

**INSTRUCTION BOOK
HYUNDAI-MAN B&W DIESEL ENGINE
MAINTENANCE**

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DAI HEAVY INDUSTRIES CO., LTD. ENGINE & MACHINERY DIVISION.**

Instructions for Main Engine

Type S90ME-C

This book forms part of a set of books consisting of three volumes entitled:

- Vol. I OPERATION
- Vol. II MAINTENANCE
- Vol. III COMPONENTS AND DESCRIPTIONS

The purpose of these books is to provide general guidance on operation and maintenance and to describe the constructional features of a standard version of the above engine type. Deviations may be found in a specific plant. In addition, the books can be used for reference purposes, for instance in correspondence and when ordering spare parts.

It is essential that the following data is stated in spare parts orders as it is used by us to ensure the supply of the correct parts for the individual engines:

1. Name of vessel
2. Engine No. built by
3. Plate No.
4. Part No.
5. Quantity required (and description)

Example: M/S (HYUNDAI NO. 1) B200-90201-H40-072
 10 pcs (piston crown)

As reliable and economical operation of the diesel engines is conditional on correct operation and maintenance, it is essential that the engine-room personnel is fully acquainted with the contents of this book.

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The Checking and Maintenance Schedules indicate the intervals at which it is deemed appropriate to inspect the individual components of the engine and to carry out overhauls, if necessary, based on the engine condition or on time criteria.

The stated **Normal hours of service** should only be used as a guide, as differences in the actual service conditions, the quality of the fuel oil or lubricating oil, the treatment of cooling water, etc. will decisively influence the actual service results, and thus the intervals between necessary overhauling.

Design modifications may necessitate a revision of the instructions, in which case the revised instructions and changed overhauling intervals, if any, will apply and supersede those originally issued (see *e.g. our Service Letters*).

In addition to the checking and overhauling intervals stated in this schedule, please note that the periodical survey requirements of the classification society may require additional checks and overhauls to be carried out. For further information please refer to the classification society.

The procedures are divided into three categories:

Condition checking procedures

marked under the heading **Normal hours of service** with a **C**, deal with the service condition of a number of engine components, and form the basis for estimating whether further overhauling is necessary. In a number of cases the condition checking procedures refer to **Volume I** of the instruction book, in which more detailed descriptions and working procedures can be found.

Condition-based overhauling procedures

are those procedures which under the heading **Normal hours of service** are marked with an **O**, and opposite which, under the heading **Overhaul to be based on procedure No.** (column P), a procedure number is stated.

This procedure number normally refers to one of the above condition checking procedures which form the basis of the overhaul. For this reason, the intervals stated are for guidance only.

Time-based overhauling procedures

also marked with an **O** under the headings **Normal hours of service** or **Based on observations**, are the procedures where an actual basis for estimation is lacking. It is recommended, therefore, to carry out these procedures at the overhauling intervals stated as a basis.

Where a symbol **O** or **C** is indicated in **Based on observations** (column B), this is due to the fact that special service conditions may make checking or overhauling necessary beyond the actual standard schedules indicated.



V : See Volume I “Operation”			M : See maker’s instructions											R : Parts to be replaced		
A : Adjustment to be carried out			O : Overhaul to be carried out											B : Based on observations		
C : Check the condition			H : Check new/overhauled parts after 500-1500 hours											P : Refer to		
			Regular Checks			Service interval (x 1000 hours of operation)										
No.	Procedure	H	Daily	Weekly	Monthly	2	4	6	8	12	16	24	32	B	P	Remarks
901	Cylinder Cover															* Check whenever exhaust valve is removed
-1	Cylinder cover										C*			O		
	Indicator cock													O		
902	Piston with Rod and Stuffing box															* Check clearances without dismantling segments
-1	Piston										C,O					
	Inspection through scavenge ports				C										V	
-2	Piston rod stuffing box										C*			O		
903	Cylinder Liner and Cylinder Lubrication															Bearings should only be opened if bearing material fragments fall out. Vol. I Chapter 702-01
-1	Cylinder liner													O		
	Inspection through scavenge ports				C											
	Measuring wear inside liner										C					
-2	Cylinder lubricators										C			A	V,M	
	Accumulators nitrogen pressure										C			A		
	Lubricator level sensor						C							O	V,M	
904	Crosshead with connecting rod															
-1	Crosshead bearing	C							C					C,O		
-2	Crosshead	C							C					C,O		
-3	Reciprocating parts								C					C,O		
-4	Crankpin bearing	C							C					C,O		
-5	Connecting rod													O		
905	Crankshaft and Thrust Bearing															Bearings should only be opened if bearing material fragments fall out.
-2	Main bearing	C							C					C,O	V	
-3	Thrust bearing	C							C					C,O		
-3	Guide bearing	C							C					C,O		
-4	Journal bearing	C							C					C,O	V	

Checking and Maintenance Schedule, ME Engines

V : See Volume I "Operation"
 A : Adjustment to be carried out
 C : Check the condition

M : See maker's instructions
 O : Overhaul to be carried out
 H : Check new/overhauled parts after 500-1500 hours

R : Parts to be replaced
 B : Based on observations
 P : Refer to

No.	Procedure	H	Regular Checks			Service interval (x 1000 hours of operation)								B	P	Remarks
			Daily	Weekly	Monthly	2	4	6	8	12	16	24	32			
-5	Axial vibration damper													O		
	Electronic axial vibration monitor		C													
	Mechanical checking								C							
-7	Tacho pick-up													C,O	M	
-8	Angle encoder													C,O	M	
906	Mechanical Control Gear															
-1	Chains	C					C							R	V	New or overhauled chain to be checked/retightened after 500, 1500 and 4000 hours
-2	Chain tightener	C,A					C,A							A		
	Chain wheels, spray nozzles and guide bars	C					C							R		
-5	Moment compensator	C					C							C,A		
-20	Gear drive	C								C						
-21	Hydraulic pumps												C	R	M	
-22	Hydraulic system												C	O		
-23	Accumulators						C							A		
-24	Control valves												C	R	M	
-25	Pick-up arrangement													C,A	M	
-28	Special running													O	V	
	Start-up pumps						C							O	V	Vol. I, Chapter 702-01
	HCU safety by-pass						C							O	V	Vol. I, Chapter 702-01
	MPC units shut-down signal						C							O	V	Vol. I, Chapter 702-01
	Hydraulic system leakage test						C							O	V	Vol. I, Chapter 702-01
	Double-wall pipes leakage test	C					C							O	V	Vol. I, Chapter 702-01
	Boll & Kirch filter										C			O	M	
	Functional check of overspeed device								C						M	
	Functional check of speed-setting system (engine with bridge control system)								C						M	

V : See Volume I "Operation"			M : See maker's instructions										R : Parts to be replaced			
A : Adjustment to be carried out			O : Overhaul to be carried out										B : Based on observations			
C : Check the condition			H : Check new/overhauled parts after 500-1500 hours										P : Refer to			
No.	Procedure	H	Regular Checks			Service interval (x 1000 hours of operation)								B	P	Remarks
			Daily	Weekly	Monthly	2	4	6	8	12	16	24	32			
907	Starting Air System															* Vol. I, Chapter 702-01 After arrival in port
-2	Starting air valve		C*							C,O					V	
	Main starting valve pilot valve		C*												V	
908	Exhaust Valve															
-1	High-pressure pipe													O		
-2	Exhaust valve										O					
-3	Exhaust valve actuator												O			
	Actuator safety valve								C,A							
-7	Exhaust valve special running													O		
909	Fuel Oil System															
	Fuel oil water content			C											V,M	
-11	Fuel valve								C,O							
-	Fuel nozzle								R							
-12	Spindle guide										R					
-13	Non-return valve								O							
-14	Fuel oil high-pressure pipes													O		
-16	Fuel oil pressure booster special running													O		
-20	Fuel oil pressure booster													O		
-21	Fuel oil pressure booster top cover													O		
-22	Fuel oil pressure booster suction valve								C,O							
910	Turbocharger System															Check Δp and Δt Check at every port inspection
-1	Air cooler		C											O	V	
-2	Non-return valve				C									O		
-3	Auxiliary blower													O		
-4	Butterfly valves				C									O		
-5	Turbocharger turbine		C*						C					C,O	V,M	* Dry cleaning daily

Checking and Maintenance Schedule, ME Engines

V : See Volume I "Operation"
 A : Adjustment to be carried out
 C : Check the condition

M : See maker's instructions
 O : Overhaul to be carried out
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R : Parts to be replaced
 B : Based on observations
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No.	Procedure	H	Regular Checks			Service interval (x 1000 hours of operation)								B	P	Remarks
			Daily	Weekly	Monthly	2	4	6	8	12	16	24	32			
	Turbocharger air filter		C*											O		* Check Δp
	Protective grid before turbocharger								C					R	V	
	Turbocharger lubricating oil water content			C											M	
-6	Water mist catcher		C*											C,O		* Check Δp
911	Safety Equipment															
-1	Overpressure indicator valve								C					O		
-2	Relief valve								C					O		
-3	Scavenge air receiver safety valve								C					O		
	LOP lamp test			C										O	V	Vol. I Chapter 702-01
	Electronic boxes								C					O	V	Vol. I Chapter 702-01
	Functional test of alarm system for thrust bearing and slow down /shut down system	C				C									M	
	Checking and adjustment of pressure gauge								C					A	M	
	Checking and adjustment of thermometers								C					A	M	
	Checking and adjustment of thermostats								C					A	M	
	Checking and adjustment of pressurestats								C					A	M	
	Checking and adjustment of turning gear switch								C					A	M	
912	Assembly of Large Parts															
-2	Holding-down and end chock bolts	C							C							
-3	Stay bolts	C											C			
	Top bracings	C							C							
	Diaphragm in crankcase oil outlet												C	R		
	System lubricating oil water content			C											V,M	
	System lubricating oil bottom tank												O			Empty and clean tank
	Cooling water quality			C										A	V,M	
	Crankcase								C*							* Check for loose nuts and bearing material fragments

V	: See Volume I “Operation”
A	: Adjustment to be carried out
C	: Check the condition

M : See maker's instructions
O : Overhaul to be carried out
H : Check new/overhauled parts after 500-1500 hours

R : Parts to be replaced
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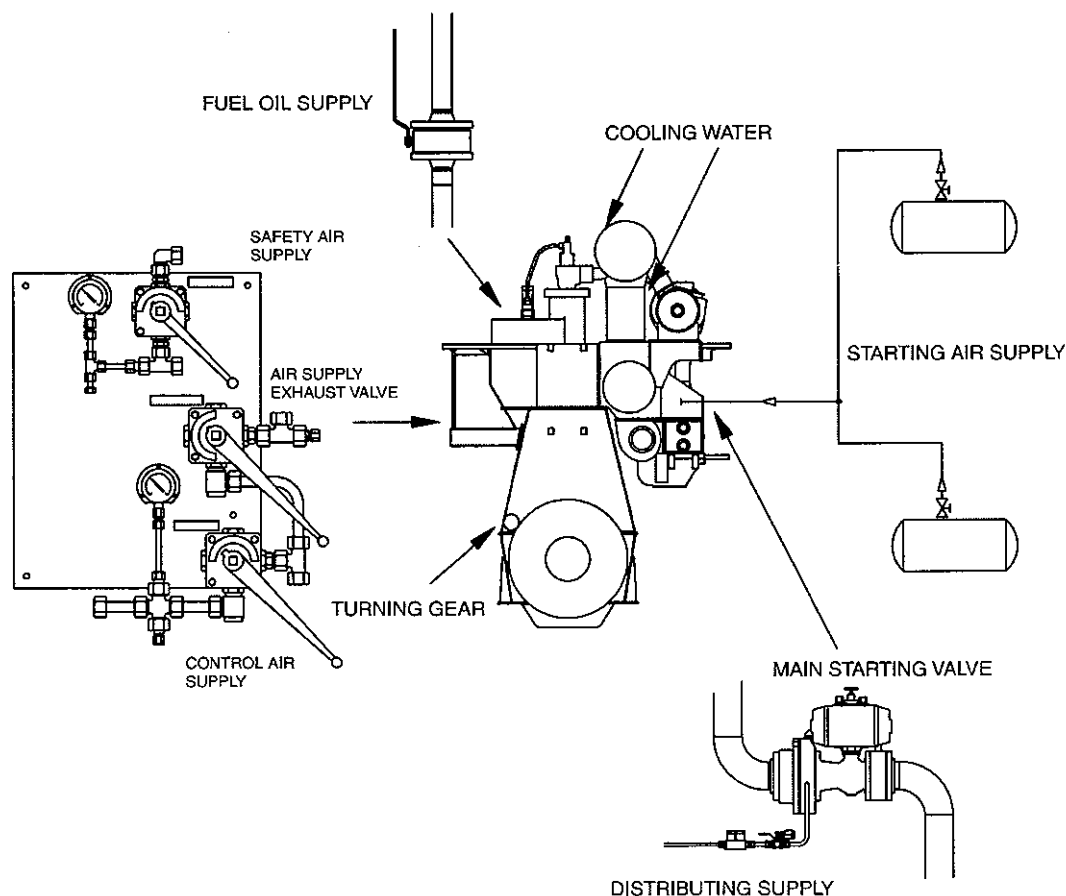
No.		Procedure	H	Regular Checks			Service interval (x 1000 hours of operation)								B	P	Remarks
				Daily	Weekly	Monthly	2	4	6	8	12	16	24	32			
913		General Tools															
-1		Hydraulic tools								C					O	M	

Before maintenance work is carried out, the engine must be stopped and blocked according to the safety precautions given on the specific Data Sheet.

SAFETY PRECAUTIONS

X	Stopped engine
X	Shut off starting air supply – <i>At starting air receiver</i>
X	Block the main starting valve
X	Shut off starting air distributor/distributing system supply
X	Shut off safety air supply – <i>Not ME-engines</i>
X	Shut off control air supply
X	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
X	Stop lubricating oil supply
X	Lock the turbocharger rotors

The sketch gives the approximate location of the valves concerned:



SAFETY PRECAUTIONS For detailed sketch, see 900-2

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☒	Shut off cooling water
☒	Shut off fuel oil
☐	Stop lubricating oil supply
☒	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D01-01	Exhaust valve stud, screwing-in torque	600	Nm
D01-02	Starting valve stud, screwing-in torque	240	Nm
D01-03	Fuel valve stud, screwing-in torque	140	Nm
D01-05	Cylinder cover stud, check distance	183 - 184	mm
D01-06	Cylinder cover, complete	8800	kg
D01-07	Cylinder cover without valves	6300	kg
D01-08	Cooling jacket	210	kg
D01-09	Exhaust valve stud	200	kg
D01-10	Cylinder cover stud	203	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90151	46	Grinding tool for exhaust valve seat
P90151	58	Milling and grinding wheel for fuel valve seat
P90151	60	Milling and grinding wheel for starting valve seat
P90151	83	Grinding handle
P90161		Cylinder cover tightening tool
P90165		Cylinder Cover - Lifting Tools
P90163		Cylinder Cover - Support Tool
P91351	10	Hydraulic pump, pneumatically operated
P91351	60	Hose with unions (5000 mm), complete

1. Set blocking device **A** on the main starting valve in the **BLOCKED** position.

Engage turning gear **B**.

Close fuel oil inlet valve **C**.

Close cooling water inlet valve **D**.

Close cooling water outlet valve **E**.

Open cooling water drain cocks **F** and **G**.

Shut off the air supply for the pneumatic exhaust valve spring, and vent the system.

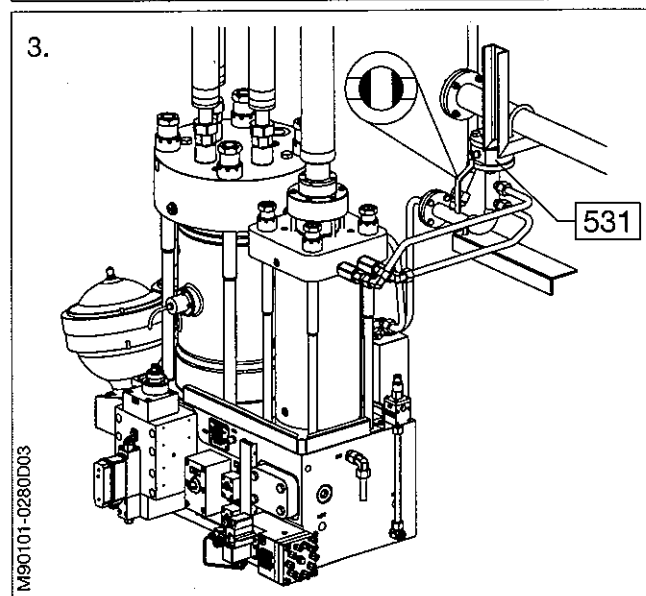
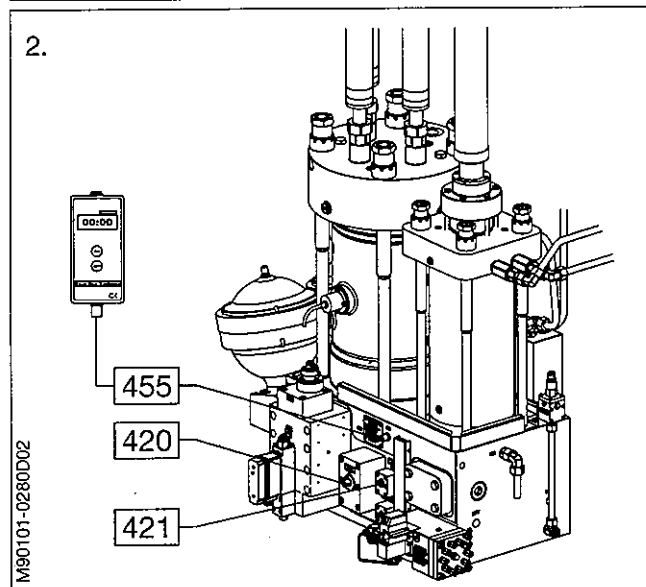
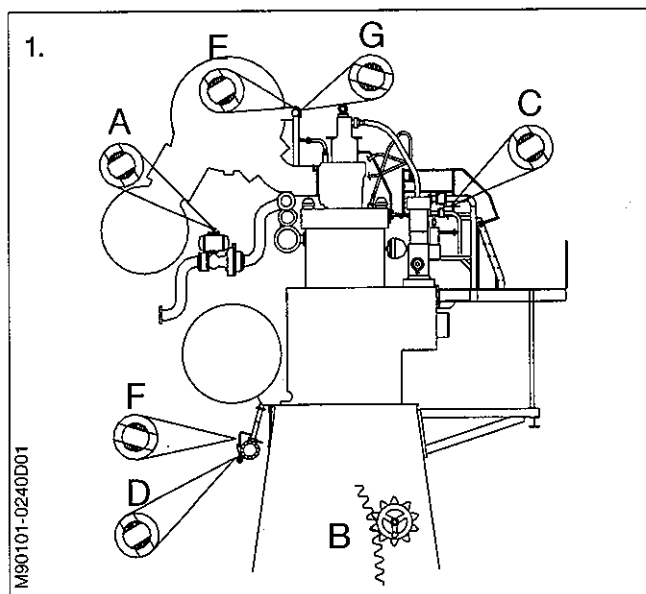
2. Connect a pressure gauge at "minimess" point 455.

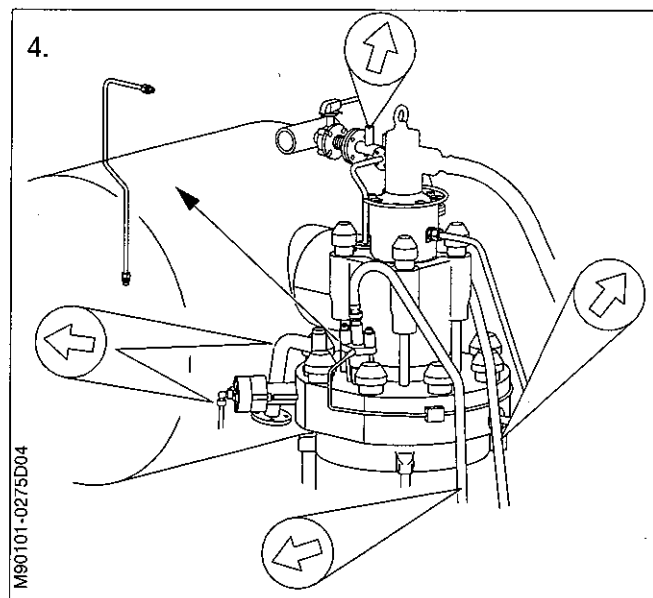
Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block.

Check that the system is pressure free.

3. Close valve 531 for hydraulic operation of the exhaust valve.





4. Remove the cooling water outlet pipe from the exhaust valve.

Remove the screws which fasten the cooling water outlet pipe to the cylinder cover.

Dismount the fuel oil high-pressure pipes. See Procedure 909-14.2.

Dismount the control air pipe from the starting valve.

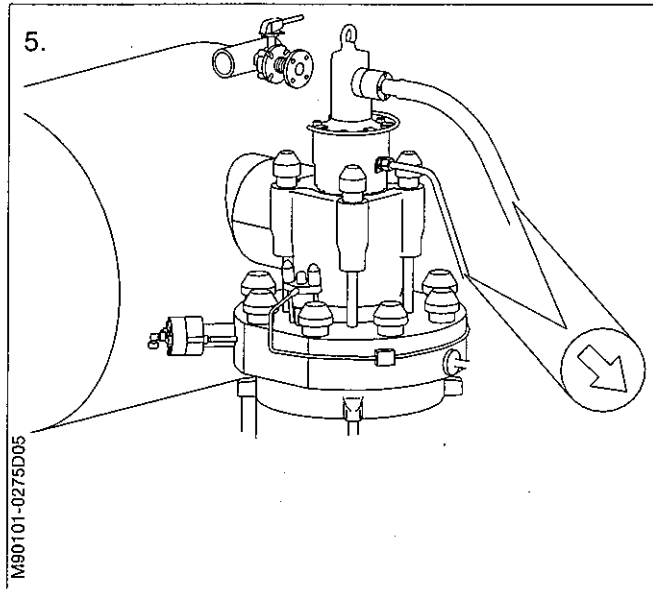
Remove the starting air pipe.

5. Dismount the hydraulic high-pressure pipe to the exhaust valve, see Procedure 908-1.2.

Remove the oil supply pipe for the hydraulic damper in the exhaust valve.

Dismount the drain oil pipe between the exhaust valve and the hydraulic actuator, and the air pipe for the pneumatic exhaust valve spring.

Disconnect the plug for the electrical connection to the exhaust valve spindle position sensor.



6. Remove the protective jacket enclosing the insulation for the intermediate pipe or compensator. Remove the insulation.

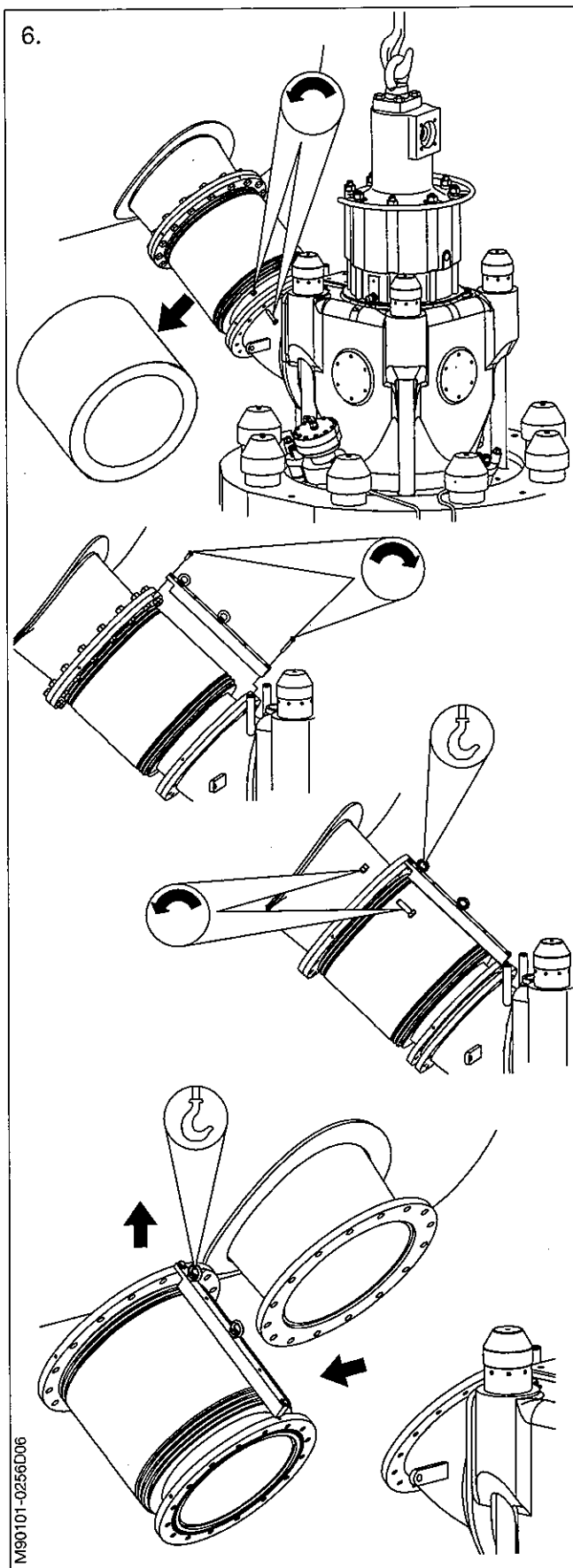
Loosen the screws in the flange between the compensator and the exhaust gas bend and let the compensator contract.

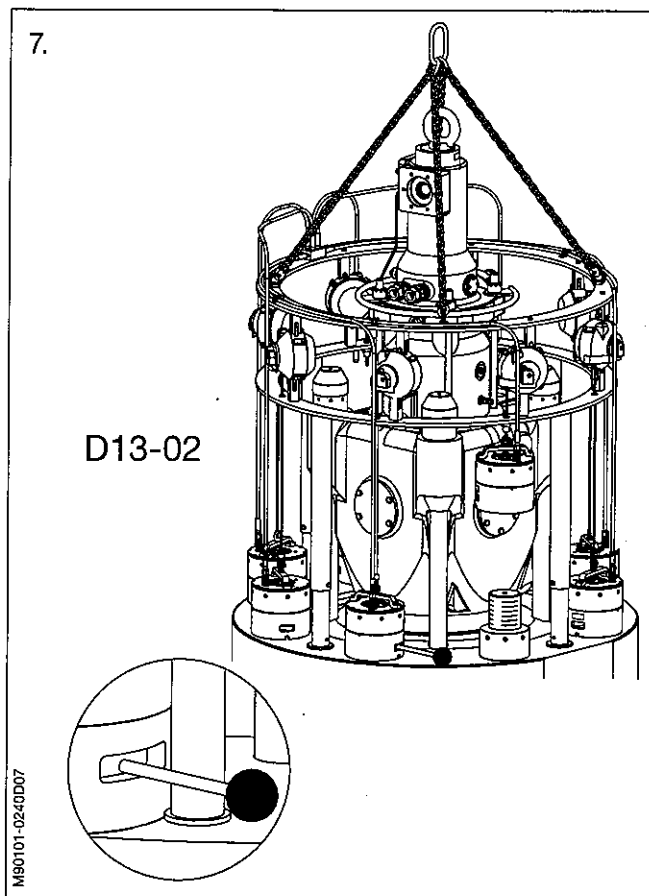
Fit the lifting tool as shown in the sketch.

Suspend the compensator in the engine room crane. Loosen and remove the screws in both the uppermost and lowermost flange.

Move the compensator forward and clear of the exhaust valve and the exhaust compensator.

Lift the compensator away.





7. Remove the protective caps from the cylinder cover nuts.

Position the cylinder cover tightening tool over the cylinder cover.

Pull down the spacer rings and the hydraulic jacks over the nuts.

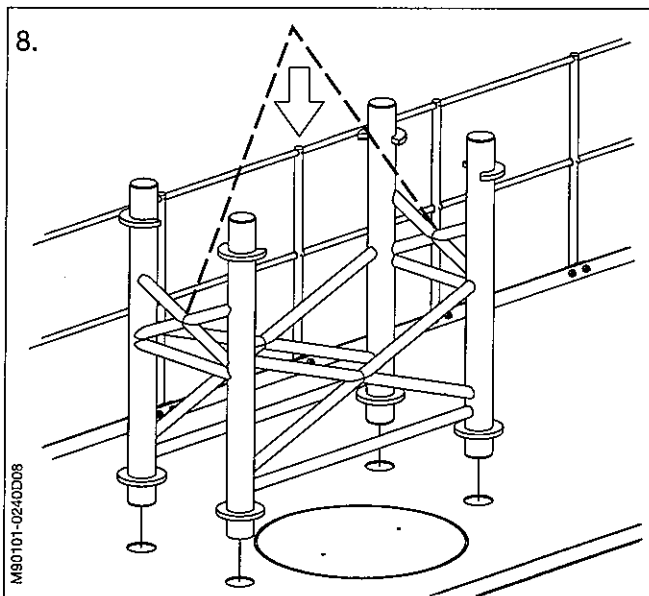
For operation of the hydraulic tools, see Chapter 913.

If the cylinder cover is not to be overhauled, the cylinder cover tightening tool may remain placed on the cylinder cover while the cylinder cover is removed from the engine.

If the cylinder cover is to be overhauled, remove the cylinder cover tightening tool from the cylinder cover.

8. Mount the cylinder cover support tool on the uppermost platform in the purposed holes.
9. Hook the engine room crane on to the lifting attachment on top of the exhaust valve.

Lift away the cylinder cover complete.



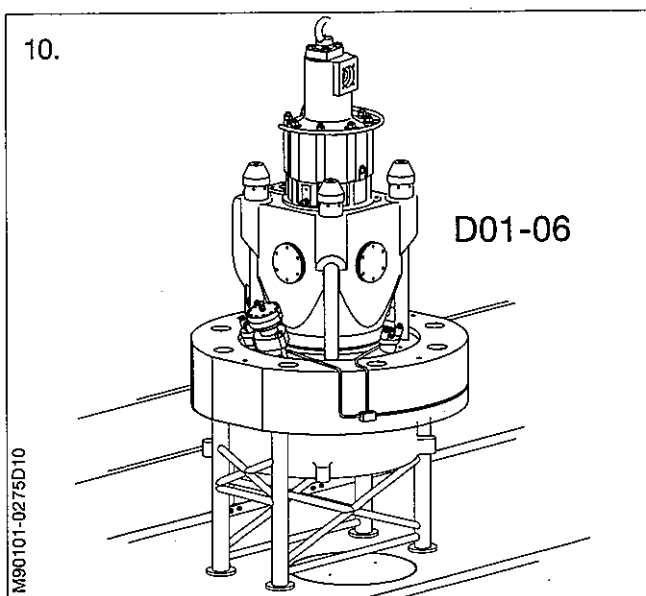
10. Land the cylinder cover on the support tool.

Note!

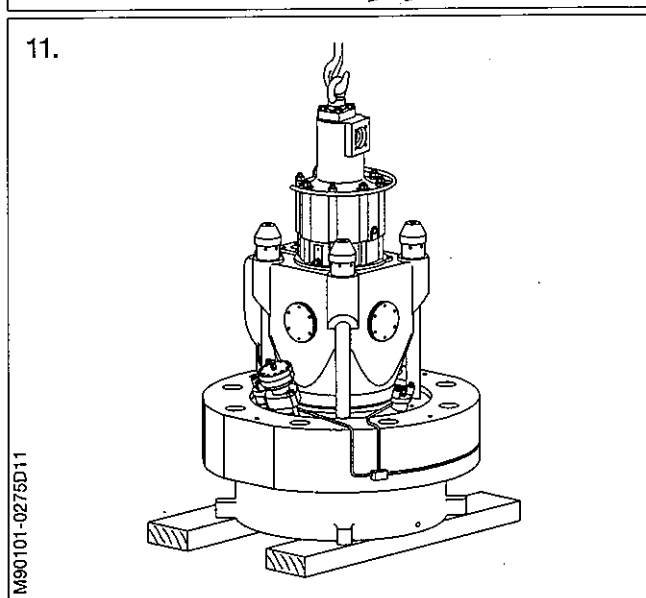
The cylinder cover support tool should only be used when the ship is in port.

11. If the cylinder cover is to be overhauled it is recommended instead to land the cylinder cover on a couple of wooden planks.
12. Remove and discard the sealing ring between cylinder cover and cylinder liner.

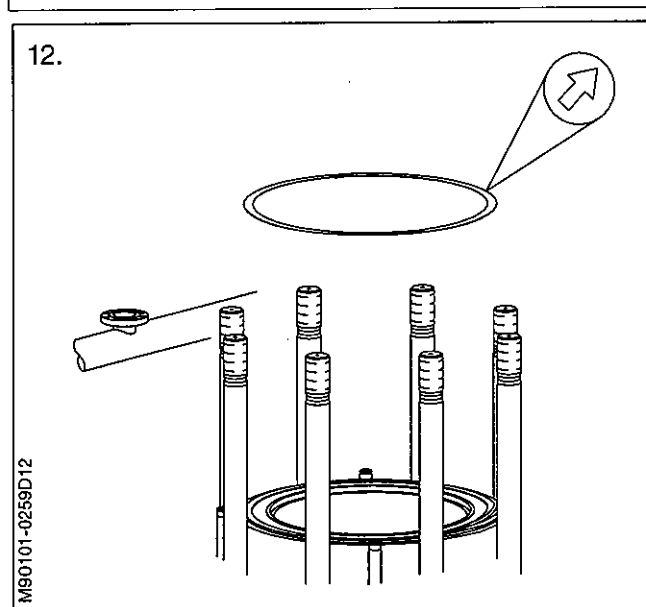
10.

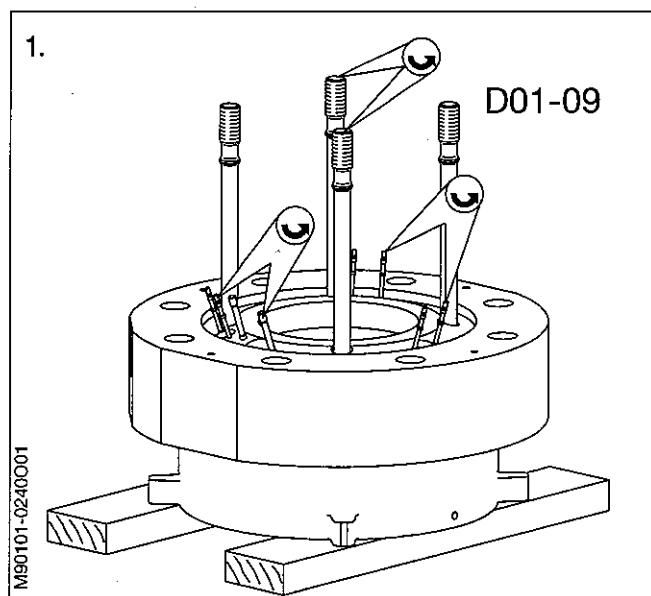


11.



12.





1. Dismount all valves and pipes on the cylinder cover. See Procedure 907-2.2, 908-2.2 and 909-11.2.

Dismount all studs on the top of the cylinder cover.

2. Unscrew the four screws which secure the cooling jacket to the cylinder cover.

Lift the cylinder cover free of the cooling jacket and land it on a couple of planks.

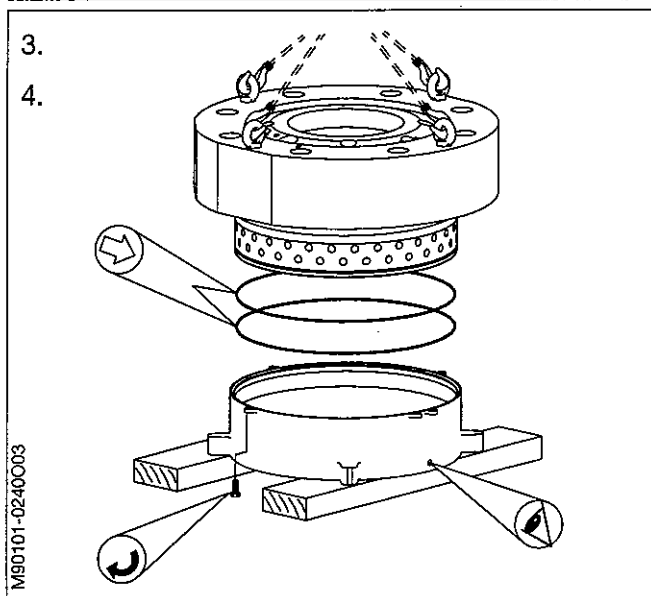
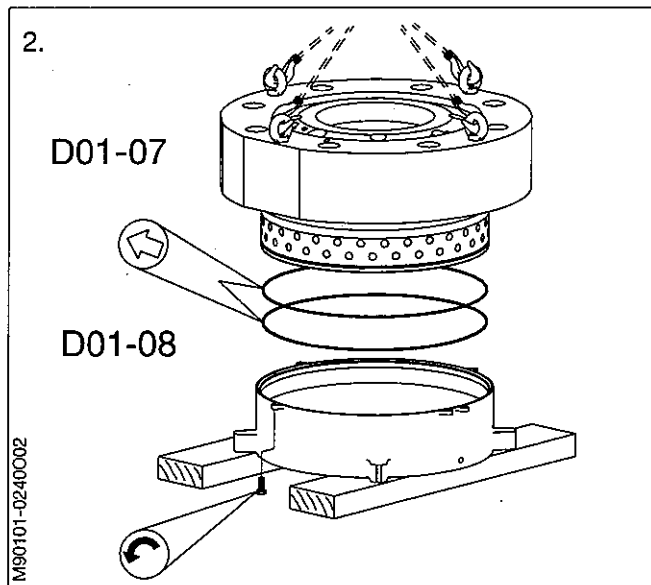
If the cooling jacket sticks, use dismantling screws to force the jacket/cover apart.

3. Remove and discard the O-rings from the cover, and carefully clean the cooling jacket and the cylinder cover.

Provide the cylinder cover with new O-rings, well lubricated with vaseline.

4. Lift the cylinder cover and guide the jacket/cover into position, using the guide pin as reference (manoeuvre side).

Mount and tighten the screws for the cooling jacket.



5. Recondition the valve bores as follows:

Fuel valve bore

6. The tool consists of a common spindle with handle, and of a guide, a carbon cutter, a seating face cutter, and a grinding mandrel.

Clean the fuel valve bores, using the carbon cutter. If required, recondition the fuel valve seating with the appropriate cutter.

Grind the seating with the grinding mandrel and a grinding compound (e.g. Carbo-rundum No. 200).

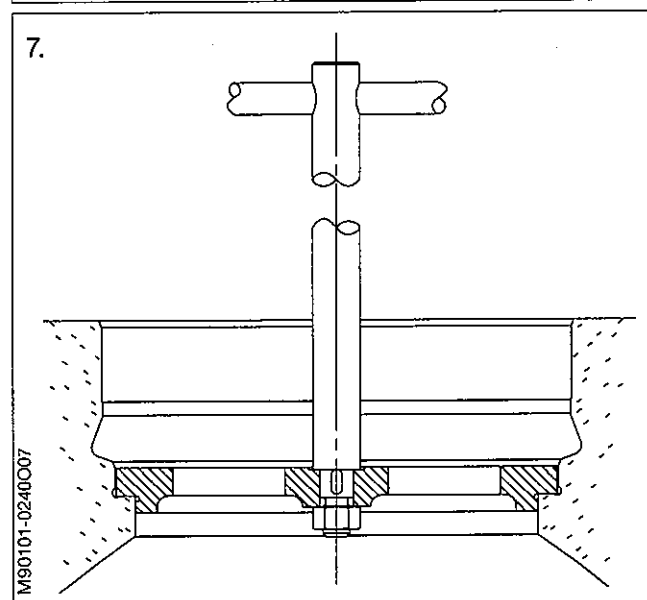
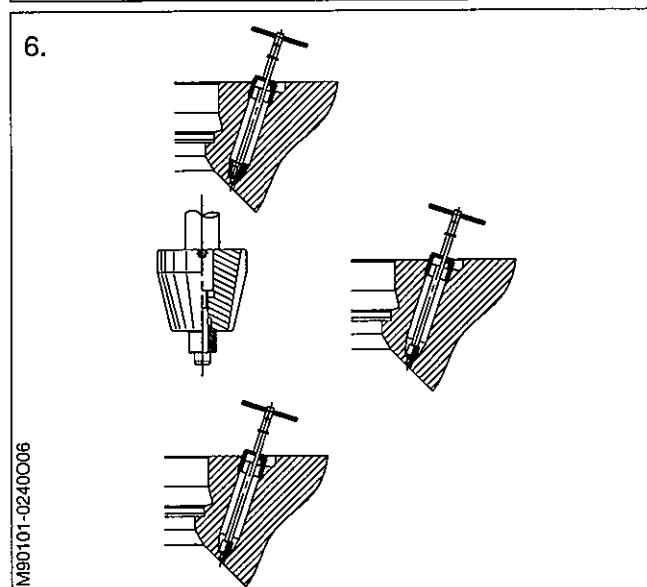
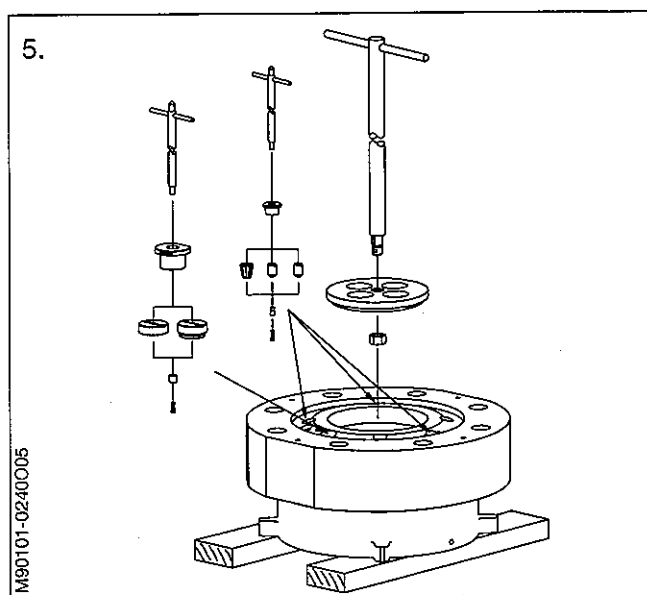
After the milling/grinding, clean the bore and seating carefully, and check that the seating is not damaged.

Exhaust valve bore

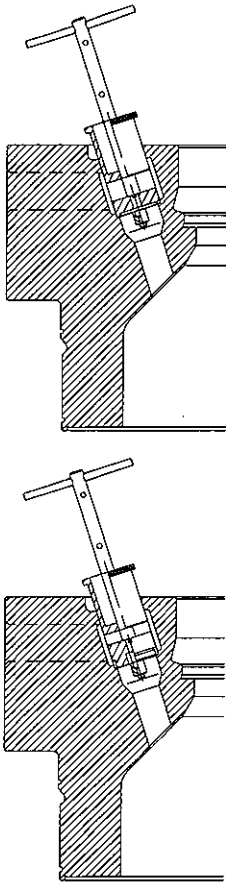
7. The tool consists of a spindle with handle and a grinding disc.

After cleaning the valve bore and seating, grind the seating with the grinding disc and a grinding compound (e.g. Carborundum No. 200).

After the grinding, clean the bore and seating carefully, and check that the seating is not damaged.



8.



M90101-0240008

Starting valve bore

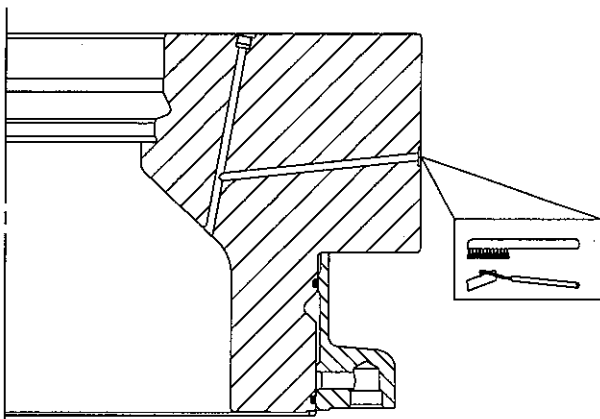
8. The tool consists of a guide, a cutter, and a grinding disc.

Recondition the starting valve bore and seating in the same way as described for the fuel valve bore.

When replacing valves on a cylinder cover that is mounted on the engine, recondition the valve bores/seating in the same way as described here, but without dismounting the studs.

9. Clean the bores for safety valve/indicator cock.

9.



M90101-0240009

10. Lubricate the threads with 'Never Seize' or Molybdenum Disulphide (MoS2) and mount the valve studs.

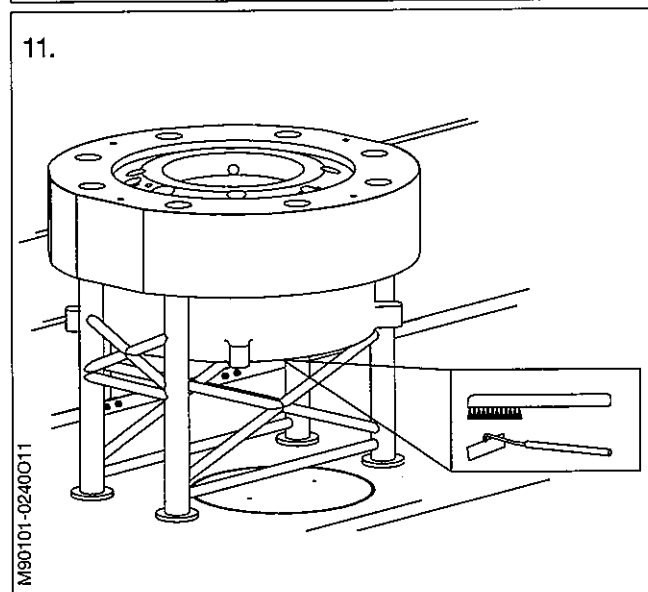
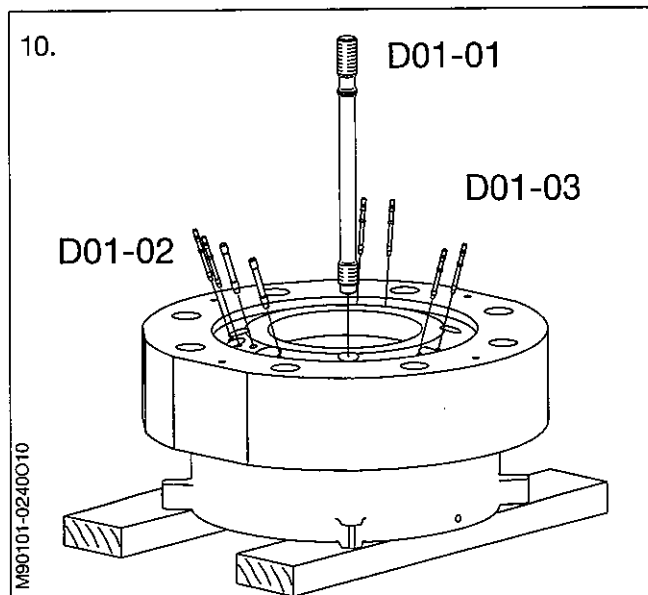
Tighten up the studs in accordance with the screwing-in torque stated on the data sheet.

Fill up the grooves between the valve studs and the bores for the valve studs with permatex to prevent water or oil from entering the bores during operation of the engine.

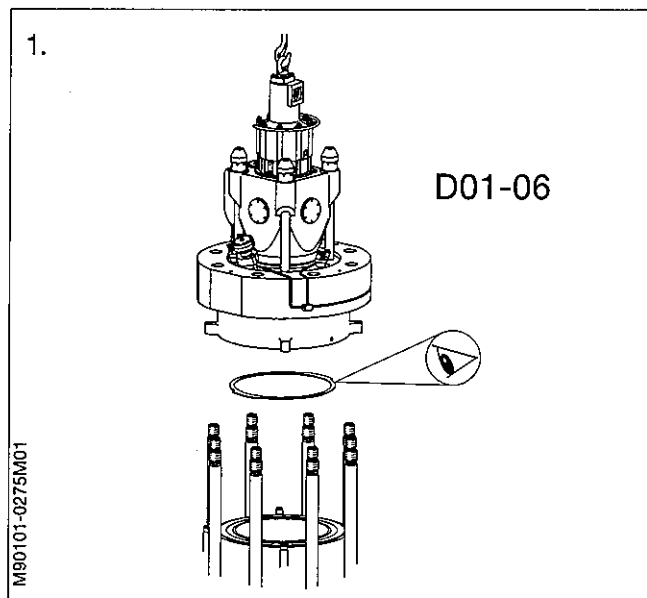
Provide the water connection flange with a new gasket, and keep the cylinder cover ready for replacement.

Always fit new or overhauled valves before a cylinder cover is mounted on the engine.

11. For examination/cleaning of the underside or the inside of the cylinder cover the cylinder cover support tool must be used.



Cylinder Cover Mounting

**HYUNDAI
MAN B&W**


1. Place a new sealing ring on top of the cylinder liner.

Note!

Both cylinder liner, PC-ring, Sealing ring and cylinder cover must be clean during mounting. NO grease or anti-seize compounds may be applied.

2. With the cylinder cover still placed on the cylinder cover support tool, carefully wipe the contact surface which faces the cylinder liner.

3. Provide the cooling water connecting pipes with new O-rings and lubricate them with grease or soft soap.

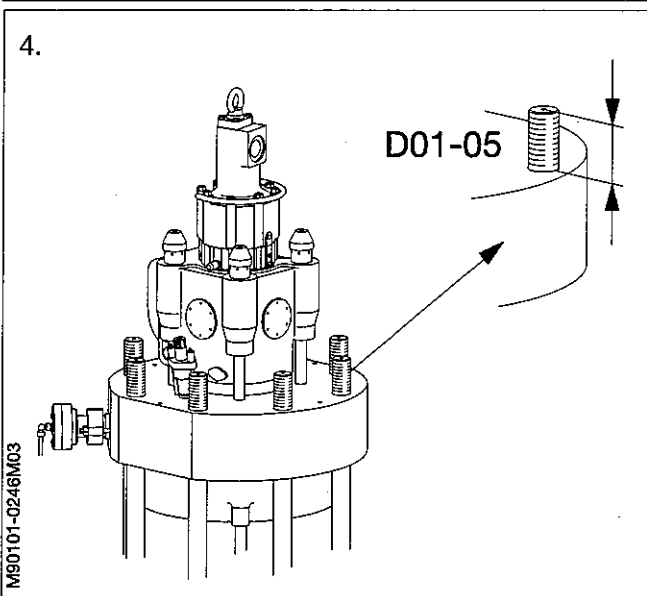
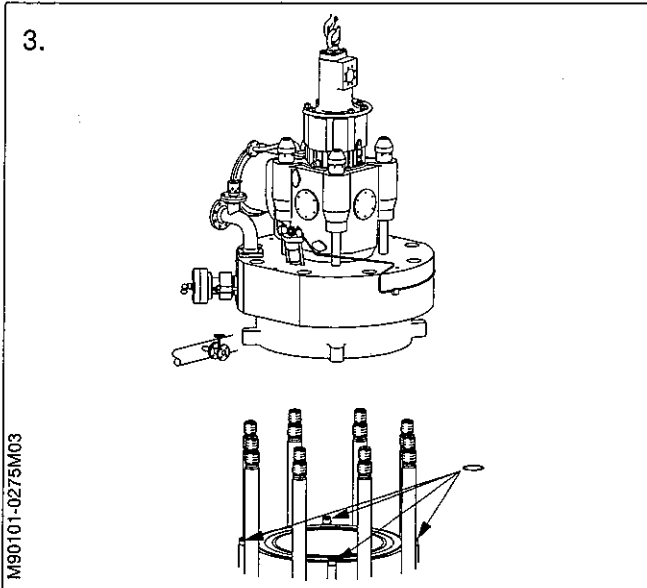
Mount a new sealing ring in the groove of the flange of the intermediate pipe.

Lower the cover **carefully** into position.

During the landing, **carefully** check that the cooling water connecting pipes engage correctly with the holes in the cooling jacket.

4. If cylinder cover studs have been removed and remounted, check the distance the stud is protruding from the cylinder cover.

If necessary, adjust to the distance D01-05 by turning the stud.



5. Mount all eight nuts on the studs and screw them down to the cylinder cover.

Position the cylinder cover tightening tool over the cylinder cover.

Pull down the spacer rings and hydraulic jacks of the tightening tool and screw the jacks on to the studs.

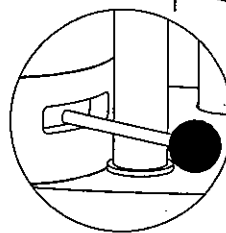
For operation of hydraulic jacks, see Procedure 913-1.

Connect the hydraulic hoses to the jacks and raise the pressure to the level stated in Data. Tighten the nuts with a tommy bar.

Release the pressure. Remove the hydraulic jacks.

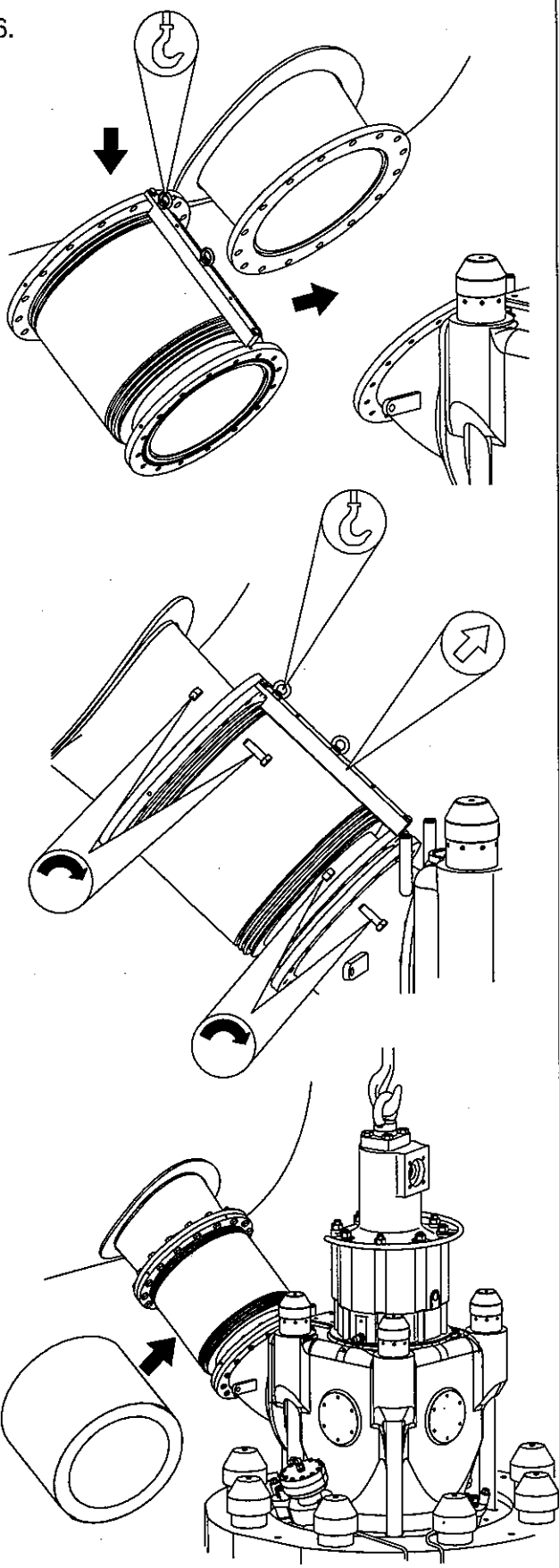
5.

D13-01



M90101-0240M05

6.



6. Mount the exhaust gas compensator.

Lift the compensator in between the flanges, from fore to aft.

Fit the screws in the uppermost flange.

Fit the screws in the lowermost flange.

Remove the lifting tool. Tighten the screws in the flanges.

Note!

Lubricate the screws with 'Never Seize' or molybdenum disulphide (MoS₂) before fitting.

Fit the insulating jacket around the intermediate pipe.

M90101-0256M06

7. Mount the return oil pipe and the air pipe for pneumatic closing of the exhaust valve.

Mount the oil supply pipe for the hydraulic damper in the exhaust valve.

Mount the high-pressure pipe for the hydraulic valve gear. See Procedure 908-1.4.

Mount the plug for the electrical sensor for the exhaust valve.

8. Mount the starting air pipe and control air pipe for the starting valve.

Mount the cooling water outlet pipe on the exhaust valve.

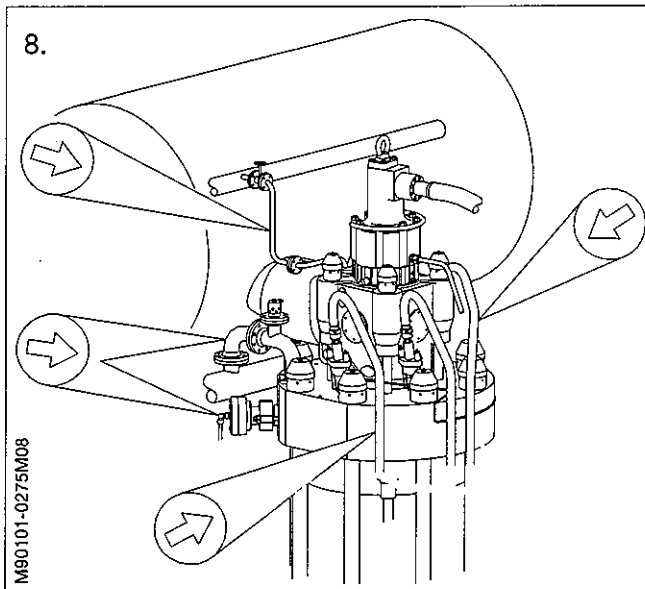
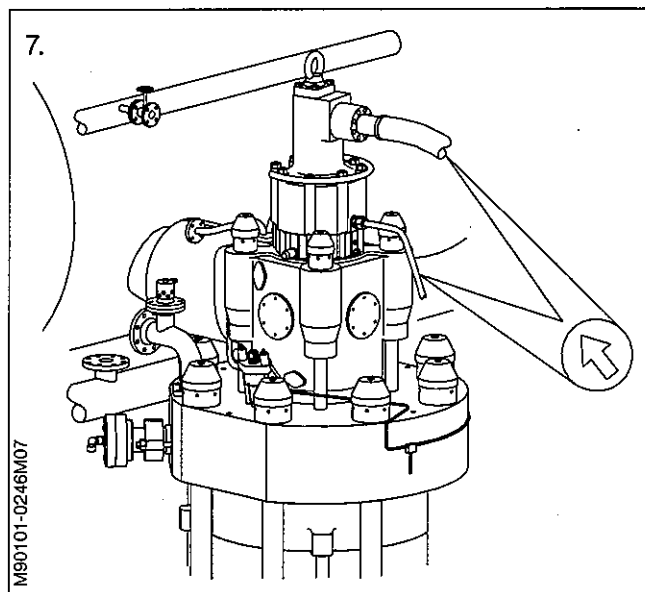
Mount the drain pipe on the intermediate pipe between the exhaust valve and the cylinder cover.

Using a crowfoot wrench and torque spanner, mount the fuel oil high-pressure pipes. See Procedure 909-14.4.

Connect the outlet pipe from the return oil pipe on the fuel valves.

Shut the drain valves and open the cooling water inlet. After venting the cylinder section, shut the vent cocks and open the cooling water outlet valve.

Open the air supply to the exhaust valves, open the fuel oil and start the lubricating oil pump.



Caution !

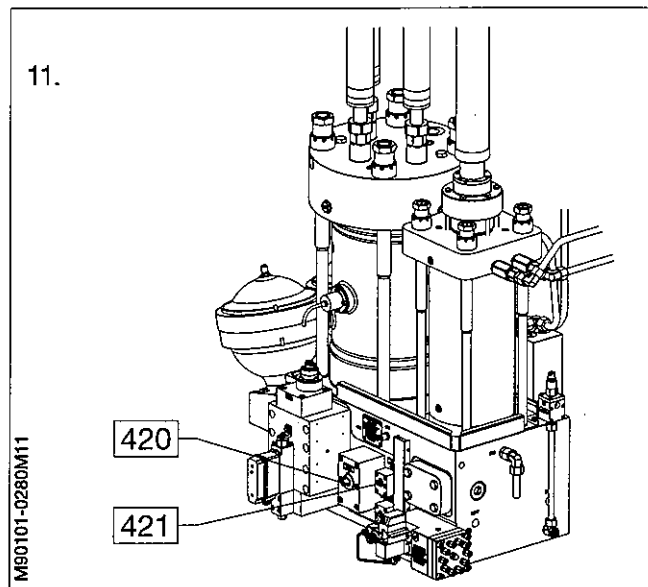
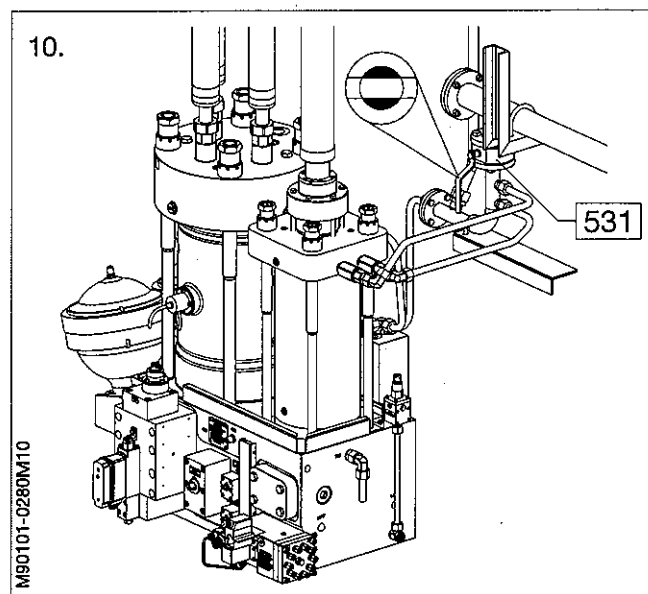
The air supply to the exhaust valve must always be connected and pressurised **before** starting the oil pumps to the exhaust valve actuator.

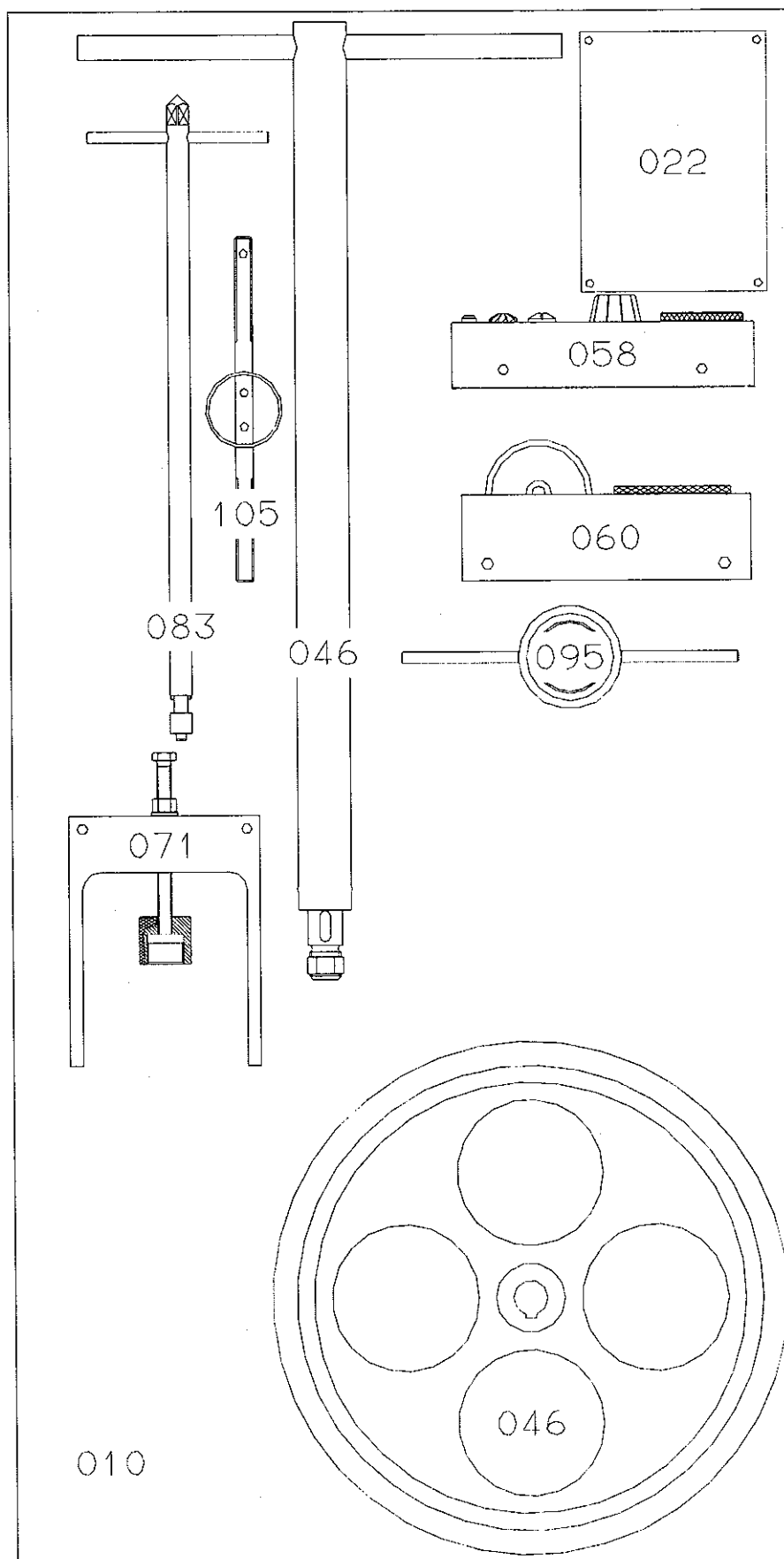
9. If the lubricating oil pumps have been started before the exhaust valve pneumatic springs are pressurised:

- Wait 5-10 minutes and check on the MOP panel that all exhaust valves are closed.
- Closing of the exhaust valves is eased if the lubricating oil pumps are stopped and the actuators drained at the drain screw.

10. Open valve 531 for hydraulic operation of the exhaust valve.

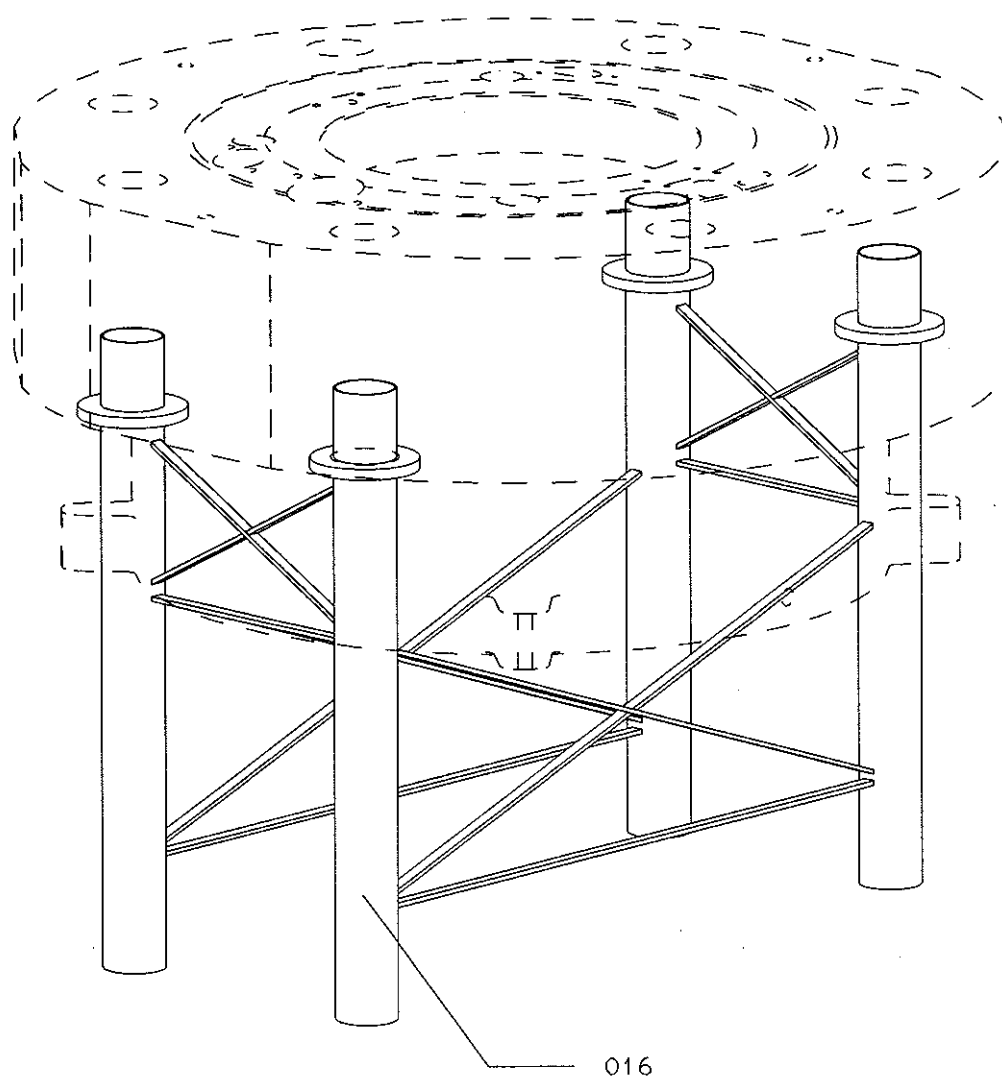
11. Close valve 421 and open valve 420 on the hydraulic block.





Item No.	Item Description
010	Panel for tools
022	Name plate
046	Grinding tool for exhaust valve seat
058	Milling and grinding wheel for fuel valve
060	Milling and grinding wheel for starting valve
071	Dismantling lever for fuel valve
083	Handle - sundry types
095	Grinding ring for starting valve
105	Pin wrench for starting valve

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
016	Cylinder cover rack		

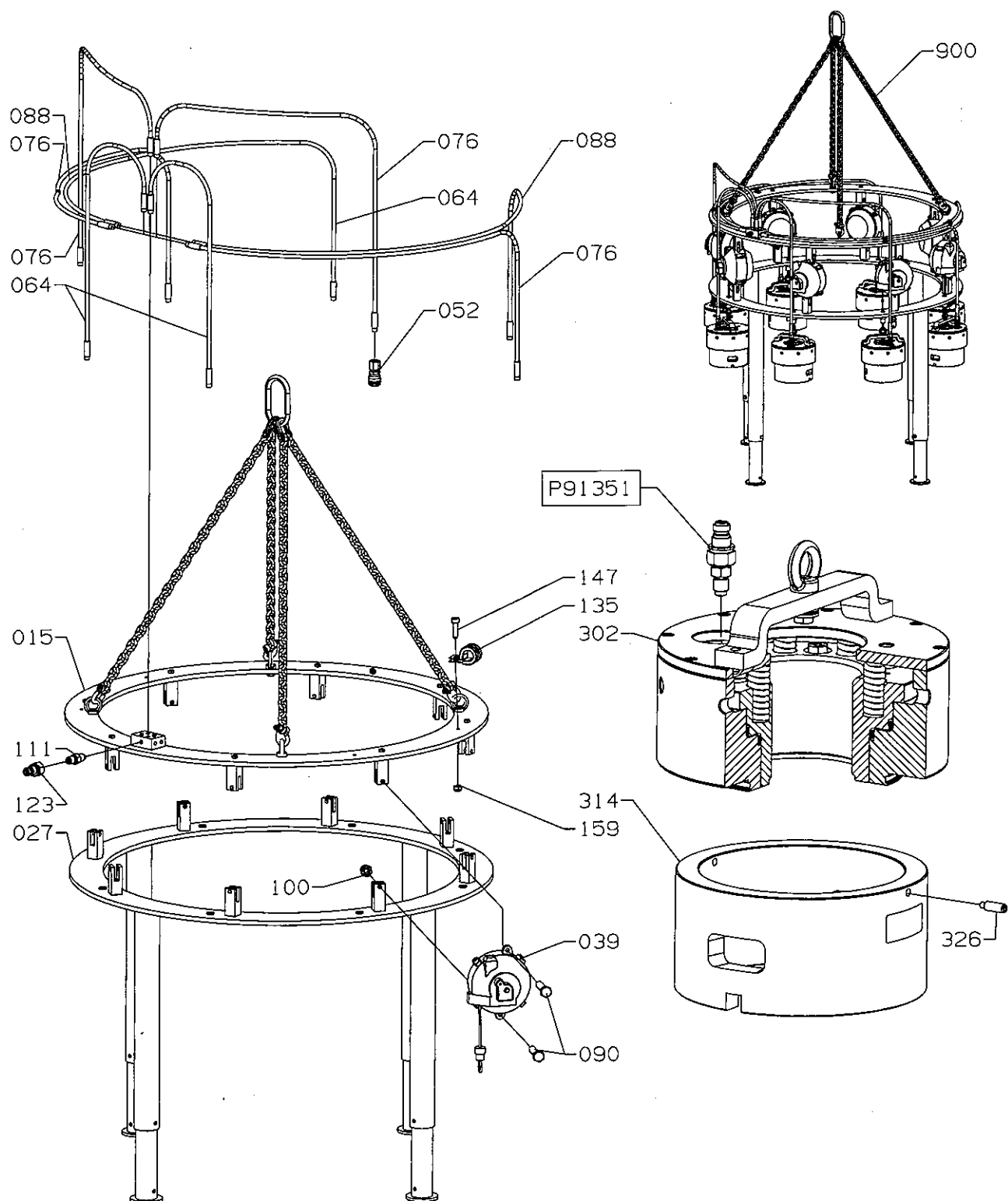
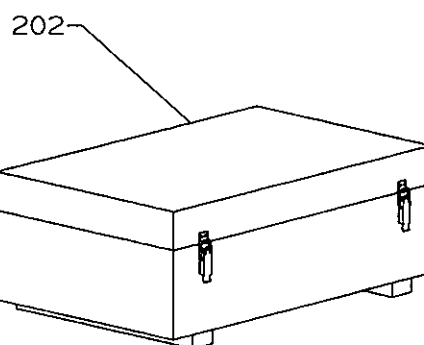
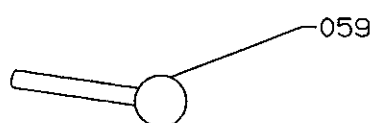
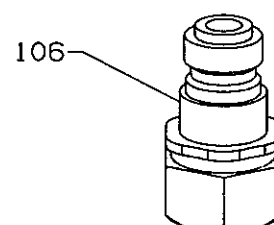
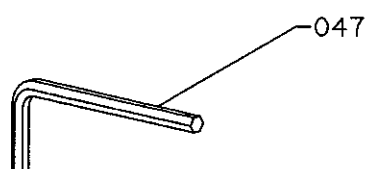
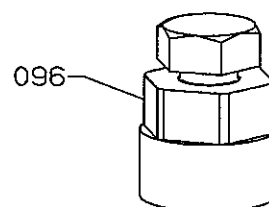
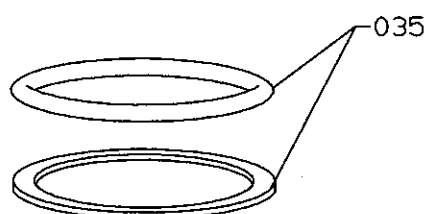
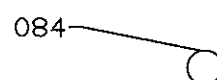
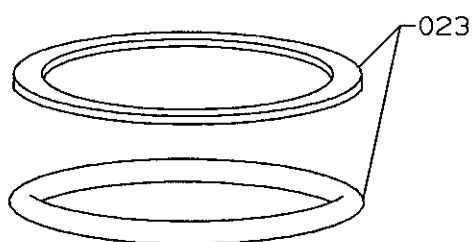


Plate
P90164-0010

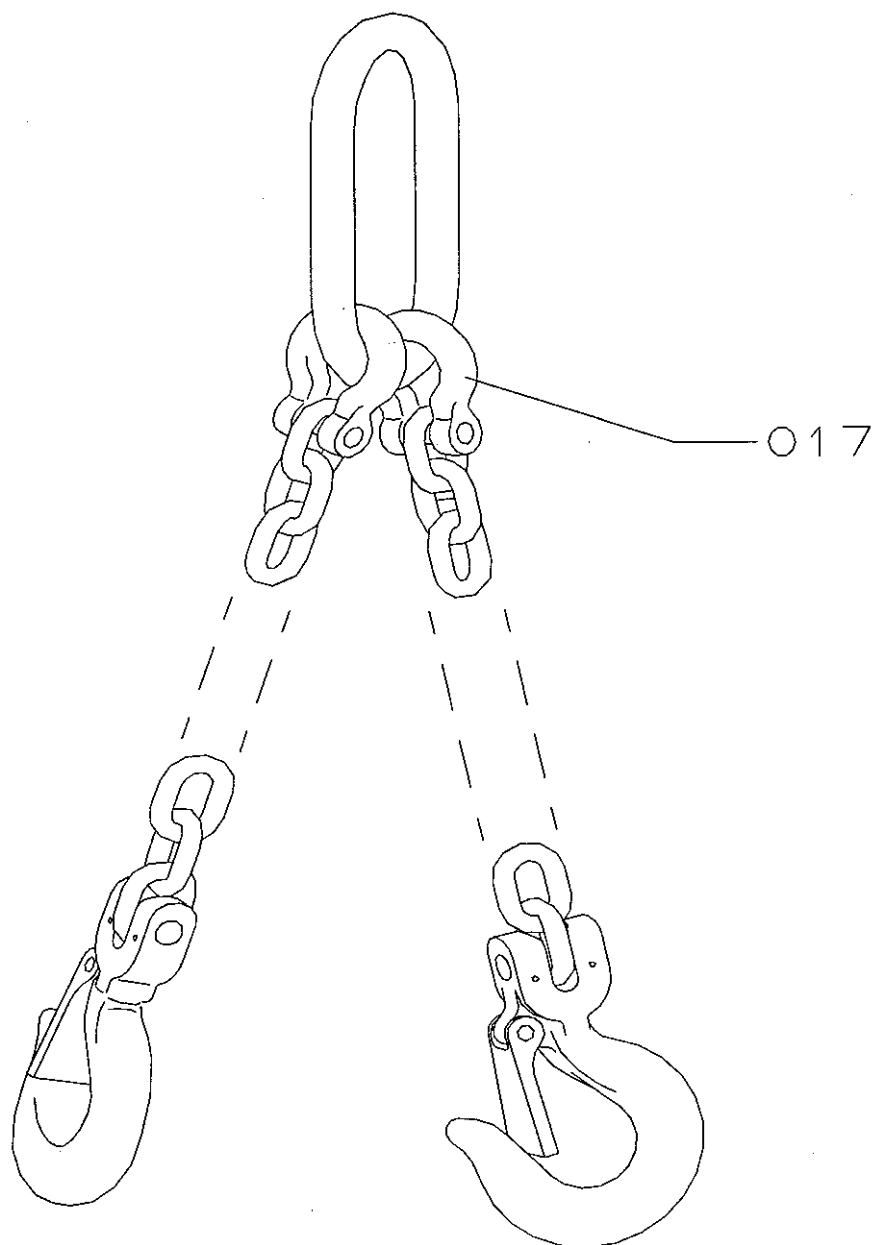
Cylinder Cover - Tools

Item No.	Item Description	Item No.	Item Description
015	Balancing ring assembly, upper		
027	Balancing ring assembly, lower		
039	Spring balance		
052	Coupling		
064	Hose, 1,5 m		
076	Hose, 3,0 m		
088	Hose, 5,0 m		
090	Screw		
100	Nut		
111	Coupling		
123	Nipple		
135	Pipe clamp		
147	Screw		
159	Nut		
302	Jack-hydraulic, complete		
314	Jack-hydraulic, support		
326	Screw		
900	Cylinder cover tightening tool, complete		



Item No.	Item Description
023	O-ring with back-up ring
035	O-ring with back-up ring
047	Key, hexagon socket screw
059	Tommy bar
072	Venting screw
084	Steel ball
096	Stud setter
106	Quick coupling, male
202	Spare part kit, complete

Item No.	Item Description



Item No.	Item Description
017	Lifting chains for cylinder cover

Item No.	Item Description

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

X	Stopped engine
X	Shut off starting air supply – <i>At starting air receiver</i>
X	Block the main starting valve
X	Shut off starting air distributor/distributing system supply
X	Shut off safety air supply – <i>Not ME engines</i>
X	Shut off control air supply
X	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
X	Stop lubricating oil supply
X	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D01-05	Cylinder cover stud, check distance	183 - 184	mm
D02-01	Test pressure	7	bar
D02-04	Piston rod/crown stud, screwing-in torque	300	Nm
D02-05	Piston skirt, tightening torque	380	Nm
D02-06	Cooling oil pipe, tightening torque	190	Nm
D02-08	Piston ring new, radial width	28	mm
D02-09	Piston ring worn, min. radial width	24	mm
D02-10	Groove No.1, max. vertical height	20.3	mm
D02-11	Groove Nos. 2, 3 and 4, max. vertical height	15.8	mm
D02-13	Piston ring new, height of ring No. 1	19.4	mm
D02-14	Piston rings new, height of ring Nos. 2, 3 and 4	14.9	mm
D02-15	Minimum free ring gap (before dismantling)	50	mm
D02-16	Minimum ring gap, ring No. 1 (new ring in new liner)	6.3	mm
D02-17	Minimum ring gap, ring Nos. 2, 3 and 4 (new ring in new liner)	4.5	mm
D02-18	Vertical clearance, new parts	0.48	mm
D02-19	Vertical clearance, worn parts, max.	0.97	mm
D02-20	Piston complete	5000	kg
D02-21	Piston crown	1220	kg
D02-22	Piston rod	3100	kg
D02-23	Piston skirt	280	kg
D02-24	Piston cooling pipe	80	kg
D02-25	Lifting tool, tightening torque	200	Nm
D02-46	CPR ring CL groove, min. depth	2	mm
D02-47	Piston top centre, max. permissible burn-away	12	mm
D02-48	Piston top centre diameter	420	mm
D02-49	Piston top outer ring area, max. permissible burn-away	8	mm
D02-59	Cooling Insert, tightening torque+angle	10/75	Nm/°
D02-60	Cooling Insert	14	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item No.	Description
P90251	040	Lifting tool for piston rod foot
P90251	051	Lifting tool for cylinder liner
P90251	075	Template for piston top
P90251	087	Distance piece for stuffing box
P90251	099	Cover for stuffing box hole
P90251	110	Pressure test tool for piston
P90251	134	Piston ring expander
P90261		Guide ring for piston
P90262		Hydraulic jack for piston rod
P90265		Support for piston
P90266		Piston - Lifting Tools
P90451	118	Rubber cover for crosshead
P91356		Lifting Tools, Etc.
P91351	010	Hydraulic pump, pneumatically operated
P91351	046	Hose with unions (1500 mm), complete
P91351	060	Hose with unions (5000 mm), complete
P91351	117	5-way distributor block, complete

Scavenge Port Inspection

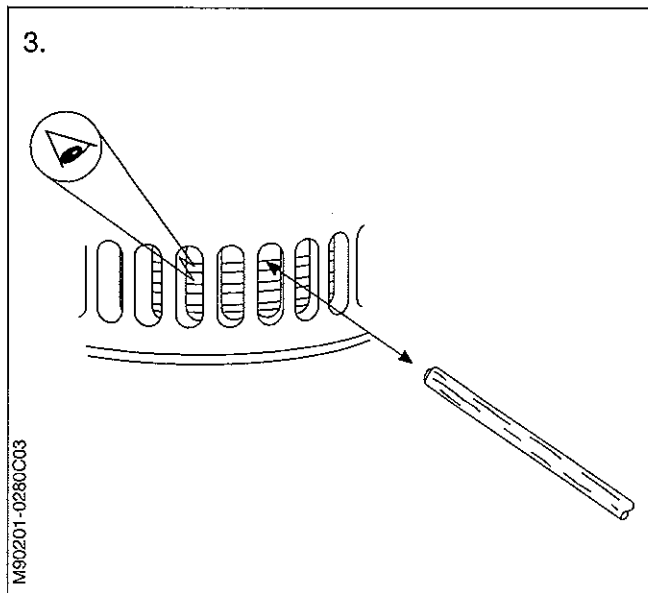
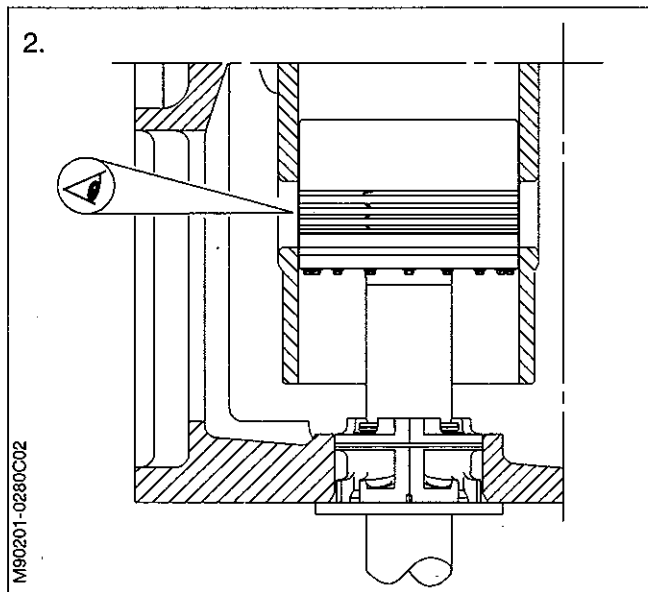
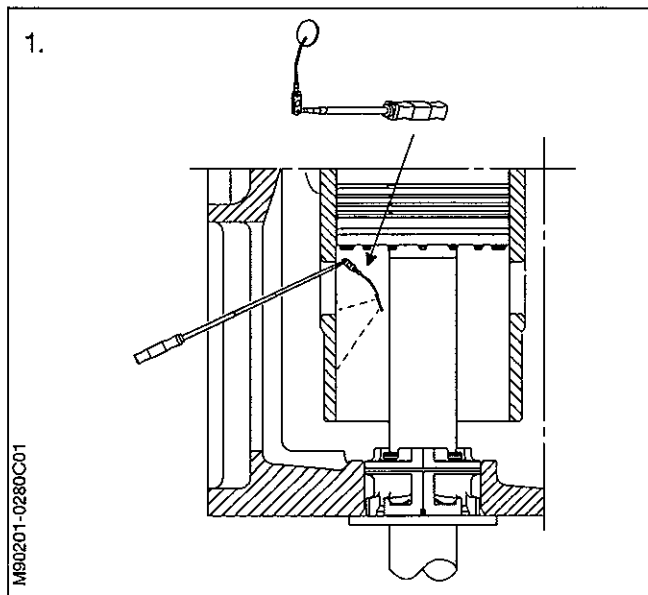
To detect possible leakages from the piston or cylinder cover, keep the cooling water and cooling oil circulating during the scavenge port inspection.

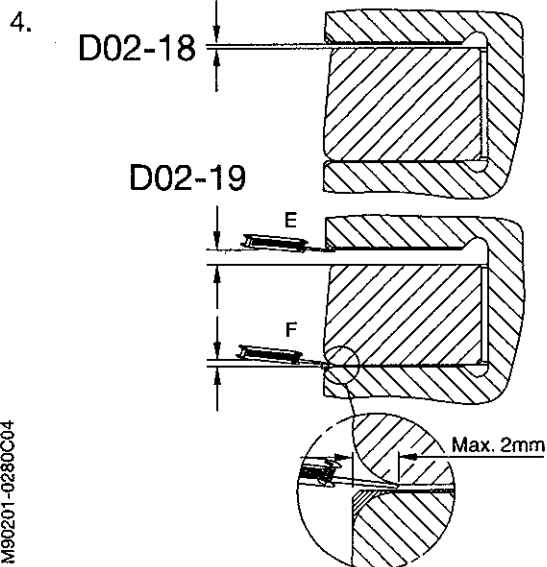
1. The scavenge port inspection is carried out from the scavenge air receiver. An additional view of the rings is possible through the cleaning cover on the manoeuvring side.

Turn the engine at least $\frac{1}{2}$ a revolution, and begin with a unit arriving downwards, just above the scavenge air ports. Inspect the piston rod and the lower part of the cylinder wall.

While the piston is passing downwards, inspect the piston skirt, all the piston rings, the ring lands and the piston top.

2. Ring inspection:
Inspect the rings, one at a time, and note down the results. See *Volume I, Operation, Chapter 707*.
3. Ring tension:
Check the tension of the piston rings, by pressing against them with a wooden stick. It is not possible to move a ring in good condition.





4. Ring grooves:
Measure the total clearance between the piston ring and the ring groove. The total clearance *must not* exceed the value stated in Data.

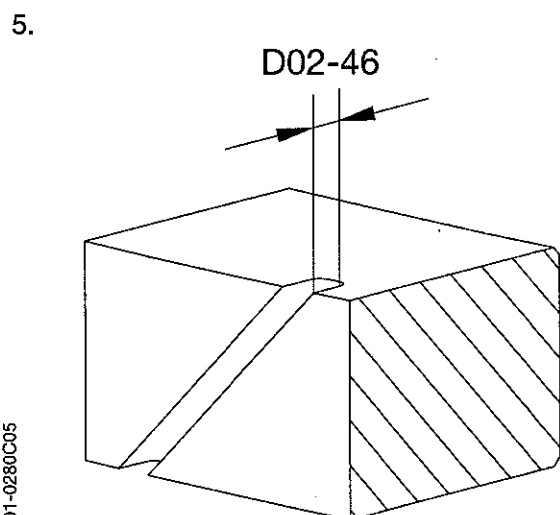
Measure the clearance at the top (E) and bottom (F) of the piston ring groove.
Total clearance = E + F.

5. Uppermost piston ring:
If possible, measure the depth of the pressure relief grooves with a calliper. The piston rings must be replaced if the radial depth of the grooves has worn down to less than stated in Data D02-46.

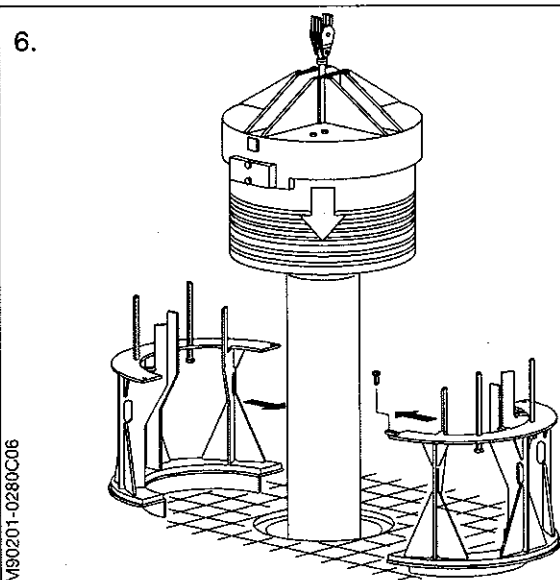
Checking, in connection with piston overhaul

Note!

It is recommended to replace all the piston rings whenever a piston is removed from the engine.



6. Piston support:
Remove the piston from the cylinder and place it on the piston support. See Procedure 902-1.2. For evaluation of the rings, see Volume I, Chapter 707.



7. Free ring gap:
Before dismantling the piston rings, measure the free ring gap of all the piston rings.

For dismantling the piston rings, see Procedure 902-1.3.

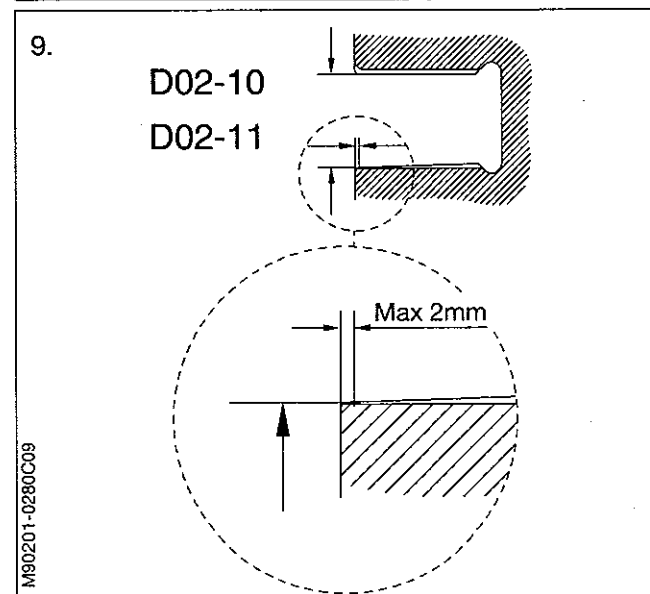
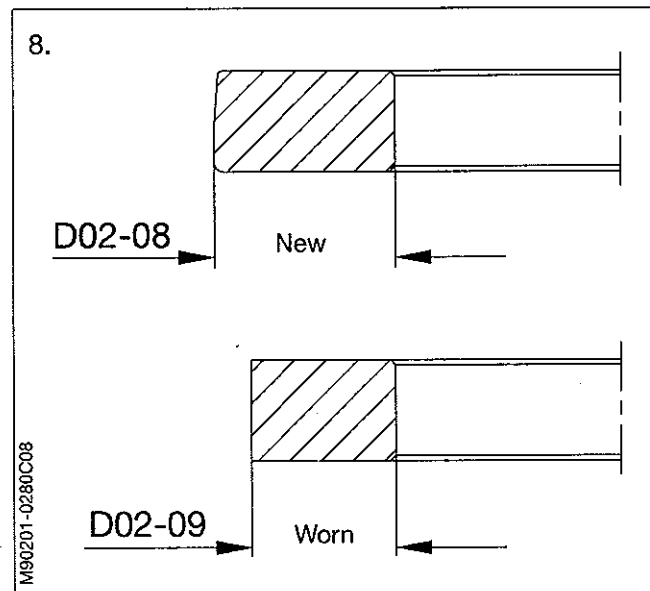
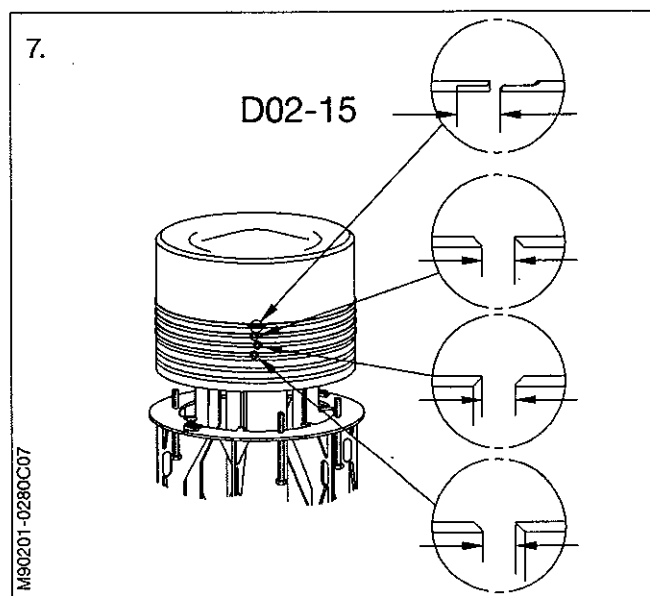
8. Radial ring width:
Measure the radial width of the rings. Note down the results See *Volume I, Operation, Chapter 707*.

9. Ring grooves:
Clean the ring grooves and check them for burn marks or other deformation.

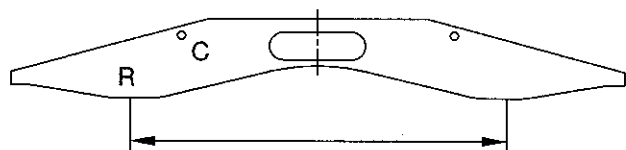
Measure the ring grooves with a calliper gauge, see *Data D02-10 and D02-11*.

Clearance in piston ring grooves:
The maximum vertical height in a worn ring groove **must not** exceed the value stated in Data. The groove is also worn out if there is no chromium layer.

If the ring grooves are worn out, the piston crown must be reconditioned, contact MAN B&W Diesel A/S for advice.



10.



D02-48

M90201-0280C10

10. Piston top template:

Check that the piston top template is permanently marked with the piston top centre diameter D02-48.

Check that the centre area **C** has been marked off, and write the maximum permissible burn-away rate on the template. See data D02-47.

Mark the outer part of the template **R** for ring area, and write the maximum permissible burn-away rate for the ring shaped area. See data D02-49.

11. Piston crown top:

Clean the piston crown and check the burn-away by means of the template.

For maximum permissible burn away on the piston top centre area, see Data D02-47.

For the ring shaped area, see Data D02-49.

Check the burn-away on the whole circumference of the piston crown top.

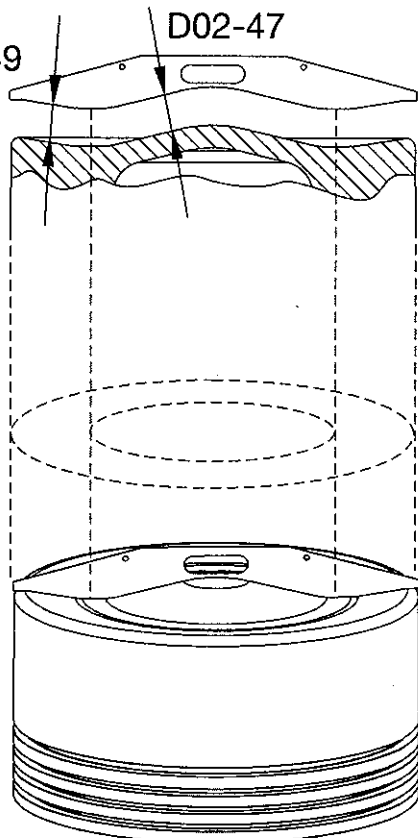
If the burn-away exceeds the values given in Data, contact MAN B&W for advice.

Note down the results for later reference.

11.

D02-49

D02-47



M90201-0280C11

Preparations in the crankcase

1. Access:
Open the crankcase door to the cylinder concerned.

Turn the crosshead down far enough to give access to the piston rod stuffing box and the piston rod/crosshead connection.

2. Stuffing box:
Release the stuffing box by removing the innermost screws from the stuffing box flange.

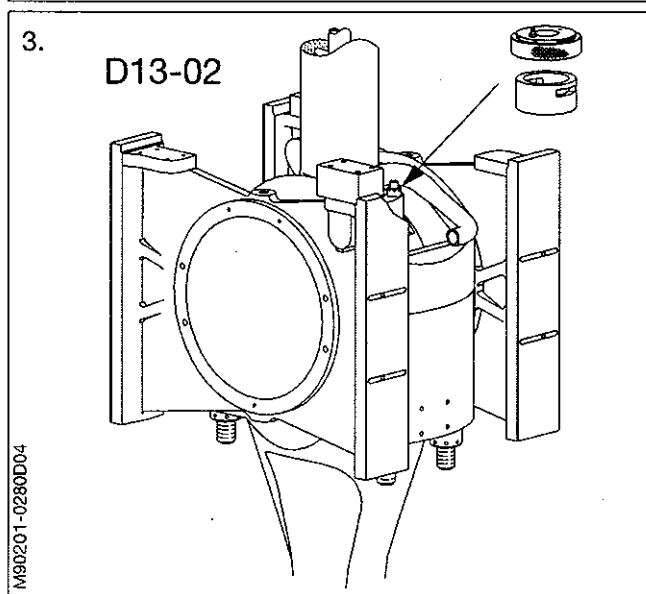
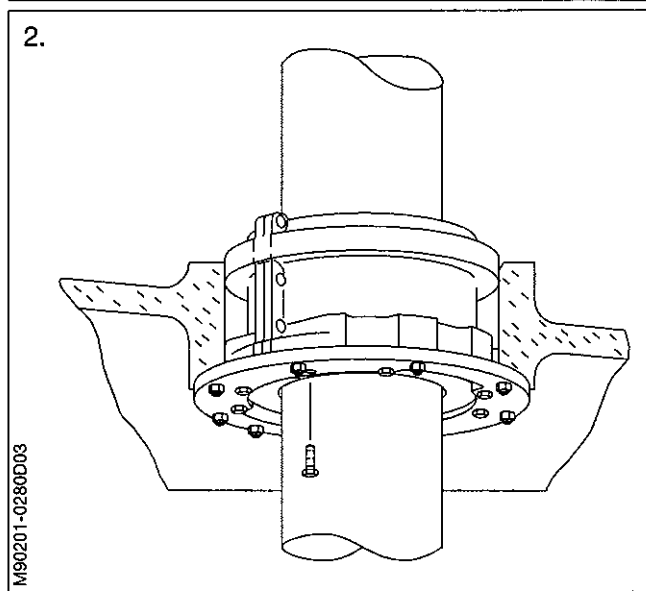
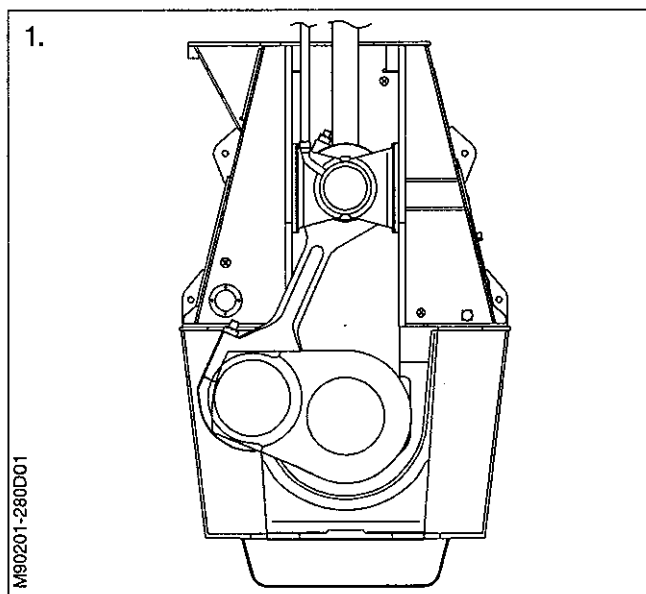
On engine models where the drain pipe is connected directly to the stuffing box:

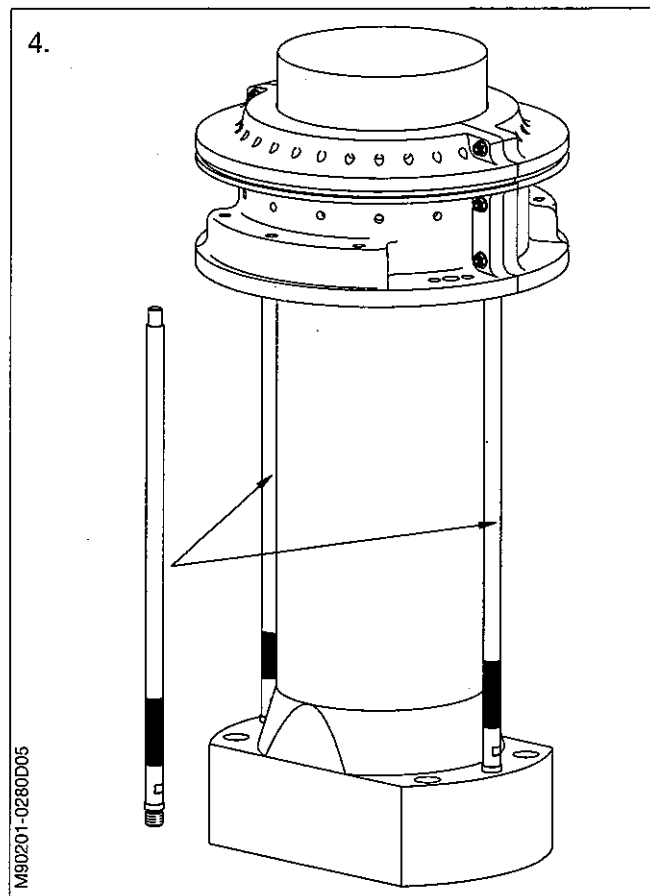
Disconnect the stuffing box drain pipe.

Note!

Do **NOT** remove the outermost screws from the flange.

3. Loosen the piston rod-crosshead connection:
Loosen and remove the hydraulic nuts, see *Data. See Procedure 913-1.*





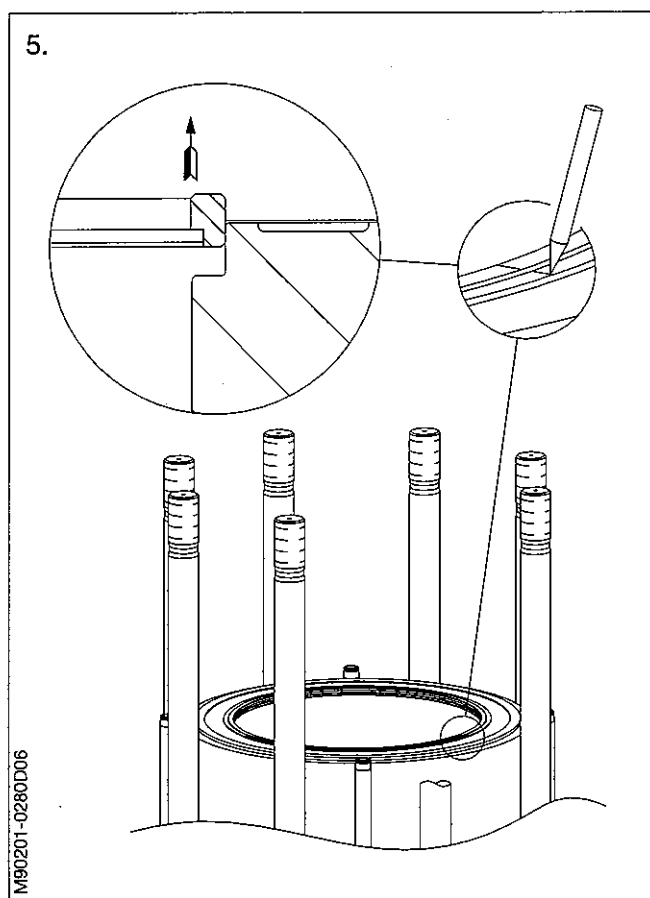
4. Stuffing box distance pieces:
Mount the two distance pieces on the piston rod foot to protect the lower scraper ring and to guide the stuffing box.

Preparations on the cylinder top

5. Cylinder cover:
Remove the cylinder cover. See *Procedure 901-1.2*.

Make a scratch mark in liner and piston cleaning ring to ensure correct re-mounting. Remove the piston cleaning ring.

Carefully remove any wear ridges at the top of the cylinder liner. See *Procedure 903-1.3*.



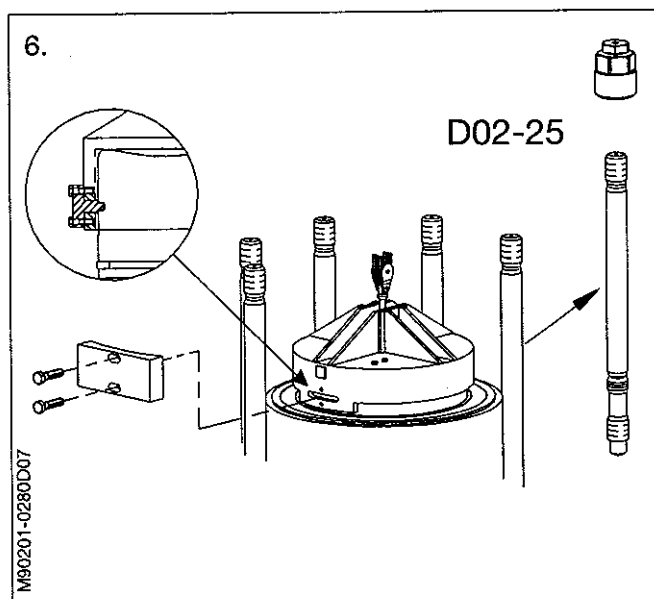
6. Piston lifting tool:
Turn the piston to TDC. The top of the piston is now free of the cylinder liner.

Clean the lifting groove of the piston crown and mount the lifting tool.

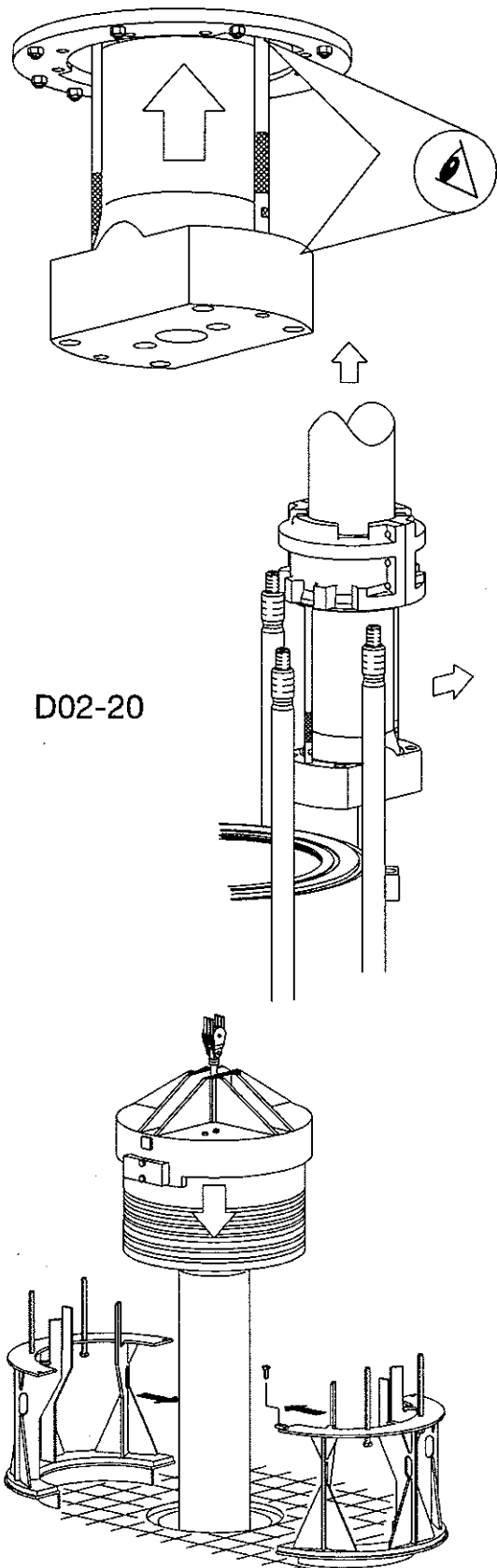
Note!

Make sure to mount the lifting tool correctly, so that the claws of the lifting tool enter the lifting grooves of the piston crown.

If the engine is not equipped with long distance pieces, remove one or two cylinder cover studs, using a stud setter.



7.



Piston lift

7. Lift the piston out of the cylinder liner and guide the piston rod foot through the stuffing box flange.

If the engine is equipped with long distance pieces for the stuffing box, the piston rod foot can pass between two cylinder cover studs.

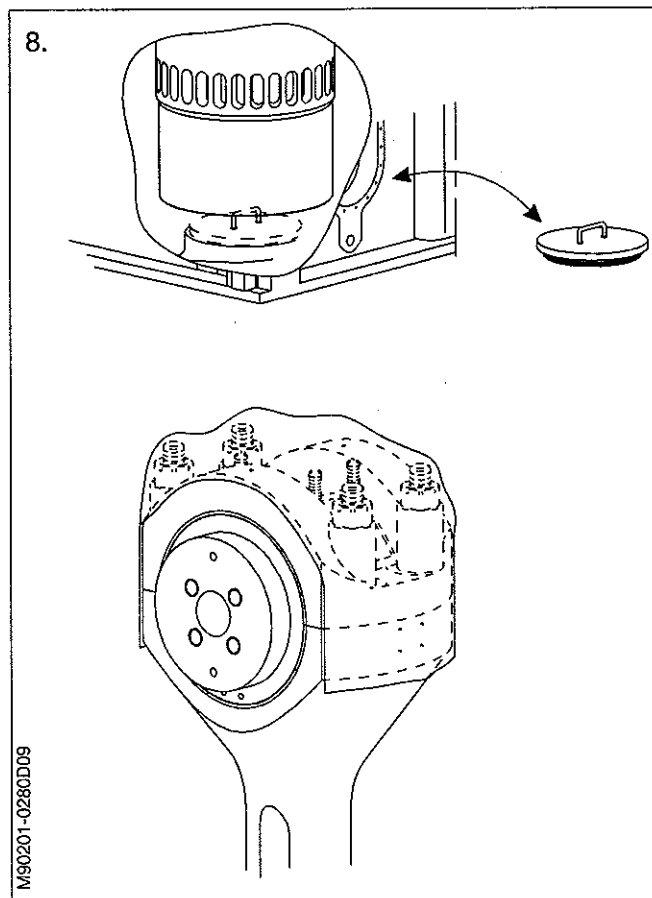
Place the two halves of the support around one of the openings in the platform. Lower the piston rod foot and stuffing box through the opening in the platform. Secure the two support halves with screws and lower the piston on the support. Check the piston is resting on the piston rod flange.

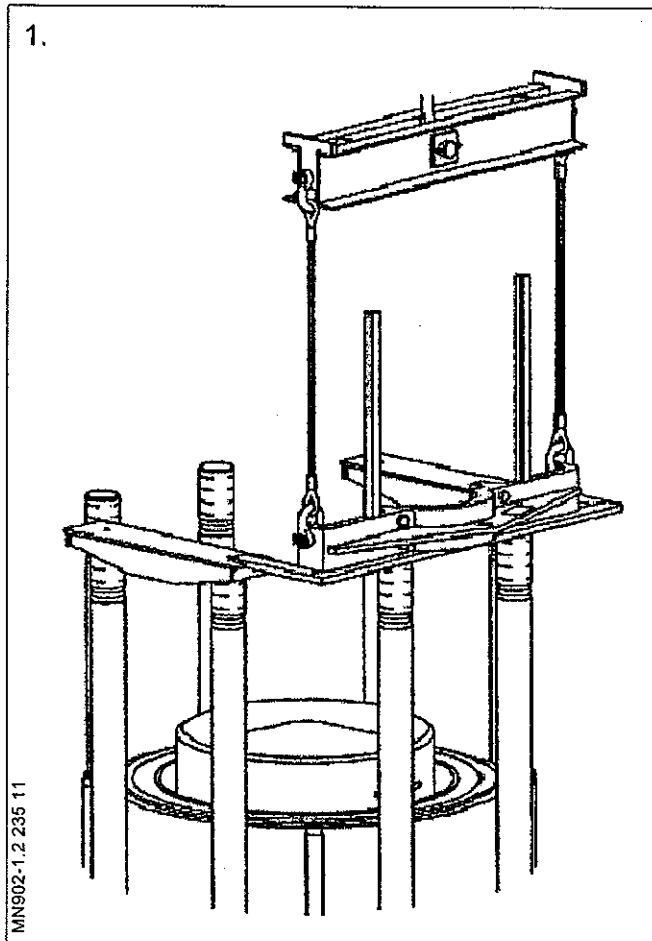
8. Protect the crosshead bearing:
Place a cover over the opening for the piston rod stuffing box at the bottom of the cylinder unit.

Turn the crosshead down far enough to permit mounting of the protective rubber cover on the crosshead bearing cap. The protective rubber cover is found on tool panel 904.

The covers must remain in place to protect the crosshead bearing journal from impurities until the piston is remounted.

Clean, measure and recondition the cylinder liner. See *Procedure 903-1*.



**Low lifting height**

1. Turn the piston to TDC.

Remove the clamp from tilting tool and place it on the supporting tools by means of the engine room crane and crossbar.

Remove the crossbar.

2. Mount the lifting tool for piston.

Lift the piston high enough to give ample space above the tilting tool.

Mount the tilting tool around the piston rod and lower the piston so that the distance pieces of the tilting tool are in contact with the piston.

Fasten the clamp to the tilting tool.

3. Lift the piston to the maximum crane height. Run the crane athwartship and, at the same time, tilt the piston.

Keep the piston rod clear of the cylinder liner and studs while carrying out the tilting.

When space conditions permit, straighten up the piston and lead it over to the cut-out in the platform for overhauling the piston.

When the piston is at a suitable height above the platform cut-out, position the piston support around the piston rod and clamp.

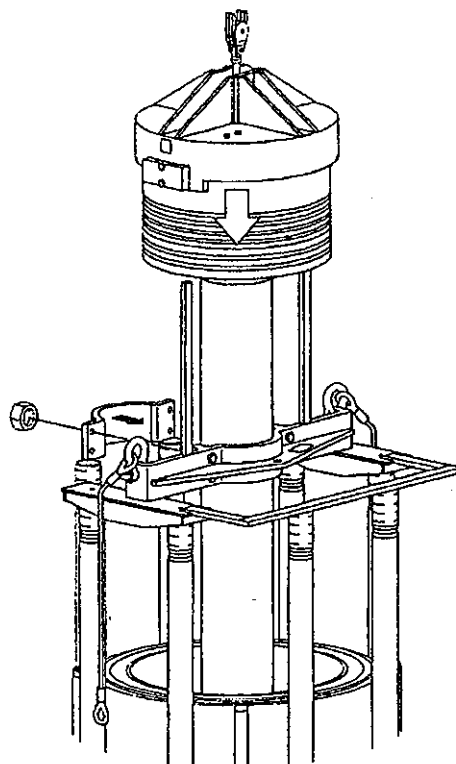
Now lower the piston while guiding the support to the platform cut-out.

After landing the piston and ensuring that it rests correctly on the support, remove the tilting tool.

Note!

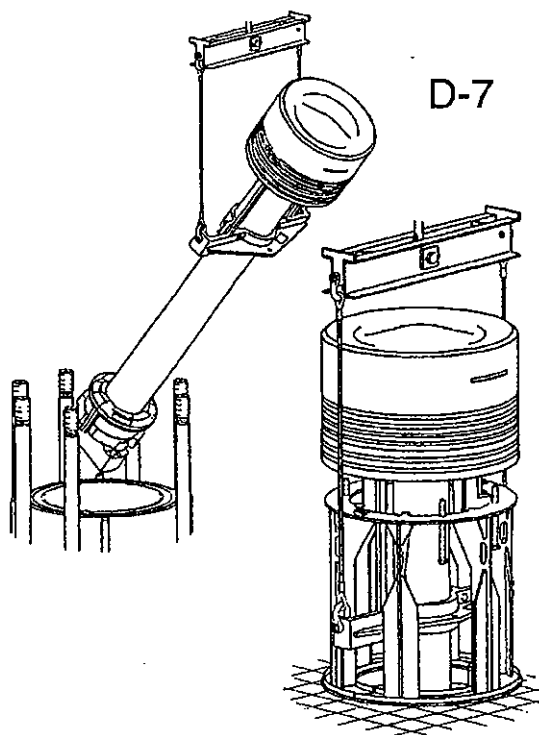
On engines with extremely low lifting height, use the engine room double-jib crane instead of the transverse piece.

2.

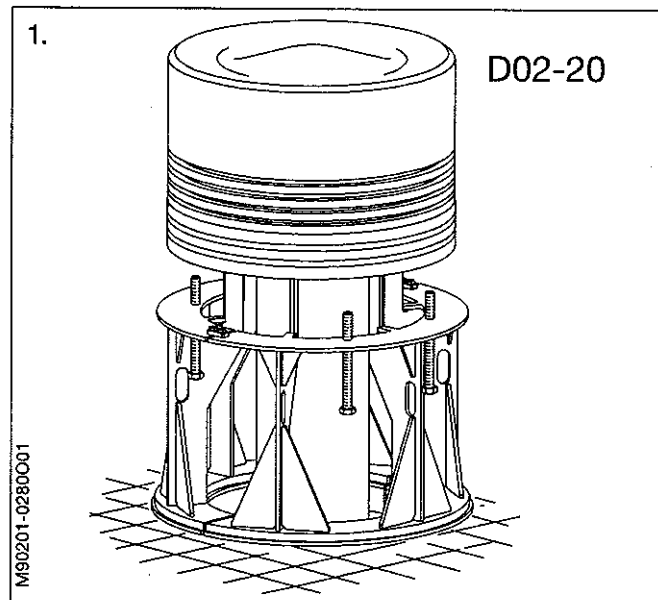


HN902-1.2 242 12

3.



MN902-1.2 235 13

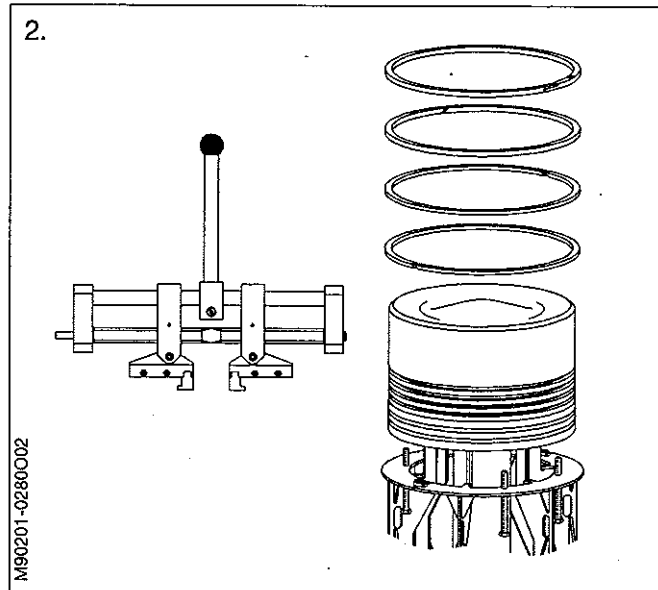


1. Piston support:
Place the piston in the support and remove the piston lifting tool.
See Procedure 902-1.2.

Clean the piston top and the piston rings.

Check the free ring gap and the burn-off on the piston top. *See Procedure 902-1.1.*

Remove the stuffing box. *See Procedure 902-2.3.*



2. Piston ring dismantling:
Take off the piston rings by means of the ring expanders. If the engine is equipped with two ring expanders, the short ring expander is for the uppermost ring.

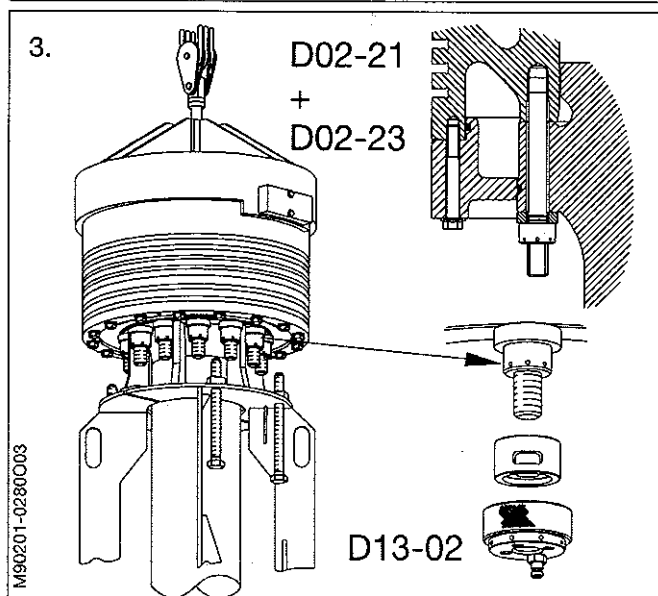
First remove the uppermost ring, then ring No. two, three and four.

Clean and inspect the rings and the ring grooves. *See Procedure 902-1.1.*

3. Piston crown dismantling:
Loosen and remove the hydraulic nuts between the rod and the piston crown. *See Data.*

For operation of hydraulic tools, see Procedure 913-1.

Lift the piston crown and skirt clear of the piston rod.

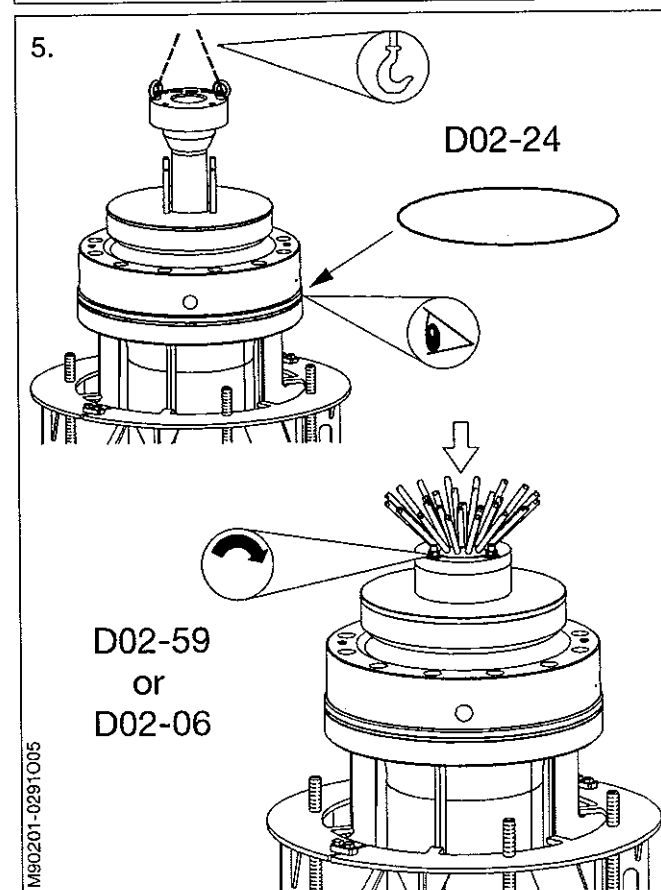
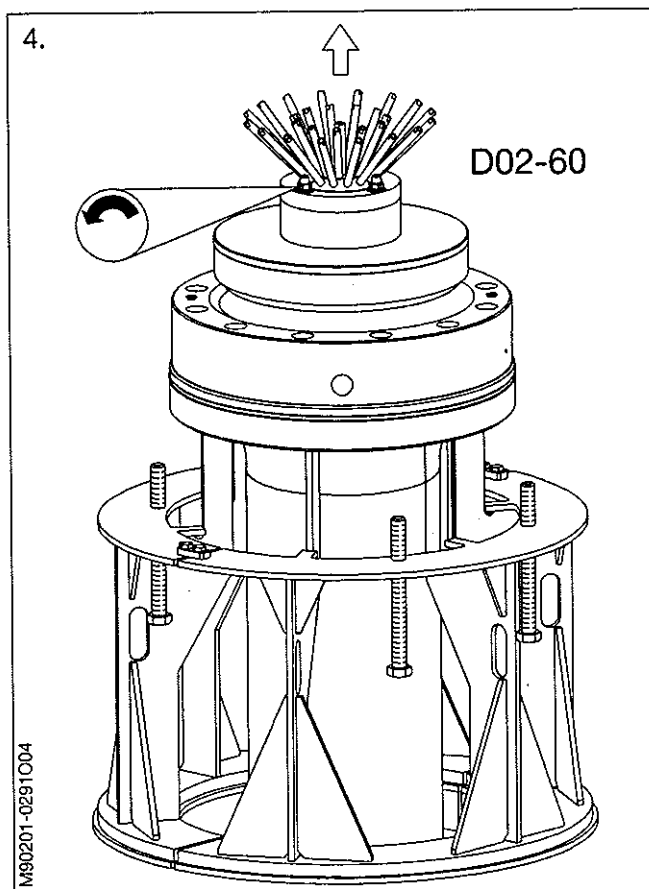


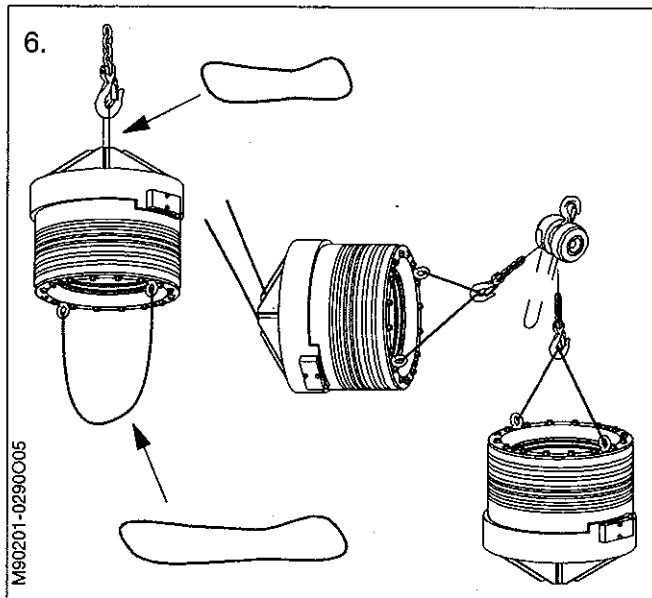
4. Cooling insert:
Unscrew and remove the nuts for the cooling insert. Remove the cooling insert. Clean and inspect the cooling insert.
5. Piston rod and cooling pipe:
Screw on the eye bolts and lift out the cooling oil pipe.

Clean and inspect the cooling oil pipe and the piston rod, then reinsert the cooling oil pipe. Refit the cooling insert and tighten the nuts as specified *in Data*.

Check that the surfaces of the O-ring groove are clean and smooth.

Fit a new O-ring on the piston rod flange.





6. Piston crown turning:
Unhook the crane from the piston lifting tool, and connect the lifting tool and the crane hook by means of a wire rope. Lift up the piston crown.

Fit two eyebolts in the piston skirt and a wire rope between the bolts as shown in the sketch.

Install a tackle in a suitable place with sufficient space below for the piston crown. Attach the tackle to the wire rope on the piston skirt and carefully turn the piston crown upside down.

Use both cranes if the engine room is equipped with two cranes.

Land the piston lifting tool and the piston crown on a sufficient support of wood pieces. Loosen the piston lifting tool and lift the piston crown clear of the tool.

7. Piston crown dismantling and cleaning:
Place the piston crown with skirt on a wooden support as shown.

Remove the locking wire and the screws in the skirt. If necessary, use two dismantling screws to pull the skirt off the piston crown. Mount two eye bolts in the skirt. Lift the skirt and land it on a couple of planks.

Discard the sealing ring on the piston skirt.

Thoroughly clean and inspect all parts of the crown and skirt. If coke deposits are found in the cooling spaces of the piston crown, the coke deposits should be washed out with Carbon Remover or a similar cleaning fluid. When all coke deposits have been dissolved, clean and inspect the piston crown again.

Note!

Coke deposits reduce the heat transfer from the piston crown to the cooling oil. The deposits must be removed as a routine procedure when a piston is overhauled.

If the piston crown is renewed, remove the piston crown studs using a stud setter.

