Wärtsilä Vasa Diesel Engine

MANUAL

No.	7841
Installation	CULLEN 161
Engine type	VASA 12V22MD
Engine No.	3072, 3073, 3074, 3075
Specification	17139

WÄRTSILÄ DIESEL

Wärtsilä Diesel Oy, Diesel Service
P.O.Box 244, SF-65101 Vaasa, Finland
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Telecopier, +358-61-111 906, +358-61-128 115 Service, +358-61-127 703 DPP

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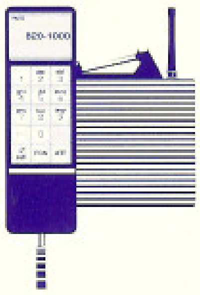
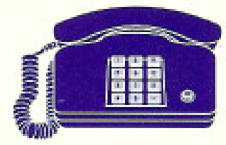


ANY TIME



CONTACT OUR DIESEL SERVICE DEPARTMENT

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During office hours (7.30 - 16.30)	Call operator **+358-61-242111** or any direct number (see reverse side)
Nights and weekends (Mon-Fri, 16.30-7.30 , Sat-Sun, 24h)	Call mobile telephone (NMT) for service engineer or spare part assistance

MOBILE TELEPHONE NUMBERS

Calling from Finland **949-365721**

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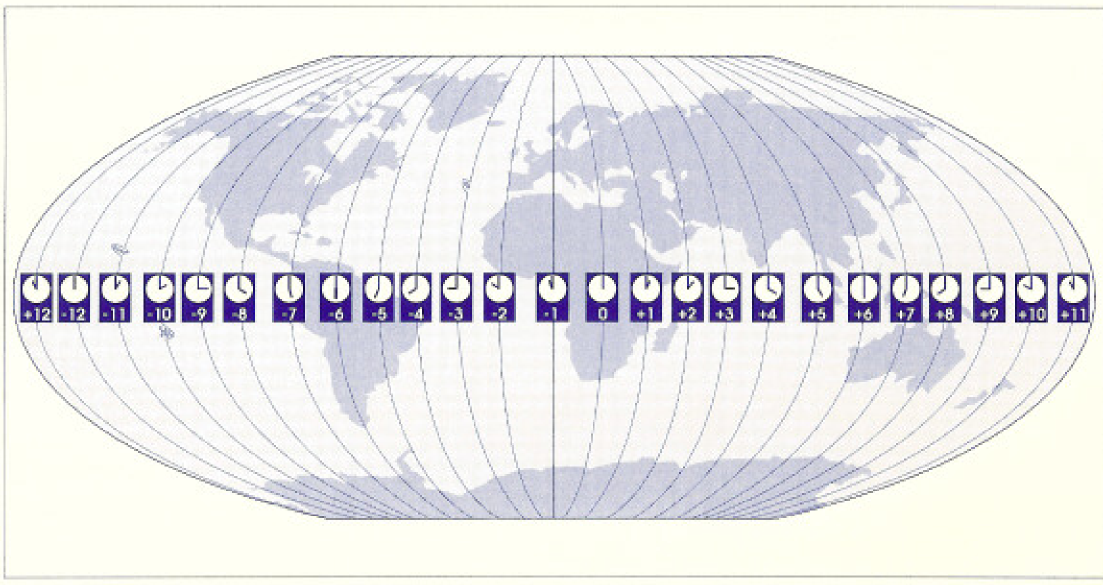
+358-61-127 719	Marine Service	
+358-61-128 115	DPP Service	
+358-61-128 515	Material Administration, Training & Information	
+358-61-128 115	Technical Service	



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GREECE

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Spare parts sales — Trained service personnel — Spare parts stock — Interpart/ Servicepart

00 Contents, instructions, terminology

01 Main data, operating data and general design

02 Fuel oil, lubricating oil, cooling water

03 Start, stop, operation

04 Maintenance schedule

05 Maintenance tools

06 Adjustments, clearances and wear limits

07 Tightening torques and instructions for screw connections

08 Operating troubles

09 Specific installation data

10 Engine block with bearings, cylinder liners, oil sump

11 Running gear: crankshaft, connecting rod, piston

12 Cylinder head with valves

13 Camshaft drive

14 Valve timing drive and camshaft

15 Turbocharging and intercooling

16 Injection system

17 Fuel system

18 Lubricating oil system

19 Cooling water system

20 Exhaust system

21 Starting air system

22 Control gear

23 Instrumentation and automation

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).

6. The contents of the Instruction Book is numbered as follows:

   - Sections in the text, e.g. 00.1.

   - Page and figure numbers, e.g. 00-1 (possible supplementary pages are provided with an additional letter, e.g. 00-1A, B, C etc.).

   - Tools with spare part numbers are grouped in section 05. In the text, only the spare part number is mentioned.

00.2 General rules

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

2. Keep an ENGINE LOG 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 (see section 07) and locked, if necessary.

00.3 Terminology

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

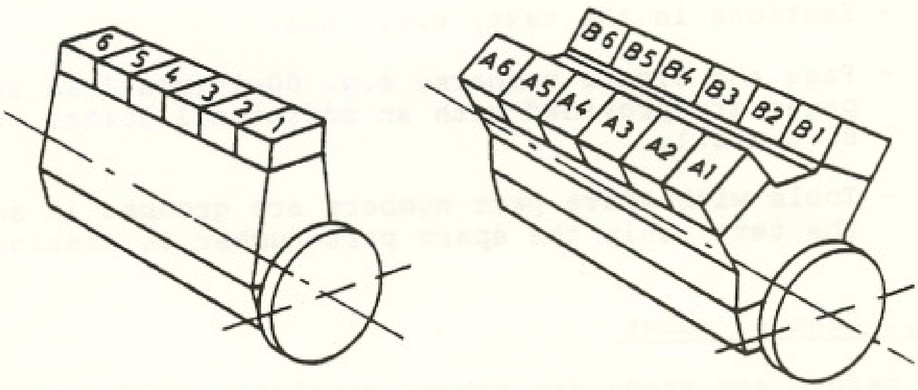
Operating side. The longitudinal side of the engine where the operating devices are located (start and stop, instrument panel, speed governor).

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:



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 centre, abbreviated BDC, is the bottom turning point of the piston in the cylinder.

Top dead centre, 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 cicuit (LT-circuit). The cooling water for the charge air cooler and the lubricating oil cooler.

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17	Fuel system
18	Lubricating oil system
19	Cooling water system
20	Exhaust system
21	Starting air system
22	Control gear
23	Instrumentation and automation

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
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	12V22	16V22
Oil volume c. litres	320	450	580	670	870
Oil volume between max. and min. marks c. litres	60	100	125	150	195
Anticorrosive oil c. litres	65	90	110	130	160

Cooling water volume in the engine, c. litres:

Engine type	4R22	6R22	8R22	12V22	16V22
Engine and inverse cooling system	90	120	160	240	320

01.2 Recommended operating data

Apply to normal operation at nominal speed.

	Normal values		Alarm (stop) limits	
	100 % load	30 % load	30-100 % l.	30 % load
1. Temperatures (°C)				
Lube oil before engine	62...70	73...80	80	90
Lube oil in oil sump	10...13 higher	5...8 higher		
HT water after engine	75...80	95 ... 100	90 (110)	105 (110)
HT water before engine	5...8 lower	2...3 lower		
HT water rise over turbocharger	8...12(15)	6...10		
LT water before engine	28...38	65...70		
Nozzle temp control	130...140	130...140	95/145	95/145
Charge air in air receiver	40...60	60...70	75	-
Exhaust gas after cylinder	See test records		50 higher	
Preheating of HT and LT water	70			
2. Gauge pressures (bar)				
Lube oil before engine at a speed of 900 RPM	3.5	3...3.5	2.0(1.5)	
1000 RPM	4.0	3.5...4.0		
1100 RPM	4.5	4.0...4.5		
1200 RPM	4.5	4.0...4.5		
LT water before LT pump (=static)	0.7...1.5			
LT water before engine	2.1...4.2			
HT water before engine	1.8...5.0 (x)		(xx)	
LT water before charge air cooler	1.8...4.4 (x)		(xx)	
Nozzle temp control before engine	1.0...1.5		0.5	
Nozzle temp control, pressure drop over engine	0.5...1.0			
Fuel before engine	5...7		4	
Starting air	max. 30		18	
Charge air	See test records			
3. 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) Depending on speed and installation

(xx) Alarm limit for main engine = idling pressure - 0.3 bar

01.3 Reference conditions

As reference conditions are stated:

Air pressure	1.013 bar
Ambient temperature	45°C
Relative air humidity	60%
Cooling water temperature of charge air cooler	
- fresh water	38°C
- sea water	32°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 percentage of reduced output may be calculated as follows:

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

a = 0.5% for every °C the ambient temperature exceeds +45°C.
b = 1% for every 100 m difference in level above 300 m from the level of the sea.
c = fresh water: 0.4% for every °C the cooling water of the charge air cooler exceeds 38°C
sea water: 0.4% for every °C the cooling water of the charge air cooler exceeds 32°C.

01.4 General engine design

The engine is a turbocharged, intercooled, four-stroke diesel engine with direct injection of fuel.

The engine block, being the body of the engine, is cast in one piece. The main bearings are arranged 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 and lube oil headers. The crankcase and camshaft covers, made of light metal, are sealed off against the engine block by means of O-rings. The lubricating oil sump is welded.

The main bearings are fully interchangeable trimetal bearings 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 gudgeon pin bearing is stepped to achieve large bearing surfaces.

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 rings are hardened.

The piston ring set includes three compression rings - the two top rings chromium-plated - and a chromium-plated spring-loaded oil scraper ring located above the gudgeon pin.

The cylinder head, made of high-tensile cast iron, is fixed by four hydraulically tensioned screws. The two inlet valves and the two exhaust valves are completely identical with the stellite-plated seat faces and chromium-plated valve stems. The valve seat rings of special iron are pressed into the bores which are efficiently cooled from the water side. The valve mechanism is pressure lubricated and completely enclosed.

The camshaft is made up from one-cylinder pieces with integral cams. The camshaft bearings are amounted directly in the engine block.

The injection pumps are fixed to the top level of the engine block and have integrated roller followers.

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 turbocharger, one for each cylinder bank, is situated at the free end of the engine.

The air coolers are arranged as removable inserts, on the V-engines two indentical ones.

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

The lubricating oil system includes a gear pump, an oil filter of the duplex type, a cooler with thermostat valve, a centrifugal by-pass filter and an electrically driven prelubricating pump. All components are mounted on the engine.

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.

00 Contents, instructions, terminology

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03 Start, stop, operation

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11 Running gear: crankshaft, connecting rod, piston

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02. FUEL, LUBRICATING OIL, COOLING WATER, NOZZLE COOLING OIL

02.1 Fuel

1. General

The engine is designed and developed to operate on heavy fuel (residual fuel) with a maximum viscosity of 380 cSt/50°C (3500 sRI/100°F) and will operate satisfactorily on blended (intermediate) fuels of lower viscosity, as well as on distillate fuel. The maximum limits of fuel characterisitics for a certain engine are stated in the documentation delivered with the engine. Blended fuels (residuals and distillate) with a viscosity between appr. 10 and 30 cSt/50°C (65 and 200 sRI/100°F) containing between 30 and 60% distillate should be avoided because of 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.

2. Fuel treatment

a) Purification

Heavy fuel (residuals, and mixtures of residuals and distillate) must be purified in an efficient centrifugal purifier before admitted into the day tank. The fuel is to be heated before centrifuging. Recommended temperatures, depending on the fuel viscosity, are stated in the table below.

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

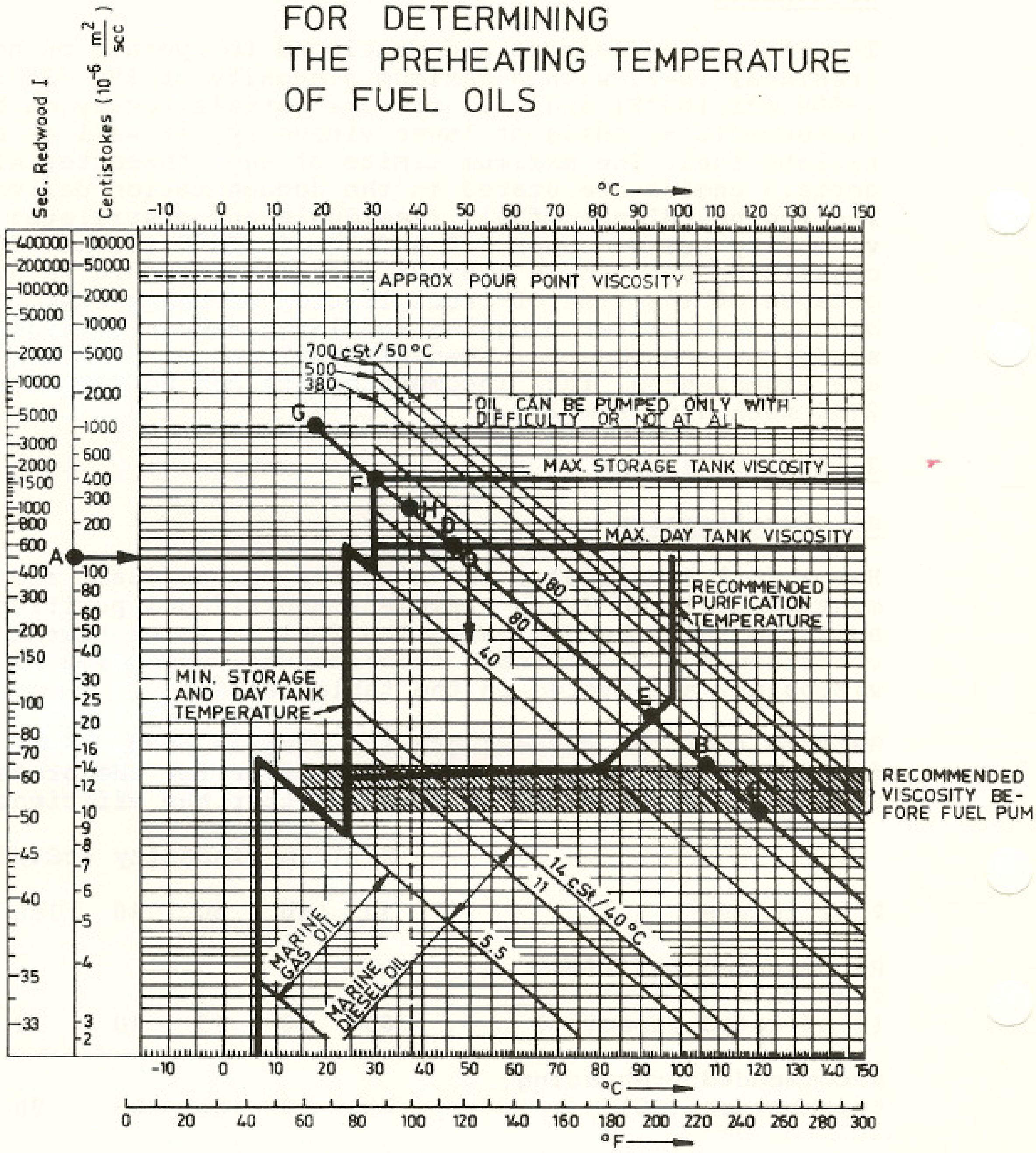
	Maximum viscosity (cSt/50°C)						
Fuel in use	30	40	60	80	180	240	380
Recommended purifier flow rate (% of rated capacity)	65	60	45	40	30	25	20
Recommended preheating temperature (°C)	73	80	86	88	98	98	98

For Marine Diesel Oil (max. viscosity 14 cSt at 40°C) a flow rate of 80% and a preheating 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.

FUEL OIL
VISCOSITY - TEMPERATURE DIAGRAM

FOR DETERMINING
THE PREHEATING TEMPERATURE
OF FUEL OILS



EXAMPLE: A FUEL OIL WITH A VISCOSITY OF 120 cSt/50°C (A) MUST BE PREHEATED BEFORE FUEL PUMP TO 107-122°C (B-C), IN THE DAY TANK TO MIN. 47°C (D), AT THE PURIFIER TO APPROX 93°C (E) AND IN THE STORAGE TANK TO MIN. 30°C (F). THE FUEL MAY NOT BE PUMPABLE BELOW 17°C (G). THE FUEL HAS A VISCOSITY OF 1000 s.RI/100°F (H).

b) Heating

See diagram, page 02-2.

Maximum recommended viscosity in the storage (bunker) tanks is 400 cSt. Because of the risk of wax formation, fuels with a lower viscosity than 120 cSt at 50°C should be kept at higher temperatures than what the viscosity would require.

Fuel viscosity (cSt at 50°C)	Minimum storage tank temperature (°C)
380	50
240	42
180	38
40...120	30
4.5...40	24
Below 4.5	6

Fuels having a viscosity higher than 5 cSt at 50°C need preheating before the purifier.

Maximum recommended viscosity in the day tank is 140 cSt. Because of the risk of wax formation fuels with a lower viscosity than 50 cSt at 50°C should be kept at higher temperatures than what the viscosity would require.

Fuel viscosity (cSt at 50°C)	Minimum storage tank temperature (°C)
380	67
240	60
180	55
120	47
80	40
40...50	30
4.5...40	24
Below 4.5	6

Fuels having a viscosity higher than 10 cSt at 50°C should be heated before admitted into the engine fuel system. It is recommendable to keep the temperature after the final heater 5 to 10°C above the recommended temperature before the injection pumps to compensate for heat losses between the heater and the engine.

c) 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.

3.1 Maximum limits of fuel characteristics

		1) Heavy fuel (HF)	2) Heavy fuel (HE)	3) Marine diesel fuel (MD)
Density at 15°C	(kg/l)	0.9910	0.9910	0.9200
Viscosity, kinematic, at 80°C	(cSt)	75.00	28.00	-
Viscosity, kinematic, at 40°C	(cSt)	-	-	14.00
Viscosity, kinematic, at 50°C	(cSt)	380.00	100.00	11.00
Viscosity, kinematic, at 100°F	(sRI)	3500.00	800.00	70.00
Carbon Residue, Conradson	(% by weight)	20.0	12.0	-
Carbon Residue, Ramsbottom	(% by weight)	-	-	2.5
Water content	(% by volume)	1.0	0.50	0.30
Water content before eng.	(% by volume)	0.2	0.2	0.2
Ash	(% by weight)	0.15	0.10	0.05
Sulphur content	(% by weight)	5.00	3.50	2.00
Pour point	(°C)	30	24	6
Vanadium content	(mg/kg)	500	250	100
Asphaltenes	(% by weight)	8	8	-
Sodium	(mg/kg)	50	50	-
Aluminium	(mg/kg)	30	30	30

3.2 Minimum limits of fuel characteristics

	1) Heavy fuel (HF)	2) Heavy fuel (HE)	3) Marine diesel fuel (MD)
Flash point, closed, Pensky Martens (°C)	60.0	60.0	60.0

1) Other aspects than viscosity are according to BS MA 100:1982 Class M6, with added limits for water content before engine and contents of asphaltenes and sodium.

2) Other aspects than viscosity are according to BS MA 100:1982 Class M4, with added limits for water content before engine and contents of asphaltenes and sodium.

3) According to BS MA 100:1982 Class M3, with added limit for water content before engine.

4. Comments on fuel characteristics

a) 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 fuel system in engines running on heavy fuel is laid out for max. 380 cSt at 50°C (3500 sRI/100°F) fuels and in those running on marine diesel fuel for max. 14 cSt at 40°C (70 sRI/100°F) fuels.

b) With a <u>density</u> of more than 0.990, water, in particular, and to some extent solid matter can no longer be removed with certainty by the centrifuge.

c) High <u>sulphur</u> content increases the risk for corrosion and wear, particularly at low loads, and may contribute to high-temperature deposit formation.

d) High <u>ash</u> content causes abrasive wear, and may cause high-temperature corrosion and contributes to deposit formation. The most harmful ash constituents are vanadium and sodium.

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

f) <u>Sodium</u> 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 contributes to fouling of the turbocharger turbine at high load.

g) High <u>Conradson carbon</u> may cause deposit formation in the combustion chamber and exhaust system, particularly at low engine output.

h) High content of <u>asphaltenes</u> may contribute to deposit formation in the combustion chamber and exhaust systems. 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.

j) Heavy fuels may contain considerable amounts of <u>water</u> (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.

k) <u>Ignition quality</u>, <u>volatility</u>. Heavy fuels may have very low cetane number or low volatility (high distillation range) at least for the major part. This may cause trouble at low load operation and when starting if the engine is not sufficiently preheated.

<u>5. Measures to avoid difficulties when running on heavy fuel</u>

The engine is designed for burning heavy fuel with characteristics according to the table in point 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:

a) to limit maximum continuos output as much as operating conditions allow if the 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.

b) to limit low load operation as much as operating conditions allow if the 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.

Idling (i.e. the main engine declutched, the generator set disconnected) should be limited as much a possible. Warming-up of the engine at no load for more than 2...3 minutes before loading, as well as idling more than 2...3 minutes before stopping is unnecessary and should be avoided.

6. General advice

To avoid 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 compatibility problems occur, never add distillate fuel, as this will probably increase precipitation. A fuel additive with 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 or visbreaking will approach at least some of the maximum limits of fuel characteristics given in the table in point 3.

Compared with "traditional" heavy fuels blended from straight run residuals the "modern" heavy fuels will 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%.

- 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^{o}C before the centrifuge) when centrifuging high viscosity fuels with densities approaching 0.990.

- sufficient preheating of the engine and the fuel systems before starting the engine.

02.2 Lubricating oil

1. System oil characteristics

Viscosity. The system oil should be of viscosity class SAE 30. SAE 40 oils may also be used and are recommended for some oil brands.

Quality. The system oil is to be of a quality developed for use in highly supercharged four-stroke marine medium speed diesel engines burning medium to high sulphur content fuels. The oil should have high thermal stability and contain additives that

- increase oxidation stability of the oil,
- increase the corrosion-protective properties of the oil,
- prevent deposit formation on internal engine parts,
- improve load carrying capacity of the oil,
- neutralize acid combustion and oxidation residuals.

The oil should have good water rejection and additive retention characteristics.

There are no universally applicable quality norms for marine diesel lubricants. As a guidance, the oil should, as to additive level and diesel performance level, correspond to the requirements of MIL-L-2104 C or API Service CD.

Alkalinity. The TBN of the oil is to be between 25 and 40 (mg KOH/g); higher at high sulphur content of the fuel.

2. Approved system oils for diesel engine Wärtsilä Vasa 22HF, HE, MD

Lubricating oil supplier	Designation (brand name) of lubricating oil supplier	
BP	Energol IC-HF 303, 304	x
Castrol	MXD 303, 304	x
Esso	Tro-Mar SR 30, SR 40, SRX 40	x
Elf	Aurelia 3030, 3040, XT 3040, 4040	
Gulf	Veritas Select 30, 40	x
Mobiloil	Mobilgard 324, 424, 342, 442	x
Nynäs	Aurelia 3030, 4030, XT 3040, 4040	x
Olje-Energi	Goth Oil 325	x
Shell	Argina T Oil 30, 40, X Oil 40	x
Teboil	Teboil Ward S30T SAE 30, 40	x
Texaco	Taro DP 30, 40	x
Compagnie Francaise de Raffinage	Total HMA SAE 30	x

Note:

For use of a lubricating oil not listed in the table, the engine manufacturer's permission is compulsory to maintain the engine guarantee.

The oils marked x have been approved on the basis of engine tests, the others on the basis of type analyses and references. Never blend different oil brands unless approved by the oil supplier and, during the guarantee time, by the engine manufacturer.

Oils having a TBN in the region 35...40 mg KOH/g are recommended when the fuel sulphur content is 4% or above, but may be used in auxiliary engines at lower fuel sulphur content if the main engine requires an oil with a TBN above 30 mg KOH/g.

3. Maintenance and control of the lubricating oil

a) 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 fow. The gravity disc should be chosen according to oil gravity at 80°C (normally stated at 15°C by the oil supplier). Caution: Defects on automatic, "self-cleaning" separators can quickly increase the water content of the oil under certain circumstances (control valve)!

b) 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 assessment of the condition of the oil in service, the sample should be furnished with the following details: 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 of almost no value.

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^{o}C below the guidance value. Min. permissible flash point (open cup) 170^{o}C. At 150^{o}C risk of crankcase explosion.

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

- TBN. Min. 15 mg KOH/g.

- Insolubles. The quantity allowed depends on various factors. The oil supplier's recommendations should be followed. 2..3% insolubles in n-Pentan call for action, however.

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.

c) 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.

d) Guidance values for oil change intervals are to be found in section 04.7. The intervals between changes are influenced by the 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:

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

2. Clean the oil spaces, including filters and camshaft compartment. Insert new filter cartridges.

3. Fill the oil sump with a small quantity of new oil and circulate with the prelubricating pump. Drain.

4. Fill the system with the required quantity of oil.

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.

4. Lubricating oil for the governor

See the Instruction Book for the governor (section 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: 1000 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.

5. Lubricating oil for the turbocharger

See the Instruction Book for the turbocharger (section 15). A mineral oil of 52...87 cSt viscosity at 40°C should be used, turbine oils are preferred. Oil change interval: 1000 h service.

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

02.3 Cooling water

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.

2. Additives

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

Note: The use of emulsion oils, phosphates and borates (sole) is not recommended.

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

Some commercially available water treatment products are listed as examples in section 02.3.4.

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.

Note: Sodium nitrite is toxic.

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.

4. Summary of the most common cooling water additives

Additive	Advantages	Disadvantages	Suitability
Sodium nitrite Nitrite + borate	- good efficiency - small active quantities, 0.5 % by mass - cheap - no increased risk of corrosion at over- or under-doses - innocuous for the skin - allowed for use in fresh water generators intended for housekeeping purposes	- determination of the concentration can be done only with special equipment - tendency to attack zinc coverings and soft solderings - toxic: lethal dosage 3...4 g solid nitrite	- suitable as additive except in air cooled heat exchangers with large soft solder surfaces
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 concentration: spot corrosion - injurious for the skin - toxic: lethal dosage 1 g - prohibited for use in fresh water generators intended for housekeeping 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 exceeds 2 m/s - commercial products very expensive - increased risk of corrosion when too low concentration: spot corrosion	- limited suitability

Examples of commercially available cooling water treatment products

Supplier	Product designation
Atlas Products & Services Ltd Fraser Road GB-Erith, Kent, DA8 1PN, England	Atlas Solvex WT2
DIA-PROSIM 107 Rue Edith Cavell 94400 Vitry France	RD 11 M
Drew Chemical Corp., Marine Division 522 Fifth Avenue New York, N.Y. 10036, USA	Drew Ameroid - DEWT-NC powder - Maxigard
Gamlen Chemical Company (UK) Ltd Wallingford Road, Uxbridge, Middlesex England	Gamlen Gamcor NB
Houseman Hegro Ltd The Priory, Burham Slough SL 1 7LS, England	Cooltreat 101 Cooltreat 102
Magnus Maritec International Inc. 150 Roosevelt Place, P.O.Box 150 Palisades Park, New Jersey 07650, USA	NCL Diesel Water treatment
Nalfloc Ltd, Marine Department P.O.Box 11, Northwich, Cheshire CW 8 4DX, UK	Nalfleet 9-121 powder Nalfleet 9-131 liquid
Nalco Chemical Co, Marine Department 100 Morris Avenue, Springfield New Jersey 07081, USA	Nalco 39 powder Nalco 39-L liquid
Perolin Co Ltd 50 Mount Street London WLY 5 RE, England	Perolin Formet Water System Treatment No. 326 and No. 326-L Perolin Inhibitin Cooling water treatment (contains no nitrite)
Rochem Ships Equipment A/S P.O.Box 2645, St Haunshaugen Oslo 1, Norway	Rochem Rocor NB Rochem Rocor NB liquid

Note: 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.

02.4 Fuel nozzle cooling oil

The same oil brand as in the engine system is to be used (applies only for engines running on heavy fuel, i.e. 22HF and 22HE).

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03

03. START, STOP, OPERATION, START AFTER PROLONGED STOP, START AFTER OVERHAUL, OPERATION SUPERVISION AFTER OVERHAUL, RUNNING-IN

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 fuel nozzle control system is in running order (correct expansion tank level, correct preheating, correct pressure, sufficient precirculation to heat the fuel nozzles)

- the circulating system and raw water system are in running order (correct pressures, circulating water preheated and pre-circulated sufficiently to heat the engine),
- the oil level in the governor and turbocharger(s) is correct,
- the starting air pressure exceeds 15 bar (normally, 11 bar is still sufficient to start the engine),
- the starting air system is drained of condensate,
- the drain pipe of the air cooler casing is open, no leakage.

1. Manual start

a) Prime the engine until the lubricating oil pressure gauge shows pressure, 0.5 bar.

b) Propulsion engines: Set the governor at idle speed and disconnect the propeller shaft or set the propeller blades at zero.

c) Always when there is time enough: Turn the crankshaft two revolutions keeping the indicator valves open. In doing so the risk of water-locks is eliminated.

d) **Remove the turning gear from the flywheel.**

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

f) 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.

g) Move the start lever into start position or push the start button until the engine starts firing. If the engine does not start after 2...3 s the reason should be checked.

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

*) Only for engines running on heavy fuel, i.e. 22HF and 22HF.

i) Check immediately after start that the pressure and temperature values are normal.

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

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 test started once a week.

a) 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.

b) 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 only long enough (1...2 s) to make the engine start. The start will be indicated by the remote tachometer or by a 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 c.

c) 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 for 10 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 attempts should be long enough to guarantee that the flywheel has stopped.

d) When the engine has reached a predetermined speed, an auxiliary relay energized by the remote 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

1. Manual stop

a) Idle the engine 2..3 min. before stopping.

b) Stop the engine by moving the stop lever in stop position. The time of slowing down offers a good opportunity to detect possible disturing sounds.

2. Remote stop

a) Point 1a is valid.

b) 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 predetermined time the shut-down solenoid will return to its initial position.

c) When the engine stops and the speed decreases below a certain limit, the systems 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.

3. Automatic stop

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

When the engine stoppes because of overspeed, the mechanical overspeed trip device and the electro-pneumatic overspeed trip device on each fuel injection pump may have tripped.

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.

Start the engine once a week to check that everything is in order.

03.3 Normal operation supervision

1. Every second day or after every 50 running hours

a) Read all thermometers and pressure gauges and, at the same time, the load of the engine. All temperatures are more or less dependent on the load. The charge air pressure is dependent on the load, and the lubricating oil, circulating water and raw water pressures (built-on pumps) are dependent on the speed. Therefore, always compare the values read with those at corresponding load and speed in the Acceptance Test Records. Guidance values are stated in section 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 section 03, page 03-52. At low loads the charge air, cooling water and oil temperatures will automatically be increased by the load dependent "inverse" temperature control system. (Applies to engines running on heavy fuel, i.e. 22HF and 22HE.)

b) Check the indicator for pressure drop over the 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).

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

d) 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. Com pensate for oil consumption by adding max. 10% fresh oil at a time.

e) Check that the ventilation (de-aerating) of the engine circulating water system and the fuel nozzle control 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).

f) Check the quantity of leak-fuel from the draining pipes and from the gossip hole of the fuel feed pump.

g) Check that the drain pipes of the air coolers are open.

h) Check that the gossip holes of the oil coolers and the circulating water coolers are open.

i) Clean the compressor side of the turbocharger by injecting water. See the instruction manual of the turbocharger.

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

k) 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.

2. Every second week or after every 250 running hours

a) 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.

b) Keep the injection pump racks clean (free from sticky deposits), check that the parts of the fuel control system move easily.

c) Clean the turbine side of the turbocharger by injecting water. When operating on very low quality fuels it may be necessary to reduce the intervals considerably. High sodium content of fuel calls for frequent turbine cleaning. See section 15.3 and the Instruction Manual of the turbocharger. This applies to engines running on heavy fuel, i.e. 22HF and 22HE.

3. Once a month or after every 500 running hours

a) Check content of additives in the circulating water.

b) 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.

c) Check the function of the load dependent "inverse" cooling system with engine loaded below 30% of rated output. This applies to engines running on heavy fuel, i.e. 22HF and 22HE.

4. In connection with maintenance work

a) 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 section 04.

5. General

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

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

c) 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. 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.

Idling (i.e. main engine declutched, generator set disconnected) should be limited as much as possible. Warming-up of the engine for more than 2...3 minutes before loading, as well as idling more than 2...3 minutes before stopping is unnecessary and should be avoided.

03.4 Start after a prolonged stop (more than 8 h)

1. Manual start

a) Check
   - the lubricating oil level
   - the cooling oil level in the nozzle control system expansion tank (this applies to engines running on heavy fuel i.e. 22HF and 22HE)

- 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 parts of the fuel control shaft system and the injection pump racks move freely. Otherwise RISK OF OVERSPEED.

b) Observe all points in section 03 pos. 1. Point c grows more important the longer the engine has been stopped.

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

d) Vent fuel and lubricating oil filters.

03.5 Start after overhaul

a) 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, that all connections are properly locked and the injection pump racks move freely in the pumps.

b) 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.

c) If the injection pumps, camshaft or its driving mechanism have been touched, check the start of delivery.

d) Check the cooling water system for leakage, especially:
- the lower part of the cylinder liners
- the oil cooler
- the charge air cooler

e) Check the fuel nozzle control system. This applies to engines running on heavy fuel, i.e. 22HF and 22HE.

f) Check/adjust the valve clearances. 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). Guidance values, see section 06.

g) Vent the fuel oil system if it was opened.

h) 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.

j) 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.

k) See the instructions in section 03 pos. 03.1 and 03.4 when starting.

03.6 Operation supervision after overhaul

a) 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.

b) 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!

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

d) 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 ventilation of the fuel nozzle control oil system. This applies to engines running on heavy fuel, i.e. 22HF and 22HE.
- 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

a) After piston overhaul, follow program A on page 03-51, as closely as possible.

The piston rings have slided into new positions and need time to refit.

If the program cannot be followed, <u>do not load the engine fully for 4 h, at least</u>.

b) After changing piston rings, pistons or cylinder liners, after honing of cylinder liners, follow program B on page 03-51, as closely as possible.

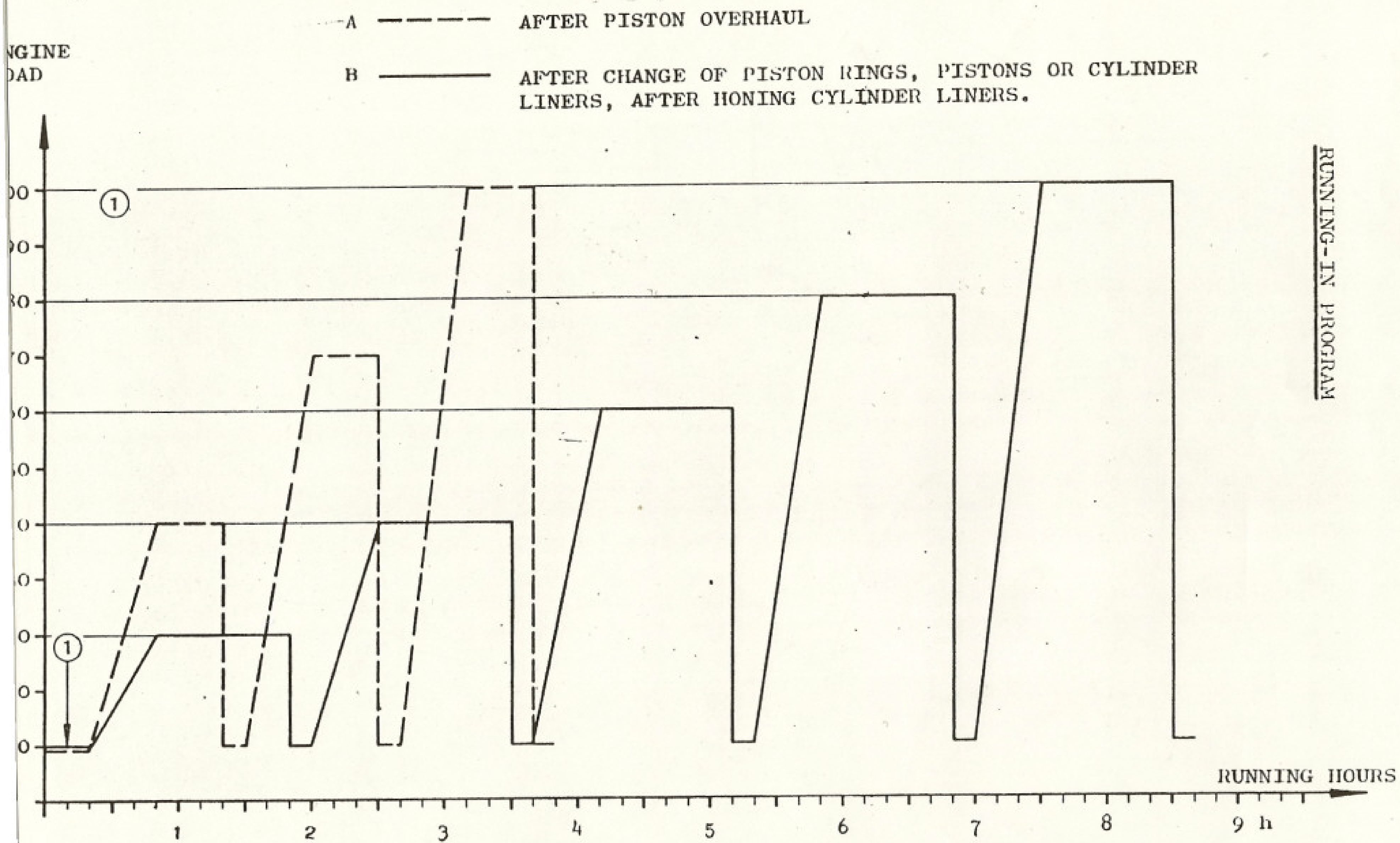
If the program cannot be followed, <u>do not load the engine fully for 10 h, at least</u>.

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.

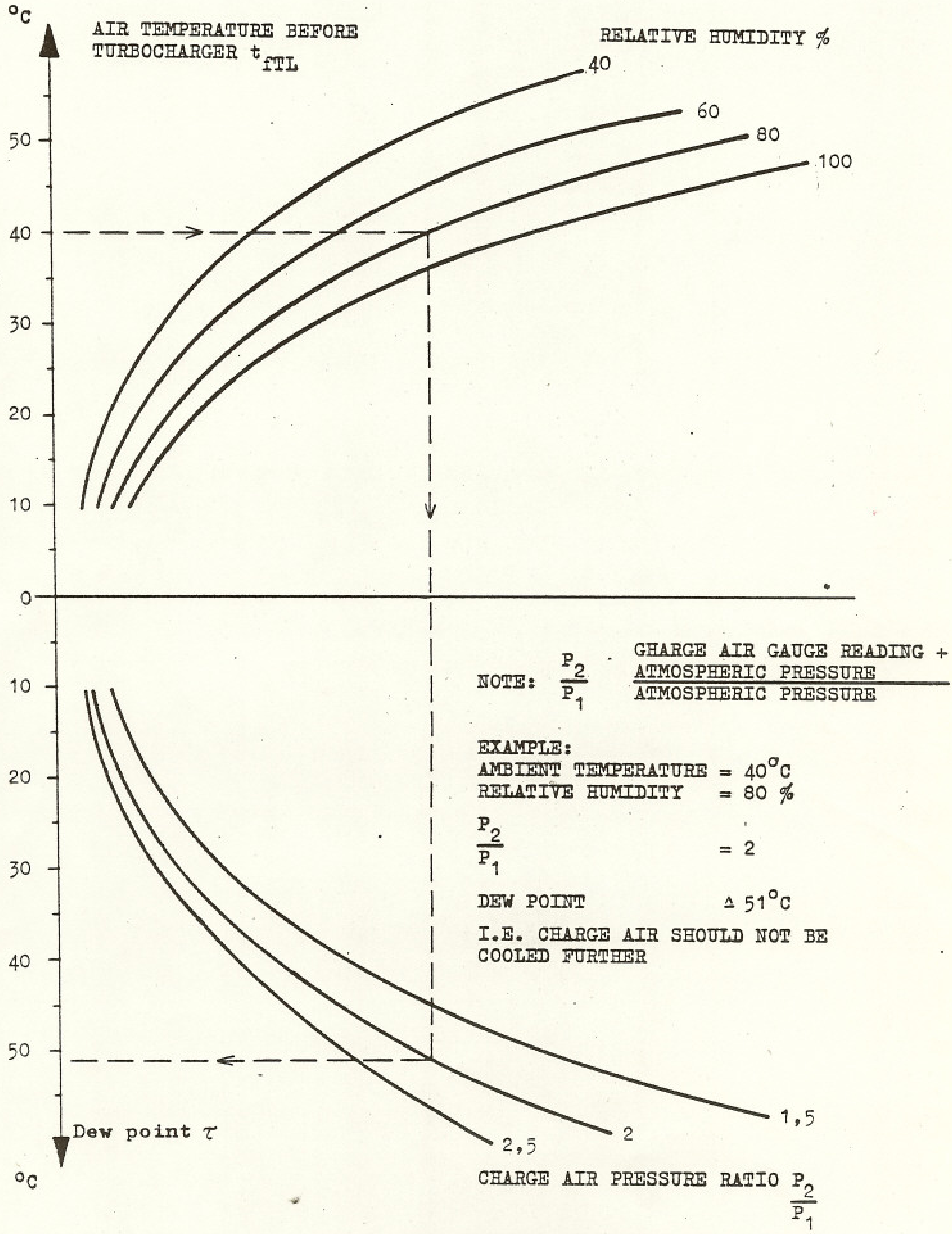
The running-in may be performed either on distillate or heavy fuel, using the normal lubricating oil specified for the engine.

RUNNING-IN PROGRAM



1 STOP. CHECK BIG END BEARING TEMPERATURES

CONDENSATION IN CHARGE AIR COOLERS



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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.

Use the form "Service Report" in connection with the maintenance work. The form is enclosed in every instruction book.

See also the instruction books of the turbocharger and the governor, separate instructions for additional equipment and section 03.

04.2 Interval: Every second day, irrespective of the engine being in operation or not		
Part	Work	Instructions in section
Automatic prelubrication	Check operation.	18.7, 23.2.1
Crankshaft	Marine engine: In a stopped engine, turn the crankshaft into a new position.	03.3.1.k

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

04.4 Interval: 50 operating hours		
Part	Work	Instructions in section
Turbocharger	Clean the compressor by injecting water, and the turbine, if necessary.	15, 03.3.1i, 03.3.2c
Temperature and pressure gauges, load indicators etc.	Read, record.	03.3.1a
Fuel filters	Turn the handle of the fuel prefilter (diesel fuel engines).	17
Fuel and lubricating oil filters	Check the pressure drop indicators.	17, 18, 21
Lubricating oil sump, governor, turbocharger(s)	Check the oil level, compensate for consumption.	02.2.3c, 02.2.4,02.2.5 15, 22, 18
Fuel nozzle temperature control system x)	Check the level in the oil container.	17
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
Fuel day tank	Drain possible water and sediment.	17

x) Applies to engines running on heavy fuel, i.e. 22HF and 22HE.

(cont.) Interval: 50 operating hours		
Part	Work	Instructions in section,
Valve mechanism	Check the valve clearances after 50 hours´ running in new and reconditioned 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	Instructions in chapter, section
Centrifugal filter	Clean, more often if necessary. Remember to open the valve before the filter after cleaning.	18 03.3.2a
Lubricating oil	In a new installation or after change to use of a new lubricating oil brand, take samples for analysing.	02.2.3b
Control mechanism	Check for free movement, clean, lubricate.	22
Turbocharger x)	Clean the turbine by injecting water; more often if necessary.	15 03.3.2c

x) Applies to engines running on heavy fuel, i.e. 22HF and 22HE.

04.6 Interval: 500 operating hours		
Part	Work	Instructions in section
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.	02.2.3b
Cylinder pressure	Check.	12
Raw water filter	Check and clean, if necessary	19
Cooling system x)	Check the function of the load dependent cooling system with the engine loaded below 30% of rated output.	19

x) Applies to engines running on heavy fuel, i.e. 22HF and 22HE.

04.7 Interval: 1000 operating hours		
Part	Work	Instructions in section
Lubricating oil	Change oil in a new installation (wet sump installation). Take samples for analysing. If the analysis values are positive and if the oil supplier or engine manufacturer recommend so, the intervals between the changes can be prolonged in steps of 500 operating hours. In dry sump installations the oil change intervals may be in the order of 4000 hours or more. When changing oil, clean all oil spaces.	02.2.3b
Lubricating oil filter	Replace the filter cartridges by new ones. (The cartridges are to be replaced when the pressure difference indicator shows too high pressure drop.) Clean the wire gauze (cartridge) and filter housing.	18
Fuel filter	Replace the filter cartridges by new ones, if necessary (the cartridges are to be replaced when the pressure difference indicator shows too high pressure drop). Clean the filter housing. Clean the prefilter in the fuel inlet pipe. Note! The fuel oil filter in a stand-by engine is loaded as much as when the engine is running because the fuel feed pump is running continuously on stand-by engines in heavy fuel installations.	17
Automation	Check the function of the alarm and automatic stop devices.	23
Turbocharger	Change lubricating oil.	02.2.5, 15
Air filter	Clean (more often, if necessary)	15
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.	06.1 12

04.8 Interval: 2000 operating hours		
Part	Work	Instructions in section
Injection valves	Test the opening pressure. Dismantle and clean the nozzles. Check the effective needle lift. Check the springs. Replace 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
Charge air coolers	Check and, the first time, if necessary, clean the water side. If it is in good condition and the deposits are unsignificant: future intervals 4000 runnin 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	Instructions in section
Crankshaft	Check the alignment. Check the axial clearance.	11 06.2, pos. 10
Camshaft	Check the contact faces of the cams and tappet rollers. Check that the rollers rotate.	14
Turbocharger	Clean the compressor and turbine by hand. Inspect the cooling water ducts for possible deposits and clean if the deposits are thicker than 1 mm.	15.6
Coolers	Clean the lubricating oil, charge air and circulating water coolers. Look carefully for corrosion.	15 18.5
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
Nozzle temperature control oil *)	Take an oil sample for analysing. Clean the filter.	17.4
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.	Page 20-51

*) Applies to engines running on heavy fuel, i.e. 22HF and 22HE.

04.10 Interval: 8000 operating hours		
Part	Work	Instructions in section
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 the pistons. Check the height of the ring grooves (the height clearance of the rings). Check the retainer rings of the gudgeon pins. Renew the complete piston ring set. Note: The running-in program, section 03.7.	11 06.2
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. Where honing marks are visible the measurement is unnecessary. If there are scuffing marks, many scratches or glossy spots, hone the bore. Hone the liners at every second overhaul irrespective of the liner condition.	10

(cont.) Interval:	8000 operating hours	
Part	Work	Instructions in section
Connecting rods	Inspect the big end bearing and mating surface serrations.	11
Main bearings	Inspect the bearing shells.	10
Gears	Inspect all gears.	11, 13
Lubricating oil pump	Inspect.	18
Thermostat valves	Clean, check.	19 18, 17
Turbocharger	Change bearings in the VTR-chargers.	15
Fuel system	Clean the fuel day tank.	17
Cooling water system	Replace the O-rings of the circulating water discharge pipe by new ones.	19
Fuel nozzle temperature control system x)	Change oil.	17

x) Applies to engines running on heavy fuel, i.e. 22HF and 22HE.

04.11 Interval: 16000 operating hours		
Part	Work	Instructions in section
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 big end and main bearing clearances.	11 10

04.12 Interval:	64000 operating hours	
Part	Work	Instructions in section,
The whole engine	General overhaul	

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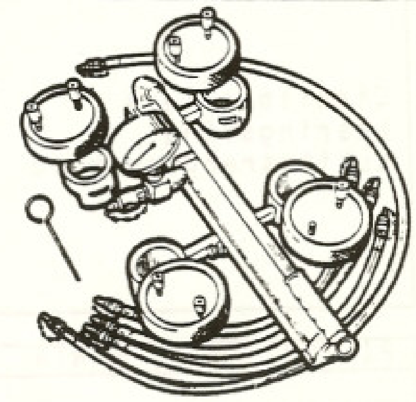
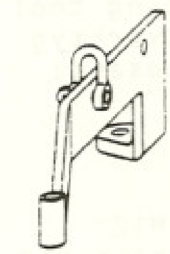
MAINTENANCE TOOLS, UNDERHÅLLSVERKTYG, HUOLTOTYÖKALUT

CYLINDER HEAD, CYLINDERLOCK, SYLINTERINKANSI

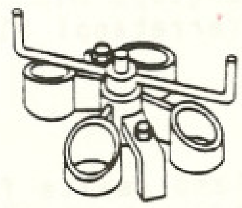
Hydraulic tightening device — Spare part No. 861020
Hydrauliskt åtdragningsverktyg — Reservdel nr.
Hydraulinen kiristystyökalu — Varaosa no.



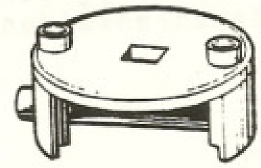
Lifting tool for cylinder head — 832005
Lyftverktyg för cylinderlock
Sylinterikannen nostotyökalu



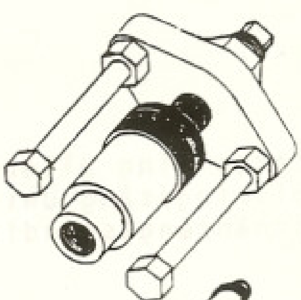
Dismantling device for valves — 846010
Verktyg för demontering av motorventiler
Työkalu venttiilien poistamista varten



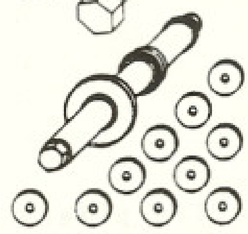
Grinding device for valves — 841001
Verktyg för inslipning av ventiler
Venttiilien hiomatyökalu



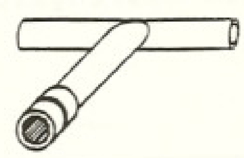
Extractor for injection valve — 837017
Utdragare för insprutningsventil
Ruiskutusventtiilin ulosvedin



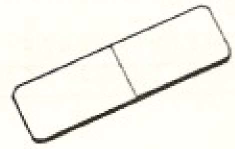
Grinding tool for injection valve sleeve bottom — 841008
Slipdorn för insprutningsventilhylsans botten
Ruiskutusventtiiliholkin pohjan hiomatyökalu



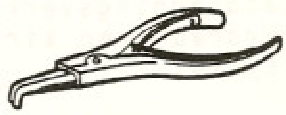
Handle for indicator valve — 808001
Vred för indikeringsventil
Vääntiö indikoimisventtiiliin



Valve clearance feeler gauge — 848003
Bladmått för ventilspel
Rakotulkki

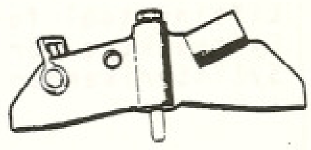


Circlip pliers — 843001
Låsringstång
Lukitusrengaspihdit



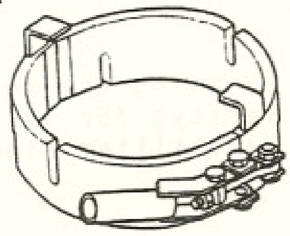
PISTON, KOLV, MÄNTÄ

Lifting tool — 832002
Lyftverktyg
Nostosanka

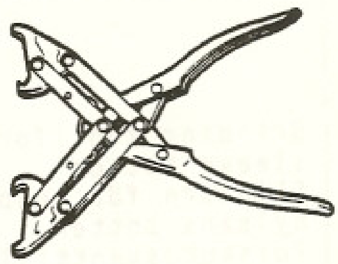


Tap M12 — 845001
Gängtapp M12
Kierretappi M12

Clamp device for piston rings — 843002
Klämverktyg för kolvringar
Männänrenkaiden puristustyökalu



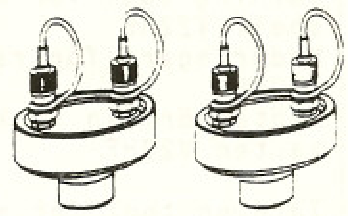
Piston ring pliers Unistress — 843003
Kolvringstång Unistress
Männänrengaspihdit Unistress



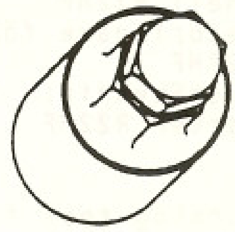
Circlip pliers — 843004
Låsringstång
Lukitusrengaspihdit

CONNECTING ROD, VEVSTAKE, KIERTOKANKI

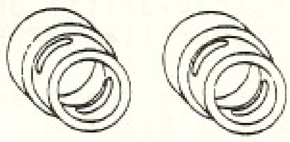
Hydraulic tightening device 861027
Hydrauliskt åtdragningsverktyg
Hydraulinen kiristystyökalu



Mounting device M33 for stud 803011
Monteringsverktyg M33 för pinnskruv
Vaarnaruuvin asennustyökalu M33

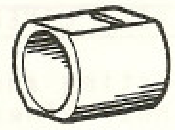


Distance sleeves for tightening device 861026
Distanshylsor för åtdragnings-verktyg
Väliholkit kiristystyökalua varten

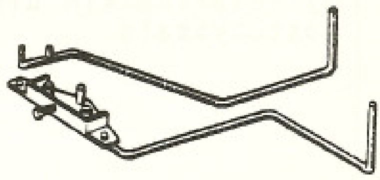


MAIN BEARINGS, RAMLAGER, RUNKOLAAKERIT

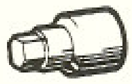
Distance sleeves for tightening device 861021
Distanshylsor för åtdragnings-verktyg
Väliholkit kiristystyökalua varten



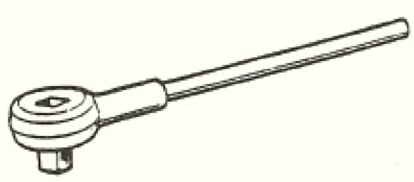
Lifting tool for main bearing cap 832003
Lyftverktyg för ramlagersadel
Runkolaakerikannen nostotyökalu

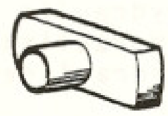
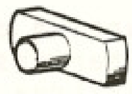
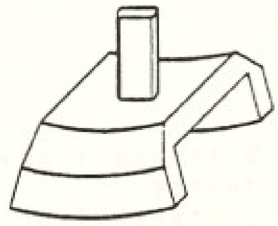
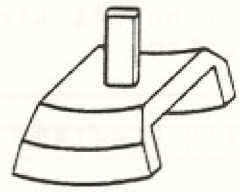


Hex. socket screw bit 22 with 1 in square drive 803001
Sexkantnyckel 22 med 1 in fästhål
22 mm:n kuusiokoloavain 1 in neliöllä

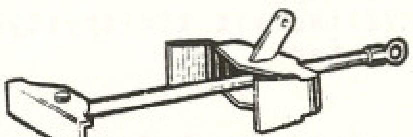


Torque multiplier X-4 822001
Momentförstorare X-4
Momentinsuurennin X-4



Turning tool for main bearing shell V22HF Medbringare för ramlagerskål V22HF Myötäpyöritin runkolaakerikuorta varten V22HF	851002	
Turning tool for main bearing shell R22HF Medbringare för ramlagerskål R22HF Myötäpyöritin runkolaakerikuorta varten R22HF	851001	
Turning tool for thrust bearing shell V22HF Medbringare för styrlagerskål V22HF Myötäpyöritin ohjaavalle laakerille V22HF	851006	
Turning tool for thrust bearing shell R22HF Medbringare för styrlagerskål R22HF Myötäpyöritin ohjaavalle laakerille R22HF	851005	

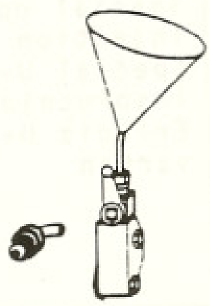
CYLINDER LINER, CYLINDERFODER, SYLINTERIHOLKKI

Extracting and lifting tool for cylinder liner Utdragnings- och lyftverktyg för cylinderfoder Sylinteriholkin ulosveto- ja nostotyökalu	836001	

INJECTION, INSPRUTNING, RUISKUTUS

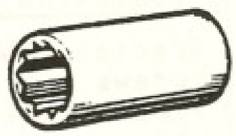
Checking device for fuel injection timing
Verktyg för granskning av flödläge
Työkalu ruiskutushetken tarkistusta varten

862007



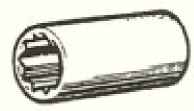
Socket wrench 30 for nozzle nut
Hylsgrepp 30 för dysmutter
Suutinmutterin holkkiavain 30

807010



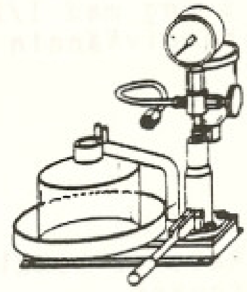
Socket wrench 22
Hylsgrepp 22
Holkkiavain 22

807004



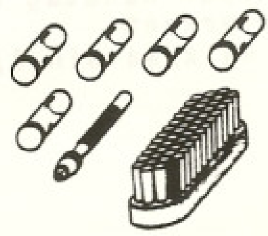
Testing device for injection valve
Proutryckningsanläggning för spridarutrustning
Ruiskutusventtiilin koeponnistuslaite

864011



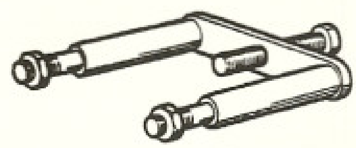
Nozzle cleaning kit
Rengöringsverktyg för spridare
Puhdistusvälineet suutinta varten

845006



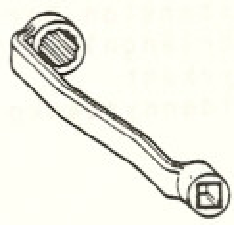
Mounting tool for injection pump tappet
Monteringsverktyg för insprutningspumpens lyftare
Ruiskutuspumpun nostimen asennustyökalu

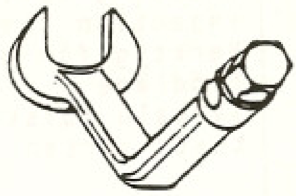
846008

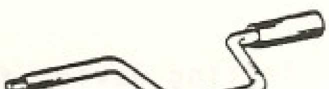
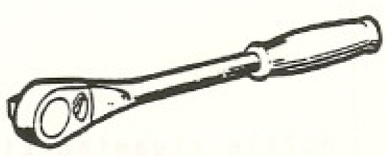
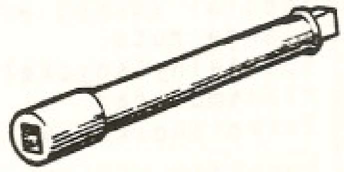


