L28/32H
Instruction Manual - Marine

Four-stroke GenSet
compliant with IMO Tier II

Engineering the Future – since 1758.

MAN Diesel & Turbo

Complete manual
date 2012.07.17

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Engine data

500/600

Instruction Manual for:

MAN Diesel & Turbo Identification No. for Instruction Manual.

Identification No. for Description: **000 . 00**

- Function
- Section No.

Identification No. for Working Card: **000 - 00 . 00**

- Sub-function
- Function
- Section No.

Identification No. for Plates: **00000 - 00 H**

- H for Holeby
- Edition
- Section No. and Function

For ordering of spare parts, see page 500.50 / 600.50

All data provided in this document/manual is non-binding. This data serves informational purposes only and is especially not guaranteed in any way.

Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

If this document/manual is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail.

Original instructions

MAN Diesel & Turbo | PrimeServ
The MAN Diesel & Turbo Group offers worldwide round-the-clock service, 365 days a year. Apart from the MAN Diesel & Turbo service headquarters in Augsburg, Copenhagen, Frederikshavn, Holeby, Stockport, St. Nazaire, Turbocharger and service centres on all continents provide comprehensive and continuous support. The long service life associated with MAN Diesel engines dictates a spare parts programme that ensures components are available for engines in operation for decades. Based on high-capacity machines, MAN Diesel & Turbo service production facilities are able to comply with special customer requests with the utmost precision and flexibility.

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Description Page 1 (1)	Warning	

General

Warning !

(Marine engines only)

It is important that all MAN Diesel & Turbo engines are operated within the given specifications and performance tolerances specified in the engines' Technical Files and are maintained according to the MAN Diesel & Turbo maintenance instructions in order to comply with given emissions regulations.

In accordance with Chapter I of the Code of Federal Regulations, Part 94, Subpart C, §94.211 NOTICE is hereby given that Chapter I of the Code of Federal Regulations, Part 94, Subpart K, §94.1004 requires that the emissions related maintenance of the diesel engine shall be performed as specified in MAN Diesel & Turbo instructions including, but not limited to, the instructions to that effect included in the Technical File.

Your opinion counts!

Your opinion is valuable to us as it helps us to evaluate our services and to continuously improve the quality of our Technical Documentation.
May we ask you for a few minutes of your time to complete and then return this questionnaire to TechDoc@mandieselturbo.com:

Your company: Your position:	Very satisfied	Rather Satisfied	Rather dissatisfied	Very dissatisfied
How do you rate the overall level of satisfaction with the manuals supplied?	☐	☐	☐	☐
Which improvements would you suggest to be made in the future?				
Ring binders and organisation	☐	☐	☐	☐
Comments/suggestions:				
Labelling of ring binders	☐	☐	☐	☐
Comments/suggestions:				
Structuring of information and documents	☐	☐	☐	☐
Comments/suggestions:				
Access aids (contents page, index, register, etc.)	☐	☐	☐	☐
Comments/suggestions:				
Preparation of CDs/DVDs (navigation, etc.)	☐	☐	☐	☐
Comments/suggestions:				
Readability of texts and drawings (paper, CD/DVD)	☐	☐	☐	☐
Comments/suggestions:				
Comprehensibility of contents	☐	☐	☐	☐
Comments/suggestions:				
Scope of information provided	☐	☐	☐	☐
Comments/suggestions:				

Your opinion counts!

Customer satisfaction

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Cycle	:	**4-stroke**
Configuration	:	**In-line**
Cyl. Nos. available	:	**5-6-7-8-9**
Power range	:	**1050-1980 kW**
Speed	:	**720/750 rpm**
Bore	:	**280 mm**
Stroke	:	**320 mm**
Stroke/bore ratio	:	**1.14:1**
Piston area per cyl.	:	**616 cm²**
Swept volume per cyl.	:	**19.7 ltr.**
Compression ratio	:	**13.9:1**
Max. combustion pressure	:	**130 bar**
Turbocharging principle	:	**Constant pressure system and intercooling**
Fuel quality acceptance	:	**HFO (up to 700 cSt/50° C, RMK700) MDO (DMB) - MGO (DMA, DMZ) according ISO8217-2010**

Power lay-out		MCR version	
Speed	rpm	720	750
Mean piston speed	m/sec.	7.7	8.0
Mean effective pressure	bar	17.8	17.9
Max. combustion pressure	bar	130	130
Power per cylinder	kW/cyl.	210	220

Overload rating (up to 10%) allowable in 1 hour for every 12 hours			
Power per cylinder	kW/cyl.	230	240

General

Introduction

This instruction book provides general information on the engine design, operation and maintenance. It can also be used as a reference when ordering spare parts. Reliable and economical operation of the plant is conditional upon its correct operation and maintenance in accordance with MAN Diesel & Turbo's instructions. Emissions-related maintenance of the diesel engine shall be performed as specified in MAN Diesel & Turbo's instructions and any additional instructions to that effect included in the Technical File. Consequently, it is essential that the engine room personnel are fully acquainted with the contents of this book and the Technical File.

Every care is taken to ensure that all information in this instruction book is present and correct.

If an instruction book is delivered in another language than English and doubts arise concerning the translation, the English text shall prevail.

Description

The book is a basic instruction manual for the particular engine supplied, with plant-adapted information such as basic media-system drawings, electrical wiring diagrams and test bed reports.

The first five sections (500-504) of the book serve as a guide to engine operation, and the next fifteen sections (505-519) contain technical descriptions, spare parts illustrations with appurtenant parts lists, as well as working cards.

The last section (520) comprises tools.

The engine is divided into a number of main components/assemblies, each of which is described in a section of this book (section 505-519).

Each of these sections starts with technical descriptions of the systems/components, followed by working cards and the spare parts illustration plates and parts lists.

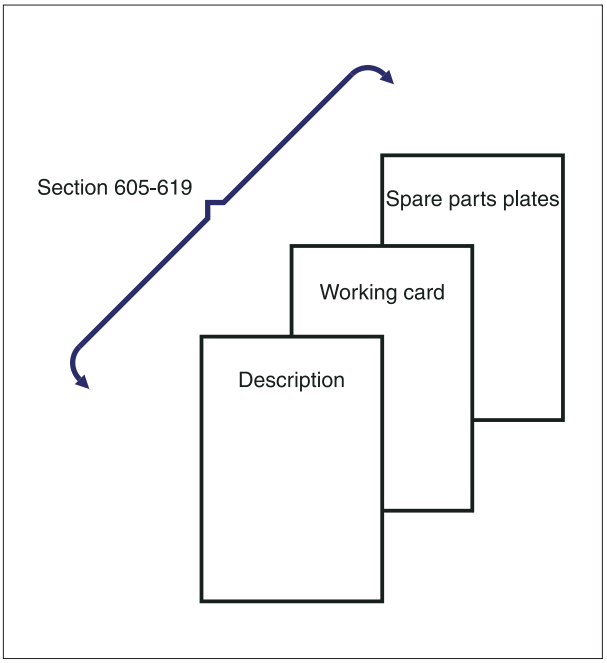

Fig. 1. Structuring of instruction book.

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General

General

Proper maintenance, which is the aim of this book, constitutes the crucial point in obtaining optimum safety in the engine room. The general measures mentioned here should therefore be a natural routine to the entire engine room staff.

Cleanliness

The engine room should be kept clean above and below the floor plates. If grit or sand blows into the engine room when the ship is in port, the ventilation should be stopped and ventilating ducts, skylights, and doors in the engine room should be closed.

In particular, welding or work which causes spreading of grit and chips must be avoided near the engine, unless this is closed or covered, and the turbocharger air intake filters are covered.

The exterior of the engine should be kept clean and the paintwork maintained so that leakages can easily be detected.

Fire

If the crankcase is opened before the engine is cold, welding and the use of naked light will involve the risk of explosions and fire. The same applies to inspection of oil tanks and the space below the fooler. Attention is furthermore drawn to the danger of fire when using paint and solvents with a low flash point. Porous insulating material drenched with oil from leakages is easily inflammable and should be renewed. See also: "Ignition in crankcase" in section 603.

Order

Hand tools should be placed easily accessible on tool boards. Special tools should be fastened to tool panels (if supplied) in the engine room close to the area of application. No major objects must be left unfastened, and the floor and passages should be kept clear.

Spares

Large spare parts should, as far as possible, be placed well strapped near the area of application and accessible by crane. The spare parts should be well preserved against corrosion and protected against mechanical damage. The stock should be checked at intervals and replenished in time.

Light

Ample working light should be permanently installed at appropriate places in the engine room, and portable working light, in explosion-proof fittings, should be obtainable everywhere.

Freezing

If there is a risk of damage due to freezing when the plant is out of service, engines, pumps, coolers, and pipe systems should be emptied of cooling water.

Warning

The opening of cocks may cause discharge of hot liquids or gases. The dismantling of parts may cause springs to be released.

The removal of fuel valves (or other valves in the cylinder head) may cause oil to run down to the piston crown, and if the piston is hot, an explosion may then blow out the valve.

When testing fuel valves with the hand pump, do not touch the spray holes, as the jet may pierce the skin. Think out beforehand which way the liquids, gases or flames will move, and keep clear.

Crankcase work

Check beforehand that the starting air supply to the engine is shut off.

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General

Feeling over

Whenever repairs or alterations have been made to the running gear, apply the "Feel-over sequence" until ensured that there is no undue heating, oil-mist formation, blow-by, or failure of cooling water or lubricating oil systems.

Feel-over sequence

Feel-over after 5-15 and 30 minutes' idle running and finally when the engine is running at full load. See also "Starting-up sequence" in the section 602.

Turning with air

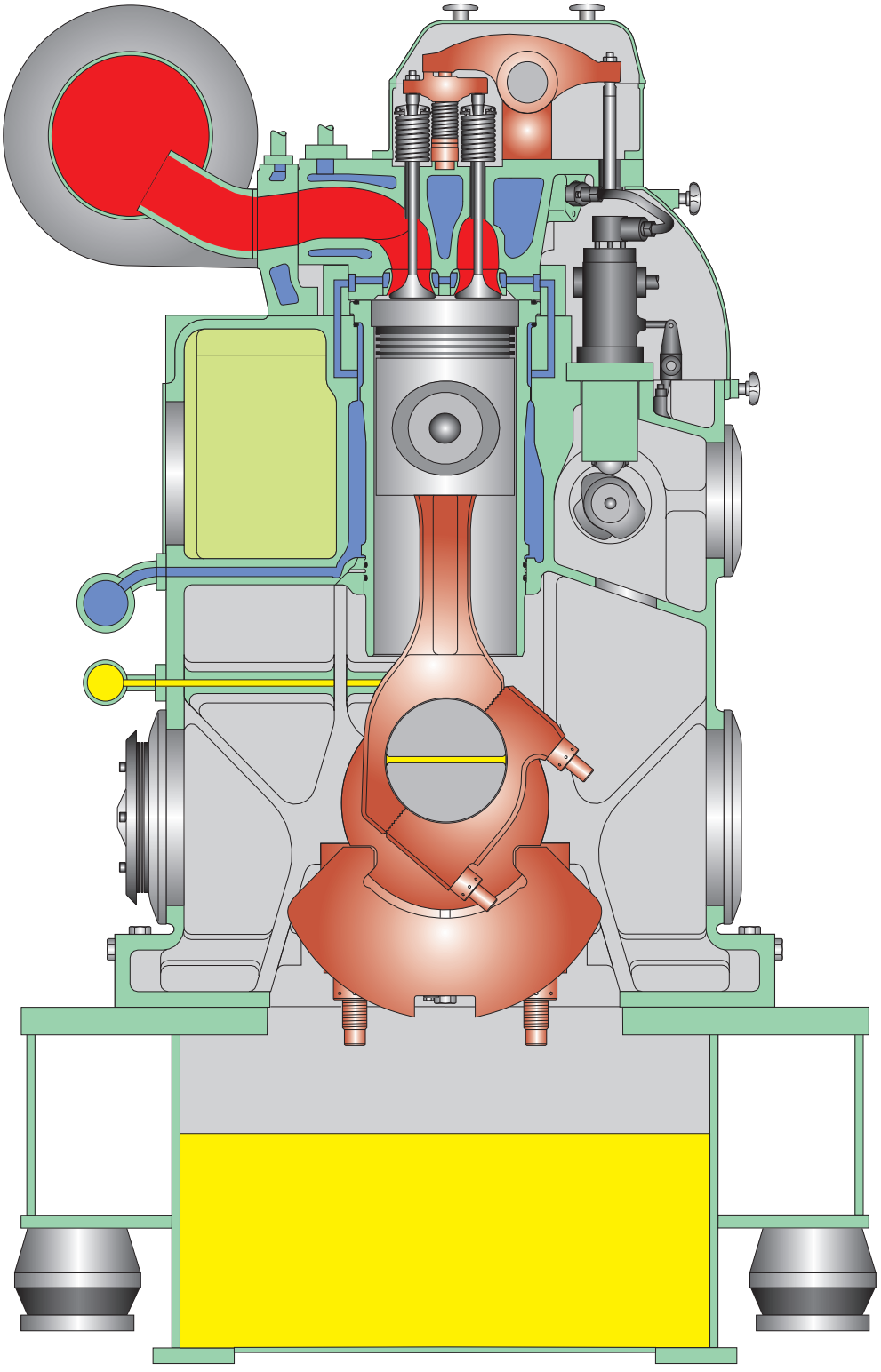
After prolonged out-of-service periods or overhaul work which may involve a risk of accumulation of liquid in the combustion spaces, turning with open indicator cocks should always be effected, through at least two complete revolutions.

Check and maintain

Lubricating oil condition, filter elements and measuring equipment.

Description Page 1 (1)	Cross Section	600.05 Edition 07H

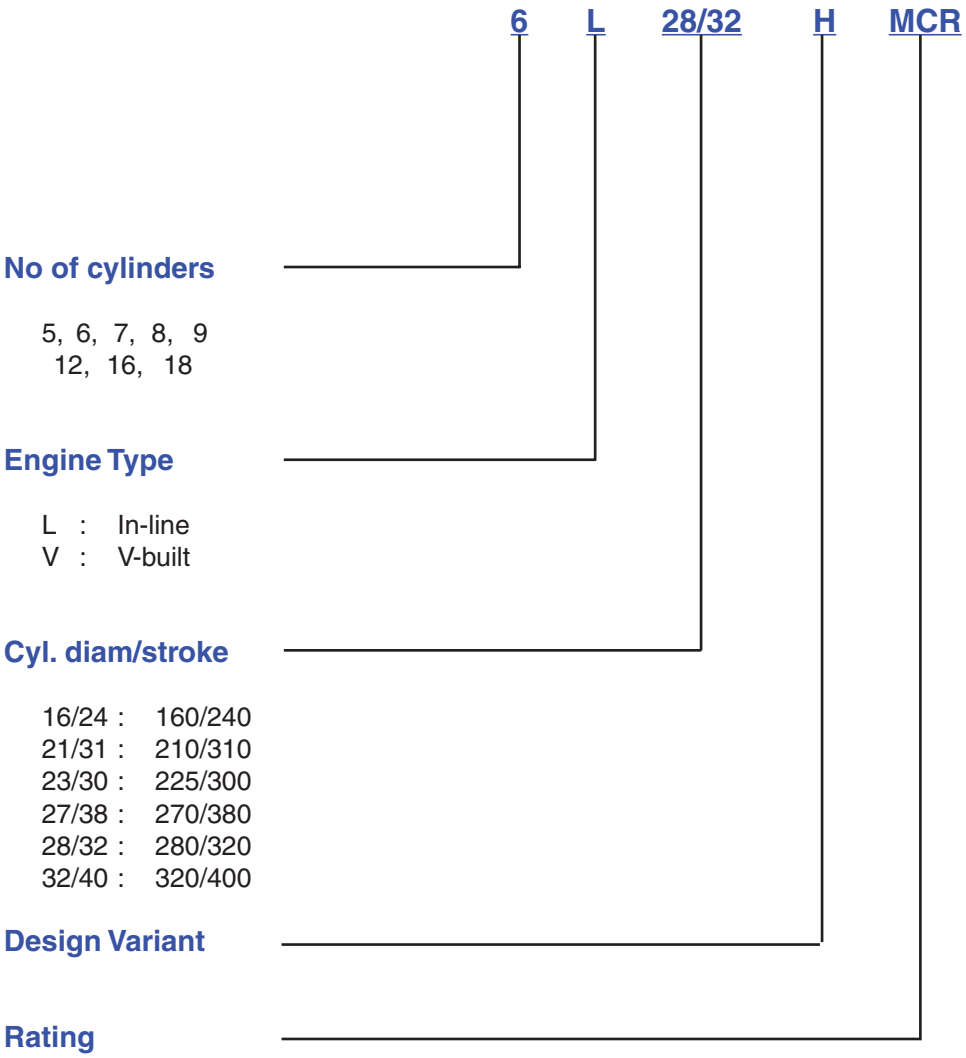
L28/32H



General

Engine Type Identification

The engine types of the MAN B&W programme are identified by the following figures:



No of cylinders

5, 6, 7, 8, 9
12, 16, 18

Engine Type

L : In-line
V : V-built

Cyl. diam/stroke

16/24 : 160/240
21/31 : 210/310
23/30 : 225/300
27/38 : 270/380
28/32 : 280/320
32/40 : 320/400

Design Variant

Rating

MCR : Maximum continuous rating
ECR : Economy continuous rating

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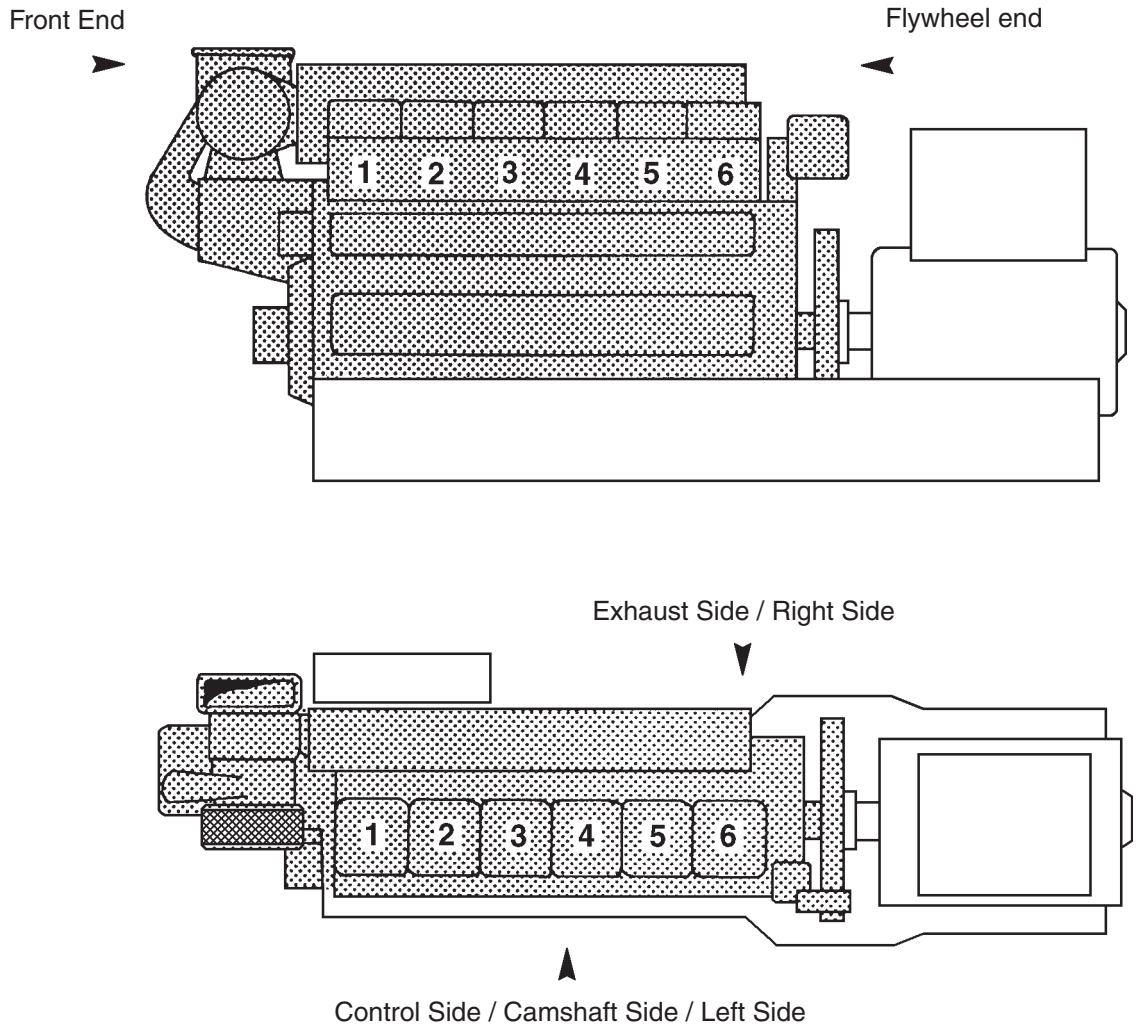
Description Page 1 (1)	**Designation of Cylinders**	**600.11** Edition 01H

L28/32H



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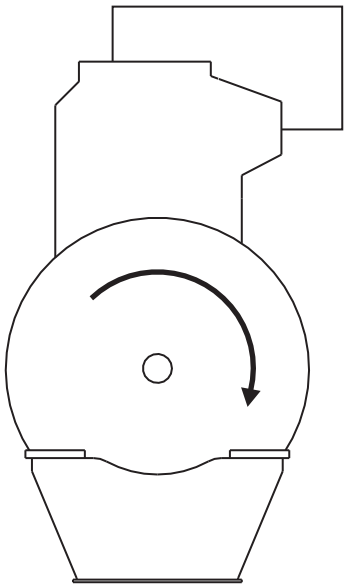
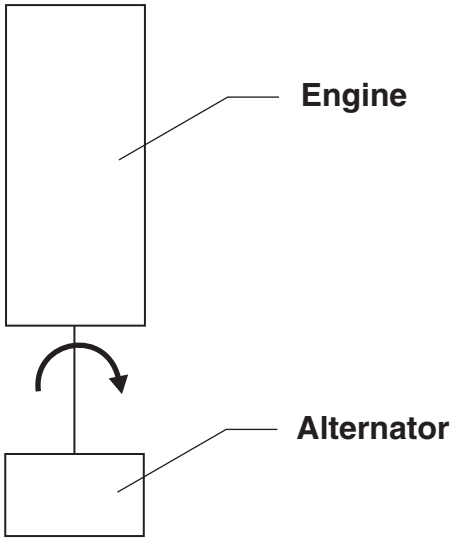
Description Page 1 (1)	Engine Rotation Clockwise	600.12 Edition 02H

General



Direction of rotation seen from flywheel end “Clockwise”

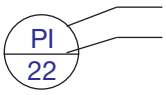


General

Explanation of Symbols

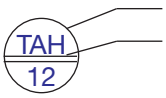
Measuring device
Local reading

Temperature **I**ndicator
No. 40 *



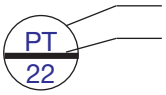
Measuring device
Sensor mounted on engine/unit
Reading/identification mounted in a panel on the engine/unit

Pressure **I**ndicator
No. 22 *



Measuring device
Sensor mounted on engine/unit
Reading/identification outside the engine/unit

Temperature **A**larm **H**igh
No. 12 *



Measureing device
Sensor mounted on engine/unit
Reading/identification in a panel on the engine/unit and reading/indication outside the engine/unit

Pressure **T**ransmitting
No. 22 *

* Refer to standard location and text for instruments on the following pages.

Specification of letter code for measuring devices			
1st letter		Following letters	
F	Flow	A	Alarm
L	Level	D	Differential
P	Pressure	E	Element
S	Speed, System	H	High
T	Temperature	I	Indicating
U	Voltage	L	Low
V	Viscosity	S	Switching, Stop
X	Sound	T	Transmitting
Z	Position	X	Failure
		V	Valve, Atuator

General

Standard Text for Instruments

Diesel Engine/Alternator

LT Water System

01 inlet to air cooler	04 inlet to alternator	07 inlet to lub. oil cooler
02 outlet from air cooler	05 outlet from alternator	08 inlet to fresh water cooler (SW)
03 outlet from lub. oil cooler	06 outlet from fresh water cooler (SW)	09

HT Water System

10 inlet to engine	14 inlet to HT air cooler	17 outlet from fresh water cooler
10A FW inlet to engine	14A FW inlet to air cooler	18 inlet to fresh water cooler
11 outlet from each cylinder	14B FW outlet from air cooler	19 preheater
12 outlet from engine	15 outlet from HT system	19A inlet to prechamber
13 inlet to HT pump	16 outlet from turbocharger	19B outlet from prechamber

Lubricating Oil System

20 inlet to cooler	24 sealing oil - inlet engine	28 level in base frame
21 outlet from cooler / inlet to filter	25 prelubricating	29 main bearings
22 outlet from filter / inlet to engine	26 inlet rocker arms and roller guides	
23 inlet to turbocharger	27 intermediate bearing / alternator bearing	

Charging Air System

30 inlet to cooler	34 charge air conditioning	38
31 outlet from cooler	35 surplus air inlet	39
32 jet assist system	36 inlet to turbocharger	
33 outlet from TC filter / inlet to TC compr.	37 charge air from mixer	

Fuel Oil System

40 inlet to engine	44 outlet from sealing oil pump	48
41 outlet from engine	45 fuel-rack position	49
42 leakage	46 inlet to prechamber	
43 inlet to filter	47	

Nozzle Cooling System

50 inlet to fuel valves	54	58 oil splash
51 outlet from fuel valves	55 valve timing	59 alternator load
52	56 injection timing	
53	57 earth/diff. protection	

Exhaust Gas System

60 outlet from cylinder	64	68
61 outlet from turbocharger	65	69
62 inlet to turbocharger	66	
63 compustion chamber	67	

Compressed Air System

70 inlet to engine	74 inlet to reduction valve	78 inlet to sealing oil system
71 inlet to stop cylinder	75 microswitch for turning gear	79
72 inlet to balance arm unit	76 inlet to turning gear	
73 control air	77 waste gate pressure	

Load Speed

80 overspeed air	84 engine stop	88 index - fuel injection pump
81 overspeed	85 microswitch for overload	89 turbocharger speed
82 emergency stop	86 shutdown	90 engine speed
83 engine start	87 ready to start	

Miscellaneous

91 natural gas - inlet to engine	94 cylinder lubricating	97 remote
92 oil mist detector	95 voltage	98 alternator winding
93 knocking sensor	96 switch for operating location	99 common alarm
100 inlet to MDO cooler	101 outlet to MDO Cooler	102 alternator cooling air

General

The overhaul intervals are based on operation on a specified fuel oil quality at normal service output, which means 70-100% of MCR.

In the long run it is not possible to obtain a secure and optimal economic running without an effective maintenance system.

With the structure and amount of information in the maintenance programme, it can be integrated in the entire ship's/power station's maintenance system or it can be used separately.

The crux of the maintenance system is the key diagram, see page 600.25, indicating the inspection intervals for the components/systems, so that the crew can make the necessary overhauls, based on the engines' condition and/or the time criteria.

The stated, recommended intervals are only for guidance as different service conditions, the quality of the fuel oil and the lubricating oil, treatment of the cooling water, etc, will decisively influence on the actual service results and thus the intervals between necessary overhauls.

Experience with the specific plant/crew is to be used for adjustment of time between overhaul. Further it is to be used for adjusting the timetable stated for guidance in the working cards.

Working cards

Each of the working cards can be divided into two: a front page and one or several pages, describing and illustrating the maintenance work.

The front page indicates the following:

1. Safety regulations, which MUST be carried through before the maintenance work can start.

2. A brief description of the work.

3. Reference to work, which must be carried out, if any, before the maintenance work can start.

4. Related procedures - indicates other works, depending on this work - or works which would be expedient to carry out.

5. Indicates x number of men in x number of hours for accomplishing the work.

The stated consumption of hours is only intended as guide.

Experience with the specific station/crew may lead to a bringing up-to-date.

6. Refers to data, which are required for carrying out the work.

7. Special tools, which must be used. Please note that not all tools are standard equipment.

8. Various requisite hand tools.

9. Indicates the components/parts, which it is advisible to replace during the maintenance work. Please note, that this is a condition for the intervals stated.

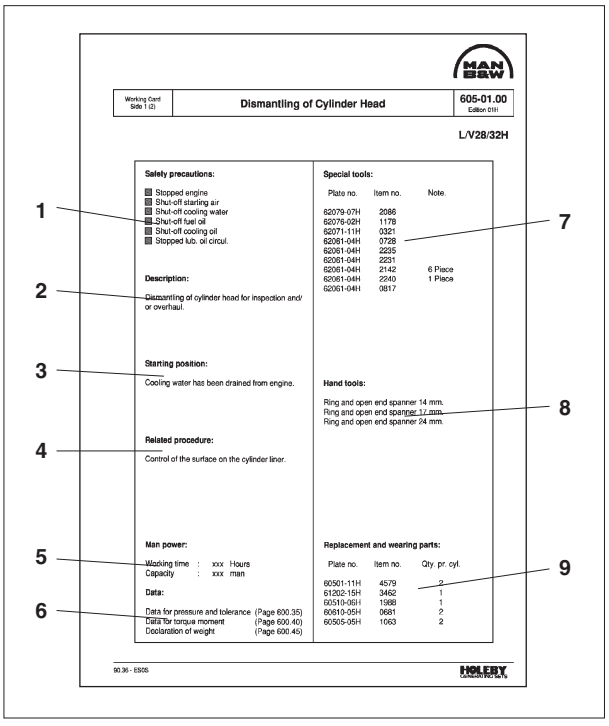


Fig 1. Guidance instruction for working cards.

L28/32H

Description ● = Overhaul to be carried out ■ = Check the condition	Check new/ Overhauled parts after -hours	Time Between Overhaul: 50	200	2000	8000	16000	32000	Daily	Weekly	Montly	3th month	Observations	Working Card No.
Operating of Engine:													
Readings of data for Engine and Generator, with reference to "Engine Performance Data", section 602-1									■				602-01.00
Cylinder Head:													
Inlet and exhaust valve - Overhaul and regrinding of spindel and valve seat						●							605-01.10
Inspection of inlet, exhaust valves and valve guide						■							605-01.05
Check of valve rotators rotation during engine rotation ...				■									605-01.05
Sleeve for fuel injector						■							605-01.30
Safety valve - Overhaul and adjustment of opening pressure						■							605-01.25
Indicator valve						■						■	605-01.26
Cylinder head cooling water space - Inspection						■							605-01.45
Cylinder head nut - Retightening	200												605-01.40
Piston, Connecting Rod and Cylinder Liner:													
Inspection of piston						■							606-01.10
Piston ring and scraper ring						●							606-01.10
Piston pin and bush for connecting rod - Check of clearance						■							606-01.15
Connecting rod - Measuring of big-end bore						■							606-01.15
Inspection of big-end bearings shells						■							606-01.16
Connecting rod - Retightening	200				■								606-01.25
Cylinder liner - Cleaning, honing and measuring						●							606-01.35
Cylinder liner removed - Check the water space and guide ring in frame							■						606-01.40
Camshaft and Camshaft Drive:													
Camshaft - Inspection of gear wheels, bolt, connections etc.	200					■							607-01.00
Camshaft bearing - Inspection of clearance						■							607-01.05
Camshaft adjustment - Check the condition						■							607-01.20
Lubrication of camshaft bearing - Check						■							607-01.00

L28/32H

Description ● = Overhaul to be carried out ■ = Check the condition	Check new/ Overhauled parts after -hours	Time Between Overhaul: 50	200	2000	8000	16000	32000	Daily	Weekly	Montly	3th month	Observations	Working Card No.
Operating Gear for Inlet Valves, Exhaust Valves and Fuel Injection Pumps:													
Roller guide for valve gear						■							608-01.00
Valve gear - Valve bridge, spring, push rod, etc						■							608-01.10
Roller guide for fuel injection pump						■							608-01.05
Roller guide housing						■							608-01.10
Inlet and exhaust valve - Check and adjustment of valve clearance				■									608-01.10
Lubricating of operating gear - Check						■							608-01.00 608-01.05
Control and Safety System, Automatics and Instruments:													
Safety, alarm and monitoring equipment											■		609-01.00
Jet system - Adjustment											■		609-01.00
Pick-up - Adjustment											■		609-10.00
Governor - Check oil level, see governor instruction book, section 609											■		
Crankshaft and Main Bearing:													
Checking of main bearings aligment, (autolog)					■								610-01.00
Inspection af main bearing							■						610-01.05
Inspection of guide bearing							■						610-01.10
Vibration damper - Check the condition						■							610-04.00
Lubricating of gear wheel for lub. oil pump and cooling water pump etc.							■						
Counter weight - Retightening, see page 600.40	200				■								
Main- and guide bearing cap - Retightening	200				■								610-01.05 610-01.10

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Description ● = Overhaul to be carried out ■ = Check the condition	Check new/ Overhauled parts after -hours	Time Between Overhaul: 50	200	2000	8000	16000	32000	Daily	Weekly	Montly	3th month	Observations	Working Card No.
Engine Frame and Bedplate:													
Holding down bolts - Retightening, see page 600.40	200				■								
Bolts between engine frame and base frame - Retightening, see page 600.40	200				■								
For flexible mounted engines - Check anti-vibration mountings	200				■								619-03.00
Safety cover - Function test					■								611-01.00
Turbocharger System:													
Dry cleaning of turbine side		●											612-10.00
Wet cleaning of turbine side									●				612-15.00
Water washing of compressor side		●											612-05.00
Cleaning of air filter - Compressor side (see turbocharger instruction book)													
Turbocharger complete - Dismantling, cleaning, inspection etc. (see turbocharger instruction book)													
Charging air cooler - Cleaning and inspection												■	612-01.00
Charging air cooler housing - Draining												●	
Exhaust pipe - Compensator												■	
Compressed Air System:													
Air starter motor - Dismantling and inspection												■	613-01.30
Function test - Main starting valve, starting valve, main valves and emergency start valve											■		613-01.40
Dirt separator - Dismantling and cleaning												●	
Muffler - Dismantling and cleaning												●	
Compressed air system - Draining												●	613-01.90
Compressed air system - Check of the system											■		613-01.90
Drain of bowl (filter element to be replaced when pressure drop exceeds 0.7 bar)								●					613-01.21

L28/32H

Description ● = Overhaul to be carried out ■ = Check the condition	Check new/ Overhauled parts after -hours	Time Between Overhaul											Working Card No.
		50	200	2000	8000	16000	32000	Daily	Weekly	Montly	3th month	Observations	
Fuel Oil System and Injection Equipment:													
Fuel oil filter - Dismantling and cleaning												●	614-01.15
Fuel oil feed pump												●	614-10.00
Fuel oil injection pump - Dismantling and cleaning												●	614-01.05
Fuel injection valve - Adjustment of opening pressure	200			■									614-01.10
Fuel oil high-pressure pipe - Dismantling and check				■									614-01.05
Adjustment of the maximum combustion pressure												●	614-05.01
Fuel oil system - Check the system											■		614-01.90
Nozzle cooling system - Check the system											■		614-01.90
Fuel oil - Oil samples after every bunkering, see sec.604													
Lubricating Oil System:													
Lubricating oil pump - Engine driven						■							615-01.00
Lubricating oil filter - Cleaning and exhange												●	615-01.10
Lubricating oil cooler												●	615-06.00
Prelubricating pump - El. driven						■							615-01.05
Thermostatic valve												■	615-01.20
Centrifugal filter - Cleaning and exhange of paper												●	615-15.00
Lubricating oil - Oil samples, see section 604											■		
Lubricating oil system - Check the system											■		615-01.90
Cooling Water System:													
Cooling water pump - Engine driven (sea water and fresh water)						■							
Thermostatic valve											■		
Cooling water system - Check the system										■			616-01.90
Cooling water system - Water samples, see sec. 604								■		■			

08028-0D/H5250/94.08.12

L28/32H

		Normal Value at Full load at ISO conditions		Acceptable value at shop test or after repair	Alarm Set point		Autostop of engine	
Lubricating Oil System								
Temp. before cooler (outlet engine)	SAE 30 SAE 40	TI 20 TI 20	60-75° C 65-82° C	<75° C <82° C	TAH 20 TAH 20	90° C 100° C		
Temp. after cooler (inlet engine)	SAE 30 SAE 40	TI 22 TI 22	45-65° C 50-72° C	<65° C <72° C	TAH 22 TAH 22	75° C 85° C	TSH 22 TSH 22	85° C 95° C
Pressure after filter (inlet eng)		PI 22	3.5-4 bar	>4.0 bar	PAL 22	3 bar	PSL 22	2.5 bar
Elevated pressure i.g. when centrifugal filter installed		PI 22	4-5 bar	>4.5 bar	PAL 22	3.5 bar	PSL 22	3.0 bar
Pressure drop across filter		PDAH 21-22	0.5-1 bar	<0.5 bar	PDAH 21-22	1.5 bar		
Prelubricating pressure Pressure inlet turbocharger		PI 23	1.5 ±0.2 bar	>1.5 bar	LAL 25	level switch		
Lub. oil, level in base frame					LAL 28/ LAH 28	low/high level		
Temp. main bearings		TE 29	75-85° C	<85° C	TAH 29	95° C		
Fuel Oil System								
Pressure after filter	MDO HFO	PI 40 PI 40	2.5-5 bar 5-16 bar (A)		PAL 40 PAL 40	1.5 bar 4 bar		
Leaking oil					LAH 42	leakage		
Press. nozz. cool. oil, inlet eng. Temp. nozz. cool. oil, outlet eng.		PI 50 TI 51	2-3 bar 80-90° C		PAL 50	1.5 bar (B) 95° C (B)		
Cooling Water System								
Press. LT-system, inlet engine		PI 01	1-2.5 bar (D)	>1.3 bar	PAL 01	0.4 bar + (C)		
Press. HT-system, inlet engine		PI 10	1.5-4.6 bar	>1.8-<6 bar	PAL 10	0.4 bar + (C)		
Temp. HT-system, inlet engine		TI 10	60-75° C					
Temp. HT-system, outl. cyl.units		TI 11	70-85° C	<85° C				
Temp. HT-system, outlet engine					TAH 12 TAH 12-2	90° C 93° C	TSH 12	95° C
Temp. raise across cyl. units			max. 10° C					
Exhaust Gas and Charge Air								
Exh. gas temp. before TC		TI 62	425-475° C		TAH 62 TAH 62-2	550° C 600° C		
Exh. gas temp. outlet cyl. Diff. between individual cyl.		TI 60	270-380° C	average ±25° C	TAH 60 TAD 60	410° C average (F) ±50° C		
Exh. gas temp. after TC		TI 61	275-350° C		TAH 61	500° C		
Ch. air press. after cooler Ch. air temp. after cooler		PI 31 TI 31	2-2.5 bar 35-55° C	<55° C	TAH 31	65° C		
Compressed Air System								
Press. inlet engine		PI 70	7-9 bar	>7.5-<9 bar	PAL 70	7 bar		

Specific plants will not comprise alarm equipment and autostop for all parameters listed above. For specific plants additional parameters can be included. For remarks to some parameters, see overleaf.

10° C change in ambient temperature correspond to approx. 15° C exhaust gas temperature change

L28/32H

	Normal Value at Full load at ISO conditions		Acceptable value at shop test or after repair	Alarm Set point		Autostop of engine	
Speed Control System							
Engine speed							
GenSets for 60 Hz							
Mechanical							
Elec.	SI 90	720 rpm	820 rpm	SAH 81	815 rpm	SSH 81	825 rpm
						SSH 81	815 rpm
GenSets for 50 Hz							
Mechanical							
Elec.	SI 90	750 rpm	855 rpm	SAH 81	850 rpm	SSH 81	860 rpm
						SSH 81	850 rpm
Turbocharger speed	SI 89	(G)		SAH 89	(E)		

Remarks to individual Parameters

A. Fuel Oil Pressure, HFO-operation.

When operating on HFO, the system pressure must be sufficient to depress any tendency to gasification of the hot fuel.

The system pressure has to be adjusted according to the fuel oil preheating temperature.

B. Nozzle Cooling Oil System

The nozzle cooling oil system is only applied for Tier II marine and stationary engines.

C. Cooling Water Pressure, Alarm Set Points.

As the system pressure in case of pump failure will depend on the height of the expansion tank above the engine, the alarm set point has to be adjusted to 0.4 bar plus the static pressure.

D. Press. LT -system, inlet engine (PI 01)

With two-string cooling water system the normal value can be higher, max. 4.0 bar.

E. Limits for Turbocharger Overspeed Alarm (SAH 89)

Engine type	720 rpm	750 rpm
5L28/32H	42,680	42,680
6L28/32H	42,680	42,680
7L28/32H	34,900	34,900
8L28/32H	34,900	34,900
9L28/32H	36,180	36,180

F. Exhaust Gas Temperatures

The exhaust gas temperature deviation alarm is normally ±50° C with a delay of 1 min., but at start-up the delay is 5 min. Furthermore the deviation limit is ±100° C if the average temperature is below 200° C.

G. Turbocharger Speed

Normal value at full load of the turbocharger is dependent on engine type (cyl. no) and engine rpm. The value given is just a guide line. Actual values can be found in the acceptance test protocol.

Description Page 1 (1)	"Green Passport"	600.33 Edition 02H

General

In 2009 IMO adopted the „Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009“

Until this convention enters into force the recommendatory guidelines “Resolution A.962(23)” (adopted 2003) apply. This resolution has been implemented by some classification societies as “Green Passport”.

MAN Diesel & Turbo is able to provide a list of hazardous materials complying with the requirements of the IMO Convention. This list is accepted by classification societies as a material declaration for “Green Passport”.

This material declaration can be provided on request.

L28/32H

Section	Description	mm. / bar
605	Safety valve to be adjusted to	170 bar
	Maximum inner diameter, valve guide	18.35 mm.
	For grinding of valve spindle and valve seat ring	
	(see also working card 605-01.10)	
	Minimum height of valve head, inlet valve and exhaust valve, "H" 1	6.5 mm.
	Maximum height of spindle above cylinder head, "H" 2	108.0 mm
606	Piston and piston ring grooves (see working card 606-01.10)	
	Clearance between connecting rod bush and piston pin	0.15 - 0.25 mm.
	Maximum ovalness in big-end bore (without bearing)	0.10 mm.
	New cylinder liner, inside diameter	280.03 - 280.08 mm.
	Maximum inside diameter cylinder liner	280.60 mm.
607	Clearance between camshaft and camshaft bearing	0.13 - 0.22 mm.
	Maximum clearance between camshaft and camshaft bearing	0.35 mm.
	Clearance between tooths on intermediate wheel	0.20 - 0.30 mm
	Plunger lift at TDC, injection timing:	
	IMO Tier II - D2, 720 rpm	$8.30^{+0.05}$ mm*
	IMO Tier II - D2, 750 rpm	$8.27^{+0.05}$ mm*
	**) for information on max settings check the engine's IMO Technical file.*	
	Plunger Lift, World Bank II**	
	***) Standard injection timing value is based on ISO condition.*	
	Special injection timing of engines can be necessary due to	
	Power plant size and/or Ambient conditions.	
608	Valve clearance, Inlet valve (cold engine 15 - 55°C)	0.40 mm.
	Valve clearance, Exhaust valve (cold engine 15 - 55°C)	0.90 mm.
	Maximum clearance between rocker arm bush and rocker arm shaft	0.30 mm.
609	Clearance between pick-up and impulse wheel	1 ±0.3 mm
	Adjustment of Lambda controller.	
	(see working card 609-10.00)	
610	Clearance (equal on both sides) between main bearing cap and frame,	
	before tightening of bracing screw (side screw)	0.06 ± 0.02 mm
	Deflection of crankchaft (autolog) (see working card 510-01.00)	
	Clearance between crankshaft and sealing ring, (upper and lower part)	0.3 - 0.4 mm.
	Clearance in main bearing	0,2-0,344 mm
	Clearance in guide bearing (axial)	0.15 - 0.46 mm
	Maximum clearance in guide bearing (axial)	0.8 mm
	Clearance between bearing and gearwheel shaft:	
	Clearance when new bearings are mounted	0.125-0.200
	Maximum clearance	0.250
	Clearance axial	0.2-0.3
611	Opening pressure of safety relief valves (on crankcase), max:	0.20 bar

L28/32H

Section	Description	mm. / bar
614	Maximum combustion pressure at full load	Max 133 bar
	Individual cylinders; admissible deviation from average	± 3 bar
	A change of the height of the thrust piece spacer ring of 0.10 mm. will change the maximum pressure by	1 bar
	1° turning of camshaft gear wheel changes max. pressure by approx	6 bar
	Measurement "X" between thrust piece and roller guide housing	11 ± 0.2 mm
	Opening pressure of fuel valve	320 bar
	Pressure testing, cooling oil sealing, on fuel valve	100 bar

L+V28/32H

Section	Description		Thread	Tightening Torque Nm	Tightening Pressure bar	Lubricant
605	Cylinder head stud (in frame)	Stud	M 39	200		Loctite 243
	Nut for cylinder head stud	Nut	M 39 x 3		700	Oil / Molykote (Unimol gl 82)
606	Connecting rod screw (see working card 606-01.25)					Molykote
	Connecting rod screw (hydraulic	Stud	M 39 x 3			(Unimol gl 82)
	tightening)	Nut	M 39 x 3		700	–
607	Camshaft assembling	Nut	M 12	85		Molykote (Unimol gl 82)
	Gear wheel on camshaft	Screw	M 12	70		–
	Intermediate wheel shaft	Nut	M 22 x 1.5	250		–
	Intermediate wheel assembling	Nut	M 12	50		–
	Gear wheel on crankshaft	Nut	M 12	50		–
608	Housing for valve gear	Screw	M 16	160		–
	Rocker arm bracket	Nut	M 12	40		–
610	Main bearing stud (in frame)	Stud	M 56	200		Loctite 243
	Nut for main bearing stud	Nut	M 52 x 3		900	Molykote (Unimol gl 82)
	Main bearing side screw - L28/32H	Screw	M 24	350		–
	Main bearing side screw - V28/32H	Screw	M 30	600		–
	Counterweight on crankshaft	Screw	M 26 x 1.5	300		–
	Vibration damper on crankshaft	Nut	M 30	500		–
	Flywheel mountng (witout fitted bolt)	Nut	M30	1350		oil
	Flywheel mounting (with fitted bolt)					
	- L28/32H	Nut	M 30	1350		–
	- V28/32H	Nut	M 30	480		–
	Gear rim on flywheel	Screw	M 16	75		–
611	Frame / baseframe	Nut	M 24	500		–
614	Fuel-pump connecting piece	Screw	M 10	60	(3 x cross-tightening 20 - 40 - 60 Nm)	–
	Fuel-pump top flange (barrel)	Screw	M 12	100		–
	Fuel-pump cavitation plugs	Plug	M 20 x 1.5	100 - 120		–
	Fuel-pump mounting	Screw	M16	150		–
	Fuel-valve (nozzle nut)	Nut	M 26 x 1.5	100 - 120		–
	Fuel-valve mounting	Nut	M 16	30		–
	Fuel-valve (lock nut)	Nut	M 16 x 1.5	100		–
	High pressure pipe	Nut	M 22 x 1.5	60		–

L+V28/32H

Section	Description		Thread	Tightening Torque Nm	Tightening Pressure bar	Lubricant
615	Gear wheel on lub. oil pump	Nut	M 30 x 2	400		Molykote (Unimol gl 82)
616	Impeller and gear wheel on fresh-water cooling pump - L28/32H	Nut	M 24 x 1.5	250		–
	Impeller and gear wheel on fresh-water cooling pump - V28/32H	Nut	M 33 x 2	400		–
619	Conical elements mounting - L28/32H					
	Upper mounting	Screw	M 20	150		–
	Lower mounting	Screw/ Nut	M 20	320		–
	Sandwich elements mounting - V28/32H					
	Upper mounting	Screw	M 16	165		–
	Lower mounting	Screw	M 16	165		–

L28/32H

Section	Component	Plate No.	Item No.	Weight in Kg.
605	Cylinder Head, incl. rocker arms	60501-60502 60508-60510		255
606	Piston, complete	60601	08	40
	Piston Pin	60601	01	19
	Connecting Rod, complete	60601	06	81
	Cylinder Liner, complete	60610	10	119
	Cooling Water Jacket	60610	15	33
607	Camshaft, section	60705	02, 16, 20	29
608	Housing for Roller Guide	60801	20	17
609	Governor, complete	60901	01-09-10	28
611	Main Bearing Cap	61101	26	75
	Guide Bearing Cap	61101	19	85
	Front cover	61102	01	164
	End cover, complete	61106	11	179
612	Turbocharger, complete			See special instruction
	Intermediate piece	61202	26	9
	Air Cooler	61203	38	450
	Inlet Bend	61203	33	93
	Charging Air Cooler Housing	61203	34	350
613	Air Starter	61309	63	40
614	Fuel Injection Pump	61401	01-02	15
	Fuel Injection Valve	61402	02	5
	Fuel Oil Feed Pump	61410	22	22
615	Lubricating Oil Pump	61501	35	45
	Thermostatic Valve	61503	11	29
	Prelubricating Oil Pump, incl. el-motor	61504	25	20
	Centrifugal Filter	61515	33	24
616	Thermostatic Valve	61604	11	29
	Cooling Water Pump	61610	19	30

General

Spare parts can be ordered from MAN Diesel & Turbo, PrimeServ.

When spare parts are ordered or inquired, the following data must be indicated, in order to ensure correct identification of the required parts:

- Name of customer
- Name of plant /vessel
- Vessel IMO No
- Engine type
- Engine serial No
- Engine builder
- Plate No and edition No
- Item No
- Quantity
- Designation of the item No

Note:

- Components from different engine builders cannot be considered as interchangeable.
- A wide number of spare parts can be orders as spare part kits.
- Selected components may be available in both original and upgraded version.

These data are necessary to ensure supply of the correct spare parts for a particular engine, even though the spare part illustrations contained in this book may not always be in complete accordance with the individual components of a specific engine.

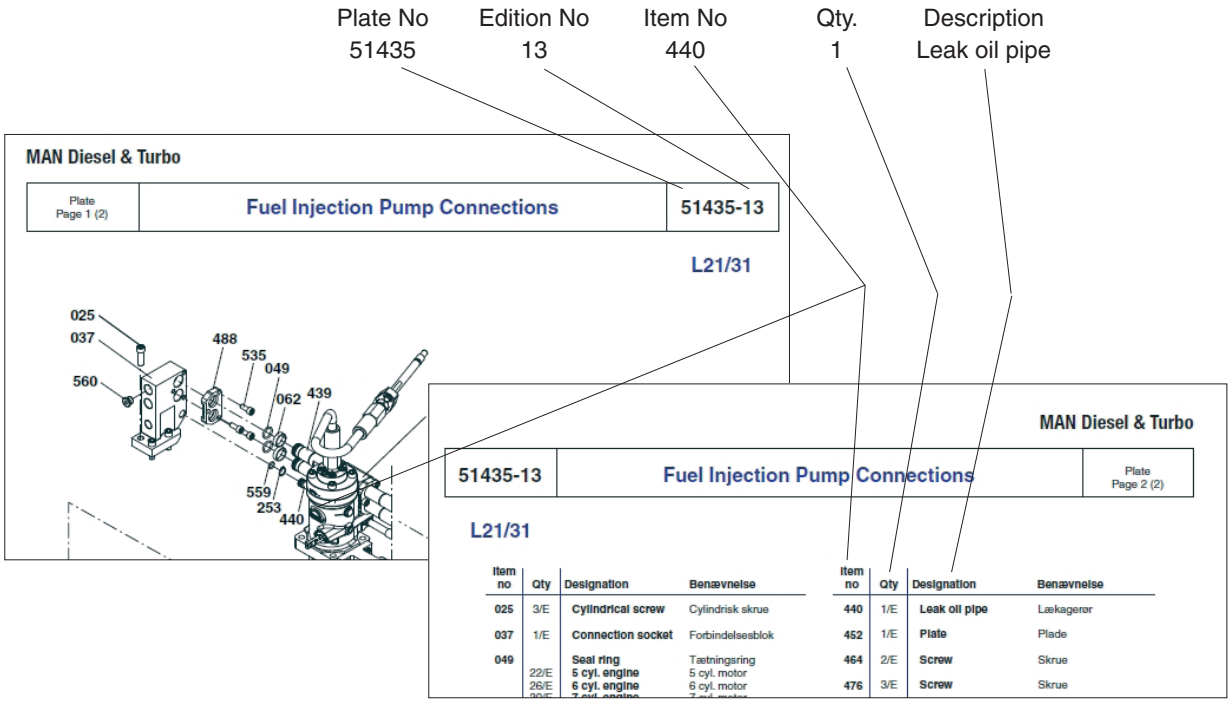
For ordering of spare parts for governor, turbocharger and alternator, please see the special chapter in the instruction book for these components.

Information found on the nameplate of the engine(s)

Example:

Name of customer	Name of Plant/Vessel	IMO No	Engine type	Engine serial No	Engine builder
Mercy Ship	Africa Mercy	L7803188	5L21/31	SB5L21-10799	MAN Diesel & Turbo or Licensee

Information found on each plate at the instruction manual:



General

Name of customer	Name of Plant/Vessel	IMO No
Engine type	Engine No	Engine Builder

Plate No Edition No	Item No	Designation of the Item No	Qty.

For ordering or inquiry for items in free text, kindly contact MAN PrimeServ Holeby at: +45 54 69 31 00 or via e-mail primeserv-hol@mandieselturbo.com

General

How to return spare parts and/or tools

If the unfortunate situation occurs that your spare parts do not fit or is damaged in any way, you need to return your spare parts to us.

The return procedure is as follows:

Send an email to our office via
Holeby: primeserv-hol@mandieselturbo.com or Frederikshavn: primeserv-frh@mandieselturbo.com

Clearly stating:

- Our order number
- Item numbers
- Reason for return
- Your reference
- Pictures of damaged parts – if any.

Please be noted that your parts are not to be returned unless there is an agreement with our Sales Coordinators and/or Superintendents.

When parts are received in good condition, we will issue a credit-note. Please mark the box with our order number or attach a copy of our packing list.

For return of tools please mark the box withour project name and number on the box (P-xxxxx)

Remarks:

Please note that spare parts and/or tools are not to be returned unless there is a written agreement with MAN Diesel & Turbo, PrimeServ in Holeby or Frederikshavn.

- If you return your spare parts and/or tools without a written agreement you will be charged a fee for unauthorised returns.
- If you return to Holeby instead of Frederikshavn, you will have to pay freight charges of minimum EUR 70,-

Please return by cheapest mean to the below address:

- **Spare Parts:**
  MAN Diesel & Turbo
  Niels Juels Vej 15
  9900 Frederikshavn
  Denmark
  Att: Dept.: Store (WLS-FRH)

- **Tools:**
  MAN Diesel & Turbo
  Langerak 74
  9900 Frederikshavn
  Denmark
  Att: Dept.: Service Center (DC5)

For returns to Singapore warehouse please use the following address:

MAN Diesel & Turbo Singapore Pte. Ltd.
14 Tuas Avenue 1
Singapore 639499
Att.: Logistic Centre, Asia

Note: Please be aware that it is only spare parts that have been purchased in Singapore that can be returned to Singapore warehouse.

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General

Description

In order to ensure the most efficient, economical and up-to-date operation of our engines, we regularly send out "Service Letters" containing first-hand information regarding accumulated service experience.

The service letters can either deal with specific engine types, or contain general instructions and recommendations for all engine types, and are used as a reference when we prepare up-dated editions of instruction books.

Since new service letters might be of great importance to the operation of the plant, we recommend that engine staff file them as supplements to the relevant chapters of this instruction book.

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General

Basic SI Units

Quantity	*Name*	*Symbol*
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
absolute temperature*	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

* Also named "thermodynamic temperature"

Supplementary SI Units

Quantity	*Name*	*Symbol*
plane angle	radian	rad
solid angle	steradian	sr

Additional SI Units

Quantity	*Name*	*Symbol*	*Definition*
time	minute	min	1 min = 60 s
time	hour	h	1 h = 60 min
plane angle	degree	°	1° = (p/180) rad
volume	litre	l	1 l = 1 dm^3
pressure	bar	bar	1 bar = 10^5 Pa

Length (m)

1 in (inch)	25.40 mm = 0.0254 m
1 ft (foot) = 12 inches	0.3048 m
1 yd (yard) = 3 ft = 36 inches	0.9144 m
1 statute mile = 1760 yds	1609 m
1 n mile (international nautical mile)	1852 m

SI Prefixes

Factor	*Prefix*	*Symbol*	*Factor*	*Prefix*	*Symbol*
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	µ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10	deca	da	10^{-18}	atto	a

Area (m^2)

1 sq. in (square inch)	0.6452 x 10^{-3} m^2
1 sq. ft (square foot)	92.90 x 10^{-3} m^2

Velocity, Speed (m/s) (3.6 km/h = 1 m/s)

1 kn (knot) = 1 nautical mile/h 1.852 km/h = 0.5144 m/s
Cincerning other conversions, see table for length

Density

1 lb/cub. ft	16.02 kg/m^3

Force (1 kg m/s^2 = 1 N)

1 kp (kilopound)*	9.807 N
1 poundal**	138.3 x 10^{-3} N
1 lbf (pound force)	4.448 N

* Can occasionally be found stated as kgf (kilogram force). Standard acceleration of free fall gn = 9.80665 m/s^2
** Unit of force in the ft-lb-s system

Stress (1 N/m^2 = 10^{-6} N/mm^2)

1 kp/mm^2 = 100 kp/cm^2	9.807 N/mm^2
1 lbf/sq. in (psi) = 0.07031 at	6.895 x 10^{-3} N/mm^2

Dynamic viscosity (N s/m^2)

1 kp s/m^2	9.807 N s/m^2 = 98.07 P (poise)
1 poundal s/sq.ft	1.488 N s/m^2
1 lbf/sq.ft	47.88 N s/m^2

poise is a special name taken from the CGS system. 1 P = 0.1 Pa s
1 cP = 1 mPa s = 10^{-3} Pa s

Kinematic viscosity (m^2/s)

1 sq.ft/s	92.90 x 10^{-3} m^2/s = 92.90 x 10^3 cSt *

* 1 cSt (centi stokes) = 10^{-6} m^2/s. Stokes is a special name taken from the CGS system. 1 St = 10^{-4} m^2/s

Energy, Work (1 Nm = 1 J, Wh)

1 cal $_{I.T}$*	4.187	J*
1 kpm	9.807	J
1 hph (metric)	2.648 x 10^6 J = 0.7355	kWh
1 ft. lbf	1.356	J
1 hph (UK, US)	2.685 x 10^6J = 0.7457	kWh
1 BTU (UK, US)	1.055 x 10^3J = 1.055	KJ

* Exact value: 4.1868 J
I.T. = International Steam Table

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General

Power (1 kg m²/s³ = 1 N m/s = 1 J/s = 1 W)

1 kpm/s	9.807	W
1 hp (metric) = 75 kpm/s	735.5	W = 0.7355 kW
1 $kcal_{I.T.}$/h	1.163	W
1 ft lbf/s	1.356	W
1 hp (UK, US) = 550 ft.lbf/s	745.7	W
1 BTU/h	0.2931	W

Moment of Force, Torque (kg m²/s² = Nm)

Can easily be derived from the above tables.

Moment of Inertia (kg m²)

1 GD² (old notation)	= 4 x I* kg m²
1 WR² (old notation)*	= 1 x I* kg m²

*$I = \int dm_r \times r^2$ m_r = mass at the radius r
G = W = mass in kg D = Diameter of gyration
R = Radius of gyration

Specific fuel consumption* (g/kWh)

1 g/hph (metric)	1.360 g/kWh

* See also table for specific fuel oil consumption values

Temperature difference (K)

1 °C (Celsius)	1 K
1 °F (Fahrenheit)	5/9 K

Temperature levels (K) (see "Derived SI Units with special Names)

t °C (Celsius)	$t_c + 273.15 = K$
t°F (Fahrenheit)	$5/9(t_f - 32) + 273.15 = K$
Celsius from Fahrenheit:	$t_c = 5/9(t_f - 32)$
Fahrenheit from Celcius:	$t_f = 9/5 \times t_c + 32$

Specific heat capacity (J/(kg K))

1 $kcal_{I.T.}$/(kg x °C)	4.187 x 10³ J/(kg K)
1 BTU*/(lb x °F) = 1 $kcal_{I.T.}$ /(kg °C)	4.187 x 10³ J/(kg K)

* British Thermal Unit (see table for energy conversions)

Heat conductance (W/(m K))

1 $cal_{I.T.}$/(cm x s x °C)	418.7	W/(m K)
1 $kcal_{I.T.}$/(m x h x °C)	1.163	W/(m K)
1 BTU*/(ft x h x °F)	1.731	W/(m K)

* British Thermal Unit (see table for energy conversions)

Heat transmission (W/(m² K))

1 $cal_{I.T.}$/(cm x s x °C)	41.87 x 10³	W/(m² K)
1 $kcal_{I.T.}$/(m² x h x °C)	1.163	W/(m² K)
1 BTU*/(ft² x h x °F	5.678	W/(m² K)

Specific fuel oil consumption (SFOC)

Reference conditions
Specific fuel oil consumption values refer to brake power, and the following reference conditions:

Reference conditions (ISO)

Blower inlet temperature 25°C	298 K
Blower inlet pressure	1000 mbar
Charge air coolant temperature 25°C	298 K
Fuel oil lower calorific value (10200 kcal/kg)	42707 kJ/kgk

Derived Si Units with Special Names

Quantity	*Name*	*Symbol*	*Expressed in basic, supplementary or derived SI units*
frequency	hertz	Hz	1 Hz = 1 s^{-1}
force	newton	N	1 N = 1 kg m/s^2
pressure, stress	pascal	Pa	1 Pa = 1 N/m^{2*}
energy, working quantity of heat	joule	J	1 J = 1 Nm
power	watt	W	1 W = 1 J/s
electric potential (DC)	volt	V	1 V = 1 W/A
temperature	Celsius	°C	1°C = 1 k**

* For mechanical stresses N/mm^2 is widely used. 1 $N/mm^2 = 10^6$ N/m^2
** t (°C) = T(K) - T_0(K), where T_0 = 273.15 K

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General

Volume (1 m^3 = 1000 l)

1 cub. in (cubic inch)	16.39×10^{-6}	m^3
1 cub. ft (cubic foot)	28.32×10^{-3}	m^3 = 28.32 l
1 gallon* (imperial, UK)	4.546×10^{-3}	m^3 = 4.546 l
1 gallon* (US)	3.785×10^{-3}	m^3 = 3.785 l
1 barrel (US petroleum barrel) = 42 gallon (US)	0.1590	m^3
1 bbl (dry barrel, US)	0.1156	m^3
1 register ton = 100 cub. ft	2.832	m^3

* 1 gallon = 4 quarts = 8 pints

Mass (kg)

1 lb (pound mass) = 16 ozs (ounces)	0.4536	kg
1 cwt (UK) (hundredweight) = 112 lbs	50.80	kg
1 long ton (UK) = 20 cwt = 2240 lbs	1.016 metric tons = 1016	kg
1 short ton (UK) = 2000 lbs	0.907 metric tons = 907	kg
1 slug*	14.59	kg

* Unit and mass in the ft-lb-s system

Pressure
(1 N/m^2 = 1 Pa, 1 bar = 10^5 Pa, 1 mbar = 10^{-3} bar)

1 kp/cm2	= 1 at	= 0.9678 atm	98.07 x 10^3 Pa = 0.9807 bar
1 at	= 735.5 mm Hg*	= 10 m H_2O**	(T = 277 K)
750 mm Hg*	10^5 Pa	= 1 bar	
1 mm Hg*	(T = 273 K)		133.3 Pa = 1.333 mbar
1 mm H_2O**	(T = 277 K)		10^{-4} at = 9.807 Pa = 98.07 x 10^{-3} mbar
1 in Hg*	(T = 273 K)		3386 Pa = 33.86 mbar
1 in H_2O**	(T = 277 K)		249.1 Pa = 2.491 mbar
1 atm	(standard atmosphere)		760 mm Hg, 1.013 x 10^5 Pa = 1013 mbar
1 atm	= 1.033 at		
1 lbf/sq.in (psi)	6895 Pa	= 68.95 mbar	

* Mercury. 1 mm Hg = 1 Torr
Values in table provided gn = 9.80665 m/s^2

** Water column (WC)

Some physical data in SI units

Nomenclature
t = temp. in °C
r = density in kg/m^3
ΔK = temperature difference
C_p = heat capacity in J/(kg DK)

	t	ρ	C_p	t range	C_p
Water	18	999	4.18 x 10^3		
Lubricating oil (approx.)*	15	900	1.96 x 10^3		
Atmospheric air (dry) (p=1 bar)	0	1.276	998	0-150	1005
Exhaust gas				200-400	1080
* Viscosity: 100-140 cSt at 40°C					
750 mm Hg = 1 bar = 10^5 Pa					
1 atm (standard pressure at sea level)	= 760 mm Hg = 1013 mbar				
Gas constant for air and exhaust gas	= 287 J/(kg x K)				
Water, heat of evaporation 100°C	1.013 bar			2.256 x 10^6 J/kg	
Fuel oil. Lower calorific value				41-43 x 10^6 J/kg	
ISO 3046/1-1986 standard reference fuel				43 x 10^6 J/kg	
Diesel engine reference fuel				(see below)	

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Description Page 1 (3)	Basic Symbols for Piping	600.65 Edition 01H

General

No	Symbol	Symbol designation
1. GENERAL CONVENTIONAL SYMBOLS		
1.1		Pipe
1.2		Pipe with indication of direction of flow
1.3		Valves, gate valves, cocks and flaps
1.4		Appliances
1.5		Indicating and measuring instruments
1.6		High-pressure pipe
1.7		Tracing
1.8		Enclosure for several components as-sembled in one unit
2. PIPES AND PIPE JOINTS		
2.1		Crossing pipes, not connected
2.2		Crossing pipes, connected
2.3		Tee pipe
2.4		Flexible pipe
2.5		Expansion pipe (corrugated) general
2.6		Joint, screwed
2.7		Joint, flanged
2.8		Joint, sleeve
2.9		Joint, quick-releasing
2.10		Expansion joint with gland
2.11		Expansion pipe
2.12		Cap nut
2.13		Blank flange
2.14		Spectacle flange
2.15		Orifice
2.16		Orifice
2.17		Loop expansion joint
2.18.		Snap coupling
2.19		Pneumatic flow or exhaust to atmosphere
3. VALVES, GATE VALVES, COCKS AND FLAPS		
		Valve, straight through
		Valve, angle
		Valve, three-way
		Non-return valve (flap), straight
		Non-return valve (flap), angle
		Non-return valve (flap), straight screw down
		Non-return valve (flap), angle, screw down
		Safety valve
		Angle safety valve
		Self-closing valve
		Quick-opening valve
		Quick-closing valve
		Regulating valve
		Ball valve (cock)
		Butterfly valve
		Gate valve

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General

No	Symbol	Symbol designation	No	Symbol	Symbol designation
3.17		Double-seated changeover valve	4. CONTROL AND REGULATION PARTS		
3.18		Suction valve chest	4.1		Fan-operated
3.19		Suction valve chest with non-return valves	4.2		Remote control
3.20		Double-seated changeover valve, straight	4.3		Spring
3.21		Double-seated changeover valve, angle	4.4		Mass
3.22		Cock, straight through	4.5		Float
3.23		Cock, angle	4.6		Piston
3.24		Cock, three-way, L-port in plug	4.7		Membrane
3.25		Cock, three-way, T-port in plug	4.8		Electric motor
3.26		Cock, four-way, straight through in plug	4.9		Electromagnetic
3.27		Cock with bottom connection	4.10		Manual (at pneumatic valves)
3.28		Cock, straight through, with bottom conn.	4.11		Push button
3.29		Cock, angle, with bottom connection	4.12		Spring
3.30		Cock, three-way, with bottom connection	4.13		Solenoid
3.31		Thermostatic valve	4.14		Solenoid and pilot directional valve
3.32		Valve with test flange	4.15		By plunger or tracer
3.33		3-way valve with remote control (actuator)	5. APPLIANCES		
3.34		Non-return valve (air)	5.1		Mudbox
3.35		3/2 spring return valve, normally closed	5.2		Filter or strainer
3.36		2/2 spring return valve, normally closed	5.3		Magnetic filter
3.37		3/2 spring return valve contr. by solenoid	5.4		Separator
3.38		Reducing valve (adjustable)	5.5		Steam trap
3.39		On/off valve controlled by solenoid and pilot directional valve and with spring return	5.6		Centrifugal pump

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General

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
5.7		Gear or screw pump	6. FITTINGS		
5.8		Hand pump (bucket)	6.1		Funnel / waste tray
5.9		Ejector	6.2		Drain
5.10		Various accessories (text to be added)	6.3		Waste tray
5.11		Piston pump	6.4		Waste tray with plug
5.12		Heat exchanger	6.5		Turbocharger
5.13		Electric preheater	6.6		Fuel oil pump
5.14		Air filter	6.7		Bearing
5.15		Air filter with manual control	6.8		Water jacket
5.16		Air filter with automatic drain	6.9		Overspeed device
5.17		Water trap with manual control	7. READING INSTR. WITH ORDINARY DESIGNATIONS		
5.18		Air lubricator	7.1		Sight flow indicator
5.19		Silencer	7.2		Observation glass
5.20		Fixed capacity pneumatic motor with direction of flow	7.3		Level indicator
5.21		Single acting cylinder with spring returned	7.4		Distance level indicator
5.22		Double acting cylinder with spring returned	7.5		Recorder
5.23		Steam trap			

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Operation of engine

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Preparations for Starting

The following describes what to do before starting, when the engine has been out of service for a longer period of time, or if major overhauls has been made.

1. Check the oil level in the base frame (or in the lub. oil tank if the engine is with dry sump), air lubricator and in the govenor.

Start-up the prelubricating pump.

The engine shall be prelubricated at least 2 minutes prior to start.

Check oil pressures before and after the filter.

2. Open the cooling water supply, start separate cooling water pumps where installed, and check the cooling water pressure.

Note: To avoid shock effects owing to large temperature fluctuations just after the start, it is recommended:

a) to preheat the engine, cooling water of at least 60 °C should be circulated through the frame and cylinder head for at least 2 hours before start.

- either by means of cooling water from engines which are running or by means of a built-in preheater (if installed).

or

b) When starting without preheated cooling water, the engine must only be started on MDO (Ma-rine Diesel Oil).

The engine should not be run up to more than 50% load to begin with, and the increase to 100% should take place gradually over 5 to 10 minutes.

Note: When starting on HFO (Heavy Fuel Oil), only item "a" should be used.

3. Open the nozzle cooling oil supply (only when started on HFO), circulate preheated oil through the nozzles for at least 15 minutes.

4. Open the fuel oil supply to the feed pump.

Starting on HFO: circulate preheated fuel through the pumps until correct working temperatures has been obtained. Takes normally 30-60 minutes.

5. Check the pressure in the starting air receiver(s) and open the starting air supply (blow-off water, if any, drain the starting air system before opening.

6. Check that the sealing oil system for the injection pumps are working correct.

7. Check in the regulating gear:

- That all fuel pumps are at index "0" when the regulating shaft is in the STOP position.

- That each fuel pump can be pressed by hand to full index when the regulating shaft is in the STOP position, and that the pumps return automatically to the "0" index when the hand is removed.

- That the spring-loaded pull rod is working correctly.

- That the stop cylinder for regulating shaft works properly, both when stopping normally and at overspeed and shut down.

- Testing is made by simulating these situations.

8. Open the indicator valves and turn the engine some few revolutions, check that no liquid is flowing out from any of the indicator valves during the turning.

Slow-turning must always be carried out, before the engine is started after prolonged out of-service periods and after overhauls, which may involve a risk of liquid having collected in the cylinders.

9. Close the indicator valves.

10. Disengage the turning gear, if fitted. Check that it is locked in the "OUT" position.

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Starting

1. Start the engine, by activating the start buttom.

2. Check the lubricating oil pressure, cooling water pressure, fuel oil feed pressure. Check that the prelubricating oil pump is stopped.

3. Check that all alarms are connected.

See also "checks after starting-up".

Tending during running

When the engine is running, the planned maintenance program and the following should be checked:

1. The lubricating oil pressure must be within the stated limits and must not fall below the stated minimum pressure. The paper filtering cartridges must be replaced before the pressure drop across the filter reaches the stated maximum value, or the pressure after the filter has fallen below the stated minimum value. Dirty filter cartridges cannot be cleaned for re-use.

2. The lubricating oil temperature must be kept within the stated limits indicated on the data sheet.

3. The fuel oil pressure must be kept at the stated value, and the filter must be cleaned before the pressure drop across the filter reaches the stated maximum value.

4. The cylinder cooling water temperature must be kept within the limits indicated and the temperature rise across the engine should not exceed 10°C.

5. The cooling water temperature at the charging air cooler inlet should be kept as low as possible; however, not as low as to produce condensation water in the charging air space.

Adjustment takes place in the external system outside the engine, and the amount of cooling water must be so adjusted that the temperature rise across the charging air cooler is 3 - 5 °C.

6. The exhaust gases should be free from smoke at all loads. For normal exhaust temperatures, see the test sheet from shop and sea trials.

7. Keep the charging air pressure and temperature under control. For normal values, see the test sheet from shop and sea trials.

8. Recharge the starting air recivers when the pressure has dropped to about 20 bar. Stop recharging at 30 bar.

9. To ensure the greatest possible operational liability, condition of the engine should be continuously observed in order that preventive maintenance work can be carried out before serious breakdowns occour.

Stopping

1. Before stopping, it is recommended to run the engine at reduced load, or to idle for about 5 minutes for cooling-down purposes.

2. The engine is stopped by keeping the fuel pump delivery rate at "0", by turning the "load- limit" knob on the governor to "0", or by activating the remote stopping device.

Start and Stop on HFO

Start and stop of the engine should take place on HFO in order to prevent any incompatibility problems by change-over to MDO.

MDO should only be used in connection with maintenance work on the engine or longer periods of engine standstill.

Before starting on HFO the engine must be properly preheated. as described in "Preparations for starting" and as below.

Stopping the engine on HFO is no problem, but it should be ensured that the temperature of fuel pipes not are reduced to a level below the pour point of the fuel, otherwise reestabilishing of the circulation might cause problems.

Starting on MDO

For starting on MDO there are no restrictions except lubricating oil viscosity may not be higher than 1500 cSt (5° C SAE 30, or 10° C SAE 40).

Initial ignition may be difficult if the engine and ambient temperature are lower than 5° C, and 15° C cooling water temperature.

General

1. Stand-by Engines

During engine standstill in stand-by position, the media cooling water, fuel oil and nozzle oil should be continuously circulated at temperatures similar to the operation conditions.

The engine shall be prelubricated 2 minutes prior to start, if there is not intermittent or continuous pre-lubricating installed. intermittent prelub. is 2 min every 10 minutes.

2. Maintenance during Standstil

in periods, duringe stand-still of the engine (not in stand-by position) it is recommended, that the pre-lubricating oil pump is startet minimum 10 minutes once every week and that the engine during the prelubricating period is turnd 2-3 revolutions..

3. Laid-up Vessels

During the lay-up period (and also when laying-up the vessel), we recommend that our special instructions for preservation of the engines, are followed.

4. Works before Major Repairs

4.1 After stopping the engine, while the oil is still warm, start the electrically driven prelubrication pump, open up the crancase and camshaft housing and check that the oil is flowing freely from all bearings. Also take off the top covers on the cylinder heads and make sure that oil is not supplied for lubrication of rocker arms, as non-return valves are fitted which do not open until the oil pressure at the inlet to the rocker arms exceeds 1 bar.

After overhaul of pistons, bearings, etc. this check should be repeated before starting the engine.

4.2. After stopping the prelubricating pump, check the bottom of the oil sump for fragments of babbitt from bearings, and check crankpin and main bearings clearances with a feeler gauge. Measure the bearing clerance at the top, at the bottom, and 10 degrees above and below the joints at both sides.

4.3. Open up all filters to check that filter elements are intact. Filter cartridges in the lub. oil filter is to be replaced before start after repair or due to excessive differential pressure. After eremoval, dirty elements can be examined for particles of bearing metal at the bottom of the paper lamellae.
(The elements can not be used again).

4.4. Check the cylinder walls.

4.5. Take deflection measurements of the crank-shaft.

4.6. A lubricating oil sample should be send to a laboratory for immediate analysis.

4.7. Drain plugs are unscrewed from the bottom of turbochargers, or the drain cock is opened, if there is installed drain fasilities in the exhaust gas system this should be opened.

5. Works during Repairs

The following should be made during the major repairs.

5.1. Retighten all bolts and nuts in the crankcase and check their locking devices. Also retighten foundation bolts.

5.2. Check the various gear wheel drives for the camshaft(s).

5.3. Remedy leakages of water and oil in the engine, and blow through blocked-up drain pipes.

5.4. Drain starting air pipes of water.

5.5. Empty the oil sump of lubricating oil and remove the sludge, if not done within a period of one year. Very thoroughly clean the sump and subsequently coat with clean lubricating oil.

6. Works after Repairs

6.1. If an opening-up of engine or lubricating oil system may have caused ingress of impurities, cleaning should be carried out very carefully before starting the engine.

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General

The differential pressure across the lub. oil filter must be watched very carefully after cleaning and starting-up the engine. Be sure to replace filter cartridges in due time.

6.2. After restoring normal lubricating oil circulation, turn the engine at least two revolutions by means of the turning rod to check the movability of the relevant parts of the engine.

6.3. Close drain cocks in the turbocharger (or in the exhaust gas system if mounted).

6.4. Lubricate bearings and rod connections in the manoeuvring gear. Disconnect the governor and move the rod connections by hand to check that the friction in bearings and fuel pumps is sufficiently low. If repair of bearings or alignment of engine has been made, checks 1, 2, and 5 should be repated.

6.5. Cheks to be made just before starting of the engine are mentioned under 601.01.

6.6. Add cooling water and check with pressure on the system for leakage at the upper and lower cy-linder liner sealings and at cooling water connections.

6.7. Check the governor as follows:
Start up the engine and run it at the synchronous number of revolutions.

6.7 a) Speed setting: Check before switching-in generator on the switchboard that the servomotor adjusts the r.p.m. with a suitable quickness after actuation of the synchronizer knob on the switchboard. The range from - 5% to + 5% from the syn-chronous r.p.m. should be tested.

6.7 b) Adjustment speed: Switch-in generator on the switchboard and set the load to about 40%. On reaching normal oil temperatures in governor and engine, increase the load instantaneously to about 80% (by starting major pump or compressor). This must not cause the frequency to fall by more than some 8%, and the engine must return to a constant r.p.m. about 3 seconds (although this r.p.m. will be a little lower than before owing to the speed drop of
the governor). If the engine is operated in parallel with other engines, an even sharing of load shall be established within about 3 seconds. If the governor reacts too slowly, compensating adjustment is effected as indicated in Woodward's instruction manual (Compensating adjustment).

Note: It is a condition for this test that the engine and turbocharger are in perfect operating condition, so that they can be elimated as possible sources of error.

6.7 c) Hunting: Run the engine at synchronous r.p.m., and without load. Provided the governor oil is warm, the regulating lever must not perform any major periodical movments, and neither must there be any variation up and down in the engine speed. If that is the case, repeat the compensating adjustment according to Woodward's instruction manual.

6.7 d) Speed Drop: in case of unsatisfactory load sharing between two ore more engines this can be rectified by increasing the speed drop of the engine that is subject to the greatest load (or by reducing the setting of the other engines).

The setting shoul not normally be increased beyond 70 on the scale, and satisfactory parallel operation can generally be obtained at settings between 40 and 60.

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The following enumerates checks are to be made immediately after starting, during load increase, and during normal running. The sequence has been accordingly.

In the following it is assumed that the engine has been out of service for some time, for instance due to repairs and

- checks during out of service periods have been carried out as described in the previous chapter.

When starting after such an out-of-service period, the following checks must be made in the stated order in addition to normal surveillance and recording.

1. To be made immediately after starting:

1.1. See that the turbocharger is running.

1.2. See that the lubricating oil pressure is in order.

1.3. See that all cylinders are firing (see exhaust temperatures).

1.4. See that everyting is normal for the engine speed, fuel oil, cooling water and system oil.

1.5. Check by simulation of the overspeed shutdown device that the engine stops. The overspeed setting should be according to " Set Points and Operation Data " section 600.

2. To be made during the starting-up, but only if required after repairs or alterations made:

2.1. If the condition of the machinery is not well-known, especially after repairs or alterations, the "feel-over sequence" should always be followed.
that is:

After 5-15 and 30 minutes' idle running, open the crankcase and the camshaft housing and feel-over on the surfaces of all moving parts where friction may arise and cause undue heating.

Feel: Main bearings, big-end bearings, (alternator), and camshaft bearings, piston pins, cylinder liners, roller guides and gear wheels.

After the last feel-over, repeat check 4 page 601.05, see also **Ignition in Crankcase** page 603.04 in section 603.

After repair or renewal of cylinder liners, piston rings or bearings, allowance must be made for a running-in period, i.e. the engine load should be increased gradually as indicated in the tables below. The engine output is determined on the basis of the fuel index and the load on the electric switchboard. The turbocharger speed gives some indication of the engine output, but is not directly proportional to the output throughout the service period.

Begin the starting-up sequence at a reduced engine speed, e.g. 400 rpm, until it can be known for certain that there areno hot spots in the engine. Then increase the speed to the normal rpm and connect to the switchboard and put on load.

The load increase during the starting-up sequence may, for instance, be:

25 % load for 2 hours
50 % load for 2 hours
75 % load for 2 hours
100 % load may be put on.

The pump index indicated in the tables has been given as a percentage of the index at full load. To enable the index to be read directly off the fuel pumps the following formula can be employed:

$$I = \frac{I\%}{100} \times I_F$$

I_F = Index at full load (from testbed table)

I% = Index expressed as % of full load index (stated in the preceding starting-up sequence).

Following the alteration of the pump index of the one or two cylinders concerned it must be checked that when in the STOP position the governor is able to move all the fuel pumps to an average pump index not exceeding 2 or 3, thus excluding the possibility of racing of the engine when the propeller is declutched.

After completing the starting-up sequence, make sure that all fuel pumps are set at the same index and that the governor can cause all fuel pumps to move to "0" index.

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General

Part load/low load operation

In certain ship and power station operation modes the diesel generating sets are exposed to part load/low load operation.

During manoeuvring of the ship all diesel generating sets are often started up for safety reasons, resulting in low
load operation of all the engines. During harbour stay one diesel generator could be low-loaded when only hotel purposes are consuming electricity.

Island mode operation of diesel generating sets in power stations is frequently exposed to low load operation like on a ship.

At part load/low load it is important to maintain constant media temperatures, i.e. for cooling water, lubricating oil and fuel oil in order to ensure adequate combustion chamber temperature and thus complete combustion.

At loads lower than 20% MCR there is a risk of time dependant retardation of the engine performance condition due to fouling of the exhaust gas channels and combustion air channels, combustion chambers and turbocharger. HFO-operation at loads lower than 20% MCR should therefore only take place within certain time limitations according to the curves.

After a certain period of HFO-operation at loads lower than 20% MCR, a change to MDO should take place in order to prevent further retardation of the engine performance condition. Alternatively, the engine load should be raised to 70% MCR over a period of 15 minutes and maintained here for some time in order to burn off the carbon deposits, thus re-establishing adequate performance condition. After such a "clean burning period" low load operation on HFO can be continued.

However, the operator must be aware of the fact that fouling in the combustion air inlet channels, if any, will not be cleaned at high load operation. Extensive low load running can therefore result in the need for manual cleaning of the combustion air inlet channels.

If special application conditions require continuous HFO-operation at loads lower than 20% MCR and occasionally performed "clean-burning" periods are inconvenient or impossible, special equipment and arrangements must be established.

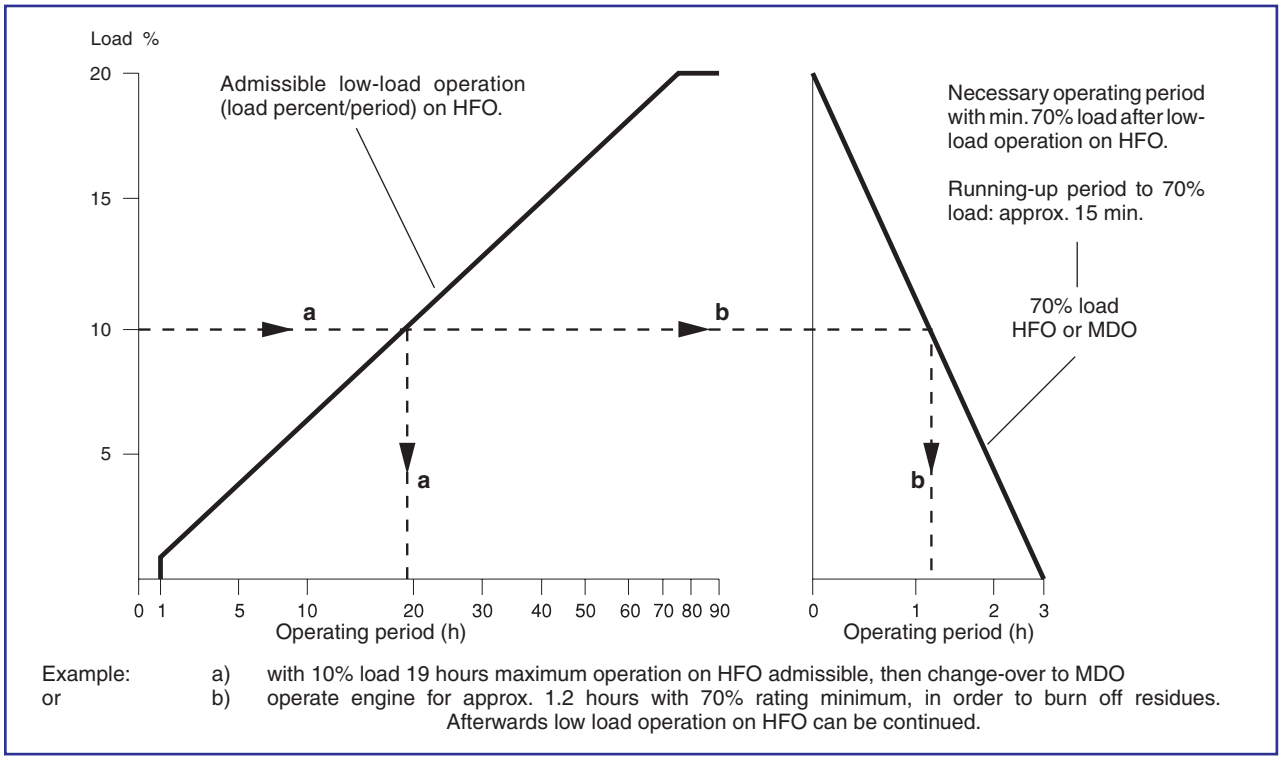

Fig 1 Low-load operation.

Description Page 1 (1)	Guidelines Regarding MAN Diesel & Turbo GenSets Operating on Low Sulphur Fuel Oil	601.16 Edition 02H

General

Exhaust emissions from marine diesel engines have been the focus of recent legislation. Apart from nitrous oxides (NOx), sulphur oxides (SOx) are considered to be the most important pollution factor. A range of new regulations have been implemented and others will follow (IMO, EU Directive, and CARB). These regulations demand reduction of SOx emissions by restricting the sulphur content of the fuel. That is to say sulphur limits for HFO as well as mandatory use of low sulphur distillate fuels for particular applications. This guideline covers the engine related aspects of the use of such fuels.

Low sulphur HFO

From an engine manufacturer's point of view there is no lower limit for the sulphur content of HFO. We have not experienced any trouble with the currently available low sulphur HFO, that are related to the sulphur content or specific to low sulphur HFO. This may change in the future if new methods are applied for the production of low sulphur HFO (desulphurization, uncommon blending components). MAN Diesel & Turbo will monitor developments and inform our customers if necessary.

If the engine is not operated permanently on low sulphur HFO, then the lubricating oil should be selected according to the highest sulphur content of the fuels in operation.

Low sulphur distillates

In general our GenSet is developed for continuous operation on HFO as well as on MDO/MGO. Occasionally changes in operation mode between HFO and MDO/MGO are considered to be within normal operation procedures for our engine types and do thus not require special precautions.

Running on low sulphur fuel (< 0.1% S) will not cause problems, but please notice the following restrictions:

In order to avoid seizure of the fuel oil injection pump components the viscosity at engine fuel oil inlet must be > 2.0 cSt. In order achieve this it may be necessary to install a fuel oil cooler, when the engine is running on MGO. This is both to ensure correct viscosity and avoid heating up the service tank, which is important as the fuel oil injection pumps are cooled by the fuel.

When operating on MDO/MGO a larger leak oil amount from fuel oil injection pumps and fuel oil injection valves can be expected compared to operation on HFO.

In order to carry out a quick change between HFO and MDO/MGO the change over should be carried out by means of the valve V1-V2 installed in front of the engine.

For the selection of the lubricating oil the same applies as for HFO. For temporary operation on distillate fuels including low sulphur distillates nothing has to be considered. A lubricating oil suitable for operation on diesel fuel should only be selected if a distillate fuel is used continuously.

Performance and condition

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Performance Data and Engine Condition

During operation small changes in the engine condition take place continuously as a result of combustion, including fouling of airways and gasways, formation of deposits, wear, corrosion, etc. If continuously recorded, these changes in the condition can give valuable information about the operational and maintenance condition of the engine. Continuous observation can contribute to forming a precise and valuable basis for evaluation of the optimum operation and maintenance programmes for the individual plant.

Engine Performance Data

If abnormal or incomprehensible deviations in operation are recorded, expert assistance in the evaluation thereof should be obtained.

We recommend taking weekly records of the most important performance data of the engine plant. During recording (working card 502-01.00 can be used) the observations are to be compared continuously in order to ascertain alterations at an early stage and before these exert any appreciable influence on the operation of the plant.

As a reference condition for the performance data, the testbed measurements of the engine or possibly the measurements taken during the sea trial on the delivery of the ship can be used. If considerable deviations from the normal conditions are observed, it will be possible, in a majority of cases, to diagnose the cause of such deviations by means of a total evaluation and a set of measurements, after which possible adjustment/overhauls can be decided on and planned.

Evaluation of Performance Data

Air Cooler

Fouling of the air side of the air cooler will manifest itself as an increasing pressure drop, lower charge air pressure and an increased exhaust/charge air temperature level (with consequential influence on the overhaul intervals for the exhaust valves).

An increase in charge air temperature involves a corresponding increase in the exhaust gas temperature level by a ratio of about 1:1.5, i.e. 1°C higher charge air temperature causes about 1.5°C higher exhaust gas temperature.

Reduction of the charge air pressure results in a corresponding reduction of the compression pressure and max. combustion pressure.

When checking the max. pressure adjustment of the engine, it is therefore to be ensured that the existing charge air pressure is correct.

Fuel Injection Pump

The amount of fuel injected is equivalent to the supplied energy and is thus an expression of the load and mean effective pressure of the engine. The fuel pump index can therefore be assumed to be proportional to the mean pressure. Consequently, it can be assumed that the connected values of the pump index are proportional to the load.

The specific fuel consumption, SFOC (measured by weight) will, on the whole, remain unchanged whether the engine is operating on HFO or on MDO, when considering the difference in calorimetric heat value. However, when operating on HFO, the combination of density and calorific value may result in a change of up to 6% in the volumetric consumption at a given load. This will result in a corresponding change in the fuel pump index, and attention should be paid to this when adjusting the overload preventive device of the engine.

To avoid overloading of the engine the charge air pressure and turbine speed recorded at the shop test should not be exceeded.

At the Power Control Synchronizing (PCS) panel in the engine control room it is possible to reduce the load by adjusting the setting for maximum MCR load limit

Abrasive particles in the fuel oil result in wear of fuel injection pumps and fuel valve nozzles. Effective treatment of the fuel oil in the purifier can keep the content of abrasive particles to a minimum. Worn fuel injection pumps will result in an increase of the index on account of an increased loss in the pumps due to leakage.

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When evaluating operational results, a distinction is to be made between changes which affect the whole engine (all cylinder units) and changes which occur in only one or a few cylinders.

Deviations occuring for a few cylinders are, as a rule, caused by malfunctioning of individual components, for example a fuel valve with a too low opening pressure, blocked nozzle holes, wear or other defects, an inlet or exhaust valve with wrongly adjusted clearance, burned valve seat, etc.

Turbochargers

Fouling of the turbine side of the turbocharger will, in its first phase, manifest itself in increasing turbocharger revolutions on account of increased gas velocity through the narrowed nozzle ring area. In the long run, the charging air quantity will decrease on account of the greater flow resistance through the nozzle ring, resulting in higher wall temperatures in the combustion chambers.

Service experience has shown that the turbine side is exposed to increased fouling when operating on HFO.

The rate of fouling and thereby the influence on the operation of the engine is greatest for small turbochargers where the flow openings between the guide vanes of the nozzle ring are relatively small. Deposits occur especially on the guide vanes of the nozzle ring and on the rotor blades. In the long run, fouling will reduce the efficiency of the turbocharger and thereby also the quantity of air supplied for the combustion of the engine. A reduced quantity of air will result in higher wall temperatures in the combustion spaces of the engine.

Detailed information and instructions regarding water washing of the turbocharger are given in the instruction manual.

Fuel Valves

Assuming that the fuel oil is purified effectively and that the engine is well-maintained, the operational conditions for the fuel valves and the overhaul intervals will not normally be altered essentially when operating on HFO.

If, for any reason, the surface temperature of the fuel valve nozzle is lower than the condensation temperature of sulphuric acid, sulphuric acid condensate can form and corrosion take place (cold corrosion). The formation of sulphuric acid also depends on the sulphur content in the fuel oil.

Normally, the fuel nozzle temperature will be higher than the approx. 180°C at which cold corrosion starts to occur.

Abrasive particles in the fuel oil involve heavier wear of the fuel valve needle, seat, and fuel nozzle holes. Therefore, abrasive particles are to the greatest possible extent to be removed at the purification.

Exhaust Valves

The overhaul intervals for exhaust valves is one of the key parameters when the reliability of the entire engine is to be judged. The performance of the exhaust valves is therefore extremely informative.

Especially under unfavourable conditions, fuel qualities with a high vanadium and sodium content will promote burning of the valve seats. Combinations of vanadium and sodium oxides with a corrosive effect will be formed during combustion. This adhesive ash may, especially in the event of increased valve temperatures, form deposits on the seats. An increasing sodium content will reduce the melting point and thereby the adhesive temperature of the ash, which will involve a greater risk of deposits. This condition will be especially unfavourable when the $\frac{na}{va}$ weight ratio increases beyond 1:3.

The exhaust valve temperature depends on the actual maintenance condition and the load of the engine. With correct maintenance, the valve temperature is kept at a satisfactory low level at all loads. The air supply to the engine (turbocharger/air cooler) and the maximum pressure adjustment are key parameters in this connection.

It is important for the functioning of the valves that the valve seats are overhauled correctly in accordance with our instructions.

The use of rotocaps ensures a uniform distribution of temperature on the valves.

Air Inlet Valves

The operational conditions of the air inlet valves are not altered substantially when using residual fuel.

Fuel Injection Pumps

Assuming effective purification of the fuel oil, the operation of the fuel injection pumps will not be very much affected.

The occurrence of increasing abrasive wear of plunger and barrel can be a consequence of insufficient purification of the fuel oil, especially if a fuel which contains residues from catalytic cracking is used. Water in the fuel oil increases the risk of cavitation in connection with pressure impulses occurring at the fuel injection pump cut-off. A fuel with a high asphalt content has deteriorating lubricating properties and can, in extreme cases, result in sticking of the fuel injection pump plungers.

Engine Room Ventilation, Exhaust System

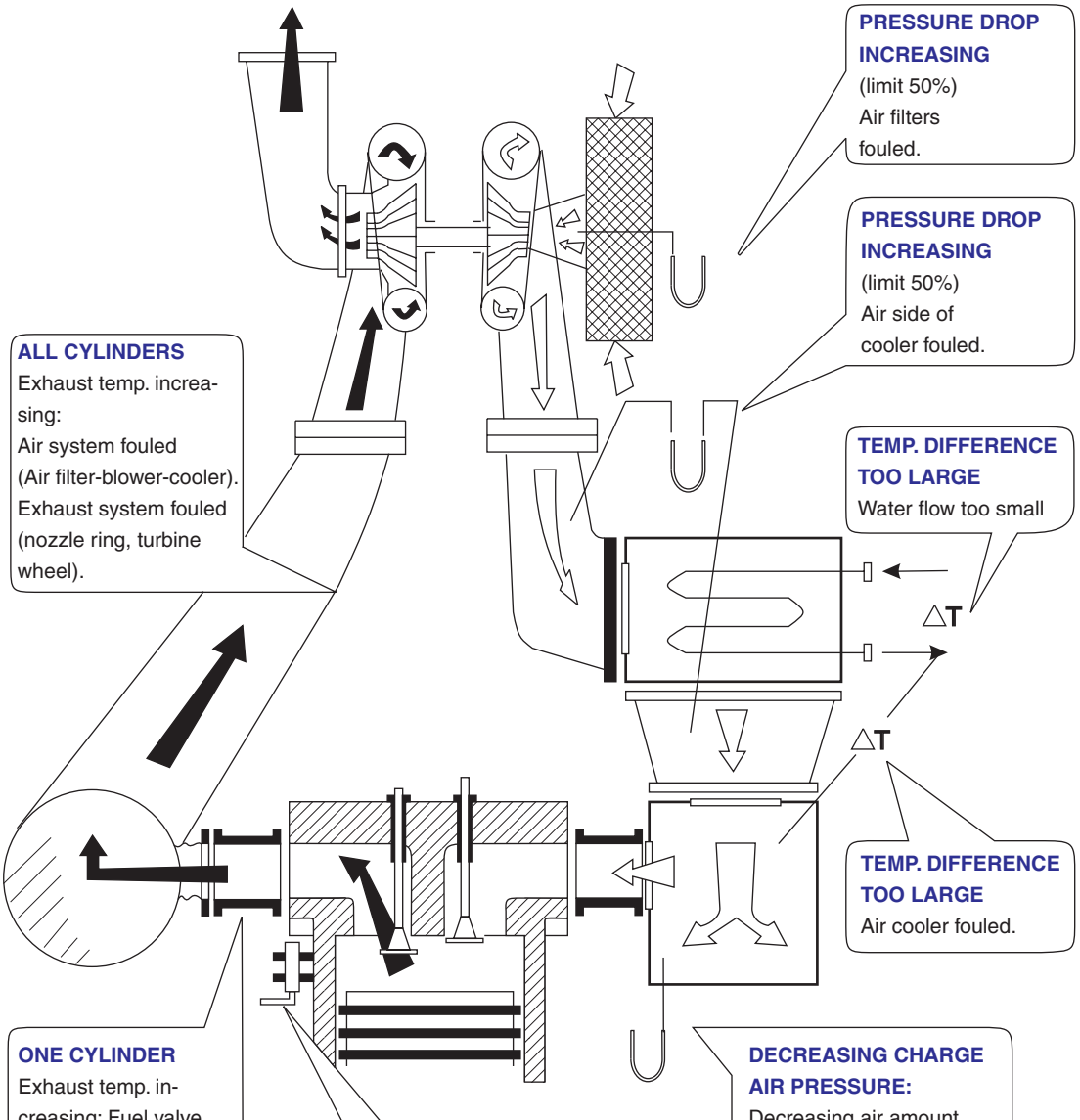
Good ventilation of the engine room and suitable location of the fresh air intake on the deck are important. Sea water in the intake air might involve corrosive attack and influence the overhaul intervals for the exhaust valves.

The fresh air supply (ventilation) to the engine room should correspond to approximately 1.5 times the air consumption of the engines and possible boilers in operation. Under-pressure in the engine room will involve an increased exhaust temperature level.

The exhaust back-pressure measured after the turbochargers at full load must not exceed 300 mm water column. An increase in the exhaust back-pressure will also cause an increased exhaust valve temperature level, and increased fuel consumption.

Description Page 1 (1)	Evaluation of Readings Regarding Combustion Condition	602.02 Edition 11H

General



Please also see Description 602.01, Engine Performance and Condition

General

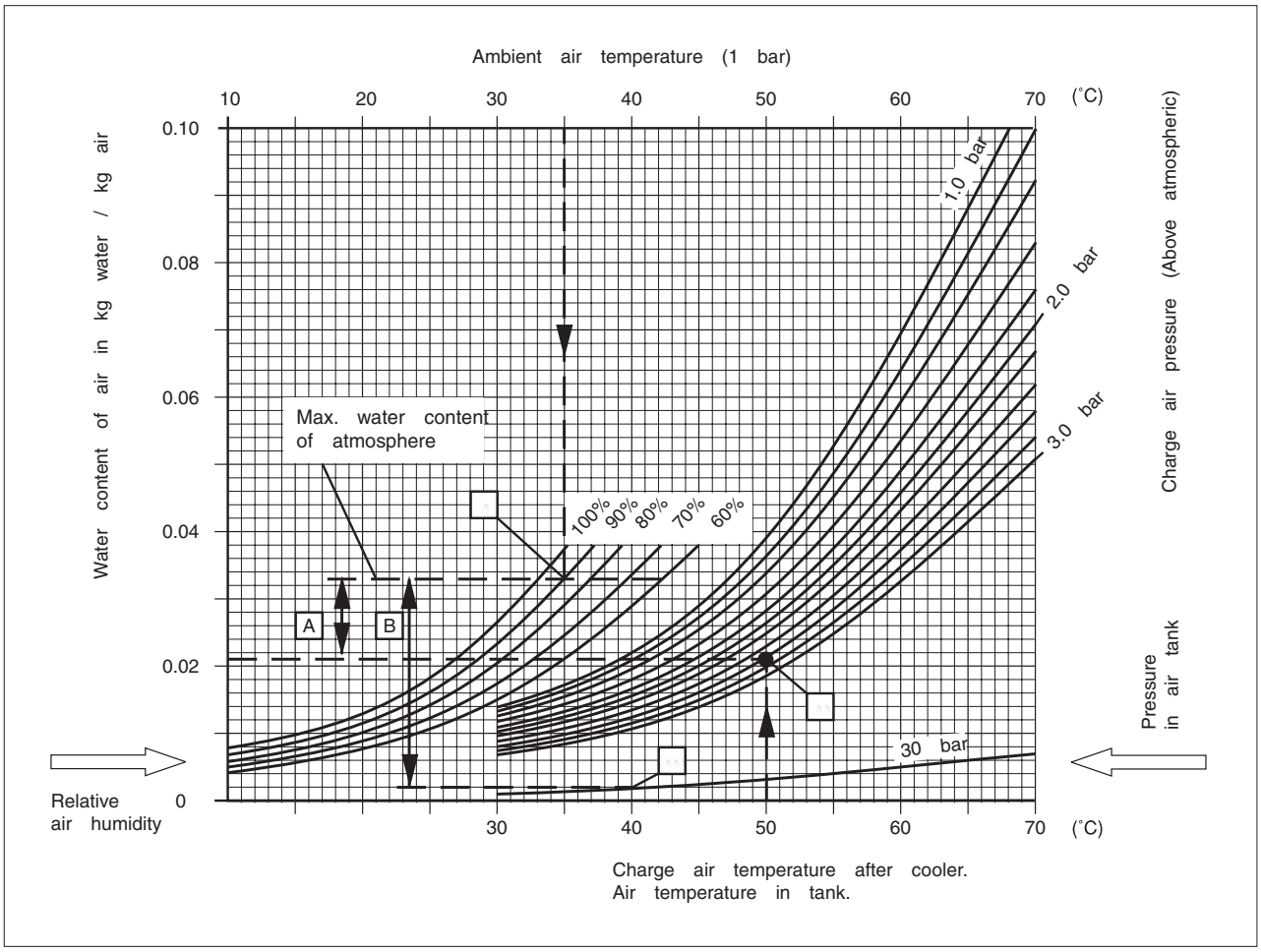


Fig. 1. Nomogram for calculation of condensate amount.

General

There is always a certain amount of water in air. When the air is saturated with aqueous vapour, the humidity is said to be 100% and there is as much water in the air as it can absorb without condensing. The amount of water in kg/kg air can be found from the diagram. The ability to absorb the water depends on the pressure and temperature of the air.

Amount of Condensation Water in The Charge Air Receiver

Both higher pressure and lower temperature reduce the ability to absorb water. A turbocharged diesel engine takes air from outside, compresses and cools the air. Then, normally, the air cannot absorb the same amount of water as before.

Condensation of water in the engine's charge air receiver is consequently dependent on the humidity and the temperature of the ambient air. To find out if condensation in the charge air receiver will occur the diagram can be used.

Example:

6L28/32H, 720 rpm (P)	1260 kW
Ambient air condition:	
air temperature	35 °C
relative air humidity	90 %
Charge air temperature	50 °C
Charge air pressure	2.6 bar

As a guidance, an air consumption of 8.2 kg/kWh (Le) at full load can be used for MAN Diesel A/S, Holeby engines.

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General

Solution according to diagram:

Water content of air (I)	0.033	kg/kg
Max. water cont. of air (II)	0.021	kg/kg

Amount of condensate in charge air recceiver.

= (I - II) x le x P
= (0.033 - 0.021) x 8.2 x 1260 = 123 kg/h

Draining of Condensation Water.

This phenomenon will occur on all turbocharged engines. For MAN B&W Holeby 4-stroke engine, there is no risk with a small amount of water in the charge air receiver. But if the charge air receiver is filled with water, there is a risk of getting water into the cylinder. This water have to be drained away. As standard a valve is mounted on the charge air receiver/cooler on the engine. This valve is to be used for draining of the water. If there is a great amount, the valve can be left half-open. If the amount is small, the charge air receiver can be drained periodically.

Amount of Condensate Water in Air Tanks.

The volume of condensate in the air tank is determined by means of the curve at the bottom to the right of the diagram, representing an operating pressure of 30 bar.

Example:

Amount of condensate in air tank.

Volumetric capacity of tank(V)	4000	dm^3
Temperature in tank (T)	40	°C=313K
Internal press. of tank (p)	30	bar
	= 31 x 10^5	N/m^2(abs.)
Gas constant for air (R)	287	Nm/kg.K
Ambient air temperature	35	°C
Relative air humidity	90	%
Weight of air in tank		

$$m = \frac{p \times V}{R \times T} = \frac{31 \times 10^5 \times 4}{287 \times 313} = 138 \text{ kg}$$

Solution acc. to above diagram:

Water content of air (I)	0.033	kg/kg
Max. water cont. of air (III)	0.0015	kg/kg

Amount of condensate in air tank

= (I - III) x m.
= (0.033 - 0.0015) x 138 = 4.35 kg.

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Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Measurements of engine performance data.

Starting position:

Engine is running.

Related procedure:

Man power:

Working time : ½ hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62005	10	Max. pressure indicator

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

Engine Performance Data

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Engine Performance Data

1	M/V	2	Engine Type	3	Engine No.	4	Date/Year	5	Hour	6	Total Engine running Hours
7	Engine RPM	8	Fuel Type Visc. Density	9	Turbocharger Type Serial No.					10	Turbocharger RPM

Switchboard

11	Effect (kW)	12	Voltage (V)	13	Current (A)	14	cos φ /kVAr

Cylinder Data

15	Cylinder No.	1	2	3	4	5	6	7	8	9	16	Ave-rage
17	Fuel Pump Index											
18	Maximum Pressure (bar)											
19	Compress. Pressure (bar)											
20	Exhaust Temp. (° C)											
21	Cooling Water (°C)											

Turbocharger

22	Temp. inlet blower (° C)	23	Pressure before blower (mmWC)	24	Temp. after blower (° C)
25	Δ Press. air cooler (mmWC)	26	Temp. charge air (° C)	27	Press. charge air (bar)
28	Temp. exhaust gas before TC (° C)	29	Temp. exhaust gas after TC (° C)	30	Press. exhaust gas after TC (mmWC)

Lubricating Oil System

31	Temp. after engine (° C)	32	Press. before filter (bar)	33	Press. after filter (bar)
34	Temp. inlet engine (° C)	35	Press. before TC (bar)	36	

Cooling Water System

37	LT temp. inlet air cooler (° C)	38	LT temp. outlet air cooler (° C)	39	LT press. inlet air cooler (bar)
40	LT temp. inlet lub. oil cooler (° C)	41	LT temp. outlet lub. oil cooler (° C)	42	LT temp. inlet alternator (° C)
43	LT temp. outlet alternator (° C)	44	HT FW temp. inlet engine (° C)	45	HT FW press. inlet engine (bar)

Fuel Oil System

46	Fuel oil temp. inlet engine (° C)	47	Fuel oil press. before engine (bar)
48	Nozz. cool. oil press. inlet engine (bar)	49	Nozz. cool. oil temp. outlet engine (° C)

50	Sign.

The Instruction for Filling in the Diagram "Engine Performance Data".

The numbers in the instruction are commensurate with the numbers on the diagram.

The automatic symbols mentioned in the instruction TI 01, TI 03, PI 01 etc, refer to the diagrams printed in the instruction books for specified plants.

Engine Performance Data.

1. Name of ship, if stationary name of plant.

2. Engine type.

3. Engine no.

4. Date/year of observations.

5. Hour, time of observations.

6. Total engine running hours - engineer's log-book.

7. Engine revolutions per minute (RPM) - can be read on tachometer SI 90.

8. Fuel oil type: The viscosity must be stated (in cSt) and the temperature by which the viscosity has been measured f.inst. 180 cSt/50°C. Density must be stated: g/cm³.

9. Turbocharger: Type and serial number are stated on the rating plate of turbocharger.

10. Turbocharger revolutions per minute (RPM) - can be read on the tachometer SI 89.

Switchboard.

11. Effect alternator (kW) - can be read on the main switchboard.

12. Voltage (V) - can be read on the switchboard.

13. Current (A) - can be read on the switchboard.

14. Cos φ/kVAr - can be read on the switchboard.

Cylinder Data.

15. Cylinder no. - can be read on engine plate. A/B is used for V-engines.

16. Average for all engine cylinders for point: 17-18-19-20-21.

17. Fuel pump index - can be read on each of the high pressure fuel oil injection pumps.

18. Max pressure (bar) can be read for each cylinder by means of indicator or P_{max} gauge.

19. Compression pressure (bar) - can be read for each cylinder by means of the indicator measurement, which is carried out during idling by nominal RPM.

20. Exhaust temperature (°C)
- Thermometer TI 60.

21. Water outlet cylinder (°C) (jacket cooling)
- Thermometer TI 11.

Turbocharger.

22. Thermometer inlet blower (°C) can be read by means of a thermometer placed in the engine room near the air filter of the TC.

23. Pressure before blower (mmWC) - can be read by means of a mmWC instrument placed in the engine room near the TC.

24. Temperature after blower (°C) - can be read by means of a thermometer TI 30.

25. Δ Pressure air cooler (mm/WC).

26. Charge air temperature (°C). Temperature of the charge air in the charge air receiver.
- Thermometer TI 31.

27. Pressure charge air (bar). Pressure of the charge air in the charge air receiver.
- Pressure gauge PI 31.

28. Tempereture of the exhaust gas before TC (°C) - Thermometer TI 62.

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29. Temperature of the exhaust gas after TC (°C)
- Thermometer TI 61.

30. Pressure of the exhaust gas after the TC (bar)
- Pressure gauge PI 61.

Lubricating Oil System.

31. Temperature of the lub. oil inlet cooler (°C)
- Thermometer TI 20.

32. Pressure of the lub. oil before the filter (bar)
- Pressure gauge PI 21.

33. Pressure of the lub. oil after the filter (bar)
- Pressure gauge PI 22.

The filter element should be replaced with a pressure drop across the filter of 1.5 bar.

34. Temperature of the lub. oil inlet engine (°C)
- Thermometer TI 22.

35. Pressure of the lub. oil before the turbocharger (bar).
- Pressure gauge PI 23.

Cooling Water System.

37. Temperature of low temperature (LT) cooling water (sea, raw or fresh) at inlet charge air cooler (°C)
- Thermometer TI 01.

38. Temperature of low temperature (LT) cooling water (sea, raw or fresh) at outlet charge air cooler (°C)
- Thermometer TI 02.

39. Pressure of the low temperature (LT) cooling water (sea, raw or fresh) at inlet charge air cooler (bar)
- Pressure gauge PI 01.

40. Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at inlet lub. oil cooler (°C)
- Thermometer TI 07.

41. Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at outlet lub. oil cooler °C)
- Thermometer TI 03.

42. Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at inlet alternator (°C)
- Thermometer TI 04.

43. Temperature of the low temperature (LT) cooling water (sea, raw or fresh) at outlet alternator (°C)
- Thermometer TI 05.

44. Temperature of the high temperature (HT) fresh water (FW) at inlet engine (°C)
- Thermometer TI 10.

45. Pressure of the high temperature (HT) fresh water (FW) of outlet engine (°C)
- Thermometer TI 10.

Fuel Oil System.

46. Temperature of the fuel oil at inlet engine (°C)
- Thermometer TI 40.

47. Pressure of the fuel oil before engine (bar)
- Pressure gauge PI 40.

48. Nozzle cooling oil pressure at inlet engine (bar)
- Pressure gauge PI 50.

49. Nozzle cooling oil pressure at outlet engine (bar)
- Pressure gauge PI 51.

50. Signature.

Trouble shooting

503/603

General

Trouble	Possible cause	Trouble shooting
Engine turns as soon as shut-off valve is opened, without start but-ton being activated	Faults in electrical system	Check electrical parts
Engine does not turn when start button is activated	Air pressure in starting air receiver too low	Start compressors, re-charge air receiver
	Main valve(s) closed	Open valve at receiver and stop valve interposed in line between receiver and engine
	Pinion does not engage the fly wheel	Check the air starter for broken clutch jaws or other broken parts
	Air motor runs, pinion engages but does not rotate	Check the air motor for broken shafting, bearing or clutch jaws
	Faults in electrical system	Check electrical parts
Engine turns too slowly or irregularly when start but-ton is depressed	Worn air motor parts	Remove and disassemble the air motor. Examine all parts and re-place any that are worn or damag-ed. Use the guidelines for determi-ning unserviceable parts
	Start valve is sticking in close position	Check start valve

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Trouble	Possible cause	Trouble shooting
Engine turns on starting air, but ignition fails. Fuel pumps are not actuated	Sluggish movement of manoeuvring gear	Lubricate and mobilize rod connections in manoeuvring gear
	Governor setting incorrect	Adjust governor, see special instruction manual
	Overspeed or another shutdown function is activated	Cancel shutdown function
	Piston in Lambda controller is actuated	Check that piston is not sticking. Check that pressure in cylinder is relieved. Check that the overspeed trip is not actuated.
	Piston in Lambda controller is actuated owing to uncancelled shutdown function (1)	Check pressures and tempera-tures. Check for faults in shut-down devices
	Failures in governor	Check that governor is working properly. For further fault location, see special instr. manual
	Incorrect adjustment of manoeuvring gear	Check rod connec. Check that fuel pump index is corresponding to "Adjustments after trials" in testbed chart
Engine turns on starting air, but no fuel is injected owing to failures in fuel system	Incorrect adjustment of limiter cylinder	Adjust setting of limiter cylinder
	Fuel oil service tank empty	Pump oil into the tank
	Air in fuel pumps and fuel injection valves (2)	Vent the fuel pumps unitl fuel with-out air bubbles appears. If ignition fails in just one cyl., vent the re-spective fuel injection valve. If igni-tion still fails, install a spare valve before attempting to start the engi-ne again.
	Worn-out fuel pump	Change fuel pumps
	Defective fuel injection valves or valve nozzles (4)	Change defective fuel valves
	Too low pressure before fuel injection pumps (3)	Increase the fuel oil feed pump pressure
Engine turns on starting air, fuel is injected, but ignition fails	Water in the fuel	Drain off water and repeat venting of fuel pumps
	Fuel valves or nozzles defective (4)	Change defective fuel valves, see Working Card 614-01.10.

Cont.

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Trouble	Possible cause	Trouble shooting
	Compression during start too low (5)	Check intake and exhaust valve for tight closing. Check cyl. wear and piston rings
	Incorrect timing of camshaft (6)	Check fuel pump timing advance, and fuel valve opening pressure as well as camshat adjustment
First ignitions are too violent (safety valves are opening). Engine runs erratically	Oil has collected on piston crown (7)	Slow turning with open indicator valves, to locate defective fuel valve, remove oil
	Sluggish movement of manoeuvring gear	Lubricate and mobilize rod connections and bearings in manoeuvring gear
	Fuel pump index to high	Check rod connection in manoeuvring gear. Check that governor is working properly. Limiter cylinder to be set lower

Remarks

1) If the shut-down function is due to overspeed, the shut-down activation is cancelled by resetting the overspeed device and thus venting the Lambda controller/air cylinder.

2) Whether air is present in the fuel oil system is seen be repeating the venting of fuel pumps. The cause may be that a fuel valve is kept in open position (spindle sticking or spring broken). Heating of fuel to a too high temperature may have a similar effect owing to formation of gas in the fuel. If a sticking valve is found, it should be changed and overhauled. It should be cheked that no oil has collected on the piston crown. Air in the fuel oil system may also be the result of the fuel oil feed pump sucking-in air through a defective stuffing box or a leaky seal.

3) If the fuel oil pressure drops, the filter may be clogged up, or the by-pass at the feed pump may have opened.

4) If the fuel is forced into the cylinder through a defective fuel valve or through worn-out atomizer holes, no or too sluggish atomization may prevent ignition, possibly followed by too violent ignition.

5) To obtain ignition temperature in the cylinders, the compression pressure during starting should be normal, see the testbed chart. This can be checked by measuring the compression pressure during starting. Cylinders having too low compression should be inspected.

6) Major alterations of the combustion characteristics of the fuel may demand adjustment of the timing of the fuel pumps. One or more cam-shaft sections may be incorrectly fitted (after dismantling). Too high opening pressure of the fuel valves will also delay the injection.

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7) Oil on the piston crown will in most cases have leaked down from a defective fuel valve. As these oil accumulations are dangerous, the lea-kage should be found and remedied before the engine is started again.

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Trouble	Possible cause	Trouble shooting
Exhaust temperature(s) increase(s)	(All cyls.) Increased charging air temperature due to ineffective air coolers	See Working Card 612-01.00.
	(All cyls.) Fouling or air and gas passages	Reduce load and water-wash turbine. Clean air filters and coolers
	(All cyls.) Insufficient cleaning of fuel oil or changed combustion characteristics	See Description 604.25.
	(All cyls.) Wrong position of camshaft (Maladjustment)	Check P_{max}. Check camshaft adjustment
	(Single cyls.) Fuel valve or valve nozzle defective	See Working Card 614-01.10.
	(Single cyls.) Leaky exhaust valves (1)	Check the valve clearance. Replace cyl. head with defective valve
	(Single cyls.) Blow-by-leaky combustion chamber (2)	See Working Card 606-01.00.
	(Single cyls.) Damaged fuel pump cam	Check timing advance of fuel pump
Exhaust temperature(s) decrease(s)	(All cyls.) Decreased charging air temperature	Check that thermostatic valve (bypass valve) in cold water system is working properly and correctly set
	(Single cyls.) Air in fuel pump(s) and fuel injection valve(s)	Venting of fuel pump(s) until fuel without air bubbles appears. Check feed pump pressure
	(Single cyls.) Spindle in fuel valve sticking (3)	Change and overhaul defective fuel valve
	(Single cyls.) Fuel pump plunger sticking or leaking	Change fuel pump plunger/barrel assembly
Engine RPM decreases	Pressure before fuel pumps too low	Raise fuel oil feed pump pressure to normal. Check filter
	Fuel valve or fuel pump defective	Change defective valve or pump
	Water in the fuel	Drain off water and vent the fuel pumps
	Governor defective (4)	Replace defective governor
	Increased internal friction in engine (5)	See "Ignition in Crankcase"

Cont.

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Trouble	Possible cause	Trouble shooting
Engine stops	Shut-down	Check pressure and temperatures. If OK, check for faults in shut-down devices. See also Starting Failures
Smoky exhaust	Turbine RPM lagging behind engine RPM	Reasonably smoke is normal when RPM increases; no measures cal-led for. If smoky exhaust during normal running, clean turbine(s) and check valves
	Air supply too low	Fouling of air and gas passages, see section 612.
	Fuel valves or nozzles defective	See Working Card 614-01.10.
	"Trumpets" at nozzle holes. Failure of cooling (especially during hea-vy-oil operation) (6)	Overhaul fuel valves. Re-establish nozzle-cooling
Exhaust valve knocking	Adjsuting screw for valve setting loose. Push rod thrust disc da-maged	Inspect and replace defective parts as necessary
Rising cooling water temperature	Pump stopped. Increased friction (7)	Stop the engine. Check the cooling water. Find cause of increased friction and remedy fault
Lubricating oil pressure fails	Lubricating oil pump defective. (8) Filters/cooler fouled	Stop the engine. For further details, see "Ignition in crankcase"
Alternator	Short circuit	Flywheel must be dismounted and guide pin replaced

Remarks

1) This manifests itself by rise of the exhaust temperature and falling of the compression and maximum combustion pressure of the respective cylinder.

To limit the damage to the valves, these should be changed immediately, if possible, or the fuel pump of the cylinder concerned should be put out of operation by moving the index to stop and locking it in this position.

2) Blow-by means a serious danger of piston seizure, and the engine must if possible be stopped and the piston in question pulled. If this is not possible, the fuel pump index must, as described above, be moved to stop. Leaky piston rings will normally result in a heavy excess pressure in the crankcase.

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3) If this happens the fuel pump barrel and plunger must be changed, and if, to obtain full load of the respective cylinder, it is necessary to increase the fuel pump index by more than 10 index degrees, the fuel pump is in most cases worn out. Usually this is confirmed by inspection of the fuel pump plunger on which the helical cut-off edge will show a pitted and corroded area where material is plucked out. In that case the pump can be provided with a new barrel and plunger.

4) The governor will not reduce the fuel pump delivery to zero in case of, for instance, failure of the governor oil pump, but the engine speed will start fluctuating.

When the governor is defective the engine is protected against racing by the overspeed trip, i.e. the engine is stopped automatically in case of excessive speed. It is essential, therefore, that the overspeed trip is kept in perfect order. Regarding governor failure, see special instruction book.

5) Usually a bearing failure will not slow down the engine appreciably, but the seizure of a piston in the cylinder liner might do so. If a PG-governor is employed, the index will increase and exhaust temperatures rise. If such cases occur, repair is necessary before starting the engine again. Feel over and look out for oil mist.

6) If the cooling of the atomizers fails (if arranged for oil cooling) while running, carbon deposits will build up round the nozzle holes, sometimes in the shape of small cones or trumpets which causes the engine to smoke, or ot will cause sticking of the valve spindle. For this reason the nozzle cooling should be well maintained.

7) If the cooling water temperature for the entire engine has risen to 90-100° C, it should be checked - by opening the test cocks, if fitted on the discharge from cylinders - whether steam has developed. If this is the case, there is no water on the cooling surfaces, which may therefore be heated unduly. To avoid heat stresses arising in cylinder liners and cylinder heads, if the water returns too early, the engine should be stopped and left to cool, while the discharge valve is closed. After 15 minutes it is opened a little to allow the water to rise slowly in the cooling jackets. Check filling at test cocks. Make crankcase inspection to ascertain that internal water leakage has not arisen. Remember slow turning withopen indicator valves at subsequent starting-up.

8) If the lubricating oil pressure drops below the minimum mentioned in Data; Find the cause of the pressure drop and remedy the defect before re-starting the engine. Feel over 5-15-30 minutes after starting, and again when full load is obtained. See section 602.

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Cause

During running, the atmosphere in the crankcase contains the same gases (N2-O2-CO2) in the same proportions as in the ambient air, but an intense spray of coarse oil drops is flung around everywhere. If undue friction and thus heating arises between sliding surfaces, or heat is transmitted otherwise to the crankcase, the heated surface will cause evaporation of the lubricating oil splashed on to it. When the oil vapours condense they form a multitude of minute drops suspended in the atmosphere, i.e. a milky white oil mist is formed, able to nourish and spread a flame if ignited. Such ignition may be caused by the same "hot spot" which produced the oil mist. If a large quantity of oil mist has developed before ignition, the burning may cause considerable pressure rise in the crankcase, forsing the relief valves to open. In a few cases, when presumably the whole crankcase has been filled with oil mist, the consequential explosion has thrown off crankcase doors and caused fire in the engine room.

Every precaution should therefore be taken to (A) avoid "hot spots" and (B) discover oil mist in time.

A. "Hot spots" in crankcase.

Overheating of bearings is a result of too bad or failing lubrication possibly caused by pullution of the lubricating oil.

It is therefore important that the lubricating oil filtration equipment is in perfect condition. Filter cartridges must not be used again, if they have been removed from the filter. Check of the oil condition by analysis is recommended.

B. Oil mist in crankcase.

Presence of oil mist may by noted at the vent pipe, which is usually fitted to the top of the engine frame.

Measures (in case of white oil mist).

Warning: Keep away from doors and relief valves on crankcase. Do not stay unnecessarily in doorways near doors of the engine room casing.

1. Stop the engine

2. Leave the engine room. Shut doors and keep away from them. Make ready fire-fighting equipment.

Warning: Do not open crankcase until 10 minutes after stopping of the engine. When opening up, keep clear of possible flames. Do not use naked light and do not smoke.

3. Take off all doors on one side of the crankcase. Cut off starting air. Engage turning gear, if fitted.

4. Locate the hot spot. Powerful lamps should be employed at once (in explosion-proof fittings). Feel over all sliding surfaces (bearings, liners, pistons, roller guides, etc.).

Look for squeezed-out bearing metal and discoloration by heat (blistered paint, burned oil, heated steel).

5. Prevent further heating, preferably by making a permanent repair. Special attention should be given to ensure lubricating oil supply and satisfactory condition of the frictional surfaces involved. It is equally important to replace filter elements in time.

6. Start electrically driven lubricating oil pump and check oil flow from all bearings and splash pipes in crankcase while turning the engine through at least two revolutions. See Description 601.05, Point 4.1.

7. Stop and feel over. Look out for oil mist.

Especially the frictional surfaces that caused the heating should be felt over (5-15-30 minutes after starting, and again when full load is obtained). See Description 601.10, Point 2.

8. In case it has not been possible to locate the hot spot, point 7 should be intensified and repeated until the cause of the oil mist has been found and remedied. In very rare cases oil mist could be due to "atomization" of lubricating oil by the action of an air jet (for instance blow-by, or blow-by through cracked piston).

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Tabulated below are the corresponding remedial actions to be taken if the following faults are observed:

Trouble	Possible cause	Trouble shooting
Oil leakage through cover nut	Missing or damaged O-ring (see Item 29, Plate 61515)	Replace O-ring
	Seal face damaged	Replace O-ring
Excessive vibrations	Rotor out of balance owing to uneven build-up of deposit on rotor walls resulting from:	
	Missing or damaged O-ring, allowing leakage (see Item 23, Plate 61515)	Replace O-ring
	O-ring seat on rotor joint faces damaged	Replace rotor assembly
	Rotor assembly inadequately tightened	Tighten and bring to notice of maintenance staff
	Standtube incorrectly seated or damaged	Re-fit or replace if damaged
	Dirt deposit not completely removed	Clean and bring to notice of maintenance staff
	Rotor castings distorted through maltreatment	Replace rotor assembly
	Rotor assembly components fitted in wrong sequence	Follow sequence in Working Card 615-15.00 in section 615.
	Bushes loose or worn in tube assembly	Fit nes bearing tube assembly

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Trouble	Possible cause	Trouble shooting
Motor will not run.	No air supply.	Check for blockage or damage to air supply lines or tank.
	Damaged motor assembly (12).	Inspect motor assembly and power train and repair power train or replace motor assembly if necessary.
	Foreign material in motor and/or piping.	Remove motor assembly and piping and remove the blockage.
	Blocked exhaust system.	Remove housing exhaust cover (1) and check for blockage.
	Defective control or relay valve.	Replace control valve or relay valve.
Loss of power	Low air pressure to starter.	Check air supply.
	Restricted air supply line.	Check for blockage or damage to air lines.
	Relay valve malfunctioning.	Clean or replace lines or relay valve. Lubricate relay valve.
	Exhaust flow restricted.	Check for blocked or damaged piping. Clean or replace piping. Check for dirt or foreign material and clean or remove. Check for ice build-up. Melt ice and reduce moisture build-up to starter.
	Damaged motor assembly.	Replace motor assembly.
Drive (36) of (57) will not engage.	No pressure to drive housing port.	Check air supply.
	Internal drive housing ports blocked.	Remove blockage.
	Fluid in drive unit components.	Remove fluid.
	Damaged or worn piston assembly (54), o-rings or seals.	Replace damaged or worn parts.
	O-rings and seals dry.	Relubricate o-rings and seals.
Motor runs, pinion engages, but does not rotate flywheel.	Damaged or broken drive train.	Disassemble drive train and replace worn or damaged parts.
Excessive butt engagement.	Damaged drive pinion (36) or (63) or flywheel.	Inspect drive pinion and flywheel and replace if necessary.
	Damaged starter drive (36) or (57) components.	Inspect drive components and replace worn or damaged parts.

Cont. ....

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Trouble	Possible cause	Trouble shooting
	Low air pressure.	Check air supply.
	Wrong drive pinion.	Replace with proper drive pinion.
Oil blowing out of exhaust.	Oil in air supply line.	Inspect air line and remove source of oil.
	Splash deflector retaining screw (5) or pipe plug missing.	Install splash deflector retaining screw or pipe plug.
	Worn or damaged rotor seals or static o-rings.	Replace static seals on outside of motor or send motor to Inger-soll-Rand to be rebuilt.
Oil leaking from gear case (28).	Worn or damaged o-rings.	Replace o-rings.
	Loose joints.	Make sure that joints fit properly and starter assembly cap screws are tightened to 60 ft-lb (81 Nm) torque. Make sure all seals and o-rings fit and seal properly at their perimeters. If they do not replace with new seals and o-rings.
	Excessive high-speed operation.	Operate according to recommen-dations.
	High number of start cycles.	Replace worn components.
	Loose or leaking pipe plugs (10) or (11).	Tighten or replace pipe plugs using Ingersoll-Rand No SMB-441 pipe sealant.
	Splash deflector retaining screw loose or pipe plug missing.	Tighten splash deflector retaining screw or replace pipe plug.
Air or gas leakage.	Loose joints.	Make sure that joints fit properly and starter assembly cap screws are tightened to 60 ft-lb (81 Nm) torque. Make sure all seals and o-rings fit and seal properly at their perimeters. If they do not replace with new seals and o-rings.
	Excessive high-speed operation.	Operate according to recommen-dations.
	High number of start cycles.	Replace worn components.
	Loose or leaking pipe plugs.	Tighten or replace pipe plugs.
	Splash deflector retaining screw loose or pipe plug missing.	Tighten splash deflector retaining screw or replace pipe plug.

General

Description

The built-on fresh water pump in the high temperature (HT) circuit is of the centrifugal type and is mounted on the front cover of the engine and is driven through a gearing.

The pump bearings are lubricated automatically with oil from the lubricating oil system of the engine.

If the pump leaks and the shaft sealing rings are worn, it is recommended to replace the shaft seal, see work card 616-02.00.

Trouble	Possible cause	Trouble shooting
The pump does not work after start	Pump draws in air at suction side	Check packings and pipes for tightness
	The system is not filled-up	Check the level in the expansion tank
	Air cannot escape on delivery side	Vent the system
	Leaking shaft seal	Check the shaft seal
Pump capacity drops after normal operation	Air leakages of shaft seal	Overhaul the shaft seal
	Fouled impeller	Clean the impeller
Pump does not give maximum delivery	Suction valve not fully open	Open the suction valve
	Defective seals	Replace the seals
	Worn impeller and worn wear rings	Overhaul the pump

Note! Running troubles with the pump, apart from mechanical faults, are most often due to leaks in the suction line. It is essential, therefore, that all packings and gaskets are in order and that they are renewed when necessary. Even a thiny hole in the suction line will reduce the pump capacity.

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General

Trouble Shooting.

In case of damage to plates or gaskets, it will often be necessary to replace them.
First examine very carefully the external conditions around the plate heat exchanger in order to localize the cause of the damage!

In case of fatigue fracture, this will normally necessitate a replacement of all plates and gaskets - as there may be a risk of fatigue fracture in all the material.
In case of corrosion, all plates must be examined carefully!
For work to be carried out see working card 615-05.00.

Visible Leakage		
Trouble	Possible cause	Trouble shooting
Leakage.	Too high pressure.	Reduce the pressure to the correct working pressure, see page 600.30 "Operating Data & Set Points".
Leakage. (Phase 1)	Insufficient tightening	Tighten up the plate heat exchanger - however, not under the minimum dimension and never, when the plate heat exchanger is under pressure or over 40°C. If the plate heat exchanger is still leaky, procede with phase 2.
Leakage. (Phase 2)	Fouled or deformed plates. Inelastic or deformed gaskets.	Separate the plate heat exchanger and check if the plates are deformed or fouled. Check that the gaskets are elastic and non-deformed, and that the faces of the joints are clean. Replace deformed plates and gaskets, if any. Before assembling, clean very carefully all plates and gaskets. Assemble the plate heat exchanger and start it up again. **Note!** Even tiny impurities such as sand grains may cause leakage.
Leakage. (Even after tightening of the plate heat exchanger to minimum dimension)	Gaskets.	Separate the plate heat exchanger. Clean the plates very carefully. Replace the gaskets. Assemble the plate heat exchanger and start it up again.
Leakage. (Through the drain holes of the gaskets)	Defective gasket or badly corroded plate.	Separate the plate heat exchanger. Replace defective plates and gaskets, if any. Assemble the plate heat exchanger and start it up again.

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General

Non-Visible Leakage		
Trouble	Possible cause	Trouble shooting
Reduced heat transmission and/or increasing pressure drop.	Fouled plates or choked plate channels.	Separate the plate heat exchanger and check if the plates are fouled. Clean the plates very carefully. Assemble the plate heat exchanger and start it up again.
Leakage. (The fluids get mixed) (Phase 1)	Holes in plates. Corrosion or fatigue fracture.	A suspected leakage can be localized in the following way: Remove one of the lower pipe connections. Then put the opposite side under pressure. If the medium continues to run out of the lower pipe connections- after the pressure has stabilized - one or several plates are leaking. Close down the plate heat exchanger. Separate the plate heat exchanger and check the plates very carefully. Check suspected plates with a dye penetrant. Check defective plates and gaskets. Before assembling, clean all plates and gaskets. Assemble the plate heat exchanger and check to find more defective plates, if any, by putting one side under pressure. Start up again.
Leakage. (The fluids get mixed) (Phase 2)	Holes in plates. Corrosion or fatigue fracture.	Close down the plate heat exchanger. Separate the plate heat exchanger. Put all plates to dry. Suspend the plates in the plate heat exchanger again and tighten it. Circulate medium at full capacity on one plate side (every second plate channel). Keep the other plate channels unpressurised and free from liquid! Stop the circulation after a few minutes of operation and open the plate heat exchanger again. Take care to avoid water spraying onto the dry plate side! By a careful study of the plates it will be possible to find moist areas, if any, on the otherwise dry plate sides. Check these areas with a dye penetrant! Replace defective plates and gaskets. Before assembling, clean all plates and gaskets. Assemble the plate heat exchanger and check to find more defective plates, if any, by putting one side under pressure. Start up again. If the unit is still leaking, check all plates with a dye penetrant!

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Media specification

504/604

L28/32H
V28/32H

The specific output achieved by modern diesel engines combined with the use of fuels that satisfy the quality requirements more and more frequently increase the demands on the performance of the lubricating oil which must therefore be carefully selected.

Medium alkalinity lubricating oils have a proven track record as lubricants for the moving parts and turbocharger cylinder and for cooling the pistons. Lubricating oils of medium alkalinity contain additives that, in addition to other properties, ensure a higher neutralisation reserve than with fully doped engine oils (HD oils).

International specifications do not exist for medium alkalinity lubricating oils. A test operation is therefore necessary for a corresponding period in accordance with the manufacturer's instructions.

Only lubricating oils that have been approved by MAN Diesel & Turbo may be used. These are listed in the table entitled "*Lubricating oils approved for use in heavy fuel oil-operated MAN Diesel & Turbo four-stroke engines*".

Specifications

Base oil

The base oil (doped lubricating oil = base oil + additives) must have a narrow distillation range and be refined using modern methods. If it contains paraffins, they must not impair the thermal stability or oxidation stability.

The base oil must comply with the limit values in the table below, particularly in terms of its resistance to ageing:

Properties/characteristics	Unit	Test method	Limit values
Make-up	-	-	Ideally paraffin based
Low temperature behaviour, still flowable	°C	ASTM D 2500	- 15
Flash point (Cleveland)	°C	ASTM D 92	> 200
Ash content (oxidised ash)	Weight %	ASTM D 482	< 0.02
Coke residue (according to Conradson)	Weight %	ASTM D 189	< 0.50
Ageing tendency following 100 hours of heating up to 135 °C	-	MAN ageing oven *	-
insoluble n-heptane	Weight %	ASTM D 4055 or DIN 51592	< 0.2
Evaporation loss	Weight %	-	< 2
Spot test (filter paper)	-	MAN Diesel & Turbo test	Precipitation of resins orasphalt-like ageing products must not be identifiable.

Table 1 Base oils - target values

** Works' own method*

L28/32H
V28/32H

Medium-alkaline lubricating oil

The prepared oil (base oil with additives) must have the following properties:

Additives

The additives must be dissolved in the oil and their composition must ensure that as little ash as possible is left over, even if the engine is provisionally operated with distillate oil.

The ash must be soft. If this prerequisite is not met, it is likely the rate of deposition in the combustion chamber will be higher, particularly at the exhaust valves and at the turbocharger inlet casing. Hard additive ash promotes pitting of the valve seats and causes the valves to burn out, it also increases mechanical wear of the cylinder liners.

Additives must not increase the rate at which the filter elements in the active or used condition are blocked.

Washing ability

The washing ability must be high enough to prevent the accumulation of tar and coke residue as a result of fuel combustion. The lubricating oil must not absorb the deposits produced by the fuel.

Dispersibility

The selected dispersibility must be such that commercially-available lubricating oil cleaning systems can remove harmful contaminants from the oil used, i.e. the oil must possess good filtering properties and separability.

Neutralisation capability

The neutralisation capability (ASTM D2896) must be high enough to neutralise the acidic products produced during combustion. The reaction time of the additive must be harmonised with the process in the combustion chamber.

For tips on selecting the base number, refer to the table entitled "*Base number to be used for various operating conditions*".

Evaporation tendency

The evaporation tendency must be as low as possible as otherwise the oil consumption will be adversely affected.

Additional requirements

The lubricating oil must not contain viscosity index improver. Fresh oil must not contain water or other contaminants.

Lubricating Oil Selection

Engine	SAE–Class
23/30H, 28/32H, 23/30A, 28/32A At cooling water temperatures > 32° C a SAE40 oil can be used. In this case please contact MAN Diesel	30

Table 2 Viscosity (SAE class) of lube oils

Neutralisation properties (BN)

Lubricating oils with medium alkalinity and a range of neutralisation capabilities (BN) are available on the market. According to current knowledge, a relationship can be established between the anticipated operating conditions and the BN number as shown in the table entitled "*Base number to be used for various operating conditions*". However, the operating results are still the overriding factor in determining which BN number produces the most efficient engine operation.

approx. BN of fresh oil (mg KOH/g oil)	Engines / Operating conditions
20	Marine diesel oil (MDO) with a lower quality (ISO-F-DMC) or heavy fuel oil with a sulphur content of less than 0.5 %
30	generally 23/30H and 28/32H. 23/30A, 28/32A and 28/32S under normal operating conditions. For engines 16/24, 21/31, 27/38, 32/40, 32/44CR, 40/54, 48/60 as well as 58/64 and 51/60DF with exclusive HFO operation only with sulphur content < 1.5 %.
40	With unfavourable operating conditions 23/30A, 28/32A and 28/32S and also where corresponding requirements in relation to the oil service life and washing ability exist. In general 16/24, 21/31, 27/38, 32/40, 32/44CR, 40/54, 48/60 as well as 58/64 and 51/60DF with exclusive HFO operation providing the sulphur content is greater than 1.5 %.
50	32/40, 32/44CR, 40/54, 48/60 and 58/64, if the oil service life or engine cleanliness is insufficient with a BN number of 40 (high sulphur content of fuel, extremely low lubricating oil consumption).

Table 3 Base number to be used for various operating conditions

Operation with low sulphur fuel

To comply with the emissions regulations, the sulphur content of fuels used nowadays varies. Fuels with a low-sulphur content must be used in environmentally-sensitive areas (SECA). Fuels with a high sulphur content may be used outside SECA zones. In this case, the BN number of the lubricating oil selected must satisfy the requirements for operation using fuel with a high-sulphur content. A lubricating oil with low BN number may only be selected if fuel with a low-sulphur content is used exclusively during operation.

However, the results obtained in practise that demonstrate the most efficient engine operation are the factor that ultimately decides which additive fraction is permitted.

Cylinder lubricating oil

In engines with separate cylinder lubrication, the pistons and cylinder liners are supplied with lubricating oil via a separate lubricating oil pump. The quantity of lubricating oil is set at the factory according to the quality of the fuel to be used and the anticipated operating conditions.

Use a lubricating oil for the cylinder and lubricating circuit as specified above.

Speed controller

Multigrade oil 5W40 should ideally be used in mechanical-hydraulic controllers with a separate oil sump. If this oil is not available when filling, 15W40 oil can be used instead in exceptional cases. In this case, it makes no difference whether synthetic or mineral-based oils are used.

The military specification for these oils is O-236.

Lubricating oil additives

The use of other additives with the lubricating oil, or the mixing of different brands (oils by different manufacturers), is not permitted as this may impair the performance of the existing additives which have been carefully harmonised with each another and also specifically tailored to the base oil.

Selection of lubricating oils / warranty

The majority of mineral oil companies are in close regular contact with engine manufacturers and can therefore provide information on which oil in their specific product range has been approved by the engine manufacturer for the particular application. Irrespective of the above, lubricating oil manufacturers are liable in any case for the quality and characteristics of their products. If you have any questions, we will be happy to provide you with further information.

L28/32H
V28/32H

Oil during operation

There are no prescribed oil change intervals for MAN Diesel & Turbo medium speed engines. The oil properties must be regularly analysed. The oil can be used for as long as the oil properties remain within the defined limit values (see table entitled "Limit values for used lubricating oil"). An oil sample must be analysed every 1-3 months (see maintenance schedule). The quality of the oil can only be maintained if it is cleaned using suitable equipment (e.g. a separator or filter).

Temporary operation with gas oil

Due to current and future emission regulations, heavy fuel oil cannot be used in designated regions. Low-sulphur diesel fuel must be used in these regions instead.

If the engine is operated with low-sulphur diesel fuel for less than 1000 h, a lubricating oil which is suitable for HFO operation (BN 30 – 40 mg KOH/g) can be used during this period.

If the engine is operated provisionally with low-sulphur diesel fuel for more than 1000 h and is subsequently operated once again with HFO, a lubricating oil with a BN of 20 must be used. If the BN 20 lubricating oil by the same manufacturer as the lubricating oil used for HFO operation with higher BN (30 or 40), an oil change will not be required when effecting the changeover. It will be sufficient to use BN 20 oil when replenishing the used lubricating oil.

If you wish to operate the engine with HFO once again, it will be necessary to change over in good time to a lubricating oil with a higher BN (30 – 40). If the lubricating oil with higher BN is by the same manufacturer as the BN 20 lubricating oil, the changeover can also be effected without an oil change. In doing so, the lubricating oil with higher BN (30 – 40) must be used to replenish the used lubricating oil roughly 2 weeks prior to resuming HFO operation.

	Limit value	Procedure
Viscosity at 40 °C	75-160 mm^2/s	ISO 3104 or ASTM D 445
Base Number (BN)	at least 50% of fresh oil	ISO 3771
Flash Point (PM)	at least 185 °C	ISO 2719
Water Content	max. 0.2% (max. 0.5% for brief periods)	ISO 3733 or ASTM D 1744
n-Heptan Insoluble	max. 1.5%	DIN 51592 or IP 316
Metal Content	depends on engine type and operating conditions	
Guide value only Fe Cr Cu Pb Sn Al	 max. 50 ppm max. 10 ppm max. 15 ppm max. 20 ppm max. 10 ppm max. 20 ppm	

Table 4 Limit values for used lubricating oil

Examinations

We can analyse heavy fuel oil for customers at our laboratory. A 0.5 l sample is required for the test.

Note!
No liability when using these oils

MAN Diesel & Turbo does not assume liability for problems that occur when using these oils.

Manufacturer	Base Number [mg KOH/g]		
	20	30	40
AGIP	-	Cladium 300 - SAE30	Cladium 400 - SAE30
BP	Energol IC-HFX 203	Energol IC-HFX 303	Energol IC-HFX 403
CASTROL	TLX Plus 203	TLX Plus 303	TLX Plus 403
CEPSA	-	Troncoil 3030 Plus	Troncoil 4030 Plus
CHEVRON (TEXACO, CALTEX)	Taro 20DP30 Taro 20DP30X	Taro 30DP30 Taro 30DP30X	Taro 40XL 30 Taro 40XL30X
EXXON MOBIL	-	Mobilgard M330 EXXMAR 30 TP 30	Mobilgard M340 EXXMAR 40 TP 30
PETROBRAS	Marbrax CCD-320	Marbrax CCD-330	Marbrax CCD-340
REPSOL	Neptuno NT 2030	Neptuno NT 3030	Neptuno NT 4030
SHELL	Argina S 30	Argina T 30	Argina X 30
TOTAL Lubmarine	-	Aurelia XL 3030 Aurelia TI 3030	Aurelia XL 3040 Aurelia TI 3040

Table 5 Approved lubricating oils for heavy fuel oil-operated MAN Diesel & Turbo four-stroke engines.

L28/32H
V28/32H

The specific output achieved by modern diesel engines combined with the use of fuels that satisfy the quality requirements more and more frequently increase the demands on the performance of the lubricating oil which must therefore be carefully selected.

Doped lubricating oils (HD oils) have a proven track record as lubricants for the drive, cylinder, turbocharger and also for cooling the piston. Doped lubricating oils contain additives that, amongst other things, ensure dirt absorption capability, cleaning of the engine and the neutralisation of acidic combustion products.

Only lubricating oils approved by MAN Diesel may be used. These are listed in the tables below.

Specifications

Base oil

The base oil (doped lubricating oil = base oil + additives) must have a narrow distillation range and be refined using modern methods. If it contains paraffins, they must not impair the thermal stability or oxidation stability.

The base oil must comply with the following limit values, particularly in terms of its resistance to ageing.

Properties/characteristics	Unit	Test method	Limit values
Make-up	-	-	Ideally paraffin based
Low temperature behaviour, still flowable	°C	ASTM D 2500	- 15
Flash point (Cleveland)	°C	ASTM D 92	> 200
Ash content (oxidised ash)	Weight %	ASTM D 482	< 0.02
Coke residue (according to Conradson)	Weight %	ASTM D 189	< 0.50
Ageing tendency following 100 hours of heating up to 135 °C	-	MAN ageing oven *	-
insoluble n-heptane	Weight %	ASTM D 4055 or DIN 51592	< 0.2
Evaporation loss	Weight %	-	< 2
Spot test (filter paper)	-	MAN Diesel test	Precipitation of resins or asphalt-like ageing products must not be identifiable.

Table 1 Base oils - target values
** Works' own method*

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Doped lubricating oils (HD-oils)

The base oil to which the additives have been added (doped lubricating oil) must have the following properties:

Additives

The additives must be dissolved in the oil and their composition must ensure that as little ash as possible remains following combustion.

The ash must be soft. If this prerequisite is not met, it is likely the rate of deposition in the combustion chamber will be higher, particularly at the exhaust valves and at the turbocharger inlet casing. Hard additive ash promotes pitting of the valve seats and causes the valves to burn out, it also increases mechanical wear of the cylinder liners.

Additives must not increase the rate at which the filter elements in the active or used condition are blocked.

Washing ability

The washing ability must be high enough to prevent the accumulation of tar and coke residue as a result of fuel combustion.

Dispersibility

The selected dispersibility must be such that commercially-available lubricating oil cleaning systems can remove harmful contaminants from the oil used, i.e. the oil must possess good filtering properties and separability.

Neutralisation capability

The neutralisation capability (ASTM D2896) must be high enough to neutralise the acidic products produced during combustion. The reaction time of the additive must be harmonised with the process in the combustion chamber.

Evaporation tendency

The evaporation tendency must be as low as possible as otherwise the oil consumption will be adversely affected.

Additional requirements

The lubricating oil must not contain viscosity index improver. Fresh oil must not contain water or other contaminants.

Lubricating Oil Selection

Engine	SAE–Class
23/30H, 28/32H, 23/30A, 28/32A At cooling water temperatures > 32° C a SAE40 oil can be used. In this case please contact MAN Diesel	30

Table 2 Viscosity (SAE class) of lube oils

Doped oil quality

We recommend doped lubricating oils (HD oils) according to international specifications MIL-L 2104 or API-CD with a base number of BN 10 – 16 mgKOH/g. Military specification O-278 lubricating oils can be used.

The operating conditions of the engine and the quality of the fuel determine which additive fractions the lubricating oil contains. If marine diesel oil with a sulphur content of up to 2.0 % by weight according to ISO-F-DMC and coke residues of up to 2.5 % by weight is used, you should choose a base number of roughly 20. However, the operating results that ensure the most efficient engine operation ultimately decide the additive content.

Cylinder lubricating oil

In engines with separate cylinder lubrication, the pistons and cylinder liners are supplied with lubricating oil via a separate lubricating oil pump. The quantity of lubricating oil is set at the factory according to the quality of the fuel to be used and the anticipated operating conditions.

Use a lubricating oil for the cylinder and lubricating circuit as specified above.

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Speed controller

Multigrade oil 5W40 should ideally be used in mechanical-hydraulic controllers with a separate oil sump. If this oil is not available when filling, 15W40 oil can be used instead in exceptional cases. In this case, it makes no difference whether synthetic or mineral-based oils are used.

The military specification for these oils is O-236.

Lubricating oil additives

The use of other additives with the lubricating oil, or the mixing of different brands (oils by different manufacturers), is not permitted as this may impair the performance of the existing additives which have been carefully harmonised with each another and also specifically tailored to the base oil.

Selection of lubricating oils / warranty

The majority of mineral oil companies are in close regular contact with engine manufacturers and can therefore provide information on which oil in their specific product range has been approved by the engine manufacturer for the particular application. Irrespective of the above, lubricating oil manufacturers are liable in any case for the quality and characteristics of their products. If you have any questions, we will be happy to provide you with further information.

Oil during Operation

There are no prescribed oil change intervals for MAN Diesel medium speed engines. The oil properties must be regularly analysed. The oil can be used for as long as the oil properties remain within the defined limit values (see table entitled "Limit values for used lubricating oil“). An oil sample must be analysed every 1-3 months (see maintenance schedule). The quality of the oil can only be maintained if it is cleaned using suitable equipment (e.g. a separator or filter).

Temporary operation with gas oil

Due to current and future emission regulations, heavy fuel oil cannot be used in designated regions. Low-sulphur diesel fuel must be used in these regions instead.

If the engine is operated with low-sulphur diesel fuel for less than 1000 h, a lubricating oil which is suitable for HFO operation (BN 30 – 40 mg KOH/g) can be used during this period.

If the engine is operated provisionally with low-sulphur diesel fuel for more than 1000 h and is subsequently operated once again with HFO, a lubricating oil with a BN of 20 must be used. If the BN 20 lubricating oil by the same manufacturer as the lubricating oil used for HFO operation with higher BN (30 or 40), an oil change will not be required when effecting the changeover. It will be sufficient to use BN 20 oil when replenishing the used lubricating oil.

If you wish to operate the engine with HFO once again, it will be necessary to change over in good time to a lubricating oil with a higher BN (30 – 40). If the lubricating oil with higher BN is by the same manufacturer as the BN20 lubricating oil, the changeover can also be effected without an oil change. In doing so, the lubricating oil with higher BN (30 – 40) must be used to replenish the used lubricating oil roughly 2 weeks prior to resuming HFO operation.

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L28/32H
V28/32H

Tests

We can analyse heavy fuel oil for customers at our laboratory. A 0.5 l sample is required for the test.

Danger!

Improper handling of fuels

If fuels are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the fuel supplier must be observed.

Note!

No liability assumed if these oils are used

MAN Diesel SE will not assume liability for any problems associated with using these oils.

Approved lubricating oils SAE 30	
Manufacturer	Base Number 10-16[1] [mgKOH/g]
AGIP	Cladium 120 - SAE 30 Sigma S SAE 30 [2]
BP	Energol DS 3-153
CASTROL	Castrol MLC 30 Castrol MHP 153 Seamax Extra 30
CHEVRON (Texaco, Caltex)	Taro 12 XD 30 Delo 1000 Marine SAE 30 Delo SHP30
EXXON MOBIL	Exxmar 12 TP 30 Mobilgard 312 Mobilgard ADL 30 [2] Delvac 1630
PETROBRAS	Marbrax CCD-310
Q8	Mozart DP30
REPSOL	Neptuno NT 1530
SHELL	Gadinia 30 Gadinia AL30 Sirius FB30 [2] Sirius/Rimula X30 [2]
STATOIL	MarWay 1530 MarWay 1030
TOTAL Lubmarine	Disola M3015

Table 3 Lubricating oils (SAE30) which have been approved for the use in MAN Diesel four-stroke engines running on gas oil and Diesel oil

[1] If marine diesel oil with a low quality (ISO-F-DMC) is used, a base number (BN) of roughly 20 should be used.
[2] with a sulphur content of less than 1%

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	Limit value	Procedure
Viscosity at 40 °C	75-160 mm^2/s	ISO 3104 or ASTM D445
Base Number (BN)	at least 50% of fresh oil	ISO 3771
Flash Point (PM)	at least 185 °C	ISO 2719
Water Content	max. 0.2% (max. 0.5% for brief periods)	ISO 3733 or ASTM D 1744
n-Heptan Insoluble	max. 1.5%	DIN 51592 or IP 316
Metal Content	depends on engine type and operating conditions	
Guide value only Fe Cr Cu Pb Sn Al	 max. 50 ppm max. 10 ppm max. 15 ppm max. 20 ppm max. 10 ppm max. 20 ppm	
When operating with biofuels: biofuel fraction	max 12%	FT-IR

Table 4 Limit values for used lubricating oil

L32/40, L28/32H, V28/32H

General

During operation of trunk engines the lubricating oil will gradually be contaminated by small particles originating from the combustion.

Engines operated on heavy fuels will normally increase the contamination due to the increased content of carbon residues and other contaminants.

Contamination of lubricating oil with either freshwater or seawater can also occur.

A certain amount of contaminants can be kept suspended in the lubricating oil without affecting the lubricating properties.

The condition of the lubricating oil must be kept under observation (on a regular basis) by analyzing oil samples. *See Section 504.04 "Criteria for Cleaning/Exchange of Lubricating Oil"*.

The moving parts in the engine are protected by the built-on duplex full-flow lubricating oil filter. The replaceable paper filter cartridges in each filter chamber have a fineness of 10-15 microns. The safety filter, at the centre of each filter chamber, is a basket filter element, with a fineness of 60 microns (sphere passing mesh).

The pressure drop across the replaceable paper filter cartridges is one parameter indicating the contamination level. The higher the dirt content in the oil, the shorter the periods between filter cartridge replacement and cleaning.

The condition of the lubricating oil can be maintained / re-established by exchanging the lubricating oil at fixed intervals or based on analyzing oil samples.

Operation on Marine Diesel Oil (MDO) & Marine Gas Oil (MGO)

For engines exclusively operated on MDO/MGO we recommend to install a built-on centrifugal bypass filter as an additional filter to the built-on full flow depth filter.

It is advisable to run bypass separators continuously for engines operated on MDO/MGO as separators present the best cleaning solution. Mesh filters have the disadvantage that they cannot remove water and their elements clog quickly.

Operation on Heavy Fuel Oil (HFO)

HFO-operated engines require effective lubricating oil cleaning. In order to ensure a safe operation it is necessary to use supplementary cleaning equipment together with the built-on full flow depth filter.

It is mandatory to run bypass separators continuously for engines operated on HFO, as an optimal lubricating oil treatment is fundamental for a reliable working condition. Therefore it is mandatory to clean the lubricating oil with a bypass separator, so that the wear rates are reduced and the lifetime of the engine is extended.

Bypass equipment

As a result of normal operation, the lubricating oil contains abraded particles and combustion residues which have to be removed by the bypass cleaning system and to a certain extent by the duplex full-flow lubricating oil filter as well.

With automatic mesh filters this can result in an undesirable and hazardous continuous flushing. In view of the high cost of cleaning equipment for removing micro impurities, this equipment is only rated for a certain proportion of the oil flowing through the engine since it is installed in a bypass.

The bypass cleaning equipment is operated

- continuously when the engine is in operation or at standstill

For cleaning of lubricating oil the following bypass cleaning equipment can be used:

- Separator unit
- Decanter unit
- Self cleaning automatic bypass mesh filter
- Centrifugal bypass filter (Holeby Gensets can be delivered with this built-on filter)
- Bypass depth filter

The separator unit, decanter unit, the self-cleaning automatic bypass mesh filter and the bypass depth filter capacity must be adjusted according to maker's recommendations.

In case full flow filtration equipment is chosen, this must only be installed as in-line cleaning upstream to the duplex full-flow lubricating oil filter, built onto the engine.

L32/40, L28/32H, V28/32H

The most appropriate type of equipment for a particular application depends on the engine output, the type and amount of combustion residues, the annual operating time and the operating mode of the plant. Even with a relatively low number of operating hours there can be a great deal of combustion residues if, for instance, the engine is inadequately preheated and quickly accelerated and loaded.

Separator

Continuous lubricating oil cleaning during engine operation is mandatory. An optimal lubricating oil treatment is fundamental for a reliable working condition of the engine.

If the lubricating oil is circulating without a separator in operation, the lubricating oil will gradually be contaminated by products of combustion, water and/or acid. In some instances cat-fines may also be present.
In order to prolong the lubricating oil lifetime and remove wear elements, water and contaminants from the lubricating oil, it is mandatory to use a by-pass separator.
The separator will reduce the carbon residue content and other contaminants from combustion on engines operated on HFO, and keep the amount within MDT's recommendation, on condition that the separator unit is operated according to maker's recommendations.

When operating a cleaning device, the following recommendations must be followed:

- The optimum cleaning effect is achieved by keeping the lubricating oil in a state of low viscosity for a long period in the separator bowl.
- Sufficiently low viscosity is obtained by preheating the lubricating oil to a temperature of 95°C - 98°C, when entering the separator bowl.
- The separator unit capacity must be adjusted according to maker's recommendations.

Slow passage of the lubricating oil through the separator is obtained by using a reduced flow rate and by operating the separator 24 hours a day, stopping only for maintenance, according to maker's recommendation.

Lubricating oil preheating

The installed heater on the separator unit ensures correct lubricating oil temperature during separation. When the engine is at standstill, the heater can be used for two functions:

- The oil in the sump can be preheated to 95 – 98 °C by the heater and cleaned continuously by the separator.
- The heater can also be used to maintain an oil temperature of at least 40 °C, depending on installation of the lubricating oil system.

Cleaning capacity

Normally, it is recommended to use a self-cleaning filtration unit in order to optimize the cleaning period and thus also optimize the size of the filtration unit. Separators for manual cleaning can be used when the reduced effective cleaning time is taken into consideration by dimensioning the separator capacity.

The required flow

In order to calculate the required lubricating oil flow through the separator, the separator maker's recommendation must be followed.

As a guidance, the following formula should form the basis for choosing the required flow for the separator capacity:

$$\frac{Q}{T} = P \times 1.36 \times n$$

Q = required flow (l/h)

P = engine output kW)

t = actual effective separator operating time per day (hour)

n = number of turnovers per day of the theoretical oil volume corresponding to 1.36 l/kW or 1 l/HP

The following values for "n" are recommended:

n = 5 for HFO operation (residual)

n = 4 for MDO operation

n = 3 for distillate fuel

Example 1
For multi-engine plants, one separator per engine in operation is recommended.

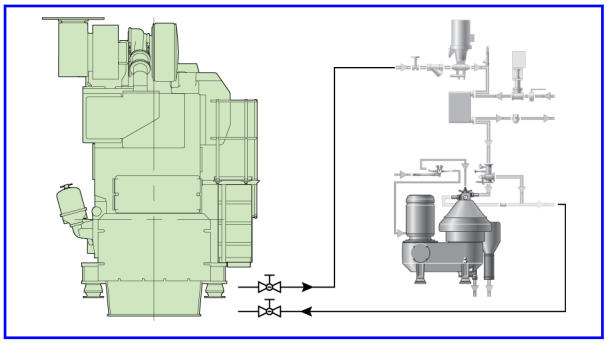

Figure 1: Example 1

One 1000 kW engine operating on HFO connected to a self-cleaning separator with a daily effective separating period of 23 hours:

$$Q = \frac{1000 \times 1.36 \times 5}{23} = 296 \text{ l/h}$$

Example 2
As alternative one common separator can be installed, with one in reserve if possible, for multi-engine plants.

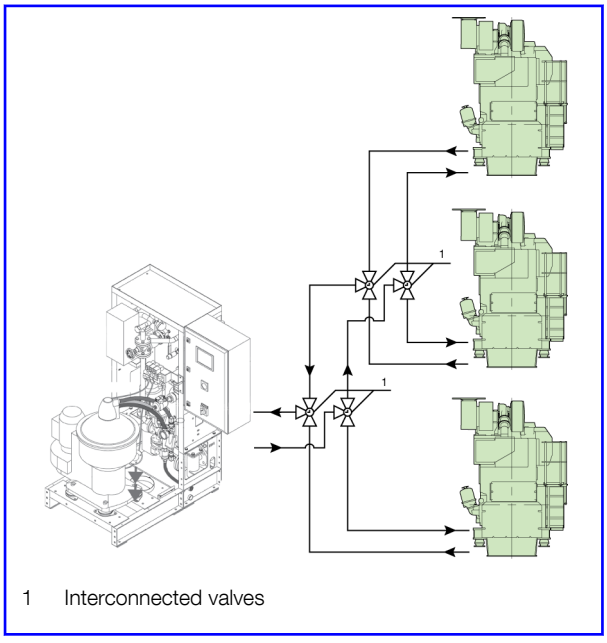

Figure 2: Example 2

Three 1000 kW engines operating on HFO connected to a common self-cleaning separator with a daily effective separating period of 23 hours:

$$Q = \frac{3000 \times 1.36 \times 5}{23} = 887 \text{ l/h}$$

Separator installation

With multi-engine plants, one separator per engine in operation is recommended, but if only one separator is in operation, the following layout can be used:

- A common separator can be installed, with one in reserve if possible for operation of all engines through a pipe system, which can be carried out in various ways. The aim is to ensure that the separator is only connected to one engine at a time. This to ensure that there is no suction and discharging from one engine to another.

It is recommended that inlet and outlet valves are connected, so that they can only be changed over simultaneously.

With only one engine in operation there are no problems with separating, but if several engines are in operation for some time it is recommended to split up the time so that there is separation on all engines, which are operating in turns.

The capacity of the separator has to correspond with the separating of oil on the single engine n times during the available time, every 24 hours. See section regarding required flow.

Check of lubricating oil system

For cleaning of the lubricating oil system after overhauls and inspection of the lubricating oil piping system the following checks must be carried out:

1. Examine the piping system for leaks.
2. Retighten all bolts and nuts in the piping system.
3. Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.
4. Blow through drain pipes.
5. Check flexible connections for leaks and damages.
6. Check manometers and thermometers for possible damages.

L32/40, L28/32H, V28/32H

Deterioration of oil

Oil seldomly loses its ability to lubricate, i.e. to form a friction-decreasing oil film, but it may become corrosive to the steel journals of the bearings in such a way that the surface of these journals becomes too rough and wipes the bearing surface.

In that case the bearings must be renewed, and the journals must also be polished. The corrosiveness of the lubricating oil is either due to far advanced oxidation of the oil itself (TAN) or to the presence of inorganic acids (SAN). In both cases the presence of water will multiply the effect, especially sea water as the chloride ions act as an inorganic acid.

Signs of deterioration

If circulating oil of inferior quality is used and the oxidative influence becomes grave, prompt action is necessary as the last stages in the deterioration will develop surprisingly quickly, within one or two weeks. Even if this seldomly happens, it is wise to be acquainted with the signs of deterioration.

These may be some or all of the following:

- Sludge precipitation in the separator multiplies
- Smell of oil becomes acrid or pungent
- Machined surfaces in the crankcase become coffee-brown with a thin layer of lacquer
- Paint in the crankcase peels off or blisters
- Excessive carbon is formed in the piston cooling chamber

In a grave case of oil deterioration the system must be cleaned thoroughly and refilled with new oil.

Oxidation of oils

At normal service temperature the rate of oxidation is insignificant, but the following factors will accelerate the process:

High temperature
If the coolers are ineffective, the temperature level will generally rise. A high temperature will also arise in electrical pre-heaters if the circulation is not continued for 5 minutes after the heating has been stopped, or if the heater is only partly filled with oil.

Catalytic action
Oxidation of the oil will be accelerated considerably if catalytic particles are present in the oil. Wear particles of copper are especially harmful, but also ferrous particles and rust are active. Furthermore, the lacquer and varnish oxidation products of the oil itself have an accelerating effect. Continuous cleaning of the oil is therefore important to keep the sludge content low.

Water washing

Water washing of HD oils (heavy duty) must not be carried out.

Water in the oil

If the TAN is low, a minor increase in the fresh water content of the oil is not immediately detrimental while the engine is in operation. Naturally, it should be brought down again as quickly as possible (below 0.2% water content, which is permissible, *see description "B 12 15 0/504.04 criteria for exchange of lube oil*"). If the engine is stopped while corrosion conditions are unsatisfactory, the crankshaft must be turned ½ - ¾ revolution once every hour. Please make sure that the crankshaft stops in different positions, to prevent major damage to bearings and journals. The lubricating oil must be circulated and separated continuously to remove water.

Water in the oil may be noted by steam formation on the sight glasses, by appearance, or ascertained by immersing a piece of glass or a soldering iron heated to 200-300°C in an oil sample. If there is a hissing sound, water is present. If a large quantity of water has entered the lubricating oil system, it has to be removed. Either to suck up sediment water from the bottom, or replace the oil in the sump. An oil sample must be analysed immediately for chloride ions.

General

Replacement of Lubricating Oil

The expected lubricating oil lifetime in operation is difficult to determine. The lubricating oil lifetime is depending on the fuel oil quality, the lubricating oil quality, the lubricating oil consumption, the lubricating oil cleaning equipment efficiency and the engine operational conditions.

In order to evaluate the lubricating oil condition a sample should be drawn on regular basis at least once every three month or depending on the latest analysis result. The lubricating oil sample must be drawn before the filter at engine in operation. The sample bottle must be clean and dry, supplied with sufficient indentification and should be closed immediately after filling. The lubricating oil sample must be examined in an approved laboratory or in the lubricating oil suppliers own laboratory.

A lubricating oil replacement or an extensive lubricating oil cleaning is required when the MAN Diesel exchange criteria's have been reached.

Evaluation of the Lubricating Oil Condition

Based on the analysis results, the following guidance are normally sufficient for evaluating the lubricating oil condition. The parameters themselves can not be jugded alonestanding, but must be evaluated together in order to conclude the lubricating oil condition.

1. Viscosity

Limit value :

	Normal value	min. value	max. value
SAE 30 [cSt@40° C]	95 - 125	75	160
SAE 30 [cSt@100° C]	11 - 13	9	15
SAE 40 [cSt@40° C]	135 - 165	100	220
SAE 40 [cSt@100° C]	13.5 - 15.0	11	19

Unit : cSt (mm^2/s)

Possible test methods : ASTM D-445, DIN 51562/53018, ISO 3104

Increasing viscosity indicates problems with insolubles, HFO contamination, water contamination, oxidation, nitration and low load operation. Decreasing viscosity is generally due to dilution with lighter viscosity oil.

2. Flash Point

Min. value : 185° C

Possible test method : ASTM D-92, ISO 2719

Normally used to indicate fuel dilution.

3. Water Content

Max. value : 0.2 %

Unit : Weight %

Possible test method : ASTM D4928, ISO 3733

Water can originate from contaminated fuel oil, an engine cooling water leak or formed as part of the combustion process. If water is detected also Sodium, Glycol or Boron content should be checked in order to confirm engine coolant leaks.

4. Base Number (BN)

Min. value : The BN value should not be lower than 50% of fresh lubricating oil value, but minimum BN level never to be lower than 10-12 at operating on HFO!

Unit : mg KOH/g

Possible test method : ASTM D-2896, ISO 3771

General

The neutralization capacity must secure that the acidic combustion products, mainly sulphur originate from the fuel oil, are neutralized at the lube oil consumption level for the specific engine type. Gradually the BN will be reduced, but should reach an equilibrium.

5. Total Acid Number (TAN)

Max. value : 3.0 acc. to fresh oil value

Unit : mg KOH/g

Possible test method : ASTM D-664

TAN is used to monitor oil degradation and is a measure of the total acids present in the lubricating oil derived from oil oxidation (weak acids) and acidic products of fuel combustion (strong acids).

6. Insolubles Content

Max. value : 1.5 % generally, depending upon actual dispersant value and the increase in viscosity.

Unit : Weight %

Possible test method : ASTM D-893 procedure B in n-Heptane, DIN 51592

Additionally test : If the level in n-Heptane insolubles is considered high for the type of oil and application, the test could be followed by a supplementary determination in Toluene.

Total insolubles is maily derived from products of combustion blown by the piston rings into the crankcase. It also includes burnt lubricating oil, additive ash, rust, salt, wear debris and abrasive matter.

7. Metal Content

Metal content	Remarks	Attention limits
Iron	Depend upon engine type and operating conditions	max. 50 ppm
Chromium		max. 10 ppm
Copper		max. 15 ppm
Lead		max. 20 ppm
Tin		max. 10 ppm
Aluminium		max. 20 ppm
Silicon		max. 20 ppm

General

Lubricating Oil Types used in the Engine.

Description	Lub. Oil Type
Engine system lubricating oil.	SAE 30 oil according to lubricating oil specification on page 604.01.
Turbocharger	Engine system lubricating oil.
Governor	See Governor instruction in section 609.
Air lubricator	SAE 10W non-detergent oil.
Alternator	See special instructions in section 618 or separate instruction.
Hydraulic tools	Hydraulic oil or turbine oil. (with a viscocity of about SAE 20).

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General

Lubricating Oil Types used in the Engine.

Description	Lub. Oil Type
Engine system lubricating oil.	SAE 40 oil according to lubricating oil specification on page 604.01.
Turbocharger	Engine system lubricating oil.
Governor	See Governor instruction in section 609.
Air lubricator	SAE 10W non-detergent oil.
Alternator	See special instructions in section 618 or separate instruction.
Hydraulic tools	Hydraulic oil or turbine oil. (with a viscocity of about SAE 20).

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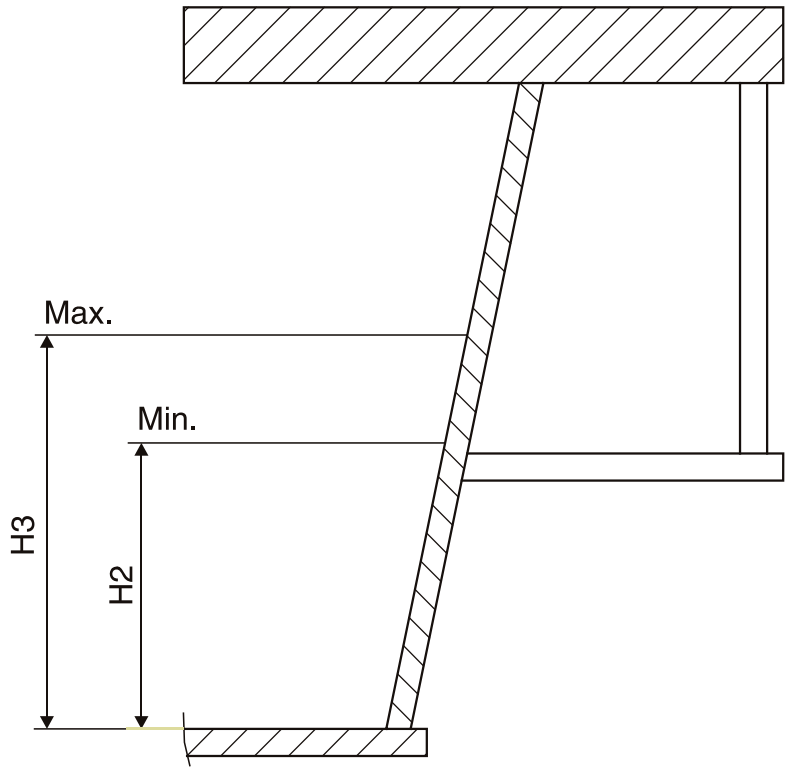
L28/32H



Type L28/32H	5 cyl.	6 cyl.	7 cyl.	8 cyl.	9 cyl.
Min. level H2 (mm)	265	265	265	265	265
Max. level H3 (mm)	365	365	365	365	365
Min. litre H2	792	935	1078	1220	1362
Max. litre H3	1111	1311	1511	1710	1910

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General

Engine type	RPM	SLOC [g/kWh]
L16/24	1000/1200	0.4 - 0.8
L21/31	900/1000	0.4 - 0.8
L23/30H	720/750/900	0.6 - 1.0
L27/38	720/750	0.4 - 0.8
L28/32H	720/750	0.6 - 1.0
V28/32H	720/750	0.6 - 1.0
V28/32S	720/750	0.4 - 0.8
L32/40	720/750	0.7 - 1.1

Please note that only maximum continuous rating (P_{MCR} (kW)) should be used in order to evaluate the SLOC, see the description 504.07.

Please note, during engine running-in the SLOC may exceed the values stated.

The following formula is used to calculate the SLOC:

SLOC [g/kWh] =

$$\frac{(\text{lubricating oil added } [dm^3]) * \rho_{\text{lubricating oil}} [kg/m^3]}{\text{run.hrs period} * P_{MCR} [kW]}$$

The lubricating oil density, ρ @ 15°C must be known in order to convert ρ to the present lubricating oil temperature in the base frame. The following formula is used to calculate ρ:

$\rho_{\text{lubricating oil}} [kg/m^3] =$

$\rho_{\text{lubricating oil @15°C}} [kg/m^3] - 0{,}64 * (t_{\text{lubricating oil}} [°C] - 15)$

The engine maximum continuous design rating (P_{MCR}) must always be used in order to be able to compare the individual measurements, and the running hours since the last lubricating oil adding must be used in the calculation. Due to inaccuracy *) at adding lubricating oil, the SLOC can only be evaluated after 1,000 running hours or more, where only the average values of a number of lubricating oil addings are representative.

Note *)
A deviation of ± 1 mm with the dipstick measurement must be expected, witch corresponds uptill ± 0.1 g/kWh, depending on the engine type.

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General

Plant / Ship

Lube oil consumption

Engine type: ____________________ Engine #: ___________________

Lube oil brand/type: ____

Density @15°C: _____________ [kg/m3]

Date	Run. hrs	Add. Lube oil	A1 + A2	L.O. Temperature	SLOC	Remarks
	[h]	[dm³]	[dm³]	[°C]	[g/kWh]	

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Heavy fuel oil (HFO) specification

Prerequisites

MAN four-stroke diesel engines can be operated with any heavy fuel oil obtained from crude oil that also satisfies the requirements in Table 1, providing the engine and fuel processing system have been designed accordingly. To ensure that the relationship between the fuel, spare parts and repair / maintenance costs remains favorable at all times, the following points should be observed.

Heavy fuel oil (HFO)

Origin/Refinery process

The quality of the heavy fuel oil largely depends on the quality of crude oil and on the refining process used. This is why the properties of heavy fuel oils with the same viscosity may vary considerably depending on the bunker positions. Heavy fuel oil is normally a mixture of residual oil and distillates. The components of the mixture are normally obtained from modern refinery processes, such as Catcracker or Visbreaker. These processes can adversely affect the stability of the fuel as well as its ignition and combustion properties. The processing of the heavy fuel oil and the operating result of the engine also depend heavily on these factors.

Bunker positions with standardised heavy fuel oil qualities should preferably be used. If oils need to be purchased from independent dealers, also ensure that these also comply with the international specifications. The engine operator is responsible for ensuring that suitable heavy fuel oils are chosen.

Specifications

Fuels intended for use in an engine must satisfy the specifications to ensure sufficient quality. The limit values for heavy fuel oils are specified in Table 1. The entries in the last column of Table 1 provide important background information and must therefore be observed.

Different international specifications exist for heavy fuel oils. The most important specifications are ISO 8217-2010 and CIMAC-2003, which are more or less identical. The ISO 8217 specification is shown in Fig. 1. All qualities in these specifications up to K700 can be used, providing the fuel preparation system has been designed accordingly. To use any fuels, which do not comply with these specifications (e.g. crude oil), consultation with Technical Service of MAN Diesel & Turbo SE in Augsburg is required. Heavy fuel oils with a maximum density of 1,010 kg/m^3 may only be used if up-to-date separators are installed.

Important

Even though the fuel properties specified in the table entitled "The fuel specification and corresponding properties for heavy fuel oil" satisfy the above requirements, they probably do not adequately define the ignition and combustion properties and the stability of the fuel. This means that the operating behaviour of the engine can depend on properties that are not defined in the specification. This particularly applies to the oil property that causes formation of deposits in the combustion chamber, injection system, gas ducts and exhaust gas system. A number of fuels have a tendency towards incompatibility with lubricating oil which leads to deposits being formed in the fuel delivery pump that can block the pumps. It may therefore be necessary to exclude specific fuels that could cause problems.

Blends

The addition of engine oils (old lubricating oil, ULO –used lubricating oil) and additives that are not manufactured from mineral oils, (coal-tar oil, for example), and residual products of chemical or other processes such as solvents

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(polymers or chemical waste) is not permitted. Some of the reasons for this are as follows: abrasive and corrosive effects, unfavourable combustion characteristics, poor compatibility with mineral oils and, last but not least, adverse effects on the environment. The order for the fuel must expressly state what is not permitted as the fuel specifications that generally apply do not include this limitation.

If engine oils (old lubricating oil, ULO – used lubricating oil) are added to fuel, this poses a particular danger as the additives in the lubricating oil act as emulsifiers that cause dirt, water and catfines to be transported as fine suspension. They therefore prevent the necessary cleaning of the fuel. In our experience (and this has also been the experience of other manufacturers), this can severely damage the engine and turbocharger components.

The addition of chemical waste products (solvents, for example) to the fuel is prohibited for environmental protection reasons according to the resolution of the IMO Marine Environment Protection Committee passed on 1st January 1992.

Leak oil collector

Leak oil collectors that act as receptacles for leak oil, and also return and overflow pipes in the lube oil system, must not be connected to the fuel tank. Leak oil lines should be emptied into sludge tanks.

Viscosity (at 50 °C)	mm^2/s (cSt)	max.	700	Viscosity/injection viscosity
Viscosity (at 100 °C)		max.	55	Viscosity/injection viscosity
Density (at 15 °C)	g/ml	max.	1.010	Heavy fuel oil processing
Flash point	°C	min.	60	Flash point (ASTM D 93)
Pour point (summer)		max.	30	Low-temperature behaviour (ASTM D 97)
Pour point (winter)		max.	30	Low-temperature behaviour (ASTM D 97)
Coke residue (Conradson)	Weight %	max.	20	Combustion properties
Sulphur content			5 or legal requirements	Sulphuric acid corrosion
Ash content			0.15	Heavy fuel oil processing
Vanadium content	mg/kg		450	Heavy fuel oil processing
Water content	Vol. %		0.5	Heavy fuel oil processing
Sediment (potential)	Weight %		0.1	
Aluminium and silicium content (total)	mg/kg	max.	60	Heavy fuel oil processing
Acid number	mg KOH/g		2.5	
Hydrogen sulphide	mg/kg		2	
Used lubricating oil (ULO)	mg/kg			The fuel must be free of lubricating oil (ULO = used lubricating oil, old oil). Fuel is considered as contaminated with lubricating oil when the following concentrations occur: Ca > 30 ppm and Zn > 15 ppm or Ca > 30 ppm and P > 15 ppm.

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Asphaltene content	Weight %		2/3 of coke residue (according to Conradson)	Combustion properties
Sodium content	mg/kg		Sodium < 1/3 Vanadium, Sodium<100	Heavy fuel oil processing
The fuel must be free of admixtures that cannot be obtained from mineral oils, such as vegetable or coal-tar oils. It must also be free of tar oil and lubricating oil (old oil), and also chemical waste products such as solvents or polymers.				

Table 1: Table_The fuel specification and corresponding characteristics for heavy fuel oil

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Figure 1: ISO 8217-2010 specification for heavy fuel oil

Characteristic		Unit	Limit	Category ISO-F-											Test method reference
				RMA	RMB	RMD	RME	RMG				RMK			
				10	30	80	180	180	380	500	700	380	500	700	
Kinematic viscosity at 50 °C		mm^2/s	max.	10,00	30,00	80,00	180,0	180,0	380,0	500,0	700,0	380,0	500,0	700,0	ISO 3104
Density at 15 °C		kg/m^3	max.	920,0	960,0	975,0	991,0	991,0				1010,0			see 7.1 ISO 3675 or ISO 12185
CCAI		—	max.	850	860	860	860	870				870			see 6.3 a)
Sulfur		mass %	max.	Statutory requirements											see 7.2 ISO 8754 ISO 14596
Flash point		°C	min.	60,0	60,0	60,0	60,0	60,0				60,0			see 7.3 ISO 2719
Hydrogen sulfide		mg/kg	max.	2,00	2,00	2,00	2,00	2,00				2,00			IP 570
Acid number		mg KOH/g	max.	2,5	2,5	2,5	2,5	2,5				2,5			ASTM D664
Total sediment aged		mass %	max.	0,10	0,10	0,10	0,10	0,10				0,10			see 7.5 ISO 10307-2
Carbon residue: micro method		mass %	max.	2,50	10,00	14,00	15,00	18,00				20,00			ISO 10370
Pour point (upper)	winter quality	°C	max.	0	0	30	30	30				30			ISO 3016
	summer quality	°C	max.	6	6	30	30	30				30			ISO 3016
Water		volume %	max.	0,30	0,50	0,50	0,50	0,50				0,50			ISO 3733
Ash		mass %	max.	0,040	0,070	0,070	0,070	0,100				0,150			ISO 6245
Vanadium		mg/kg	max.	50	150	150	150	350				450			see 7.7 IP 501, IP 470 or ISO 14597
Sodium		mg/kg	max.	50	100	100	50	100				100			see 7.8 IP 501 IP 470

ISO 8217:2010(E)

ISO 8217:2010(E)

Characteristic	Unit	Limit	Category ISO-F-											Test method reference
			RMA	RMB	RMD	RME	RMG				RMK			
			10[a]	30	80	180	180	380	500	700	380	500	700	
Aluminium plus silicon	mg/kg	max.	25	40	40	50	60				60			see 7.9 IP 501, IP 470 or ISO 10478
Used lubricating oils (ULO): calcium and zinc; or calcium and phosphorus	mg/kg	—	The fuel shall be free from ULO. A fuel shall be considered to contain ULO when either one of the following conditions is met: calcium > 30 and zinc > 15; or calcium > 30 and phosphorus > 15											see 7.10 IP 501 or IP 470 IP 500

Figure 2: ISO 8217-2010 specification for heavy fuel oil (continued)

Additional information

The purpose of the following information is to show the relationship between the quality of heavy fuel oil, heavy fuel oil processing, the engine operation and operating results more clearly.

Selection of heavy fuel oil

Economic operation with heavy fuel oil within the limit values specified in the table entitled *"The fuel specification and corresponding properties for heavy fuel oil"* is possible under normal operating conditions, provided the system is working properly and regular maintenance is carried out. If these requirements are not satisfied, shorter maintenance intervals, higher wear and a greater need for spare parts is to be expected. The required maintenance intervals and operating results determine, which quality of heavy fuel oil should be used.

It is an established fact that the price advantage decreases as viscosity increases. It is therefore not always economical to use the fuel with the highest viscosity as in many cases the quality of this fuel will not be the best.

Viscosity/injection viscosity

Heavy fuel oils with a high viscosity may be of an inferior quality. The maximum permissible viscosity depends on the preheating system installed and the capacity (flow rate) of the separator.

The prescribed injection viscosity of 12 - 14 mm^2/s (for GenSets, 23/30H and 28/32H: 12 - 18 cSt) and corresponding fuel temperature upstream of the engine must be observed. This is the only way to ensure efficient atomisation and mixture formation and therefore low-residue combustion. This also prevents mechanical overloading of the injection system. For the prescribed injection viscosity and/or the required fuel oil temperature upstream of the engine, refer to the viscosity temperature diagram.

