve out of adjustment or jamming	18.4
d) Three-way cock of lubricating oil filter wrongly set	18.7
e) Leakage in lubricating oil suction pipe connections	18.1
f) Lubricating oil badly diluted with diesel oil, viscosity of oil too low	02.2.1, 02.2.3
g) Lubricating oil pipes inside engine loose or broken	18
13. Too high lubricating oil pressure	
a) See points 12a and c	

14. Too high lubricating oil temperature	01.2.1
a) Faulty thermometer	
b) Insufficient cooling water flow through oil cooler (faulty pump, air in system, valve closed), too high raw water temperature	19.1.2 01.3
c) Oil cooler clogged, deposits on tubes	18.5
d) Faulty thermostat valve	8.6
15. Abnormally high cooling water outlet temperature, difference between cooling water inlet and outlet temperatures too large	01.2.1
a) One of thermometers faulty	
b) Circulating water cooler clogged, deposits on tubes	19.7
c) Insufficient flow of cooling water through engine (circulating water pump faulty), **air in system, valves closed**	19.3, 19.4 03.3.1
d) Thermostat valve faulty	19.5, 19.6
16. Water in lubricating oil	02.2.3, 03.3.1
a) Leaky oil cooler	18.5
b) Leakage at cylinder liner O-rings (always pressure test when cooling water system has been drained or cylinder liners have been dismantled)	
c) Faulty lubricating oil separator. See separator instruction bookl	02.2.3
17. Water in charge air receiver (escapes through drain pipe in air cooler housing)	15.5
a) Leaky air coolers	15.5
b) Condensation (too low charge air cooling water temperature)	03.3.1a, fig. 03-1
18. Engine looses speed at constant or increased load	
a) Engine overloaded, a further increase of fuel supply is prevented by the mechanical load limiter	22.1, fig. 22-51 pos. 13
b) See points 2c,f,g,**h,i**	
c) See points 4c,d, 5g, 19d	
19. Engine stops	
a) Shortage of fuel, see points 2h,i	
b) Overspeed trip device has tripped	22.5, 22.6
c) Automatic stop device has tripped	23.1.4
d) Faulty governor or governor drive	22
20. Engine does not stop although stop lever is set in stop position or remote stop signal is given	
a) Injection pump control rack wrongly set (3b,c) Trip overspeed trip device manually. If the engine does not stop immediately, block fuel supply as near the engine as possible (e.g. by fuel filter three-way cock). Before restarting the engine, the fault must be located and corrected. Great risk of overspeed.	
b) Faulty stop automation. Stop by means of stop lever	23.1.4
c) The engine driven by generator or propeller or by another engine connected to same reduction gear	

21. Engine overspeeds and does not stop although overspeed trip device trips	
a) Injection pump control rack wrongly set (3b,c) **Load the engine, if possible.** Block fuel supply, e.g. by means of fuel filter three-way cock.	
b) An overspeeding engine is hard to stop. Therefore, check regularly the adjustment of the control mechanism (the injection pump rack positions) 1) the stop lever being in stop position or the overspeed trip device being tripped and the speed governor at max. fuel admission 2) the stop lever and the overspeed trip being in work position and the speed governor in stop position. This control should be done always when the control mechanism or the injection pumps have been touched.	22.3

08. 1. Emergency operation

08. 1. 1. Operation with defective air cooler(s)

If the water tubes of an air cooler are defective, the cooling water may enter the cylinders. If water or water mist flows out of the drain pipe at the bottom of the cooler housing, check whether it is raw water or condensate. If condensate, reduce cooling (see chapter 0, fig. 03-1). If raw water, stop the engine as soon as possible and fit a spare cooler.

If no spare cooler is available, the following can be done as an emergency solution:

1 Dismantle the cooler for repair and blank off the opening in the charge air cooler housing. Shut off water supply and return pipes. Repair the cooler, e.g. by plugging the leaking tubes.

2 If there is not time enough to remove the defective cooler a nd repair it, shut off water supply and return pipes.

3 Operating with a partially plugged, shut-down or removed air cooler. Engine output must be limited so that the normal full load exhaust temperatures are not exceeded.

The turbocharger may surge before the admissible exhaust temperatures are reached. In such a case, engine load must be reduced further to avoid continuous surging.

08. 1. 2. Operation with defective turbocharger(s)

A defective turbocharger is to be treated in accordance with the service instructions given in the turbocharger instruction book (blocking of rotor etc.)

If one turbocharger on a V-engine is defective and must be blocked, the other charger should be blocked too, the air connection between the charger and the air coolers removed and the engine operated as a naturally aspirated engine.

When operating the engine without turbochargers, the engine output must be limited so that the normal full load exhaust temperatures are not exceeded.

Available load from the engine wiyh blocked turbocharger (s) is about 20 % of full load.

08. 1. 3. Operation with defective cams

If the camshaft piece with damaged cams cannot be removed and replaced by a new one, the engine can be kept running by the following measures:

1 Injection pump cams:

Slight damage:

Set injection pump control rod into zero position and lock it by a wire around the pump.

Bad damage:

Remove fuel injection pump. See chapter 16.

Attention! Concerning torsional vibrations and other vibrations, see chapter 08, section 08.2.5.

When operating with a shut-off injection pump over a long period the valve push rods of the inlet and outlet valves are to be removed, and the indicator valve on the respective cylinder is to be opened once an hour to allow any accumulated oil to escape.

With one cylinder out of operation, reduce load to prevent exhaust temperature of the remaining cylinders from exceeding normal full load temperatures.

2 Valve cams

Stop fuel injection to the cylinder concerned, see chapter 16. Remove the valve push rods and cam followers of the cylinder. Replace the tubes covering the push rods.

Attention! Concerning torsional vibrations and other vibrations, see chapter 08, section 08.2.5.

With one cylinder out of operation, reduce load to prevent exhaust temperatures of the remaining cylinders from exceeding full load temperatures.

08. 1. 4. Operation with removed piston and connecting rod

If damage on piston, connecting rod or big end bearing cannot be repaired, the following can be done to allow emergency operation:

1 **remove the piston and the connecting rod,**

2 **cover lubricating oil bore in crank pin** with a suitable hose clip, and secure,

3 **fit completely assembled cylinder head** but omit valve push rods,

4 **prevent starting air engry to the cylinder head** by removing pilot air pipe,

5 **shut down injection pump** (chapter 16, section 16.12).

Attention! **Concerning torsional vibrations and other vibrations, see chapter 08, section 08.2.5.**

With one cylinder out of operation, reduce load to prevent exhaust temperature of the remaining cylinders from exceeding normal full load temperatures.
If the turbocharger(s) surge, reduce load further to avoid continuous surging.
Operation with piston and conrod of one or more cylinders removed should be performed only in absolute emergency conditions when there are no other means of proceeding under own power.

08. 1. 5. Torsional vibrations and other vibrations

When running the engine with one cylinder or more out of operation, the balance of the engine is disturbed, and severe or even dangerous vibrations may occur. The vibration conditions are in practice dependant on the type of the installation, but as general advice it can be said that when there are cylinders out of order, the following should be applied.

In installations with variable speed the lowest speed should, if possible, be used when driving acc. to chapter 08.2.4.

10. Engine block with bearings, cylinder liners, oil sump

10. 1. Description

The engine block is cast in one piece of cast iron. The distributing pipes for lubricating oil and cooling water as well as the air receiver are incorporated in the engine block. The main bearing caps are arranged hanging and support the crankshaft in interchangeable precision type bearing shells. The upper bearing shell is guided in the oil groove by a lug at each end. The lower shell has a lug at one end to be axially located. The periphery of the shells is longer than that of the bearing bore and thus provides for the fixation of the shells. The first main bearing, seen from the driving end, is provided with four thrust washers in order to guide the crankshaft axially. An extra, so-called shield bearing may be located next to the flywheel, if necessary.

The camshaft bearing bushes are in housings directly machined in the block.

The engine block embodies the cylinder liners, made of special cast iron and honed to an optimal finish. At the top flange the liners are sealed against the block metallically, only, at the lower part by two O-rings.

The crankcase covers and the thick light metal covers of the camshaft openings are provided with rubber profile gaskets. Some of the crankcase covers include a spring-loaded safety valve which releases the overpressure in case of a crankcase explosion. The crankcase is provided with an air vent pipe including a non-return valve. The air vent pipe should be conducted away from the engine. A cover incorporating the oil filling hole is located at the driving end of the engine.

The oil sump is made of welded steel plates. A rubber profile gasket seals off against the block.

10. 2. Dismantling of main bearing shells

1 **Remove the crankcase covers** closest to the bearing in question.

2 ***Unscrew the main bearing cap side screws*** *about one turn* by using the wrench combination X-4, see fig. 10-54A.

3 **Lift the distance sleeves (8) in position** (fig. 10-51A) and insert the pins (10) into the slots of the sleeves to fix the sleeves.

Note! For V-engines, equipped with torsional vibration damper Hasse & Wrede ASK 1728, two extra distance sleeves are delivered. These two sleeves are to be used on the main bearing at the torsional vibration damper only. The sleeves are marked 3V86B56.

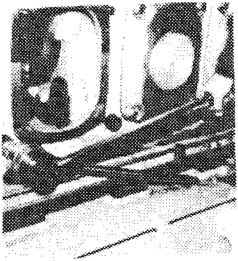


Fig 10-54 A

Fig 10-54 B

4 Connect the hydraulic cylinders (9) to the main bearing screws, fig. 10-54B. Connect the hoses according to the scheme 10-51C and open the valve (3) of the hydraulic pump. Tighten the hydraulic cylinders further by hand to force possible oil back to the pump. Then unscrew the cylinders half a turn (180°). (See section 07.3). This is specially important when using the sleeves 3V86B56.

5 Elongate the screws by pumping the pressure to the value stated in section 07.3. Fig. 10-54C. Then unscrew the nuts about one turn by means of the pins.

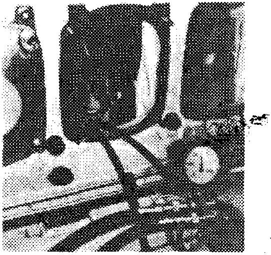


Fig 10-54 C

6 Release pressure by slowly opening the valve on the hydraulic pump. Remove the hoses, unscrew the cylinders and remove the sleeves.

7 Remove the nuts and apply the main bearing cap lifting tool 832003 (fig. 10-52, 10-54D). Remove the side screws and lower the cap by means of the lifting tool until the handle rests on the bottom edge of the crankcase opening. The lower bear ring shell can now be removed out of the cap.

If the main bearing cap is to be removed, shift angle position of the handle by inserting the locking pins into the other pair of holes. In doing so it is possible to further lower the main bearing cap until it is free from the bolts and can be dismantled. To facilitate this procedure, remove the neighboring side screws.

Fig 10-54 D

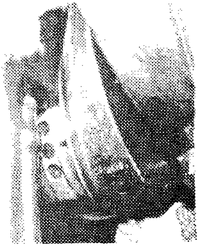


Fig 10-54 F

8 To dismantle the upper bearing shell, insert the dog 851001 (in-line engine) or 851002 (V-engine) into the crankshaft journal radial oil hole, turn the crankshaft carefully until the bearing shell has been turned 180° and remove it. Fig. 10-54F.

Cover the two crankshaft journal oil holes with tape.

At least every third main bearing must be in place at the same time to support the crankshaft.

9 The thrust washers can be removed from the main bearing cap when it is in lowered position.

To remove the upper halves of the thrust washers, insert the turning tool 851005 (in-line engine) or 851006 (V-engine) into the bearing journal radial oil hole. Turn the crankshaft carefully 180° and remove the washers.

10. 3. Inspection of the main bearing shells and thrust washers

Wash the bearing shells and check for wear, scoring and other damage. Wear is settled according to document no. 3210T00101E in section 6. Mark the new bearings with the bearing numbers.

The thrust washers should be changed in pairs to ensure that the flanges of the axial bearing surfaces are of equal thickness.

No scraping or other fitting of bearing shells, caps or bores is allowed. Burrs or dirt should be locally removed,only.

The bearing journals should be inspected for surface finish. Damaged journals (rough surface, scratches, marks of shocks) should be polished. If after a longer period of running considerably uneven wear appears, section 06.2. pos. 11, the crankshaft may be reground and reassembled together with thicker bearing shells. Concerning these, see the Spare Parts Catalogue.

10. 4. Installing main bearing shells and thrust washers

1 Clean the main bearing bore, caps, shells and crankshaft journal very carefully .

2 Take off the protecting tape from the crankshaft oil holes and lubricate the journal with pure engine oil.

3 Lubricate the upper shell bearing surface (not the rear side). Check that the bearing shells are installed correctly.

4 Place the edge of the shell in the slot between the crankshaft and the bearing bore and push it in by hand as far as possible. Fig. 10-55A.

5 Place the dog 851001 (in-line engine) or 851002 (V-engine) in the crankshaft journal radial oil hole and turn the crankshaft carefully until the bearing shell has been turned into position . Take care that the bearing shell guiding flap enters the groove without being damaged. Remove the dog.

6 Lubricate the lower shell bearing surface (not the rear side) and place it in the bearing cap; raise the cap by means of lifting tool 832003 (fig. 10-52, 10-56C) until the lubricated side screws can be screwed into the threads of the bearing cap by hand. Remove the lifting tool.

7 Lubricate the nuts and screw on by hand.

Fig 10-55 A

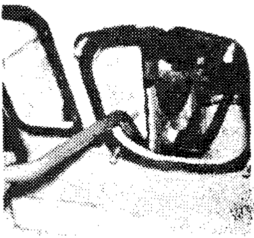


Fig 10-55 C

8 Put the distance sleeves (8) fig. 10-51A in place and keep them in position by inserting the pins (10) into the holes of the nuts through the sleeve slots. Screw on the cylinders (fig. 10-55D) and connect the hoses. Open the valve of the hydraulic pump. Tighten the cylinders by hand to force possible oil back into the pump.

9 When reinstalling the thrust main bearing, force the crankshaft axially towards the free end.

10 When reinstalling the main bearing with thrust washer, proceed as follows: Remove the tape from the oil holes. Place the dog 851005 (in-line engine) or 851006 (V-engine) in the oil hole. Oil the crankshaft, bearing (not the rear side) and thrust washers. Place them on the crankshaft and turn the crankshaft 180° until the bearings are in the correct position, then turn the crankshaft backwards and remove the dog.

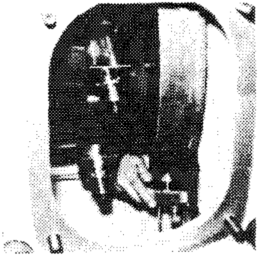


Fig 10-55 D

Mounting of the lower bearing half: Oil the bearings and thrust washers and mount them in the main bearing cap. Mount the cap as described in point 8.

Note! **The thrust washers are marked according to fig. 10-59 (operating side of the engine).**

11 **Tighten the side screws,** at the rear side only, to 300 Nm torque, then elongate the main bearing screws by pumping pressure to the value stated in section 07.3. Fig. 10-55E.

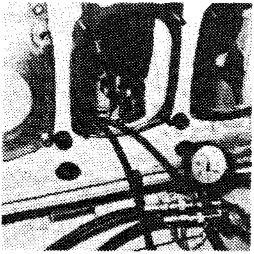


Fig 10-55 E

12 **Tighten the nuts by the pin (10)** until face-to-face contact. The pressure should be kept constant all the time.

13 **Release pressure** by opening the valve on the pump. Remove the hoses, unscrew the cylinders and take off the distance sleeves and pins.

14 **Tighten the side screws** by using the tool combination fig. 05-15A to the value stated in section 07.1.

15 **Before starting the engine** after a bearing inspection, check the crankshaft axial clearance (section 11.3).

10. 5. Dismantling and assembling of the shield bearing

10. 5. 1. Dismantling

If the engine is equipped with an extra main bearing (i.e. a shield bearing) between the main thrust bearing and the flywheel, the inspection may proceed as follows:

1 **Remove the bottom pieces of the tripartite end cover.** The topmost piece can be left loose in place.

2 **Unscrew the four screws** fastening the bottom of the bearing housing to the engine block by means of the tool combination according to fig. 10-56A.

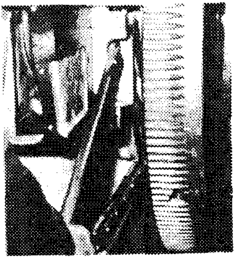


Fig 10-56 A

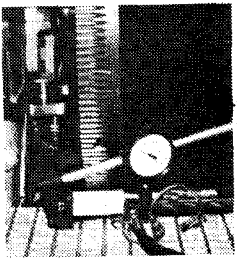


Fig 10-56 B

3 **Loosen the nuts** of the two vertical screws by the hydraulic tool according to 10-56B. See section 07.3.

4 **Lower the bearing cap** so that it rests against the edge of the oil sump. Fig. 10-56C. (If the cap is to be removed from the engine, loosen the studs.)

5 **Remove the upper shell** by turning in clockwise direction using the tool 851004 placed in the crankshaft journal radial oil hole. Fig. 10-56D. Remove the turning device. Cover the oil hole with tape.

6 **Check the bearing** in the same way as normal main bearings, section 10.3.

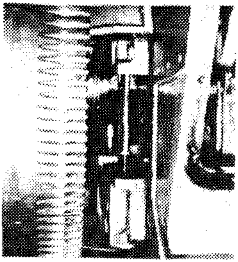


Fig 10-56 C

Fig 10-56 D

10. 5. 2. Assembling

1 Lubricate the upper bearing shell surface and crankshaft journal.

2 Insert the bearing shell end without lug in the clearance between the journal and bearing bore grooved edge. Push in the shell by hand as far as possible.

3 Place the turning device 851004 in the crankshaft journal radial oil hole and turn carefully in **counterclockwise** direction until the edge of the bearing shell levels with the bearing housing mating face. Check that the flap at the bear ring edge is not damaged. Remove the turning device. Fig. 10-56 D and C.

4 Lubricate the lower bearing shell surface and place the bearing shell in the bearing cap. Fig. 10-56C.

5 Raise the bearing cap until the bearing shell edges level and tighten the nuts by hand.

6 Knock the two dowel pins from above to get the lower bearing house centered.

7 Put the distance sleeves in place, insert the pins in the slots.

8 Screw on the hydraulic cylinders.

9 Connect the hose, open the pump valve and tighten the cylinders further.

10 Pump pressure to the value state in section 07.3 so that the screws elongate. Fig. 10-56B.

11 Keep pressure constant and tighten nuts by the pins 861025 (fig. 10-51B).

12 **Release pressure** by opening the pump valve. Remove the hoses, unscrew the cylinders and take off the distance sleeves and pins.

13 **Tighten the four fastening screws to torque** according to section 07.1. Fig. 10-56A.

10. 6. Removing and installing the cylinder liners

Caution! **A new type of cylinder liner (drawing number 1V10F117) has been taken in to use.**
Before mounting note that: a new cylinder liner must not be mounted in an engine block with a contraction edge for the cooling water. Should there be such a contraction edge (see fig. 10-60), its diameter must be machined from ø 265 to ø 273 as shown in fig. 10-60 before mounting. The water flow around the cylinder stops unless the edge is removed, resulting in an immediate risk of breakdown.

The tool required for the prescribed machining, drawing number 1V-T24420, can be ordered or rented from the Wärtsilä Vasa Factory.

If a cylinder liner is to be replaced or checked on the water side, use the tool 836001. Lubricate the threads of the tool and the contact face of the nut with Molykote Paste G.

When installing the cylinder liner:

1 Check that the guides and contact face (upper level) of the engine block are perfectly clean and intact, as well as the corresponding surfaces of the cylinder liner.

2 Check that the two O-ring grooves are clean and fit new O-rings.

3 Lubricate the O-rings and sealing faces with Molykote Paste G or soft soap and apply the above mentioned tool on the liner, this time for lifting.

4 Lower the liner carefully into the bore of the block. When the first O-ring touches the sealing face, align liner so that the scribing mark on the liner flange points to the driving end, lower a bit and press the liner in position by hand. Give the liner a few blows with a rubber or plastic hammer, if necessary.

5 Check the bore of the liner, especially straight in front of the O-rings (390 mm from the upper edge of the liner); see section 06.2 pos. 10. The out-of-roundness of a replaced liner must not exceed 0.03 mm.

After having installed the cylinder liner and refilled the cooling water, check the O-ring seals from the crankcase side. Circulate water through the engine under high pressure (1.25 x nominal pressure), if possible (separate cooling water pump).

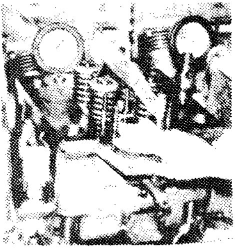


Fig 10-53 A

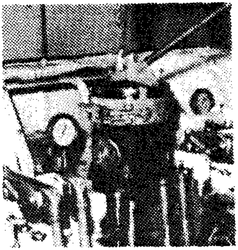


Fig 10-53 B

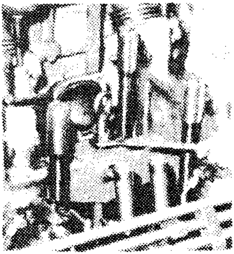


Fig 10-53 C

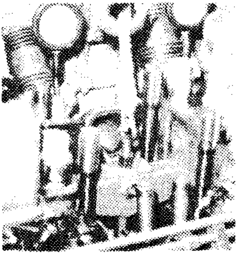


Fig 10-53 D

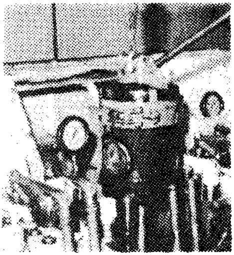


Fig 10-53 E

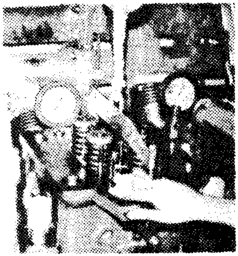


Fig 10-53 F

10. 7. Inspection of the camshaft bearing bush

When the camshaft bearing journal has been removed the inner diameter of the bearing bush can be measured in situ by using a ball anvil micrometer screw. The wear limit is stated in section 06.2 pos. 10. For visual inspection of the camshaft bearing bush, proceed as follows:

1 Remove the both camshaft covers adjacent to the bearing concerned.

2 Remove the cover from the starting air distributor, see section 14.

3 Open the flange connection camshaft piece bearing journal towards the driving end of the engine seen from the bearing concerned.

4 Move the part of the camshaft locating towards the free end of the engine max. 20 mm in direction of the free end by using a suitable lever.

5 Check the uncovered part of the bearing bush by means of a mirror. All camshaft bearing bushes towards the free end of the engine, seen from the bearing concerned, can be checked when the camshaft is in this position.

10. 8. Removing of the camshaft bearing bush

1 Remove the camshaft cover, injection pump, guide blocks and camshaft piece from the two cylinders adjacent to the bearing concerned. If it is the question of an end bearing the respective camshaft end piece has to be removed.

2 Remove the camshaft bearing journal.

3 Assemble the removing device 834001 according to fig. 10-58 or, for the bearing next to the free end of the engine according to fig. 10-58B. When it is the question of an end bearing, insert the guide sleeve (part of 834001) the thicker part being directed towards the middle of the engine.

4 Tighten the hydraulic cylinder by light tensioning of the pull screw.

5 Connect the hoses of the hydraulic pump to the hydraulic tool.

6 Pump pressure to the hydraulic tool to withdraw the bearing bush. **The pressure must not exceed 600 bar.** If the bearing bush does not move when this pressure is achieved, a light knock at the end flange of the tool may be necessary.

7 **Open the pump valve,** disconnect the hoses of the hydraulic tool and dismantle the removing device.

10. 9. Mounting of the camshaft bearing bush

1 **Lubricate the new bearing bush** lightly with clean engine oil at the outer surface and put it on the guide sleeve.

2 **Assemble the mounting device** 834001 according to fig. 10-58C or, for the bearing next to the free end of the engine, according to fig. 10-58D. When it is the question of an end bearing, insert the guide sleeve the thinner part being directed towards the middle of the engine. Position the mark on the bearing bush against that on the engine block.

3 **Tighten the hydraulic cylinder** by light tensioning of the pull screw.

4 **Connect the hoses** of the hydraulic pump to the hydraulic tool.

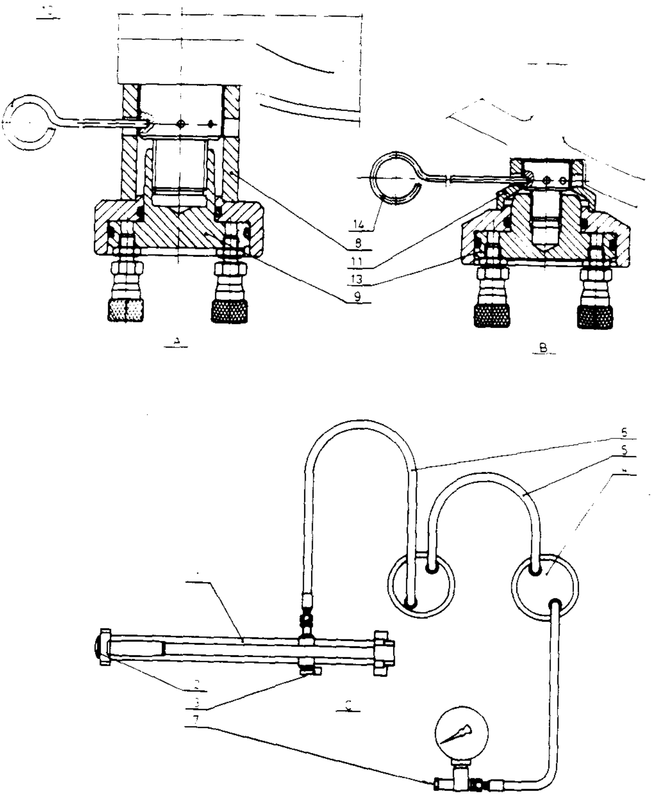
5 **Pump pressure to the hydraulic tool** to withdraw the bearing bush. **The pressure must not exceed 600 bar.**

6 **Open the pump valve,** disconnect the hoses of the hydraulic tool and dismantle the mounting device.

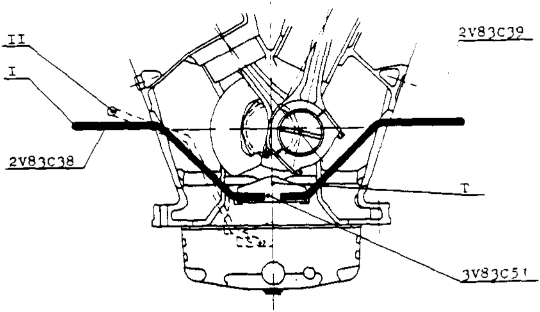
7 **Lubricate the bearing bush running surface** and fit the cam shaft bearing journal.

8 **Mount the camshaft pieces,** guide blocks, injection pump and camshaft covers.

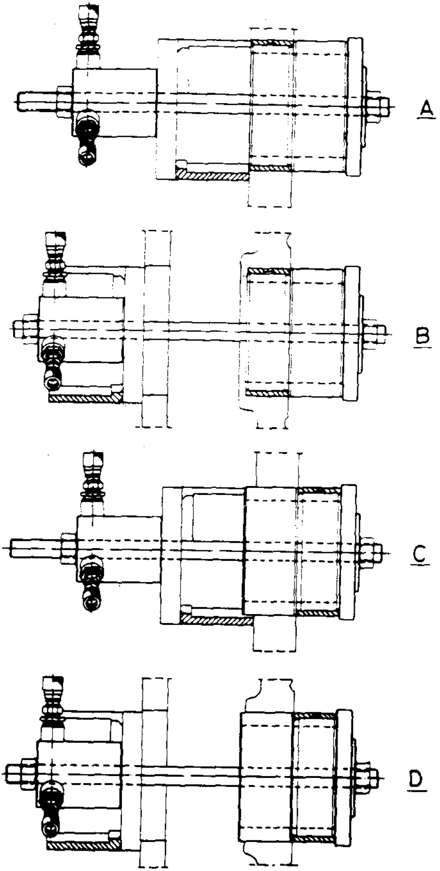
Hydraulic tool assebly 10-51



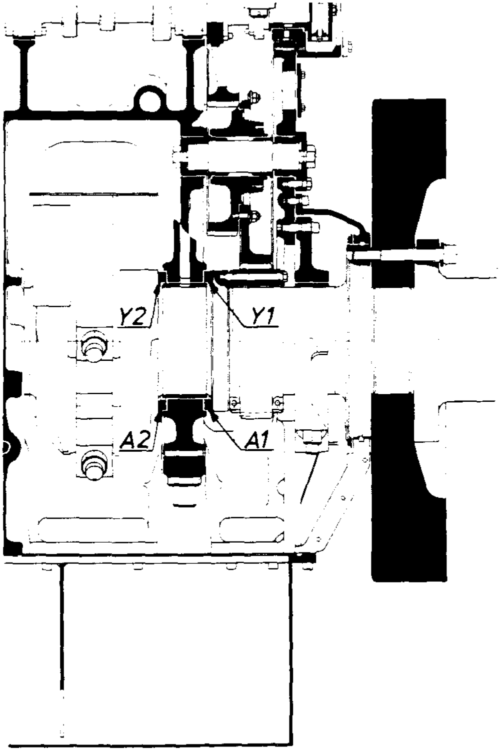
Lifting toolfor main bearing cap 10-52



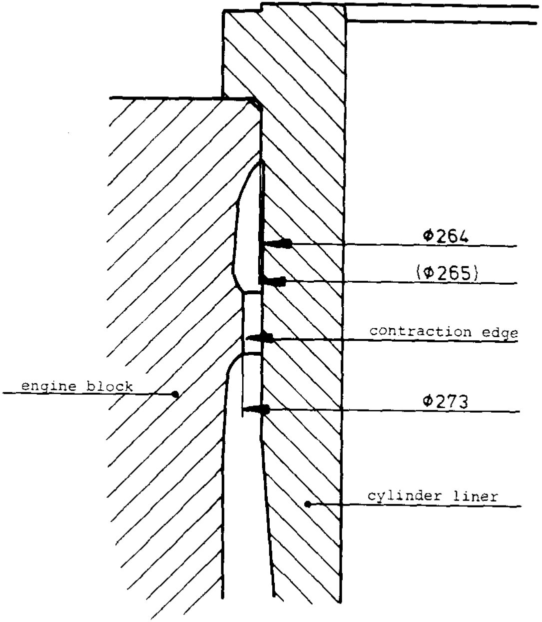
Tools for camshaft bearing bush 10-58



Marking of the thrust washers of the crankshaft 10-59



Machining of engine block for new type of cylinder liner 10-60



11. Running gear: Crankshaft, connecting rod, piston

11. 1. Description

The crankshaft is forged in one piece. The first main bearing, seen from the driving end, is provided with thrust washers and guides the crankshaft axially. On V-engines all crank webs are provided with counterweights; on in-line engines counterweights are used when necessary. Each counterweight is fastened with hexagon tension screws.