Special socket wrench 19 for flange nuts
Specialhylsnyckel 19 för flänsmuttrar
Erikoisholkkiavain laippamuttereiden kiristämistä varten

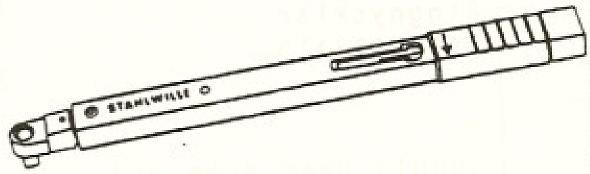
806005



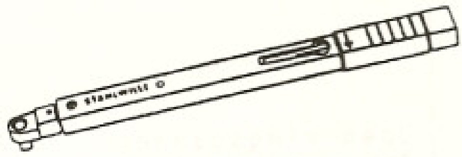
Special open wrench for injection pipe Special U-nyckel för insprutningsrör Erikois U-avain ruiskutusputkea varten	806007	

TIGHTENING, ÅTDRAGNING, KIRISTYS		
Special key for camshaft flange screws Specialnyckel för nockaxel-flänsarnas skruvar Erikoisavain nokka-akselin laipan ruuveille	806006	
Speed brace with 1/2 in square Sväng med 1/2 in fyrkant Kampiväännin 1/2 in neliöllä	808002	
Ratchet handle with 1/2 in square Spärrhandtag med 1/2 in fyrkant Räikkäavain 1/2 in neliöllä	808003	
Extension bar with 1/2 in square Förlängningsstång med 1/2 in fyrkant Pidennystanko 1/2 in neliöllä	808005	

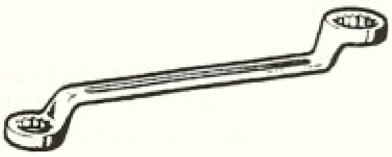
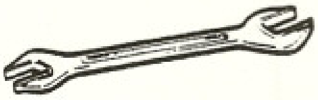
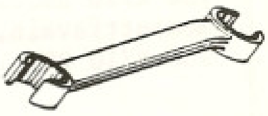
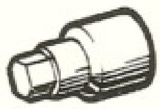
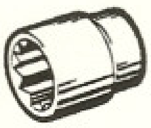
Torque wrench,Stahlwille 730 R/40 75...400Nm
Momentnyckel,Stahlwille 730 R/40 75...400Nm
Momenttiavain,Stahlwille 730 R/40 75...400Nm
820009



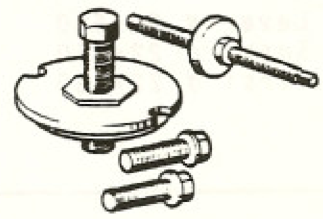
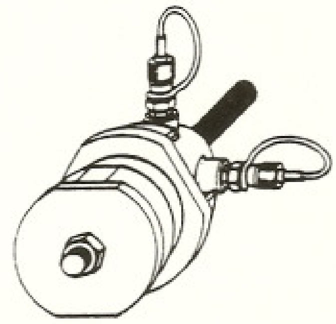
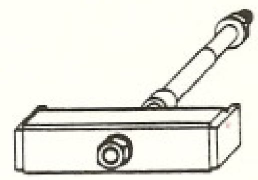
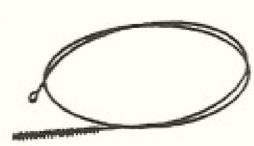
Torque wrench,Stahlwille 730 R/10 20...100Nm
Momentnyckel,Stahlwille 730 R/10 20...100Nm
Momenttiavain,Stahlwille 730 R/10 20...100Nm
820008



WRENCHES, SKRUVNYCKLAR, RUUVIAVAIMET

Ring wrenches Ringnycklar Rengasavain	10-12 13-17 19-22 24-27	801004 801003 801002 801001	
Double head open end wrenches Dubbla U-nycklar Kaksipäinen U-avain	10-12 13-17 14-17 19-22 24-27 30-32 32-36 41-46	800008 800007 800006 800005 800004 800003 800002 800001	
Open ringspanner Öppen ringnyckel Avorengasavain	30-32	801005	
Hex. socket screw key Sexkantnyckel Kuusiokoloavain	5 6 8 10 12	803006 803005 803004 803003 803002	
Hex. socket screw bit with 1/2 in square drive Sexkantnyckel med 1/2 in fästhål Kuusiokoloholkkiavain 1/2 in sisäneliöllä	6 10 14 17	803007 803008 803009 803010	
Socket wrench Hylsgrepp Holkkiavain	13 17 19 24	807005 807006 807007 807008	

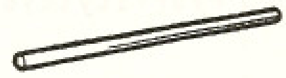
MISCELLANEOUS, DIVERSE, SEKALAISET

Extractor for gear wheels etc. Utdragare för pumparnas kugghjul m.m. Pumppujen hammaspyörien ulosvedin	837012	
Mounting device for camshaft bearing bush Monteringsverktyg för nockaxelns lagerbussning Nokka-akselin laakerin asennus-työkalu	834001	
Dismantling device for centrifugal filter Demonteringsverktyg för centri-fugalfilter Purkamistyökalu keskipakosuodat-timelle	837013	
Screw driver Skruvmejsel Ruuvitaltta	808006	
Eye bolt for fuel filter Lyftögla för bränslefilter Nostosilmukka polttoainesuodatinta varten	832004	
Brushes for cleaning charge air cooler Borstar för rengöring av laddningsluftkylare Harjat ahtoilmanjäähdyttimen puhdistusta varten	845003	
Brushes for cleaning oil- and water coolers Borstar för rengöring av olje- och CV-kylare Harjat öljyn- ja kiertoveden-jäähdyttimien puhdistusta varten	845004	

Lever ø 22x550 Spak ø 22x550 Varsi ø 22x550	844001	

R-ENGINES, R-MOTORER, R-MOOTTORIT

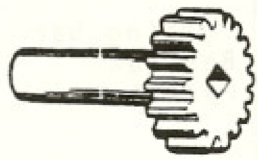
Turning bar — 844002
Baxspak
Pyöritysvipu



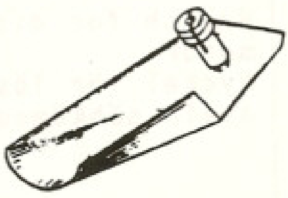
Wrench for dismantling electric motor — 803012
Nyckel för lösgöring av elmotor
Avain sähkömoottorin irrotukseen

V-ENGINES, V-MOTORER, V-MOOTTORIT

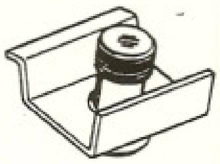
Turning device 483001
Baxverktyg
Pyoristystyökalu



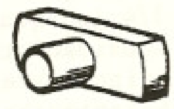
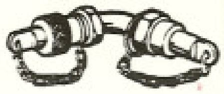
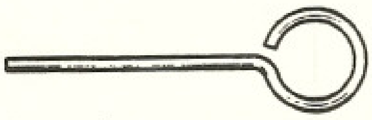
Protecting sleeve for connecting rod 835003
Skyddsskena för vevstake
Kiertokangen suojuskisko



Protecting plug for connecting rod 835004
Skyddstapp för vevstake
Kiertokangen suojustappi

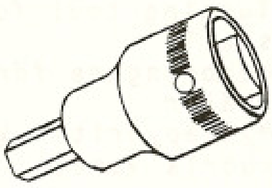


SHIELD BEARING, SKÖLDLAGER, KILPILAAKERI

Turning tool for shield bearing shell Medbringare för sköldlagrets skålar Myötäpyöritin kilpilaakerin kuoria varten	851004	
Distance sleeves Distanshylsor Väliholkit	861022	
Reducing pieces Förminskningsstycken Supistuskappaleet	861023	
Elbow coupling Vinkelkoppling Kulmaliitin	861024	
Pin for hydraulic tightening device Tapp för hydraulverktyg Tappi hydraulista työkalua varten	861025	

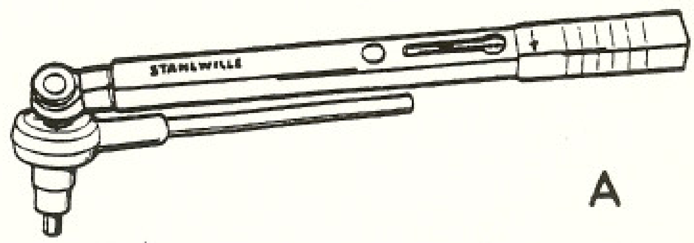
4-CYLINDER ENGINE, 4-CYLINDRIG MOTOR, 4-SYLINTERINEN MOOTTORI

Bit 14, hexagon socket screws,with
3/4 in square drive
Kuusiokoloterä 14, 3/4 in sisäneliö-
kiinnityksellä
6-kantnyckel 14, med 3/4 in 4-kant-
fästhål



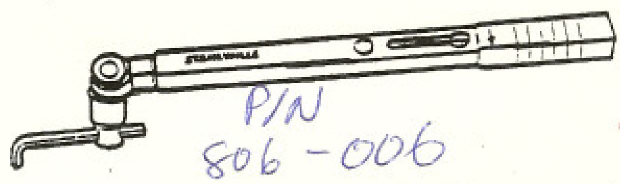
TOOL COMBINATIONS, VERKTYGSKOMBINATIONER, TYÖKALUYHDISTELMAT

Lateral tie bolt
Ramlagersidoskruv
Runkolaakerin sivuruuvi



A

Camshaft screws
Nockaxelskruvar
Nokka-akselin ruuvit



P/N
806-006

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06. ADJUSTEMENTS, 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	15 ~~19°~~ before TDC
Fuel rack position at 100% load, heavy fuel	28 mm
marine diesel fuel	30 mm
Opening pressure of fuel injection valve	320 bar

Tripping speed

Nominal engine speed	Tripping speed of mechanical overspeed trip device	Tripping speed of electro-pneumatic overspeed trip device
15 r/s (900 RPM)	17.83 r/s (1070 RPM) 18%	17.33 r/s (1040 RPM) 15%
16.7 r/s (1000 RPM)	19.67 r/s (1180 RPM)	19.17 r/s (1150 RPM)
20 r/s (1200 RPM)	23 r/s (1380 RPM)	22.5 r/s (1350 RPM)

DEGO
1080=20

06.2 Clearances and wear limits (at 20°C)

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
10	Main bearing clearance (also main thrust bearing and shield 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...~~-0.15~~ -0.015		7.38
	Bore of main bearing housing	215 +0.029...-0		
	Main bearing diameter, in situ	200 +0.239...+0.180		
	Main thrust bearing, axial clearance		0.12...0.25	0.5
	Main thrust bearing width	100 -0.160...-0.210		

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
	Corresponding crankshaft width	100 +0.035...-0		
10	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, in situ	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, width	70 -0.24 ...-0.37		
	Cylinder liner diameter	220.08 +0.046...-0	top : bottom:	220.45 220.25
	Cylinder liner circularity	0.02		0.15
11	Big end bearing clearance		0.14...0.23	
	Crank pin diameter	180 +0...-0.025		
	Crank pin circularity	0.015		
	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 diameter, in situ	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		
	Connecting rod axial clearance in piston		0.55...0.80	

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
	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 ⌀220)			
	compression rings		0.65...0.95	
	oil scraper rings		0.80...1.05	
	Piston ring height clearance			
	compression ring 1		0.12...0.15	0.35
	-"- 2		0.07...0.10	0,35
	-"- 3		0.07...0.10	0,35
	oil scraper ring		0.04...0.07	0.35
	Piston ring groove height			
	groove I	4.11 +0.02...-0		
	-"- II	4.06 +0.02...-0		
	-"- III	4.06 +0.02...-0		
	-"- IV	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		0.39...1.03	
	radial clearance around crankshaft flange		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		
	Valve seat bore in cylinder head	78 +0.019...0		
13	Intermediate gear of camshaft drive			
	bearing clearance		0.03...0.09	0.20
	axial clearance		0.15...0.35	0.50
	Bearing diameter, in situ	60 +0.03...-0		
	Bearing journal diameter	60 -0.03...-0.06		

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
	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		99.60
	- large intermediate gear	146.003 +-0.027		14
	- small intermediate gear	99.842 +-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		0.02...0.05	0.10
	bush - tappet pin		0.03...0.06	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
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		0.05...0.114	0.15
	bush - tappet pin		0.085..0.153	0.20
17	Fuel feed pump, engine driven			
	Shaft diameter	20 +0.009...-0.004		

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
	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		53.50
	Crankshaft gear for pump operation			
	Base tangent length,			
	standard design z = 70	115.348+-0.024		115.19
	fast transm.ratio z = 73	115.159+-0.024		115.00
18	Lube 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	
	Back lash for driving gear		0.36...0.49	
	Base tangent length, driving gear			
	standard design i=70/48	84.404 +-0.024		84.26
	fast transm.ratio i=73/45	84.489 +-0.024		84.35
	pump gear	42.95 +-0.030		42.50
	Lube 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	84.404 +-0.024		84.26
	fast transm.ratio i=73/45	84.489 +-0.024		84.35
	pump gear	28.53 +-0.030		28.20
19	Water pump, backlash for driving shaft gear		0.30...0.68	
	Base tangent length for driving gear			
	standard design i = 70/30	53.515 +-0.021		53.34
	fast transm.ratio i=73/27	53.735 +-0.021		53.55
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	

Pos	Part, measuring point	Drawing dimensions (mm)	Normal clearance (mm)	Wear limit (mm)
	Backlash for driving gear		0.10...0.20	0.30
23	Backlash, balancing shaft gear			
	Crankshaft gear - intermediate gear		0.1 ...0.6	
	Intermediate gear - balancing shaft gear		0.1 ...0.5	
	Balancing shaft gear		0.1 ...0.35	

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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. Note 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 connection	Torque Nm	Scale setting
1	Main bearing side screws. Use tool combination acc. to 05-15A.	1200 ±20	30 kpm
2	Shield bearing fixing. Apply Loctite 242 on threads.	210±10	21 kpm
3	Connecting rod screw (not hydraulically tightened screws). After tightening the screws are locked in pairs with steel wire ø2 mm. Apply Molykote G-n Plus under the screw head, on the screw guiding and the threads.	260±10	
4A	Counterweight pressure screw (connection 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

Pos.	Screw connection	Torque Nm	Scale setting
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 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

Pos.	Screw connection	Torque Nm	Scale setting
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
15	Injection pump head piece (L´Orange), fastening screws M10.	65±3 (0-30-50-65)	6.5 kpm
16 A	Injection pump element (L´Orange), fastening screws M12.	100±5 (0-50-80-100)	10 kpm
16 B	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 the cylinder head.	85±5	8.5 kpm
22	Starting valve: - fastening screws - stem nut	40±4 (0-20-40) 14±2	4 kpm 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

Pos.	Screw connection	Torque Nm	Scale setting
23 A	Fastening screws for water pump driving gear (connection with three Inbus Plus fastening screws)	23±3	2.3 kpm
B	Fastening screws for lubricating oil pump driving gear 6R, 8R, V22 (connection with four Inbus Plus fastening screws)	75±5	7.5 kpm
C	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	13.5kpm
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 also when tightening other screws and nuts. The following torques apply to screws of the strength 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 degreasing 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 bearing screw M42	540 bar	200	560 bar	861020
28	Cylinder head screw M42	500 bar	200	520 bar	861020
29A V22	Connecting rod screw M30x2	555 bar	85	565 bar	861027
29B R22	Connecting rod screw M30x2	555 bar	85	565 bar	861034
30	Shield bearing screw M24	285 bar	50	295 bar	861020 861030

07.3.2 Filling, venting and control of the hydraulic tool set (page 07-52)

a) 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.

b) 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.

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

d) 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.

e) Replace the filling screw and plastic plug.

f) 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).

g) 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 the centre of the 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.

<u>07.3.3 Dismantling hydraulically tightened connections</u> (page 07-52)

a) Attach the distance piece and hydraulic cylinder according to fig. 07-52A. Screw on the cylinder by hand.

b) Connect the hoses to the pump and cylinder according to the wiring diagram 07-52B. Check that the relief valve pos. 3 is open and screw the cylinders in clockwise direction to expel possible oil.

c) Screw the cylinders in counter-clockwise direction half a turn (180°).

d) Close the relief valve and pump pressure to the stated value.

e) Screw the nut in counter-clockwise direction about one turn.

f) Open the relief valve and remove the hydraulic tool set.

<u>07.3.4 Reassembling hydraulically tightened connections</u>

a) Screw on the nuts and attach the distance pieces and hydraulic cylinders. Screw on cylinders by hand.

b) Connect the hoses to the pump and cylinders. Check that the relief valve is open and screw the cylinders in clockwise direction to expel possible oil.

c) Close the relief valve and pump pressure to the stated value.

d) Screw the nut in clockwise direction until close fitting to the contact face. Keep the pressure constant at the stated value.

e) Open the relief valve and remove the hydraulic tool set.

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08. OPERATING TROUBLES, EMERGENCY OPERATION

Preventive measures, see section 03 and 04.

Some possible operating troubles require prompt action. The operators should acquire knowledge of this section for immediate action when needed.

08.1 Trouble, possible reason	See section, pos.
1. THE CRANKSHAFT DOES NOT ROTATE AT STARTING ATTEMPTS	
a) V-engines: The turning device is connected.	11, 21
NOTE: The engine cannot be started when the turning device is connected. However, before starting, always check that the turning device is removed.	
b) The starting air pressure is too low, the shut-off valve on the starting air inlet pipe is closed.	21
c) Jamming of the starting valve in the cylinder head.	21
d) Jamming of the starting air distributor piston.	21
e) The starting air solenoid is faulty.	21
f) The inlet or exhaust valve is jamming when open. No or "negative" valve clearance (strong blowing noise).	12
g) The starting automatics outside the engine are faulty.	03.1.2, 23
h) The four-cylinder engine: The starting motor is faulty.	21
2. THE CRANKSHAFT ROTATES BUT THE ENGINE FAILS TO FIRE	
a) Too low speed.	08.1.1b
b) The automatic shut-down device is not in start position.	23
c) Load limit of the control shaft or of the governor is set at too low a value.	22

Trouble, possible reason	See section, pos.
d) The overspeed trip device has tripped.	22
e) The starting fuel limiter is wrongly adjusted.	22
f) Some part of the fuel control mechanism is jamming and prevents fuel admission.	22
g) The fuel and injection system is not vented, the pipe connections between the injection pumps and the valves are not tightened.	17
h) The fuel filter is clogged.	17
i) The three-way cock of the fuel filter is wrongly set, the valve in the fuel inlet pipe is closed, the fuel day tank is empty, the fuel feed pump is not started or is faulty.	17
k) Very low air and engine temperatures (preheat the circulating water!) combined with fuel of low ignition quality.	02.1.4k
l) The fuel is insufficiently heated or precirculated.	02.1.2b, page 2
m) Too low compression pressure.	08.1.1f
3. THE ENGINE FIRES IRREGULARLY, SOME CYLINDERS DO NOT FIRE AT ALL	
a) Jamming valves, inadequate fuel supply, too low temperatures	08.1.1f, 08.1.2f, g,h,k,l, 08.1.4d
b) The injection pump control rack is wrongly adjusted.	22
c) The injection pump control sleeve doese not mesh properly with the rack (may cause overspeed if set in direction of increased fuel supply).	16
d) The injection pump is faulty (plunger or tappet sticking; delivery spring broken, delivery valve sticking).	16
e) The injection valve is faulty; the nozzle holes are clogged.	16
f) The piston rings are ruined; too low compression pressure.	11

Trouble, possible reason	See section, pos.
g) 8...16-cylinder engines: It may be troublesome to make these fire on all cylinders while idling because of the small quantity of fuel required. In normal operation this is acceptable. In special cases, in engines which have to idle continuously for longer periods (several hours) for some reason, it is advisable to adjust the rack positions carefully (reduce rack position somewhat on the cylinders having the highest exhaust gas temperatures, increase somewhat on those not firing). This adjustment should be done in small steps and the difference between the rack positions of various cylinders should not exceed 1 mm.	
4. THE ENGINE SPEED IS NOT STABLE	
a) The governor is faulty (normally too low compensation).	22
b) Some parts of the fuel control mechanism is jamming and prevents fuel admission.	
c) The fuel feed pressure is too low.	01.2.2
d) Water in the preheated fuel (vapour lock in injection pumps).	
e) The loading automatics (e.g. controllable pitch propeller) outside the engine are faulty).	23
5. KNOCKS OR DETONATIONS OCCUR IN THE ENGINE (if the reason cannot be found immediately, stop the engine!)	
a) The big end bearing clearance is too large (loose screws!)	06.2.11, 07.1.3
b) The valve spring or injection pump tappet spring is broken.	12, 16
c) The inlet or exhaust valve is jamming when open.	
d) Much too large valve clearances.	06.1, 12
e) One or more cylinders are badly overloaded.	08.1.3b,c
f) The injection pump or valve tappet guide block is loose.	16, 14

Trouble, possible reason	See section, pos.
g) Incipient phase of piston seizure.	
h) Insufficient preheating of the engine in combination with fuel of low ignition quality (combustion knock).	
6. DARK EXHAUST GASES	
a) The engine is badly overloaded (check the injection rack positions and exhaust gas temperatures).	Test Records
b) Late injection (wrongly set camshaft drive).	06.1, 16, 13
c) Faulty fuel injection pump or injection valve	08.1.3b,c,d,e
d) Insufficient charge and scavenging air pressure: - charge air filter clogged - turbocharger compressor dirty - charge air cooler clogged on air side - turbocharger turbine badly fouled	Test Records 15, 04.7 04.4
e) The load dependent cooling system is not working properly, the temperatures are too low at low load. This applies to engines running on heavy fuel, i.e. 22HF and 22HE.	18
NOTE: Engines starting on heavy fuel may smoke if left idling.	
7. THE ENGINE EXHAUST GASES ARE BLUE-WHITISH	
a) Excessive lubricating oil consumption because of gas blow-by past the 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 the sliding surfaces.	11
b) Blue whitish exhaust gases may occur occasionally when the engine has been idling for a lengthy time or at low ambient temperature, or for a short time after starting.	
8. THE EXHAUST GAS TEMPERATURES OF ALL CYLINDERS ARE ABNORMALLY HIGH	
a) The engine is badly overloaded (check the injection pump rack positions).	Test Records
b) Insufficient charge air pressure.	08.1.6d

Trouble, possible reason	See section, pos.
c) The charge air temperature is too high	Test Records, 01.2.1
- the charge air cooler clogged on the water side or dirty on the air side	15
- the temperature of the air cooler inlet water too high, the water quantity insufficient	01.3
- the engine room temperature abnormally high	01.3
d) Excessive deposits in cylinder head inlet or exhaust ports.	
e) The turbocharger compressor or turbine fouled.	04.4, 04.5, 15
9. THE EXHAUST GAS TEMPERATURE OF ONE CYLINDER IS ABOVE NORMAL	Test Records
a) Faulty exhaust gas thermometer.	23, 03.3.1a
b) The exhaust valve - jamming when open - no or "negative" valve clearance - sealing surface blown by (burned).	
c) Faulty injection valve	
- opening pressure much too low	06.1
- sticking of the nozzle needle when open	16
- broken springs.	
d) Late injection.	06.1, 16
e) The fuel filter is clogged.	
f) The injection pump is faulty.	08.1.3d
10. THE EXHAUST GAS TEMPERATURE OF ONE CYLINDER IS BELOW NORMAL	
a) Faulty exhaust gas thermometer.	23, 03.3.1a
b) Inadequate fuel supply, faulty fuel injection pump or injection valve.	08.1.2f,h, 08.1.3b,c,d,e
c) Leaky injection pipe or pipe fittings.	16
d) When idling, see point 08.1.3g.	03.3.1a
11. EXHAUST GAS TEMPERATURES VERY UNEQUAL	
a) Faulty exhaust gas thermometer, faulty fuel injection valve.	08.1.9c

Trouble, possible reason	See section, pos.
b) Too low fuel feed pressure: too small flow through the injection pumps. May cause great load differences between the cylinders although the injection pump rack positions are the same. Dangerous! Causes high thermal overload in individual cylinders.	01.2.2 08.1.2h,i
c) The fuel control mechanism is jamming.	
d) When idling, see point 08.1.3g.	08.1.3g
e) Late injection.	
12. LUBRICATING OIL PRESSURE LACKING OR TOO LOW	01.2.2
a) Faulty pressure gauge, the gauge pipe clogged	23
b) The lubricating oil level in the oil sump is too low.	01.1, 18
c) Lubricating oil pressure control valve is out of adjustment or jamming.	18
d) The three-way cock of the lubricating oil filter is wrongly set.	18
e) Leakage in the lubricating oil suction pipe connections.	18
f) The lubricating oil is badly diluted with diesel oil, the viscosity of the oil too low.	02.2.1, 02.2.3b
g) The lubricating oil pipes inside the engine are loose or broken.	18
13. TOO HIGH LUBRICATING OIL PRESSURE	
a) Faulty pressure gauge or pressure control valve.	18
14. TOO HIGH LUBRICATING OIL TEMPERATURE	01.2.1
a) Faulty thermometer.	
b) Insufficient cooling water flow through the oil cooler (faulty pump, air in the system, the valve closed), too high LT water temperature.	19
c) The oil cooler is clogged, deposits on the tubes.	18, 19
d) Faulty thermostat valve.	

Trouble, possible reason	See section, pos.
15. ABNORMALLY HIGH COOLING WATER OUTLET TEMPERATURE, THE DIFFERENCE BETWEEN COOLING WATER INLET AND OUTLET TEMPERATURES TOO LARGE	
a) One of the thermometers is faulty.	
b) The circulating water cooler is clogged, deposits on the tubes.	19
c) Insufficient flow of cooling water through the engine (the circulating water pump faulty), air in the system, the valves are closed.	19 03.3.1e
d) The thermostat valve is faulty.	19
16. THE FUEL NOZZLE TEMPERATURE CONTROL OIL TEMPERATURE TOO HIGH OR TOO LOW, THE DIFFERENCE BETWEEN THE OIL INLET AND OUTLET TEMPERATURE TOO LARGE (This applies to engines running on heavy fuel, i.e. 22HF and 22HE.)	
a) One of the thermometers is faulty.	
b) Insufficient oil flow.	
c) Gas enters the system through some faulty nozzle.	
d) Faulty thermostat valve.	17
e) Faulty heater/cooler.	17
17. WATER IN THE LUBRICATING OIL	02.2.3b, 03.3.1d
a) Leaky oil cooler.	18
b) Leakage at the cylinder liner O-rings (always pressure test when the cooling water system has been drained or the cylinder liners have been dismantled).	10.6
c) Faulty lubricating oil separator. See the separator instruction book!	02.2.3a
18. WATER IN THE CHARGE AIR RECEIVER (escapes through the drain pipe in the air cooler housing)	15
a) Leaky air coolers.	15
b) Condensation (too low charge air cooling water temperature).	03.3.1a, page 03-52

Trouble, possible reason	See section, pos.
19. THE ENGINE LOOSES SPEED AT CONSTANT OR INCREASED LOAD	
a) The engine is overloaded, a further increase of fuel supply is prevented by the mechanical load limiter.	22
b) Shortage of fuel.	08.1.2c,f,g,h,i 08.1.4c,d
c) Mechanical disturbance	08.1.5g, 08.20d
20. THE ENGINE STOPS	
a) Shortage of fuel.	08.1.2.h,i
b) The overspeed trip device has tripped.	22
c) The automatic stop device has tripped.	23
d) Faulty governor.	22
21. THE ENGINE DOES NOT STOP DESPITE THE STOP LEVEL IS SET IN STOP POSITION OR REMOTE STOP SIGNAL IS GIVEN	
a) The injection pump control rack is wrongly set.	08.1.3b,c
Trip the overspeed trip device manually. If the engine does not stop immediately, block the fuel supply as near the engine as possible (e.g. by the fuel filter three-way cock.)	
Before restarting the engine the faults must be detected and corrected.	
Great risk of overspeed	
b) Faulty stop automation. Stop by means of the stop lever.	23
c) The engine is driven by the generator or by another engine connected to the same reduction gear.	
22. THE ENGINE OVERSPEEDS AND DOES NOT STOP ALTHOUGH THE OVERSPED TRIP DEVICE TRIPS	
a) The injection pump control rack is wrongly set.	08.1.3.b,c
Load the engine, if possible.	

Trouble, possible reason	See section, pos.
Block the fuel supply, by means of the fuel filter three-way cock or block the air supply by covering the air intake filter.	
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	22
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 any measure has been taken in the control mechanism or the injection pumps.	

08.2 Emergency operation

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 of water mist flows out of the drain pipe at the bottom of the cooler housing, check wether it is cooling water or condensate. If condensate, reduce cooling (see section 03, page 03-52). If cooling water, stop the engine as soon as possible and fit a spare cooler.

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

a) 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.

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

c) 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.

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, engine output must be limited so that the normal full load exhaust temperatures are not exceeded.

3. Operation with defective cams

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

a) Fuel pump cams
Slight damage:
Set the fuel pump control rod into zero position and lock it by a wire around the pump.
Bad damage:
Remove the fuel injection pump. See section 16.

Attention!
Concerning torsional vibrations and other vibrations, see section 08.5.

When operating with a shut-off fuel pump over a long period, the inlet and outlet valve push rods 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 drain.

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

b) Valve cams

Stop fuel injection to the cylinder concerned, see section 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 section 08.5.

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

4. Operation with removed piston and connecting rod

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

- remove the piston and connecting rod

- cover the lubricating oil bore in the crank pin with a suitable hose clip, and secure,

- fit the completely assembled cylinder head but omit the push rods

- prevent starting air entry to the cylinder head by removing the pilot air pipe,

- shut down the fuel pump (section 08.3a).

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

If the turbocharger(s) surge, reduce load further to avoid continuous surging.

Operation with the piston and connecting rod of one or more cylinders removed should only be performed in absolute emergency conditions when there are no other means of proceeding under own power.

5. Torsional vibrations and other vibrations

When running the engine with one or more cylinders out of operation, the balance of the engine is disturbed, and severe or even dangerous vibrations may occur.

00 Contents, instructions, terminology

01 Main data, operating data and general design

02 Fuel oil, lubricating oil, cooling water

03 Start, stop, operation

04 Maintenance schedule

05 Maintenance tools

06 Adjustments, clearances and wear limits

07 Tightening torques and instructions for screw connections

08 Operating troubles

09 Specific installation data

10 Engine block with bearings, cylinder liners, oil sump

11 Running gear: crankshaft, connecting rod, piston

12 Cylinder head with valves

13 Camshaft drive

14 Valve timing drive and camshaft

15 Turbocharging and intercooling

16 Injection system

17 Fuel system

18 Lubricating oil system

19 Cooling water system

20 Exhaust system

21 Starting air system

22 Control gear

23 Instrumentation and automation

1. MAXIMUM LIMITS OF FUEL CHARACTERISTICS

DENSITY, AT 15 °C	(kg/l)	0,9200
VISCOSITY, KINEMATIC, AT 40 °C	(cSt)	14,00
VISCOSITY, KINEMATIC, AT 50 °C	(cSt)	11,00
VISCOSITY, KINEMATIC, AT 100 °F	(s.RI)	70,00
CARBON RESIDUE, RAMSBOTTOM	(% by weight)	2,5
WATER CONTENT	(% by volume)	0,30
WATER CONTENT, BEFORE ENGINE	(% by volume)	0,2
ASH	(% by weight)	0,05
SULPHUR CONTENT	(% by weight)	2,00
POUR POINT	(°C)	6
VANADIUM CONTENT	(mg/kg)	100
ALUMINIUM	(mg/kg)	30

2. MINIMUM LIMITS OF FUEL CHARACTERISTICS

FLASH POINT, CLOSED, PENSKY-MARTENS	(°C)	60,0

THIS SPECIFICATION IS IN ACCORDANCE WITH BS MA 100: 1932 CLASS M3 WITH ADDED LIMIT FOR WATER CONTENT BEFORE ENGINE.

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WÄRTSILÄ VASA DIESEL	Suhde SCALE	FUEL SPECIFICATION FOR DIESEL ENGINE WÄRTSILÄ VASA 22C, 22MD
Tyyppi TYPE VASA 22C, 22MD	Painot WEIGHTS kg	
Oy Wärtsilä Ab FINLAND	Mitat MEASURES mm	
Piirt. DRWN. 25.4.83 GBk/rk	Kokoonp.piir. ASSEMBLY DRG.	Piir. no DRG. NO. 4V92G27 b
Tark. CHKD.		
Hyv. APPVD.	Korvaa SUPERSEDES	Muutos

024 WT OFFSETPAINO

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	
ORDER NO.	5611 - 0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3392
DATE	
SIGN	

TEST RESULT

Test No.		1	2	3
Test time		13^{12} 31/8-84	17^{30} 31/8-84	19^{10} 31/8-84
Load	%	25%	50%	75%
Revs	rpm	547	714	818
Voltage	V			—
Current	A			—
Brake load	kp	990	1514	1983
Engine power	kW	398	795	1193
Alternator efficiency	%			—
Alternator output	kW			—
Fuel consumption/time Kg/h	~~g/min~~	92	166	245
Specific fuel consumption	g/kWh	231	209	205
Load indicator position		4.7 (14)	5.0 (18.5)	6.4
Turbocharger speed A	rpm	12900	21100	27100
Turbocharger speed B	rpm	13000	21000	27170

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	260	14	82	300	18	102	320	23	117
	A2	280		82	310		104	330		119
	A3	265		82	290		106	320		115
	A4	260		84	295		106	320		115
Cylinder	A5	275		80	285		102	310		117
	A6	280		82	295		102	320	↓	115
	A7									
	A8									
Mean values	A									
	B1	275	14	82	305	18	100	320	23	115
	B2	280		84	320		102	340		113
	B3	305		82	345		102	370		119
	B4	270		82	310		100	330		115
Cylinder	B5	280		82	300		102	320		117
	B6	270		82	310		102	330	↓	117
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	32	29	30
Cooling water temp. B/A engine (after turb.)	°C	64/71 (70)	64/71 (71)	63/72
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	20 / 21	21 / 24	20/25
Cooling water temp. B/A oil cooler	°C	21 / —	24 / —	25/—
Lube oil temp. B/A engine	°C	62/68	63/70	62/76
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	23	23	24
Scavenging air pressure	bar	0.25	0.67	1.25
HT water pressure B/A engine	bar	2.7/—	3.0	3.3
LT water pressure B/A engine	bar	1.0/—	1.2	1.5
Lube oil pressure B/A filter	bar	3.2 3.4/3.[illegible]	3.9 4.1/3.9	4.2 4.4/4.2
Fuel oil pressure B/A engine	bar	3.0 4.4/4.1	3.0	3.0
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	752	753	753
Relative humidity	%	61	59	60

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12 V 22
ENGINE NO.	NO 3392
DATE	
SIGN	

TEST RESULT

Test No.		4	5	6
Test time		20.30 31/8-84	21.30 31/8	22.15 31/8
Load	%	100	75	50
Revs	rpm	900	818	714
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	1983	1514
Engine power	kW	1590	1193	795
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time Kg/h	~~g/min~~	324	242	162
Specific fuel consumption	g/kWh	204	~~242~~ 203	204
Load indicator position		7.5	~~203~~ 6.4	4.5
Turbocharger speed A	rpm	31250	26900	20700
Turbocharger speed B	rpm	31450	27000	20750

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	350	27	131	320	23	110	300	18	96
	A2	360		138	330		114	310		98
	A3	350		129	320		114 ~~115~~	300		98
	A4	340		133	320		113	300		98
Cylinder	A5	350		131	320		113	300		98
	A6	350		129	320		112	310		98
	A7									
	A8									
Mean values	A									
	B1	350	27	129	330	23	110	300	18	98
	B2	370		129	340		110	320		96
	B3	390		133	370		114	340		98
	B4	350		127	330		112	310		96
Cylinder	B5	330		133	320		114	300		98
	B6	350		129	330		114	300		98
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	30	28	29
Cooling water temp. B/A engine	°C	64/72	60/72	64/70
Cooling water temp. B/A centr.cooler	°C	16/—	16/—	16/—
Cooling water temp. B/A air cooler	°C	20/26	22/25	20/22
Cooling water temp. B/A oil cooler	°C	26/—	25/—	22 -
Lube oil temp. B/A engine	°C	64/76	64/72	62/70
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	24	24	23
Scavenging air pressure	bar	1.75	1.25	0.65
HT water pressure B/A engine	bar	3.5	3.2	2.8
LT water pressure B/A engine	bar	1.5	1.3	1.2
Lube oil pressure B/A filter	bar	4.2 4.6/4.3	4.0 4.4/4.2	3.8 4.1/3.8
Fuel oil pressure B/A engine	bar	~~4.4~~ 3.0	3.0	3.0
Nozzle cooling pressure B/A engine	bar		—	—
Barometric pressure	mmHg	753	753	753
Relative humidity	%	60	63	64

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3392
DATE	
SIGN	

TEST RESULT

Test No.		7	8	
Test time		11.30 31/8-84	24.00 31/8	
Load	%	25	0	
Revs	rpm	547	500	
Voltage	V	–	–	
Current	A	–	–	
Brake load	kp	990	100	
Engine power	kW	398	38	
Alternator efficiency	%	–	–	
Alternator output	kW	–	–	
Fuel consumption/time kg/h	~~g/min~~	90	14	
Specific fuel consumption	g/kWh	227	367	
Load indicator position		4.5	1.0	
Turbocharger speed A	rpm	12870	5550	
Turbocharger speed B	rpm	12930	5450	

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	260	14	78	90	7	38			
	A2	270		78	120		40			
	A3	260		80	120		40			
	A4	260		78	90		38			
Cylinder	A5	270		78	130		40			
	A6	280		78	130		41			
	A7									
	A8									
Mean values	A									
	B1	270	14	78	130	7	42			
	B2	280		78	130		42			
	B3	310		80	140		44			
	B4	270		80	120		42			
Cylinder	B5	280		80	130		44			
	B6	270		78	120		41			
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	31	32	
Cooling water temp. B/A engine	°C	62/69	62/66	
Cooling water temp. B/A centr.cooler	°C	16	16	
Cooling water temp. B/A air cooler	°C	20/21	18 – 20	
Cooling water temp. B/A oil cooler	°C	21	20	
Lube oil temp. B/A engine	°C	61/69	60/62	
Nozzle cooling oil temp. B/A engine	°C	–	–	
Fuel oil temp. B engine	°C	–	–	
Ambient temperature	°C	21	20	
Scavenging air pressure	bar	0.15	0	
HT water pressure B/A engine	bar	2.4	2.2	
LT water pressure B/A engine	bar	1.0	1.0	
Lube oil pressure B/A filter	bar	3.0 3.2/2.9	2.8 3.0/2.8	
Fuel oil pressure B/A engine	bar	2.8	2.8	
Nozzle cooling pressure B/A engine	bar	–	–	
Barometric pressure	mmHg	763	763	
Relative humidity	%	64	64	

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3392
DATE	
SIGN	

TEST RESULT

Test No.		~~7~~ 9	~~8~~ 10	~~9~~ 11
Test time		07.00 3/9-84	12.45 3/9-84	13.45 3/9-84
Load	%	0	25	50
Revs	rpm	900	900	900
Voltage	V	–	–	–
Current	A	–	–	–
Brake load	kp	280	601	1201
Engine power	kW	185	398	795
Alternator efficiency	%	–	–	–
Alternator output	kW	–	–	–
Fuel consumption/time kg/h	~~g/min~~	56	91	165
Specific fuel consumption	g/kWh	300	228	208
Load indicator position		1.4 (2,2)	2.5	4.5
Turbocharger speed A	rpm	10650	14500	21350
Turbocharger speed B	rpm	10500	14450	21400

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	185	8.5	53	225	11	80	270	17	110
	A2	180		55	275		84	290		110
	A3	200		55	240		81	270		110
	A4	195		53	240		82	270		112
Cylinder	A5	220		55	245		82	270		112
	A6	220		55	220		82	280		112
	A7									
	A8									
Mean values	A									
	B1	225	8.5	56	245	11	80	280	17	110
	B2	230		57	250		83	290		110
	B3	250		57	280		84	310		112
	B4	215		56	240		82	280		112
Cylinder	B5	225		57	240		84	270		113
	B6	215		57	240		82	280		113
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	28	~~70/70~~ 29	29
Cooling water temp. B/A engine	°C	68/68	70/70	65/70
Cooling water temp. B/A centr.cooler	°C	16	~~20~~ 16	16
Cooling water temp. B/A air cooler	°C	20/20	20/20	20/22
Cooling water temp. B/A oil cooler	°C	20	20	22
Lube oil temp. B/A engine	°C	62/68	64/70	64/72
Nozzle cooling oil temp. B/A engine	°C	–	–	–
Fuel oil temp. B engine	°C	–	–	–
Ambient temperature	°C	19	19	20
Scavenging air pressure	bar	0.2	0.45	0.65
HT water pressure B/A engine	bar	3.8	3.8	3.8
LT water pressure B/A engine	bar	1.2	1.5	1.5
Lube oil pressure B/A filter	bar	4.8/4.5	4.8/4.5	4.7/4.4
Fuel oil pressure B/A engine	bar	3.5	3.5	3.2
Nozzle cooling pressure B/A engine	bar	–	–	–
Barometric pressure	mmHg	764	764	764
Relative humidity	%	62	64	64

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12 V 22
ENGINE NO.	NO 3392
DATE	
SIGN	

TEST RESULT

Test No.		12	13	14
Test time		16.30 3/9-84	3/9-84	1850 3/9-84
Load	%	75	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	1802	2403	2403
Engine power	kW	1193	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time Kg/h	~~g/min~~	242	326	325
Specific fuel consumption	g/kWh	203	205	204
Load indicator position		6.0	7.5	7.5 (28)
Turbocharger speed A	rpm	27000	31200	31300
Turbocharger speed B	rpm	26950	31300	31500

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	315	22	122	350	27	129	360	27.5	134
	A2	330		122	370		133	375		136
	A3	310		122	350		129	355		134
	A4	320		122	360		129	360		136
Cylinder	A5	305		124	340		129	345		134
	A6	320		123	360		129	360		134
	A7									
	A8									
Mean values	A									
	B1	320	22	118	350	27	129	360	27.5	134
	B2	330		118	370		129	375		134
	B3	350		122	390		131	395		136
	B4	320		122	360		127	360		134
Cylinder	B5	310		123	350		133	350		136
	B6	320		124	360		129	355		136
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	28	30	38
Cooling water temp. B/A engine	°C	70/70	64/74	64/70
Cooling water temp. B/A centr.cooler	°C	16	16	
Cooling water temp. B/A air cooler	°C	20/20	20/26	26 / 35
Cooling water temp. B/A oil cooler	°C	20	26	35
Lube oil temp. B/A engine	°C	64/70	64/76	66 / 74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	21	22	23
Scavenging air pressure	bar	1.2	1.75	1.75
HT water pressure B/A engine	bar	3.8	3.8	3.8/ —
LT water pressure B/A engine	bar	1.5	1.5	0.65/ —
Lube oil pressure B/A filter	bar	4.7/4.4	4.6/4.3	4.6/4.3
Fuel oil pressure B/A engine	bar	—	—	3.0/ —
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	764	764	750
Relative humidity	%	65	67	68

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	ND 3392
DATE	3/9-84
SIGN	[signature]

TEST RESULT

Test No.		15	16	17
Test time		20^50 3/9-84	22^50 3/9-84	00^50 4/9-84
Load	%	100%	100%	100%
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	g/min	327	327	325
Specific fuel consumption	g/kWh	206	206	204
Load indicator position		7.5 (28)	7.5 (28)	7.5 (28)
Turbocharger speed A	rpm	31400	31400	31300
Turbocharger speed B	rpm	31600	31600.	31400

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	365	27.5		370	27.5		365	27.5	
	A2	380			375			370		
	A3	355			355			350		
	A4	365			360			360		
Cylinder	A5	350			345			340		
	A6	365	↓		365	↓		355	↓	
	A7									
	A8									
Mean values	A									
	B1	360	27.5		360	27.5		355	27.5	
	B2	375			370			370		
	B3	400			400			395		
	B4	365			360			360		
Cylinder	B5	350			350			350		
	B6	360	↓		360	↓		355	↓	
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	37	37	37
Cooling water temp. B/A engine	°C	64/70	64/70	64/70
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	24/36	26/35	26/34
Cooling water temp. B/A oil cooler	°C	36/	35/	34/—
Lube oil temp. B/A engine	°C	66/74	66/74	66/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	23	25	23
Scavenging air pressure	bar	1.75	1.8	1.8
HT water pressure B/A engine	bar	3.8/—	3.8/—	3.8/—
LT water pressure B/A engine	bar	0.65/—	0.65/—	0.65/—
Lube oil pressure B/A filter	bar	4.6/4.3	4.6/4.3	4.6/4.3
Fuel oil pressure B/A engine	bar	3.0/—	3.0/—	3.0/—
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	748	747	748
Relative humidity	%	67	67	64

NOHAB DIESEL
WARTSILÄ DIESEL DIVISION

TEST REPORT	ORDER NO. 5611-0100
	ENGINE TYPE 12V22
ORDERED BY	ENGINE NO. ND 3392
	DATE 4/9-84
	SIGN

TEST RESULT

Test No.		18	19	20
Test time		02⁵⁰ 4/9-84	04⁵⁰ 4/9-84	06⁵⁰ 4/9-84
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time Kg/h	~~g/min~~	324	325	322
Specific fuel consumption	g/kWh	204	204	203
Load indicator position		7.5 (28)	7.5 (28)	7.5
Turbocharger speed A	rpm	31300	31200	31050
Turbocharger speed B	rpm	31400	31300	31250

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	27.5		360	27.5		360	27.5	
	A2	370	↓		370	↓		370	↓	
	A3	350			350			340		
	A4	355			350			350		
Cylinder	A5	340			340			330		
	A6	355			350			350		
	A7									
	A8									
Mean values	A									
	B1	350	27.5		350	27.5		350	27.5	
	B2	370	↓		365	↓		370	↓	
	B3	395			395			380		
	B4	360			360			360		
Cylinder	B5	350			345			350		
	B6	350			350			350		
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	37	36	35
Cooling water temp. B/A engine	°C	64/70	64/70	64/72
Cooling water temp. B/A centr.cooler	°C			—
Cooling water temp. B/A air cooler	°C	26/34	25/34	24/34
Cooling water temp. B/A oil cooler	°C	34/	34/	34/
Lube oil temp. B/A engine	°C	66/74	66/74	~~[illegible]~~ 66/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	22	20	19
Scavenging air pressure	bar	1.8	1.8	1.8
HT water pressure B/A engine	bar	3.8/—	3.8/—	3.8
LT water pressure B/A engine	bar	0.65/—	1.1/—	1.5
Lube oil pressure B/A filter	bar	4.6/4.3	4.6/4.3	4.6/4.3
Fuel oil pressure B/A engine	bar	3.0/—	3.0/—	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	748	749	750
Relative humidity	%	62	59	57

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3392
DATE	4/9-84
SIGN	

TEST RESULT

Test No.		21	22	23
Test time		08.50 4/9-84	10.50 4/9-84	12.30 4/9-84
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	g/min	322	322	326
Specific fuel consumption	g/kWh	203	203	205
Load indicator position		7.5	7.5	7.5
Turbocharger speed A	rpm	31300	31200	31200
Turbocharger speed B	rpm	31100	31300	31350

NY MÄT

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	27.5	120	350	27.5	~~[illegible]~~ 127	360	27.5	127
	A2	370		138	370		120	350		131
	A3	350	(127)	130	350		128	360		129
	A4	350		130	350		127	340		127
Cylinder	A5	340		130	340		122	360		127
	A6	350		130	350		127	350		127
	A7									
	A8									
Mean values	A									
	B1	350	27.5	120	350	27.5	122	350	27.5	127
	B2	360		130	370		127	370		129
	B3	390		138	400		132	400		133
	B4	360		130	360		127	360		129
Cylinder	B5	350		130	350		127	350		132
	B6	350		130	360		127	360		132
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	37	37	36
Cooling water temp. B/A engine	°C	64/72	64/72	64/72
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	24/34	26/34	26/34
Cooling water temp. B/A oil cooler	°C	34	34	34
Lube oil temp. B/A engine	°C	66/74	64/74	66/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	20	20	20
Scavenging air pressure	bar	1.8	1.8	1.8
HT water pressure B/A engine	bar	3.8	3.8	3.8
LT water pressure B/A engine	bar	1.2	1.0	1.0
Lube oil pressure B/A filter	bar	4.2	4.2	4.3
Fuel oil pressure B/A engine	bar	3.0	2.8	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	754	754	750
Relative humidity	%	56	56	55

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3392
DATE	84-09-04
SIGN	

TEST RESULT

Test No.		24	25	26
Test time		13.30 4/9-84	14.30 4/9-84	16.15 4/9-89
Load	%	110	110	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2643	2643	2403
Engine power	kW	1749	1749	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	~~g/min~~	360	360	322
Specific fuel consumption	g/kWh	206	206	203
Load indicator position		8.0	8.0	7.5
Turbocharger speed A	rpm	32600	32550	31100
Turbocharger speed B	rpm	32830	32800	31270

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	380	30	135	380	30	135	360	27.5	127
	A2	390		139	390		139	380		131
	A3	370		137	370		137	350		127
	A4	380		137	380		137	360		129
Cylinder	A5	360		137	360		137	340		127
	A6	380		137	380		137	360		127
	A7									
	A8									
Mean values	A									
	B1	370	30	135	370	30	135	360	27.5	127
	B2	390		137	390		137	370		129
	B3	400		139	400		139	380		133
	B4	380		137	380		137	360		127
Cylinder	B5	370		140	370		140	360		133
	B6	380		139	380		139	360		133
	B7									
	B8									
Mean values	B									

	°C			
	°C		~~38~~	
Scavenging air temperature	°C	39	38	36
Cooling water temp. B/A engine	°C	64/72	64/72	64/72
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	26/38	28/38	26/36
Cooling water temp. B/A oil cooler	°C	38	38	36
Lube oil temp. B/A engine	°C	66/76	68/76	66/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	21	21	21
Scavenging air pressure	bar	2.0	2.0	1.8
HT water pressure B/A engine	bar	3.9	3.9	3.6
LT water pressure B/A engine	bar	1.0	1.0	1.05
Lube oil pressure B/A filter	bar	4.5/4.2	4.5/4.2	4.6/4.3
Fuel oil pressure B/A engine	bar	2.7	2.7	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	750	750	750
Relative humidity	%	55	54	55

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO3391 (V3073)
DATE	9/9-84
SIGN	Shd

TEST RESULT

Test No.		1	2	3
Test time		9/9-84	9/9-84	9/9-84
Load	%		25	50
Revs	rpm	900	900	900
Voltage	V			
Current	A			
Brake load	kp	240	601	1201
Engine power	kW	159	398	795
Alternator efficiency	%			
Alternator output	kW			
Fuel consumption/time kg/h	~~g/min~~	51	94.5	165
Specific fuel consumption	g/kWh	(322)	237	208
Load indicator position		1.5 (7.5)	2.7 (11.5)	4.5 (17)
Turbocharger speed A	rpm	10200	14900	22200
Turbocharger speed B	rpm	10600	15200	22300

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	190	7.5	49	230	11	69	280	16.5	98
	A2	200	↓	49	230	↓	↓	265	↓	98
	A3	200	↓	44	230	↓	↓	270	↓	103
	A4	210	↓	49	240	↓	↓	280	↓	98
Cylinder	A5	200	↓	44	250	↓	↓	280	↓	98
	A6	200	↓	44	235	↓	↓	275	↓	98
	A7									
	A8									
Mean values	A									
	B1	240	7.5	49	280	11	69	300	16.5	93
	B2	225	↓	44	270	↓	↓	285	↓	93
	B3	240	↓	49	270	↓	↓	275	↓	93
	B4	190	↓	49	240	↓	↓	285	↓	98
Cylinder	B5	250	↓	49	270	↓	↓	290	↓	93
	B6	260	↓	49	265	↓	↓	310	↓	103
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	29	29	34
Cooling water temp. B/A engine	°C	68/70	69/70	69/70
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	20/21	22/24	26/30
Cooling water temp. B/A oil cooler	°C	21/–	24/–	30/–
Lube oil temp. B/A engine	°C			
Nozzle cooling oil temp. B/A engine	°C	62/68	64/71	65/74
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	17	18	19
Scavenging air pressure	bar	0.1	0.3	0.75
HT water pressure B/A engine	bar	3.7	3.8	3.8
LT water pressure B/A engine	bar	1.25	1.20	1.25
Lube oil pressure B/A filter	bar	4.1 4.4/4.2	4.1 4.4/4.2	4.0 4.3/4.1
Fuel oil pressure B/A engine	bar	3.5	3.5	3.5
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	749	749	749
Relative humidity	%	68	68	68

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3391 (V3073)
DATE	84.09.09
SIGN	

TEST RESULT

Test No.		4	5	6
Test time				
Load	%	75	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	1802	2403	2403
Engine power	kW	1193	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time Kg/h	~~kg/min~~	242	323	323
Specific fuel consumption	g/kWh	203	203	203
Load indicator position		6.2 (22)	7.8 (27.5)	8. (27.5)
Turbocharger speed A	rpm	28000	32000	32000
Turbocharger speed B	rpm	27900	31900	31900

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	320	22	110	360	27.5	132	360	27.5	137
	A2	305		107	330		127	330		133
	A3	310		108	340		132	340		133
	A4	320		108	350		127	350		127
Cylinder	A5	320		108	355		132	360		135
	A6	310		112	350		127	350		129
	A7									
	A8									
Mean values	A									
	B1	340	22	105	390	27.5	132	390	27.5	133
	B2	330		105	365		127	370		132
	B3	335		105	370		132	370		135
	B4	315		110	345		127	350		132
Cylinder	B5	335		112	365		132	370		132
	B6	345		115	375		132	370		139
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	32	34	35
Cooling water temp. B/A engine	°C	72/70	68/70	64/72
Cooling water temp. B/A centr.cooler	°C		—	—
Cooling water temp. B/A air cooler	°C	28/38	26/36	26/38
Cooling water temp. B/A oil cooler	°C	38	36	38
Lube oil temp. B/A engine	°C	68/78	67/75	68/76
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	19.5	21	21
Scavenging air pressure	bar	1.35	1.77	1.85
HT water pressure B/A engine	bar	3.8	3.6	3.6
LT water pressure B/A engine	bar	1.3	1.2	1.1
Lube oil pressure B/A filter	bar	4.1 4.4/4.2	4.1 4.4/4.2	4.1 4.4/4.1
Fuel oil pressure B/A engine	bar	3.3	3.3	3.0
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	749	749	745
Relative humidity	%	68	66	65

NOHAB DIESEL
WARTSILÄ DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3391 (V3073)
DATE	84.09.10
SIGN	

TEST RESULT

Test No.		7	8	9
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	~~g/min~~	326	324	324
Specific fuel consumption	g/kWh	~~336~~ 205	204	204
Load indicator position		~~205~~ 7.8	7.8 (27.5)	7.8 (27.5)
Turbocharger speed A	rpm	32000	32100	32000
Turbocharger speed B	rpm	32000	32000	32000

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	27.5	139	360	27.5	139	360	27.5	137
	A2	330		135	340		137	330		137
	A3	340		137	340		137	340		137
	A4	350		133	350		132	350		132
Cylinder	A5	360		139	350		137	360		139
	A6	350		132	350		132	360		132
	A7									
	A8									
Mean values	A									
	B1	390	27.5	135	390	27.5	135	390	27.5	135
	B2	370		137	370		137	370		137
	B3	370		137	370		139	370		137
	B4	350		132	350		135	350		135
Cylinder	B5	370		132	370		132	370		133
	B6	370		139	380		143	370		139
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	35	34
Cooling water temp. B/A engine	°C	64/72	64/72	62/72
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	26/38	26/38	24/38
Cooling water temp. B/A oil cooler	°C	38	38	38
Lube oil temp. B/A engine	°C	68/76	66/76	66/76
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	21	19	19
Scavenging air pressure	bar	1.85	1.95	1.9
HT water pressure B/A engine	bar	3.65	3.7	3.65
LT water pressure B/A engine	bar	1.1	1.1	1.1
Lube oil pressure B/A filter	bar	4.1 4.4/4.1	4.0 4.4/4.1	4.0 4.4/4.1
Fuel oil pressure B/A engine	bar	3.0	3.0	3.2
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	745	745	745
Relative humidity	%	65	65	65

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12V22
ENGINE NO.	ND 3391 (V3073)
DATE	84-09-10
SIGN	

TEST RESULT

Test No.		10	11	12
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	
Current	A	—	—	
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	~~g/min~~	324	323	322
Specific fuel consumption	g/kWh	204	203	203
Load indicator position		7.8 (27.5)	7.8 (27.5)	7.8 (27.5)
Turbocharger speed A	rpm	32000	32000	31900
Turbocharger speed B	rpm	32000	32000.	31900

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	27.5	138	360	27.5	138	360	27.5	138
	A2	330		138	330		138	335		138
	A3	340		138	340		138	340		138
	A4	350		131	350		131	350		131
Cylinder	A5	360		138	360		138	355		138
	A6	350		132	350		132	350		132
	A7									
	A8									
Mean values	A									
	B1	390	27.5	137	390	27.5	138	390	27.5	138
	B2	370		136	370		132	365		132
	B3	370		137	370		132	370		132
	B4	350		132	350		137	350		137
Cylinder	B5	370		132	370		132	370		132
	B6	375		138	370		138	375		138
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	35	35
Cooling water temp. B/A engine	°C	62/72	62/72	64/70
Cooling water temp. B/A centr.cooler	°C	-	—	—
Cooling water temp. B/A air cooler	°C	26/40	26/40	26/37
Cooling water temp. B/A oil cooler	°C	40	40/—	37 /—
Lube oil temp. B/A engine	°C	67/76	66/75	67/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	19	19	20
Scavenging air pressure	bar	1.9	1.9	1.9
HT water pressure B/A engine	bar	3.6	3.6	3.6
LT water pressure B/A engine	bar	1.2	1.2	1.2
Lube oil pressure B/A filter	bar	4.0 4.4/4.2	4.0 4.4/4.1	4.0 4.4/4.1
Fuel oil pressure B/A engine	bar	3.0	3.2	3.2
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	744	744	744
Relative humidity	%	66	67	67

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	ND3391 (V3073)
DATE	
SIGN	19/9-84