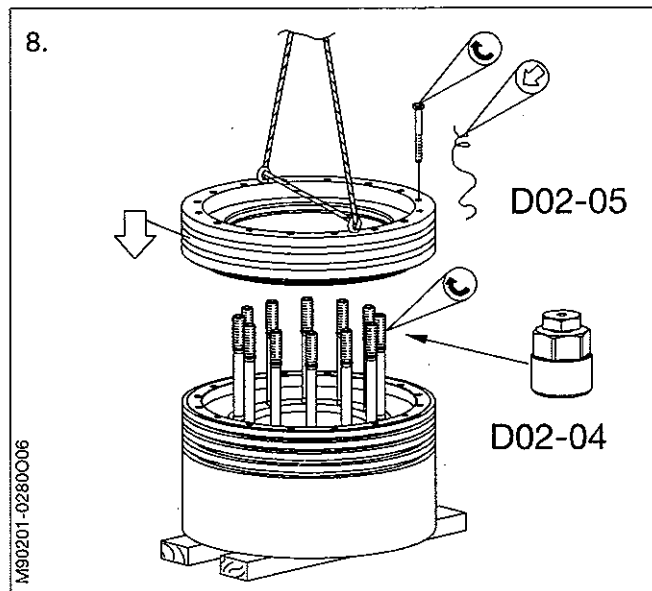
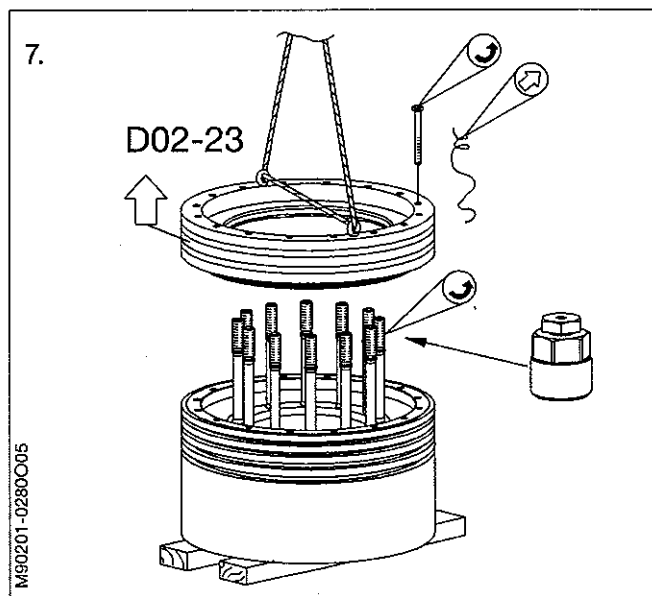
8. Piston crown assembly:
Mount the piston crown studs in a new or overhauled piston crown, lubricate the threads on the studs with molybdenum disulphide (MoS_2).

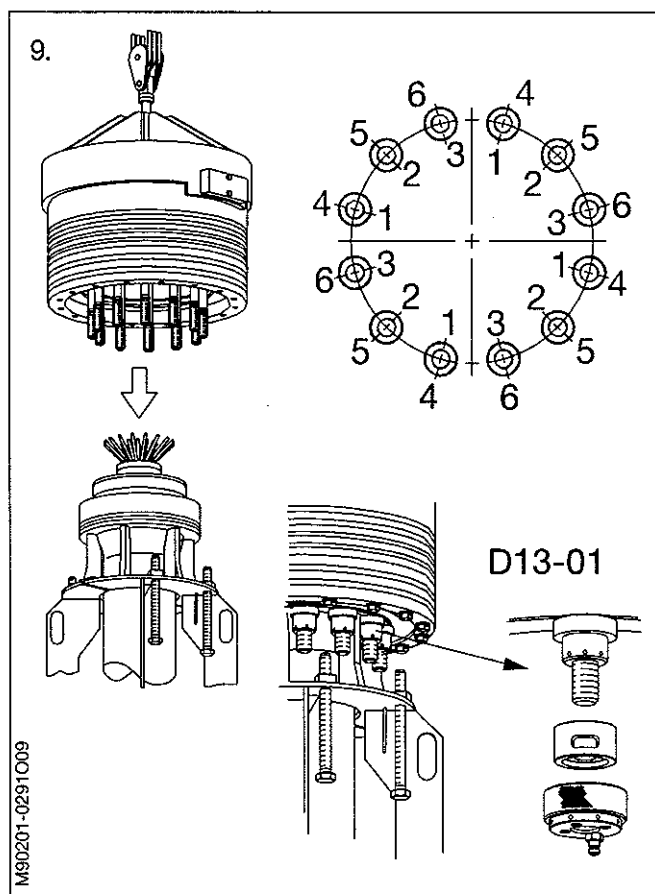
Tighten the studs to the specified torque using a stud setter, see *Data D02-04*.

Mount a new O-ring on the piston skirt, check that the surfaces of the O-ring groove is clean and smooth, coat the ring with lubricating oil before mounting.

Mount the piston skirt on the piston crown.

Tighten the screws to the specified torque, see *Data D02-05*. Lock the screws with locking wire. See *Procedure 913-7*.





9. Piston crown and skirt mounting:
Lubricate the O-ring on the piston rod flange with lubricating oil.

Land the overhauled piston crown and skirt on the piston rod.

Mount and tighten the hydraulic nuts on the piston crown studs.

When tightening the hydraulic nuts follow the tightening sequence. All the nuts must be tightened twice to full tightening pressure, see *Data*.

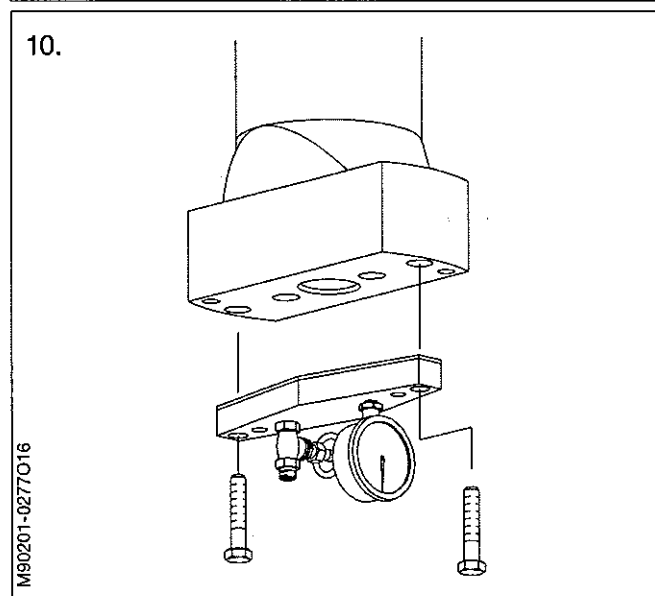
Sealing ring and pressure test

According to current class rules, the piston must be pressure tested hydraulically. It is possible to carry out a test of the sealing rings with compressed air before filling the piston with oil. The sealing ring test can also be carried out when the piston is resting in the support tool.

10. Sealing ring test:
Mount the pressure-testing tool on the piston rod foot. Connect compressed air to the testing tool and fill the piston to 4-5 bar. Close the valve on the testing tool and remove the air connection. The piston must now hold the pressure for minimum 30 minutes.

Spray a little soap water on to the surface joints between piston rod/crown/skirt and around the hydraulic nuts to detect leaks.

Dry off all soap water.

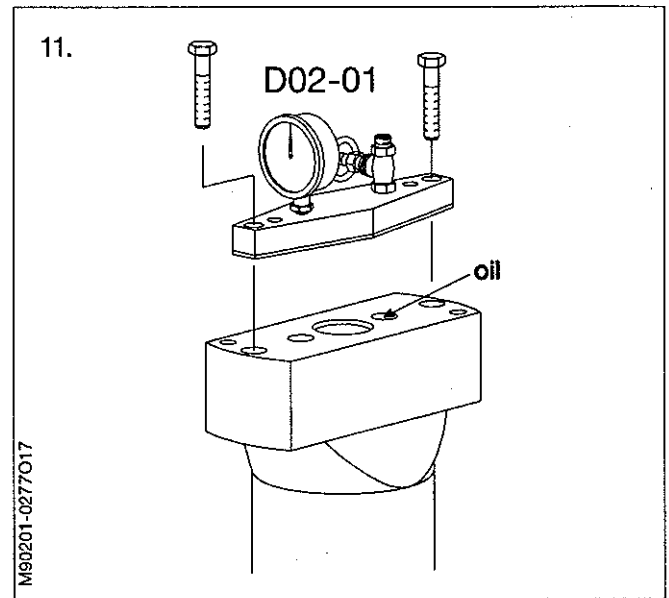


11. Pressure test:

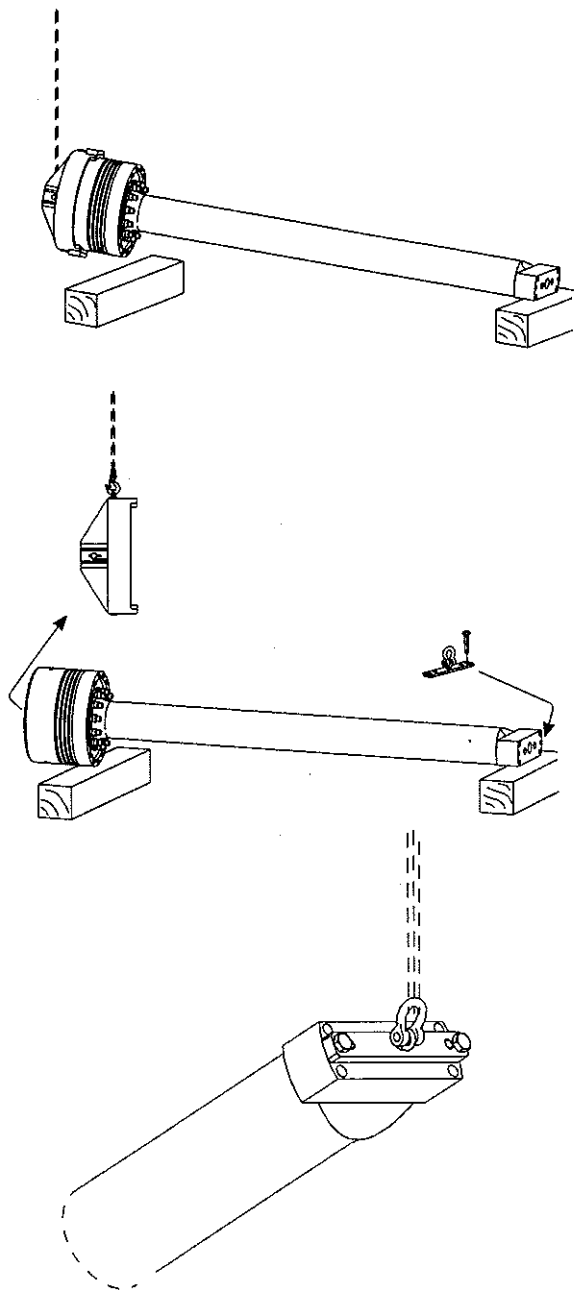
For this test, the piston must be turned upside down (see next step to turn a complete piston).

Fill the piston and piston rod with lubricating oil. Mount the pressure-testing tool on the piston rod foot. Pressure-test the piston at the pressure stated on the Data Sheet. Check the contact surfaces of the piston and the sealing rings for tightness. Check that there are no cracks in the piston crown.

Turn the piston upside up and drain out the piston oil.



12.



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12. Piston turning:

Lift the piston with the normal lifting tool. Lower the piston rod foot until it is close to the platform. Land the foot on a wooden block.

Lower the piston crown to the platform and land it on a wooden block in such a way that it is possible to remove the lifting tool.

Mount an eyebolt in the side of the lifting tool, hook on the crane and remove the lifting tool from the piston crown.

Attach the lifting bracket to the bottom of the piston rod foot. Hook the crane on to the lifting bracket. Lift the piston rod foot clear of the wooden block. Keep lifting until the piston rod is in a vertical position.

Note!

During the lift, follow with the crane to keep the crane positioned vertically above the lifting point. The stuffing box must be removed.

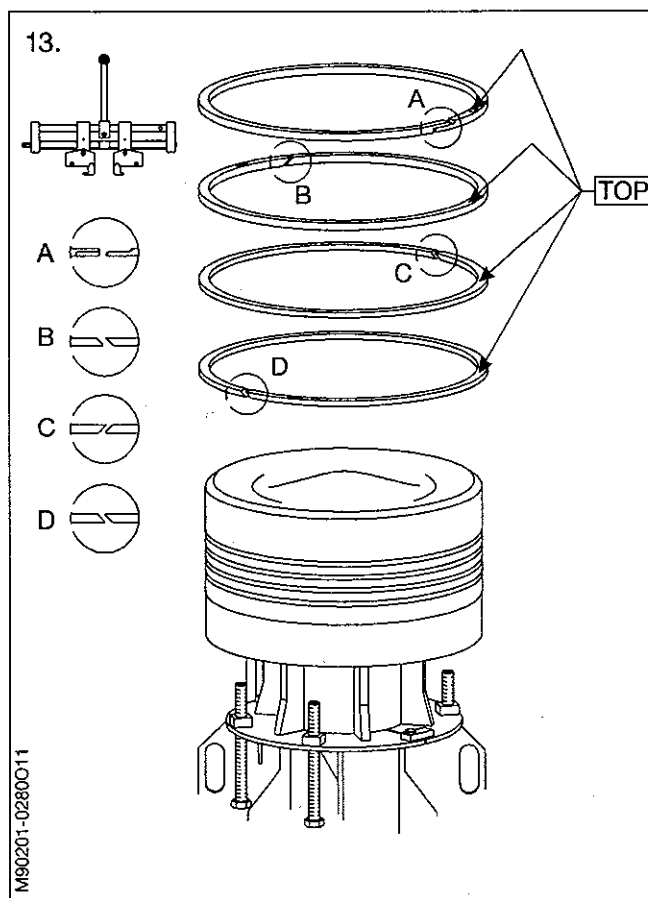
13 .Piston completion:

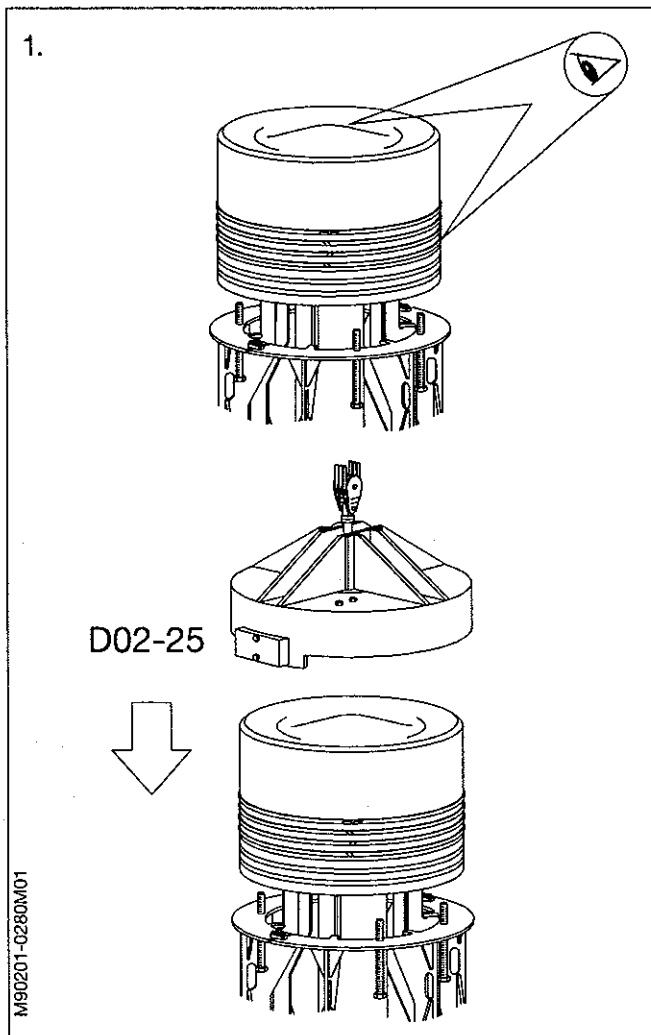
Fit the new piston rings (alternately right-hand and left-hand cuts, with the ring gaps staggered 180° and with the TOP mark upwards), using the ring expander.

When mounting the piston rings, use the ring expanders to prevent unintended deformation of the rings.

Do not expand the rings more than necessary. The uppermost ring (CPR-ring) must be mounted with the short ring expander.

Mount the piston rod stuffing box.
See Procedure 902-2.3.

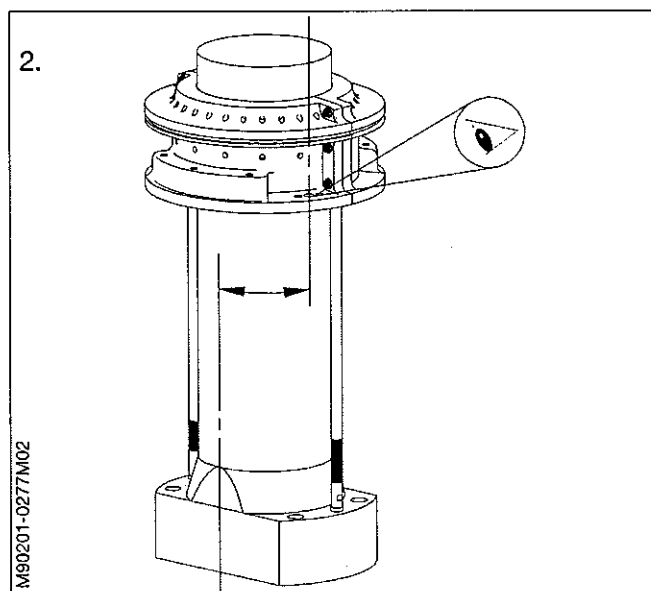


**Preparation of piston**

1. Check the piston rings and piston crown in accordance with Procedure 902-1.1, if not already done.

Mount the lifting tool on the piston crown.
See *Data D02-25*.

2. Stuffing box position:
Ensure that the stuffing box is correctly positioned over the distance pieces mounted on the piston rod foot. Both the holes for the flange and the drain hole for the drain pipe must be positioned correctly.

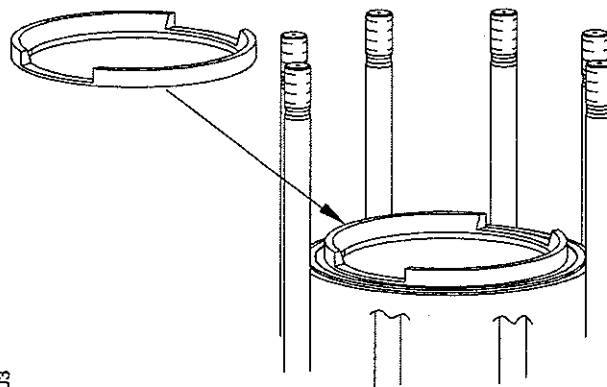


Preparation of cylinder liner

3. Mount the guide ring:
Mount the guide ring in the top of the cylinder liner. The cut outs for the lifting tool must be turned to fore-aft position.
4. Stuffing box cover:
Remove the cover from the piston rod stuffing box opening in the bottom of the cylinder unit.

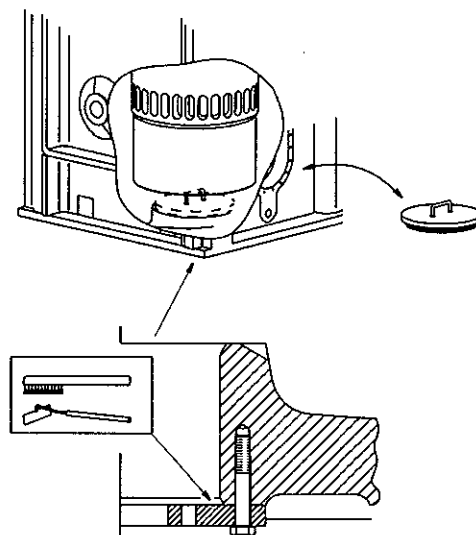
Clean the stuffing box flange.
5. Crosshead position:
Turn the crosshead to a position 45° from TDC (crank web pointing towards exhaust side).

3.



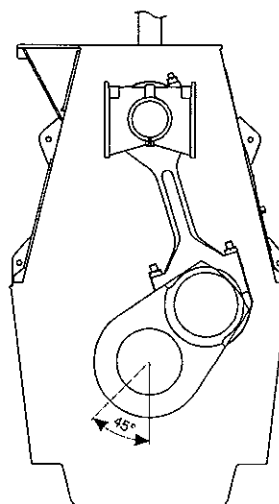
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4.

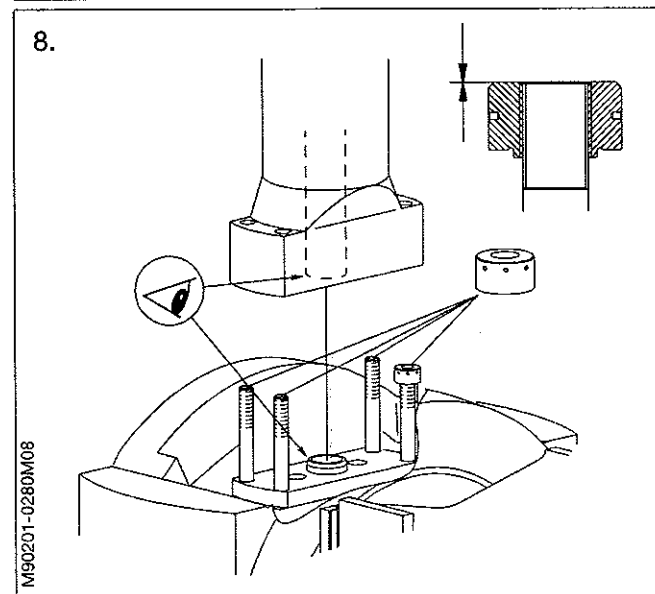
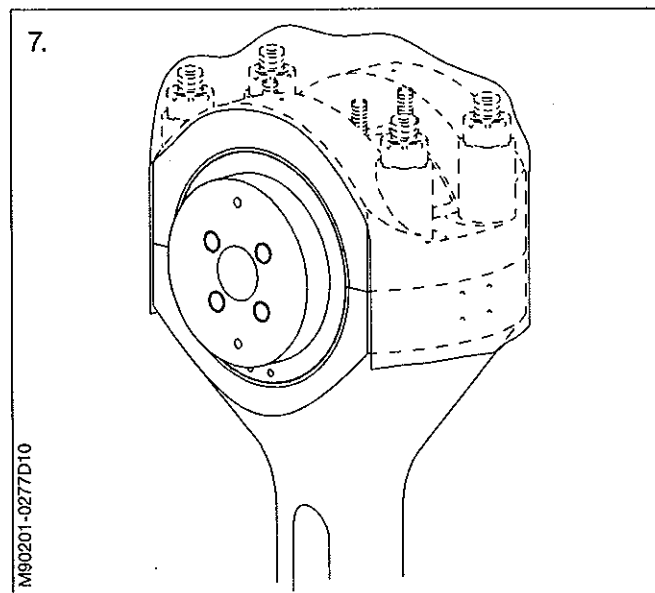
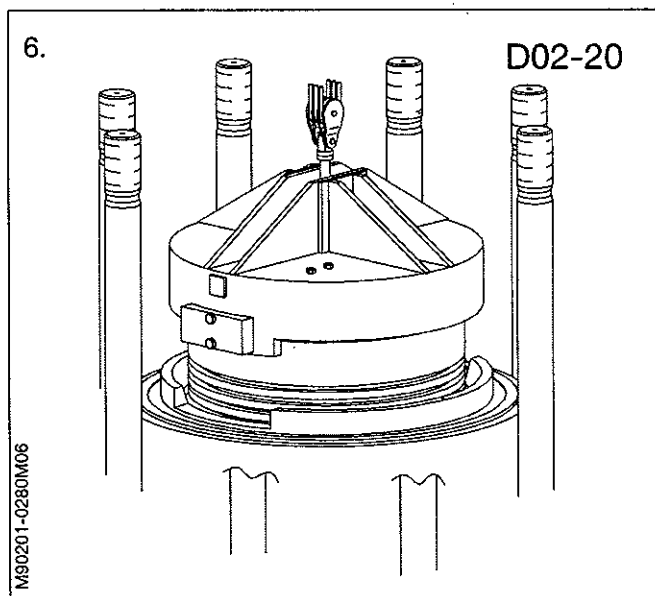


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5.



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Mounting of piston

6. Coat the O-rings of the stuffing box and the piston rod with oil. Coat the piston rings and cylinder liner with cylinder lubricating oil.

Lower the piston into the cylinder liner – while guiding the piston rod foot through the cut-out in the stuffing box flange – until the piston rings are inside the liner.

7. Protective cover:
Remove the protective rubber cover from the crosshead.

8. Crosshead alignment:
Turn the crosshead almost to TDC.

If necessary, mount the hydraulic nuts on the studs and screw down until the nuts are flush with the top of the studs.

Turn the crosshead upwards until the piston rod foot lands on the nuts, thereby turning the crosshead until the face is parallel to the piston rod foot.

Lower the crosshead just enough to enable removal of the nuts. Turn the crosshead upwards until the piston rod lands on the crosshead. When mounting the piston on the crosshead, make sure that the piston rod foot does not damage the threads of the studs. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.

Unscrew the lifting tool and remove the lifting tool and the guide ring for piston rings.

9. Stuffing box:

Turn down and land the stuffing box on the stuffing box flange. Check that the holes in the stuffing box and stuffing box flange are correctly centered.

Tighten the piston rod stuffing box by means of the screws through the inner holes in the stuffing box flange. *For Data, see Procedure 902-2.*

On engine models where the drain pipe is connected directly to the stuffing box:

- Mount the stuffing box drain pipe.

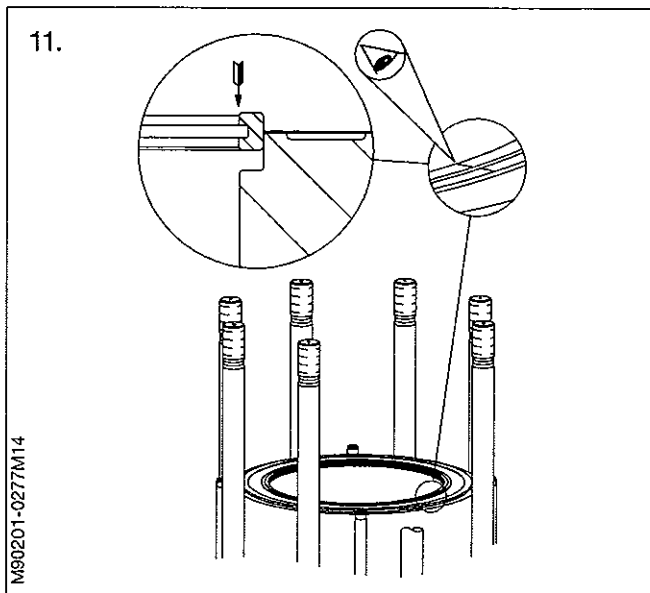
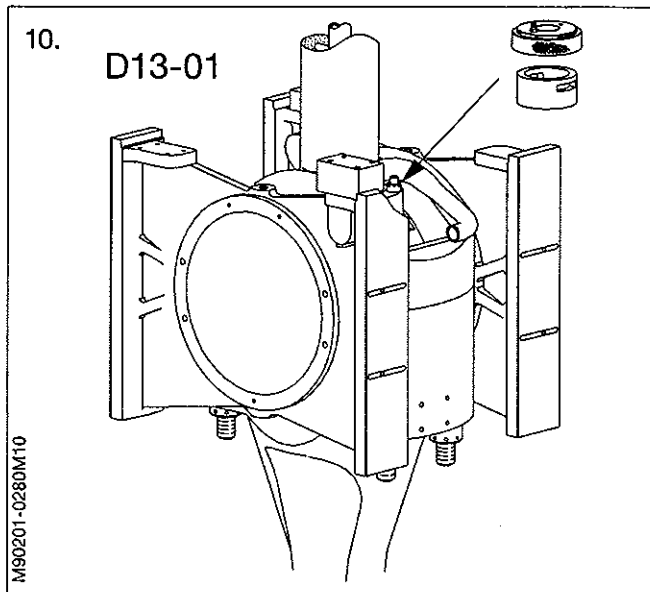
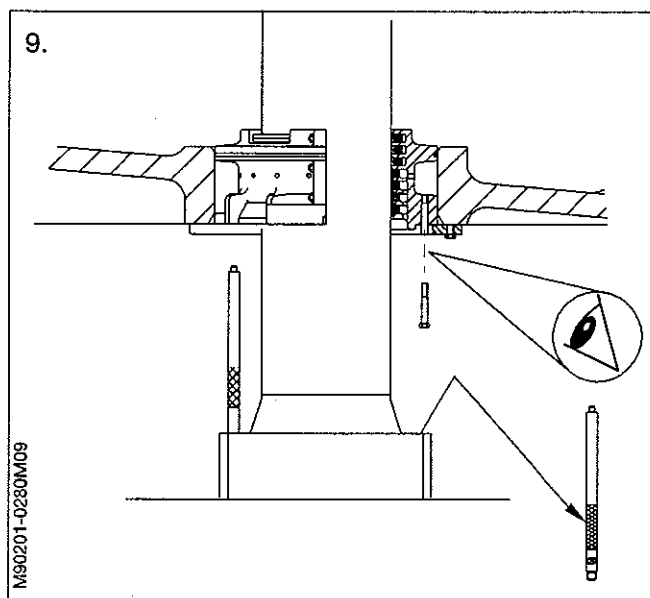
Remove the distance pieces from the piston rod foot.

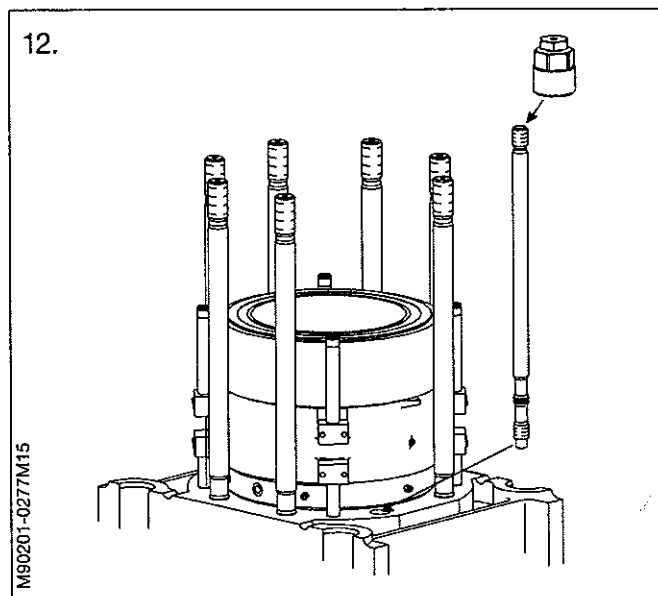
10. Tightening of the piston rod-crosshead connection:

Mount and tighten the piston rod nuts with the hydraulic jacks. *See Data. See Procedure 913-1.*

11. Piston cleaning ring:

Mount the piston cleaning ring in accordance with the scratch mark. If the PC-ring is damaged (broken or cracked), it must be replaced by another ring. *See Procedure 903-1.*





12. Cylinder cover studs:

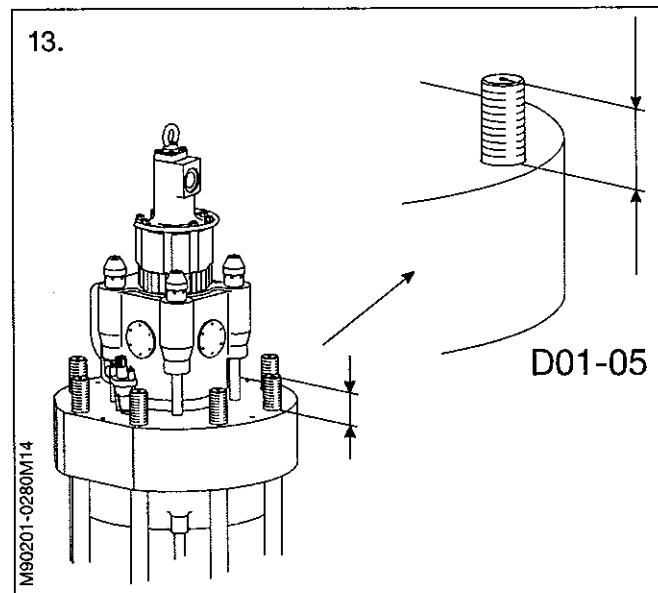
If the cylinder cover studs have been removed, remount them. Carefully clean the surfaces around the base of the studs and check the O-rings on the studs.

Mount the cylinder cover studs with the stud setter. Screw the stud down to contact and half a revolution back.

13. Cylinder cover:

Land the cylinder cover on the liner and check the distance that the stud is protruding from the cylinder cover. If necessary, adjust the distance D01-05 by turning the stud.

Tighten the cylinder cover nuts and mount the necessary pipes.
See *Procedure 901-1.4*.



14. Running-in:

Smear the piston rod with molybdenum disulphide, and turn the crankshaft a couple of revolutions.

At the first opportunity, start the engine and keep it running for about 15 minutes at a speed corresponding to "Dead Slow" Ahead.

Then stop the engine and inspect the piston rod and stuffing box.

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☒	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D02-26	Stuffing box flange, outer screws tightening torque	180	Nm
D02-27	Stuffing box flange, inner screws tightening torque	200	Nm
D02-28	Stuffing box halves, tightening torque	80	Nm
D02-29	Uppermost rings, ring-end clearance	4x6	mm
D02-30	Lowermost rings, ring-end clearance	3x3	mm
D02-34	Sealing ring springs new, free length	889	mm
D02-38	Scraper ring springs new, free length	839	mm
D02-44	Stuffing box complete	190	kg
D02-45	Stuffing box half	56	kg

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90251	87	Distance piece for stuffing box
P90251	109	Mounting tool for stuffing box spring
P90251	122	Worktable for stuffing box
P90451	120	Rubber cover for crosshead

1. After the piston rod stuffing box has been dismantled, check the following clearances:
See Procedure 902-2.2.

Uppermost scraper ring and sealing rings

Clearance at ring ends (scraper ring).
Total clearance (scraper ring). (D02-29)

Clearance at ring ends (sealing rings).
Total clearance (sealing rings). (D02-29)

Lowermost scraper rings

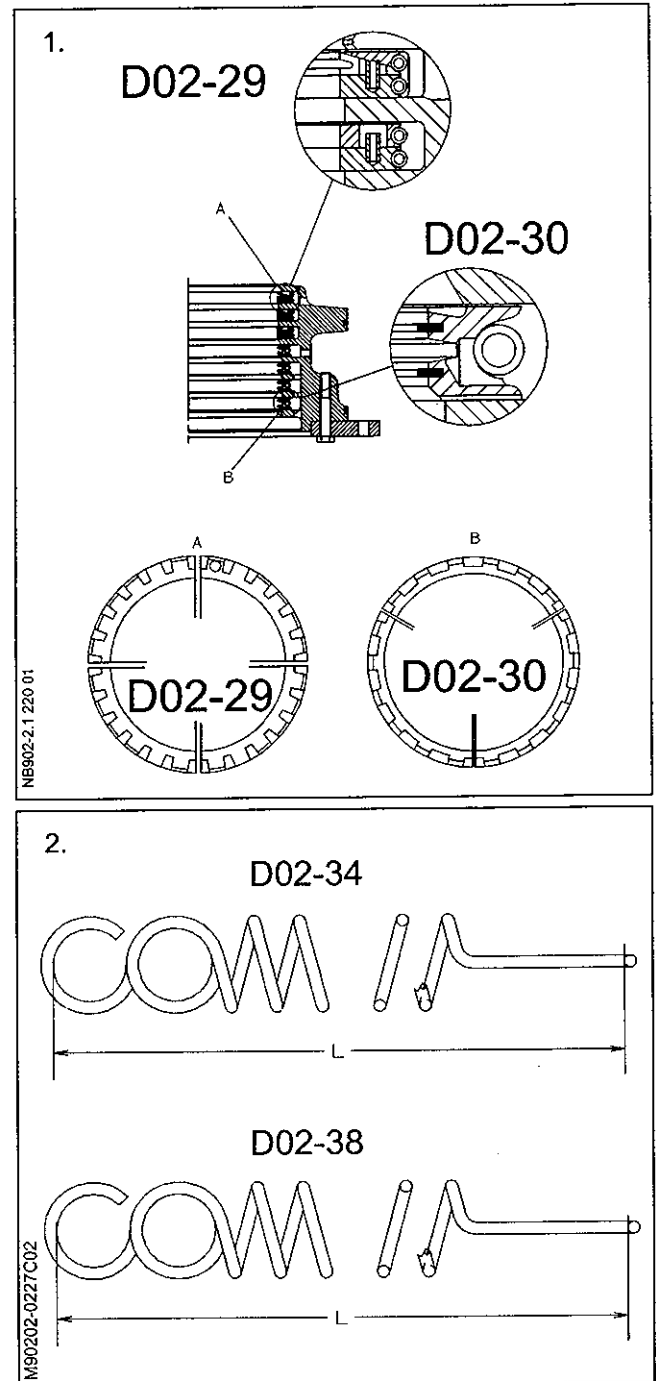
Clearance at ring ends.
Total clearance. (D02-30)

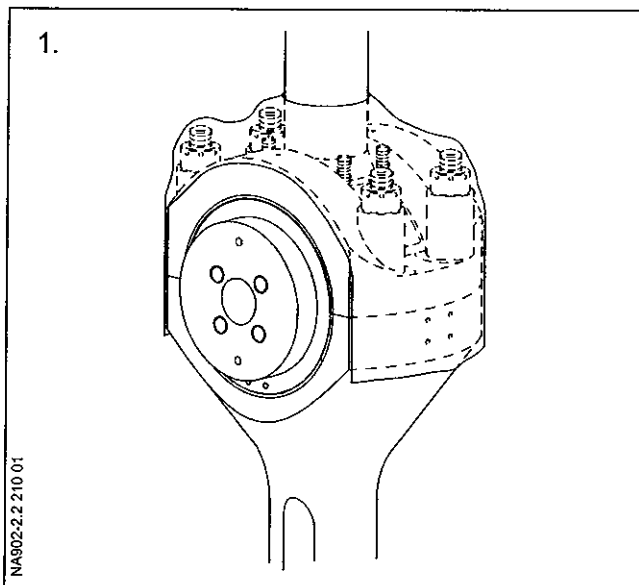
The ring clearances stated in Data apply to new rings.

As a general guide, it is recommended – depending on the overhauling intervals and one's own experience – to replace sealing rings and scraper rings when the specified clearance values D02-29 and D02-30 have been halved.

2. Garter springs:
Generally, it is recommended to renew the springs when the sealing rings and scraper rings are renewed.

The springs can be checked as follows:
Place the springs on the table, measure L_0 (free length), and compare with Data. If a spring is extended more than 8% from the value given in data, it must be discarded.





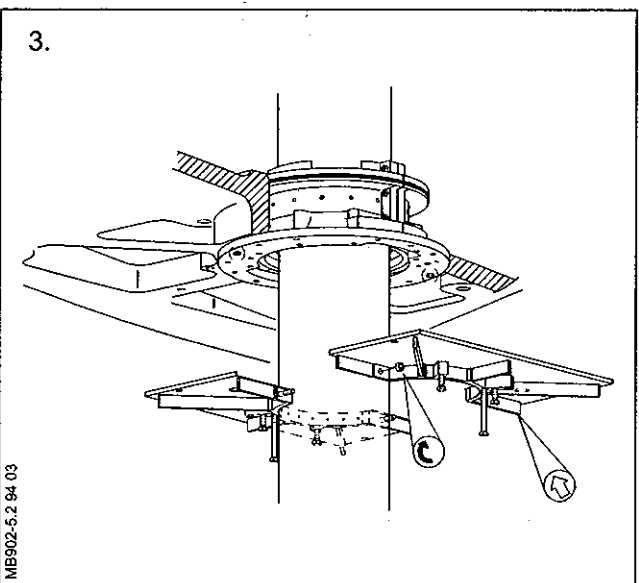
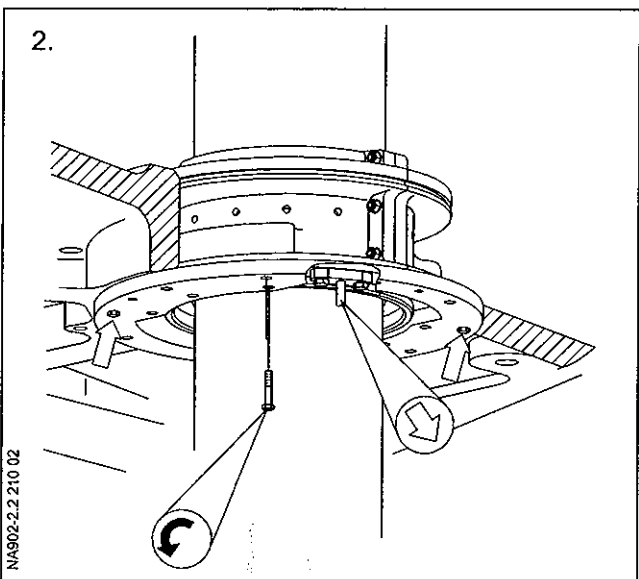
If, in the period between piston overhauls, it becomes necessary to inspect the piston rod stuffing box, proceed as follows:

1. Turn the crosshead to about 90° from TDC.

Mount the rubber cover around the piston rod to protect the crosshead bearing from impurities.

2. Remove the drain oil pipe and all innermost screws and all outer screws except for two screws placed diametrically opposite in the stuffing box flange, longitudinally to the engine.

3. Mount the worktable around the piston rod so that the two remaining screws in the stuffing box flange can be loosened through the holes.



4. Mount the two distance pieces for the stuffing box.

Remove the two long dismantling screws from the worktable.

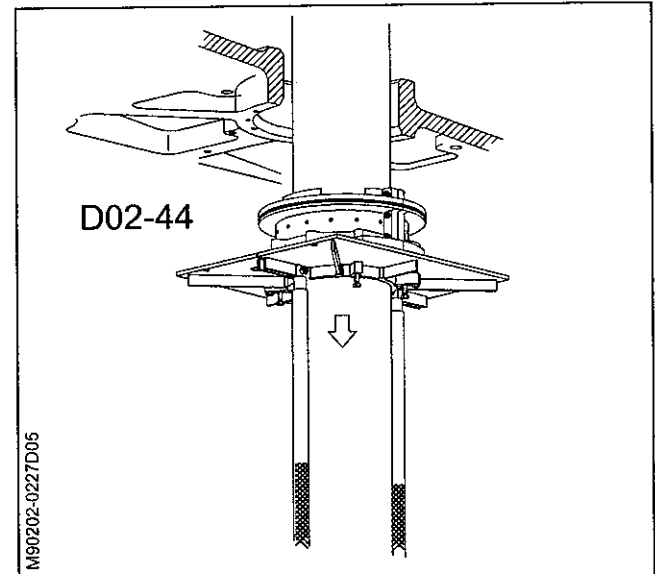
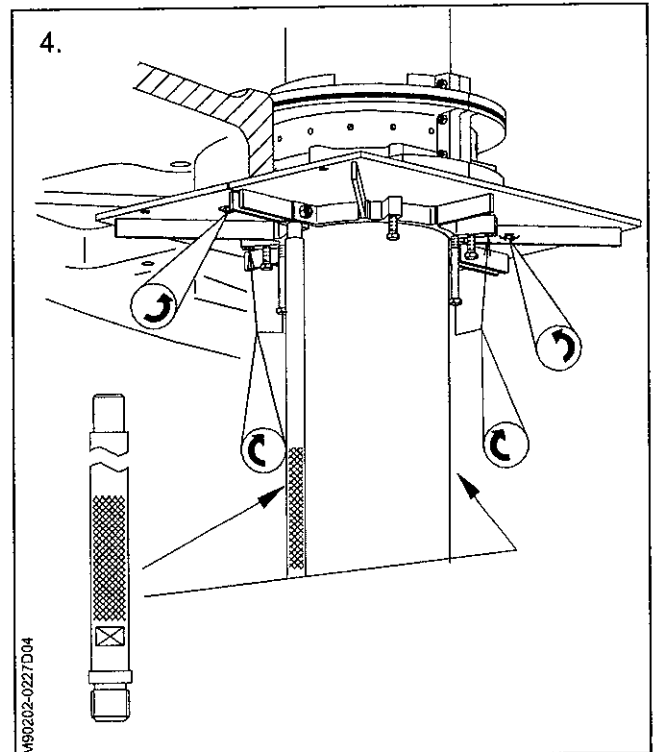
Mount them in the stuffing box through the holes in the worktable.

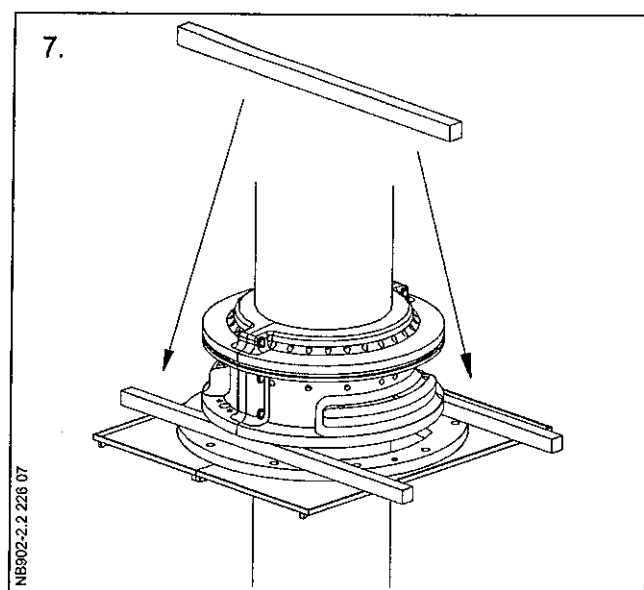
Remove the remaining two screws from the stuffing box flange.

5. Turn the piston to BDC, thereby withdrawing the stuffing box from the cylinder frame bottom.

Remove the two long dismantling screws from the stuffing box and mount them in the worktable.

6. By means of the four short screws in the worktable, press the stuffing box out of the flange and 30 mm up.





7. Place two steel bars (40 x 40 mm) between the stuffing box and the stuffing box flange, one on each side of the piston rod, see the sketch. Use the steel bars as supports when the stuffing box is disassembled. For overhauling the stuffing box, see Procedure 902-2.3.

Normally, overhaul of the piston rod stuffing box is carried out by routine methods in connection with the dismantling (pulling) of the pistons.

During such overhauls, the piston rests on a support placed over one of the cut-outs in the top platform.

Work on the stuffing box is then carried out from the platform below.

If the stuffing box is overhauled inside the engine, it is also done as described here, but the stuffing box halves are supported by the steel bars described in 902-2.2.

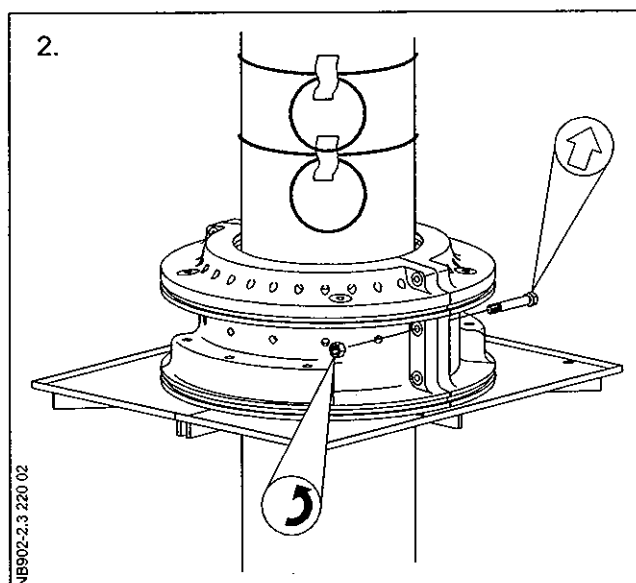
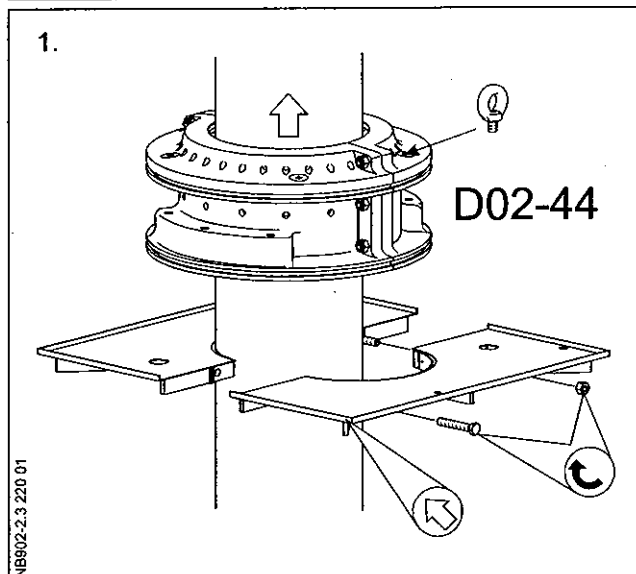
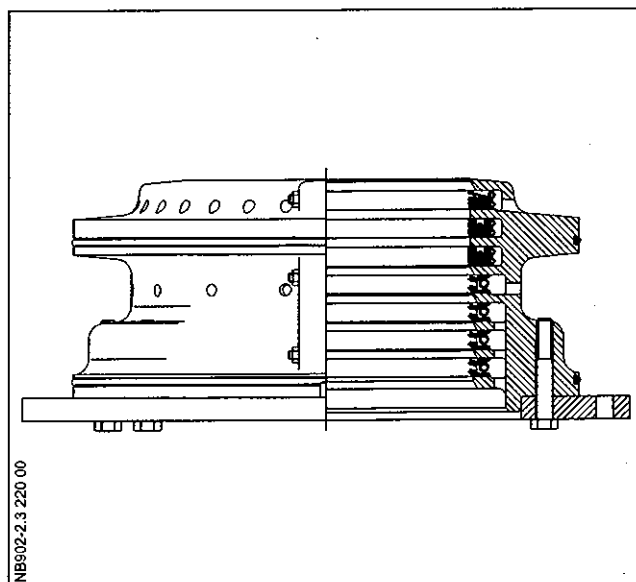
1. Mount two eye bolts in the stuffing box flange, and hook on two tackles.

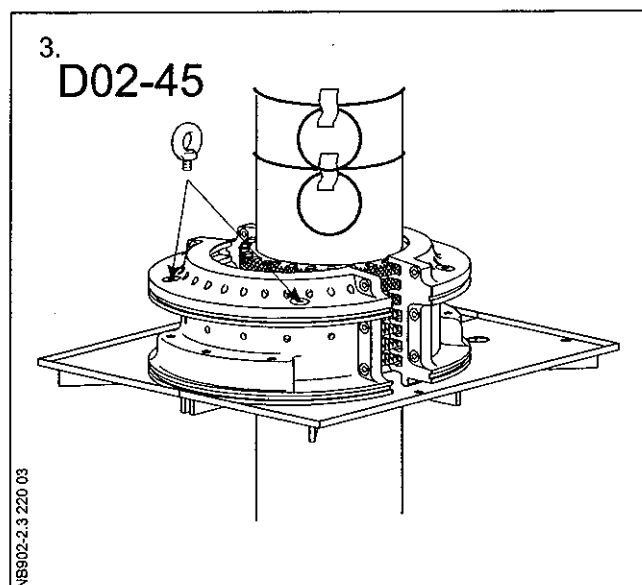
Lift the stuffing box a little up the piston rod, and mount the worktable round the piston rod at a suitable working height.

Land the stuffing box on the worktable, and remove the tackles and eye bolts.

2. Remove the O-rings of the stuffing box. If the O-rings are intact and are to be used again, move them up the piston rod and secure them in this position, for example with tape.

Remove the nuts from the stuffing box assembling bolts.



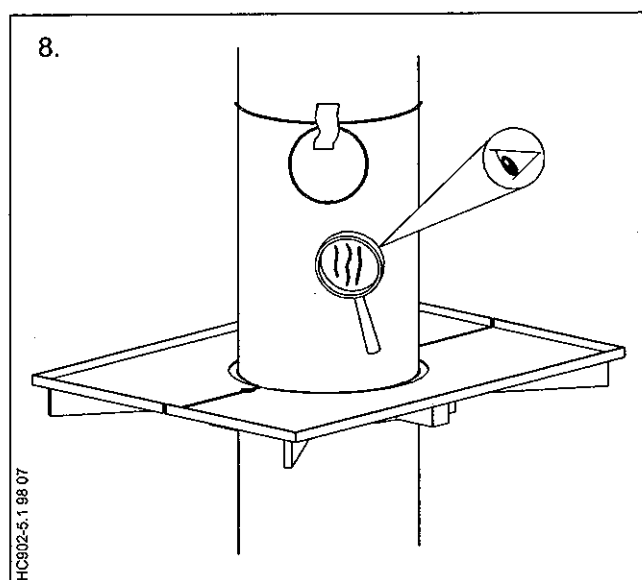


3. Take out the six bolts, and pull away one stuffing box half.
4. Mount two eye bolts on the stuffing box half and remove it from the worktable.
5. Remove the remaining stuffing box half.
6. Measure the clearance between the ring segments to determine whether replacement is necessary.
See Procedure 902-2.1.

Dismantle and stack the rings in the same order as when fitted in the stuffing box.

Carefully clean all the ring segments.

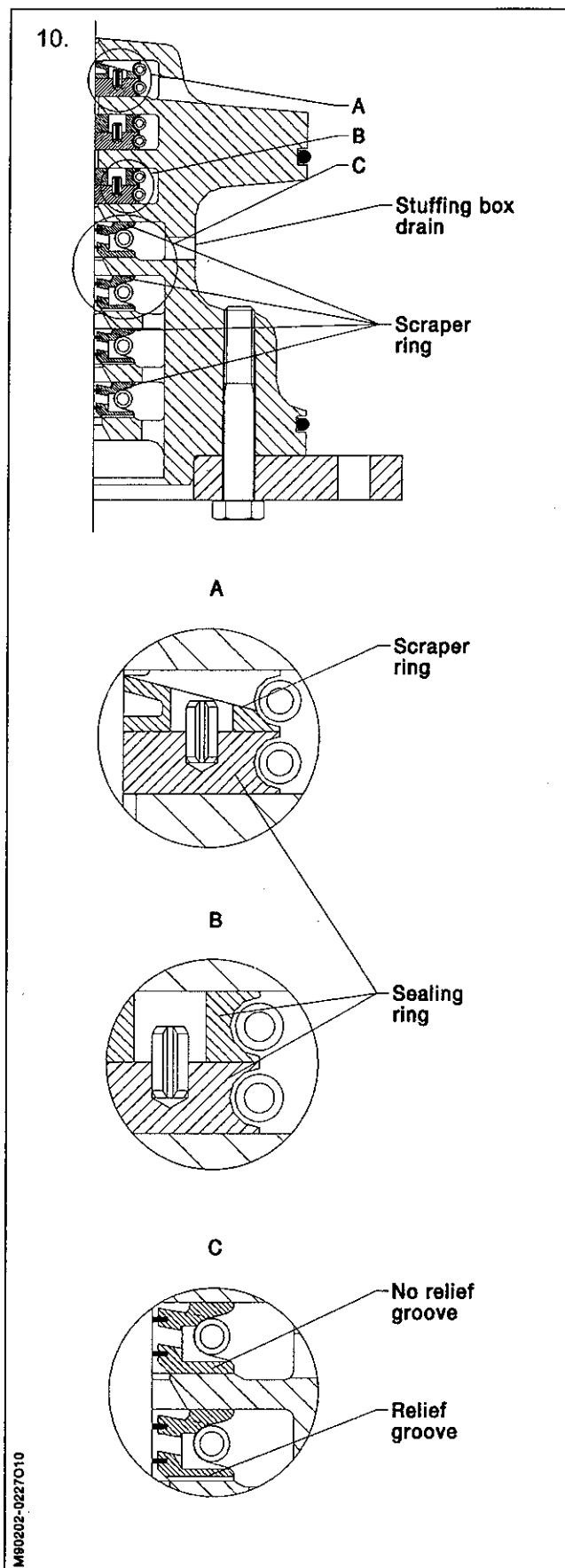
Inspect and assess the surface quality of the sealing rings. If their sliding surfaces have scratches or marks, replace the rings.

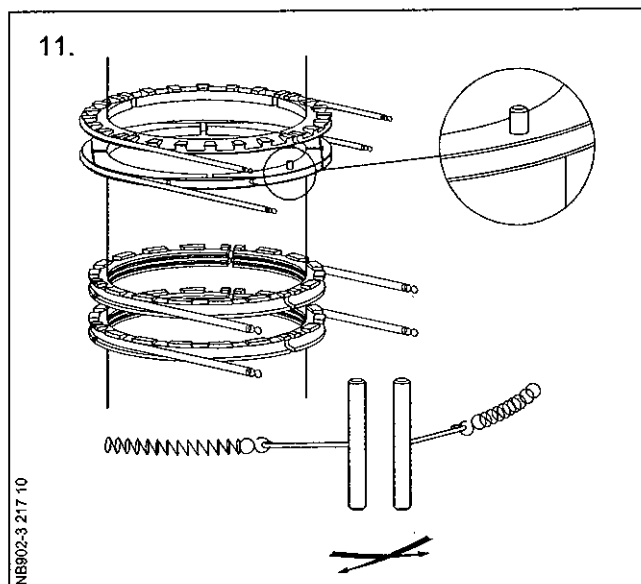


7. Check the lengths of the springs.
See Procedure 902-2.1.
8. Inspect the surface of the piston rod. If small longitudinal scratches have occurred (caused by poorly adapted stuffing box rings), smooth the piston rod surface carefully with a fine grained carborundum stone. In the case of coarse scratches, it may prove necessary to machine-grind the surface in a workshop.
9. Clean the halves of the stuffing box housing.

10. Lubricate the piston rod (in the area where all the ring units in the stuffing box will be positioned) with molybdenum disulphide (MoS_2).

For correct mounting of the sealing and scraper rings see the sketch. The scraper ring in groove no. 4 must be without relief grooves on the underside.





11. Assemble all the stuffing box ring units round the piston rod, on the worktable, in the following way:

- Place the lowermost scraper ring segments on the worktable.
- Place the spring round the segments, and hook the spring ends together.

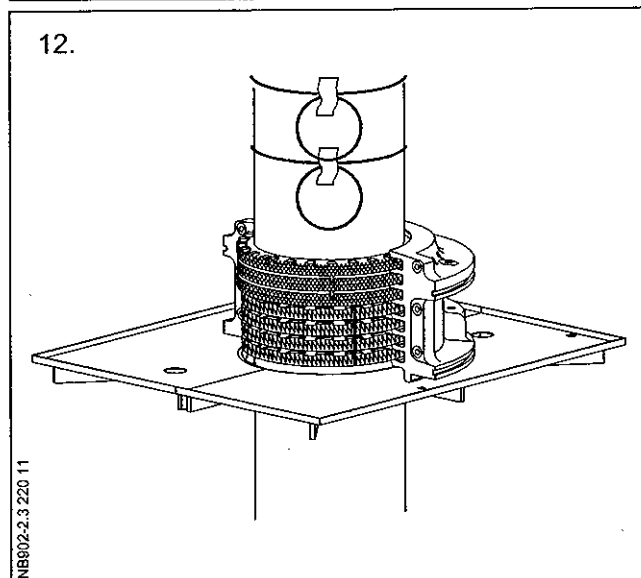
Repeat this procedure for the remaining scraper rings.

On top of the scraper rings, assemble the two sealing ring units (each consisting of a 4-part and an 8-part ring).

Assemble the 8-part sealing ring so that the two guide pins face upwards, place the spring round the segments and, hook the spring ends together.

Assemble the 4-part sealing ring above the 8-part sealing ring. Push the two rings together in such a manner that the guide pins in the lower sealing ring engage with the two holes in the upper sealing ring.

Finally, assemble the uppermost ring unit (consisting of a 4-part scraper ring and an 8-part sealing ring).



12. Use the stuffing box half on the worktable to adjust the height of all the assembled ring units on the piston rod until the ring units are opposite the corresponding grooves in the stuffing box housing. Subsequently, push the stuffing box half into contact with the piston rod, round the ring units.

13. Check the ring clearance again.

Then place the other half of the stuffing box housing on the worktable, pushing it into place round the rings.

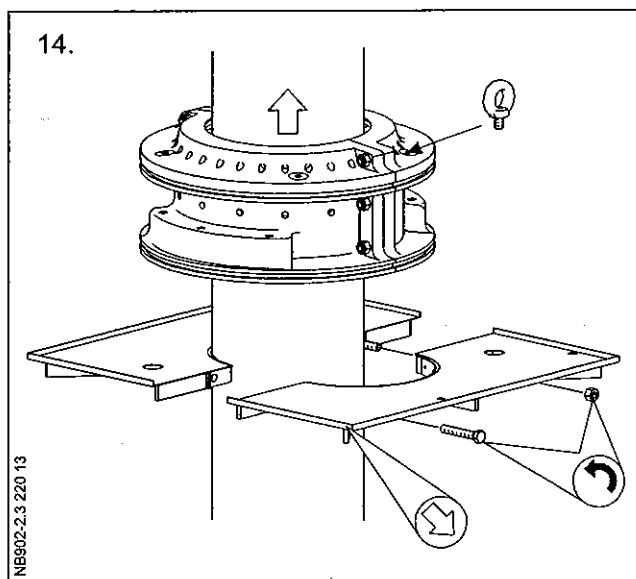
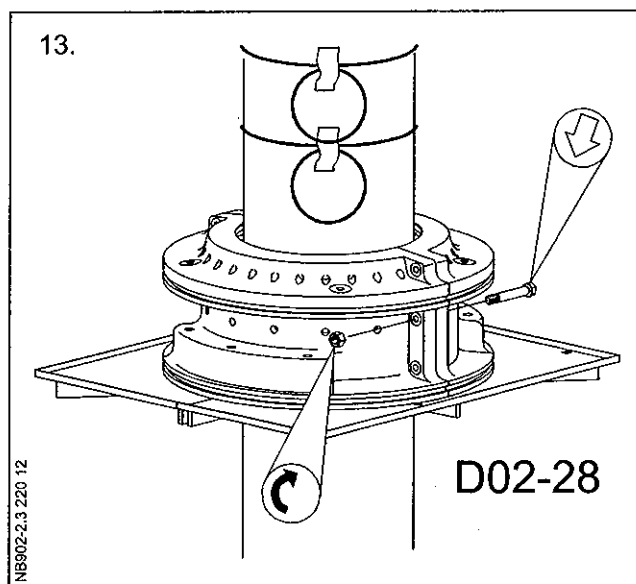
Mount and tighten up the fitted bolts to the torque specified on the Data Sheet.

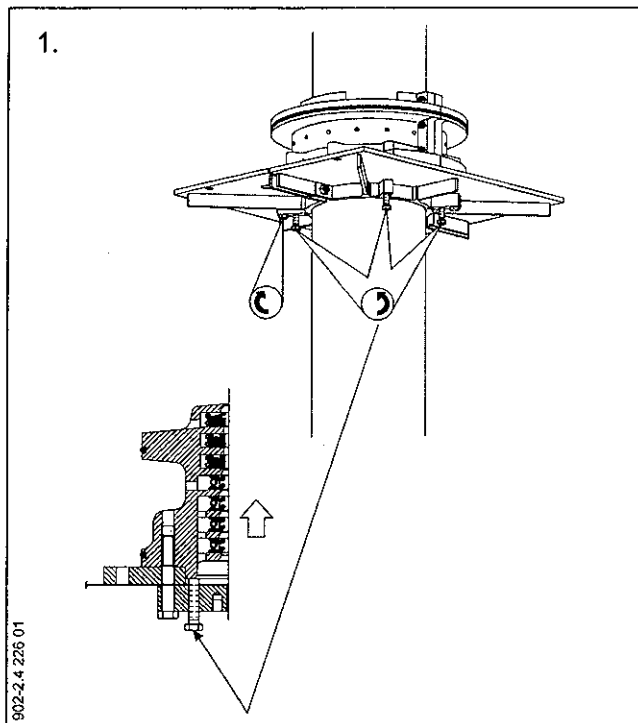
Mount the O-rings in the stuffing box grooves.

14. Mount eye bolts and wire ropes, and lift the stuffing box a little.

Remove the worktable and lower the stuffing box until it rests against the distance pieces on the piston rod foot.

Remove wire ropes and screws.





1. After overhauling, assemble the stuffing box halves on top of the four screws.

Mount the two long screws from the worktable in the stuffing box.

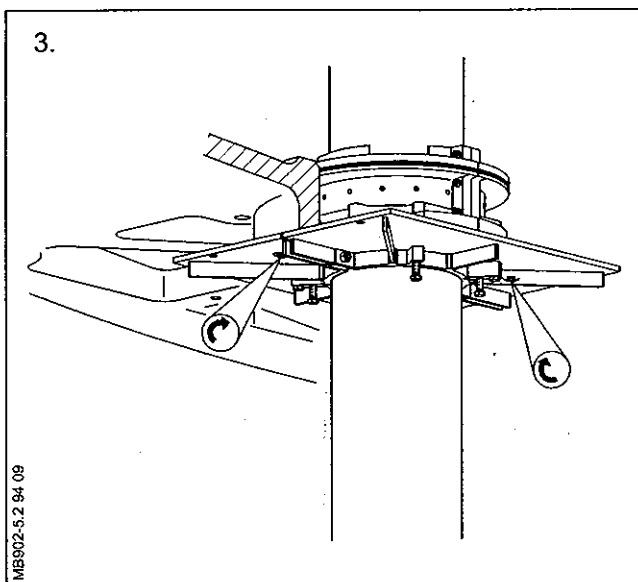
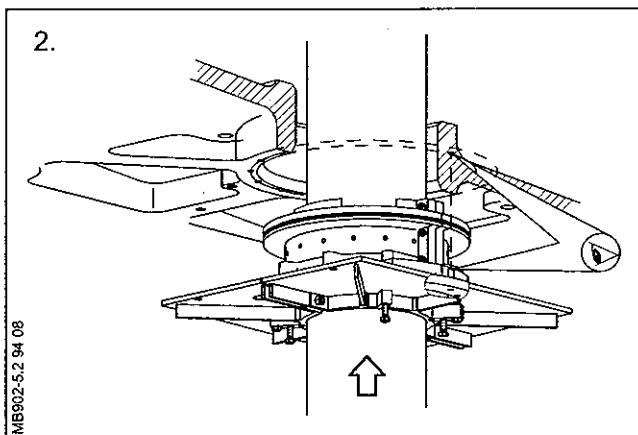
Turn down the short screws so that the stuffing box lands on the flange.

2. Turn the piston upwards until the stuffing box is in place in the cylinder frame.

Note!

Make sure that the two guide pins in the flange enter the guide holes in the bottom of the cylinder frame.

3. Mount two screws in the flange through the holes in the worktable.



4. Remove the long screws from the stuffing box and mount them in the worktable.

Remove the worktable from the piston rod.

5. Mount and tighten all the inner and outer screws for the stuffing box. *See Data.*
6. Remove the protecting rubber cover from the piston rod/crosshead.

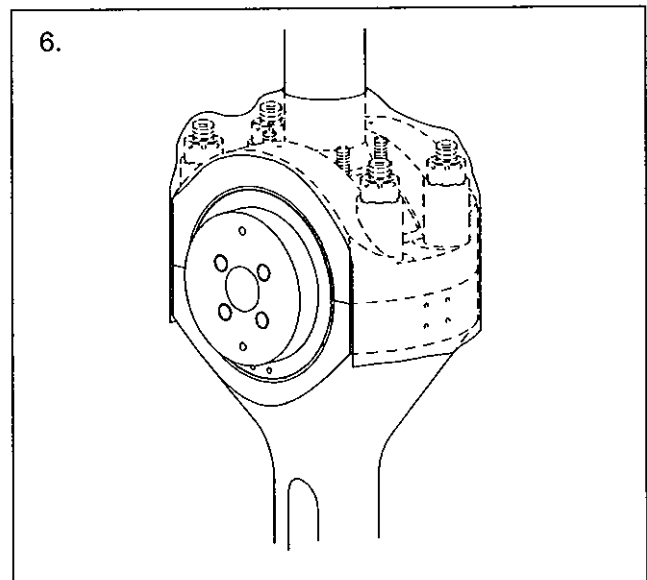
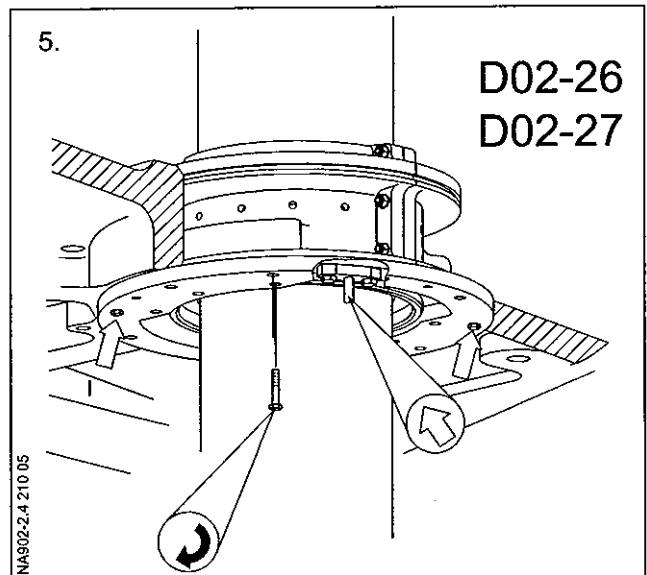
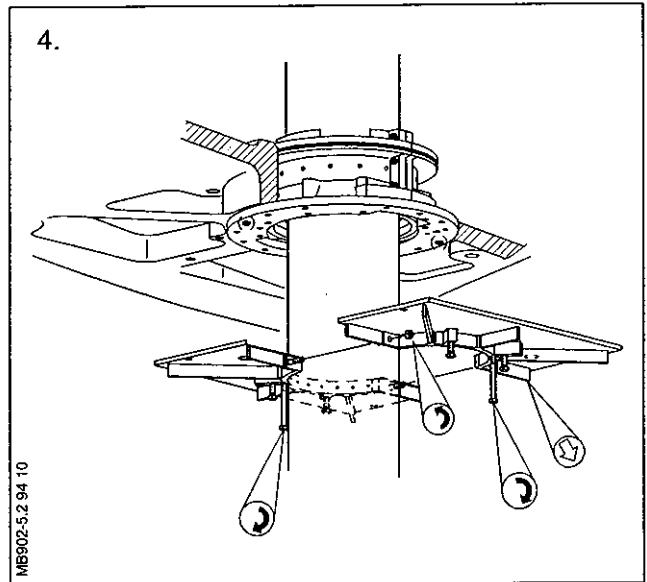
Smear the piston rod with molybdenum disulphide.

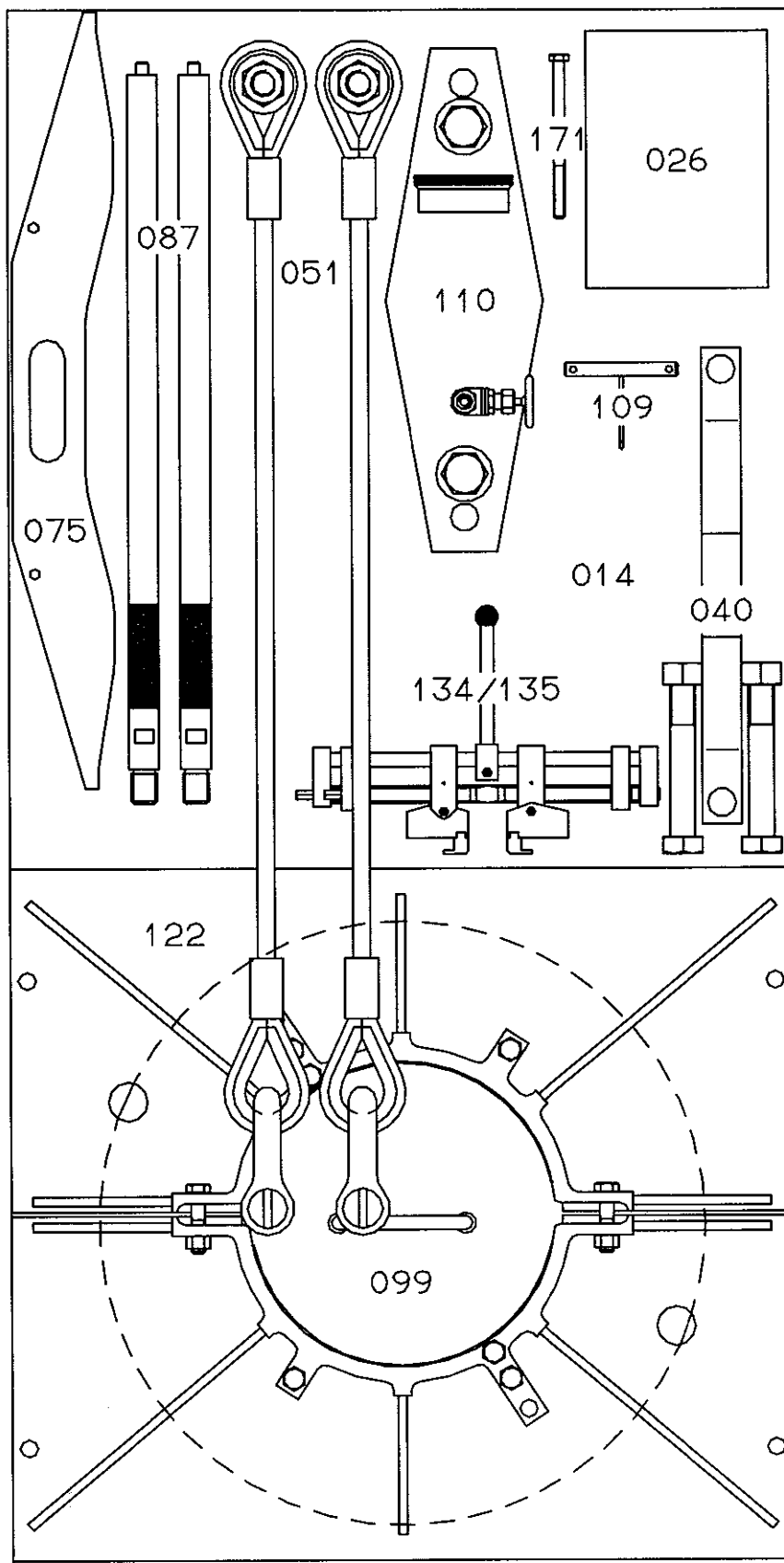
Then turn the crankshaft a couple of revolutions.

If possible:

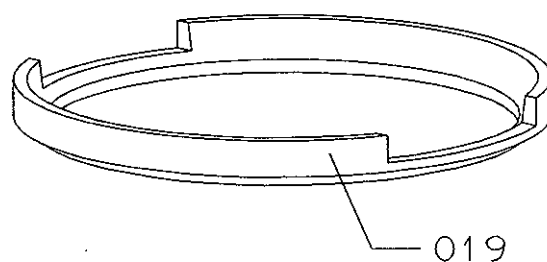
Start up the engine and keep it running for about fifteen minutes at a number of revolutions corresponding to very slow or idle speed.

Then stop the engine and inspect the piston rod and stuffing box.



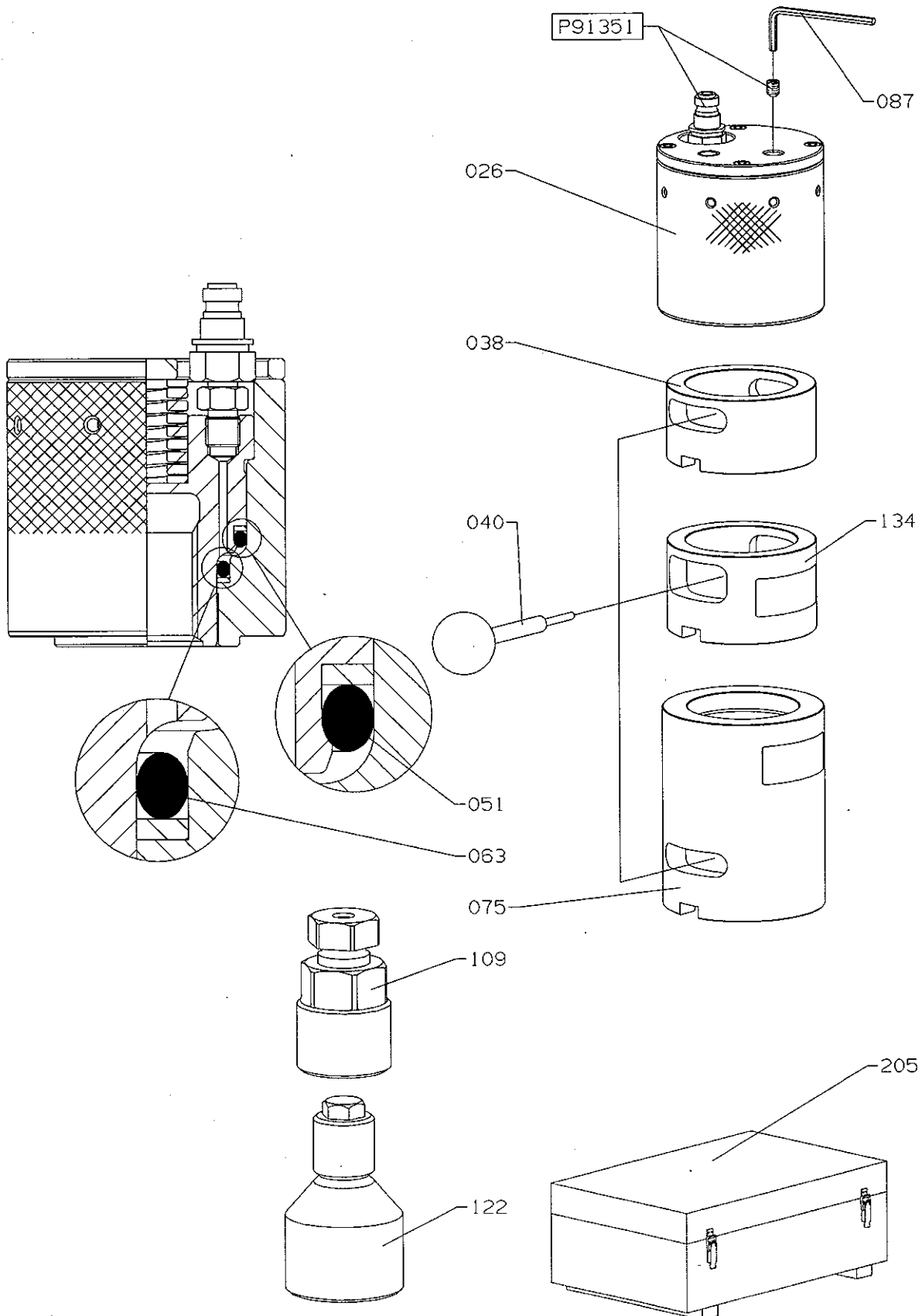


Item No.	Item Description	Item No.	Item Description
014	Panel for tools		
026	Name plate		
040	Lifting tool, piston rod foot		
051	Lifting tool, cylinder liner		
075	Template, piston top		
087	Distance piece, stuffing box		
099	Cover, stuffing box hole		
109	Mounting tool, stuffing box spring		
110	Pressure test tool, piston		
122	Worktable, stuffing box		
134	Expander, piston ring		
135	Expander, piston ring-CPR ring		
171	Screw, dismantling piston skirt		



Item No.	Item Description
019	Guide ring for piston

Item No.	Item Description



Item No.	Item Description
026	Hydraulic jack, complete
038	Support
040	Tommy bar
051	O-ring with back-up ring
063	O-ring with back-up ring
075	Support
087	Spanner
109	Stud setter
122	Extension stud for hydraulic jack
134	Support
205	Hydraulic tool set, complete

Item No.	Item Description

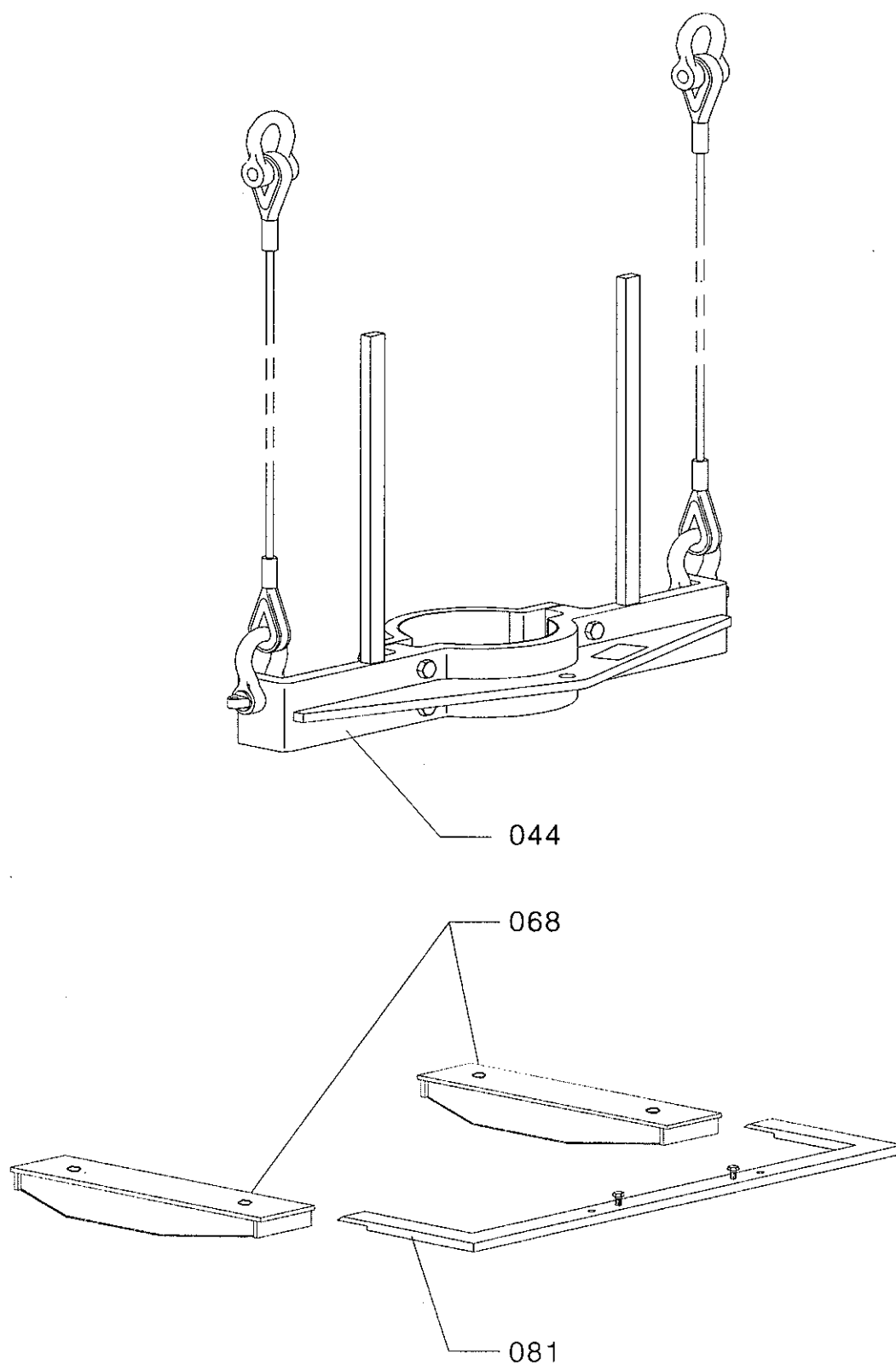


Plate 90264-0003 Piston and Piston Rod - Extra Tools

Item No.	Item Description
044	Lifting collar
068	Support for tilting tool
081	Support for tilting tool

Item No.	Item Description

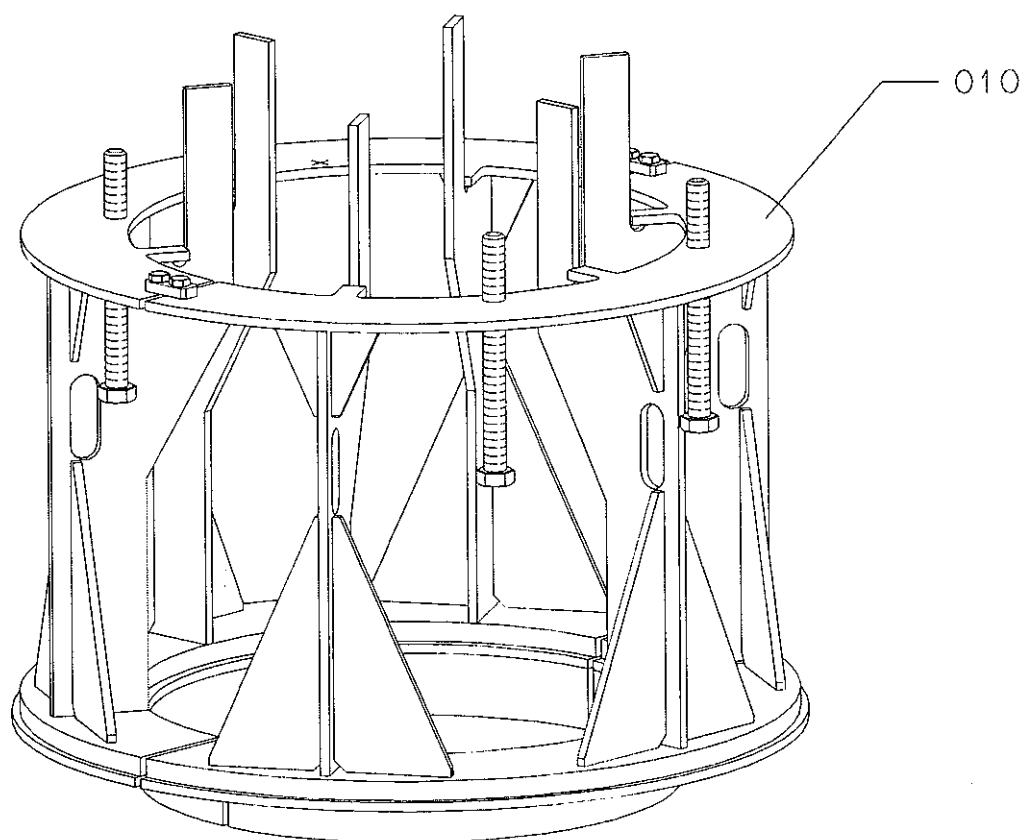


Plate 90265-0003 Piston and Piston Rod - Support Tools

Plate 90265-0003 Piston and Piston Rod - Support Tools

Item No.	Item Description
010	Support iron for piston

Item No.	Item Description

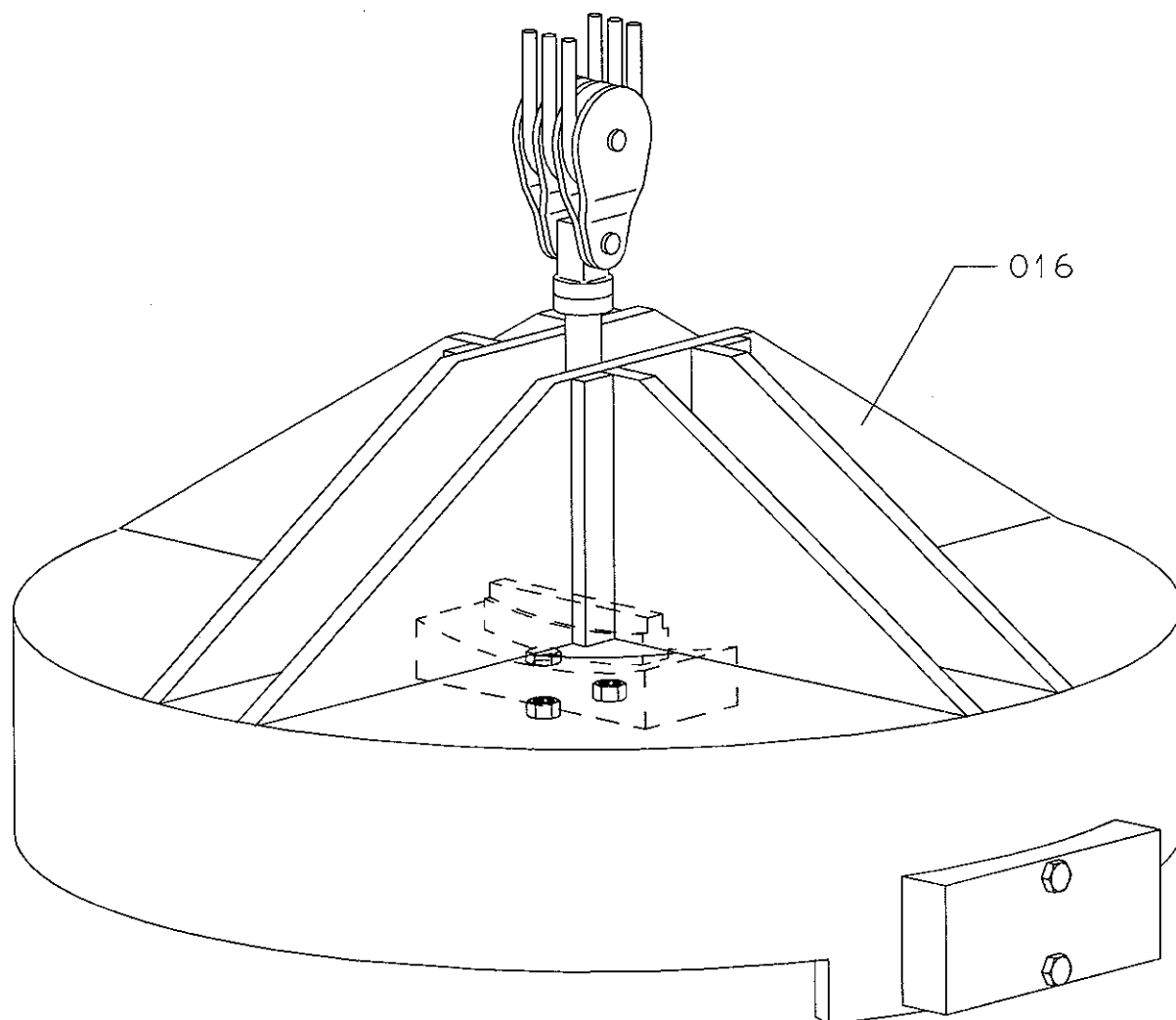


Plate 90266-0001

Piston - Lifting Tools

Item No.	Item Description
016	Lifting tool for piston

Item No.	Item Description

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☒	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit																				
D01-10	Cylinder cover stud	122	kg																				
D03-01	Lifting tool screws, tightening torque	200	Nm																				
D03-03	Cylinder diameter, new	900	mm																				
D03-04	Piston cleaning ring diameter, new	897.8	mm																				
D03-05	Cylinder liner, complete	9100	kg																				
D03-06	Cooling jacket	420	kg																				
D03-16	Piston cleaning ring radial width, new	21.1	mm																				
D03-17	PC-ring/Liner max. wear deviation	0.9	mm																				
D03-18	PC-rings replacement criteria:																						
<table border="1"> <tr> <td colspan="2">Liner diameter</td><td colspan="2">900 mm</td></tr> <tr> <td colspan="2">Liner wear</td><td colspan="2">Install :</td></tr> <tr> <td>0 -</td><td>0,90 mm</td><td>Standard PC-ring (new or max.diameter wear of</td><td>0,90 mm)</td></tr> <tr> <td>0,90 -</td><td>1,8 mm</td><td colspan="2">Oversize PC-ring</td></tr> <tr> <td>></td><td>1,8 mm</td><td colspan="2">No Pc-ring</td></tr> </table>				Liner diameter		900 mm		Liner wear		Install :		0 -	0,90 mm	Standard PC-ring (new or max.diameter wear of	0,90 mm)	0,90 -	1,8 mm	Oversize PC-ring		>	1,8 mm	No Pc-ring	
Liner diameter		900 mm																					
Liner wear		Install :																					
0 -	0,90 mm	Standard PC-ring (new or max.diameter wear of	0,90 mm)																				
0,90 -	1,8 mm	Oversize PC-ring																					
>	1,8 mm	No Pc-ring																					

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90251	51	Lifting tool for cylinder liner
P90361		Measuring tool for cylinder liner
P90362		Cylinder Liner - Extra Tool
P90366		Cylinder Liner - Lifting Tools

1. Dismount the cylinder cover, the piston cleaning ring and the piston.
See Procedures 901-1.2 and 902-1.2.

Clean the cylinder liner and scavenge air ports.

2. Position the cylinder liner measuring tool.

Measure the cylinder liner with an inside micrometer at the positions indicated on the measuring tool.

Take measurements in the fore-and-aft and athwartship directions.

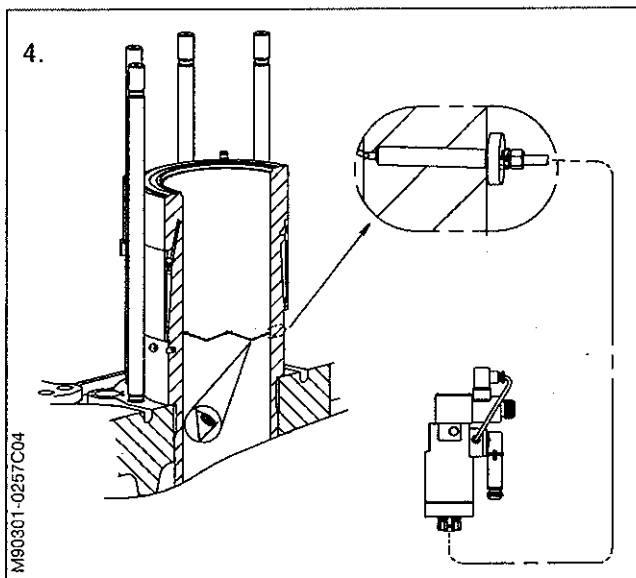
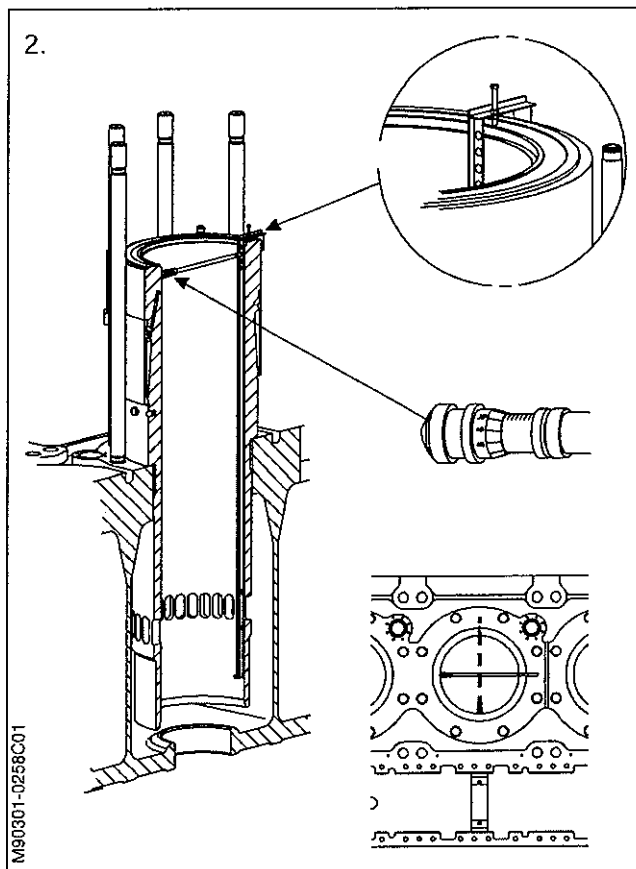
Check and assess the condition of the cylinder liner according to the description given in Volume I, Chapter 707.

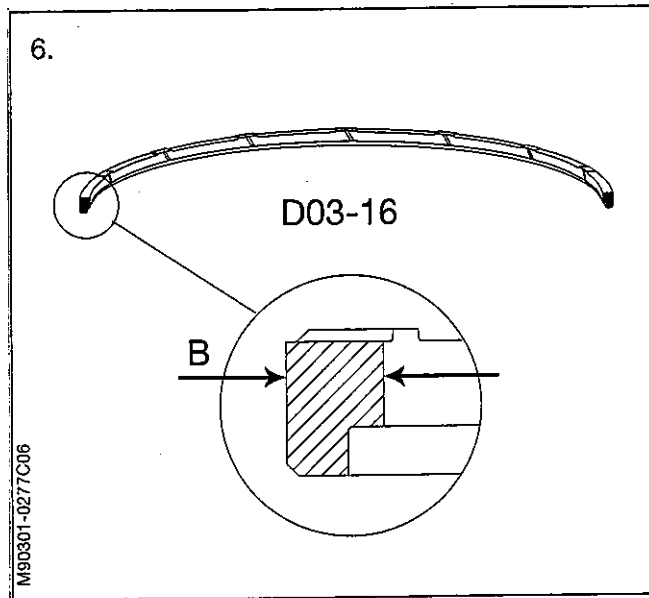
3. Carefully scratch over any scores or marks and grind away the wear ridges.
See Procedure 903-1.3.

4. Check the lubricating points of the cylinder by pumping cylinder oil to each lubricating point with the cylinder lubricator.

Clean any blocked lubricating duct.

Mount the piston and cylinder cover.
See Procedures 902-1.4 and 901-1.4.





5. Piston cleaning (PC) ring:

The PC-ring is to be regarded as an integrated part of the liner and it is intended to follow the service life of the liner.

During inspection of the piston and the liner, the PC-ring must also be inspected.

6. Measure the PC-ring radial width B, and find the most worn place. Compare with Data D03-16 and calculate the wear of the PC-ring, multiply the wear by 2 to get the PC-ring diameter wear.

Measure the liner in the fore-aft and athwart-ship directions at piston skirt TDC position, corresponding to measuring point No. 5 on the liner-measuring tool. Compare the measurements with the diameter of a new liner as stated in Data. Calculate the wear of the liner.

7. Compare the PC-ring diameter wear with the wear of the liner. If wear of the two components does not deviate more than D03-17 then reinstall the PC-ring.

If deviation between PC-ring wear and liner wear is more than D03-17 or if the PC-ring is broken or cracked, replace the ring with a new PC-ring, an oversize ring or no ring according to Table D03-18 on the Data sheet.

If it is necessary to install an oversize PC-ring, contact MAN B&W Diesel for advice.

When a new liner is installed, also a new PC-ring must be installed. When a new liner is ordered, also a new PC-ring must be ordered.

1. Dismount the cylinder cover.
See Procedure 901-1.2.

Discard the sealing ring from the top of the cylinder liner.

Turn the piston down far enough to make it possible to remove the wear ridges at the top of the liner.
See Procedure 903-1.3.

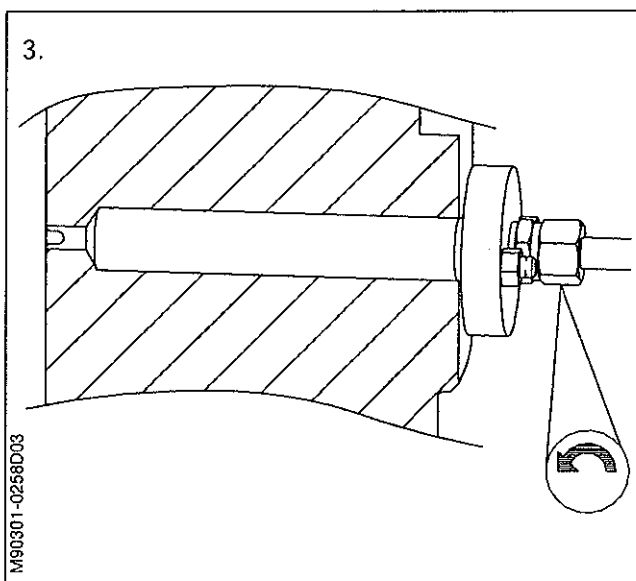
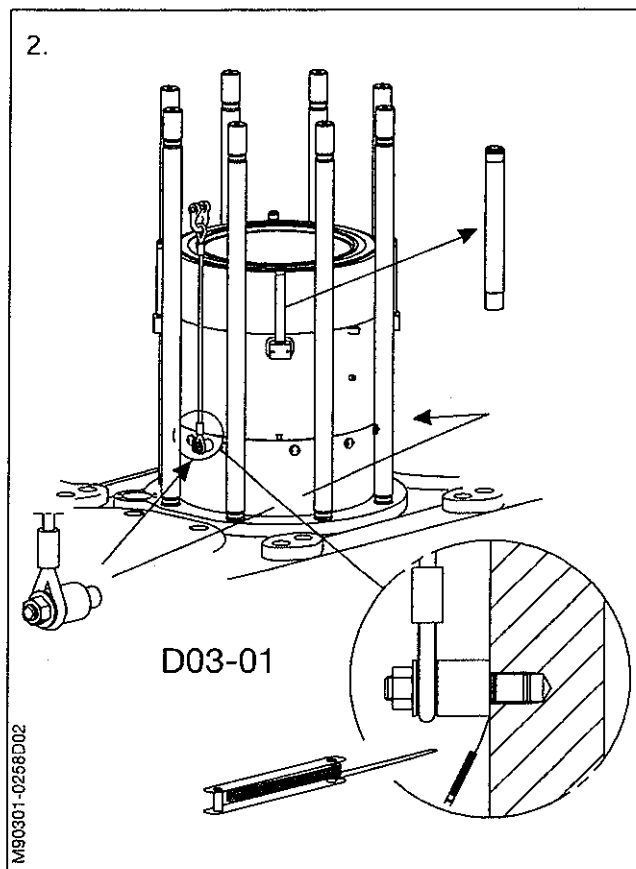
Dismount the piston cleaning ring and the piston.
See Procedure 902-1.2.

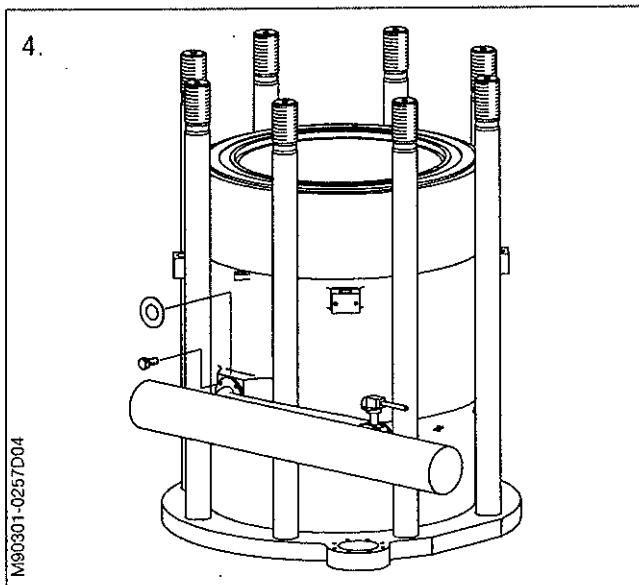
2. Dismount the four cooling water pipes - between the cooling jacket and cylinder cover and discard the O-rings from the pipes - and clean them carefully.

Screw the two lifting tools on to the cylinder liner. Check with a feeler gauge that there is no clearance between lifting tool and cylinder liner. For tightening torque, *see Data*.

3. Disconnect the oil pipes leading from the cylinder lubricator to the cylinder liner.

Depending on pipe layout, disconnect the pipes directly at the non-return valves or at the distributor block mounted on the liner.





4. Remove the screws of the cooling water inlet pipe.

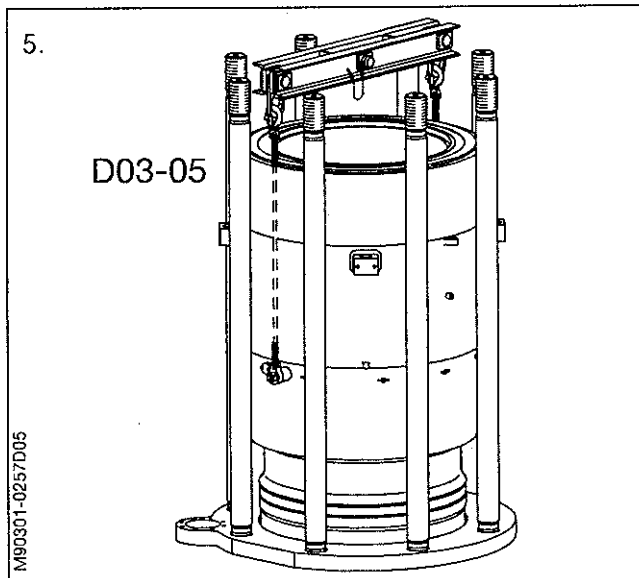
5. Attach the crane to the lifting crossbar.

Hook the lifting tools on to the crossbar on both sides of the cylinder liner.

Lift the liner with the cooling jacket out of the cylinder frame.

Note!

Low lifting height in the engine room may require the removal of one or more cylinder cover studs before dismantling the cylinder liner.



Land the cylinder liner vertically on, for instance, a couple of planks.

6. Clean the cylinder frame internally, taking special care with the contact surfaces for the cylinder liner at the top of the cylinder frame.

The lifting tools are also used for transporting the cylinder liner.

1. Unscrew the non-return valves from the cylinder liner.

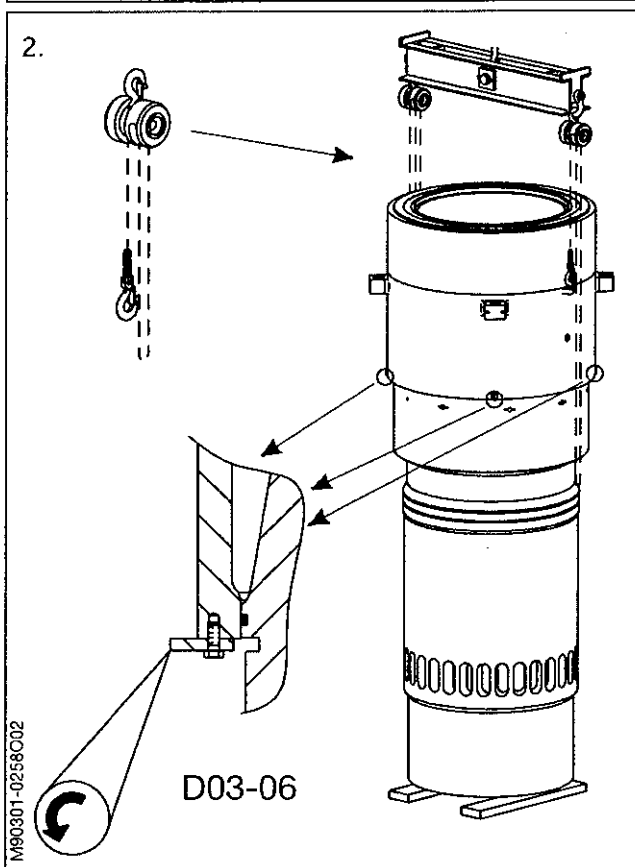
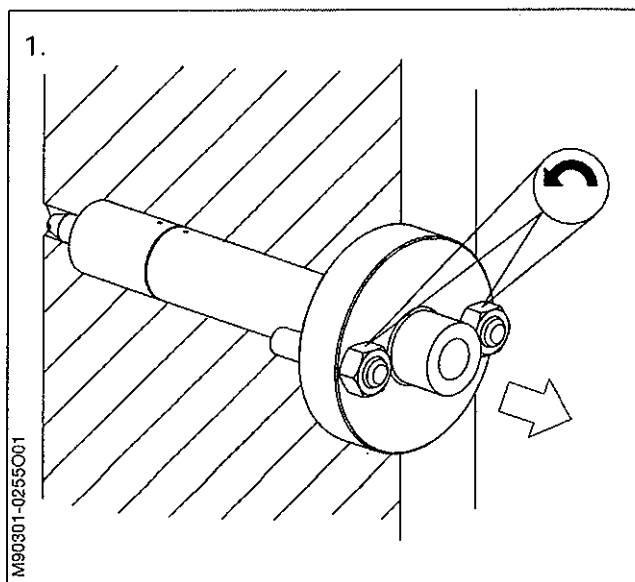
Clean and inspect the non-return valves.

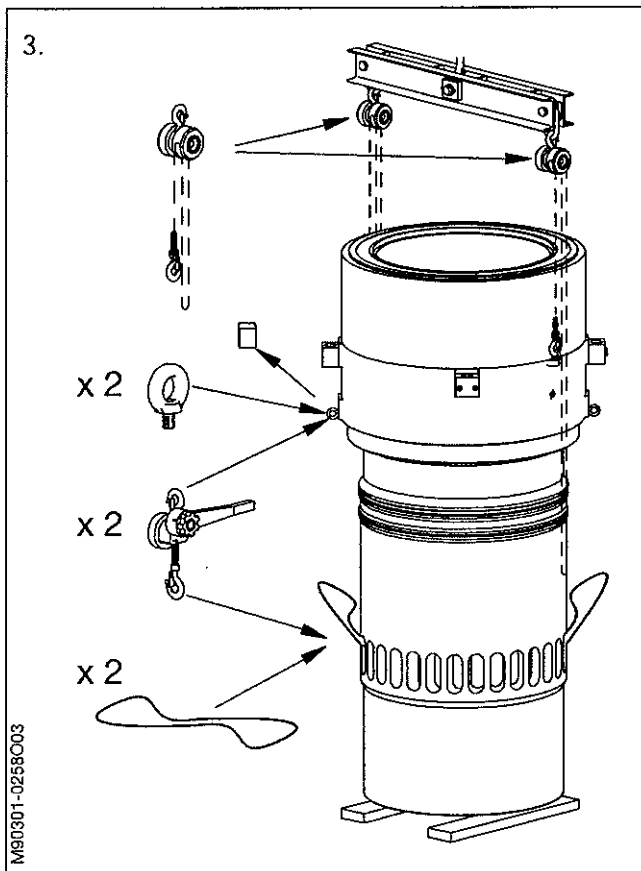
2. Attach two tackles to the crossbar, as shown.

Mount two lifting eye bolts in the cooling jacket.

Hook the tackles on to the lifting eye bolts on the cooling jacket and haul tight.

Loosen the screws on the clamps which fix the cooling jacket to the cylinder liner. Turn the clamps away from the liner.





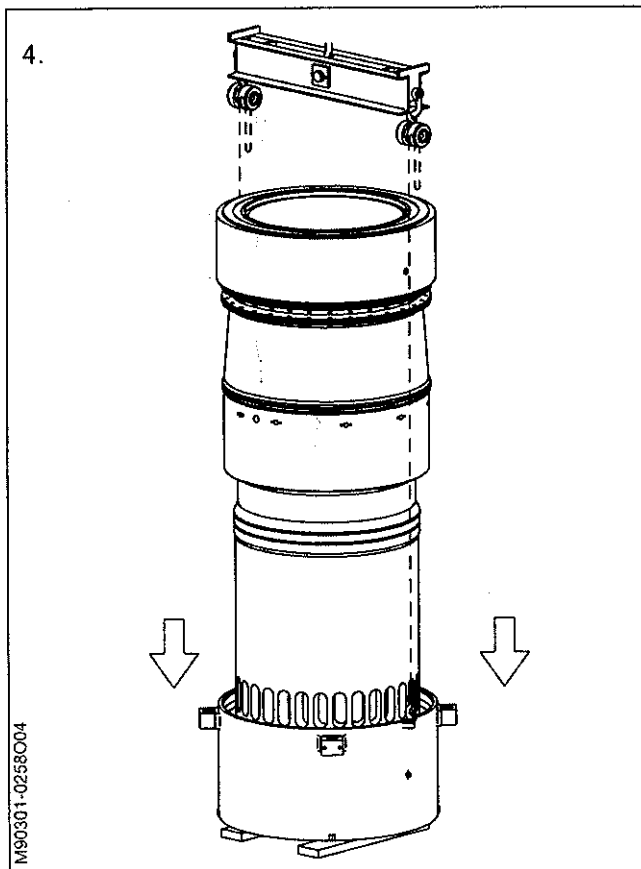
3. If the cooling jacket sticks, it is possible to pull down the jacket by means of two tackles and a suitable piece of pipe or wire. Unscrew two water connections and mount two eye bolts.

Mount two soft straps in the scavenge air ports and attach two tackles to the straps and the eye bolts.

Carefully pull down the cooling jacket.

4. Lower the cooling jacket by means of the tackles and the crane, and land it on the wooden planks.

Check that the cooling jacket does not tilt when it is lowered.



5. Mount the lifting tools in the cylinder liner.

Lift the cylinder liner away from the cooling jacket.

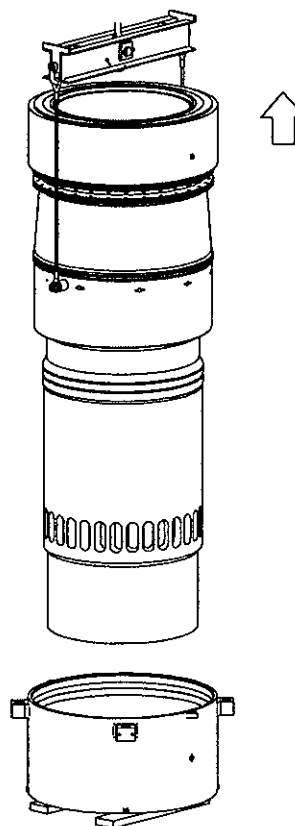
Clean the cooling jacket internally.

6. Check and assess the condition of the cylinder liner according to the description given in Volume I, Chapter 707.

Carefully scratch over any scores or marks on the cylinder liner running surface, by means of a rough grindstone held in the hand.

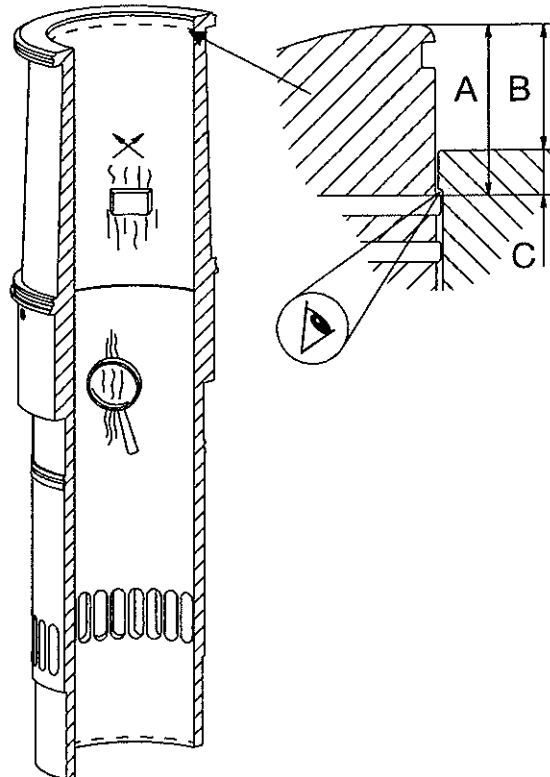
Check in the top of the liner for a wear ridge (where the piston rings reverse direction). If there is any sign of a wear ridge, it is necessary to create a groove by grinding. The groove serves to prevent the build-up of a new wear ridge.

5.

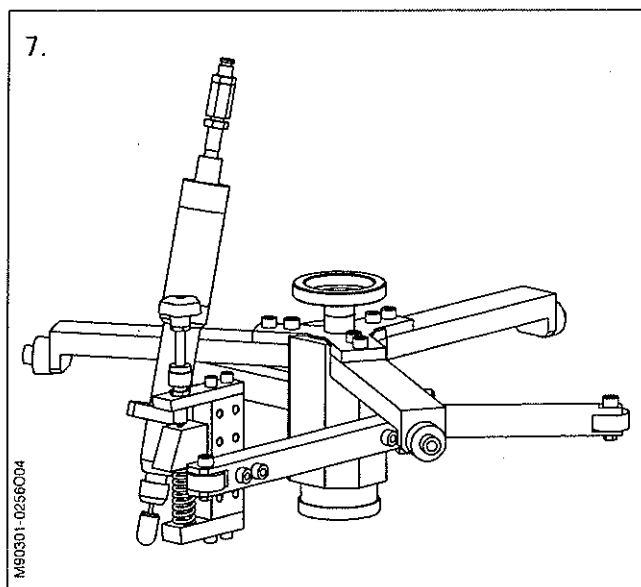


M90301-0258O05

6.



M90301-0258O06

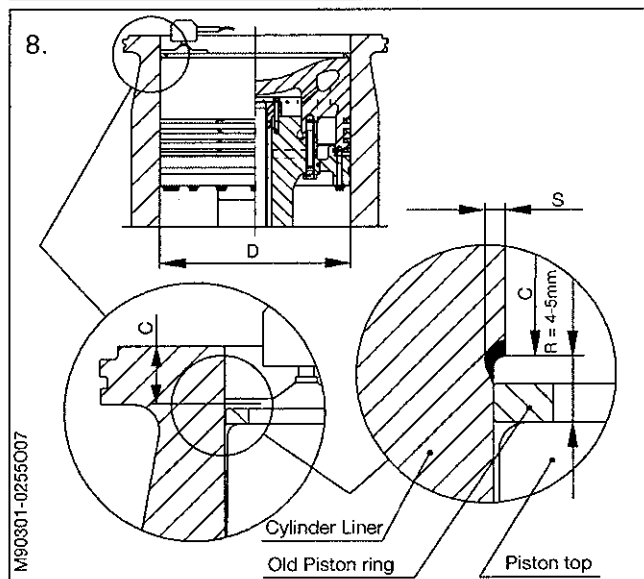


7. It is recommended to use a wear ridge milling machine to create the groove. *For use of the milling machine, see supplier's instruction.*

8. Alternatively, place an old piston ring on the top of the piston and turn to a position that enables the grinding disc to rest on the old piston ring while removing the wear ridge. Use a grinding disc with a round edge.

Check the distance **C** before grinding to ascertain that the wear ridge was caused by the top ring at TDC.

The maximum depth of the groove is calculated as $S_{max} = D \times 0.0045$.



Note!

It is of the utmost importance that the groove is made with a regular rounding as shown in the sketch.

9. If necessary, mount a new cylinder liner.

Note!

If a new cylinder liner is mounted, a new piston cleaning ring must also be mounted after mounting the piston.

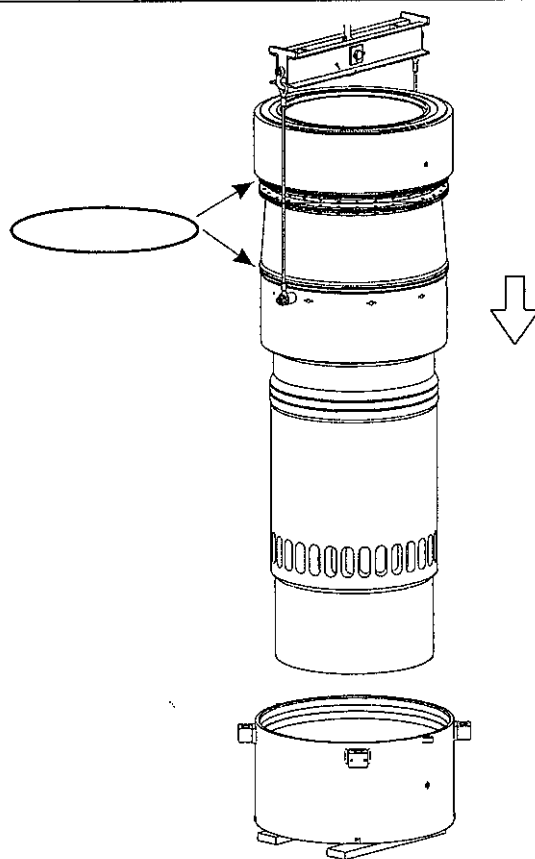
Apply a thin layer of grease on the contact surface for the cooling jacket on the liner.

Mount the lifting tools on the liner. Lift the liner a little and mount new O-rings for the cooling jacket. Then place the liner in the cooling jacket.

Remove the lifting tools.

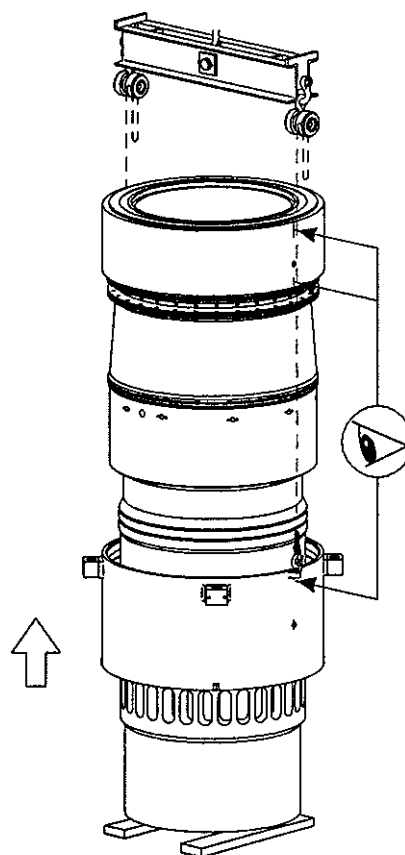
10. Lift the cooling jacket into position – marking scratches jacket/cylinder liner must coincide (manoeuvring side).

9.

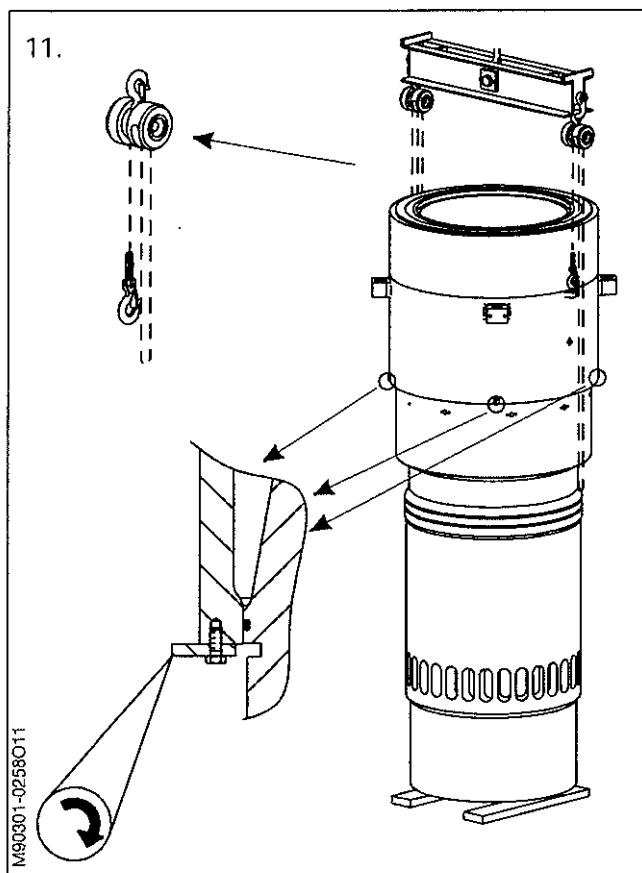


M90301-0258009

10.



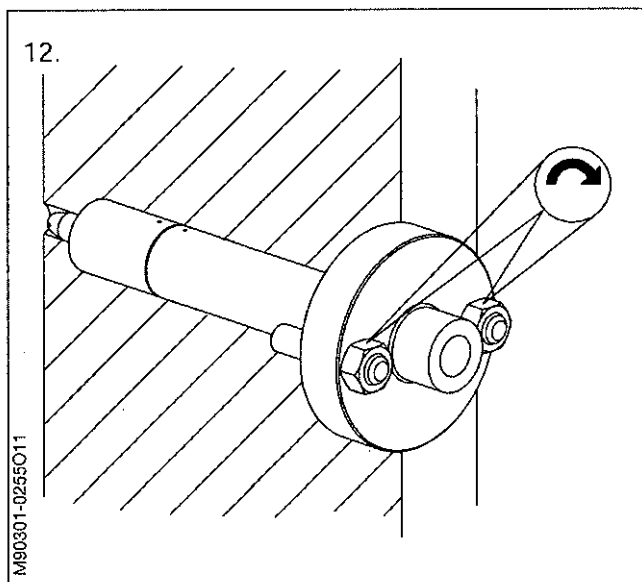
M90301-0258010



11. Turn the clamps until they fit in the groove of the liner, and tighten the screws.

Remove the tackles and the eye bolts from the cooling jacket.

12. Mount the non-return valves for cylinder lubrication.



1. Mount the lifting tools on the cylinder liner and tighten to the specified torque.
See Data.

Hook the lifting tools on to the crossbar, and lift the jacket/liner assembly.

Mount the lowermost O-ring and apply a little lubricating oil on the ring.

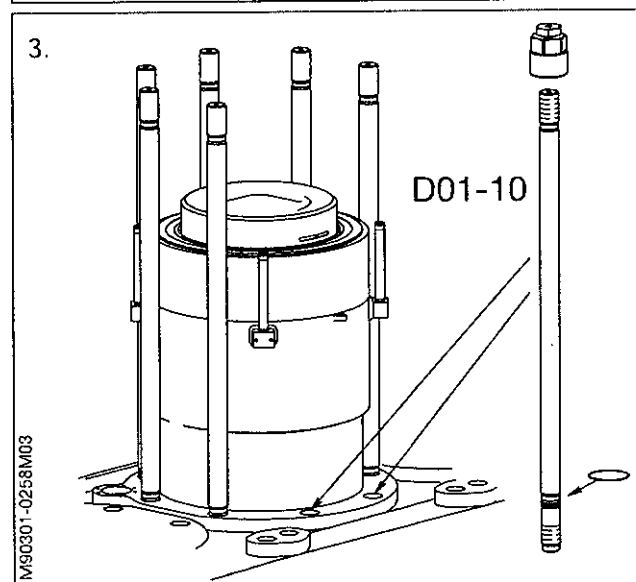
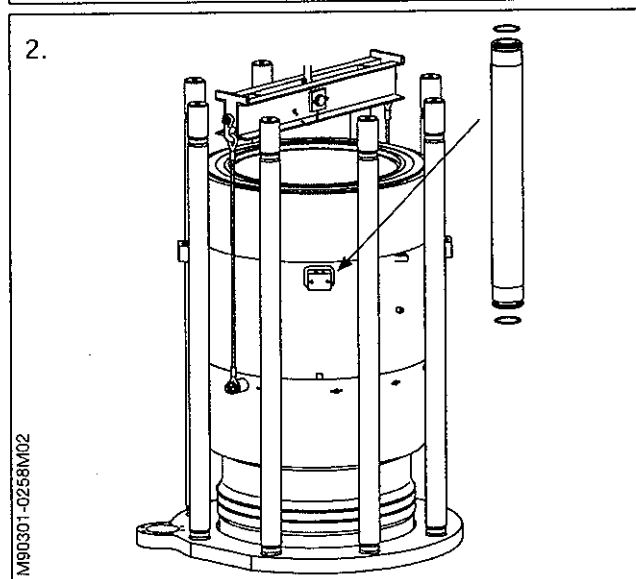
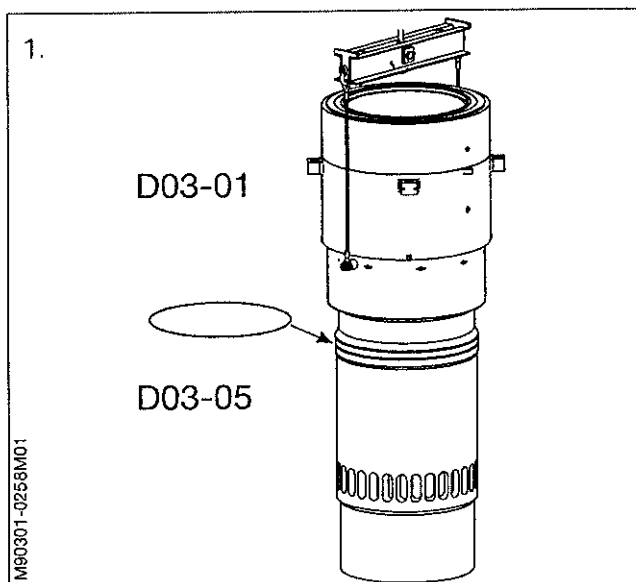
2. Check that the joint surfaces on the cylinder frame and cylinder liner are completely clean.

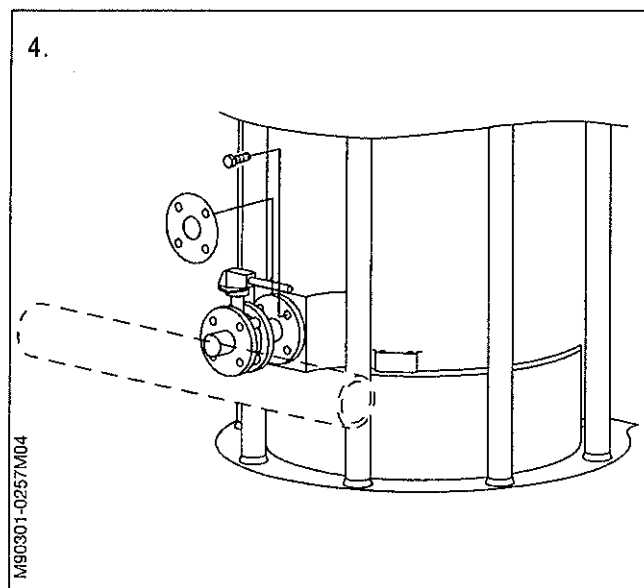
Coat the joint surfaces with permatex or a similar liquid sealing compound.

Mount the cylinder liner in the cylinder frame. Replace the O-rings on the water connections and mount the water connections on the cooling jacket.

3. If one or more cylinder cover studs have been removed during the dismantling of the cylinder cover, discard the old O-rings and mount new ones on the cylinder cover studs.

Mount the studs in the cylinder frame, using the stud setter.





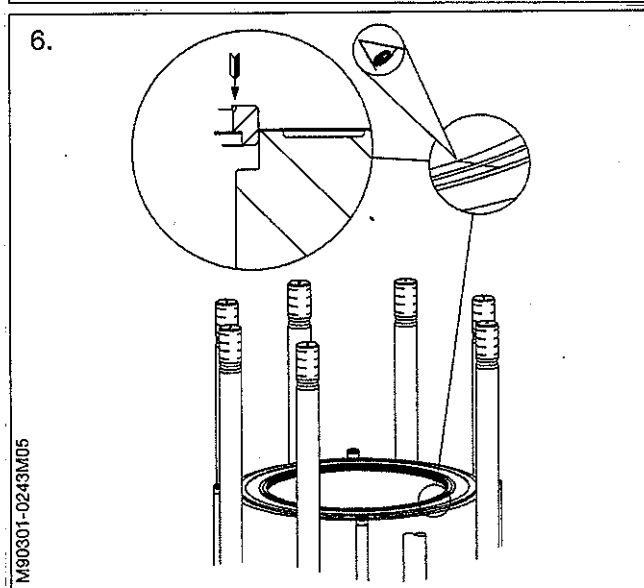
4. Screw the pipes from the lubricator on to the non-return valves, but do not tighten.

Vent the cylinder lubricating system by pumping through until oil, without air bubbles, comes out from the union pipe/non-return valve.

When this is in order, tighten the pipes firmly on the non-return valves and again pump manually until it is certain that each individual lubricating point functions correctly.

5. Lubricate the inside of the cylinder liner with cylinder lubricating oil and mount the piston.

See Procedure 902-1.4.