At the driving end of the crankshaft there is a shrunk-on oil ring preventing oil and gas leakage, and a split gear, see section 13. At the free end of the shaft there is, if necessary, a tuning mass or a vibration damper as well as a gear for driving of the pumps.

4R22 balancing arrangement. The four-cylinder in-line engine is equipped with two balancing shafts which rotate at a speed twice the crankshaft speed. The shafts are driven by the crankshaft through an intermediate gear. Each shaft is pivoted in four pressure lubricated sliding bearings, one of which is axially guiding. The counterweights are integrated into the shaft.

Normally, the arrangement needs no maintenance. In connection with overhauls of the engine the sliding bearings can be inspected. In case the transmission has been opened it is absolutely necessary to make sure that the marks of the gears remain in their initial positions. See figures 11-55 and 11-56.

8V22 balancing arrangement. The eight-cylinder V-engine has four balancing wheels rotating at a speed twice the crankshaft speed. Each wheel is driven by the crankshaft through an intermediate gear. The bearing arrangement is similar to the one used in the camshaft intermediate gear.

Normally the balancing arrangement needs no maintenance. In case the transmission has been opened, for example in connection with water pump exchange, it is absolutely necessary to make sure that the marks of the gears remain in their initial position. See figures 11-57 and 11-58.

The flywheel is fastened to the crankshaft by four screws, partly, and partly by the screws of the power take off shaft. Normally, these screws are provided with clearance holes and compress the flanges, the flywheel being in between. The power is conveyed by the frictional force between the flanges. The Vasa 22 diesel engines can be equipped with a power takeoff at the free end of the engine, when necessary.

The flywheel position indicator is equipped with a nonius scale for reading of the engine crank angles, at an accuracy of 1°, on the graduation of the flywheel.

The turning device for V-engines consists of a gear to be coupled to the square pin of the ratchet, fig. 11-52D. The rotational direction for turning can be reversed by altering the ratch position of the ratchet. A warning light on the instrument panel of the engine will switch on when the turning device is connected.

In line engines are turned by means of a lever to be inserted in the flywheel holes.

Note! Always remove the turning device before starting.

Fig 11-52 D

The connecting rod is drop forged and precision serrated in the mating face. The big end bearing is a trimetal bearing of the same design as the main bearings. Lubricating oil is fed through the main bearings and bores in the crankshaft.

The gudgeon pin bearing has a larger bearing surface on the lower side where the load is larger. Lubricating oil is led through bores in the connecting rod from the big end bearing. The connecting rod is axially guided by the piston through the top part of the gudgeon pin bearing.

The gudgeon pin is hollow and is provided with radial holes to convey lubricating oil from the connecting rod to the piston. The pin ends are covered to prevent oil from escaping. The gudgeon pin is axially fixed in the piston by means of oval retainer rings.

The piston is made of nodular iron and is cooled with the engine lubricating oil conveyed through the gudgeon pin into an annular space, from which the oil is allowed to flow to the engine oil sump. The skirt of the piston is lubricated with oil from bores drilled to the gudgeon pin bearing. The two top ring grooves are hardened.

Note! Always handle the piston with care.

The piston ring combination includes three compression rings, the two top rings of which are chromium-plated, and one springloaded, chromium-plated oil scraper ring.

11. 2. Crankshaft alignment (applies to a heated engine)

1 Turn the crank of the first cylinder near the bottom dead enter, apply the crankshaft indicator (a dial micrometer with the tip distance of 150 mm for the V-engine and 96 mm for the in-line engine) between the two crank webs into the center marks provided for this purpose, whereby the clearance between the micrometer and connecting rod should be as small as possible, and set the micrometer at zero.

2 Read the various deviations when turning the crank to the rear side, top dead center, operating side etc. Record in the crankshaft alignment measurement records (the forms are included in every delivery). Repeat this procedure with the other cylinders. The difference between two diametral readings of the same crank must not exceed 0.04 mm after installing and realigning. If the difference is more than 0.07 mm realignment is recommended: at 0,10 mm realignment is absolutely necessary. Before realigning the engine and the driven machinery, check the main bearing shell thickness.

3 When the last crank throw is in the TDC the reading should be negative, max. -0.04 mm, or zero. The recommended value is -0.02 mm.

4 If the values stated in point 2 and 3 cannot be achieved, repeat the alignment.

5 When the cylinder block and the generator have been aligned, always check the axial clearance.

Engines with a torsional elastic coupling connected to the flywheel have a larger difference at the crank web next to the flywheel owing to the crankshaft deflection. After installing and realigning such engines the difference must not exceed 0.06 mm. The crank pin being upwards the reading is negative on this crank web. Maximum allowed deviation before realignment is absolutely necessary is in this case 0.11 mm.

11. 3. Control of the the axial clearance

Before checking the crankshaft axial clearance by using a dial micrometer, run the engine prelubricating pump for a few minutes to lubricate the bearings. Stop the pump and apply the dial micrometer to the face of the flywheel, for instance. Then set the micrometer at zero, move the crankshaft in the opposite direction and read the axial clearance on the micrometer.

The axial clearance should be kept within the limits stated in section 06.2 pos. 10.

When installing and realigning, check also the radial clearance around the periphery between the crankshaft flange and the tripartite driving end cover. The normal clearance is 0.62...0.93 mm.

11. 4. Removal of the connecting rod and piston

1 Remove the cylinder head (section 12.2). Scrape off any carbon around the upper portion of the cylinder liner. (It is advisable to cover the piston top with cloth or paper pressed tightly against the wall to collect carbon or other dirt which has come loose.)

2 Clean the threaded hole in the piston with the tap M12 and screw on the lifting tool 832002 by using the hexagon screw M12x80. Fig. 11-52B,C.

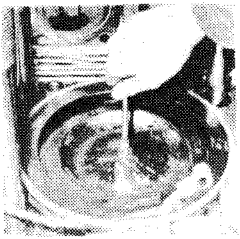


Fig 11-52 B

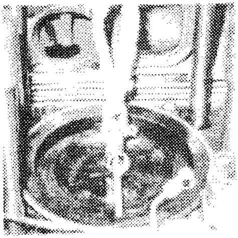


Fig 11-52 C

3 In-line engine: Turn the crankshaft 95° from the TDC towards the manoeuvering side of the cylinder in question.
V-engine, A-bank: Turn the crankshaft 95° from the TDC towards the A-bank of the cylinder in question.
V-engine, B-bank: Turn the crankshaft 95° from the TDC towards the B-bank of the cylinder in question. When turning in-line engines, use a turning lever (844002) which should be attached to the holes on the flywheel.)

4 Lift the distance sleeves, 861033 for the in-line engine and 861026 for the V-engine, on to the connecting rod screws.

5 Screw on the hydraulic tools; for the in-line engine the hydraulic tool 861020 with the distance piece 861032 screwed on to the hydraulic piston (fig. 11-52E), for the V-engine the hydraulic tool 861027.

6 Connect the hoses according to fig. 11-52E and open the pump valve.

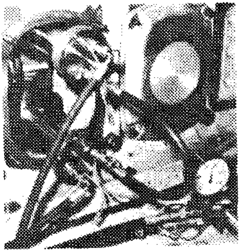


Fig 11-52 E

7 Screw on the hydraulic tools until the piston is in bottomposition.

8 Unscrew the hydraulic tools about half a turn (180°).

9 Shut the pump valve and pump to stated pressure.

10 Unscrew the nuts about half a turn by the pin 861025.

11 Slowly open the pump valve, disconnect the hoses and screw off the hydraulic tools.

12 Screw off the nuts and undo the connecting rod screws by the stud tool 803011. Fig. 11-52F,G.

13 Lift the big end bearing cap together with the bearing shell out of the engine. Fig. 11-52H.

14 Lift the piston a little to remove the upper big end bearing shell; this applies to the in-line engine, only. On **V-engines**, mount the protecting rails 835003 and 835004 in position above the connecting rod serration. Fig. 11-54. When lifting the piston, take care not to damage the crank pin and the cylinder liner wall. Fig. 11-52I.

15 Cover the crank pin oil holes with tape.

16 If the connecting rod is to be withdrawn from the piston, remove the retainer ring from the gudgeon pin hole in the piston, fig. 11-53A, on the side where the gudgeon pin drawing number is, by using the retainer ring pliers 843004.

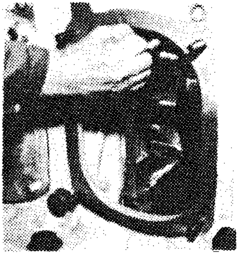


Fig 11-52 F


Fig 11-52 G


Fig 11-52 H

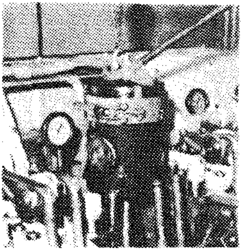


Fig 11-52 I

Note! Never compress the retainer ring more than barely to be able to remove it from the groove.

Push out the gudgeon pin from the opposite side. If the piston temperature is lower than +18...19°C the gudgeon pin may stick but will be easily removed when heating the piston to about 30°C.

17 To remove the piston rings, use the piston ring pliers 843003, fig. 11-53B. The design of these pliers prevents from overstressing the rings. However, the piston rings should not be removed unless the rings and grooves require cleaning, measuring etc. If the piston rings are to be reinstalled, note how they are turned, see section 11.6.3.

Every time when removing the piston, careful records should be made. Use the sheet "Service report" supplied with every installation.

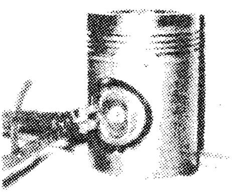


Fig 11-53 A

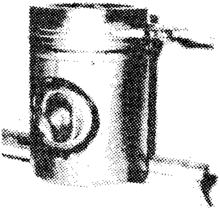


Fig 11-53 B

11. 5. Maintenance of the piston and connecting rod

1 When removing burned carbon deposits from the pistons particular care should be taken not to damage the piston material. Never use emery cloth. The cleaning is facilitated if coked parts are soaked in kerosene or fuel. An efficient carbon solvent — e.g. ARDROX No. 668 or similar — should preferably be used to facilitate the cleaning and to protect the pistons against mechanical damage. When using chemical cleaning agents, take care not to clean the piston skirt with such agents; the phosphate/graphite overlay may be damaged. Measure the height of the piston ring grooves, see section 06.2 pos.11.

2 In case of excessive fouling or sticking, the piston rings should be removed from the pistons and checked.

Check the rings for wear by inserting them into a new cylinder liner and measuring the ring gaps at the joint. Also check the clearance of the rings in their grooves, see section 06.2 pos. 11.

Especially the two chromium-plated topmost piston rings should be examined. If the chromium-plating is worn through, the ring should immediately be replaced by a new one. If the cylinder liner is new or horned, all rings are to be be replaced by new ones.

3 Check the end plugs of the gudgeon pins.

4 Check the gudgeon pin and big end bearing clearances (section 06.2 pos. 11) at intervals according to section 04. They will easily be checked by measuring the pins and bearing separately (the big end bearing being tightened to full torque). When using a feeler gauge the gauge should be formed of as many thin blades as possible; if using thick blades the overlay plating of the bearing may be damaged.

5 Check that the serration of the connecting rod is not damaged.

11. 6. Installing the connecting rod and piston

1 Check that the bores for the skirt lubrication are not blocked.

2 The gudgeon pins should always be inserted from the same side of the piston from which they have been removed and should be placed the same way around, see section 11.4.5. If the piston temperature is lower than +18...19°C the gudgeon pin may stick but will move freely if the piston is heated in oil to about 30°C. Oil the pin with lubricating oil before installing.

Note! Never compress the retainer ring more than barely to be able to fit it in the groove. If the ring is loose in the groove after installation it should be replaced. When mounting the piston in the connecting rod, see that the cylinder number stamped on the piston crown and the connecting rod are on the same side. When changing a piston, mark the new piston with the same number as the replaced one. The arrow on the piston head should point to the camshaft side.

3 Old piston rings should always be placed in the same groove and the same way around as when taken out.

Before installing new piston rings always check the gap clearance by fitting the rings into a new cylinder liner. Check also the vertical clearance in the ring grooves (section 06.2 pos. 11). When installing the rings, use the piston ring pliers. The ring joints should be located 120° in relation to each others.

4 **Clean the piston,** cylinder liner, connecting rod bearing bore and crank pin carefully. Wash the big end bearing. When changing bearings, both bearing shells should be marked with the cylinder number in the same way as the replaced one. Oil the piston and crank pin with lubricating oil. Place the clamp device for the piston rings around the piston, fig.11-53C. Check that the piston rings slide into the grooves without being damaged.

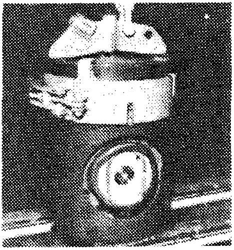


Fig 11-53 C

In-line engine: Turn the crankshaft 95° from the TDC towards the manoeuvering side of the cylinder in question.
V-engine A-bank: Turn the crankshaft 95° from the TDC towards the A-bank of the cylinder in question.
V-engine B-bank: Turn the crankshaft 95° from the TDC towards the B-bank of the cylinder concerned.
In V-engines, mount the upper bearings shell and the protecting rails 835003 and 835004, see page 11-54. Lower carefully the piston. Turn the piston and connecting rod so that the side with the cylinder number faces the camshaft.
In-line engine: When the connecting rod is lowered to the vicinity of the crank pin, apply the upper bearing shell in the bearing bore observing that the guiding flap slides into the recess of the connecting rod.

5 **Lubricate the threads** of the big end bearing screws with oil. Lift the bearing cap together with the lower bearing shell in place. Fig. 11-53E. Attach the connecting rod screws and tighten to stated torque by using the stud tool 803011. Fig.11-53F, G. Screw on the nuts and tighten by hand until the lower joint face of the big end bearing cap contacts that of the connecting rod, starting with the lower nut.

6 **Lift the distance sleeves,** 861033 for the in-line engine and 861026 for the V-engine, on to the connecting rod screws.

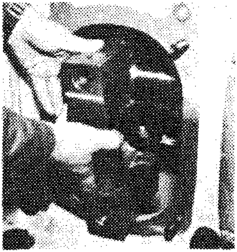


Fig 11-53 E


Fig 11-53 F

7 Screw on the hydraulic tools; for the in-line engine the hydraulic tool 861020 with the distance piece 861032 screwed on to the hydraulic piston (fig. 11-53H), for the V-engine the hydraulic tool 861027.

8 Connect the hoses according to fig. 11-53H and open the pump valve.

9 Tighten the hydraulic tools until the piston is in bottom position.

10 Shut the pump valve and pump to stated pressure. Fig. 11-53H.

11 Tighten the nuts by the pin 861025.

12 Slowly open the pump valve, disconnect the hoses and screw off the hydraulic tools.

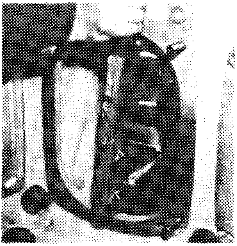


Fig 11-53 G

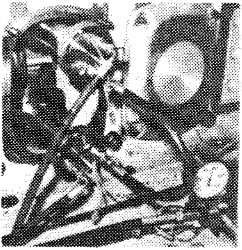


Fig 11-53 H

11. 7. Dismantling and assembling of the counterbalance system

Note! **Applies for 8-cylinder V-engines only.**

11. 7. 1. Dismantling (at the free end)

(fig. 11-57c)

1 **Remove the water pumps,** lube oil pump and the fuel feed pump as well as the pipes connected to the end cover.

2 **Remove the end cover.**

Note! **The end cover is fastened by 4 screws also from the inner side of the crankcase.**

3 **Check the axial clearance,** section 06.2 pos. 23 B.

4 **Remove the screws (1), (2) and (3).**

5 **Remove the flange (4) and the shaft (5).** The whole package counterweights - gear wheel can now be removed.

6 **Check the bearing clearance,** section 06.2 pos. 23 B.

7 **If the bearing clearance exceeds the normal values** or if the bearing is found to be damaged, remove the bearing bushes (6) by using an extractor.

11. 7. 2. Assembling (at the free end)

(fig. 11-57c, 11-58)

1 **Clean thoroughly the bearing housing,** i.e. the counterweights, and mount new bearings. The bearings should be cooled down with, for example, liquid air.

Note! **The longitudinal oil grooves (12) in the bushes shall point towards the center of gravity of the counterweights (marked with a distinct mark).**

2 **Mount the bush (13) to the shaft (5),** apply LOCTITE 275 on the threads of the fixing screw (3) and tighten the screw to the torque of 450 Nm.

3 **Put the counterweights,** the shaft and the flange (4) to their places, apply LOCTITE 275 on the threads of the screw (1) and tighten the screw to the torque of 450 Nm.

4 Measure with a dial indicator the axial clearance of the bearing bushes in the counterbalance system (see section 06.2 pos. 23 B).

5 Turn the crankshaft 30° clockwise from the top dead center of cylinder no. A1 (in this position the crankpin of cylinder 1 points straight upwards).

6 Reinstall the end cover with help of the guiding pins. Check that the hose seal against the underneath surface of the end cover comes to its place properly and that the under edge of the pump cover comes 0.15...0.55 mm above the under edge of the engine block. Do not forget to fasten the end cover also from the inside of the block (4 screws).

7 Reinstall the water pumps. Provided the assembly has been carried out correctly the counterweights now point downwards and the crankpin of cyl. 1 straight upwards (see fig. 11-58).

11. 7. 3. Checking

1 Turn the crankshaft 45° clockwise (from the position when the crankpin of cylinder 1 points straight upwards). The counterweights rotate with a speed twice the speed of the crankshaft. This means that the counterweight on bank A should point straight to the side. The scribing mark on the counterweight is now visible through the hole (14) provided the assembly is correct.

2 Turn the crankshaft further 90° clockwise . The scribing mark of the counterweight on bank B should now be visible through the hole (14), otherwise the assembly is to be repeated.

3 Check the backlash of the gear wheel (12) and the backlash of the water pump gear wheel through the holes in the cover (see section 06.2 pos. 19 and 23 b).

4 Reinstall the lube oil pump, pipes and before start check that the bearings get lube oil.

Note! When dismantling a water pump(s) it will affect the counterbalance system as it gets its driving force via the gear wheels of the water pumps.

It is most convenient to turn the crankshaft 30° clockwise from the top dead center of cylinder 1 (to the position when crankpin no. 1 points straight upwards and the counterweights point straight downwards). In this position the water pump(s) can be removed and installed without affection to the counterbalance system.

11. 7. 4. Dismantling (at the flywheel end)

(fig. 11-57b)

1 Check the axial clearance, section 06.2 pos. 23 B.

2 Unscrew the screw (15) and remove the flange (16).

3 Unscrew the screw (21) and remove the shaft (19). The whole package counterweights - gear wheel can now be removed.

4 Check the bearing clearance, section 06.2 pos. 23 B.

5 If the bearing clearance exceeds the normal values or if the bearing is found to be damaged, remove the bearing bushes by using an extractor.

11. 7. 5. Assembling

1 Clean thoroughly the bearing housing, i.e. the counter-weight and gear wheel and mount new bearings. The bearings should be cooled down with, for example, liquid air.

Note! **The longitudinal oil grooves (12) in the bushes shall point towards the center of gravity of the counterweights (marked with a distinct mark).**

---

2 Mount the bush (20) to the shaft (19), apply LOCTITE 275 on the threads of the fixing screw (21) and tighten the screw to the torque of 450 Nm.

3 Turn the crankshaft 30° clockwise from the top dead center of cylinder 1 (in this position the crankpin of cylinder 1 points straight upwards), fig. 11-58.

4 Put the counterweight, the shaft (19) and the flange (16) to their places, apply LOCTITE 275 on the threads of the screw (15) and tighten the screw to the torque of 450 Nm.

5 Measure with a dial indicator the axial clearance of the bearing bushes in the counterbalance system (see section 06.2 pos. 23 B).

Note! **The counterweights shall point straight downwards when the crankpin of cylinder 1 points straight upwards.**

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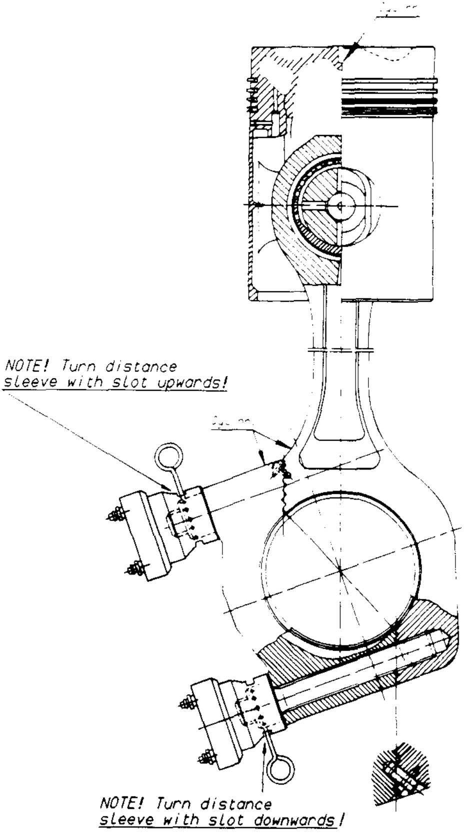
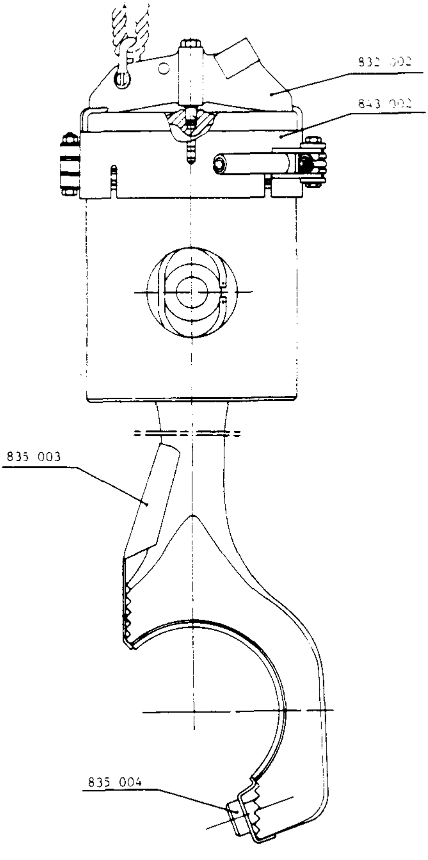
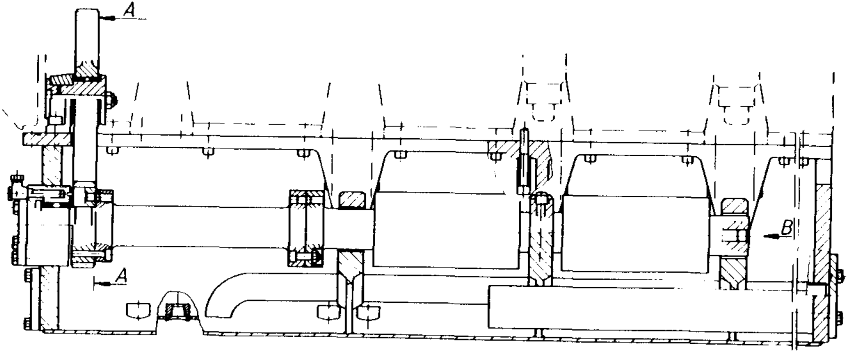
6 Before start check that the bearings get lube oil.

Connecting rod 11-51



Lifting of connecting rod 11-54



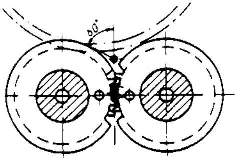


Tightening torques, see section 07.1.26

4R22 balancing arrangement

A-A

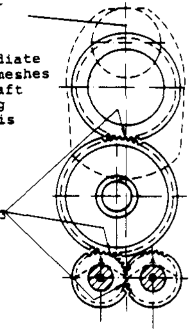
Phase 1

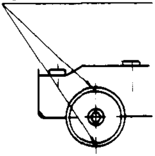


Push the driving gears of the balancing shafts so that they mesh when the guiding pins are horizontal in relation to the centre line of the engine

A-A

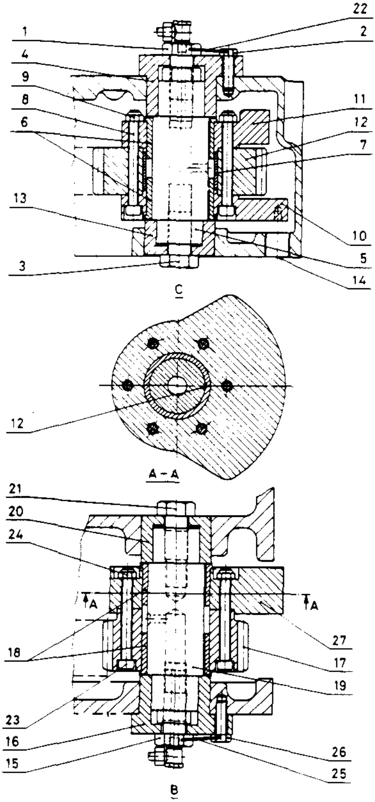
Phase 2





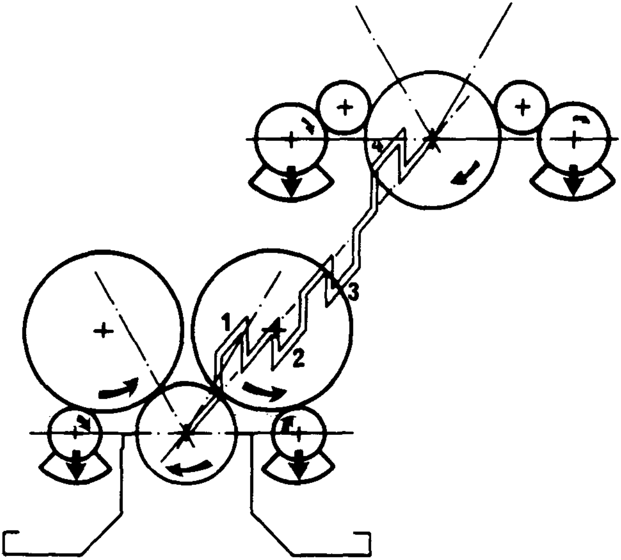
View B

8V22 balancing wheels 11-57



8V22 balancing arrangement

11-58



12. Cylinder head with valves

12. 1. Description

(fig. 12-51)

The engine cylinders are provided with separate heads of cast iron. Each head includes two inlet valves, two exhaust valves, a centrally located fuel injection valve, a starting valve and an indicator valve.

The inlet and exhaust valves are identical and designed with hard-faced seat surfaces and chromium-plated stems and they tight against shrunk-in seat rings in the cylinder head. The exhaust valve seats are water-cooled.

Use the forms "Service Report".

12. 2. Removing the cylinder head assembly

1 Drain cooling water. Remove the cooling water outlet pipe. Fig. 12-53A.

2 Remove the cylinder cover and the sheet covering the injection pumps. Fig. 12-53B.

Fig 12-53 A

Fig 12-53 B

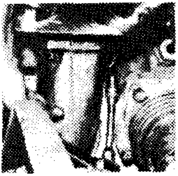


Fig 12-53 C

3 Remove the exhaust pipe fastening screws using the tool according to fig. 12-53C. Loosen the oil pipe and the starting air pipe. Remove the injection pipe. Fig. 12-53D.

4 Remove the rocker arm bracket and the push rods as well as the caps of the cylinder head screws. Fig. 12-53E.

5 Lift the hydraulic cylinders 861020 in place and screw them on the cylinder head screws, fig. 12-53F. Connect the hoses according to the scheme 07-52B, open the valve of the hydraulic pump and tighten the cylinders further to drain possible oil. **Then loosen the cylinders half a turn (180°),** Fig.12-53H. See section 07.3.

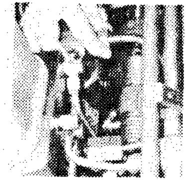


Fig 12-53 D

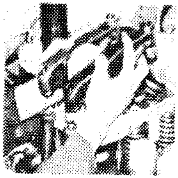


Fig 12-53 E

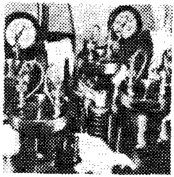


Fig 12-53 F

6 Tighten the screws by pumping hydraulic pressure to the value stated in section 07.3, and then loosen the nuts about one turn. Fig. 12-53I.

Fig 12-53 G

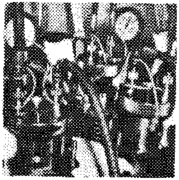


Fig 12-53 H

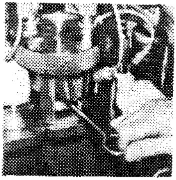


Fig 12-53 I

7 Release pressure by opening the valve of the hydraulic pump, loosen the hoses, unscrew and lift off the cylinders.
Remove the cylinder head nuts. Fig. 12-53K.

Apply the lifting tool 832005. Fig. 12-53L.

8 Lift off the cylinder head, fig. 12-53L. Cover the cylinder opening with a slab of wood or similar. Fig. 12-53M.

9 Apply the caps to protect the screw threads.

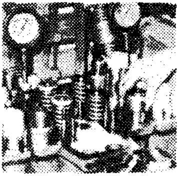


Fig 12-53 K


Fig 12-53 L

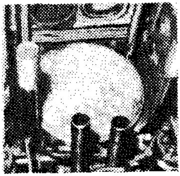


Fig 12-53 M

12. 3. Installing the cylinder head

1 Check the sealing rings of the water, charge air and starting air connections and of the push rod protecting pipes, check the cylinder head gaskets. Clean and oil all sealing surfaces. Put the exhaust pipe sealing ring in place. If necessary, press it slightly to make it stick in the groove. Fig. 12-54A.