TEST RESULT

Test No.		13	14	15
Test time				
Load	%	100	110	110
Revs	rpm	900	900	900
Voltage	V			
Current	A			
Brake load	kp	2403	2643	2643
Engine power	kW	1590	1749	1749
Alternator efficiency	%			
Alternator output	kW			
Fuel consumption/time kg/h	g/min	323	357	363
Specific fuel consumption	g/kWh	203	204	207
Load indicator position		7.8 (27.5)	8.5 (30)	8.5 30
Turbocharger speed A	rpm	32000	33400	33600
Turbocharger speed B	rpm	32000	33400	33600

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	27.5	137	380	30	146	385	30	146
	A2	335		137	355		149	360		149
	A3	345		137	360		141	365		141
	A4	350		131	370		141	370		141
Cylinder	A5	360		138	380		146	380		146
	A6	355		133	375		138	375		138
	A7									
	A8									
Mean values	A									
	B1	390	27.5	137	410	30	142	415	30	142
	B2	365		132	390		144	390		144
	B3	375		132	390		147	400		147
	B4	350		137	365		143	375		143
Cylinder	B5	370		136	390		144	390		144
	B6	370		137	395		149	395		149
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	36	37
Cooling water temp. B/A engine	°C	64/72	70/72	70/72
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	26/38	26/38	26/38
Cooling water temp. B/A oil cooler	°C	38/—	38/—	38/—
Lube oil temp. B/A engine	°C	67/75	68/76	68/76
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	21	23	24
Scavenging air pressure	bar	1.9	2.1	2.1
HT water pressure B/A engine	bar	3.55	3.45	3.4
LT water pressure B/A engine	bar	1.8	1.35	1.35
Lube oil pressure B/A filter	bar	4.0 4.3/4.1	4.0 4.3/4.1	4.0 4.3/4.1
Fuel oil pressure B/A engine	bar	3.0	3.2	3.1
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	744	744	744
Relative humidity	%	66	61	61

NOHAB DIESEL

Dokumentnamn: Eng nr ND 3391 V 3073

Uttärdare | Sign | Ref | Tel | Datum | Beteckning · Ref.nr · Dokumentnr: 5611-0100

Ärende | Distribution

TEST NO.	1	2	3	4	5	6
LOAD	0	25	50	75	100	100
TEMP. BEFORE COMP.	36	33	33	34	26	26
TEMP. AFTER COMP.STB.CH.	44	61	101	140	169	170
TEMP. BEFORE TURB. UPPER STB.	189	272	356	415	458	461
TEMP. BEFORE TURB. LOWER STB.	199	276	361	419	463	464
TEMP. BEFORE TURB. UPPER PORT	230	306	379	442	488	489
TEMP. BEFORE TURB. LOWER PORT	240	304	380	438	480	480
TEMP. AFTER TURB. STB.	166	224	272	293	306	307
TEMP. AFTER TURB. PORT	205	254	292	312	324	324
PRESS. AFTER COMP. (BAR)	0.17	0.33	0,78	1.25	1.85	1.85
PRESS. BEFORE TURB. (BAR)	0.05	0,25	0.60	1.20	1.75	1.7
PRESS. AFTER TURB. STB (MM H_2O) A	2	3	5	7.5	7.5	5
PRESS.AFTER TURB. PORT (MM H_2O) B	3	3	5	7.5	5	10
CRANKCASE VACUUM PRES.	4	3	2	0	0	0

NOHAB DIESEL

Dokumentnamn	Sida nr
Eng nr ND 3391 V 3073	

Utfärdare	Sign	Ref	Tel	Datum	Beteckning Retur-Dokumentnr
					5611-0100

Ärende

Distribution

TEST NO.	7	8	9	10	11	12
LOAD	100	100	100	100	100	100
TEMP. BEFORE COMP.	25	33	33	33	33	34
TEMP. AFTER COMP.STB.CH.	170	175	174	174	174	173
TEMP. BEFORE TURB. UPPER STB.	462	466	465	464	465	464
TEMP. BEFORE TURB. LOWER STB.	466	469	466	467	469	468
TEMP. BEFORE TURB. UPPER PORT	493	496	493	494	494	493
TEMP. BEFORE TURB. LOWER PORT	482	486	484	484	484	482
TEMP. AFTER TURB. STB.	308	311	310	311	311	311
TEMP. AFTER TURB. PORT	326	329	328	328	328	328
PRESS. AFTER COMP. (BAR)	1.85	~~1.85~~ 1.9	1,9	1.9	1.9	1,85
PRESS. BEFORE TURB. (BAR)	1.8	1.8	1.8	1.8	1.8	1.65
PRESS. AFTER TURB. STB (MM H_2O)	5	7	12	12	12	12
PRESS.AFTER TURB. PORT (MM H_2O)	10	12	18	18	10	8
CRANKCASE VACUUM PRES.	0	0	0	0	0	0

NOHAB DIESEL

Dokumentnamn: Eng nr ND 3391 V 3073

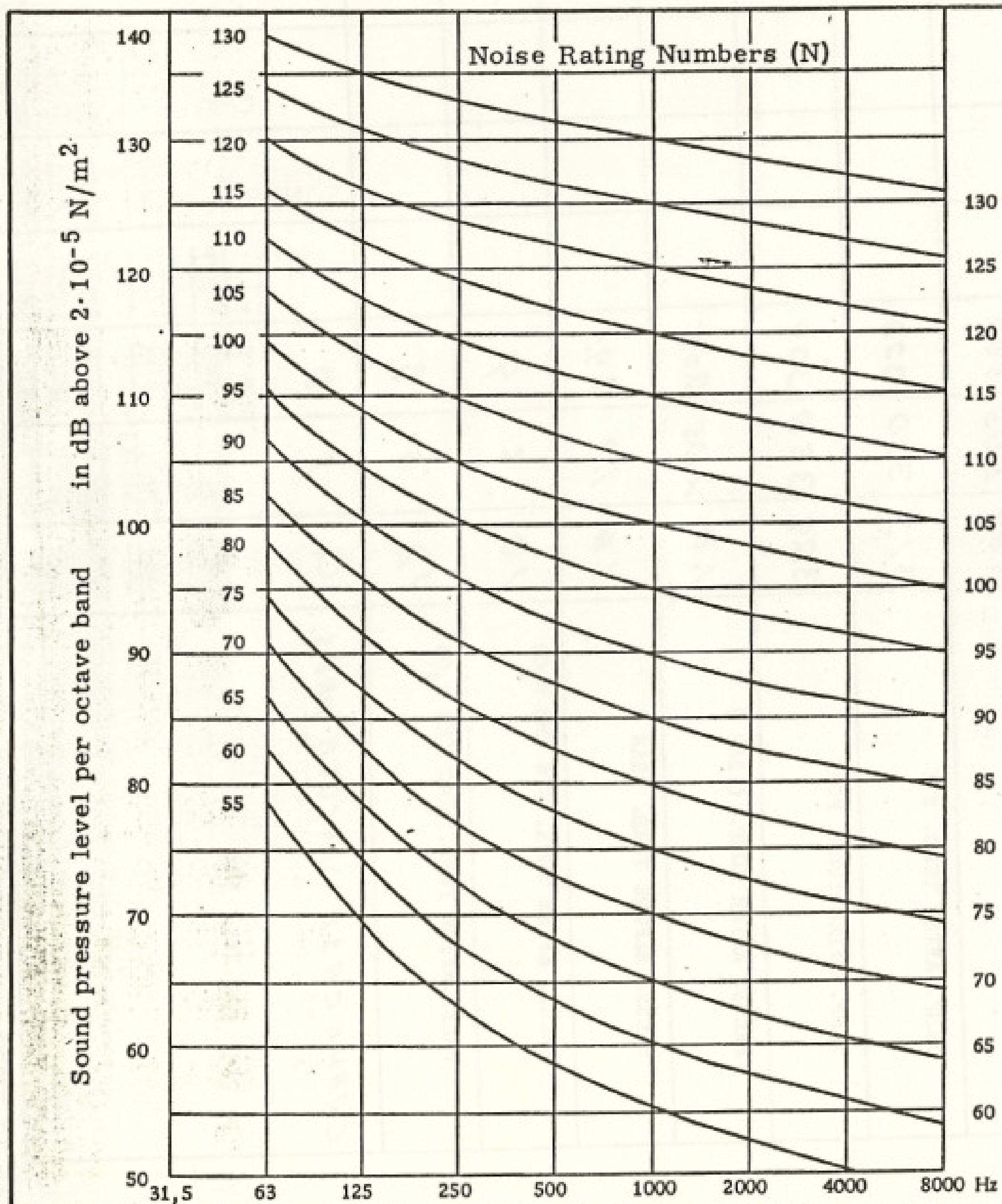
Sida nr

Utfärdare | Sign | Ref | Tel | Datum: 10/9-84 | Beteckning Ref.nr Dokumentnr: 5611-0100

Ärende | Distribution

TEST NO.	13	14	15				
LOAD	100	110	110				
TEMP. BEFORE COMP.	34	26	28				
TEMP. AFTER COMP.STB.CH.	174	183	185				
TEMP. BEFORE TURB. UPPER STB.	466	485	489				
TEMP. BEFORE TURB. LOWER STB.	470	489	491				
TEMP. BEFORE TURB. UPPER PORT	495	518	521				
TEMP. BEFORE TURB. LOWER PORT	484	505	507				
TEMP. AFTER TURB. STB.	313	320	322				
TEMP. AFTER TURB. PORT	329	338	339				
PRESS. AFTER COMP. (BAR)	1.8	2.05	2.05				
PRESS. BEFORE TURB. (BAR)	1.8	1.9	1.95				
PRESS. AFTER TURB. STB (MM H_2O)	10	6	4				
PRESS.AFTER TURB. PORT (MM H_2O)	12	3	2				
CRANKCASE VACUUM PRES.	0	1	2				

ND 101 BIARK-offset



Measuring point	A	B	
Total dB			
Filter C dB			
Filter B dB			
Filter A dB			
Band centre freq. in Hz	dB	dB	dB
31,5	85	82	
63	88	92	
125	93	96	
250	99	96	
500	98	101	
1000	102	100	
2000	99	96	
4000	98	101	
8000	98	102	
16000	91	97	
31500	76	78	

BOFORS NOHAB

Plant: BOX 4 ENGINE NO ND 33917 12V22

Date: 840910

Measuring point: 5611-0800

Time:

Drawing:

Sign.:

Remarks:

Dept.:

NOHAB DIESEL

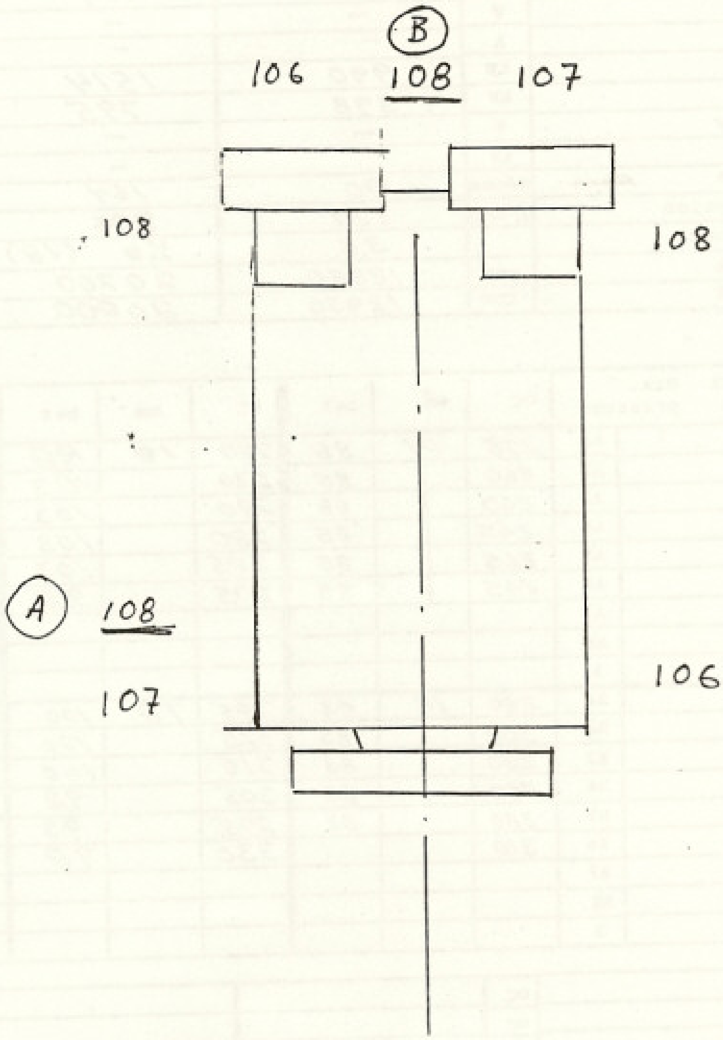
Dokumentnamn	Sida nr

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr/Dokumentnr
				840910	

Ärende	Distribution

NOISE LEVEL dB(A) AT 100% 1590 KW

ENGINE NO ND 3391 (V 3073)



ND 101 BJARK-offset

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	ND 3394 (V 3074)
DATE	84-09-05
SIGN	

TEST RESULT

Test No.		1	2	3
Test time		18.45 5/9-84		
Load	%	25	50	75
Revs	rpm	547	714	818
Voltage	V	–	–	–
Current	A	–	–	–
Brake load	kp	990	1514	1983
Engine power	kW	398	795	~~818~~ 1193
Alternator efficiency	%	–	–	–
Alternator output	kW	–	–	–
Fuel consumption/time Kg/h	~~g/min~~	90	164	245
Specific fuel consumption	g/kWh	227	206	205
Load indicator position		3.5	4.8 (18)	6.7 (23.5)
Turbocharger speed A	rpm	12850	20700	27500
Turbocharger speed B	rpm	12930	20800	27400

Exhaust temperature Fuel rack position Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	255	14	85	280	18	98	320	23	118
	A2	260	↓	85	280		103	325	↓	123
	A3	260		88	290		103	330		118
	A4	245		85	280		103	330		123
Cylinder	A5	265		85	285		103	320		123
	A6	245		88	275		98	295		113
	A7									
	A8									
Mean values	A									
	B1	280	14	83	305	18	100	310	23	118
	B2	300		83	325		100	325	↓	123
	B3	280		83	310		100	320		123
	B4	280		83	305		93	318		123
Cylinder	B5	280		83	295		93	295		118
	B6	310			330		98	335		118
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	32	30	31
Cooling water temp. B/A engine	°C	64/69	64/68	62/69
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	22/24	22/24	23/29
Cooling water temp. B/A oil cooler	°C			
Lube oil temp. B/A engine	°C	60/67	62/70	64/68
Nozzle cooling oil temp. B/A engine	°C			
Fuel oil temp. B engine	°C			
Ambient temperature	°C	20	18	18
Scavenging air pressure	bar	0.25	0.73	1.4
HT water pressure B/A engine	bar	2.95	3.25	3.45
LT water pressure B/A engine	bar	0.75	0.85	0.95
Lube oil pressure B/A filter	bar	3.0	3.8 4.1/3.8	4.0 4.3/4.1
Fuel oil pressure B/A engine	bar	2.9	2.8	2.9
Nozzle cooling pressure B/A engine	bar			
Barometric pressure	mmHg	759	760	760
Relative humidity	%	45	49	48

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	ND3394 (V3074)
DATE	84-09-06
SIGN	

TEST RESULT

Test No.		4	5	6
Test time				
Load	%	100	75	50
Revs	rpm	900	900	900
Voltage	V			–
Current	A			–
Brake load	kp	2403	1802	1201
Engine power	kW	1590	1193	795
Alternator efficiency	%			–
Alternator output	kW			–
Fuel consumption/time	g/min	323	240	165
Specific fuel consumption	g/kWh	205	201	208
Load indicator position		8.1 (28.5)	6.4 (22)	4.5 (2.2)
Turbocharger speed A	rpm	31800	27500	21900
Turbocharger speed B	rpm	31600	27500	21800

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	345	28	132	300	22	108	270	17	98
	A2	350		138	310		113	270		103
	A3	365		132	320		115	270		98
	A4	350		132	310		113	260		103
Cylinder	A5	340		137	305		118	260		103
	A6	325		127	280		110	240		98
	A7									
	A8									
Mean values	A									
	B1	335	28	137	305	22	110	270	17	105
	B2	350		140	325		115	290		98
	B3	340		140	310		113	270		103
	B4	330		125	305		105	270		98
Cylinder	B5	320		125	295		105	260		98
	B6	365		132	335		115	290		103
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	34	31	29
Cooling water temp. B/A engine	°C	63/69	63/68	64/70
Cooling water temp. B/A centr.cooler	°C	~~24/3~~	—	—
Cooling water temp. B/A air cooler	°C	24/34	23/29	20/24
Cooling water temp. B/A oil cooler	°C	34/–	29/–	24
Lube oil temp. B/A engine	°C	64/72	63/71	62/72
Nozzle cooling oil temp. B/A engine	°C	—	—	–
Fuel oil temp. B engine	°C	—	—	–
Ambient temperature	°C	17	16	18
Scavenging air pressure	bar	2.0	1.4	0.7
HT water pressure B/A engine	bar	3.7	3.7	3.7
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.2 4.5/4.0	4.2 4.6/4.2	4.4 4.7/4.5
Fuel oil pressure B/A engine	bar	2.8	2.8	2.9
Nozzle cooling pressure B/A engine	bar	—	—	–
Barometric pressure	mmHg	760	760	760
Relative humidity	%	48	48	48

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 – 0100
ENGINE TYPE	12 V 22
ENGINE NO.	NO 3394 (V 3074)
DATE	84.09.06
SIGN	

TEST RESULT

Test No.		7	8	9
Test time				
Load	%	25	0	100
Revs	rpm	900	900	900
Voltage	V	–	–	–
Current	A	–	–	–
Brake load	kp	601	270	2403
Engine power	kW	398	180	1590
Alternator efficiency	%	–	–	–
Alternator output	kW	–	–	–
Fuel consumption/time Kg/h	~~g/min~~	95	57	319
Specific fuel consumption	g/kWh	235	317	200
Load indicator position		3.0 (11)	1.5 (7)	8.0 (27.5)
Turbocharger speed A	rpm	15000	10700	31700
Turbocharger speed B	rpm	15000	10800	31600

Exhaust temperature, Fuel rack position, Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	250	11	83	210	7	54	350	27.5	129
	A2	240		83	200		53	360		135
	A3	240		78	210		54	360		132
	A4	220		78	180		53	350		132
Cylinder	A5	240		78	210		53	340		135
	A6	200		78	170		51	370		135
	A7									
	A8									
Mean values	A									
	B1	230	11	78	210	7	54	340	27.5	132
	B2	270		78	230		55	360		136
	B3	240		78	200		53	350		136
	B4	230		78	200		54	340		130
Cylinder	B5	240		78	220		55	330		130
	B6	250		82	230		55	370		132
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	27	24	35
Cooling water temp. B/A engine	°C	66/70	66/68	64/72
Cooling water temp. B/A centr.cooler	°C	–	–	–
Cooling water temp. B/A air cooler	°C	20/22	18/20	24/34
Cooling water temp. B/A oil cooler	°C	22	20	34
Lube oil temp. B/A engine	°C	60/68	60/66	62/74
Nozzle cooling oil temp. B/A engine	°C	–	–	–
Fuel oil temp. B engine	°C	–	–	–
Ambient temperature	°C	16	14	19
Scavenging air pressure	bar	0.35	0.2	1.8
HT water pressure B/A engine	bar	3.6	3.6	3.6
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.4 4.8/4.5	4.4 4.8/4.5	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	3.0	3.0	2.8
Nozzle cooling pressure B/A engine	bar	–	–	–
Barometric pressure	mmHg	761	761	761
Relative humidity	%	47	47	48

NOHAB DIESEL
WARTSILÄ DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12 V 22
ENGINE NO.	ND 3394 (V 3074)
DATE	84.09.06
SIGN	

TEST RESULT

Test No.		10	11	12
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	~~g/min~~	319	319	323
Specific fuel consumption	g/kWh	200	200	203
Load indicator position		8.0 (27.5)	8.0 27.5	8.5 27.5
Turbocharger speed A	rpm	31600	31600	31600
Turbocharger speed B	rpm	31600	31500	31500

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	345	27.5	129	345	27.5	129	350	27.5	129
	A2	355		135	360		135	360		137
	A3	365		132	370		132	370		132
	A4	350		138	350		132	350		132
Cylinder	A5	340		135	340		135	340		137
	A6	320		135	325		135	320		130
	A7									
	A8									
Mean values	A									
	B1	350	27.5	132	350	27.5	132	350	27.5	137
	B2	360		136	360		136	360		137
	B3	350		136	350		136	350		140
	B4	340		130	340		130	340		130
Cylinder	B5	330		130	330		130	330		130
	B6	380		135	380		135	380		137
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	35	35
Cooling water temp. B/A engine	°C	64/72	64/72	66/72
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	24/34	24/34	26/34
Cooling water temp. B/A oil cooler	°C	34	34	34
Lube oil temp. B/A engine	°C	64/76	64/76	64/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	19	19	23
Scavenging air pressure	bar	1.8	1.8	1.8
HT water pressure B/A engine	bar	3.6	3.6	3.6
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.2 4.5/4.2	4.2 4.5/4.2	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	2.8	2.8	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	761	761	761
Relative humidity	%	49	49	47

NOHAB DIESEL
WÄRTSILÄ DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3394 (V3074)
DATE	84.09.06
SIGN	

TEST RESULT

Test No.		13	14	15
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	–	–	–
Current	A	–	–	–
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	–	–	–
Alternator output	kW	–	–	–
Fuel consumption/time	~~g/min~~ Kg/h	322	322	322
Specific fuel consumption	g/kWh	203	203	203
Load indicator position		8.5 (27.5)	8.0 (28.0)	8.0 (27.5)
Turbocharger speed A	rpm	31600	31600	31600
Turbocharger speed B	rpm	31500	31500	31500

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	350	27.5	129	350	28.0	137	350	27.5	129
	A2	360		137	360		142	360		137
	A3	370		132	370		142	370		132
	A4	350		132	350		137	350		132
Cylinder	A5	340		137	350		137	360		137
	A6	320		130	330		137	340		130
	A7									
	A8									
Mean values	A									
	B1	350	27.5	137	350	28.0	137	340	27.5	137
	B2	360		137	370		142	360		137
	B3	350		140	360		135	360		142
	B4	340		130	340		135	350		130
Cylinder	B5	330		130	330		137	330		130
	B6	380		137	380		135	380		137
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	36	35	37
Cooling water temp. B/A engine	°C	66/72	64/72	64/72
Cooling water temp. B/A centr.cooler	°C	–	–	–
Cooling water temp. B/A air cooler	°C	26/34	24/34	26/34
Cooling water temp. B/A oil cooler	°C	34	34	34
Lube oil temp. B/A engine	°C	64/74	64/76	64/76
Nozzle cooling oil temp. B/A engine	°C	–	–	–
Fuel oil temp. B engine	°C	–	–	–
Ambient temperature	°C	23	24	24
Scavenging air pressure	bar	1.8	1.9	1.9
HT water pressure B/A engine	bar	3.6	3.6	3.5
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.2 4.5/4.2	4.2 4.5/4.2	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	2.7	2.7	2.7
Nozzle cooling pressure B/A engine	bar	–	–	–
Barometric pressure	mmHg	762	762	762
Relative humidity	%	47	47	47

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT
ORDERED BY

ORDER NO.	5611-0100
ENGINE TYPE	12 V 22
ENGINE NO.	NO 3394 (V 3074)
DATE	84.09.06
SIGN	

TEST RESULT

Test No.		10	11	12
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	~~g/min~~	319	319	323
Specific fuel consumption	g/kWh	200	200	203
Load indicator position		8.0 (27.5)	8.0 27.5	8.5 27.5
Turbocharger speed A	rpm	31600	31600	31600
Turbocharger speed B	rpm	31600	31500	31500

Exhaust temperature, Fuel rack position, Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	345	27.5	129	345	27.5	129	350	27.5	129
	A2	355		135	360		135	360		137
	A3	365		132	370		132	370		132
	A4	350		138	350		132	350		132
Cylinder	A5	340		135	340		135	340		137
	A6	320		135	325		135	320		130
	A7									
	A8									
Mean values	A									
	B1	350	27.5	132	350	27.5	132	350	27.5	137
	B2	360		136	360		136	360		137
	B3	350		136	350		136	350		140
	B4	340		130	340		130	340		130
Cylinder	B5	330		130	330		130	330		130
	B6	380		135	380		135	380		137
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	35	35
Cooling water temp. B/A engine	°C	64/72	64/72	66/72
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	24/34	24/34	26/34
Cooling water temp. B/A oil cooler	°C	34	34	34
Lube oil temp. B/A engine	°C	64/76	64/76	64/74
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	19	19	23
Scavenging air pressure	bar	1.8	1.8	1.8
HT water pressure B/A engine	bar	3.6	3.6	3.6
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.2 4.5/4.2	4.2 4.5/4.2	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	2.8	2.8	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	761	761	761
Relative humidity	%	49	49	47

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3394 (V3074)
DATE	84.09.06
SIGN	

TEST RESULT

Test No.		16	17	18
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	–	—
Current	A	—	–	–
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	–
Fuel consumption/time kg/h	~~g/min~~	323	322	322
Specific fuel consumption	g/kWh	203	203	203
Load indicator position		8.0 (27.5)	8.0 (27.5)	8.0
Turbocharger speed A	rpm	31700	31700	31600
Turbocharger speed B	rpm	31600	31600	31500

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	350	27.5	132	350	27.5	132	350	27.5	124
	A2	360		137	360		137	360		129
	A3	375		132	375		132	375		124
	A4	360		132	360		132	355		124
Cylinder	A5	350		137	350		137	350		124
	A6	325		132	325		132	325		124
	A7									
	A8									
Mean values	A									
	B1	350	27.5	137	350	27.5	137	350	27.5	124
	B2	370		137	370		137	365		124
	B3	350		137	350		137	355		129
	B4	350		137	350		132	345		124
Cylinder	B5	340		132	340		137	340		124
	B6	330		137	330			385		124
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	35	35	36
Cooling water temp. B/A engine	°C	64-72	64/72	64/70
Cooling water temp. B/A centr.cooler	°C	–	–	—
Cooling water temp. B/A air cooler	°C	26/34	26/34	26/35
Cooling water temp. B/A oil cooler	°C	34	34	35
Lube oil temp. B/A engine	°C	64/76	64/76	64/74
Nozzle cooling oil temp. B/A engine	°C	—	—	
Fuel oil temp. B engine	°C	–	–	
Ambient temperature	°C	24	24	24
Scavenging air pressure	bar	1.9	1.9	1.9
HT water pressure B/A engine	bar	3.6	3.6	3.5
LT water pressure B/A engine	bar	1.0	1.0	1.0
Lube oil pressure B/A filter	bar	4.2 4.5/4.2	4.2 4.5/4.2	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	2.7	2.7	2.7
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	761	761	762
Relative humidity	%	46	46	46

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0/00
ENGINE TYPE	12V28
ENGINE NO.	NB3394 (V3074)
DATE	
SIGN	6/4-84

TEST RESULT

Test No.		19	20	21
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time	g/min	325	324	324
Specific fuel consumption	g/kWh	204	204	204
Load indicator position		8.0 (28)	8.0 (28)	8.0 (28)
Turbocharger speed A	rpm	31700	31700	31700
Turbocharger speed B	rpm	31600	31600	31600

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	350	27.5	124	350	27.5		350	27.5	
	A2	355		124	355			355		
	A3	375		120	370			370		
	A4	355		124	350			350		
Cylinder	A5	350		120	350			345		
	A6	325	↓	124	325	↓		325	↓	
	A7									
	A8									
Mean values	A									
	B1	350	27.5	120	350	27.5		350	27.5	
	B2	360		124	360			360		
	B3	355		129	350			350		
	B4	345		124	345			345		
Cylinder	B5	340		124	340			340		
	B6	385	↓	124	380	↓		380	↓	
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	36	36	36
Cooling water temp. B/A engine	°C	64/70	64/70	64/70
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	26/35	24/36	24/36
Cooling water temp. B/A oil cooler	°C	35/	36/—	36/—
Lube oil temp. B/A engine	°C	64/74	64/74	64/74
Nozzle cooling oil temp. B/A engine	°C			
Fuel oil temp. B engine	°C			
Ambient temperature	°C	24	21	21
Scavenging air pressure	bar	1.9	1.95	1.95
HT water pressure B/A engine	bar	3.5	3.45	3.45
LT water pressure B/A engine	bar	1.0	0.9	0.9
Lube oil pressure B/A filter	bar	4.2 4.5/4.2	4.2 4.5/4.2	4.2 4.5/4.2
Fuel oil pressure B/A engine	bar	2.7	2.8	2.8
Nozzle cooling pressure B/A engine	bar			
Barometric pressure	mmHg	762	762	762
Relative humidity	%	47	50	50

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611 - 0100
ENGINE TYPE	12 V 22
ENGINE NO.	NO 3394 (V 3074)
DATE	
SIGN	

TEST RESULT

Test No.		28		
Test time				
Load	%	110		
Revs	rpm	900		
Voltage	V	—		
Current	A	—		
Brake load	kp	2643		
Engine power	kW	1749		
Alternator efficiency	%	—		
Alternator output	kW			
Fuel consumption/time Kg/h	g/min	355		
Specific fuel consumption	g/kWh	203		
Load indicator position		8.5 (30)		
Turbocharger speed A	rpm	33000		
Turbocharger speed B	rpm	32800		

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	360	29.5	134						
	A2	370		146						
	A3	385		139						
	A4	370		139						
Cylinder	A5	360		149						
	A6	335		139						
	A7									
	A8									
Mean values	A									
	B1	365	29.5	144						
	B2	385		149						
	B3	365		149						
	B4	355		136						
Cylinder	B5	350		139						
	B6	395		144						
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	40		
Cooling water temp. B/A engine	°C	64/70		
Cooling water temp. B/A centr.cooler	°C			
Cooling water temp. B/A air cooler	°C	28/41		
Cooling water temp. B/A oil cooler	°C			
Lube oil temp. B/A engine	°C	66/76		
Nozzle cooling oil temp. B/A engine	°C	—		
Fuel oil temp. B engine	°C	—		
Ambient temperature	°C	18		
Scavenging air pressure	bar	2.2		
HT water pressure B/A engine	bar	3.4		
LT water pressure B/A engine	bar	1.0		
Lube oil pressure B/A filter	bar	4.1 4.4/4.1		
Fuel oil pressure B/A engine	bar	26		
Nozzle cooling pressure B/A engine	bar	—		
Barometric pressure	mmHg	764		
Relative humidity	%	48		

NOHAB DIESEL

Dokumentnamn	Sida nr

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr/Dokumentnr

Ärende

Distribution

Test no	1	2	3	4	5	6	7	8
Load	25	50	75	100	75	50	25	0
1 Temp bef. comp	29	27	26	27	27	27	28	27
2 Temp aft comp. SB-ch	56	90	135	169	137	97	61	46
3 Temp bef turb. upper -"-	325	366	438	470	421	363	294	226
4 -"- lower -"-	322	367	418	449	401	346	276	210
5 -"- upper port ch	365	412	428	469	426	376	305	236
6 -"- lower -"-	370	400	410	452	409	361	291	236
7 Temp aft turb SB turbine	264	285	305	306	290	270	235	187
8 -"- port turbine	304	315	297	309	295	280	244	203
Press aft compr (bar)	0.32	0.8	1.45	2.0	1.5	0.9	0.05	0,25
Press bef turbine (bar)		0.3	0.9	1.4	1.0	0.4	0.4	0
Press aft turbine SB ch (mm H_2O)	10	5	6	11	10	7	8	0.25
Pres aft turbine port ch (mm H_2O)	10	5	5	5	5	10	0	0

ND 101 BIARK-offset

ND 3394 V3074.

NOHAB DIESEL

Dokumentnamn			Sida nr
Utfärdare	Sign	Ref	Tel
Datum	Beteckning/Ref.nr/Dokumentnr 56/1 -0100	Ärende	Distribution

TEST NO.	9	10	11	12	13	14
LOAD	100	100	100	100	100	100
TEMP. BEFORE COMP.	27	27	27	28	28	28
TEMP. AFTER COMP.STB.CH.	170	169	170	172	172	172
TEMP. BEFORE TURB. UPPER STB.	478	479	479	479	480	480
TEMP. BEFORE TURB. LOWER STB.	453	453	454	453	455	454
TEMP. BEFORE TURB. UPPER PORT	474	475	475	477	478	477
TEMP. BEFORE TURB. LOWER PORT	456	457	459	460	460	460
TEMP. AFTER TURB. STB.	312	312	313	314	315	315
TEMP. AFTER TURB. PORT	313	313	314	316	316	316
PRESS. AFTER COMP. (BAR)	2.0	1.95	1.95	1.9	1.9	1.9
PRESS. BEFORE TURB. (BAR)	1.4	1.4	1.4	1.3	1.3	1.4
PRESS. AFTER TURB. STB (MM H_2O)	10	10	10	10	10	10
PRESS.AFTER TURB. PORT (MM H_2O)	5	ø	ø	5	5	4

NOHAB DIESEL

Dokumentnamn		Sida nr
Utfärdare	Sign	Ref
Tel	Datum	Beteckning Ref.nr Dokumentnr
Ärende		Distribution

TEST NO.	15	16	17	18	19	20	
LOAD	100	100	100	100	100	100	
TEMP. BEFORE COMP.	29	30	29	29	29	29	
TEMP. AFTER COMP.STB.CH.	172	174	172	171	172	172	
TEMP. BEFORE TURB. UPPER STB.	481	482	482	480	480	479	
TEMP. BEFORE TURB. LOWER STB.	456	458	457	454	455	456	
TEMP. BEFORE TURB. UPPER PORT	478	479	481	478	478	478	
TEMP. BEFORE TURB. LOWER PORT	462	463	462	460	461	461	
TEMP. AFTER TURB. STB.	316	317	317	316	315	315	
TEMP. AFTER TURB. PORT	318	318	319	317	317	318	
PRESS. AFTER COMP. (BAR)	1.8	1.8	1.8	1.9	1.9	1.9	
PRESS. BEFORE TURB. (BAR)	1.4	1.4	1.4	1.4	1.4	1.4	
PRESS. AFTER TURB. STB (MM H_2O)	10	10	10	10	10	11	
PRESS.AFTER TURB. PORT (MM H_2O)	3	3	0	2	2	2	

ND 101 BLAKE-offset

ND3394 V3074

NOHAB DIESEL

Dokumentnamn	Sida nr

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr/Dokument-nr
					5611-0100

Ärende — Distribution

TEST NO.	21	22	23	24	25	26
LOAD	100	100	100	100	100	100
TEMP. BEFORE COMP.	28	28	28	28	27	27
TEMP. AFTER COMP.STB.CH.	172	171	173	172	171	171
TEMP. BEFORE TURB. UPPER STB.	479	478	479	479	477	476
TEMP. BEFORE TURB. LOWER STB.	455	453	454	453	451	451
TEMP. BEFORE TURB. UPPER PORT	476	476	478	477	476	475
TEMP. BEFORE TURB. LOWER PORT	461	460	462	461	460	460
TEMP. AFTER TURB. STB.	315	314	315	315	314	314
TEMP. AFTER TURB. PORT	317	316	318	318	317	316
PRESS. AFTER COMP. (BAR)	1.9	1.9	1.9	2.0	2.0	2.0
PRESS. BEFORE TURB. (BAR)	1.4	1.4	1.4	1.4	1.45	1.45
PRESS. AFTER TURB. STB (MM H_2O)	11	11	11	11	11	11
PRESS.AFTER TURB. PORT (MM H_2O)	2	2	2	2	2	2

NOHAB DIESEL

Dokumentnamn	Sida nr

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr/Dokument nr

Ärende / Distribution

TEST NO.	27	28
LOAD	110	110
TEMP. BEFORE COMP.	28	28
TEMP. AFTER COMP.STB.CH.	186	186
TEMP. BEFORE TURB. UPPER STB.	502	500
TEMP. BEFORE TURB. LOWER STB.	478	477
TEMP. BEFORE TURB. UPPER PORT	497	497
TEMP. BEFORE TURB. LOWER PORT	480	480
TEMP. AFTER TURB. STB.	327	326
TEMP. AFTER TURB. PORT	327	327
PRESS. AFTER COMP. (BAR)	2.25	2.25
PRESS. BEFORE TURB. (BAR)	1.7	1.7
PRESS. AFTER TURB. STB (MM H_2O)	11	11
PRESS.AFTER TURB. PORT (MM H_2O)	2	2

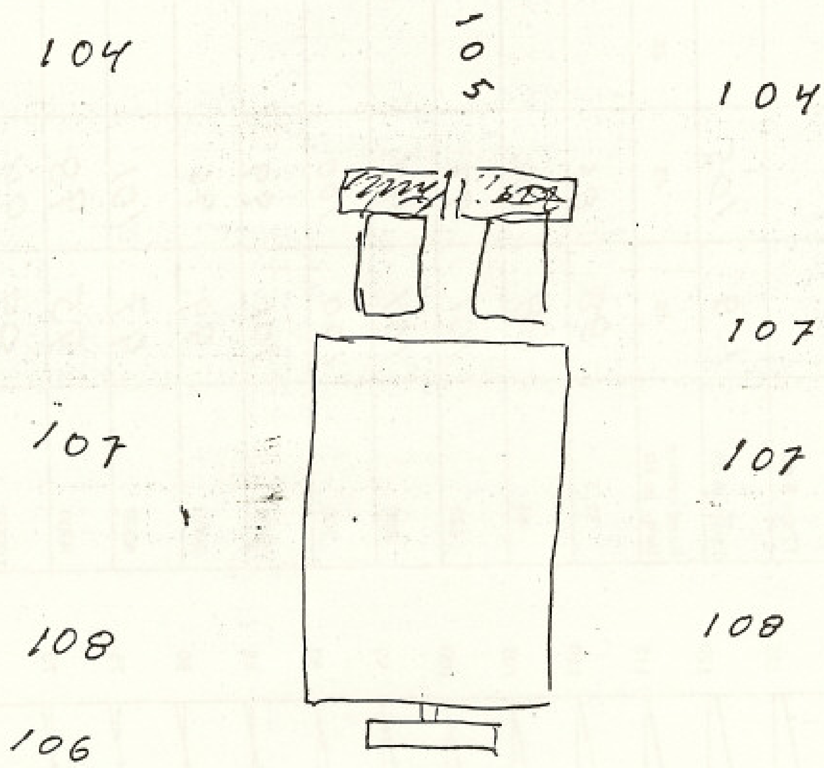
NOHAB DIESEL

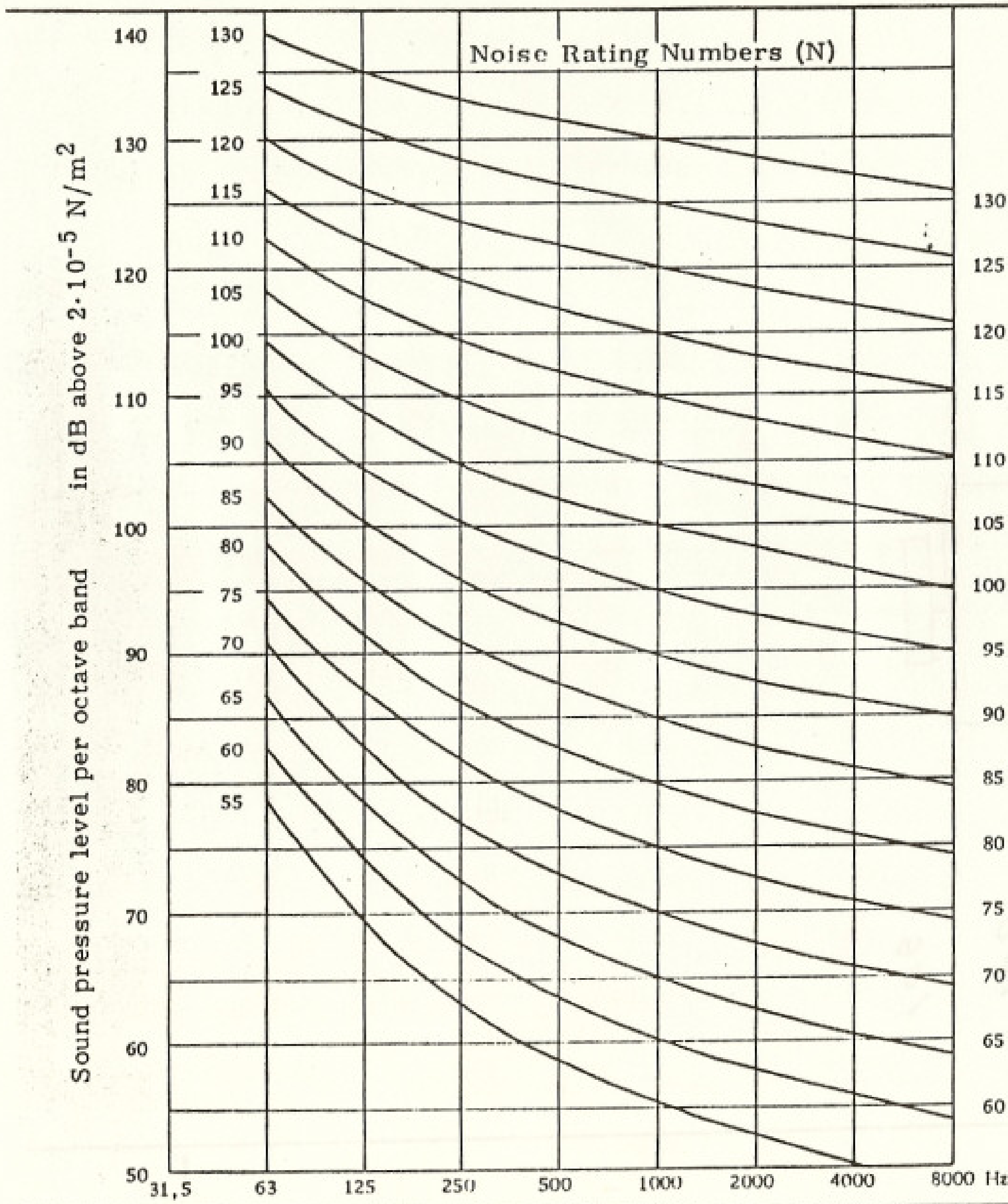
Dokumentnamn	Sida nr

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr Dokumentnr
					5611-0100

Ärende	Distribution

Noise Level dB(A) at 100% 1590 kW motor nr ND3394 (V3074)





Measuring point	A	B	
Total dB			
Filter C dB			
Filter B dB			
Filter A dB	108	105	
Band centre freq. in Hz	dB	dB	dB
31,5	88	86	
63	88	88	
125	101	97	
250	104	97	
500	100	100	
1000	101	99	
2000	99	96	
4000	97	101	
8000	95	98	
16000	89	94	
31500	68	73	

BOFORS NOHAB

Plant: Box Nr. 4 5611-0100 NE. NO 3394 12V22

Measuring point

Drawing

Remarks

Date: 84-09-07

Time

Sign.

Dept.

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	ORDER NO. 5611 - 0100
	ENGINE TYPE 12V22
ORDERED BY	ENGINE NO. ND 3393
	DATE 84 09 11
	SIGN

TEST RESULT

Test No.		1	2	3
Test time		11/9-84	11/9 - 84	11/9 - 84
Load	%		25	50
Revs	rpm	900	900	900
Voltage	V			
Current	A			
Brake load	kp	240	601	1201
Engine power	kW	159	398	795
Alternator efficiency	%			
Alternator output	kW			
Fuel consumption/time	kg/h ~~g/min~~	47	93,2	164,8
Specific fuel consumption	g/kWh	(294)	234	207
Load indicator position		1.8	3,0	4,7
Turbocharger speed A	rpm	10450	15000	22200
Turbocharger speed B	rpm	10480	15000	22300

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	205	8,0	54	260	12,5	78	280	17,0	103
	A2	205		59	260		81	260		108
	A3	210		54	240		77	265		103
	A4	230		59	260		85	280		103
Cylinder	A5	205		57	230		76	260		108
	A6	235		58	265		79	300		108
	A7									
	A8									
Mean values	A	215		57	253		79	274		104
	B1	210	8,0	58	250	12,5	74	290	17,0	103
	B2	210		55	265		82	280		108
	B3	210		54	250		75	295		103
	B4	195		57	230		82	270		103
Cylinder	B5	195		57	235		78	270		108
	B6	230		56	255		79	290		103
	B7									
	B8									
Mean values	B	208		56	248		78	283		105

	°C			
	°C			
Scavenging air temperature	°C	27	38	38
Cooling water temp. B/A engine	°C	68 / 68	60 / 70	68 / 70
Cooling water temp. B/A centr.cooler	°C	—		
Cooling water temp. B/A air cooler	°C	18 / 18	20 / 20	20 / 24
Cooling water temp. B/A oil cooler	°C	18 /	20 /	24 /
Lube oil temp. B/A engine	°C	62 / 68	64 / 70	65 / 73
Nozzle cooling oil temp. B/A engine	°C			
Fuel oil temp. B engine	°C			
Ambient temperature	°C	20	20	21
Scavenging air pressure	bar	0,12	0,3	0,7
HT water pressure B/A engine	bar	3,7	3,7	3,7
LT water pressure B/A engine	bar	[illegible]	1,15	1,15
Lube oil pressure B/A filter	bar	4,2	4,2	4,2
Fuel oil pressure B/A engine	bar	4,1	[illegible]	4,1
Nozzle cooling pressure B/A engine	bar	—		
Barometric pressure	mmHg	744	744	744
Relative humidity	%	61	61	61

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0[illegible]00
ENGINE TYPE	12V22
ENGINE NO.	ND3393
DATE	840911
SIGN	

TEST RESULT

Test No.		4	5	6
Test time		11/9 - 84	11/9 - 84	
Load	%	75	100	100
Revs	rpm	900	900	900
Voltage	V			—
Current	A			—
Brake load	kp	1802	2403	2403
Engine power	kW	1193	1590	1590
Alternator efficiency	%			
Alternator output	kW			
Fuel consumption/time kg/h	~~g/min~~	243	323	325
Specific fuel consumption	g/kWh	204	203	204
Load indicator position		6.6	8.1	8.1
Turbocharger speed A	rpm	27800	31900	32000
Turbocharger speed B	rpm	27900	31900	32000

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	325	22	108	375	27.5	128	370	27.5	134
	A2	300		113	340		132	340		137
	A3	290		103	325		137	330		129
	A4	325		116	365		129	370		131
Cylinder	A5	300		108	340		131	340		131
	A6	345		108	385		132	390		137
	A7									
	A8									
Mean values	A	314		109	355		132			
	B1	330	22	106	370	27.5	137	370	27.5	134
	B2	320		108	350		137	360		134
	B3	335		106	375		128	380		139
	B4	315		105	355		135	350		129
Cylinder	B5	310		110	350		135	340		131
	B6	320		103	360		137	360		124
	B7									
	B8									
Mean values	B	320		106	360		135			

	°C			
	°C			
Scavenging air temperature	°C	30	34	35
Cooling water temp. B/A engine	°C	68 / 70	68 / 71	64/72
Cooling water temp. B/A centr.cooler	°C			—
Cooling water temp. B/A air cooler	°C	22 / 28	24 / 34	26/38
Cooling water temp. B/A oil cooler	°C	28/	34 /	38/
Lube oil temp. B/A engine	°C	66 / 74	66 / 76	66/76
Nozzle cooling oil temp. B/A engine	°C			—
Fuel oil temp. B engine	°C			—
Ambient temperature	°C	22	23	22
Scavenging air pressure	bar	1,35	1,9	1.9
HT water pressure B/A engine	bar	3,7	3,7	3.8
LT water pressure B/A engine	bar	1,15	1,15	0.9
Lube oil pressure B/A filter	bar	4,1	4,1	4.0 4.3/4.0
Fuel oil pressure B/A engine	bar	4,0	3,75	3,7
Nozzle cooling pressure B/A engine	bar			—
Barometric pressure	mmHg	744	744	745
Relative humidity	%	61	62	60

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	NO 3393(V3075)
DATE	84-09-12
SIGN	

TEST RESULT

Test No.		7	8	9
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	–	–	–
Current	A	–	–	–
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%		–	–
Alternator output	kW		–	–
Fuel consumption/time kg/h	~~g/min~~	323	323	323
Specific fuel consumption	g/kWh	203	203	203
Load indicator position		8.0	8.0	8.0
Turbocharger speed A	rpm	31900	31900	32000
Turbocharger speed B	rpm	31900	31800	32000

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	370	27.5	134	380	27.5	134	380	27.5	135
	A2	340		135	340		135	350		139
	A3	330		129	330		129	330		131
	A4	370		131	370		131	370		134
Cylinder	A5	340		131	340		131	340		134
	A6	390		137	390		135	390		131
	A7									
	A8									
Mean values	A									
	B1	370	27.5	134	370	27.5	134	370	27.5	135
	B2	360		134	350		134	360		134
	B3	380		139	370		139	380		141
	B4	360		129	360		131	360		134
Cylinder	B5	340		129	350		131	350		134
	B6	360		121	360		124	370		124
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	38	38	38
Cooling water temp. B/A engine	°C	64/72	64/72	64/72
Cooling water temp. B/A centr.cooler	°C			–
Cooling water temp. B/A air cooler	°C	28/38	28/38	28/38
Cooling water temp. B/A oil cooler	°C	38	38	38
Lube oil temp. B/A engine	°C	68/74	68/74	68/74
Nozzle cooling oil temp. B/A engine	°C	–	–	–
Fuel oil temp. B engine	°C	–	–	–
Ambient temperature	°C	22	21	21
Scavenging air pressure	bar	1.9	1.9	1.9
HT water pressure B/A engine	bar	3.8	3.8	3.8
LT water pressure B/A engine	bar	2.2	2.2	2.2
Lube oil pressure B/A filter	bar	4.0 4.4/4.0	4.0 4.3/4.0	4.0 4.3/4.0
Fuel oil pressure B/A engine	bar	3.7	3.7	3.7
Nozzle cooling pressure B/A engine	bar	–	–	–
Barometric pressure	mmHg	745	745	745
Relative humidity	%	~~745~~ 61	~~745~~ 62	62
		~~64~~	~~62~~	

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12 V22
ENGINE NO.	ND 3393 (3075)
DATE	12/9-84
SIGN	

TEST RESULT

Test No.		10	11	12
Test time				
Load	%	100	100	100
Revs	rpm	900	900	900
Voltage	V	—	—	—
Current	A	—	—	—
Brake load	kp	2403	2403	2403
Engine power	kW	1590	1590	1590
Alternator efficiency	%	—	—	—
Alternator output	kW	—	—	—
Fuel consumption/time kg/h	g/min	323	323	322
Specific fuel consumption	g/kWh	203	203	202
Load indicator position		8.0	8.0	8.0
Turbocharger speed A	rpm	32000	31900	31900
Turbocharger speed B	rpm	31900	31900	31800

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	380	27.5	134	380	27.5	133	380	27.5	131
	A2	345	↓	138	345	↓	133	345	↓	133
	A3	330	↓	132	330	↓	124	330	↓	124
	A4	370	↓	133	370	↓	127	370	↓	127
Cylinder	A5	345	↓	134	345	↓	133	340	↓	129
	A6	385	↓	138	385	↓	137	385	↓	133
	A7									
	A8									
Mean values	A									
	B1	370	27.5	138	370	27.5	130	370	27.5	130
	B2	355	↓	135	355	↓	129	350	↓	132
	B3	375	↓	141	375	↓	136	375	↓	136
	B4	355	↓	133	355	↓	126	355	↓	126
Cylinder	B5	345	↓	131	345	↓	128	345	↓	127
	B6	365	↓	124	365	↓	123	365	↓	122
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	38	38	38
Cooling water temp. B/A engine	°C	64/68	64/72	64/71
Cooling water temp. B/A centr.cooler	°C	—	—	—
Cooling water temp. B/A air cooler	°C	28/39	28/40	28/40
Cooling water temp. B/A oil cooler	°C	39/—	40/-	40/
Lube oil temp. B/A engine	°C	67/74	67/75	
Nozzle cooling oil temp. B/A engine	°C	—	—	—
Fuel oil temp. B engine	°C	—	—	—
Ambient temperature	°C	21	21	21
Scavenging air pressure	bar	1.9	1.9	1.9
HT water pressure B/A engine	bar	3.8	3.8	3.8
LT water pressure B/A engine	bar	2.3	2.3	2.3
Lube oil pressure B/A filter	bar	4.0 4.3/4.0	4.0 4.3/4.0	4.0 4.4/4.1
Fuel oil pressure B/A engine	bar	3.7	3.7	3.6
Nozzle cooling pressure B/A engine	bar	—	—	—
Barometric pressure	mmHg	745	745	745
Relative humidity	%	62	60	58

NOHAB DIESEL
WARTSILA DIESEL DIVISION

TEST REPORT	
ORDERED BY	

ORDER NO.	5611-0100
ENGINE TYPE	12V22
ENGINE NO.	ND3393 (V3075)
DATE	12/9-84
SIGN	

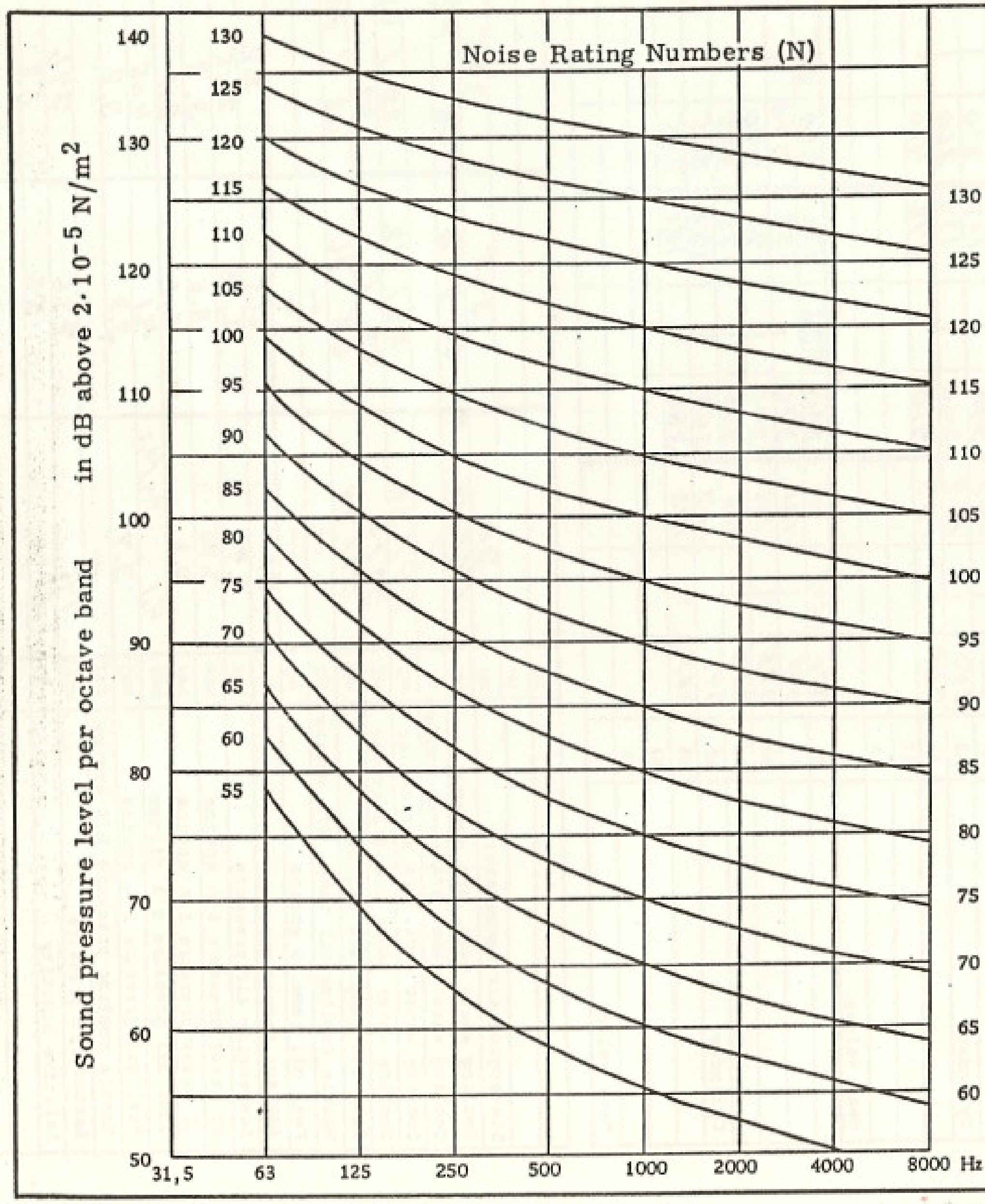
TEST RESULT

Test No.		13	14	15
Test time				
Load	%	100	110	110
Revs	rpm	900	900	900
Voltage	V	—	—	
Current	A	—	—	
Brake load	kp	2403	2643	2643
Engine power	kW	1590	1749	1749
Alternator efficiency	%		—	
Alternator output	kW		—	
Fuel consumption/time kg/h	~~g/min~~	324	359	360
Specific fuel consumption	g/kWh	204	205	206
Load indicator position		8.0	8,7	8,7
Turbocharger speed A	rpm	31800	33300	33200
Turbocharger speed B	rpm	31800	33300	33200

Exhaust temperature / Fuel rack position / Max. pressure		°C	mm	bar	°C	mm	bar	°C	mm	bar
	A1	380	27.5	131	395	28,5	132	395	28,5	137
	A2	345	↓	133	370	↓	127	370	↓	135
	A3	330		124	340		132	345		126
	A4	370		127	390		125	390		128
Cylinder	A5	340		129	360		132	360		129
	A6	385		133	410		142	410		137
	A7									
	A8									
Mean values	A									
	B1	370	27.5	—	390	28,5	132	390	28,5	137
	B2	355	↓	132	370	↓	132	370	↓	137
	B3	375		136	390		142	390		142
	B4	350		126	375		135	375		137
Cylinder	B5	345		127	365		132	365		132
	B6	365		123	385		126	385		126
	B7									
	B8									
Mean values	B									