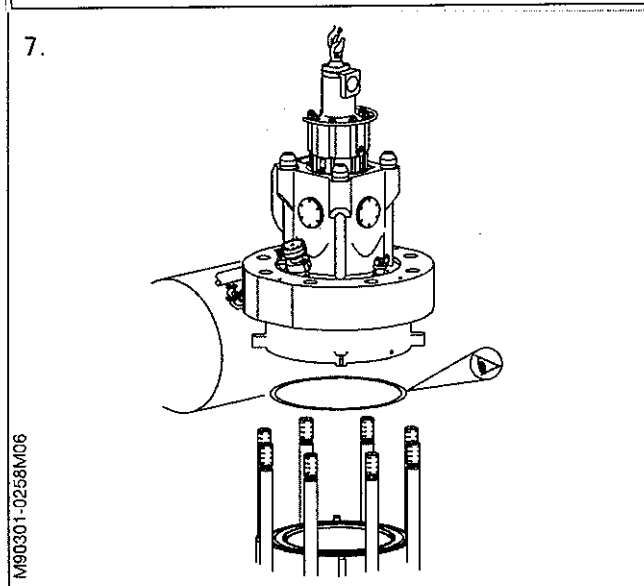
6. Mount the piston cleaning ring.

Note!

Make sure to mount the piston cleaning ring correctly, so that the scratch marks are aligned.

7. Mount the cylinder cover, see Procedure 901-1.4.

Tighten the upper water connections on the cooling jacket as soon as the cylinder cover is correctly positioned.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90364		Test Equipment for Lubricator

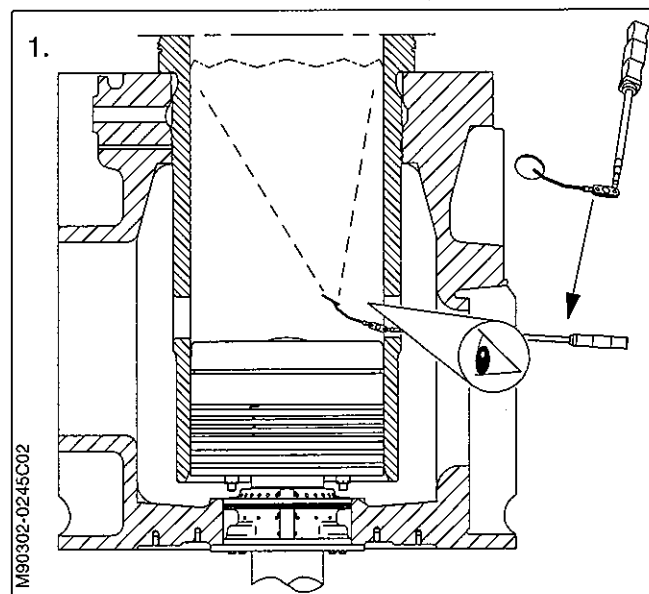
Check of Oil Injection:

With stopped engine and normally when the system has been disassembled:

1. Activate the prelub.-function on the MOP control panel, and check that the lubricators concerned are operating correctly by watching through the covers for scavenge port inspection.

Turn the piston concerned to BDC and check inside the liner e.g. with a mirror and a powerful light source that all lubrication points are working properly.

For use of the MOP Panel, see Volume I Chapter 703.



With running engine:

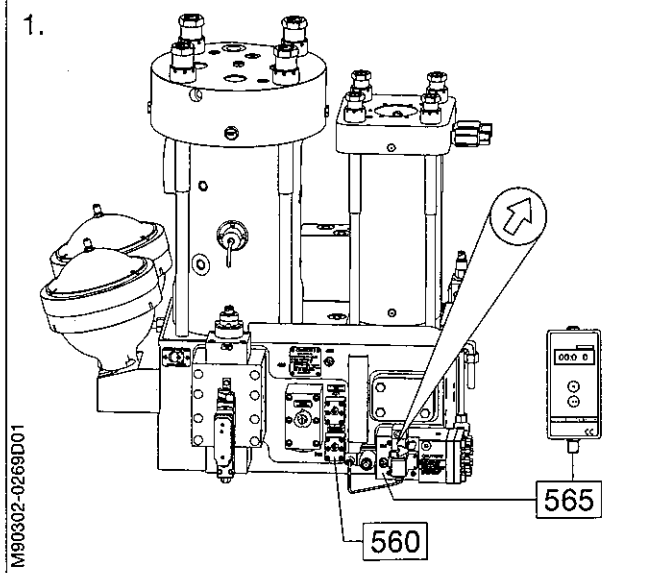
2. The system is automatically checked.

The Engine Control System will generate an alarm if faults occur.

Additionally, it is possible to check the pressure shocks from the injection of the lubricators on each lubricator pipe by feeling with a hand.

If in doubt, disconnect the pipe at the cylinder liner to observe the oil flow.

1.

**Dismantling of lubricators:**

The engine must be stopped and blocked before dismantling a lubricator.

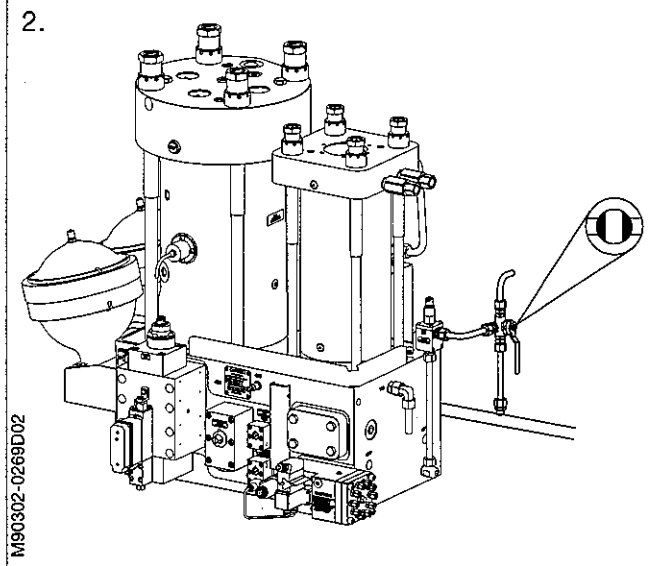
Disconnect the electrical plug on the side of the lubricator.

1. Mount a pressure gauge at "minimess" point 565.

Check the pressure.

Close valve 560. Check that the cylinder lubricator is pressure free. If pressure is still present, activate the "prelub" function on the Mop panel to remove the pressure.

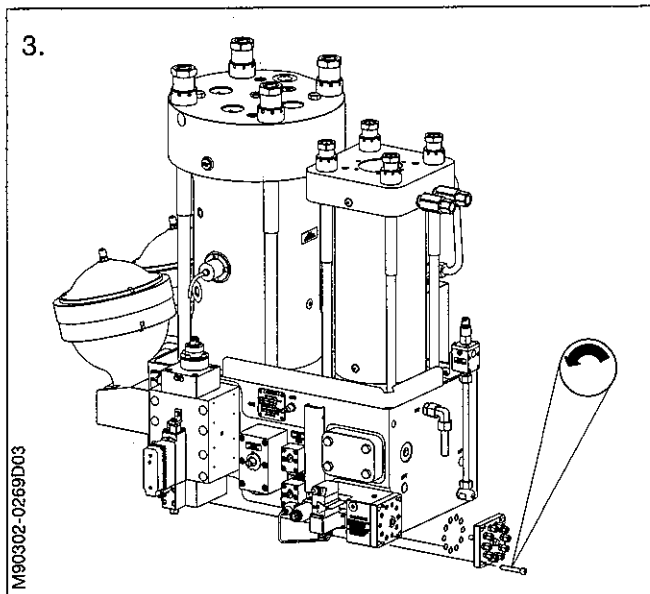
2.



2. Close the supply valve for cylinder lubricating oil.

3. Unscrew the four screws in the aft side of the lubricator and disconnect the cover with pertaining pipes.

3.



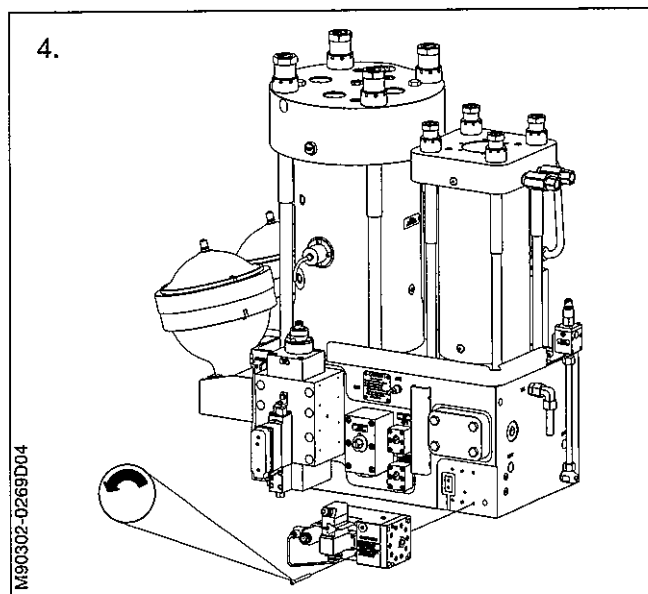
4. Unscrew the four screws on the front that secure the lubricator to the hydraulic cylinder unit.

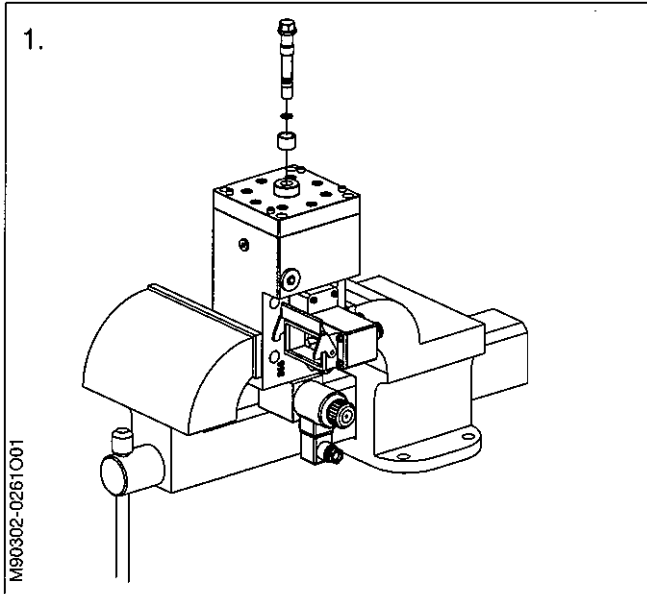
Pull the pipe flange aftwards and pull the lubricator out and clear of the guide pins.

Special running

It is possible to change a lubricator while the engine is running if a spare lubricator with O-rings and the necessary tools is available. The change should be done in a maximum of 15 minutes.

- Reduce the engine rpm to below 40% of MCR-rpm
- Dismount the lubricator as described in steps 1-3
- Mount a spare lubricator as described in Procedure 903-2.4.





1. Place the lubricator in a bench vice with soft "jaws".

Remove the adjusting screw with bushings.

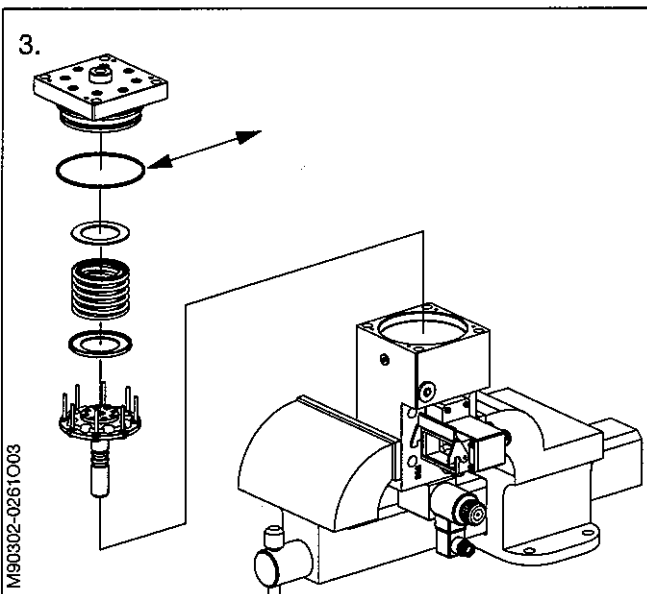
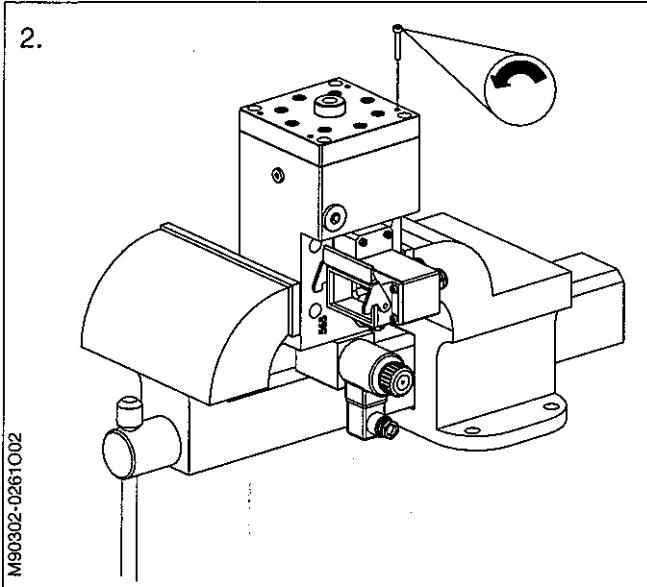
Discard the O-ring from the adjusting screw.

2. Push down the cylinder block and remove the four screws from the cylinder block.

3. Pull up the cylinder block.

Remove the springs, spring discs and actuator piston with plungers.

Remove and discard the O-ring from the cylinder block.



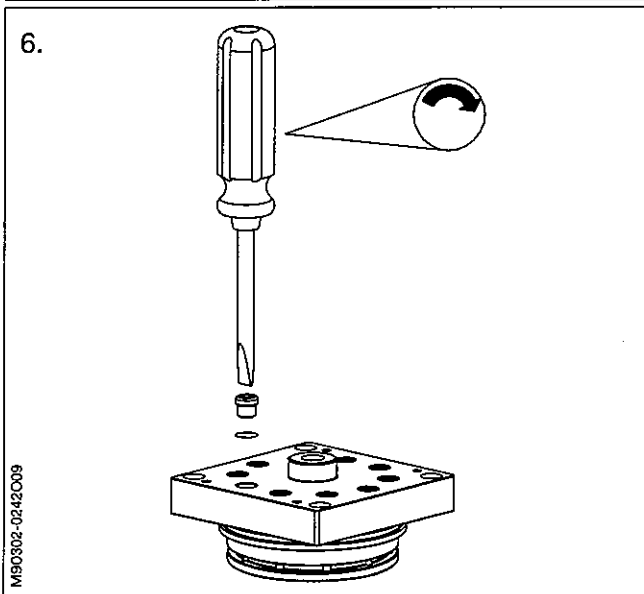
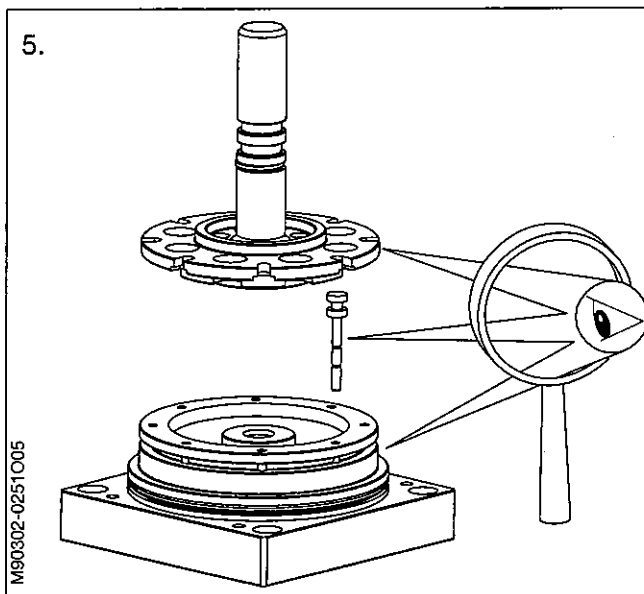
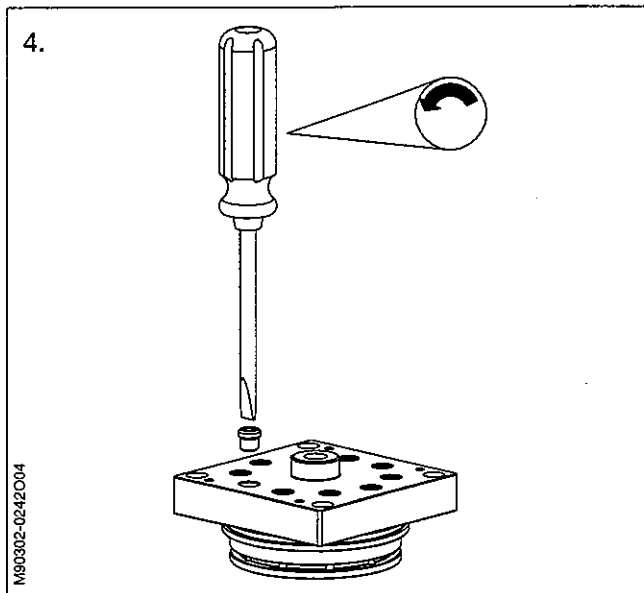
4. Screw out the non-return valves and remove and discard the O-rings.

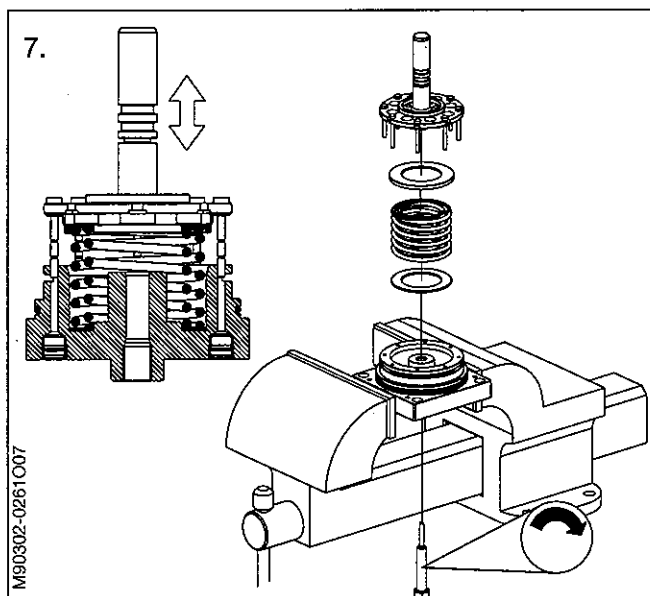
Clean the valves and check them with compressed air.

5. Inspect the plungers, actuator piston and cylinder block for wear, using a magnifying glass.

6. Fit the non-return valve with new O-rings.

Mount the non-return valves in the cylinder block.





7. Fit the cylinder block with a new O-ring. Pre-assemble the cylinder block with the actuator piston and plungers to ensure correct guidance of the plungers, before finally assembling the cylinder block unit.

Fit the springs and spring discs and press down the actuator piston with plungers. Mount the special screw, supplied with the test equipment for accumulators to keep the spring compressed.

8. Remove the cover from the terminal box, and disconnect the wires for the feedback (pick-up) sensor.

Remove the terminal box.

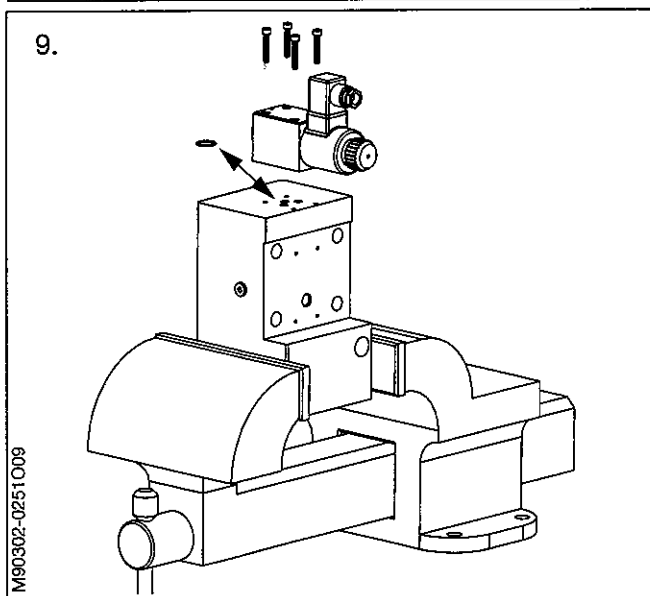
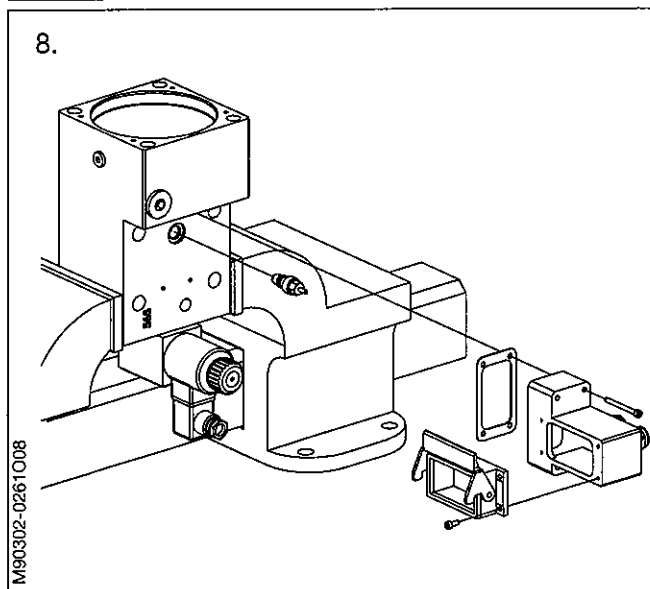
Carefully unscrew the feedback sensor and remove and discard the O-ring.

Clean the housing with diesel oil or kerosene and dry with a non-fluffy cloth.

9. Turn the lubricator upside down in the vice.

Unscrew the solenoid valve.

Discard the O-rings



10. Before mounting the feedback sensor, check that the sensor is flush with the sensor housing.

Install the feedback sensor or a new one, if necessary, with a new O-ring.

Check with an object with a straight edge (e.g. the end of a calliper) that the end of the feedback sensor does not protrude into the actuator piston cylinder.

11. Mount the terminal box.

Connect the wires and mount the cover on the terminal box.

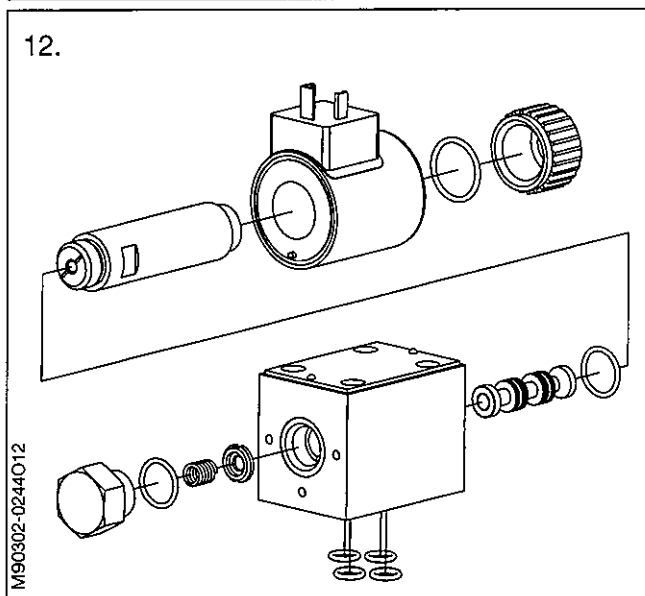
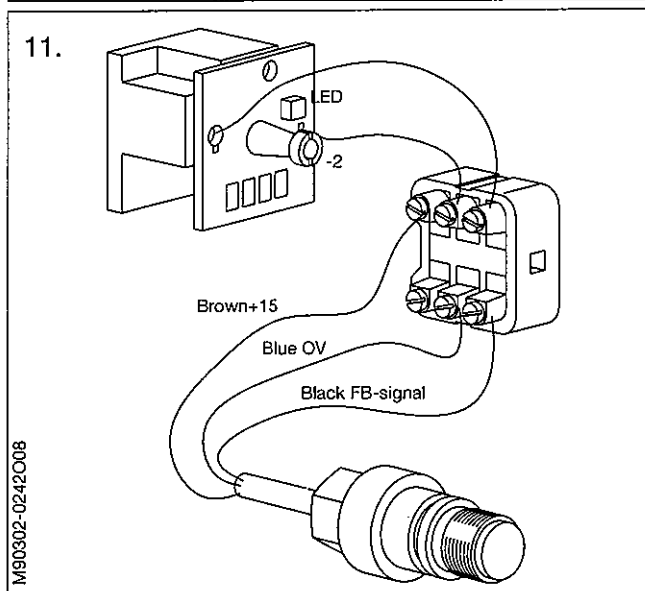
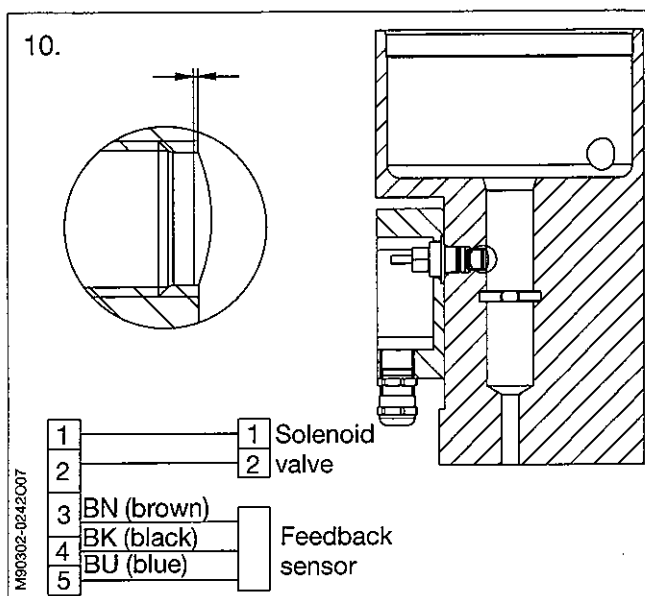
Solenoid Valve:

12. Disassemble and clean the valve.

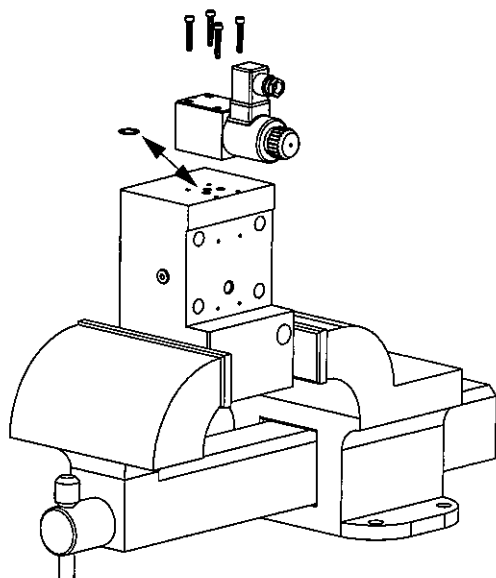
Check the slide for wear. If the slide is scratched or scuffed, the valve must be replaced by a new one.

Lubricate the slide with oil and check that the slide can move lightly with a good fit in the housing.

Assemble the valve.



13.



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13. Install the solenoid valve fitted with new O-rings. Coat the O-rings with a little grease to keep the rings in place during mounting.

14. Fit the cylinder block assembly in the cylinder housing.

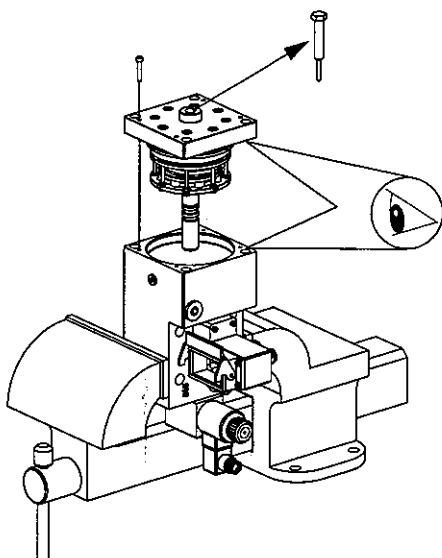
Check that the spring pin engages correctly with the cylinder block assembly.

Mount the screws and tighten the block to the housing.

Remove the special screw.

15. Mount the adjusting screw fitted with a new O-ring and the distance bushing.

14.

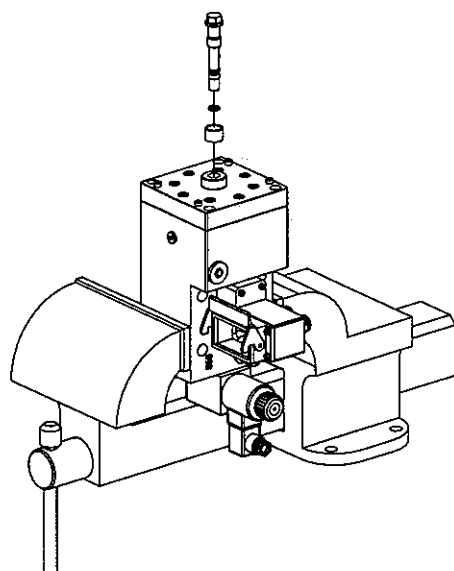


M90302-0261014

16. If the lubricator is not to be installed on the engine immediately after overhauling, cover all openings with plastic to prevent dirt from entering the lubricator during storage.

Cover all surfaces with a thin layer of oil.

15.



M90302-0261001

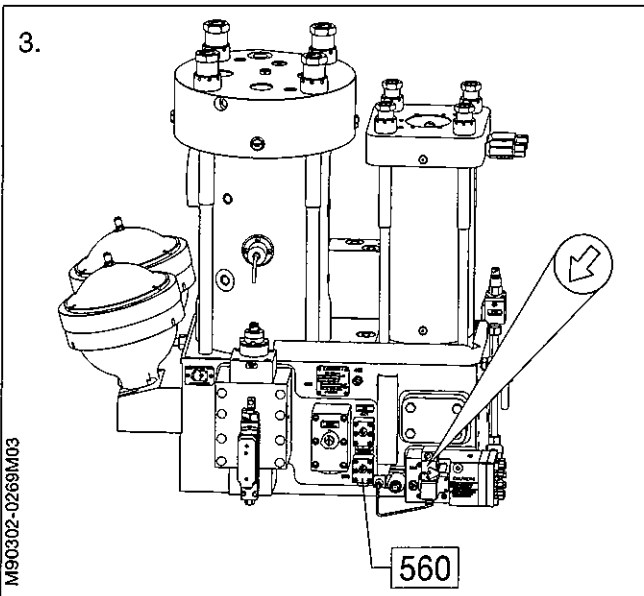
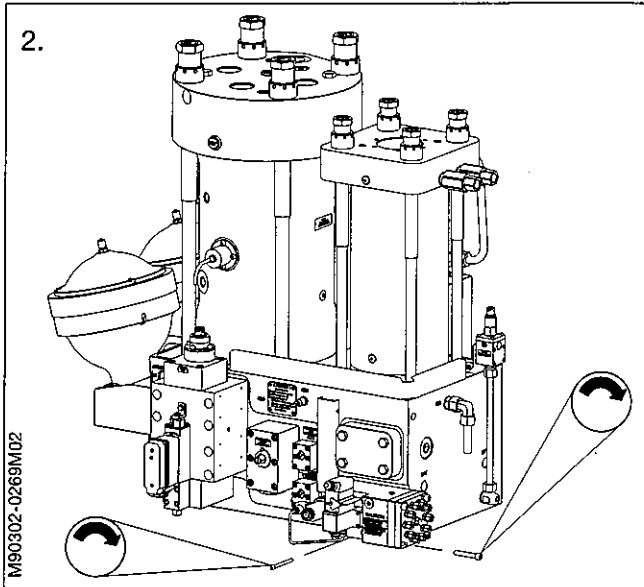
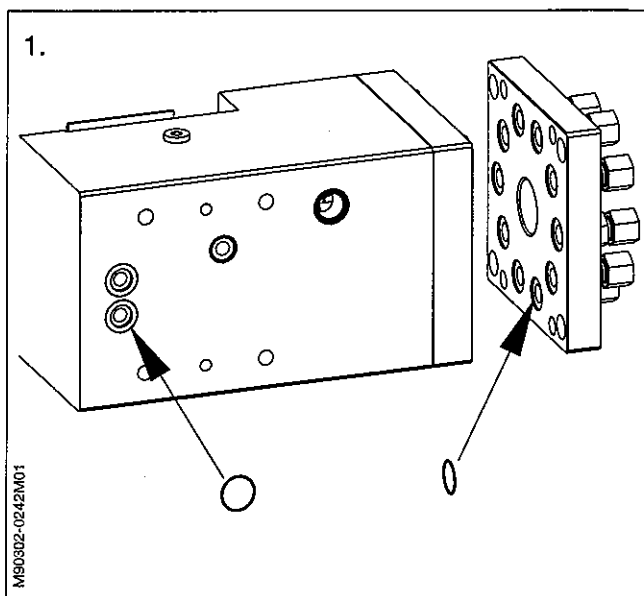
1. Fit new O-rings on the lubricator and on the cover with pipes.
2. Fit the lubricator and tighten the screws on the hydraulic cylinder unit.

Tighten the screws in the aft end of the lubricator to the pipe connection.

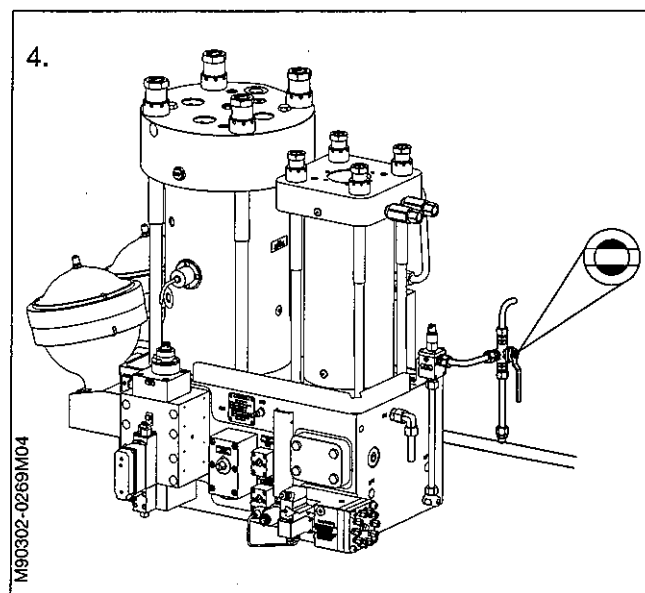
Connect the cylinder oil supply pipe.

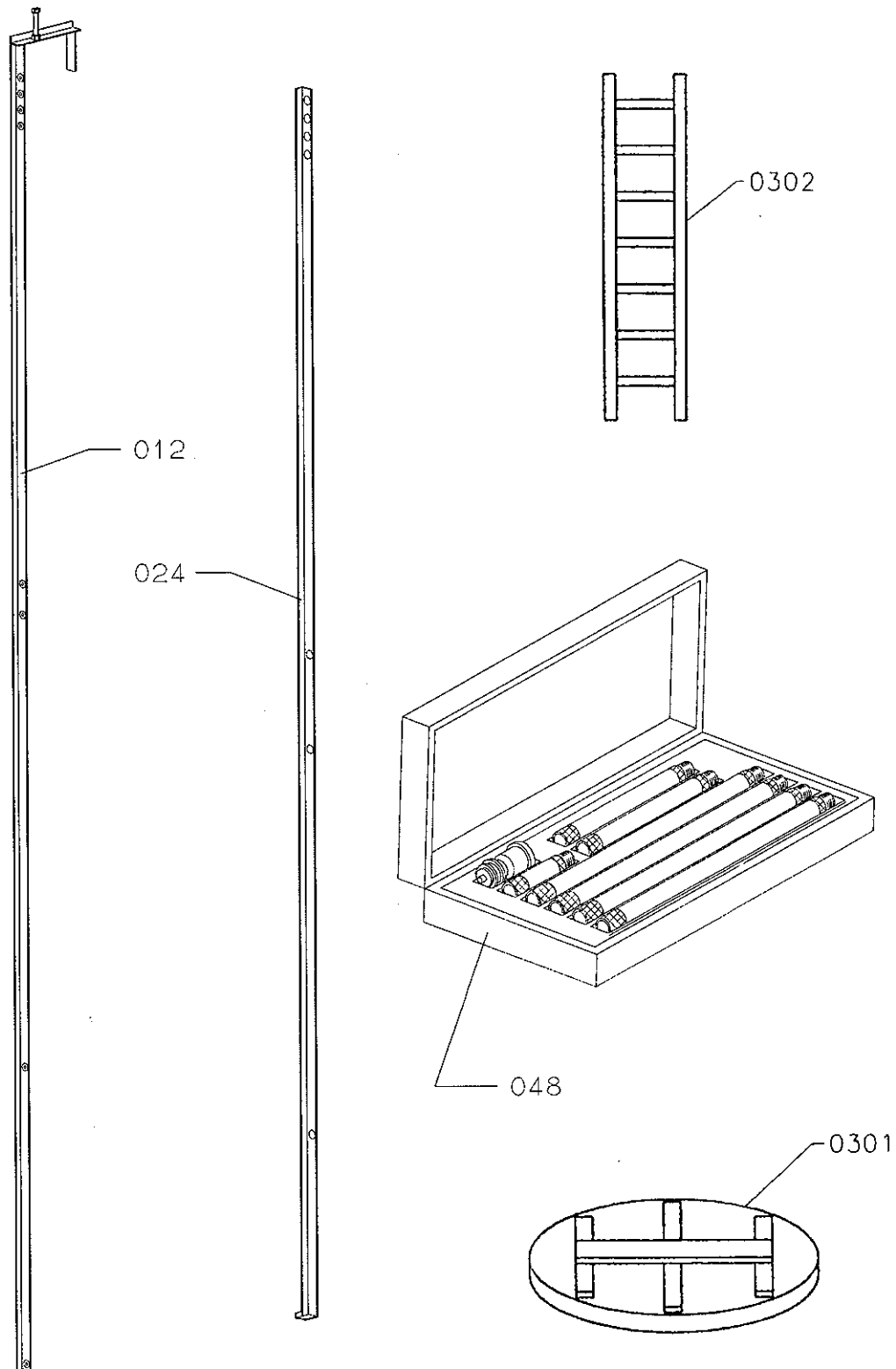
3. Mount the electrical plug. Check the injection of cylinder oil on the feedback LED on the terminal box for the specific lubricator.

Open valve 560 for hydraulic oil supply.



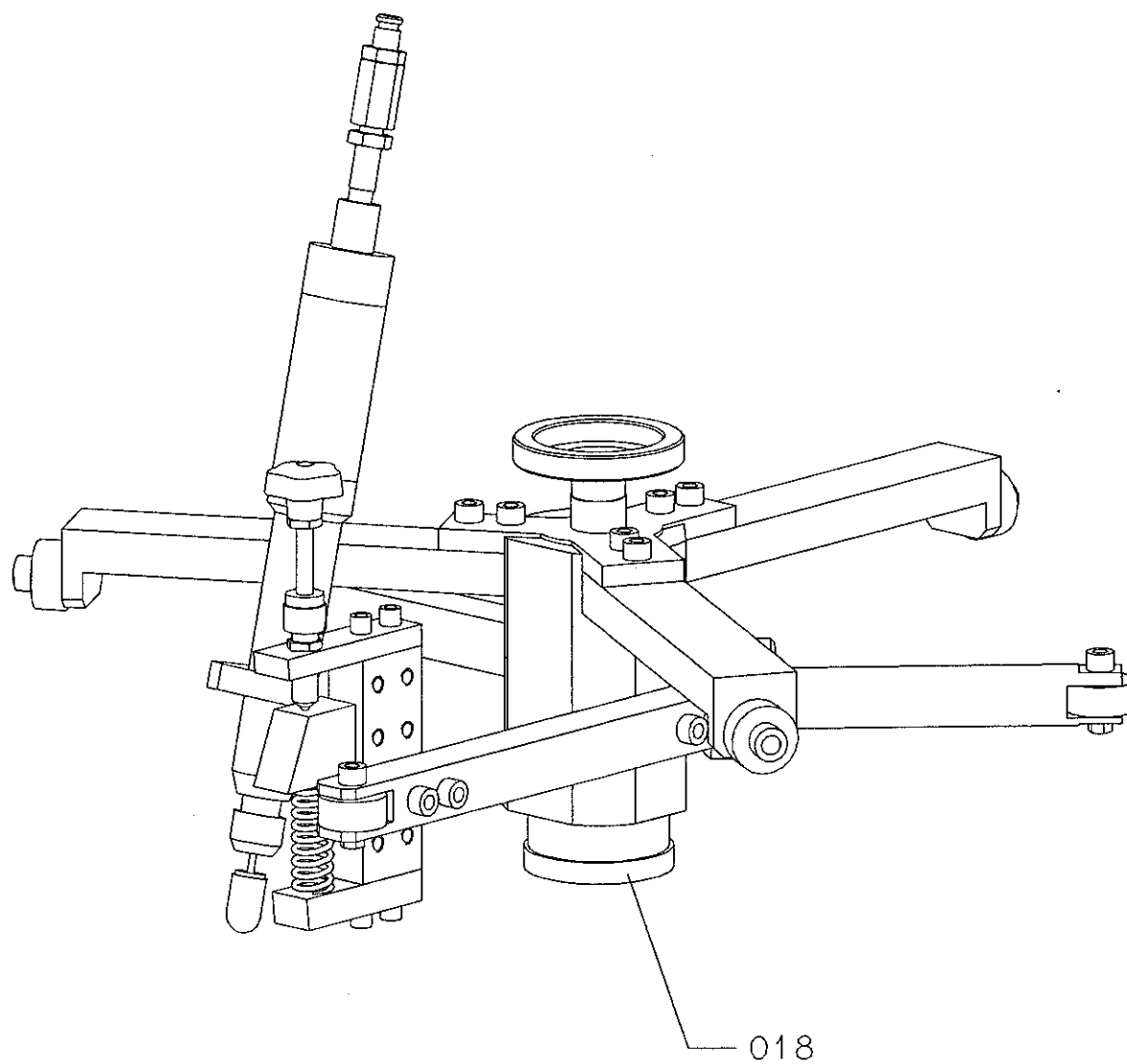
4. Open the valve for cylinder lubricating oil supply.





Item No.	Item Description
012	Measuring rod for cylinder liner, long
024	Measuring rod for cylinder liner, short
048	Measuring tool for cylinder liner
0301	Cover for cylinder bore
0302	Ladder for cylinder liner

Item No.	Item Description



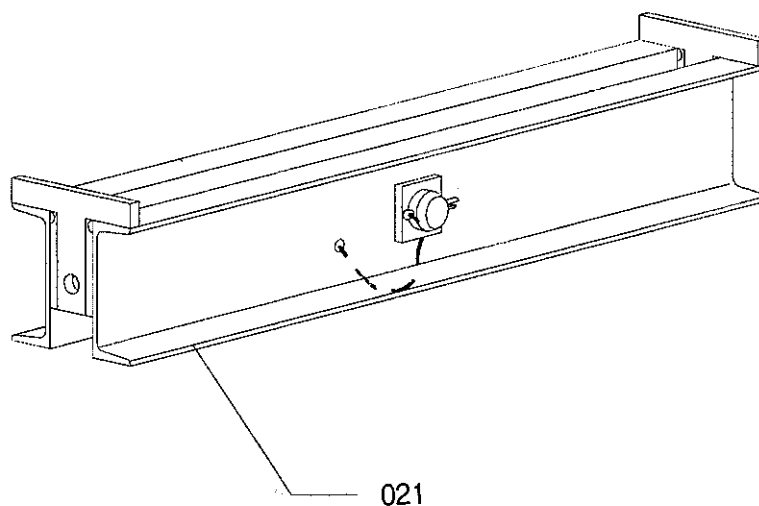


Plate 90366-0004

Cylinder Liner Lifting - Tools

Item No.	Item Description	Item No.	Item Description
021	Crossbar for cylinder liner		

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-01	Crosshead bearing, top clearance max.	0,7	mm
D04-02	Crosshead bearing, top clearance min.	0,35	mm
D04-03	Oil wedge length, L	20	mm
D04-04	Crosshead bearing cap	1285	kg
D04-05	Crosshead bearing shell, upper	118	kg
D04-06	Crosshead bearing shell, lower	190	kg
D04-07	Crosshead bearing cap with bearing shell	1400	kg
D04-16	Thrust piece, tightening torque	450	Nm
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

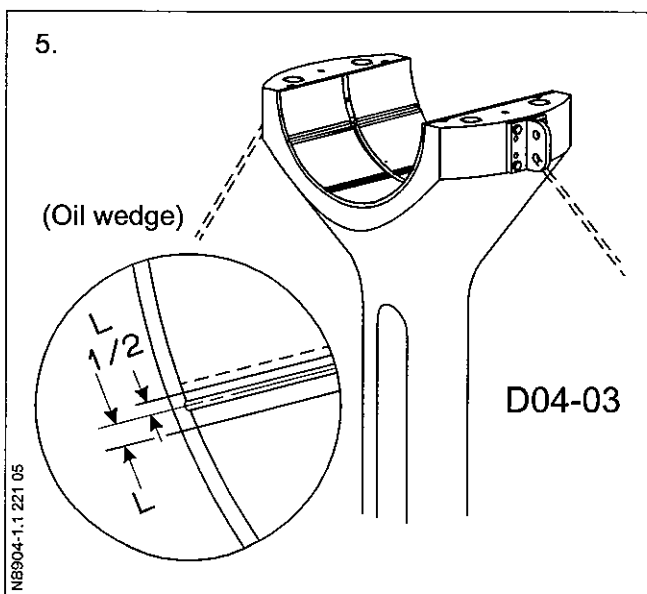
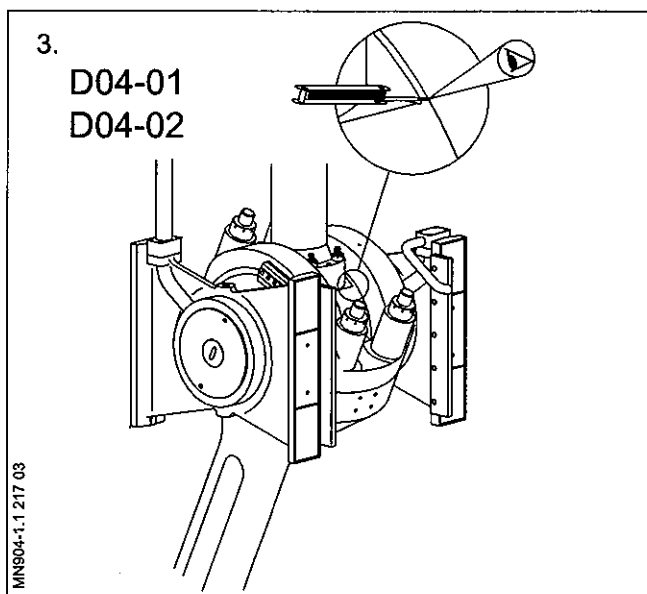
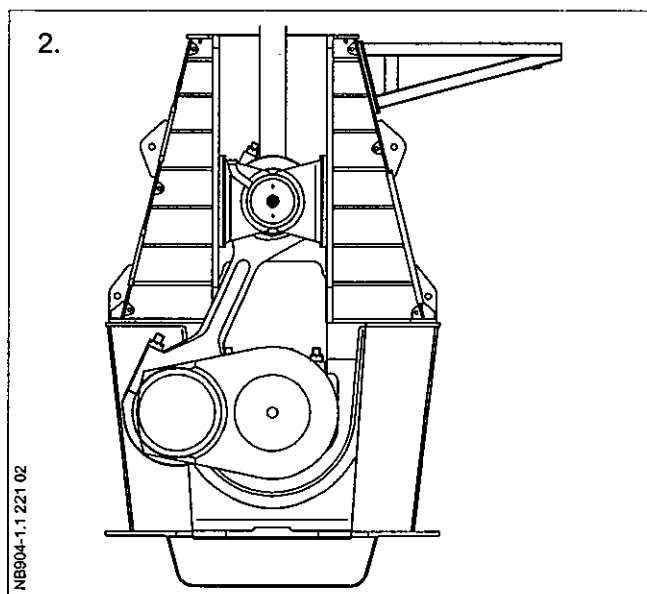
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

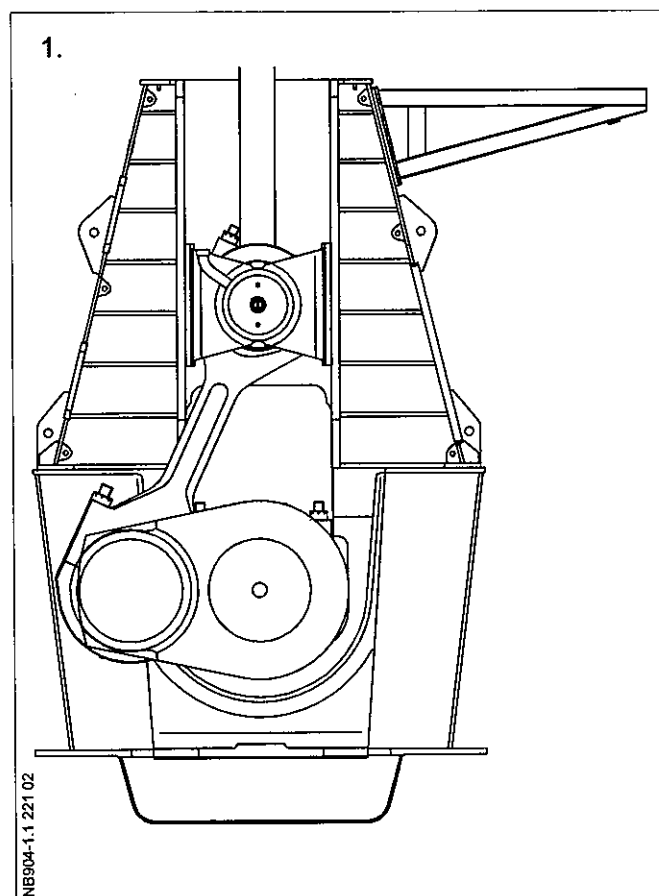
Plate	Item No.	Description
P90262		Hydraulic jack for piston rod
P90451	47	Wire guide
P90451	59	Lifting attachment - connecting rod
P90451	72	Chain for suspending piston
P90451	84	Retaining tool telescope pipe
P90451	202	Extension (X-Head Cap / Piston Rod)
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	117	5-way distributor block, complete
P91356		Lifting Tools, Etc.
P91359		Torque Spanners
P91366	57	Feeler gauge
P91368		Working Platforms

The top clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assembly components.

For the top clearance of a specific bearing, see the measurement in the Adjustment Sheet in Volume I, OPERATION.

1. Open the crankcase door at the relevant cylinder.
2. Turn the crankthrow concerned to 90° before BDC on the exhaust side.
3. Measure the clearance in the crosshead bearing by inserting a feeler gauge between the bearing cap and the crosshead journal, exactly next to the landing surface for the piston rod foot. See *Data*.
4. The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm. If so, the crosshead bearing must be disassembled for inspection.
See Procedure 904-1.2.
5. The wear limit for a crosshead bearing shell is confined to a 50% reduction of the oil wedge length (L). See *Data*.
6. *For further external inspection of the crosshead bearing, see Chapter 708, 'Bearings' in the instruction book, Volume I, OPERATION.*





This procedure applies to the following two dismantling situations:

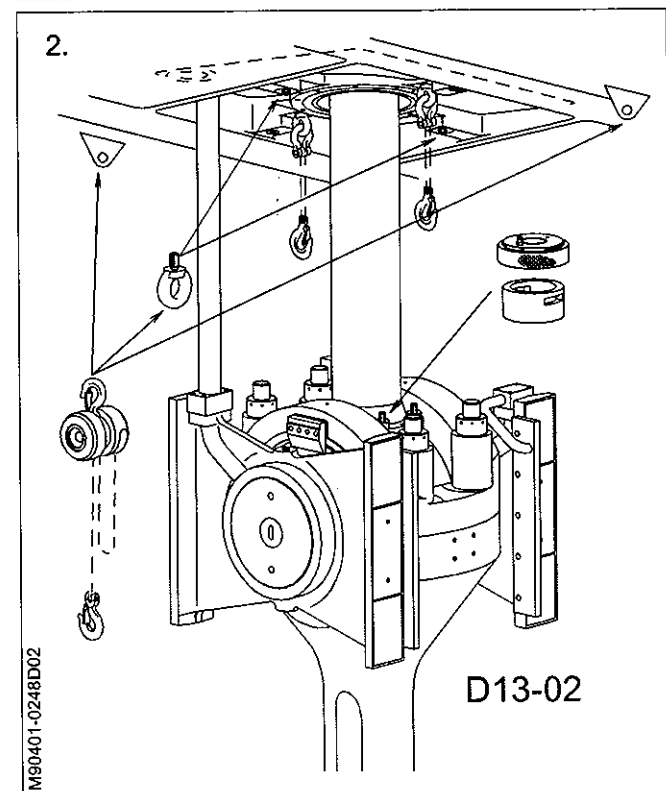
- with piston mounted (steps 1 to 16)
- with piston removed (steps 5 to 16)

1. Turn the crankshaft down far enough to give access to the nuts and screws on the piston rod.
2. Mount two chains in the inner screw holes in the top of the crankcase, in the athwartship direction, for suspending the piston rod.

Mount two eye bolts in the outer screw holes in the top of the crankcase, in the fore and aft direction, and hang up two tackles. Suspend two tackles from the lifting brackets in the athwartship direction.

Place the spacer rings on the piston rod nuts and screw the hydraulic jacks on to the studs.

Loosen the nuts. *For operation of the hydraulic jacks, see Procedure 913-1.*



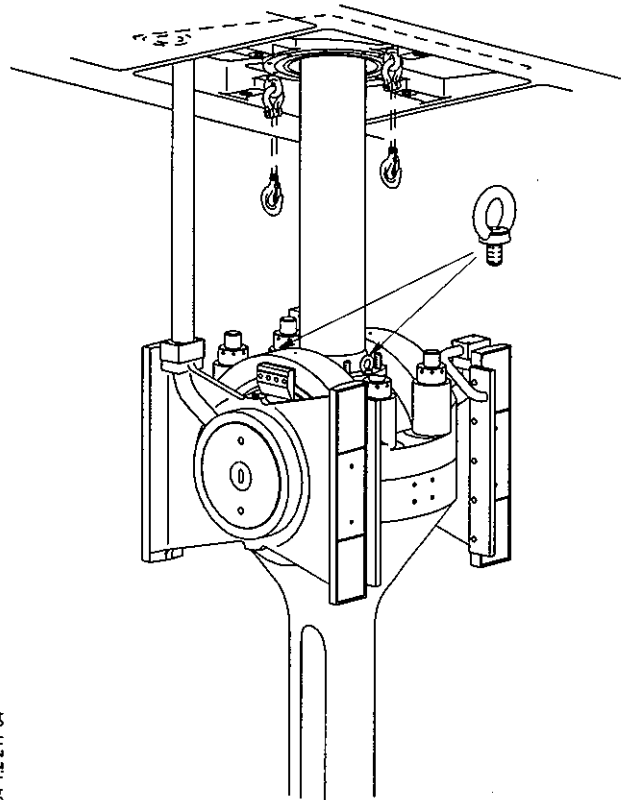
3. Mount a lifting eye bolt on each side of the piston rod.

Turn the crosshead to TDC.

4. Hook the chains to the lifting eye bolts in the piston rod.

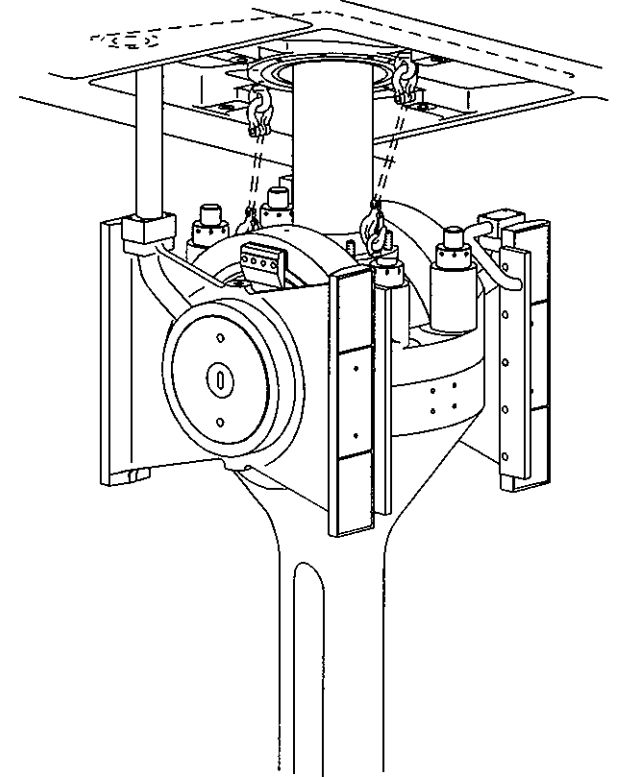
Turn the crosshead downward, and the piston rod will remain suspended from the two chains.

3.

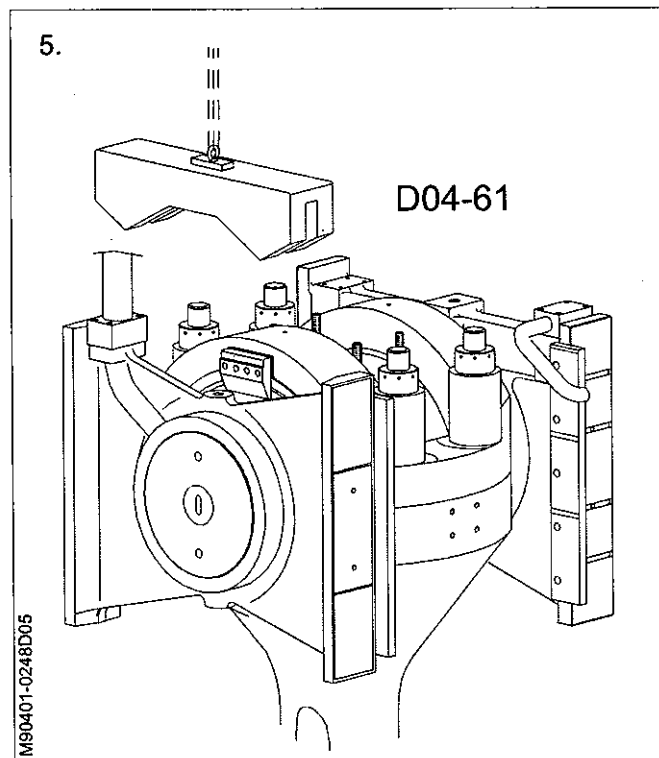


MN904-1.2 217 04

4.



MN904-1.2 217 05



5. Turn to BDC.

On some engines the guide shoes on a number of cylinders may be fitted with counterweights.

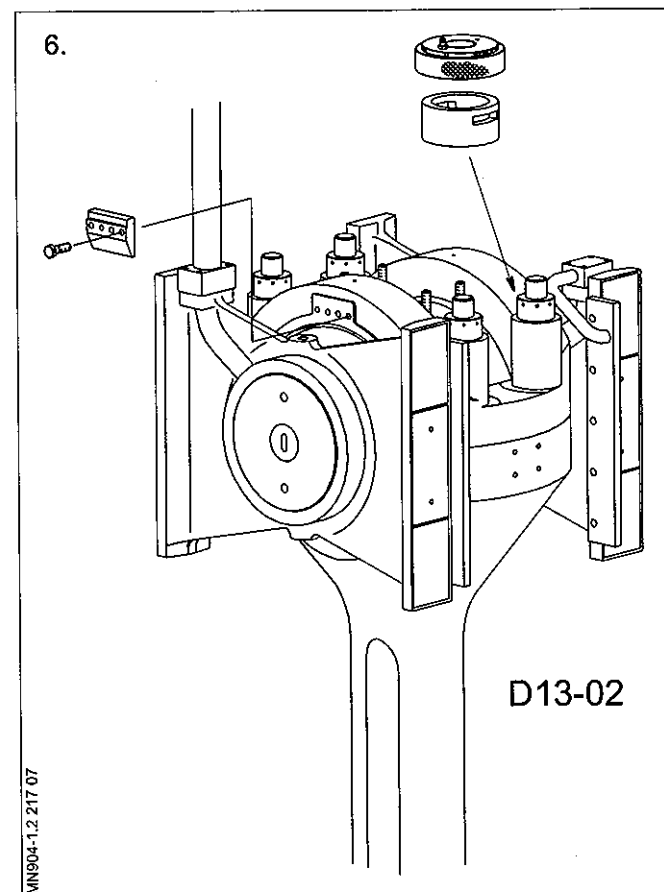
If necessary, dismantle the counterweights and suspend them in the top of the crank casing.

6. Place the spacer rings around the nuts and screw the hydraulic jacks on to the studs.

Loosen the crosshead bearing cap nuts. *For operation of the hydraulic jacks, see Procedure 913-1.*

Remove the hydraulic jacks and the spacer rings, and unscrew the nuts.

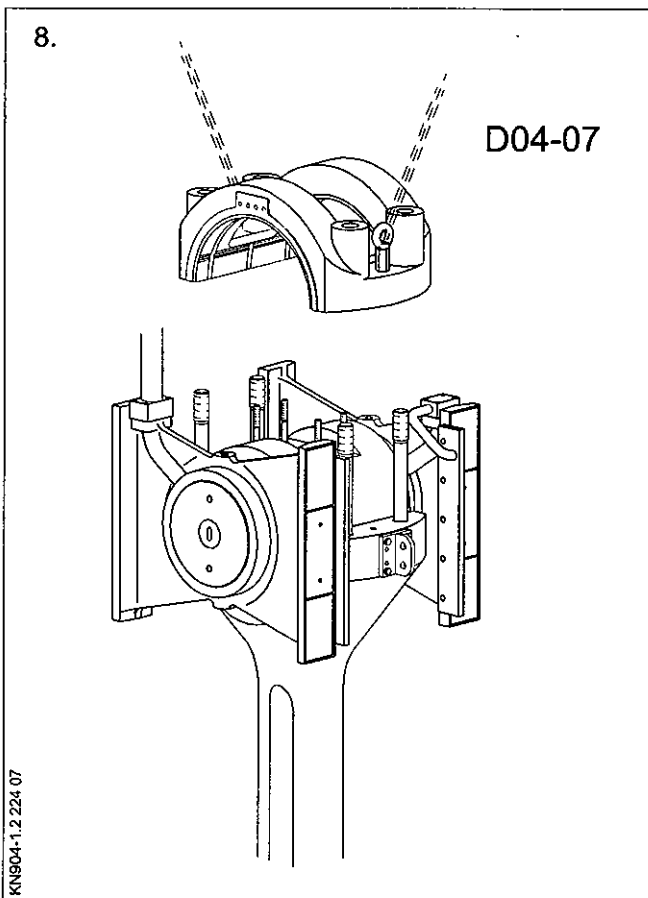
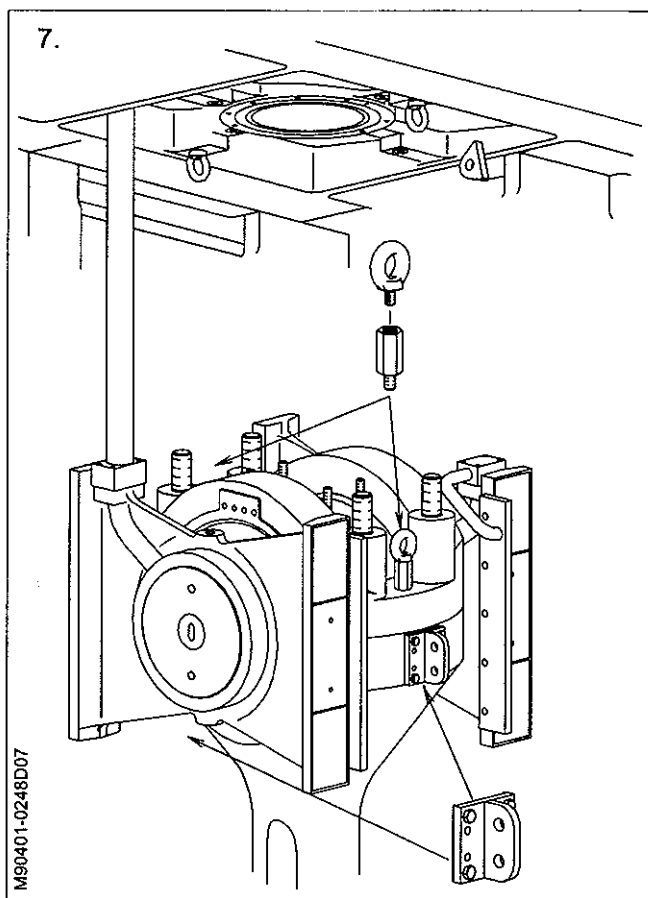
Dismantle the thrust pieces from the bearing cap.

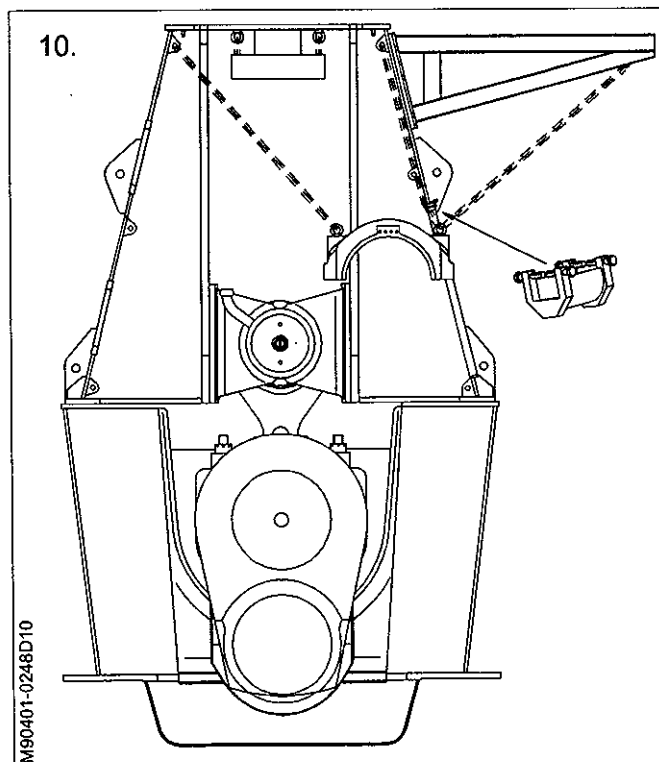


7. Mount the lifting attachments on the head of the connecting rod.

Mount the lifting tools with eye bolts on top of the crosshead bearing cap.

8. Hook the tackles on to the eye bolts and remove the bearing cap from the crosshead.
9. Check the upper part of the journal.





10. Mount the wire guide in the top of the door opening.

Hook a third tackle on to the eye bolt and lift the bearing cap out of the engine.

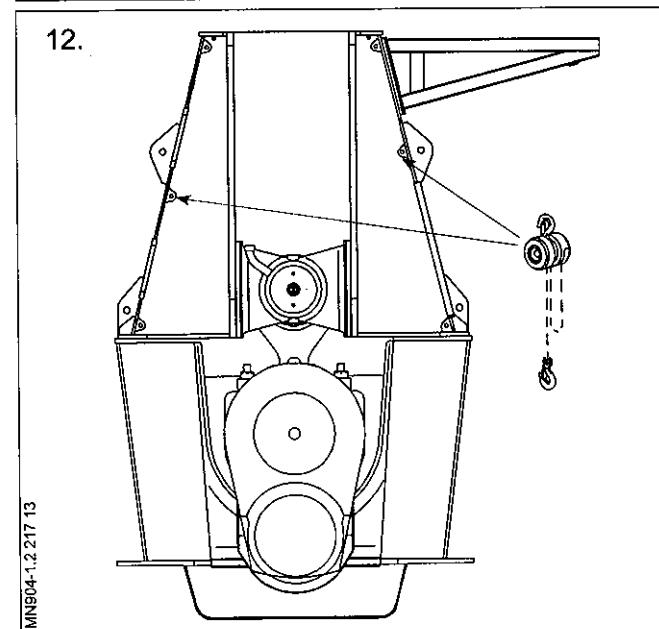
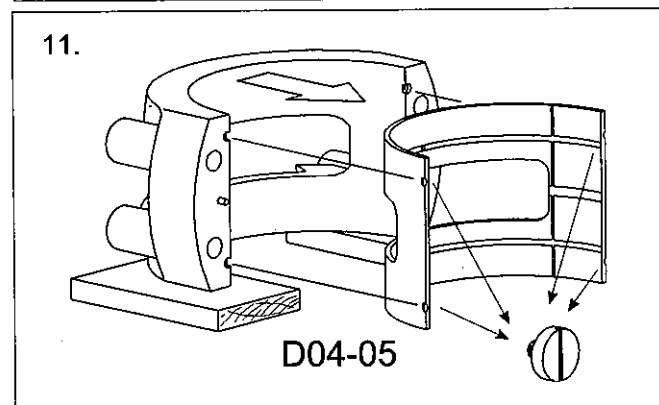
11. Place the bearing cap on one side on a couple of wooden planks.

If necessary, dismantle the locking screws to replace the bearing shell.

12. Fasten tackles to the fixed lifting brackets on the frame box wall.

Hook the tackles onto the lifting attachment on the connecting rod and secure it.

Mount an eye bolt in the top of each guide shoe.

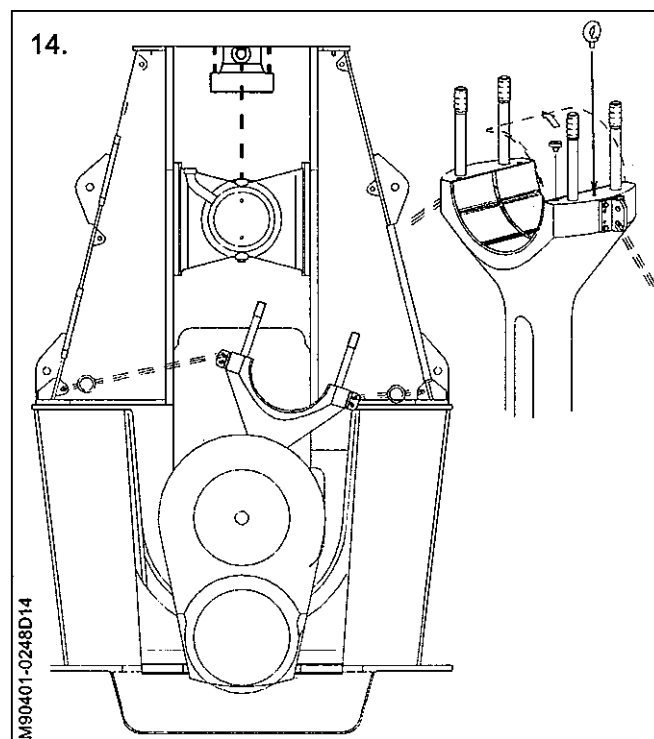
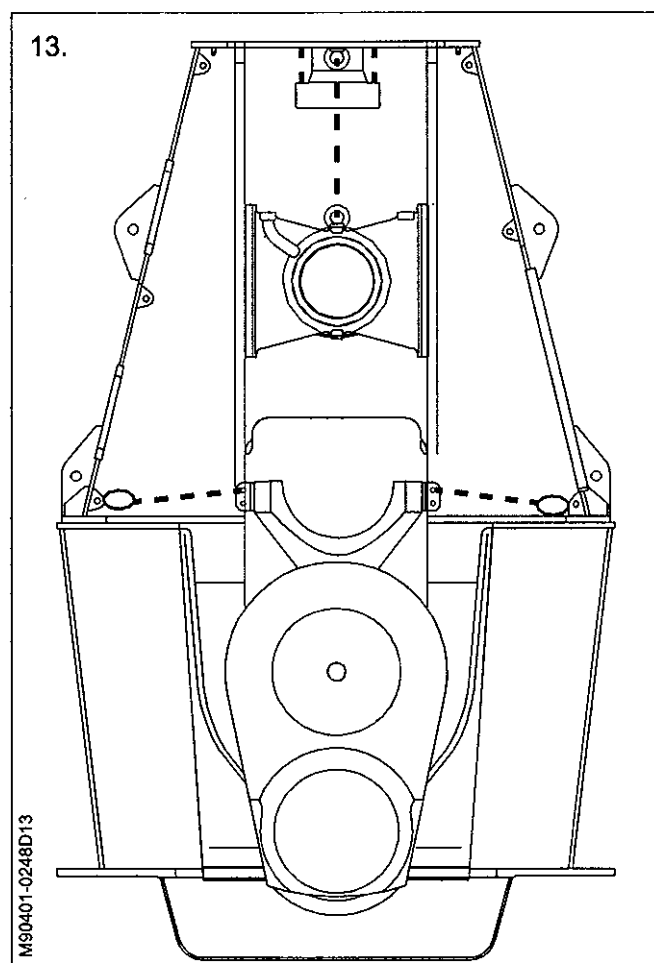


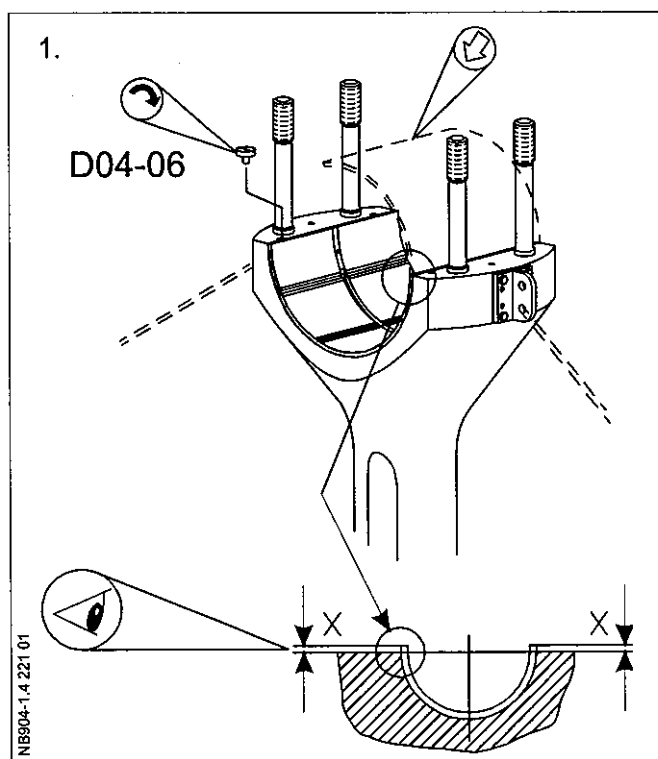
13. Hook the tackles onto the eye bolts in the guide shoes and lift the crosshead to provide access to the crosshead bearing.

14. In cases where it is necessary to remove the lower bearing shell, tilt the connecting rod towards the doorway on the camshaft side, using the tackles.

Dismount the lock screws, and turn the bearing shell so far up that an eye bolt can be mounted.

Lift the bearing shell out of the engine.



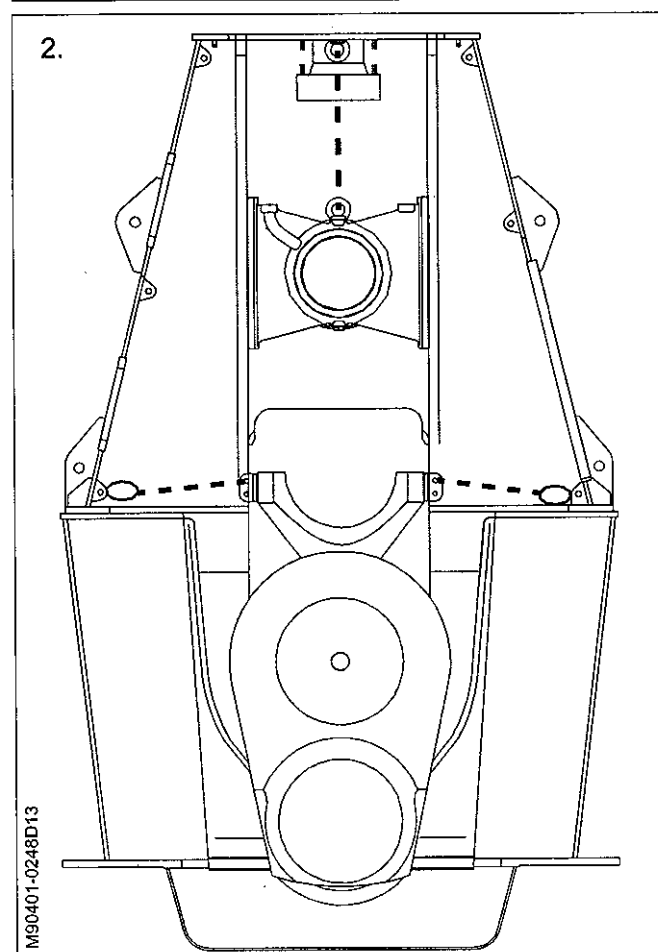


**With the piston mounted/
With the piston removed:**

1. Mount and secure the bearing shell in the bearing housing.

The excess height **X** is to ensure the correct tightening-down of the bearing shell and **must not** be eliminated.

2. Gently lower the crosshead, taking care not to damage the bearing shell and crosshead journal.



3. Lift the bearing cap into the engine. Lower the bearing cap onto the crosshead and remove the tackles.

Remove the lifting attachments from the connecting rod.

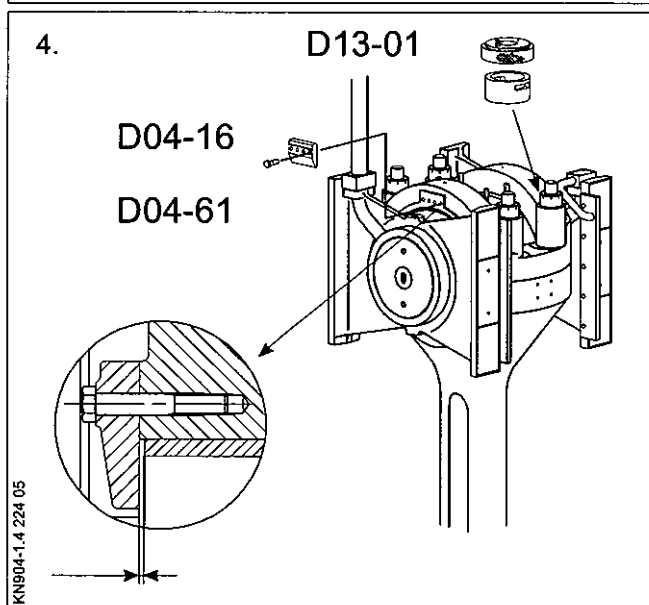
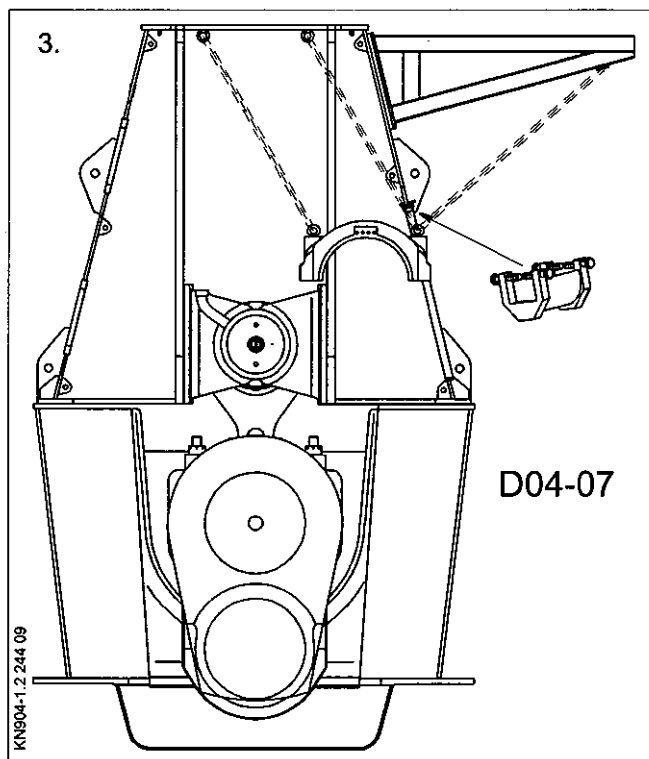
Remove the wire guide from the engine.

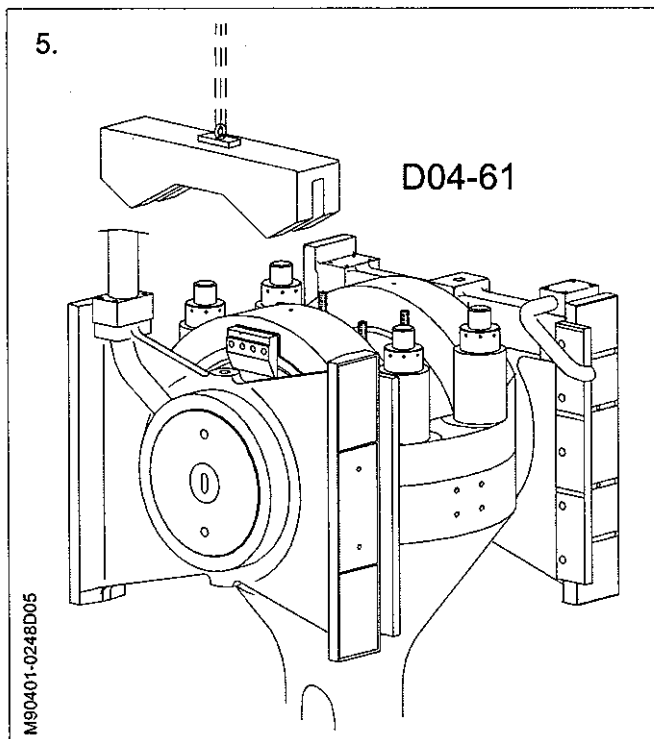
4. Tighten all four crosshead bearing cap nuts simultaneously. *See Data.*
For operation of hydraulic jacks, see Section 913-1.

Mount the thrust pieces on the bearing cap. Tighten the screws to the torque stated in Data.

Note!

It must be ensured that a clearance between the thrust piece and the crosshead exists fore and aft before any tightening of the thrust piece.





5. If the guide shoes are equipped with counterweights, mount the counterweights on the guide shoes.

Tighten the screws and secure with locking wire.

6. Mount the piston.
See Procedure 902-1.4.

With the piston mounted:

7. Use a rubber cover to cover the oil inlets/outlets on top of the crosshead.

Mount all hydraulic nuts on the studs, screw down until the nuts are flush with the top of the studs.

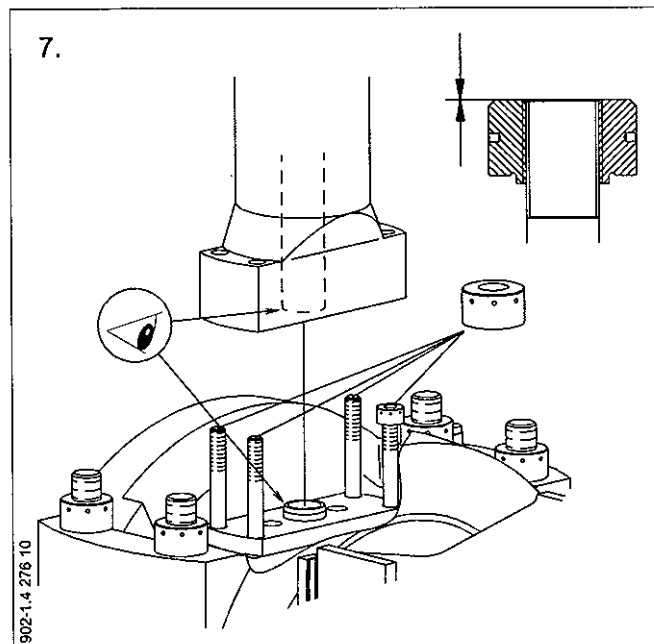
Turn the crosshead upwards until the piston rod foot lands on the nuts, thereby turning the crosshead until the face is parallel to the piston rod foot.

Lower the crosshead just enough to enable removal of the nuts and the rubber cover.

If any shims have been removed from the crosshead, mount them again.

Turn the crosshead upwards until the piston rod lands on the crosshead. When mounting the piston on the crosshead, make sure that the piston rod foot does not damage the threads of the studs.

Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.



8. Unhook the chains from the lifting eye bolts in the piston rod. Remove the chains and eye bolts from the top of the crankcase, from the piston rod and from the crosshead bearing cap.
9. Turn down to BDC and mount the hydraulic jacks on the studs. *For operation of the hydraulic jacks, see Procedure 913-1*

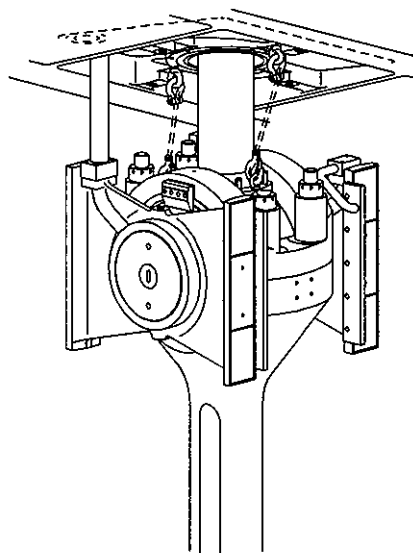
Tighten the nuts as stated in Data.

10. Remove all tools from the engine.

Note!

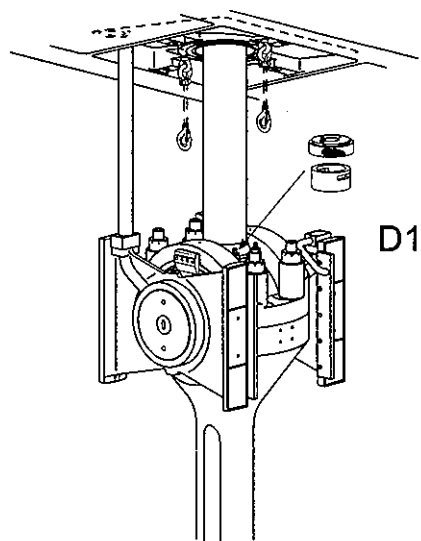
Search the crankcase to ensure that there are no tools, shackles or rags left behind.

8.



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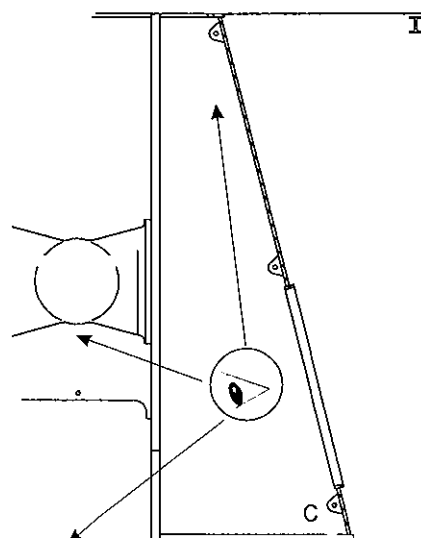
9.



D13-01

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10.



KN905-2.4 238 14

SAFETY PRECAUTIONS For detailed sketch, see 900-2

☒	Stopped engine
☒	Shut off starting air supply – At starting air receiver
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – Not ME engines
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – Only with stopped lubricating oil pumps
☒	Engage turning gear
☒	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-07	Crosshead bearing cap with bearing shell	1400	kg
D04-08	Cooling oil outlet pipe, tightening torque	280	Nm
D04-12	Guide strip screws, tightening torque	450	Nm
D04-15	Telescopic pipe, tightening torque	280	Nm
D04-16	Thrust piece, tightening torque	450	Nm
D04-21	Crosshead complete	7300	kg
D04-22	Guide shoe	964	kg
D04-51	Connecting rod complete	6100	kg
D04-56	Studs on crosshead, tightening torque	680	Nm
D04-62	Crosshead without guide shoes	5360	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90451	47	Wire guide
P90451	59	Lifting attachment - connecting rod
P90451	60	Lifting tools - crosshead
P90451	72	Chain for suspending piston
P90451	84	Retaining tool telescope pipe
P90451	118	Rubber cover for crosshead
P90451	120	Rubber cover for crosshead
P90451	167	Crowfoot wrench head
P90451	202	Extension (X-Head Cap / Piston Rod)
P90451	214	Torque wrench offset tool
P90464		Crosshead - Hydraulic Tools
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete
P91356		Lifting Tools, Etc.
P91359		Torque Spanners
P91368		Working Platforms

1. Dismount the main bearing lubricating oil pipes.

Dismount the cooling oil outlet pipe from the guide shoe and the drain oil slotted pipe.

2. Loosen and remove the screws which secure the telescopic pipe to the guide shoe.

In order to reach the screw in the corner behind the telescopic pipe, use the offset tool along with a socket wrench.

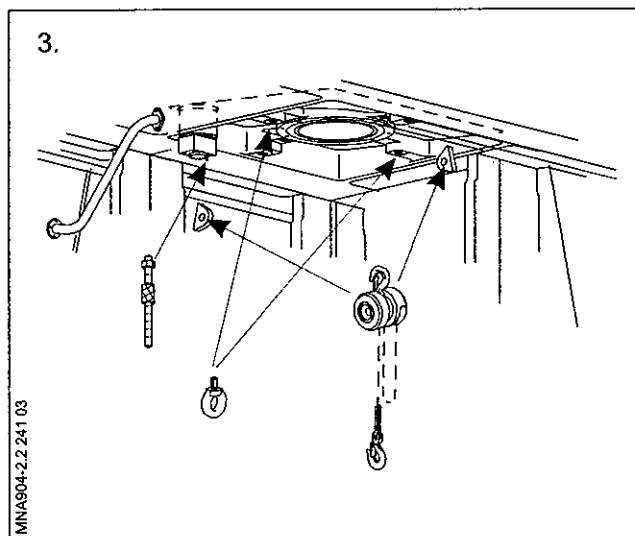
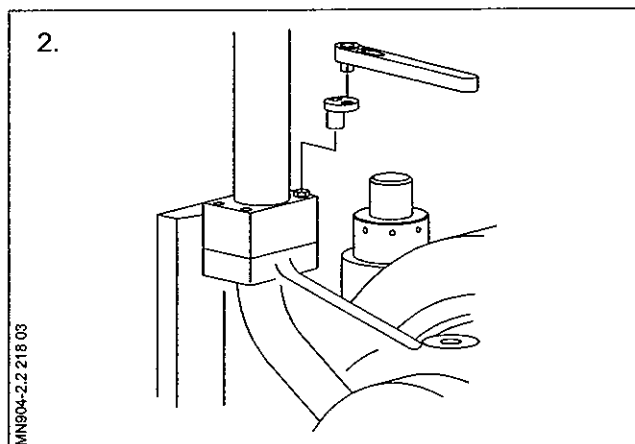
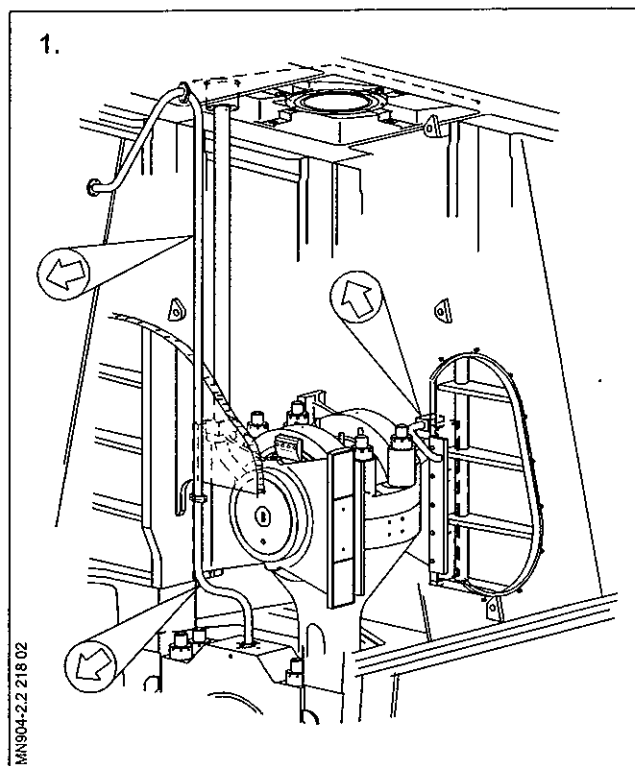
3. Mount the retaining tool for the telescopic pipe on the stuffing box housing for the telescopic pipe.

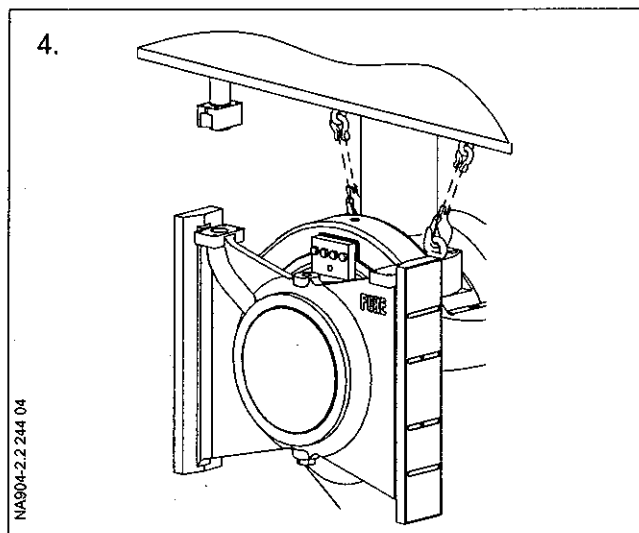
Turn the crosshead to TDC.

Suspend the telescopic pipe by means of the tool.

Mount two eye bolts in the top of the crankcase in the fore-and-aft direction and two in the athwartship direction.

Suspend two tackles from the lifting brackets in the athwartship direction.





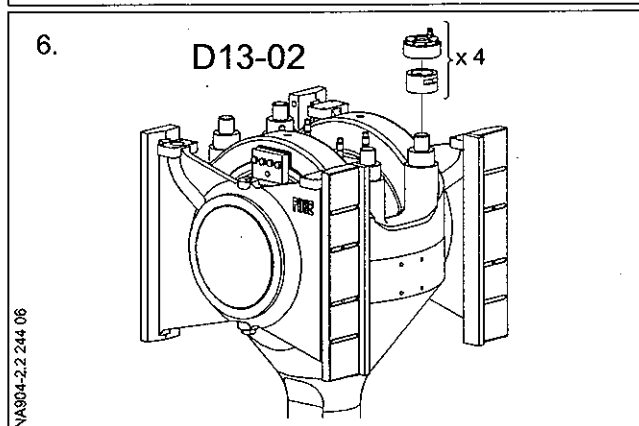
4. Suspend the piston.
To suspend piston, see Procedure 904-1.2.

5. Turn to BDC.

6. Mount the spacer rings around the nuts and screw the hydraulic jacks on to the studs.

Loosen the crosshead bearing cap nuts.
For operation of the hydraulic jacks, see Procedure 913-1.

Remove the hydraulic jacks and the spacer rings, and unscrew the nuts.



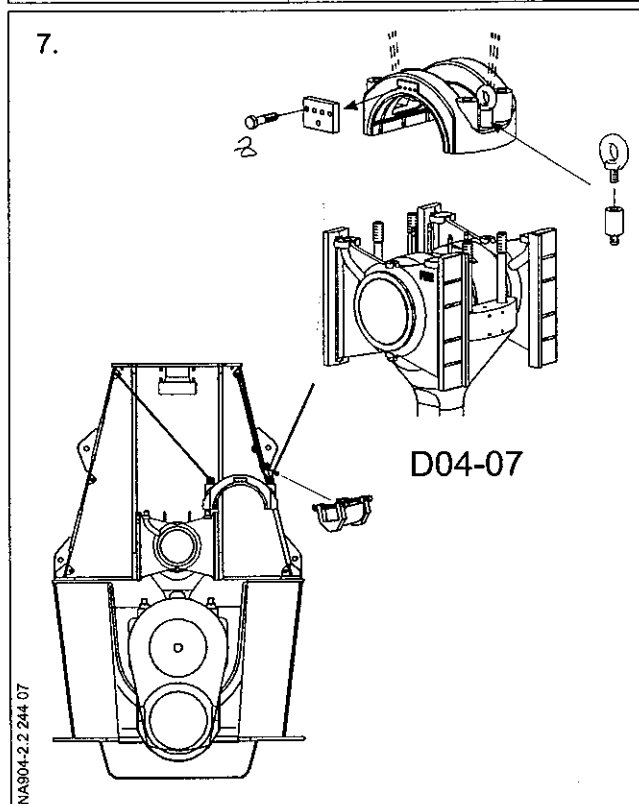
7. Remove the locking wire and dismantle the thrust pieces from the bearing cap.

Mount two eye bolts and extension screws in the crosshead bearing cap.

Hook the tackles on to the eye bolts and remove the bearing cap from the crosshead. Check the upper part of the journal.

Mount the wire guide in top of the door opening.

Lift the bearing cap out of the engine



8. Using the stud setter, unscrew the studs from the connecting rod.
9. Remove the lifting tool from the bearing cap and mount it on the crosshead.

Mount the lifting attachments for fixing the connecting rod, on the head of the connecting rod.

Fasten tackles to the lifting brackets on the frame box wall and attach the tackle hooks to the lifting attachments. Haul the tackles tight.

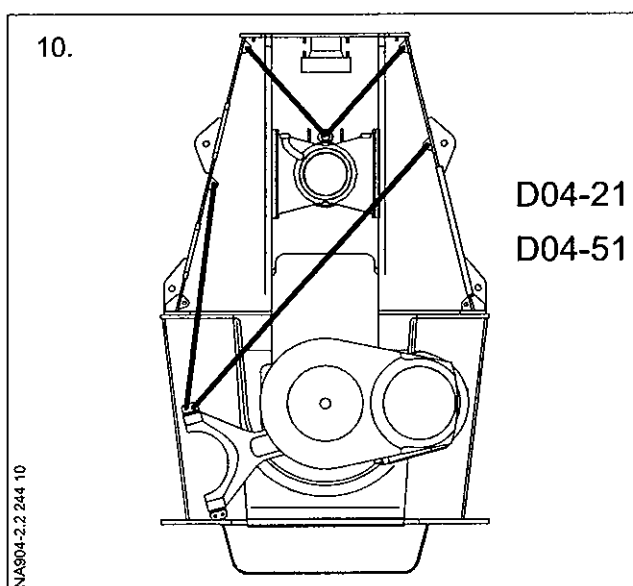
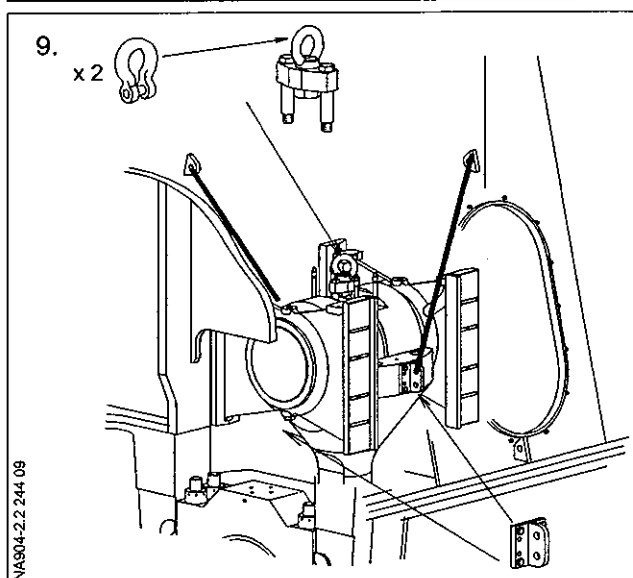
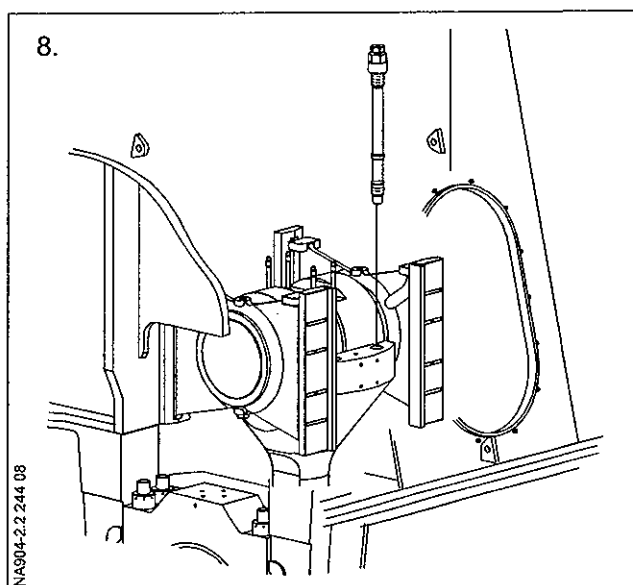
Fasten two tackles to the eye bolts mounted in the athwartship direction and attach the tackle hooks to two shackles on the lifting tool on the crosshead, and lift the crosshead clear of the connecting rod.

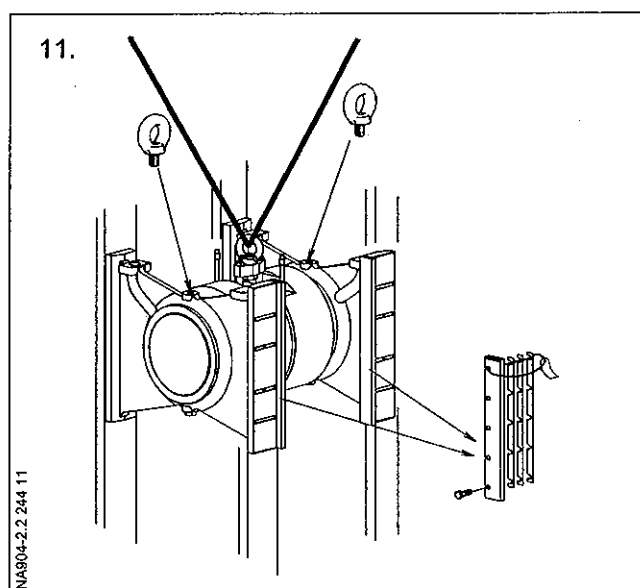
10. Using the tackles, tilt the connecting rod towards the exhaust side, while turning the crankthrow towards the camshaft side.

Transfer the tackles from one lifting attachment to another as necessary.

When the crankthrow is 90° after BDC, stop turning.

By alternate use of the tackles, tilt the connecting rod until it rests against a couple of wooden planks in the bottom of the bed-plate.



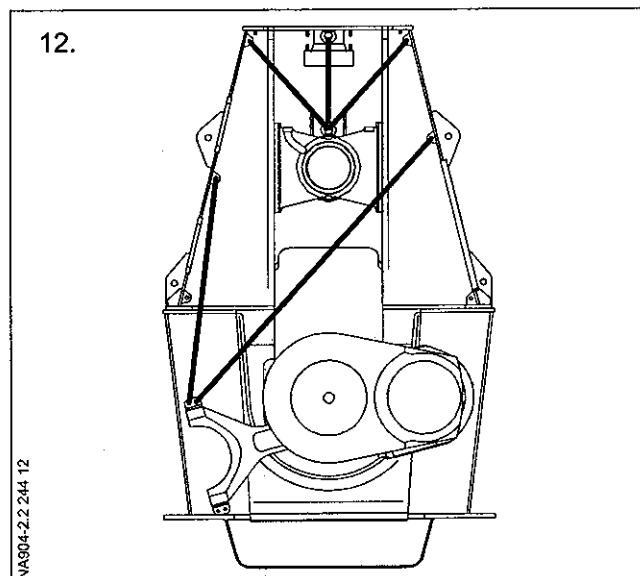


11. Remove the guide strips and the guide screws from the guide shoes.

Mount an eye bolt in the top of each guide shoe.

Note!

It is recommended to tag the guide strips and shims to avoid mixing them.



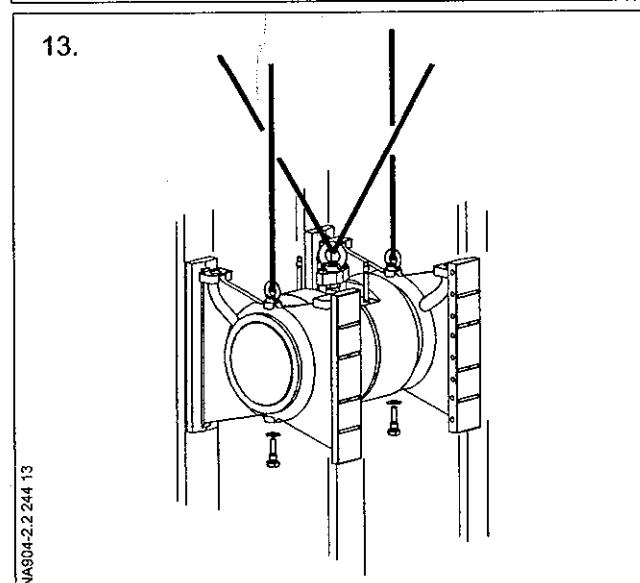
12. Suspend two tackles from the eye bolts in the bottom of the cylinder frame in the fore-and-aft direction.

Lower the crosshead until there is access to the screws on the end of the guide shoe journals.

Place a thin wooden plank, or similar, on top of the crank to protect the crosshead.

Note!

Make sure that the crosshead journal does not touch the crank.

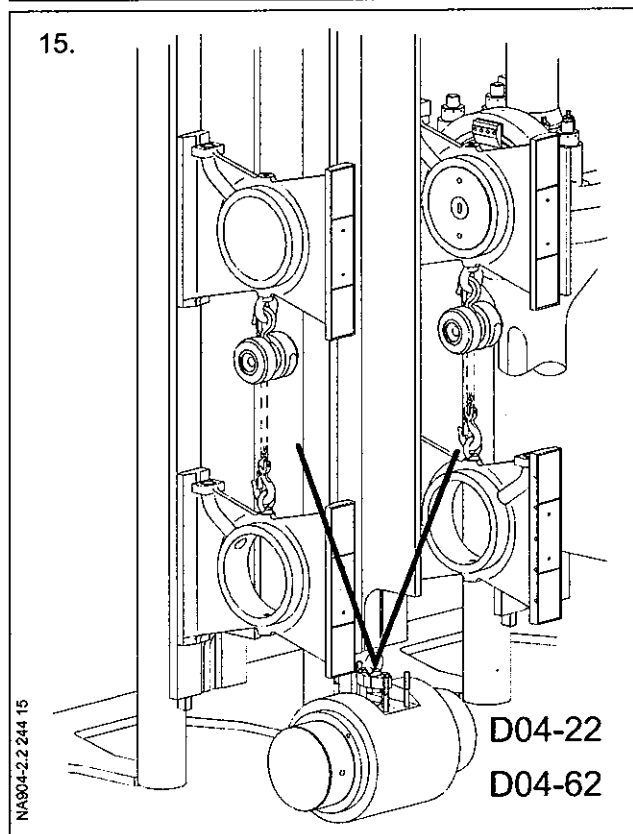
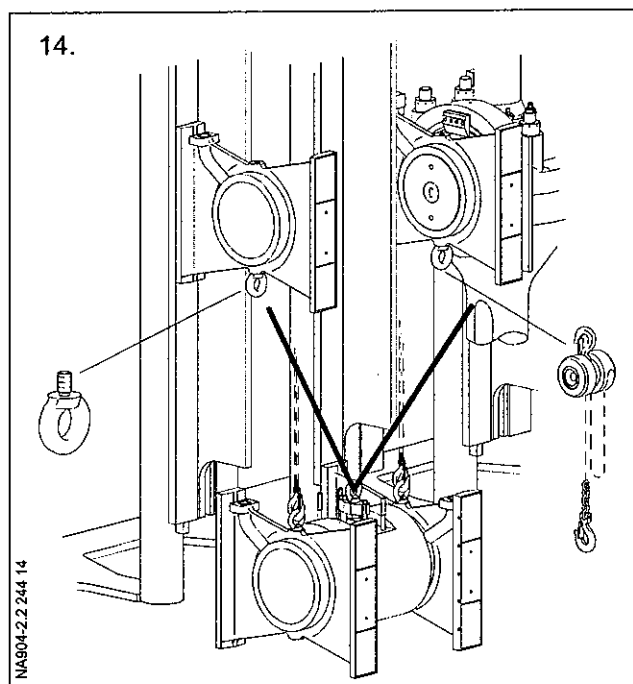


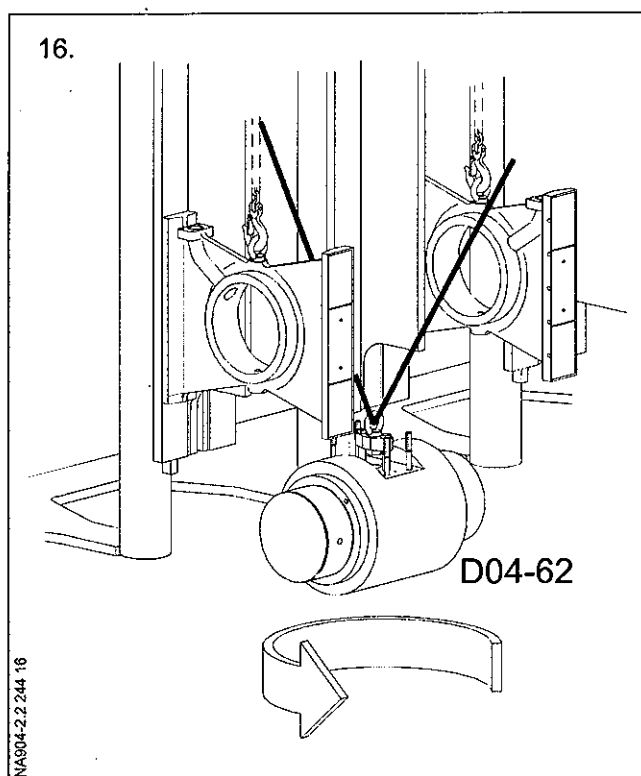
13. Hook the tackles on to the eye bolts in the guide shoes and haul tight.

Remove the guide screws from the bottom of the guide shoes.

14. Mount two eye bolts in the holes for stop screws in the guide shoes in the adjacent cylinder units, and suspend two tackles from the eye bolts.
15. Haul the tackles for the guide shoes tight and, at the same time, pull the guide shoes sideways until they are free of the cross-head.

Take the guide shoes through the openings in the side walls by means of the tackles in the two adjacent cylinders. Lift the guide shoes to provide space for turning the crosshead.





16. Turn the crosshead 90°.

Note!

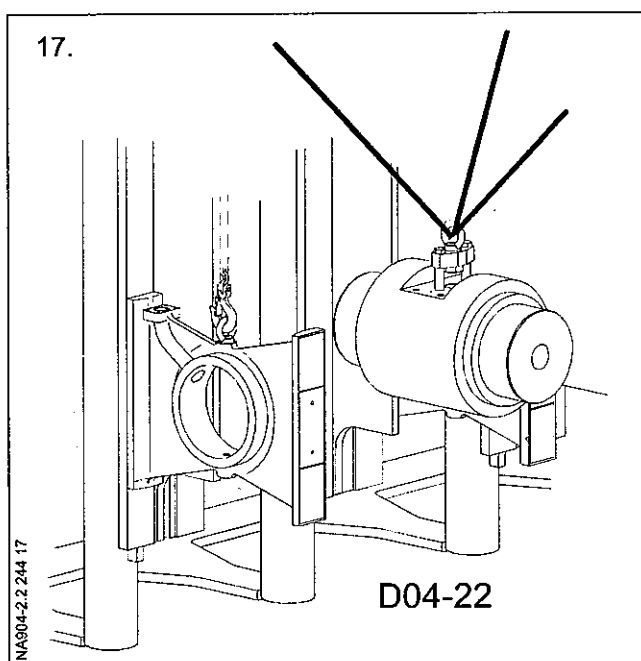
Take care that the crosshead does not bump into anything as this will damage the sliding surfaces of the crosshead.

To protect the sliding surfaces of the crosshead, use the rubber covers provided.

17. Mount a tackle outside the engine and, by means of wire rope and tackle, remove the crosshead from the engine.

Land and protect the crosshead outside the engine.

Remove the guide shoes from the engine and tag them.



1. Clean the crosshead and mount the lifting bracket.

Mount the wire guide tool in the framebox door opening.

Suspend two tackles from the top of the frame box between the guides.

Mount a tackle outside the engine. Hook a wire rope on to the engine room crane. Lower the wire rope down through the cylinder frame, through the crankcase, and out of the framebox door opening.

Hook the wire rope and the tackle on to the lifting bracket mounted on the crosshead, carefully lift the crosshead and ease it into the crankcase.

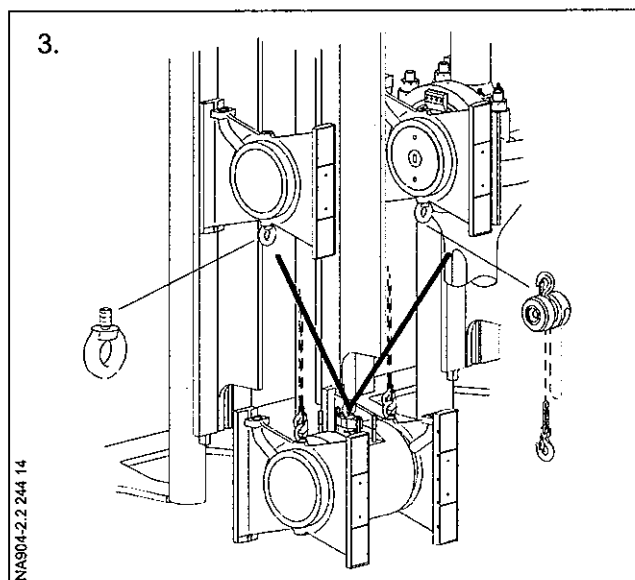
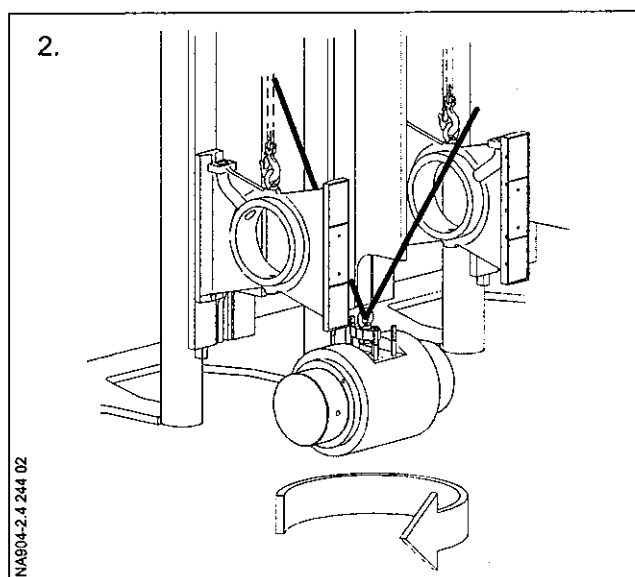
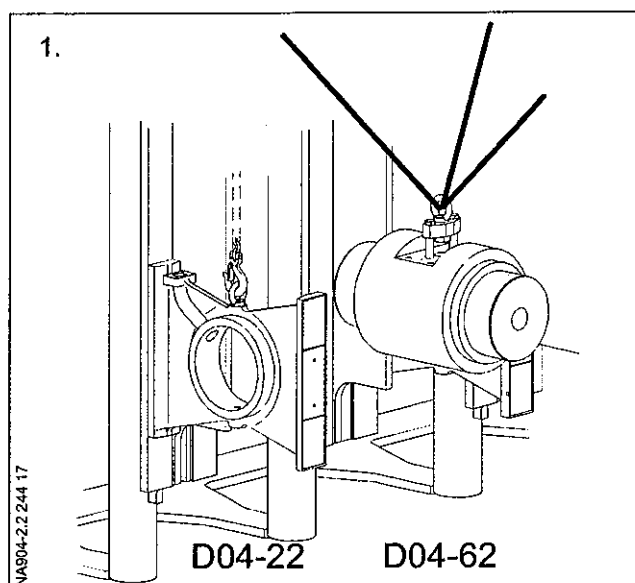
2. Turn the crosshead 90° to enable mounting of the guide shoes. Check that the oil inlet and outlet holes are pointing towards the exhaust side.

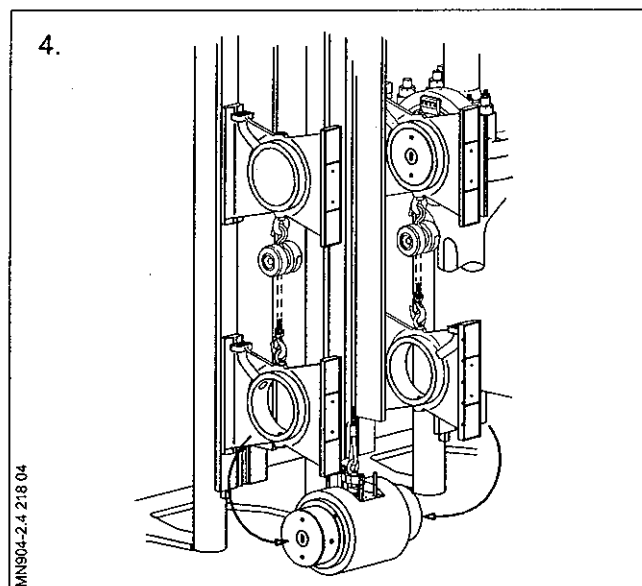
Note!

When handling the crosshead, take great care that its surfaces are not scratched or damaged. If necessary, protect the crosshead with the rubber covers.

3. Attach two tackles to the eye bolts at the bottom of the guide shoes in the adjacent cylinders.

Using these tackles and a tackle outside the engine, carefully lift the guide shoes into the engine.





4. Lubricate the sliding surfaces of the guide shoes and the hole for the crosshead with plenty of clean lubricating oil, and push the guide shoes into position through the openings in the side walls.

5. Mount the shims and the guide strips on the guide shoes.

Mount the guide screws.

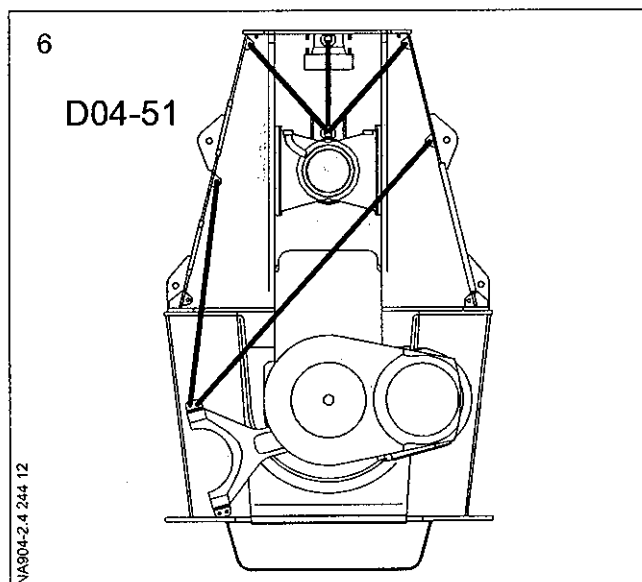
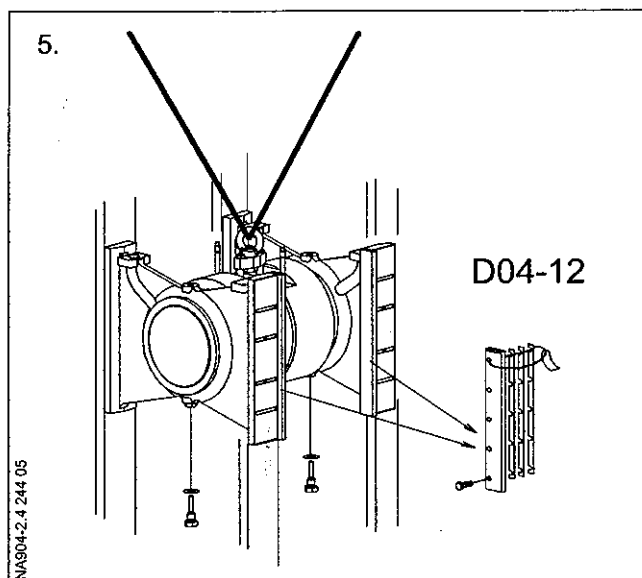
6. Lift up the crosshead with the guide shoes.

Hook tackles on to the lifting attachment mounted on the connecting rod.

Using the tackles, lift the connecting rod until it 'points' towards the crosshead.

Note!

At this point, check the condition of the crosshead bearing shell.
See Procedure 904-1.1.



7. Lubricate the crosshead bearing shell with plenty of clean lubricating oil.

Turn the crankthrow upwards while following with the tackles, until the connecting rod bears firmly against the crosshead.

Remove the tackles, the lifting attachments and the wire ropes from the engine.

8. Turn the engine to BDC.

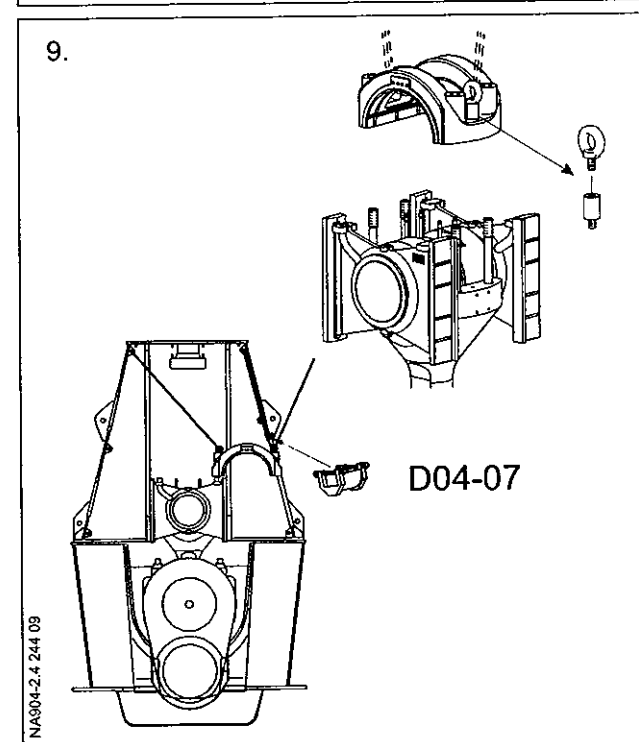
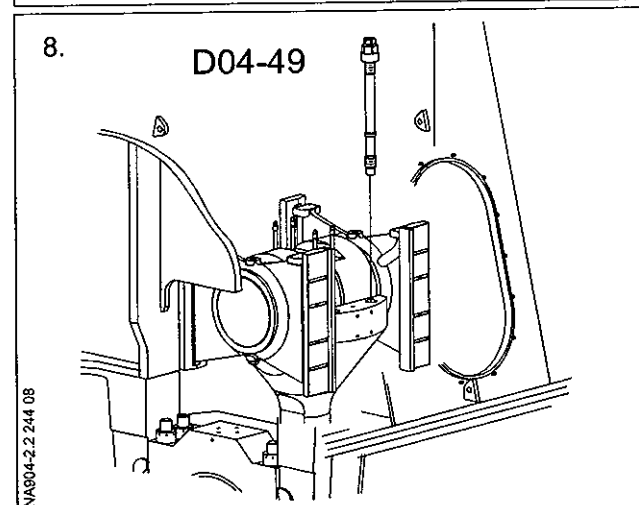
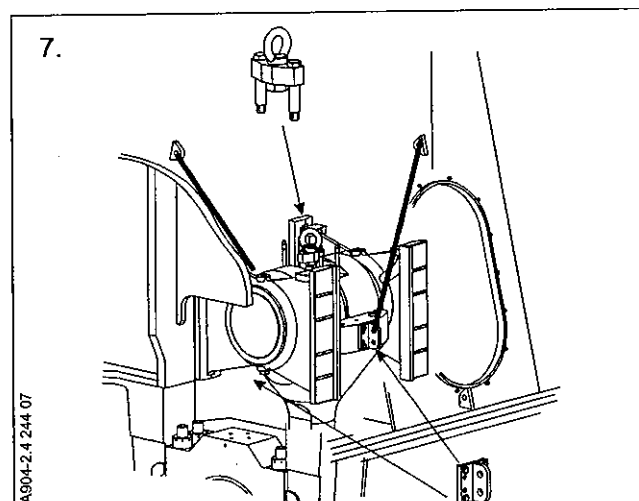
Mount the studs on the connecting rod. Using the stud setter and a torque wrench, tighten the studs to the torque stated in Data.

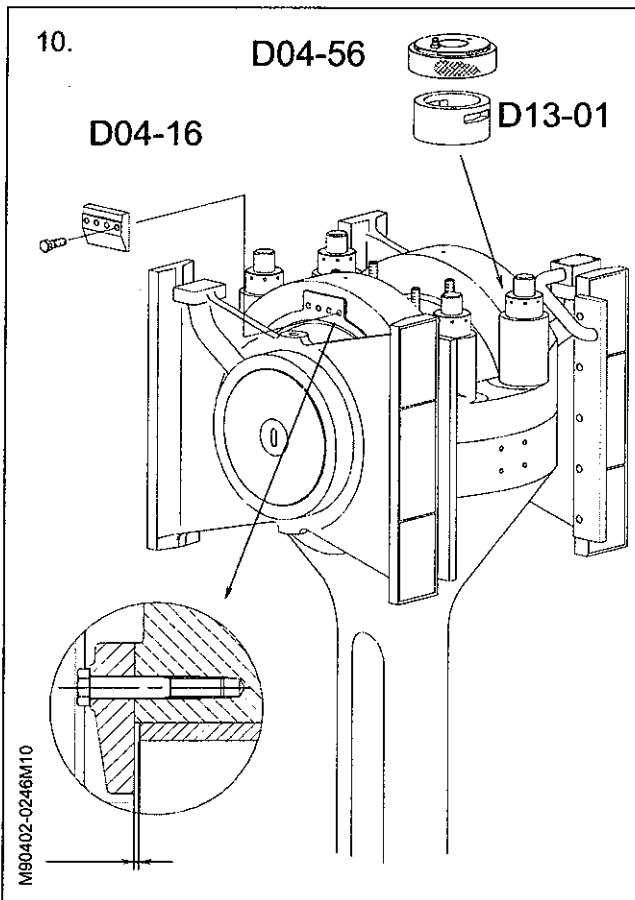
9. Lubricate the crosshead journal with plenty of clean lubricating oil.

Carefully lift the crosshead bearing cap into the crankcase and mount it on the crosshead.

Note!

During handling and mounting of the crosshead bearing cap, take great care that the studs for the crosshead bearing cap do not scratch the sliding surface of the bearing shell in the cap.





10. Mount and tighten the nuts on the crosshead bearing studs.

For operation of the hydraulic tools, see Procedure 913-1.

Note!

At this point it is recommended to check the crosshead bearing clearance.
See Procedure 904-1.1.

Remove the hydraulic tools and the eye bolts from the engine.

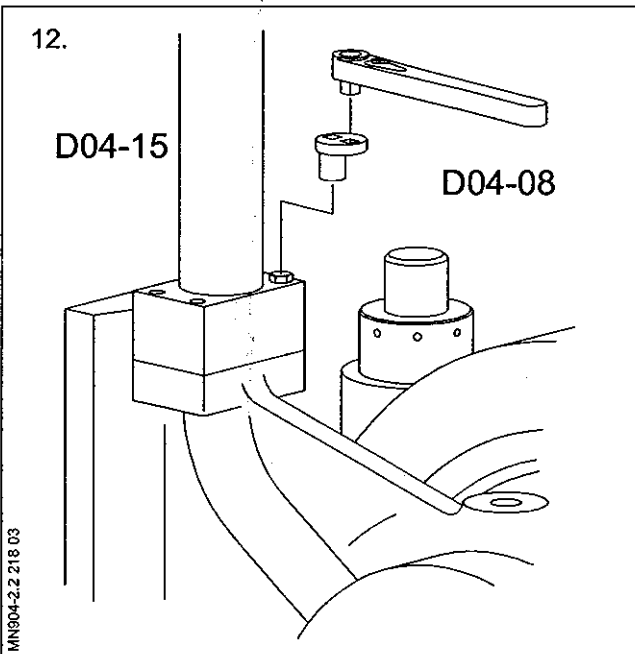
Mount the thrust pieces on the bearing cap.

Note!

It must be ensured that a clearance between the thrust piece and the crosshead exists fore and aft before any tightening of the thrust piece.

Tighten the screws to the torque stated in Data.

For correct tightening, see also Procedure 913-5.



11. Check the clearances between the guide strips, guide shoes and crosshead guides.
See Procedure 904-3.1.

12. Turn the crosshead upwards until the foremost guide shoe touches the telescopic pipe.

Remove the suspension tool from the telescopic pipe.

Mount and tighten the screws which secure the telescopic pipe to the guide shoe.

In order to reach the screw in the corner behind the telescopic pipe, use the offset tool along with a socket wrench.

Mount the cooling oil outlet pipe on the aft-most guide shoe.

13. Mount the main bearing lubricating oil pipes.

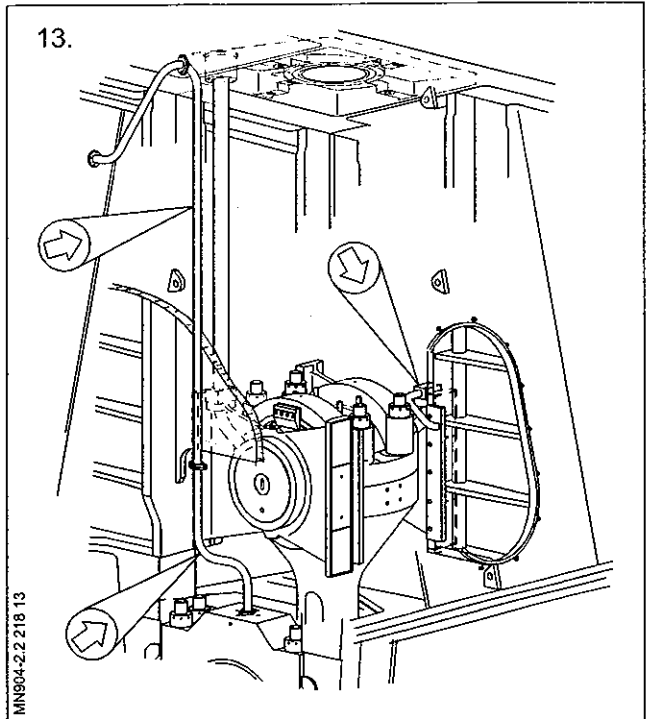
Mount the piston. See *Procedure 902-1.4*.