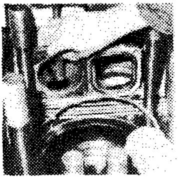


Fig 12-54 A


Fig 12-54 B

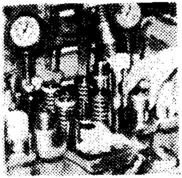


Fig 12-54 C

2 Apply the lifting tool 832005 to the cylinder head.

3 Lift the head above the cylinder and lower it carefully. When lowering the head, take care that the starting air connection pipe, the air pipe and the push rod protecting pipes slide into the seals without force. Fig. 12-54B.

4 Screw on the cylinder head nuts. Fig. 12-54C.

5 Lift the hydraulic cylinders 861020 in place. Screw on the cylinders, connect the hoses and open the valve of the hydraulic pump. Tighten the cylinders by hand to drain possible oil in the cylinders. Fig. 12-54D,E,F,G.

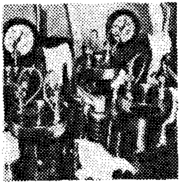


Fig 12-54 D

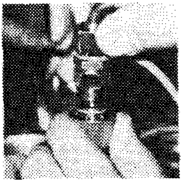


Fig 12-54 E

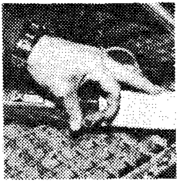


Fig 12-54 F

6 Tension the screws by pumping pressure to the value stated in section 07.3. Fig. 12-54H

7 Tighten the nuts by means of the pin until firm contact. Keep pressure constant. Fig. 12-54I.

Fig 12-54 G

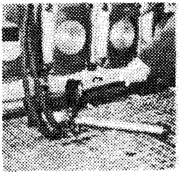


Fig 12-54 H

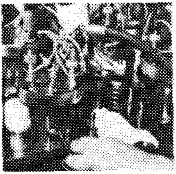


Fig 12-54 I

8 Release pressure by opening the pump valve. Fig. 12-54K.

9 Remove the hoses, unscrew and lift off the hydraulic cylinders.

10 Apply the protecting caps to the cylinder head screws. Fig. 12-54L.

11 Fit the yokes. The yokes must be fitted on the correct yoke guides.

Note the marks on the yokes: Ex = exhaust valves; In = inlet valves. Fig. 12-54M.

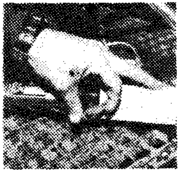


Fig 12-54 K

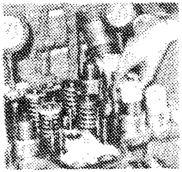


Fig 12-54 L

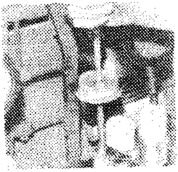


Fig 12-54 M

Check that all studs of the rocker arm bracket fastening are fully countersunk in the cylinder head before the rocker arm is mounted. If the studs are not fully screwed in, loosen them and apply LOCTITE 270 on the threads. Then screw in the studs completely in the cylinder head.

12 Fit the push rods and the rocker arm bracket. Tighten the nuts to the torque stated in section 07.1. Fig. 12-54N, O.

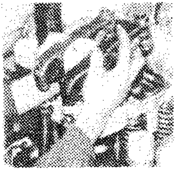


Fig 12-54 N

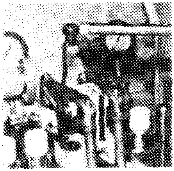


Fig 12-54 O

Fig 12-54 P

13 Connect the exhaust, oil, injection and starting air pipes and fit the water outlet pipe. Fig. 12-54 P,R,S.

14 Adjust the valve clearances. Fig. 12-54T and page 12-55.

15 Replace the cylinder head cover and injection pump cover. Fig. 12-54U.

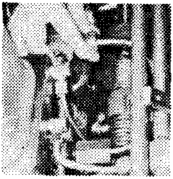


Fig 12-54 R


Fig 12-54 S

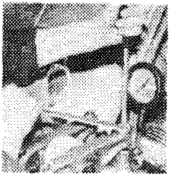


Fig 12-54 T

16 **Before starting,** fill the engine circulating water system and turn the engine some revolutions the indicator valves being open. Fig. 12-54V,W.

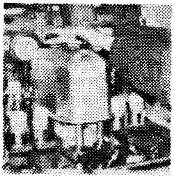


Fig 12-54 U

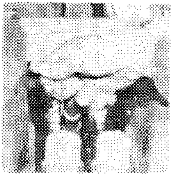


Fig 12-54 V

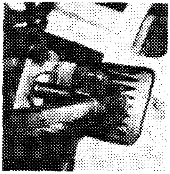


Fig 12-54 W

12. 4. Adjusting the valve clearance

1 **Turn the engine to the TDC at ignition** for the cylinder concerned See section 00.3.

2 **Loosen the locking nuts** of the adjusting screws on the rocker arm as well as on the yoke. Unscrew the adjusting screws to provide ample clearance. Fig. 12-55 B,C,D.

3 **Press the fixed yoke pin** against the end of the valve and tighten the adjusting screw. When the adjusting screw touches the valve end (fig. 12-55F), turn further until the fixed pin starts lifting from the valve end (fig. 12-55G). Turn the adjusting screw backwards to a position between 12-55F and 12-55G. Tighten the locking nut while fixing the adjusting screw. Fig. 12-55H.

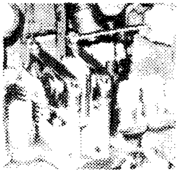


Fig 12-55 B

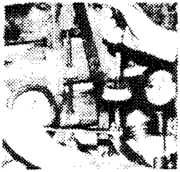


Fig 12-55 C

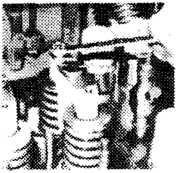


Fig 12-55 D

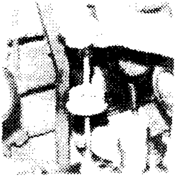


Fig 12-55 F

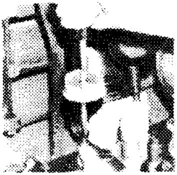


Fig 12-55 G

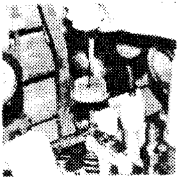


Fig 12-55 H

4 Insert a feeler gauge corresponding to the valve clearance (page 06-1) between the pressure surface of the yoke and the shoe of the rocker arm. Tighten the adjusting screw until the feeler gauge can be somewhat moved to and fro. Tighten the locking nut while fixing the adjusting screw. Fig. 12-55I,K. Check that the clearance has not changed while tightening. The feeler gauge to be used should be broad enough, otherwise the sliding shoe may come on the cross.

Fig 12-55 I

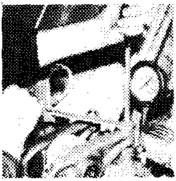


Fig 12-55 K

12. 5. Maintenance of the inlet and exhaust valves

12. 5. 1. Removing the valves

1 Fit the tool 846010 according to fig. 12-52D.

2 Depress the springs by turning the device clockwise.

3 Knock at the center of the valve discs, one at a time, whereby the cotters come loose and can be removed.

4 Unload the tool. The spring retainers and the springs can now (fig. 12-52)be removed.

5 Check that the valves move easily in the guides.

Note in which guide each valve was situated before.

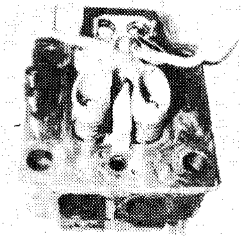


Fig 12-52 D

12. 5. 2. Checking and reconditioning the valves and seats

1 Clean the valves, seats, ducts and guides as well as the underside of the head.

2 Control the burning-off on the valve disc according to the sketch in fig. 12-56. The measure "Y" should be more than 5mm (nominal 6 mm) and measure "Z" should be less than 2mm. If the measures exceed these limits the valve must be replaced.

Control of the burning of

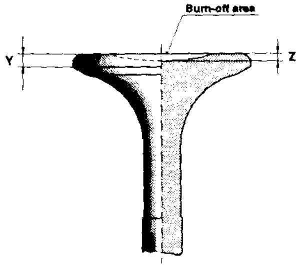


Fig 12-56

3 Check the sealing faces at the valves and the sealing rings. For this purpose it is recommended to apply a thin layer of fine lapping compound to the valve seat and rub the valve slightly against the seat a few times by hand. If the sealing faces are bright or if there is a coherent sealing face grinding is not recommended. If there is slight pitting, only, lapping is recommended. If the pitting extends over nearly the entire sealing face or if imperfect sealing is observed the valve and the seat should be reground.

4 Before grinding, check the valve stem clearance. If the clearance is too large, measure the stem and guide and change the worn part; the valve guide can be pressed out. Check the bore in the cylinder head. When refitting, cooling-in with liquid air is recommended, but pressing in with oil lubrication can also be accepted. After fitting in, check the guide bore and calibrate, if necessary.

5 Lapping If there are slight pits on the sealing faces they can be lapped by hand:

- Fit the turning tool to the valve, fig. 12-52E.
- Apply a thin layer of lapping compound to the sealing surface of the valve; No 1 for coarse lapping, No 3 for fine lapping.
- Rotate the valve to and fro towards the seat with the nut speeder. Lift the valve from the seat at intervals while lapping.
- Remove the smallest possible amount of material because the sealing faces have hardened during operation and are valuable. It is not necessary to grind off all pits.
- Clean the valve and seat carefully after lapping.

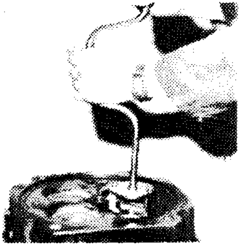


Fig 12-52 E

6 Machine grinding. If there is deep pitting or other damage the valve and seat should be ground by machine:

a. Seat face of the valve

The seat angle of the valve is 30° with a tolerance of -0.5° to achieve contact to the seat at the periphery. Minimum allowable edge thickness of the valve is 5.2 mm; after that the valve must be replaced.

After grinding, light lapping is recommended to provide contact of the seat and valve all around.

b. Seat ring for the inlet valve

The seat angle of the inlet valve seat ring is 30° with a tolerance of 0.25°.

The seat can be ground until the outer seat diameter is 74mm; after that the ring must be replaced by a new one. After grinding, light lapping is recommended to provide contact between the valve and seat.

c. Seat ring for the exhaust valve

The seat angle of the inlet valve seat ring is 30° with a tolerance of +0.2°.

The seat can be ground until the outer seat diameter is 73 mm. After grinding, light lapping is recommended to provide contact between the valve and seat.

7 Change of the seat ring

a) Removal of the old ring

1 *Fit a flat bar* of the dimensions 10x30, roughly, to the seat inner diameter and weld it to the seat by electric beam welding.
Also a scrapped valve can be used, and in such a case it is recommended to weld all around, fig. 12-52A.

2 Press or knock out the ring through the valve guide with an arbor.

b) Fitting a new inlet valve seat ring

1 Check the bore diameter in the cylinder head, see section 06.2, pos. 12.

2 **The ring can be assembled** by freezing in with liquid air of -190°C the cylinder head temperature being min. 20°C , or by pressing in with a guided arbor.
Always make sure that the ring contacts the bottom of the bore.

3 **Check the excentricity** of the sealing face in relation to the valve guide, fig. 12-52D , and if it exceeds 0.1 mm the seat surface must be ground by a seat grinding machine.

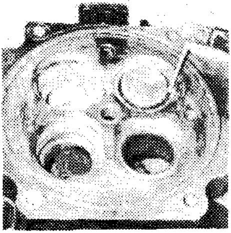


Fig 12-52 A

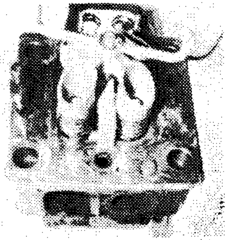


Fig 12-52 D

c) **Fitting a new exhaust valve seat ring**

1 **For fitting an exhaust valve seat ring** the tool 834002 is required.

2 **Check the bore diameters** in the cylinder head. Cool the seat rings in a thermostat controlled freeze box to -15...30°C.

Note! **The seal rings will be damaged at lower temperatures.**

3 **Put the new seal ring** on the seat ring and apply LOCTITE 272 on the bores in the cylinder head and on the corresponding surfaces of the seat ring.

4 **Put the seat ring** into the guiding bush and press in the seat with the guided arbor.

5 **Check the excentricity** of the sealing face in relation to the valve guide, fig. 12-52D ; if it exceeds 0.1 mm the seat surface must be ground by a seat grinding machine.

6 **Keep the cylinder head temperature** at min. 20°C for six hours to harden the locking fluid.

12. 5. 3. Reassembling the engine valves

1 **Check the valve springs** for cracks and wear marks on the coils. If any, replace the springs by new ones.

2 **Put the new seal rings** in the valve guides.

3 **Lubricate the valve stems** with engine oil.

4 **Put in the valves** and check for free movement.

5 **Check that the exhaust valve rotators turn smoothly** by hand. If the movement between upper and lower part of the rotator is not smooth and free, exchange the complete rotator.

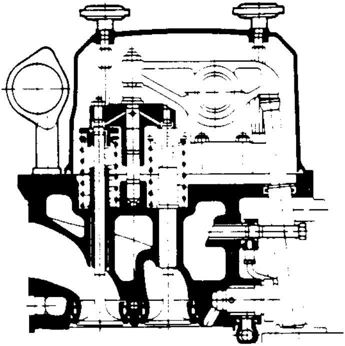
6 **Put on the valve springs** and spring discs and compress the springs with the tool set. Fit the valve cotters and unload the springs.
Check that the valve cotters fit properly.

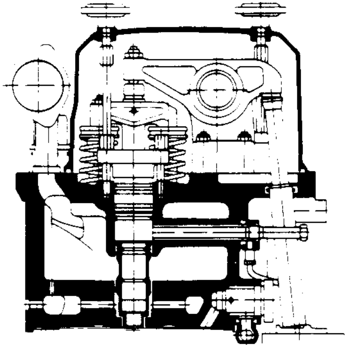
12. 6. General maintenance of the cylinder head

1 **The starting valves** are described in section 21. When refitting, the starting valves the outer cylindrical surfaces should be lubricated with engine oil or an special lubricant.

2 **The injection valves** are described in section 16. When refitting, the injection valves should be lubricated with engine oil, only.

Cylinder head with valves 12-51





13. Camshaft drive

13. 1. Description

(fig. 13-51)

The camshaft is driven by the crankshaft (1) through a gearing. The gear on the crankshaft is split and fixed to a flange on the crankshaft with axial screws (4). These screws as well as the fastening screws of the gear are locked with LOCTITE 242. A pair of intermediate wheels (5) and (6) are pivoted on a bearing journal.

The camshaft driving gear (18) is guided to the camshaft bearing journal with a pin (22) and fastened by means of a flange connection between the bearing piece (20) and the camshaft extension (25). The camshaft extension supports also a worm gear (23) for the speed governor drive and the overspeed trip (in the V-engine on the A-bank). An oil jet provides for lubrication and cooling of the gears.

13. 2. Disassembling the gearing

The pair of intermediate gears should not be disassembled unless necessary because the two wheels are adjusted between themselves to give correct cam positions on each cylinder bank. Before removing the gearing, check the tooth and bearing clearances at intervals according to section 04.

1 **Remove the camshaft cover** and the gear covers.

2 **Unscrew the screws** of the flange connection (19).

3 **Unscrew the fastening screws** (28) of the overspeed trip, on the B-bank the screws of the bearing housing.

4 **The overspeed trip** or the bearing housing as well as the camshaft extension (25) can now be withdrawn axially.

5 **Unscrew the screws** (21) of the camshaft driving gear. Remove the camshaft gear (18).

6 **Loosen the screws** (13), (10) and (15) (2 pcs) in the order mentioned. Remove the flange (14).

7 **Turn the crankshaft** until the flywheel hole (diameter 60 mm) at the inside of the rim is in front of the intermediate wheel bearing pin.

8 **Unscrew the screw** (13) about 10 mm and press out the bearing pin. Remove the screw and withdraw the bearing pin.

9 **The intermediate wheel** can now be lifted out, for instance by means of a rope sling.

10 **Crank the flywheel** to a position that makes it possible to remove the intermediate wheel bearing pin (11) out of the flywheel hole.

13. 3. Installing the gearing

1 **Turn the crankshaft as follows:**

- **In-line engines:** Turn the crankshaft to the TDC for cylinder No 1.
- **V-engines,** the camshaft gearings of both cylinder banks removed: Turn the crankshaft to the TDC for cylinder No A1.
- **V-engines,** the gearing of the A-bank installed, the gearing of the B-bank removed: Turn the crankshaft to the TDC at ignition for cylinder No A1 (see section 00.3). Then turn 55° to the TDC for cylinder No B1.
- **V-engines,** the gearing of the B-bank installed, the gearing of the A-bank removed: Turn the crankshaft to the TDC at ignition for cylinder No B1 (see section 00.3). Then turn to the TDC for cylinder No A1.

In connection with turning, place the bearing pin in the hole of the flywheel rim which is nearest to "Cyl. 1 TDC".

2 **Place the intermediate bush** (12) in its bore and lower the completely assembled intermediate wheel for instance by means of a rope sling. By using a mirror, check that the marked tooth of the intermediate wheel meshes properly with the marked tooth gap on the split gear (2). See fig. 13-51.

3 **Turn the crankshaft** carefully, the intermediate wheel meshing with the crankshaft gear, until the bearing pin (11) is in front of the bore and can be fitted in the intermediate gear and the bush (12). Turn the crankshaft to its original position, i.e. the TDC at ignition for cyl. 1 according to pos. 1.

4 **Coat the screw** (13) with LOCTITE 242 and screw it in by hand.

5 **Fit the flange** (14) together with a new O-ring and tighten the screw (15). First tighten the screw (10) and then the screw (13). Tightening torque, see section 07.

6 **Measure the axial clearance** of the intermediate wheel bearing and the backlash between the wheels (2) and (5). See section 06.2 pos. 13.

7 **Apply locking wire** between the screws (10) and (15).

8 **The camshaft driving gear** is meshed in and is installed so that the mark matches the edge of the engine block, fig. 13-51D. On the driving gear there are marks for the A-bank as well as for the B-bank. The guiding pin (22) indicates the fixing of the camshaft and the gear in relation to each other. Tighten the screws (21) to torque according to section 07.1. These screws are treated with locking compound and may be reused twice before the locking effect is lost, in case they are only slightly cleaned with rags.

9 **Install the overspeed trip** and the extension piece (25).

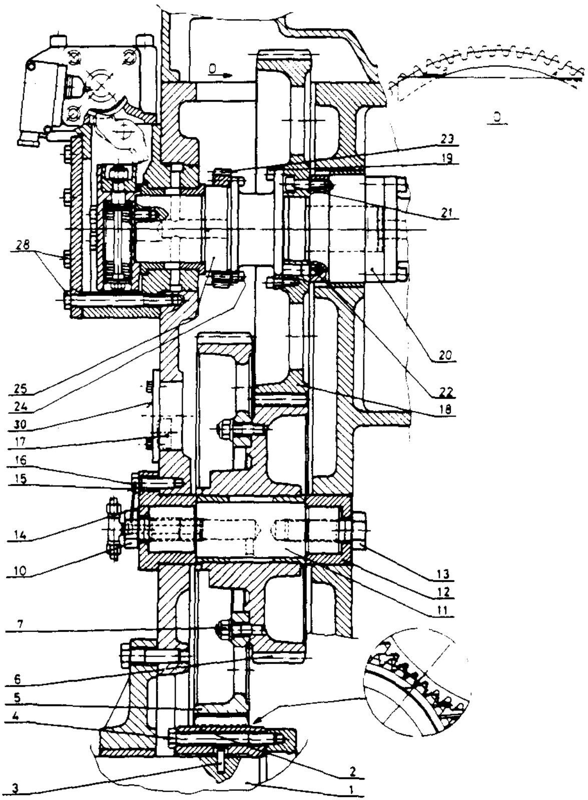
10 **Measure the backlash** between the wheels (6) and (18). See section 06.2 pos. 13.

11 **Install the adjacent components.** For covers not having gaskets, use non-drying sealing compound.

12 **Check the firing sequence** of the V-engine cylinder banks (section 01.1)

13 **Check the valve timing** of one cylinder, at least (see section 06). If any details of the gearing have been changed, the injection pump delivery start should be checked according to section 16.4.

Camshaft drive 13-51



14. Valve timing gear and camshaft

14. 1. Valve mechanism, description

(fig. 14-51)

The valve mechanism consists of valve tappets of the piston type moving in a common guide block of cast iron, tubular push rods with ball joints, drop forged rocker arms pivoted in a rocker arm bearing bracket and a yoke guided by a yoke pin. Normally, the valve mechanism needs no maintenance, but inspection of the components and check for wear should be done at intervals according to section 04. Data are stated in section 06. The valve clearance adjustments are described in section 12.4.

As a rule it can be said that components which have been working together for a long time and thus have worn somewhat in relation to each other should be installed in the same place to avoid unnecessary wear.

14. 2. Dismantling and assembling the rocker arm bearing bracket

1 **Remove the bearing bracket.** from the cylinder head by loosening the nuts (4).

2 **The rocker arms** can be dismantled by removing the locking ring (1) with the pliers 843001.

3 **When cleaning** the rocker arm bearing bracket and the bearing pin, pay special attention to the oil holes.

4 **Inspect and measure** the details for wear (section 06.2 pos. 14).

5 **Oil the details** with lubricating oil before reassembling.

6 **Measure the axial clearance** of the rocker arms after assembling, min. 0.15 mm.

14. 3. Dismantling and assembling the valve tappets

1 **Remove the guide block** (10) from the engine. The rocker arm bracket and the push ros including the protecting sleeves have to be dismantled first.

2 Remove the locking sheet (15).

3 The valve tappets can now be withdrawn. Mark the components so that they can be refitted in the same position.

4 The tappet rollers, bushes and pins are separated by pushing out the pin (14).

5 Remove the covers (17) to clean and measure the guide block bores. Change the O-rings of the cover if they are damaged or hard.

6 When cleaning the components, pay special attention to the angular holes in the tappet and the pin.

7 Inspect and measure the components for damage and wear. Section 06.2 pos. 14.

8 When reassembling, it is advisable to lubricate the components with Molykote Paste G.

9 When fitting the locking sheet (15), use undamaged corners of the sheet to lock the screws (16). Take care that there are — or are caused — no metal parts which may come loose.

10 *Before fitting the guide block,* check the flange gasket and replace it by a new one, if necessary.

14. 4. Camshaft description

(fig. 14-52)

The camshaft is built up of one-cylinder camshaft pieces and separate bearing journals. The drop forged camshaft pieces have integrated cams the sliding surface of which are case hardened.The bearing surfaces of the journals are induction hardened. The camshaft is driven by the crankshaft through a gearing at the driving end of the engine. At this end the camshaft is equipped with an overspeed trip and a helical gear for driving of the speed governor. At the free end the camshaft has an extension with a cam for operating the starting air distributor.

On the V-engine B-bank the camshaft has only an axial bearing situated at the driving end.

14. 5. Removing a camshaft piece

1 Remove the camshaft cover, the injection pump and the guide blocks from the cylinder concerned.

2 Unscrew the flange connection screws (fig. 14-53A) from both ends of the camshaft piece by using the tool combination 05-15B.

2 Unscrew the flange connection screws (fig. 14-53A) from both ends of the camshaft piece by using the tool combination 05-15B.

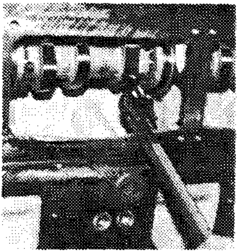


Fig 14-53 A

3 Remove the cover from the starting air distributor and move the part of the camshaft locating towards the free end of the engine 15...20 mm in direction of the free end by using a suitable lever.

4 Disengage the camshaft piece from the centerings and fixing pins and remove it sideways (fig. 14-53B, C).

Fig 14-53 B

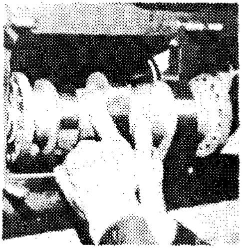


Fig 14-53 C

14. 6. Mounting of a camshaft piece

1 **Clean and degrease** the flange connection surfaces and the threaded holes.

2 **Fit the fixing pins** and retainer rings with the longer part of the pin in the bearing journal.

3 **Mount the camshaft piece** on the fixing pin and centering at either end. Then compress the camshaft.

4 **Fit the flange connection screws** dry and tighten by using the tool combination 05-15B. The flange connection screws are treated with locking compound and can be used three times if carefully cleaned.

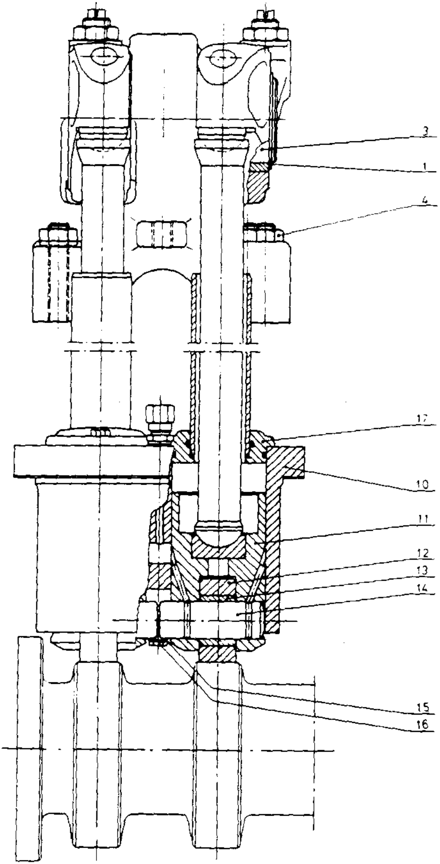
5 **Check the valve tappets** and rollers carefully. Even slightly damaged tappet rollers have to be changed.

6 **Mount the cover** of the starting air distributor, the guide blocks, injection pumps etc.

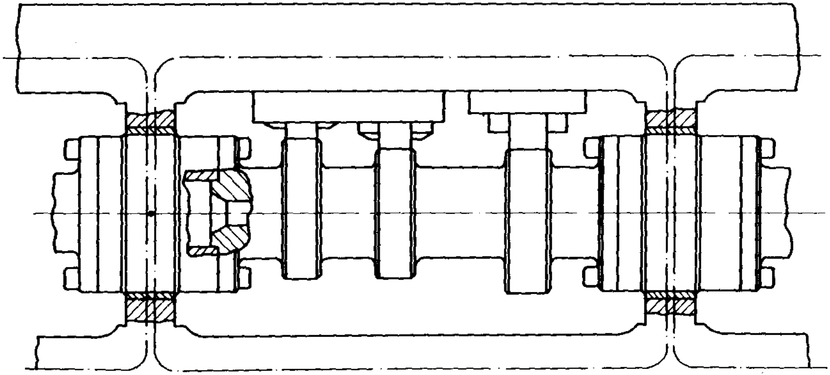
7 **Check the valve clearance** and delivery start of the injection pumps on all cylinders towards the free end.

Valve mechanism

14-51



CAM SHAFT ASSEMBLY, VASA 22HF, MD



15. Turbocharging and air cooling

15. 1. Description

(fig. 15-51)

The turbochargers are of the axial turbine type. The insert type charge air cooler is mounted in a welded housing which, at the same time, serves as a bracket for the turbocharger. 12 and 16 cylinder V-engines have two identical cooler inserts in a common housing.

The turbocharger is cooled with water and connected to the engine cooling system. The turbocharger has a lubricating oil system of its own.

The air outlet casing is connected to the air duct and the exhaust pipes to the gas inlet casing through metal bellows. The exhaust pipe after the turbocharger should be arranged according to the installation instructions.

The turbochargers are equipped with cleaning devices for washing by water of the compressor and the turbine.

15. 2. Turbocharger maintenance

Normal overhauls can be carried out without removing the turbocharger from the engine.

When dismantling, remove the connection pipes for water. Loosen the exhaust inlet and outlet pipes.

When reassembling, take care that all seals are intact. High temperature resistant lubricants are used for exhaust pipe screws.

Maintenance of the turbocharger is carried out according to section 15.3 and to the instructions of the turbocharger manufacturer. It is recommended to use the service net of the engine manufacturer or the turbocharger manufacturer.

15. 3. Water cleaning of turbine during operation

(fig. 15-52)

15. 3. 1. Principles of the cleaning method

As practical experiences show, the dirt deposits on the turbine side can be reduced by periodic cleaning (washing) during operation.

The principle is to employ water-droplet action to clean the guard, turbine nozzle and turbine blades of combustion products while the engine is running at reduced power, by a combination of scouring action and partial dissolving of the deposits.

Under no circumstances the turbine should be allowed to run long enough to become very heavily coated with deposits.

A fouled turbine can be recognized by abnormal exhaust gas temperature, charger speed and charge air pressure. In some case it can lead to compressor surging. The bearings of the turbocharger are also sensitive to the imbalance caused by the deposits.

The water supply is conveyed to an injector (1) with fixed size orifice, fitted into each branch of the engine exhaust gas pipe. Turbochargers, which have one gas inlet, are provided with two injectors on the same pipe. The injectors are connected to a quick-coupling (2).

15. 3. 2. Cleaning intervals

The optimum period between cleaning operations will obviously vary from one installation to another, and will depend on the type of fuel used as well as on running conditions. Under "average" conditions, with engines running on residual fuels, experience shows that cleaning intervals of about 200 hours are satisfactory.

15. 3. 3. Water flow rates

The necessary water flow is basically dependent on the volume of gas and its temperature. The flow should be adjusted so that about 50 to 70% of the water is evaporated and escapes through the exhaust gases, while the remaining water is drained through the tap in the exhaust casing.

Recommended water flow rates:

VTR 184 .... 2...3 l/min
VTR 214, ... 3...4.5 l/min
VTR 254 .... 4.5...7 l/min

Additives or solvents must not be used in the cleaning water. The use of salt water is out of question.

15. 3. 4. Cleaning procedure:

1 Record blower charge air pressure, cylinder exhaust gas temperatures, charger speed, for later use to assess efficacy of cleaning.

2 Reduce engine load to between 10 and 20% of full load rating.

3 Open the valves (1), and check that they are not clogged.

4 **Connect the water hose.**

5 **Open the drain valve** (3) and check that it is clear of blockage.

6 **Open the valve** (5) and valves (1) completely.

7 **The pressure control valve** (4) must be adjusted to a pressure of 1 bar.

8 **Check the water drains** through the drain pipe.

9 **Cleaning is terminated** after about 10 min. The water supply valve (5) is closed.

10 **After termination** of water injection the engine must run for three minutes at constant load until all parts are dry.

11 **Shut all valves** and disconnect the hose to ensure that no water can possibly enter the exhaust pipes except during the cleaning periods.