	°C			
	°C			
Scavenging air temperature	°C	38	39,5	39,5
Cooling water temp. B/A engine	°C	64/68	68 / 72	68 / 72
Cooling water temp. B/A centr.cooler	°C	—		
Cooling water temp. B/A air cooler	°C	28/39	28 / 42	28 / 42
Cooling water temp. B/A oil cooler	°C	39/-	42 /	42
Lube oil temp. B/A engine	°C	67/74	68 76	68 / 76
Nozzle cooling oil temp. B/A engine	°C	—	—	
Fuel oil temp. B engine	°C	—	—	
Ambient temperature	°C	21	21,5	22
Scavenging air pressure	bar	1.9	2,15	2,15
HT water pressure B/A engine	bar	3.75	3,8	3,8
LT water pressure B/A engine	bar	2.3	2,1	2,1
Lube oil pressure B/A filter	bar	4.1 4.4/4.1	4,1	4,05
Fuel oil pressure B/A engine	bar	3.7	3.7	3,7
Nozzle cooling pressure B/A engine	bar	—		
Barometric pressure	mmHg	746	746	746
Relative humidity	%	58	58	58

NOHAB-offset 5535



Measuring point	A	B	
Total dB			
Filter C dB			
Filter B dB			
Filter A dB	108		
Band centre freq. in Hz	dB	dB	dB
31,5	87	83	
63	88	91	
125	94	94	
250	98	95	
500	100	100	
1000	102	99	
2000	98	97	
4000	97	101	
8000	96	100	
16000	91	96	
31500	70	76	

BOFORS NOHAB

Plant: 80x4 ENGINE NO ND3393 12V22

Measuring point:

Drawing: 5611-0100

Remarks:

Date: 840912

Time:

Sign.:

Dept.:

NOHAB DIESEL

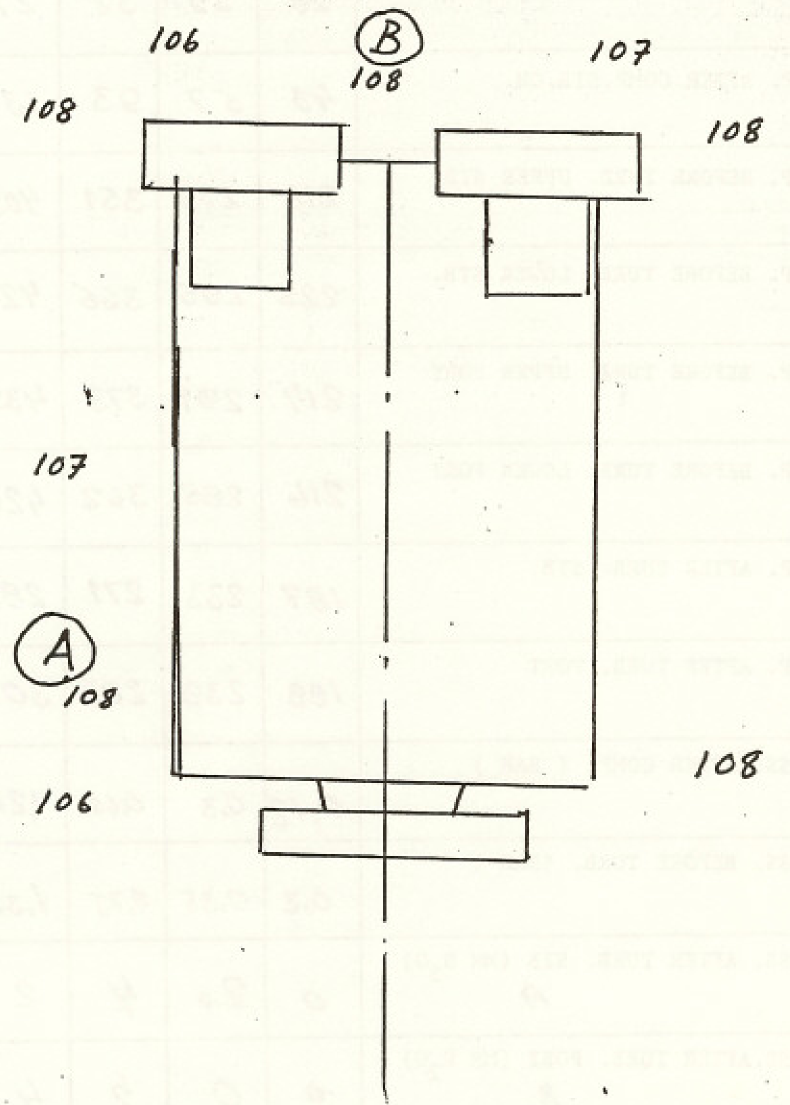
Utfärdare	Sign	Tel	Datum	Beteckning/Ref.nr/Dokumentnr
			840912	

Dokumentnamn | Sida nr

Ärende | Distribution

NOISE LEVEL dB(A) AT 100% 1590 KW 900 R/M

ENGINE NO ND 3393 (V 3075)



ND 101 BIARK-offset

NOHAB DIESEL

Dokumentnamn	Sida nr
Eng.no. ND 3393 (V3075)	

Utfärdare	Sign	Ref	Tel	Datum	Beteckning/Ref.nr/Dokumentnr
					5611-0100

Ärende

TEST NO.	1	2	3	4	5	6
LOAD	0	25	50	75	100	100
TEMP. BEFORE COMP.	28	29	32	27	28	28
TEMP. AFTER COMP.STB.CH.	43	57	93	131	161	165
TEMP. BEFORE TURB. UPPER STB.	216	279	351	405	457	463
TEMP. BEFORE TURB. LOWER STB.	225	295	366	423	472	478
TEMP. BEFORE TURB. UPPER PORT	214	291	373	435	482	489
TEMP. BEFORE TURB. LOWER PORT	216	285	362	420	468	473
TEMP. AFTER TURB. STB.	187	233	271	288	308	312
TEMP. AFTER TURB. PORT	188	239	283	301	320	323
PRESS. AFTER COMP. (BAR)	0,18	0,3	0,65	1,20	1,60	1.9
PRESS. BEFORE TURB. (BAR)	0,2	0,35	0,75	1,35	1,85	1,8
PRESS. AFTER TURB. STB (MM H_2O) A	0	2,0	4	2	3	13
PRESS.AFTER TURB. PORT (MM H_2O) B	0	0	2	4	5	5
CRANKCASE VACUUM PRESS.	0	1	2	2	2	0

ND 101 BIARK-offset

NOHAB DIESEL

Dokumentnamn	Sida nr
Motor nr ND3393 (V3075)	

Utfärdare	Sign	Ref	Tel	Datum	Beteckning: Dokument nr
					5611 - 0100

Ärende						
TEST NO.	7	8	9	10	11	12
LOAD	100	100	100	100	100	100
TEMP. BEFORE COMP.	28	29	30	31	32	31
TEMP. AFTER COMP.STB.CH.	164	164	165	165	165	165
TEMP. BEFORE TURB. UPPER STB.	463	462	464	463	461	462
TEMP. BEFORE TURB. LOWER STB.	477	477	478	477	476	476
TEMP. BEFORE TURB. UPPER PORT	490	487	490	490	489	488
TEMP. BEFORE TURB. LOWER PORT	474	474	475	476	475	474
TEMP. AFTER TURB. STB.	312	312	313	312	312	313
TEMP. AFTER TURB. PORT	324	324	326	326	326	325
PRESS. AFTER COMP. (BAR)	1.9	1.9	1.9	1.9	1.9	1.9
PRESS. BEFORE TURB. (BAR)	1.7	1.7	1.7	1.7	1.8	1.7
PRESS. AFTER TURB. STB (MM H_2O)	4	4	5	6	6	5
PRESS. AFTER TURB. PORT (MM H_2O)	7	7	5	6	9	6
CRANKCASE VACUUM PRESS.	0	0	0	0	0	0

NOHAB DIESEL

Dokumentnamn: ENGINE NO ND3393 (V3075)

Sida nr:

Utfärdare | Sign | Ref | Tel | Datum | Beteckning/Ref.nr/Dokument nr: 5611-0100

Ärende | Distribution

TEST NO.	13	14	15				
LOAD	100	110	110				
TEMP. BEFORE COMP.	31	31	31				
TEMP. AFTER COMP.STB.CH.	166	177	178				
TEMP. BEFORE TURB. UPPER STB.	463	483	486				
TEMP. BEFORE TURB. LOWER STB.	477	501	504				
TEMP. BEFORE TURB. UPPER PORT	488	509	510				
TEMP. BEFORE TURB. LOWER PORT	475	499	501				
TEMP. AFTER TURB. STB.	313	324	326				
TEMP. AFTER TURB. PORT	325	336	338				
PRESS. AFTER COMP. (BAR)	1.9	1,95	1,95				
PRESS. BEFORE TURB. (BAR)	1.7	2,1	2,1				
PRESS. AFTER TURB. STB ($MM\ H_2O$)	6	3	3				
PRESS.AFTER TURB. PORT ($MM\ H_2O$)	5	2	2				
CRANKCASE VACUUM press.	0	0	1.0				

00 Contents, instructions, terminology

01 Main data, operating data and general design

02 Fuel oil, lubricating oil, cooling water

03 Start, stop, operation

04 Maintenance schedule

05 Maintenance tools

06 Adjustments, clearances and wear limits

07 Tightening torques and instructions for screw connections

08 Operating troubles

09 Specific installation data

10 Engine block with bearings, cylinder liners, oil sump

11 Running gear: crankshaft, connecting rod, piston

12 Cylinder head with valves

13 Camshaft drive

14 Valve timing drive and camshaft

15 Turbocharging and intercooling

16 Injection system

17 Fuel system

18 Lubricating oil system

19 Cooling water system

20 Exhaust system

21 Starting air system

22 Control gear

23 Instrumentation and automation

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 (fig. 10-54)

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.

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).

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.

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 bearing 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 neighbouring side screws.

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. 10-54E,F.

   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 by measuring the thickness of the lower bearing shells. Use a ball anvil micrometer for this purpose. If all lower bearing shells are worn to the same thickness they can be used again unless the shell thickness goes below the wear limit according to section 06.2 pos. 10, or unless the overlay plating is worn off from more than 30 % of the surface (trimetal bearings). If the wear is uneven it is recommendable to replace the bearing shell.

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 (fig. 10-55)

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. Fig. 10-55B. 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 the rear side) and place it in the bearing cap; raise the cap by means of lifting tool 832003 (fig. 10-52, 10-55C) 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.
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. 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.

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).

<u>10.5 Dismantling and assembling of the shield bearing</u>

<u>Dismantling</u> (fig. 10-56)

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.

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.

Assembling (fig. 10-57)

7. Lubricate the upper bearing shell surface and crankshaft journal.

8. 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.

9. Place the turning device 851004 in the crankshaft journal radial oil hole and turn carefully in counter-clockwise direction until the edge of the bearing shell levels with the bearing housing mating face. Check that the flap at the bearing edge is not damaged. Remove the turning device. Fig. 10-57A,B.

10. Lubricate the lower bearing shell surface and place the bearing shell in the bearing cap. Fig. 10-57B.

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

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

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

14. Screw on the hydraulic cylinders.

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

16. Pump pressure to the value state in section 07.3 so that the screws elongate. Fig. 10-57C.

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

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

19. Tighten the four fastening screws to torque according to section 07.1. Fig. 10-57D.

10.6 Removing and installing the cylinder liners (fig. 10-53)

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 to 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).

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 (fig. 10-58)

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 (fig. 10-58)

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.

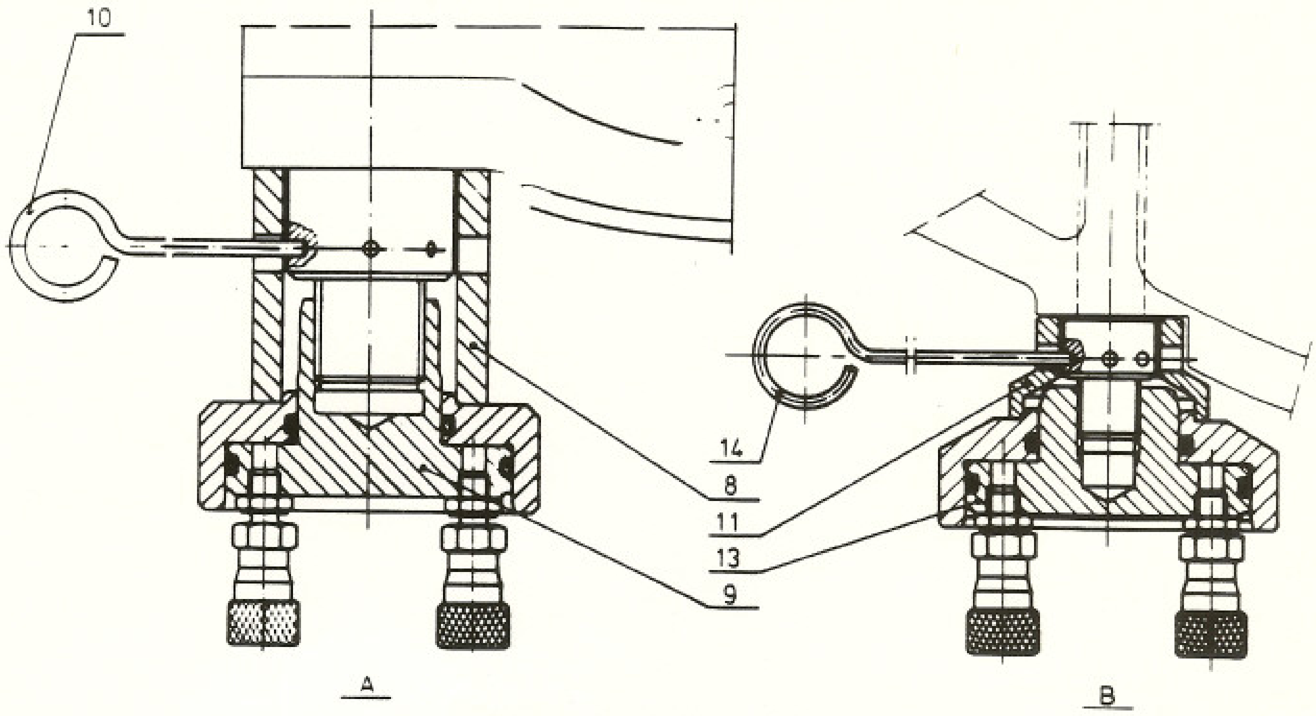
4. Connect the hoses of the hydraulic pump to the hydraulic tool.

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 camshaft bearing journal.

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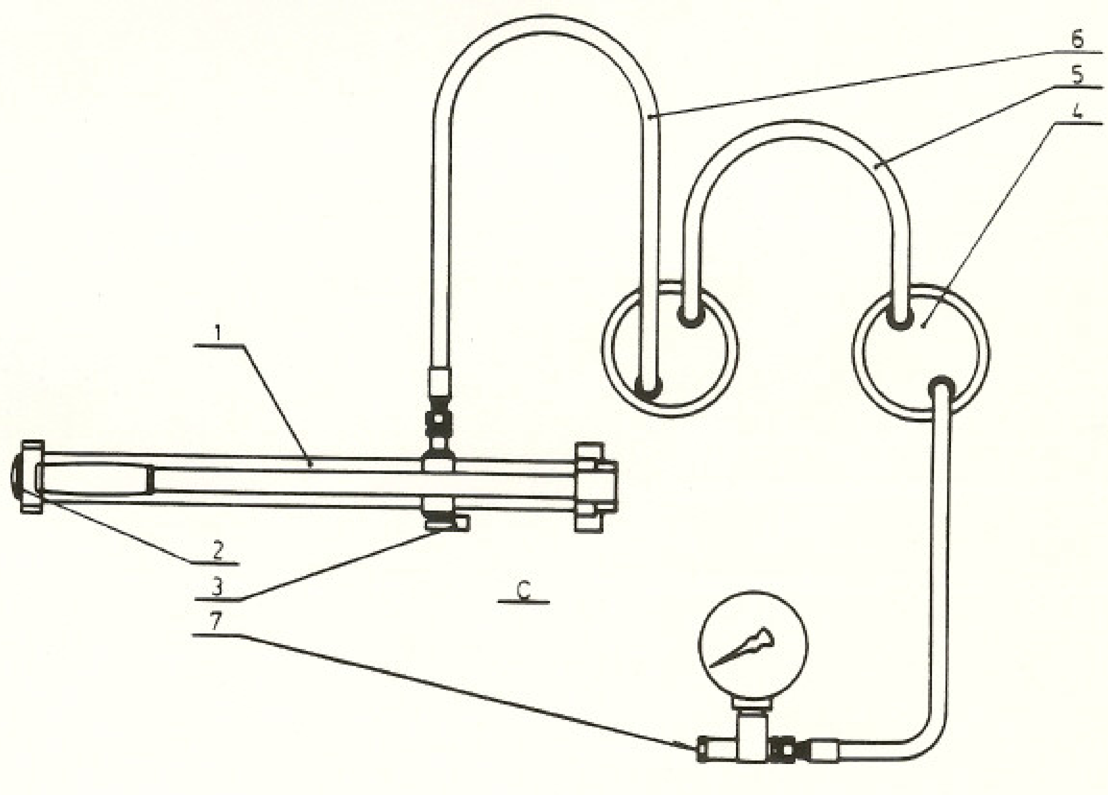
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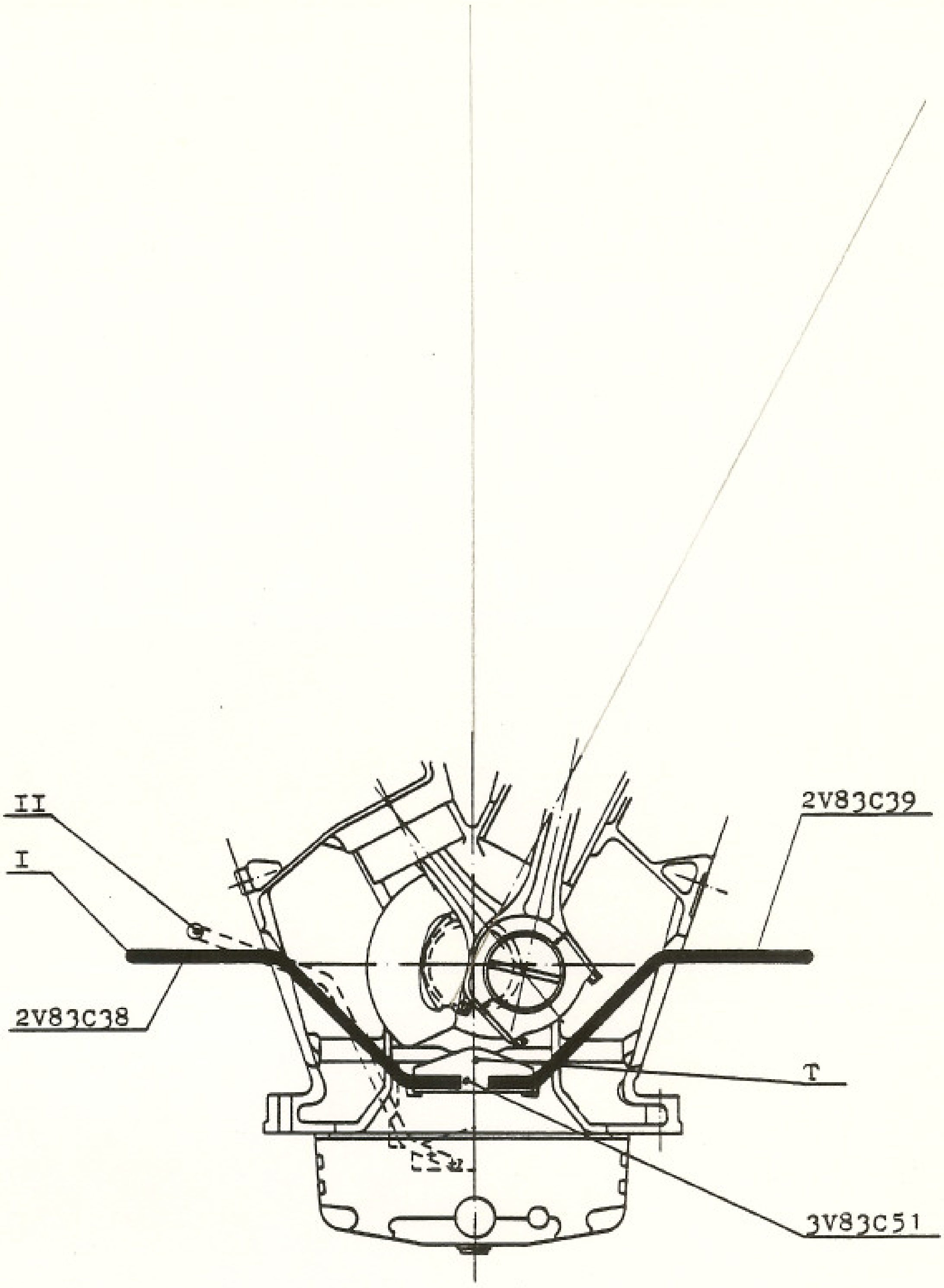
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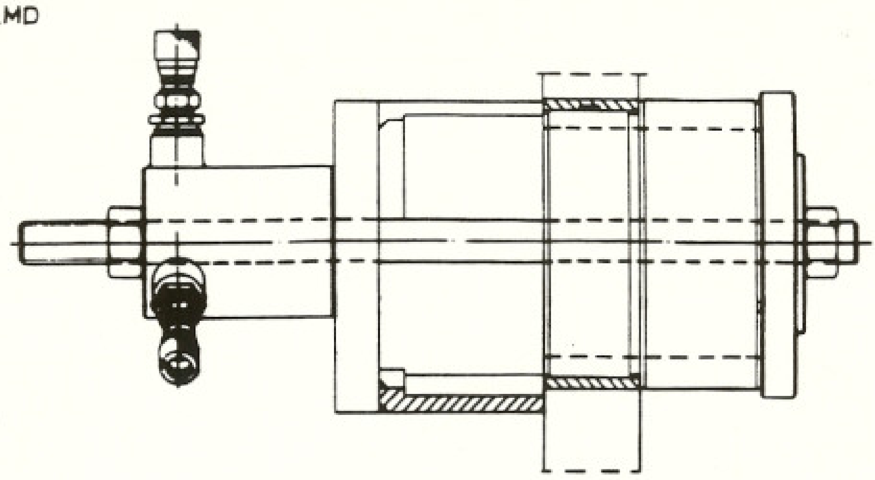

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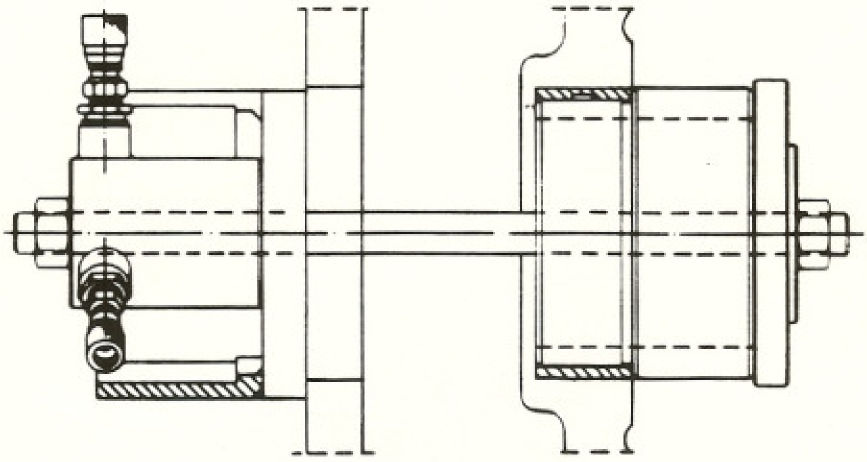

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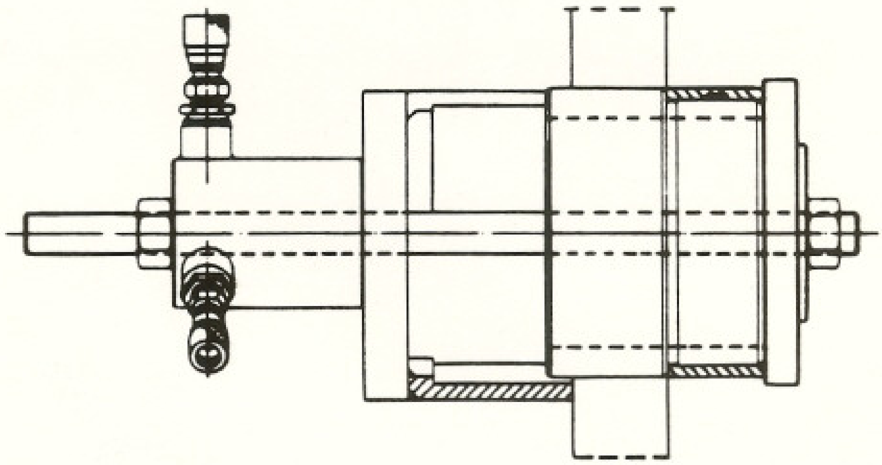

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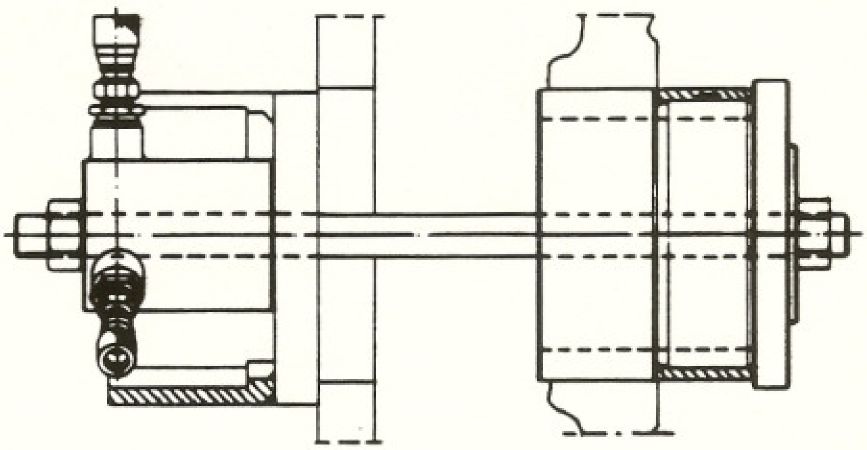
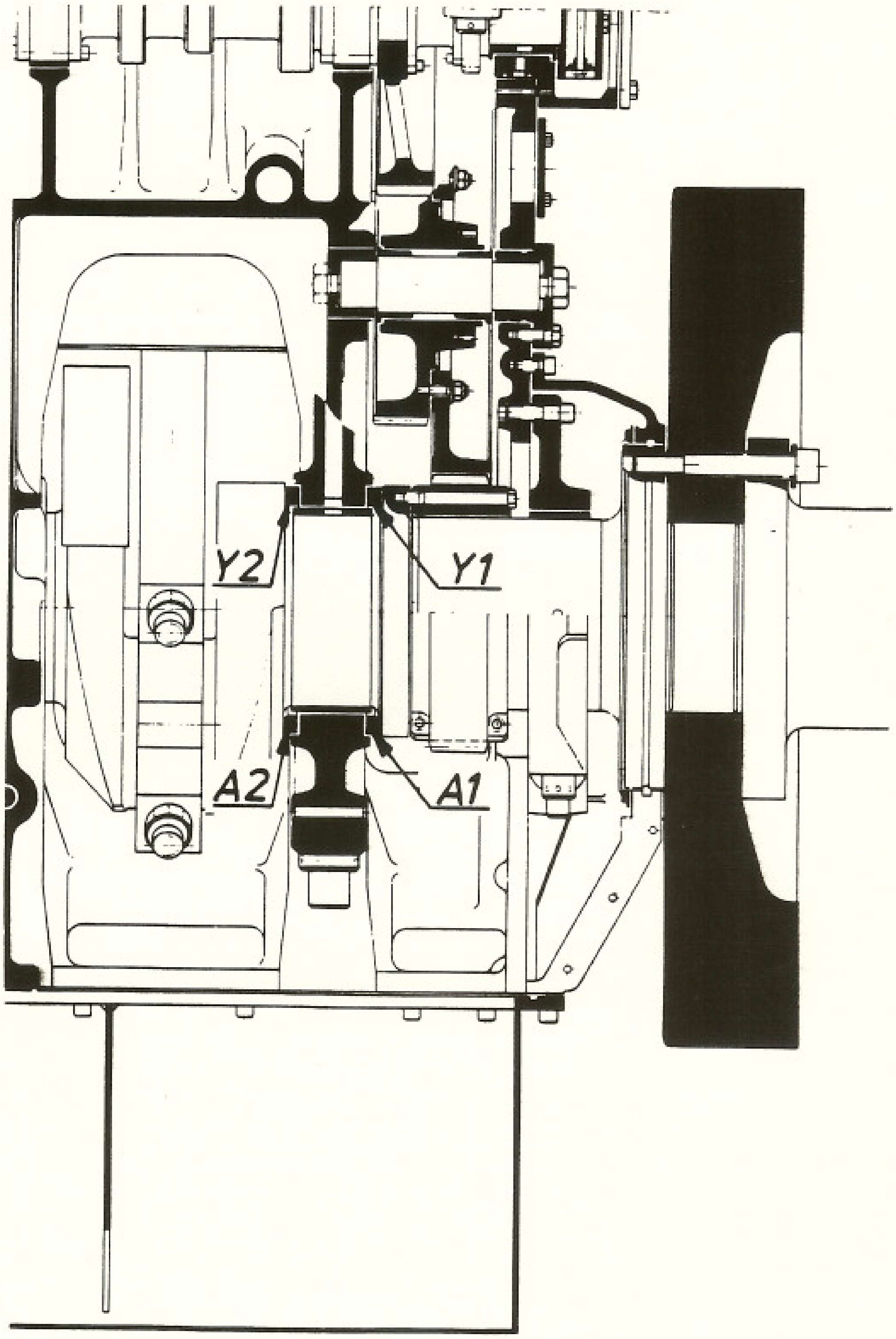


D

Marking of the thrust washers of the crankshaft



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03 Start, stop, operation

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07 Tightening torques and instructions for screw connections

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09 Specific installation data

10 Engine block with bearings, cylinder liners, oil sump

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12 Cylinder head with valves

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11. RUNNING GEAR: CRANKSHAFT, CONNECTING ROD, PISTON

11.1 Description (pages 01-51, 01-52, 01-53, 01-54, 11-51)

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 by two 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.

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 22HF, HE, MD diesel engines can be equipped with a power take-off 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 accurcy of 1°, on the graduation of the flywheel.

The turning device 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.

The connecting rod is drop forged, machined 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 guided axially from 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 fixed axially 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 through a hole. 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 spring-loaded, 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 centre, 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 centre 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 centre, 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 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 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 (fig. 11-52)

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.

3. In-line engine: Turn the crankshaft 95° from the TDC towards the manoeuvring 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.

   Fig. 11-52D. (The figure applies to V-engines, only. When turning in-line engines, use a turning lever (844022) 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 861034 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. 11-55 and open the pump valve.

7. Screw on the hydraulic tools until the piston is in bottom position.

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.

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 after 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.

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 rehoned, all rings are to 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 meauring 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 (fig. 11-53)

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.

   In-line engine: Turn the crankshaft 95° from the TDC towards the manoeuvring 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.

7. Screw on the hydraulic tools; for the in-line engine the hydraulic tool 861034 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. 11-55 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.

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Operator: dg

Attn: Peter Green

February 25, 1997

Fax No:

# of pages including Cover sheet: 6

From: M. Gammon

our ref: 970225-01

Subject: Vibration Damper

Please find attached information on the Giesllnger dampers installed on the 12V22 engines. Sorry the earlier information was for a larger damper.

The damper should have oil inside. On start up after installation the unit should be bleed by removing the bleed screw No. 32. When the engine is in operation the oil is vented by the way of a nozzle. When servicing the damper this nozzle should be cleaned.

If as you say the damper has no oil inside please remove plate No. 110-019 and check that there is no plug inside the C/S, if there is plug please remove it and reinstall plate 110-019.

Attached you will find a parts list, drawings of the damper, and where to check the dimensions.

March 1976
le/ma

Schedule below shows intervals of various kinds of inspections.

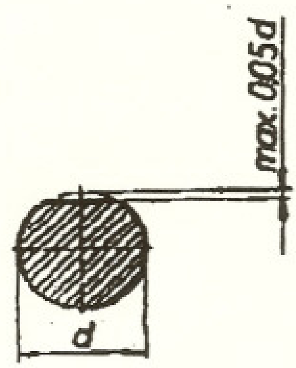
Kind of inspection	Intervals in hours of service		
	1000-2000	18-20000	40-60000
Superficial inspection for oil leakage acc.to chapter 4.1	x		
Dismantle damper, clean all parts and replace all rubber seal rings (chapter 3)		x	
Service or replacement of spring packs			x

5. Allowable wear

5.1 Rubber seal rings

Total wear must not exceed 5 % of the rope diameter (see fig.1) Independent from wear all rubber rings and gaskets should be renewed whenever damper is taken apart. Because of leakage problems vulcanized rubber rings do not suit this application! Use seamless rings only!
For ring-material see list of parts!

fig. 1



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5.2 Inner spring ends and groove flanks

Wear takes place due to lack of oil supply.
Spring packs consisting of two conical spring blades only are clamped in the innerstar grooves at their inner spring ends, thus producing a slight preload of the springs. The allowable wear will be attained as soon as the preload of the springs is not existing any more and an additional clearance of 'z' mm per side between spring ends and groove flanks occures (totalling 2'z mm if one side of spring end rests on groove flank) see fig.2.

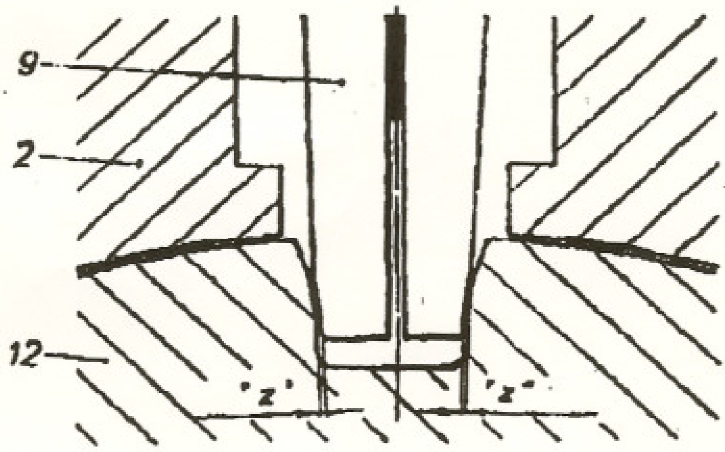


fig. 2

z = 0,2.. mm

6. General working conditions:

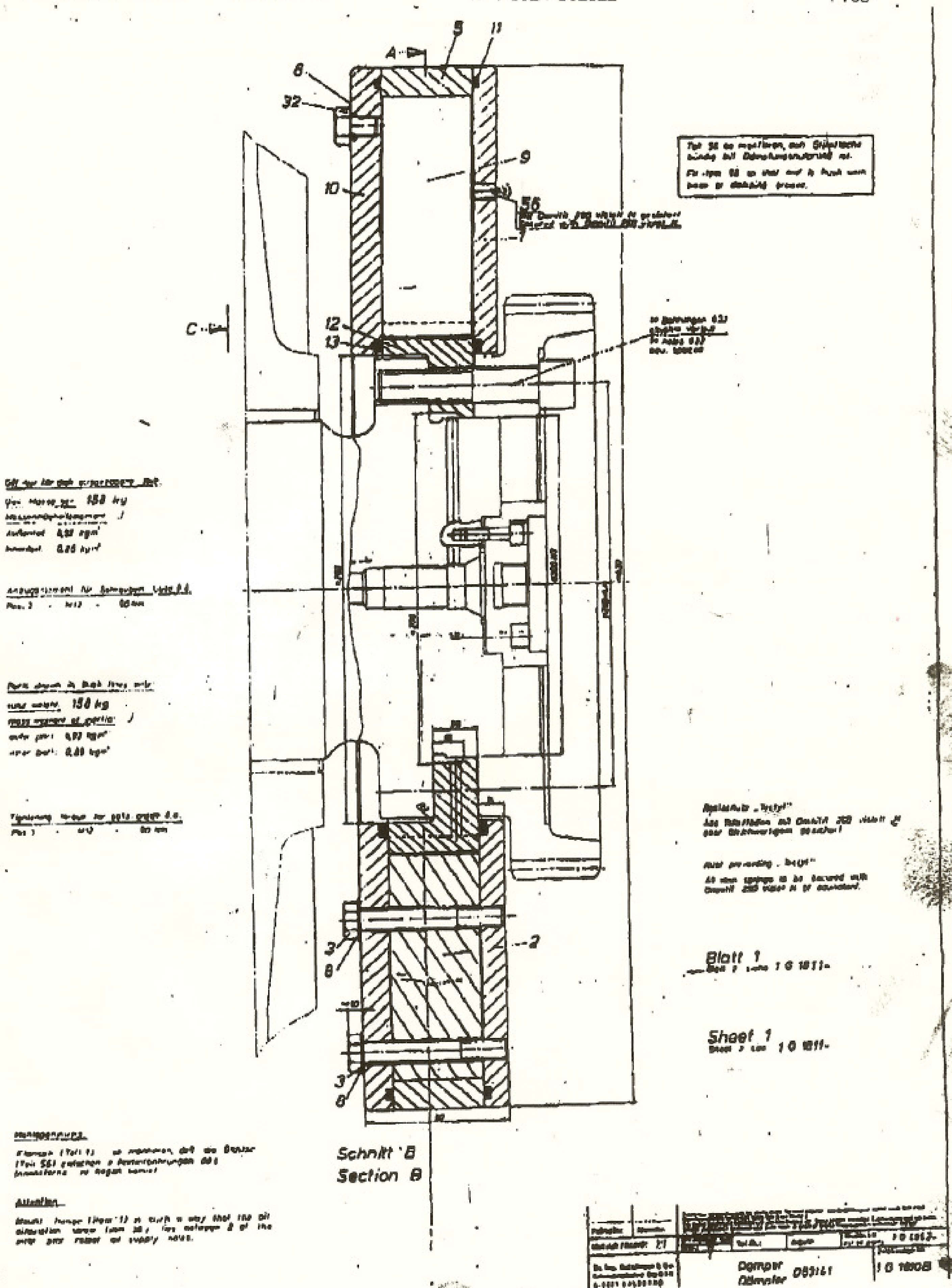
- Oil pressure at oil-inlet of damper to be 2,5 bar minimum.(u.o.s)
- Ambient temperature from - 20° to + 120 ° C (unless otherwise stated).

7. Assembly and disassembly of spring unit:

7.1 Disassembly of spring unit with intermediate ring (4)

7.1.1 Note that mark numbers on intermediate ring (4) and clamping ring (5) must concide. (see dwg.G6476)

7.1.2 To press off the clamping (5) use auxiliary rings as shown on dwgs.no.G 6475 (item 60,61) or equivalent rings of same hight.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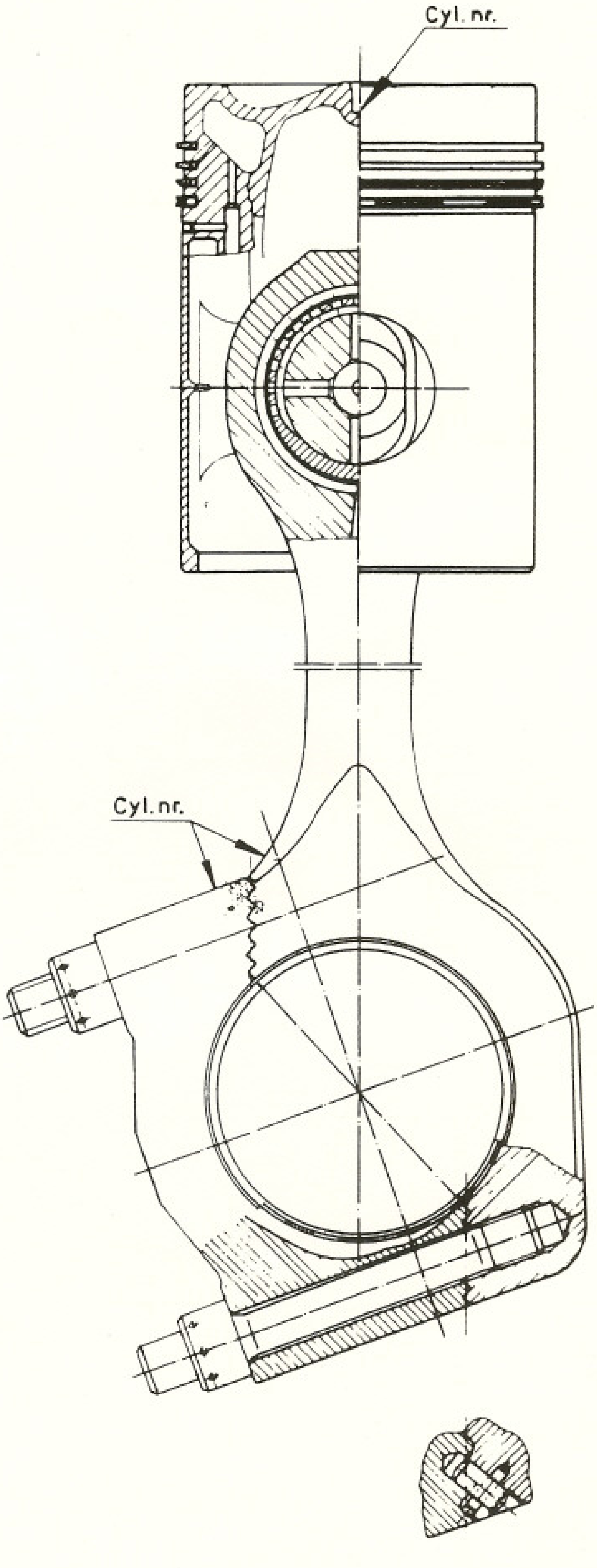
Blatt 1
Sheet 1
Damper
Dämpfer

Teil Nr. / Item no.	Anzahl / Number	Werkstoff / Material	Benennung / Name	Zeichnung nr. / Drawing no.
1	1	St 50-2	flange	2G 2745 A
2	1(24)	St 50-2	ring for intermediate pieces	3G 2575 B
3	48	grade 8.8	hexagon bolt M 12 x 80	DIN 931
5	1	41Cr4v	clamping ring	1G 4170
8	50	spring steel	disc spring Ø 25 x Ø 13 x 1,5	-
9	24	spring steel	spring pack	2G 2744
10	1	St 50-2	lateral plate	2G 3746 A
11	2	Viton	o-ring Ø 5 x Ø 607	RS
12	1	Ck 45	innerstar	3G 25778
13	2	Viton	o-ring Ø 6 x Ø 280	OR
9	as reqd.	CuSn6	shim 32 $48^{+0,1}$ x 0.2	-
22	24	CuSn6	shim $97^{+0,1}$ x $48^{+0,1}$ x 1,5	-
32	2	grade 8.8	hexagon bolt M12x12	DIN 933
56	2	grade 4.6	threaded oil nozzle M10x13,5/ Ø1,5	G4 07724

	Datum: / date: 82/12/02	geprüft: / checked:
Ing. Geislinger & Co. Schwingungstechnik Ges. m. b. H. A-5023 SALZBURG ÖSTERREICH/AUSTRIA	Stückliste / List of parts Damper D 63141 Zeichnung Nr. / drawing no.: 1G 1810B 1G 1811B	1G 4842E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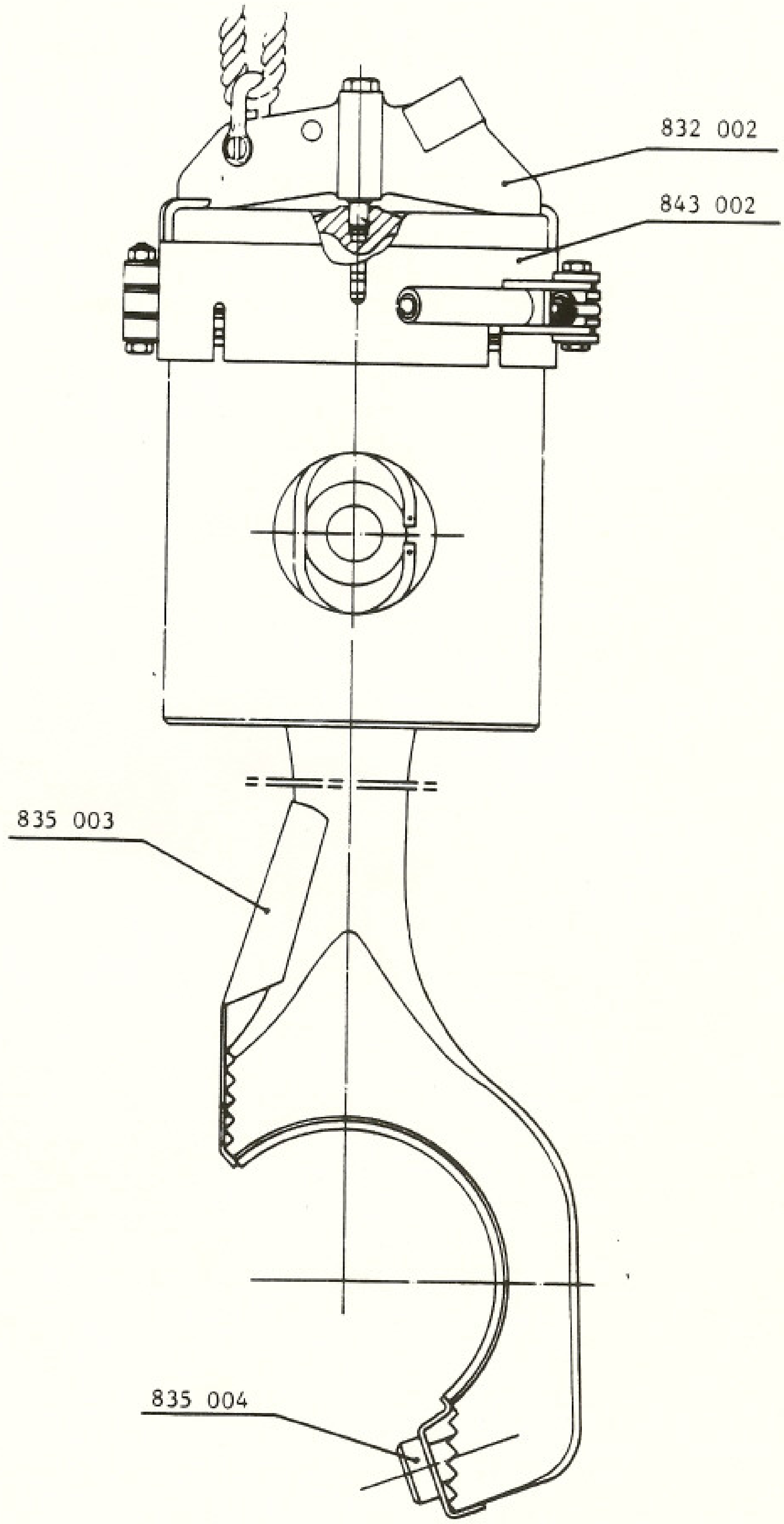
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12. CYLINDER HEAD WITH VALVES

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 (fig. 12-53)

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.

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.

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.

7. Release pressure by opening the valve of the hydraulic pump, loosen the hoses, unscrew and lift off the cylinders.

8. Remove the cylinder head nuts. Fig. 12-53K.

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

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

11. Apply the caps to protect the screw threads.

12.3 Installing the cylinder head (fig. 12-54)

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.

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.

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.

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

9. Remove the hoses, unscrew and lift of the hydrulic 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. 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.

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

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

12.4 Adjusting the valve clearance (fig. 12-55)

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. 12-55B,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.

4. Insert a feeler gauge corresponding to the valve clearance 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.

12.5 Maintenance of the inlet and exhaust valves (fig. 12-52)

12.5.1 Removing the valves

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

b) Depress the springs by turning the device clockwise.

c) Knock at the centre of the valve discs, one at a time, whereby the cotters come loose and can be removed.

d) Unload the tool. The spring retainers and the springs can now be removed.

e) Check that the valves move easily in the guides. Note in which guide each valve was situated before.

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. 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.

3. 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.

4. 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.

5. 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 74 mm; 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.

6. Change of the seat ring

Removal of the old ring (fig. 12-52A)

a. 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.

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

Fitting a new inlet valve seat ring (page 12-52)

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

d. 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.

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

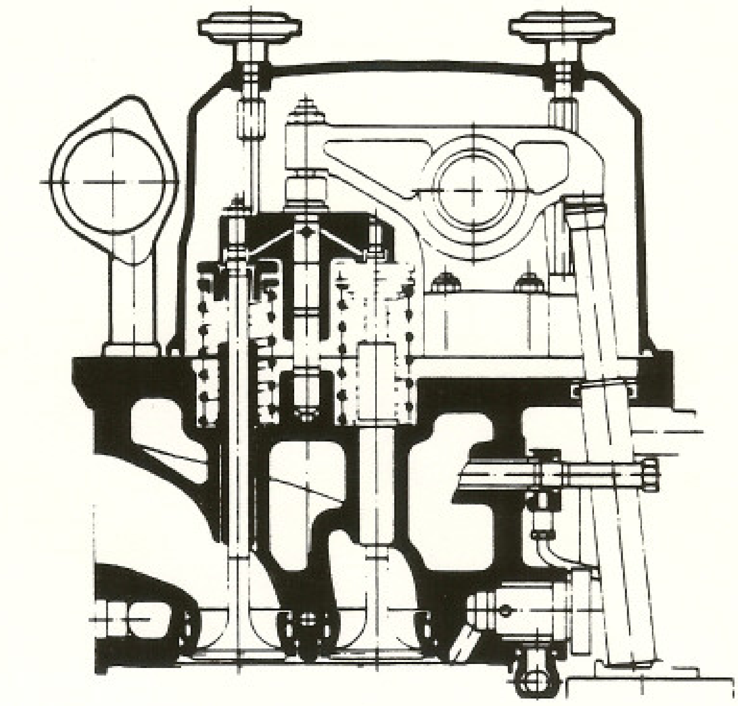
Fitting a new exhaust valve seat ring

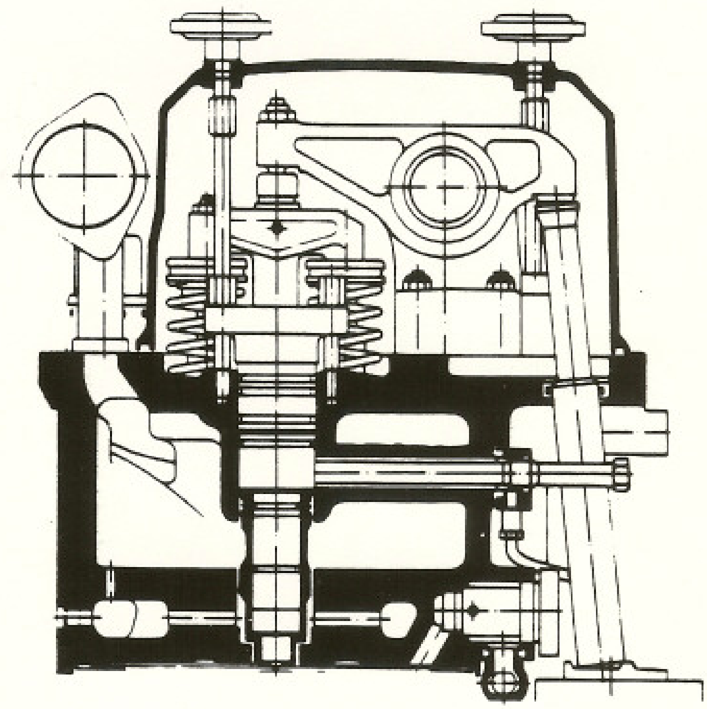
f. For fitting an exhaust valve seat ring the tool 834002 is required.

g. 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.

h. 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.

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





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13. CAMSHAFT DRIVE (fig. 13-51)

13.1 Description

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

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.

11. 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.

13.3 Installing the gearing

1. Turn the crankshaft as follows:
   a. In-line engines: Turn the crankshaft to the TDC for cylinder No 1.
   b. V-engines, the camshaft gearings of both cylinder banks removed: Turn the crankshaft to the TDC for cylinder No A1.
   c. 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.
   d. 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).
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.

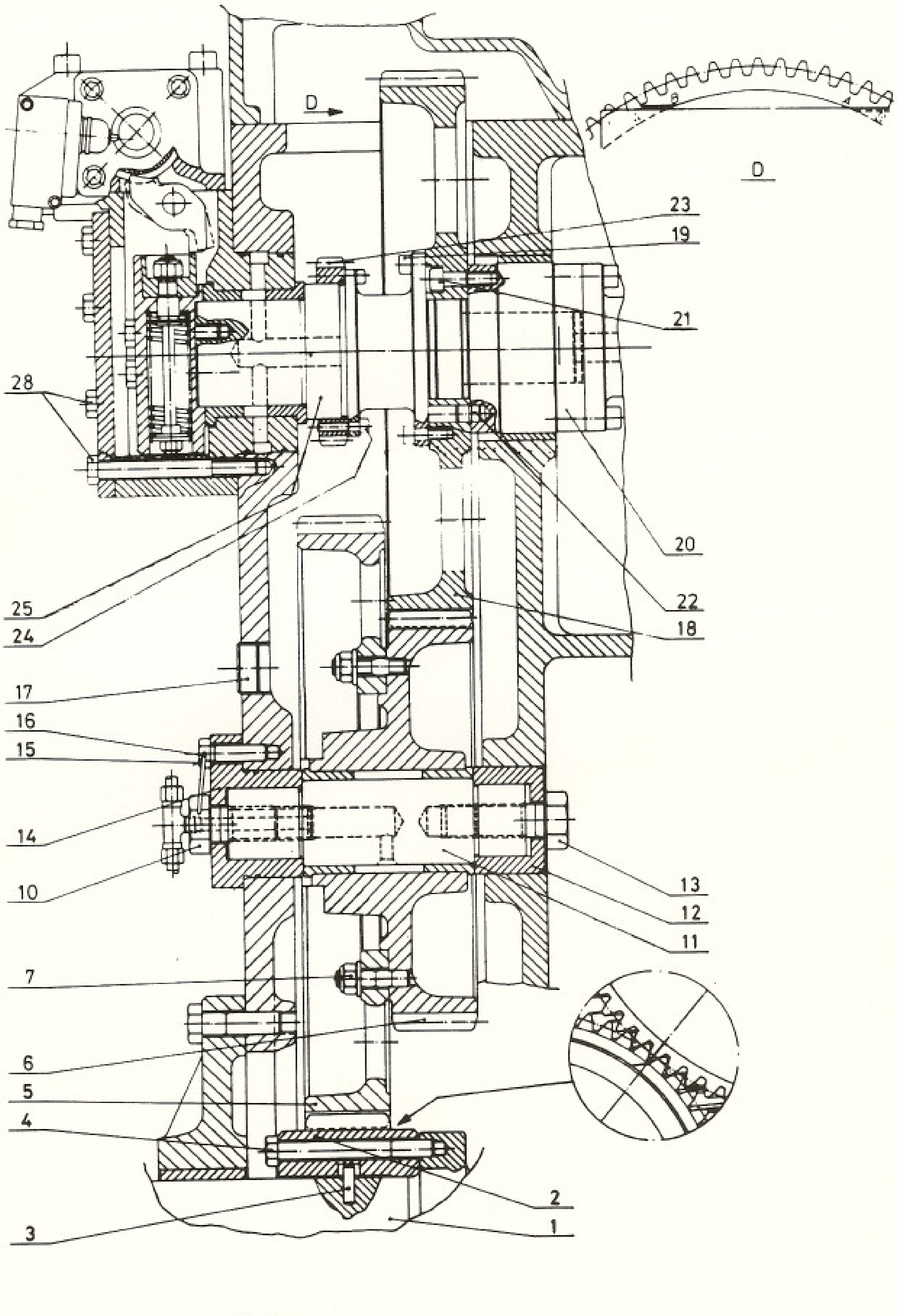
9. Install the overspeed trip and the extension piece (25).

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.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14. VALVE TIMING GEAR AND CAMSHAFT (fig. 14-51)

14.1 Valve mechanism, description

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 rods 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 (fig. 14-53)

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.

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).

14.6 Mounting of a camshaft piece (fig. 14-53)

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.

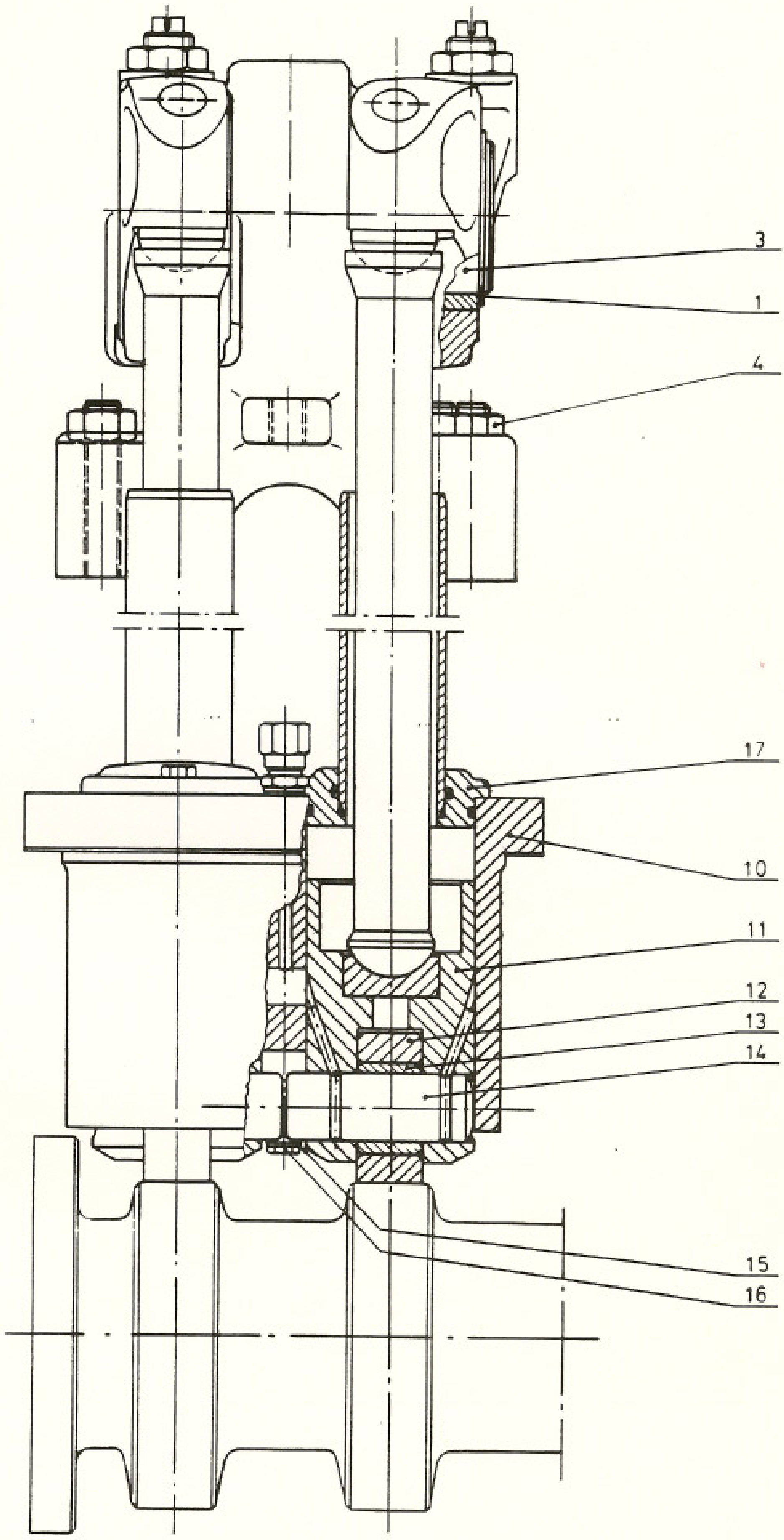
3. Mount the camshaft piece on the fixing pin and centering at either end. Then compress the camshaft.