Heavy fuel oil processing

Whether or not problems occur with the engine in operation depends on how carefully the heavy fuel oil has been processed. Particular care should be taken to ensure that highly-abrasive inorganic foreign matter (catalyst particles, rust, sand) are effectively removed. It has been shown in practice that wear as a result of abrasion in the engine increases considerably if the aluminum and silicium content is higher than 15 mg/kg.

Viscosity and density influence the cleaning effect. This must be taken into account when designing and making adjustments to the cleaning system.

Settling tank

Heavy fuel oil is precleaned in the settling tank. The longer the fuel remains in the tank and the lower the viscosity of heavy fuel oil is, the more effective the precleaning process will be (maximum preheating temperature of 75 °C to prevent the formation of asphalt in heavy fuel oil). A settling tank is sufficient for heavy fuel oils with a viscosity of less than $380^2/s$ at 50 °C. If the heavy fuel oil has a high concentration of foreign matter, or if fuels in accordance with ISO-F-RM, G/H/K380 or H/K700 are to be used, two settling tanks will be required one of which must be sized for 24-hour operation. Before the content is moved to the service tank, water and sludge must be drained from the settling tank.

Separators

A separator is particularly suitable for separating material with a higher specific density – water, foreign matter and sludge, for example. The separators must be self-cleaning (i.e. the cleaning intervals must be triggered automatically).

Only new generation separators should be used. They are extremely effective throughout a wide density range with no changeover required, and can separate water from heavy fuel oils with a density of up to 1.01 g/ml at 15 °C.

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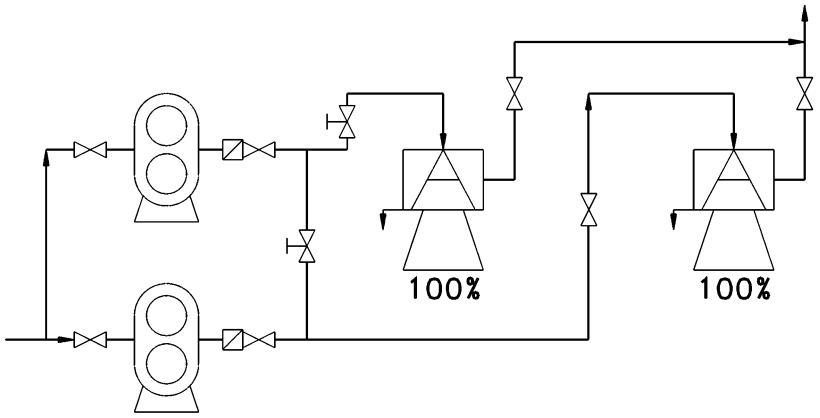
Table *"Achievable proportion of foreign matter and water (following separation)"* shows the prerequisites that must be met by the separator. These limit values are used by manufacturers as the basis for dimensioning the separator and ensure compliance.

The manufacturer's specifications must be complied with to maximize the cleaning effect.



Application in ships and stationary use: parallel installation

1 Separator for 100 % flow rate

1 Separator (reserve) for 100 % flow rate

Figure 3: Location of heavy fuel oil cleaning equipment and/or separator

The separators must be arranged according to the manufacturers' current recommendations (Alpha Laval and Westfalia). The density and viscosity of the heavy fuel oil in particular must be taken into account. If separators by other manufacturers are used, MAN Diesel should be consulted.

If processing is carried out in accordance with the MAN Diesel specifications and the correct separators are chosen, it may be assumed that the results stated in the table entitled *"Achievable proportion of foreign matter and water"* for inorganic foreign matter and water in the heavy fuel oil will be achieved at the engine inlet.

Results obtained during operation in practice show that the wear occurs as a result of abrasion in the injection system and the engine will remain within acceptable limits if these values are complied with. In addition, an optimum lubricating oil treatment process must be ensured.

Definition	Particle size	Quantity
Inorganic foreign matter including catalyst particles	< 5 µm	< 20 mg/kg
Al+Si content	--	< 15 mg/kg
Water content	--	< 0.2 % by vol. %

Table 2: Achievable proportion of foreign matter and water (after separation)

Water

It is particularly important to ensure that the water separation process is as thorough as possible as the water takes the form of large droplets, and not a finely distributed emulsion. In this form, water also promotes corrosion and sludge formation in the fuel system and therefore impairs the supply, atomisation and combustion of the heavy fuel oil. If the water absorbed in the fuel is seawater, harmful sodium chloride and other salts dissolved in this water will enter the engine.

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	Water-containing sludge must be removed from the settling tank before the separation process starts, and must also be removed from the service tank at regular intervals. The tank's ventilation system must be designed in such a way that condensate cannot flow back into the tank.
Vanadium/Sodium	If the vanadium/sodium ratio is unfavorable, the melting point of the heavy fuel oil ash may fall in the operating area of the exhaust-gas valve which can lead to high-temperature corrosion. Most of the water and water-soluble sodium compounds it contains can be removed by pretreating the heavy fuel oil in the settling tank and in the separators. The risk of high-temperature corrosion is low if the sodium content is one third of the vanadium content or less. It must also be ensured that sodium does not enter the engine in the form of seawater in the intake air. If the sodium content is higher than 100 mg/kg, this is likely to result in a higher quantity of salt deposits in the combustion chamber and exhaust-gas system. This will impair the function of the engine (including the suction function of the turbocharger). Under certain conditions, high-temperature corrosion can be prevented by using a fuel additive that increases the melting point of the heavy fuel oil ash (also see "Additives for heavy fuel oils”).
Ash	Fuel ash consists for the greater part of vanadium oxide and nickel sulphate (see above chapter for more information). Heavy fuel oils containing a high proportion of ash in the form of foreign matter, e.g. sand, corrosion compounds and catalyst particles, accelerate the mechanical wear in the engine. Catalyst particles produced as a result of the catalytic cracking process may be present in the heavy fuel oils. In most cases, these are aluminium silicate particles that cause a high degree of wear in the injection system and the engine. The aluminium content determined, multiplied by a factor of between 5 and 8 (depending on the catalytic bond), is roughly the same as the proportion of catalyst remnants in the heavy fuel oil.
Homogeniser	If a homogeniser is used, it must never be installed between the settling tank and separator as otherwise it will not be possible to ensure satisfactory separation of harmful contaminants, particularly seawater.
Flash point (ASTM D 93)	National and international transportation and storage regulations governing the use of fuels must be complied with in relation to the flash point. In general, a flash point of above 60 °C is prescribed for diesel engine fuels.
Low-temperature behaviour (ASTM D 97)	The pour point is the temperature at which the fuel is no longer flowable (pumpable). As the pour point of many low-viscosity heavy fuel oils is higher than 0 °C, the bunker facility must be preheated, unless fuel in accordance with RMA or RMB is used. The entire bunker facility must be designed in such a way that the heavy fuel oil can be preheated to around 10 °C above the pour point.
Pump characteristics	If the viscosity of the fuel is higher than 1000 mm^2/s (cST), or the temperature is not at least 10 °C above the pour point, pump problems will occur. For more information, also refer to “Low-temperature behaviour (ASTM D 97)”.
Combustion properties	If the proportion of asphalt is more than two thirds of the coke residue (Conradson), combustion may be delayed which in turn may increase the formation of combustion residues, leading to such as deposits on and in the injection nozzles, large amounts of smoke, low output, increased fuel consumption and a rapid rise in ignition pressure as well as combustion close to the cylinder wall (thermal overloading of lubricating oil film). If the ratio of asphalt to coke residues reaches the limit 0.66, and if the asphalt content exceeds 8%, the risk of deposits forming in the combustion chamber and injection

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system is higher. These problems can also occur when using unstable heavy fuel oils, or if incompatible heavy fuel oils are mixed. This would lead to an increased deposition of asphalt (see "Compatibility").

Ignition quality

Nowadays, to achieve the prescribed reference viscosity, cracking-process products are used as the low viscosity ingredients of heavy fuel oils although the ignition characteristics of these oils may also be poor. The cetane number of these compounds should be > 35. If the proportion of aromatic hydrocarbons is high (more than 35 %), this also adversely affects the ignition quality.

The ignition delay in heavy fuel oils with poor ignition characteristics is longer; the combustion is also delayed which can lead to thermal overloading of the oil film at the cylinder liner and also high cylinder pressures. The ignition delay and accompanying increase in pressure in the cylinder are also influenced by the end temperature and compression pressure, i.e. by the compression ratio, the charge-air pressure and charge-air temperature.

The disadvantages of using fuels with poor ignition characteristics can be limited by preheating the charge air in partial load operation and reducing the output for a limited period. However, a more effective solution is a high compression ratio and operational adjustment of the injection system to the ignition characteristics of the fuel used, as is the case with MAN Diesel piston engines.

The ignition quality is one of the most important properties of the fuel. This value does not appear in the international specifications because a standardised testing method has only recently become available and not enough experience has been gathered at this point in order to determine limit values. The parameters, such as the calculated carbon aromaticity index (CCAI), are therefore aids that are derived from quantifiable fuel properties. We have established that this method is suitable for determining the approximate ignition quality of the heavy fuel oil used.

A testing instrument has been developed based on the constant volume combustion method (fuel combustion analyser FCA) and is currently being tested by a series of testing laboratories.
The instrument measures the ignition delay to determine the ignition quality of a fuel and this measurement is converted into a an instrument-specific cetane number (FIA-CN or EC). It has been established that in some cases, heavy fuel oils with a low FIA cetane number or ECN number can cause operating problems.

As the liquid components of the heavy fuel oil decisively influence the ignition quality, flow properties and combustion quality, the bunker operator is responsible for ensuring that the quality of heavy fuel oil delivered is suitable for the diesel engine. (Also see illustration entitled *"Nomogram for determining the CCAI – assigning the CCAI ranges to engine types"*).

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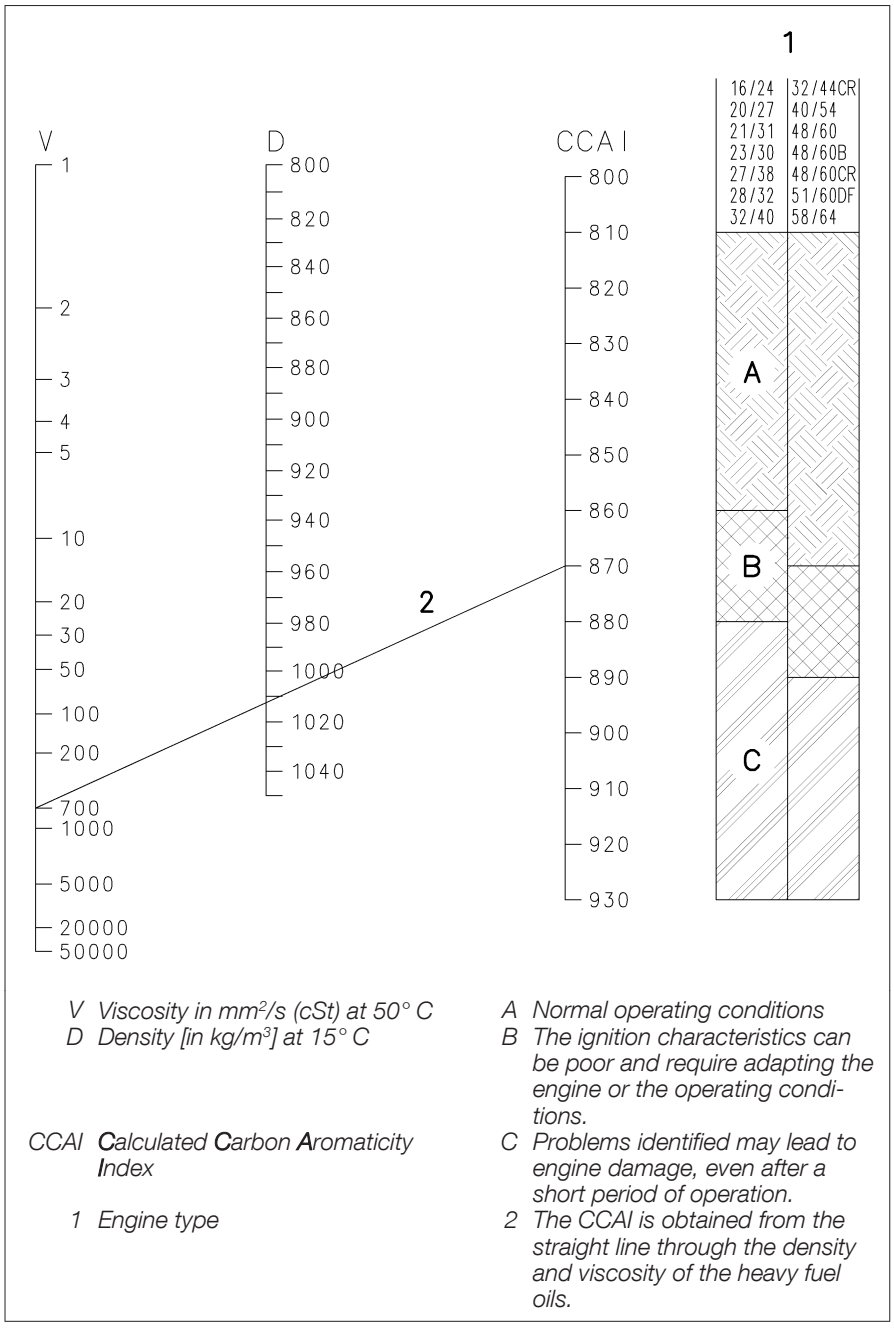

Figure 4: Nomogram for determining the CCAI – assigning the CCAI ranges to engine types

The CCAI can be calculated using the following formula:

CCAI = D - 141 log log (V+0.85) - 81

Sulphuric acid corrosion

The engine should be operated at the cooling water temperatures prescribed in the operating handbook for the relevant load. If the temperature of the components that are exposed to acidic combustion products is below the acid dew point, acid corrosion can no longer be effectively prevented, even if alkaline lubricating oil is used.

The BN values specified in Section 3.3.6 are sufficient, providing the quality of lubricating oil and the engine's cooling system satisfy the requirements.

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Compatibility

The supplier must guarantee that the heavy fuel oil is homogeneous and remains stable, even after the standard storage period. If different bunker oils are mixed, this can lead to separation and the associated sludge formation in the fuel system during which large quantities of sludge accumulate in the separator that block filters, prevent atomisation and a large amount of residue as a result of combustion.

This is due to incompatibility or instability of the oils. Therefore heavy fuel oil as much as possible should be removed in the storage tank before bunkering again to prevent incompatibility.

Blending the heavy fuel oil

If heavy fuel oil for the main engine is blended with gas oil (MGO) to obtain the required quality or viscosity of heavy fuel oil, it is extremely important that the components are compatible (see "Compatibility").

Additives for heavy fuel oils

MAN Diesel & Turbo SE engines can be operated economically without additives. It is up to the customer to decide whether or not the use of additives is beneficial. The supplier of the additive must guarantee that the engine operation will not be impaired by using the product.

The use of heavy fuel oil additives during the warranty period must be avoided as a basic principle.

Additives that are currently used for diesel engines, as well as their probable effects on the engine's operation, are summarised in the table below *"Additives for heavy fuel oils – classification/effects"*.

Precombustion additives	▪ Dispersing agents/stabilisers ▪ Emulsion breakers ▪ Biocides
Combustion additives	▪ Combustion catalysts (fuel savings, emissions)
Post-combustion additives	▪ Ash modifiers (hot corrosion) ▪ Soot removers (exhaust-gas system)

Table 3: Additives for heavy fuel oils – Classification/effects

Heavy fuel oils with low sulphur content

From the point of view of an engine manufacturer, a lower limit for the sulphur content of heavy fuel oils does not exist. We have not identified any problems with the low-sulphur heavy fuel oils currently available on the market that can be traced back to their sulphur content. This situation may change in future if new methods are used for the production of low-sulphur heavy fuel oil (desulphurisation, new blending components). MAN Diesel & Turbo will monitor developments and inform its customers if required.

If the engine is not always operated with low-sulphur heavy fuel oil, corresponding lubricating oil for the fuel with the highest sulphur content must be selected.

DANGER

Improper handling of operating fluids

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

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Tests

Sampling

To check whether the specification provided and/or the necessary delivery conditions are complied with, we recommend you retain at least one sample of every bunker oil (at least for the duration of the engine's warranty period). To ensure that the samples taken are representative of the bunker oil, a sample should be taken from the transfer line when starting up, halfway through the operating period and at the end of the bunker period. “Sample Tec" by Mar-Tec in Hamburg is a suitable testing instrument which can be used to take samples on a regular basis during bunkering.

Analysis of samples

Our department for fuels and lubricating oils (Augsburg factory, department EQC) will be pleased to provide further information on request.

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

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Diesel oil (MDO) specification

Marine diesel oil

Other designations: Marine diesel oil, marine diesel fuel.

Origin: Marine diesel oil (MDO) is supplied as heavy distillate (designation ISO-F-DMB) exclusively for marine applications. MDO is manufactured from crude oil and must be free of organic acids and non-mineral oil products.

Specification

The suitability of fuel depends on the design of the engine and the available cleaning options, as well as compliance with the properties in the following table that refer to the as-delivered condition of the fuel.

The properties are essentially defined using the ISO 8217-2010 standard as the basis. The properties have been specified using the stated test procedures.

Properties	Unit	Testing method	Designation
ISO-F specification			DMB
Density at 15 °C	kg/m^3	ISO 3675	900
Kinematic viscosity at 40 °C	mm^2/s ≙ cSt	ISO 3104	> 2,0 < 11 *
Pour point (winter quality)	°C	ISO 3016	< 0
Pour point (summer quality)	°C		< 6
Flash point (Pensky Martens)	°C	ISO 2719	> 60
Total sediment content	% by weight	ISO CD 10307	0.10
Water content	% by vol.	ISO 3733	< 0.3
Sulphur content	% by weight	ISO 8754	< 2.0
Ash content	% by weight	ISO 6245	< 0.01
Carbon residue (MCR)	% by weight	ISO CD 10370	< 0.30
Cetane number or cetane index	-	ISO 5165	> 35
Hydrogen sulphide	mg/kg	IP 570	< 2
Acid value	mg KOH/g	ASTM D664	< 0.5
Oxidation resistance	g/m^3	ISO 12205	< 25
Lubricity (wear scar diameter)	µm	ISO 12156-1	< 520
Copper strip test	-	ISO 2160	< 1
Other specifications:			
British Standard BS MA 100-1987			Class M2
ASTM D 975			2D
ASTM D 396			Nr. 2

Table 1: Marine diesel oil (MDO) – characteristic values to be adhered to

* For engines 27/38 with 350 resp. 365 kW/cyl the viscosity must not exceed 6 mm^2/s @ 40 °C, as this would reduce the lifetime of the injection system.

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Additional information

During transshipment and transfer, MDO is handled in the same manner as residual oil. This means that it is possible for the oil to be mixed with high-viscosity fuel or heavy fuel oil – with the remnants of these types of fuels in the bunker ship, for example – that could significantly impair the properties of the oil.

Lubricity

Normally, the lubricating ability of diesel oil is sufficient to operate the fuel injection pump. Desulphurisation of diesel fuels can reduce their lubricity. If the sulphur content is extremely low (< 500 ppm or 0.05%), the lubricity may no longer be sufficient. Before using diesel fuels with low sulphur content, you should therefore ensure that their lubricity is sufficient. This is the case if the lubricity as specified in ISO 12156-1 does not exceed 520 µm.

The fuel must be free of lubricating oil (ULO – used lubricating oil, old oil). Fuel is considered as contaminated with lubricating oil when the following concentrations occur:

Ca > 30 ppm and Zn > 15 ppm or Ca > 30 ppm and P > 15 ppm.

The pour point specifies the temperature at which the oil no longer flows. The lowest temperature of the fuel in the system should be roughly 10 °C above the pour point to ensure that the required pumping characteristics are maintained.

A minimum viscosity must be observed to ensure sufficient lubrication in the fuel injection pumps. The temperature of the fuel must therefore not exceed 45 °C.

Seawater causes the fuel system to corrode and also leads to hot corrosion of the exhaust valves and turbocharger. Seawater also causes insufficient atomisation and therefore poor mixture formation accompanied by a high proportion of combustion residues.

Solid foreign matter increase mechanical wear and formation of ash in the cylinder space.

We recommend the installation of a separator upstream of the fuel filter. Separation temperature: 40 – 50°C. Most solid particles (sand, rust and catalyst particles) and water can be removed, and the cleaning intervals of the filter elements can be extended considerably.

DANGER

Improper handling of operating fluids

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

Analyses

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

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Gas oil / diesel oil (MGO) specification

Diesel oil

Other designations

Gas oil, marine gas oil (MGO), diesel oil

Gas oil is a crude oil medium distillate and therefore must not contain any residual materials.

Military specification

Diesel oils that satisfy specification F-75 or F-76 may be used.

Specification

The suitability of fuel depends on whether it has the properties defined in this specification (based on its composition in the as-delivered state).

The DIN EN 590 and ISO 8217-2010 (Class DMA or Class DMZ) standards have been extensively used as the basis when defining these properties. The properties correspond to the test procedures stated.

Properties	Unit	Test procedure	Typical value
Density at 15 °C	kg/m³	ISO 3675	≥ 820.0 ≤ 890.0
Kinematic viscosity at 40 °C	mm²/s (cSt)	ISO 3104	≥ 2 ≤ 6.0
Filterability* in summer and in winter	 °C °C	 DIN EN 116 DIN EN 116	 ≤ 0 ≤ -12
Flash point in closed cup	°C	ISO 2719	≥ 60
Sediment content (extraction method)	weight %	ISO 3735	≤ 0.01
Water content	Vol. %	ISO 3733	≤ 0.05
Sulphur content	weight %	ISO 8754	≤ 1.5
Ash		ISO 6245	≤ 0.01
Coke residue (MCR)		ISO CD 10370	≤ 0.10
Hydrogen sulphide	mg/kg	IP 570	< 2
Acid number	mg KOH/g	ASTM D664	< 0.5
Oxidation stability	g/m³	ISO 12205	< 25
Lubricity (wear scar diameter)	µm	ISO 12156-1	< 520
Cetane number or cetane index	-	ISO 5165	≥ 40
Copper strip test	-	ISO 2160	≤ 1
Other specifications:			
British Standard BS MA 100-1987			M1
ASTM D 975			1D/2D

Table 1: Diesel fuel (MGO) – properties that must be complied with.

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* The process for determining the filterability in accordance with DIN EN 116 is similar to the process for determining the cloud point in accordance with ISO 3015

Additional information

Use of diesel oil

If distillate intended for use as heating oil is used with stationary engines instead of diesel oil (EL heating oil according to DIN 51603 or Fuel No. 1 or no. 2 according to ASTM D 396), the ignition behaviour, stability and behaviour at low temperatures must be ensured; in other words the requirements for the filterability and cetane number must be satisfied.

Viscosity

To ensure sufficient lubrication, a minimum viscosity must be ensured at the fuel pump. The maximum temperature required to ensure that a viscosity of more than 1.9 mm^2/s is maintained upstream of the fuel pump, depends on the fuel viscosity. In any case, the fuel temperature upstream of the injection pump must not exceed 45 °C.

Lubricity

Normally, the lubricating ability of diesel oil is sufficient to operate the fuel injection pump. Desulphurisation of diesel fuels can reduce their lubricity. If the sulphur content is extremely low (< 500 ppm or 0.05%), the lubricity may no longer be sufficient. Before using diesel fuels with low sulphur content, you should therefore ensure that their lubricity is sufficient. This is the case if the lubricity as specified in ISO 12156-1 does not exceed 520 µm.

You can ensure that these conditions will be met by using motor vehicle diesel fuel in accordance with EN 590 as this characteristic value is an integral part of the specification.

DANGER

Improper handling of operating fluids

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

Analyses

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

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Bio fuel specification

Biofuel

Other designations: Biodiesel, FAME, vegetable oil, rapeseed oil, palm oil, frying fat

Origin: Biofuel is derived from oil plants or old cooking oil.

Provision

Transesterified and non-transesterified vegetable oils can be used.

Transesterified biofuels (biodiesel, FAME) must comply with the standard EN 14214.

Non-transesterified biofuels must comply with the specifications listed in Table 1.

These specifications are based on experience to d/ate. As this experience is limited, these must be regarded as recommended specifications that can be adapted if necessary. If future experience shows that these specifications are too strict, or not strict enough, they can be modified accordingly to ensure safe and reliable operation.

When operating with bio-fuels, lubricating oil that would also be suitable for operation with diesel oil (see Sheet 3.3.5) must be used.

Properties/Characteristics	Unit	Test method
Density at 15 °C	900 - 930 kg/m^3	DIN EN ISO 3675, EN ISO 12185
Flash point	> 60 °C	DIN EN 22719
lower calorific value	> 35 MJ/kg (typical: 37 MJ/kg)	DIN 51900-3
Viscosity/50 °C	< 40 cSt (corresponds to a viscosity/40 °C of < 60 cSt)	DIN EN ISO 3104
Cetane number	> 40	FIA
Coke residue	< 0.4%	DIN EN ISO 10370
Sediment content	< 200 ppm	DIN EN 12662
Oxidation stability (110 °C)	> 5 h	ISO 6886
Phosphorous content	< 15 ppm	ASTM D3231
Na and K content	< 15 ppm	DIN 51797-3
Ash content	< 0.01%	DIN EN ISO 6245
Water content	< 0.5%	EN ISO 12537
Iodine number	< 125g/100g	DIN EN 14111
TAN (total acid number)	< 5 mg KOH/g	DIN EN ISO 660
Filterability	< 10 °C below the lowest temperature in the fuel system	EN 116

Table 1: Non-transesterified bio-fuel - Specifications

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DANGER

Improper handling of operating fluids

If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

Analyses

We can analyse fuel for customers at our laboratory. A 0.5 l sample is required for the test.

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Viscosity-temperature diagram (VT diagram)

Explanations of viscosity-temperature diagram

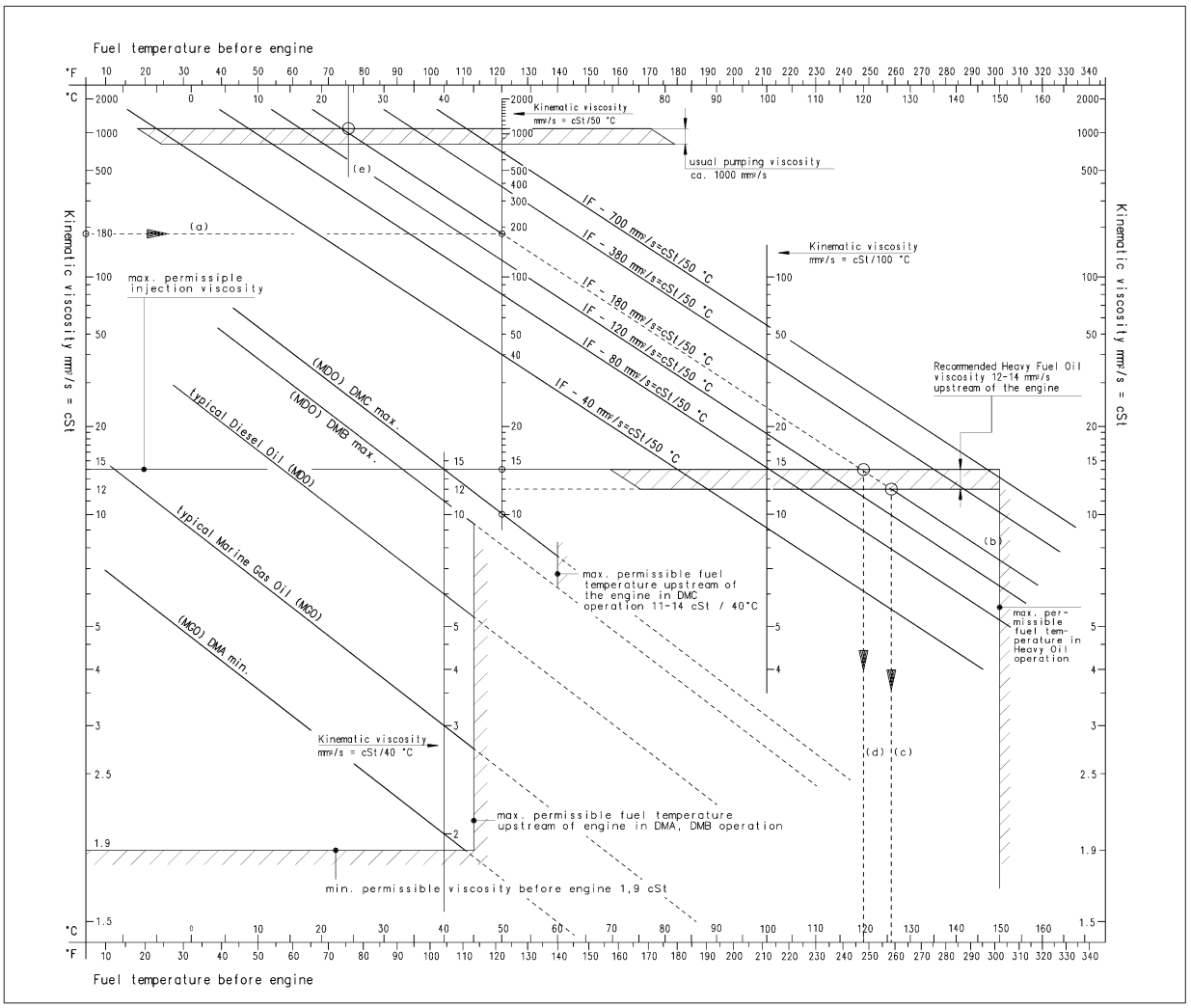

Figure 1: Viscosity-temperature diagram (VT diagram)

In the diagram, the fuel temperatures are shown on the horizontal axis and the viscosity is shown on the vertical axis.

The diagonal lines correspond to viscosity-temperature curves of fuels with different reference viscosities. The vertical viscosity axis in mm^2/s (cSt) applies for 40, 50 or 100 °C.

Determining the viscosity-temperature curve and the required preheating temperature

Example: Heavy fuel oil with 180 mm^2/s at 50 °C

Prescribed injection viscosity in mm^2/s	Required temperature of heavy fuel oil at engine inlet* in °C
≥ 12	126 (line c)
≤ 14	119 (line d)

Table 1: Determining the viscosity-temperature curve and the required preheating temperature

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* With these figures, the temperature drop between the last preheating device and the fuel injection pump is not taken into account.

A heavy fuel oil with a viscosity of 180 mm^2/s at 50 °C can reach a viscosity of 1000 mm^2/s at 24 °C (line e) – this is the maximum permissible viscosity of fuel that the pump can deliver.

A heavy fuel oil discharge temperature of 152 °C is reached when using a recent state-of-the-art preheating device with 8 bar saturated steam. At higher temperatures there is a risk of residues forming in the preheating system – this leads to a reduction in heating output and thermal overloading of the heavy fuel oil. Asphalt is also formed in this case, i.e. quality deterioration.

The heavy fuel oil lines between the outlet of the last preheating system and the injection valve must be suitably insulated to limit the maximum drop in temperature to 4 °C. This is the only way to achieve the necessary injection viscosity of 14 mm^2/s for heavy fuel oils with a reference viscosity of 700 mm^2/s at 50 °C (the maximum viscosity as defined in the international specifications such as ISO CIMAC or British Standard). If heavy fuel oil with a low reference viscosity is used, the injection viscosity should ideally be 12 mm^2/s in order to achieve more effective atomisation to reduce the combustion residue.

The delivery pump must be designed for heavy fuel oil with a viscosity of up to 1 000 mm^2/s. The pour point also determines whether the pump is capable of transporting the heavy fuel oil. The bunker facility must be designed so as to allow the heavy fuel oil to be heated to roughly 10 C above the pour point.

NOTICE

Viscosity

The viscosity of gas oil or diesel oil (marine diesel oil) upstream of the engine must be at least 1.9 mm^2/s. If the viscosity is too low, this may cause seizing of the pump plunger or nozzle needle valves as a result of insufficient lubrication.

This can be avoided by monitoring the temperature of the fuel. Although the maximum permissible temperature depends on the viscosity of the fuel, it must never exceed the following values:

- 45 °C at the most with MGO (DMA) and MDO (DMB) and
- 60 °C at the most with MDO (DMC).

A fuel cooler must therefore be installed.

If the viscosity of the fuel is < 2 cSt at 40 °C, consult the technical service of MAN Diesel & Turbo SE in Augsburg.

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General

Purification Recommendations.

Fuel oils are always contaminated and should therefore be thoroughly cleaned for solid as well as liquid contaminants before use. The solid contami-nants in the fuel are mainly rust, sand, dust and re-finery catalysts. Liquid contaminants are mainly water, i.e. either fresh water or salt water.

The impurities can cause damage to fuel pumps and fuel valves, can result in increased cylinder liner wear and deteriorate the exhaust valve seats. Also increased fouling of gas ways and turbocharger blends may result from the use of inadequately cleaned fuel oils.

Effective cleaning can only be ensured by means of a centrifuge. We recommend the capacity of the installed centrifuges to be at least according to the centrifuging maker's recommendations. To obtain optimum cleaning it is of the utmost importance to operate the centrifuge with as low a viscosity of the fuel oil as possible and allow the fuel oil to remain in the centrifuge bowl as long time as possible.

Cleaning of H.F.O. by Centrifuging		
Operating options	Single centrifuge as purifier. Two centrifuges in parallel. Two centrifuges in series.	
Optimum operating configurations		
Normal conditions	Water content below 1 % Density at 15°C below 0.991	Parallel operation Purifier / Purifier or Series operation Purifier + Clarifier
Extreme conditions	Water content below 1 % Density at 15°C below 0.991	Parallel operation Purifier / Purifier
	High content of catalyst fines	Series operation Purifier + Clarifier

Table 1. Cleaning of HFO.

Especially for fuels above 180 cST/50°C (1500 sec. RW/100°F) the highest possible temperature 98°C (208°F) should be maintained in the centrifuge oil preheater.

The fuel is kept in the centrifuge as long as possible by adjusting the flow rate through the centrifuge so that it corresponds to the amount of fuel required by the engine without excessive re-circulating. Consequently, the centrifuge should operate for 24 hours a day except during necessary cleaning.

Taking today's fuel qualities into consideration the need for cleaning centrifuges ("shooting frequency") should not be underestimated. Correct choice and adjustment of the regulating screws and/or the gravity discs are of special importance for efficient water removal. The centrifuge manual states the disc or screw adjustment which should be chosen on the basis of the specific gravity of the fuel.

Normal practice is to have at least two centrifuges available for fuel cleaning. Results from experimental work on centrifuges, treating today's qualities of residual fuel, have shown that the best cleaning effect, especially as regards removal of catalyst fines is achieved when the centrifuges are operated in series, in purifier/clarifier mode.

Therefore - series operation of centrifuges ensuring a maximum of safety is a fully accepted alternative to the previously recommended parallel operation, provided the operating capacity of each individual centrifuge can handle the total amount of fuel required by the engine, without exceeding the flow rate recommended by the centrifuge maker for the operating mode in question.

If the installed centrifuge capacity is on the low side corresponding to the specific viscosity of the used fuel oil and if more than one centrifuge is available, parallel operation in order to obtain an even lower flow rate may be considered. However, in view of the above results and recommendations serious considerations should be given to installing new equipment in correspondance with today's fuel qualities and flow recommendation.

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General

For the determination of centrifuging capacity, we generally advise to follow the recommendations of the centrifuge maker, but the curves on fig. 1, can be used as a guidance.

A Homogenizer may be installed in the fuel oil system as a supplement to the centrifuges to homogenize possible water and sludge still present in the fuel after centrifuging.

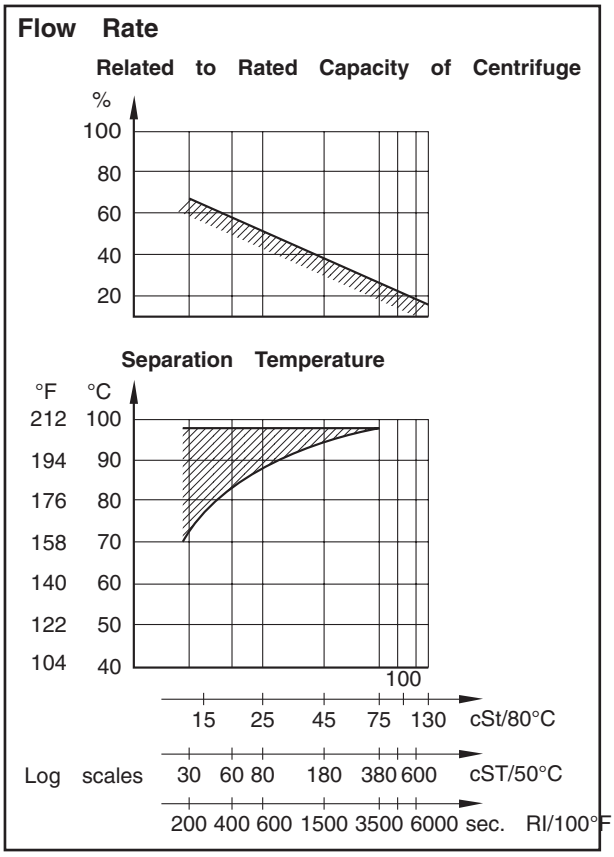

Fig. 1. Flowrate through centrifuge related to nominel capacity of centrifuge.

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Engine cooling water specifications

Preliminary remarks

As is also the case with the fuel and lubricating oil, the engine cooling water must be carefully selected, handled and checked. If this is not the case, corrosion, erosion and cavitation may occur at the walls of the cooling system in contact with water and deposits may form. Deposits obstruct the transfer of heat and can cause thermal overloading of the cooled parts. The system must be treated with an anticorrosive agent before bringing it into operation for the first time. The concentrations prescribed by the engine manufacturer must always be observed during subsequent operation. The above especially applies if a chemical additive is added.

Requirements

Limit values

The properties of untreated cooling water must correspond to the following limit values:

Properties/Characteristic	Properties	Unit
Water type	Distillate or fresh water, free of foreign matter. The following are prohibited: Seawater, brackish water, river water, brines, industrial waste water and rainwater.	-
Total hardness	max. 10	°dH*
pH value	6.5 - 8	-
Chloride ion content	Max. 50	mg/l**

Table 1: Cooling water - properties to be observed

*) 1°dH (German hardness) ≙ 10 mg CaO in 1 litre of water ≙ 17.9 mg $CaCO_3$/l

≙ 0.357 mval/l ≙ 0.179 mmol/l

**) 1 mg/l ≙ 1 ppm

Testing equipment

The MAN Diesel water testing equipment incorporates devices that determine the water properties referred to above in a straightforward manner. The manufacturers of anticorrosive agents also supply user-friendly testing equipment. For information on monitoring cooling water, refer to Work Card 000.07.

Additional information

Distillate

If distilled water (from a fresh water generator, for example) or fully desalinated water (from ion exchange or reverse osmosis) is available, this should ideally be used as the engine cooling water. These waters are free of lime and salts which means that deposits that could interfere with the transfer of heat to the cooling water, and therefore also reduce the cooling effect, cannot form. However, these waters are more corrosive than normal hard water as the thin film of lime scale that would otherwise provide temporary corrosion protection does not form on the walls. This is why distilled water must be handled particularly carefully and the concentration of the additive must be regularly checked.

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Hardness

The total hardness of the water is the combined effect of the temporary and permanent hardness. The proportion of calcium and magnesium salts is of overriding importance. The temporary hardness is determined by the carbonate content of the calcium and magnesium salts. The permanent hardness is determined by the amount of remaining calcium and magnesium salts (sulphates). The temporary (carbonate) hardness is the critical factor that determines the extent of limescale deposit in the cooling system.

Water with a total hardness of > 10°dGH must be mixed with distilled water or softened. Subsequent hardening of extremely soft water is only necessary to prevent foaming if emulsifiable slushing oils are used.

Damage to the cooling water system

Corrosion

Corrosion is an electrochemical process that can widely be avoided by selecting the correct water quality and by carefully handling the water in the engine cooling system.

Flow cavitation

Flow cavitation can occur in areas in which high flow velocities and high turbulence is present. If the steam pressure is reached, steam bubbles form and subsequently collapse in high pressure zones which causes the destruction of materials in constricted areas.

Erosion

Erosion is a mechanical process accompanied by material abrasion and the destruction of protective films by solids that have been drawn in, particularly in areas with high flow velocities or strong turbulence.

Stress corrosion cracking

Stress corrosion cracking is a failure mechanism that occurs as a result of simultaneous dynamic and corrosive stress. This may lead to cracking and rapid crack propagation in water-cooled, mechanically-loaded components if the cooling water has not been treated correctly.

Processing of engine cooling water

Formation of a protective film

The purpose of treating the engine cooling water using anticorrosive agents is to produce a continuous protective film on the walls of cooling surfaces and therefore prevent the damage referred to above. In order for an anticorrosive agent to be 100 % effective, it is extremely important that untreated water satisfies the requirements in the Section *Requirements*.

Protective films can be formed by treating the cooling water with an anticorrosive chemical or an emulsifiable slushing oil.

Emulsifiable slushing oils are used less and less frequently as their use has been considerably restricted by environmental protection regulations, and because they are rarely available from suppliers for this and other reasons.

Treatment prior to initial commissioning of engine

Treatment with an anticorrosive agent should be carried out before the engine is brought into operation for the first time to prevent irreparable initial damage.

⚠ CAUTION

Treatment of the cooling water

The engine must not be brought into operation without treating the cooling water first.

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Additives for cooling water

Only the additives approved by MAN Diesel and listed in the tables under the section entitled *"Approved cooling water additives"* may be used.

Required approval

A cooling water additive may only be permitted for use if tested and approved as per the latest directives of the ICE Research Association (FVV) "Suitability test of internal combustion engine cooling fluid additives." The test report must be obtainable on request. The relevant tests can be carried out on request in Germany at the staatliche Materialprüfanstalt (Federal Institute for Materials Research and Testing), Abteilung Oberflächentechnik (Surface Technology Division), Grafenstraße 2 in D-64283 Darmstadt.

Once the cooling water additive has been tested by the FVV, the engine must be tested in the second step before the final approval is granted.

Only in closed circuits

Additives may only be used in closed circuits where no significant consumption occurs, apart from leaks or evaporation losses.

Chemical additives

Sodium nitrite and sodium borate based additives etc. have a proven track record. Galvanised iron pipes or zinc sacrificial anodes must not be used in cooling systems. This corrosion protection is not required due to the prescribed cooling water treatment and electrochemical potential reversal can occur due to the cooling water temperatures which are normally present in engines nowadays. If necessary, the pipes must be deplated.

Slushing oil

This additive is an emulsifiable mineral oil with added slushing ingredients. A thin film of oil forms on the walls of the cooling system. This prevents corrosion without interfering with the transfer of heat and also prevents limescale deposits on the walls of the cooling system.

The significance of emulsifiable corrosion-slushing oils is fading. Oil-based emulsions are rarely used nowadays for environmental protection reasons and also because stability problems are known to occur in emulsions.

Anti-freeze agents

If temperatures below the freezing point of water in the engine cannot be excluded, an anti-freeze solution that also prevents corrosion must be added to the cooling system or corresponding parts. Otherwise, the entire system must be heated. (Military specification: Sy-7025).

Sufficient corrosion protection can be provided by adding the products listed in the table entitled *"Anti-freeze solutions with slushing properties"* while observing the prescribed concentration. This concentration prevents freezing at temperatures down to -22 °C. However, the quantity of anti-freeze solution actually required always depends on the lowest temperatures that are to be expected at the place of use.

Anti- freezes are generally based on ethylene glycol. A suitable chemical anti-corrosive agent must be added if the concentration of the anti-freeze solution prescribed by the user for a specific application does not provide an appropriate level of corrosion protection, or if the concentration of anti-freeze solution used is lower due to less stringent frost protection requirements and does not provide an appropriate level of corrosion protection. For information on the compatibility of the anti-freeze solution with the anticorrosive agent

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and the required concentrations, contact the manufacturer. As regards the chemical additives indicated in the table *„Nitrite-Containing Chemical Additives“*, their compatibility with ethylene glycol-based antifreezes has been proved. Anti-freeze solutions may only be mixed with one another with the consent of the manufacturer, even if these solutions have the same composition.

Before an anti-freeze solution is used, the cooling system must be thoroughly cleaned.

If the cooling water contains an emulsifiable slushing oil, anti-freeze solution must not be added as otherwise the emulsion would break up and oil sludge would form in the cooling system.

Observe the applicable environmental protection regulations when disposing of cooling water containing additives. For more information, consult the additive supplier.

Biocides

If you cannot avoid using a biocide because the cooling water has been contaminated by bacteria, observe the following steps:

- You must ensure that the biocide to be used is suitable for the specific application.
- The biocide must be compatible with the sealing materials used in the cooling water system and must not react with these.
- The biocide and its decomposition products must not contain corrosion-promoting components. Biocides whose decomposition products contain chloride or sulphate ions are not permitted.
- Biocides that cause foaming of cooling water are not permitted.

Prerequisite for effective use of an anticorrosive agent

Clean cooling system

As contamination significantly reduces the effectiveness of the additive, the tanks, pipes, coolers and other parts outside the engine must be free of rust and other deposits before the engine is started up for the first time and after repairs are carried out on the pipe system. The entire system must therefore be cleaned with the engine switched off using a suitable cleaning agent (see Work Cards 000.03 and 000.08 by MAN Diesel).

Loose solid matter in particular must be removed by flushing the system thoroughly as otherwise erosion may occur in locations where the flow velocity is high.

The cleaning agents must not corrode the seals and materials of the cooling system. In most cases, the supplier of the cooling water additive will be able to carry out this work and, if this is not possible, will at least be able to provide suitable products to do this. If this work is carried out by the engine operator, he should use the services of a specialist supplier of cleaning agents. The cooling system must be flushed thoroughly following cleaning. Once this has been done, the engine cooling water must be treated immediately with anticorrosive agent. Once the engine has been brought back into operation, the cleaned system must be checked for leaks.

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Regular checks of the cooling water condition and cooling water system

Treated cooling water may become contaminated when the engine is in operation, which causes the additive to loose some of its effectiveness. It is therefore advisable to regularly check the cooling system and the cooling water condition. To determine leakages in the lube oil system, it is advisable to carry out regular checks of water in the compensating tank. Indications of oil content in water are, e.g. discoloration or a visible oil film on the surface of the water sample.

The additive concentration must be checked at least once a week using the test kits specified by the manufacturer. The results must be documented.

NOTICE

Concentrations of chemical additives

The chemical additive concentrations shall not be less than the minimum concentrations indicated in the table *„Nitrite-containing chemical additives“*.

Excessively low concentrations can promote corrosion and must be avoided. If the concentration is slightly above the recommended concentration this will not result in damage. Concentrations that are more than twice the recommended concentration should be avoided.

Every 2 to 6 months send a cooling water sample to an independent laboratory or to the engine manufacturer for integrated analysis.

Emulsifiable anticorrosive agents must generally be replaced after abt. 12 months according to the supplier's instructions. When carrying this out, the entire cooling system must be flushed and, if necessary, cleaned. Once filled into the system, fresh water must be treated immediately.

If chemical additives or anti-freeze solutions are used, cooling water should be replaced after 3 years at the latest.

If there is a high concentration of solids (rust) in the system, the water must be completely replaced and entire system carefully cleaned.

Deposits in the cooling system may be caused by fluids that enter the cooling water, or the break up of emulsion, corrosion in the system and limescale deposits if the water is very hard. If the concentration of chloride ions has increased, this generally indicates that seawater has entered the system. The maximum specified concentration of 50 mg chloride ions per kg must not be exceeded as otherwise the risk of corrosion is too high. If exhaust gas enters the cooling water, this may lead to a sudden drop in the pH value or to an increase in the sulphate content.

Water losses must be compensated for by filling with untreated water that meets the quality requirements specified in the section Requirements. The concentration of the anticorrosive agent must subsequently be checked and adjusted if necessary.

Subsequent checks of cooling water are especially required if the cooling water had to be drained off in order to carry out repairs or maintenance.

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Protective measures

Anticorrosive agents contain chemical compounds that can pose a risk to health or the environment if incorrectly used. Comply with the directions in the manufacturer's material safety data sheets.

Avoid prolonged direct contact with the skin. Wash hands thoroughly after use. If larger quantities spray and/or soak into clothing, remove and wash clothing before wearing it again.

If chemicals come into contact with your eyes, rinse them immediately with plenty of water and seek medical advice.

Anticorrosive agents are generally harmful to the water cycle. Observe the relevant statutory requirements for disposal.

Auxiliary engines

If the same cooling water system used in a MAN Diesel & Turbo two-stroke main engine is used in a marine engine of type 16/24, 21/ 31, 23/30H, 27/38 or 28/32H, the cooling water recommendations for the main engine must be observed.

Analysis

We analyse cooling water for our customers in our chemical laboratory. A 0.5 l sample is required for the test.

Permissible cooling water additives

Nitrite-containing chemical additives

Manufacturer	Product designation	Initial dosing for 1,000 litres	Minimum concentration ppm		
			Product	Nitrite (NO_2)	Na-Nitrite ($NaNO_2$)
Drew Marine One Drew Plaza Boonton New Jersey 07005 USA	Liquidewt Maxigard	15 l 40 l	15,000 40,000	700 1,330	1,050 2,000
Wilhelmsen (Unitor) KJEMI-Service A.S. P.O.Box 49/Norway 3140 Borgheim	Rocor NB Liquid Dieselguard	21.5 l 4.8 kg	21,500 4,800	2,400 2,400	3,600 3,600
Nalfleet Marine Chemicals P.O.Box 11 Northwich Cheshire CW8DX, U.K.	Nalfleet EWT Liq (9-108) Nalfleet EWT 9-111 Nalcool 2000	3 l 10 l 30 l	3,000 10,000 30,000	1,000 1,000 1,000	1,500 1,500 1,500
Nalco	Nalcool 2000 TRAC 102 TRAC 118	30 l 30 l 3 l	30,000 30,000 3,000	1,000 1,000 1,000	1,500 1,500 1,500
Maritech AB P.O.Box 143 S-29122 Kristianstad	Marisol CW	12 l	12,000	2,000	3,000

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Manufacturer	Product designation	Initial dosing for 1,000 litres	Minimum concentration ppm		
			Product	Nitrite (NO_2)	Na-Nitrite ($NaNO_2$)
Uniservice Via al Santuario di N.S. della Guardia 58/A 16162 Genova, Italy	N.C.L.T. Colorcooling	12 l 24 l	12,000 24,000	2,000 2,000	3,000 3,000
Marichem – Marigases 64 Sfaktirias Street 18545 Piraeus, Griechen-land	D.C.W.T. - Non-Chromate	48 l	48,000	2,400	-
Marine Care 3144 NA Maasluis The Netherlands	Caretreat 2	16 l	16,000	4,000	6,000
Vecom Schlenzigstraße 7 21107 Hamburg Deutschland	Cool Treat NCLT	16 l	16,000	4,000	6,000

Table 2: Nitrite-containing chemical additives

Nitrite-free additives (chemical additives)

Manufacturer	Product designation	Initial dosing for 1 000 litres	Minimum concentration
Arteco Technologiepark Zwijnaarde 2 B-9052 Gent, Belgium	Havoline XLI	75 l	7.5 %
Total Lubricants Paris, France	WT Supra	75 l	7.5 %
Q8 Oils	Q8 Corrosion Inhibitor Long-Life	75 l	7.5 %

Table 3: Chemical additives - nitrite free

Emulsifiable slushing oils

Manufacturer	Product (designation)
BP Marine, Breakspear Way, Hemel Hempstead, Herts HP2 4UL	Diatsol M Fedaro M
Castrol Int., Pipers Way, Swindon SN3 1RE, UK	Solvex WT 3
Deutsche Shell AG, Überseering 35, 22284 Hamburg, Germany	Oil 9156

Table 4: Emulsifiable slushing oils

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Anti-freeze solutions with slushing properties

Manufacturer	Product designation	Minimum concentration
BASF Carl-Bosch-Str. 67063 Ludwigshafen, Rhein Deutschland	Glysantin G 48 Glysantin 9313 Glysantin G 05	35%
Castrol Int. Pipers Way Swindon SN3 1RE, UK	Antifreeze NF, SF	
BP, Britannic Tower Moor Lane, London EC2Y 9B, UK	Anti-frost X2270A	
Deutsche Shell AG Überseering 35 22284 Hamburg Deutschland	Glycoshell	
Mobil Oil AG Steinstraße 5 20095 Hamburg Deutschalnd	Frostschutz 500	
Arteco, Technologiepark Zwijnaarde 2 B-9052 Gent, Belgium	Havoline XLC	
Total Lubricants Paris, France	Glacelf Auto Supra Total Organifreeze	

Table 5: Anti-freeze solutions with slushing properties

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Cooling water inspecting

Summary

Acquire and check typical values of the operating media to prevent or limit damage.

The fresh water used to fill the cooling water circuits must satisfy the specifications. The cooling water in the system must be checked regularly in accordance with the maintenance schedule.
The following work/steps is/are necessary:
Acquisition of typical values for the operating fluid,
evaluation of the operating fluid and checking the concentration of the anti-corrosive agent.

Tools/equipment required

Equipment for checking the fresh water quality

The following equipment can be used:

- The MAN Diesel & Turbo water testing kit, or similar testing kit, with all necessary instruments and chemicals that determine the water hardness, pH value and chloride content (obtainable from MAN Diesel & Turbo or Mar-Tec Marine, Hamburg)

Equipment for testing the concentration of additives

When using chemical additives:

- Testing equipment in accordance with the supplier's recommendations. Testing kits from the supplier also include equipment that can be used to determine the fresh water quality.

Testing the typical values of water

Short specification

Typical value/property	Water for filling and refilling (without additive)	Circulating water (with additive)
Water type	Fresh water, free of foreign matter	Treated cooling water
Total hardness	≤ 10°dGH [1)]	≤ 10°dGH [1)]
pH value	6.5 - 8 at 20 °C	≥ 7.5 at 20 °C
Chloride ion content	≤ 50 mg/l	≤ 50 mg/l [2)]

Table 1: Quality specifications for cooling water (abbreviated version)

[1)] dGH German hardness

1°dGh = 10 mg/l CaO
= 17.9 mg/l $CaCO_3$
= 0.179 mmol/L

[2)] 1mg/l = 1 ppm

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Testing the concentration of anticorrosive agents

Short specification

Anticorrosive agent	Concentration
Chemical additives	according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7
Anti-freeze agents	according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7

Table 2: Concentration of the cooling water additive

Testing the concentration of chemical additives

The concentration should be tested every week, and/or according to the maintenance schedule, using the testing instruments, reagents and instructions of the relevant supplier.

Chemical slushing oils can only provide effective protection if the right concentration is precisely maintained. This is why the concentrations recommended by MAN Diesel & Turbo (quality specifications in Volume 010.005 Engine – Operating Instructions, Chapter 3, Page 3.3.7) must be complied with in all cases. These recommended concentrations may be other than those specified by the manufacturer.

Testing the concentration of anti-freeze agents

The concentration must be checked in accordance with the manufacturer's instructions or the test can be outsourced to a suitable laboratory. If in doubt, consult MAN Diesel & Turbo.

Regular water samplings

Small quantities of lubricating oil in cooling water can be found by visual check during regular water sampling from the expansion tank.

Testing

We test cooling water for customers in our laboratory. To carry out the test, we will need a representative sample of abt. 0.5 l.

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Cooling water system
Cleaning

Summary

Remove contamination/residue from operating fluid systems, ensure/re-establish operating reliability.

Cooling water systems containing deposits or contamination prevent effective cooling of parts. Contamination and deposits must be regularly eliminated.
This comprises the following:
Cleaning the system and, if required,
removal of limescale deposits,
flushing the system.

Cleaning

The cooling water system must be checked for contamination at regular intervals. Cleaning is required if the degree of contamination is high. This work should ideally be carried out by a specialist who can provide the right cleaning agents for the type of deposits and materials in the cooling circuit. The cleaning should only be carried out by the engine operator if this cannot be done by a specialist.

Oil sludge

Oil sludge from lubricating oil that has entered the cooling system or a high concentration of anticorrosive agents can be removed by flushing the system with fresh water to which some cleaning agent has been added. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing oil sludge*". Products by other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed.

Manufacturer	Product	Concentration	Duration of cleaning procedure/temperature
Drew	HDE - 777	4 - 5%	4 h at 50 – 60 °C
Nalfleet	MaxiClean 2	2 - 5%	4 h at 60 °C
Unitor	Aquabreak	0.05 – 0.5%	4 h at ambient temperature
Vecom	Ultrasonic Multi Cleaner	4%	12 h at 50 – 60 °C

Table 1: Cleaning agents for removing oil sludge

Lime and rust deposits

Lime and rust deposits can form if the water is especially hard or if the concentration of the anticorrosive agent is too low. A thin lime scale layer can be left on the surface as experience has shown that this protects against corrosion. However, limescale deposits with a thickness of more than 0.5 mm obstruct the transfer of heat and cause thermal overloading of the components being cooled.

Rust that has been flushed out may have an abrasive effect on other parts of the system, such as the sealing elements of the water pumps. Together with the elements that are responsible for water hardness, this forms what is known as ferrous sludge which tends to gather in areas where the flow velocity is low.

Products that remove limescale deposits are generally suitable for removing rust. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing lime scale and rust deposits"*. Products by

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other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed. Prior to cleaning, check whether the cleaning agent is suitable for the materials to be cleaned. The products listed in the table entitled *"Cleaning agents for removing lime scale and rust deposits"* are also suitable for stainless steel.

Manufacturer	Product	Concentration	Duration of cleaning procedure/temperature
Drew	SAF-Acid Descale-IT Ferroclean	5 - 10% 5 - 10% 10%	4 h at 60 - 70 °C 4 h at 60 - 70 °C 4 - 24 h at 60 - 70 °C
Nalfleet	Nalfleet 9 - 068	5%	4 h at 60 – 75 °C
Unitor	Descalex	5 - 10%	4 - 6 h at approx. 60 °C
Vecom	Descalant F	3 – 10%	Approx. 4 h at 50 – 60°C

Table 2: Cleaning agents for removing limescale and rust deposits

In emergencies only

Hydrochloric acid diluted in water or aminosulphonic acid may only be used in exceptional cases if a special cleaning agent that removes limescale deposits without causing problems is not available. Observe the following during application:

- Stainless steel heat exchangers must never be treated using diluted hydrochloric acid.
- Cooling systems containing non-ferrous metals (aluminium, red bronze, brass, etc.) must be treated with deactivated aminosulphonic acid. This acid should be added to water in a concentration of 3 - 5 %. The temperature of the solution should be 40 - 50 °C.
- Diluted hydrochloric acid may only be used to clean steel pipes. If hydrochloric acid is used as the cleaning agent, there is always a danger that acid will remain in the system, even when the system has been neutralised and flushed. This residual acid promotes pitting. We therefore recommend you have the cleaning carried out by a specialist.

The carbon dioxide bubbles that form when limescale deposits are dissolved can prevent the cleaning agent from reaching boiler scale. It is therefore absolutely necessary to circulate the water with the cleaning agent to flush away the gas bubbles and allow them to escape. The length of the cleaning process depends on the thickness and composition of the deposits. Values are provided for orientation in the table entitled *"Detergents for removing lime scale and rust deposits"*.

Following cleaning

The cooling system must be flushed several times once it has been cleaned using cleaning agents. Replace the water during this process. If acids are used to carry out the cleaning, neutralise the cooling system afterwards with suitable chemicals then flush. The system can then be refilled with water that has been prepared accordingly.

⚠ CAUTION

Only carry out the cleaning operation once the engine has cooled down

Start the cleaning operation only when the engine has cooled down. Hot engine components must not come into contact with cold water. Open the venting pipes before refilling the cooling water system. Blocked venting pipes prevent air from escaping which can lead to thermal overloading of the engine.

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CAUTION

Cleaning products can cause damage

The products to be used can endanger health and may be harmful to the environment.

Follow the manufacturer's handling instructions without fail.

The applicable regulations governing the disposal of cleaning agents or acids must be observed.

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Water specification for fuel-water emulsions

Prerequisites

The water used for the fuel-water emulsion is an operating fluid that must be carefully selected, processed (if necessary) and monitored. If this is not done, deposits, corrosion, erosion and cavitation may occur on the fuel system components that come into contact with the fuel-water emulsion.

Specifications

Limit values

The characteristic values of the water used must be within the following limit values:

Properties/ Characteristic	Characteristic value	Unit
Water type	Seawater, brackish water, river water, brines, industrial waste water and rainwater, distilled or fresh water	-
Total hardness	max. 10	°dH*
pH value	6.5 - 8	-
Chloride ion content	max. 50	mg/l

Table 1: Fuel-water emulsion - characteristic values to be observed

*) 1° dH (German hardness)	≙ 10 mg CaO in 1l water	≙ 17.9 mg $CaCO_3$/l
	≙ 0.357 mval/l	≙ 0.179 mmol/l

Testing instruments

The MAN Diesel water testing kit contains instruments that allow the water characteristics referred to above (and others) to be easily determined.

Additional information

Distillate

If distillate (e.g. from the fresh water generator) or fully desalinated water (ion exchanger) is available, this should ideally be used for the fuel-water emulsion. These types of water are free of lime and salts.

Hardness

The total hardness of the water is the combined effect of the temporary and permanent hardness. It is largely determined by the calcium and magnesium salts. The temporary hardness depends on the hydrocarbonate content in the calcium and magnesium salts. The lasting (permanent) hardness is determined by the remaining calcium and magnesium salts (sulphates).

Water with hardness greater than 10°dH (German total hardness) must be blended or softened with distillate. It is not necessary to increase the hardness of extremely soft water.

⚠ CAUTION

Treatment with anticorrosive agents not required

Treatment with anticorrosive agents is not required and must be omitted.

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Specifications for intake air (combustion air)

General

The quality and condition of intake air (combustion air) have a significant effect on the power output, wear and emissions of the engine. In this regard, not only are the atmospheric conditions extremely important, but also contamination by solid and gaseous foreign matter.

Mineral dust in the intake air increases wear. Chemicals and gases promote corrosion.

This is why effective cleaning of intake air (combustion air) and regular maintenance/cleaning of the air filter are required.

When designing the intake air system, the maximum permissible overall pressure drop (filter, silencer, pipe line) of 20 mbar must be taken into consideration.

Requirements

Gas engines or dual-fuel engines may only be equipped with a dry filter. An oil filter should not be installed, because they enrich air with oil mist, which is not permissible for gas operated engines. Filters of efficiency class G4 according to EN 779 must be used. The concentrations downstream of the air filter and/or upstream of the turbocharger inlet must not exceed the following limit values:

Properties	Typical value	Unit *
Dust (sand, cement, CaO, Al_2O_3 etc.)	max. 5	mg/Nm³
Chlorine	max. 1.5	
Sulphur dioxide (SO_2)	max. 1.25	
Hydrogen sulphide (H_2S)	max. 5	
Salt (NaCl)	max. 1	
* One Nm³ corresponds to one cubic meter of gas at 0 °C and 101.32 kPa.		

Table 1: Intake air (combustion air) - typical values to be observed

WARNING

Intake air shall not contain any flammable gases

Intake air shall not contain any flammable gases. Make sure that the combustion air is not explosive.

2012-01-17 - de

Cylinder head

505/605

L28/32H, V28/32H

General

The cylinder head is made of cast iron and is tightened to form a gas-tight seal against a sealing ring on the cylinder liner by means of 6 nuts and 6 studs, which are screwed into the engine frame. The nuts are tightened by means of hydraulic jacks.

Each cylinder head is equipped with two air inlet and two exhaust valves which are actuated by rocker arms running in bearings on a shaft supported in a bracket on top of the cylinder head.

The fuel injection valve (see section 614) is located in a interchangeable sleeve in the center of the cylinder head.

Furthermore the cylinder head is equipped with an indicator valve and a safety valve.

The cylinder head has a screwed-on coaming which encloses the valves. The coaming is closed with a top cover and thus provides an oil tight enclosure for the valve gear. The coaming is equipped with an inspection cover for the rotators.

Air inlet and exhaust valves

The inlet valve spindles are identical to the exhaust spindles.

The valves are made of heat-resistant material. Hard metal is welded on to the valve spindle seats to avoid depressions by combustion particles.

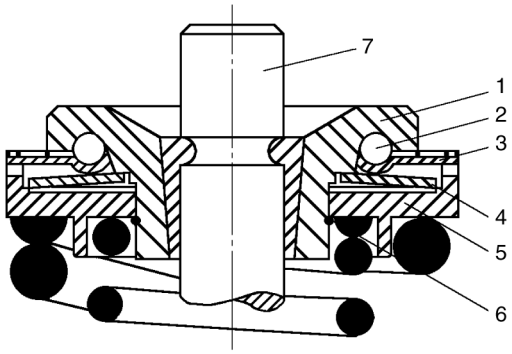
The valve spindles are fitted with valve rotators which turn the spindles a little each time the valves open.

The cylinder head is equipped with interchangeable seat rings and valve guides for inlet and exhaust valves.The valve seat rings and valve guides for inlet and exhaust valves are identical.

The seat rings are made of heat-resistant steel, directly hardened on the seating surface and the seat rings are directly water cooled in order to assure low valve temperature.

Valve rotator

The retainer body of the valve rotator (1) has a number of pockets, arranged in circumferential direction, with balls that are forced against the upper end of an inclined race by coil springs acting in tangential direction. The ball race (3) serves as ball track in the opposite direction. The spring washer (4) seats against the inner rim of the retainer body and is encased by the seating collar (5) which overlaps it. The assembled valve rotator is held together, when removed, by the retaining ring (6).



1	Retainer body	2	Balls
3	Ball race	4	Spring washer
5	Seating collar	6	Retainer ring
7	Valve spindle		

Figure 1: Valve rotator

As the valve starts to open, the increasing valve spring-load causes the spring washer to flatten, and the load applied to the balls in the pockets of the retainer body forces the balls in the ball race to roll down the inclined races. The transfer of the reaction load of the ball race to the spring washer reduces the reaction load of the spring washer on the inner rim of the retainer body. Ball race, spring washer, seating collar and valve springs are, however, force-locked by friction grip. The reaction load of the balls on the inclined races induces rotation to the retainer body and valve with relation to the seating collar and the valve springs. As the valve closes, load is released from the spring washer and thus from the balls, allowing them to be returned to their original positions without rolling by the tangential force of the coil springs.

L/V28/32H

Safety precautions:

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

Description:

Dismantling of cylinder head for inspection and/or overhaul.

Starting position:

Cooling water has been drained from engine.

Related procedure:

Dismounting of piston and connecting rod,	606-01.00
Dismounting and inspection of inlet valve, exhaust valve and valve guide,	605-01.05
Safety valve,	605-01.25
Dismantling, overhaul and test pressure of fuel oil valve,	614-01.10

Man power:

Working time	:	1 Hour
Capacity	:	2 men

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62021	10	
62021	01	Oil injector, (complete)
62021	50	6 Piece
62021	51	1 Piece
62021	15	
62005	01	
62021	25	Hydraulic tools
62014	15	

Hand tools:

Ring and open end spanner 14 mm.
Ring and open end spanner 17 mm.
Ring and open end spanner 24 mm.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L/V28/32H

1) Open the drain cock and vent cock for cooling water.

2) Take off the rocker arm top cover.

3) Take off the cover which gives access to the injection pump.

4) Disconnect the fuel oil high-pressure pipe.

5) Disconnect the cooling oil pipes, (inlet and outlet.

6) Disconnect the rocker arm lubricating oil pipe.

7) Remove the thermometer attachment branch (cooling water outlet pipe).

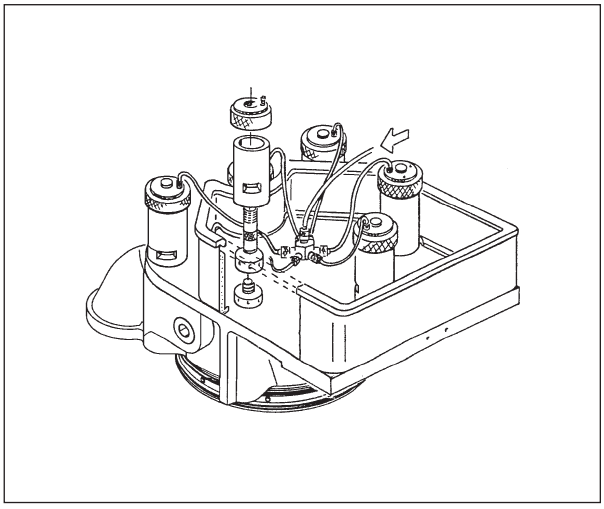


Fig. 1

8) Remove the exhaust pipe flange screws.

9) Remove the cylinder head nuts, as shown, by means of hydraulic jacks, see working card 620-01.05.

10) Mount the lifting tool on the cylinder head.

11) Attach the hook to the lifting tool and lift the cylinder head away.

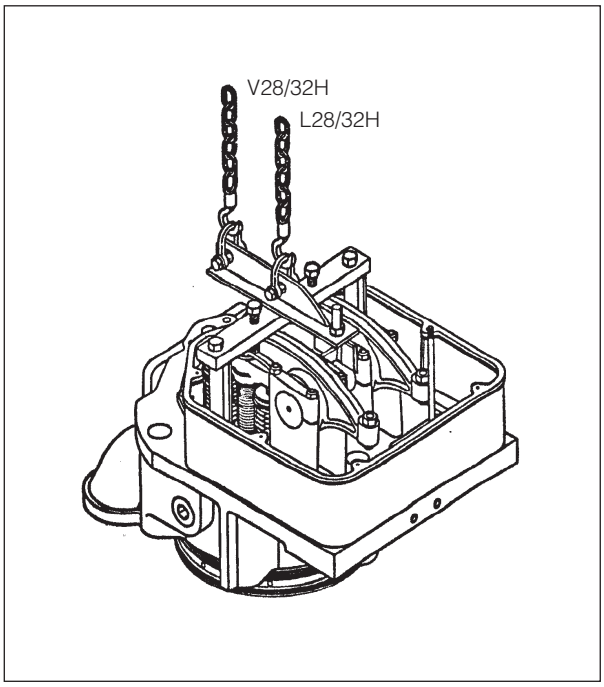


Fig. 2

Working Card Page 1 (3)	Inspection of Inlet Valve, Exhaust Valve and Valve Guide	605-01.05 Edition 06H

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Dismounting of inlet and exhaust valve, inspection of valve guide and mounting of inlet and exhaust valve.

Starting position

Cylinder head, dismantled from engine 605-01.00

Related procedure

Reconditioning of valve spindle seat and valve seat ring,	605-01.10
Valve rotator,	605-01.15
Replacement of valve guide,	605-01.20
Replacement of valve seat ring,	605-01.35
Mounting of cylinder head,	605-01.45

Man power

Working time	:	1	hour
Capacity	:	1	man

Data

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools

Plate no	Item no	Note
62005	01	
62005	05	
62005	25/30	Extra tools
62005	55	

Hand tools

Ring and open end spanner, 19 mm.
Ring and open end spanner, 24 mm.
Small screw driver.
Measuring tools.

Replacement and wearing parts

Plate no	Item no	Qty. /
60501	017	4/cyl.

L+V28/32H

Dismantling of Inlet and Exhaust Valve Spindles

1) Land and fasten the cylinder head upon the special work table and remove the lifting tool.

Or as an Alternative:

Land the cylinder head on the floor upon wooden supports and remove the lifting tool.

2) Mount the supporting devices for the valve spindle heads on the work table.

Or as an Alternative:

Place wooden blocks under the valve spindle heads.

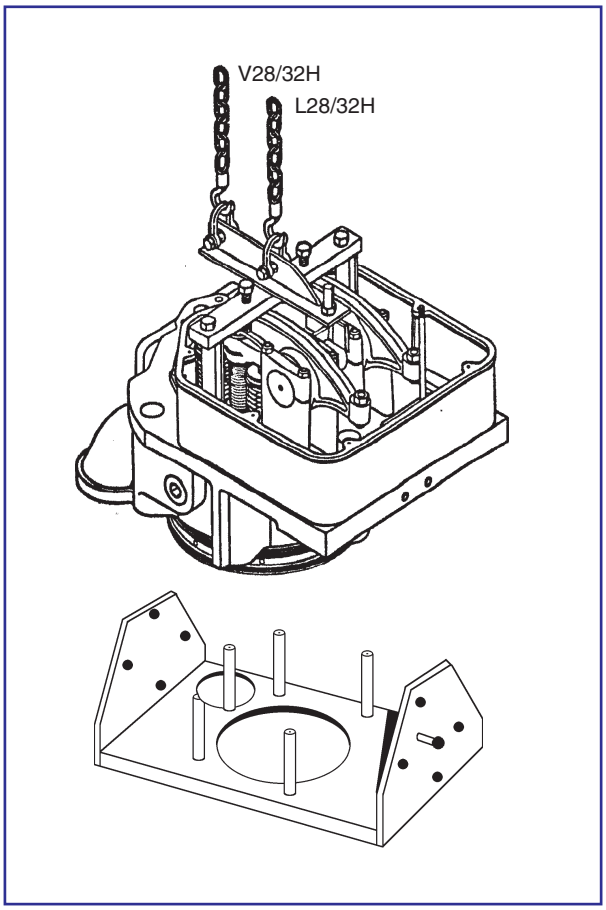


Fig 1

3) Turn back the rocker arm and remove the spring-loaded valve bridge over the valve spindles.

4) After having removed the valve bridge and turned the rocker arm back, the tool should be fitted by means of the screws (A), see fig 2 tightened in the threaded holes in the cylinder head.

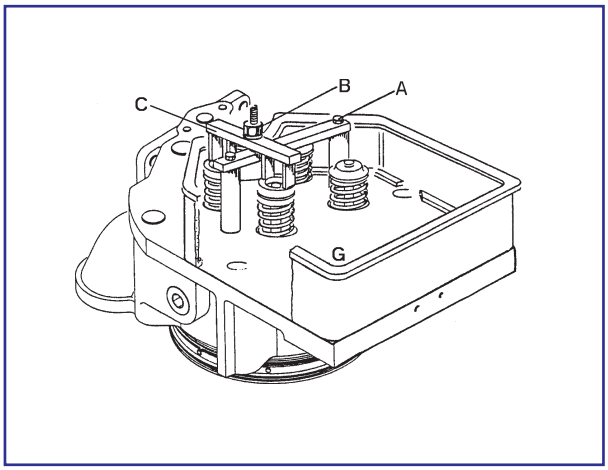


Fig 2

5) Now compress the valve springs by tightening the nut (B), after which the cone rings can be re-moved, see fig 3.

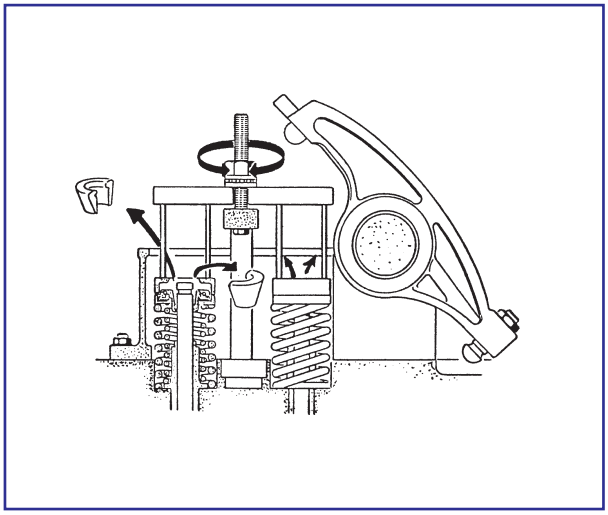


Fig 3

6) Release the springs again. Remove the nut (B) and the traverse (C). Now valve rotator and springs can be removed.

7) Remove the supporting devices under the work table and take out the valve spindle.

8) Repeat point 4 - 7 to remove the two other valve spindles.

Inspection of Valves/Valve Seats

9) A slight grinding of valve/valve seat can be carried out by means of the handle as shown, see fig 4.

If the valve seat is heavily burnt or scarred, it should be ground using the valve seat grinder according to working card 605-01.10.

Inspection of valve guide

10) Too much clearance between valve spindle and spindle guide may cause increased lub. oil consumption, fouling up of the spindle guide and thus give the risk of a sticking valve spindle.

Too much clearance also means insufficient guid-ance of the valve spindle, and thus bad alignment between spindle head and valve seat ring. In connection with overhaul of the cylinder head, the valve spindle guides should be cleaned, inspected and measured for wear. If the inner diameter of the valve spindle guide exceeds the tolerance, see page 600.35 the valve spindle guide must be replaced. See working card 605-01.20.

11) For mounting of valve spindle follow the in-structions in point 4 - 7 in reversed order.

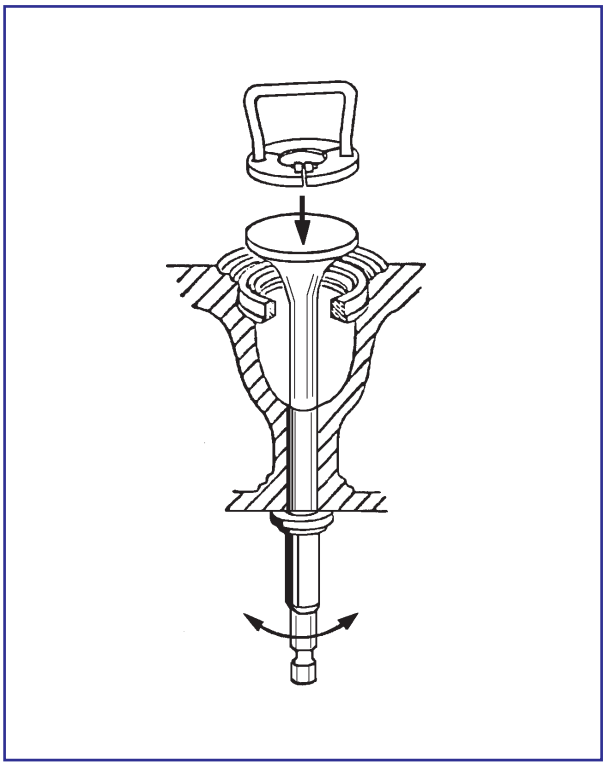


Fig 4

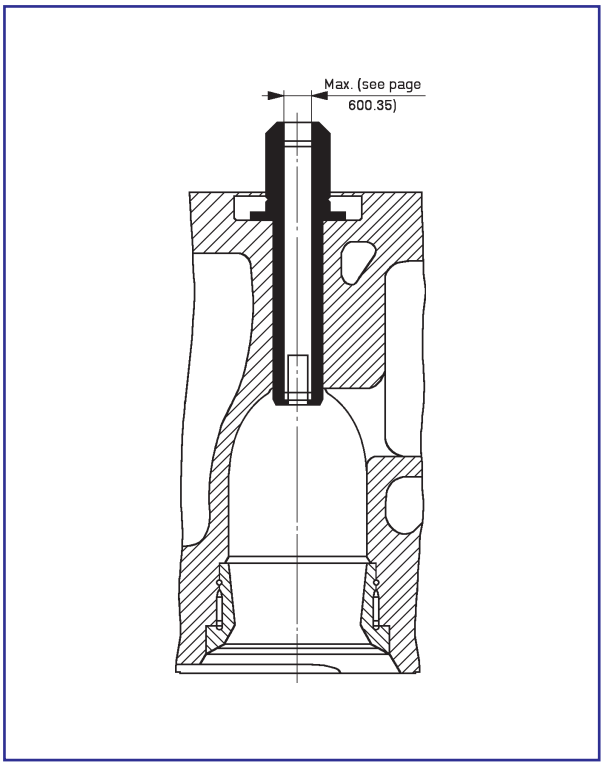


Fig 5

Working Card Page 1 (3)	**Reconditioning of Valve Spindle Seat and Valve Seat Ring**	**605-01.10** Edition 01H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Reconditioning of valve spindle seat and valve seat ring, with special grinding machine.

Starting position:

Valve spindle has been removed, 605-01.05

Related procedure:

Mounting of valve spindle, 605-01.05

Man power:

Working time : 6 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62005	40	Grinding machine for valve spindle.
62005	35	Grinding machine for valve seat ring. (Extra tools).

Hand tools:

All the hand tools and new stones, are included in the tools box for grinding machine.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L/V28/32H

Reconditioning of Valve Seat Ring.

Reconditioning of valve seat rings by machining is carried out by means of a grinding machine, the pilot spindle of which is to be mounted in the valve spindle guide. For operation of the grinding machine, see separate instructions.

The grinding of the valve seat ring should be carried out according to the following sequence:

1) The seating surface itself is ground with a feed at an angle "A" of 30° $\pm^{0,10°}_{0.}$

The grinding should be continued until a clean and uniform surface condition has been obtained.

Carry out the final grinding with a feed in direction from inside to outwards, as normally the best surface quality is obtained in this way.

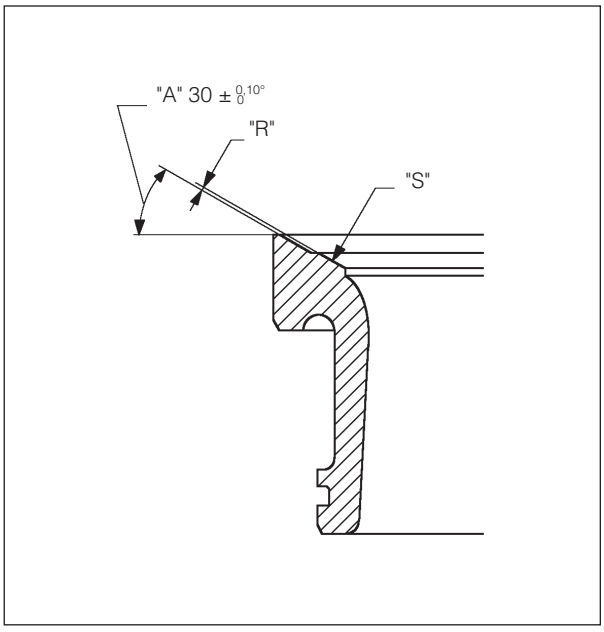


Fig. 1.

2) Normally the valve seat ring can be reconditioned several times.

However when the seat "S" has been ground to such an extent, that the recess "R" disappears, the valve seat ring has to be scrapped and a new one to must installed, see working card 605-01.35

Reconditioning of Valve Spindle.

Reconditioning by machining is carried out with the valve spindle being rotated in a turning lathe and a special grinding machine mounted on the tool post of the turning latch.

For operation of the grinding machine, see separated instructions.

1) The seating surface itself is ground with a feed at an angel "A" of 30° $\pm^{0.}_{0,25°.}$

2) The grinding shoud be continued until a clean and uniform surface condition has been obtained.

3) After completing the grinding, the height "H"1 of the valve head should be checked.

"H"1 has to be at least, see page 600.35.

If measured to be less, the spindle has to be scrapped.

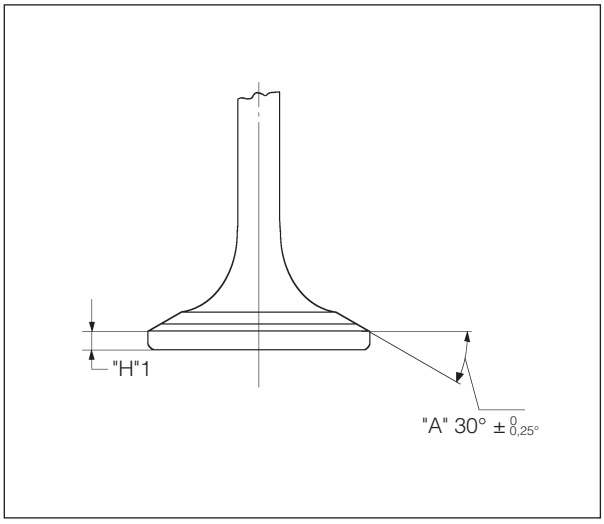


Fig. 2.

After assembling the valves, check - on account of the valve motion - that distance "H"2 between the upper edge of the cylinder head and the upper edge of the valve spindle does not exceed the maximum value, see page 600.35.

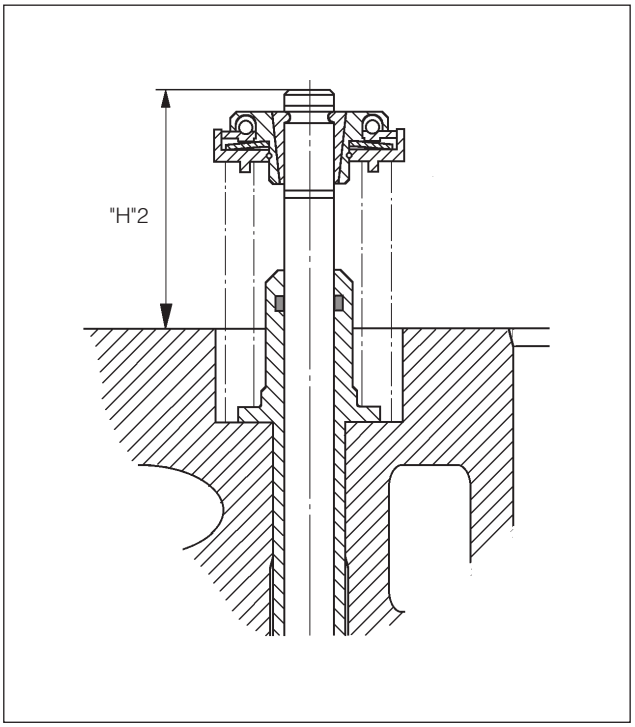


Fig. 3.

Working Card Page 1 (2)	Valve Rotator	605-01.15 Edition 01H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Dismantling, inspection and mounting of valve rotator.

Starting position:

Valve spindles has been removed, 605-01.05

Related procedure:

Mounting of valve spindles, 605-01.05

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62005	05	

Hand tools:

Small screw driver.
Ring and open end spanner 24 mm.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L/V28/32H

Inspection of Rotocap.

Dirt especially in the ball pockets due to residues in the oil (abrasives, combustion products), can cause the individual parts to become stuck, and hinder the movement of the balls.

Rotocap valve rotators need no servicing under normal operating conditions.

Unusual operating conditions may lead to disturbances. Rotation of the valve should be checked at the intervals specified in the "Maintenance program". Rotator performance is satisfactory when the valve rotates visibly and evenly.

Dismantling of Rotocap.

See working card 605-01.05, point 3 to 6.

Overhauls

Valve rotators should be cleaned and inspected for wear and ball impressions whenever the valves are removed. The individual parts can be disassembled after removal of the retaining ring, by means of which the seating collar is fastened to the retainer body.

Parts showing wear grooves or depressions formed by the balls should be replaced.

When inserting the balls and the tangential springs, note that all balls on the inclined races of the ball pockets point in the same direction, see fig. 1.

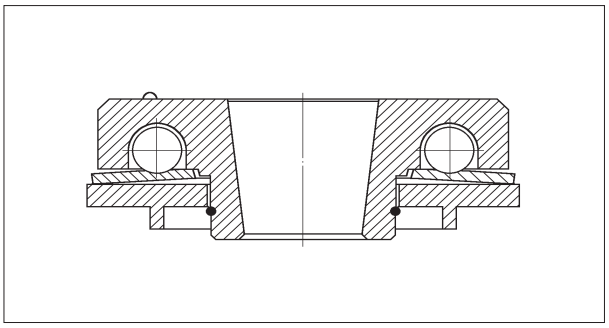


Fig. 1.

The inner ring of the spring washer should rest on the retainer body.

Note ! Having assembled the valve rotator in dry condition it should be placed in clean lubricating oil for a short period of time.

Mounting of Rotocap

See working card 605-01.05, point 3 to 6 , opposite direction.

Working Card Page1 (2)	Replacement of Valve Guide	605-01.20 Edition 05H

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Dismantling and mounting of valve guide, for inlet and exhaust valve.

Starting position

Valve spindle has been removed, 605-01.05

Related procedure

Mounting of valve spindles, 605-01.05

Man power

Working time : 3/4 Hour
Capacity : 1 man

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no.	Item no.	Note.
62005	60	Lytra tools

Hand tools

Hammer.
Nitrogen (N_2), or similar.

Replacement and wearing parts

Plate no.	Item no.	Qty. /
60501	017	4/cyl.
60501	029	4/cyl.

L+V28/32H

If the clearance exceeds the shown max. limit, (see page 600.35), the valve guide must be replaced.

Dismounting of valve guide

1) The valve guide is knocked out from the bottom of the cylinder head,by means of a mandrel, which has a shoulder turning that fits into the valve guide, see fig. 1.

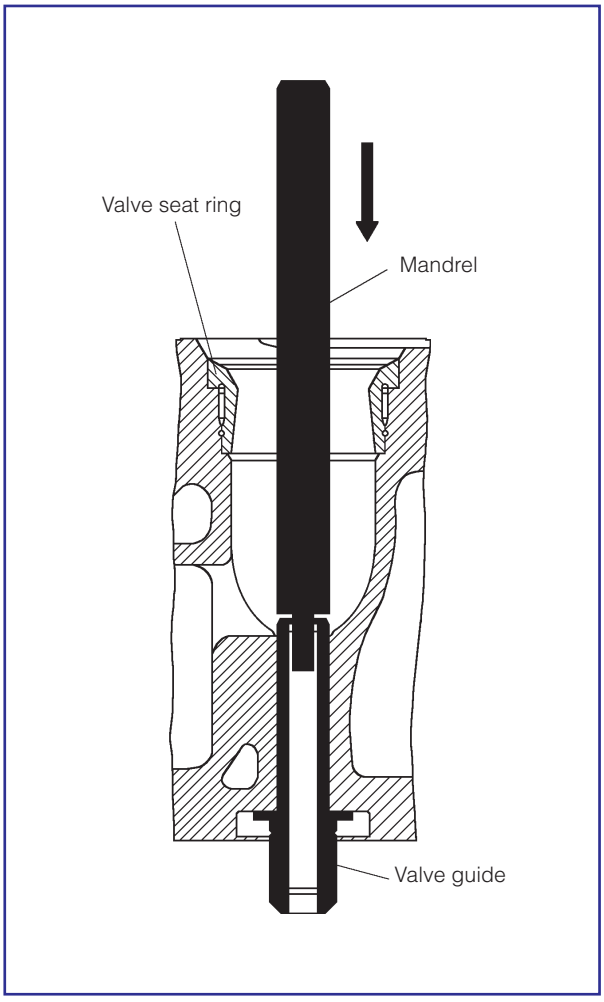


Fig 1

2) After having knocked out the valve guide, carefully clean the bore of the cylinder head and inspect for marks that can prvent mounting of a new valve guide.

3) Before mounting the new valve guide, it has to be cooled down to approx. -70°C with nitrogen or similar.

When the new valve guide has been inserted into the bore be sure that the shoulder bears against the cylinder head, by knocking slightly with the mandrel and a hammer.

4) Before mounting of the valve spindle insert a new o-ring in the valve guide.

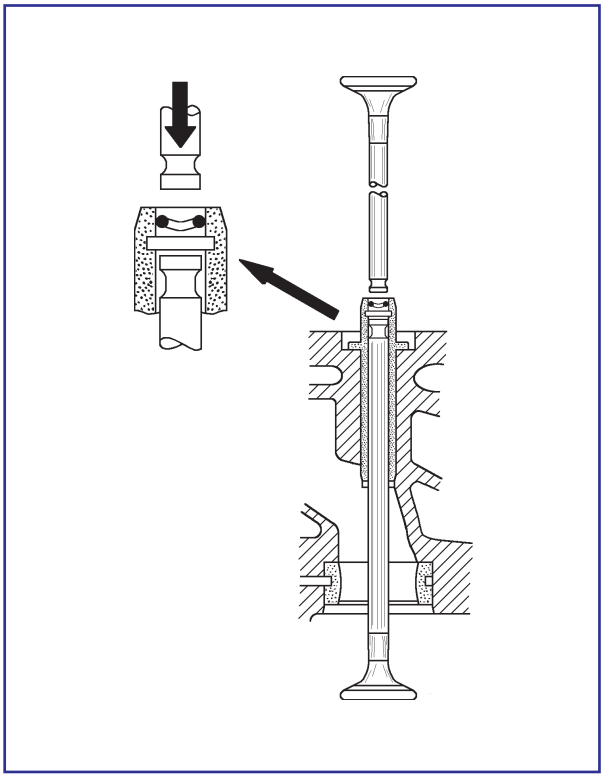


Fig 2.

Correct mounting can easily be done by the use of two valve spindles as mounting tool, one spindle to be used as support and the other spindle to be used for pushing the o-ring downwards.

Screw drivers or other sharp tools should never be used for this purpose.

5) For mounting of valve spindle, see working card 605-01.05.

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismantling, inspection, reassembling and pressure testing of safety valve.

Starting position:

Related procedure:

Indicator valve	605-01.26

Man power:

Working time	:	1 hour
Capacity	:	1 man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no	Item no	Note
62014	01	Pressure test pump.
62014	04	Pipe for fuel injector

Hand tools:

Open end spanner, 32 mm.
Small hammer.
Copaslip.

Replacement and wearing parts:

Plate no	Item no	Qty. /
60508	14	1/cyl.

L+V28/32H

Maintenance and Checking.

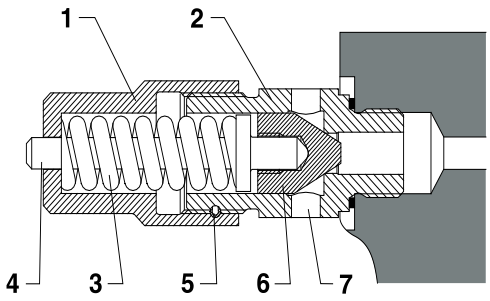
During extended periods of standstill and at general engine overhauls, the safety valves should be thoroughly cleaned.

Note: Do not attempt to stop a safety valve from leaking by increasing the spring load.

The setting of the opening pressure is stamped onto the cap nut (1), *see fig 1.*

1. Dismantling.

1.1 Screw the safety valve out of the cylinder head.



1. Cap nut
2. Valve housing
3. Pressure spring
4. Valve spindle
5. Split pin
6. Valve cone
7. Valve ports

Fig 1. Safety valve

1.2 Clamp valve in vice.

1.3 Unscrew cap nut (1).

1.4 Remove pressure spring (3), valve spindle (4) and valve cone (6).

1.5 Inspect and carefully clean all parts and condition valve, if necessary.

2. Reassembling.

2.1 Lubricate the threads on valve housing (2) with copaslip or similar.

2.2 Reassemble the safety valve, reverse sequence of operations outlined above, point 1.1 to 1.5.

3. Test of Safety Valve.

The valve is to be tested after each overhaul by making a leakage test and testing the opening pres-sure.

3.1 Mount the safety valve in the fuel injection test pump by using the test pipe for fuel injections.

3.2 Vent the system by pumping until the oil flows free of air bubbles through the valve ports (7) in the valve housing (2).

Leakage Test

3.3 Increase the pressure to 135 bar.

3.4 Check that the pressure do not sink below 135 bar within 1 minute.

If the pressure is	Then
OK	Continue with point 3.5.
below 135 bar	Scrap the valve. or Lap the valve cone and seat.

Test of Opening Pressure

3.5 Increase the pressure to the opening pressure.

If the opening pressure is	Then
OK	The procedure is ended.
Not OK	The valve must be adjusted, see point 4.

4. Adjustment of Opening Pressure

4.1 Increase the pressure to the opening pressure.

4.2 Turn the cap nut (1) to the correct opening pressure.

4.3 Drill a new hole for mounting of split pin (5).

5. Mounting of Safety Valve

5.1 Lubricate the threads on the valve housing (2) with copaslip or similar.

5.2 Mount the safety valve on the cylinder head.

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Dismounting, inspection and mounting of indicator valve.

Starting position:

Related procedure:

Safety valve	605-01.25

Man power:

Working time	:	1/2	hour
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque momen	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate No	Item No	Note

Hand tools:

Ring and open end spanner	10 mm
Ring and open end spanner	27 mm
Steel brush	
Copaslip	

Replacement and wearing parts:

Plate No	Item No	Qty./
60508	16	1/Cyl.

L+V28/32H

Maintenance

By normal working conditions the indicator valve require very little maintenance except an inspection in connection with the normal cylinder cover overhaul.

Inspection of the Indicator Valve:

1. Disassemble the indicator valve.

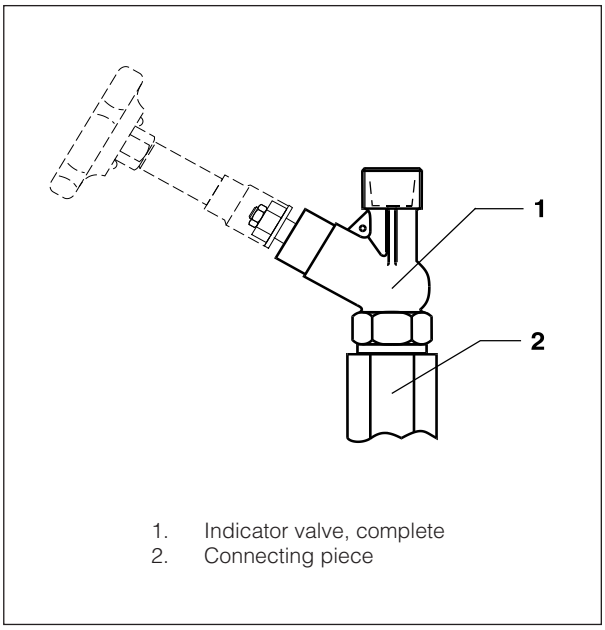
2. Check the valve seat and the cone for "burning through".

If the valve seat in the housing is "burned", the entire valve is to be replaced.

3. Clean and lubricate all components before remounting.

4. Ensure that the spindle is in "OPEN" position when assembling the valve.

NOTE: *Otherwise cone and seat may be damaged.*



1. Indicator valve, complete
2. Connecting piece

Fig 1 Indicator valve.

Working Card Page 1 (2)	Replacement of Sleeve for Fuel Injector	605-01.30 Edition 04H

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Dismounting, inspection and mounting of sleeve for fuel injector.

Starting position

The cylinder head has been dismounted from engine, 605-01.00
The fuel injector has been removed, 614-01.10

Related procedure

Mounting of fuel valve, 614-01.10

Man power

Working time : 1 Hour
Capacity : 1 man

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no.	Item no.	Note.

Hand tools

Brass mandrel.
Hammer.
Lub. oil.
Two small screw driver.
Loctite 572.

Replacement and wearing parts

Plate no.	Item no.	Qty./
60501	125	1/cyl.
60501	137	1/cyl.
60501	149	1/cyl.

L+V28/32H

Dismounting of Sleeve for Fuel Injector

1) Remove the snap ring by means of two screw drivers.

2) The sleeve can now be driven out of the bore by use of a brass mandrel and a hammer.

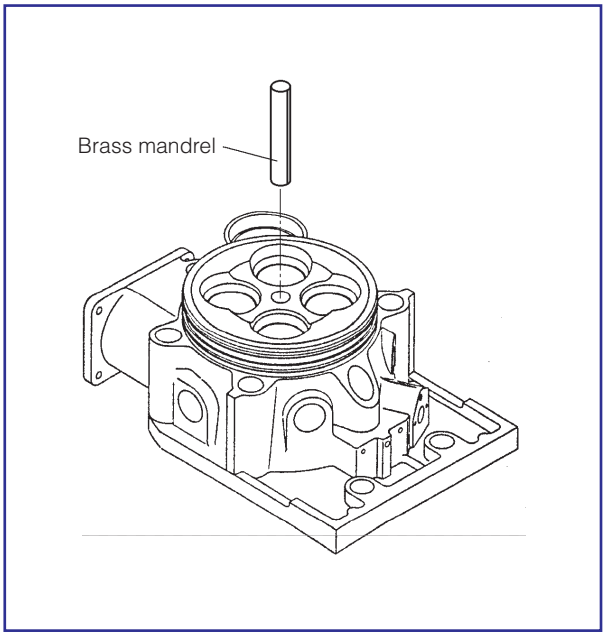


Fig 1

Inspection of Bore in Cylinder Head and mounting of the Sleeve:

3) Clean and inspect the bore in the cylinder head. Any marks which could prevent mounting of the sleeve, should be gently smoothed.

4) Coat the sealing ring zone in the bore with grease or lub. oil.

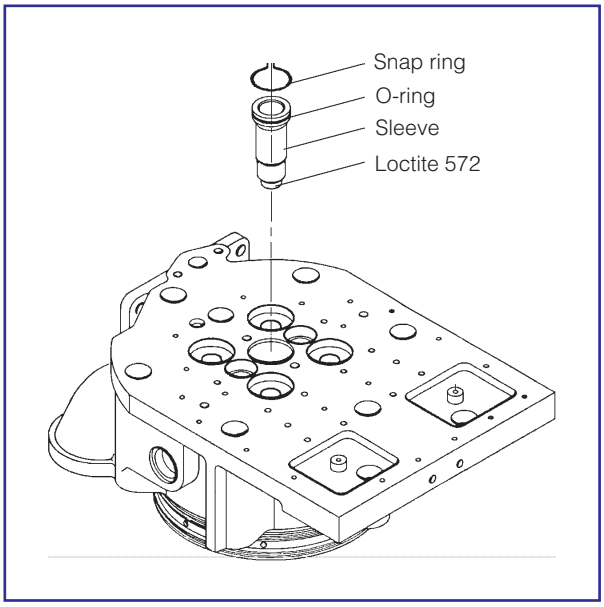


Fig 2

5) Install new sealing rings on the sleeve.

6) Coat the sealing surfaces on the sleeve with loctite 572.

7) Insert the sleeve in the bore.

8) Mount the snap ring.

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Replacement of valve seat ring, for inlet and exhaust valve.

Starting position

Inlet and exhaust valves have been removed, 605-01.05

Related procedure

Mounting of valve spindles, 605-01.05

Man power

Working time : 1 1/2 Hours
Capacity : 1 man

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no.	Item no.	Note.
62021	01	
62021	50	1 piece
62005	45	Extra tools
62005	50	Extra tools
62021	46	1 piece

Hand tools

Ring and open end spanner 36 mm
Hammer.
Loctite, 648.
Lub. oil.

Replacement and wearing parts

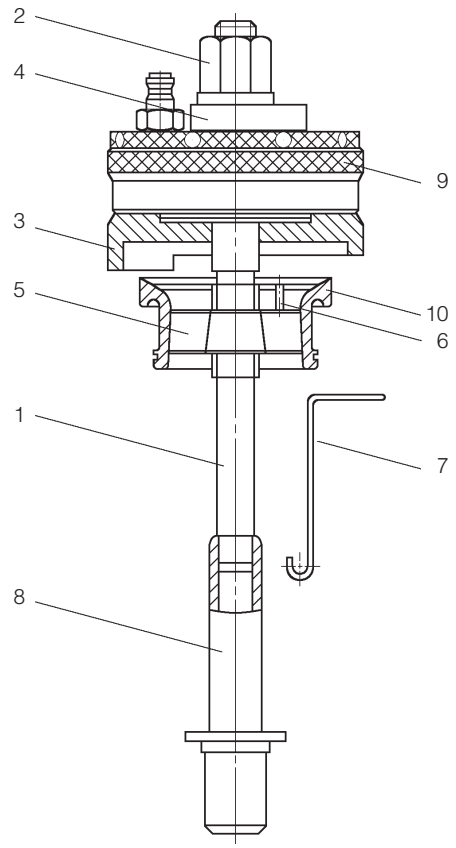
Plate no.	Item no.	Qty. /
60501	245	4/cyl.
60501	257	4/cyl.

L+V28/32H

Dismounting of Valve Seat Rings

When reconditioning of a valve seat ring no longer is possible due to dimensions exceeding the scrapping criteria, the seat ring has to be replaced.

Dismounting of a valve seat ring is carried out by means of a special extractor tool set somprising following components, see fig 1.



1 Stud
2 Collar nut hexagon
3 Guide disc
4 Disc
5 Guide disc
6 Eye screw
7 Guide pin
8 Valve guide
9 Hydraulic jack
10 Valve seat ring

Fig 1

Procedure for Dismounting a Valve Seat Ring

1) By means of the guide pin (7) the guide disc (5) is led vertically through the valve seat ring. Then the guide disc (5) is lifted with the guide pin (7) until the latter is guided by the valve seat ring. The stud (1) is then screwed in until it rests in the valve guide.

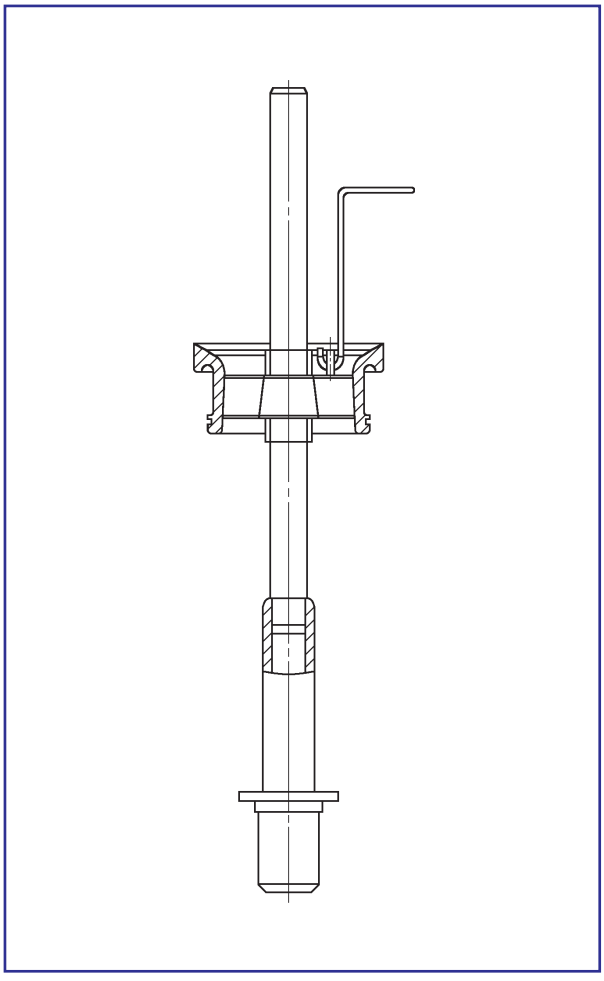


Fig 2

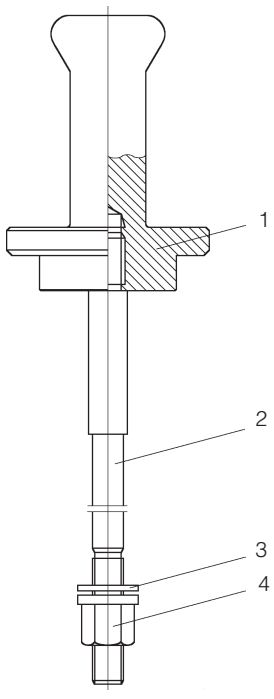
2) The guide disc (3) is positioned so that it bears against the bottom of the cylinder head, and the hydraulic jack is clamped with the disc (4) and collar nut hexagon (2), see fig 1. The hydraulic jack is the one used for main bearing caps.

3) By pumping up the pack, see working card 620-01.05 for the use of hydraulic tools, the valve seat is pressed out max. 6 mm, and the pressure is released again. The collar nut hexagon is tightenied and the operation is continued until the valve seat ring can be removed.

Mounting of Valve Seat Rings

1) Prior to mounting of a new valve seat ring, the bore must be cleaned thoroughly and inspected for marks. Marks that can hinder mounting of the valve seat ring must be removed.

2) Tools for mounting of valve seat rings are shown in fig 3.



1 Handle
2 Stud
3 Washers
4 Hexagon nut with collar

Fig 3

3) To facilitate mounting of the valve seat ring it is cooled down, however to no more than -25°C or the O-ring can be damaged.

4) Place the O-ring on the valve seat ring and coat with oil/loctite as shown in fig 4, just before positioning it in the bore.

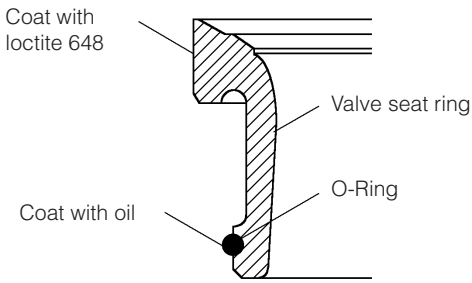


Fig 4

5) The valve seat ring is positioned in the bore, handle with stud inserted as shown in fig 5, and washer with screw is screwed tight.

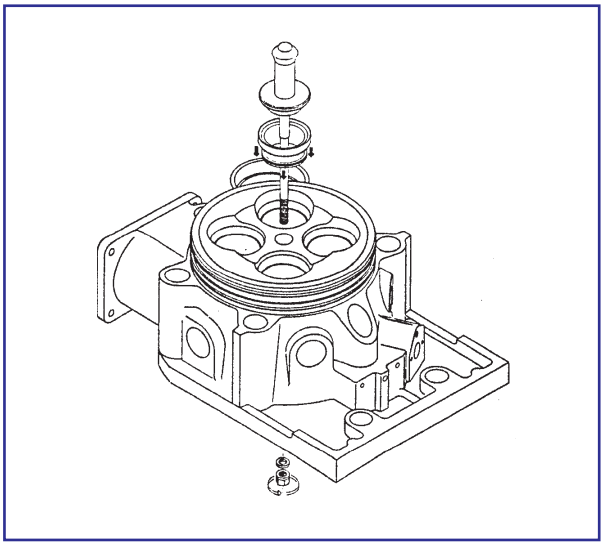


Fig 5

L+V28/32H

6) By knocking on the handle and at the same time tightening the nut (4), the valve seat ring slides in place in the bore and it is felt on the knocks when it bears in the bore.

7) Prior to mounting of the valve spindle the valve seat ring must be ground to ensure correct centering of valve guide and valve seat ring. This can be done according to working card 605-01.05 or 605-01.10.

Working Card Page 1 (2)	Mounting of Cylinder Head	605-01.40 Edition 06H

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Mounting of cylinder head after inspection and/or overhaul.

Starting position

Cylinder head is completely assembled, 605-01.05 to 605-01.35
Valve gear of respective cylinder is in right position (valve closed).
Control of the surface on the cylinder liner, 606-01.45

Related procedure

Adjustment of valve clearance 608-01.10

Man power

Working time : 1 1/2 Hour
Capacity : 2 men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no.	Item no.	Note.
62021	10	
62021	01	
62021	50	6 Pieces
62021	51	1 Piece
62021	15	
62005	01	
62010	01	
62021	25	
62014	15	

Hand tools

Ring and open end spanner, 14 mm.
Ring and open end spanner, 17 mm.
Ring and open end spanner, 24 mm.
Lub. oil and copaslip.

Replacement and wearing parts

Plate no.	Item no.	Qty. /
60501	269	2/cyl.
60510	08	1/cyl.
60610	01	2/cyl.
61202	31	1/cyl.
61625	01	2/cyl.

L+V28/32H

1) Check the jointing surfaces of the cylinder head/cylinder liner to see that they are clean and without damage marks, see working card 606-01.45, Fit new o-rings on the water passage, lubricate the o-rings with a little oil.

2) Check all contact faces on the cylinder head and nuts, including threads, and make sure that these are plane and smooth and absolutely free from foreign particles.

3) Attach the lifting tool to the cylinder head that has been made ready for installation, and position it carefully on the cylinder liner.

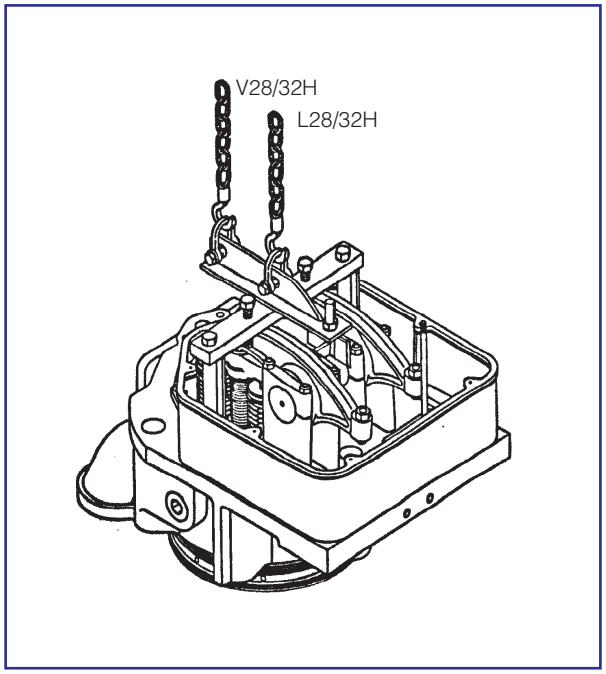


Fig 1

4) Make sure that the nuts run easily on the threads and that they bear on their entire contact surfaces.

5) Coat threads and contact faces with copaslip before fitting the nuts.

6) Screw nuts onto the studs and tighten lightly with the tommy bar.

Place the spacer ring around the nuts with the slot in such a position that the tommy bar can be used.

Tighten the hydraulic jacks and make sure that the cylinder of the jacks bears firmly against the spacer ring. Tighten up all the nuts, see page 600.40. For using the hydraulic tools, see working card 620-01.05.

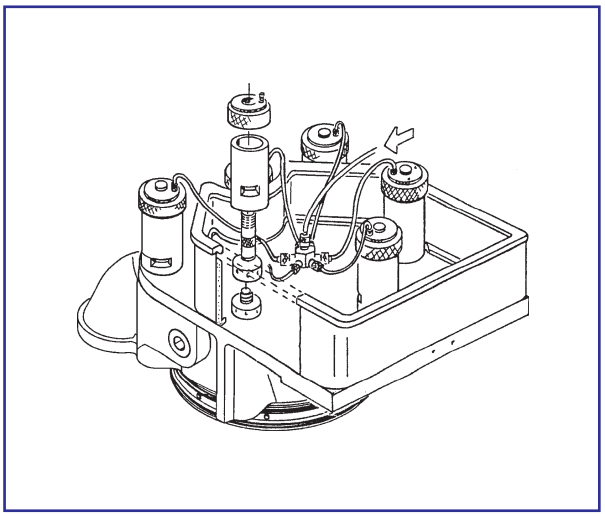


Fig 2

7) If new studs or nuts have been fitted, the nuts must be tightened and loosened three times, in order to compensate for deformation of the thread and in order to ensure a safe minimum load of the studs through the tightening.

8) Adjust the valve clearance, see working card 608-01.10.

9) Fit the pipes for fuel oil, lub. oil, cooling oil. cooling water and the flange for exhaust pipe.

10) Prior to start up check for leakages, and after start up check for leakages and oil flow.

11) Mount the cover for rocker arm and the front cover for fuel pump.

Working Card Page 1 (2)	Inspection of Cylinder Head Cooling Water Space	605-01.45 Edition 01H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Inspection of cylinder head cooling water space.

Starting position:

The cylinder head dismantled from engine, 605-01.00

Related procedure:

Man power:

Working time : ¼ Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Steel brush

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L/V28/32H

Inspection of Cylinder Head Cool. Water Space.

1) Inspect the cooling water inlet at the bottom and the cooling water outlet in the top of the cylinder head, see fig. 1.

2) Remove all possible deposits.

3) Pour water into the cooling water outlet and make sure, that water is coming out of all the cooling water inlet bores at the bottom of the cylinder head.

4) Clean if necessary the cooling water inlet and outlet by means of a steel brush. Flush the cooling water space after cleaning.

5) Should the cylinder head cooling water space contrary to expectation be blocked with deposits, contact MAN B&W Diesel, Holeby for further instructions.

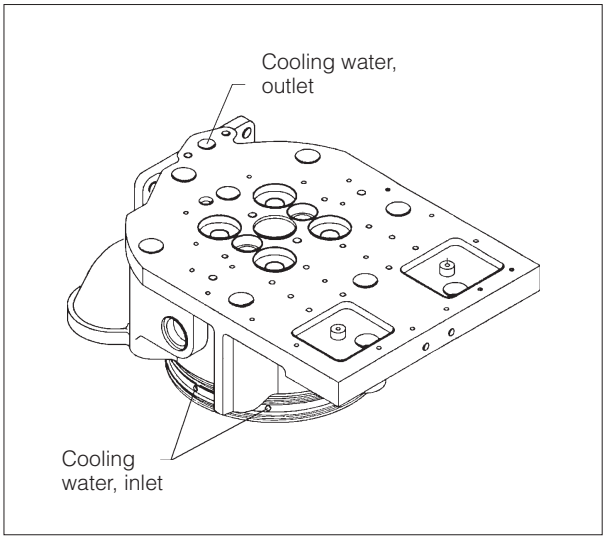
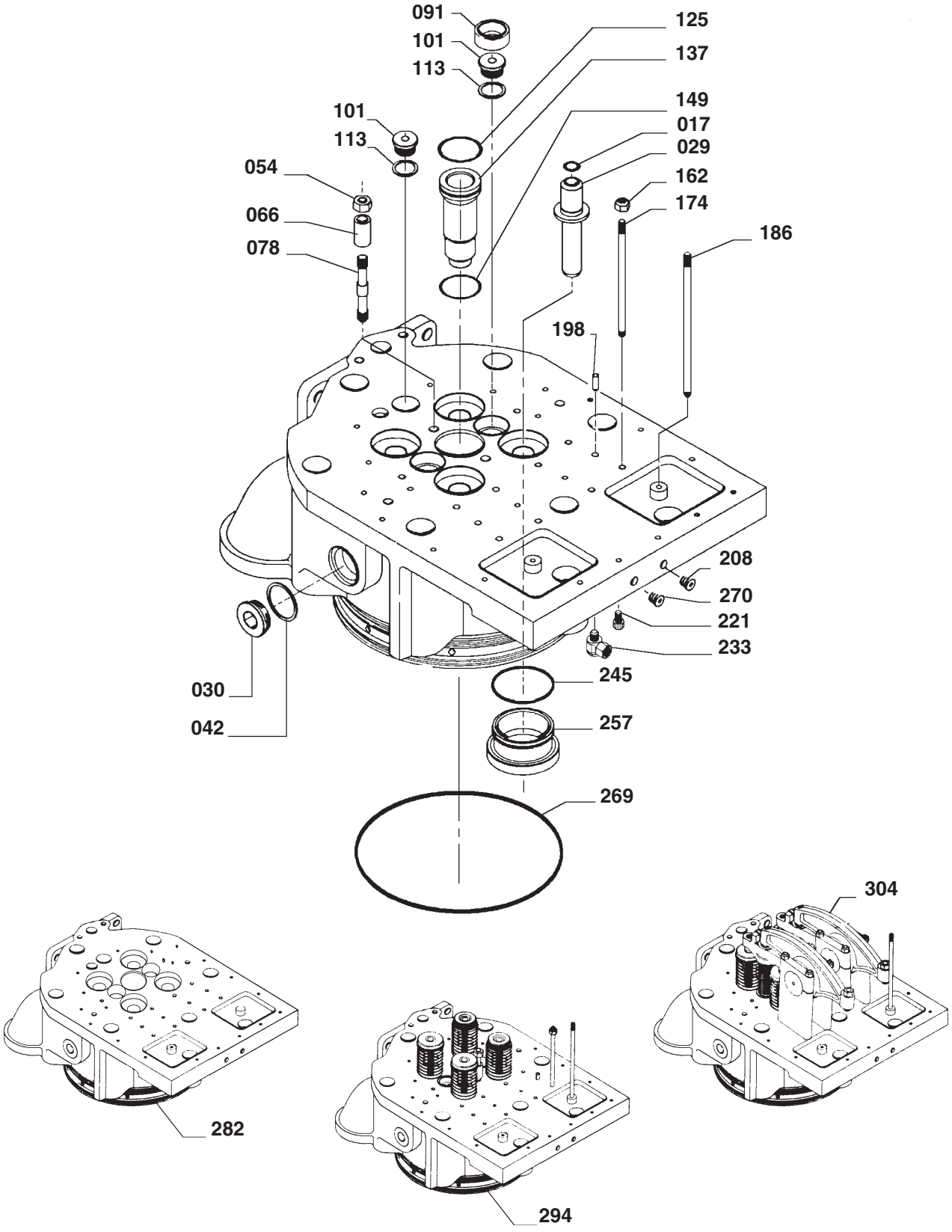


Fig. 1. Cylinder Head

Plate Page 1 (2)	**Cylinder Head**	**60501-19H**

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
017	4/C	**O-ring**	O-ring
029	4/C	**Valve guide, inlet and exhaust**	Ventilstyr, indstr. og udstr.
030	6/C	**Plug screw**	Propskrue
042	6/C	**Gasket**	Pakning
054	2/C	**Nut**	Møtrik
066	2/C	**Distance pipe**	Afstandsrør
078	2/C	**Stud**	Tap
091	2/C	**Thrust collar**	Trykflange
101	4/C	**Plug screw**	Propskrue
113	4/C	**Gasket**	Pakning
125	1/C	**Snap ring**	Låsering
137	1/C	**Sleeve for fuel valve**	Foring for br. ventil
149	1/C	**O-ring**	O-ring
162	8/C	**Nut**	Møtrik
174	8/C	**Stud**	Tap
186	4/C	**Stud**	Tap
198	4/C	**Spring pin**	Fjederstift
208	2/C	**Plug screw**	Propskrue
221	2/C	**Screw**	Skrue
233	2/C	**Coupling**	Kobling
245	4/C	**O-ring**	O-ring
257	4/C	**Valve seat ring, (inlet and exhaust)**	Ventilsædering, (indstr. og udstødning)
269	2/C	**O-ring**	O-ring
270	2/C	**Plug screw**	Propskrue
282		**Cylinder head with valve guide sleeve for fuel valve and valve seat rings**	Cylinderdæksel monteret med spindelstyr, foring for br. ventil og ventilsæderinge
294		**Cylinder head (as 282) with valve spindles installed**	Cylinderdæksel (som 282), monteret med ventilspindler
304		**Cylinder head (as 294) with brackets and rockerarms installed**	Cylinderdæksel (som 294) monteret med bukke og vippearne.

When ordering spare parts, see also page 600.50.

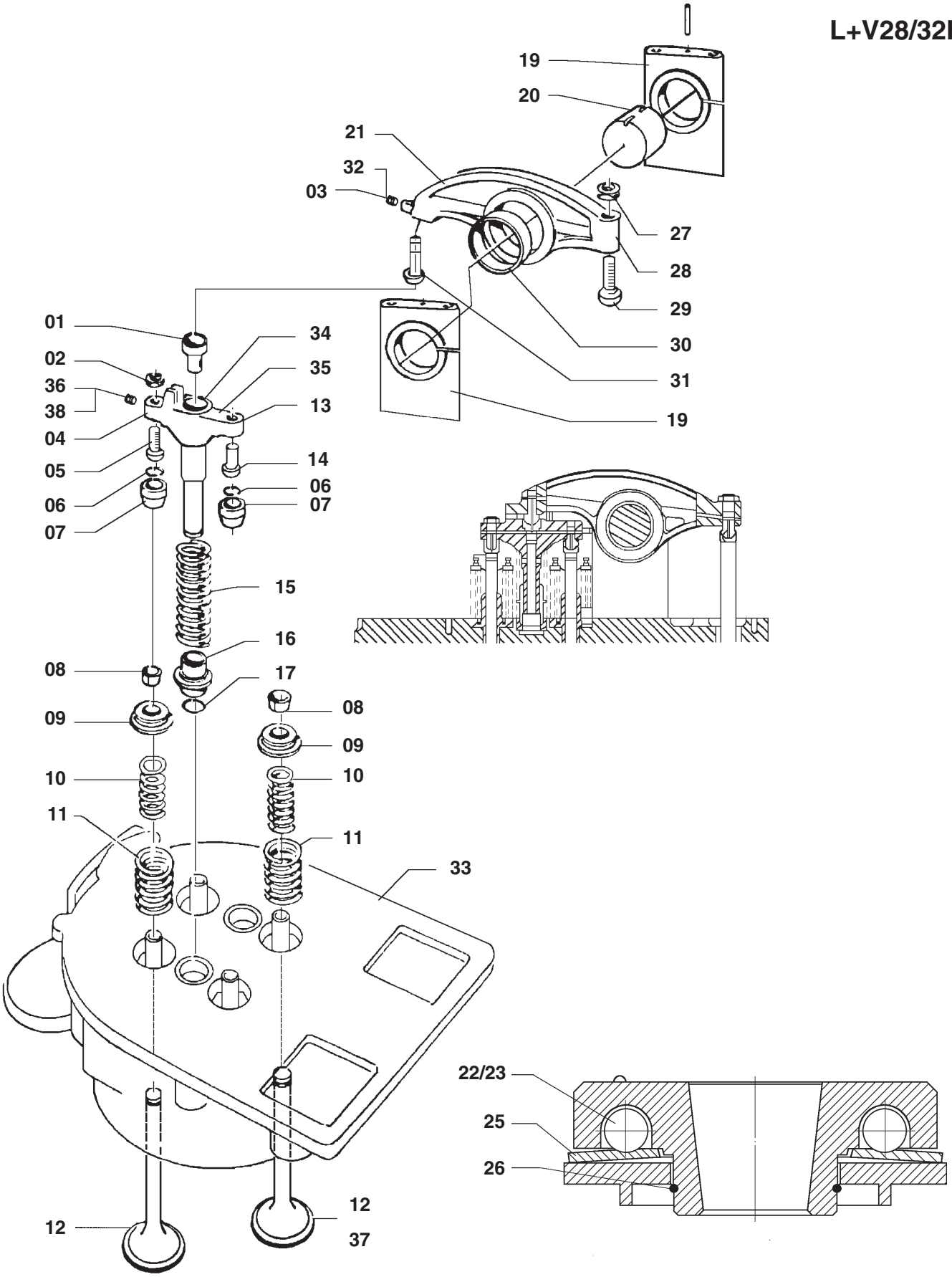
*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder

Plate Page 1 (2)	**Valve Spindles and Valve Gear**	**60502-31H**

L+V28/32H



08028-0D/H5250/94.08.12

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	2/C	**Thrust piece**	Trykstykke
02	2/C	**Nut**	Møtrik
03	4/C	**Plug screw**	Propskrue
04	1/C	**Valve bridge, inlet**	Ventilbro, indstrømning
05	2/C	**Thrust screw**	Trykskrue
06	4/C	**Circlip**	Fjederring
07	4/C	**Thrust piece**	Trykstykke
08	4/C	**Conical ring in 2/2**	Konisk ring 2/2
09	4/C	**Rotocap, complete incl. item 22, 23, 25, 26**	Rotationsgiver, komplet inkl. item 22, 23, 25, 26
10	4/C	**Inner spring**	Indvendig fjeder
11	4/C	**Outer spring**	Udvendig fjeder
12	4/C	**Valve spindle, inlet and exhaust (valve spindle exh. only for marine engines)**	Ventilspindel, inds. og uds. (ventilspindel uds. kun for marine motorer)
13	1/C	**Valve bridge,exhaust**	Ventilbro, udstødning
14	2/C	**Thrust piece**	Trykstykke
15	2/C	**Spring**	Fjeder
16	2/C	**Ball guide**	Kuglestyr
17	2/C	**Securing ring**	Sikring
19	4/C	**Rocker arm bracket incl spring pin**	Buk for vippearm inkl spændstift
20	2/C	**Rocker arm shaft**	Aksel for vippearm
21	2/C	**Rocker arm, compl. (Item 03, 27, 28, 29, 30, 31)**	Vippearm, komplet (Item 03, 27, 28, 29 30, 31)
22	24/C	**Spring**	Fjeder
23	24/C	**Ball**	Kugle
25	4/C	**Spring washer**	Fjederskive
26	4/C	**Retainer ring**	Låsering
27	2/C	**Nut**	Møtrik
28	2/C	**Rocker arm**	Vippearm
29	2/C	**Thrust screw**	Trykskrue
30	2/C	**Bearing bush**	Lejebøsning
31	2/C	**Thrust pin**	Trykskrue
32	/I	**Loctite 572**	Loctite 572
33	1/C	**Cylinder head as Plate 60501 + Plate 60502**	Cylinderdæksel som Plate 60501 + Plate 60502
34	1/C	**Valve bridge, inlet complete incl. item 01, 02, 04, 05, 06, 07, 14, 15, 16 and 17**	Ventilbro, indstrømning komplet inkl. item 01, 02, 04, 05, 06, 07, 14, 15, 16 og 17
35	1/C	**Valve bridge, exhaust complete incl. item 01, 02, 05, 06, 07, 13, 14, 15, 16 and 17**	Ventilbro, udstødning komplet inkl. item 01, 02, 05, 06, 07, 13, 14, 15, 16 og 17
36	4/C	**Screw**	Skrue
37	2/C	**Valve spindle, exhaust (only for stationary engines)**	Ventilspindel, uds. (kun for stationære motorer)
38	/I	**Loctite 243**	Loctite 243

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder
Qty./ = Qty./Individual

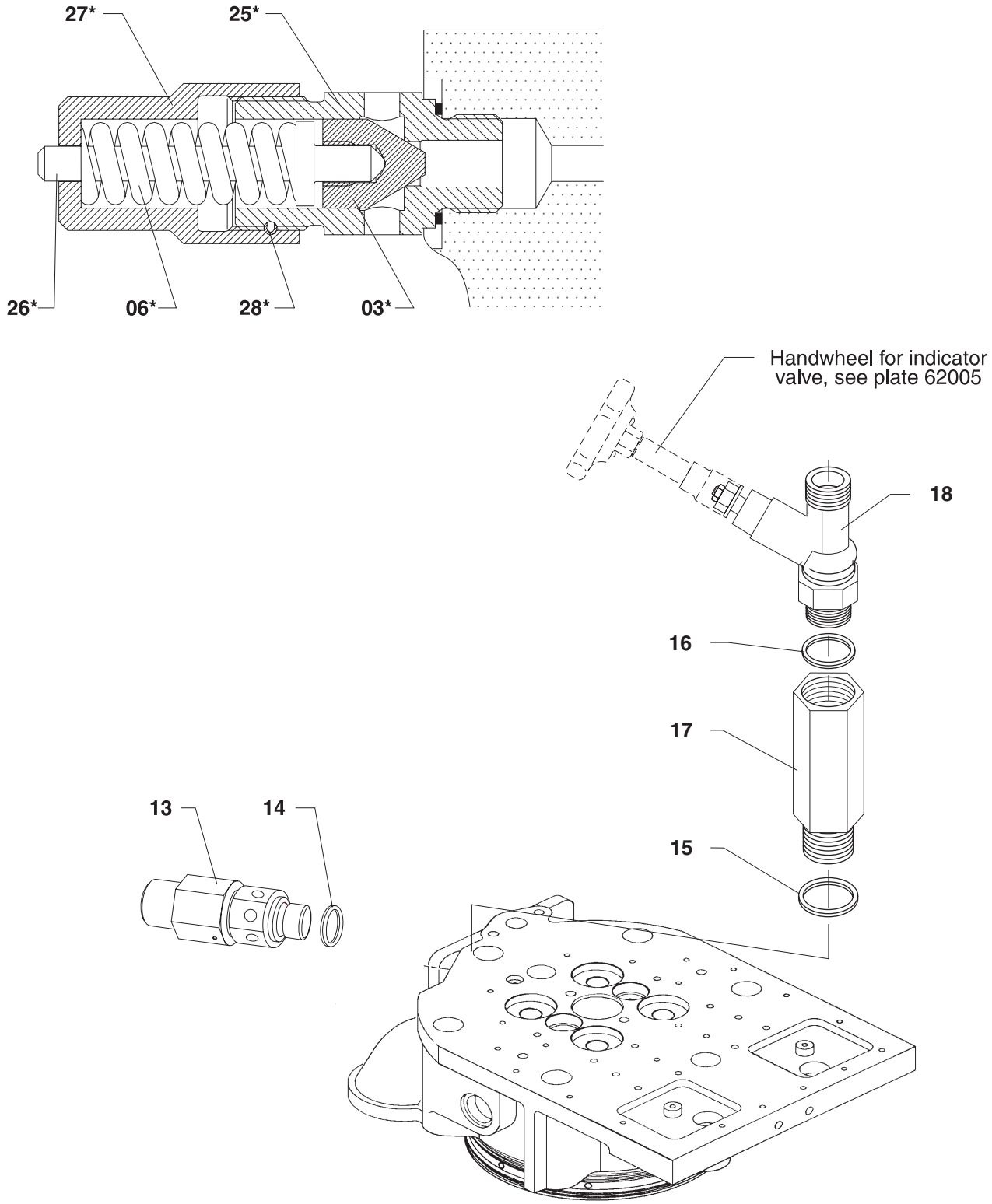
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder
Antal/I = Antal/Individuelt

08028-0D/H5250/94.08.12

Plate Page 1 (2)	**Safety Valve and Indicator Valve**	**60508-11H**

L+V28/32H



60508-11H	Safety Valve and Indicator Valve	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
03*	1/C	**Valve cone**	Ventilkugle
06*	1/C	**Pressure spring**	Trykfjeder
13	1/C	**Safety valve, complete incl. item 03, 06, 25, 26, 27, 28**	Sikkerhedsventil, komplet inkl. item 03, 06, 25, 26, 27, 28
14	1/C	**Gasket**	Pakning
15	1/C	**Gasket**	Pakning
16	1/C	**Gasket**	Pakning
17	1/C	**Connecting piece**	Forbindelsesstykke
18	1/C	**Indicator valve, complete**	Indikatorventil, komplet
25*	1/C	**Valve housing**	Ventilhus
26*	1/C	**Valve spindle**	Ventilspindel
27*	1/C	**Cap nut**	Dækselmøtrik
28*	1/C	**Split pin**	Fjedernot

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

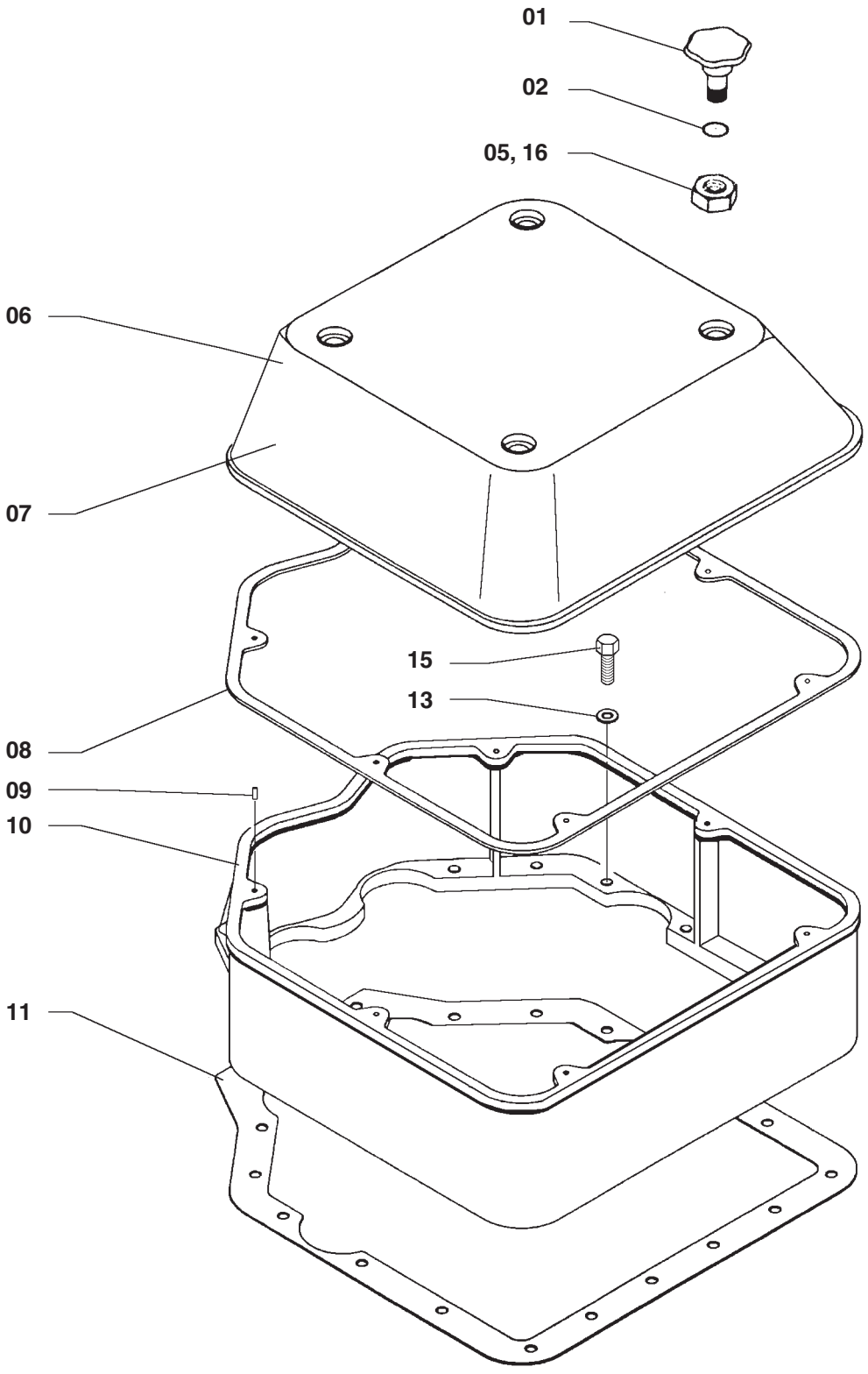
*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder

Plate Page 1 (2)	**Cylinder Head, Top Cover**	**60510-12H**

L+V28/32H



60510-12H	Cylinder Head, Top Cover	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	4/C	**Handle**	Håndtag
02	4/C	**O-ring**	O-ring
05	4/C	**Nut**	Møtrik
06	1/C	**Top cover**	Topdæksel
07	1/C	**Top cover, compl. incl. item Nos. 01, 02, 05, 06**	Topdæksel, kompl. inkl. pos. nr. 01, 02, 05, 06
08	1/C	**Gasket**	Pakning
09	6/C	**Spring pin**	Fjederstift
10	1/C	**Coaming**	Karm
11	1/C	**Gasket**	Pakning
13	18/C	**Washer**	Skive
15	18/C	**Screw**	Skrue
16	/I	**Loctite 638**	Loctite 638

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder

Piston/connecting rod

506/606

Piston

The piston, which is oil-cooled and of the monobloc type made of nodular cast iron, is equipped with 3 compression rings and 1 scraper ring.

By the use of a combination of compression rings with different barrel-shaped profiles and chrome-plated running surface on all rings, the piston ring pack is optimized for maximum sealing effect and minimum wear rate.

The piston has a cooling oil space close to the piston crown and the piston ring zone. The heat transport and thus the cooling effect is based on the shaker effect arising during the piston movement. As cooling oil is used oil from the engine's lubricating oil system.

Piston Pin

The piston pin is fully floating which means that it can turn freely in the pin bosses of the piston as well as in the connecting rod bush. The piston pin is upwords in place in axial direction by two circlips (seeger rings).

Connecting Rod

The connecting rod is die-forged. The big-end has an inclined joint in order to facilitate the piston and connecting rod assembly to be withdrawn up through the cylinder liner. The joint faces on connecting rod and bearing cap are serrated to ensure precise location and to prevent relative movement of the parts.

The big-end bearing is of trimetal type, i.e. steel shells lined with tin-aluminium or lead-bronze coated with a running layer. Design as plain type or rillentype. The bearing shells are of the precision type and are therefore to be fitted without scraping or any other kind of adaption.

The small-end bearing is of trimetal type and is pressed into the connecting rod.

Cylinder Liner

The cylinder liner is made of fine-grained, pearlite cast iron and is fitted in a bore in the engine frame. Between the liner and the cylinder head and between the liner and the frame there are fitted replaceable cast iron sealing rings. The liner is clamped by the cylinder head and is guided by a bore at the bottom of the cooling water space of the engine frame. The liner can thus expand freely downwards, when heated during the running of the engine. Sealing for the cooling water is obtained by means of silicone rubber rings which are fitted in grooves machined in the liner.

Tell-tale borings in the frame, starting from a level between the sealing rings and leading to the exterior will reveal any sealing malfunction by sign of leaking water or lubricating oil mist.

08028-0D/H5250/94.08.12

Working Card Page 1 (3)	**Dismounting of Piston and Connecting Rod**	**606-01.00** Edition 01H

L28/32H

Safety precautions:

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

Description:

Dismounting of piston and connecting rod assembly, for inspection and/or overhaul.

Starting position:

Cylinder head has been dismounted from engine, 605-01.00
Crank case open.

Related procedure:

Separation of piston and connecting rod, 606-01.05
Inspection and honing of cylinder liner, 606-01.35

Man power:

Working time : 1 Hour
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	01	
62006	03	
62006	09	2 pieces
62006	22	
62006	28	140 - 760 Nm
62010	01	

Tool combination for dismounting of connecting rod screw, see working card 620-01.20.

Hand tools:

Threaded pin M16.
Open end spanner 32 mm.
Wire.
Scraper or similar.
Small adjustable spanner.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

08028-0D/H5250/94.08.12

L28/32H

1) Clean the upper part of the cylinder, if not, the piston may get stuck during removal in the carbon deposited in this area.

If the liner is mounted with a flame ring then start with item No a to e.

If the liner is not mounted with a flame ring then continue with item No 2.

a) Turn the piston to the buttom.

b) Mount the tool for dismounting of the flame ring in the cylinder at the top of the piston.

c) Place a used piston ring on top of the flame ring tool.

d) Mount the tube (for holding down the cylinder liner during the piston withdrawal) on one of the cylinder head studs, screw on the nut and tighten it slightly.

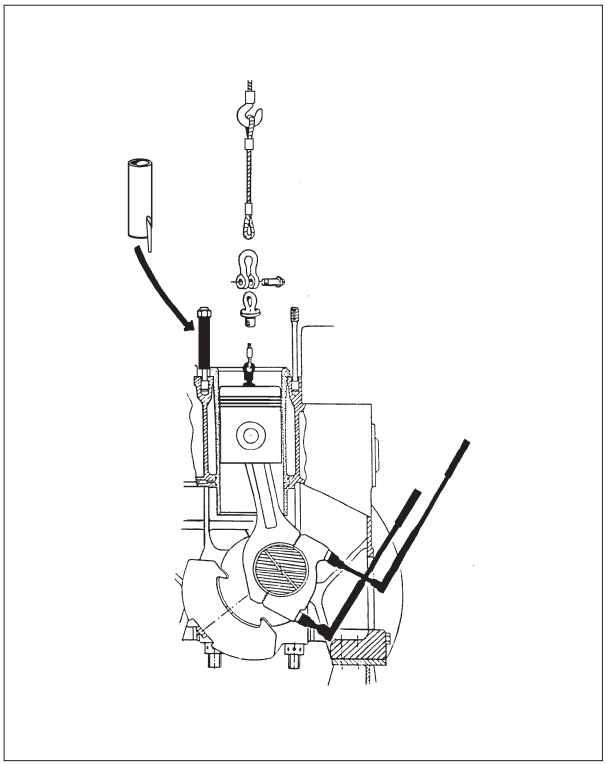


Fig. 1. Mounting of tools. (placing).

e) Turn the piston in top, in order to push the flame ring out of the cylinder by means of the tool.

Info: It is the used piston ring which pushes the flame ring out of the cylinder, while the flame ring tool guides the piston ring out against the cylinder liner.

2) Remove the gangway, if any installed, in order to improve the access conditions.

3) Turn the crankshaft to bring the crank throw concerned into a position approx. 50 degrees before TDC.

This position is identifiable by the connecting rod shaft being very close to cylinder liner shirt, see fig. 1.

4) Clean the threaded hole in the piston top, and mount the eye screw.

Mount the tube (for holding down the cylinder liner during the piston withdrawal) on one of the cylinder head studs, screw on the nut and tighten it slightly.

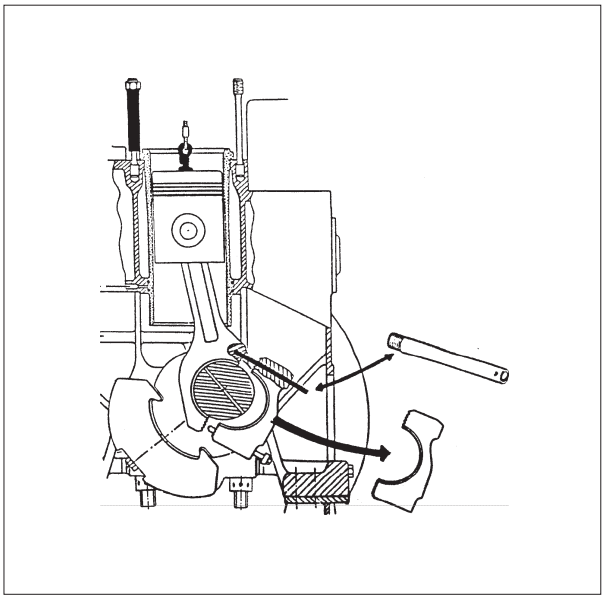


Fig. 2. Removal of bearing cap.

5) Attach a wire rope to the eye bolt by means of a shackle, hook the wire on to a tackle and pull the wire rope tight.

08028-0D/H5250/94.08.12

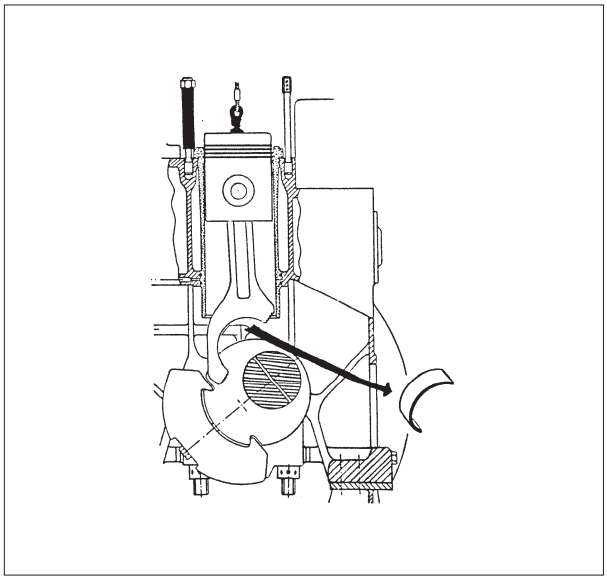


Fig. 3. Removal of upper big-end bearing shell.

If minor adjustment of the crank throw position appears necessary for acces to the connecting rod screws, the wire rope must be slackened before turning of the crankshaft and tightened up again in the new crank throw position.

6) Unload the connecting rod screws and unscrew one of the upper screws.

7) Mount the guide pin for the bearing cap in one of the threaded holes and fit a screwdrive or similar in the hole in the guide pin, and unscrew the screws.

8) Remove the screwdriver from the guide pin, and dismount the bearing cap by sliding it along the guide pin, see fig. 2.

9) Remove the guide pin from the connecting rod.

10) Pull the piston and connecting rod assembly upwards and remove the upper big-end bearing shell, see fig. 3.

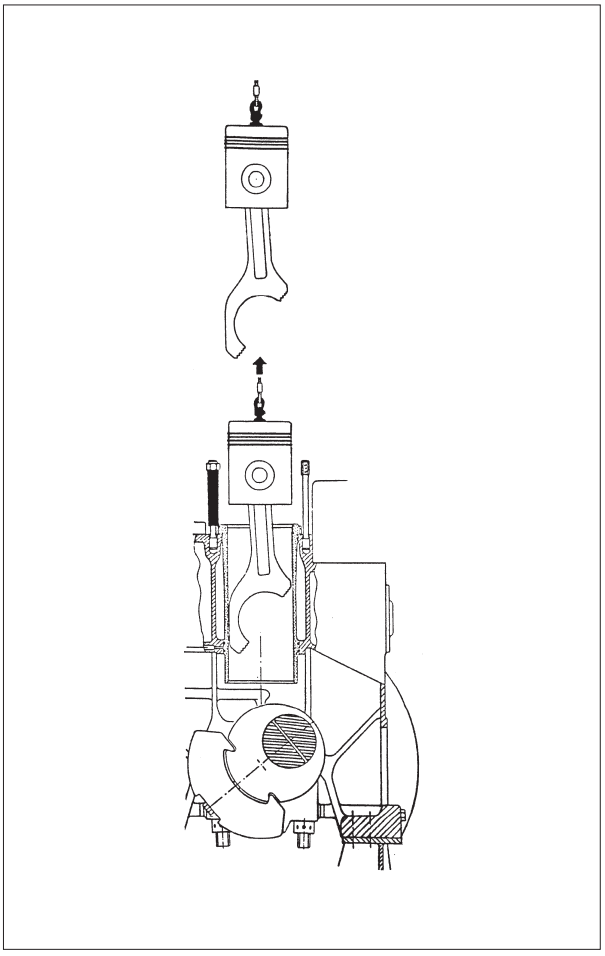


Fig. 4. Lift of piston and connecting rod assembly.

11) Lift the piston and connecting rod assembly up through the cylinder liner and out of the engine, see fig. 4.

NOTE: The purpose of the guide pin is to prevent any damage of crank journal, joint faces or bearing surface to occur during dismounting of the bearing cap, and to facilitate easy handling when removing the bearing cap from the crankcase.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Separation of Piston and Connecting Rod**	**606-01.05** Edition 03H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Separation of piston and connecting rod for inspection or/and overhaul.
Assembly of the piston and connecting rod after inspection or/and overhaul.

Starting position:

Piston and connecting rod are dismounted from engine, 606-01.00

Related procedure:

Inspection or/and overhaul of piston, 606-01.10
Inspection or/and overhaul of connecting rod, 606-01.15
Inspection of connecting rod big-end bearing, 606-01.16

Man power:

Working time : 1/4 hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	01	L28/32H
62006	03	L28/32H
62006	05	V28/32H
62006	20	

Hand tools:

Open end spanner, 32 mm.
Wooden wedge, 2 pieces.
Wooden support.
Wire.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

08028-0D/H5250/94.08.12

L/V28/32H

Separation of the Piston and Connecting Rod:

1) Land the piston and connecting rod carefully on wooden support to prevent damage of piston and scraper ring, see fig. 1 or 2.

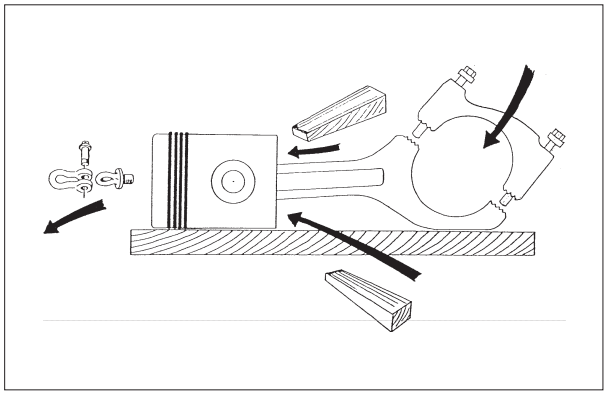


Fig. 1. L28/32H

2) The bearing cap should be mounted with the screws tightened only by hand, in order to protect the serrated joint faces during handling of the assembly, see fig. 1 or 2.

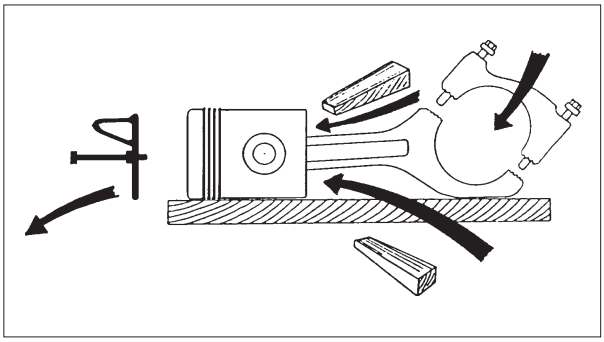


Fig. 2. V28/32H

3) Remove the shackle and eye screw/lifting tool from the piston crown, see fig. 1 or 2.

4) Place the piston and connecting rod assembly in upright position resting on the top face of the piston crown, see fig. 3.

Wooden wedges should be used to prevent the connecting rod from swinging out and thus impact the piston skirt during the lifting into upright position.

5) Place a wire around the big-end of the connecting rod, attach a tackle and tighten the wire rope, see fig. 3

6) Take out the securing ring, (seeger circlips), push out the piston pin and lift the connecting rod away.

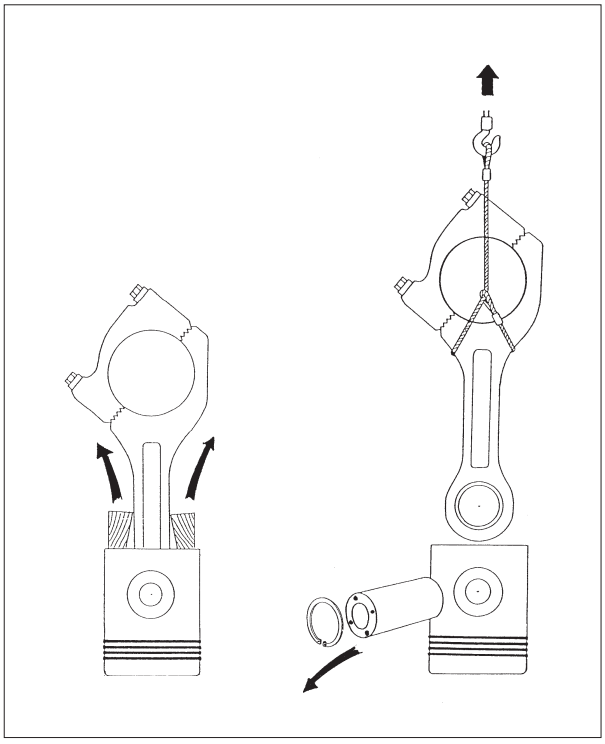


Fig. 3.

Assembly of the Piston and Connecting Rod.

7) For assembly of the piston and connecting rod, see point 1-6 in opposite direction.

8) Lubricate the piston pin before assembling.

08028-0D/H5250/94.08.12

Working Card Page 1 (4)	**Piston (with flame ring)**	**606-01.10** Edition 09H

L+V28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Cleaning and inspection of piston. Control of piston ring, scraper ring and ring grooves.

Starting position

Piston has been dismantlet from connecting rod 606-01.05

Related procedure

Mounting of piston and connecting rod 606-01.20

Man power

Working time : 1/2 Hour
Capacity : 1 man

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no	Item no	Note.
62006	13	
62006	15	
62006	16	

Hand tools

Tools for cleaning of piston, steel brush, scraper etc.

Replacement and wearing parts

Plate no	Item no	Qty. /

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L+V28/32H

Removal of Piston Ring

For removal of piston rings, which are to be used again, and for all mounting of rings, only the special ring opener which prevents local over stressing of the rings should be used.

Straps to expand the ring gap or tools working on the same principle must not be used, as this would result in permanent deformation which might cause blow-by or broken rings.

Inspection of Piston

1) Remove the piston and scraper rings.

2) Clean and examine the piston rings to determine if reuse is acceptable, see page 3.

3) Clean the piston outside and inside.

4) Inspect the piston ring and scraper ring grooves for wear, see page 3.

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L+V28/32H

The piston has to be scrapped if:

A) The wear limit on the testing mandrel is exceeded, see fig 1A

or

B) The clearance between the new piston/scraper ring and ring groove is exceeded, see fig 1B.

Note: At each piston overhaul:

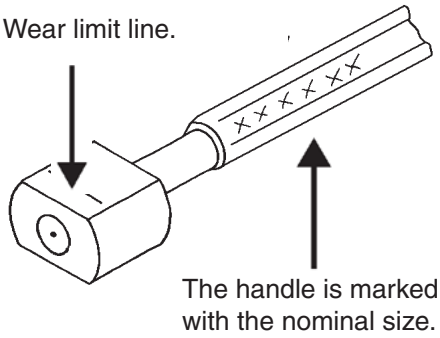
- ***The piston and scraper ring must be exchanged.***
- ***The cylinder liner must be honed according to the instructions.***

	Piston and oil scraper ring. *Nominal* size.	New ring grooves. Tolerances.	Ring grooves. Max. wear limit.
Piston ring no 1	New 5.0 mm	5.0 mm +0.18 +0.16	5.43 mm
Piston ring no 2	New 5.0 mm	5.0 mm +0.14 +0.12	5.43 mm
Piston ring no 3	New 4.95 mm	5.0 mm +0.14 +0.12	5.43 mm
Scraper ring	New 8.0 mm	8.0 mm +0.12 +0.10	8.43 mm

Table 1 Nominal size, new ring groove tolerance and wear limit for ring grooves

A) Testing Mandrel for Ring Grooves

If the wear limit (2 mm mark) on the testing mandrel is exceeded, the specified max. wear limits are exceeded, and the piston must be scrapped.



B) Clearance Ring/Groove

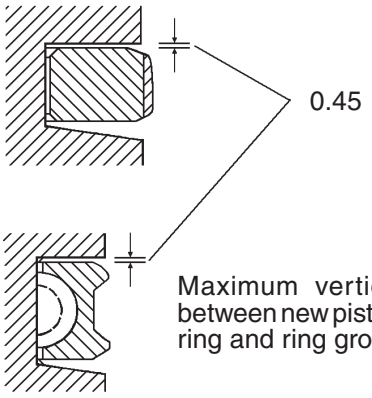
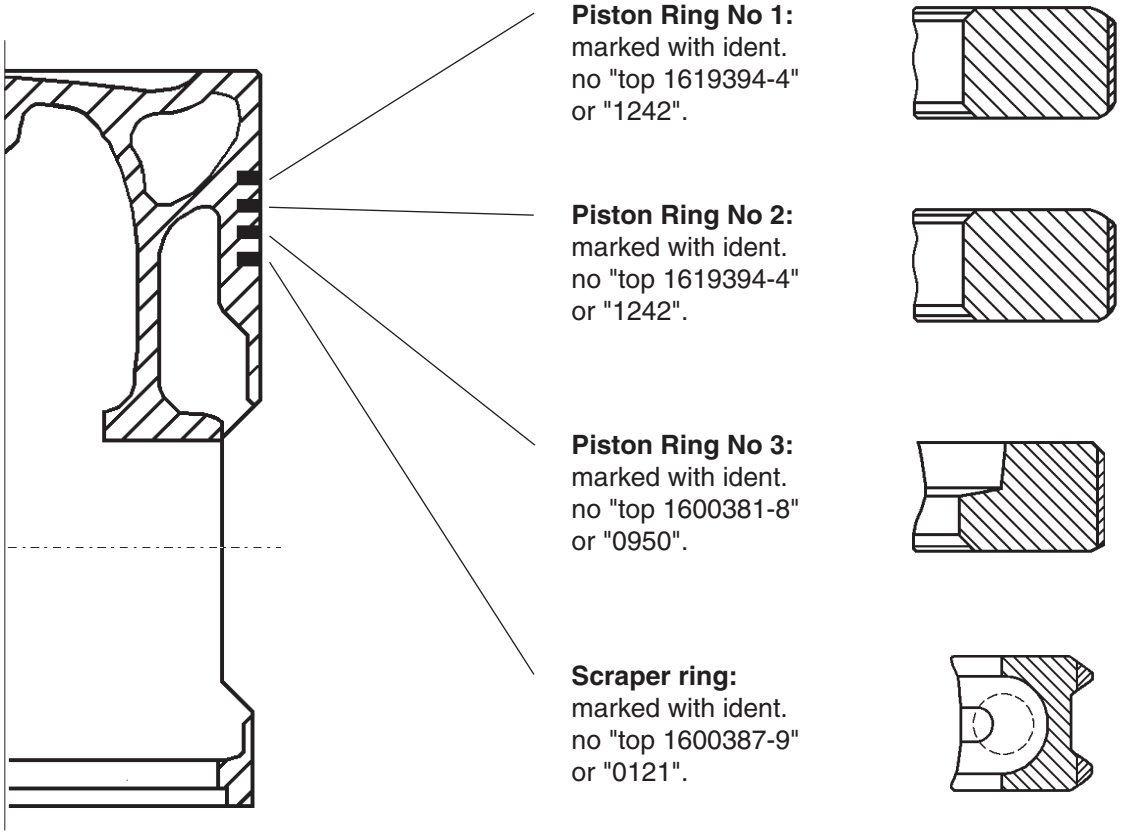


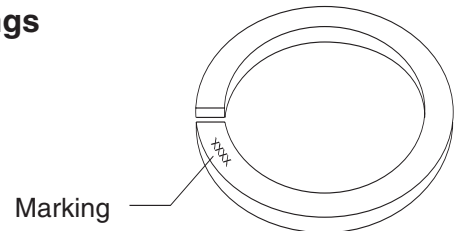
Fig 1 Wear limits for ring grooves

L+V28/32H

Position of Piston and Scraper Rings



Marking of Piston and Scraper Rings



Identification marks to face upwards against the piston crown when mounted.

Note: The marking may include other figures than mentioned above, for instance trade mark and production codes.

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Working Card Page 1 (4)	**Connecting Rod**	**606-01.15** Edition 04H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Cleaning, inspection and test measurement of connecting rod.

Starting position:

Connecting rod has been dismantlet from piston, 606-01.05

Related procedure:

Mounting of piston and connecting rod, 606-01.20

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	28	140-760 Nm

Hand tools:

Inside micrometer (242 mm).
Feeler gauge 0,15 - 0,20 mm.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

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L/V28/32H

Cleaning and Inspection of Big-end Bore.

The connecting rod is cleaned on all machined surfaces.

The serrated joint faces and threaded screw holes are to be degreased with a volatile solvent and blown dry with working air.

The serrated joint faces are inspected.

The serration on the connecting rod may, due to relative movements between the mating surfaces, show damages in form of wear marks and pittings or even cracks in highly loaded zones.

Observed damages should be registered in the schem "Connecting Rod Inspection". See page 4.

Wear marks are visible but not appreciable at a fingernail. Pittings are not only visible but also noticeable at a fingernail.

Single distinctly raised spots caused by pitting should be gently smoothed by careful, local treatment with a file.

The serration on the connecting rod and on the bearing cap can be damaged by improper handling during dismounting, transport and overhaul work.

Note ! The connecting rod and bearing cap must therefore be handled with care.

Single dent marks caused by impact can be rectified by gentle and careful local treatment with a file.

In case of damage of the serration, reuse must be rejected, and a new connecting rod assembly including new bearing shells must be mounted in the engine.

The connecting rod screws are to be carefully cleaned.

The threads are inspected for seizures and tested in the threaded holes in the connecting rod. The test must confirm, that the screws can be turned into bottom position by hand. The contact surface of the screw heads is inspected for seizure and pittings.

Screws, which are damaged as mentioned above or cannot be turned into the threaded holes by hand, must be renewed.

Measurement of Big-end Bore.

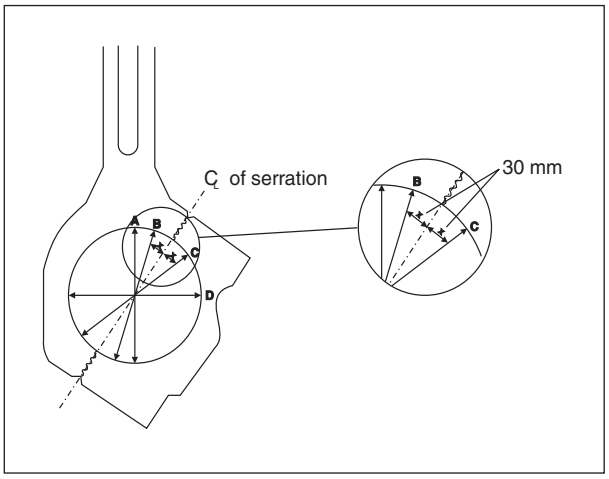


Fig. 1. Point of measurement

For check of roundness the big-end bore has to be measured in a condition, where the connecting rod is mounted with the bearing cap but without bearing shells, and the connecting rod screws are tightened up with the prescribed torque, see working card 606-01.25.

Note ! The ident no. on the connecting rod and the bearing cap, **must** always be the same, see fig. 3.

Measurements **must** be taken 30 mm from seration centerline. See fig. 1.

The measuring is executed with an inside micrometer.

Five different diameters are measured in the middle of the boring, see fig. 1 and registered in the scheme "Connecting Rod Inspection". See page 4.

The maximum ovalnees is calculated as the difference between biggest and smallest diamenter measured. For maximum allowable ovalness see page 600.35.

08028-0D/H5250/94.08.12

If the ovalness exceeds this value, reuse must be rejected and a new complete connecting rod, including new screws and new bearing shells has to be mounted in the engine.

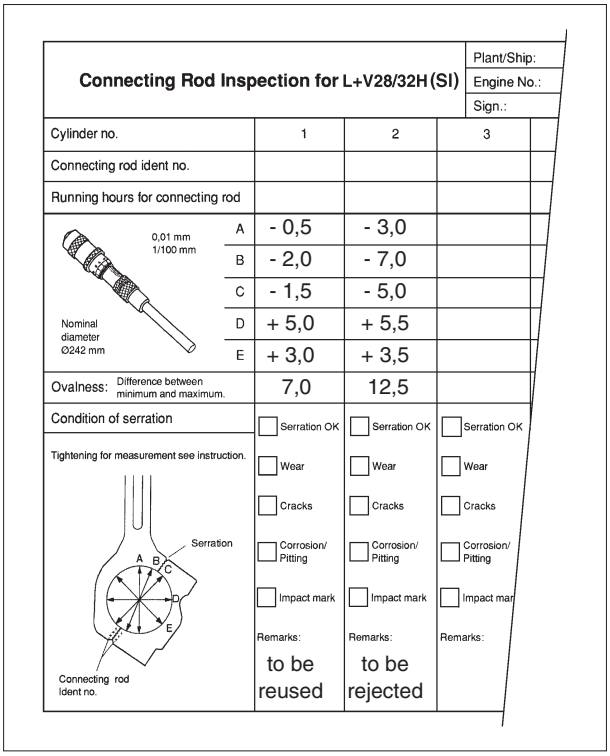


Fig. 2. "Connecting rod inspection".

The example, see fig. 2 shows measurements and damage observations for two connecting rods, on the scheme "Connecting Rod Inspection", (In case the specified maximum ovalness is exceeded, contact MAN B&W Diesel A/S, Holeby for overhaul).

For connecting rod no. 1 the maximum ovalness is 0,07 mm and reuse thus acceptable.

For connecting rod no. 2 the maximum ovalness is 0,125 mm and therefore the connecting rod is being rejected.

Please note that squares for statement of information and identification, should also be properly filled in.

Connecting Rod Bush.

Inspect the surface of the piston pin and the connecting rod bush. Measure the clearance between the piston pin and bush, max. clearance between pin and bush, see page 600.35.

In case the specified clearance is exceeded, contact MAN B&W Diesel A/S, Holeby for replacement.

Bearing Shells for Big-end.

Criteria for replacement of connecting rod big-end bearing, see working card 606-01.16.

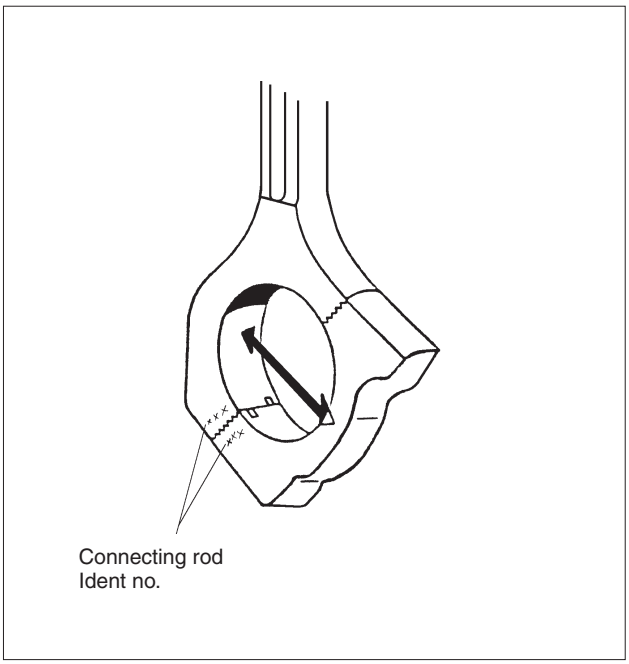
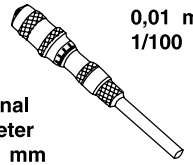
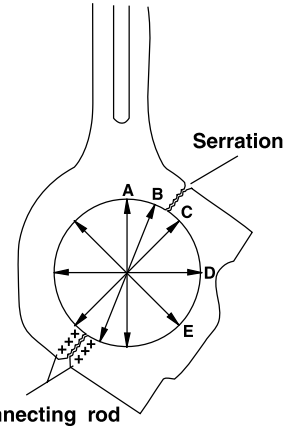


Fig. 3.

Connecting Rod Inspection for L/V28/32H(SI)

				Plant/Ship:			Engine Type:		
				Engine No.:			Running Hours:		
				Sign.:			Insp. Date:		
Cylinder no.		1	2	3	4	5	6	7	8	9
Connecting rod ident no.										
Running hours for connecting rod										
 0,01 mm 1/100 mm Nominal diameter Ø242 mm	A									
	B									
	C									
	D									
	E									
Ovalness: Diff. between min./max.										
Condition of serration		☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK	☐ Serration OK
Tightening for measurement see instruction.		☐ Wear	☐ Wear	☐ Wear	☐ Wear	☐ Wear	☐ Wear	☐ Wear	☐ Wear	☐ Wear
		☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks	☐ Cracks
		☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting	☐ Corrosion/ Pitting
		☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark	☐ Impact mark
		Remarks:	Remarks:	Remarks:	Remarks:	Remarks:	Remarks:	Remarks:	Remarks:	Remarks:



Connecting rod Ident no.

Note ! The ident no. on the connecting rod and on the bearing cap, must always be the same.

Working Card Page 1 (8)	**Criteria for Replacement of Connecting Rod Big-end and Main Bearing Shells**	**606-01.16** Edition 02H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Inspection of bearing shells.

Starting position:

Bearing shells removed from engine:
Big-end bearing, 606-01.00 and 606-01.30
or
Main bearing, 610-01.05
Guide bearing, 610-01.10

Related procedure:

Mounting af bearing shells:
Big-end bearing, 606-01.20 and 606-01.30
Main bearing, 610-01.05
Guide bearing, 610-01.10

Man power:

Working time : 1/4 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	55	

Hand tools:

Magnifier (x30).

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

L+V28/32H

This paper gives information about the evaluation of the connecting rod big-end and main bearing shells when wear appears on the running surface under normal operating conditions.

Bearing damages caused by incorrect running conditions, like

- Scoring of the running surface due to foreign particles in the lubricating oil.
- Cavitation.
- Corrosion
- Overloading, overheating a.s.o.

are not described in this paper.

In these cases, the bearing shells must be exchanged, of course, and in order to avoid further bearing failures, the cause of the failure must be found and eliminated.

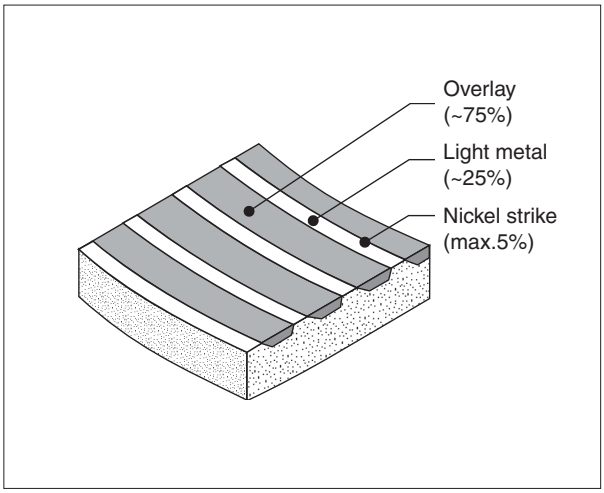


Fig. 1. Running surface of the bearing shell.

A new bearing shell has a running surface with approx. 75 % galvanic overlay and approx. 25 % light-alloy metal, see fig. 1.

Wear of the bearings running surface starts primarily in the soft overlay, where the overlay in the slots is reduced approx. 0.001 mm. The difference between the light-alloy metal and the overlay is by further wear almost constant, i.e. approx. 0.005 mm.

The gravity of the running surface's wear must be determined with a magnifier (x30), hereby the overlay can be seen as the dark area and the light-alloy metal as the light area.

The ratio between the width of the light-alloy metal and the width of the slot as well as the dimension of the worn area are important for determining the wear of the bearing.

The bearing can also operate although part of the overlay is missing in the slots. Practice has shown, that bearings with partly empty slots can run without any negative influence on the operation of the bearing.

By determining the condition of the bearing shell, the overlay at a minor stressed area must be used as comparison.

The valuation of the bearing shell condition is divided into 5 groups:

1. Re-use
2. Limiting case - wear
3. Limiting case - local levelling
4. Limiting case - permanent breakage on the overlay
5. Empty slots.

In case of a combination of the above mentioned conditions, the lowest possible limits are valid.

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1.1. Bearing Shells for Re-use.

Condition: The slot geometry corresponds to a new bearing shell. The overlay in the slots is fully preserved, see fig. 2.

Dark spots are mainly oil coke remains.

Valuation: The ratio between light-alloy metal and overlay is 75 % to 25 %. Re-use!

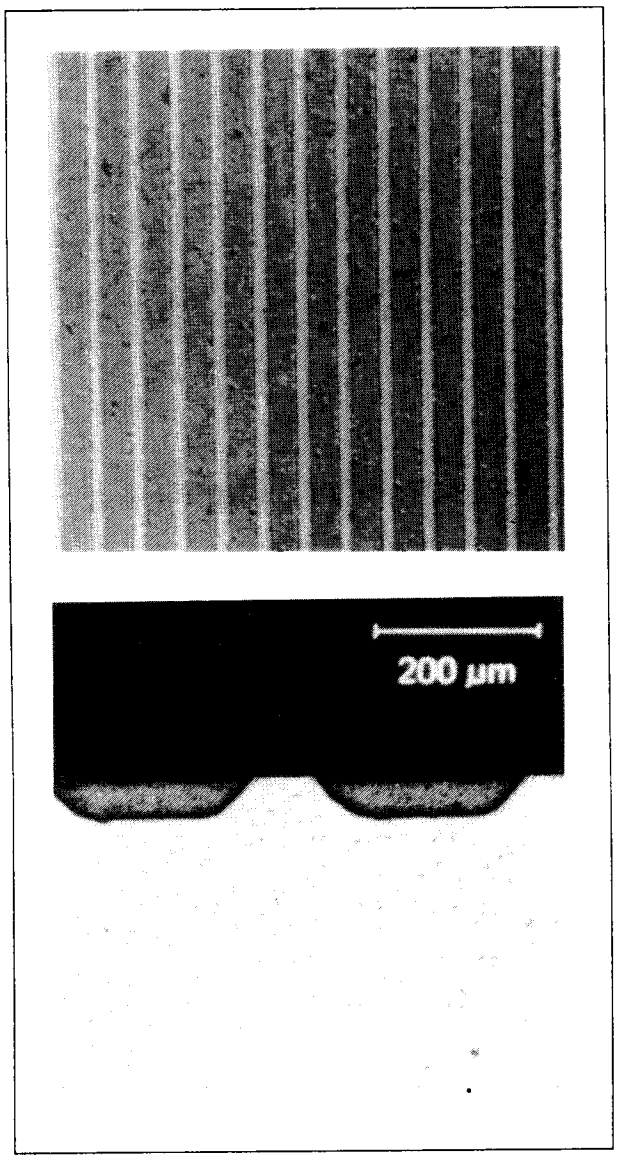

Fig. 2.

1.2. Bearing Shells for Re-use.

Condition: The overlay is equally worn, approx. 0.005 mm in the slots. The light-alloy strips show no wear, see fig. 3.

Dark spots are mainly oil coke remains.

Valuation: Due to worn running surface the light-alloy strips are slightly widened. Re-use!

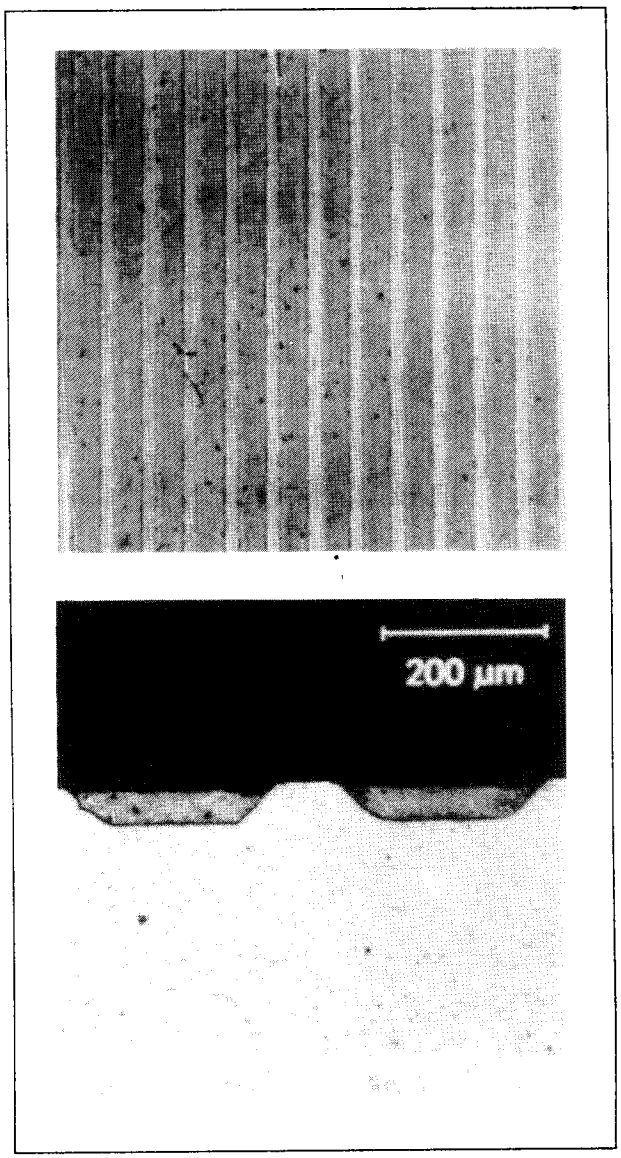

Fig. 3.

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1.3. Bearing Shells for Re-use.

Condition: Small particles all over the overlay. The light- alloy metal shows no changes of importance, see fig. 4.

Valuation: Re-use of the shell, as the particles are wedged in the slots.

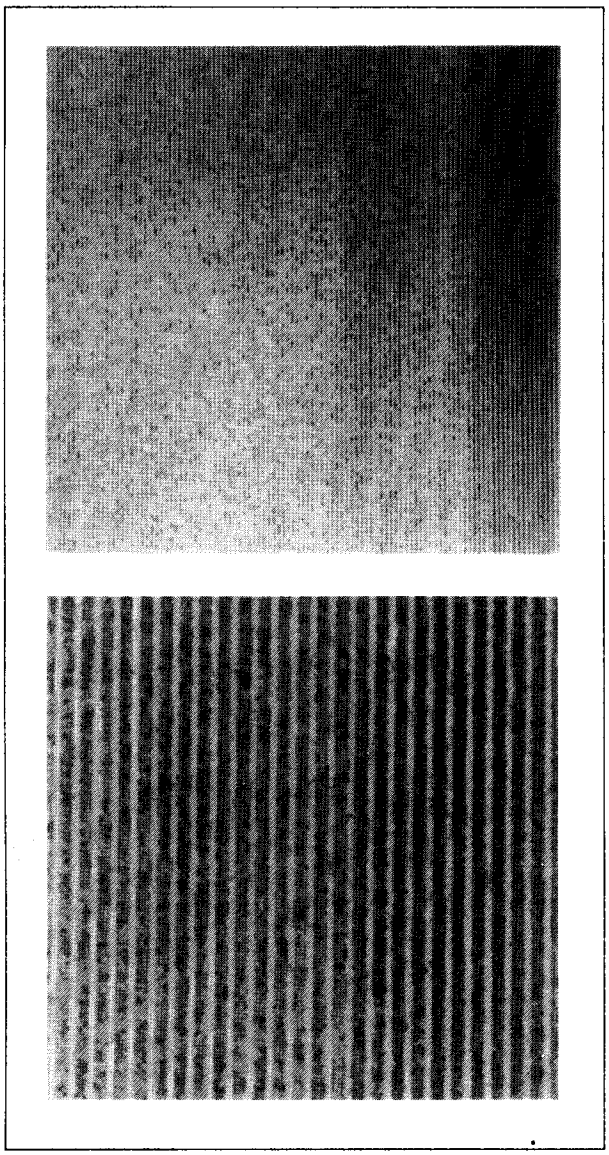

Fig. 4.

1.4. Bearing Shells for Re-use.

Condition: The overlay has been dragged and smudged over the light-alloy metal. These are only partly visible, see fig. 5.

Valuation: Re-use of the shell.

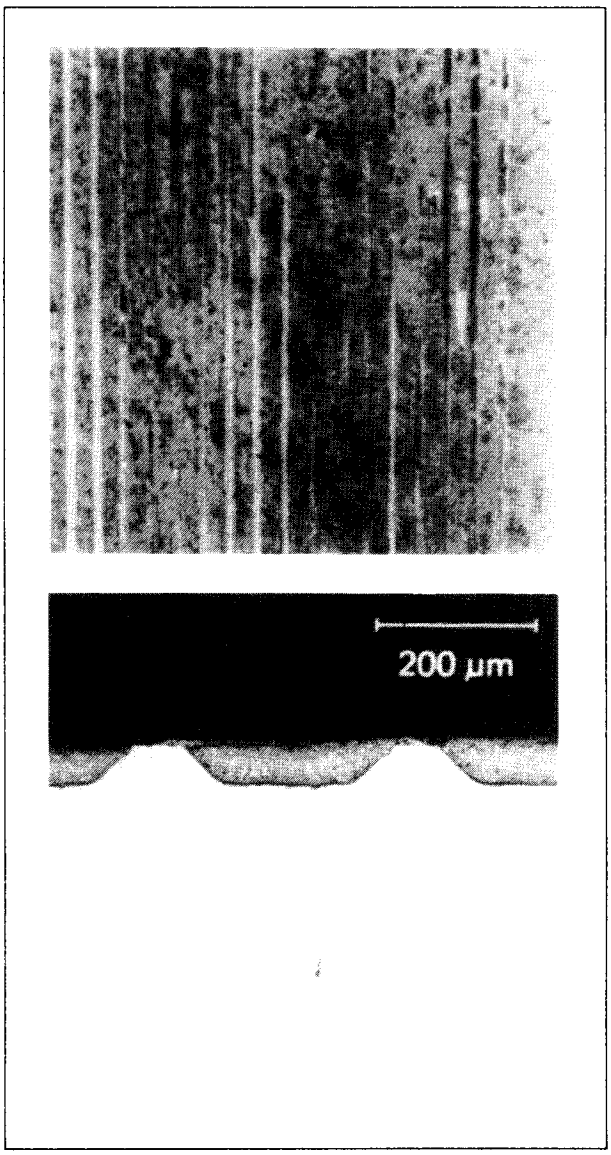

Fig. 5.

08028-0D/H5250/94.08.12

2. Limiting Case - Wear

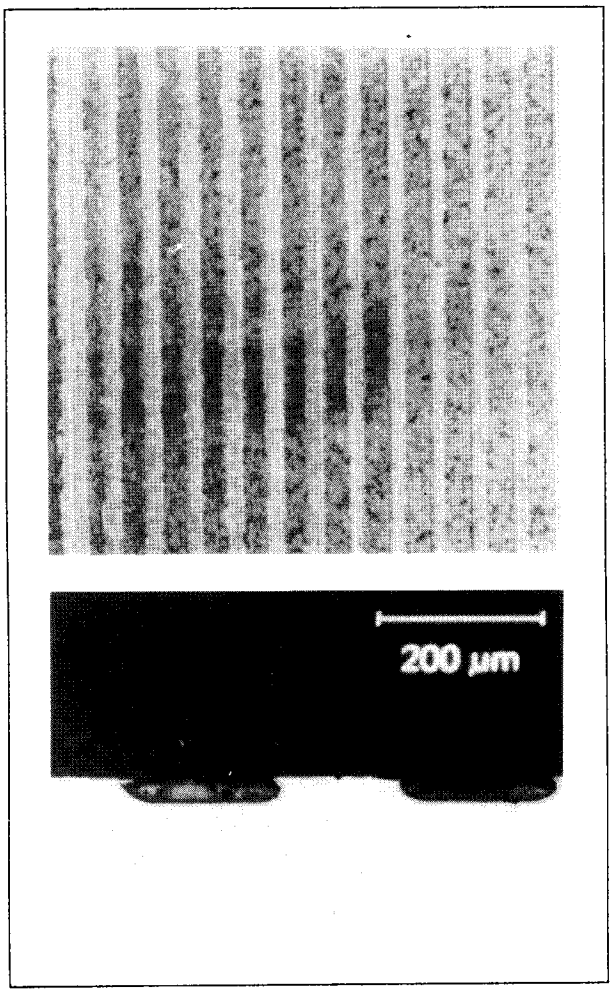

Fig. 6.

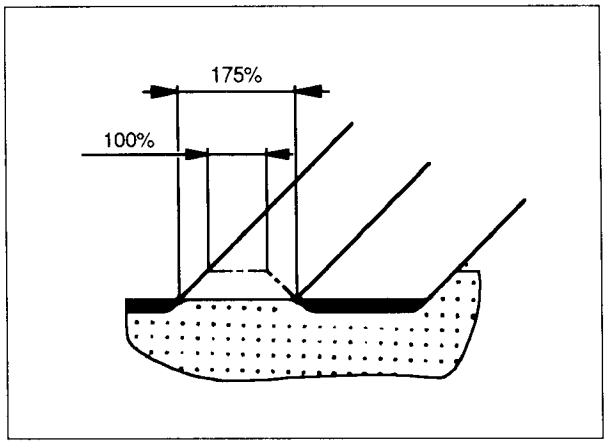

Fig. 7.