12 **Resume normal engine operation** at higher output and, as soon as possible, repeat the readings taken under heading 15.4.1. for comparative purposes.

Water washing of the compressor side during operation, see enclosed separate manual for the turbocharger.

15. 4. Maintenance of charge air cooler

(fig. 15-51)

- Condensate from the air is drained through a small pipe (6) at the bottom of the cooler housing, after the insert. Examine regularly that the pipe is open by checking the air flow when running.

If water keeps on dripping or flowing from the draining pipe for a longer period (unless running all the time in conditions with very high humidity) the cooler insert may be leaky and must be dismantled and pressure tested.

- At longer stops, the cooler should be either completely filled or completely emptied, as a half-filled cooler increases the risk of corrosion. If there is a risk of sinking water level in the system when the engine is stopped, drain the cooler completely. Open the air vent screw (3) to avoid vacuum when draining.
- Clean and pressure test the cooler at intervals according to section 04. or if the receiver temperature cannot be held within stipulated values at full load.
- Always when cleaning, check for corrosion.

15. 5. Cleaning cooler insert

(fig. 15-51)

1 Remove the cooling water pipes . Loosen the cooler insert flange screws and withdraw the insert until the thread or the hole (7) for the lifting tool is visible. If necessary, use the screws in the two threaded extractor holes in the flange.

2 Apply the lifting tool and lift off the insert.

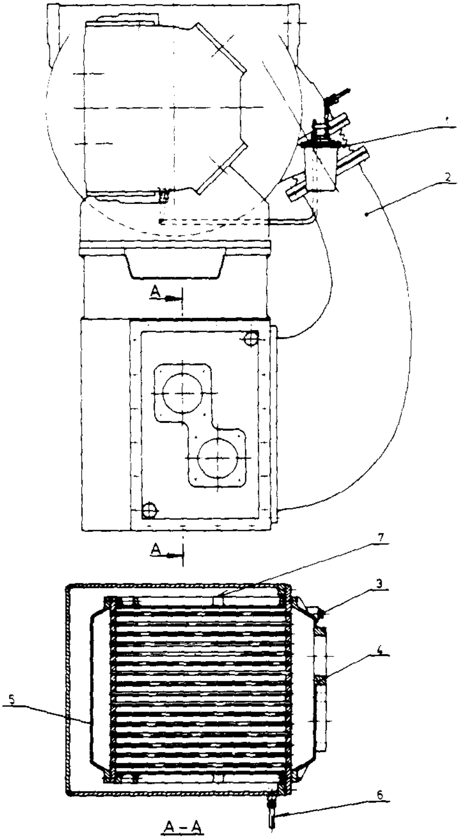
3 Clean the air side with a degreasing liquid and blow pressure air or steam through the insert. See also section 18.5.3.

4 Remove the water boxes (4) and (5) to make the water side accessible.

5 Clean the water side according to the instructions for oil cooler in section 18.5.4.

6 Check the gaskets.

7 Reassemble the cooler insert and mount it on the engine. Check tightness when starting up.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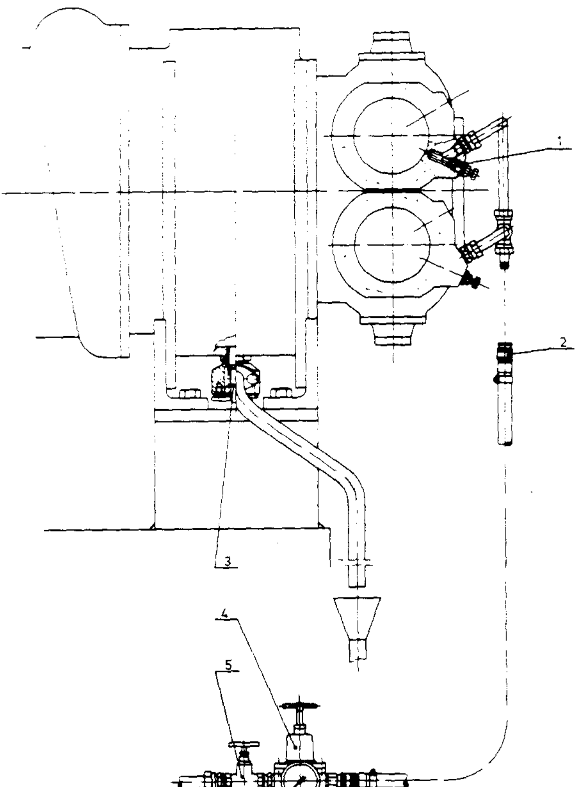
Water cleaning of turbine 15-52



16. Injection system

16. 1. Description

This chapter deals with the high pressure side of the fuel system including injection pump, high pressure pipe and injection valve.

The injection pumps are one-cylinder pumps with built-in roller tappets. The element is pressure lubricated and the drain fuel is led to a pipe system with atmospheric pressure outside the pump.

Each injection pump is equipped with an emergency stop cylinder coupled to an electro-pneumatic overspeed protecting system.

The high pressure line consists of a high pressure pipe and a high pressure adapter, screwed sideways into the nozzle holder.

The injection valve consists of a nozzle holder and a multiorifice nozzle.

16. 2. Injection pump, description

(fig. 16-51)

The injection pump body consists of a cast housing provided with flanges for fastening against the engine block. The tappet with roller is at the bottom of the housing. The roller rolls against the injection cam of the camshaft under the pressure of a spring (17). Between the tappet and the plunger there is a disc (28) against which the plunger end is pressed.

The pump element, (5) of the monoelement type, is included in the top part of the housing and consists of a plunger and a cylinder which are matched between themselves and should be treated as a unit. The upper part, i.e. the fuel side, is sealed from below by O-rings (24). The element cylinder is pressure lubricated, which prevents fuel from penetrating downwards and mixing with lubricating oil.

The fuel delivery control, i.e. the rotary motion of the plunger, is actuated by a control rack through a control sleeve (14).

The delivery valves are located in the upper part of the element and in the head piece. The sealing element cylinder-head piece is metallic.

16. 3. Removing and reinstalling injection pump

16. 3. 1. Removal

1 **Shut fuel supply** to the engine before removing the injection pump.

2 **Remove the fuel feed pipe elbows,** injection pipe and leak fuel pipe. Cover immediately all openings with tape or plugs to prevent dirt from entering the system.

3 **Remove the fastening stud** for the cover of the fuel injection equipment.

4 **Remove the pneumatic shutdown cylinder** (22-53 pos. 6) inclusive pipe, which is loosened only from the distributing pipe.

5 **Disengage the connection piece** from the pump rack by removing the nut and pulling the screw aside. Put the nut on its place at once to avoid loosing any part.

6 **Turn the crankshaft** so that the pump tappet roller rests upon the base circle of the fuel cam.

7 **Loosen the flange nuts** with the tool 806005 and lift off the pump. Cover the oil supply inlet hole and pump bore in the engine block.

8 **Clean the pump externally.**

16. 3. 2. Re-installing

1 **The pump is assumed to be assembled** and cleaned and the surface and bore of the engine block to be cleaned.

2 **Check the O-ring** of the pump body, grease and enter it into the groove. Check that the fuel cam is not in the lifting position.

3 **Put the pump into place** and tighten the flange nuts to torque.

4 **Connect the connection piece** between the control lever and pump rack with the screw and nut.

Note! **Center the joint by applying force between the pump rack and connection piece, see section 22, fig. 22-51. Check that the joint moves easily.**

---

5 **Remove the protecting tape** or plugs and connect the fuel feed pipes and leak fuel pipe. Reinstall the injection pipe.Tighten the injection pipe cap nuts to torque according to section 07.1 pos. 18 with the tool 806009.

6 **Open the fuel supply** to the engine and vent the fuel filter and injection pumps according to the instructions in chapter 17. The injection pump is provided with a venting plug (42).

7 **Check the fuel rack positions** according to section 22.3.1.

16. 4. Checking fuel delivery start

The beginning of the effective pump stroke is determined by an indirect method, i.e. by observing when the duct between the low pressure side and the high pressure side of the injection pump is shut by the edge of the element plunger, fig. 16-52A, the so called "flowing position".

Control of fuel delivery start is necessary only if major components have been changed, e.g. injection pump, injection pump element or camshaft piece. Proceed as follows:

1 **Cut fuel supply** to the engine.

2 **Fuel supply is arranged** by connecting the funnel 862007 to the pump (fig. 16-52A).

3 **Remove the injection pump head piece** (35) and the delivery valve (5) including the spring. Reinstall the head piece. See sections 16.5.6 and 16.6.6.

4 **Connect the pipe elbow** to the head piece according to fig. 16-52A.

5 **Set the injection pump rack** at a position between 32 and 36 mm.

6 **Turn the crankshaft** to a position 22° before TDC at ignition.

7 **Fill the funnel** with **distillate fuel**. Fuel is now flowing outfrom the pipe elbow.

8 ***Keep the level in the funnel constant*** by refilling and turn the crankshaft slowly in the engine rotating direction. Watch when fuel stops emerging. Read the position of the crankshaft. See section 06.1.

9 ***Repeat pos. 2...8*** on all cylinders to be checked.

10 **Compare the crankshaft positions** with correct values.
The deviation between the different cylinders is one engine should not exceed 1 crank angle.If larger deviations are noted the injection pumps must be changed and/or overhauled and checked.

11 **Reassemble the fuel discharge valve.**

16. 5. Dismantling of injection pump

(fig. 16-51)

Observe utmost cleanliness when working with the injection equipment. It is presupposed that the injection pump is removed from the engine and the outside of the pump carefully cleaned.

1 **It is recommendable** to put the pump in a screw vice to positions convenient for the different operations.

2 **Support the roller tappet** by hand and open the fixing screw (21).

3 **The roller tappet** and element plunger can now be taken out. Take care when handling the plunger because it may come loose from the tappet.

4 **Remove the spring** and control sleeve.

5 **Turn the pump** into vertical position.

6 **Open the screws** (52) of the head piece in steps of 30°.

7 **Open the screws** (9) of the element cylinder in steps of 30° to avoid overloading the last screw.

8 **Remove the delivery valves.**

9 **Take out the element cylinder.**

10 **Wash the element plunger** and cylinder in clean fuel or special oil and keep them always together, the plunger being inserted in the cylinder.

Note! **Normally, further dismantling is not necessary. It is recommendable to keep the components of different pumps apart from each other, or to mark the details so that they can be fitted into the same pump. The details must be protected against rust and especially the element plunger running surface should not be unnecessarily handled with bare fingers.**

16. 6. Reassembling injection pump

(fig. 16-51)

1 **Wash the details** in absolutely clean diesel oil and lubricate the internal parts with engine oil. When handling details of the injection equipment, keep hands absolutely clean and grease them with grease or oil.

2 **Renew the seal rings** on the element cylinder and lubricate the rings with lubricating oil.

3 **Reinstall the element cylinder** into the position where the fixing groove corresponds to the fixing pin.

4 **Reinstall the delivery valves** (if control of fuel delivery commencement is necessary, see 16.4).

5 **Fit the pump head piece** into place and tighten the screws (52) by hand. Fit and tighten the screws (9) by hand.

6 ***Tighten the screws to torque*** in three steps according to 07.1 pos. 16 for (9) and according to 07.1 pos. 15 for (52) to ensure equal tightening of every screw.

7 ***Turn the pump*** and fit the control sleeve. Move the fuel rack to a position where two marks can be seen. One of the control sleeve teeth is chamfered and this tooth must slide into the tooth space between the marks of the rack.

8 **Reinstall the upper spring disc** (16), ring (19) and spring (17).

9 **Assemble the element plunger** and tappet with the spring disc and pressure plate (28).

10 **Note the mark** on one side of the plunger vane. The marked side of the plunger vane must slide into the fuel rack side of the control sleeve, i.e. correspond to the marks on the fuel rack and the chamfered tooth of the control sleeve. The guiding groove of the tappet must correspond to the fixing screw (21).

11 **Reinstall the plunger tappet assembly.**

12 **Screw in and tighten the fixing screw (21).**

13 **Check that the fuel rack can be easily moved.**

14 ***Unless the pump is immediately mounted*** on the engine it must be well oiled and protected by a plastic cover or similar. The fuel ports and injection line connection must always be protected by plugs or tape.

16. 7. Injection pipe

The injection line consists of two parts, the high pressure connection piece which is screwed into the nozzle holder, and the injection pipe.

The high pressure connection piece seals with plain metallic surfaces and these surfaces are to be checked before mounting. Always tighten the connection piece to correct torque before mounting the injection pipe; also in case only the injection pipe has been removed, because there is a risk of the connection piece coming loose when removing the pipe.

The injection pipes are delivered complete with connection nuts assembled. Always tighten the connections to correct torque.

If necessary, the engine can be provided with alarm for a broken injection pipe. In that case the injection pipes are enclosed in a pipe, from which a drain pipe goes to a collecting vessel for the leak fuel lines. The vessel is provided with a level switch, which gives alarm at the set level. To prevent the normal leak fuel flow from triggering the alarm the vessel is fitted with a valve. This valve should be adjusted so that the normal leak fuel continuously flows through it. The switch gives alarm only when the flow is abnormal (a broken injection pipe).

When removed, the injection line details have to be protected against dirt and rust.

16. 8. Injection valve, description

(fig. 16-53)
The injection valve is centrally located in the cylinder head and includes nozzle holder and nozzle. The fuel enters the nozzle holder sideways through a connection piece screwed into the nozzle holder.

16. 9. Removing injection valve

1 **Remove the cylinder head cover** and injection pump cover.

2 **Remove the high pressure injection pipe.**

3 **Remove the fastening nuts** of the injection valve.

4 **Lift out the injection valve.** If much force has to be used there is a risk of the stainless sleeve of the cylinder head coming loose, which, in such a case, must be checked.

5 **Protect the fuel inlet hole** of the injection valve and bore in the cylinder head.

16. 10. Mounting injection valve

1 **Check that the bottom** of the stainless sleeve in the cylinder head is clean. If necessary, clean or lap the surface with the tool 841008. If lapping is necessary the cylinder head must be lifted off. For lapping, a steel washer and fine lapping compound is used. The injection valve is sealed off directly to the bottom of the stainless sleeve!

2 **Put new O-rings** on the injection valve. Lubricate the injection valve with oil.

3 **Fit the injection valve** into cylinder head bore.

4 **Put new O-rings** in the sealing flange of the high pressure connection piece. Place the flange on the connection piece and screw in the connection. Tighten to correct torque.

5 **Tighten the fastening nuts** of the injection valve to correct torque in steps of 10 Nm.

6 **Fasten the sealing flange** of the high pressure connection.

7 **Mount the injection line** and tighten the cap nuts to torque.

8 **Replace the covers.**

16. 11. Overhauling injection valve

(fig. 16-53)

1 **Inspect the nozzle** immediately after removing the injection valve from the engine. Carbon deposits (trumpets) may indicate that the nozzle is in poor condition, the spring is broken. Clean the outside of the nozzle with a brass wire brush.

2 **Release the nozzle spring tension** by opening the counternut (10) and screwing up the adjusting screw (9).

3 **Remove the nozzle** from the holder by opening the cap nut (5). Be careful not to drop the nozzle. If there is coke between the nozzle and the nut it may be difficult to remove the nozzle. In such a case, place then nozzle with the nut on a soft support and knock it out by using a piece of pipe (fig. 16-52B).

Never knock directly on the nozzle tip!

4 **Check the nozzle needle** movement which may vary as follows: needle completely free

- needle free to move within normal lifting range
- needle is sticking

The needle must not be removed by force because this often results in complete jamming. Unless it can be easily removed, immerse the nozzle in lubricating oil and heat the oil to 150...200°C. Normally, the needle can be removed from a hot nozzle.

5 **Clean the details.** If possible, use a chemical carbon dissolving solution. If there is none available, immerse the details in clean fuel oil, white spirit or similar to soak carbon. Then clean the details carefully by the tools 845006. Do not use steel wire brushes or hard tools! Clean the nozzleorifices with needles provided for this purpose. After cleaning, rinse the details to remove carbon residues and dirt particles.

The cooling spaces of the nozzle must be carefully cleaned by a coke dissolving agent. Before inserting the needle in the nozzle body, immerse the details in clean fuel oil or special oil for injection systems. Seat surfaces, sliding surfaces (needle shaft) and sealing faces against the nozzle holder should be carefully checked.

6 Clean the nozzle holder and cap nut carefully; if necessary, dismantle the nozzle holder to clean all details. Check the nozzle spring.

7 Check the high pressure sealing faces of the nozzle holder, i.e. the contact face to the nozzle and the bottom of the fuel inlet hole.

8 Check max. lift of the nozzle, i.e. the sum of measures A and B in fig. 16-53. If wear B exceeds 0.05 mm the nozzle holder can be sent to the engine manufacturer for reconditioning. If the total lift is out of the value stated in section 06.2 pos. 16, the nozzle should be replaced by a new one.

9 Reassemble the injection valve.

10 Connect the injection valve to the test pump 864011. Pump to expel air. Shut the manometer valve and pump rapidly to blow dirt out of the nozzle orifices. Place a dry paper under the nozzle and give the pump a quick blow. Note fuel spray uniformity.

11 Check the opening pressure:

- open the manometer valve
- pump slowly and watch the manometer to note the opening pressure. If the opening pressure is more than 50 bar below the stated value it indicates a broken spring or badly worn parts.

12 If the spray is uniform, adjust the opening pressure to stated value and check once more the spray uniformity (according to pos. 10).

13 Check the needle seat tightness:

- increase pressure to a value 20 bar below stated opening pressure.
- keep pressure constant and check that no fuel drops occur on the nozzle tip. A slight dampness may be acceptable.

14 Check the needle spindle tightness:

- pump until pressure is 20 bar below stated opening pressure
- measure time for a pressure drop of 50 bar. The time must not be below 3 seconds. A time longer than 20 seconds indicates fouled spindle.

15 If the tests according to pos. 10...14 give satisfactory results the injection valve can be reinstalled in the engine. Otherwise, replace the nozzle by a new one.

16 If leakage occurs on the high pressure sealing surfaces the damaged detail should be replaced by a new one or reconditioned.

17 If nozzles or injection valves are to be stored they should be treated with corrosion protecting oil.

16. 12. Change of beginning of effective pump stroke (delivery start)

(fig. 13-51)

1 **Check the delivery start** on one of the cylinders.

2 **In-line engine:** Open the camshaft gear wheel cover and the cover (30).
V-engine : Open the camshaft gear wheel cover on one bank as well as the cover (30) on the B-bank or the plug (17) on the A-bank.

3 **Mark the nut** (7) for the camshaft intermediate wheel next to the opening (17).

4 **Loosen all nuts** (7) on the intermediate wheel, the marked nut last.

5 **The last nut** (7) having been loosened, turn the crankshaft opposite to the direction of rotation the number of crank angle degrees required for an earlier delivery commencement.

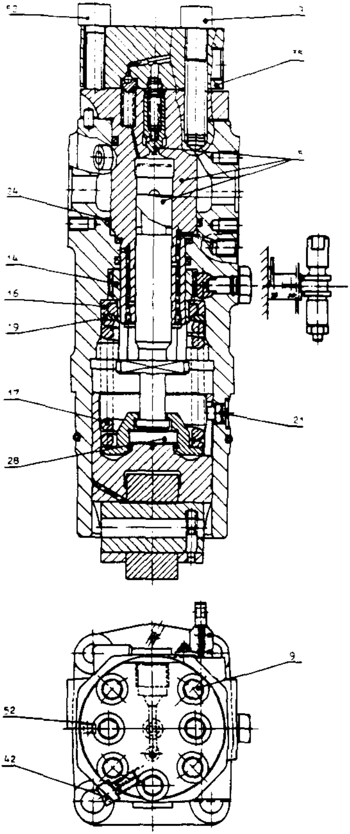
Note! **The camshaft must not rotate while turning.**

6 **Secure the marked nut** (7) and check the new delivery commencement.

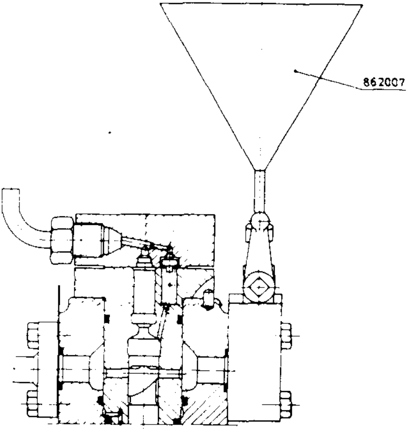
7 **If the desired delivery commencement** has been obtained, tighten the other nuts (7).

8 **V-engine:** Repeat the procedure for the other bank.

Injection pump 16-51



Checking of fuel delivery start, removing of nozzle 16-52



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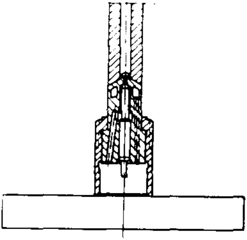
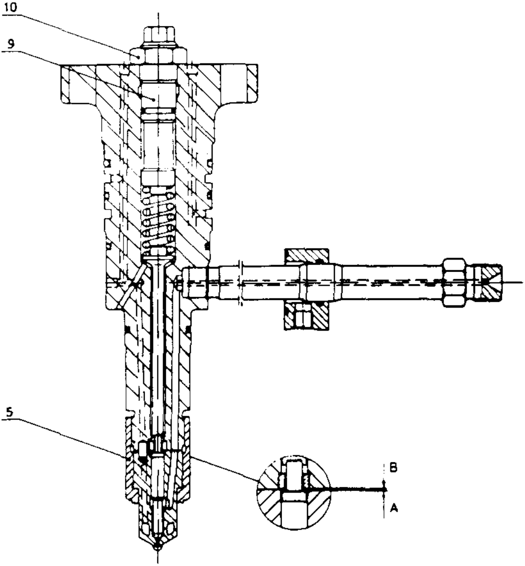


B

Injection valve 16-53



17. Fuel system

17. 1. General description

(fig. 17-51)

The engine is designed for continuous heavy fuel duty. The main engine as well as the auxiliary engine can be started and stopped on heavy fuel.

As the fuel treatment system before the engine can vary widely from one installation to another, this system is not described in detail in this book. See separate instructions.

The engine is normally equipped with an electrically driven fuel feed pump and a duplex filter to provide correct flow, pressure and filtration irrespective of the number of engines connected to a common external treatment system.

Figure 17-51 shows a typical installation with a day tank for heavy fuel (1), day tank for diesel fuel (2), mixing pipe (3) and the fuel treatment module (4) consisting of suction filters, feed pumps, preheaters, automatic filter and viscosimeter.

The electrically driven pump (9) delivers the correct flow to the engine through the duplex filter (8). The pressure control valve (11) maintains the correct pressure in the engine system. By means of the pressure control valves (12) both sides of the duplex filter can be in operation at the same time to get maximum capacity of the filter cartridges and it is still possible to change cartridges during operation. Part of the fuel is then flowing through the valves (12) thus bypassing the engine. This will happen also when heating up a cold system containing heavy fuel; fuel flows through the valves (12) until the filter and the whole system gradually are heated up.

A pressure gauge (5) on the instrument panel indicates fuel inlet pressure and a local thermometer (6) indicates the inlet temperature. A pressure switch (7) for low fuel pressure is connected to the automatic alarm system.

Fuel leaking from injection pumps and injection valves is collected in a separate enclosed system. Thus this fuel can be reused.

A separate pipe system leading from the top level of the engine block collects waste oil, fuel or water arising when overhauling cylinder heads, for example.

The high pressure system with injection pump and injection valve is described in section 16.

17. 2. Maintenance

When working with the fuel system, always observe utmost cleanliness. Pipes, tanks and the fuel treatment equipment such as pumps, filters, heaters and viscosimeters, included in the engine delivery or not, should be carefully cleaned before taken into use.

Change the filter cartrigdes regularly.

The fuel filter is provided with a combined visual indicator/ electrical switch connected to the automatic alarm system which indicates too high pressure drop over the filter, which means that the paper cartridges should be changed as soon as possible.

The intervals between changes of cartridges depend largely on the quality and dirt content of the fuel as well as on fuel treatment before the engine. Guidance values are stated in section 04.

The fuel should always be separated and it is recommendable to fit an automatic filter in the fuel treatment system.

Always when the system has been opened it should be vented after reassembly, see pos. 17.1.3.

For maintenance of the fuel treatment equipment not mounted on the engine, see separate instructions.

17. 3. Venting

Open the air vent screws on the injection pumps (see section 16, fig. 16-51 pos. 42.) If the static pressure from the day tank is not sufficient, the fuel feed pump should be started.

After changing element in the filter, vent the filter. If the engine is stopped and the feed pump is not running, the three-way valve of the filter can be directly changed over to both sides in operation and the air can be vented through the air vent screw of the filter. If the engine is running, the change-over of the three-way valve should be carried out very carefully to give only a small flow of fuel to the filter side to be vented. The best way is to use the slow filling valve on the three-way valve. Set the valve in "slow filling" position (see fig. 17-54) and the filter side will be slowly filled. Vent the filter side. Set the three-way valve and slow-filling valve in normal position (both filter sides in use).

A sudden change-over of the three-way valve to an empty filter side will cause a temporary pressure drop in the engine system and the alarm switch gives signal for too low fuel pressure. This may involve the risk of air escaping from the filter to the injection pumps, which may cause the engine to stop.

To avoid this, fill up the filter with clean fuel before changing over.

17. 4. Adjustment of pressure control valves

(fig. 17-51)
Check the adjustment at intervals recommended in section 04. Adjust the valves at normal temperatures with an idling engine, i.e. the booster pump (9) running. The pressure stated in the adjustment instructions apply to the engine manometer.

Turn the adjusting screws of the pressure control valves clockwise to achieve higher pressure, counterclockwise to achieve lower pressure.

All pressures mentioned in the instruction apply to the readings of the pressure gauge (5) in the instrument panel of the engine.

17. 4. 1. Adjustment of the valve (10) on the pump

Raise the pressure in the system slowly by closing the valve (14). Adjust the valve (10) to 10 bar when the pressure is 5...7 bar and to 12 bar when the pressure is 8 bar (see fig. 01.2). Open the valve (14) completely.

This adjustment should be carried out rapidly as the pump (9) may run hot if the system is closed for a lengthy time.

17. 4. 2. Adjustment of pressure control valve (11)

Adjust the valve (11) to 6 bar.

17. 4. 3. Adjustment of pressure control valves (12)

Shut off the valve (15). Check that the recommended operating pressure +2.5 bar is achieved. Check that the valves are equally adjusted by closing one side of the filter, one after the other. When doing so a

somewhat higher pressure can be achieved owing to double overflow through the filter. Adjust the valves (12), if necessary.
After adjustment, open the valve (15) completely.

17. 5. Fuel feed pump

The pump is of the screw type, driven by an electric motor.
The pump is provided with an adjustable pressure control valve (15). The pressure should be limited to the minimum value, about 4bar, by unscrewing the adjusting screw (14).
As a shaft seal a mechanical seal is used consisting of two plane sealing surfaces facing each other - one of them (8) rotating with the shaft and the other one (6) being stationary.

17. 5. 1. General maintenance

Normally, no regular maintenance is required. Lubricating interval, see chapter 04.
After 3...6 years the shaft seal may have to be replaced due to ageing. Oil leaking out of the opening (5) indicates that the shaft seal is defective and has to be changed.
Take care not to damage the sealing ring faces. A slight scratch may disturb the sealing function. The rotating coal ring (8) is very fragile. Avoid touching the sealing faces with your fingers.

17. 5. 2. Dismantling

1 **Loosen the pipes** and fastening screws (9) and withdraw the pump.

2 **Draw the coupling** half (1) off the shaft.

3 **Remove the front plate** (10) together with the drive screw (2) and the shaft seal. Place the front plate on two rods, the shaft journal turned upwards.

4 **Remove the drive screw locking ring** (3). Give the shaft journal a few blows with a plastic hammer until the screw is disengaged from the ball bearing. Take care not to damage the screw by dropping it on the work bench.

5 **Remove the sealing ring (8).**

6 **Force the sealing unit** (13) off the drive screw (2). Pressing force may be relatively strong due to the rubber bellows.

7 **Tap the stationary sealing ring** (6) together with the O-ring out of the front plate by using a chisel.

8 **To remove the ball bearing** (4) from the front plate, first remove the locking ring.

Note! **Always clean the ball bearing in fresh gas oil. Protect the bearing when the pump parts are being cleaned as the used washing liquid contains dirt particles that may damage the bearing.**

17. 5. 3. Reassembly

The reassembly is performed in the reversed order.

1 **Remount the ball bearing** in the front plate, the protective washer turned outwards. Lock with the locking ring.

2 **Oil the O-ring** (7). Insert the stationary sealing ring (6) in the front plate. Take care not to damage the sealing faces and check that the ring enters the pin (11).

3 **Clean the drive screw** carefully and enter the sealing unit (13) without the coal ring on to the shaft. Take care that the rubber bellows are pressed against the seal spring supporting washer. Keep the seal in this position for a moment to enable the bellows to fix. A drop of lubricating oil on the drive screw shaft will facilitate reassembly.

4 **Put the coal ring into position,** the smaller sealing face upwards and the grooves matching the marks.

5 **Place the front plate** (10) over the drive screw shaft journal.

6 **Force the ball bearing inner ring** against its shoulder on the drive screw. Use a suitable sleeve matching the bearing inner ring.

7 **Lock with the ring (3).**

8 **Install the end plate unit** and screw in the set in the pump housing. Do not forget the O-ring (12) which seals between the pump housing and the front plate. Fill the ball bearing with grease. See section 02.2.6.

9 **Install the coupling half** (1) on the pump shaft and fasten the pump to the bracket. Check that the clearance between the coupling halves (x in fig. 17-55) is 2 mm.

10 **If the electric motor has been disconnected** or changed, check that it rotates in the right direction by switching it on a few times.

17. 6. Fuel filter

(fig. 17-53)

17. 6. 1. Description

The filter is a duplex filter. By means of the three-way valve (8) the fuel flow can be guided to one side or the other, or to both sides in parallel.

The direction of the flow appears from the mark on the cock (7). **At normal operation, both sides of the filter are used in parallel** to provide maximum filtration. Figure 17-53A shows the valve in this position. When changing cartridges during operation one side can be closed. Figure 17-53B shows the position of the valve when the right side of the filter is closed. Part of the fuel is then flowing through the pressure control valve (12), fig. 17-51, from the inlet side of the open filter half to the return pipe from the engine.