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.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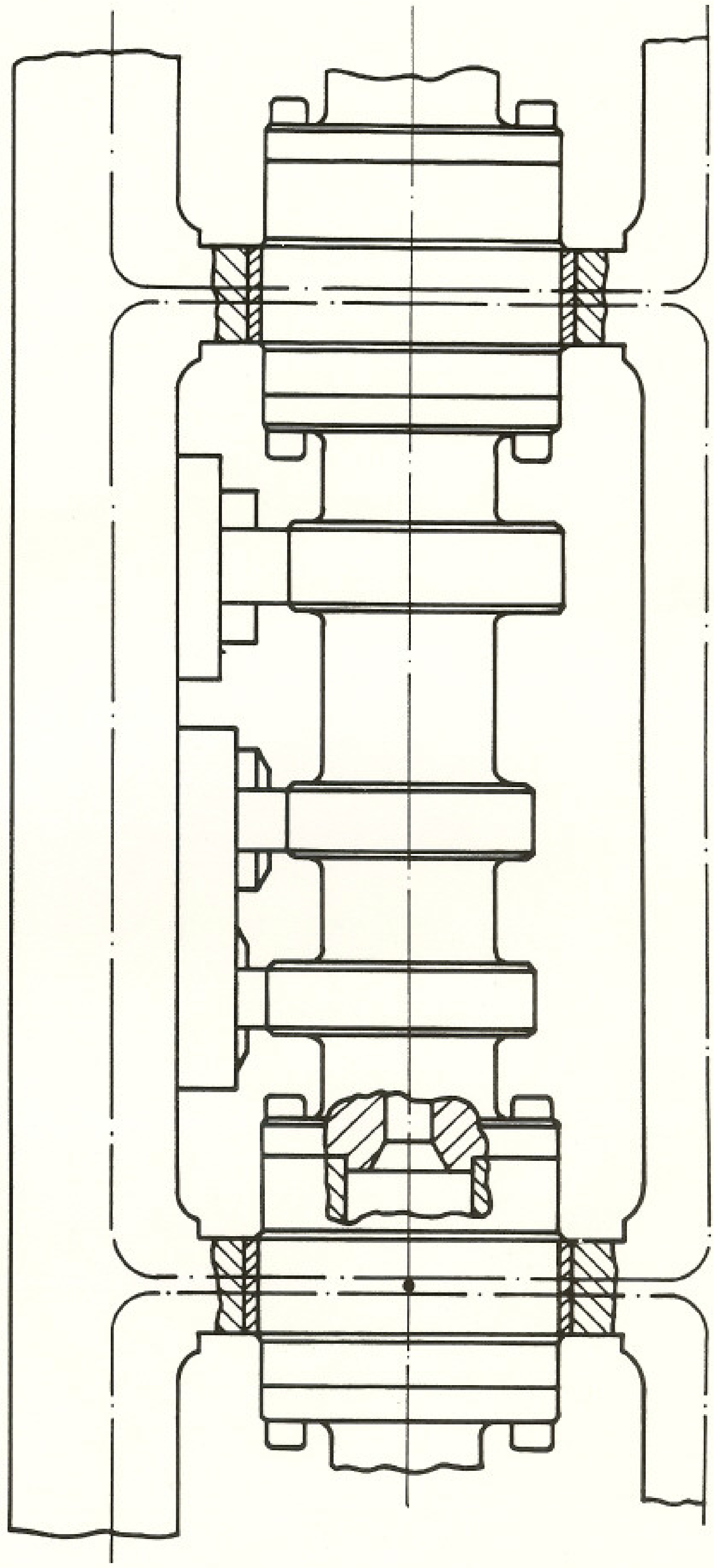
CAM SHAFT ASSEMBLY, VASA 22HF, MD



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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. The housing is fastened to the engine block by screws at the free end of the engine. V-engines have two identical cooler inserts in a common housing.

The gas inlet and outlet casings of the turbocharger are 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.

Turbochargers for engines running on heavy fuel (22HF and 22HE) are equipped with cleaning devices for washing by water of the compressor and the turbine.

Turbochargers for engines running on marine diesel fuel (22MD) are equipped with cleaning devices for washing by water of the compressor.

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)
(applies to engines running on heavy fuel, i.e. 22HF and 22HE)

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).

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.

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 161	2 ...3	l/min
VTR 201	3 ...4.5	"
VTR 251	4.5...7	"

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

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 section 15.6 pos. 2.0.6.

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)

a) 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.

b) Apply the lifting tool and lift off the insert.

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

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

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

f) Check the gaskets.

g) Reassemble the cooler insert and mount it on the engine. Check tightness when starting up.

15.6 According to the Brown Boveri manual for the actual type of turbocharger

SEP 07 '94 14:24 FLT TECH SVCS OTTAWA P.2/3

WÄRTSILÄ DIESEL

COVER LETTER

Diesel Service, Vasa Engines
Technical Service
K. Berg

04.07.1994

GOVERNMENT OF CANADA

8TH FLOOR CANADA BUILDING
MINTO PLACE 344 SLATER STREET
OTTOWA
ONTARIO K1A 0N7
CANADA

att.

RECEIVED REÇU 19 1994 #122.9 AMF

AMTF/E JUL 25 1994

JUL 20 1994

A1 dacosta

AFTER SALES INFORMATION FOR WÄRTSILÄ VASA DIESEL ENGINE

Please find enclosed the Operating Instruction WV02Q062 concerning the "LUBRICATING OIL FOR ABB (BBC), VTR-TURBOCHARGERS".

Please note the changes in the list of approved lubricating oils and the new requirements in the specification. Especially, the synthetic lubricant "Rarus 827" from Mobil was included in the list of approved lubricants. This product has been removed from this list in the latest issue of the instruction manual. The "Rarus 827" is superseded by a new synthetic lubricant from Mobil, designated "Mobil Rarus SHC 1026", which has an improved thermal stability and a higher viscosity index compared to Rarus 827. Especially under severe operating conditions, as high load and high ambient temperature, the benefits of this improvement is obvious.

RECEIVED SEP 25 1994 CCGS SAMUEL RISLEY

Due to above mentioned, we strongly recommend those of our customers who are using Mobil Rarus 827 to change to the new synthetic lubricant Mobil Rarus SHC 1026 in order to provide additional safety margin and favourable operating conditions for the turbocharger bearings.

If you have any questions please contact our Service Network or:

Wärtsilä Diesel Oy
Attn. Mr. Kaj Berg
telephone no. +358 61 327 2782
telefax no. +358 61 356 7355

Yours faithfully,

RECEIVED REÇU JUL 20 1994 AMFO

Wärtsilä Diesel Oy
Diesel Service, Vasa engines
Technical Service

I. Råback
I. Råback
Manager

ENCLOSURE Operating Instruction WV02Q062GB

Postal address	Office address	Telephone	Telefax	Telex
Wärtsilä Diesel Oy Diesel Service P.O. Box 252 FIN-65101 VAASA FINLAND	Tarhaajantie 2 FIN-65380 VAASA FINLAND	+358-61-3270	+358-61-356 7355 Power Plant Service Technical Service +358-61-356 7366 Marine Service +358-61-355 7344 Material Administration +358-61-358 7378 Training and Information	74251 wva sf

LUBRICATING OIL FOR ABB (BBC), VTR-TURBOCHARGERS

Following lubricating oils are approved for use in VTR type turbochargers. Only such lubricants may be used which have a viscosity of 61 - 90 cSt at 40°C **and** 7.5 - 12 at 100°C, turbine oils are preferred. Oil change interval is 500 h service for normal mineral oils, 1 500 h service for special mineral oils and 2 500 h service for synthetic lubricating oils. See also the Instruction Book for the turbocharger.

! **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**	**Viscosity (cSt)**		**Viscosity index (VI)**
		40°C	**100°C**	
Agip	Ote 68	64	8.6	107
British Petroleum	Energol THB 68	65	8.4	99
	Energol THB 77	77	9.4	98
	Energol HLP 68	68	9.0	105
	Energol SHF 68	64	10.0	144
Caltex	Regal Oil R & O 68	65.5	8.5	100
	Rando Oil 68	64.9	8.5	101
	Rando Oil HD 68	67	8.8	104
	Rando Oil HDZ 68	66	10.7	152
Castrol	Perfekto T 68	64	8.25	95
	Hyspin AWS 68	68	8.6	96
	Hyspin AWH 68	68	10.9	150
Chevron	Chevron GST Oil 68	68	9.02	107
	Mechanism LPS 68	68	10.9	151
Cosmo	Turbine Super 68	68	8.7	100
Elf	Turbine T 68	71	9.0	100
	Turbelf SA 68	68	8.94	105
	Visga 68	73	11.7	155
	Hydrelf DS 68	72.5	11.6	151
Esso	Esso Tro-Mar T / Teresso 77	76	9.5	103
	Teresso 68	67	8.8	108
	Nuto H 68	64	8.4	101
Fina	Turbine oil medium(68) /BAKOLA 68	68	9.2	112
	Turbine oil heavy (80)	80	10.2	108
	Hydran LZ 68	70.6	9.07	100
Idemitsu	Daphne super turbine HT-68	68.1	9.1	110

Distribution: For owners of Wärtsilä VASA diesel engines.
Validity: Supersedes 3215Q007. Until further notice.

Wärtsilä Diesel Oy, Diesel Service, Vasa Engines, P.O. Box 252, (Tarhaajantie 2), FIN-65101 Vaasa, Finland, Telecop. +358 61 356 7355 Telex 74251 wva sf Service Tel. +358 61 3270

Mineral oils: oil change interval 500 h

Manufacturer	Brand name	Viscosity (cSt)		Viscosity Index (VI)
		40°C	100°C	
Indian Oil Corp.	Servoprime 68	64-72	8.15	95
	Servoprime 76	74-80	9.13	95
	Servopress 68	64-72	8.5	95
	Servosystem HLP-68	64-72	8.5	95
Mobil	Mobil Rarus 427 (Not US version)	81	9.9	95
	Mobil DTE Oil Heavy Medium	61.2	8.6	100
	Mobil DTE 16 M	71	10.3	130
Noroil	Statoil Turbway 68	67	8.5	96
	Statoil Hydraway HMA 68	63	8.0	95
Shell	Turbo Oil T 68	68	8.7	98
	Turbo Oil T 78	78	9.4	96
	Tellus Oil 68	68	8.8	102
Texaco	Regal Oil R & O 68	64.7	8.3	96
	Rando Oil HD 68	61.5	8.2	101
Total	Total Preslia 68	68	8.7	100

Special mineral oils: oil change interval 500 h

Manufacturer	Brand name	Viscosity (cSt)		Viscosity Index (VI)
		40°C	100°C	
British Petroleum	BP Energol RC 68	68	8.8	104
Valvoline	Valvoline Compressor oil 62	90	10.0	92

Synthetic lubricating oils: oil change interval 2 500h

Manufacturer	Brand name	Viscosity (cSt)		Viscosity Index (VI)
		40°C	100°C	
Elf	Barelf CH 68	69.9	8.9	100
Esso	Exxon Synesstic 68	65.0	7.7	67
Mobil	Mobil Rarus SHC 1026	66.8	10.4	144
Nyco	Nyco Nycolube 3060	93.0	10.0	85

These lubricating oils are, regarding viscosity and quality, according to the recommendations.

WÄRTSILÄ DIESEL

CANADIAN COAST GUARD 14.9.1990 1(2)

1 Yonge Street, 20th floor
TORONTO, ONTARIO M5E 1E5
CANADA

att. Mr Dave Marsh File No. 5371

AFTER SALES INFORMATION FOR DIESEL ENGINE VASA 22

Please find enclosed documents 3215Q007GB and 3215S011GB.
Each of the attached two documents covers the turbocharger in a way or another.

LUBRICATING OIL FOR ASEA BROWN BOVERI TURBOCHARGERS/3215Q007GB

As the cooling system in our engines today operates with a water temperature of about 90 C at the turbocharger inlet there is a need to reduce the oil change interval from previously applied 1000 running hours. Also in older engines running with high temperature on the cooling water to the turbocharger shorter lube oil change interval should be applied.

We thus refer to the oil change intervals given in the Operation Instruction for different typs of lube oil.

copy to C/E Samuel Risley
Jim.
15.10.90

RECEIVED
OCT 23 1990
CCGS
SAMUEL RISLEY

RECEIVED
9172-1
OCT 12 1990
BY RMFS

Log in's PA
copy to Chief Eng

Postal address Office address Telephone Telex Telecopier

WÄRTSILÄ DIESEL

TURBOCHARGER CLEANING/3215S011GB

Although the Service Letter is self-explanatory we would like to stress the importance of regular cleaning of the turbocharger by water cleaning according to the instruction manual.

Deposits, especially on the turbine parts, cause higher thermal load of the engine itself and also impaired operating conditions for the turbocharger components in particular the bearings. Regular cleaning by water injection and otherwise normal maintenance of the turbocharger is therefore essential for optimal operation of the engine as well as the charger

Eventhough they are originally made for the VASA 32, the information can be applied directly to the VASA 22 engine, except cylinder output when cleaning, which is about 50 kW/cyl for the VASA 22.

Yours faithfully,

Wärtsilä Diesel Oy
Diesel Service, Vasa engines
Technical Service

I Råback
Manager

ENCLOSURES 3215Q007GB
3215S011GB

LUBRICATING OIL CHANGE INTERVALS FOR TURBOCHARGERS

According to earlier instructions the lubricating oil change intervals for the VTR-turbochargers have been 1000 hours for mineral oils. This is also what the turbocharger manufacturer recommends.

Our experience today is that the turbocharger oil is ageing more rapidly if the cooling water temperature after the turbocharger exceeds 95°C.

Our strong recommendation is to shorten the oil change intervals to the half of earlier interval, i.e. 500 hours for mineral oils for engines where the cooling water temperature exceeds 95°C.

Mineral oils: oil change interval 500 h		
Manufacturer	**Brand name**	**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 °C 68 Turbine Oil °C 100	40 49
Gulf	Harmony Gulfcrest 68	40
Esso	Esso Tro-Mar T 68 Esso Tro-Mar T 77	39 48
Indian Oil Corp.	Servoprime 68 Servoprime 76	
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 & O Regal Oil PE 100 R & O	39 52
Total	Total Preslia 40 (68) Total Preslia 50 (68)	39 48

In installations where a change interval of 500 hours is inconvenient, a special mineral oil or a synthetic oil can be used.

Special mineral oils: oil change interval 1 500 h		
Manufacturer	**Brand name**	**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**	**Viscosity cSt at 50°C**
Mobil	Mobil Rarus 827	50
Nyco	Nyco Nycolube 3060	-
Esso	Exxon Synesstic 68	

Engine Section	Engine type	Ref.	Date	Issue	Doc. No.	Page
15 Turbocharger	32	K. Berg	18.04.1990	01	3215S011GB	1(1)

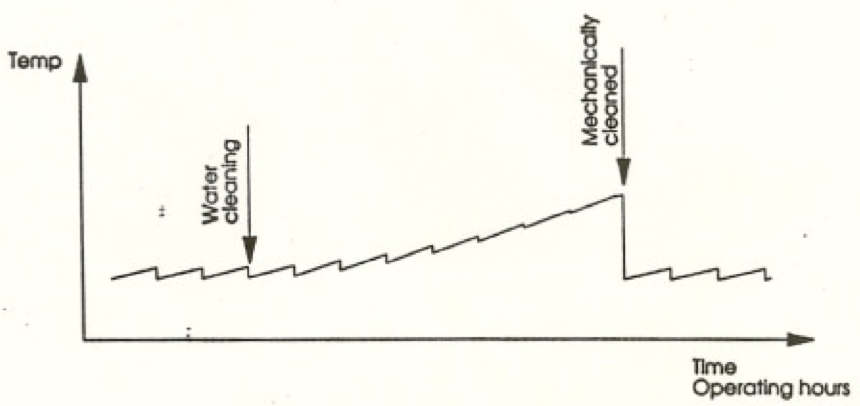
TURBOCHARGER CLEANING

From some installations, visited by our service engineers, we have noted that the engine personnel have not paid attention to the cleaning of turbocharger. It is of outmost importance that the compressor, as well as the turbine are cleaned regularly in operation. A dirty or fouled turbocharger increase the fuel consumption and thermal load of the engine.

Recommended water cleaning interval for the compressor is 50 hours and for the turbine 250 hours. The interval must be shortened if it is noted that the exhaust temperatures have risen in a shorter time. The procedure for cleaning of the turbine is described in the Engine Manual and the compressor cleaning in the Turbocharger Operation Manual.

Our experience is that even if the water cleaning has been done properly, hard deposits are, by the time, built up on the nozzle ring and turbine blades in the turbocharger, exhaust side. This can be detected by a higher level on the exhaust gas temperatures compared to a clean turbine and the trend is even increasing.

Exhaust gas temperature trend



An other indication of fouled turbine is that normal water cleaning does not effect much on the temperature level. If it is suspected that the turbine is fouled, the nozzle ring and the rotor has to be cleaned mechanically. For that purpose the rotor and the nozzle ring have to be removed from the turbocharger.

We also recommend that the turbine side is checked at about every 8000 hours, or at least when the turbocharger bearings are changed, and the fouled parts are mechanically cleaned.

Note ! **Maintenance on the turbocharger should be carried out by authorized personnel only!**

15.3.2 Cleaning procedure

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

2 **Reduce engine load** to about 100 kW/cyl at nominal speed or reduce speed to between 400 and 500 RPM with fixed propeller. **Maximum exhaust gas temperature after cylinder is 380°C!**

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

4 **Connect water hose.**

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

6 **Open valve** (5) slowly within 30 s and increase the water flow until about 0.1 l/min flows off through the drain opening of the gas outlet casing.

7 **Pressure control valve must be adjusted** to a pressure of about 2...3 bar or the pressure noticed when calibrating.

8 **The washing time** is about 10 min. A measure for the washing time is also the cleanliness and clarity of the draining water. If the drained water is still dirty after 10 minutes washing, finish the cleaning procedure but **repeat it after one to two hour normal operating.**

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

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

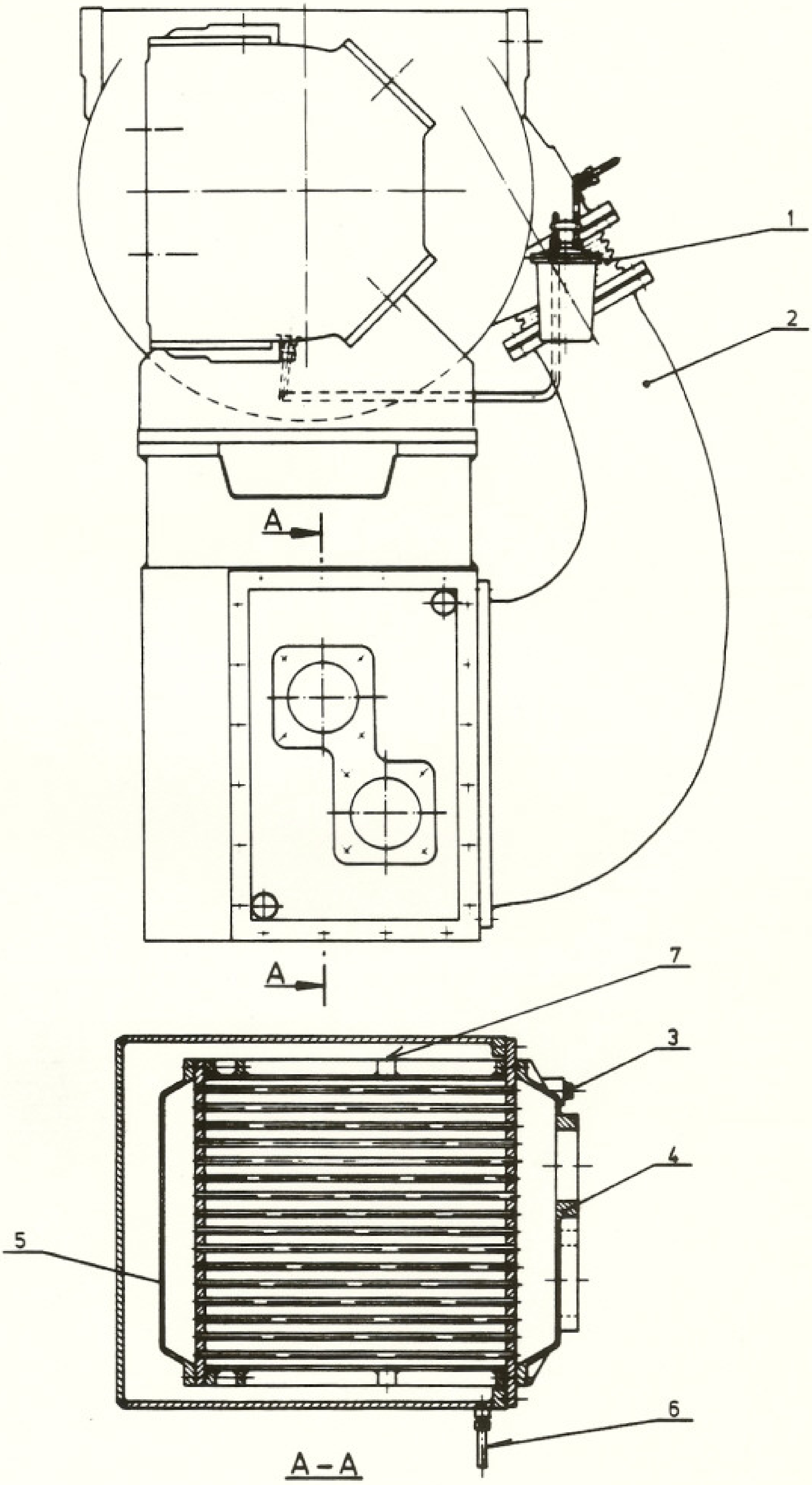
11 **Resume normal engine operation** at higher output and, as soon as possible, repeat the readings taken in step 1 above for comparative purposes.

Note! **Clean the turbine (exhaust side) of the turbocharger at low loads (20...40 % of full rated load).**

15.3.3 Water cleaning of compressor

Water washing of the compressor side during operation, see turbocharger instruction manual, section 2.0.6.

Note! **Clean the compressor (air side) of the turbocharger at as high load as possible (full rated load).**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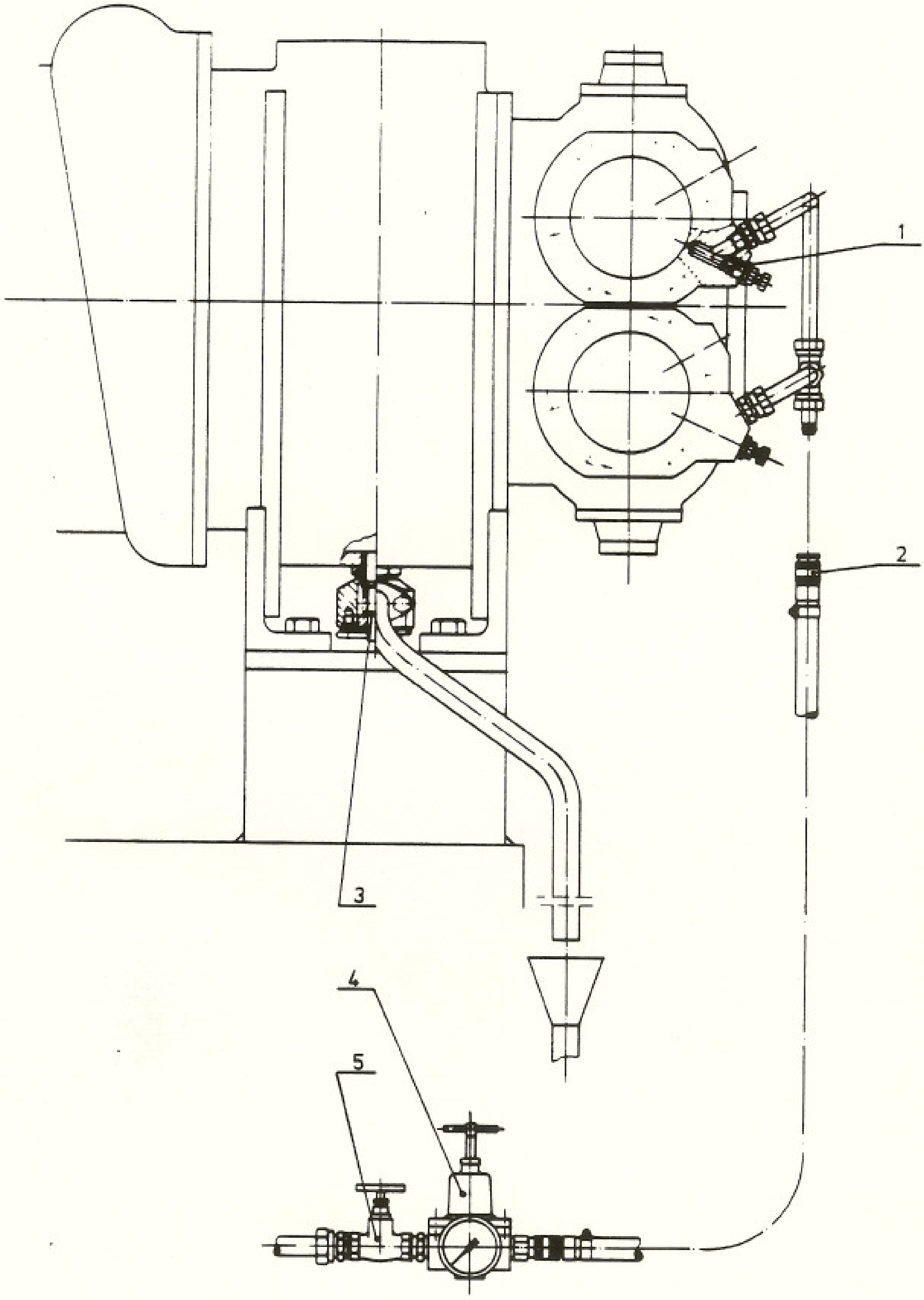
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02 Fuel oil, lubricating oil, cooling water

03 Start, stop, operation

04 Maintenance schedule

05 Maintenance tools

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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 multi-orifice nozzle.

The nozzles are oil heated/cooled and must not be run without oil flow. (This applies to engines running on heavy fuel, i.e. 22HF and 22HE.)

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

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 shut-down cylinder (22-53 pos. 6) inclusive pipe, which is loosened only from the distributing pipe.

5. Disengage the control lever from the pump rack by bending sideways the spring, which presses the rack against the control lever.

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.

Reinstalling

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

10. 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.

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

12. Connect the control arm and pump rack by bending the spring in position. Check the control rack for free movement.

13. 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 806007.

14. 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).

15. Check the fuel rack positions according to section 22.3.1b.

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 <u>distillate fuel</u>. Fuel is now flowing out from 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.

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. Reinstal 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. The nozzle is oil heated/cooled and the oil enters the nozzle holder between two O-rings. (This applies to engines running on heavy fuel, i.e. 22HF and 22HE.)

16.9 Removing injection valve (refer to letter at the end of the section)

1. Remove the cylinder head cover and injection pump cover. Shut off nozzle temperature control system (only 22HF and 22HE).

2. Remove the high pressure injection pipe.

3. Loosen the sealing flange of the high pressure connection piece and unscrew the connection piece.

4. Remove the fastening nuts of the injection valve.

5. 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.

6. Protect the fuel inlet hole of the injection valve and bore in the cylinder head.

16.10 Mounting injection valve (refer to letter at the end of the Section

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. Puth 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.

<u>16.11 Overhauling injection valve</u> (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 or, for engines running on heavy fuel, i.e. 22HF and 22HE, there has been disturbances in the nozzle temperature control system. 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 nozzle orifices 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 (fig. 13-51) (delivery start)

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.

WÄRTSILÄ DIESEL

WÄRTSILÄ DIESEL CANADA INC.
50 Akerley Boulevard
Dartmouth, Nova Scotia
Canada B3B 1R8
Telephone (902) 468-1264

FAX WORK ORDER

Fax No. (902) 468-1265

Date: May 25, 1993

To: C.C.G.S. Samuel Risley

Attn: Peter Green

Ref. No.

Fax No: 1-807-345-3690 or 344-5893

No. of pages inc. cover page 3

From: Mike Gammon

Subject: Nozzle Holders

This is in response to your inquiry concerning the cracking of the nozzle holders code 167150 of the Vasa 12V22 engine.

Wärtsilä Diesel has experienced some similar cases. Reasons for cracking nozzle holders have been found to be crossthreads, overtightening and unclear cases. It has been confirmed that it is possible to "build in" tensions in the connection piece when the nuts (3) and screws (4) are tightened before the connection piece (1) and the high pressure pipe nuts (2) are tightened, see attached figure.

Please see attached, new instructions of Wärtsilä diesel recommended tightening procedures for the injection pipes/nozzle holder of the Vasa 22 engine. No complaints have been made after other customers have been advised of this instruction. W.D. is of the opinion that the problem will be eliminated by using this tightening procedure.

We hope that you will find this information helpful and please keep us informed of the results.

Regards;

Mike Gammon

16.4 Injection valve

16.4.1 Description

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.

Injection valves

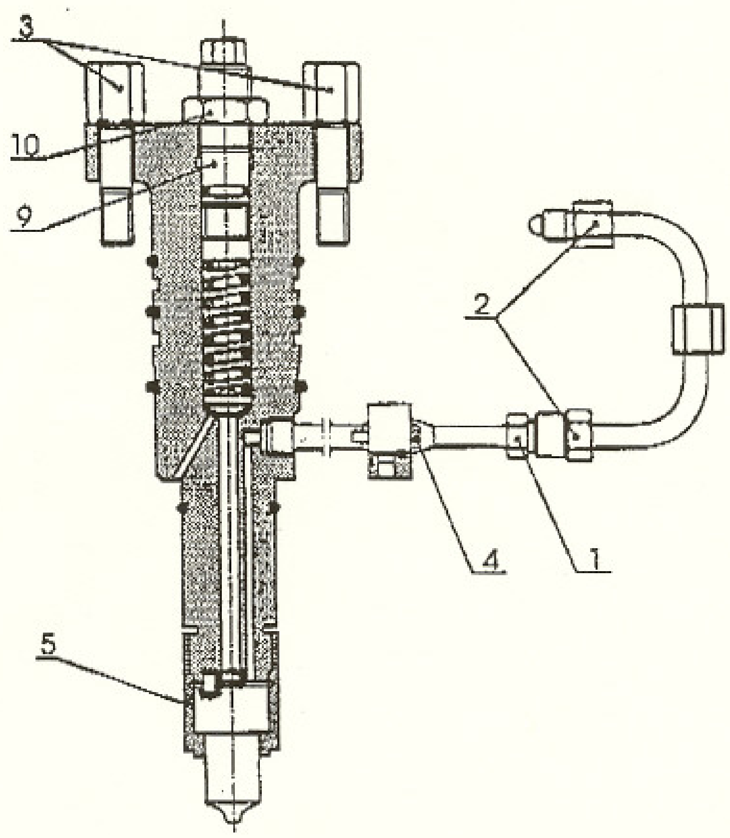


Fig 16-2 2216539213

16.4.2 Removing injection valve

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

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.

16.4.3 Mounting injection valve and high pressure pipes

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 metal to metal 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 but do not tighten the nuts (3), Fig 16-2.

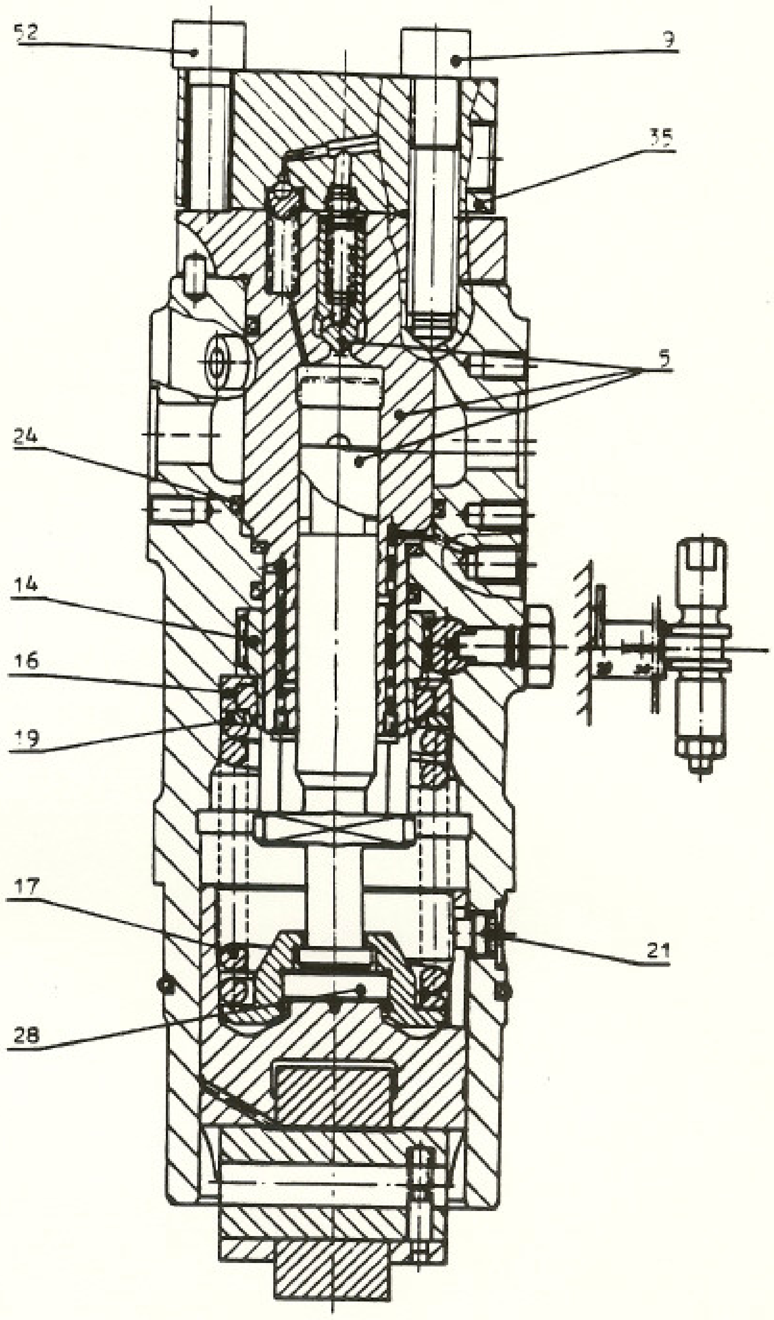
4 **Put new O-rings** in the sealing flange of the high pressure connection piece. Place the flange on the connection piece and screw in the connection by hand, (be sure that the flange screws (4) is loose). Tighten the connection piece (1) to correct torque.

5 **Mount the injection line** and tighten the two cap nuts (2) to correct torque.

6 **Tighten the fastening nuts (3)** of the injection valve to correct torque in steps of 10 Nm.

7 **Fasten the hexagon nuts on the sealing flange (4) of** the high pressure connection.

8 **Replace the covers.**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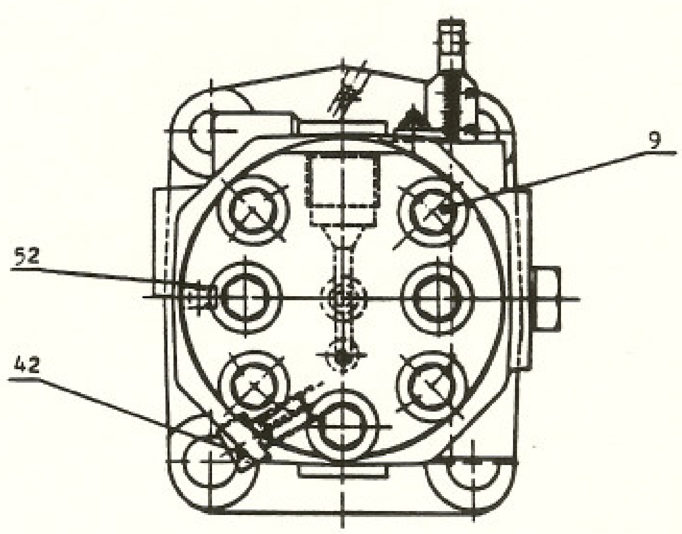
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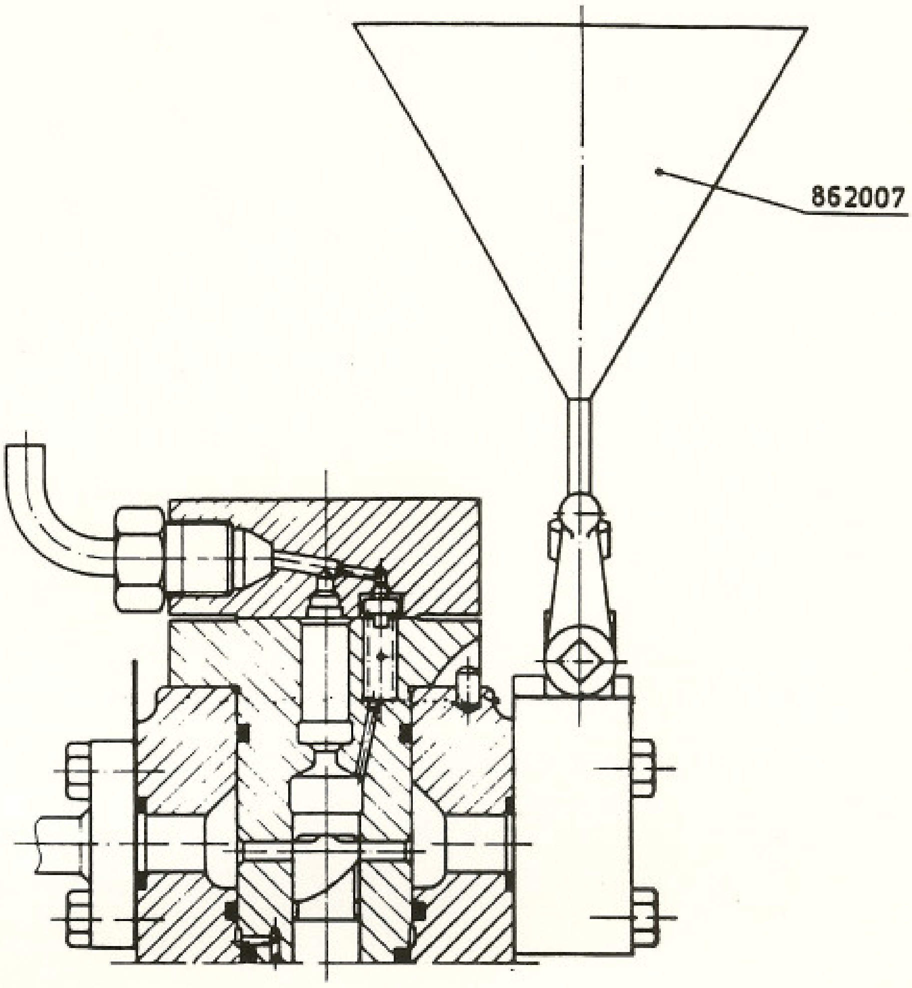

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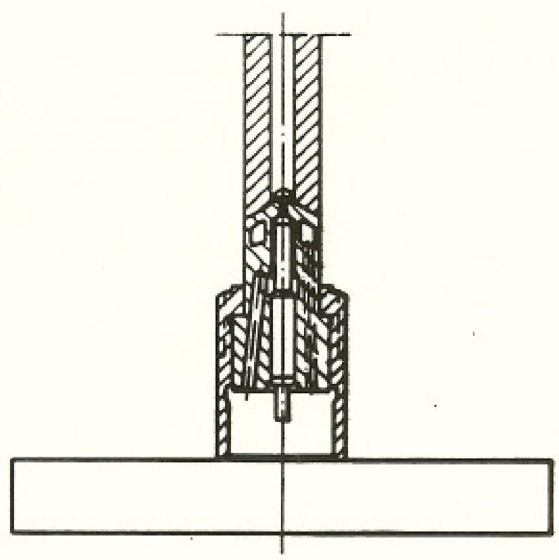

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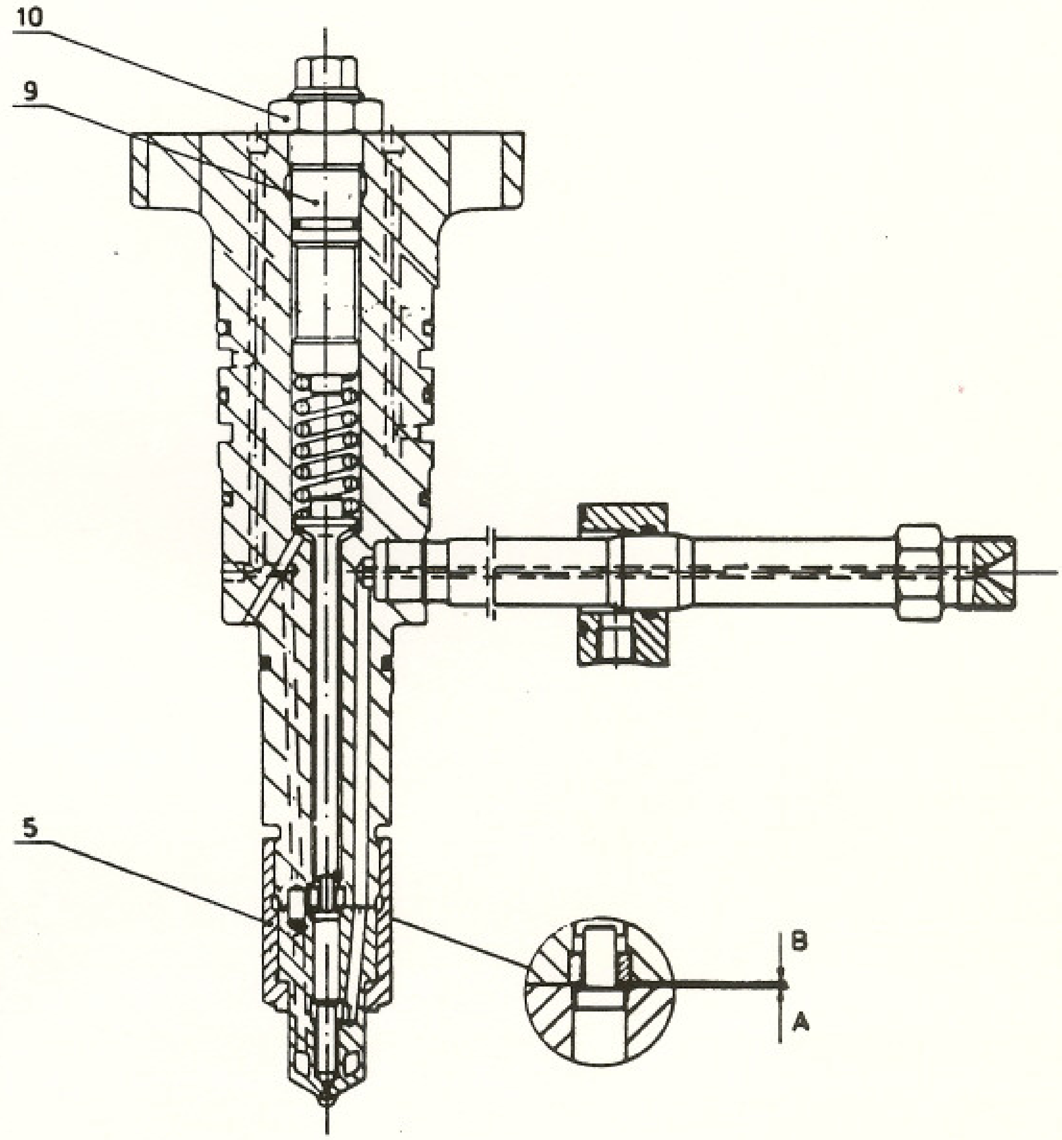
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17. FUEL SYSTEM

17.1 General

The engine is equipped with a fuel system that allows running on fuels stated in class M3 in BS MA 100:1982 (Marine Diesel Oils) or better qualities.

As the fuel system outside the engine can vary widely from one installation to another, this system is not described in this book. See separate instructions.

17.2 Description (page 17-51A)

The engine is equipped with a built-on fuel feed pump (3) which usually is electric (engine driven pumps can be supplied on request). The fuel flows over a knife-edge filter (1) from the day tank (7) to the feed pump where it is pressed through a duplex filter (4) to the engine distributing pipe and injection pumps.

The pressure control valve (8) controls the fuel pressure and maintains it at the recommended value stated in section 01. The pressure control valves (10) at both sides of the duplex filter allow both sides to be used simultaneously, ensuring maximum filter capacity of the cartridges. Additionally, one side at a time can be shut off for filter change: part of the fuel flows then through the valve (10), by-passing the engine.

A pressure gauge (6) in the instrument panel shows the inlet pressure of the fuel. A pressure switch (5) for low fuel pressure is connected to the automatic alarm system. Leak fuel from the injection pumps and valves is conveyed to a separate enclosed system and can be reused.

Regarding injection pumps and valves, see section 16.

17.3 Maintenance

Always observe utmost cleanliness when working on the fuel system. Pipes, tanks, pumps, etc. (included in the delivery or not) must be carefully cleaned before taken into use. Change the filter cartridges regularly.

> The fuel filter is provided with a visual indicator/electric switch giving alarm at too high pressure drop over the filter, which means that the cartridge must be changed as soon as possible.

Guidance values for the change intervals are stated in section 04.

Regularly clean the knife-edge filter (section 04) by turning the handle a few times. When cleaning the main filter, open also the knife-edge filter and clean it completely.

Always vent the fuel system when it has been opened.

17.4 Venting

Open the vent screws on the injection pumps (section 16, page 16-51 pos. 42). Start the feed pump if the static pressure is not sufficient.

Always vent the filter after change of the filter cartridges.

If the engine has been stopped and the feed pump is not running, the three-way valve can be put in the position where both sides are in operation. The air is then vented through the respective vent screw. In a running engine the side to be vented should be carefully connected to the three-way valve. The most practical way is to use the slow-filling valve on the three-way valve. Set the valve in slow-filling position (see page 17-54A). The filter is now slowly filled. Vent the filter. Set the three-way and slow-filling valves on normal position (both sides connected).

> 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, and may cause the engine to stop.

17.5 Adjustment of fuel feed pressure

Check the setting at intervals mentioned in section 04.

Adjust the pressures at idling (nominal speed for the engine driven pump). Turn the adjusting screw clockwise for higher pressure and counter-clockwise for lower pressure.

All pressures mentioned in the instructions refer to values read on the pressure gauge on the engine.

17.5.1 Adjusting the pump valve

Slowly increase the pressure by closing the valve (9). Adjust the valve (2) to 8 bar. Open the valve (9) completely.

> The adjustment must be carried out quickly because the pump runs hot if the system is disconnected for long periods.

17.5.2 Adjustment of pressure control valve (8)

Adjust the valve (8) to 4 bar.

17.5.3 Adjustment of pressure control valves (10)

Shut off the valve (11).

Check that the recommended operating pressure plus 2.5 bar, i.e 6.5 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 (10), if necessary.

After the adjustment, open the valve (11) completely.

17.6 Fuel feed pump, electric

The pump is of the same type as the prelubricating pump, see the description in section 18.9. Regularly lubricate the ball bearing at the motor end of the fuel feed pump.

17.6.1 Fuel feed pump (engine-driven, page 17-52A)

17.6.1.1 Description

The fuel feed pump is of the gear wheel type and is actuated by the gearing at the free end of the engine. The shafts are pivoted in the bushes (2, 11), which need no external lubrication, and in the ball bearing (18).

The driving shaft is sealed by two radial seals (14) separated by a draining bore (13). The inner seal is lubricated by fuel and the outer one as well as the ball bearing by splash oil entering through the opening (15).

The pump cover includes a control valve regulating the pressure in the system. When the pressure has reached a certain value the plunger (5) opens and admit surplus fuel to return to the suction side of the pump. The pressure is regulated to the value required by means of the adjusting screw (3). Increased pressure is achieved by screwing in the adjusting screw whereby the spring (7) is tensioned.

The pumps of clockwise and counter-clockwise rotating engines are identical except that the pump housing (1) is turned 180° around the driving shaft.

17.6.1.2 Maintenance

Besides normal maintenance according to section 04 the pump should be opened and the seals changed if fuel or oil is leaking from the pipe (13). However, a few drops every now and then can be considered normal.

a) Open the self-locking nut (19) and remove the gear wheel (16) from the shaft using the tool 837012.

b) The pump may now be opened, and the shafts and bearings withdrawn. Take care not to scratch the portion of the shaft where the seals are located.

c) Check the bearings, shafts, teeth and seals. Replace worn or damaged parts with new ones.

d) If the seals (14) are to be changed, remove the locking ring (17) and drive out the bearing (18). The seals may now be removed.

e) Check that the piston (5) moves easily.

f) When installing new radial seals (14), take care that they are not inclined when mounted. Insert the seals and distance ring (12) until they are 2...3 mm inside the surface of the bearing shield. Press the bearing bush (11) in place, whereby the seal automatically slides into the right position. Check that the contact between the bush (11) and the bearing shield is correct.

g) Check that there are no scratches on the driving shaft which may damage the seals when the shaft is installed.

h) Clean and degrease the conical part of the joint. Do not apply any lubricant.

i) Apply lubricating oil on the shaft thread and the contact face of the nut.

j) Tighten the nut (19) to torque stated in section 07.1.

17.7 Fuel prefilter

17.7.1 Description

The fuel prefilter is an edge-type filter with a spacing of 0.05 mm. The fuel flows from the outside to the inside, whereby dirt particles larger than the spacing gather in the filter. When the handle of the filter is turned a special device wipes off the dirt, which sinks to the bottom of the container located under the fuel cartridge.

17.7.2 Cleaning

The filter is cleaned by turning the handle a few times.

The dirt collecting container must be removed from the filter for cleaning.

17.8 Fuel filter (page 17-53A)

17.8.1 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 A on page 17-53A shows the valve in this position. When changing cartridges during operation one side can be closed. Figure B on page 17-53A 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 (10), page 17-51A, from the inlet side of the open filter half to the return pipe from the engine.

The arrows in the figure 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.

17.8.2 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 17-54A.

a) Shut off the filter side to be served.

b) Carefully open and remove the air vent screw (1). Open the drain plug (6).

c) Open the filter cover (2).

d) Remove the wire gauze insert (4). Wash in gas oil. Check that it is intact.

e) Remove the paper cartridge(s) and throw away. Paper cartridges cannot be cleaned. Always keep a sufficient quantity of cartridges in stock.

f) Clean and rinse filter housing carefully with gas oil.