Condition: The bearing shell is locally so worn, that the ratio between the light-alloy metal and the overlay is 1:1, see fig. 6. The width of the light-alloy metal has increased from 100 % (new bearing shell) up to 175 %. In the slots some overlay is still left, see fig. 7.

Valuation: The bearing can operate with wear of the below listed size, see fig. 8 og 9. If the wear limits are exceeded the bearing shells must be exchanged due to safety precausions.

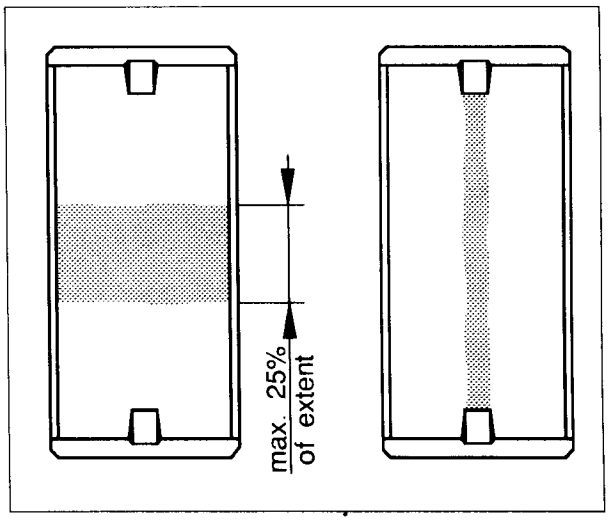

Fig. 8.

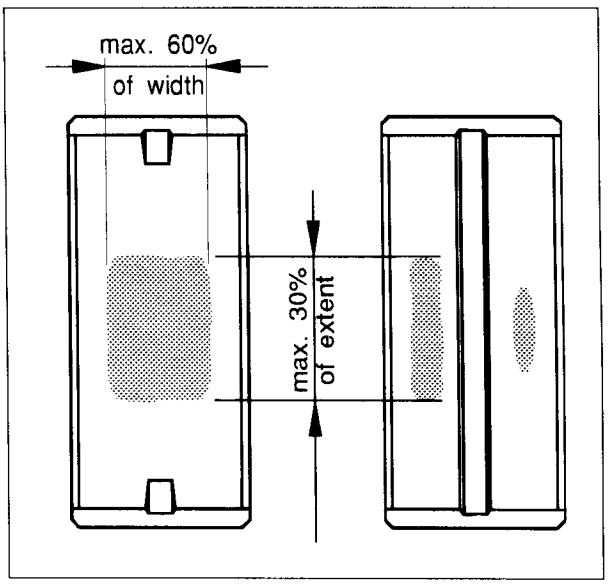

Fig. 9.

L+V28/32H

3. Limit Case - Levelling

Condition: The slots are locally totally levelled as shown in fig. 10.

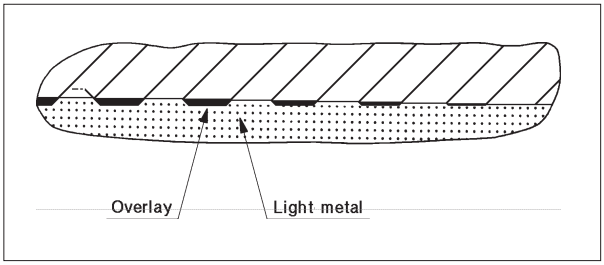

Fig. 10.

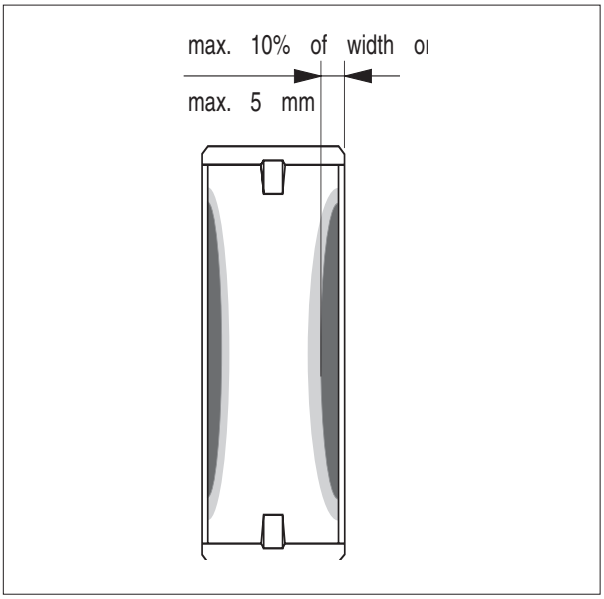

Fig. 11.

Valuation: If the limits shown in fig. 11 and 12 are exceeded the bearing shells must be exchanged.

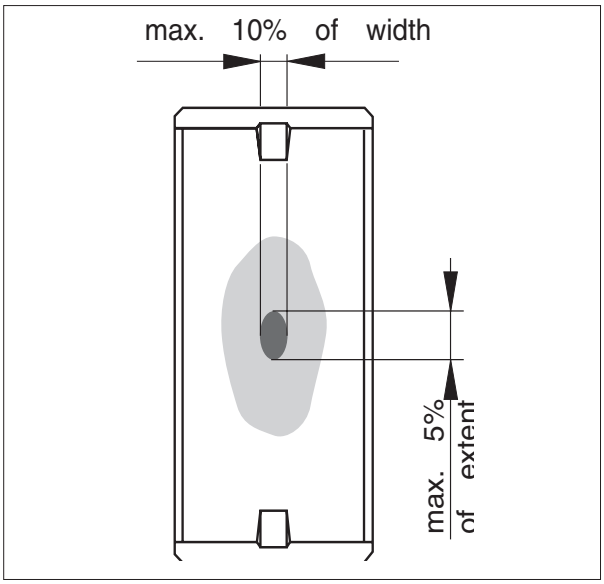

Fig. 12.

08028-0D/H5250/94.08.12

4. Limit Case - Permanent Breakage of the Running Surface

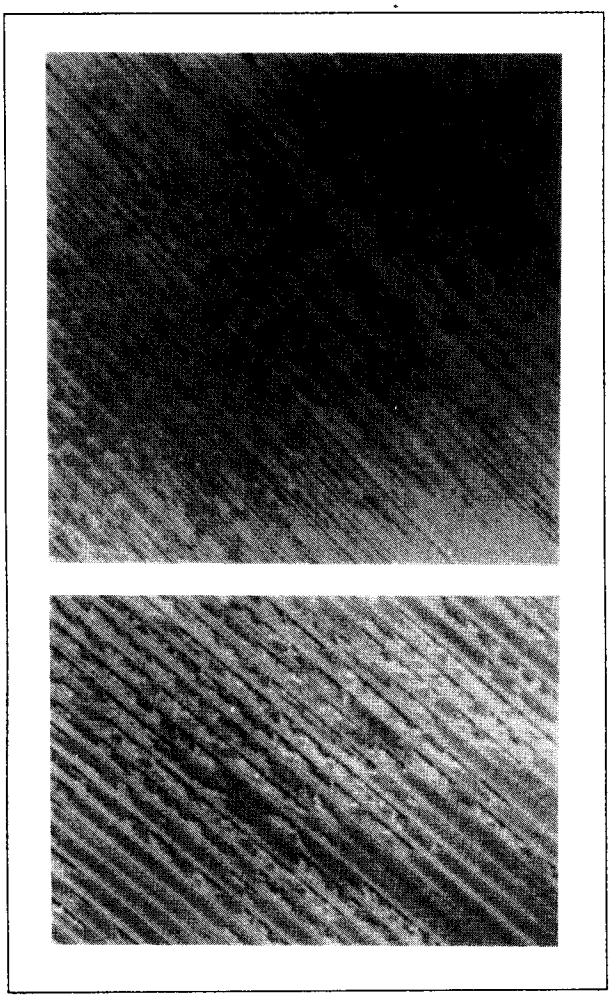

Fig. 13.

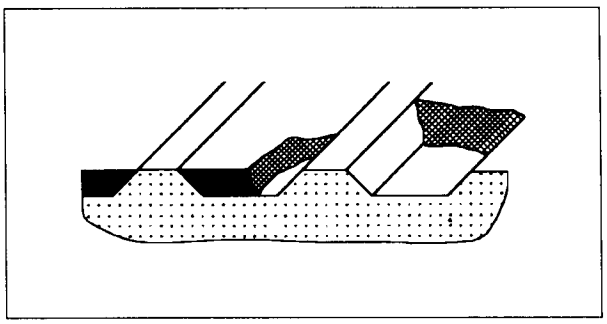

Fig. 14.

Condition: Breakage in the overlay due to local overload, as shown in fig. 13 and 14.

Valuation: If the limits as shown below in fig. 15 and 16 below are exceeded with totally or partially empty slots, the bearing shells must be exchanged.

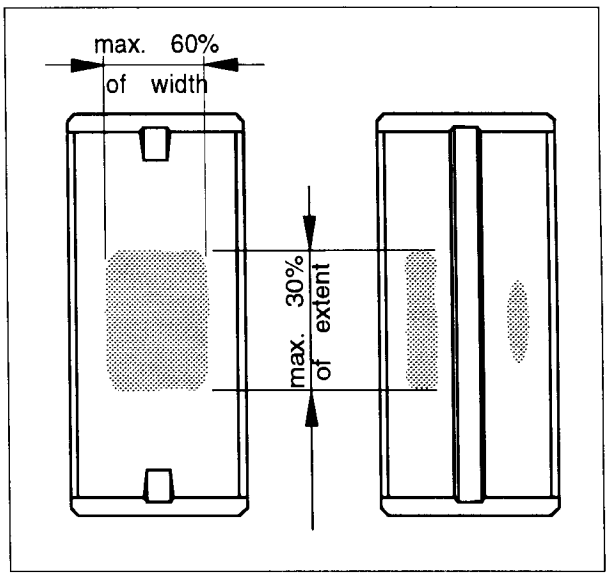

Fig. 15.

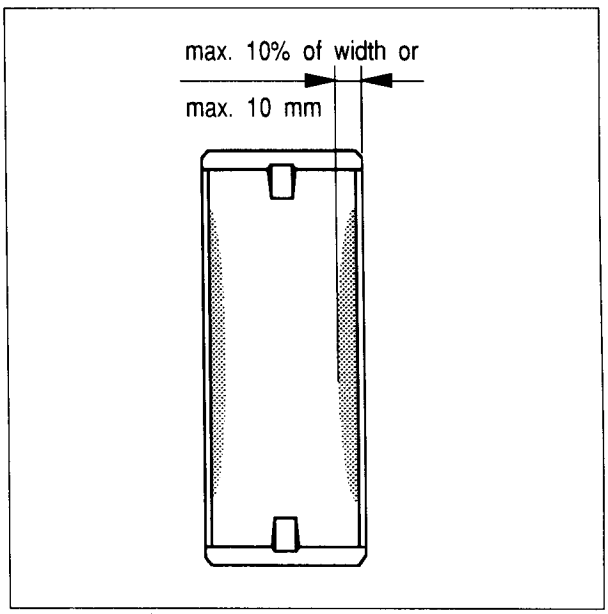

Fig. 16.

L+V28/32H

5. Limit Case - Empty Slots

Condition: In some areas there is no overlay in the slots, see fig. 17.

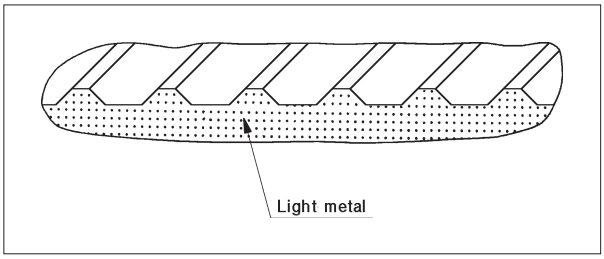

Fig. 17.

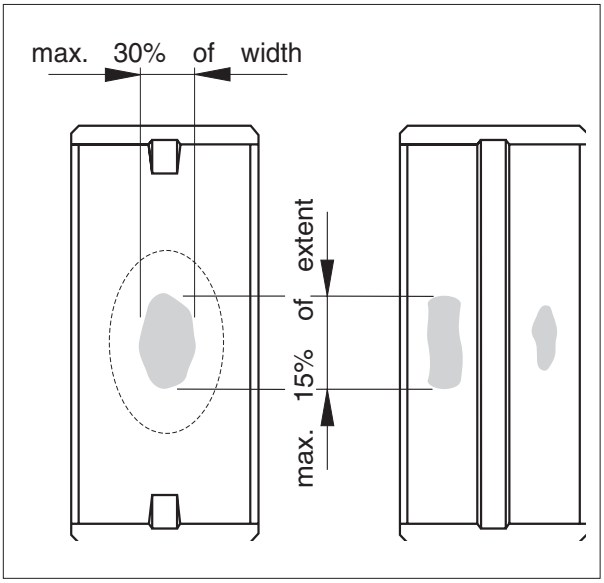

Fig. 18.

Valuation: If the limits shown in the below fig. 18 and 19, are exceeded, the bearing shells must be exchanged.

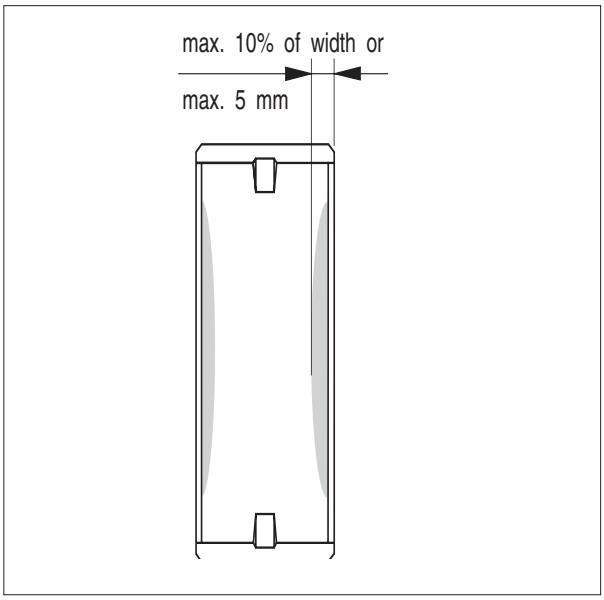

Fig. 19.

08028-0D/H5250/94.08.12

Working Card Page 1 (4)	**Assembling of Piston and Connecting Rod**	**606-01.20** Edition 01H

L28/32H

Safety precautions:

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

Description:

Mounting of piston and connecting rod assembly, after overhaul and/or inspection.

Starting position:

Piston mounted on the connecting rod, crank-shaft turned in the right position and the cylinder liner is OK, see working card 606-01.35.

Related procedure:

Tightening of connecting rod screws, 606-01.25
Mounting of cylinder head, 605-01.40

Man power:

Working time : 1 1/2 Hours
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	01	
62006	03	
62006	11	
62006	13	
62006	22	

Hand tools:

Open end spanner 32 mm.
Clean lubricating oil.

Replacement and wearing parts:

Plate no.	Item no.	Qty./
60601	09	1/cyl.
60601	10	1/cyl.
60601	11	1/cyl.
60601	12	1/cyl.

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L28/32H

1) Mount the lifting device comprising eye screw, shackle and wire rope on the piston.

2) Lift up the piston and connecting rod and mount the piston and scraper rings, see point 14, and working card 606-01.10.

3) Remove the backstop for cylinder liner and place the piston guide ring on top of the cylinder liner, see fig. 1.

4) When the piston approaches the guide ring, stop the lowering, coat guide ring, piston, piston rings and scraper ring, with clean lubricating oil in order to minimize friction during the subsequent lowering of the assembly.

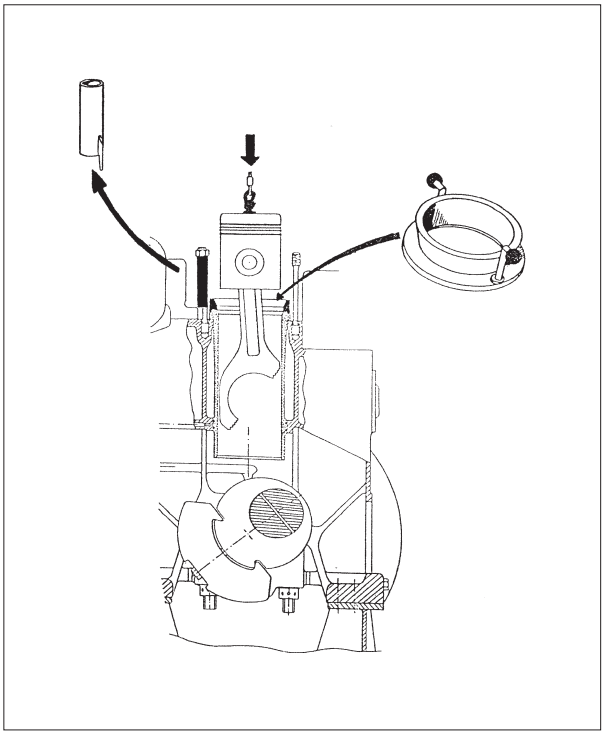

Fig. 1.

5) Make sure that the crank throw is in a position allowing the connecting rod to go clear of both crank journal and cylinder liner skirt during further lowering.

A crank throw position of approx 50 degrees before TDC will ensure this and also be suitable for the further mounting procedure.

6) Lower the piston further down, lubricate the ends of the bearing shells (a in fig. 2) with copaslip, molycote pasta or similar and mount the upper shell of the big-end bearing.

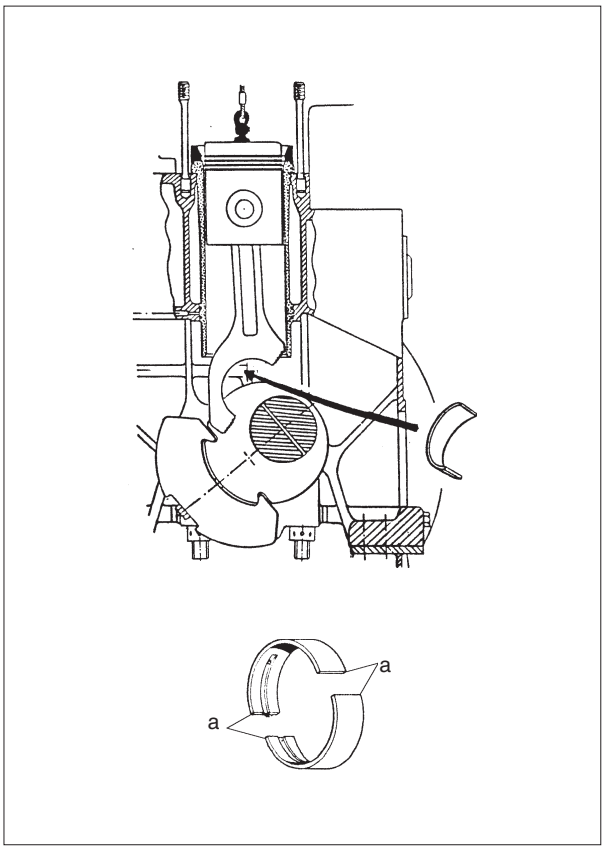

Fig. 2.

7) Coat the crank journal with clean lubricating oil.

8) Now lower the piston and connecting rod slowly into correct landing on the journal.

During this the connecting rod must be guided by hand to ensure correct approach and landing on the journal, see fig. 3.

08028-0D/H5250/94.08.12

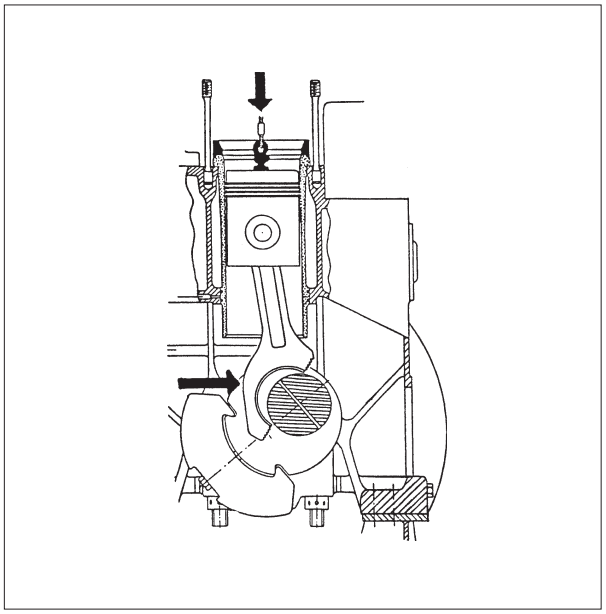

Fig. 3.

Note ! The ident no. on the connecting rod and on the bearing cap, must always be the same, see fig. 4.

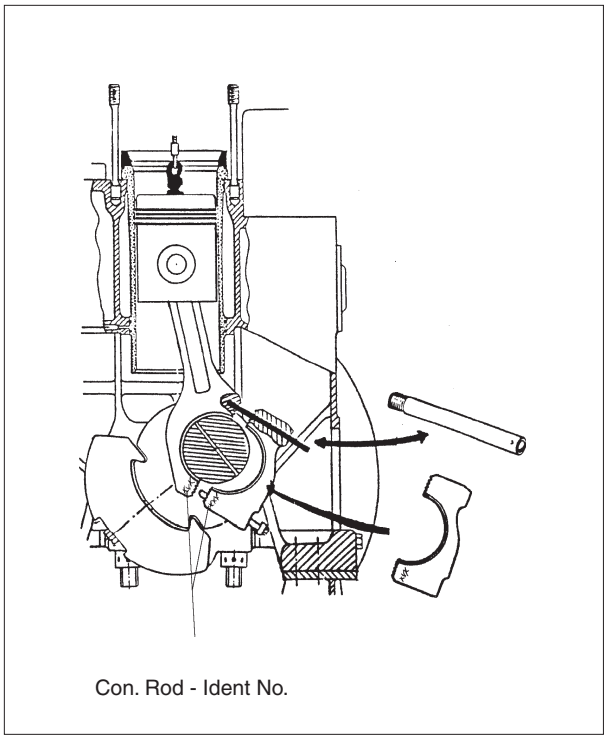

Fig. 4.

9) Mount the bearing cap with inserted lower shell of the big-end bearing, using the guide pin, see fig. 4.

10) Lubricate threads and contact face of the connecting rod screws with copaslip, molycote pasta or similar.

11) Mount the screws and tighten them slightly using an open end spanner.

12) Slacken the tackle and dismount the eye screw/shackle from the piston.

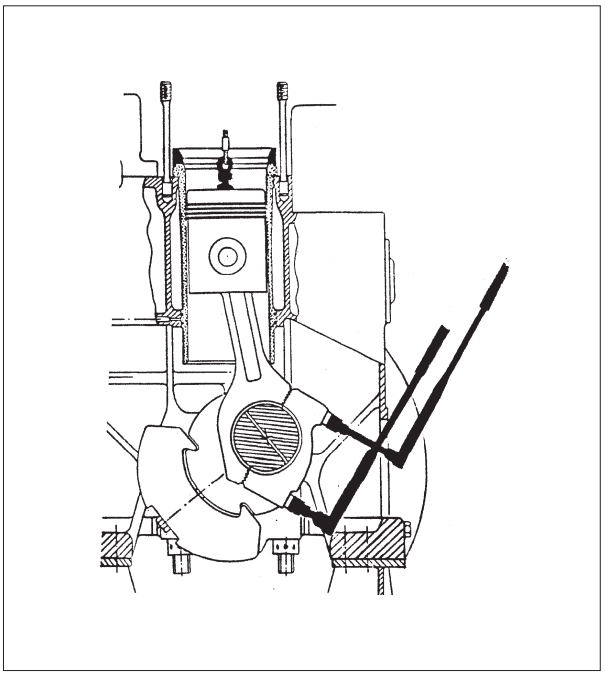

Fig. 5.

13) Tighten the screws according to "Tightening Procedure for Connecting Rod Screws", see working card 606-01.25.

Fitting of Piston and Scraper Rings.

14) Piston rings should only be removed from and fitted to the piston by the use of a special tool, the socalled piston ring opener.

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L28/32H

If the rings are opened further than necessary there is a risk of overstressing, which means that rings will become permanently distorted and will not confirm to the cylinder inner running surface.

The piston rings should be installed with the identification mark, which is stamped into the ring close to the ring joints, facing upwords.

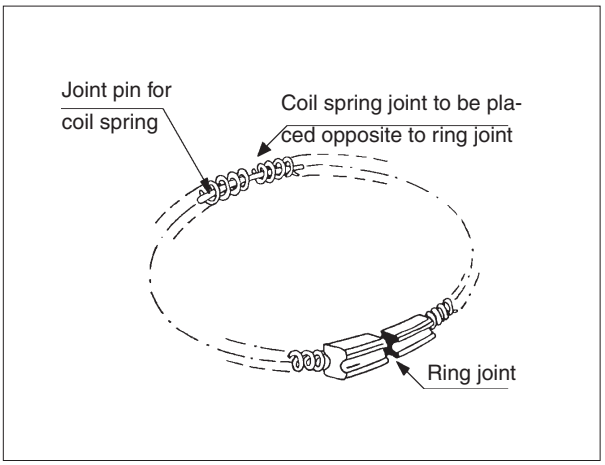

Fig. 6.

Before fitting the coil spring loaded scraper ring, the coil spring is dismantled from the ring by removal of the joint pin. The coil spring is placed and assembled in the ring groove then the scraper ring is fitted in the groove in such a way that the ring joint is approximately 180° offset to the spring joint.

Ascertain correct assembling by checking the back clearance. The back clearance is suffient when the face of the ring is below the groove edge, when the ring is pressed against the bottom of the groove.

When installed on the piston, the rings should be pushed back and forth in the grooves to make sure that they can move freely. It is also advisable to insert a feeler gauge of adequate thickness between ring and groove.

Adequate clearance is present of the feeler gauge can be moved all the way round.

To prevent gas leakage through coinciding ring joints the piston rings should be turned into positions offsetting the ring joint 180° to each other.

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Working Card Page 1 (2)	**Hydraulic Tightening of Connecting Rod Screws**	**606-01.25** Edition 04H

L+V28/32H

Safety Precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Tightening procedure for connecting rod screws.
Check of connecting rod screws, tightening condition.

Starting Position:

Piston, connecting rod, bearing shells and bearing cap preassembled. 606-01.20

Related Procedure:

Man Power:

Working time : 1/2 Hour
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special Tools:

Plate No	Item No	Note
62021		

Hand Tools:

Replacement and Wearing Parts:

Plate No	Item No	Qty./

08028-0D/H5250/94.08.12

606-01.25 Edition 04H	Hydraulic Tightening of Connecting Rod Screws	Working Card Edition 2 (2)

L+V28/32H

1) Tighten the screw pos. 3 home to the connecting rod by hand.

2) Mount the lower part pos. 2 and fasten the lower part with the nuts, pos. 4.

3) Tighten the nuts by hand.

4) Mount the hydraulic tool, pos. 5.

Be aware of the max. lifting heigt of the tool and adjust the distance between the piston and the cylinder before adding pressure to the tool. Please *see Working Card 620-01.05*

5) Connect the tool to the hydraulic tool.

6) Add the prescribed hydraulic pressure, (to both screws simultaneously). *Please see Description 600.40,* and tighten the screws by using a handle, pos 6.

7) Relieve the hydraulic pressure on the tool.

8) Add the hydraulic pressure to the tool.

9) Tighten the nuts again.

Note: The Points 7 to 9 are to be followed in order to remove tensions in the screws, if any.

10) If there still is a distance and the nuts still can be tightened then repeat the points 7, 8 and 9.

11) Relieve the pressure on the tool and remove it from the screws.

Note: General instruction about hydraulic tightening. *Please see Working Card 620-01.10*

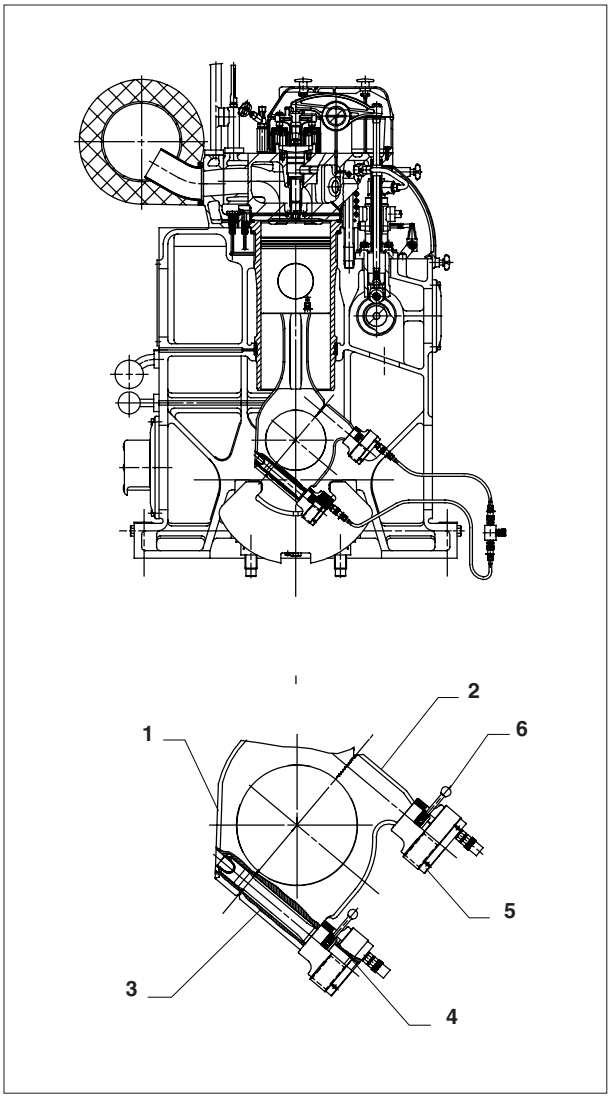

Fig. 1

08028-0D/H5250/94.08.12

Working Card Page 1 (3)	**In-situ Inspection of Connecting Rod Big-end Bearing**	**606-01.30** Edition 01H

L28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

In-situ inspection and/or replacement of connecting rod big-end bearing, dismounting and moun-ting.

Starting position:

Fuel injector dismounted, 614-01.00
Crankcase open.
Top cover for cylinder head removed.

Related procedure:

Inspection of connecting rod big-end bearing 606-01.16
Tightening and check of connecting rod screws, 606-01.25

Man power:

Working time : 1 1/2 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	07	
62006	22	
62006	28	140 - 760 Nm

Tool combination for tightening of connecting rod screw, see working card 620-01.20.

Hand tools:

Open end spanner 32 mm.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

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L28/32H

The big-end bearing shells can be inspected and/or replaced in-situ i.e. without dismounting the piston and connecting rod assembly from the engine.

Dismounting.

1) The crankshaft of the engine is turned into a position allowing the connecting rod screws to be loosened. Having loosened the connecting rod screws, the crankshaft is turned until the piston in a position thus allowing the connecting rod bearing cap to be dismounted, see fig. 1.

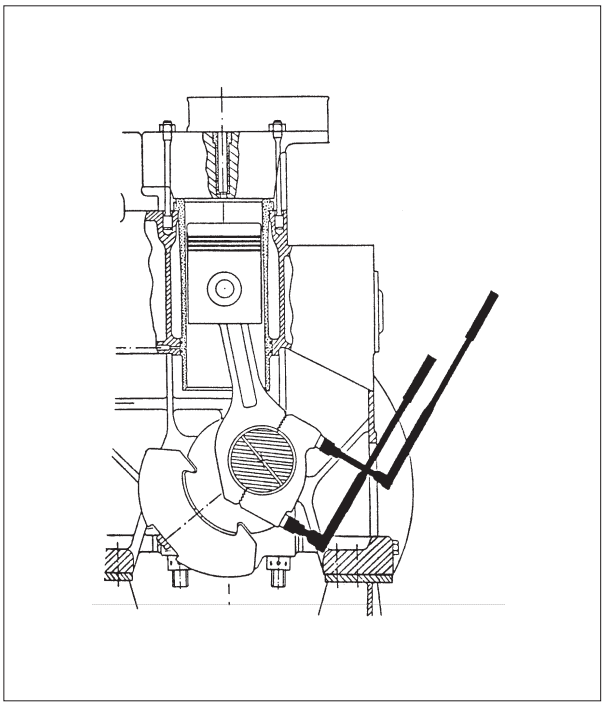

Fig. 1.

2) Before removing connecting rod bearing cap, the especially long eye bolt is mounted. It is inserted through the fuel injector sleeve and is screwed into the thread hole in the piston, see fig. 2. Then by means of a tackle it is slightly tightened.

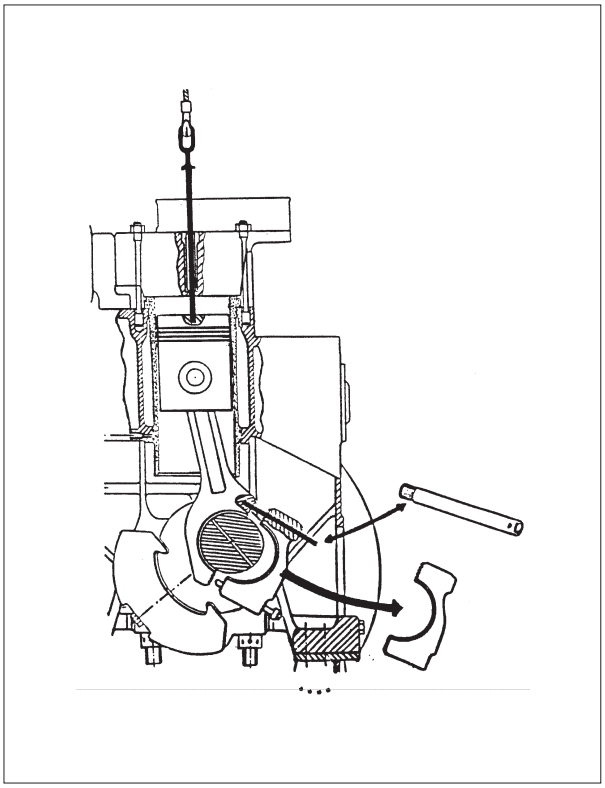

Fig. 2.

3) Having tightened the tackle slightly, the connecting rod bearing cap and bearing shell are dismounted, see working card 606-01.00, for use of guide pin.

4) When connecting rod bearing cap and bearing shell have been dismounted, the piston/connecting rod is lifted from the bearing journal. Piston/connecting rod should not be lifted further than just to allow dismounting of the upper bearing shell, see fig. 3.

08028-0D/H5250/94.08.12

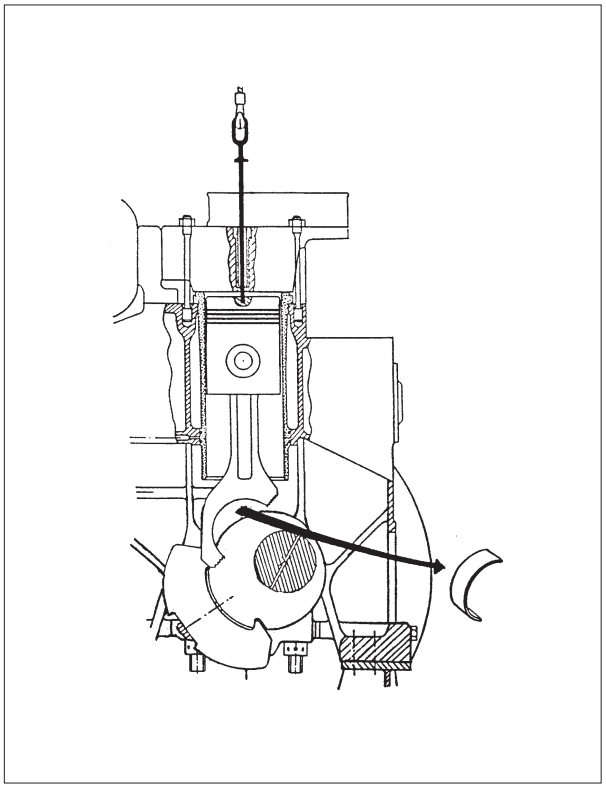

Fig. 3.

5) For inspection of bearing shell, see working card 606-01.16

Mounting.

Before remounting of inspected or new bearing, all components must be cleaned.

Note: See also working card 606-01.20.

1) The bearing shell is placed in the bore, the contact surfaces of the shells to be in parallel to the contact surface of the connecting rod, the bearing cap respectively.

2) Ascertain that the crank throw concerned is in a position of approx 50 degrees before TDC.

3) Coat the journal with clean lubricating oil and lower the piston and connecting rod assembly slowly into correct landing on the journal.

While lowering the connecting rod, it must be guided by hand to ensure correct approach and landing on the journal, see fig. 4.

4) Mount the bearing cap with inserted lower big-end bearing shell, using the guide pin.

5) Lubricate threads and contact face of the connecting rod screws with copaslip or similar.

6) Mount the screws and tighten them slightly using an open-end spanner.

7) Slacken the tackle and dismount the eye screw from the piston crown.

8) Tighten the screws according to "Tightening Procedure for Connecting Rod Screw", see working card 606-01.25.

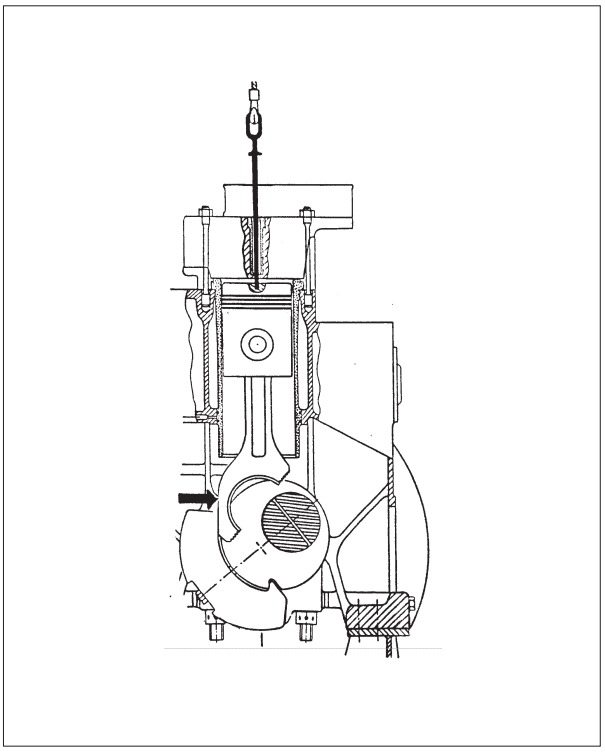

Fig. 4.

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Working Card Page 1 (4)	**Inspection and Honing of Cylinder Liner**	**606-01.35** Edition 08H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Inspection and honing of cylinder liner with honing brush.

Starting position:

Piston and connecting rod is removed, 606-01.00

Related procedure:

Mounting of piston and connecting rod, 606-01.20
Replacement of cylinder liner, 606-01.40
Grinding of seal face on cylinder head and cylinder liner, 606-01.45

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	50	Extra tools
62006	51	Extra tools
62006	60	Extra tools

Hand tools:

Drilling machine 60-180 rpm.
Honing oil.
Gas oil.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

08028-0D/H5250/94.08.12

L+V28/32H

Measurement of Cylinder Diameter.

While the piston is removed from the cylinder, the latter is measured to record the wear. The measurements are taken by means of an inside micrometer, with measuring points at TDC-position for uppermost piston ring, halfway down and at the bottom of the cylinder liner, see fig. 1.

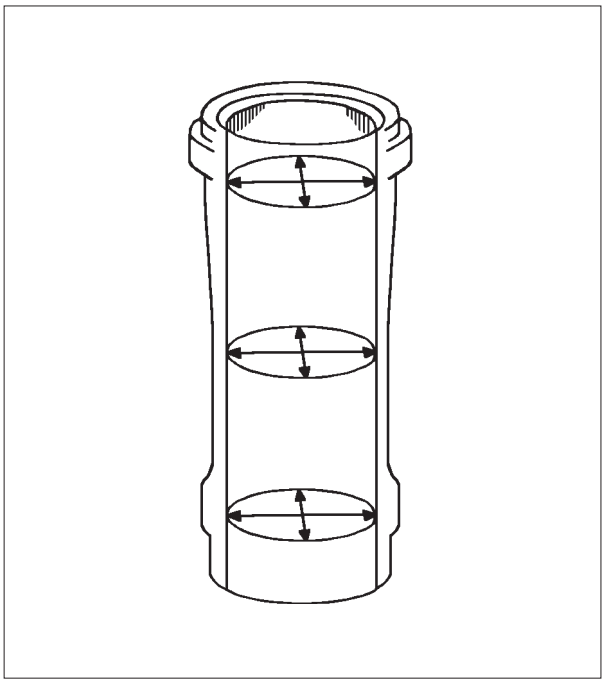

Fig. 1.

The measurements should normally be taken in transverse as well as in longitudinal direction.

When measuring, take care that the measuring tool has the approximately same temperature as the liner. When the wear of a cylinder liner exceeds the value indicated on page 600.35, i.e. when it becomes too troublesome to maintain satisfactory service con-ditions, the cylinder liner in question should be ex-changed.

Honing the Cylinder Liner.

The renovation can be made either with dismantled liner in the workshop or with liner mounted in the engine frame and by the use of the belonging funnel.

Prior to the honing, deposits of coke and possible wear edges in the top of the liner must be removed by scraping.

If the cylinder is of the flame ring type, the used flame ring has to be cleaned in water. Subsequently, the flame ring is remounted in the cylinder before carrying out the honing process.

Note: After the honing process has taken place the used flame ring is discarded. A new flame ring is always mounted in the cylinder when replacing a piston ring.

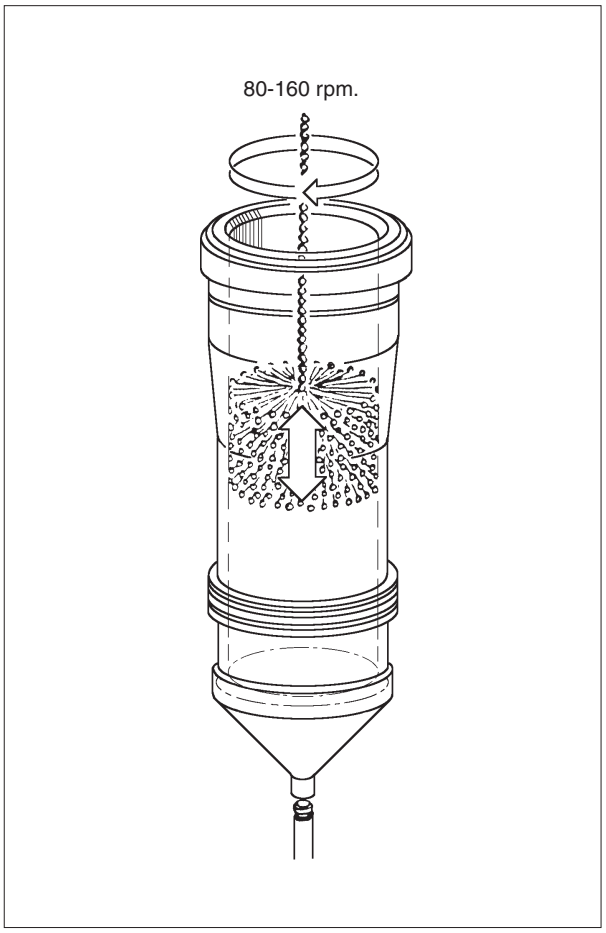

Fig. 2.

The honing is made by means of a flex-honer with finess grains 80-120. A revolution speed between 80 and 160 rpm is chosen.

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In order to achieve the required angle between the honing grooves, see fig. 2, the vertical speed is adjusted to about 1 m/sec. which corresponds to about 2 sec. for one double movement (the flex honer is lead from below up and down in 2 sec.)

The procedure is to be continued until the cylinder wall is covered by honing grooves and the surface has a slight matt appearance and without any signs of glaze .

During the honing it is important to lubricate freely with honing oil or cutting oil.

After the honing, the liner is carefully cleaned with gas oil, and make sure that all abrasive particles have been removed.

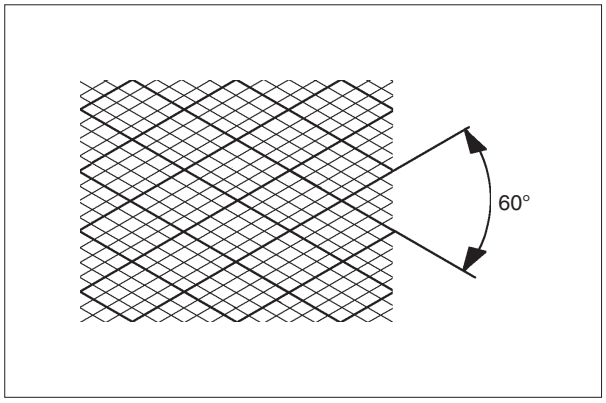
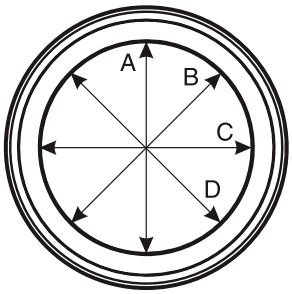
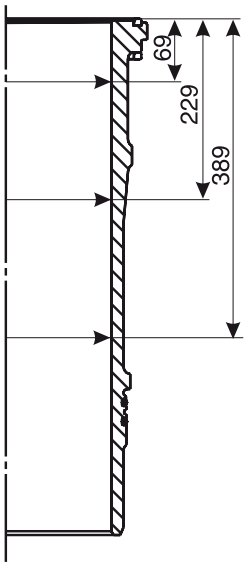


Fig. 3.

08028-0D/H5250/94.08.12

L+V28/32H

Measurements of Cylinder Liner

Plant/ship:			Engine Type:		Engine No.:			
Date:	Sign.:	Cyl. no.	Pos.	☐ A-side		☐ B-side	
				A	B	C	D
Running hours:		1	1				
Fuel: cSt		1	2				
Separator: Yes		1	3				
 		2	1				
			2				
			3				
		3	1				
			2				
			3				
		4	1				
			2				
			3				
		5	1				
			2				
			3				
		6	1				
			2				
			3				
		7	1				
			2				
			3				
		8	1				
			2				
Tem. of cyl. liner	25°C		3				
Nom. diameter	280H8	9	1				
Minimum	280.0		2				
Maximum	280.60		3				

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Working Card Page 1 (3)	**Replacement of Cylinder Liner**	**606-01.40** Edition 01H

L/V28/32H

Safety precautions:

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circul.

Description:

Replacement of cylinder liner.
Dismounting and mounting of cooling water guide jacket.

Starting position:

Cylinder head and piston/connecting rod dismantled,working card 605-01.00 and 606-01.00.

Related procedure:

Mounting of piston and connecting rod,	606-01.20
Grinding of seal face on cylinder head and cylinder liner,	606-01.45

Man power:

Working time : 2 Hours
Capacity : 2 men

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	45	

Hand tools:

Allen key, 8 mm.
Adjustable spanner.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
60610	04	1/cyl.
60610	07	12/cyl.
60610	08	2/cyl.
60610	11	2/cyl.

See also plate 60610.

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L/V28/32H

Dismounting of Cylinder Liner.

1) Dismount the cooling water guide jacket.

2) Prior to mounting of the lifting tool and dismounting from the frame, it must be ensured that the liner and frame have been marked to match, for the sake of a posible remounting of the liner, see fig. 1.

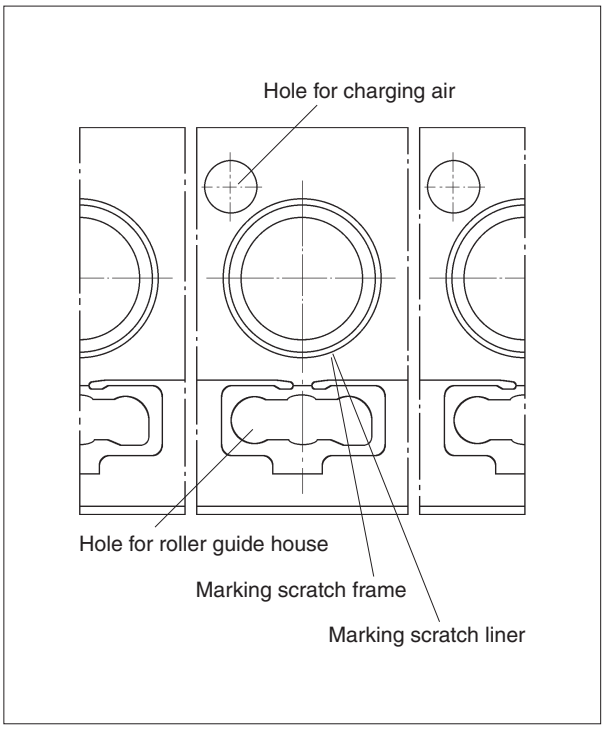

Fig. 1.

3) Mount the lifting tool as shown, see fig. 2.

4) Turn the lifting eye nut to pull out the liner, until the upper edge of the liner lie aligned against the copper protecting pieces of the cross bar.

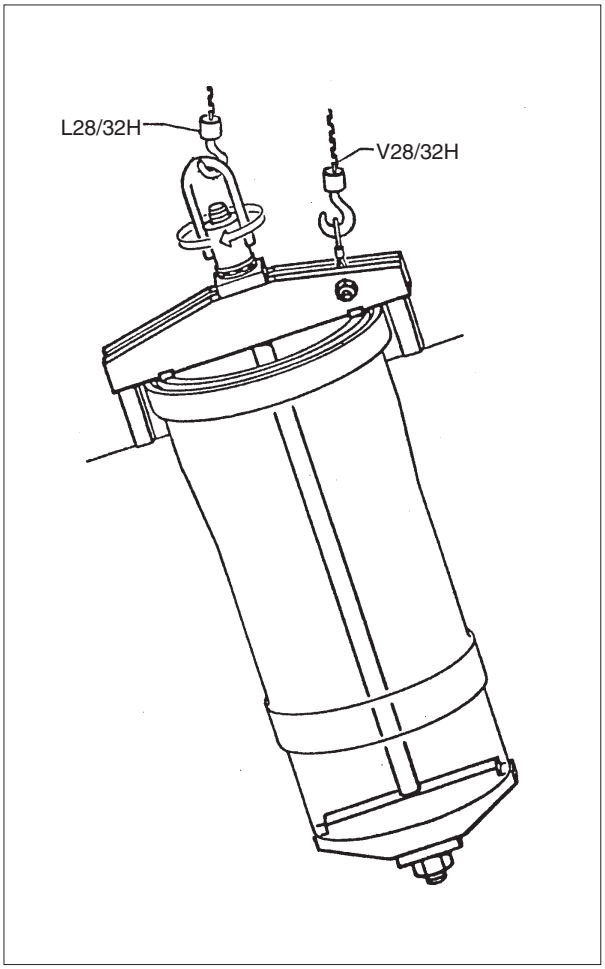

Fig. 2.

5) Attach a tackle hook to the eye nut or the wire and the cross bar, and lift the liner out from the engine frame and stand it careful onto wooden supports.

6) Clean all parts and inspect for damage and wear, according to the description. For measurement of cylinder liner, see working card 606-02.00.

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Mounting of Cylinder Liner.

7) Check that the sealing surfaces on engine, cylinder liner, and sealing rings are perfectly clean.

8) Mount the lifting tool, attach a tackle hook to the eye nut or to the wire in the cross bar and lift the liner.

9) Check that the o-ring grooves are clean. Mount the o-rings and lubricate with a little oil. Place a new sealing on top of the frame.

10) Lower the cylinder liner carefully into the engine frame.

When the first o-ring touches the sealing face, align the liner so that the scratch mark on the liner flange points to the scratch mark on the frame as illustrated, or align the liner so that the milling groove in the liner flange coinside with the fixing piece on the engine frame control side (if mounted).

11) After having cleaned and inspected the cooling water jacket, mount new o-rings on the cooling water connections and change air connections.

Fit a new sealing ring and mount the jacket.

12) Mount the cooling water jacket, (for torque moment see page 600.40), piston/connecting rod and cylinder head according to working card 606-01.20 and 605-01.40.

13) When preparing the start-up, check for possible leakages of water and oil, including the inspection hole in the frame, see fig. 3.

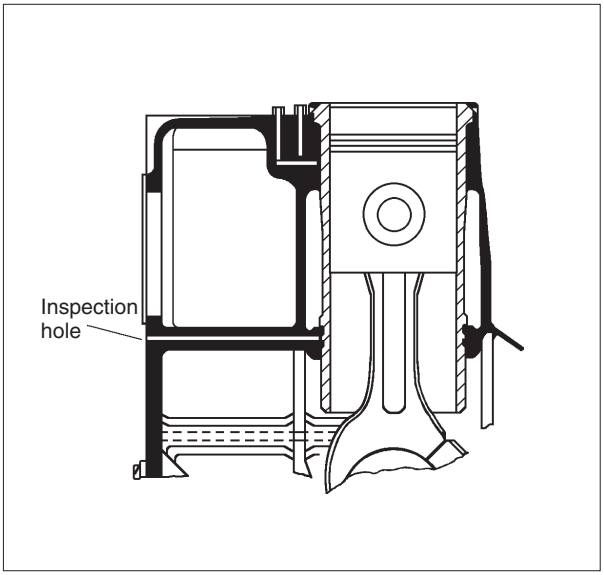


Fig. 3.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Grinding of Seal Face on Cylinder Liner and Cylinder Head.**	**606-01.45** Edition 01H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Grinding of seal face on cylinder liner and cylinder head by hand, with grinding tools and grinding pasta.

Starting position:

Cylinder head has been removed from the engine, 605-01.00
Cooling water guide jacket, removed.

Related procedure:

Mounting of cylinder head, 605-01.40

Man power:

Working time : 1 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62005	20	

Hand tools:

Grinding pasta.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
60610	08	1/cyl.

08028-0D/H5250/94.08.12

L/V28/32H

Note: The grinding tool is used for both grinding the groove in the liner flange (1) and the seating surface on the cylinder head (2), see fig. 1.

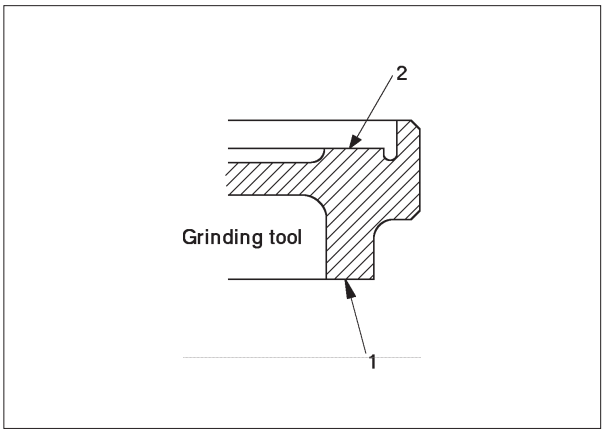


Fig. 1.

Grinding.

1) Loosen the sealing ring in liner flange and take it out.

2) Face-grind sealing groove in cylinder liner flange, see fig. 2 and sealing surface on the cylinder head, see fig. 3. With the use of grinding pasta and the grinding tool.

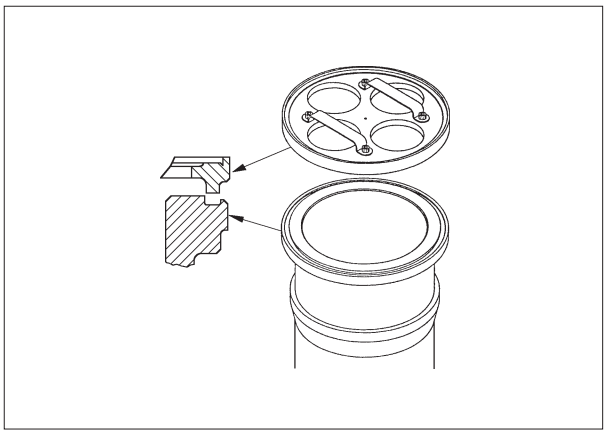


Fig. 2.

To do so, move the tool back and forth and lift it out from time to time, to allow the grinding compound to distribute evenly.

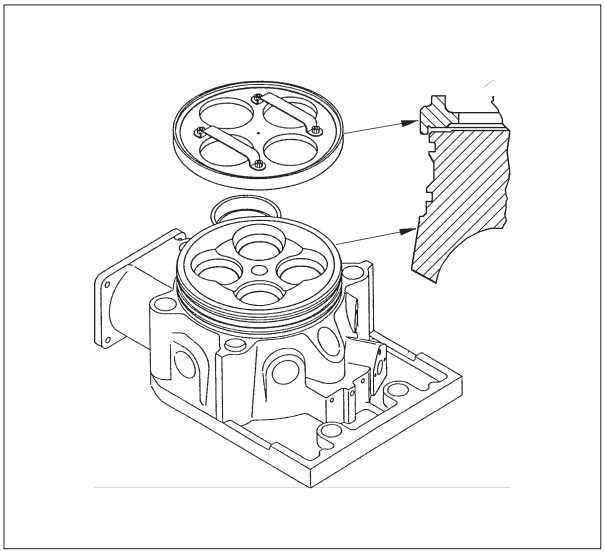


Fig. 3.

3) After grinding, remove all traces of abrasive and grinding compound.

4) When having ground the contact faces, it must be observed that the gap between cylinder head and liner is no less than 0,5 mm, that is, the difference between measurements y and z must not be less than 0,5 mm, see fig. 4.

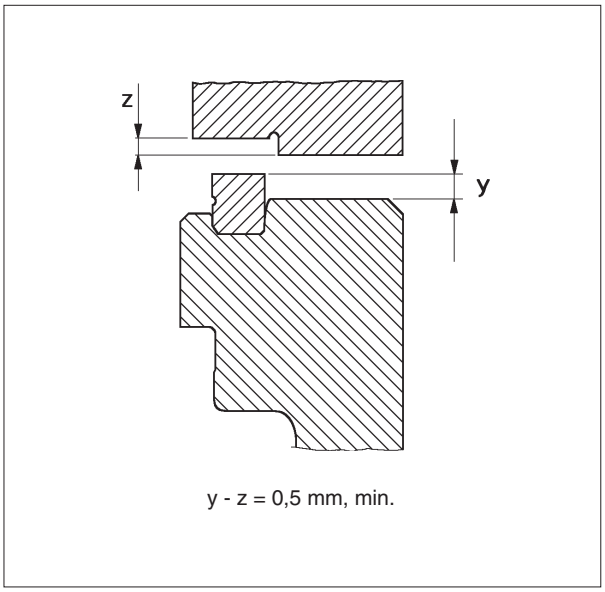


Fig. 4.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Dismounting of Piston and Cylinder Liner at Low Overhaul Heights**	**606-01.50** Edition 01H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Dismounting of piston, connecting rod and cylinder liner for inspection and/or overhaul.

Starting position:

Cylinder head has been dismounting from the engine.
Crankcase open.

Related procedure:

Separation of piston and connecting rod.
Inspection and honing of cylinder liner.

Manpower:

Working time : 2 ½ Hours
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no	Item no	Note
62050		
62006	05	
62006	09	2 pieces
62006	22	
62006	24	
62006	28	
62006	65	
62010	01	If necessary

Tool combination for dismounting of conncting rod screw, 620-01.20

Hand tools:

Inside micrometer (195 mm).
Feeler gauge 0,15 - 0,20 mm.

Replacement and wearing parts:

Plate no	Item no	Qty/

08028-0D/H5250/94.08.12

L+V28/32H

Dismantling of Piston at Low Overhaul Heights.

1) Lift up the piston and the connecting rod through the cylinder liner until the piston is clear of the liner.

2) Mount collar on the connecting rod, see plate 62050, item 1896.

3) Place the piston with the collar on the cylinder liner.

4) Mount pull-lifts on the collar.

If	Then
The overhaul height is too low to pull out piston and connecting rod in one piece.	Dismount the piston from the connecting rod, remove the piston and pull out the connecting rod by the pull-lifts.
The overhaul height is sufficient to pull out the piston and the connecting rod in one piece.	Remove the piston and connecting rod by means of the pull-lifts.

Dismantling of Cylinder Liner at Low Overhaul Heights.

1) Mount normal lifting tool for cylinder liners.

2) Carefully pull the cylinder liner half-way out of the frame.

3) Mount special lifting tool for cylinder liners at low overhaul heights, see plate 62050, item 1895.

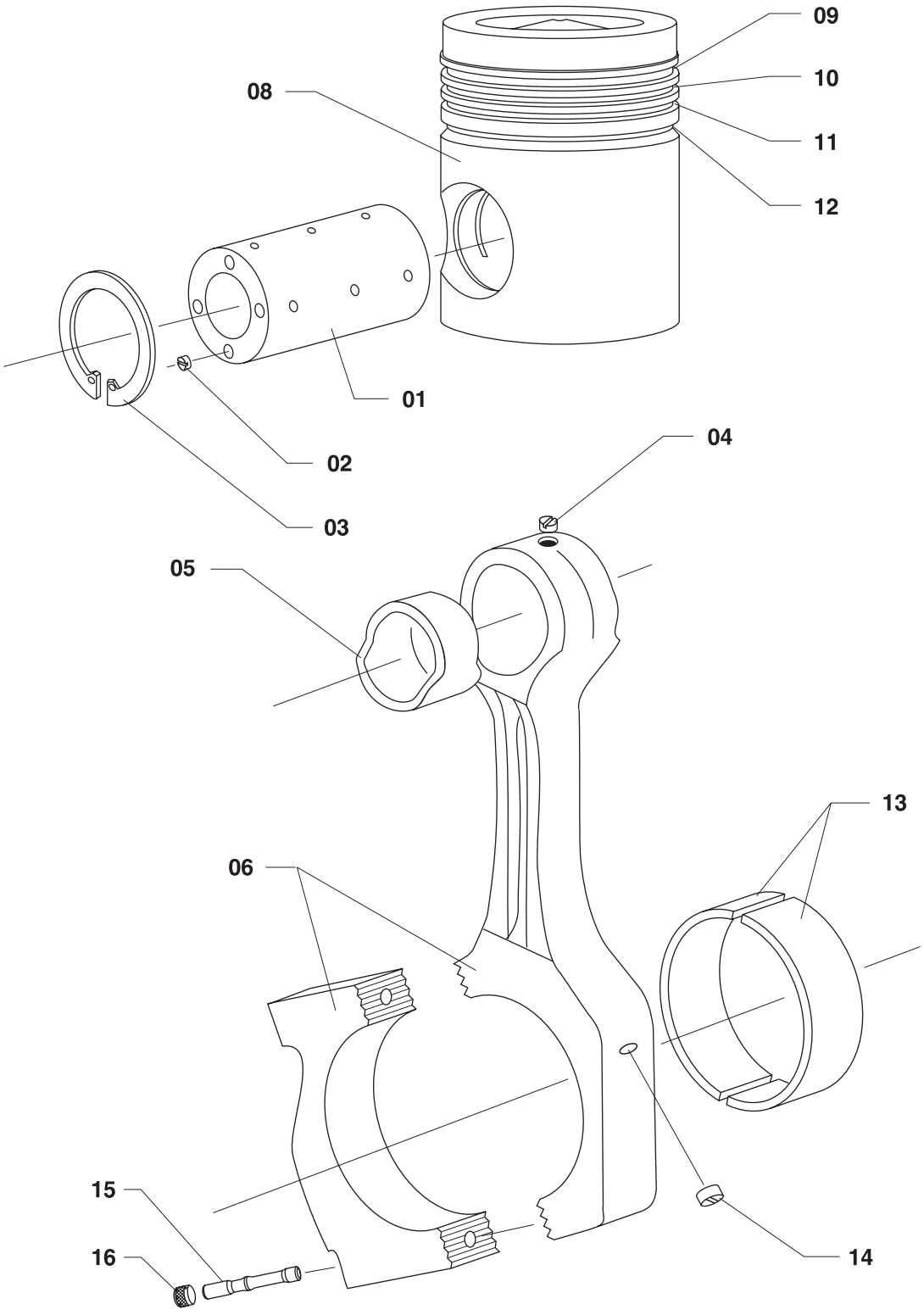
4) Attach pull-lifts on the lifting tool for the cylinder liner, see plate 62050, item 1895

5) Take out the liner over the camshaft side.

08028-0D/H5250/94.08.12

Plate Page 1 (2)	**Piston and Connecting Rod (Hydraulic Tightened)**	**60601-34H**

L28/32H



60601-34H	Piston and Connecting Rod (Hydraulic Tightened)	Plate Page 2 (2)

L28/32H

Item No	Qty.	Designation	Benævnelse
01	1/C	**Piston pin incl. item No 02**	Stempelpind inkl. pos. nr. 02
02	4/C	**Socket screw**	Kraterskrue
03	2/C	**Retaining ring**	Sikringsring
04	1/C	**Plug screw**	Propskrue
05	1/C	**Bush for connecting rod**	Plejlstangs-bøsning
06	1/C	**Connecting rod incl. item Nos 04, 05, 14, 15, 16**	Plejlstang inkl. pos. nr. 04, 05, 14, 15, 16
08	1/C	**Piston**	Stempel
09	1/C	**Piston ring**	Stempelring
10	1/C	**Piston ring**	Stempelring
11	1/C	**Piston ring**	Stempelring
12	1/C	**Oil scraper ring**	Olieskrabering
13	1/C	**Connecting rod bearing 2/2**	Plejlstangs-leje 2/2
14	1/C	**Plug screw**	Propskrue
15	2/C	**Connecting rod stud**	Plejlstangsbolt
16	2/C	**Nut**	Møtrik

Item No	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

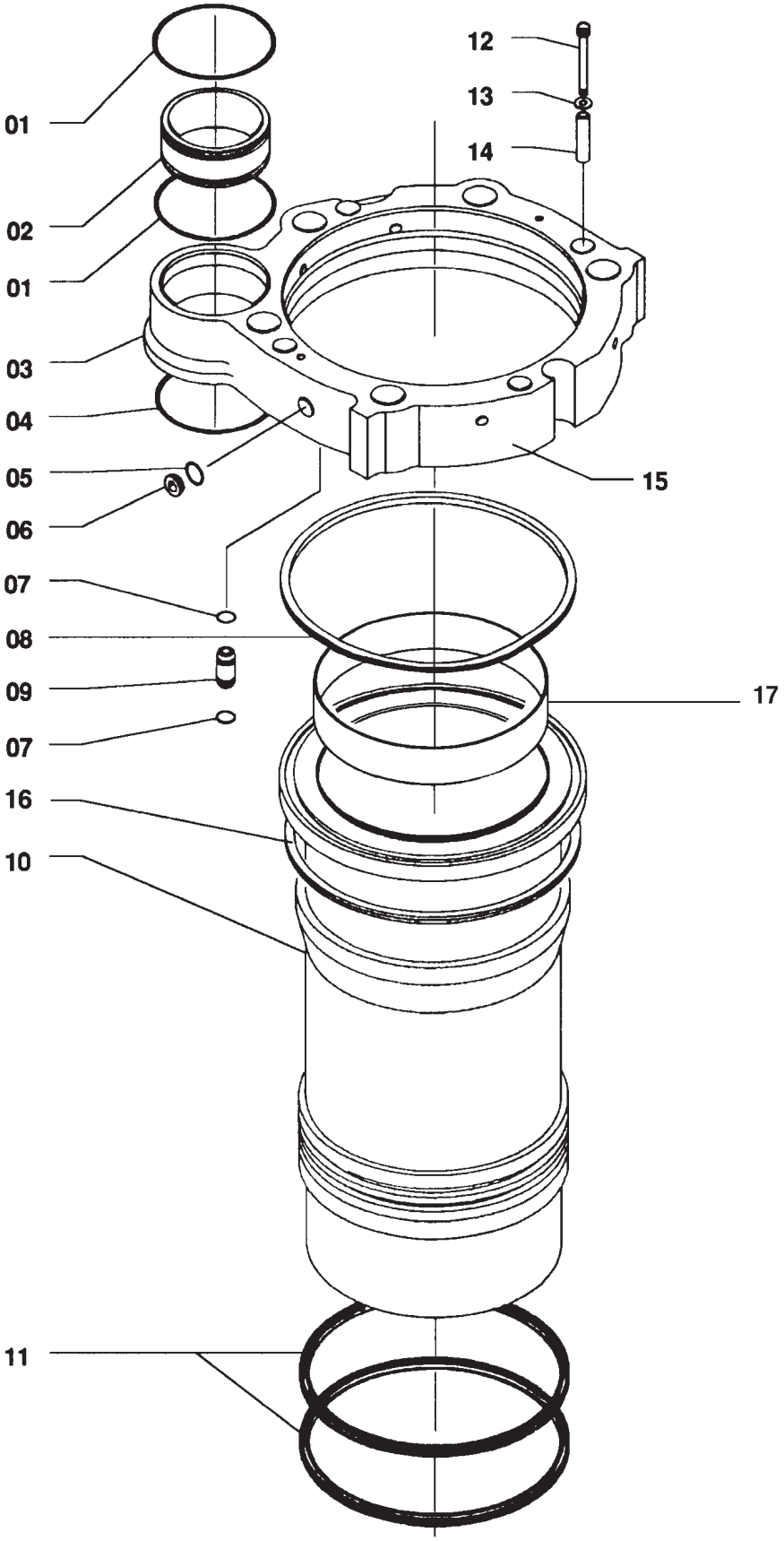
*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder

Plate Page 1 (2)	Cylinder Liner and Water Guide Jacket	60610-09H

L28/32H



L28/32H

Item No	Qty.	Designation	Beskrivelse
01	2/C	**O-ring**	O-ring
02	1/C	**Sleeve**	Muffe
03	1/C	**Water guide jacket**	Kølekappe
04	1/C	**O-ring**	O-ring
05	6/C	**Sealing ring**	Tætningsring
06	6/C	**Plug screw**	Propskrue
07	12/C	**O-ring**	O-ring
08	1/C	**Sealing ring**	Tætningsring
09	6/C	**Cooling water connection**	Kølevands-overgang
10	1/C	**Cylinder liner**	Cylinderforing
11	2/C	**O-ring**	O-ring
12	4/C	**Hexagon screw**	Unbracoskrue
13	4/C	**Washer**	Skive
14	4/C	**Sleeve**	Foring
15	1/C	**Water guide jacket incl. item no. 05 and 06.**	Kølekappe inkl. item nr. 05 og 06
16	1/C	**Sealing ring**	Tætningsring
17	1/C	**Flame ring**	Flammering

Item No	Qty	Designation	Beskrivelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50

* = Kun tilgængelig som en del af et reservedelssæt
Antal/C = Antal/Cylinder

Camshaft

507/607

General

The camshaft which controls the actuation of inlet valves, exhaust valves and fuel injection pumps is driven by a gear wheel on the crankshaft through an intermediate wheel, and rotated by a speed which is half of that of the crankshaft, see fig. 1.

The camshaft is placed in the engine frame at the control side, (left side, seen from the flywheel end) and is carried in bearing bushes which are fitted in bores in the engine frame, each bearing is replaceable and locked in position in the engine frame by means of lock screws.

The camshaft is built-up of sections, one for each cylinder unit. Each section is equipped with fixed cams for operation of fuel injection pump, air inlet valve and exhaust valve. The sections are assembled by bolting of the ample dimensioned and precision made flange connections, which also act as bearing journals.

Except for the foremost and the aftmost ones, the sections are identical and therefore interchangeable. The foremost section is equipped with a clutch for driving the fuel oil feed pump (if mounted). The gear wheel for driving the camshaft as well as a gear wheel connection of governor are screwed on the aftmost section.

The lubricating oil pipes for the gear wheels are equipped with nozzles which are adjusted to apply the oil at the points where the gear wheels are in mesh. The position of the nozzles is determined by direction of rotation of the engine.

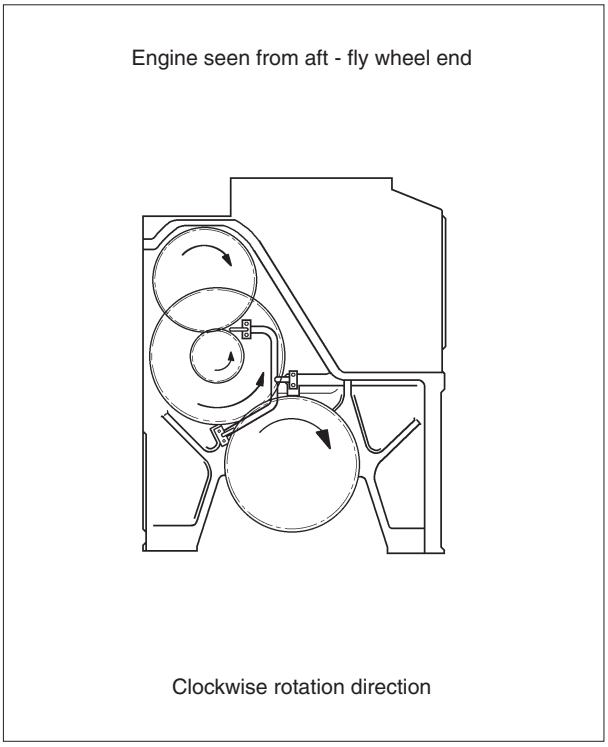


Fig. 1. Intermediate wheel

08028-0D/H5250/94.08.12

L/V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Checking of gear wheels, bolted connections and lubricating system.

Starting position:

Related procedure:

Special tools:

Plate no.	Item no.	Note.
62006	26	20 - 120 Nm.

Hand tools:

Allen key, 12 mm.
Ring and open end spanner, 19 mm.
Socket spanner, 19 mm.

Man power:

Working time : 3 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Replacement and wearing parts:

Plate no.	Item no.	Qty./
60705	12	6/eng.
60705	24	3/eng.
61106	11	1/cyl.
61106	13	1/cyl.
61106	14	1/eng.

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L/V28/32H

1) Dismount the covers which give access to the gear wheels, camshaft and crankcase.

Examine all gear wheels for cracks, wear and deformations. While turning the engine to enable inspection allover the circumference of the gear wheels.

2) Check all screws, nuts and bolted connections, including locking devices everywhere in the gear wheel housing, camshaft housing and crankcase to check that they have not worked loose. Tightening torques, see page 600.40.

3) Examine all lubricating oil spray pipe nozzles.

4) Start the electrical lubricating oil pump and check the oil flow everywhere. Be particularly careful to check that the oil jet hits the gear wheels correctly at the points where the wheels mesh.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Inspection and Replacement of Camshaft Bearing**	**607-01.05** Edition 01H

L+V28/32H

Safety precautions

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description

Check of roller path of cams and check of camshaft bearing.
Replacement of camshaft bearing.

Starting position

Cover for camshaft and gear wheel has been removed.

Related procedure

Camshaft and camshaft drive, 607-01.00

Man power

Working time : 2 Hours
Capacity : 2 men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate No	Item No	Note
62006	26	20 - 120 Nm.

Hand tools

Ring and open end spanner, 19 mm.
Socket spanner, 19 mm.
Feeler gauge.
Big screw driver.

Replacement and wearing parts

Plate No	Item No	Qty. /
60705	01	1/eng.
60705	03	1/cyl.
60705	21	1/cyl.

08028-0D/H5250/94.08.12

L+V28/32H

To Check Roller Path of Cams.

1) While turning the engine, examine the cam discs and in particular, check the roller path of all cams for cracks, crackles and ruffle. Also examine the rollers of the roller guides.

Note: if there are flat spots on the roller and if some of the rollers may be blocked, if so, the roller must be replaced by a new one, see working card 608-01.00.

To Check Camshaft Bearings.

2) The wearing surface of the camshaft bearings cannot be checked without dismounting the camshaft. However, ab-normal wear of one or more bearings will become apparent in the form of burrs of white metal at the circumference of the camshaft journal, and in that case the bearing will in no doubt be discoloured, as well.

The bearing clearance is measured with a feeler gauge, see data sheet 600.35.

To Replace Camshaft Bearing.

3) If one or several of the camshaft bearings should be replaced the camshaft must be wholly or partly dismantled.

Dismount the fuel oil feed pump, if mounted and check that the camshaft sections are marked in relation to each other. Disassemble the camshaft aft (toward flywheel) of the bearing that is to be replaced. Dismount all roller guides that are located forward of the disassembling position, see working card 608-01.00 and 608-01.05.

Pull the disconnected sections of the camshaft so far a head that the bearing which is to be replaced is free.

Take out the locating screw of the camshaft bearing concerned and push the bearing out of the bore in the engine frame, see fig. 1.

Check the lubricating oil ducts to the bearing for free flow.

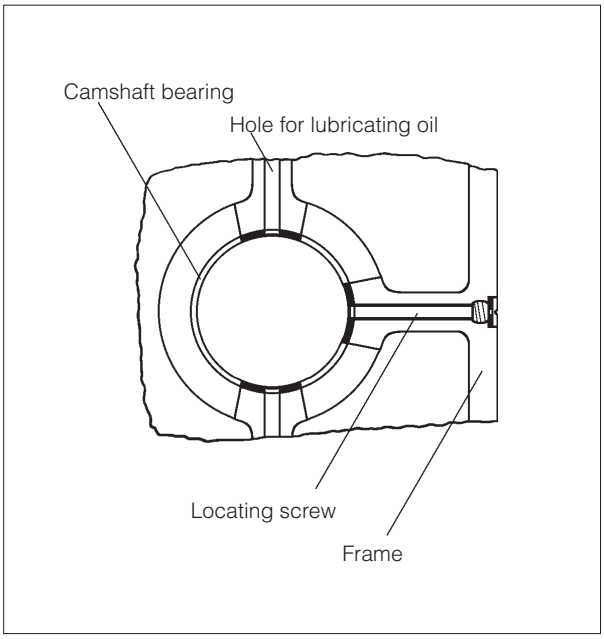


Fig. 1.

Mount a new camshaft bearing in the bore and make sure that the hole for insertion of the locating screw in the bearing is in a correct position. Lock the bearing by means of the locating screw, which is to be provided with a new gasket. To facilitate the fitting of the bearing it can be cooled down with Co_2.

Inspect the camshaft journal for seizures.

If necessary, the camshaft section must be entirely removed from the engine, and the journal concerned must be polished.

Coat all the journals of the camshaft section with clean lubricating oil and push the camshaft into position, making sure that the marks on the flanges coincide.

Assemble the sections and fit the bolts (coated with Molycote or similar).

Tighten the nuts with a torque spanner, see data sheet 600.40.

Mount all roller guides as well as the fuel oil feed pump.

08028-0D/H5250/94.08.12

Working Card Page 1 (4)	Adjustment of Camshaft for Valve and Injection Timing	607-01.20 Edition 04H

L28/32H

Safety precautions

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description

Adjustment of the injection timing.

Starting position

Related procedure

Manpower

Working time : 2-5 hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 500.35)
Data for torque moment (Page 500.40)
Declaration of weight (Page 500.45)

Special tools

Plate no	Item no	Note
62006	26	20 - 120 Nm.
62010	01	
62008	05	

Hand tools

Ring and open end spanner, 19 mm.
Socket spanner, 19 mm.
Depth gauge.
Plastic hammer.

Replacement and wearing parts

Plate no	Item no	Qty /
60801	23	1 set/cyl

L28/32H

Measure of fuel pump lead

1) Dismantle covers for fuel camshaft and fuel pump and covers for gear whell

2) Check the mobility of the regulating device. Turn engine to pos. cylinder No. 1 until the cambase circle is reached (approx. 40° BTDC).

3) Position the support of the measuring tool on the two bolts of the camshaft covering. Slip on the distance sleeves and fasten to the cylinder crankcase by means of hexagon nuts.

Note: During attaching, pay attention to the correct fitting position of the contact point, *see fig 1.*

4) Insert the dial gauge into the support.

5) Set the dial gauge to "Zero".

6) Turn the engine until the TDC mark (ignition DC) for the actual cylinder is reached.
Read the dial gauge and note down the gauge value.

7) Determine the values for the other cylinders in the same way.

Calculate the average value of all measurements.

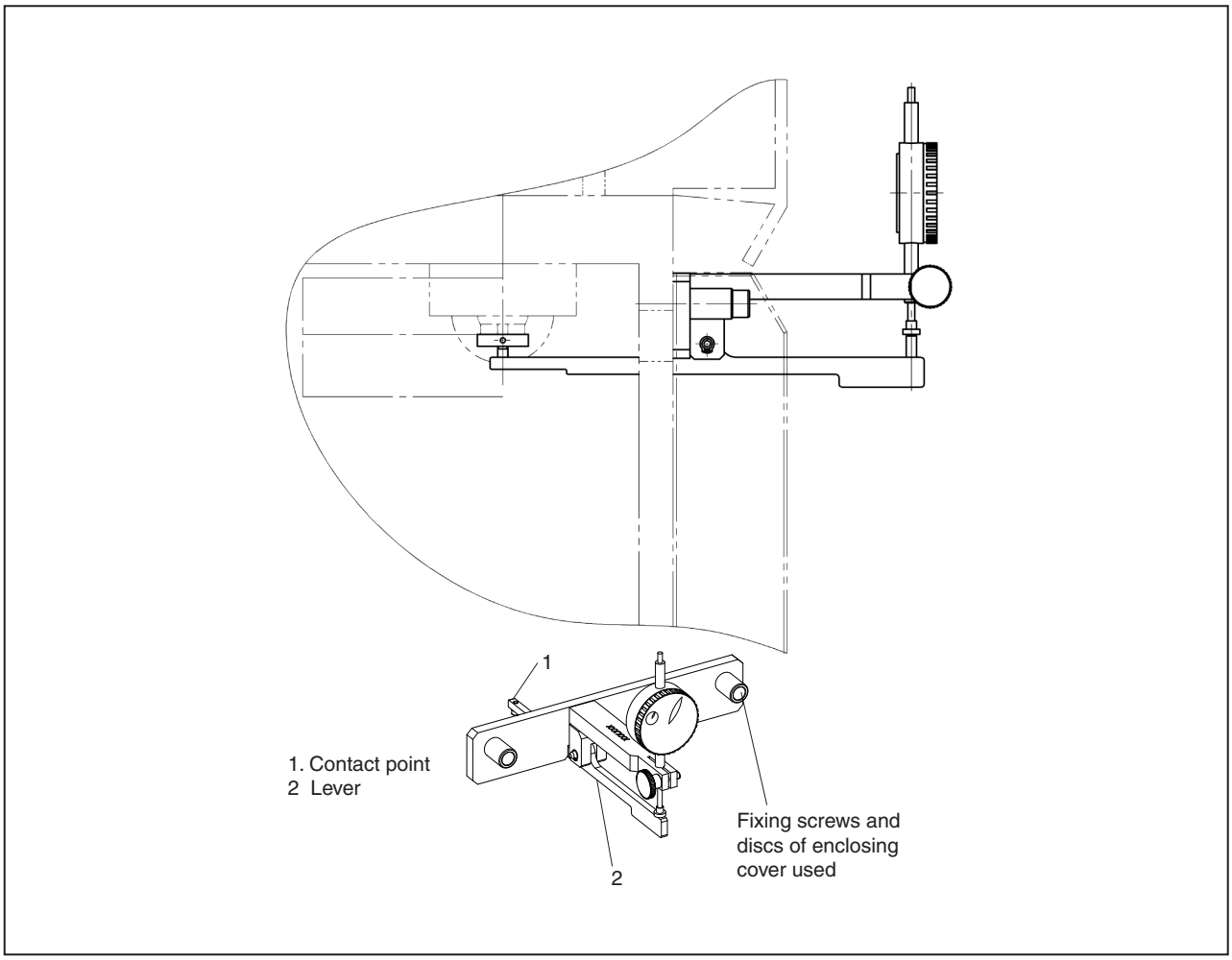


Fig 1 Fitting position of the contact point.

8) Compare the calculated value determined with the value mentioned below.

9) If the values exceeds the limits, an adjustment must be done in order to correct the errors, on the X-measure or reset the gear wheel, see following text for changing "X"-measuring.

Cyl.	kW/Cyl.	rpm	Average value
5-6-7-8-9	210	720	*See section 600, Desription 600.35*
5-6-7-8-9	220	750	

Fig 2 Plunger lift (average value)

To get a consistent lifting values on the plunger/ combustion pressure on the different cylinders the "X"-measure can be changed.

When changing “X” it must be ensured that the distance between the upper edge of the roller guide housing and the thrust piece on the roller guide is not exceeded, when the roller is resting on the circular part of the fuel cam, *please see description 500.35.*

In all cases “X” must be checked and adjusted, if necessary, when fuel oil pump, roller guide, roller guide housing and/or camshaft section have been replaced/dismantled.

Note: If several fuel oil pumps, roller guides, roller guide housings and/or camshaft sections are dismantled at the same time it is advisable to number the parts in order to facilitate remounting and adjustment.

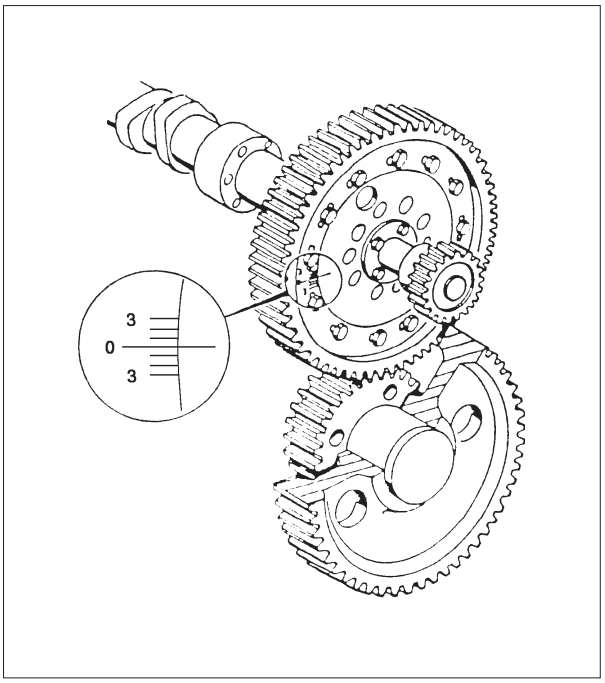


Fig 3 Gear wheel with engraved scale.

The gear wheel is provided with an engraved scale, *see fig 3*, and the hub of the cam shaft is provided with a mark.

When the screws, which fasten the gear wheel, are loosened the gear wheel is turned (by turning the crankshaft) in relation to the camshaft.

If the crankshaft is turned in the engines normal direction of rotation the injection timin is retarded (closer to TDC).

If the crankshaft is turned against the engines normal direction of rotation the injection timing is advanced (away from TDC).

After the adjustment the screws are fastened with a torque wrench, *please see description 500.40*, and secured.

L28/32H

The injection timing can be altered on each cylinders by inserting or removing shims under the thrust piece on the roller guide, thus changing the measure “X”, *see Fig 4.*

Thinner and/or fewer shims (increase of the distance “X”) results in a retarded injection timing.

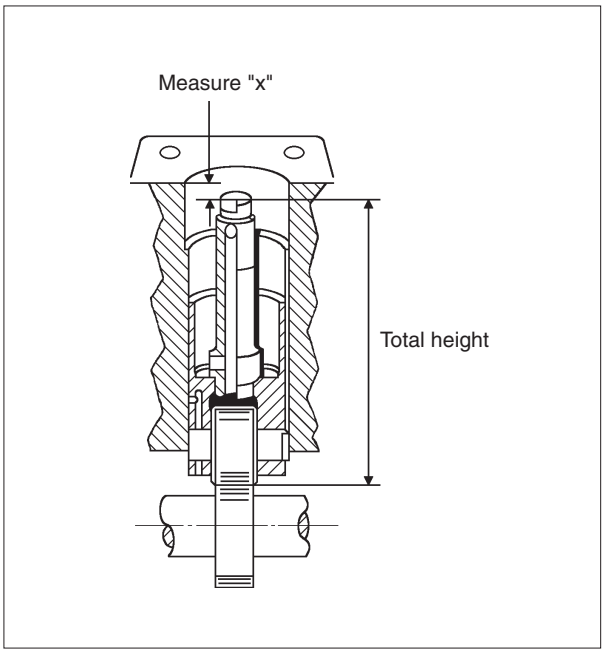


Fig 4 Measure "X"

Thicker and/or more shims (reduction of the distance “X”) results in an advanced injection.

If the distance “X” is to be changed the trigger (1) is used for dismantling of the thrust piece (2), whereafter the thickness and/or the number of shims (3) can be changed.

After replacement of shims the thrust piece is remounted, *see fig 5,* in the roller guide (4) with a soft hammer (5).

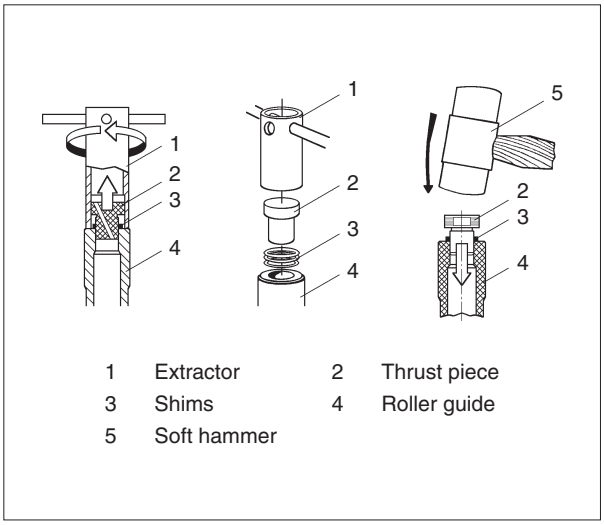


Fig 5 Remounting of thrust piece.

Action	Results		
Total height on roller guide	Distance "x"	Injection timing	Max. combustion pressure
increased ↑	Reduced ↓	Advanced ↑	increased ↑
Reduced ↓	increased ↑	Delayed ↓	Reduced ↓

Fig 6

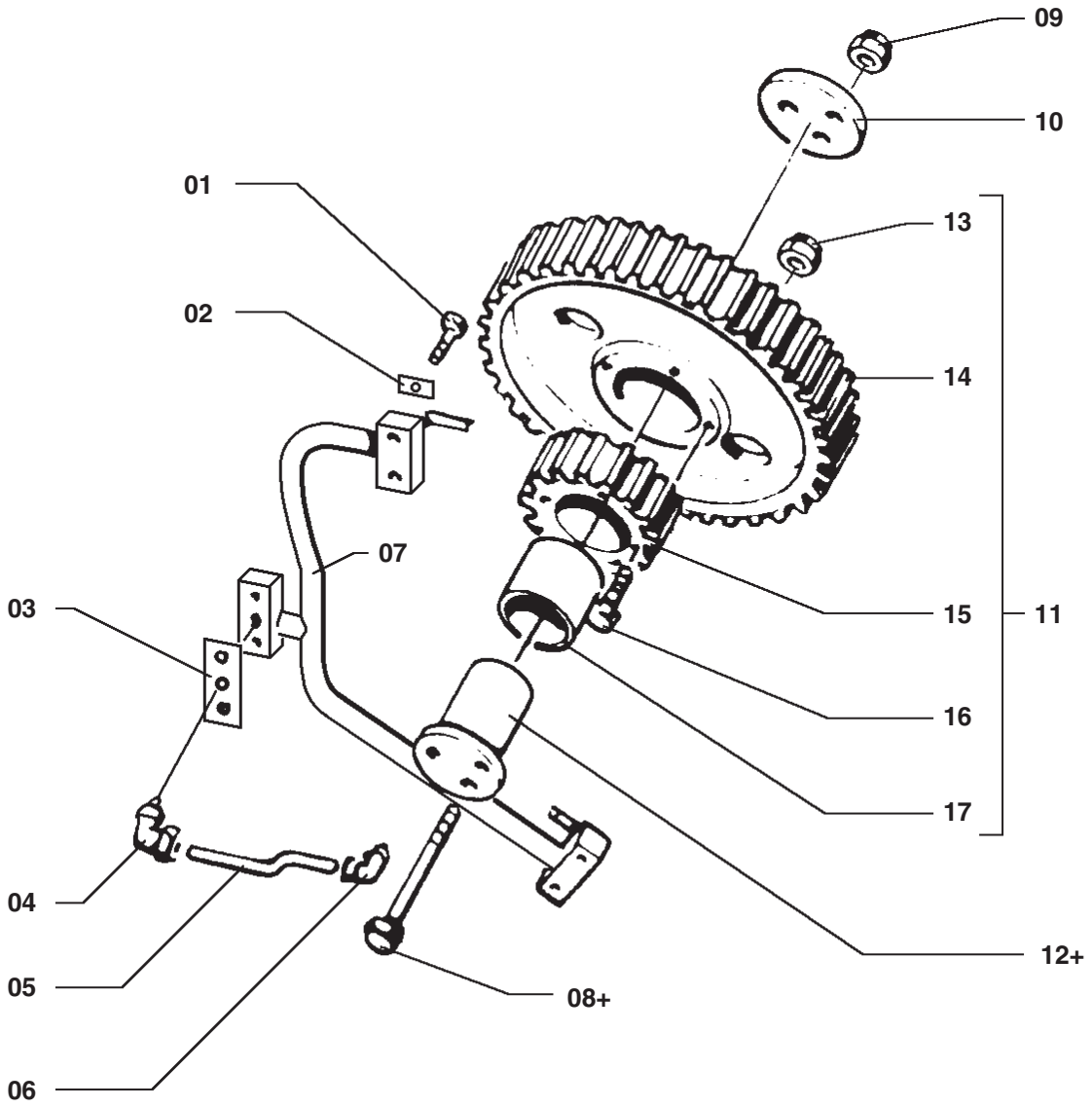
10) Remove the complete measuring tool.

11) Mount all camshaft covers.

12) Plunger lift value, *please see description 500.35.*

Plate Page 1 (2)	**Intermediate Wheel**	**60701-06H**

L28/32H



60701-06H	Intermediate Wheel	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	6/E	**Screw**	Skrue
02	6/E	**Lock plate**	Sikringsplade
03	3/E	**Gasket**	Pakning
04	1/E	**Union**	Vinkelforskruning
05	1/E	**Pipe**	Rør
06	1/E	**Union**	Vinkelforskruning
07	1/E	**Spray pipe**	Sprøjterør
08+	3/E	**Fitted bolt**	Pasbolt
09	3/E	**Self locking nut**	Selvlåsende møtrik
10	1/E	**Cover**	Dæksel
11	1/E	**Gear wheel, complete**	Tandhjul, kompl.
12+	1/E	**Axle journal**	Lejetap
13	4/E	**Self locking nut**	Selvlåsende møtrik
14	1/E	**Spur gear**	Tandhjul
15	1/E	**Spur gear**	Tandhjul
16	4/E	**Bolt**	Bolt
17	1/E	**Bearing bush**	Lejebøsning
		+ Item No. 08 and 12 require an individual matching, before mounting, contact MAN B&W, Holeby	+ Item nr. 08 og 12 kræver en individuel tilpasning, før montering kontakt MAN B&W, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

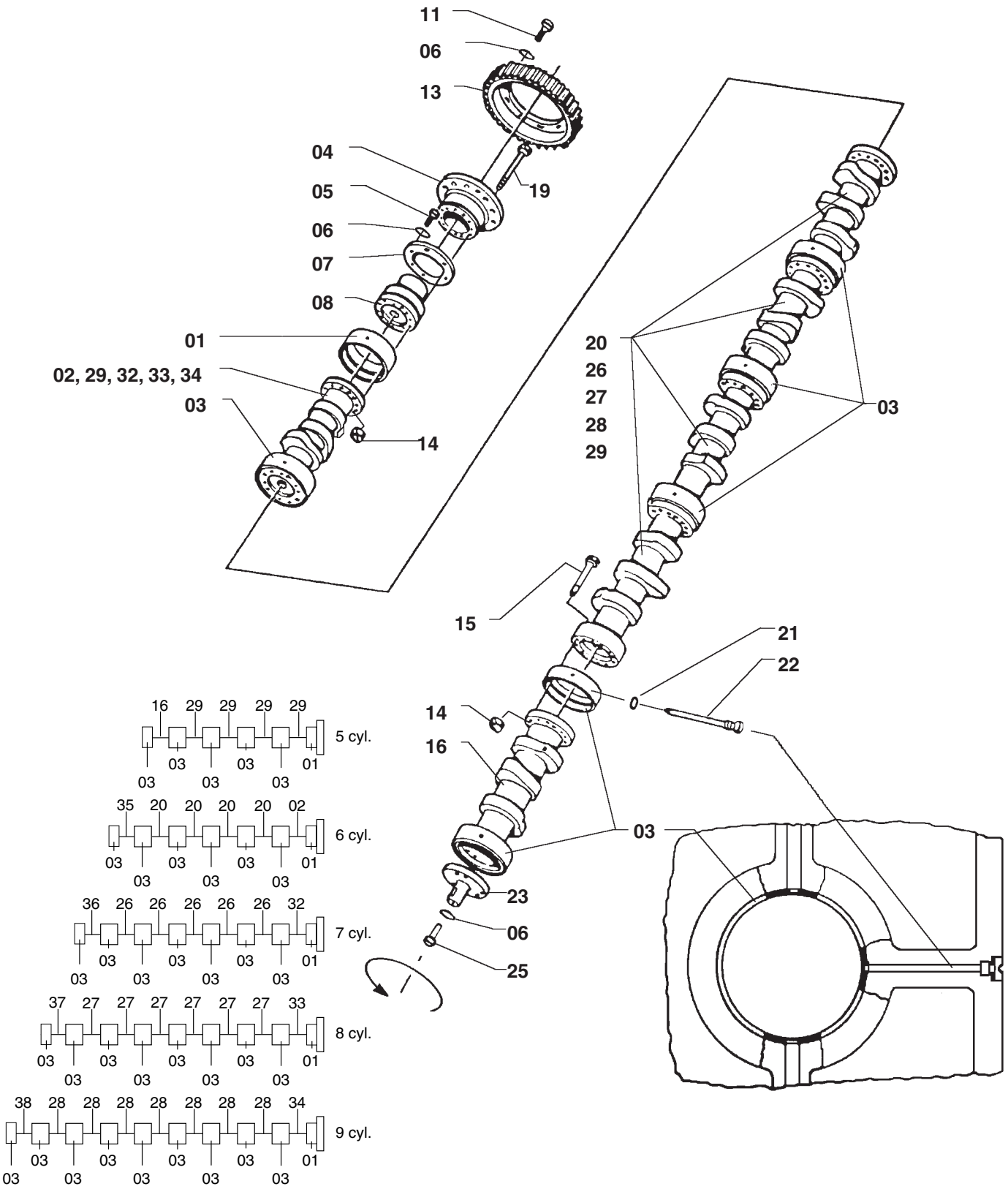
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	Camshaft and Camshaft Bearing	60705-22H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Camshaft bearing**	Styreakselleje
02	1/E	**Camshaft section "aft", 6 cyl. engine**	Styreakselssektion "agter", 6 cyl. motor
03	1/C	**Camshaft bearing**	Styreakselleje
04	1/E	**Hub**	Nav
05	6/E	**Screw**	Skrue
06	24/E	**Disc spring**	Skivefjeder
07	1/E	**Guide ring**	Styrering
08	1/E	**Shaft pin**	Akseltap
11	12/E	**Screw**	Skrue
13	1/E	**Gear wheel**	Tandhjul
14		**Self locking nut**	Selvlåsende møtrik
	70/E	**6 cyl. engine**	6 cyl. motor
	52/E	**7 cyl. engine**	7 cyl. motor
	66/E	**8 cyl. engine**	8 cyl. motor
	92/E	**9 cyl. engine**	9 cyl. motor
		Screw	Skrue
15	60/E	**6 cyl. engine**	6 cyl. motor
	42/E	**7 cyl. engine**	7 cyl. motor
	56/E	**8 cyl. engine**	8 cyl. motor
	82/E	**9 cyl. engine**	9 cyl. motor
16	1/E	**Camshaft "Fore" 5 cyl. engine**	Styreaksel "For" 5 cyl. motor
19	10/E	**Screw**	Skrue
20	4/E	**Camshaft, intermediate, 6 cyl. engine**	Styreaksel, mellem, 6 cyl. motor
21		**Gasket**	Pakning
	7/E	**6 cyl. engine**	6 cyl. motor
	8/E	**7 cyl. engine**	7 cyl. motor
	9/E	**8 cyl. engine**	8 cyl. motor
	10/E	**9 cyl. engine**	9 cyl. motor
22		**Guide screw**	Styreskrue
	7/E	**6 cyl. engine**	6 cyl. motor
	8/E	**7 cyl. engine**	7 cyl. motor
	9/E	**8 cyl. engine**	8 cyl. motor
	10/E	**9 cyl. engine**	9 cyl. motor
23	1/E	**Coupling flange**	Koblingssflange
25	6/E	**Screw**	Skrue
26	5/E	**Camshaft, intermediate, 7 cyl. engine**	Styreaksel, mellem 7 cyl. motor
27	6/E	**Camshaft, intermediate, 8 cyl. engine**	Styreaksel, mellem 8 cyl. motor
28	7/E	**Camshaft, intermediate, 9 cyl. engine**	Styreaksel, mellem 9 cyl. motor
29	4/E	**Camshaft section "aft", 5 cyl. engine**	Styreakselsektion "agter", 5 cyl. motor
32	1/E	**Camshaft section "aft", 7 cyl. engine**	Styreakselssektion "agter", 7 cyl. motor
33	1/E	**Camshaft section "aft", 8 cyl. engine**	Styreakselssektion "agter", 8 cyl. motor
34	1/E	**Camshaft section "aft", 9 cyl. engine**	Styreakselssektion "agter", 9 cyl. motor
35	1/E	**Camshaft "Fore" 6 cyl. engine**	Styreaksel "For" 6 cyl. motor
36	1/E	**Camshaft "Fore" 7 cyl. engine**	Styreaksel "For" 7 cyl. motor
37	1/E	**Camshaft "Fore" 8 cyl. engine**	Styreaksel "For" 8 cyl. motor
38	1/E	**Camshaft "Fore" 9 cyl. engine**	Styreaksel "For" 9 cyl. motor

When ordering spare parts, see also page 600.50.

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Qty./C = Qty./Cylinder
Qty./E = Qty./Engine

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* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder
Antal/E = Antal/Motor

Operating gear

508/608

Roller Guides

The fuel injection pumps and the rocker arms for inlet and exhaust valves are operated by the cams, on the camshaft through roller guides. The roller guides for fuel pump, inlet and exhaust valves are located in bores in a common housing for each cylinder, this housing is bolted to the engine frame.

The roller runs on a bush fitted on a pin that is pressed into the roller guide and secured by means of a lock screw.

Operating Gear for Fuel Injection Pumps

The injection pumps which is mounted directly on the roller guide housing is activated via thrust pieces from the roller guide.

The roller is pressed down on to the cam by a spring, which is fixed between the roller guide and the foot plate of the fuel injection pump.

Operating Gear for Inlet and Exhaust Valves

The movment from the roller guides for inlet and exhaust is transmitted via the push rods the rocker arms and spring-loaded valve bridges to each of the two valve sets. The bridge is placed between the valve spindles and in the one end it is provided with a pressed-on thrust shoe and in the other end it is fitted with a thrust screw for adjustment of the valve clearance.

On its top the bridge is controlled by a spherical thrust shoe on the rocker arm and at the bottom by a guide which rests in a spherical socket in the cylinder head.

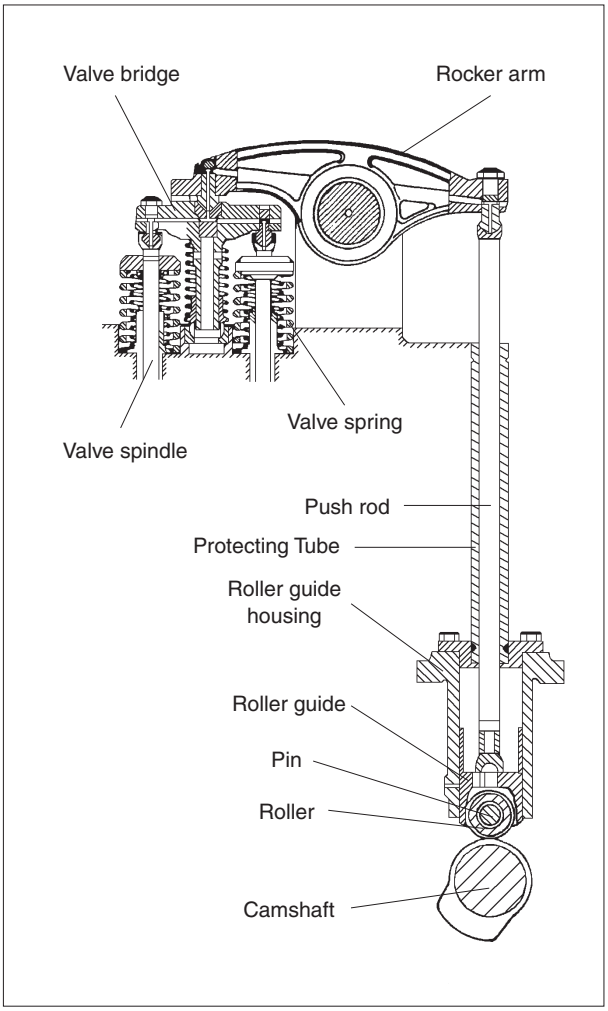


Fig. 1. Valve Operating Gear.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	Inspection of Valve Roller Guides	608-01.00 Edition 01H

L/V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismounting, inspection and/or overhaul, and mounting of valve roller guides.
Inspection of roller guide housing.

Starting position:

Top cover for cylinder head and cover for fuel injection pump removed.

Related procedure:

Inspection of fuel injection pump roller guide,	608-01.05
Control and adjusting of valve clearance,	608-01.10

Man power:

Working time	:	2	Hours
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	26	20 - 120 Nm

Hand tools:

Ring and open end spanner, 19 mm.
Socket spanner, 19 mm.
Socket spanner, 24 mm.
Allen key, 3 mm.
Ratchet spanner.
Hammer.
Drift.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
60801	04	4/cyl.
60801	08	2/cyl.
60801	09	1/cyl.

See also plate 60801.

L/V28/32H

Dismounting of Roller Guide.

1) Turn the engine so that the roller, rests on the circular part of the cam.

2) Unscrew the nuts which secure the rocket arm brackets, and lift off the rocker arm with brackets.

3) Remove the push rods (1), see fig. 1.

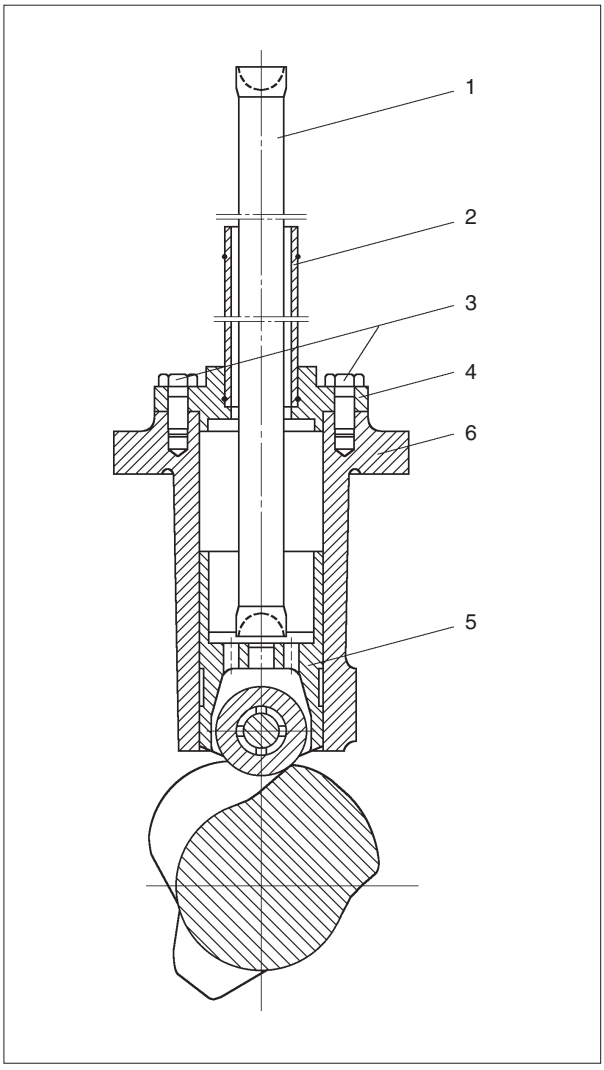


Fig. 1.

4) Loosen the lock screw for the push rod protecting tube, see plate 60801, item 07, on the roller guide top cover and lift up and remove the protecting tube (2).

5) Dismount the screws (3) which secure the roller guide top cover, take off the cover, and lift out the roller guide (5).

Disconnect any pipes that may be in the way (lub. oil and fuel oil pipes).

6) If the roller guide housing is to be dismantled, the fuel injection pump and the fuel injection pump roller guide are to be dismounted, see working card 614-01.05 and a number af lubricating oil and fuel oil pipes are also to be disconnected.

The roller guide housing (6) cannot be dismantled with the roller guides fitted.

7) If the event of any marks or scores from sezures, these must be polished away.

8) Inspect the spherical stud for deformations (replace as necessary).

Examine the surface of the roller for marks and other deformations.

Make sure that there is free rotation between the roller and the bush and the shaft pin, and replace the bush, if necessary.

Replacement of Roller, Bush and Shaft Pin.

9) Remove the lock screw which secures the roller guide shaft pin and push out the shaft pin.

The roller, shaft pin, and bush can now be replaced as required.

10) Blow through the lubricating ducts in roller guide and roller guide housing, and clean the lubricating grooves.

Mounting of Roller Guide.

11) When assembling the parts, which is carried out in the reverse order to the above care must be exercised not to damage the o-rings when mounting the proctecting tube.

12) Adjusting of valve clearance, see working card 608-01.10.

Working Card Page 1 (2)	Inspection of Fuel Injection Pump Roller Guide	608-01.05 Edition 01H

L/V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismounting, inspection and/or overhaul, and mounting af roller guide for fuel injection pump.

Starting position:

Cover for fuel injection pump removed.
Fuel injection pump has been removed, 614-01.05

Related procedure:

Adjustment and/or check of max. combustion pressure, 614-01.20

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Allen key, 3mm.
Hammer.
Drift.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L/V28/32H

Dismounting of Roller Guide.

1) Remove the support ring (1) and spring (2) and take up the roller guide (3), see fig. 1.

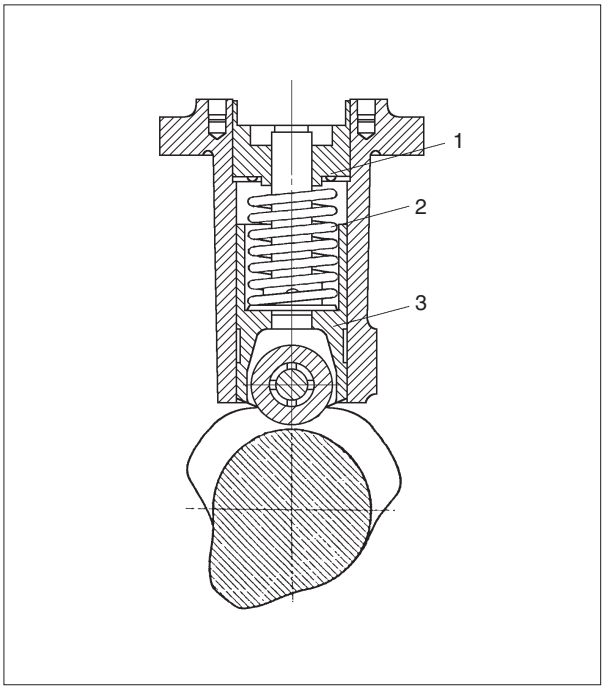


Fig. 1.

Inspection of Roller Guide.

2) If the event of any marks or scores from sezures, these must be polished away.

3) Inspect the spherical stud for deformations (replace as necessary).

Examani the surface of the roller for marks and other deformations.

Make sure that there is free rotation between the roller and the bush and the shaft pin, and replace the bush if necessary.

Replacement of Roller, Bush and Shaft Pin.

4) Remove the lock screw which secures the roller guide shaft pin and push out the shaft pin.

The roller, shaft pin, and bush can now be replaced as required.

5) Blow through the lubricating ducts in roller guide and roller guide housing, and clean the lubricating grooves.

Mounting of Roller Guide.

6) When assembling the parts which is carried out in the reverse order.

7) For adaption of the thrust piece of the roller guide, see working card 614-01.20.

Working Card Page 1 (3)	Control and Adjusting of Valve Clearance	608-01.10 Edition 01H

L/V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Control and/or adjusting of valve clearance.

Starting position:

Cover for rocker arm are removed.
All indicator valves open.

Related procedure:

Man power:

Working time : 1/4 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62008	02	Exhaust
62008	01	Inlet
62010	01	

Hand tools:

Ring and open end spanner, 30 mm.
Big screw driver.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

See also plate 60502.

L/V28/32H

Adjusting of Inlet Valve Clearance.

1) Turn the engine so that the roller, rests on the circular part of the cam, i.e. the inlet valves and the exhaust valves are closed.

2) Loosen the adjustment screws on valve bridge and rocker arm, see fig. 1.

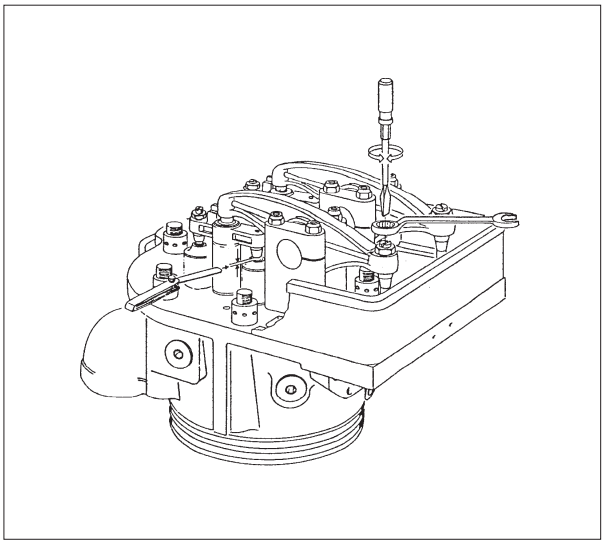


Fig. 1.

3) Clearance between valve bridge and valve spindle, see page 600.40.

4) Place the feeler gauge marked with "correct" o,4 mm above the valve spindle nearest to the rocker arm bracket, see fig. 1.

5) Adjust the clearance between valve bridge and valve spindle by means of the adjustment screw on the rocker arm (above the push rod) and tighten the lock nut.

The feeler gauge is to remain in this position when adjusting the clearance of the other valve.

6) Place another feeler gauge, at the same size o,40 mm above the other valve spindle, see fig. 2.

7) Adjust the clearance between valve bridge and valve spindle by means of the adjusment screw on the valve bridge, and tighten the lock nut, see fig. 2.

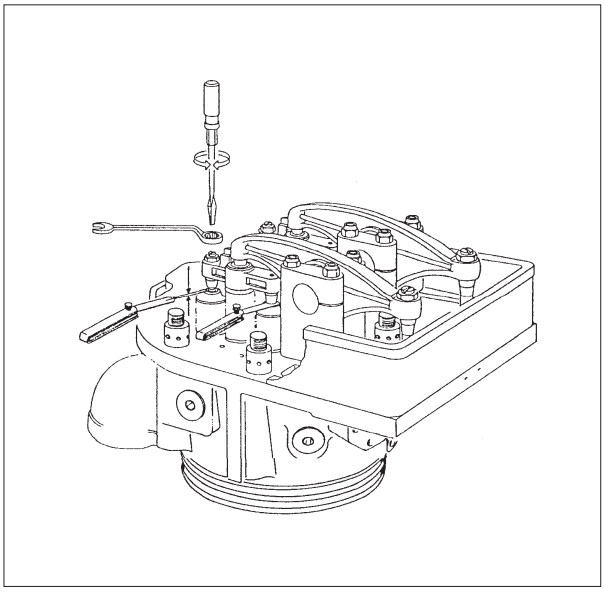


Fig. 2.

8) Check that the clearance is correct simultaneously at both valve spindles.

Adjusting af Exhaust Valve Clearance.

9) Carry out adjusment in the same way as deseribed for the inlet valves, but using the feeler gauge for exhaust valve clearance o,90 mm.

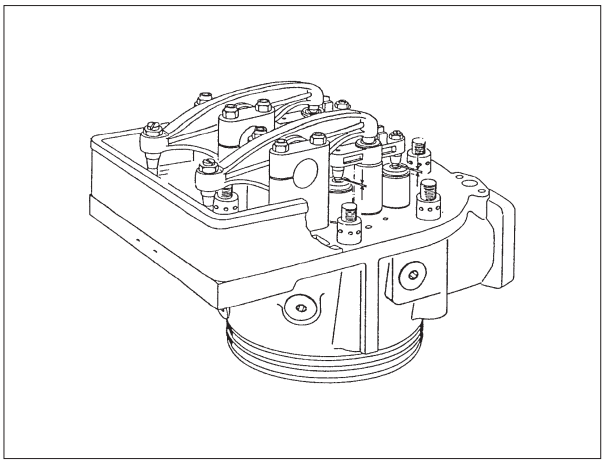


Fig. 3.

10) The feeler gauges for checking the clearance have two gauges which are marked "incorrect" and "correct", the latter to be used when adjusting the valve clearance, see fig. 4.

After tightening up the counter nuts on rocker arms and valves bridge, be sure that the feeler gaugs marked "correct" can be inserted into the two clearances simultaneously as where it must not be possible to insert the gauges marked "incorrect".

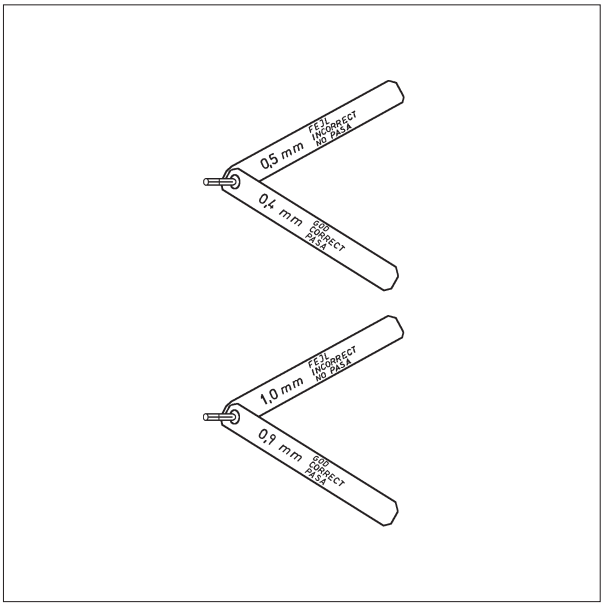
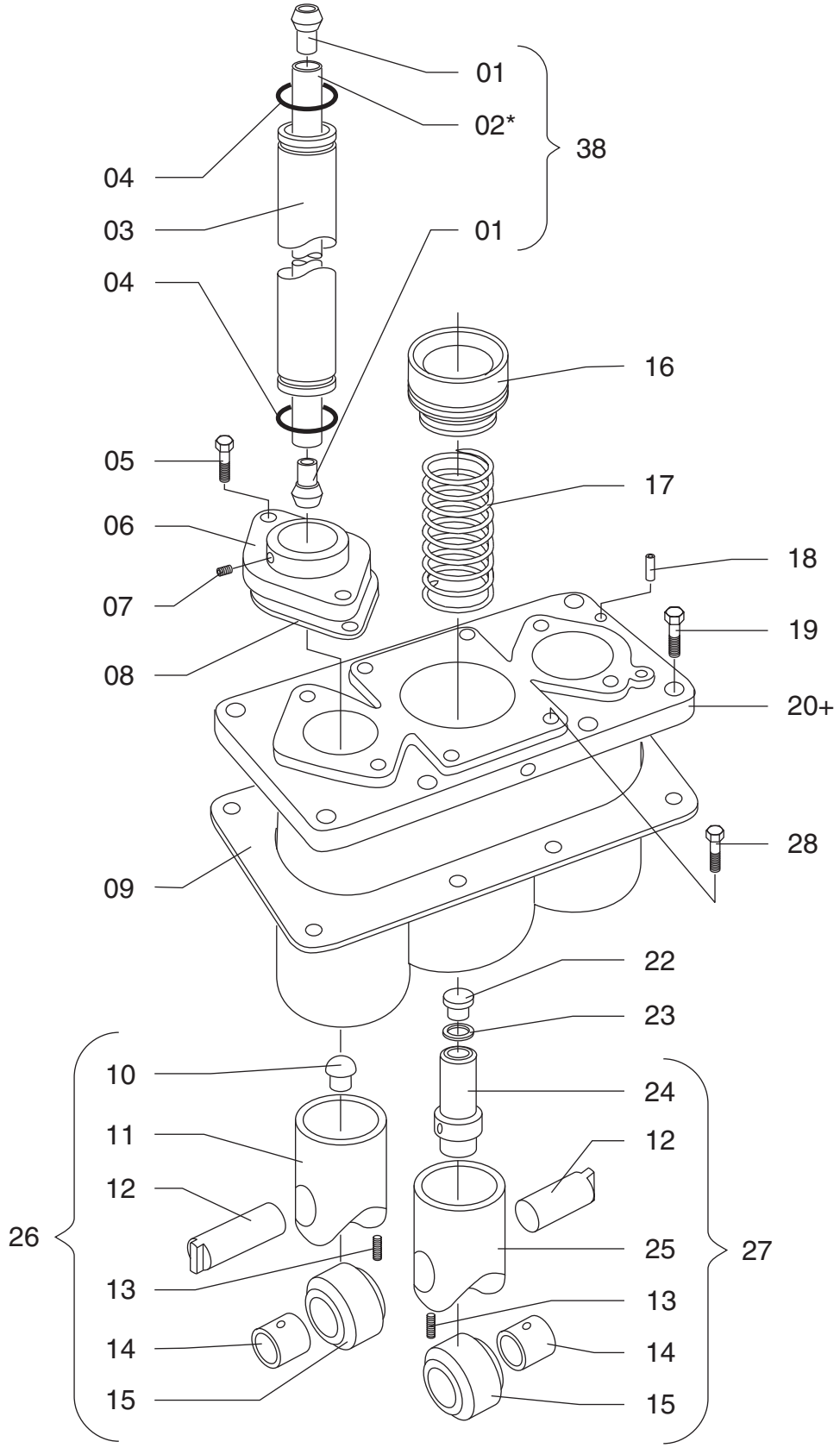


Fig. 4.

Plate Page 1 (2)	Roller Guide and Push Rods	60801-17H

L28/32H



L28/32H

Item no	Qty.	Designation	Benævnelse
01	4/C	**Thrust piece**	Trykstykke
02*	2/C	**Pipe**	Rør
03	2/C	**Protecting tube**	Skærmrør
04	4/C	**Sealing ring**	Tætningsring
05	4/C	**Screw**	Skrue
06	2/C	**Cover**	Dæksel
07	2/C	**Screw**	Skrue
08	2/C	**Gasket**	Pakning
09	1/C	**Gasket**	Pakning
10	2/C	**Ball pin**	Kugletap
11	2/C	**Roller guide**	Rullestyr
12	3/C	**Pin**	Tap
13	3/C	**Stop screw**	Stopskrue
14	3/C	**Bush**	Foring
15	3/C	**Roller**	Rulle
16	1/C	**Washer for spring**	Skive for fjeder
17	1/C	**Spring**	Fjeder
18	2/C	**Guide pin**	Styrestift
19	8/C	**Screw**	Skrue
20+	1/C	**Housing for roller guides**	Hus for rullestyr
22	1/C	**Thrust piece**	Tryktap
23	1/C	**1 set shims (0.1, 0.3, 0.5 and 1.0 mm)**	1 sæt shims (0,1, 0,3, 0,5 og 1,0 mm)
24	1/C	**Thrust piece**	Tryktap
25	1/C	**Roller guide**	Rullestyr
26	2/C	**Roller guide for valve gear, complete incl. item 10, 11, 12, 13, 14, 15**	Rullestyr for ventilbevægelse, komplet inkl. item 10, 11, 12, 13, 14, 15
27	1/C	**Roller guide for fuel injection pump, complete incl. item 12, 13, 14, 15, 24, 25**	Rullestyr for brændselspumpe, komplet inkl. item 12, 13, 14, 15, 24, 25
28	4/C	**Screw**	Skrue
38	2/C	**Push rod, complete incl. item 01, 02**	Stødstang, komplet inkl. item 01, 02
		+ Item no 20 require an individual matching before mounting, contact MAN Diesel & Turbo, Holeby	+ Item nr. 20 kræver en individuel tilpasning før montering, kontakt MAN Diesel & Turbo, Holeby

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/C = Antal/Cylinder

Control/safety

509/609

Governor

The engine speed is controlled by a hydraulic governor. The purpose of the governor is to regulate the rate of delivery from the fuel pumps, so that the engine speed is kept within certain limits, independing on the load.

Information about the design, function and operation of the governor is found in the special governor instruction book.

The governor is mounted on the fly wheel end of the engine and is driven from the camshaft via a cylindrical gear wheel and a set of bevel gears.

Pick-up for Engine RPM

The pick-up for transfer of signal to the tachometer instrument for engine RPM is mounted on the fly wheel end cover of the engine.

A signal varying proportionally to engine RPM is created in the pick-up by the rotating toothed impulse wheel mounted on the camshaft end.

Pick-up for Turbocharger RPM

See turbocharger instruction book, section 612.

Regulating Shaft

The governor movements are transmitted through a spring-loaded pull rod to the fuel pump regulating shaft which is fitted along the engine.

The spring-loaded pull rod permits the governor to give full deflection even if the stop cylinder of the manoeuvring system keep the fuel pump regulating shaft at "no fuel" position.

Each fuel pump is connected to the common, longitudinal regulating shaft by means of a two-piece, spring-loaded arm.

Should a fuel pump plunger seize in its barrel, thus blocking the regulating guide, governing of the remaining fuel pumps may continue un impaired owing to the spring-loaded linkage between the blocked pump and the regulating shaft.

Stop Screw for Max. Delivery Rate

The bracket for stop cylinder/limiting cylinder is fitted with a stop screw which prevents the fuel pumps from being set to a higher delivery rate than what corresponds to the permissible overload rating.

This is effected by the arm on the regulating shaft being stopped by the stop screw, *see fig. 1*.

Mechanical Overspeed (SSH 81)

The engine is protected against overspeeding in the event of, for instance, governor failure by means of an overspeed trip.

The engine is equipped with a stopping device which starts to operate if the maximum permissible revolution number is exceeded.

The overspeed tripping device is fitted to the end cover of the lubricating oil pump and is driven through this pump.

If the pre-set tripping speed is exceeded, the spring-loaded fly weight (1), see fig. 1, will move outwards and press down the arm (2).

The arm is locked in its bottom position by the lock pin (3) which is pressed in by the spring (4).

At the same time the arm (2) presses down the spindle (5), and the pneumatic valve (6) opens, whereby compressed air will be led to the Lambda cylinder , see Description 609.10, in which the piston is pressed forward and turns the fuel pump regulating rod to STOP position, thereby the engine stops, the spring-loaded pull rod connection to the governor being compressed.

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The engine can be stopped manually by pressing down the button (7), see fig. 1, which will activate the spring-loaded fly weight (1) through the lever (8).

If the overspeed has been activated the overspeed must be reset before the engine can be started. Reset is done by means of the button (10).

The overspeed alarm (SAH 81) is activated by means of the micro switch (9).

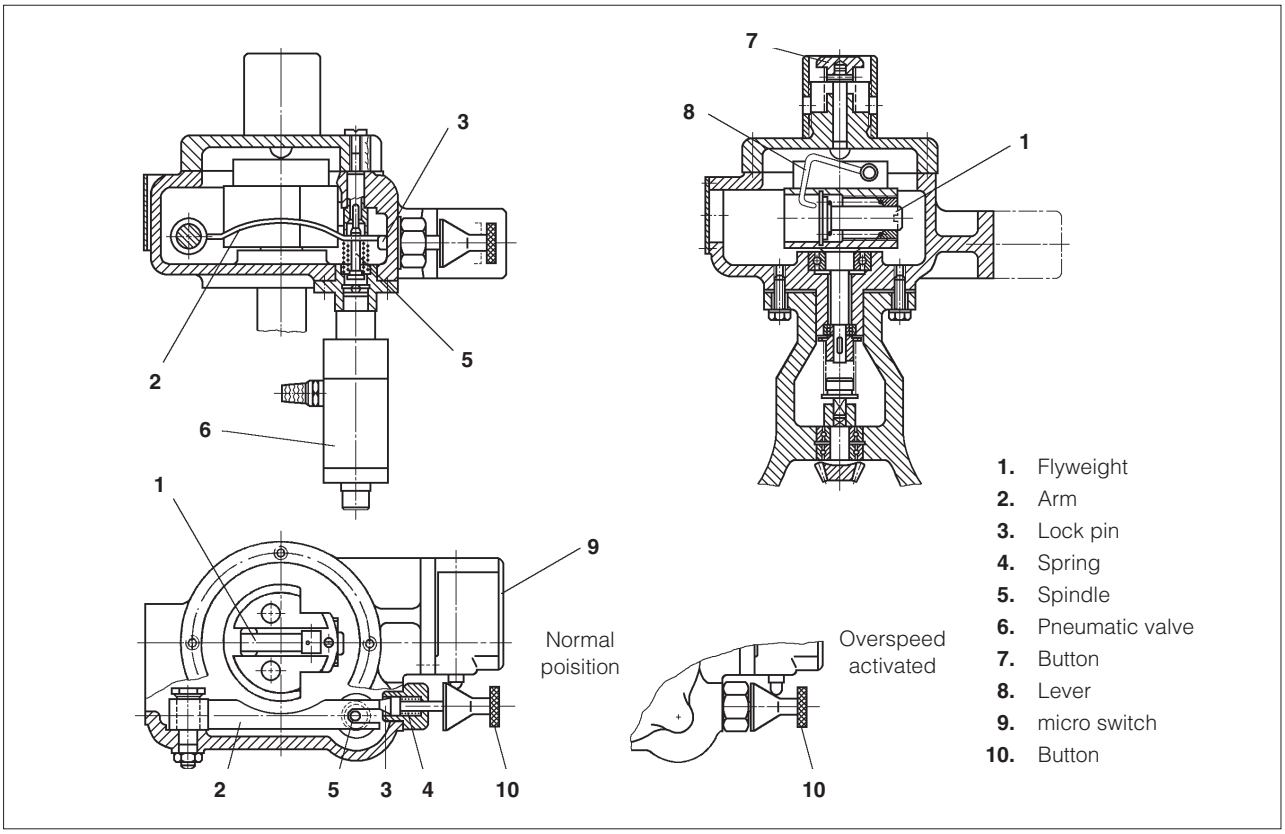
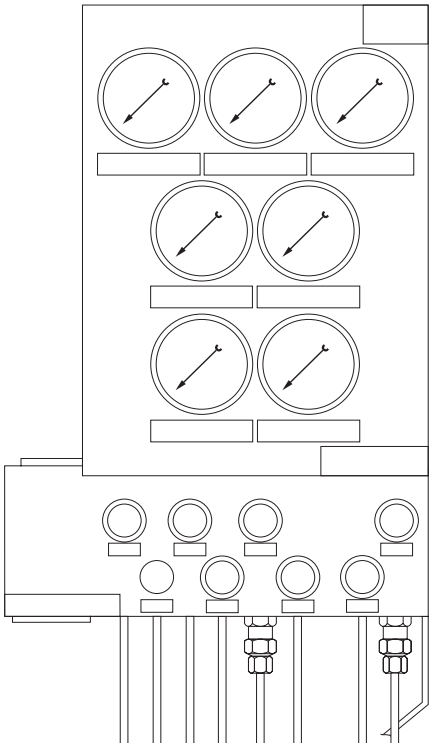


Fig 1 Mechanical overspeed (SSH 81).

Main instrument panel

As standard the engine is equipped with an instrument panel, comprising instruments for visual indication of the most essential pressures.
Illustrated on fig. 1.



On the engine is as standard mounted an instrument panel.

The following incorporating pressure gauges for the most essential pressures.

Pressure gauge for:

PI 01	LT fresh water, inlet to air cooler
PI 10	HT fresh water, inlet engine
PI 21/22	Lubricating oil, inlet/outlet to filter
PI 23	Lub. oil, inlet to turbocharger
PI 31	Charge air, outlet from cooler
PI 40	Fuel oil, inlet to engine
PI 50 (*)	Nozz. cool. oil, inlet to fuel valves Switch for PI 21/22
(*)	If nozzle cooling oil applied only.

Fig. 1. Lay-out of instrument panel

The instrument panel is mounted flexibly on rubber elements and all manometer connections are connected to the panel by means of flexible hoses, as shown on fig. 2.

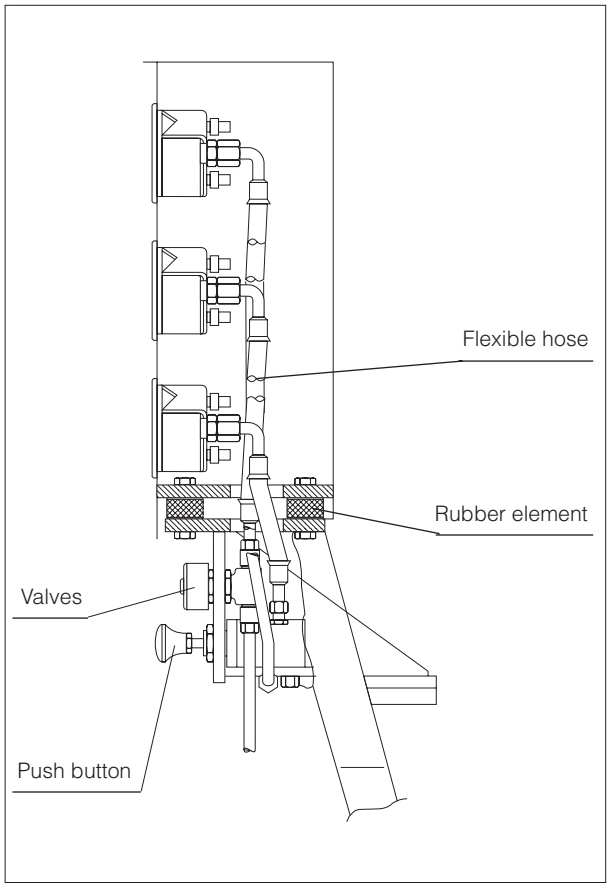


Fig. 2. Cross section of instrument panel

The connecting pipes to the manometers are equipped with valves which make it possible to replace the manometers during operation.

In the charging air and nozzle oil piping damping filters are inserted for levelling out pressure fluctuations.

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Instrumentation

As standard the engine is supplied with the following instrumentation mounted local on the engine:

Thermometer	TI 01	LT water - inlet air cooler
Thermometer	TI 02	LT water - outlet from air cooler
Thermometer	TI 03	LT water - outlet from lub. oil cooler
Thermometer	TI 10	HT fresh water - inlet to engine
Thermometer	TI 11	HT fresh water - outlet each cylinder
Thermometer	TI 20	Lubricating oil - inlet to cooler
Thermometer	TI 22	Lubricating oil - outlet from filter
Thermometer	TI 30	Charge air - inlet to cooler
Thermometer	TI 31	Charge air - outlet from cooler
Thermometer	TI 40	Fuel oil - inlet to engine
Thermometer*)	TI 51	Nozz. cool. oil - outlet from fuel valves
Thermometer	TI 60	Exhaust gas - outlet each cylinder
Thermometer	TI 61	Exhaust gas - outlet turbocharger

*) If nozzle cooling oil applied only.

The actual number of the instrumentation for the plant can be seen on the diagrams for the specific plant in the sections 612-613-614-615-616.
For code identification see 600.20.

Pressostates and Thermostates

The engine is supplied with a number of alarm- and shut-down functions. The alarms shall via the alarm panel worn against an abnormal working condition, which can lead to break down and the shut-down functions shall stop the engine before a break down. I.e. a shut-down is "worse" than an alarm because a shut-down is given if the engine could be severe damage by running on these conditions.

As standard the engine is equipped with:

Shut-down Switches for

- too low lubricating oil pressure - inlet engine
- too high HT FW temperature - outlet engine
- too high engine speed (over speed)

Alarm Switches for

- leaking fuel oil
- too low lubricating oil pressure - inlet engine
- too low prelubricating oil pressure (level alarm)
- too high press. drop across lub. oil filter
- too high HT FW temperature - outlet engine
- too low starting air pressure - inlet engine
- too high engine speed (overspeed)

The actual number and type of the alarm- and shut-down switches for the plant can be seen in the list "Engine Automatic part list" in this section.

Leakage Alarm (LAH 42)

Waste and leak oil from the comparement, for the injection equipment, fuel valves, high-pressure pipes and engine feed pump (if mounted) is led to a fuel leakage alarm unit.

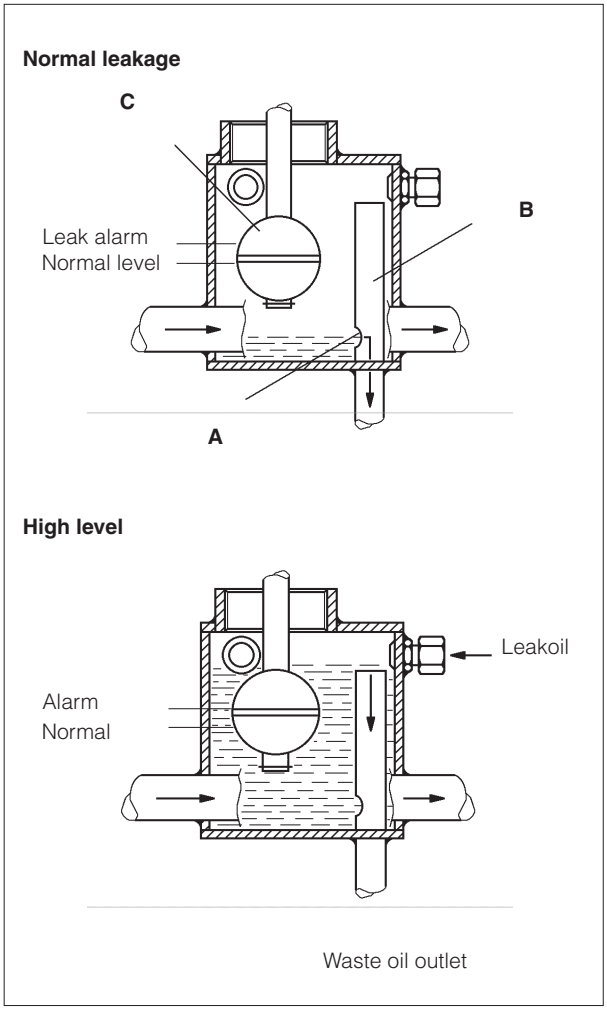

Fig. 4. Fuel oil leakage alarm.

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The alarm unit consist of a box with a float switch for level monitoring, see fig. 4.

The supply fuel oil to the engine is led through the unit in order to keep heated up, thereby ensuring free drainage passage even for high-viscous waste/leak oil.

Under normal conditions there will always be a smaller amount of waste/leak oil from the comparement, this will be led out through the bore "A" in the pipe "B" as illustrated.

In case of a larger then normal leakage, the level in the box will rise and the level switch "C" will be activated. The larger amount of leak oil will be lead out through the top of the pipe "B".

Alarm for Prelubricating (LAL 25)

Alarm for missing prelubricating, when the engine is stopped is given by means of a level switch (LAL 25) mounted in the main lubricating oil pipe.

Alarm and Shut-down for Overspeed

When the mechanical overspeed is activated, see 609.01 fig. 2, a micro-switch will release the alarm for overspeed (SAH 81) and activate the shut-down solenoid in the governor.

The latter function is a back-up for the mechanical overspeed.

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Purpose

The purpose with the lambda controller is to prevent injection of more fuel in the combustion chamber than can be burned during a momentary load in-crease. This is carried out by controlling the relation between the fuel index and the charge air pressure.

The Lambda controller is also used as stop cylinder.

Advantages

The lambda controller has the following advantages:

- Reduction of visible smoke in case of sudden momentary load increases.
- Improved load ability.
- Less fouling of the engine's exhaust gas ways.
- Limitation of fuel oil index during starting procedure.

Principles for functioning

Figure 1 illustrates the controller's operation mode. In case of a momentary load increase, the regulating device will increase the index on the injection pumps and hereby the regulator arm (1) is turned, the switch (2) will touch the piston arm (3) and be pushed downwards, whereby the electrical circuit will be closed.

Thus the solenoid valve (4) opens. The jet system is activated, the turbocharger accelerates and increases the charge air pressure, thereby pressing the piston (3) backwards in the lambda cylinder (5). When the lambda ratio is satisfactory, the jet system will be de-activated.

At a 50% load change the system will be activated for about 3-8 seconds.

If the system is activated more than 10 seconds, the solenoid valve will be shut off and there will be a remote signal for "jet system failure".

Fuel oil limiting during start procedure

During the start procedure the lambda controller is used as an index limiter.

Hereby heavy smoke formation is prevented during start procedure and further the regulating device cannot over-react.

Air Consumption

At 50% step load the air consumption will be as follows:

Cyl. no.	5	6	7	8	9
Nm^3	1.12	1.35	1.57	1.80	2.02

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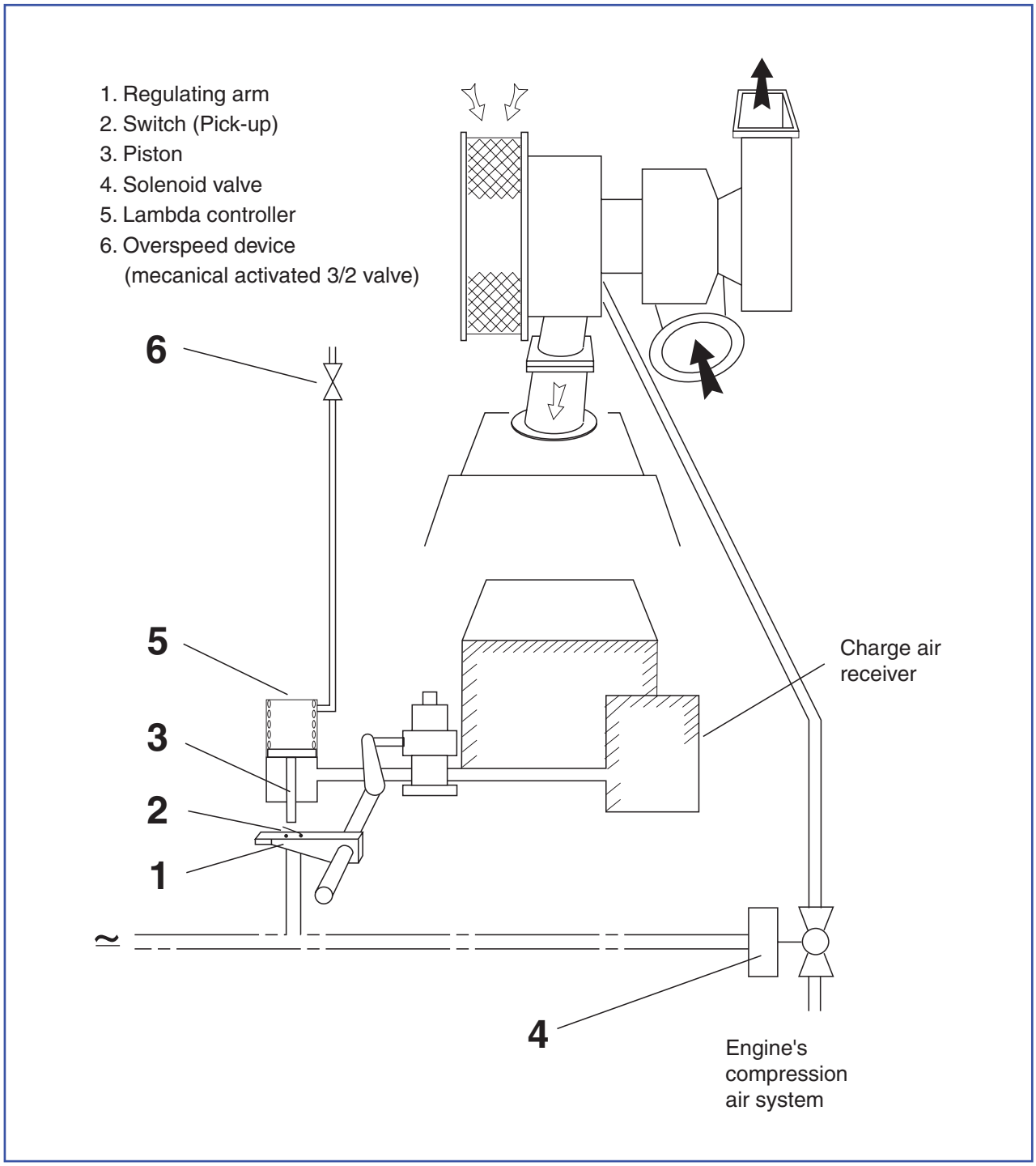


Fig 1 Lambda controller incl. start limitation

Description

The starting box is mounted on the engine's control side. On front of the box there are the following indications/pushbuttons:

- Indication of engine or turbocharger RPM
- Indication of electronic overspeed
- Pushbutton for "Manual Start"
- Pushbutton for "Manual Stop"
- Pushbutton for "Remote" *
- Pushbutton for "Local" *
- Pushbutton for "Blocking" *
- Pushbutton for change-over between engine and turbocharger RPM

* The function chosen is indicated in the pushbutton. See fig. 1.

Manual Start

The engine can be started by means of the start button, but only if the button "Local" is activated.

The manual, local start is an electrical, pneumatic start, i.e. when activating the start button a solenoid valve opens for air to the air starter, thereby engaging the starter and starting the diesel engine. Throughout the starting cycle the start button must be activated.

The air starter is automatically disengaged when the diesel engine exceeds 110 RPM. If the start button is disengaged before the diesel engine has exceeded 110 RPM, further starting cycles are blocked, until 5 sec. after the engine is at standstill.

Remote Start

Remote start can only take place if the pushbutton for "Remote" is activated.

Manual Stop

The "Manual Stop" button is connected to the stop coil on the governor.

Blocking

If "Blocking" is activated, it is not possible to start the diesel engine.

Engine / Turbocharger RPM

By activating the "Engine RPM/TC RPM" button, the indication is changed.

Engine RPM indication is green light-emitting diodes and turbocharger RPM indication is red light-emitting diodes.

External Indications

There are output signals for engine RPM and turbocharger RPM.

Engine: 0 - 1200 RPM ~ 4-20 mA
TC: 0 - 60000 RPM ~ 4-20 mA

The pushbuttons for "Remote", "Local" and "Blocking" have potential free switches for external indication.

All components in the starting box are wired to the built-on terminal box.

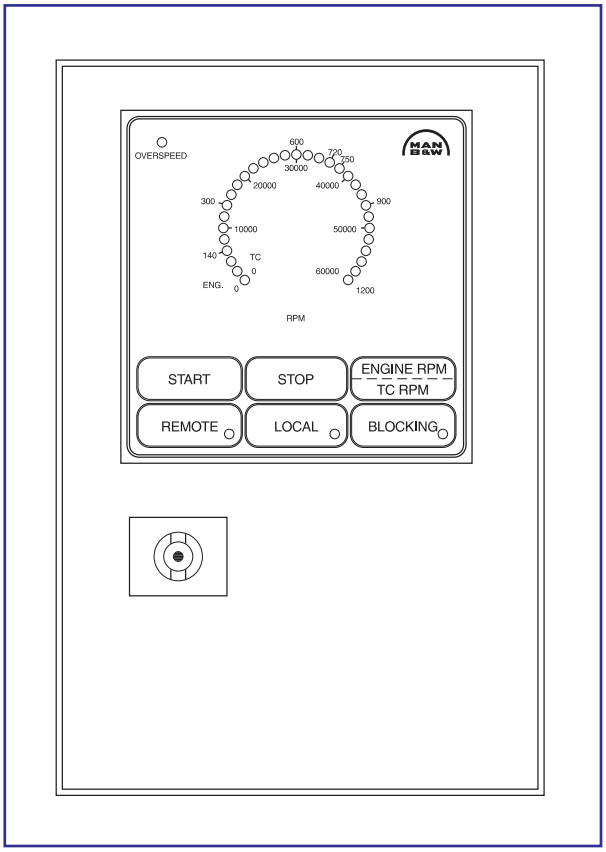


Fig 1 Starting box.

Description Page 1 (1)	**Converter for Engine- and Turbocharger RPM Signal**	**609.40** Edition 01H

L+V28/32H

Engine RPM signal

For measuring the engine's RPM, a pick-up mounted on the engine is used giving a frequency depending on the RPM. To be able to show the engine's RPM on an analogue tachometer, the frequency signal is sent through an f/I converter (frequency/current converter), where the signal is transformed into a proportional 4-20 mA ~ 0-1200 RPM signal.

Further, the converter has following signals:

- overspeed
- engine run
- safe start
- tacho fail

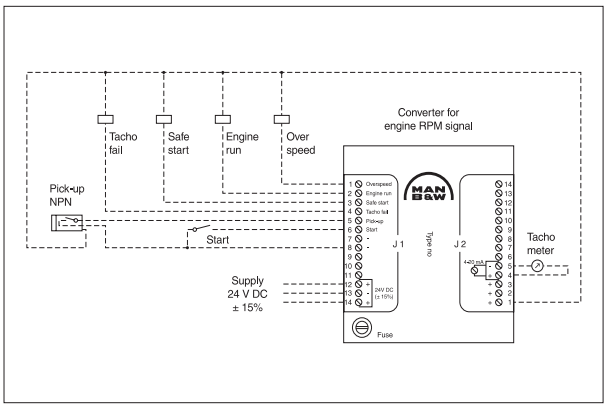


Fig 1. Converter for engine RPM.

Overspeed

When the engine speed reach the setpoint for electronic overspeed the converter gives a shutdown signal and a alarm signal through a relay.

Engine run

When the engine speed reach 710 RPM or 200 RPM + 10 seconds, the converter gives a "engine run" signal.

The engine run signal will be deactivated when the speed is 640 RPM. If the engine speed haven't been over 710 RPM the signal will be deactivated at 200 RPM.

The "engine run" signals will be given through a relay. One for synchronizing and one for start/stop of pre. lub. oil pump or alarm blocking at start/stop.

Safe start

When the safe start signal is activated the engine can start. When the engine reach 140 RPM the air starter will be shut-off.

Further, the safe start signal is a blocking function for the air starter during rotation.

Tacho fail

The tacho fail signal will be on when everything is normal. If the pick-up or the converter failes the signal will be deactivated. E.g. if there is power supply failure.

The converter for engine RPM signal is mounted in the terminal box on the engine.

Turbocharger RPM signal

For measuring the turbocharger RPM, a pick-up mounted on the engine is used giving a frequency depending on the RPM. To be able to show the turbocharger's RPM on an analogue tachometer, the frequency signal is sent through a f/I converter (frequency/current converter), where the signal is transferred into a proportional 4-20 mA ~ 0-60000 RPM.

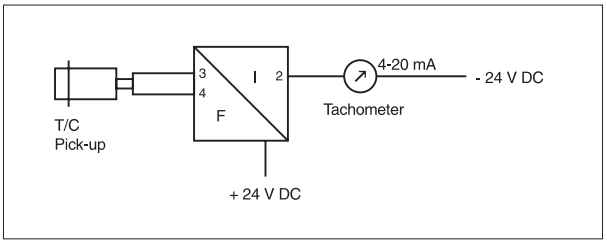


Fig 2. Converter for TC RPM.

The converter is mounted in the terminal box on engine.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	Functional Test and Adjustment of Safety, Alarm and Monitoring Equipment	609-01.00 Edition 01H

General

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Function test and adjustment of safety, alarm and monitoring equipment.

Starting position

Related procedure

Overspeed trip	609-01.05
Pressostate	609-05.00
Thermostate	609-05.01
Level switch (LAL 25)	609-05.02
Analog pressure transmitter	609-05.03
Analog temperature transmitter	609-05.04

Man power

Working time : hours
Capacity : man

Data

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools

Plate No	Item No	Note.

See Related Procedure

Hand tools

See Related Procedure

Replacement and wearing parts

Plate No	Item No	Qty. /

08028-0D/H5250/94.08.12

General

Maintenance of monitoring and safety systems

One of the most important parameters in the preventive work is that the alarm system as well as the shutdown and overspeed devices are functioning 100%.

If some of these functions are out of operation, they have to be repaired immediately. If this is not possible because of the present working situation, the engine has to be under constant observation until it can be stopped.

It is recommended that all functions are tested every three month according to the mentioned working cards.

The extent of the alarm and safety functions is variable from plant to plant.

For check of these functions use the working cards mentioned under related procedure on page 1.

Alarm System

It is important that all alarms lead to prompt investigation and remedy of the error.
No alarm is insignificant. It is therefore important that all engine crew members are
familiar with and well trained in the use and importance of the alarm system.
The most serious alarms are equipped with slowdown and/or shutdown functions.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Functional Test and Adjustment of Overspeed Trip**	**609-01.05** Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Functional test and adjustment of overspeed trip.

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62009	01	

Hand tools:

Allen key, 4 mm.
Allen key, 2 mm.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

General

1) The engine is run up manually, (on governor "synchronizer") and at no load, while watching the tachometer.

On reaching the revolution number indicated on page 600.30 or in "Test Report", the overspeed tripping device must function, thus actuating the stop cylinders. The fuel injection pump control rods are now moved to zero index, and the engine stops.

2) If the overspeed divice trip at a revolution number different from that stated on page 600.30 or in the "Test Report" the overspeed device must be adjusted.

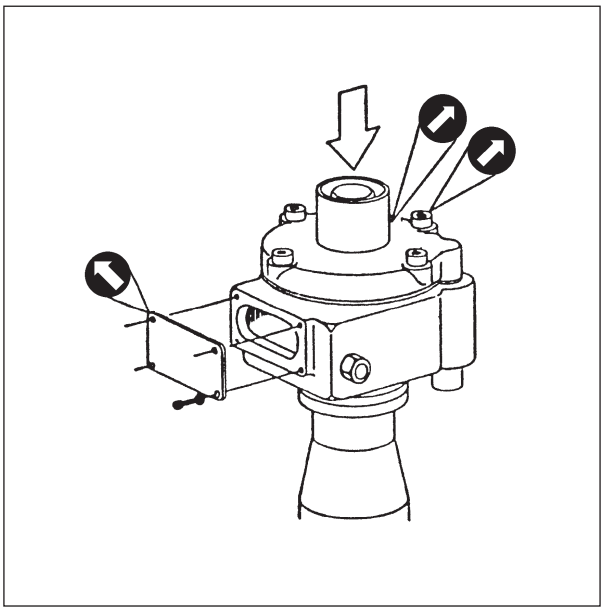


Fig. 1.

Adjustment of Overspeed Trip.

3) Remove both covers on the housing of the overspeed tripping device, see fig. 1.

Turn the engine until the adjusting screw is opposite the opening on the side of the housing. Now loosen the lock screw and turn the adjusting screw, using the tubular pin spanner supplied, se fig. 2.

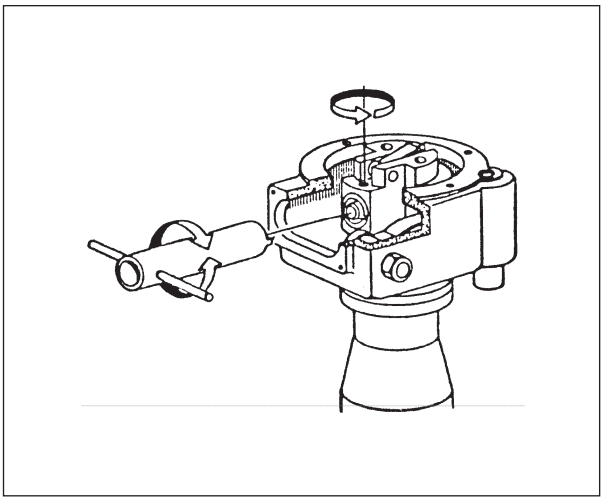


Fig. 2.

Turn the adjusting screw outwards (slacken flyweight spring) to reduce the revolution number. Be careful not to screw the adjusting screw so far out that it may touch the release arm. Tighten the lock screw and test the overspeed device again.

4) Refit the covers when the overspeed device functions at correct revolution number.

5) The overspeed device can be tested manually by depressing the button on top af the housing,see fig. 1. This will activate the flyweight and the arm for release of the air valve for the stop cylinders and the engine should thus stop. (This test must also be carried out without load).

6) It is recommended now and then, while the engine is at a standstill, to move the flyweight by means of the push button to ensure that the flyweight can always move with sufficient ease.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Adjustment and Test of On/Off Pressostate**	**609-05.00** Edition 02H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Adjustment and test of on/off pressostate. (lub. oil,fuel oil, water etc.).

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Screw driver.
Testing pump.
Ring and open end spanner, 10 mm.

Replacement and wearing parts:

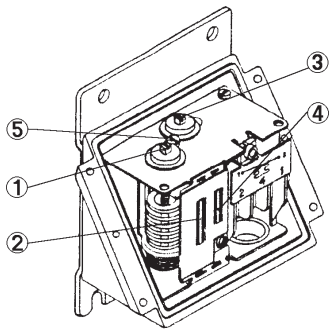
Plate no.	Item no.	Qty./

08028-0D/H5250/94.08.12

General

Adjustment:

1) When the pressostate cover is removed and locking screw pos. 5, fig. 1 is loosened, the range can be set with the spindle pos. 1 while at the same time the scale pos. 2 is read.



1. Range spindle.
2. Range scale.
3. Differential spindle.
4. Differential scale.
5. Locking screw.

Fig. 1.

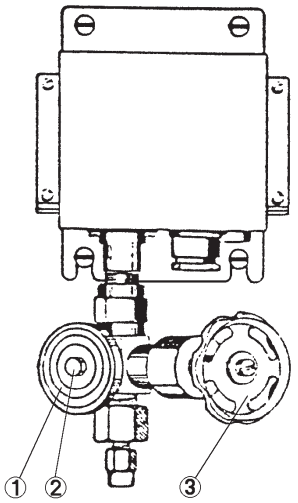
2) In pressostates having an adjustable differential, the spindle pos. 3 must be used to make the adjusment. The differential obtained can be read directly on the scale pos. 4.

Set points, see page 600.30.

Test:

It is possible to make a functional test of the pressure switch. This is to be carried out according to the following procedure.

3) Shut off system pressure with the valve pos. 3, fig. 2.



1. Trial flange.
2. Drain screw.
3. Valve.

Fig. 2.

4) Remove the screw pos. 2.

5) Mount the testing pump on the trial flange pos. 1.

Alarm for Falling Pressure:

6) Pump up the pressure until the switch has changed. The pressure will slowly be relieved and it must be checked that the switch change back to the pressure stated as the alarm point.

Alarm for Rising Pressure:

7) Pump up the pressure until the switch changes, and check that it happens at the stated alarm point.

8) After the final check and adjustment, remove the testing pump, mount the screw pos. 2 and open the valve pos. 3.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Adjustment and Test of On/Off Thermostate**	**609-05.01** Edition 02H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Adjustment and test of on/off thermostate. (lub. oil, fuel oil, water etc.).

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Screw driver.
Special testing devices.

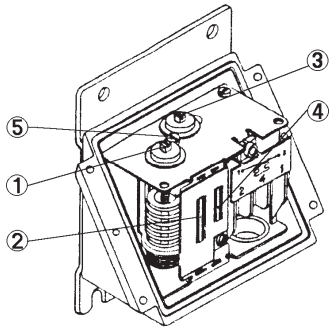
Replacement and wearing parts:

Plate no.	Item no.	Qty. /

L+V28/32H

Adjustment:

1) When the thermostate cover is removed and locking screw pos. 5, fig. 1 is loosened, the range can be set with the spindle pos. 1 while at the same time the scale pos. 2 is read.



1. Range spindle.
2. Range scale.
3. Differential spindle.
4. Differential scale.
5. Locking screw.

Fig. 1.

2) Thermostates having an adjustable differential, the spindle pos. 3 can be used while the scale pos. 4 is read.

Set points, see page 600.30.

Test:

3) The funcional test of the thermostate is to be carried out according to the following procedure.

4) Take out the sensor of the pocket.

5) Test the sensor in a water bath, where the temperature can be controlled.

Alarm for Falling temperature:

6) Raise the temperature until the switch has changed.

Then the temperature must slowly be reduced, and check that the switch changes back at the temperature stated in the list page 600.30.

Alarm for Rising temperature:

7) Raise the temperature until the switch changes and check that is happens at the stated alarm points.

8) Adjust if necessary.

9) The sensor is mounted again.

Working Card Page 1 (2)	**Function and Test of Level Switch (LAL 25)**	**609-05.02** Edition 02H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Function and test of level switch, LAL 25, in lubricating oil system.

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

General

The level switch LAL 25, which is mounted on the main lubricating oil pipe of the engine, gives alarm for missing prelubricating oil.

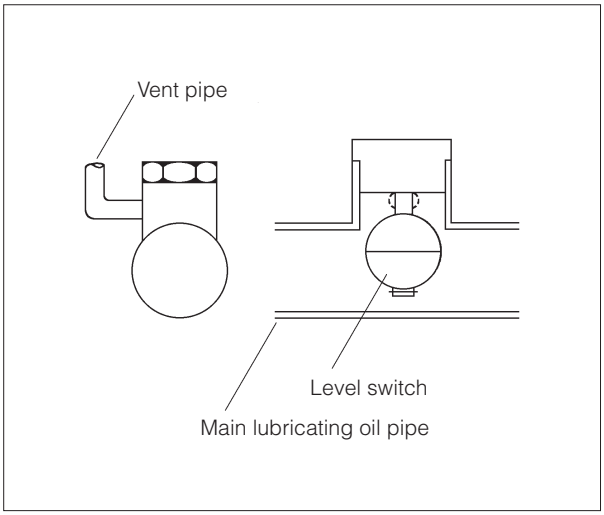


Fig. 1.

Function.

1) By starting the prelubricating oil pump the main lubricating oil pipe will be filled with lubricating oil, which means that the level switch is lifted and the alarm is disconnected.

2) When the prelubricating is interrupted, the lub. oil will run out of the system through the bearings, which means that level switch is lowered and the alarm starts.

Test:

The test is carried out when the engine is stopped.

3) Start the lubricating oil pump, and let the pump run about 5 min.

4) Stop the prelubricating oil pump. The alarm must be released after 0 - 5 min., depending of the oil viscosity.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Adjustment and Test of Analogous Pressure Transmitter**	**609-05.03** Edition 02H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ■ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Adjustment and test of analogous pressure transmitter.

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Ring and open end spanner, 10 mm.
Testing pump.

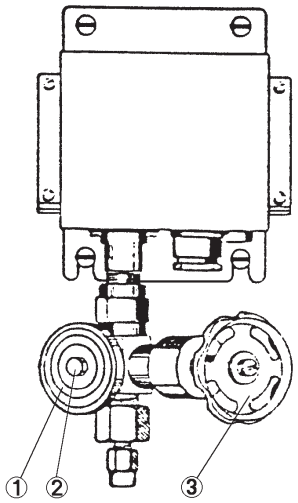
Replacement and wearing parts:

Plate no.	Item no.	Qty./

08028-0D/H5250/94.08.12

General

The pressure transmitter registers the actual pressure and marks the change to an electrical signal, which adjusts the pressure.



1. Trial flange.
2. Drain screw.
3. Valve.

Fig. 1.

Adjustment:

1) The pressure transmitter shall not be adjusted, but the alarm limit must be set on the alarm plant. Kindly see the instruction book for the alarm plant.

Set points, see page 600.30.

Test:

2) It is possible to make a functional test of the pressure transmitter. This is carried out according to the following procedure:

3) Shut off system pressure with the valve pos. 3.

4) Remove the screw pos. 2.

5) Mount the testing apparatus on the trial flange pos. 1. and pump on a pressure within the working area of the transmitter.

If the alarm plant has an instrument unit, the pressure can be read on this. Other wise the test can be carried out by watching if the alarm plant gives any alarm, when the alarm limit which is stated on page 600.30 is exceeded (if the alarm plant is adjusted).

6) The screw pos. 2 is mounted, and the valve pos. 3. is opened after the test is finished.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Adjustment and Test of Analogous Temperature Transmitter**	**609-05.04** Edition 02H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Adjustment and test of analogous temperature transmitter, (PT 100 sensor).

Starting position:

Functional test and adjustment of safety alarm and monitoring equipment, 609-01.00

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Special testing devices.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

L+V28/32H

The PT 100 sensor consist of a resistance wire which changes resistance depending on the temperature.

Look and design varify depending on the place of measurement and manufacture.

Adjustment:

1) The PT 100 sensor connot be adjusted, but the alarm limit must be set on the alarm plant.

Set point, see page 600.30.

Test:

2) The functional trial of the PT 100 sensor can be carried out according to the following procedure.

3) Take out the sensor of the pocket.

4) Test the sensor by diving the sensor in the water. Compare the signal from the sensor with the water temperature.

If the alarm plant has an instrument unit, the temperature can be read on this.

Otherwise the test can be carried out by watching if the alarm plant gives any alarm, when the alarm limit which is stated on page 600.30 is exceeded (if the alarm plant is adjusted).

5) The sensor is mounted again.

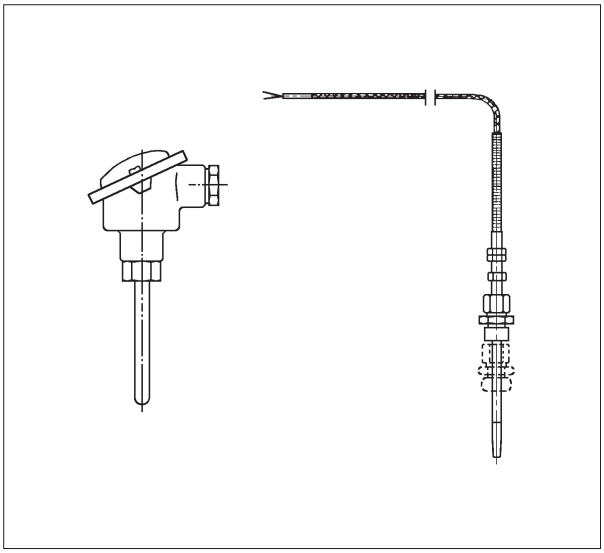


Fig. 1.

Working Card Page 1 (2)	**Lambda Controller**	**609-10.00** Edition 16H

L28/32H

Safety precautions:

- ■ Stopped engine
- ☐ Shut off starting air
- ☐ Shut off cooling water
- ☐ Shut off fuel oil
- ☐ Shut off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Adjustment of lambda controller.

Starting position:

Related procedure:

Manpower:

Working time : 1 hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no	Item no	Note

Hand tools:

Allen key.

Replacement and wearing parts:

Plate no	Item no	Qty /

L28/32H

Adjustment of the Lamda Controller

All adjustments are made when the engine is in standstill position.

1. Check that the free space between the pick-up and the band steel on the regulating arm is min. 1 mm, *see fig 1.*

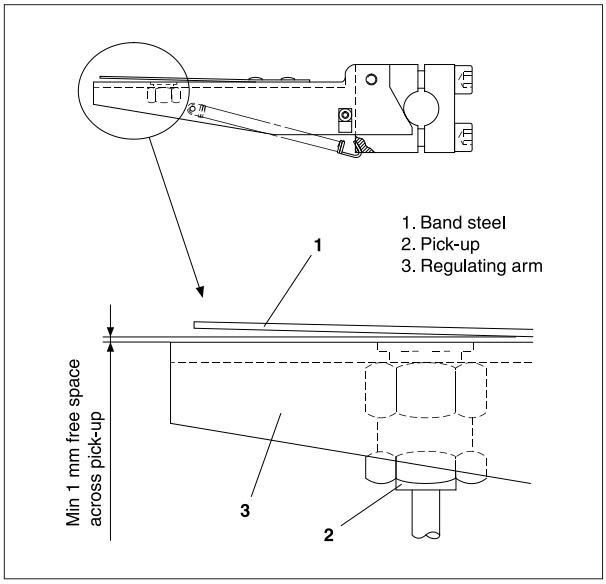


Fig 1.

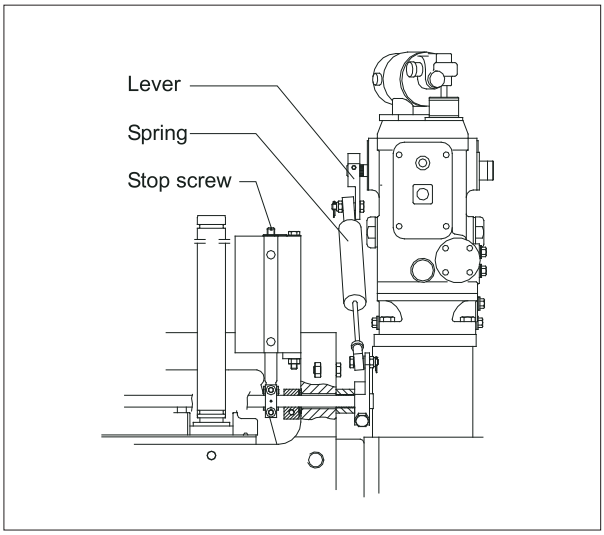


Fig 2.

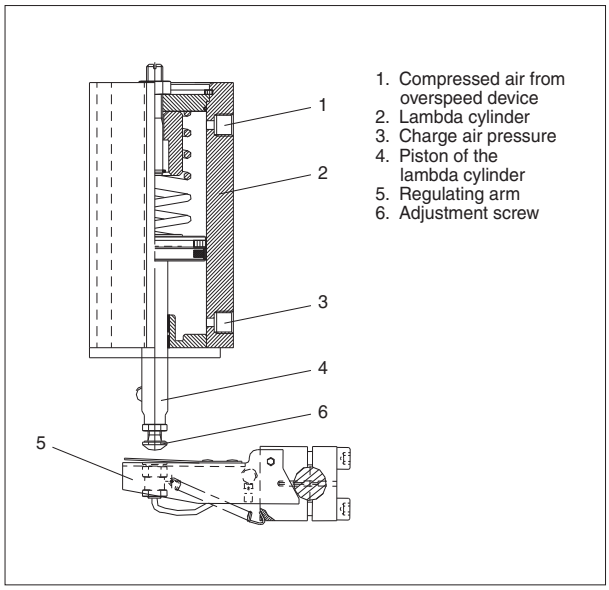


Fig 3.

2. Turn the lever *(fig 2)* of the governor a few times to full load with an adjustable spanner (spring between governor and fuel rack full com-pressed). Check that the fuel index is 24 mm at the fuel pump.

Note: Be sure that the fuel index is 24 mm at the fuel pump when the engine is started.

3. In case of large deviation from index 24 adjustment is done by turning the regulating arm (5), *fig 3*. Finally adjustment is done at the adjustment screw (6), *fig 3*.

4. Adjustment completed.

Adjustment of the stop screw

5. Remove pipe for charge air pressure, see fig 3.

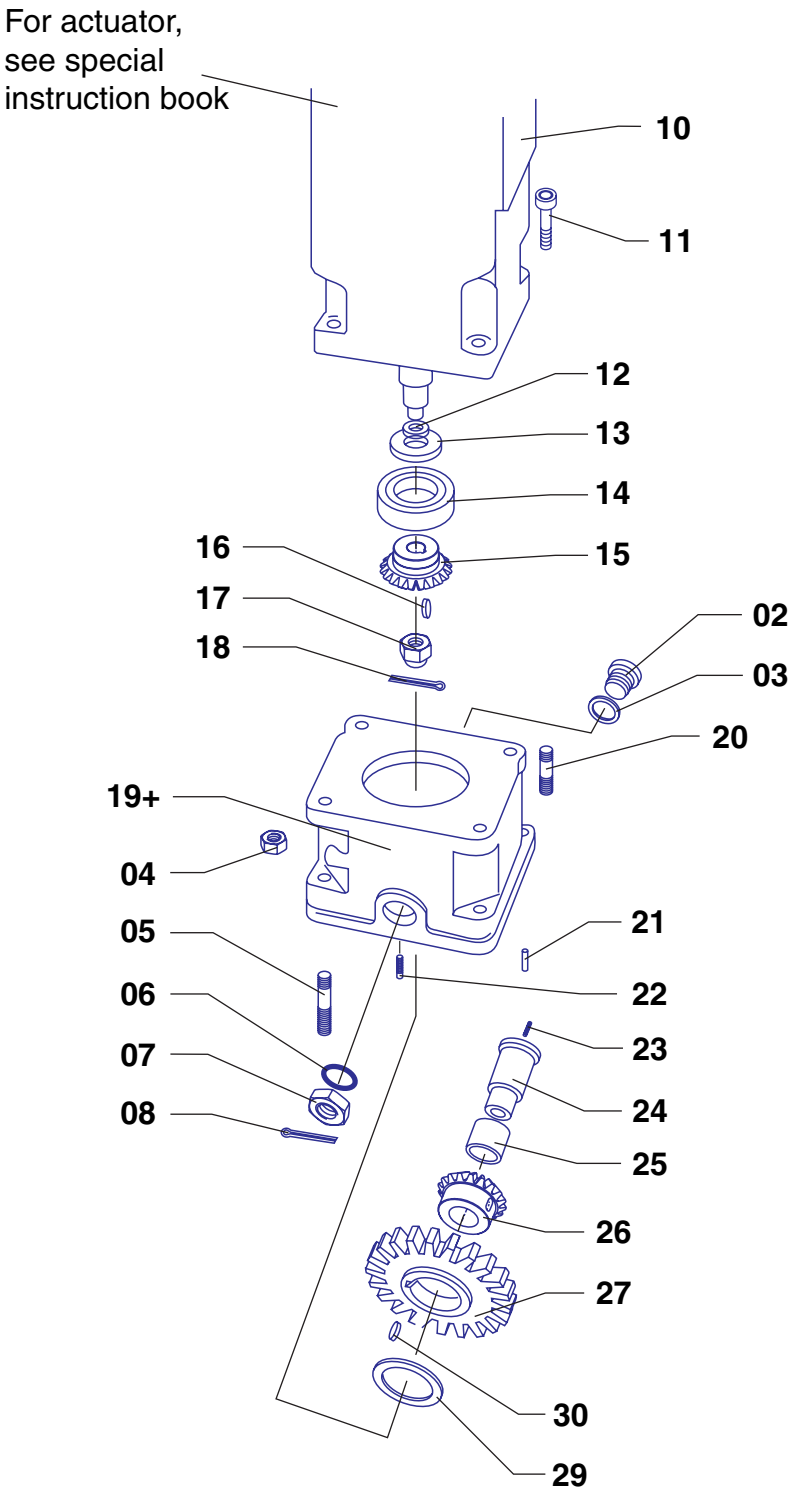
6. Supply air pressure until the piston rod reaches its upper position.

7. Adjust the stop screw, see fig 2, to 110% load according to the test bed, plus 1.5 index.
Use the index arm on the fuel pump nearest to the lambda controller as control for the index.

8. Adjustment finished.

Plate Page 1 (2)	Governor and Governor Drive	60901-13H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
02	1/E	**Plug screw**	Propskrue
03	1/E	**Gasket**	Pakning
04	4/E	**Nut**	Møtrik
05	2/E	**Stud**	Tap
06	1/E	**O-ring**	O-ring
07	1/E	**Castle nut**	Kronemøtrik
08	1/E	**Split pin**	Split
10	1/E	**Actuator**	Aktuator
11	4/E	**Screw**	Skrue
12	1/E	**Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm)**	Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm)
13	1/E	**Disc**	Skive
14	1/E	**Ball bearing**	Kugleleje
15	1/E	**Bevel gear wheel**	Konisk tandhjul
16	1/E	**Key**	Feder
17	1/E	**Castle nut**	Kronemøtrik
18	1/E	**Split pin**	Split
19+	1/E	**Housing**	Hus
20	2/E	**Stud**	Tap
21	2/E	**Pin**	Stift
22	1/E	**Plug**	Prop
23	1/E	**Plug**	Prop
24	1/E	**Axle journal**	Akseltap
25	1/E	**Bush**	Bøsning
26	1/E	**Bevel gear wheel**	Konisk tandhjul
27	1/E	**Gear wheel**	Tandhjul
29	1/E	**Wear disc**	Slidskive
30	1/E	**Key**	Feder
		+ Item No. 19 require an individual matching (by shims) before mounting, contact, MAN B&W, Holeby	+ Item nr. 19 kræver en individual tilpasning (med shims) før montering, kontakt MAN B&W, Holeby.

When ordering spare parts, see also page 600.50.

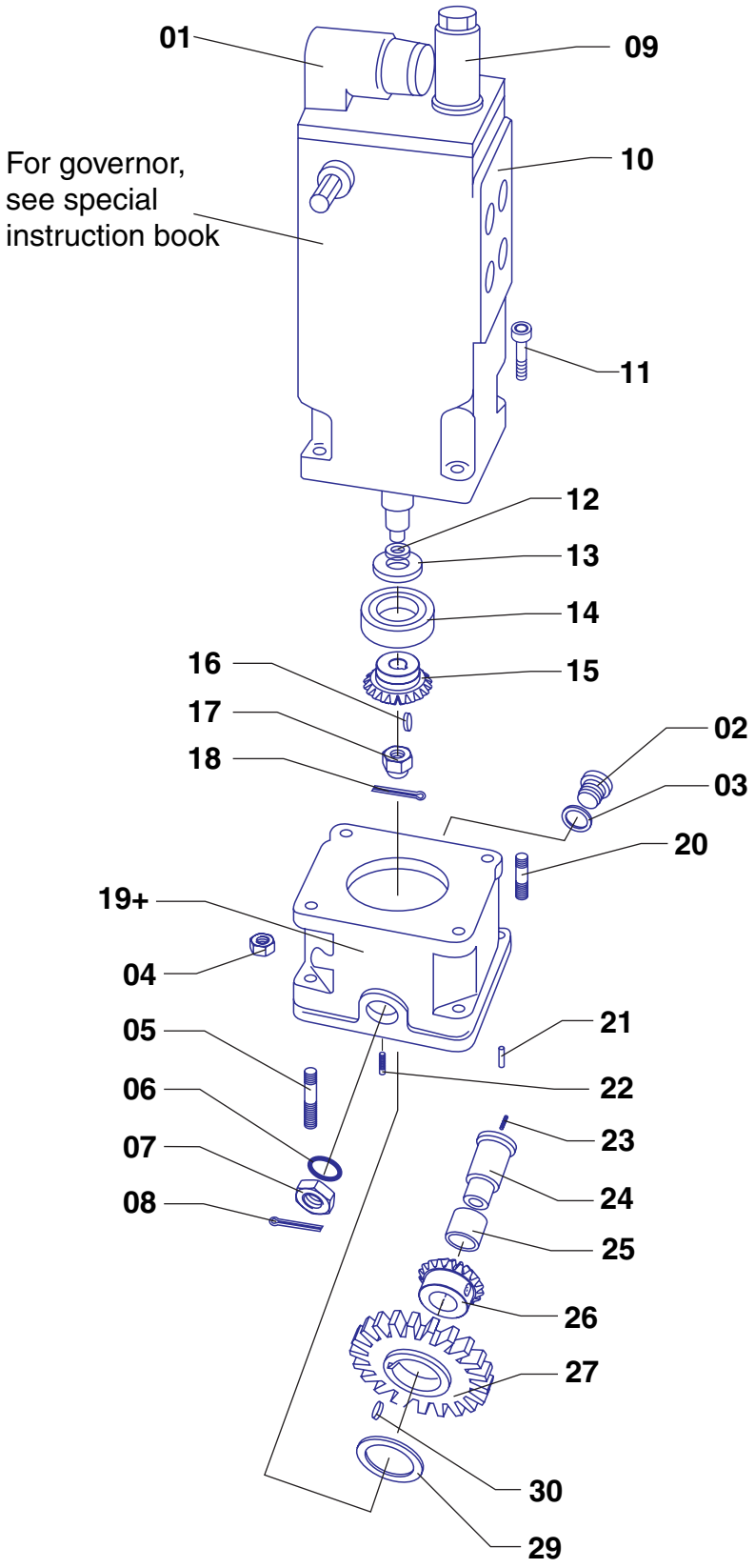
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	Governor and Governor Drive	60901-14H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Synchronnizing motor**	Synchroniserings-motor
02	1/E	**Plug screw**	Propskrue
03	1/E	**Gasket**	Pakning
04	4/E	**Nut**	Møtrik
05	2/E	**Stud**	Tap
06	1/E	**O-ring**	O-ring
07	1/E	**Castle nut**	Kronemøtrik
08	1/E	**Split pin**	Split
09	1/E	**Shut down solenoid**	Shut-down spole
10	1/E	**Governor - incl. item 01, 09 and 12**	Regulator - inkl. item 01, 09 og 12
11	4/E	**Screw**	Skrue
12	1/E	**Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm)**	Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm)
13	1/E	**Disc**	Skive
14	1/E	**Ball bearing**	Kugleleje
15	1/E	**Bevel gear wheel**	Konisk tandhjul
16	1/E	**Key**	Feder
17	1/E	**Castle nut**	Kronemøtrik
18	1/E	**Split pin**	Split
19+	1/E	**Housing**	Hus
20	2/E	**Stud**	Tap
21	2/E	**Pin**	Stift
22	1/E	**Plug**	Prop
23	1/E	**Plug**	Prop
24	1/E	**Axle journal**	Akseltap
25	1/E	**Bush**	Bøsning
26	1/E	**Bevel gear wheel**	Konisk tandhjul
27	1/E	**Gear wheel**	Tandhjul
29	1/E	**Wear disc**	Slidskive
30	1/E	**Key**	Feder
		+ Item No. 19 require an individual matching (by shims) before mounting, contact, MAN B&W, Holeby	+ Item nr. 19 kræver en individual tilpasning (med shims) før montering, kontakt MAN B&W, Holeby.

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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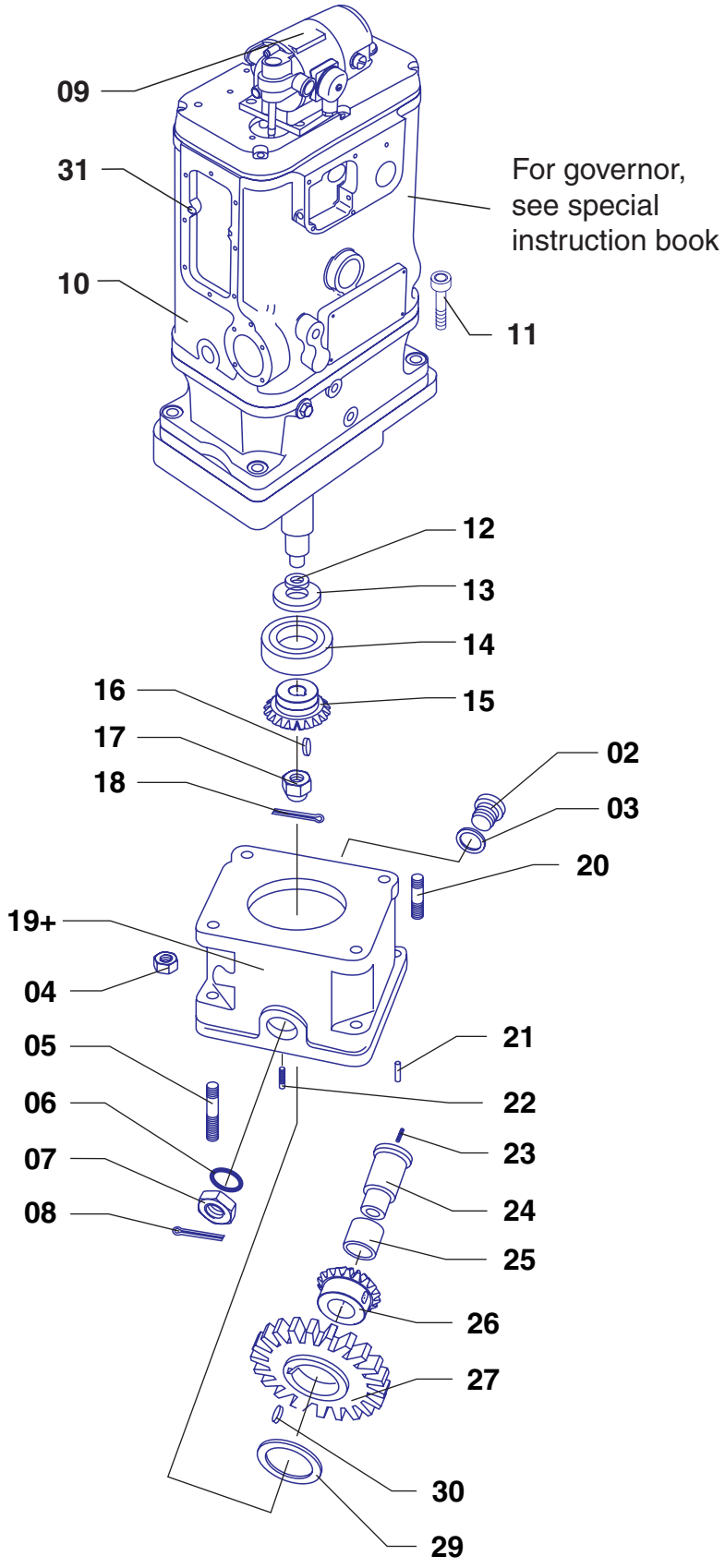
Antal/E = Antal/Motor

Plate Page 1 (2)	Governor and Governor Drive	60901-15H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
02	1/E	**Plug screw**	Propskrue
03	1/E	**Gasket**	Pakning
04	4/E	**Nut**	Møtrik
05	2/E	**Stud**	Tap
06	1/E	**O-ring**	O-ring
07	1/E	**Castle nut**	Kronemøtrik
08	1/E	**Split pin**	Split
09	1/E	**Synchronizing motor**	Synkroniseringsmotor
10	1/E	**Governor, Europa (720/750 rpm)**	Regulator, Europa (720/750 rpm)
11	4/E	**Screw**	Skrue
12	1/E	**Shim (set 0,1 - 0,3 - 0,5 - 1,0 mm)**	Mellemlæg (sæt 0,1 - 0,3 - 0,5 - 1,0 mm)
13	1/E	**Disc**	Skive
14	1/E	**Ball bearing**	Kugleleje
15	1/E	**Bevel gear wheel**	Konisk tandhjul
16	1/E	**Key**	Feder
17	1/E	**Castle nut**	Kronemøtrik
18	1/E	**Split pin**	Split
19+	1/E	**Housing**	Hus
20	2/E	**Stud**	Tap
21	2/E	**Pin**	Stift
22	1/E	**Plug**	Prop
23	1/E	**Plug**	Prop
24	1/E	**Axle journal**	Akseltap
25	1/E	**Bush**	Bøsning
26	1/E	**Bevel gear wheel**	Konisk tandhjul
27	1/E	**Gear wheel**	Tandhjul
29	1/E	**Wear disc**	Slidskive
30	1/E	**Key**	Feder
31	1/E	**Shutdown solenoid**	Shutdown spole
		+ Item No. 19 require an individual matching (by shims) before mounting, contact, MAN Diesel A/S.	+ Item nr. 19 kræver en individual tilpasning (med shims) før montering, kontakt MAN Diesel A/S.