The arrows in thefigure show the flow through the filter. The oil flows first through a cartridge (3) made of special paper, filtering off particles larger than 15 μm, then through an insert (4) of pleated wire gauze around a firm perforated case. The wire gauze insert, with a mesh size of 40 μm serves as a safety filter in case of failure of the paper element. There is a slow filling valve in the three-way valve to make filling of an empty filter side easier.

17. 6. 2. Changing of filter cartridges and cleaning of filter

Change cartridges regularly (see section 04) and, if the pressure drop indicator gives alarm, as soon as possible. As the useful life of the cartridges is largely dependent on fuel quality, experience from the installation concerned will give the most suitable times between changes of cartridges.

Change of cartridges and cleaning is most conveniently done during stoppage. By closing one side of the filter the cartridges can, however, be changed during operation as follows:

Take care not to open the side of the filter which is in operation. See instructions how to close a filter side by the three-way valve on the filter or on page 17-54.

1 **Shut off the filter side** to be served.

2 **Carefully open and remove** the air vent screw (1). Open the drain plug (6).

3 **Open the filter cover (2).**

4 **Remove the wire gauze insert** (4). Wash in gas oil. Check that it is intact.

5 **Remove the paper cartridge(s)** and throw away. Paper cartridges cannot be cleaned. Always keep a sufficient quantity of cartridges in stock.

6 **Clean and rinse filter housing** carefully with gas oil.

7 **Fit new paper cartridges** and the cleaned wire gauze insert. Check that all seals are intact and in position.

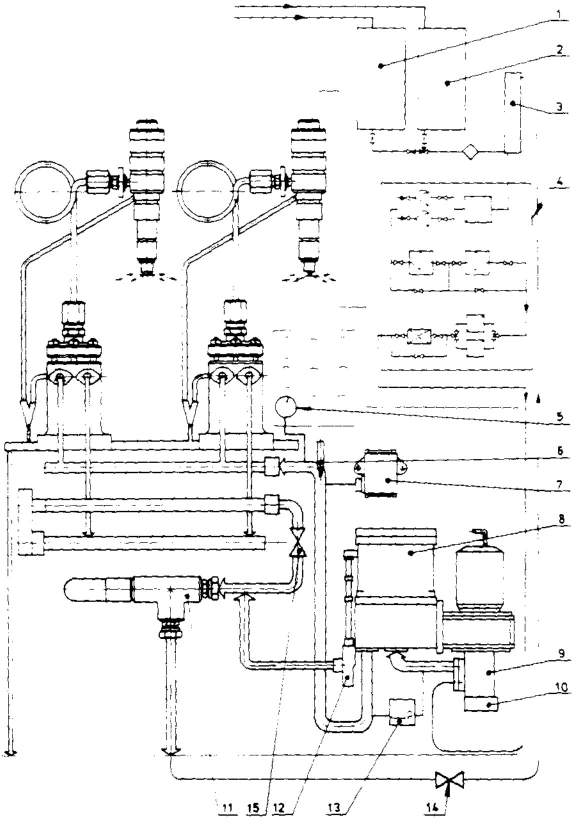
8 **In V-engines** equipped with two paper cartridges per filter side, check that the guide ring (5) is mounted.

9 **Mount the drain plug and cover.**

10 **If possible,** fill the filter with clean fuel before changing over to working position (both sides of filter in operation). If the filter cannot be filled, change over very slowly, see pos. 17.3.

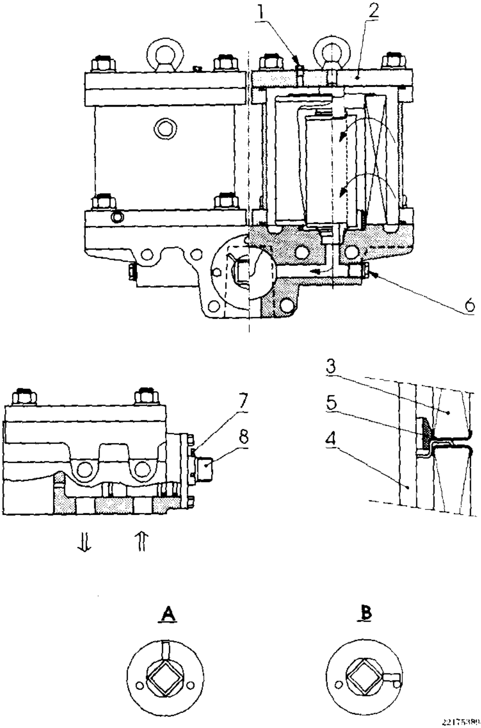
11 **Vent the filter** if not completely filled according to pos.10. See pos. 17.3.

Fuel system 17-51



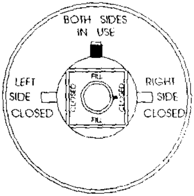
Fuel filter

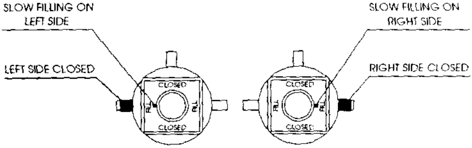
17-53



Fuel filter valve positiond 17-54

VALVE POSITION	IN USE	CLOSED
1. 2. WORK POSITION	1, 2	
1. 2.	2	1
1. 2.	1	2





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18. Lubricating oil system

18. 1. General design

(fig. 18-51)

The engine is provided with a lubricating oil pump (2) directly driven by the pump gear at the free end of the crankshaft. In some installations there is a separately driven standby pump in parallel. The pump sucks oil from the engine oil sump and forces it through the lubricating oil cooler (16) equipped with a thermostat valve (17) controlling the oil temperature, through the lubricating oil main filter(s) (13) to the main distributing pipe (12) cast in the engine block. From the main distributing pipe the oil flows, via bores in the block, to the main bearings and through bores in the connecting rod further to the gudgeon pin (11) and piston cooling space. Through separate pipes the oil is conveyed to the other lubricating points like camshaft bearing (10), injection pump tappets and valves, rocker arm bearings (9) and valve mechanism gear wheel bearings and oil syringes for lubricating and cooling. Part of the oil flows through a centrifugal filter(s) (5) back to the oil sump. The oil sump may be provided with a lever switch connected to the automatic alarm system.

For preheating the LT-water of the engine a heat exchanger (18) is fitted in the lubricating oil pipe after the prelubricating pump. Warm water for preheating the HT-circuit flows through this heat exchanger thereby heating the lubricating oil. When the engine is started the warm lubricating oil will heat the LT-water via the lubricating oil cooler.

An electrically driven prelubricating pump (4) in parallel to the direct driven pump pumps the oil through the system when the engine is out of operation and especially before starting. A nonreturn valve (3) prevents the oil from flowing in the wrong direction during operation. The pressure pipe from the prelubricating pump may be provided with a three-way valve; thus the oil sump can be emptied by means of this pump.

The pressure in the distributing pipe (12) is controlled by a pressure control valve (1) on the pump. The pressure can be adjusted by means of a set screw (fig. 18-52) on the control valve. It is very important to keep the correct pressure in order to provide efficient lubrication of bearings and cooling of pistons. Normally, the pressure stays constant after having been adjusted to the correct value. The pressure can rise above the nominal value when starting with cold oil but will return to the normal value when the oil is heated. A pressure gauge (7) on the instrument panel shows the lubricating oil pressure before the engine (in the engine distributing pipe). The system includes three pressure switches for low lubricating oil pressure (8), two connected to the automatic alarm system and one to the automatic stop system (see section 23).

The temperature can be checked from thermometers before and after the oil cooler, i.e. the temperature after and before the engine. A temperature switch for high oil temperature is connected to the automatic alarm system (see section 23).

The speed governor and the turbocharger have their own oil systems, see separate instruction books.

Connections for a separator are provided on the oil sump at the free end of the engine.

The oil filling opening (14) locates at the driving end and an oil dipstick (15) at the middle of the engine.

18. 2. General maintenance

Use only high quality oils approved by the engine manufacturer according to section 02.2.2.

Always keep a sufficient quantity of oil in the system. The oil dipstick shows the maximum and minimum limits between which the oil level may vary. Keep the oil level near the maximum mark and never allow the level to go below the minimum mark. The limits apply to the oil level in a running engine. Add max. 10% new oil at a time (see section 02.2). One side of the dipstick is graduated in centimetres. This scale can be used when checking the lubricating oil consumption.

Change oil regularly at intervals determined by experience from the installation concerned, see section 04 and 02.2.3. The oil still being warm, drain the oil system, also the oil cooler and filter. Clean the crankcase and the oil sump with proper rags (not cotton waste). Clean the main filter(s) and the centrifugal filter(s). Change cartridges in the main filter(s) unless they have been changed recently.

Centrifuging of the oil is recommended, see section 02.2.3.

Utmost cleanliness should be observed when treating the lubricating oil system. Dirt, metal particles and similar may cause serious bearing damage. When dismantling pipes or details from the system, cover all openings with blank gaskets, tape or clean rags. When storing and transporting oil, take care to prevent dirt and foreign matters from entering the oil. When refilling oil, use a screen.

18. 3. Lubricating oil pump

(fig. 18-52)

18. 3. 1. Description

The pump is of the gear type, equipped with a built-on, combined pressure control/safety valve. Five identical bronze bearings are used. No outside lubrication is required. The cover is sealed by an O-ring.

18. 3. 2. Dismantling

1 **Remove and inspect** the control valve according to section 18.4.

2 **Remove the screw** (4) and withdraw the gear (2) by means of the tool 837012 according to fig. 18-52D.

3 **Withdraw the pump cover** by using two of the fastening screws (1) in the two threaded holes located in the cover.

18. 3. 3. Inspection

1 **Check all parts** for wear (section 06.2) and replace worn parts.

2 **Remove worn bearings** from the housing by driving them out with a suitable mandrel, from the cover by machining.

3 **Mount new bearings** (freezing is recommended) so that the bearings are 3 mm below the cover and housing level (measure x = 3 mm). Be careful so that the bearing lubrication grooves (5) slide into the right position according to fig. 18-52C.

4 **Check the bearing diameter** after mounting. Check the gear wheel axial clearance (see section 06.2 pos. 18).

18. 3. 4. Assembling

Clean all details carefully before assembling. Check that the O-ring in the cover is intact and in position.

Pull the gear wheel (2) on to the shaft by using the tool 837012 according to fig. 18-52E, including the washer (3).

Coat the fastening screw (4) with LOCTITE 274 and tighten to torque (section 07).

If the gear wheel (2) has been changed, check the back lash after mounting the pump on the engine.

18. 4. Lubricating oil pressure control valve and safety valve

(fig. 18-52B)

18. 4. 1. Description

The pressure control valve is mounted on the lubricating oil pump and controls the oil pressure before the engine by conducting the surplus oil direct from the pressure side of the pump to the suction side.

The pipe (10) is connected to the oil distributing pipe on the engine, where the pressure keeps constant in engines running at constant speed. This pressure actuates the servo piston (9) and the force is transferred to the control piston (14) through the pin (6). The spring (16) is tensioned to balance this force at the required pressure. Thus the pressure keeps constant in the distributing pipe irrespective of the pressure in the pressure side of the pump and of the pressure drop in the system. By tensioning the spring (16) a higher oil pressure is obtained.

In engines which are run at varying speeds the valve is arranged to give a pressure depending on the speed according to operating pressures recommended at various speeds (section 01).

If, for some reason, the pressure should increase strongly in the pressure pipe, e.g. due to clogged system, the ball (12) will open and admit oil to pass to the servo piston (9) which will open the control piston (14) by means of the pin (6). Then the valve serves as a safety valve.

18. 4. 2. Maintenance

1 Dismantle all moving parts. Check them for wear and replace worn or damaged parts by new ones.

2 Clean the valve carefully. Check that the draining bore (13)is open.

3 Check that no details are jamming.

Do not forget the copper sealing rings (8) and (11)when reassembling. If the sealings are changed, check that the thickness is correct, (8) = 2 mm, (11) = 1.5 mm, as the thickness of these sealings influence valve function.

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4 After reassembling, check that the piston (14) closes (especially if some details have been replaced by new ones).

18. 5. Lubricating oil cooler

(fig. 18-53)

18. 5. 1. Description

A tube stack (2) is inserted in a jacket (3). The tube stack is firmly clamped at one end while the other one is movable in longitudinal direction to allow expansion. The movable end is provided with two O-rings (5) with drain holes (6) from the intermediate space to indicate leakage and prevent mixing of water and oil.

The oil flows outside the tubes guided by baffle plates (4) to achieve a favorable flow direction and velocity.

18. 5. 2. General maintenance

1 Clean and test the cooler by hydraulic pressure at intervals according to section 04 or if the lubricating oil temperature tends to rise abnormally.

2 The water side can be cleaned by removing the water boxes without removing the cooler from the engine. Remove the cooler to clean more carefully (see pos. 3 and 4).

3 Always when cleaning, check for corrosion and test by hydraulic pressure.

4 It is preferable to change the tube stack too early rather than too late.

Water leakage to lubricating oil has serious consequences.

5 Check that the drain holes (6) are open.

6 Check that the screw (8) is in position. This screw fixes the tube stack in correct position.

7 Apply sealing compound to the sealing surface between the dividing wall in the water box and the end plate of the tube stack.

18. 5. 3. Cleaning of oil side

Fouling of the oil side is normally insignificant. On the other hand, possible fouling will influence the cooler efficiency very strongly.

Due to the design, the tube stack cannot be cleaned mechanically on the outside.

Slight fouling can be removed by blowing steam through the tube stack.

If the amount of dirt is considerable, use chemical cleaning solutions available on the market:

- **Alkaline degreasing agents.**

Suitable for normal degreasing, however not effective for heavy greases, sludge and coking. Require high temperature. Always pour the degreasing agent slowly into hot water, never the contrary. Rinse carefully with water after treatment.

- **Hydrocarbon solvents.**

Include the whole range from light petroleum solutions to chlorinated hydrocarbons, e.g. trichlorethylene. These products should be handled with care as they are often extremely volatile, toxic and/or narcotic.

- **Solvent emulsions.**

Heavy fouling, e.g. coked oil, can often be solved only by using these solutions. Several brands are available on the market.

Follow the manufacturer's instructions to achieve the best results.

18. 5. 4. Cleaning of water side

The cleaning should be carried out either so that it does not damage the protective coating on the tubes or so that the coating is entirely removed. Defective cleaning or damage on the coating increases the risk of corrosion.

Remove loose sludge and deposits with brush 845004. Rinse with water. To speed up the cleaning the brush can be fixed to a hand-drilling machine.

If the protective oxide coating has been damaged it is advisable to remove the coating entirely.

If the deposit in the tubes is hard, e.g. calcium carbonate, it can be removed chemically by using some commercial agents (see section 19). After this treatment the tubes should be rinsed and, if necessary, treated with a solution neutralizing the residual washing agents. Otherwise, follow the manufacturer's instructions.

18. 6. Thermostat valve

(fig. 18-53)

18. 6. 1. Description

The figure shows the valve in closed position. When the temperature exceeds the nominal value the contents of the bulb (9) expands and forces the valve unit (10) towards the seat (11) thus passing part of the oil through the cooler. This movement continues until the right temperature of the mixed oil is obtained. As the cooler becomes dirtier the temperature will rise some degrees, which is quite normal, because the valve needs a certain temperature raise for a certain opening to increase the oil flow through the cooler.

18. 6. 2. Maintenance

Normally, no service is required. Too low oil temperature depends on defective thermostat, too high temperature may depend on defective thermostat, although, in most cases, it depends on a dirty cooler.

Remove the elements by unscrewing the pipe after the valve and opening the cover.

Check the element by heating it slowly in water. Check at which temperatures the element starts opening and is fully open. The correct values can be found in section 01; the lower value for lube oil temperature is the opening temperature, the higher one is the fully open value.

Change the defective element. Check O-rings and change, if necessary.

18. 7. Lubricating oil main filter

(fig. 18-54)

18. 7. 1. Description

This description applies to in-line engines. V-engines have two similar filters in parallel.

The filter is a full-flow duplex filter, i.e. the whole oil flow passes through the filter(s). The flow can be adjusted by the three-way valve (9) to pass over one side or the other, or over both sides in parallel.

The direction of the flow appears from the mark on the cock. Normally, both sides of the filter (for V-engines both sides of both filters) are used at the same time to provide maximum filtration. Figure 18-54 shows the valve (9) in this position. When changing cartridges during operation one side can occasionally be closed, e.g. closing of the right side according to fig. 18-54D.

The arrows in the figure show the flow through the filters. At first, the oil flows through a cartridge (2), made of special paper, separating particles larger than 10...15µm, then through an insert (3) consisting of a pleated wire gauze around a perforated case. The wire gauze insert, with a mesh size of 60µm, serves as a safety filter in case of failure or bypassing of the paper cartridge.

At the bottom of the filter there is a bypass valve (7) over the paper cartridges which opens at a pressure drop of 2...3 bar. The filter is provided with a combined visual indicator/ electrical switch connected to the automatic alarm system, which indicates too high pressure drop over the filter which means that the paper cartridges should be changed as soon as possible.

18. 7. 2. Changing of filter cartridges and cleaning of filter

Careful maintenance of the filter reduces engine wear. Change cartridges regularly (see section 04) and, if the pressure drop indicator gives alarm, as soon as possible.

As the useful life of the cartridge is, to a great extent, dependent on the fuel quality, load, lubricating oil quality, centrifuging and care of centrifugal filter, experience from the installation concerned will give the most suitable intervals between changes of cartridges.

Change of cartridges and cleaning should, if possible, be done during stoppages. By closing one of the filter halves the cartridge can, however, be changed during operation. As the load on the other cartridges will increase, the change of cartridges should be carried out as fast as possible.

1 **Shut off the filter side** to be served.

2 **Remove the protection cover** on V-engines.

3 **Open the air vent screw** (1) about two turns.

4 **Open the plug** (8) and drain the oil.

5 **Open the plug** (13) and drain the oil. On in-line engines, open the complete cover (12).

6 **Open the filter cover.**

7 **Remove the wire gauze insert.** Wash in gas oil. Check that it is intact.

8 **Remove the paper cartridges** and throw away.

Paper cartridges cannot be cleaned. Always keep a sufficient quantity of cartridges in stock.

9 **Clean and rinse the filter housing** carefully with gas oil.

10 **Fit new paper cartridges** and the cleaned wire gauze insert. Check that all seals are intact and in position.

11 **Check that the guide** (4) slides into position.

12 **Mount the plugs and the cover.** Tighten the vent screw.

13 **Move the three-way valve** over to working position (fig. 18-54C).

18. 8. Centrifugal filter

(fig. 18-55)

18. 8. 1. Description

A bypass filter of the centrifugal type is provided as a complement to the main filter. For V-engines two identical filters are used.

The filter comprises a housing (13) containing a hardened steel spindle (3) on which a dynamically balanced rotor unit (5) is free to rotate. Oil flows through the housing, up the central spindle into the rotor.

The rotor comprises two compartments, a cleaning chamber and a driving chamber. Oil flows from the central tube (6) into the upper part of the rotor, where it is subject to a high centrifugal force, and the dirt is deposited on the walls of the rotor in the form of heavy sludge.

The oil then passes from the cleaning compartment through the separation cone (9) into the driving compartment which carries two driving nozzles (12). The passage of the clean oil through the nozzles provides a driving torque to the rotor and the oil returns through the filter housing to the engine oil sump. The filter is provided with a cut-off valve (15) which opens at about 2.5 bar.

18. 8. 2. Cleaning

It is very important to clean the filter regularly (section 04) as it collects considerable quantities of dirt and thus unload the main filter giving longer lifetime for the paper cartridges. If it is found that the filter has collected the maximum quantity of dirt (about 3.7 kg) at the recommended cleaning intervals,it should be cleaned more frequently.

Clean the filter as follows, the engine being running, by closing the valve on the oil delivery pipe to the filter:

1 **Slacken off the filter cover clamp** (11), unscrew the cover nut (1) and lift off the filter body cover (4).

2 **Withdraw the rotor assembly** from the spindle (3) and drain oil from the nozzles before removing the rotor from the filter body (13). Hold the rotor body and unscrew the rotor cover nut (2), then separate the rotor cover (5) from the rotor body.

3 **Remove the upper circlip** (8) and the separation cone (9).

4 **Remove sludge** from the inside of the rotor cover and body by means of a wooden spatula or a suitably shaped piece of wood, and wipe clean.

5 **Clean the separation cone.**

6 **Wash all details**, for example in gas oil.

7 **Clean out the nozzles** with brass wire and compressed air. Examine the top and bottom bearings in the tube assembly to ensure that they are free from damage or excessive wear. Examine the O-ring (7) for damage. Renew, if necessary.

8 **Reassemble the rotor complete**, align the location pins and tighten the nut (2). Do not forget the O-ring (7) as this will cause leakage of the rotor which, in turn, will cause unbalance and damage the filter.

9 **Examine the spindle journals** to ensure that they are free from damage or excessive wear. Examine the O-ring (10) for damage. Renew, if necessary.

10 **Remove the cutoff valve plug** (14) and cutoff valve assembly. Check that the spring and shuttle are undamaged and free to move. Change the plug seal, if necessary.

11 **Reassemble the filter**, checking that the rotor assembly is free to rotate, and then replace the filter body cover. Tighten the cover nut and secure the filter cover clamp.

18. 9. Prelubricating pump

(fig. 18-56)

18. 9. 1. Description

The pump is of the screw type, driven by an electric motor.

The pump is provided with an adjustable pressure control valve (15). The pressure should be limited to the minimum value, about 2 bar, by unscrewing the adjusting screw (14) to the end position in order to prevent the electric motor from being overloaded when running with very cold oil.

As a shaft seal a mechanical seal is used consisting of two plane sealing surfaces facing each other — one of them (8) rotating with the shaft and the other one (6) being stationary.

18. 9. 2. General maintenance

Lubricating interval, see chapter 04.

After 3...6 years the shaft seal may have to be replaced due to ageing. Oil leaking out of the opening (5) indicates that the shaft seal is defective and has to be changed.

Take care not to damage the sealing ring faces. A slight scratch may disturb the sealing function. The rotating coal ring (8) is very fragile. Avoid touching the sealing faces with your fingers.

18. 9. 3. Dismantling

1 **Loosen the pipes** and fastening screws (9) and withdraw the pump.

2 **Draw the coupling half** (1) off the shaft.

3 **Remove the front plate** (10) together with the drive screw (2) and the shaft seal. Place the front plate on two rods, the shaft journal turned upwards.

4 **Remove the drive screw locking ring** (3). Give the shaft journal a few blows with a plastic hammer until the screw is disengaged from the ball bearing. Take care not to damage the screw by dropping it on the work bench.

5 **Remove the sealing ring (8).**

6 **Force the sealing unit** (13) off the drive screw (2). Pressing force may be relatively strong due to the rubber bellows.

7 **Tap the stationary sealing ring** (6) together with the O-ring out of the front plate by using a chisel.

8 **To remove the ball bearing** (4) from the front plate, first remove the locking ring.

Note! **Always clean the ball bearing in fresh gas oil. Protect the bearing when the pump parts are being cleaned as the used washing liquid contains dirt particles that may damage the bearing.**

18. 9. 4. Reassembly

The reassembly is performed in the reversed order.

1 **Remount the ball bearing** in the front plate, the protective washer turned outwards. Lock with the locking ring.

2 **Oil the O-ring** (7). Insert the stationary sealing ring (6) in the front plate. Take care not to damage the sealing faces and check that the ring enters the pin (11).

3 Clean the drive screw carefully and enter the sealing unit (13) without the coal ring on to the shaft. Take care that the rubber bellows are pressed against the seal spring supporting washer. Keep the seal in this position for a moment to enable the bellows to fix. A drop of lubricating oil on the drive screw shaft will facilitate reassembly.

4 Put the coal ring into position, the smaller sealing face upwards and the grooves matching the marks.

5 Place the front plate (10) over the drive screw shaft journal.

6 Force the ball bearing inner ring against its shoulder on the drive screw. Use a suitable sleeve matching the bearing inner ring.

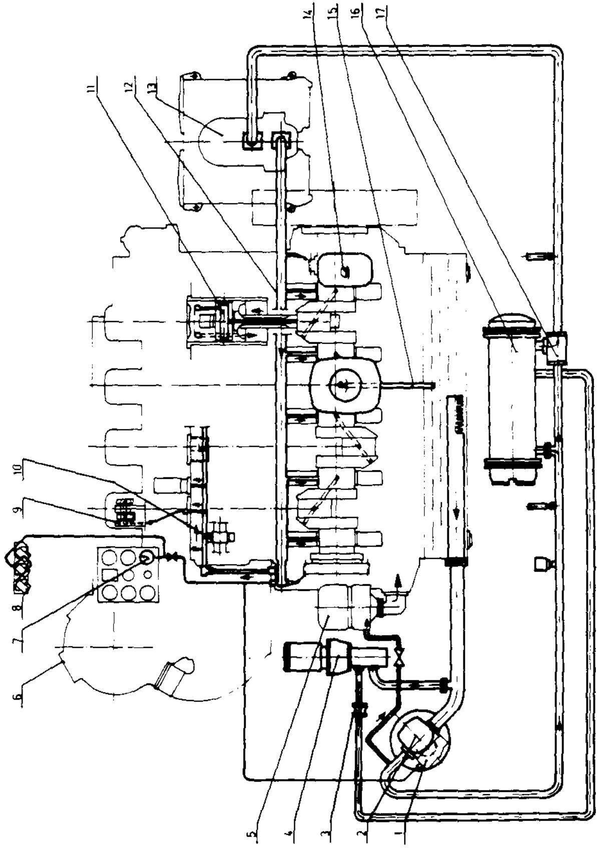
7 Lock with the ring (3).

8 Install the end plate unit and screw in the set in the pump housing. Do not forget the O-ring (12) which seals between the pump housing and the front plate. Fill the ball bearing with grease. See section 02.2.7.

9 Install the coupling half (1) on the pump shaft and fasten the pump to the bracket. Check that the clearance between the coupling halves (x in fig. 18-56) is 2 mm.

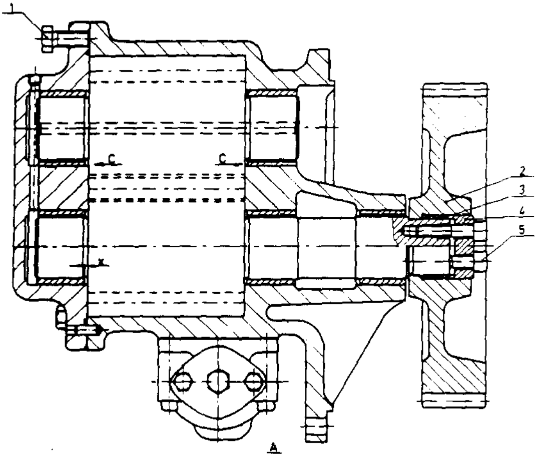
10 *If the electric motor has been disconnected* or changed, check that it rotates in the right direction by switching it on a few times.

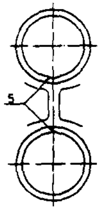
Lubricating oil system 18-51

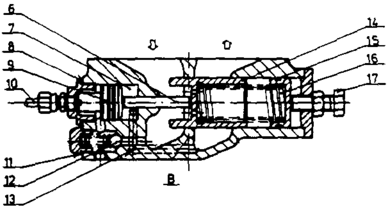


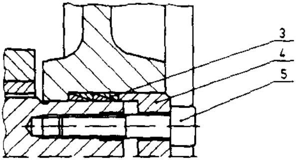
Lub oil pump

18-52



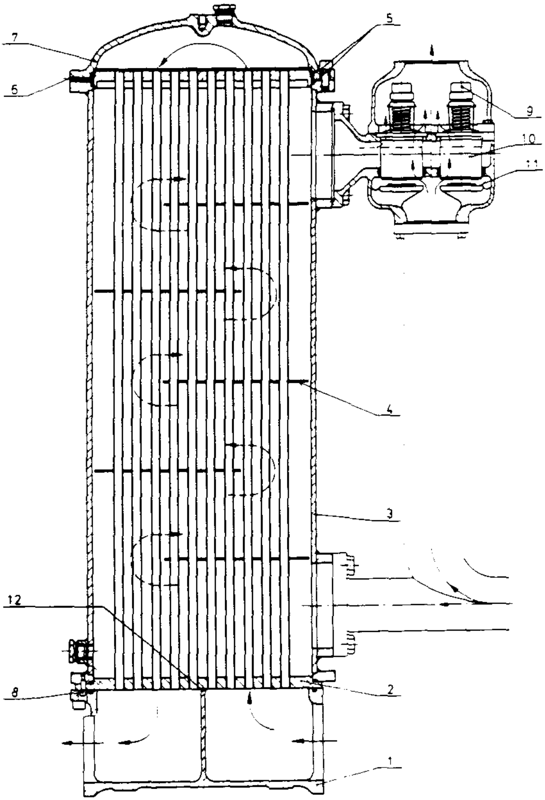




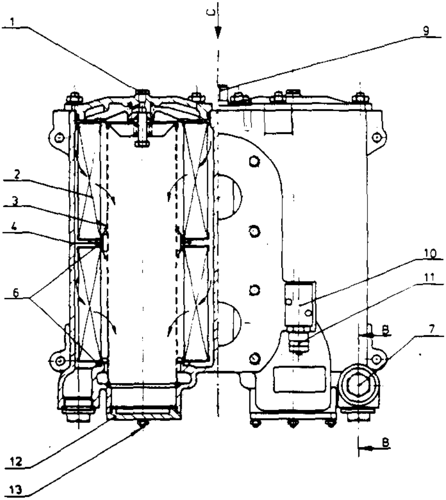


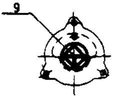
Lube oil cooler

18-53



Lube oil filter 18-54





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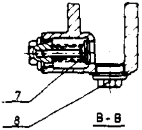

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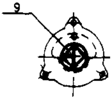

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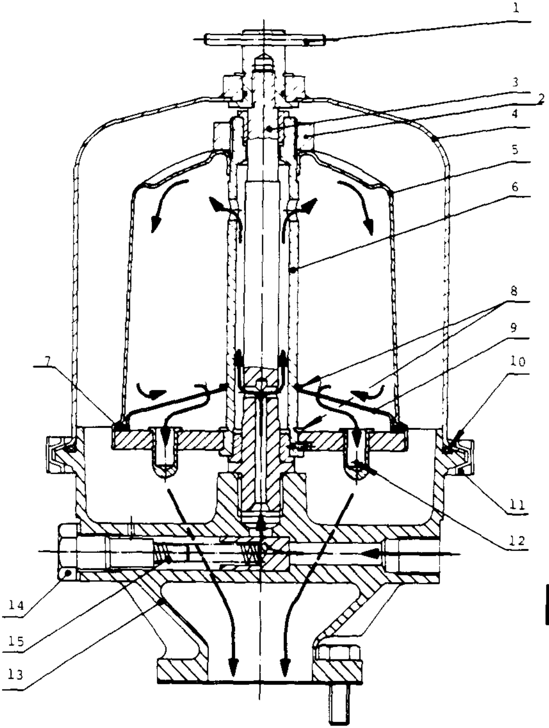
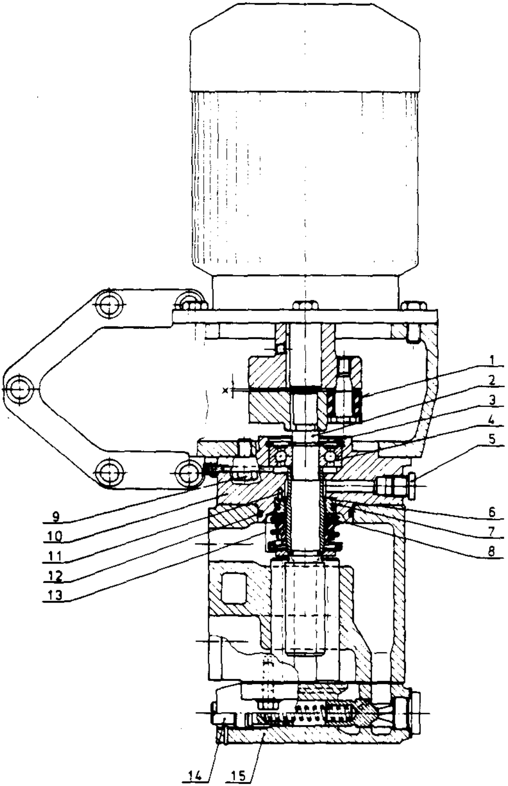
Centrifugal filter 18-55



Prelubricating pump 18-56



19. Cooling water system

19. 1. Description

(fig. 19-51)

19. 1. 1. General

The engine is cooled by a fresh water system, divided into a high temperature circuit (HT) and a low temperature circuit (LT). The complete system with pumps, temperature control valves etc. is mounted on the engine. The fresh water is cooled in a separate central cooler.