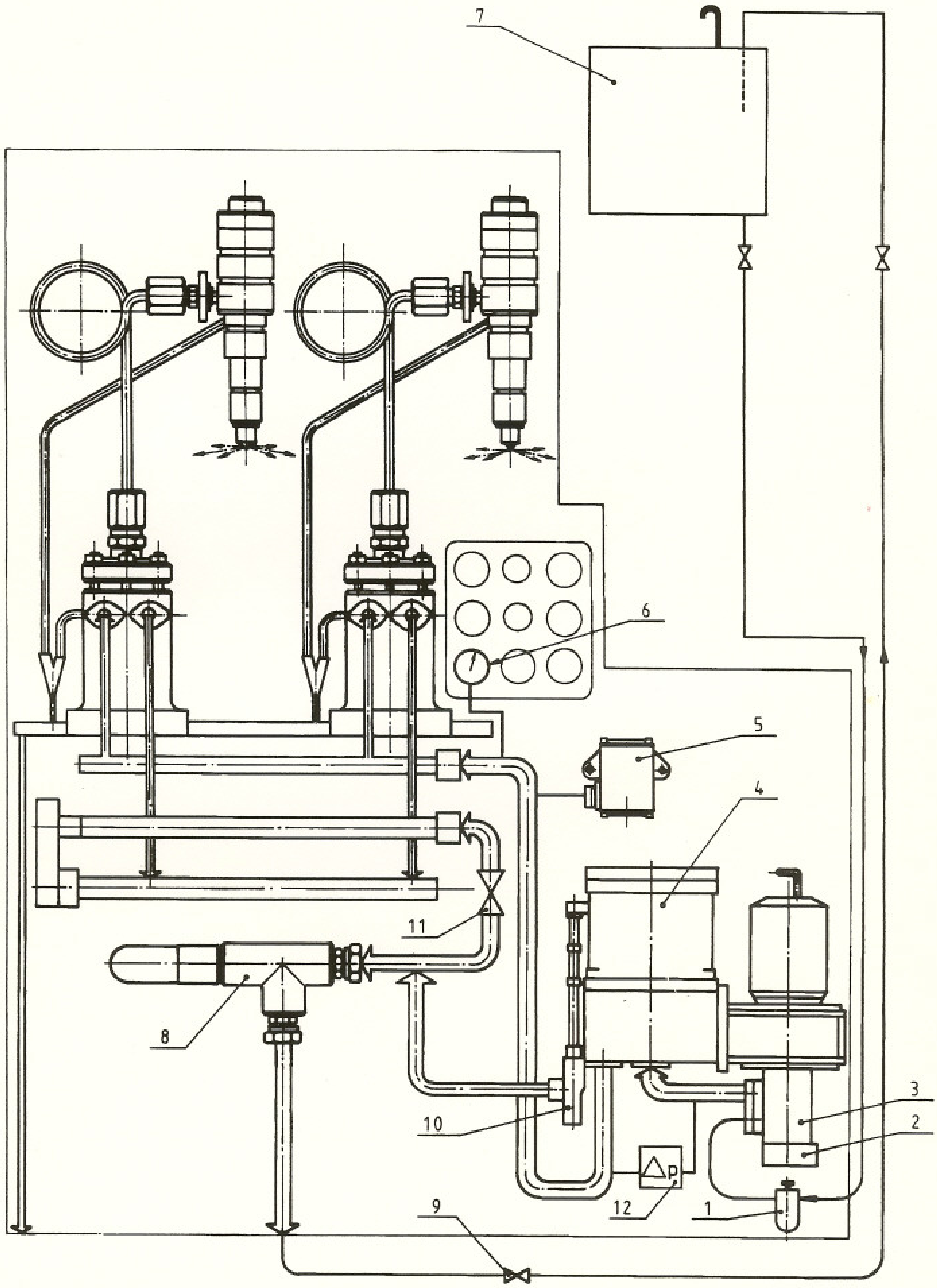
g) Fit new paper cartridges and the cleaned wire gauze insert. Check that all seals are intact and in position.

h) In V-engines equipped with two paper cartridges per filter side, check that the guide ring (5) is mounted.

i) Mount the drain plug and cover.

k) 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. 17.4.

l) Vent the filter if not completely filled according to pos. k. See pos. 17.4.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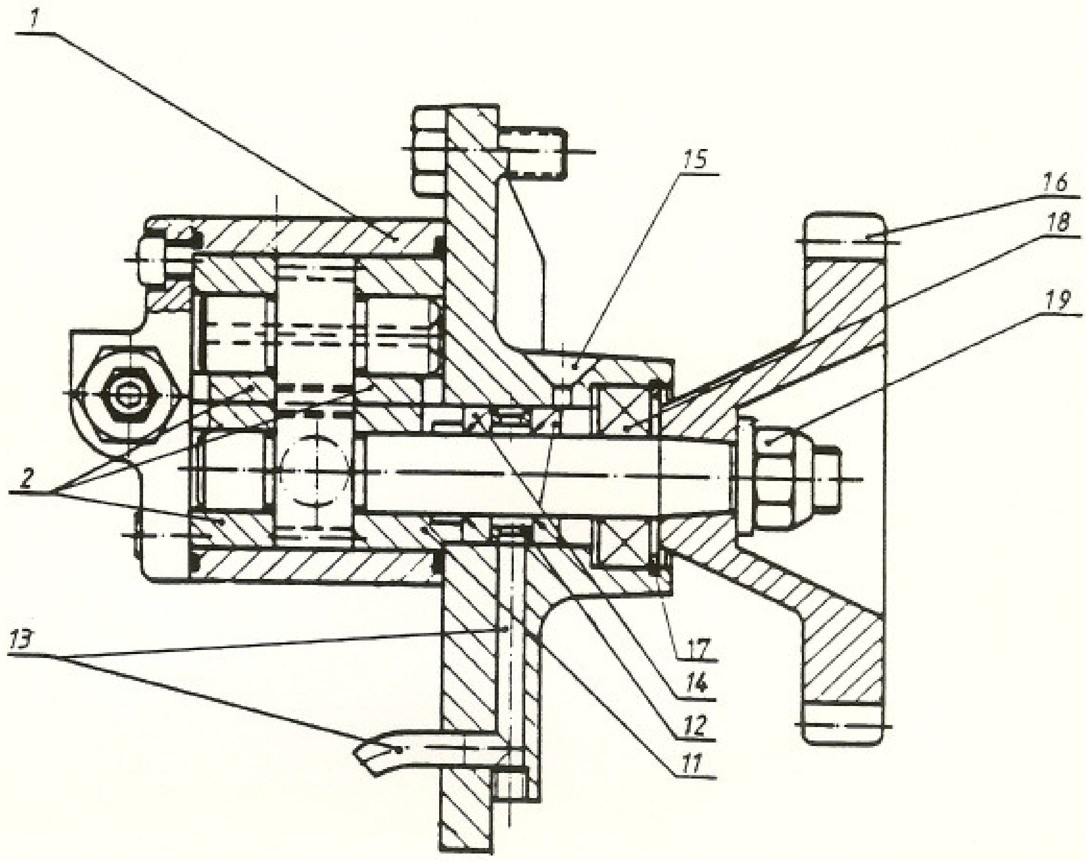
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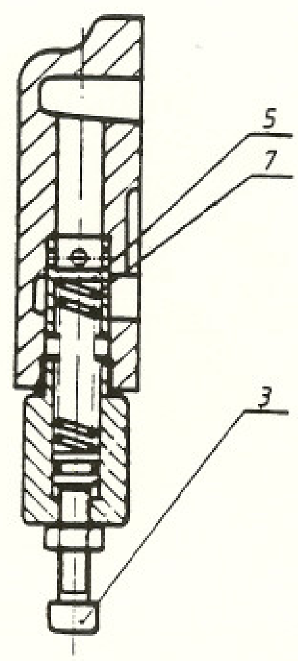
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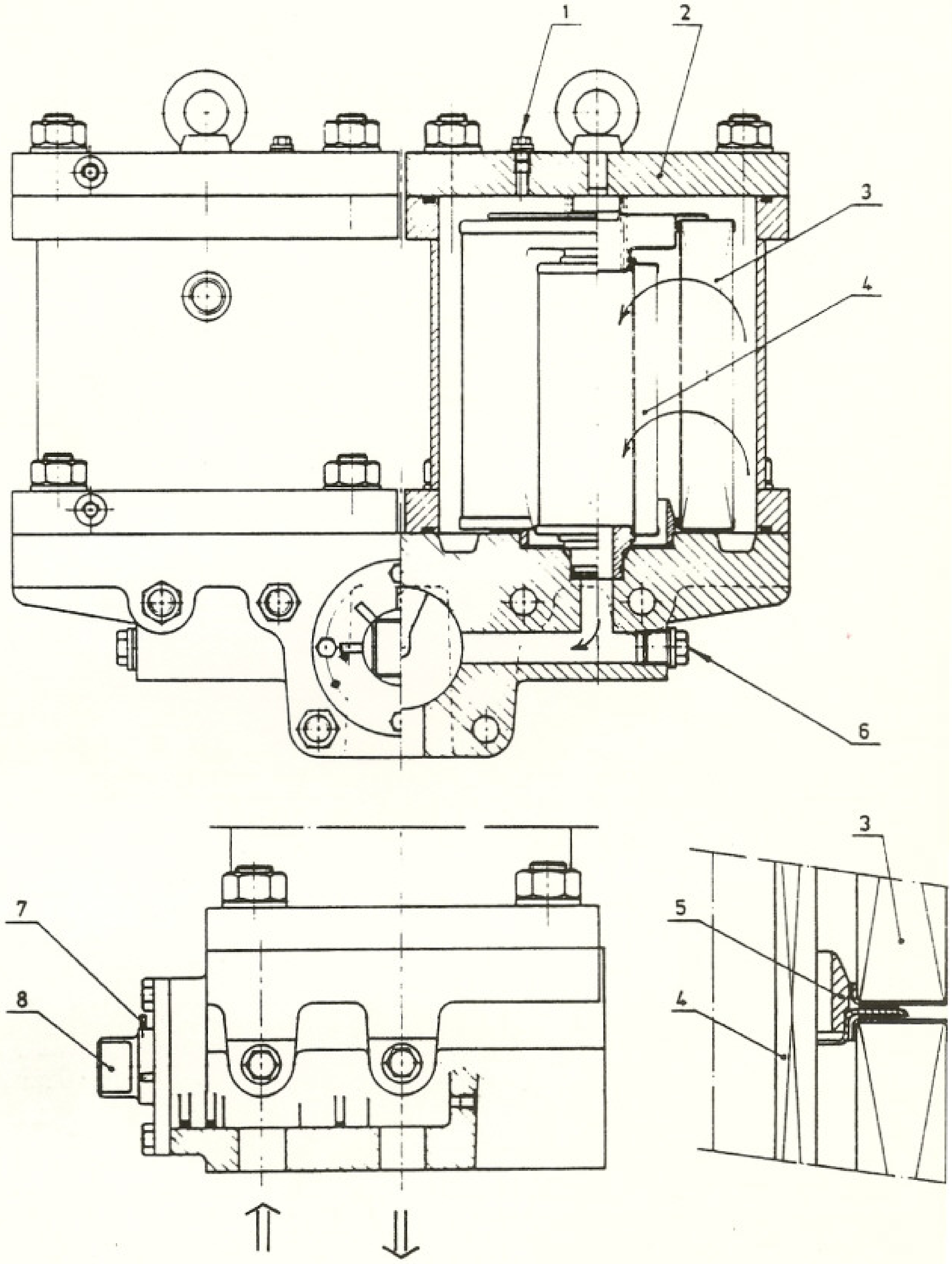

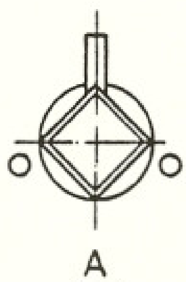

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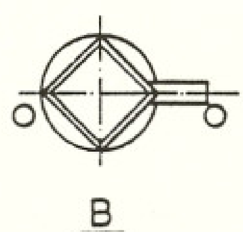

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VALVE POSITION	IN USE	CLOSED
1. 2. WORK POSITION	1.2	
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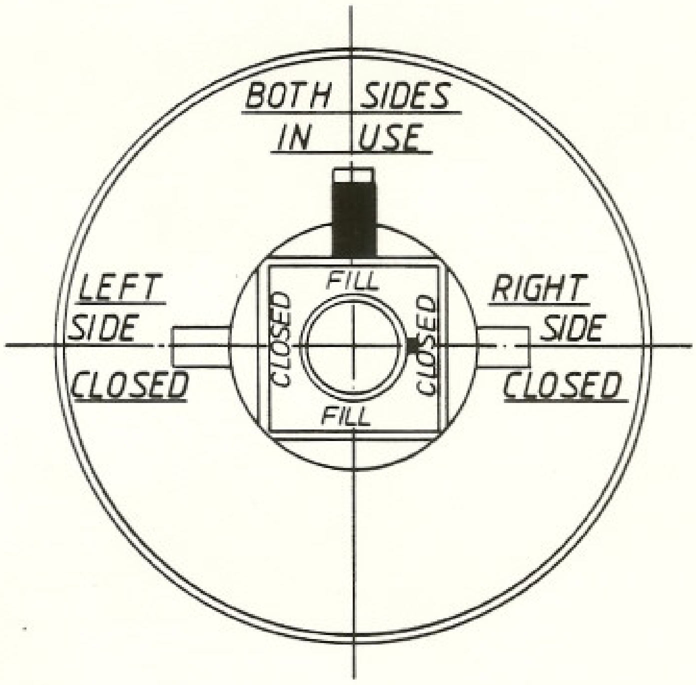
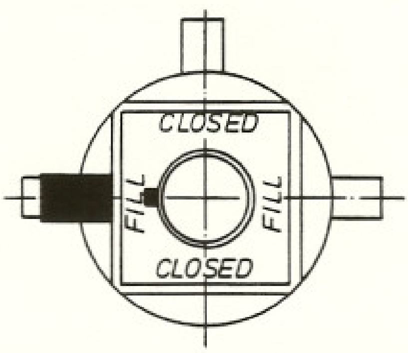
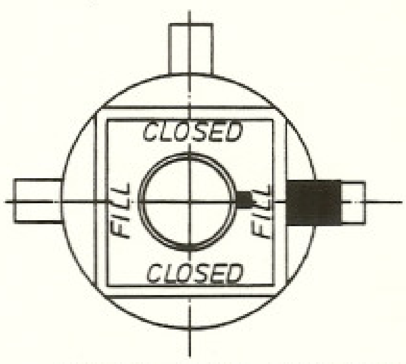
1. 2.	1	2





LEFT SIDE CLOSED
SLOW FILLING ON
LEFT SIDE



RIGHT SIDE CLOSED
SLOW FILLING ON
RIGHT SIDE

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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 stand-by 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.

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 non-return 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 runnig 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 distmantling 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)

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.

2. Dismantling

a) Remove and inspect the control valve according to section 18.4.

b) Remove the screw (4) and withdraw the gear (2) by means of the tool 837012 according to fig. 18-52D.

c) Withdraw the pump cover by using two of the fastening screws (1) in the two threaded holes located in the cover.

3. Inspection

a) Check all parts for wear (section 06.2) and replace worn parts.

b) Remove worn bearings from the housing by driving them out with a suitable mandrel, from the cover by machining.

c) 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.

d) Check the bearing diameter after mounting. Check the gear wheel axial clearance (see section 06.2 pos. 18).

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)

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.

2. Maintenance

a) Dismantle all moving parts. Check them for wear and replace worn or damaged parts by new ones.

b) Clean the valve carefully. Check that the draining bore (13) is open.

c) Check that no details are jamming.

d) 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.

e) 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)

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 favourable flow direction and velocity.

2. General maintenance

a) Clean and test the cooler by hydraulic pressure at intervals according to section 04 or if the lubricating oil temperature tends to rise abnormally.

b) 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).

c) Always when cleaning, check for corrosion and test by hydraulic pressure.

d) It is preferable to change the tube stack too early rather than too late. Water leakage to lubricating oil has serious consequences.

f) Check that the drain holes (6) are open.

g) Check that the screw (8) is in position. This screw fixes the tube stack in correct position.

h) Apply sealing compound to the sealing surface between the dividing wall in the water box and the end plate of the tube stack.

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.

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)

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.

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)

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...15 µm, then through an insert (3) consisting of a pleated wire gauze around a perforated case. The wire gauze insert, with a mesh size of 60 µm, serves as a safety filter in case of failure or by-passing of the paper cartridge.

At the bottom of the filter there is a by-pass 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.

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.

a) Shut off the filter side to be served.

b) Remove the protection cover on V-engines.

c) Open the air vent screw (1) about two turns.

d) Open the plug (8) and drain the oil.

e) Open the plug (13) and drain the oil. On in-line engines, open the complete cover (12).

f) Open the filter cover.

g) Remove the wire gauze insert. Wash in gas oil. Check that it is intact.

h) Remove the paper cartridges and throw away. Paper cartridges cannot be cleaned. Always keep a sufficient quantity of cartridges in stock.

i) Clean and rinse the filter housing carefully with gas oil.

k) Fit new paper cartridges and the cleaned wire gauze insert. Check that all seals are intact and in position.

l) Check that the guide (4) slides into position.

m) Mount the plugs and the cover. Tighten the vent screw.

n) Move the three-way valve over to working position (fig. 18-54C)

18.8 Centrifugal filter (fig. 18-55)

1. Description

A by-pass 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 return 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.

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:

a) Slacken off the filter cover clamp (11), unscrew the cover nut (1) and lift off the filter body cover (4).

b) Withdraw the rotor assembly from the spindle (3) and drain oil from the nozzles before removing the rotor from the filter body. Hold the rotor body and unscrew the rotor cover jacking nut (2), then separate the rotor cover from the rotor body.

c) Remove the circlip (8) and the separation cone (9).

d) 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.

e) Clean the separation cone.

f) Wash all details, for example in gas oil.

g) 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.

h) Reassemble the rotor complete, align the location pins and tighten the top nut. 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.

j) 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.

k) Remove the cut-off valve plug (14) and cut-off valve assembly. Check that the spring and shuttle are undamaged and free to move. Change the seal, if necessary.

l) 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)

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.

2. General maintenance

Normally, no regular maintenance is required.

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.

3. Dismantling

a) Loosen the pipes and fastening screws (9) and withdraw the pump.

b) Draw the coupling half (1) off the shaft.

c) 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.

d) 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.

e) Remove the sealing ring (8).

f) Force the sealing unit (13) off the drive screw (2). Pressing force may be relatively strong due to the rubber bellows.

g) Tap the stationary sealing ring (6) together with the O-ring out of the front plate by using a chisel.

h) 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.

4. Reassembly

The reassembly is performed in the reversed order.

a) Remount the ball bearing in the front plate, the protective washer turned outwards. Lock with the locking ring.

b) 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).

c) 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.

d) Put the coal ring into position, the smaller sealing face upwards and the grooves matching the marks.

e) Place the front plate (10) over the drive screw shaft journal.

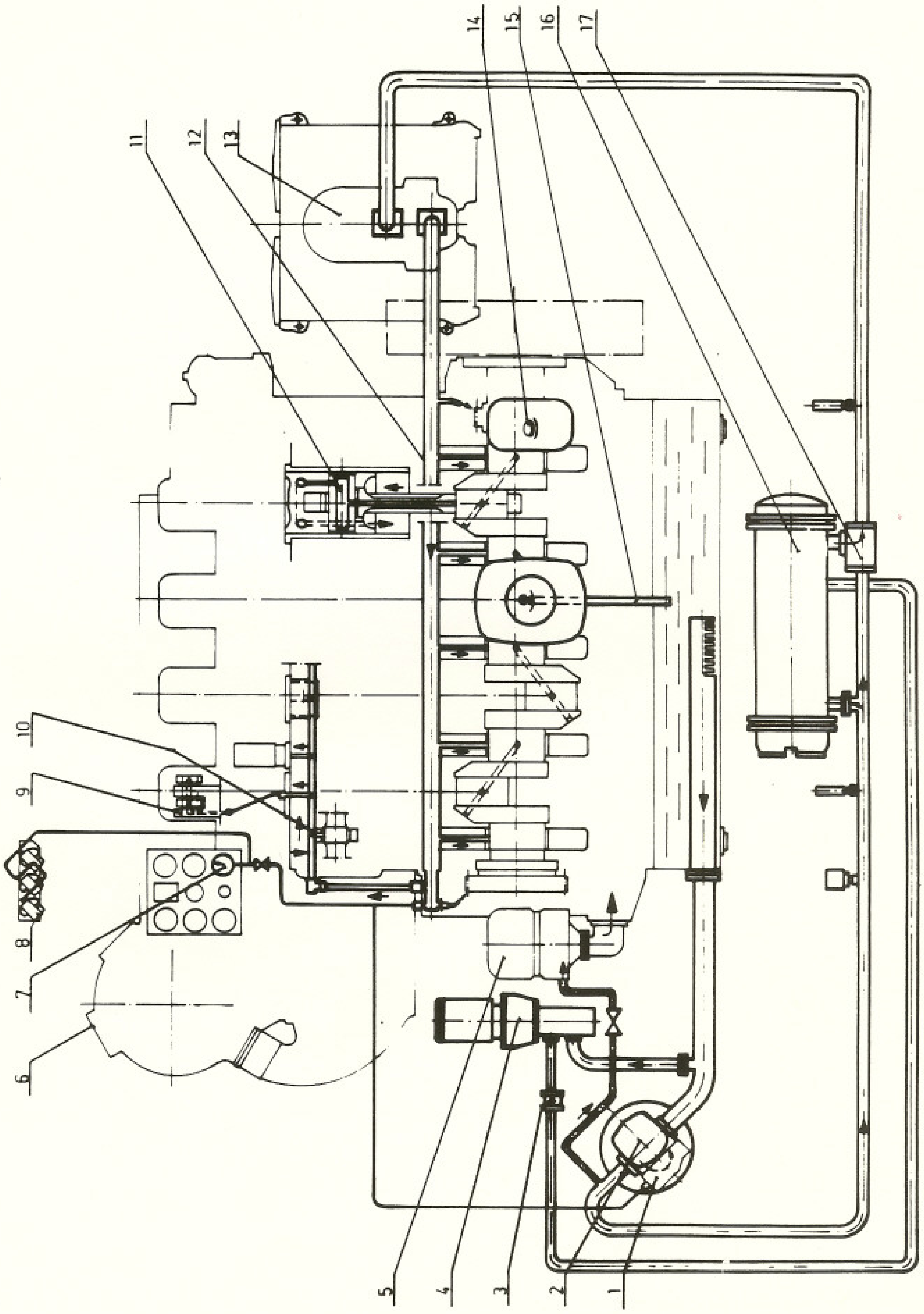
f) Force the ball bearing inner ring against its shoulder on the drive screw. Use a suitable sleeve matching the bearing inner ring.

g) Lock with the ring (3).

h) 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.

j) 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.

k) If the electric motor has been disconnected or changed, check that it rotates in the right direction by switching it on a few times.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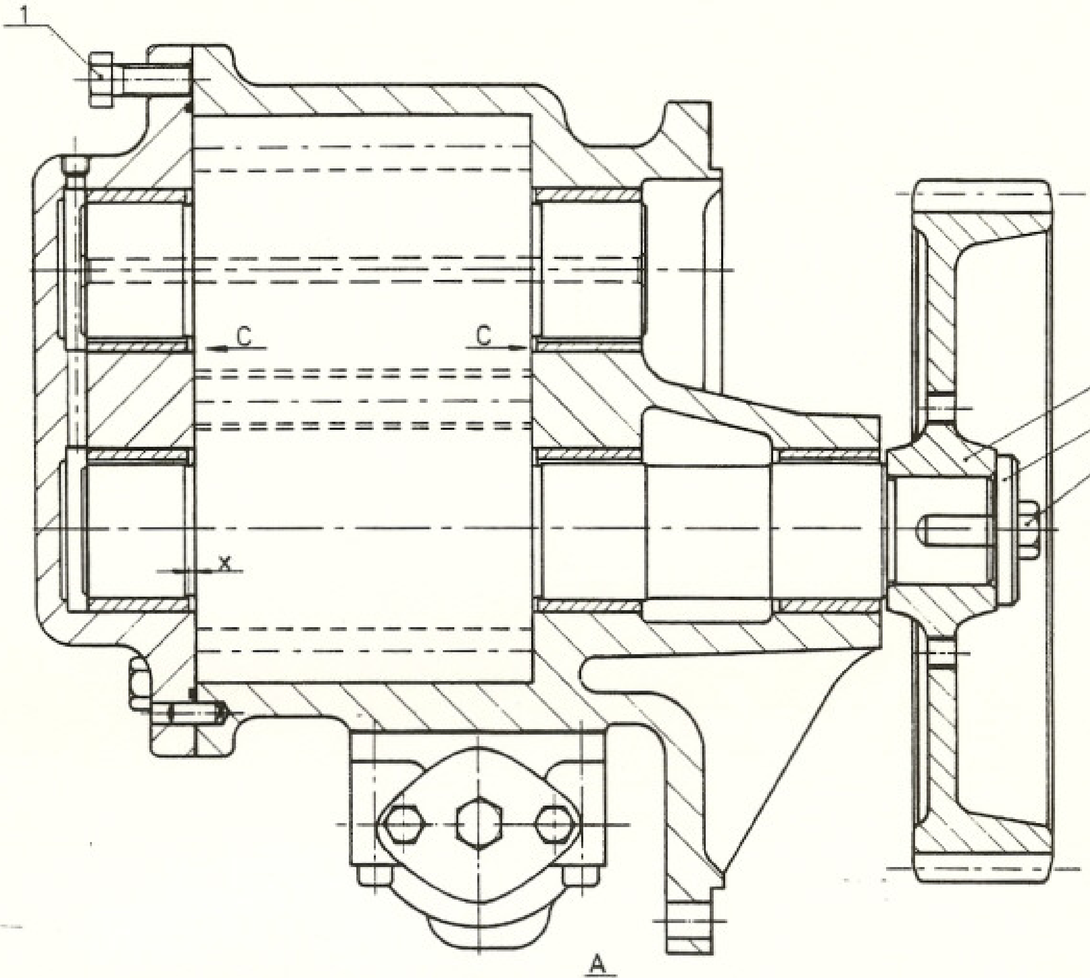

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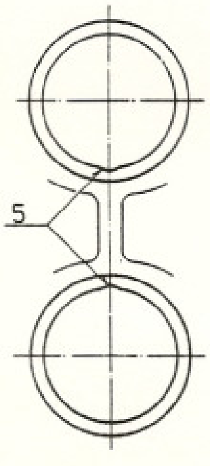

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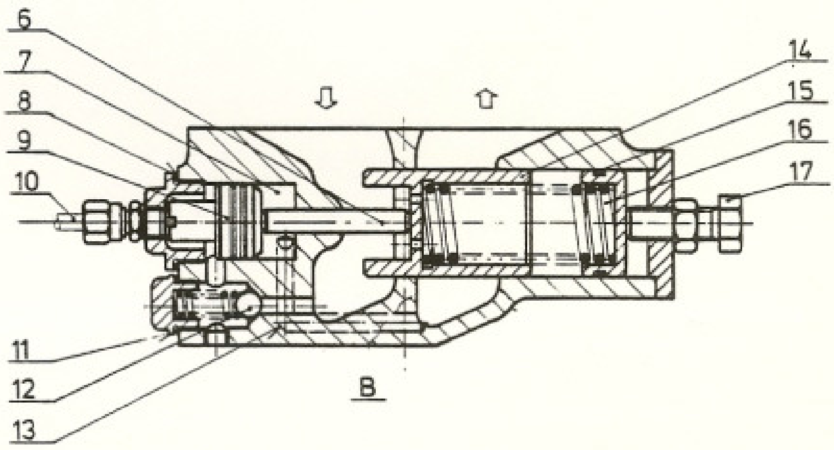

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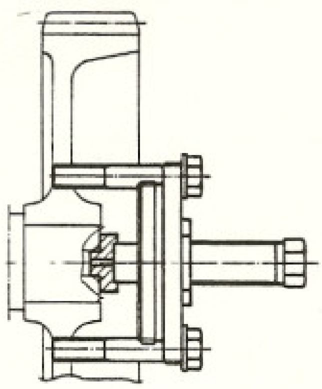

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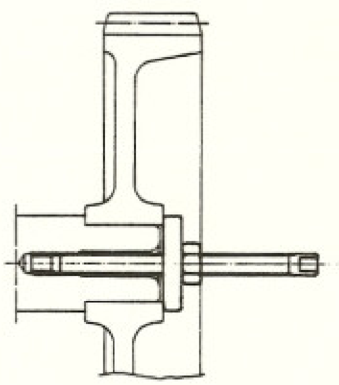

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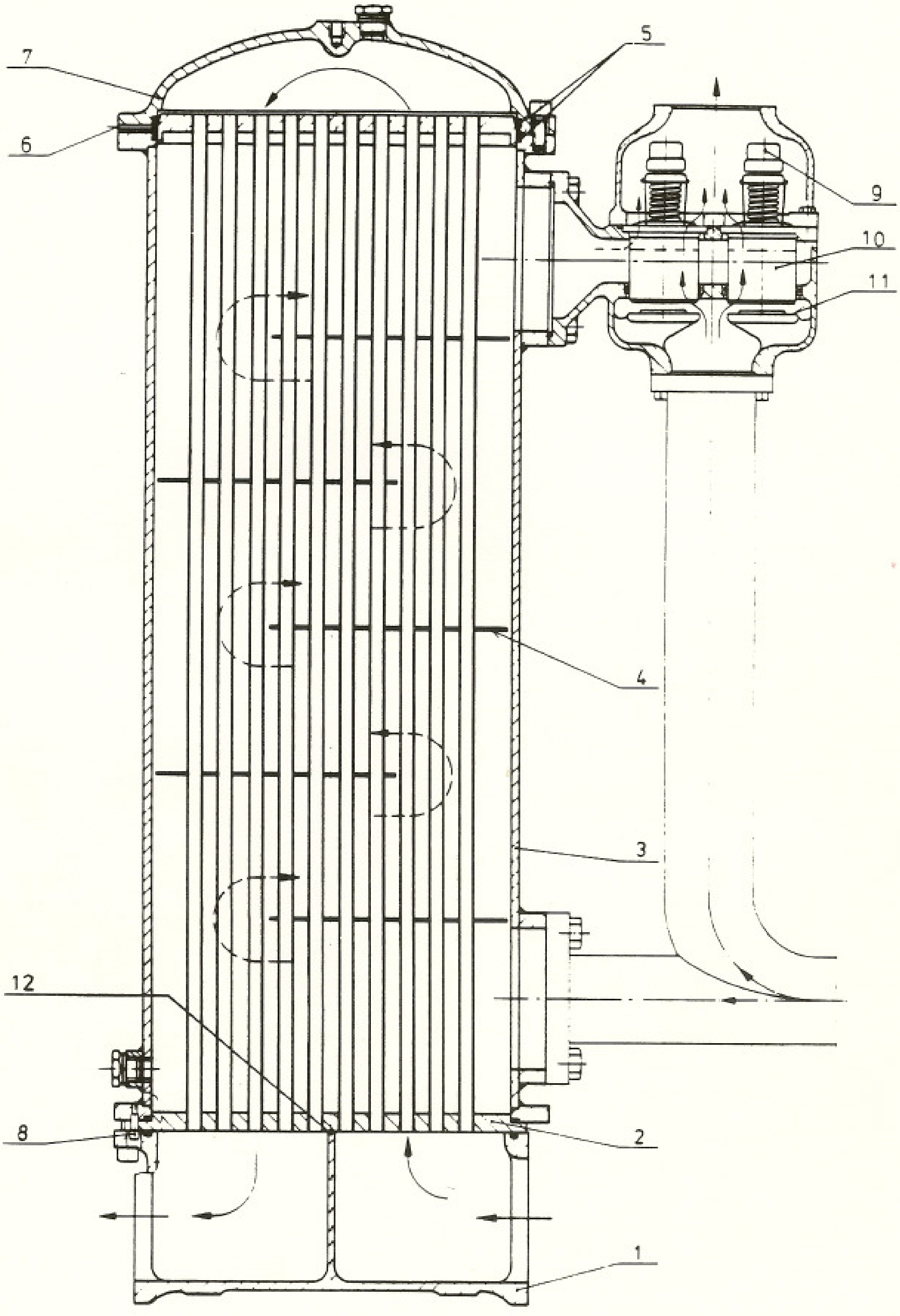
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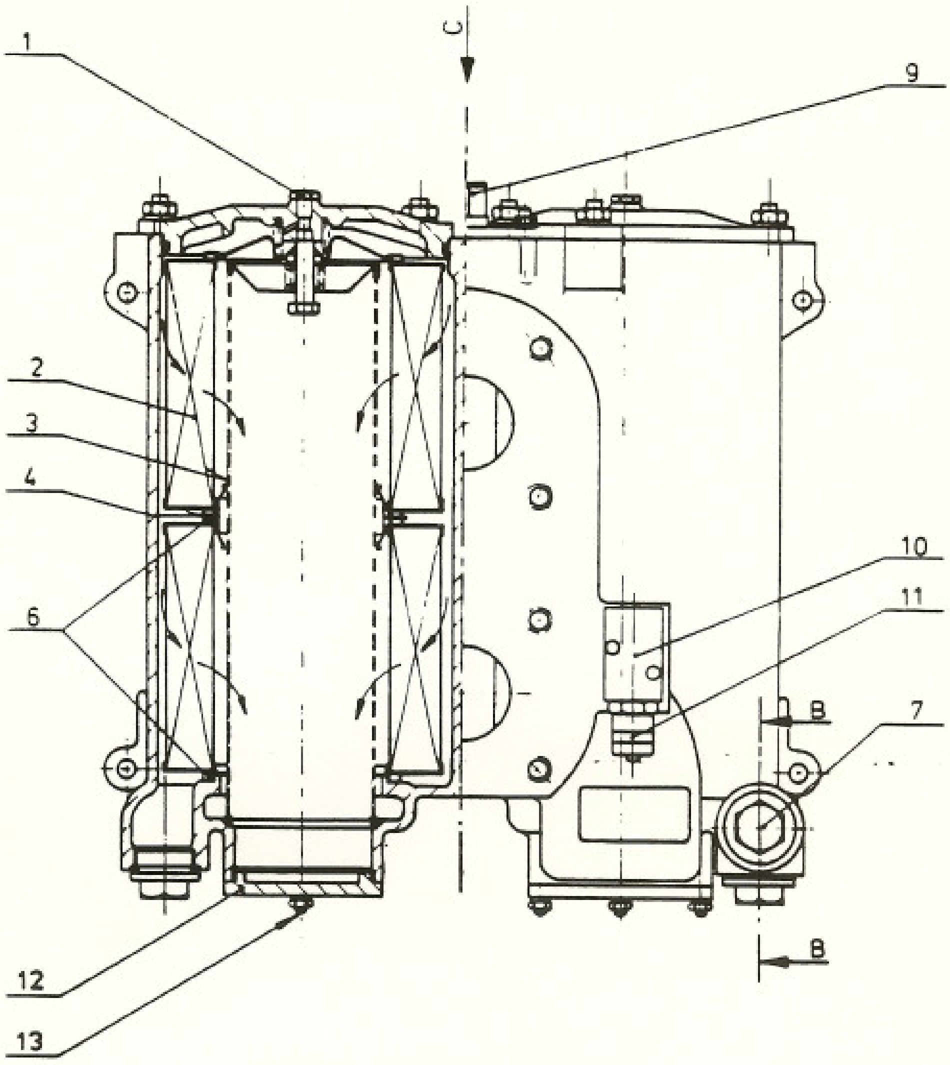

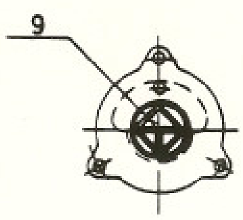

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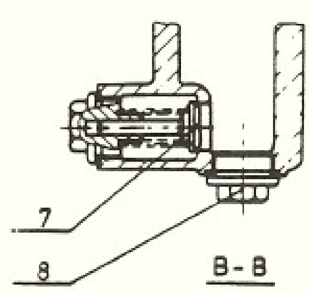

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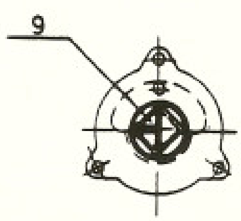

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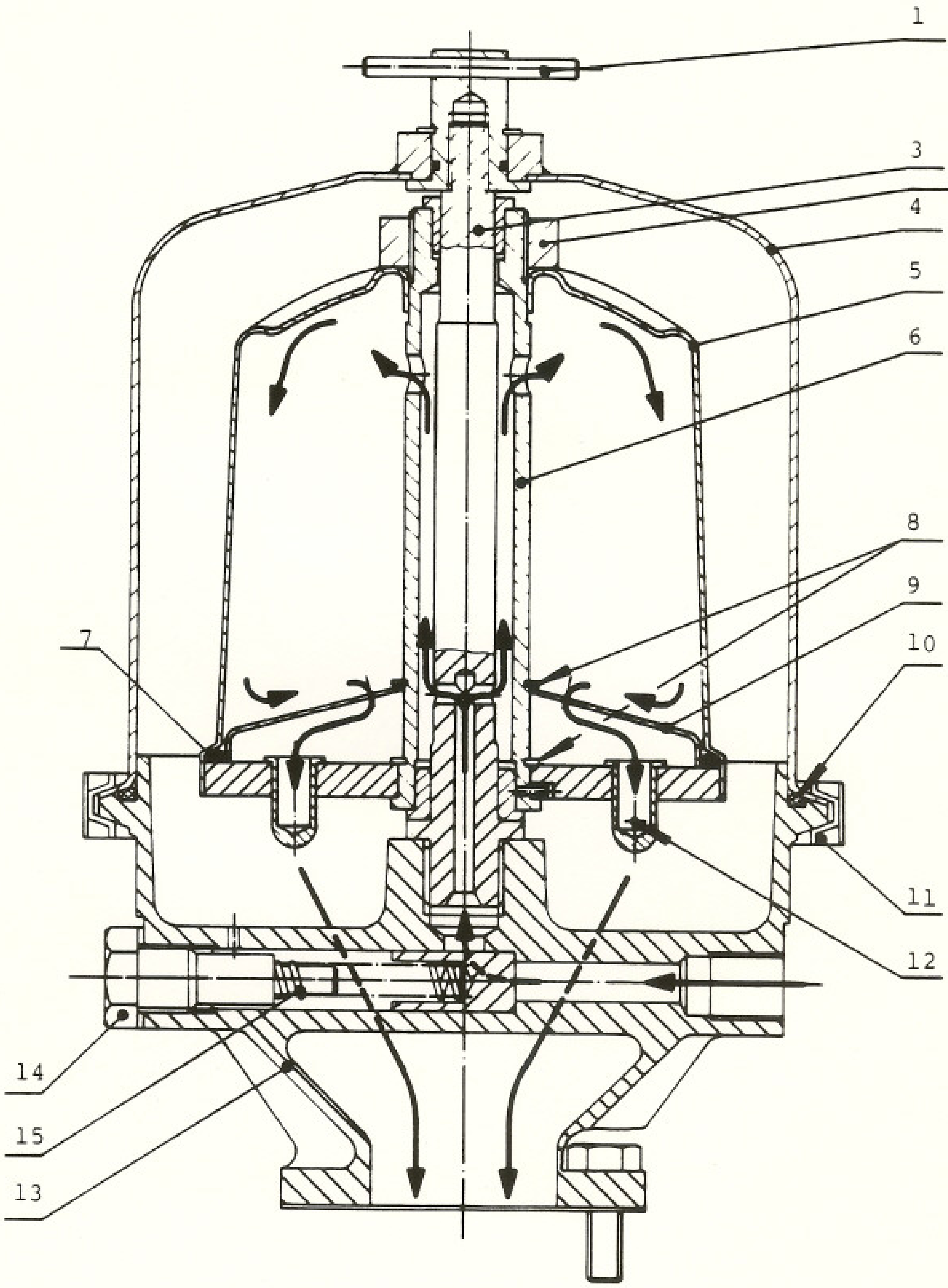
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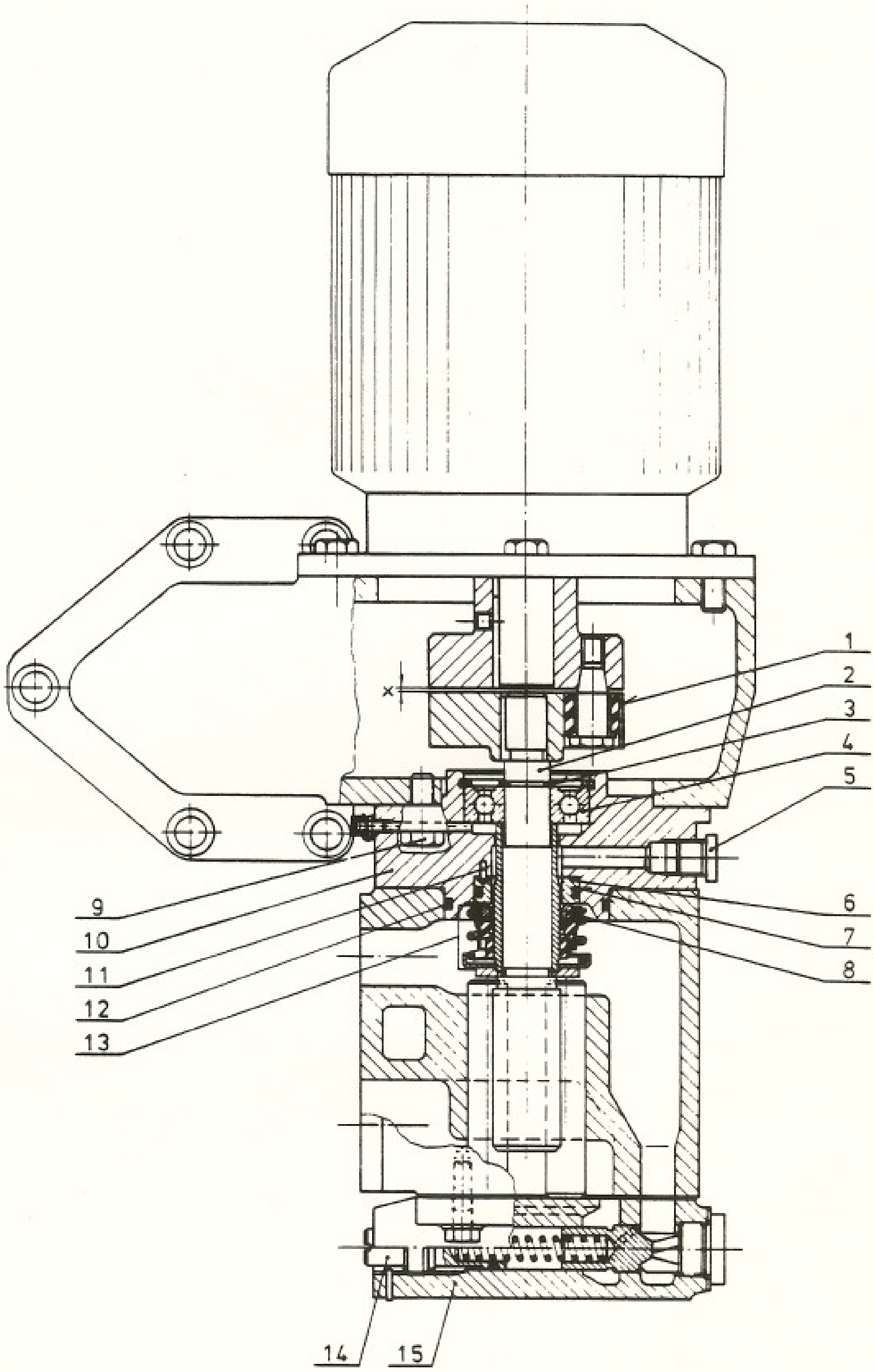
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INFO ON LOAD DEPENDENT COOLING SYSTEM

3.10 Load-dependent cooling system

As already mentioned, a real heavy fuel engine requires optimum temperatures in order to function satisfactorily at all loads. Wärtsilä Diesel has designed a unique cooling water system which actively controls the temperatures of the engine components and the combustion chamber in order to provide adequate temperatures at all loads. At low load the charge air temperature is heated to permit sufficiently high compression and combustion temperatures. To avoid cold-corrosion in the combustion chamber components, mainly the cylinder liner, the temperatures must be kept sufficiently high. At high load the temperatures must, on the other hand, be kept low to decrease the thermal load on the engine components and avoid hot corrosion on the components (Fig. 31).
This system works automatically. The energy for heating the charge air and cylinder liner is taken from the engine waste heat. Investigations of available heat quantities at low load indicate that most of the energy is generated by the lubricating oil cooler. This is because the quantity of heat supplied to the lubricating oil by friction is relatively large even when idling (Fig. 32).

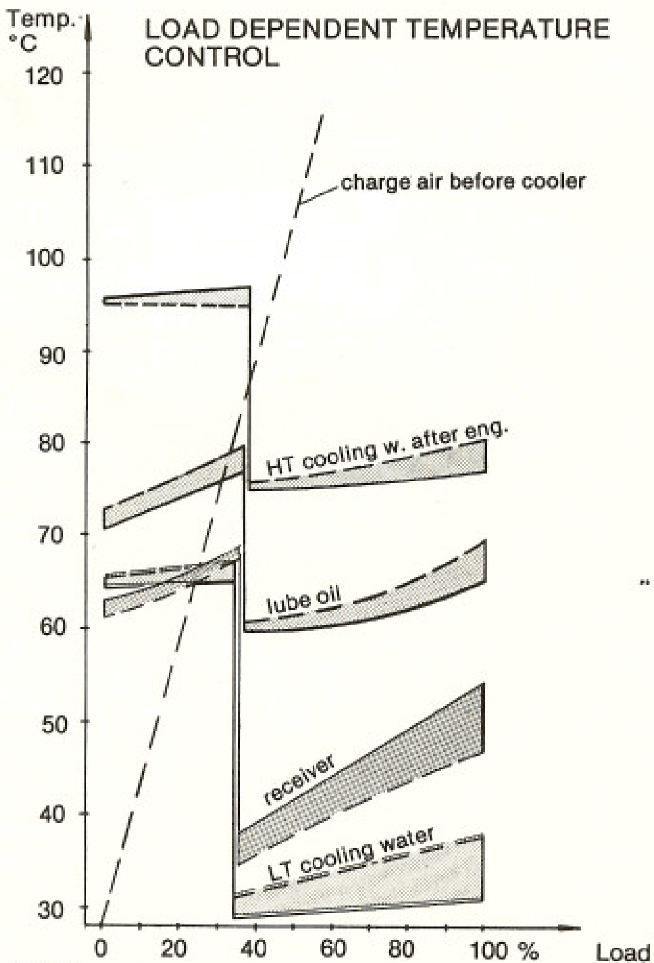


Fig. 31
A load dependent cooling system is necessary in order to ensure safe and economical operation on heavy fuel over the entire load range.

The engine cooling system consists of two connected circuits: a low-temperature one and a high-temperature one. The low-temperature circuit includes the charge air and oil coolers. The temperature is controlled by a special thermostat with two set points, one for high-load and one for low-load operation. The high-temperature circuit includes the cylinder and turbocharger cooling. The temperatures are controlled with a similar thermostat with two set points. By using a load sensor the temperatures can be maintained automatically at the correct level in the respective load range (Fig. 33).
The load-dependent cooling system is simple and compact because all the components such as charge air cooler, oil cooler, thermostat valves, cooling water pumps and connecting pipes are mounted on

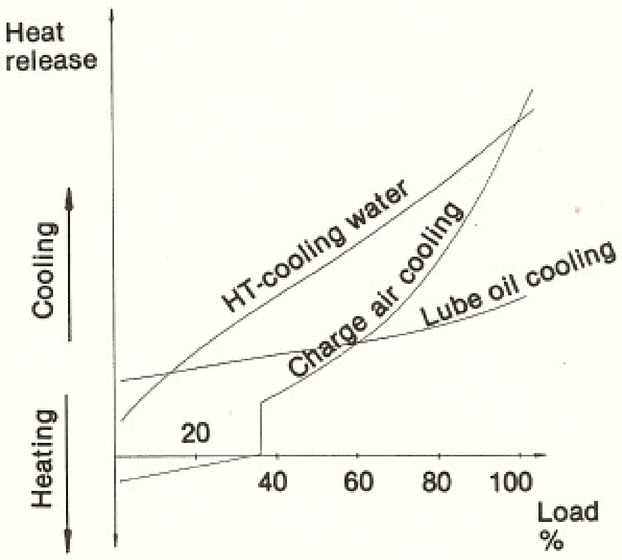


Fig. 32
The heat balance shows that the lubricating oil is the most important heat source at no-load.

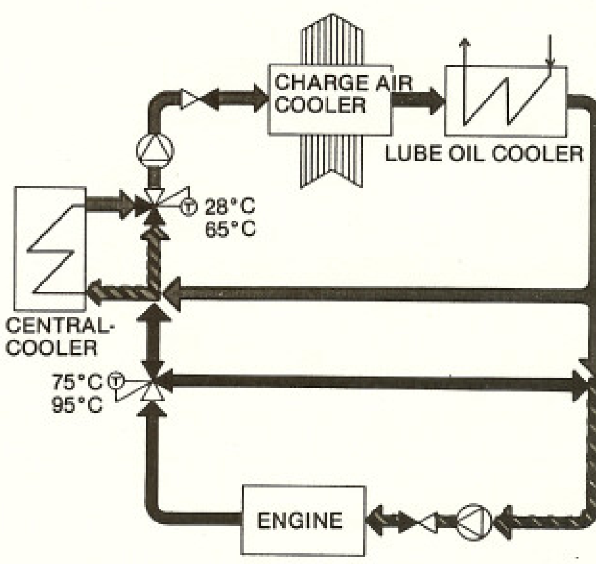


Fig. 33
The load dependent cooling system.

19. COOLING WATER SYSTEM

19.1 Description and operation (page 19-51A)

There are two cooling systems in the engine: a high temperature system with circulating fresh water for cooling of the cylinders and turbochargers and a low temperature system for cooling of the engine heat exchangers, i.e. air cooler, oil cooler and circulating water cooler.

1. Circulating water system (high temperature system)

The engine should be cooled with circulating fresh water, treated according to the recommendations in section 02.3 to prevent corrosion and deposits.

A circulating water pump (6), direct driven from the engine, or a separate pump, pumps the water through the system. From the pump the water flows to the distributing duct cast in the engine block of the in-line engine. In V-engines the water is distributed to the cylinder banks through a duct cast in the free end cover. From the distributing ducts the water flows to the cylinder water jackets and 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 and up around the injection valve, efficiently cooling all these components. From the cylinder heads the water flows through a connection piece to the collecting pipes.

Parallel to the cylinder cooling, part of the water flows to the turbocharger turbine side (2). From the engine collecting pipe the water is led to a circulating water cooler (10), separate or mounted on the engine base plate and from there back to the circulating water pump. A thermostat valve (9) keeps the water temperature as constant as possible after the cooler and, consequently, before the engine (see section 18.6 Thermostat valve).

The system also includes an expansion tank (1) to be connected immediately before the pump (6). For the water of the collecting pipes and of the turbocharger cooling, a common connection for the air vent pipe (16) is provided; the connection should be led rising to the expansion tank.

Local thermometers indicate the temperatures before and after the engine as well as after the turbocharger. The temperature stated in section 01.2, page 01-2A, should not be exceeded.

The engine is equipped with an alarm device for high circulating water temperature after the engine (13) as well as a switch for automatic stoppage (12) if the temperature would rise further (set points according to section 01.2). A pressure gauge (14) on the instrument panel indicates the pressure before the engine. The pressure depends on the engine speed. An alarm device for too low pressure can be delivered as extra equipment (section 23).

If risk of frost occurs, drain all cooling water spaces. Avoid changing the cooling water. Save the discharged water and use it again.

Concerning cleaning of the system, see section 19.2.

A connection for preheating is provided. In case of preheating the system should include a non-return valve forcing the preheated water to circulate through the engine.

2. Low temperature system

The low temperature system can, in principle, be arranged in two different ways: Cooling direct with raw water, or central cooling with fresh water, which, in turn, is cooled in a central cooler.

The charge air cooler (4) and the oil cooler (11), which are normally mounted on the engine, are coupled in series. In case a circulating water cooler (10) is installed, it is coupled in series after the two above mentioned coolers. In the V-engine, which is provided with two air coolers, the cooling water first runs in parallel over both air coolers and from there further to the oil cooler.

A pressure gauge on the instrument panel indicates the pressure before the engine. Local thermometers indicate the temperature of inlet and outlet water.

2.1 Cooling with raw water

All pipes are made of special brass, valves and water boxes of bronze and cooler tube stacks of copper nickel.

The pump may be direct driven by the engine or separate. The direct driven pump is identical with the direct driven circulating water pump, but all details exposed to sea water are noncorrosive (see section 19.3).

The raw water system should be arranged so that part of the warm discharge water can be led back to the suction side of the pump to maintain a temperature of about 25°C. This will most easily be arranged by using a thermostat valve (8).

The raw water pipe should be provided with a filter (7), with a mesh width of 1.6...2.0 mm, before the engine.

If the engine is to be stopped for a longer time it is advisable to drain the raw water from the coolers. Risk of corrosion!

Concerning cleaning, see section 19.2.

2.2 Cooling with fresh water (central cooling)

All pipes are made of steel and cooler tube stacks of special brass.

The pump may be direct driven by the engine or separate. The direct driven pump is quite identical with the direct driven circulating water pump (see section 19.3).

19.2 Cleaning of cooling water spaces

In completely closed systems the fouling will be minimized if the cooling water is treated according to our instruction 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. Especially coolers which are cooled directly with sea water may foul quickly. 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 pulling 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 varying structure and consistence. 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.

a. 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 accessability 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.

b. 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).

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 residuals. 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 (page 19-52)

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 sealed against the housing with the O-ring (10). Possible leak-off water from the sealing can flow out through the opening (15).

2. Maintenance

Check the pump at intervals according to the recommendatons in section 04 or, if water and oil leakage occurs, immediately.

a. Disassembling and assembling impeller

- Remove the volute casing by loosening the nuts (17).
- Remove the cotter pin and loosen the nut (1).
- Pull off the impeller by using the tool 837012, see fig. 19-52A.

- When reassembling the impeller, tighten the nut to torque, see section 07.1 pos. 25.
- Secure the nut with a new stainless cotter pin.
- Check that the O-ring (18) is intact and in position when reinstalling 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 (25).

b. Disassembling and assembling mechanical shaft seal

- Remove the impeller according to pos. 2a.
- 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.
- 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 that 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 counter-clockwise 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 pos. a. Do not forget the thin washer (6) between the spring (5) and the O-ring (7).

c. Replacing bearings

- Remove the pump from the engine.
- Disassemble the impeller and mechanical seal according to pos. a and b.
- Remove the rear plate (19) by undoing the screws (16).
- Loosen the screws (21) and remove the cap (27).
- 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.

Using an extractor will only damage the shaft (axial scratches).

- Loosen the bearing retainer (23) and drive out the shaft and bearing. In doing this also the seal (14) will come loose.
- Check the seals (13) and (14) and the bearings for wear and damage, see pos. d.
- Remove the bearings.
- Press the bearing (13) by its inner ring with a suitable pipe. Before fitting the bearing, oil the collar. See fig. 19-53A.
- Turn the shaft according to fig. 19-53B.
- Fit the distance ring and oil the collar.
- Press the bearing (11) by its inner ring with a suitable pipe. See fig. 19-53B.
- Turn the bearing housing according to fig. 19-53C 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.
- Fit the bearing retainer (23).
- Before reinstalling the gear wheel, all contact surfaces should be cleaned and oiled.
- Reinstall the conical ring elements (25), see fig. 19-52B.

The conical ring elements should fall easily in place and must not jam.

- Reinstall the cap and the screws.
- Tighten the screws a little and check that the gear wheel is in the right position.
- Tighten the screws to torque according to section 07.1.23A.
- Reinstall the seals (13) and (14), see pos. d.
- Reinstall the rear plate (19) as well as the mechanical seal, impeller and volute casing according to pos. 2a and 2b.

d. 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:

- Remove the volute casing and mechanical seal according to pos. 2a and 2b as well as the rear plate (19).

- Remove the seals (14) and (13) by prying (damaging) without scratching the shaft.

- 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 pos. 2c.

- Oil the new seal and fit it by pressing against the shoulder.

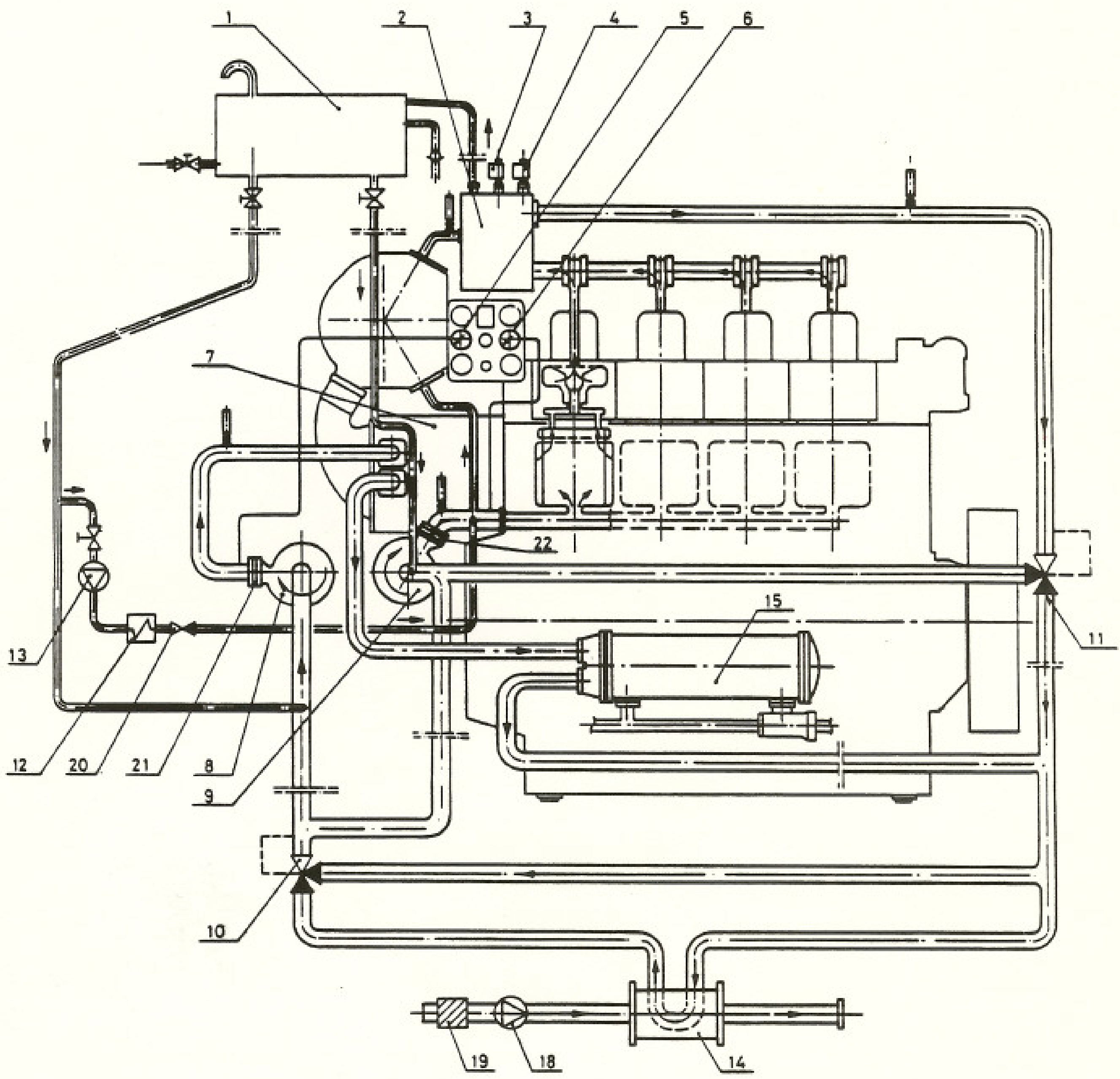
- Grease the axial seal (14) and install by using the tool 837012, see fig. 19-52C.

- Install the rear plate as well as the mechanical seal and the volute casing according to pos. 2a and 2b.

19.4 Circulating water cooler

The circulating water cooler is, in principle, identical with the lubricating oil cooler and the raw water side should be inspected and cleaned according to section 18.4.