14. Remove all tools from the engine.

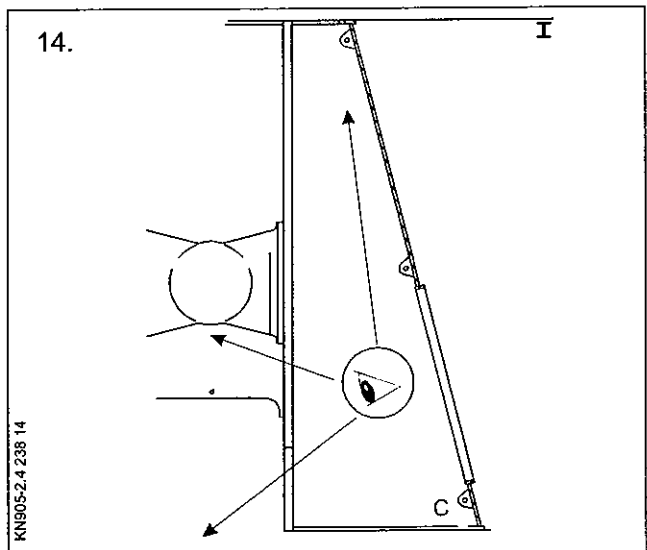
Note!

Search the crankcase to ensure that there are no tools, shackles or rags left behind.

13.



14.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☒	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☒	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-24	Acceptance criteria with piston in centre (F-A direction)		
D04-25	PF+PA, N max.	0,95	mm
D04-26	PF+PA, O max.	1,45	mm
D04-28	E+G, H+F, N max.	0,65	mm
D04-29	E+G, H+F, N min.	0,2	mm
D04-30	E+G, H+F, O max.	0,95	mm
D04-34	J+X, L+Y, K+X, M+Y, N max.	1,2	mm
D04-35	J+X, L+Y, K+X, M+Y, N min.	0,6	mm
D04-36	J+X, L+Y, K+X, M+Y, O max.	1,4	mm
D04-39	QF/QA, O max.	0,8	mm
D04-41	ZF/ZA O min.	6	mm
D04-42	TF + TA	0,8	mm

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P91366	57	Feeler gauge

In order to achieve uniform measuring conditions on board, the ship's trim must be as close as possible to 0°.

1. Mount a transparent plastic tube along the length of the bedplate.

Bend each end approx. 250 mm up along the framebox side. See **T**.

Fill the tube with water (possibly coloured) until the water level is approx. 100 mm from the end of the tube.

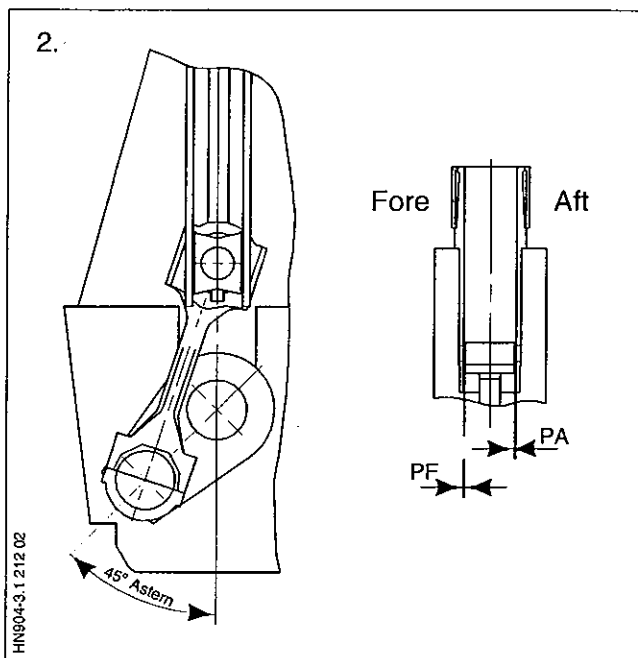
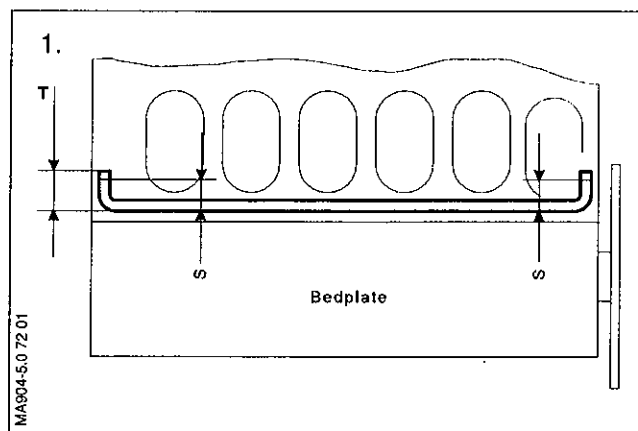
Trim the ship until the difference between the water level **S** fore and aft is less than 1.5 mm per 1000 mm.

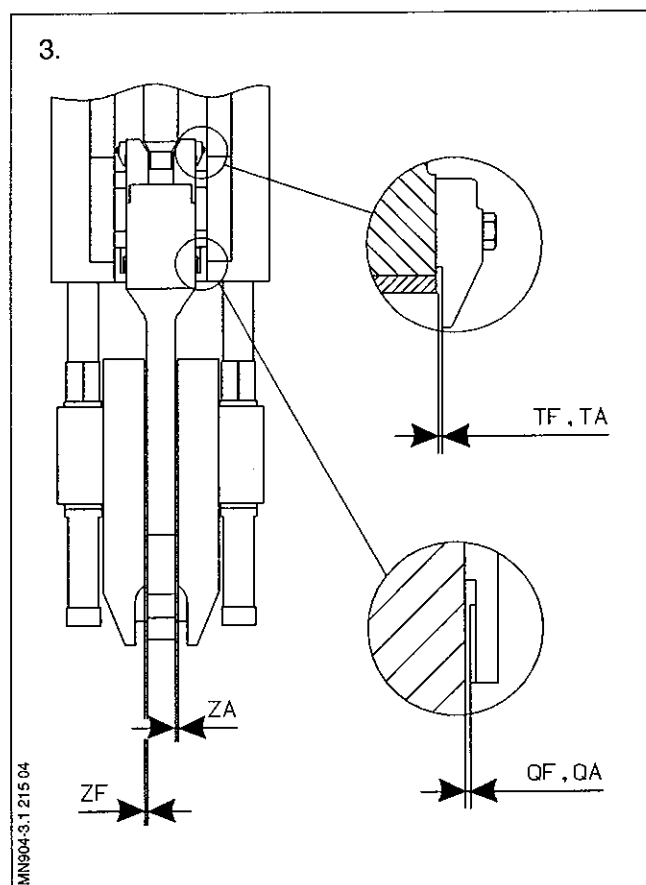
Measurements are to be taken with a ruler.

2. Turn the crankshaft in ASTERN direction to 45° after BDC (the guide shoe must rest against the crosshead guide).

Check the centering of the piston in the cylinder liner by measuring the clearance (by applying a long feeler gauge from the scavenge air space) between the piston skirt and the cylinder liner in the Fore and Aft positions (**PF-PA**).

Make sure that the piston is clear of the cylinder liner in the fore-and-aft direction.





3. Measure the clearance between the crank-throw and the connecting rod.
4. Measure the clearance between the thrust piece and the crosshead (TF and TA or QF and QA).

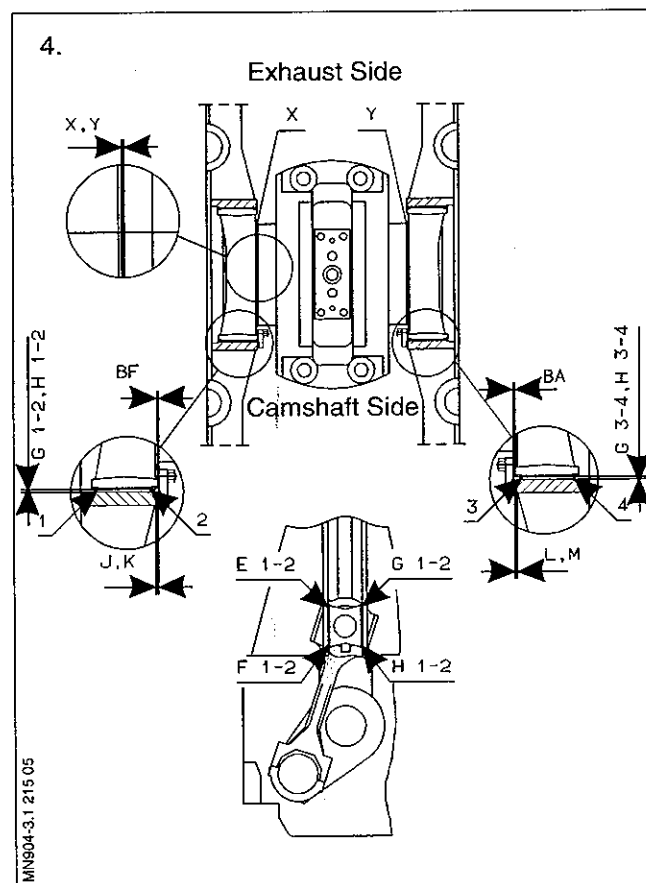
Measure the clearance between the cross-head guides and the guide shoes (E, F, G and H).

Measure the clearance between the guide strips and crosshead guides (J, K, L and M).

The clearance, calculated as $J+X$, $K+Y$, $L+Y$ and $M+Y$, is adjusted by the insertion of shims so that it is symmetrical in relation to the clearance between the piston skirt and the cylinder liner.

Parallelism between the guide strip and guide is to be kept within a tolerance of 0.2 mm per 1000 mm.

BF and BA correspond to the thickness of the shims and are only to be measured if an adjustment is carried out.



5. *It is recommended that the measured results are noted down so that possible later changes can be ascertained.*

5.	Cyl.	1	2	3	4
Piston/Liner	PF				
	PA				
Shim Thickness	BF				
	BA				
Frame Box	E1				
	E2				
	E3				
	E4				
	F1				
	F2				
	F3				
	F4				
	G1				
	G2				
	G3				
	G4				
	H1				
	H2				
	H3				
	H4				
Crosshead Connecting Rod	J+X				
	L+Y				
	K+X				
	M+Y				
Crankthrow Connecting Rod	QF/TF				
	QA/TA				
Crankthrow Connecting Rod	ZF				
	ZA				

MN904-3.1 215 06

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-43	Crankpin bearing clearance, max.	0,85	mm
D04-44	Crankpin bearing clearance, min.	0,5	mm
D04-45	Crankpin bearing cap complete	805	kg
D04-46	Crankpin bearing, upper shell	100	kg
D04-47	Crankpin bearing, lower shell	75	kg
D04-48	Crankpin bearing cap + shell + bearing studs	990	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

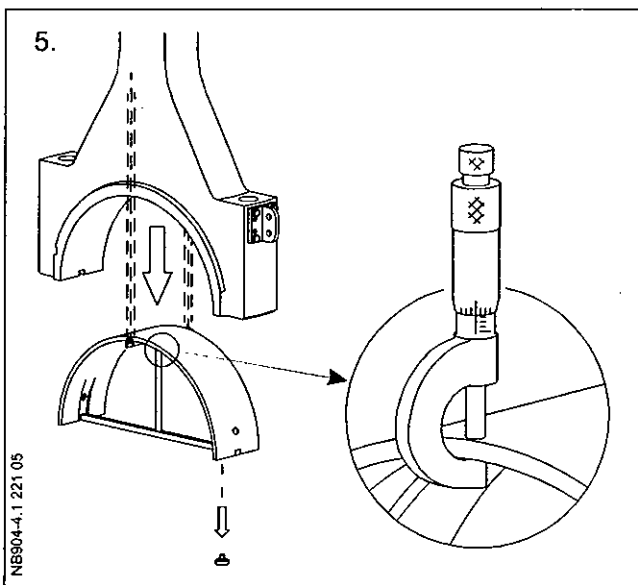
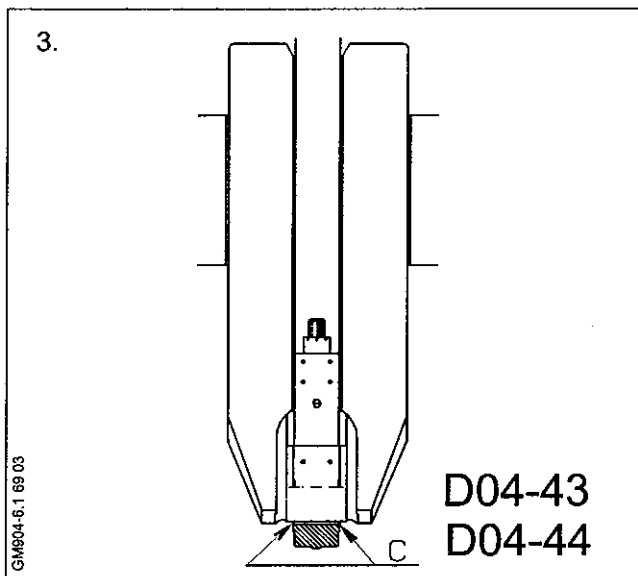
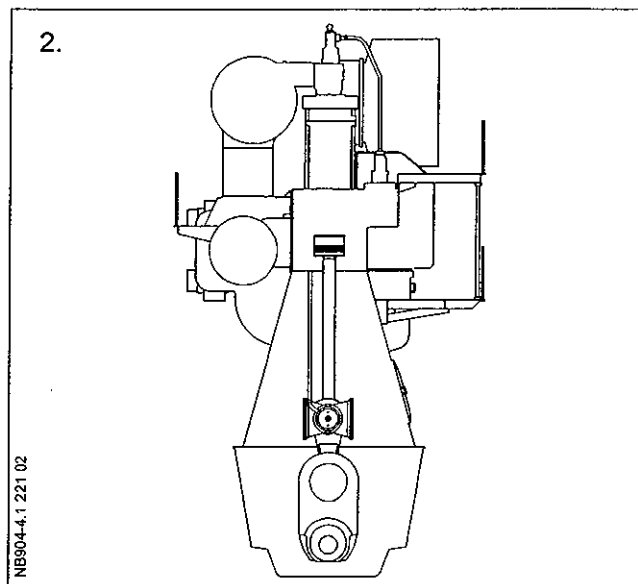
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

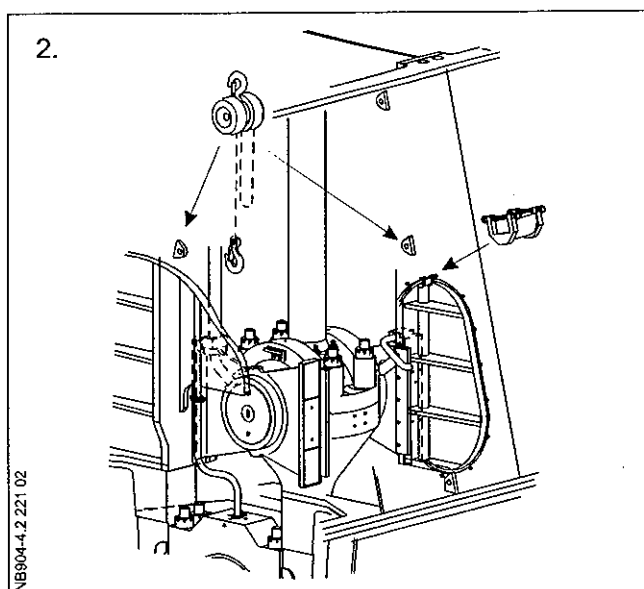
Plate	Item No.	Description
P90451	47	Wire guide
P90451	59	Lifting attachment - connecting rod
P90451	96	Bracket for support, Crosshead
P90451	106	Bracket for support, Crosshead
P90461		Connecting Rod - Hydraulic Tools
P90462		Lifting tool for crankshaft shell
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete
P91356		Lifting Tools, Etc.
P91366	57	Feeler gauge
P91366	61	Slide caliper
P91368		Working Platforms

The bottom clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assembly components.

For the bottom clearance of a specific bearing, see the measurement in the Adjustment Sheet in Volume I, OPERATION.

1. Open the crankcase door at the relevant cylinder.
2. Turn the crank concerned to BDC.
3. Measure the clearance in the crankpin bearing by inserting a feeler gauge at the bottom of the bearing shell in both sides. *See Data for bottom clearance.*
4. The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.05 mm. If so, the crankpin bearing must be disassembled for inspection. *See Procedure 904-4.2.*
5. The wear limit for the crankpin bearing shells is based on an evaluation of the bearing condition at the time of inspection.
6. *For further external inspection of the crankpin bearing, see Chapter 708 'Bearings' in the instruction book, Volume I, OPERATION.*





1. Turn the crank to BDC.
2. Suspend two tackles from the lifting brackets, in the athwartship direction.

Mount the wire guide in the crankcase door opening.

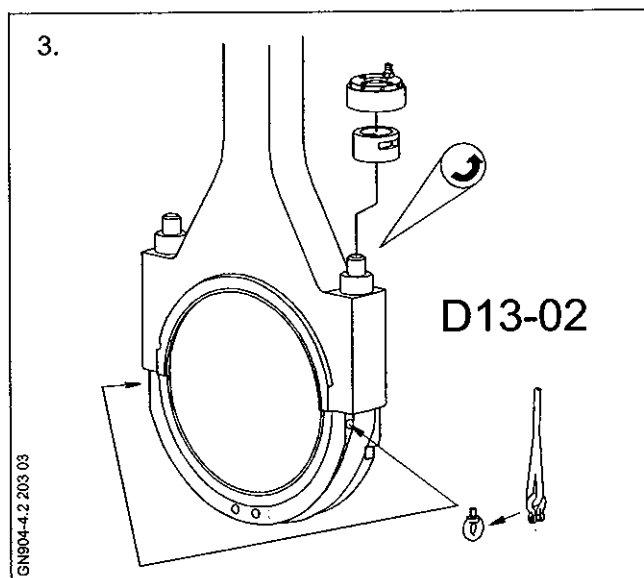
3. Turn the crank to TDC.

Mount eye bolts in each side of the crankpin bearing cap and, using shackles and wire ropes, hook on the tackles and haul tight.

Loosen the crankpin bearing stud nuts, using the hydraulic jacks.

For operation of the hydraulic jacks, see Procedure 913-1.

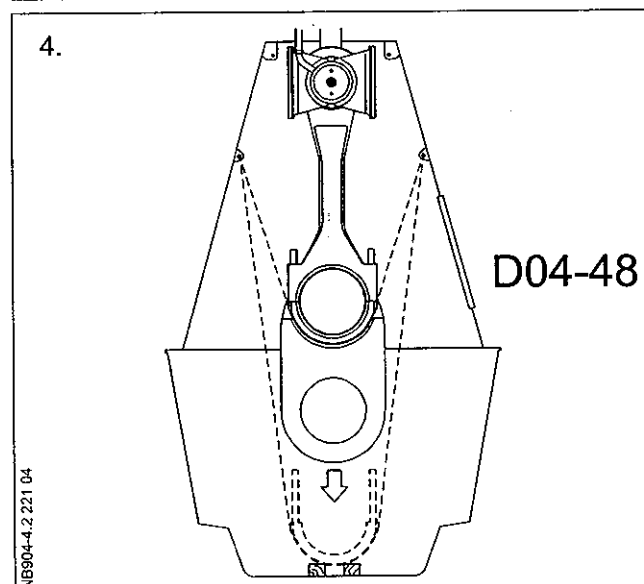
Remove the hydraulic jacks and the nuts.



4. Lower the bearing cap while seeing **carefully** that the studs do not damage the crankpin journal.

Land the bearing cap on a couple of planks placed in the oil pan.

Inspect the bearing shell.



5. If the bearing shell needs to be replaced, remove the whole bearing cap from the crankcase.

Suspend a tackle from the lifting bracket on the inside camshaft side of the frame box above the crankcase door opening.

Hook the tackle on to an eye bolt on one side of the bearing cap.

Mount the wire guide in the top of the crankcase door opening.

Using the tackle from the frame box inside wall, together with a tackle suspended from the platform bracket, lift the bearing cap out of the crankcase.

6. Place the bearing cap on one side on a couple of planks.

Dismount the bearing shell lock screws and replace the bearing shell by a new one.

The bearing shells **must** be replaced in pairs.

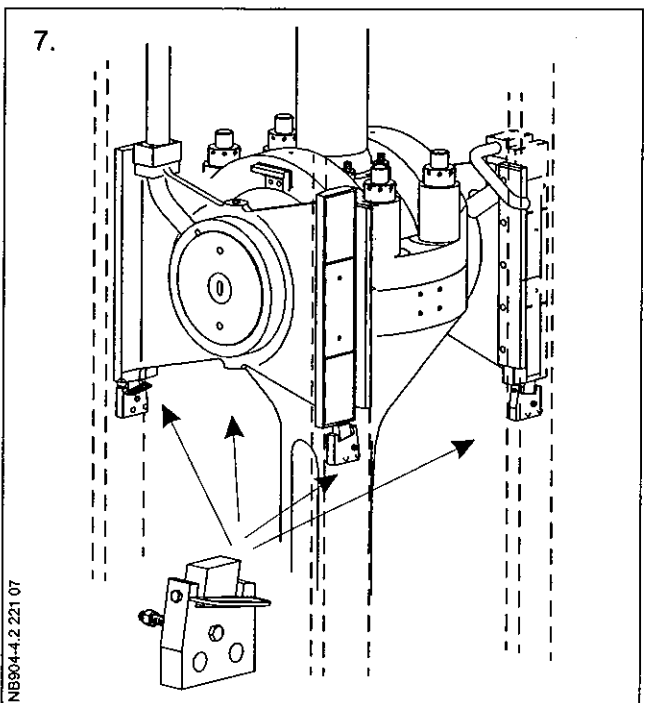
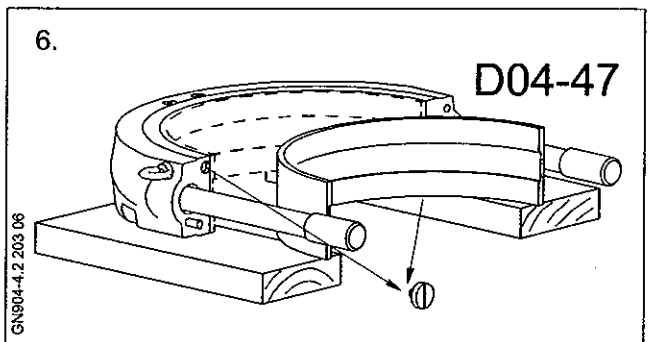
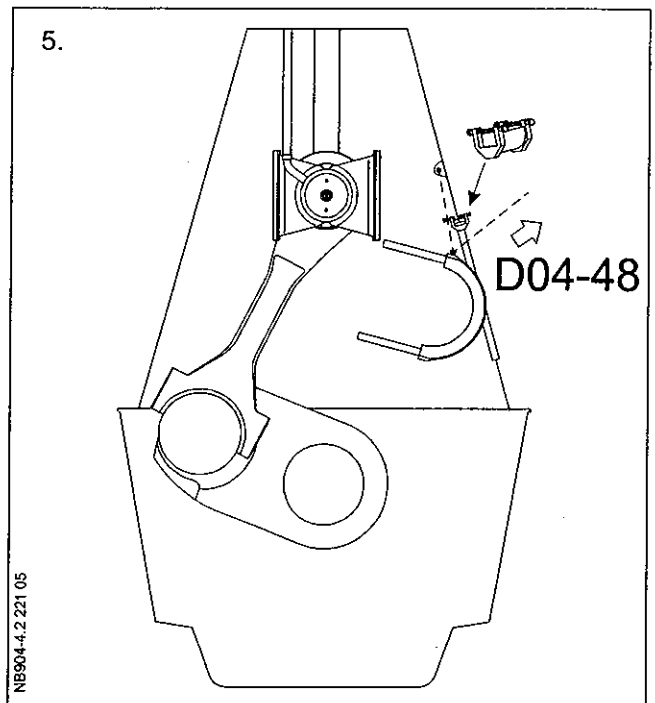
7. Turn to TDC.

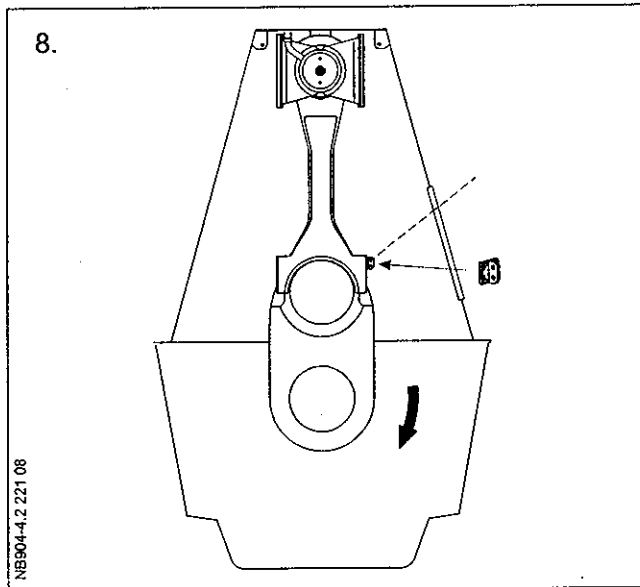
Mount the four supports for the guide shoes on the crosshead guides.

Adjust the support bracket sledges to their lowest position.

Carefully turn the crank down until the guide shoes are approx. 1 mm from the support bracket sledges.

Adjust the sledges to support the guide shoes so that the weight of the crosshead is evenly distributed on the four supports.





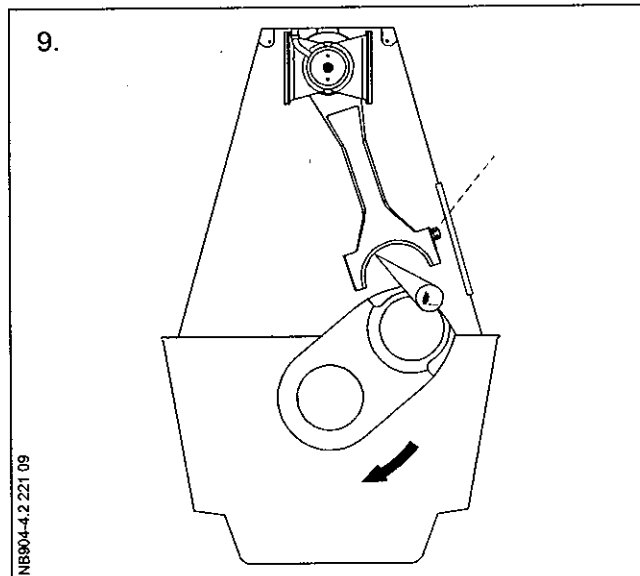
8. Mount a lifting attachment for securing the connecting rod at the lower end, on one side.

Hook on the tackle to a beam under the gallery platform and haul tight.

9. **Carefully** turn the crankshaft downwards, while 'following' with the tackle, making sure that the upper part of the bearing comes completely clear of the recess in the crankshaft when the parts begin to 'separate'.

Continue turning the crankshaft until the bearing surface can be freely inspected.

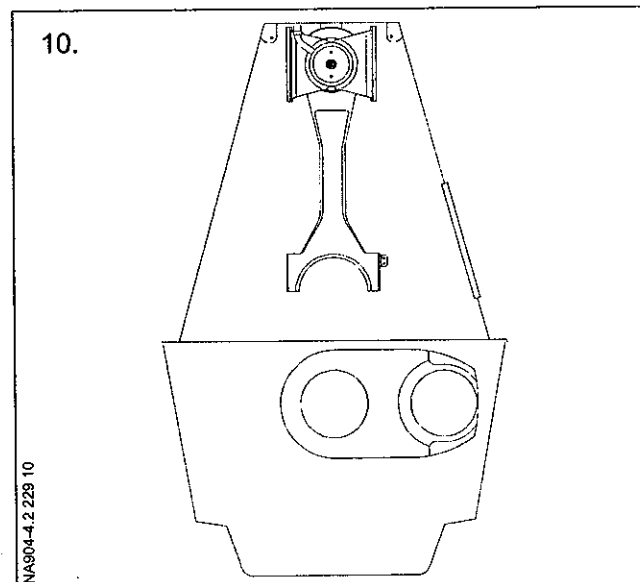
Inspect the bearing shell surface and the crankpin journal.



10. If it is necessary to replace the bearing shell, proceed as follows:

Turn the crankshaft to horizontal.

Release the tackle so that the connecting rod is hanging freely.



11. Mount an eye bolt in the bottom of each guide shoe.

Suspend two tackles from the eye bolts.

12. Place the lifting tool for the crankpin upper shell on the crank webs and hook the tackles on to the lifting tool.

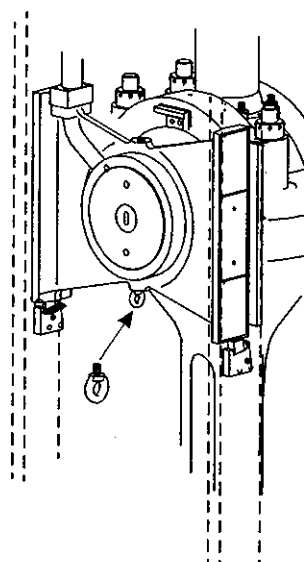
Mount the tool on the bearing shell in the connecting rod, using the tackles, and haul tight.

13. Dismount the bearing shell lock screws.

Lower the lifting tool with the bearing shell, using the tackles.

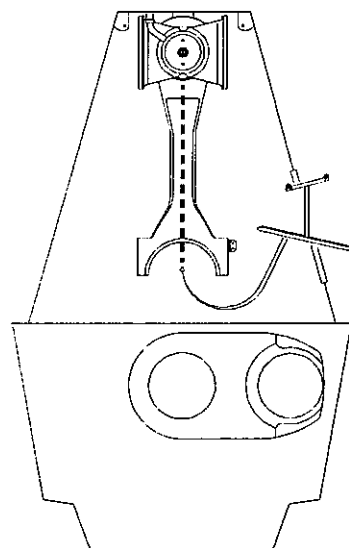
Pull the bearing shell sideways and lift it out of the crankcase.

11.



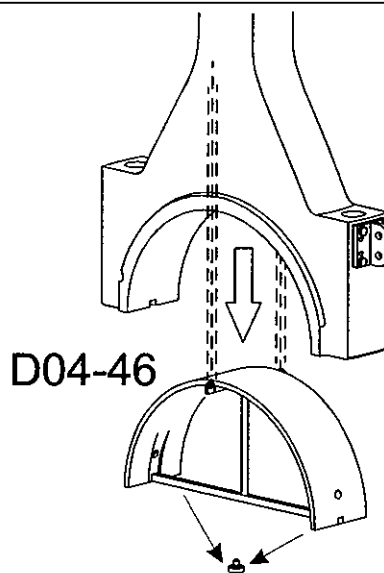
NB904-4.2 221 11

12.

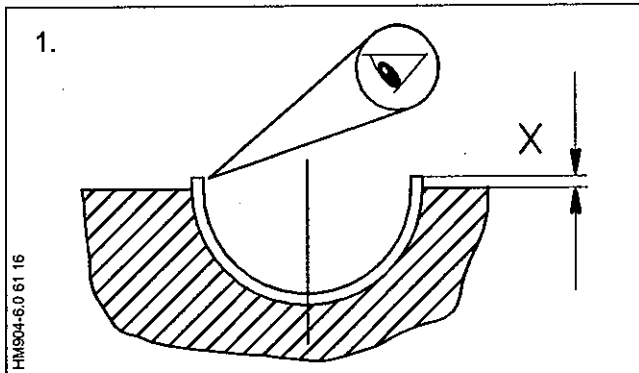


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13.



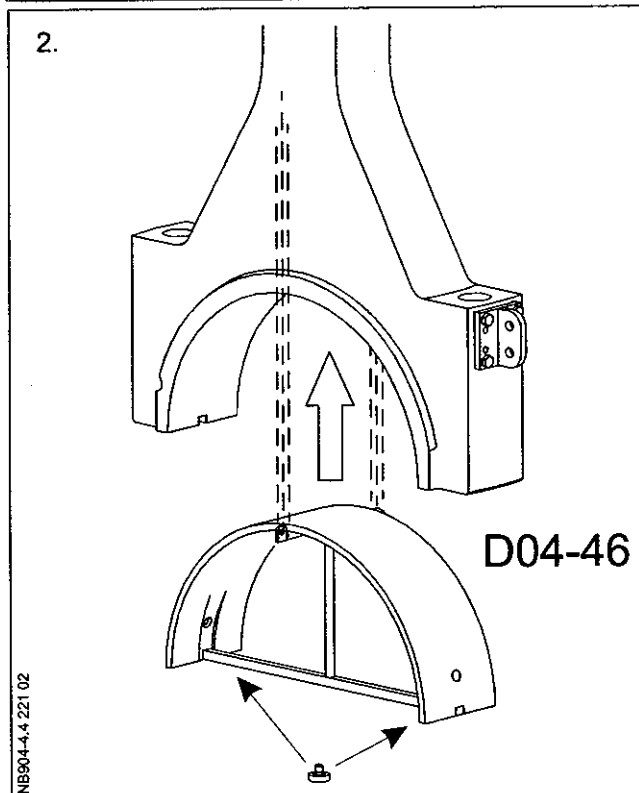
NB904-4.2 221 13



1. If necessary, replace the bearing shells with new ones. The bearing shells **must** be replaced in pairs.

Bearing shells of three mm undersize are available as spares in case of journal rectification.

Coat the bearing shell surfaces and the journal with clean oil.

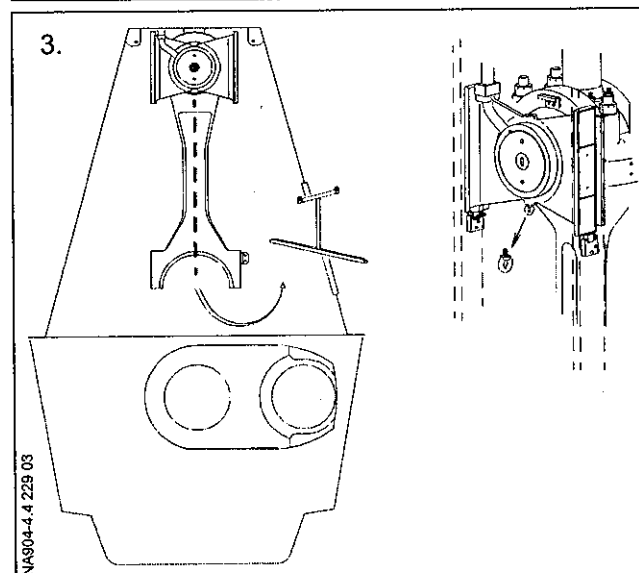


The excess height **X** is to ensure the correct tightening-down of the bearing shell, and **must not** be eliminated.

2. Lift the upper bearing shell for the crankpin concerned into the crankcase.

Carefully lift the bearing shell into position in the connecting rod, and mount the lock screws.

3. Remove the lifting tool, the tackles and the eye bolts from the guide shoes.



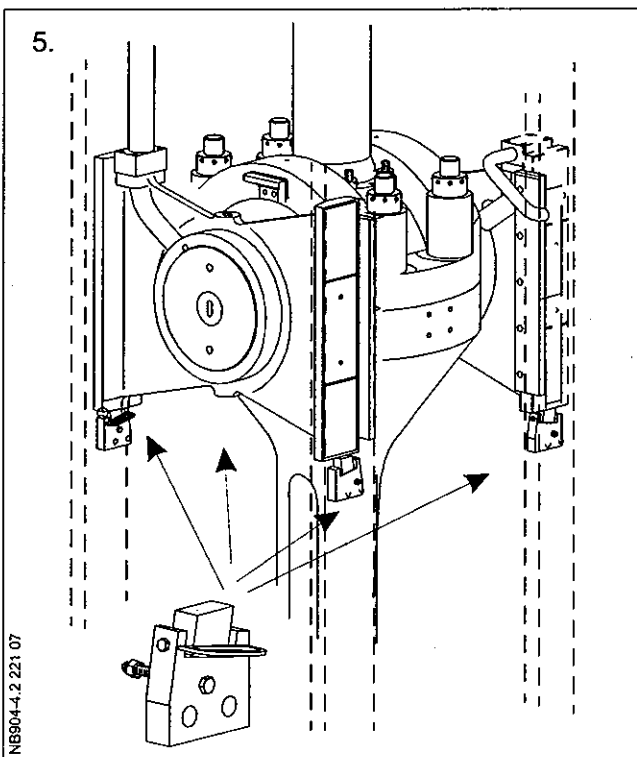
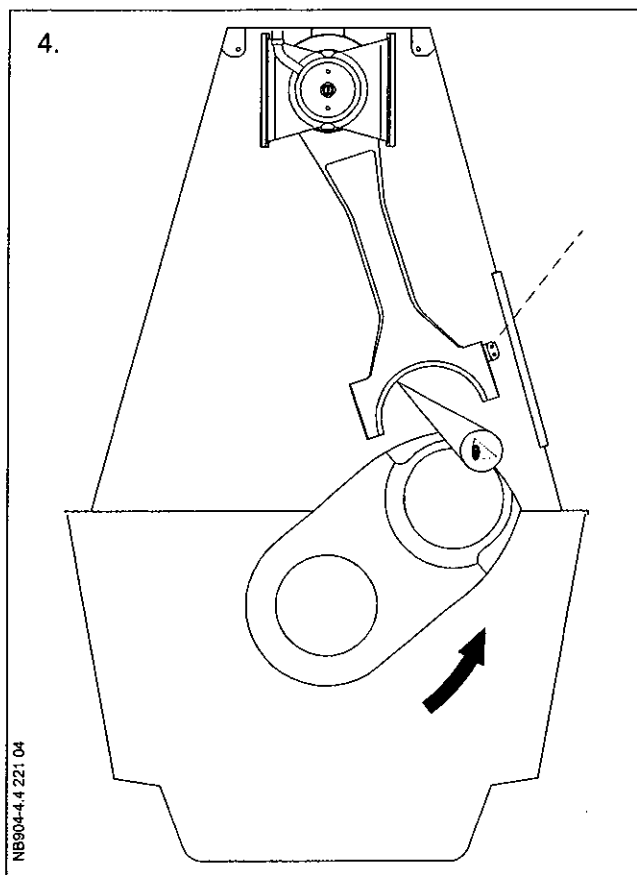
4. Hook the tackle on to a beam under the gallery platform and on to the lifting attachment on the connecting rod, and haul tight.

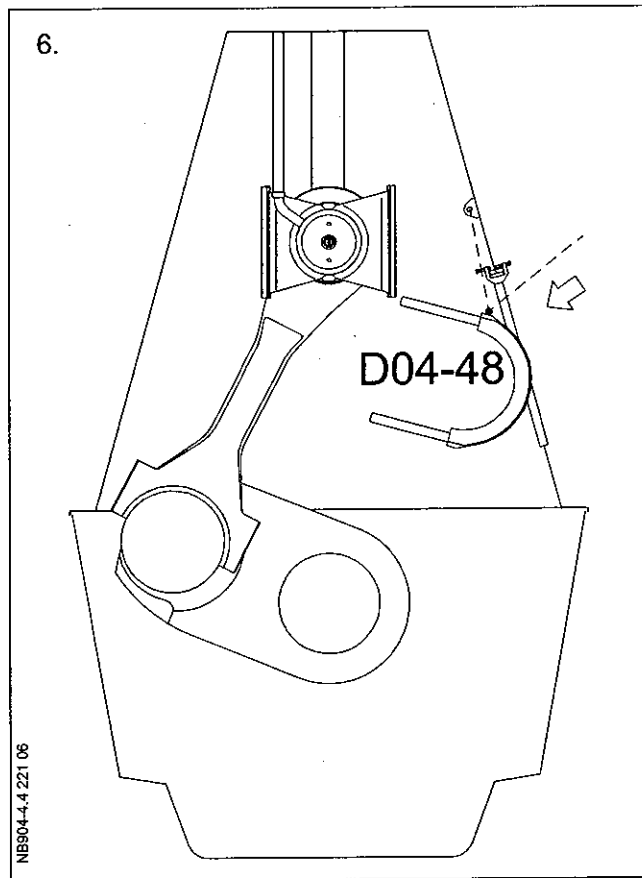
Carefully turn the crankshaft upwards, while following up with the tackle, making sure that the upper part of the bearing enters the recess in the crankshaft when the parts turn together.

Remove the tackle and the lifting attachment from the connecting rod.

5. Turn the crosshead to TDC.

Remove the guide shoe support brackets from the crosshead guides.





6. Suspend the tackles from the lifting brackets in the top of the frame box.

Lift the bearing cap assembly into the crankcase and land it on a couple of planks placed in the oil pan.

Remove the wire guide tool from the engine.

7. Hook the tackles on to the wire ropes and lift the bearing cap into position against the connecting rod.

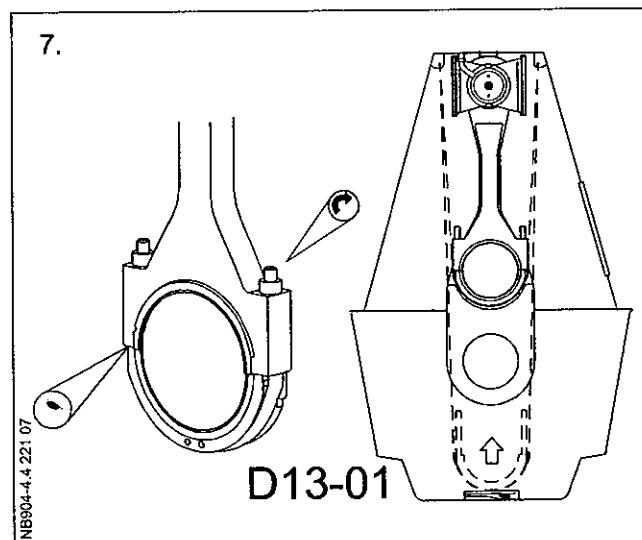
Caution!

During mounting, take care that the studs do not damage the crankpin journal, and check that the guide pins mounted in the bearing cap enter the holes in the connecting rod.

Mount the nuts and, by means of spacer rings and hydraulic jacks, tighten the crankpin bearing cap. See *Data*.

For operation of hydraulic jacks, see Procedure 913-1.

Remove the tackles from the top of the frame box.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

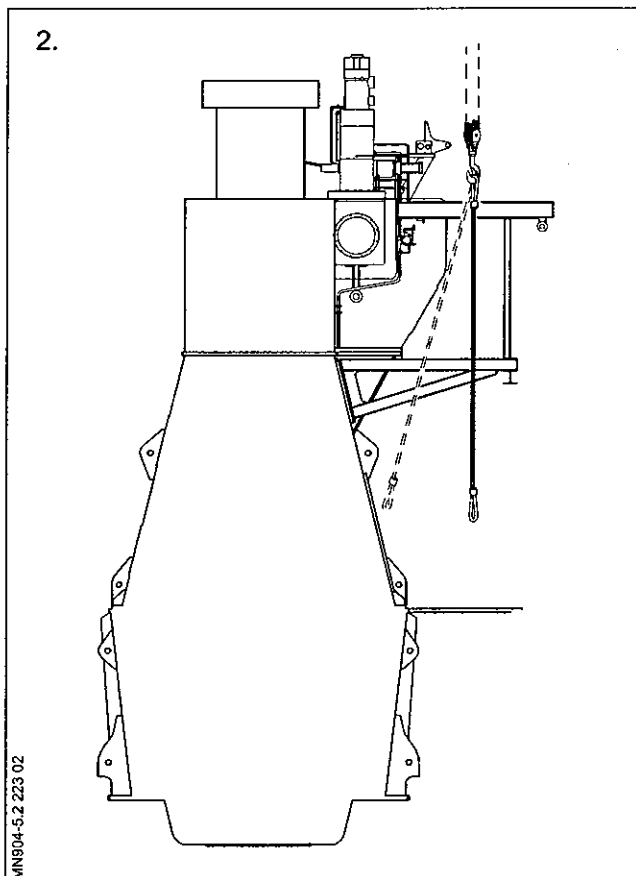
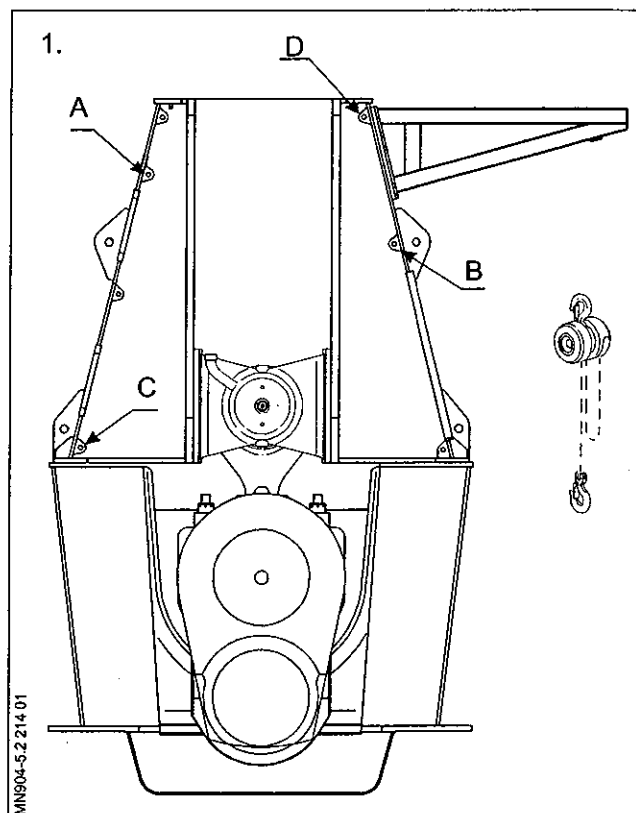
Data

Ref.	Description	Value	Unit
D04-48	Crankpin bearing cap + shell + bearing studs	990	kg
D04-49	Connecting rod studs , screwing-in torque	600	Nm
D04-50	Connecting rod, without bearing caps	5970	kg
D04-52	Connecting rod stud	30	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

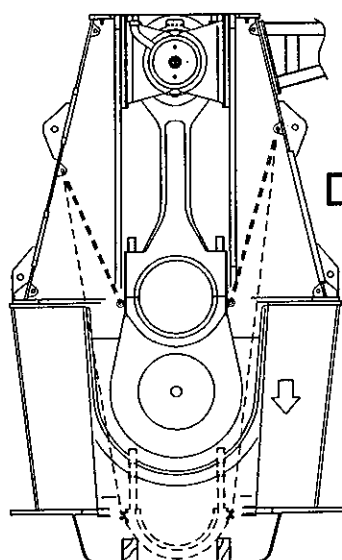
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90451	47	Wire guide
P90451	59	Lifting attachment - connecting rod
P90451	72	Chain for suspending piston
P90451	96	Bracket for support, Crosshead
P90451	106	Bracket for support, Crosshead
P90451	179	Socket Spanner
P90461		Connecting Rod - Hydraulic Tools
P90464		Crosshead - Hydraulic Tools
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	117	5-way distributor block, complete
P91356		Lifting Tools, Etc.
P91366	57	Feeler gauge
P91366	61	Slide caliper
P91368		Working Platforms

1. Mount tackles in the following positions inside the crank casing:
 - A. Second uppermost bracket at the exhaust side
 - B. Middle bracket at the camshaft side
 - C. Lowermost bracket at the exhaust side
 - D. Uppermost bracket at the camshaft side
2. Remove the floor plates on the upper and middle galleries. Lower the hook of the engine room crane with an extension of a wire rope down to the lowermost gallery.



3.



D04-48

MIN904-4.2 213 03

3. Turn the crankthrow to TDC.

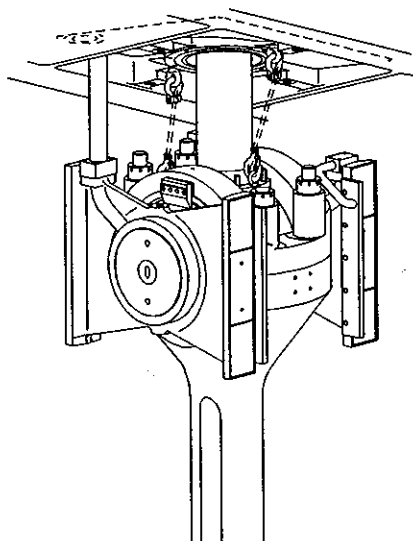
Dismount the crankpin bearing cap, and remove it from the engine.

See Procedure 904-4.2.

4. Suspend the piston rod from the top of the crank casing, see Procedure 904-1.2, or remove the piston from the engine.

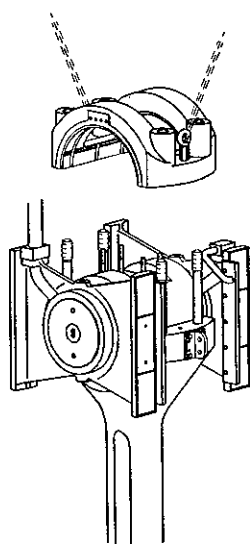
5. Dismantle the crosshead bearing cap. See Procedure 904-1.2.

4.



MIN904-1.2 217 05

5.



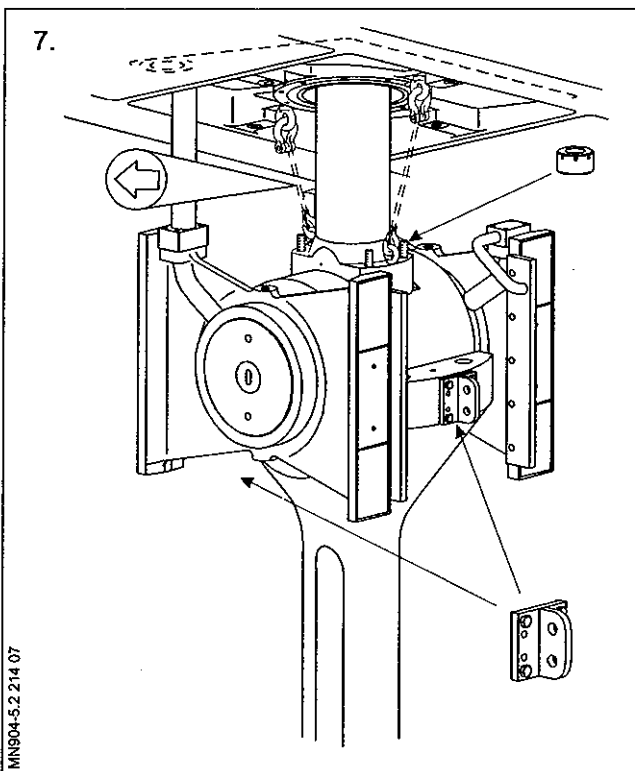
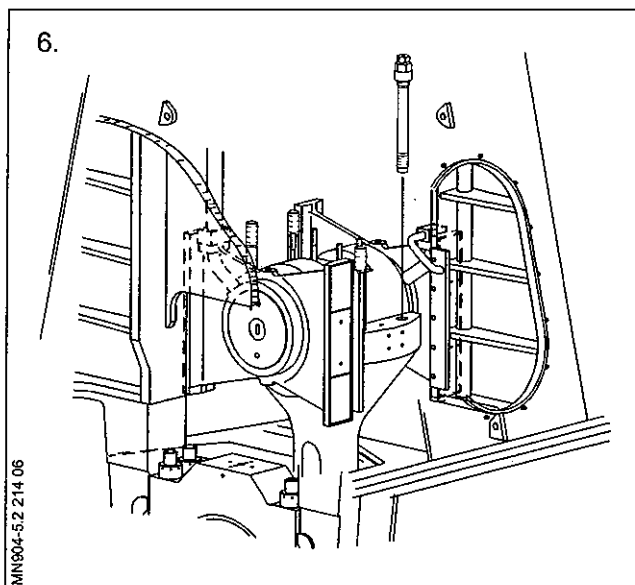
KN904-1.2 224 07

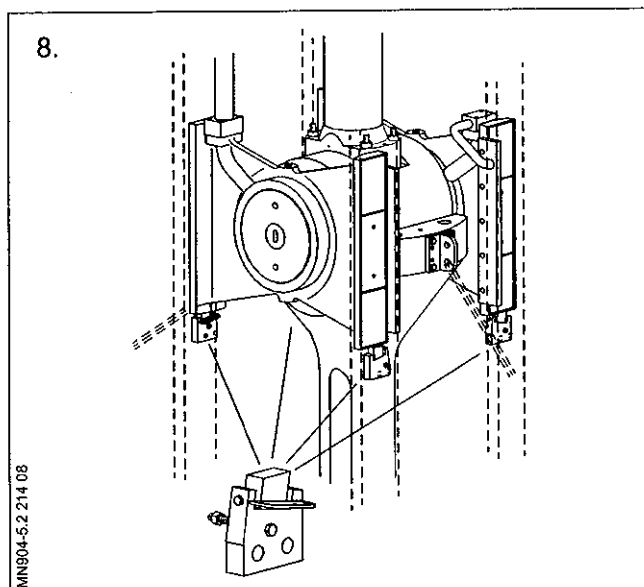
6. Using the stud setter, dismantle the studs from the connecting rod.
7. Turn the crosshead upwards, until the piston rod foot lands on the crosshead.

Remove the chains from the piston rod foot.

Screw the piston rod nuts on to the studs of the crosshead.

Mount the lifting attachments for fixing the connecting rod on the connecting rod head.





8. Turn the crosshead to TDC. Hook two tackles from points **A** and **B** on to the lifting attachments on the connecting rod head.

Haul the tackles tight.

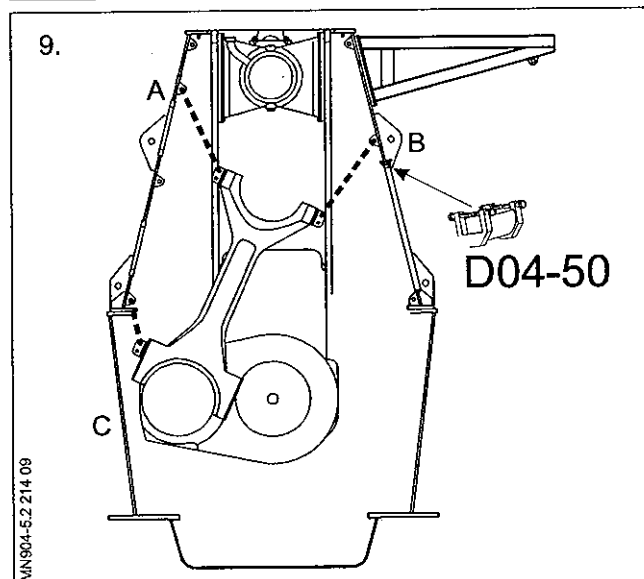
Mount a lifting attachment on the lower end of the connecting rod on the exhaust side.

Mount the four supports for guide shoes on the crosshead guides.

Adjust the support bracket sledges to their lowest position.

Carefully turn the crank down until the guide shoes are approx. 1 mm from the support bracket sledges.

Adjust the sledges to support the guide shoes so that the weight of the crosshead is evenly distributed on the four supports.

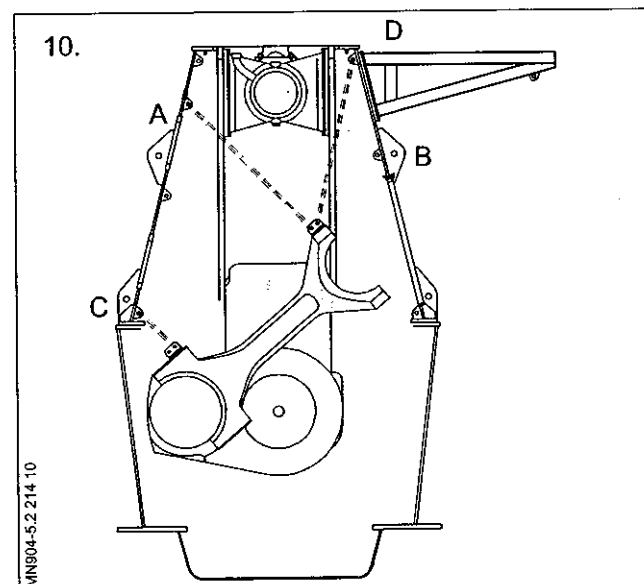


9. Turn the crank to approx. 90 degrees before TDC. Hook tackle **C** on to the lifting attachment mounted on the lower end of the connecting rod.

Mount the wire guide at the top of the doorway.

10. Hook tackle **D** on to the lifting attachment mounted on the upper end of the connecting rod on the exhaust side. Tighten up the tackle.

Remove tackle **B** and remove the lifting attachment from the camshaft side of the connecting rod head.



11. Shift tackle **A** from the lifting attachment on the connecting rod head to the lifting attachment on the connecting rod foot.

Turn the crank **carefully** upwards while 'following' with tackles **A**, **C** and **D**, guiding the connecting rod head out of the doorway.

12. Using a shackle and a wire rope, hook the engine room crane on to the lifting attachment mounted on the connecting rod head.

Remove tackle **C**.

Shift tackle **D** from the lifting attachment on the connecting rod head to the lifting attachment on the connecting rod foot.

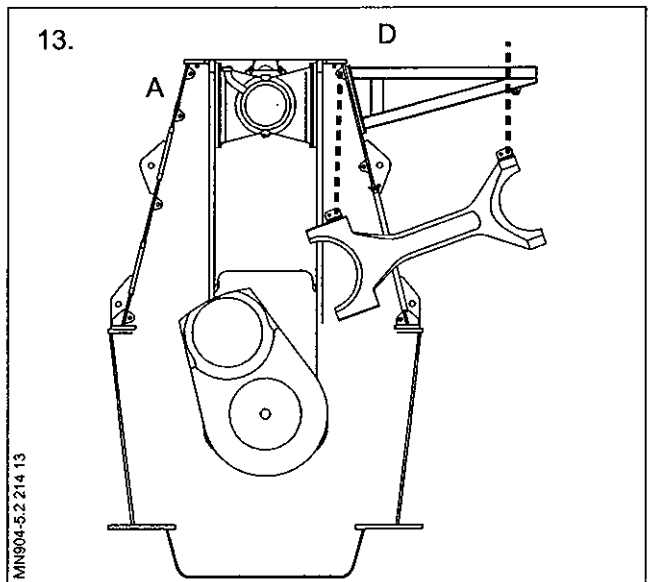
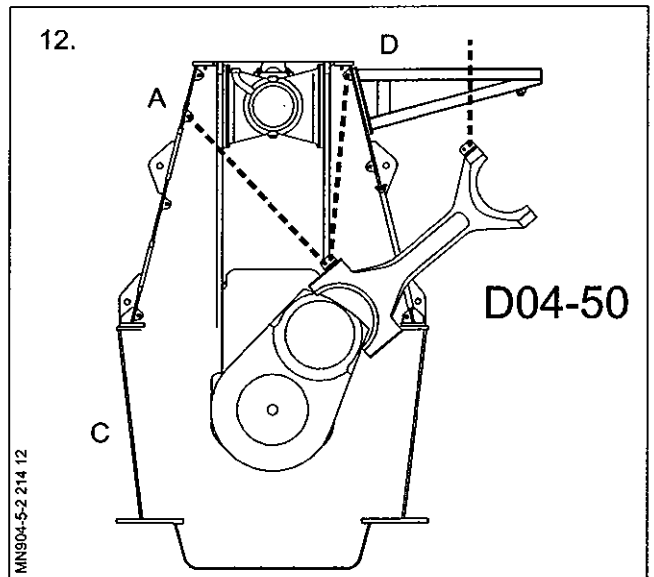
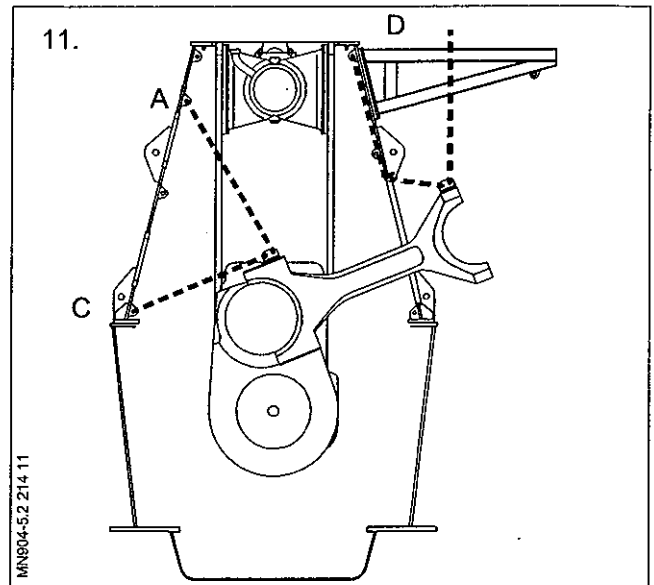
Turn the engine until the crank is 'pointing' towards the doorway, while 'following' with the engine room crane and tackles **A** and **D**.

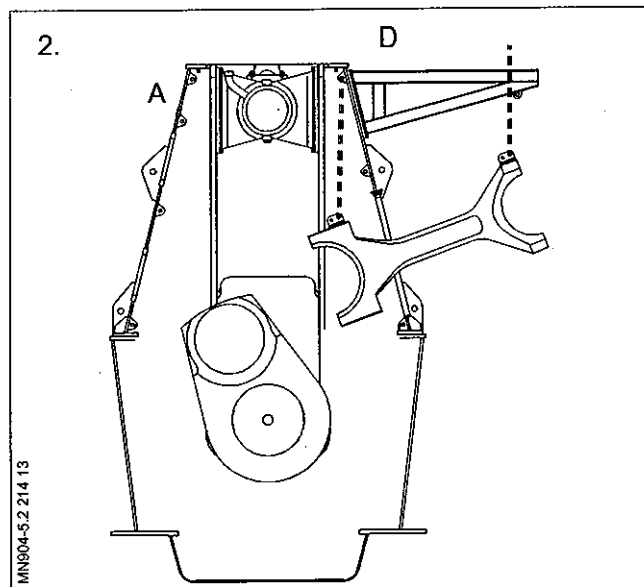
13. Remove tackle **A**. Using tackle **D**, **carefully** lift the lower end of the connecting rod clear of the bearing journal while, at the same time, turning the crankthrow towards the exhaust side of the engine.

Note!

Take care that the connecting rod does not damage the crankpin bearing journal.

14. Using the engine room crane, lift the connecting rod out of the engine.





1. Equip the connecting rod with the same lifting attachments as mentioned under dismantling.

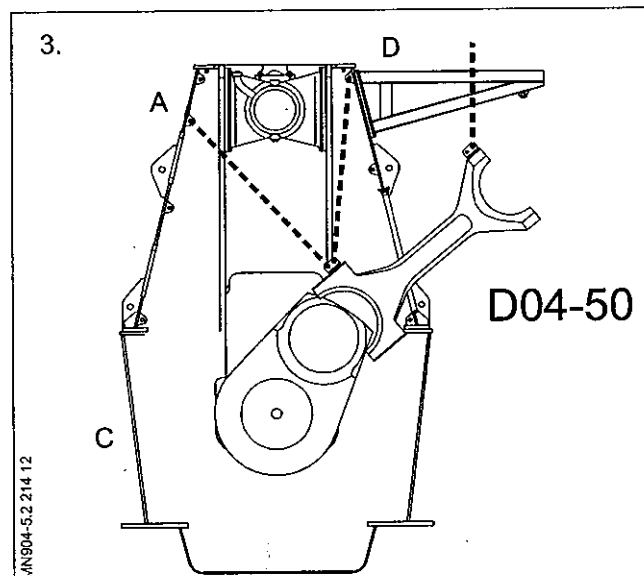
Apply clean lubricating oil to the crankpin bearing shell and journal.

2. Lift the connecting rod carefully into the crankcase by alternate use of the engine room crane and the tackles attached to lifting bracket D.
3. Hook the chain of tackle A on to the lifting attachment on the connecting rod foot.

By alternate use of the engine room crane and tackles A and D, carefully lower the connecting rod towards the crankpin bearing journal while, at the same time, turning the crankthrow until it 'points' towards the connecting rod.

Note!

Take care that the connecting rod does not damage the crankpin bearing journal.

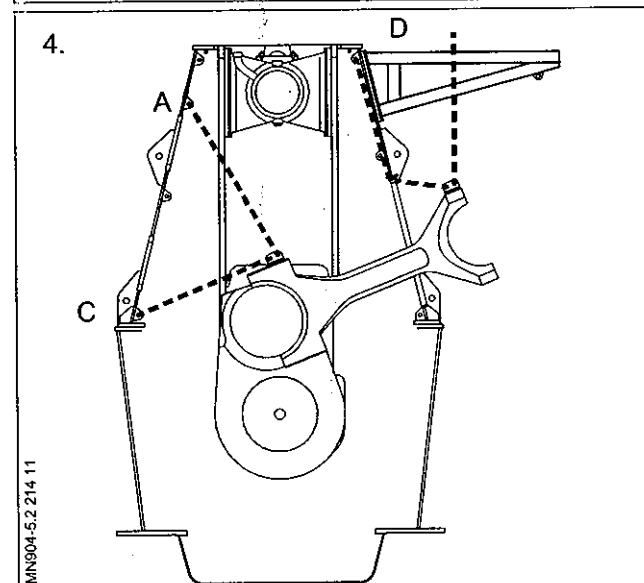


4. When the end of the connecting rod rests on the crankpin journal, hook the chain of tackle C on to the lifting attachment on the connecting rod foot.

Turn the crankthrow towards the exhaust side of the engine while 'following' with the engine room crane and tackles A, C and D.

When the head of the connecting rod is close to the doorway, shift tackle D to the lifting attachment on the connecting rod head.

Remove the wire rope connected to the engine room crane from the lifting attachment on the connecting rod head.



5. Turn the crankthrow to 90° before BDC while 'following' with the tackles.

Shift tackle **A** from the lower end to the top of the connecting rod.

Tighten up tackles **A**, **C** and **D** to turn the connecting rod upwards.

Note!

Take care that the wire rope of tackle **D** does not touch the crosshead bearing journal.

6. Mount a lifting attachment on the camshaft side, upper end, of the connecting rod and remove the wire guide from the doorway.

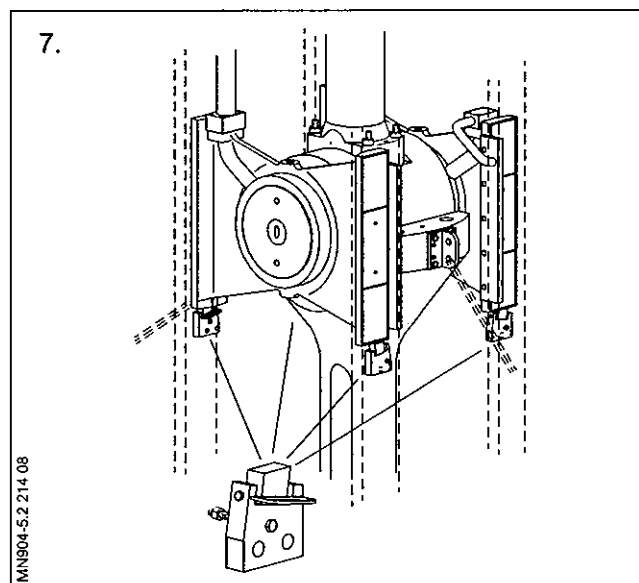
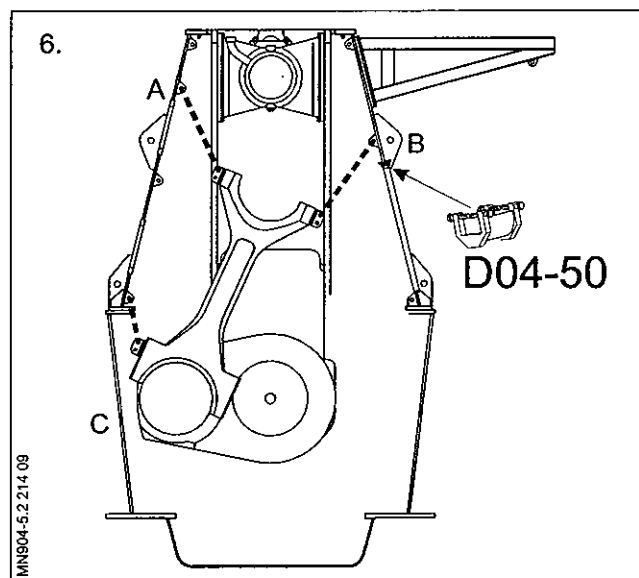
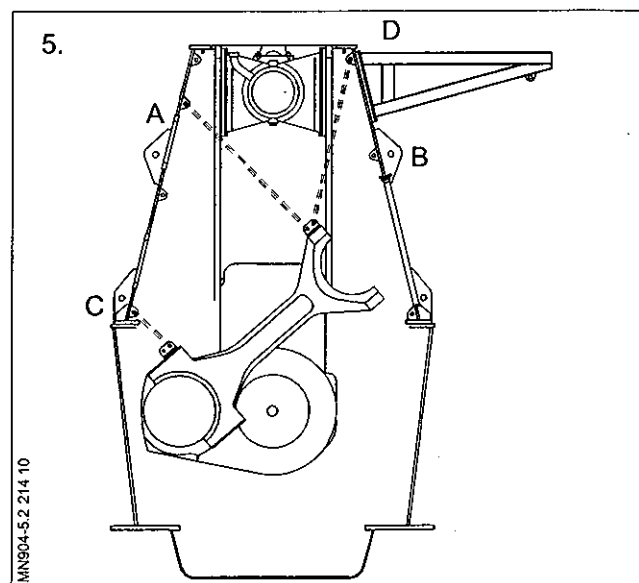
Mount a tackle in bracket **B** and hook this tackle on to the lifting attachment on the camshaft side of the connecting rod head.

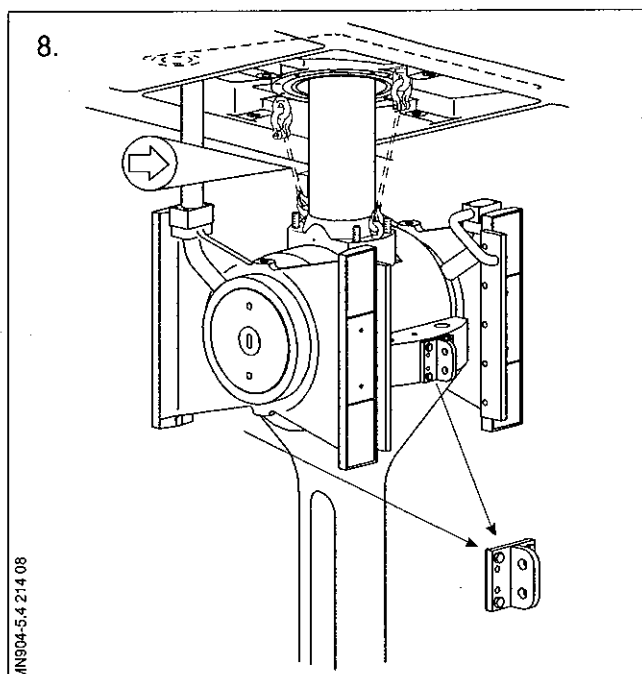
Remove the tackle in bracket **D**.

7. Lubricate the crosshead bearing journal and the crosshead bearing shell with plenty of clean lubricating oil.

Turn the crankthrow to TDC while 'following' with tackles **A**, **B** and **C**.

Remove the four supports from the crosshead guides. Relieve tackles **A**, **B** and **C** from the lifting attachments on the connecting rod. Remove all tackles from the connecting rod.





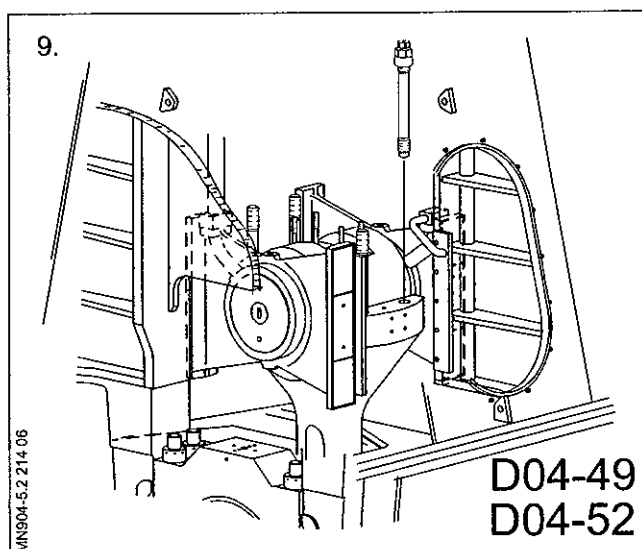
8. Turn the crosshead downwards far enough to enable access to the piston rod nuts.

Unscrew and remove the piston rod nuts.

Mount the lifting chains between the top of the crankcase and the piston rod foot.

Remove all tackles and lifting attachments.

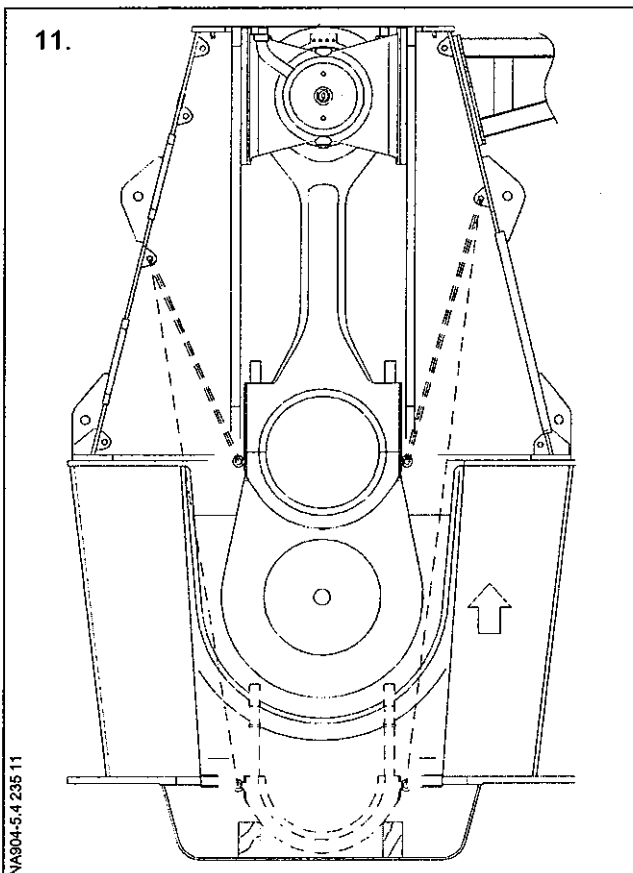
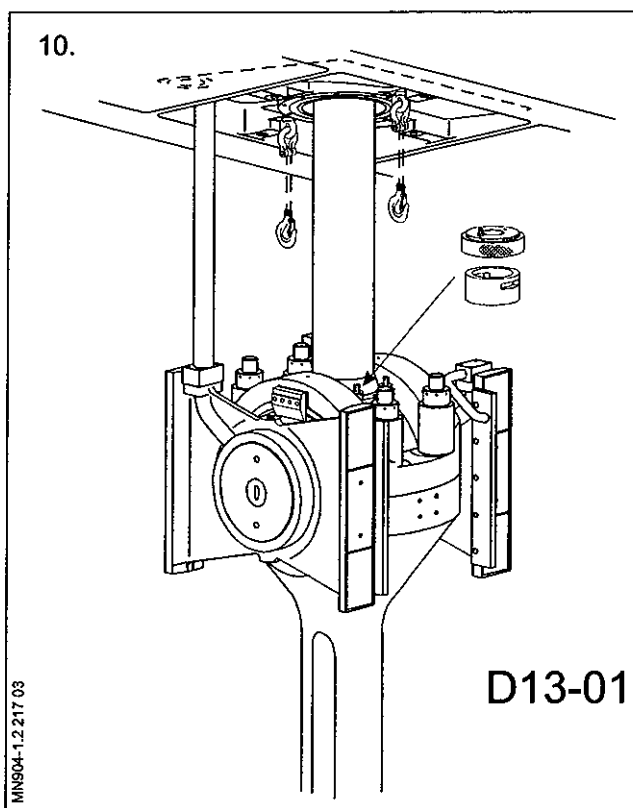
9. Turn the crankthrow to BDC. Mount the studs on the connecting rod. Using the stud setter, tighten the studs to the correct torque, as stated in Data.

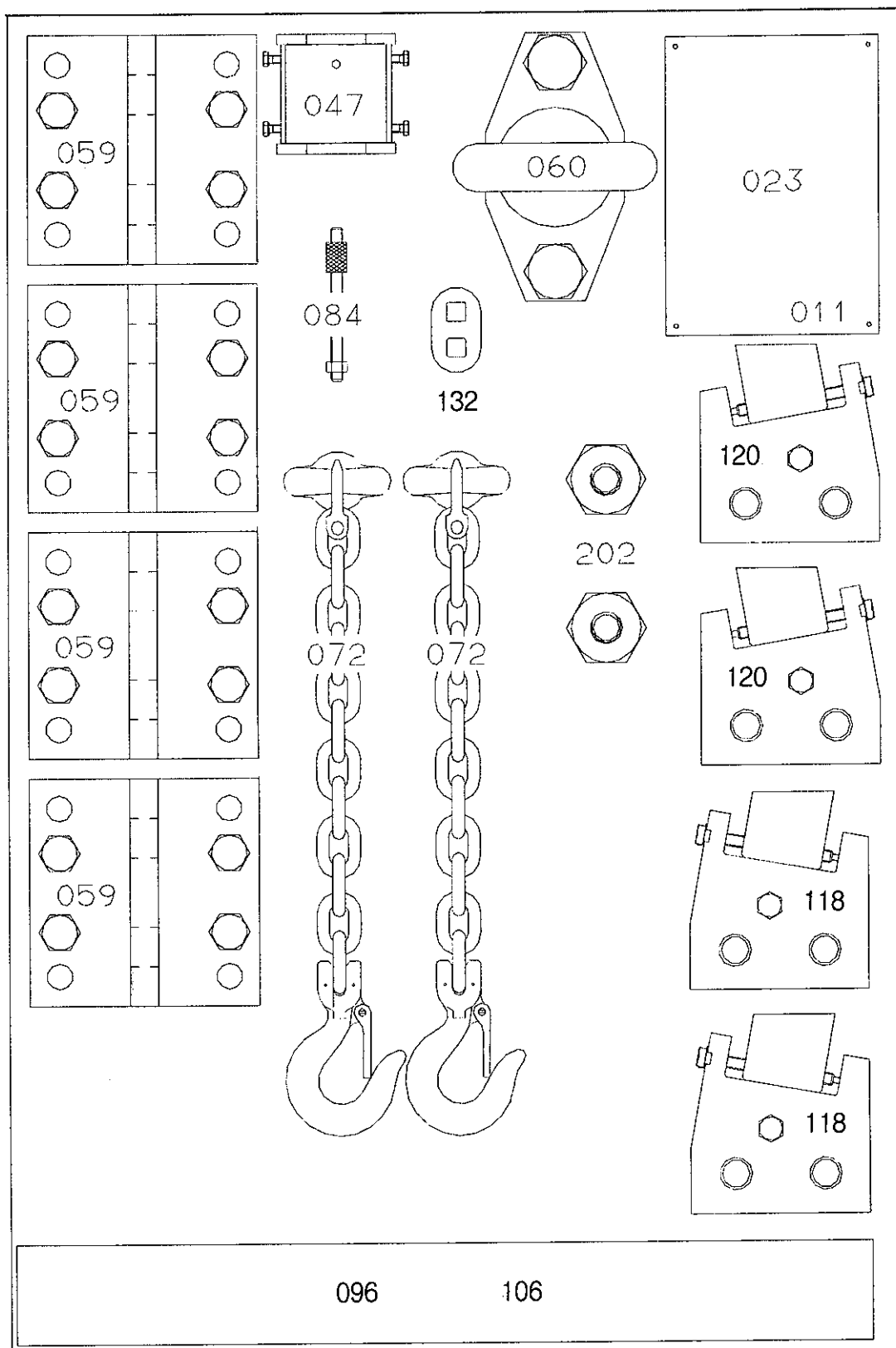


10. Mount the crosshead bearing cap.
See Procedure 904-1.4.

Mount the piston rod on the crosshead.
See Procedure 904-1.4.

11. Turn the crankthrow to TDC, and mount the crankpin bearing cap.
See Procedure 904-4.4.
12. Remove the tackles from the crank casing.
13. Remount the gallery floor plates.





Item No.	Item Description	Item No.	Item Description
011	Tool panel		
023	Name plate		
047	Wire guide		
059	Lifting attachment - connecting rod		
060	Lifting tools - crosshead		
072	Chain for suspending piston		
084	Retaining tools telescope pipe		
096	Rubber cover for crosshead		
106	Rubber cover for crosshead		
118	Bracket - support of x-head		
120	Bracket - support of x-head		
132	Torque wrench offset tool		
202	Extension, cutting tool		

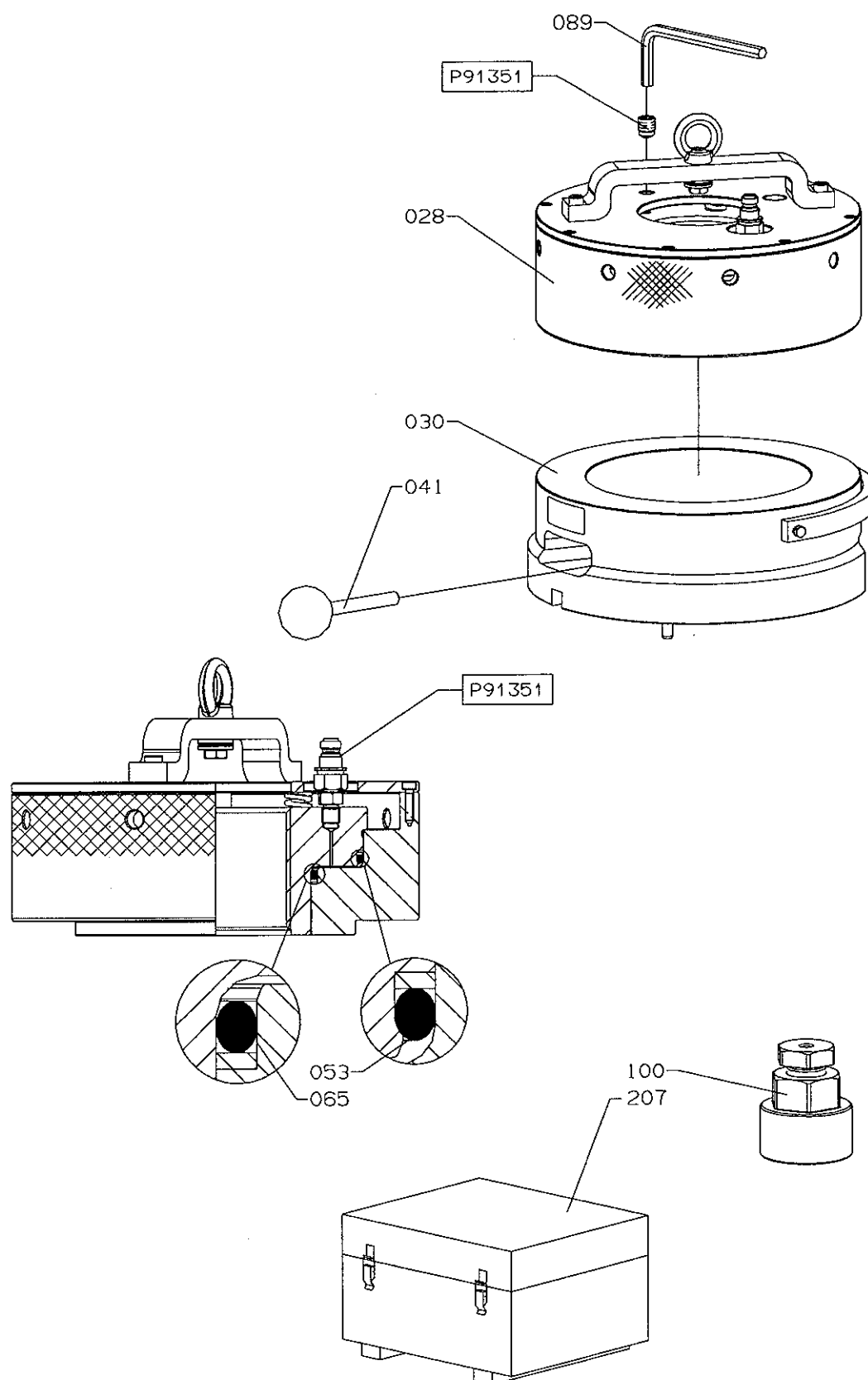
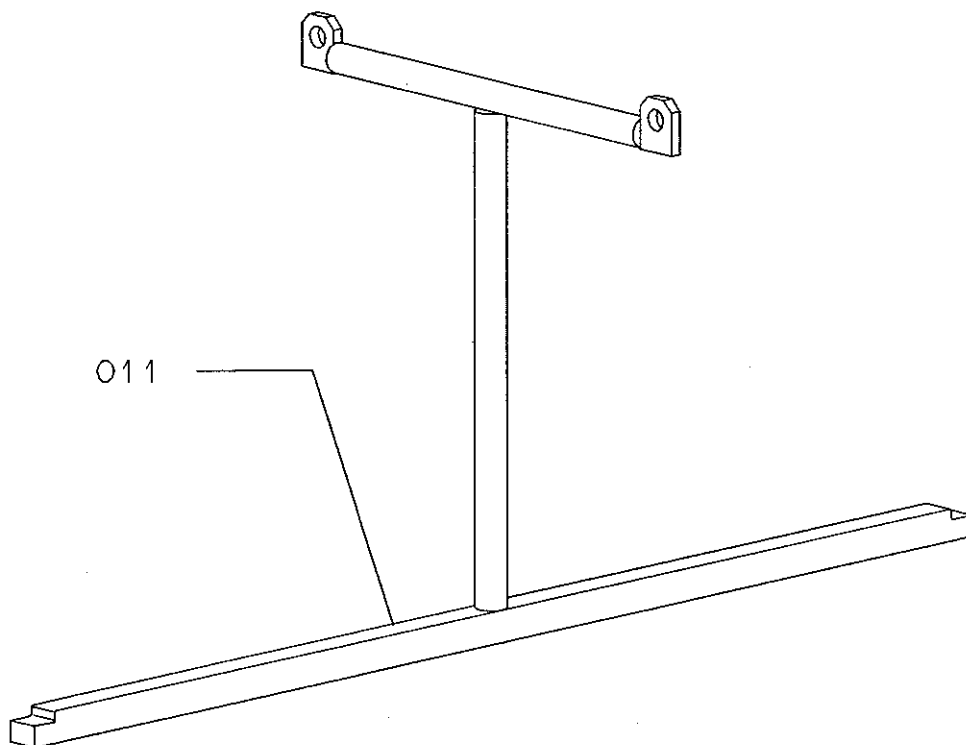


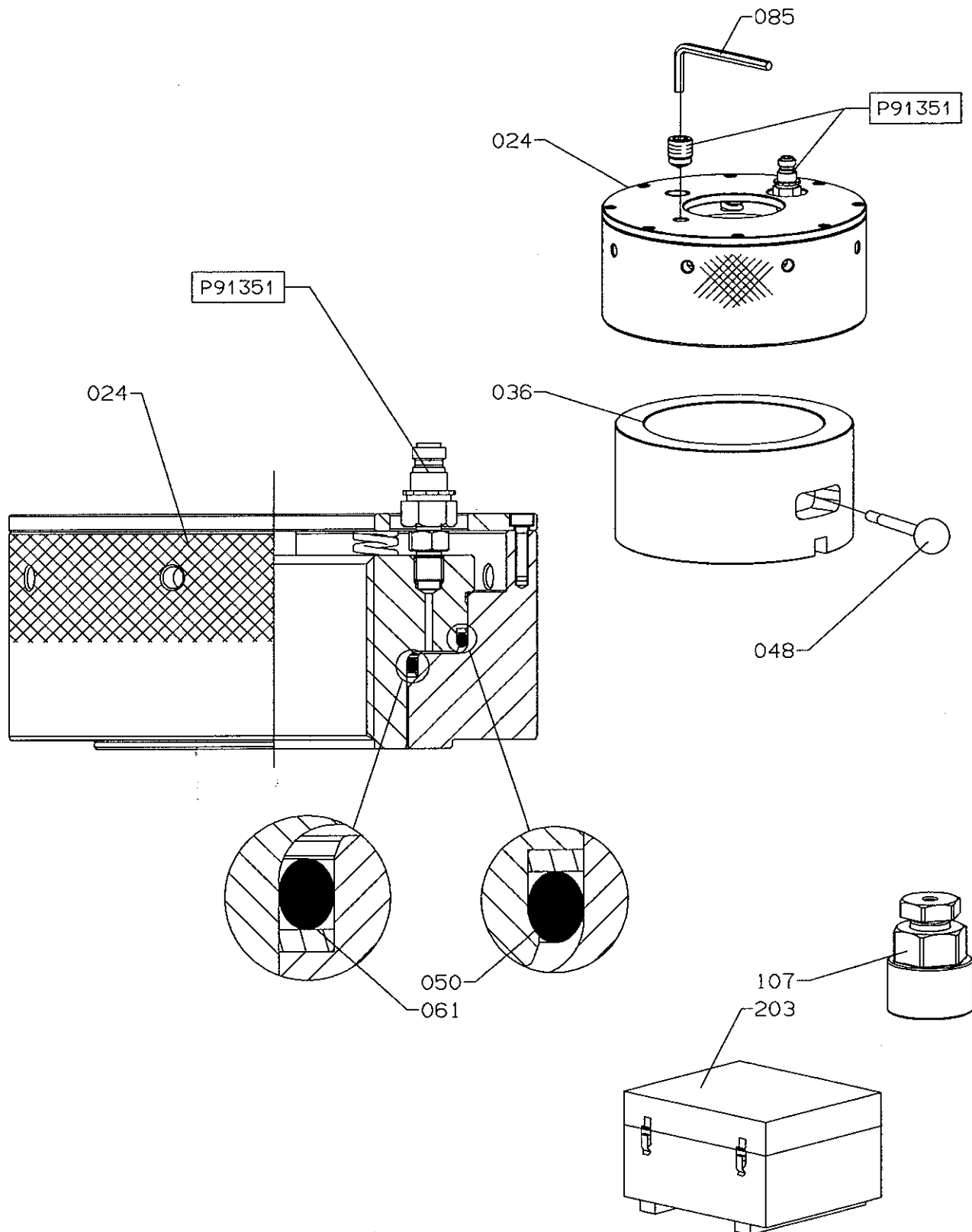
Plate 90461-0071 Connecting Rod - Hydraulic Tools

Item No.	Item Description	Item No.	Item Description
028	Hydraulic jack, complete		
030	Support		
041	Tommy bar		
053	Sealing ring with back-up ring		
065	Sealing ring with back-up ring		
077	Tommy bar		
089	Spanner		
100	Stud setter		
207	Hydraulic toolset, complete		



Item No.	Item Description
011	Lifting tool for crankpin shell

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
024	Hydraulic jack, complete		
036	Support		
048	Tommy bar		
050	O-ring with back-up ring		
061	O-ring with back-up ring		
085	Spanner		
107	Stud setter		
203	Hydraulic toolset, complete		

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☐	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-01	Main bearing, top clearance max.	0.70	mm
D05-02	Main bearing, top clearance min.	0.30	mm
D05-03	Main bearing cap	1527	kg
D05-04	Main bearing shell, upper	89	kg
D05-05	Main bearing shell, lower	95	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90451	047	Wire guide
P90551	040	Pulley for wire for main bearing
P90551	076	Lifting tool - main bearing cap
P90551	088	Dismantling tool, main bearing shell
P90551	090	Mounting tool for bearing shell
P90551	123	Retaining tool for main bearing shell
P90551	159	Eye bolt
P90551	160	Wire
P90551	172	Mounting tool, thin bearing shell
P90561		Main Bearing - Hydraulic Tool
P90562		Crankshaft - Tools
P90571		Main Bearing Shell - Tools
P90572		Main Bearing - Measuring Tools
P91351	010	Hydraulic pump, pneumatically operated
P91351	022	Hydraulic pump, hand operated
P91351	046	Hose with unions (1500 mm), complete
P91351	058	Hose with unions (3000 mm), complete
P91351	117	5-way distributor block, complete
P91351	166	Angle union
P91356		Lifting Tools, Etc.
P91366	048	Autolog, measuring tool for crankshaft
P91366	057	Feeler gauge
P91366	1501/02	Dial gauge and stand tool
P91368		Working Platforms

General

The condition of the main bearings can be checked by:

- Deflection readings
- Visual checking
- Edge checking and
- Measuring of top clearance.

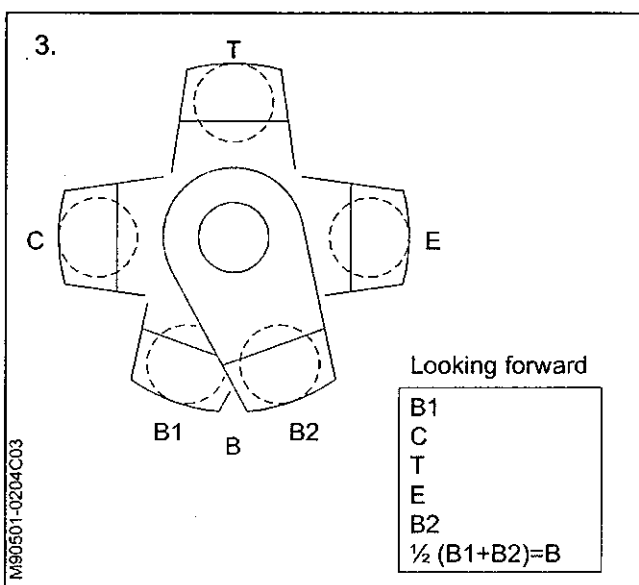
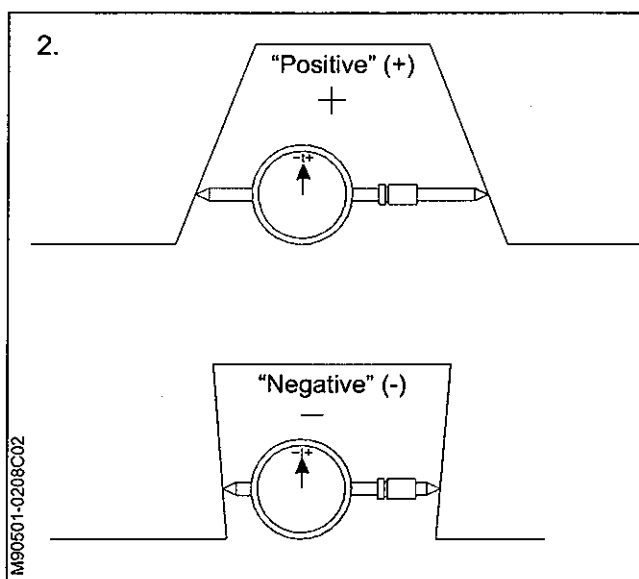
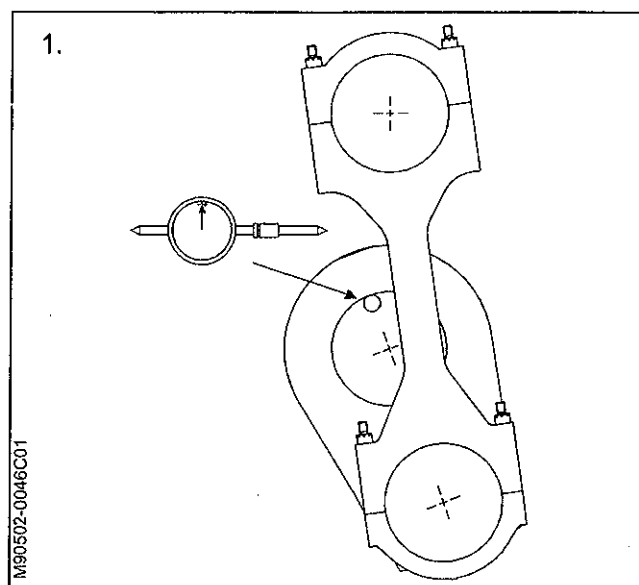
Crankshaft deflection readings

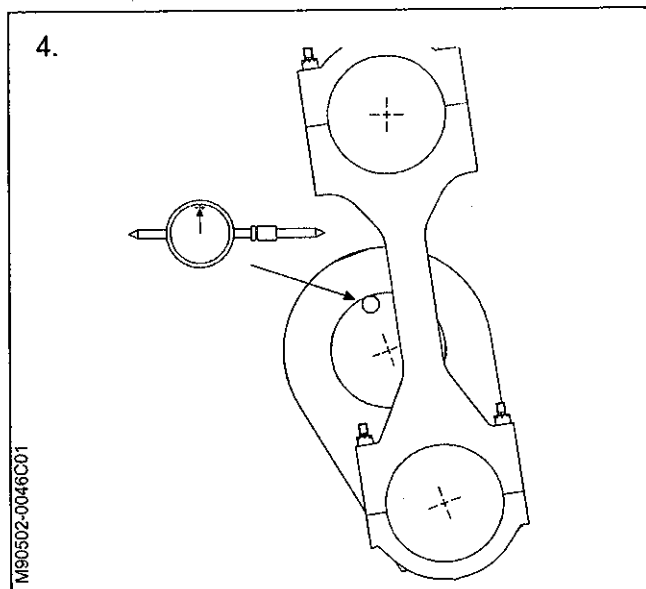
Crankshaft deflection readings should be taken while the ship is afloat (i.e. not while in dry dock).

As the alignment is influenced by the engine temperature as well as the loading conditions, deflection measurements should, for comparison purposes, always be made under nearly the same temperature and load conditions.

1. Place a dial gauge axially in the crank throw opposite the crankpin, as illustrated on the sketch. The correct mounting position is marked with punch marks on the crank throw. See also Chapter 708 in Volume I.
2. "Closing" of the crank throw (compression of the gauge) is regarded as negative (-) and "opening" as positive (+).
3. Set the dial gauge to zero at the **B1** side near BDC. Whilst turning clockwise, take the readings when the throw passes the positions:

- B1** (near bottom)
C (camshaft side)
T (top)
E (exhaust side)
B2 (near bottom)
B = $1/2 (B2+B1)$

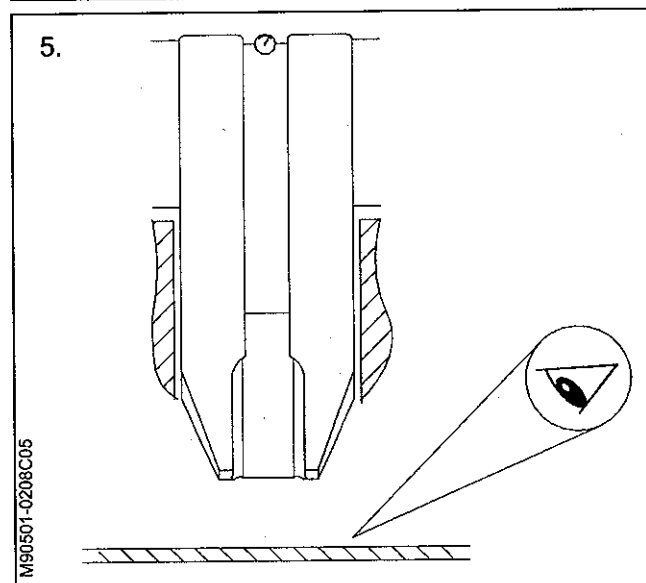




4. When taking deflection readings for the three aftmost cylinders, the turning gear should, at each stoppage, be turned a little backwards to ease off the tangential pressure on the turning wheel teeth. Otherwise, this pressure may falsify the readings.

For evaluation of the crankshaft deflection readings, see *Volume I, OPERATION, Chapter 708*.

If the crankshaft deflection (alignment indicator) is approaching the tolerance limits (see *Vol. I, OPERATION*), the two adjacent main bearings must be checked for wear. See next page for checking of main bearing.



If the bearings are found to be in good order, please contact MAN B&W Diesel or the engine manufacturer for checking of the bedplate alignment.

As reference, use the "after seatrial" deflection table.

The condition of the bearing can be checked as follows:

5. Visually look for bearing metal fragments in the oil pan, and check the filters for metal fragments.

Such fragments can be from crosshead, guide shoe or crankpin bearings. If fragments are found, the damaged bearing can be found by edge checking with a feeler.

General

Bearing damage usually propagates rather quickly towards the edge of the bearing where, eventually, it causes chips to be broken off, which means that loose pieces of white metal can fall down into the crankcase beneath the bearing support.

Large, thick pieces will normally be found during a crankcase inspection, and small, thin pieces can enter the filter. A check of the bearing edges together with inspection of the crankcase and the filter normally provides a good indication of the bearing condition.

Checking the bearing edges

6. Bearing edges can be checked with a "feeler" that is able to follow the bearing edge against the journal the whole way round on each side. If white metal is missing at the edge, the tip of the "feeler" will enter the hole, thus locating the damage. In most cases this hole can be seen by the naked eye as a dark spot when using a strong flashlight.

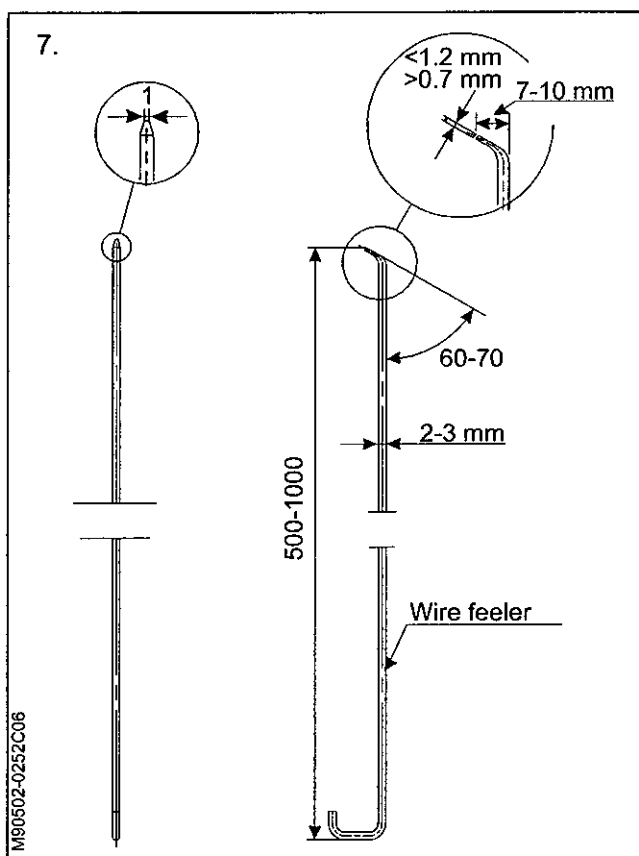
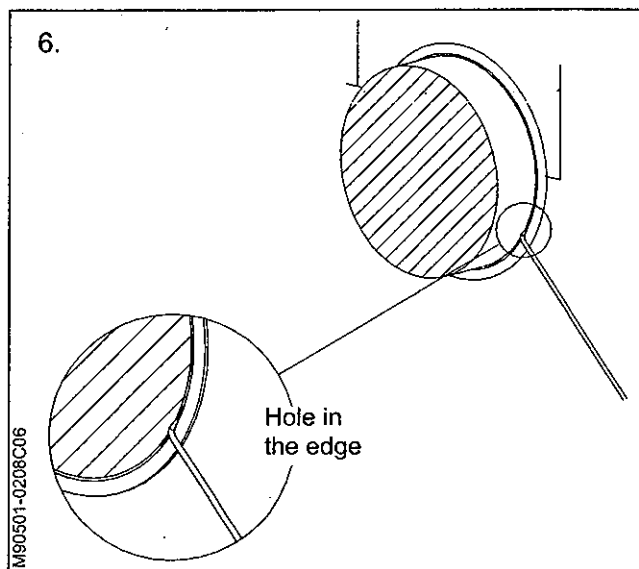
The No. 1 and the two aftmost main bearings are more difficult to access on the whole circumference on each side, but it is often possible to bend the "feeler" to suit the situation and thus reach as far round as possible.

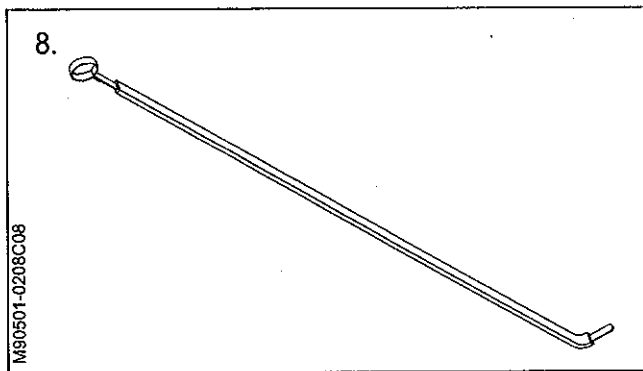
Wire-feeler

7. It is rather easy to make a feeler (see sketch). The "feeler" should be made from a piece of steel wire (e.g. a welding rod) approx. 0.6 - 1 m long depending on the engine type, and 2 to 3 mm thick. Approx. 7 to 10 mm of the wire should be bent to an angle of approx. 65° to form a "feeler tip". Grind the tip smooth to obtain the shape and dimension shown on the sketch. Note that the thickness of the white metal is approx. 1.5 mm, which is why the tip should be less than 1.2 mm thick, and bigger than the max. top clearance. At the other end of the tip, a "handle" should be made by bending a hook or similar in the same direction as the tip.

Note!

The above dimensions of the "wire-feeler" are guideline values and may depend on the engine type as well as individual, personal designs.

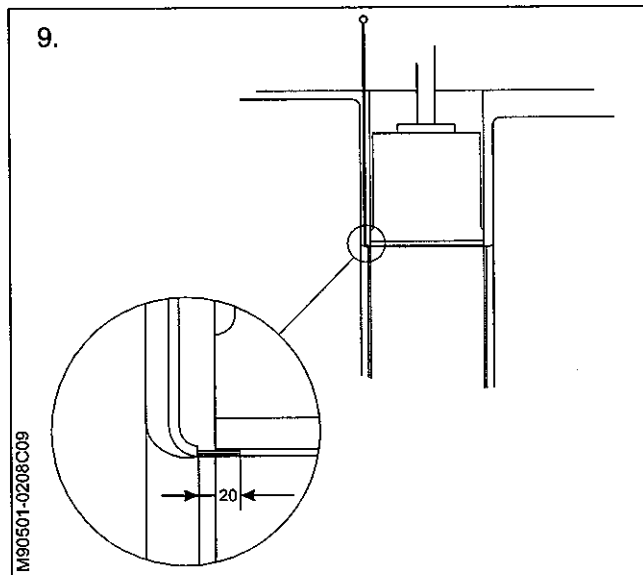




8. If there is too large a difference in the crankshaft deflection readings (autolog) check the clearance in the individual bearings.

Bearing clearance checks should also be carried out during time-based overhauls, surveys and during crankcase inspections.

If there is a suspicion of a damaged bearing, it is recommended to edge check the bearing, without opening up.

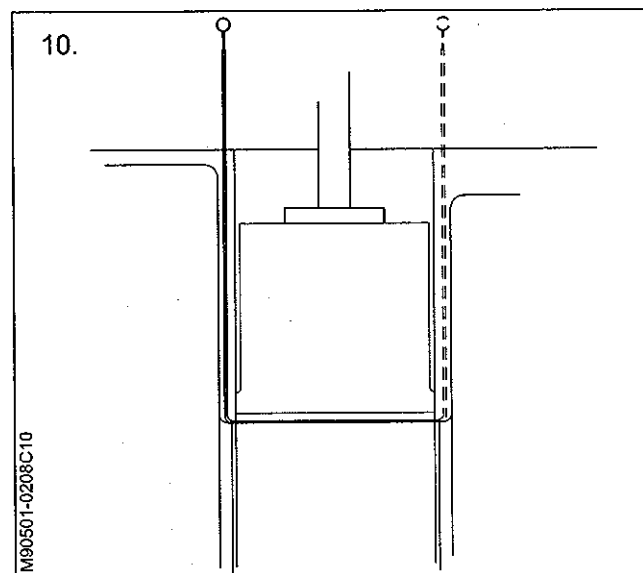


9. Before measuring, check that the feeler blades are in good condition.

The feeler is inserted along the crank throw. When the feeler hits the journal, gently attempt to enter the feeler gauge into the bearing. Do not use force.

Measure until a Go/No go difference of 0.05 mm has been found, e.g. Go = 0.65 mm / No go = 0.7 mm.

Check the feeler blades after measuring.



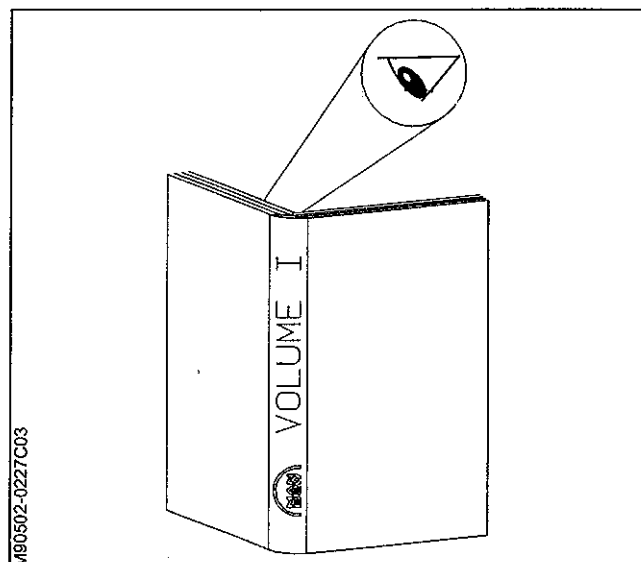
10. The clearance is measured at both the fore and the aft part of the bearing.

Note!
The bearing clearances for a new bearing stated in Data (see Data 105-2) are for guidance purposes only.

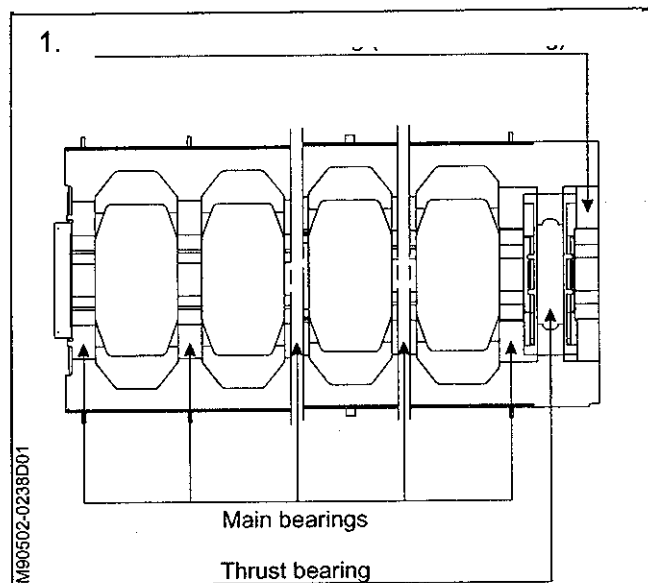
11. The difference between the actual clearance measurement and the measurement recorded in the adjustment sheet (or the clearance noted for a new bearing installed later) must not exceed 0.10 mm. If it does, see Volume I, Operation, Chapter 708.

For evaluation of the bearing, see *Volume I, Operation, Chapter 708*.

If the bearing needs to be disassembled for inspection, see procedure 905-2.2.



M90502-0227C03

**Positioning the crankshaft**

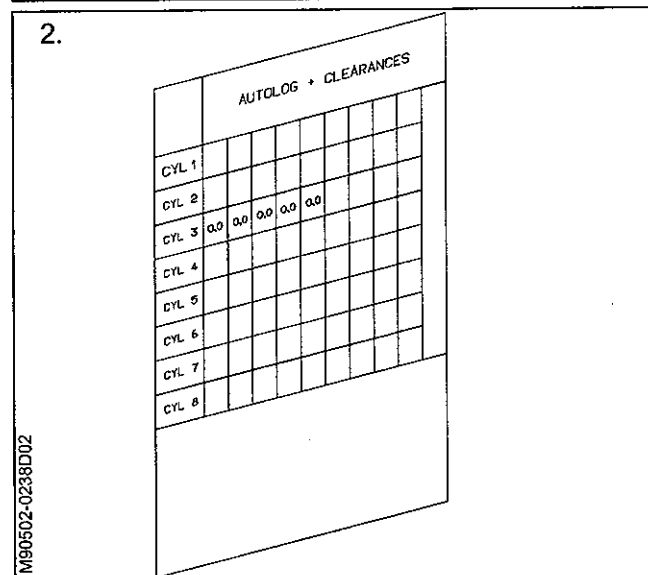
1. Dismantling of main bearing.

The bearings are divided into two categories:

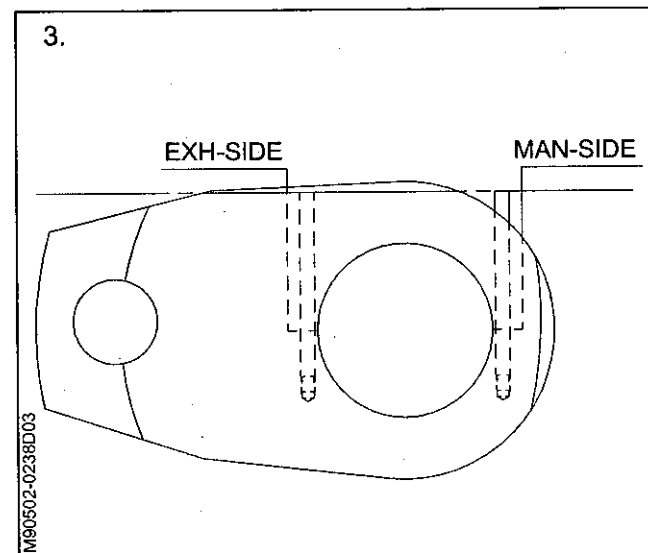
- The main bearings
- The aftmost main bearing often referred to as "Journal bearing" (See Procedure 905-4).

2. Before any dismantling, check and write down the main bearing top clearances and crankshaft deflection readings for the cylinder unit concerned.

3. Turn the crank throw to the position shown on the sketch and in such a way that the top of the studs is flush with or slightly above the crank throw.

**Note!**

Be sure that the crosshead for the neighbouring cylinder is in a higher position than for the cylinder you are working on, otherwise it will be impossible to lift the cap.



Oil pipes

4. Disconnect the lubricating oil pipe from the main pipe.

Note!

On some engines, the oil pipes for the Axial Vibration Damper (AVD) have to be removed together with the oil pipe on main bearing No. 1.

Note!

Some engines have temperature sensors fitted to the main, crosshead, and crank-pin bearings. These sensors must be carefully handled to avoid damaging the equipment.

Mounting of tools and tackles

5. Mount pulley E above the bearing cap and an eye bolt in the stop screw fitted in the bottom of the opposite guideshoe.

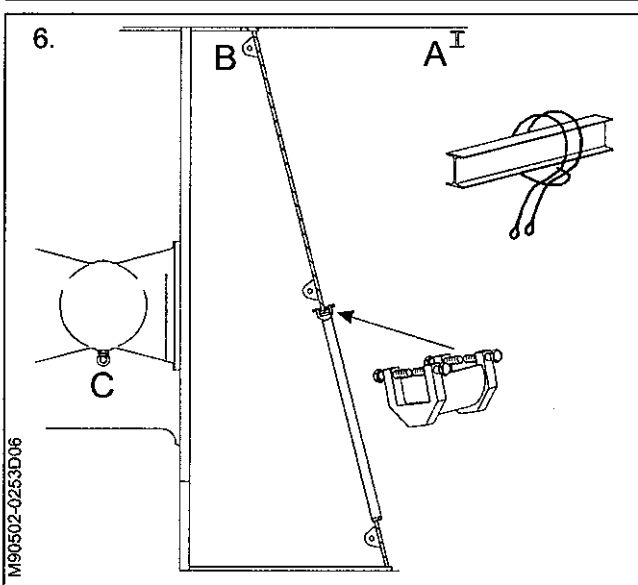
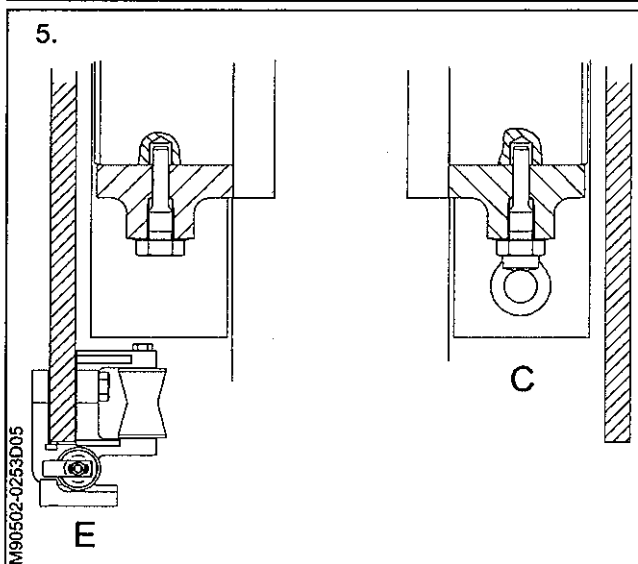
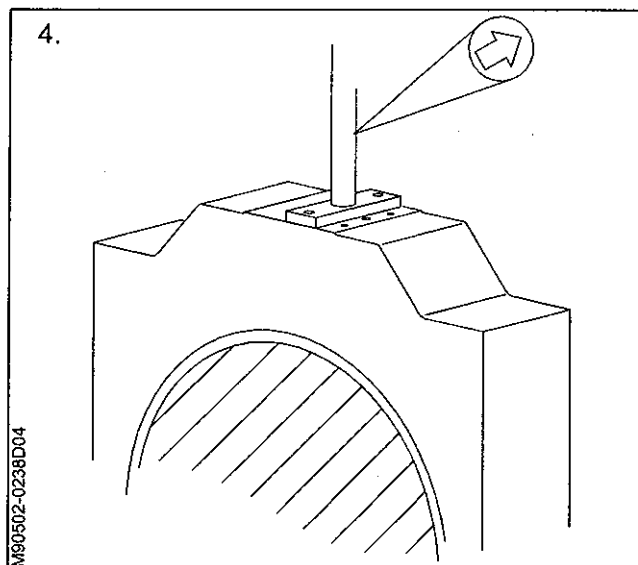
Be sure that the eyebolt is tightened to full contact.

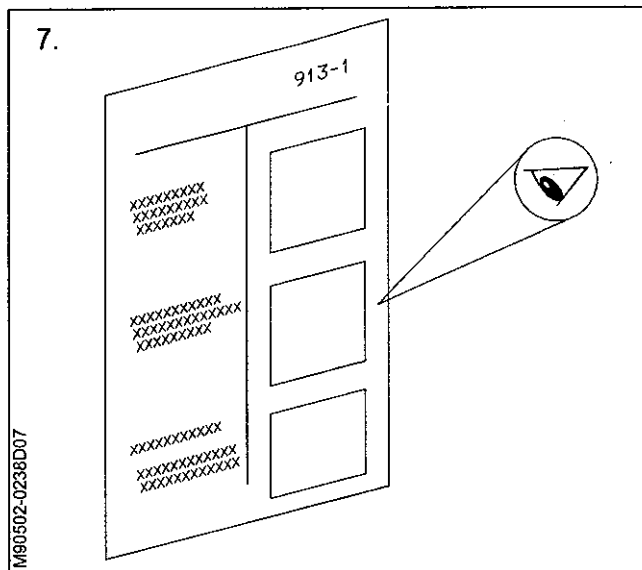
6. Mount the wire guide as shown. Mount tackles in the following positions:

A: a 3 tonne chain tackle, in a wire strap around the beam

B: a 3 tonne chain tackle

C: a 3 tonne pull lift





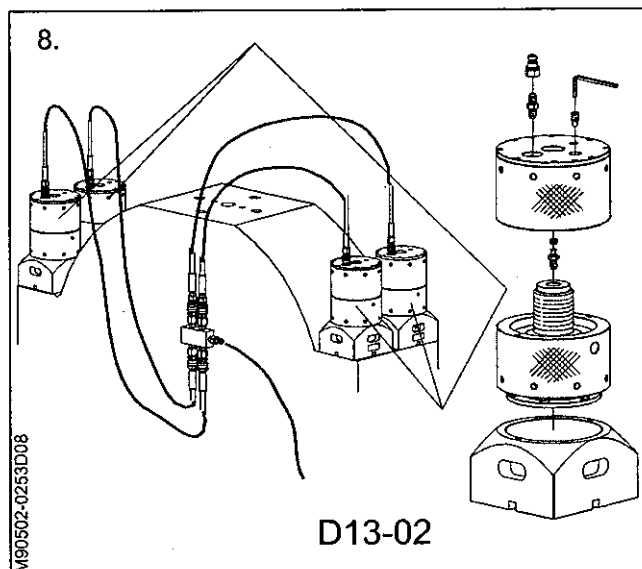
Loosening the nuts

7. Before mounting, assemble and check the jacks as shown in *Procedure 913-1*.
8. Assemble the main bearing hydraulic jacks on the bearing studs. Connect the hydraulic pump.

Loosen the nuts.

Remove the hydraulic main bearing tools from the engine.

Unscrew and remove the nuts from the main bearing studs.



9. For operation of the hydraulic tools, see Procedure 913-1.

Remove the hydraulic main bearing tools from the engine.

Unscrew and remove the nuts from the main bearing studs.

Removal of main bearing cap

10. Mount the main bearing lifting tool on the main bearing cap

Wind the longest of the free wire ropes around pulley **E** as shown, and attach it to tackle **A** from outside the door.

Note!

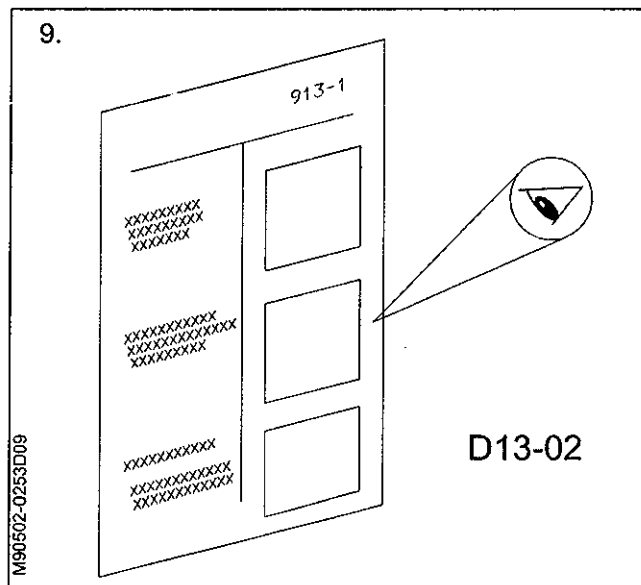
When tightening up the tackle, be sure that the wire guide is positioned correctly to protect the doorframe.

Carefully lift the main bearing cap clear of the studs.

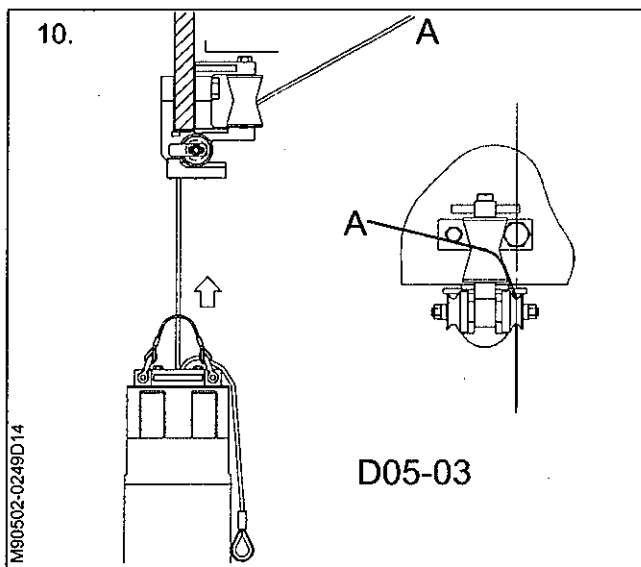
11. Attach pull lift **C** to the short wire rope across the lifting attachment.

By tightening pull lift **C**, and loosening tackle **A**, pull the bearing cap clear of the cross-head guides.

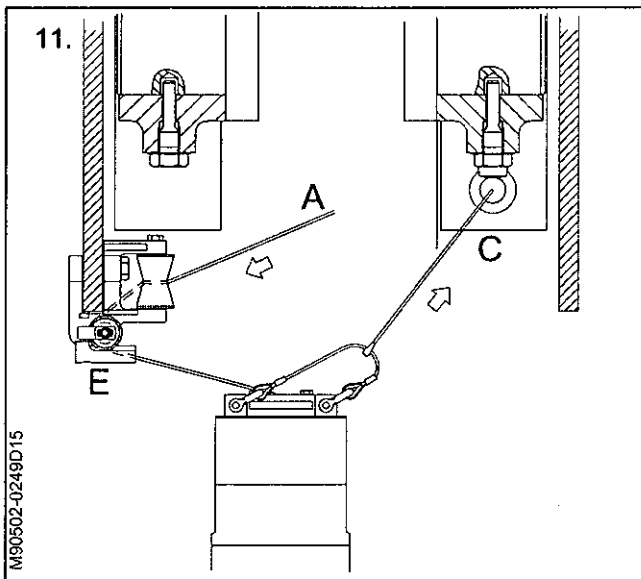
9.

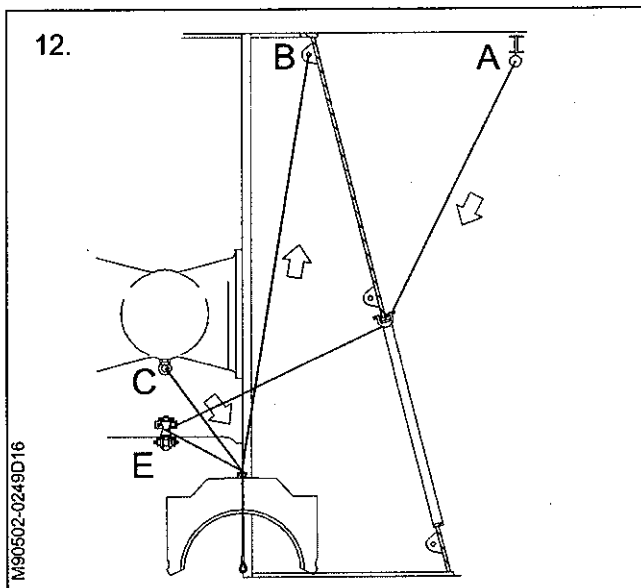


10.



11.





12. Attach tackle **B** to the shortest of the free wire ropes.

By loosening tackle **A** and pull lift **C**, and at the same time tightening tackle **B**, move the bearing cap until it is hanging freely below tackle **B**.

Release tackle **A** and pull lift **C**, and wind the long wire rope off pulley **E**.

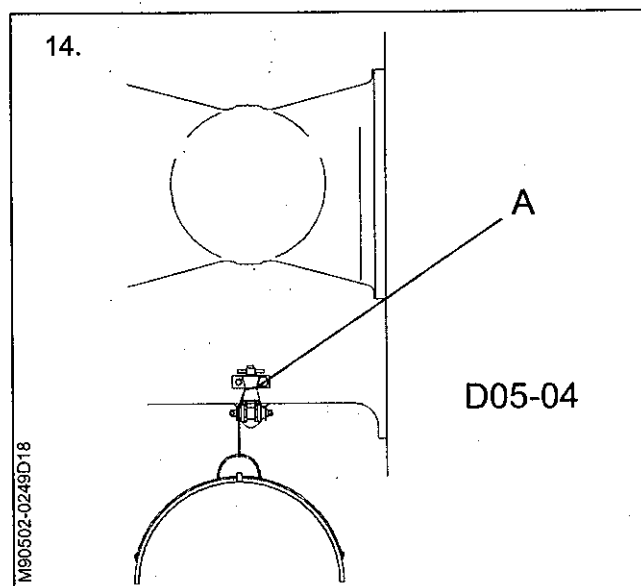
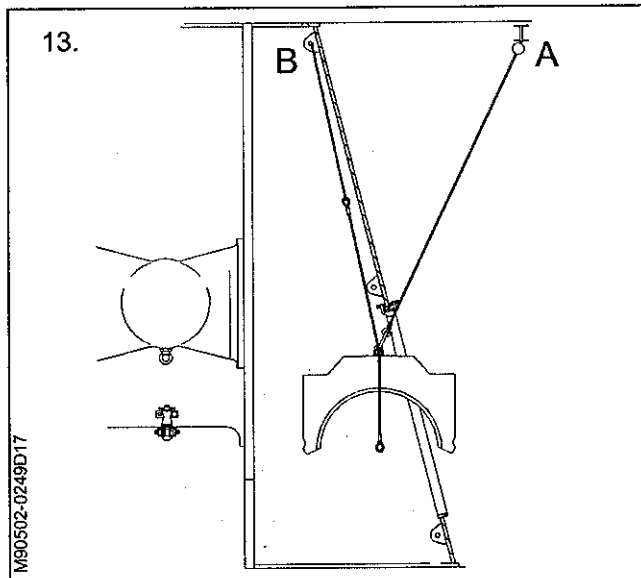
13. Attach tackle **A** to the short wire rope across the lifting tool, and lift the bearing cap out of the engine.

Removal of upper bearing shell

14. Mount the bearing shell lifting tool on the upper main bearing shell, pull the wire around pulley **E**, as shown, and attach it to tackle **A** outside the engine.

Carefully lift the bearing shell until it is hanging freely below the guideshoe.

Lift the bearing shell out of the engine in the same way as the bearing cap.



Removal of upper bearing shell

15. If the crankshaft is turned with the bearing cap dismantled, use the two stops to prevent the lower shell from being rolled out.

16. Place the crosspiece in the bedplate with the ends resting on the cross girders, and position the hydraulic jacks beneath the crank webs as shown.

Tighten the screws against the crank webs and compress the jacks.

Connect the hydraulic jacks to the high pressure pump, and raise the pressure until the crankshaft has been lifted 0.2-0.5 mm, but max. the clearance in the two adjacent bearings.

Note down the pressure for later reference.

17. Check that there is min. 0.1 mm clearance between journal and bearing shell, or between bearing shell and main bearing support, on both sides of the journal.

Note!

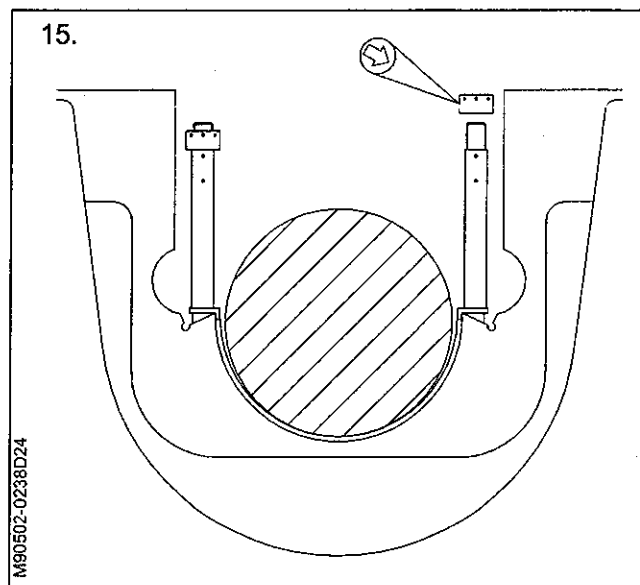
The feeler blade must be inserted minimum 60 mm into the gap to pass the bore relief in the bearing shell.