The LT circuit is provided with a temperature control valve which keeps the temperature in the circuit at a load dependent level. Thus the temperature in the LT system rises at low load and the charge air is heated instead of cooled. The heat for this purpose is gained from the oil system via the oil cooler.

The system outside the engine can vary widely. The fig. on page 19-51 shows a system with separate coolers (14) and (16) for the LT and HT circuit. The system can also be built with a common cooler for the HT and LT circuit.

19. 1. 2. HT circuit

The HT circuit cools the cylinders, cylinder heads and turbocharger(s).

A centrifugal pump (9), direct driven by the engine, pumps the water through the HT circuit. From the pump the water flows to the distributing duct, cast in the engine block (in V-engines the water is distributed to the distributing ducts of each cylinder bank through ducts cast into the pump cover at the free end of the engine). From the distributing ducts the water flows to the cylinder water jackets, further through connection pieces to the cylinder heads where it is forced by the intermediate deck to flow along the flame plate, around the valves to the exhaust valve seats, efficiently cooling all these components. From the cylinder head the water flows through a connection piece to the collecting pipe.

Parallel to the flow to the cylinders, part of the water flows to the turbocharger(s). The necessary cooling is gained from the central cooler (14).

19. 1. 3. LT circuit

The LT circuit consists of a charge air cooler (7) and a lube oil cooler (15) through which a pump (8), identical to the HT pump, pumps the water. The circuit temperature is controlled by a temperature control valve (10) maintaining the LT circuit temperature at a load dependent level. The necessary cooling is gained from the central cooler (16).

19. 1. 4. Venting and pressure control

The collecting pipes from the cylinder and turbocharger cooling system are connected to a box (2) for venting of the system. From this box the vent pipe leads to the expansion tank (1) from which the expansion pipe is connected to the inlet pipes of the pumps (8, 9). Static pressure of 0.7...1.5 bar is required before the pumps. If the expansion tank cannot be located high enough to provide this pressure, the system is to be pressurized.Vent pipes for the circuits are also provided.

19. 1. 5. Preheating

Before start, the HT and LT circuits are heated up to about 70°C. This is of utmost importance when starting and idling on heavy fuel. As the lube oil is also heated (indirectly) by the LT water, all fluids are close to working temperatures when the engine is started. Thus the charge air is heated directly in the charge air cooler when starting.

19. 1. 6. Monitoring

Local thermometers:

- HT before and after engine
- HT after turbocharger
- LT before charge air cooler - LT before lube oil cooler
- LT after lube oil cooler

The temperatures mentioned in section 01.2 should be followed.

The manometers (5) and (6) on the instrument panel indicate HT and LT pressures after the pumps. The pressures depend on the speed and the installation. Guidance values, see section 01.2.

The HT water outlet after the engine is provided with an alarm switch and a stop switch. Main engines are provided with alarm switches for low HT and LT pressure. For further information, see section 23.

19. 2. Maintenance

19. 2. 1. General

The installation — including expansion, venting, preheating, pressurizing — should be carried out strictly according to the instructions of the engine manufacturer to obtain correct and troublefree service.

The circulating fresh water should be treated according to the recommendations in section 02.3 to prevent corrosion and deposits.

If risk of frost occurs, drain all cooling water spaces. Avoid changing the cooling water. Save the discharged water and use it again.

19. 2. 2. Cleaning

In completely closed systems fouling will be minimal if the cooling water is treated according to our instructions in section 02.3. Depending on the cooling water quality and the efficiency of the treatment the cooling water spaces will foul more or less in course of time. Deposits on cylinder liners, cylinder heads and cooler stacks should be removed as they may disturb the heat transfer to the cooling water and thus cause serious damage.

The need of cleaning should be examined, especially during the first year of operation. This may be done by overhauling a cylinder liner and check for fouling and deposits on liner and block. The cylinder head cooling water spaces may be checked by opening the lower large plugs on the sides of the cylinder heads. The turbochargers can be checked through the covers of the water space and the coolers by removing the water boxes of the inlet water.

The deposits can be of the most various structure and consist- ence. In principle, they can be removed mechanically and/or chemically as described below. More detailed instructions for cleaning of coolers are stated in section 18.5.

19. 2. 2. 1. Mechanical cleaning

A great deal of the deposits consists of loose sludge and solid particles which can be brushed and rinsed off with water.

On places where the accessibility is good, e.g. cylinder liners, mechanical cleaning of considerably harder deposits is efficient.

In some cases it is advisable to combine chemical cleaning with a subsequent mechanical cleaning as the deposits may have dissolved during the chemical treatment without having come loose.

19. 2. 2. 2. Chemical cleaning

Narrow water spaces (e.g. cylinder heads, coolers) can be cleaned chemically. At times, degreasing of the water spaces may be necessary if the deposits seem to be greasy (see section 18.5.4).

Deposits consisting of primarily limestone can be easily removed when treated with an acid solution. Contrarily, deposits consisting of calcium sulphate and silicates may be hard to remove chemically. The treatment may, however, have a certain dissolving effect which enables the deposits to be brushed off if there is only access.

On the market there are a lot of suitable agents on acid base (supplied e.g. by the companies mentioned in section 02.3). The cleaning agents should contain additives (inhibitors) to prevent corrosion of the metal surfaces.

Always follow the manufacturer's instructions to obtain the best result.

After treatment, rinse carefully to remove cleaning agent resi- duals. Brush the surfaces, if possible. Rinse again with water and further with a sodium solution of 5% to neutralize possible acid residuals.

19. 3. Water pump

(fig. 19-52)

19. 3. 1. Description

The water pump is a centrifugal pump and is driven by the gear mechanism at the free end of the engine. The shaft is made of acid resistant steel, the impeller (2) and the sealing ring (3) of bronze and the remaining details of cast iron.

The shaft is mounted in two ball bearings (11) and (12), which are lubricated by splash oil entering through the opening (20). The radial seal (13) prevents the oil from leaking out and, at the same time, dirt and leak water from entering. Also the axial seal (14) sealing against the outside of the seal (13) assists in this.

The gear wheel (24) is fastened to the shaft by conical ring elements (25). When the screws (21) are tightened the rings exert a pressure between the gear wheel and the shaft. Due to the friction the power from the gear wheel is transmitted to the pump shaft.

The water side of the pump is provided with a mechanical shaft seal. The ring (8) rotates along with the shaft and is sealed against it with the O-ring (7). The spring (5) presses the rotating ring against a fixed ring (9) which is sealedagainst the housing with the O-ring (10). Possible leak-off water from the sealing can flow out through the opening (15).

Note! **(only 8-cylinder V-engines) The counterbalance system in the free end is driven by the gear wheels of the water pumps. Always when reinstalling the water pumps after maintenance, make sure that the counterweight positions are correct in relation to the crankshaft. For further instructions, see section 11.**

19. 3. 2. Maintenance

Check the pump at intervals according to the recommendations in section 04 or, if water and oil leakage occurs, immediately.

19. 3. 2. 1. Disassembling and assembling impeller

1 **Remove the volute casing** by loosening the nuts (17).

2 **Remove the cotter pin** and loosen the nut (1).

3 **Pull off the impeller** by using the tool 837012, see fig. 19-52A.

4 **When reassembling the impeller,** tighten the nut to torque, see section 07.1 pos. 25.

5 **Secure the nut** with a new stainless cotter pin.

6 **Check that the O-ring (18) is intact** and in position when re-installing the volute casing. Check that the volute casing is in position. The opening (20) should be turned upwards when the pump is installed.

If the bearing housing is turned wrongly, the bearings (11) and (12) will be left without lubrication. Before mounting the pump on the engine, fill up the bearing housing (20) with oil until oil flows out through the draining holes (26).

19. 3. 2. 2. Disassembling and assembling mechanical shaft seal

1 **Remove the impeller** according to section 19.3.2.1.

2 **Carefully dismantle all seal details.** The sealing rings are very fragile.

Take particular care not to damage the sealing surfaces as a slight scratch may disturb the sealing function.

3 **Replace the complete seal** if it is leaky, if the sealing faces are corroded, uneven or worn. Avoid touching the sealing faces with your fingers.

Note! **The seal is dependent on the direction of rotation due to the self-locking effect of the spring on the shaft.**

In a clockwise rotating engine the spring should be left-wound (and contrarily right-wound in a counterclockwise rotating engine). Untensioned, the spring may cause the ring (8) not to rotate properly with the shaft, whereby the O-ring gets worn thus causing leakage.

- Reassemble the details in proper order
- and install the impeller according to section 19.3.2.1. Do not forget the thin washer (6) between the spring (5) and the O-ring (7).

19. 3. 2. 3. Replacing bearings

1 **Remove the pump from the engine.**

2 **Disassemble the impeller and mechanical seal** according to sections 19.3.2.1 and 2.

3 **Remove the rear plate (19)** by undoing the screws (16).

4 **Loosen the screws (21)** and remove the cap (27).

5 **Pull off the gear wheel without using any tool.** If the gear wheel does not come loose, a few strokes with a non-recoiling hammer will help. (The conical ring elements come loose together with the gear wheel.) Using an extractor will only damage the shaft (axial scratches).

6 **Loosen the bearing retainer (23)** and drive out the shaft and bearing. In doing this also the seal (14) will come loose.

7 **Check the seals (13) and (14)** and the bearings for wear and damage, see pos. d.

8 **Remove the bearings.**

9 **Press the bearing (12) by its inner ring with a suitable pipe.** Before fitting the bearing, oil the collar. See fig. 19-55A.

10 **Turn the shaft according to fig. 19-55B.**

11 **Fit the distance ring** and oil the collar.

12 **Press the bearing (11)** by its inner ring with a suitable pipe. See fig. 19-55B.

13 **Turn the bearing housing** according to fig. 19-55C and oil the outer surfaces of the bearings. Press the shaft into the housing by both the inner and outer ring of the bearing (11) with a suitable pipe.

14 **Fit the bearing retainer (23).**

15 **Before reinstalling the gear wheel,** all contact surfaces should be cleaned and oiled.

16 **Reinstall the gear wheel.**

17 **Reinstall the conical ring elements (25),** see fig. 19-52B. The conical ring elements should fall easily in place and must not jam.

18 **Reinstall the cap** and the screws.

19 **Tighten the screws a little** and check that the gear wheel is in the right position.

20 Tighten the screws to torque according to section 07.1.23A.

21 Reinstall the seals (13) and (14), see section 19.3.2.4.

22 Reinstall the rear plate (19) as well as the mechanical seal, impeller and volute casing according to section 19.3.2.1 and 2.

19. 3. 2. 4. Replacing radial seal

This will be most easily done at the same time as replacing the bearings. If, for some reason, the seal is leaky and there is no need of changing the bearing, proceed as follows:

1 Remove the volute casing and mechanical seal according to pos. 2a and 2b as well as the rear plate (19).

2 Remove the seals (14) and (13) by prying (damaging) without scratching the shaft.

3 Inspect the shaft. In case the seal has worn the shaft by more than 0.5 mm radially, the shaft should be replaced according to section 19.3.2.3.

4 Oil the new seal and fit it by pressing against the shoulder.

5 Grease the axial seal (14) and install by using the tool C in fig. 19-52.

6 Install the rear plate as well as the mechanical seal and the volute casing according to section 19.3.2.1 and 2.

19. 4. Temperature control system

19. 4. 1. General description

(fig. 19-53)

The HT thermostatic valve is a conventional valve with one set point. The LT valve has two set points.

At low load the valve controls at high temperature, and at high load it controls at low temperature, by the thermostatic elements (8). Set points according to section 01.2.

The change-over between high and low temperature is pneumatically controlled.

The signal is taken from the charge air receiver by a pressure switch (3). The switch controls a three-way solenoid valve (2) providing air pressure to the pneumatic cylinder (6) on the temperature control valve at low load operation. Thus the valve will work as a constant low temperature valve without air pressure or without signal from the pressure switch. The air pressure is taken from the starting air pressure, max. 30 bar. This pressure is reduced by the pressure reducing valve (9) to a constant pressure of about 6 bar.

The complete system is mounted on the engine.

The switch (3) has a small hysteresis to make the system stable in the change-over area.

19. 4. 2. Temperature control valve for LT circuit

(fig. 19-54)

19. 4. 2. 1. Description

The valve is a two-step valve working with two fixed thermostatic elements (6) mounted in series inside the valve.

The water to be controlled, is the inlet to the charge air cooler, which is connected to port A, bypass to B and cooling to C.

The springs (10) force the valve (8) to the left (bypass position).

At high load - low temperature operation there is no control air pressure (14) beneath the position control piston (3). Thus the spring (12) forces the piston (3) to the right (high load - low temperature position). In this situation the low temperature thermostatic element controls the valve while the high temperature thermostatic element is completely compressed. When the temperature rises the low temperature element expands and moves the valve against cooling position until steady state is reached.

At low load - high temperature operation the position control piston (3) moves to the left against the spring (12) to low load - high temperature position. The valve is then bypassing until the low temperature thermostatic element has expanded completely and the high temperature element starts expanding and takes over the control of the valve.

The pin (18) shows the position of the valve.

The drain bore (15) gives an indication of leakage of water (or air).

19. 4. 2. 2. Maintenance

Check the valve according to the recommendations in section 04 or if the temperatures are abnormal. Open and clean, change sealings, adjust according to section 19.4.3.3 and check temperatures at high and low load.

Wrong temperatures may be caused by damaged thermostatic elements, dirt or corrosion in the valve, fault in the position control system. Trouble-shooting can be carriedout according to the sections a...d below.

A mark (e.g. tape) on the indicator pin (18) for closed position of the valve (cooling cut off) will help in indicating the position of the valve. The movement of the valve is max. 11 mm for normal control and max. 30 mm when changing from low to high load.

a) Too low temperature at low load

When idling the temperatures can be somewhat lower than the guidance values.)

Check that the position piston (3) is in high temperature position (moved to the left). This can be seen from the position of the screw (2).

a)Piston in correct position:

- check the thermostatic elements
- check that the valve (8), pin (5) and element cage (7) move freely
- check the adjustment according to section 19.4.3.3.

b)Piston in wrong position:

- check if control air is fed to the piston
- if there is pressure, the piston (3) jams, or the pressure is too low: Check pressure and clean the parts. Also check for air leakage in the opening (15). Leakage indicates that the O-ring (19) is damaged and has to be replaced by a new one for proper function of the thermostatic valve.
- if there is no pressure: Check the signal from the switch (3) page 19-53.
- if the signal is not correct: Change the switch
- if the signal is correct: Check the pressure before the three-way valve.
- if the pressure is too low, or if there is no pressure at all, check the pressure control valve (9), page 19-53, and the primary pressure before the valve. If the pressure cannot be adjusted to correct value with correct primary pressure, clean the valve. If no improvement, change the valve.
- if pressure and control signal to the three-way valve (2), page 19-53, is satisfactory, check the valve itself.
- check the coil. Change if damaged.
- clean the valve.
- change the complete valve, if damaged.

b) Too high temperature at low load

- Cooling is insufficient.

Check temperature after the central cooler. If the valve is fully open for cooling, the pin (18) is in outer position.

- Damaged thermostatic element(s).

(The low temperature element should also work correctly to give the correct high temperature characteristic).

- The valve is jamming. Clean the valve.

c) Too low temperature at high load

- Defective thermostatic element(s) (the element(s) will not go back to cold position).
- Jamming valve. Clean the valve.
- The valve is not closing correctly. Check adjustment according to section 19.4.4.

d) Too high temperature at high load
Cooling is insufficient. Check the temperature after the central cooler. Check that the valve is fully open. Utilize the indicator pin (18).

- Defective low temperature element. Change the element.
- Check that the piston (3) is in low temperatureposition, utilize the position of the screw (2).
- If the position piston (3) is in wrong position, check pressure (14) before the cylinder.
- If there is no pressure, the valve is jamming. Open and clean the valve.
- If there is pressure, the position control system is faulty.
- If the pressure disappears when opening the connection (14) the drain hole of the three-way valve (2) page 19-53 can be clogged.

Clean the drain opening.

- If the air flow does not stop, check the switch (3) page 19-53.
- If the switch is intact, clean the three-way valve (2) page 19-53, or change if damaged.

19. 4. 3. Adjustment of the valve

For correct closing position, adjust as follows:

Note! The temperatures of the valves must not exceed 25°C when adjusting. This is to guarantee that the low temperature elements are completely compressed.

1 Remove the screw (11).

2 Turn the adjusting nut (1) clockwise until the indication pin (18) starts moving. Then turn the adjusting nut counter- clockwise about one turn.

3 Mount the screw (11) in the nearest hole to lock the adjustment.

The temperatures can be altered only by changing the elements inside the valve.

19. 4. 4. Changing of thermostatic element

1 Drain as much cooling water as necessary to empty the valve.

2 Shut off air supply.

3 Loosen the indicator pin (18) but do not remove it from the tap (17).

4 Remove the tap (17) and the indicator pin.

5 Carefully remove the cover (9).

Notice that the cover it is spring loaded.

6 Remove the complete valve assembly (8).

7 Remove the element cage (7).

8 Remove the retainer ring (16), after which the thermostatic elements can be changed.

9 Check the parts, including the push rod (5), for wear and corrosion.

10 Mount the elements and the valve in reverse order.

19. 4. 5. Check of the thermostatic element

The elements can be checked by heating up slowly in water.
Put a strong rubber ring longitudinally over the element and its push rod to keep the rod pressed into the element.

At the nominal opening temperature, stamped on the element (for example 4.051.35 means that the nominal opening temperature is 35°C); the push rod of the element should be flush with the end surface of the body. At a temperature 10°C higher, the movement of the push rod should be about 10 mm (i.e. stroke 10 mm from the stamped temperature).

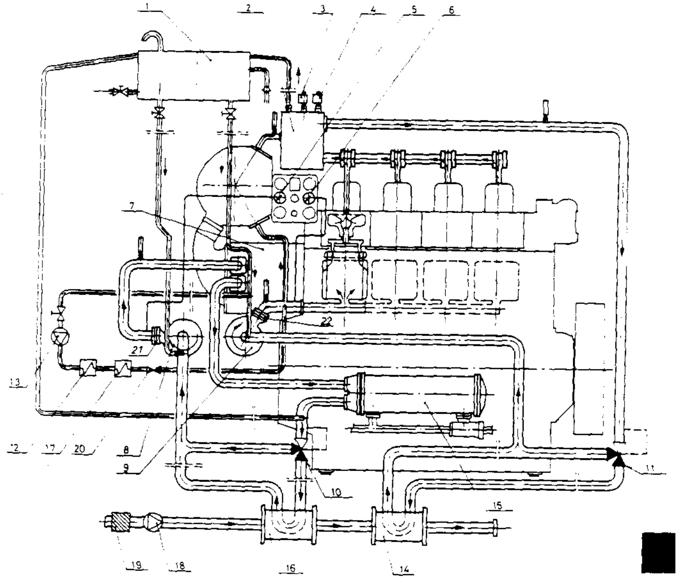
Note! There are two different elements in each valve, one element 35°C (4.051.35) and one element 65°C (4.051.65).

19. 4. 6. Check of change-over point

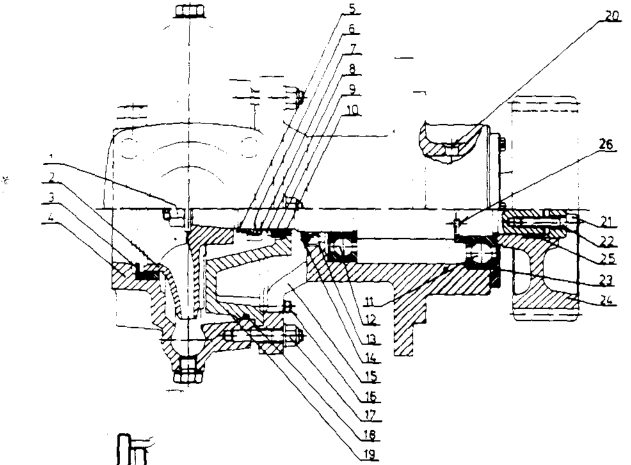
1 Raise the load slowly over the change-over point, normally at 35%±2% load (if no other value has been agreed with the manufacturer). Check the change-over from the movement of the screw (2), page 19-54, or from the electrical side (no current at high load). Adjust the set value (10) of the pressure switch, if necessary. Open the locking screw (11) during adjustment.

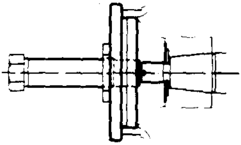
2 Decrease the load slowly over the change-over point which should be 2...3% lower than the point of increased load. Adjust the hysteresis (p) of the switch (13), if necessary. Open the locking screw (12) during adjustment.

Cooling water system 19-51



Water pump 19-52





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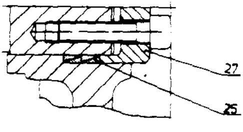

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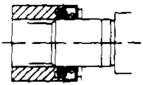

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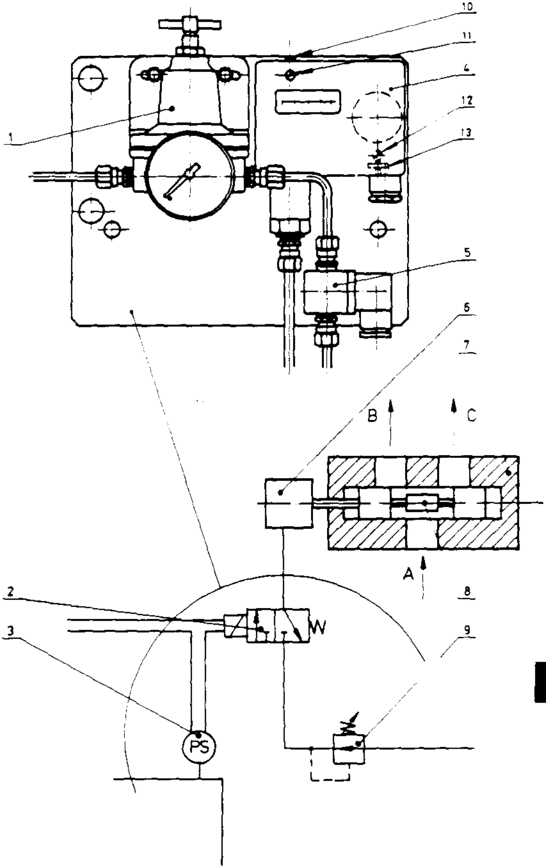
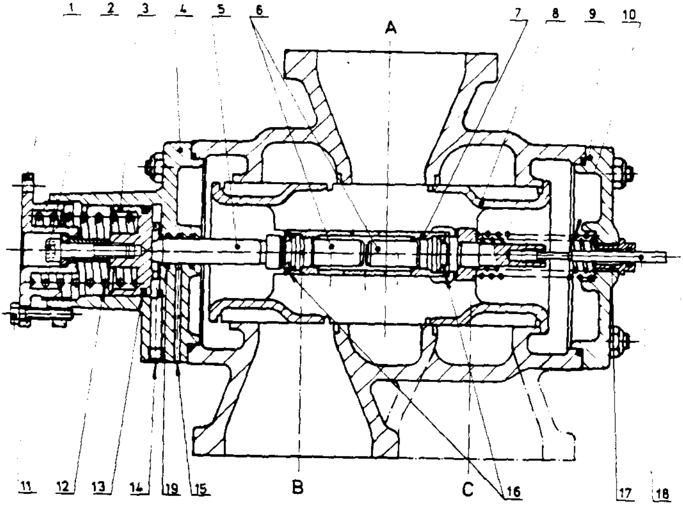
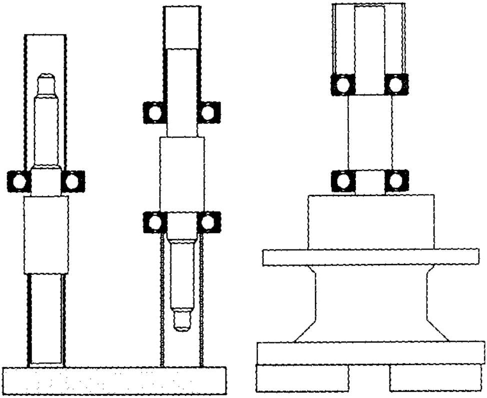
Temperature contrl system 19-53



Temperature control valve 19-54



Mounting of bearings 19-55



20. Exhaust system

20. 1. Description

(page 20-51)

The exhaust pipes are cast of special alloy nodular cast iron, with separate sections for each cylinder.

Metal bellows of the multiply type absorb heat expansion between the cylinder heads and the pipe system as well as between the turbocharger and the pipe system.

All connections between pipes, expansion bellows, cylinder heads and turbocharger are made with rigid flanges and gaskets.

The pipe system is supported and fixed by a bracket (5) but is free to move axially in the supporting bracket (3). The disc springs (2) maintain a positive force between the bracket and the pipe.

The complete exhaust system is enclosed by an insulation box built up of insulated sandwich steel sheets, flexibly mounted on the engine structure. Mineral wool is used as insulating material.

The exhaust gas temperatures can be checked on local thermometers after each cylinder. Sensors for remote measuring of the temperature (or for the alarm system) can be mounted after each cylinder as well as before and after the turbocharger.

20. 2. Replacing expansion bellows

1 Remove the cover (4) of the insulation box to get access to the expansion bellows between the exhaust pipes and the cylinder head.

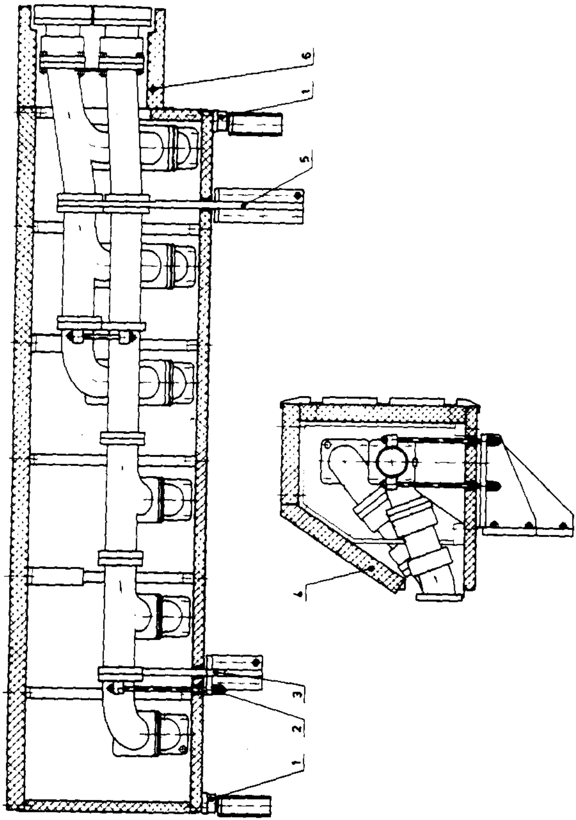
2 Remove the covers (6) to get access to the expansion bellows between the exhaust pipes and the turbocharger.

3 Check that the flanges between the turbocharger and the exhaust pipe are parallel and located on the same center line to avoid lateral forces on the bellows when mounting.

20. 3. Suspension of the insulation box

The insulation box is mounted with flexible elements (1) to dampen vibrations thus protecting the insulation. Replace the elements by new ones, if necessary.

Exhaust system 20-51



21. Starting air system

21. 1. Description

(Fig. 21-51)

The engine is started with compressed air of maximum 30 bar. The minimum pressure required is about 11 bar depending on the cylinder number and the installation. A pressure gauge (15) indicates the pressure before the main starting valve.

The inlet air pipe from the starting air receiver includes a non- return valve (13) and a filter (20). A blow-off valve (14) is located before the main starting valve. The main starting valve may be operated either with the lever (1) at manual starting or with a solenoid valve (8) at remote or automatic starting of the engine.

When the main starting valve opens, starting air passes partly through the flame arrester (16) and partly through the start limiting valve (23). The start limiting valve prevents the passage of control air if the cover to the turning opening at the flywheel is removed.

The starting air distributor guides the control air to the starting valves which open and admit starting air to flow to the various cylinders for suitable periods.

Four-cylinder engines are equipped with a pneumatic starting motor which turns the crankshaft through a gear ring on the flywheel until the engine has reached a speed enabling start.

V-engines have starting valves on the A-bank, only.