When ordering spare parts, see also page 500.50.

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Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 500.50.

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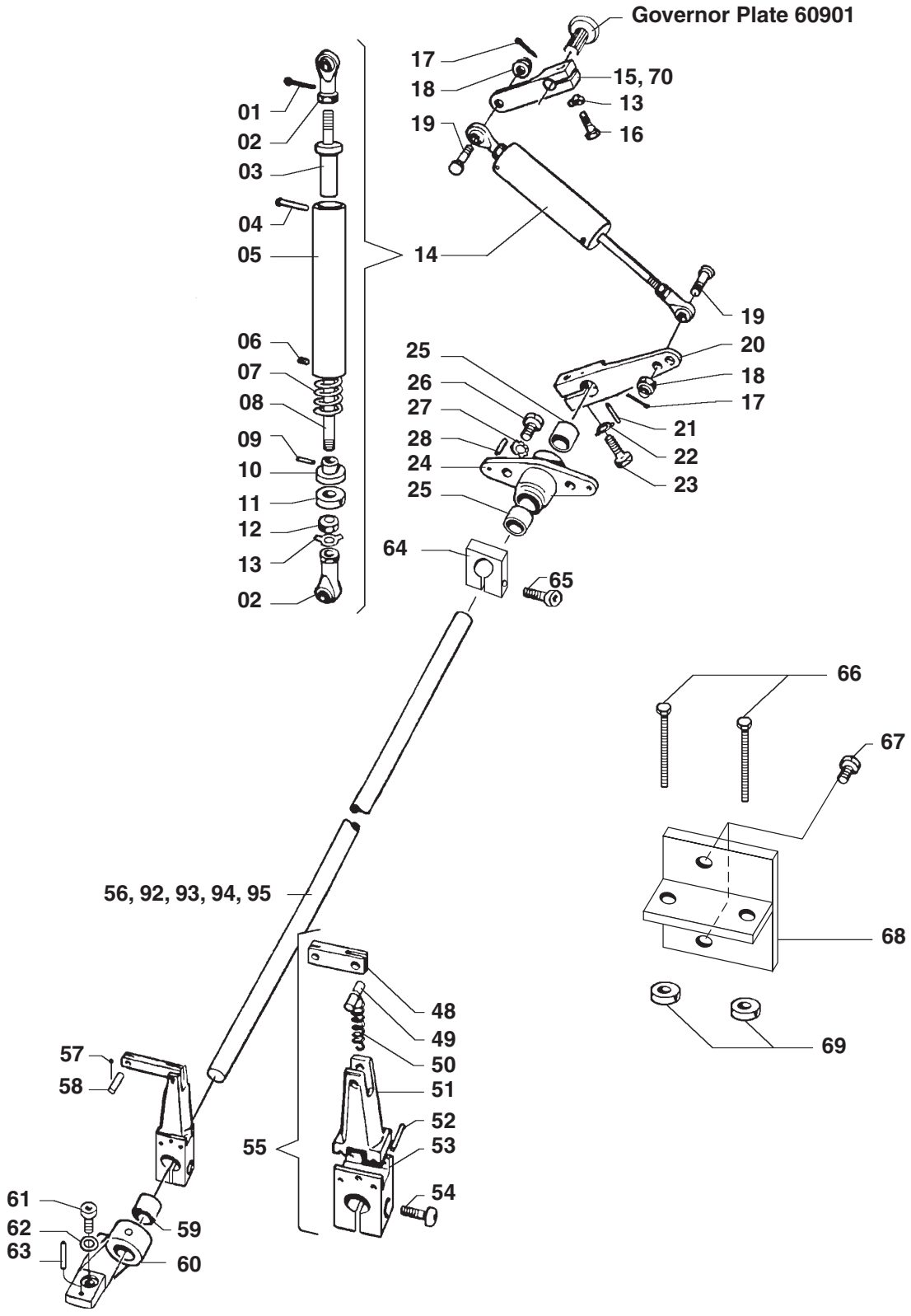
Antal/E = Antal/Motor

Plate Page 1 (3)	**Regulation Mechanism**	**60902-18H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/R	**Split pin**	Split
02	2/R	**Pull rod head**	Trækstangshoved
03	1/R	**Pull rod end**	Trækstangsende
04	1/R	**Cylindrical pin**	Cylindrisk stift
05	1/R	**Spring housing**	Fjederhus
06	1/R	**Pointed screw**	Pinolskrue
07	1/R	**Spring**	Fjeder
08	1/R	**Pull rod**	Trækstang
09	1/R	**Cylindrical pin**	Cylindrisk stift
10	1/R	**Guide ring**	Styrering
11	1/R	**Guide ring**	Styrering
12	1/R	**Nut**	Møtrik
13	2/R	**Locking plate**	Låseblik
14	1/R	**Spring loaded pull rod, complete**	Fjederbelastet træk-stang, komplet
15	1/R	**Governor arm, Woodward**	Regulator arm, Woodward
16	1/R	**Screw**	Skrue
17	2/R	**Split pin**	Split
18	2/R	**Self locking nut**	Selvlåsende møtrik
19	2/R	**Screw for ball head**	Skrue for kuglehoved
20	1/R	**Arm**	Arm
21	1/R	**Spring pin**	Fjederstift
22	1/R	**Locking plate**	Låseblik
23	1/R	**Screw**	Skrue
24	1/R	**Bearing housing incl. item 25**	Lejehus inkl. item 25
25	2/R	**Bush**	Bøsning
26	2/R	**Screw**	Skrue
27	2/R	**Washer**	Skive
28	2/R	**Spring pin**	Fjederstift
48	1/C	**Linkage**	Lænkeled
49	1/C	**Pin**	Stift
50	1/C	**Spring**	Fjeder
51	1/C	**Spring arm**	Fjederarm
52	3/C	**Spring pin**	Fjederstift
53	1/C	**Arm holder**	Armholder
54	1/C	**Screw**	Skrue
55	1/C	**Spring loaded lever, complete**	Fjederbelastet arm, komplet
56	1/E	**Regulating shaft 5 cyl. engine**	Reguleringsaksel 5 cyl. motor
57	1/C	**Split pin**	Split
58	1/C	**Pin**	Stift
59	1/C	**Bush**	Bøsning
60	1/C	**Bearing bracket incl. item 59**	Lejeblik inkl. item 59
61	2/C	**Screw**	Skrue
62	2/C	**Washer**	Skive
63	2/C	**Spring pin**	Fjederstift
64	1/E	**Stop ring**	Stopring
65	1/E	**Screw**	Skrue
66	2/E	**Screw**	Skrue
67	2/E	**Screw**	Skrue
68	1/E	**Bracket**	Konsol
69	2/E	**Nut**	Møtrik
70	1/E	**Governor arm, Europa**	Regulator arm, Europa
92	1/E	**Regulting shaft 6 cyl. engine**	Reguleringsaksel 6 cyl. motor
93	1/E	**Regulating shaft 7 cyl. engine**	Reguleringsaksel 7 cyl. motor

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder
Qty./R = Qty./Regulation mechanism

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/Cylinder
Antal/R = Antal/Reguleringsmekanisme

L28/32H

Item No.	Qty.	Designation	Benævnelse
94	1/E	**Regulating shaft 8 cyl. engine**	Reguleringsaksel 8 cyl. motor
95	1/E	**Regulating shaft 9 cyl. engine**	Reguleringsaksel 9 cyl. motor

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Engine
Qty./C = Qty./Cylinder
Qty./R = Qty./Regulation mechanism

Ved bestilling af reservedele, se også side 600.50.

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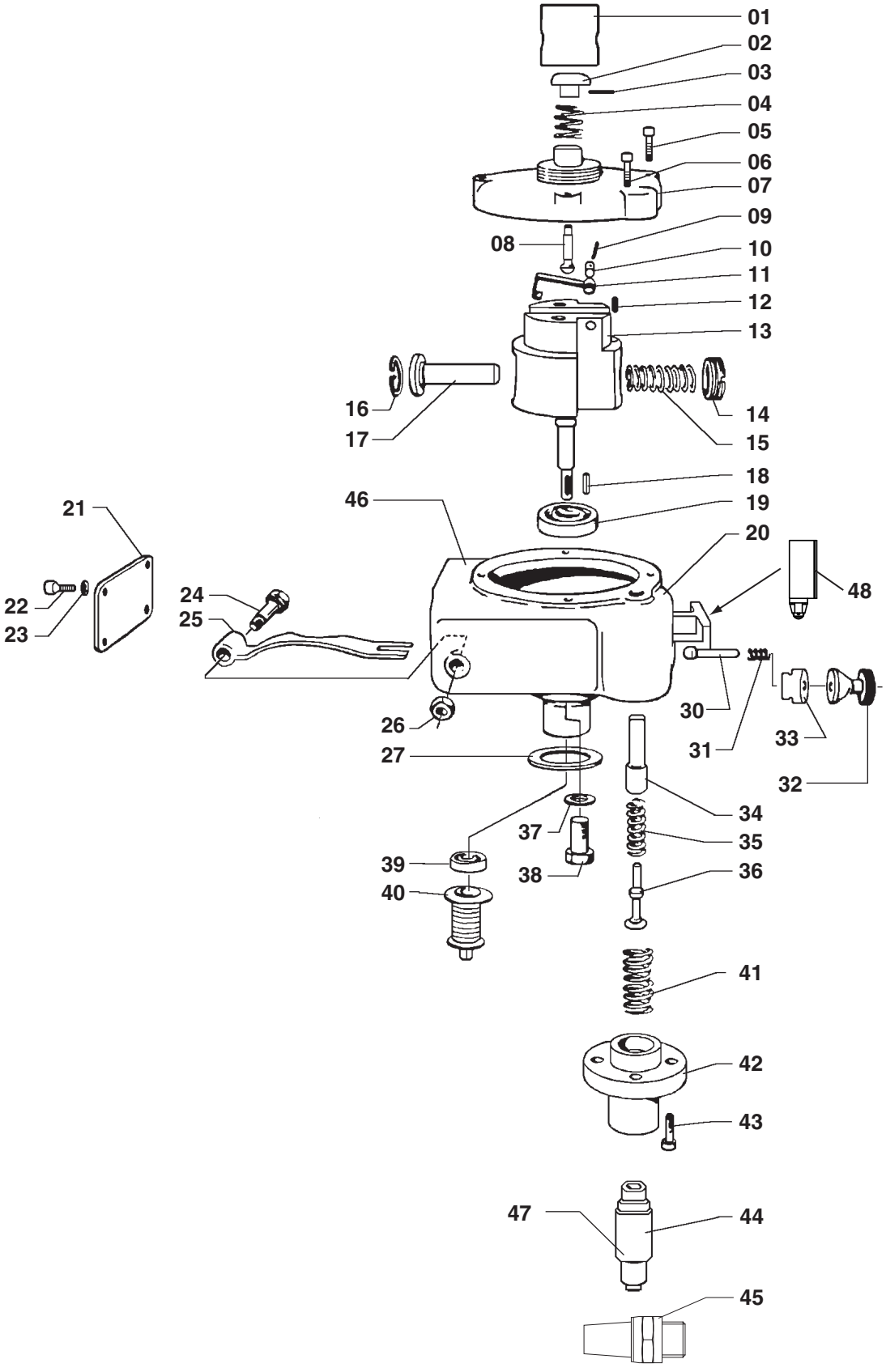
Antal/E = Antal/Motor
Antal/C = Antal/Cylinder
Antal/R = Antal/Reguleringsmekanisme

Plate Page 1 (2)	Overspeed Device	60903-38H

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Socket**	Muffe
02	1/E	**Button**	Knap
03	1/E	**Spring pin**	Fjederstift
04	1/E	**Spring**	Fjeder
05	4/E	**Screw**	Skrue
06	1/E	**Screw**	Skrue
07	1/E	**Cover**	Dæksel
08	1/E	**Spindle**	Spindel
09	1/E	**Spring pin**	Fjederstift
10	1/E	**Cylindrical pin**	Cylindrisk stift
11	1/E	**Lever**	Arm
12	1/E	**Screw**	Skrue
13	1/E	**Flyweight housing**	Hus for svingvægt
14	1/E	**Adjusting screw**	Justeringsskrue
15	1/E	**Spring**	Fjeder
16	1/E	**Circlip**	Sikringsring
17	1/E	**Flyweight**	Svingvægt
18	1/E	**Key**	Not
19	1/E	**Ball bearing**	Kugleleje
20	1/E	**Housing**	Hus
21	1/E	**Cover**	Dæksel
22	4/E	**Washer**	Skive
23	4/E	**Screw**	Skrue
24	1/E	**Pin**	Stift
25	1/E	**Lever**	Arm
26	1/E	**Nut**	Møtrik
27	1/E	**Gasket**	Pakning
30	1/E	**Spindle**	Spindel
31	1/E	**Spring**	Fjeder
32	1/E	**Button**	Knap
33	1/E	**Nipple**	Nippel
34	1/E	**Spindle**	Spindel
35	1/E	**Spring (left)**	Fjeder (venstre)
36	1/E	**Spindle**	Spindel
37	2/E	**Washer**	Skive
38	2/E	**Screw**	Skrue
39	1/E	**Ball bearing**	Kugleleje
40	1/E	**Elastic coupling**	Elastisk kobling
41	1/E	**Spring (right)**	Fjeder (højre)
42	1/E	**Valve attachment**	Ventilholder
43	4/E	**Screw**	Skrue
44	1/E	**Pneumatic valve**	Pneumatisk ventil
45	1/E	**Silencer**	Lyddæmper
46	1/E	**Overspeed device, complete excl. item 27, 37, 38, 44**	Overspeed anordning, komplet eksl. item 27, 37, 38, 44
47	1/E	**Spare parts kit for item 44**	Reservedelskit for item 44
48	1/E	**Limit switch (optinal)**	Afbryder (option)

When ordering spare parts, see also page 600.50.

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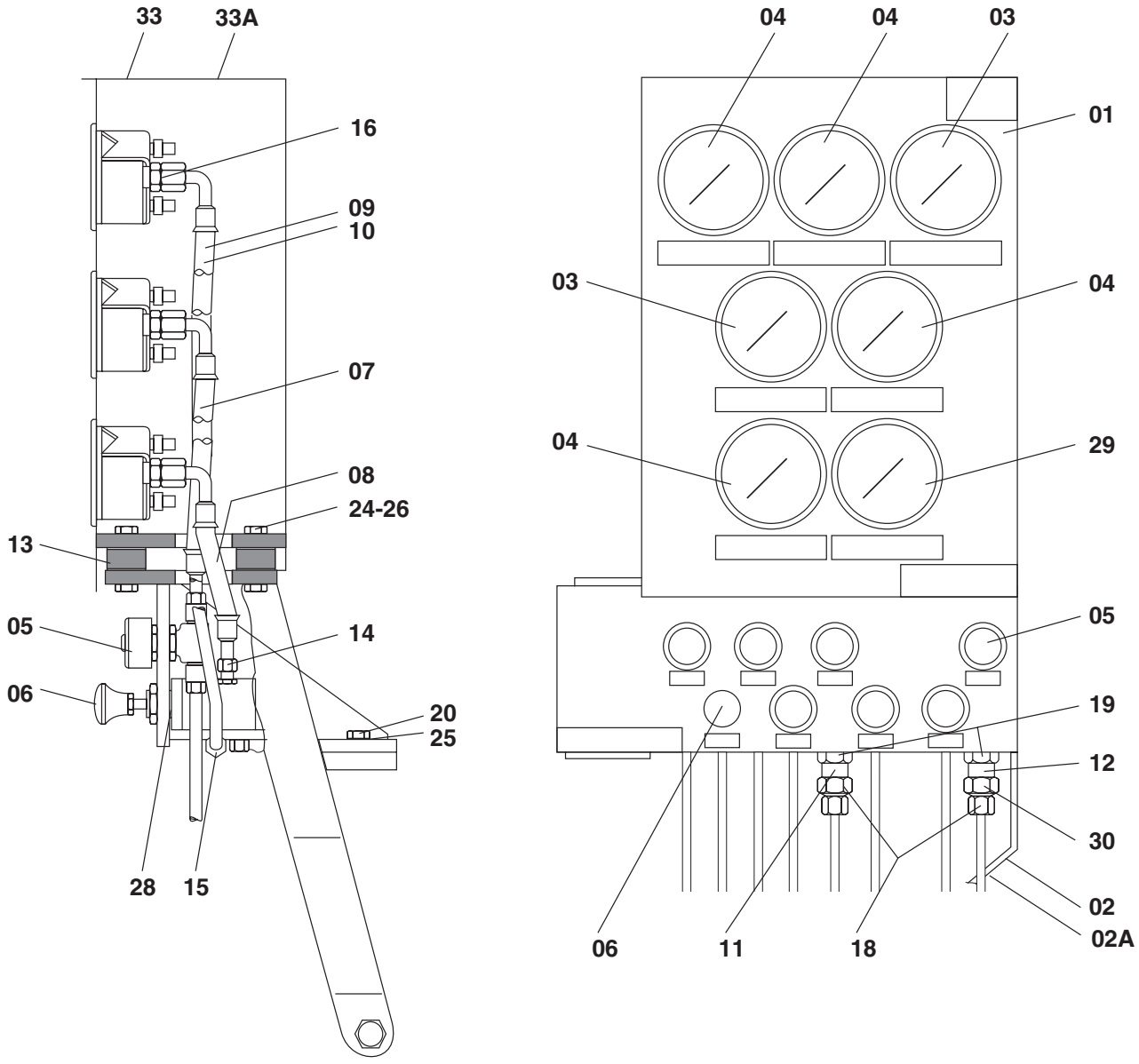
Antal/E = Antal/Motor

Plate Page 1 (2)	**Instrument Panel**	**60905-20H**

L28/32H



PI 01	LT fresh water, inlet to air cooler
PI 10	HT fresh water, inlet engine
PI 21/22	Lubricating oil, inlet/outlet to filter
PI 23	Lub. oil, inlet to turbocharger
PI 31	Charge air, outlet from cooler
PI 40	Fuel oil, inlet to engine
PI 50	Nozz. cool. oil, inlet to fuel valves

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Housing for instrument panel**	Hus for instrument panel
02	1/E	**Bracket for instrument panel , L23/30H**	Konsol for instrument panel, L23/30H
02A	1/E	**Bracket for instrunent panel, L28/32H**	Konsol for instrument panel, L28/32H
03	2/E	**Pressure gauge 0-3 bar (PI 31 and PI 23)**	Manometer 0-3 bar (PI 31 og PI 23)
04	4/E	**Pressure gauge 0-6 bar, PI 01, PI 10, PI 50, PI 21-22**	Manometer 0-6 bar, PI 01, PI 10, PI 50, PI 21-22
05	8/E	**Needle valve**	Nåleventil
06	1/E	**3-way valve for PI 21-22**	3-vejsventil for PI 21-22
07	3/E	**Pressure gauge hose 195 mm**	Manometer slange 195 mm
08	2/E	**Pressure gauge hose 140 mm**	Manometer slange 140 mm
09	1/E	**Pressure gauge hose 300 mm**	Manometer slange 300 mm
10	2/E	**Pressure gauge hose 340 mm**	Manometer slange 340 mm
11	1/E	**Damper (charging air)**	Dæmper (ladeluft)
12	1/E	**Damper (fuel oil)**	Dæmper (fuel oil)
13	4/E	**Rubber clutch**	Gummikobling
14	2/E	**Union**	Forskruning
15	1/E	**Screwed connection**	Skrue forbindelse
16	8/E	**Packing ring**	Pakningsring
18	2/E	**Union**	Forskruning
19	2/E	**Union**	Forskruning
20	3/E	**Screw**	Skrue
24	8/E	**Nut**	Møtrik
25	4/E	**Serrated washer**	Stjerneskrue
26	8/E	**Washer**	Skive
28	1/E	**Washer**	Skive
29	1/E	**Pressure gauge 0-10 bar, PI 40**	Manometer 0-10 bar, PI 40
30	4/E	**Packing ring**	Pakningsring
33	1/E	**Instrument panel, complete, L23/30H**	Instrument panel, komplet, L23/30H
33A	1/E	**Instrument panel, complete, L28/32H**	Instrument panel, komplet, L28/32H

When ordering spare parts, see also page 600.50.

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Ved bestilling af reservedele, se også side 600.50.

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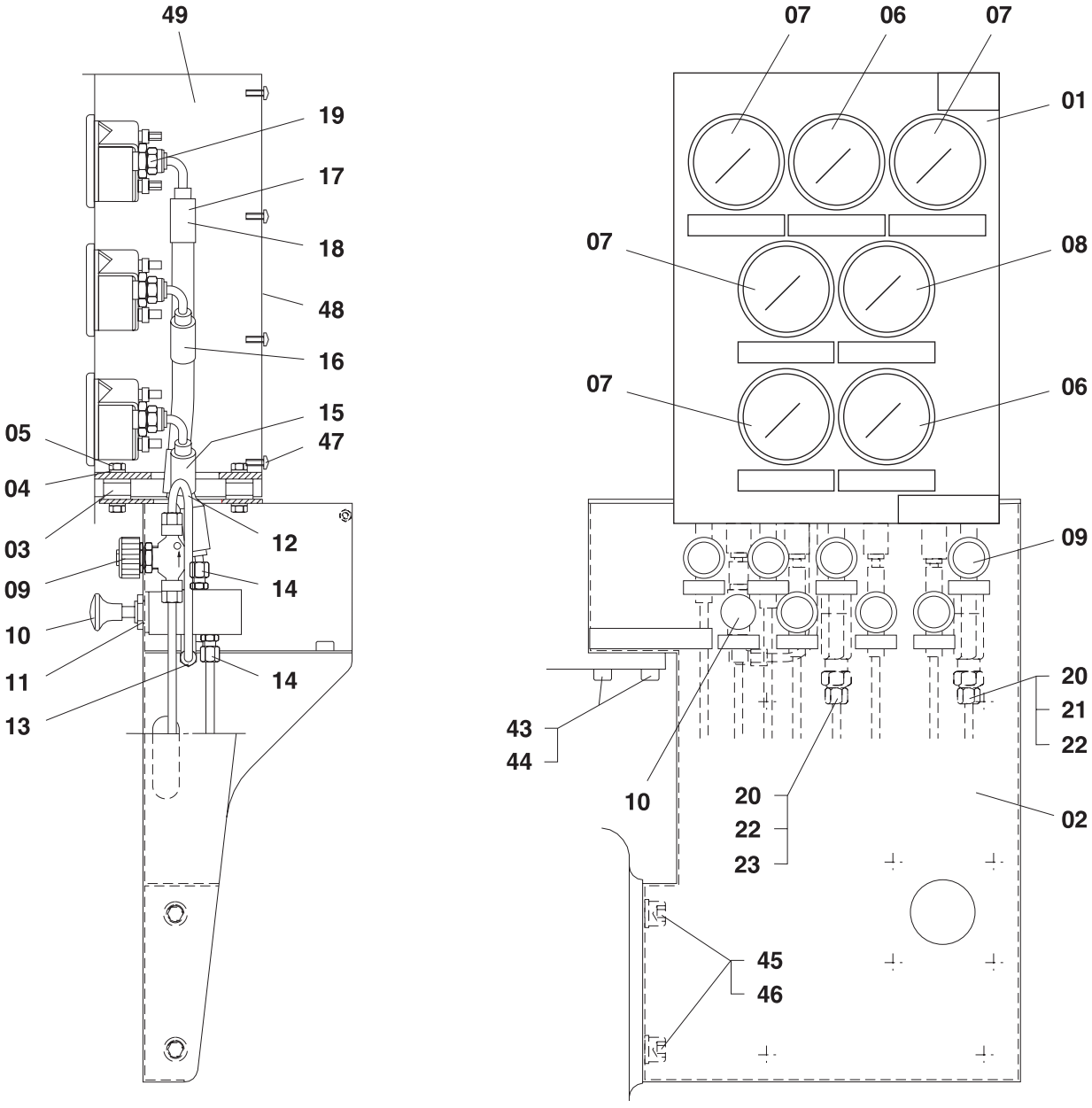
Antal/E = Antal/Motor

Plate Page 1 (2)	**Instrument Panel**	**60905-27H**

L28/32H



PI 01	LT fresh water, inlet to air cooler
PI 10	HT fresh water, inlet engine
PI 21/22	Lubricating oil, inlet/outlet to filter
PI 23	Lub. oil, inlet to turbocharger
PI 31	Charge air, outlet from cooler
PI 40	Fuel oil, inlet to engine
PI 50	Nozz. cool. oil, inlet to fuel valves

L28/32H

Item No	Qty.	Designation	Benævnelse
01	1/E	**Housing for instrument panel**	Hus for instrumentpanel
02	1/E	**Bracket for instrument panel**	Konsol for instrumentpanel
03	4/E	**Rubber clutch**	Gummikobling
04	8/E	**Nut**	Møtrik
05	8/E	**Spring lock**	Fjederskive
06	2/E	**Pressure gauge 0-3 bar (PI 31 and PI 23)**	Manometer 0-3 bar (PI 31 og PI 23)
07	4/E	**Pressure gauge 0-6 bar (PI 01, PI 10, PI 50, PI 21-22)**	Manometer 0-3 bar (PI 01, PI 10, PI 50, PI 21-22)
08	1/E	**Pressure gauge 0-10 bar (PI 40)**	Manometer 0-10 bar (PI 40)
09	7/E	**Needle valve**	Nåleventil
10	1/E	**3-way valve for PI 21-22**	3-vejsventil for PI 21-22
11	1/E	**Washer**	Skive
12	1/E	**Pipe**	Rør
13	1/E	**Angle union**	Vinkelforskruning
14	2/E	**Straight union**	Ligeforskruning
15	2/E	**Pressure gauge hose 195 mm**	Manometer slange 195 mm
16	2/E	**Pressure gauge hose 140 mm**	Manometer slange 140 mm
17	2/E	**Pressure gauge hose 300 mm**	Manometer slange 300 mm
18	1/E	**Pressure gauge hose 340 mm**	Manometer slange 340 mm
19	7/E	**Packing ring**	Pakningsring
20	2/E	**Reduction**	Reduktion
21	1/E	**Damper (fuel oil)**	Dæmper (fuel oil)
22	2/E	**Coupling for manometer**	Kobling for manometer
23	1/E	**Damper (charging air)**	Dæmper (ladeluft)
43	4/E	**Screw**	Skrue
44	4/E	**Serrated lock washer**	Stjernefjederskive
45	2/E	**Screw**	Skrue
46	2/E	**Serrated lock washer**	Stjernefjederskive
47	8/E	**Screw**	Skrue
48	1/E	**Side plate**	Sideplade
49	1/E	**Instrument panel, complete**	Instrument panel, komplet

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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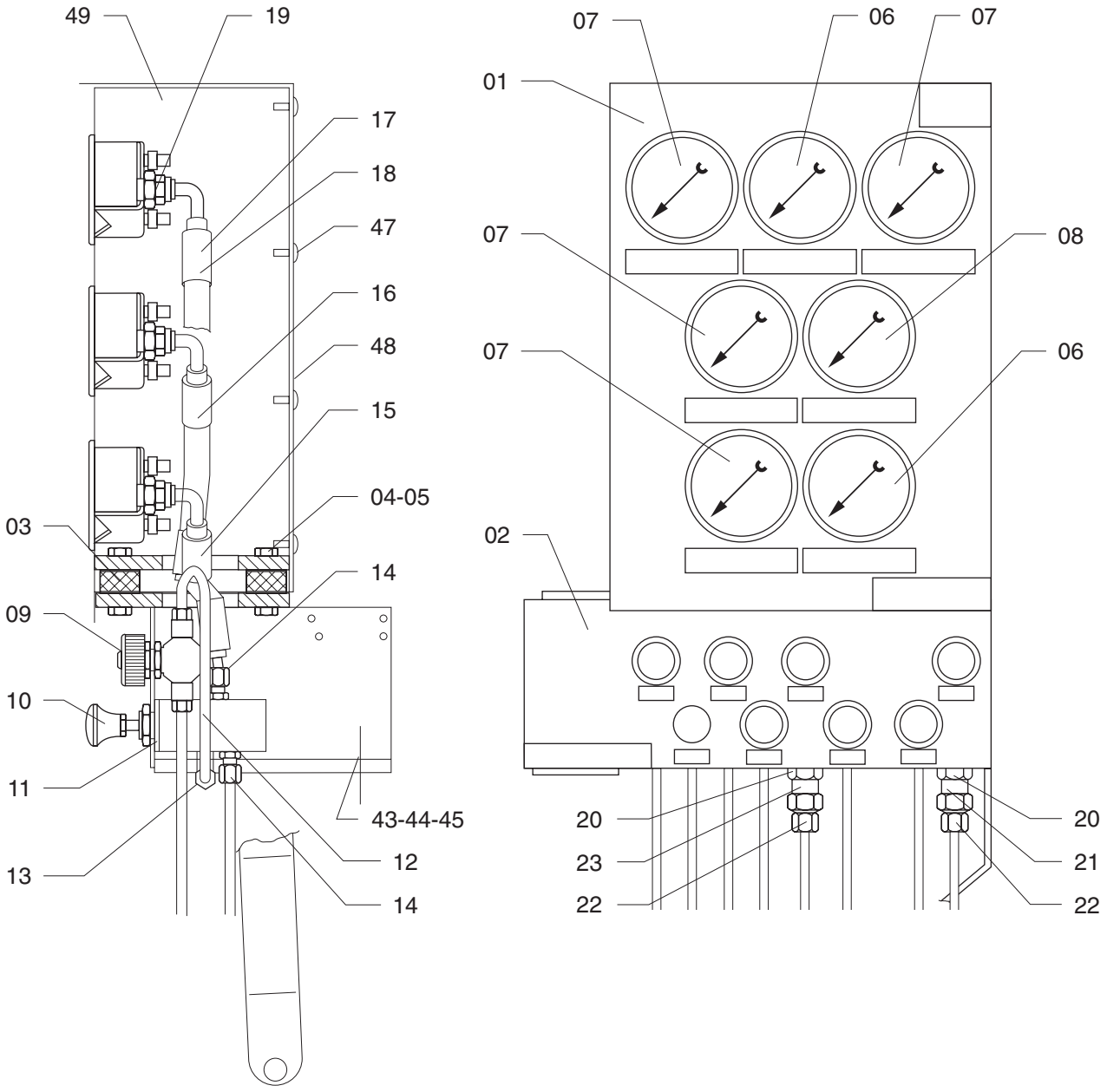
Antal/E = Antal/Motor

Plate Page 1 (2)	**Instrument Panel**	**60905-32H**

L28/32H



PI 01	LT fresh water, inlet to air cooler
PI 10	HT fresh water, inlet engine
PI 21/22	Lubricating oil, inlet/outlet to filter
PI 23	Lub. oil, inlet to turbocharger
PI 31	Charge air, outlet from cooler
PI 40	Fuel oil, inlet to engine
PI 50	Nozz. cool. oil, inlet to fuel valves

L28/32H

Item No	Qty.	Designation	Benævnelse
01	1/E	**Housing for instrument panel**	Hus for instrumentpanel
02	1/E	**Bracket for instrument panel**	Konsol for instrumentpanel
03	4/E	**Rubber clutch**	Gummikobling
04	8/E	**Nut**	Møtrik
05	8/E	**Spring lock**	Fjederskive
06	2/E	**Pressure gauge 0-3 bar (PI 31 and PI 23)**	Manometer 0-3 bar (PI 31 og PI 23)
07	4/E	**Pressure gauge 0-6 bar (PI 01, PI 10, PI 50, PI 21-22)**	Manometer 0-3 bar (PI 01, PI 10, PI 50, PI 21-22)
08	1/E	**Pressure gauge 0-10 bar (PI 40)**	Manometer 0-10 bar (PI 40)
09	7/E	**Needle valve**	Nåleventil
10	1/E	**3-way valve for PI 21-22**	3-vejsventil for PI 21-22
11	1/E	**Washer**	Skive
12	1/E	**Pipe**	Rør
13	1/E	**Angle union**	Vinkelforskruning
14	2/E	**Straight union**	Ligeforskruning
15	2/E	**Pressure gauge hose 195 mm**	Manometer slange 195 mm
16	2/E	**Pressure gauge hose 140 mm**	Manometer slange 140 mm
17	2/E	**Pressure gauge hose 300 mm**	Manometer slange 300 mm
18	1/E	**Pressure gauge hose 340 mm**	Manometer slange 340 mm
19	7/E	**Packing ring**	Pakningsring
20	2/E	**Reduction**	Reduktion
21	1/E	**Damper (fuel oil)**	Dæmper (fuel oil)
22	2/E	**Coupling for manometer**	Kobling for manometer
23	1/E	**Damper (charging air)**	Dæmper (ladeluft)
43	4/E	**Screw**	Skrue
44	4/E	**Lock washer**	Låseskive
45	4/E	**Nut**	Møtrik
47	8/E	**Screw**	Skrue
48	1/E	**Side plate**	Sideplade
49	1/E	**Instrument panel, complete**	Instrument panel, komplet

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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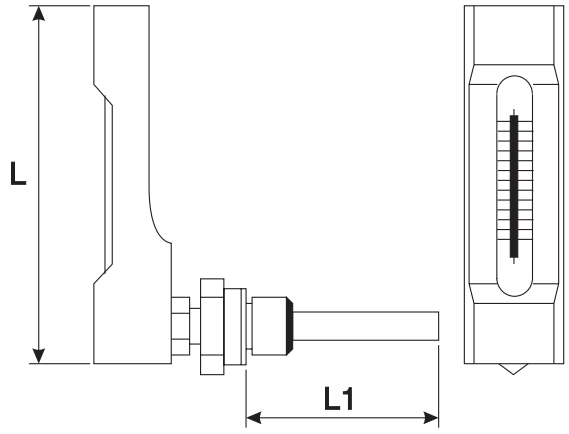
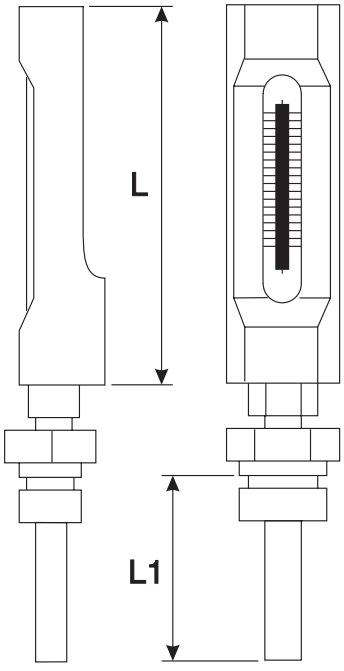
Antal/E = Antal/Motor

Plate Page 1 (3)	**Thermometer**	**60907-19H**

L28/32H

Fig.	Scale		Length		Code	Item No
	°F	°C	L	L1		
	40-240	0-120	110	100	TI 01 TI 02 TI 31	01
	40-240	0-120	110	63	TI 22 TI 20	02
	40-600	0-300	150	100	TI 30	03
	40-400	0-200	110	40	TI 40 TI 51	04
	40-220	0-120	110	100	TI 03 TI 10 TI 11	05

60907-19H	Thermometer	Plate Page 2 (3)

L28/32H

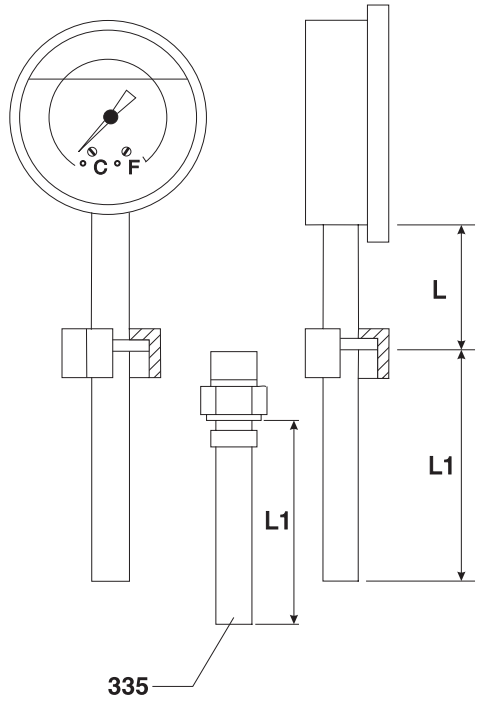
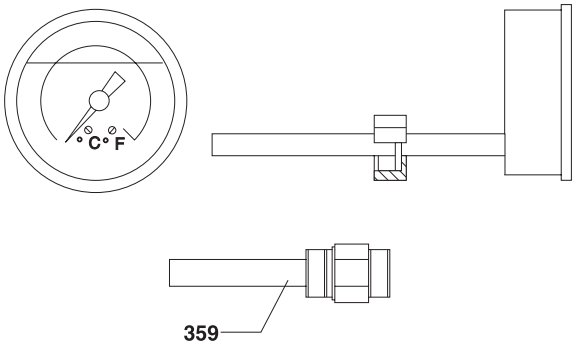
Fig.	Scale °F	Scale °C	Length L	Length L1	Code	Item No.
	100-1300	50-650	100	115	TI 60	06
	Pocket			115		07
	100-1300	50-650	65	215	TI 61	08
	Pocket			215		09

Plate Page 3 (3)	**Thermometer**	**60907-19H**

L28/32H

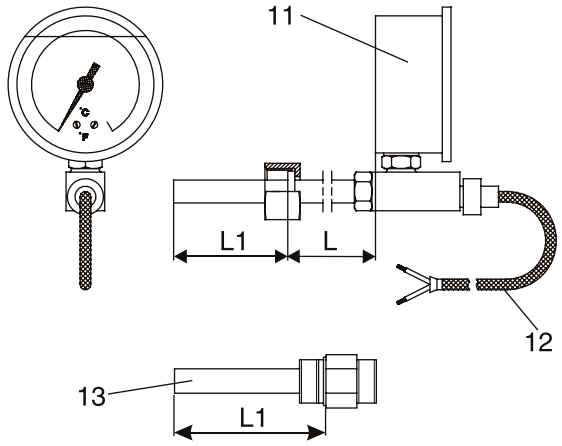
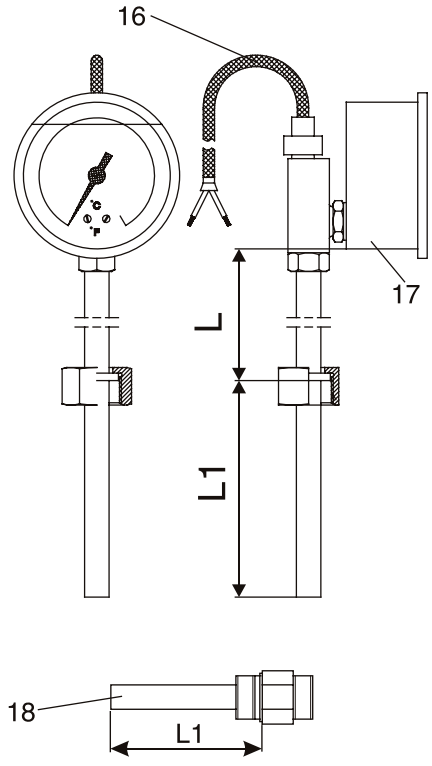
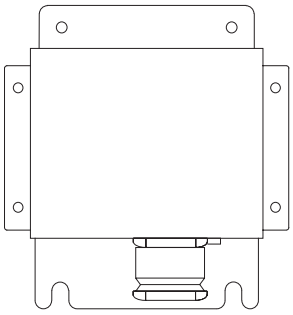
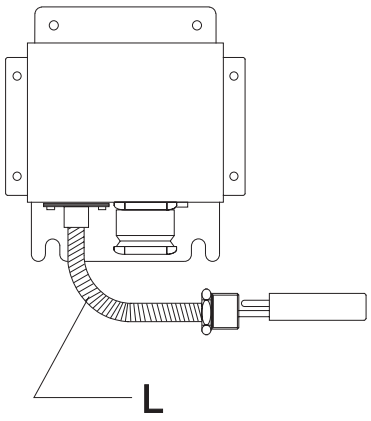
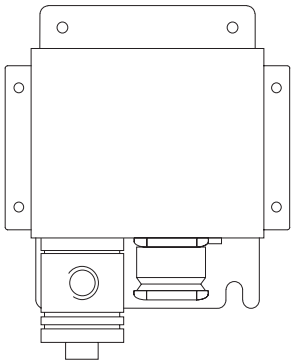
Fig.	Scale		Length		Code	Item No.
	°F	°C	L	L1		
	120-1200	50-650	140	215	TI 61 TI 62	10
	Thermo-meter					11
	Feeler NiCr-Ni					12
	Pocket			100		13
	120-1200	50-650	165	115	TI 60	14
	120-1200	50-650	190	115	TI 60	15
	Feeler NiCr-Ni					16
	Thermo-meter					17
	Pocket			200		18

Plate Page 1 (2)	**Pressostate, Thermostate Difference Pressostate and Pressure Transmitter**	**60907-02H**

General

Fig. and Description	Range	Code	L	Item No.
 Pressostate	0-8 bar	PSL 22 PAL 10 PAL 22		01
	6-18 bar	PAL 70 PAL 24		02
	10-35 bar			03
	1-10 bar	PAL 40		04
 Thermostate	20-60°C	TAL 10	2 m 5 m	05 06
	50-100°C		2 m 5 m 8 m	07 08 09
	70-120°C	TAH 12 TSH 12 TAH 20 TSH 22 TSH 12	2 m 5 m 8 m	10 11 12
 Difference Pressostate	0.2-2.5 bar	PDAH 21-22		13

60907-02H	**Pressostate, Thermostate Difference Pressostate and Pressure Transmitter**	Plate Page 2 (2)

General

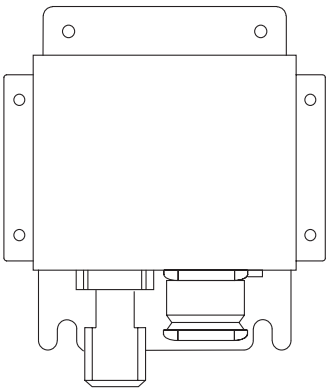
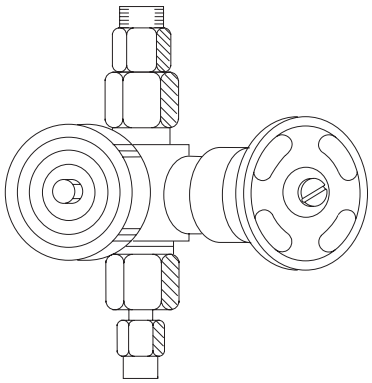
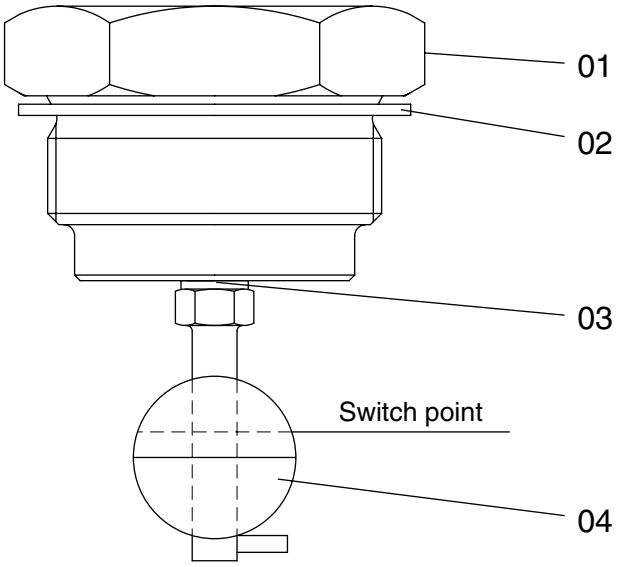
Fig. and Description	Range	Code	L	Item No.
 Pressure Transmitter	0-2.5 bar	PT 31		14
	0-4 bar	PT 10		15
	0-6 bar	PT 22		16
	0-10 bar	PT 40		17
	0-16 bar	PT 70		18
	0-40 bar			19
	0-400 bar			20
 Needle Valve	Needle Valve with 3/8" pipe thread			25
	Needle valve with 1/2" pipe thread			26

Plate Page 1 (2)	**Prelubricating Oil Alarm (LAL 25)**	**60919-01H**

L+V28/32H



08028-0D/H5250/94.08.12

60919-01H	Prelubricating Oil Alarm (LAL 25)	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Plug screw**	Propskrue
02	1/E	**Packing ring**	Pakningsring
03	1/E	**Loctite 577**	Loctite 577
04	1/E	**Level switch**	Niveauafbryder

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

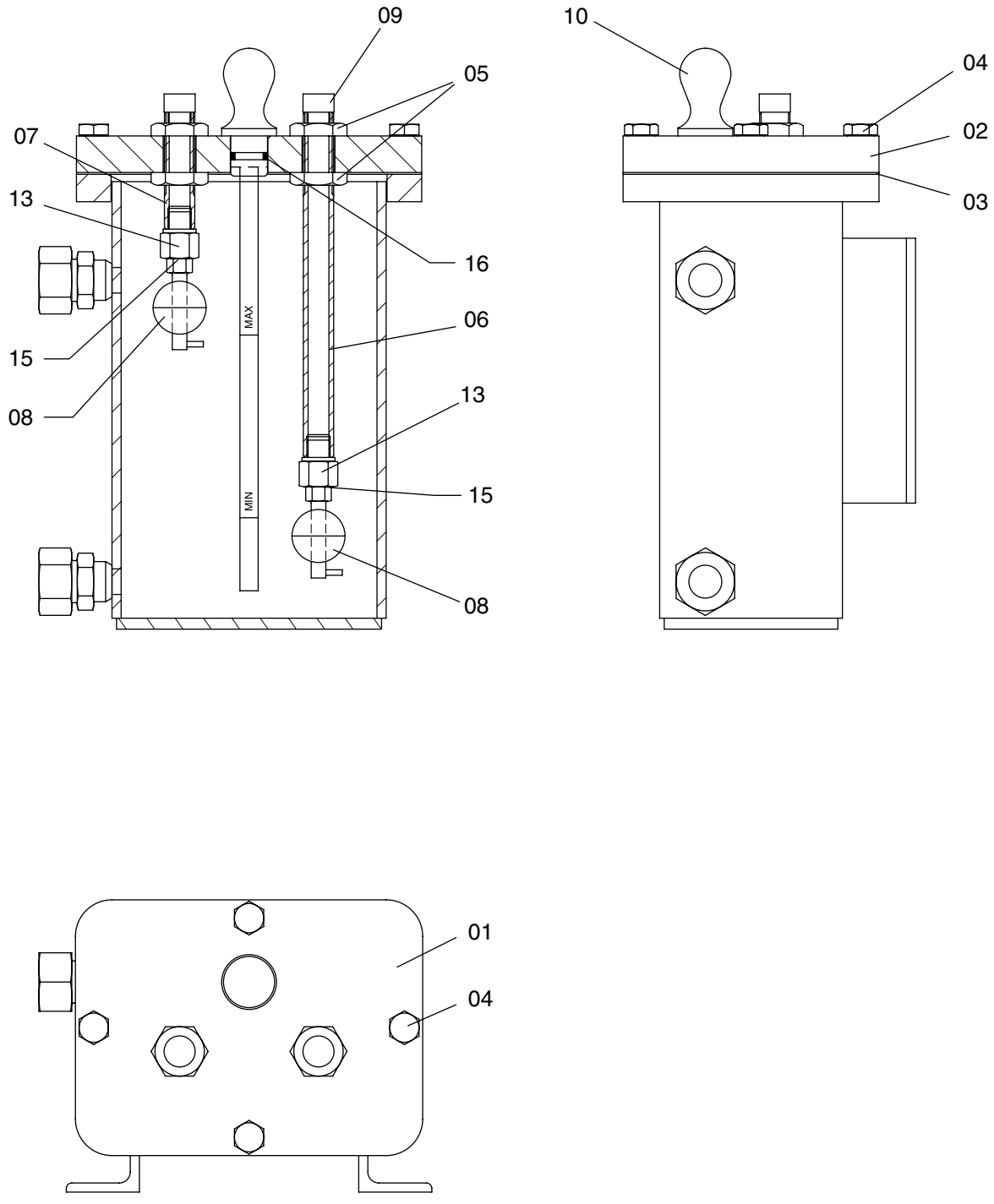
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Level Switch in Oil Sump (LAL/LAH 28)**	**60920-01H**

L28/32H



08028-0D/H5250/94.08.12

60920-01H	Level Switch in Oil Sump (LAL/LAH 28)	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Level alarm**	Niveaualarm
02	1/E	**Flange**	Flange
03	1/E	**Packing**	Pakning
04	4/E	**Screw**	Skrue
05	4/E	**Nut**	Møtrik
06	1/E	**Pipe, LAL**	Rør, LAL
07	1/E	**Pipe, LAH**	Rør, LAH
08	2/E	**Level switch**	Niveaukontakt
09	2/E	**Reduction adaptor**	Reduktionsadapter
10	1/E	**Dipstick complete**	Pejlestok komplet
13	2/E	**Reduction adaptor**	Reduktionsadapter
15	/I	**Loctite 577**	Loctite 577
16	1/E	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Engine

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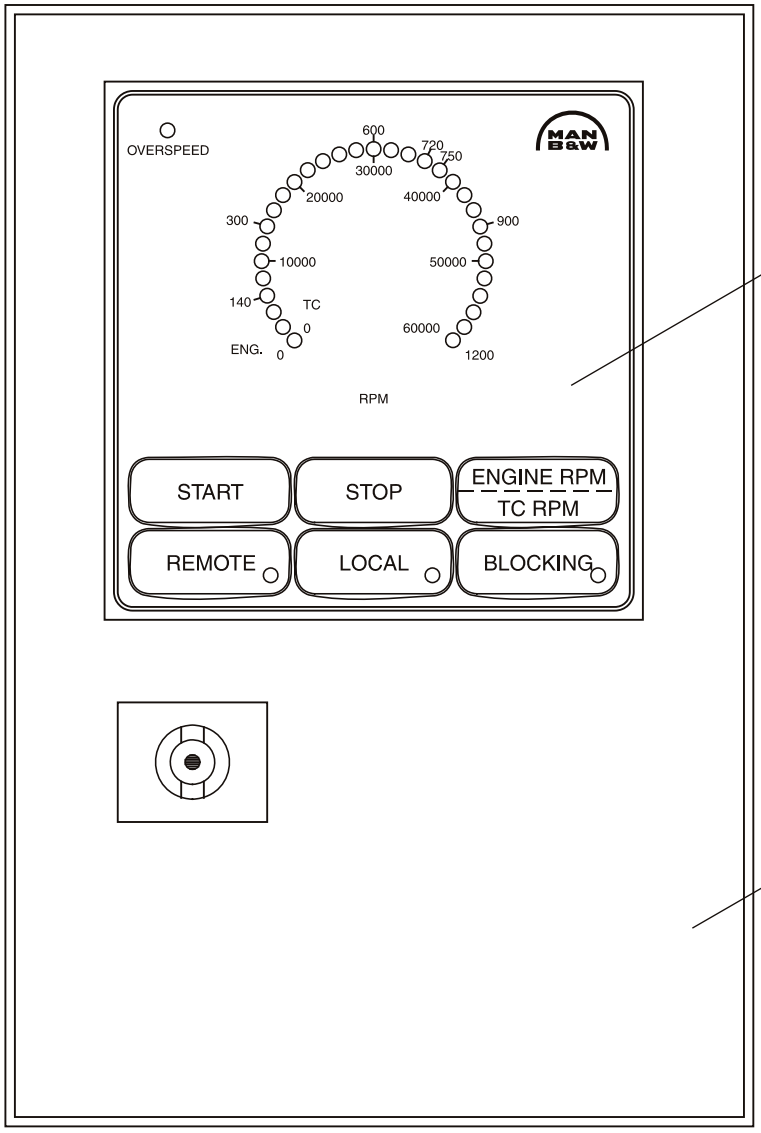
Antal/E = Antal/Motor

Plate Page 1 (2)	Local Starting Box - No 1	60935-13H

L+V28/32H



60935-13H	Local Starting Box - No 1	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/E	**Panel**	Panel
029	1/E	**Starting box**	Startboks

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Enigne.

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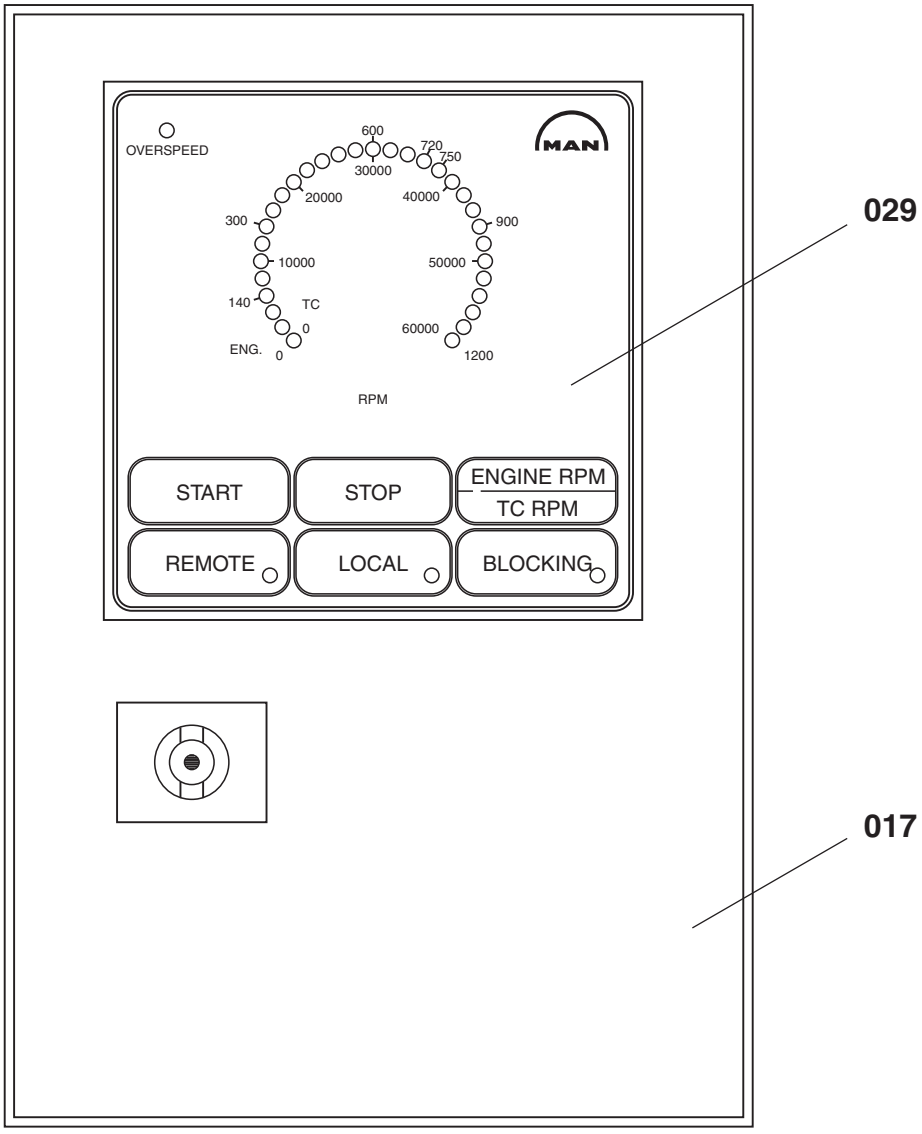
Qty./E = Qty./Motor

Plate Page 1 (2)	**Local Starting Box - No 1**	**60935-16H**

L28/32H



08028-0D/H5250/94.08.12

60935-16H	Local Starting Box - No 1	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/E	**Panel**	Panel
029	1/E	**Starting box**	Startboks

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Enigne.

Ved bestilling af reservedele, se også side 600.50.

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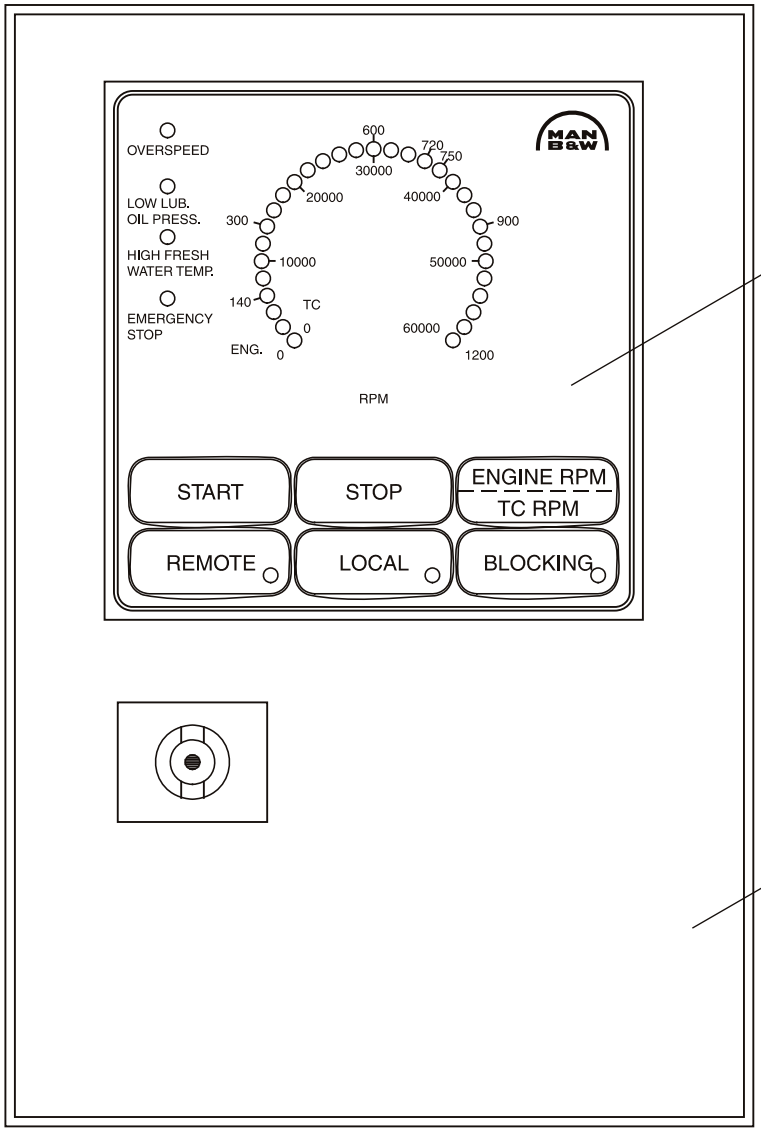
Qty./E = Qty./Motor

Plate Page 1 (2)	Local Starting Box - No 2	60935-14H

L+V28/32H



60935-14H	Local Starting Box - No 2	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/E	**Panel**	Panel
029	1/E	**Starting box**	Startboks

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

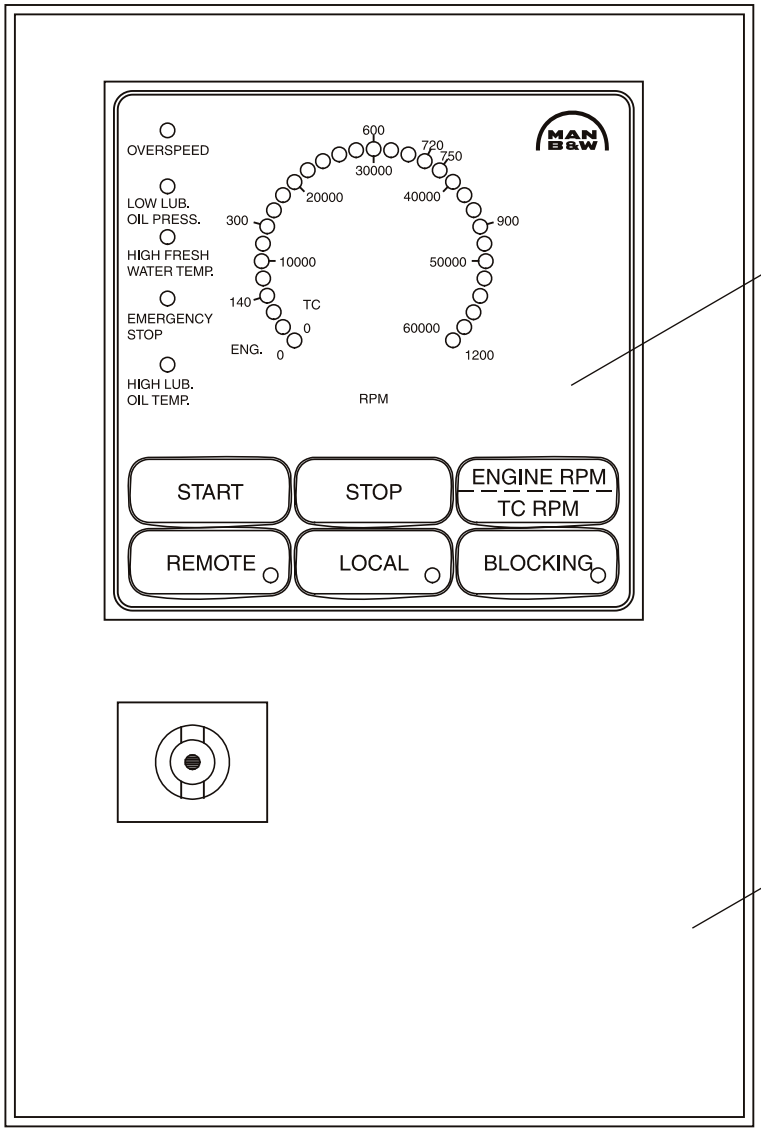
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Enigne.

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor

Plate Page 1 (2)	**Local Starting Box - No 2 (incl. high lub. oil temp.)**	**60935-15H**

L+V28/32H



60935-15H	Local Starting Box - No 2 (incl. high lub. oil temp.)	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/E	**Panel**	Panel
029	1/E	**Starting box**	Startboks

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

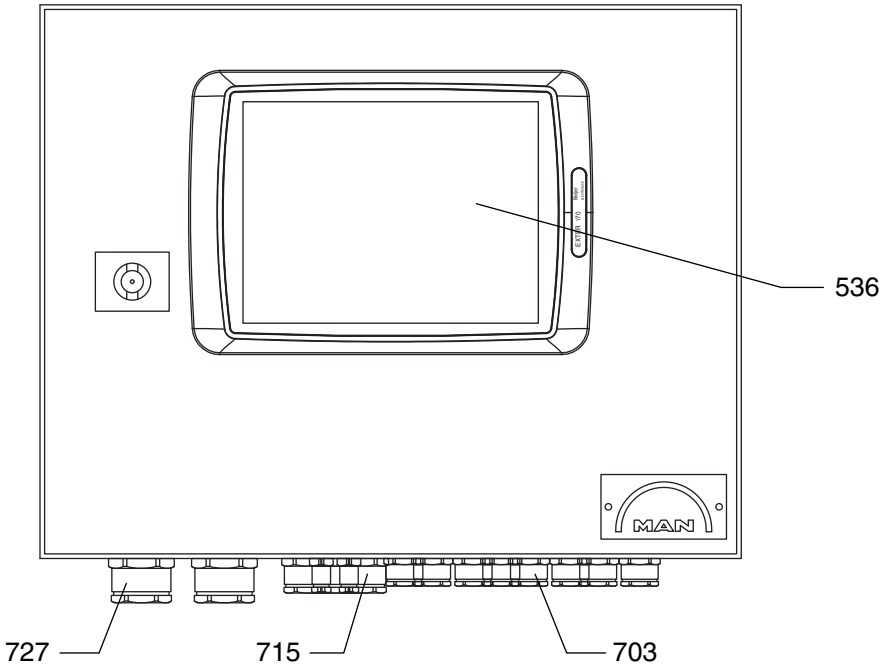
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Enigne.

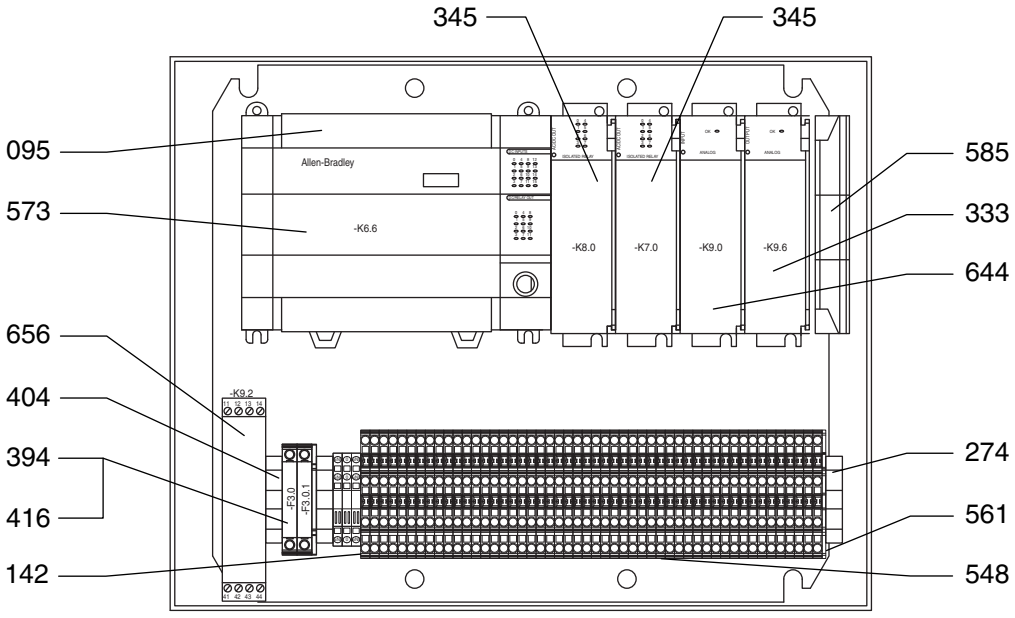
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor

Plate Page 1 (2)	Engine Control Box	60936-08H

General





General

Item no	Qty	Designation	Benævnelse
095	1/E	**Safety system, Base unit**	Sikkerhedssystem, Base unit
142	1/E	**Terminal, earth**	Jordklemme
274	3/E	**End stop**	Endestop
333	1/E	**Analog output module**	Analog outputmodul
345	2/E	**Digital output module**	Digital outputmodul
394	2/E	**Fuse terminal**	Sikringsklemme
404	1/E	**End plate**	Endeplade
416	4/E	**Fuse**	Sikring
536	1/E	**Panel**	Panel
548	50/E	**Terminal double**	Klemme, dobbelt
561	1/E	**End plate**	Endeplade
573	1/E	**Processor unit (CPU)**	Processor unit (CPU)
585	1/E	**End cap**	Endestykke
644	1/E	**Analog input module**	Analog inputmodul
656	1/E	**Converter**	Konverter
668	1/E	**Cable**	Kabel
703	8/E	**Cable union**	Kabelforskruning
715	3/E	**Cable union**	Kabelforskruning
727	2/E	**Cable union**	Kabelforskruning

Item no	Qty	Designation	Benævnelse

When ordering spare parts, see also page 500.50.

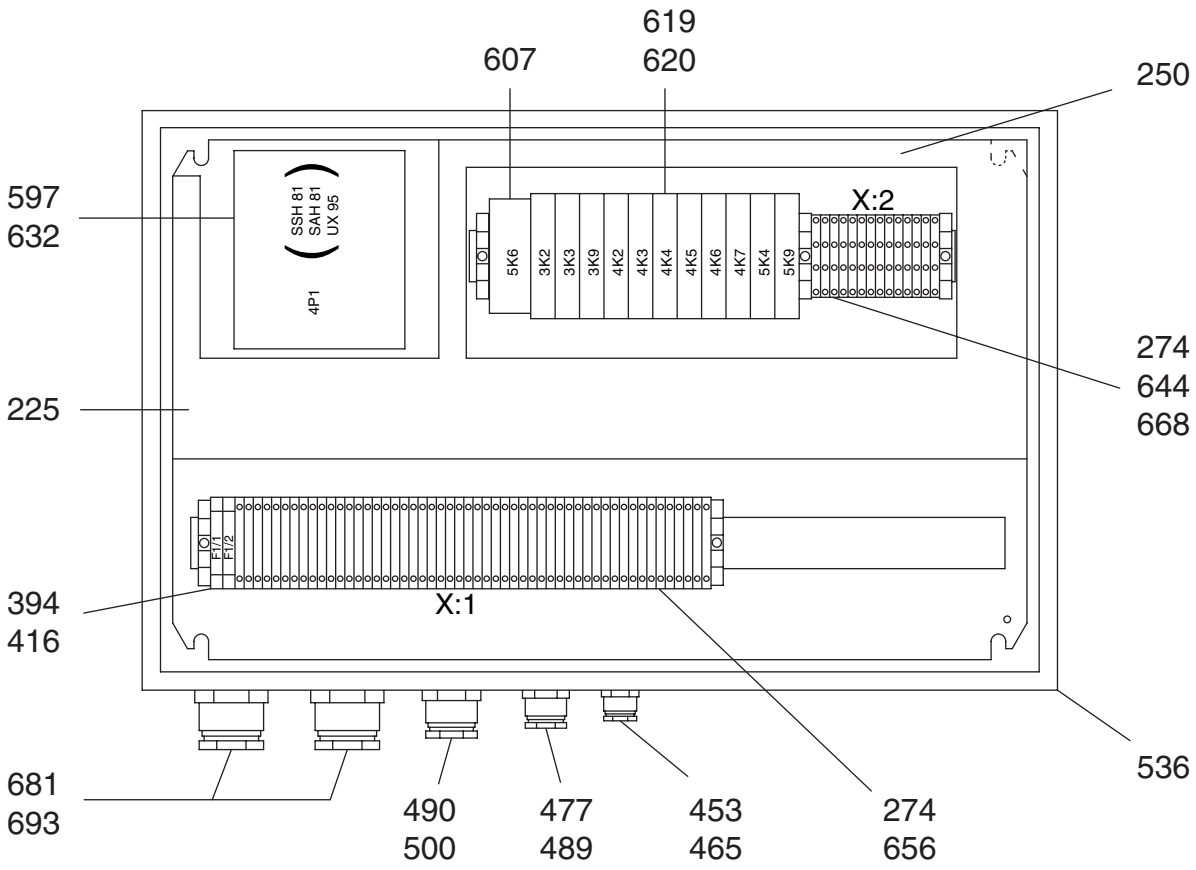
*** = Only available as part of a spare parts kit.**
Qty/E = Qty/Engine

Ved bestilling af reservedele, se også side 500.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty/E = Qty/Motor

Plate Page 1 (2)	Terminal Box	60936-07H

L28/32H



08028-0D/H5250/94.08.12

L28/32H

Item no	Qty	Designation	Benævnelse
225	1/E	**Conduit**	Ledningskanal
250	1/E	**Conduit**	Ledningskanal
274	4/E	**End stop**	Endestop
394	2/E	**Fuse terminal**	Sikringsklemme
416	2/E	**Fuse 2A**	Sikring 2A
453	2/E	**Cable union M16**	Kabelunion M16
465	2/E	**Nut M16**	Møtrik M16
477	2/E	**Cable union M20**	Kabelunion M20
489	2/E	**Nut M20**	Møtrik M20
490	2/E	**Cable union M25**	Kabelunion M25
500	2/E	**Nut M25**	Møtrik M25
536	1/E	**Panel**	Panel
597	1/E	**Speed converter, engine 720 rpm**	Speed converter, motor 720 omdr
607	1/E	**Timer**	Timer
619	11/E	**Aux. relay**	Hjælperelæ
620	11/E	**Socket**	Sokkel
632	1/E	**Speed converter, engine 750 rpm**	Speed converter, motor 750 omdr
644	12/E	**Terminal**	Klemme
656	54/E	**Terminal**	Klemme
668	2/E	**Diode terminal**	Diode klemme
681	3/E	**Cable union M32**	Kabelunion M32
693	3/E	**Nut M32**	Møtrik M32

Item no	Qty	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

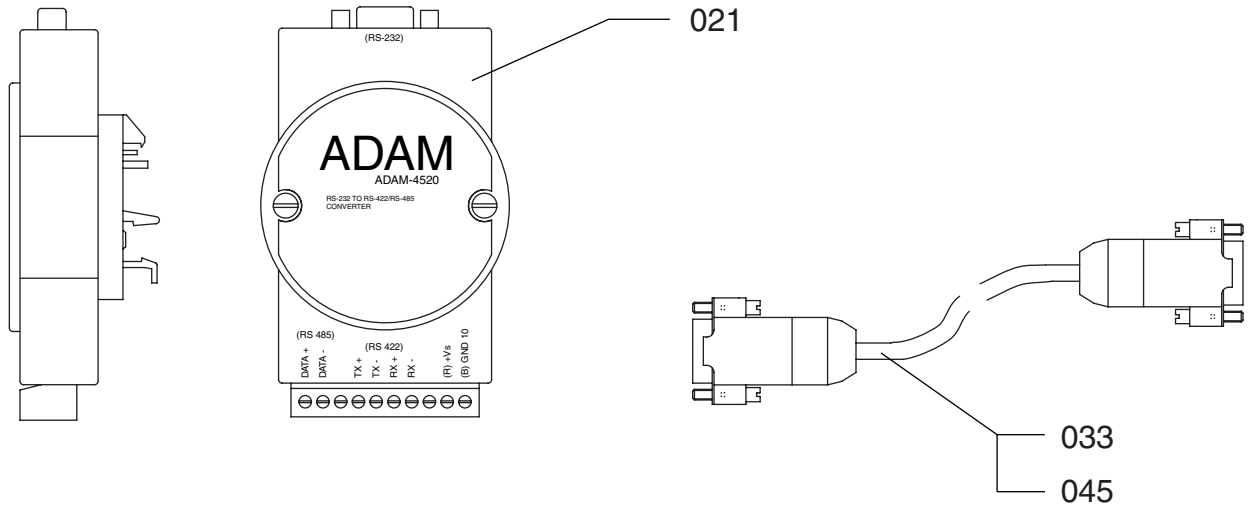
*** = Only available as part of a spare parts kit.**
Qty/E = Qty/Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty/E = Qty/Motor

Plate Page 1 (2)	**Converter**	**60956-01**

General



08028-0D/H5250/94.08.12

60956-01	Converter	Plate Page 2 (2)

General

Item no	Qty	Designation	Benævnelse
021	1/E	**Coverter**	Converter
033	1/E	**Cable, length 1.8 m**	Kabel, længde 1.8 m
045	1/E	**Cable, length 10 m**	Kabel, længde 10 m

Item no	Qty	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

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Qty/E = Qty/Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty/E = Qty/Motor

Crankshaft

510/610

L/V28/32H

Crankshaft

The crankshaft, which is a one-piece forging with ground main bearing and crankpin journals, is suspended in inderslung bearings. The main bearings are equipped with insertion-type shells, which are coated with a wearing surface. To attain a suitable bearing pressure the crankshaft is provided with counterweights, which are attached to the crankshaft by means of dovetail joints and secured with a centrally placed screw.

At the flywheel end the crankshaft is fitted with a gear wheel which through an intermediate wheel drives the camshaft. Also fitted here is the flywheel and a coupling flange for connection of a reduction gear or a alternator. At the opposite end there is a claw-type coupling for the lub. oil pump or a flexible gear wheel connection for lub. oil and water pumps.

Vibration Damper

In special cases a vibration damper is mounted on the crankshaft to limit torsional vibrations. The damper consists essentially of a heavy flywheel totally enclosed in a light casing. A small clearance is allowed between the casing and the flywheel, and this space is filled with a highly viscous fluid. The casing is rigidly connected to the front end of the engine crankshaft and the only connection between the crankshaft and the damper flywheel is through the fluid. Under conditions of no vibration, the casing and damper flywheel tend to rotate as one unit, since the force required to shear the viscous film is consi-derable. As the torsional vibration amplitudes increase, the casing follows the movement of the crankshaft but the flywheel tends to rotate uniformly by virtue of its inertia, and relative motion occurs between the flywheel and the casing. The viscous fluid film therefore undergoes a shearing action, and vibration energy is absorbed and appears as heat.

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Working Card Page 1 (6)	**Checking of Main Bearings Alignment (Deflection) (Hydraulic Tightened Connecting Rod)**	**610-01.00** Edition 10H

L28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Checking of main bearings alignment (deflection).

Starting position:

Turning gear in engagement. (If mounted).
Cover for crankshaft has been removed from frame.
All indicator valves open.

Related procedure:

Man power:

Working time : 1 1/2 hours
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62010	01	
62010	05	
62010	35	Angle for mounting on crank web

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

L28/32H

Alignment of Main Bearings.

The lower main bearing shells should be positioned so that they keep the main bearing journals of the crankshaft centered in a straight (ashore horizontal) line. Deviations from this centre line cause the crankshaft to bend and increase the load on some main bearings.

If two adjacent main bearings are placed too low, the crankshaft centre line will in this place be lowered to form an arc, causing the intermediate crank throw to bend in such a way that it "closes" when turned into bottom position and "opens" in top position.

As the magnitude of such axial lengthening and shortening during the turning of the throw increases in proportion to the difference in the height of the bearing, it is measured as a check on the alignment and condition of the bearing.

As the crankshafts of medium speed engines are very stiff, any great deviations in the alignment will result in clearance at the bottom shell of the bearings.

The cause of incorrect main bearing position may be wear of the bearings or misalignmnet of the engine.

Effecting The Deflection Measurement.

The deflection measurement is effected by placing a springloaded dial gauge in the centre punch marks provided for this purpose, see fig. 1.

"Closing" of the throw in top dead centre is regarded as negative, (compression of the gauge).

In the example, page 3, the deflection reading is therefore negative.

As during the turning of the throw, the gauge and the connecting rod will meet near the bottom position of the throw, the measurement for the bottom position is to be replaced by the average of the two near by positions on either side.

The dial gauge is set to zero, when the crank throw is in the near-bottom (x in fig. 8) and during the turning the throw is stopped in the position horizontal-top-horizontal-near bottom (P-T-S-Y in fig. 8) for reading of the gauge.

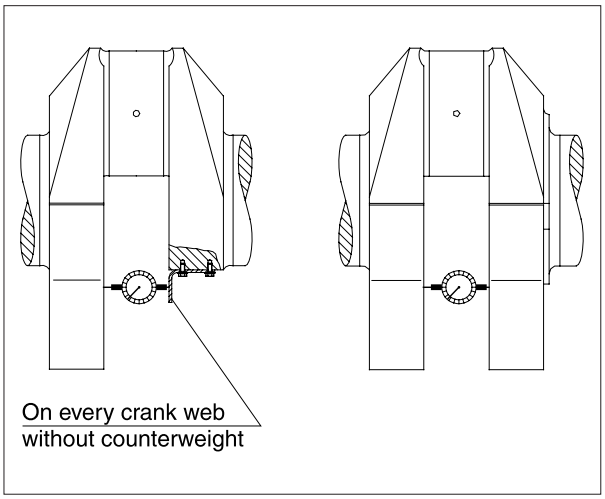

Fig. 1 Placing of dial gauge

Checking The Deflection Measurement.

The reading is entered in the table page 6, see example in fig. 2 - 6.

As "bottom" reading is used the mean value of the two "near bottom" readings X and Y, fig. 3.

The total deflection ("opening-closing") of the throw during the turning from bottom to top position is entered in fig. 4.

These figures are due to vertical misalignment of the main bearings.

Similarly, horizontal misalignment procedures the figures in the table fig. 5.

Besides misalignment of the bearings, the readings can be influenced by ovality or eccentricity of the journals.

Engines Equipped with Turning Gear.

When taking these deflection readings for the three aftmost cylinders, the turning gear should at each stoppage be turned a little backwards to ease off the tangential pressure on the teeth of the turning wheel as this pressure may otherwise falsify the readings.

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Deflection of crankshaft in 1/100 mm. (0.01 mm).

Crank position		Cyl. No. 1	2	3	4	5	6
Bottom start	X	0	0	0	0	0	0
Left side	P	2	0	2	0	-1	2
Top	T	3	-2	4	5	-2	3
Right side	S	3	-2	2	0	0	1
Bottom stop	Y	2	-1	0	1	0	2

Fig. 2.

Bottom (0,5 x Y) =	B	1	-0.5	0	-0.5	0	1

Fig. 3.

Deflection from vertical misalignment top - bottom or T - B =	V	2	-1.5	4	4.5	-2	2

Fig. 4.

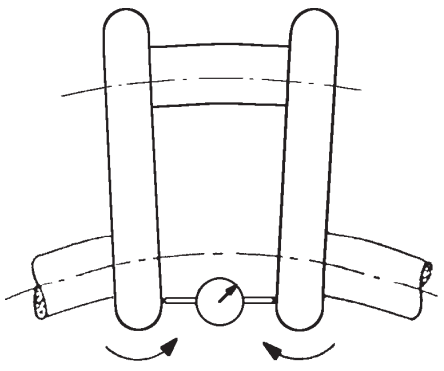
Deflection from horizontal misalignment Right side - left side or P - S =	H	-1	2	0	0	-1	1

Fig. 5.

Check on gauge readings	T + B = C	4	-2.5	4	5.5	-2	4
	P + S = D	5	-2	4	0	-1	3

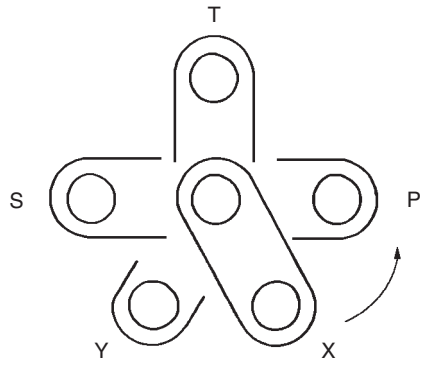
Fig. 6.

C and D should be nearly the same, reading for cylinder 4 to be repeated.



"Closing" of the crankthrow is considered negative.

Fig. 7.



Front end view.
Start in position X.
Turn anti clockwise

Fig. 8.

08028-0D/H5250/94.08.12

L28/32H

Measurement of Crank Throw Deflections by Means of Dial Indicator (Autolog)		
Crank throw deflection	=	Difference in dial indicator readings in two diametrically opposite crank throw positions, i.e. two positions displaced 180°.
Vertical deflection	=	Difference in top-bottom readings.
Horizontal deflection	=	Difference in side-side readings.

Vertical and Horizontal Deflections of Crank Throws Unless otherwise stated the values refer to cold engine.		
For new or realigned aggregate	Aim for Acceptable	+ or - 4/100 mm + or - 6/100 mm
For aggregate in service realignment is recommended if deflections exceed		+ or -10/100 mm

Vertical Deflection of Crank Throw at Flywheel Unless otherwise stated the values refer to cold engine.	
Rigid coupling between diesel engine and driven machine	Flexible coupling between diesel engine and driven machine
For new or realigned aggregate 0 to + 4/100 mm	For new or realigned aggregate Aim for - 7/100 mm Acceptable - 10/100 mm
For aggregate in service realignment is recommended if deflection measured on warm engine exceeds - 10/100 mm	For aggregate in service realignment recommendable if deflection exceeds - 14/100 mm

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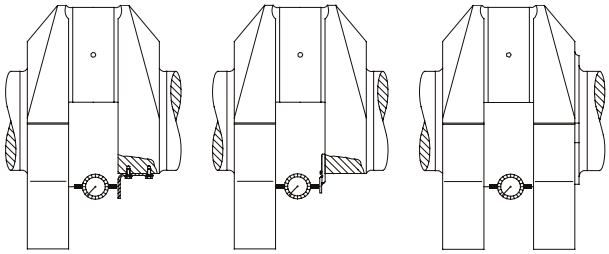
Working Card Page 5 (6)	**Checking of Main Bearings Alignment (Deflection)** **(Hydraulic Tightened Connecting Rod)**	**610-01.00** Edition 10H

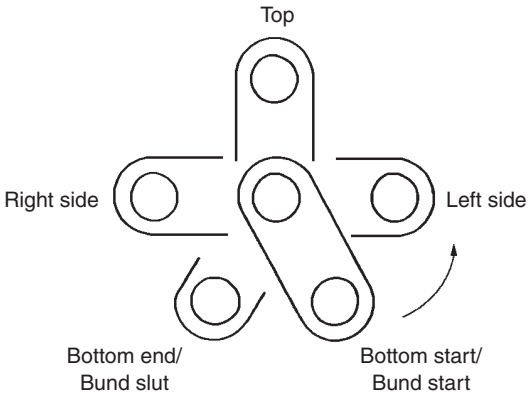
L28/32H

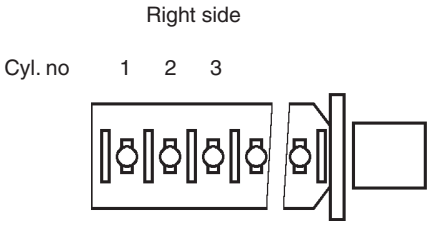
Process/Proces		I.D. no.
Plant/Anlæg		Page of/Side af
Engine Type/Motortype	Engineer/Operatør	Date/Dato

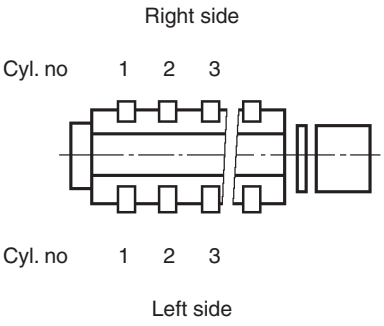
Instruction/Instruktion



1/100 mm







Remarks/Bemærkninger

08028-0D/H5250/94.08.12

610-01.00 Edition 10H	**Checking of Main Bearings Alignment (Deflection)** **(Hydraulic Tightened Connecting Rod)**	Working Card Page 6 (6)

L28/32H

Component/Komponent	Type	I.D. no.
Process/Proces		Page of/Side af

Test place/ Condition Teststed/ Tilstand	☐ Test bed/prøvehal ☐ On board/Om bord ☐ Plant/Maskinhal	☐ Cold/Kold ☐ Warm/Varm
Engine no.: Motornr.:		

Cyl. no.		1	2	3	4	5	6	7	8	9
Bottom	X	0	0	0	0	0	0	0	0	0
Left side	P									
Top	T									
Right side	S									
Bottom	Y									

Bottom (0.5xY)=B									

Deflection from vertical misalign-ment. Top - bottom or T - B = V									

Deflection from horizontal mis-alignment. Left side - Right side or P - S = H									

Check on gauge readings. T + B = C									
P + S = D									

08028-0D/H5250/94.08.12

Working Card Page 1 (3)	**Inspection of Main Bearing Shells**	**610-01.05** Edition 05H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismantling, inspection and/or replacement and mounting of main bearing shells.

Starting position:

Related procedure:

Inspection of guide bearing shell,	610-01.10
Criteria for replacement of bearings,	606-01.16

Manpower:

Working time	:	2	hours
Capacity	:	2	men

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no	Item no	Note
62010	10	2 pieces
62010	20	
62010	01	
62010	15	2 pieces
62010	30	Extra tools
62021	40	Hydraulic tools
62021	50	2 pieces
62021	51	
62021	20	

Hand tools:

Allen key, 12 mm.
Socket spanner, 36 mm.
Lead hammer.
Silastene.
Copaslip.

Replacement and wearing parts:

Plate no	Item no	Qty/

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L+V28/32H

Make Ready for Dismantling of the Main Bearing

1) Dismount crankcase covers in front and opposite the bearing concerned.

2) Turn the engine until the crank is in a convenient position for carrying out the work.

3) Dismount the bracing screw (side screw).

4) Mount the hydraulic tools and loosen the main bearing stud nuts. For operation of the hydraulic tools, see working card 620-01.05.

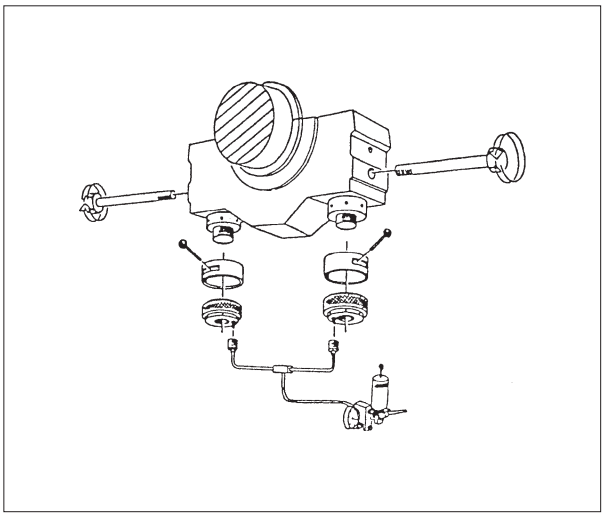

Fig 1. Mounting of Hydraulic Tools.

5) Dismount the hydraulic tools and slacken the nuts somewhat.

Dismantling of the Main Bearing Cap

6) Fit the eye screws, diagonally, in the threaded holes in the main bearing cap, see fig 2.

Pass the wire supplied through the eye screw and attach it as shown, so as to keep the bearing cap in place when the main bearing stud nuts are removed.

7) Work the main bearing cap loose from the engine frame with a lead hammer or similar.

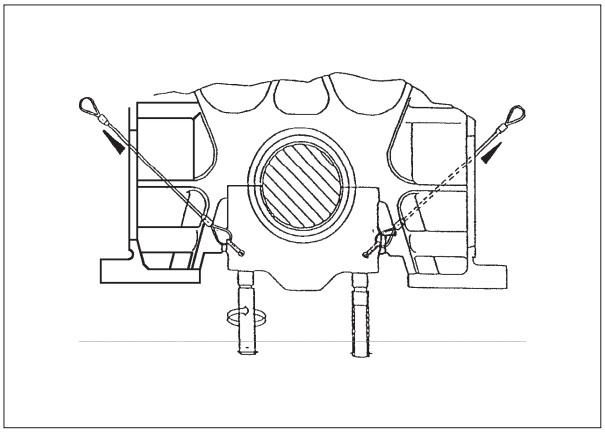

Fig 2. Mounting of Wire Straps.

8) Lift the main bearing cap a little and unscrew the bearing stud nut.

9) Fit guide tubes on the threads of the bearing studs and lower the bearing cap to make it rest on the collar of the guide tubes.

Dismantling of the Main Bearing Shells

10) Remove the locking piece from the bearing cap and take out the bearing shell.

11) Fit the tool for upper main bearing, for dis-mantling of upper main bearing shell, in the lubricating hole in the crankshaft and turn out the upper bearing shell by turning the crankshaft, see fig 3.

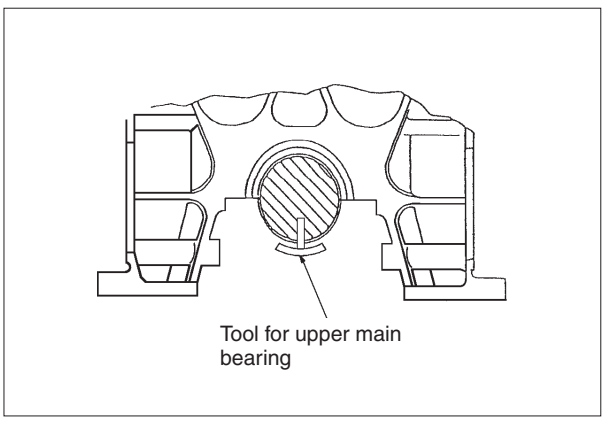

Fig 3. Mounting of tool for upper main bearing.

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Cleaning

12) Clean all machined surfaces, on frame, bearing cap, stud, nuts and bearing shells.

Inspection of Main Bearing Shells

13) Inspect the main bearing shells according to working card 606-01.16.

Note: The bearing is marked according to size and when replaced it must be by a new bearing of the same size.

Mounting of the Main Bearing Shells

14) Push the upper bearing shell as far into position as possible.

15) Fit the tool for upper main bearing in the lubricating hole in the crankshaft and turn in the upper bearing shell by turning the crankshaft.

Make sure that the shell enters its correct position then remove the tool for upper main bearing.

16) Lubricate the end of the bearing shells with molycote pasta or similar.

17) Insert the lower bearing shell in the bearing cap and mount the locking piece.

Lubricate the bearing shell and journal with clean lubricating oil.

Mounting of the Main Bearing Cap

18) Raise the bearing cap into position, dismount the guide tubes, coat the bearing studs with molycote pasta or similar and fit the bearing stud nuts.

Make sure that the bearing cap and bearing shell are in their correct position.

19) Dismantle the wire straps.

20) Mount the hydraulic tools, see working card 620-01.05, and tighten the nuts as prescribed on page 600-40.

21) Coat the back side of the bracing screws' (side screws') hexagonal head with a thin coat of silastene or similar.

22) Mount the screws and tighten with a torque spanner as indicated on page 600.40.

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Working Card Page 1 (4)	Inspection of Guide Bearing Shells	610-01.10 Edition 08H

L+V28/32H

Safety precautions

- [x] Stopped engine
- [x] Shut-off starting air
- [ ] Shut-off cooling water
- [ ] Shut-off fuel oil
- [ ] Shut-off cooling oil
- [x] Stopped lub. oil circul.

Description

Dismantling, inspection and/or replacement and mounting of guide bearing shells and thrust washer.

Starting position

Related procedure

Inspection of main bearing shells.	610-01.05
Criteria for replacement of bearing shells.	606-01.16

Manpower

Working time : 2 hours
Capacity : 2 men

Data

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools

Plate no	Item no	Note
62006	28	140 - 760 Nm
62010	10	2 pieces
62010	20	
62010	01	
62010	25	
62010	15	2 pieces
62010	30	Extra tools
62021	40	Hydraulic tools
62021	50	2 pieces
62021	51	
62021	20	

Hand tools

Allen key, 12 mm
Socket spanner, 36 mm
Lead hammer
Silastene
Molycote

Replacement and wearing parts

Plate no	Item no	Qty/

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Make Ready for Dismantling of the Guide Bearing

1) Dismount the crankcase covers opposite the bearing concerned.

2) Turn the engine until the crank is in a convenient position for carrying out the work.

3) Dismount the bracing screw (side screw).

4) Mount the hydraulic tools, see fig 1, and loosen the guide bearing stud nuts. For operation of the hydraulic tools, see working card 620-01.05.

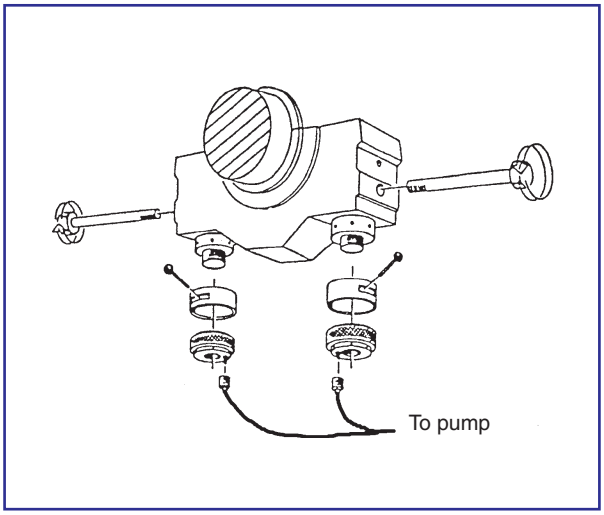

Fig 1 Mounting of Hydraulic Tools

5) Dismount the hydraulic tools and slacken the nuts somewhat.

Dismantling of the Guide Bearing Cap

6) Fit the eye screws, diagonally, in the threaded holes in the guide bearing cap, see fig 2.

   Pass the wire supplied through the eye screw and attach it as shown, so as to keep the bearing cap in place when the guide bearing stud nuts are removed.

7) Work the guide bearing cap loose from the engine frame with a lead hammer or similar.

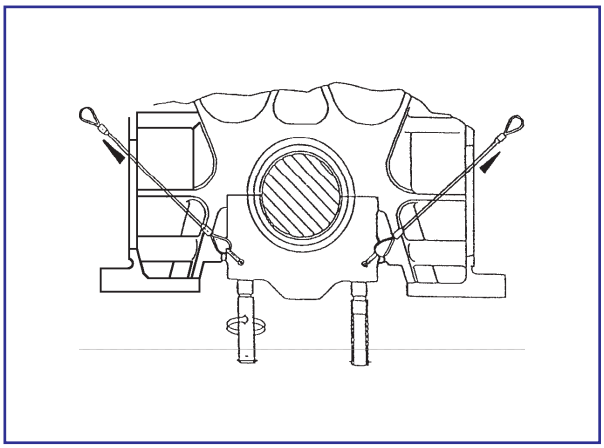

Fig 2 Mounting of Wire Straps

8) Lift the guide bearing cap a little and unscrew the bearing stud nut.

9) Fit guide tubes on the threads of the bearing studs and lower the bearing cap to make it rest on the collar of the guide tubes.

Dismantling of the Guide Bearing Shells

10) Remove the locking piece from the bearing cap and take out the bearing shell.

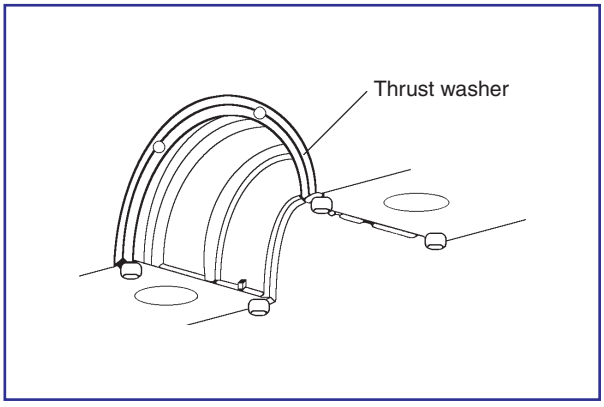

Fig 3 Guide Bearing with Thrust Washer

The thrust washer of the guide bearing is partially countersunk into the engine frame and attached by means of four screwed-on clamps which are visible after lowering the bearing cap, see fig 3.

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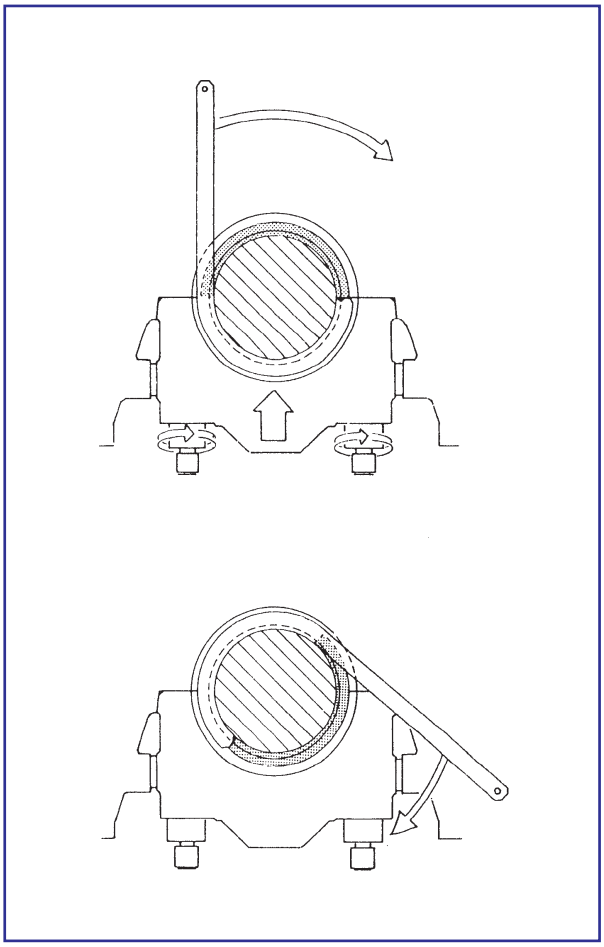


Fig 4 Dismounting of Upper Shell

11) Unscrew the clamns and push out the thrust washers.

12) Fit the tools for dismantling of upper guide bearing shell, see fig 4, in the bearing cap and raise the bearing cap into position, making sure that the guide shell is not being damaged.

After that, dismount the guide tubes, fit and tighten the nuts slightly.

13) With the guide shell tool, which is guided by the bearing cap, the upper bearing shell is carefully turned out into the bearing cap. Then dismount the nuts and lower the bearing cap on the collar of the guide tubes. Take out the bearing shell and the guide shell tool.

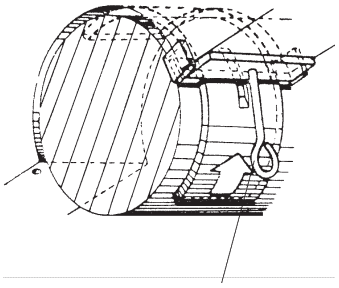
In case the guide shell tool is locked between guide bearing and bearing studs, use the bolt on the back of the guide shell tool to dislodge it.

Cleaning of Components

14) Clean all machined surfaces, on frame, bearing cap, stud, nuts and bearing shells.

Inspection of Guide Bearing Shells

15) Inspect the guide bearing shells according to working card 606-01.16.



Guide for mounting of upper shell.

Fig 5 Mounting of Upper Shell in Guide Bearing

Mounting of the Guide Bearing Shells

The bearing shells of the guide bearing, which are identical to those of the main bearings, are narrower than the bore for the guide bearing and it is therefore essential that the shells are positioned perfectly correct in the bore.

For this purpose a guide tool is supplied for positioning on the engine frame when the upper bearing shell is to be fitted, see fig 5.

16) Push the bearing shell as far as possible into position through this guide tool.

17) Insert the guide shell tool in the bearing cap, which is resting on the collar of the guide tubes.

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18) Raise the bearing cap with the guide shell tool into its correct position, dismount the guide tubes, fit and tighten the bearing stud nuts slightly.

19) Now push the bearing shell into its correct position with the guide shell tool.Make sure that the shell enters its correct position.

20) Then unscrew the bearing stud nuts, fit the guide tubes and lower the bearing cap again.

21) Fit the thrust washers and clamps.

Note: Clearance in guide bearing axially, see page 600.35.

22) Lubricate the end of the bearing shells with molycote pasta or similar.

23) Insert the lower bearing shell in the bearing cap, and mount the locking piece.

Bearing Cap

Lubricate the bearing shell and journal with clean lubricating oil.

24) Raise the bearing cap into position, dismount the guide tubes, coat the bearing stud with molycote pasta or similar and fit the bearing stud nuts.

Make sure that the thrust washers, bearing shell and bearing cap are in their correct position.

25) Dismantle the wire straps.

26) Mount the hydraulic tools, see working card 620-01.05, and tighten the nuts as prescribed on page 600-40.

27) Coat the back side of the bracing screws' (side screws') hexagonal head with a thin coat of silastene or similar.

28) Mount the screws and tighten with a torque spanner as indicated on page 600.40.

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Working Card Page 1 (3)	Vibration Damper	610-04.00 Edition 01H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Taking a silicone oil sample

Starting position:

Related procedure:

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Ring and open end spanner, 19 mm.

Man power:

Working time	:	2-4	hours
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

See plate 61004

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General

The vibration damper is equipped with extraction plugs which provide the opportunity of testing the viscosity of the silicone oil inside the damper without having to dismantle it.

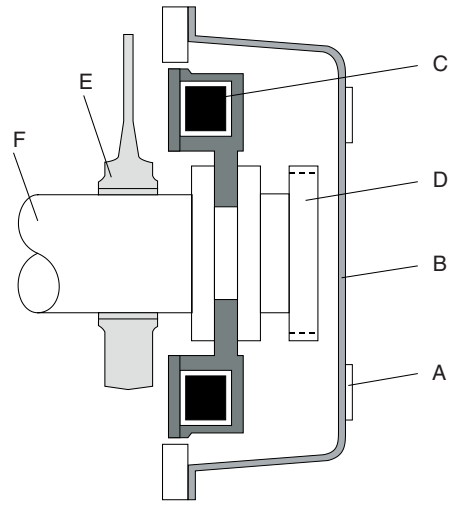
Corresponding to the condition of the silicone oil an approximate assessment of the damper efficiency is possible.

A silicone oil sample should be extracted as follows by means of a special tube that can be required from MAN Diesel & Turbo, PrimeServ Holeby, see plate 61004.

1. After the engine is stopped let damper cool down to approximately 40°C.

2. For access to the damper remove the blank flange (A) on the front end cover (B) see fig. 1.

In some cases it is necessary to dismount the lub. oil pump or the cooling water pump, for access to the damper.



A. Blank flange or cooling water pump.
B. Front end cover.
C. Damper.
D. Gearwheel (if mounted)
E. Main bearing (Frame)
F. Crankshaft.

Fig. 1. Mounting of Vibration Damper.

3. Rotate the engine in order to bring the extraction plugs (6) of the damper in optimal position, see fig. 2 A .

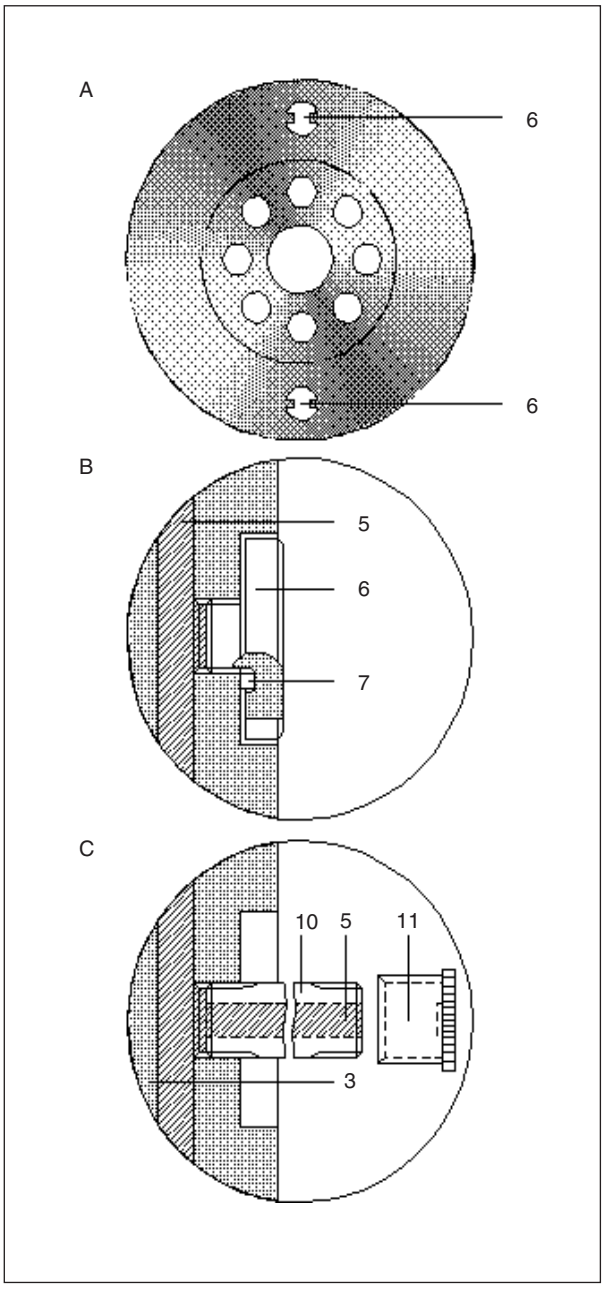


Fig. 2. Vibration Damper

4. Prepare the sample container (10) by removing one of its caps (11), see fig. 2 C.

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General

5. Unscrew and remove one of the extraction plugs (6) and replace it with the sample container (10).

If meeting the inertia ring (3) unscrew the container one revolution.

6. Remove the second cap from the sample container and wait until silicone fluid (5) begins to flow out from the free end. Depending on the silicone viscosity the process needs a certain amount of time. If possible it, can be speeded up by means of:

A Turning the damper until the sample container is underneath the crankshaft.
B Temporarily removing the second extraction plug too.

7. As soon as the silicone fluid begins to flow, close the sample container by the cap. Remove the container from the damper casing, wipe off the sealing jace round the extraction hole and screw in the plugs together with new sealing washers (7). Now close the second side of the container.

8. Tighten both extraction plugs with thumb and forefinger then turn them further 45° (about 20 Nm). Seal both plugs by caulking their grooves.

9. Send the sample container to:

MAN Diesel & Turbo
PrimeServ Holeby
Østervej 2
4960 Holeby
Denmark

The sample must be marked in such a way that we can forward the result of the analysis correctly.

- Name of ship.
- Engine type.
- Engine no.
- Running hours.
- Data for vibration damper.

10. For hours between taking new samples, see page 600.25.

The quantity of silicone oil removed its so small that up to 10 such samples can be taken without risk.

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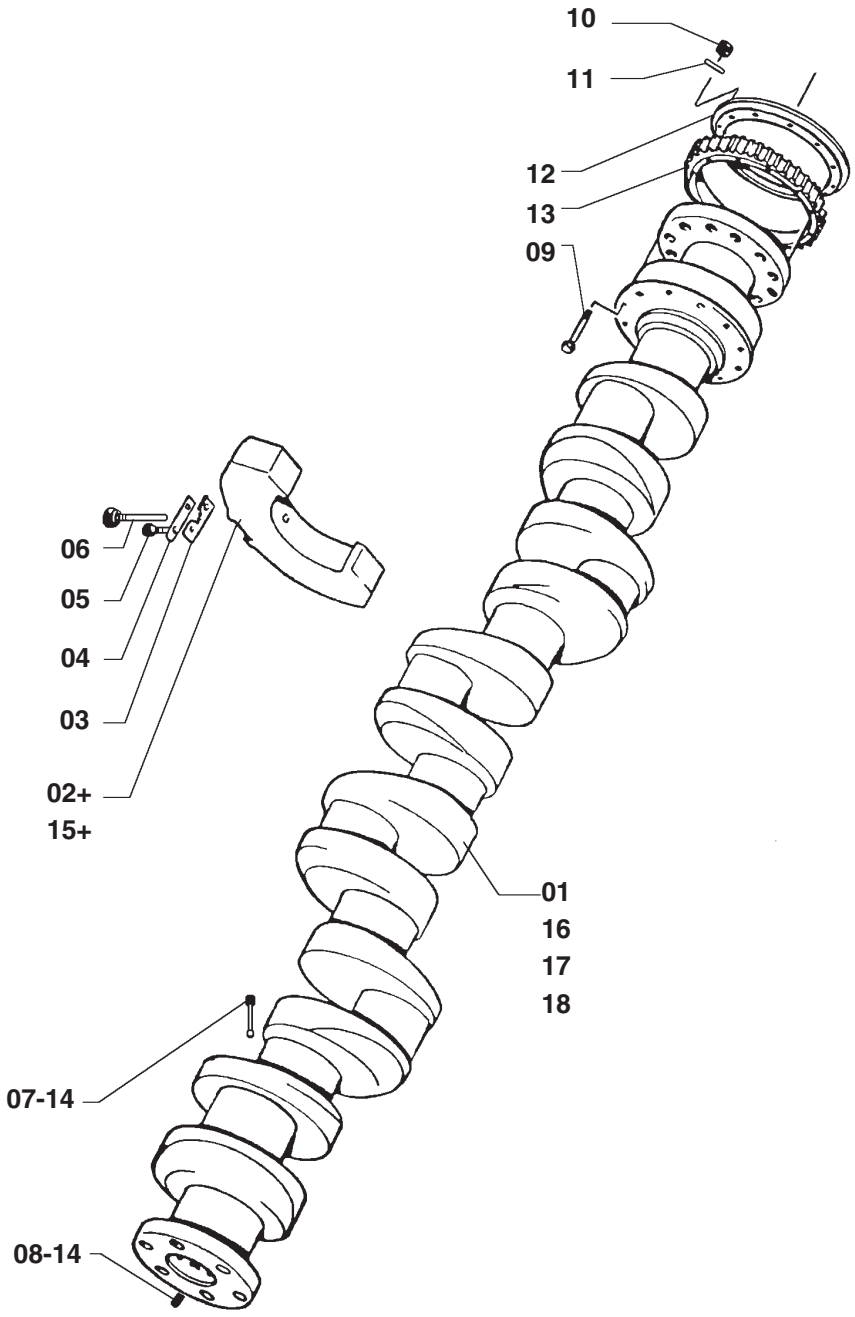
Plate Page 1 (2)	**Crankshaft**	**61001-15H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Crankshaft 6 cyl. engine**	Krumtapaksel 6 cyl. motor
02+	/I	**Counterweight 6,7,9 cyl. engine**	Kontravægt 6,7,9 cyl. motor
03	1/W	**Locking plate**	Sikringsplade
04	1/W	**Locking plate**	Sikringsplade
05	2/W	**Screw**	Skrue
06	1/W	**Screw for counterweight**	Skrue for kontravægt
07	1/C	**Plug screw**	Propskrue
08	1/E	**Plug screw**	Propskrue
09	12/E	**Screw**	Skrue
10	12/E	**Self locking nut**	Selvlåsende møtrik
11	12/E	**Washer**	Skive
12	1/E	**Oil throw ring**	Olieafslyngningsring
13	1/E	**Gear wheel (crankshaft)**	Tandhjul (krumtap)
14	/I	**Loctite 242**	Loctite 242
15+	/I	**Counterweight 8 cyl. engine**	Kontravægt 8 cyl. motor
16	1/E	**Crankshaft 7 cyl. engine**	Krumtapaksel 7 cyl. motor
17	1/E	**Crankshaft 8 cyl. engine**	Krumtapaksel 8 cyl. motor
18	1/E	**Crankshaft 9 cyl. engine**	Krumtapaksel 9 cyl. motor
		+ Item No. 02 and 15 require an individual matching before mounting contact MAN Diesel, Holeby	+ Item nr. 02 og 15 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

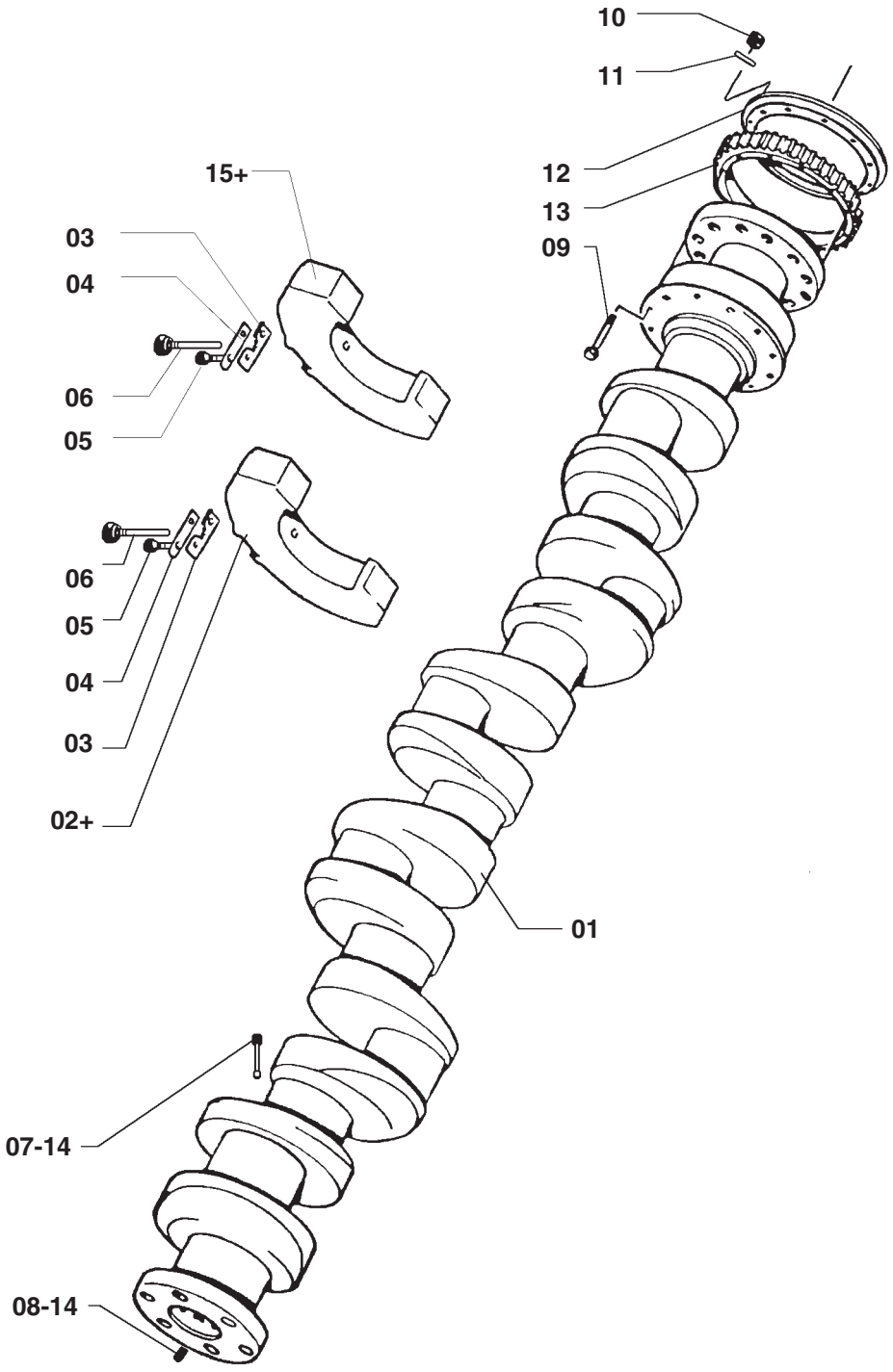
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./W = Qty./Counterweight
Qty./I = Qty./Individual
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/W= Antal/Kontravægt
Antal/I = Antal/Individuelt
Antal/C = Antal/Cylinder

Plate Page 1 (2)	Crankshaft	61001-21H

5L28/32H



5L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Crankshaft**	Krumtapaksel
02+	/I	**Counterweight**	Kontravægt
03	1/W	**Locking plate**	Sikringsplade
04	1/W	**Locking plate**	Sikringsplade
05	2/W	**Screw**	Skrue
06	1/W	**Screw for counterweight**	Skrue for kontravægt
07	1/C	**Plug screw**	Propskrue
08	1/E	**Plug screw**	Propskrue
09	12/E	**Screw**	Skrue
10	12/E	**Self locking nut**	Selvlåsende møtrik
11	12/E	**Washer**	Skive
12	1/E	**Oil throw ring**	Olieafslyngningsring
13	1/E	**Gear wheel (crankshaft)**	Tandhjul (krumtap)
14	/I	**Loctite 242**	Loctite 242
15+	/I	**Counterweight**	Kontravægt
		+ Item No. 02 and 15 require an individual matching before mounting contact MAN Diesel, Holeby	+ Item nr. 02 og 15 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

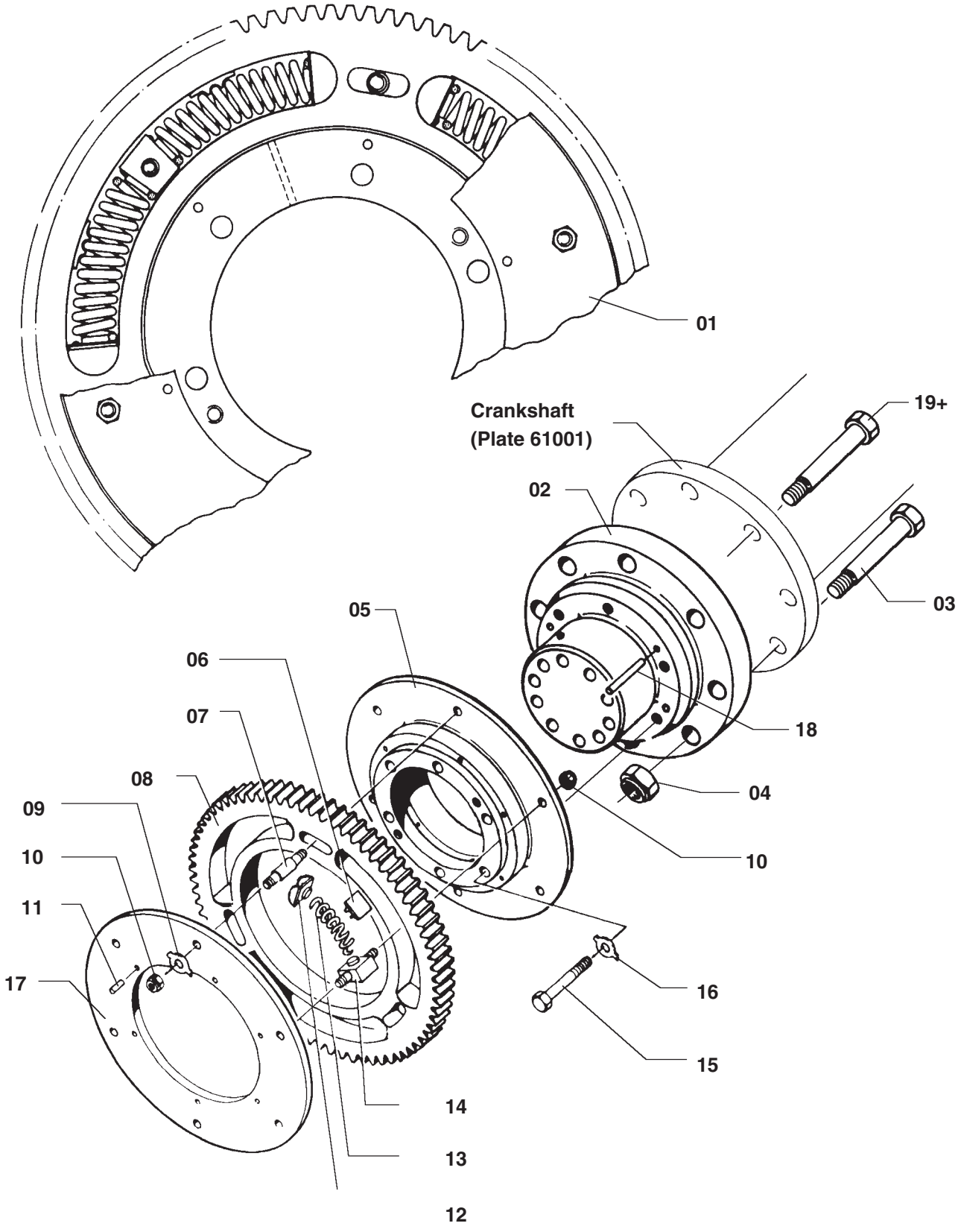
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./W = Qty./Counterweight
Qty./I = Qty./Individual
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/W= Antal/Kontravægt
Antal/I = Antal/Individuelt
Antal/C = Antal/Cylinder

Plate Page 1 (2)	**Resilient Gear Wheel**	**61002-07H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Resilient gear wheel, compl.**	Fjedrende tandhjul, komplet
02	1/E	**Axle journal**	Akseltap
03	4/E	**Screw**	Skrue
04	6/E	**Self locking nut, for Item No. 03 and 19**	Selvlåsende møtrik, for Item nr. 03 og 19
05	1/E	**Hub**	Nav
06	6/E	**Slide shoe**	Glidesko
07	3/E	**Distance piece**	Afstandsstykke
08	1/E	**Gear wheel**	Tandhjul
09	12/E	**Locking washer for item No. 10**	Låseblik for item nr. 10
10	12/E	**Nut**	Møtrik
11	4/E	**Cylindrical pin**	Cylindrisk stift
12	6/E	**Spring guide**	Fjederstyr
13	6/E	**Spring**	Fjeder
14	3/E	**Distance piece**	Afstandsstykke
15	6/E	**Screw**	Skrue
16	6/E	**Locking washer, for Item No. 15**	Låseblik for Item nr. 15
17	1/E	**Side plate**	Sideplade
18	2/E	**Cylindrical pin**	Cylindrisk stift
19+	2/E	**Fitted bolt**	Pasbolt
		+ Item 19 require an individual matching during mounting, contact MAN Diesel, Holeby	+ Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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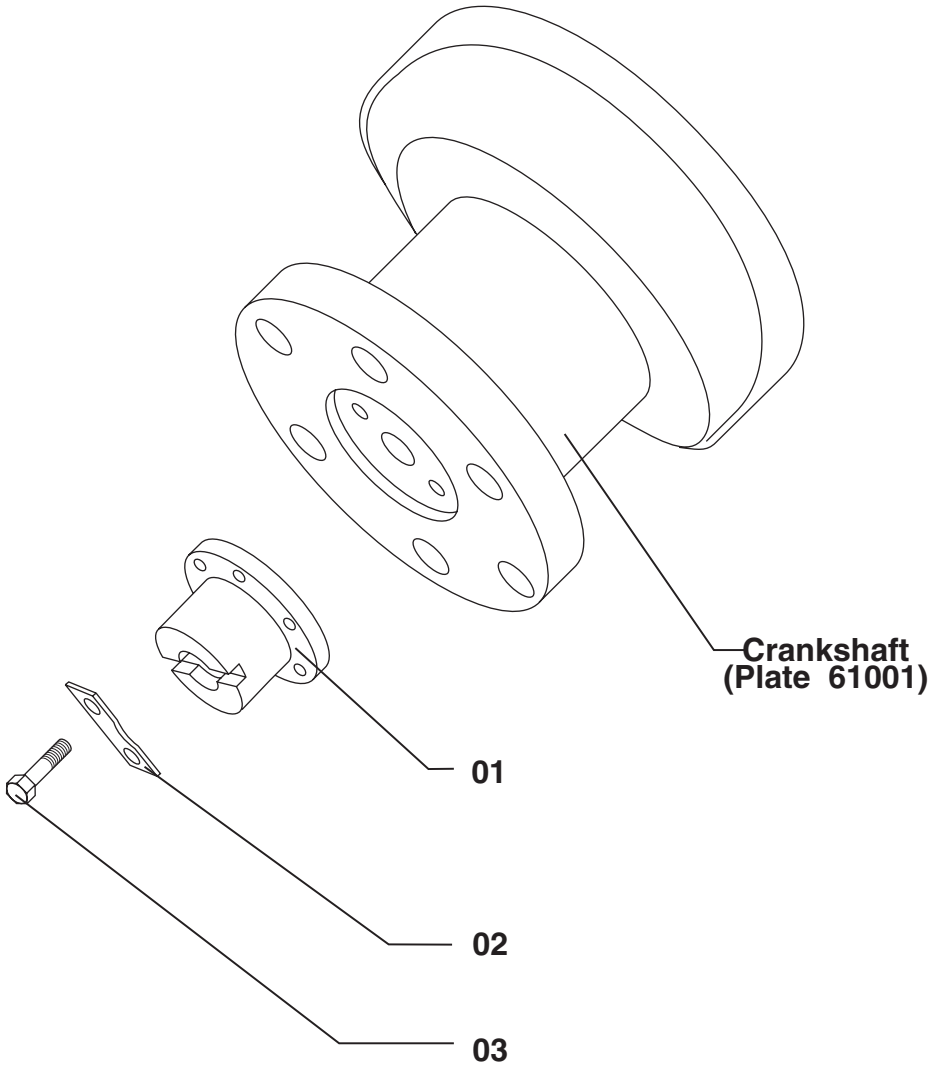
Antal/E = Antal/Motor

Plate Page 1 (2)	**Coupling for Central Driven Lub. Oil Pump**	**61002-11H**

6-7-8-9L28/32H



61002-11H	Coupling for Central Driven Lub. Oil Pump	Plate Page 2 (2)

6-7-8-9L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Coupling flange**	Koblingsflange
02	3/E	**Locking plate**	Låseplade
03	6/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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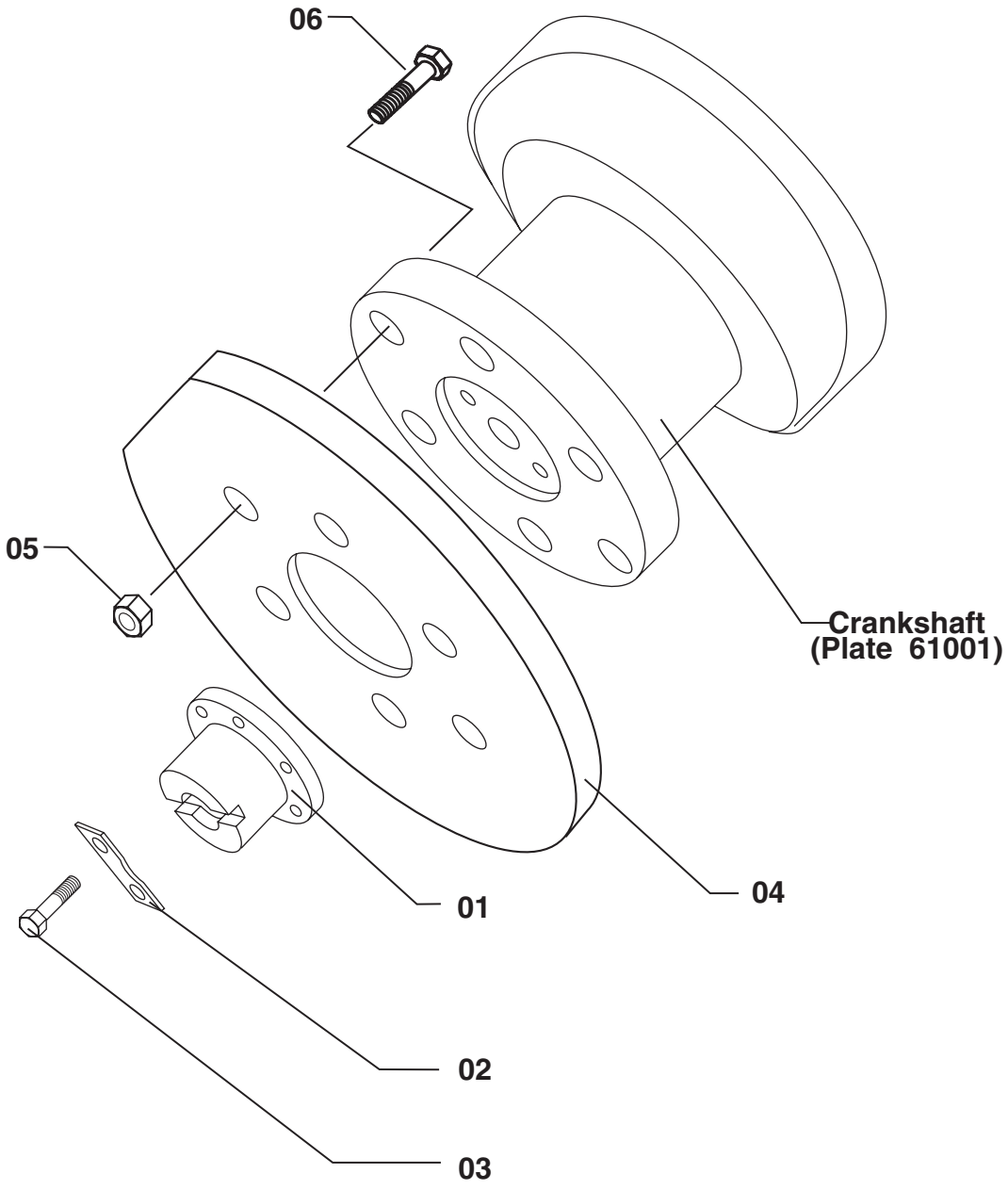
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Coupling for Central Driven Lub. Oil Pump**	**61002-12H**

5L28/32H



61002-12H	Coupling for Central Driven Lub. Oil Pump	Plate Page 2 (2)

5L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Coupling flange**	Koblingsflange
02	3/E	**Locking plate**	Låseplade
03	6/E	**Screw**	Skrue
04	1/E	**Flyweight**	Svingklods
05	6/E	**Nut**	Møtrik
06	6/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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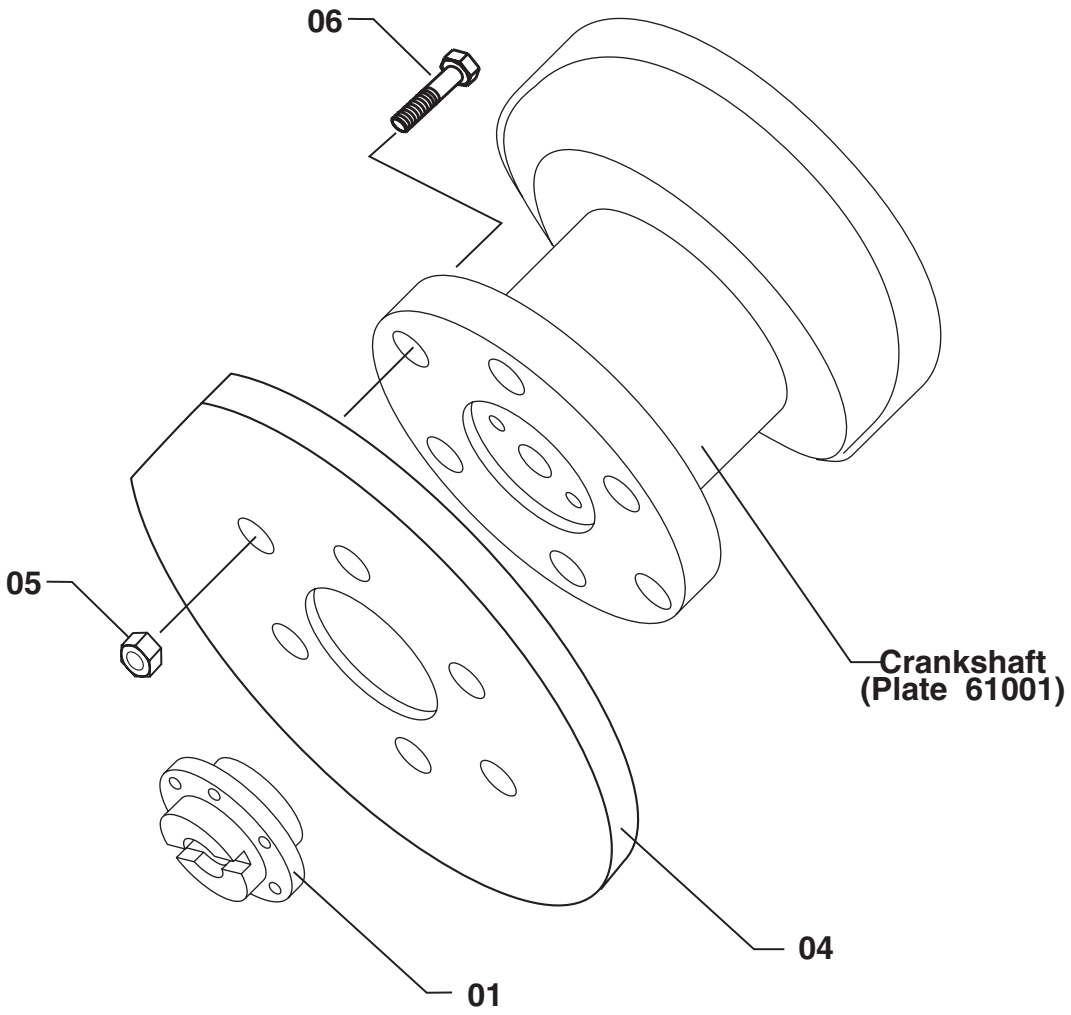
Antal/E = Antal/Motor

Plate Page 1 (2)	**Coupling for Central Driven Lub. Oil Pump**	**61002-13H**

5L28/32H



61002-13H	Coupling for Central Driven Lub. Oil Pump	Plate Page 2 (2)

5L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Coupling flange**	Koblingsflange
04	1/E	**Flyweight**	Svingklods
05	6/E	**Nut**	Møtrik
06	6/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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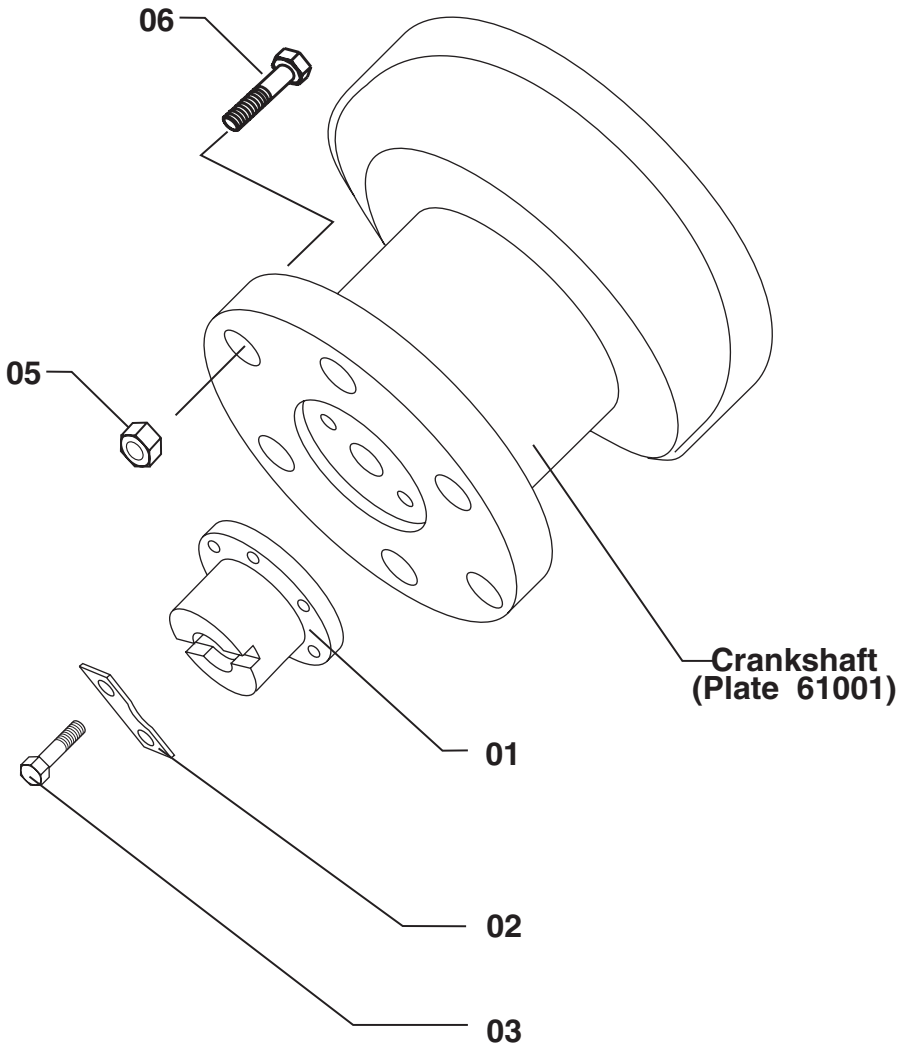
Antal/E = Antal/Motor

Plate Page 1 (2)	**Coupling for Central Driven Lub. Oil Pump**	**61002-14H**

L28/32H



61002-14H	Coupling for Central Driven Lub. Oil Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Coupling flange**	Koblingsflange
02	3/E	**Locking plate**	Låseplade
03	6/E	**Screw**	Skrue
05	6/E	**Nut**	Møtrik
06	6/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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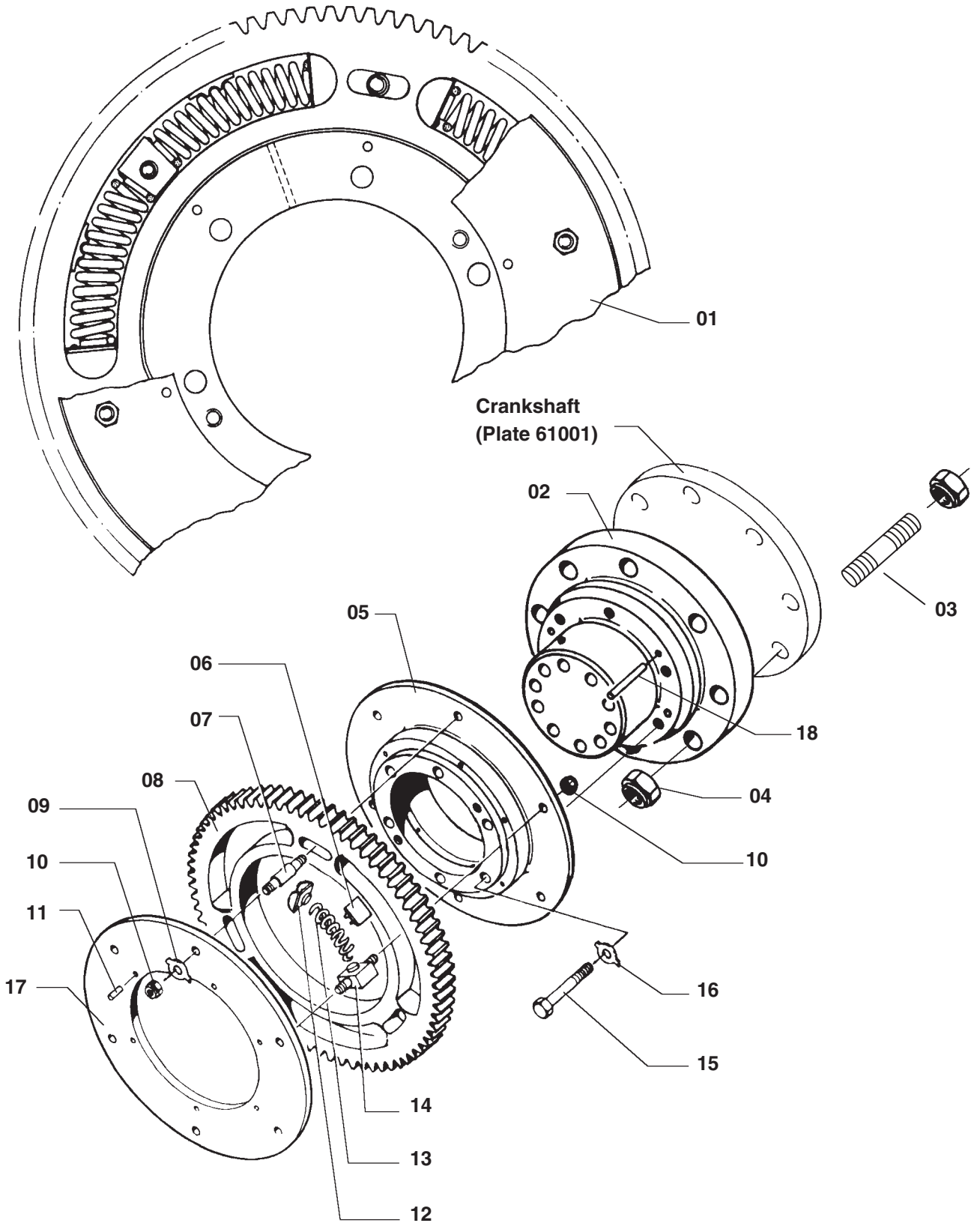
Antal/E = Antal/Motor

Plate Page 1 (2)	**Resilient Gear Wheel**	**61002-15H**

L28/32H



61002-15H	Resilient Gear Wheel	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Resilient gear wheel, compl.**	Fjedrende tandhjul, komplet
02	1/E	**Axle journal**	Akseltap
03	6/E	**Stud**	Tap
04	12/E	**Self locking nut, for Item No. 03**	Selvlåsende møtrik, for Item nr. 03
05	1/E	**Hub**	Nav
06	6/E	**Slide shoe**	Glidesko
07	3/E	**Distance piece**	Afstandsstykke
08	1/E	**Gear wheel**	Tandhjul
09	12/E	**Locking washer for item No. 10**	Låseblik for item nr. 10
10	12/E	**Nut**	Møtrik
11	4/E	**Cylindrical pin**	Cylindrisk stift
12	6/E	**Spring guide**	Fjederstyr
13	6/E	**Spring**	Fjeder
14	3/E	**Distance piece**	Afstandsstykke
15	6/E	**Screw**	Skrue
16	6/E	**Locking washer, for Item No. 15**	Låseblik for Item nr. 15
17	1/E	**Side plate**	Sideplade
18	2/E	**Cylindrical pin**	Cylindrisk stift

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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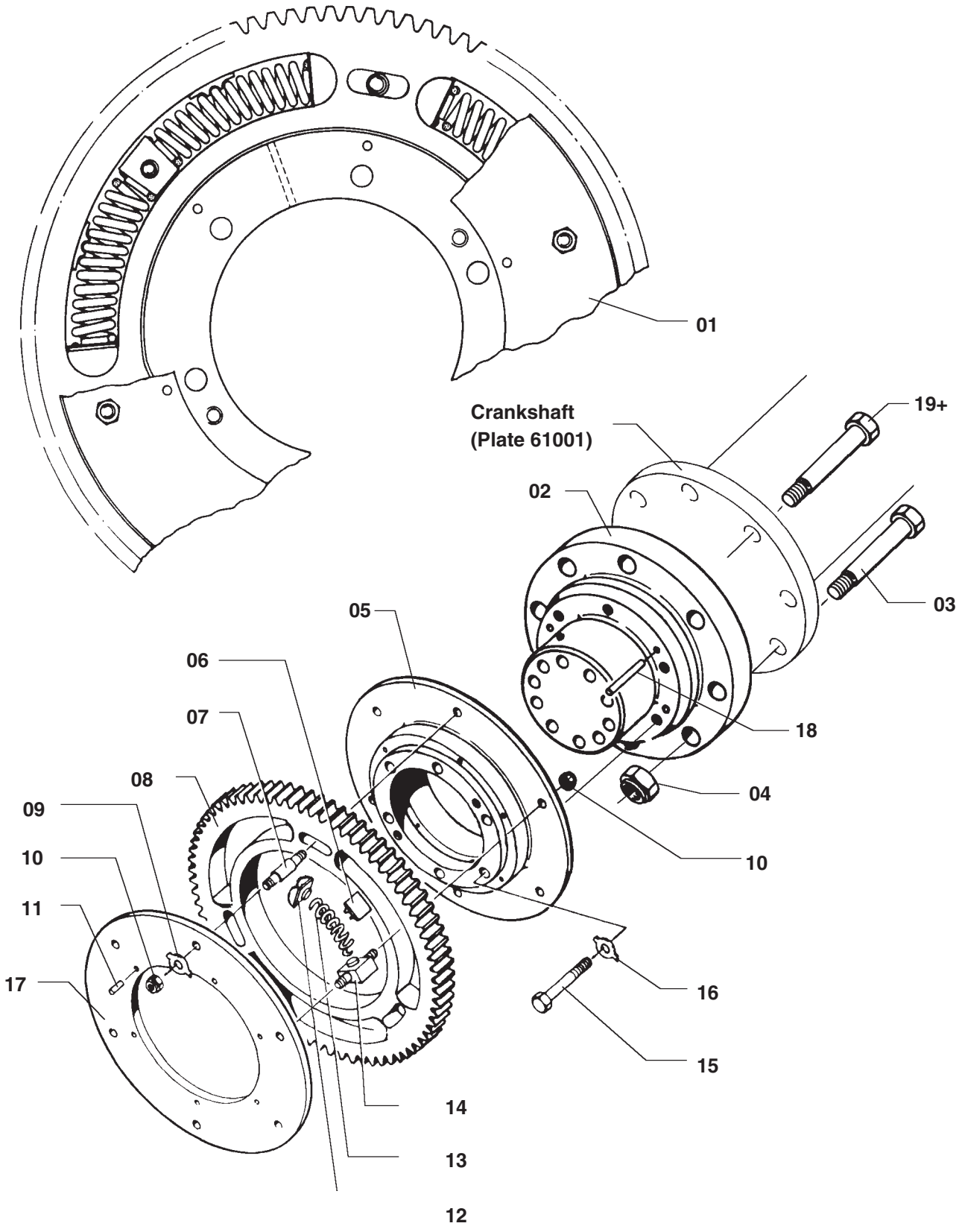
Plate Page 1 (2)	**Resilient Gear Wheel**	**61002-16H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Resilient gear wheel, compl.**	Fjedrende tandhjul, komplet
02	1/E	**Axle journal**	Akseltap
03	4/E	**Screw**	Skrue
04	6/E	**Self locking nut,for Item No. 03 and 19**	Selvlåsende møtrik, for Item nr. 03 og 19
05	1/E	**Hub**	Nav
06	6/E	**Slide shoe**	Glidesko
07	3/E	**Distance piece**	Afstandsstykke
08	1/E	**Gear wheel**	Tandhjul
09	12/E	**Locking washer for item No. 10**	Låseblik for item nr. 10
10	12/E	**Nut**	Møtrik
11	4/E	**Cylindrical pin**	Cylindrisk stift
12	6/E	**Spring guide**	Fjederstyr
13	6/E	**Spring**	Fjeder
14	3/E	**Distance piece**	Afstandsstykke
15	6/E	**Screw**	Skrue
16	6/E	**Locking washer, for Item No. 15**	Låseblik for Item nr. 15
17	1/E	**Side plate**	Sideplade
18	2/E	**Cylindrical pin**	Cylindrisk stift
19+	2/E	**Fitted bolt**	Pasbolt
		+ Item 19 require an individual matching during mounting, contact MAN diesel, Holeby	+ Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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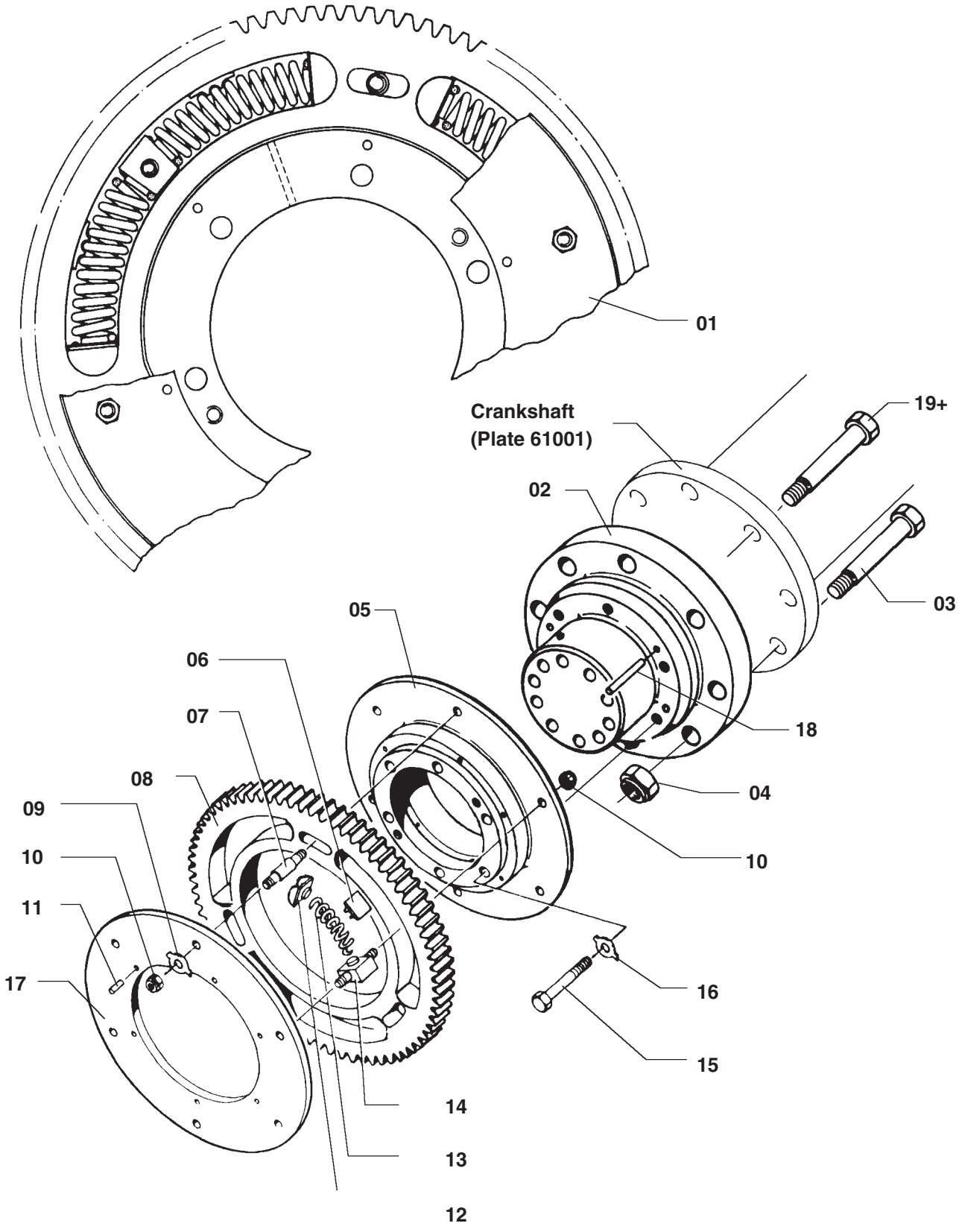
Plate Page 1 (2)	**Resilient Gear Wheel**	**61002-17H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Resilient gear wheel, compl.**	Fjedrende tandhjul, komplet
02	1/E	**Axle journal**	Akseltap
03	4/E	**Screw**	Skrue
04	6/E	**Self locking nut,for Item No. 03 and 19**	Selvlåsende møtrik, for Item nr. 03 og 19
05	1/E	**Hub**	Nav
06	6/E	**Slide shoe**	Glidesko
07	3/E	**Distance piece**	Afstandsstykke
08	1/E	**Gear wheel**	Tandhjul
09	12/E	**Locking washer for item No. 10**	Låseblik for item nr. 10
10	12/E	**Nut**	Møtrik
11	4/E	**Cylindrical pin**	Cylindrisk stift
12	6/E	**Spring guide**	Fjederstyr
13	6/E	**Spring**	Fjeder
14	3/E	**Distance piece**	Afstandsstykke
15	6/E	**Screw**	Skrue
16	6/E	**Locking washer, for Item No. 15**	Låseblik for Item nr. 15
17	1/E	**Side plate**	Sideplade
18	2/E	**Cylindrical pin**	Cylindrisk stift
19+	2/E	**Fitted bolt**	Pasbolt
		+ Item 19 require an individual matching during mounting, contact MAN Diesel, Holeby	+ Item 19 kræver en individuel tilpasning før montering, kontakt MAN Diesel, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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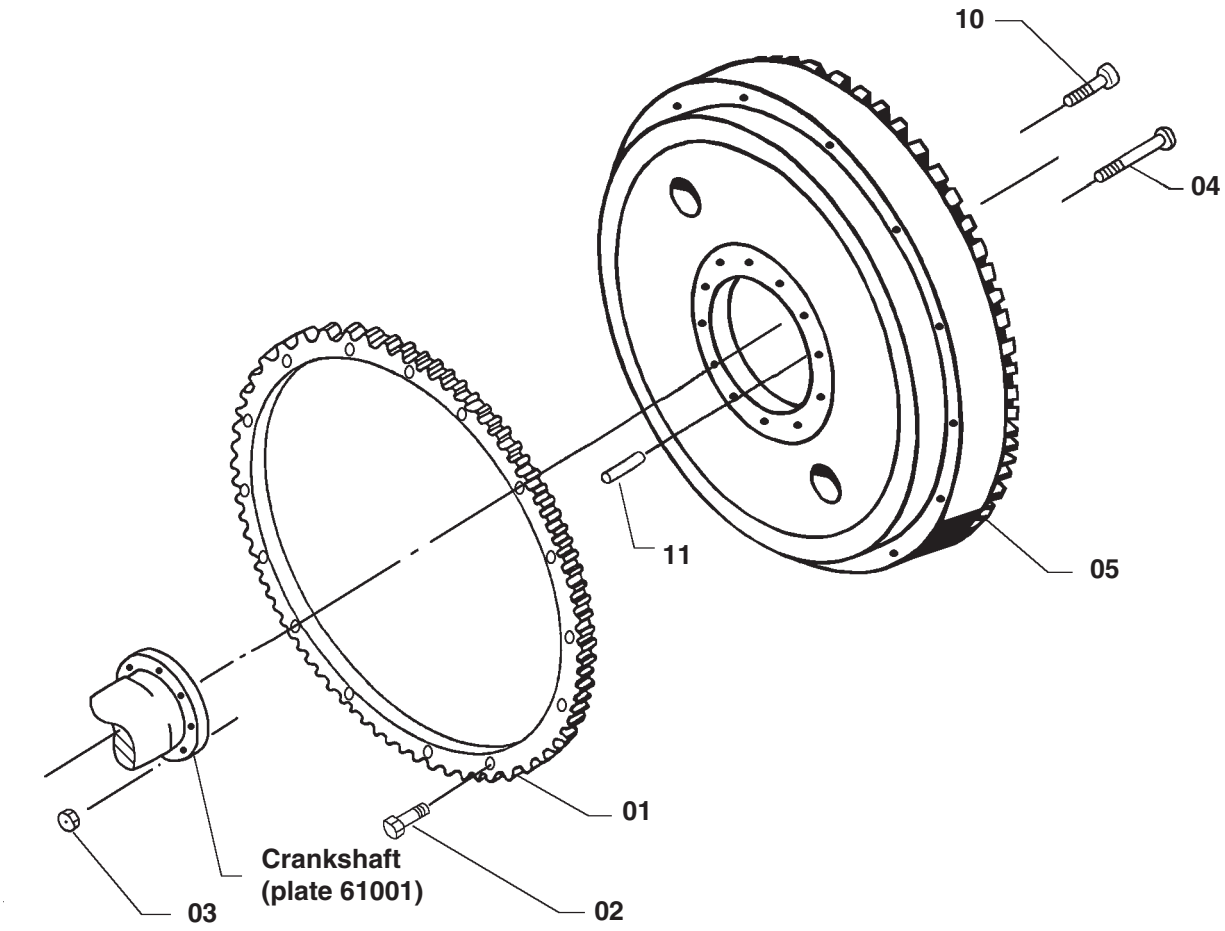
Antal/E = Antal/Motor

Plate Page 1 (2)	Flywheel with Gear Rim	61003-02H

5L28/32H



61003-02H	Flywheel with Gear Rim	Plate Page 2 (2)

5L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Gear rim 2/2**	Tandkrans 2/2
02	18/E	**Screw**	Skrue
03	12/E	**Self locking nut, for item no. 04**	Selvlående møtrik for item nr. 04
04	12/E	**Screw**	Skrue
05	1/E	**Flywheel**	Svinghjul
10	2/E	**Screw**	Skrue
11	1/E	**Guide pin**	Styrestift

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

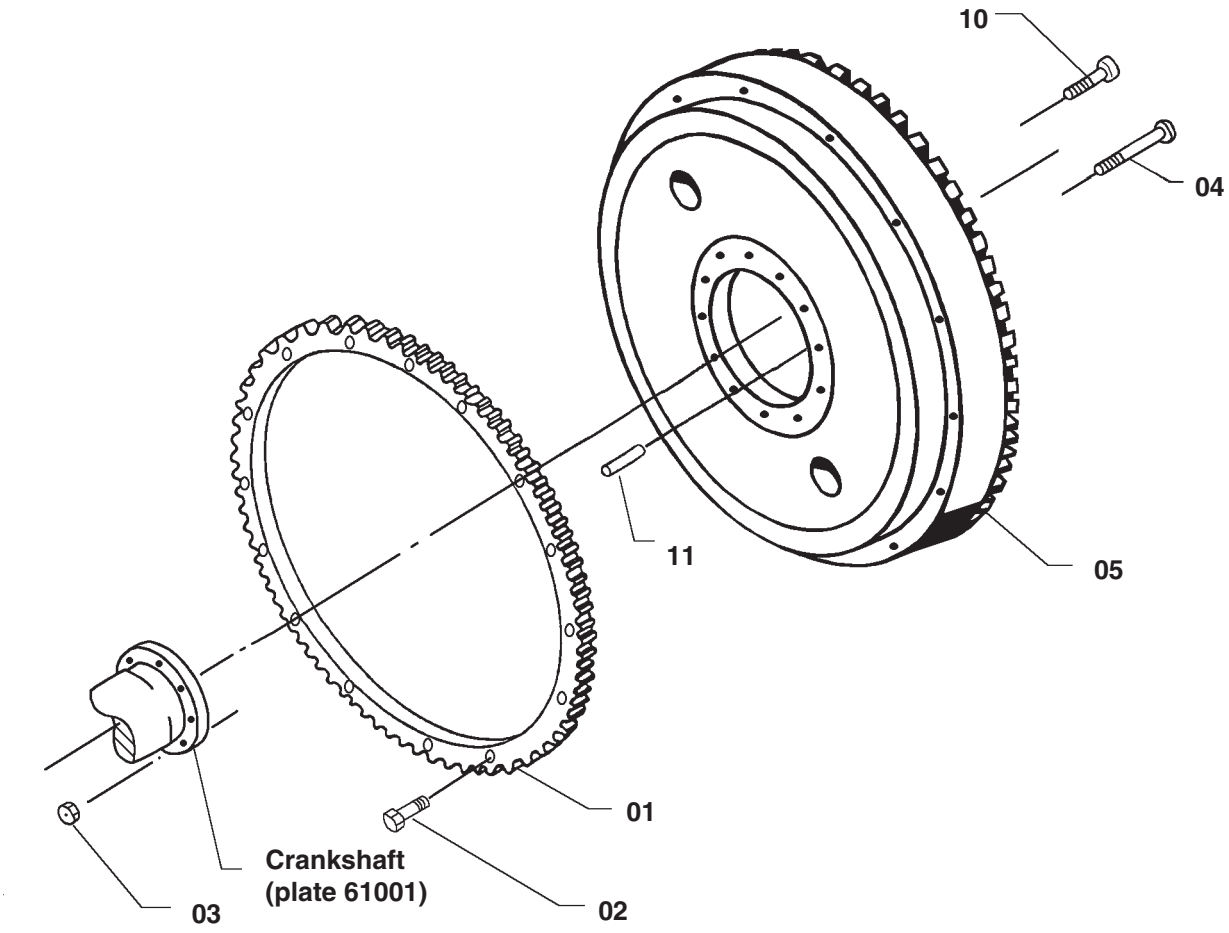
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

Qty./E = Antal/Motor

Plate Page 1 (2)	Flywheel with Gear Rim	61003-05H

L28/32H



61003-05H	Flywheel with Gear Rim	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Gear rim 2/2**	Tandkrans 2/2
02	18/E	**Screw**	Skrue
03	12/E	**Self locking nut, for item no. 04**	Selvlående møtrik for item nr. 04
04	12/E	**Screw**	Skrue
05	1/E	**Flywheel**	Svinghjul
10	2/E	**Screw**	Skrue
11	1/E	**Guide pin**	Styrestift

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

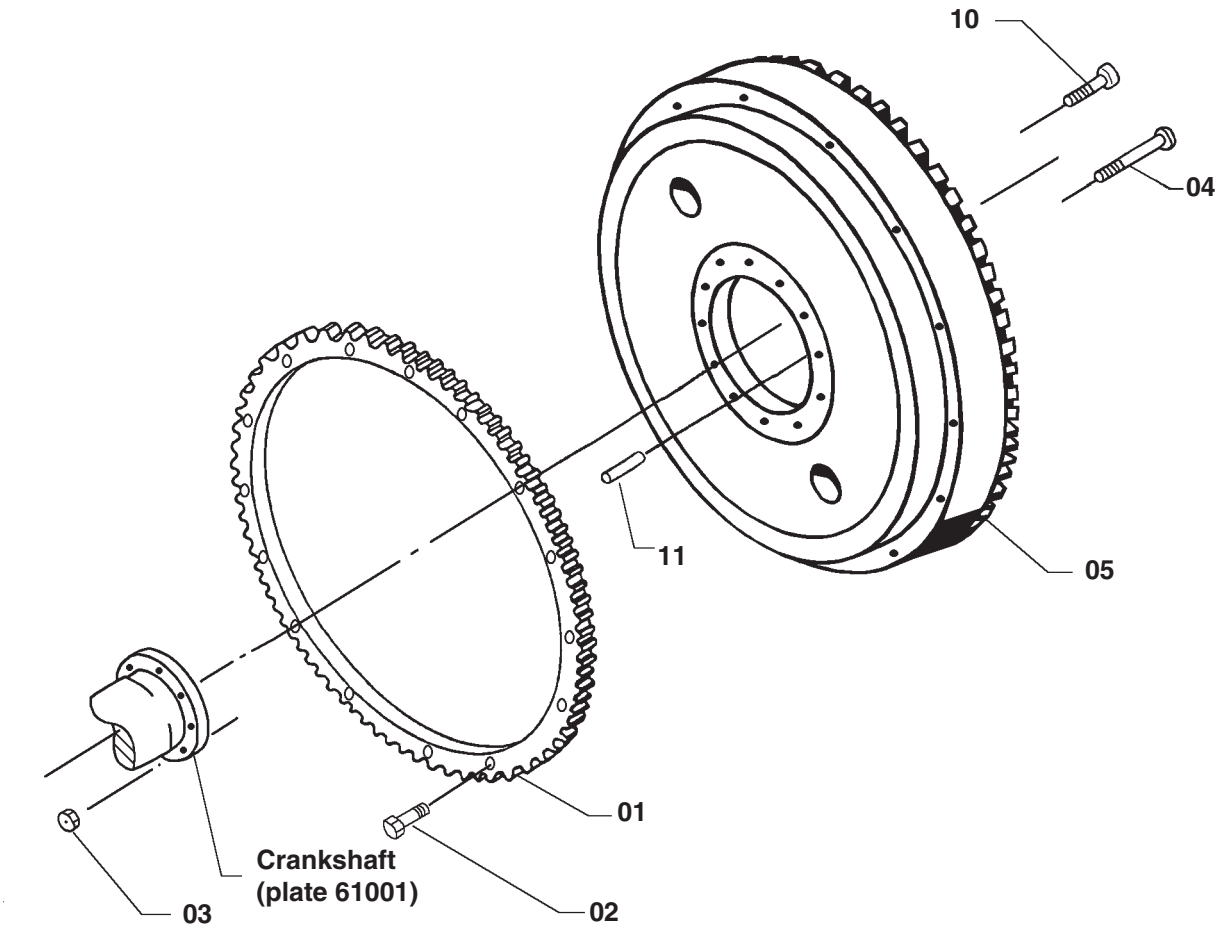
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

Qty./E = Antal/Motor

Plate Page 1 (2)	Flywheel with Gear Rim	61003-06H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Gear rim 2/2**	Tandkrans 2/2
02	18/E	**Screw**	Skrue
03	12/E	**Self locking nut, for item no. 04**	Selvlående møtrik for item nr. 04
04	12/E	**Screw**	Skrue
05	1/E	**Flywheel**	Svinghjul
10	2/E	**Screw**	Skrue
11	1/E	**Guide pin**	Styrestift

When ordering spare parts, see also page 600.50.

Qty./E = Qty./Engine

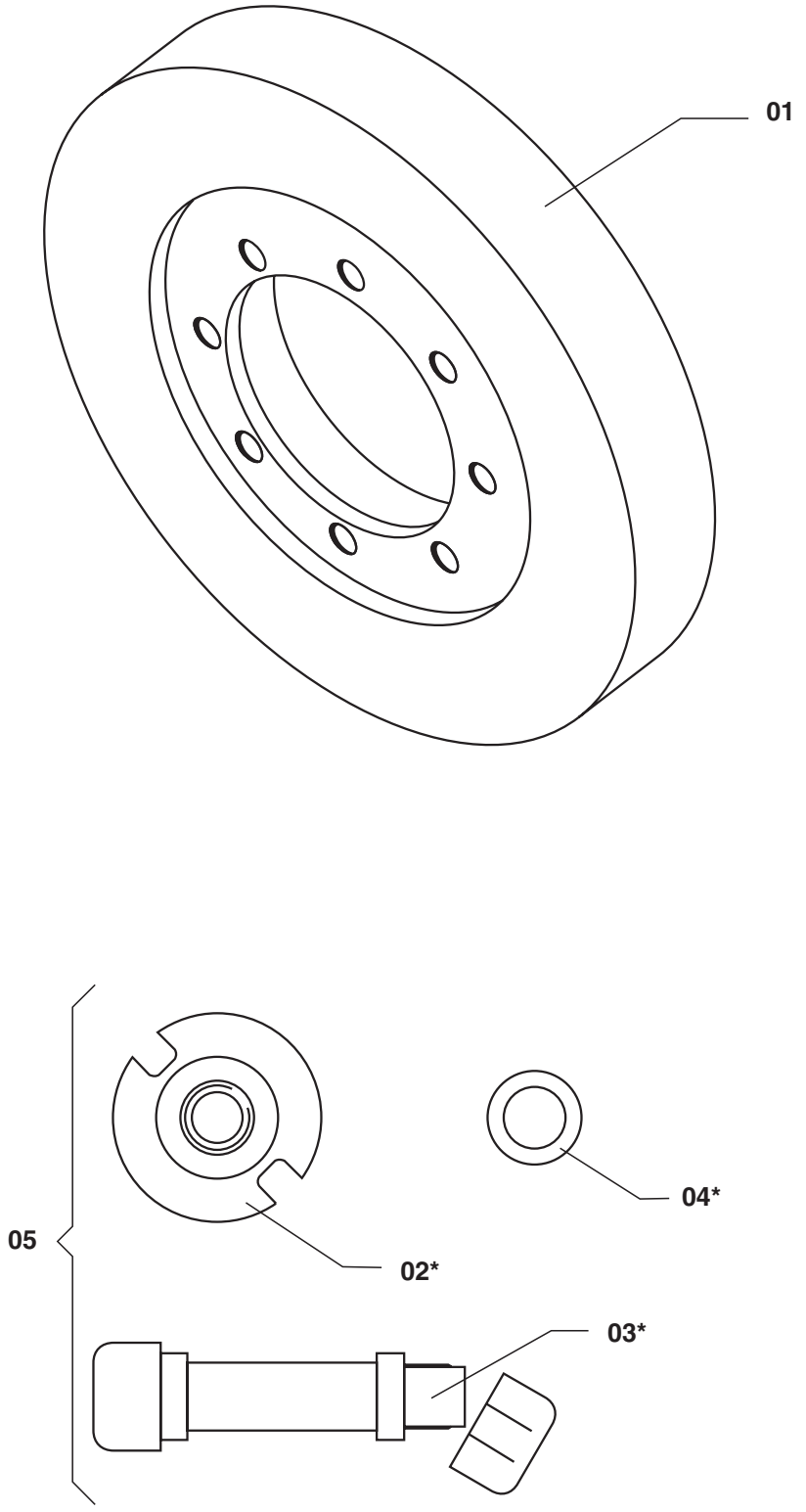
Item No.	Qty.	Designation	Benævnelse

Ved bestilling af reservedele, se også side 600.50.

Qty./E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-05H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

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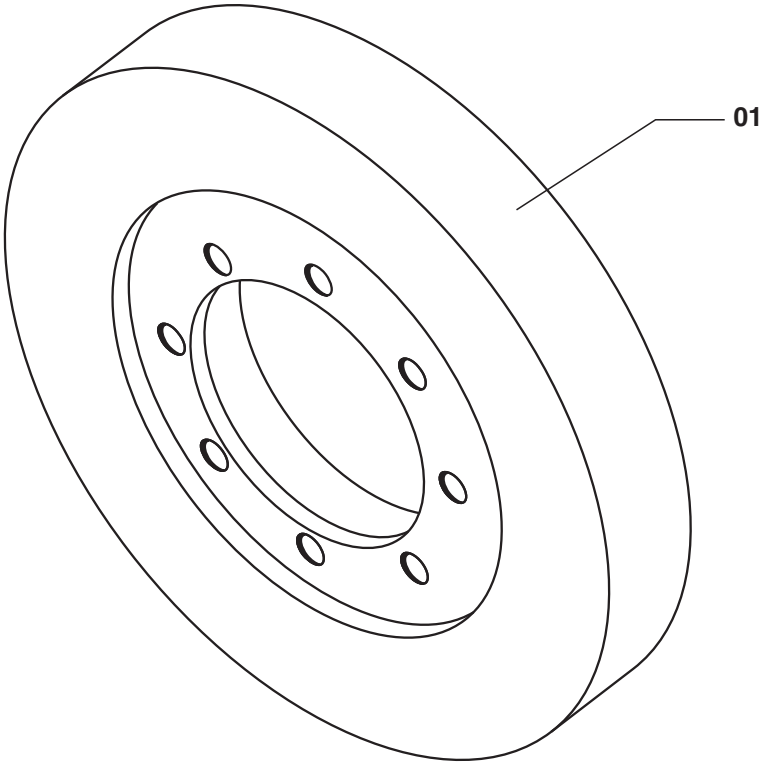
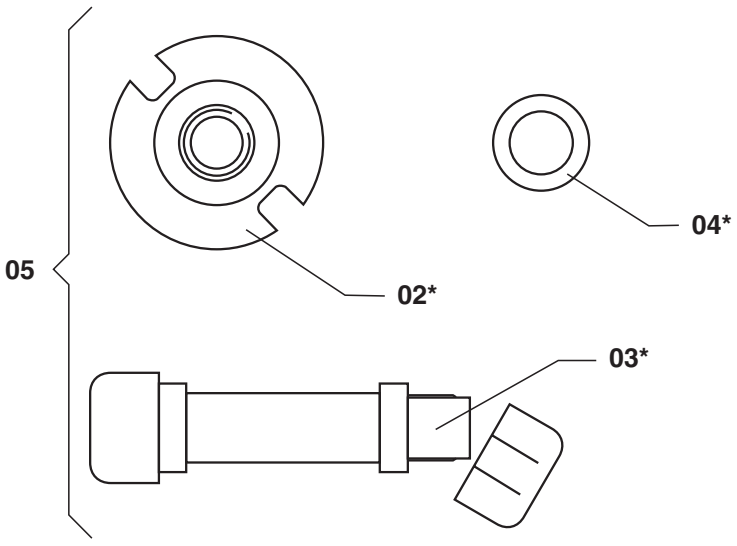
* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-12H**

L28/32H





L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

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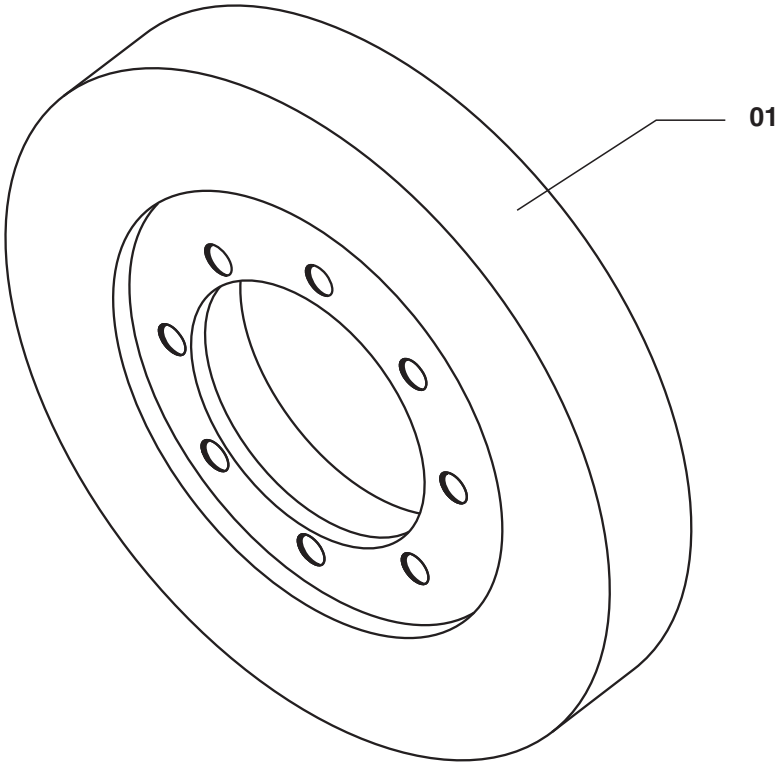
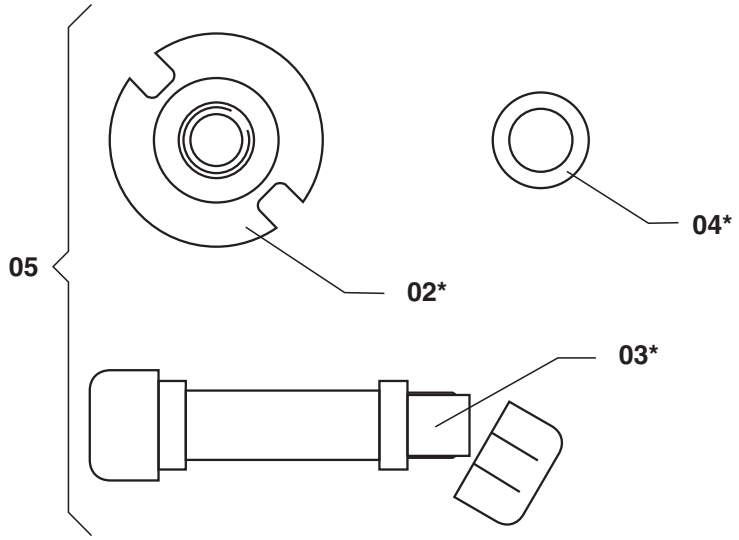
Antal/E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-13H**

L28/32H





61004-13H	Torsional Vibration Damper	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

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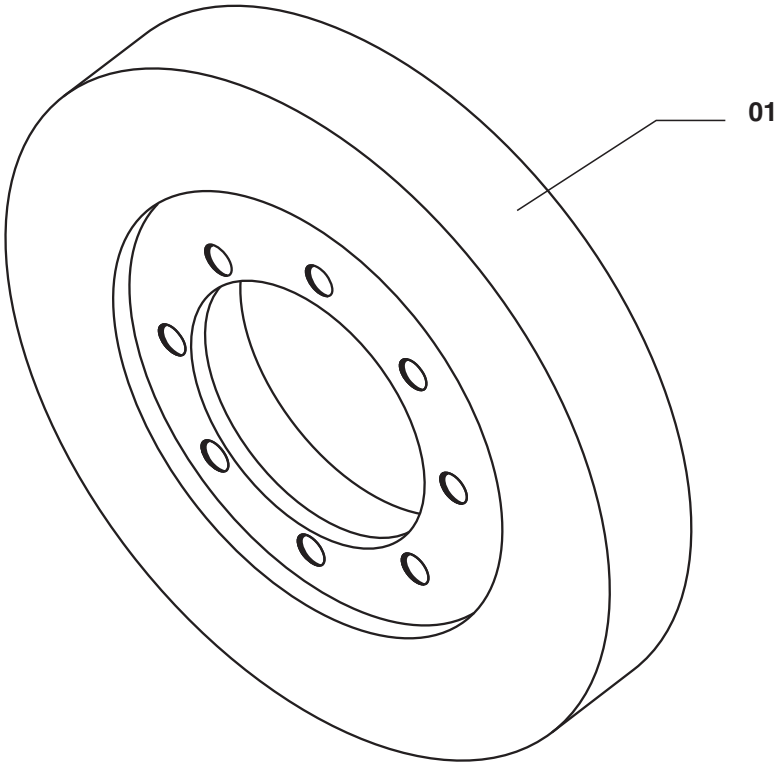
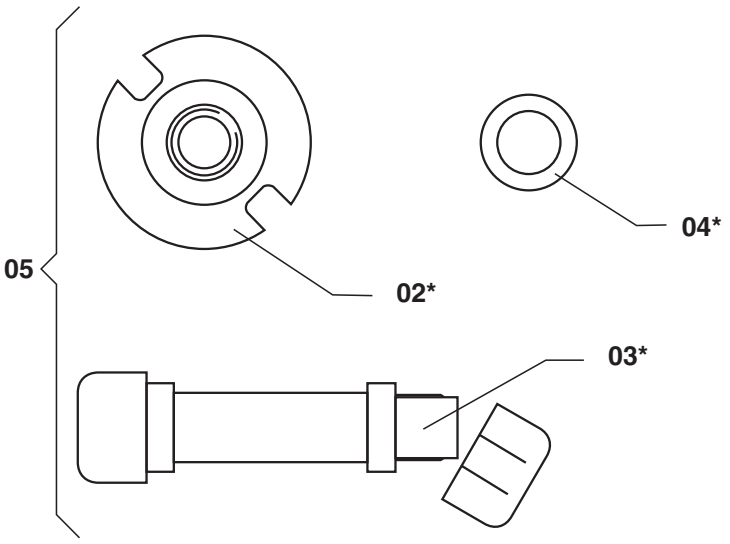
Antal/E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-14H**

L28/32H





L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

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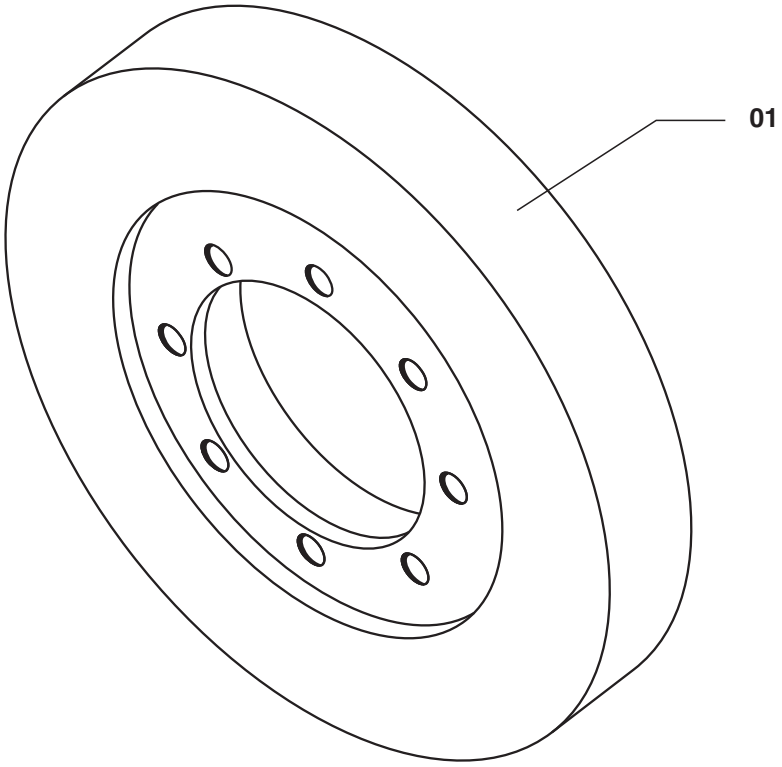
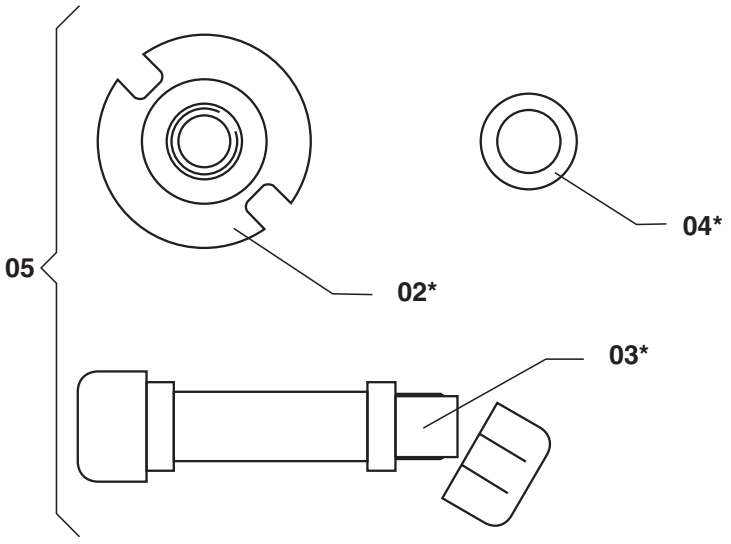
Antal/E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-15H**

L28/32H





L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

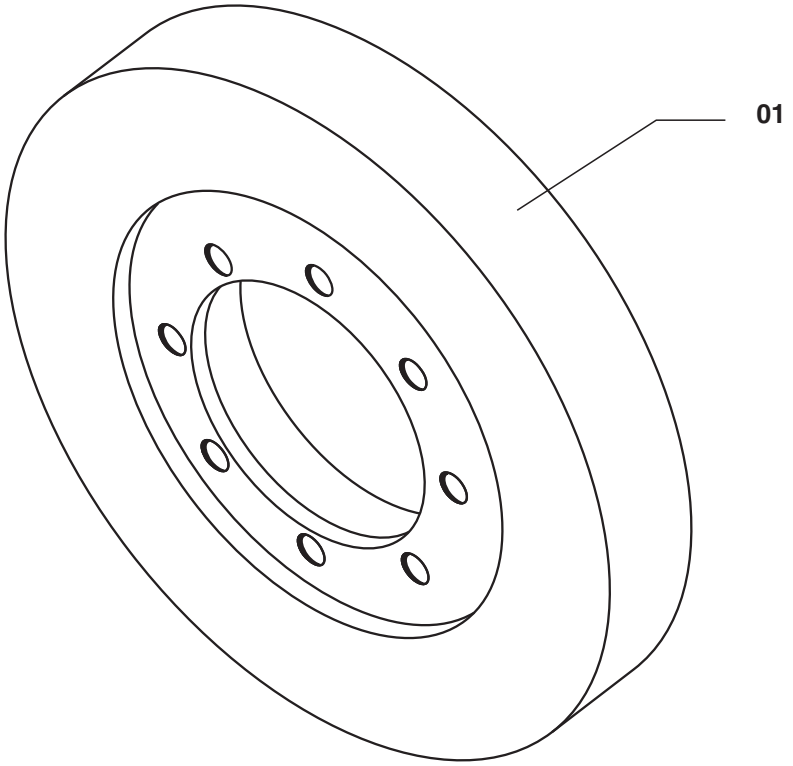
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

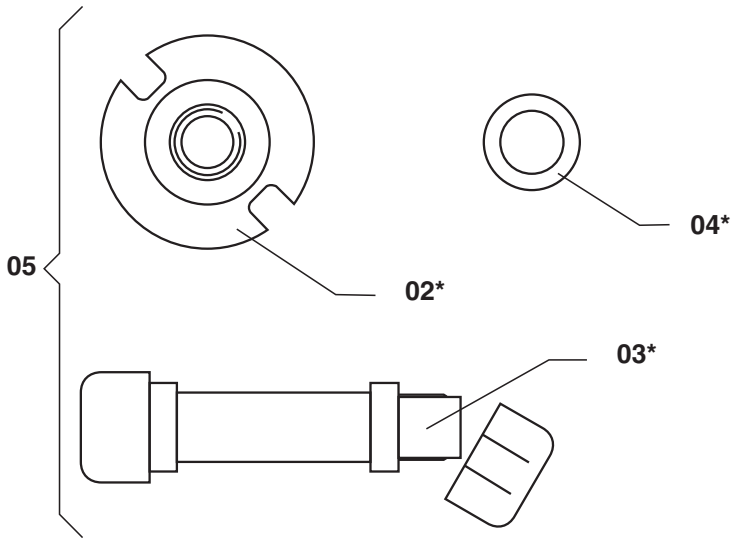
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Torsional Vibration Damper**	**61004-16H**

L28/32H





L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Torsional vibration damper, with 30 mm mounting flange**	Svingningsdæmper med 30 mm monterings-flange
02*	1/E	**Plug screw**	Propskrue
03*	1/E	**Sample container**	Prøveudtagings-beholder
04*	1/E	**O-ring**	O-ring
05+		**Sampling kit for torsional vibration damper (the kit includes an analysis of the sample taken. All information is available in the kit)**	Prøvesæt for svingningsdæmper (Sættet er inklusiv en analyse af prøven. Alle informationer er tilgængelige i sættet)
		+ See also working card 610-04.00	+ Se også arbejdskort 610-04.00

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

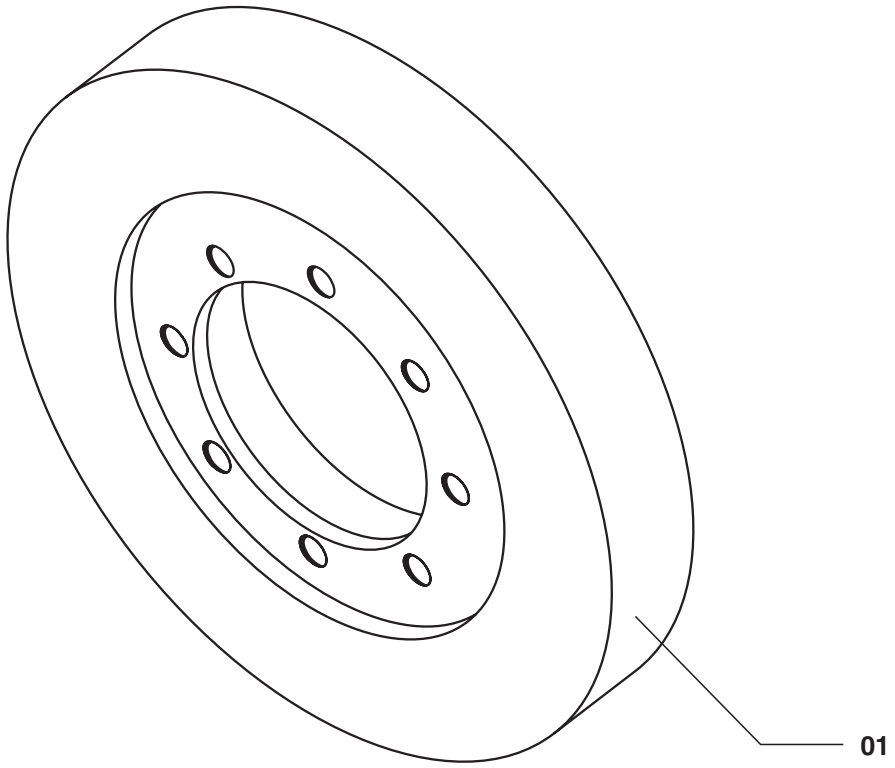
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Tuning Wheel**	**61004-06H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Tuning wheel with, 30 mm mounting flan-ge**	Afstemningshjul med 30 mm monterings-flan-ge

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Engine frame/Oil pan

511/611

L28/32H

Frame

The engine frame is made of cast iron, and is attached to the top of the base frame by means of bolts. The cross girders of the frame are provided with bores for the main bearings in which the crankshaft is underslung, i.e. it is carried by the main bearing caps.