If the clearance is less than 0.1 mm, move the crosspiece sideways until clearance is obtained. Normally, adjustment needs to be 50-150 mm to the exhaust side (the side where the clearance is missing).

Note!

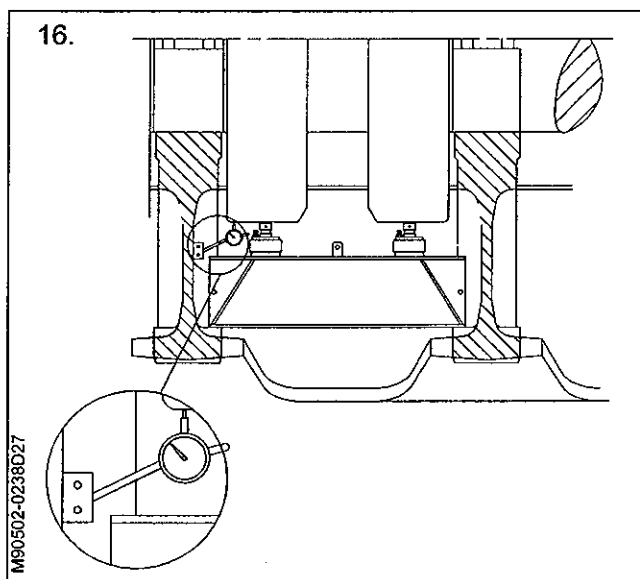
The lower shell must be lifted out to the side with the most clearance, which is normally the manoeuvre side.

15.



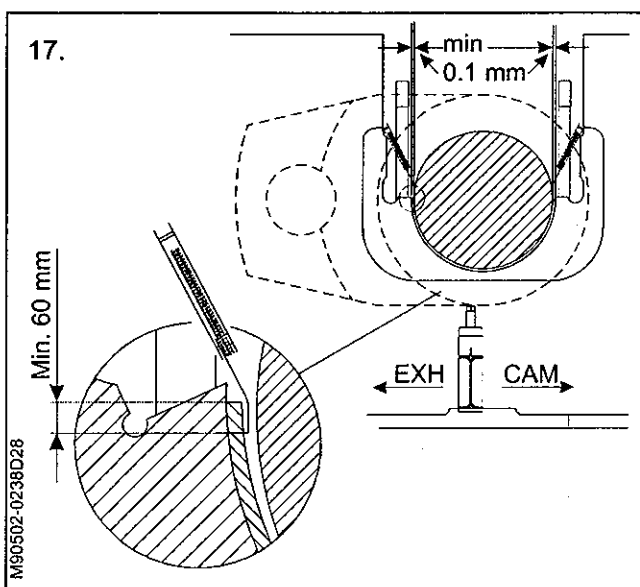
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16.

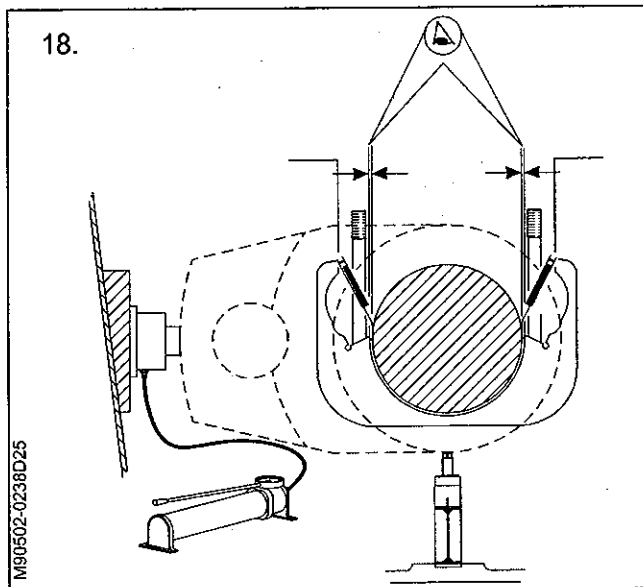


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17.



M90502-0238D28

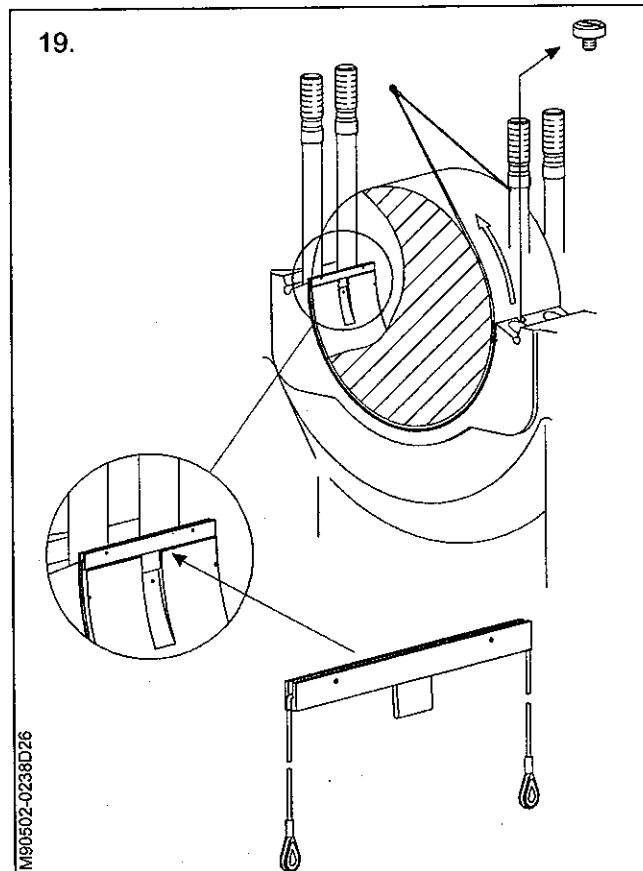


18. If re-positioning of the crosspiece does not ensure a vertical lift, place a 5-tonne jack between the side wall and the crank throw, to correct the journal position in this way.

If it is available, note down the pressure applied to the jack. This data is used to ensure that the crankshaft is in the same position when the new bearing is installed.

Note!

It is recommended that the crankshaft lifting tool is only removed if it is urgently necessary and then only after the main bearing shell has been reinstalled.



19. Dismount the locking screws.

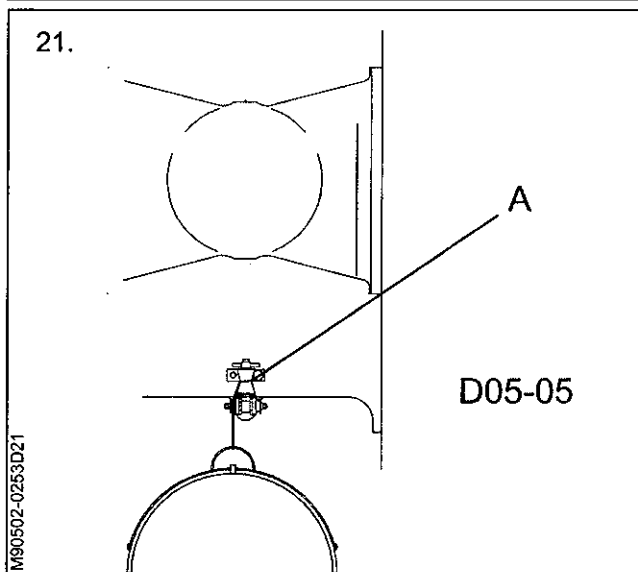
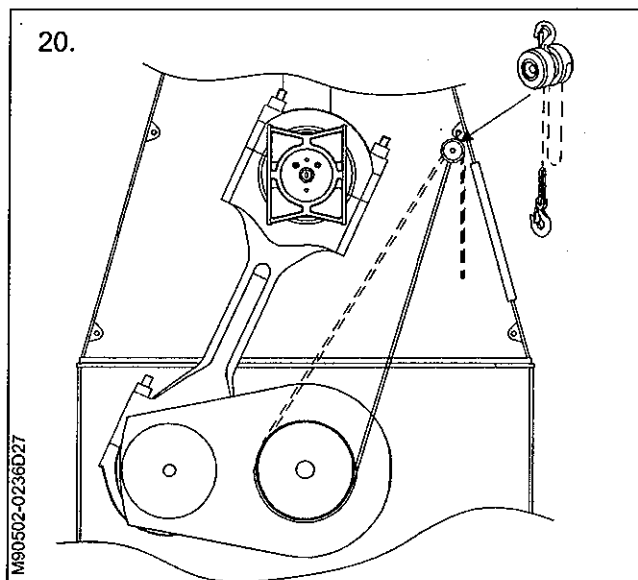
Place the dismantling tool on top of the lower bearing shell. Make sure that the flap on the dismantling tool enters the oil groove in the bearing shell.

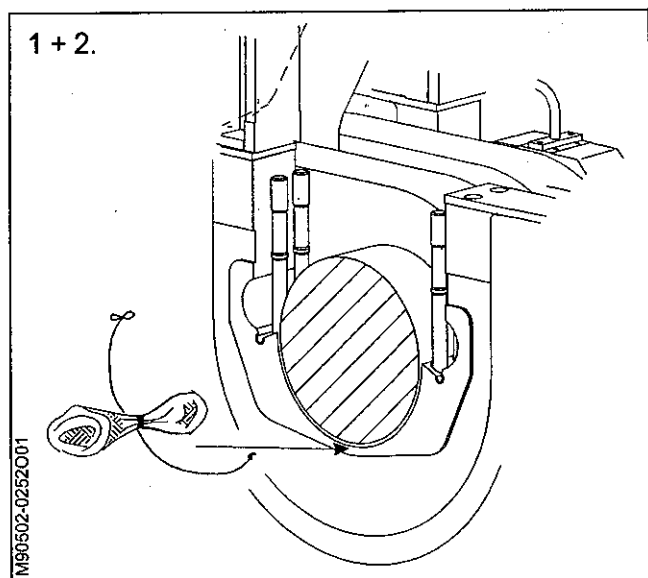
20. Pull the lower shell around and up until it lies over the main bearing journal. Never use a tackle larger than 0.5 tonne.

Note!

While pulling out the shell, it is recommended to hold a foot or hand on the wire rope, to tighten it up and to observe whether the shell is sticking.

21. Take the lower shell out of the engine in the same way as the upper shell, using the lifting tool.





1. Clean and inspect the bearing shells. It is recommended that the main bearing shells be replaced in pairs.

If it is nevertheless desired to replace only one shell, this requires a careful evaluation of the condition of the shell that is to be re-installed.

See *Instruction book, Volume I, Chapter 708.*

For advice on replacing individual bearing shells, it is recommended to contact MAN B&W Diesel A/S or the engine builder.

2. Before remounting:

- Check the bearing support for damage and burrs. If damage is found, contact MAN B&W Diesel for advice.
- Make sure that all parts are clean, use non-fluffy cloth to clean between journal and main bearing support.
- Lubricate the bearing journal, the main bearing support and the back of the shell, with main engine lubricating oil.

Mounting of bearing shells

1. Using the bearing shell lifting tool, the pulleys and tackles, lift the lower bearing shell into the crankcase until it is hanging above the crankshaft journal.
2. Place the dismantling tools for the bearing shell in the same side as when the shell was dismantled and attach them to the 0.5 tonne tackle.

Position the guide tool for the lower bearing shell on the main bearing support.

Lubricate the journal, the lower bearing shell and the bearing support with clean oil.

Land the bearing shell on the journal, and remove the lifting tool from the bearing shell.

Push down, by hand, the bearing shell, while following with the dismantling tool, in order to prevent the bearing shell from falling.

Note!

The bearing shell should always be mounted in the same side as it was dismantled.

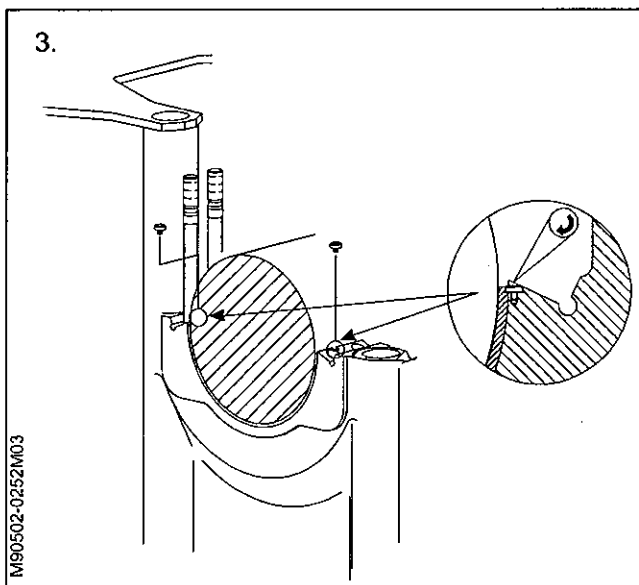
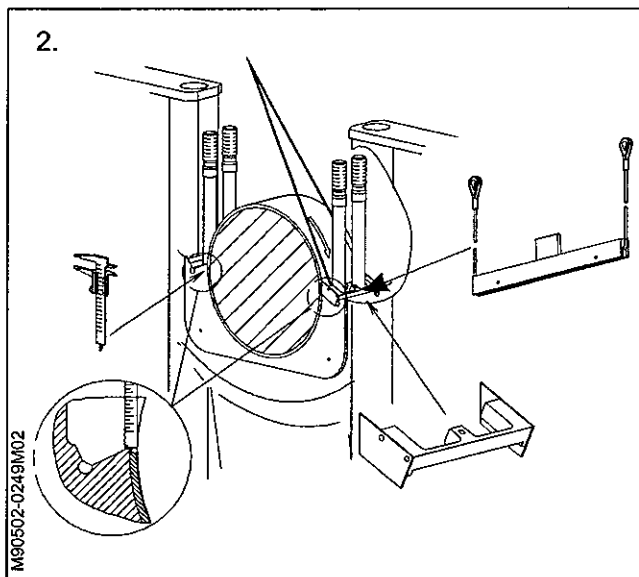
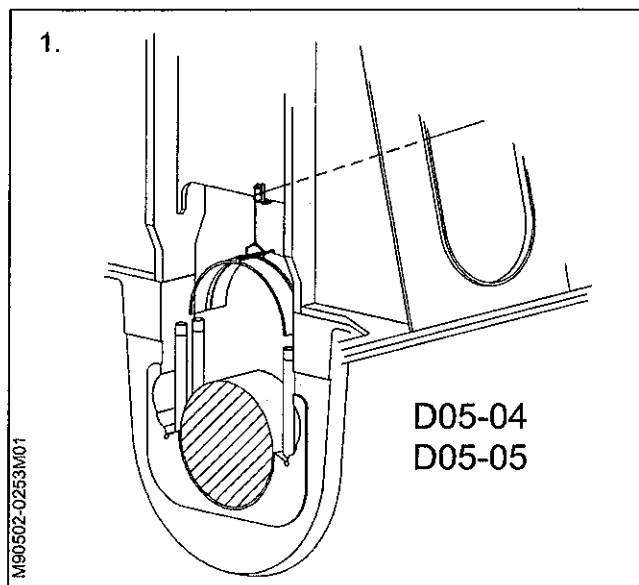
To ensure that the shell is correctly mounted, check that the distance from the main bearing support to the shell is equal in both sides.

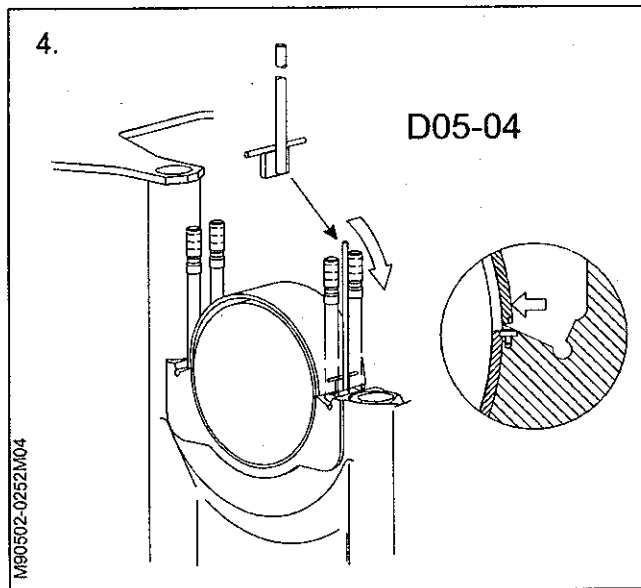
3. Remove the guide tool when the lower bearing shell has been mounted.

Mount the locking screws in the bearing support.

Lower the crankshaft and remove the hydraulic jacks and the crosspiece from below the crankshaft.

Wipe the contact surfaces between the upper and the lower bearing shells clean with a non-fluffy piece of cloth.





4. Land the upper bearing shell on the main journal in the same way as the lower bearing shell.

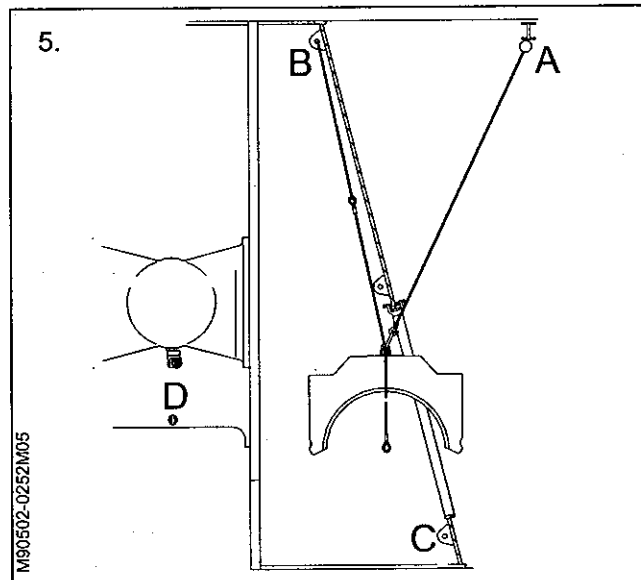
Make sure that none of the edges of the upper bearing shell are resting on the edge of the bearing support.

If necessary, place the special tool between the studs and press the shell into place.

Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.

5. Mount the lifting tool on the bearing cap. Using the tackles and wire ropes on the main bearing cap lifting tool, lift the bearing cap into the crankcase in reverse order to dismantling.

See Procedure 905-2.2, step 17.

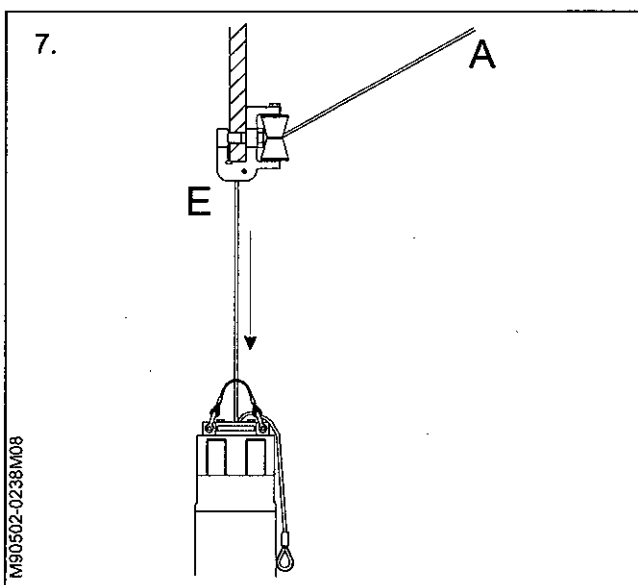
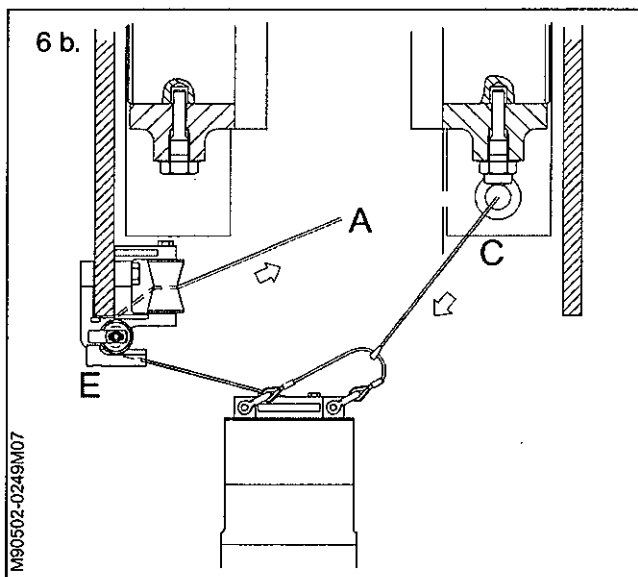
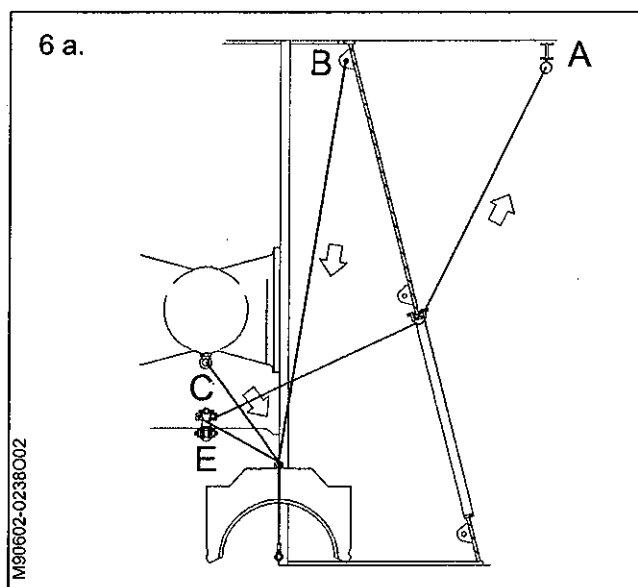


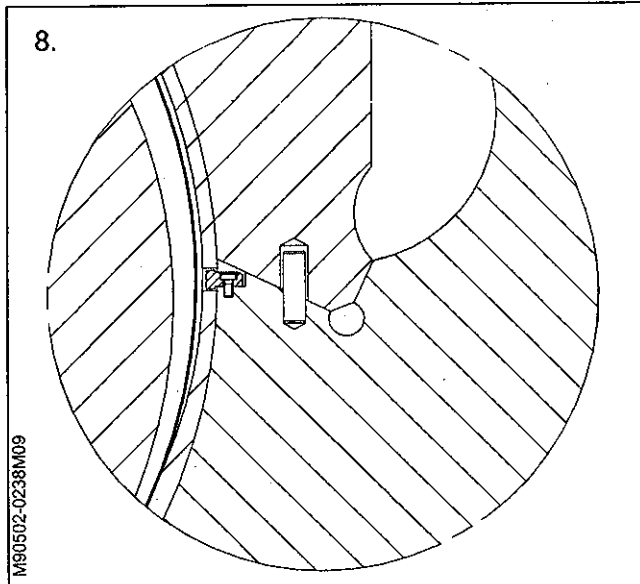
6. Using pulley **E** mounted above the bearing and the pull lift mounted below the opposite guideshoe, move the bearing cap into position vertically above the bearing journal in the reverse order to dismantling.
See Procedure 905-2.2, steps 16-14.

Note!

Be sure that it is the longest wire rope that is pulled around pulley **E** below the webplate.

7. Carefully lower the main bearing cap on to the upper bearing shell. Keep a hand on the wire rope while lowering, so that sticking of the bearing cap is immediately felt.





8.

Note!

Be sure that the cap lands correctly and that the guide pin in the assembly surface enters the hole in the bearing cap.

9. Remove the bearing cap lifting tool.

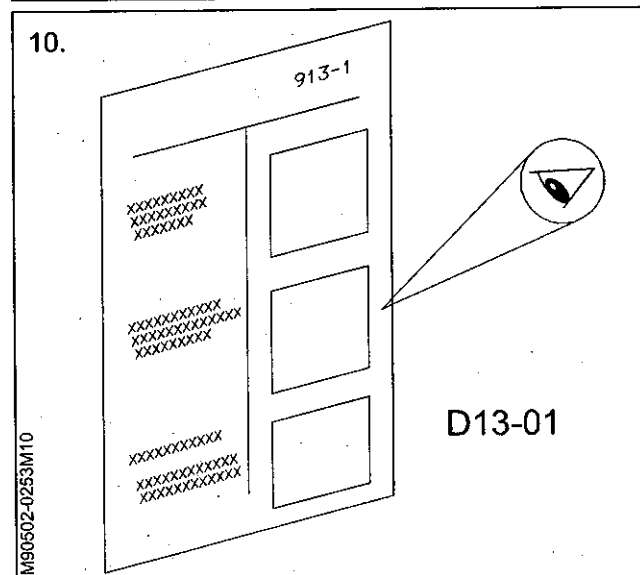
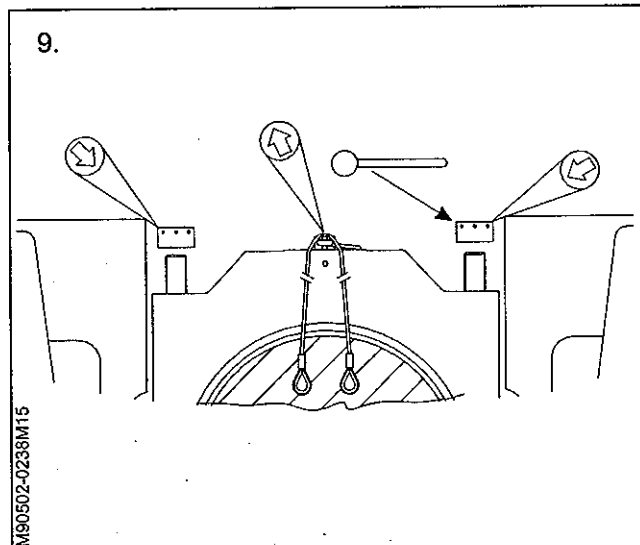
Screw the nuts on to the main bearing studs.

Using a tommy bar, tighten the nuts on both sides of the bearing cap.

Tightening of hydraulic nuts

10. Mount the hydraulic jack nuts on the studs.
See Procedure 905-2.2, step 7-13.

For operation of the hydraulic tools, see Procedure 913-1.



11.

Note!

Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

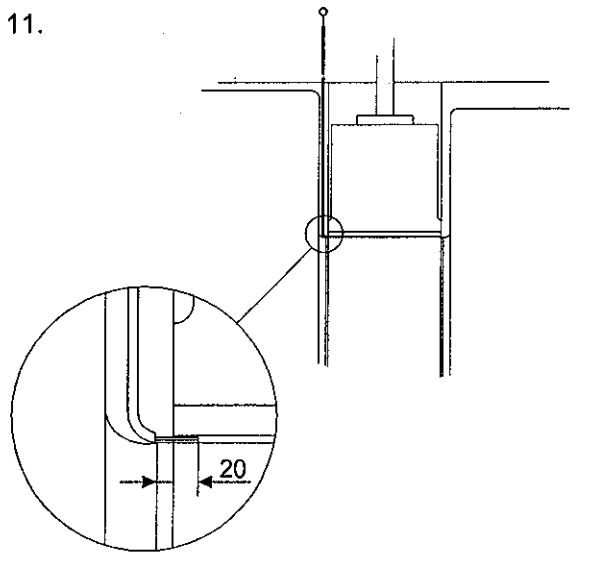
12. Remove all tools from the engine.

Note!

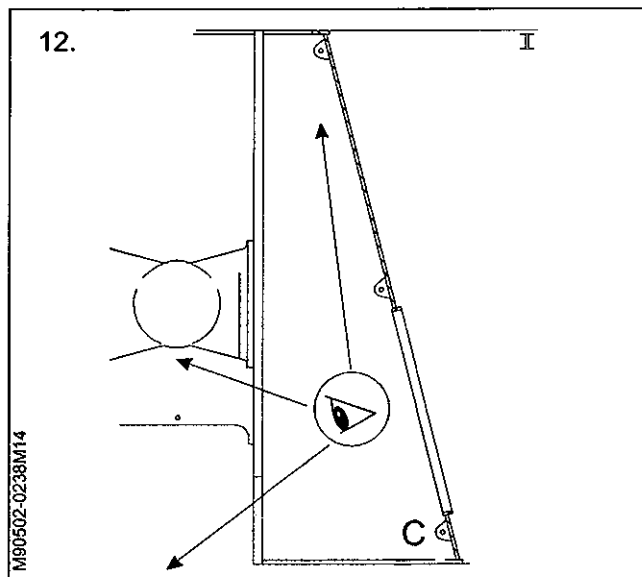
Search the crankcase to ensure that there are no tools, shackles or rags left behind.

13. Mount the lubricating oil pipe on the main bearing cap,

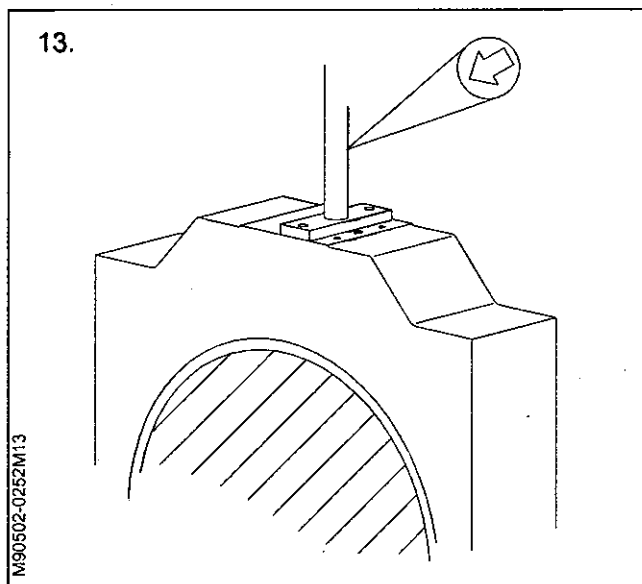
11.



12.



13.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-06	Thrust bearing segment	151	kg
D05-07	Segment stopper	115	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90551	100	Tool for turning out segments
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete
P91356		Lifting Tools, Etc.

The clearance in the thrust bearing was measured during testbed trials of the engine and noted down in the 'Adjustment Sheet' which is inserted at the front of Volume I, OPERATION.

For a new engine the clearance is 0.5-1.0 mm, and for an engine in service it must not exceed 2.0 mm.

In service it is only necessary to measure the wear of the thrust bearing pads, and to inspect for white metal below the thrust bearing.

1. To measure the wear in the thrust bearing, it is necessary to dismount the foremost segment stopper.

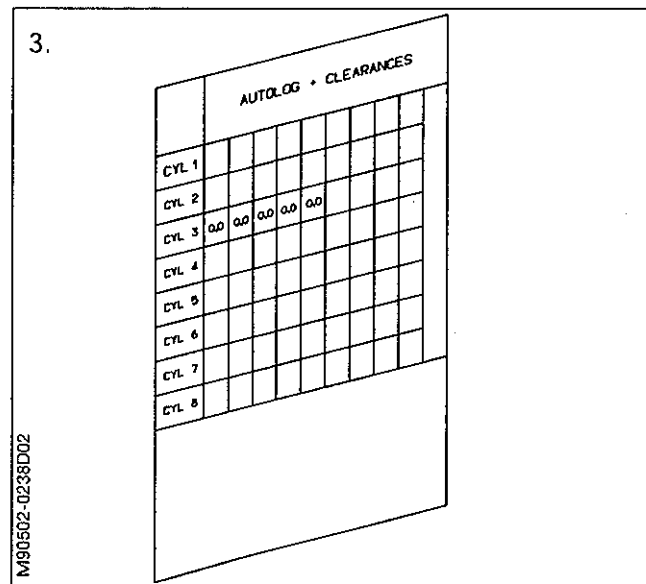
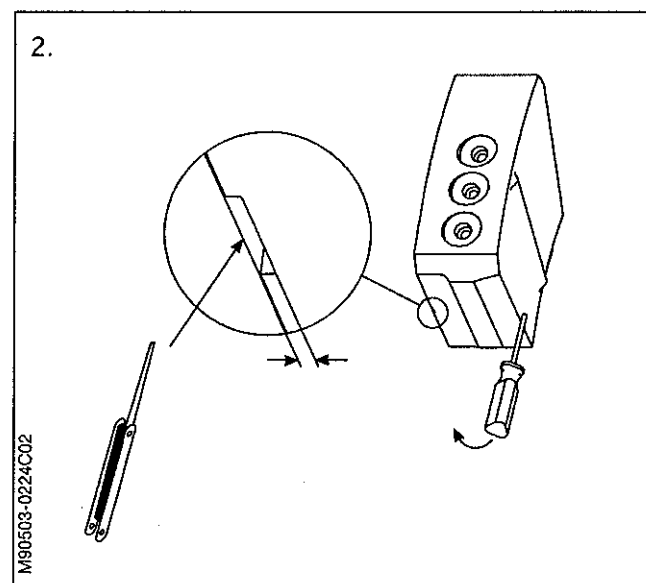
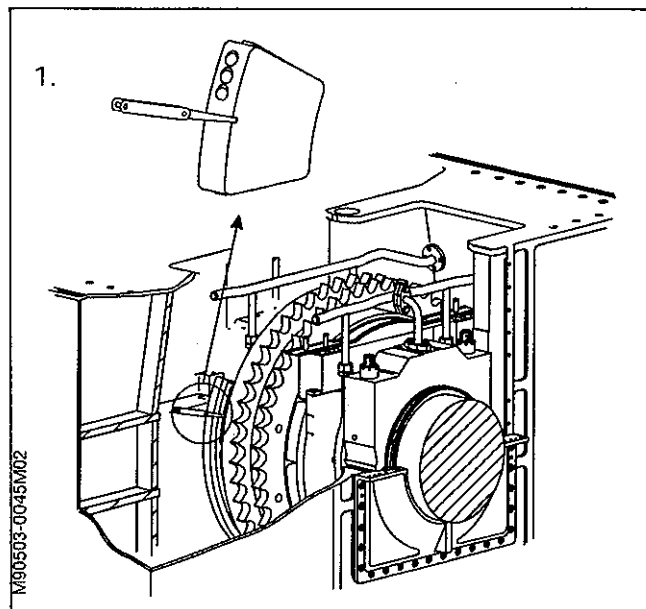
For dismantling the segment stopper, see Procedure 905-3.2.

A wear groove of 1 mm is positioned in the uppermost thrust segment. (The segment with thermometers).

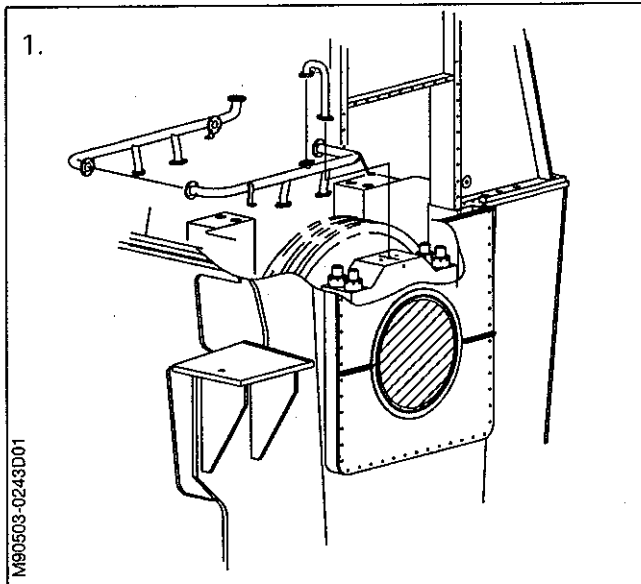
2. To measure the wear, the thrust segment has to be pressed against the thrust cam, to eliminate any gap, i.e. by using a suitable crowbar on the back of the segment.

If a feeler gauge of 0.1 mm is **not** able to enter the groove (the wear is more than 0.9 mm), the thrust bearing must be overhauled.

3. Note down the wear for later reference.



Thrust Bearing Dismantling



1. Remove the end cover of the engine.

Remove the lub. oil pipe from the aftmost main bearing shell.

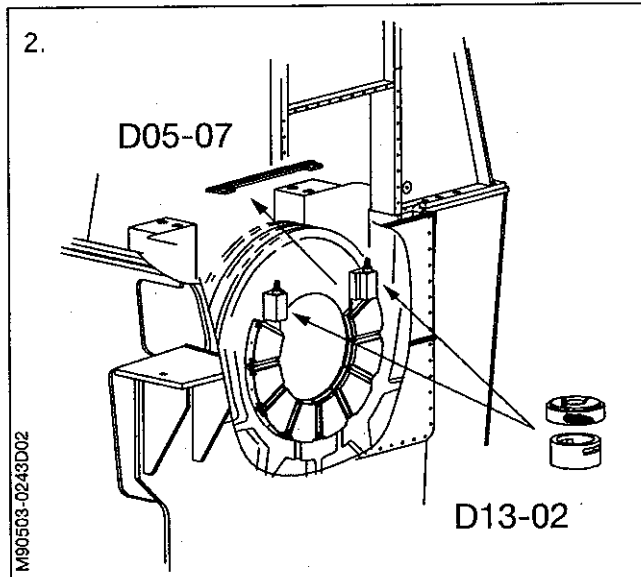
Remove the lub. oil pipe above the thrust segments.

2. Remove the protective shield from the segment stoppers.

Loosen and remove the nuts from the segment stoppers.

For operation of the hydraulic jacks, see Procedure 913-1.

Screw an eye bolt into the stoppers that are to be removed.



Suspend a tackle above each stopper and hook the tackle on to the eye bolt.

Remove the stoppers from the chain drive above the thrust segments (AHEAD or ASTERN) that are to be taken out.

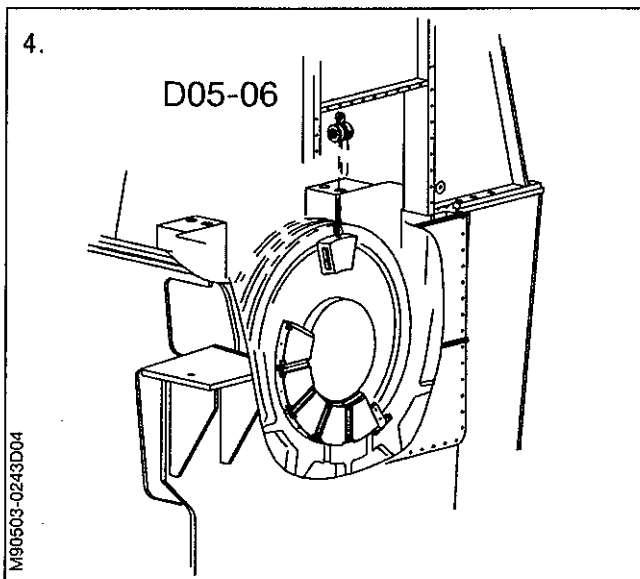
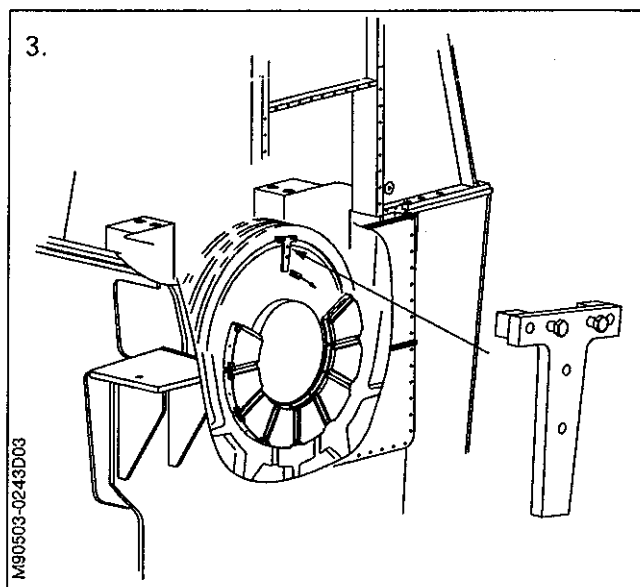
3. Suspend a tackle from the chain tightener bracket above the segments which are to be removed.

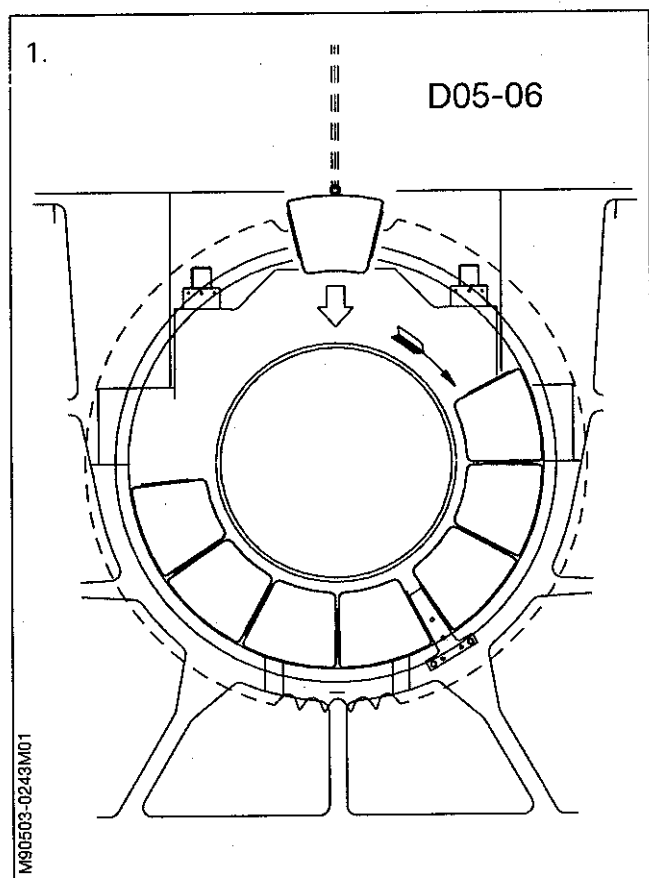
For turning-up the thrust segments, mount the segment tool on the chainwheel.

4. Turn up the segments, one at a time, by turning the engine, and remove the segment from the chain casing. Inspect the segment and remount it before turning up the next segment. See Procedure 905-3.4.

Note!

Never remove more than one segment at a time





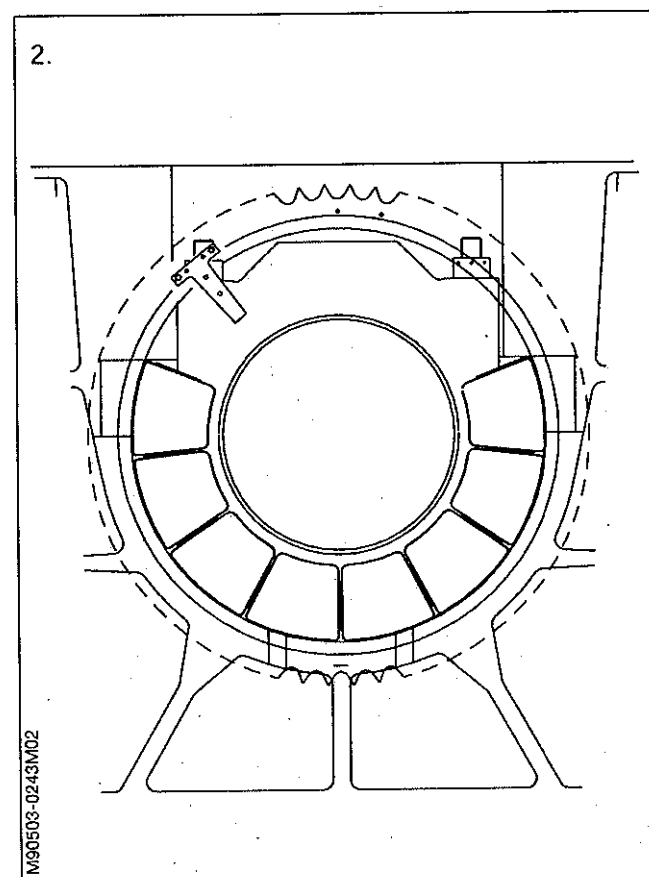
1. Suspend a tackle from the crossbar above the segments which are to be mounted.

Mount the segment tool on the chainwheel.

Land the segment on the journal and remove the eye bolt from the segment.

Carefully slide the segment on to the segment tool. Turn the engine to dismantle the next segment. See Procedure 905-3.2.

2. After the last segment has been mounted, turn the segment tool up and dismount it.



3. Mount the segment stoppers.

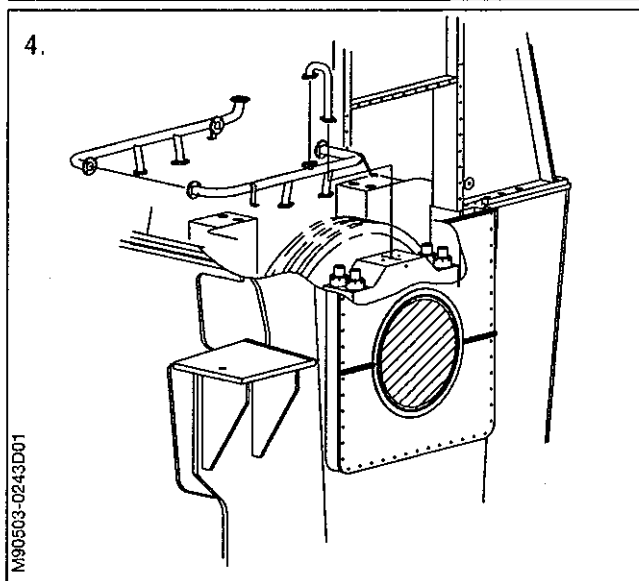
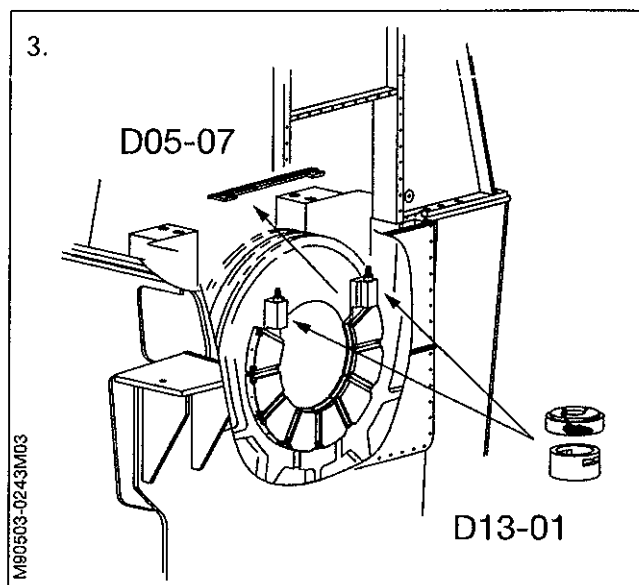
Mount the hydraulic jacks and tighten the nuts on the stoppers. *See Data.*

4. Mount the protective shield.

Mount the lub. oil pipe for the thrust segments.

Mount the lub. oil pipe for the aftmost main bearing.

5. Mount the end cover.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

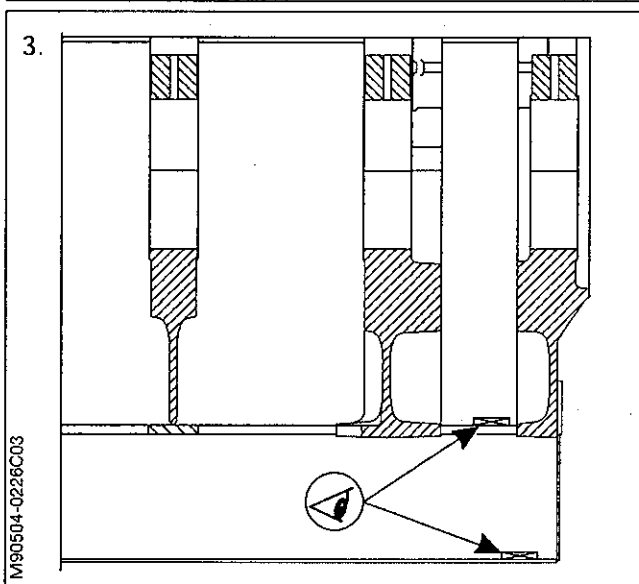
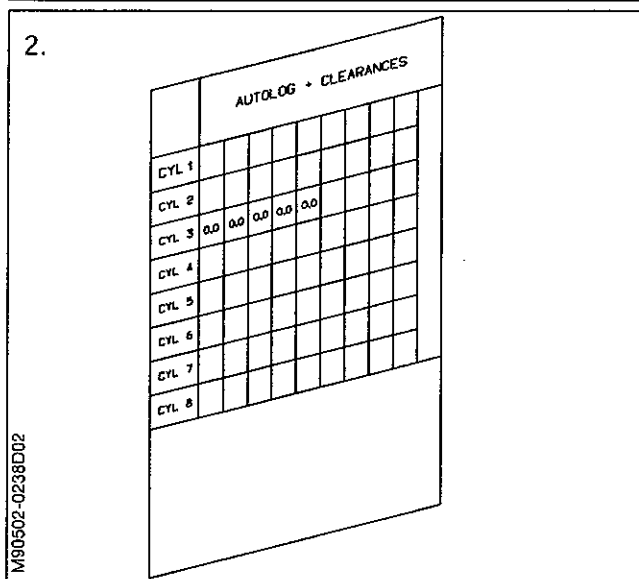
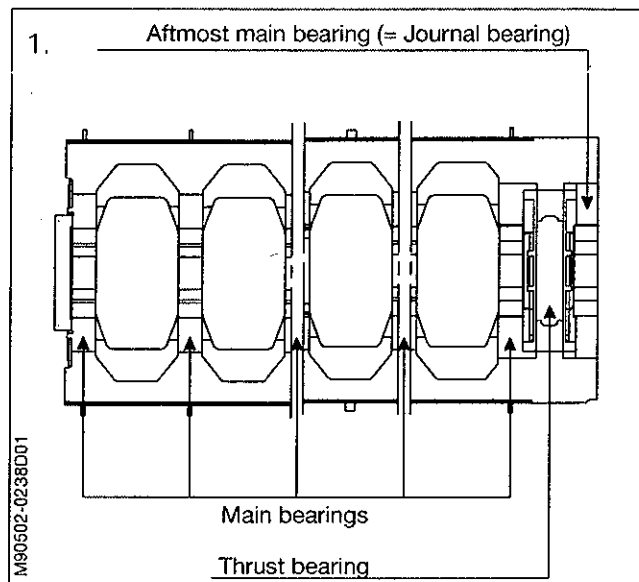
Data

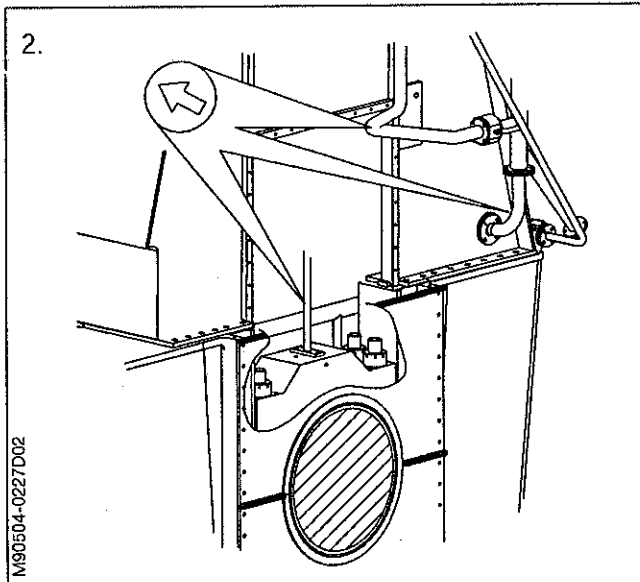
Ref.	Description	Value	Unit
D05-11	Min. bearing clearance	0.65	mm
D05-12	Max. bearing clearance	0.95	mm
D05-13	Journal bearing cap	1677	kg
D05-14	Upper bearing shell	89	kg
D05-15	Lower bearing shell	95	kg
D05-16	End cover	560	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90551	088	Dismantling tool, main bearing shell
P90551	090	Mounting tool for bearing shell
P90551	111	Lifting attachment
P90551	172	Mounting tool, thin bearing shell
P90561		Main Bearing - Hydraulic Tools
P90570		Thrust Shaft - Tools
P90571		Main Bearing - Shell Tools
P90572		Main Bearing - Measuring Tools
P91351	010	Hydraulic pump, pneumatically operated
P91351	046	Hose with unions (1500 mm), complete
P91351	058	Hose with unions (3000 mm), complete
P91356		Lifting Tools, Etc.
P91366	057	Feeler gauge

1. Check the journal bearing in the same way as the remaining main bearings, see *Procedure 905-2.1*.
2. Write down the journal bearing clearances.
3. Also check the journal bearing by visually searching the area underneath the bearing support for bearing material.





1. Dismount the screws for the end cover.

Mount a ½-ton tackle above the end cover.

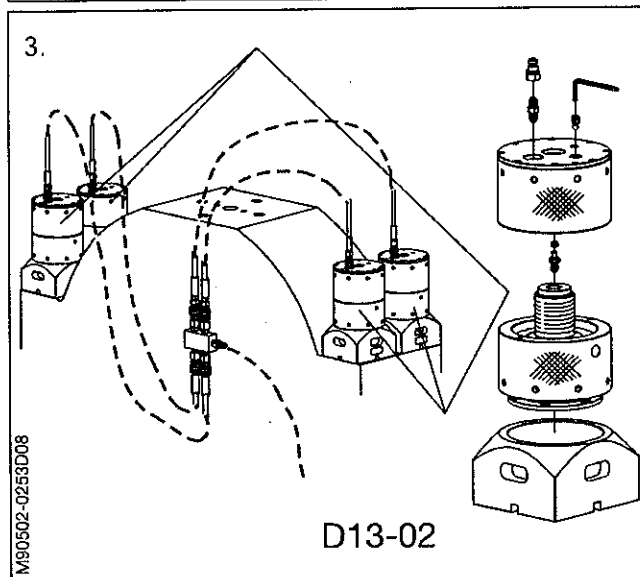
Remove the end cover.

2. Disconnect the lubricating oil pipe from the main pipe.

Remove the protective shield for the thrust bearing.

Turn the crank throw for the aftmost cylinder to horizontal position. Remove other piping if necessary.

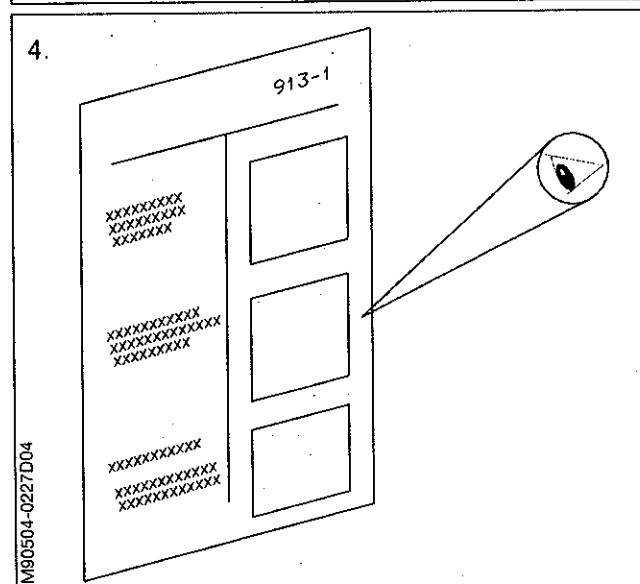
3. Loosen the bearing stud nuts, using the hydraulic jacks



4. *For operation of the hydraulic tools, see Procedure 913-1.*

5. Remove the hydraulic main bearing tools from the engine

Unscrew and remove the nuts from the bearing studs.



Note!

As piping may vary, the amount of piping necessary to be removed may also vary.

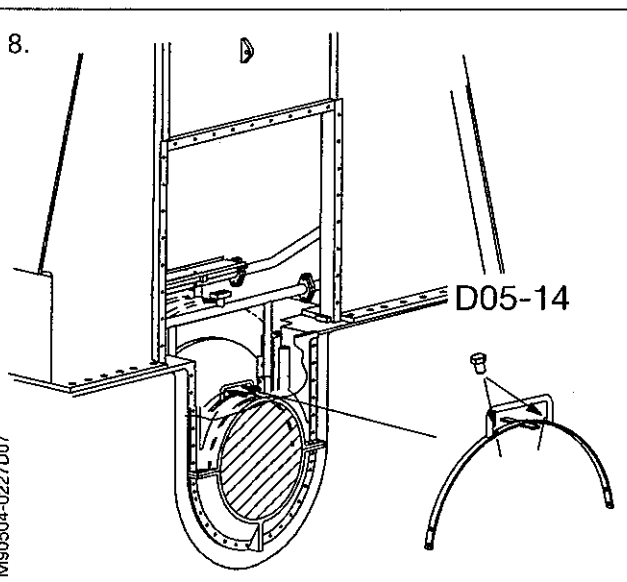
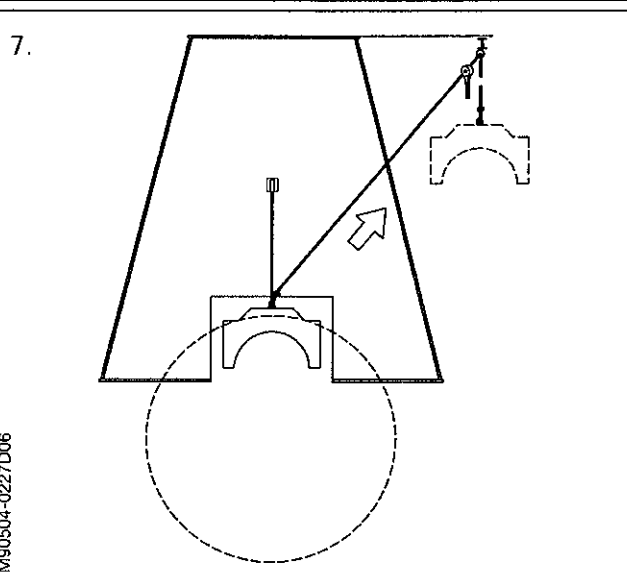
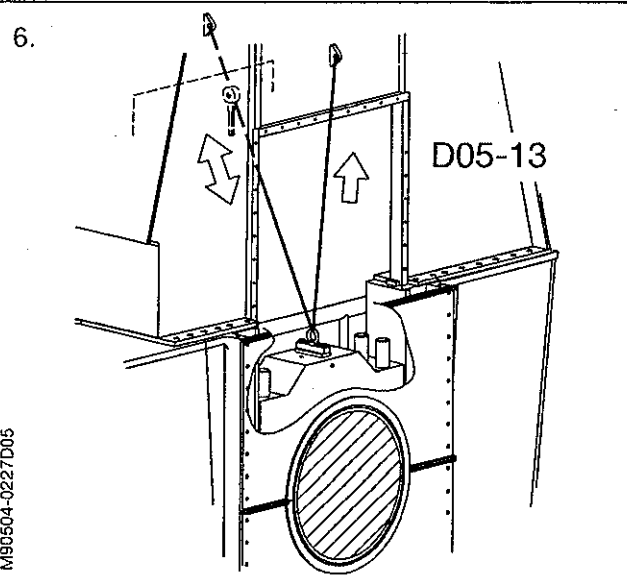
6. Mount the lifting attachment on the journal bearing cap, and lift the cap out of the engine using the ½-ton tackle.

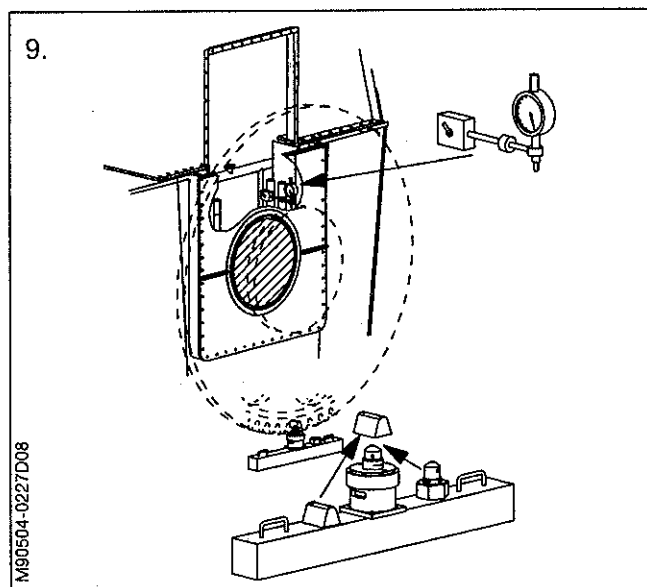
Use a pull lift mounted on the opposite webplate to guide the vertical lift.

7. Mount a tackle on the lifting beam on the exhaust side engine gallery.

Lift the journal bearing cap out through the cut-out in the engine wall in the exhaust side.

8. Mount the lifting attachment on the upper shell, and lift the shell out of the engine.





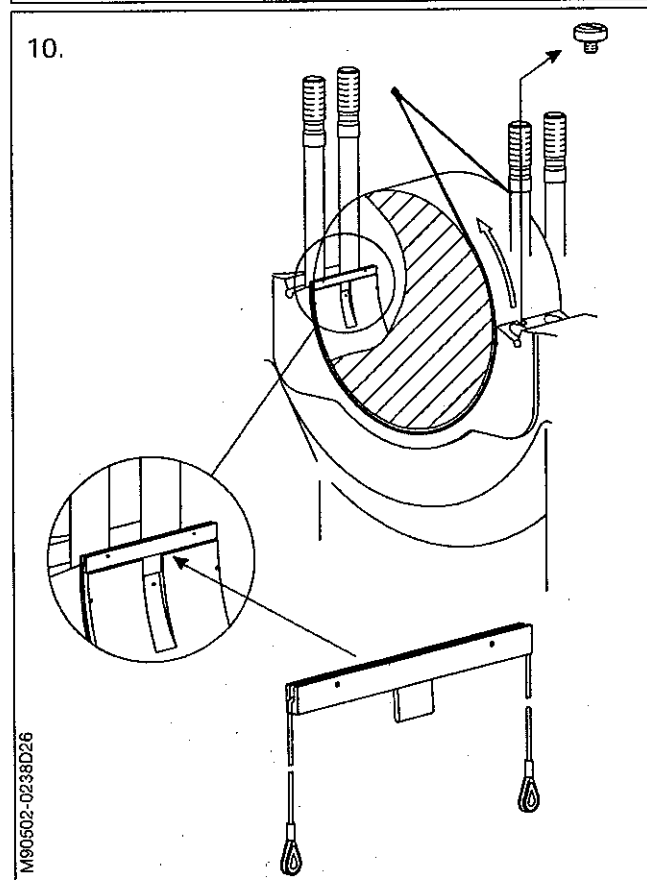
8. Place the crosspiece under the turning wheel as shown. Mount a dial gauge to measure the lift of the crankshaft.

Tighten the screw against the turning wheel and compress the jacks.

Connect the hydraulic jacks to the high-pressure pump, and raise the pressure until the crankshaft has been lifted 0.2-0.5 mm, but max. the clearance in the adjacent bearing.

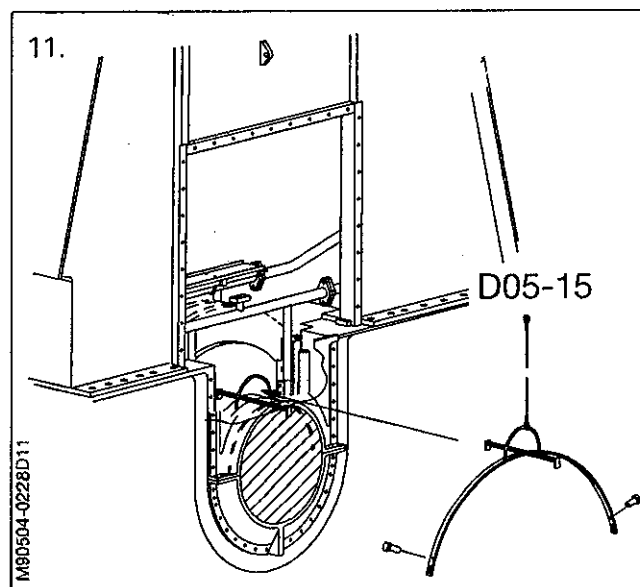
9. Dismount the locking screws.

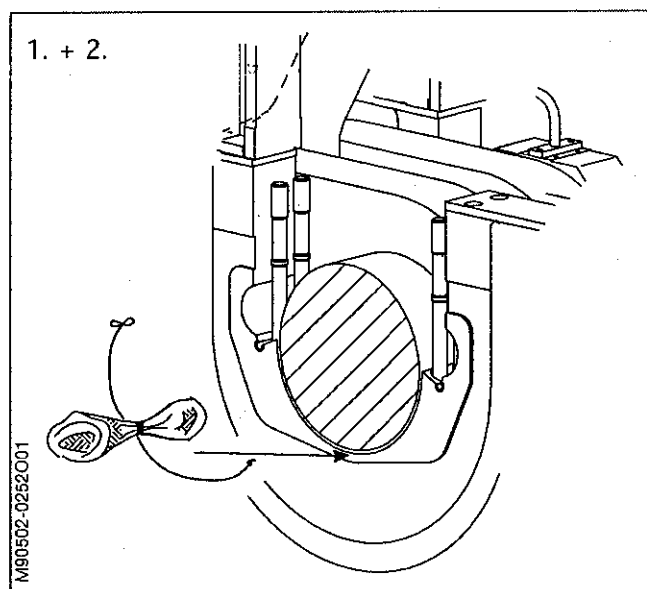
Place the dismantling tool on top of the lower bearing shell. Make sure that the flap on the dismantling tool enters the oil groove in the bearing shell.



Pull the lower bearing shell round and upwards until it lies over the bearing journal. Never use a tackle larger than 1/2-ton.

11. Take the lower shell out of the engine in the same way as the upper shell, i.e., using the lifting tool.





1. Clean and inspect the bearing shells. It is recommended that the main bearing shells be replaced in pairs.

If it is nevertheless desired to replace only one shell, this requires a careful evaluation of the condition of the shell that is to be reinstalled.

See Instruction book, Volume I, Chapter 708.

For advice on replacing individual bearing shells, it is recommended to contact MAN B&W Diesel A/S or the engine builder.

2. Before remounting:

- Check the bearing support for damage and burrs. If damage is found, contact MAN B&W Diesel for advice.
- Make sure that all parts are clean, use non-fluffy cloth to clean between journal and bearing support.
- Lubricate the bearing journal, the bearing support and the back of the shell, with main engine lubricating oil.

1. Lubricate the journal, the lower bearing shell and the bearing support with clean oil.

Using the bearing shell lifting tool, lift the lower bearing shell into the crankcase and land it on the crankshaft journal.

2. Position the guide tool for the lower bearing shell on the bearing support. Remove the lifting tool from the bearing shell.

Lubricate the journal, the lower bearing shell and the bearing support with clean oil.

Place the lower bearing shell on the journal and push it down by hand.

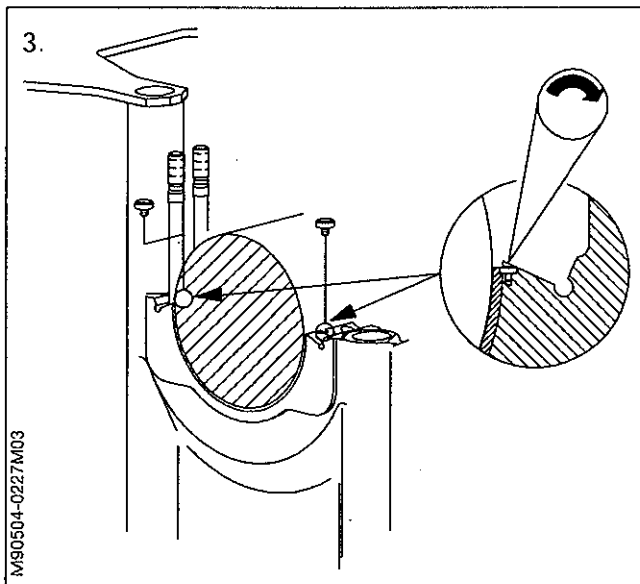
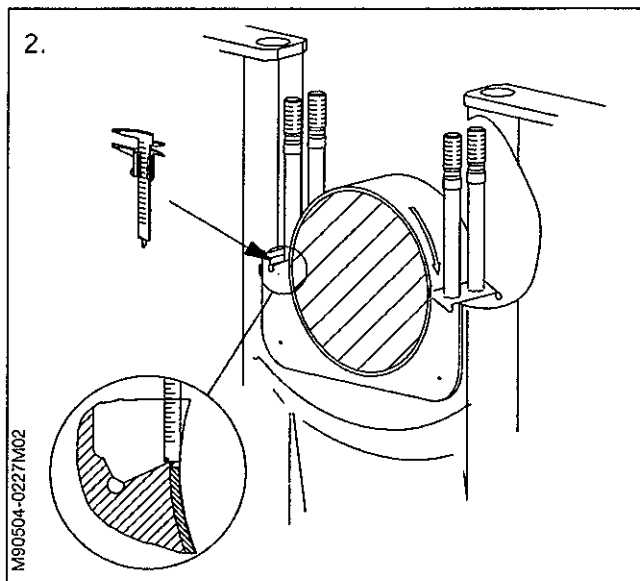
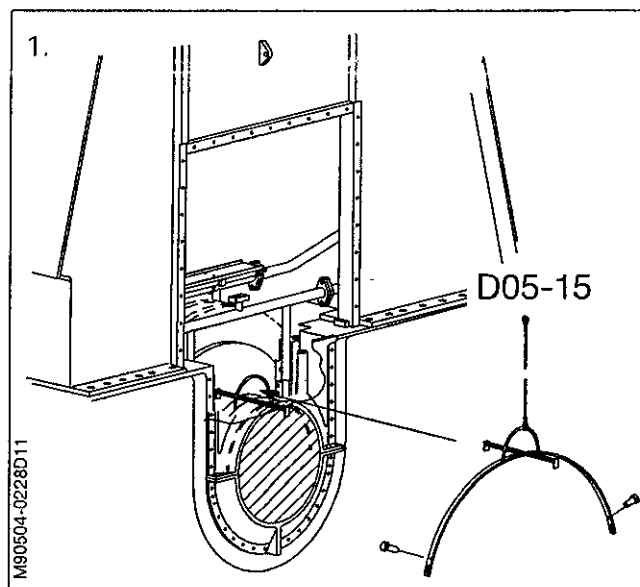
To ensure that the shell is correctly mounted, check that the distance from the bearing support to the shell is equal in both sides.

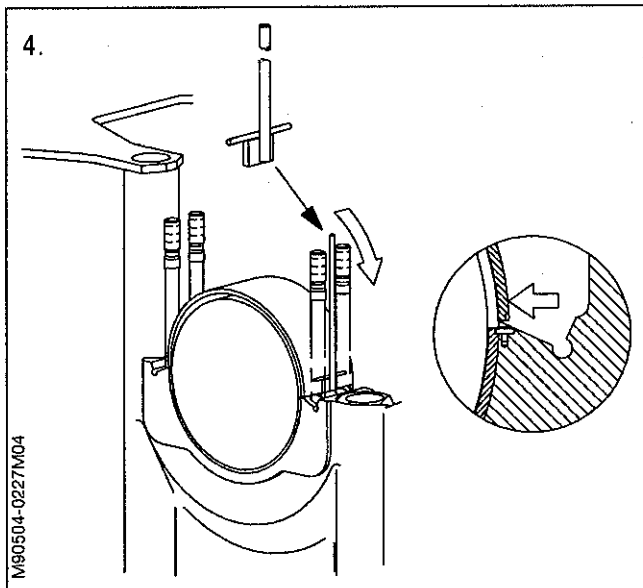
3. Remove the guide tool when the lower bearing shell has been mounted.

Mount the locking screws in the bearing support.

Lower the crankshaft and remove the hydraulic jacks and the crosspiece from under the crankshaft.

Wipe the contact surfaces between the upper and the lower bearing shells clean with a non-fluffy piece of cloth.



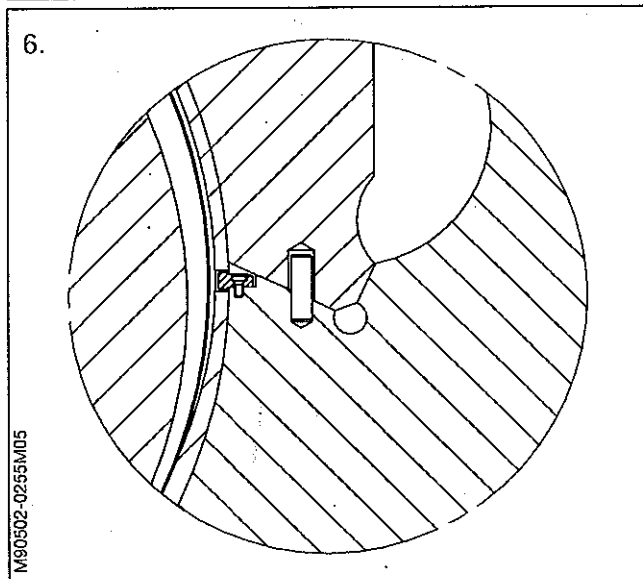


4. Land the upper bearing shell on the main journal in the same way as the lower bearing shell.

Make sure that none of the edges of the upper bearing shell are resting on the edge of the bearing support.

If necessary, place the special tool between the studs and press the shell into place.

Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.



5. Mount the lifting tool on the bearing cap. Using the lifting tool and the tackles, lift the bearing cap into the crank casing in reverse order to dismantling.
See Procedure 905-4, steps 5 and 6.

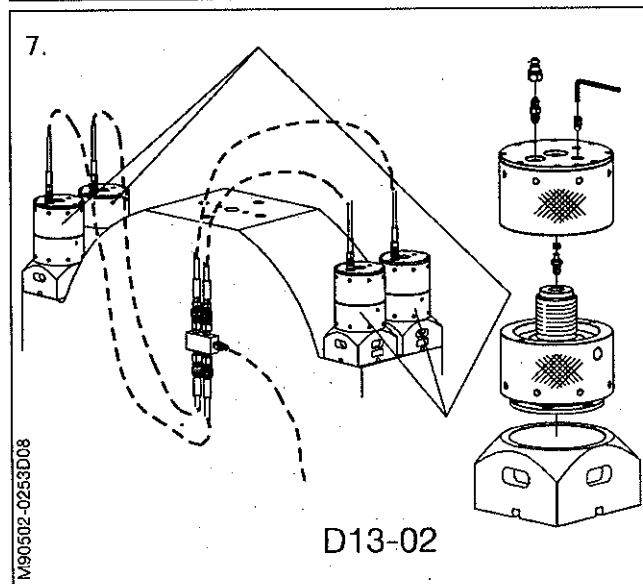
6.

Note!

Be sure that the cap lands correctly and that the guide pin in the assembly surface enters the hole in the bearing cap.

7. Mount the nuts, the spacer rings, the hydraulic jacks, and tighten the nuts.
See Data.

For operation of the hydraulic tools, see *Procedure 913-1*.



8.

Note!

Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

9. Remove all tools from the engine.

Note!

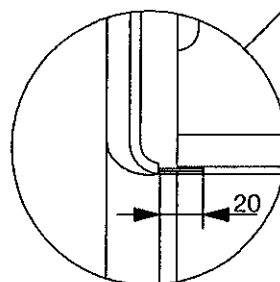
Search the crankcase to ensure that there are no tools, shackles or rags left behind.

10. Mount all disassembled piping, and mount the end cover.

8.

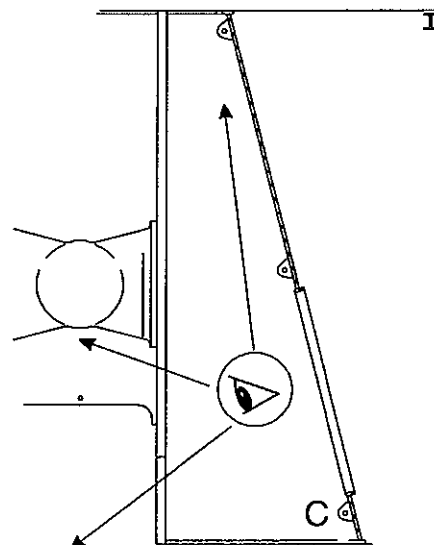
D05-11
D05-12

M90504-0227M08



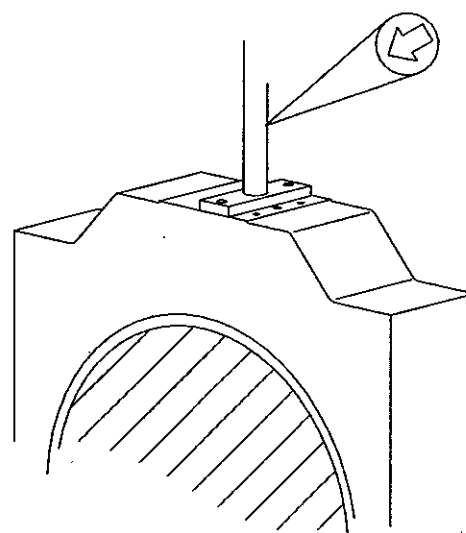
9.

M90502-0238M14



10.

M90502-0232M13



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-18	Inner studs, screwing-in torque	140-180	Nm
D05-22	Outer studs, screwing-in torque	140-180	Nm
D05-24	Horizontal screws, tightening torque/angle	100/42	Nm/°
D05-25	Damper housing, upper part	1840	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90262		Hydraulic jack for piston rod
P90551	111	Lifting attachment
P90551	196	Tightening template A.V.D.
P90551	206	Crowfoot spanner
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete
P91356		Lifting Tools, Etc.
P91359		Torque Spanners
P91366	61	Slide caliper

For checking the effectiveness of the axial vibration damper, it is necessary to measure the longitudinal movements of the fore end of the crankshaft during running.

The measurement (or reading) should be taken at the same r/min as during the sea trials. (Preferably 90% and 100% of MCR.)

As different equipment can have been mounted on the specific engines, the checking procedure describes three different systems:

A: Electronic, with Axial Vibration Monitor

B. Mechanical, with angle encoder fore.

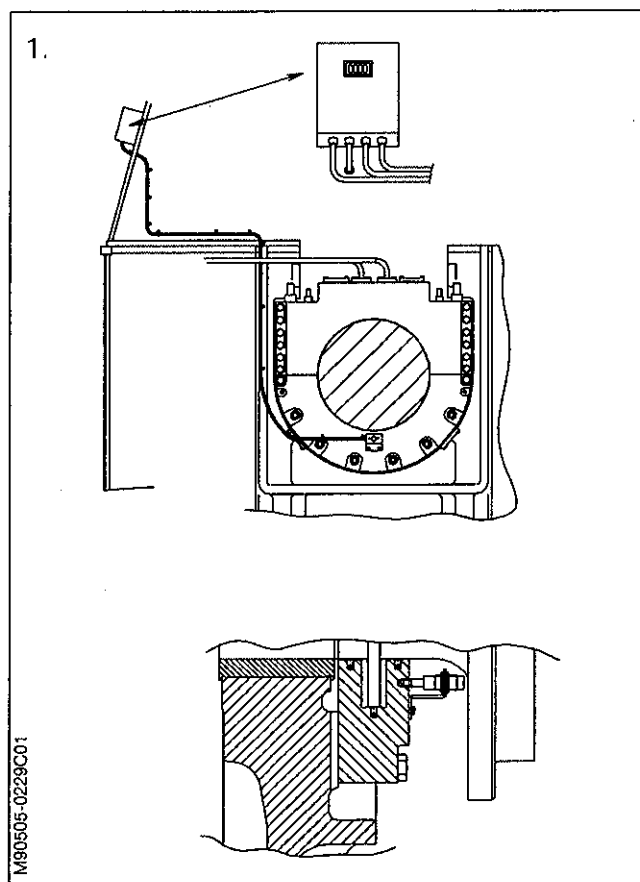
A: Electronic, with Axial Vibration Monitor

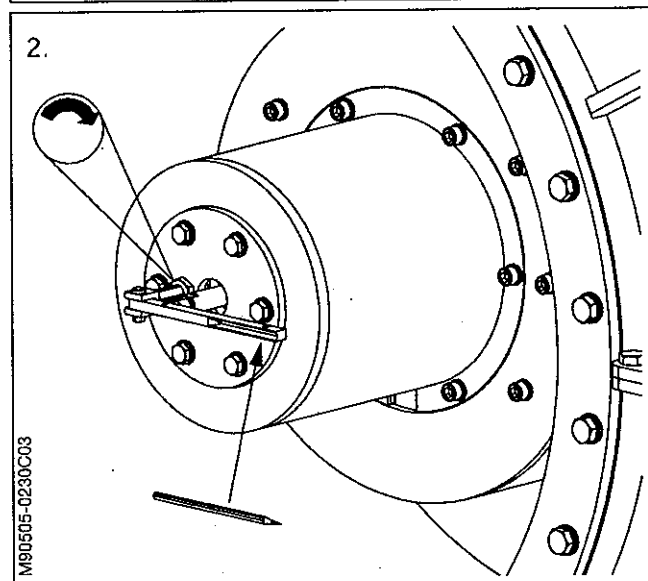
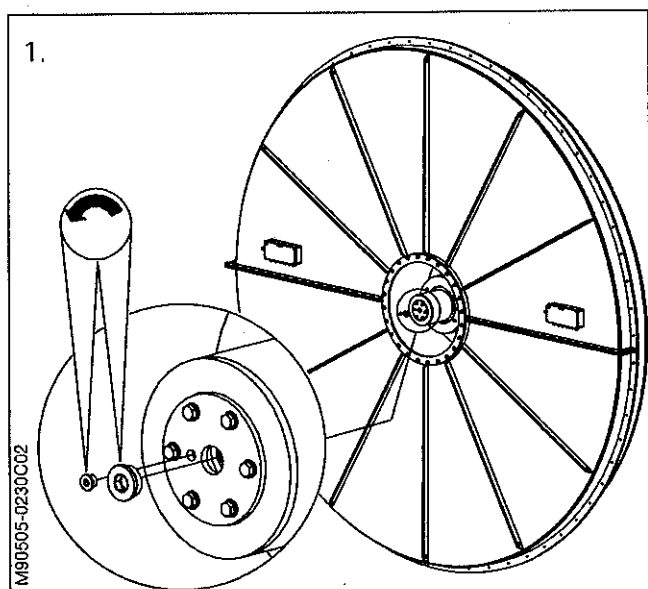
A proximeter probe is built on to the lower part of the damper housing. The probe is connected to a control unit which displays peak-to-peak movements and sends signals to the engine control system.

1. Concerning overhaul and setting of the electronic device, refer to makers instructions and *Volume I, Operation, Chapter 701*.

The peak-to-peak values displayed in mm are to be compared with the original values obtained during sea trial and the limits given in *Volume I, Operation, Chapter 701*.

If the peak-to-peak value exceeds the *Normal Service Value*, it is necessary to overhaul the axial vibration damper, see *Procedure 905-5.2*.



**B: Mechanical, with angle encoder fore**

1. Stop the engine.

Unscrew the two plugs from the cover at the front of the engine.

2. Mount the shaft piece in the end of the crankshaft.

Screw the measuring arm into the small threaded hole beside the centre hole, so that the arm is perpendicular to the shaft piece. Tighten the lock nut.

Attach a pencil to the arm.

Note!

To obtain a correct measurement, the tip of the pencil should protrude **10 mm** from the end of the arm.

Start the engine, and let the speed rise to the number of revolutions at which the measurement is to be taken. (Preferably 90% and 100% of MCR.)

When measuring, press the measuring arm against the shaft piece with the one hand. With the other hand, move a sheet/block of paper, clipped on to a solid backing plate, lightly downwards against the tip of the pencil.

To ensure a certain inertia, the backing plate should have a mass of approx. 1-2 kg.

The axial movements (S2) recorded on the paper must be measured with a slide calliper as shown in the sketch.

Before comparing the measured value (S2) with the *Normal Service Value* (S1), stated in *Volume I, Operation, Chapter 701*, it is necessary to compensate for the ratio in the tool.

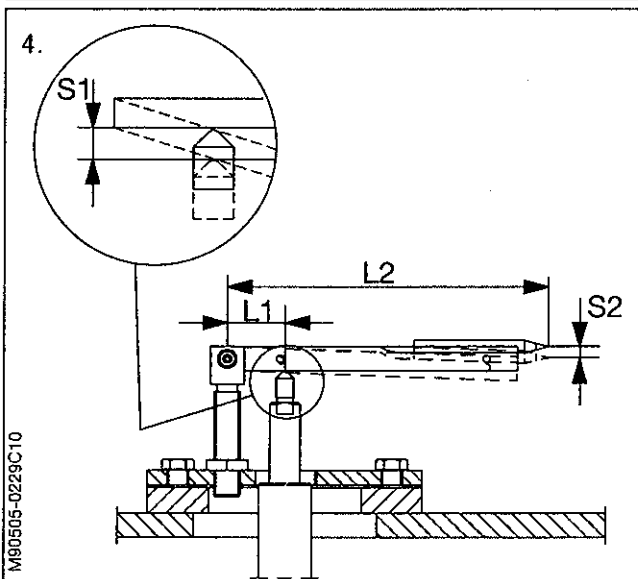
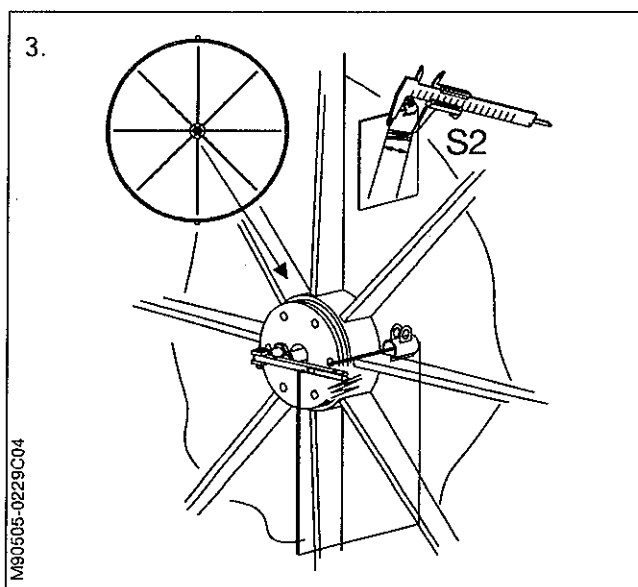
For a standard measuring tool (L1 = 38 mm and L2 = 200 mm), the ratio is 5.3. Therefore, S1 can be calculated as follows:

$$S1 = \frac{S2}{5.3}$$

If a non-standard tool is used, S1 can be calculated as follows:

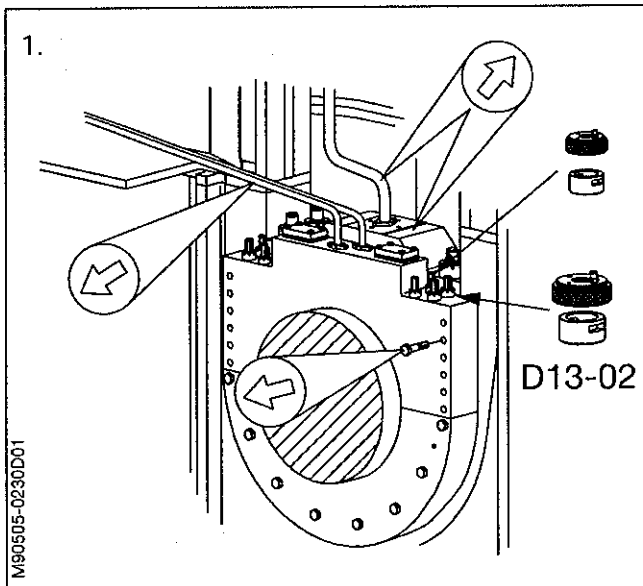
$$S' = S2 \times \frac{L_1}{L_2}$$

If the peak-to-peak value exceeds the *Normal Service Value*, it is necessary to overhaul the axial vibration damper, see *Procedure 905-5.2*.



Axial Vibration Damper

Dismantling

HYUNDAI
MAN B&W


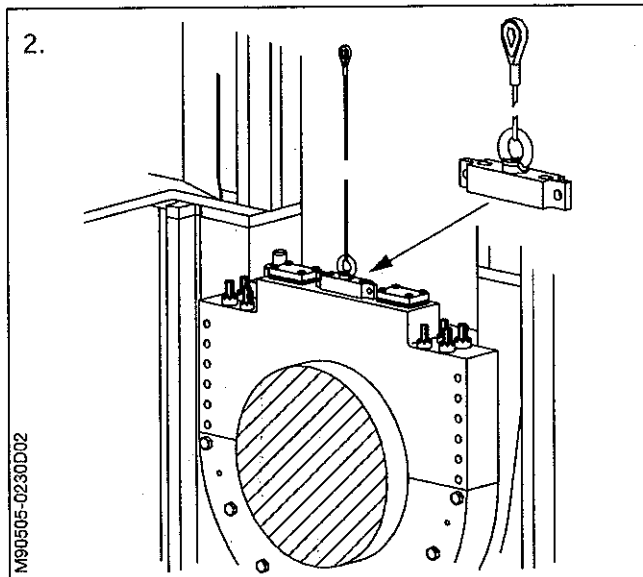
1. Dismantling of the axial vibration damper is carried out from cyl. No. 1.

Disconnect and remove the oil pipes from the foremost bearing cap and the axial vibration damper housing.

Loosen and remove the No. 1 main bearing cap. See Procedure 905-2.2.

Note!

Before working on top of the main bearing shell, be sure that the open bearing is well protected, i.e. by use of clean rags.



Loosen and remove the nuts and screws from the damper housing upper part.

2. Only the upper part of the housing needs to be removed, while the lower half remains mounted on the bedplate.

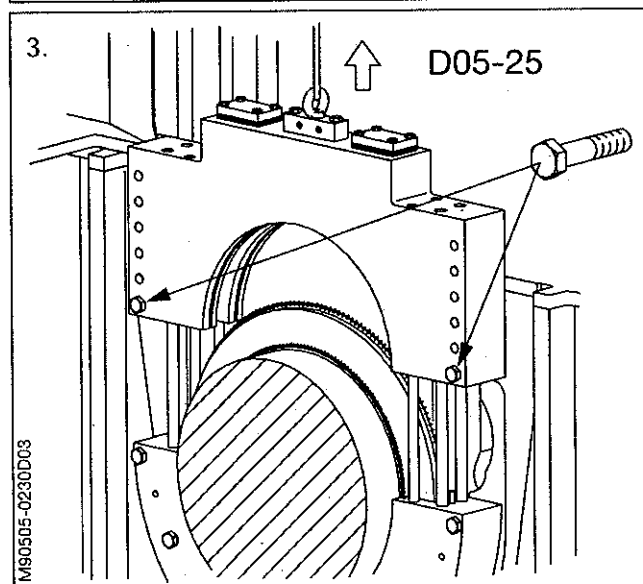
Mount the lifting tool on the upper part of the damper.

Engines with chainbox fore:

Mount a tackle in the bracket above the axial vibration damper inside the chain box.

Engines without chainbox fore:

Mount a tackle below the fore end platform, and dismount the cover on the lifting hole above the axial vibration damper.



3. By means of a tackle and wire rope, separate and raise the upper part of the damper housing.

Note!

Before working below the suspended upper part, secure the upper part e.g. by mounting two of the vertical screws in the upper threaded holes.

1. Dismantle and remove the springs from the oil sealing rings.

Remove the oil sealing rings.

Note!

It is recommended to discard both the springs and the oil sealing rings.

When mounting the new oil sealing rings, first insert the lower half of the rings in the lower housing.

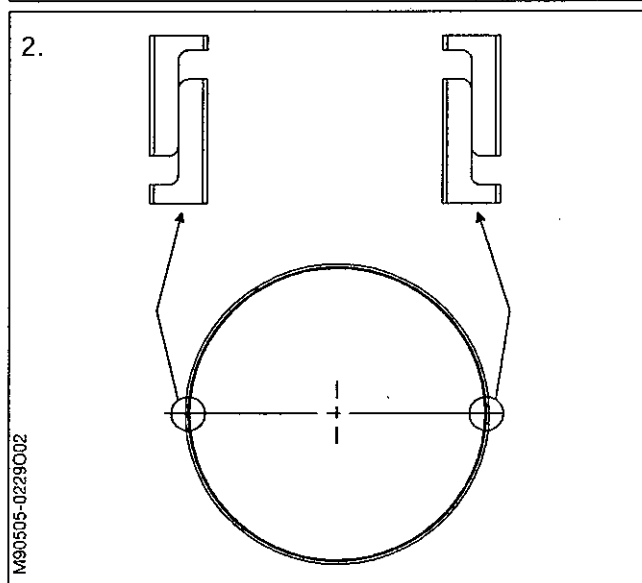
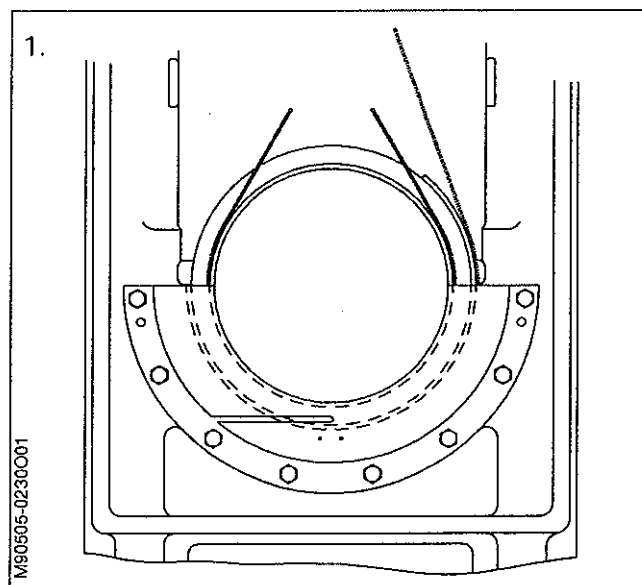
Then press the tension springs into the groove between the oil sealing ring half and the housing.

2. Mount all the upper halves of the oil sealing rings in such a way that the clearance at both the joints on each oil sealing ring is the same.

Now hook the new tension springs into place, ensuring that they are centralised in the grooves of the oil sealing rings.

Note!

The lower half of the oil sealing rings will protrude above the centreline.



1. Remove the screws securing the upper part of the damper housing.

Release and carefully lower the upper part of the damper housing.

When reaching the oil sealing rings, take care that the rings enter the sealing ring grooves correctly.

Before landing the upper part on the lower part, be sure that the guide pins have entered the guide pin holes.

2. If the studs have been removed, re-mount them at this stage.

For screwing-in torque, see *Data*.

Remove the lifting tools.

Mount the horizontal screws, without tightening.

Mount the nuts on the vertical studs, and tighten them two by two, using the hydraulic jacks. For operation of the hydraulic tools, see *Procedure 913-1*.

Tighten the horizontal screws, see *Data*.

Mount and tighten the main bearing cap.
See *Procedure 905-2.4*.

Note!

Search the crankcase to ensure that there are no tools, shackles or rags left behind.

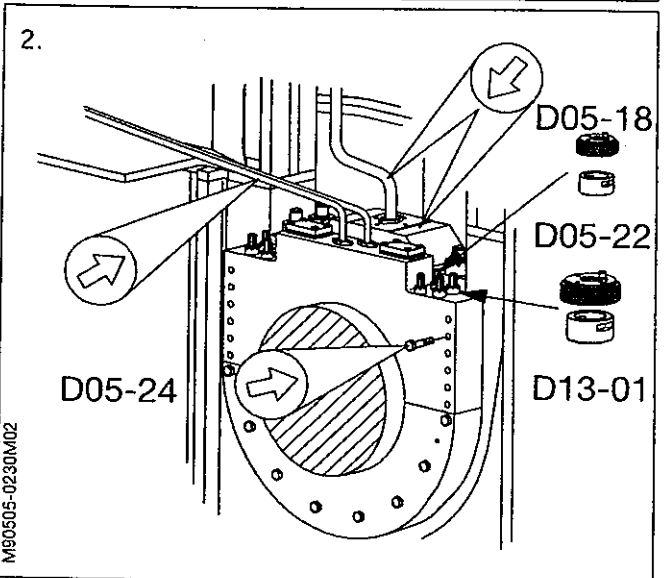
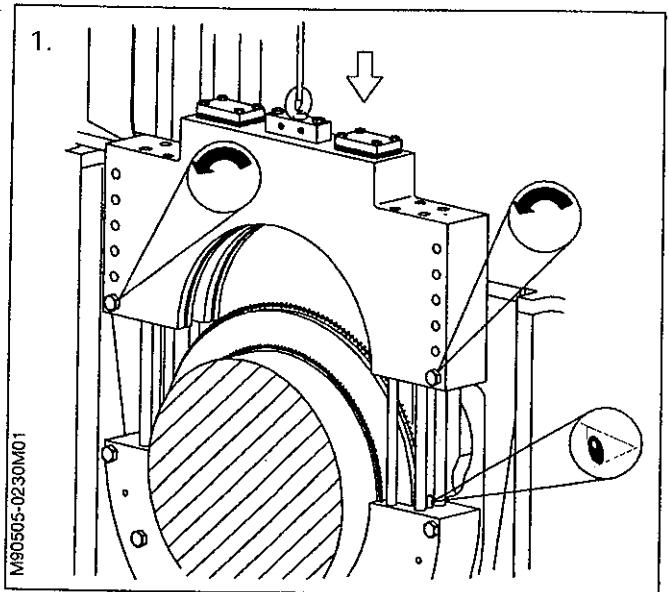
Mount the lubricating oil pipes for damper and main bearing.

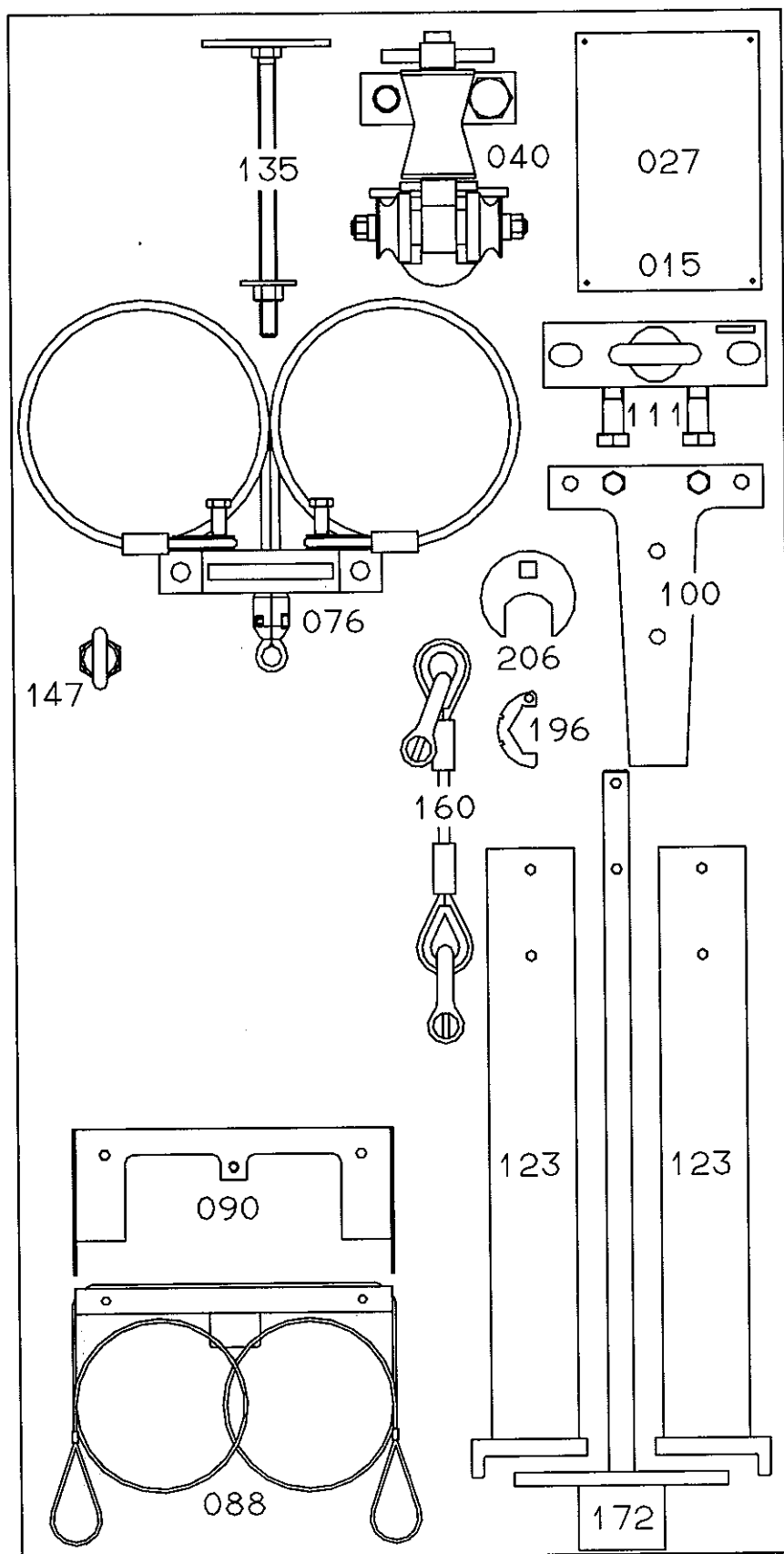
Engines without chainbox fore:

Mount the cover for the lifting hole above the axial vibration damper.

Note!

After overhaul of the axial vibration damper, it is recommended to check the axial vibrations. See *Procedure 905-3.1*.





Plate

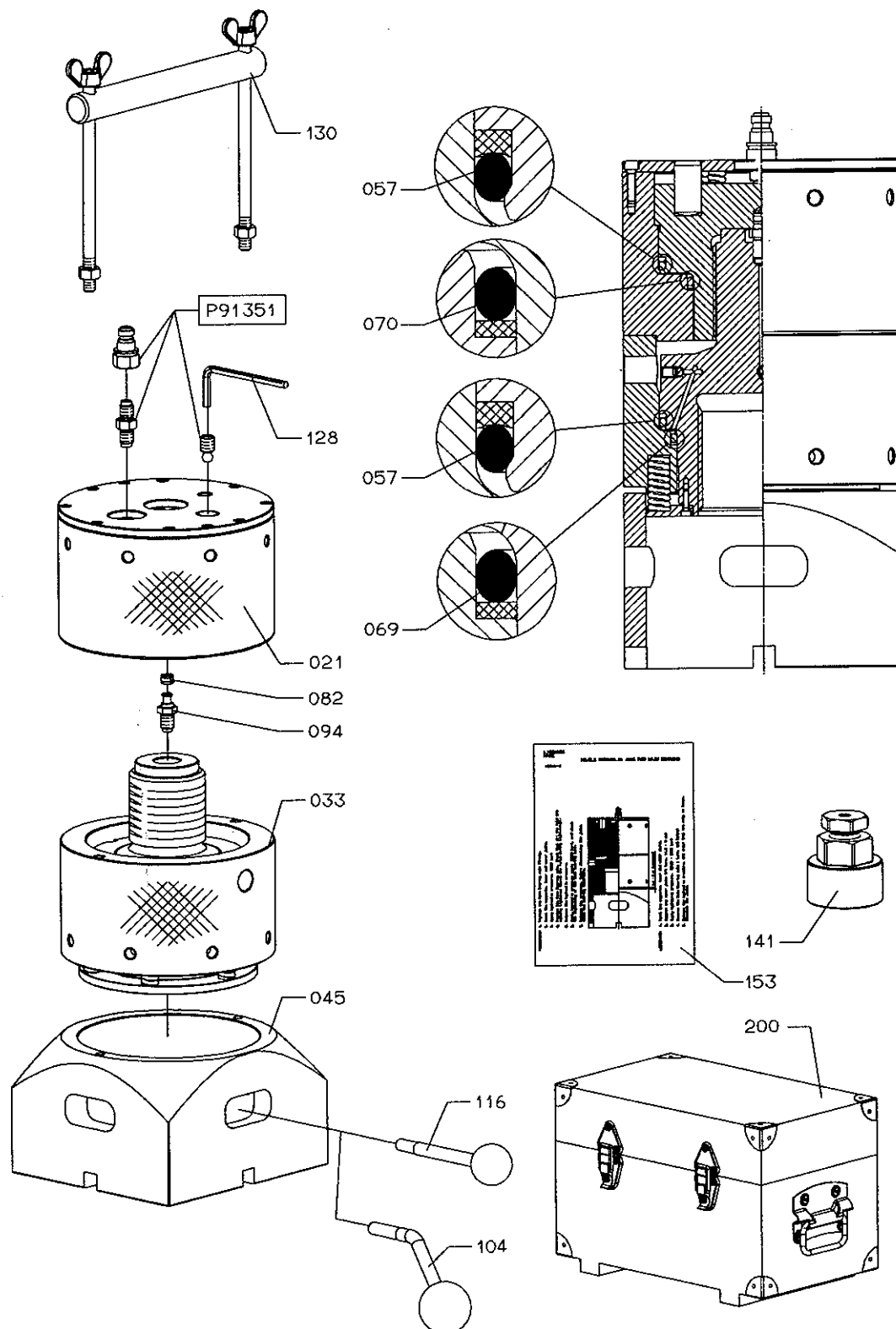
Crankshaft, Thrust Shaft, Main Bearing, Etc. -

90551-0235

Panel

Item No.	Item Description
015	Panel for tools
027	Name plate
040	Wire pulley for main bearing
076	Lifting tool for main bearing cap
088	Dismantling tool for main bearing shell
090	Mounting tool for thin bearing shell
100	Tool for turning out segments
111	Lifting attachment
123	Retaining tool for main bearing shell
135	Lifting tool for relief valve
147	Eye bolt
160	Wire
172	Mounting tool for thin bearing shell
196	Tightening template for A.V.D.
206	Crowfoot wrench head

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
021	Jack-hydraulic, complete		
033	Jack-hydraulic, complete		
045	Support		
057	Sealing ring with back-up ring		
069	Sealing ring with back-up ring		
070	Sealing ring with back-up ring		
082	Sealing ring with back-up ring		
094	Coupling		
104	Tommy bar		
116	Tommy bar		
128	Spanner		
130	Handle, complete		
141	Stud setter		
153	Instruction plate		
200	Hydraulic tool set, complete		

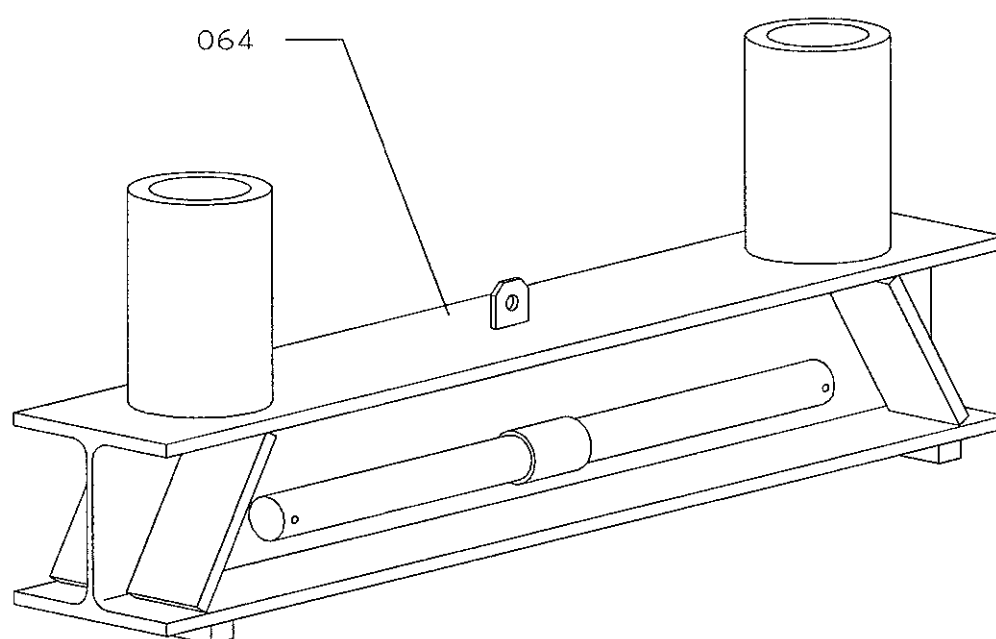


Plate 90562-0121

Crankshaft - Tools

Item No.	Item Description
064	Lifting tool for crankshaft

Item No.	Item Description

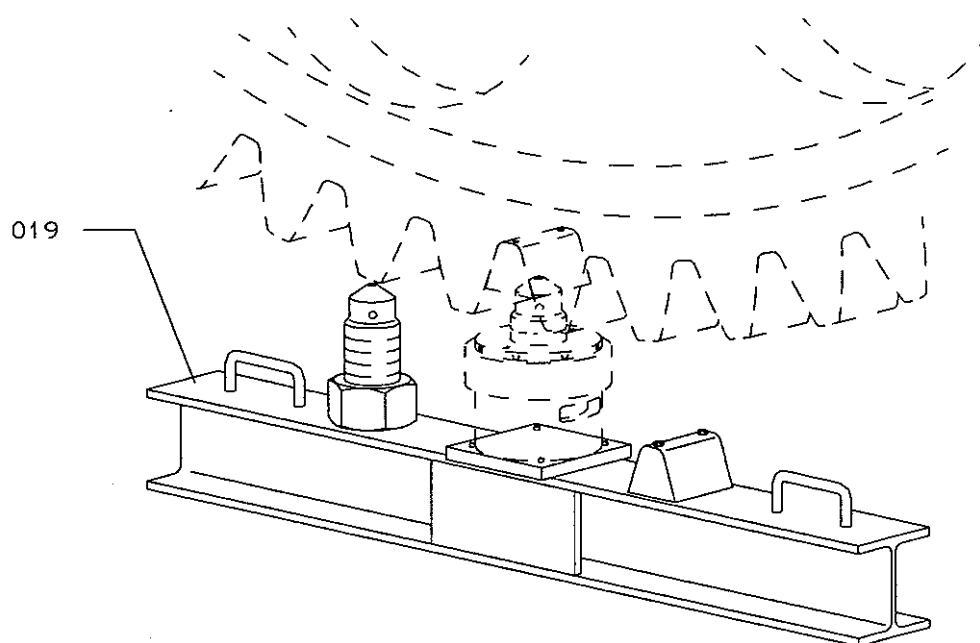


Plate 90570-0001

Thrust Shaft - Tools

Item No.	Item Description
019	Lifting tool for thrust shaft

Item No.	Item Description

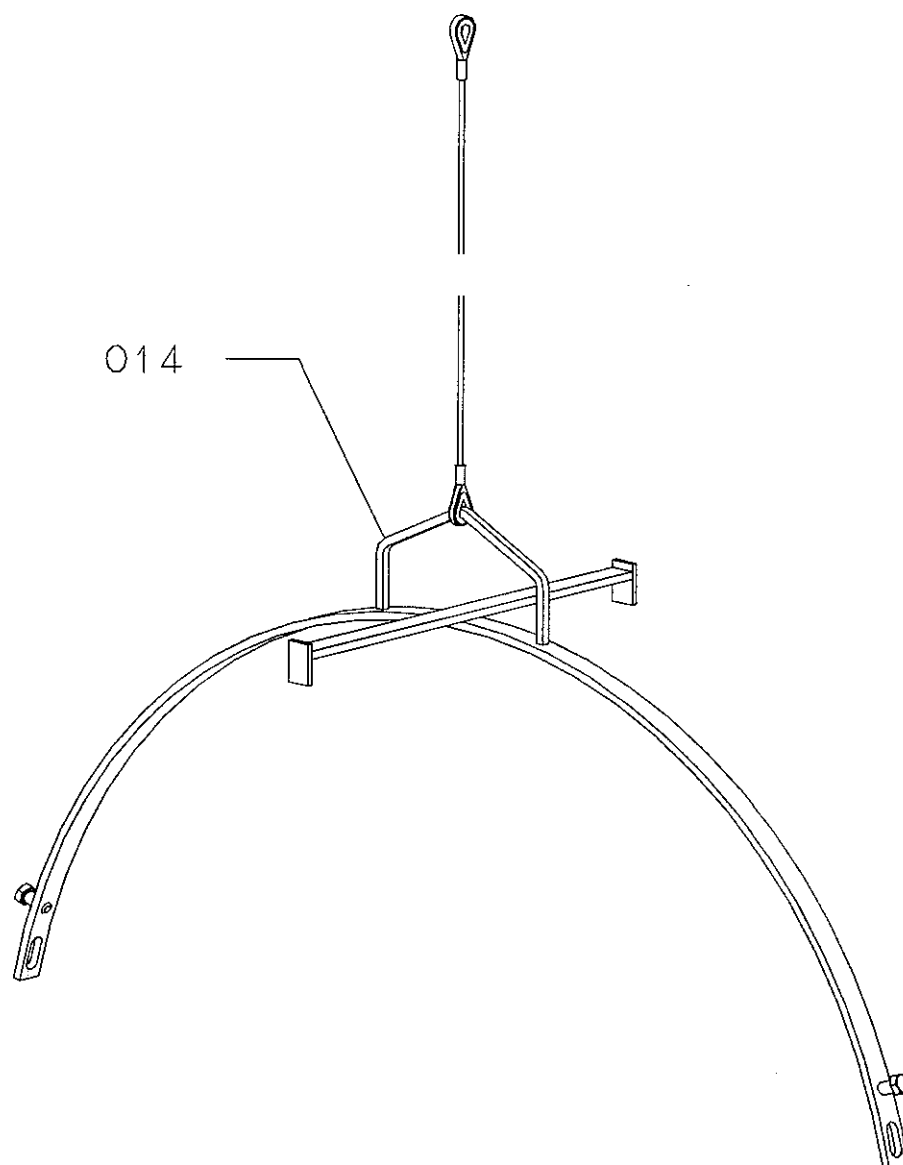
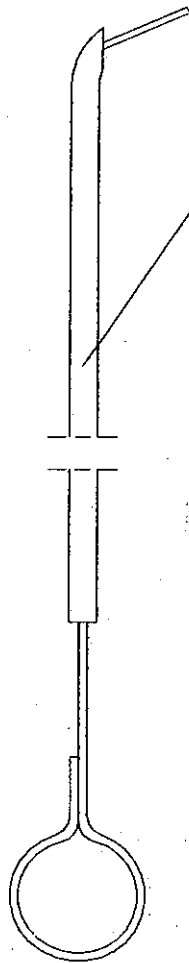
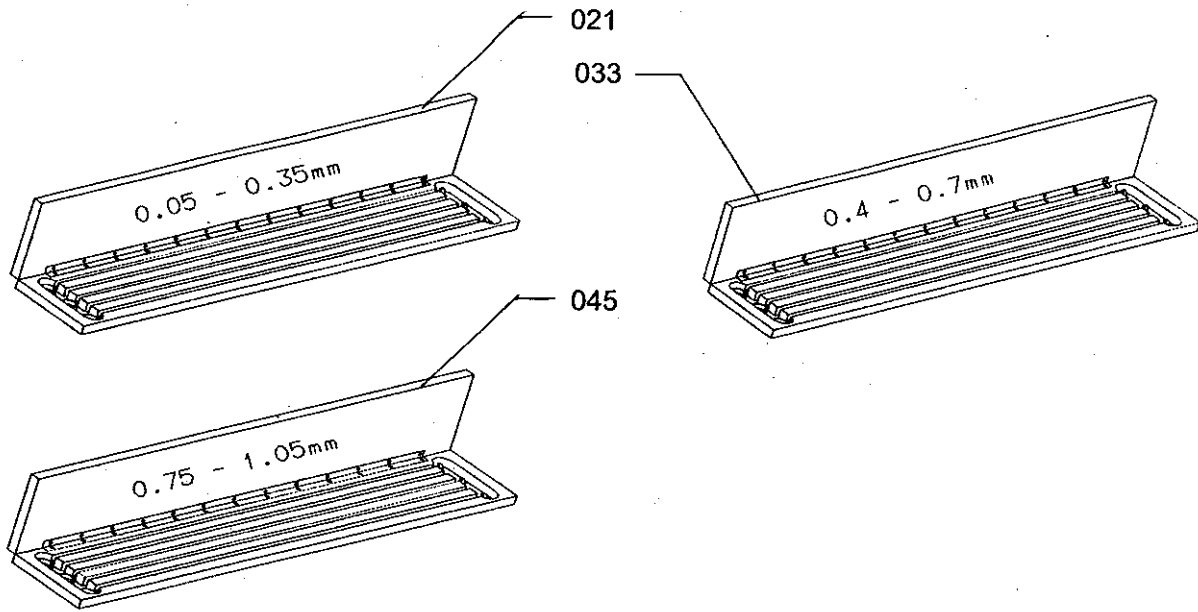


Plate 90571-0001

Main Bearing Shell - Tools

Item No.	Item Description	Item No.	Item Description
014	Lifting tool for main bearing shell		



Item	Size (mm)
069	0.05
070	0.10
082	0.15
094	0.20
104	0.25
116	0.30
128	0.35
141	0.40
153	0.45
165	0.50
177	0.55
189	0.60
190	0.65
200	0.70
212	0.75
224	0.80
236	0.85
248	0.90
261	0.95
273	0.100
285	0.105



Item	Size (mm)
332	0.05
344	0.10
356	0.15
368	0.20
381	0.25
393	0.30
403	0.35
415	0.40
427	0.45
439	0.50
440	0.55
452	0.60
464	0.65
476	0.70
488	0.75
511	0.80
523	0.85
535	0.90
547	0.95
559	0.100
560	0.105

Item No.	Item Description	Item No.	Item Description
021	Feeler gauge set		
033	Feeler gauge set		
045	Feeler gauge set		
069	Feeler gauge		
070	Feeler gauge		
082	Feeler gauge		
094	Feeler gauge		
104	Feeler gauge		
116	Feeler gauge		
128	Feeler gauge		
141	Feeler gauge		
153	Feeler gauge		
165	Feeler gauge		
177	Feeler gauge		
189	Feeler gauge		
190	Feeler gauge		
200	Feeler gauge		
212	Feeler gauge		
224	Feeler gauge		
236	Feeler gauge		
248	Feeler gauge		
261	Feeler gauge		
273	Feeler gauge		
285	Feeler gauge		
332	Spare tip for feeler gauge		
344	Spare tip for feeler gauge		
356	Spare tip for feeler gauge		
368	Spare tip for feeler gauge		
381	Spare tip for feeler gauge		
393	Spare tip for feeler gauge		
403	Spare tip for feeler gauge		
415	Spare tip for feeler gauge		
427	Spare tip for feeler gauge		
439	Spare tip for feeler gauge		
440	Spare tip for feeler gauge		
452	Spare tip for feeler gauge		
464	Spare tip for feeler gauge		
476	Spare tip for feeler gauge		
488	Spare tip for feeler gauge		
511	Spare tip for feeler gauge		
523	Spare tip for feeler gauge		
535	Spare tip for feeler gauge		
547	Spare tip for feeler gauge		
559	Spare tip for feeler gauge		
560	Spare tip for feeler gauge		

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME-engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D06-18	Teeth on chain wheel, max. wear	4	mm
D06-19	Original length (chain pitch x 10 links)	1143	mm
D06-20	10 links measurements + 1% of a tensioned chain = scrapping of chain	1154.4	mm

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90651	70	Chain assembling tool
P90651	81	Chain disassembling tool

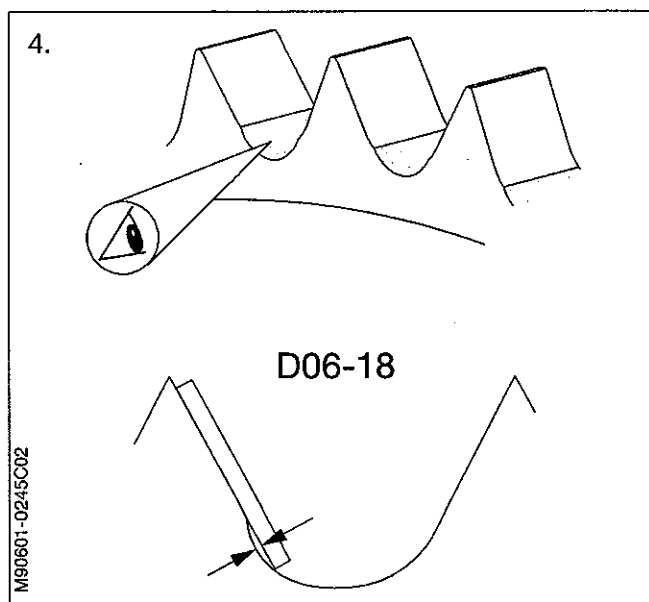
Carry out the inspection as follows:

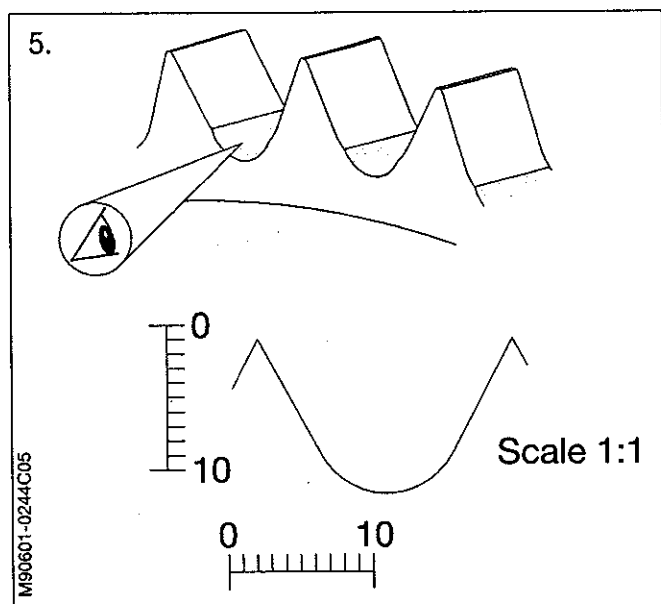
1. Make a general inspection for loose bolts and screws.
2. Inspect lube oil pipes for damage, and check jet nozzles for possible stoppages or deformations.
3. Examine the rubber track of the guideways for cracks or other damage.

Replace the guideway if bits have started to be "plucked out" of the rubber track.

4. Check the teeth of the chain wheels. If abnormal wear is found, take a measurement (see *Data*).

Measurements are best taken by placing a short straight-edge over the straight part of the chain wheel and then measuring the distance D06-18.





5. If abnormal wear is observed at the bottom of the teeth, make a drawing in scale 1:1 of the teeth and wear profile.

Draw two rulers on the drawing.

For assessing the wear profile, contact MAN Diesel.

In most cases, scratches caused by the side plates of the chain will be found on the sides of the teeth. Such scratches can generally be considered normal.

6. The chains for the camshaft drive are matched together to ensure an even load distribution.

To keep such matching chains in their pairs, the side plates of the outer link nearest to the assembled link have been marked with year, month, day and chain number.

Example:

No. 1 order,

840520 1A

840520 1B

(840520 2C, possible 3rd chain)

No. 2 order,

840520 2A

840520 2B

(840520 2C, possible 3rd chain)

On the same links there is an arrow (→) which indicates the mounting direction.

Check the chains for cracks on possibly defective rollers and side plates.

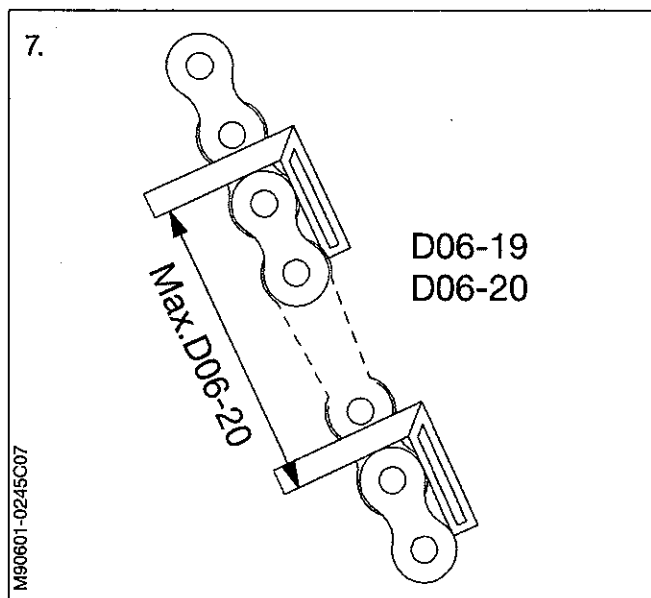
Check that the chain rollers can run freely and that the chain links can freely move on the pin and bushing (that they are not "seized" between the pin and the bushing).

It is normal, however, that the rollers get light, circumferential scratches during the running-in period. These fine scratches are of no importance and need not be considered.

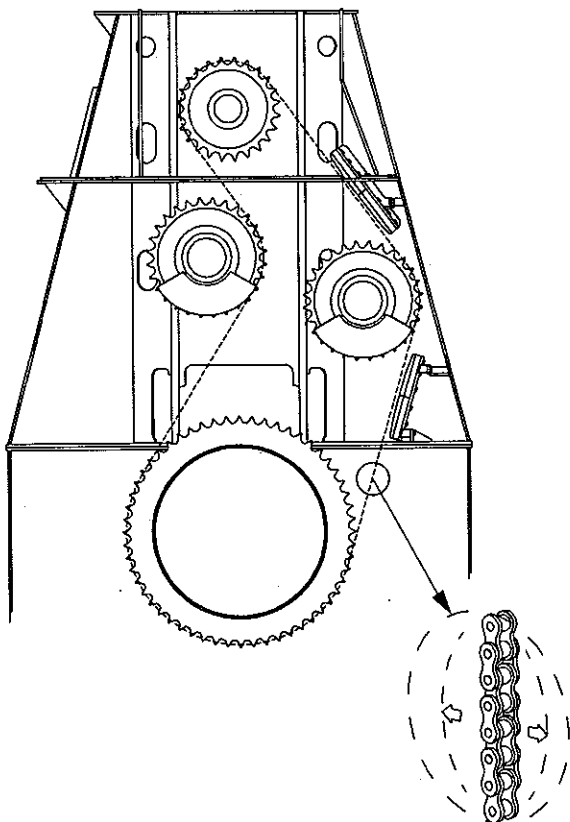
It is recommended that each single link is checked.

7. Check chain wear by measuring the length of 10 chain links. Use two master squares and a steel measuring tape as shown on the sketch. Compare the result with the value given in Data.

If necessary, adjust the chain tightener.
See *Procedure 906-2.3*.

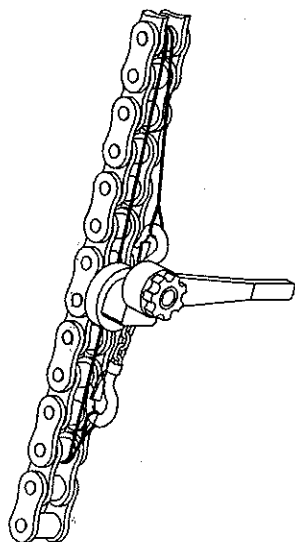


1.



M90601-0248D01

2.



M90601-0238D02

It may become necessary to disassemble the chain if, for instance, cracked rollers or seizures between pin and bushing have been discovered during the inspection. See Procedure 906-1.1.

Note!

Every time a chain link is disassembled, a new link must **always** be fitted as the link pin press-fit is destroyed when breaking the chain.

When a new link is fitted in one chain, the corresponding link in the other chain must also be renewed.

1. Remove the tension on the chain by loosening the chain tightener. (See Procedure 906-2.3).

Turn the engine until the slack part of the chain, with the chain link that is to be disassembled, is in a favourable position for the work. If the engine is equipped with balanceweights, continue the turning until the balanceweights are hanging vertically downwards, as shown in the sketch.

2. Mount a wire round the link rollers a short distance from the disassembly point, and tighten the wire lightly with a tackle.

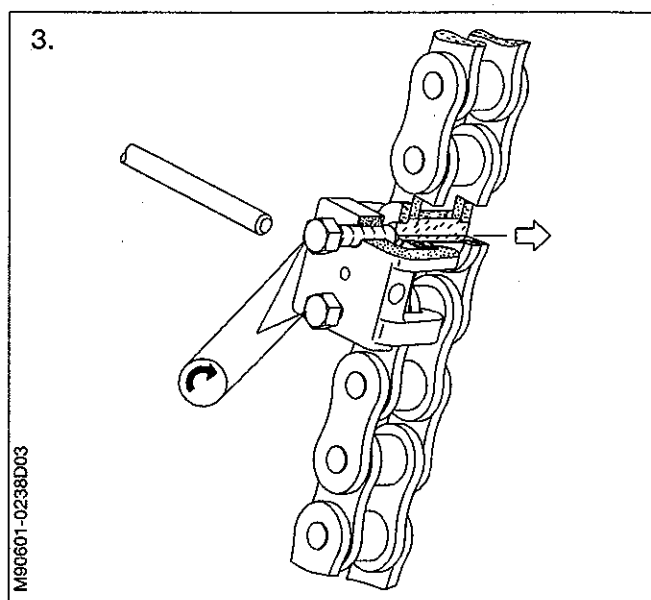
Protect the link rollers over which the wire is wrapped.

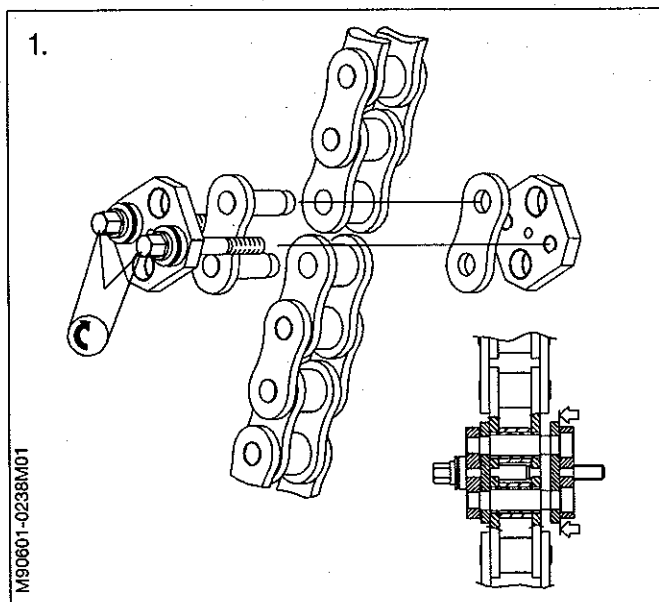
Note!

If the chain is to be completely removed, contact MAN Diesel for further information.

The riveting of the pins that are to be pressed out is to be chiselled or ground away.

3. Place the chain bursting tool over the outer chain link, and dismantle the link by alternately tightening the screws on the tool.





Before assembling the inner and outer links, clean the pins and bushings.

1. Combine the inner chain link with the outer chain link and mount the compression tool.

Force the loose side plate of the outer link into place by alternately tightening the screws on the compression tool.

2. When the link has been assembled, remove the compression tool and lock the pin ends by riveting.

Repeat this procedure until the chain has been assembled.

Remove the tackle and wire and adjust the chain tension.

(See *Data and Procedure 906-2.3*).