21. 2. Main starting valve

(Fig. 21-51)

21. 2. 1. Description

The starting air for the engine is led to the space (12), and through holes in the sealing piston (11) also to the rear side of the piston which means that the piston normally is closed.

At manual start, open the valve by depressing the lever (1). The pin (3) will then move the piston (11) and starting air is admitted to the space (5), to which the distributing pipe and the starting air distributor inlet pipe are connected.

At remote or automatic start the solenoid valve (8) opens and the servo piston (6) moves the sealing piston (11) upwards through the lever (2) and the pin (3). The solenoid valve opens when it is energized. When it closes, the space behind the servo piston (6) is vented (9) and the main starting valve closes.

21. 2. 2. Maintenance

Normally, the main starting valve requires little maintenance. In case it is to be opened for inspection:

1 Remove the valve from the engine by loosening the starting air pipe, the pipe from the valve to the start limiting valve and the bracket with the starting lever. On V-engines, also remove the pressure gauge pipes from the instrument panel and, as a unit, the instrument panel and the bracket with starting lever. The valve can now be removed from the end cover.

2 Open the plug (10) for inspection. Clean the sealing piston (11) and the seat. Do not use hard tools.

3 Check the pin (3) and the servo piston (6) for free movement. The servo piston is removed by undoing the two hexagon socket head screws by which the cylinder is fixed. Replace the O-rings rings, if necessary.

4 Lubricate the details before reassembling. Fill the servo piston lubricating grooves with Molykote Paste G.

5 When installing, check that the O-rings are undamaged and in position.

Lubricate the contact faces of the lever arm with Molykote.

The solenoid valve (8) requires, in principle, no maintenance. If the coil has broken, e.g. because of overvoltage, replace the coil by a new one. If the valve is probable to be clogged by dirt it can be dismantled for cleaning if caution is observed. Check that the sealing surfaces are not damaged. Reinstall all details in correct position and order. If further troubles, replace the valve by a new one.

21. 3. Starting air distributor

(Fig. 21-51)

21. 3. 1. Description

The starting air distributor is of the piston type. The distributor pistons are guided by a cam (19) at the camshaft end. When the main starting valve opens, the guiding pistons (17) are pressed against the cam, whereby the guiding piston of the engine cylinder which is in starting position admits control air to the control piston (22) of the starting valve. The starting valve opens and allows pressure air to pass into the engine cylinder. The procedure will be repeated as long as the main starting valve is open or until the engine speed is so high that the engine fires.

After the main starting valve has closed, the pressure drops quickly and the springs (18) lift the pistons off the cam, what means that the pistons touch the cam only during the starting cycle. Thus wear is unsignificant.

21. 3. 2. Maintenance

Normally, the starting air distributor is only slightly worn. If it has to be opened for inspection and cleaning:

1 **Take care** not to damage the sliding surfaces of the piston and the distributor housing bores.

2 **The piston** are individually matched and are not interchangeable. Utilize the cylinder number stamped at every control air outlet.

3 **Apply Molykote Paste G** to the piston sliding surfaces and fill up the lubricating oil grooves before reassembly. Check that the pistons do not stick.

4 **After installing** the distributor but before connecting control air pipes, check that all pistons are working satisfactorily, e.g. by connecting compressed air to the distributor air inlet and turning the crankshaft; it is then possible to see whether the pistons follow the cam profile.

Caution! **If the control air pipes have been connected prior to checking,the crankshaft will rotate.**

21. 4. Starting valve in the cylinder head

21. 4. 1. Description

The valve is an exchangable unit consisting of a valve spindle with a spring-loaded control piston installed in a housing.

21. 4. 2. Maintenance

Check and, if necessary, clean the valve when overhauling the cylinder head.

1 **Remove the flange** and pull out the starting valve.

2 **Unscrew the self-locking nut** (21) and remove the piston (22).

3 **Check the sealing faces** of the valve disc and valve seat.

4 **After reassembling the piston,** spindle and spring, check that the valve moves easily and closes completely.

5 When installing the valve, check that the sealing under the valve is in position and intact.

6 Tighten the valve to torque recommended in section 07.1.

21. 5. Starting air vessel and piping

The starting air system should be designed so that explosion is prevented.

An oil and water separator should be included in the feed pipe between the compressor and the starting air vessel. At the bottom point of the piping there should be a drain valve.

Drain the starting air vessel from condensate through the drain valve before starting.

The piping between the air vessels and the engines should be carefully cleaned when installing. Also later on they should be kept free from dirt, oil and condensate.

The starting air vessels should be inspected and cleaned with intervals according to section 04. If possible, they should then be coated with a suitable anti-corrosive agent. Let them dry long enough.

At the same time, inspect the valves of the starting air vessels. Too strong tightening may result in damage on the seats, which in turn causes leakage. Leaky and worn valves including safety valves should be reground. Pressure test the safety valves.

The filter (20) on the engine should be inspected and cleaned with intervals according to section 04. Drain the filter from condensate with the built-on drain valve.

21. 6. Starting air system equipped with pneumatic starting motor

21. 6. 1. Description

(Fig. 21-52)

In order to ensure automatic start irrespective of the crankshaft position, the four-cylinder engines are equipped with a pneumatic starting motor, which turns the crankshaft through a gear ring on the flywheel until the speed necessary for start is reached. The starting air pressure is max. 30 bar. The minimum pressure for start is abt 15 bar but it can vary from one installation to another.

As an extra safety measure there is a device on the engine that prevents undesirable starting during turning. Air is led through a start limiting valve (10) that prevents the passage of control air if the cover to the turning opening at the flywheel is removed.

If the engine is started up manually, the push-button (7) should be released as soon asthe engine starts, otherwise the starting motor is exposed to unnecessary wear.

21. 6. 2. Maintenance

It is very important to keep the system free from dirt and condensate to achieve troublefree function. See section 21.5.

Vent the servo lubricator circuit when starting up a new motor or if, by mistake, the oil container went empty.

If the servo lubricator circuit is not thoroughly vented the starting motor will get no lubrication and may be damaged.

21. 6. 3. Venting

1 Loosen the air connection from the lubricator (10) and the oil connection from the non-return valve (11).

2 Plug up the oil pipe opening with a finger and, by means of an air nozzle, blow compressed air into the air connection several times until oil emerges from the oil pipe. If compressed air is not available, the connection 1 on the valve (7) can be opened and the valve can be connected to the servolubricator air connection. Then it is possible to use the normal start button of the engine for venting without starting the engine.

When using the start button of the engine when venting as described above, connection on the valve (7) must absolutely be removed. Otherwise the engine will start when venting.

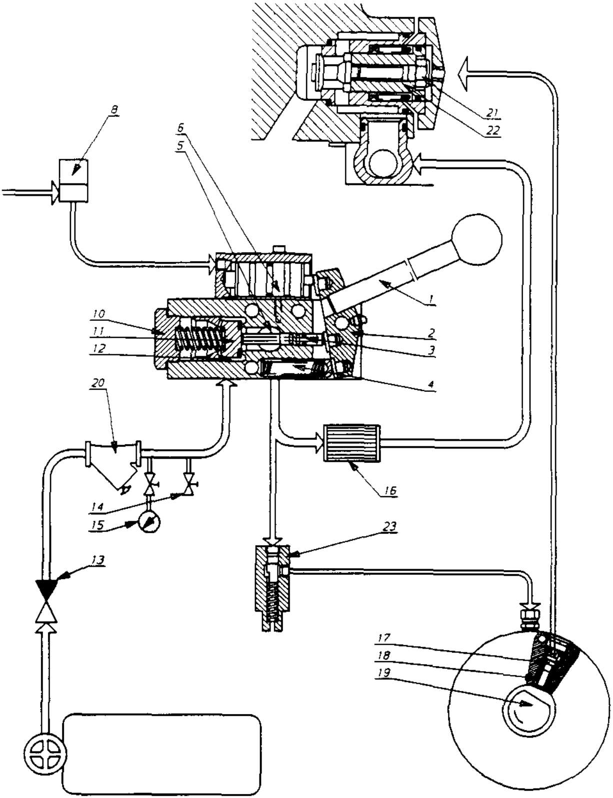
3 Connect the pipe to the non-return valve (11) and check thatoil is supplied through the valve when blowing compressed air.

4 Apply all pipes to the initial connections.

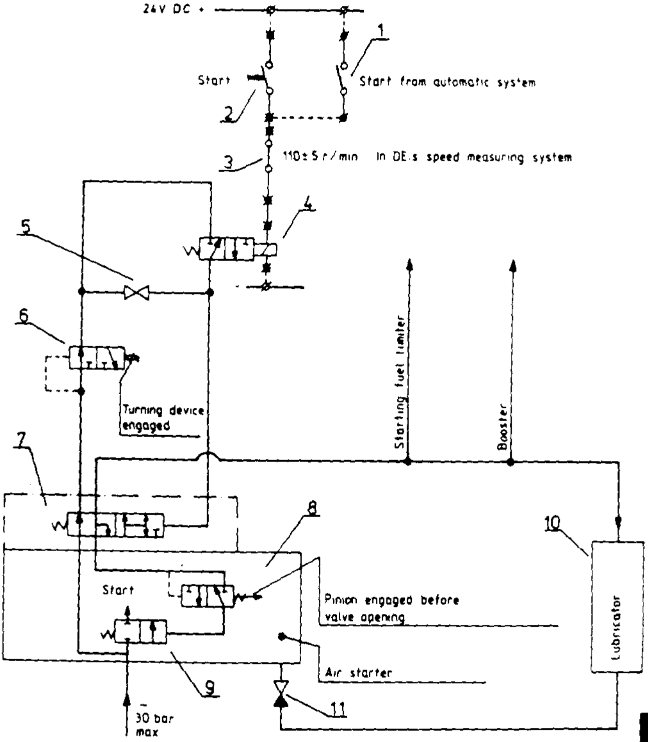
5 Check function during a few starts. When pressing the start button, oil level in the glass tube should momentarily drop by 15...20 mm and then rise to a level corresponding the oil level in the container.

Regularly check that the oil level keeps between the maximum and minimum marks.

Starting air system 21-51



Starting air system with pneumatic motor 21-52



22. Control mechanism

22. 1. Description

(fig 22-51)

During normal operation the engine speed is controlled by a speed governor (22) which regulates the injected fuel quantity to correspond to the load.

The regulating movement is transferred to the control shaft (10) through a spring-loaded lever (20) which enables stop or limit functions to be transferred to the control shaft irrespective of the governor position. The control shafts on the cylinder banks in a V-engine are connected with rods in such a way that the two control shafts work synchronously together.

The movement from the control shaft to the injection pump fuel racks (1) is transferred through the control lever (8) and the connection piece (4), in fuel-on direction through the dog (7) and the torsional spring (6), and in fuel-off direction through the torsional spring (9).

The torsional spring (9) allows the control shaft and conse- quently the other fuel racks to be moved to stop position even if one of the racks has seized. In the same way the torsional spring (6) allows the control shaft to be moved towards fuel-on position even if an injection pump has seized in no fuel position. This feature can be of importance in an emergency situation.

The indicator (17) indicates the fuel rack position.

The engine can be stopped by means of the stop lever (14). When the lever is moved to stop position, the lever (16) actuates the lever (15) forcing the control shaft to stop position.

The engine is provided with two independent overspeed trip devices, an electro-pneumatic device with tripping speed about 15% above the nominal speed, and a mechanical device with tripping speed about 18% above the nominal speed. The electro-pneumatic device moves every fuel rack to no-fuel position by means of a pneumatic cylinder on every injection pump. The mechanical device actuates the lever (14) moving the control shaft to stop position. Both the electro-pneumatic and the mechanical device can be tripped also manually, see section 22.5 and 22.6.

The speed governor is provided with a stop solenoid by which the engine can be stopped remotely. The solenoid is also connected to the electro-pneumatic overspeed protection system and to the automatic stop system which stops the engine at too low lube oil pressure, too high circulating water temperature, or at any other desired function.

When starting, a fuel limiter automatically limits the movement of the control shaft to a suitable value. A pressure air cylinder limits the position of the lever (11), see section 22.7.

Next to the governor there is a fixed mechanical limiter affecting the control shaft directly by means of the lever (13).

22. 2. Maintenance

(fig 22-51)

Special attention should be paid to the function of the system as a defect in the system may result in a disastrous overspeeding of the engine or in the engine not being able to take load.

1 The system should work with minimum friction. Clean and lubricate regularly the racks, connection piece, bearings (also the self-lubricating bearings (12)) and the ball joints with lubricating oil.
The maximum torque to which the control shaft can be moved at running temperatures (the speed governor disconnected) is 1Nm/cylinder (= 8 Nm for a 8R22HF).

2 The system should be as free from clearances as possible. C heck clearances of all connections. The total clearance may correspond to max. 0.5 mm of the injection pump fuel rack positions.

3 Check regularly (see recommendations in section 04) adjustment of the system; stop position, overspeed trip devices, starting fuel limiter, see section 22.3.
d)When reassembling the system, check that all details are placed in the right position, that all nuts are properly tightened and to torque, if so prescribed, that all locking elements like pins and self-locking nuts are in positions. Check according to pos. a...c.

Note! **Center the joint by applying force (F) between the rack and the connection piece, fig. 22-51.**

22. 3. Check and adjustment

(fig 22-51)

22. 3. 1. Stop lever stop position

a) Check:

- Set the terminal shaft lever (23) in max. fuel position and the stop lever (14) in stop position.
- Check that the fuel rack position of all injection pumps is less than 5 mm.

b) Adjustment:

- Set the stop lever in the stop position and check that the lever (15) contacts the lever (8) properly. A small torque can be set from the governor, but not a too large one, because this will twist the shaft unnecessarily, although little.
- Adjust the fuel rack position to 4 mm by adjusting the screws (5).

22. 3. 2. Governor stop position

a) Check:

- Move the stop lever into work position.
- Set the governor terminal shaft lever in stop position.
- Check the fuel rack positions to be 4 mm.

b) Adjustment:

- If the fuel rack positions are unequal, adjust first according to pos. 1b.
- Adjust the spring-loaded rod so that the fuel rack position of 4 mm is obtained.
- If changing the governor, see section 22.4.

22. 3. 3. Mechanical overspeed trip device

a) Check of stop position

- Set the stop lever in work position and the terminal shaft lever in max. fuel position.
- Release the overspeed trip device manually.
- Check the fuel rack positions to be less than 5 mm.

b) Adjustment of stop position

- The stop position is adjusted and locked by the engine manufacturer to provide a stop position equal to that of the stop lever. If deviations occur, check lever fixations and wear.

c) Check and adjustment of tripping speed

- See section 22.5.

22. 3. 4. Electro- pneumatic overspeed trip device

(fig 22-53)

a) Check of stop position

- Set the stop lever in work position and the terminal shaft lever in max. fuel position.
- Release the overspeed trip device manually.
- Check the fuel rack positions to be less than 5 mm.

b) Adjustment of stop position

- The electro-pneumatic overspeed trip device requires no adjustment.
- If a fuel rack position of less than 5 mm cannot be obtained, check for wear.

c) Check and adjustment of tripping speed

- See section 22.6.

22. 3. 5. Starting fuel limiter

(fig 22-54)

a) Check of limit position

- Set the stop lever in work position and the terminal shaft lever in max. fuel position.
- Connect pressure air to the nozzle (5) at which the limiter piston (1) will turn the control shaft to the limit position.
- Check the fuel rack position. The suitable limitation depends on the installation, normally about 18 mm.

b) Adjustment of limit position

- Connect pressure air to the nozzle (5).
- Loosen the fastening screw (3) of the limitation lever.
- Turn the control shaft to the desired limitation of the fuel rack position.
- Move the limitation lever against the limitation piston (1). Tighten the fastening screw in this position.
- Check according to pos. 5a.

c) Check of function

- See section 22.7.

22. 3. 6. Indicator of fuel rack position

Check that the indicator corresponds to the fuel rack positions. If not, loosen the grub screw and adjust the indicator to the correct value.

22. 4. Speed governor

(fig 22-51)

22. 4. 1. General

The engine can be equipped with various governor alternatives depending on the kind of application. Concerning the governor in itself, see the governor instruction book, end of section 22.

22. 4. 2. Hydraulic governor drive

The governor is driven by a separate drive unit which, in turn, is driven by the camshaft through helical gears. The governor is fastened to this drive unit and connected to the drive shaft through a serrated connection. The governor with drive can thus be removed and mounted as a unit or the governor can be changed without removing the drive unit.

Pressure oil is led through drillings in the bracket to the bearings and to a nozzle for lubricating the gears. The gear and the serrated coupling sleeve are mounted to the shaft with interference and secured with spring pins.

Check at recommended intervals

- the radial and axial clearances of the bearings
- the gear clearance
- the oil drillings and the nozzle to be open
- that the gears and serrated coupling sleeve are firmly fastened to the shaft

Change worn parts.

22. 4. 3. Removal of governor

1 Loosen the terminal shaft lever (23) and governor electrical connection.

2 Open the screws (21) and pull the governor vertically upwards. The governor must not fall or rest on its driving shaft.

22. 4. 4. Mounting of governor

When mounting the same governor, check that the mark on the lever (23) corresponds to that of the shaft. Check the setting accordingto section 22.3.

When mounting a new governor, proceed as follows:

1 Mount the governor into position on the governor drive.

2 Turn the governor terminal shaft to stop position (in counterclockwise direction seen from the driving end).

3 Mount the terminal shaft lever (14) as follows (see figure for Woodward UG8):

Woodward UG8 in-line engine : in horizontal level

Woodward PG16 in-line engine : 30° upwards from horizontal level

Regulateur Europa 1103, V-engine: 12° downwards from horizontal level

Woodward PG16 and EGB29, V-engine : 60° upwards from horizontal level

4 Lock the fastening screw and mark the position of the terminal shaft lever with a mark on the shaft corresponding to that of the lever.

5 Move the stop lever into the stop position. (Fuel rack position 5 mm)

6 Adjust the spring-loaded rod length to fit between the levers (23) and (19). Do not forget to secure the nuts.

7 Check according to section 22.3.

22. 5. Mechanical overspeed trip device

(fig 22-52)

22. 5. 1. Description

The overspeed trip device is of the centrifugal type. It will trip when the engine speed exceeds the speed mentioned in section 06.1. The tripping mechanism is fastened direct to the camshaft end. When the engine speed increases, the centrifugal force on the tripping mechanism increases and exceeds the force of the spring (1) at the set tripping speed, whereby the weight (2) is thrown outwards forcing the latch (3) to turn, thus releasing the spindle (4), which is forced outwards by the work- ing spring (5). The V-engine is provided with double working springs. The force is transferred to the control shaft by the lever (6) and a claw coupling on the control shaft, and the control shaft is turned to stop position.

The overspeed trip device may be tripped manually by the lever (7).

The engine cannot be restarted before the lever (6) has manually been depressed so far that the latch (3) engages the piston of the spindle (4).

A switch (8), indicating released overspeed trip device, may be provided.

22. 5. 2. Check of tripping speed

Check the tripping speed at idle by increasing the engine speed above the nominal speed by quickly turning the speed control knob of the governor. Turn the knob back approximately to the initial position and retension the working spring of the overspeed trip device manually by means of the lever (6). Use a steel bar or pipe with the outside diameter of max. 22 mm, e.g. the steel bar 844001. Do not increase the engine speed by more than 40 RPM above thetripping speed.

The tripping speed should be according to the values mentioned in section 06.1. When checking the tripping speed, the electro-pneumatic overspeed trip device must be disconnected on the electrical side as it has a lower tripping speed. Do not forget to reconnect it.

22. 5. 3. Adjustment of tripping speed

1 Remove the plug (9).

2 **Turn the crankshaft** until the adjusting nut (14) is in front of the opening.

3 **If a higher tripping speed is desired,** tension the spring by screwing the nut in. If a lower tripping speed is desired, screw the nut outwards.

4 **Mount the plug** (9) and check the tripping speed according to pos. 2.

5 **The spring can be replaced** through the opening of the plug.

22. 5. 4. Maintenance

- Remove the tripping mechanism by removing the screws (13) and (11).
- Remove the spindle (4) with piston and spring (5).

Be very careful when removing the spring (5). Use the tool 837015.

- Check all moving parts for wear and replace by new ones, if necessary.
- Check the drain hole (12) to be open.
- Change the self-locking adjusting nut (14) always when it seems to be loose.
- Tighten the screws (11) to torque according to section 07.1 when assembling and lock with steel wire.
- Tighten the screws (13) to torque according to section 07.1.
- Use tool 837015 when mounting the spring.
- Check the tripping speed according to section 22.5.3.

22. 6. Electro-pneumatic overspeed trip device

(fig 22-53)

22. 6. 1. Description

The overspeed trip device is electronically controlled. Starting air of max. 30 bar is used as operating medium. The tripping speed is according to section 06.1.

There are two separate air inlets, one for starting air and one for the electro-pneumatic overspeed trip device. The line for the electro-pneumatic overspeed trip device is provided with a non-return valve (1) and an air vessel (4) large enough to make it possible to stop the engine even if the air pressurebefore the non-return valve disappears.

The three-way solenoid valve (5) gets the stop signal for overspeed from the electronic speed measuring system. Besides, the solenoid is also connected to the stop system.

When the solenoid valve opens air is fed to the pneumatic cylinders, one for each injection pump. The piston (6) of the air cylinder actuates the fuel rack, moving it to stop position.

The stop signal is normally energized long enough to stop the engine completely. When de-energized, the air is evacuated through the three-way valve and the piston is forced back to the end position by the fuel rack.

In some installations (mostly main engines) the stop circuit is energized only during the time when the overspeed contact is closed (i.e. the slow down system). A parallel contact to the alarm system is used as an overspeed indicator.

The solenoid valve can also be operated manually.

22. 6. 2. Check and adjustment of stop position

See section 22.3 pos. 4 a and b.

22. 6. 3. Check of tripping speed

Check the tripping speed at idle by increasing the engine speed above the nominal speed by turning the speed control knob of the governor. Turn the knob back approximately to the initial position before restarting. Do not increase the engine speed by more than 60 RPM above thetripping speed.

The tripping speed should be 15 % above the nominal speed (13 % at a nominal speed of 1200RPM), see section 06.01.

22. 6. 4. Adjustment of tripping speed

Adjustments will be made in the box of the electronic speed measuring system, see the instructions for speed measuring system, section 23.

22. 6. 5. Maintenance

a) General

- Regularly remove condensate through the drain valve (3).
- Check tightness of the non-return valve (2). If not tight, dismantle the valve and check the sealing surface of the rubber O-ring.
- Check that the valve element moves freely.

b) Three-way solenoid valve

- If the solenoid is out of order, replace it by a new one.
- If the valve does not move, clean all channels. Check the valve piston.
- If air is leaking to the cylinders, change the sealings.

c) Air cylinder

- Check for wear.
- Check tightness of the piston. Replace the sealings by new ones, if necessary. Take care not to deform the teflon ring outside the O-ring more than necessary.
- Lubricate the sealings and the piston with lubricating oil.
- Check that the piston does not stick.

22. 7. Starting fuel limiter

(fig 22-54)

22. 7. 1. General

Always when starting either automatically, remotely or manually, a limiter automatically limits the injected fuel quantity.

Always when the engine is not operating (and provided with auxiliary voltage), the three-way solenoid valve (6) is energized connected to the air distributing pipe with the limiting cylinder. As the main starting valve is opened when starting the engine, starting air is admitted to pass from the distributing pipe through a non-return valve (8) to the limiting cylinder, whereby the piston (1) is forced out, thus limiting the fuel injection by a lever (7) which is fastened to the control shaft. As the engine reaches a speed 100 RPM below the nominal speed, a relay in the speed measuring system de-energizes the solenoid valve (6). The de-energizing is delayed for two seconds so that the engine reaches the nominal speed before the limitation is cut off.

The pressure is relieved through the nozzle (5). On main engines started up to a lower speed, a lower de-energizing speed may also be used.

22. 7. 2. Check and adjustment of limitation

See section 22.5.1 and 2.

22. 7. 3. Check of function

1 Check that limitation is achieved as soon as the main starting valve opens.

2 **Check that correct limitation is achieved** during the acceleration period.

3 **The limitation is cut off** when 100 RPM below the nominal speed delayed with two seconds. This can be checked by increasing- the speed very slowly above the cutoff speed by turning slowly the speed control knob of the governor. On main engines a cutoff speed lower than the minimum running speed is applied.

22. 7. 4. Maintenance

1 **If limitation gradually retires** before the three-way solenoid valve (6) releases the pressure through the nozzle (5), it can depend on:

- Leaky piston (1). Replace the sealing by a new one. Take care not to deform the teflon ring outside the O-ring more than necessary. Apply a few drops of lubricating oil on piston before assembly.
- The non-return valve (8) does not close. Dismantle the valve and clean. If the valve does not, however, keep tight, replace it by a new one.
- Leaky three-way valve.

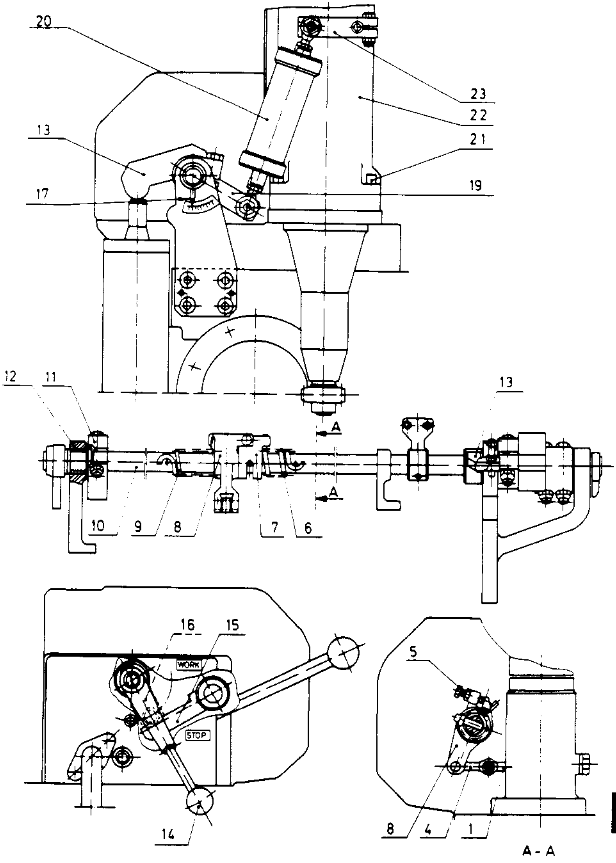
2 **If the valve does not receive voltage** or receives voltage during wrong periods, check the control relays. See wiring diagram and manufacturer s instruction, section 23.

3 **If the limiter does not work** , check the coil (6). If the coil (6) is undamaged, check that the cylinder (2), three-way valve (4) or the non-return valve (8) does not stick.

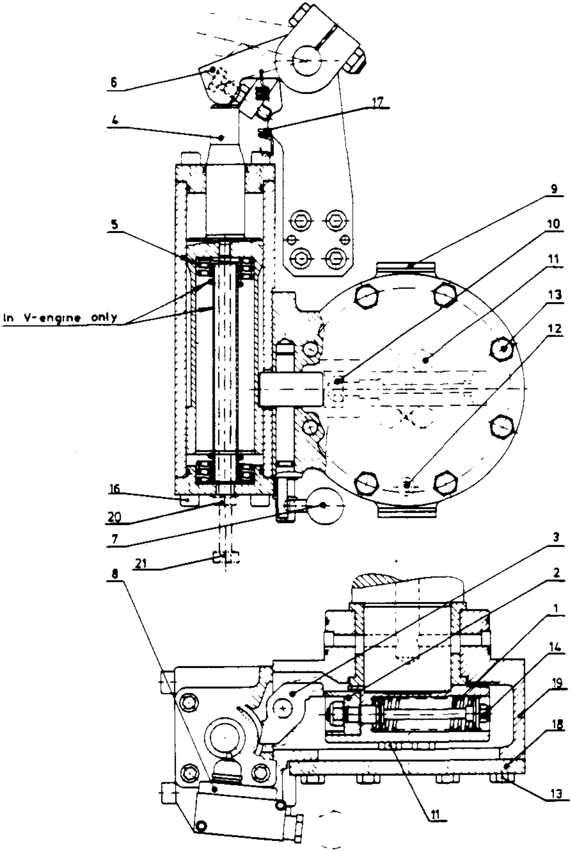
4 **The three-way valve** requires normally no maintenance. If the coil has broken, e.g. due to overvoltage, replace the coil by a new one. If the valve is probable to be blocked by dirt, it can be dismantled for cleaning provided that special care is taken. Do not damage the sealing faces. Check that all parts are mounted correctly. If further troubles, replace the valve by a new one.

5 **Check according to section 22.7.2 and 3.**

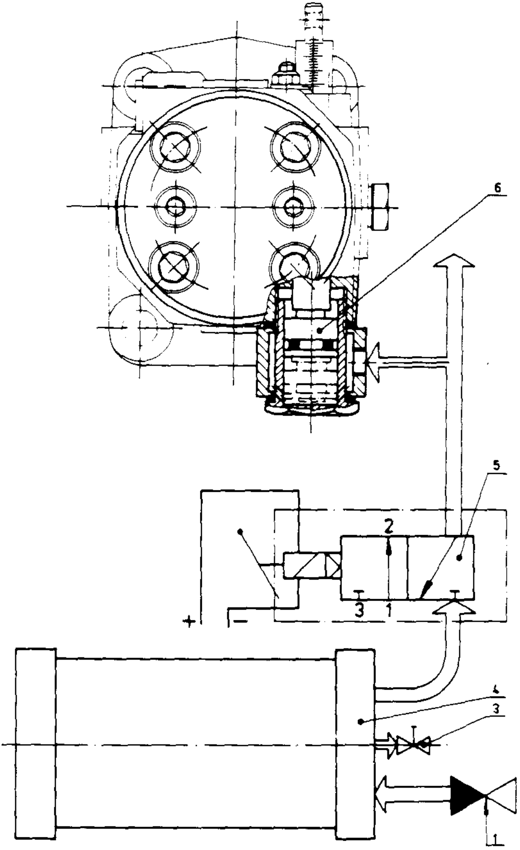
Speed governor 22-51



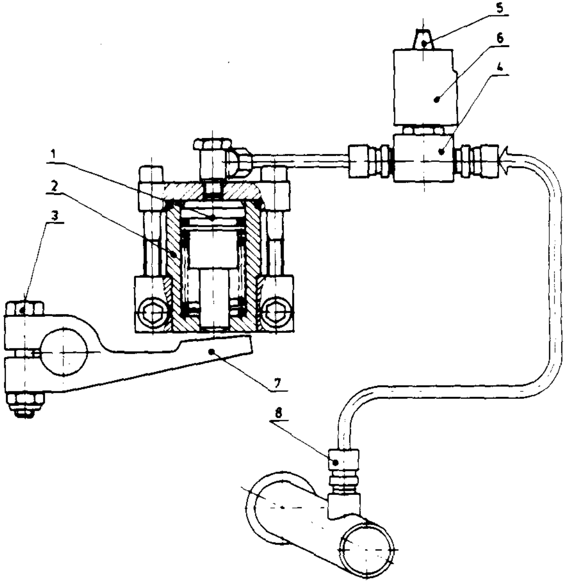
Overspeed trip device 22-52



Electro-pneumatic overspeed trip device 22-53



Starting fuel limiter 22-54



23. Instrumentation and automation

23. 1. Monitoring equipment mounted on the engine

(Fig. 23-51)

23. 1. 1. Instrument panel

The instrument panel is flexibly suspended on three rubber elements at the free end of the engine. The following instruments are included:

- Manometer for:
  - starting air before the engine
  - fuel oil before the engine
  - lube oil before the engine
  - high temperature (HT) water before the engine
  - low temperature (LT) water before the engine - charge air
- Instrument for engine speed
- Running hour counter

The connection pipes to the manometers are provided with valves which make it possible to change the manometers during operation.