The main bearing caps are attached by means of studs and nuts, which are loosened and tightened with the aid of hydraulic tools. After mounting, the main bearing caps are further secured by means of bracing screws, which are screwed horizontally into the sides of the caps and tightened against the sides of the engine frame. The main bearings are equipped with replaceable shells which are fitted without scraping.

The crankshaft guide bearing is located at the flywheel end of the engine.

On the sides of the frame there are covers for acces to the camshaft, the charge air receiver and crankcase. Some of the covers are fitted with relief valves which will act, should oil vapours in the crankcase be ignited, for instance in the event of a hot bearing.

Base Frame

Engine and alternator (gear, pump) are mounted on a common base frame which is in welded design.

The base frame is used as lubricating oil reservoir "wet sump".

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Working Card Page 1 (2)	**Functional Test of Crankcase Safety Relief Valves**	**611-01.00** Edition 04H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Functional test of crankcase safety relief valves.

Starting position:

Related procedure:

Man power:

Working time : 1/4 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61106	13	1/cyl.
61106	39	12/relief valve
61106	45	1/relief valve

08028-0D/H5250/94.08.12

General

Functional Testing

Functional testing of the crankcase safety relief valves cannot be performed during operation of the engine, but it must be checked during overhauls that the valve flap is movable.

When Painting

When painting the engine, take care not to block up the safety relief valves with paint.

Check of Opening Pressure

To check the proper opening pressure, proceed as follows:

1) Remove the relief valve cover from the engine.

2) Place the cover on the floor with the pressure area upwards.

3) Apply a weight at 18 kg on the pressure area.

The relief valve must open under this pressure.

4) Remount the relief valve cover of the engine.

If the safety relief valves are actuated, the engine must be stopped immediately, and it must not be restarted until the cause is detected and the fault is detected, *see also description 503.04, Ignition in Crankcase.*

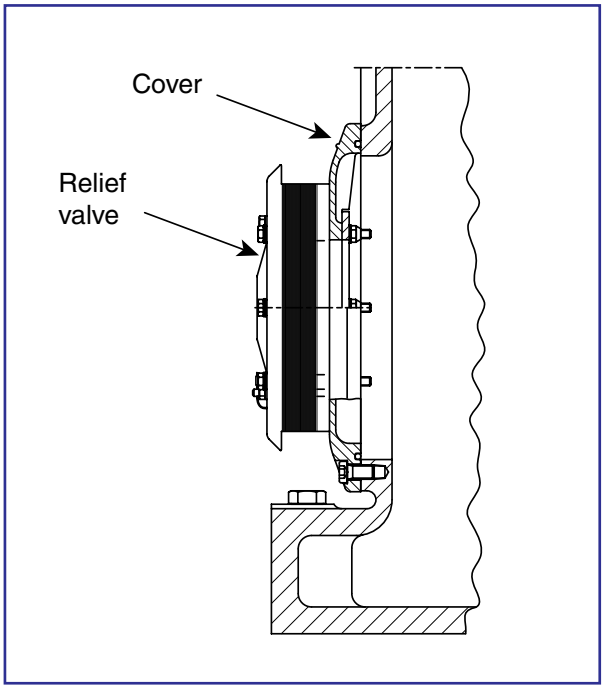
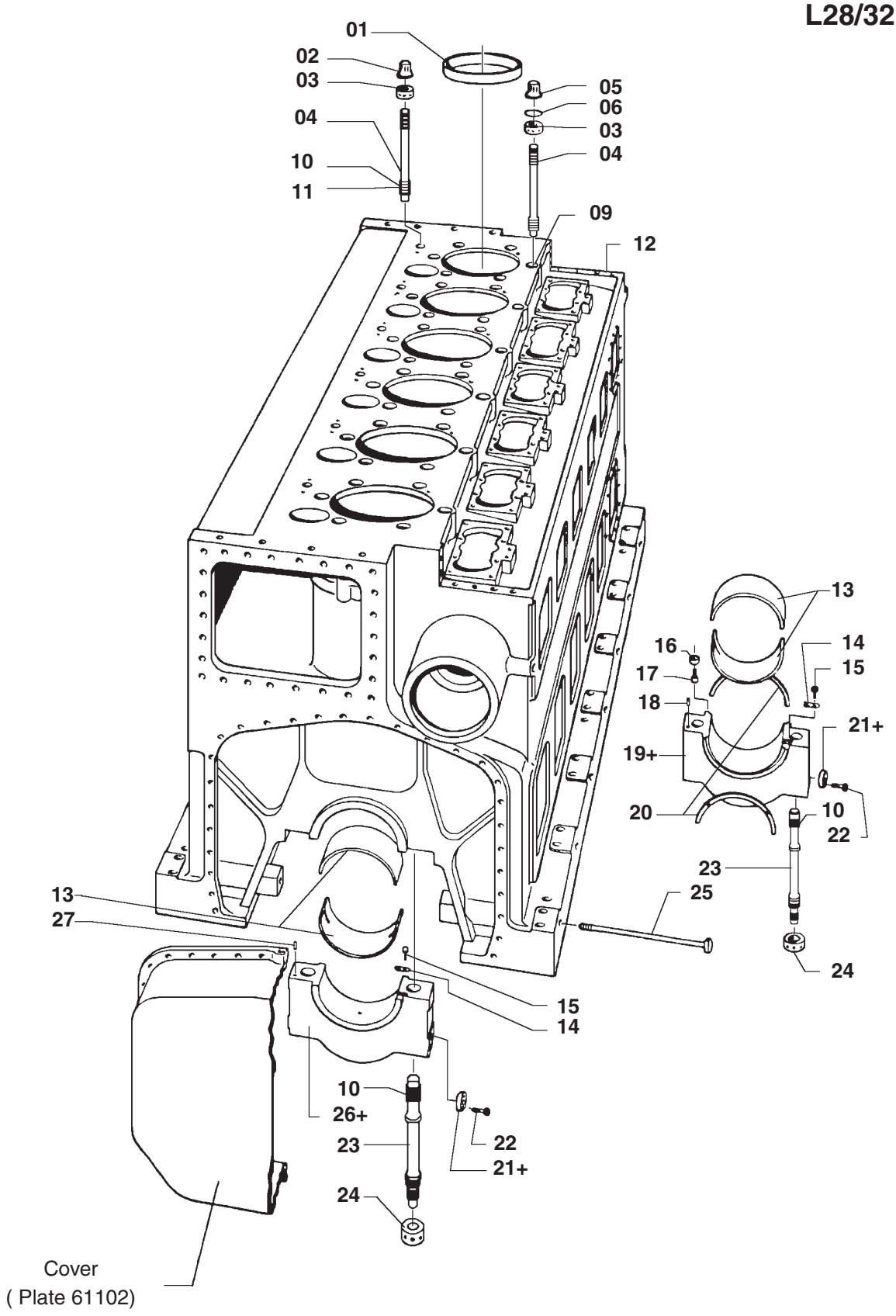


Fig 1 Cover with relief valve

08028-0D/H5250/94.08.12

Plate Page 1 (2)	**Frame with Main Bearings**	**61101-11H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/C	**Wear ring**	Slidring
02	3/C	**Protective cap, plastic**	Beskyttelseshætte, plastik
03	6/C	**Nut for cylinder cover**	Møtrik for cylinderdæksel
04	6/C	**Cylinder cover stud**	Tap for cylinderdæksel
05	3/C	**Protective cap, metal**	Beskyttelseshætte, metal
06	3/C	**O-ring**	O-ring
09	6/C	**Sealing kit for cap**	Tætningssæt for dæksel
10		**Loctite 243**	Loctite 243
11		**Silicone oil**	Silikoneolie
12	1/E	**Frame**	Stativ
13	1/B	**Main bearing shell 2/2**	Hovedleje-skaller 2/2
14	1/B	**Locking piece**	Låsestykke
15	2/B	**Screw**	Skrue
16	4/E	**Safety sleeve**	Sikkerhedsbøsning
17	4/E	**Screw**	Skrue
18	1/E	**Cylindrical pin**	Cylindrisk stift
19+	1/E	**Guide bearing cap**	Styrelejedæksel
20	2/E	**Thrust bearing**	Trykleje
21+	2/B	**Distance piece**	Afstandsstykke
22	6/B	**Screw**	Skrue
23	2/B	**Main bearing stud**	Hovedleje tap
24	2/B	**Nut for main bearing stud**	Møtrik for hovedlejetap
25	2/B	**Bracing screw**	Sideskrue
26+	1/C	**Main bearing cap**	Hovedlejedæksel
27	1/C	**Cylindrical pin**	Cylindrisk stift
		+ Item No. 19, 21 and 26 require an individual matching before mounting, contact MAN B&W, Holeby	+ Item nr. 19, 21 og 26 kræver en individuel tilpasning før montering, kontakt MAN B&W, Holeby

When ordering spare parts, see also page 600.50.

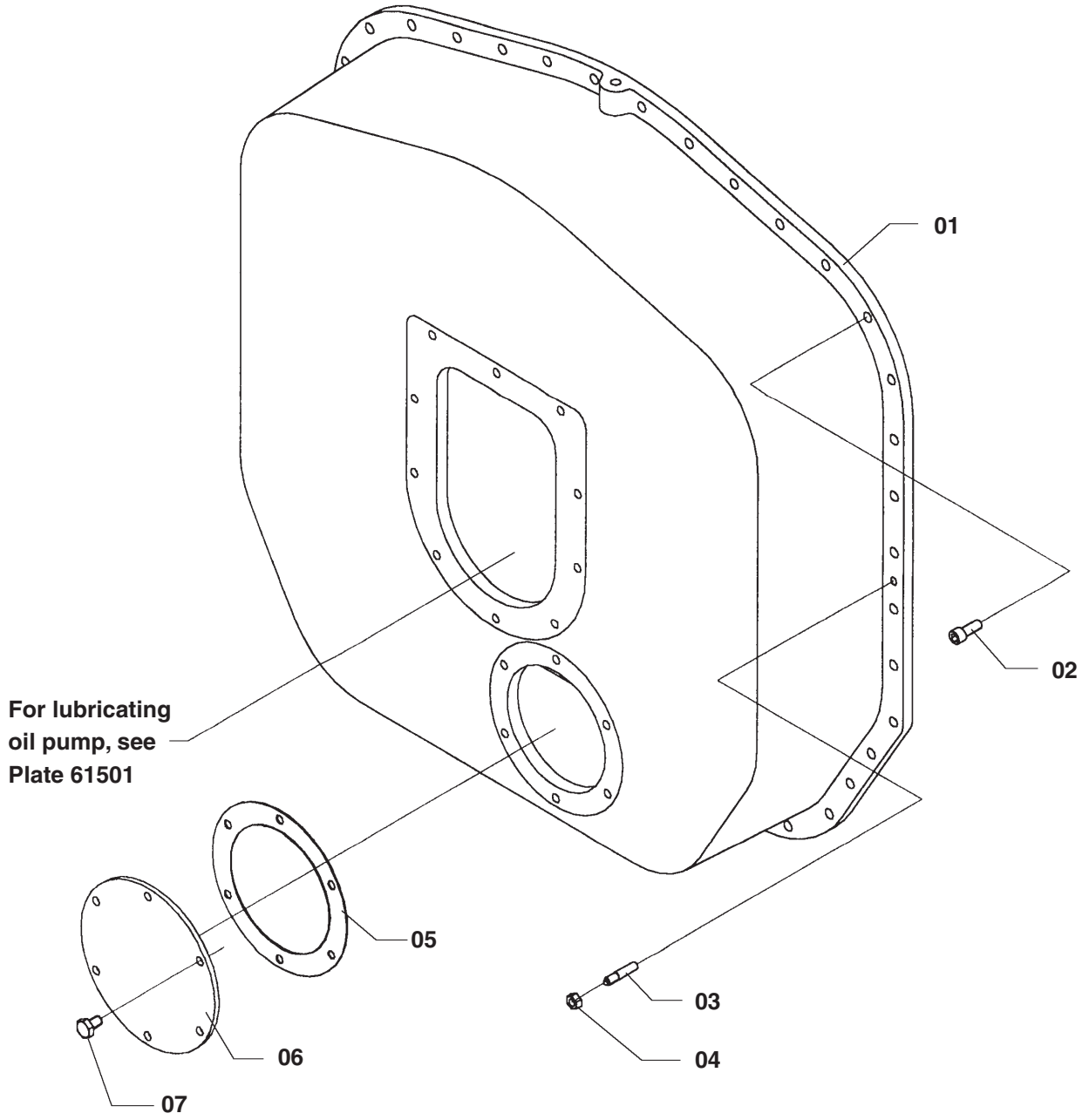
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty/Cylinder
Qty./B = Qty/Bearing

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/Cylinder
Antal/B = Antal/Leje

Plate Page 1 (2)	**Front Cover for Lubricating Oil Pump**	**61102-09H**

L28/32H



61102-09H	Front Cover for Lubricating Oil Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Cover**	Dæksel
02	40/E	**Screw**	Skrue
03	2/E	**Guide pin**	Styrestift
04	2/E	**Nut**	Møtrik
05	1/E	**Gasket**	Pakning
06	1/E	**Cover**	Dæksel
07	6/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

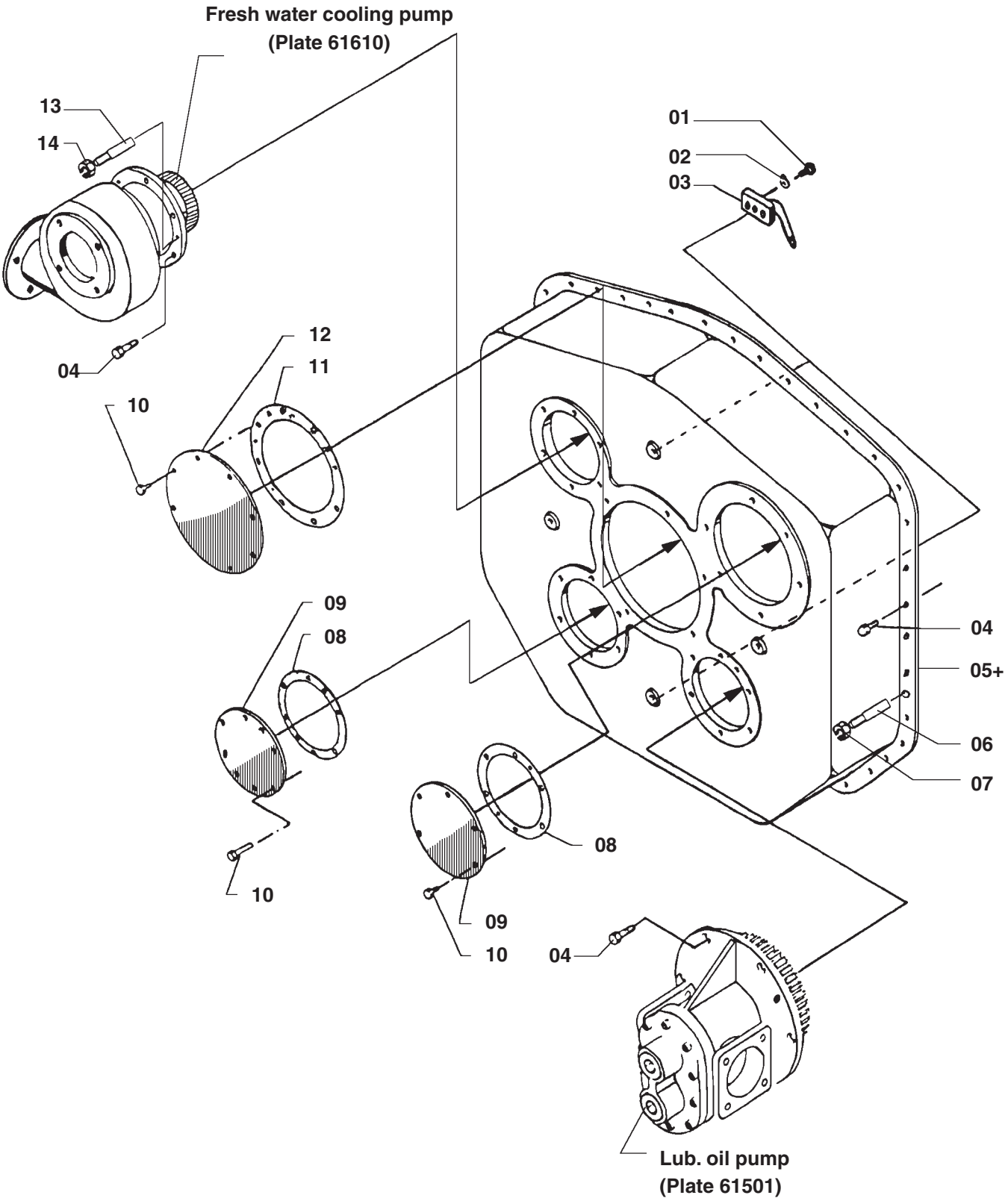
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Front Cover for Lubricating Oil Pump and Cooling Water Pump**	**61102-07H**

L28/32H



61102-07H	Front Cover for Lubricating Oil Pump and Cooling Water Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	4/E	**Screw**	Skrue
02	4/E	**Locking plate**	Låseskive
03	2/E	**Spray pipe**	Sprøjterør
04	52/E	**Screw**	Skrue
05+	1/E	**Cover**	Dæksel
06	2/E	**Guide pin**	Styrestift
07	2/E	**Nut**	Møtrik
08	2/E	**Gasket**	Pakning
09	2/E	**Cover**	Dæksel
10	18/E	**Screw**	Skrue
11	1/E	**Gasket**	Pakning
12	1/E	**Cover**	Dæksel
13	2/E	**Guide pin**	Styrestift
14	2/E	**Nut**	Møtrik
		+ Item No. 05 require an individual matching before mounting, contact MAN B&W, Holeby	+ Item nr. 05 kræver en individuel tilpasning før montering, kontakt MAN B&W, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

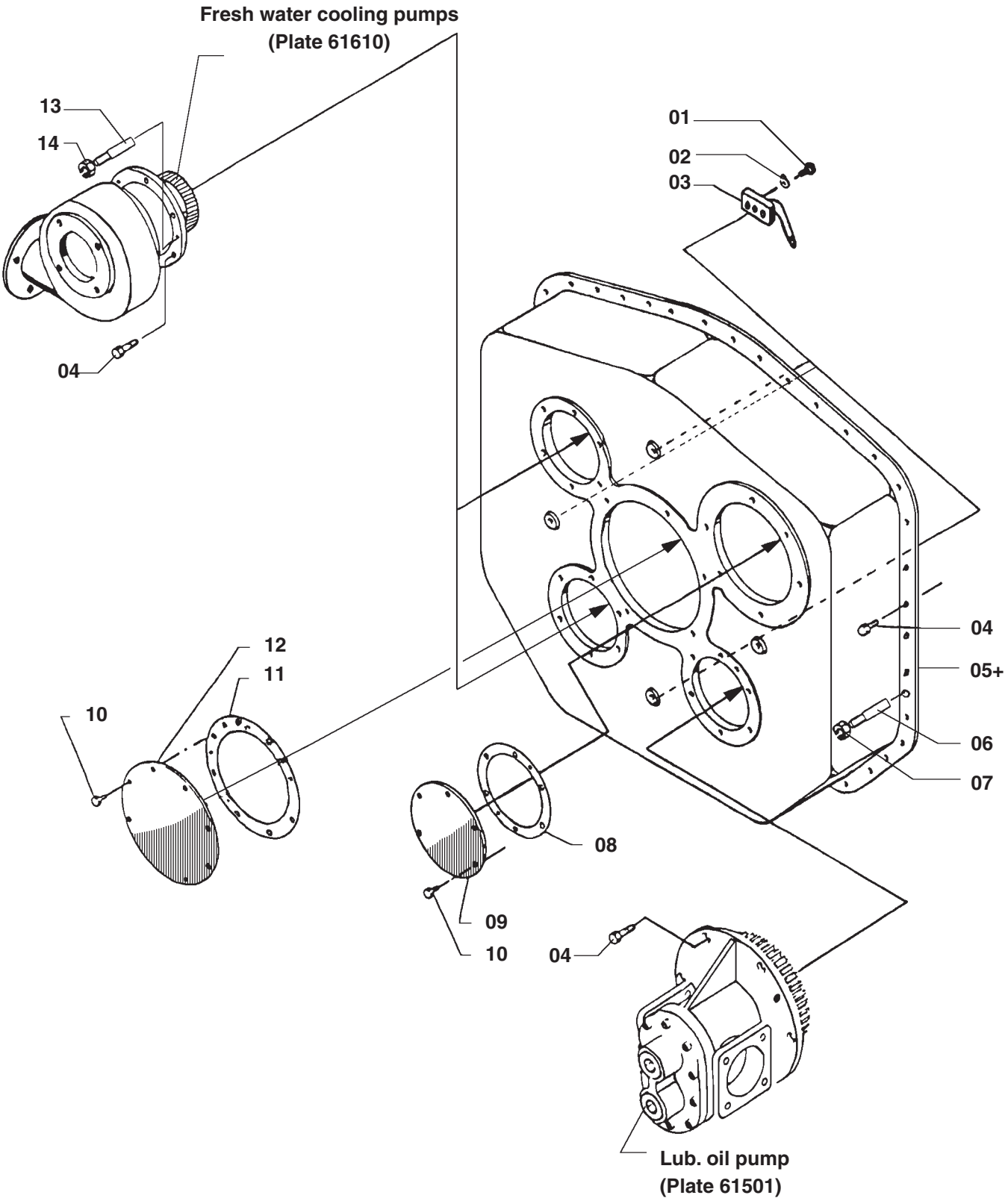
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Front Cover for Lubricating Oil Pump and Cooling Water Pumps**	**61102-10H**

L28/32H



61102-10H	Front Cover for Lubricating Oil Pump and Cooling Water Pumps	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	6/E	**Screw**	Skrue
02	6/E	**Locking plate**	Låseskive
03	3/E	**Spray pipe**	Sprøjterør
04	58/E	**Screw**	Skrue
05+	1/E	**Cover**	Dæksel
06	2/E	**Guide pin**	Styrestift
07	2/E	**Nut**	Møtrik
08	1/E	**Gasket**	Pakning
09	1/E	**Cover**	Dæksel
10	12/E	**Screw**	Skrue
11	1/E	**Gasket**	Pakning
12	1/E	**Cover**	Dæksel
13	4/E	**Guide pin**	Styrestift
14	4/E	**Nut**	Møtrik
		+ Item No. 05 require an individual matching before mounting, contact MAN B&W, Holeby	+ Item nr. 05 kræver en individuel tilpasning før montering, kontakt MAN B&W, Holeby

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

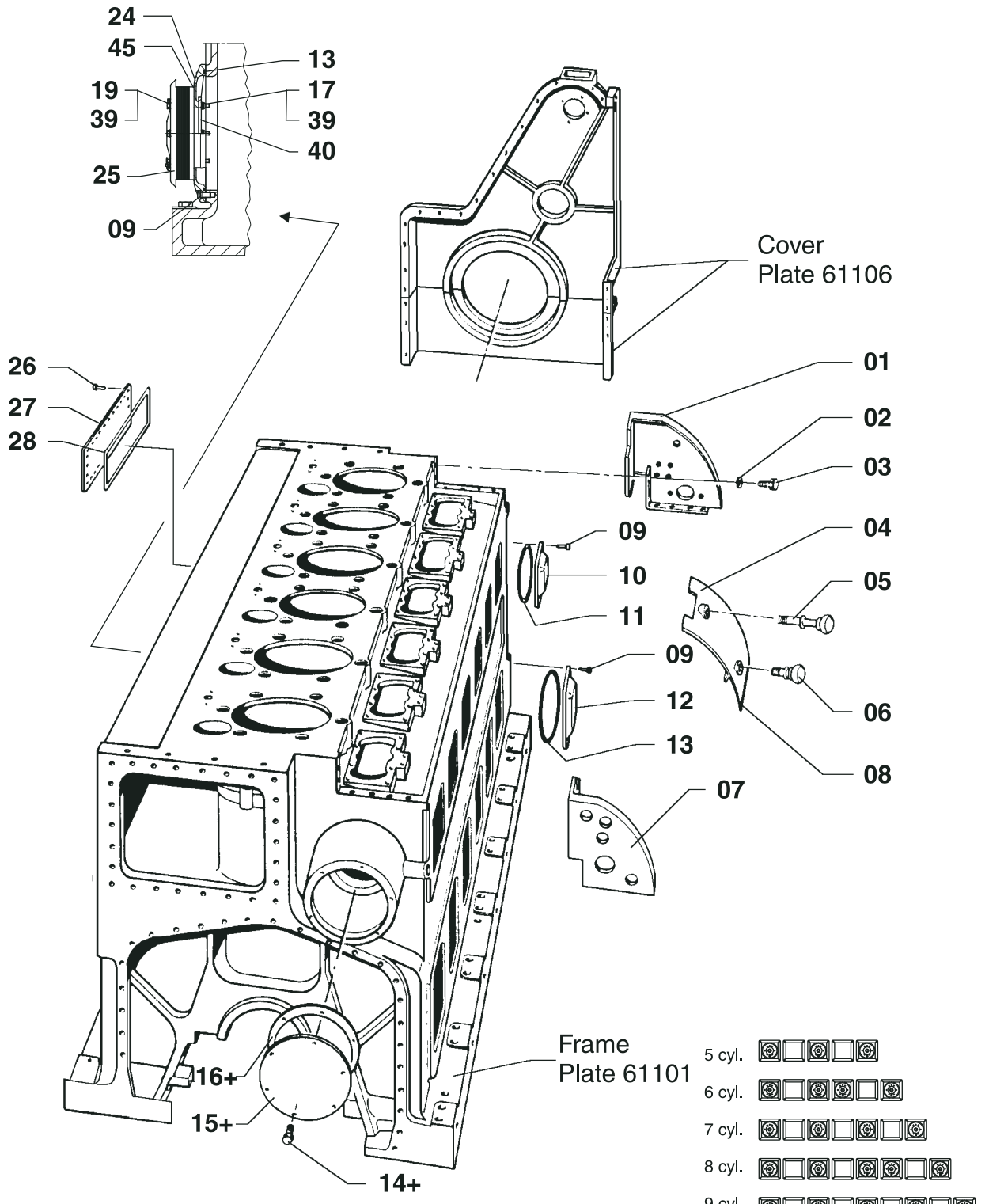
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	Covers on Frame	61106-20H

L28/32H



When ordering cover for crankshaft with relief valve, please see diagram with covers.

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Guard end aft**	Skærm, agter
02	12/E	**Washer**	Skive
03	12/E	**Screw**	Skrue
04	1/C	**Intermediate guard**	Mellemskærm
05	1/C	**Handle, upper**	Håndtag, øverst
06	1/C	**Handle, lower**	Håndtag, nederst
07	1/E	**Guard end fore**	Skærm, for
08	1/C	**Intermediate gauge complete, Item 04, 05 and 06**	Mellemskærm, komplet, Item 04, 05 and 06
09	12/C	**Screw**	Skrue
10	1/C	**Cover for camshaft housing**	Dæksel for Kamakselhus
11	1/C	**O-ring**	O-ring
12		**Cover for crankcase**	Dæksel for krumtaphus
	7/E	**5 cyl. engine**	5 cyl. motor
	8/E	**6 cyl. engine**	6 cyl. motor
	10/E	**7 cyl. engine**	7 cyl. motor
	11/E	**8 cyl. engine**	8 cyl. motor
	12/E	**9 cyl. engine**	9 cyl. motor
13	2/C	**O-ring**	O-ring
+14	6/E	**Screw**	Skrue
+15	1/E	**Cover**	Dæksel
+16	1/E	**Gasket**	Pakning
17	6/D	**Self locking nut**	Selvlåsende møtrik
19	6/D	**Screw**	Skrue
24		**Cover with safety valve complete**	Dæksel med sikkerhedsventil komplet
	3/E	**5 cyl. engine**	5 cyl. motor
	4/E	**6 cyl. engine**	6 cyl. motor
	4/E	**7 cyl. engine**	7 cyl. motor
	5/E	**8 cyl. engine**	8 cyl. motor
	6/E	**9 cyl. engine**	9 cyl. motor
25	1/D	**Safety valve complete**	Sikkerhedsventil, komplet
26	/I	**Screw**	Skrue
27	/I	**Cover**	Dæksel
28	/I	**Gasket**	Pakning
39	12/D	**Washer**	Skive
40	1/D	**Flange**	Flange
45	1/D	**O-ring**	O-ring
		+ Item 14, 15 and 16 are only mounted if the engine is delivered without fuel oil feed pump	+ Item 14, 15 og 16 er kun monteret hvis motoren er leveret uden fuel olieforpumpe

When ordering spare parts, see also page 600.50.

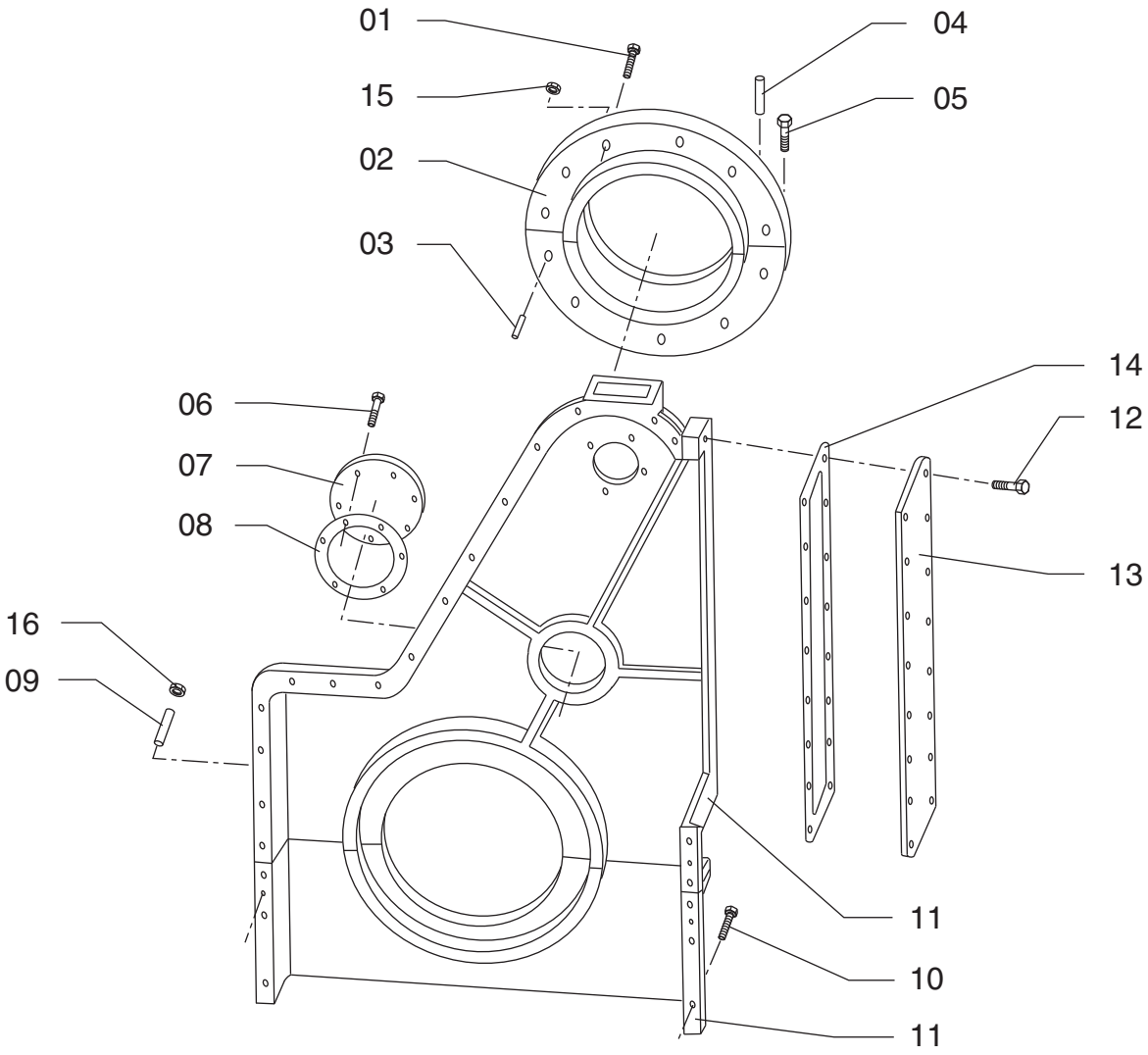
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder
Qty./D = Qty./Safety cover
Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/Cylinder
Antal/D = Antal/Sikkerhedsdæksel
Antal/I = Antal/Individuelt

Plate Page 1 (2)	Covers on Frame	61106-14H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	12/E	**Screw**	Skrue
02	1/E	**Sealing ring 2/2**	Tætningsring 2/2
03	2/E	**Guide pin**	Styrestift
04	2/E	**Cylindrical pin**	Cylindrisk stift
05	2/E	**Screw**	Skrue
06	6/E	**Screw**	Skrue
07	1/E	**Flange**	Flange
08	1/E	**Gasket**	Pakning
09	4/E	**Guide pin**	Styrestift
10	39/E	**Screw**	Skrue
11	1/E	**Cover 2/2**	Dæksel 2/2
12	18/E	**Screw**	Skrue
13	1/E	**Cover**	Dæksel
14	1/E	**Gasket**	Pakning
15	2/E	**Nut**	Møtrik
16	4/E	**Nut**	Møtrik

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

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Antal/E = Antal/Motor

Turbocharger

512/612

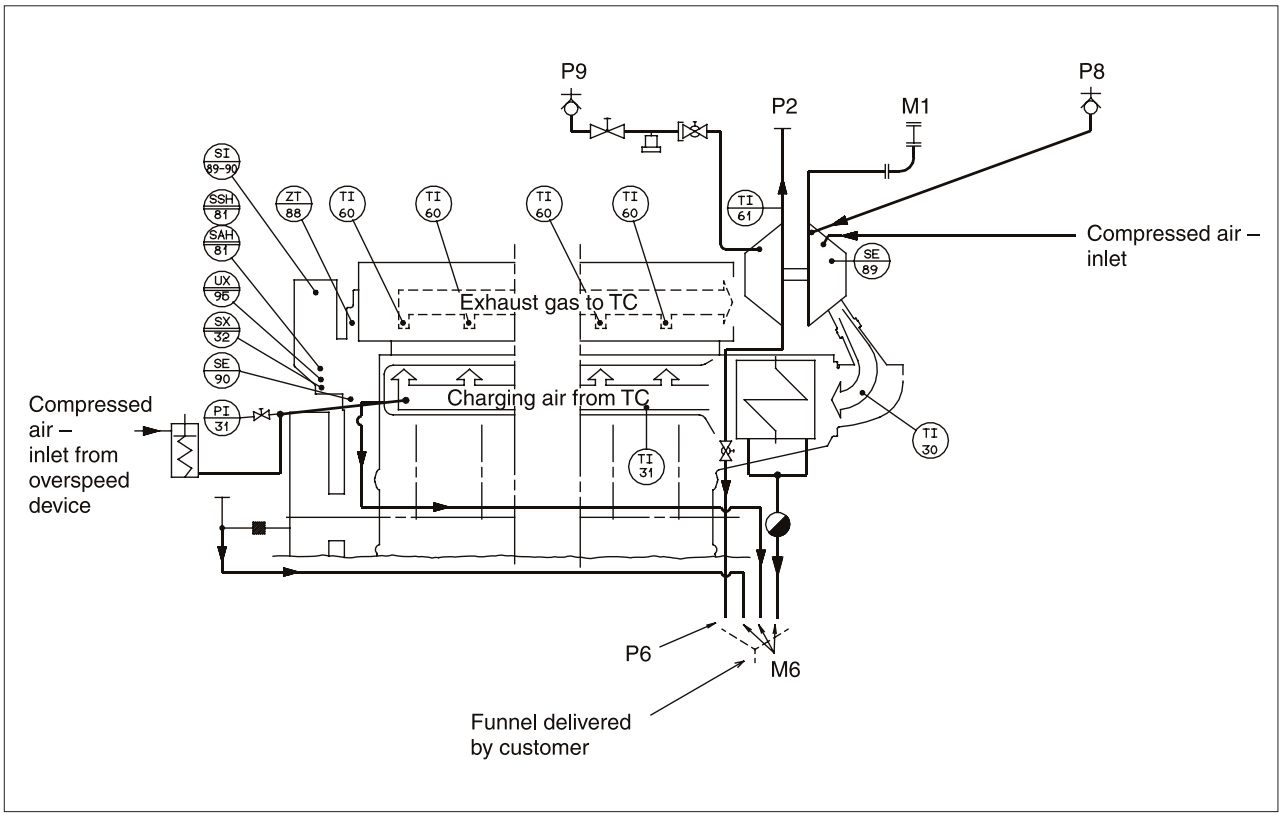

Fig. 1. Diagram for Turbocharger System

Turbocharger System

The turbocharger system of the engine, which is a constant pressure system, consists of an exhaust gas receiver, a turbocharger, a charging air cooler and a charging air receiver, the latter being integrated in the engine frame.

The turbine wheel of the turbocharger is driven by the engine exhaust gas, and the turbine wheel drives the turbocharger compressor, which is mounted on the same shaft.

Turbocharger, see separate manual.

The turbocharger pumps the air through the charging air cooler to the charging air receiver. From the charging air receiver, the air flows to each cylinder through the inlet valves.

The charging air cooler is of the compact tube-type with a large cooling surface. The cooling water is passed twice through the cooler, the end covers being designed with partitions which cause the cooling water to turn.

The cooling water tubes are fixed to the tube plates by expansion.

From the exhaust valves, the exhaust is led through water cooled intermediate pieces to the exhaust gas receiver where the pulsatory pressure from the individual exhaust valves is equalized and passed to the turbocharger as a constant pressure, and further to the exhaust outlet and silencer arrangement.

The exhaust gas receiver is made of pipe sections, one for each cylinder. The pipe sections are connected to each other with compensators. This prevents excessive stress in the pipes due to heat expansion.

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In the cooled intermediate piece a thermometer for reading the exhaust gas temperature is fitted. It is also possible to fit a sensor for remote reading.

To avoid excessive thermal loss and to ensure a reasonably low surface temperature, the exhaust gas receiver is insulated.

The turbocharger is equipped with a jet system for supply of extra driving torque to the compressor.

The purpose is to increase the compressor performance. With this system the engine can take up a large momentary load increase.

The system is activated automatically and only when the engine is exposed to a large momentary load increase, see section 609.

Description Page 1 (1)	Cleaning the Turbocharger In Service Water Washing of Compressor	612.05 Edition 07H

General

Compressor

Fouling of the airways depends primarily on the purity of the inlet air and thus, in turn, on the general maintenance condition of the machinery, i.e. mainly of the gas and oil tightness of the engines and on the fresh air ventilation system of the engine room.

Fouling of air filter, compressor or charging air cooler may be observed as changes in performance parameters:

- Decreasing charging air pressure.
- Decreasing turbocharger rotor speed.
- Increasing exhaust gas temperature.
- Severe fouling of airways may even result in compressor surge.

Regular cleaning during operation by injection of water before the compressor wheel will reduce the fouling rate considerably, and consequently prolong the intervals between dismantling necessary for mechanical cleaning.

Chemical cleaning will not improve the cleaning process as this primarily is based on the mechanical effect from the impact of the water droplets.

Certain types of fluid solvents can give formation of deposits on the compressor wheel, and should under no circumstances be used.

The intervals between cleaning by injection of water should be adjusted after assessing the degree and rate of fouling in the particular plant, i.e. based on observations and experience.

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Description Page 1 (3)	**Cleaning the Turbocharger in Service Dry Cleaning - Turbine**	**612.10** Edition 09H

L+V28/32H

Description

The tendency to fouling on the gas side of turbochargers depends on the combustion conditions, which are a result of the load and the maintenance condition of the engine as well as the quality of the fuel oil used.

Fouling of the gas ways will cause higher exhaust gas temperatures and higher wall temperatures of the combustion chamber components and will also lead to a higher fuel consumption rate.

Tests and practical experience have shown that radial-flow turbines can be successfully cleaned by the dry cleaning method.

This cleaning method employs cleaning agents consisting of dry solid bodies in the form of granules. A certain amount of these granules, depending on the turbocharger size, is, by means of compressed air, blown into the exhaust gas line before the gas inlet casing of the turbocharger.

The injection of granules is done by means of working air with a pressure of 5-7 bar.

On account of their hardness, particularly suited blasting agents such as nut-shells, broken or artificially shaped activated charcoal with a grain size of 1.0 mm to max. 1.5 mm should be used as cleaning agents.

The solid bodies have a mechanical cleaning effect which removes any deposits on nozzle vanes and turbine blades.

Dry cleaning can be executed at full engine load and does not require any subsequent operating period of the engine in order to dry out the exhaust system.

Experience has shown that regular cleaning intervals are essential to successful cleaning, as ex-cessive fouling is thus avoided. Cleaning every second day during operation is recommended.

The cleaning intervals can be shorter or longer based on operational experience.

Cleaning System

The cleaning system consists of a cleaning agent container (**2**) with a capacity of approx. 0.5 liters and a removable cover. Furthermore the system consists of an air valve (**3**), a closing valve (**1**) and two snap on connectors.

The position numbers (**2**) and (**3**) indicate the system's "blow-gun". Only one "blow-gun" is used for each engine plant. The blow-gun is working according to the ejector principle with pressure air (working air) at 5-7 bar as driven medium. Injection time approx. 2 min. Air consumption approx. 5 Nm^3/2 min.

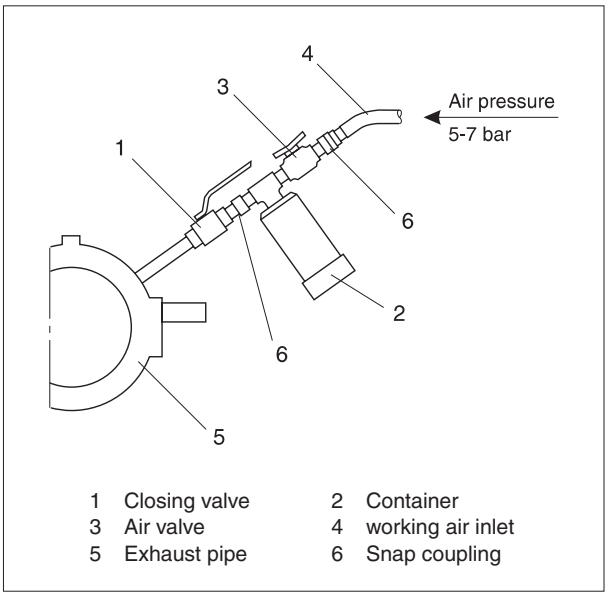

Fig 1 Arrangement of dry cleaning of turbocharger - Turbine.

L+V28/32H

Dry cleaning of turbochargers

Suppliers of cleaning agents:

1. "Solf Blast Grit, Grade 14/25"

TURCO Products B.V.
Verl. Blokkenweg 12, 617 AD EDE - Holland
Tel.:08380 - 31380, Fax.: 08380 - 37069

2. Designation unknown

Neptunes Vinke B.V.
Schuttevaerweg 24, 3044 BB Rotterdam
Potbus 11032, 3004 E.A. Rotterdam, Holland
Tel.: 010 - 4373166 Fax.: 4623466

3. "Grade 16/10"

FA. Poul Auer GmbH
Strahltechnik
D-6800 Mainheim 31, Germany

4. "Granulated Nut Shells"

Eisenwerke Würth GmbH + Co.
4107 Bad Friederichshall, Germany
Tel.: 0 71 36-60 01

5. "Soft Blasting Grade 12/3a"

H.S. Hansen Eftf. Kattegatvej 2
2100 Copenhagen Ø, Denmark
Tel.:(31) 29 97 00 Telex: 19038

6. "Crushed Nutshells"

Brigantine, Hong Kong

7. "Turbine Wash"

Ishikawajima-Harima Heavy Industries Co.
Ishiko Bldg., 2-9-7 Yassu, Chuo-Ku
Tokyo 104, Japan
Tel.: 03-2 77-42 91

8. "A-C Cleaner" (Activated Coal)

Mitsui Kozan Co. Ltd. (Fuel Dept.)
Yamaguchi Bldg., 2-1-1 Nihonbashi
Muromachi, Chuo-Ku
Tokyo 103, Japan

9. "OMT-701"

Marix KK
Kimura Bldg., 6-2-1 Shinbashi
Minato-Ku, Tokyo 105, Japan
Tel.: 03-4 36-63 71, Telex: 242-7232 MAIX J

10. "OMT-701"

OMT Incorporated
4F, Kiji Bldg., 2-8 Hatchobori,
4-chome, Chuo-Ku, Tokyo 104, Japan
Tel.: 03-5 53-50 77, Telex: 252-2747 OMTINC J

11. "Marine Grid No. 14" (Walnut)

Hikawa Marine
Kaigan-Dori 1-1-1, Kobe 650, Japan
Tel.: 0 78-3 21-66 56

12. "Marine Grid No. 14"

Mashin Shokai
Irie-Dori, 3-1-13, Hyogo-Ku
Kobe 652, Japan
Tel.: 0 78-6 51-15 81

13. Granulate

MAN B&W Diesel A/S
Teglholmsgade 41 2450 København SV, Danmark
Tel.: +45 33 851100 Fax.: +45 33 851030

The list is for guidance only and must not be considered complete. We undertake no responsibility that might be caused by these or other products.

Description Page 1 (1)	Cleaning the Turbocharger in Service Water Washing - Turbine Side	612.15 Edition 02H

General

Description

The tendency to fouling on the gas side of turbochargers depends on the combustion conditions, which are a result of the load on and the maintenance condition of the engine as well as the quality of the fuel oil used.

Fouling of the gas ways will cause higher exhaust gas temperatures and higher surface temperatures of the combustion chamber components and will also lead to a lower performance.

Tests and practical experience have shown that radial-flow turbines can be successfully cleaned by injection water into the inlet pipe of the turbine. The cleaning effect is based on the water solubility of the deposits and on the mechanical action of the impinging water droplets and the water flow rate.

The necessary water flow is dependent on the gas flow and the gas temperature. Enough water must be injected per time unit so that, not the entire flow will evaporate, but about 0.25 l/min. will flow off through the drainage opening in the gas outlet. Thus ensuring that sufficient water has been injected.

Service experience has shown that the above mentioned water flow gives the optimal reduced or disappear. If the recommended water flow is exceed, there is a certain risk of a accumulation of water in the turbine casing, which can result in damage on the turbocharger.

The best cleaning effect is obtained by cleaning at low engine load approx. 20% MCR. Cleaning at low load will also reduce temperature shocks.

Experience has shown, that washing at regular intervals is essential to successful cleaning, as excessive fouling is thus avoided. Washing at intervals of 100 hours is therefore recommended. Depending on the fuel quality these intervals can be shorter or longer. However, the turbine must be washed at the latest when the exhaust gas temperature upstream of the turbine has risen about 20° C above the normal temperature.

Heavily contaminated turbines, which where not cleaned periodically from the very beginning or after an overhaul, cannot be cleaned by this method.

If vibration in the turbocharger occur after water-washing has been carried out, the washing should be repeated. If unbalance still exists, this is presumably due to heavy fouling, and the engine must be stopped and the turbocharger dismantled and manually cleaned.

The washing water should be taken from the fresh water system and not from the fresh cooling water system or salt water system. No cleaning agents are solvents need to be added to the water.

To avoid corrosion during standstill, the engine must, upon completing of water washing run far at least 1 hour before stop so that all parts are dry.

Water Washing System

The water washing system consists of a pipe system equipped with a regulating valve, a manoeuvring valve, a 3-way cock and a drain pipe with a drain valve from the gas outlet, see illustration on work card 612-15.00.

The water for washing the turbine, is supplied from the external fresh water system through a flexible hose with couplings. The flexible hose must be disconnected after water washing.

By activating the manoeuvring valve and the regulating valve, water is led through the 3-way cock to the exhaust pipe intermediate flange, equipped with a channel to lead the water to the gas inlet of the turbocharger.

The water which is not evaporated, is led out through the drain pipe in the gas outlet.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Overhaul of Charging Air Cooler**	**612-01.00** Edition 02H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ■ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Overhaul of charging air cooler.

Starting position:

Related procedure:

Man power:

Working time : 3-4 Hours
Capacity : 2 men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Ring and open end spanner, 13 mm.
Ring and open end spanner, 19 mm.
Ring and open end spanner, 24 mm.
Allen key, 10 mm.
Wire rope.
Tackle.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61203	14	8/cooler
61203	35	1/cooler
61203	37	1/cooler
61203	39	1/cooler

08028-0D/H5250/94.08.12

L+V28/32H

The charging air cooler is normally cleaned and overhauled at the intervals indicated in the "Planned Maintenance Program", or if observations prove that the cooler does not work satisfactory, see section 602.

Overhaul of Charging Air Cooler.

1) Close the cooling water inlet and outlet valves and disconnect the pipes.

2) Remove the screw (1), fig. 1, which secure the end cover of the cooler element to the cooler housing, and pull the cooler element half-way out.

Place a wire rope round the cooler element and attach a tackle hook, after which the elements are lifted and pulled out of the cooler housing and landed on a couple of wooden planks on the floor.

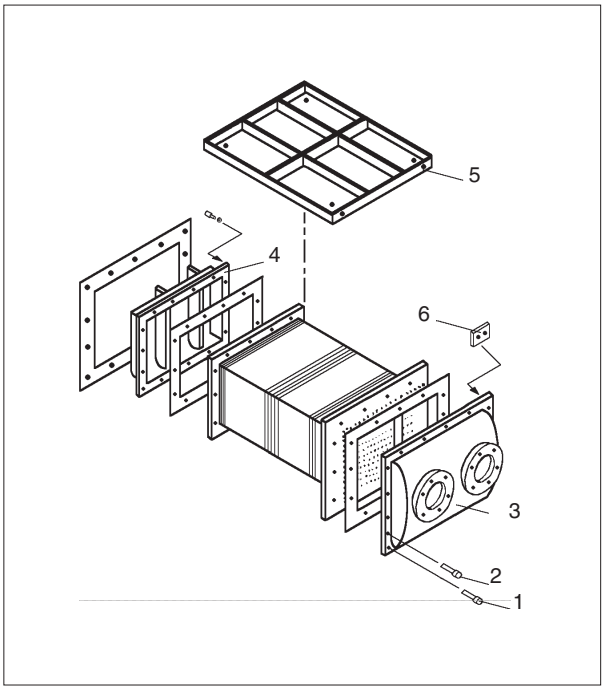

Fig. 1.

3) Remove screws (2) and end cover (3) reversal chamber (4) and side plates (5).

4) Clean the cooler element of the water and air sides.

After using cleaning agents the manufacting recommendting must be followed.

The greatest care must be exercised when dismantling cleaning and mounting the cooler element, as the thin fins of the tubes cannot stand impacts and pressure.

If nevertheless, the metal is damaged, it should be carefully straightened, as bent fins will increase the pressure drop across the cooler considerably.

Should one ore more cooler tubes become leaky it/they must immediately be made tight, either by expending the tube ends into the tube plates or by blanking of the tube(s) concerned with plugs.

It is important that the charging air cooler is not leaky as any sea water that leaks in will be carried along with the air to the cylinders where the salt contained in the water will damage valves, piston rings, and cylinder liners.

5) Also clean end cover and coat it on the inside with an anti-corrosion blocks agent. Inspect the anti-corrosion (6) and renew if necessary.

Note: That paint or similar must not be applied to these blocks.

6) Fouling and deposite in the pipes can be removed by using a hand or machine operated circular steel brush. The pipe inner diameter is 13 mm.

7) When mounting the air cooler, renew all gaskets.

Out of Service Periods.

At longer periods out of service the air cooler is drained if the coolant is sea water followed by flushing with fresh water and left with drain and venting cocks open.

At fresh water coolant systems recommendations for the entire system is followed.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Charge Air Cooler Housing - Draining**	**612-01.05** Edition 02H

L+V28/32H

Safety Precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Check of drain from charge air cooler housing.

Starting Position:

Related Procedure:

Man Power:

Working time :
Capacity : 1 person

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special Tools:

Plate No	Item No	Note

Hand Tools:

Replacement and Wearing Parts:

Plate No	Item No	Qty. /

08028-0D/H5250/94.08.12

L+V28/32H

In order to prevent water from collecting at the bottom of the gas outlet of the turbocharger, the charge air cooler and the charge air receiver, the charge air cooler is equipped with a drain and an automatic water discharger.

This installation will prevent water from the charge air to be sucked into the engine, where it will destroy the lubricating oil film on the cylinder walls, resulting in increasing wear. Further, the water will cause corrosion of the intake components.

Therefore, frequent control of the drain and the water discharger has to take place to secure that these components are free of foreign substances which could foul them.

1) The drain screw at the bottom of the water discharger has to be loosened and cleaned of impurities, if any.

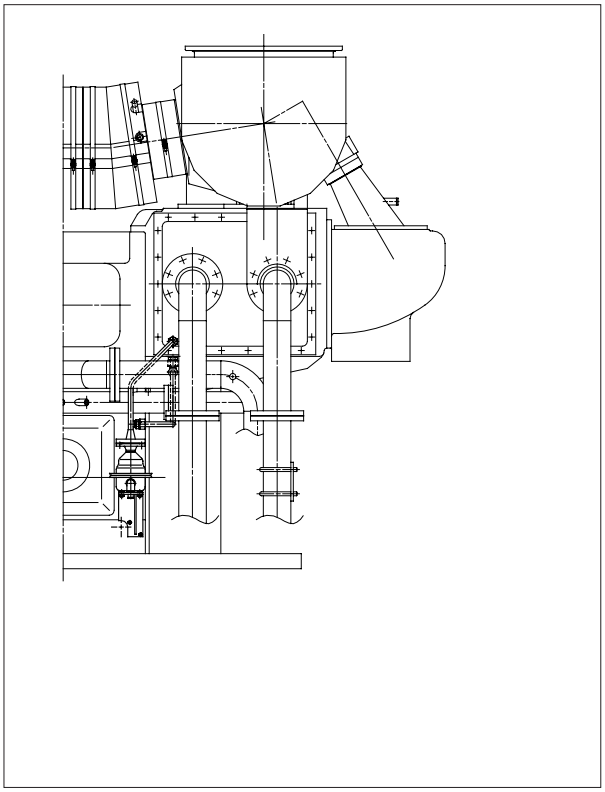

Fig 1 Placement of Steam Trap

If, with the drain screw dismounted	If, with the drain screw dismounted
- a constant air flow is present: **1.** Everything is all right. **2.** Mount the drain screw at the bottom of the water discharger.	- no constant air flow is present: **1.** Dismount the drain pipe and blow-through the pipe by means of compressed air. Clean the discharge hole in the charge air cooler in order to secure a clear passage of water. **2.** Mount the drain pipe and check with your hand that a constant air flow is present. **3.** Mount the drain screw at the bottom of the water discharger.

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Working Card Page 1 (3)	**Water Washing of Compressor Side Turbocharger Type NR15/R - NR20/R - NR24/R - NR26/R.**	**612-05.00** Edition 03H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Water washing of compressor side.
Turbocharger cleaning with engine in service.

Starting position:

Related procedure:

Man power:

Working time	:	1/4	hour
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no	Item no	Note

Hand tools:

Replacement and wearing parts:

Plate no	Item no	Qty. /

See the special instructions for turbocharger.

L+V28/32H

Before Cleaning

The cleaning process is only to be carried out when the engine is at operating temperature (see Operating Data 600.30) and when it is loaded as close as possible to full load (see Main Data 600.00).

See also "Description for Water Washing of Compressor side", 612.05.

Cleaning Procedure

1) Run the engine with as high a load as possible.

2) Discharge the excesspressure in the container by drawing out the spindle in the safety valve (see fig. 1) before loosening the top cover.

The spindle returns automatically by means of a built-in spring.

3) Fill the container with 2 litres fresh water (see the scale on the container).

Warning: Do not use sea water or cooling water.

4) Mount the top cover on the container.

5) Blow air into the container by means of a blow gun, until an operation pressure of 3 bar is reached (see fig 2).

The safety valve will open at a pressure of 4 bar.

Excesspressure will discharge through the safety valve.

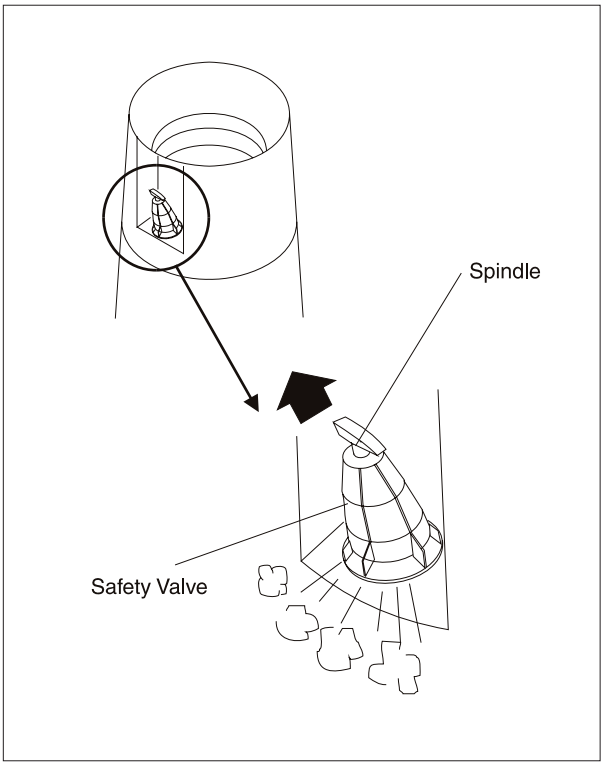


Fig 1

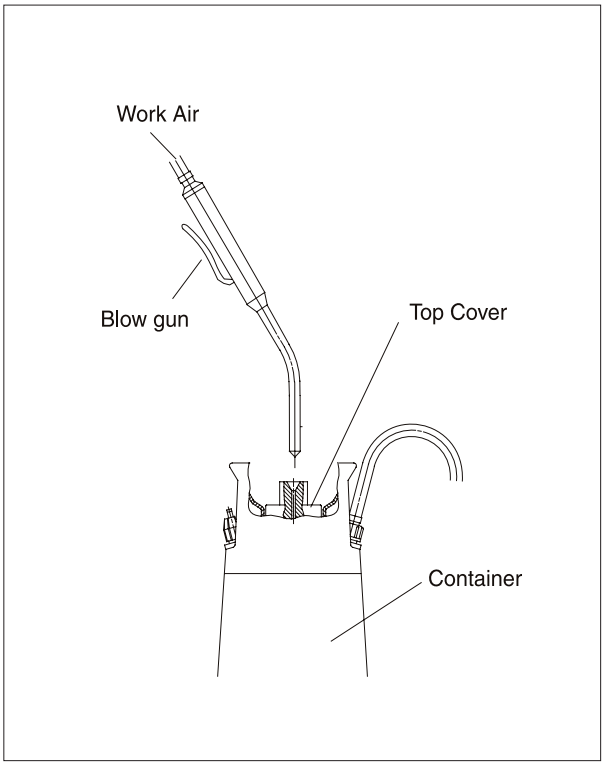
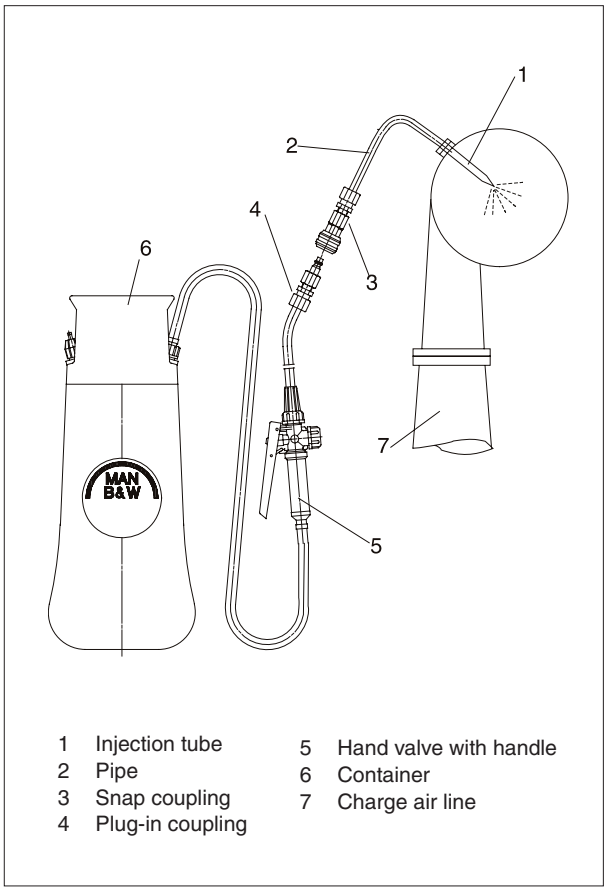


Fig 2

L+V28/32H



1 Injection tube
2 Pipe
3 Snap coupling
4 Plug-in coupling
5 Hand valve with handle
6 Container
7 Charge air line

Fig 3

6) Connect the plug-in coupling of the lance to the snap coupling on the pipe (see fig 3).

7) Depress the handle on the hand valve until the water is completely injected into the compressor (approx. 30 seconds).

The water will enter the compressor in atomized condition, impinge the vanes of the compressor wheel with high velocity and thus wash off the dirt deposited.

8) Release the plug-in coupling and vent the container by drawing the spindle out of the safety valve.

After Cleaning

9) Run the engine for minimum 10 minutes at unaltered high load.

10) Compare the measurements of the operating data (see fig 4) before and after the cleaning procedure (see Operating Data 600.30).

IF	THEN
the comparison indicates success of the washing procedure	the water washing of the compressor side is finished
the comparison indicates lack of the washing procedure	carry out the washing procedure from step 1 with 10 minutes interval from the initial washing
severe dirt is being deposited in the compressor	dismantling of the compressor components for manual cleaning is necessary (see special turbocharger manual in section 612).

Fig 4

Working Card Page 1 (2)	**Dry Cleaning of Turbocharger - Turbine Side**	**612-10.00** Edition 02H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Dry cleaning of turbine side, cleaning with engine in service.

Starting position:

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Blow gun with container.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

See the special instruction for turbocharger.

L+V28/32H

Cleaning Procedure.

1) The cleaning is carried out during high engine load minimum 75 % at full load.

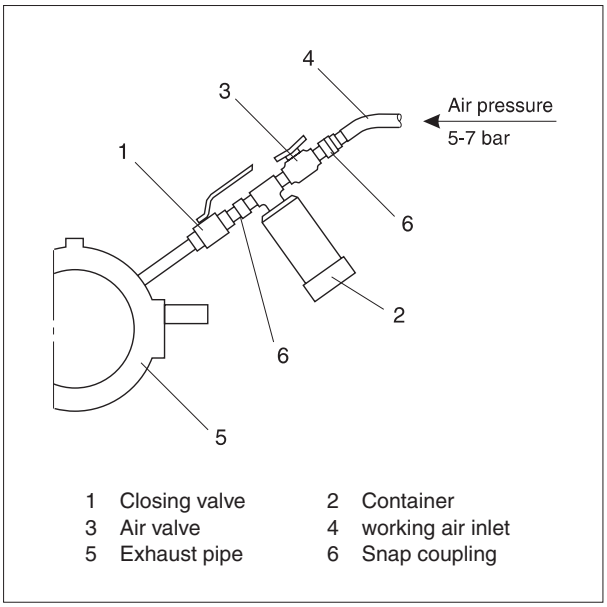


Fig 1 Arrangement of dry cleaning of turbocharger - Turbine.

2) Before connecting the "blow-gun" open the closing valve (1), see fig 1 and check whether there is free passage.

3) Fill cleaning granulated substance into the container (2) for turbocharger type:

NR20/R - NR20S:	0.2 - 0.3 liters.
NR24/R - NR26/R:	0.3 - 0.4 liters.

Connect to the working air system (4), 5 -7 bar.

4) Connect the "blow-gun" to valve (1). Open air valve (3).

Then open valve (1) slowly until a whisling sound indicates that blowing-in of granulated substance takes place.

Injection time approx. 2 min.

For dry cleaning of turbine side, see also description 612.10 "Cleaning the Turbocharger in Service, Dry Cleaning - Turbine Side.

Working Card Page 1 (2)	**Water Washing of Turbine Side**	**612-15.00** Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Water washing of turbine side, cleaning with engine in service.

Starting position:

Related procedure:

Man power:

Working time	:	1/2	Hour
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

See the special instruction for turbocharger.

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General

Cleaning Procedure.

1) Adjust the engine load to approx. 20 % and let the engine stabilize for 10 min.

2) Open the drain cock at the turbocharger outlet and check for free passage, see fig. 1.

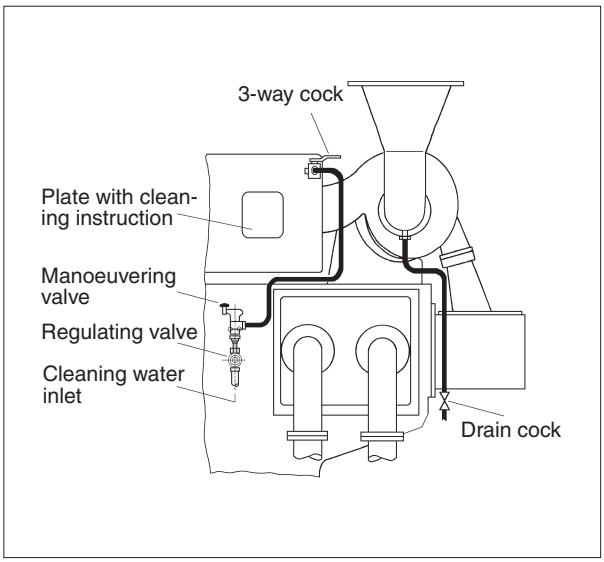


Fig. 1. Arrangement for water washing.

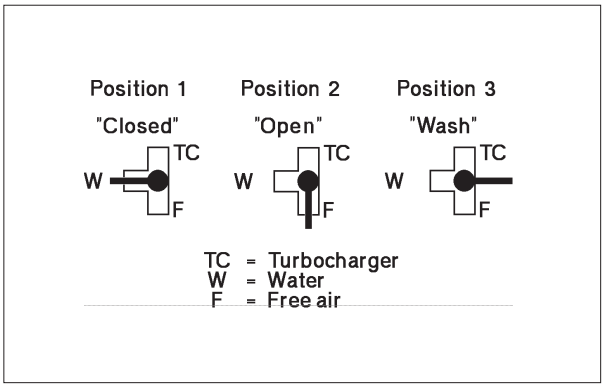


Fig. 2. 3-way cock.

3) Turn the 3-way cock to position 2 "Open", see fig. 2 and check for free passage. If ok turn to the water wash position 3 "Wash".

4) Connect the water supply to the water wash system.

5) Activate the manoeuvring valve, see fig. 1.

Then open the regulating valve and adjust the water flow until the drain flow is approx. 0,25 l/min.

6) Continue the water washing 5 - 10 min. or until the drain water is free of particles.

7) Release the manoeuvring valve and disconnect the water supply.

Turn the 3-way cock to position 1, "Closed" and check that the water drain flow has stopped.

8) Continue at this load at least 5 min. before increasing the load to the normal condition.

9) After the water washing, the engine should run for at least 1 hour before stop.

Note: The regulating valve has to be opened slowly.

The manoeuvring valve must not be locked in open position.

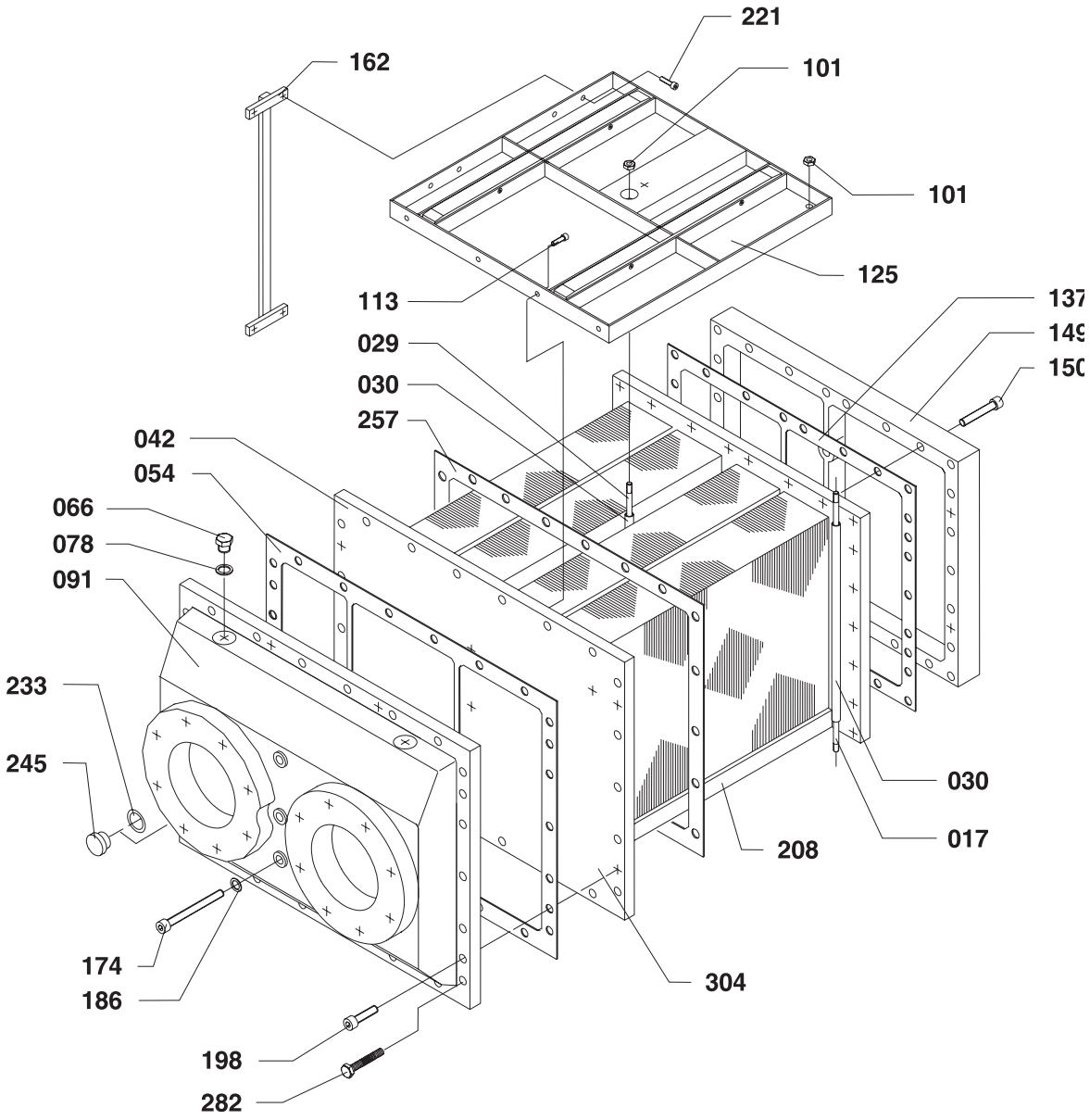
The water injection time mentioned in item 6 must be not exceeded.

For water washing of turbine side, see also description for water washing.

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Freshwater	61201-12H

5-6L28/32H



08028-0D/H5250/94.08.12

5-6L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
029	1/K	**Crossmember**	Travers
030	2/K	**Pipe**	Rør
042	1/K	**Cooler block**	Kølerblok
054	1/K	**Gasket end cover**	Pakning endedæksel
066	4/K	**Plug screw**	Propskrue
078	4/K	**Cu-washer**	Cu-skive
091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Side plate right**	Sideplade højre
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
162	1/K	**Crossmember**	Travers
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Side plate left**	Sideplade venstre
221	4/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
245	1/K	**Plug**	Prop
257	1/K	**Gasket**	Pakning
282	22/K	**Screw**	Skrue
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 and 245**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 og 245

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler

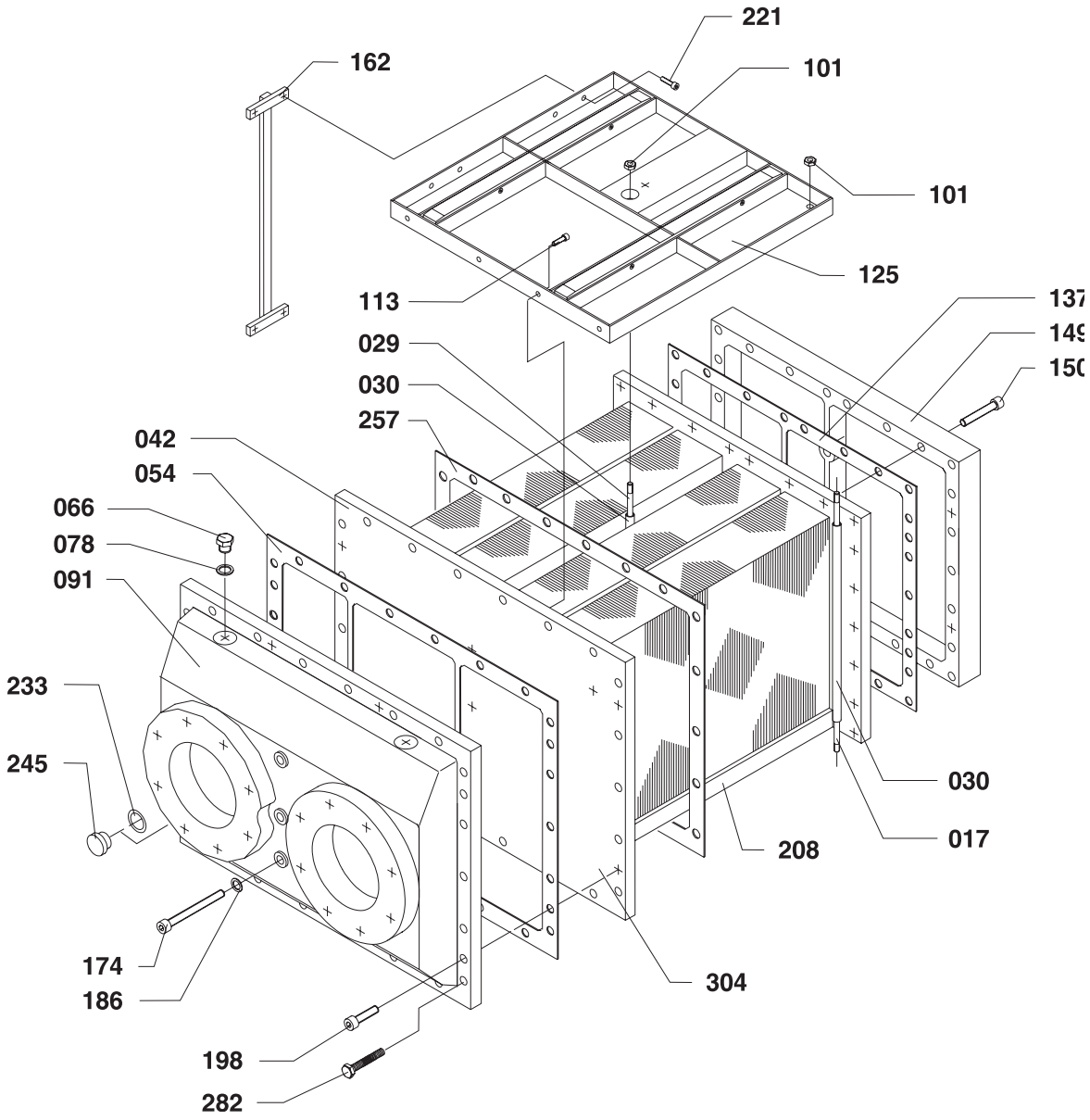
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Freshwater	61201-13H

7-8-9L28/32H



08028-0D/H5250/94.08.12

7-8-9L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
029	1/K	**Crossmember**	Travers
030	2/K	**Pipe**	Rør
042	1/K	**Cooler block**	Kølerblok
054	1/K	**Gasket end cover**	Pakning endedæksel
066	4/K	**Plug screw**	Propskrue
078	4/K	**Cu-washer**	Cu-skive
091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Side plate right**	Sideplade højre
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
162	1/K	**Crossmember**	Travers
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Side plate left**	Sideplade venstre
221	4/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
245	1/K	**Plug**	Prop
257	1/K	**Gasket**	Pakning
282	22/K	**Screw**	Skrue
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 and 245**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 162, 174, 186, 198, 208, 221, 233 og 245

Item No.	Qty.	Designation	Benævnelse

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*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
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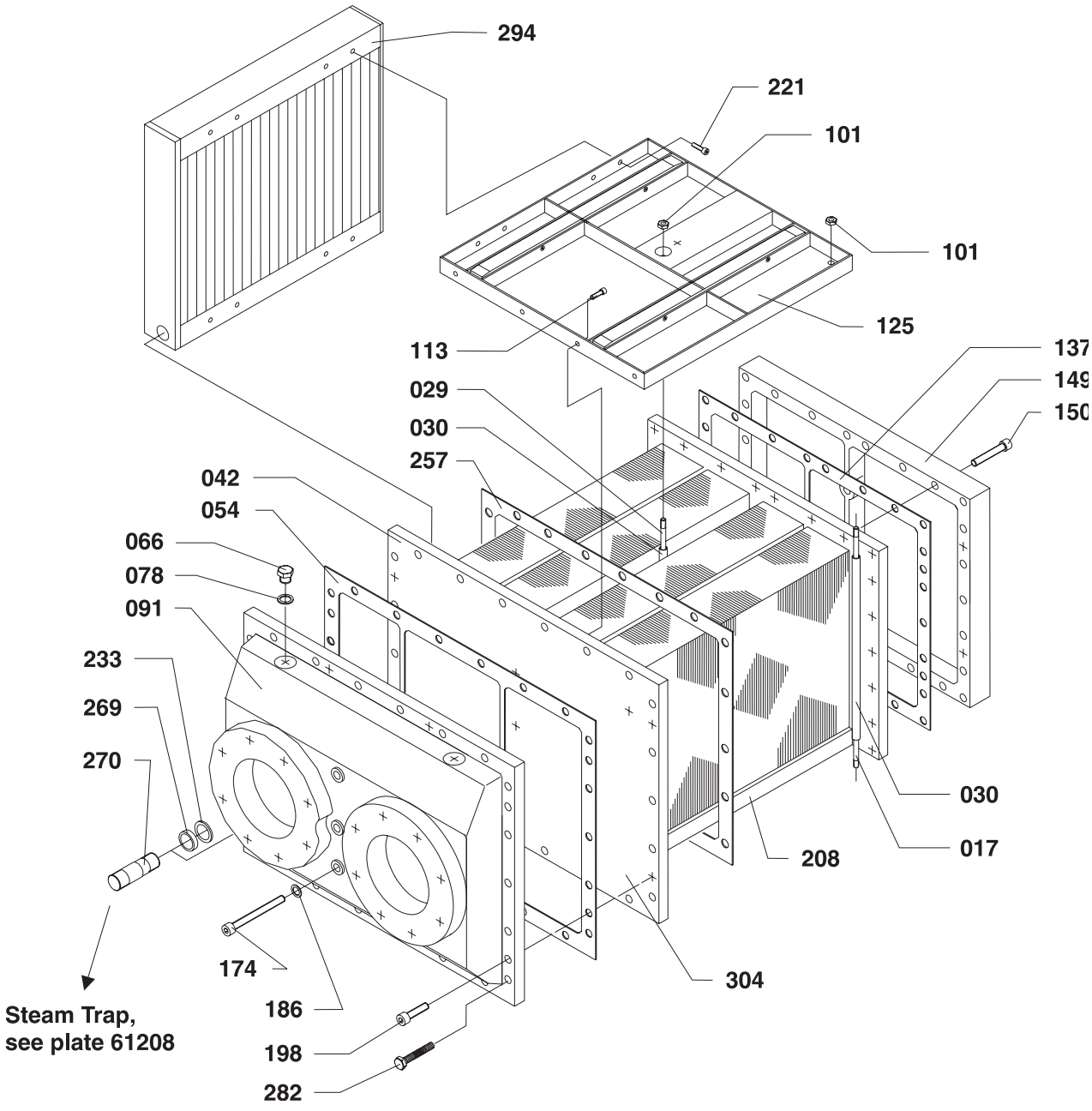
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Freshwater	61201-14H

5-6L28/32H



08028-0D/H5250/94.08.12

5-6L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
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091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Side plate right**	Sideplade højre
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Side plate left**	Sideplade venstre
221	8/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
257	1/K	**Gasket**	Pakning
269	1/K	**Ring**	Ring
270	1/K	**Drain pipe for WMC**	Drænrør for WMC
282	22/K	**Screw**	Skrue
294	1/K	**Water mist catcher**	Vandudskiller
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 and 294**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 og 294

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler

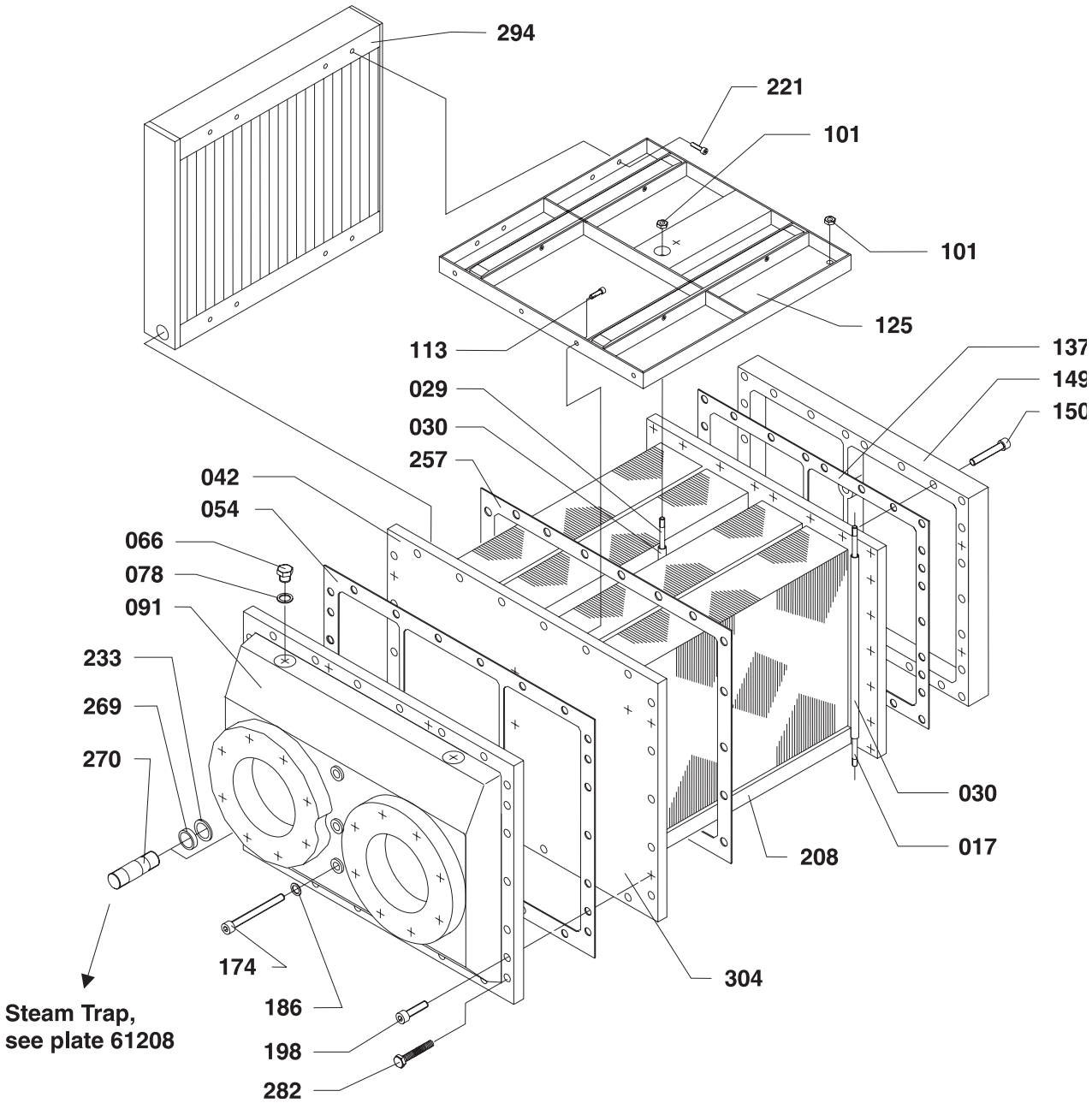
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Freshwater	61201-15H

7-8-9L28/32H



08028-0D/H5250/94.08.12

7-8-9L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
029	1/K	**Crossmember**	Travers
030	2/K	**Pipe**	Rør
042	1/K	**Cooler block**	Kølerblok
054	1/K	**Gasket end cover**	Pakning endedæksel
066	4/K	**Plug screw**	Propskrue
078	4/K	**Cu-washer**	Cu-skive
091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Side plate right**	Sideplade højre
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Side plate left**	Sideplade venstre
221	8/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
257	1/K	**Gasket**	Pakning
269	1/K	**Ring**	Ring
270	1/K	**Drain pipe for WMC**	Drænrør for WMC
282	22/K	**Screw**	Skrue
294	1/K	**Water mist catcher**	Vandudskiller
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 and 294**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270 og 294

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler

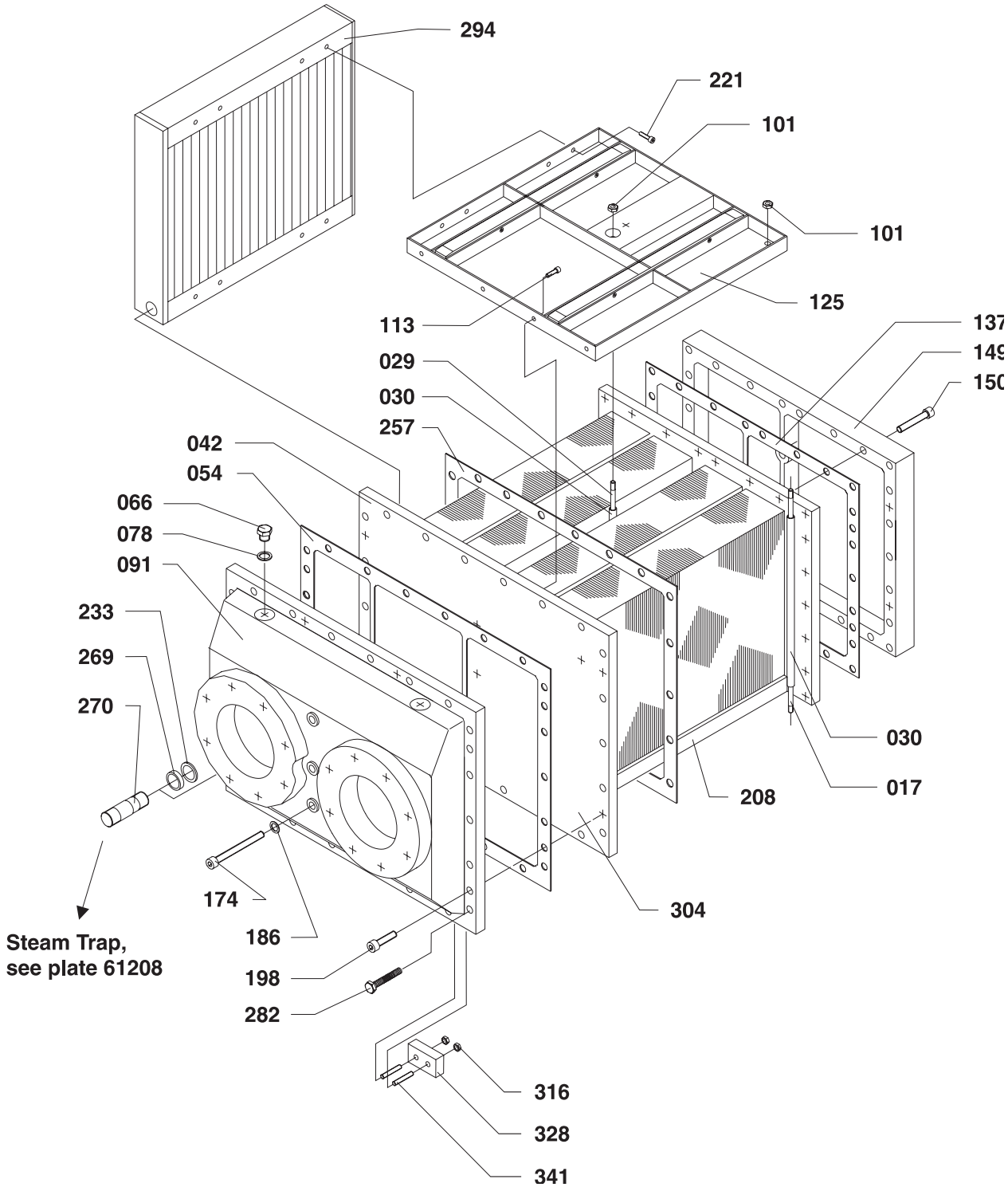
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Seawater	61201-16H

5-6L28/32H



08028-0D/H5250/94.08.12

5-6L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
029	1/K	**Crossmember**	Travers
030	2/K	**Pipe**	Rør
042	1/K	**Cooler block**	Kølerblok
054	1/K	**Gasket end cover**	Pakning endedæksel
066	4/K	**Plug screw**	Propskrue
078	4/K	**Cu-washer**	Cu-skive
091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Top plate**	Topplade
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Bottom plate**	Bundplade
221	8/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
257	1/K	**Gasket**	Pakning
269	1/K	**Ring**	Ring
270	1/K	**Drain pipe for water mist catcher**	Drænrør for vandudskiller
282	22/K	**Screw**	Skrue
294	1/K	**Water mist catcher**	Vandudskiller

Item No.	Qty.	Designation	Benævnelse
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341
316	12/K	**Nut**	Møtrik
328	6/K	**Anti-corrosion block**	Anode
341	12/K	**Stud**	Tapskrue

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler

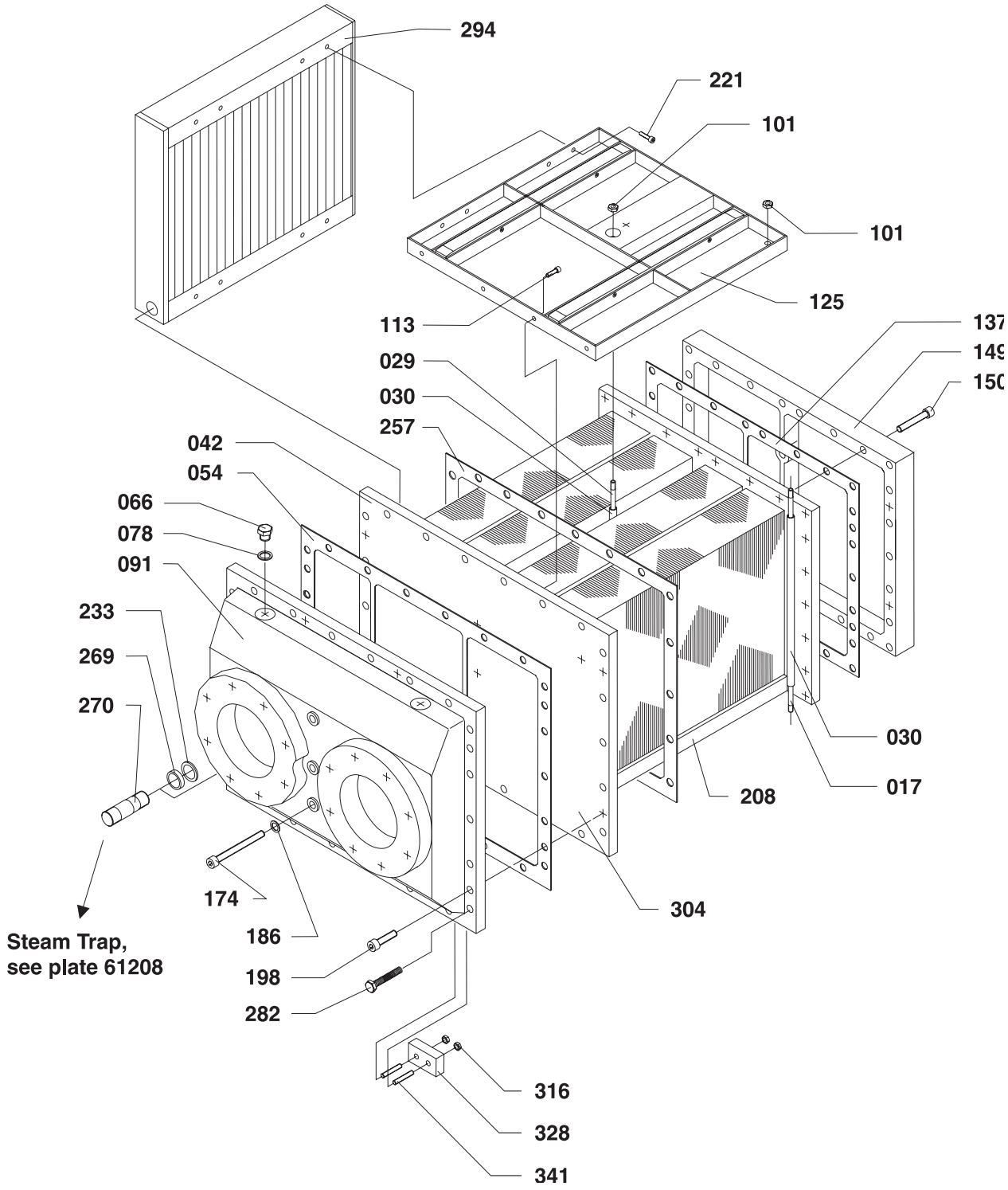
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Seawater	61201-17H

7-8-9L28/32H



08028-0D/H5250/94.08.12

61201-17H	Charging Air Cooler - Seawater	Plate Page 2 (2)

7-8-9L28/32H

Item No.	Qty.	Designation	Benævnelse
017	1/K	**Crossmember**	Travers
029	1/K	**Crossmember**	Travers
030	2/K	**Pipe**	Rør
042	1/K	**Cooler block**	Kølerblok
054	1/K	**Gasket end cover**	Pakning endedæksel
066	4/K	**Plug screw**	Propskrue
078	4/K	**Cu-washer**	Cu-skive
091	1/K	**End cover**	Endedæksel
101	4/K	**Nut**	Møtrik
113	8/K	**Screw**	Skrue
125	1/K	**Top plate**	Topplade
137	1/K	**Gasket reversing cover**	Pakning vendekammer
149	1/K	**Reversing cover**	Vendekammer
150	32/K	**Screw**	Skrue
174	5/K	**Screw**	Skrue
186	5/K	**Cu-washer**	Cu-skive
198	5/K	**Screw**	Skrue
208	1/K	**Bottom plate**	Bundplade
221	8/K	**Screw**	Skrue
233	1/K	**O-ring**	O-ring
257	1/K	**Gasket**	Pakning
269	1/K	**Ring**	Ring
270	1/K	**Drain pipe for water mist catcher**	Drænrør for vandudskiller
282	22/K	**Screw**	Skrue
294	1/K	**Water mist catcher**	Vandudskiller

Item No.	Qty.	Designation	Benævnelse
304	1/E	**Charging air cooler, complete, incl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341**	Ladeluftkøler, komplet, inkl. item 017, 029, 030, 042, 054, 066, 078, 091, 101, 113, 125, 137, 149, 150, 174, 186, 198, 208, 221, 233, 269, 270, 294, 316, 328, 341
316	12/K	**Nut**	Møtrik
328	6/K	**Anti-corrosion block**	Anode
341	12/K	**Stud**	Tapskrue

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler

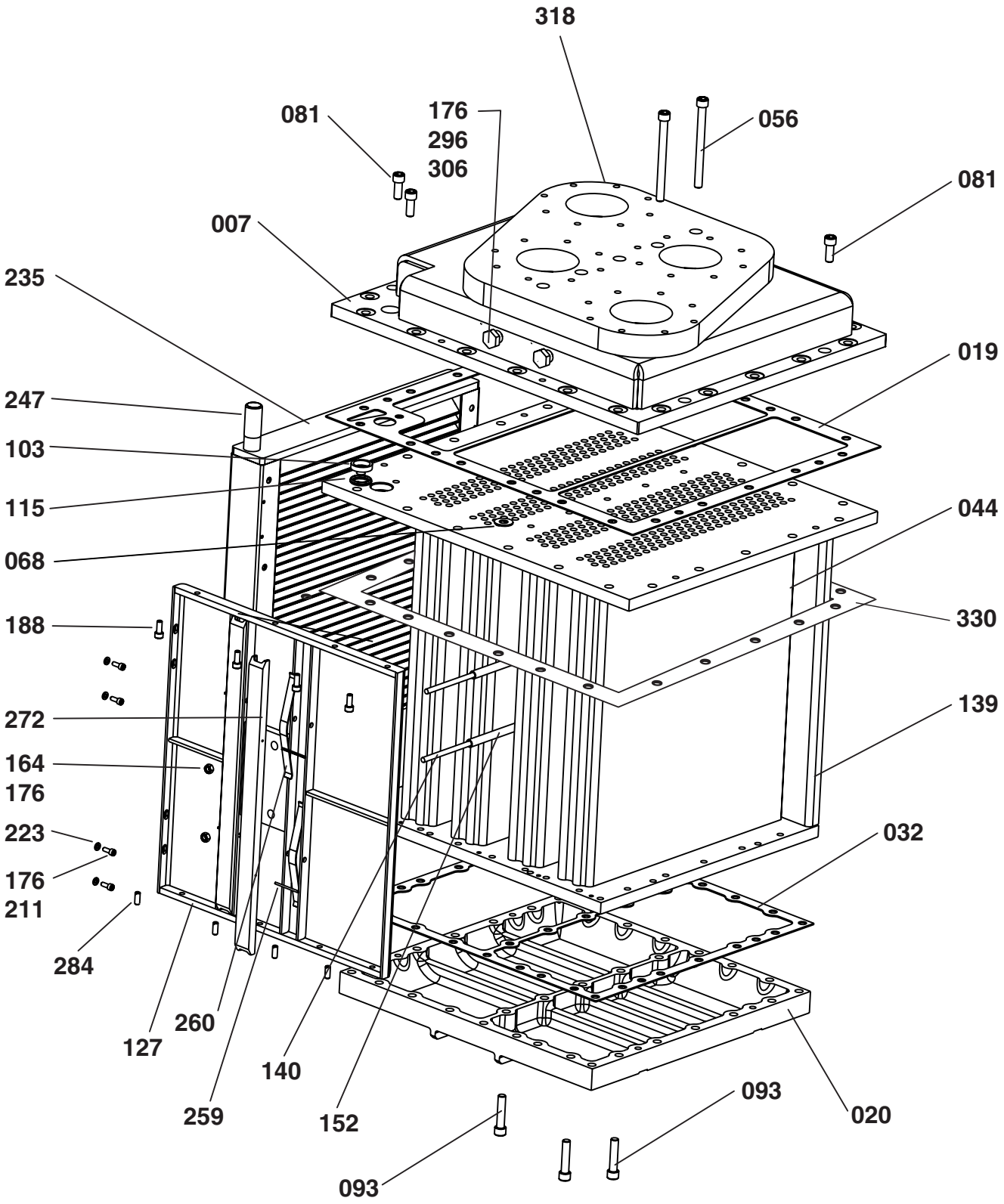
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Charging Air Cooler - Freshwater	61201-29H

L28/32H



08028-0D/H5250/94.08.12

61201-29H	Charging Air Cooler - Freshwater	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
007	1/K	**End cover**	Endedæksel
019	1/K	**Gasket for end cover**	Pakning for endedæksel
020	2/K	**Reversing chamber**	Vendekammer
032	1/K	**Gasket for reversing chamber**	Pakning for vendekammer
044	1/K	**Cooler block**	Kølerblok
056	5/K	**Screw**	Skrue
068	5/K	**Gasket ring**	Pakningsring
081	5/K	**Screw**	Skrue
093	32/K	**Screw**	Skrue
103	1/K	**Ring by drain pipe**	Ring ved drænrør
115	1/K	**O-ring**	O-ring
127	1/K	**Side cover- right**	Sidedæksel - højre
139	1/K	**Side cover- left**	Sidedæksel - venstre
140	2/K	**Crossmember**	Travers
152	2/K	**Distance pipe**	Afstandsrør
164	4/K	**Nut**	Møtrik
176	/I	**Locktite**	Locktite
188	8/K	**Screw**	Skrue
211	8/K	**Screw**	Skrue
223	8/K	**Washer**	Skive
235	1/K	**Water mist catcher**	Vandudskiller
247	1/K	**Drain pipe for water mist catcher**	Drænrør for vandudskiller
259	8/K	**Spring, straight pin slotted**	Spændestift
260	8/K	**Spring, side cover**	Fjeder, sideplade
272	4/K	**Lock, side cover**	Lås, sideplade
284	8/E	**Screw**	Skrue
296	4/K	**Plug screw**	Propskrue
306	4/K	**Gasket**	Pakning
318	1/E	**Charge air cooler, complete**	Ladeluftkøler, komplet
330	1/K	**Gasket**	Pakning

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./K = Cooler
Qty./I = Individual

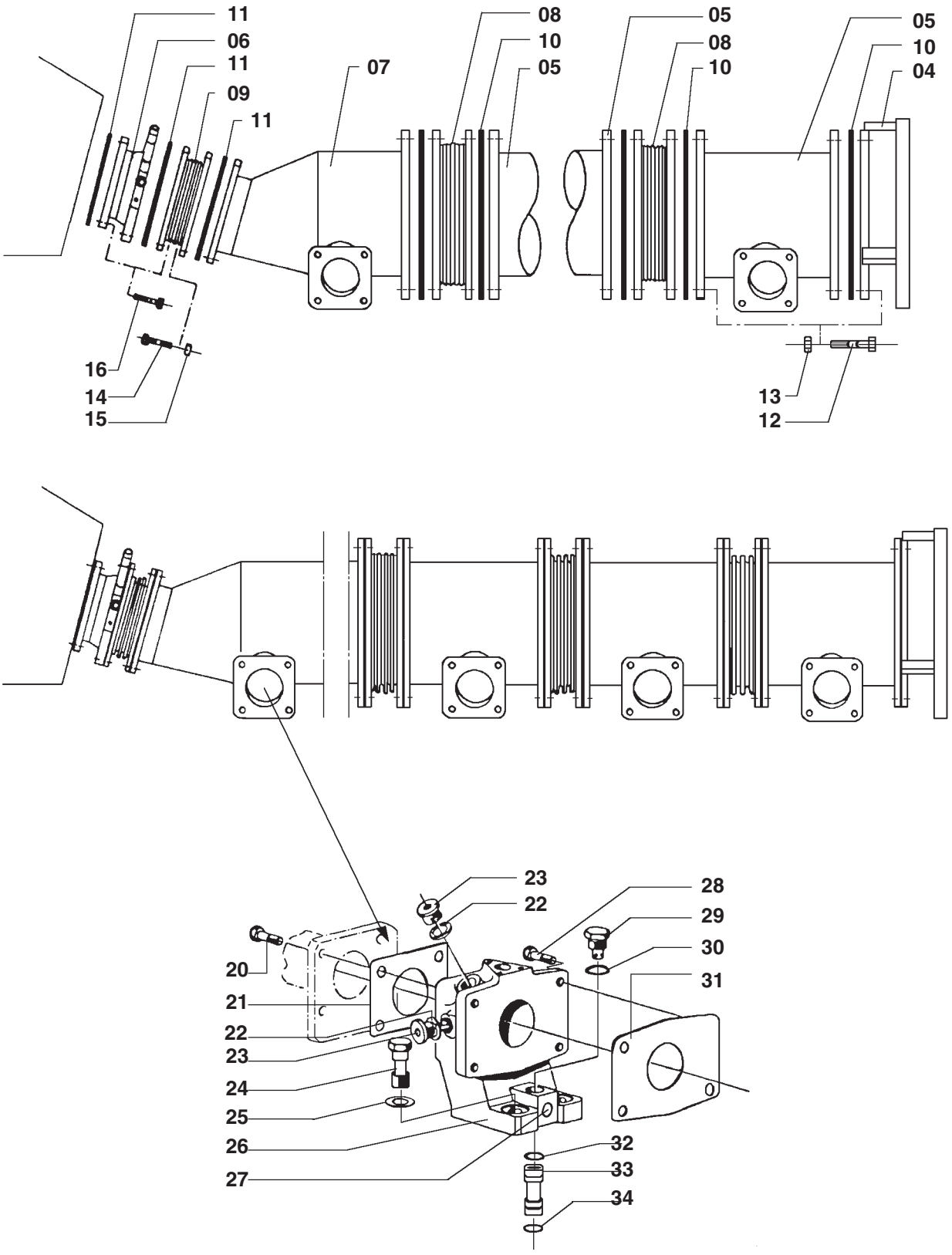
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Køler
Antal/I = Individuelt

08028-0D/H5250/94.08.12

Plate Page 1 (2)	**Exhaust Pipe Arrangement**	**61202-23H**

5,6L28/32H



5,6L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05		**Exhaust pipe**	Udstødsrør
	4/E	**5 cyl. engine**	5 cyl. motor
	5/E	**6 cyl. engine**	6 cyl. motor
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08		**Compensator**	Kompensator
	4/E	**5 cyl. engine**	5 cyl. motor
	5/E	**6 cyl. engine**	6 cyl. motor
09	1/E	**Compensator**	Kompensator
10		**Gasket**	Pakning
	9/E	**5 cyl. engine**	5 cyl. motor
	11/E	**6 cyl. engine**	6 cyl. motor
11	3/E	**Gasket**	Pakning
12		**Screw**	Skrue
	108/E	**5 cyl. engine**	5 cyl. motor
	132/E	**6 cyl. engine**	6 cyl. motor
13		**Nut**	Møtrik
	108/E	**5 cyl. engine**	5 cyl. motor
	132/E	**6 cyl. engine**	6 cyl. motor
14	8/E	**Screw**	Skrue
15	8/E	**Nut**	Møtrik
16	16/E	**Screw**	Skrue
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

When ordering spare parts, see also page 600.50.

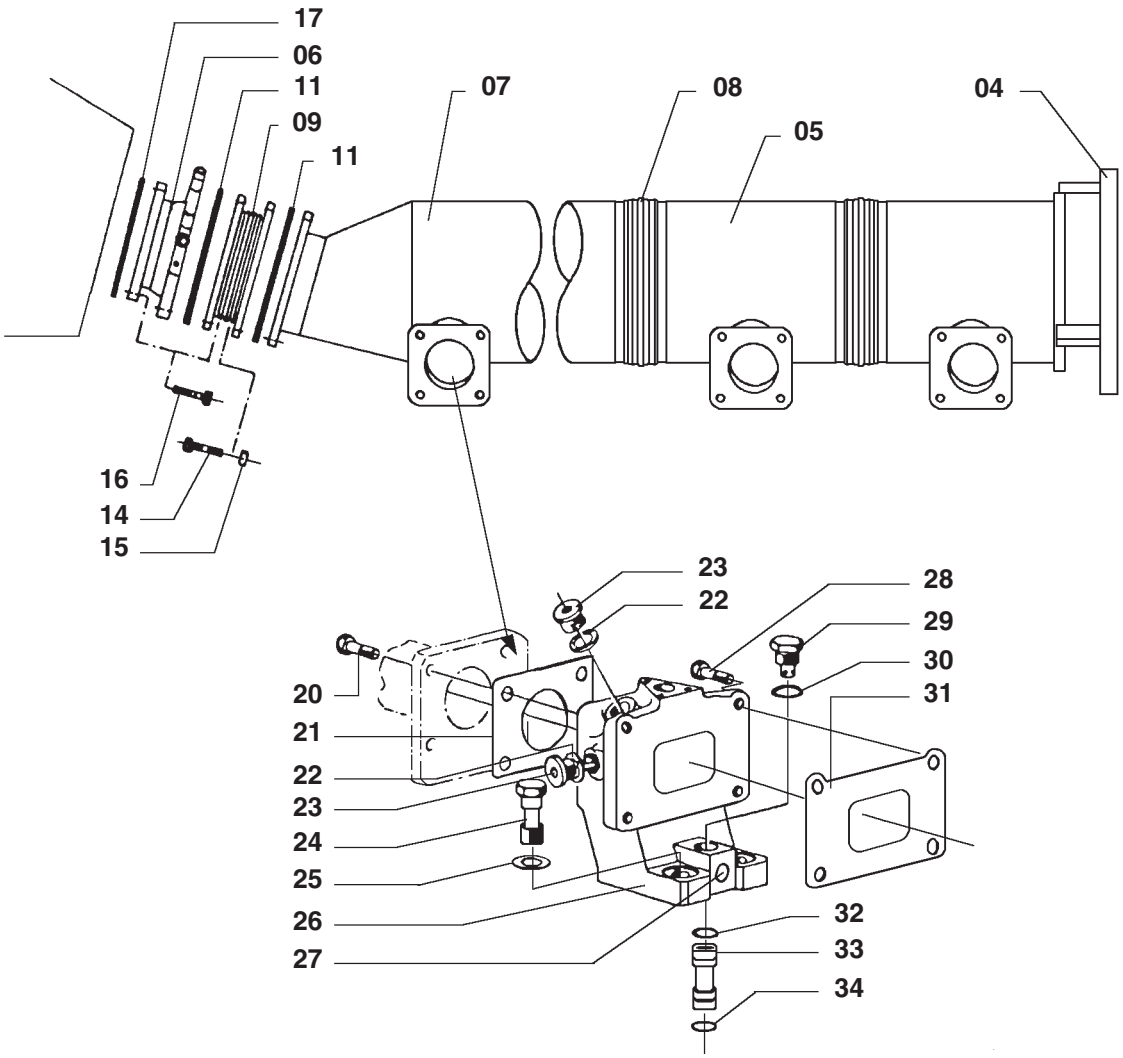
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	**Exhaust Pipe Arrangement with Welded Compensator**	**61202-32H**

5,6L28/32H



5,6L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05		**Exhaust pipe**	Udstødsrør
	4/E	**5 cyl. engine**	5 cyl. motor
	5/E	**6 cyl. engine**	6 cyl. motor
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08		**Compensator**	Kompensator
	4/E	**5 cyl. engine**	5 cyl. motor
	5/E	**6 cyl. engine**	6 cyl. motor
09	1/E	**Compensator**	Kompensator
11	2/E	**Gasket**	Pakning
14	8/E	**Screw**	Skrue
15	8/E	**Nut**	Møtrik
16	16/E	**Screw**	Skrue
17	1/E	**Gasket**	Pakning
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

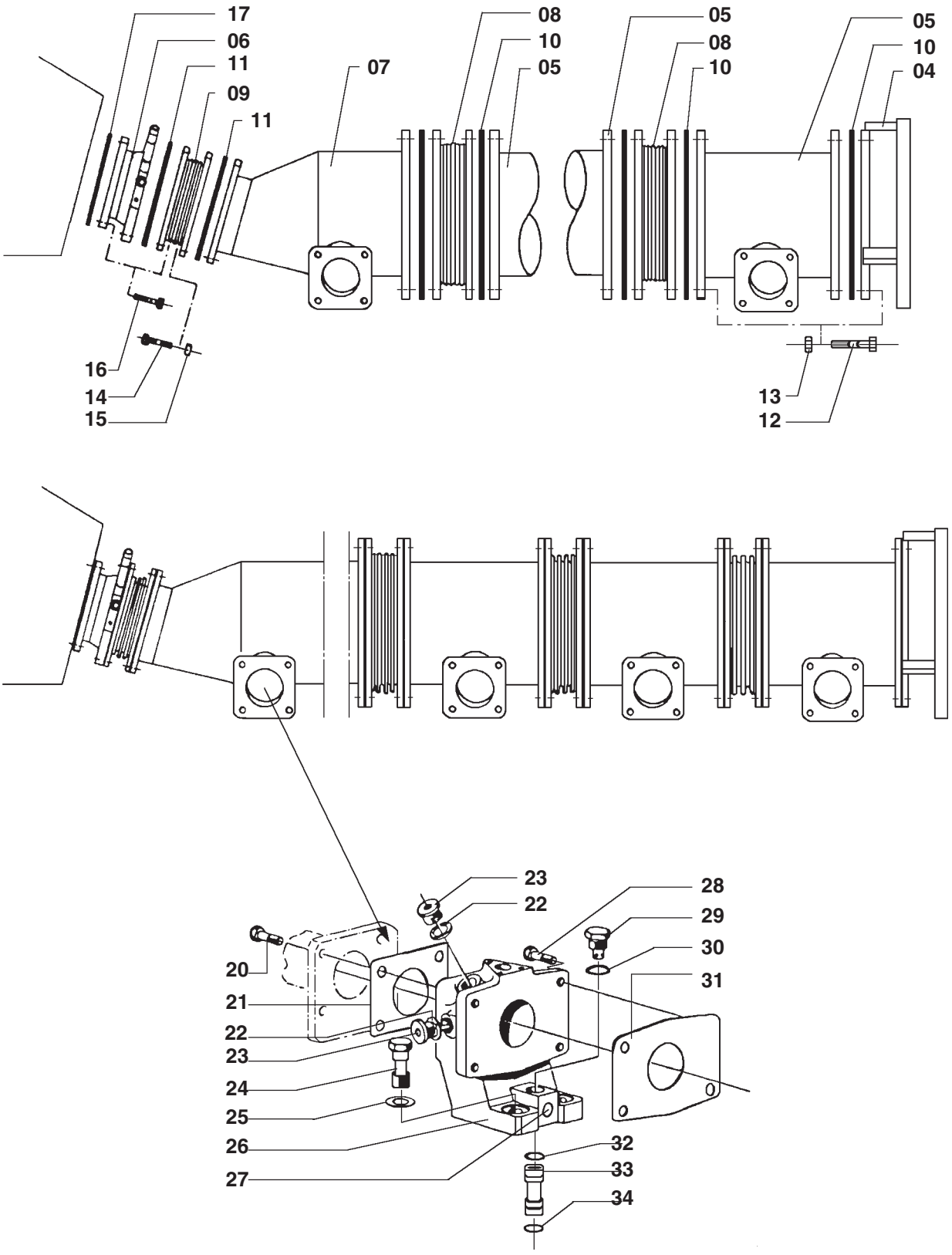
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	**Exhaust Pipe Arrangement**	**61202-26H**

7,8L28/32H



7,8L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05		**Exhaust pipe**	Udstødsrør
	6/E	**7 cyl. engine**	7 cyl. motor
	7/E	**8 cyl. engine**	8 cyl. motor
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08		**Compensator**	Kompensator
	6/E	**7 cyl. engine**	7 cyl. motor
	7/E	**8 cyl. engine**	8 cyl. motor
09	1/E	**Compensator**	Kompensator
10		**Gasket**	Pakning
	13/E	**7 cyl. engine**	7 cyl. motor
	15/E	**8 cyl. engine**	8 cyl. motor
11	2/E	**Gasket**	Pakning
12		**Screw**	Skrue
	156/E	**7 cyl. engine**	7 cyl. motor
	180/E	**8 cyl. engine**	8 cyl. motor
13		**Nut**	Møtrik
	156/E	**7 cyl. engine**	7 cyl. motor
	180/E	**8 cyl. engine**	8 cyl. motor
14	8/E	**Screw**	Skrue
15	8/E	**Nut**	Møtrik
16	16/E	**Screw**	Skrue
17	1/E	**Gasket**	Pakning
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

When ordering spare parts, see also page 600.50.

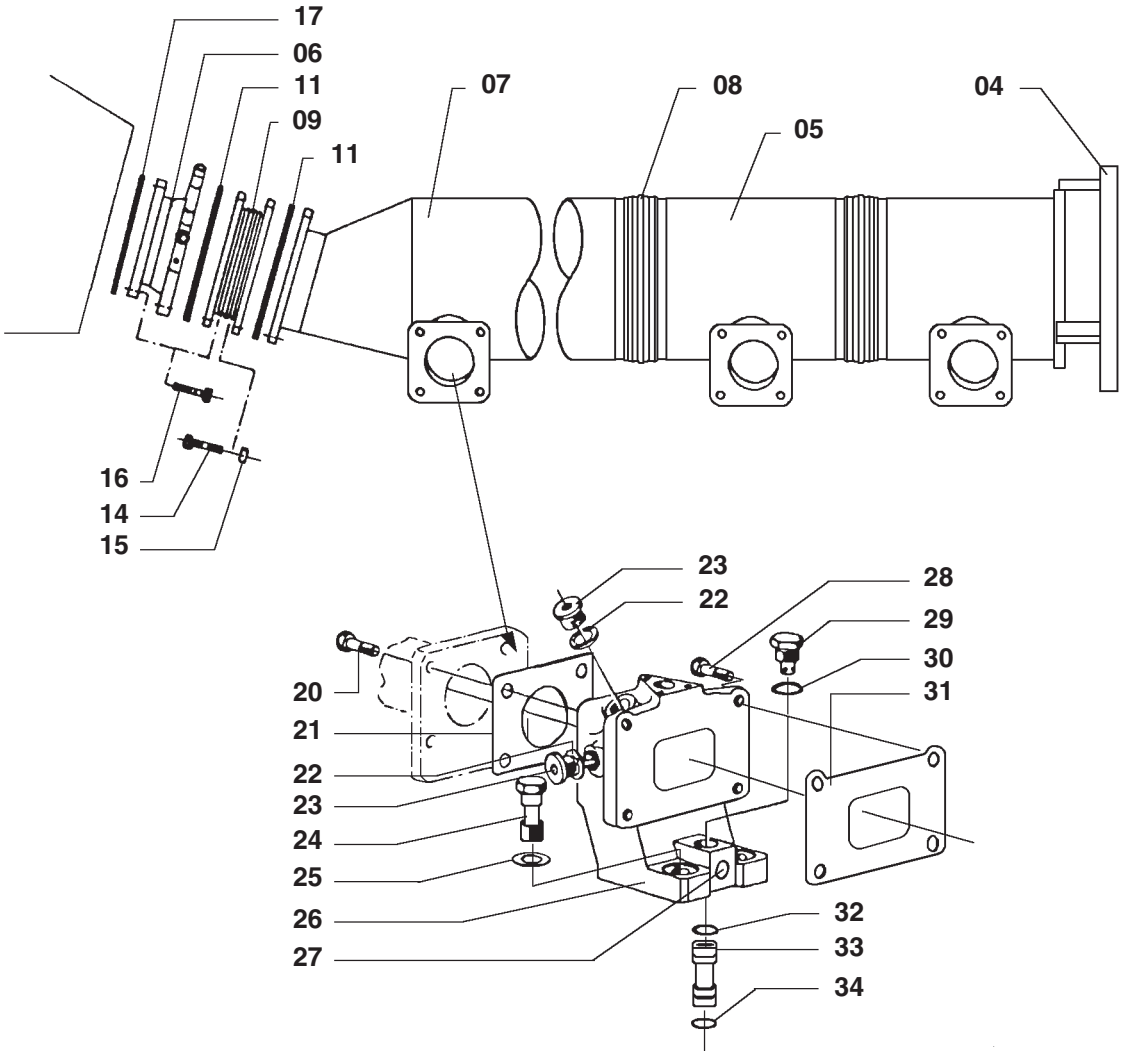
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	**Exhaust Pipe Arrangement with Welded Compensator**	**61202-28H**

7,8L28/32H



7,8L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05		**Exhaust pipe**	Udstødsrør
	6/E	**7 cyl. engine**	7 cyl. motor
	7/E	**8 cyl. engine**	8 cyl. motor
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08		**Compensator**	Kompensator
	6/E	**7 cyl. engine**	7 cyl. motor
	7/E	**8 cyl. engine**	8 cyl. motor
09	1/E	**Compensator**	Kompensator
11	2/E	**Gasket**	Pakning
14	8/E	**Screw**	Skrue
15	8/E	**Nut**	Møtrik
16	16/E	**Screw**	Skrue
17	1/E	**Gasket**	Pakning
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

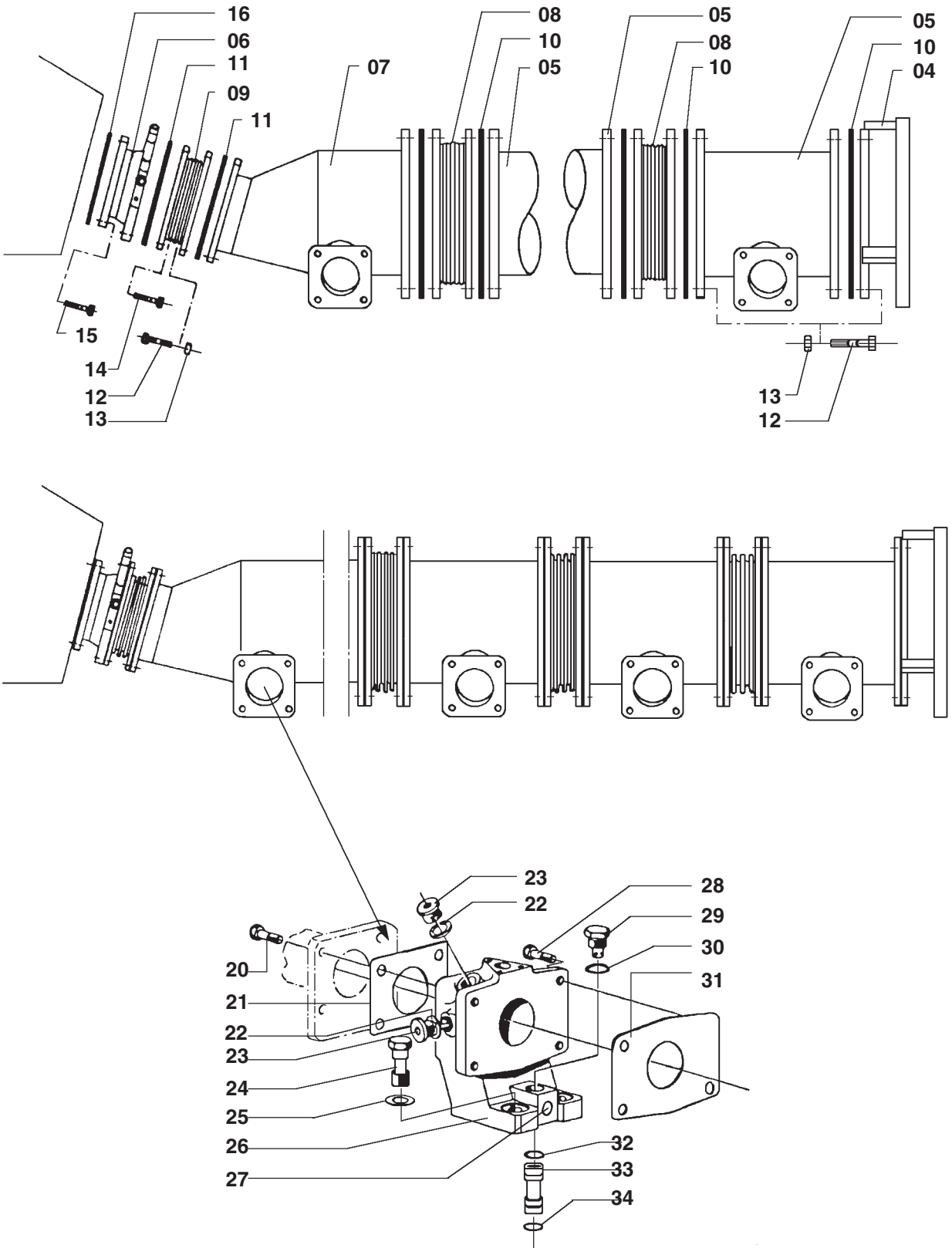
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	**Exhaust Pipe Arrangement**	**61202-27H**

9L28/32H



9L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05	8/E	**Exhaust pipe**	Udstødsrør
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08	8/E	**Compensator**	Kompensator
09	1/E	**Compensator**	Kompensator
10	17/E	**Gasket**	Pakning
11	2/E	**Gasket**	Pakning
12	216/E	**Screw**	Skrue
13	216/E	**Nut**	Møtrik
14	12/E	**Screw**	Skrue
15	12/E	**Screw**	Skrue
16	1/E	**Gasket**	Pakning
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

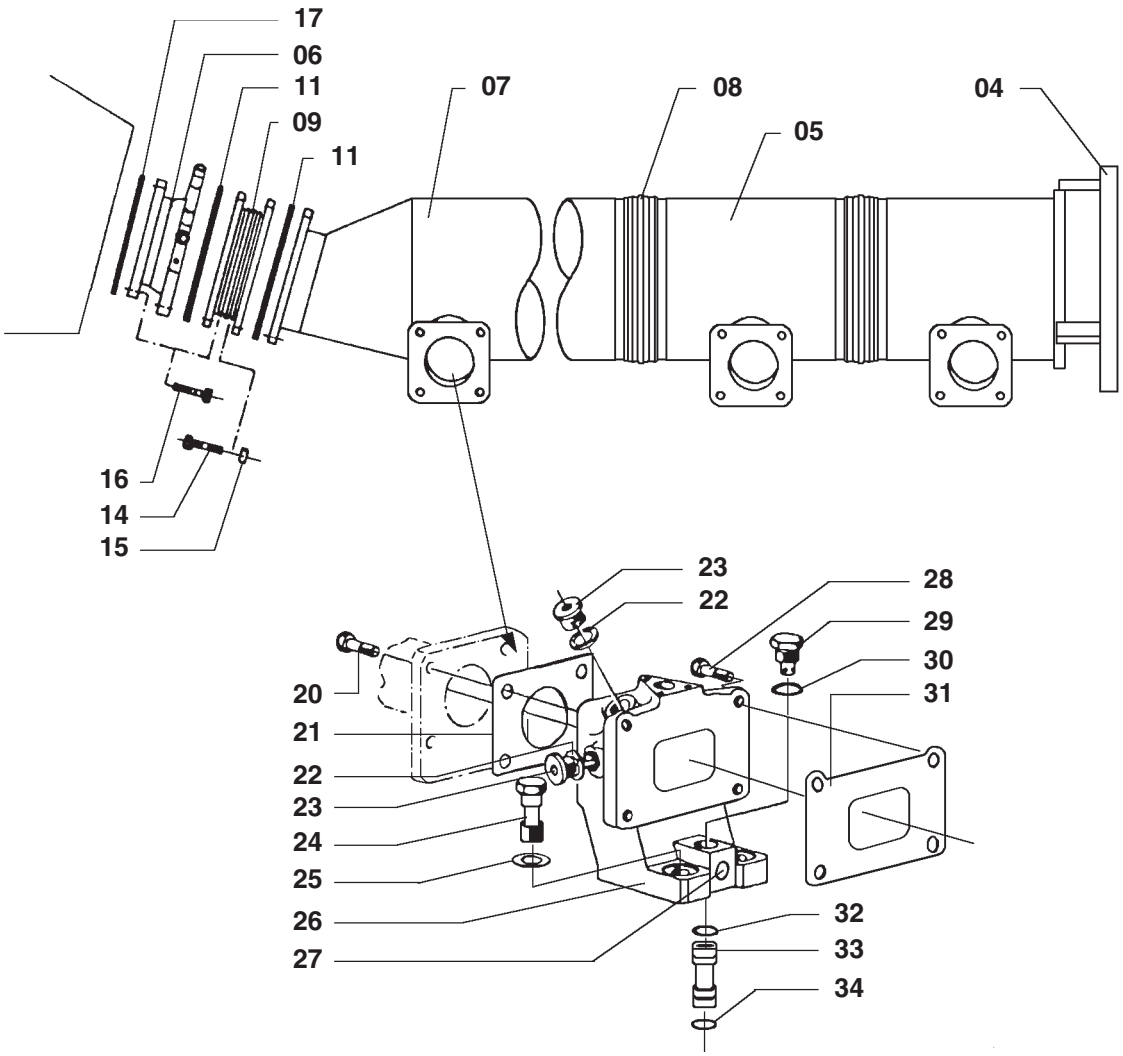
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	**Exhaust Pipe Arrangement with Welded Compensator**	**61202-42H**

9L28/32H



61202-42H	Exhaust Pipe Arrangement with Welded Compensator	Plate Page 2 (2)

9L28/32H

Item No.	Qty.	Designation	Benævnelse
04	1/E	**End cover, aft**	Endeplade, bag
05	8/E	**Exhaust pipe**	Udstødsrør
06	1/E	**Exhaust pipe, inlet TC.**	Udstødsrør, tilgang turbolader
07	1/E	**Exhaust pipe for cyl. 1**	Udstødsrør for cyl. 1
08	8/E	**Compensator**	Kompensator
09	1/E	**Compensator**	Kompensator
11	2/E	**Gasket**	Pakning
14	12/E	**Screw**	Skrue
15	12/E	**Nut**	Møtrik
16	24/E	**Screw**	Skrue
17	1/E	**Gasket**	Pakning
20	4/C	**Screw**	Skrue
21	1/C	**Gasket**	Pakning
22	4/C	**Gasket**	Pakning
23	4/C	**Plug**	Prop
24	2/C	**Screw**	Skrue
25	2/C	**Washer**	Skive
26	1/C	**Intermediate piece**	Mellemstykke
27	1/C	**Plug screw**	Propskrue
28	4/C	**Screw**	Skrue
29	1/C	**Plug screw**	Propskrue
30	1/C	**Gasket**	Pakning
31	1/C	**Gasket**	Pakning
32	1/C	**O-ring**	O-ring
33	1/C	**Cooling water nipple**	Kølevandsnippel
34	1/C	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

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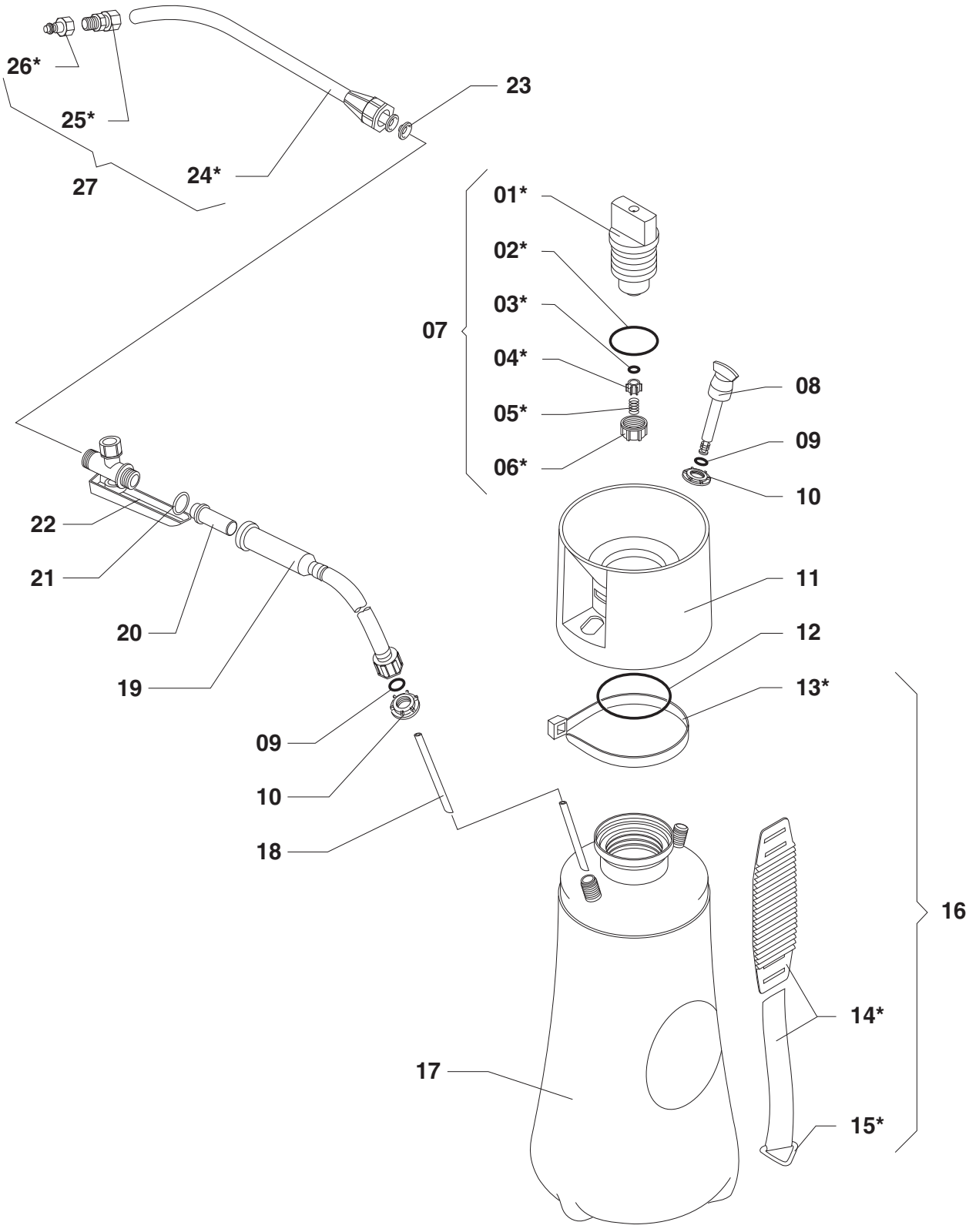
Antal/E = Antal/Motor
Antal/C = Antal/cylinder

Plate Page 1 (2)	Water Washing of Compressor Side	61205-02H

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01*	1/E	**Top cover with non-return valve**	Topdæksel med kontraventil
02*	1/E	**O-ring for top cover**	O-ring for topdæksel
03*	1/E	**O-ring for non-return valve**	O-ring for kontraventil
04*	1/E	**Valve seat**	Ventilsæde
05*	1/E	**Spring for non-return valve**	Fjeder for kontraventil
06*	1/E	**Cap screw for non-return valve**	Omløber til kontraventil
07	1/E	**Top cover with non-return valve complete, incl. item 01-02-03-04-05 and 06**	Topdæksel med kontraventil komplet, inkl. item 01-02-03-04-05 og 06
08	1/E	**Safety valve**	Sikkerhedsventil
09	2/E	**O-ring**	O-ring
10	2/E	**Finger nut**	Fingermøtrik
11	1/E	**Cap**	Top
12	1/E	**Gasket for the cap**	Pakning for top
13*	1/E	**Cable binder**	Kabelbinder
14*	1/E	**Strap**	Gjord
15*	1/E	**Eye for strap**	Øje for gjord
16	1/E	**Strap complete, incl. item 13-14 and 15**	Gjord komplet, inkl. item 13-14 og 15
17	1/E	**Container**	Beholder
18	1/E	**Flexible pipe**	Fleksibel slange
19	1/E	**Handle with flexible pipe and cap screw**	Håndtag med fleksibel slange og omløber
20	1/E	**Filter insert**	Filterinsats
21	1/E	**Gasket for handle**	Pakning til håndtag
22	1/E	**Hand valve**	Håndventil
23	1/E	**Gasket for hand valve**	Pakning til håndventil
24*	1/E	**Lance**	Lanse
25*	1/E	**Straight male stud coupling**	Ligeforskruning
26*	1/E	**Plug in coupling**	Kobling
27	1/E	**Lance complete, incl. item 24-25 and 26**	Lanse komplet, inkl. item 24-25 og 26
28	1/E	**Container complete, as shown on plate**	Beholder komplet, som vist på plate

When ordering spare parts, see also page 600.50.

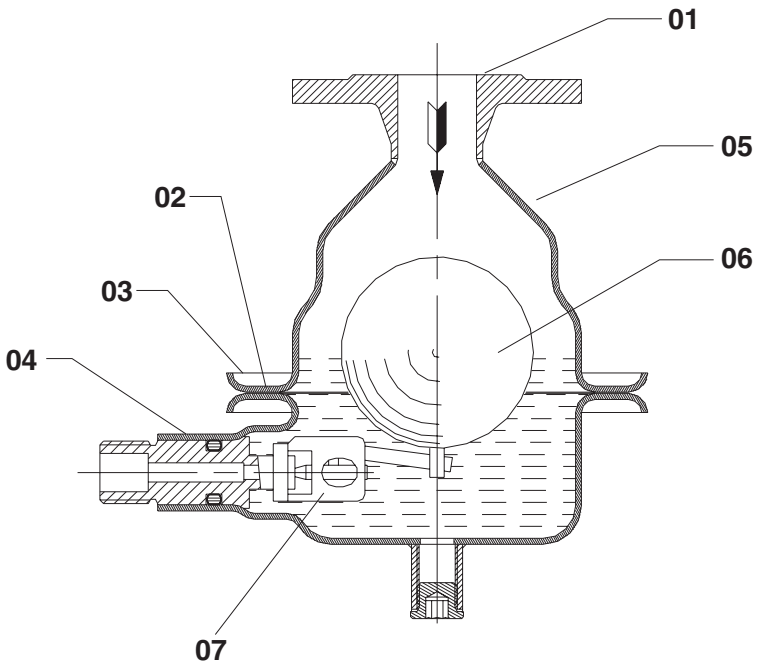
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

Plate Page 1 (2)	**Steam Trap**	**61208-01H**

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Steam trap, complete**	Vandudlader, komplet
02	1/E	**Packing**	Pakning
03	1/E	**Clip**	Klemme
04	1/E	**House, bottom**	Hus, bund
05	1/E	**House, top**	Hus, top
06	1/E	**Swimmer**	Svømmer
07	1/E	**Valve**	Ventil

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

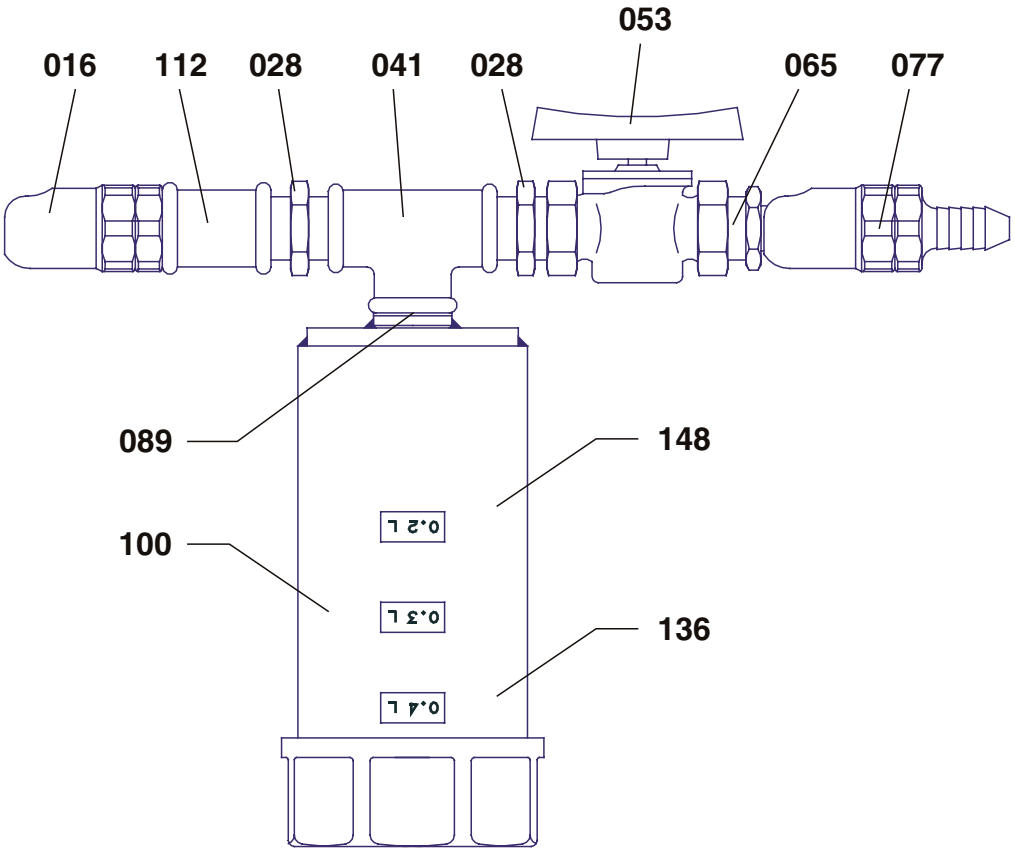
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor

Plate Page 1 (2)	Blowgun for Dry Cleaning of Turbocharger	61210-02H

General



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61210-02H	Blowgun for Dry Cleaning of Turbocharger	Plate Page 2 (2)

General

Item No.	Qty.	Designation	Benævnelse
016	1/E	**Snap coupling**	Snapkobling
028	2/E	**Nipple**	Nippel
041	1/E	**Tee**	T-stykke
053	1/E	**Ball valve**	Kugleventil
065	1/E	**Snap coupling**	Snapkobling
077	1/E	**Snap coupling**	Snapkobling
089	1/E	**Packing ring**	Pakningsring
100	1/E	**Container, complete**	beholder, komplet
112	1/E	**Socket**	Muffe
136	1/E	**Blowgun, complete**	Rensepistol, complete
148	/I	**Granulate**	Granulat

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor
Qty./I = Qty./Individuelt

Compressed air system

513/613

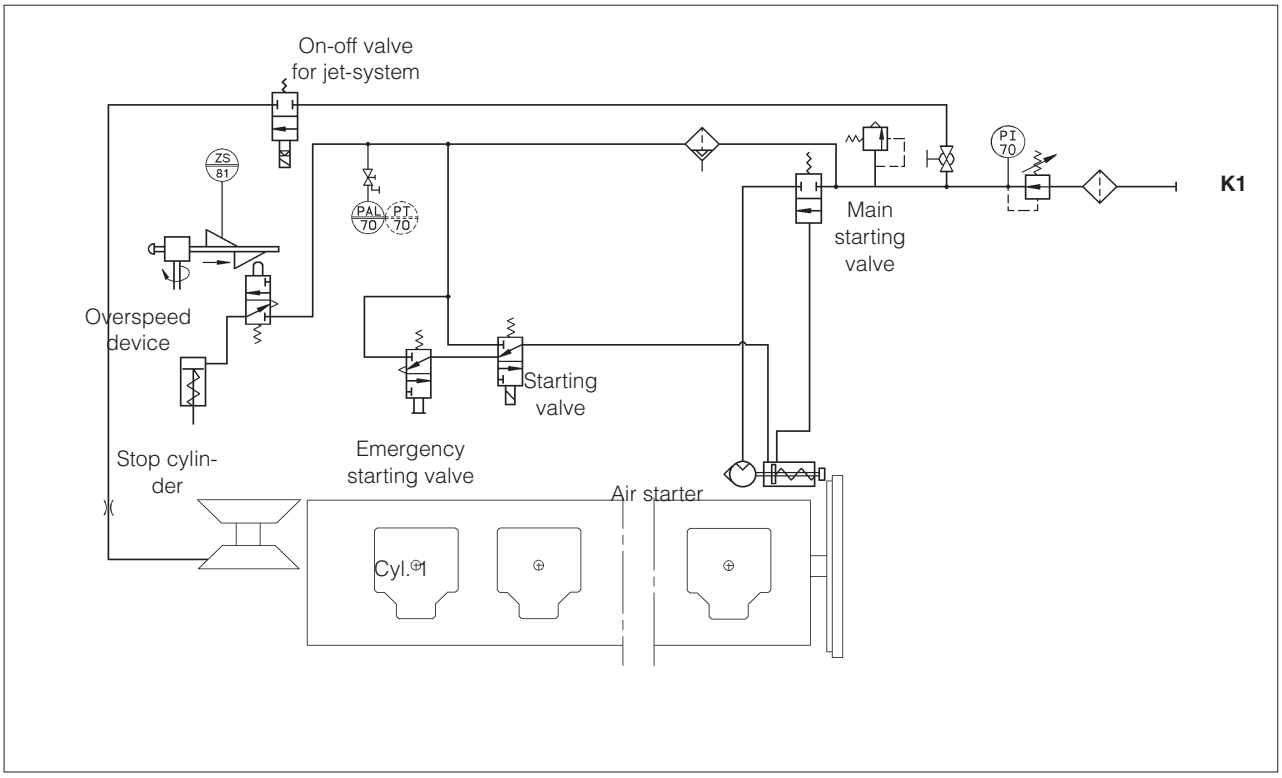

Fig. 1. Diagram for Compressed Air System

General

The compressed air system on the engine contains a starting system, starting control system and safety system. Further, the system supplies air to the jet system.

The compressed air is supplied from the starting air receivers (30 bar) through a reduction station, where from compressed air is supplied to the engine.

To avoid dirt particles in the internal system, a dirt separator is mounted in the inlet line to the engine.

The intervals between cleaning and draining will depend on the condition of the air in the main supply system, and has therefore to be determined according to service experience gained with the particular plant.

Note: Due to the safety system, the air supply to the engine must not be interrupted during operation of the engine.

Starting System

The engine is started by means of a built-on air starter, which is of the turbine starter motor type with gear box, safety clutch and drive shaft with pinion. Further, the starting system consists of a main starting valve.

Control System

The air starter is activated electrically with a pneumatic 3/2 way solenoid valve (starting valve).

The valve can be activated manually from the starting box on the engine, and it can be arranged for remote control, manual or automatic.

For remote activation, the starting spool must be connected so that every starting signal to the starting spool goes through the converter for engine RPM signal or via the engine control box if supplied.

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Further, the system is equipped with an emergency starting valve which makes it possible to activate the air starter manually in case of a power failure.

Emergency Starting Valve

The emergency starting valve is activated by means of a screw-driver or similar as illustrated in fig. 2.

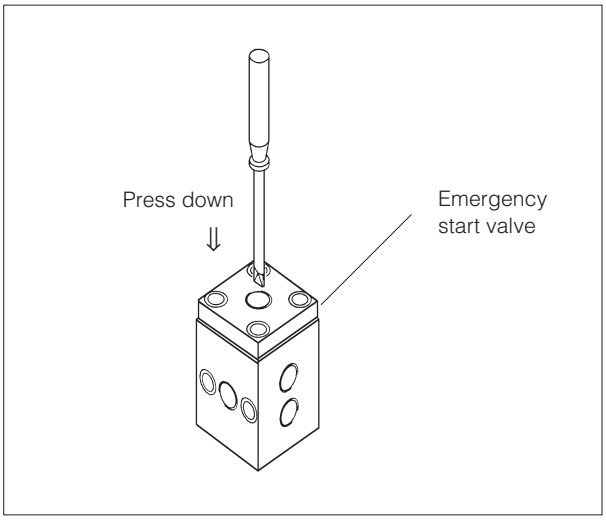

Fig. 2. Emergency start valve

Safety System

As standard the engine is equipped with a pneumatically/mechanically overspeed device, which starts to operate if the maximum permissible RPM is exceeded. This device is fitted to the end cover of the engine driven lubricating pump and is driven from the pump through a resilient coupling, see section 609.

When the maximum permissible RPM is exceeded, the overspeed device will activate a pneumatically controlled stop cylinder, which will bring the fuel index to zero and stop the engine.

Pneumatic Start Sequence

When the starting valve is opened, air will be supplied to the drive shaft housing of the air starter.

The air supply will - by activating a piston - bring the drive pinion into engagement with the gear rim on the engine fly wheel.

When the pinion is fully engaged, the pilot air will flow to, and open the main starting valve, whereby air will be led to the air starter, which will start to turn the engine.

Simultaneously with air supply for the air starter, air will be supplied to the fuel limitating cylinder, thus limiting the fuel supply during the start sequence.

When the RPM exceeds approx. 110, at which firing has taken place, the starting valve is closed whereby the air starter is disengaged.

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Working Card Page 1 (2)	Air Filter	613-01.21 Edition 02H

General

Safety precautions

- ■ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description

Cleaning and/or maintenance of air filter.

Starting position

Related procedure

Manpower

Working time : hours
Capacity : man

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no	Item no	Note

Hand tools

Replacement and wearing parts

Plate no	Item no	Qty/

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General

Cleaning Air Filter

1) Depressurize unit.

2) Remove bowl and bowl guard assembly by turning counter-clockwise.

3) Inspect bowl for damage seals and replace, if nessesary.

4) If bowl becomes dirty clean it by wiping the bowl with a soft dry cloth or mild detergent.

5) Before returning to service, insure that all seals have been reinstalled or replaced.

6) Reinstall bowl and bowl guard assembly and rotate bowl guard clockwise to securely lock in place. Align arrow on bowl guard with arrow on filter body.

To replace filter element

7) Depressurize unit.

8) Remove bowl and bowl assembly by turning counter-clockwise.

9) Unscrew baffle by turning counter-clockwise.

10) Remove filter element and discard.

11) Install new filter element and reassemble in reverse order.

12) Before returning to service, insure that all seals have been reinstalled or replaced.

13) Reinstall bowl and bowl guard assembly and rotate bowl guard clockwise to securely lock in place. Align arrow on bowl guard with arrow on filter body.

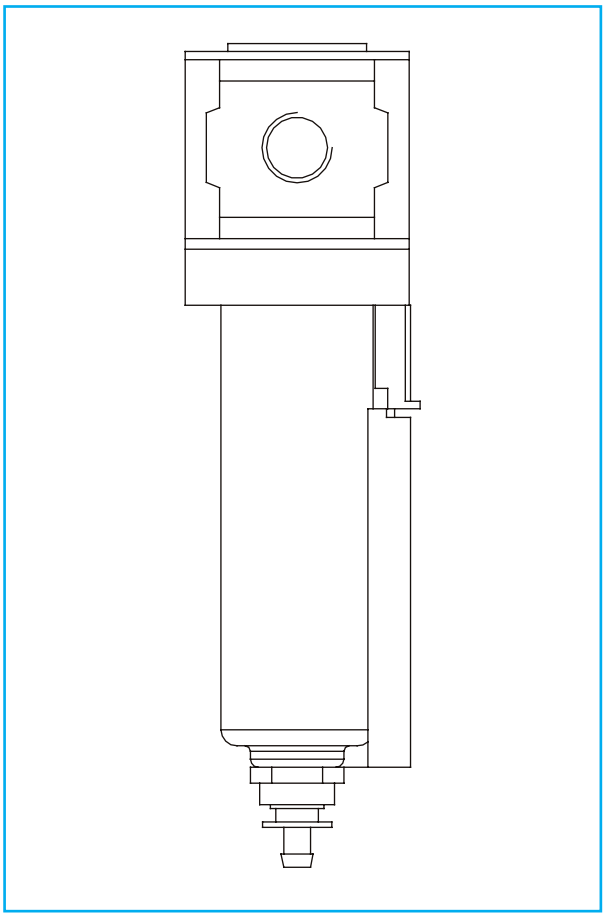

Fig 1 Air Filter

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Working Card Page 1 (9)	**Overhaul, Test and Inspection of Turbine Starter**	**613-01.30** Edition 02H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Disassembly, overhaul and assembly of the air starter.

Starting position:

All connection to the air starter have been removed, and air starter is removed.

Related procedure:

Man power:

Working time : 4 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	xx	20 - 120 Nm.

Hand tools:

Allen key, 4 mm.
Allen key (long), 8 mm.
Screwdriver.
Big screwdriver.
Chisel.
Retaining ring pliers.
Plastic hammer.
Lubricating oil.
Copaslip or similar.
Sleeve.
Bearing puller.
Impact Wrench
Bearing pressing tool.

Replacement and wearing parts:

Plate no.	Item no.	Qty./

See plate 61309.

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L+V28/32H

General Information

1. Always mark adjacent parts on the housing exhaust cover (1), motor housing (8), intermediate gear case (13), gear case (28) and drive housing (38) so these members can be located in the same relative position when the starter is reassembled.

Note: Do not disassemble the starter any further than necessary to replace worn or damaged parts.
Never reuse old seals or o-rings.
Never wash the inertia drive in a solvent.

2. Do not remove any part which is a press fit in or on a subassembly unless the removal of that part is necessary for replacement or repairs.

3. Always have a complete set of seals and o-rings on hand before starting any overhaul of the turbine starter.

4. When grasping a part in a vise, always use copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members.

Housing Exhaust Cover, Motor Assembly, and Motor Housing

1. If replacing the motor assembly (12), remove both housing plugs (10) and drain the oil from the gearing before beginning disassembly of the starter. Inspect the magnetic housing plugs (10) for metal particles. Very fine metal particles are normal. Remove particles and reinstall plugs. Large particles or chips are an indication of a problem. Disassemble gear case (28) and inspect.

2. Using a screw driver, unscrew the exhaust cover (67) from the housing exhaust cover (1).

3. Using an 8 mm hex-head wrench, unscrew and remove the starter assembly cap screws (6) and washers (7), See fig 1.

4. Pull the housing exhaust cover (1) from the motor housing (8). To dislodge the housing exhaust cover, rotate it until the ears clear the motor housing. Using a plastic hammer, tap the ears alternately until the housing cover can be removed from the motor housing.

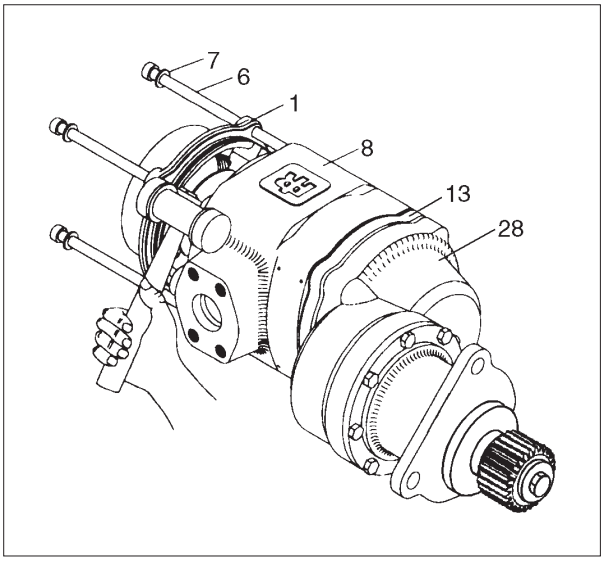

Fig 1.

5. Remove the deflector retaining screw (5), deflector retai-ning spring (4) and the splash deflector (3) from the housing exhaust cover (1), See fig 2.

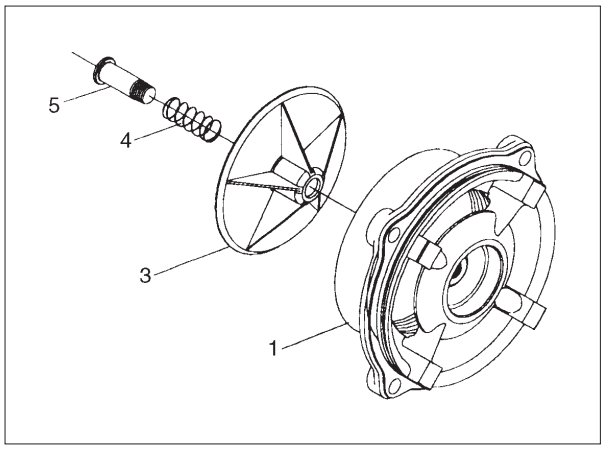

Fig 2.

6. Tap the motor housing with a plastic hammer to dislodge it from the intermediate gear case (13).

7. Grasp the rear of the motor assembly (12) and pull it from the rear of the motor housing (8).
If the motor assembly (12) is difficult to remove, lightly push the motor pinion which is on the front of the motor assembly toward the exhaust side of the motor housing in order to free the motor assembly.

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8. Tap the intermediate gear case (13) with a plastic hammer to dislodge it from the gear case (28).

9. Position the intermediate gear case (13) on a bench in a copperfaced vise so that the intermediate pinion (26) is secured in the jaws of the vise. Tighten the vise only enough to hold the intermediate pinion securely.

10. Loosen the intermediate pinion retaining screw (27) 1-1/2 turns only. Do not remove.

Warning: If the intermediate gear case is not supported on a bench and if the intermediate pinion retaining screw is completely removed, the intermediate gear case and compoments could fall causing injury.

11. Tap the intermediate pinion lightly to back the planet gear frame assembly out of the intermediate gear case.

12. Remove the intermediate gear case assembly from the vise and remove the intermediate pinion (26). Remove the rear gear case o-ring (14) and front gear case o-ring (15) from the intermediate gear case (13), See fig 3.

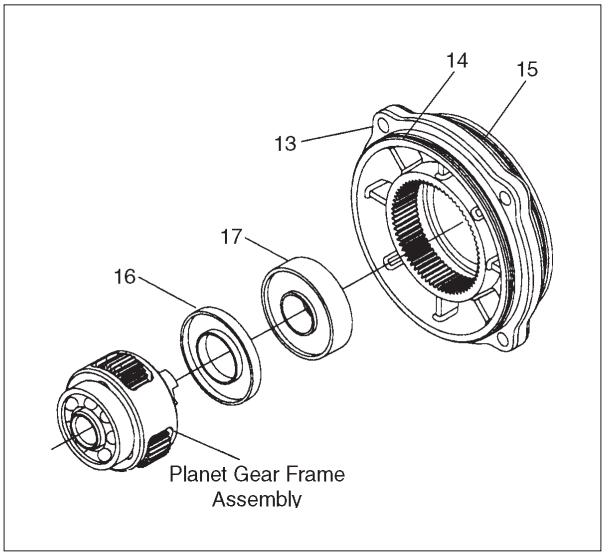

Fig 3.

13. Remove the planet gear frame assembly from the intermediate gear case. Using a sleeve that contacts the outer race of the front gear frame bearing (17), press the planet gear frame shaft seal (16) and the front gear frame bearing (17) from the front end and out of the rear of the intermediate gear case.

14. Remove the rear gear frame bearing (24) from the planet gear frame (18), using a bearing puller and remove the gear shaft retaining washer (23), See fig. 4.
Remove the planet gear shafts (22), planet gears (19), planet gear bearings (20) and bearing spacers (21).

15. Remove the front bearing spacer (25), using a bearing puller and the gear shaft retaining washer (23) from the front of the planet gear frame by pressing on the front of the planet gear frame shaft.
Remove the gear shaft retaining washer only if the washer or front bearing spacer is damaged.

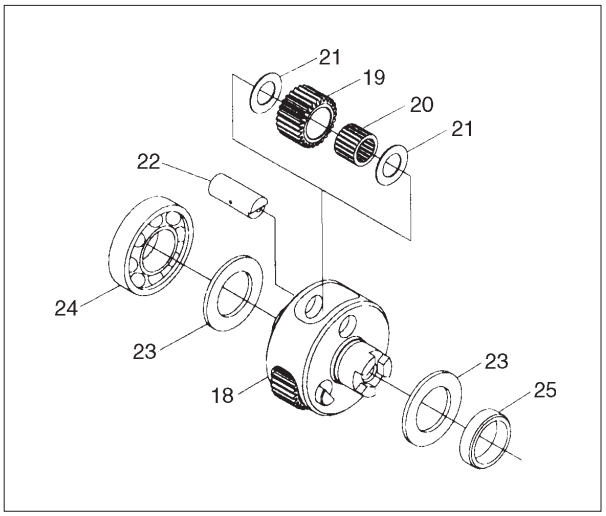

Fig 4.

Drive Housing

1. Grasp the drive pinion (63) in a copper-faced vise with the starter supported on the workbench.

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2. Remove the drive pinion retaining screw (61) which has a right-hand thread.

3. Remove the starter from the vise.

4. Remove the drive pinion washer (62) and the drive pinion (63).

5. Slide the pinion spring sleeve (64) and the pinion spring (65) off the drive shaft (57).

6. Unscrew the drive gear screw (34). Using an impact wrench with a 5/16" (8 mm) x 8" (203 mm) log hex inserted into the end of the drive shaft.

7. Unscrew and remove the drive housing cap screws (38) and lock washers (39).

8. Tap the drive housing (40) with a plastic hammer to help dislodge it from the gear case (28).

Warning: Failure to follow this procedure could result in injury to personnel.

9. Place the drive housing (40) in an arbor press, piston end up. Apply a load to the piston (54) using the arbor press to compress the piston return spring (59) before removing the bulkhead retainer (45). Do not use compressed air to load the piston.

10. Remove the bulkhead retainer (45). Using a screwdriver and the arbor press.

Caution: Make sure the tension of the spring pushes the bulkhead out of the drive housing before removing the drive housing from the arbor press.

11. Remove the bulkhead (46) from the piston (54).

12. Remove the outer bulkhead ring (47) and the inner bulkhead ring (48).

13. Slide the drive shaft (57) from the drive housing (40).

14. Pull the piston return spring (59) off the drive shaft.

Note: Do not remove the front drive shaft bearing (42) or the drive housing seal (43) unless replacement is necessary and new parts are available. The bearing and/or the seal will always be damaged when removed from the drive housing.

15. Remove the piston ring (55) from the piston (54).

16. Press the clutch spring cup (50) down and remove the clutch spring cup retainer (49).

17. Remove the clutch spring cup and clutch spring (51).

18. Remove the two clutch jaws (52).

19. Remove the front drive gear bearing (30), drive gear cup (36), drive gear lock washer (35), drive gear screw ring (37) and drive gear screw (34).

20. Remove the large drive shaft bearing retainer (53) using a screwdriver.

21. Press the rear drive shaft bearing and drive shaft (57) out of the piston. If the rear drive shaft bearing needs to be replaced, proceed as follows:

a. Cut and remove the small drive shaft bearing retained in the drive shaft, using a small chisel.
b. Press the rear drive shaft bearing (58) off the drive shaft.

22. Place the gear case (28) on a workbench.

23. Remove the drive gear bearing retainer (32), using retaining ring pliers and working through the access holes in the gear web, See fig 5.

24. Pull the drive gear (29) out of the gear case.

Note: Do not disassemble the drive gear and clutch parts of the turbine powered starters. If the drive shaft is defective, install a new or factory-rebuilt unit.

25. Remove the drive gear shaft bearing retainer (33), using retaining ring pliers.

26. Remove the rear drive gear bearing (31) from the drive gear.

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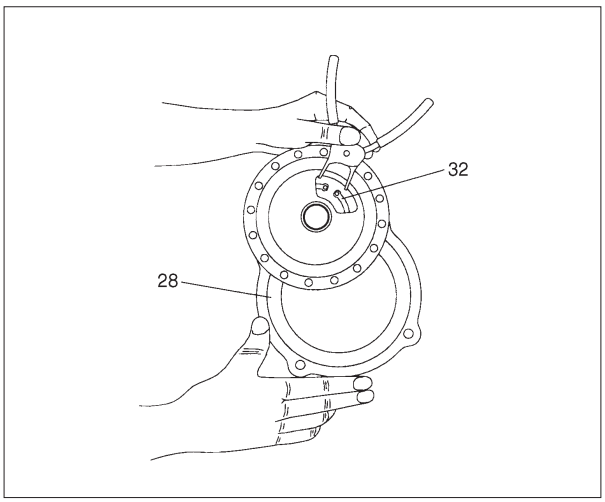

Fig 5.

Assembly of the Starter

1. Always press on the inner ring of a ball bearing when installing the bearing on a shaft.

2. Always press on the outer ring of a ball bearing when pressing the bearing in a bearing recess.

3. Whenever grasping a part in a vise, always use leather-covered, copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members.

4. Always clean every part, and wipe every part with a thin film of oil before installation.

Gear Case

1. Place the drive gear bearing retainer over the rear end of the drive gear.

2. Press the rear drive gear bearing (31) onto the rear end of the drive gear, using an arbor press.

3. Seat the rear drive gear bearing into the gear case by tap-ping the opposite end of the drive gear, using a plastic hammer.

4. Install the drive gear shaft bearing retainer (33), using retaining ring pliers.

5. Install the drive gear bearing retainer, using retaining ring pliers and working through the access holes in the gear web.

6. Lubricated the drive gear with approximately 240 ml of SHELL ALVANIA EPO grease.

7. Press the rear drive shaft bearing (58) onto the drive shaft.

8. Slide the small bearing retainer convex side first, onto the drive shaft. Press it into position in accordance with the in-structions packaged with the new retainer.

9. Assemble the drive gear Schrew (34), drive gear lock washer (35), drive gear cup (36) and drive gear screw o-ring (37).

10. Grasp the drive shaft (57) in a vise, external splined end down. Place assembled drive shaft screw Unit into the drive shaft, screwhead down. Lubricate the inside diameter of the drive shaft with SHELL ALVANIA EPO grease.

11. Slide the drive gear bearing (30) into the drive shaft.

12. Lubricate with SHELL ALVANIA EPO grease and install the driving clutch jaw teeth facing up and driven clutch jaw teeth facing down into the drive shaft.

13. Insert the clutch spring (51) into the drive shaft.

14. Insert the clutch spring cup (50) into the drive shaft.

15. Press the inserted parts into the drive shaft, and install the clutch spring cup retainer (49).

Note: If it is necessary to replace the drive housing (40) and drive components, make sure that the piston seal has been removed from the rear of the new piston (54).The piston seal must be removed to prevent pressure build-up which will cause movement of the planet gear frame shaft seal (16). If this conditions occurs, the piston cannot retract and the drive pinion (63) will remain in engagement with the

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flywheel, causing damage to the starter drive train and/or starter motor. To remove the piston seal, insert a screwdriver inside the lip of the seal and pry it loose from the piston.

16. Install the piston (54) onto the drive shaft until the rear drive shaft bearing seats into the piston.

17. Coil the large drive shaft bearing retainer (53) into the groove of the piston to retain the outer race of the drive shaft bearing, using a thin flat blade screwdriver to assist in this operation.

18. Lubricate the piston o-ring (55) and install it in the groove of the piston.

19. Position the drive housing in an arbor press, pinion-end down and install the drive housing seal (43) into the drive housing. Using a pressing sleeve of the proper size, press the seal into the drive housing so that the lip of the seal faces away from the drive pinion.

20. Press the bearing into the drive housing until it seats, using a sleeve that contacts the outer race of the front drive shaft bearing (42). Drop the piston return spring seat (60) on top of front drive shaft bearing.

21. Slide the piston return spring (59) onto the drive shaft and snap it into the front of the piston so that it is against the large drive shaft bearing retainer (53).

22. Lubricate and insert the assembled drive shaft into the drive housing.

23. Lubricate and install the outer bulkhead o-ring (47) and the Inner bulkhead o-ring (48) on the bulkhead (46).

24. Slide the bulkhead onto the piston.

25. With the drive housing in the arbor press, press down on the rear face of the piston.

Note: Feel the underside of the drive housing to make sure the drive shaft passes through the bearing.

26. Install the bulkhead retainer (45), using a screwdriver.

Warning: Make sure the bulkhead retainer is properly seated in the motor housing groove before easing off the arbor press. Failure to do so will allow improperly retained parts to separate when removed from the arbor press resulting in injury to personnel.

27. Remove the drive housing from the arbor press.

28. Lubricate and install the drive housing o-ring (41) in the groove of the drive housing.

29. Position the assembled gear case on a workbench. The as-sembled unit must be upright to accept the drive housing.
Carefully position the assembled drive housing (40) onto the gear case so as not to damage the piston seal. Align the punch marks of the gear case and drive housing.

30. Install the drive housing cap screw lock washers (39) and the drive housing cap screws (38) and tighten to 28 Nm torque.

31. Tighten the drive gear screw (34) 77.3 Nm torque, using an impact wrench with a 8 mm x 203 mm long hex inserted into the end of drive shaft.

32. Grease and slide the pinion spring (65) and the pinion spring sleeve (64) over the pinion end of the drive shaft.

33. Grease the pinion end of the drive shaft and install the drive pinion (63).

34. Grasp the drive pinion in a copper-covered vise with the starter supported on a workbench.

35. Place the drive pinion washer (62) onto drive pinion retaining screw (61).

Note: The thread on the drive pinion retaining screw is right-hand thread.

36. Install the drive pinion retaining screw into the end of the drive shaft and tighten it to 108.5 Nm torque.

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Intermediate Gear Case, Motor Housing, Motor Assembly and Housing Exhaust Cover

1. Press the front gear frame bearing (17) into the rear of the intermediate gear case (13), using a bearing pressing tool of the proper size.

2. Press the planet gear frame shaft seal (16) into the rear of the intermediate gear case over the front gear frame bearing, using a sleeve which contacts the outer ring of the seal.

Note: Make sure the flat side of the seal is installed against the bearing.

3. Install the rear gear case o-ring (14) in the groove at the rear of the intermediated gear case and the front gear case o-ring (15) in the groove at the front of the intermediate gear case. coat both o-rings.

4. Install one gear shaft retaining washer (23) on the front of the planet gear frame (18). Press the front bearing spacer (25) on the front shaft of the planet gear frame to hold the gear shaft retaining washer snugly in position.

Note: Coat the front bearing spacer with gear Lube before installing it. Be careful not to gouge or scratch the front bearing spacer during installation as this could result in leakage between the planet gear frame and gear case.

5. Place planet gear frame on a bench, shaft side down. Place the planet gear bearing (20) inside of planet gear (19). Place bearing spacers (21) on top and bottom of bearing and gear. Slide the components into the slots in the side of the planet gear frame. Align holes in spacers and bearing with holes in planet gear frame and insert planet gear shaft (22), integral keyed end down, through the spacers and bearing so that the larger portion of the keyed end of the shaft contacts the planet gear shaft retaining washer (23). Repeat the procedure for the two remaining planet gears and components.

Note: Do not move or turn over the planet gear frame until step 6 and 7 have been completed. Movement of the planet gear frame assembly could dislodge assembled components, making it necessary to repeat step 5.

6. Install the other planet gear shaft retaining washer over the shaft at the rear of the planet gear.

7. Press the rear gear frame bearing (24) on the shaft at the rear of the planet gear frame, using the proper size bearing inserting tool.

8. Slide the planet gear frame assembly, coupling end first, into the rear of the intermediate gear case (13), making sure that the planet gears mesh with the ring gear. Use care so as to not damage the seal.

9. Install the intermediate pinion (26), making sure that the notches at the rear of the pinion align with the notches and tangs in the shaft of the planet gear frame.

10. Clean the threads of the intermediate pinion retaining screw (27) and apply 2-3 drops of Permabond HM 118 to the threads approximately 3 mm from the end of the screw. Install screw and tighten enough to hold assembly together.

11. For final tightening, position the intermediate gear case so the intermediate pinion is secured in the jaws of the copperfaced vise. Tighten the intermediate pinion retaining screw to 122 Nm torque.

12. Remove the intermediate gear case from the vise and set it on a bench.

Note: The intermediate gear case will work in only one orientation.

Align the punch marks on the intermediate gear case and gear case and tap the intermediate gear case with a plastic hammer until it seats in the rear of the gear case. Make sure the intermediate pinion meshes with the drive gear.

Coat the o-rings on the motor assembly and the inside of the cylinder before installing the motor assembly.

13. Install the motor assembly through the rear of the motor housing with the geared end of the rotor toward the front.

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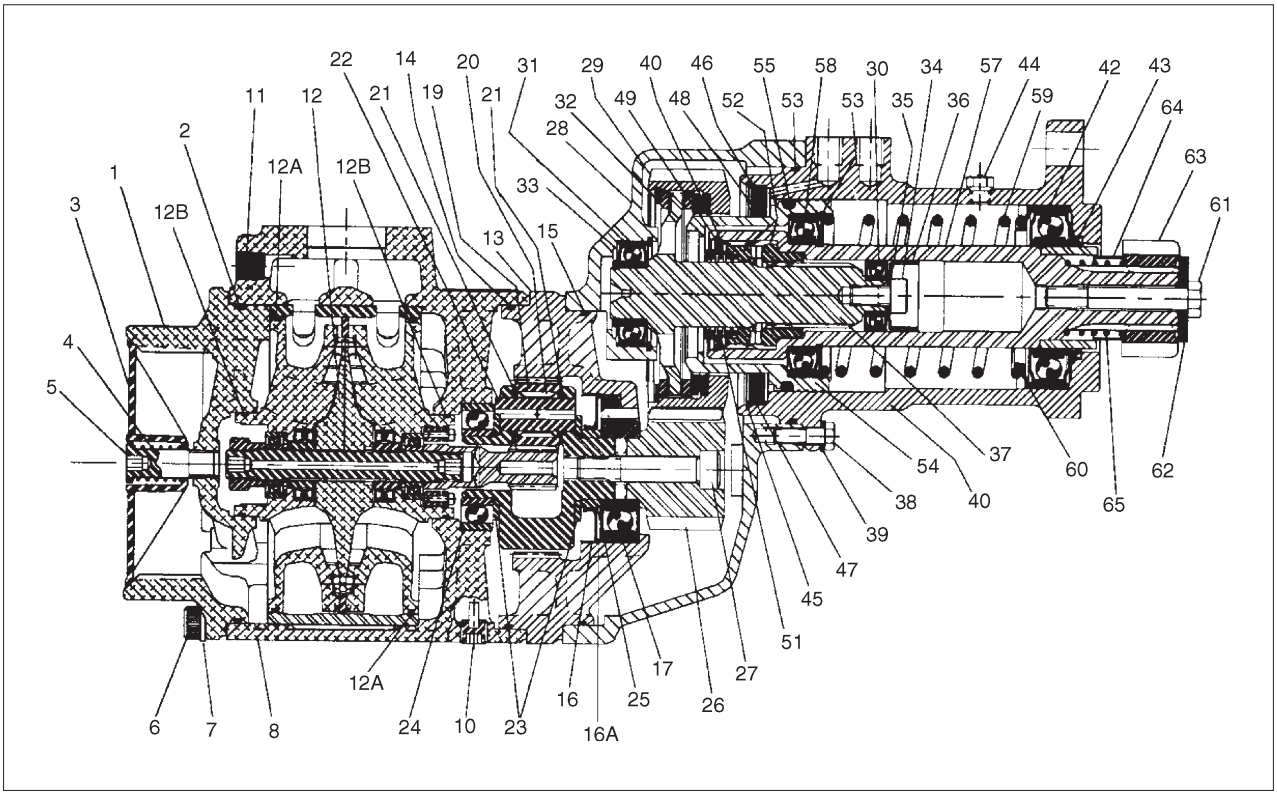

Fig 6. Turbine Starter.

Note: Turn the intermediate pinion so that the gear on the rotor meshes with the planet gears. Make sure that the rear of the motor assembly is installed flush with the rear of the cylinder.

14. Align the punch marks on the motor housing with the punch marks on the intermediate gear case and tap the motor housing with a plastic hammer until it seats on the rear of the intermediate gear case.

15. Install the splash deflector (3), deflector retaining spring (4) and deflector retaining screw (5) in the rear of the housing exhaust cover.

Note: Coat the threads of the deflector retaining screw with Ingersoll-Rand SMB-441 sealant.

16. Coat the exhaust cover seal (2) and install it in the groove on the housing exhaust cover.

17. Align the punch marks on the housing exhaust cover with the punch marks on the motor housing and tap the housing exhaust cover with a plastic hammer until it seats.

18. Install the housing exhaust cover on the rear of the motor housing using the starter assembly cap screws (6) and cap screw washers (7). Use an 8 mm hex-head wrench to tighten each a little at a time to a final torque of 61 to 68 Nm increments.

19. Mount the exhaust cover (68) on the housing exhaust cover (1).

Note: Use Intersoll-Rand SMB-441 pipe sealant on all plugs.

20. Install the bottom housing plug (10) and the housing plug inlet boss (11). Put the starter on its side with the side plug hole upward. Add 175 ml automatic transmission fluid fulfilling DEXRON II D specification, e.g. SHELL DONAX TA, through the side plug hole.

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Caution: **Do not overfill.**
Install the side housing plug (10) and tighten all plugs to 6.8 to 13.6 Nm torque.

Test and Inspection Procedure

1. **Clutch Ratcheting**: Turn the drive shaft pinion (63) by hand in the direction of the starter rotation. The clutch should rachet smoothly with a slight clicking action.

2. **Motor and Gearing Freeness:** Turn the drive shaft pinion (63) opposite the direction of the starter rotation. The drive shaft pinion should turn by hand.

Note: Inadvertent application of air pressure to the "OUT" port will result in drive malfunction (pinion will fail to retract). If this condition occurs, loosen the drive housing cap screws (38) to vent gear case (28). Also, loosen housing plugs (10) and (11) to vent motor.

3. **Pinion Engagement:** Apply 50 psig (3.4 bar/345 kPa) pressure to the engagement "IN" port. drive shaft pinion (63) should move outward and air should escape from the "OUT" port.

Plug the "OUT" port and apply 150 psig (10.3 bar/1034 kPa) pressure to the "IN" port. Check and make sure that no air is escaping.

Measure the dimension from the face of the drive shaft pinion (63) to the face of the mounting flange. It should be 69.0 +2.0 mm).

Remove the pressure from the "IN" port. Measure the distance form the face of the drive shaft pinion the the face of the mounting flange. It should be 45.0 +2.0 mm.

4. **Motor Action:** Secure starter in a vise and apply 90 psig (6.2 bar/620 kPa) pressure using a 3/8" (9 mm) supply line to the inlet of the motor. starter should run smoothly.

5. **Motor Seals:** Plug the exhaust and slowly apply 20 psig (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the starter for 30 seconds in o non-flammable, bubble-producing liquid. If the starter is properly sealed, no bobbles will appear.

6. **Gear Case Seals:** Plug the exhaust and slowly apply 20 psig (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the starter for 30 seconds in o non-flammable, bubble-producing liquid.

There should be no leakage in the housing joints in the gear case area or in the shaft seal in the intermediate gear system. If the starter is properly sealed, no bubbles will appear.

7. **Confirm Drive Rotation:** Apply low pressure to the motor and observe rotation. drive pinion (63) must rotate in the direction stamped on the nameplate. Chamfer on pinion teeth should be on the trailing edge of the gear tooth.

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Working Card Page 1 (2)	**Main Starting Valve**	**613-01.40** Edition 01H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Lubricating, disassembly and reassembly of main starting valve in starting system.

Starting position:

Related procedure:

Man power:

Working time : 1 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Soft hammer.
Locking ring plier.
Allen key, 1/4".

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61310	02	1/eng.
61310	03	1/eng.
61310	04	1/eng.
61310	07	1/eng.

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L+V28/32H

Warning:

Do not attempt any maintenance on the main starting valve before the starting air system has been bled off.

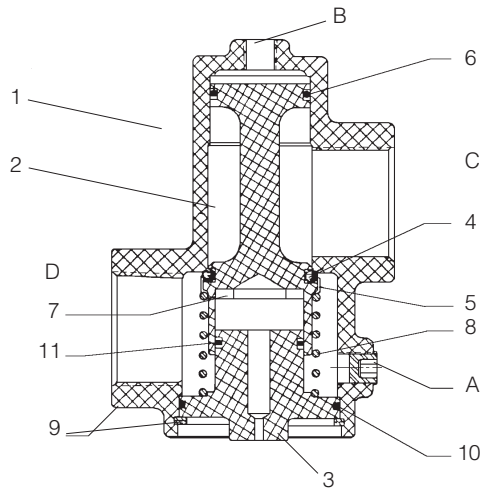
Important:

The main starting valve should be periodically lubricated as follows:

1) Blend off the air pressure.

2) Remove the plug screw (A) , see fig. 1. and squirt about 30 g of 10 w oil into the valve through the plug opening.

3) Reinstall the plug.



A Plug screw
B Pilot air
C Starting air outlet
D Starting air inlet

1 Valve housing
2 Piston
3 End plug
4 Piston o-ring
5 O-ring retainer
6 Piston o-ring
7 Bumper
8 Spring
9 Retaining ring
10 O-ring
11 O-ring

Fig. 1. Main starting valve.

Disassembly:

4) Clamp the main starting valve, in a vice with the locking ring (9) end up.

5) Carefully remove the locking ring (9). The end plug (3) should spring out. If it does not, tap the valve housing (1) lightly with a soft hammer until it does.

6) Remove the end plug (3), spring (8) and piston (2) assembly.

7) Remove and discard all used o-rings, o-rings retainer (5), bumper (7) and spring (8).