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

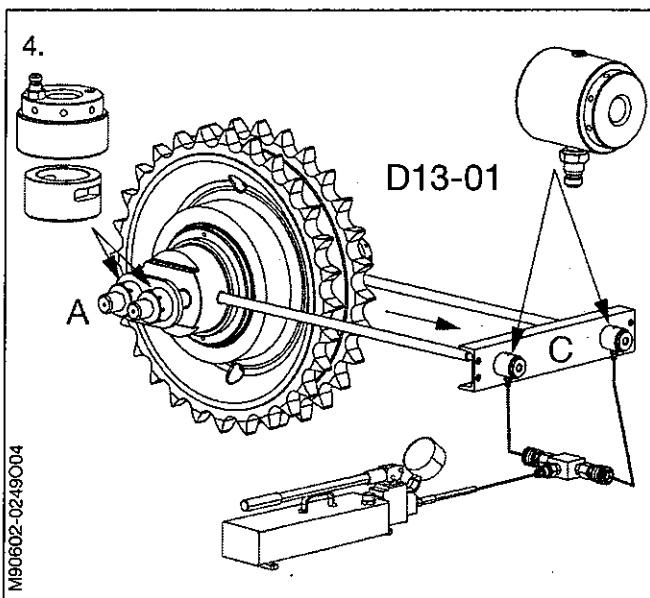
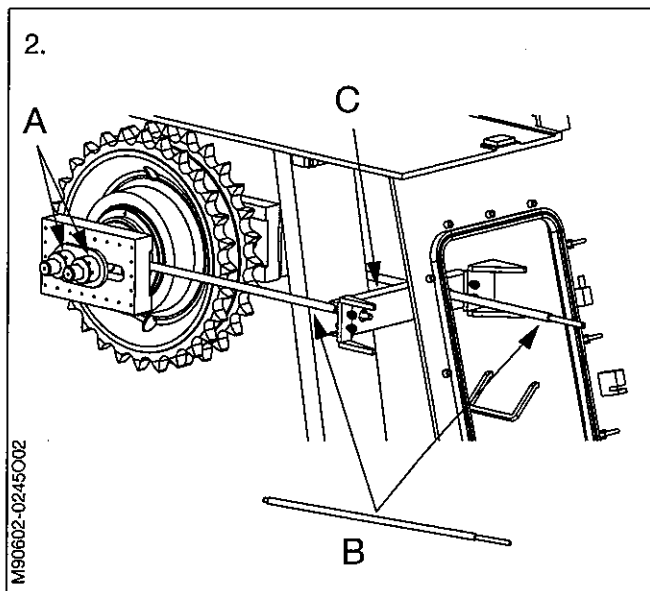
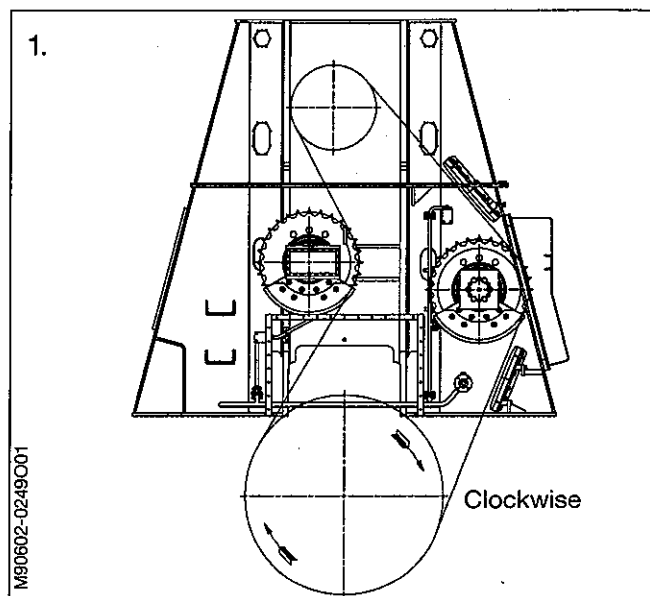
Plate	Item No.	Description
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete
P90671		Hydr. Tools, Chain Tightener

Remove the chain tightener cover.

1. Turn the engine in the clockwise direction to get the slack part of the chain to the tightening wheel. Continue turning until the flyweights are hanging almost vertically downwards, see the sketch.
2. Mount the tightening tool studs **B** in the threaded holes in the tightener wheel shaft. This is done through the opening in the supports on the guide bar **C**.
3. Loosen the hydraulic nut **A** on the fore side of the chain tightener wheel.
For operation of the hydraulic tools, see Procedure 913-1.
4. Mount the chain tightener tool hydraulic jacks on the studs **C** and tighten both simultaneously to the value stated in Data D13-01.

Use the hand operated hydraulic pump for this operation.

5. Tighten the hydraulic nut **A** to the value stated in data D13-01. Use the hydraulic pump for this operation.
6. Loosen the hydraulic chain tightener tools and remove the tools from the engine.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90671		Hydraulic tools - chain tightener

If dismantling has been necessary, the flyweights must be assembled in the correct position in relation to the engine crankshaft. Incorrectly mounted flyweights can cause (heavy) vibrations of the engine.

Note!
The following applies to a clockwise-rotating engine

Aftmost 2nd Order Moment Compensator

Turn the crankthrow of cylinder No. 1 in the ahead direction to the position shown in the figures for 4, 5, 6-cylinder engines, respectively.

Check that the flyweights point vertically downwards (max. deviation one-half chainwheel tooth pitch).

Turn the camshaft relative to the crankshaft in accordance with the 'valve opening diagram', and then mount the chain.
Tighten the chain in accordance with the instruction.

See Procedure 906-2.3.

Turn the crankthrow of cylinder No. 1 in the ahead direction to TDC and carry out fine adjustment of the camshaft.

Foremost 2nd Order Moment Compensator

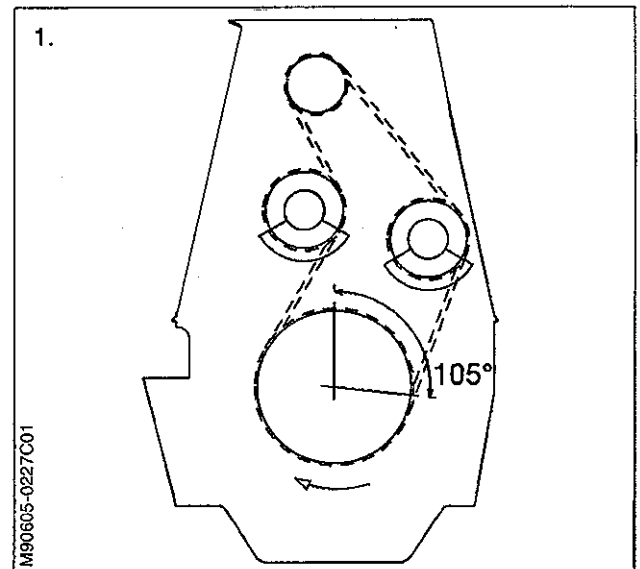
Turn the crankthrow of cylinder No. 1 in the ahead direction to the position shown in the figures for 4, 5, 6-cylinder engines, respectively.

Check that the flyweights point vertically downwards (max. deviation one-half chainwheel tooth pitch) and then mount the chain.

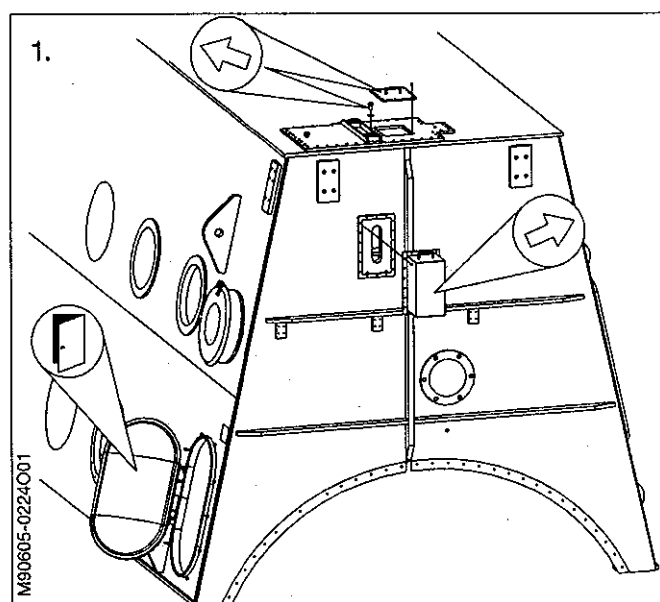
Tighten the chain in accordance with the instruction.

See Procedure 906-5.3.

Note!
For an anticlockwise-rotating engine, the degrees mentioned in the respective figures must be before tdc, not after tdc.

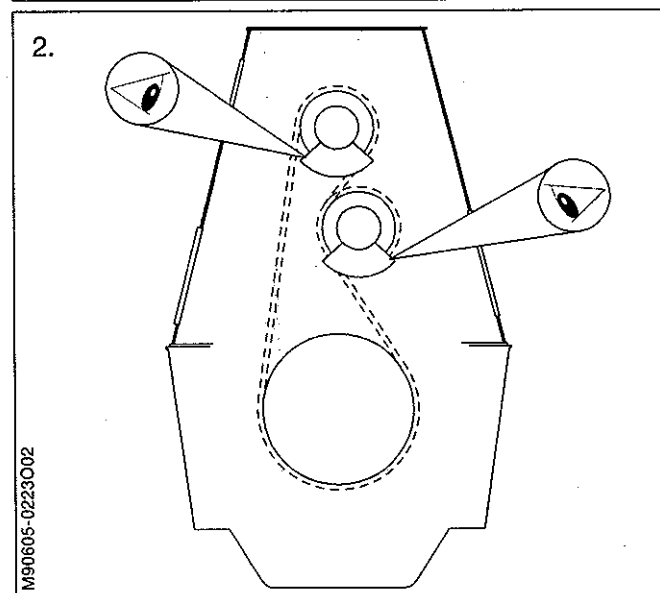


Moment Compensator Adjustment

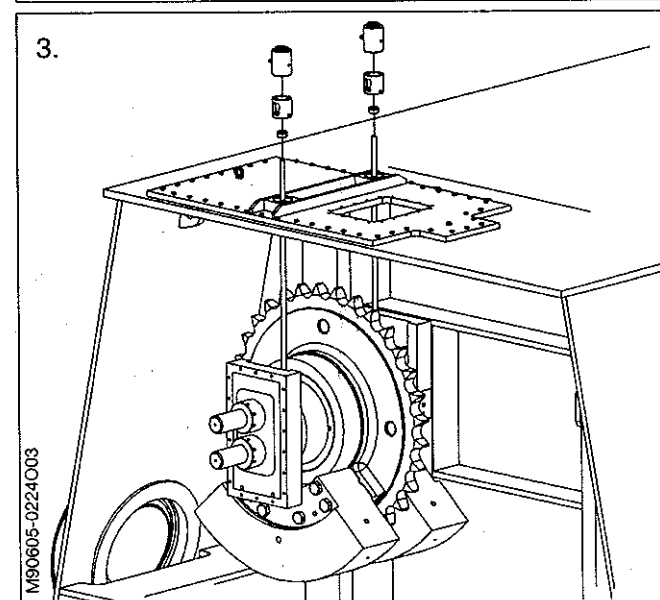


1. At the front of the engine, open the foremost door on the exhaust side of the engine and remove the cover to the chain tightener nuts.

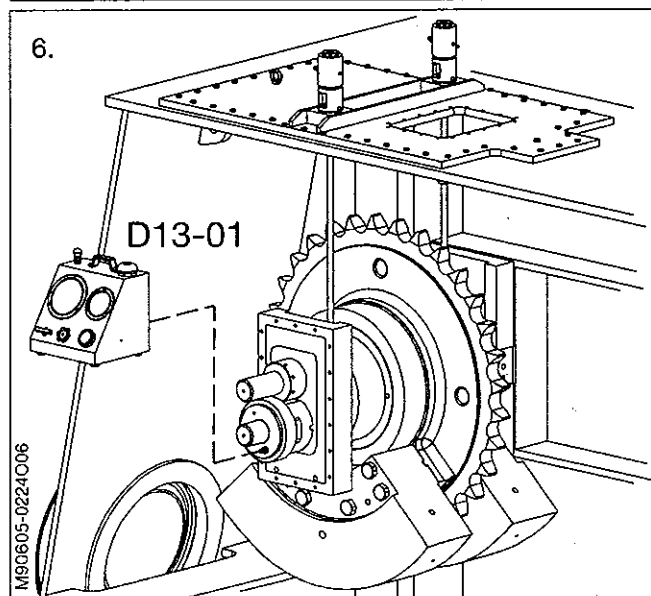
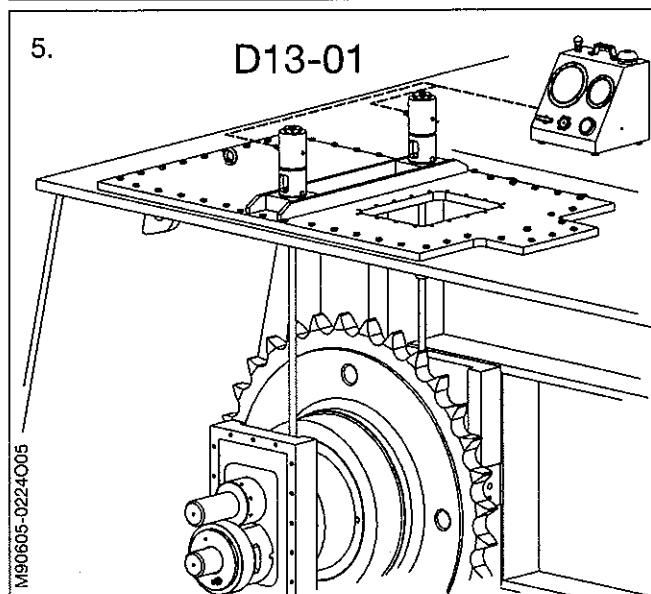
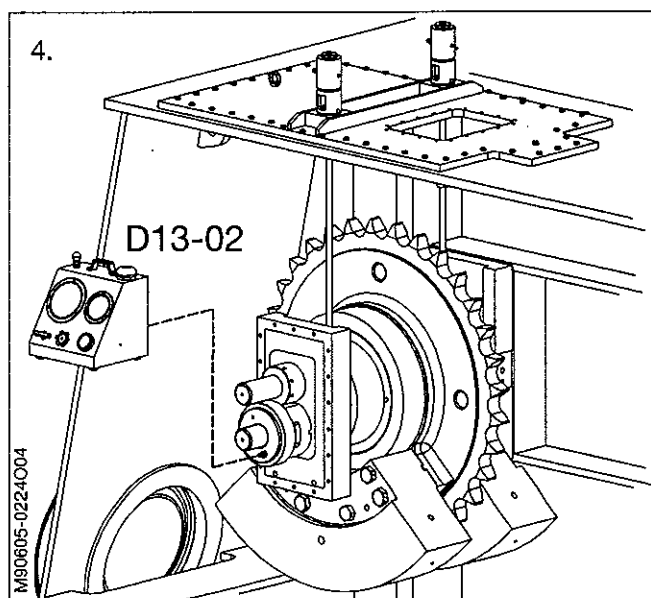
Remove the access cover and the two hexagon screws from the top cover.



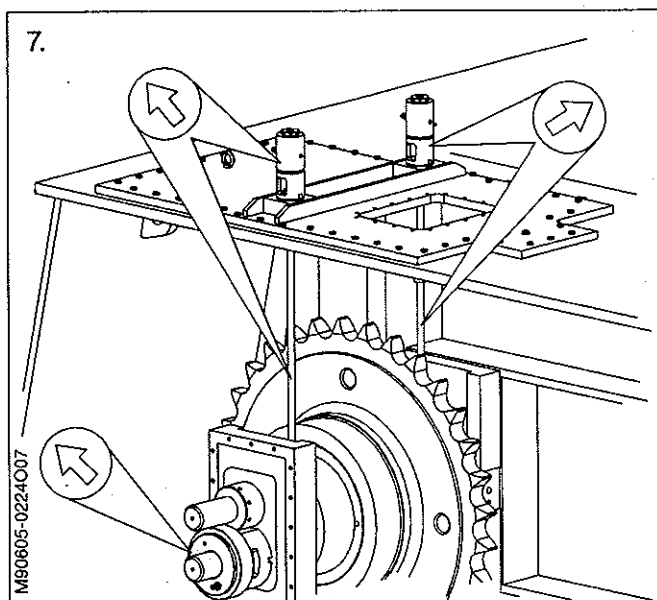
2. When tightening the chain, bring the two flyweights to a vertical downward position.
3. Mount the chain tightening tool with the hydraulic nut through the two holes in the top cover. Tighten the hydraulic nut by hand.



4. Loosen the hydraulic nuts on the chain tightener. Use one hydraulic jack from the crosshead bearing.
For use of hydraulic tools, see Procedure 913-1.
5. Tighten the hydraulic nuts on the chain tightening tool.
For correct tightening pressure, see Data.
6. Tighten the hydraulic nuts on the chain tightener, one at a time. See *Data*.



Moment Compensator Adjustment

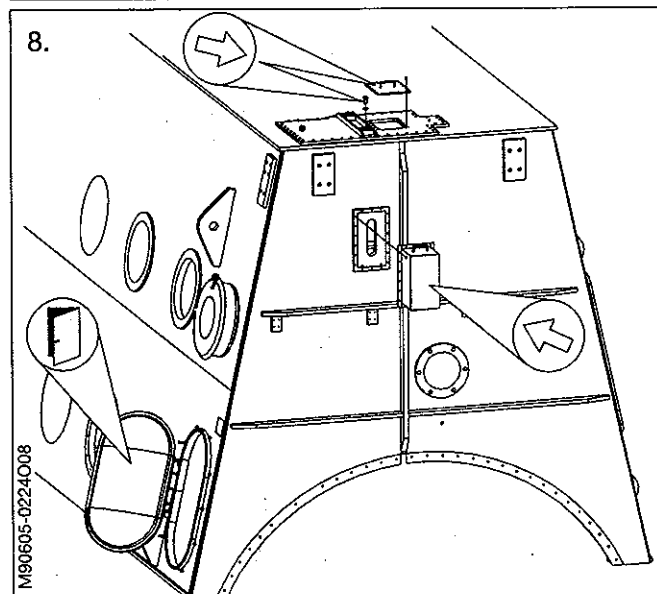


7. Loosen the hydraulic nuts on the chain tightening tool.

Remove the hydraulic tools and the chain tightening tool from the engine.

8. Mount the cover to the chain tightener nuts and close the door to the moment compensator.

Mount the access cover and the two hexagon screws on the top cover.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors
☒	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit



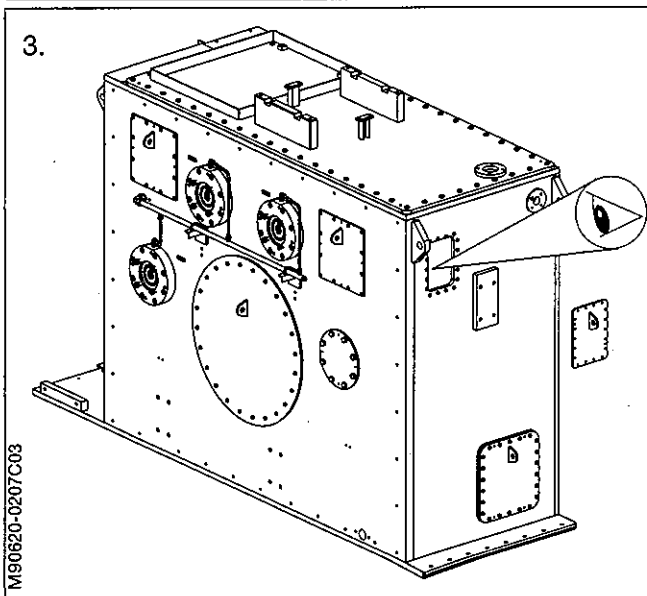
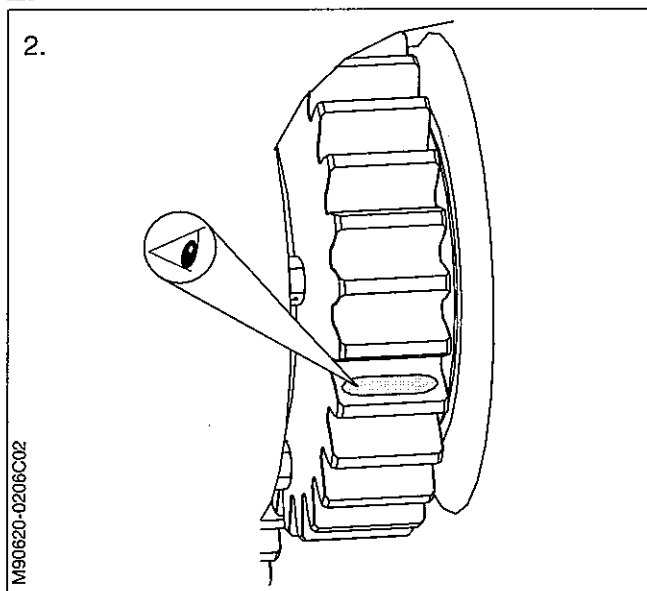
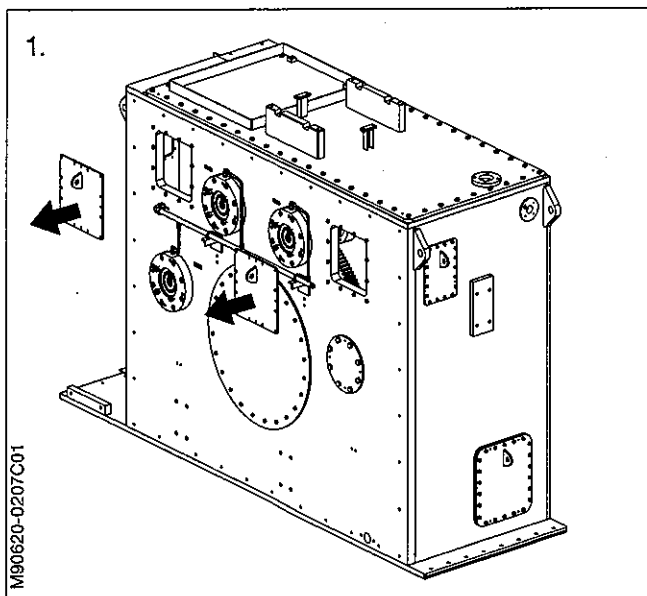
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

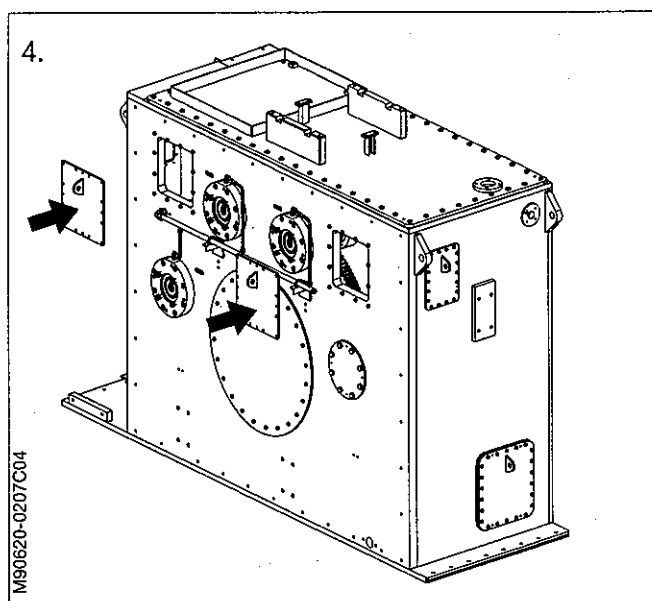
Plate	Item No.	Description
P91356		Lifting Tools, Etc.

1. Remove the covers on the exhaust and rear side of the chain drive.

Carry out a visual inspection of the gear wheels.

2. Check that there are no signs of abnormal wear on the contact faces of the gear wheel teeth.
3. Check that there are no particles of bearing material on the horizontal surfaces below the bearings.





4. Mount the covers on the exhaust and rear side of the chain drive.

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors
☒	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
D06-206	Hydraulic pump	100	kg
D06-210	Internal drive shaft	16	kg

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item No.	Description
P91356		Lifting tools, etc.
P91359		Torque spanners
P91366		Instruments

Check that startup and booster pumps are stopped before any part of the hydraulic system is disassembled.

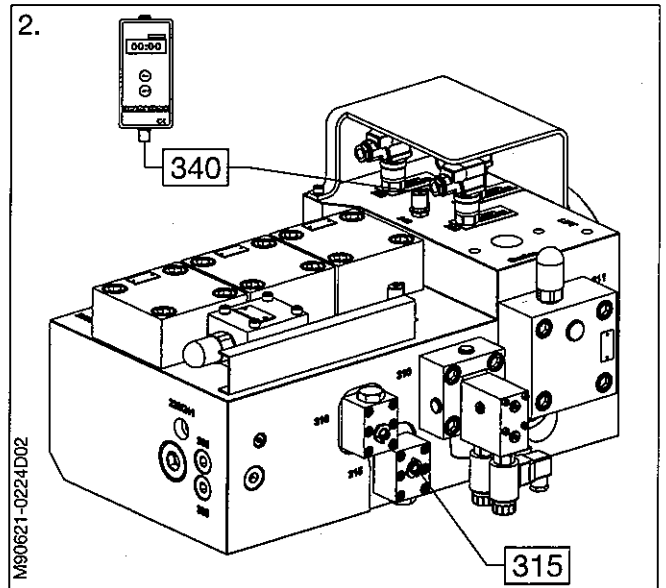
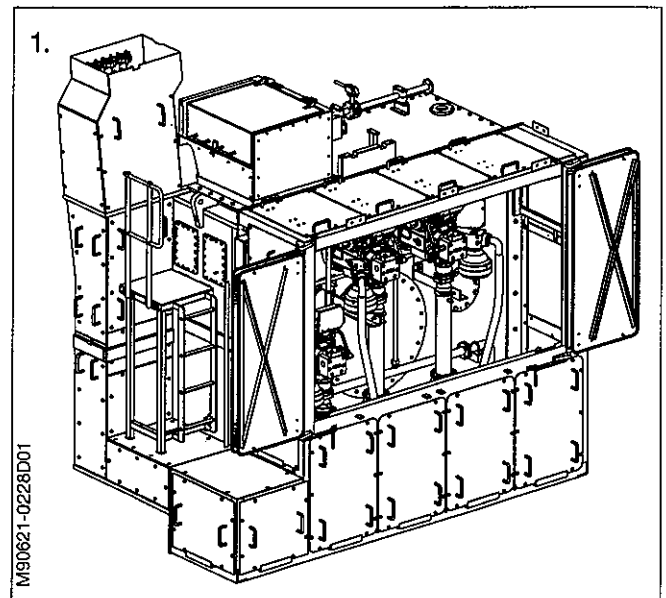
Note!

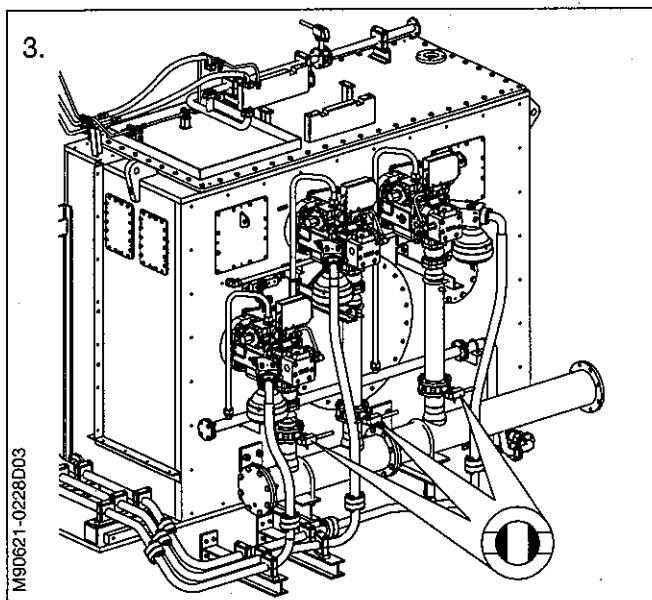
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

1. Open the covers enclosing the hydraulic pumps.
2. Mount a pressure gauge on the "minimess" coupling No. 340. Check the pressure.

Open valve 315 to release the hydraulic pressure from the system.

Check on the pressure gauge that the system is pressure free.

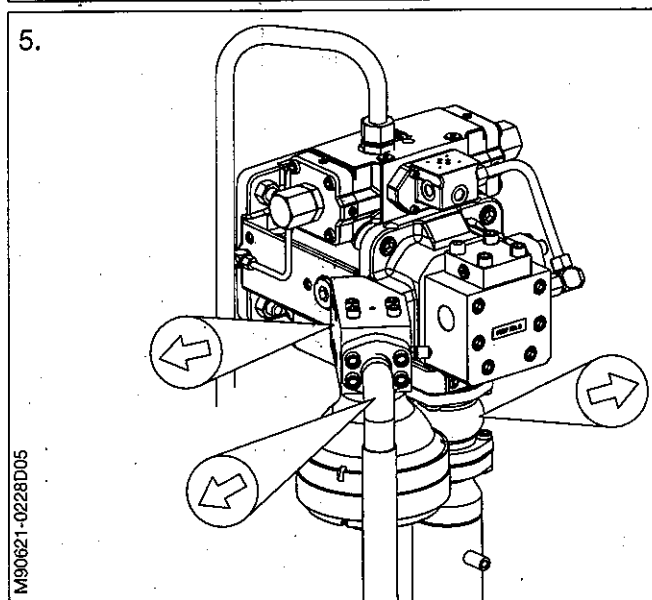
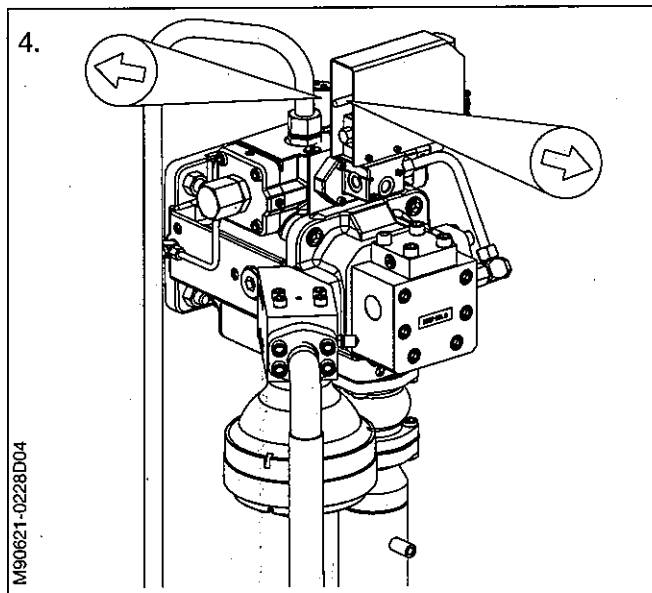




3. Close the suction valve for the pump concerned.
4. Unscrew the shield protecting the solenoid valve and remove the electrical connection to the solenoid valves.
5. Unscrew the bolts from the flange on the suction pipe.

Unscrew the bolts from the discharge pipe and remove the pipe.

Remove the accumulator and the block connected.



6. Unscrew the servo oil pipes.
7. Suspend a tackle above the hydraulic pump and put a strap around the pump.

Hook the tackle on to the strap and tighten up.

Note!

The pump must be in balance when it is lifted.

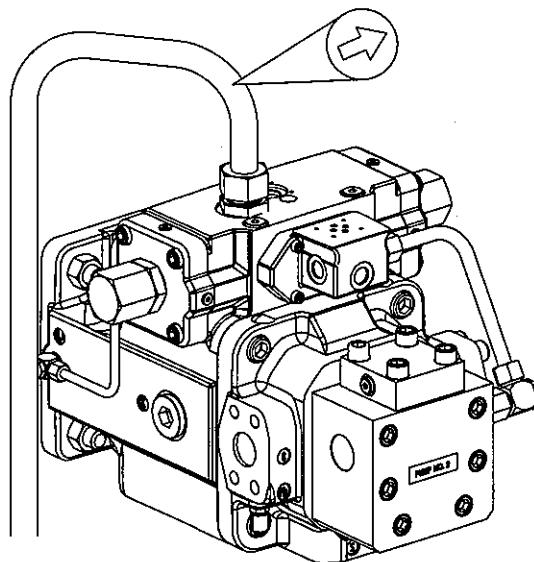
Unscrew the four nuts from the studs in the end-flange.

8. Carefully pull out the pump and the internal drive shaft. See *Data*.

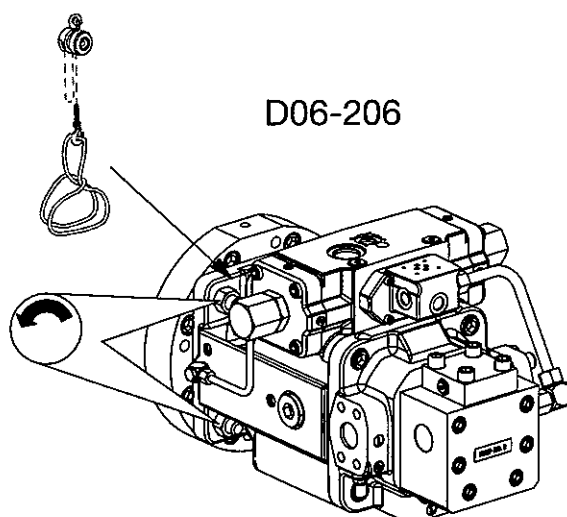
For overhaul of the pump, send it to an authorized MAN Diesel workshop.

The internal drive shaft also functions as an overload protection. If it is necessary to renew the drive shaft, contact MAN Diesel for advice.

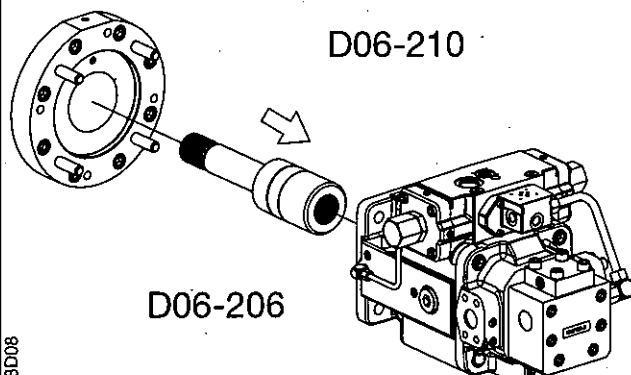
6.

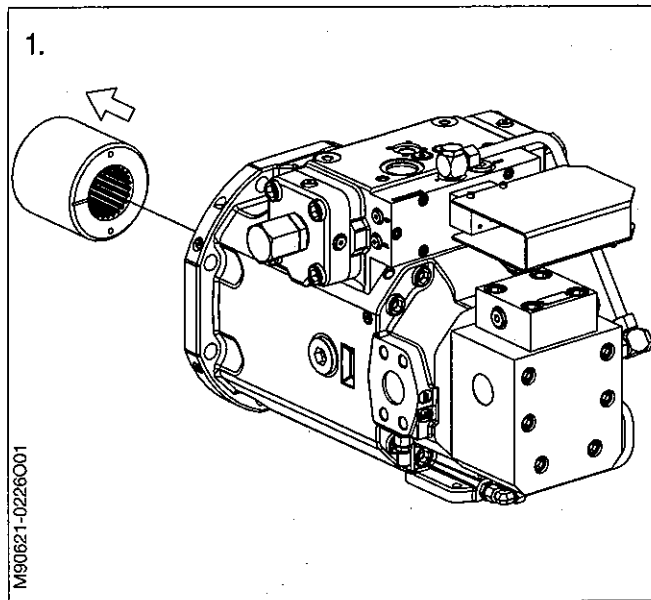


7.



8.





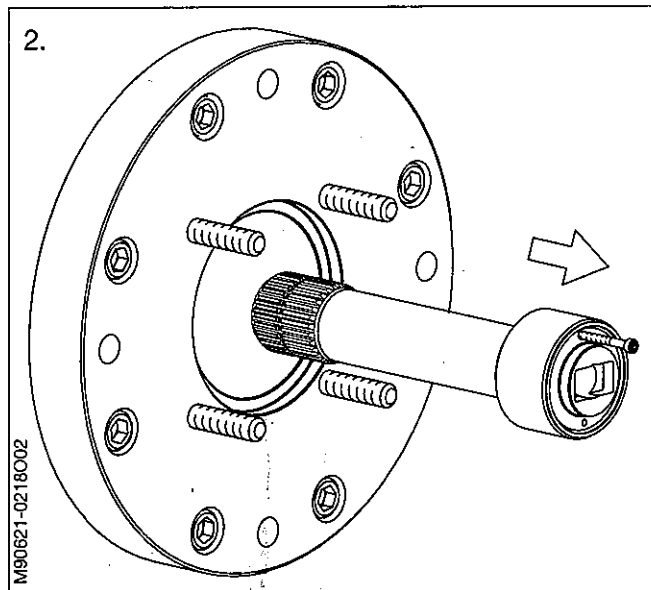
When the internal drive shaft has been overloaded, it must be renewed.

1. Dismantle the hydraulic pump.

Remove the broken end of the internal drive shaft.

Note!

Take care to catch all loose bits and other parts.

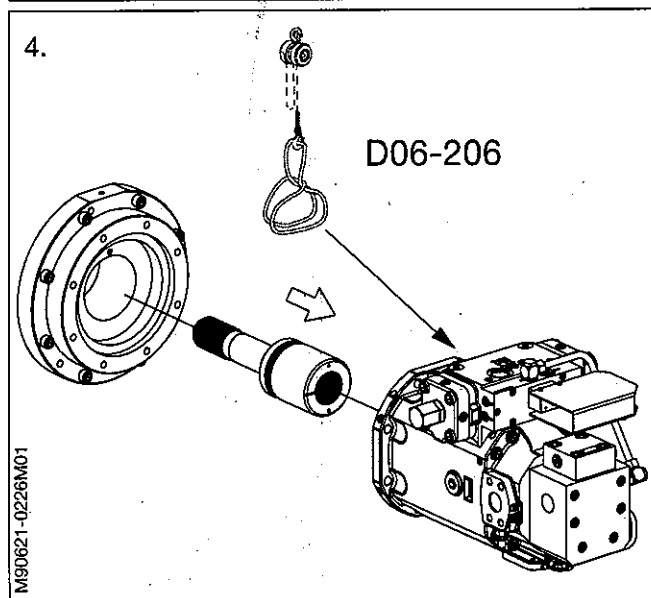


2. Screw an appropriate screw into thread in the end of the internal drive shaft and pull it out.

3. Discard the broken drive shaft.

4. Mount a new internal drive shaft and the hydraulic pump.

Splines on the internal drive shaft must be degreased before mounting. Lubricate with engine oil.



Note!

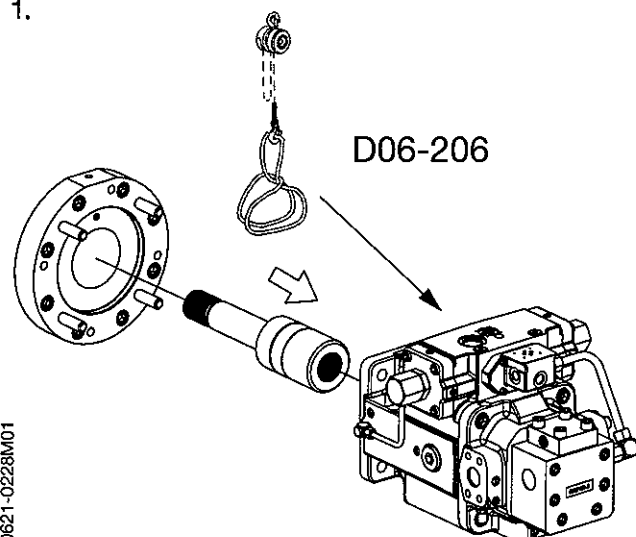
Always ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

1. Mount the intermediate shaft in the gear-box. Suspend a tackle above the gear box and put strap around the hydraulic pump.

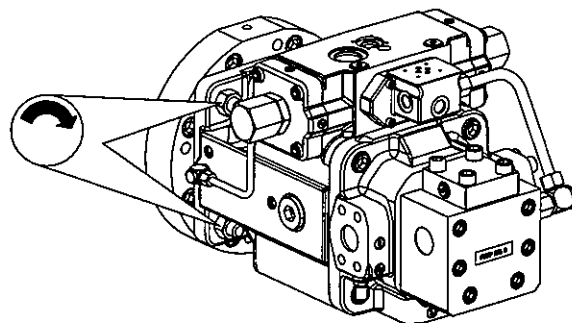
Lift up the pump in position, and carefully push in the pump to engage the pump shaft with the drive shaft.

2. Mount and tighten the screws on the pump flange.
3. Mount the servo oil pipes.

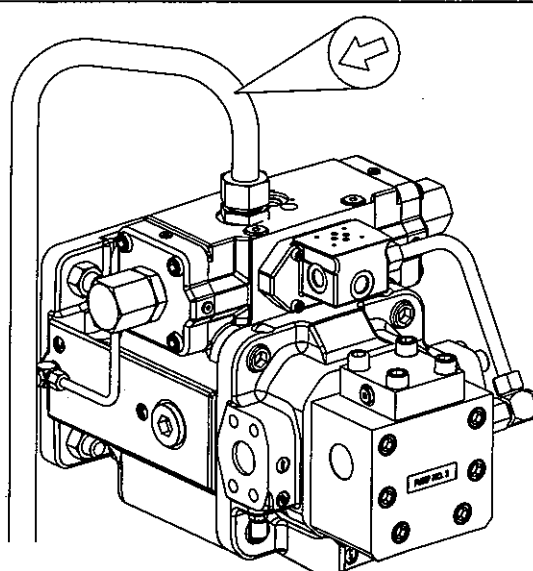
1.



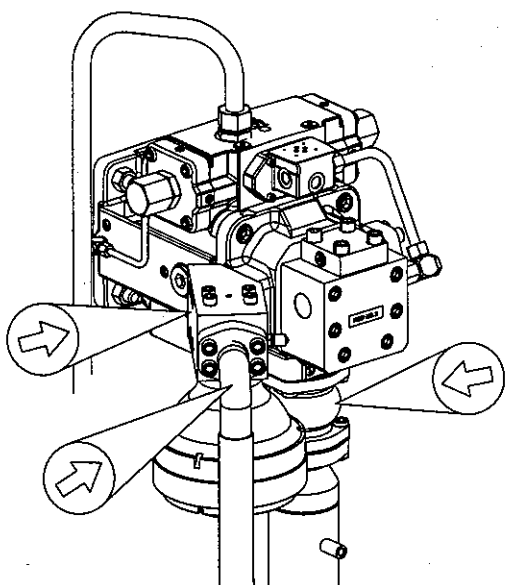
2.



3.



4.



4. Mount the bolts in the flange on the suction pipe.

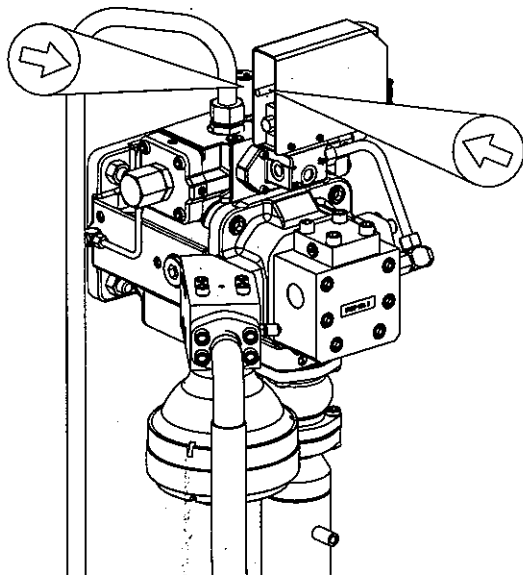
Mount the block with accumulator.

Mount the discharge pipe and tighten the bolts.

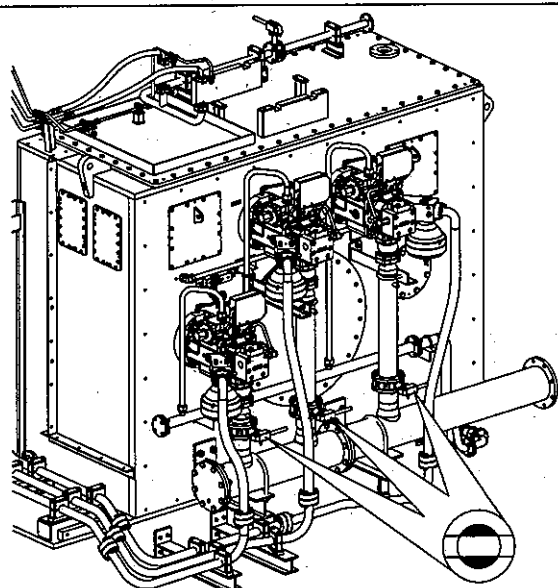
5. Mount the electrical connections to the solenoid valves and replace the protective shield.

6. Reopen the suction valves.

5.

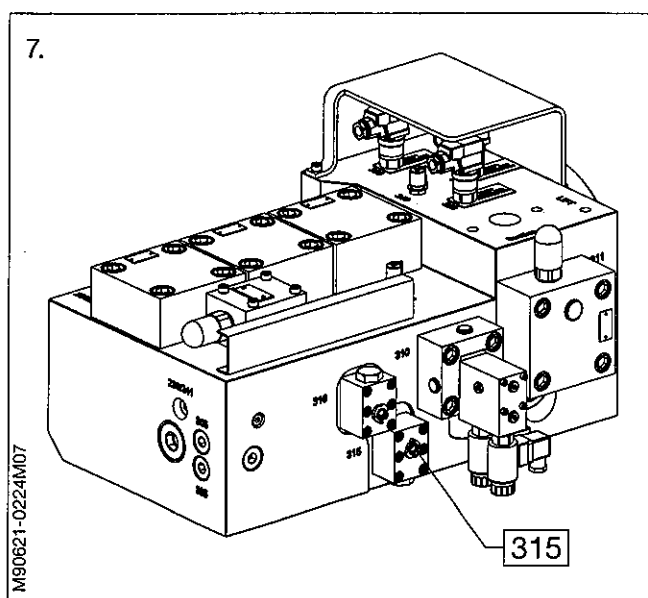


6.

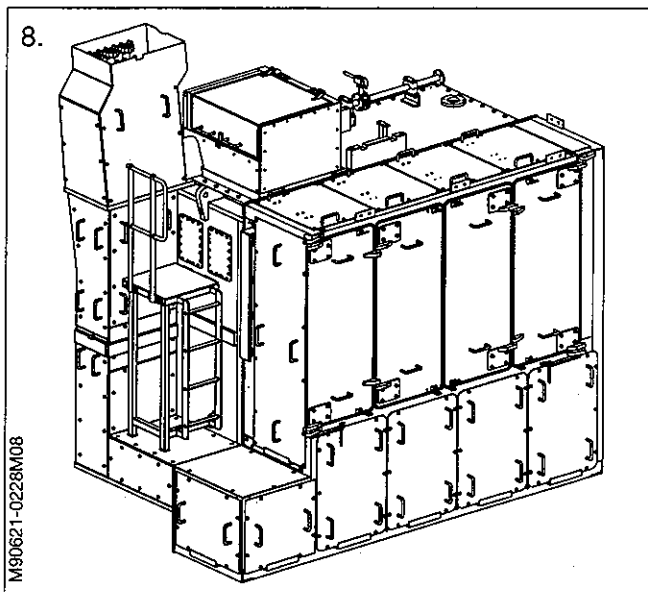


7. Close valve 315 on the foremost flange.
8. Close the cover.

7.



8.



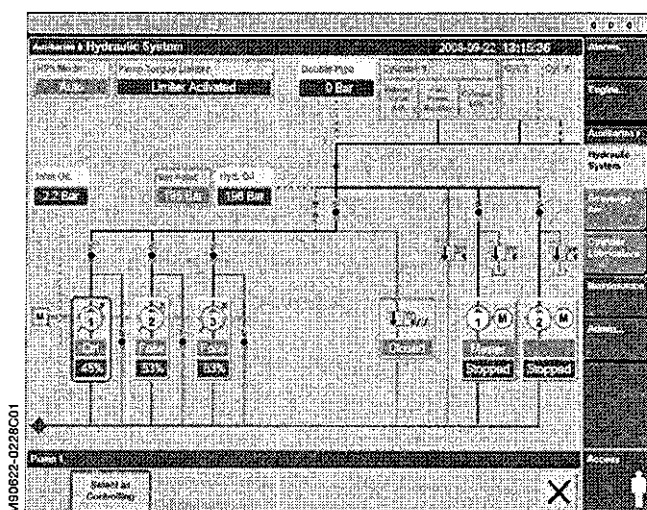
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

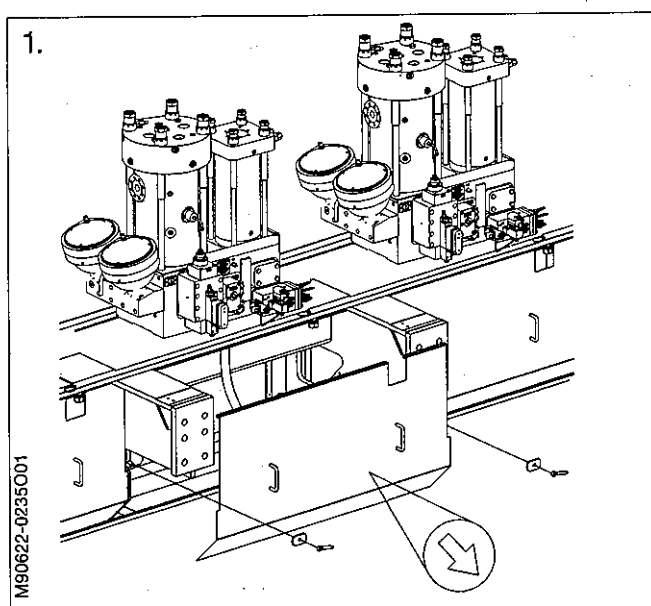
Plate	Item No.	Description
P90951	333	Cleaning tool for NC valve
P91356		Lifting tools, etc.
P91366		Pressure gauge

The integrity of the hydraulic system can be checked by observing the Hydraulic Pressure Decay Time on the Main Operating Panel when stopping the engine.

If the graph moves in to the yellow or red area, the leak has to be located and stopped.

Leakage during operation may be observed by poor engine performance or visible leaks on the engine.



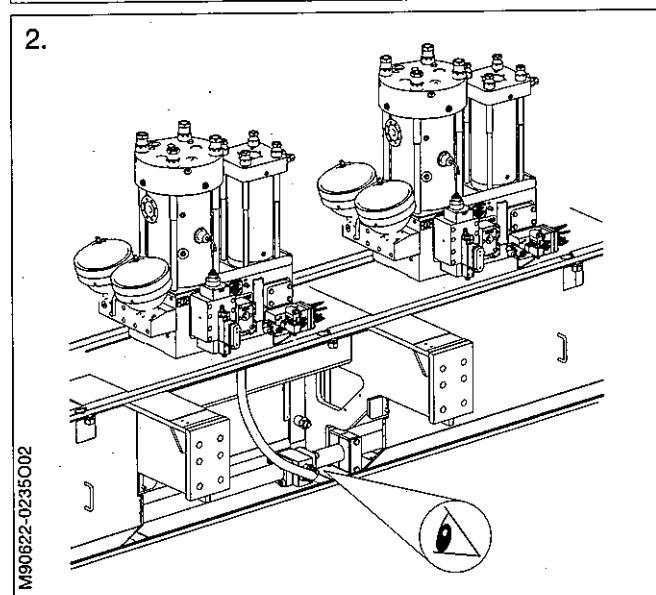
**Main High-Pressure Pipe**

1. Remove the cover to access the main high-pressure pipe.
2. Check the high-pressure pipe connections for visible leaks.

Caution!

Do not use your hands to detect leakages!

If necessary use a mirror on a stick.



3. Pressure free system

Mount a pressure gauge on the "minimess" coupling No. 340.

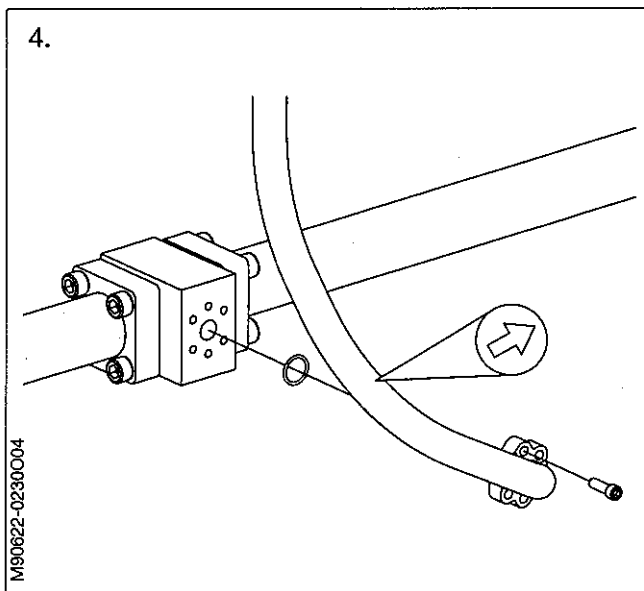
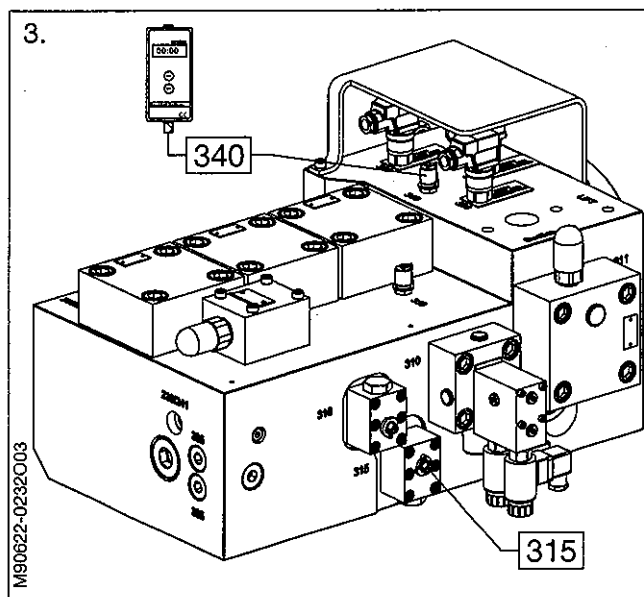
Check the pressure.

Open valve 315 to relieve the system of hydraulic pressure.

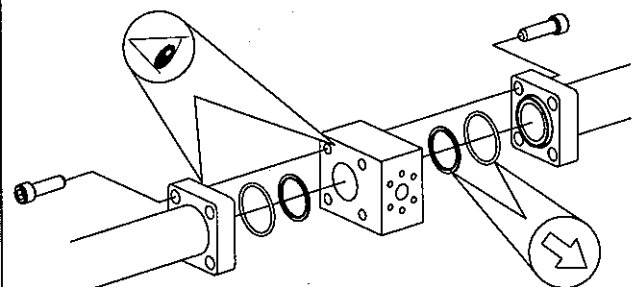
Check on the pressure gauge that the system is pressure free.

4. Remove the bolts

Loosen and remove the bolts from the pipe flanges on the high-pressure pipe or hose concerned.



5.



M90622-0230005

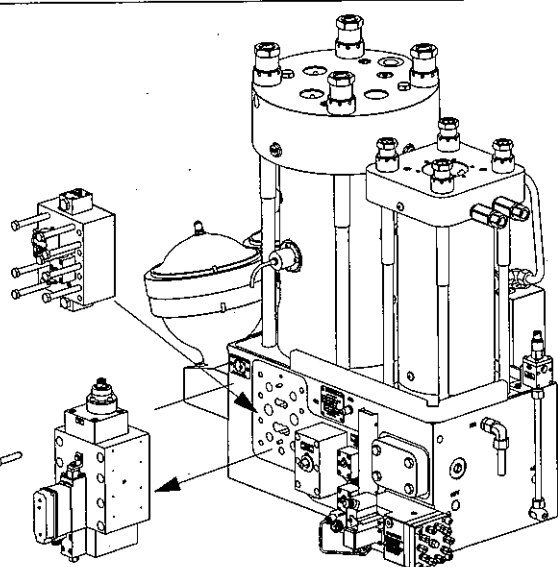
5. Remove the sealing rings and clean the pipe flanges.

Inspect the flange and pipe visually.

6. Fit the high-pressure pipes and new sealing rings.
7. Put covers back into place.
8. Close valve 315.
9. After renewing sealing rings or hoses on the high-pressure system it is recommended to test the pipe system according to the "checking" section.

Flushing of HCU Block

11.



M90622-0235011

10. If large components on the HCU block has been renewed or if there is suspicion that the HCU block has been contaminated, it is recommended to flush it.

11. Prior to flushing, remove the FIVA valve as described in procedure 906-24.2.

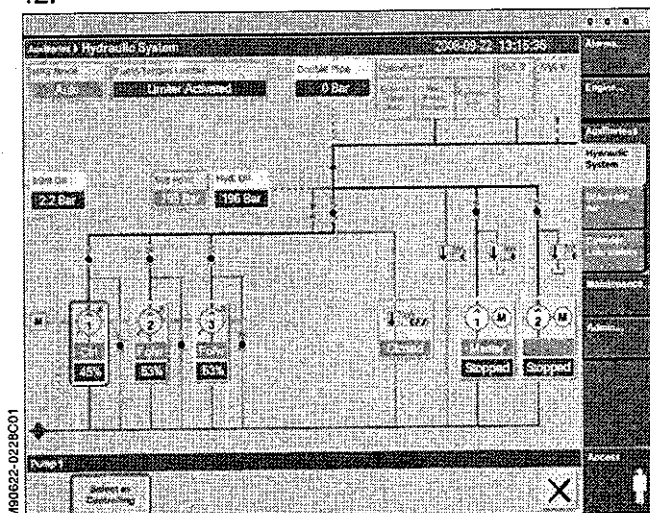
Mount the flushing valve on the HCU block. Connect a hose to the flushing valve in order to lead the flushing oil away.

Check the integrity of the hydraulic system

12. Check that the integrity of the hydraulic system has been restored.

See the checking section.

12.



M90622-0228001

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors
☒	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
D06-201	Accumulator	24/55	kg
D06-202	N2 Charging pressure	136	bar at 20°
D06-204	Pressure Adjustment Table		
	Accumulator temperature t °C		bar
	0	124	
	10	130	
	20	136	
	30	142	
	40	148	
	50	154	
	60	160	
	70	166	
	80	172	
	90	178	
	100	185	
	Filling pressure must be as stated above		
	Check pressure within ± 5 bar		
D06-216	assembly off-set 4-liter accumulator	9	mm
D06-217	assembly off-set 10-liter accumulator	10	mm
D06-226	Screw, flange to Accumulator	120	Nm
D06-227	Screw, flange to Hydraulic Cylinder Unit	130	Nm

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item No.	Description
P90653		Tools for Accumulator
P90674		Test Equipment for Accumulators
P91356		Lifting Tools, Etc.
P91359		Torque Spanners
P91366		Instruments

Check of Accumulators on Hydraulic Cylinder Unit

The engine must be stopped and pressure free.

1. Mount the pressure gauge at "minimess" point No. 455. Check the pressure.

Close the high pressure inlet valve 420 and open the high pressure outlet valve 421 to drain all oil out of the hydraulic cylinder unit. Check that the hydraulic cylinder unit is pressure free.

Mount the pressure gauge connected with a "minimess" hose on the accumulator.

Check the nitrogen pressure.

For correct pressure, see Data D06-204.

For use of pressure setting tool, see step 4.

Check of Accumulators on Hydraulic Power Supply Unit

2. Check of each accumulator on the HPS pump unit can only be performed on a stopped engine and with stopped start-up pumps.

Mount a pressure gauge on the "minimess" coupling No. 339. Check the pressure.

Open valve 315 to release the hydraulic pressure from the system and drain all oil out of the accumulators.

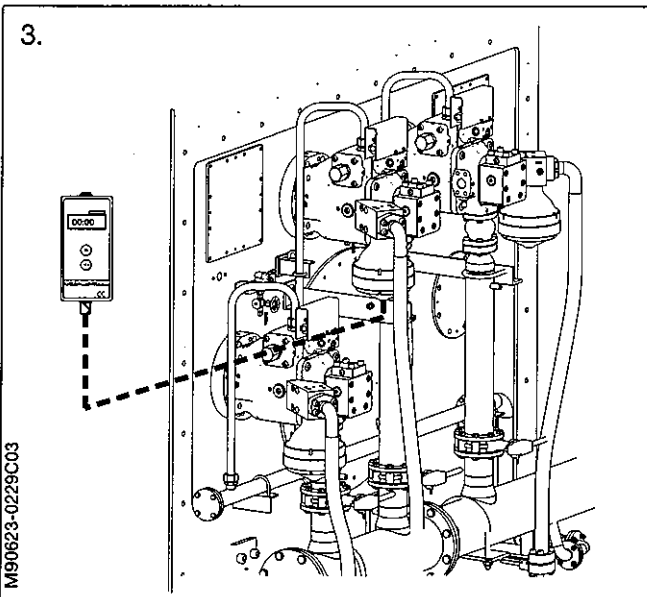
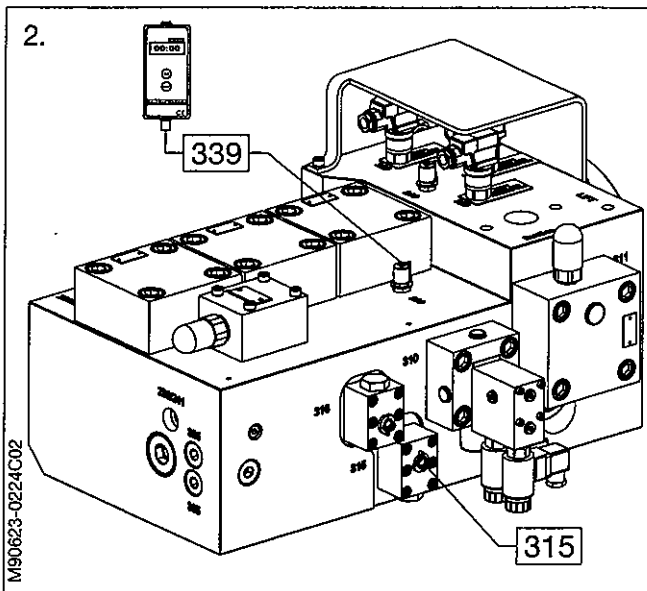
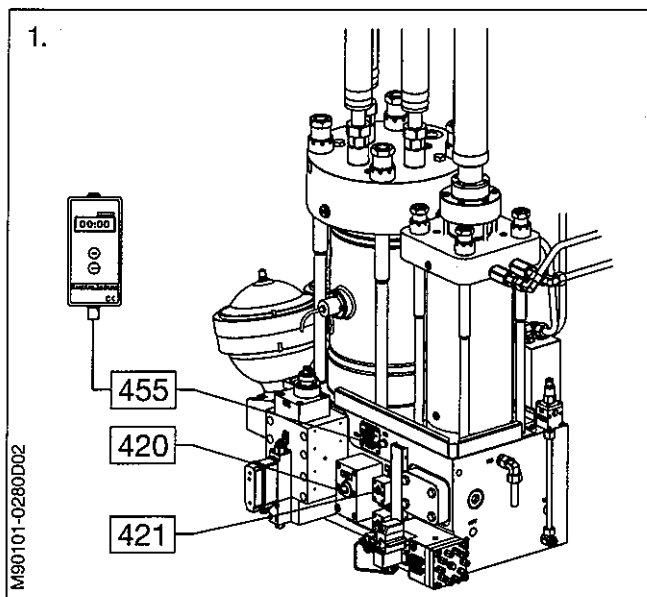
3. Check on the pressure gauge that the system is pressure free.

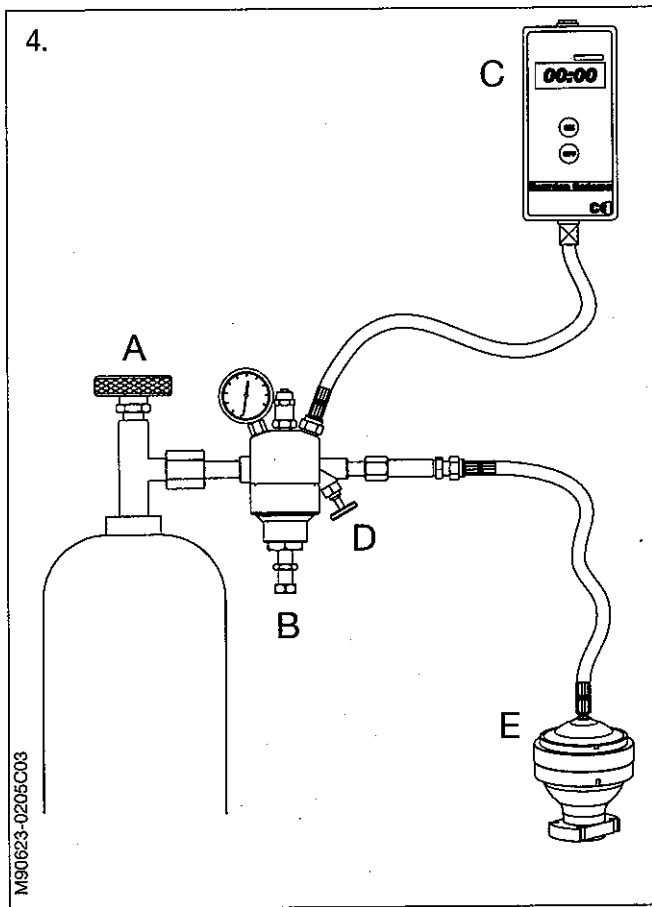
Mount the pressure gauge connected with a "minimess" hose on the accumulator.

Check the nitrogen pressure.

For correct pressure, see Data D06-204.

For use of pressure setting tool, see step 4.





Use of Reducing Valve as Pressure Setting Tool

4. Assemble the reducing valve as shown in the figure, and mount the reducing valve on the nitrogen cylinder. If necessary, use a threaded adaptor.

Before mounting the filling valve on the accumulator, check that the accumulator top is clean.

Check that valves **A** and **D** are closed.

Mount the filling hose on the relevant accumulator with the union nut **E**.

It is now possible to read the actual nitrogen pressure in the accumulator on the dial gauge **C** on the filling valve.

If the accumulator needs to be refilled with nitrogen, open valve **A** and adjust the outlet pressure on spindle **B** to 1-2 bar above the pressure stated in the Pressure Adjustment Table. See *Data D06-204*.

Keep valve **A** open until the accumulator is filled.

Close valve **A**.

Wait five minutes for the temperature to stabilise.

Check the pressure in the accumulator on gauge **C** according to the Pressure Adjustment Table. See *Data D06-204*.

Adjust the pressure in the accumulator at bleed screw **D**.

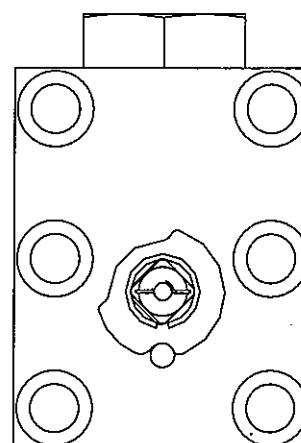
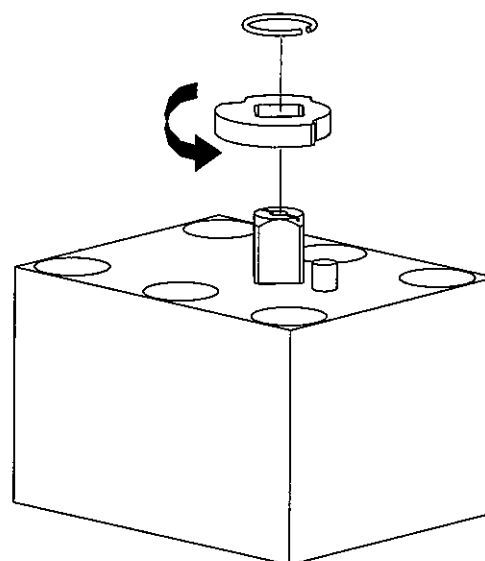
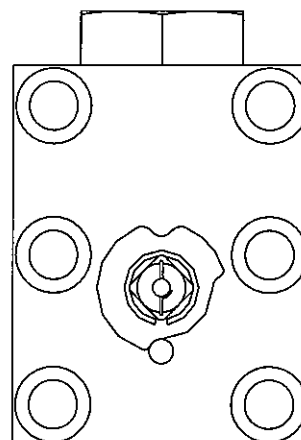
Unscrew the union nut **E** to remove the filling valve from the accumulator.

Dismantling

1. Turn the square to closed, lift off the locking disc.

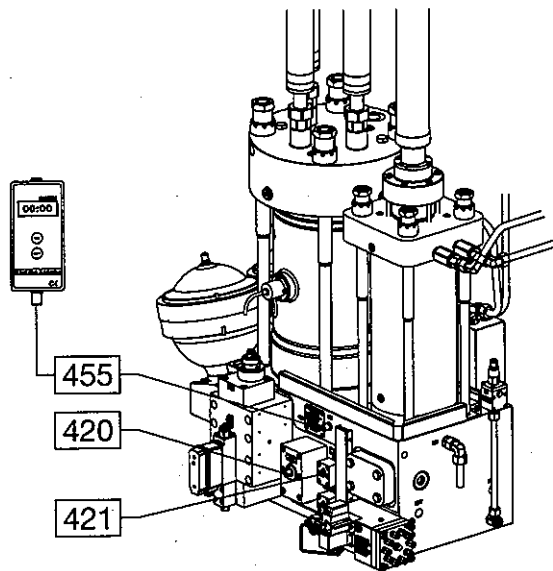
Turn the locking disc 180° and place it on the square again to lock the valve.

1.



M90623-0210D02

2.



M90101-0280D02

Note!

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

Dismantling of Accumulators from Hydraulic Cylinder Unit

2. Connect at pressure gauge at "minimess" point No. 455. Check the pressure.

Close the high pressure inlet valve 420 and open the high pressure outlet valve 421 to drain all oil out of the accumulator.

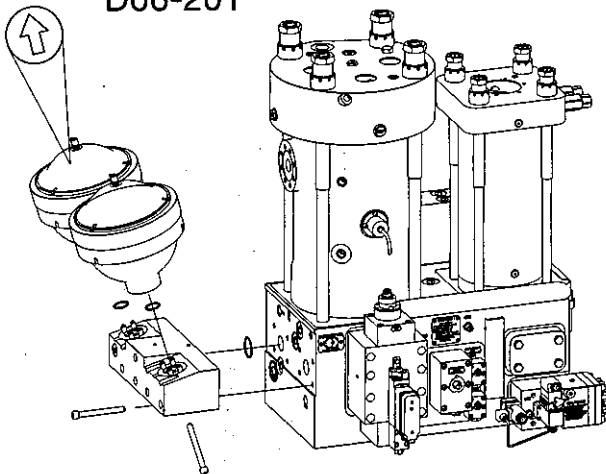
Check that the hydraulic cylinder unit is pressure free.

3. Dismount the accumulator flange from the hydraulic cylinder unit.

Dismount the accumulator flange from the accumulator.

3.

D06-201



M90623-0229D03

Dismantling of Accumulators from Hydraulic Power Supply Unit

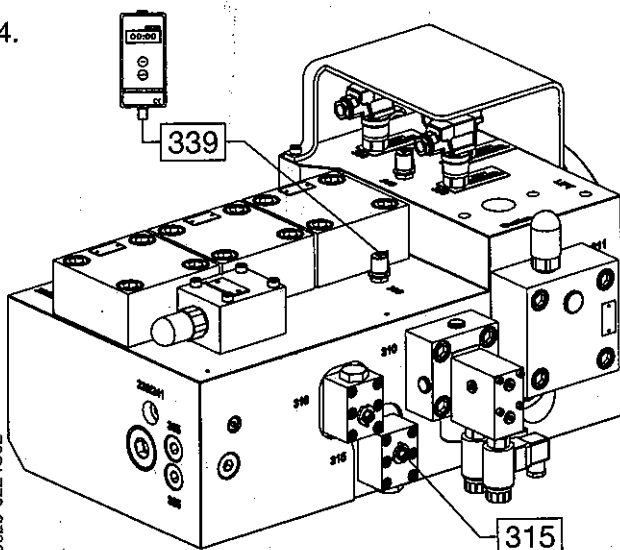
4. Dismantling of accumulators can only be performed on a stopped engine and with stopped start-up and booster pumps.

Mount a pressure gauge on the "minimess" coupling No. 339 on the safety block and check the pressure.

Open valve 315 on the safety block to release the hydraulic pressure from the system.

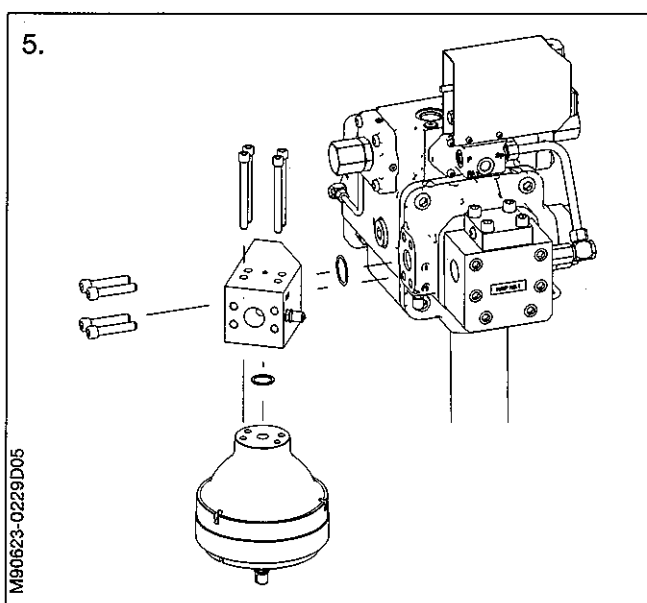
Check on the pressure gauge that the system is pressure free.

4.

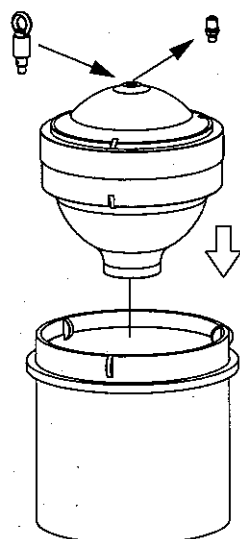


M90623-0224C02

5. Remove the high pressure hose from the accumulator block and remove the accumulators from the hydraulic power supply unit as shown.



3.



M90623-0209003

1. Remove the accumulator with the accumulator flange. See Procedure 906-23.2.

2. Use the pressure adjustment tool to drain the accumulator of nitrogen gas. See Procedure 906-23.1.

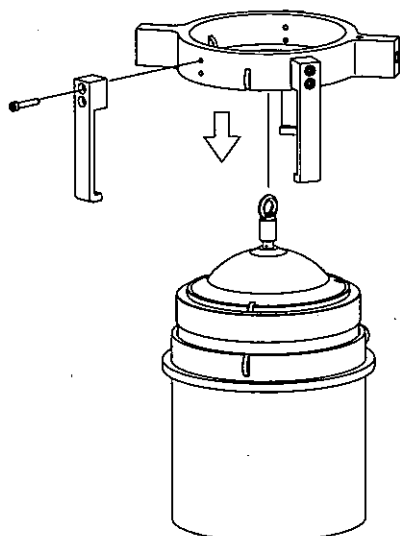
3. Unscrew the "minimess" valve on the accumulator.

Screw the dowel pin from the upper half of the accumulator tool into the upper part of the accumulator. Fit an eyebolt into the dowel pin.

Make sure that the lower half of the accumulator tool is securely fastened to the engine room deck. This can be done by screwing or welding the flanges of the accumulator tool onto the engine room deck in a convenient place.

Use the eyebolt to lift the accumulator into the bottom half of the accumulator tool. Make sure that the guides on the tool fit into the slots on the accumulator.

4.



M90623-0209004

4. Mount the upper half of the accumulator tool with two of the claws fitted, on the accumulator. The claws must reach below the ridge on the lower accumulator tool. Make sure that the guides on the tool fit into the slots on the accumulator.

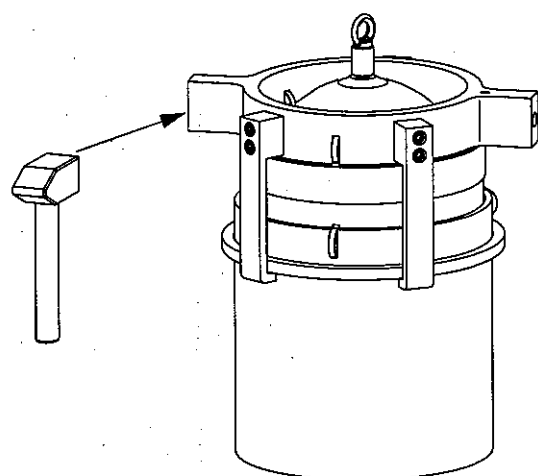
5. Fit the last claw onto the accumulator tool.

Unscrew the upper half of the accumulator.

Use a piece of pipe in the holes at the end of the wings of the accumulator tool to provide leverage.

If the upper half binds, it may be loosened by tapping a few times with a hammer on the wings of the accumulator tool.

5.



M90623-0209005

6. Remove the defective diaphragm "A".
7. Clean both accumulator halves thoroughly, especially the threads, and make sure that the parts are dry afterwards.
8. Assemble the two accumulator halves **without** fitting the diaphragm. Tighten until the halves are in contact.

Mark the relative position of the accumulator halves.

9. Disassemble the accumulator and install the new diaphragm and anti-extrusion ring.

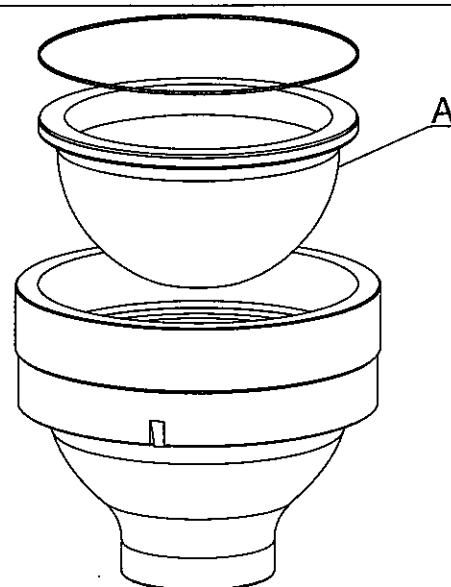
Note!

Check that the new diaphragm is made of the same material as the old one.

Do not lubricate the diaphragm lip lodging.

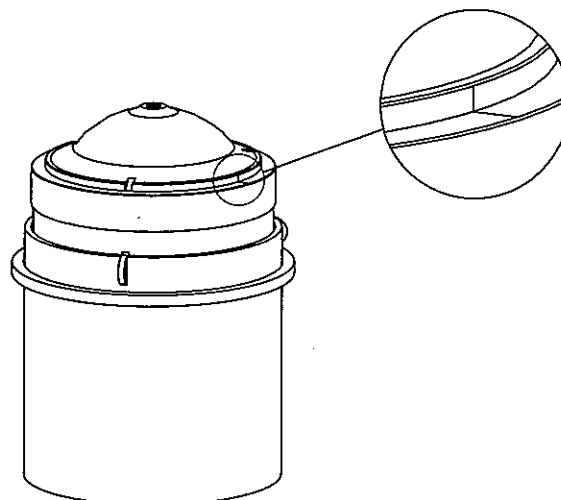
10. Lubricate the upper part of the diaphragm lip and the accumulator threads with molybdenum disulphide grease.

6.



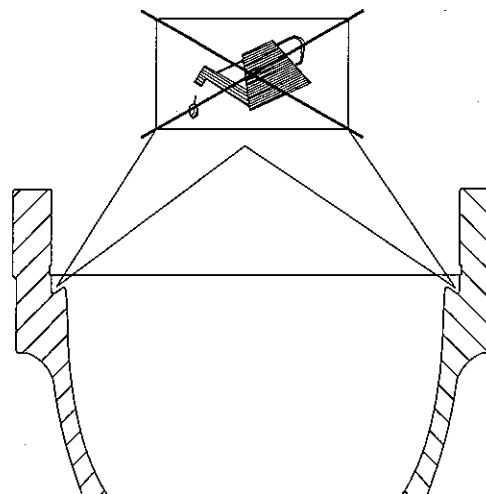
M90623-0210006

7.



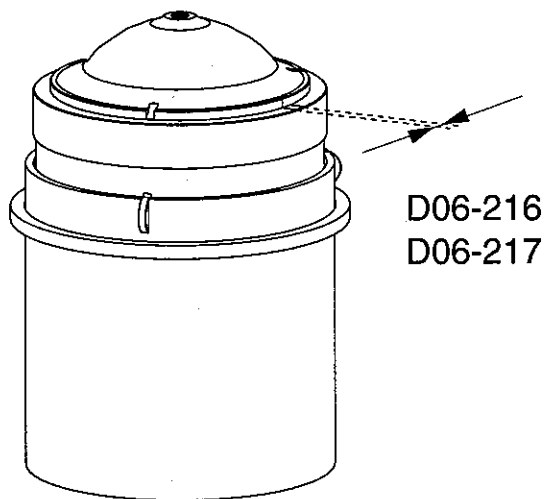
M90623-0209008

8.



M90623-0206008

11.



11. Assemble the accumulator. Tighten until the marks made in section 7 are off-set according to D06-216.

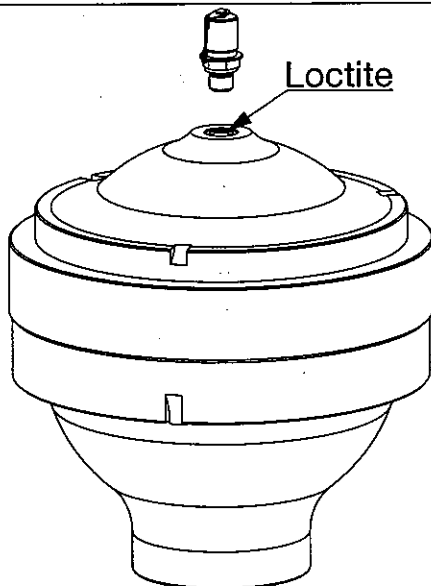
12. Mount the "minimess" valve, by using a new O-ring.

Fill the accumulator with nitrogen gas as described in Procedure 906-23.1

Use soapy water to check the accumulator for any leakages.

Mount the accumulator.

12.



Note!

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

Mounting of Accumulators on Hydraulic Cylinder Unit

1. Mount the flange and a new sealing ring on the accumulator.

Mount the accumulator assembly and a new second sealing ring on the hydraulic cylinder unit.

2. Connect at pressure gauge at "minimess" point No. 455. Check the pressure.

Close the high pressure outlet valve 421 and open the high pressure inlet valve 420.

Check that the hydraulic cylinder unit is pressurised.

Mounting of Accumulators on Hydraulic Power Supply Unit

3. This can only be performed on a stopped engine and with stopped start-up pumps.

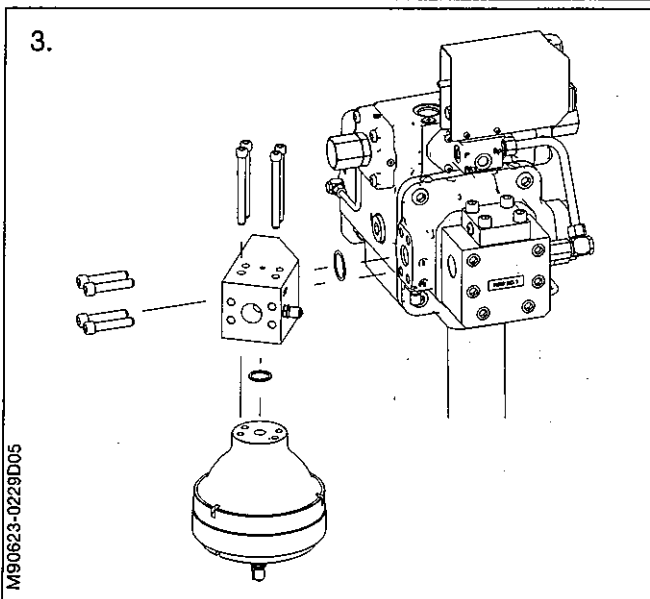
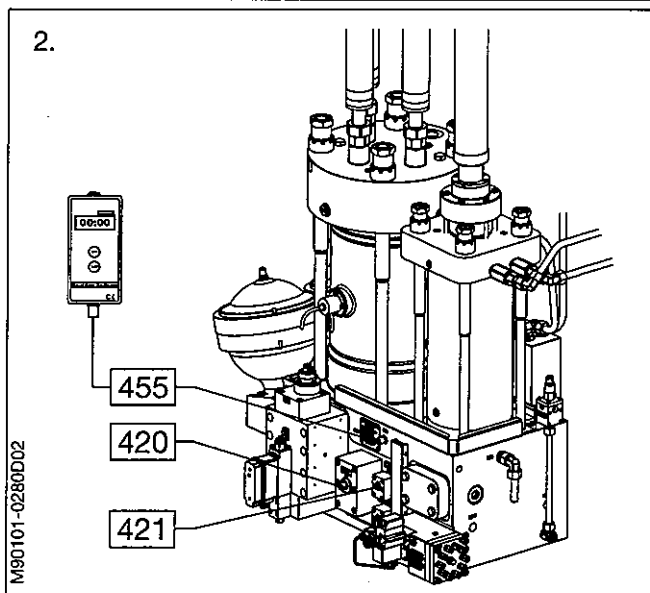
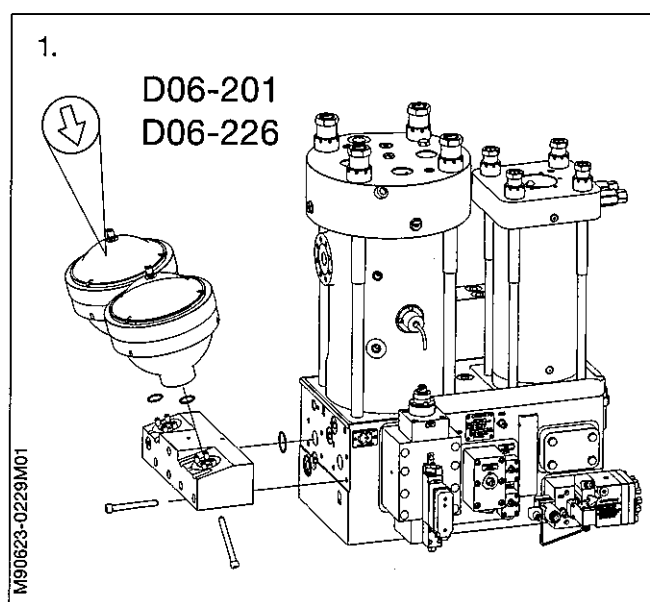
The accumulators on the hydraulic power supply unit and the high pressure hose are mounted.

Close valve 315.

Mount a pressure gauge on the "minimess" coupling No. 339 on the safety block and check the pressure.

Close valve 315 on the safety block.

Check on the pressure gauge that the system is pressurised.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors
☒	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
D06-215	FIVA control valve	79	kg
D06-228	Screw, FIVA valve to hydraulic cylinder unit	168	Nm

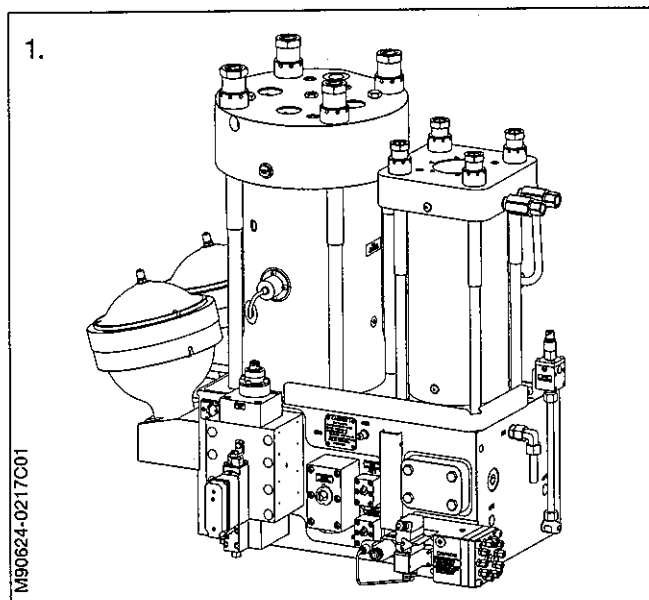
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

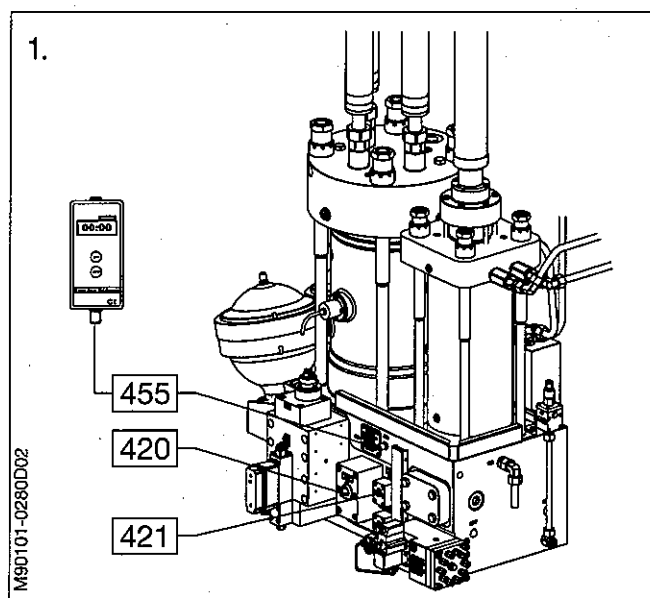
Plate	Item No.	Description
P91356		Lifting tools, etc.
P91359		Torque spanners
P91366		Instruments

1. The function of the **Fuel Injection** and the **Valve Activation Valve (FIVA)** is continuously checked by the Engine Control System.

Malfunctions will be reported by the system to the MOP system and to the common alarm system.

Malfunctioning FIVA valves are to be overhauled by the supplier or by MAN Diesel.



**Note!**

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

1. Dismantling of the FIVA valve can only be carried out with stopped engine and stopped hydraulic power supply pumps.

Mount a pressure gauge at "minimess" point No. 455. Check the pressure.

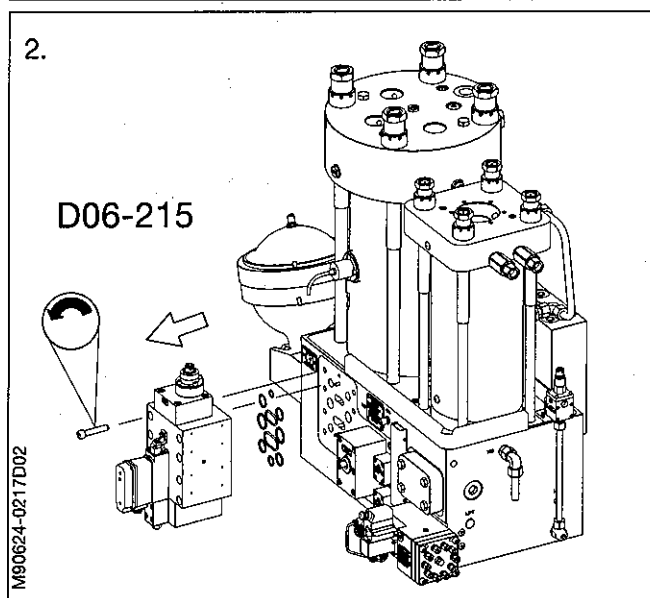
Close the high pressure inlet valve 420 and open the high pressure outlet valve 421 to drain all oil out of the hydraulic cylinder unit.

Check that the hydraulic cylinder unit is pressure free.

2. Disconnect the electrical connections.

Use the two eye bolts mounted on the FIVA valve when handling the FIVA valve.

Dismount the eight screws and carefully pull the FIVA valve out past the two guide pins.



Note!

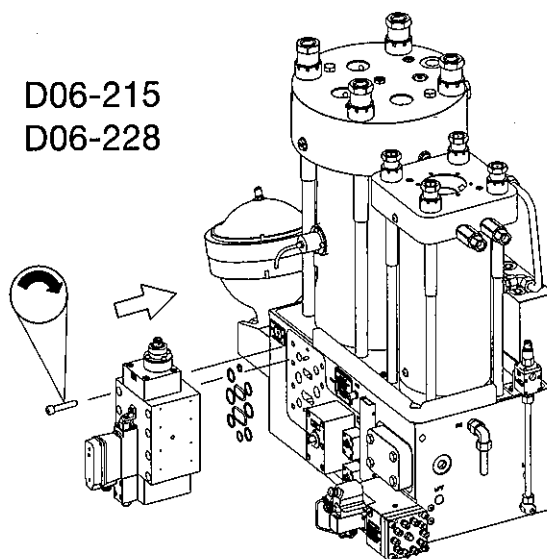
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

1. Mount new square section sealing rings in the control valve.

Mount the control valve on the two guide pins and tighten the eight screws.
2. Close the high pressure outlet valve 421 and open the high pressure inlet valve 420.
3. Connect the electrical connections

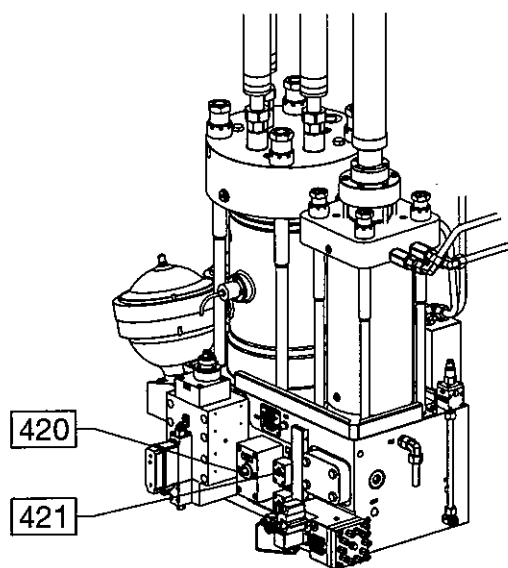
1.

D06-215
D06-228



M90624-0217M01

2.



M90101-0280M11

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

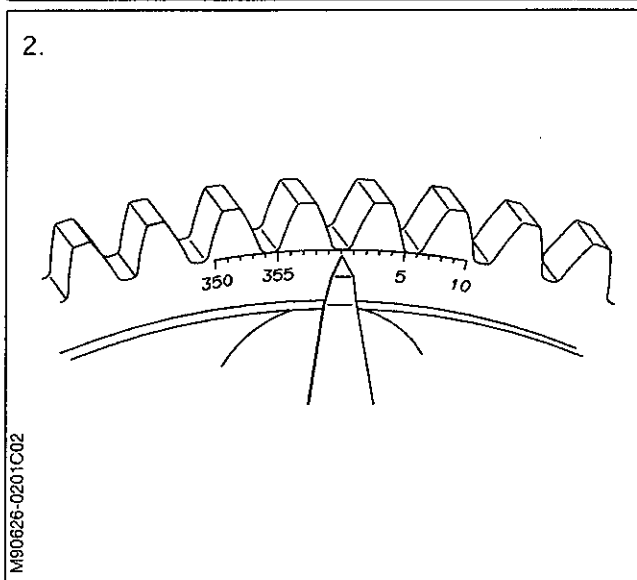
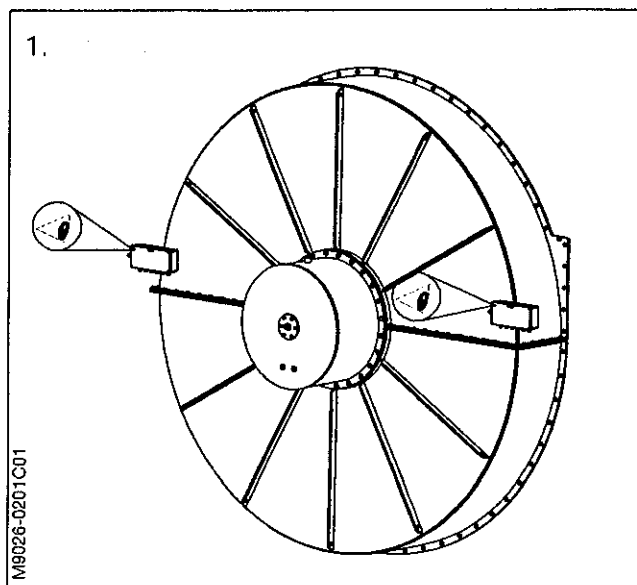
Ref.	Description	Value	Unit
D06-218	Angle Encoder cover	238	kg
D06-219	Angle Encoder bracket	46	kg

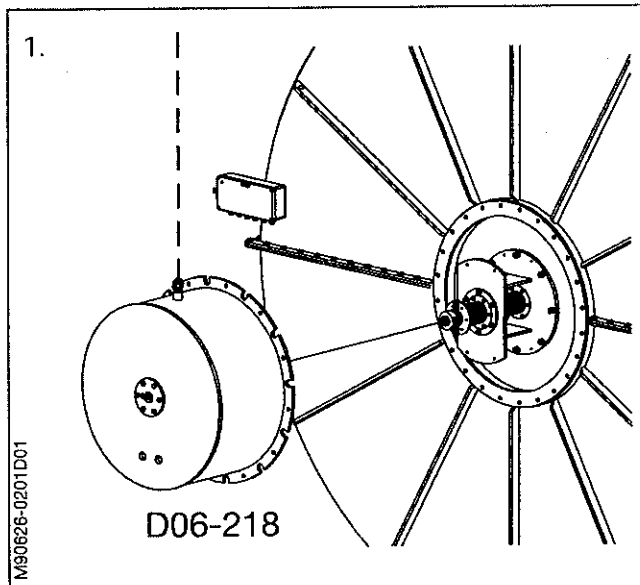
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P91356 P91366	61	Lifting Tools, Etc. Slide caliper

1. Check that power is supplied to the Tacho Signal Amplifier box.
Turn the crankthrow for cylinder 1 towards TDC. The LED indicator on TSA-A lights up when TDC is reached.
2. Check the TDC of cylinder 1 against the mark on the turning wheel.
3. Turn the engine a further 45 degrees in the engines rotational direction. The LED on TSA-B should now turn on.

For adjustment of the angle encoder, see Procedure 905-8.3.





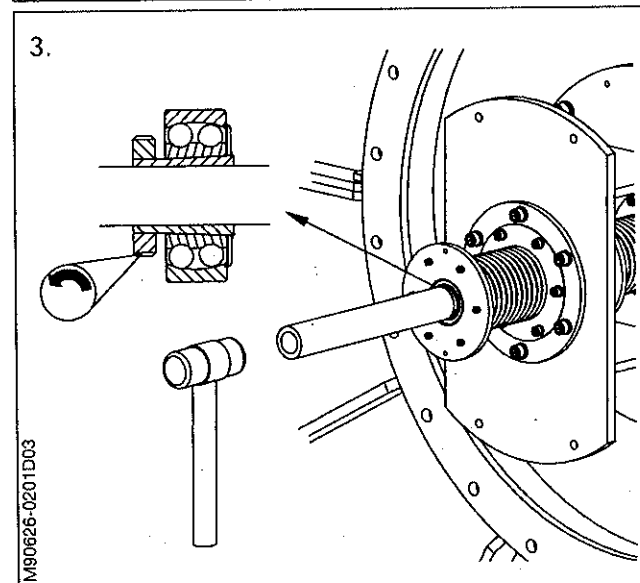
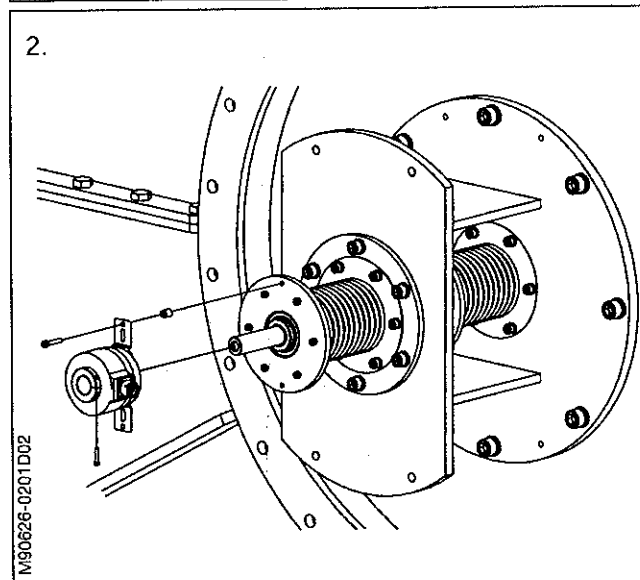
1. Use a tackle to lift off the angle encoder cover where applicable.
2. Tag the electrical plugs "Inner encoder" and "Outer encoder" before disconnecting them.

Loosen the screws as shown and pull the outer encoder off.

3. Loosen the locking washer and use a hook wrench to unscrew the locking nut on the bearing adapter sleeve. The locking nut should be unscrewed so far that the nut covers the thread on the end of the sleeve.

Slide a piece of pipe onto the axel. Tap the end of the pipe with a mallet to loosen the bearing adapter sleeve.

Unscrew the locking nut and remove the locking washer.



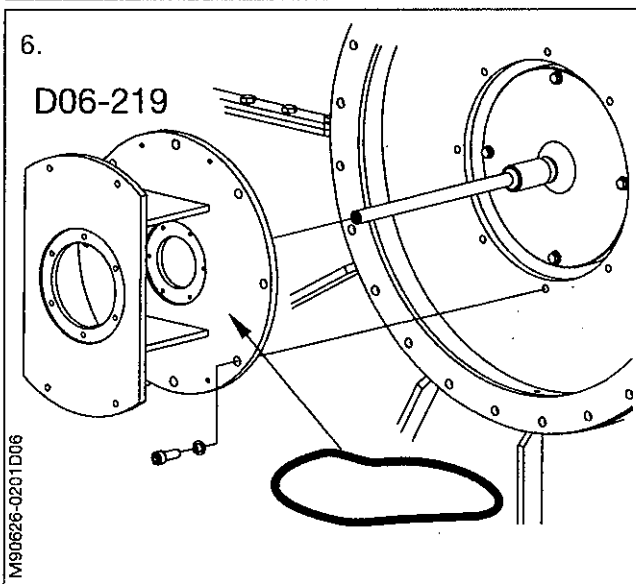
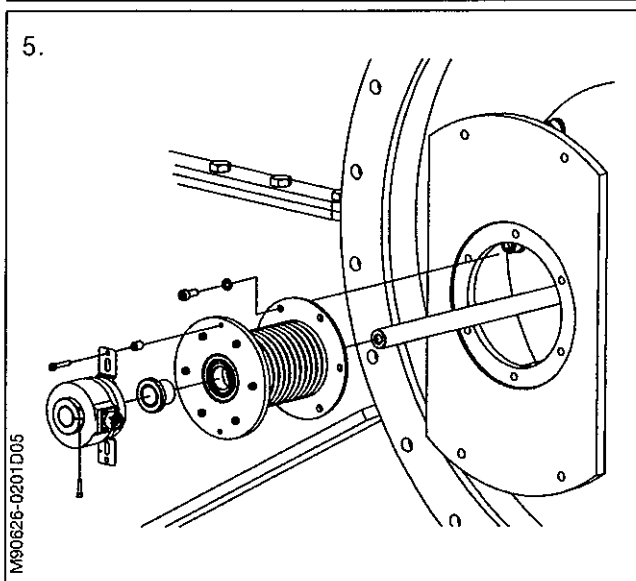
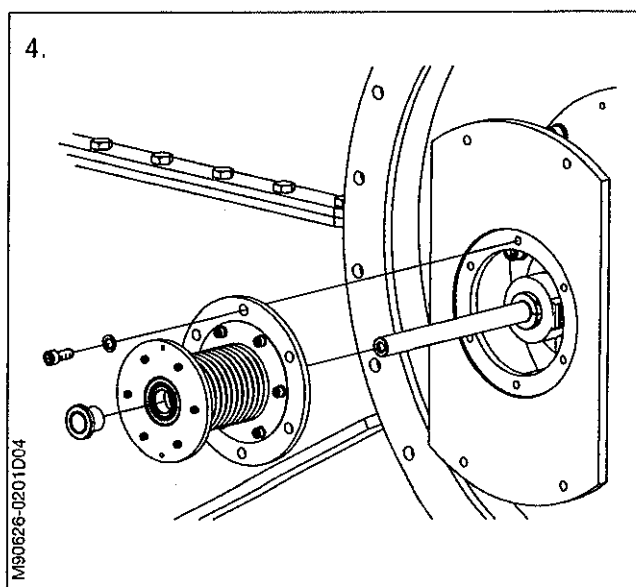
4. Unscrew the outer screws on the flange and remove the compensator.
5. The inner encoder and compensator is dismantled in the same way as the outer encoder and compensator.
6. If it is necessary the mounting bracket can be dismantled.

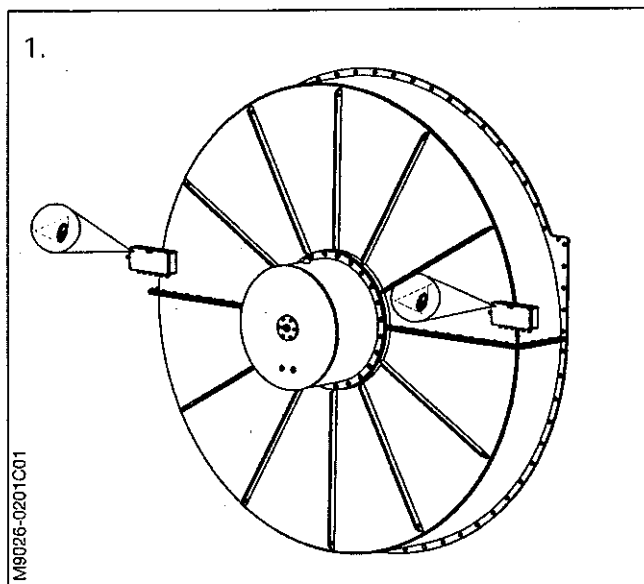
Use a tackle and lifting strap to secure the bracket.

Unscrew the screws in the base plate and remove the bracket.

Note!

Due to the need for realignment the mounting bracket should only be dismantled when it is absolutely necessary.

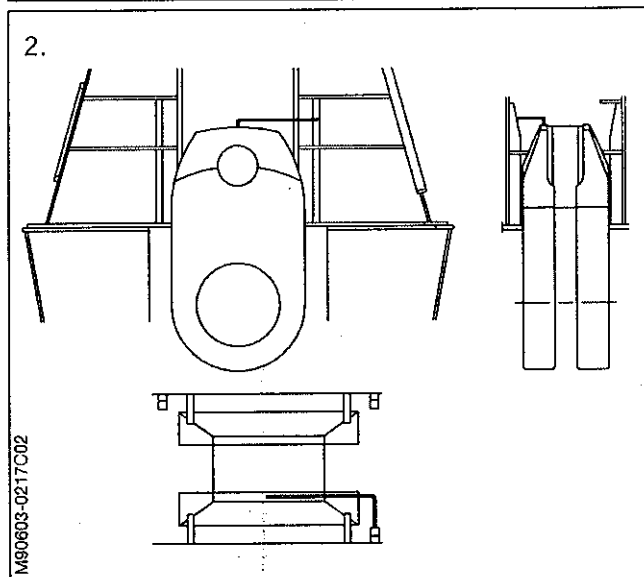




1. Use a tackle to lift off the angle encoder cover where applicable.
2. Turn the crankthrow for cylinder 1 to TDC.
3. Check the TDC position with the pin gauge on the crankthrow, D06-29

Note!

Before using the pin gauge, check the measurement from tip to tip with the value stamped on the pin gauge, and/or the check-marks stamped on the fore end of the cylinder frame.



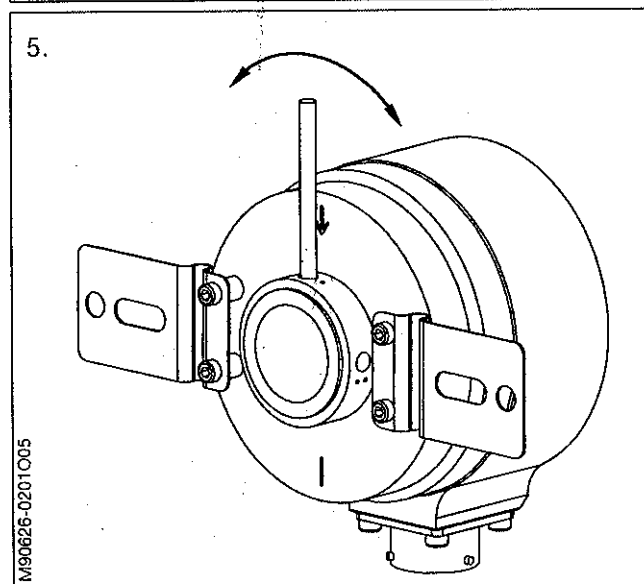
4. Loosen the clamping ring on the inner encoder.
5. Use a mandrel or a drill to turn the encoder hollow shaft until the indicator light turns on.

If the indicator light already is on, turn until it goes off and then back until it turns on again. Tighten the clamping ring.

6. Turn the engine 45 degrees in the engines rotational direction and repeat the procedure in section 4 and 5 on the outer angle encoder.

Note!

When adjusting the outer angle encoder a CLOCKWISE turning engine must be turned 45 degrees in the CLOCKWISE direction and an ANTICLOCKWISE turning engine must be turned 45 degrees in the ANTICLOCKWISE direction.



7. Mount the angle encoder cover where applicable.

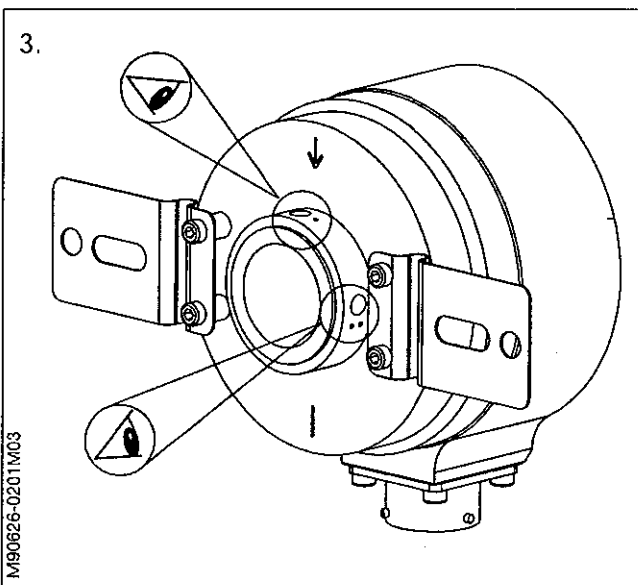
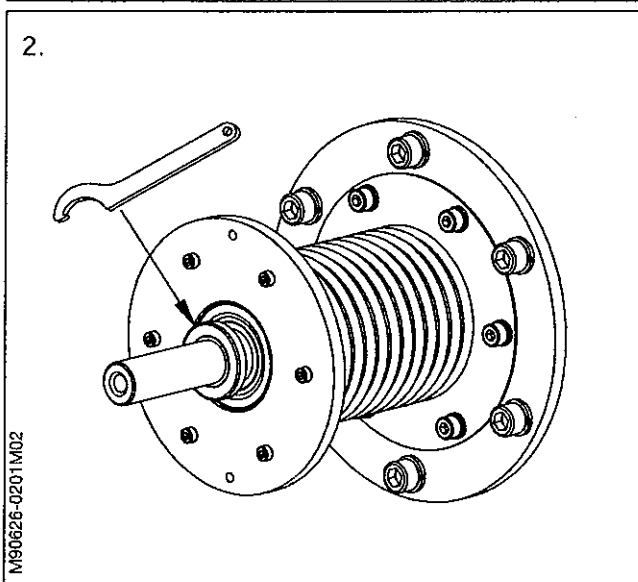
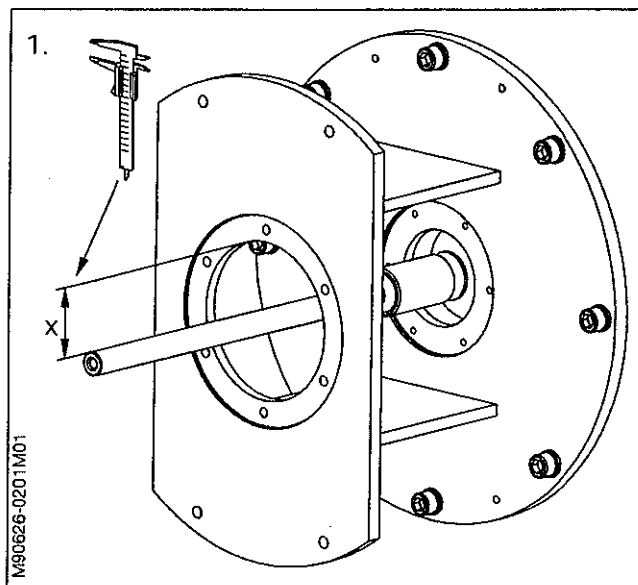
This concludes the mechanical adjustment of the angle encoders.

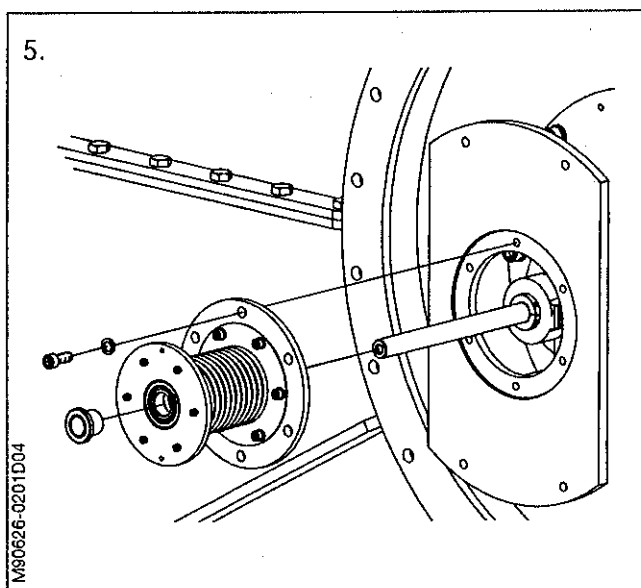
If the software settings need to be adjusted please contact MAN B&W Diesel A/S

1. Mount the mounting bracket. Use a Slide caliper to ensure a maximum deviation from "X" of ± 0.1 mm around the center shaft.
2. Loosely assemble the bearing sleeve, locking washer, locking nut and compensator. Slide the assembly onto the axel and mount the screws.

Tighten the locking nut to surface contact, then tighten a further 60° using a hook wrench.

3. Perform a basic adjustment of the angle encoder by turning the hollow shaft to a position where the dot; in case of a clock-wise turning engine or the two dots in case of a counter clockwise turning engine, are in line with the arrow.

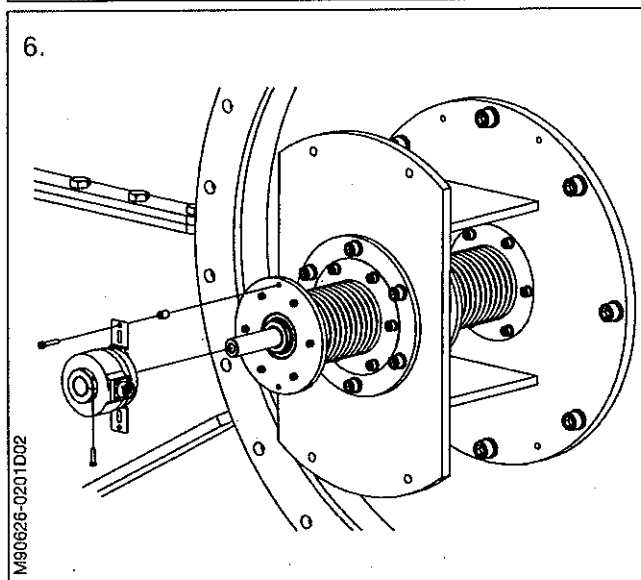




4. Mount the inner encoder on the shaft.

Adjust the encoder according to M906-26.3

5. Mount the outer compensator with bearing in the same way as shown in section 2.
6. Perform a basic adjustment on the outer encoder as shown in section 3 and mount the encoder on the shaft.
7. Adjust the encoder according to M906-26.3
8. Use a tackle to lift and mount the angle encoder cover where applicable



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☐	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☒	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☒	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors
☒	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item No.	Description
P90365 P90851 P91366	124	Equipment for special running Tool for emergency open exhaust valve Instruments

For all special running conditions, see *Volume I, Chapter 704*.

Under conditions where it is necessary to run the engine with an open exhaust valve, an exhaust emergency opening tool must be mounted as follows.

1. Stop the engine.

Mount a pressure gauge at "minimess" point No. 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

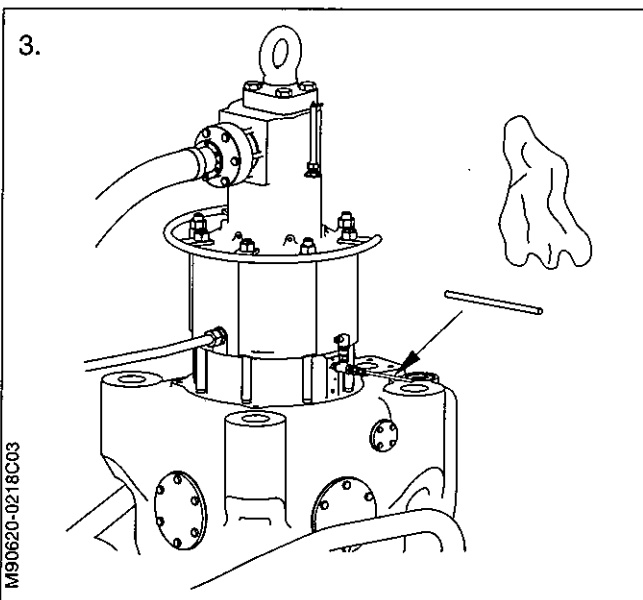
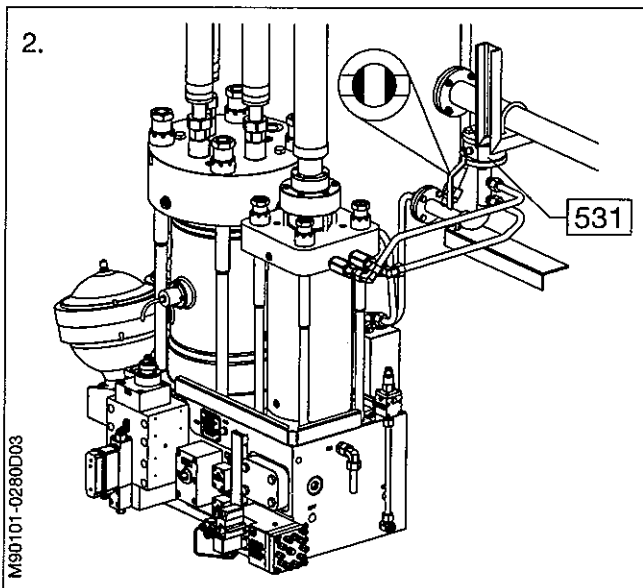
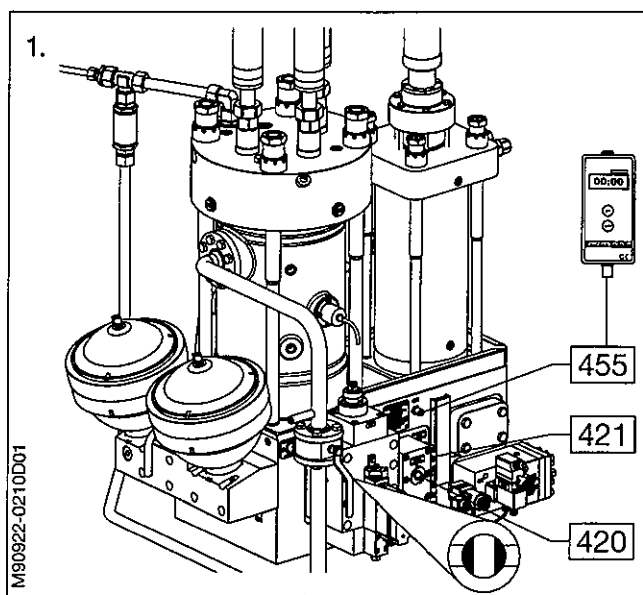
Check that the hydraulic cylinder unit is pressure free.

2. Shut off the oil damper oil supply by closing valve 531 on the hydraulic cylinder unit.

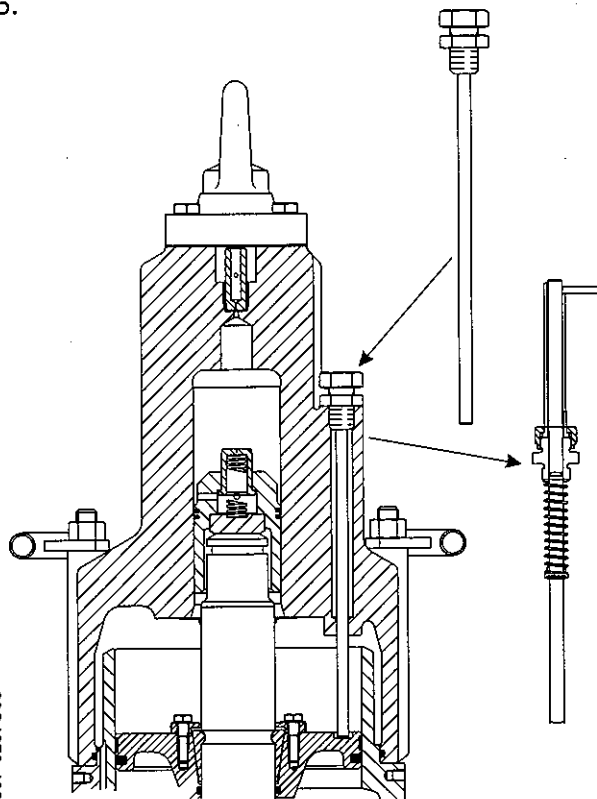
3. Shut off and disconnect the exhaust valve air supply.

Use a mandrel to puncture the non-return valve. Cover the valve with a cloth to protect against oil spray.

4. Check on the MOP panel that the exhaust valve spindle has moved to the open position.



5.



M90807-0237C08

5. Dismantle the rotation indicator on the air cylinder and mount the tool for opening of the exhaust valve.

The tool will keep the piston of the air cylinder in the bottom position and thus keep the exhaust valve open.

6. Open the oil damper oil supply by opening valve 531 on the hydraulic block.
7. Reconnect the exhaust valve air supply.

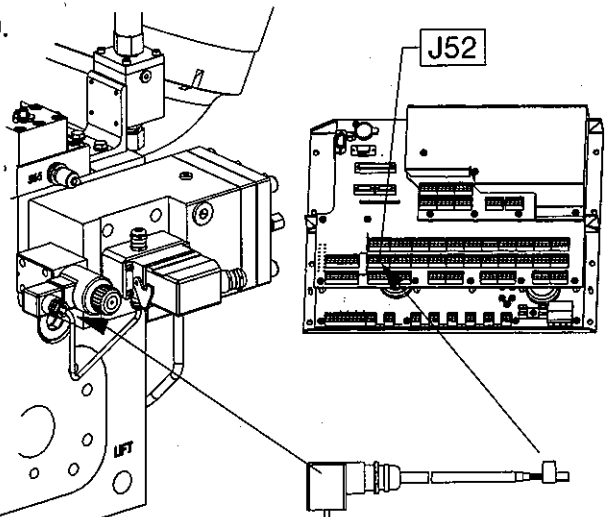
CCU Failure:

8. In case of CCU failure (and the CCU can not be changed immediately), activation of the ME lubricator can be achieved as follows.

Note!

In case of CCU failure, the engine is running in »Slow Down« mode.

9.



M90628-0212C09

9. Remove the plug from the cylinder lubricator solenoid valve. Connect the plug on the ECU temporary backup cable for lubricator

with the solenoid valve.

Connect the other end of the ECU temporary backup cable with the ECU **A** or **B** MPC board.

Return to normal:

When the special running with open exhaust valve is finished, the engine must be brought back to normal operation condition.

10. Stop the engine.

Mount a pressure gauge at "minimess" point No. 455. Check that the hydraulic cylinder unit is pressureless.

Check that valve 531 is closed.

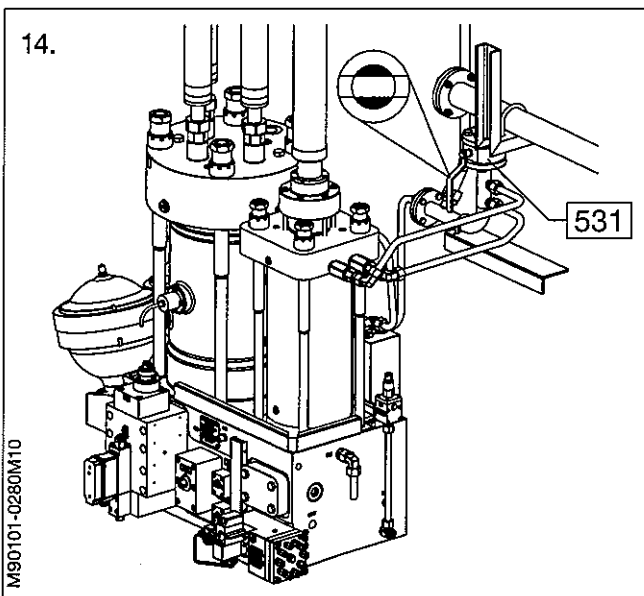
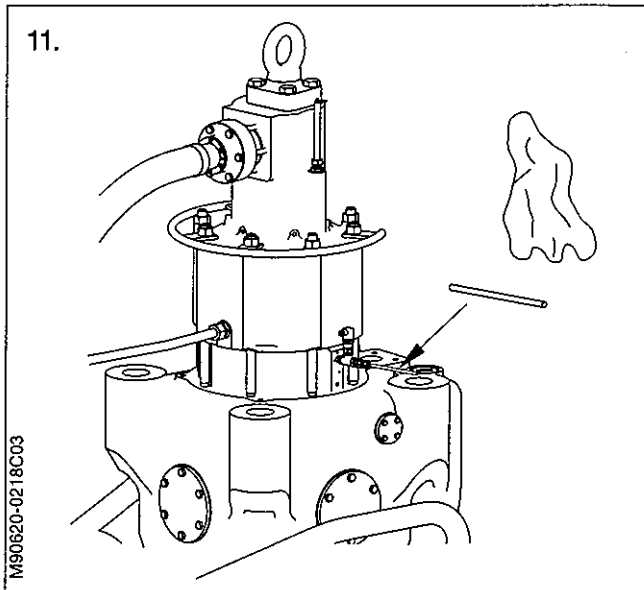
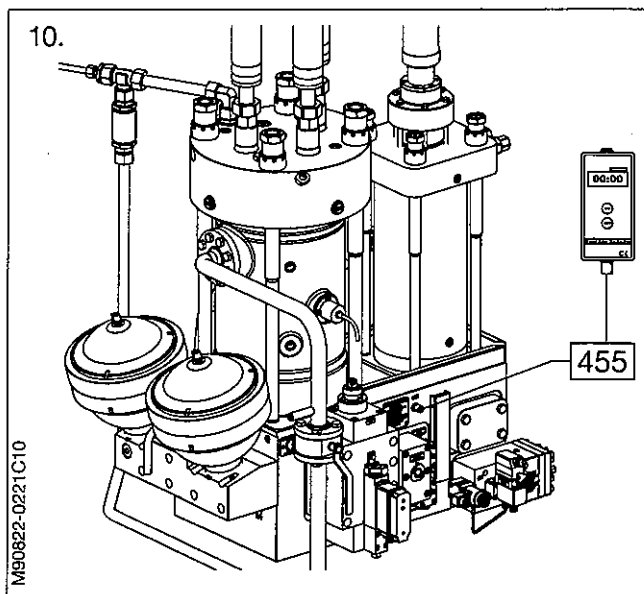
11. Shut off and disconnect the exhaust valve air supply.

Use a mandrel to puncture the non-return valve. Cover the valve with a cloth to protect against oil spray.

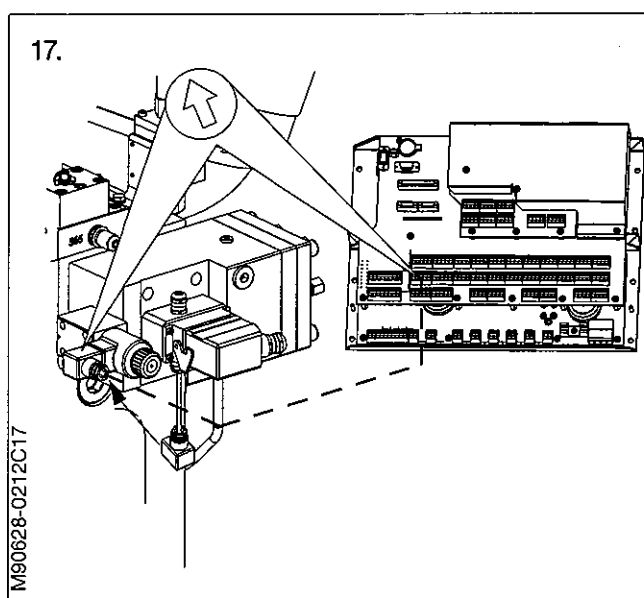
12. Check that the exhaust valve spindle has moved to the open position.

13. Remove the tool for emergency opening of exhaust valve and remount the rotation indicator.

14. Open the oil damper oil supply by opening valve 531 on the hydraulic block.



15. Reconnect the exhaust valve air supply.
16. Close valve 421 and open valve 420 on the hydraulic block for the cylinder concerned.
17. When the CCU has been replaced, restore the cylinder lubricator to normal by removing the ECU temporary backup cable and reconnecting the normal plug with the cylinder lubricator solenoid valve.