The instruments require no service. Erroneous or damaged instruments should be repaired or changed at the first opportunity.

The rubber elements for suspension of the instrument panel are to be checked after longer operating periods and to be replaced by new ones, if necessary.

23. 1. 2. Thermometers

- Exhaust gas thermometer for each cylinder (18)
- For lube oil before (20) and after (22) the lube oil cooler
- For HT water before (2) and after (24) the engine
- For HT water after the turbocharger (25)
- For charge air in the air receiver (17)
- For LT water before the charge air cooler (11), after the charge air cooler (same as before lube oil cooler) (29) and after the lube oil cooler (30)
- For fuel before the engine (28)

Erroneous and damaged thermometers are to be replaced by new ones at the first opportunity.

23. 1. 3. Combined visual pressure drop indicators and alarm switches

- For too high pressure drop across the lube oil filter (P204). The indicator/switch is mounted on each lube oil filter.
- For too high pressure drop over the fuel filter when mounted on the engine (P103).

23. 1. 4. On/off switches

a) Alarm switches

The following switches for automatic alarm may be mounted on the engine as standard:

- too high charge air temperature after the charge air cooler (T601)
- low lubricating oil pressure before the engine (P202)
- low lubricating oil pressure of prelubrication (P203)
- low fuel oil pressure (P102)
- low HT water pressure (P402) (main engines, only)
- low LT water pressure (P403) (main engines, only)
- too low lubricating oil level(L202)
- too high lubricating oil temperature (T202)
- too high HT water temperature after the engine (T402)

b) Stop switches

The following switches for automatic stop are mounted on the engine as standard:

- for too low lube oil pressure (P201)
- for too high cooling water temperature after the engine (T401)

c) Indicating switches

The following switches for indication are mounted on the engine as standard:

- for tripped mechanical overspeed trip (S710)

As extra equipment the following switches may be supplied:

- for load indication; one or two switches (E705)

The switches may differ from the above mentioned.

d) Other switches

Pressure switch is connected to the air receiver for control of the load dependent cooling system (this applies to 22HF).

e) Check of switches

All switches are preadjusted at the factory.

Check the function of all switches at intervals recommended in section 04. If any switch is supposed to be wrongly set or broken, it should immediately be checked and, if necessary, adjusted or replaced by a new one. Pressure and temperature switches can be checked during operation.

23. 1. 4. 1. Check of switches:

All switches are preadjusted at the factory.

Check the function of all switches at intervals recommended in chapter 04. If any switch is supposed to be wrongly set or broken, it should immediately be checked and, if necessary, adjusted or replaced by a new one. Pressure and temperature switches can be checked during operation.

a) Temperature switches The switches are fitted into special pockets and can thus be lifted off for checking also during operation. The check should be carried out so that the sensor part of the switch is immersed in liquid, e.g. oil, which is slowly heated. Watch at which temperature the microswitch opens. Note that there are two switching points to be checked in the double switches. The correct temperature is stated in section 01 and is normally stamped on the switch as long as the switch has not been adjusted to another temperature. Connect the switch correctly when mounting. Also the pockets are to be removed and cleaned when the systems are emptied for other reasons.

b) Pressure switches The manometer of the instrument panel may be utilized for checking during operation as follows:

- Shut the ball cock on the common pipe to the manometer and the switch.
- Open carefully the pipe union nut on the pressure switch so that the pressure switch gives signal.

The alarm switch for too low prelube oil pressure is set for rising pressure and, thus, this method does not give the correct value. A rough check can however be made when taking into consideration that the switch will display a value about 0.2 bar lower at falling pressure.

All pressure switches can also be connected to a separate test unit.

c) Pressure drop indicator Remove the lube oil switch from the filter and the fuel switch from the pipes.

Connect a hydraulic pressure test device (pump + manometer) tothe switch connection which is connected to the filter inlet (the higher pressure).

Raise the pressure to the switching point which should be 1.5±0.3 bar. At this point a red indicator ring at the end of the switch should be visible.

d) Indicator switches These switches can easily be checked when the engine is standing, for instance:

- The mechanical overspeed trip device is tripped manually (section 22 pos. 5) and should give indication.
- The control shaft is turned until the load indicating switch operates. Check which load this corresponds to.

Never set any of the alarm or stop switches out of function.

If any of the switches gives false alarm the reason should be found out and the fault is to be remedied immediately.

23. 1. 5. Transducers for remote measuring

The engine is as standard supplied ready for connection of the following transducers:

a) Temperatures The connection points are located next to the respective local thermometers unless otherwise stated.

- charge air in the air receiver
- lubricating oil before and after the oil cooler
- HT water before and after the engine (HT = high temperature)
- inlet LT water (LT = low temperature)
- exhaust gas temperatures for the individual cylinders
- exhaust gas temperatures before and after the turbocharger.

b) Pressures The connection points are located on the pipes of the respective manometers in the instrument panel.

- charge air pressure
- lubricating oil pressure before the engine
- inlet LT water
- fuel oil after the filter
- starting air

c) Miscellaneous

- transducers for turbocharger speed
- detector for crankcase smoke (one per cylinder)
- load indicator

The instrument specification supplied with the engine documentation specifies which transducers should be installed, as to type as well as to manufacturing.

23. 1. 6. Speed measuring equipment including relay functions

23. 1. 6. 1. General

The engine is provided with an electronic contactless system (no mechanical drive) for speed measuring which also includes the relay functions for automation.

An inductive pickup is mounted close to the teeth of the crankshaft drive gear and generates pulses, the frequency of which is proportional to the engine speed. In a measuring converter this signal is converted to DC voltage which is proportional to the engine speed. The measuring converter is part of the engine delivery and is usually mounted on the wall of the engine room.

Normally, it is possible to connect five extra remote instruments.

For main engines, measuring of the turbocharger speed is included in the measuring equipment.

23. 1. 6. 2. Service

Measuring instruments and relays are carefully set at the factory and we recommend no further adjustments to be made unless there are considerable deflections.

For checking the relay for fuel injection limitation during start, see section 22 pos. 3.5.1.

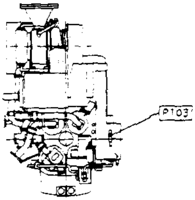
For checking the relay for overspeed, see section 22.6.3.

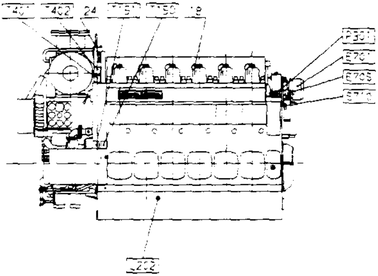
Damaged or broken components are replaced by new ones. See the wiring diagrams and the manufacturer's instructions.

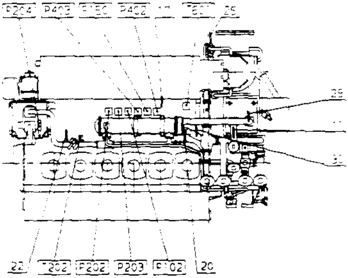
The inductive pickup is to be mounted 1.5±0.5 mm from the camshaft gear.

Check at intervals the elastic suspension of the measuring converter box.

Monitoring equipment, R22 23-51







23. 2. Despemes Speed Measuring System for Diesel Engine

23. 2. 1. Introduction

DESPEMES — Diesel Engine Speed Measuring System — is an *electronic* speed measuring system especially designed for diesel engines in marine and stationary installations.

The following functions are included in the equipment:

- measuring of engine speed
- 4 speed-controlled relay functions
- measuring of one or two turbocharger speeds
- 3 additional relay functions as option

23. 2. 2. Theory of Operation

23. 2. 2. 1. Diesel engine speed

The engine speed is sensed by means of a touchfree, inductive proximity switch mounted to count the cogs passing its sensing head when the engine is running.

The freqency output from the sensor, proportional to the engine speed, is converted to a DC-voltage of 0...10 V. This voltage is buffered and fed out to be measured by the remote voltage-measuring, panel mounted, speed indicators.

23. 2. 2. 2. Relay functions

The speed signal is transferred to the relay driver circuit, controlling the relay functions. There are 4 separate relays, which can individually be adjusted to switch at any speed of the engine speed range, additionally with an individually adjustable delay.

The relays have two change-over contacts with a breaking capacity of 110 V DC/0.3 A or 24 V DC/1 A.

23. 2. 2. 3. Turbocharger speed

A magnetic sensor is attached against the end of the turbocharger shaft, sensing its speed. The sinusoidal voltage from the sensor is ampilfied and converted to a square wave signal before being converted into a speed propotional DC-voltage.

23. 2. 2. 4. Digital output

The speeds can be measured as a frequency with a frequency counter.

Note! The frequency is not equal to the numerical value of the speed.The actual conversion factors are written on the printed circuit cards.

23. 2. 2. 5. Additional relay functions

Additional triple-relay card with voltage-controlled relays can be supplied as option.

The relays can be controlled by engine speed or by an external DC-voltage or with a potentiometer.

23. 2. 3. Functional Circuit Cards

The DESPEMES speed measuring system includes the following printed circuit boards:

1 Power supply

DC/DC 24 V DC
alt.48...110 V DC C1

2 nDE measuring converter with relay function

for engine speed C2

3 Relay I

3 speed-controlled relay functions with optional delay C3

4 nTC measuring converter

for one or two turbochargers C4

5 Relay II

3 voltage-controlled relay functions with optional delay C5

23. 2. 3. 1. C1, Power supply DC/DC

Supply voltage: .... 18...40 V DC smoothed
.... alt. 40...160 V DC
Output voltage: .... ±12 V ±0.5 V
Output current: .... ±500 mA
Output ripple: .... max±100 mV
Ambient temperature: .... - 25 ... + 71°C
Short-circuit-proof: .... by current limitation
Isolation voltage: .... 2 kV, 50 Hz, 1 min
.... 5 kV, 1.2/50 µs
Fuse: .... 1,6 A, 5 x 20 mm

The power supply is short-circuit-proof and overheating protected. A green light emitting diode indicates that voltage is provided.

Power supply C1

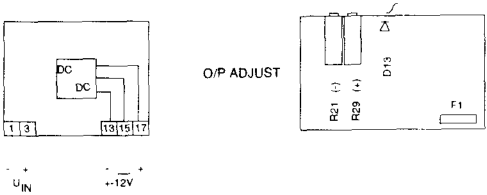


Fig 23 - 1

22235489.35

23. 2. 3. 2. C2, n_{DE} measuring converter with relay function for the engine speed

a) Theory of operation: The speed sensor is touchfree proximity switch attached against a cogwheel to count the cogs passing. The output from the sensor is a square-wave frequency proportional to the engine speed.

The freqency is converted to a DC-voltage proportional to the input frequency. This voltage flows through a buffer which provides the measuring voltage for the remote speed indicators. The same buffered voltage operates the relay.

The switchpoint can be adjusted over the whole speed range with an adjustable delay.

Frequency output can be used for measuring the speed digitally.

There is an on-card precalibrated test function which simulates a certain engine speed and can be used for checking the system.

b) Adjustment procedures:

- The analog speed measuring signal 0...10 V DC

The card is accurately precalibrated at the factory. Nevertheless, if a recalibration is required, there is a potentiometer, P501, at the outmost left hand side of the card. When turning CW, the output will increase and vice versa.

- The relay switchpoint and delay

The switchpoint is preadjusted at the factory. However, if an adjustment is required, the procedure is as follows:

P502: switchpoint: the middle potentiometer
P503: delay: at the right hand side of the card

1 Determine the n_{DE}-card amplification:

$$n_{max}\,(rpm) = U_{max}\,(V\,DC)$$

2 Calculate corresponding output voltage at specified relay switching speed:

$$U_x\,(V\,DC) = \frac{n_x\,(rpm) \times U_{max}\,(V\,DC)}{n_{max}\,(rpm)}$$

3 Adjust P502 to the calculated TP4 voltage:

Ex: VASA 22: Specified switching speed: 900 rpm

$$1500\ rpm \mathrel{\hat{=}} 10\ V\ DC$$

$$U_{900} = \frac{900\ rpm \times 10\ V\ DC}{1500\ rpm} \approx 6.0\ V$$

Adjust the TP4 voltage to 6.0 V

The delay can be determined by bridging TP3 and counting the delay time until the relay turns on and the LED lights up.

- Test points

TP1: The pulse train from the speed sensor or the calibrating frequency when TP3 is bridged.

TP2: The unbuffered output from the frequency/voltage converter: 0...10 V DC, depending on the engine speed.

TP3: Bridging the points, using eg. a small screwdriver, the test oscillator will start. (*The sensor cable must be disconnected.*)

TP4: The P502 adjusted voltage corresponding to the relay switchpoint wanted.

TP5: The P503 adjusted voltage corresponding to the specified delay.

c) Thecnical specification

Inputs:

Freqency: .... 0...8000 Hz
.... 12 V pk square wave
Supply voltage: .... +12 V, -12 V, 0 V
Current consumption: .... Max. 40 mA

Outputs:

Freqency: ....12 V pk, square wave
.... short-circuit-proof
Voltage: .... 0...10 V DC

. . . . 15 mA, short-circuit-proof
Unlinearity: . . . . ±0.1 %
Temperature coefficient: . . . . 0.03 %/K

Relay function

Switchpoint: . . . . 0...100 % of measuring range
Delay: . . . . 0...10 sec
Contacts: . . . . 2 change-over contacts
Breaking capacity: . . . . 110 V DC/0.3 A
. . . . 24 V DC/1.0 A

Test

Test point: . . . . Approx. 80 % of full scale
Ambient temperature: . . . . - 25...+71°CRelay Card C3

nDE measuring converter C2

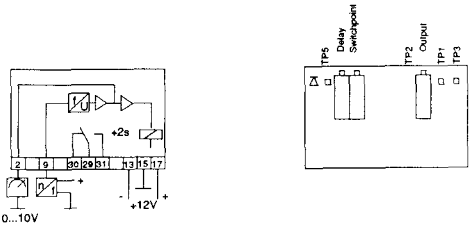


Fig 23 - 2 2223558935

23. 2. 3. 3. C3, Relay Card

a) **Theory of operation** The card includes three relays each relay having two change-over contacts. The output voltage from the nDE-card: C2 is supplied to three comparators where the relay switchpoints can be individually adjusted for each relay optionally with adjustable delay.

The relays operate either according to the closed circuit principle or to the open circuit principle.

The relays can be programmed for either delay on operate or release or without delay.

The third relay channel can be programmed with self-holding, demanding external reset. One change-over contact of the relay is, however, needed for this operation. A green or red light emitting diode indicates that the relay is switched on.

b) Adjustment procedures: The switchpoint of the relays are adjustable with trimpotentiometers. The testpoints indicate the adjustment.

P601, TP1 . . . . relay n_{DE1}
P602, TP2 . . . . relay n_{DE2}
P603, TP3 . . . . relay n_{DE3}

1 Determine the amplification of the n_{DE}-card:

$$n_{max}\,(rpm) = U_{max}\,(V\ DC)$$

(n_{max} is normally 1500 rpm and U_{max} 10VDC on VASA 22)

2 Calculate the voltage corresponding to the rotation speed at which the relay switches on.

$$U_x\,(V\ DC) = \frac{n_x\,(rpm) \times U_{max}(V\ DC)}{n_{max}\,(rpm)}$$

3 Adjust the channel potentiometer to the calculated value of the TP voltage.

By short-circuiting TP3 on the n_{DE}-card (C2) the possible delay of the relays can de determined. Respective trimpotentiometers are P604, P605, P606.

Note! During the test the adjusted switchpoint of the relay can be adjusted to a value below the test voltage, if this is higher than the voltage generated by the test oscillator (TP3 at card C2).

c) Technical specification

Inputs:

Supply voltage: . . . . +12 V, 0, -12 V
Current consumption: . . . . max 60 mA
Control voltage: . . . . 0...10 V DC

Outputs:

3 relays, each having two changeover contacts.

Switchpoint: . . . . 0...100 % of the measuring range
Delay: . . . . 0...30 sec.
Breaking capacity: . . . . 110 V DC/0.3 A
. . . . 24 V DC/1.0 A
Ambient temperature: . . . . -25...+71°

Relay card C3

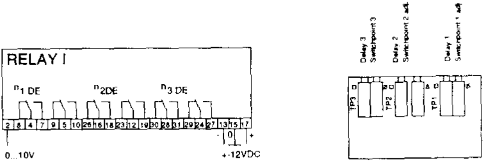


Fig 23 - 3 2223568935

23. 2. 3. 4. C4, TC-card: Measuring converter for one alt. two turbochargers

a) Theory of operation: The sine wave signal of the turbocharger speed sensor is amplified and transmitted to a squarewave signal. This can be measured by frequency counter.

The square wave frequency signal is converted to a speed-proportional voltage 0...10 V. On VASA22 engines 0...10V DC normally corresponds to the turbocharger speed range 0...50.000rpm. This voltage is buffered and forms the measuring voltage for the remote speed indicators.

The card may consist of two channels.

b) Adjustment procedures: The analog output re-adjustment can be done by means of the potentiometers P701 and P711.

P701 : n_{TC1}

P711 : n_{TC2}

When turning the pot. CW, the output will increase and vice versa.

c) Technical specification:

Inputs:

Freqency: .... 0...8000 Hz
.... > 100 mVpp sine

Supply voltage: .... +12 V, 0, -12 V

Current consumption: .... max 35 mA

Outputs:

Freqency: .... 12 Vpp
.... 10 mA, short-circuit-proof

Voltage: .... 0...10 V, 15 mA, short-circuit-proof

Unlinearity: .... ± 0.1 %

Temperature dependence: .... < 0.03 %/K

TC-card C4

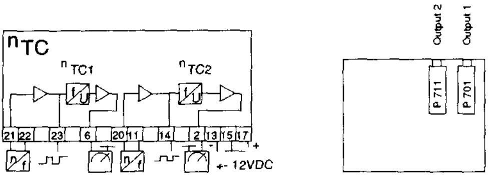


Fig 23 - 4 2223578935

23. 2. 3. 5. C5 Relay II

a) **Theory of operation:** The card consists of 3 voltage-controlled relays, each having one change-over contact.
Any internal or external voltage between 0 and 10 V DC can be used as control. The switchpoints and delays are adjustable. LED indicates an activated relay.

b) **Adjustment procedures:** See adjustment instruction for C3 relay card.

c) **Tehcnical specification:**

Inputs:

Control in: .... 0...10 V DC
Supply voltage: .... +12 V, 0, -12 V
Current consumption: .... 60 mA

Outputs:

3 relay functions, each having one change-over contact.
Switchpoint: .... 0...100 % of measuring range
Delay: .... 0...30 sec
Breaking capacity: .... 110 V DC/0.3 A
.... 24 V DC/1.0 A
Ambient temperature: .... -25...+71°C

Relay II C5

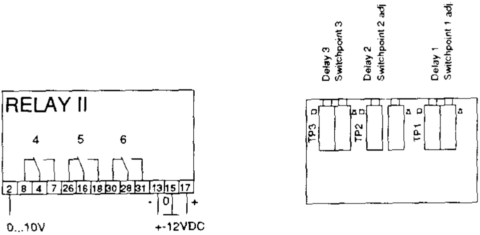


Fig 23 - 5 2223588935

23. 2. 4. Engine Speed Sensor

a) Theory of operation: The sensor is an inductive, touchfree poximity switch supplied with +12 V and 0 V DC. The third pin is a speed-proportional pulse train.

The electronics of the sensor is resin-moulded into a tubular housing of nickel plated brass with external thread of 18x1.5 mm. The three-wire cable is connected by means of a four-pole connector (Euchner BS4).

b) Mounting the sensor Turn the engine until the top of a cog is visual in the sensor mounting hole. Screw the sensor completely in. Unscrew it and tighten it well to the shown sensing displacement (see Fig 23 - 6)

Engine speed sensor

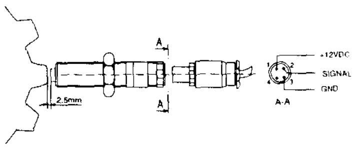


Fig 23 - 6 2223598935

The output signal (terminal 55 in the electronic box or TP1 on the nDE-card) should now be appr. 12 V DC. If the sensor is between two cogs, the output will show appr. 0 V.

Note! The engine must not run while the sensor is mounted.

23. 2. 5. Turbocharger Speed Sensor BM8

a) **Theory of operation:** This sensor is magnetic, therefore it does not require any voltage supply.
The sensor head is splitted by a yoke causing a sinusoidal output voltage when a magnetic material passes its sensing head. The metal housing is threaded to 12 x 1.25 mm.

On the BBC type VTR, the turbocharger housing and a disc with six holes inthe end of the turbocharger shaft is prepared for this type of sensors.

When the turbocharger rotates and the above mentioned holes pass the sensor head, a sinusoidal voltage is generated. The cable is connected by means of a four-pole connector (Euchner BS4).

b) **Mounting the sensor:** Screw the sensor completely in and then unscrew it for a sensing gap about 3/4 of a turn.

Note! The engine must not run while the sensor is mounted.

Turbocharger speed sensor

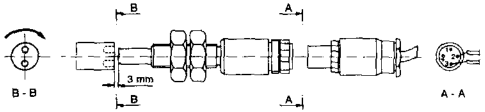


Fig 23 - 7 2223608935

23. 2. 6. Trouble shooting procedures

Power supply DC/DC

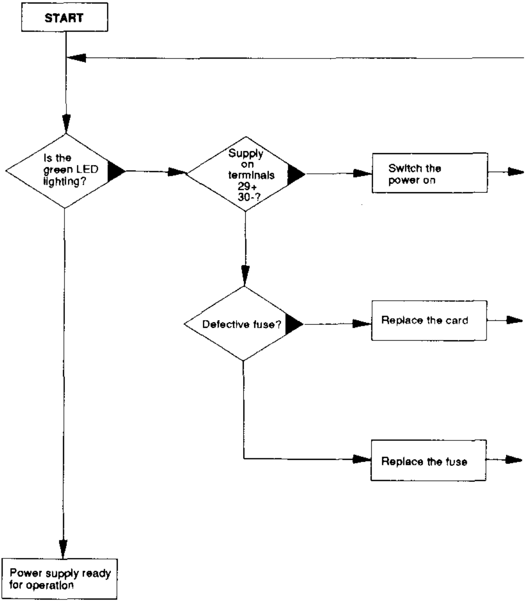


Fig 23 - 8

2223618935

	Polarity	Terminal	Card connector
Operating voltage	+	29	3
	-	30	1
Output	+12 V	24	17
COM		26	15
	-12 V		13

2. n_{DE}-measuring converter with relay function

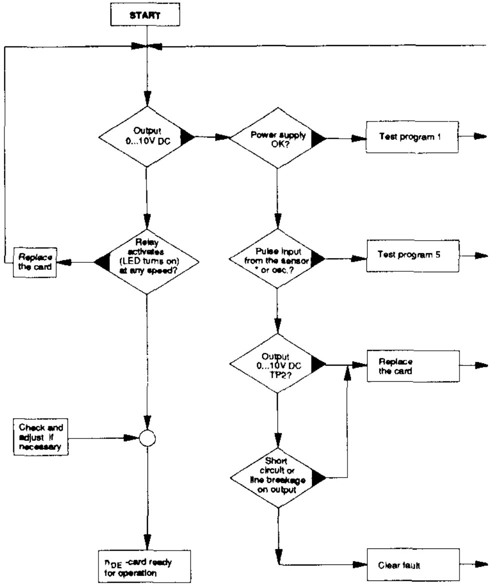


Fig 23 - 9

2223628935

	Terminal	Card connector
Frequency in	55(+)	19
	57(-)	15
Measuring voltage	25(+)	2
	26(-)	15
Pulse output	58(+)	
	59(-)	

*) V-meter reading: Sensor output 5.8 V DC. Osc. about 4.2 V DC.

3. Relay card

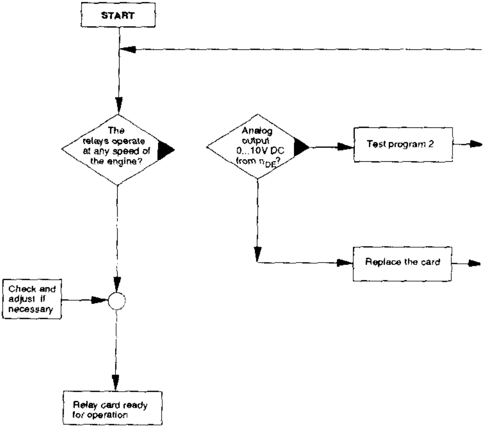


Fig 23 - 10

2223638935

4. n_{TC}-measuring converter with 2 channels

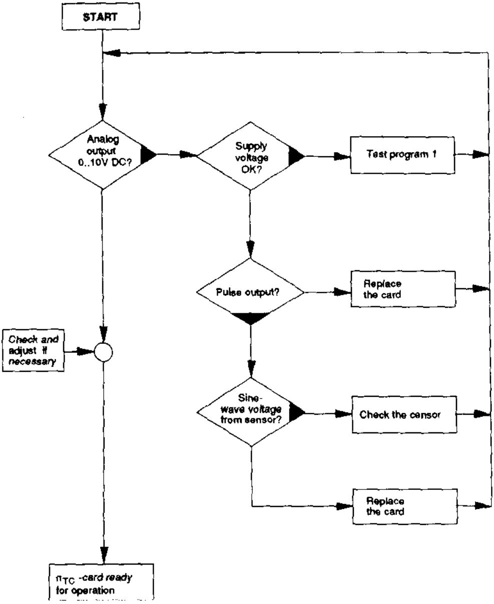


Fig 23 - 11

2223648935

		Channel 1	Channel 2
Pulse input	Terminal	10(+), 11(-)	39(+), 40(-)
	Card connector	21(+), 22(-)	20(+), 11(-)
Pulse output	Terminal	12(+), 13(-)	41(+), 42(-)
	Card connector	23	14
Voltage output	Terminal	8(+), 9(-)	37(+), 38(-)
	Card connector	8	2

5. Engine speed sensor

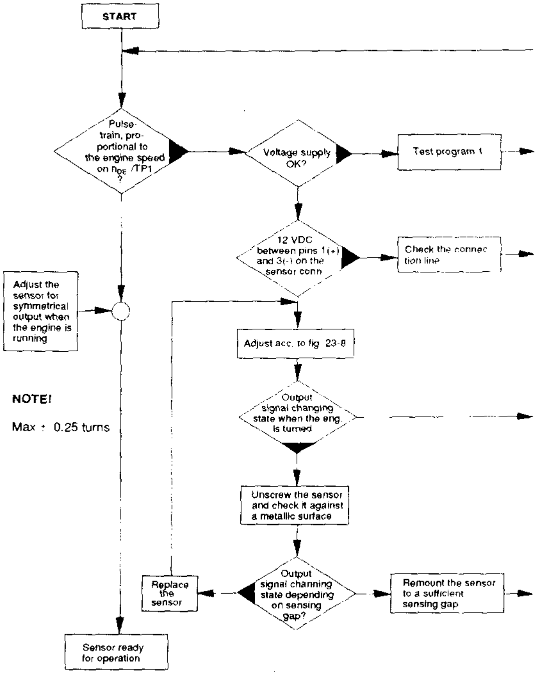


Fig 23 - 12

2223658935

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Tlx .... 957587 swale g
Telecopier .... +44-732-450 571

Spare parts sales — Trained service personnel — Spare parts stock — Interpart/Servicepart

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Wartsila Diesel, Inc.
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Tlx . . . 460080 swd u
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Rancho Cucamonga, CA 91730
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SACM Uni Diesel Inc.
10399 West Gray Co., P.O. Box 13647
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Tlx . . . 1 6 1107 swdc ut
Telecopier . . . +1 713 526 6708

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Detroit Engine & Turbine Company
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Tlx . . . 82427
Telecopier . . . +61-8-349 4142

AUSTRALIA
Engineers & Agents Pty. Ltd.
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Queensland 4870
Tel . . . +61 70 514600
Tlx . . . 48081 agent aa

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Dicsa
Bulnes 1203, P.O. Box 1230, Santiago
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Tlx . . . 340 538 dicsa ck
Telecopier . . . +56-2-699 3528

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41 Lockhart Road, Wanchai, Hong Kong
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Tlx . . . 60414 ws hx
Telecopier . . . +852 861 2465

CHINA
Kex-Sun Shine Engineering & Trading
2F-2, 666 Tung Hwa S. Road, P.O. Box 44-13
Taipei, Taiwan
Tel . . . +886 2 7042850-7
Tlx . . . 25163 sunshine
Telecopier . . . +886-2-7058194

EGYPT
Alarm Consulting & Contracting
1st Building, Flat 507, El Alarm City
Agouza, Cairo
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Tlx . . . 21860 hany un
Telecopier . . . +20-2-341 2416

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Postboks 2175, FR 165 Argir
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Velar Og Skip HF
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Tel . . . +354 1 624 40, 11017
Tlx . . . 2169 sefur is
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Malta Drydocks
The Docks
Tel . . . 822451/822491
Tlx . . . 1210, 1310 drydks mw

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Spare parts sales — Trained service personnel — Spare parts stock — Interport / Serviceport

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