8) Wash all other parts in a clean, nonflammable solvent.

Reassembly:

9) Using o-ring lubricant, lubricate and install the new piston o-ring (4) and the new upper piston o-ring (6) on the piston (2).

Note: The upper piston o-ring (6) is slightly larger in diameter than the end plug o-ring (11).

10) Turn the piston over and insert the new bumber (7).

11) Using o-ring lubricant, lubricate and install the new end plug seal o-ring (10) and the new end plug o-ring (11) on the end plug (3).

12) Lubricate the lower small bore of the valve housing (1) with o-ring lubricant.

13) Insert the piston assembly into the valve housing. Push on the piston until the piston o-ring seats against the bevelied face.

14) Install the new o-ring retainer (5) with the large opening over the piston o-ring.

15) Place the new piston spring (8) on the piston.

16) Place the end plug assembly on the piston spring.

17) Using a press to hold down the end plug assembly, install the end plug locking ring (9).

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Working Card Page 1 (2)	**Check of Compressed Air Piping System**	**613-01.90** Edition 02H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Check of compressed oil piping system.

Starting position:

Compressed air connected to the engine.

Related procedure:

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Screwdriver.

Man power:

Working time: ½ hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

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L+V28/32H

With air connected.

1) Examine the piping system for leaks.

2) Retighten all bolts and nuts in the piping system.

3) Drain the system for condensed water. - This should be based on observations.

4) Check flexible connections for leaks and damages.

5) Check manometers.

With air disconnected and stopped engine.

6) Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.

7) Connect the air supply and make a function test of the emergency valve. See description 613.01.

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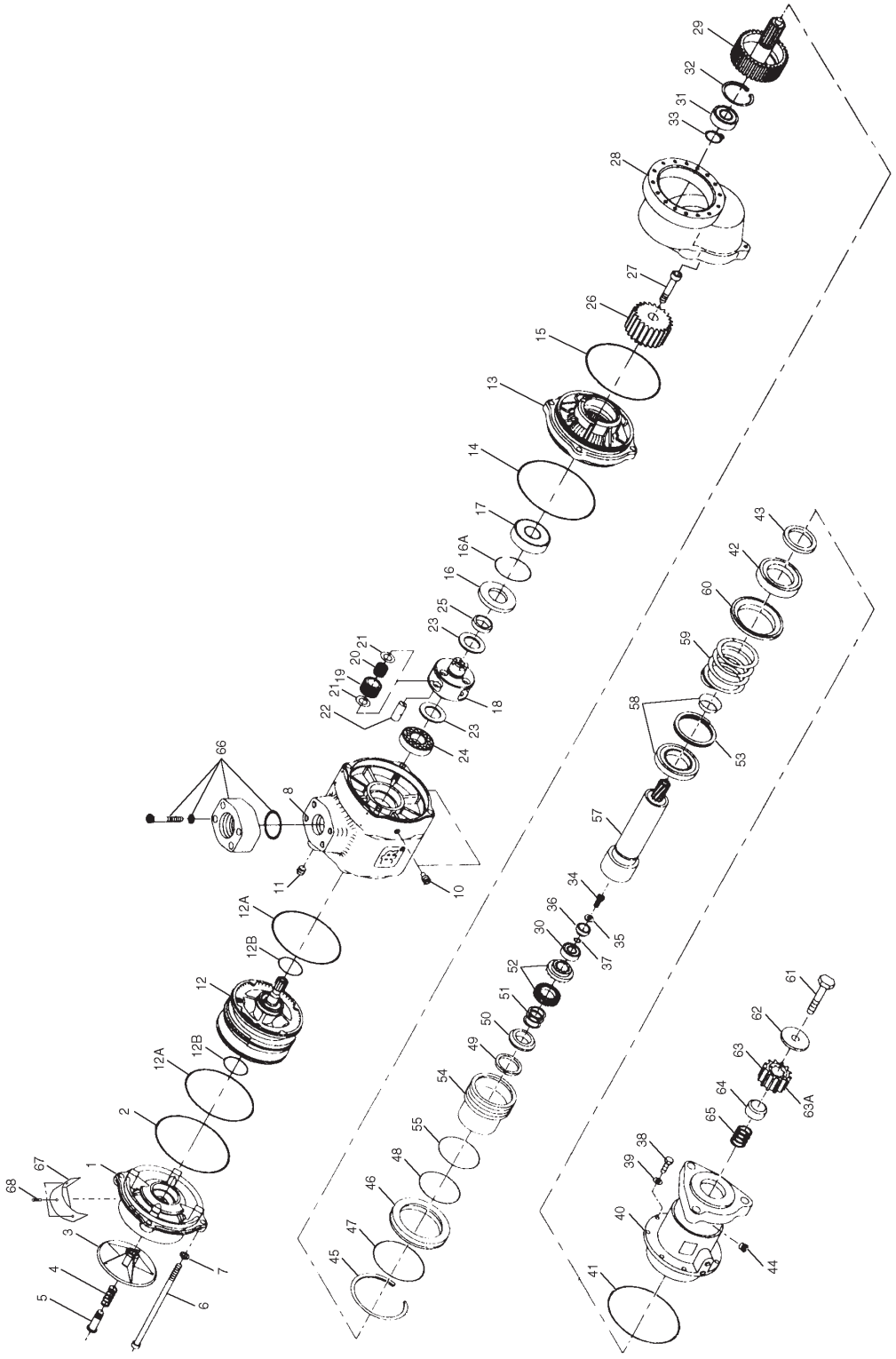
Plate Page 1 (3)	**Turbine Starter**	**61309-05H**

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
1	1/S	**Housing exhaust cover.**	Hus for udstøds-dæksel.
2	1/S	**Exhaust cover seal.**	Tætningsring for udstødsdæksel.
3	1/S	**Splash deflector.**	Stænk deflektor.
4	1/S	**Deflector return spring.**	Returfjeder for deflektor.
5	!/S	**Deflector retaining screw.**	Spændeskive for deflektor.
6	4/S	**Starter assembly cap screw.**	Dækselskrue for montage af starter.
7	4/S	**Cap screw washer.**	Skive for dækselskrue.
8	1/S	**Motor housing.**	Motorhus.
10	1/S	**Housing plug.**	Prop til motorhus.
11	1/S	**Housing plug inlet boss.**	Tilgangsknast for prop til motorhus.
12	1/S	**Motor assembly.**	Motor samling.
12A	2/S	**Cylinder o-ring seal.**	O-ringstætning for cylinder.
12B	2/S	**Housing o-ring seal.**	O-ringstætning for motorhus.
13	1/S	**Intermediate gear case.**	Mellem gearkasse.
14	1/S	**Rear gear case o-ring.**	Bagerste gearkasse o-ring.
15	1/S	**Front gear case o-ring.**	Forreste gearkasse o-ring.
16	1/S	**Planet gear frame shaft seal.**	Tætningsring for planetgearakselstel.
16A	1/S	**Spacer ring.**	Afstandsring.
17	1/S	**Front gear frame bearing.**	Forreste gearstelleje.
18	1/S	**Planet gear frame.**	Planetgearstel.
19	1/S	**Planet gear.**	Planetgear.
20	1/S	**Planet gear needle roller.**	Nålevalse for planetgear.
21	1/S	**Bearing spacer.**	Ligemellemstykke.
22	1/S	**Planet gear shaft.**	Planetgearaksel.
23	2/S	**Gear shaft retainer washer.**	Spænderingsskive for gearaksel.
24	1/S	**Rear gear frame bearing.**	Bagerste gearstelleje.
25	1/S	**Front bearing spacer.**	Forreste gearstelleje.
26	1/S	**Intermediate pinion.**	Mellemtandhjul.
27	1/S	**Intermediate pinion retaining screw.**	Spændeskrue for mellemtandhjul.
28	1/S	**Gear case.**	Gearkasse.
29	1/S	**Drive gear.**	Drivgear.
30	1/S	**Front drive gear bearing.**	Forreste drivgearleje.
31	1/S	**Rear drive gear bearing.**	Bagerste drivgearleje.
32	1/S	**Drive gear bearing retainer.**	Spændskrue for drivgearleje.
33	1/S	**Drive gear shaft bearing retainer.**	Spændskrue for drivgearakselleje.
34	1/S	**Drive gear screw.**	Drivgearskrue.
35	1/S	**Drive gear lock washer.**	Skive for drivgear.
36	1/S	**Drive gear cup.**	Dæksel for drivgear.
37	1/S	**Drive gear screw o-ring.**	O-ring for drivgearskrue.
38	8/S	**Drive housing cap screw.**	Dækselskrue for drivgear.
39	8/S	**Drive housing cap screw lock washer.**	Skive for dækselskrue til drivgearhus.
40	1/S	**Drive housing kit.**	Drivgearhus.
41	1/S	**Drive housing o-ring**	O-ring for drivgearhus.
42	1/S	**Front shaft bearing.**	Forreste akselleje.
43	1/S	**Drive housing seal.**	Tætningsring for drivgearhus.
44	1/S	**Drive housing vent plug.**	Afluftningsprop for drivgearhus.

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty.//E = Qty./Engine
Qty./S = Qty./Turbine Starter

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor
Qty./S = Qty./Turbinestarter

Plate Page 3 (3)	**Turbine Starter**	**61309-05H**

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
45	1/S	**Bulkhead retainer.**	Skotholder
46	1/S	**Bulkhead kit.**	Skotsæt
47	1/S	**Outer bulkhead o-ring.**	Ydre skot o-ring.
48	1/S	**Inner bulkhead o-ring.**	Indre skot o-ring.
49	1/S	**Clutch spring cup retainer.**	Fjedertallerken holder.
50	1/S	**Clutch spring cup.**	Fjedertallerken.
51	1/S	**Clutch spring.**	Koblingsfjeder.
52	1/S	**Clutch jaw kit.**	Koblingssæt.
53	1/S	**Large drive shaft bearing retainer.**	Stor lejespændering for drivaksel.
54	1/S	**Piston kit.**	Stempelsæt.
55	1/S	**Piston o-ring.**	Stempel o-ring.
57	1/S	**Drive shaft kit.**	Drivakselsæt.
58	1/S	**Rear drive shaft bearing.**	Bagerste drivakselleje.
59	1/S	**Piston return spring.**	Stempel returfjeder.
60	1/S	**Seat.**	Sædering.
61	1/S	**Drive pinion retaining screw.**	Tandhjulsspændeskrue.
62	1/S	**Drive pinion washer.**	Tandhjulsskive.
63	1/S	**Drive pinion. L28/32H**	Tandhjul. L28/32H.
63A	1/S	**Drive pinion. V28/32H**	Tandhjul. V28/32H.
64	1/S	**Pinion spring sleeve.**	Tandhjulsbøsning.
65	1/S	**Pinion spring.**	Tandhjulsfjeder.
66	1/S	**Inlet flange kit.**	Tilgangsflangesæt.
67	3/S	**Cover**	Dæksel
68	1/S	**Self drilling screws**	Selvborende skruer
69	1/E	**Turbine starter, complete. L28/32H**	Turbinestarter, komplet. L28/32H.
69A	2/E	**Turbine starter, complete. V28/32H.**	Turbinestarter, komplet. V28/32H.
70		**Spare parts kit, incl. item 2, 12A, 12B, 14, 15, 16, 16A, 17, 21, 23, 24, 25, 41, 45, 47, 48, 55, 61 and 62**	Reservedelssæt incl. item 2, 12A, 12B, 14, 15, 16, 16A, 17, 21, 23, 24, 25, 41, 45, 47, 48, 55, 61 og 62.

When ordering spare parts, see also page 600.50.

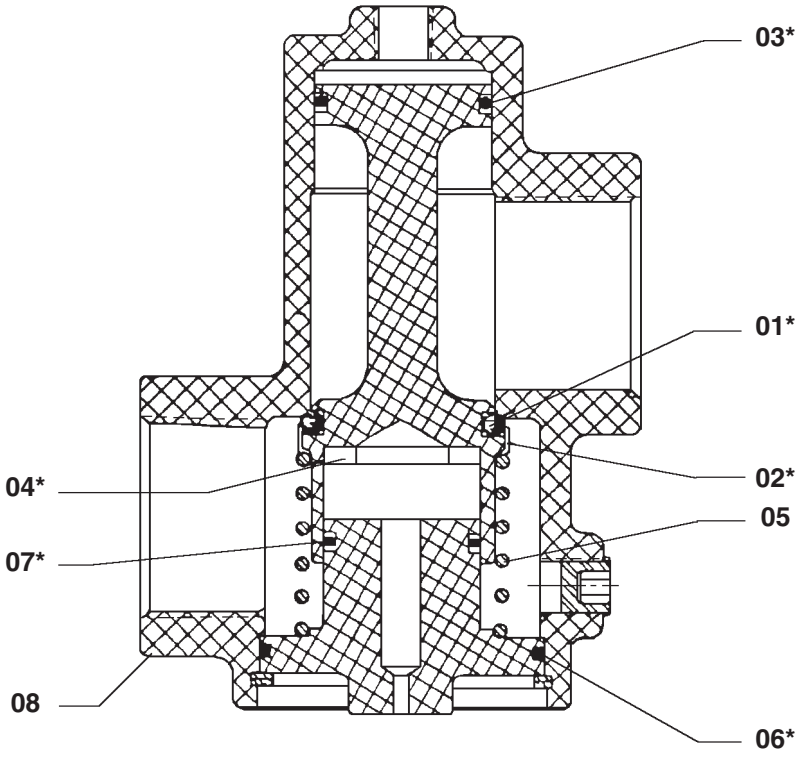
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./S = Qty./Turbine Starter

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor
Qty./S = Qty./Turbinestarter

Plate Page 1 (2)	**Main Starting Valve**	**61310-03H**

L+V28/32H



61310-03H	Main Starting Valve	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01*	1/V	**O-ring**	O-ring
02*	1/V	**O-ring retainer**	O-ring holder
03*	1/V	**O-ring**	O-ring
04*	1/V	**Bumper**	Stødfanger
05	1/V	**Spring**	Fjeder
06*	1/V	**O-ring**	O-ring
07*	1/V	**O-ring**	O-ring
08	1/E	**Main starting valve, complete**	Hovedstartventil, komplet
09	1/V	**Spare part kit Item No. 01, 02, 03, 04, 06 and 07**	Reservedelssæt Item nr. 01, 02, 03, 04, 06 og 07

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

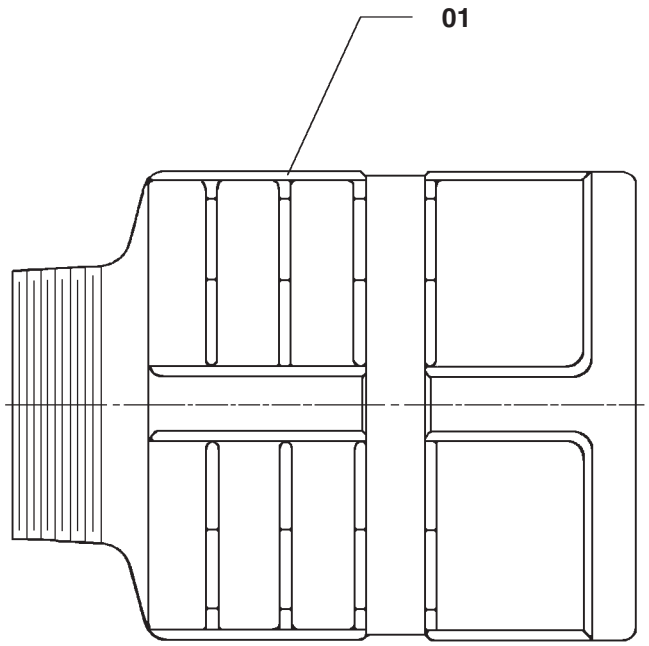
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./V = Qty./Valve

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/V = Antal/Ventil

Plate Page 1 (2)	**Muffler**	**61312-02H**

L+V28/32H



61312-02H	Muffler	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/S	**Muffler**	Dæmper

Item No.	Qty	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

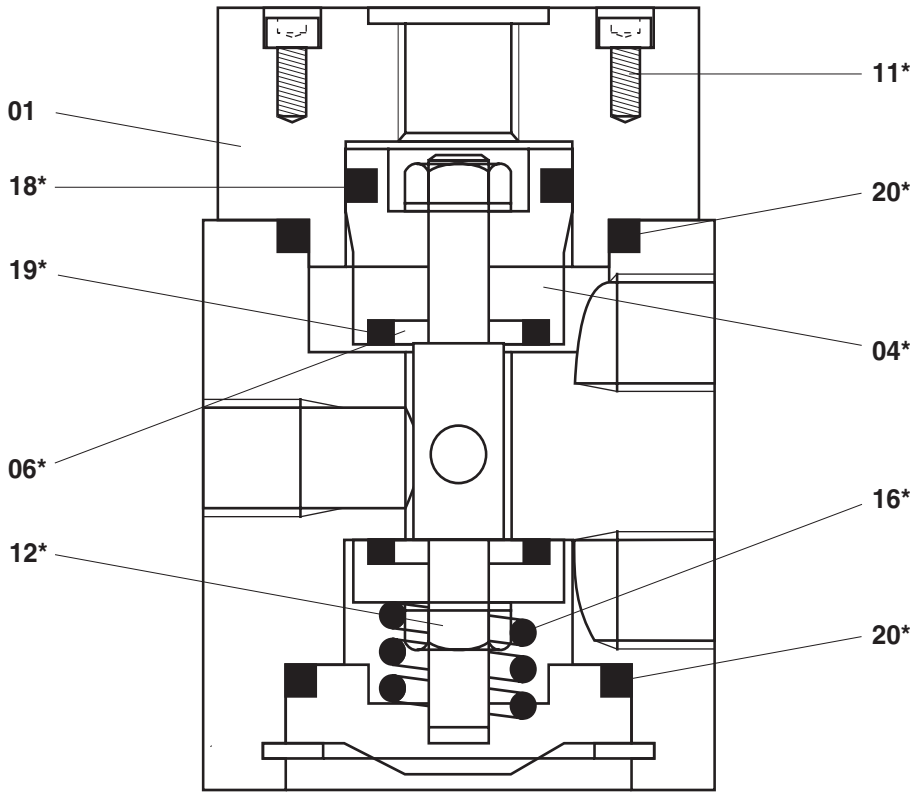
*** = Only available as part of a spare parts kit.**
Qty./S = Qty./Starting air motor

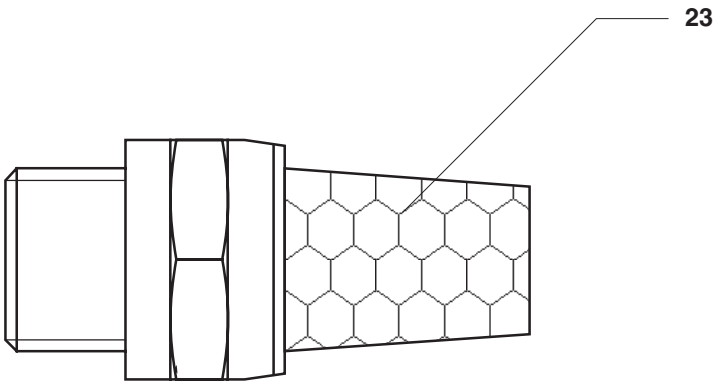
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/S = Antal/Startemotor

Plate Page 1 (2)	**Emergency Starting Valve**	**61313-03H**

L+V28/32H





61313-03H	Emergency Starting Valve	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Emergency starting valve, complete**	Nødstarteventil, komplet
04*	1/V	**Piston**	Stempel
06*	1/V	**Washer**	Skive
11*	4/V	**Screw**	Skrue
12*	1/V	**Nut**	Møtrik
16*	1/V	**Spring**	Fjeder
18*	1/V	**Gasket**	Pakning
19*	1/V	**Gasket**	Pakning
20*	2/V	**Gasket**	Pakning
21	1/V	**Repair kit, incl. item 11, 18, 19, and 20**	Reservedelssæt, inkl. item 11, 18, 19 og 20
22	1/V	**Repair kit, incl. item 4, 6, 12, 16, and 21**	Reservedelssæt, inkl. item 4, 6, 12, 16 og 21
23	1/V	**Silencer**	Lyddæmper

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

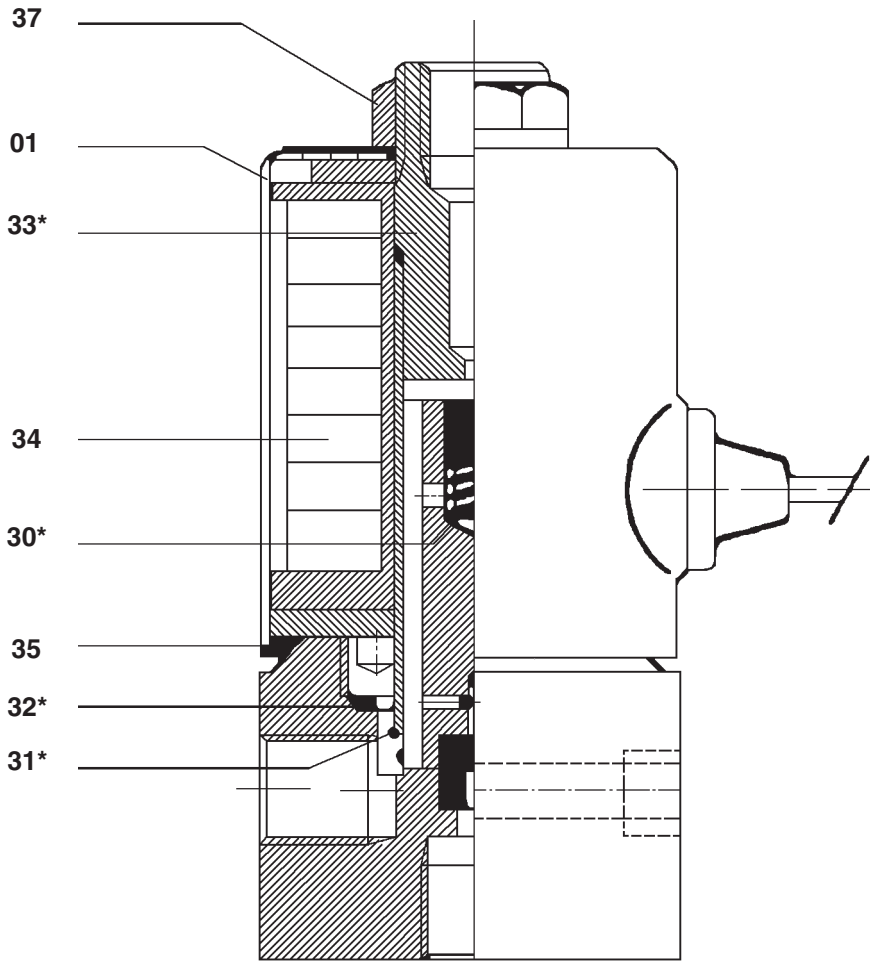
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./V = Qty./Valve

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/V = Antal/Ventil

Plate Page 1 (2)	**Starting Valve**	**61314-03H**

L+V28/32H



61314-03H	Starting Valve	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Starting valve, complete**	Starteventil, komplet
30*	1/V	**Armature, complete**	Anker, komplet
31*	1/V	**Spring**	Fjeder
32*	1/V	**Gasket**	Pakning
33*	1/V	**Gude pipe, complete**	Styrerør, komplet
34	1/V	**Solenoid**	Spole
35	1/V	**Gasket**	Pakning
37	1/V	**Nut**	Møtrik
38*	1/V	**Repair kit, consisting of item 30, 31, and 32**	Reservedelssæt, bestående af item 30, 31, and 32
39	1/V	**Repair kit, consisting of item 33 and 38**	Reservedelssæt, bestående af item 33 og 38

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

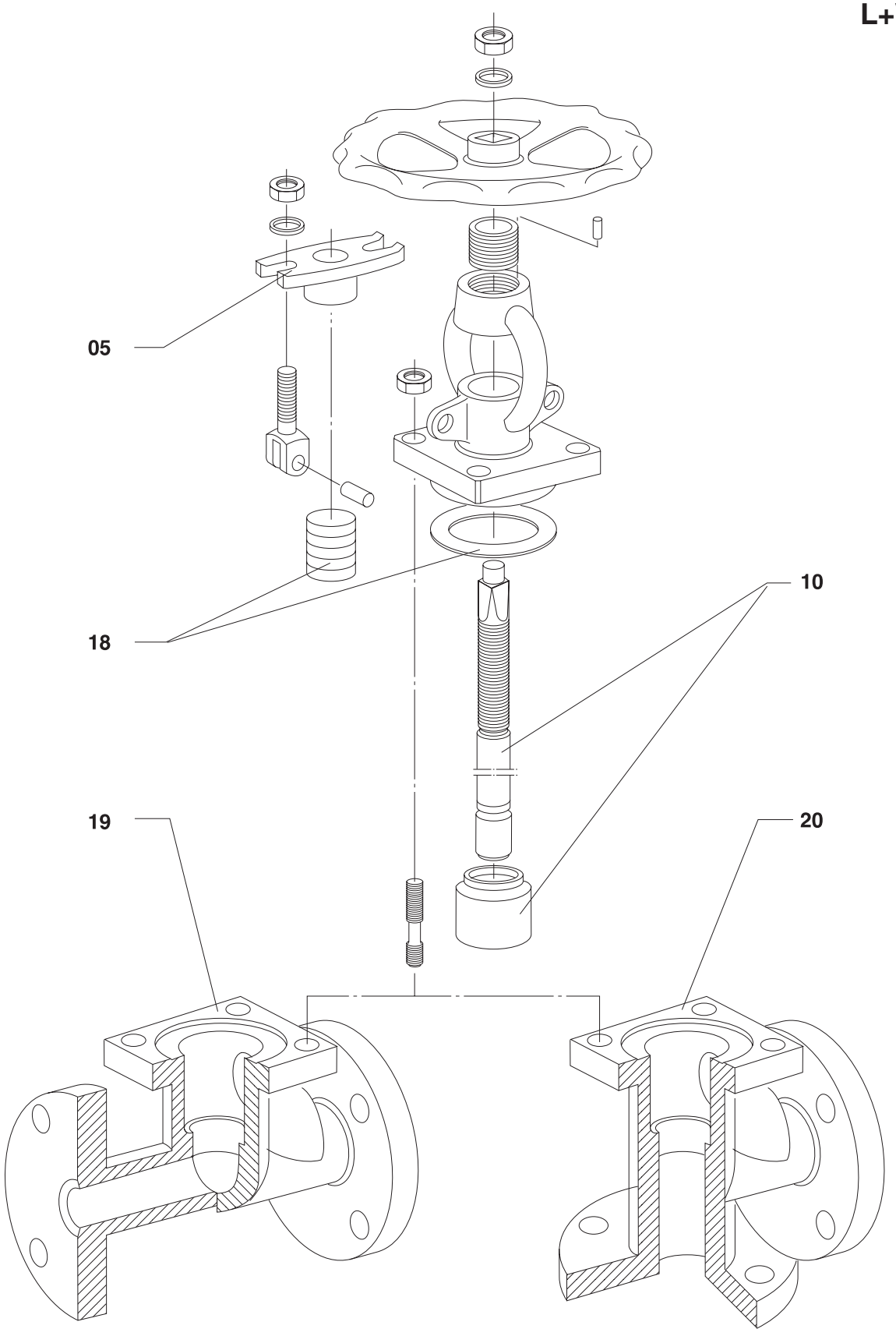
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./V = Qty./Valve

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/V = Antal/Ventil

Plate Page 1 (2)	**Main Stop Valve**	**61315-03H**

L+V28/32H



61315-03H	Main Stop Valve	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
05	1/V	**Gland flange**	Ters
10	1/V	**Stem with disc**	Spindel med skive
18	1/V	**Gasket**	Pakning
19	1/E	**Stop valve, complete (straight way)**	Stopventil, komplet (ligeløb)
20	1/E	**Stop valve, complete (angel way)**	Stopventil, komplet (vinkelløb)

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

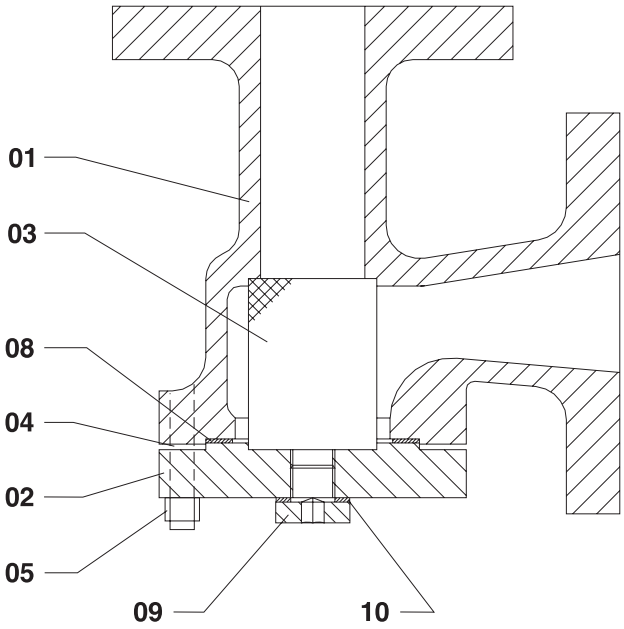
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./C = Qty./Valve.

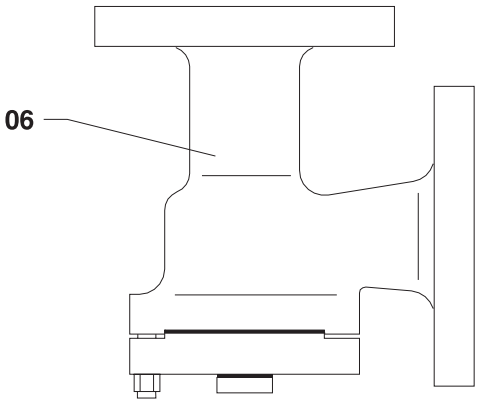
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor.
Antal/V = Antal/Ventil.

Plate Page 1 (2)	**Air Strainer**	**61316-03H**

L+V28/32H





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61316-03H	Air Strainer	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/F	**Housing**	Hus
02	1/F	**Cover**	Dæksel
03	1/F	**Filter**	Filter indsats
04	4/F	**Stud**	Tap
05	4/F	**Nut**	Møtrik
06	1/E	**Air strainer, complete**	Filter, komplet
08	1/F	**Gasket**	Pakning
09	1/F	**Plug screw**	Propskrue
10	1/F	**Gasket**	Pakning

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

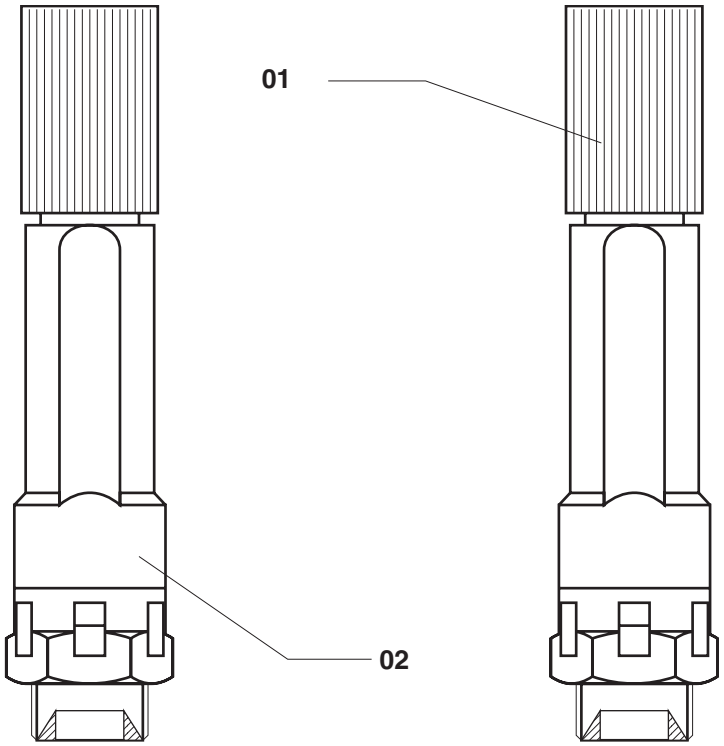
* = Only available as part of a spare parts kit.
Qty./E = Qty./Engine.
Qty./F = Qty./Filter.

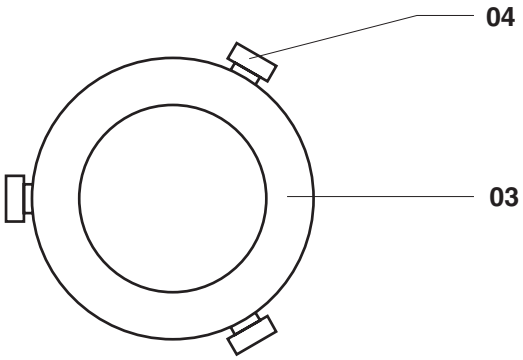
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor.
Antal/F = Antal/Filter.

Plate Page 1 (2)	**Safety Valve**	**61319-01H**

L28/32H





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61319-01H	Safety Valve	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Safety valve, (10 bar)**	Sikkerhedsventil, (10 bar)
02	1/E	**Safety valve, (15 bar)**	Sikkerhedsventil, (15 bar)
03	1/E	**Protective device**	Beskyttelseshætte
04	3/E	**Screw**	Skrue

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

* = Only available as part of a spare parts kit.
Qty./E = Qty./Engine.

Ved bestilling af reservedele, se også side 600.50.

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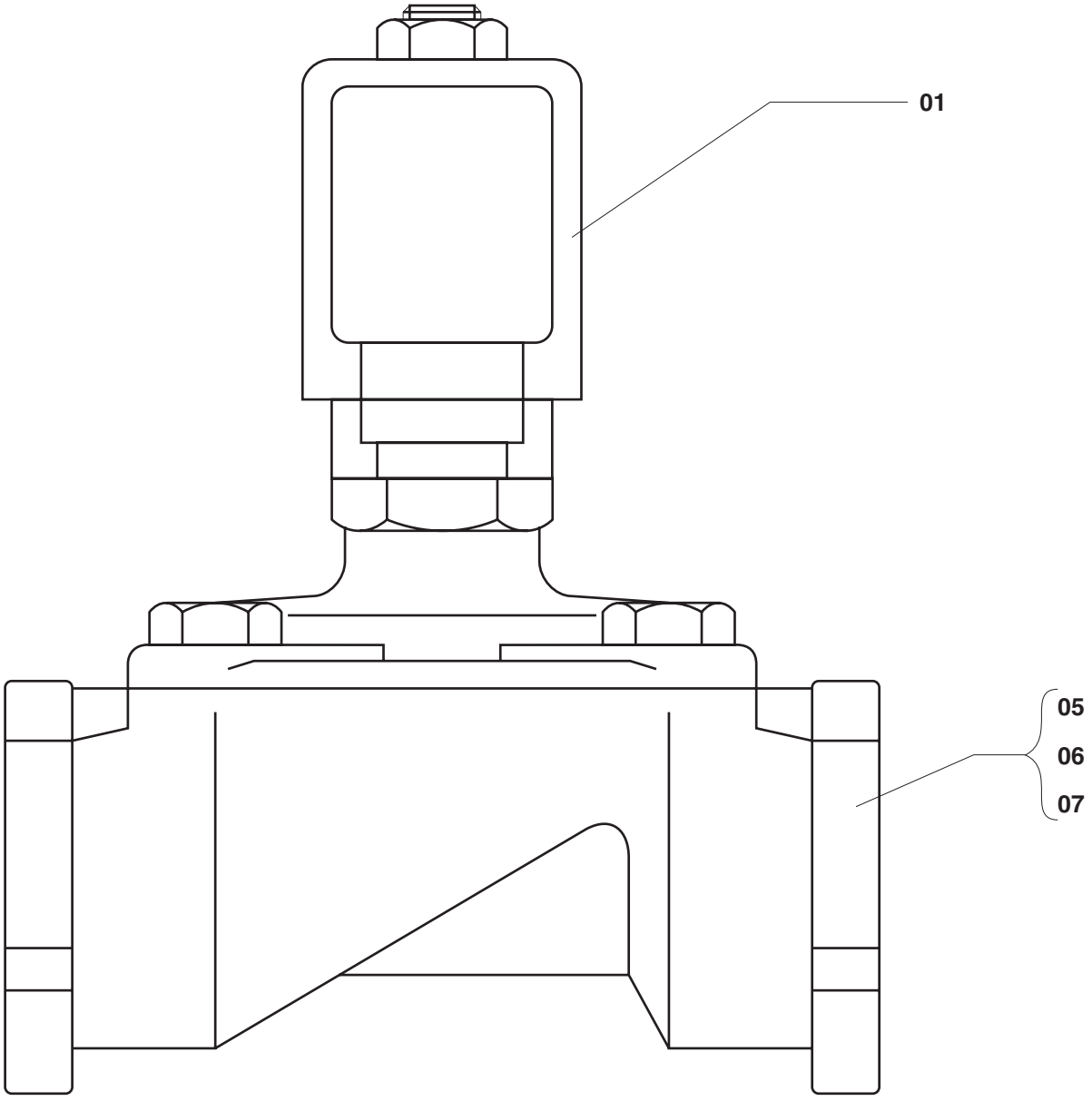
Antal/E = Antal/Motor.

Plate Page 1 (2)	**ON-OFF Valve for Jet System**	**61320-05H**

L+V28/32H



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61320-05H	ON-OFF Valve for Jet System	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/V	**Coil**	Spole
05	1/E	**Valve, complete 1 ¼" connecting branch**	Ventil, komplet 1 ¼" tilslutningsstuds
06	1/E	**Valve, complete 1 ½" connecting branch**	Ventil, komplet 1 ½" tilslutningsstuds
07	1/E	**Valve, complete 2" connecting branch**	Ventil, komplet 2" tilslutningsstuds

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

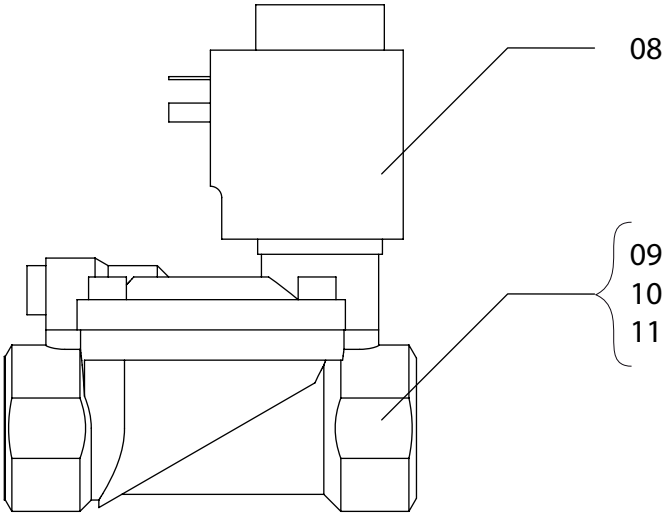
* = Only available as part of a spare parts kit.
Qty./E = Qty./Engine.
Qty./V = Qty./Valve.

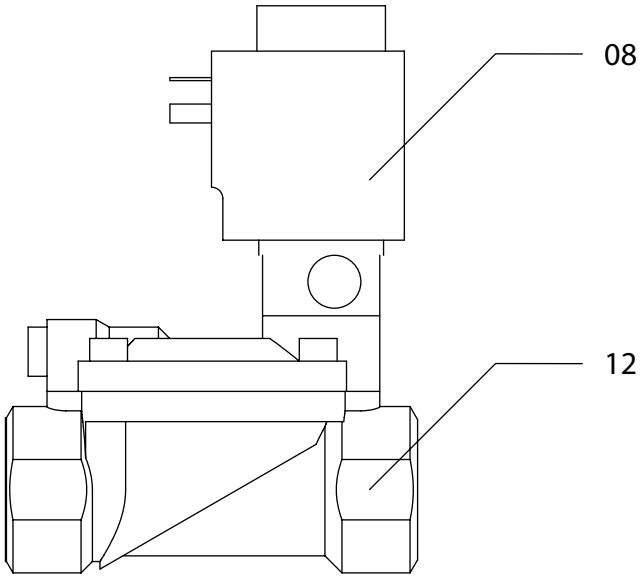
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor.
Antal/V = Antal/Ventil.

Plate Page 1 (2)	**ON-OFF Valve for Jet System**	**61320-06H**

L+V28/32H





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61320-06H	ON-OFF Valve for Jet System	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
08	1/V	**Coil**	Spole
09	1/E	**Valve, complete ½" connecting branch**	Ventil, komplet ½" tilslutningsstuds
10	1/E	**Valve, complete ¾" connecting branch**	Ventil, komplet ¾" tilslutningsstuds
11	1/E	**Valve, complete 1" connecting branch**	Ventil, komplet 1" tilslutningsstuds
12	1/E	**Valve, complete 1" connecting branch, with button for manual override**	Ventil, komplet 1" tilslutningsstuds, med knap for manuel overstyring

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

* = Only available as part of a spare parts kit.
Qty./E = Qty./Engine.
Qty./V = Qty./Valve.

Ved bestilling af reservedele, se også side 600.50.

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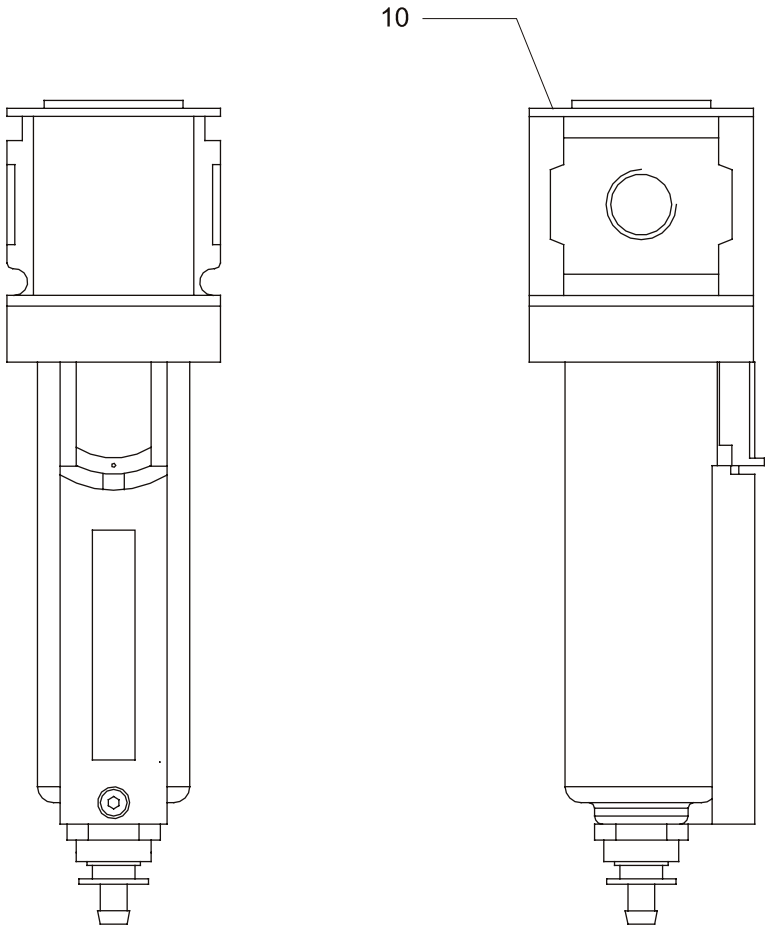
Antal/E = Antal/Motor.
Antal/V = Antal/Ventil.

Plate Page 1 (2)	Air Filter	61321-03H

General



General

Item No.	Qty.	Designation	Benævnelse
10	1/E	**Filter complete**	Filter komplet
11	1/F	**Repair kit (filter and O-ring)**	Reparationssæt (filter og O-ring)

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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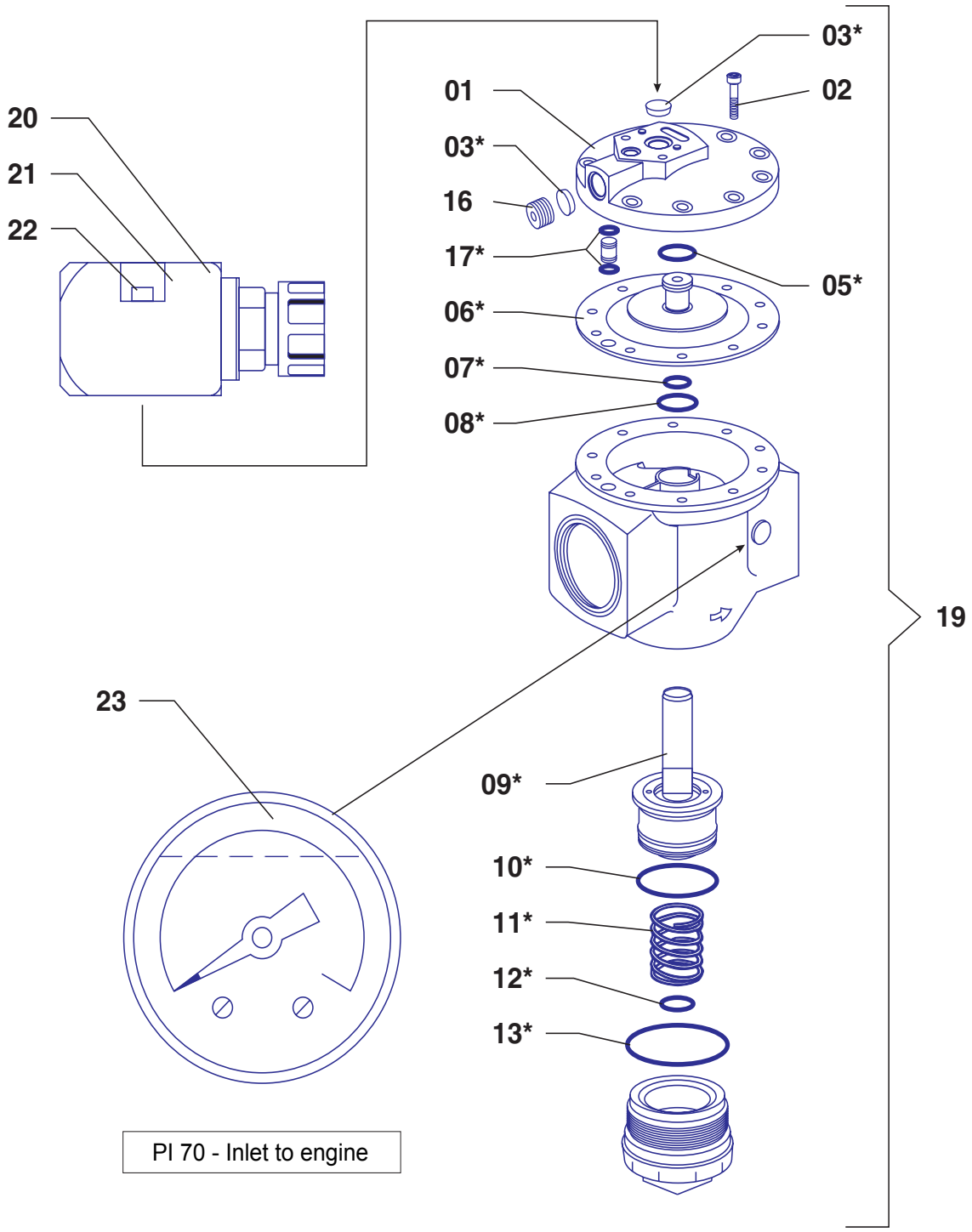
Qty./E = Qty./Engine.

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor.

Plate Page 1 (2)	Pressure Reduction Valve	61322-04H

L+V28/32H



L+V28/32H

Item no	Qty.	Designation	Benævnelse
01	1/V	**Cover**	Dæksel
02	10/V	**Screw**	Skrue
03*	2/V	**Filter**	Filter
05*	1/V	**O-ring**	O-ring
06*	1/V	**Diaphragh**	Membran
07*	1/V	**O-ring**	O-ring
08*	1/V	**O-ring**	O-ring
09*	1/V	**Valve, complete**	Ventil, komplet
10*	1/V	**O-ring**	O-ring
11*	1/V	**Valve spring**	Ventilfjeder
12*	1/V	**O-ring**	O-ring
13*	1/V	**O-ring**	O-ring
16	2/V	**Pipe plug**	Rørprop
17*	2/V	**O-ring**	O-ring
18	1/V	**Repair kit for item 19, incl. item 03, 05, 06, 07, 08, 09, 10, 11, 12, 13, and 17**	Reparationssæt til item 19, inkl. item 03, 05, 06, 07, 08, 09, 10, 11, 12, 13 og 17
19	1/E	**Reduction valve, complete**	Reduktionsventil, komplet
20	1/E	**Pilot valve, complete**	Styreventil, komplet
21	1/V	**Repair kit for item 20**	Reparationssæt for item 20
22	2/V	**Screw**	Skrue
23	1/V	**Manometer 0-25 bar - PI 70**	Manometer 0-25 bar - PI 70
24	1/E	**Pressure reduction valve, complete as plate 61322**	Trykreduktionsventil, komplet som plate 61322
25	1/V	**Gasket kit for item 19, incl. item 03, 05, 07, 08, 10, 12, 13 and 17**	Pakningssæt til item 19, inkl. item 03, 05, 07, 08, 10, 12, 13 og 17

Item no	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

* = **Only available as part of a spare parts kit.**
Qty/E = Qty/Engine
Qty/V = Qty/Valve

Ved bestilling af reservedele, se også side 600.50.

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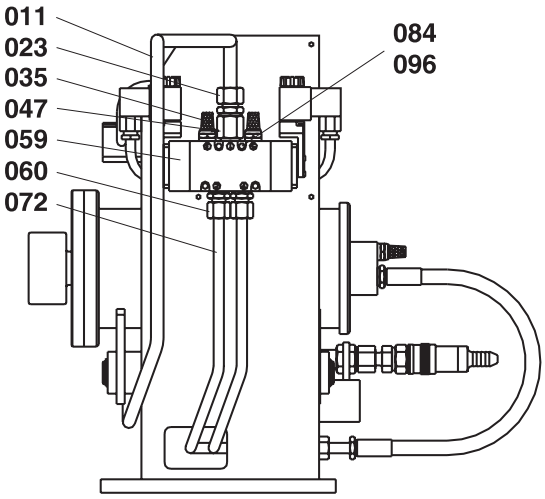
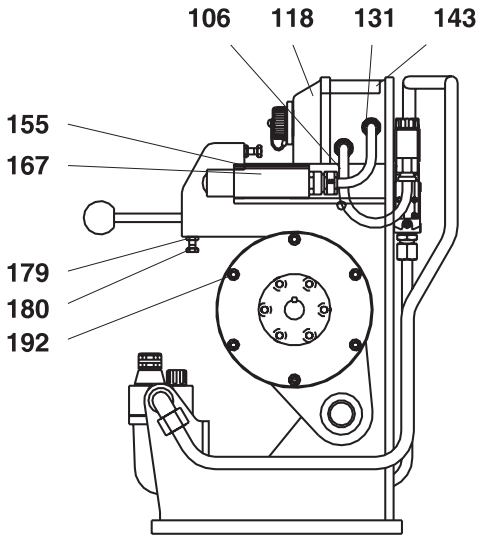
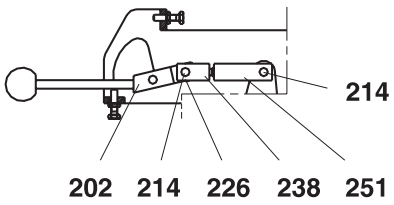
Antal/E = Antal/Motor
Antal/V = Antal/Ventil

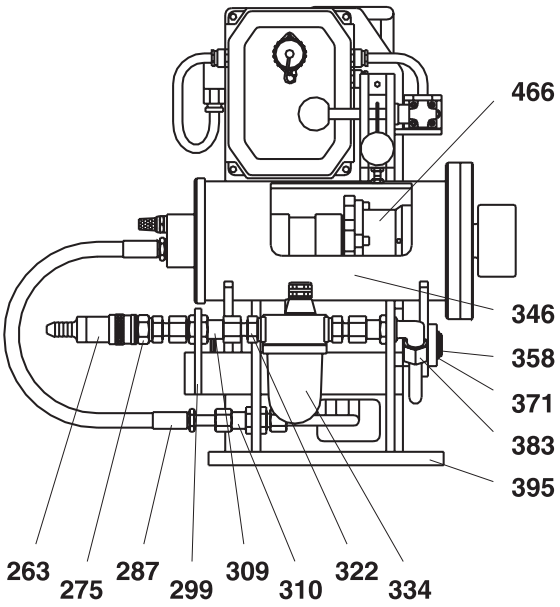
Plate Page 1 (2)	Turning Gear	61325-07H

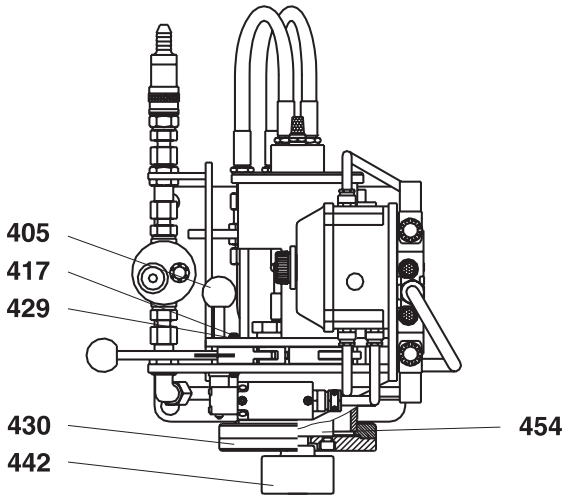
L28/32H











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L28/32H

Item No.	Qty.	Designation	Benævnelse
011	1/E	**Steel pipe**	Stålrør
023	1/E	**Stud coupling**	Kobling
035	3/E	**Silencer**	Lyddæmper
047	1/E	**Reducing adaptor**	Reduktionsstykke
059	1/E	**Solenoid valve**	Magnetventil
060	2/E	**Stud coupling**	Forskruning
072	1/E	**Steel pipe**	Stålrør
084	4/E	**Screw**	Skrue
096	4/E	**Washer**	Skive
106	1/E	**Cable**	Kabel
118	1/E	**Terminal box**	Klemkasse
131	2/E	**Cable union**	Kabelunion
143	4/E	**Screw**	Skrue
155	2/E	**Screw**	Skrue
167	1/E	**Position switch**	Switch
179	2/E	**Nut**	Møtrik
180	2/E	**Screw**	Skrue
192	6/E	**Screw**	Skrue
202	1/E	**Handle**	Håndtag
214	2/E	**Pin**	Stift
226	1/E	**Screw**	Skrue
238	1/E	**Linkage**	Lænkeled
251	1/E	**Linkage**	Lænkeled
263	1/E	**Snap coupling**	Lynkobling
275	1/E	**Snap coupling**	Lynkobling
287	2/E	**Flexible hose**	Fleksibel slange
299	1/E	**Plate**	Plade
309	1/E	**Bulkhead coupling**	Forskruning
310	3/E	**Stud coupling**	Forskruning
322	2/E	**Bulkhead coupling**	Forskruning
334	1/E	**Lubricator**	Smøreapparat
346	1/E	**House for air motor**	Hus for luftmotor
358	1/E	**Shaft**	Aksel
371	2/E	**Retaining ring**	Låsering
383	1/E	**Screwed connection**	Forskruning
395	1/E	**Bracket**	Konsol
405	1/E	**Handle**	Håndtag
417	1/E	**Shaft**	Aksel
429	2/E	**Retaining ring**	Låsering
430	1/E	**Flange**	Flange
442	1/E	**Gear wheel**	Tandhjul
454	6/E	**Screw**	Skrue
466	1/E	**Air motor**	Luftmotor

When ordering spare parts, see also page 500.50.

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Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 500.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor

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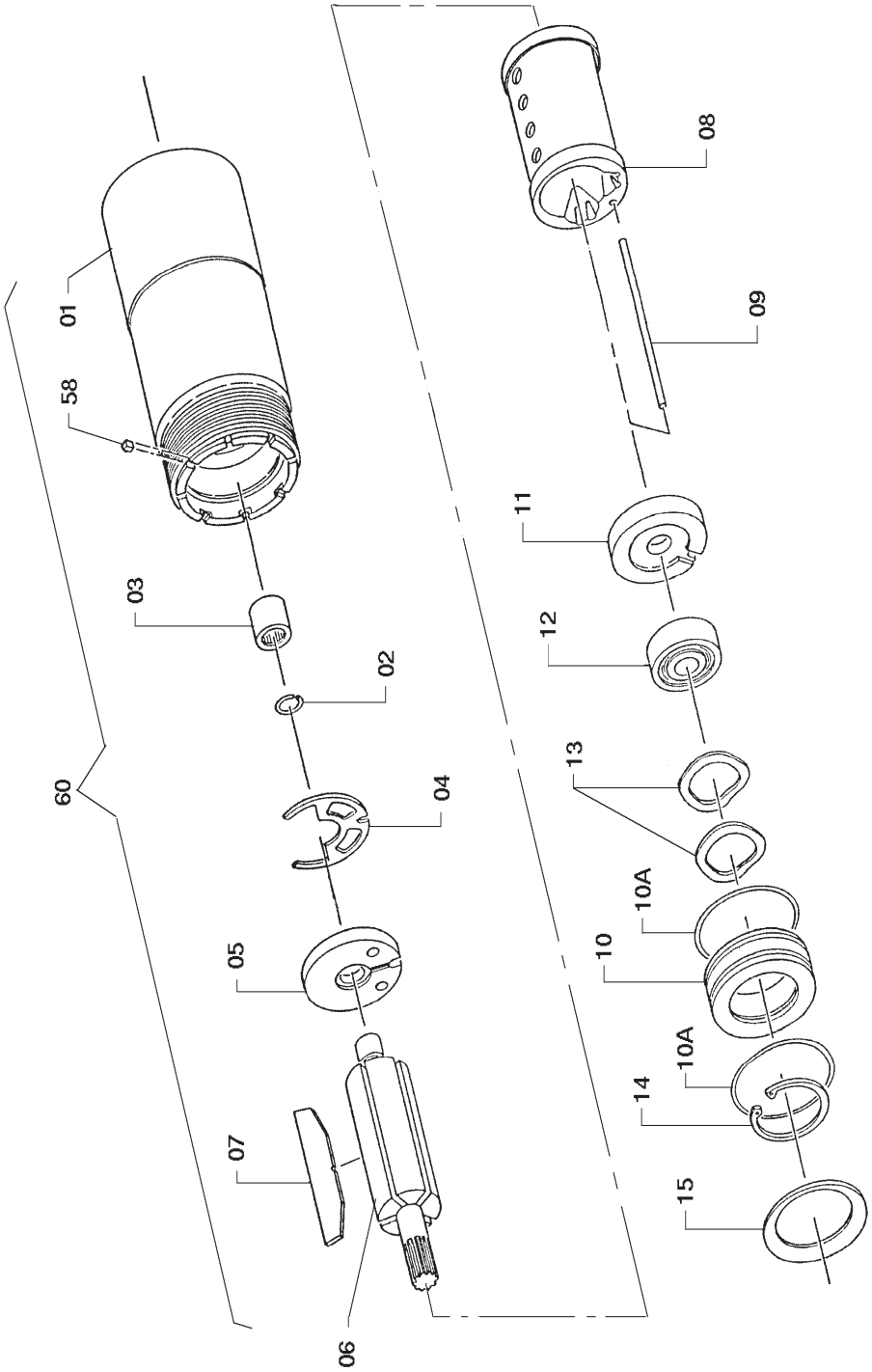
Plate Page 1 (2)	**Pneumatic Turning Gear (Motor Power Unit)**	**61325-08H**

L28/32H



08028-0D/H5250/94.08.12

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/G	**Motor housing**	Motorhus
02	1/G	**Plate retainer, rear end**	Pladeholder, bagende
03	1/G	**Rotor bearing, rear**	Rotorleje, bagende
04	1/G	**Plate gasket, rear end**	Pladepakning, bagende
05	1/G	**Plate, rear end**	Plade, bagende
06	1/G	**Rotor**	Rotor
07	1/G	**Vane packet (set of 5 vanes)**	Vingesæt (bestående af 5 vinger)
08	1/G	**Cylinder**	Cylinder
09	1/G	**Cylinder dowel**	Cylinderstyretap
10	1/G	**Rotor bearing housing assembly**	Rotorlejehus (samling)
10A	2/G	**Rotor bearing housing seal**	Tætning for rotorlejehus
11	1/G	**Plate, front end**	Plade, forende
12	1/G	**Rotor bearing, front**	Rotorleje, forende
13	2/G	**Rotor spring washer, front end**	Rotorlejepakning, forende
14	1/G	**Rotor bearing retainer, front end**	Rotorlejeholder, forende
15	1/G	**Motor clamp washer**	Motorspændeskive
58	2/G	**Flange key**	Flangelås
60	1/E	**Turning gear (motor power unit), complete**	Tørneapparat (motorenhed), komplet
63	1/E	**Motor power unit and spindle, gear case and gearing, complete as plate 61325-08H + 61325-09H**	Motorenhed og spindel, gearboks og gearing, komplet som plate 61325-08H + 61325-09H
64	1/E	**Repair kit for Plate 61325-08H and 61325-09H comprising item 02, 03, 04, 07, 10A, 12, 14, 25, 26, 29, 34, 35, 45, 52, 58**	Reservedelssæt for plate 61325-08H og 61325-09H bestående af item 02, 03, 04, 07, 10A, 12, 14, 25, 26, 29, 34, 35, 45, 52, 58

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./G = Qty./Turning gear

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/G = Antal/Tørneapparat

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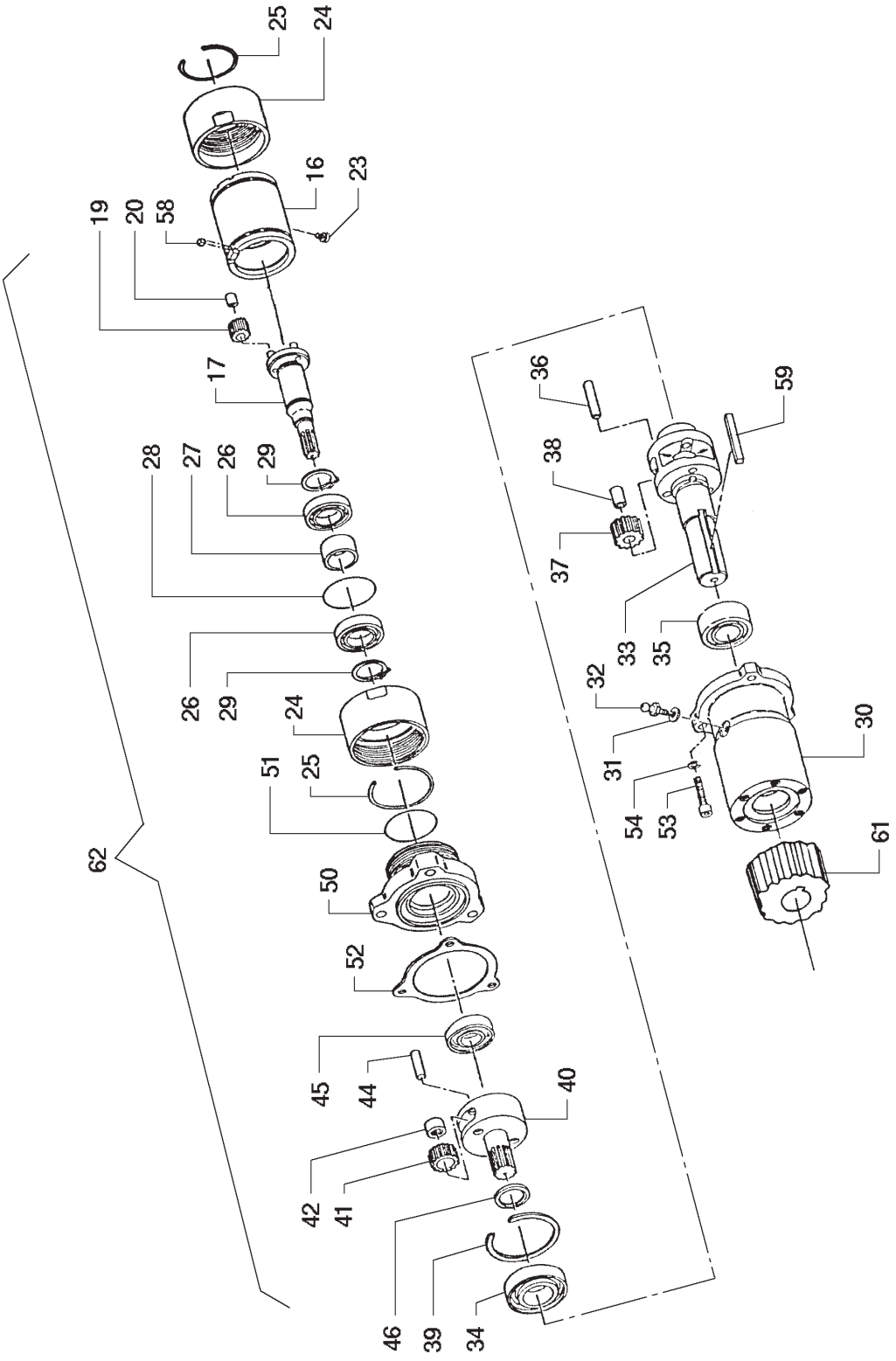
Plate Page 1 (2)	Pneumatic Turning Gear (Spindle, Gear case and Gearing)	61325-09H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
16	1/G	**Gear case**	Hus for drev
17	1/G	**Spindle**	Spindel
19	3/G	**Spindle planet gear assembly**	Planethjulsakselsæt
20	3/G	**Planet gear bearing**	Planethjulleje
23	1/G	**Grease screw**	Smøreskrue
24	2/G	**Coupling nut**	Koblingsmøtrik
25	2/G	**Coupling nut retainer**	Holder for koblingsmøtrik
26	2/G	**Spindle bearing**	Spindelleje
27	1/G	**Spindle bearing spacer**	Spindellejebøsning
28	1/G	**Gear case seal**	Tætning for drevhus
29	2/G	**Spindle and spindle bearing retainer ring**	Spindel og sikringsring for spindelleje
30	1/G	**Gear case assembly**	Hus for drev (samling)
31	1/G	**Grease fitting washer**	Fedtmonteringsskive
32	1/G	**Grease fitting**	Fedttilpasning
33	1/G	**Spindle**	Spindel
34	1/G	**Spindle bearing, rear**	Spindelleje, bagende
35	1/G	**Spindle bearing, front**	Spindelleje, forende
36	3/G	**Planet gear shaft**	Planethjulsaksel
37	3/G	**Planet gear assembly**	Planethjul
38	1/G	**Planet gear bearing**	Planethjulleje
39	1/G	**Spindle retainer**	Spindelholder
40	1/G	**Gear head**	Drevhoved
41	3/G	**Gear head planet gear assembly**	Planethjul for drevhoved
42	1/G	**Planet gear bearing**	Planethjulleje
44	2/G	**Planet gear shaft**	Planethjulsaksel
45	1/G	**Gear head bearing**	Drevhovedleje
46	1/G	**Gear head spacer**	Drevhoved afstandsrør
50	1/G	**Gear case adapter**	Drevhusindsatsbøsning
51	1/G	**Seal, Gear case adapter**	Tætning for drevhusindsats
52	1/G	**Gasket, Aux. gear case front**	Pakning for hjælpedrevhus, forende
53	1/G	**Cap screw, Aux. gear case**	Sætskrue for hjælpedrevhus
54	1/G	**Lock washer, Aux. gear case**	Låseskive for hjælpedrevhus
58	2/G	**Flange key**	Flangelås
59	1/G	**Spindle key**	Spindellås
61	1/G	**Gear wheel**	Tandhjul
62	1/E	**Turning gear (spindle, gear case and gearing), complete**	Tørneapparat (spindel, gearboks og gearing), komplet
63	1/E	**Motor power unit and spindel, gear case and gearing, complete as plate 61325-08H + 61325-09H**	Motorenhed og spindel, gearboks og gearing, komplet som plate 61325-08H + 61325-09H
64	1/E	**Repair kit for Plate 61325-08H and 61325-09H comprising Item 02, 03, 04, 07, 10A, 12, 14, 25, 26, 29, 34, 35, 45, 52, 58**	Reservedelssæt for plate 61325-08H og 61325-09H bestående af item 02, 03, 04, 07, 10A, 12, 14, 25, 26, 29, 34, 35, 45, 52, 58

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./G = Qty./Turning gear

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/G = Antal/Tørneapparat

Fuel oil system

514/614

Internal fuel oil system

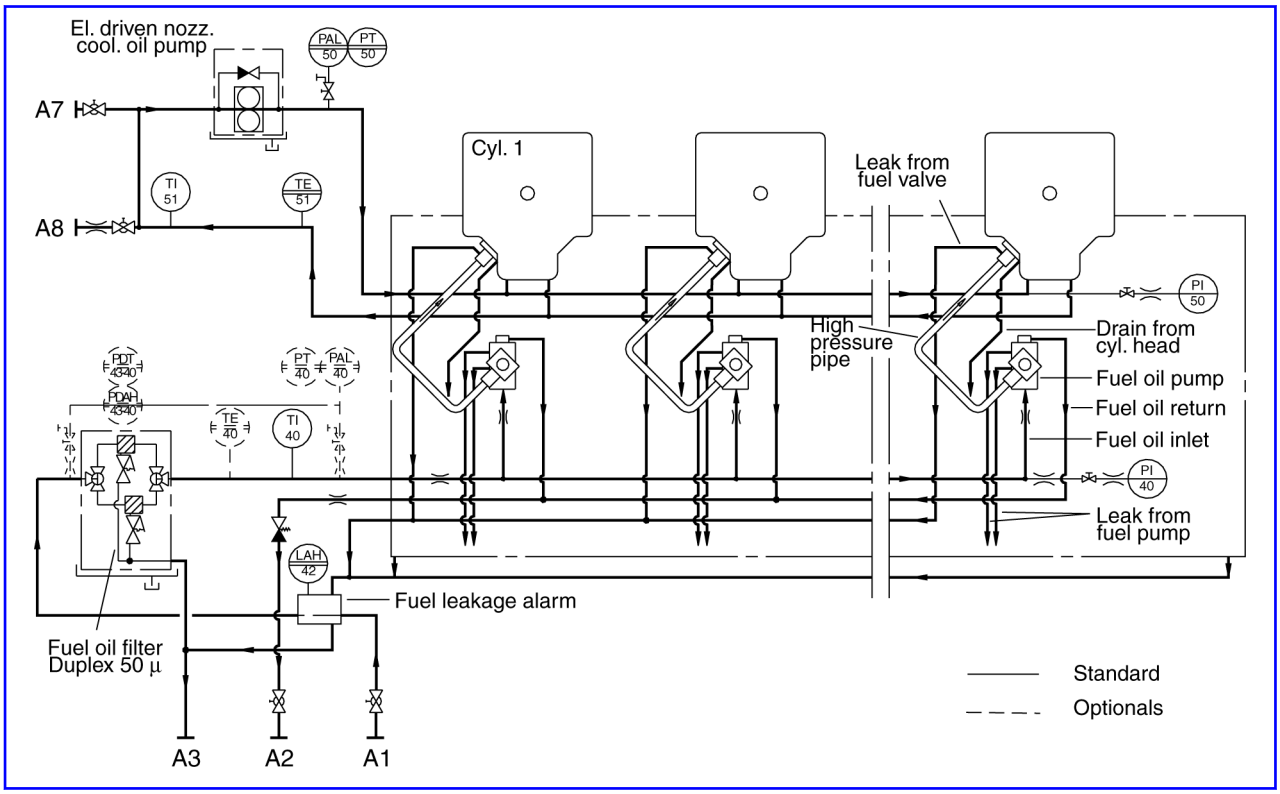


Figure 1: Diagram for fuel oil system

Pipe description		
A3	Waste oil outlet	DN15
A1	Fuel oil inlet	DN25
A2	Fuel oil outlet	DN25
A7	Nozzle cooling oil inlet	DN15
A8	Nozzle cooling oil outlet	DN15

Table 1: Flange connections are as standard according to DIN 2501

General

The internal built-on fuel oil system as shown in fig 1 consists of the following parts:

- the high-pressure injection equipment
- a nozzle cooling system
- a waste oil system

Fuel oil system

The fuel oil is delivered to the injection pumps through a safety filter.

The safety filter is a duplex filter of the split type with a filter fineness of 50 my. The filter is equipped with a common three-way cock for manual change of both the inlet and outlet side.

Fuel injection equipment

Each cylinder unit has its own set of injection equipment, comprising injection pump, high-pressure pipe and injection valve.

The injection equipment and the distribution supply pipes are housed in a fully enclosed compartment thus minimizing heat losses from the preheated fuel.

This arrangement reduces external surface temperatures and the risk of fire caused by fuel leakage.

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Fuel oil injection pump

The fuel oil injection pump is installed on the roller guide housing directly above the camshaft, and it is activated by the cam on the camshaft through roller guides fitted in the roller guide housing.

The injection amount of the pump is regulated by transversal displacement of a toothed rack in the side of the pump housing.

By means of a gear ring, the pump plunger with the two helical millings, the cutting-off edges, is turned. Hereby the length of the pump stroke is specified when the plunger closes the inlet holes until the cutting-off edges again uncover the holes.

The release of high pressure through the cutting-off edges presses the oil with great force against the wall of the pump housing. At the spot, two exchangeable plug screws are mounted.

The amount of fuel injected into each cylinder unit is adjusted by means of the governor.

It maintains the engine speed at the preset value by a continuous positioning of the fuel pump racks, via a common regulating shaft and spring-loaded linkages for each pump.

The injection valve is for "deep" building-in to the centre of the cylinder head.

Fuel oil injection valve

The joint surface between the nozzle and holder is machine-lapped to make it oil-tight.

The fuel injector is mounted in the cylinder head by means of the integral flange in the holder and two studs with distance pieces and nuts.

A bore in the cylinder head vents the space below the bottom rubber sealing ring on the injection valve, thus preventing any pressure build-up due to gas leakage, but also unveiling any malfunction of the bottom rubber sealing ring for leak oil.

Fuel oil high pressure pipe

The high-pressure pipe between fuel injection pump and fuel injector is a shielded pipe with coned pipe ends for attachment by means of a union nut, and a nipple nut, respectively.

The high-pressure pipe is led through a bore in the cylinder head, in which it is surrounded by a shielding tube, also acting as union nut for attachment of the pipe end to the fuel injector.

The shielding tube has two holes in order to ensure that any leakage will be drained off to the cylinder head bore. The bore is equipped with drain channel and pipe.

The shielding tube is supported by a sleeve, mounted in the bore with screws.

The sleeve is equipped with O-rings in order to seal the cylinder head bore.

Internal nozzle cooling system

The nozzles of the injection valves on HFO-engines are temperature controlled by means of a separate circuit containing diesel oil or thermal oil as media.

The system maintains a nozzle surface temperature low enough to prevent formation of carbon trumpets on the nozzle tips during high load operation and high enough to avoid cold corrosion during idling or low-load operation.

Waste oil system

Waste and leak oil from the comparements, fuel valves is led to a fuel leakage alarm unit.

The alarm unit consists of a box with a float switch for level monitoring. In case of a larger than normal leakage, the float switch will initiate alarm. The supply fuel oil to the engine is lead through the unit in order to keep this heated up, thereby ensuring free drainage passage even for high-viscous waste/leak oil.

Optionals

Besides the standard components, the following standard optionals can be built-on:

- Pressure differential alarm high
  - PDAH 43-40 Fuel oil, inlet and outlet filter
- Pressure differential transmitting
  - PDT 43-40 Fuel oil, inlet and outlet filter
- Pressure alarm low
  - PAL 40 Fuel oil, inlet fuel oil pump
- Pressure transmitting
  - PT40 Fuel oil, inlet fuel oil pump

- Temperature element
  - TE40 Fuel oil, inlet fuel oil pump

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Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismounting, inspection/overhaul and mounting of fuel injection pump. Inspection of fuel injection pipe.

Starting position:

Cover in front of fuel injection pump has been removed.

Related procedure:

Inspection of roller guide for fuel injection pump 608-01.05.

Man power:

Working time : 4 Hours
Capacity : 1 Man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate No.	Item No.	Note
62014	01	
62014	15	
62014	20	
62014	25	
62006	26	20-120 Nm
62006	28	140-760 Nm

Hand tools:

Ring and open end spanner	13 mm
Ring and open end spanner	14 mm
Ring and open end spanner	17 mm
Ring and open end spanner	19 mm
Allen key	8 mm, 10 mm

Plier for lock ring.
Tools for cleaning.
Clean kerosene or gas oil.
Clean lubricating oil.
Anti seize product (Copaslip, Molykote GN Plus or similar).

Spare and wearing parts:

Plate No.	Item No.	Qty./
61401	24	1/pump
61401	25	1/pump
61401	26	1/pump
61401	36	1/pump
61401	37	1/pump
61401	38	1/pump

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Dismounting of fuel injection pump

1. Dismount the fuel injection pipe pos. 1 fig. 1 and the fuel inlet pipe pos. 2.

2. Separate the spring loaded lever from the regulating rod on the fuel injection pump.

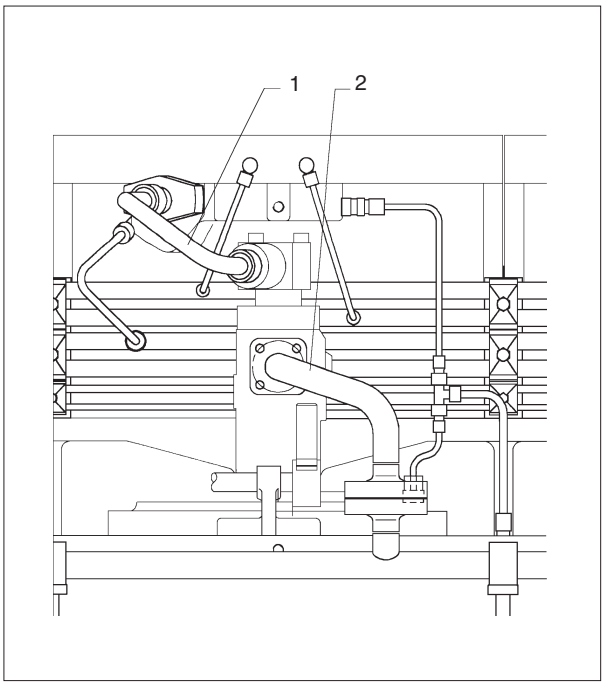


Fig. 1 View from Control Side

3. Remove the pipe for lub.oil and drain.

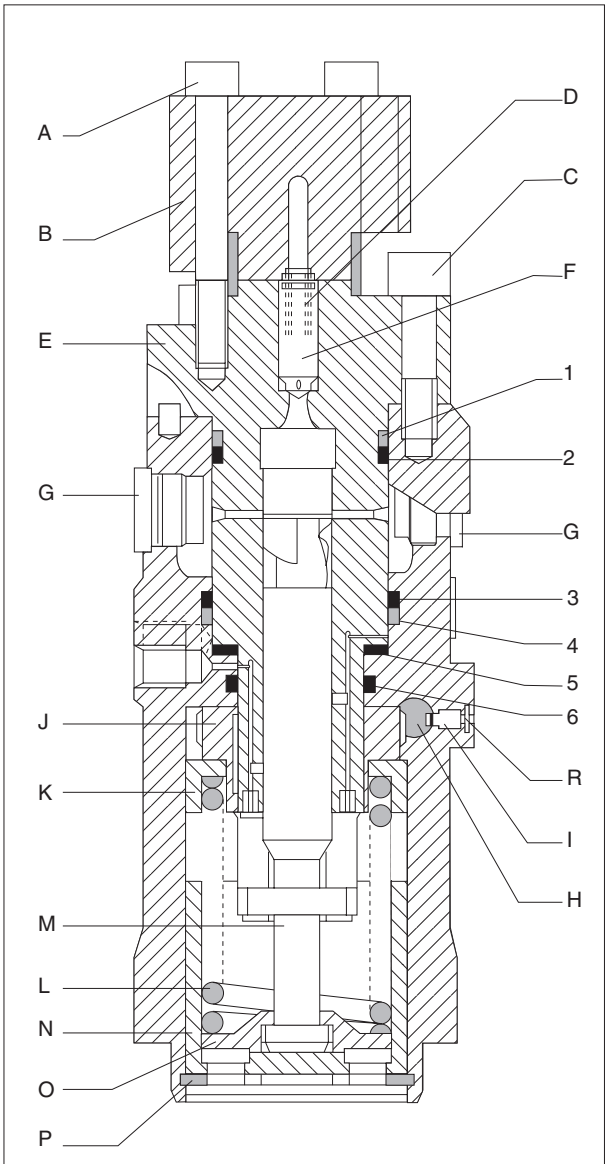
4. Remove the screws in the bottom flange (4 pieces) and take the fuel injection pump away.

Separation of fuel injection pump.

5. If necessary, clean the exterior of the injection pump.

6. Mount the injection pump in the clamping bracket PYO-W020 (see plate 62014 item 03), on the test pump.

7. Press the thrust cap (N) fig. 2 downwards and remove the securing ring (P). Remove the thrust cap (N) with lower spring plate (O) and plunger (M). **Be sure not to damage the plunger.**



1. Back-up ring (spirally coiled)
2. O-ring inside dia. 45.7 mm x 2.6
3. O-ring inside dia. 51 mm x 3
4. Back-up ring
5. O-ring inside dia. 43 mm x 3.5
6. O-ring inside dia. 37 mm x 3

Fig. 2 Cross Section of Fuel Injection Pump

8. Take out the plunger spring (L), upper spring plate (K) and pinion (J). If necessary remove the lock ring (R) and guide pin (I) and dismount the regulating rod (H) as well as the cap screw in the opposite end of the regulating rod (H).

9. Unscrew the four screws (A) and remove the connecting piece (B). Take out the valve spring (D) and the non-return valve (F).

10. Loosen and remove the four screws (C) and take out the barrel (E).

11. Remove all the O-rings and back-up rings from the injection pump.

12. All parts must be cleaned, using kerosene or gas oil and a hand brush (not a steel brush).
Blow through the holes for sealing oil in the pump houses and the barrel (E).

Inspection of fuel injection pump:

13. Insert plunger (M) and non-return valve (F) into the barrel (E) after wetting with clean gas oil. Plunger and non-return valve must slide into the barrel by their own weight.

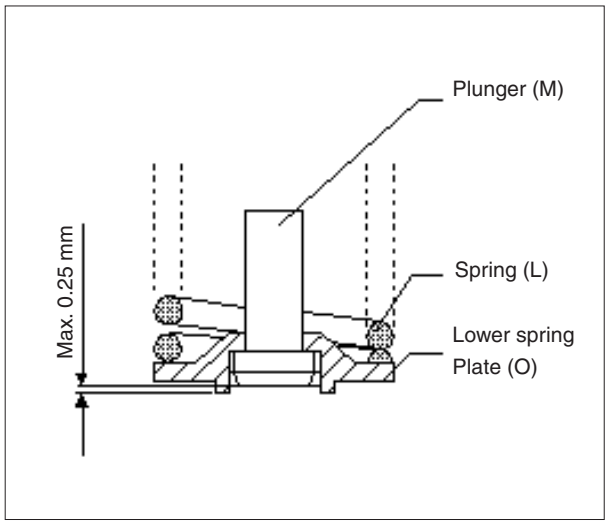


Fig. 3 Clearance between Lower Spring Plate and Plunger

14. The axial clearance between lower spring plate and plunger foot must not exceed 0.25 mm. The clearance between lower spring plate and plunger foot is 0.05 to 0.1 mm when new. See fig. 3.

15. Check the cavitation plugs (G) for wear and renew if necessary.

16. Barrel (E), plunger (M) and non-return valve (F) are manufactured to very close tolerances.
Any attempt to refinish these parts causes alterations of the tolerances and must therefore **NOT** be carried out.
If during the visual inspection of the parts, heavy abrasion symptoms or damage can be observed, the part in question must be replaced.

Assembling of fuel injection pump:

17. When assembling the injection pump, proceed in the reverse order to disassembling. Pay attention to the following:

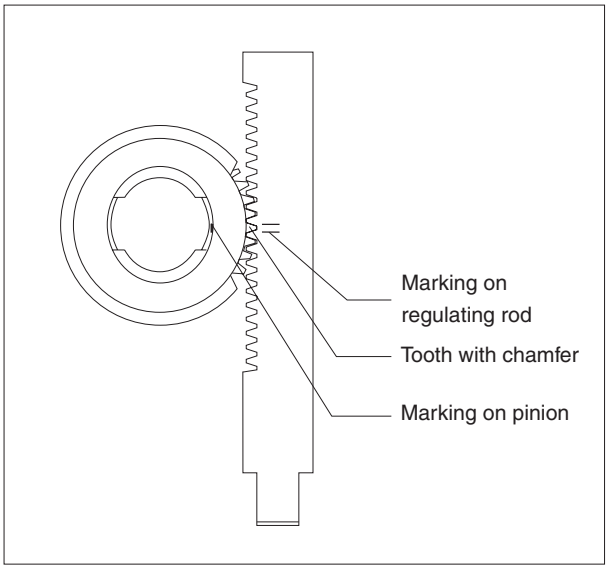


Fig. 4 Mounting of Regulating Rod Mechanism

A. At initial tightening up of new parts the following (C) for barrel (E).
Tighten screws to 90 Nm, loosen and tighten again to 90 Nm and then tighten to 90 Nm + 10 Nm.
Employ the same procedure when tightening the other pump components for the first time.

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B. Renew all sealing and back-up rings. For placing of the rings, see fig. 1.

C. Coat all the threads with an anti seize product.

D. Wipe dry with paper plane sealing surface on barrel (E) and connecting piece (B).

E. Before inserting the pinion (J), the easy motion of the plunger (M) in the barrel (E) must be checked.

F. When assembling the pinion (J), ascertain that the tooth (recognizable by the chamfer) will enter the space of the regulating rod (H) marked by two sings, see fig. 4.

G. The marking on the guide cam of the plunger (M), must be in line with the marking in the slots of the pinion (J). (Not shown on fig. 4).

18. After assembling, the easy motion of the regulating rod (H), must be checked and the plunger (M) must be moved from the no-load stop to full-load stop.

Mounting of fuel injection pump:

19. Before mounting the fuel injection pump, clean the roller guide spring and washer for spring in the roller guide housing.

20. Reconnect the regulating rod (H) to the spring loaded lever and all the pipes to the fuel pump.

Fuel injection pipe:

By normal working conditions the fuel injection pipe require very little maintenance except replacement of O-rings and gasket in connection with the normal overhaul of fuel injection equipment. (See also description of fuel injection pipe page 614.10).

Working Card Page 1 (4)	Fuel Injection Pump and Fuel Injection Pipe	614-01.05 Edition 05H

L/V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismounting, inspection/overhaul and mounting of fuel injection pump. Inspection of fuel injection pipe.

Starting position:

Cover in front of fuel injection pump has been removed.

Related procedure:

Inspection of roller guide for fuel injection pump 608-01.05.

Man power:

Working time : 4 Hours
Capacity : 1 Man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate No.	Item No.	Note
62014	01	
62014	15	
62014	20	
62014	25	
62006	26	20-120 Nm
62006	28	140-760 Nm

Hand tools:

Ring and open end spanner 13 mm
Ring and open end spanner 14 mm
Ring and open end spanner 17 mm
Ring and open end spanner 19 mm
Allen key 8 mm, 10 mm
Plier for lock ring.
Tools for cleaning.
Clean kerosene or gas oil.
Clean lubricating oil.
Anti seize product (Copaslip, Molykote GN Plus or similar).

Spare and wearing parts:

Plate No.	Item No.	Qty./
61401	05	1/pump
61401	06	1/pump
61401	07	1/pump
61401	08	1/pump
61401	09	1/pump
61401	10	1/pump

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Dismounting of fuel injection pump

1. Dismount the fuel injection pipe pos. 1 fig. 1 and the fuel inlet pipe pos. 2.

2. Separate the spring loaded lever from the regulating rod on the fuel injection pump.

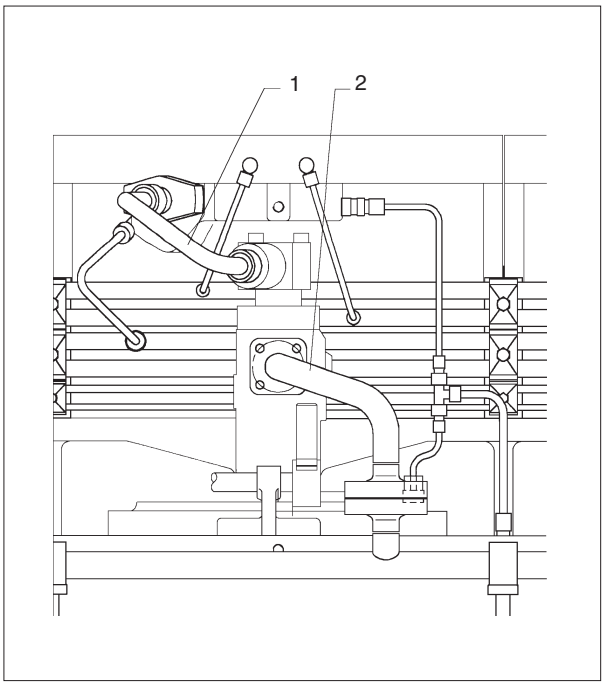


Fig. 1 View from Control Side

3. Remove the pipe for lub.oil and drain.

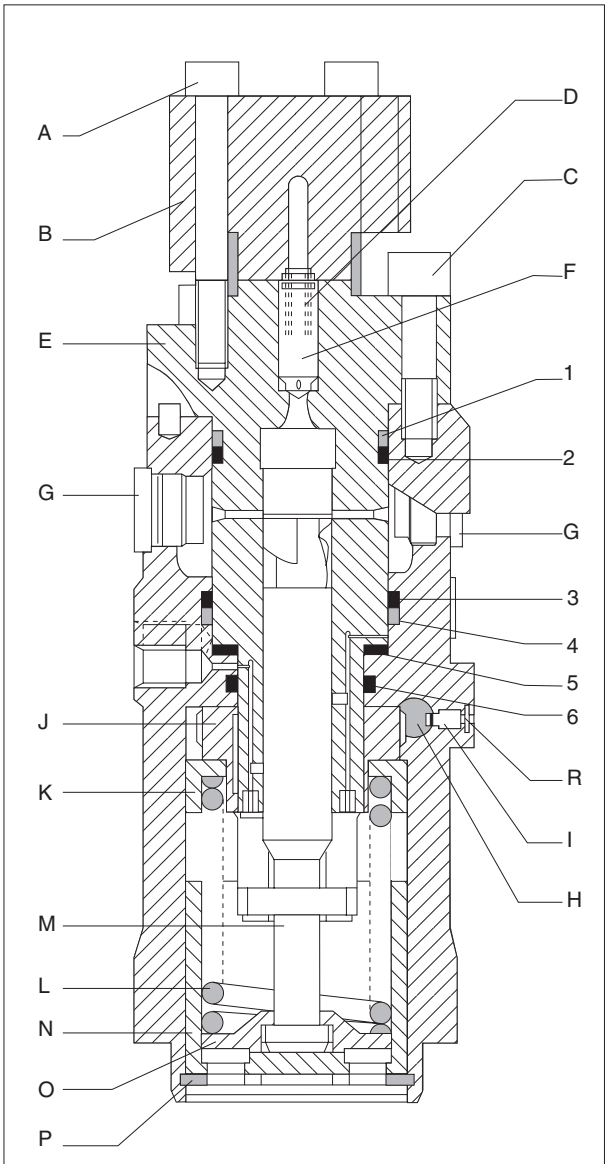
4. Remove the screws in the bottom flange (4 pieces) and take the fuel injection pump away.

Separation of fuel injection pump.

5. If necessary, clean the exterior of the injection pump.

6. Mount the injection pump in the clamping bracket PYO-W020 (see plate 62014 item 03), on the test pump.

7. Press the thrust cap (N) fig. 2 downwards and remove the securing ring (P). Remove the thrust cap (N) with lower spring plate (O) and plunger (M). **Be sure not to damage the plunger.**



1. Back-up ring (spirally coiled)
2. O-ring inside dia. 45.7 mm x 2.6
3. O-ring inside dia. 51.4 mm x 3.1
4. Back-up ring
5. O-ring inside dia. 41.7 mm x 3.5
6. O-ring inside dia. 37.2 mm x 3

Fig. 2 Cross Section of Fuel Injection Pump

8. Take out the plunger spring (L), upper spring plate (K) and pinion (J). If necessary remove the lock ring (R) and guide pin (I) and dismount the regulating rod (H) as well as the cap screw in the opposite end of the regulating rod (H).

9. Unscrew the four screws (A) and remove the connecting piece (B). Take out the valve spring (D) and the non-return valve (F).

10. Loosen and remove the four screws (C) and take out the barrel (E).

11. Remove all the O-rings and back-up rings from the injection pump.

12. All parts must be cleaned, using kerosene or gas oil and a hand brush (not a steel brush).
Blow through the holes for sealing oil in the pump houses and the barrel (E).

Inspection of fuel injection pump:

13. Insert plunger (M) and non-return valve (F) into the barrel (E) after wetting with clean gas oil. Plunger and non-return valve must slide into the barrel by their own weight.

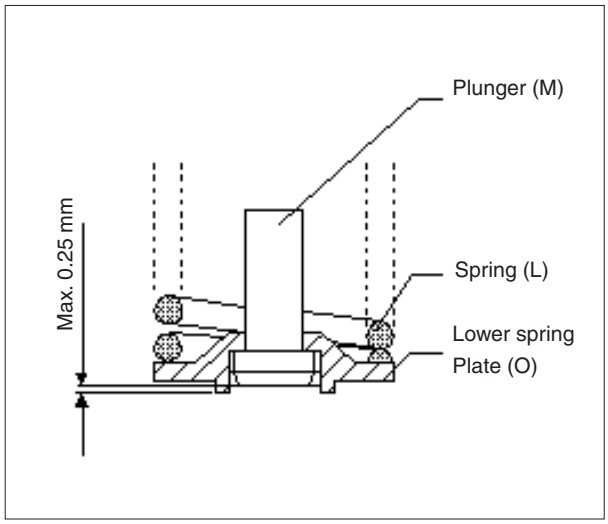


Fig. 3 Clearance between Lower Spring Plate and Plunger

14. The axial clearance between lower spring plate and plunger foot must not exceed 0.25 mm. The clearance between lower spring plate and plunger foot is 0.05 to 0.1 mm when new. See fig. 3.

15. Check the cavitation plugs (G) for wear and renew if necessary.

16. Barrel (E), plunger (M) and non-return valve (F) are manufactured to very close tolerances.
Any attempt to refinish these parts causes alterations of the tolerances and must therefore **NOT** be carried out.
If during the visual inspection of the parts, heavy abrasion symptoms or damage can be observed, the part in question must be replaced.

Assembling of fuel injection pump:

17. When assembling the injection pump, proceed in the reverse order to disassembling. Pay attention to the following:

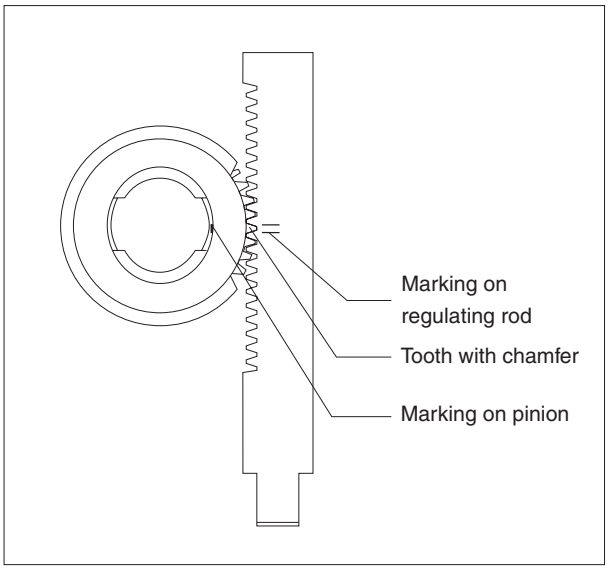


Fig. 4 Mounting of Regulating Rod Mechanism

A. At initial tightening up of new parts the following (C) for barrel (E).
Tighten screws to 90 Nm, loosen and tighten again to 90 Nm and then tighten to 90 Nm + 10 Nm.
Employ the same procedure when tightening the other pump components for the first time.

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B. Renew all sealing and back-up rings. For placing of the rings, see fig. 1.

C. Coat all the threads with an anti seize product.

D. Wipe dry with paper plane sealing surface on barrel (E) and connecting piece (B).

E. Before inserting the pinion (J), the easy motion of the plunger (M) in the barrel (E) must be checked.

F. When assembling the pinion (J), ascertain that the tooth (recognizable by the chamfer) will enter the space of the regulating rod (H) marked by two sings, see fig. 4.

G. The marking on the guide cam of the plunger (M), must be in line with the marking in the slots of the pinion (J). (Not shown on fig. 4).

18. After assembling, the easy motion of the regulating rod (H), must be checked and the plunger (M) must be moved from the no-load stop to full-load stop.

Mounting of fuel injection pump:

19. Before mounting the fuel injection pump, clean the roller guide spring and washer for spring in the roller guide housing.

20. Reconnect the regulating rod (H) to the spring loaded lever and all the pipes to the fuel pump.

Fuel injection pipe:

By normal working conditions the fuel injection pipe require very little maintenance except replacement of O-rings and gasket in connection with the normal overhaul of fuel injection equipment. (See also description of fuel injection pipe page 614.10).

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Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- □ Stopped lub. oil circul.

Description:

Dismounting, overhaul, pressure testing and mounting of fuel injection valve.

Starting position:

Top cover on the cylinder head and front cover on the fuel injection pump have been dismounted. For dismounting of fuel injection pipe, see working card 614-01.05.

Related procedure:

Man power:

Working time	:	2	hours
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no	Item no	Note
62006	26	20-120 Nm
62014	01	
62014	10	
62014	15	
62014	30	Extra tools
62014	35	
62014	40	

Hand tools:

Ring and open end spanner	12 mm
Ring and open end spanner	24 mm
Socket spanner	24 mm
Socket spanner	30 mm

Tools for cleaning.
Clean kerosene or gas oil.
Antiseize product.
(Copaslip, Molykote GN Plus or similar).

Replacement and wearing parts:

Plate no	Item no	Qty. /
61402	04	2/C
61402	05	1/C
61402	12	1/C

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The fuel injection valve is the one component that has the greatest influence on the diesel engine condition.

Various operation forms the fuel oil and quality affect the overhaul intervals. In some cases it may be necessary to shorten the prescribed overhaul inter-vals.

Dismounting and cleaning:

1. Dismount the fuel injection valve from the cylinder head by means of the special tool as shown in fig 1.

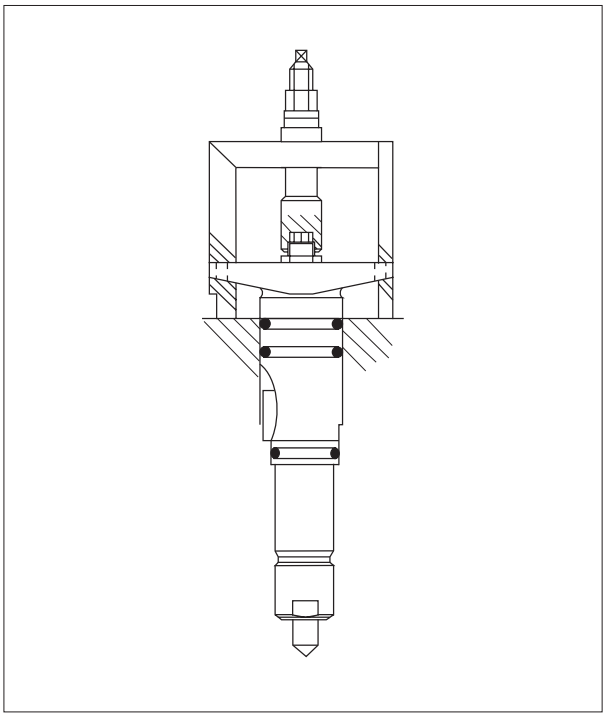


Fig 1 Dismounting of fuel injection valve from cylinder head.

2. Mount the fuel injection valve into the clamping bracket VTO-W022 (see plate 62014, item 02) on the pressure testing pump, and loosen the lock nut (B) fig 2.

Unstress the nozzle spring by turning the adjusting screw (D).

3. Clean the lower part of the nozzle (J) of carbonized oil deposits before dismantling the nozzle nut (H).

Attention!
Do not damage the lapped surfaces, when removing the nozzle nut (H) and the nozzle (J).

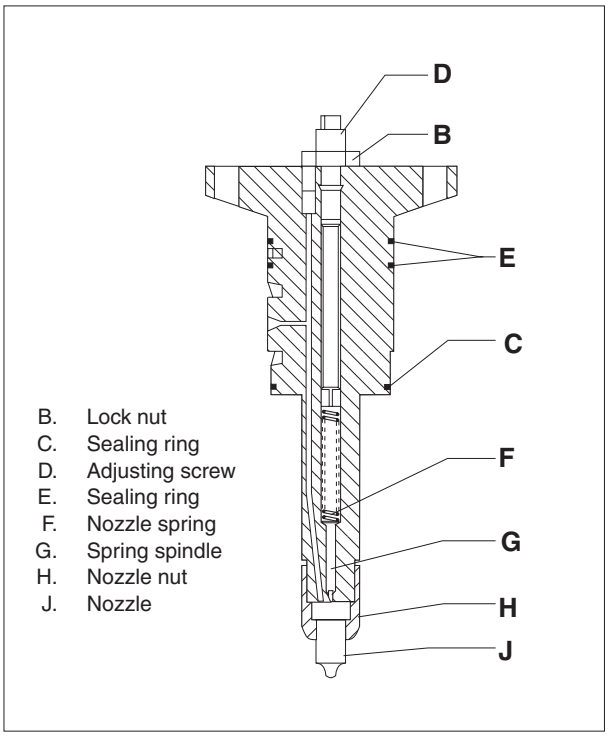


Fig 2 Fuel injection valve.

4. The nozzle spring (F) and the spring spindle (G) are to be taken out by unscrewing the adjusting screw (D) completely.

5. Clean all parts with kerosene or gas oil and with a hard brush (not a steel brush).

6. Clean the nozzle holes of charred coke by means of the supplied special drill with holder.

7. Clean the cooling chamber and the cooling ducts in the nozzle guide and injector body.

Place them in a cleaning liquid and then blow through the parts with working air.

Inspection of the parts:

The nozzle body and needle are matched by lapping and are therefore only interchangeable as units.

8. Insert the nozzle needle with gas oil in the needle guide. It must be controlled whether the nozzle needle slides down by its dead weight on its seat.

9. Check if the holes in the nozzle are worn oval.

This is done by means of a magnifying glass.

WHEN the nozzle holes..	THEN
are worn oval	Scrap the nozzles
are not worn oval	Re-use the nozzles

The best way, however, to check if the holes are worn out is to control the flow rate of the nozzle which, in general, only can be made by MAN B&W Holeby.

10. Replace parts with heavy abrasion symptoms, respectively damages, which were observed at the visual inspection of the parts.

Every effort to refinish will result in alterations of these values and malfunction of the nozzle.

If heavy abrasion symptoms, respectively damages are observed at the visual inspection of the parts, the parts in question must be replaced.

Reassembling:

When all parts have been carefully cleaned, inspected and overhauled and found in good order, then assemble the fuel injection valve.

When assembling the injection valve, proceed in the opposite order compared to the disassembly.

Pay attention to the following:

11. Lubricate the threads on the adjusting screw (D) with lub. oil, and the threads of the nozzle holder for the nozzle nut.

12. Lubricate the shoulder of the nozzle which is in contact with the nozzle nut with an antiseize product.

13. Wipe the plane sealing surface of body and nozzle dry with paper.

14. Renew the sealing rings (C) and (E).

Tightening torque for nozzle nut, see page 600.40.

Pressure testing of fuel injection valve:

The most effective checking of the fuel valves is obtained through pressure testing, preferably carried out after each overhaul and also in case of irregularities in operation.

The pressure testing is carried out in the following way by means of the pressure testing apparatus supplied.

15. Mount the fuel injection valve in the bracket VTO-W022. The bracket must be in such a position that the nozzle of the injector is pointing downwards.

IF	THEN
the engine is mounted with cooling oil system	mount the test pipe VWM-W007 (see plate 62014, item 05) on to the bracket for test of the cooling oil system. Increase the pressure by using the lever on the test pump. Apply pressure to the cooling oil system, (see data page 600.35) after venting. Check the sealing tightness of the O-rings.

16. Mount the test pipe VTO-W023 (see plate 62014, item 04) for test of the injection pressure and atomizing.

L+V28/32H

17. Adjust the opening pressure to 320 bar by means of the adjusting screw (D), see fig 2, then tighten the lock nut (B).

18. Check opening pressure again.

Do not expect chattering, but make sure that the nozzle spray from all holes is in the same angle. The nozzle might chatter if the lever is worked very fast, actually by hitting it.

Do not expect a nozzle tip with more than 1000 running hours to perform like a new nozzle in the test pump.

19. Increase the pressure to 300 bar and keep the pressure by working the lever slowly downwards.

When the pressure is kept at 300 bar, there should be no more than one drip from the nozzle tip for approx. 3-5 sec.

WARNING:

Keep out of the fuel jets as they will penetrate the skin. Fuel which has penetrated the skin can cause painful inflammations (blood poisoning).

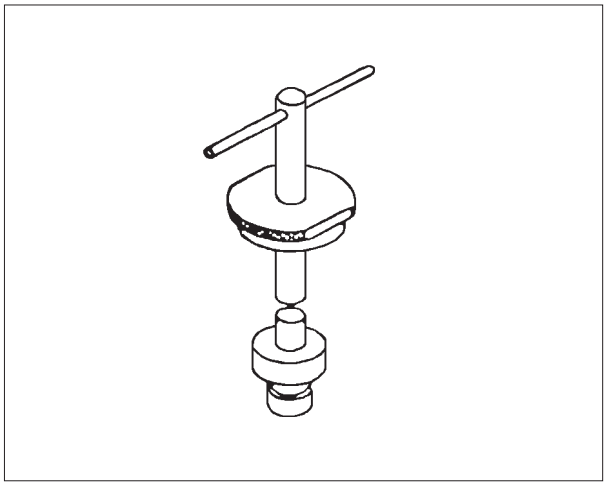


Fig 3 Grinding tools for seat for fuel and liner i njection valve.

Mounting of the fuel injection valve in the cylinder head:

20. Clean and inspect the valve bore in the cylinder head before mounting the fuel valve.

21. Grind the seating face, if necessary, with the grinding tool (see fig 3).

22. Coat the O-rings and the lower part of the valve with an anti seize product and place the valve in the cylinder head, and press it down to the seat.

23. Mount the high pressure pipe before tightening the nuts. Then it is easier to fit the threads.

24. Put on the distance pieces, fit the nuts and tighten up with a torque spanner (for torque moment, see page 600.40).

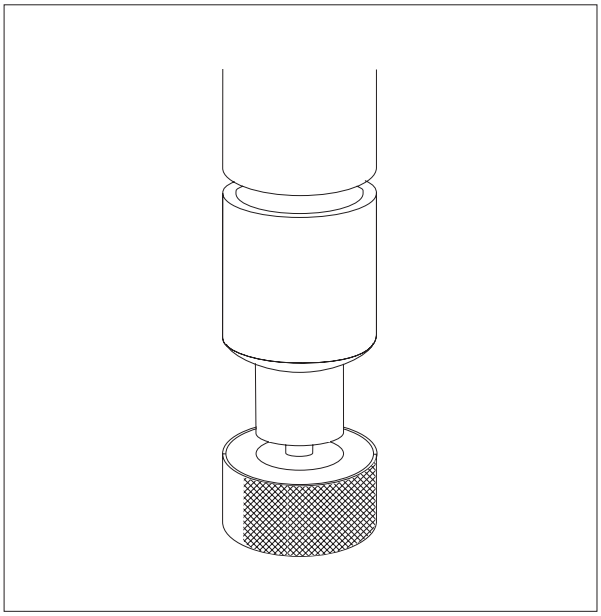


Fig 4 Grinding tools for fuel injection valve (extra tools).

Working Card Page 1 (2)	Fuel Oil Split Filter	614-01.15 Edition 01H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- ■ Shut-off fuel oil
- □ Shut-off cooling oil
- □ Stopped lub. oil circul.

Description:

Disassembly, cleaning and assembly of fuel oil split filter.

Starting position:

Related procedure:

Man power:

Working time : 1/2 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Ring and open end spanner, 13 mm.
Ring and open end spanner, 17 mm.
Kerosene, gas oil or similar.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

General

1) During normal operation both filters should be in operation, single operation only to be used when dismantling one of the filters for manual cleaning or inspection.

2) Normally the filters are cleaned during operation by turning the handle, (1) see fig. 1, on the filter housing top a couple of turns. (clockwise).

Simultaneously with turning of the handle, the drain cock, (2) in bottom of the filter housing should be opened in order to drain of the dirt being scraped of the filter element, (3).

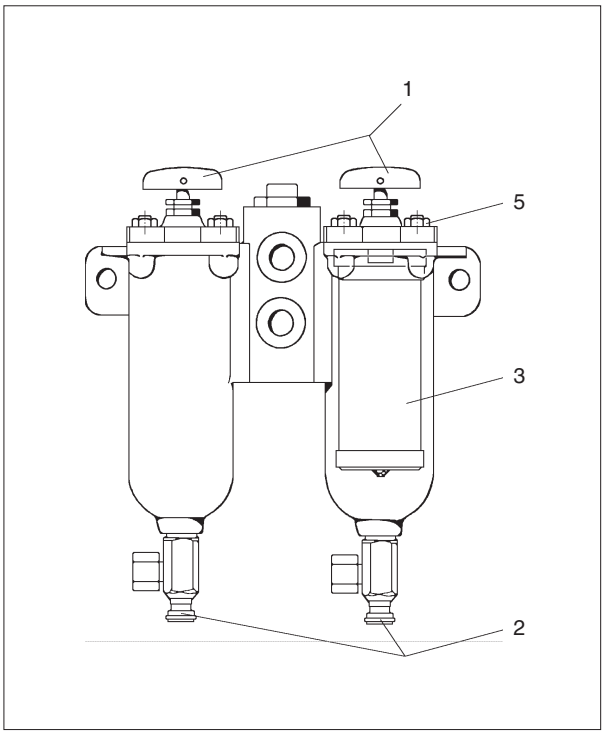


Fig. 1. Fuel oil split filter

3) Position of three way cock, see fig. 2.

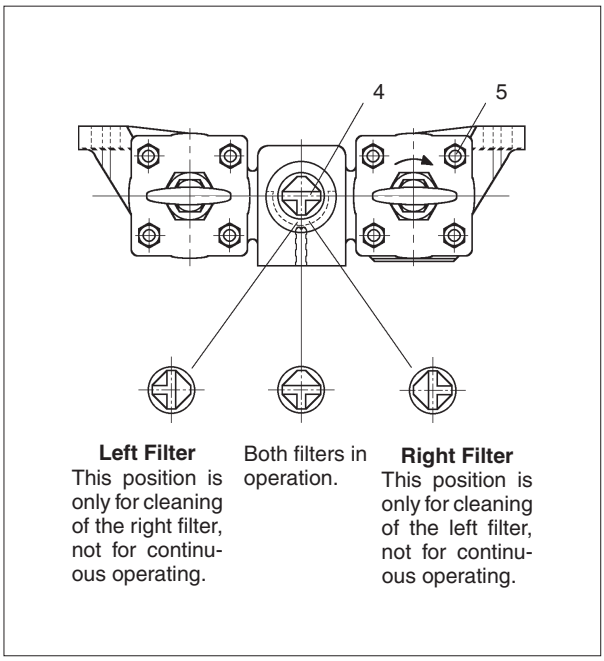


Fig. 2. Fuel oil split filter (top view).

Note: Shut-off fuel oil, before dismantling filter element.

4) If no drainage occurs when the drain cock is opened, the filter housing should be dismantled for manual cleaning. Remove the nuts (5), and take out the filter element (3).

5) Clean the filter element in kerosene gas oil or similar and blow it dry with working air.

6) Mount the filter element again.

7) The filter element itself should never be dismantled, but has to be replaced if damage or mal function is experienced.

Working Card Page 1 (2)	Check of Fuel Oil Piping System	614-01.90 Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Check of fuel oil piping system.

Starting position:

Engine is running.

Related procedure:

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Man power:

Working time: ½ hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

General

Fuel Oil System

1) Dismount the covers to the injection pumps. Blow-through drain pipes.

2) Examine the piping system for leaks.

3) Retighten all bolts and nuts in the piping system.

4) Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.

5) Check flexible connections for leaks and damages.

6) Check the condition of the lower O-ring for the fuel injecting valves by means of the venting pipe.

For fuel oil condition, see section 604.

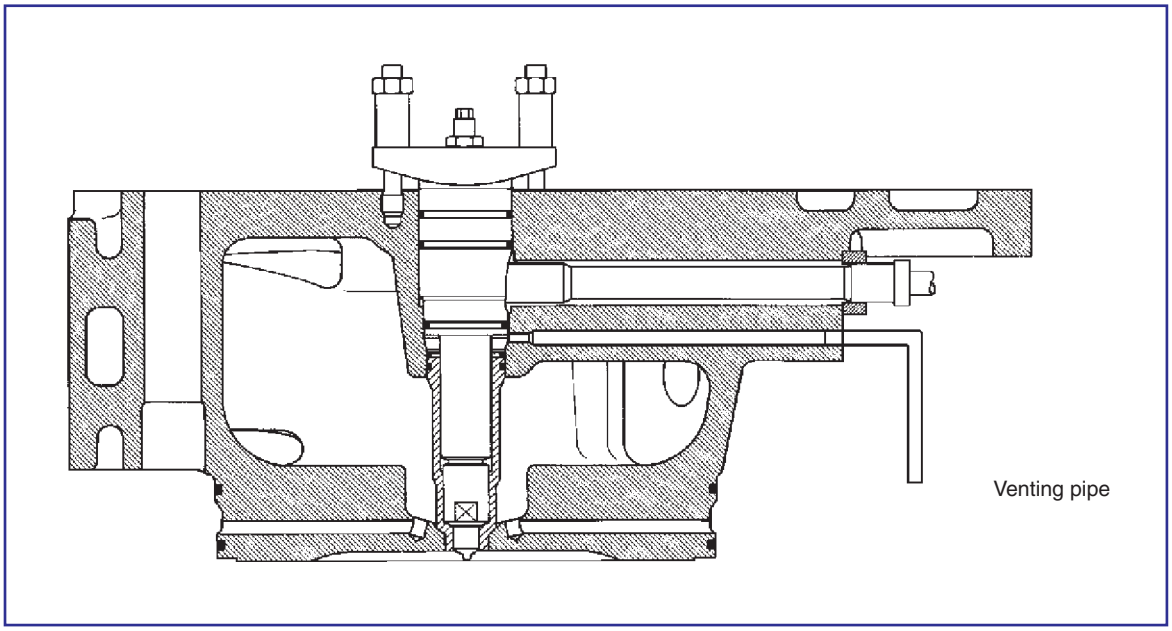


Fig. 1. Cross section of cylinder head

Working Card Page 1 (3)	Adjustment of The Maximum Combustion Pressure	614-05.01 Edition 02H

General

Safety precautions:

- [x] Stopped engine
- [x] Shut-off starting air
- [ ] Shut-off cooling water
- [ ] Shut-off fuel oil
- [ ] Shut-off cooling oil
- [x] Stopped lub. oil circul.

Description:

Adjustment of the maximum combustion pressure for the cylinders one by one and for all cylinders in total.

Starting position:

Camshaft mounted and adjusted in relation to the crankshaft (lead), 607-01.20
Intermediate wheel mounted.

Related procedure:

Man power:

Working time : 2-5 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	26	20 - 120 Nm.
62010	01	
62008	05	

Hand tools:

Ring and open end spanner, 19 mm.
Socket spanner, 19 mm.
Depth gauge.
Plastic hammer.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
60801	23	1 set/cyl.

General

If fuel oil valve, piston, inlet and exhaust valves as well as turbocharger and charge air cooler are working correct and the compression pressure P_{comp} is normal the maximum combustion pressure will indicate the injection timing for the fuel oil pump.

If P_{max} is too low it indicates that the injection timing is delayed.

If P_{max} is too high it indicates that the injection timing is advanced.

The injection timing can be altered by inserting or removing shims under the thrust piece on the roller guide, thus changing the measure “X”, see fig. 1.

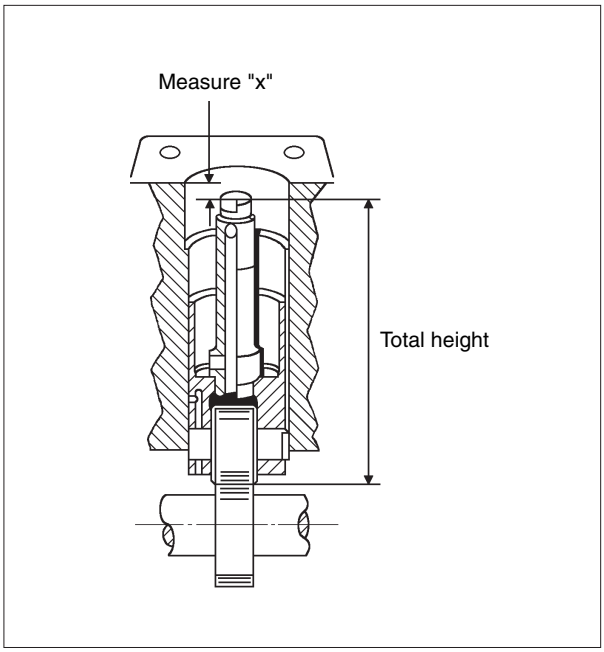


Fig. 1.

Thinner and/or fewer shims (increase of the distance “X”) results in a delayed injection timing and a lower P_{max}.

Thicker and/or more shims (reduction of the distance “X”) results in an advanced injection timing and a higher P_{max}.

If the distance “X” is to be changed the trigger (1) is used for dismantling of the thrust piece (2), whereafter the thickness and/or the number of shims (3) can be changed.

By changing “X” with 0.10 mm the maximum combustion pressure is changed with - see page 600.35.

After replacement of shims the thrust piece is remounted in the roller guide (4) with a soft hammer (5).

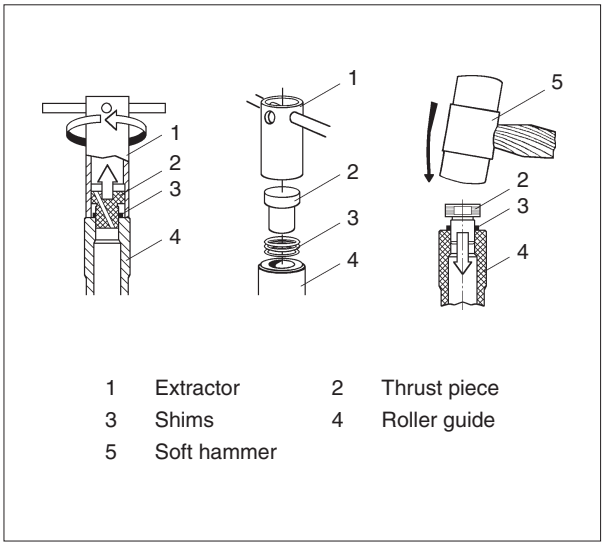


Fig. 3.

Action	Results		
Total height on roller guide	Distance "x"	Injection timing	Max. combustion pressure
increased ↑	Reduced ↓	Advanced ↑	increased ↑
Reduced ↓	increased ↑	Delayed ↓	Reduced ↓

Fig. 2.

General

When changing “X” it must be ensured that the distance between the upper edge of the roller guide housing and the thrust piece on the roller guide is not exceeded, when the roller is resting on the circular part of the fuel cam, see page 600.35.

In all cases “X” must be checked and adjusted, if necessary, when fuel oil pump, roller guide, roller guide housing and/or camshaft section have been replaced/dismantled.

Note: If several fuel oil pumps, roller guides, roller guide housings and/or camshaft sections are dismantled at the same time it is advisable to number the parts in order to facilitate remounting and adjustment.

If the maximum combustion pressure differs from the test bed records after adjustment of each individual pump the camshafts placement can be changed, as the camshafts gear wheels are provided with oblonged holes so that they can be turned in relation to the hub.

The gear wheel is provided with an engraved scale, see fig. 4, and the hub of the cam shaft is provided with a mark.

When the screws, which fasten the gear wheel, are loosened the gear wheel is turned (by turning the crankshaft) in relation to the camshaft. By reading the angle in which the gear wheel is displaced in relation to the camshaft the altered P_{max} can be calculated. A line on the scale corresponds to: see page 600.35.

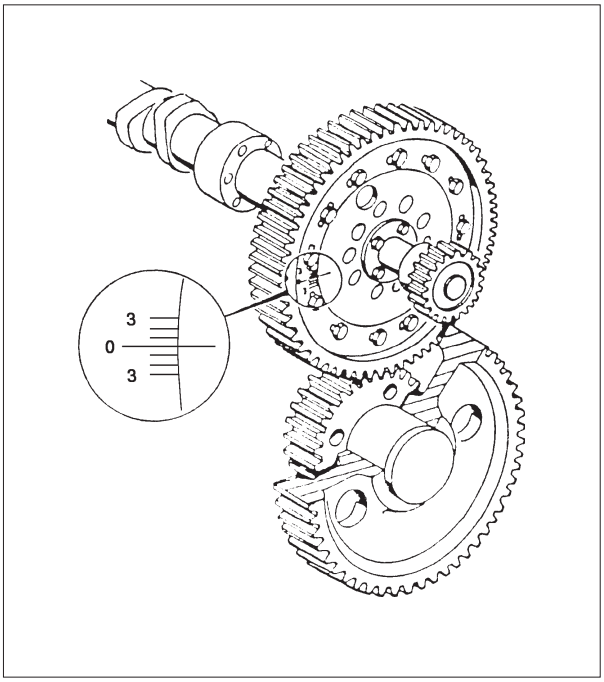


Fig. 4.

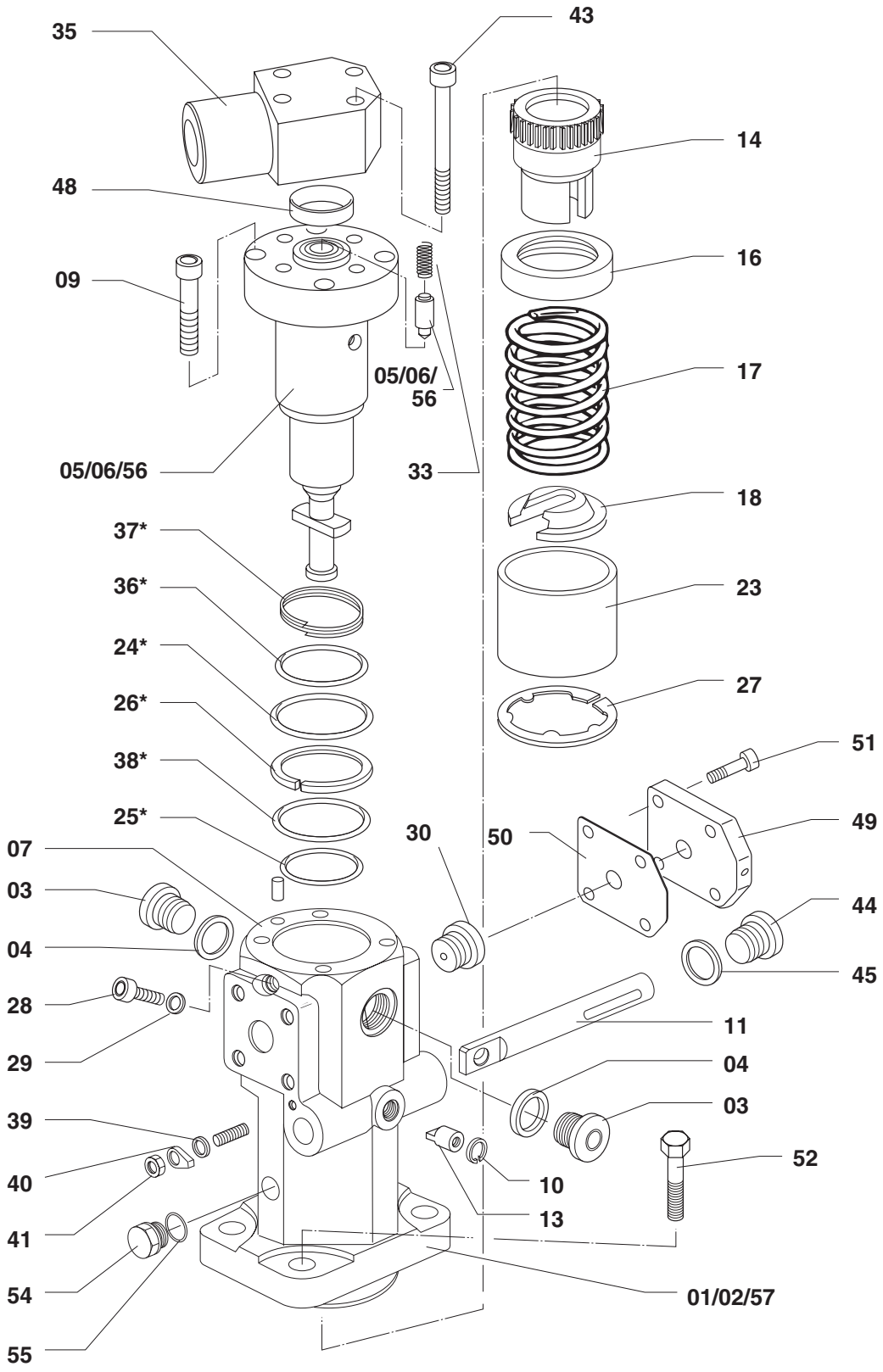
If the crankshaft is turned in the engines normal direction of rotation the maximum combustion pressure $P\text{-}_{max.}$ is reduced.

If the crankshaft is turned against the engines normal direction of rotation the maximum combustion pressure $P\text{-}_{max.}$ is increased.

After the adjustment the screws are fastened with a torque wrench, see page 600.40, and secured.

Plate Page 1 (2)	Fuel Injection Pump	61401-03H

L/V28/32H



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L/V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/C	**Fuel injection pump, complete (MDO)**	Fuel indsprøjtnings-pumpe, komplet, MDO
02	1/C	**Fuel injection pump, complete (HFO)**	Fuel indsprøjtnings-pumpe, komplet, HFO
03	2/P	**Shock screw**	Stødskrue
04	2/P	**Joint washer**	Pakning
05	1/P	**Plunger and barrel, incl. non-return valve (MDO)**	Stempel og cylinder inkl. kontraventil (MDO)
06	1/P	**Plunger and barrel, incl. non-return valve (HFO)**	Stempel og cylinder inkl. kontraventil (HFO)
07	1/P	**Pump housing witout IMO number and classification**	Pumpehus uden IMO nummer og klassifikation
09	4/P	**Screw**	Skrue
10	1/P	**Lock washer**	Låseskive
11	1/P	**Regulating rod**	Reguleringstandstang
13	1/P	**Locating bolt**	Styrebolt
14	1/P	**Pinion**	Tanddrev
16	1/P	**Upper spring plate**	Øverste fjederplade
17	1/P	**Spring**	Fjeder
18	1/P	**Lower spring plate**	Nederste fjederplade
23	1/P	**Thrust cap**	Trykhætte
24*	1/P	**O-ring**	O-ring
25*	1/P	**O-ring**	O-ring
26*	1/P	**Back-up ring**	Støttering
27	1/P	**Circlip**	Låsering
28	1/P	**Screw**	Skrue
29	1/P	**Joint washer**	Pakning
30	1/P	**Throttle screw**	Drosselskrue
33	1/P	**Non-return valve spring**	Kontraventilfjeder
35	1/P	**Connecting piece**	Forbindelsesstykke
36*	1/P	**O-ring**	O-ring
37*	1/P	**Back-up ring**	Støttering
38*	1/P	**O-ring**	O-ring
39	3/P	**Disc**	Skive
40	1/P	**Pointer**	Viser
41	1/P	**Nut**	Møtrik
43	4/P	**Screw**	Skrue
44	1/P	**Cap screw**	Hætteskrue
45	1/P	**Joint washer**	Pakning
48	1/P	**Ring**	Ring
49	1/P	**Flange**	Flange
50	1/P	**Gasket**	Pakning
51	4/P	**Screw**	Skrue
52	4/P	**Screw f. mounting**	Skrue f. montering
53	1/P	**Kit comprising item 24, 25, 26, 36, 37, 38**	Sæt bestående af item 24, 25, 26, 36, 37, 38
54	1/P	**Plug screw**	Propskrue
55	1/P	**Gasket**	Pakning
56	1/P	**Plunger and barrel, incl. non-return valve (Low sulphur fuel, WC/C)**	Stempel og cylinder inkl. kontraventil (Svovlfattig brændstof, WC/C)
57	1/C	**Fuel injection pump, complete (Low sulphur fuel, WC/C)**	Fuel indsprøjtnings-pumpe, komplet (Svovlfattig brændstof, WC/C)

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./P = Qty./Pump
Qty./C = Qty./Cylinder.

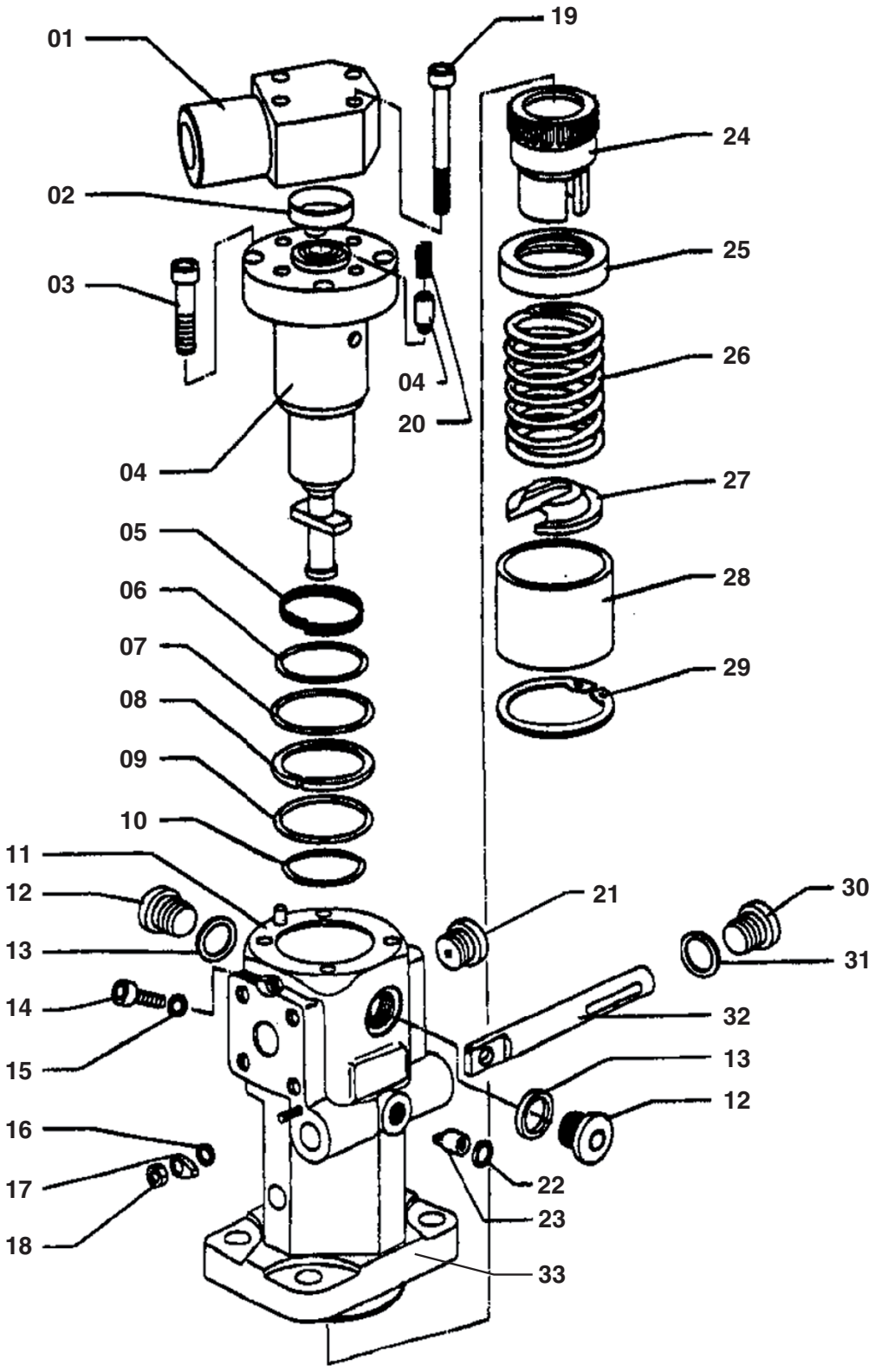
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./P = Qty./Pump
Qty./C = Qty./Cylinder.

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Fuel Injection Pump	61401-09H

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Case : Delivery valve**	Hus for ventil
02	1/P	**Ring**	Ring
03	4/P	**Bolt**	Bolt
04	1/P	**Plunger, complete**	Stempel, komplet
05	1/P	**Back-up ring**	Støttering
06	1/P	**O-ring**	O-ring
07	1/P	**O-ring**	O-ring
08	1/P	**Back-up ring**	Støttering
09	1/P	**O-ring**	O-ring
10	1/P	**O-ring**	O-ring
11	1/P	**Housing, complete**	Hus, komplet
12	2/P	**Deflector**	Deflektor
13	2/P	**Gasket**	Pakning
14	1/P	**Bolt**	Bolt
15	1/P	**Gasket**	Pakning
16	1/P	**Washer**	Skive
17	1/P	**Pointer**	Viser
18	1/P	**Nut**	Møtrik
19	4/P	**Bolt**	Bolt
20	1/P	**Spring: Delivery valve**	Fjeder
21	1/P	**Plug**	Prop
22	1/P	**Snap ring**	Låsering
23	1/P	**Rack stopper**	Stop for tandstang
24	1/P	**Control sleeve**	Kontrolbøsning
25	4/P	**Spring seat**	Fjederplade (øverste)
26	1/P	**Spring: Plunger**	Fjeder
27	1/P	**Spring seat**	Fjederplade (nederste)
28	1/P	**Guide: Plunger**	Styr
29	1/P	**Snap ring**	Låsering
30	1/P	**Plug**	Prop
31	1/P	**Gasket**	Pakning
32	1/P	**Control rack**	Reguleringstandstang
33	1/C	**Fuel injection pump, complete**	Brændselspumpe, komplete

When ordering spare parts, see also page 500.50.

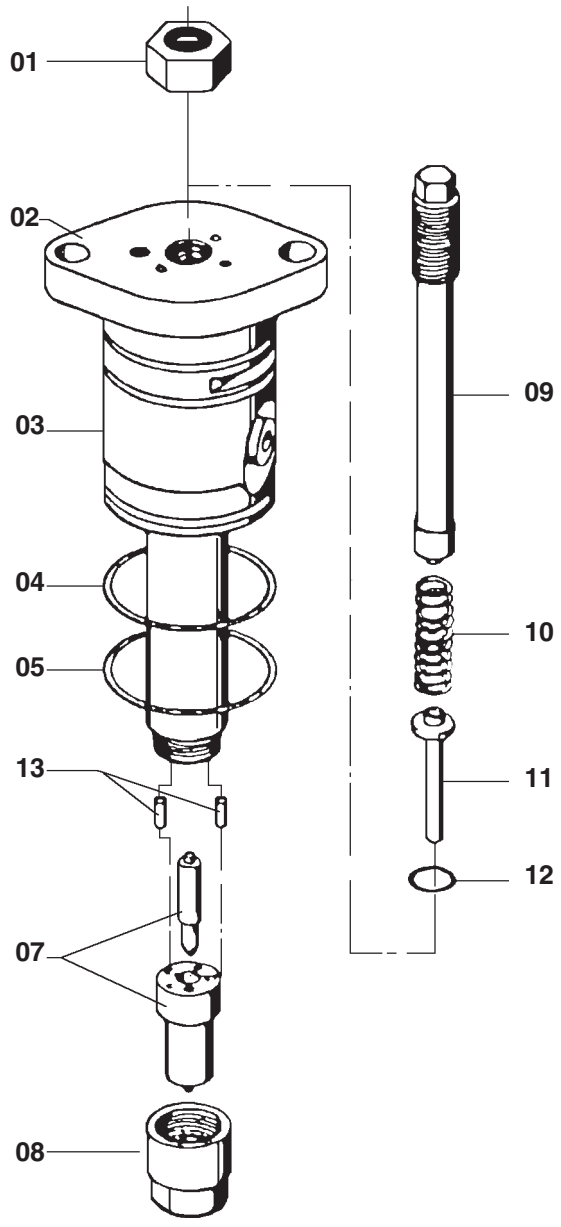
*** = Only available as part of a spare parts kit.**
Qty./P = Qty./Pump
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 500.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/P = Antal/Pumpe
Antal/C = Antal/Cylinder

Plate Page 1 (2)	**Fuel Injection Valve**	**61402-04H**

L/V28/32H



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L/V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/V	**Lock nut**	Låsemøtrik
02	1/C	**Fuel injection valve, complete**	Brændselsventii, komplet
03	1/V	**Injector housing**	Ventilhus
04	2/V	**O-ring**	O-ring
05	1/V	**O-ring**	O-ring
07	1/V	**Nozzle, complete**	Forstøver, komplet
08	1/V	**Screw cap**	Omløber
09	1/V	**Adjusting screw**	Justeringsskrue
10	1/V	**Spring**	Fjeder
11	1/V	**Thrust spindle**	Trykspindel
12	1/V	**O-ring**	O-ring
13	2/V	**Dowel pin**	Styrestift

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

* = Only available as part of a spare parts kit.
Qty./V = Qty./Valve
Qty./C = Qty./Cylinder.

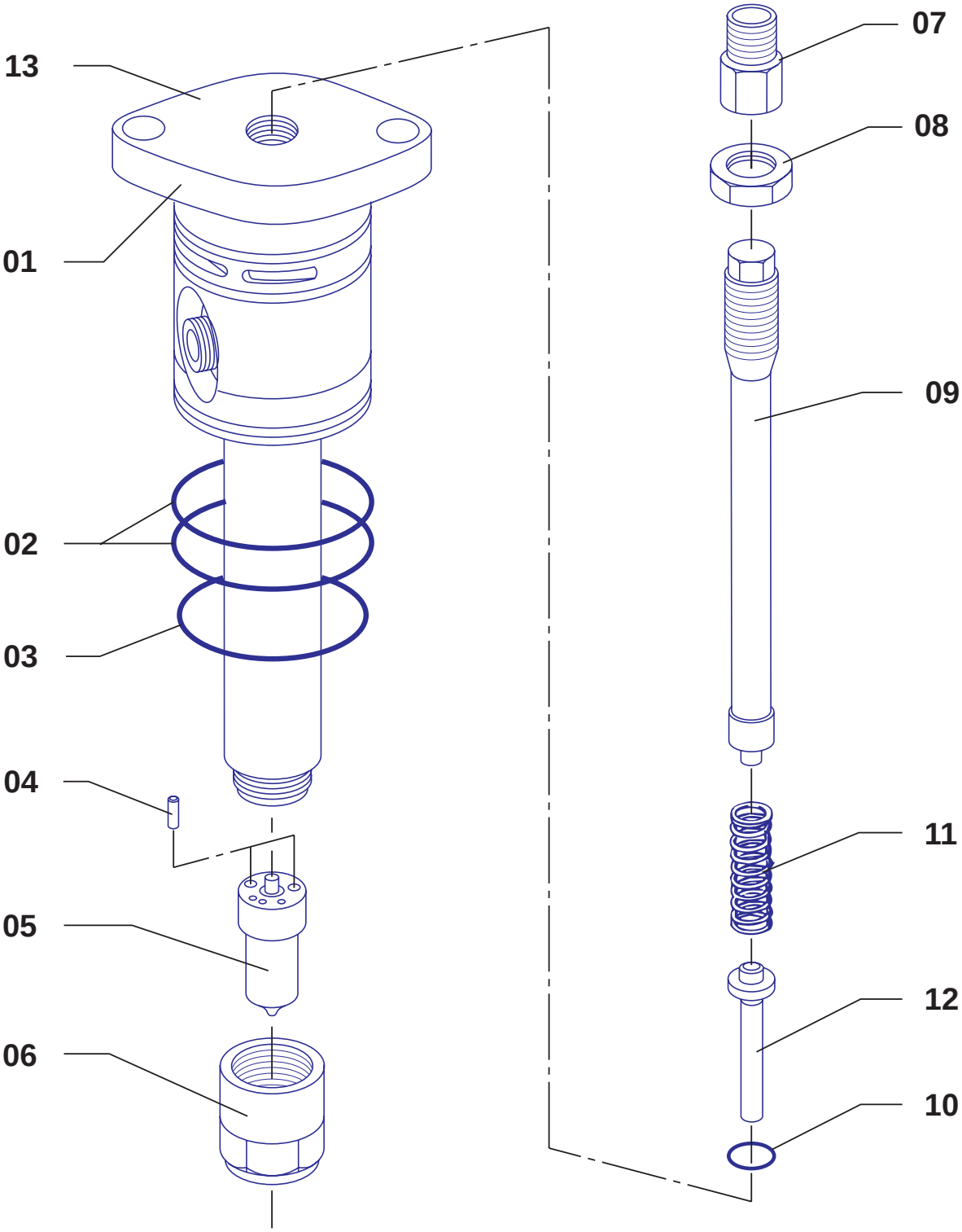
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./V = Qty./Ventil
Qty./C = Qty./Cylinder.

08028-0D/H5250/94.08.12

Plate Page 1 (2)	Fuel Injection Valve, Cooled - NICO	61402-07H

L+V28/32H



08028-0D/H5250/94.08.12

61402-07H	Fuel Injection Valve, Cooled - NICO	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/V	**Injector body**	Brændstofsventil
02	2/V	**O-ring**	O-ring
03	1/V	**O-ring**	O-ring
04	2/V	**Dowel pin**	Styrestift
05	1/V	**Atomized, complete**	Forstøver, komplet
06	1/V	**Nozzle nut**	Forstøver
07	1/V	**Cap nut**	Omløber
08	1/V	**Nut**	Møtrik
09	1/V	**Adjusting screw**	Justeringsskrue
10	1/V	**O-ring**	O-ring
11	1/V	**Spring**	Fjeder
12	1/V	**Spindle**	Spindel
13	1/V	**Fuel injection valve, complete**	Brændstofsventil, komplet

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 500.50.

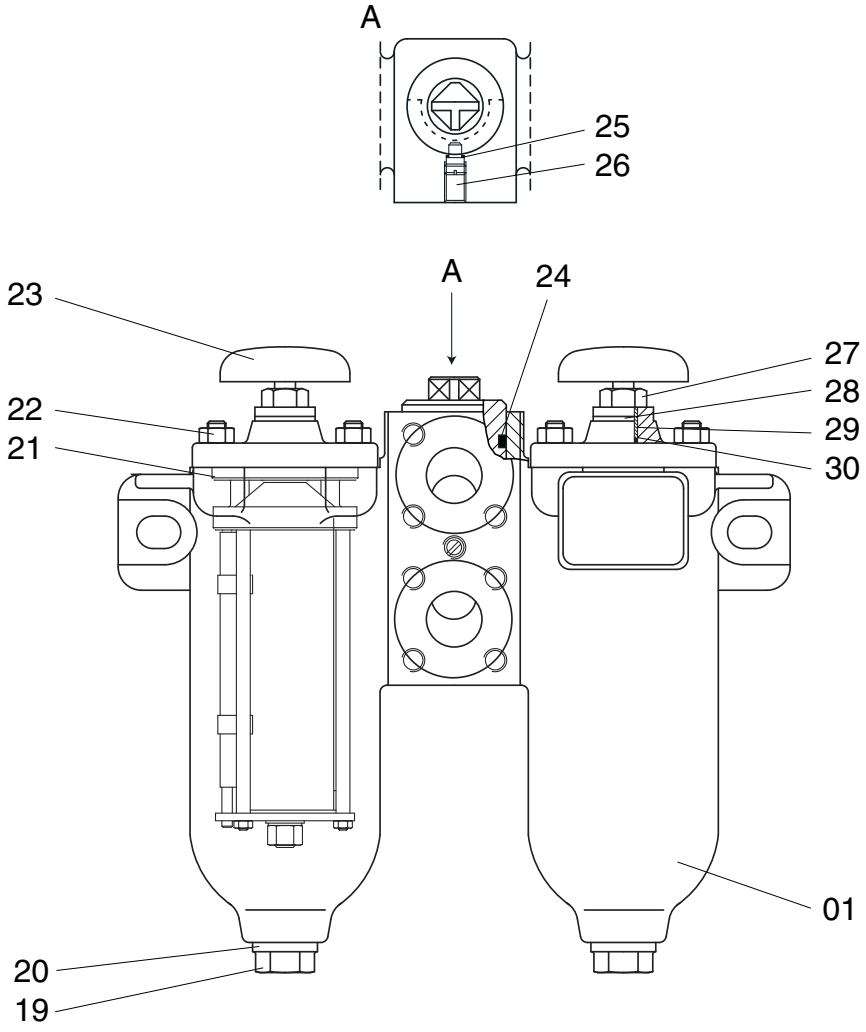
*** = Only available as part of a spare parts kit.**
Qty./V = Qty./Valve
Qty./C = Qty./Cylinder.

Ved bestilling af reservedele, se også side 500.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./V = Qty./Ventil
Qty./C = Qty./Cylinder.

Plate Page 1 (2)	Fuel Oil Filter Duplex	61403-15H

L+V28/32H



L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Fuel oil filter duplex, complete**	Brændselsoliespalte-filter, komplet
19	2/F	**Lock screw**	Låseskrue
20	2/F	**Gasket**	Pakning
21	2/F	**O-ring**	O-ring
22	4/F	**Nut**	Møtrik
23	2/F	**Filter element**	Filterelement
24	1/F	**O-ring**	O-ring
25	1/F	**Gasket**	Pakning
26	1/F	**Fixing screw**	Fastspændingsskrue
27	2/F	**Lock screw**	Låseskrue
28	2/F	**Gasket**	Pakning
29	2/F	**Bushing**	Bøsning
30	2/F	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

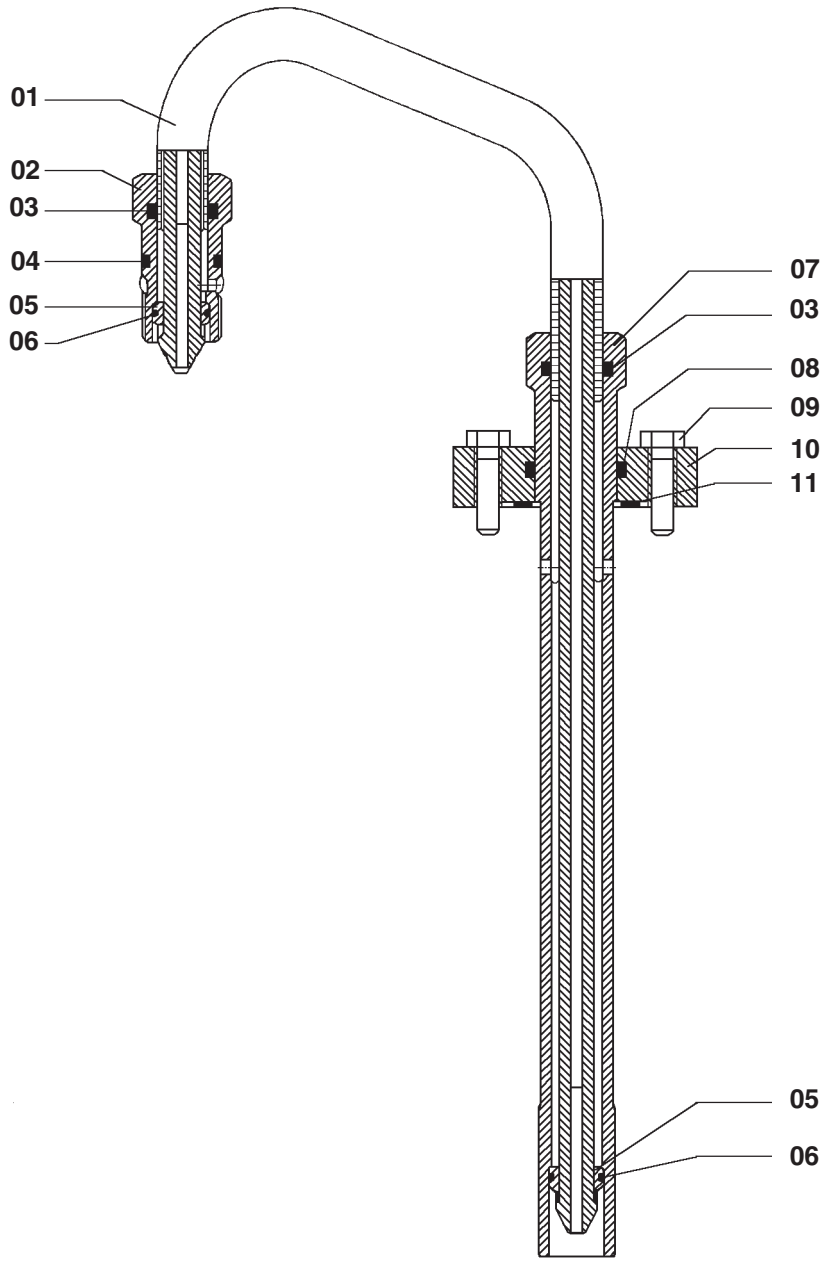
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./F = Qty./Filter

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Engine.
Qty./F = Qty./Filter.

Plate Page 1 (2)	Fuel Injection Pipe	61404-06H

L/V28/32H



L/V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/C	**Fuel oil high-pressure pipe, complete**	Højtryksrør, komplet
02	1/H	**Screwed socket**	Gevinmuffe
03	2/H	**O-ring**	O-ring
04	1/H	**O-ring**	O-ring
05	2/H	**Sleeve devided**	Bøsning 2-delt
06	2/H	**Round wire exp. ring**	Låsefjeder
07	1/H	**Sleeve**	Styrebøsning
08	1/H	**O-ring**	O-ring
09	2/H	**Screw**	Skrue
10	1/H	**Flange**	Flange
11	1/H	**Sealing ring**	Tætningsring

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

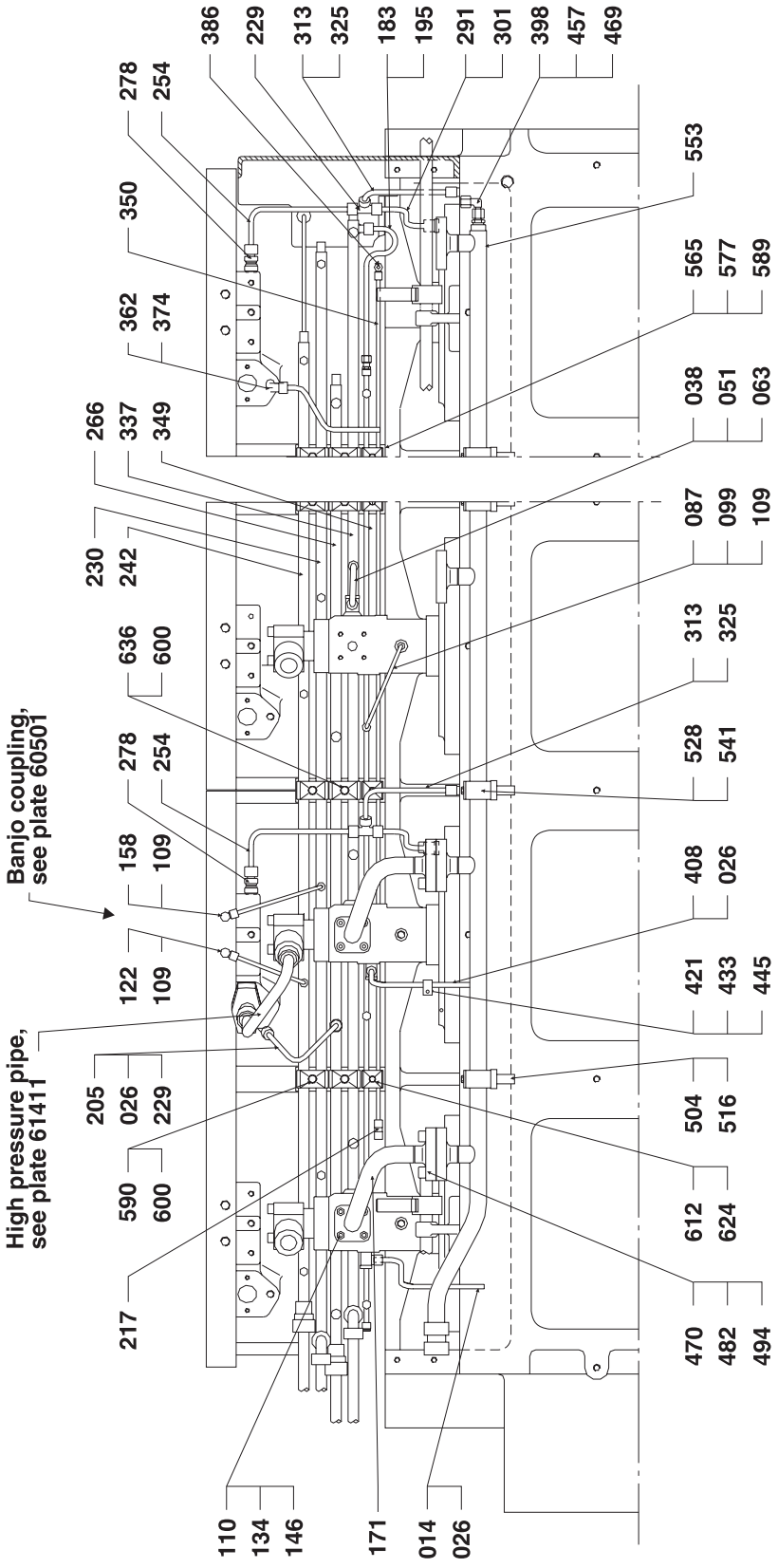
Ved bestilling af reservedele, se også side 600.50.

Item Nos. marked with * are only available as part of a spare parts kit.
Qty./H = Qty./High pressure pipe.
Qty./C = Qty./Cylinder.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./H = Qty./Højtryksrør.
Qty./C = Qty./Cylinder.

Plate Page 1 (3)	Pipes on Cylinder Section Forced Lubrication with Cooling Oil Pipes	61430-03H

L28/32H



61430-03H	Pipes on Cylinder Section Forced Lubrication with Cooling Oil Pipes	Plate Page 2 (3)

L28/32H

Item No.	Qty.	Designation	Benævnelse
014	1/C	**Drain pipe from fuel pump**	Drænrør fra fuel pumpe
026	2/C	**Banjo coupling**	Banjoforskruning
038	1/C	**Branch pipe for fuel oil, outlet**	Stikrør for fuel olie, afgang
051	1/C	**Banjo coupling**	Banjoforskruning
063	1/C	**Straight male stud coupling**	Ligeforskruning
087	1/C	**Branch pipe, lub. oil**	Stikrør, smøreolie
099	1/C	**Banjo coupling**	Banjoforskruning
109	3/C	**Straight male stud coupling**	Ligeforskruning
110	1/C	**Packing, square**	Pakning, firkantet
122	1/C	**Branch pipe, cooling oil**	Stikrør, køleolie
134	4/C	**Screw**	Skrue
146	4/C	**Spring lock**	Fjederskive
158	1/C	**Branch pipe, cooling oil**	Stikrør, køleolie
171	1/C	**Pipe for fuel oil pump, inlet**	Rør for fuel pumpe, tilgang
183	1/E	**Branch pipe**	Stikrør
195	1/E	**Elbow bulkhead coupling**	Vinkelskotforskruning
205	1/C	**Branch pipe, cylinder head**	Stikrør, cylinderdæksel
217	1/E	**Straight coupling**	Ligeunion
229	2/C	**Equal tee coupling**	T-forskruning
230	1/E	**Main pipe**	Stammerør
242	1/E	**Main pipe**	Stammerør
254	1/C	**Lub. oil pipe for rocker arm**	Smøreolierør for vippearm
266	1/E	**Main pipe**	Stammerør
278	1/C	**Non-return valve**	Kontraventil
291	1/C	**Lub. oil pipe for roller guide**	Smøreolierør for rullestyr
301	1/C	**Straight male stud coupling**	Ligeforskruning
313	1/C	**Lub. oil pipe**	Smøreolierør
325	1/C	**Straight male stud coupling**	Ligeforskruning
337	1/E	**Main pipe**	Stammerør
349	1/E	**Main pipe**	Stammerør
350	1/E	**Steel pipe**	Stålrør
362	1/C	**Drain pipe from cylinder head**	Drænrør fra cylinderdæksel
374	1/C	**Male stud coupling**	Vinkelforskruning
386	1/E	**Equal elbow coupling**	Vinkelforskruning
398	1/E	**Screwed connection**	Vinkelforskruning
408	1/C	**Drain pipe from fuel pump**	Drænrør fra fuel pumpe
421	1/C	**Pipe clamp**	Rørholder
433	1/C	**Screw**	Skrue
445	1/C	**Nut**	Møtrik
457	1/E	**Packing ring**	Pakningsring
469	1/E	**Restriction**	Restriktion
470	1/C	**Gasket, oval**	Pakning, oval
482	2/C	**Screw**	Skrue
494	2/C	**Spring lock**	Fjederskive
504		**Support**	Beslag
	4/E	**5 cyl.**	5 cyl.
	5/E	**6 cyl.**	6 cyl.
	6/E	**7 cyl.**	7 cyl.
	7/E	**8 cyl.**	8 cyl.
	8/E	**9 cyl.**	9 cyl.

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.
Qty./C = Qty./Cylinder.

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor.
Antal/C = Antal/Cylinder.

Plate Page 3 (3)	Pipes on Cylinder Section Forced Lubrication with Cooling Oil Pipes	61430-03H

L28/32H

Item No.	Qty.	Designation	Benævnelse
516		**Screw**	Skrue
	4/E	**5 cyl.**	5 cyl.
	5/E	**6 cyl.**	6 cyl.
	6/E	**7 cyl.**	7 cyl.
	7/E	**8 cyl.**	8 cyl.
	8/E	**9 cyl.**	9 cyl.
528		**Pipe clamp**	Rørholder
	4/E	**5 cyl.**	5 cyl.
	5/E	**6 cyl.**	6 cyl.
	6/E	**7 cyl.**	7 cyl.
	7/E	**8 cyl.**	8 cyl.
	8/E	**9 cyl.**	9 cyl.
541		**Screw**	Skrue
	8/E	**5 cyl.**	5 cyl.
	10/E	**6 cyl.**	6 cyl.
	12/E	**7 cyl.**	7 cyl.
	14/E	**8 cyl.**	8 cyl.
	16/E	**9 cyl.**	9 cyl.
553	**1/E**	**Fuel oil distributor pipe**	Fuel oliefordelingsrør
565		**Support**	Beslag
	4/E	**5 cyl.**	5 cyl.
	5/E	**6 cyl.**	6 cyl.
	6/E	**7 cyl.**	7 cyl.
	7/E	**8 cyl.**	8 cyl.
	8/E	**9 cyl.**	9 cyl.
577		**Screw**	Skrue
	8/E	**5 cyl.**	5 cyl.
	10/E	**6 cyl.**	6 cyl.
	12/E	**7 cyl.**	7 cyl.
	14/E	**8 cyl.**	8 cyl.
	16/E	**9 cyl.**	9 cyl.
589		**Spring lock**	Låsefjeder
	8/E	**5 cyl.**	5 cyl.
	10/E	**6 cyl.**	6 cyl.
	12/E	**7 cyl.**	7 cyl.
	14/E	**8 cyl.**	8 cyl.
	16/E	**9 cyl.**	9 cyl.
590		**Pipe clamp**	Rørholder
	4/E	**5 cyl.**	5 cyl.
	5/E	**6 cyl.**	6 cyl.
	6/E	**7 cyl.**	7 cyl.
	7/E	**8 cyl.**	8 cyl.
	8/E	**9 cyl.**	9 cyl.
600		**Screw**	Skrue
	8/E	**5 cyl.**	5 cyl.
	10/E	**6 cyl.**	6 cyl.
	12/E	**7 cyl.**	7 cyl.
	14/E	**8 cyl.**	8 cyl.
	16/E	**9 cyl.**	9 cyl.

Item No.	Qty.	Designation	Benævnelse
612	**4/E**	**Pipe clamp**	Rørholder
	5/E	**5 cyl.**	5 cyl.
	6/E	**6 cyl.**	6 cyl.
	7/E	**7 cyl.**	7 cyl.
	8/E	**8 cyl.**	8 cyl.
		9 cyl.	9 cyl.
624	**4/E**	**Screw**	Skrue
	5/E	**5 cyl.**	5 cyl.
	6/E	**6 cyl.**	6 cyl.
	7/E	**7 cyl.**	7 cyl.
	8/E	**8 cyl.**	8 cyl.
		9 cyl.	9 cyl.
636	**4/E**	**Pipe clamp**	Rørholder
	5/E	**5 cyl.**	5 cyl.
	6/E	**6 cyl.**	6 cyl.
	7/E	**7 cyl.**	7 cyl.
	8/E	**8 cyl.**	8 cyl.
		9 cyl.	9 cyl.

When ordering spare parts, see also page 600.50.

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Qty./E = Qty./Engine.
Qty./C = Qty./Cylinder.

Ved bestilling af reservedele, se også side 600.50.

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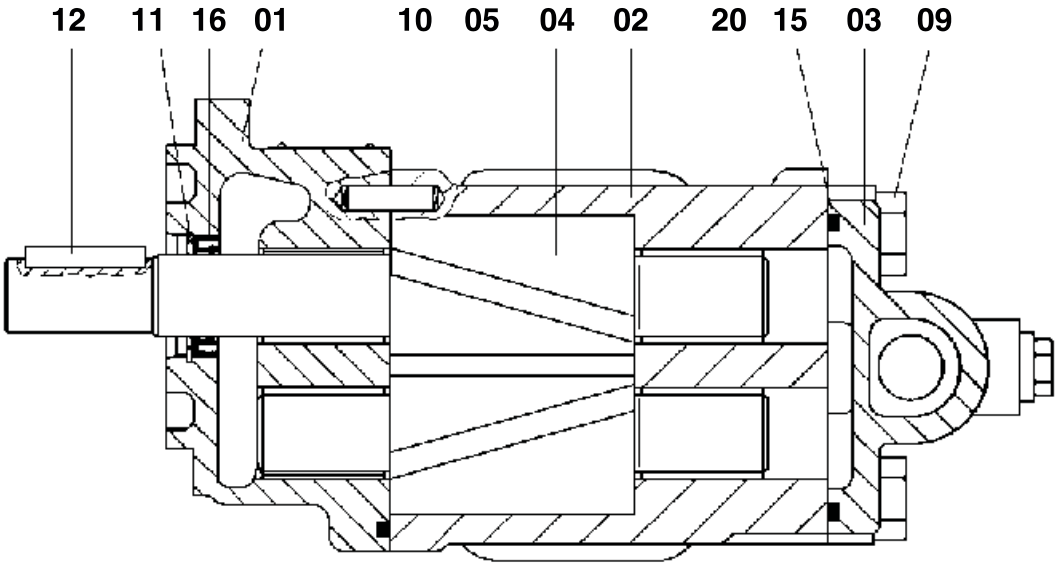
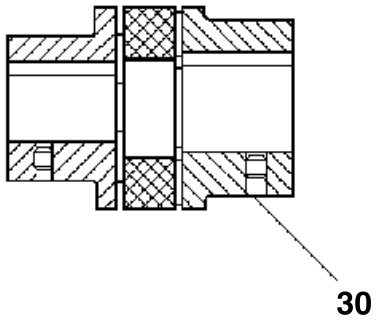
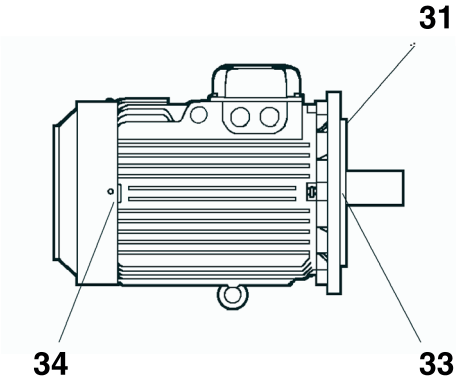
Antal/E = Antal/Motor.
Antal/C = Antal/Cylinder.

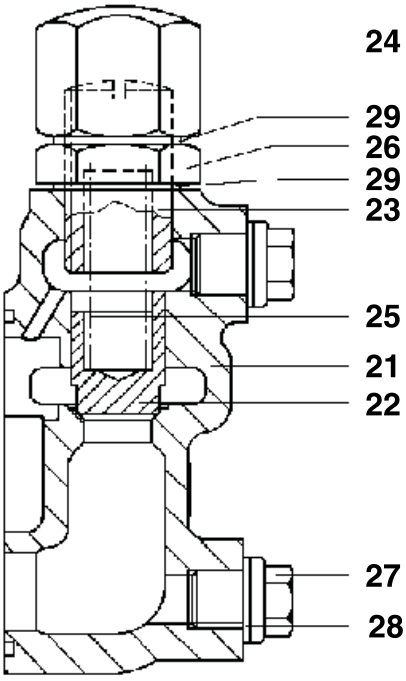
Plate Page 1 (2)	Nozzle Cooling Pump	61440-05H

L28/32H









61440-05H	Nozzle Cooling Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Driving cover**	Medbringerdæksel
02	1/P	**Gear casing**	Gearhus
03	1/P	**End cover, complete, incl. item 21 to 29**	Endedæksel, komplet inkl. item 21 til 29
04	1/P	**Driving gear shaft**	Drivende gear aksel
05	1/P	**Gear shaft**	Gear aksel
09	4/P	**Screw**	Skrue
10	2/P	**Parallel pin**	Styrestift
11	1/P	**Retaining ring**	Sikringsring
12	1/P	**Parallel key**	Not
15	2/P	**O-ring**	O-ring
16	1/P	**Rotary shaft seal**	Roterende aksel tætning
20	1/E	**Pumpe, complete without El-motor**	Pumpe, komplet uden el-motor
21	1/P	**End cover**	Endedæksel
22	1/P	**Piston**	Stempel
23	1/P	**Spindle**	Spindel
24	1/P	**Dome nut**	Lukkemøtrik
25	1/P	**Spring**	Fjeder
26	1/P	**Pipe nut**	Rørmøtrik
27	2/P	**Screwed plug**	Propskrue
28	2/P	**Sealing ring**	Tætningsring
29	2/P	**Sealing ring**	Tætningsring
30	1/P	**Coupling, complete**	Kobling, komplet
31	1/E	**El-motor, complete**	El-motor, komplet
32	1/E	**Pre.lub oil pump, complete with el-motor**	Forsmørepumpe, komplet med el-motor
33	1/E	**Ball bearing, rear**	Kugleleje, bagside
34	1/E	**Ball bearing, front**	Kugleleje, forside

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

* = **Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

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Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Lubricating oil system

515/615

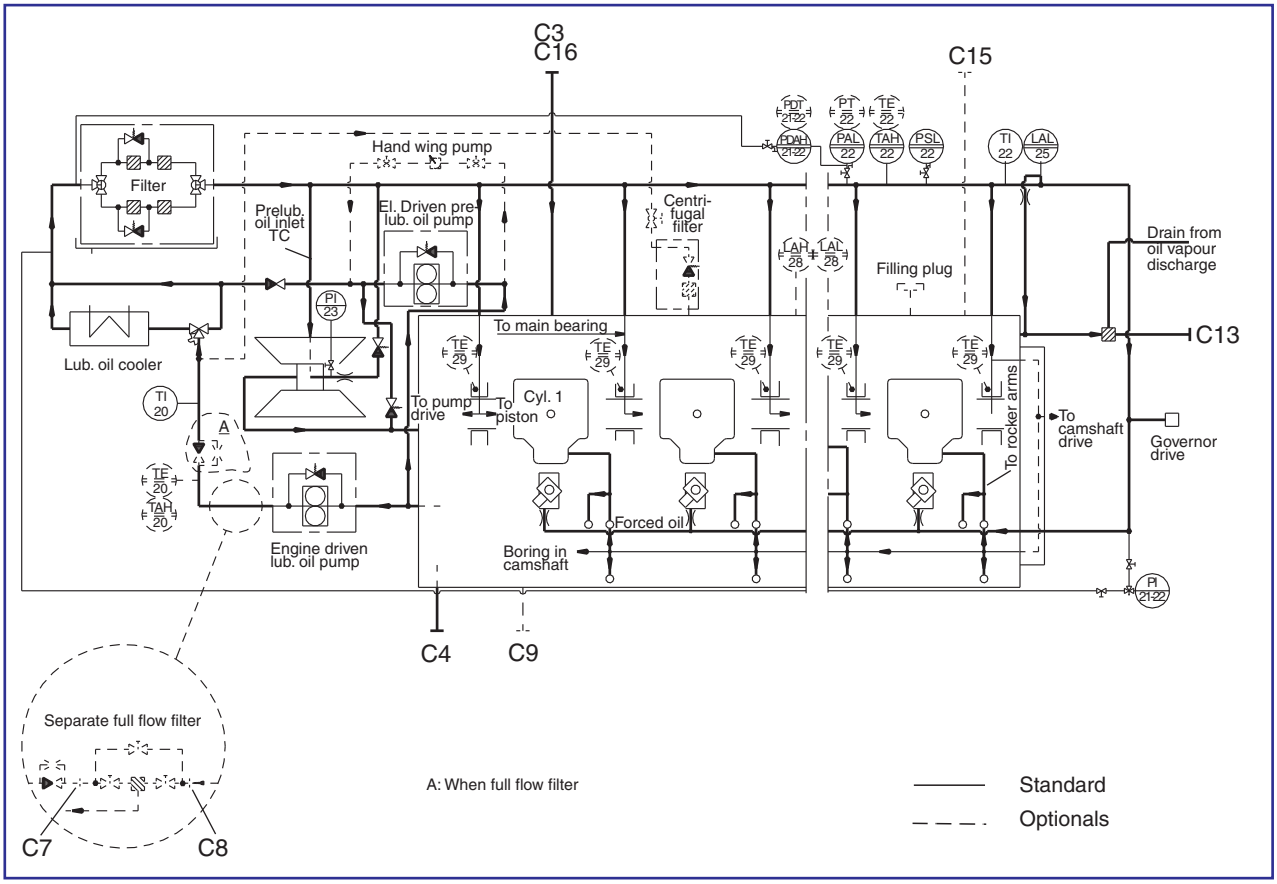

Fig 1 Diagram for internal lubricating oil system.

Pipe description for connection at the engine		
C3	Lubricating oil from separator	DN 25
C4	Lubricating oil to separator	DN 25
C7	Lubricating oil from separate filter	DN 80
C8	Lubricating oil to separate filter	DN 80
C9	Back-flush from full-flow filter	DN 20
C13	Oil vapour discharge*	DN 50
C15	Lubricating oil overflow	DN 50
C16	Lubricating oil supply	DN 25

Flange connections are as standard according to DIN 2501

* For external pipe connection, please see section for crankcase ventilation.

General

As standard the lubricating oil system is based on wet sump lubrication. All moving parts of the engine are lubricated with oil circulating under pressure in a closed built-on system.

The lubricating oil is furthermore used for the purpose of cooling the pistons.

The standard engine is equipped with built-on:

- Engine driven lubricating oil pump
- Lubricating oil cooler
- Lubricating oil thermostatic valve
- Duplex full-flow depth filter
- Pre-lubricating oil pump

L28/32H

Oil Quantities

The approximate quantities of oil necessary for a new engine, before starting up are given in the table, see "B 12 01 1 / 604.06 Lubricating Oil in Base Frame" (max. litre H3)

If there are connected external, full-flow filters etc., the quantity of oil in the external piping must also be taken into account.

Max. velocity recommendations for external lubricating oil pipes:

- Pump suction side 1.0 - 1.5 m/s
- Pump discharge side 1.5 - 2.0 m/s

Lubricating Oil Consumption

The lubricating oil consumption is 0.6 - 1.0 g/kWh, see "Specific Lubricating Oil Consumption - SLOC, B 12 15 0 / 604.07"

It should, however, be observed that during the running in period the lubricating oil consumption may exceed the values stated.

Quality of Oil

Only HD lubricating oil (Detergent Lubricating Oil) should be used, characteristic stated in "Lubricating Oil Specification B 12 15 0 / 604.01".

System Flow

The lubricating oil pump draws oil from the oil sump and presses the oil through the cooler and filter to the main lubricating oil pipe, from where the oil is distributed to the individual lubricating points. From the lubricating points the oil returns by gravity to the oil sump.

The main groups of components to be lubricated are:

1 – Turbocharger

2 – Main bearings, big-end bearing etc.

3 – Camshaft drive

4 – Governor drive

5 – Rocker arms

6 – Camshaft

1) For priming and during operation, the turbocharger is connected to the lubricating oil circuit of the engine, the oil serves for bearing lubrication.

The inlet line to the turbocharger is equipped with an orifice in order to adjust the oil flow and a non-return valve to prevent draining during stand-still.

The non-return valve has back-pressure function requiring a pressure slightly above the priming pressure to open in normal flow direction. In this way overflooding of the turbocharger is prevented during stand-still periods, where the pre-lubricating pump is running.

2) Lubricating oil for the main bearings is supplied through holes drilled in the engine frame. From the main bearings it passes through bores in the crankshaft to the connecting rod big-end bearings.

The connecting rods have bored channels for supply of oil from the big-end bearings to the small-end bearings, which has an inner circumferential groove, and a pocket for distribution of oil in the bush itself and for supply of oil to the pin bosses and the piston cooling through holes and channels in the piston pin.

From the front main bearings channels are bored in the crankshaft for lubricating of the pump drive.

3) The lubricating oil pipes, for the camshaft drive gear wheels, are equipped with nozzles which are adjusted to apply the oil at the points where the gear wheels are in mesh.

4) The lubricating oil pipe, and the gear wheels for the governor drive are adjusted to apply the oil at the points where the gear wheels are in mesh.

5) The lubricating oil to the rocker arms is led

through pipes to each cylinder head. It continuos through bores in the cylinder head and rocker arm to the movable parts to be lubricated at rocker arms and valve bridge. Further, lubricating oil is led to the movable parts in need of lubrication.

6) Through a bore in the frame lubricating oil is led to the first camshaft bearing and through bores in the camshaft from where it is distributed to the other camshaft bearings.

Lubricating Oil Pump

The lubricating oil pump, which is of the gear wheel type, is mounted on the front end of the engine and is driven by means of the crankshaft through a coupling. The oil pressure is controlled by an adjustable spring- loaded relief valve built-on the oil pump.

Thermostatic Valve

The thermostatic valve is designed as a T-piece with the inlet in the cover (A) under which the thermostatic elements are located.

The outlet to the engine (by-passing cooler) is marked (B) and outlet to the cooler is marked (C). In the warming up period, the oil is by-passing the cooler. When the oil from the engine reaches the normal temperature see "Operation data & set points 600.30" a controlled amount af oil passes through the cooler.

The thermostatic elements must be replaced if the temperature during normal operation deviates essential from the one stated in the test report.

The valve cannot be set or adjusted, and it requires no maintenance.

Built-on Full-flow Depth Filter

The lubricating oil filter is a double filter which is generally used with only one filter chamber being in operation, the other filter chamber being stand-by.

If the filter chamber in operation needs to be serviced, the operation can be switched to the other filter

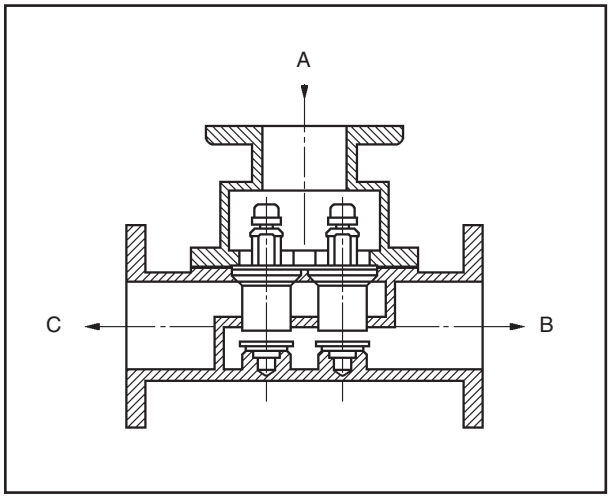

Fig 2 Thermostatic Valve

chamber without any interruption in lubricating oil supply to the engine.

Servicing is generally restricted to replacing of the paper cartridges, cleaning of the radial mesh insert and inspection of sealings, the latter to be replaced if damages observed.

Each filter chamber is equipped with 1 or 2 replaceable paper cartridges of fineness 10-15 microns.

In the centre of each filter chamber a filter basket (central element) is situated. This filter basket is acting as a safety filter, having a fineness of about 60 microns.

During operation an increased pressure drop across the filter will be observed as dirt particles will deposit on the filtration surfaces of the paper cartridges and thus increase the flow resistance through the filter.

If the pressure drop across the filter exceeds 2.0 bar, a release valve will open and by-pass the 10-15 microns filter element, and the engine will run with only the 60 microns safety filter.

To ensure safe filtering of the lubricating oil, none of the by-pass valves must open during normal service and the elements should be replaced at a pressure drop across the filter of 1.5 bar.

L28/32H

Servicing is essential the exchange of the paper cartridges.

When exchanging cartridges, it is advisable to release any old oil remaining in the filter housing by means of the drain plug provided for this purpose, and to wipe out the housing with a cloth.

The filter chambers can be serviced successively during operation or when the engine is at standstill.

It is essential to follow the instructions in work card 615-01.10 closely when replacing filter cartridges.

Filter cartridges must under no circumstances be cleaned and used again.

Pre-lubricating

As standard the engine is equipped with an electric-driven prelubricating pump mounted parallel to the main pump. The pump must be arranged for automatic operation, ensuring stand-still of the pre-lubricating pump when the engine is running, and running during engine stand-still in stand-by position.

Running period of the pre-lubricating pump is preferably to be continuous. If intermittent running is required for energy saving purpose, the timing equipment should be set for shortest possible intervals, say 2 minutes of running, 10 minures of stand-still, etc. Further, it is recommended that the pre-lubricating pump is connected to the emergency switch board thus securing that the engine is not started without pre-lubrication.

Draining of the Oil Sump

It is recommended to use the separator suction pipe for draining of the lubricating oil sump.

Optionals

Besides the standard components, the following optionals can be built-on:

- Level switch for low/high level in oil sump (LAL/LAH 28)
- Centrifugal by-pass filter (standard for stationary engines)
- Hand wing pump
- Filling plug

Pressure differential transmitting
- PDT 21-22 Lubricating oil inlet across filter

Temperature alarm high
- TAH 20 Lubricating oil inlet before cooler

Pressure transmitting
- PT 22 Lubricating oil inlet after cooler

Temperature element
- TE 20 Lubricating oil inlet before cooler

Temperature element
- TE 22 Lubricating oil inlet after cooler

Temperature element
- TE 29 Lubricating oil inlet main bearings

Branches for:

- External fine filter
- External full/flow filter

Branches for separator is standard.

L+V28/32H

Principle of the Plate Heat Exchanger

The built-on lubricating oil cooler is a plate heat exchanger.

The plate heat exchanger consist of a number of cold pressed plates which are compressed between a frame plate (head) and the pressure plate (follower) by means of tie bolts.

The plates are made with special corrugations, which ensures turbolent flow and high heat transfer cofficients.

Plates

After clamping of the plate pack, the plates - which are fitted gaskets - ensure an effective seal between fluids and atmosphere. In addition, intermixing of the fluids is eliminated by a double gasket seal around the inlet ports.

Every second plate is turned through 180°. This means that the double gasket seal occurs around every second inlet to the channels between the plates.

The plate pack now forms a series of parallel flow channels in which the fluids flow in a counter current regime.

08028-0E/H5250/94.08.12

L+V28/32H
L32/40

Description

The centrifugal filter is a by-pass filter mounted directly at the engine base frame. The centrifugal filter is a supplement to the main filter.

During service, a part of the lubricating oil supplied from the engine driven lubricating oil pump enters the centrifugal filter and returns to the oil sump in the base frame.

The centrifugal filter relies on the centrifugal force and can therefore remove high density, sub-micron particles.

Principle of Operation

Oil enters the base of the filter and depresses the cut-off valve (A) which has a pre-set pressure valve. The cut-off valve is fitted to ensure that at low pressure and flow conditions the entire oil pump output is supplied to the engine working parts. Having depressed the cut-off valve the oil travels up the centre of the spindle. Through holes at the top (B) and enters the rotor (C) at the maximum height above the stand tube. The oil completely fills the cleaning chamber (D) and travels through the strainer (E) into the drive chamber (F), leaving under pressure via diametrically opposed tangential nozzles in the bottom of the rotor.

The reaction of the oil leaving the nozzles provides the driving force causing the rotor to spin about the spindle at high speed. The oil leaving the nozzles is then allowed to drain back to the sump, by gravity at atmospheric pressure.

The centrifugal force field within the spinning rotor forces the contaminants to travel to the inner wall of the rotor, where they form a dense rubber-like sludge which is easily removed.

For proper filtration, it is important that the rotor is always correctly balanced.

An out-of-balance condition can occur as a result of an uneven built-up of sludge or as a result of excessive bearing or spindle wear.

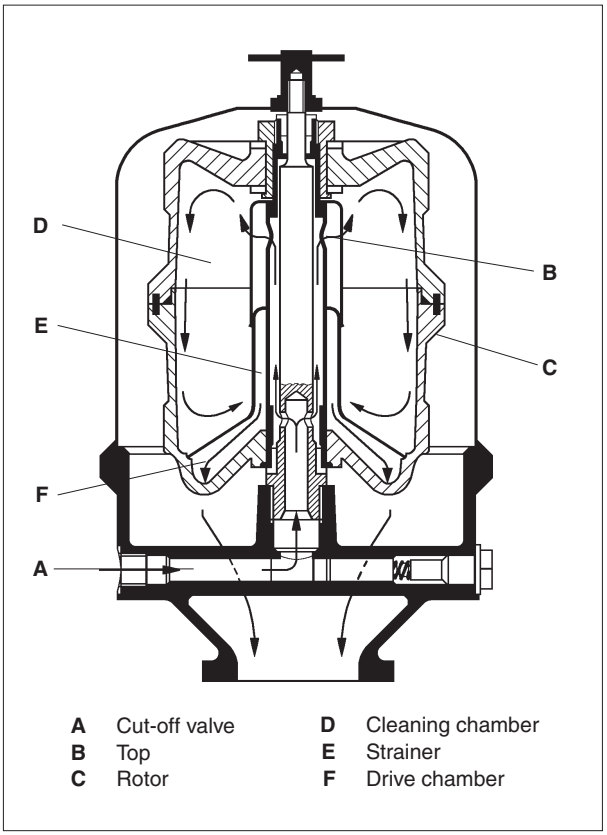

Fig. 1. Diagram showing Principle of Operation.

L32/40, L28/32H, V28/32H

Crankcase ventilation

The crankcase ventilation is not to be directly connected with any other piping system. It is preferable that the crankcase ventilation pipe from each engine is led independently to the open air. The outlet is to be fitted with corrosion resistant flame screen separately for each engine.

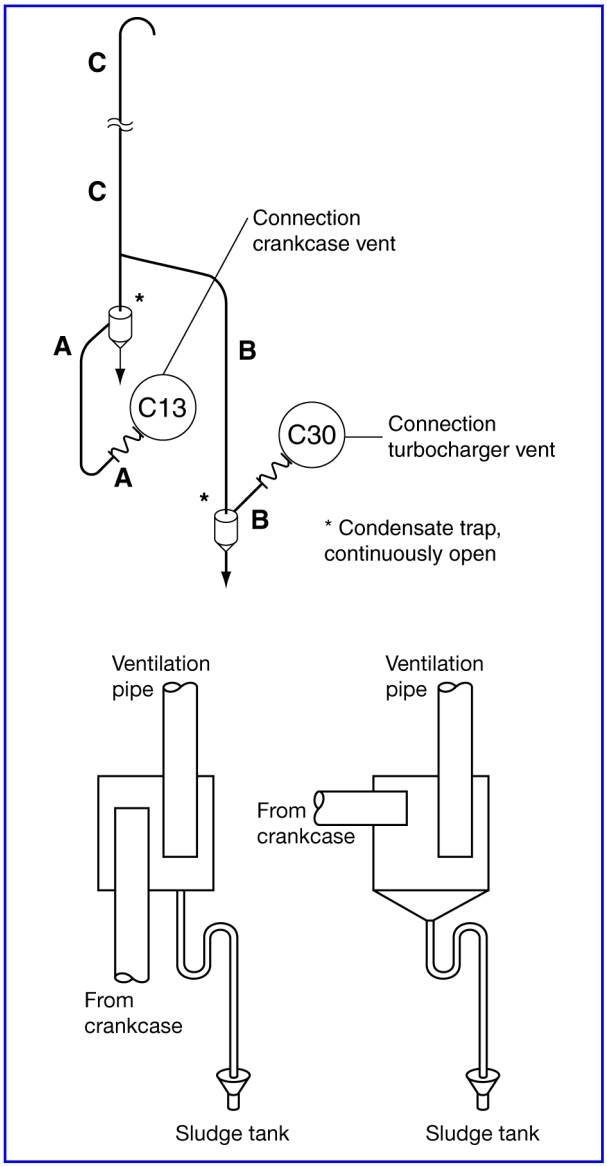

Figure 1: Crankcase ventilation

However, if a manifold arrangement is used, its arrangements are to be as follows:

1) The vent pipe from each engine is to run independently to the manifold and be fitted with corrosion resistant flame screen within the manifold.
2) The manifold is to be located as high as practicable so as to allow a substantial length of piping, which separates the crankcase on the individual engines.
3) The manifold is to be vented to the open air, so that the vent outlet is fitted with corrosion resistant flame screen, and the clear open area of the vent outlet is not less than the aggregate area of the individual crankcase vent pipes entering the manifold.
4) The manifold is to be provided with drainage arrangement.