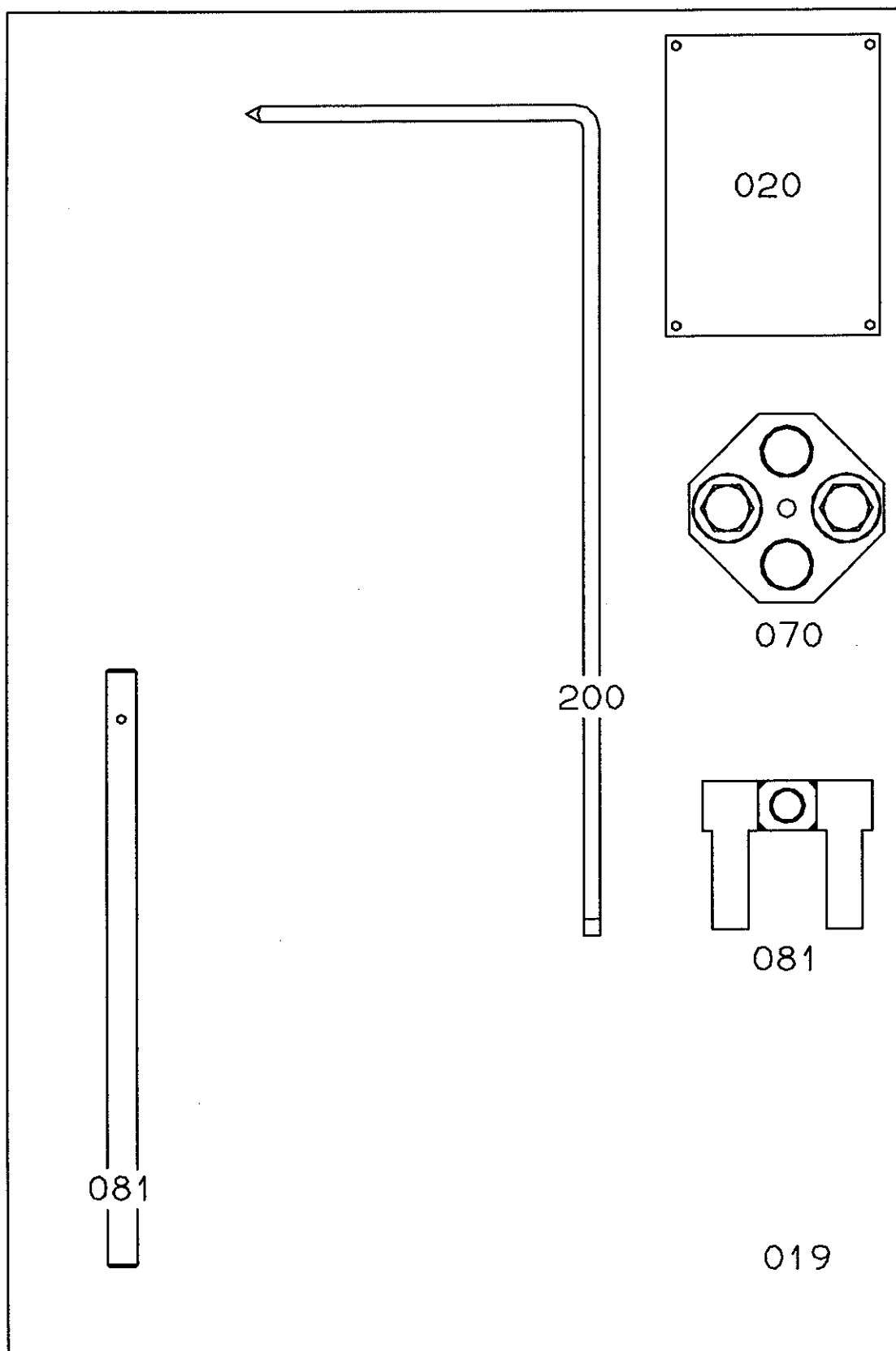
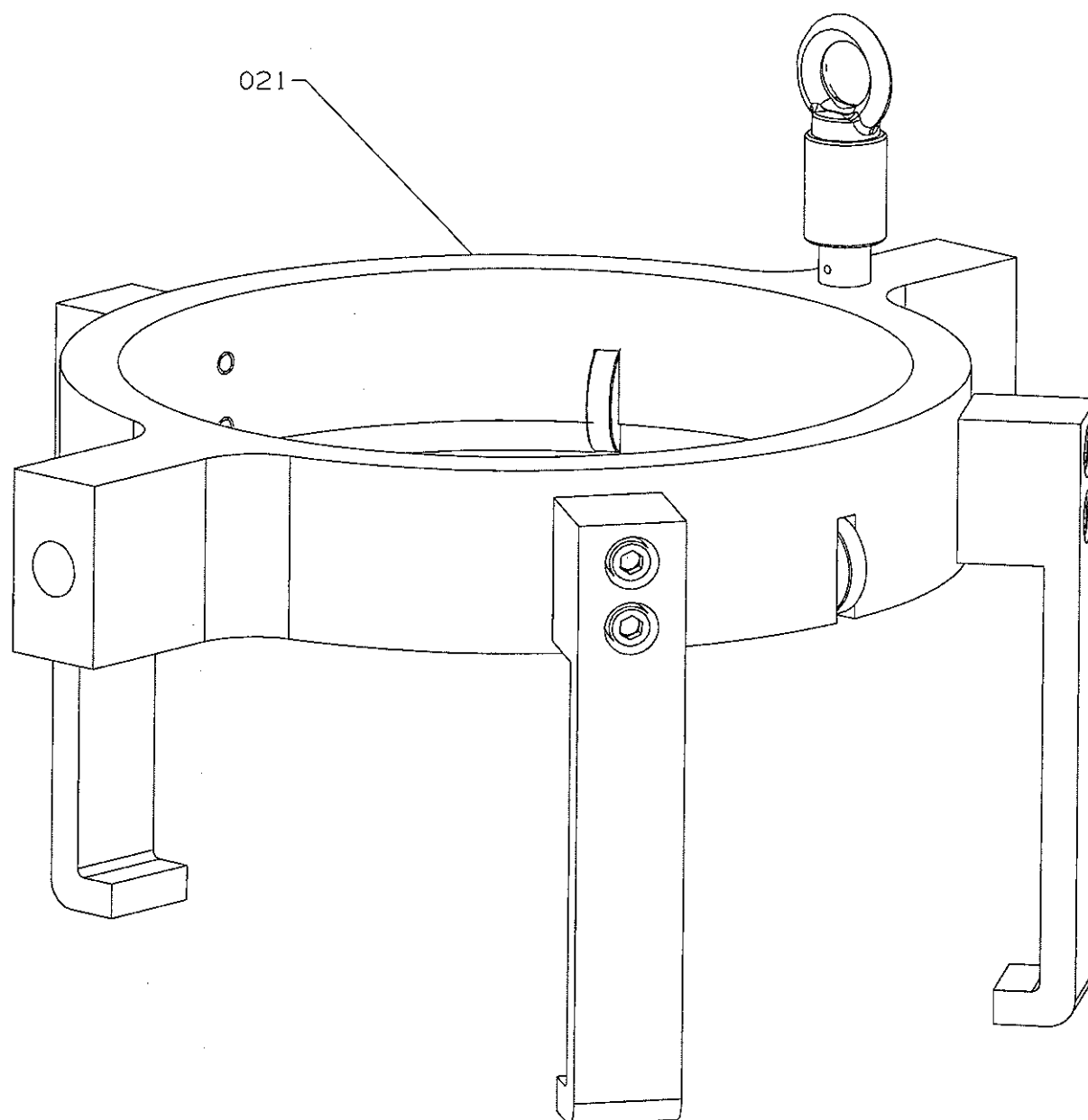


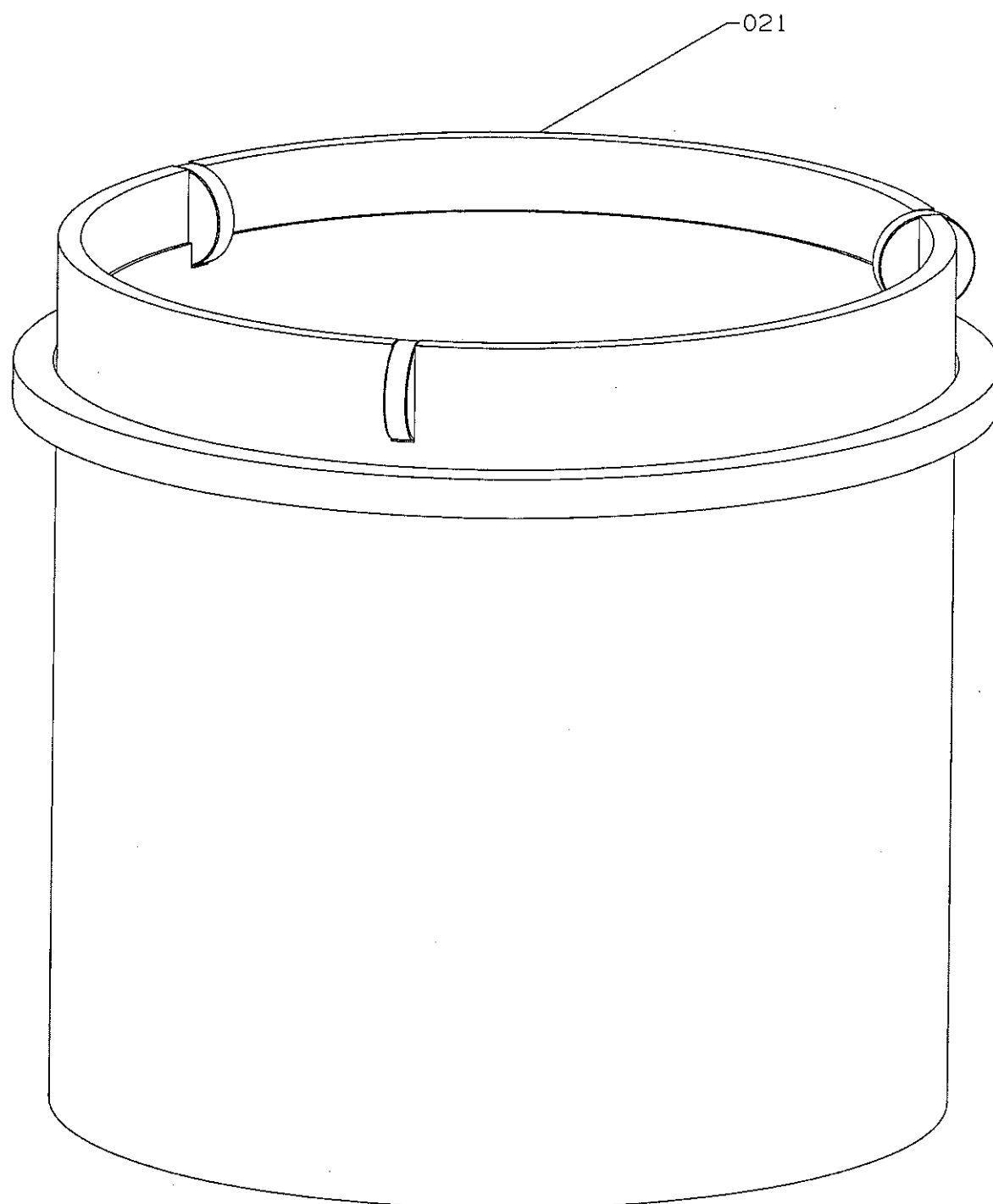
Plate 90651-0208 Chain Drive and Camshaft - Panel

Item No.	Item Description
019	Panel for tools
020	Name plate
070	Assembling tool, chain
081	Disassembling tool, chain
200	Pin gauge, crankshaft



Item No.	Item Description
021	Hook spanner Note: * When ordering, please state size of accumulator.

Item No.	Item Description



Item No.	Item Description
021	Pin wrench-special* Note: * When ordering, please state size of accumulator.

Item No.	Item Description

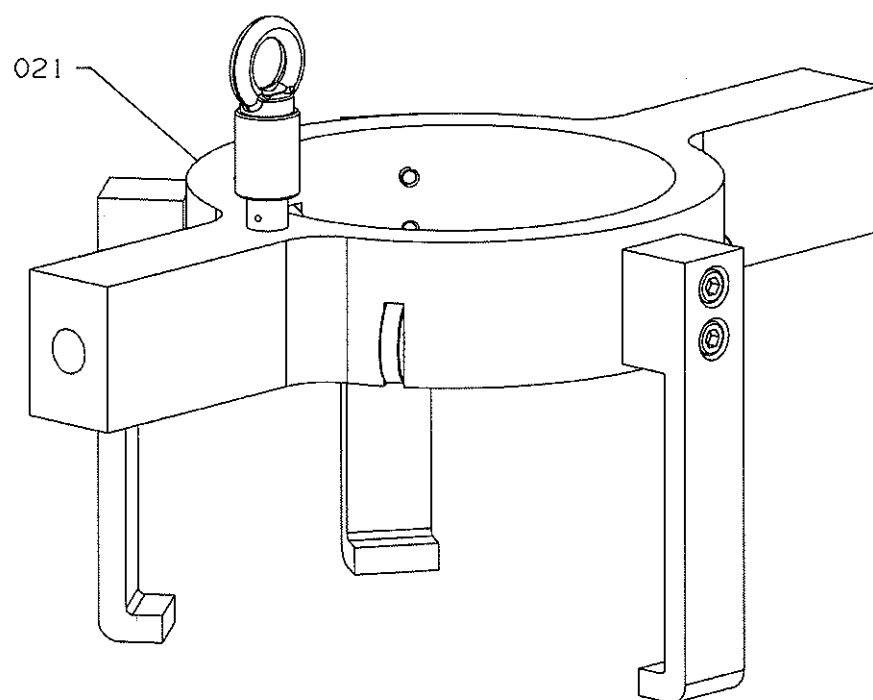
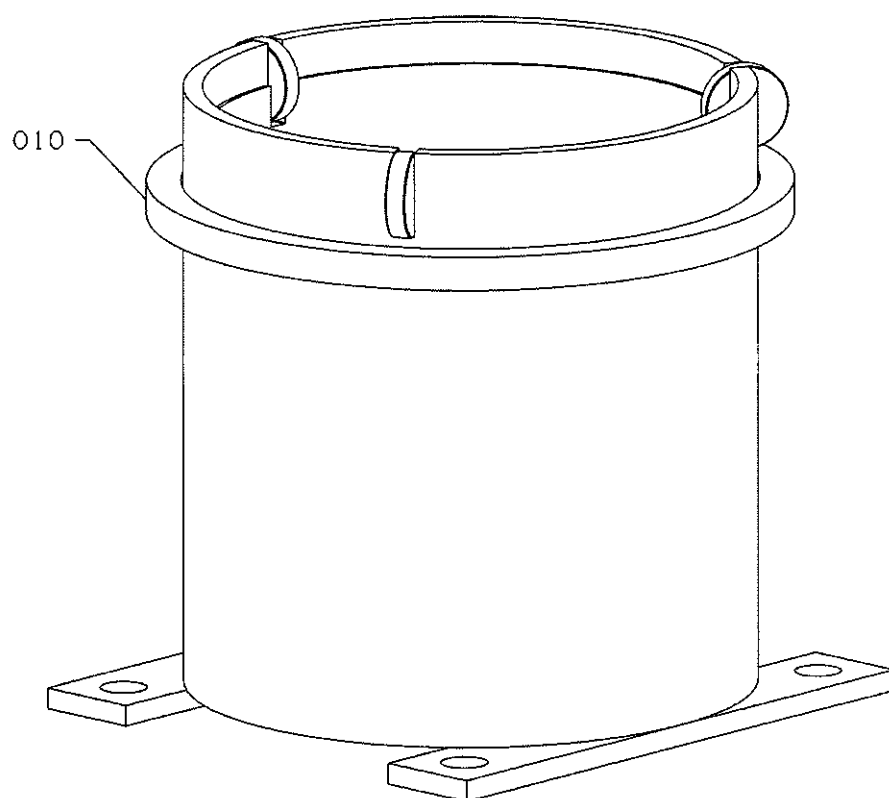


Plate P90653-0005

Tools for Accumulator

Item No.	Item Description
010	Pin wrench, special
021	Hook wrench

Item No.	Item Description

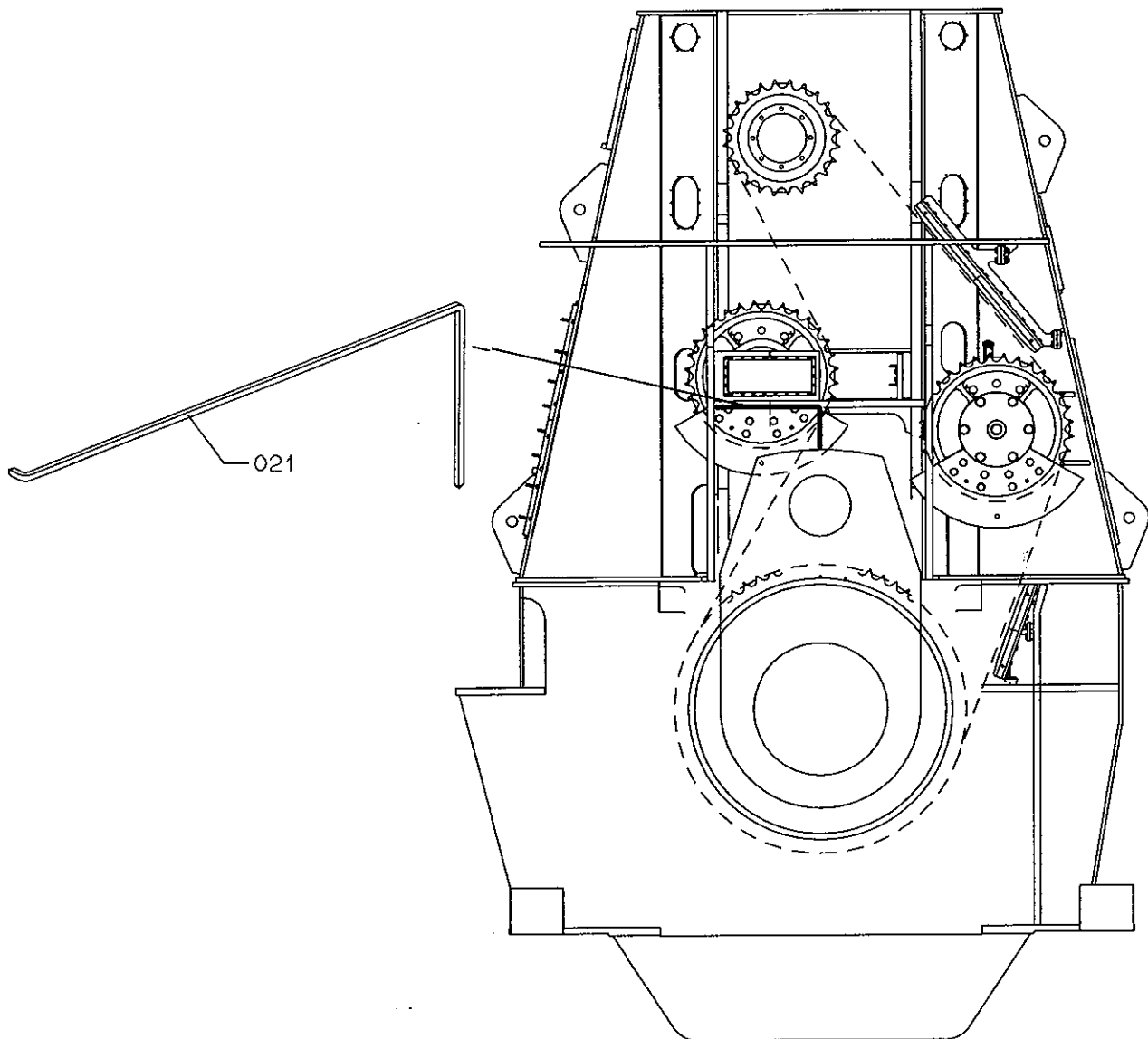
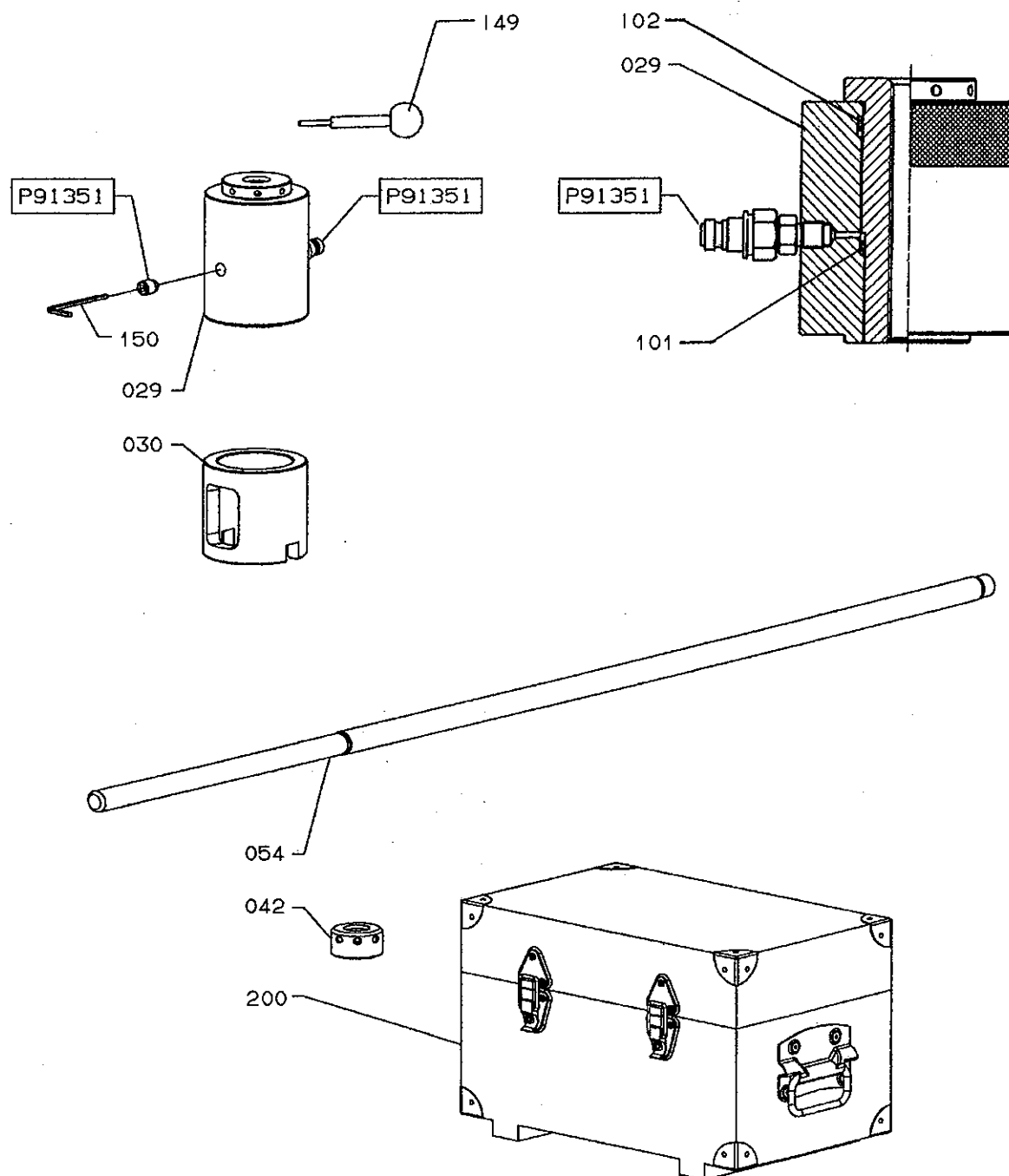


Plate 90664-0001

Crankshaft - Pin Gauge

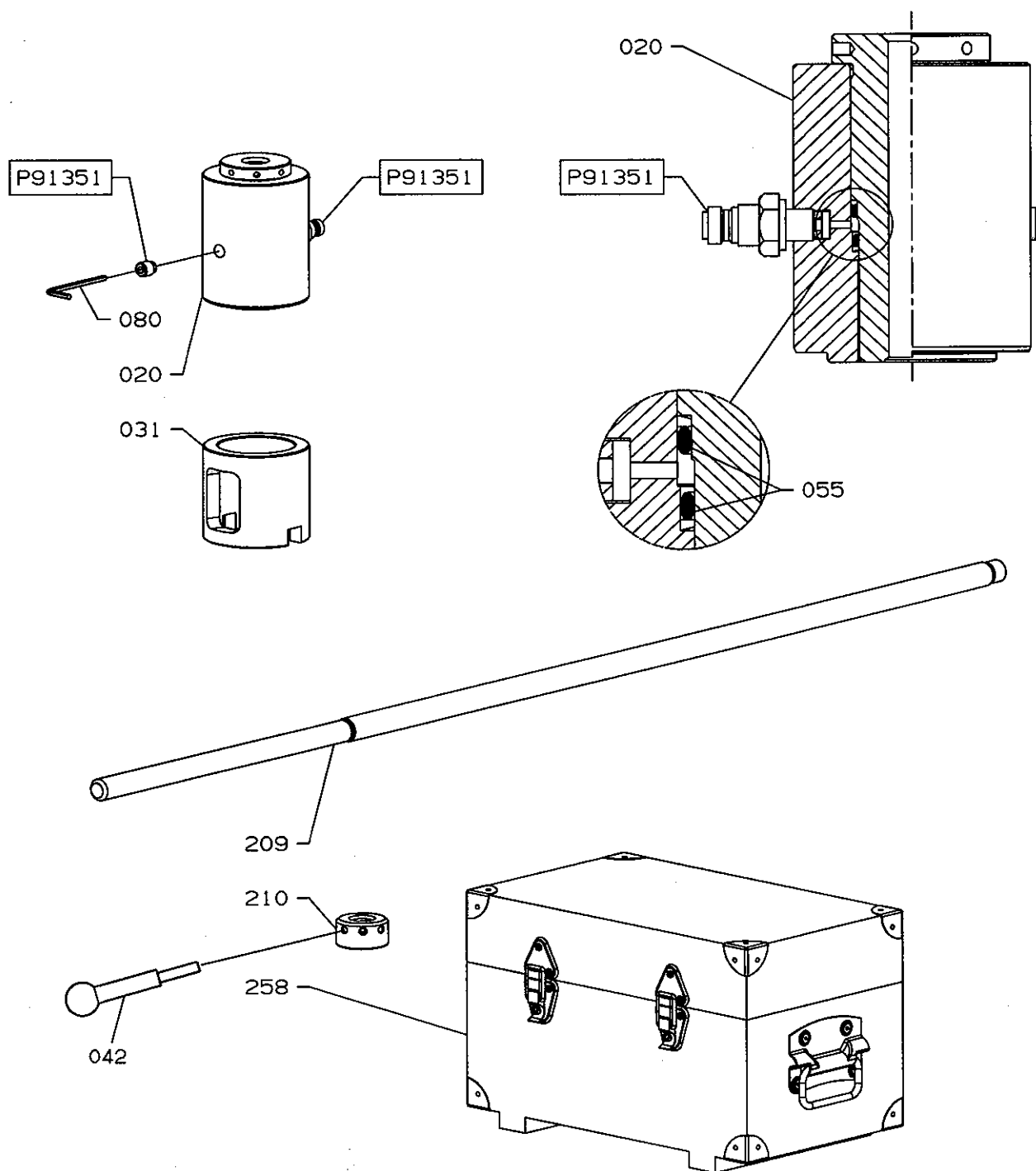
Item No.	Item Description
021	Pin gauge for crankshaft

Item No.	Item Description



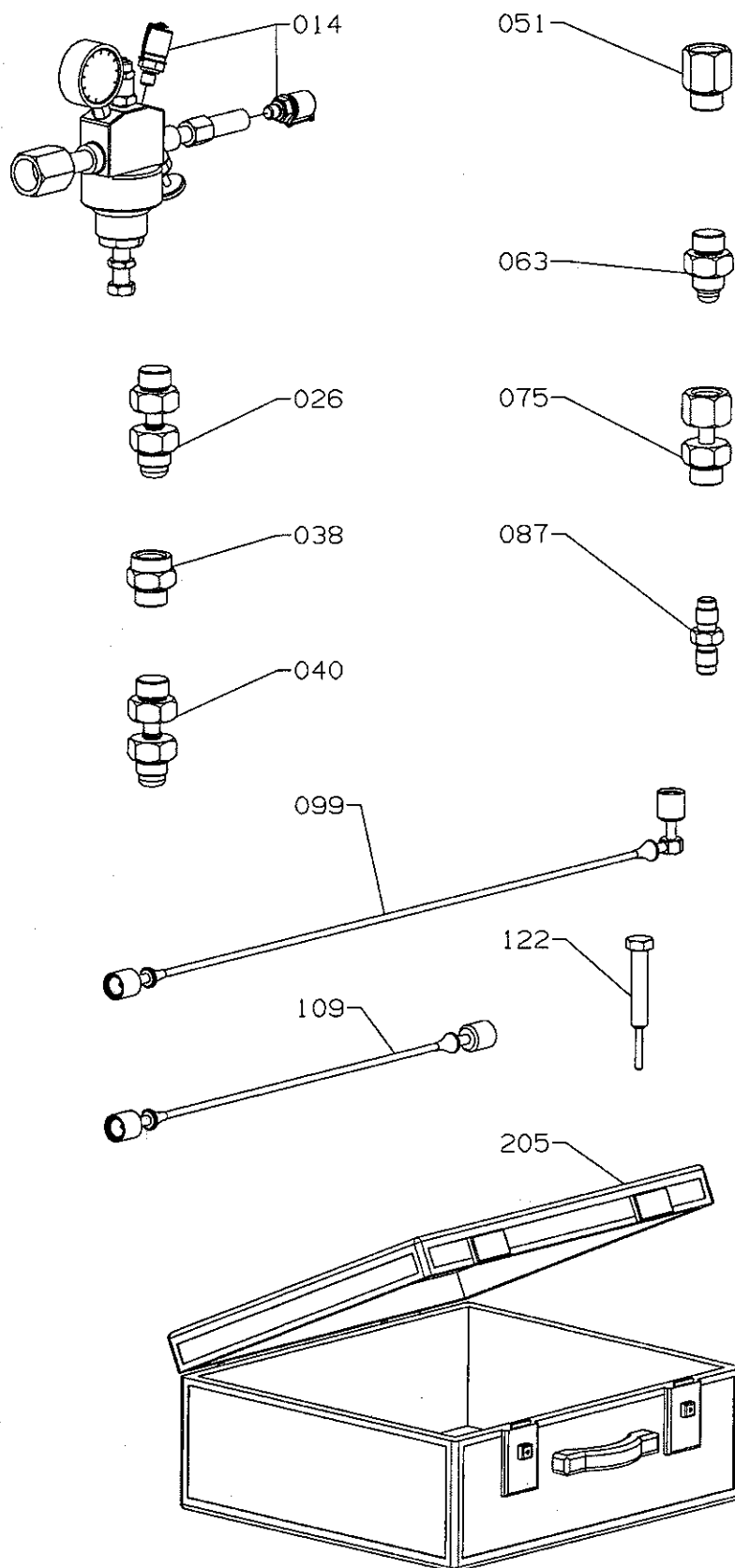
Item No.	Item Description
029	Hydraulic jack, complete
030	Support
101	Sealing ring with back-up ring
102	Sealing ring with back-up ring
150	Hex key
054	Stud
042	Nut
200	Hydraulic tool set, complete
149	Ball handle

Item No.	Item Description



Item No.	Item Description
020	Hydraulic jack, complete
031	Support
055	Sealing ring with back-up ring
080	Hex key
209	Stud
210	Nut
258	Hydraulic tool set, complete
042	Ball handle

Item No.	Item Description



Item No.	Item Description
014	Reducing valve
026	Adaptor
038	Adaptor
040	Adaptor
051	Adaptor
063	Adaptor
075	Adaptor
087	Adaptor
099	Quick coupling, Minimesh
109	Quick coupling, Minimesh
122	Special screw
205	Test equipment for accumulators set, complete

Item No.	Item Description

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D07-09	Piston tightening torque	140	Nm
D07-11	Valve tightening angle	60	°
D07-12	Starting air valve	75	kg

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90151	95	Grinding ring for starting valve
P90151	105	Grinding handle for starting valve

1. When the starting air valve has been overhauled, see *Procedure 907-2.3*, connect a supply of working air to the control air inlet at the top of the valve.

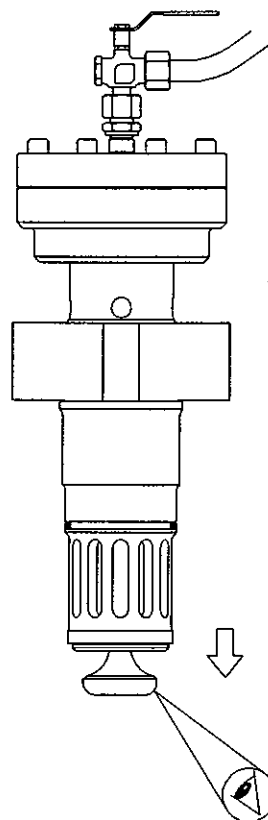
Check that the valve opens approx. 15-20 mm.

2. Shut off the air supply

Check that the valve closes fully.

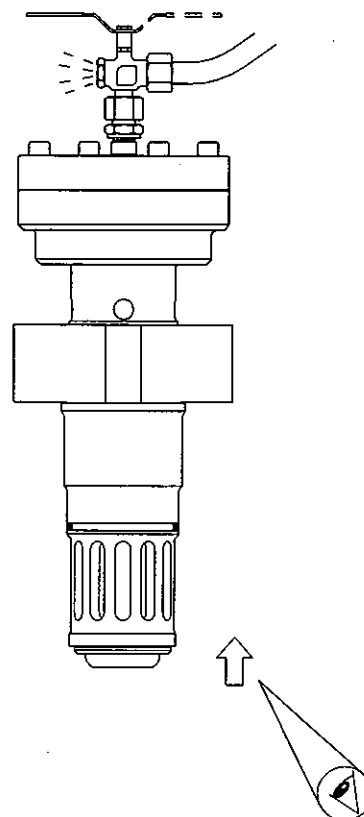
3. Repeat steps 1 and 2 a couple of times.

1.



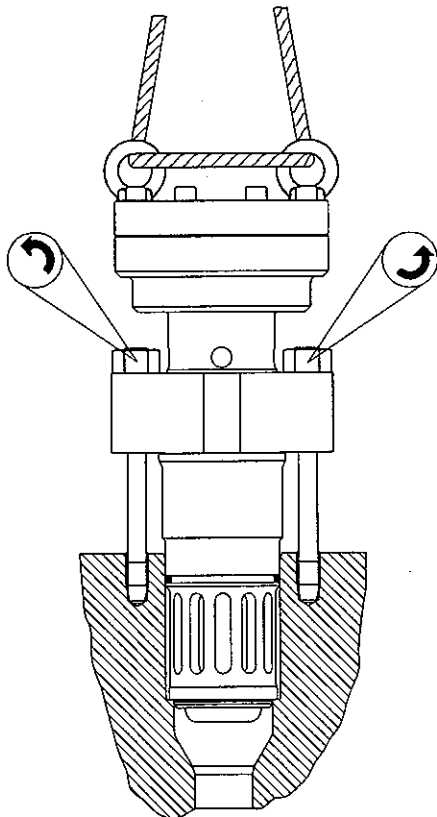
HM907-2.1 202 01A

2.



HM907-2.1 202 01B

1.



HG901-2.2 59 02

1. Shut off the starting air and control air inlet.

Dismount the control air pipes

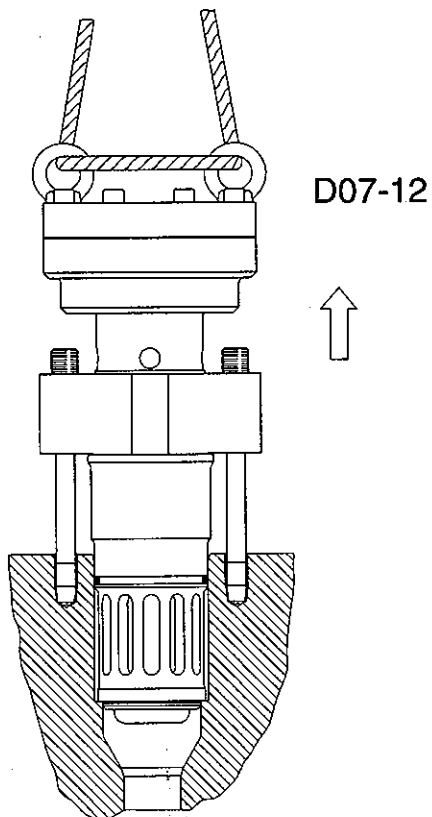
Mount two eye bolts in the top cover of the valve.

Hook a lifting wire on to the eye bolts.

Unscrew the fixing nuts of the starting valve flange.

2. Lift away the starting valve.

2.



HG907-2.3 201 02

1. Place the starting air valve horizontally in a bench vice provided with "soft" jaws.

Remove and discard the O-ring from the valve housing.

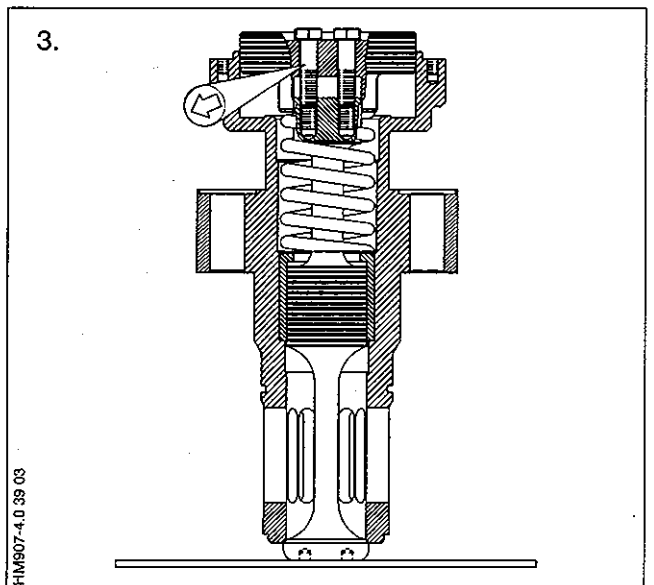
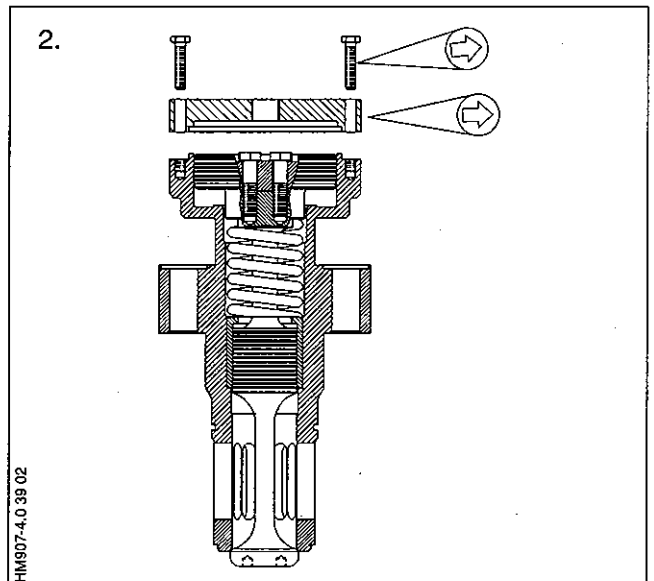
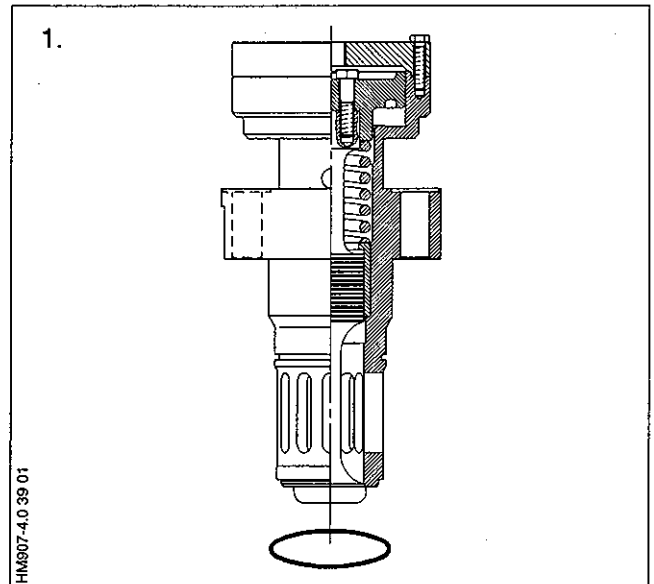
2. Loosen and remove the screws from the top cover.

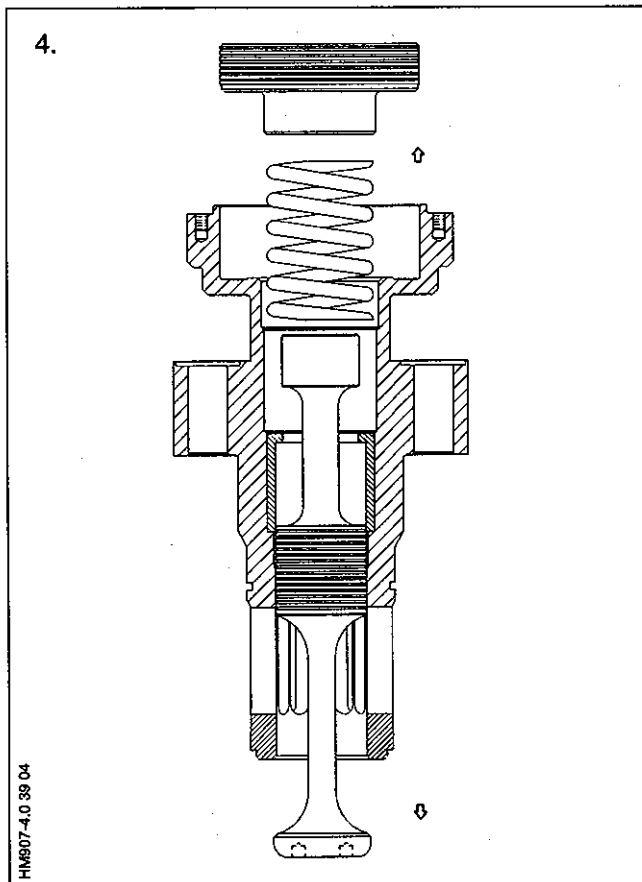
Dismount the top cover.

3. Use the face wrench for the spindle as a back-stop when loosening the two screws which tighten the piston to the spindle.

Remove the screws and discard the locking device.

When unscrewing, the piston will partially be pressed out of the valve housing due to the spring force.





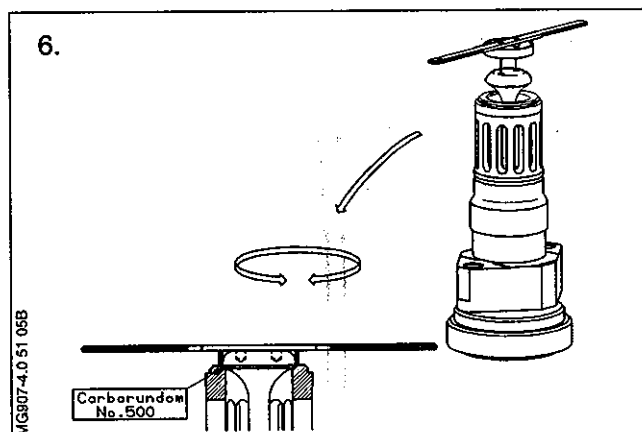
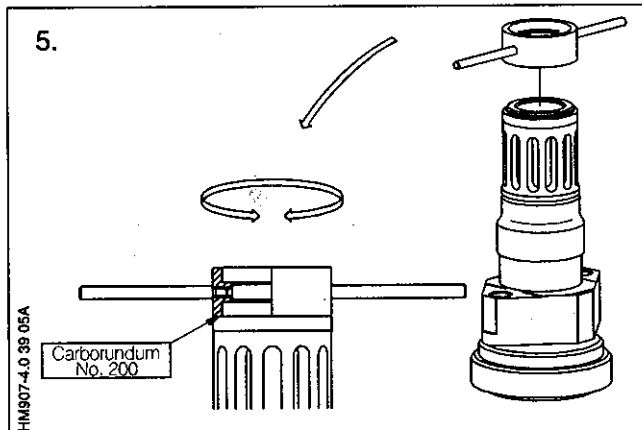
4. Remove the piston from the top end of the valve housing.

Take out the spindle from the bottom end of the valve housing.

Remove the spring from the top end of the housing.

5. Apply grinding paste, e.g. carborundum No. 200. Grind the valve housing seating with the grinding ring.
6. When lapping the seatings of the spindle and valve housing to match, use the face wrench to rotate the spindle.

As grinding paste, use e.g. carborundum No. 500.



7. Thoroughly clean the valve housing and all the parts in diesel oil or kerosene.

Lubricate all internal parts and sliding surfaces with, e.g., Molybdenum Disulphide, MoS₂.

Insert the spindle in the valve housing. Then mount the spring in the housing around the spindle and, finally, place the piston on top of the spindle.

8. Fit the discs and the two screws.

When tightening the screws, the piston will compress the spring.

Tighten the screws continuously until the piston faces tightly against the spindle. Use the face wrench as a back-stop. *See Data.*

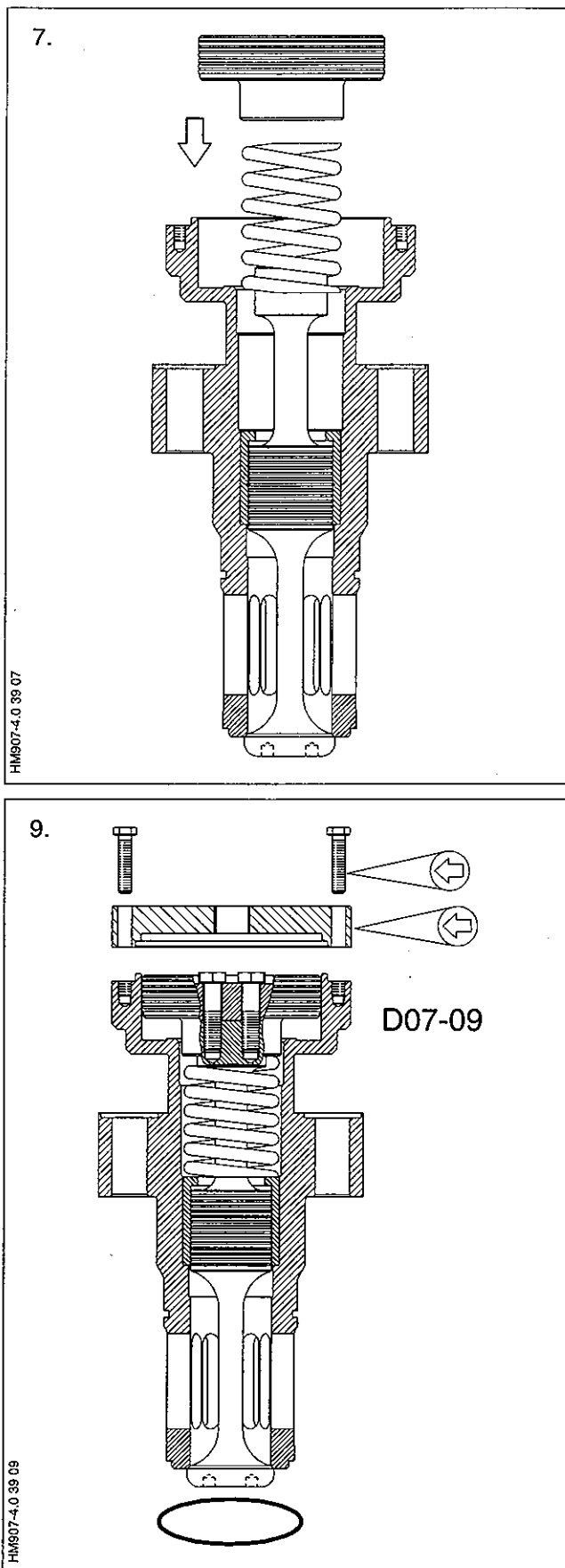
Lock the screws with locking device.
For correct use of locking device, see Procedure 913-7.

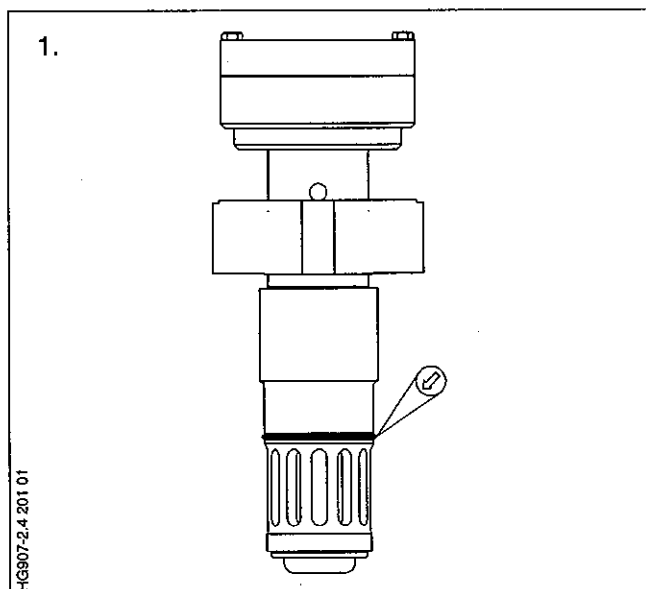
9. Mount and tighten the top cover.

Fit a new O-ring on the valve housing.

10. Check the starting air valve.
See Procedure 907-2.1.

If the valve is not to be mounted in the engine immediately, cover all openings with plastic to prevent dirt from entering the valve during storage.



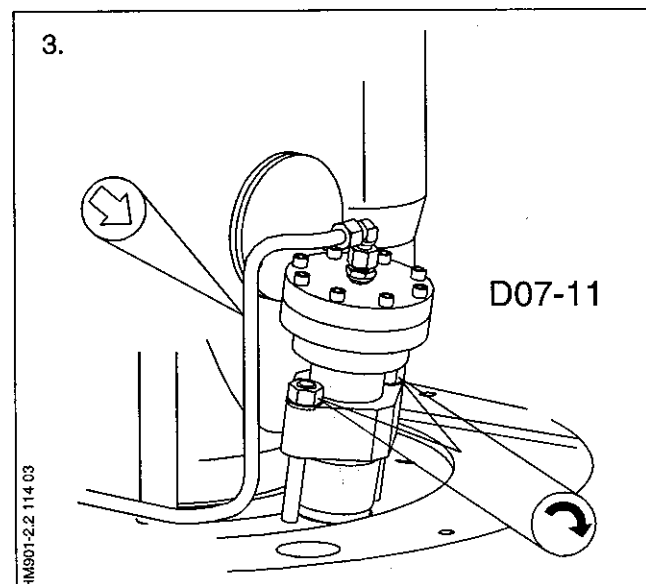
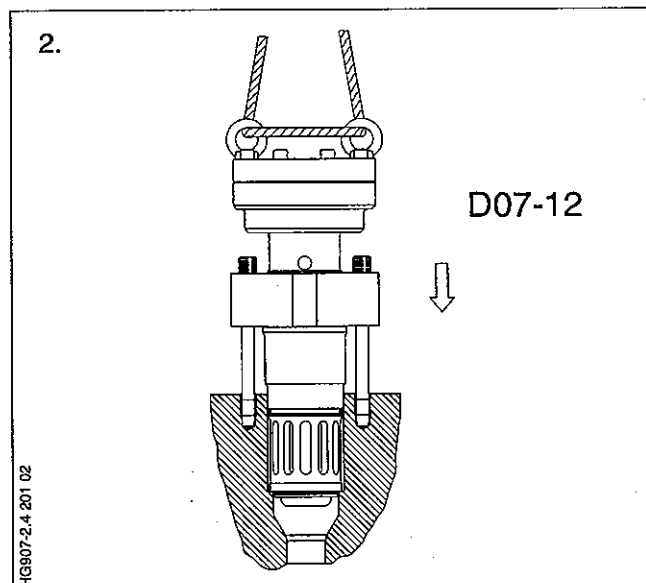


1. Carefully clean the starting valve bore in the cylinder cover and, if necessary, recondition the seat for the starting valve in the bore, *see Procedure 901-1.3*.

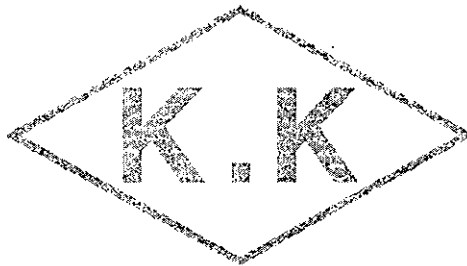
If not already done, fit a new O-ring on the overhauled valve and lubricate with 'Never Seize' or Molybdenum Disulphide, MoS₂.
For overhaul, *see Procedure 907-2.3*.

2. Mount the valve in the cylinder cover.
3. Mount the nuts and tighten-up in at least three steps, to reach the full tightening angle, *see Data*.

Mount the control air pipe and turn on starting air and control air.



**Instruction and Maintenance
Manual For Main Starting Valve**



MODEL : KKMW & KKMO

**KKMW : MAIN STARTING VALVE WITH SLOW TURNING DEVICE
&**

KKMO : MAIN STARTING VALVE WITHOUT SLOW TURNING DEVICE

“ 고객이 만족하는 품질을 창출한다. ”

**KUMKANG
PRECISION CO., LTD.**



KUM KANG
PRECISION CO., LTD.

Instruction and Maintenance Manual For Main Starting Valve



D N V 인 증 원
ISO 9002 인증업체

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DESCRIPTION	PAGE
1. Instruction for KKMW Series	1
2. Instruction for KKMO Series	2
3. KKBV Series Ball Valve Instruction	3 ~ 10
4. KKPA Series Actuator Instruction	11 ~ 12



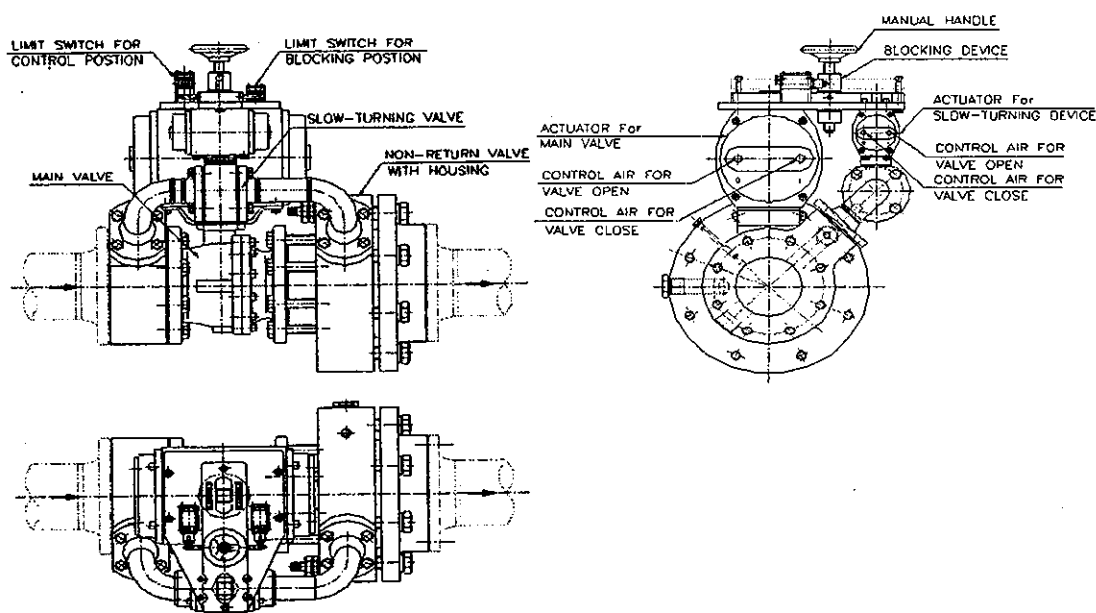
KUM KANG
PRECISION CO., LTD.

Instruction For Main Starting Valve - KKMW



DNV 인증 원
ISO 9002 인증업체

- MAIN STATING VALVE WITH SLOW-TURNING DEVICE



- General Specification

Ball Valve Hydro. Test Pressure : 70 Bar
Ball Valve Working Pressure : Max. 40 Bar
Ball valve End Connection : DIN PN 40 Bar
Actuator Air Source Range : 4~8 kg/cm² G
Application Fluid : Compressed Air

- Operation

- ① Before operating the valve by controlling the air source Valve to the actuator, check whether the blocking device is at valve operating position.
- ② For valve operating and closing operation, Fully turn the manual handle to the direction of counter-clock-wise viewing from topside.
- ③ Turn on the control air source valve to the actuator for each direction.
- ④ When finished engine start up or valve are not using condition, Be sure to close the valve and to blocking the valve by turning manual handle to the direction of clock-wise viewing from topside.

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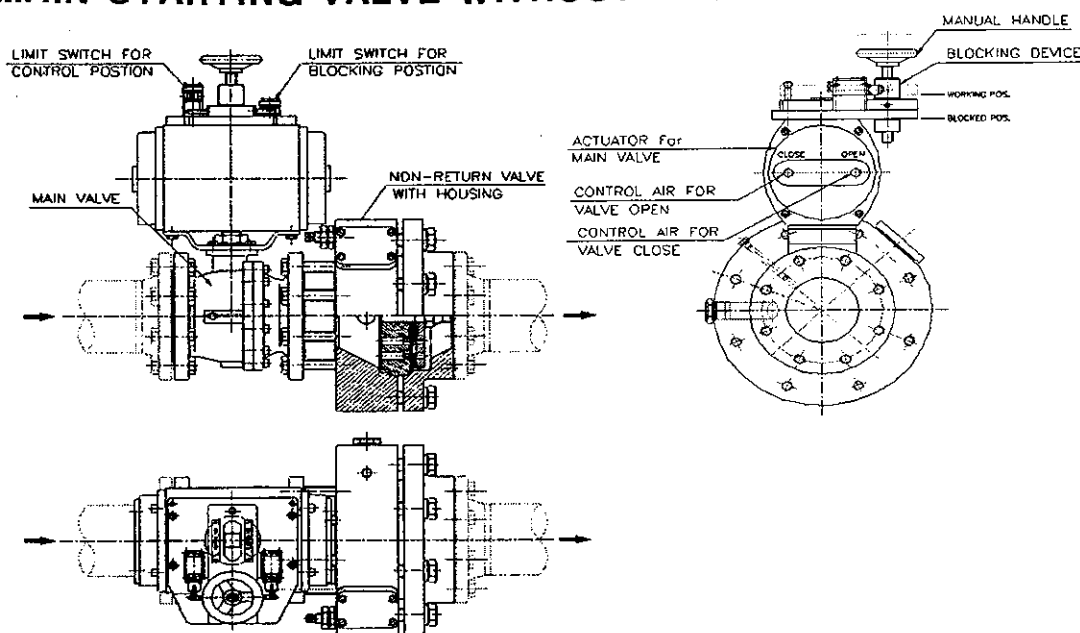
KUM KANG
PRECISION CO., LTD.

Instruction For Main Starting Valve - KKMO



DNV 인증
ISO 9002 인증업체

- MAIN STARTING VALVE WITHOUT SLOW TURNING DEVICE



- General Specification

Ball Valve Hydro. Test Pressure : 70 Bar
Ball Valve Working Pressure : Max. 40 Bar
Ball valve End Connection : DIN PN 40 Bar
Actuator Air Source Range : 4~8 kg/cm² G
Application Fluid : Compressed Air

- Operation

- ① Before operating the valve by controlling the air source Valve to the actuator, check whether the blocking device is at valve operating position.
- ② For valve operating and closing operation, Fully turn the manual handle to the direction of counter-clock-wise viewing from topside.
- ③ Turn on the control air source valve to the actuator for each direction.
- ④ When finished engine start up or valve are not using condition, Be sure to close the valve and to blocking the valve by turning manual handle to the direction of clock-wise viewing from topside.

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PRECISION CO., LTD.

KKBV Series Ball Valve Installation Operation & Maintenance Instructions



DNV 인증원
ISO 9002 인증업체

A. Installation

1. General

Keep protective cover in place until moment of install - Valve performance depends upon prevention of damage to ball surface. Upon removal of cover make sure that the valve is completely open and free of obstruction.

When dispatched, valves contain a silicon based lubricant which aids the bedding in of the valve, this may be removed with a solvent if found objectionable.

Certain ferrous valve are phosphated and oil dipped during the course of manufacture, but the processes used are completely non-toxic and the valve are quite safe to use for edible or potable products.

2. Flanged valves

The customer is required to supply the necessary flanges, gaskets and bolting in order to fit the valve into his pipe-work

B. Operation

1. Use

KUMKANG Valves provide tight shut off when used under normal conditions.

If these valves are used in a partially open (throttled) position, seat life may be reduced.

Any media which might solidify, crystallize or polymerize, should not be allowed to stand in the valve cavities unless regular maintenance is envisaged.

2. Manual operation

The basic type of wrench which is fitted to all sizes of malleable iron with separate malleable iron stop plate.

KUMKANG valves have 1/4 turn operation, closing in a clockwise direction. It is possible to see, where the wrench is correctly fitted, when the valve is open or closed by the position of the wrench: When the wrench is in line with the pipeline, the valve is open when the wrench is across the pipeline, the valve is closed.



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KKBV Series Ball Valve Installation Operation & Maintenance Instructions



D N V 인 증 원
ISO 9002 인증업체

3. Remote operation

Where manual operation is not required, valves may be automated for remote operation, instrument control, etc. A range of pneumatic and electro pneumatic actuators is available.

No stop is fitted to the valve, since the stop is normally part of the actuator.

Operation will be in accordance with installation, operation and maintenance instructions for the relevant actuator.

C. Maintenance

1. General

With self-wipe ball/seats and patented pressure equalizing slots. KUMKANG valves have a long, trouble free life, and maintenance is seldom required. But, when necessary, valves may be refurbished by relatively unskilled labour, using a small number of components, none of which require machining in site. KUMKANG valves are designed for easy service and assembly in the field. The following checks should, however, help to extend valve life further, or reduce plant problems.

Stem leakage

Tighten the gland nut. If it requires excessive tightening, check that valve torque Remains acceptable.

If tightening does not solve the problem it will be necessary to dismantle the stem assembly only. It will not be necessary to dismantle the valve.

Leakage at body join

Check for tightness in the body connector cap-screws.

If slack, tighten-connector flanges are metal to metal, standard wrenches only should be used excessive force will only stretch or strip the bolts.

If there is still leakage, this be due to damage to body connector seal and it will be necessary to dismantle valve.

In-line leakage

Check that valve is fully closed. If it is, leakage will be due to damage seat or ball sealing surfaces and it will be necessary to dismantle the valve.



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KKBV Series Ball Valve Installation Operation & Maintenance Instructions



D N V 인 증 원
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Note :

Stem leak and leakage at body joint, if not cured by simple means described above, necessitate dismantling valve, but if there is not stem leakage the stem assembly should not be touched.

Leakage at pipeline joint

Test for tightness in the flange bolts. if slack, tighten—valve flange and pipe-work flanges have flange gasket between them, standard wrenches only should be used—excessive force will only the flange, stretch or strip the bolt. If over-tightened, bolts cause flange leaks and slackening of bolts may then sometimes solve the problem.

2. Refurbishing

Maintenance kits are available from KUMKANG and consist of the following:

2seat rings, 1 body connector seal, 1 stem thrust seal, 3 gland packing rings, 1 gland nut.

Where a valve need repairing, rather that maintaining, it must be notes that only KUMKANG authorized spare part should be used, and these include basic components available from KUMKANG are balls, stems, glands.

If additional parts are required, it is normally recommended that the complete valve is replaced.

Parts of valves from different series, should nor be interchanged.

This is to ensure, so far as is reasonably practicable, that the valve remains capable of being used for the purpose for which it was designed and constructed, without risk to health and safety when properly used.

However, if the valve is altered in any way, no liability can be accepted by KUMKANG



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3. Safety precautions

Before removing valve from pipeline:

Media flowing through a valve may be corrosive toxic, inflammable, or of a contaminant nature.

Where there is evidence of harmful fluids having flowed through the valve, the utmost care be taken.

It is suggested that the following safety precaution should be taken when handling valves.

- ① Always wear eye shields.
- ② Always wear gloves and overalls.
- ③ Wear protective footwear.
- ④ Wear protective headgear.
- ⑤ Ensure that running water is easily available.
- ⑥ Have suitable fire extinguisher ready if media is inflammable.

By asking responsible personnel and by checking line gauges, ensure that no pressure exists on either the upstream or downstream sides of the valve.

Ensure that any trapped media is released by operating valve slowly to half open position.

Leave valve in fully open position before removing from the pipeline.

After removing valve from pipeline.

If the valve is closed and not in the fully open position as suggested in preceding safety precautions now ensure that any trapped media is released by operating valve slowly to half open position.

The safety place to stand. when operating the valve, is away from the end of the stem and to one side.

Ideally, the valve should be decontaminated when the ball in the half open position, Leave in fully open position.

4. Tools

No special tools are required for maintenance of KUNKANG valves.



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KKBV Series Ball Valve Installation Operation & Maintenance Instructions



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D. Dismantling

If the valve is closed and not in fully open position as suggested in proceeding safety precaution, refer to these precautions before proceeding further.

Also, during dismantling, do not assume that valve is totally decontaminated – harmful fluid, etc., may still be trapped in crevices.

Valve should be placed with the body connector uppermost and on a clean surface, the valve preferably clamped or bolted down. To remove body connector, extract body connector mid-flange connection should break open. Repeat if not successful at first try.

The body connector should now be lifted vertically from the body and placed on the clean surface with mid-flange uppermost.

If the body connector seal comes away easily during removal of body connector, it may be removed at this time. If not leave it until later.

With the valve still in the close position the ball may now be lifted from the body cavity, and the seat rings and body connector seal should now be exposed in either body or body connector.

The seat rings and body connector seal should now be removed. Care must be taken to avoid scratching the machined faces on which they make contact with valve body and body connector.

To dismantle stem assembly, first removed the wrench nut, identification plate and wrench from stem. Using wrench to prevent the stem from turning, remove the gland nut, disk spring and gland. It is not normally possible to remove gland packing at this stage. Withdraw stem through body cavity and remove stem trust seal from stem or body recess. Gland packing may now be removed.

Clean all components thoroughly and examine all seating/sealing surfaces.

If there is a build-up of solids which cleaning fluids will not move—do not scratch the machined surfaces—use a broad, flat, blunt tool.

No eroded or corroded leak paths are permissible. If any are found, the part must be replaced. The ball must have no scratches across its seating surfaces and any damage to the port lip will destroy the seal—a damaged ball must not be re-used – fit a new one.



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KKBV Series Ball Valve Installation

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E. Rebuilding

Before rebuilding, check that all the correct compositions are available and that they are fit for the purpose. When rebuilding, cleanliness is essential to allow long valve life and provide cost effective maintenance.

Body should be placed with the mid-flange connection uppermost and on a clean surface, the body preferably clamped or bolted down.

Fit inner seat ring before stem assembly.

Fit stem thrust seal to stem and insert stem through body cavity into stem hole and fully up into body recess. Fit gland packing, gland and disk with their outer edges touching. Using wrench to prevent stem from turning, fit gland nut and screw down until disk springs are firmly compressed. Operate stem several times and re-adjust. Over-tightening will only reduce the life of the assembly. Now fit wrench, identification plate and wrench nut to stem assembly and move stem into the closed position-wrench across the pipeline.

With the stem still in the closed position, the ball may be placed into the body cavity by sliding the ball slot over the stem tang. Open the valve.

Fit second seat ring and body connector seal into body.

Note :

A trace of silicon based lubricant or clean grease(such as petroleum jelly) if compatible with the future pipeline media, will ease the rebuilding by holding the seat rings and insert/body connector seals in place.

Use no grease with abrasive additives.

With mid-flange facing down and customer flange holes correctly positioned, place the body connector into the body using 2 or 3 body connector cap-screws to align mid-flange fixing holes.

When correctly located, strike body connector with mallet to push down body connector further into body.

Fit body connector cap-screws, and by tightening, pull down body connector until finally both mid-flanges touch. Valve flanges will be metal to metal, standard wrenches only should be used-excessive force will only stretch or strip the bolts.

Test

If practical, leak tightness and torque should be checked.



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KKBV Series Ball Valve Installation Operation & Maintenance Instructions



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BALL VALVE

Type : KKBV Series 150mm Fire-safe.

Max. Working Pressure : 40Bar.

Test Pressure : 70Bar.

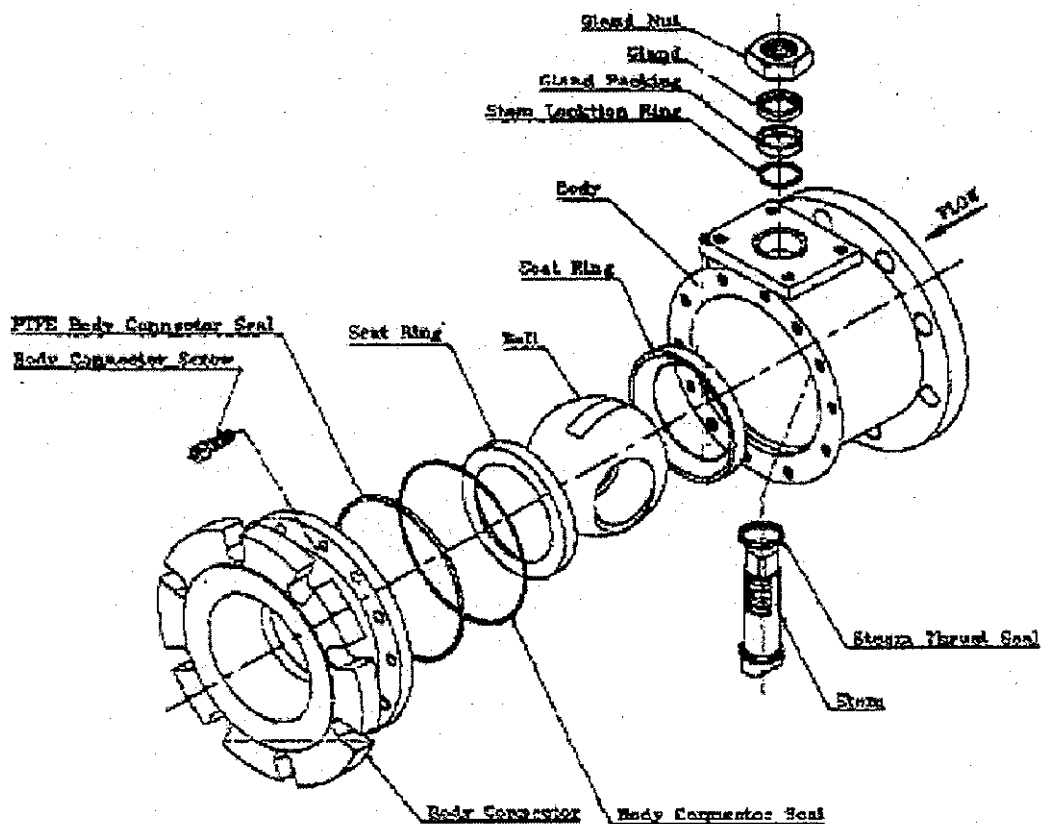
Flange Connection. Drilled to DN40x100 or 150

Housing : Cast Steel (SC480).

Ball and Stem : ANSI 316/SIS 2343

Upstream seat : Al-Bronze

Sealing : Downstream : Seat Ht Modified Fire-safe Gasket(PTFE)



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KKPA Series PNEUMATIC ACTUATOR

Operation & Maintenance Instructions

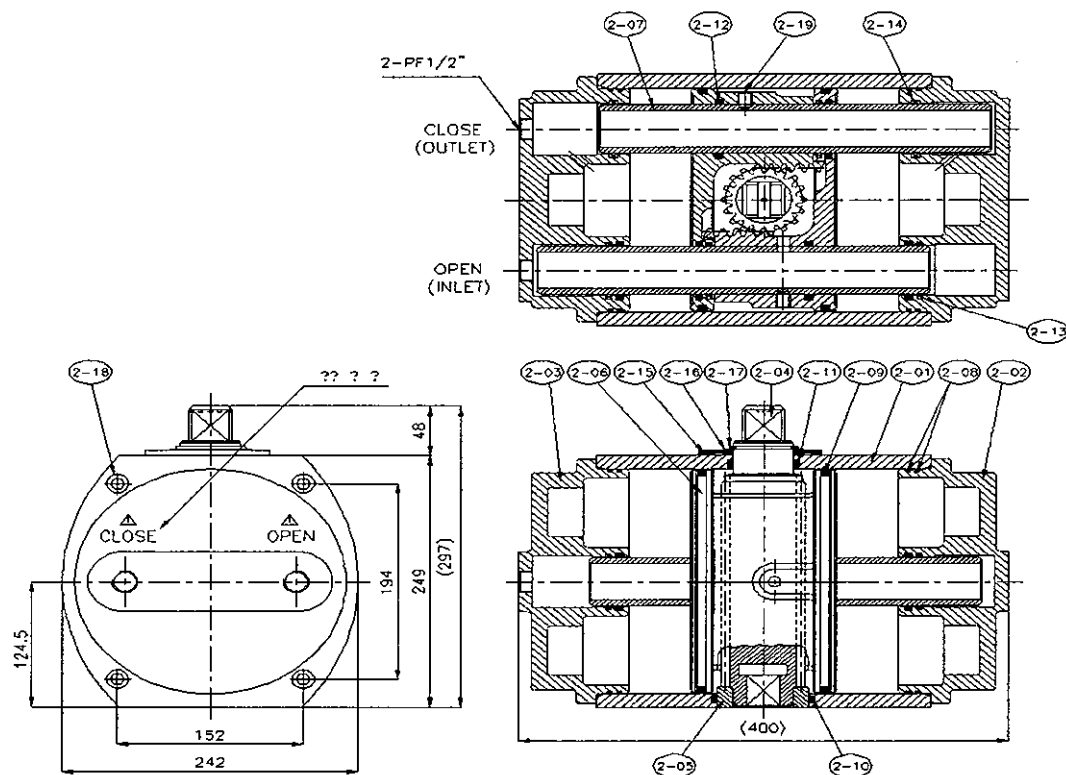


DNV 인증 원
ISO 9002 인증업체

ACTUATOR

Type : Hap Double Acting.

Ball valve and actuator to be mounted in closed position all dimensions to be in accordance with the drawing



The actuator is of a pneumatic type with a simple and safe construction, ensuring that the actuator operation is reliable regardless of high or low speeds, and a different air gas pressure abt. 2~8.4 kg/cm²

Operation Conditions

Pressure range : 2~8.4 kg/cm²

Temperature range : -18°C ~ to 100°C

Direction : Actuators rotate in anti-clockwise direction when the right and air connection is pressurized

Media : Air or non corrosive gas.

Movement : 90° with up to 1 1/2° overrun each end.

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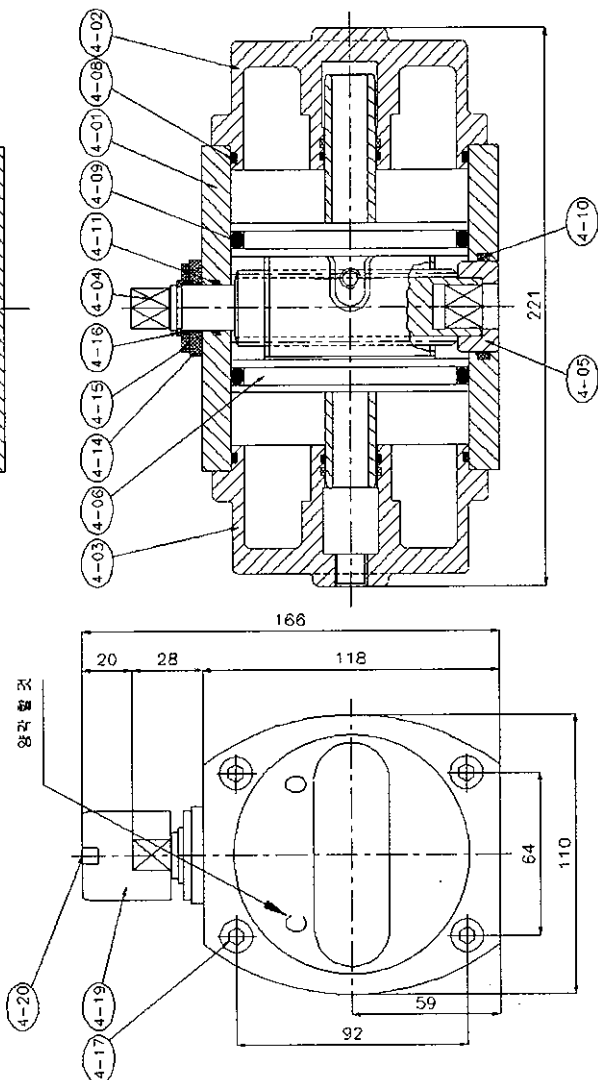
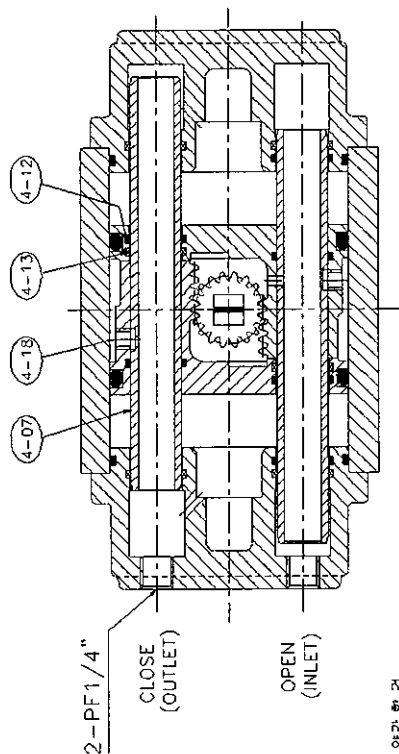
KKPA Series PNEUMATIC ACTUATOR

Operation & Maintenance Instructions



DNV 인증
ISO 9002 인증업체

APPRO	CHECK	DRAWN	DATE	DESCRIPTION	P
					△
					△
					△



20	HEX SOCKET BOLT	SCM435	1	MB7EL
19	BLOCK	SCM435	1	MB
18	SET SCREW	S45C(N)	2	MB
17	HEX SOCKET BOLT	SCM435	8	MB-25H
16	SNAP RING	SKS	1	G-TYPE 18
15	RING	SUS304	1	Q15.5X35X3
14	TOP WASHER	NBR	1	Q15.5X35X3
13	RETAINING RING	PI1E	1	Q15.5X35X3
12	RETAINING RING	PI1E	6	Q15.5X35X3
11	O-RING	NBR	1	P18
10	O-RING	NBR	1	P18
09	O-RING	NBR	2	P85
08	O-RING	NBR	2	P85
07	SPRING ROD	SUS304	2	Q15.5X35X3
06	SPRING ROD	SUS304	2	Q15.5X35X3
05	SPRING FLANGE	SUS304	1	Q15.5X35X3
04	SPRING	SUS304	1	Q15.5X35X3
03	CAP	AC4E-16	1	Q15.5X35X3
02	CAP	AC4E-16	1	Q15.5X35X3
01	BODY	AC4E-16	1	Q15.5X35X3
00	NAME OF PARTS	MATL	NO. REQUIRED	REMARK
RULE	CUSTOMER	NO. REQUIRED	WEIGHT(kg)	
APPROVED	J. J. YANG	SCALE	SETS/SHIP	
BY	J. B. SUNG	NONE	60MC ~ 90MC	
CHECKED	J. B. SUNG	NONE		
DRAWN	J. B. SUNG	NO REF		
DATE				
TITLE PNEUMATIC ACTUATOR ASSY (50A)				DWG NO. V10939c
PRECISION, CO., LTD.				
PUSAN, KOREA				
				

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-01	High-pressure pipe, tightening torque	55	Nm
D08-03	High-pressure pipe	100	kg

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90851	112	Grinding mandrel for h.p. pipe

1. Stop the engine and shut off the oil supply.

Connect a pressure gauge at "minimess" point 455. Check the pressure.

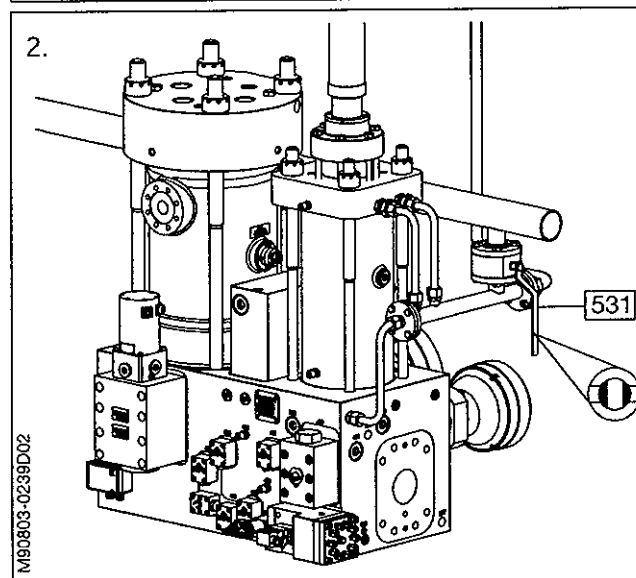
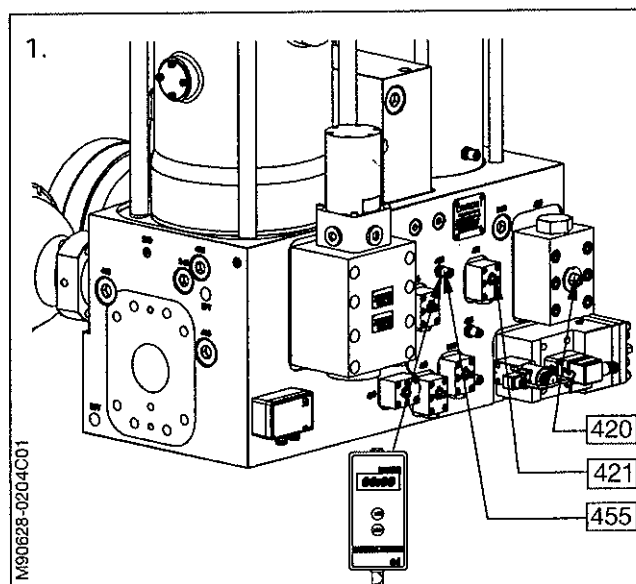
Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

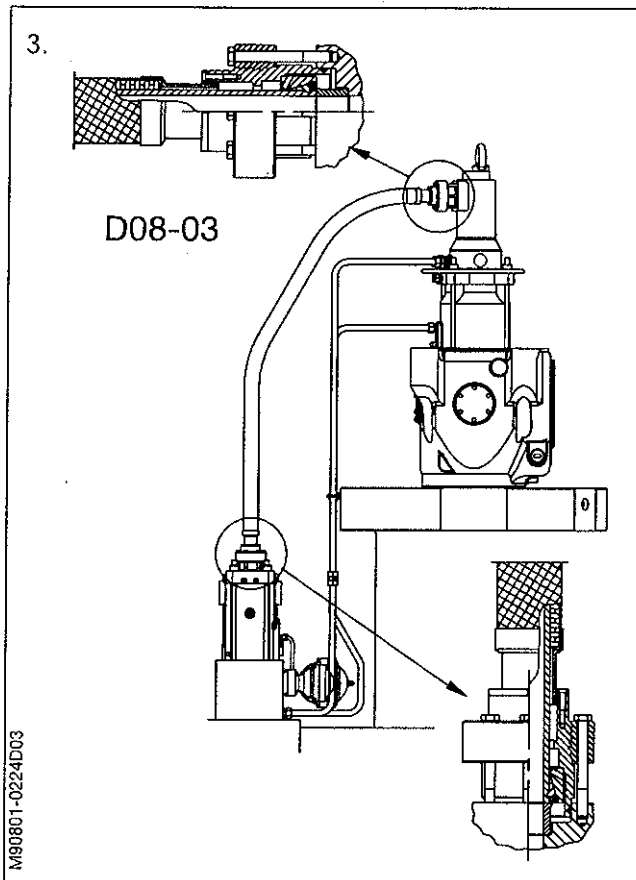
Check that the system is pressure free.

Note!

Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

2. Close the valve 531 for the actuator oil supply.

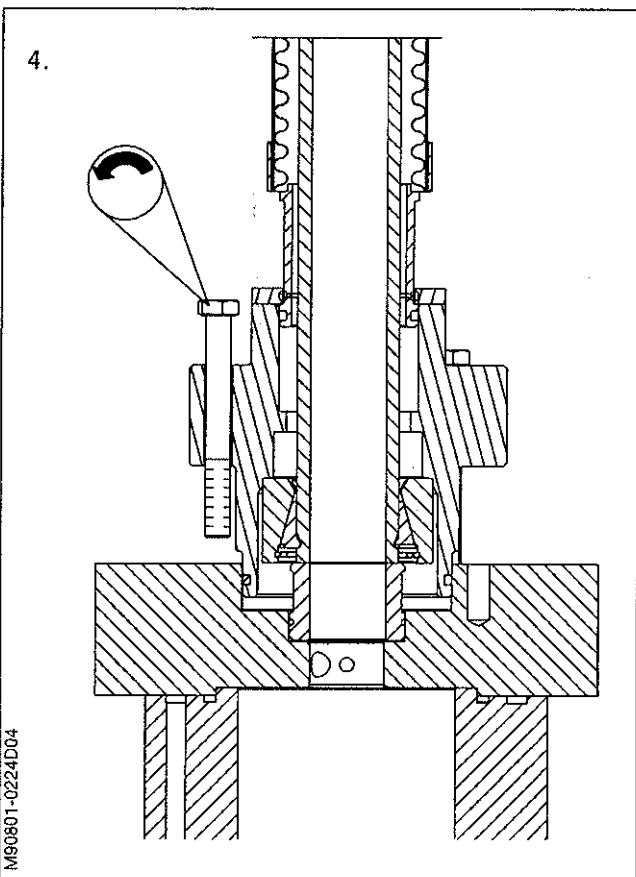




3. When replacing the hydraulic high-pressure pipe, the exhaust valve or the hydraulic actuator, check the high-pressure pipe sealing surfaces.

Loosen the screws for the high-pressure pipe and lift the pipe slightly away from the actuator to let the oil in the pipe drain through the drain holes in the actuator.

4. Remove the screws in both ends of the high-pressure pipe. Lift the high-pressure pipe away from the engine.



The two ends of the pipe are identical and should both be overhauled as follows:

1. Remove the thrust piece from the actuator and exhaust valve.

Remove and discard the O-rings from the thrust piece and the thrust flange.

2. Pull the thrust flange clear of the pipe end.

Remove the spring ring.

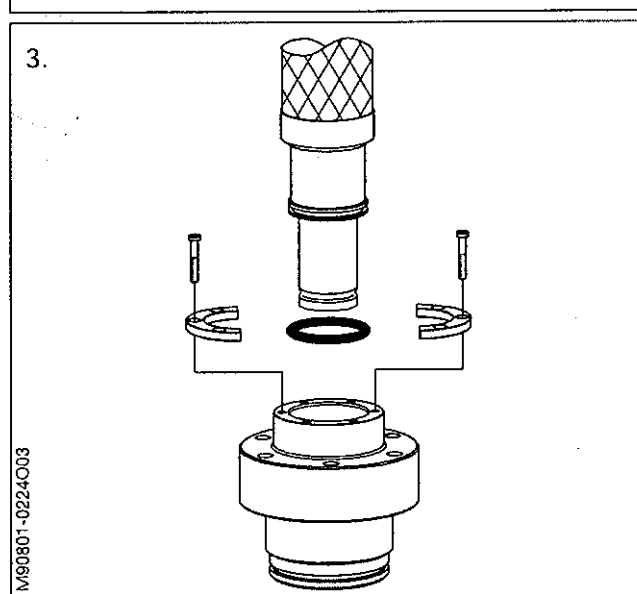
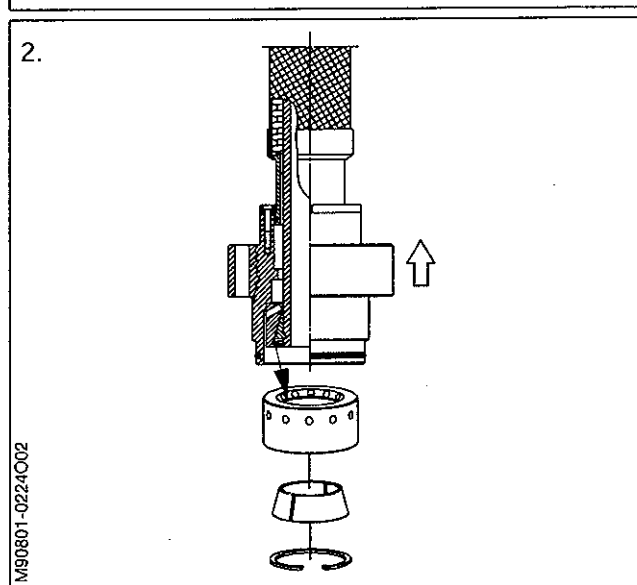
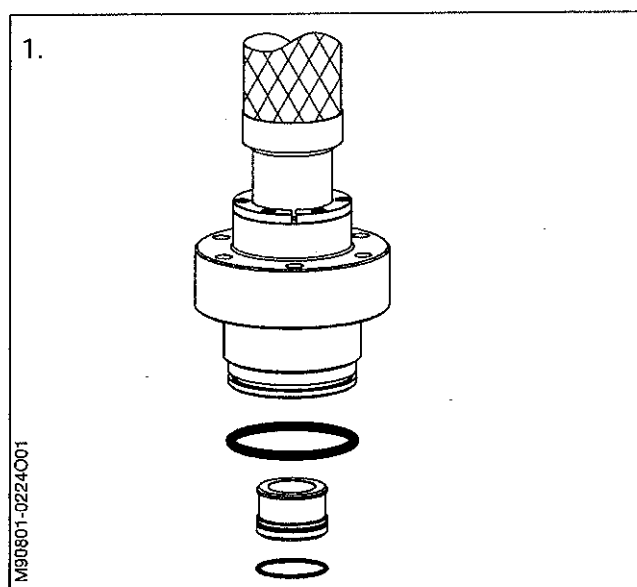
Push in the sleeve and remove the two-part conical locking ring.

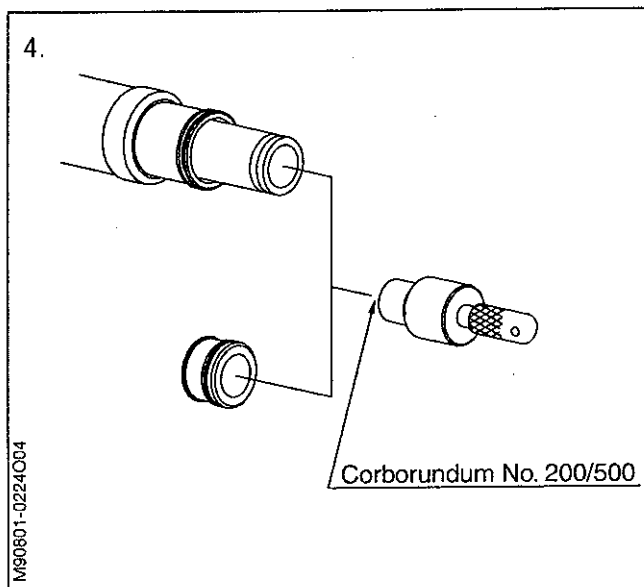
Pull the sleeve off the pipe.

3. Remove the screws and the two-part disc from the thrust flange.

Pull the thrust flange off the pipe.

Remove and discard the O-ring.





4. Clean and inspect the contact surfaces of the high-pressure pipe and the thrust piece.

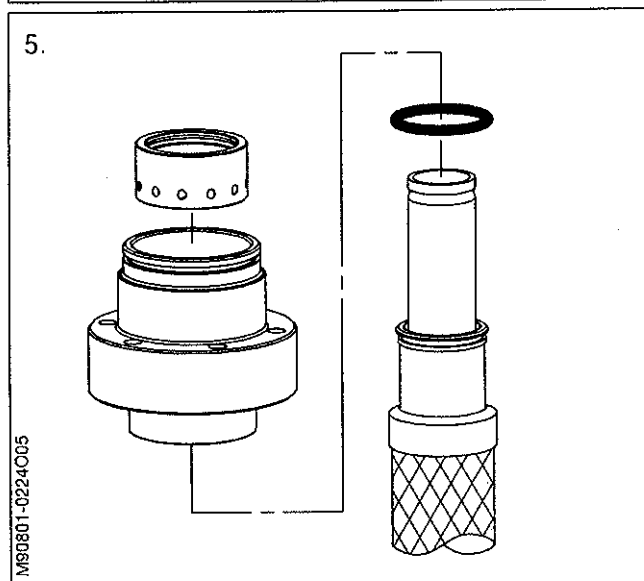
If necessary, grind the contact surfaces by means of the grinding mandrel.

Start grinding with a coarse grinding paste, for example Carborundum No. 200, and finish with a fine grinding paste, for example Carborundum No. 500.

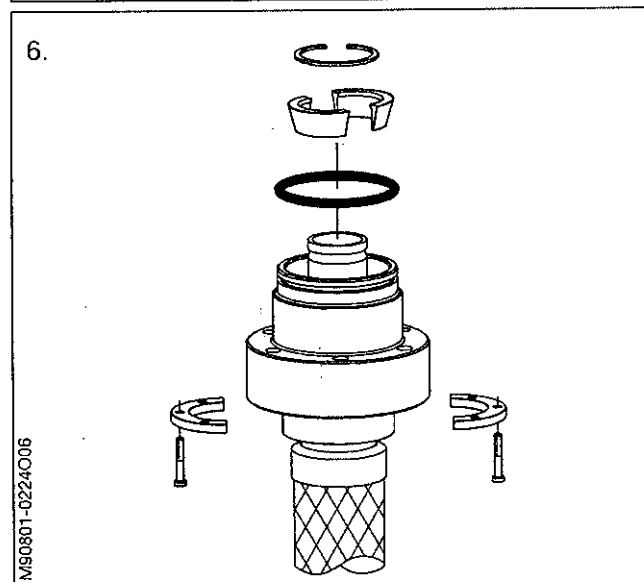
After the grinding, clean the high-pressure pipe and the thrust piece.

5. Mount a new O-ring on the flexible hose.

Mount the thrust flange and the sleeve.



6. Mount the two-part conical locking ring and the spring ring.



1. If not already done, mount new O-rings, lubricated with a little lubricating oil, on the thrust flanges.

Mount the high-pressure pipe on the engine.

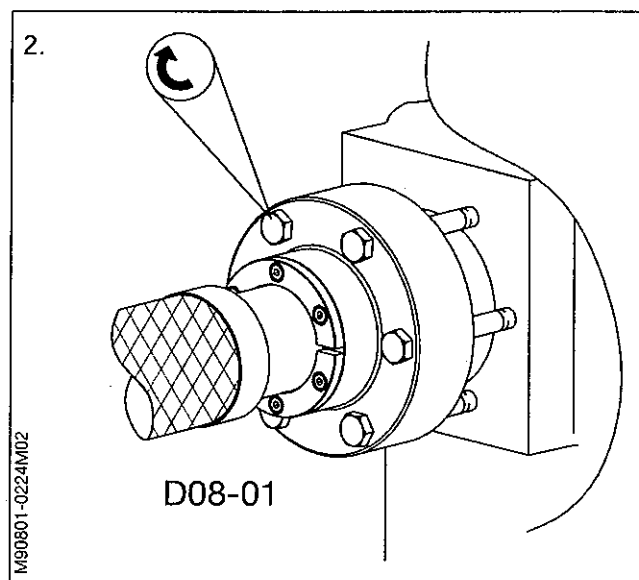
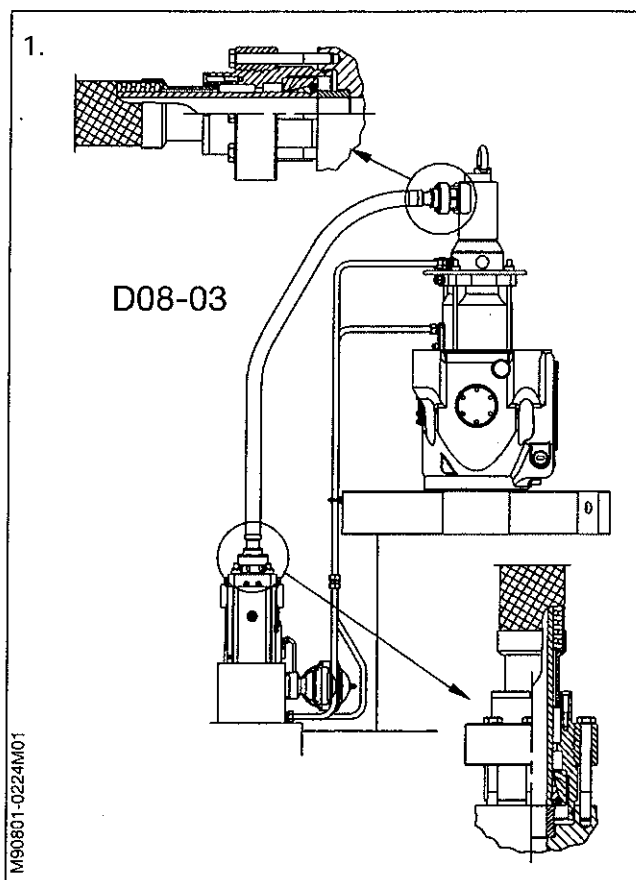
Note!

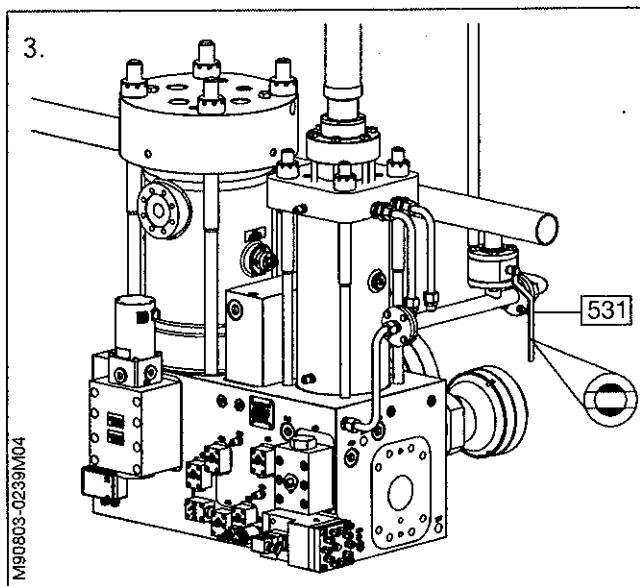
When mounting the high-pressure pipe, take care not to damage the sealing surfaces of the pipe/thrust pieces.

2. After fitting the pipe to the exhaust valve and actuator, mount and tighten the screws by hand.

Finally, tighten the screws diagonally to the torque stated in Data, using a torque spanner.

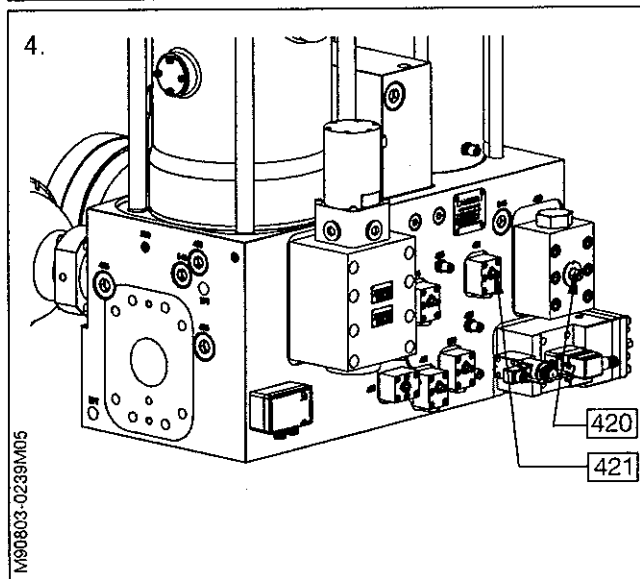
For correct use of the torque spanner, see Procedure 913-5.





3. Open the valve 531 for actuator oil supply.

4. Close valve 421, and open valve 420 on the hydraulic block.



Safety precautions
For detailed sketch, see 900-2

X	Engine stopped
X	Shut off starting air supply - At starting air receiver
X	Block the main starting valve
X	Shut off starting air distributor/distributing system supply
X	Shut off safety air supply - Not ME engines
X	Shut off control air supply
X	Shut off air supply to exhaust valve - Only when stopped lubricating oil pumps
X	Engage turning gear
X	Shut off cooling water
X	Stop lubricating oil supply
X	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-04	Safety valve, opening pressure	25	bar
D08-07	Safety valve, tightening torque	50 - 80	Nm
D08-09	Bottom piece seat, grinding angle	29.9 - 30.0	°
D08-10	Valve spindle seat, grinding angle	30.7 - 30.8	°
D08-11	Bottom piece seat, max. grinding	2.3	mm
D08-12	Gap of bottom piece seat	1.0	mm
D08-13	Spindle, max. burn-off	12.0	mm
D08-14	Spindle, max. grinding	2.0	mm
D08-15	Spindle stem, measuring area, min.	435	mm
D08-16	Spindle stem, measuring area, max.	610	mm
D08-17	Spindle stem, min. diameter	107.8	mm
D08-18	Bushing max. diameter, top	108.8	mm
D08-19	Bushing max. diameter, bottom	112.0	mm
D08-20	Oil cylinder max. inside diameter	125.2	mm
D08-21	Piston rings, min. thickness	4.7	mm
D08-22	Damper piston, min. distance	36.3	mm
D08-23	Damper piston, max. distance	39.3	mm
D08-24	Exhaust valve, complete	2400	kg
D08-25	Exhaust valve housing	1350	kg
D08-26	Oil cylinder	270	kg
D08-27	Air cylinder	160	kg
D08-28	Spindle	250	kg
D08-29	Bottom piece	300	kg
D08-30	Air piston	11	kg
D08-45	Damper piston	22	kg
D08-46	Damper flange	21	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item no.	Description
P90851	65	Lifting tool for exhaust valve
P90851	89	Pressure tester for safety valve
P90851	90	Gauge for exhaust valve spindle
P90851	136	Bridge gauge for exhaust valve
P90851	148	Tool for hydraulic piston
P90851	150	Gauge for exhaust valve bottom piece
P90851	161	Lifting tool for exhaust valve spindle
P90851	185	Grinding ring for exhaust valve bottom piece
P90851	077	Cone ring
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500 mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	117	5-way distributor block, complete

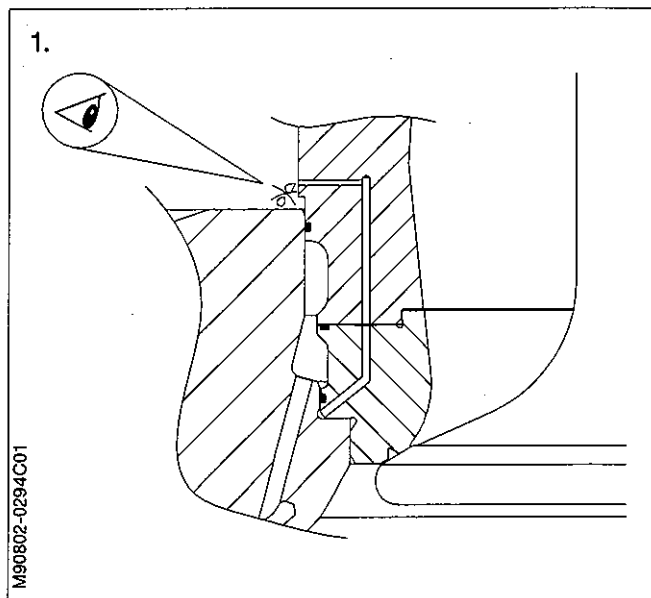
Checks during running:

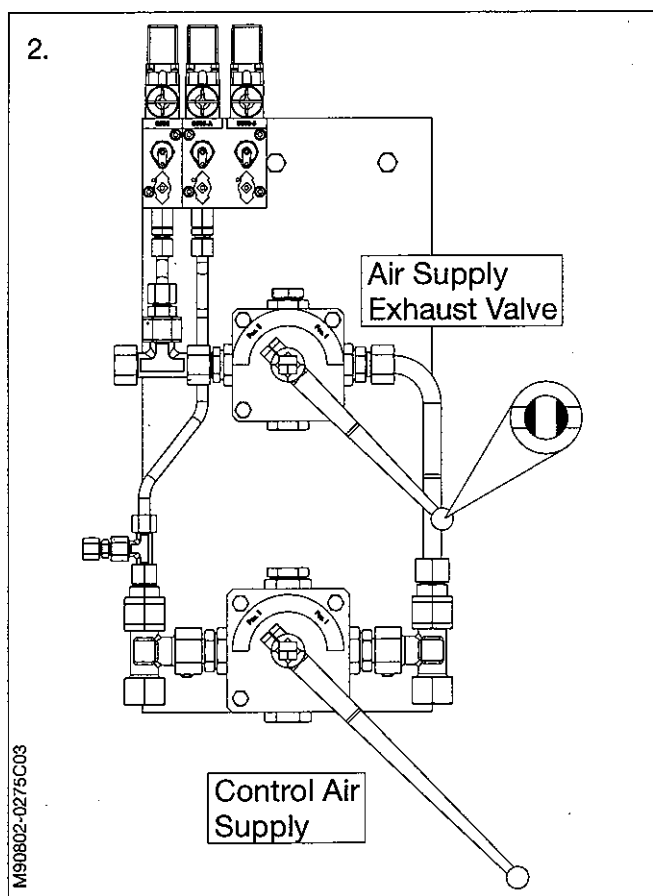
1. Check of bottom piece sealings.

With the exhaust valve mounted on the cylinder cover, check the cooling water inlet and outlet to the cylinder cover and check that exhaust valve is open.

Check the tightness of the sealing rings between the bottom piece and the exhaust valve housing. If water flows from the small bore on the manoeuvring side of the exhaust valve, the lowermost sealing ring or the sealing ring between the bottom piece and the exhaust valve housing is leaking.

If water flows from any of the rings, the exhaust valve must be removed and the sealing rings replaced.



**Check with stopped engine:**

In connection with port stays, at an interval of e.g. one month, an check of all exhaust valves is recommended.

2. Check of spindle drop-down time.

Check the position of the exhaust valve spindles on the MOP-panel.

Shut off and release the air spring on the valve next to the engine-side manoeuvring stand.

Check the drop down time for all spindles:

- drop-down within 30 minutes: check and overhaul, see next step "Check of air spring tightness".
- drop-down between 30 minutes and 1 hour: keep under observation.
- drop-down after 1 hour: OK.

Note!

If the air cylinder is fitted with new sealing rings, the time at which the valve is closed may vary considerably from the above stated, especially for new exhaust valves.

3. Check of air spring tightness.

Connect compressed air to the non-return (A) valve on the air cylinder.

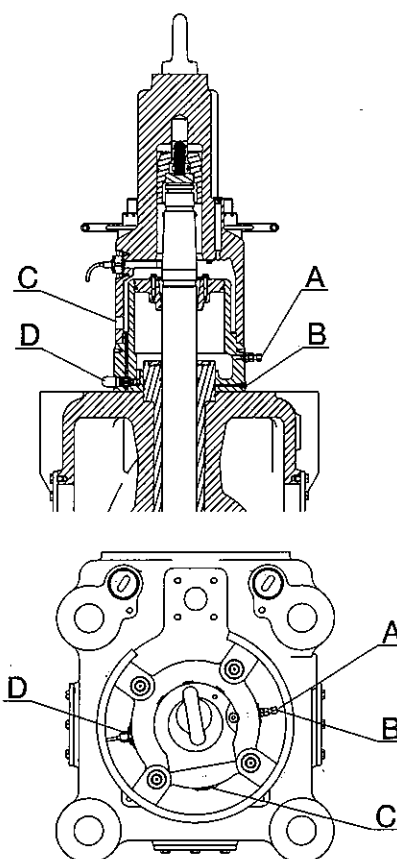
Disconnect and remove the drain oil pipe from the air cylinder (C).

Check if air is coming out from:

- The bore (B): leakage from spindle stem sealing, change and overhaul.
- Hole for drain oil (C): if yes, the leakage comes from the safety valve or the air piston. Check the safety valve (D). If air still is coming out, the leakage comes from the air piston: change and overhaul.
- Remove the air supply to the non-return valve on the air cylinder and check the non-return valve for tightness.

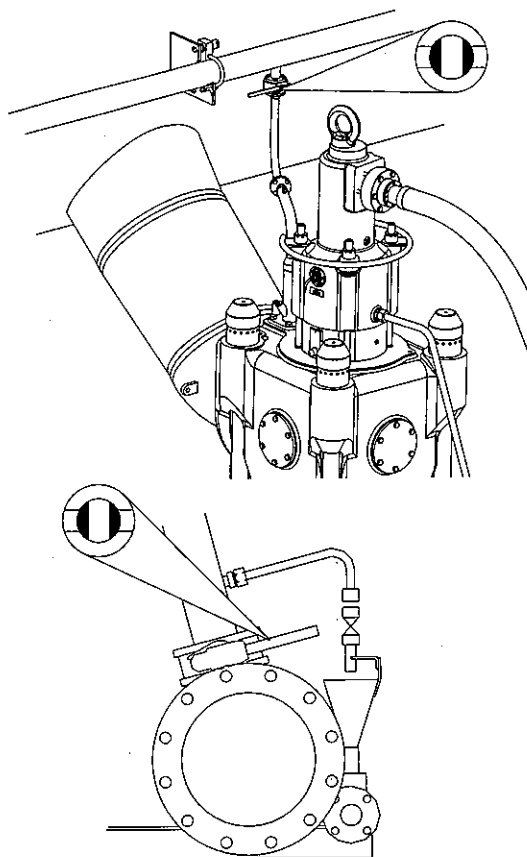
The checks are for guidance only, minor leaks are difficult to detect.

3.



M90802-0294C03

1.

**1. Shut off the cooling water.**

Shut the cooling water inlet and outlet connections, and drain the exhaust valve.

Shut off and relieve the air supply to the exhaust valve.

2. Disconnect the oil pipe connections.

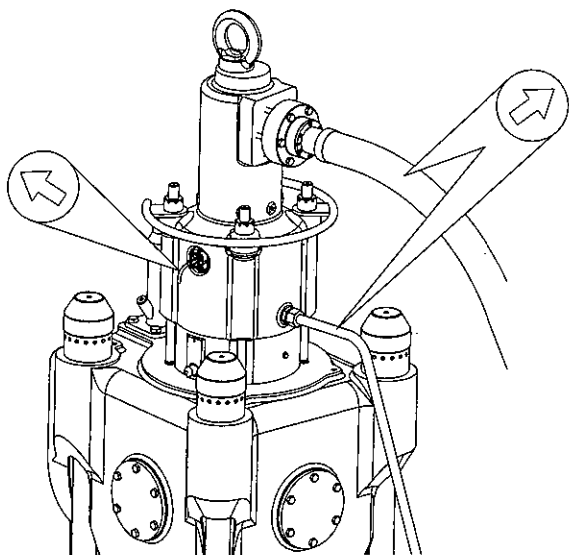
Disconnect the high-pressure pipe for the hydraulic valve actuation.

See Procedure 908-1.2

Disconnect the return oil pipe from the exhaust valve.

Disconnect the electrical plug for the valve position sensor.

2.



3. Disconnect pipe connections.

Disconnect the cooling water connections from the exhaust valve and the air pipe for the air spring.

If necessary, remove the plate jacket and insulation from the intermediate pipe.

Loosen the screws which attach the intermediate pipe to the exhaust valve housing.

Support the intermediate pipe by e.g. a chain block and remove the screws.

4. Intermediate Pipe.

If necessary to lift the intermediate pipe (compensator) alone, use the special tool from tool panel 901.

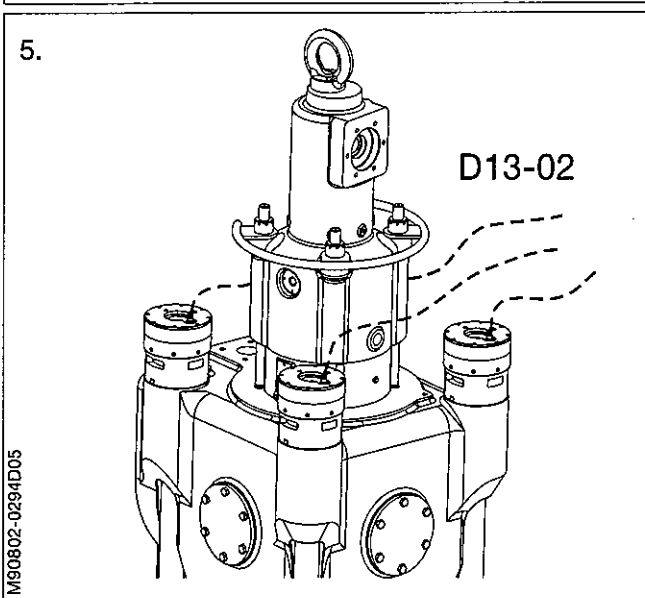
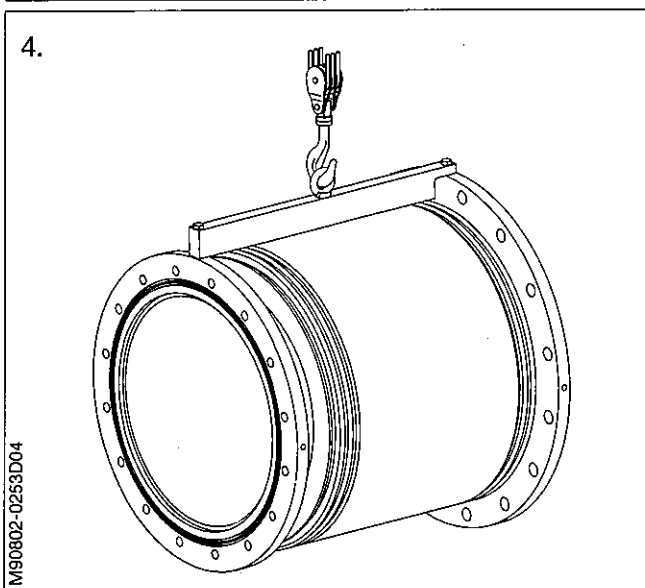
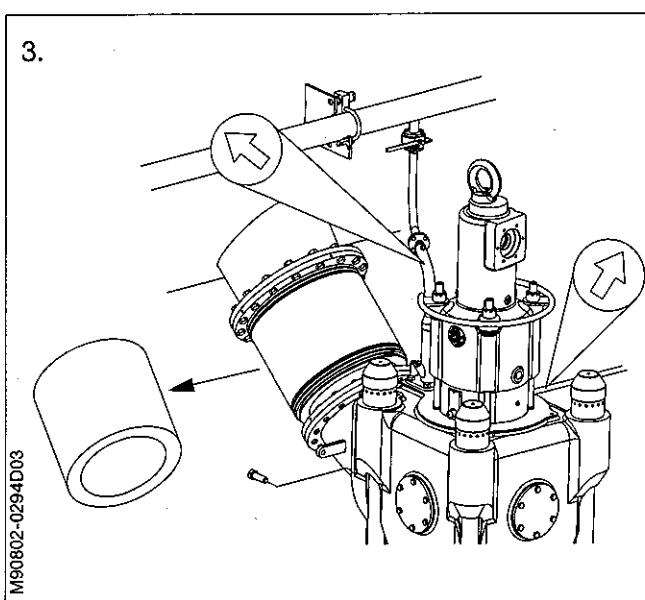
5. Dismantling of nuts.

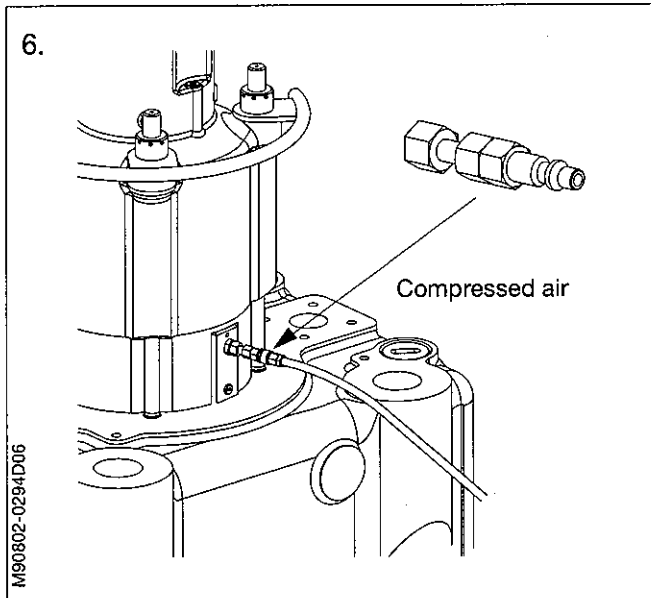
Remove the protective caps from the exhaust valve studs, and mount the four hydraulic jacks.

Connect the high-pressure pump to the jacks by means of the distributor block and four high-pressure hoses.

Bleed the hydraulic system and raise the pressure as stated in Data.

Then loosen and remove the nuts.
See Procedure 913-1.





6. Retaining bottom piece.

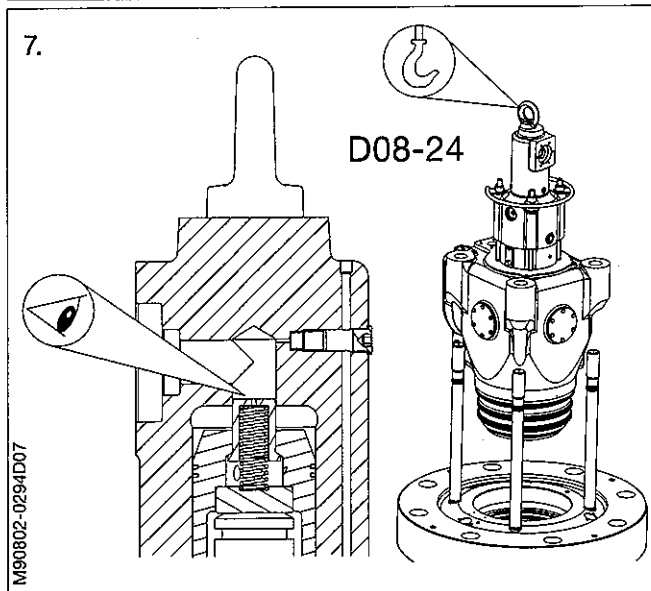
Connect 7 bar working air to the valve air spring, thereby keeping the valve closed when it is removed from the engine.

The 7 bar working air must be connected during the entire lift of the exhaust valve.

The special air coupling is found on tool panel 908.

7. Lifting of exhaust valve.

Attach the crane to the eye bolt fitted on top of the valve and start lifting the exhaust valve.



Caution!

Before attempting to lift the exhaust valve, check the position of the oil piston damper in the top of the oil cylinder.

If the bottom piece has got stuck in the cylinder cover, risky situations can occur in connection with the parts separating with the air spring force still in action. (The bottom piece is not fixed to the valve housing by other means than the force of the air spring.)

This situation can be checked with a look into the oil duct. If the oil piston moves downwards during valve lifting, the parts are not kept together and the alternative lifting procedure must be followed, see steps 8 and 9.

Land the exhaust valve on a wooden plate on the platform.

Disconnect the 7 bar working air hose.

Carefully clean the exhaust valve bore in the cylinder cover and recondition the seating and sealing surfaces of the bore, if required.

See Procedure 901-1.3.

For overhaul of the exhaust valve, see Procedure 908-2.3.

Special lift:

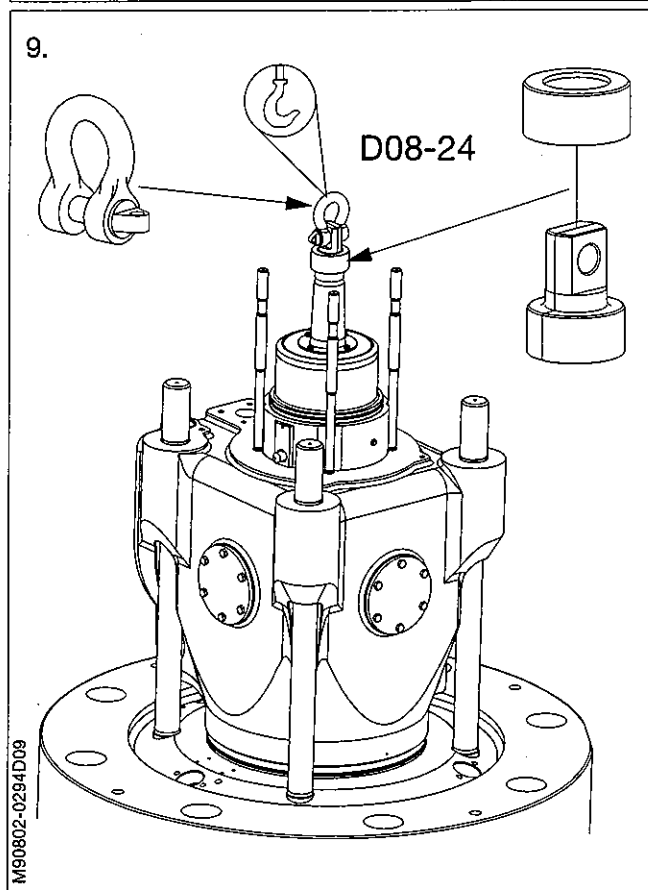
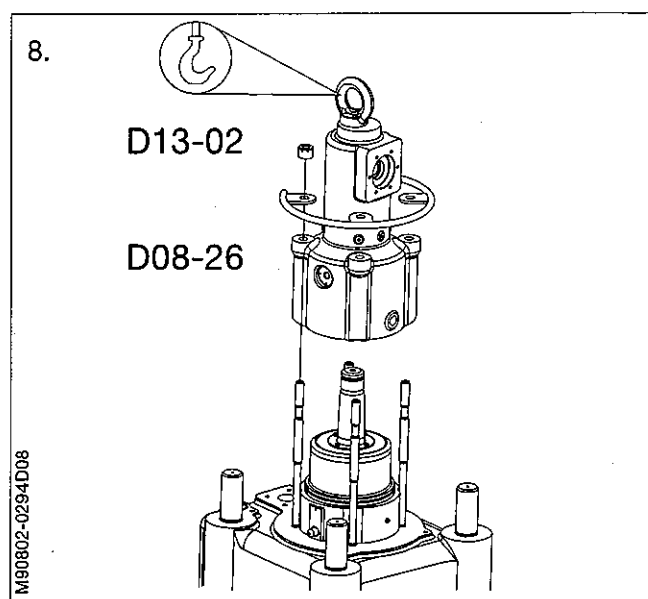
8. Dismantle the oil cylinder.

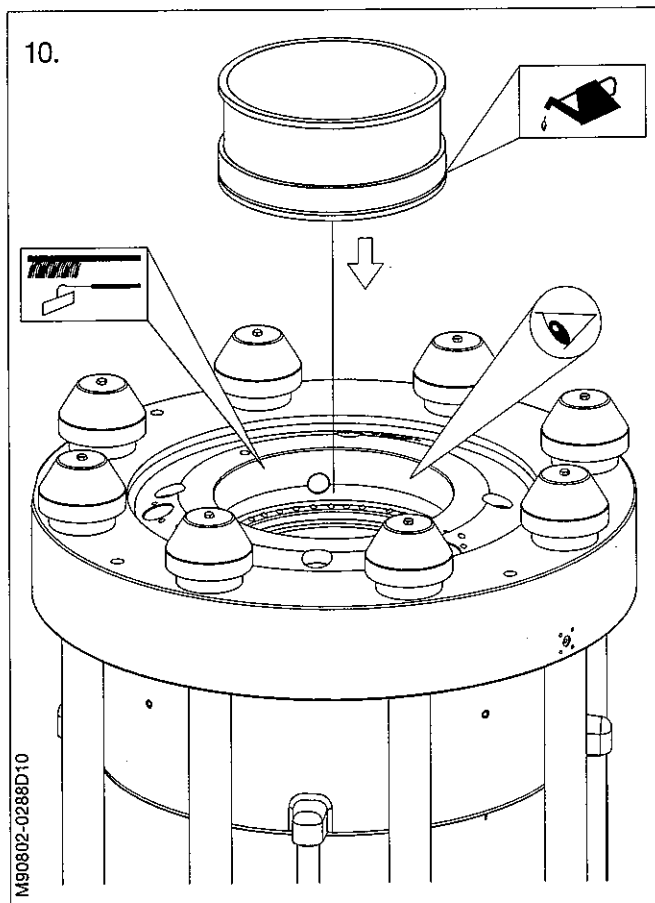
Remove the four hydraulic nuts and the safety strap from the oil cylinder.

Attach the crane hook to the oil cylinder. Lift the oil cylinder away and place it on a wooden support.

9. Spindle lift.

Mount the spindle lifting tool on the exhaust valve spindle and carefully lift the exhaust valve away. The tool is found on the tool panel 908.





Cylinder liner inspection through exhaust valve bore (optional):

Note!

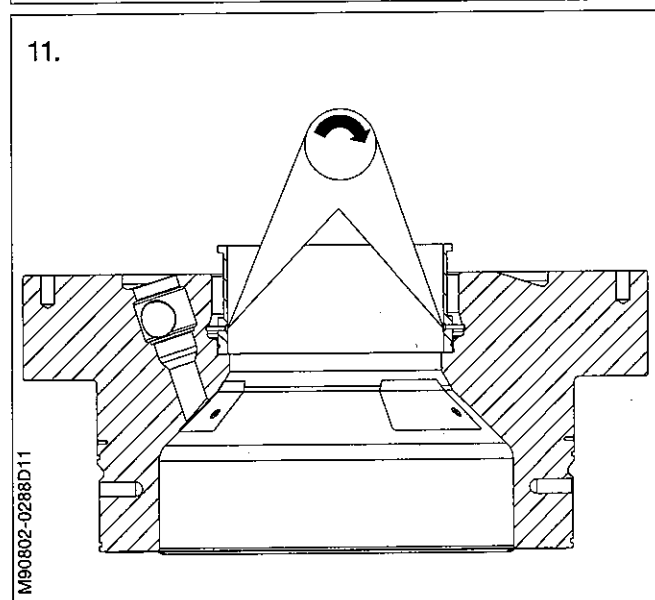
It is recommended by MAN Diesel, to remove the cylinder cover before cylinder liner inspection. However it is permissible to inspect the cylinder liner through the exhaust valve bore, when the special safety ring is installed in the cylinder cover. (Optional tool)

10. Mount safety ring.

Before mounting the tool, clean and inspect the exhaust valve bore. Check and lubricate the o-ring in the lower groove of the safety ring, and carefully land the tool inside the exhaust valve bore.

Caution!

The pictures in this section are for guidance only. It is very important, that the fuel valves and starting air valve are mounted in the cylinder cover while performing cylinder liner inspection through the exhaust valve bore.



11. Tighten screws.

When the safety ring is centered in the exhaust valve bore and aligned with the cylinder cover surface, evenly apply pressure on top of the safety ring until the tool lands in the bottom of the exhaust valve bore.

Mount and tighten the two screws in the safety ring to ensure correct mounting of the tool.

Check and assess the condition of the cylinder liner according to the description given in Volume I, Chapter 707.

12. Dismount safety ring.

When the cylinder liner inspection is completed, remove the two screws from the safety ring and lift away the tool from the cylinder cover.

1. Oil cylinder

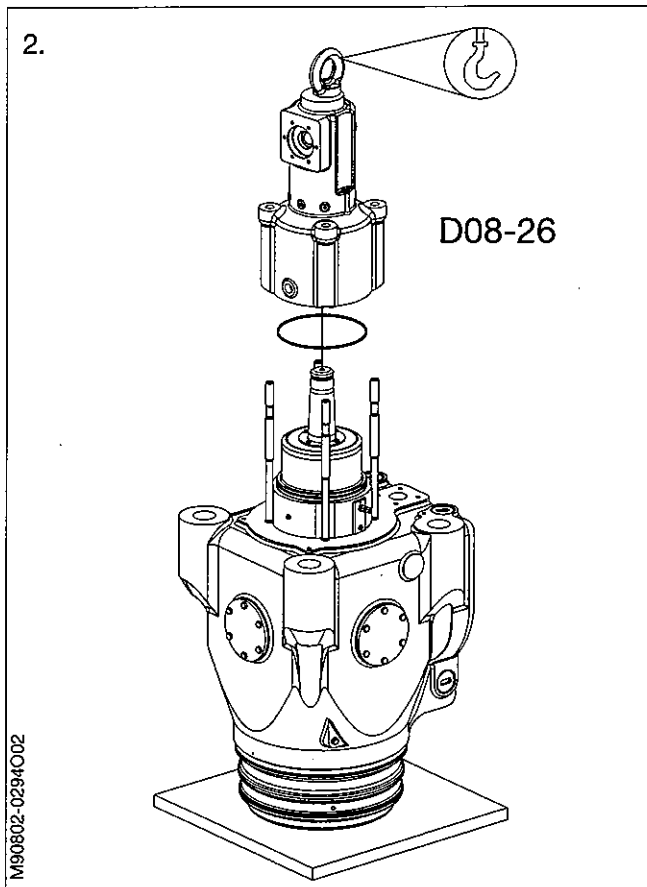
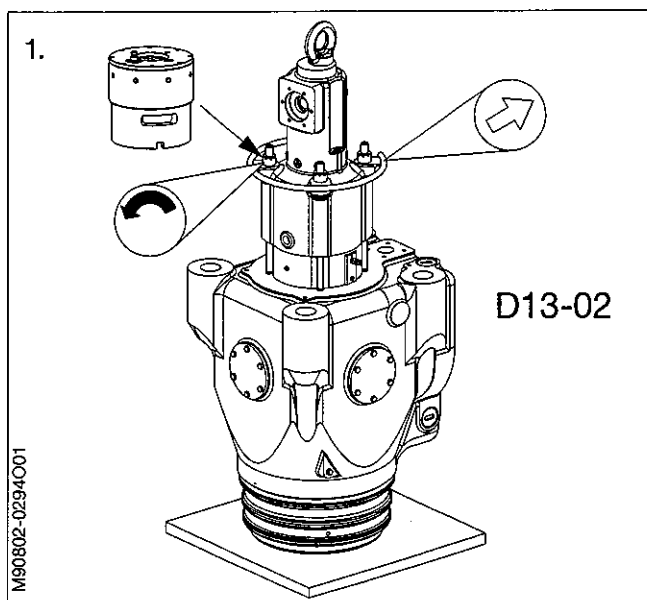
Place the exhaust valve on a wooden support on the platform.

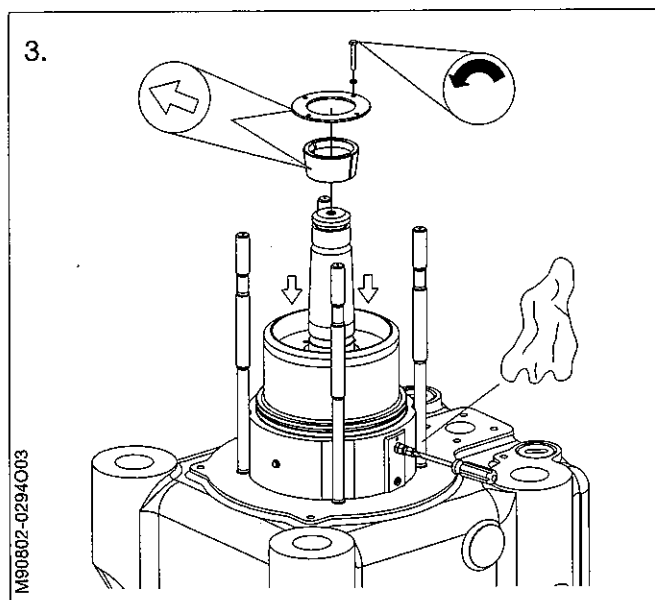
Fit the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in Data. Loosen and remove the nuts.