The fouling of the tube stack outside, around which circulating water is flowing, is minimized in case the water has been carefully treated. If fouled, clean in the same way as the water system on the whole.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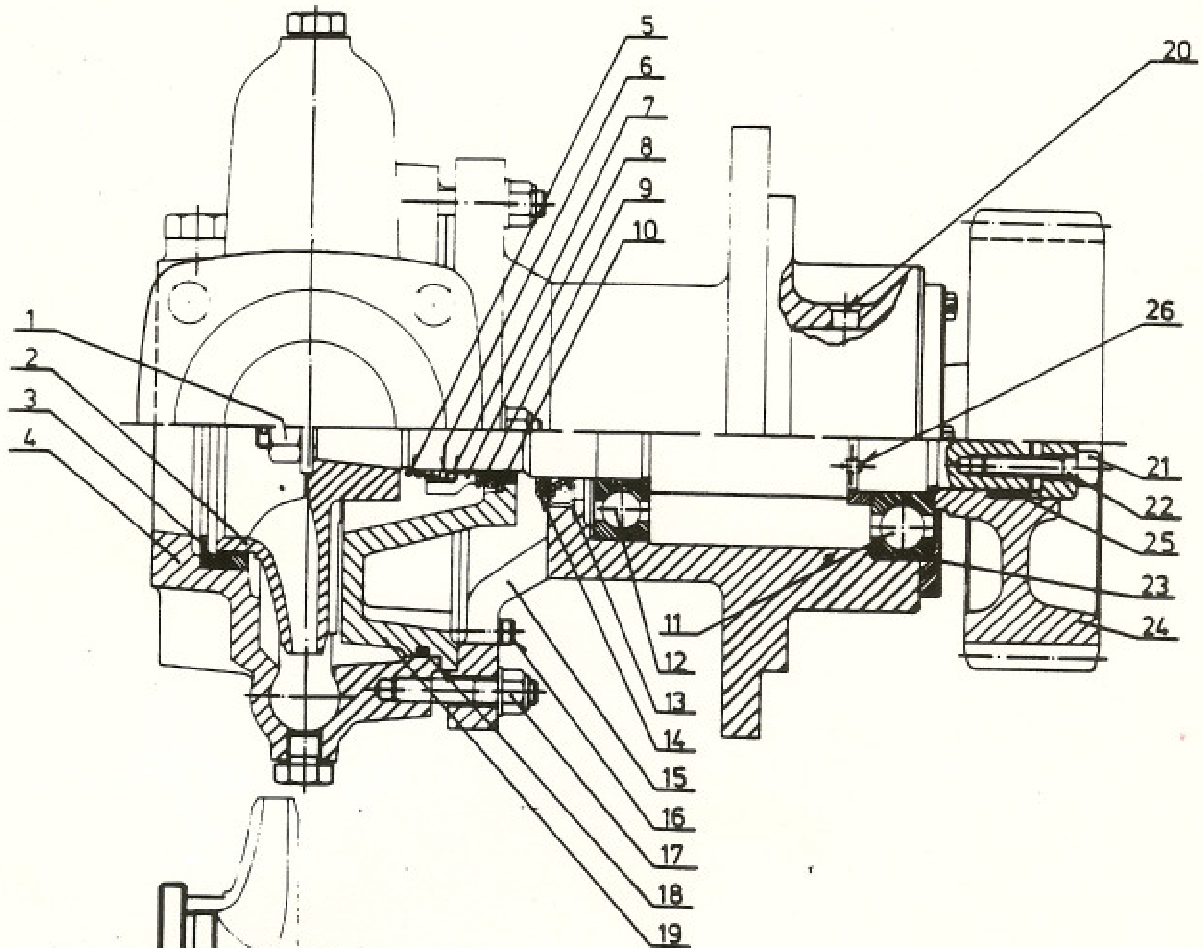

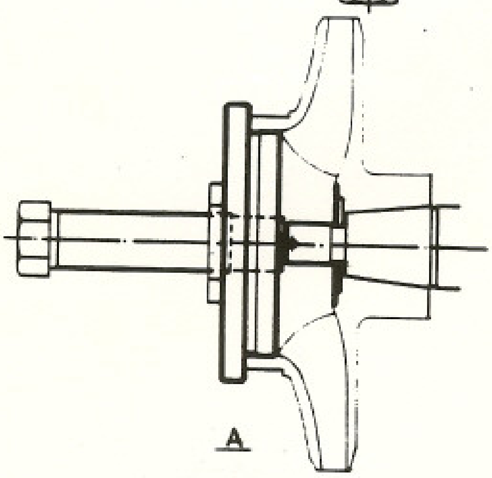

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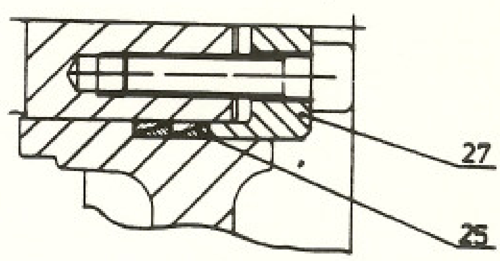

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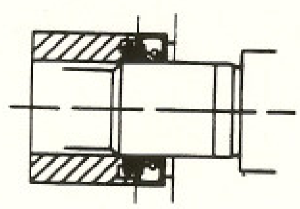

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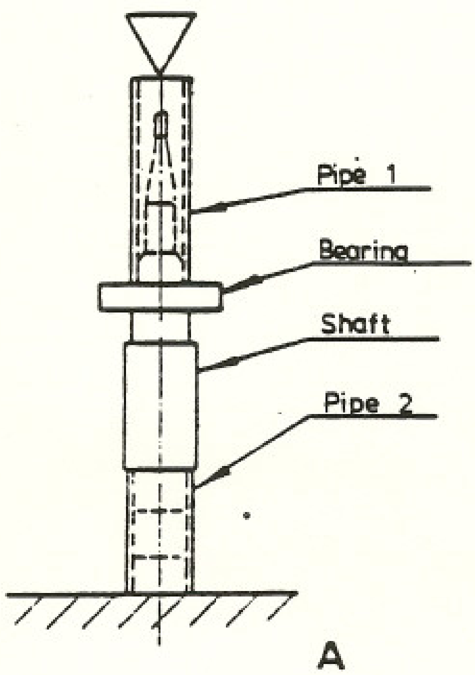
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Shaft
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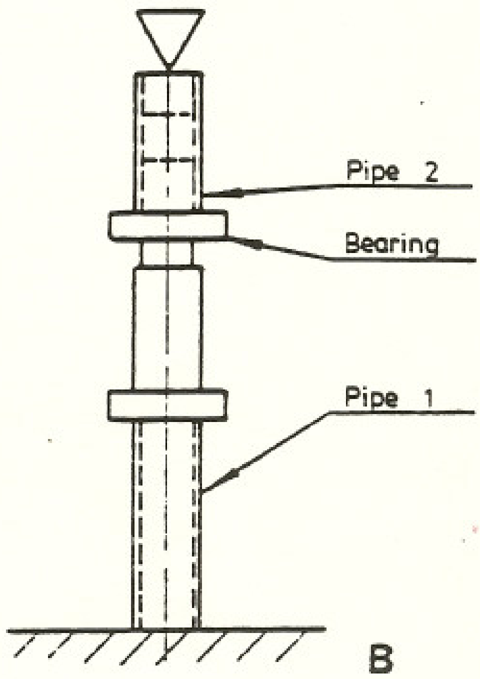
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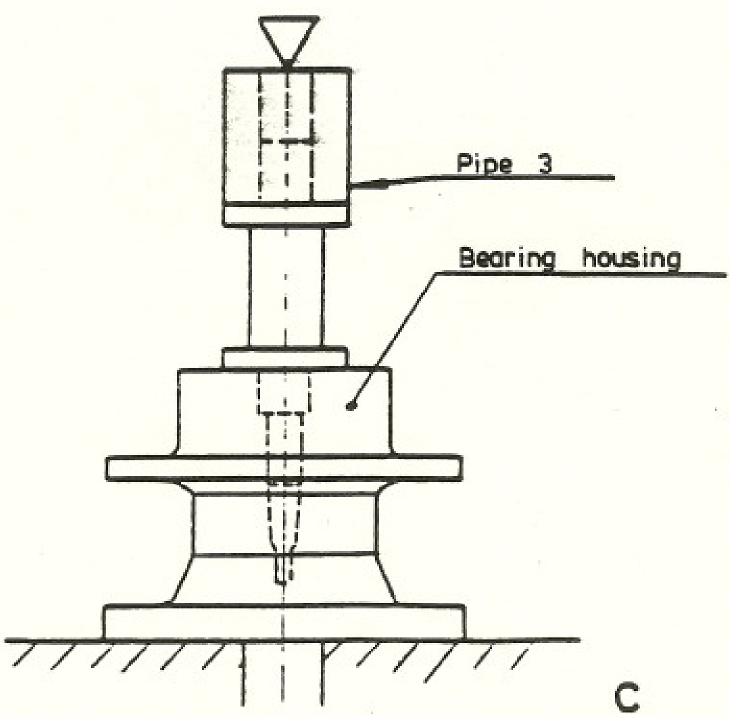
Pipe 3
Bearing housing

C

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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 multi-ply 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

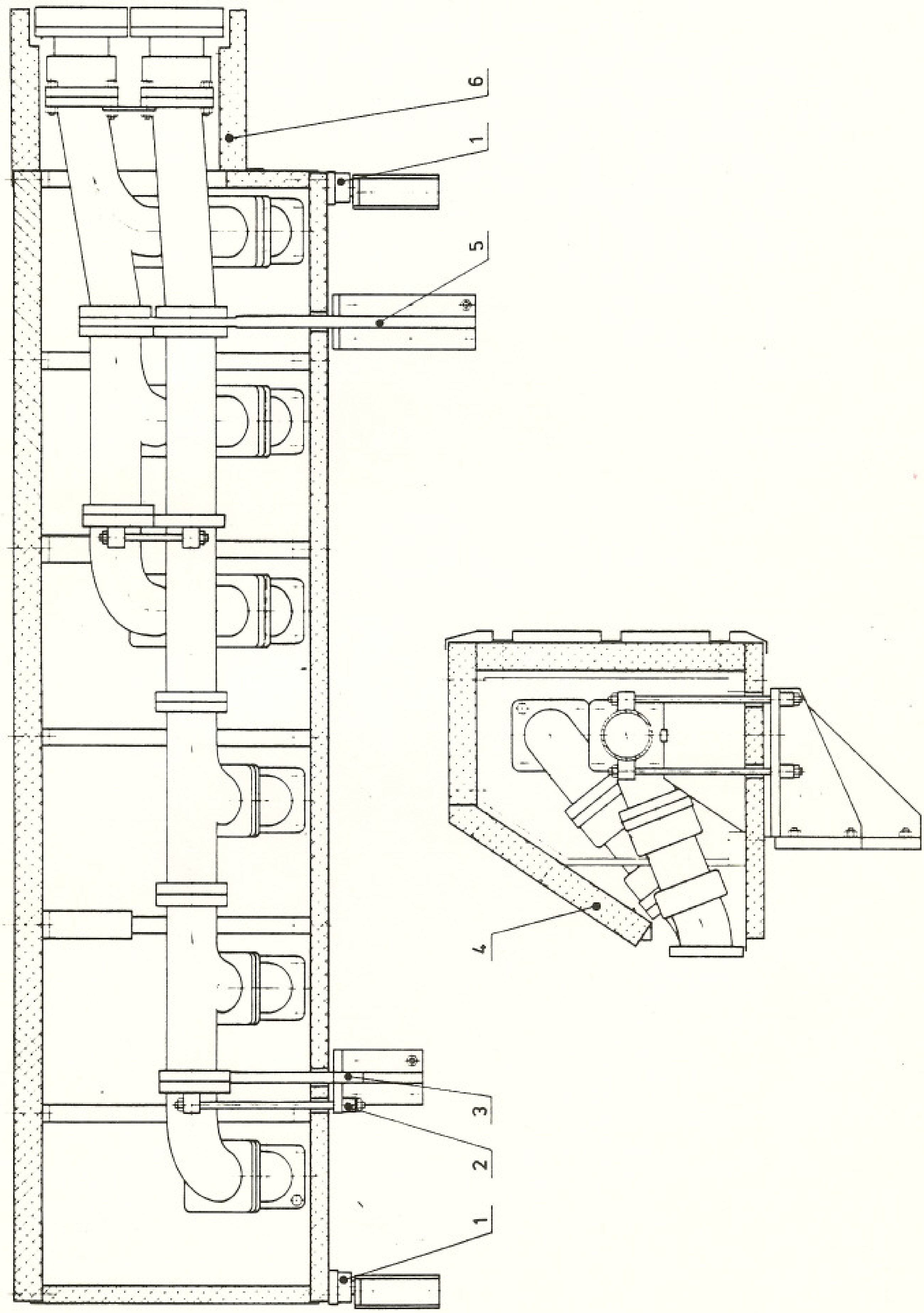
a) Remove the cover (4) of the insulation box to get access to the expansion bellows between the exhaust pipes and the cylinder head.

b) Remove the covers (6) to get access to the expansion bellows between the exhaust pipes and the turbocharger.

c) Check that the flanges between the turbocharger and the exhaust pipe are parallel and located on the same centre 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.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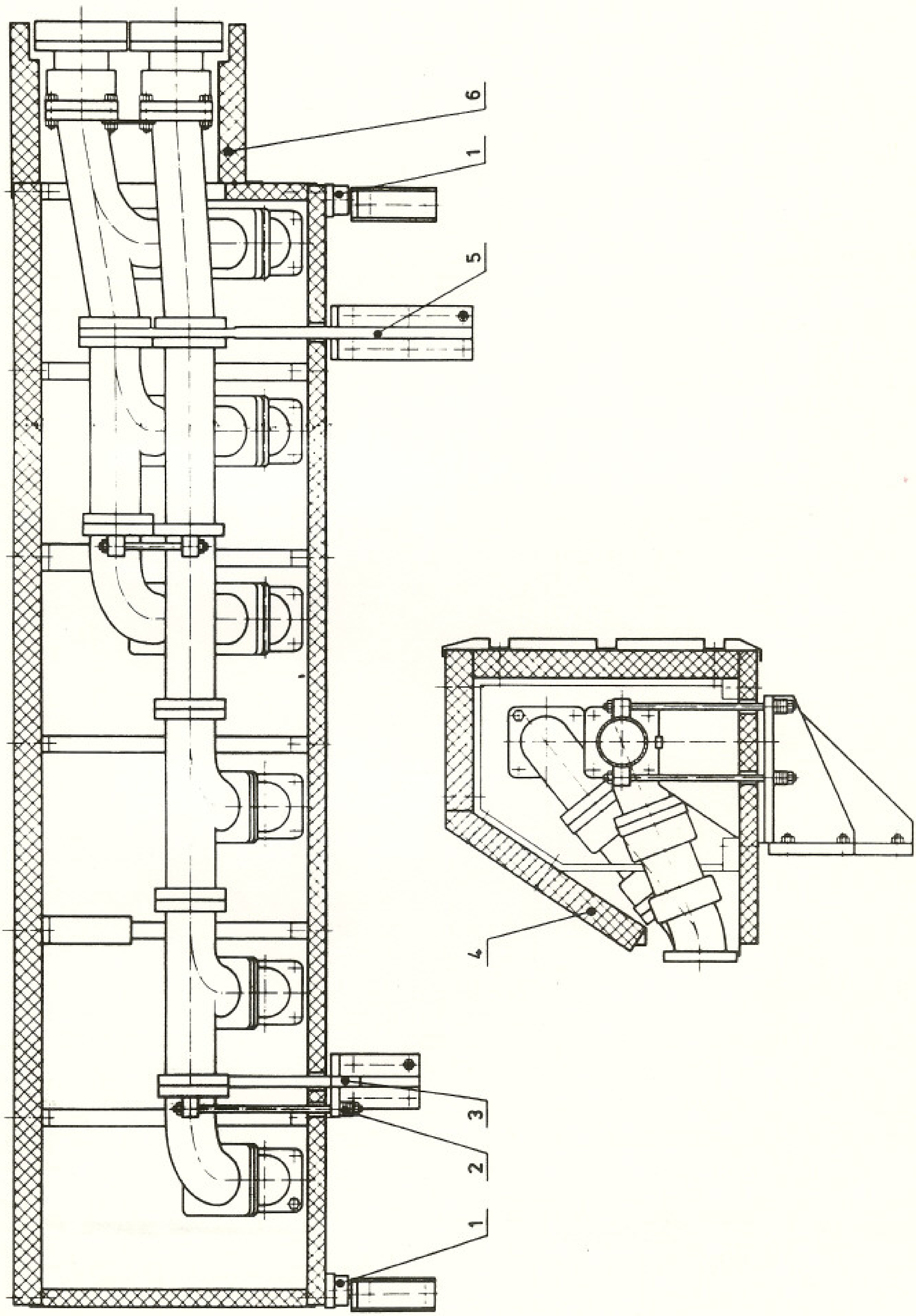
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21. STARTING AIR SYSTEM

21.1 Description (page 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 built-on 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 (page 21-51)

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 the duct (7) between the rear side of the sealing piston (11) and the servo piston (6), which 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 through the nozzle (9) and the valve closes.

2. Maintenance

Normally, the main starting valve requires little maintenance. In case it is to be opened for inspection:

a) 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.

b) Open the plug (10) for inspection. Clean the sealing piston (11) and the seat. Do not use hard tools.

c) 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, if necessary.

d) Lubricate the details before reassembling. Fill the servo piston lubricating grooves with Molykote Paste G.

e) When installing, check that the connection pipe 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 (page 21-51)

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.

2. Maintenance

Normally, the starting air distributor is only slightly worn. If it has to be opened for inspection and cleaning:

a) Take care not to damage the sliding surfaces of the piston and the distributor housing bores.

b) The piston are individually matched and are not interchangeable. Utilize the cylinder number stamped at every control air outlet.

c) 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.

d) 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

1. Description

The valve is an exchangable unit consisting of a valve spindle with a spring-loaded control piston installed in a housing.

2. Maintenance

Check and, if necessary, clean the valve when overhauling the cylinder head.

a) Remove the flange and pull out the starting valve.

b) Unscrew the self-locking nut (21) and remove the piston (22).

c) Check the sealing faces of the valve disc and valve seat.

d) After reassembling the piston, spindle and spring, check that the valve moves easily and closes completely.

e) When installing the valve, check that the sealing under the valve is in position and intact.

f) 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

1. Description (page 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 as the engine starts, otherwise the starting motor is exposed to unnecessary wear.

2. Maintenance

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

Use one of the following oils:

Gali HI 33 EP

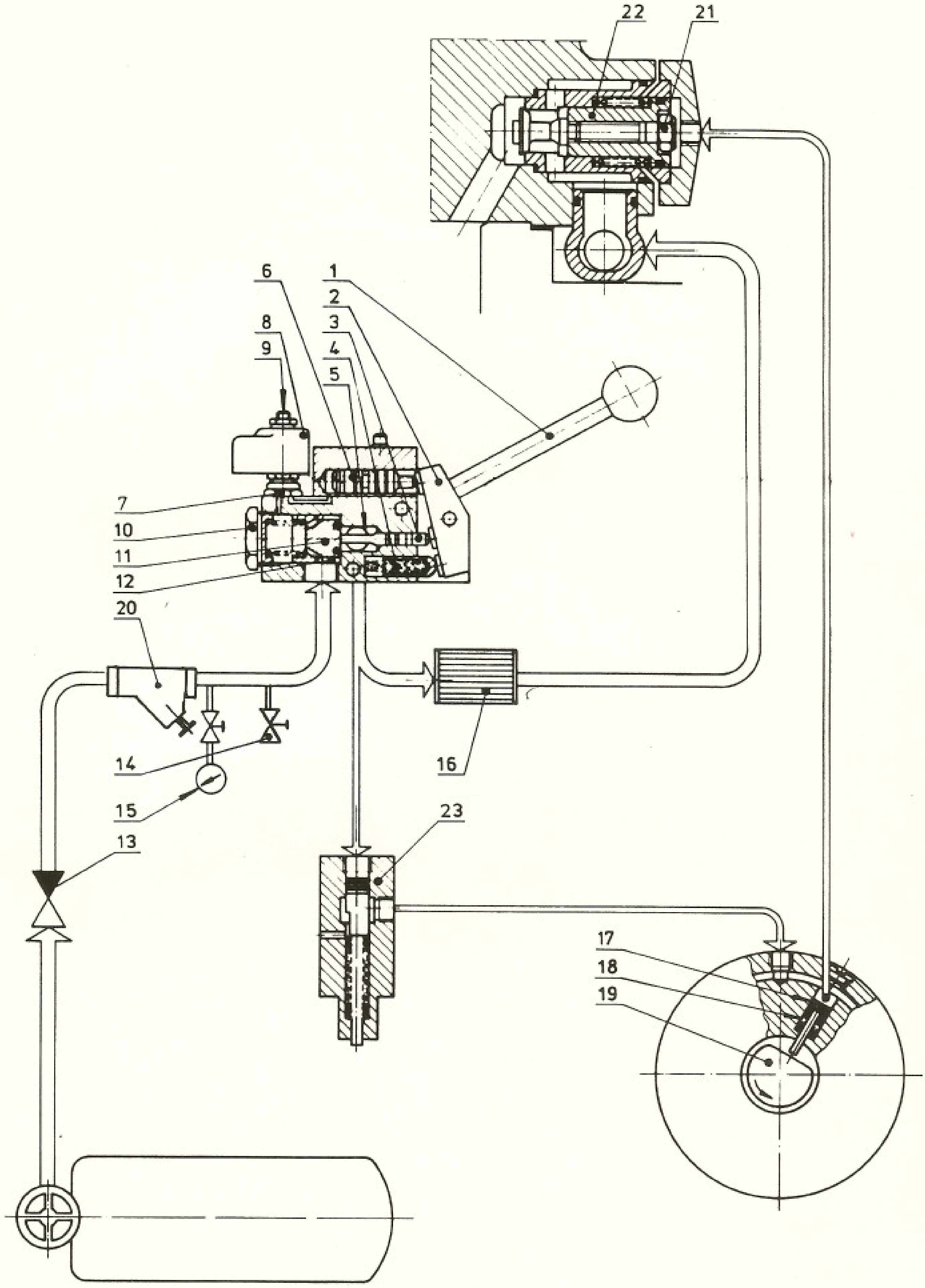
Shell Turbo Z7

Castrol Huspin 80

BP Energoil HP 46

Mobil Detergent Light

If necessary, use the same oil as in the diesel engine oil system.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22. CONTROL MECHANISM

22.1 Description (page 22-51)

During normal operation the engine speed is controlled by a governor (18) which regulates the injected fuel quantity to correspond the load.

The regulation movement is transferred to the control shaft (10) through a spring-loaded rod (16) which enables stop or limit functions to be transferred to the control shaft irrespective of the governor position. In V-engines the control shafts of the cylinder banks 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 (4) and the spring (3) which press the pin (2) at the end of the fuel rack against the control lever. The torsion spring (3) enables the control shaft and, consequently, the other fuel racks to be moved to stop position even if one of the racks has jammed. In the same way the torsion spring (5) enables the control shaft to be moved towards fuel-on position even if an injection pump has jammed in no-fuel position. This feature can be of importance in an emergency situation.

The engine can be stopped by means of the stop lever (6). When the stop lever is moved to stop position, the lever (8) actuates the lever (7) 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 cylinder actuates the pin (2) at the fuel rack. 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.

When starting, a fuel limiter will automatically limit 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.

The indicator (12) indicates the fuel rack position.

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 lubricating oil pressure, too high circulating water temperature, or at any other desired function.

Next to the governor there is a fixed mechanical limiter effecting the control shaft directly by means of the lever (13).

22.2 Maintenance (page 22-51)

> Special attention should be paid to the functon 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.

a) The system should work with minimum friction. Clean and lubricate regularly the racks, bearings (also the self-lubricating bearings (9)) and the ball joints with lubricating oil.

b) The system should be as free from clearances as possible. Check clearances of all connections. The total clearance may correspond to max. 0.5 mm of the injection pump fuel rack positions.

c) 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, retainer rings, locking plates are in positions. Check according to pos. a...c.

22.3 Check and adjustment (page 22-51)

1. Stop lever stop position

a) Check:

- Set the terminal shaft lever (17) in max. fuel position and the stop lever (6) 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 (7) 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 (20).

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. lb.

- Adjust the spring-loaded rod so that the fuel rack position of 4 mm is obtained.

- If changing the governor, see section 22.4.

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.

4. Electro-pneumatic overspeed trip device (page 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) <u>Adjustment of stop position</u>

- 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) <u>Check and adjustment of tripping speed</u>

- See section 22.6.

<u>5. Starting fuel limiter</u> (page 22-54)

a) <u>Check of limit position</u>

- 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) <u>Adjustment of limit position</u>

- 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) <u>Check of function</u>

- See section 22.7.

<u>6. Indicator of fuel rack position</u>

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 (page 22-51)

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.

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 irmly fastened to the shaft

Change worn parts.

3. Removal of governor

a) Loosen the terminal shaft lever (17) and governor electrical connection.

b) Open the screws (19) and pull the governor vertically upwards. The governor must not fall or rest on its driving shaft.

4. Mounting of governor

When mounting the same governor, check that the mark on the lever (17) corresponds to that of the shaft. Check the setting according to section 22.3.

When mounting a new governor, proceed as follows:

a) Mount the governor into position on the governor drive.

b) Turn the governor terminal shaft to stop position (in counter-clockwise direction seen from the driving end).

c) 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

d) 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.

e) Move the stop lever into the stop position. (Fuel rack position 5 mm).

f) Adjust the spring-loaded rod length to fit between the levers (17) and (15). Do not forget to secure the nuts.

g) Check according to section 22.3.

22.5 Mechanical overspeed trip device (page 22-52)

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 working 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.

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 the tripping 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.

3. Adjustment of tripping speed

a) Remove the plug (9).

b) Turn the crankshaft until the adjusting nut (14) is in front of the opening.

c) 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.

d) Mount the plug (9) and check the tripping speed according to pos. 2.

e) The spring can be replaced through the opening of the plug.

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 pos. 3.

22.6 Electro-pneumatic overspeed trip device (page 22-53)

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 pressure before 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.

The solenoid valve can also be operated manually.

2. Check and adjustment of stop position

See section 22.3 pos. 4 a and b.

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 the tripping speed.

The tripping speed should be 15 % above the nominal speed (13 % at a nominal speed of 1200 RPM), see section 06.01.

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.

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 (page 22-54)

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.

2. Check and adjustment of limitation

See section 22.5 a and b.

3. Check of function

a) Check that limitation is achieved as soon as the main starting valve opens.

b) Check that correct limitation is achieved during the acceleration period.

c) 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 cut-off speed by turning slowly the speed control knob of the governor. On main engines a cut-off speed lower than the minimum running speed is applied.

4. Maintenance

a) 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.

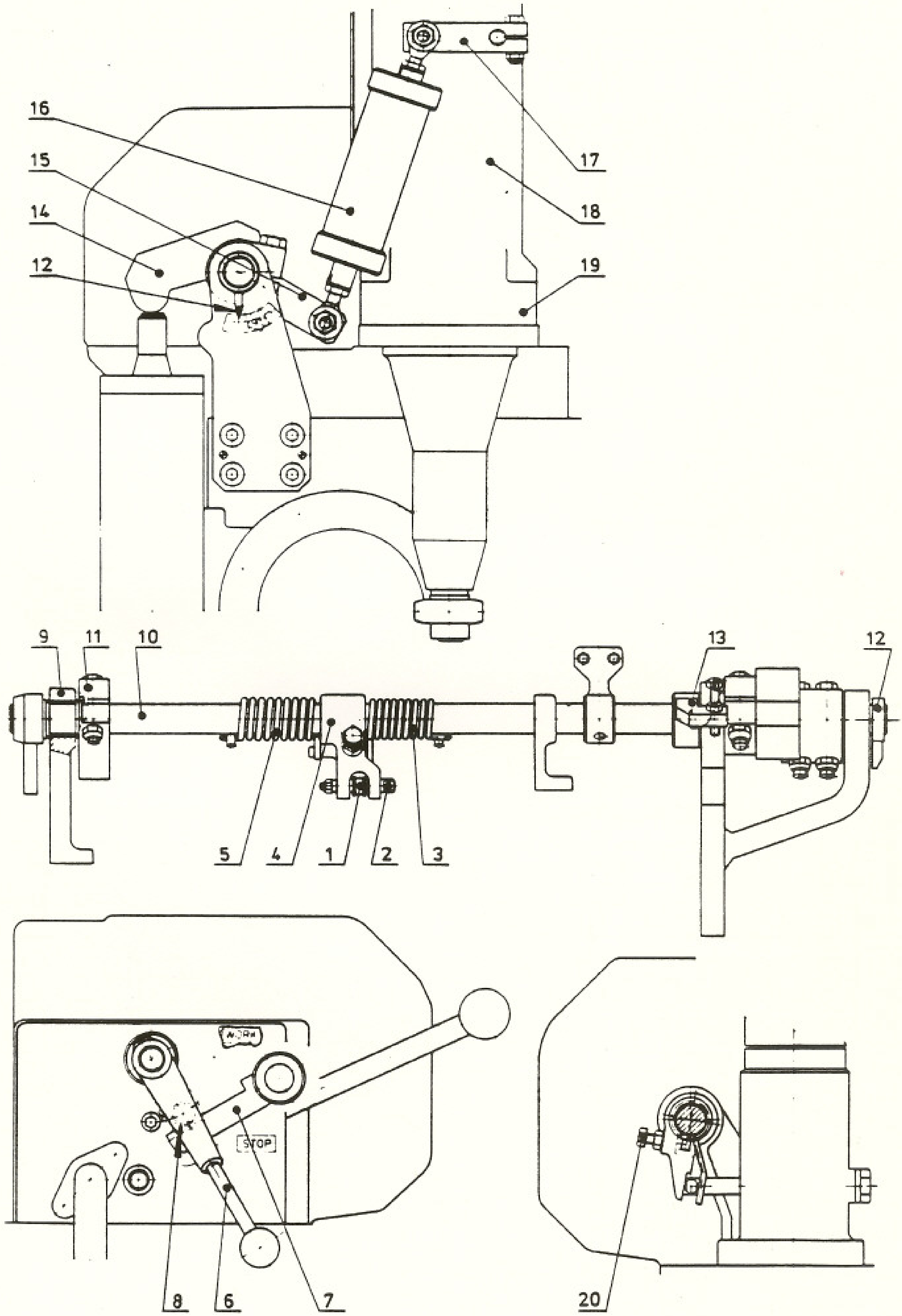
- Leaky three-way valve.

b) 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.

c) 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.

d) 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.

e) Check according to pos. 2 and 3.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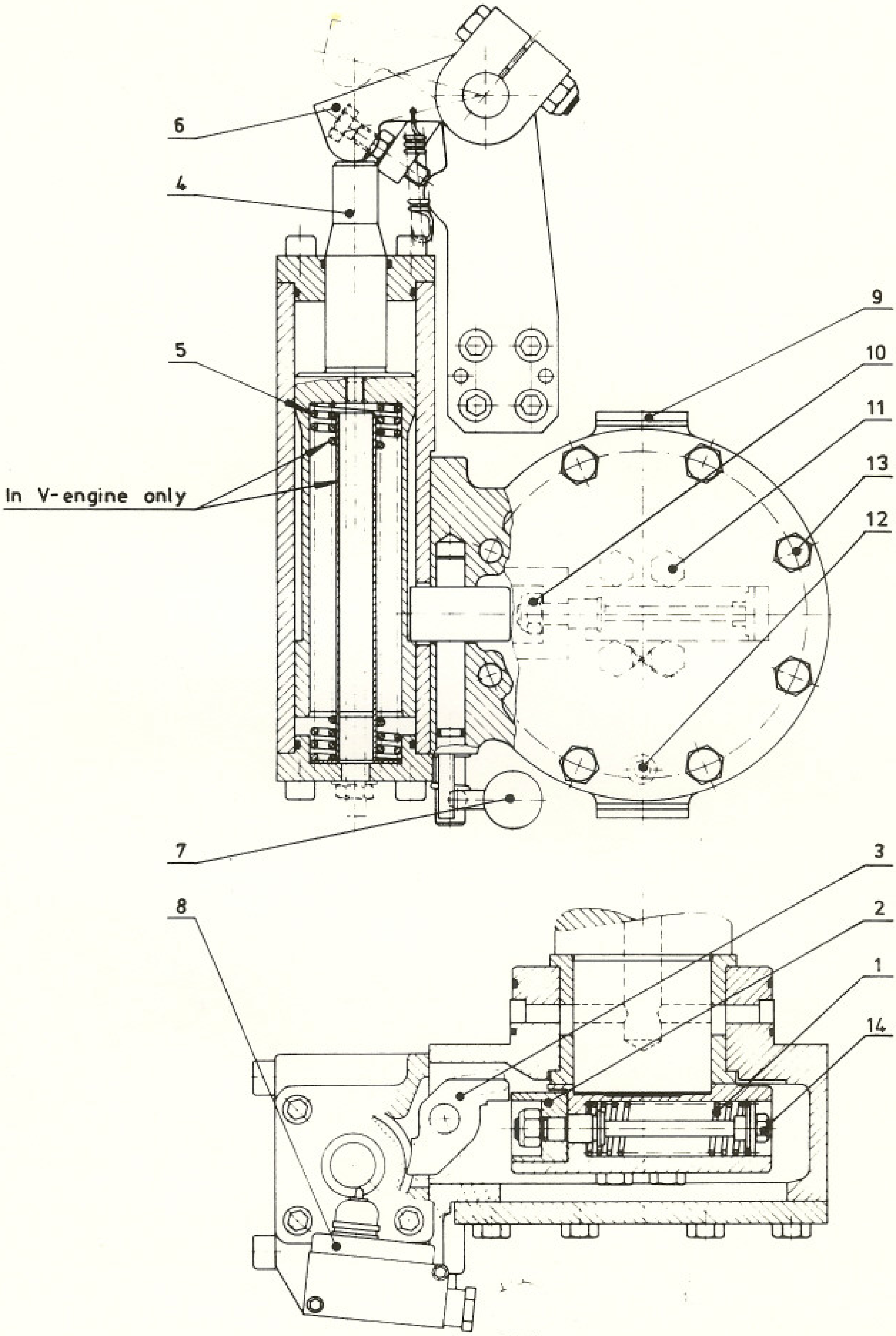
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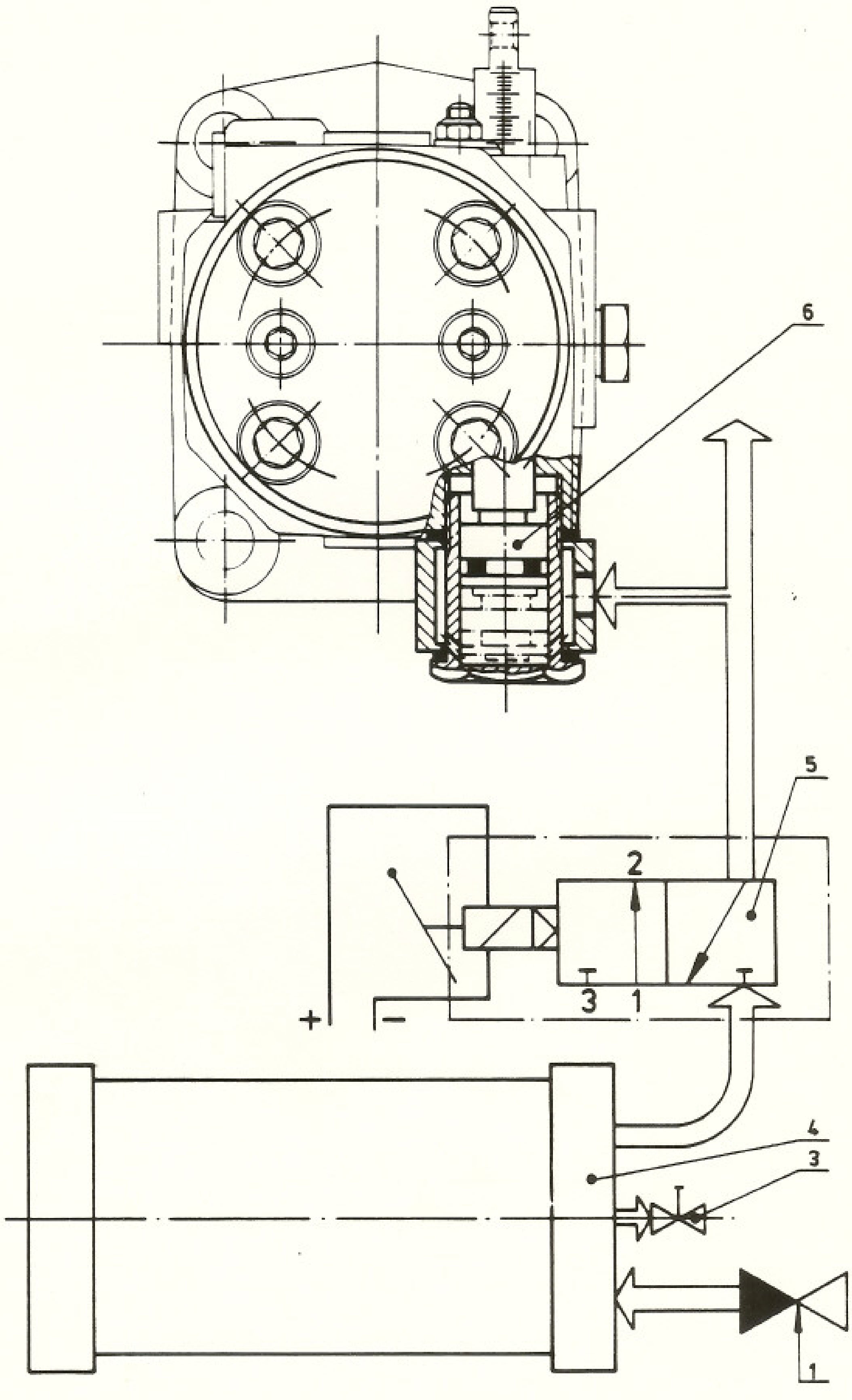
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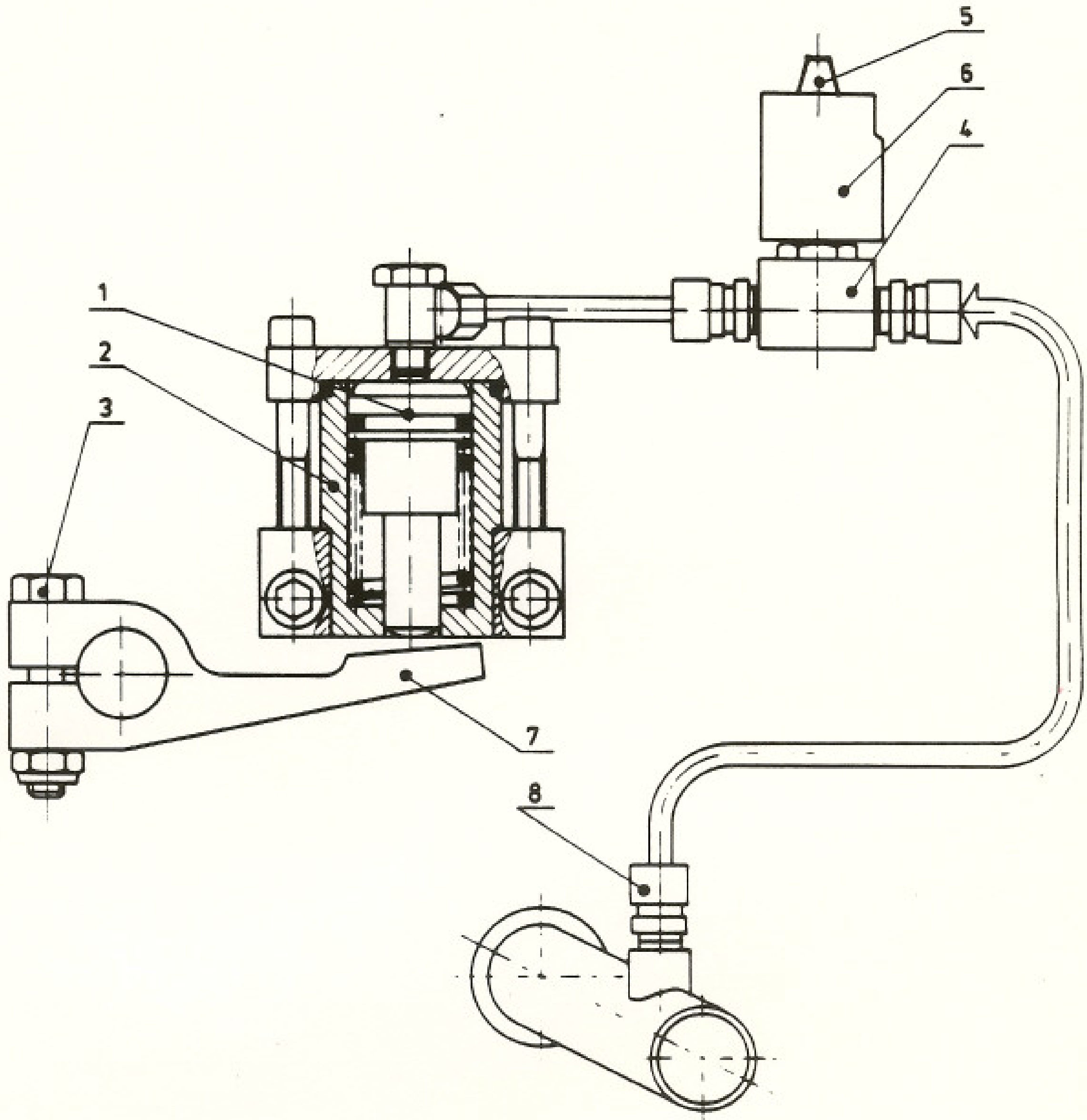
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00 Contents, instructions, terminology

01 Main data, operating data and general design

02 Fuel oil, lubricating oil, cooling water

03 Start, stop, operation

04 Maintenance schedule

05 Maintenance tools

06 Adjustments, clearances and wear limits

07 Tightening torques and instructions for screw connections

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09 Specific installation data

10 Engine block with bearings, cylinder liners, oil sump

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15 Turbocharging and intercooling

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17 Fuel system

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19 Cooling water system

20 Exhaust system

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22 Control gear

23 Instrumentation and automation

23. INSTRUMENTATION AND AUTOMATION

23.1 Monitoring equipment mounted on the engine (page 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
  - x) nozzle temperature control oil before and after the engine (double pointers)
- 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 (11), between (29) and after the coolers (30)
- x) For nozzle temperature control oil before (9) and after (8) the engine
- For fuel before the engine (28)

Erroneous and damaged thermometers are to be replaced by new ones at the first opportunity.

x) Only for engines running on heavy fuel, i.e. 22HF and 22HE.

23.1.3 Combined visual pressure drop indicators and alarm switches

- For too high pressure drop across the lube oil filter (19). The indicator/switch is mounted on each lube oil filter.
- For too high pressure drop over the fuel filter when mounted on the engine (14)

23.1.4 On/off switches

a) Alarm switches

The following switches for automatic alarm are monted on the engine as standard:

Single-step switches for:
- too high charge air temperature (3)
- x) - too low inlet temperature of the nozzle temperature control oil (16)
- x) - too high outlet temperature of the nozzle temperature control oil (15)
- low lubricating oil pressure before the engine (4)
- low lubricating oil pressure of prelubrication (6)
- low fuel oil pressure (9)
- x) - low nozzle temperature control oil pressure (10)
- low HT water pressure (7) (main engines, only)
- low LT water pressure (8) (main engines, only)
- too high pressure drop over the lubricating oil filter (19)
- too high pressure drop over the fuel oil filter (14)
too low lubricating oil level (27)

Two-step switches for:
- too high lubricating oil temperature (28)
- too high HT water temperature (26)

c) Stop switches

The following switches for automatic stop are mounted on the engine as standard:

- for too low lube oil pressure (5)
- for too high cooling water temperature (23)

c) Indicating switches

The following switches for indication are mounted on the engine as standard:
- for tripped mechanical overspeed trip (21)

As extra equipment the following switches may be supplied:
- for load indication; one or two switches

The switches may differ from the above stated standard set.

x) The switches are mounted only on engines running on heavy fuel, i.e. 22HF and 22HE.

d) Other switches

A pressure switch is connected to the air receiver for control of the load dependent cooling system (this applies to 22HF and 22HE).

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.

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.

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.

Pressure drop indicator

Remove the lube oil switch from the filter and the the fuel switch from the pipes.

Connect a hydraulic pressure test device (pump + manometer) to the 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.

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
- nozzle temperature control oil, inlet (applies to 22HF and 22HE, only)
- 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

a) 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 pick-up 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 inlcuded in the measuring equipment.

b) 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.

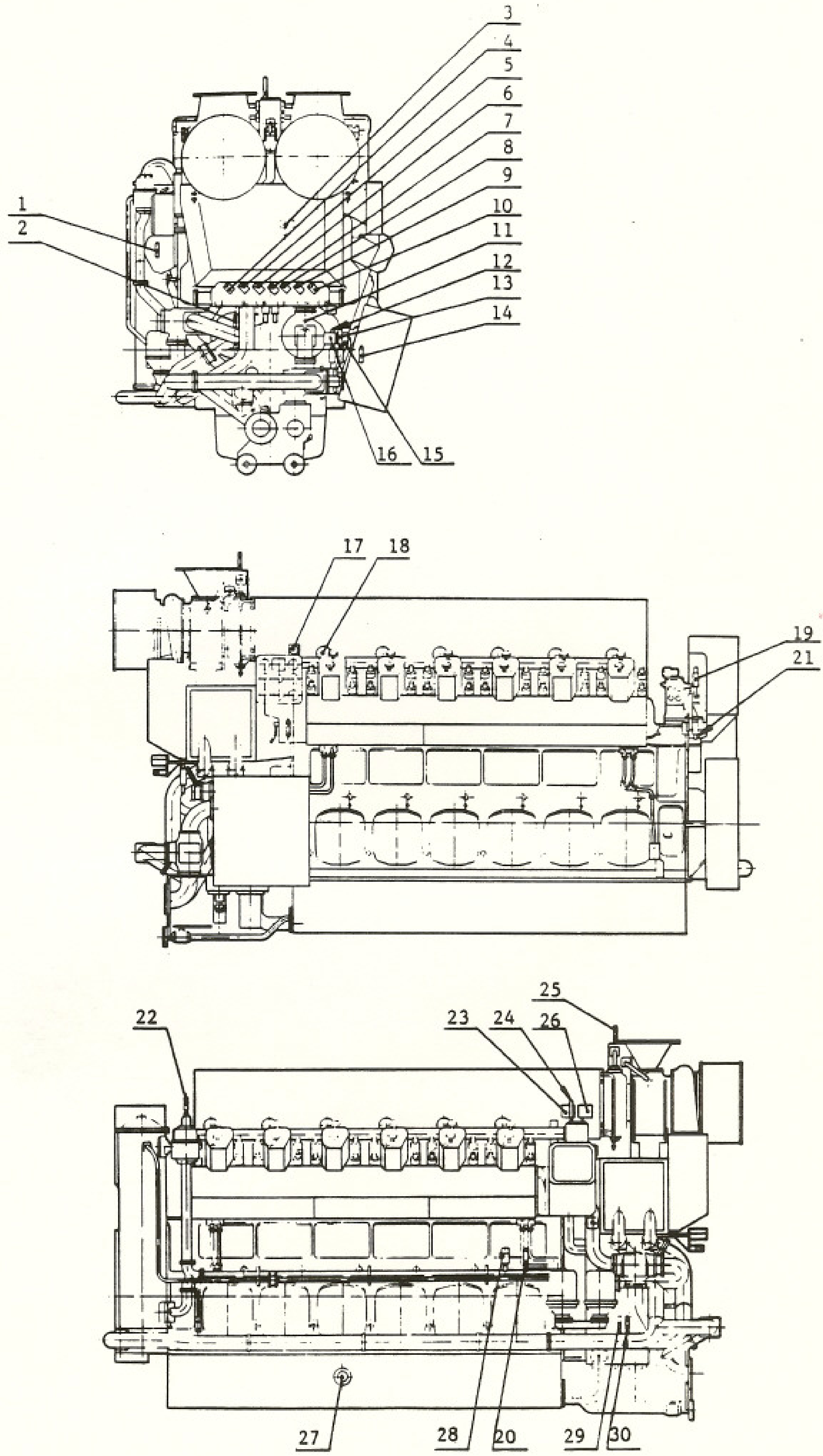
For checking the relay for fuel injection limitation during start, see section 22 pos. 3.5a.

For checking the relay for overspeed, see section 22 pos. 6.3.

Damaged or broken components are replaced by new ones. See the wiring diagrams and the manufacturer´s instructions.

The inductive pick-up is to be mounted 1.5±0.5 mm from the camshaft gear.

Check at intervals the elastic suspension of the measuring converter box.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DESPEMES

SPEED MEASURING SYSTEM FOR DIESELENGINE

WÄRTSILÄ
VASA DIESEL

1. INTRODUCTION

2. THEORY OF OPERATION

2.1 Diesel engine speed
2.2 Relay functions
2.3 Turbocharger speed
2.4 Digital output
2.5 Additional relay functions

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3.2 Measuring converter for the diesel engine speed n_{DE}
3.2.1 Theory of operation
3.2.2 Adjustment procedures
3.2.3 Technical specification

3.3 Relay card I
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3.4 Measuring converter for turbocharger speed n_{TC}
3.4.1 Theory of operation
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4. ENGINE SPEED SENSOR

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5. TURBOCHARGER SPEED SENSOR

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6. TROUBLE SHOOTING PROCEDURES

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6.2 n_{DE}-measuring converter with relay function
6.3 Relay card
6.4 n_{TC}-measuring converter
6.5 Engine speed sensor

APPENDIX: A: Outline drawing 3V72H83
B: Connection diagram

YUXX0031 40 000 K H

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 1 or 2 turbocharger speeds
- 3 additional relay functions as option

2. THEORY OF OPERATION

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 frequency 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.

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.

2.3 Turbocharger speed

A magnetic sensor is attached against the end of the turbocharger's rotating shaft, sensing its speed. The sinusoidal voltage from the sensor is amplified and converted to a square wave signal before being converted into a speed proportional DC-voltage.

YUXX0031 40 000 K-H

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.

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.

3. FUNCTIONAL CIRUCUIT CARDS

The DESPEMES speed measuring system includes the following printed circuit boards:

a. Power supply
DC/DC 24 V DC — C1
alt. 48...110 V DC

b. n_{DE} measuring converter with relay function for engine speed — C2

c. Relay I
3 speed-controlled relay functions with optional delay — C3

d. n_{TC} measuring converter for one or two turbochargers — C4

e. Relay II
3 voltage-controlled relay functions with optional delay — C5

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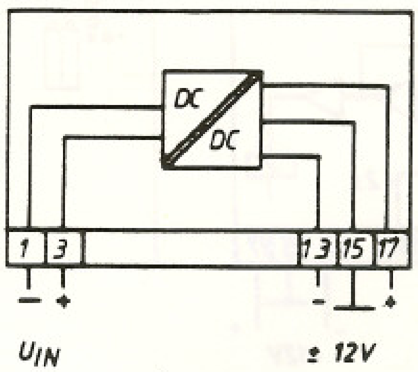
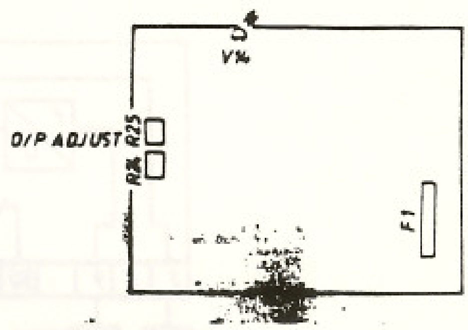
3.1 Cl Power supply DC/DC

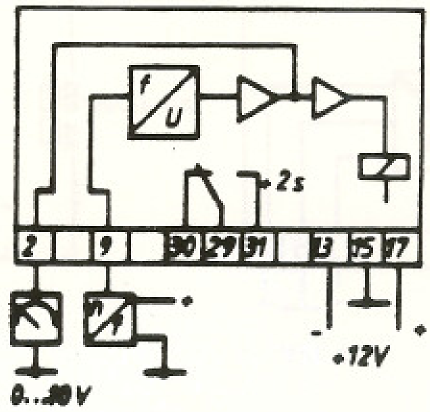


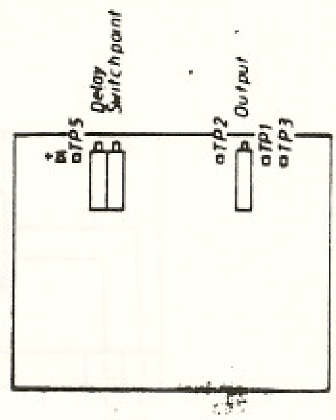


Supply voltage:	18...40 V DC smoothed alt. 40...160 V DC
Output voltage:	± 12 V ± 0.3 V
Output current:	± 350 mA
Output ripple:	± 100 mV
Ambient temperature:	-25...+71°C
Short-circuit-proof:	5 s
Isolation voltage:	2 kV, 50 Hz, 1 min 5 kV, 1.2/50 us
Fuse:	500 mA, 5 x 20 mm

The power supply is short-circuit-proof and overheating protected.
A green light emitting diode indicates that voltage is provided.

3.2 C2 n_{DE} measuring converter with relay function for the engine speed





3.2.1 Theory of operation

The speed sensor is a 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 frequency 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 controls 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.

3.2.2 Adjustment procedures

The analog speed measuring signal 0...10 VDC

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

a. Determine the n_{DE}-card amplification:
   n_{max} [rpm] ≙ U_{max} [VDC]

b. Calculate corresponding output voltage at specified relay switching speed:

$$Ux\ [VDC] = \frac{n_x\ [rpm]}{n_{max}\ [rpm]} \times U_{max}\ [rpm]$$

c. Adjust P502 to the calculated TP4 voltage:
   Ex: VASA 32: Specified switching speed: 620 rpm
   a. 1000 rpm ≙ 10 VDC
   b. $U_{620} = \frac{620\ rpm}{1000\ rpm} \times 10\ VDC = 6.2\ V$
   c. Adjust the TP4 voltage to 6.2 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 VDC, 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:

3.2.3 Technical specification

Inputs:

Frequency:	0...8000 Hz 12 V pk square wave
Supply voltage:	+12V, -12V, OV
Current consumption:	Max. 40 mA

Outputs:

Frequency:	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

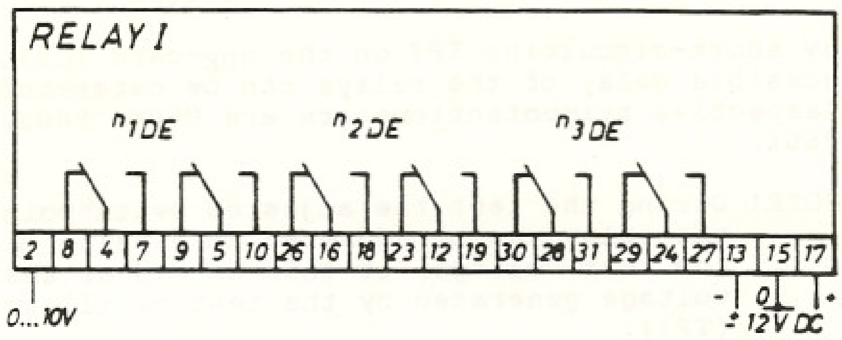
Relay function

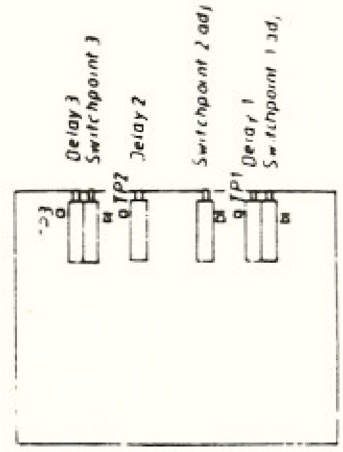
Switchpoint:	0...100 % of measuring range
Delay:	0...10 sec.
Contacts:	2 change-over contacts
Breaking capacity:	110 V DC 0.3 A, 24 V DC, 1.0 A

Test

Test point:	Approx. 80 % of full scale
Ambient temperature:	-25...+71 °C

3.3 C3 Relay card





3.3.1 Theory of operation

The card includes 3 relays each relay having 2 change-over contacts. The output voltage from the n_{DE}-card: C2 is supplied to 3 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.

3.3.2 Adjustment procedures

The switchpoint of the relays are adjustable with trimpotentiometers. The testpoints indicate the adjustment.

P601, TP1	relay n_1
P692, TP2	relay n_2
P603, TP3	relay n_3

a. determine the amplification of the n_{DE}-card: n_{max} [rpm] $\hat{=}$ U_{max} [VDC]

b. calculate the voltage corresponding to the rotation speed at which the relay switches on.

$$Ux\ [VDC] = \frac{n_x\ [rpm]}{n_{max}\ [rpm]} \times U_{max}\ [rpm]$$

c. 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 be 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).

3.3.3 Technical specification

Inputs:

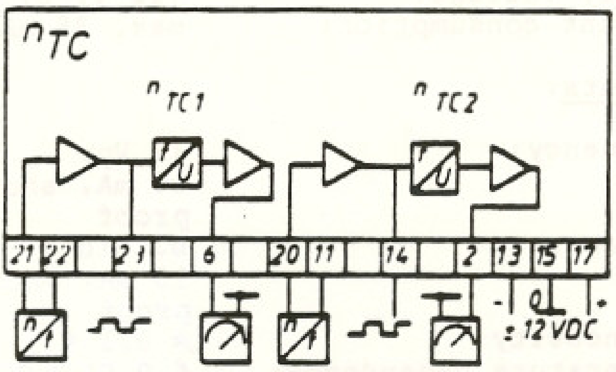
Supply voltage:	+12V, 0, -12 V
Current consumption:	max. 60 mA
Control voltage:	0...10 V DC

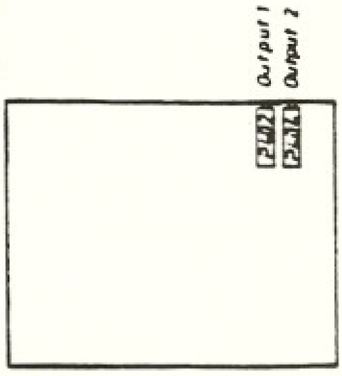
Outputs:

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°C

3.4 C4 TC-card: Measuring converter for 1 alt. 2 turbochargers





3.4.1 Theory of operation

The sine wave signal of the turbocharger speed sensor is amplified and transmitted to a square-wave signal. This can be measured by a frequency counter.

The square wave frequency signal is converted to a speed-proportional voltage 0...10 V. This is buffered and forms the measuring voltage for the remote speed indicators.

The card may consist of 2 channels.

3.4.2 Adjustment procedures

The analog output readjustment can be done by means of the potentiometers P402 and P404.

P402: n_{TC1}
P404: n_{TC2}

When turning the pot. CW, the output will increase and vice versa.

3.4.3 Technical specification

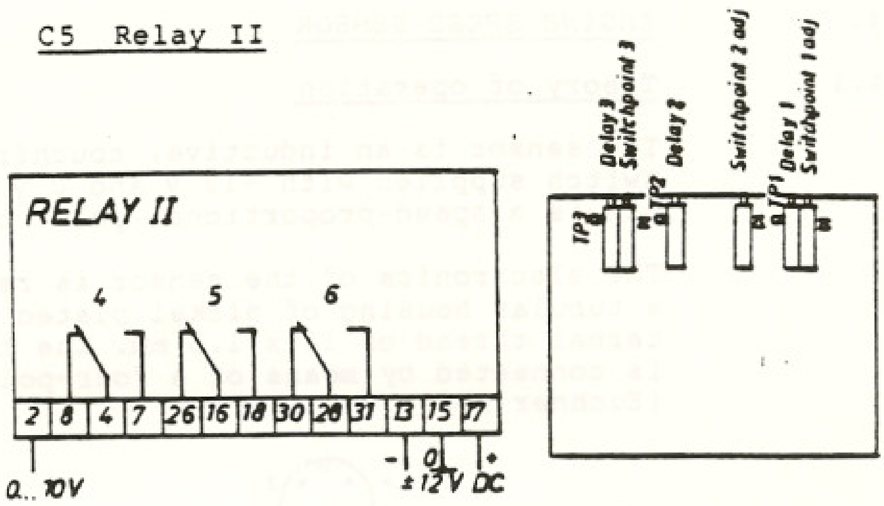
Inputs:

Frequency:	0...8000 Hz > 100 mVpp sine
Supply voltage:	+12 V, 0, -12V
Current consumption:	max. 35 mA

Outputs:

Frequency:	12 Vpp 10 mA, short-circuit-proof
Voltage:	0...10 V 15 mA, short-circuit-proof
Unlinearity:	± 0.1 %
Temperature dependence:	< 0.03 %/K

3.5 C5 Relay II



3.5.1 Theory of operation

The card consists of 3 voltage-controlled relays, each having one change-over contact.
Any external voltage between 0 and 10 V DC can be used as control.
The switchpoints and delays are adjustable.
LED indicates an activated relay.

3.5.2 Adjustment procedures

See point 3.3.2

3.5.3 Technical 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

4. ENGINE SPEED SENSOR

4.1 Theory of operation

The sensor is an inductive, touchfree poximity switch supplied with +12 V and 0 V C. 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 18 x 1.5 mm. The three-wire cable is connected by means of a four-pole connector (Euchner BS4).

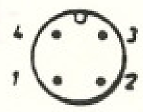


Fig. 4.1 BS4-connector
View from the cable
connection side.

1. +12V
2. Output
3. OV

4.2 Mounting the sensor

NOTE! The engine must not run while the sensor is mounted.

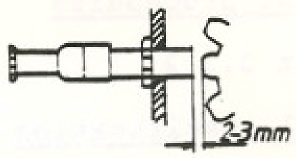


Fig. 4.2

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. 4.2).

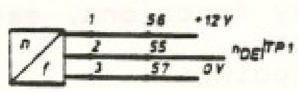


Fig. 4.3

The output signal (terminal 55 in the electronic box or TP1 on the n_{OE}-card) should now be 12 V DC. If the sensor is between two cogs, the output will show 0 V.

5. TURBOCHARGER SPEED SENSOR BM9, BM8

5.1 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.

The turbocharger housing and the end of the shaft are prepared for this type of sensors as follows:

BBC type RR: 2 excentric grooves in the shaft end
type VTR: a disc with 6 holes in the shaft end

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).