The ventilation pipe must be designed to eliminate the risk of water condensation in the pipe flowing back into the engine and should end in the open air:

- The connection between engine (C13 / C30) and the ventilation pipe must be flexible.
- The ventilation pipe must be made with continuous upward slope of minimum 5°, even when the ship heel or trim (static inclination).
- A continuous drain must be installed near the engine. The drain must be led back to the sludge tank.

Engine	Nominal diameter ND (mm)		
	A	B	C
L16/24	50		65
L21/31	65	40	80
L23/30H	50	-	65
L27/38	100	-	100
L28/32H	50	-	65
V28/32H	100	-	125
L32/40	125	50	125
V28/32S	100	-	125

Table 1: Pipe diameters for crankcase ventilation

- Dimension of the flexible connection, see pipe diameters Fig 2.
- Dimension of the ventilation pipe after the flexible connection, see pipe diameters Fig 2.

L32/40, L28/32H, V28/32H

The crankcase ventilation flow rate varies over time, from the engine is new/major overhauled, until it is time to overhaul the engine again.

The crankcase ventilation flow rate is in the range of 3.5 – 5.0 ‰ of the combustion air flow rate [m³/h] at 100 % engine load.

If the combustion air flow rate at 100 % engine load is stated in [kg/h] this can be converted to [m³/h] with the following formula (Tropic Reference Condition) :

$$\frac{287.04\ [Nm/(kg \cdot K)] \cdot \text{Mass flow}\ [kg/h] \cdot 318.16\ [°K]}{1\ [bar] \cdot 100000\ [N/m^2]}$$

Example :

Engine with a mechanical output of 880 kW and combustion air consumption of 6000 [kg/h] corresponds to :

$$\frac{287.04\ [Nm/(kg \cdot K)] \cdot 6000\ [kg/h] \cdot 318.16\ [°K]}{1\ [bar] \cdot 100000\ [N/m^2]} = 5479\ [m^3/h]$$

The crankcase ventilation flow rate will then be in the range of 19.2 – 27.4 [m³/h]

The maximum crankcase backpressure measured right after the engine at 100 % engine load must not exceed 3.0 [mbar] = 30 [mmWC].

Working Card Page 1 (3)	**Lubricating Oil Pump, Engine Driven**	**615-01.00** Edition 01H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Disassembly, overhaul and assembly of lubricating oil pump, engine driven.
Adjusment of lub. oil pressure.

Starting position:

All pipe connections to the lub. oil pump have been disconnected, and the lub. oil pump is removed from the engine.

Related procedure:

Man power:

Working time	:	6-8	Hours
Capacity	:	1	man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62005	28	140 - 760 Nm.

Hand tools:

Ring and open end spanner, 19 mm.
Ring and open end spanner, 10 mm.
Ring and open end spanner, 46 mm.
(Socket spanner, 46 mm).
Allen key, 8 mm, 4 mm.
Plier for locking ring.
Soft hammer.
Big screw driver.
Adjustable spanner.
Puller.
Silastene or similar.
Hard brush.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61501	04	1/pump
61501	06	5/pump
61501	32	1/pump

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L+V28/32H

Disassembly:

1) Remove the coupling part or gear wheel (1), see fig. 2, by means of a puller or a soft hammer.

2) Remove screws (2) and dismount the cover (3).

3) Dismount the locking ring (4), screws (5) and remove the cover (6) with the overspeed device.

4) Remove the gear wheel (7 and 8).

5) Dismounting of the spring loaded adjustable by-pass valve.

Remove the cap nut (9), nut (10), spring housing (11), spring (12) and the cylinder (13). If the piston (14) cannot be pulled out from the same side, the plug screw (15) can be removed and the piston can be pressed out from this side with a screw driver or the like.

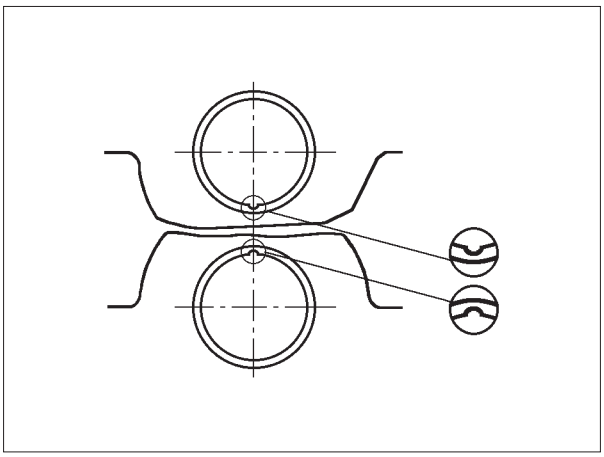

Fig. 1.

Overhaul.

6) Clean all the parts with gas oil and a hard brush, (never use a steel brush). The parts are blown clean with working air.

7) If the bearing bush is to be removed the existing bearing bush is plugged out by means of a mandrel, the bores are cleaned and new bearing bush is mounted, see fig. 1.

Before the gear wheels (7 and 8) can be mounted the bearing bush must be adjusted with a reamer or a bearing scraper, so that the gear wheel can run easily when the pump is assembled.

8) Inspect all other parts for wear and damage, and renew, if necessary.

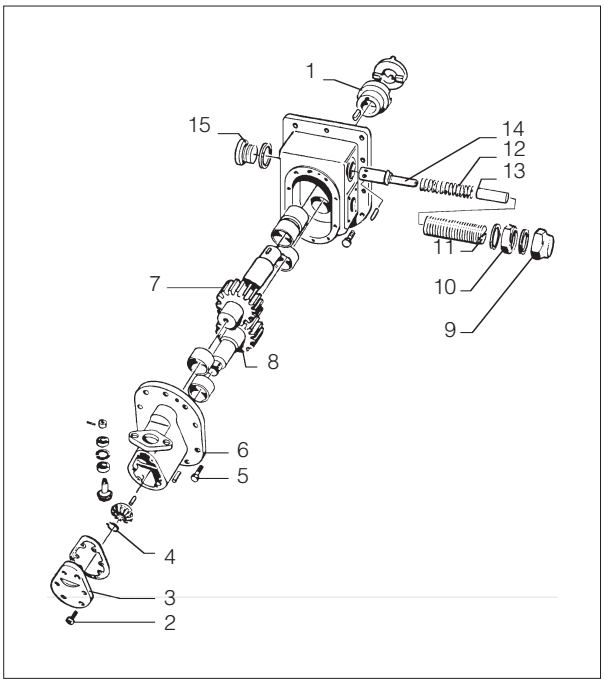

Fig. 2.

Assembly:

9) Mount the gear wheel (7 and 8).

Coat the sealing lip with silastene or similar and mount the cover (6) with gear wheel and locking ring (4).

10) Mount the cover (3) with gasket.

11) Mount the gear wheel or coupling part (1).

For tightening the nut for gear wheel, see page 600.40.

12) Mount the spring loaded by-pass valve, nut (10) with gasket, cap nut (9) and plug screw (15).

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Adjusting of Lub. Oil Pressure.

13) The outlet pressure of the lub. oil pump, can be adjusted by means of a adjusting screw in the by-pass valve.

Remove the cap nut (9) and loosen the nut (10).

By turning the spring housing clockwise the pressure is raised and reverse the pressure is lowered by turning the spring housing (11) anti-clockwise. When the correct pressure is reached , see page 600.30, the spring housing (11) is locked with nut (10) and finally the gasket and cap nut (9) are mounted.

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Working Card Page 1 (3)	**Prelubricating Pump**	**615-01.05** Edition 02H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Dismounting, replacement of the rotary shaft seal and assembly of prelubricating pump.

Starting position:

Related procedure:

Man power:

Working time : 2-3 Hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Wheel puller for bearing bush.
Compressed pin.
Protection cover for shaft seal.
Compressed pin for shaft seal.

(The special tools must be ordered separately from MAN B&W Diesel A/S, Holeby)

Hand tools:

Bench vice.
Spanner.
Torque spanner.
Plier for lock ring.
Soft hammer.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

See plate 61504.

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General

Overhauls.

Overhauls for the purpose of avoiding functional trouble are not normally necessary for the prelubricating pumps, when properly used, there is very little wear on the pump gear shaft.

Spare Parts.

Before any overhaul is done, please note the following:

If a pump gets unusable by wear, it must be replaced. Installation of spare parts cannot bring it back to normal condition.

It pays to keep extra pumps in stock or to have repairs (overhauls) carried out at our repair shop.

The shaft seal needs only to be replaced in case of leakage or after dismounting of drive shaft. The marks from the seal do not necessarily mean that the sealing is defective, but there is a risk of leakage after replacement of sealing.

We advise not to change the bearing bushes. In connectin with damages on the bearings it is normal that also the shafts and the parts in the gear box will be damaged.

When ordering spare parts, do not forget to state the factory no. of the pump.

Replacement of mechanical seal.

1) Disconnect the cable and pipe connection to the pump.

2) Remove the pump from the engine base frame.

3) Separate the pump and the el-motor.

4) Remove the coupling part and key (12), see fig. 1, from the driving gear shaft (4).

5) Tighten the pump to the flange. Pressure control valve (3) upwards.

6) Loosen screws (9) and take off the pressure control valve (3).

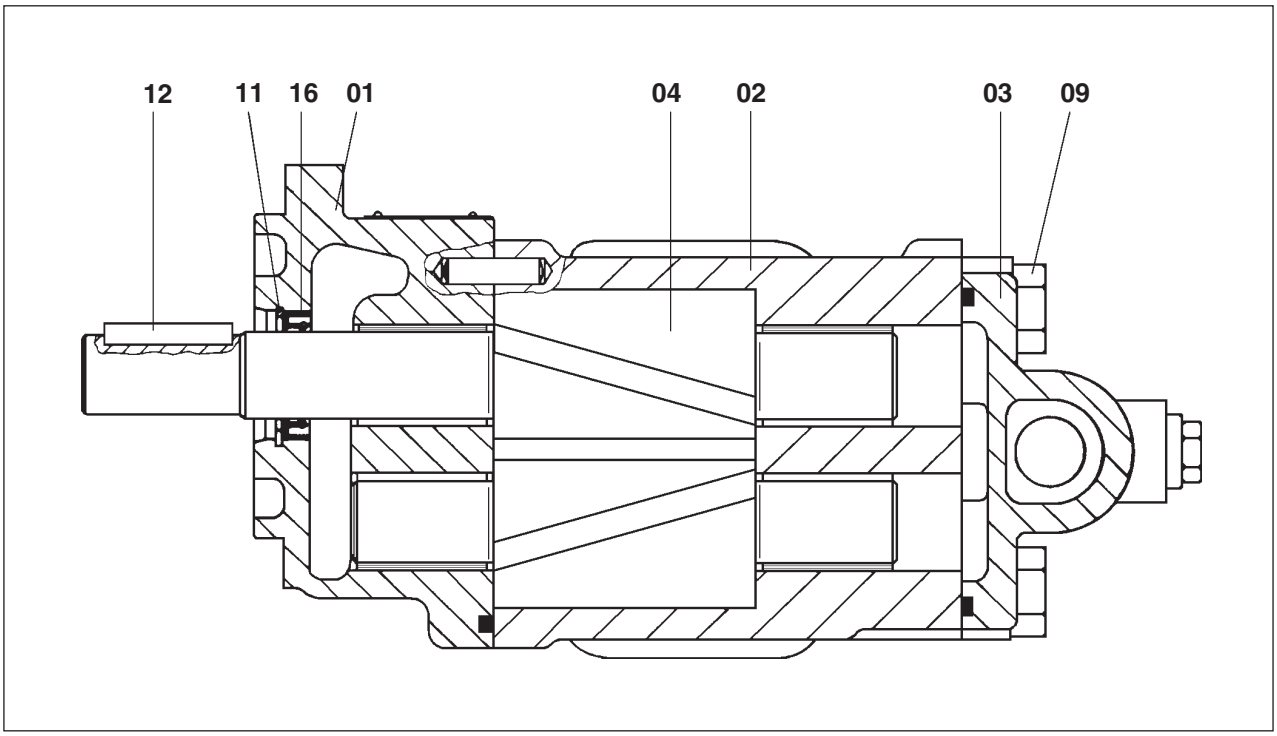

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Fig. 1. Prelubricating Pump.

General

7) Take off the gear box (2), if necessary use a soft hammer for separation.

8) Remove the gear wheels from the cover (1). Dismounting is only possible by disturbing the rotor shaft seal and by breaking the bearing bush.

9) Remove the security ring (11) and take off the rotary shaft seal (16).

10) Press out the driving gear shaft bearing bush, pull out the running bearing bush with the inner wheel puller.

11) Gear box (2). Dismounting is only possible by damaging the shaft bush. Press out the shaft bushes.

12) Pressure control valve (3). The pressure control valve can be dismounted also without dismounting the pump.

Mounting.

13) The mounting process follows in reverse order, it is stressed that an exact cleaning works is necessary.

Especially the sealing faces must be clean.

Tightening of screw pos. (9):

R25 10 Nm
R35 50 Nm

In connection with the bearing bush, attention must be paid to the placement of the butt joint and the mounting depth.

The new shaft seal cannot be pressed into the protection cover before exact mounting of the pump.

O-ring must be changed.

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Working Card Page 1 (3)	**Lubricating Oil Filter**	**615-01.10** Edition 01H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Replacement of paper filter element(s).
Cleaning of safety filter and filter housing.

Starting position:

Related procedure:

Man power:

Working time	:	2	Hours
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Ring and open end spanner, 22 mm.
Ring and open end spanner, 24 mm.
Ring and open end spanner, 27 mm.
Adjustable spanner.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61502	01	See plate 61502
61502	28	1/Filter.

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General

The lubricating oil filter is dimensioned so that each of the two filter parts has sufficent capacity to treat the amount of lubricating oil delivered by the pump.

The three-way valve positioned is determining whether the left hand or the right hand filter chamber is in operation, and also gives the possibility of having both filter chambers in operation simultaneously.

The three-way valve is marked with flow directions and the figure indicates the operation modes according to valve positions.

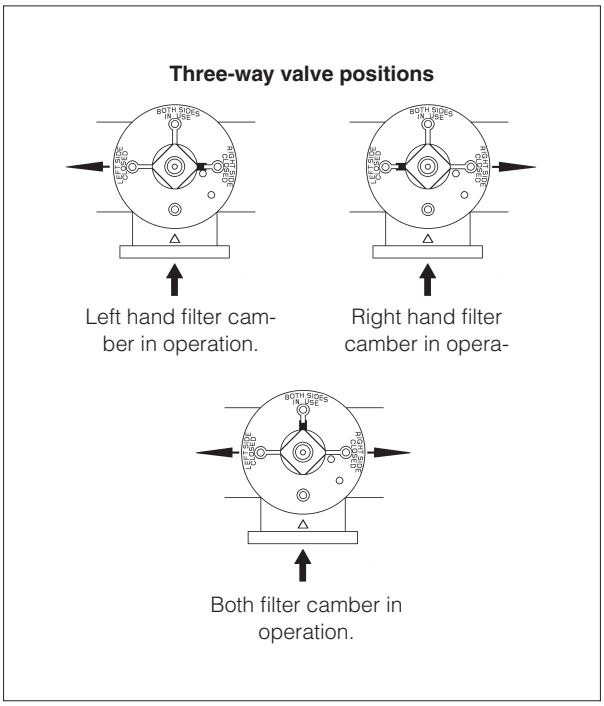

Fig. 1. Three-way valve positions.

Service Procedure.

1) Turn the three-way valve, see fig. 2, into the position setting the stand-by filter chamber in operation and the filter chamber requiring service out of operation.

2) Open the vent screw (5) on the top of the filter to get the pressure out of the filter half.

3) Open the drain plug (8) under the filter housing and drain off oil.

4) Filter housing cap is dismantled.

5) Remove the inner safety element. Clean the element with detergent. Check that it is intact.

6) Remove the outer element(s). Filter element is of disposable type. It change always to new original filter.

7) Clean the filter housing and the cap. Be careful of not to let the oil from the dirty side to go into the clean oil channel in the middle of bottom.

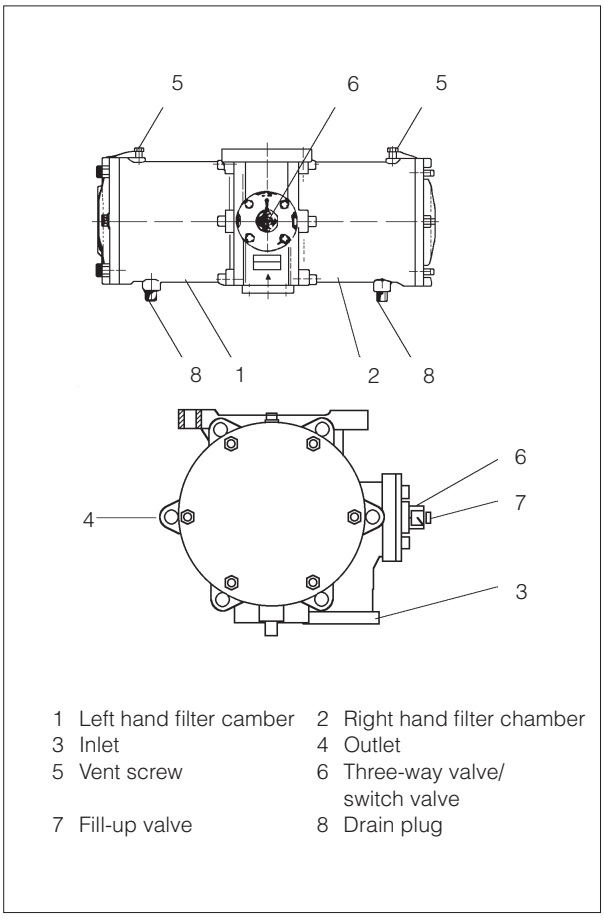

Fig. 2.

8) Check the seal on the bottom of the filter housing and in the cap. Change if needed.

9) Assemble the filter in opposite order.

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General

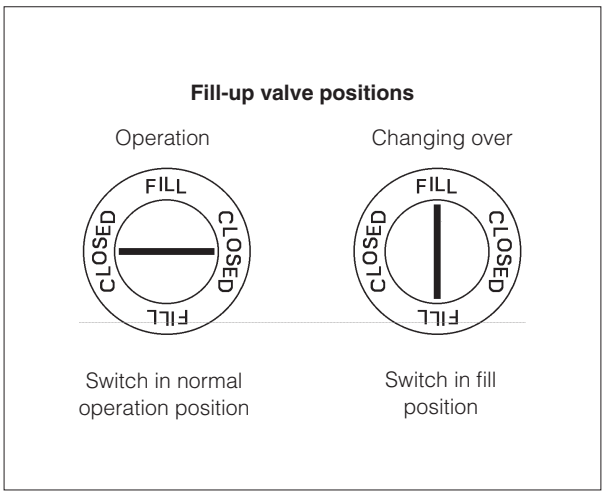

Fig. 3. Fill-up valve position.

10) Let the air valve be open and fill the filter housing with oil by means of the slow fill-up valve (7) in position FILL, see fig. 3. This valve is inside the three-way valve and by using it, the filling can be made so slowly that the pressure on the other part of the filter does not drop too much.

11) Close the vent screw (5) after the housing is filled up with oil.

12) Open the three-way valve (6) and close the fill-up valve (7) by turning it to position CLOSED, see fig. 3.

13) The filter just serviced is now ready to be set in operation.

Inspect for oil leakages in order to ascertain all sealings to be tight.

Check that pressure drop across filter is correct.

Clean the other side of the filter correspondingly.

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Working Card Page 1 (2)	**Lubricating Oil, Thermostatic Valve**	**615-01.20** Edition 01H

General

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Inspection of thermostatic valve and replacement of elements.

Starting position:

Lubricating oil drained from engine (if necessary).

Related procedure:

Man power:

Working time : 2 Hour
Capacity : 1 Man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate No.	Item No.	Note.

Hand tools:

Ring and open end spanner 24 mm
Copaslip
Tools and cleaning preparation for cleaning.

Replacement and wearing parts:

Plate No.	Item No.	Qty./
61503	03	1/engine
61503	05	2 or 4/engine
61503	09	3/engine

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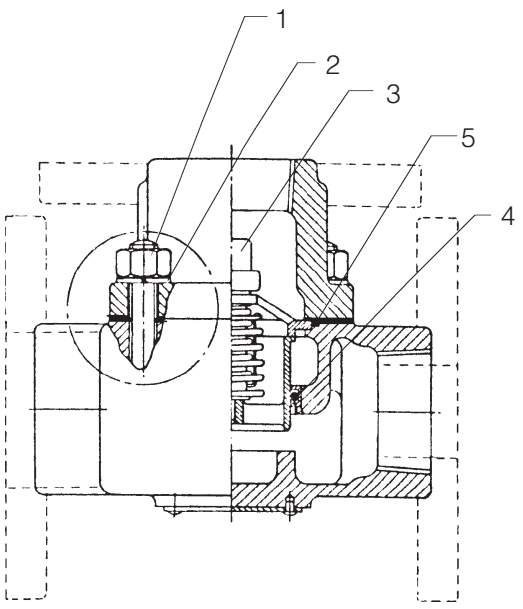
General

The thermostatic valve cannot be adjusted and under normal working conditions maintenance is not required. However, in some cases it is necessary to replace the elements in the thermostatic valve.



1. Nut
2. Washer
3. Element
4. O-rings sealing
5. Gasket

Fig. 1 Thermostatic valve

Replacement of elements:

1) Remove nuts (1) and washers (2), 4 or 6 pcs. See fig. 1.

2) Disconnect upper and lower part of the housing.

3) Remove the assembled elements (3) and the elements O-ring sealing.

4) Remove the gaskets between the upper and lower part of the housing.

5) The upper and lower part of the housing are thoroughly cleaned inside and on the gasket surfaces.

6) The sealing rings (4) for the elements in the housing are replaced and lubricated with a thin layer of copaslip.

7) Remount the assembled elements in the housing by wriggling these somewhat over side.

8) Upper and lower part of the housing are assembled with a new gasket (5), the nuts (1) are mounted and tightened "cross-wise".

Note:

After inspection or replacement of the elements the lub. oil temperature is checked to ensure that the elements are working correctly.

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Working Card Page 1 (2)	**Check of Lubricating Oil Piping System**	**615-01.90** Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Check and examination of the lubricating oil piping system.

Starting position:

Engine running.

Related procedure:

Man power:

Working time : ½ hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

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General

Checks to be carried out.

1) Examine the piping system for leaks.

2) Retighten all bolts and nuts in the piping system.

3) Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.

4) Blow-through drain pipes.

5) Check flexible connections for leaks and damages.

6) Check manometers and thermometers for possible damages.
For lubricating oil condition, see section 604.

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Working Card Page 1 (4)	**Lubricating Oil Cooler**	**615-06.00** Edition 02H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ■ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Separation, cleaning and assembling.
Replacement of plates and gaskets.

Starting position:

Cooling water and lub. oil have been drained from cooler/engine. All pipes are disconnected.

Related procedure:

Manpower:

Working time : 4 hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate No	Item No	Note

Hand tools:

Ring and open end spanner	10 mm
Ring and open end spanner	55 mm
Ring and open end spanner	30 mm
Adjustable spanner	

Replacement and wearing parts:

Plate No	Item No	Qty./
61506	09	4/cooler

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L+V28/32H

Introduction

Cleaning of the cooler has to take place, when the pressure drop on the oil and water side is larger than allowable and/or if the oil cannot be sufficiently cooled.

Separation

Cooling and Pressure Relief

Before opening the plate heat exchanger, it has to be cooled down to below 40° C and be without pressure!

The cooling must ***not*** exceed 10° C per minute.
The pressure drop must ***not*** exceed 10 bar per minute.

Note: If these norms are exceeded, the guarantee will cease to be valid.

Separation of Edge-clamped Frame

Upon completion of the procedure “Cooling and Pressure Relief”, separate the frame by retaining two or four diagonally placed bolts.

Note: Take care that the movable cover does not tilt!

Loosen all bolts uniformly and diagonally (max. 10 mm at a time), then push the movable cover towards the pillar. When the pressure plate is not tight anymore, the plates can be removed.

Note: When using plate heat exchangers on board ships, the movable covers have to be secured in order to avoid danger due to the movements of the ship.

Cleaning

The capacity and corrosion resistance of the plate heat exchangers depend on the purity of the plates. Any coating on the plates can be removed manually.

Manual Cleaning

Clean the plates with a soft brush and a suitable detergent. In case of dense coating of scale or organic materials, the plates must be put in a bath of detergent.

Note: Never use a steel brush, metal scraper or the like.

A high-pressure cleaner can be used with care, however, never with sand or other abrasives added.

Detergents

A detergent is suitable, if it will remove any coating on the plates without causing any damage to plates and gaskets.

Note: It is of great importance that decomposition of the protective film on the stainless steel does not take place - the film preserves the corrosion resistancy of the steel.

Do ***not*** use chlorine-containing agents such as hydrochloricacid (HCl)!

Oil and fats are removed by using a **water emulsifying oil solvent**, e.g. BP-system cleaner.

Organic and greasy coatings are removed by using **sodium hydroxide (NaOH)**:

- max. concentration 1.5%
  (1.5% concentration corresponds to 3.75 l 30% NaOH per 100 l water).
- max. temperature 85° C.

Stone and lime/calcareous deposits are removed by using **nitric acid (HNO_3)**:

- max. concentration 1.5%
  (1.5% concentration corresponds to 1.75 l 62% HNO_3 per 100 l water).
- max. temperature 65° C.

Note: The nitric acid has an important constructive effect on the protective film of stainless steel.

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Control of Cleaning Fluid Concentrations

Sodium hydroxide (NaOH) solution is tritrated with 0.1 n hydro-chloric acid (HCl) with methyl orange or methyl red as indicator.

Nitric acid (HNO_3) solution is titrated with 0.1 n sodium hydroxide (NaOH) with phenolphtalin as indicator.

The concentration of the cleaning fluid in % can be calculated from the titration result by means of the following formula:

$$\text{Concentration} = \frac{b \times n \times m}{a \times 10} \%$$

a : ml cleaning fluid taken out for titration
b : ml titration fluid used as cover
n : the molecular concentration of titration fluid
m : The molecular weight of the cleaning fluid (NaOH) molecular weight 40, HNO3 molecular weight 63)

Replacement of Plates and Gaskets

Marking

The plates are marked with material codes and reference numbers at each end, plus codes for non-glue gaskets, if any, and stamped with the letter V and H at either end *(Fig 1)*.

Looking towards the gasket side, the plate is designated as a left plate, when the letter V is turning upwards - and a right plate when the letter H is turning upwards. Inlets and outlets of the V-plates are taking place through the corner holes Nos 1 and 4. Inlets and outlets of the H-plates are taking place through the corner holes Nos 2 and 3.

Replacement of Plates

Before mounting a spare plate in the plate stack, please make sure that the spare plate is identical with the defective plate.

Note: The same corner holes must be open and the letters V and H must be placed correctly.

Replacement of Glued Gaskets

On Plate 61506 are stated gasket and glue quantity.

Please use a degreasing agent on the new gaskets.

The first plate after the end cover and the connector grid must have gaskets in all grooves. The gaskets are to be cut according to the existing gaskets.

Loosen the glued gaskets by heating the plate in water at 100° C. Clean the plates and remove the coatings, if any.

Cleaning of New Gaskets and Plates

New gaskets and gasket grooves of the plates are cleaned with a cloth moistened with degreasing agent. The glue surfaces ***must*** be absolutely clean - without finger prints etc.

Please use our cleaning fluid, which is according to suppliers recommendations.

Alternatively, please use:

- Trichloroethylene
- Chlorothene VG
- Acetone
- Methyl ethyl ketone
- Ethylacetat

It is important that all degreasing agent has evaporated, before the glue is applied. This will normally take approx. 15 min. at 20° C.

Clean the new gaskets on the glue surfaces with fine-grain sandpaper instead of the degreasing agent supplied.

Gluing

Pliobond 25, which is a nitrile rubber glue on solvent basis (25% solids). The glue is applied with a brush in a thin layer on the backs of the gaskets and the gaskets are to dry in a clean place free of dust.

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L+V28/32H

Apply a thin layer of glue on the gasket grooves of the plates and press the gaskets down into the gasket grooves.

The insertion of gaskets starts at both ends of the plate - and continues with the straight sections along the edges.

The gluing process is most easily effected by placing the gaskets and the plates on a table. After having pressed the gaskets into the grooves of a plate, it is stacked.

The plates with the gaskets are now mounted in the frame which is lightly clamped. In case of use of rubber grooves, they are assembled to the minimum measure stated on the engine sign plus 0.2 mm per plate.

Heat up the plate heat exchanger to 90-100°C by means of water or steam.

Please note:

- The temperature must be kept for 1½-2 hours.
- The liquid pressure must be kept as low as possible.

If there is no possibility of heating the plate heat exchanger, it must be placed in a spot as warm as possible with dismounted connections.

The drying time will at 20°C be approx. 48 hours. At for instance 40°C, the drying time is reduced to approx. 24 hours.

Assembling

If the plates have been dismounted, they have to be correctly assembled according to the plate item numbers.

The fixed cover has number 1 and the serial numbers for the subsequent plates and intermediate frames, if any, have the numbers 2, 3, 4, 5 etc.

The serial number are stamped in the right top corner of the plates. Further, **please note** that the gasket side must face the fixed cover.

Fastening

Fasten the plate heat exchanger until the movable cover touches the duct spacers.

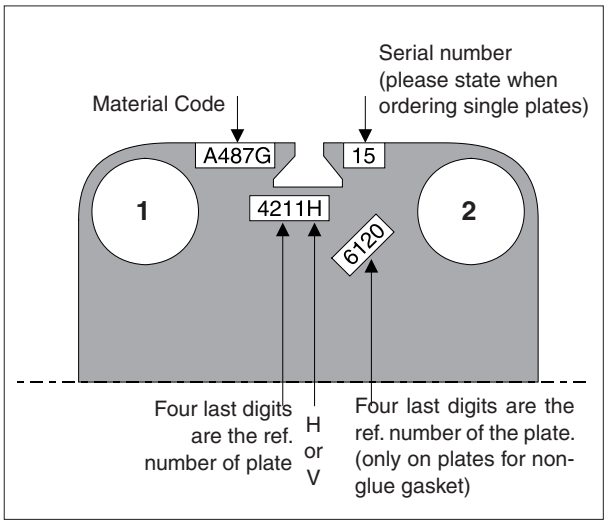

Fig. 1.

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Working Card Page 1 (3)	**Centrifugal Bypass Filter**	**615-15.00** Edition 01H

L/V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Cleaning procedure, cleaning intervals. Maintenance intervals and procedures.

Starting position:

Isolate the filter for lub. oil inlet

Related procedure:

Man power:

Working time : 1 Hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Big adjustable spanner.
Tools for cleaning.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
61515	39	1/Filter
61515	40	1/Filter
61515	41	1/Filter
61515	42	1/Filter

L/V28/32H

Cleaning procedure:

1) Isolate the filter by closing the valve for lubricating oil inlet to the filter.

2) Slacken cover clamp ring (26), see fig. 1. Unscrew cover nut (27) and lift off cover (31).

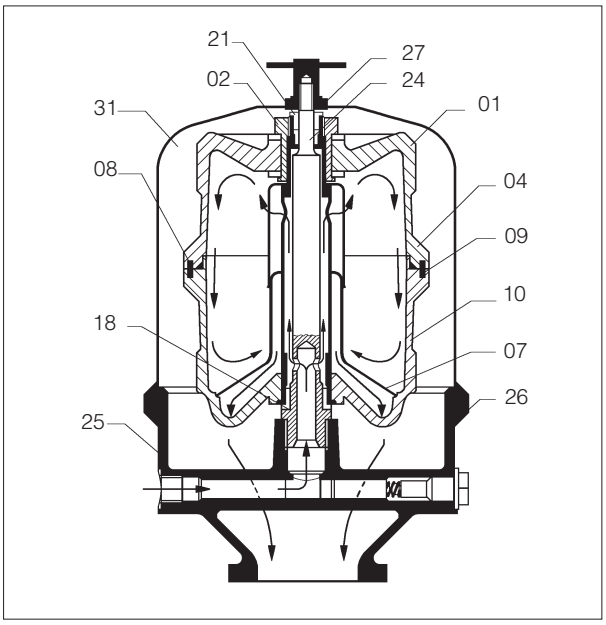


Fig. 1 Centrifugal Bypass Filter

3) Lift off rotor assembly (01) having allowed the oil to drain from the nozzles. Ensure that the rotor assembly is removed from and replaced on to the spindle (24) with extreme care so as not to damage the bushes (18) and (21).

4) Unscrew rotor cover jacking nut (2) and separate rotor cover (4) from rotor body (10).

5) Remove sludge from inside the rotor by means of a spatula and wipe clean. Then remove standtube (07). Ensure that all rotor components are thoroughly cleaned and free from deposits of dirt before reassembling the rotor. Failure to do so could cause an out-of-balance condition which will accelerate bearing and spindle wear.

6) Reassemble rotor body on to rotor base. Ensure that locating pins (8) and (9) in joint face of body align with holes in cover and that standtube fits correctly in the rotor base.

7) Examine spindle in areas corresponding to top and bottom bushes. If damaged or worn replace with body assembly complete (25).

8) Replace rotor on to spindle ensuring rotor revolves freely. Then replace body cover. Tighten cover nut by hand only and refit safety cover clamp ring. The clamp ring must be securely fitted at all times when the filter is running. Do not run filter with clamp ring loose.

9) Open for lubricating oil.

10) With filter running, check all joints for leakage. Check for excessive vibration.

Cleaning intervals:

It is recommended to clean the centrifugal filter every 100 hours maximum or when the dirt deposit is 25 mm thick, whichever comes first. For cleaning intervals, see also page 600.25.

Maintenance intervals and procedures:

Recommended maintenance intervals for the filter are as follows:

At 3000 hours change O-rings (23, 06 and 29). Change these sooner if damaged. See Plate 61515.

At 12000 hours change tube assembly (17). The procedure for removing the tube assembly is to secure the rotor base in a tool, loosen circlip (19) and with pressure applied via a fly press or hide mallet extract tube assembly from rotor base. See Plate 61515.

For inserting new tube assembly invert the rotor base and follow reverse of above procedure ensuring that pin (20) is correctly aligned with recess in rotor base. See Plate 61515.

At 24000 hours replace the filter complete.

Important note:

The maximum bush clearances when new are 0.10 mm in the top bush (21) and 0.13 mm in the bottom bush (18). See fig. 1.
Dependent on the conditions, wear will eventually take place both on the spindle and on the bushes and if clearance is found to be in excess of 0.35 mm in top bush or 0.33 mm in bottom bush, then replace with new bearing tube assembly.

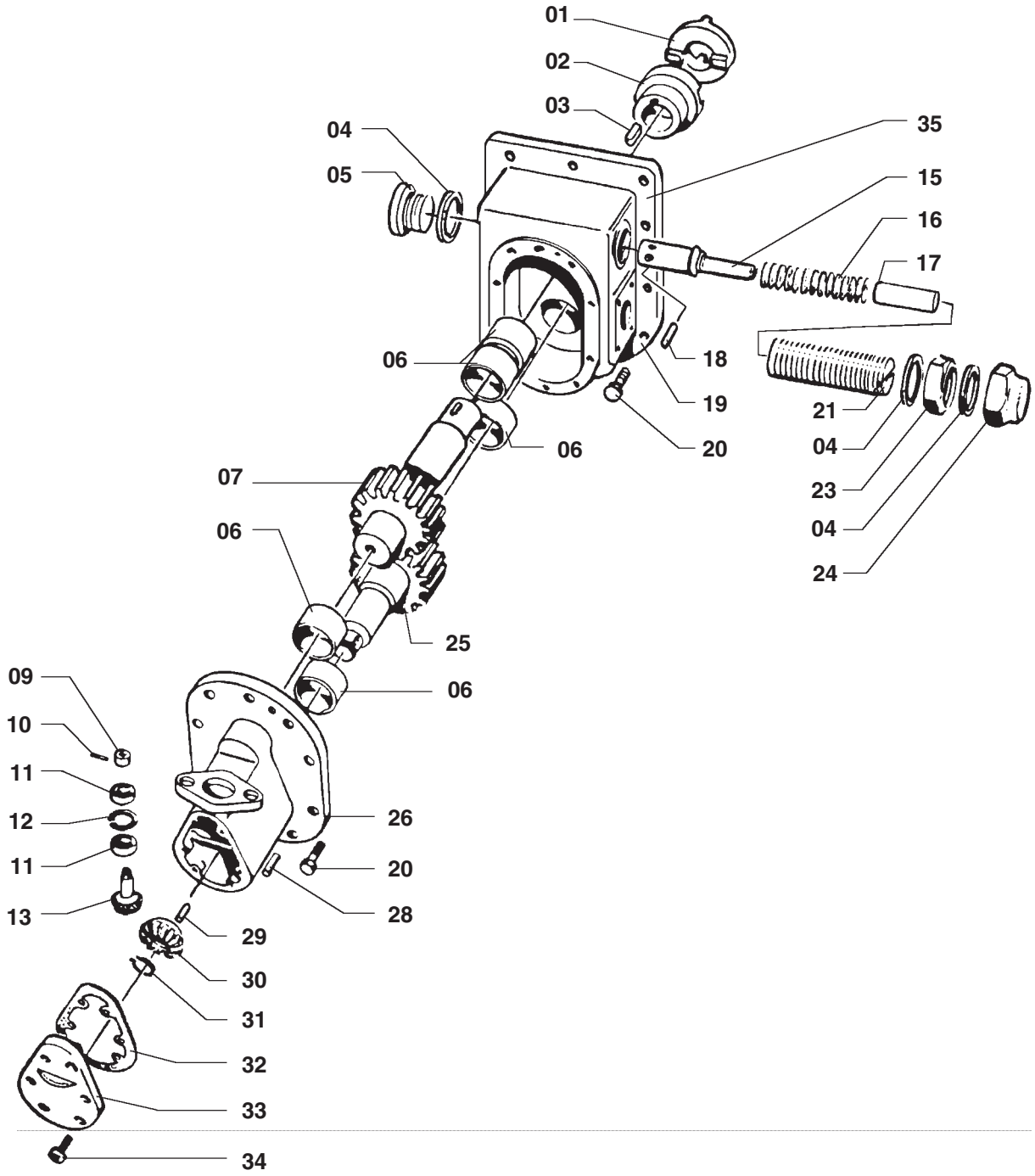
The spindle/body assembly (25) and the rotor bearing tube assembly (17) are factory assembled items and should only be replaced with complete assemblies.

All rotors are precision balanced before leaving the factory.

Trouble shooting guide for centrifugal bypass filter, see page 603.05

Plate Page 1 (2)	**Lubricating Oil Pump (Central driven)**	**61501-12H**

L28/32H



08028-0D/H5250/94.08.12

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Dog**	Medbringer
02	1/P	**Coupling**	Kobling
03	1/P	**Key**	Feder
04	3/P	**Gasket**	Pakning
05	1/P	**Plug screw**	Propskrue
06	5/P	**Bush**	Foring
07	1/P	**Gear wheel**	Tandhjul
09	1/P	**Sleeve**	Muffe
10	1/P	**Spring pin**	Fjederstift
11	2/P	**Ball bearing**	Kugleleje
12	1/P	**Circlip**	Sikringsring
13	1/P	**Cog wheel**	Konisk tandhjul
15	1/P	**Piston**	Stempel
16	1/P	**Spring**	Fjeder
17	1/P	**Cylinder**	Cylinder
18	2/P	**Guide pin**	Styrestift
19	1/P	**Pump housing**	Pumpehus
20	20/P	**Screw**	Skrue
21	1/P	**Adjusting screw**	Juster skrue
23	1/P	**Nut**	Møtrik
24	1/P	**Cap nut**	Kapselmøtrik
25	1/P	**Gear wheel**	Tandhjul
26	1/P	**End cover**	Endedæksel
28	2/P	**Cylindrical pin**	Cylindrisk stift
29	1/P	**Key**	Feder
30	1/P	**Cog wheel**	Konisk tandhjul
31	1/P	**Circlip**	Sikringsring
32	1/P	**Gasket**	Pakning
33	1/P	**Cover**	Dæksel
34	6/P	**Screw**	Skrue
35	1/E	**Lub. oil pump, complete**	Smøreoliepumpe, komplet

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

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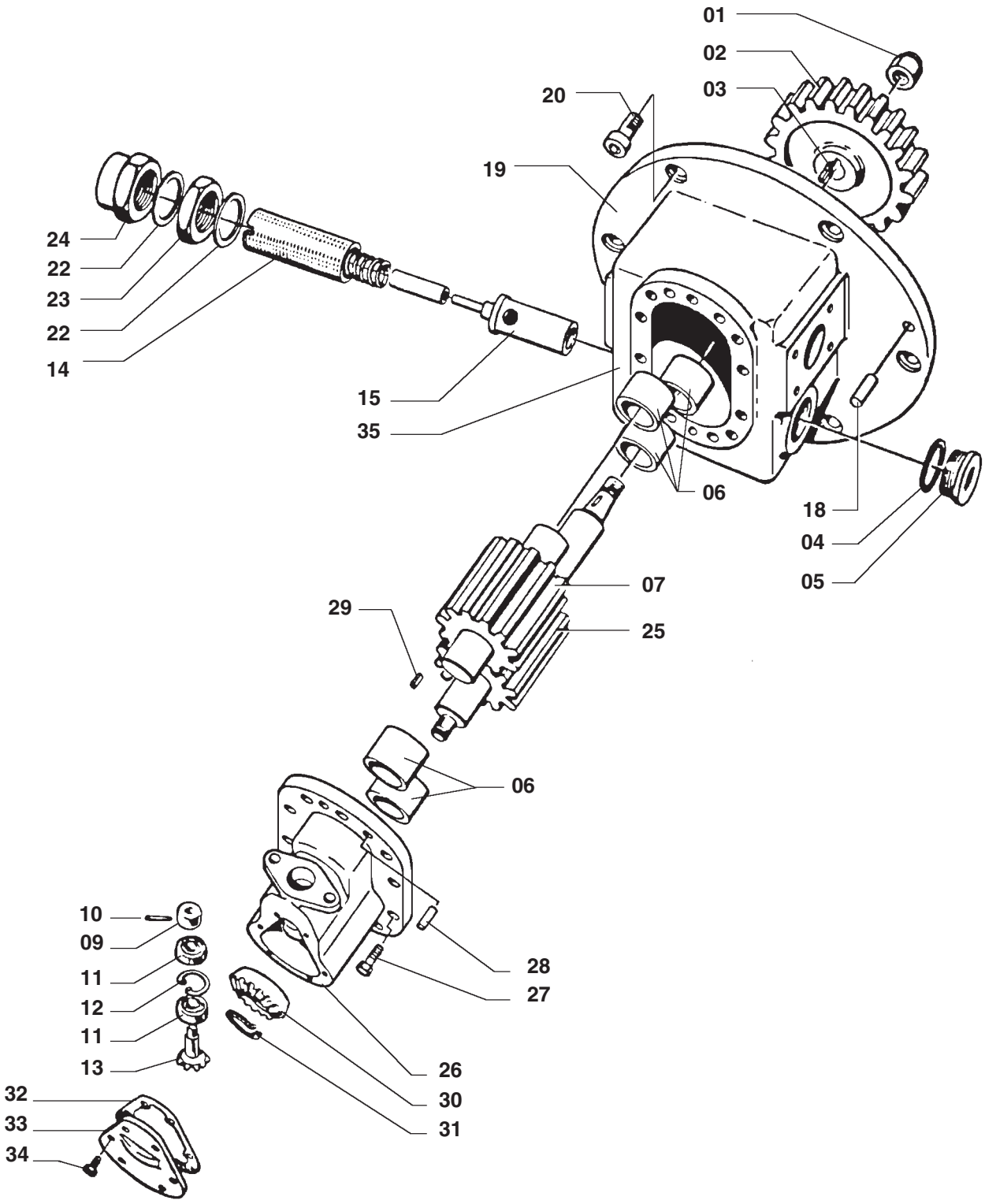
Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Plate Page 1 (2)	Lubricating Oil Pump (Gear driven)	61501-22H

L28/32H



08028-0D/H5250/94.08.12

61501-22H	Lubricating Oil Pump (Gear driven)	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Nut**	Møtrik
02	1/P	**Gear wheel**	Tandhjul
03	1/P	**Key**	Feder
04	1/P	**Gasket**	Pakning
05	1/P	**Plug screw**	Propskrue
06	5/P	**Bush**	Bøsning
07	1/P	**Shaft with gear wheel, short**	Aksel med tand-hjul, kort
09	1/P	**Socket**	Muffe
10	1/P	**Pin**	Stift
11	2/P	**Ball bearing**	Kugleleje
12	1/P	**Circlip**	Sikringsring
13	1/P	**Cog wheel**	Konisk tandhjul
14	1/P	**Piston, complete**	Trykregulering - stempel, komplet
15	1/P	**Piston**	Stempel
16	1/P	**Spring**	Fjeder
17	1/P	**Cylinder**	Cylinder
18	2/P	**Guide pin**	Styrestift
19	1/P	**Pump housing, incl. bushes**	Pumpehus, inkl. bøsninger
20	6/P	**Screw**	Skrue
21	1/P	**Adjusting screw**	Justerskrue
22	2/P	**Gasket**	Pakning
23	1/P	**Nut**	Møtrik
24	1/P	**Cap nut**	Hættemøtrik
25	1/P	**Shaft with gear wheel, long**	Aksel med tand-hjul, lang
26	1/P	**End cover, incl. bushes**	Endedæksel, inkl. bøsninger
27	10/P	**Screw**	Skrue
28	2/P	**Cylindrical pin**	Cylindrisk stift
29	1/P	**Key**	Feder
30	1/P	**Cog wheel**	Konisk tandhjul
31	1/P	**Circlip**	Sikringsring
32	1/P	**Gasket**	Pakning
33	1/P	**Cover**	Dæksel
34	6/P	**Screw**	Skrue
35	1/E	**Lub. oil pump, complete**	Smøreoliepumpe, komplet

When ordering spare parts, see also page 600.50.

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Qty./P = Qty./Pump

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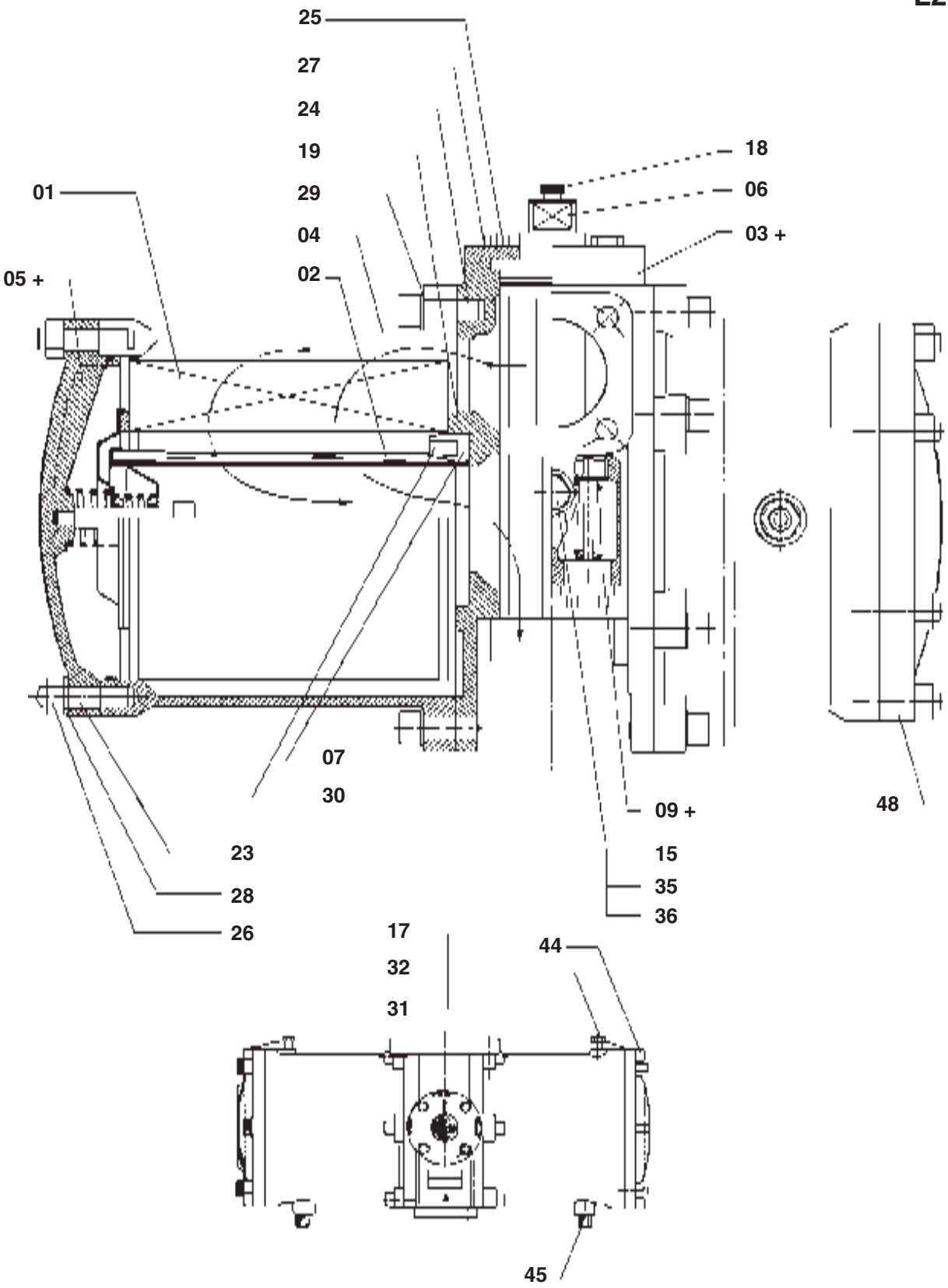
Antal/P = Antal/Pumpe

08028-0D/H5250/94.08.12

Plate Page 1 (2)	**Lubricating Oil Filter (Type A)**	**61502-11H**

L28/32H



+ For detaljer se / for details see Plate 61502-15H

08028-0D/H5250/94.08.12

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	2/F	**Paper element**	Papirelement
02	2/F	**Safety element**	Sikkerhedselement
03 +	1/F	**Valve housing, incl. item 07 and 30**	Ventilhus, inkl. item 07 og 30
04	2/F	**Housing, incl. O-ring**	Hus, inkl. O-ring
05 +	2/F	**Cap, complete, incl. item 12, 13, 14, 19 and 20**	Dæksel , komplet, inkl. item 12, 13, 14, 19 og 20
06	1/F	**Spindle, incl. item 8, 18 and 37**	Spindel, inkl. item 8, 18 og 37
07	2/F	**Thrust ring**	Trykring
09 +	2/F	**By-pass code, incl. item 10, 11, 16, 34 and 49**	By-passventil, inkl. item 10, 11, 16, 34 og 49
15	1/F	**Plug to indicator hole, incl. O-rings**	Propskrue til indikator hul, inkl. O-ringe
17	2/F	**Vent screw, incl. item 31 and 32**	Luftskrue, inkl. item 31 og 32
18	1/F	**Fill-up valve**	Opfyldningsventil
19	4/F	**Sealing ring**	Tætningsring
23	12/F	**Stud**	Støttetap
24	12/F	**Screw**	Skrue
25	4/F	**Screw**	Skrue
26	12/F	**Nut**	Møtrik
27	4/F	**Washer**	Skive
28	12/F	**Washer**	Skive
29	12/F	**Washer**	Skive
30	5/F	**Pin**	Tap
31	6/F	**Pin**	Tap
32	2/F	**Gasket**	Pakning
35	1/F	**O-ring**	O-ring
36	1/F	**O-ring**	O-ring
44	2/F	**Opening guard, incl. vent screw**	Åbningsbeskyttelses-skærm, inkl. luftskrue
45	2/F	**Drain plug**	Drænskrue
47	1/F	**Seal kit, not shown on the front side of the plate**	Pakningssæt, ikke vist på forsiden af platen
48	1/E	**Lub. oil filter, complete**	Smøreoliefilter, komplet

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

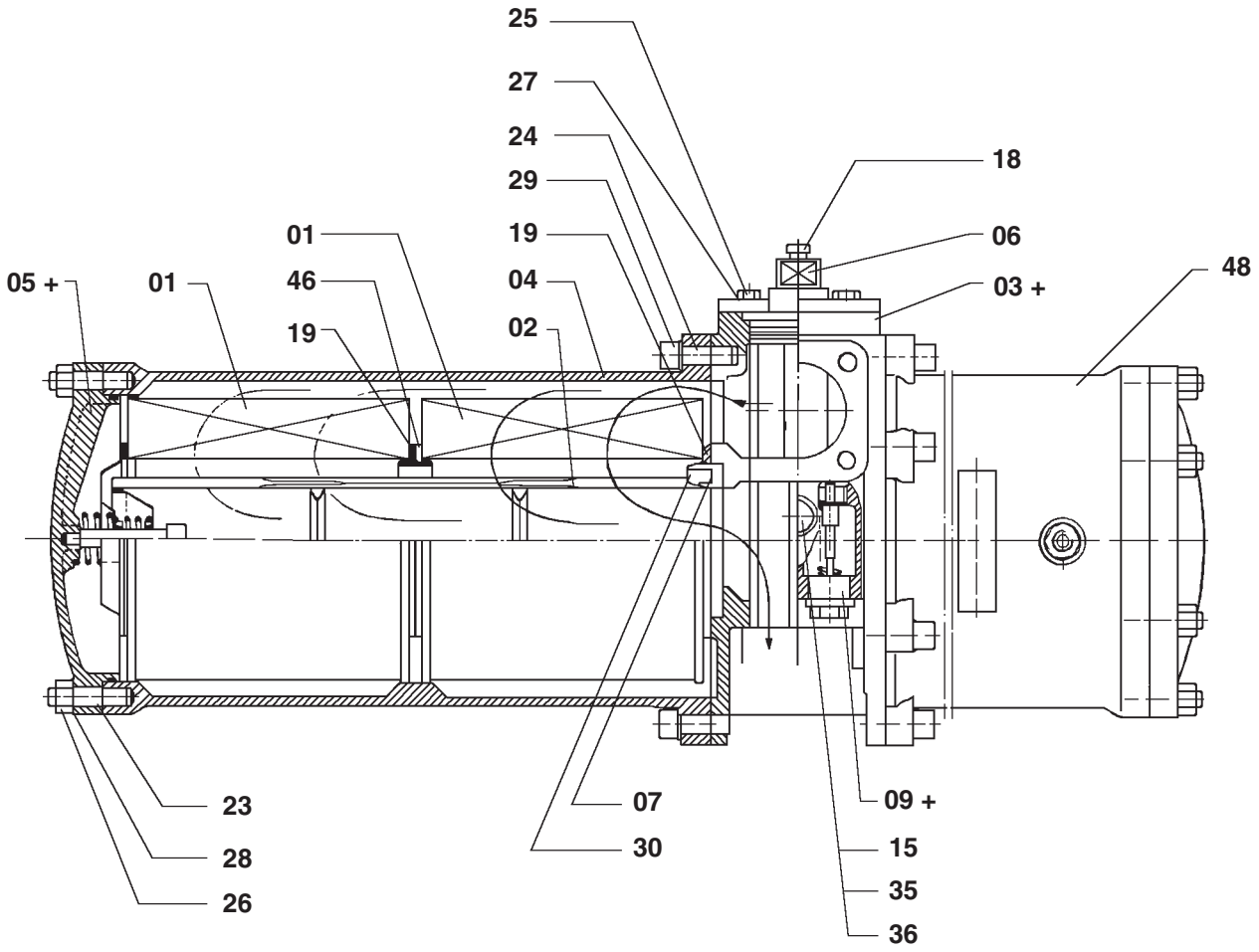
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./F = Qty./Filter

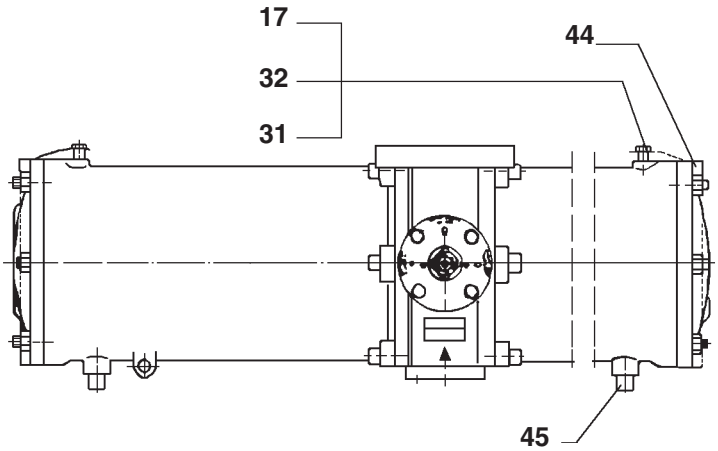
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/F = Antal/Filter

Plate Page 1 (2)	Lubricating Oil Filter (Type B)	61502-12H

L+V28/32H





+ For detaljer se / for details see Plate 61502-15H

08028-0D/H5250/94.08.12

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	4/F	**Paper element**	Papirelement
02	2/F	**Safety element**	Sikkerhedselement
03 +	1/F	**Valve housing, incl. item 07 and 30**	Ventilhus, inkl. item 07 og 30
04	2/F	**Housing, incl. O-ring**	Hus, inkl. O-ring
05 +	2/F	**Cap, complete, incl. item 12, 13, 14, 19 and 20**	Dæksel , komplet, inkl. item 12, 13, 14, 19 og 20
06	1/F	**Spindle, incl. item 8, 18 and 37**	Spindel, inkl. item 8, 18 og 37
07	2/F	**Thrust ring**	Trykring
09 +	2/F	**By-pass code, incl. item 10, 11, 16, 34 and 49**	By-passventil, inkl. item 10, 11, 16, 34 og 49
15	2/F	**Plug to indicator hole, incl. O-rings**	Propskrue til indikator hul, inkl. O-ringe
17	2/F	**Vent screw, incl. item 31 and 32**	Luftskrue, inkl. item 31 og 32
18	1/F	**Fill-up valve**	Opfyldningsventil
19	8/F	**Sealing ring**	Tætningsring
23	12/F	**Stud**	Støttetap
24	12/F	**Screw**	Skrue
25	4/F	**Screw**	Skrue
26	12/F	**Nut**	Møtrik
27	4/F	**Washer**	Skive
28	12/F	**Washer**	Skive
29	12/F	**Washer**	Skive
30	5/F	**Pin**	Tap
31	6/F	**Pin**	Tap
32	2/F	**Gasket**	Pakning
35	1/F	**O-ring**	O-ring
36	1/F	**O-ring**	O-ring
44	2/F	**Opening guard, incl. vent screw**	Åbningsbeskyttelses-skærm, inkl. luftskrue
45	2/F	**Drain plug**	Drænskrue
46	2/F	**Spacer ring, complete incl. seal**	Afstandsring, komplet inkl. tætning
47	1/F	**Seal kit, not shown on the front side of the plate**	Pakningssæt, ikke vist på forsiden af platen
48	1/E	**Lub. oil filter, complete**	Smøreoliefilter, komplet

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

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Qty./F = Qty./Filter

Ved bestilling af reservedele, se også side 600.50.

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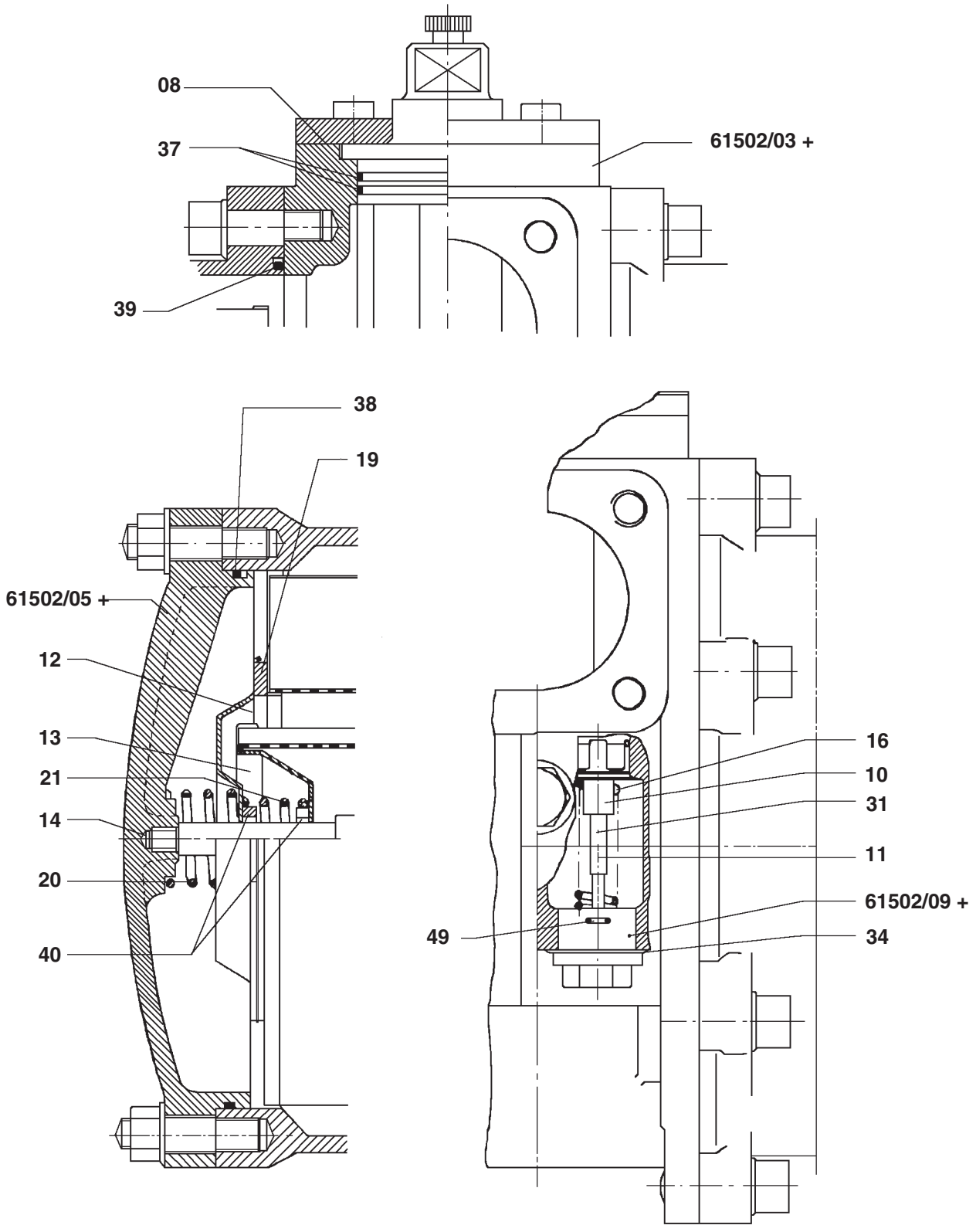
Antal/E = Antal/Motor
Antal/F = Antal/Filter

Plate Page 1 (2)	**Lubricating Oil Filter (Suppl. for Plate 61502-11H/12H)**	**61502-15H**

L+V28/32H



08028-0D/H5250/94.08.12

+ se/see Plate 61502-11H (Type A), Plate 61502-12H (Type B)

61502-15H	Lubricating Oil Filter (Suppl. for Plate 61502-11H/12H)	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
08	1/F	**Cap**	Dæksel
10	2/F	**By-pass valve seat**	By-passventilsæde
11	2/F	**By-pass valve spool**	By-passvnetilspindel
12	2/F	**Flange**	Flange
13	2/F	**Flange**	Flange
14	2/F	**Screw**	Skrue
16	2/F	**By-pass valve spring**	By-passventilfjeder
19	8/F	**Seal**	Tætningsring
20	2/F	**Spring**	Fjeder
21	2/F	**Spring**	Fjeder
31	6/F	**Pin**	Stift
34	2/F	**Gasket**	Pakning
37	2/F	**O-ring**	O-ring
38	2/F	**O-ring**	O-ring
39	2/F	**O-ring**	O-ring
40	4/F	**O-ring**	O-ring
49	2/F	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

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Qty./F = Qty./Filter

Ved bestilling af reservedele, se også side 600.50.

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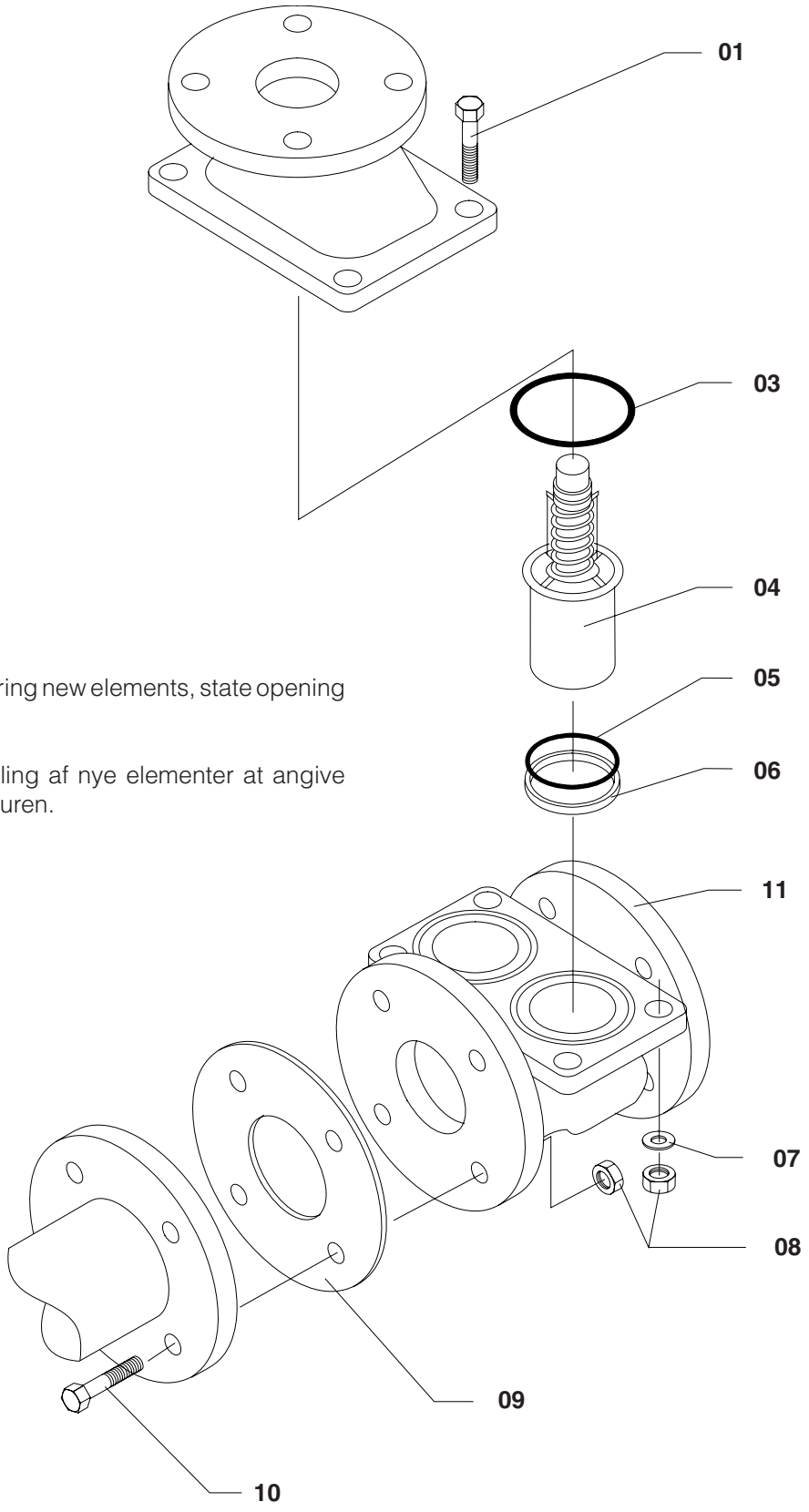
Antal/F = Antal/Filter

Plate Page 1 (2)	**Lubricating Oil Thermostatic Valve**	**61503-08H**

L28/32H



Note: When ordering new elements, state opening temperature.

Husk! Ved bestilling af nye elementer at angive åbningstemperaturen.

61503-08H	Lubricating Oil Thermostatic Valve	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	4/T	**Screw**	Skrue
03	2/T	**O-ring**	O-ring
04	2/T	**Thermostatic element**	Følerelement
05	2/T	**O-ring**	O-ring
06	2/T	**Sleeve**	Bøsning
07	4/T	**Washer**	Skive
08	16/T	**Nut**	Møtrik
09	3/T	**Gasket**	Pakning
10	12/T	**Screw**	Skrue
11	1/E	**Thermostatic valve, complete**	Termostatventil, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

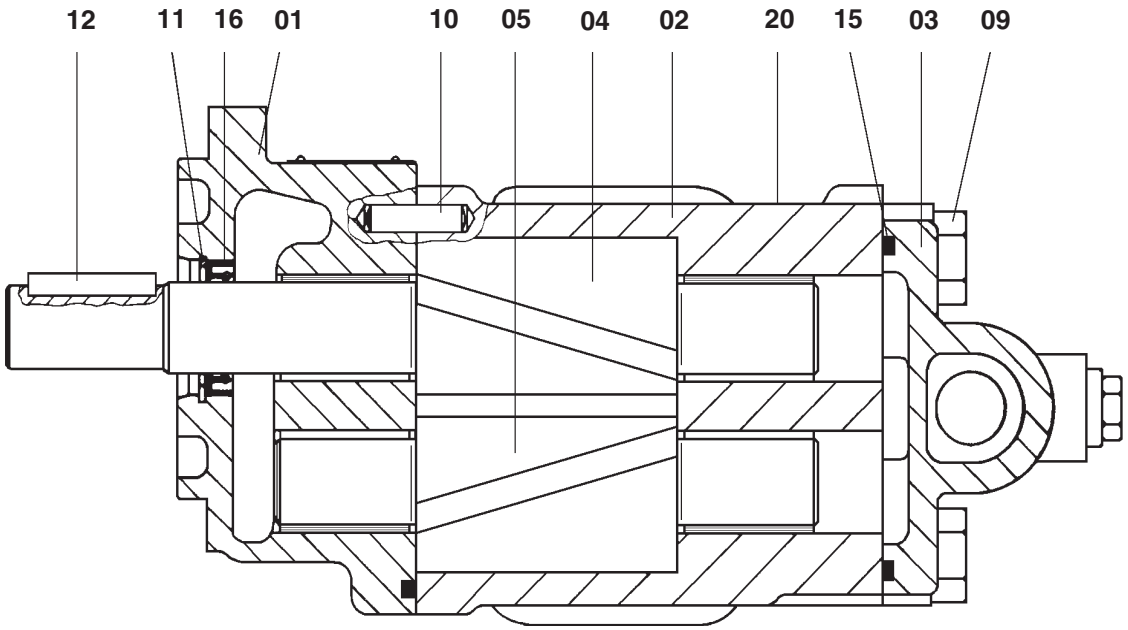
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./T = Qty./Thermostatic valve

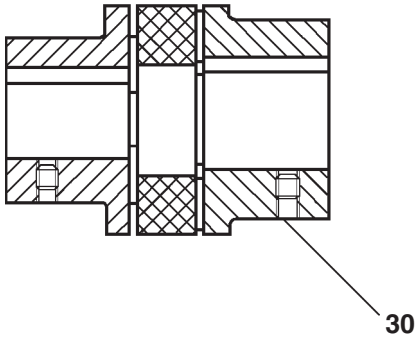
Ved bestilling af reservedele, se også side 600.50.

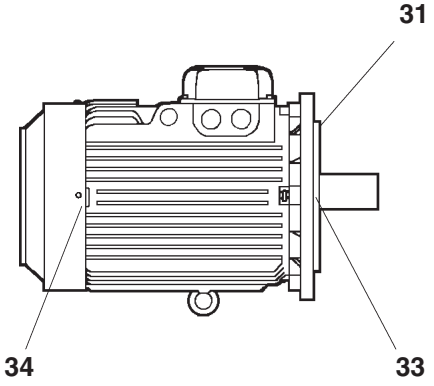
* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/T = Antal/Termostatsventil

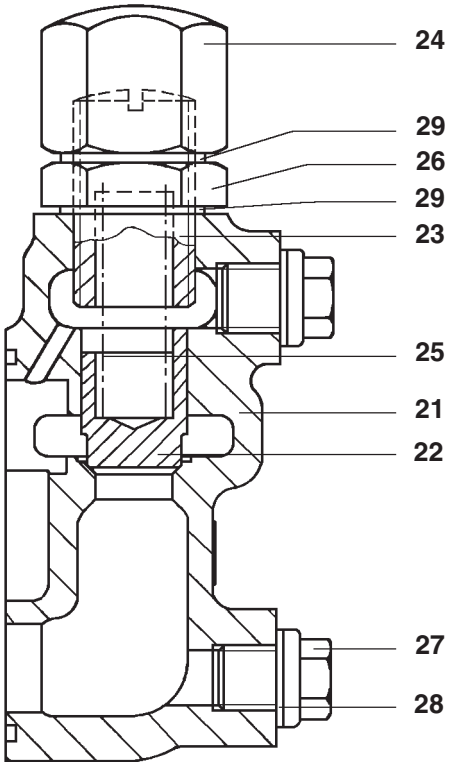
Plate Page 1 (2)	**Prelubricating Pump with El-Motor**	**61504-04H**

L28/32H









61504-04H	Prelubricating Pump with El-Motor	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Driving cover**	Medbringerdæksel
02	1/P	**Gear casing**	Gearhus
03	1/P	**End cover, complete, incl. item 21 to 29**	Endedæksel, komplet inkl. item 21 til 29
04	1/P	**Driving gear shaft**	Drivende gear aksel
05	1/P	**Gear shaft**	Gear aksel
09	4/P	**Screw**	Skrue
10	2/P	**Parallel pin**	Styrestift
11	1/P	**Retaining ring**	Sikringsring
12	1/P	**Parallel key**	Not
15	2/P	**O-ring**	O-ring
16	1/P	**Rotary shaft seal**	Roterende aksel tætning
20	1/E	**Pumpe, complete without El-motor**	Pumpe, komplet uden el-motor
21	1/P	**End cover**	Endedæksel
22	1/P	**Piston**	Stempel
23	1/P	**Spindle**	Spindel
24	1/P	**Dome nut**	Lukkemøtrik
25	1/P	**Spring**	Fjeder
26	1/P	**Pipe nut**	Rørmøtrik
27	2/P	**Screwed plug**	Propskrue
28	2/P	**Sealing ring**	Tætningsring
29	2/P	**Sealing ring**	Tætningsring
30	1/P	**Coupling, complete**	Kobling, komplet
31	1/E	**El-motor, complete**	El-motor, komplet
32	1/E	**Pre.lub oil pump, complete with el-motor**	Forsmørepumpe, komplet med el-motor
33	1/E	**Ball bearing, rear**	Kugleleje, bagside
34	1/E	**Ball bearing, front**	Kugleleje, forside

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

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Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

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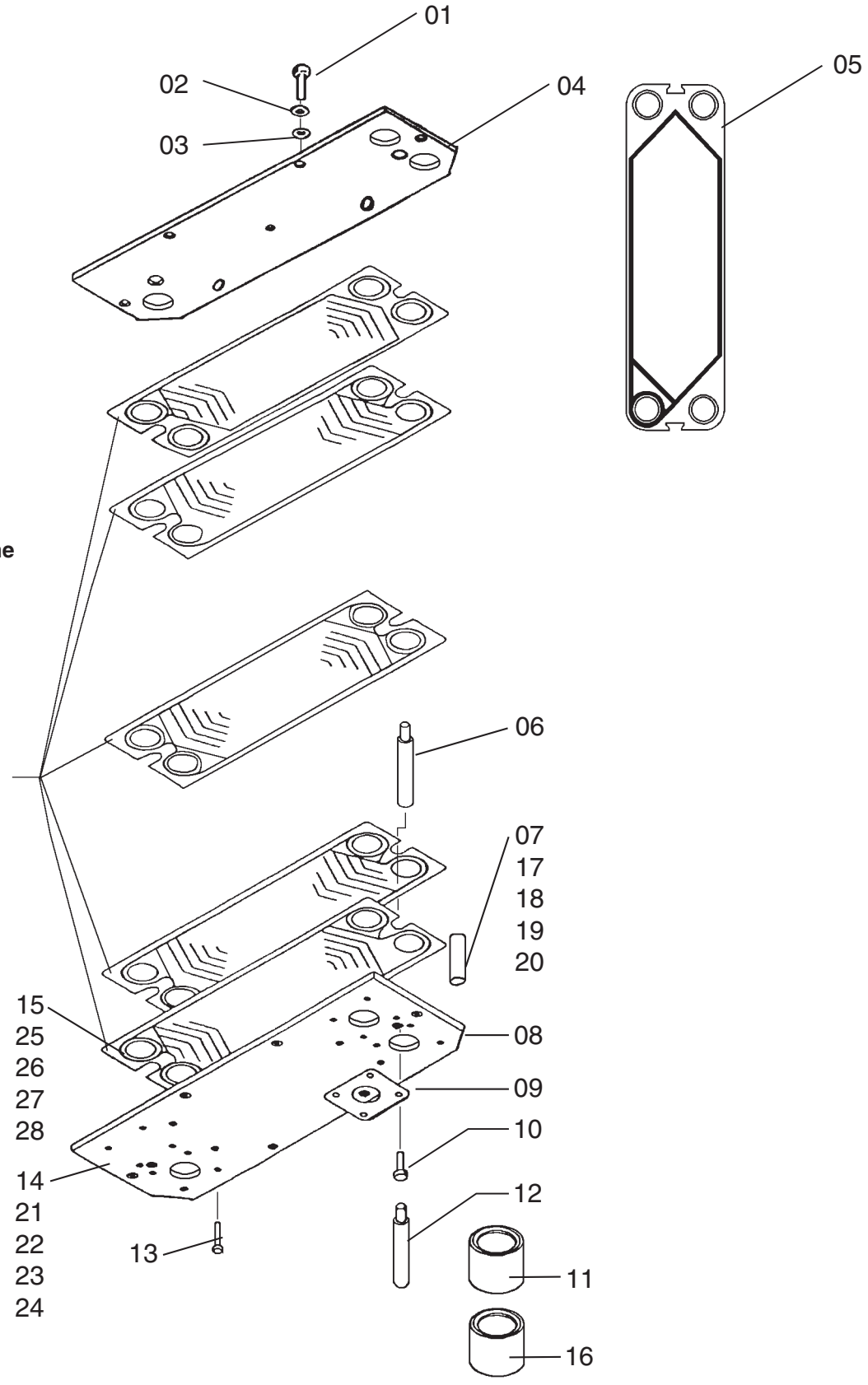
Antal/P = Antal/Pumpe

Plate Page 1 (2)	**Lubricating Oil Cooler**	**61506-10H**

L+V28/32H



Note: When ordering plates, please state the serial number of the plates. The serial number of the plates can be found in the top right-hand corner of the plates. (See Working Card 615-06.00).

Husk: Ved bestilling af plader angives serie-nummeret på pladen. Serienummeret er stemplet i toppen af pladen til højre. (Se arbejdskort 615-06.00).

08028-0E/H5250/94.08.12

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	6/K	**Hexagon screw**	Bolt
02	6/K	**Washer**	Skive
03	6/K	**Washer**	Skive
04	1/K	**Pressure plate**	Trykplade
05	/I	**Gasket**	Pakning
06	2/K	**Guide bar**	Styrepind
07	6/K	**Distance piece 5 cyl. engine**	Afstandsstykke 5 cyl. motor
08	1/K	**Frame plate**	Stativplade
09	4/K	**Gasket**	Pakning
10	2/K	**Screw**	Skrue
11	1/K	**Glue**	Lim
12	2/K	**Guide bar (for dismantling)**	Styrepind (for demontering)
13	32/K	**Screw**	Skrue
14	1/E	**Lubricating oil cooler, complete 5 cyl. engine**	Smøreoliekøler, komplet 5 cyl. motor
15	/I	**Plates 5 cyl. engine**	Plader 5 cyl. motor
16	/I	**Cleaning fluid**	Rensevæske
17	6/K	**Distance piece 6 cyl. engine**	Afstandsstykke 6 cyl. motor
18	6/K	**Distance piece 7 cyl. engine**	Afstandsstykke 7 cyl. motor
19	6/K	**Distance piece 8 cyl. engine**	Afstandsstykke 8 cyl. motor
20	6/K	**Distance piece 9 cyl. engine**	Afstandsstykke 9 cyl. motor
21	1/E	**Lubricating oil cooler, complete 6 cyl. engine**	Smøreoliekøler, komplet 6 cyl. motor
22	1/E	**Lubricating oil cooler, complete 7 cyl. engine**	Smøreoliekøler, komplet 7 cyl. motor
23	1/E	**Lubricating oil cooler, complete 8 cyl. engine**	Smøreoliekøler, komplet 8 cyl. motor
24	1/E	**Lubricating oil cooler, complete 9 cyl. engine**	Smøreoliekøler, komplet 9 cyl. motor
25	/I	**Plates 6 cyl. engine**	Plader 6 cyl. motor
26	/I	**Plates 7 cyl. engine**	Plader 7 cyl. motor
27	/I	**Plates 8 cyl. engine**	Plader 8 cyl. motor
28	/I	**Plates 9 cyl. engine**	Plader 9 cyl. motor

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./K = Qty./Cooler
Qty./I = Qty./Individual

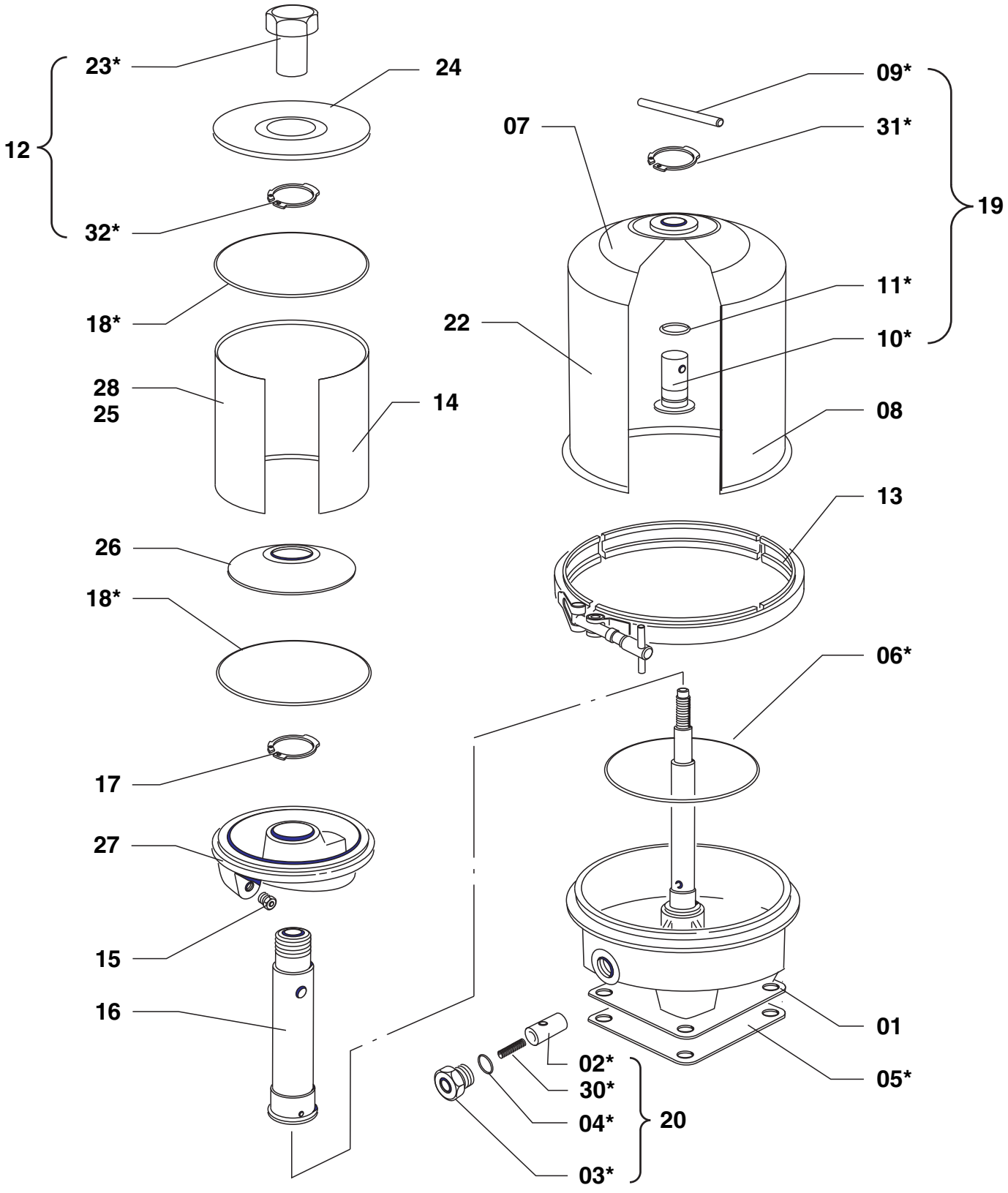
Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/K = Antal/Køler
Antal/I = Antal/Individuel

08028-0E/H5250/94.08.12

Plate Page 1 (2)	Centrifugal By-Pass Filter	61515-09H

L+V28/32H
L32/40



L+V28/32H L32/40

Item No.	Qty.	Designation	Benævnelse
01	1/F	**Body, assembly**	Sokkel, komplet
02*	1/F	**Valve body**	Ventilsokkel
03*	1/F	**Valve adaptor**	Ventiladapter
04*	1/F	**Valve seal**	Ventiltætning
05*	1/F	**Flange gasket**	Flangepakning
06*	1/F	**Filter body O-ring**	Filtersokkel O-ring
07	1/F	**Cover, complete**	Dæksel, komplet
08	1/F	**Cover**	Dæksel
09*	1/F	**Cover nut pin**	Stift for dækselmøtrik
10*	1/F	**Cover fixing nut**	Dækselmøtrik
11*	1/F	**Cover nut O-ring**	Dækselmøtrik O-ring
12	1/F	**Jacking nut kit, incl item 23 and 32**	Møtrik kit, inkl 23 og 32
13	1/F	**Band clamp**	Spændering
14	1/F	**Rotor, complete**	Rotor, komplet inkl
15	1/F	**Nozzle**	Dyse
16	1/F	**Bearing tube**	Lejerør
17	1/F	**Circlip**	Låsering
18*	2/F	**Rotor O-ring**	Rotor O-ring
19	1/F	**Cover nut fixing kit, incl item 10, 11, 31 and 09**	Dækselmøtrikskit, inkl item 10, 11, 31 og 09
20	1/F	**Valve kit, incl item 02, 03, 04, 30**	Ventilkit, inkl item 02, 03, 04, 30
21	1/F	**Seals kit, incl item 05, 06, 18**	Tætningskit, 05, 06, 18
22	1/E	**Centrifugal by-pass filter, complete**	Centrifugal by-pass filter, komplet
23*	1/F	**Nut**	Møtrik
24	1/F	**Rotor top**	Rotortop
25	1/F	**Paper insert**	Papir indsats
26	1/F	**Separation cone**	Afstandsbøsning
27	1/F	**Rotor base**	Rotor bund
28	1/F	**Rotor tube**	Rotor rør
30*	1/F	**Spring**	Fjeder
31*	1/F	**Circlip**	Låsering
32*	1/F	**Circlip**	Låsering

When ordering spare parts, see also page 500.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./F = Qty./Filter

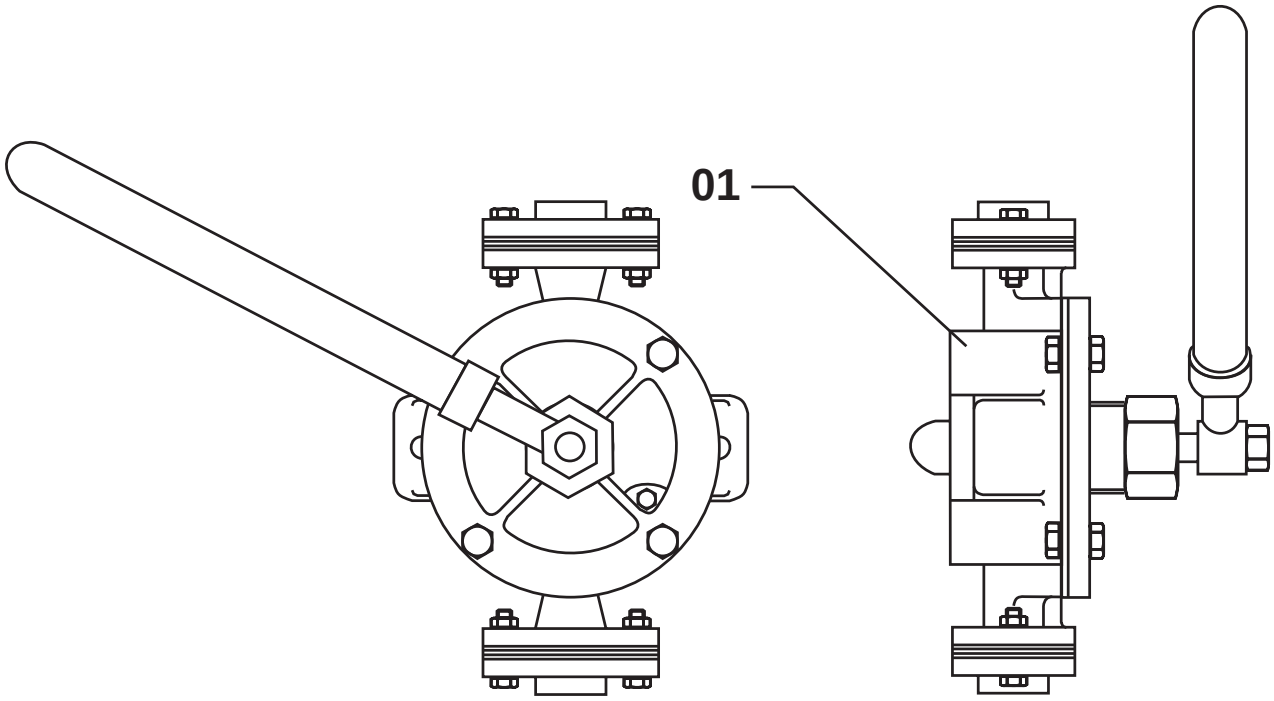
Ved bestilling af reservedele, se også side 500.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/F = Antal/Filter

08028-0E/H5250/94.08.12

Plate Page 1 (2)	**Hand Wing Pump**	**61525-02H**

L+V28/32H



08028-0E/H5250/94.08.12

61525-02H	Hand Wing Pump	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/E	**Hand wing pump, complete**	Håndvingepumpe, komplet

Item No.	Qty.	Designation	Benævnelse

08028-0E/H5250/94.08.12

When ordering spare parts, see also page 600.50.

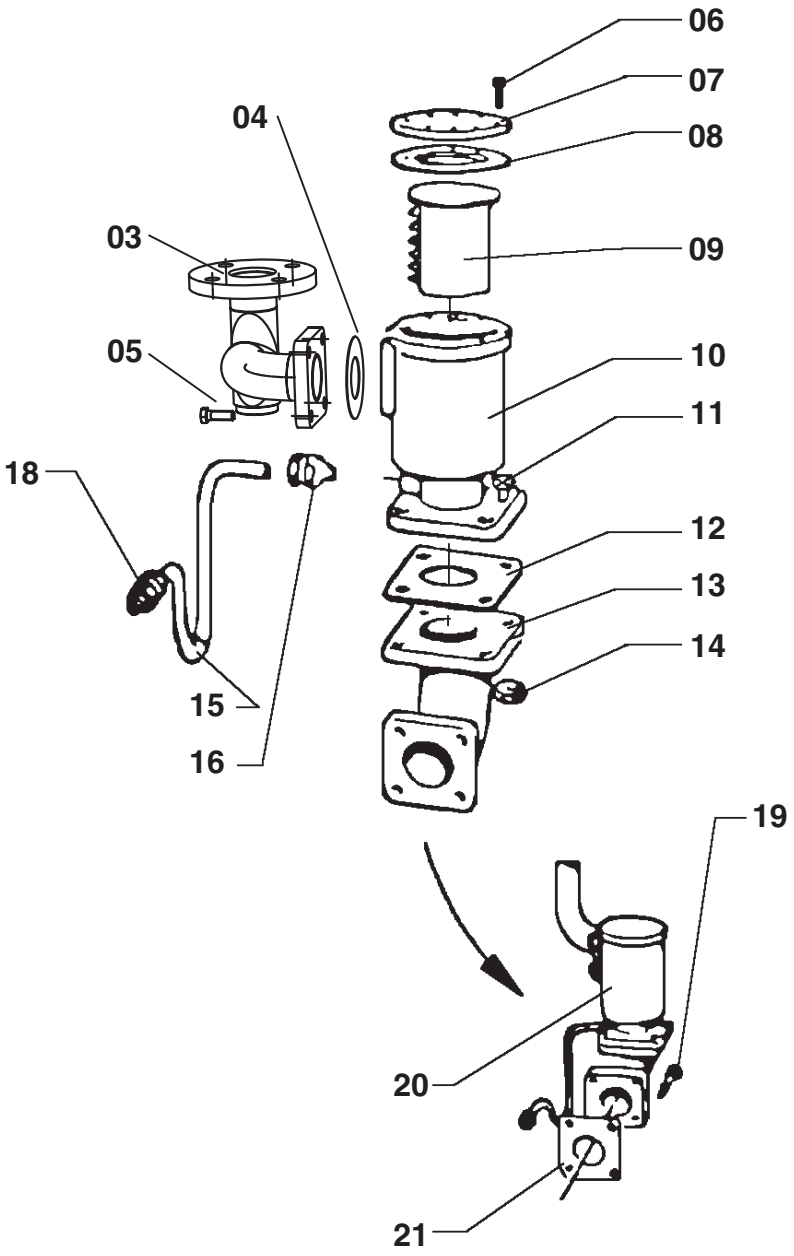
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor

Plate Page 1 (2)	**Lubricating Oil Separator**	**61530-07H**

L28/32H



61530-07H	Lubricating Oil Separator	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
03	1/F	**Breather with flange**	Ånderør med flange
04	1/F	**Gasket**	Pakning
05	4/F	**Screw**	Skrue
06	8/F	**Screw**	Skrue
07	1/F	**Cover**	Dæksel
08	1/F	**Gasket**	Pakning
09	1/F	**Insert for oil separator**	Indsats for olieudskiller
10	1/F	**Housing for oil separator**	Hus for olieudskiller
11	4/F	**Screw**	Skrue
12	1/F	**Gasket**	Pakning
13	1/F	**Bend**	Bøjning
14	4/F	**Nut**	Møtrik
15	1/F	**Oil trap**	Olielås
16	1/F	**Union**	Forskruning
18	1/F	**Union**	Forskruning
19	4/F	**Screw**	Skrue
20	1/E	**Oil separator, complete, consisting of item 06, 07, 08, 09, and 10**	Olieseparator, komplet bestående af item 06, 07, 08, 09 og 10
21	1/F	**Gasket**	Pakning

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

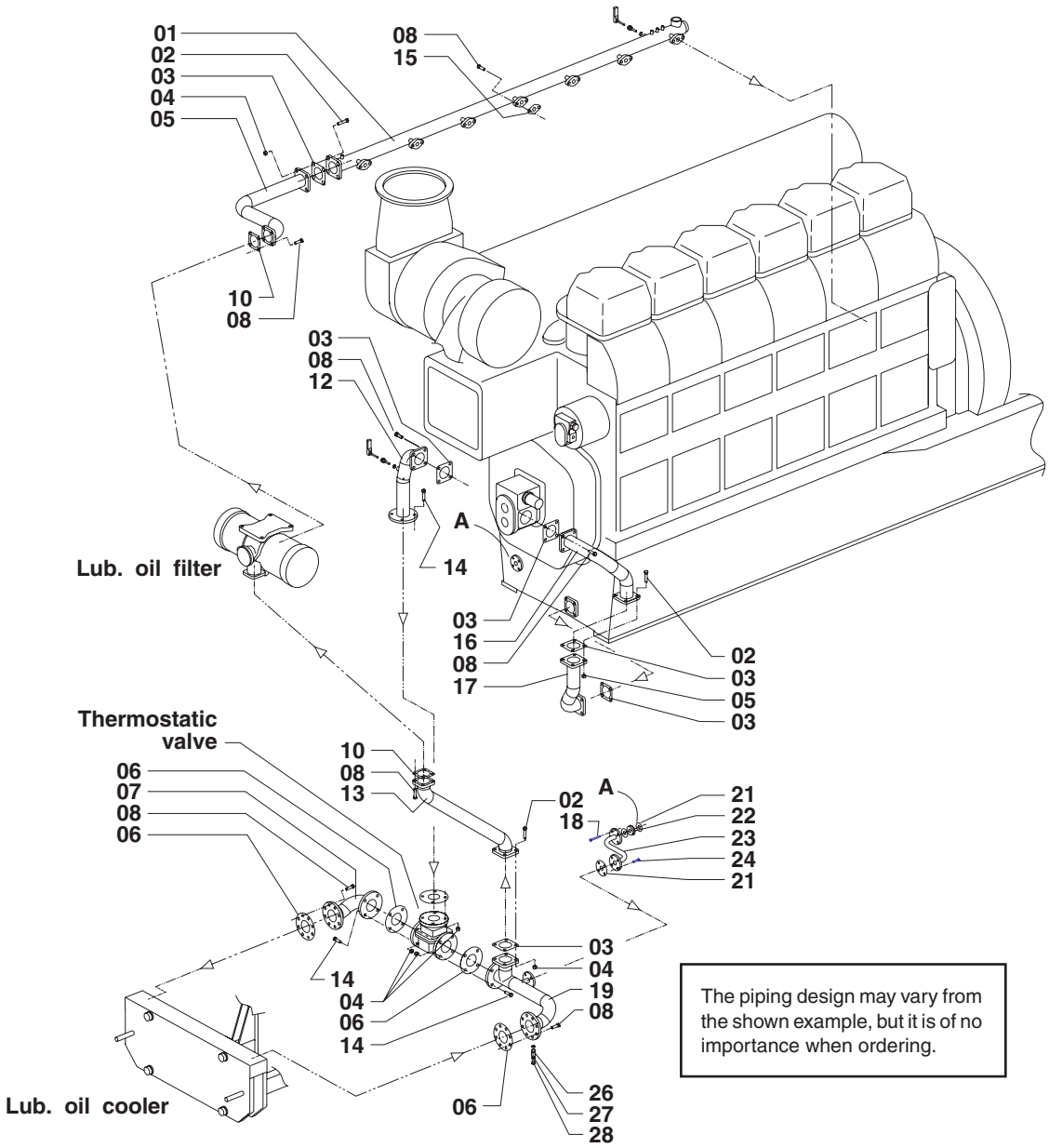
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./F = Qty./Filter

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/F = Antal/Filter

Plate Page 1 (2)	**Lubricating Oil Pipes on Engine**	**61530-02H**

L28/32H



The piping design may vary from the shown example, but it is of no importance when ordering.

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	/I	**Lub. oil distributing pipe**	Sm. oliefordelingsrør
02	/I	**Stud**	Bolt
03	/I	**Pakning**	Pakning
04	/I	**Lub. oil pipe outlet filter**	Sm. olierør afgang filter
05	/I	**Nut**	Møtrik
06	/I	**Gasket**	Pakning
07	/I	**Lub. oil pipe inlet cooler**	Sm. olierør tilgang køler
08	/I	**Screw**	Sekskantskrue
10	/I	**Pakning**	Pakning
12	/I	**Outlet pump/Inlet therm. valve**	Sm. olierør afgang pumpe/tilgang term. ventil
13	/I	**Lub. oil pipe inlet filter**	Sm. olierør tilgang filter
14	/I	**Stud**	Bolt
15	/I	**Pakning**	Pakning
16	/I	**Lub. oil pipe inlet pump**	Sm. olierør tilg. pumpe
17	/I	**Lub. oil suction pipe**	Sm. oliesugerør
18	/I	**Stud**	Bolt
19	/I	**Lub. oil pipe outlet cooler**	Sm. olierør afgang køler
21	/I	**Gasket**	Pakning
22	/I	**Non-return valve**	Kontraventil
23	/I	**Pipe**	Rør
24	/I	**Stud**	Bolt
26	/I	**Ball valve**	Kugleventil
27	/I	**Gasket**	Pakning
28	/I	**Plug screw**	Propskrue

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/I = Antal/Individuel

Cooling water system

516/616

General

Description

The cooling water system consists of two separate systems the low temperature (LT) and the high temperature (HT) circuits.

Low Temperature Circuit

The low temperature circuit is used for cooling of the charge air and the lubricating oil, and the alternator if the latter is water cooled.

High Temperature Circuit

The high temperature circuit is used for cooling of the cylinder units.

Cooling water is led through a distributing pipe to the bottom of the cooling water space between the liner and the frame of each cylinder unit. The water is led out through bores in the top of the frame via the cooling water guide jacket to the bore.

08028-0D/H5250/94.08.12

General

Thermostatic Valve

The thermostatic valve in the high temperature circuit is mainly located imediately after the outlet of the engine, but alternatively in the external cooling system near the fresh water cooler.

The cooling water enters through the cover (A) under which the thermostatic elements are located.

The number of elements depends on the size of the valve.

The outlet to the suction side of the pump is marked (B) and outlet to the cooler is marked (C).

In the warming-up period the cooling water is by-passing the cooler. When the outlet water from the cylinder heads reaches the normal temperature (75-85° C) a controlled amount of water passes through the cooler.

The thermostatic elements must be replaced if the cooling water temperature during normal operation deviates essentially from the one stated in the test report.

The thermostatic valve cannot be set or adjusted, and requires no maintenance.

In some plants a corresponding thermostatic valve is installed in the low temperature circuit. The thermostatic elements of this valve have an other temperature range.

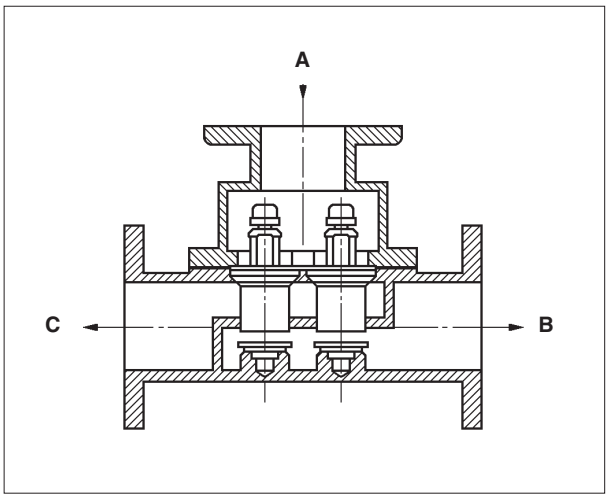


Fig. 1. Thermostatic Valve

Working Card Page 1 (2)	Check of Cooling Water System	616-01.90 Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Check of cooling water system.

Starting position:

Engine is running

Related procedure:

Man power:

Working time : ½ hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

General

Checks to be carried out.

1) Examine the piping system for leaks.

2) Retighten all bolts and nuts in the piping system.

3) Move all valves and cocks in the piping system. Lubricate valve spindles with graphite or similar.

4) Check flexible connections for leaks.

5) Check manometers and thermometers for possible damages.

6) Check the condition of the uppermost of the two O-rings (which makes up the tightening between the jacket cooling water space in the frame and the crankcase) by means of the inspection holes in the engine frame - see also Working Card 606-01.40.

For check of the fresh water condition, see section 604.

08028-0D/H5250/94.08.12

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ■ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Inspection of thermostatic valve and replacement of elements.

Starting position:

Cooling water drained from engine (if necessary).

Related procedure:

Man power:

Working time : 2 Hour
Capacity : 1 Man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate No.	Item No.	Note.

Hand tools:

Ring and open end spanner 24 mm
Copaslip
Tools and cleaning preparation for cleaning.

Replacement and wearing parts:

Plate No.	Item No.	Qty./
61604	03	1/engine
61604	05	2 or 4/engine
61604	09	3/engine

L+V28/32H

The thermostatic valve cannot be adjusted and under normal working conditions maintenance is not required. However, in some cases it is necessary to replace the elements in the thermostatic valve.

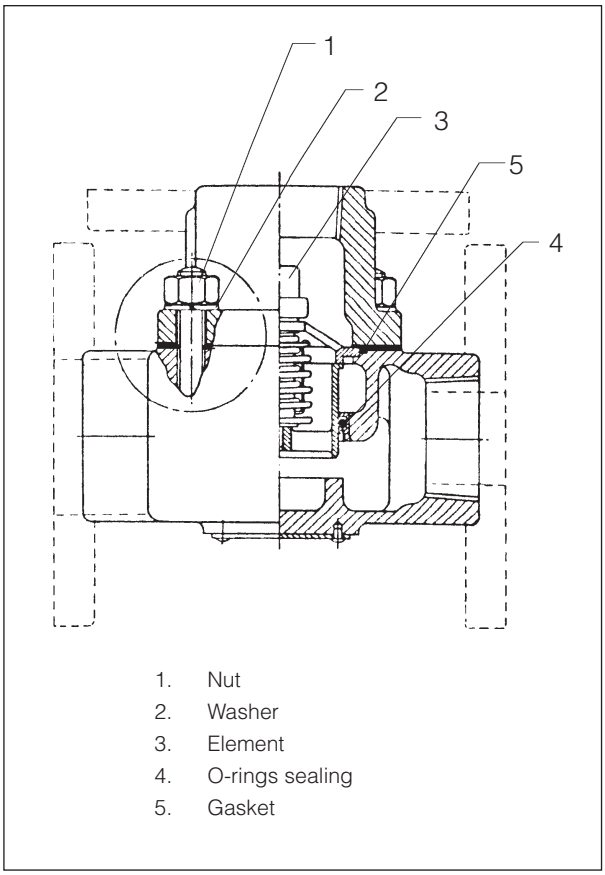


Fig. 1 Thermostatic valve

Replacement of elements:

1) Remove nuts (1) and washers (2), 4 or 6 pcs. See fig. 1.

2) Disconnect upper and lower part of the housing.

3) Remove the assembled elements (3) and the elements O-ring sealing.

4) Remove the gaskets between the upper and lower part of the housing.

5) The upper and lower part of the housing are thoroughly cleaned inside and on the gasket surfaces.

6) The sealing rings (4) for the elements in the housing are replaced and lubricated with a thin layer of copaslip.

7) Remount the assembled elements in the housing by wriggling these somewhat over side.

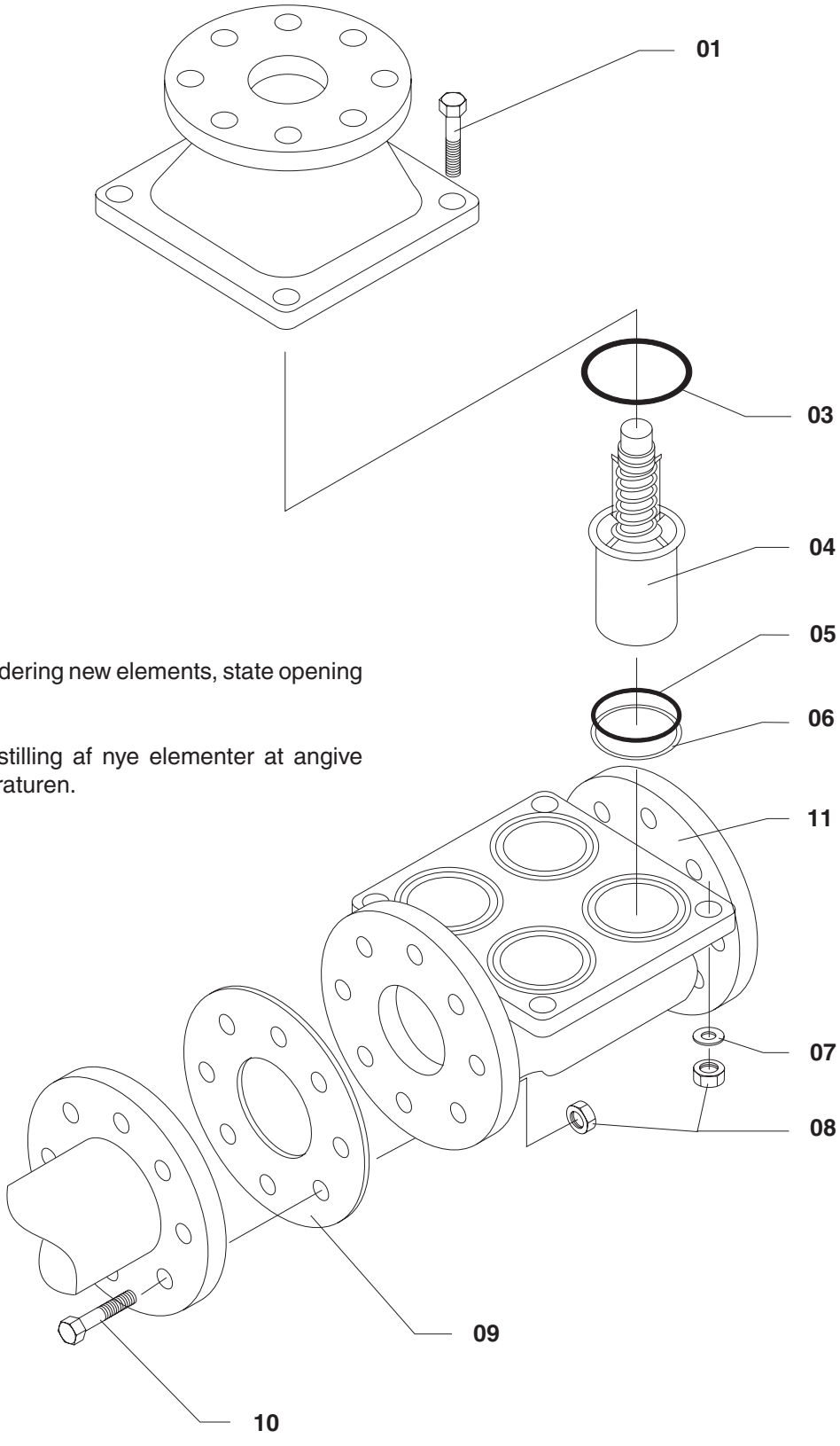
8) Upper and lower part of the housing are assembled with a new gasket (5), the nuts (1) are mounted and tightened "cross-wise".

Note:

After inspection or replacement of the elements the cooling water temperature is checked to ensure that the elements are working correctly.

Plate Page 1 (2)	**Fresh Water Thermostatic Valve**	**61604-07H**

L28/32H
L32/40



Note: When ordering new elements, state opening temperature.

Husk! Ved bestilling af nye elementer at angive åbningstemperaturen.

61604-07H	Fresh Water Thermostatic Valve	Plate Page 2 (2)

L28/32H
L32/40

Item No.	Qty.	Designation	Benævnelse
01	4/T	**Screw**	Skrue
03	4/T	**O-ring**	O-ring
04	4/T	**Thermostatic element**	Følerelement
05	4/T	**O-ring**	O-ring
06	4/T	**Sleeve**	Bøsning
07	4/T	**Washer**	Skive
08	28/T	**Nut**	Møtrik
09	3/T	**Gasket**	Pakning
10	24/T	**Screw**	Skrue
11	1/E	**Thermostatic valve, complete**	Termostatventil, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

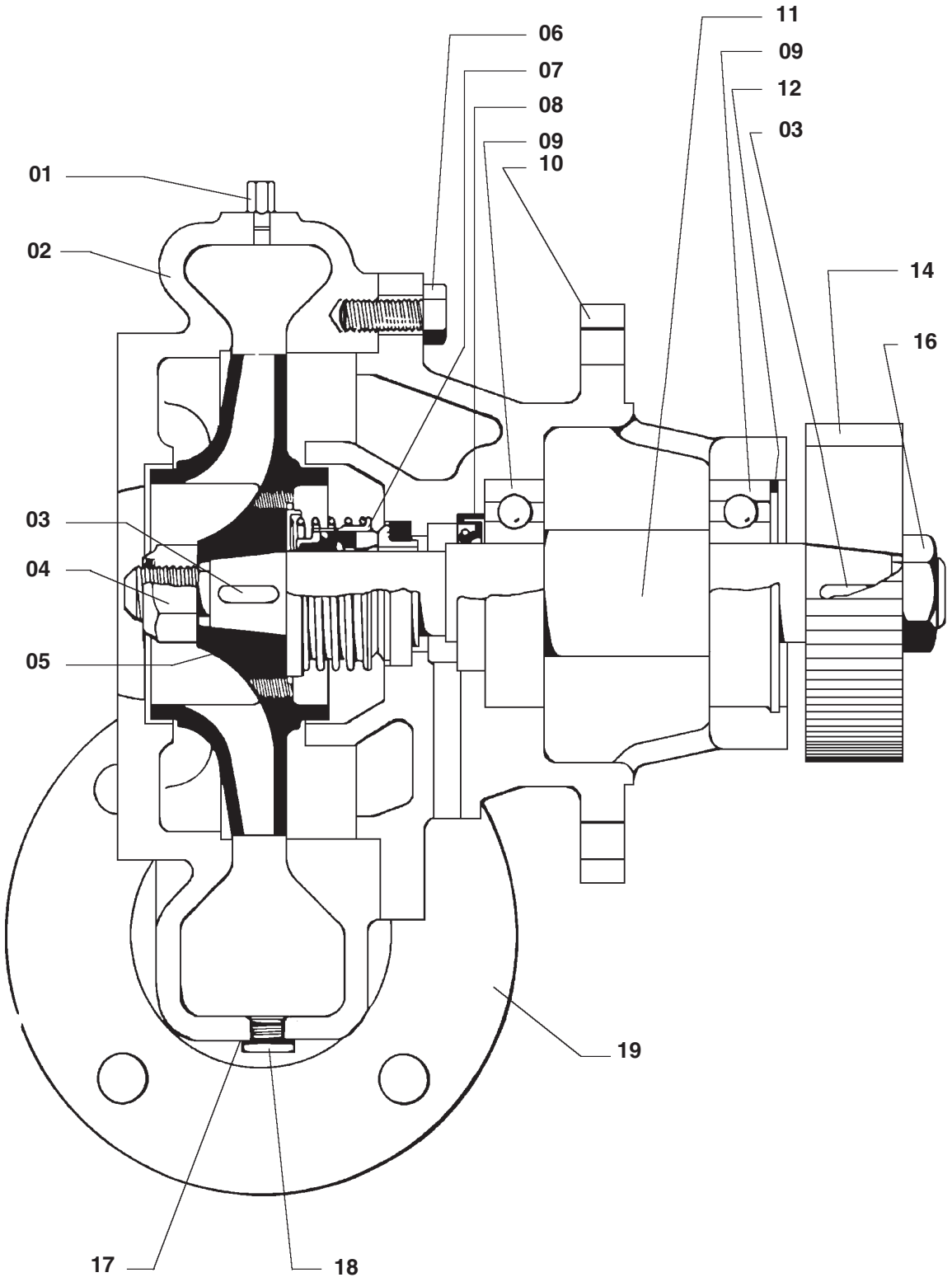
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./T = Qty./Thermostatic valve

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/T = Antal/Termostatsventil

Plate Page 1 (2)	High Temperature Fresh Water Pump	61610-05H

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Ball cock**	Kugleventil
02	1/P	**Pump housing**	Pumpehus
03	2/P	**Key**	Feder
04	1/P	**Self locking nut**	Selvlåsende møtrik
05	1/P	**Impeller**	Løbehjul
06	8/P	**Screw**	Skrue
07	1/P	**Rotating sealing**	Roterende pakdåse
08	1/P	**Sealing ring**	Tætningsring
09	2/P	**Ball bearing**	Kugleleje
10	1/P	**Bearing housing**	Lejehus
11	1/P	**Shaft**	Aksel
12	1/P	**Circlip**	Låsering
14	1/P	**Gear wheel**	Tandhjul
16	1/P	**Self locking nut**	Selvlåsende møtrik
17	3/P	**Gasket**	Pakning
18	3/P	**Plug screw**	Propskrue
19	1/E	**Fresh water pump, complete**	Ferskvandspumpe, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

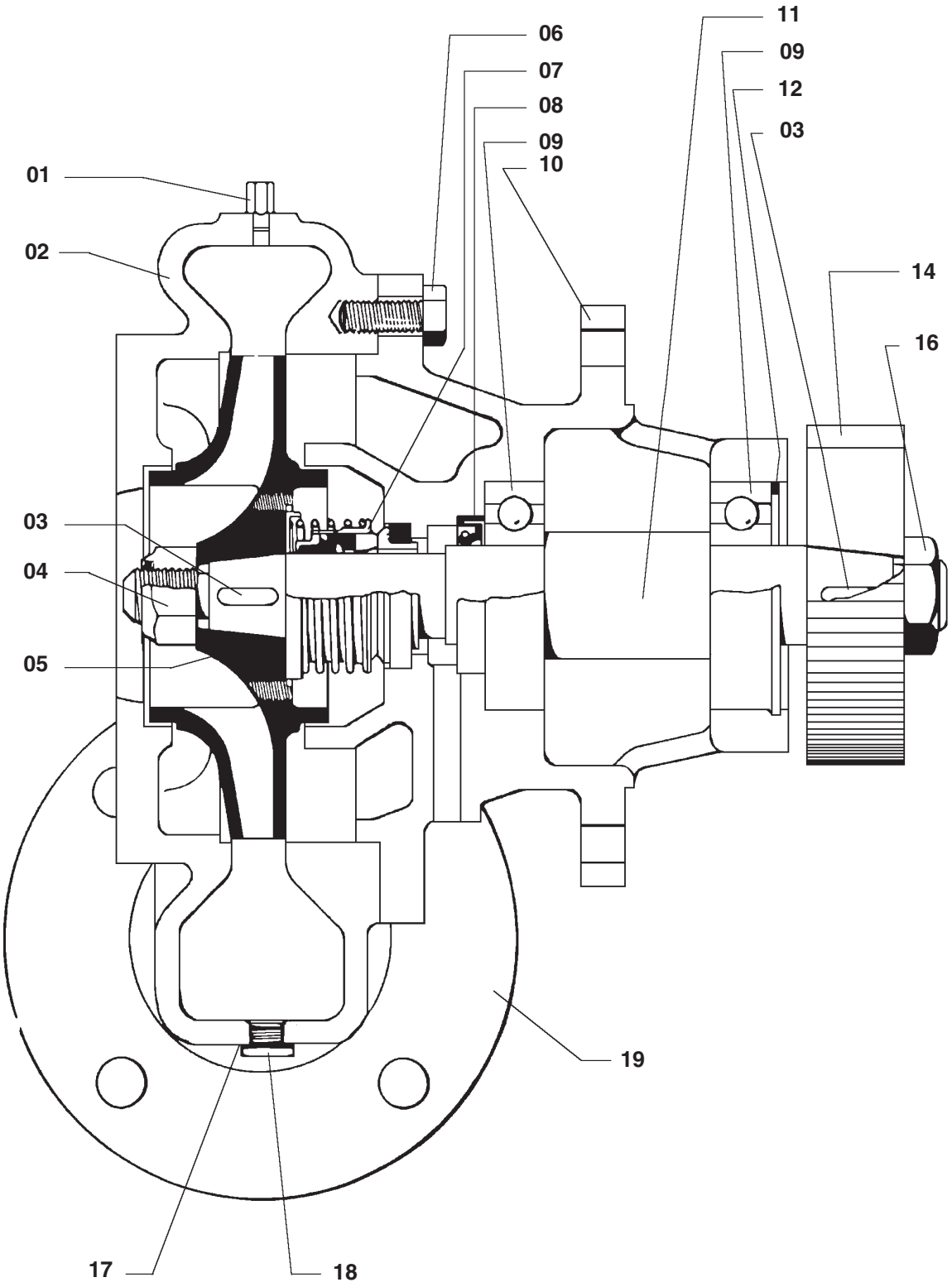
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Plate Page 1 (2)	Low Temperature Fresh Water Pump	61610-07H

L28/32H



61610-07H	Low Temperature Fresh Water Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Ball cock**	Kugleventil
02	1/P	**Pump housing**	Pumpehus
03	2/P	**Key**	Feder
04	1/P	**Self locking nut**	Selvlåsende møtrik
05	1/P	**Impeller**	Løbehjul
06	8/P	**Screw**	Skrue
07	1/P	**Rotating sealing**	Roterende pakdåse
08	1/P	**Sealing ring**	Tætningsring
09	2/P	**Ball bearing**	Kugleleje
10	1/P	**Bearing housing**	Lejehus
11	1/P	**Shaft**	Aksel
12	1/P	**Circlip**	Låsering
14	1/P	**Gear wheel**	Tandhjul
16	1/P	**Self locking nut**	Selvlåsende møtrik
17	3/P	**Gasket**	Pakning
18	3/P	**Plug screw**	Propskrue
19	1/E	**Fresh water pump, complete**	Ferskvandspumpe, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

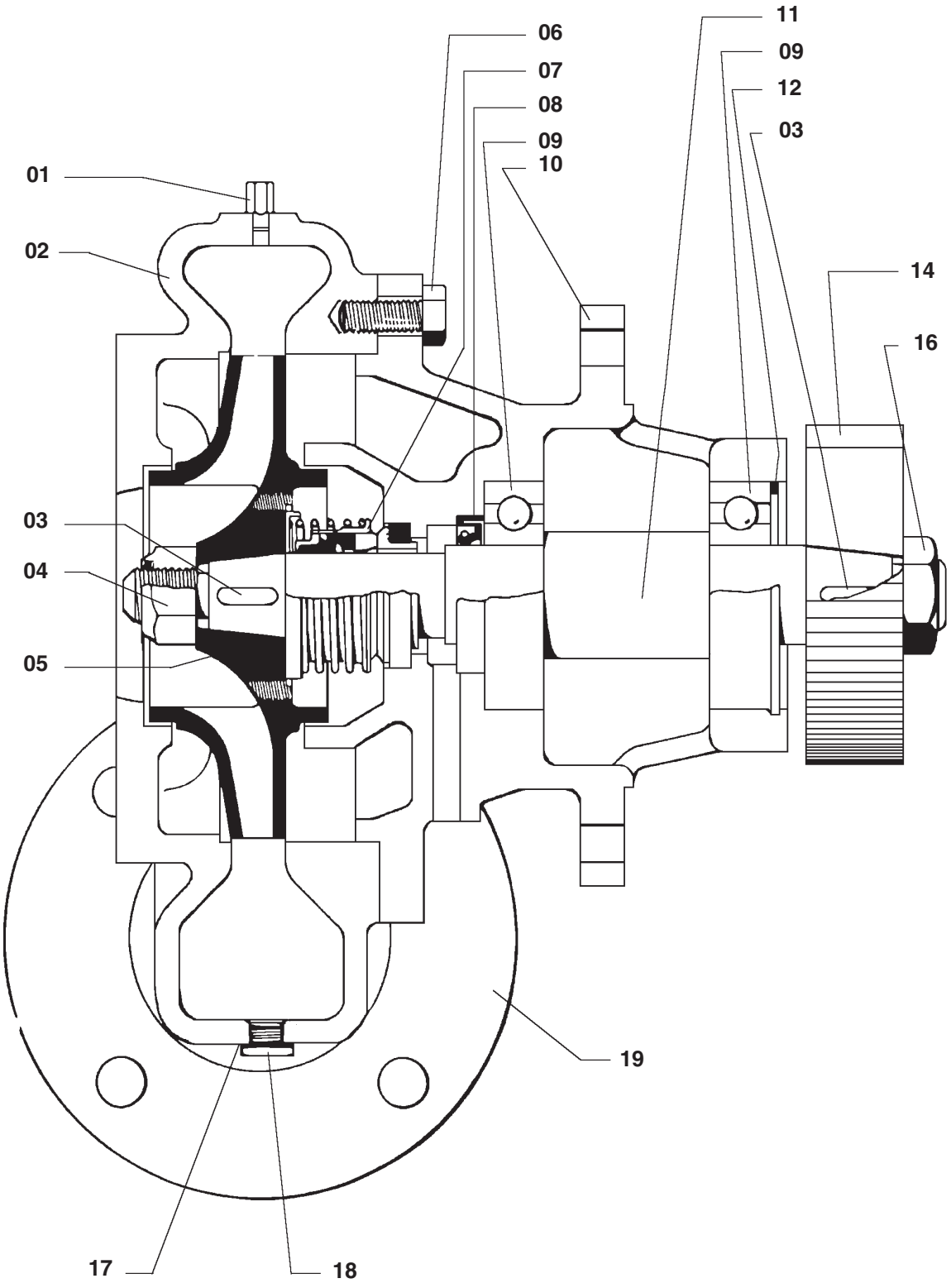
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Plate Page 1 (2)	Low Temperature Fresh Water Pump	61610-10H

L28/32H



61610-10H	Low Temperature Fresh Water Pump	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Ball cock**	Kugleventil
02	1/P	**Pump housing**	Pumpehus
03	2/P	**Key**	Feder
04	1/P	**Self locking nut**	Selvlåsende møtrik
05	1/P	**Impeller**	Løbehjul
06	8/P	**Screw**	Skrue
07	1/P	**Rotating sealing**	Roterende pakdåse
08	1/P	**Sealing ring**	Tætningsring
09	2/P	**Ball bearing**	Kugleleje
10	1/P	**Bearing housing**	Lejehus
11	1/P	**Shaft**	Aksel
12	1/P	**Circlip**	Låsering
14	1/P	**Gear wheel**	Tandhjul
16	1/P	**Self locking nut**	Selvlåsende møtrik
17	3/P	**Gasket**	Pakning
18	3/P	**Plug screw**	Propskrue
19	1/E	**Fresh water pump, complete**	Ferskvandspumpe, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

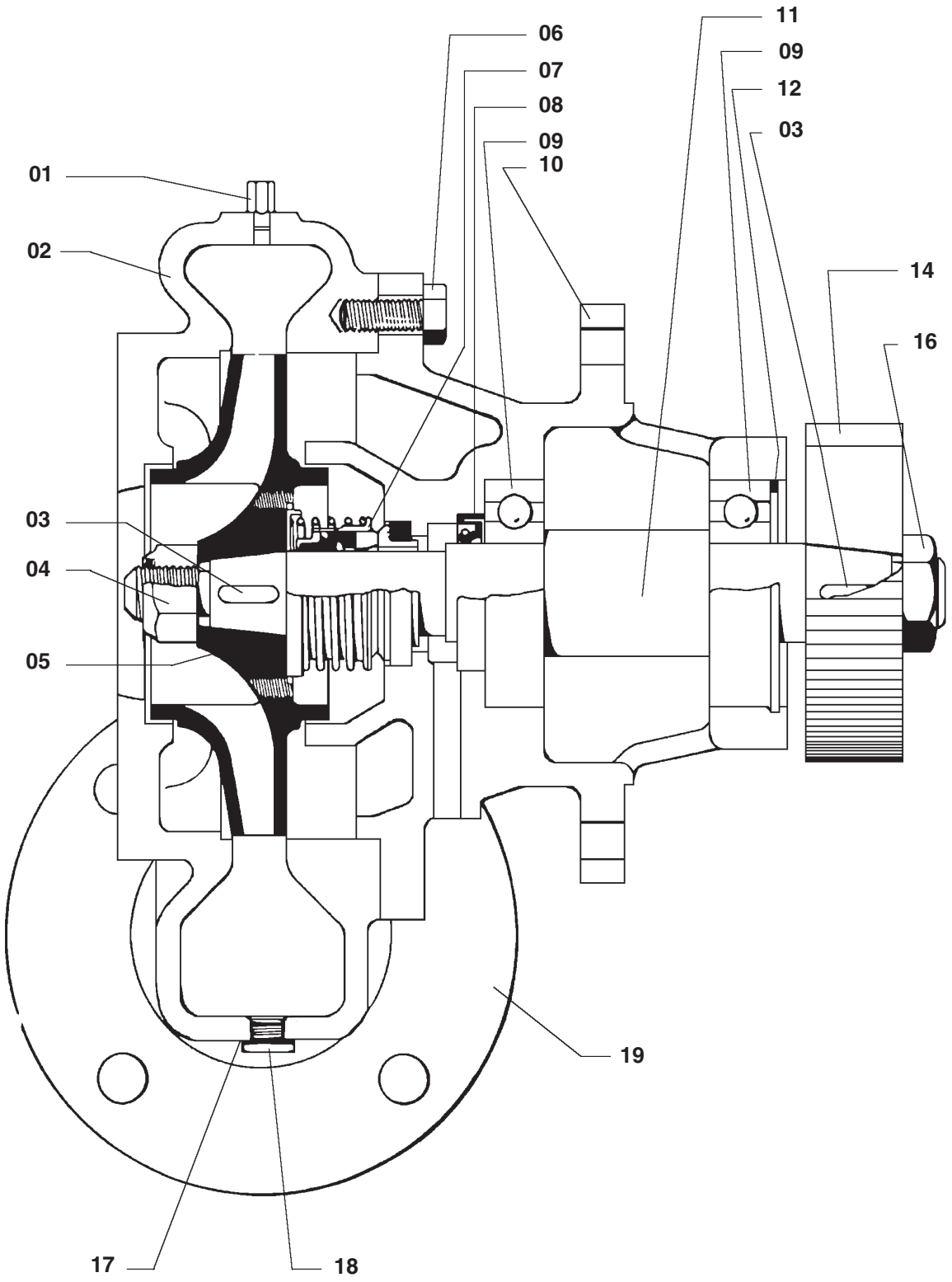
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Plate Page 1 (2)	**Sea Water Pump**	**61615-04H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
01	1/P	**Ball cock**	Kugleventil
02	1/P	**Pump housing**	Pumpehus
03	2/P	**Key**	Feder
04	1/P	**Self locking nut**	Selvlåsende møtrik
05	1/P	**Impeller**	Løbehjul
06	8/P	**Screw**	Skrue
07	1/P	**Rotating sealing**	Roterende pakdåse
08	1/P	**Sealing ring**	Tætningsring
09	2/P	**Ball bearing**	Kugleleje
10	1/P	**Bearing housing**	Lejehus
11	1/P	**Shaft**	Aksel
12	1/P	**Circlip**	Låsering
14	1/P	**Gear wheel**	Tandhjul
16	1/P	**Self locking nut**	Selvlåsende møtrik
17	3/P	**Gasket**	Pakning
18	3/P	**Plug screw**	Propskrue
19	1/E	**Sea water pump, complete**	Saltvandspumpe, komplet

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

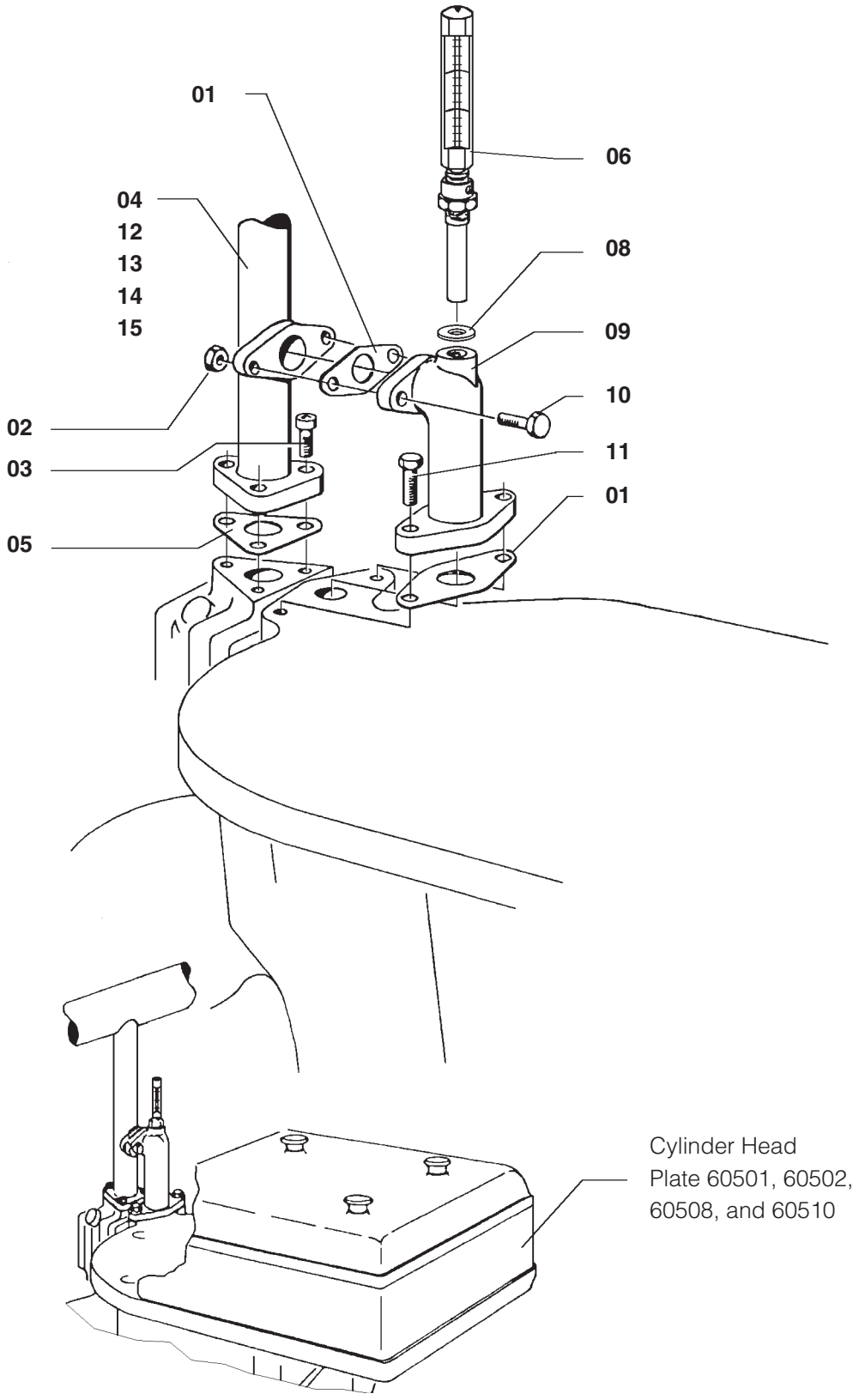
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./P = Qty./Pump

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/P = Antal/Pumpe

Plate Page 1 (2)	**Pipes on Cylinder Head**	**61625-04H**

L28/32H



08028-0D/H5250/94.08.12

61625-04H	Pipes on Cylinder Head	Plate Page 2 (2)

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	2/C	**Gasket**	Pakning
02	2/C	**Nut**	Møtrik
03	3/C	**Screw**	Skrue
04	1/E	**Branch for cooling water outlet pipe for 5 cyl.**	Grenrør for kølevand for 5 cyl.
05	1/C	**Gasket**	Pakning
06	1/C	**Thermometer, TI-11**	Termometer, TI-11
08	1/C	**Gasket**	Pakning
09	1/C	**Cooling water connecting pipe**	Forbindelsessrør for kølevand
10	2/C	**Screw**	Skrue
11	2/C	**Screw**	Skrue
12	1/E	**Branch for cooling water outlet pipe for 6 cyl.**	Grenrør for kølevand for 6 cyl.
13	1/E	**Branch for cooling water outlet pipe for 7 cyl.**	Grenrør for kølevand for 7 cyl.
14	1/E	**Branch for cooling water outlet pipe for 8 cyl.**	Grenrør for kølevand for 8 cyl.
15	1/E	**Branch for cooling water outlet pipe for 9 cyl.**	Grenrør for kølevand for 9 cyl.

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

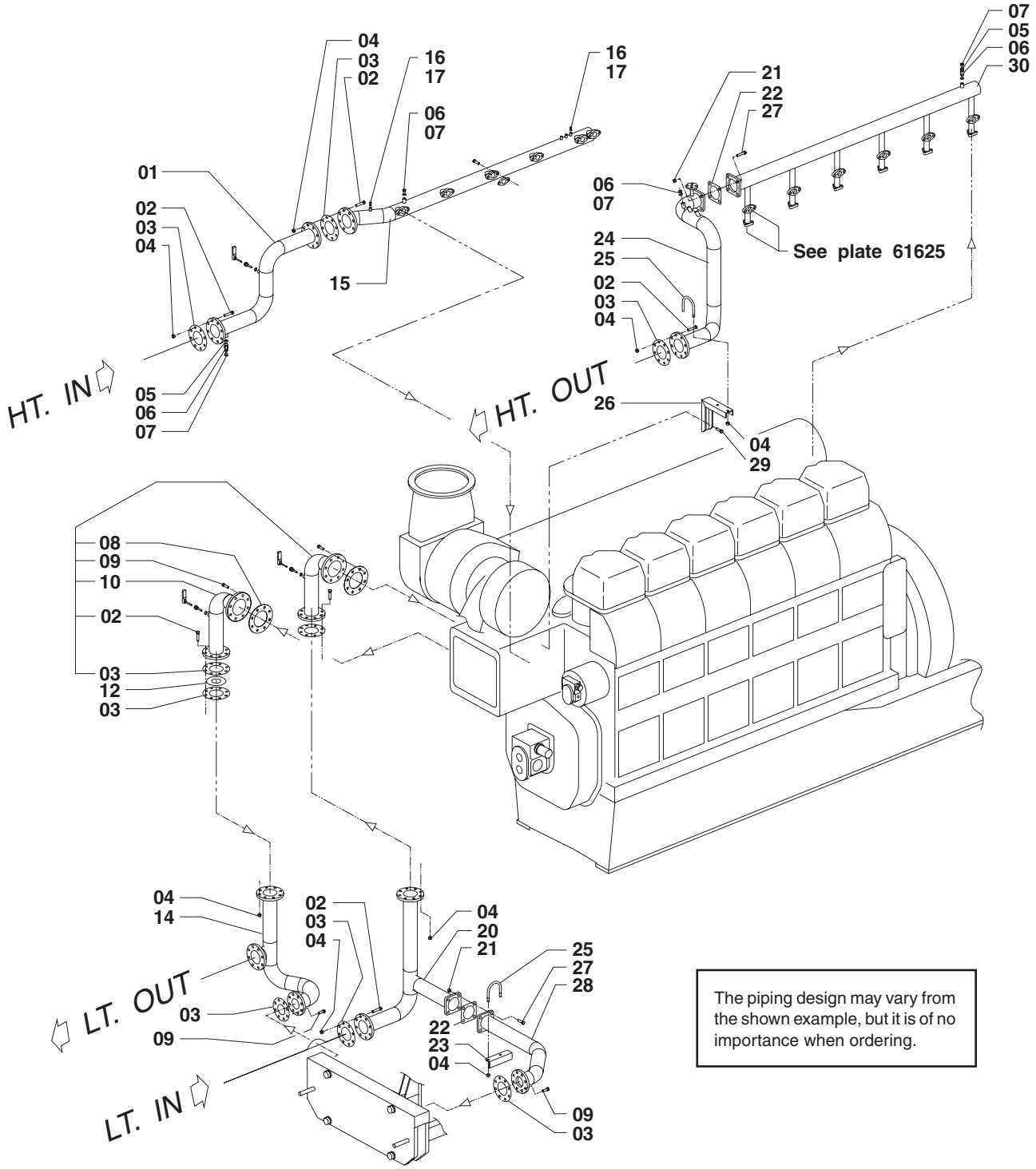
*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine
Qty./C = Qty./Cylinder

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/E = Antal/Motor
Antal/C = Antal/Cylinder

Plate Page 1 (2)	**Cooling Water Pipes on Engine**	**61630-01H**

L28/32H



The piping design may vary from the shown example, but it is of no importance when ordering.

L28/32H

Item No.	Qty.	Designation	Benævnelse
01	/I	**HT water pipe inlet GenSet**	HT. tilgangsrør GenSet
02	/I	**Stud**	Bolt
03	/I	**Gasket**	Pakning
04	/I	**Nut**	Møtrik
05	/I	**Ball valve**	Kugleventil
06	/I	**Gasket**	Pakning
07	/I	**Plug screw**	Propskrue
08	/I	**Gasket**	Pakning
09	/I	**Screw**	Sekskantskrue
10	/I	**LT pipe inlet/outlet charge air cooler**	LT. rør ind/ud ladeluft-køler
12	/I	**Orifice**	Blænde
14	/I	**LT water pipe outlet lub. oil cooler**	LT. afgangsrør sm.køler
15	/I	**HT water distributing pipe inlet engine**	HT.fordelingsrør tilgang motor
16	/I	**Plug screw**	Propskrue
17	/I	**Gasket**	Pakning
20	/I	**LT water inlet GenSet**	LT. tilgang GenSet
21	/I	**Nut**	Møtrik
22	/I	**Gasket**	Pakning
23	/I	**Bracket**	Konsol
24	/I	**HT water outlet collecting pipe**	HT. afgang samlerør
25	/I	**Clamp**	Bøjle
26	/I	**Bracket**	Konsol
27	/I	**Screw**	Sekskantskrue
28	/I	**LT water inlet lub. oil cooler**	LT. tilgang sm.køler
29	/I	**Screw**	Sekskantskrue
30	/I	**HT water collecting pipe outlet engine**	HT. samlerør

When ordering spare parts, see also page 600.50.

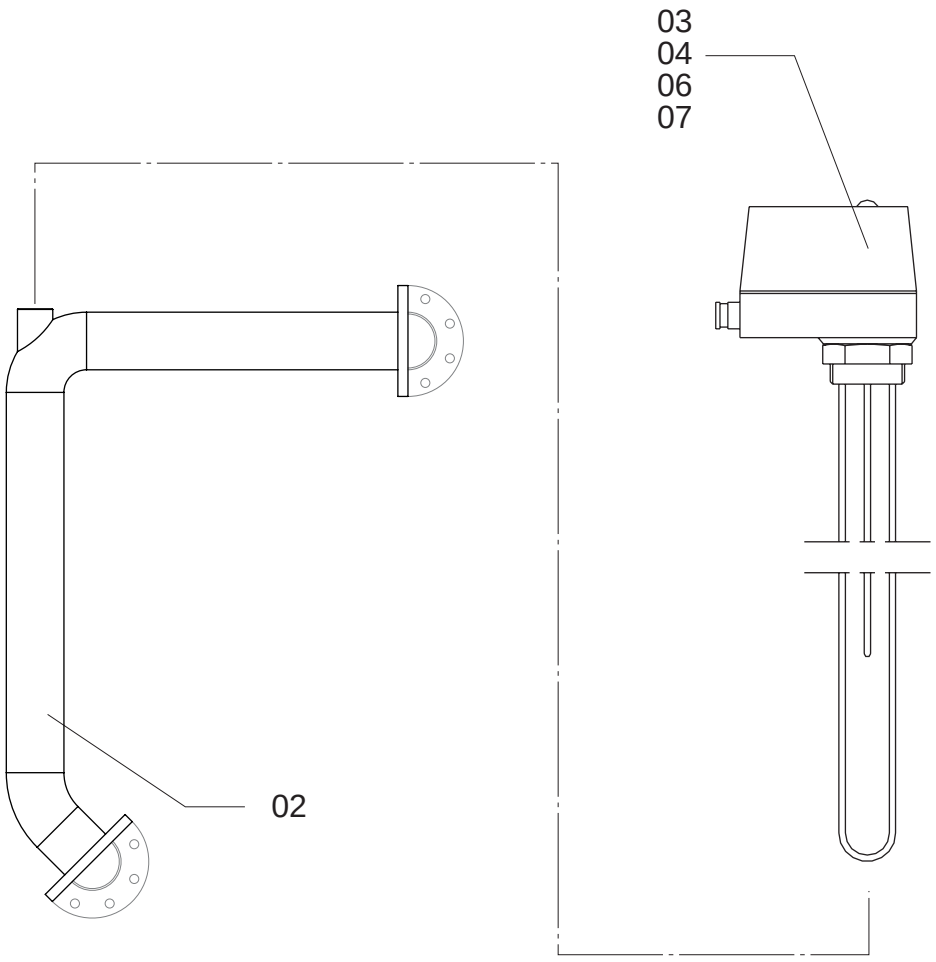
*** = Only available as part of a spare parts kit.**
Qty./I = Qty./Individual

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/I = Antal/Individuel

Plate Page 1 (2)	**Preheater - Fresh Water**	**61635-06H**

L28/32H



L28/32H

Item No.	Qty.	Designation	Benævnelse
02	1/E	**Pipe for Preheater**	Rør for Forvarmer
03*	1/E	**Preheater 5, 6 L28/32H, stationary**	Forvarmer 5, 6 L28/32H, stationær
04*	1/E	**Preheater 7, 8, 9 L28/32H, stationary**	Forvarmer 7, 8, 9 L28/32H, stationær
06*	1/E	**Preheater 5, 6 L28/32H, marine**	Forvarmer 5, 6 L28/32H, marine
07*	1/E	**Preheater 7, 8, 9 L28/32H, marine**	Forvarmer 7, 8, 9 L28/32H, marine
		*** At ordering please inform of voltage (V) and output (W)**	* Ved ordre oplyses spænding (V) og effekt (W)

Item No.	Qty.	Designation	Benævnelse

When ordering spare parts, see also page 600.50.

* = Only available as part of a spare parts kit.
Qty./E = Qty./Engine

Ved bestilling af reservedele, se også side 600.50.

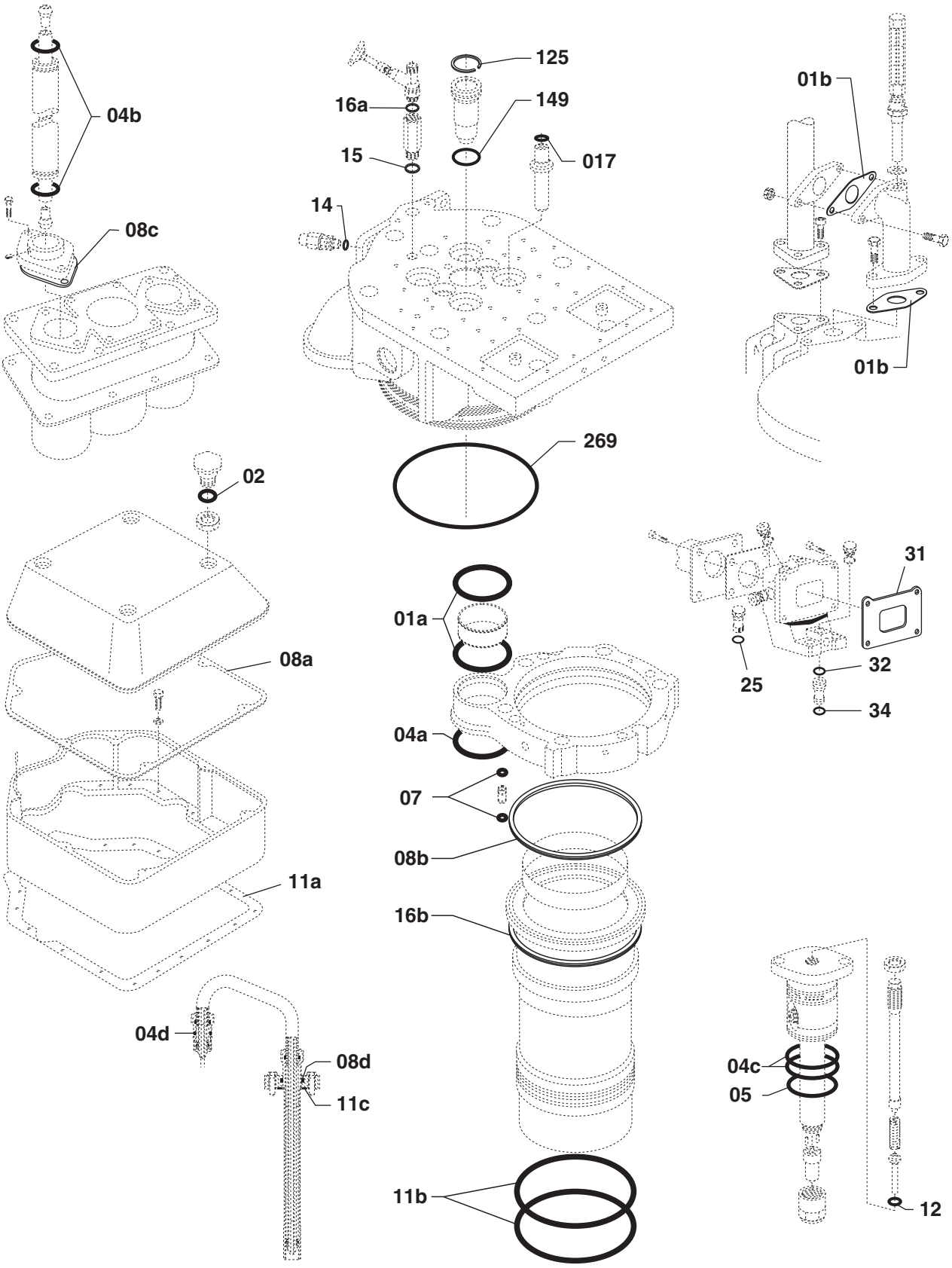
* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor

Special equipment

517/617

Kit Page 1 (2)	Kit for Cylinder Unit	61704-02H

L+V28/32H



L+V28/32H

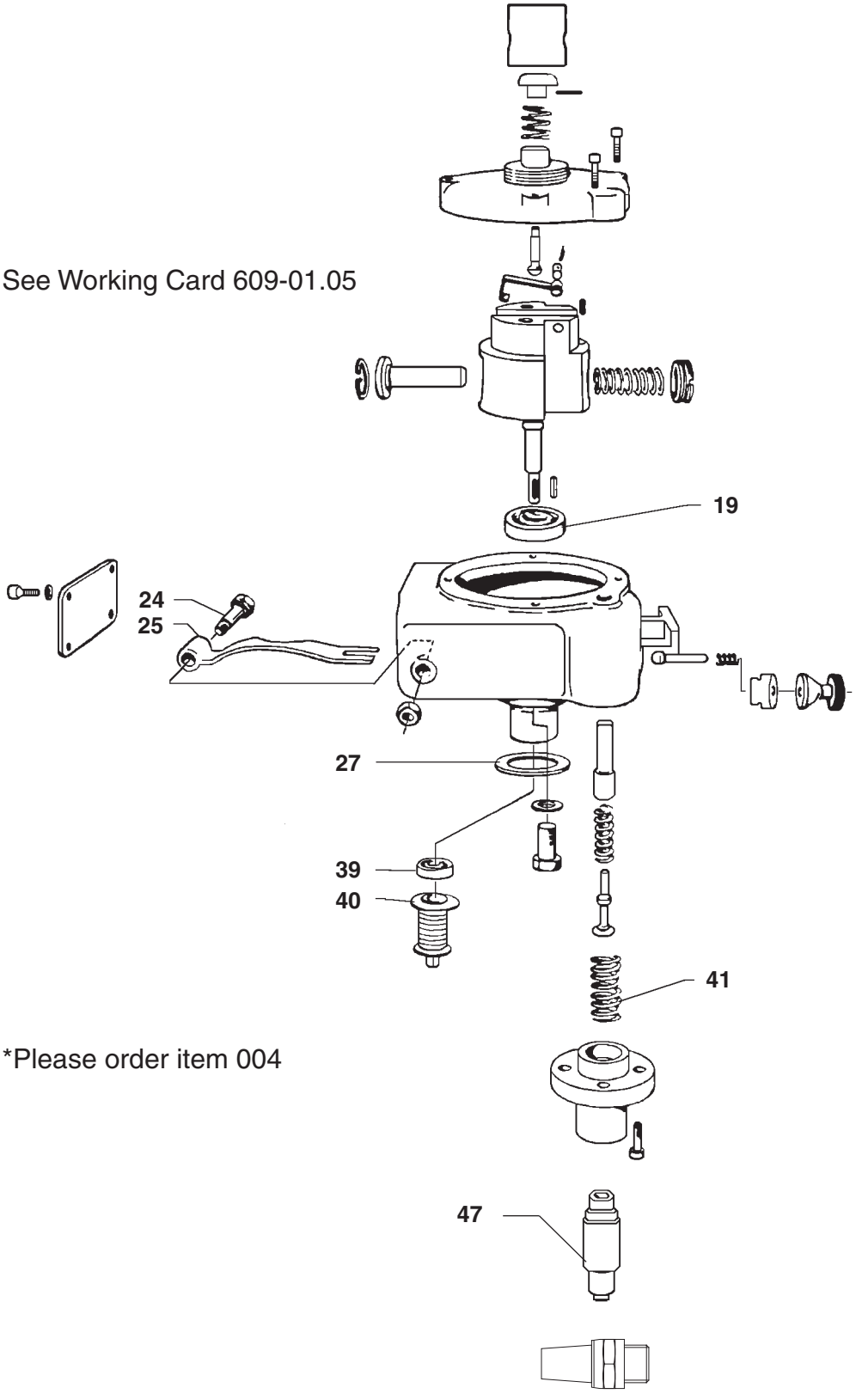
Item no	Qty	Designation	Where to find in the engine instruction book	
021		Kit per cylinder unit		
	4	O-ring	Plate 60501	Item 017
	1	Snap ring	Plate 60501	Item 125
	1	O-ring	Plate 60501	Item 149
	2	O-ring	Plate 60501	Item 269
	1	Gasket	Plate 60508	Item 14
	3	Gasket	Plate 60508	Item 15
	1	Gasket	Plate 60508	Item 16a
	4	O-ring	Plate 60510	Item 02
	1	Gasket	Plate 60510	Item 08a
	1	Gasket	Plate 60510	Item 11a
	2	O-ring	Plate 60610	Item 01a
	1	O-ring	Plate 60610	Item 04a
	12	O-ring	Plate 60610	Item 07
	1	Sealing ring	Plate 60610	Item 08b
	2	O-ring	Plate 60610	Item 11b
	1	Sealing ring	Plate 60610	Item 16b
	4	Gasket	Plate 60801	Item 04b
	2	Gasket	Plate 60801	Item 08c
	2	Gasket	Plate 61202	Item 25
	1	Gasket	Plate 61202	Item 31
	1	O-ring	Plate 61202	Item 32
	1	O-ring	Plate 61202	Item 34
	2	O-ring	Plate 61402	Item 04c
	1	O-ring	Plate 61402	Item 05
	1	O-ring	Plate 61402	Item 12
	1	O-ring	Plate 61404	Item 04d
	1	O-ring	Plate 61404	Item 08d
	1	Sealing ring	Plate 61404	Item 11c
	2	Gasket	Plate 61625	Item 01b

Please Note **that this is a kit supply, and that any exceeding number of parts are not accepted as return goods.**

Kit Page 1 (2)	Kit for Overspeed Device	61743-01H

L+V28/32H

See Working Card 609-01.05



*Please order item 004

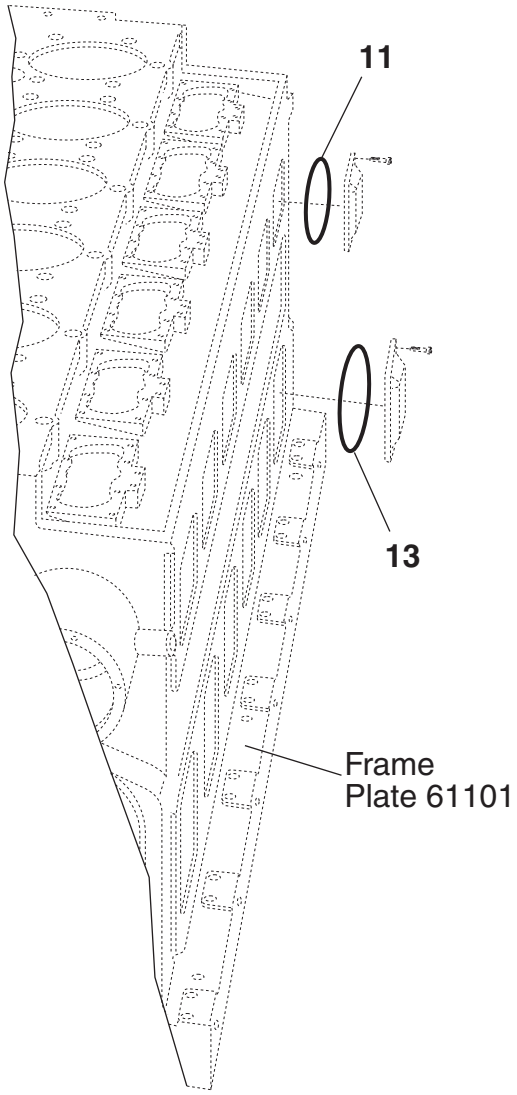
L+V28/32H

Item no	Qty	Designation	Where to find in the engine instruction book	
004		Kit per overspeed device, complete consisting of:		
	1	Ball bearing	Plate 60903	Item 19
	1	Pin	Plate 60903	Item 24
	1	Lever	Plate 60903	Item 25
	1	Gasket	Plate 60903	Item 27
	1	Ball bearing	Plate 60903	Item 39
	1	Elastic coupling	Plate 60903	Item 40
	1	Spring (right)	Plate 60903	Item 41
	1	Spare parts kit for pneumatic valve	Plate 60903	Item 47

Please Note **that this is a kit supply, and that any exceeding number of parts are not accepted as return goods.**

Kit Page 1 (2)	Kit for Covers on Frame	61751-01H

L28/32H



L28/32H

Item no	Qty	Designation	Where to find in the engine instruction book	
006		Kit per coves on frame		
	1	O-ring	Plate 61106	Item 11
	2	O-ring	Plate 61106	Item 13

Please Note **that this is a kit supply, and that any exceeding number of parts are not accepted as return goods.**

Specific plant information

519/619

L28/32H

Resilient Mounting of Generating Sets

On resilient mounted generating sets, the diesel engine and the generator are placed on a common rigid base frame mounted on the ship's/erection hall's foundation by means of resilient supports, type Conical.

All connections from the generating set to the external systems should be equipped with flexible connections, and pipes, gangway etc. must not be welded to the external part of the installation.

Resilient Support

A resilient mounting of the generating set is made with a number of conical mountings. The number and the distance between them depend on the size of the plant. These conical mountings are bolted to brackets on the base frame (see fig 1).

The setting from unloaded to loaded condition is normally between 5-11 mm for the conical mounting.

The exact setting can be found in the calculation of the conical mountings for the plant in question.

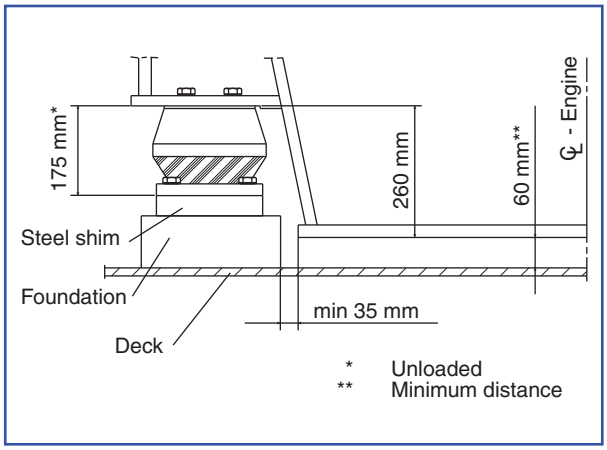


Fig 1 Resilient mounting of generating sets.

The support of the individual conical mounting can be made in one of the following three ways:

1) The support between the bottom flange and the foundation of the conical mounting is made with a loose steel shim. This steel shim is adjusted to an exact measurement (min. 40 mm) for each conical mounting.

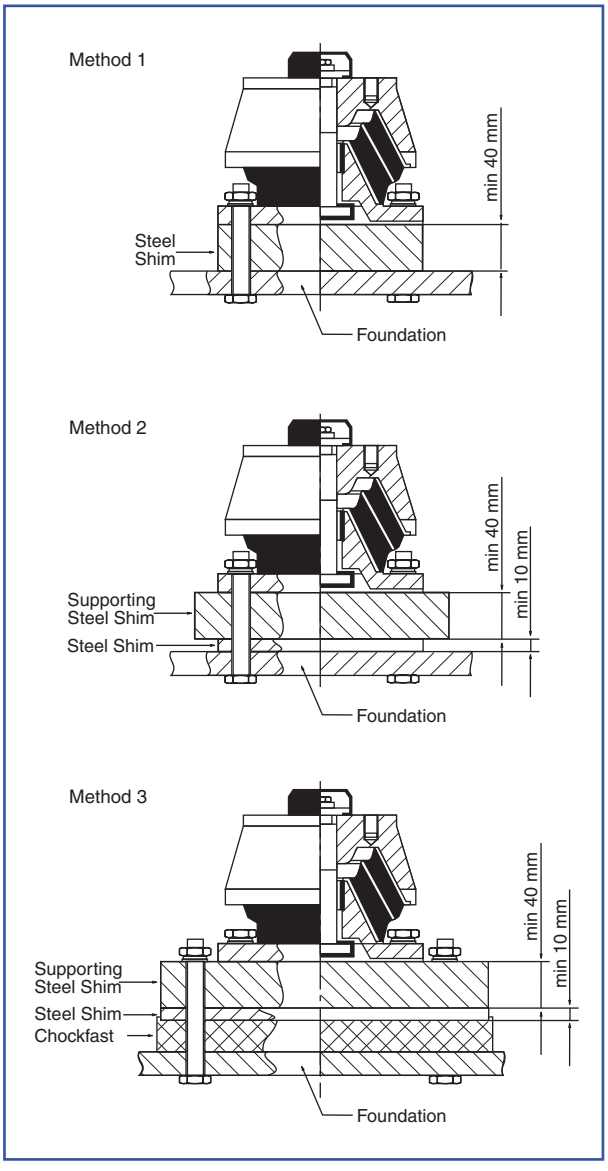


Fig 2 Support of conicals.

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L28/32H

2) The support can also be made by means of two steel shims, at the top a loose shim of at least 40 mm and below a shim of approx. 10 mm which are adjusted for each conical mounting and then welded to the foundation.

3) Finally, the support can be made by means of chockfast. It is recommended to use two steel shims, the top shim should be loose and have a minimum thickness of 40 mm, the bottom shim should be cast in chockfast with a thickness of at least 10 mm.

Irrespective of the method of support, it is recommended to use a loose steel shim to facilitate a possible future replacement of the conical mountings.

Check of Crankshaft Deflection

The resilient mounted generating set is normally delivered from the factory with engine and generator mounted on the common base frame.
Eventhough engine and alternator have been adjusted by the engine builder, with the alternator rotor placed correctly in the stator and the crankshaft deflection of the engine (autolog) within the prescribed tolerances, it is recommended to check the crankshaft deflection (autolog) before starting up the GenSet.

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Working card Page 1 (4)	Fitting Instructions for Resilient Mounting of GenSets	619-03.00 Edition 21H

L28/32H

Safety precautions

- ■ Stopped engine
- ■ Shut-off starting air
- ■ Shut-off cooling water
- ■ Shut-off fuel oil
- ■ Shut-off cooling oil
- ■ Stopped lub. oil circulation

Description

Mounting and adjustment instruction for new GenSets, and adjustment instruction for existing plants.

Starting position

The foundation should be welded and milled off on shim surfaces.

Related procedure

Check of main beraings alignment (autolog) 610-01.00
Replacement of conicals 619-03.00

Man power

Working hours : 2 Hours
Capacity : 2 Men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate No	Item No	Note

Hand tools

Ring and open end spanner, 22 mm
Ring and open end spanner, 30 mm
Allen key, 6 mm
Feeler gauge, 1-2 mm
Measurement tool
Hydraulic jack (if necessary)

Spare and wearing parts

Plate No.	Item No.	Qty./
61903	01	4/conical mount.
61903	02	4/conical mount.
61903	03	1/conical mount.
61903	04	4/conical mount.

08028-0D/H5250/94.08.12

L28/32H

Mounting and Adjustment Instructions for New Generating Sets (Method 1)

Make Ready for Adjustment of Conical Elements

If the conical elements have not been mounted by the factory, they must be mounted on the prepared brackets on the base frame. In case they have been mounted by the factory, please start with item number 2.

1) Fit the conical elements to the bracket on the base frame by means of four bolts screwed into the tapped holes on the top casting (5), see fig 1.

2) Remove fixing bolt (7), spring washer (8) and top lock ring (6) from the conical element, see fig 1.

3) Position the four jacking bolts in the tapped holes (9) see fig 1, in the base casting (1).

4) Position the jacking bolts with a through-going of minimum 40 mm, see fig 2.

5) Lower the generating set until it rests completely on the foundation.

6) Check that all jacking bolts have full contact with the foundation.

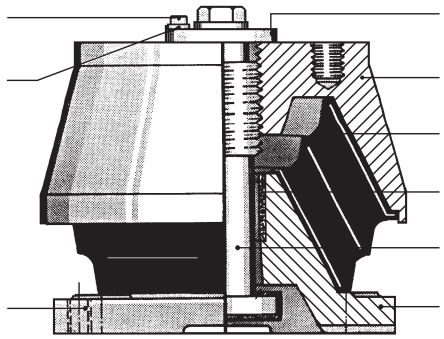

Fig 1 Conical element

7) Turn all the internal buffers (2), see fig 1, to check that they can move freely.

If all internal buffers	Then
Can move freely	Let conical elements settle for 48 hours.
Cannot be moved	Turn the four jacking in the base casting clockwise or anticlockwise to release the internal buffer.

Adjustment of Conical Elements after 48 Hours Settling

After the conical elements have been deflected under static load for 48 hours, the laden height (H1) see fig 2, should be measured and compared to the recommended laden height.

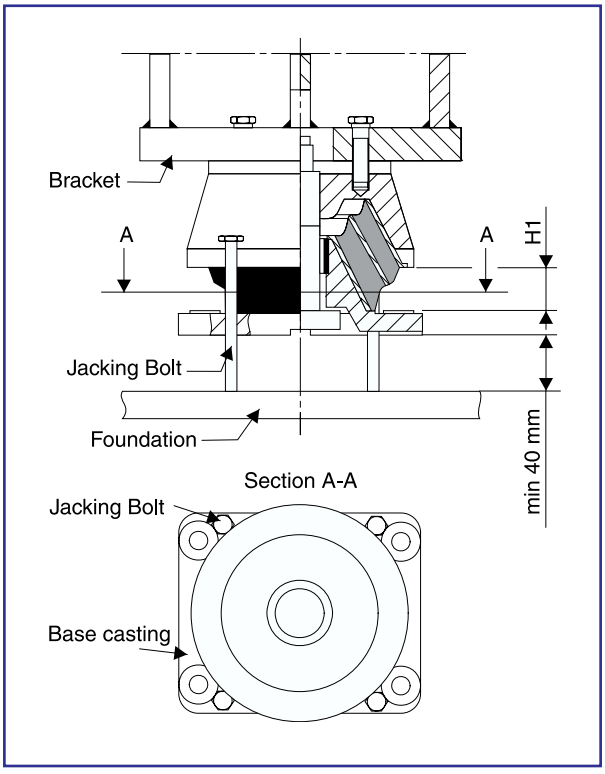

Fig 2 Conical mounting.

08028-0D/H5250/94.08.12

8) Care must be taken, during levelling of the installation, to ensure that individual mountings are not overloaded. The variation in laden height should not exceed 2 mm and should ideally be less. The laden height can be measured between top and base casting at H, on two sides (see fig 1).

Example:

$$\text{Average} = \frac{H_1 + H_2 + H_3 \text{ ----- } H_N}{\text{Number of conical elements}}$$

If	Then
Difference exceeds 2 mm.	Level the conical element by adjusting the jacking bolts - commencing with the conical element with the largest deviation.
Difference does not exceed 2 mm	The height of the steel shim can be measured.

The difference between the two sides of a conical mounting should not be more than 0.6 mm.

Measuring of Steel Shim

9) Measure the steel shim on several points to obtain the highest possible accuracy during preparation.

Fabricating Steel Shim

10) Make sure that the minimum height of the steel shim is 40 mm to secure a future replacement of the conical element.

Drill the mounting holes in the steel shim according to the conical base casting dimensions.

Mounting of the Completed Steel Shim

11) Turn the internal buffer anticlockwise until it contacts the base casting to secure the laden height of each conical element.

12) Lift the generating set with crane or hydraulic jack.

13) Remove all the jacking bolts.

14) Position each completed steel shim.

15) Lower the generating set until it rests completely in itself.

16) Number each steel shim together with each conical element.

Adjustment of Internal Buffer

17) Turn the internal buffer clockwise (downwards) until it makes contact with the steel shim or foundation.

18) Turn the internal buffer anticlockwise (upwards) until it obtains contact with the base casting.

This must be four full turns.

19) Turn the internal buffer two full turns clockwise (downwards) and check with a feeler gauge between the base casting of the conical element and the steel shim that the internal buffer (2), see fig 1, does not touch the steel shim or foundation.

20) Lock the internal buffer by remounting the top lock ring (6) and turn it to the nearest thread hole - then secure with fixing bolt (7) and spring washer (8), see fig 1.

Mounting of Conical Elements on the Foundation

21) Drill four mounting holes in the foundation for each conical element, either

a) Mark the positions of the mounting holes on the foundation through the conical element and the steel shim.

(Re)move the set completely so that the markings can be reached by drilling with conventional tools.

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Place the set on its former position by aligning it with the drilled holes.

or

b) Drill the mounting holes in the foundation by means of the drilling pattern from the installation drawing.

The drilling has to be done on beforehand and the set must be aligned with the foundation holes before the work starts to avoid further removal of the set.

22) Fix all the conical elements and the steel shims to the foundation with four bolts per conical.

Note! After completion of all works the buffer clearance must be checked, see points 17, 18, 19 and 20.

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Working card Page 1 (4)	Fitting Instructions for Resilient Mounting of GenSets	619-03.00 Edition 22H

L28/32H

Safety precautions

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Shut-off cooling oil
- Stopped lub. oil circulation

Description

Mounting and adjustment instruction for new GenSets, and adjustment instruction for existing plants.

Starting position

The foundation should be welded and milled off on shim surfaces.

Related procedure

Check of main beraings alignment (autolog) 610-01.00
Replacement of conicals 619-03.00

Man power

Working hours : 2 Hours
Capacity : 2 Men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate No	Item No	Note

Hand tools

Ring and open end spanner, 22 mm
Ring and open end spanner, 30 mm
Allen key, 6 mm
Feeler gauge, 1-2 mm
Measurement tool
Hydraulic jack (if necessary)

Spare and wearing parts

Plate No.	Item No.	Qty./
61903	01	4/conical mount.
61903	02	4/conical mount.
61903	03	1/conical mount.
61903	04	4/conical mount.

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L28/32H

Mounting and Adjustment Instructions for New Generating Sets (Method 2)

Make Ready for Adjustment of Conical Elements

If the conical elements have not been mounted by the factory, they must be mounted on the prepared brackets on the base frame. In case they have been mounted by the factory, please start with item number 2.

1) Fit the conical elements to the bracket of the base frame by means of four bolts screwed into the tapped holes on the top casting (5), see fig 1.

A supporting steel shim with a minimum height of 40 mm, to secure a future replacement of the conical element, complete with tapped holes for three jacking bolts and mounting holes drilled according to conical base casting dimensions, is required.

2) Remove fixing bolt (7), spring washer (8) and top lock ring (6) from the conical element, see fig 1.

3) Position the supporting steel shim as per fig 2 and locate the conical element by means of dowel pins.

4) Position the three jacking bolts in the tapped holes in the supporting steel shim as per fig 2.

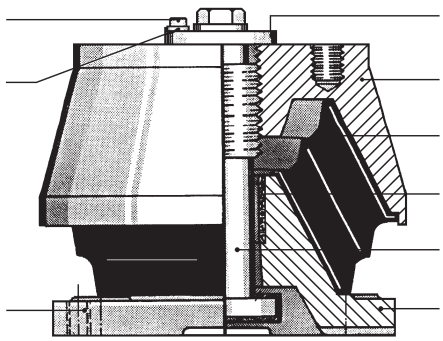

Fig 1 Conical element

5) Position the jacking bolts with a through-going of minimum 10 mm, see fig 2.

6) Lower the generating set until it rests completely on the foundation.

7) Check that all jacking bolts have full contact with the foundation.

8) Turn the internal buffer (2), see fig 1 to check that it can be moved freely.

If all internal buffers	Then
Can move freely	Let conical elements settle for 48 hours.
Cannot be moved freely	Turn the three jacking bolts in the supporting steel shim clockwise, or anticlockwise to release the internal buffer.

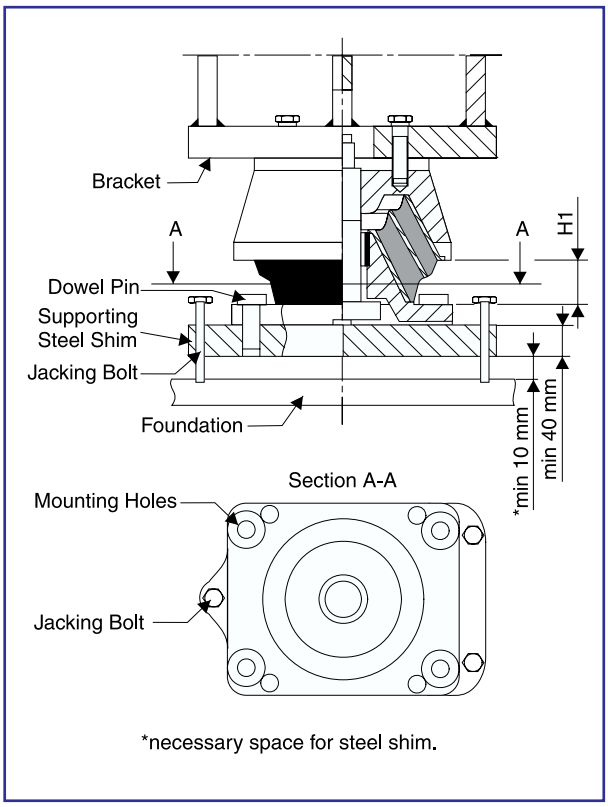

Fig 2 Conical mounting.

08028-0D/H5250/94.08.12

Adjustment of Conical Elements after 48 Hours Settling

After the conical elements have been deflected under static load for 48 hours, the laden height (H1) see fig 2, should be measured and compared to the recommended laden height.

9) Care must be taken, during levelling of the installation, to ensure that individual mountings are not overloaded. The variation in laden height should not exceed 2 mm and should ideally be less. The laden height can be measured between top and base casting at H, on two sides (see fig 1).

Example:

$$\text{Average} = \frac{H_1 + H_2 + H_3 \text{ ----- } H_N}{\text{Number of conical elements}}$$

If	Then
Difference exceeds 2 mm.	Level the conical element by adjusting the jacking bolts - commencing with the conical element with the largest deviation.
Difference does not exceed 2 mm	The height of the steel shim can be measured.

The difference between the two sides of a conical mounting should not be more than 0.6 mm.

Measuring of Steel Shim

10) Measure the steel shim on several points to obtain the highest possible accuracy during preparation.

Fabricating Steel Shim

11) Make sure that the minimum height of the steel shim is 10 mm.

Drill the mounting holes in the steel shim according to the mounting holes in the conical base casting and the mounting holes in the supporting steel shim.

Mounting of the Completed Steel Shim

12) Lift the generating set 1 mm totally be means of the three jacking bolts.

13) Position each completed steel shim.

14) Re-lower the generating set by means of the three jacking bolts until it rests completely in itself.

Adjustment of Internal Buffer

15) Turn the internal buffer clockwise (downwards) until it makes contact with the steel shim or foundation.

16) Turn the internal buffer anticlockwise (upwards) until it obtains contact with the base casting.

This must be four full turns.

17) Turn the internal buffer two full turns clockwise (downwards) and check with a feeler gauge between the base casting of the conical element and the steel shim that the internal buffer (2), see fig 1, does not touch the steel shim or foundation.

18) Lock the internal buffer by remounting the top lock ring (6) and turn it to the nearest thread hole - then secure with fixing bolt (7) and spring washer (8), see fig 1.

Mounting of Conical Elements on the Foundation

19) Remove the dowel pins.

20) Drill four mounting holes in the foundation for each conical element, either

a) Mark the positions of the mounting holes on the foundation through the conical element and the steel shims.

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(Re)move the set completely so that the markings can be reached by drilling with conventional tools.

Place the set on its former position by aligning it with the drilled holes.

or

b) Drill the mounting holes in the foundation by means of the drilling pattern from the installation drawing.

The drilling has to be done on beforehand and the set must be aligned with the foundation holes before the work starts to avoid further removal of the set.

21) Fix all the conical elements and the supporting steel shims/steel shims to the foundation with four bolts per conical.

22) Weld the lowest steel shim of approx. 10 mm height to the foundation.

Note! After completion of all works, the buffer clearance must be checked, see points 15, 16, 17 and 18.

08028-0D/H5250/94.08.12

Working card Page 1 (4)	Fitting Instructions for Resilient Mounting of GenSets	619-03.00 Edition 23H

L28/32H

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circulation

Description

Mounting and adjustment instruction for new GenSets, and adjustment instruction for existing plants.

Starting position

The foundation should be welded and milled off on shim surfaces.

Related procedure

Check of main beraings alignment (autolog) 610-01.00
Replacement of conicals 619-03.00

Man power

Working hours : 2 Hours
Capacity : 2 Men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate No	Item No	Note

Hand tools

Ring and open end spanner, 22 mm
Ring and open end spanner, 30 mm
Allen key, 6 mm
Feeler gauge, 1-2 mm
Measurement tool
Hydraulic jack (if necessary)

Spare and wearing parts

Plate No.	Item No.	Qty./
61903	01	4/conical mount.
61903	02	4/conical mount.
61903	03	1/conical mount.
61903	04	4/conical mount.

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Mounting and Adjustment Instructions for New Generating Sets (Method 3)

Make Ready for Adjustment of Conical Elements

If the conical elements have not been mounted by the factory, they must be mounted on the prepared brackets on the base frame. In case they have been mounted by the factory, please start with item number 2.

1) Fit the conical elements to the bracket of the base frame by means of four bolts screwed into the tapped holes on the top casting (5) see fig 1.

A supporting steel shim with a minimum height of 40 mm, complete with tapped holes for three jacking bolts, four mounting holes and four tapped holes, drilled according to the conical base casting dimension, is required see fig 2.

2) Remove fixing bolt (7), spring washer (8) and top lock ring (6) from the conical element, see fig 1.

3) Position the supporting steel shim as per fig 2 and locate the conical element by means of four hold-down bolts.

4) Position the three jacking bolts in the tapped holes in the supporting steel shim as per fig 2.

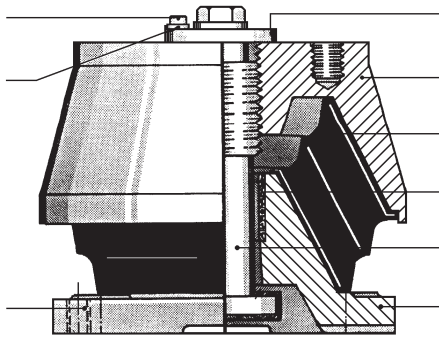

Fig 1 Conical element

5) Position the jacking bolts with a through-going of minimum 10 mm plus permitted thickness, as specified from the chockfast supplier, see fig 2.

6) Lowed the generating set until it rests completely on the foundation.

7) Check that all jacking bolts have full contact with the foundation.

8) Turn the internal buffer (2), see fig 1, to check that it can be moved freely.

If all internal buffers	Then
Can move freely	Let conical elements settle for 48 hours.
Cannot be moved freely	Turn the three jacking bolts in the supporting steel shim clockwise, or anticlockwise and slacken the four hold-down bolts to release the internal buffer.

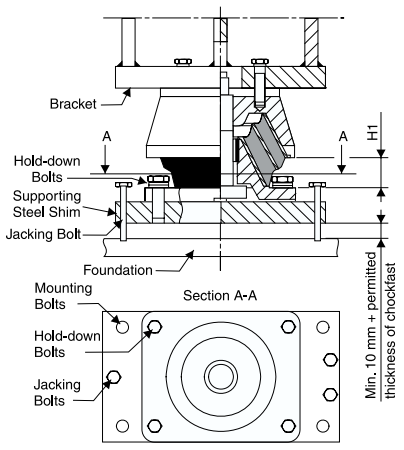

Fig 2 Conical mounting.

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Adjustment of Conical Element after 48 Hours Settling

After the conical elements have been deflected under static load for 48 hours, the laden height (H1) see fig 2, should be measured and compared to the recommended laden height.

9) Care must be taken, during levelling of the installation, to ensure that individual mountings are not overloaded. The variation in laden height should not exceed 2 mm and should ideally be less. The laden height can be measured between top and base casting at H, on two sides (see fig 1).

Example:

$$\text{Average} = \frac{H_1 + H_2 + H_3 \text{ ----- } H_N}{\text{Number of conical elements}}$$

If	Then
Difference exceeds ment 2 mm.	Level the conical ele- by adjusting the jacking bolts - commencing with the conical element with the largest deviation.
Difference does not exceed 2 mm	The height of the steel shim and the chockfast can be measured.

The difference between the two sides of a conical mounting should not be more than 0.6 mm.

Measuring of Steel Shim and Chockfast

10) The steel shim should be at least 10 mm high.

Check the minimum permitted thickness of chockfast for the load and surface of this application with chockfast supplier.

Fabricating Steel Shim

Make sure that the minimum height of the steel shim is 10 mm.

11) Drill the mounting holes in the steel shim according to the mounting holes in the conical base casting and in the supporting steel shim.

Adjustment of Internal Buffer

12) Turn the internal buffer clockwise (downwards) until it makes contact with the steel shim or foundation.

13) Turn the internal buffer anticlockwise (upwards) until it obtains contact with the base casting.

This must be four full turns.

14) Turn the internal buffer two full turns clockwise (downwards) and check with a feeler gauge between the base casting of the conical element and the steel shim that the internal buffer (2), see fig 1, does not touch the steel shim or foundation.

15) Lock the internal buffer by remounting the top lock ring (6) and turn it to the nearest thread hole - then secure with fixing bolt (7) and spring washer (8), see fig 1.

Mounting of Conical Elements on the Foundation

16) Drill four mounting holes in the foundation for each conical element according to the supporting steel shim/steel shim, either

a) Mark the positions of the mounting holes on the foundation through the conical element and the shims.

(Re)move the set completely so that the markings can be reached by drilling with conventional tools.

Place the set on its former position by aligning it with the drilled holes.

or

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b) Drill the mounting holes in the foundation by means of the drilling pattern.

The drilling has to be done on beforehand and the set must be aligned with the foundation holes before the work starts to avoid further removal of the set.

Make sure that the mounting bolts are isolated from the chockfast.

Note! After completion of all works, the buffer clearance must be checked, see points 12, 13, 14 and 15.

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Working card Page 1 (2)	**Replacement of Conicals**	**619-03.05** Edition 01H

L+V28/32H

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circulation

Description:

Replacement of conicals

Starting position:

Safety precautions

Related procedure:

Fitting instructions for resilient mounting

Man power:

Working hours : xxx Hours
Capacity : 2 Men

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaratiom of weight (Page 600.45)

Special tools:

Plate No.	Item No.	Note.

Hand tools:

Ring and open end spanner, 22 mm
Ring and open end spanner, 30 mm
Hydraulic jack

Spare and wearing parts:

Plate No.	Item No.	Qty./

L+V28/32H

Replacement of Conicals

1. Loosen all conicals in one side.

2. Mount a jack under the base frame, *see fig 1.*

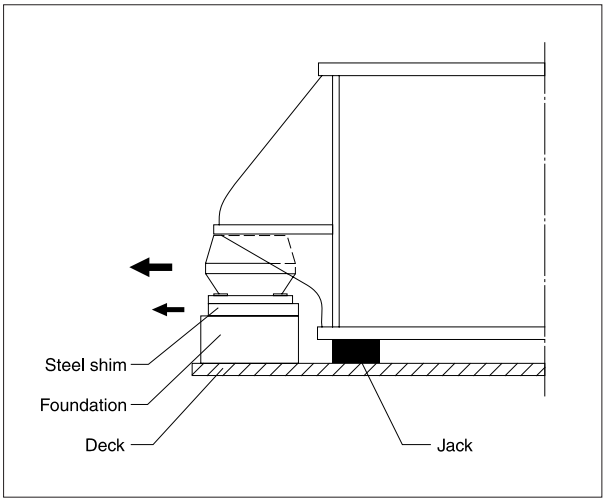

Fig 1 Removal of conicals

3. Lift the GenSet until the steel shim can be removed. This will give enough space for removing damaged conical.

4. Mount the GenSet conical.

Note! *Conicals should only be replaced in pairs, see fig 2 and plate 61903.*

5. Lower the GenSet again.

6. Repeat point 1-5 for the other side.

7. Adjust the conicals, *see Working Card 619-03.00 "Fitting Instructions for Resilient Mounting of GenSet.*

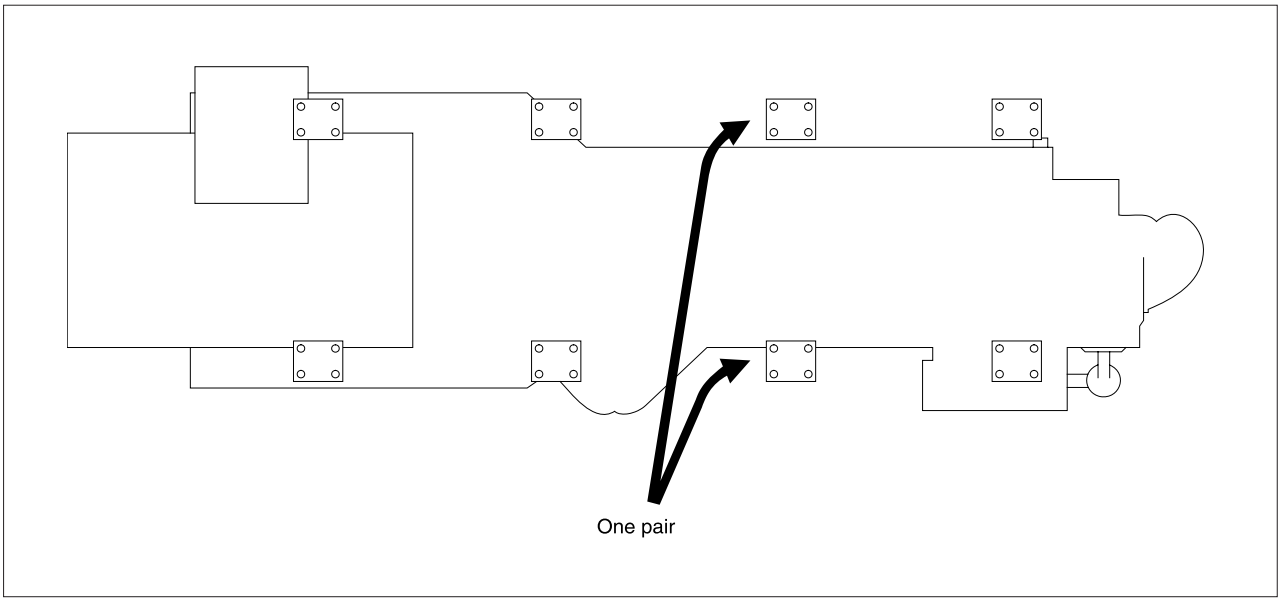

Fig 2 The conicals must be pairs

Working Card Page 1 (2)	**Maintenance of Conicals**	**619-03.10** Edition 01H

L+V28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Control and adjustment of conicals.

Starting position:

Related procedure:

Check of crankshaft bend (autolog)

Manpower:

Working time : 2 hours
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no	Item no	Note

Hand tools:

Ring and open end spanner.
Feeler gauge, 1-2 mm.
Hexagon socket key 6 mm.

Replacement and wearing parts:

Plate no	Item no	Qty/

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L+V28/32H

1. Visual Check

1.1. What to check.

Check for oil deposits on the rubber element.
Check for loose mounting bolts.
Check for damage in the rubber element.

1.2. Result of visual check.

If	Then
Everything is OK	Continue to next conical
Oil deposits on rubber element	Clean rubber element
Loose mounting bolts	Fasten mounting bolts
Damage in conicals	Replace conical according to *Working Card 619-03.05*

2. Clearance Check

2.1. What to check.

Check clearance on all conicals between steel shim and internal buffer through the slot in the base casting of the conical (see fig 1) with a feeler gauge of app. 2 mm.

2.2. Result of clearance check.

If	Then
Everything is OK	Check is completed
Everything is not OK	Adjust conicals which do not comply with the clearance demands acc. to item 2.3. Re-check all conicals acc. to item 2.1.
Everything is still not OK	Replace conical acc. to *Working Card 619-03.05*

2.3. Adjustment of conicals.

a. Remove protective cap (no 10).

b. Remove fixing bolt (no 9) and top locking ring (no 7).

c. Turn buffer clockwise until it has contact with the steel shim (no 2).

d. Turn buffer anticlockwise until it has contact with the conical base casting (no 3). This must be four full rotations.

e. Turn buffer two full rotations clockwise. This will ensure full vertical movement for the buffer.

f. Check all conicals again.

g. Replace top locking ring, fixing bolt and protective cap etc.

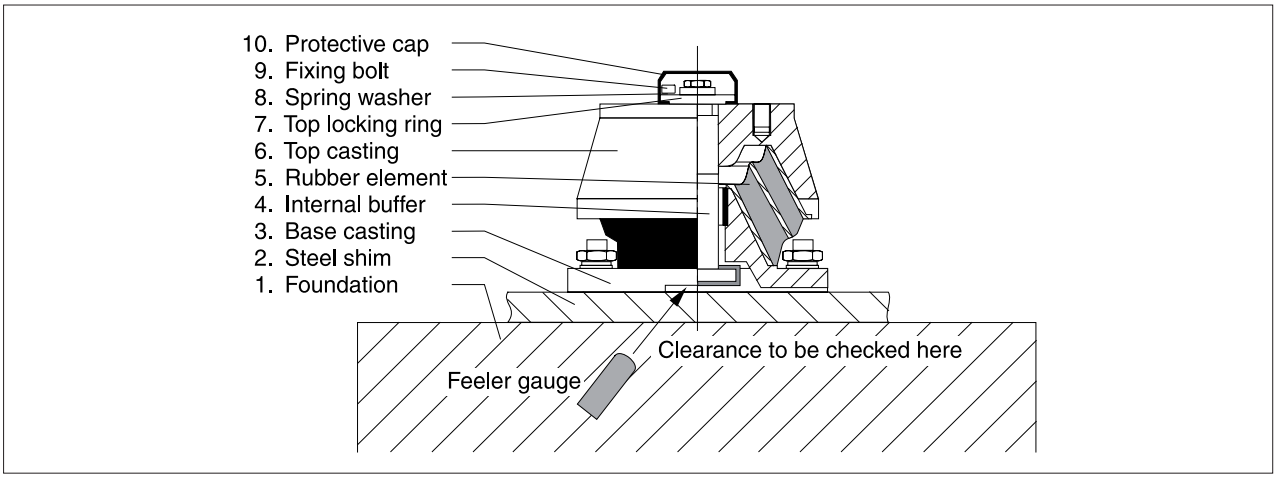

Fig 1 Conical

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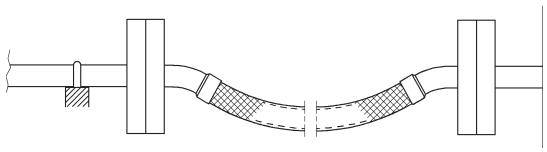
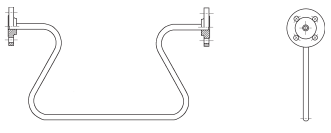
Plate Page 1 (2)	**Flexible External Connections**	**61902-03H**

L28/32H

Fig.	Designation	Connection	Item No.
	Waste oil, outlet	A3	01
	Nozzle cooling oil, inlet	A7	02
	Nozzle cooling oil, outlet	A8	03
	Lubricating oil from separator, inlet	C3	04
	Lubricating oil to separator, outlet	C4	05
	Back flush from full-flow filter, inlet	C9	06
	Lub. oil from by pass filter, inlet	C11	07
	Lub. oil to by pass filter, outlet	C12	08
	Lub. oil supply, inlet	C16	09
	Venting to expansion tank	F3	10
	HT freshwater from preheater, inlet	F5	11
	HT freshwater to preheater, outlet	F6	12
	Fresh water for filling/draining	F7	13
	Compressed air, inlet	K1	14
	Control air, inlet	K2	15
	Drain from charge air cooler, outlet	M6	16
	Fuel oil, inlet	A1	17
	Fuel oil, outlet	A2	18

L28/32H

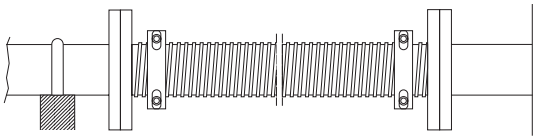
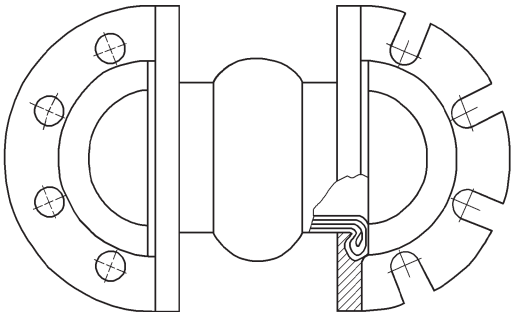
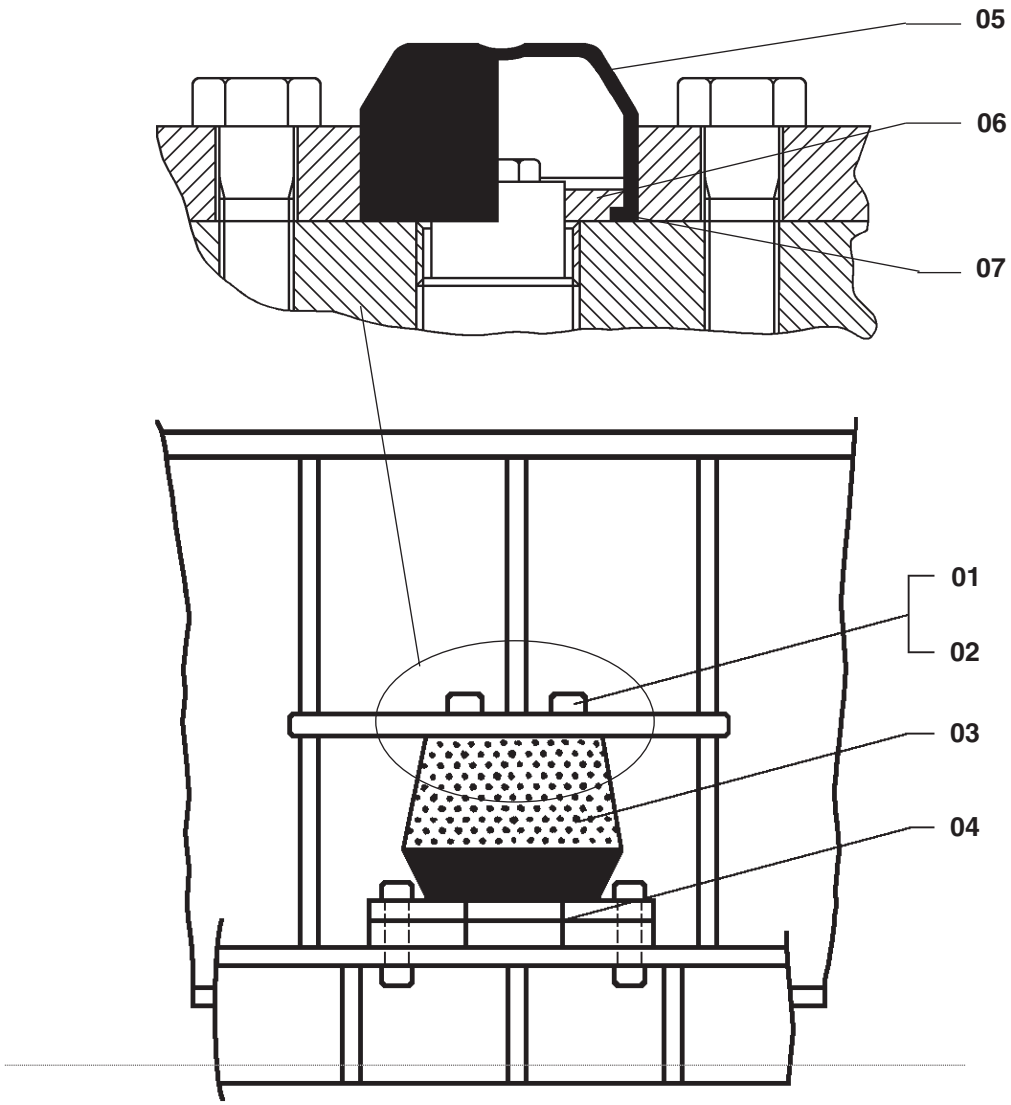
Fig.	Designation	Connection	Item No.
	Oil vapour discharge, outlet	C13	19
	Lubricating oil from full-flow filter, inlet	C7	20
	Lubricating oil to full-flow filter, outlet	C8	21
	HT freshwater, inlet	F1	22
	HT freshwater, outlet	F2	23
	LT freshwater/raw water, inlet	G1	24
	LT freshwater/raw water, outlet	G2	25
	Sea water, Inlet	G3	26
	Sea water, outlet	G4	27

Plate Page 1 (2)	**Conical Element**	**61903-04H**

L+V28/32H



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Note! When ordering, be aware that conical elements always should be replaced in pairs, state manufacturing no. of existing conical elements.

Bemærk! Ved bestilling af conicals elementer. Conicals elementer udskiftes parvis, opgiv fabrikations nr. på eksisterende conicals elementer.

61903-04H	Conical Element	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
01	4/M	**Screw**	Skrue
02	4/M	**Washer**	Skive
03	1/M	**Conical element**	Konisk understøtning
04	4/M	**Adjusting screw**	Justerskrue
05	1/M	**Protecting cap**	Beskyttelseskapsel
06	1/M	**Fixing ring**	Fiksering ring
07	1/M	**O-ring**	O-ring

Item No.	Qty.	Designation	Benævnelse

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When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./M = Qty./Conical mounting.

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Antal/M = Antal/Conical montering.

Tools

520/620

Description Page 1 (1)	**Introduction to Spare Part Plates for Tools**	**620.01** Edition 01H

General

The contents of these spare part plates with tools are a summary of STANDARD TOOLS for normal maintenance and EXTRA TOOLS for reconditioning, which can be supplied by MAN Diesel A/S, Holeby. Thus, the list comprises the total extent of tools available for this engine type.

For each specific plant, the amount of tools delivered depends of the contractual specifications.

The tools listed are assembled in sections corresponding to the chapters of the instruction book.

However, some tools, such as torque spanners, hydraulic tools etc., may also have other applications. Information about the exact use of the tools appears from the relevant sections in the instruction book.

Note: The table on the spare part plates is marked with an S or an E. An S means that the tools are supplied when ordering Standard tools and an E means that the tools are supplied when ordering Extra tools, i.e. Tools for Reconditioning. (Extra tools are not standard delivery)

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Working Card Page 1 (7)	Function of the Hydraulic Tools	620-01.05 Edition 03H

General

Safety precautions

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Stopped lub. oil circul.
- ☐ Press Blocking - Reset

Description

Safety hints andd function of hydraulic tools.

Starting position

Application of hydraulic tools	620-01.06

Related procedure

Manpower

Working time	:	hours
Capacity	:	men

Data

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools

Plate no	Item no	Note

Hand tools

Replacement and wearing parts

Plate no	Item no	Qty/

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General

Function of the Bolt Tensioning Device

In order to achieve an optimal result with one or several devices, some rules have to be considered. We expressly point out that a conscientious handling of the device as well as the accessories is of highest importance. To ignore these rules or separate hints means danger to life or danger of injuries! *See Safety Hints.*

Safety Hints

Beside regarding the general accident-prevention rules, the safe handling of the device and the hydraulic accessories demand especially the consideration of the following hints. When disregarding even single items, you can cause danger to life and/or danger of injuries!

1. When leakages occur during the pressurization, bleed pressure immediately and seal the leakage or replace defect parts.

2. In case of repair, use exclusively original spare parts. Inexpert substitution of damaged parts by non-original spare parts is prohibited.

3. All assembly parts are to be handled in correspondence to the working cards only. A change in the procedure or another operation of the device is not allowed.

4. Make sure that the components to be tensioned do not exceed the admissible strain.

5. In order to use the device, the thread has to be sufficiently exceeding in order to avoid that the turn of a thread cracks, *see item 4.*

6. During the pressurization the people involved have to remain in an appropriate distance. Staying in direction towards the bolt axis is forbidden.

7. Tensioning pressures or tensioning forces are to be given or changed by authorized personnel only while considering the admissible component loads, *see item 4.*

8. The operation and handling of the device are to be carried out by expert staff only.

9. The given max. operation pressure is not to be exceeded in any case and is to be watched at the manometer of the pressure generator during the complete tensioning or loosening procedure. When having achieved the given pressure, stop the pressurization immediately.

10. During the pressurization when tensioning or loosening the bolt connection, always watch the admissible stroke of the device. Exceeding this stroke is connected with insufficient generating of tensioning force because the device is tensioned in itselve or the hydraulic pressure is bleeded automaticly.

11. On principle, when connecting high-pressure hoses it has to be taken care that the connections are correct (see also separate hints).

12. The hydraulic hoses have to be installed in a way that they are not run over by vehicles or unnecessarily walked over by people. Never lay hoses across sharp objects (danger of cuts) and never bend or jam them in.

13. Never hold or transport the device by using the high-pressure hoses.

14. An incorrect working manometer that doesn´t show the right pressure leads to overstressing of the parts and to an incorrect bolt connection. Apart from damaged parts an incorrect bolt connection can also cause conditions that are danger to life. Therefore take care that the manometer shows the right value or the tensioning force is checked in an other way (for example by using a master manometer). Tensioning forces can be checked for example by measuring the linear deformation. Damaged manometers have to be exchanged immediately.

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General

Working Hints

In order to achieve a bolt connection of high precision, it is vital to consider the following working hints:

- Prior to setting the device, clean all threads and remove possible damages in order to avoide a “freeze on”.
- The base plate for the device must be plain and free of dirt. Further check the squareness towards the bolt axis in order to avoid that the bolt has a bending stress during the pressurization (tensioning).
- The stroke of the device may not at any point be exceeded.
- For transporting the device it is necessary to uncouple all high-pressure hoses.
- After each pressurization, bring the device back to zero, *see also Piston Return Stroke.*

Turnable Connection Unit

In order to simplify the connection of the hydraulic hose, a turnable connection unit is mounted on some devices.
The turnable connection unit consists of the following components:

- bolt nipple
- disc
- seal
- securing ring

Furthermore, an entry guide is available or contained in the scope of supply, *see fig.1.*

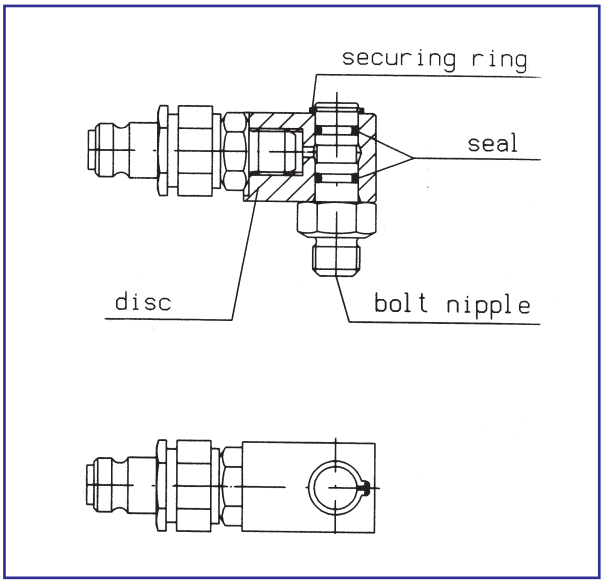

Fig. 1. Turnable connection unit.

Exchange of the Seals

Should leakages show up at the connection unit, it might be necessary to exchange the seals.
For doing so, loosen the securing ring and take the disc off the bolt nipple. Having removed the seals, clean the components with fluff-free cleaning material. You can also apply compressed air. Having checked the components for damages and oiled them slightly, apply new seals by help of the entry guide and reassemble the turnable connection unit.

Hint:
- For the cleaning, never use aggressive cleaning liquids.
- For oiling the parts, use exclusively hydraulic oil.
- For replacements, use exclusively new seals.

Coupling of the High-Pressure Hoses

- Only couple when the hydraulic system is in a pressureless condition.
- To produce a high-pressure connection, put one coupling and one nipple into each other while the coupling socket is pulled back. When letting the coupling socket go, there is a form fit barring the connection.

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General

- By drawing the hose with a manual force of about 100 N make sure that the connection is correctly barred.

- For decoupling the high-pressure hose in a pressureless condition, first pull back the coupling socket and then take off the hose.

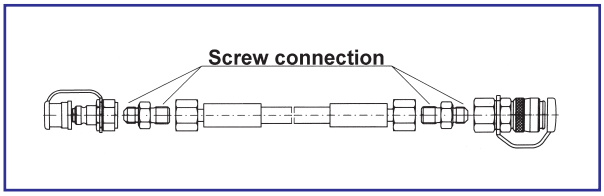

Fig. 2. Coupling of the high-pressure hoses.

Hoses with fast-lock coupling sockets avoid, also when uncoupled, that oil runs out. When the hoses get heated, there can be an inside pressure in the uncoupled condition making a coupling impossible. By loosening one screw connection (*see fig. 2*) the pressure can be bleeded

- To avoid a contamination use protecting caps for the sockets.

Tensioning Procedure

Prior to the tensioning procedure make sure that the components to be tensioned are correctly positioned towards each other. Then screw the device onto the bolt.

First put the support sleeve on the bolt and align it centrically to the bolt axis. When screwing on the device take care that the support sleeve at the cylinder is correctly centered (consider centering shoulder).

Screw the device until the support sleeve or the support cylinder fits exactly to the flange. The piston of the device must be at its zero position. Furthermore, take care that the hydraulic connector and the window for the adjusting rod is well accessible.

If necessary, turn back the device, but make sure that the max. admissible stroke of the device is not exceeded. Beside that, it has to be ensured that the cylinder and the support sleeve remain centrically towards each other (consider centering shoulder).

Having made all hydraulic connections correctly, *see fig. 2*, start the pressurization for the tensioning procedure. If the necessary pressure is achieved stop pressurization. The inducted force causes the bolt to extend or an edging of the components to be tensioned so that the main nut is lifted from the flange. Screw it back to the flange, *see fig. 3*. Check by help of a feeler gauge leaf whether the main nut really fits tight to the flange. After that, bleed hydraulic pressure. Now the connection is tensioned.

Having brought the piston to its zero position, *see fig. 4*, the hydraulic hoses can be decoupled. In order to prevent impurities, it is advisable to close coupling sockets and coupling nipples at once by protecting caps. The device can be unscrewed from the bolt.

- Always consider the safety and working hints!

Loosening Procedure

In order to loosen an existing bolt connection, screw the device onto the bolt. First put the support sleeve on the bolt and align it centrically to the bolt axis. When screwing on the device take care that the support sleeve at the cylinder is correctly centered (consider centering shoulder).

The piston of the device must be at its zero position. Having screwed the device down until the support sleeve or the support cylinder fits tight to the flange, turn back the device by at least the value (slit measure) which the bolt and the components spring back elastically during the loosening procedure.

Hint: The adjusted slit measure may never exceed the admissible stroke of the device! Furthermore, take care that the window for the adjusting rod are well accessible.
Having made all hydraulic connections correctly, *see fig. 2*, start the pressurization.

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General

During the pressurization, a slight turn-back momentum is applied to the main nut with the adjusting rod. At the moment, when the main nut can be loosened, interrupt the pressurization. Should it not be possible to loosen the main nut when achieving the original tensioning pressure, interrupt the pressurization immediately. Find the cause with expert staff.

Having achieved the loosening pressure, turn back the main nut by the value that the bolt and the components spring back during the loosening procedure. The slit measure, however, must be lower than the slit measure adjusted at the device before, *see also hint b*.

The main nut may never be turned back until it fits to the piston or the cylinder since then the device can be tensioned in itself.

Having turned back the main nut, the pressure can be bled. The bolt connection is loosened. Before unscrewing the device, bring the piston back to its zero position, *see fig. 4*. After that, the hydraulic hoses can be decoupled. In order to prevent impurities, it is advisable to close coupling sockets and coupling nipples at once by protecting caps. The device can be unscrewed from the bolt.

- Make sure that no operational forces (e.g. inner pressure) affect the components to be loosened since only part of the bolts take over these forces and thus the bolts, which are not yet loosened, might be overburdened.

- The pressure when the main nut can be loosened may never exceed the tensioning pressure by help of which the connection was tensioned! Should it not be possible to loosen the main nut when reaching the original tensioning pressure interrupt the pressurization immediately. Find the cause with expert staff.

- Always consider the safety and working hints!

Hint:

a) Should it be impossible to unscrew the device after the depressurization, it has been turned back by a too low measure prior to the pressurization. Pressurize again until the original tensioning pressure is reached, turn the main nut and bleed the pressure again (tensioning procedure). Now you can turn back the device further. *(Attention: consider the admissible stroke of the device!)* Now repeat the loosening procedure explained above.

b) Should it be impossible to loosen the main nut after the depressurization, it has been turned back by a too low measure prior to the pressurization. Pressurize again and turn the main nut further back. Bleed the pressure again.

Hint: Never screw the main nut back until it fits to the piston since the device can be tensioned in itself.

Adjustment and Turn Back of the Main Nut

During the pressurization of the device, the bolt is being extended by the tensioning force and the components are being edged. The result is that the main nut does no longer fit to the flange.

Having achieved the necessary pressure, adjust the main nut - when tensioning - until it fits to the flange again before bleeding the pressure, *see Tensioning Procedure.* When loosening the bolts, turn back the main nut after the pressurization according to the bolt and component deformations, *(see Loosening Procedure.*

Hint: During the loosening procedure, never turn back the main nut until it fits to the piston or the cylinder since the main nut sticks after the depressurization.

The main nut is equipped with several radial bores where the adjusting rod can be put in. The main nut is accessible through the window in the support sleeve.

08028-0D/H5250/94.08.12

General

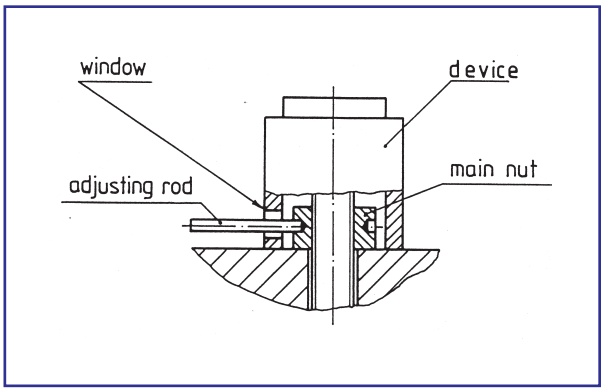

Fig. 3 Adjustment and turn back of the main nut.

Piston Return Stroke

After each pressurization it must be ensured that the piston of the device is brought back to its zero position. On principle, it has to be considered that hydraulic oil is being displaced from the piston area. In order to enable the oil to flow back to the tank of the pressure generator, the corresponding hydraulic connections must be done.

The piston return stroke is done by a screw-down at the bolt itself before the device is taken off.

Hint: When using fast lock coupling elements, the oil's running out and thus a piston return stroke in an uncoupled condition is impossible!

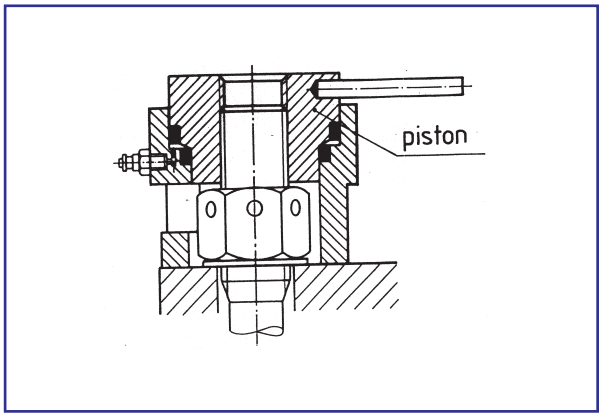

Fig. 4. Piston return stroke.

During the piston return stroke, considerable back-pressures can occur in the piston area of the device since quite large quantities of oil have to flow back through the small cross sections of the high-pressure connections.

In order not to unnecessarily increase the force for the piston return stroke turn the piston slowly. On principle the piston of the device has to be pushed back until it fits to the cylinder again.

Exchange of the Seals

Should leakages occur at the piston of the device, an exchange of the seals might be necessary.
Drive out the piston by carefully beating with a hammer while using a plastic spacer in order to protect the device from unnecessary damages. After removing the hydraulic connector, you can also carefully lead compressed air into the piston area.

Attention: Sudden input of compressed air can lead to the piston's uncontrolled outlet.
After removal of the piston, the seals and the backup rings can be removed from the piston and the cylinder.

Carefully clean the components with fluff-free material and check them for damages. If necessary, use compressed air for the cleaning, but never aggressive cleaning liquids. After that, slightly oil these components with hydraulic oil and assemble new backup rings as well as new seals to the piston and the cylinder according to the drawing.

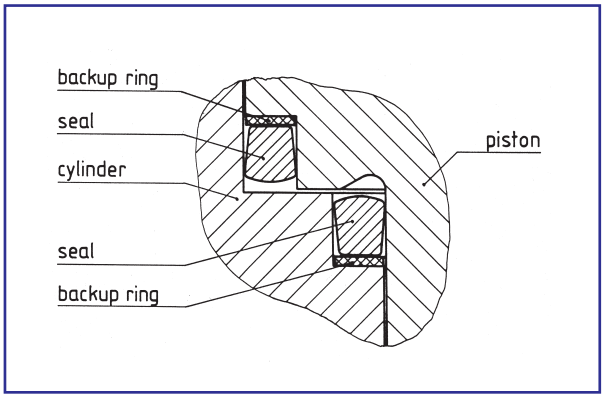

Fig. 5. Exchange of the seals.

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As shown in the picture, first assemble the backup ring, then put the seal onto the backup ring. Piston and cylinder can now be assembled again by putting the components together. By slightly hammering on the piston (with plastic spacer), it can be driven in until it fits tightly to the cylinder (piston in its zero position). It is essential that the piston does not tilt during being driven in since this might damage the seals as well as the components. When assembling the piston it has to be taken care that the air can come out of the piston area.

Maintenance and Storage

Regular maintenance of the device is not necessary, but you should consider the following points:

a) Storage

After each operation, repair possible damages and clean the device in order for it to be ready for the next operation immediately. In order to avoid a corrosion it is advisable to oil the device and especially its thread. All coupling nipples, coupling sockets and also loosened screw connections are to be closed by protecting caps.

In addition, check the components of the device and its accessories for completion.
Keep the device in the tool box also offering protection from mechanical damages.
The temperature must be between -20 C and +70 C in order to exclude a damage of the seals.

b) Start-up of the device

Prior to the device's operation, repair possible damages and clean the device.

Check the components of the device and its accessories for completion.

The operating manual has to be read by all users.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	Application of Hydraulic Tools	620-01.06 Edition 01H

L/V28/32H

Safety precautions

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Stopped lub. oil circul.
- Press Blocking - Reset

Description

Application of hydraulic tools.

Starting position

Function of hydraulic tools	620-01.05

Related procedure

Manpower

Working time	:	hours
Capacity	:	men

Data

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools

Plate no	Item no	Note

See page 2

Hand tools

Replacement and wearing parts

Plate no	Item no	Qty/

08028-0D/H5250/94.08.12

L/V28/32H

This working card gives the information for application of hydraulic tools, to be used in connection with working card 620-01.05.

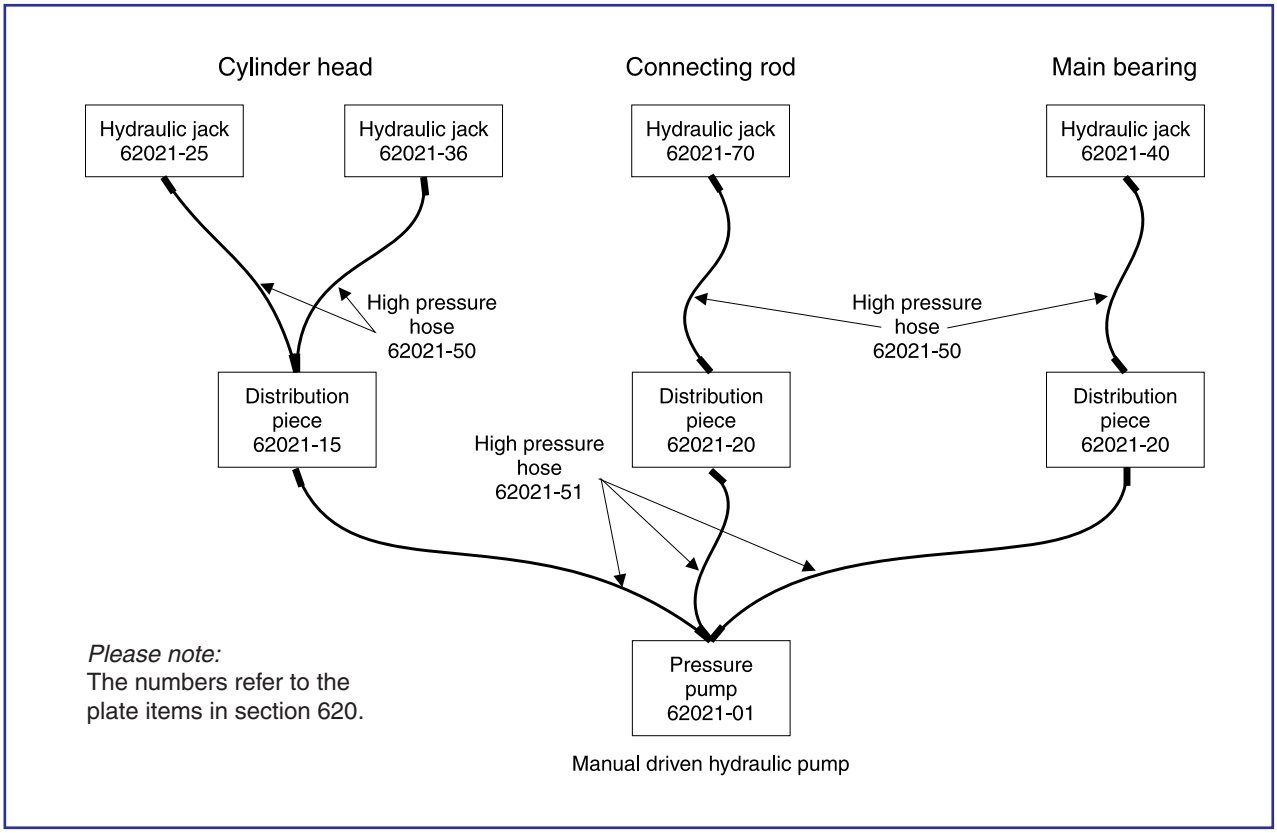


Fig 1 Hydraulic tools.

08028-0D/H5250/94.08.12

Working Card Page 1 (4)	Hand Lever Pump	620-01.07 Edition 01H

General

Safety precautions

- Stopped engine
- Shut-off starting air
- Shut-off cooling water
- Shut-off fuel oil
- Stopped lub. oil circul.
- Press Blocking - Reset

Description

Application of hydraulic tools.

Starting position

Related procedure

Manpower

Working time : hours
Capacity : men

Data

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools

Plate no	Item no	Note
62021	01	

Hand tools

Replacement and wearing parts

Plate no	Item no	Qty/

08028-0D/H5250/94.08.12

General

Warning: The hand lever pump is not equipped with a pressure relief valve.
Never use the pump without a mounted manometer. Always pay attention to the given pressure of the connected pressure consumers. Do never exceed this pressure or the max. pressure of the hand lever pump.

Important: Except for hydraulic oil, never use different liquids such as petrol, water, diesel oil, alcohol or brake liquid, since these can lead to damages or even to destruction of the pump and/or the parts connected with it. Choose a place of assembling and operation where the pump can always stand safe and firm on a horizontal plain. There should always be sufficient space for operating the pump.
Never handle the pump lever with oiled hands and never use hand lever extensions. Never expose the pump to great heat, fire or extreme coldness, since this leads to damages or even destruction. Protect the pump from falling objects and avoid hard blows or pushes.

Attention - Danger to life

Check the manometer of the pump for the needed hydraulic pressure, given by an authorized person, not to be exceeded. Make sure that the pressure you want to generate is also admissible for all connection parts.

All pressure connections and connecting elements have to be clean and undamaged. High-pressure connections from the pump to the tools have to be established correctly prior to any pressurization. Disregard leads to danger to life. *Please see working card 520-01.06.*

Attention - Danger on injuries

Loads being lifted by the pump may never be held by the pump valves alone. Use additional non-return valves or safety relief valves and secure the load by sufficient support against falling.

Initial Start-up and Venting

In general and venting

Please make sure that all parts of the pump, especially the manometer and the pressure port, are in a perfect condition. Defect parts are to be exchanged against new ones immediately.

Turn the carrying handle with counter-clockwise rotation out of his fixing. Then turn it into the hand lever of the pump against the stopping face.

Attention: If the carrying handle is not srewed-in into the hand lever, it can cause injuries while using the pump.

Open the oil filler cap and check the oil level. If neccessary, fill up the tank with hydraulic oil according to IS0 VG 32. Never overfill the tank. Close the oil filler cap.
Open the tank breather with the square wrench (included in the scope of supply) by about one turn. Now loosen the breather screw at the pump on the left side on the pump housing with an allen key SW 2,5 by about one turn. Close the depressurization valve tightly. Seal the nipple on the pump with a hose and pump at the hand lever until oil flows out of the breather screw bladder-free. Only then are you allowed to close the breather screw. The pump is now vented and ready for operation.

After each operation and for the transport, close the tank breather in order to avoid the hydraulic oil's running out.

Pressurization

- Open the tank breather with the square wrench approx. one turn.

Remark: The pump is only to be operated with open tank breather.

- Close the depressurization valve at the pump when turning clockwise by handoperation.

Remark: The depressurization valve is designed for manual operation. The use of any tools at the depressurization valve could cause damages of the valve or the valve seat.

08028-0D/H5250/94.08.12

General

- Pump at the hand lever until the wanted pressure is achieved. Check the pressurization at the manometer and take care of possible leakages.

Remark: The pump works with two stages. The change from the first stage to the second stage happens automatical at a system pressure of about 30 bar.

Attention: The pump is not equipped with an internal pressure relief valve. The use of a manometer and the control of the system pressure during pressurization is indispensable.

Attention: Do not stand directly over the moving line of the pump lever. Under arising circumstances the lever can “hit back”. To avoid accidents stand sideways the pump.

Attention - High-pressure hydraulic
On principle, tihen leakages occur during the pressurization, immediately release the hydraulic pressure and seal the leakage or renew defect parts.

Depressurization

- Open the depressurization valve slowly by a turn to the left.

- Make sure that the hydraulic pressure at the manometer has been completely released. Consider the returning time of the hydraulic oil.

Adjustment of change-over pressure from stage 1 to stage 2

In exeptional case, it can be useful to adjust the change-over pressure from stage 1 to stage 2 (factory adjusted at approx. 30 bar).

Below of the pressure relief valve is an adjusting screw with inner hexagon (wrench size 10 mm). Turning out counter-clockwisely the adjusting screw minimizes the change-over pressure, turning in clockwise maximizes the change-over pressure.

Attention: Inside of the adjusting screw is another grub screw with inner hexagon (wrench size 4 mm) to limit the stroke of the change-over piston inside of the pump block. It is absolutely necessary, to screw out the grub screw approx. 2 times before turning the adjusting screw!

The regulation of the adjusting screw follows gradually in approx. 10° - steps. After everv adjusting step the grub screw is to screw in until it fits closely and approx. a l/4 turn to loosen.

Check by carefully pumping if the change-over pressure wanted has been reached. If necessary, repeat the procedure as described above.

08028-0D/H5250/94.08.12

General

Analysis and Correction of Malfunction

Correction of malfunctions

In case of malfunctions at the pump, the following points are to help you with the analysis of the problem and correcting it yourself.
For this, uncouple or unscrew all consumer and high-pressure hoses from the pump.

Malfunction	Correction
No pressurization	1. Check the oil level and, if necessary, fill it up as described in chapter maintenance and storage. 2. Close depressurization valve. 3. Visual inspection whether there are leakages. If so, seal them. 4. Vent the pump as described in chapter initial start-up and venting.
Insufficient pressurization (prior to any corrections, open de-pressurization valve and release hydraulic pressure completely)	1. Check the oil level and, if necessary, fill it up, as described in chapter mainteance and storage. 2. Close depressurization valve. 3. Visual inspection whether ther are leakages. If so, seal them. 4. Vent the pump as described in chapter initial start-up and venting.
Pressure drop (prior to any corrections, open de-pressurization valve and release hydraulic pressure completely).	1. Visual inspection whether there are leakages. If so, seal them. 2. Close depressurization valve.

If the problem cannot be solved, please contact MAN Diesel, Holeby.

Pressure Port

The pressure port of the pump is produced according to our customers' wishes. In addition, there is a variety of possibilities to connect the pump with one or more pressure consumers.

Attention - Danger to life

Prior to the pump' s start-up please make sure that, no matter which pressure port you chose, all connection elements are in a perfect condition. Convince yourself of the fact that these are correctly connected and suitable for the necessary pressure.

Attention - High-pressure hydraulic

On principle, when leakages occur during the pressurization, immediately release the hydraulic pressure and seal the leakane or renew defect parts.

Maintenance and Storage

The pump should be lubricated frequently at the movable parts. Protect it from contamination because dirt in the oil or in the pressure port can lead to the pump' s failure. A dry storage avoids the steel parts' getting rusty.
The storage and transport of the pump should always be done in a horizontal position. Thus, you avoid a possibly necessary venting of the pump during its start-up.

For checking the oil level, please open the depressurization valve and let the oil completely flow back into the tank. Open the oil filler cap and fill up hydraulic oil according to IS0 VG 32, if neccessary. Do not overcharge the tank. Close the oil filler
cap.

The use of the pump in a dirty area requires a regular oil change. Fill the pump with clean hydraulic oil and lubricate all moving parts (hinges) regulary.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Maintenance of Hydraulic Tools**	**620-01.10** Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Maintenance of hydraulic tools and pressure testing of hoses.

Starting position:

Related procedure:

Man power:

Working time	:	1/2	Hour
Capacity	:	1	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Allen key, 6 mm.
Ring and open end spanner, 22 mm.
Clean lub. oil.

Replacement and wearing parts:

Plate no.	Item no.	Qty. /
62021	43	Hydraulic tool.
62021	44	Hydraulic tool.
62021	29	Hydraulic tool.
62021	30	Hydraulic tool.

08028-0D/H5250/94.08.12

General

1) The hydraulic jacks require no maintenance except replacement of defective sealing rings, each of which consists of an o-ring and a back-up ring fitted in ring grooves in the piston and cylinder.

The piston and cylinder are easily separated by taking out the bleed screw and pressing the parts apart with the help of working air.

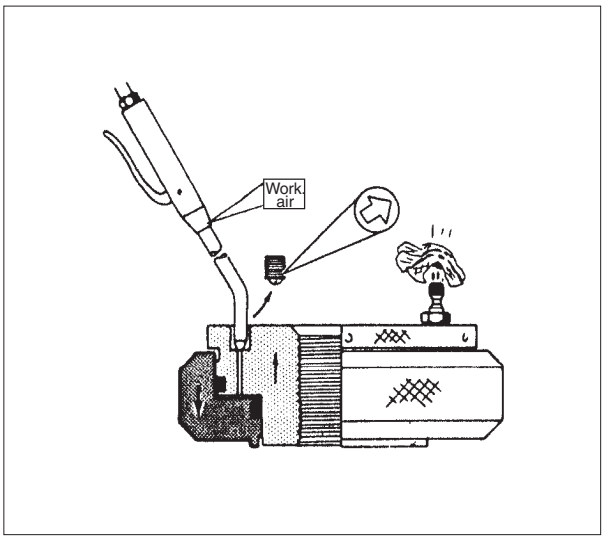


Fig. 1.

Make sure that there are no marks or scratches on the sliding surfaces of the parts. The presence of metal particles will damage the sealing rings.

2) The sealing rings are to be fitted with the o-rings nearest to the pressure chamber and with the back-up rings away from the pressure chamber.

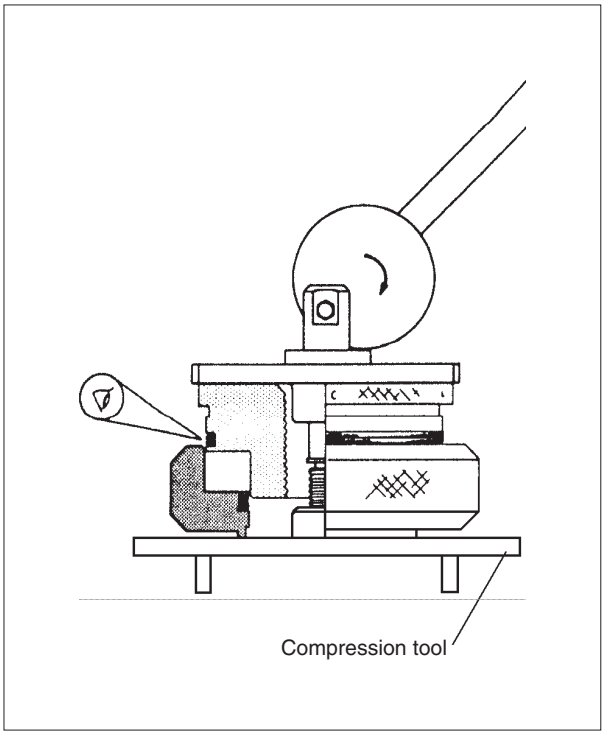


Fig. 2.

Fit the sealing rings and lubricate with clean lub. oil. The piston and cylinder are pressed together by means of the tool supplied. See that the rings do not get stuck between the piston and cylinder.

Pressure Testing of Hoses.

To avoid working accidents caused by emission of pressure oil from the hydraulic hoses, they should be pressure tested at 1200 bar once a year.

Note: During the pressure testing the hoses must be covered carefully.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Tightening with Torque Spanner**	**620-01.15** Edition 01H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Starting position:

Related procedure:

Man power:

Working time
Capacity

Data:

Data for pressure and tolerance (Page 600.35)
Data for torque moment (Page 600.40)
Declaration of weight (Page 600.45)

Special tools:

Plate no.	Item no.	Note.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

General

1) Before the nuts are screwed on, the threads and the contact faces should be grease with copaslip or similar, the tightening torques being based on a coefficient of fiction in the threads.

2) The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

3) In the case of new nuts and studs, tighten and loosen the nuts 2 or 3 times so that the thread may assume its difinite shape, thus obviating the risk of loose nuts.

4) Nuts secured with a split pin are tightened to the stated torque and then to the next split-pin hole.

5) The following instructions apply to the use and maintenance of torque spanner.

Torque Spanner.

6) The handle of the torque spanner is provided with a scale indicating the torque at which the spanner can be set.

7) For setting the spanner at the torque required, there is a ball on a small arm at the end of the handle.

8) When pulling the ball with the arm outwards, a small crank handle is formed.

A spring-loaded slide in the handle provided with a mark which, when turning the crank handle, can be set at the required torque on the scale.

The torque spanner functions as follows:

9) The above-mentioned spring activates a pawl system in the handle, and when using the spanner, this pawl system will be released when the pre-set torque has been reached, at which moment a small jerk is felt in the spanner and a small click is heard.

10) The torque spanner must not be used for torque higher than those stamped on it, and it must not be damaged by hammering on it or the like.

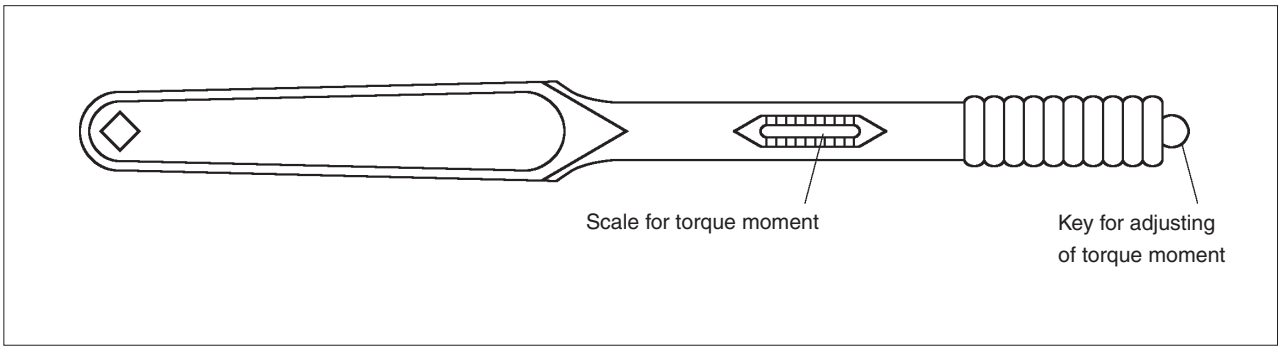


Fig. 1. Torque spanner.

08028-0D/H5250/94.08.12

Working Card Page 1 (3)	**Tool Combinations for Tightening of Connecting Rod Screws**	**620-01.20** Edition 01H

L28/32H

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- □ Shut-off cooling water
- □ Shut-off fuel oil
- □ Shut-off cooling oil
- ■ Stopped lub. oil circul.

Description:

Tool combinations for tightening and checking connecting rod screws.

Starting position:

Related procedure:

Dismounting of piston and connecting rod,	606-01.00
Tightening and check of connecting rod screws,	606-01.25
In-situ inspection of connecting rod big-end bearing,	606-01.30

Man power:

Working time	:	Hours
Capacity	:	man

Data:

Data for pressure and tolerance	(Page 600.35)
Data for torque moment	(Page 600.40)
Declaration of weight	(Page 600.45)

Special tools:

Plate no.	Item no.	Note.
62006	28	140 - 760 Nm.
62006	30	Ekstra tools.
62006	32	Only for tightening
62006	34	200 mm.
62006	37	32 mm.
62006	39	Ekstra tools.
62006	41	Ekstra tools.

Hand tools:

Replacement and wearing parts:

Plate no.	Item no.	Qty. /

08028-0D/H5250/94.08.12

L28/32H

The tightening procedure for connecting rod screws can be executed with the tools originally delivered with the GenSets.

The enclosed pages illustrate different tool combinations applicable to tightening of connecting rod screws.

The turning of the screws through a 60° angle, can be executed with less muscle power if a planet gear spanner (extra tools) is used.

If tool combination with planet gear spanner is used for check of the connecting rod screws tightening condition, the gear ratio (1:4) has to be taken into consideration when setting the torque spanner. For prescribed test torque of 700 Nm, the torque spanner should be set at 175 Nm. (4 x 175 = 700).

It is also acceptable to execute the turning of the screws through a 60° angle, by means of a pneumatic impact spanner, if available are adequate power and dimensions.

Tightening with torque spanner ratchet, extension piece (only for upper screws) and socket.

Tool combinations for tightening of upper screws, see fig. 1.

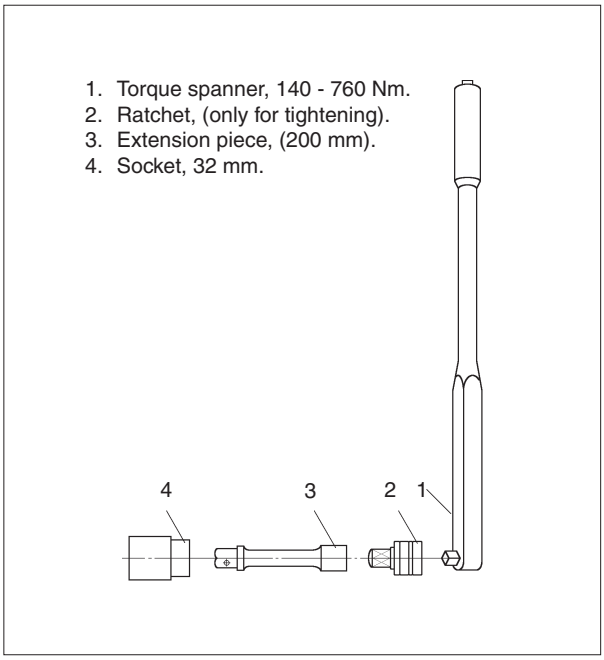


Fig. 1. Tools combinations for tightening of upper screws.

Tool combinations for tightening of lower screws, see fig. 2.

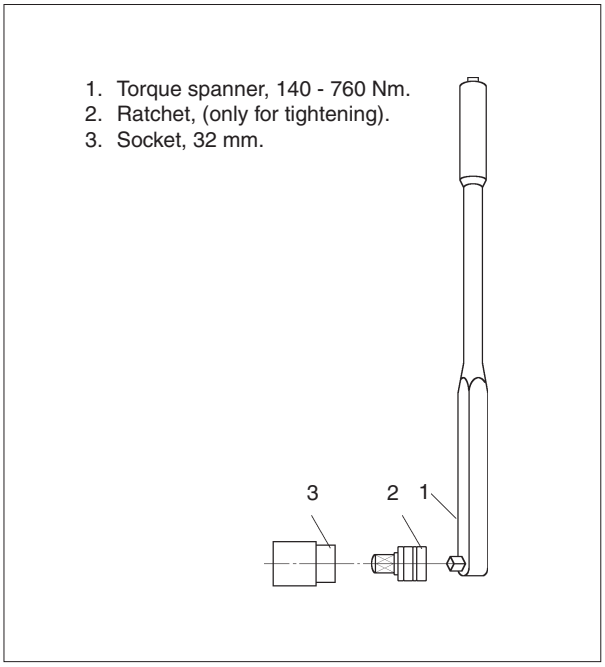


Fig. 2. Tools combinations for tightening of lower screws.

Tightening with torque spanner, ratchet, planet gear spanner, extension piece (only for upper screws) and socket.

Tool combinations for tightening of upper screws, see fig. 3.

Tool combinations for tightening of lower screws, see fig. 4.

Tightening with pneumatic spanner and special socket. (extra tools).

The turning of the screws through a 60° angle, can be executed with a pneumatic impact spanner.

The impact spanner must be of adequate dimensions and capacity, with 1" quadrangular terminal shaft.

The 32 mm socket to be used must be a socalled specially designed for use with mechanical or pneumatic impact tools.

08028-0D/H5250/94.08.12

L28/32H

Compared to sockets for manually operated spanner, the power top has increased dimensions.

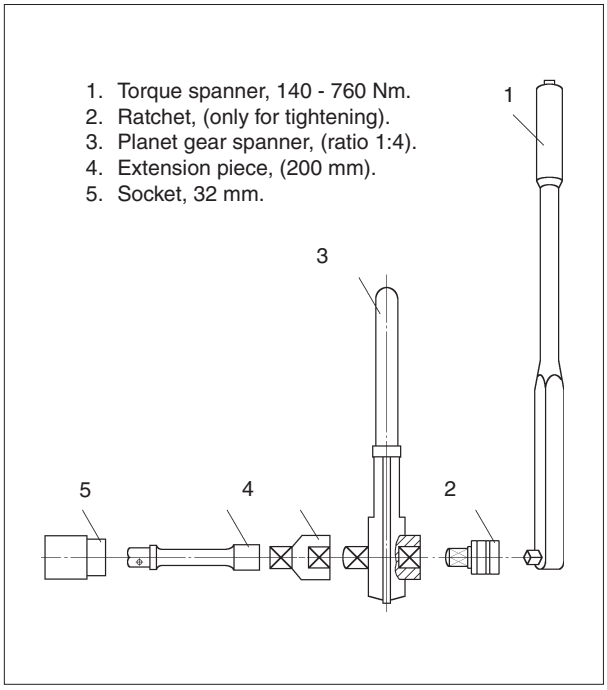


Fig. 3. Tools combination for tightening of upper screws with planet gear.

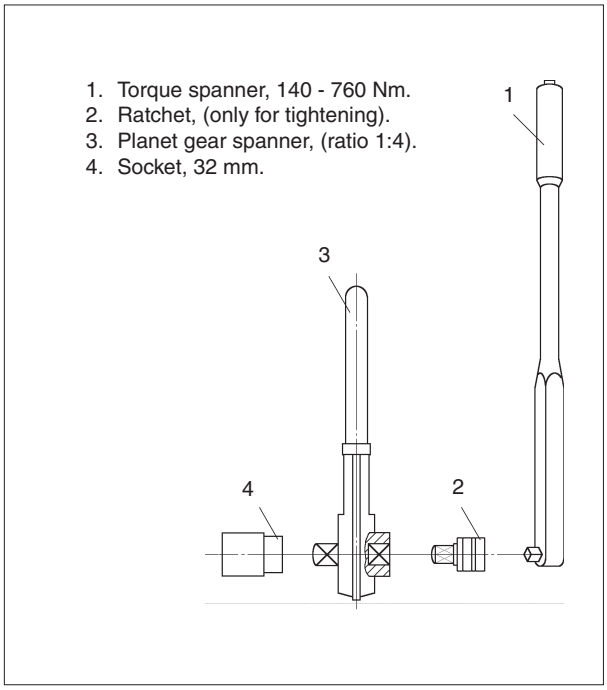


Fig. 4. Tools combination for tightening of lower screws with planet gear.

The connecting rod screws are situated very closely, leaving only minor space between collars and hexagonals of the screw heads.

Dependent of the manufactures, it can be necessary to adapt the power top to the limited space conditions around the screws.

In such case only the absolutely necessary machining should be executed.

An external diameter of 51 mm, see fig. 5 in a length of 21 mm at the hexagonal end of the power top is sufficient for access to the screws.

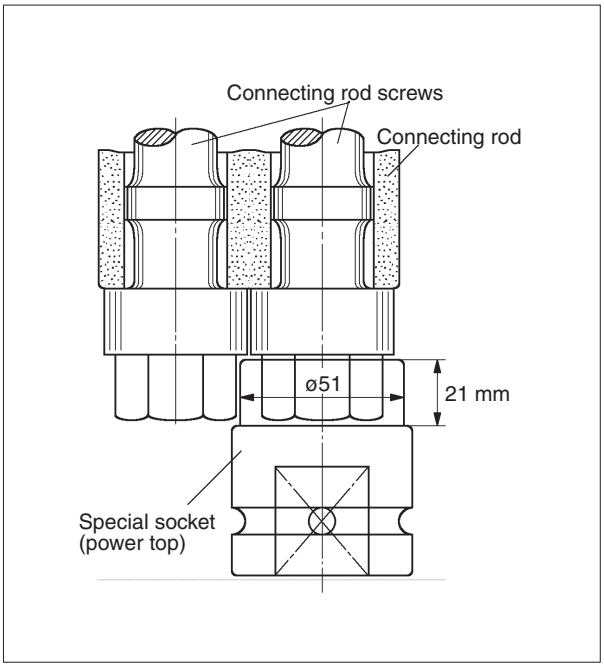


Fig. 5. Special socet.

Machining beyond these dimensions should not take place as it could influence the rigidity of the power top.

08028-0D/H5250/94.08.12

Working Card Page 1 (2)	**Max Pressure Indicator**	**620-01.25** Edition 02H

General

Safety precautions:

- ☐ Stopped engine
- ☐ Shut-off starting air
- ☐ Shut-off cooling water
- ☐ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Operation.
Overhaul intervals.
Dismantling, overhaul and assembly.

Starting position:

Related procedure:

Man power:

Working time	:	1/2	hour
Capacity	:	1	man

Data:

Data for pressure and tolerance
Data for torque moment
Declaration of weight

Special tools:

Plate no	Item no	Note
62005	10	Max pres. indicator

Hand tools:

Allen key, 3 and 6 mm.
Copaslip or similar.

Replacement and wearing parts:

Plate no	Item no	Qty/

See Plate 62005

08028-0D/H5250/94.08.12

General

Operation:

1) Open the indicator valve and blow through shortly.

2) Connect the max pressure indicator to the indicator valve and open the valve.

3) After 3-5 seconds read the max pressure on the gauge.

Attention: The indicator valve has to be open while reading the max pressure on the gauge. The measuring period should not exceed 30 seconds.

4) Close the indicator valve and open the valve screw (5), fig 1.

5) Disconnect the max pressure indicator and close the valve screw (5), fig 1.

6) Measure the remaining cylinders by following step 1 to 5.

Overhaul Intervals.

1) Dismount and clean the non-return valve after 200 measuring periods. If the pressure drop is more than 5 bar within 60 seconds (test pressure 100 bar) it is recommended to relap the non-return valve.

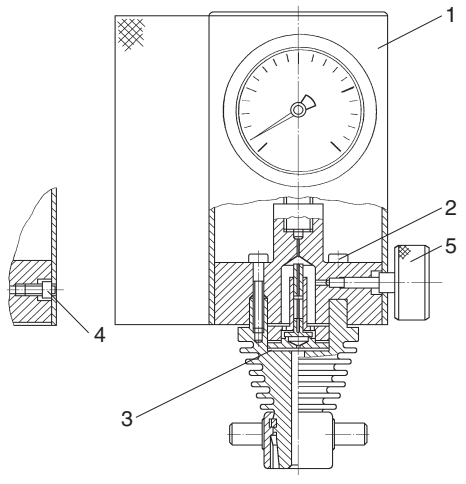
2) Check the pressure gaugeafter 1.000 measuring periods or after 12 month use.

Attention: Use only exhaust gas or nitrogen gas and never oil for testing the pressure drop and the pressure gauge. By using oil carbon will deposit inside the measuring instrument.

Dismantling and Assembly:

1) Dismount the valve screw (5), fig 1.

2) Turn the screw (4) into the instrument to enable dismounting of the housing (1).



1 Housing
2 Allen screw
3 Sealing
4 Screw
5 Valve screw

Fig 1 Pressure Indicator.

3) Loosen the screws (2) (4 pieces) for separating upper and lower part.

4) After separation of the upper and lower part, take off the non-return valve assembly.

5) Lap the valve and the valve seat.

6) Renew the sealing ring (3) and screws (2), if necessary.

7) When mounting the upper and lower part, use only original screws.

8) Coat the screws (2) with copaslip or similar and tighten to 10 Nm.

9) After assembly the instrument can be used without any new calibration.

Check of the Pressure Gauge:

10) Testing of the instrument should only be made by skilled specialists, and it is recommended to send the instrument to MAN Diesel A/S, Holeby for calibration.

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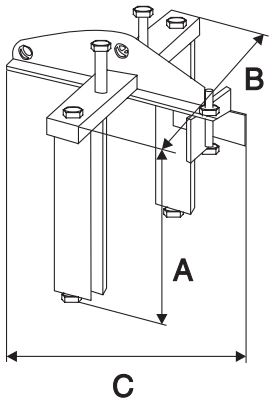
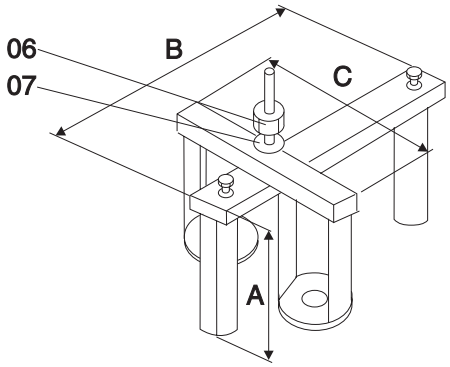
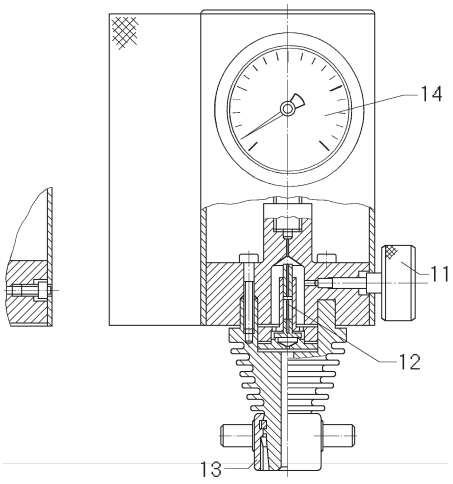
Plate Page 1 (5)	**Tools for Cylinder Head**	**62005-03H**

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Lifting tool for cylinder head (complete).	380	400	230	S	S	01
	Mounting tool for valves (complete). Nut. Thrust bearing.	155	290	190	S	S	05 06 07
	Max. pressure indicator. Spare Parts: Valve screw. Non return valve, complete incl. seals and housing screws. Connecting nut incl. wedge for mounting. Pressure gauge 0-180 bar.				S	S	10 11 12 13 14

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L+V28/32H

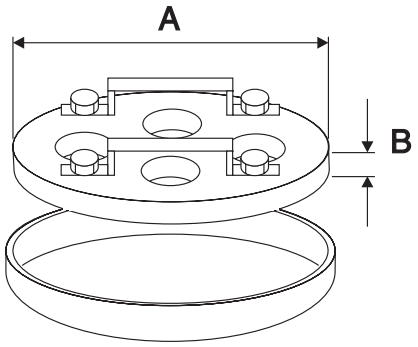
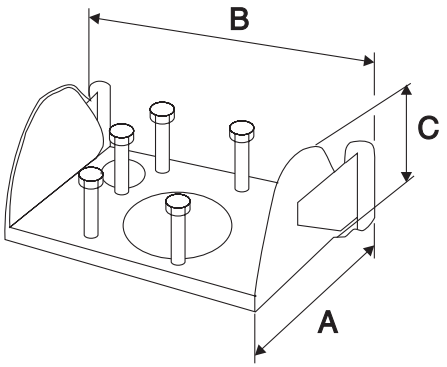
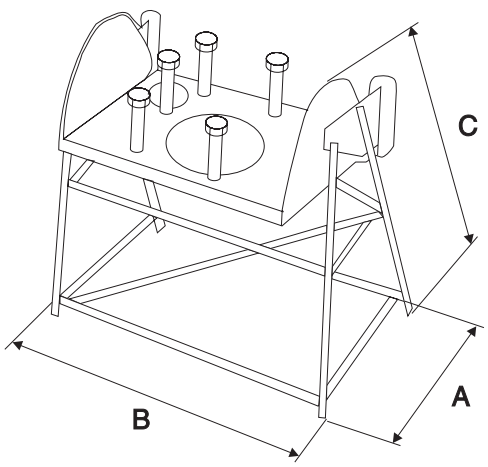
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Grinding ring for cylinder head and cylinder liner.	376	30		S	S	20
	Grinding table for cylinder head, with bracket for wall mounting (complete).	650	825	400	E	E	25
	Grinding table for cylinder head, with frame for floor mounting (complete).	715	805	1050	E	E	30

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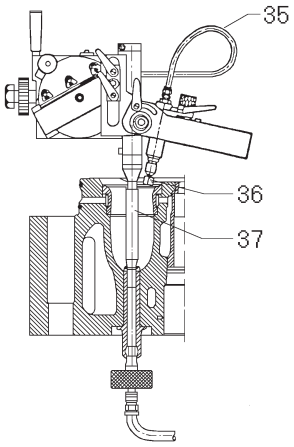
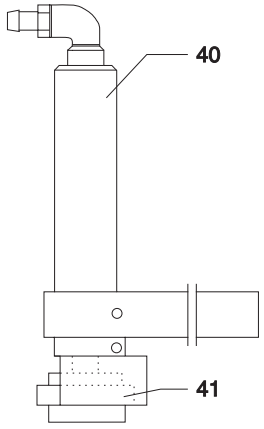
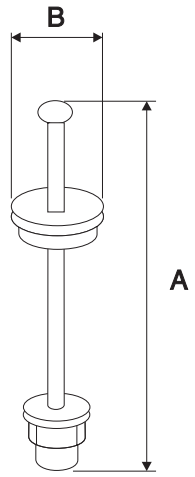
Plate Page 3 (5)	Tools for Cylinder Head	62005-03H

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Grinding machine for valve seat ring (complete). Spare parts: Stone Guide				E	E	35 36 37
	Grinding machine for valve spindle (complete). Spare parts: Stone				E	E	40 41
	Mounting tool for valve seat rings (complete).	472	101		E	E	45

08028-0D/H5250/94.08.12

L+V28/32H

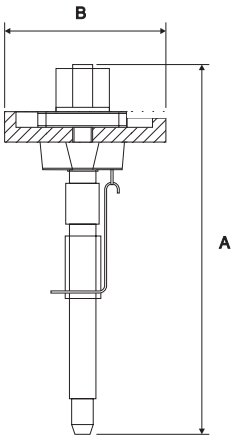
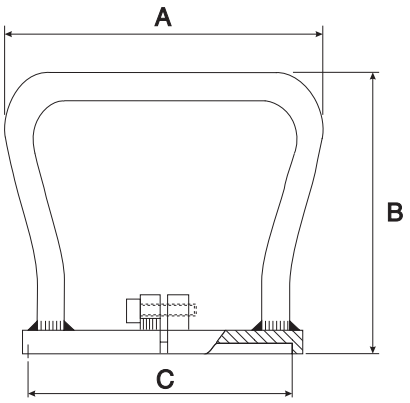
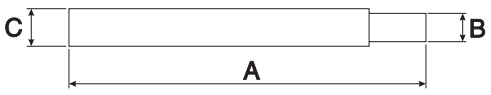
Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Extractor for valve seat ring (complete).	300	140		E	E	50
	Tools for grinding of valves.	110	95	ø90	S	S	55
	Mandrel for dismounting of valve guide.	400	ø 17.5	ø25	E	E	60

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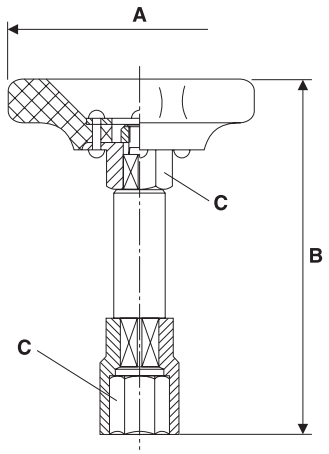
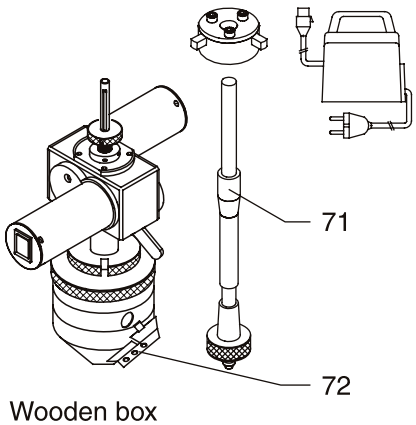
Plate Page 5 (5)	**Tools for Cylinder Head**	**62005-03H**

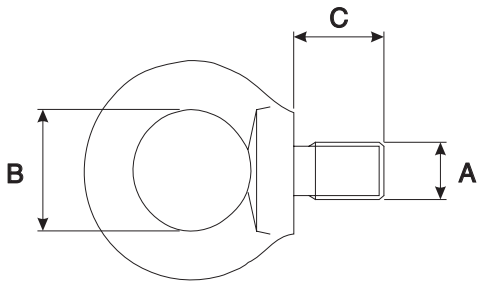
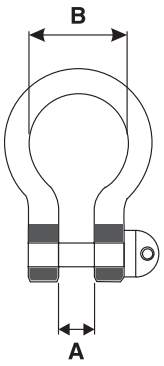
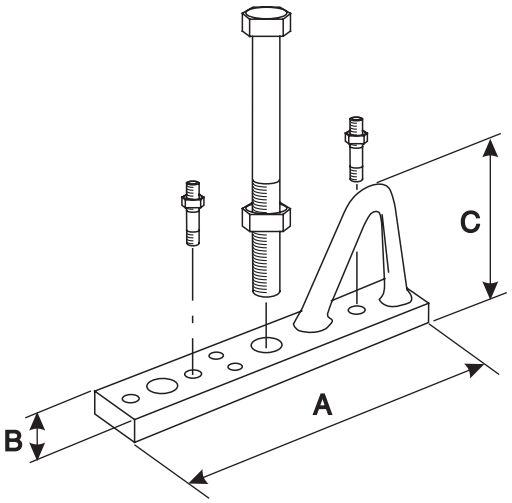
L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Handwheel for indicator valve	ø80	110	17	S	S	65
 Wooden box L x B x H = 450 x 380 x 190 mm	Grinding machine for valve seat ring incl. wooden box, complete				E	E	70
	Mandrel				E	E	71
	Cutting tool				E	E	72

08028-0D/H5250/94.08.12

Plate Page 1 (6)	Tools for Piston, Connecting Rod and Cylinder Liner	62006-11H

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Eye screw for lifting of piston.	M16	35	27	S		01
	Shackle for lifting of piston.	28	50		S		03
	Lifting tool for piston.	270	75	100		S	05

L+V28/32H

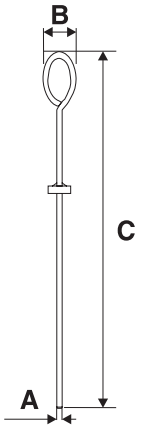
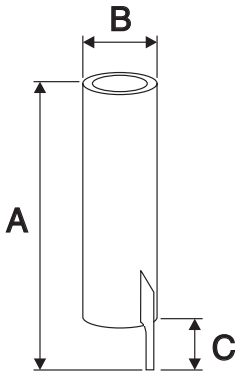
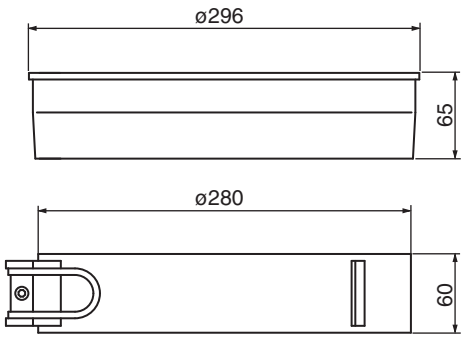
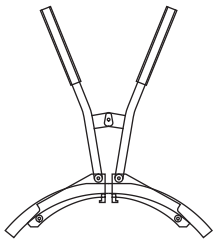
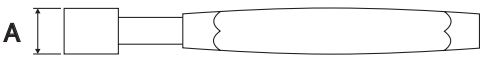
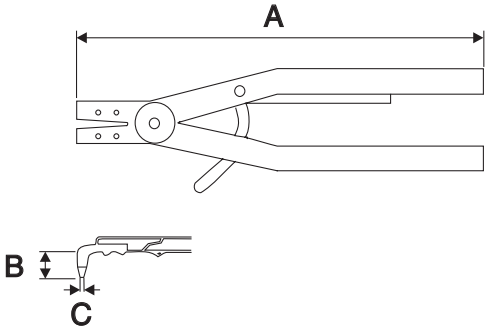
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Eye bolt for piston lift at check of connecting rod big-end bearing.	M16	65	611	S	S	07
	Back stop for cylinder liner (2 pieces).	325	48	65	S	S	09
	Guide ring for mounting of piston.				S	S	11

Plate Page 3 (6)	Tools for Piston, Connecting Rod and Cylinder Liner	62006-11H

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Piston ring opener.				S	S	13
	Testing mandrel for piston ring and scraper ring grooves.						
	Grooves for piston ring.	5.43			S	S	15
	Grooves for scraper ring.	8.43			S	S	16
	Plier for piston pin lock ring.	550	25	ø3.5	S	S	20

62006-11H	Tools for Piston, Connecting Rod and Cylinder Liner	Plate Page 4 (6)

L+V28/32H

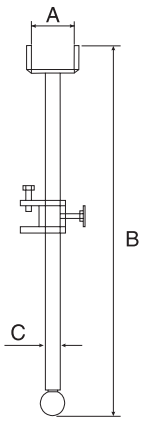
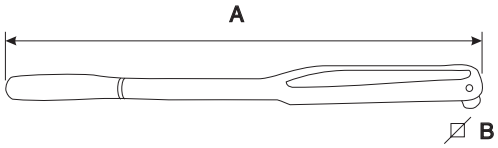
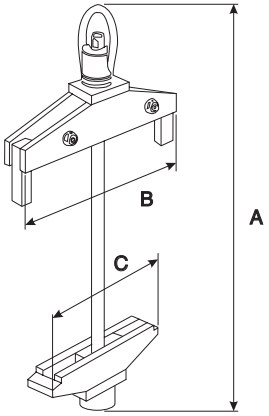
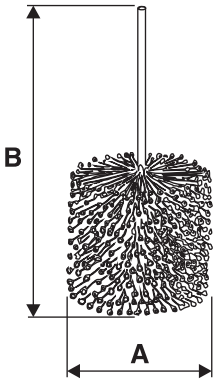
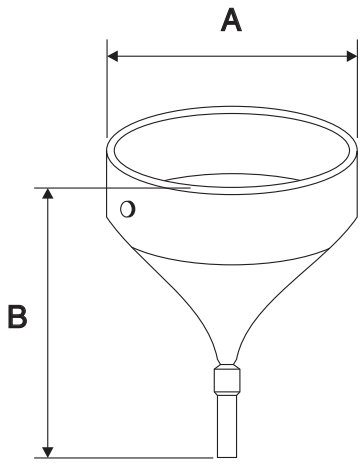
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Guide fork for connecting rod	90	740	ø25		S	24
	Torque spanner 20-120 Nm Torque spanner 50-300 Nm	463 618	1/2" 1/2"		S S	S S	26 27
	Pneumatic impact spanner.	1"			E	E	41

Plate Page 5 (6)	Tools for Piston, Connecting Rod and Cylinder Liner	62006-11H

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Lifting tool for cylinder liner.	1116	465	304	S	S	45
	Honing brush.	ø280	900		S	S	50
	Funnel for honing of cylinder liner.	ø323	1610		S	S	51

L+V28/32H

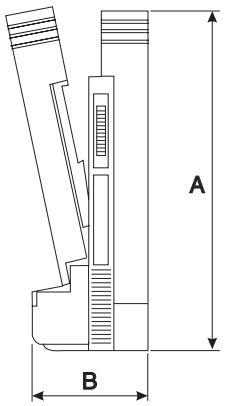
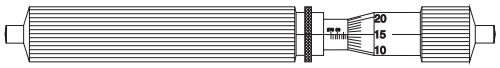
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Magnifier (30 x).	140	50		S	S	55
	Inside micrometer: Measuring range: 275-300 mm (cylinder liner). Measuring range: 225-250 mm (connecting rod).				E E	E E	60 61

Plate Page 1 (1)	**Tools for Operating Gear for Inlet Valves Exhaust Valves and Fuel Injection Pumps**	**62008-03H**

L+V28/32H

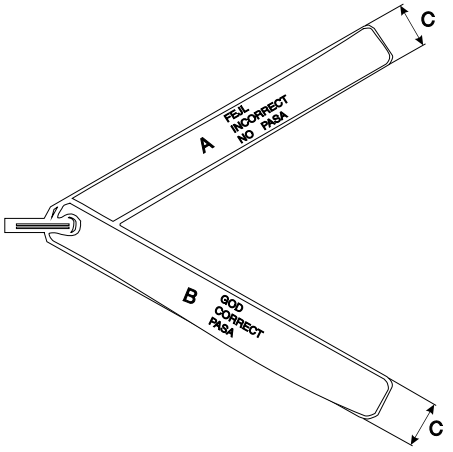
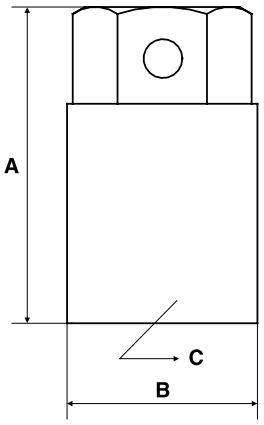
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Feeler gauge for inlet valves. Feeler gauge for exhaust valves. (2 sets of each).	0.5 1.0	0.4 0.9	13 13	S S	S S	01 02
	Extractor for thrust piece, on roller guide for fuel pump.	49	ø 29.5	M24 x 1.5	S	S	06

Plate Page 1 (1)	**Tools for Control and Safety Systems Automatics and Instruments**	**62009-02H**

L+V28/32H

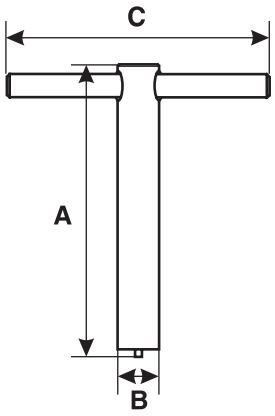
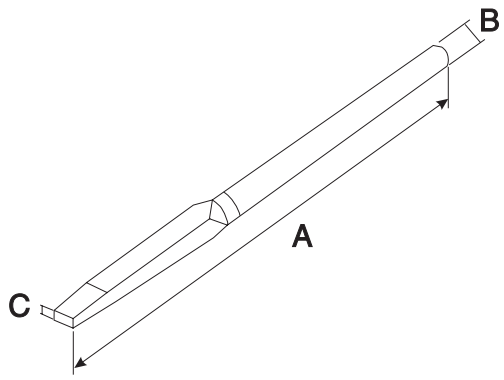
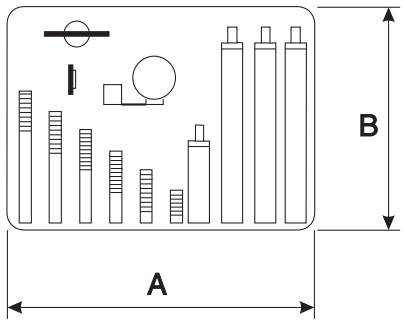
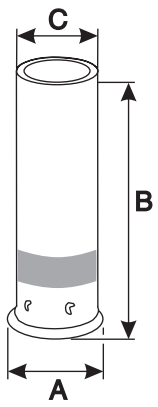
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Spanner for adjusting of over-speed stop	125	ø20	100	S	S	01

Plate Page 1 (3)	**Tools for Crankshaft and Main Bearing**	**62010-07H**

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Turning rod.	1000	ø38	20	S	S	01
	Crankshaft alignment gauge (autolog).	210	150		S	S	05
	Guide pipe for main bearing cap, 2 pieces.	ø65	220	M48	S	S	10

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L+V28/32H

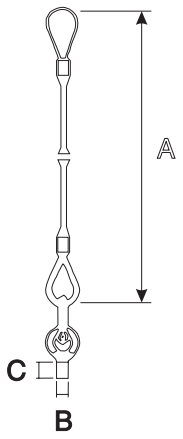
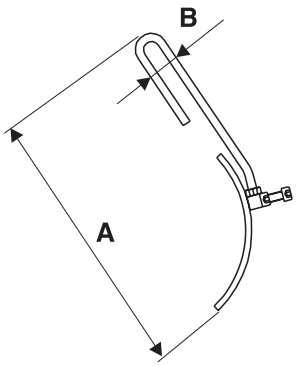
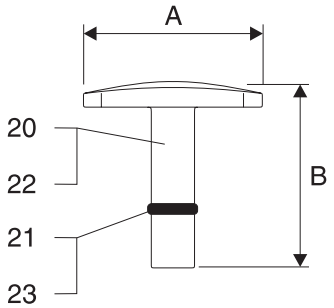
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Lifting straps for main and guide bearing cap, 2 pieces.	1000	M16	20	S	S	15
	Dismantling tool for guide bearing shells.	250 250	32 32		S	 S	18 19
	Tool for upper main bearing O-ring Tool for upper main bearing O-ring	ø50 ø7.9 ø50 ø9.9	51.5 ø2.6 52.5 ø2.6		S S	 S S	20 21 22 23

Plate Page 3 (3)	**Tools for Crankshaft and Main Bearings**	**62010-07H**

L+V28/32H

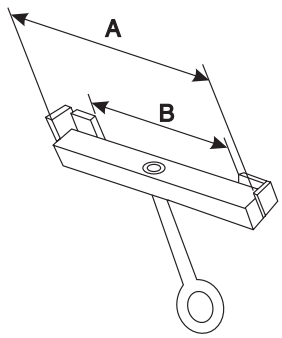
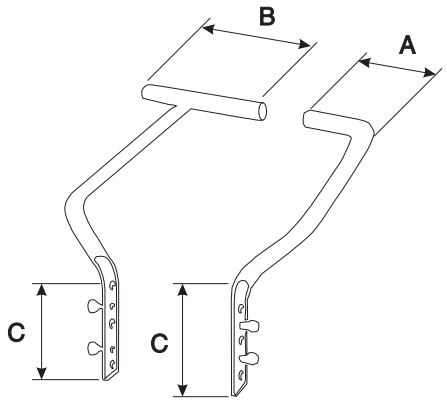
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Guide tools for mounting of upper guide bearing shell.	148	120		S	S	25
	Lifting handle for main bearing cap.	315	500	210	E	E	30

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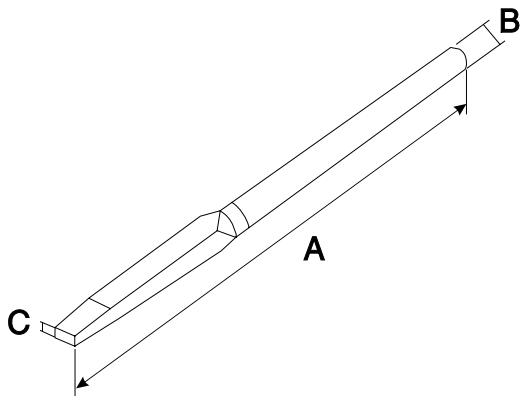
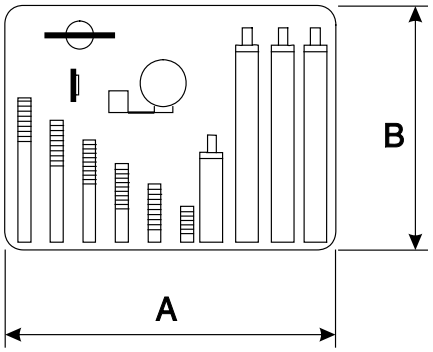
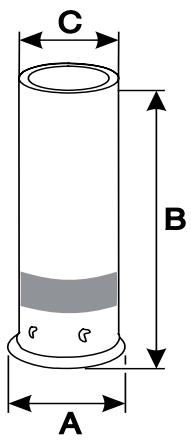
Plate Page 1 (3)	**Tools for Crankshaft and Main Bearing**	**62010-10H**

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Turning rod.	1000	ø38	20	S	S	01
	Crankshaft alignment gauge (autolog).	210	150		S	S	05
	Guide pipe for main bearing cap, 2 pieces.	ø65	220	M48	S	S	10

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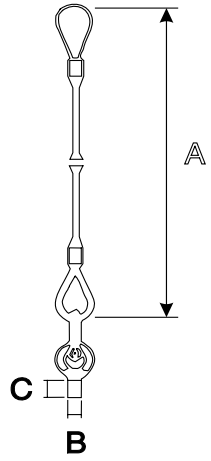
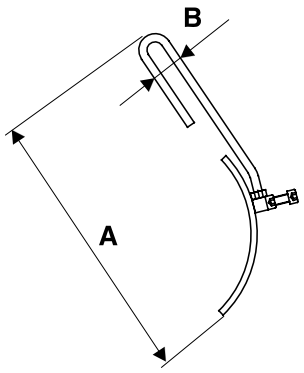
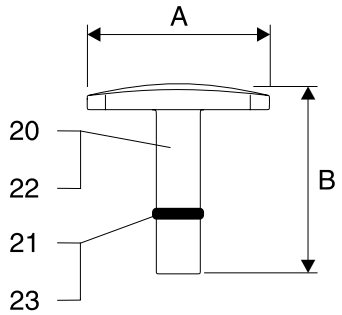
62010-10H	Tools for Crankshaft and Main Bearings	Plate Page 2 (3)

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Lifting straps for main and guide bearing cap, 2 pieces.	1000	M16	20	S	S	15
	Dismantling tool for guide bearing shells.	250 250	32 32		S	 S	18 19
	Tool for upper main bearing O-ring Tool for upper main bearing O-ring	ø50 ø7.9 ø50 ø9.9	51.5 ø2.6 52.5 ø2.6		S S	 S S	20 21 22 23

08028-0D/H5250/94.08.12

Plate Page 3 (3)	**Tools for Crankshaft and Main Bearings**	**62010-10H**

L+V28/32H

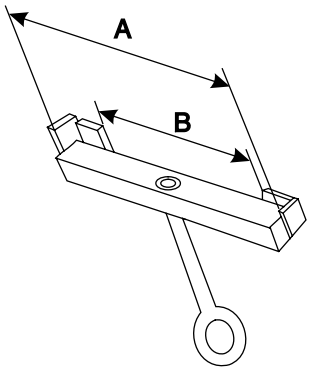
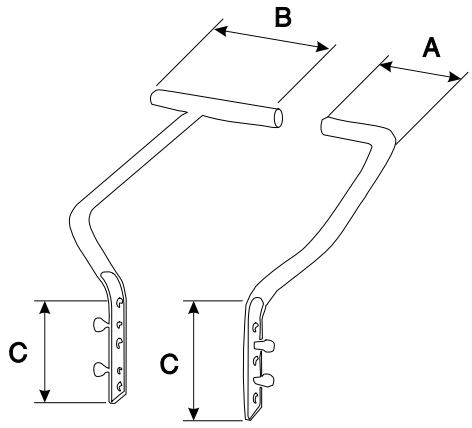
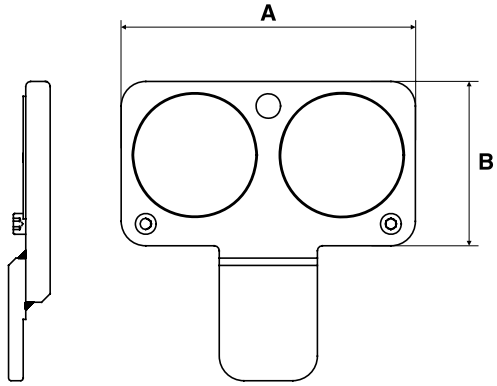
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Guide tools for mounting of upper guide bearing shell.	148	120		S	S	25
	Lifting handle for main bearing cap.	315	500	210	E	E	30
	Magnetic tool for mounting on crankweb without counterweight (for checking of main bearings alignment – autolog)	120	67		S	S	35

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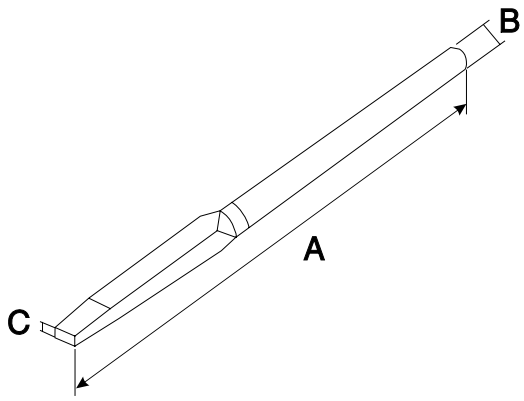
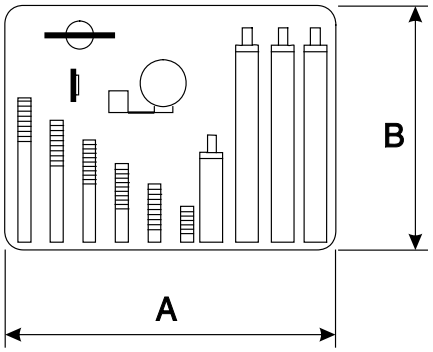
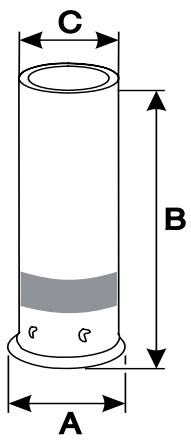
Plate Page 1 (3)	**Tools for Crankshaft and Main Bearing**	**62010-11H**

L+V28/32H

Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Turning rod.	1000	ø38	20	S	S	01
	Crankshaft alignment gauge (autolog).	210	150		S	S	05
	Guide pipe for main bearing cap, 2 pieces.	ø65	220	M48	S	S	10

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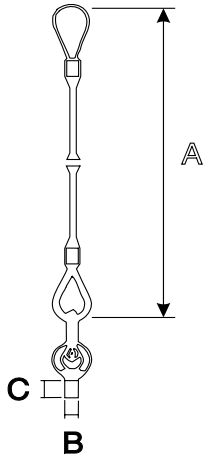
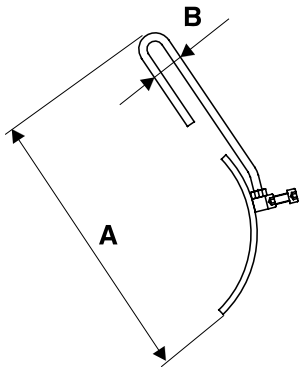
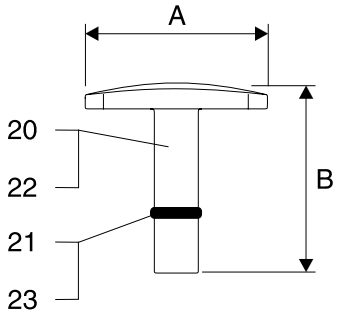
L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Lifting straps for main and guide bearing cap, 2 pieces.	1000	M16	20	S	S	15
	Dismantling tool for guide bearing shells.	250 250	32 32		S	 S	18 19
	Tool for upper main bearing O-ring Tool for upper main bearing O-ring	ø50 ø7.9 ø50 ø9.9	51.5 ø2.6 52.5 ø2.6		S S	 S S	20 21 22 23

08028-0D/H5250/94.08.12

Plate Page 3 (3)	**Tools for Crankshaft and Main Bearings**	**62010-11H**

L+V28/32H

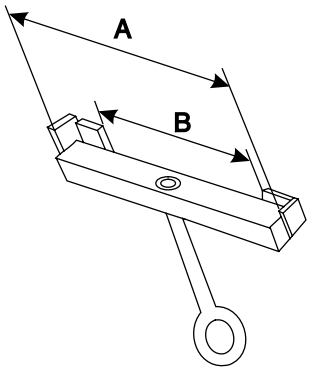
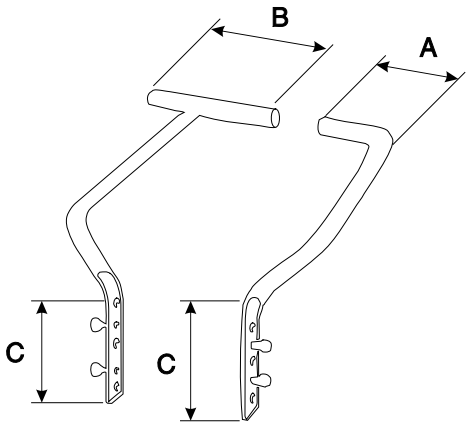
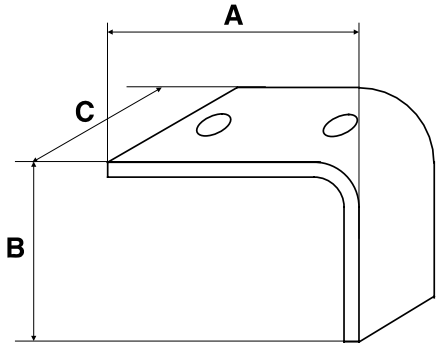
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Guide tools for mounting of upper guide bearing shell.	148	120		S	S	25
	Lifting handle for main bearing cap.	315	500	210	E	E	30
	Angle for mounting on crankweb without counterweight (for checking of main bearings alignment – autolog)	84	60	25	S	S	40

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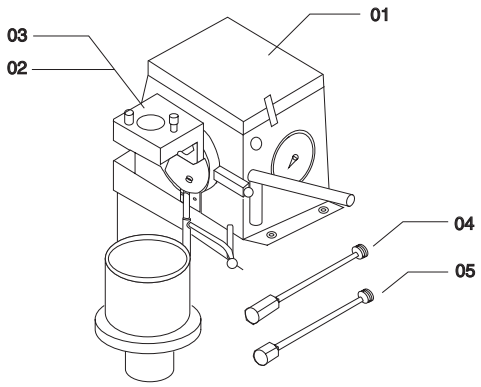
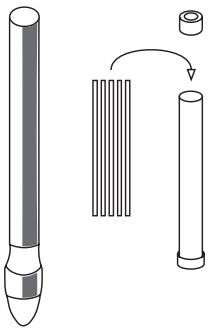
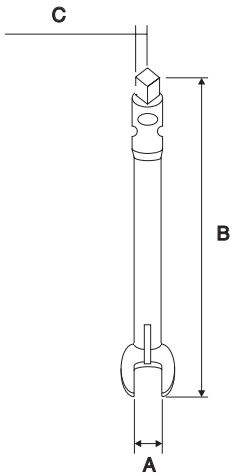
Plate Page 1 (4)	Tools for Fuel Oil System and Injection Equipment	62014-02H

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Pressure testing pump, compl. GOU-G001				S	S	01
	Clamping bracket for fuel injector. VTO-W022				S	S	02
	Clamping bracket for fuel injection pump. PYO-W020				S	S	03
	Fuel pipe. VTO-W023				S	S	04
	Fuel pipe. VWM-W007				S	S	05
	Cleaning tool for fuel injector, consist of: 1 pcs tool holder. 5 pcs needles.				S	S	10
	Spanner for high pressure pipe.	30	270	19	S	S	15

L+V28/32H

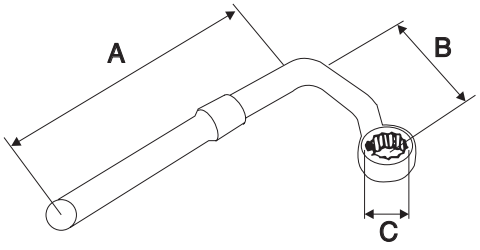
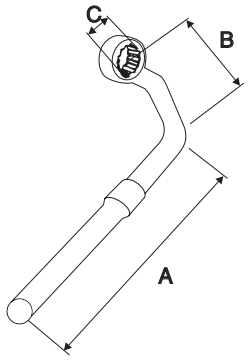
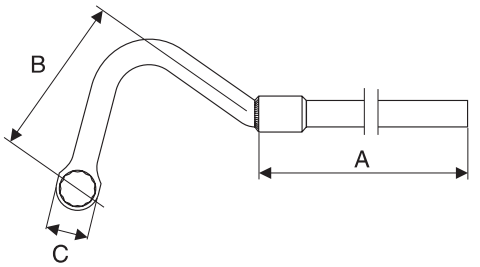
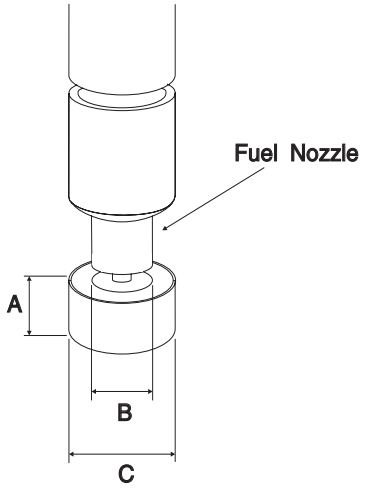
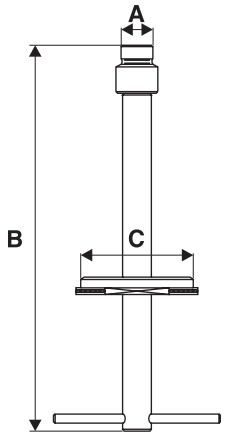
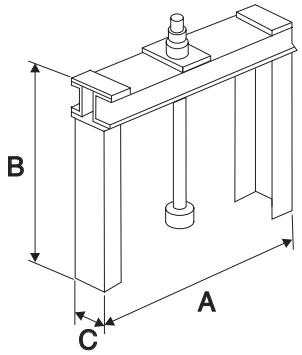
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Spanner for fuel injection pump (left side).	270	88	24	S	S	20
	Spanner for fuel injection pump (right side).	270	88	24	S	S	25
	Spanner for fuel injection pump (right side)	270	88	24	S	S	27

Plate Page 3 (4)	Tools for Fuel Oil System and Injection Equipment	62014-02H

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Grinding tool for fuel injection valve.	25	ø20	ø55	E	E	30
	Grinding tool for seat for fuel injection valve.	ø20	530	ø70	S	S	35
	Extractor for fuel injector valve	150	215	58	S	S	40

L+V28/32H

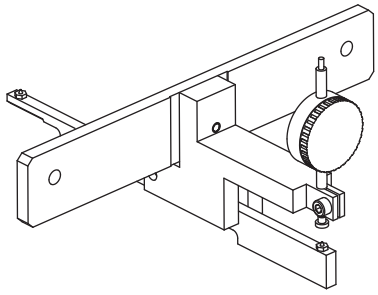
Fig.	Designation	Dimensions			L28/32H	V28/32H	Item No.
		A	B	C			
	Measuring device for plunger lift				S	S	42

Plate Page 1 (1)	**Tools for Lubricating Oil System**	**62015-02H**

L28/32H

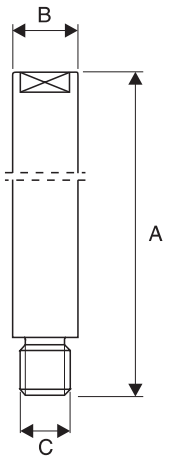
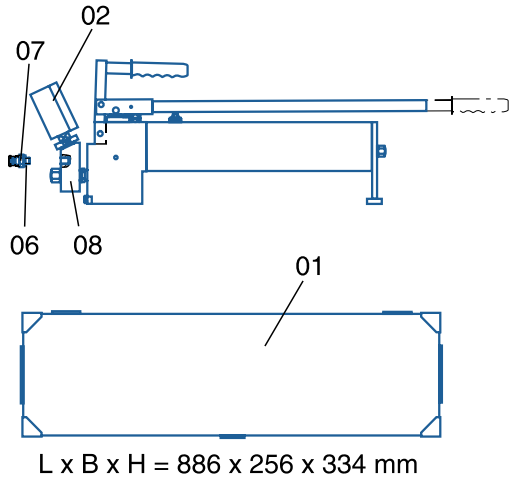
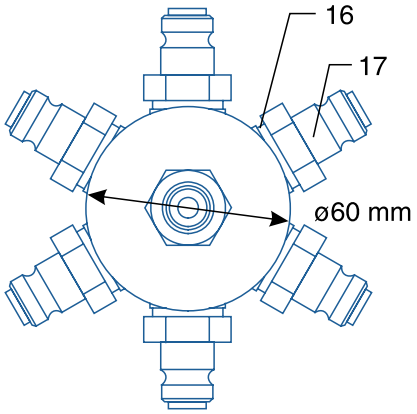
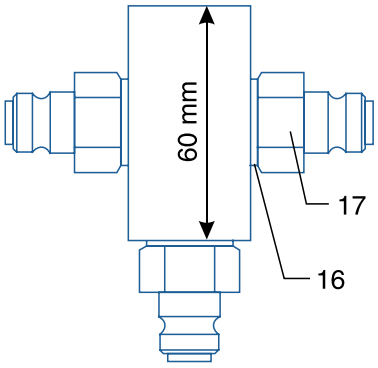
Fig.	Designation	Dimensions			L28/32H		Item No.
		A	B	C			
	Guide bar for dismantling of lubricating oil cooler, 2 pieces.	305	ø30	M20	S		02

Plate Page 1 (5)	**Hydraulic Tools**	**62021-08H**

L+V28/32H

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Pressure pump, complete, with wooden box				S	S	01
	Manometer						02
	Gasket for Item 07						06
	Quick coupling						07
	Distributor						08
	Distributing piece for cylinder head, complete.				S	S	15
	Gasket						16
	Quick coupling						17
	Distributing piece for main bearing, complete.				S	S	20
	Gasket						16
	Quick coupling						17

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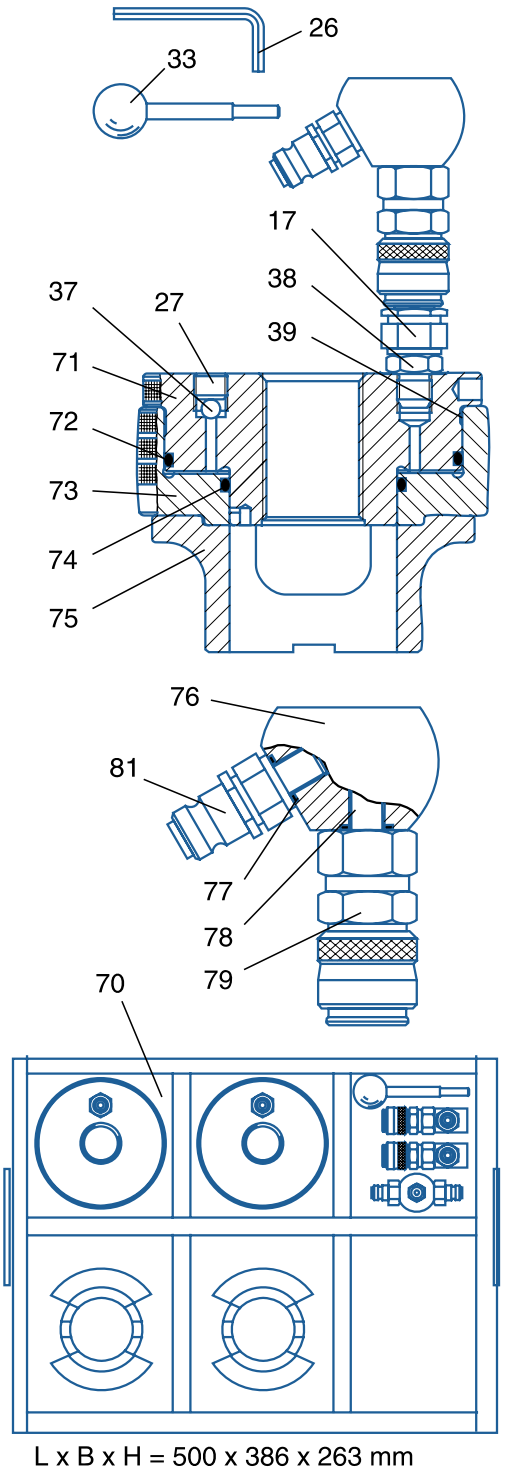
L+V28/32H



Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
Quick coupling						17
Allen key, 7 mm						26
Venting screw						27
Tommy bar						33
Ball						37
Adapter						38
Stroke indicator band						39
Hydraulic tools for connecting rod with wooden box, complete				S	S	70
Piston for hydraulic jack						71
O-ring with back-up ring						72
O-ring with back-up ring						74
Cylinder for hydraulic jack						73
Spacer piece						75
Angle piece complete, incl. item 77, 78, 79, 81						76
O-ring						77
Adapter						78
Coupling socket						79
Hydraulic jack as item nos. 17, 27, 38, 39, 47, 71, 72, 73, 74, 75						80
Quick coupling						81

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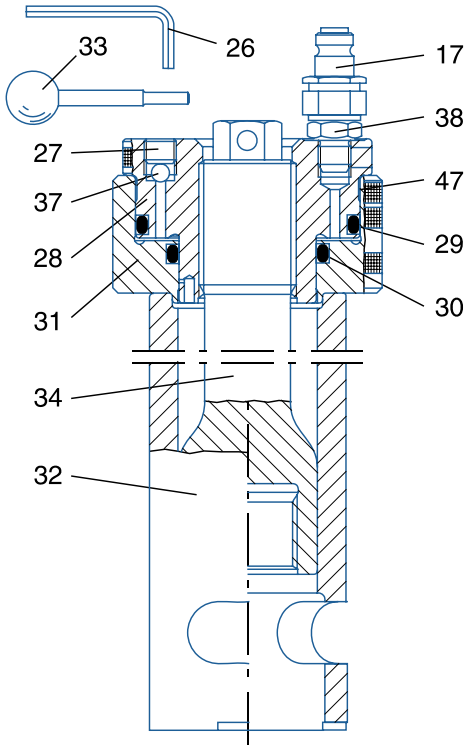
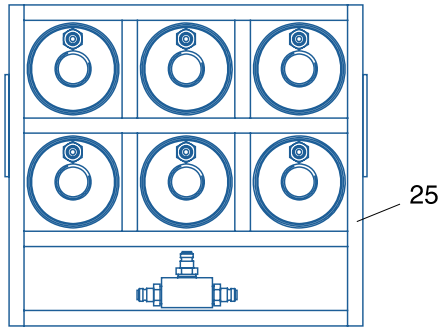
L+V28/32H



L x B x H = 417 x 377 x 373 mm



L x B x H = 327 x 327 x 378 mm

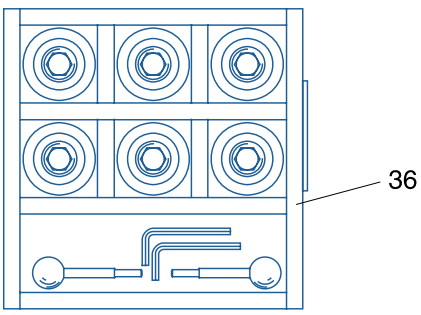


Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Quick coupling						17
	Hydraulic tools for cylinder head with wooden box, complete				S	S	25
	Allen key, 7 mm						26
	Venting screw						27
	Piston for hydraulic jack						28
	O-ring with back-up ring						29
	O-ring with back-up ring						30
	Cylinder for hydraulic jack						31
	Spacer piece						32
	Tommy bar						33
	Tension screw						34
	Hydraulic jack as Item Nos. 17, 27, 28, 29, 30, 31, 37, 38, 47						35
	Tools for cylinder head with wooden box, complete				S	S	36
	Ball						37
	Adapter						38
	Stroke indicator band						47

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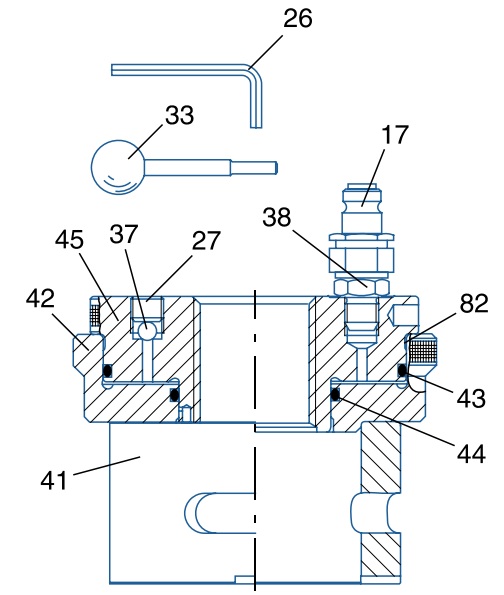
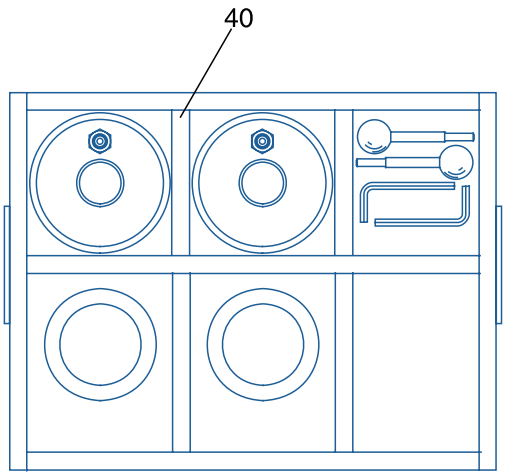
L+V28/32H





L x B x H = 500 x 386 x 263 mm

Fig.	Designation	Dimensions A	Dimensions B	Dimensions C	L28/32H	V28/32H	Item No.
	Quick coupling						17
	Allen key, 7 mm						26
	Venting screw						27
	Tommy bar						33
	Ball						37
	Adapter						38
	Hydraulic tools for main bearings with wooden box, complete				S	S	40
	Spacer piece						41
	Cylinder for hydraulic jack						42
	O-ring with back-up ring						43
	O-ring with back-up ring						44
	Piston for hydraulic jack						45
	Hydraulic jack as Item 17, 27, 37, 38, 42, 43, 44, 45, 82						46
	Stroke indicator band						82

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L+V28/32H

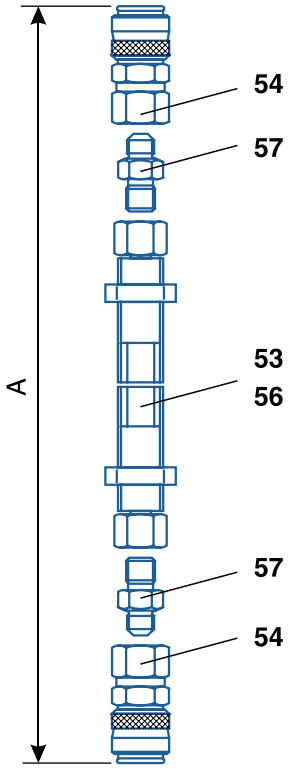
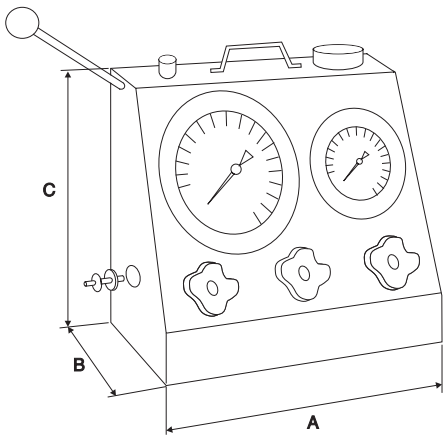
Fig.	Designation	Dimensions A	B	C	L28/32H	V28/32H	Item No.
	Hose for hydraulic tools, 6 pieces complete	600	ø27		S	S	49
	Hose for hydraulic tools, 1 pieces complete	3000	ø27		S	S	51
	Hose	3000					53
	Quick coupling with protecting cap						54
	Hose	600					56
	Adapter						57
	Air driven High pressure pump for hydraulic tools.	367	256	326	E	E	60

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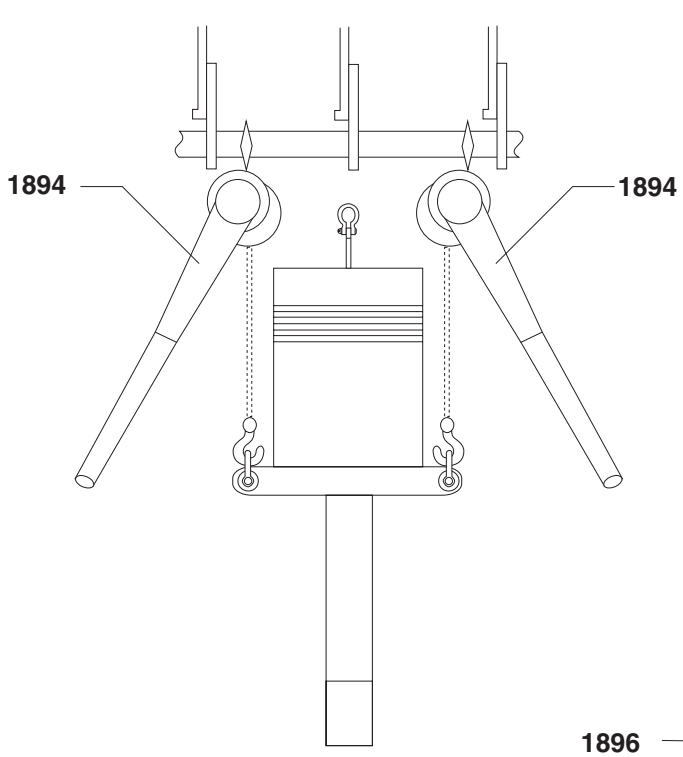
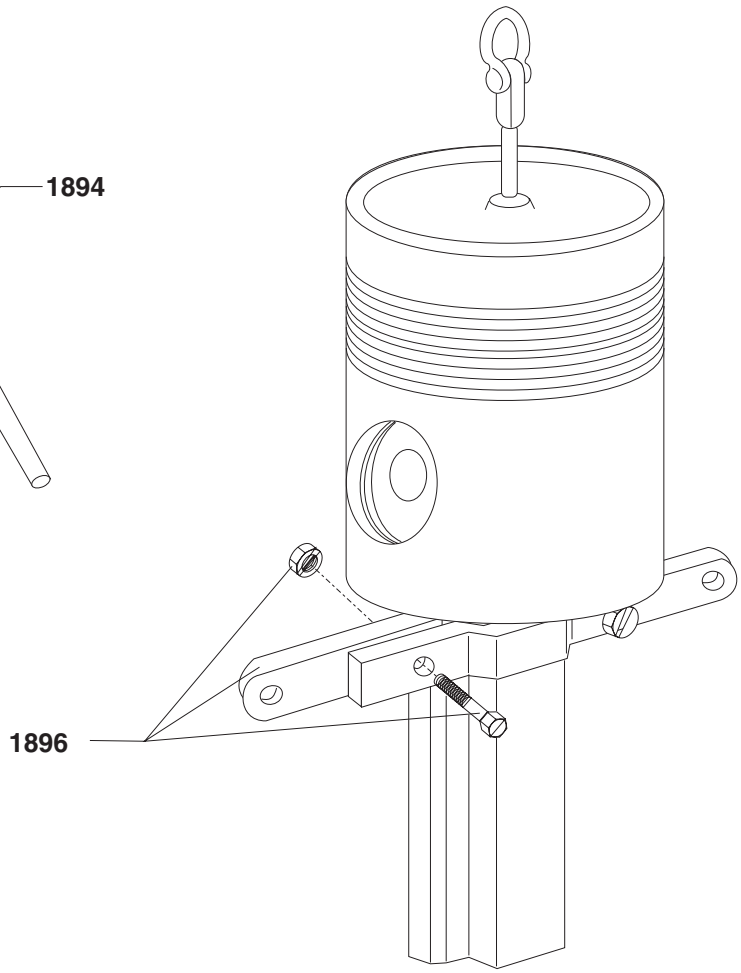
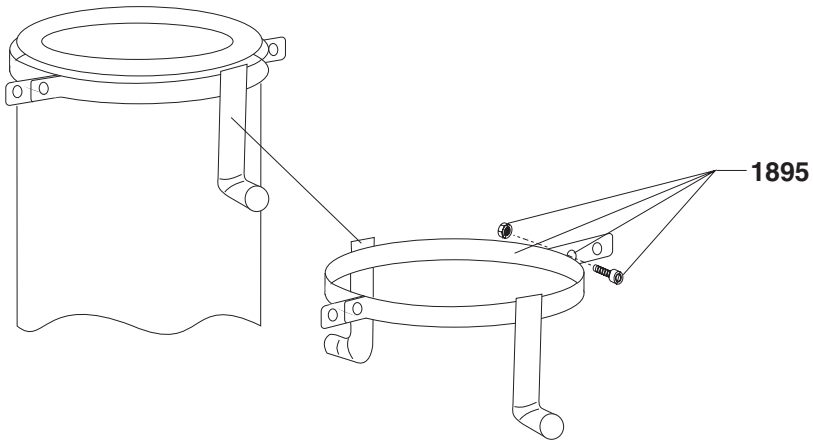
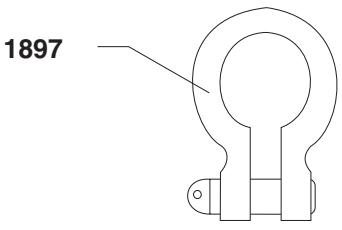
Plate Page 1 (2)	**Tools for Low Overhaul Height, Piston, Cylinder Liner and Connecting Rod**	**62050-01H**

L+V28/32H









08028-0D/H5250/94.08.12

62050-01H	Tools for Low Overhaul Height, Piston, Cylinder Liner and Connecting Rod	Plate Page 2 (2)

L+V28/32H

Item No.	Qty.	Designation	Benævnelse
1894	2/E	**Pull-lift**	Pull-lift
1895	1/E	**Lifting tool for cylinder liner, complete**	Løfteværktøj for cylinderforing, komplet
1896	1/E	**Collar for connecting rod, complete**	Halsjern for plejlstang, komplet
1897	2/E	**Shackle**	Sjækel

Item No.	Qty.	Designation	Benævnelse

08028-0D/H5250/94.08.12

When ordering spare parts, see also page 600.50.

*** = Only available as part of a spare parts kit.**
Qty./E = Qty./Engine.

Ved bestilling af reservedele, se også side 600.50.

* = Kun tilgængelig som en del af et reservedelssæt.
Qty./E = Qty./Motor.

L'orange
YOUR POWERFUL INJECTION

Operating manual

Test rig **GXO-G010a / GXO-G011a**

Die Betriebsanleitung ist zur Vermeidung von Störungen oder Schäden beim Betrieb zu beachten und daher vom Betreiber dem jeweiligen Wartungs- und Bedienungspersonal zur Verfügung zu stellen. Außerhalb dieses Verwendungszwecks darf die Betriebsanleitung ohne unsere vorherige Zustimmung nicht benutzt, vervielfältigt oder Dritten sonstwie zugänglich gemacht werden.

Änderungen bleiben vorbehalten

The owner should make this operating manual available to maintenance and operating staff who should follow the instructions it contains to prevent malfunctions or damage during operation. Other than for this purpose, the operating manual may not be reproduced, used or disclosed to third parties by any other means without our prior consent.

Subject to alterations and amendments

Änderungsdienst/Amendments service!

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Betriebsanleitungs-Nr. / Operating manual No.

Betriebsanleitung für GXO-G010a / -G011a
GXO-D001
Operating manual for GXO-G010a / -G011a
GXO-D001/E

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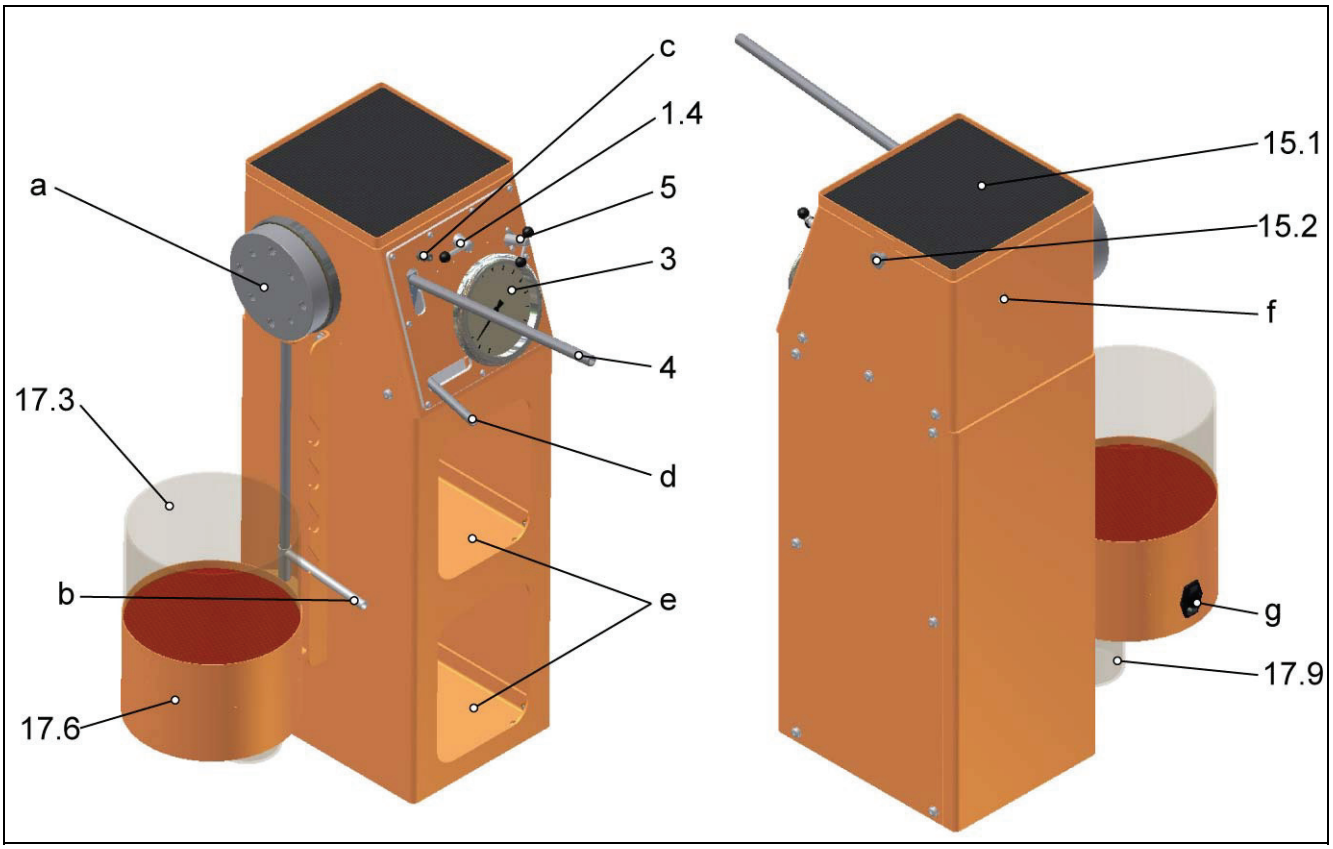
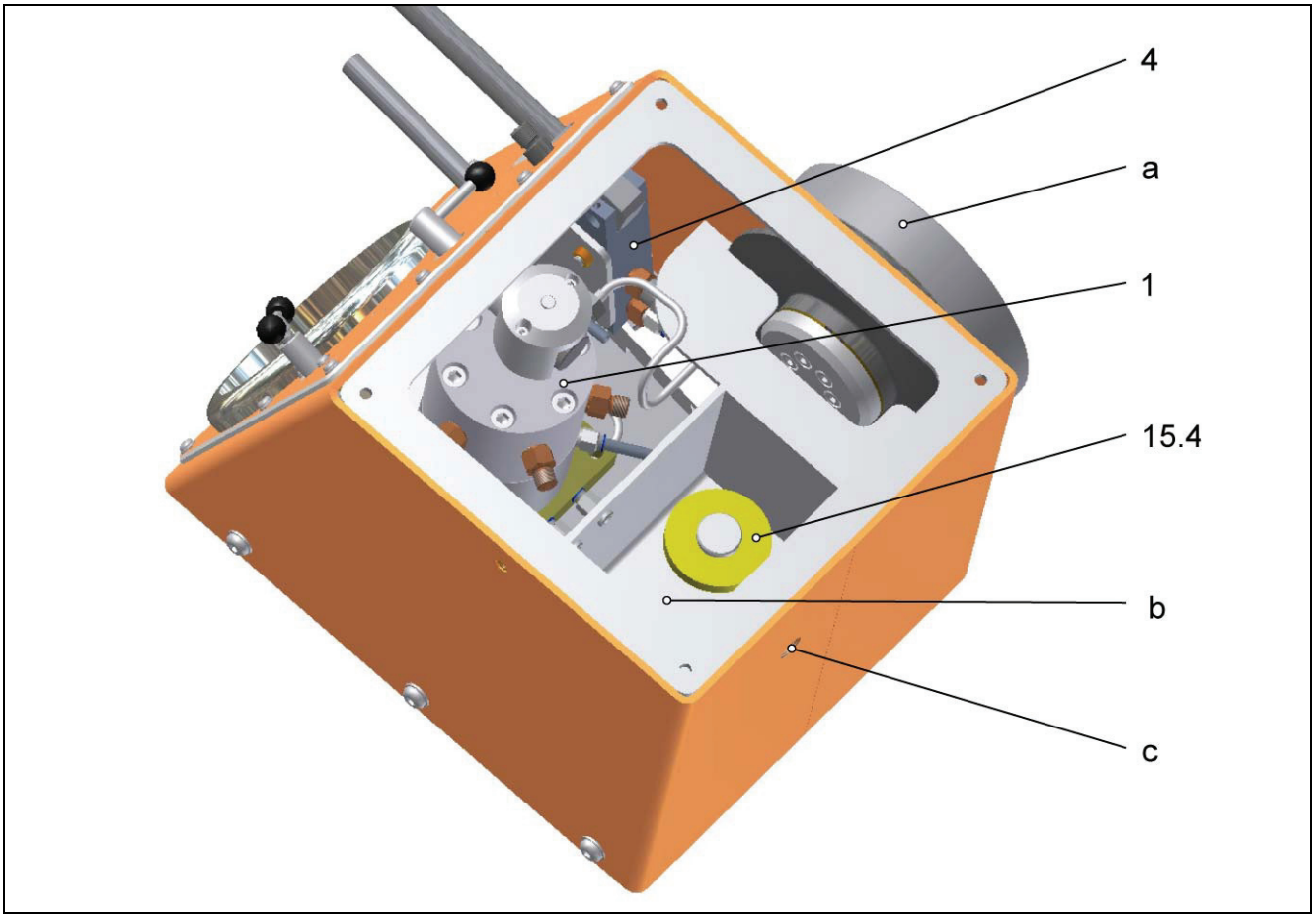
1 Structure of the test rig (exterior)

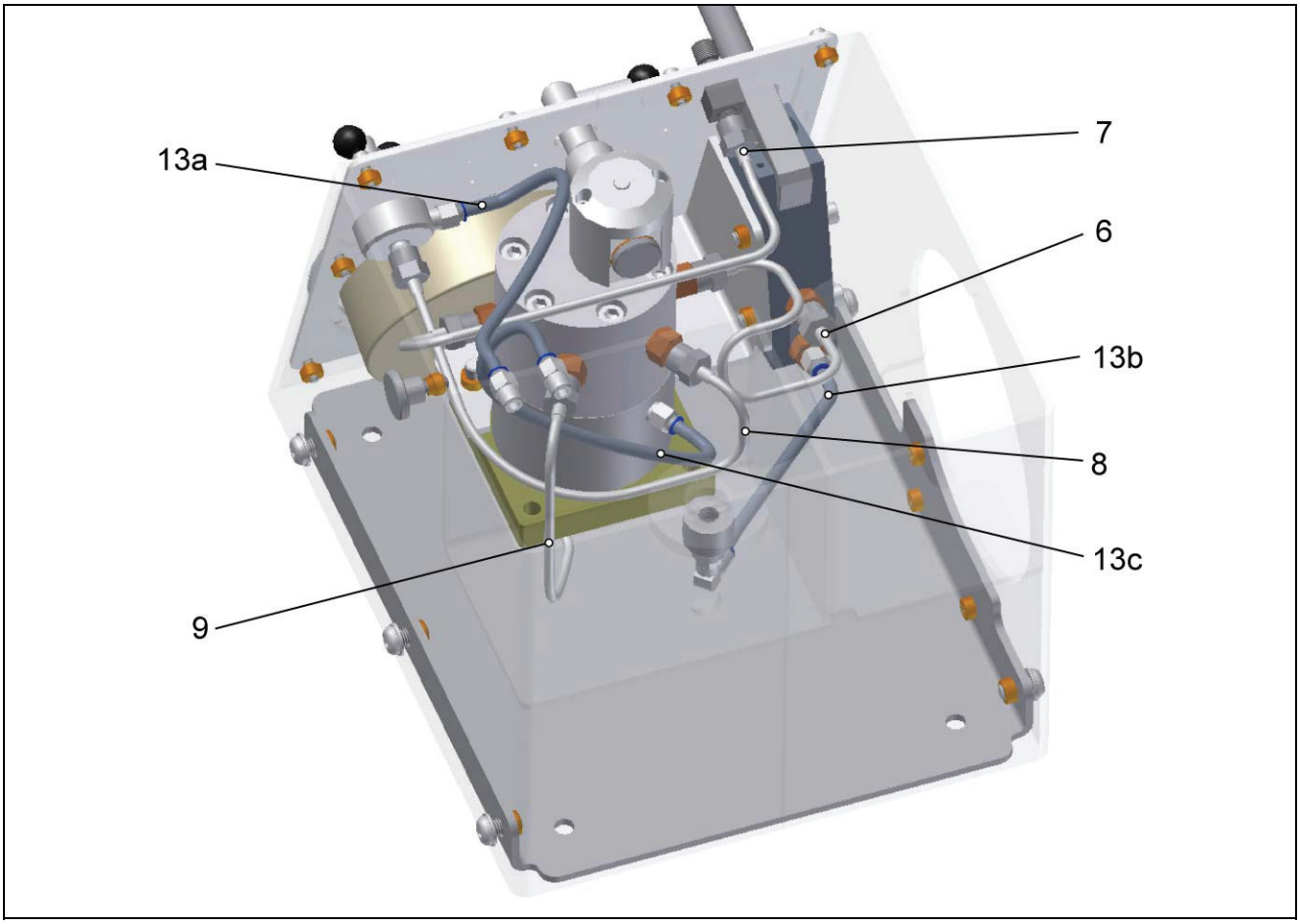


Item	Part	Item	Part	Item	Part
1.4	Selector switch for mode	5	Relief valve	17.3	Plexiglass tube (sight glass)
3	Pressure gauge (pressure display bar/psi)	15.1	Cover (tray)	17.6	Extraction (spray container)
4	Hand lever (hand pump)	15.2	Knurled screw (to fix cover in position)	17.9	Oil collector
a	Rotary receiver (pump/valve)	d	Release lever (rotating mechanism)	f	Oil sight glass
b	Height adjustment	e	Storage compartments	g	Switch (extraction)
c	Socket (test line)				

2 Structure of test rig (interior)



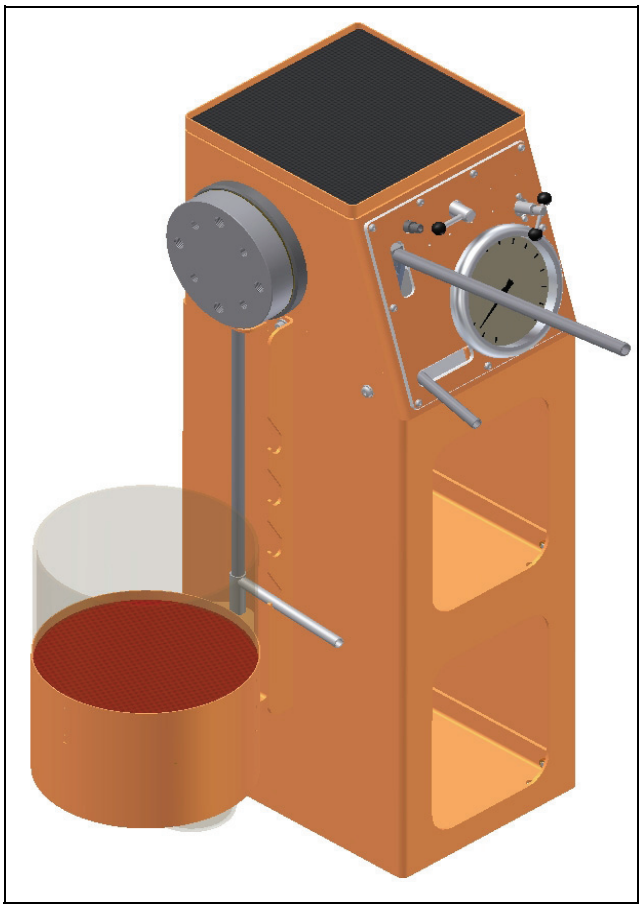
Item	Part	Item	Part	Item	Part
1	Booster	4	Hand pump	15.4	Mesh filter
a	Rotary receiver (pump/valve)	b	Test oil reservoir	c	Oil sight glass



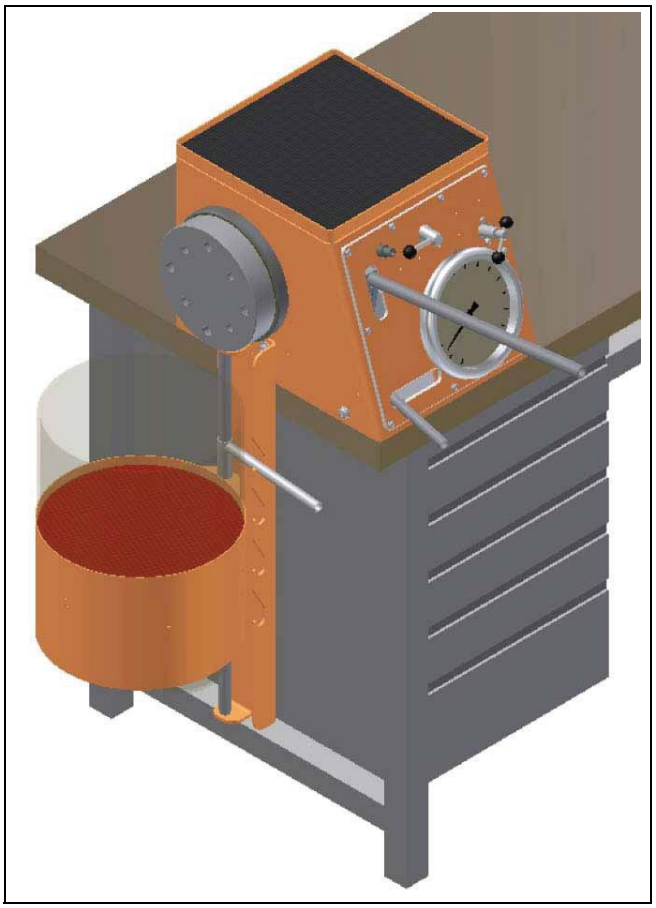
Item	Part	Item	Part	Item	Part
6	Tube Pump – booster	9	Tube Booster – pressure gauge	13b	Hose Oil container – pump
7	Tube Booster – test line connection	13a	Hose Relief valve – test oil reservoir	13c	Hose Booster – test oil reservoir
8	Tube Booster – relief valve				

The test rig was developed for checking leaks, pressure-testing injection, measuring the pressure drop of injection valves and for assembling/dismantling all L'O devices for medium-speed large diesel engines.

There are two versions: GXO-G010a has a base for mounting directly to the floor, whilst GXO-G011a is intended to be fitted to a bench. Both devices have identical functions and operation.



GXO-G010a



GXO-G011a

The test rig has a safety valve (integrated in the booster) which opens at 900 bar!

3 Handling the test rig

This operating manual applies primarily to the professional assembly/dismantling of L'O devices, in particular injection pumps and injection valves. The instructions below must be followed.

- In the event of malfunctions, the test rig must be professionally examined and repaired with the utmost care by specialist staff. We therefore recommend that you make use of the fitter service set up by L'Orange or take the test rig to a L'Orange customer service center.
- L'Orange is unable to accept any liability for any damage caused by independent assembly or repair work performed on the test rig.
- In the event of special circumstances requiring immediate work on the test rig, proceed in accordance with the instructions in Assembly Instruction GXO-D002.
- The components of hand pump GCO-G005d are precision-engineered to match and can consequently only be replaced as an entire unit (paired).
- Repair work may only be performed using the tools intended for the purpose.
- The test rig serves solely for testing, assembling and dismantling components up to a maximum weight of 120 kg. All components are to be professionally attached to the receiver and secured against rotation using the locator angle and screws.
- All locator angles for the preceding type (GUO, GXO) will fit the new test rigs without modification.
- The function test (pressure drop time, opening pressure, leak test) of injection valves is meaningful only up to a needle diameter of Ø 12 mm (e.g. VVO, VWM). The function test on larger injection valves should be performed on test rig GXO-G004.

4 Maintenance

The test rig is largely maintenance-free. Moving parts are subject to natural wear which experience shows is very limited. However, the wear characteristics of the components depend largely on the test rig being handled and cared for properly. To ensure smooth operation of the test rig in the long term, please note and comply with the following care and maintenance instructions.

- Clean the outside of the test rig after every use.
- Subject all components to a visual inspection once a month – damaged or worn components should be replaced by specialist staff if required.
- All electrical components should be inspected for damage once a month. Likewise check monthly that plug connections are tight – damaged components should be replaced by specialist staff if required.
- Check all hydraulic lines and components once a month for pressure loss and damage. The lines must be located firmly in their screwed connections to prevent them coming loose – damaged components should be replaced by specialist staff if required.
- Check six-monthly that mechanical components have not come loose and are tight – if required, components should be adjusted and tightened up.
- Check once a month that safety devices are working properly.
- All moving parts on the device should be greased. The locking bolt and sliding bar on the spray container should also be oiled occasionally.
- Check the oil collector daily. Empty the collector if necessary. Used oil must be disposed of properly and may not, under any circumstances, be reused.

5 General safety instructions

5.1 Use in accordance with purpose

The test rig is solely for assembling/dismantling injection pumps which do not exceed a total maximum weight of 120 kg (injection pump incl. valve) and for testing injection valves up to size "VVO".

The owner of the system is responsible for those setting up, operating or maintaining the device and for third parties following the safety precautions outlined in this operating manual.

L'Orange hereby refuses to accept any liability for damage to those operating or setting up the device, to maintenance staff, to the company and/or to other third parties if the system is used in any way not covered by "use in accordance with purpose", unless L'Orange causes such damage deliberately or as a result of gross negligence.

5.2 Handling the system

5.2.1 Hazards in handling the test rig

The test rig is built in accordance with the state of the art and satisfies recognized safety regulations. Nevertheless, its use can still present a hazard to the life and limb of the user or of third parties, as well as damage to the system or to other material resources. The system should therefore only be used in accordance with purpose and when it is in a perfectly safe condition. Faults which may impair safety should be eliminated immediately and avoided during operation.

5.2.2 Safety measures in normal operation

Operate the test rig only if all the safety devices are fully functional. Check the system for externally visible damage and always check that the safety devices are working before starting operation.

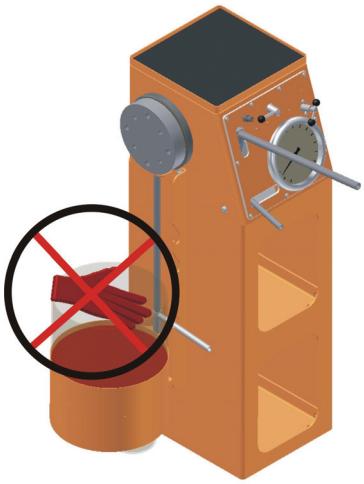
Before assembling, dismantling or modifying any circuit:
switch off the power supply and depressurize the test rig.
Follow the general safety instructions of DIN 58126 and VDE 0100.

5.2.3 Hazards from electrical energy

Once maintenance work is complete, check that the safety devices are working properly. Only a professional trained electrician or electronics engineer may perform any work on the electrical supply.

5.2.4 Hazards from hydraulic energy

Keep away from the spray jet during the function test (pressure build-up) – risk of blood poisoning!



Observed the permitted opening pressure for the injection valve in question (see catalogue sheet).

5.2.5 Servicing – Maintenance – Troubleshooting

During the warranty period, servicing and maintenance work will be performed within the scope of the maintenance contract. Make sure that the specified setting and servicing work is performed at the prescribed intervals. Secure the hydraulic and electrical systems from being switched on unintentionally.

The test rig must be disconnected from the power supply and depressurized for all maintenance, servicing and repair work. Check that all screwed connections undone in the course of maintenance, servicing and repair work are firm.

5.2.6 Organizational measures

All safety devices provided are to be checked regularly.

5.3 Staff

5.3.1 Notes relating to staff

- The test rig may only be operated by persons who have received instruction. This applies to both operation and the safety devices of the test rig.
- Wear safety footwear when working on the test rig.
- Wear oil-resistant clothing.
- Wear safety glasses.
- Wear oil-resistant gloves and clothing.
- Avoid several people working on maintenance and set-up tasks at the same time.
- Naked flames and smoking are forbidden within a radius of 5 m of the test rig!

5.3.2 Outside normal operation

Activities involved in maintaining, servicing or repairing the system may be performed only by people with adequate specialist qualifications.

5.4 General operating instructions

The test rig demands some rules of operation which *must* be complied with. If these rules are ignored, it is possible for faults to arise in the testing process and hazards to physical health cannot be ruled out. You are strongly advised to follow the rules below.

5.4.1 How to behave

- Naked flames and smoking are absolutely prohibited at the test rig and within a radius of 5 m.
- It is prohibited to reach into the spray container (plexiglass tube) during the testing process.
- Stations should be made safe by mechanical means in the event of relatively large groups of spectators.
- It is prohibited to pull out any live cable connection.
- Water of any kind is to be kept away from the system.
- Test lines should be carefully examined for cracks or leaks before each use.

5.4.2 Rules for operation

- The test rig may only be operated by people who have received instruction.
- Operation should be in accordance with the operating manual.
- Prevent unsupervised operation of any equipment.

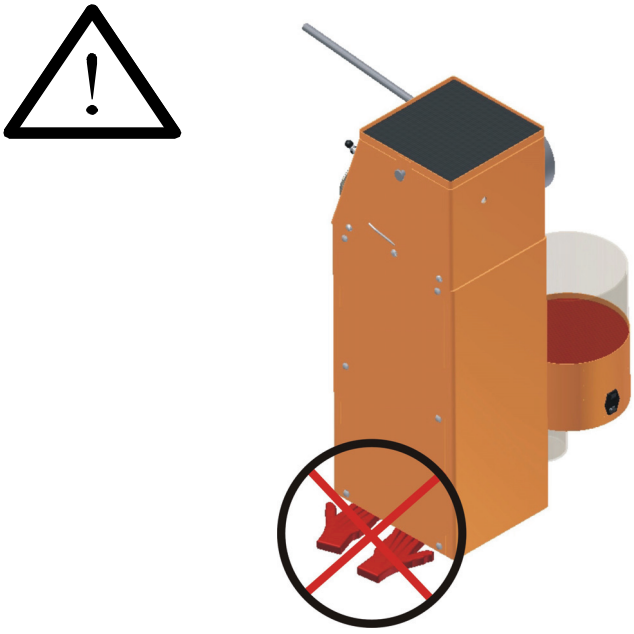
6 Commissioning

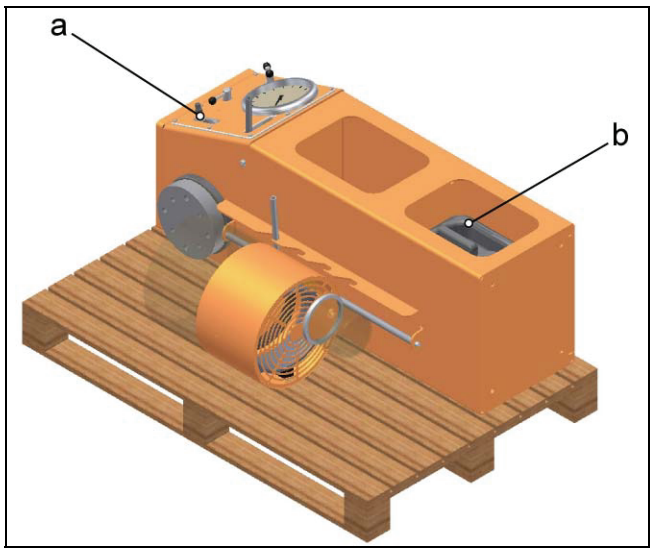
6.1 Transport

When the test rig is delivered, ensure that it is only transported using suitable transportation equipment. The GXO-G010a weighs approx. 150 kg and the GXO-G011a approx. 75 kg.
The routes to be taken should be cleared for transport and be accessible for the transportation equipment. If appropriate, put up warning signs or barrier tape.

Take care when opening the transport box, preventing extra components like the test oil supplied from falling out. Once the transport box is open and any additional components have been removed, the test rig can be removed and taken to its final location.

Please check that all screwed connections are tight. Vibration during transport may have caused them to come loose. The test rig may not be gripped by its feet and certainly not under the feet – increased risk of crushing or trapping.

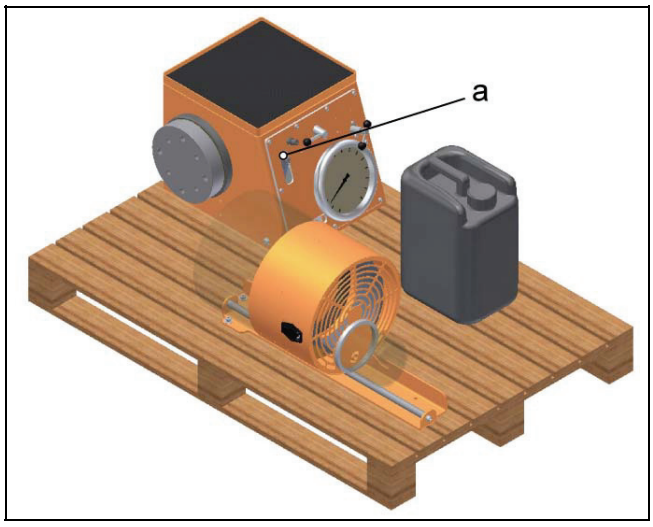




State in which GXO-G010a delivered

Canister [b] containing the test oil is in the base of the test rig.

The lever for the pump is enclosed with the delivery and needs to be fitted for commissioning [a].



State in which GXO-G011a delivered

The lever for the pump is enclosed with the delivery and needs to be fitted for commissioning [a].

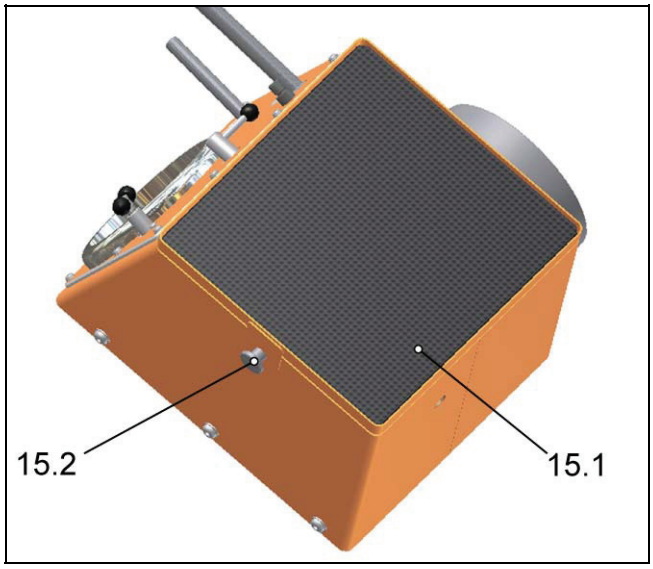
6.2 Setting up

6.2.1 General information

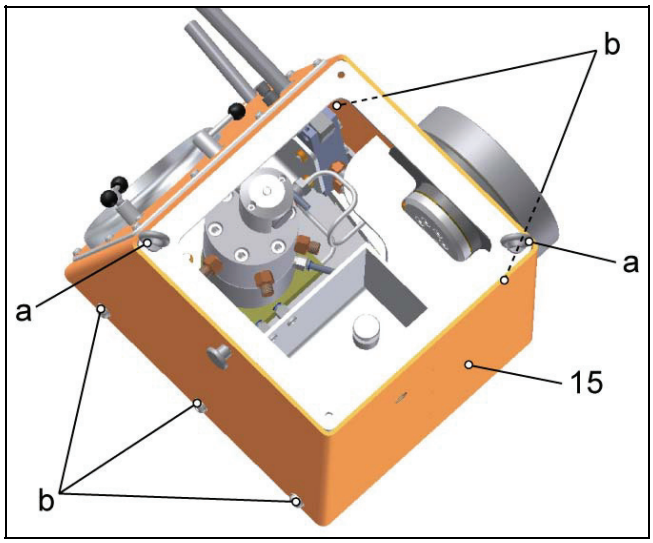
The test rig should be screwed to the floor (GXO-G010a) or bench (GXO-G011a) at its intended location. In addition, the workbench should likewise be affixed to the floor to prevent tipping over. A loadbearing/solid floor is a prerequisite for smooth assembly and operation.

An appropriate gap should be planned between the test rig and the wall.
Keep dust and dirt away from the test rig (cover).

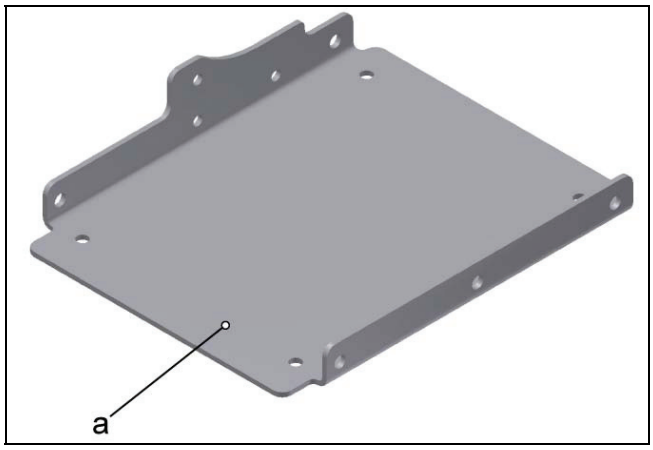
6.2.2 Bench-top mounting (GXO-G011a)



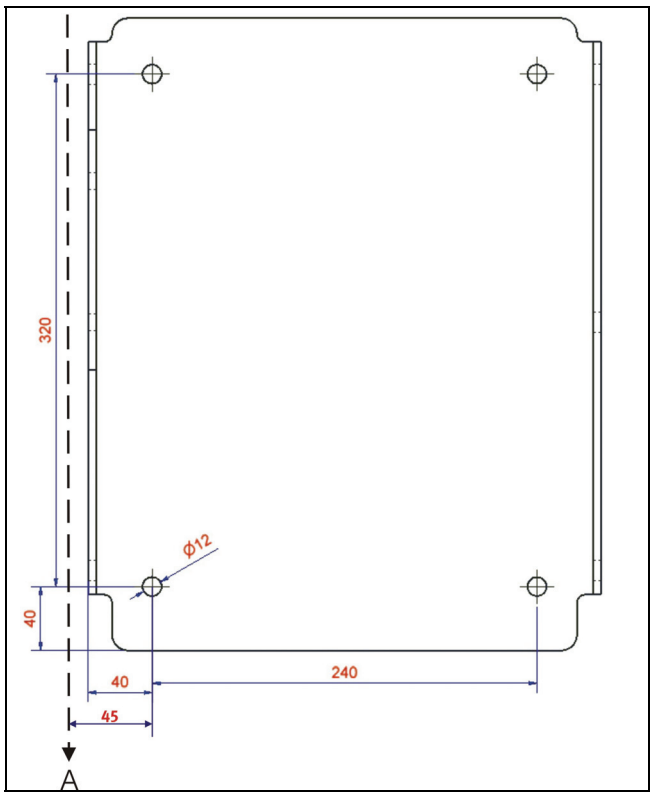
- Remove screw [15.2].
- Remove cover [15.1].



- Fit dismantling aid [a] and hold the body [15] steady using a crane.
- Undo and remove screws [b].
- Carefully lift body [15] using the crane and place it aside.



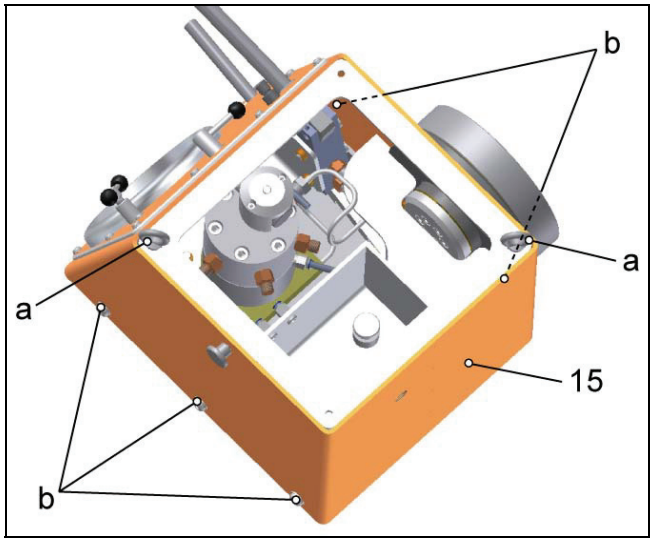
- The baseplate [a] is now in front of you ready for assembly.



- Transfer the bores in the baseplate as shown in the sketch to the workbench and drill into the worktop using a Ø 12 mm bit.

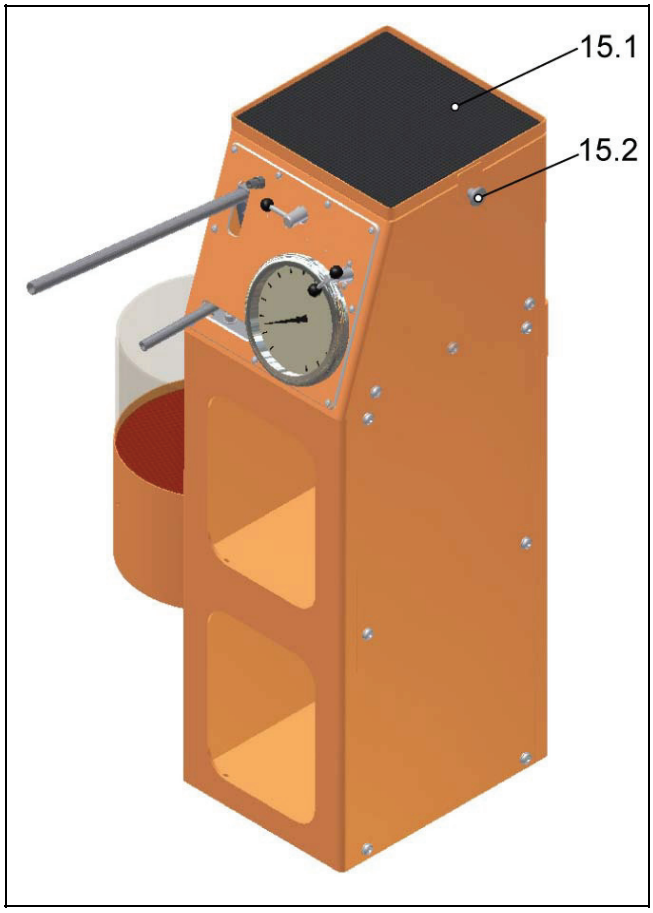
  Line A represents the edge of the bench!

- Screw the baseplate firmly to the bench using M10 screws (length depending on the thickness of the workbench). The screws must be pushed in from above and tightened up from underneath with washers and a nut.

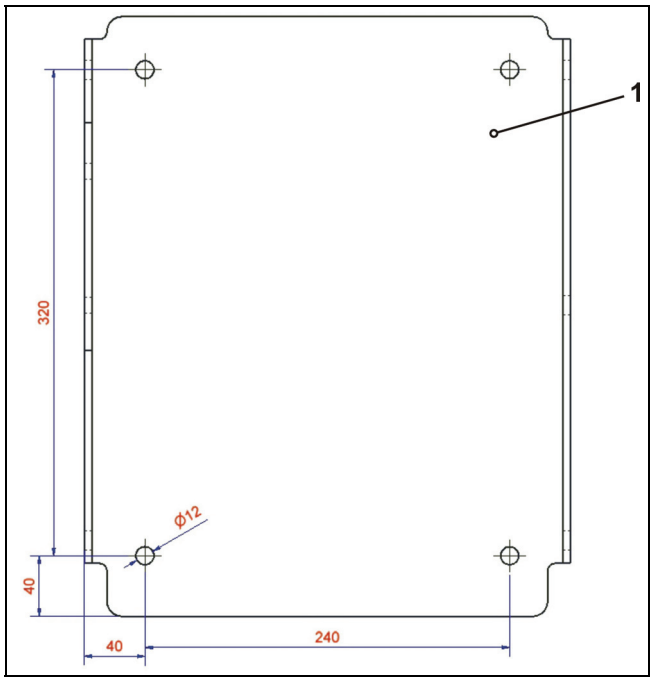


- Put body [15] on the baseplate and attach with screws [b].

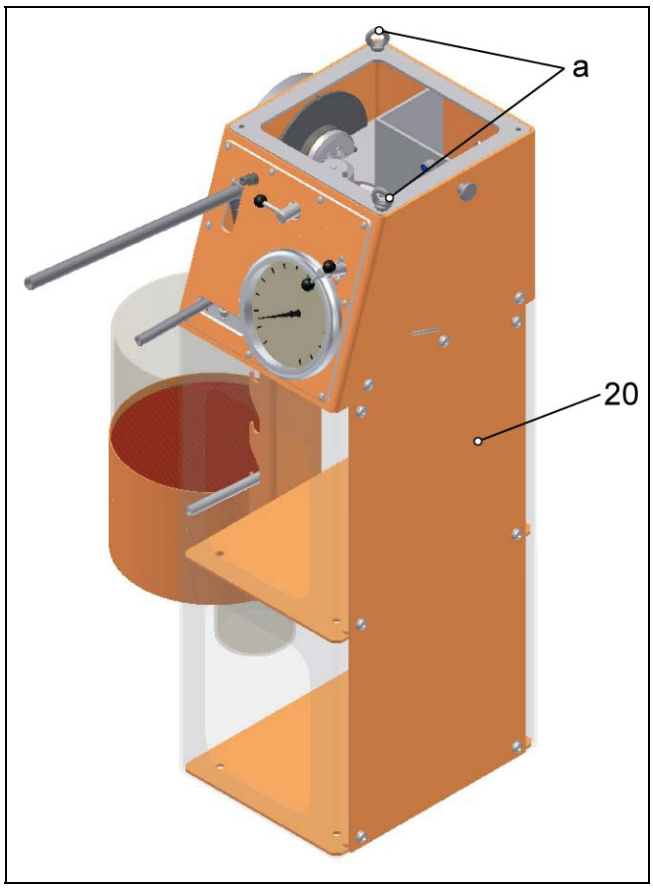
6.2.3 Floor mounting (GXO-G010a)



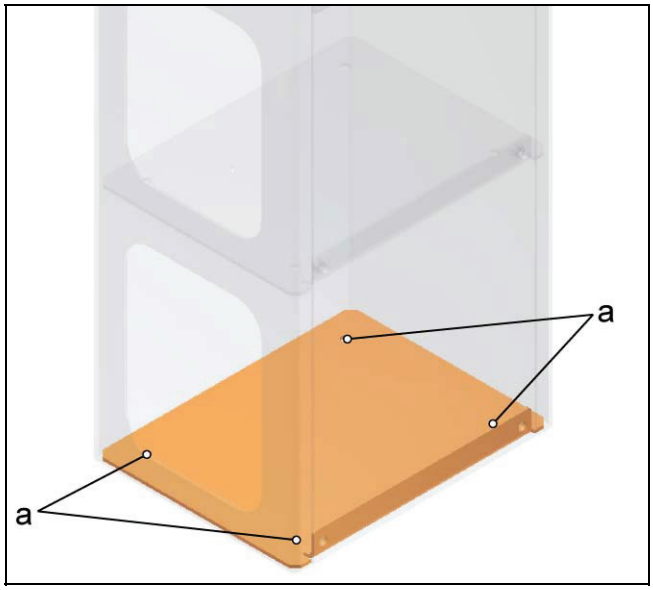
- Remove screw [15.2].
- Remove cover [15.1].



- Align the test rig and transfer the bore positions for baseplate [1] to the floor.



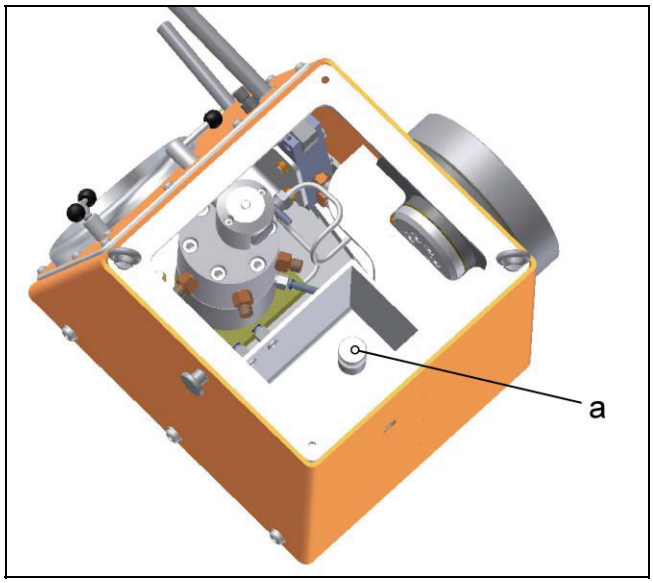
- Fit dismantling aid [a].
- Carefully lift subframe [20] using a crane and place it aside.
- Drill holes in the floor.
- Use the crane to return subframe [20] to its assembly position.
- Remove the dismantling aid [a].



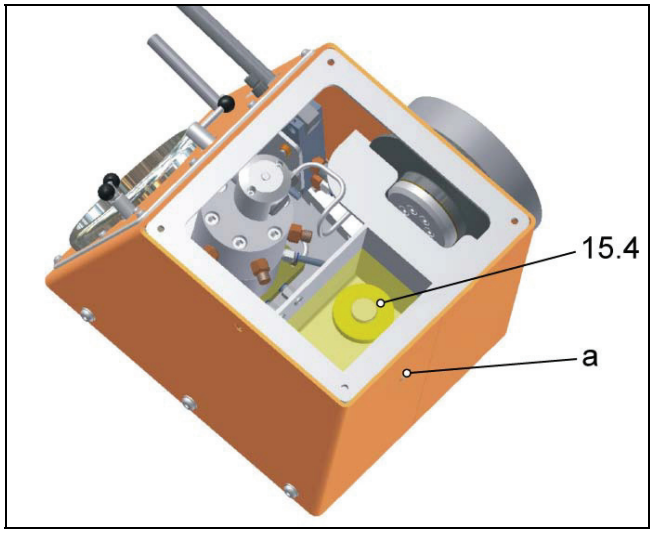
- Depending on the substrate, attach the baseplate of the test rig with four screws [a].

6.3 Commissioning the hydraulic system

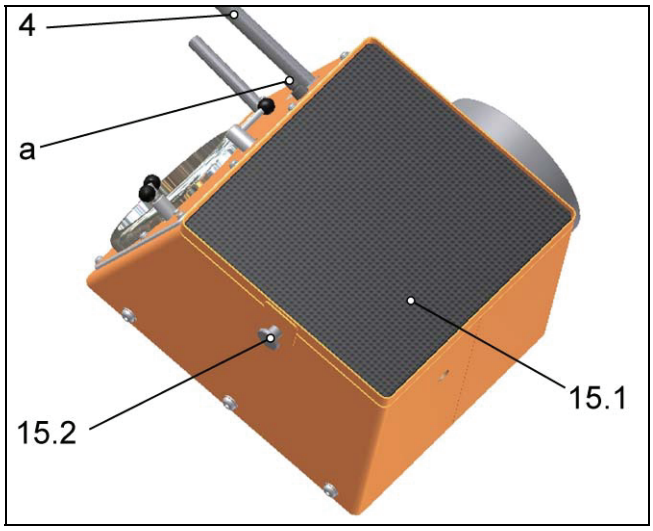
The owner commissions the rig independently. The procedure required to do so is described below. A prerequisite is that the test rig is already firmly screwed as described in the previous section.



- Remove transport sealing plug [a].

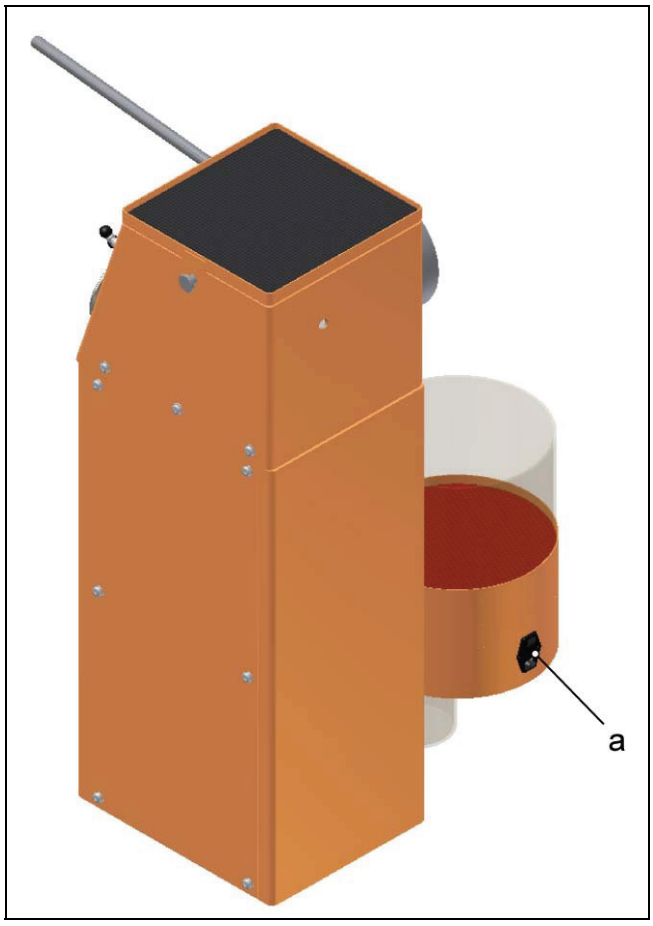


- Fit filter [15.4].
- Pour Fuchs Renotest test oil into the test oil reservoir to at least oil sight glass [a] (capacity approx. 3.5 liters).



- Fit cover [15.1] and fix in position with screw [15.2].
- Pump lever [4] until test oil escapes from connection [a] without bubbles.

6.4 Commissioning the electrical system



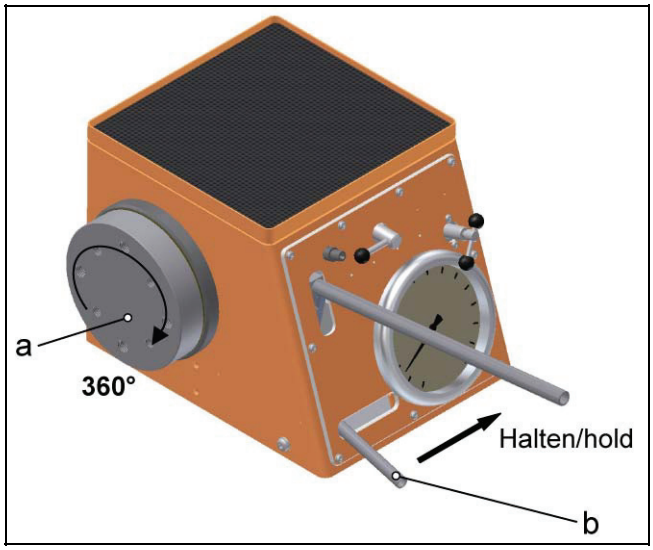
- Connect the cable for non-heating appliances supplied to socket [a] and supply with electrical power.

  Extraction operates at a voltage of 230 V and cannot be switched to 110 V!

  The fitted plug can be changed if required, but this should be done only by a qualified specialist. The connection for this must be fused at a rating to suit the consumers. To prevent problems in operation, we strongly recommend separate fuse protection for the test rig.

6.5 Preparations for commissioning the test rig

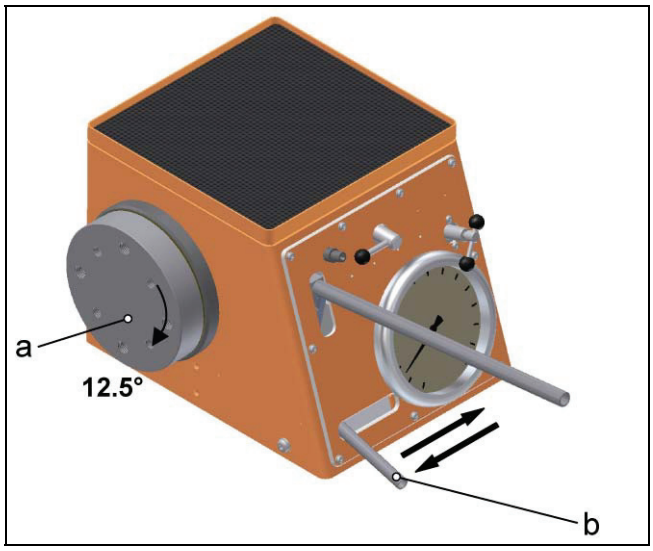
If rotary receiver [1] needs to be swivelled, follow the instructions below.



- 360° rotation

  The swivel restriction can be released using release lever [b]. If the lever is moved to the right and held there, rotary receiver [a] can be turned through 360°.

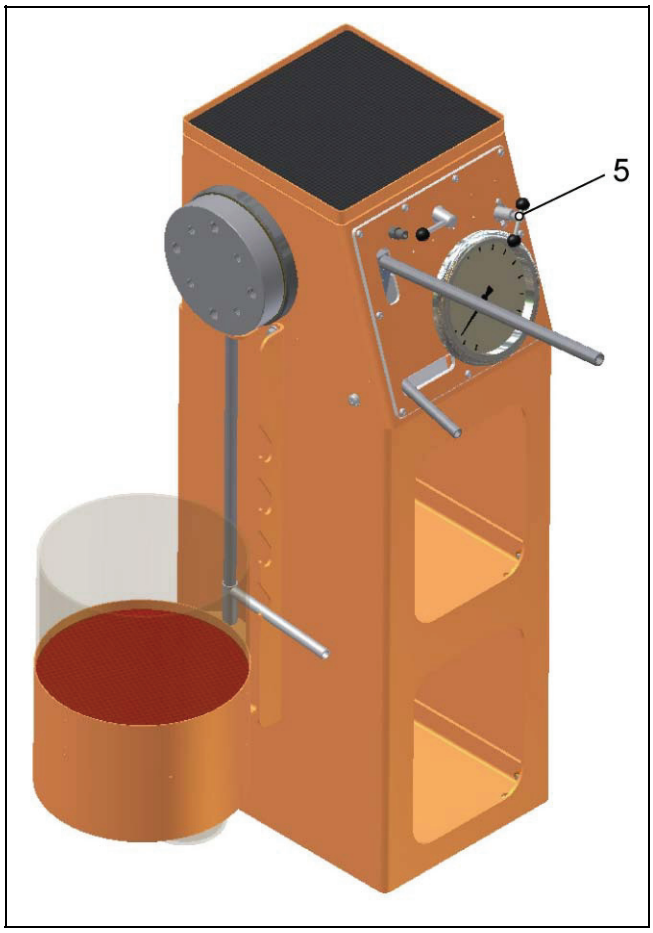
  Warning, risk of injury!
  The valve can rotate in an uncontrolled manner once the swivel restriction is released.



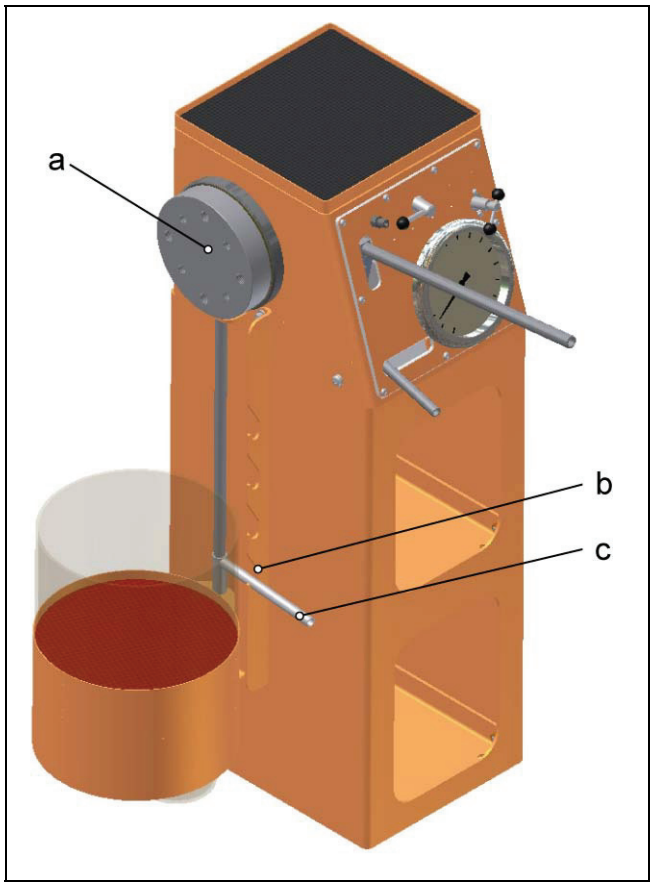
- 12.5° rotation

  If lever [b] is moved only briefly to the right and then returned to the left-hand position, rotary receiver [a] can be turned through 12.5°.

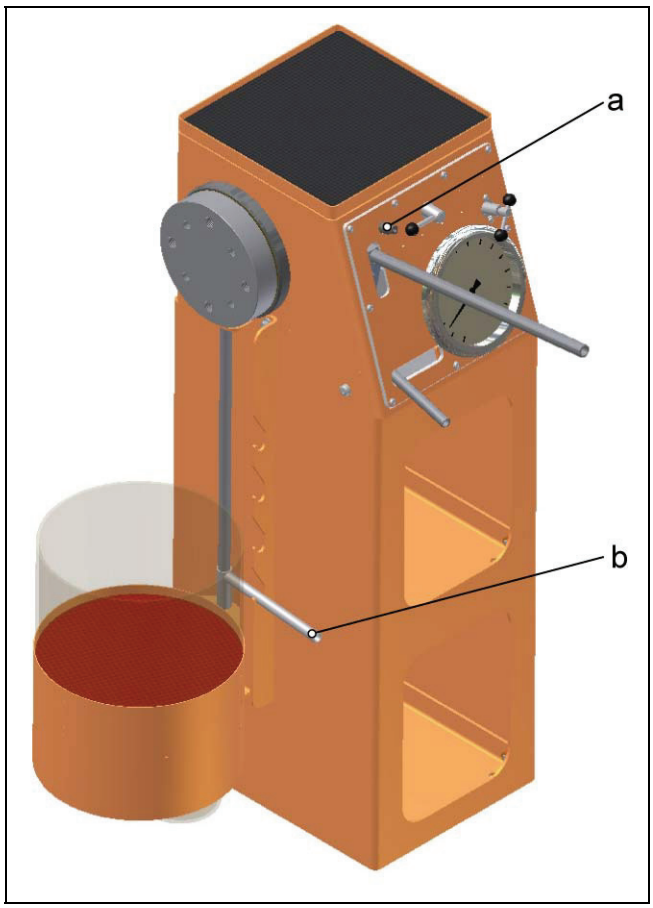
Make the following preparations every time you use the test rig.



- Follow the safety instructions!
- Only staff who have received instruction may operate the test rig.
- The test rig must be depressurized completely using relief valve [5].



- Use height adjuster [c] to move the spray container right to the bottom and secure the lever in the lowest latching position [b].
- Fit valve receiver on rotary receiver [a].
- Fit valve in receiver.



- Connect the injection valve to connector [a] of the test rig using the corresponding test line. Tighten screwed connections firmly!
- Use height adjuster [b] to move the spray container upwards until the injection nozzle of the valve is inside the plexi-glass tube. Secure the lever in one of the latching positions!
- Switch on extraction.
- You can now select operating mode.

7 Technical data

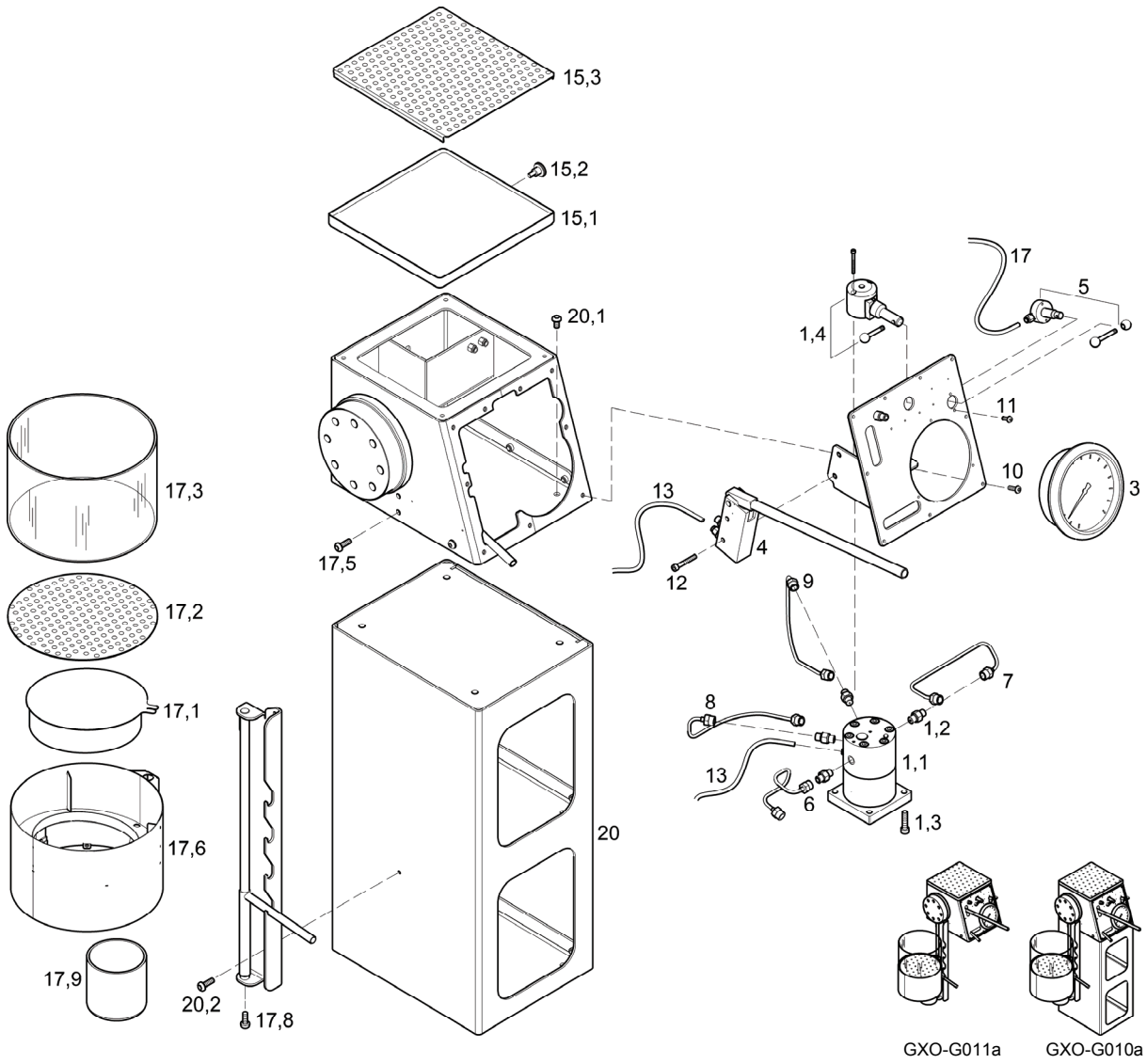
7.1 GXO-G010a (floor-mounted system)

Purpose:	medium-speed diesel engines
Weight:	GXO-G010a = 146 kg
Dimensions:	height: 1130 mm
	width: 440 mm excl. spray container
	width: 670 mm incl. spray container
	depth: 510 mm excl. spray container
	depth: 560 mm incl. spray container
Piston diameter:	8 mm
Safety valve:	opening pressure = 900 bar
Pressure gauge:	display up to 1000 bar / 14400 psi
Test oil:	Fuchs Renotest LO
Test oil viscosity:	4.5 cSt/40°C
Test oil reservoir:	approx. 3.5 liters
Test oil line:	connecting thread 24 x 1.5
Maximum load:	120 kg (receiver)

7.2 GXO-G011a (bench-top system)

Purpose:	medium-speed diesel engines
Weight:	GXO-G011a = 71 kg
Dimensions:	height: 330 mm excl. spray container
	height: 1120 mm incl. spray container
	width: 440 mm excl. spray container
	width: 670 mm incl. spray container
	depth: 510 mm excl. spray container
	depth: 560 mm incl. spray container
Piston diameter:	8 mm
Safety valve:	opening pressure = 900 bar
Pressure gauge:	display up to 1000 bar / 14400 psi
Test oil:	Fuchs Renotest LO
Test oil viscosity:	4.5 cSt/40°C
Test oil reservoir:	approx. 3.5 liters
Test oil line:	connecting thread 24 x 1.5
Maximum load:	120 kg (receiver)

8 Parts list and exploded drawing



Item	Pcs.	Part	L'O-No.	Weight g
		Test rig	**GXO-G011a** (replacement for all GUO-G...)	71000
1		Booster, compl.	GXO-U058	13500
1,1		Booster	GXO-U056	12000
1,2	4	Connection piece	GXO-T173	30
1,3	2	Screw	D912-M10x40-12.9	35
1,4		Valve actuator	GXO-U057	1350
3		Gauge	FMA-160.1000AH	1100
4		Hand pump Ø8	GCO-G005d	2700
5		Relief valve	GXO-U059	350
6		Tube	GXO-T126	110
7		Tube	GXO-T127	130
8		Tube	GXO-T128	130
9		Tube	GXO-T129	125
10	9	Screw	D7380-M6x20	7
11	2	Screw	D7380-M5x12	5
12	2	Screw	D912-M8x60-12.9	30
13	3	Hose	GXO-T130 L = 1200 mm	50
15		Body	GXO-U062	44150
15,1		Oil tray	GXO-U063	2150

Item	Pcs.	Part	L'O-No.	Weight g
15,2		Screw	D464-M8x16	10
15,3		Perforated plate	GXO-T133	700
15,4		Filter screw	GCO-T065	60
15,5		Mesh filter	FSH-1	5
17		Spray container	GXO-U065	7150
17,1		Cover	GXO-U067	1100
17,2		Perforated plate	GXO-T159	700
17,3		Plexiglass tube	GXO-T155	1350
17,5	3	Screw	D7380-M8x25	15
17,6		Spray container	GXO-U066	3900
17,8		Screw	D7380-M8x20	12
17,9		Collector	GUO-T041	75
		Test rig	**GXO-G010a** (replacement for all GXO-G003...)	146000
20		Lower section	GXO-U055	57500
20,1	4	Screw	D912-M10x20-10.9	25
20,2		Screw	D7380-M8x25	15
not specified items like GXO-G011a				06/07