5.2 Mounting the sensor

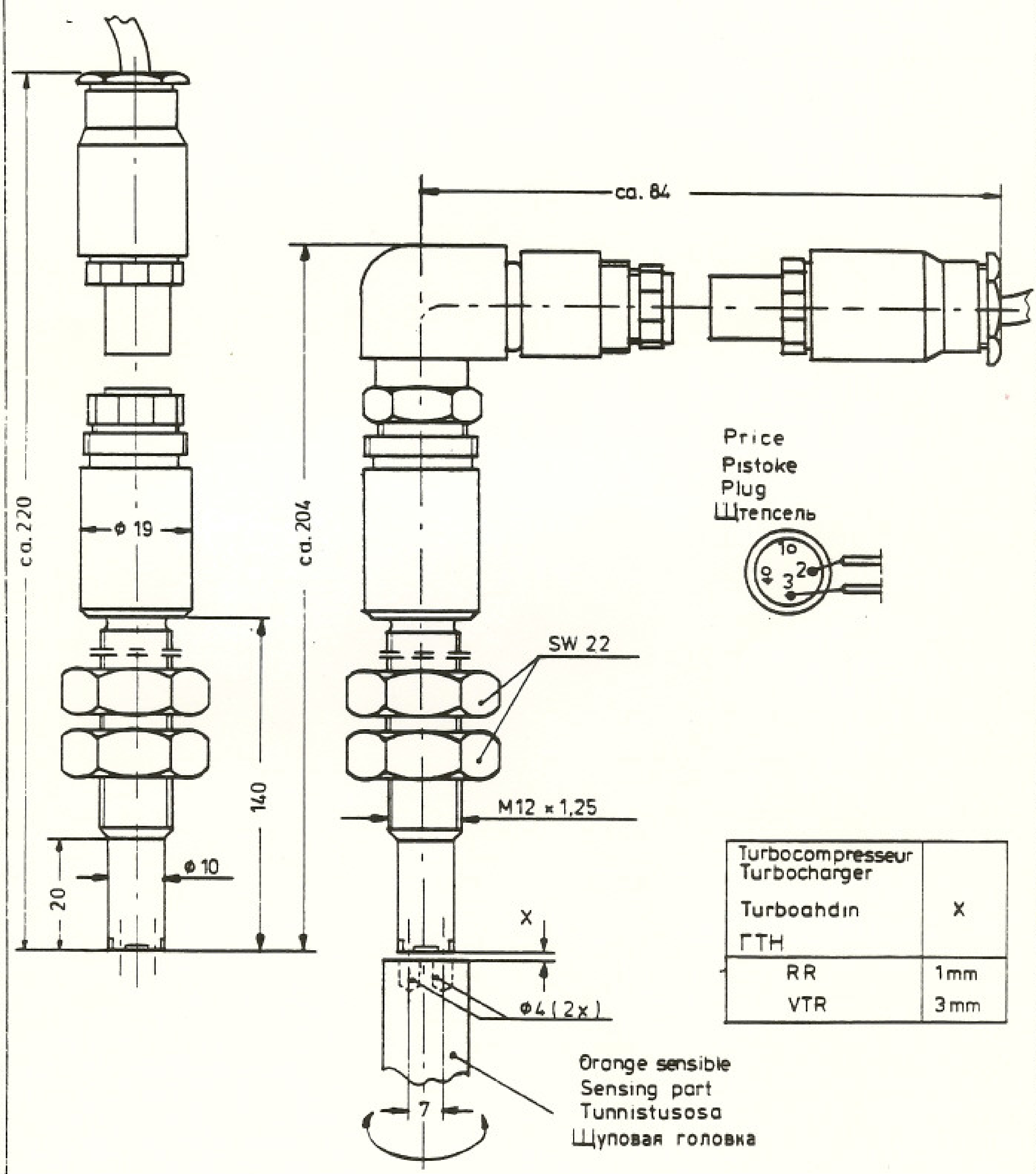
NOTE! The engine must not run while the sensor is mounted.

Screw the sensor completely in and then unscrew it for a sensing gap about 0.8...1.5 turns.

Oy Wärtsilä Ab Vaasan Tehdas Oy Wärtsilä Ab Vasafabriken VAASA VASA	BM 9 MAGNETIC SPEED SENSOR MAGNEETTINEN KIERROSLUKUANTURI ЧУВСТВИТЕЛЬНЫЙ ЭЛЕМЕНТ, МАГНИТНЫЙ CAPTEUR DE VITESSE MAGNETIQUE	4V23L43	
		8.10.80	HB
		8.10.80	Zk

Style "a"
Rakenne "a"
Исполнение "а"

Style "b"
Rakenne "b"
Исполнение "б"

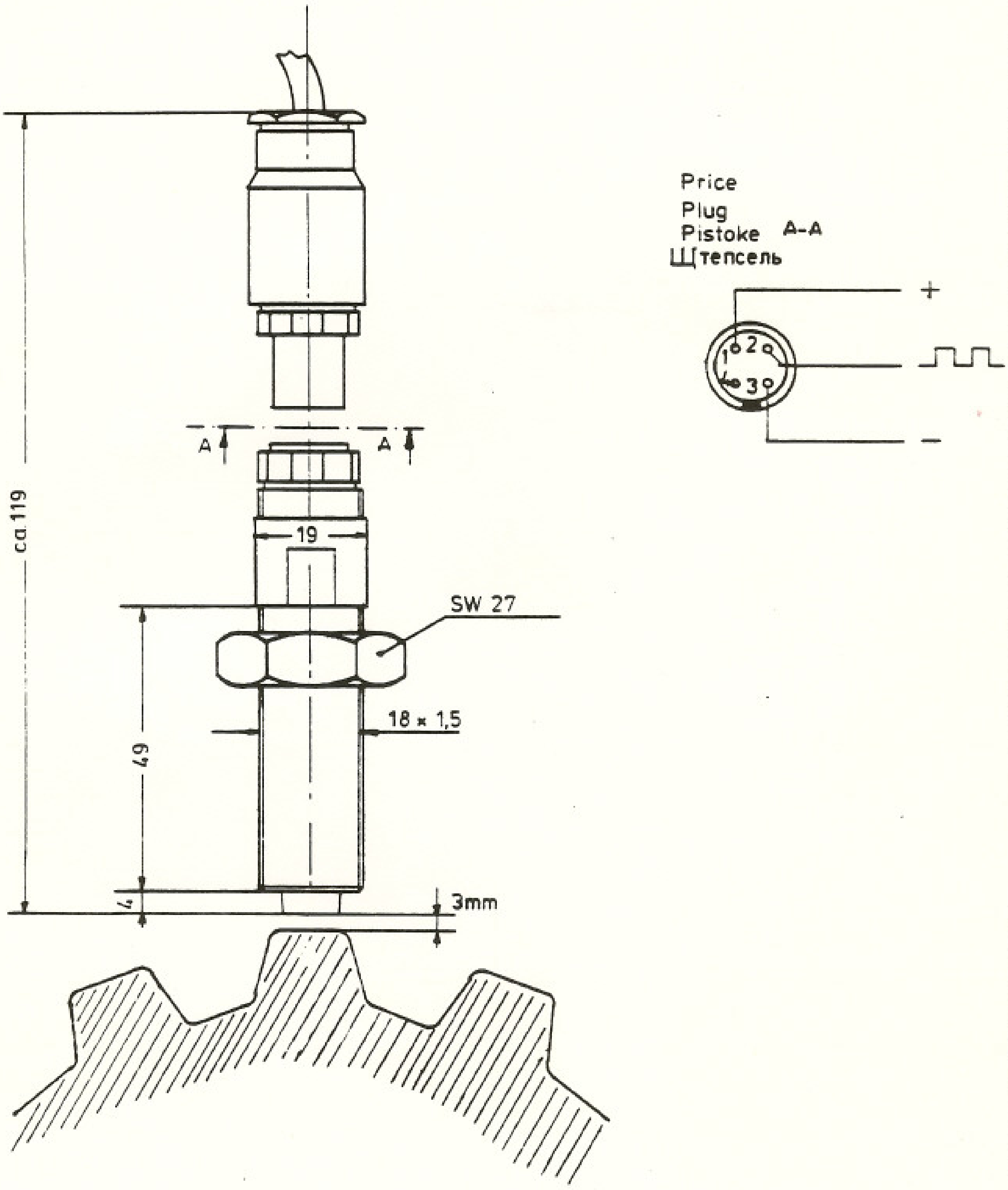


Turbocompresseur Turbocharger Turboahdin ГТН	X
RR	1mm
VTR	3mm

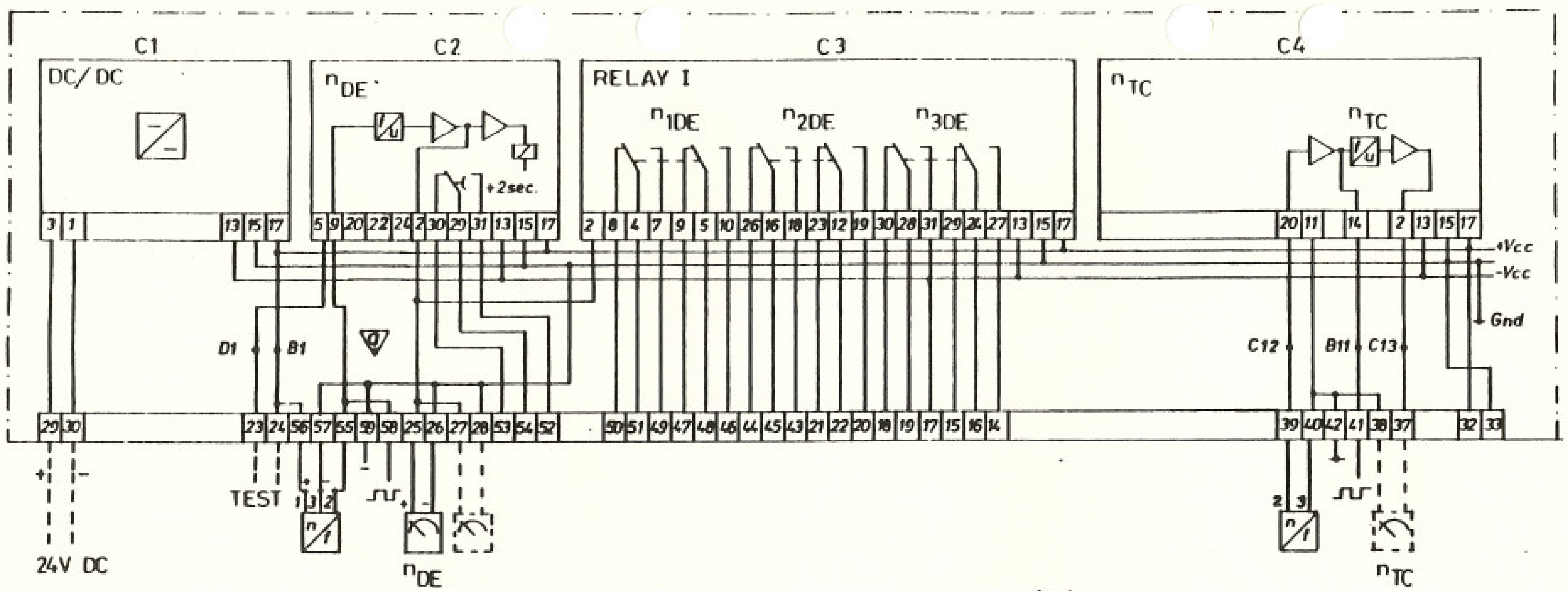
23L43

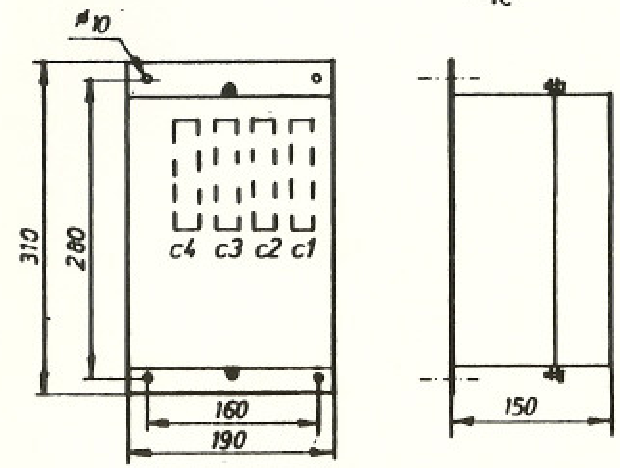
Oy Wärtsilä Ab Oy Wärtsilä Ab VAASA VASA	BAUMER IFR 18.24.31. K53 INDUCTIVE PROXIMITY SWITCH INDUKTIIVINEN LÄHESTYMISKYTKIN ИНДУКТИВНЫЙ ВЫКЛЮЧАЕЛЬ БЛИЖНЕГО ДЕЙСТВИЯ	4V23L45 16.1.81

COMMUTATEUR DE PROXIMITE INDUCTIF



4V23L45





Main dimensions in m.m.

a Valid for 0V72H73 rev 2

POS	TYYPPI TYPE	TOIMINTA FUNCTION	Max. rpm. / Hz	VDC
C1	DC DC	Jännitteen syöttö Power supply		24 V 420mA
C2	n_{DE}	Mittausmuunnin Measuring converter	-22- 1500/950 -32- 1000/417	± 10V DC max. 15mA ± 10V DC max. 15mA
C3	n_{1DE}, n_{2DE}, n_{3DE}	Relekortti Relay card		
C4	n_{TC}	Mittausmuunnin Measuring converter	-22- 50000/5000 -32- 30000/3000	± 10V DC max. 15mA ± 10V DC max. 15mA

ALTER	DATE	CHKD	EXPLANATION
a	22 12 83	MHn	Frekv. output changed

WÄRTSILÄ
VASA FACTORY
VASA-FINLAND

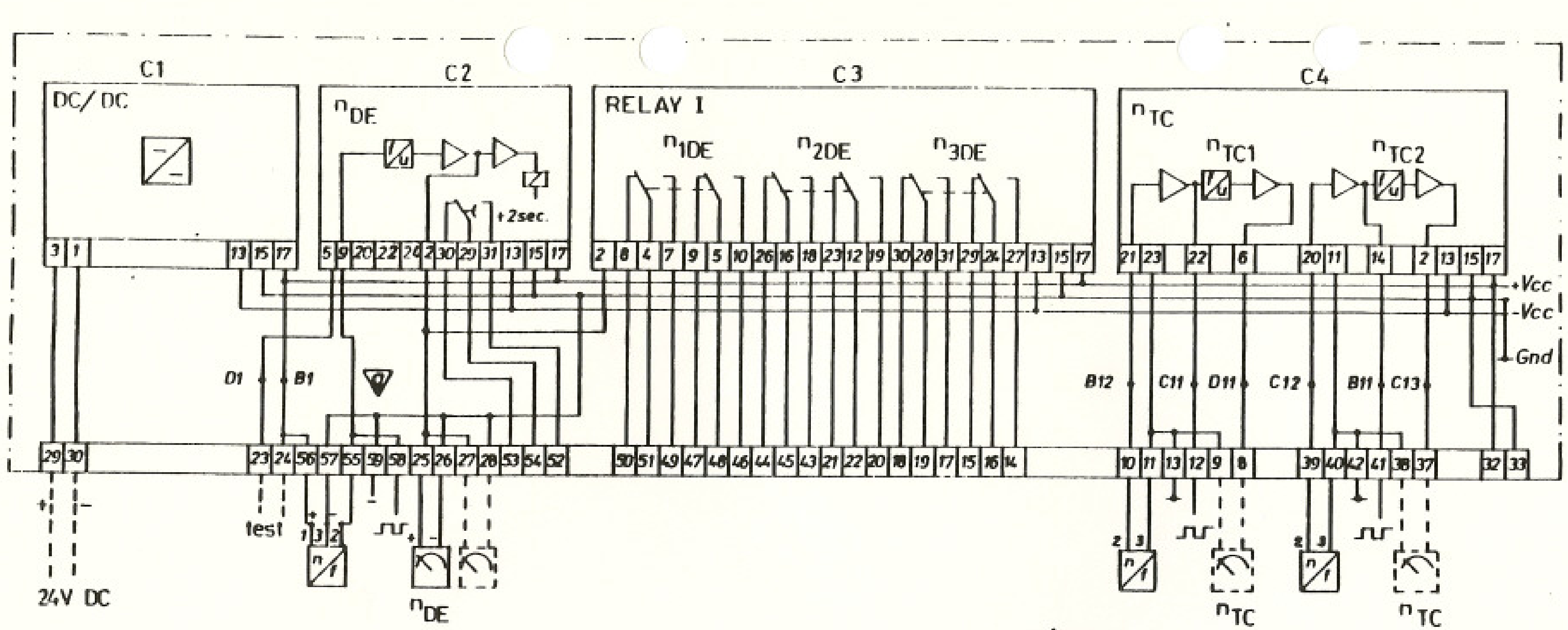
DESPEMES kierroslukumittausjärjestelmä
DESPEMES speed measuring system

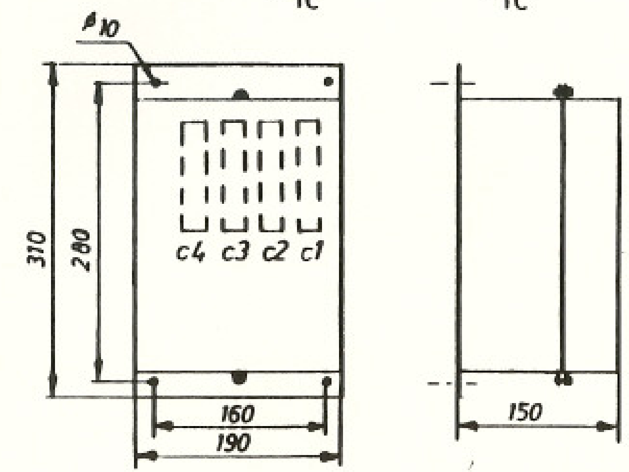
Drwn 5.7.82 RKa
Chkd
Appd

Type R22, R32

4V50L976 a

4V50L976





Main dimensions in mm.

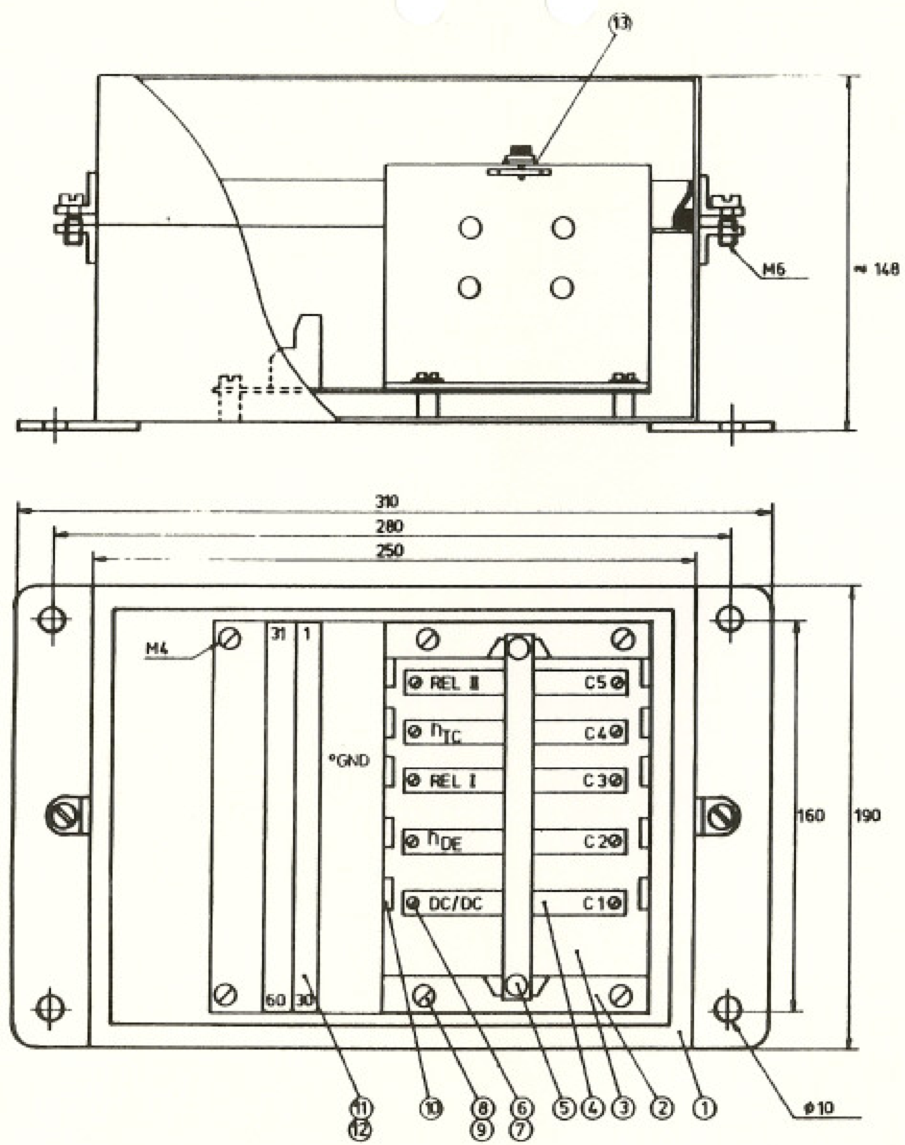
a Valid for 0V72H73 rev. 2

POS.	TYYPPI TYPE	TOIMINTA FUNCTION	Max. rpm / Hz	V DC
C1	DC DC	Jännitteen syöttö Power supply		24 V 420 mA
C2	n_{DE}	Mittausmuunnin Measuring converter	-22- 1500/950 ± 10V DC max. 15mA -32- 1000/417 ± 10V DC max. 15mA	
C3	n_{1DE}, n_{2DE}, n_{3DE}	Relekortti Relay card		
C4	n_{TC1}, n_{TC2}	Mittausmuunnin Measuring converter	-22- 50000/5000 ± 10V DC max. 15mA -32- 30000/3000 ± 10V DC max. 15mA	

ALTER	DATE	CHKD	MEMO NR	EXPLANATION
a	22 12 83	MHn		Frekv. output changed

WÄRTSILÄ VASA FACTORY VASA-FINLAND	DESPEMES kierroslukumittausjärjestelmä DESPEMES speed measuring system	Drwn.	5.7.82	RBa
		Chkd.		
		Appd		
	Type V22, V32	4V50L977 a		

4V50L977



Pos	Nimitys	Description	Piir/Tyyppi Dwg/Type	Mater. no Code	Määrä Qty
13	Kumiliuska	Rubber strip	3×12×130	333-014-8	1
12	Numeroliuska	Terminal number strip	Phönix 1401213	765-052-5	1
11	Riviliitin	Terminals	Phönix - MKKDS 3	719-023-6	10
10	Korttiohjain	Card support	Unitrack Calabro-PT2500-38	753-068-3	5
9	Prikka	Washer	M 4 DIN 125 ST	484-068-2	6
8	Uraruuvi	Screw	M 4×10 DIN 84 5,8 gal Znbk	411-092-7	6
7	Mutteri	Nut	M 2,5 DIN 934 m8	452-077-5	10
6	Uraruuvi	Screw	M 2,5×15 DIN 84 5,8 gal Znbk	411-101-2	10
5	Peukaloruuvi	Thumb screw	Akaset - H2.423.7 M 3×15	449-009-4	2
4	Korttiliitin	Card contact	Contact - GSW 31FE	756-012-7	5
3	Emälevy	Mother board	0V72H73	737-024-5	1
2	Peltikehikko	Steel rack	3V72H71	753-066-9	1
1	Peltikotelo	Steel housing	3V72H78	753-067-6	1

Kpl	Osa no	Aineen koodi	Malli no, ainepiir., ainemitat, ostotun tai normiosan merkintä	Normi tai piirustus	Aineen laatu ja toimitustila	Ainenormi	Raaka-paino	Valmis paino

Yleistoleranssit DIN 7168		
Nimellismitta Yli	Enint.	Toleranssit
0,5	3	±
3	6	±
6	30	±
30	120	±
120	315	±
315	1000	±

Tark	Pvm	D:no	Muutos

WÄRTSILÄ
VAASAN TEHDAS
VAASA · FINLAND

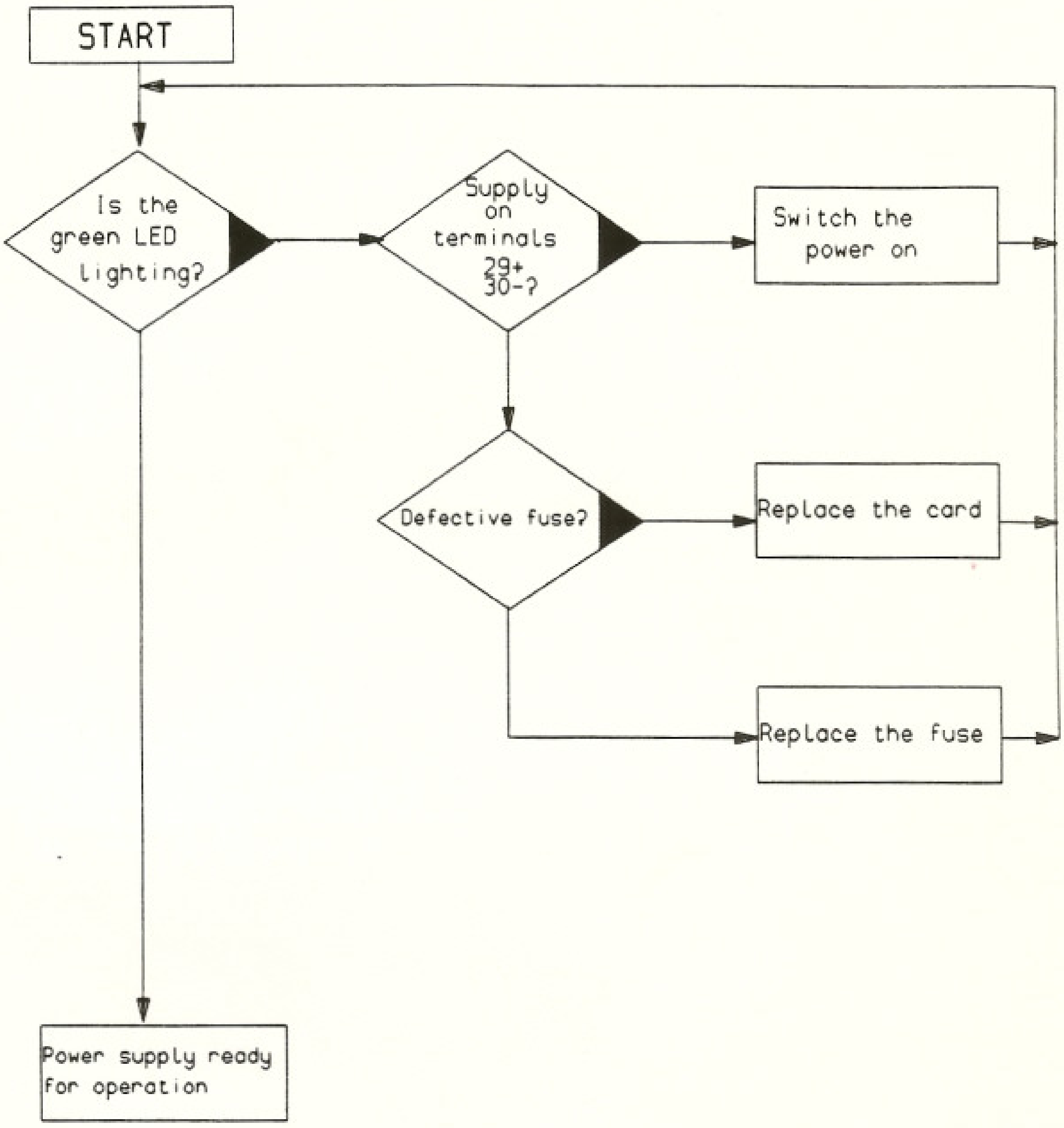
DESPEMES
Kierroslukumittausjärjestelmä, Speed measuring system
Kokoonpanopiirustus Outline drawning

D E S R
Piirt. 800123
Tark. 800128 HB
Hyv.

Korvaa:
Korvattu:
Tyyppi
Kok. p. piir.
Suhde: 1:2
3V72H83

6. TROUBLE SHOOTING PROCEDURES

6.1 Power supply DC/DC



Operating voltage:

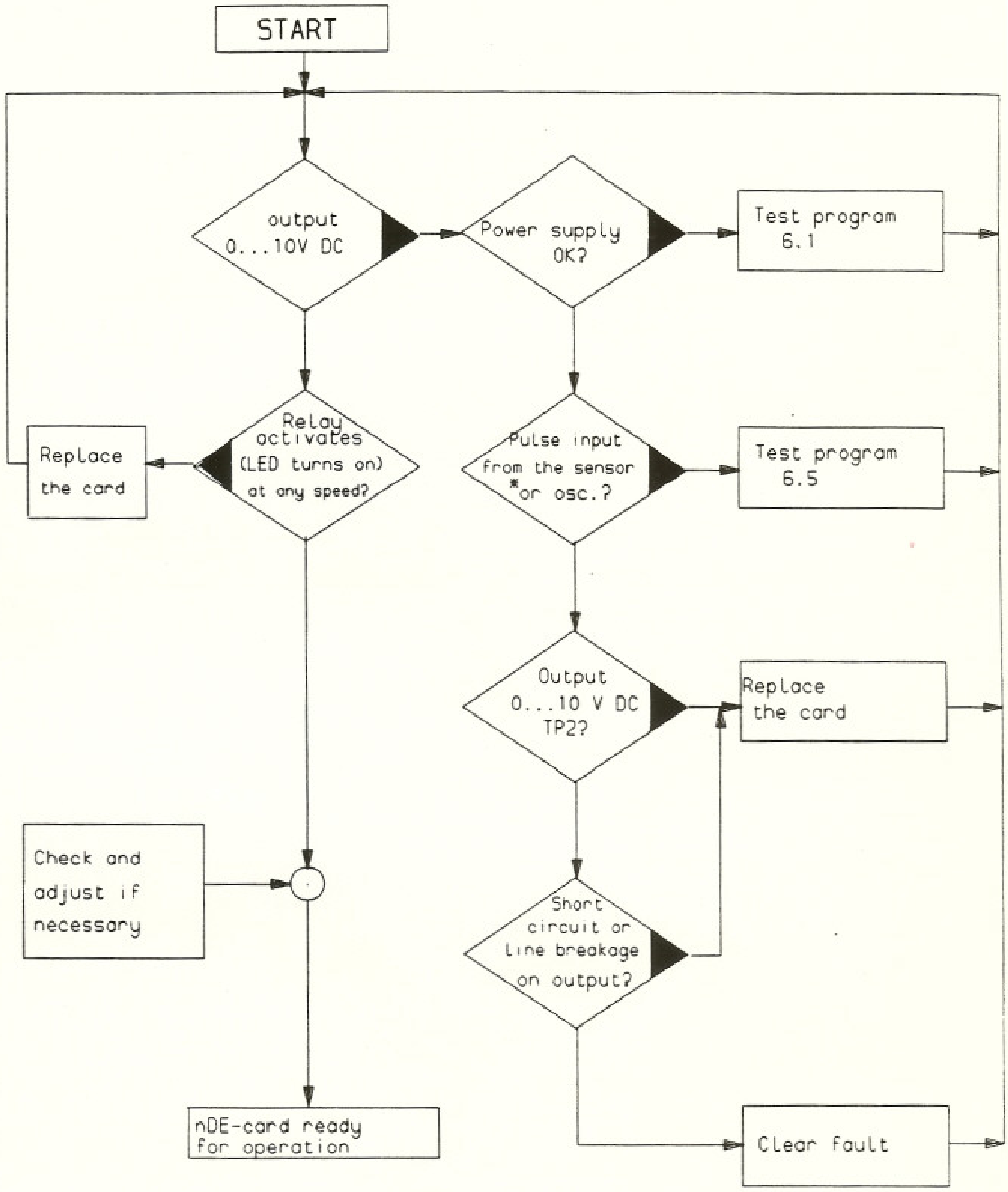
(+)	Terminal 29,	card connector 3.
(-)	Terminal 30,	card connector 1.

Output:

+12V	Terminal 24,	card connector 17
COM	Terminal 26,	card connector 15.
-12V		card connector 13.

ES PT FR SU D GB FI SE

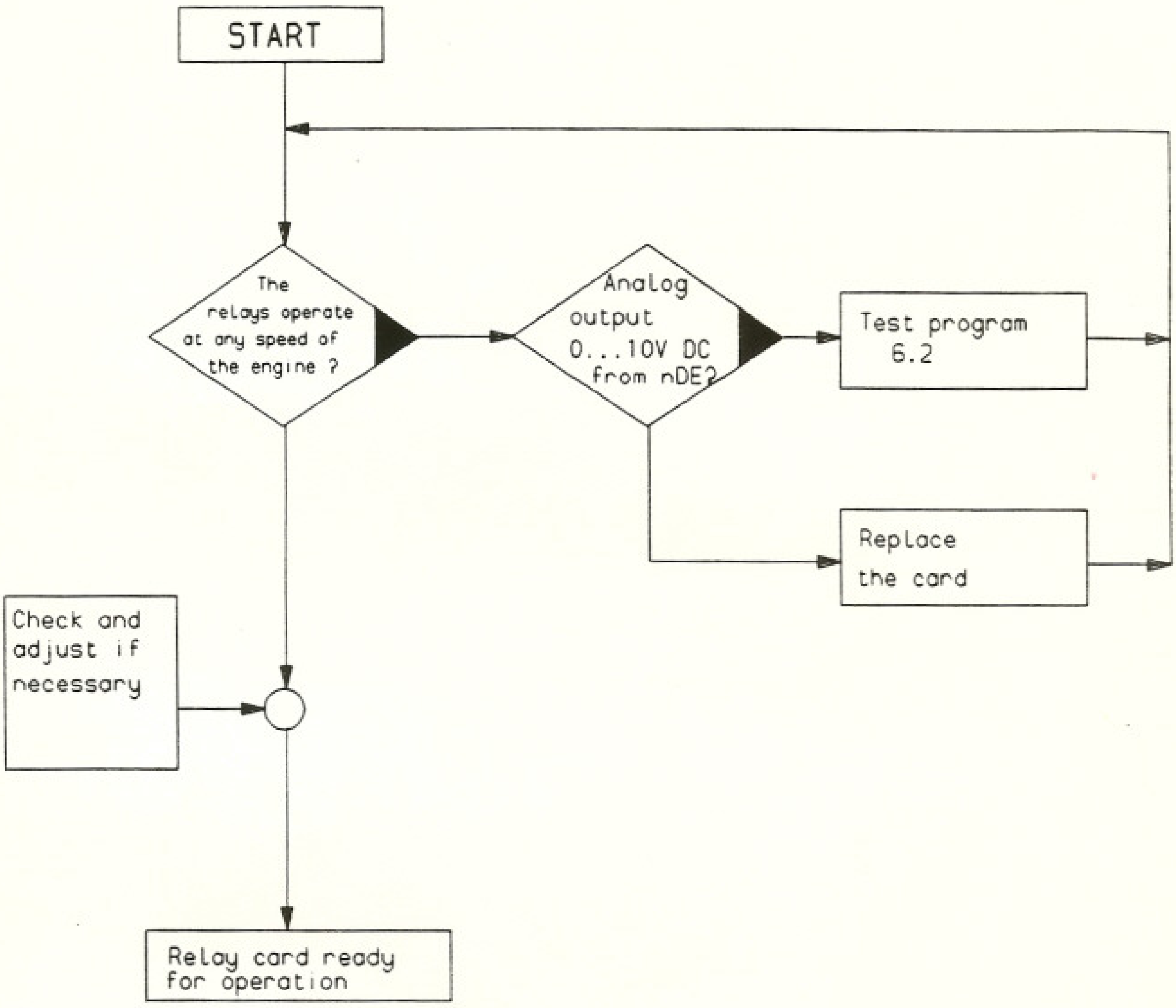
6.2 nDE-measuring converter with relay function



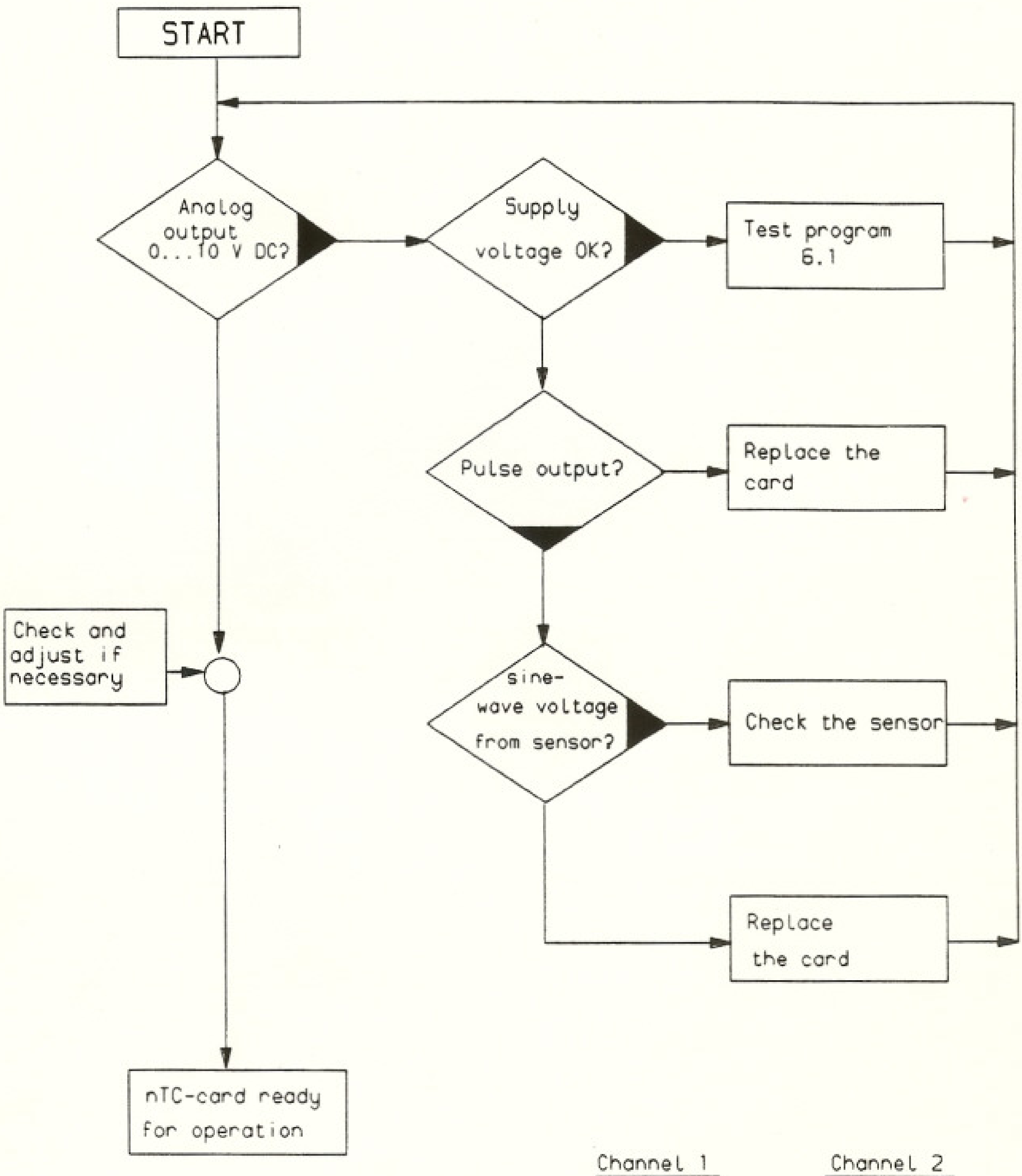
Frequency in:	Terminal	55 (+),	card connector	19.
	-"-	57 (-),	-"- -"-	15
Measuring voltage:	-"-	25 (+),	-"- -"-	2,
	-"-	26 (-),	-"- -"-	15,
Pulse output:	-"-	58 (+)		
	-"-	59 (-)		

* V-meter reading: Sensor about 5,8V DC. Osc. about 4,2V DC.

6.3 Relay card

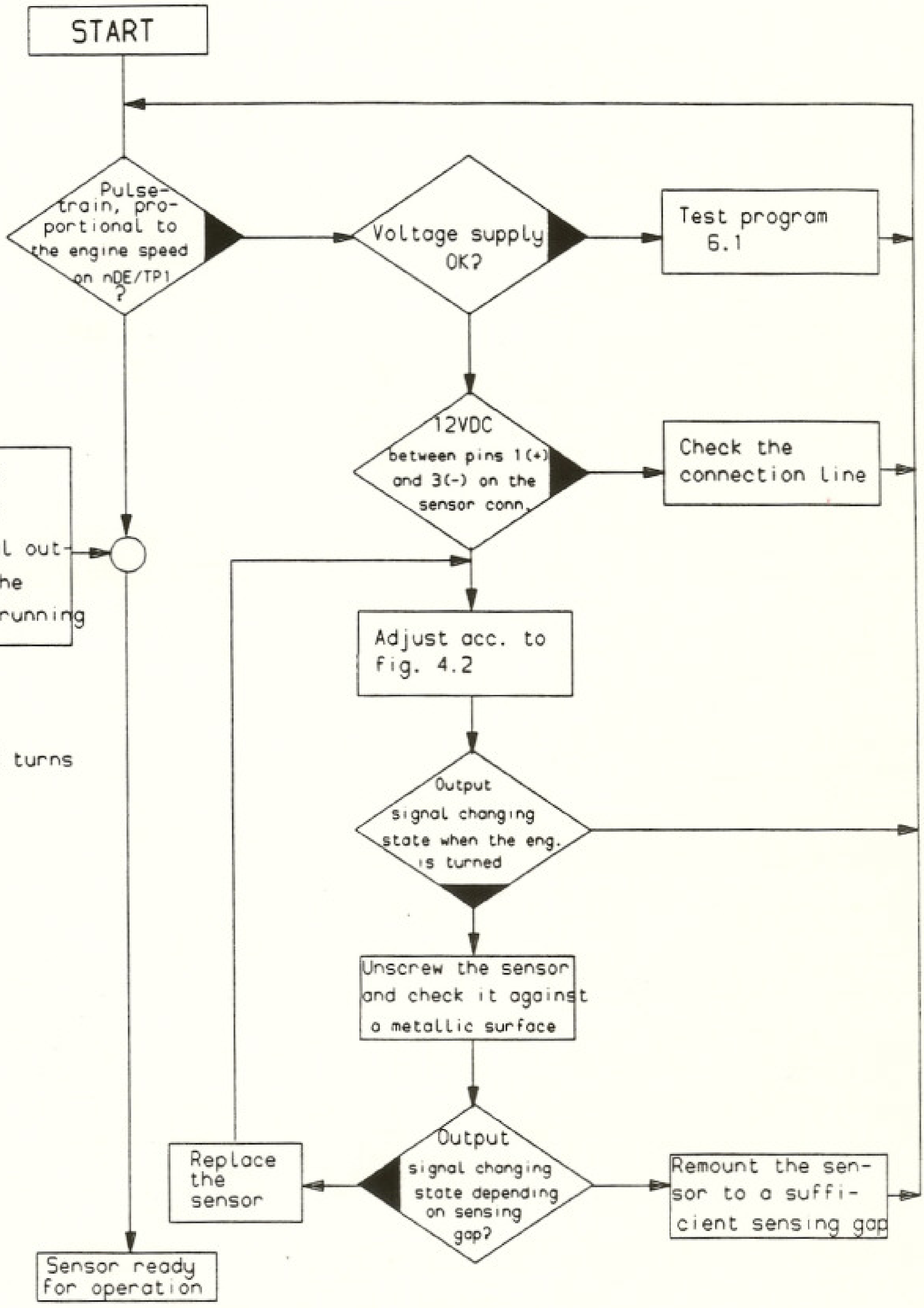


6.4 nTC-measuring converter with 2 channels



		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

6.5 Engine speed sensor



NOTE!

Max ± 0,25 turns

ATTACHMENTS

Operating instructions for:

- [x] Oil chart
- [x] Judgement of bearing condition
- [ ] Vibration damper
- [ ] Vibration coupling
- [x] Turbocharger
- [x] Pumps
- [ ] Starting motor
- [x] Speed control devices (Governor etc.)
- [ ] Oil mist detector
- [ ]
- [ ]
- [ ]
- [ ]

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OPERATING INSTRUCTIONS

Engine	Section	Engine type	Ref.	Date	Issue	Document no.
02	LUBE OIL	22	HSs	07.11.1990	04	2202Q005GB

Introduction

The purpose of this bulletin is to inform the users of the diesel engine Wärtsilä Vasa 22 about the approved lubricating oil products. The recommended intervals between changes for respective oils and lubricants are also given. The following factors should be noted when maintaining the lubricating oil (see also sections 02, 04 and 18 in the instruction manual).

Lubricating oil for the engine (table A)

— Take samples for analysis after the first 1000 operating hours. After that the change intervals are prolonged in stages of 500 hours on the basis of the analysing values if this is recommended by the oil supplier or the engine manufacturer.

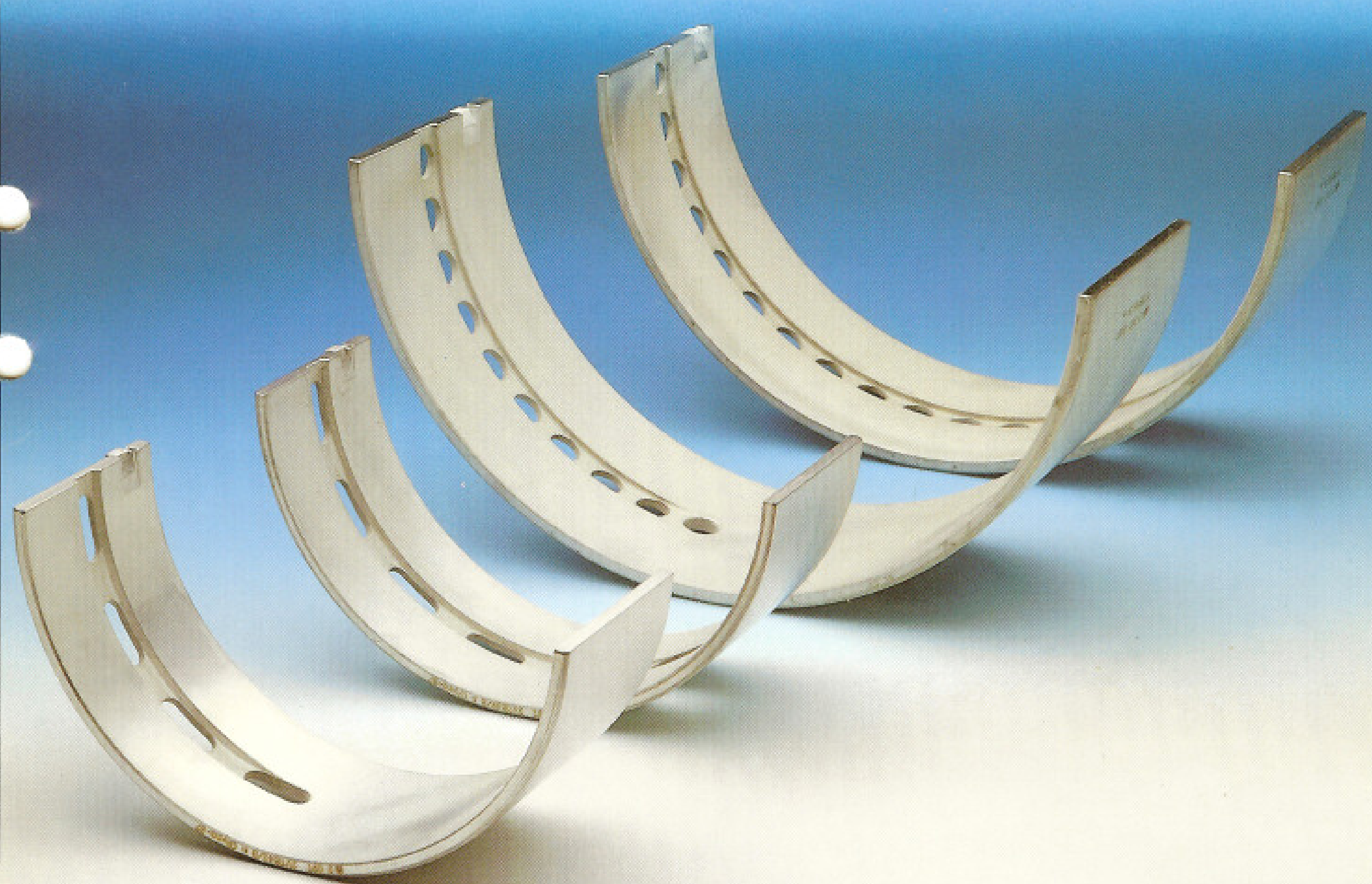
— When separating the lubricating oil, use max. 20% of the nominal flow of the separator.

— Use only filter types approved by the engine manufacturer.

— Change the lubricating oil filter if the differential pressure indicator gives alarm. Remember to clean the filter housing carefully before changing.

— Clean the centrifugal filter regularly. The cleaning intervals vary according to the operating conditions and they have to be shortened if the filter has collected the maximum quantity of dirt (about 40 mm thick deposit). The filter is less efficient when deposits grow thick.

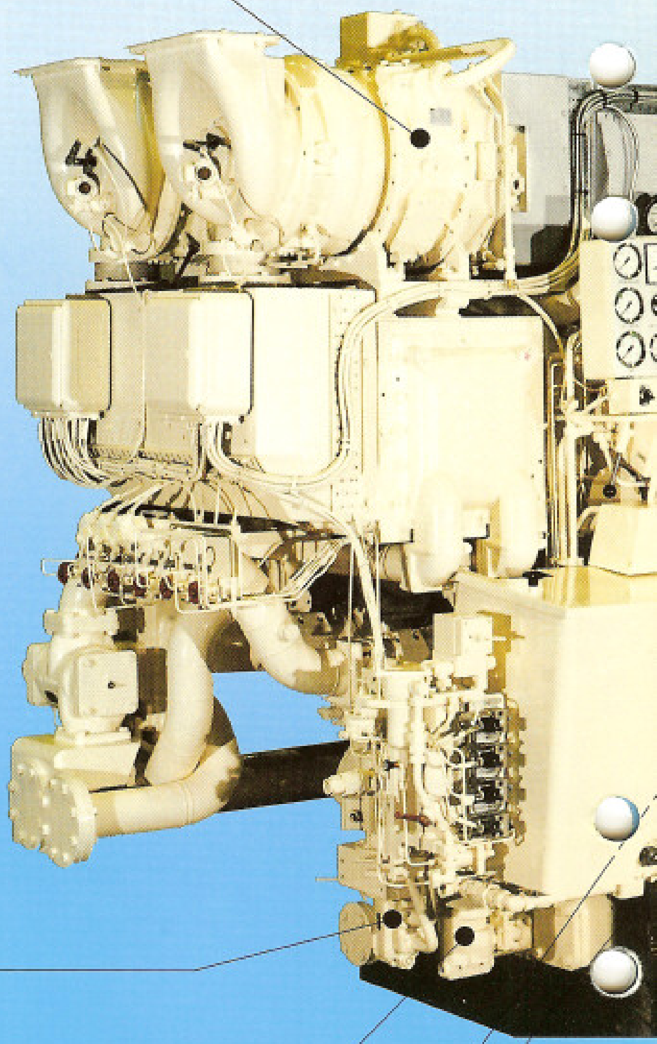
— Always observe utmost cleanliness when maintaining the lubricating oil system.



THE WÄRTSILÄ

Turbocharger

Type	Volume c.litres	Quality	Oil	Oil change interval
VTR 161	2.8	See table B	See table B	500 h
VTR 201	0.9			
VTR 184	1.1			
VTR 214	1.5			
VTR 251	1.7			
Napier NA 155	—	Connected to the lubricating oil system of the engine		
TCU NR 15/R	—	Connected to the lubricating oil system of the engine		
TCU NR 20/R	—	Connected to the lubricating oil system of the engine		



Electrically operated prelubricating oil pump

Amount	Grease	First time of regreasing	Regreasing interval
10 gr	See table C	After one hour of operation	1 000 h

Electrically operated fuel feed pump

Amount	Grease	First time of regreasing	Regreasing interval
5 gr	Kluber Unisilikon L 50/2	After one hour of operation	1 000 h

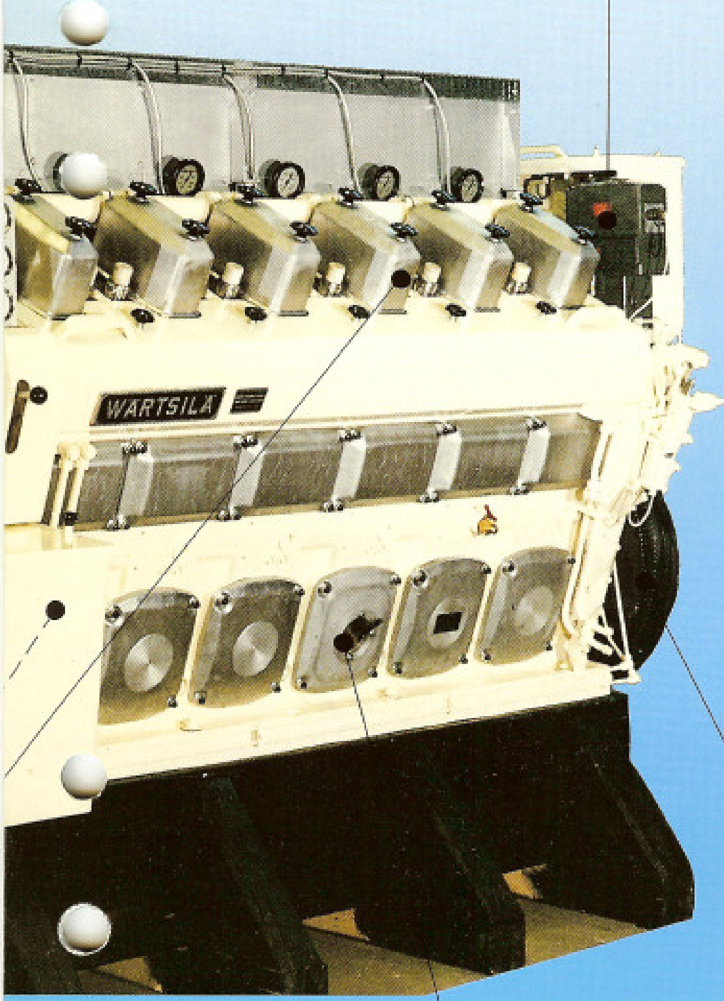
Fuel nozzle temperature control system (HF only)

Volume	Oil	Oil change interval
100—300 l	Same oil quality as in the engine	8 000 h

VASA 22 ENGINE

Governor

Type	Volume	Oil	Oil change interval
Woodward	~1.4—2 l	The same oil quality as in the engine or as in the turbocharger	1 000 h
Regulateurs Europa	1.4 l		



Pneumatically operated starting motor (4R22 only)

Volume	Oil	Interval
0.2 l	See table D	Check regularly that the oil level in the lubricator is between the max. and min. values

Engine

Type	Volume (wet sump)	Quality	Oil	Oil change interval
4R22	320 l	(SAE 30) SAE 40	See table A	2 000 h*
6R22	450 l			
8R22	580 l			
8V22	580 l			
12V22	670 l			
16V22	870 l			

* Guidance value

Document No 2202 Q 0050 GB Mainostoimisto 3P Oy/Erik Martin Ky. Printed in Finland

Table A. Approved system oils — all fuel categories — for Wärtsilä Vasa engines

Lubricating oil supplier	Designation (brand name) of lubricating oil supplier	Visc.	TBN
Agip	Cladium 350 SAE 30 Cladium 350 SAE 40	SAE 30 SAE 40	35 35
BP	Energol IC HF 303 Energol IC HF 304 Energol IC HF 404	SAE 30 SAE 40 SAE 40	30 30 40
Caltex	RPM DELO 3000 Marine Oil 30 RPM DELO 3000 Marine oil 40	SAE 30 SAE 40	30 30
Castrol	MXD 303 MXD 304 MXD 403 MXD 404	SAE 30 SAE 40 SAE 30 SAE 40	30 30 40 40
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
Compagnie Francaise de Raffinage	Total HMA SAE 30	SAE 30	30
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
Elf	Aurelia XT 4040 Aurelia XT 3040 Aurelia 3030 Aurelia 4030	SAE 40 SAE 30 SAE 30 SAE 40	40 40 30 30
Indian Oil Company (IOC)	Servo Marine C-303 Servo Marine C-304 Servo Marine C-403 Servo Marine C-404	SAE 30 SAE 40 SAE 30 SAE 40	30 30 40 40
Mobil	Mobilgard 342 Mobilgard 442 Mobilgard 324 Mobilgard 424	SAE 30 SAE 40 SAE 30 SAE 40	40 40 30 30
Neste	NST 30 NST 40	SAE 30 SAE 40	30 30
Norol	Marine HA 303 Marine HA 304 Marine HA 404	SAE 30 SAE 40 SAE 40	30 30 40
Olje-Energi	Goth Oil 325	SAE 30	25
Petrobras	Marbrax CCD-330 Marbrax CCD-430 Marbrax CCD-340 Marbrax CCD-440	SAE 30 SAE 40 SAE 30 SAE 40	30 30 40 40
Petrofina, IMOD	Stellano 330 Stellano 430	SAE 30 SAE 40	30 30
Phillips Oil Trading Ltd	Marine SR 30 Marine SR 40	SAE 30 SAE 40	30 30
Shell	Argina T Oil 30 Argina T Oil 40 Argina X Oil 40	SAE 30 SAE 40 SAE 40	30 30 40
Teboil	Teboil Ward S 30T SAE 30 Teboil Ward S 30T SAE 40	SAE 30 SAE 40	30 30
Texaco	Taro DP 30 Taro DP 40 Taro XL 40	SAE 30 SAE 40 SAE 40	32 32 42

In case of destillate fuels, additional lubricants may be considered. For further information contact Diesel Laboratory at Vasa Factory.

Table B. Oils for turbocharger

Manufacturer	ISO viscosity class (at 40°C)
Antar	Misola H 68
British Petroleum	BP THB 68 BP THB 77
Castrol	Perfekto T 68 Perfekto T 100
Chevron	Chevron GST Oil 68 Chevron GST Oil 100
Gulf	Harmony Gulfcrest 68
Esso	Esso Tro-Mar T 68 Esso Tro-Mar T 77
Mobil	Mobil Rarus 427 Mobil DTE Oil Heavy Medium 68 Mobil DTE Oil Heavy 82
Shell	Turbo Oil T 68 Turbo Oil T 78 Turbo Oil T 100
Texaco, Caltex	Regal Oil PC 68 R&O Regal Oil PE 100 R&O
Total	Total Preslia 40 (68) Total Preslia 50 (68)

Table C. Grease for prelubricating oil pump

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

Table D. Lubricating oils for pneumatic starting motor

Gali HI 33 EP
Shell Turbo 27
Castrol Hyspin 80
BP Energol HLP 100
Mobil Detergent Light
Esso Nuto H44

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