For use of hydraulic tools, see also Procedure 913-1.

Remove the the safety strap from the oil cylinder.

2. Lift away and place the oil cylinder on a wooden support.

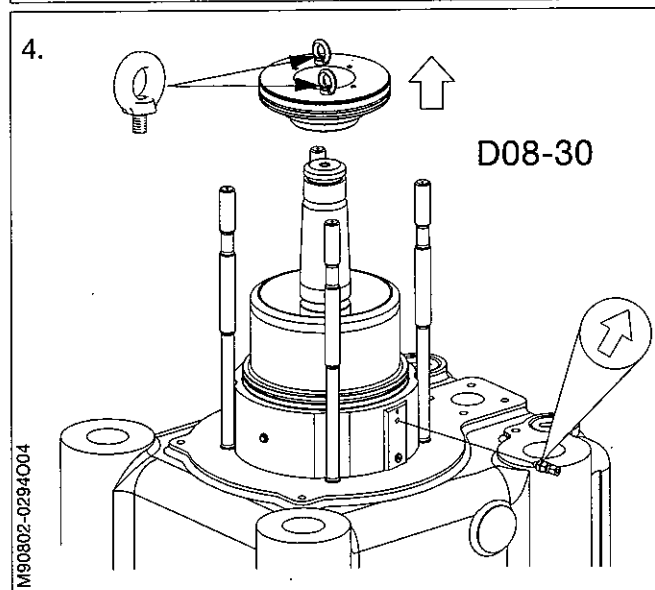


**3. Conical locking ring.**

Relieve the air pressure through the non-return valve from below the piston. Use a small screwdriver to press the ball into the non-return valve. Cover the non-return valve with a rag to catch the oil drops.

Remove the four screws from the flange on top of the air piston and dismount the flange.

Loosen the air piston from the conical locking ring by means of a tin hammer, and remove the conical locking ring.

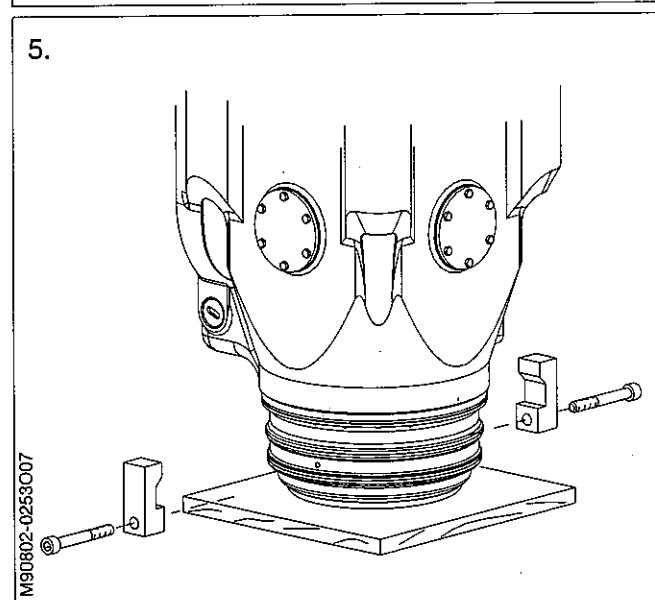
**4. Air piston.**

Remove the non-return valve.

Mount two eyebolts in the top of the air piston. Remove the air piston from the air cylinder.

5. Retaining tool.

Mount the retaining tools for the bottom piece.



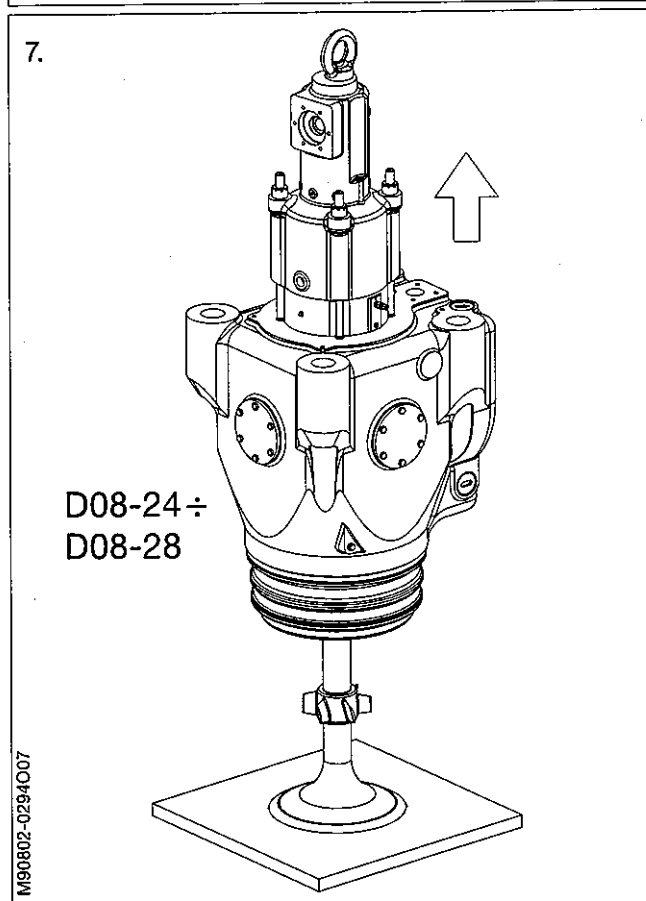
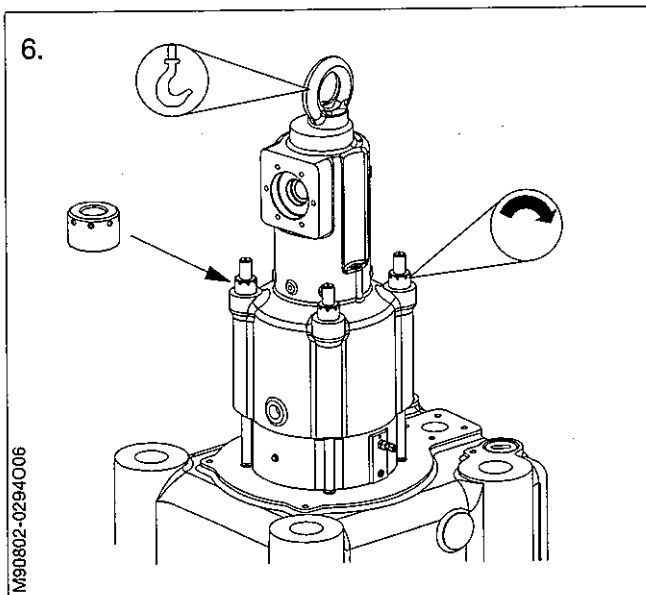
6. Mount oil cylinder for lifting.

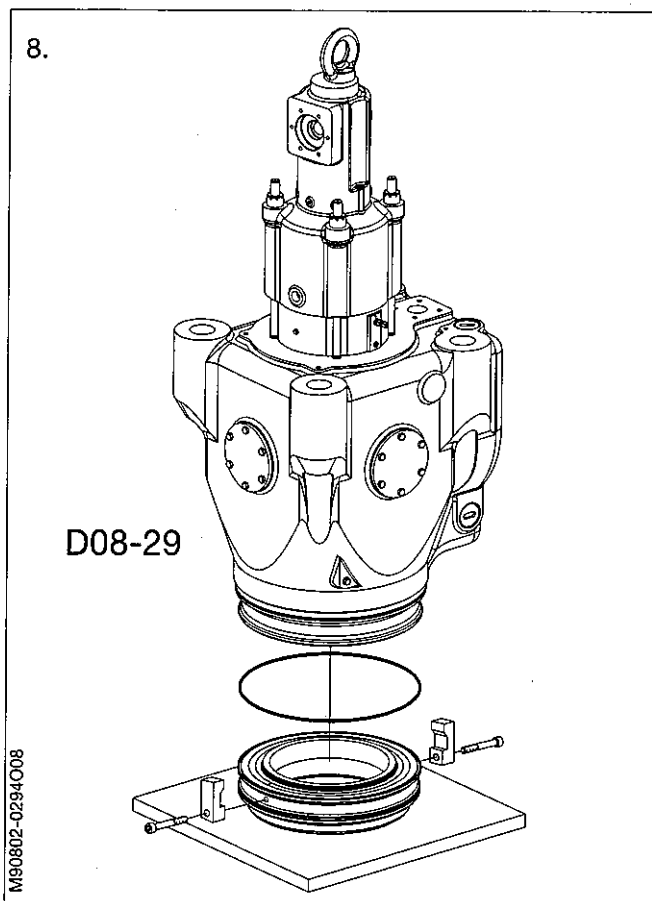
Use the oil cylinder as a lifting tool for the exhaust valve housing. Lift the oil cylinder with the crane, and guide it down over the studs for the oil cylinder. Mount the four nuts so that the load from the valve housing is evenly distributed.

7. Lift valve housing

Lift the oil cylinder and the valve housing clear of the exhaust valve spindle.

Land the valve housing on a wooden support and let the oil cylinder hang in the crane.



**8. Bottom piece**

Unscrew and remove the special tool which retains the bottom piece. Lift the valve housing approx. 10 mm.

If the bottom piece has become stuck, use a tin hammer to release it.

Lift the valve housing away and land it on a couple of wooden planks.

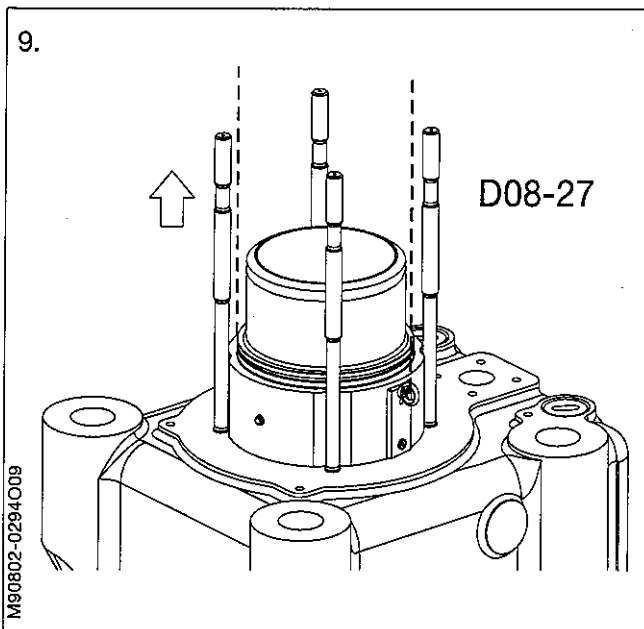
Remove and discard the O-ring from the groove in the top of the bottom piece.

Remove the oil cylinder.

9. Air cylinder.

Fit two eye bolts in the air cylinder and lift off the air cylinder.

Remove and discard the O-ring on the air cylinder.



Guide Bushing:

10. Seals.

Remove the spring disc on top of the guide bushing.

Remove and discard the O-rings and the inside sealing ring.

Inspect the spring disc for knocks and burrs. If necessary replace the disc.

11. Inspect guide bushing.

Clean the exhaust valve housing.

Inspect the bushing in the spindle guide for wear and measure the top and bottom diameters. See *Data*.

12. Bushing renewal.

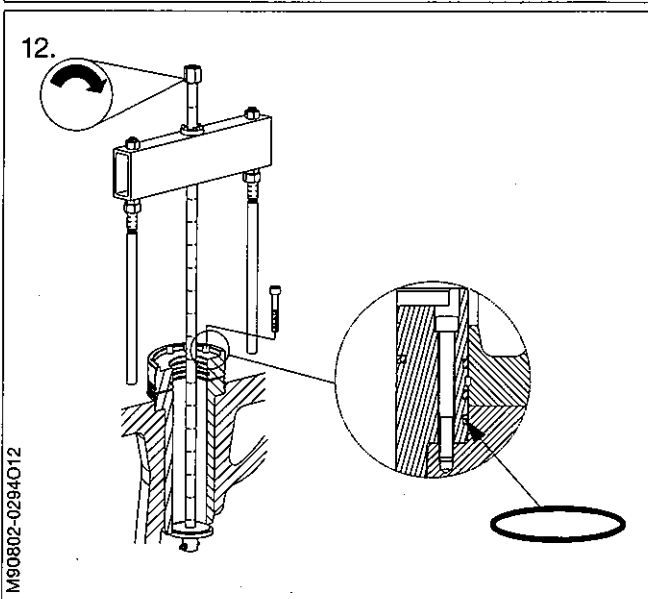
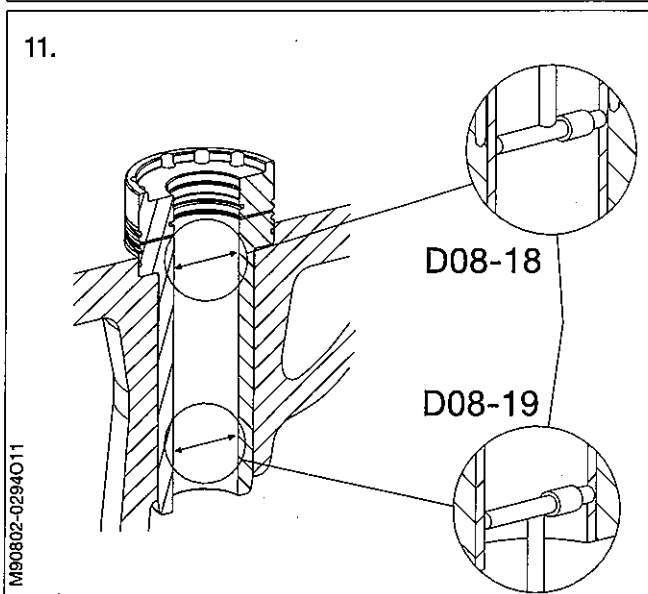
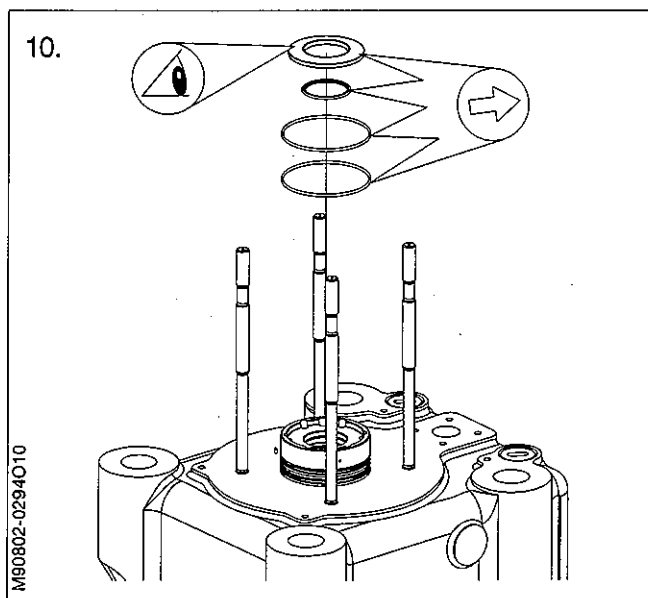
If it proves necessary to replace the bushing, knock out the bushing with a hammer and a suitable mandrel.

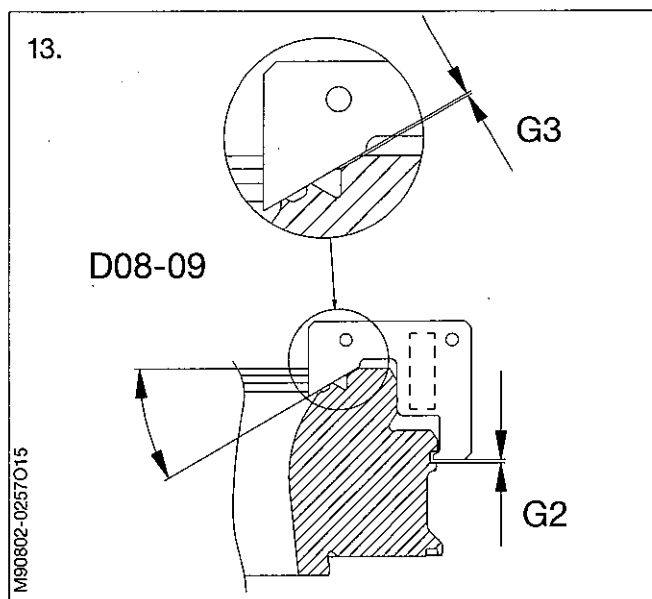
Alternatively, if the extractor tool is available, mount the extractor tool and pull up the bushing.

The extractor tool is optional, and can be ordered as sparepart.

When a new bushing is mounted, fit a new O-ring for sealing between bushing and exhaust valve housing.

Fit and tighten the screws for the bushing.



**Bottom piece:****13. Bottom piece inspection.**

Inspect the seating of the bottom piece **carefully** for damage and check with the bottom piece template.

Note!

Before using the bottom piece template, thoroughly clean the contact faces on the valve housing w-seat with a steel brush.

All measurements should be taken at four diametrically opposite points on the circumference of the bottom piece seating.

Small dent marks in the bottom piece seating are acceptable and need not be ground away, provided that the dent marks do not allow blow-by of exhaust gas from the combustion chamber to the exhaust gas receiver.

For further evaluation of the bottom piece seating, see also chapter 707 in the instruction book, Volume I, Operation.

Take measurements **G2** and **G3**, using a feeler gauge. Compare the results with the figures stated in Data D08-11 and D08-12.

IF burn marks are visible on the bottom piece seating OR **G3** does not equal D08-12, THEN the bottom piece seat must be ground.

IF the template rests on the lower surface in the groove, i.e. **G2** = 0, THEN the bottom piece seating must be discarded and replaced with a new bottom piece. Further grinding or reconditioning is not recommended.

14. Bottom piece grinding.

If it is necessary to grind the seating, proceed as follows:

Before placing the bottom piece on the grinding machine, turn the grinding head away from the grinding table.

Fit and secure the bottom piece in the grinding machine. Using a dial gauge, check that the bottom piece is correctly centered.

Adjust the grinding head to achieve the correct grinding angle as stated in Data.

Note!

As the grinding angle is very important for the correct operation of the exhaust valve, make absolutely sure that the grinding head is correctly adjusted.

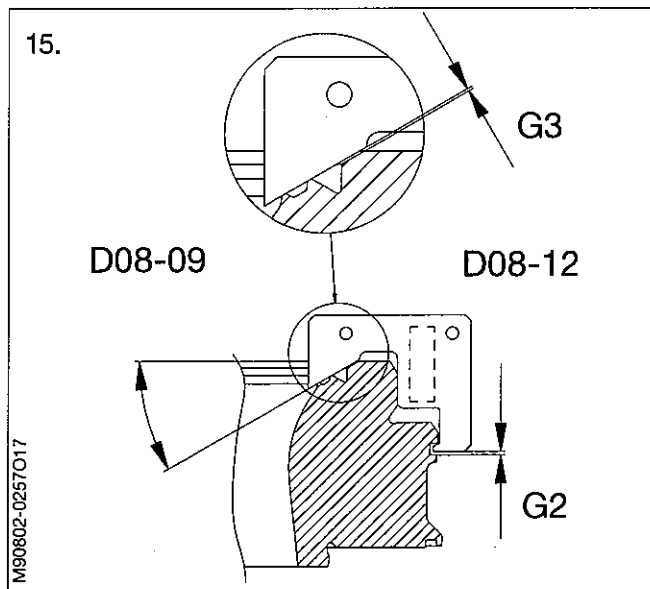
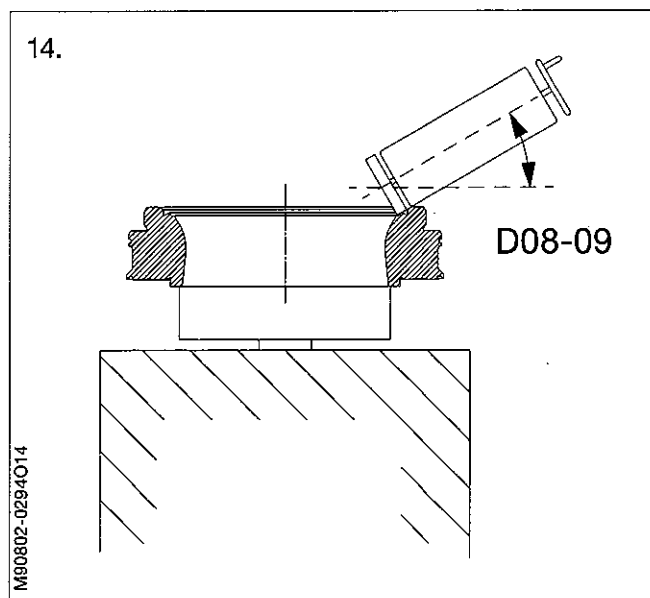
Regarding the use of the grinding machine, see separate instructions from the grinding machine manufacturer.

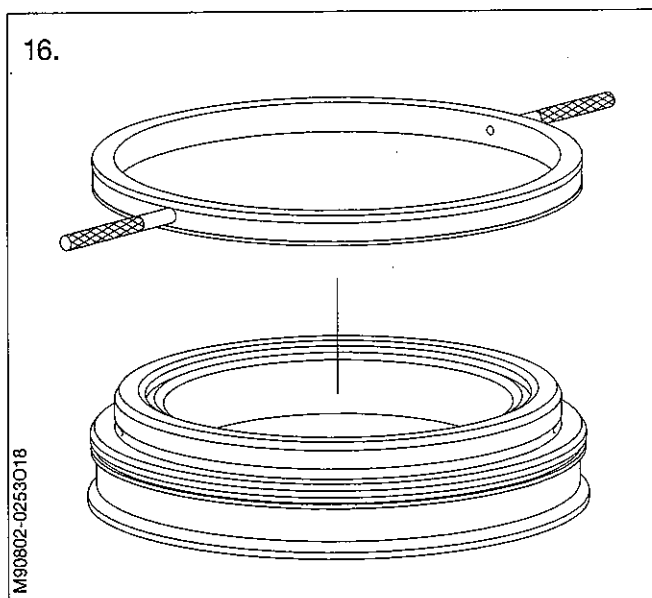
15. During grinding.

During the grinding, use the bottom piece template frequently to ensure that maximum grinding is not exceeded.

After grinding, inspect the bottom piece seating again, using a feeler gauge and the bottom piece template, to measure how much material has been ground away.

Grind the recess so that gap **G3** equals D08-12 as stated on the Data sheet.



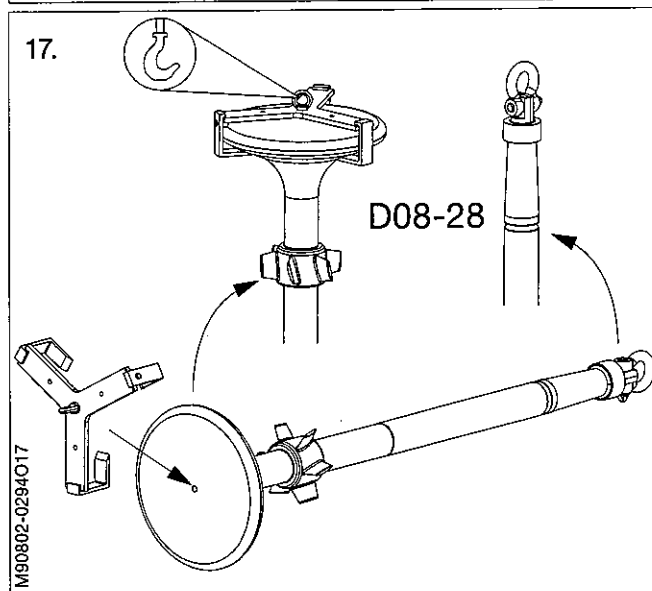
**16. Bottom piece sealing face.**

After grinding the inside seating of the bottom piece, grind the outside seating using carborundum 200 and the special grinding tool.

Note!

Turn the special grinding tool **by hand**, alternately turning clockwise and anti-clockwise.

Grind until a smooth surface is achieved.
Clean the bottom piece.

Valve spindle:**17. Spindle lift.**

When lifting or handling the exhaust valve spindle, use the special valve spindle lifting tools.

When turning the exhaust valve upside down, mount the small lifting tool in the top of the spindle. Lift the spindle with the engine room crane and land it on one side on a wooden support (e.g. a piece of plywood).

Fit the large lifting tool designed for the bottom of the spindle. Lift up the valve spindle as shown in the sketch.

18. Spindle inspection.

Inspect the seating of the valve spindle for burn marks.

Check the burn-off F1 of the valve spindle by measuring along the spindle template from point A to point D and in point E.

Note!

Before using the spindle template, thoroughly clean the contact faces on the valve spindle with a steel brush.

All measurements should be taken at four diametrically opposite points on the circumference of the valve spindle. Make sure that the most burned-off point is measured.

Small dent marks in the valve spindle seating are acceptable and need not be ground away, provided that the dent marks do not allow blow-by of exhaust gas from the combustion chamber to the exhaust gas receiver.

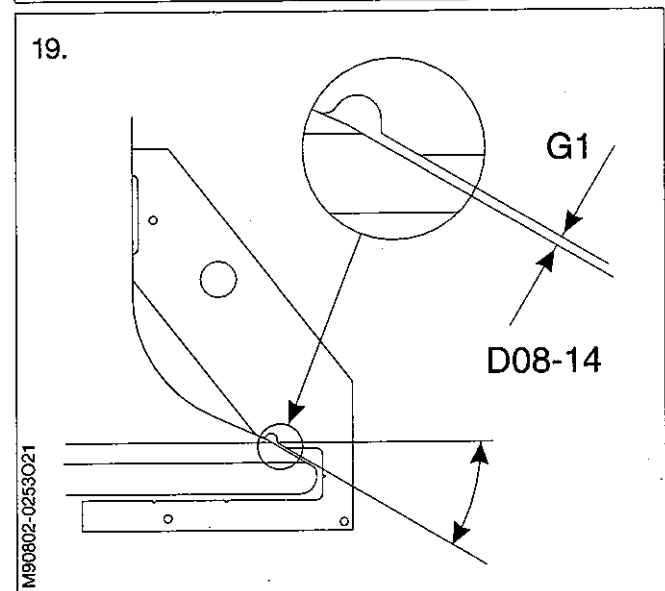
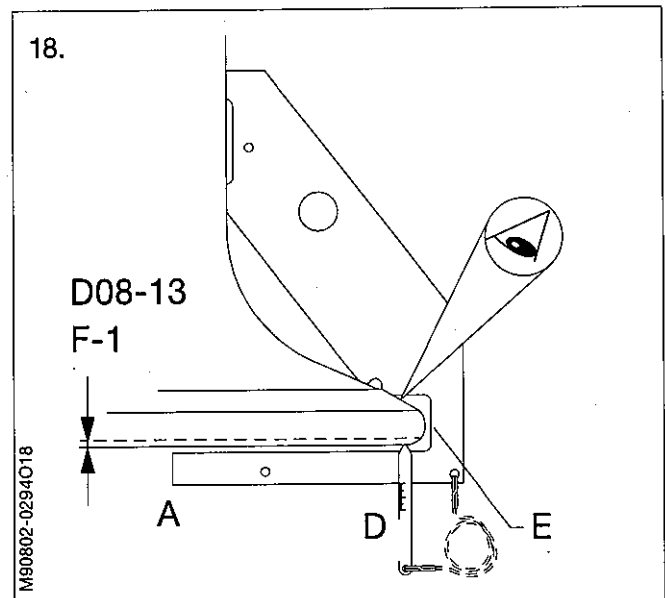
For further evaluation of the valve spindle seating, see also Chapter 707 in the instruction book, Volume I, Operation.

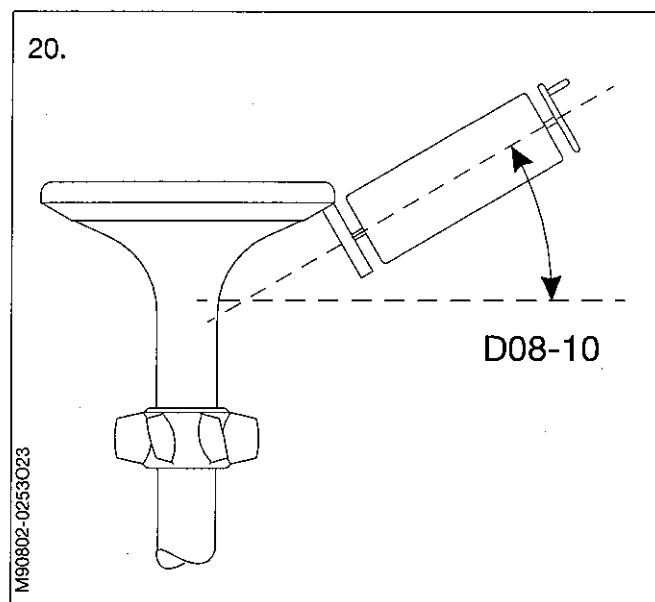
19. Criterias for reconditioning.

IF burn marks are visible on the seating, the spindle must be ground.

IF gap **G1** exceeds the maximum allowable value D08-14, see Data, OR the burn-off **F1** exceeds the maximum allowable burn-off D08-13, the spindle must not be ground. Instead the spindle must be reconditioned.

Contact MAN Diesel & Turbo for advice on reconditioning.



**20. Grinding angle.**

Mount and secure the spindle in the grinding machine. Using a dial gauge, check that the spindle is correctly centered.

Adjust the grinding head to achieve the correct grinding angle as stated in Data.

Note!

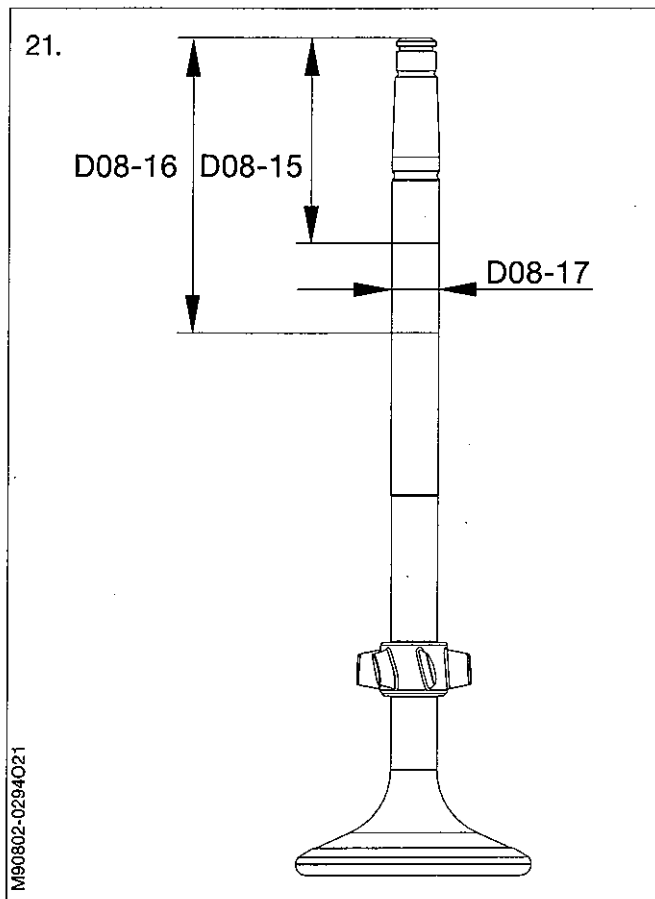
As the grinding angle is very important to the operation of the exhaust valve, make absolutely sure to adjust the grinding head correctly.

Regarding the use of the grinding machine, see separate instructions from the grinding machine manufacturer.

During grinding, measure gap **G1** frequently. The max. grinding of the spindle, see Data, must not be exceeded.

If the max. grinding limit is reached, and burn marks are still visible on the seating of the spindle, contact MAN Diesel & Turbo for advice on reconditioning.

Clean the spindle.

**21. Spindle stem.**

Check the spindle stem for wear in the area D08-15 to D08-16 measured from the top of the spindle.

If the stem diameter is less than stated in Data, or the hard facing layer is worn away, contact MAN Diesel & Turbo for advice.

22. Mount seals.

Mount the O-rings and sealing ring on the spindle guide.

Note!

Make sure to mount the sealing ring correctly, see the sketch.

Mount the spring disc on top of the spindle guide.

23. Retaining tools.

Mount the oil cylinder as a lifting tool on the valve housing.

Mount a new O-ring in the groove in the top of the bottom piece.

Land the exhaust valve housing on the bottom piece.

Install and tighten the bottom piece retaining tools.

24. Spindle mounting.

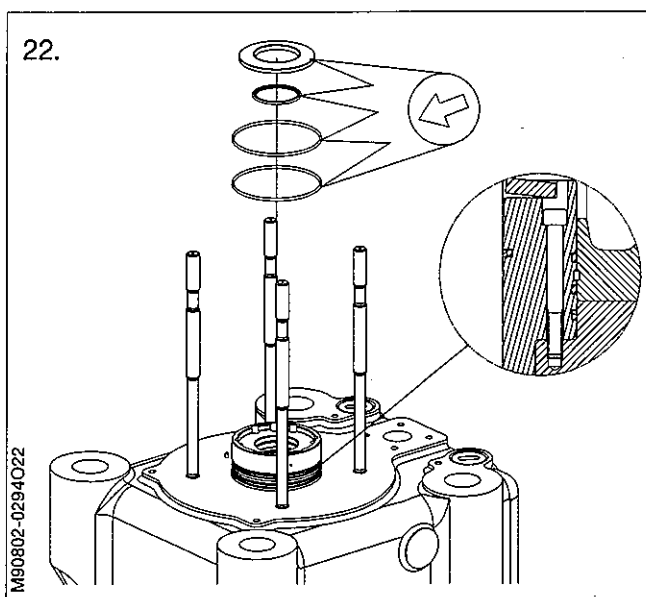
Lubricate the inside of the bushing in the spindle guide with plenty of lubricating oil.

Use the oil cylinder as a lifting tool for the exhaust valve housing.

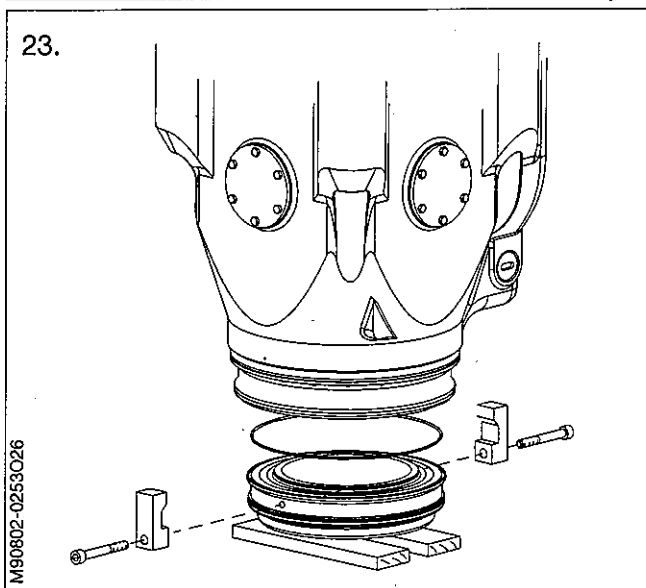
Carefully land the exhaust valve housing with the bottom piece on the exhaust valve spindle.

Remove the oil cylinder.

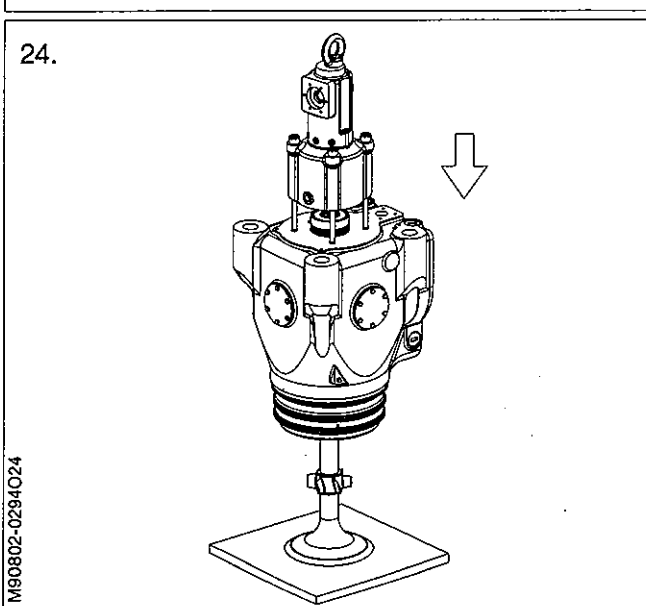
22.



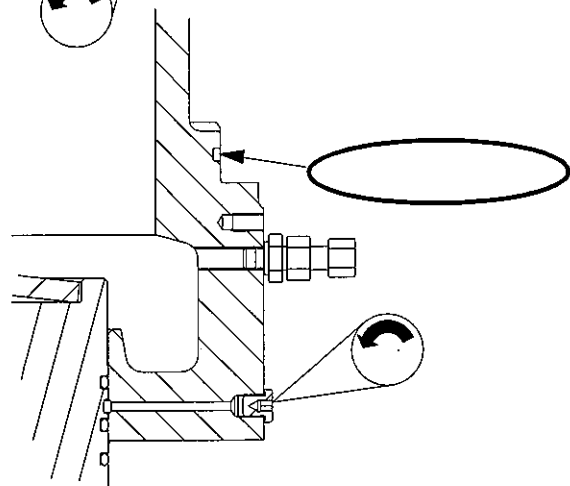
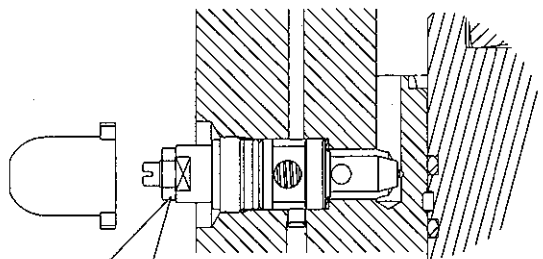
23.



24.



25.



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Air Cylinder:**25. Air cylinder.**

Disassemble the safety valve from the air cylinder, use the machined faces to unscrew the valve.

Clean the air cylinder carefully inside and outside including all bores.

Fit a new O-ring in the groove on the outside of the air cylinder.

26. Safety valve.

Place the safety valve in the pressure testing device. Connect the testing device with the high pressure pump by means of a hose.

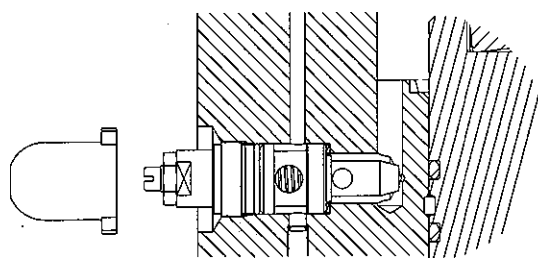
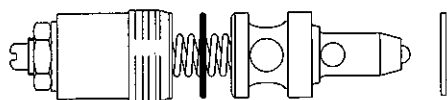
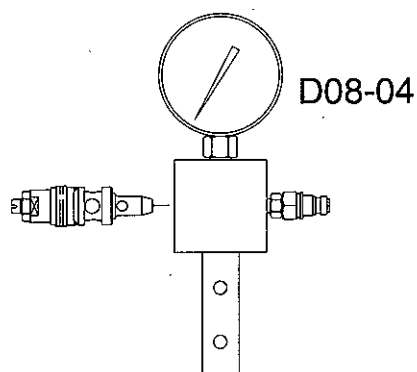
Check the opening pressure, see *Data D08-04*.

If the opening pressure is not correct, loosen the lock nut and, using a screwdriver, adjust the safety valve until the correct pressure is indicated. Tighten the lock nut and test the opening pressure once more.

Fit a new gasket and a new O-ring on the safety valve. Install the safety valve in the bore near the bottom of the air cylinder. When installing the safety valve in the air cylinder, only use the machined faces on the valve housing and tighten, see *Data*.

Finally, mount the protective cap.

26.



D08-07

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27. Air cylinder mounting.

Lubricate the O-rings on the spindle stuffing box.

Carefully land the air cylinder on the exhaust valve housing and check its correct engaging with the locating pin.

Note!

Take care not to damage the O-rings on the outside of the stuffing box.

Air Piston:

28. Air piston seals.

Check the teflon guide ring and teflon sealing ring for wear, if it is necessary to replace the sealing rings on the air piston, cut them and remove them.

Be careful not to damage the edges of the ring grooves in the piston.

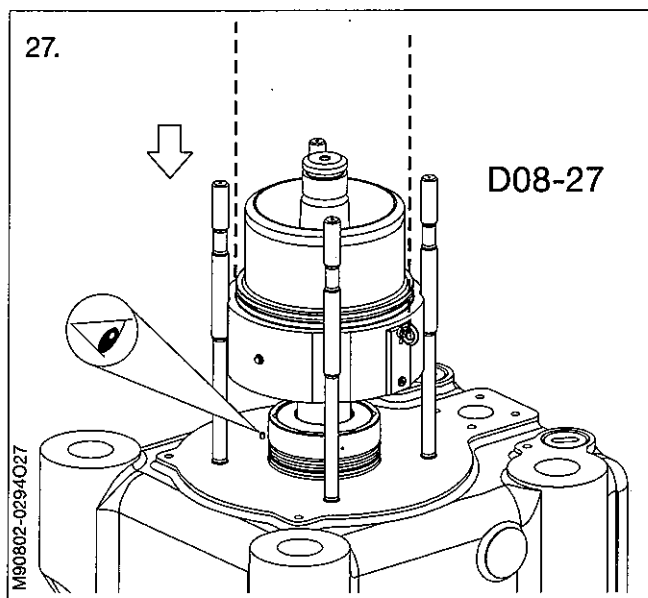
Note!

Before mounting, heat the new teflon rings in 100°C hot water for at least five minutes. When mounting the teflon rings, **be careful** not to damage the running surfaces.

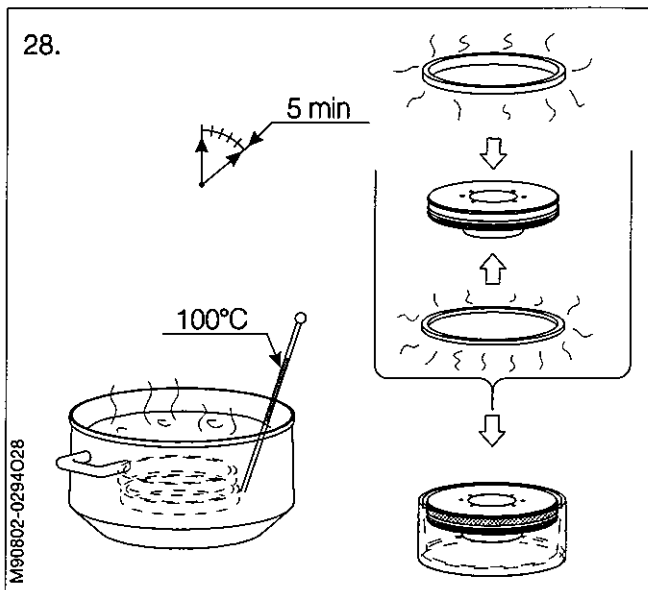
After mounting, compress the teflon rings by means of the conical ring from tool panel 908. This is done by pressing the air piston through the conical ring.

Fit a new O-ring in the inner groove of the air piston.

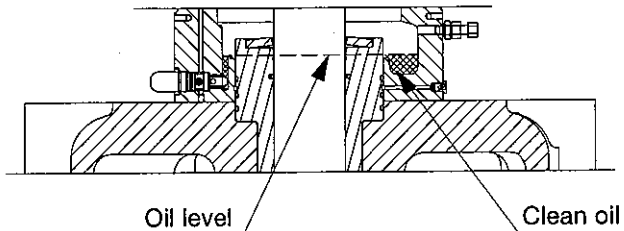
27.



28.



29.



29. Air piston mounting.

IMPORTANT!

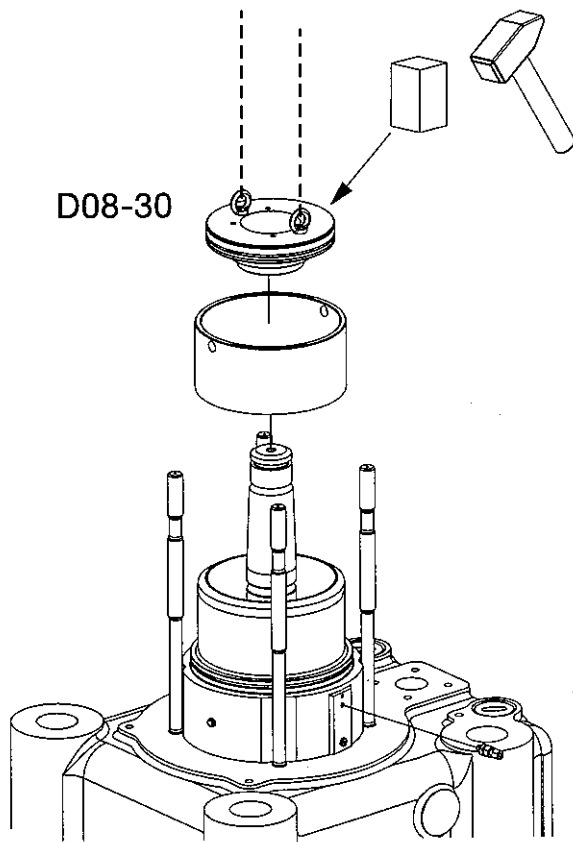
Fill the bottom of the air cylinder up to the drain hole with clean lubricating oil.

Fit the conical guide ring for the air piston on the air cylinder. Lubricate the guide ring and the running surface of the air cylinder. Lower the air piston down over the valve spindle into the air cylinder.

Use a nylon block and a hammer to press the air piston down into the cylinder.

Remove the conical guide ring from the air cylinder.

Mount the non return valve for compressed air.



D08-30

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30. Locking ring.

Fit the two-part conical locking ring and apply compressed air below the air piston to lift the piston.

Mount the flange on top of the air piston and, using four screws, tighten together the air piston and the flange.

On valves designed with securing bolts, secure the bolts. See *Procedure 913-7*.

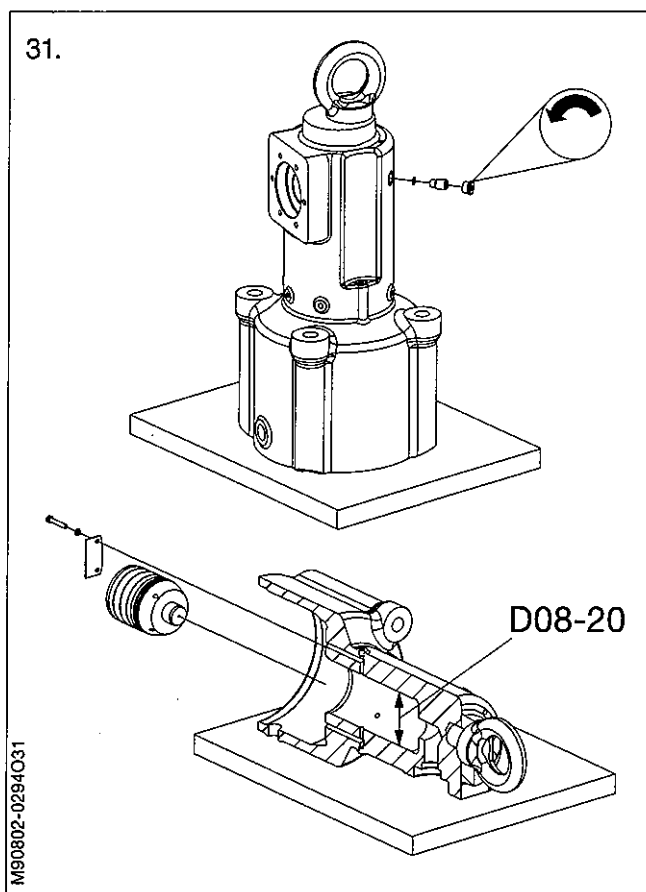
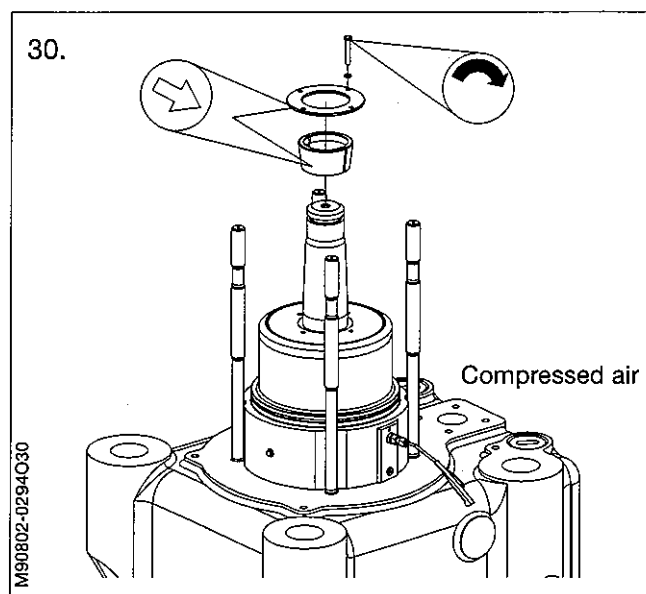
Oil Cylinder:

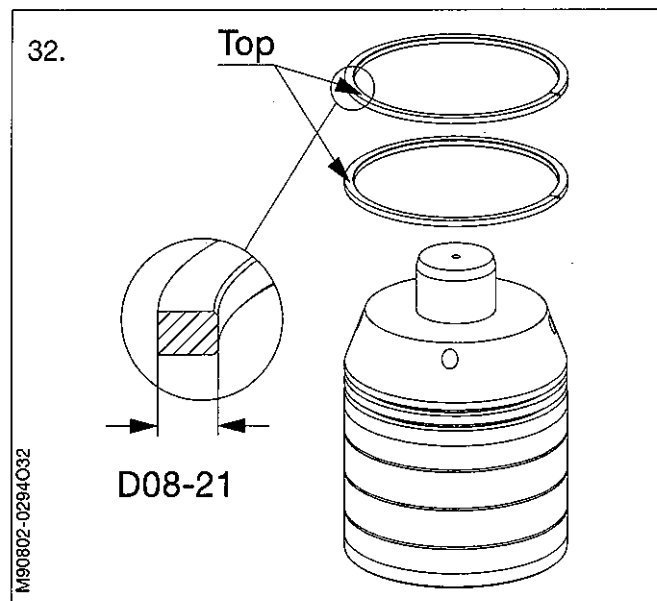
31. Oil cylinder.

Place the oil cylinder in a horizontal position.

Remove the plug screw from the bore of the orifice plug. Unscrew and clean the orifice plug. Remove and discard the sealing disc. Check and clean the bore for the orifice plug in the top of the oil cylinder.

Remove the flange and take out the actuator piston. Inspect the inside of the oil cylinder for scoring. Measure the cylinder diameter. If the diameter of the oil cylinder exceeds Data D08-20, send the complete oil cylinder to an authorised MAN Diesel & Turbo workshop for reconditioning.



**32. Oil piston.**

Remove the piston rings from the oil piston and check them for wear. If the thickness of the rings has worn down to the minimum, see Data, discard the rings and fit new ones.

Check that the **TOP** mark on the piston rings faces upwards.

33. Oil piston damper check.

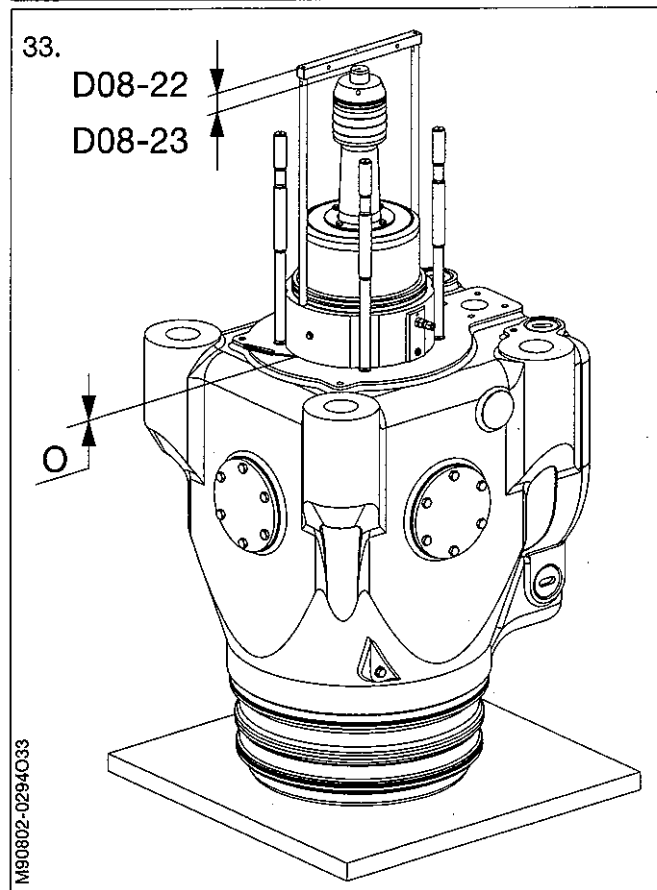
Fit the piston on top of the spindle and check the mesh of the damper piston by checking the height of the damper relative to the oil cylinder.

Connect compressed air supply to the space below the air piston, in order to keep the valve closed, and to keep the air cylinder in close contact with the valve housing.

Place the measuring tool on the air cylinder across the piston.

Check the mesh of the damper piston by checking the distance from the upper edge of the crossbar to the top of the damper piston. See Data.

If the measurement is outside the value stated in Data, an adjustment must be made by changing the disc in the damper piston as follows:



34. Oil piston damper adjustment.

Place the piston in the special tool. Press out the damper piston and the disc using the centre screw.

Inspect the spring and the piston.

A thicker disc decreases the mesh and a thinner disc increases the mesh.

Assemble the damper piston with the new disc in the special tool. Place the piston upside down in the tool and press the disc into place in the piston.

Check the mesh once more.

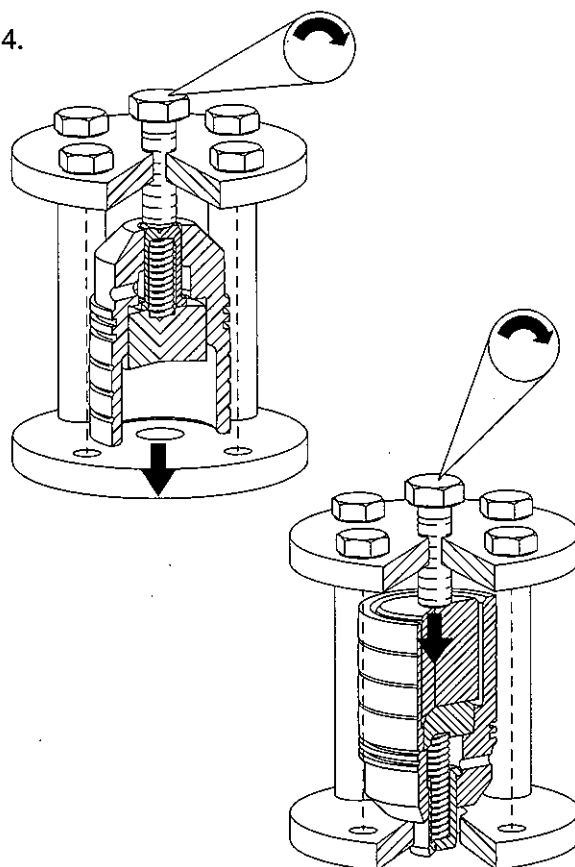
35. Oil cylinder assembly.

Mount the actuator piston and the flange in the oil cylinder. Tighten and lock the screws.

Fit a new sealing disc in the bore for the orifice plug. Screw the orifice plug into the bore and mount the plug screw.

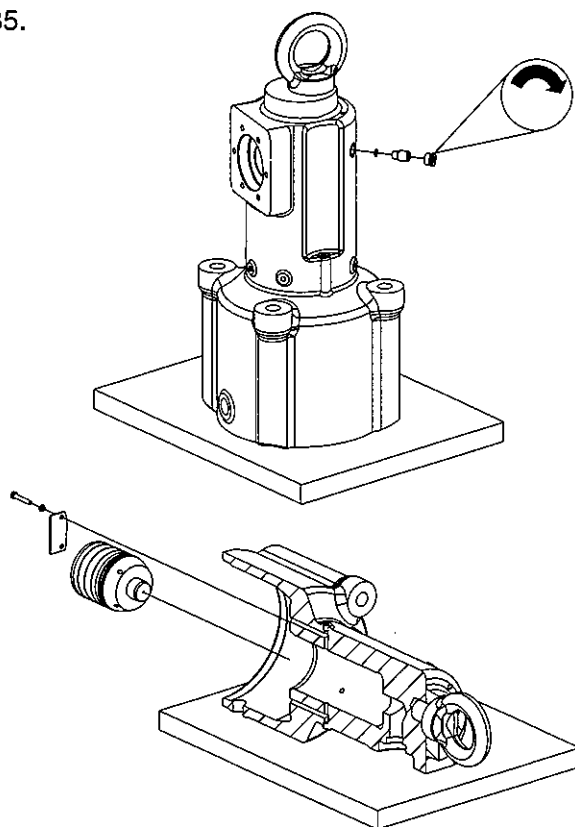
Return the oil cylinder to an upright position.

34.

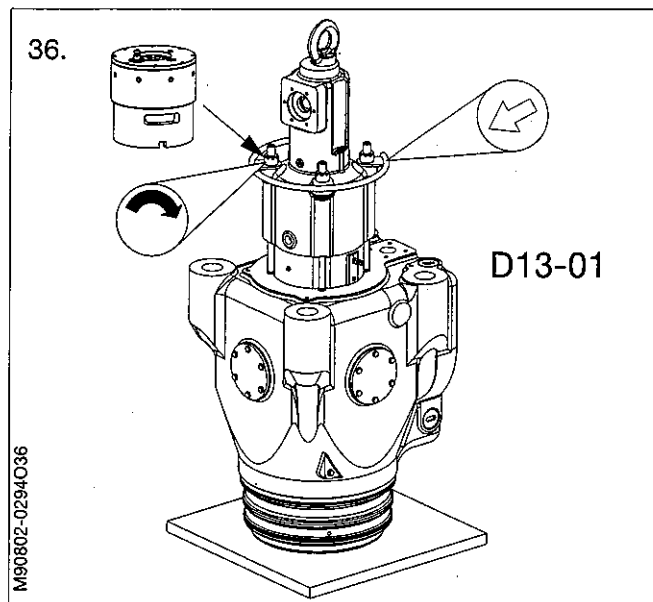


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35.



M90802-0294O35

**36. Oil cylinder mounting.**

Check that a new O-ring has been mounted in the outer groove of the air cylinder.

Mount the overhauled oil cylinder and the safety strap on top of the air cylinder.

Tighten two nuts at a time diagonally.

Screw the nuts onto the studs. Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the jacks to the tightening pressure, as specified in Data. Tighten the nuts and remove the hydraulic jacks and the spacer rings.

For the use of hydraulic tools, see also Procedure 913-1.

Checks Before Mounting

1. Checks before mounting.

Before mounting an overhauled exhaust valve on the engine, it is recommended that the valve is checked and prepared as follows:

Check the oil level in the bottom of the air cylinder. Unscrew and remove the non-return valve and the safety valve.

Fill oil into the non-return valve hole, until oil flows out from the safety valve hole.

Refit the two valves again.

Connect compressed air to the air cylinder to close the valve.

Fit the bottom piece retaining tools.

Lift up the valve with the engine room crane.

Check that a 1.0 mm feeler gauge can be inserted about 15 mm into gap **G3**, to ensure that there is a clearance between the outer parts of the seating faces of valve housing and spindle.

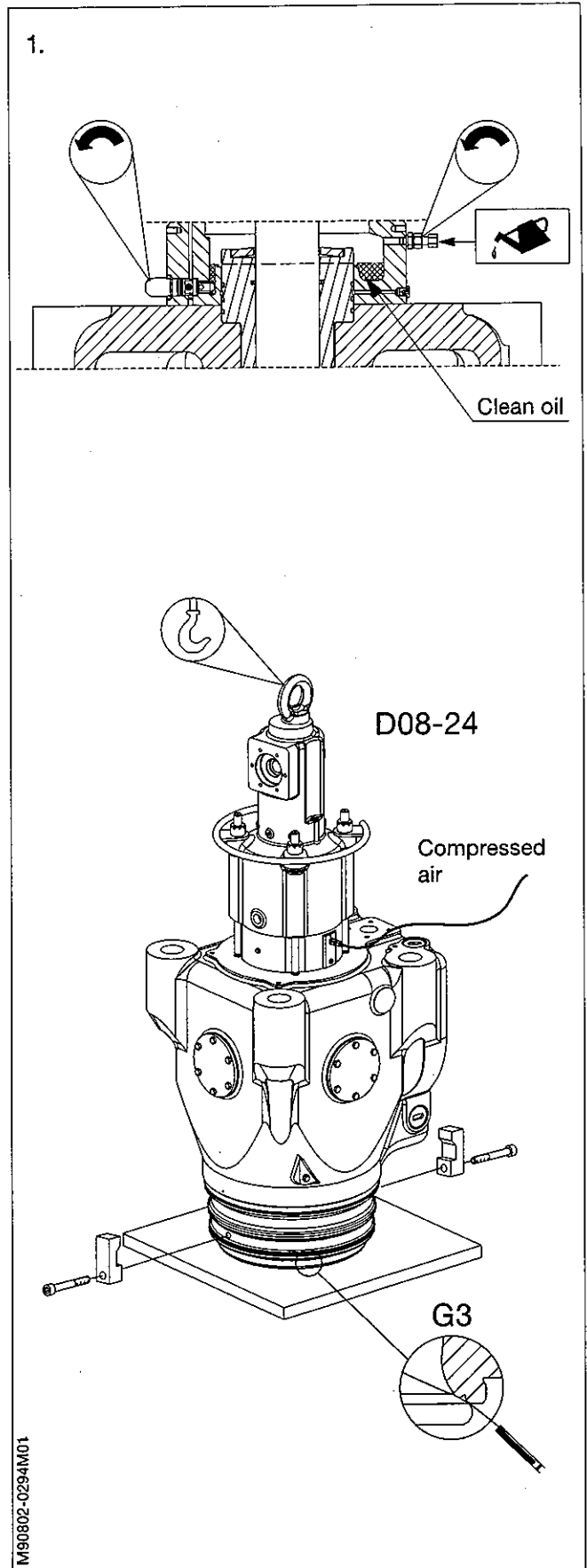
Remove the compressed air supply to the air cylinder.

The valve must be able to stay closed for a minimum of 15 minutes or according to the dropdown test in *Procedure 908-2.1*.

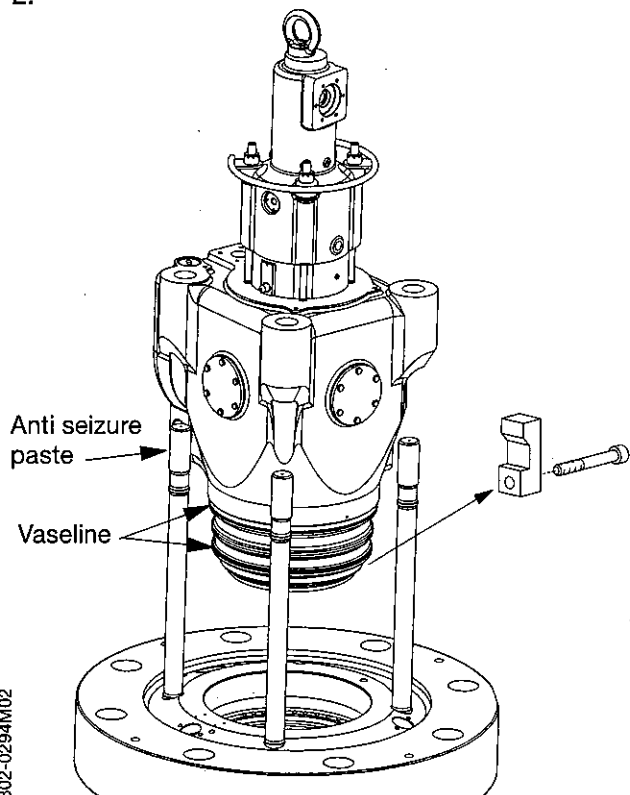
Note!

If the air cylinder is fitted with new sealing rings, the time the valve is closed may be considerably shorter than 15 minutes. The dropdown test should not be carried out until after a "running-in" period of 500 hours on valves with new sealing rings.

Check the valve is fitted with new sealing rings in the grooves on the bottom piece.



2.



M90802-0294M02

2. Exhaust valve landing.

Note!

Before mounting the valve on the engine, connect 7 bar working air to the air cylinder to keep the exhaust valve closed during the mounting process. Use the special coupling tool. Remove the retaining tools from the bottom piece.

Lubricate the sealing rings with vaseline and the threads of the studs with anti-seizure paste.

Position the valve in the cylinder cover bore, guiding it in accordance with the exhaust flanges and the guide pin on the exhaust side of the exhaust valve.

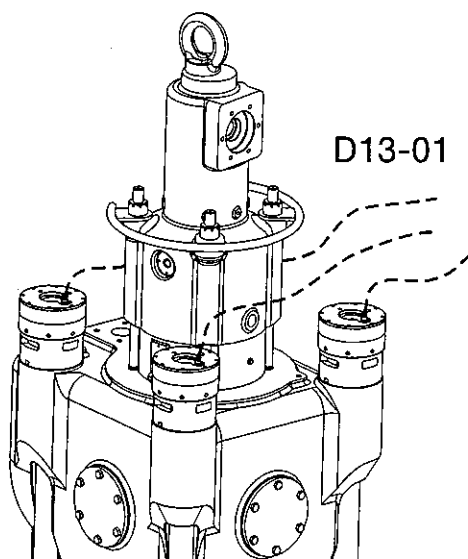
3. Fitting of nuts.

Mount and tighten the nuts hydraulically, see Data.

For use of hydraulic tools See *Procedure 913-1*.

Place the protective caps on the exhaust valve studs.

3.



M90802-0294M03

4. Assemble the pipe connections.

Connect the intermediate pipe to the exhaust valve.

Fit and tighten the screws to the exhaust valve housing.

Assemble the insulation and plate jacket for the intermediate pipe if it has been removed.

Assemble the cooling water connections for the exhaust valve and the air pipe for the air spring.

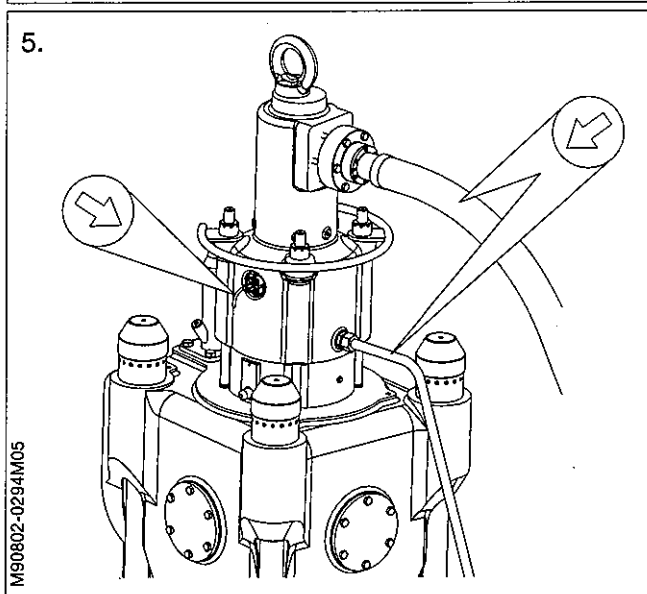
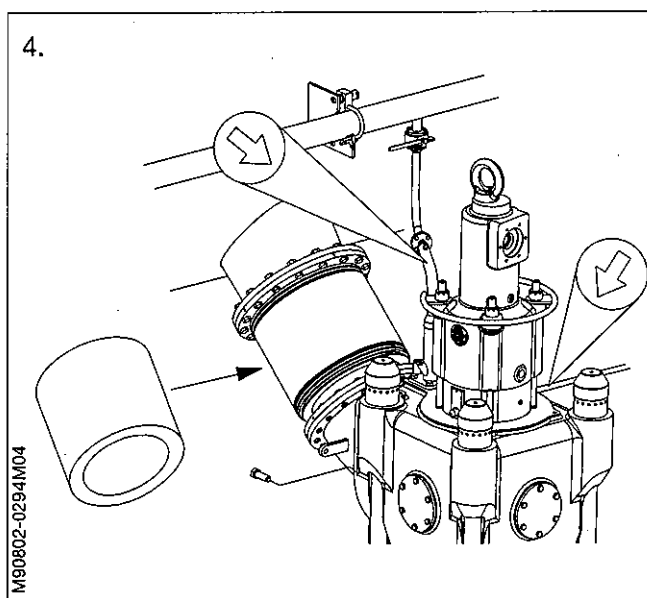
5. Assemble the oil pipe connections.

Connect the high-pressure pipe for the hydraulic valve actuation.
See Procedure 908-1.2.

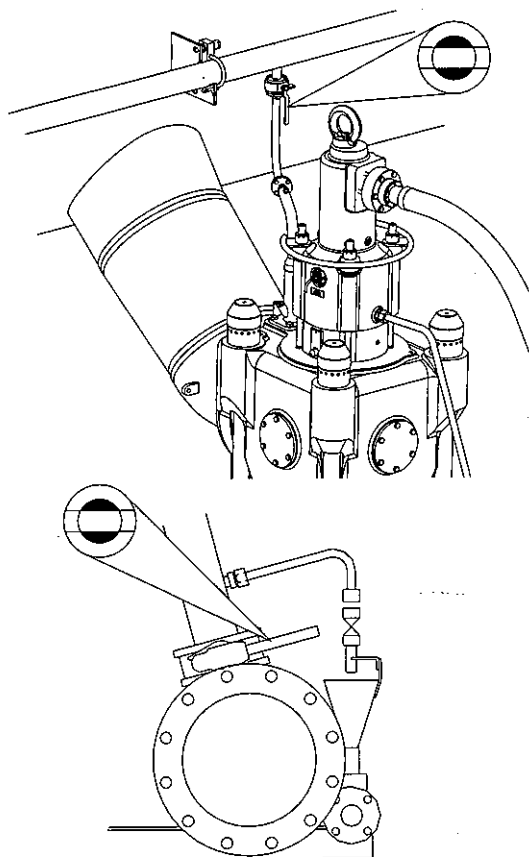
Connect the return oil pipe to the exhaust valve.

Check that all pipe connections are properly tightened.

Connect the electrical plug for the position sensor.

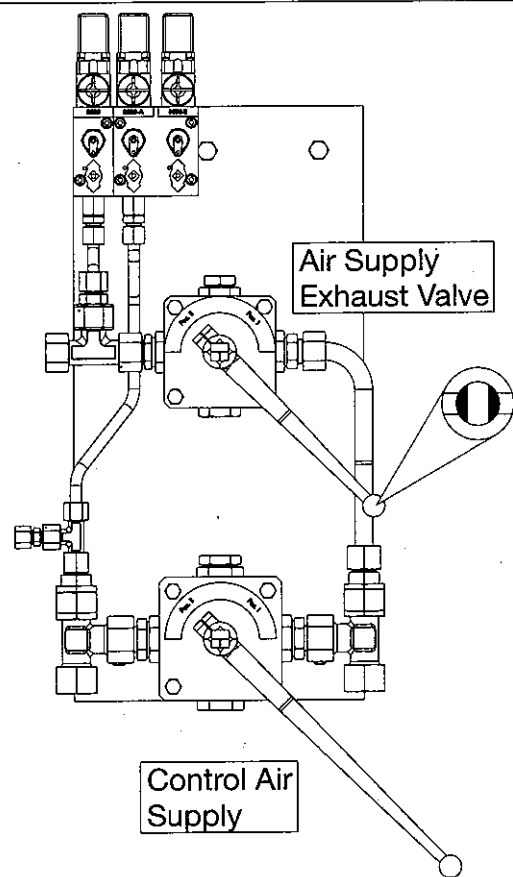


6.



M90802-0294M06

7.



M90802-0275C03

Prepare for Operation**6. Open cooling water supply.**

Check that all water connections are assembled and tightened.

Open the cooling water inlet supply, and vent the exhaust valve, open the cooling water outlet valve.

Open the air supply to the exhaust valve.

Check the tightness of the sealing ring between the bottom piece and the exhaust valve housing. See *Procedure 908-2.1*.

7. Air supply.

The air supply to the exhaust valve must always be connected and pressurized **before** turning on the oil supply to the exhaust valve actuator.

Note!

If the lubricating oil pumps have been started before the exhaust valve air springs are pressurized, the valves can move to open position, thus giving starting problems.

To close the exhaust valves as fast as possible, pressurize the air springs, stop the lubrication oil pumps and drain the actuators at the drain screws.

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-35	Hydraulic actuator	270	kg
D08-47	Top flange	56	kg
D08-48	Actuator piston	22	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90862		Exhaust Valve - Hydraulic Tools
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	105	3-way distributor block, complete

1. Stop the engine and shut off the oil supply.

Connect a pressure gauge at "minimess" point 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

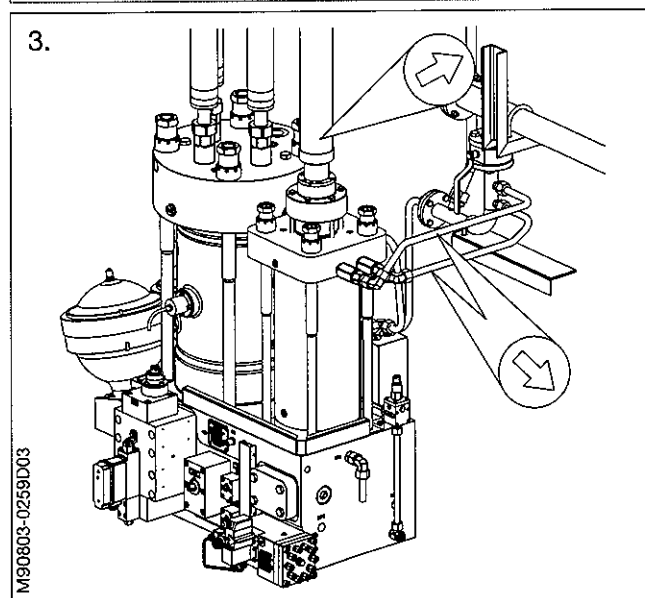
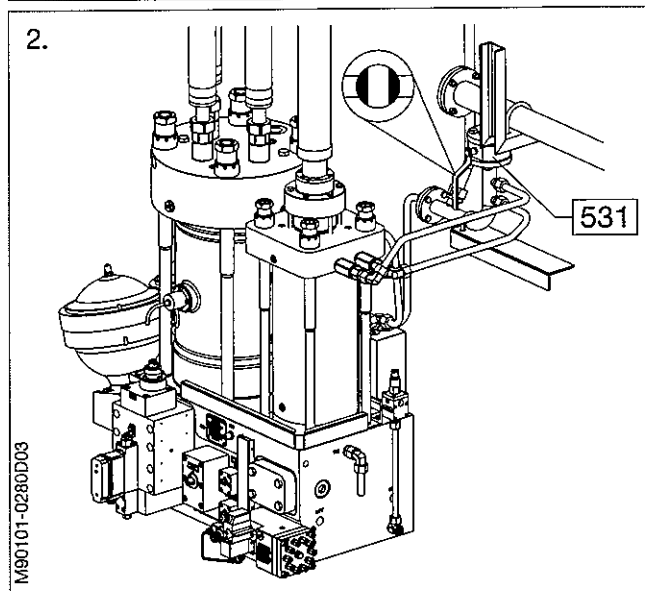
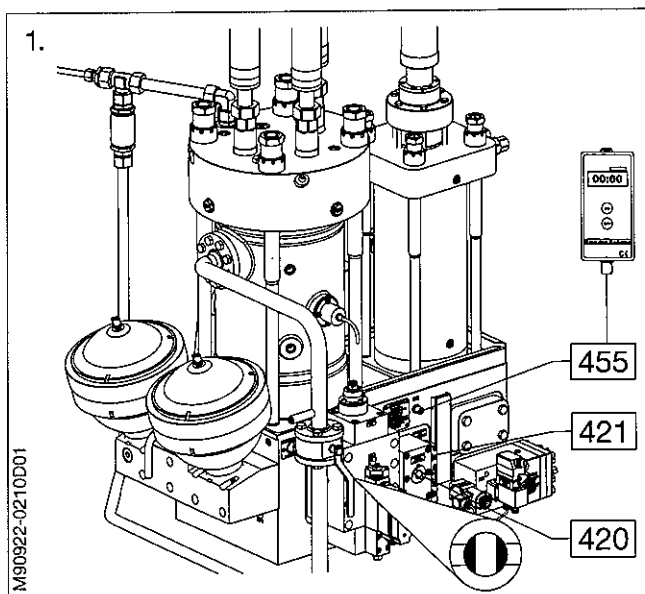
Note!

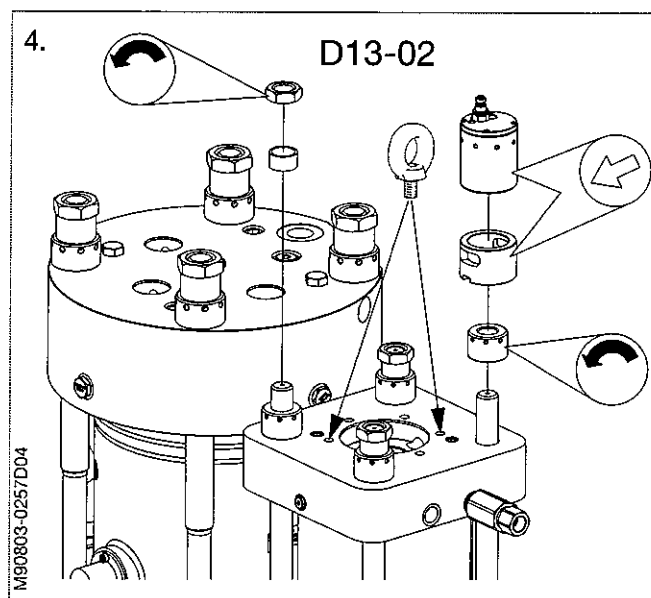
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

2. Close valve 531 for the actuator oil supply.

3. Remove the hydraulic high pressure pipe, see Procedure 908-1.2.

Disconnect the oil pipe from the side of the top flange.





4. Remove the thread protective caps.

Loosen the nuts, two at a time, diagonally.

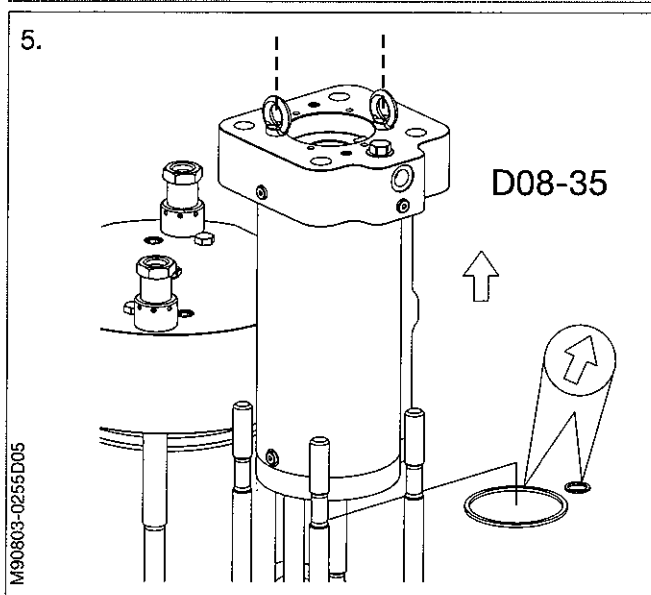
Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in Data. Loosen and remove the nuts.

For use of hydraulic tools, see also Procedure 913-1.

Mount two eyebolts in the top flange of the actuator.

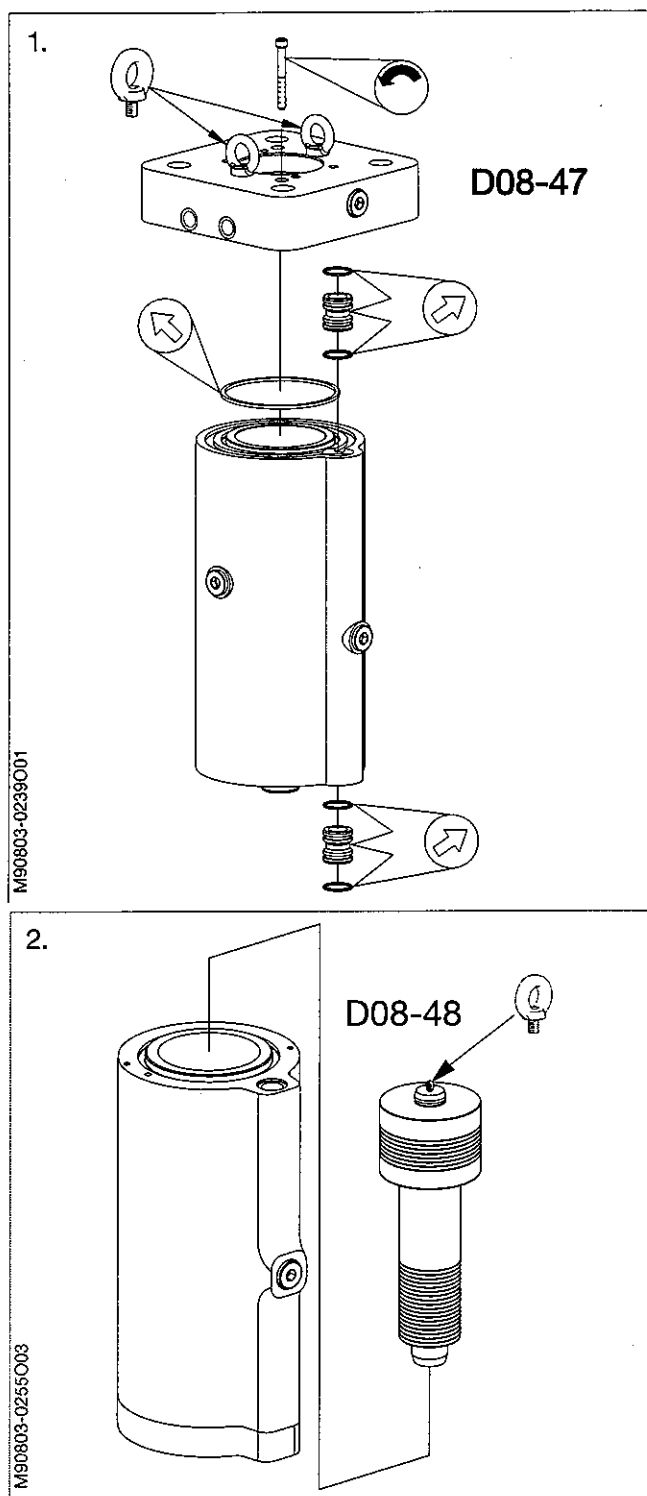
5. Lift the actuator unit clear of the actuator block.

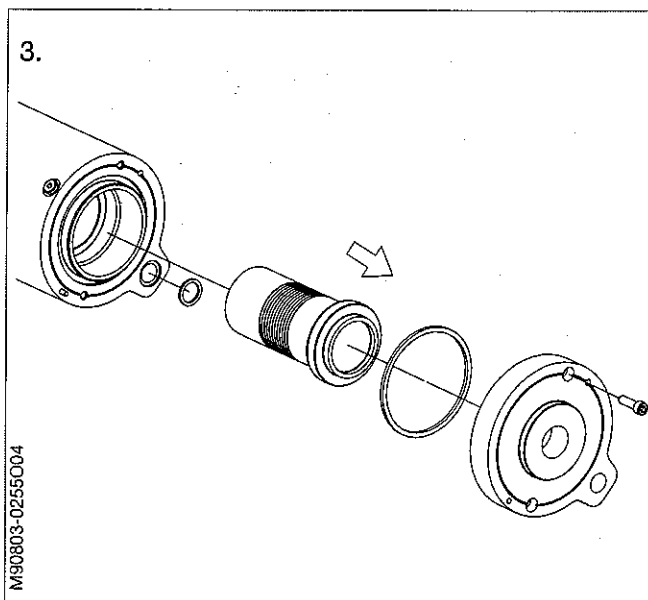
Remove the sealing rings from the bottom and discard them.



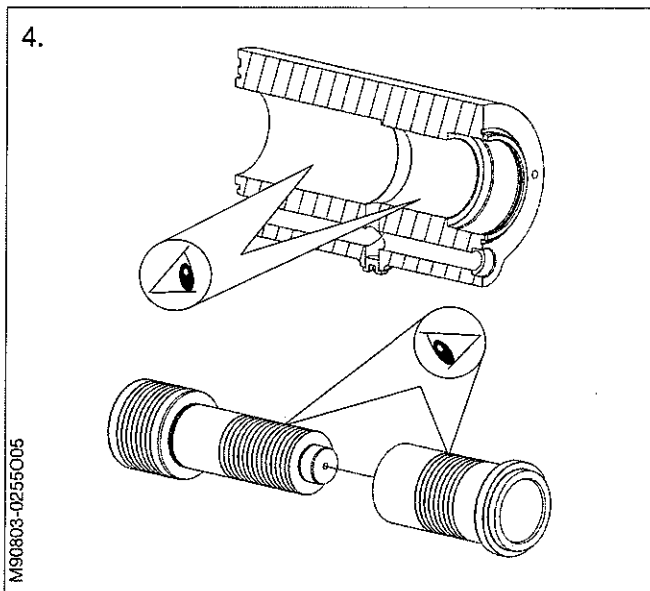
1. Remove the two screws which retain the top flange to the cylinder unit.

Mount two eyebolts in the top flange and lift away the top flange. Discard the sealing rings.
2. Mount an eyebolt in the top of the actuator piston. Lift out the piston.





3. Place the actuator on it's side.
Remove the bottom plate.
Pull out the bushing piston.
Remove and discard the sealing ring.
4. Clean all parts and check all running surfaces for abnormal wear and scores.



5. Lubricate the cylinder inside with lubricating oil.

Mount the bushing piston in the bottom of the cylinder.

Mount a new sealing ring.

Replace the bottom plate.

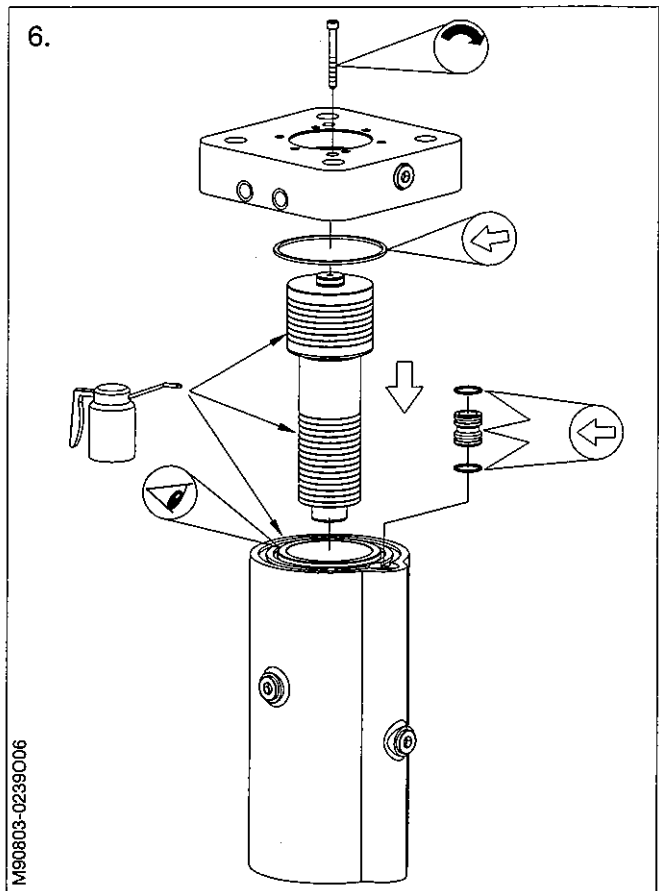
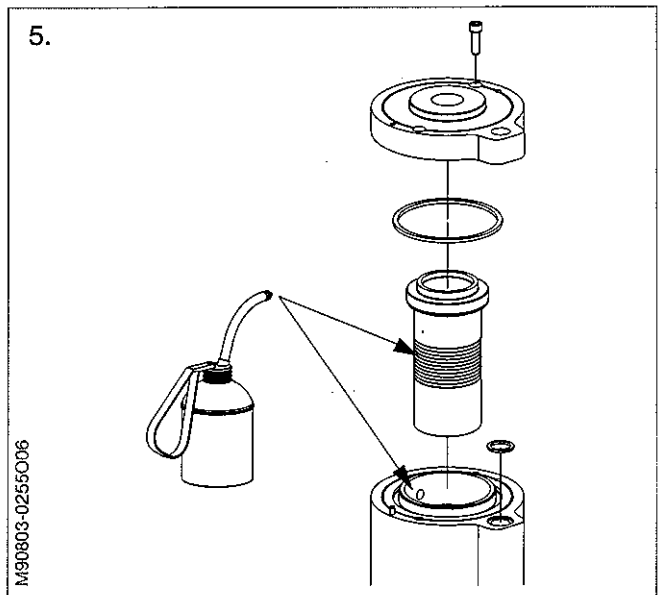
6. Lubricate the actuator piston on all sliding surfaces.

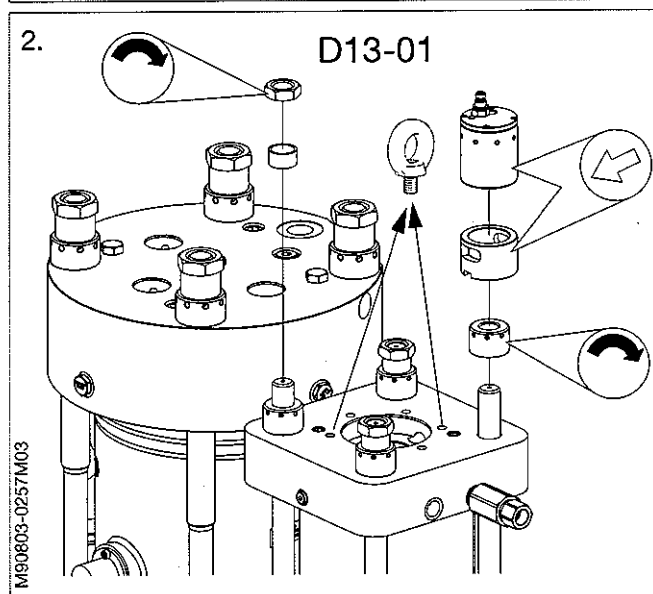
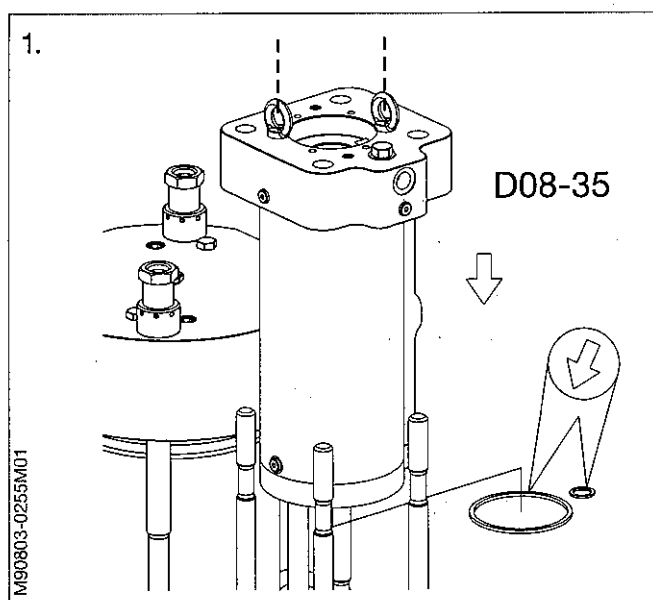
Mount the piston from the top side of the cylinder.

Mount a new sealing ring.

Mount a new sealing ring for drain oil.

Mount the top flange and tighten the screws.





Note!

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

1. Check the oil holes and the face of the hydraulic block and the bottom of the hydraulic actuator to see that they are clean and free of impurities.

Mount two eyebolts in the top of the actuator assembly and a new sealing ring in the bottom groove.

Mount a new sealing ring on the drain oil bushing.

Carefully land the actuator assembly on the hydraulic block.

2. Remove the eyebolts from the top flange.

Tighten two nuts at a time diagonally.

Screw the nuts on to the studs. Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the jacks to the tightening pressure, as specified in Data. Tighten the nuts, and remove the hydraulic jacks and the spacer rings.

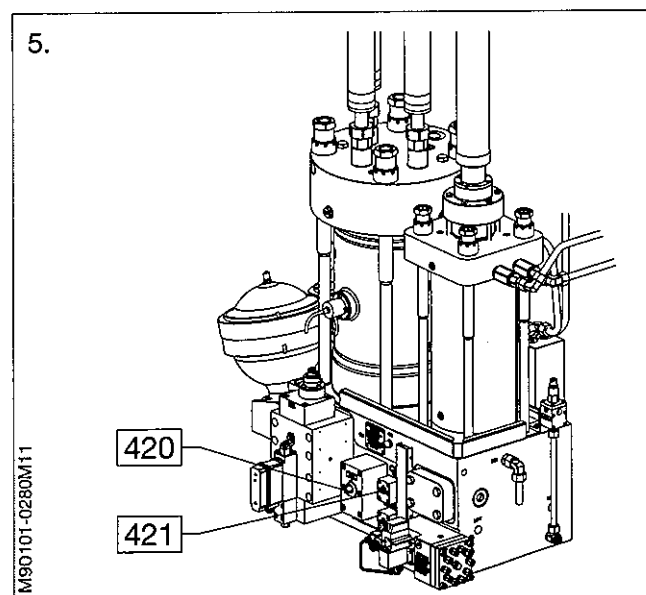
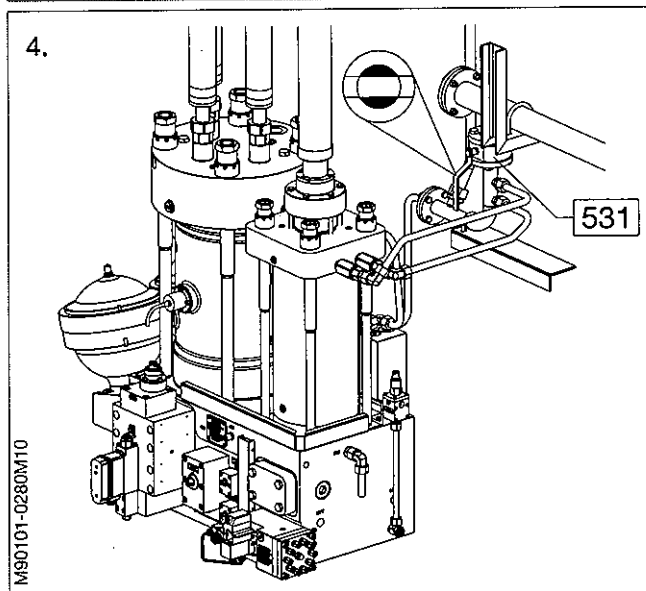
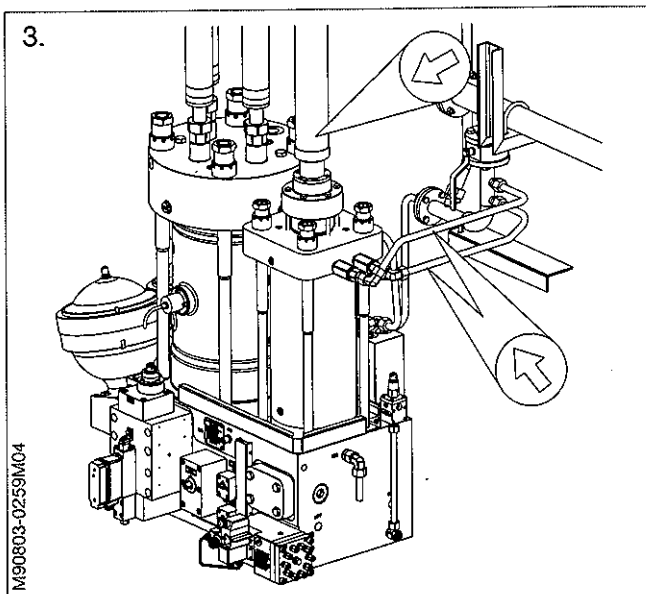
For use of hydraulic tools, see also Procedure 913-1.

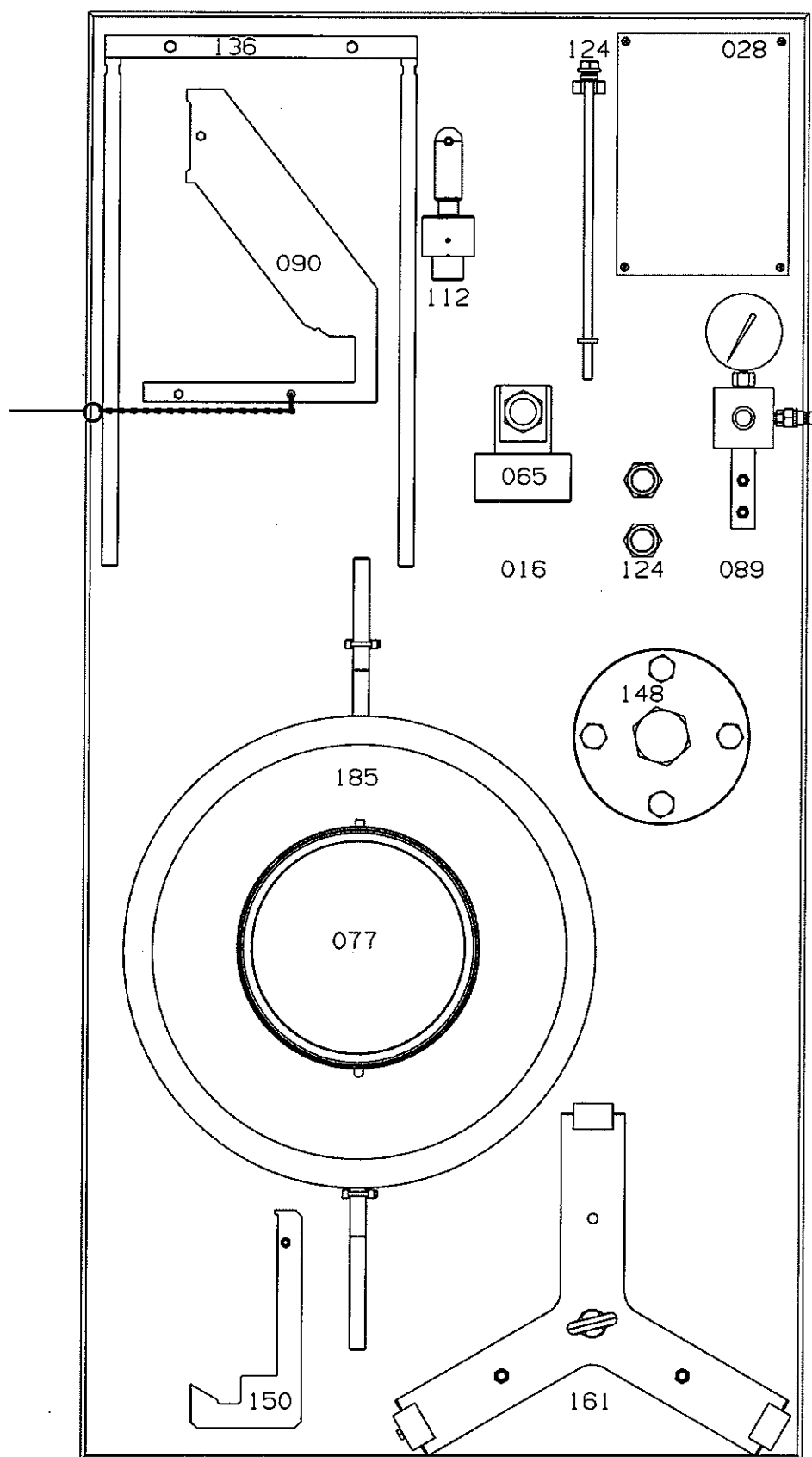
Mount the thread protecting caps.

3. Mount and tighten the oil pipe for oil supply.

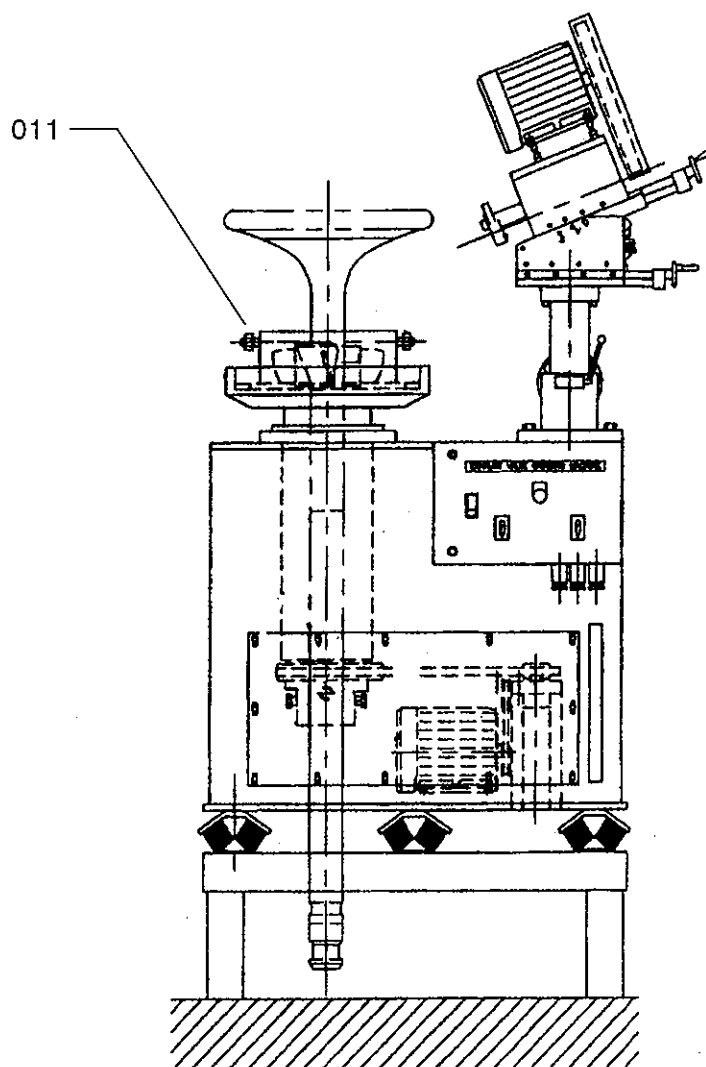
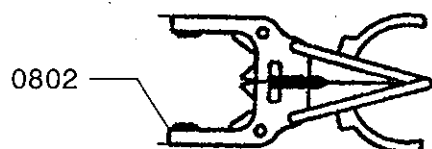
Mount the hydraulic high pressure pipe,
see Procedure 908-1.4.

4. Open valve 531 for actuator oil supply.
5. Close valve 421, and open valve 420 on the hydraulic block.



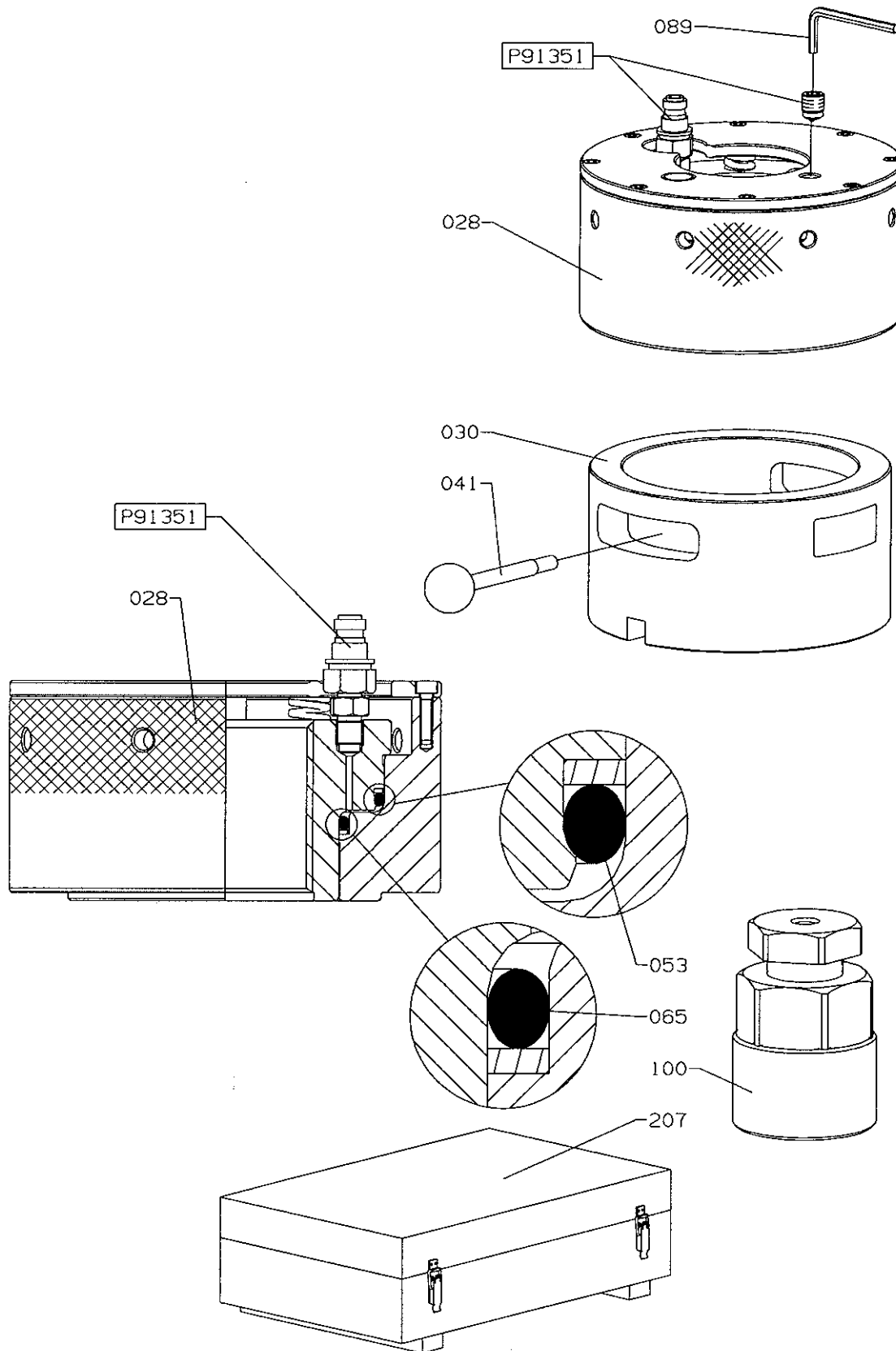


Item No.	Item Description	Item No.	Item Description
016	Panel for tools		
028	Name plate		
065	Lifting tool for exhaust valve		
077	Cone ring		
089	Pressure testing equipment for exhaust valve		
090	Gauge for exhaust valve spindle		
112	Grinding tool for high pressure pipe		
124	Tool for emergency opening of exhaust valve		
136	Bridge gauge for exhaust valve		
148	Tool for hydraulic piston		
150	Gauge for exhaust valve bottom piece		
161	Lifting tool for exhaust valve		
185	Grinding ring for exhaust valve bottom piece		



Item No.	Item Description
011	Grinding machine, complete When ordering spare parts, please refer to the KOREA KOKACO Manual
0802	Piston ring opener

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
028	Hydraulic jack, complete		
030	Support		
041	Tommy bar		
053	O-ring with back-up ring		
065	O-ring with back-up ring		
089	Spanner		
100	Stud setter		
207	Hydraulic toolset, complete		

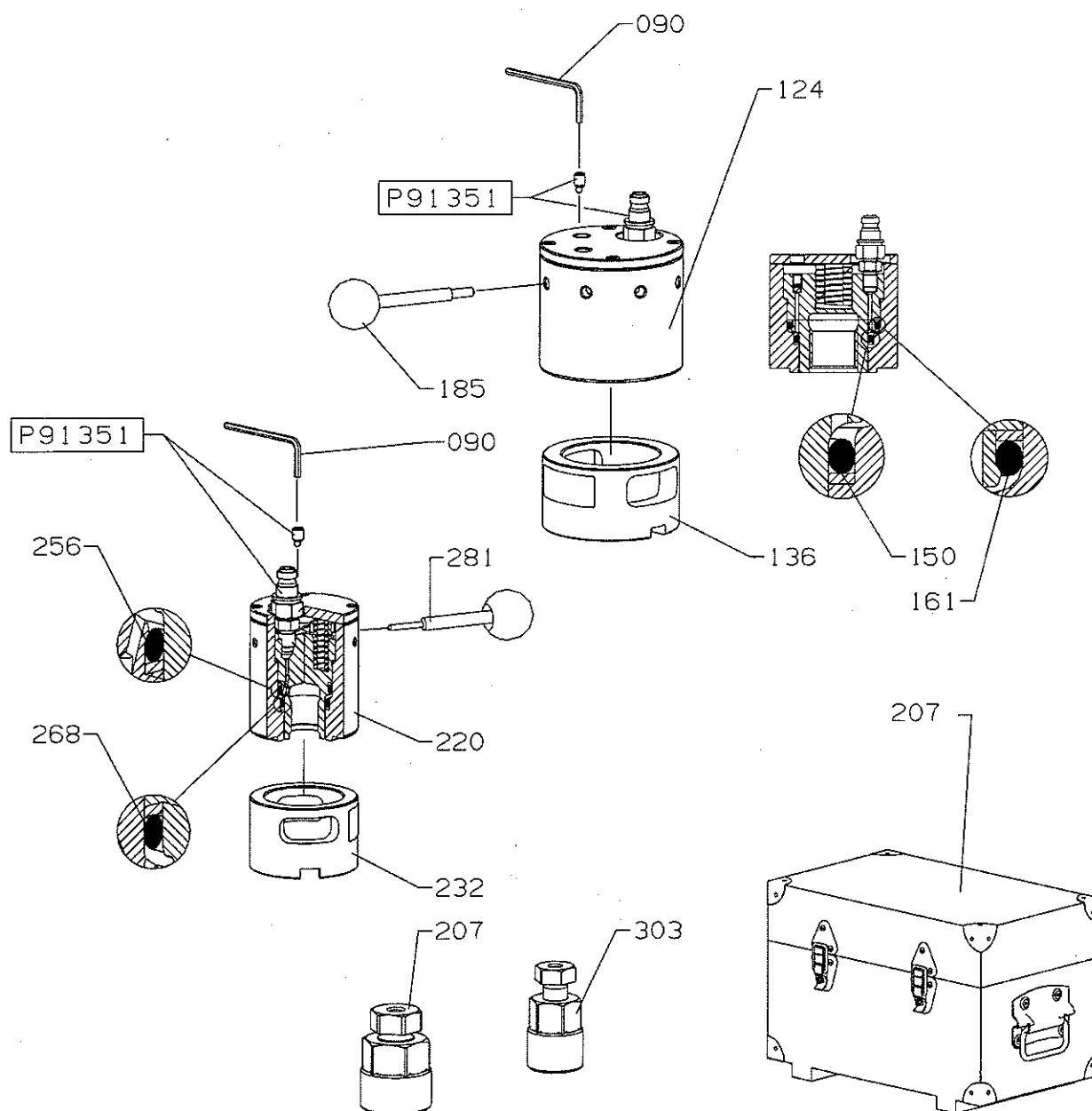


Plate
P90865-0004E

Exhaust Valve - Hydraulic Tools

Item No.	Item Description
090	Spanner
124	Hydraulic jack, complete
136	Support
150	O-ring with back-up ring
161	O-ring with back-up ring
185	Tommy bar
207	Stud setter
220	Hydraulic jack, complete
232	Support
256	O-ring with back-up ring
268	O-ring with back-up ring
281	Tommy bar
303	Stud setter
207	Hydraulic toolset, complete

Item No.	Item Description

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☒	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-40	Fuel valve opening pressure	300 - 380	bar
D09-42	Inlet seat, max. diameter	30	mm
D09-43	Fuel valve	15	kg

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90151	71	Dismantling tool for fuel valve
P90951	94	Milling tool for fuel oil pipe seats
P90951	165	Grinding mandrel for valve head
P90951	177	Grinding mandrel for thrust spindel
P90951	189	Grinding mandrel for holder - outside
P90951	190	Grinding mandrel for holder - inside
P90951	297	Assembling tool for fuel valve
P90961		Fuel Valve tester, complete

1. Fuel Valve

The fuel valves must be given the utmost attention and care, as the greater part of irregularities that may occur during the running of the engine can be attributed to defects in these valves.

If the engine gives normal performance in accordance with diagrams and exhaust temperatures, it is only necessary to inspect the fuel valves after the service period stated in the Checking and Maintenance Programme. See *Chapter 900-1*.

In order to obtain reliable results during testing of the fuel valves, all fuel valves that are dismantled from the engine must be disassembled, cleaned, inspected and re-assembled before testing. See *Procedure 909-11.3* and *909-12.3*.

Note!

In the event that the slide-type fuel valve is pressure tested without being cleaned between the fuel nozzle and the cut-off slide, the opening pressure value measured might be considerably lower than specified.

All fuel valves **must** be function-tested before being mounted in the cylinder cover.

Pressure testing pump

Use only hydraulic oil (rust-preventing) with a viscosity of between 7 and 10 cSt at 50°C.

For operation of the pressure testing pump, see the supplier's instructions.

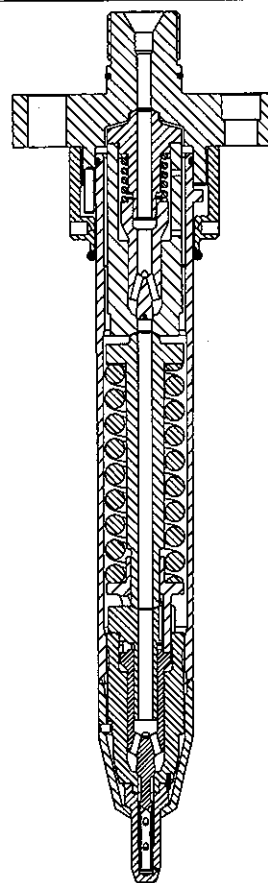
Note that the high-pressure pump should be periodically checked in accordance with the supplier's instructions.

2. Spring housing

To ensure that over tightening has not taken place, check that the locking/indicating pin has not been bent or broken off.

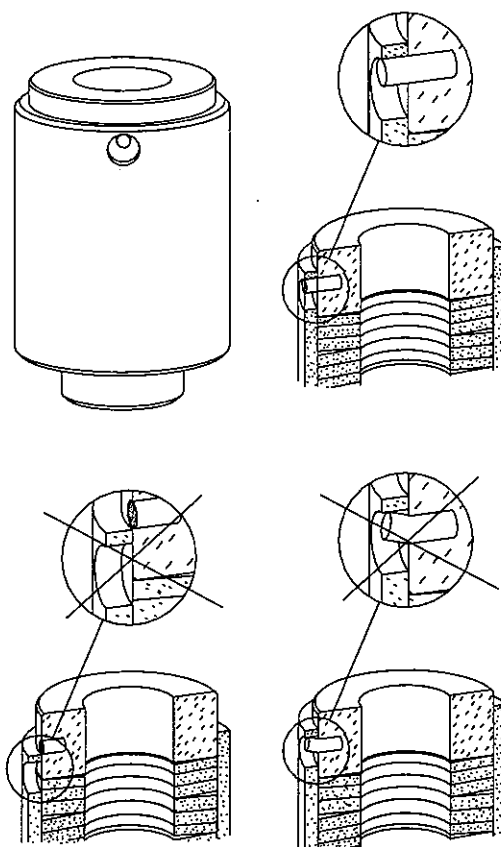
In the event of over tightening, replace the spring housing by a new one.

1.

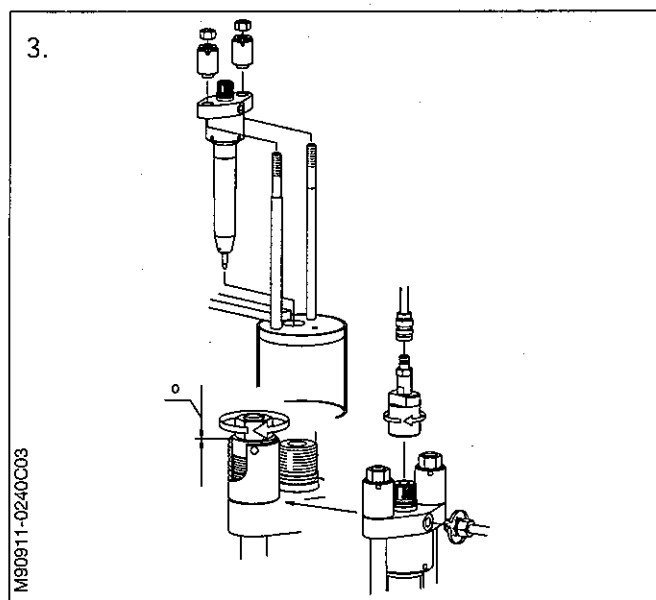


M90911-0243C01

2.



M90911-0240C02



3. Setting-up the fuel valve

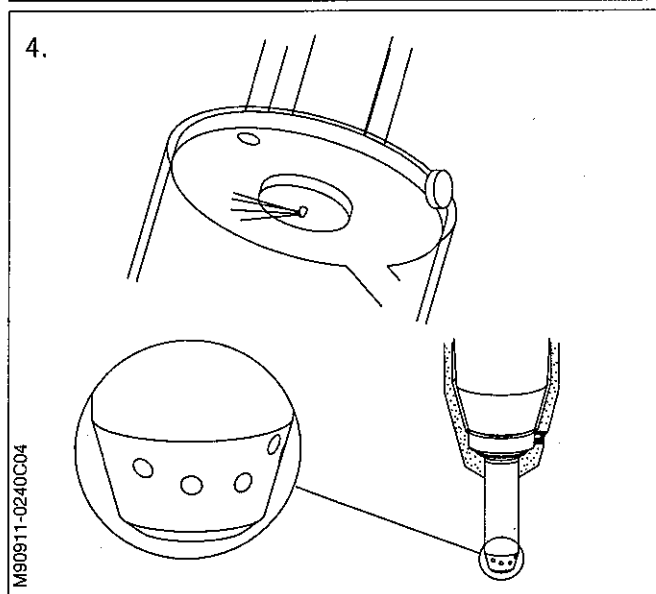
Place the fuel valve in the test rig and secure it with the spring housings and nuts.

Tighten the nuts until the top face of the pressure disc is flush with the top face of the spring housings. Mount the oil pipe between the pressure testing pump and the fuel valve.

Pressure testing procedure

The following functions of the fuel valve must be checked:

- Flushing and jet control
- Opening pressure
- Sealing test and sliding function
- Pressure test, O-ring sealing



4. Flushing and jet control

Remove air in the system and check the fuel jet in the following way.

Slowly increase the oil pressure until straight jets of oil are ejected from the nozzle holes (no atomization).

Acceptance criteria:

There is to be a continuous jet of oil through at least one of the nozzle holes.

Owing to the geometry of the internal part of the nozzle - and because of the height to which the spindle is lifted during pressure testing is lower than the height it is lifted during normal engine operation - the fuel oil will not necessarily flow from all of the nozzle holes.

Cause of fault:

If the jets do not fulfil the above point, the cause may be:

Dirt in the nozzle holes

The nozzle is not mounted correctly

5. Opening pressure

To check the opening pressure, increase the oil pressure until oil is admitted through the nozzle holes.

Acceptance criteria:

Check the opening pressure on the pressure gauge and compare with Data D09-40 on the datasheet.

Note!

Do NOT attempt to carry out an atomization test on the slide type fuel valves, as this may damage the cut-off slide and nozzle.

Cause of fault:

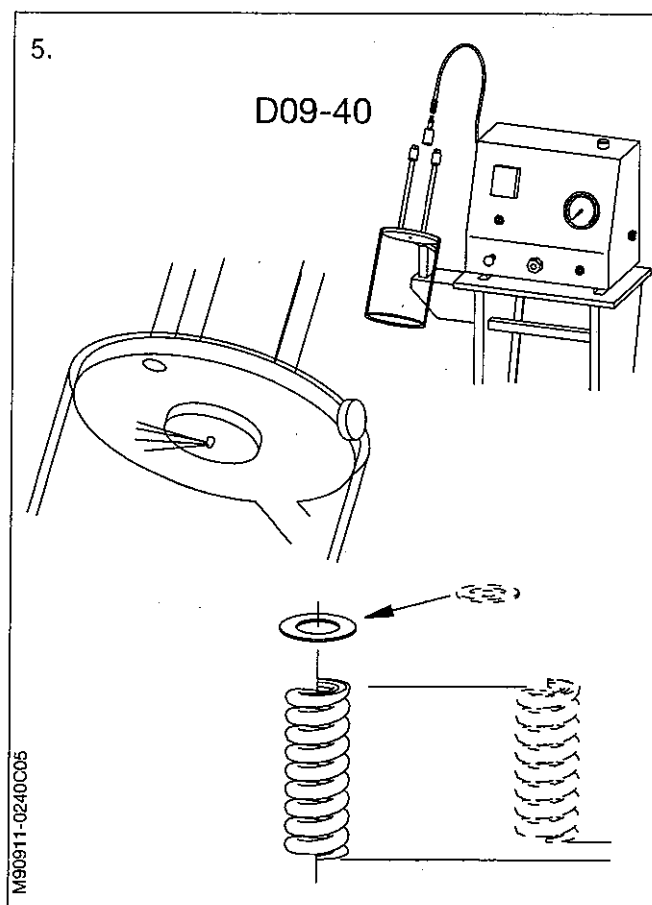
If the opening pressure is higher than specified in D09-40, the cause may be that a wrong type of spring is used - replace the spring on the thrust spindle, if necessary, replace the complete thrust spindle.

If the opening pressure is lower than specified in D09-40, the cause may be that the spring has sagged - replace the spring, or add a special thin disc.

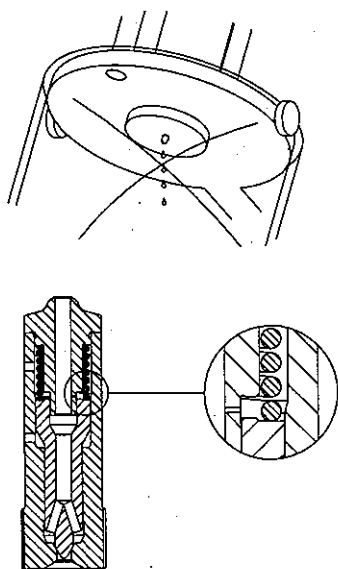
Note!

Special thin discs are available as spares.

If a spring or a disc has been changed, the pressure testing procedure of the fuel valve must be repeated.



6.



M90911-0240C06

6. Sealing test and sliding function

To check the needle valve seat for tightness and the slide for correct closing.

Slowly increase the oil pressure to about 50 bar below the opening pressure. Maintain the built-up pressure by closing for the oil supply.

Acceptance criteria:

Oil must not flow from the nozzle holes.

The pressure drops relatively slowly to about 15 bar, after which it drops quickly to 0 (the slide is pressed against the conical seat and opens for circulation oil).

Note!

Oil flows out of the leak oil outlet when the fuel valve is full of oil.

Cause of fault:

If oil flows out of the nozzle holes, the cause is either:

- Defective spindle guide at needle seat, or a sticking spindle. Examine and/or replace the spindle guide.
See Procedure 909-12.3.
- Too quick pressure drop:

- the clearances of the movable parts, both of the spindle guide and of the non-return valve, are too large, or the seats between the thrust piece/spindle in the spindle guide or thrust piece/valve slide in the non-return valve are damaged.

Examine and/or replace both the spindle guide and non-return valve. *See Procedure 909-12.3.*
See Procedure 909-13.3.

If a quick pressure drop from 15 to 0 bar cannot be registered:

- The valve slide is sticking; or
- The vent hole in the thrust piece is blocked.

If so, disassemble and examine the spindle guide, replace if necessary. *See Procedure 909-12.3.*

7. Pressure test, O-ring sealing

To ensure that the leak oil (circulation oil) remains in the closed system, build up a working pressure of about max. 10 bar until oil flows out of the leak oil outlet.

Close the leak oil outlet with a gasket and plug screw.

Increase the working pressure to about 100 bar.

Acceptance criteria:

The built-up pressure of about 100 bar should be maintained.

Cause of fault:

If oil leaks out at the union nut, the O-ring inside the fuel valve head is defective, and must be replaced.

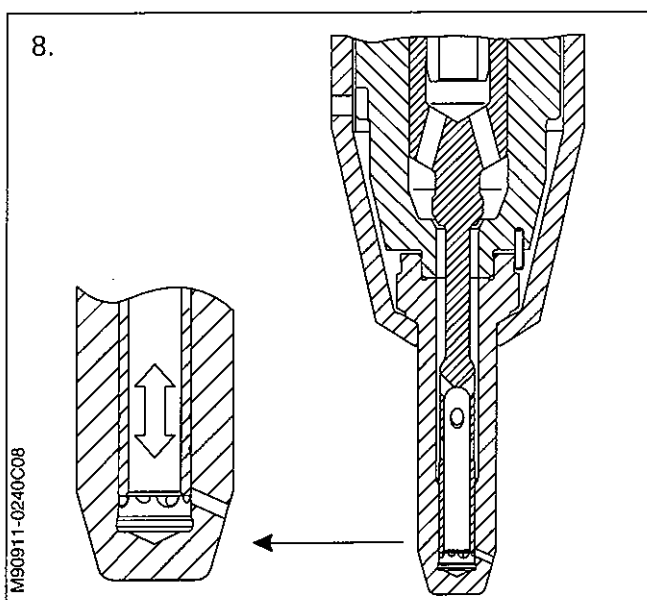
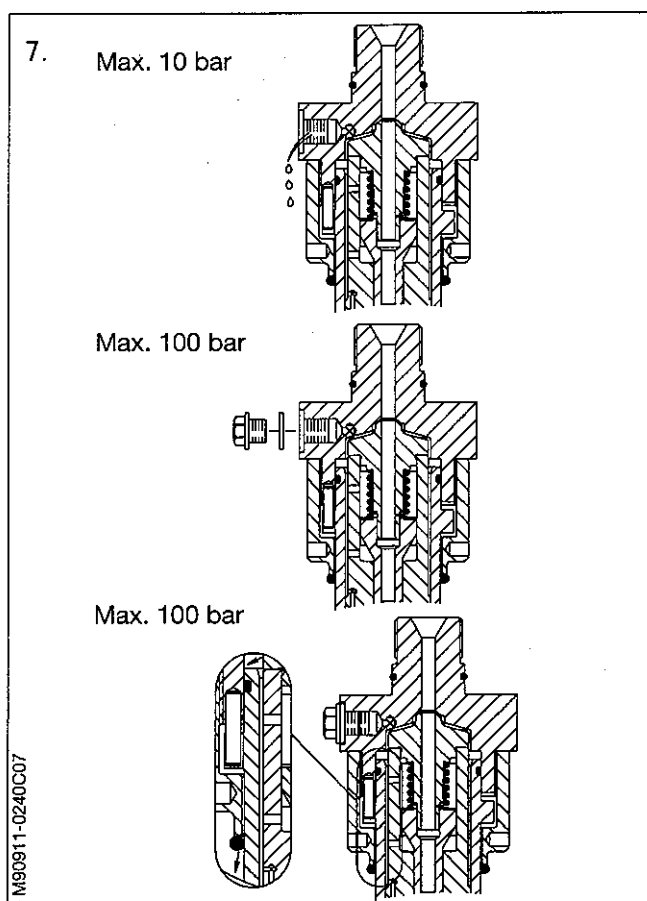
8. Atomization test

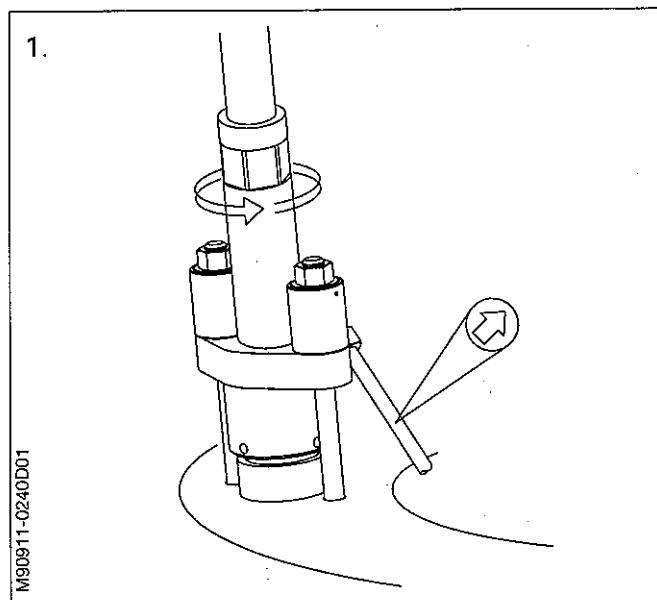
Note!

Do **NOT** attempt to carry out an atomization test on slide type fuel valves, as this may damage the cut-off slide and nozzle.

The atomization test may damage the valve because it makes the needle oscillate, with a small lift at a very high frequency. The high pressure drop across the cut-off edge and the high contact pressure between slide and fuel nozzle, in combination with the poor lubricity of the test oil, increase the risk of seizures between cut-off slide and nozzle.

All of these conditions involve the risk of seizure between the cut-off slide and the nozzle.



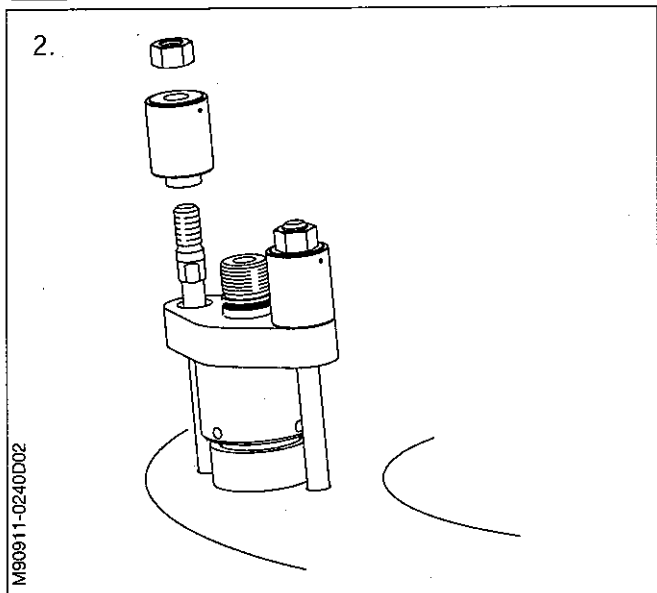


1. Close the fuel oil inlet and outlet valves, and drain the high-pressure pipe and the fuel valve.

Dismantle and remove the fuel oil high-pressure pipe.

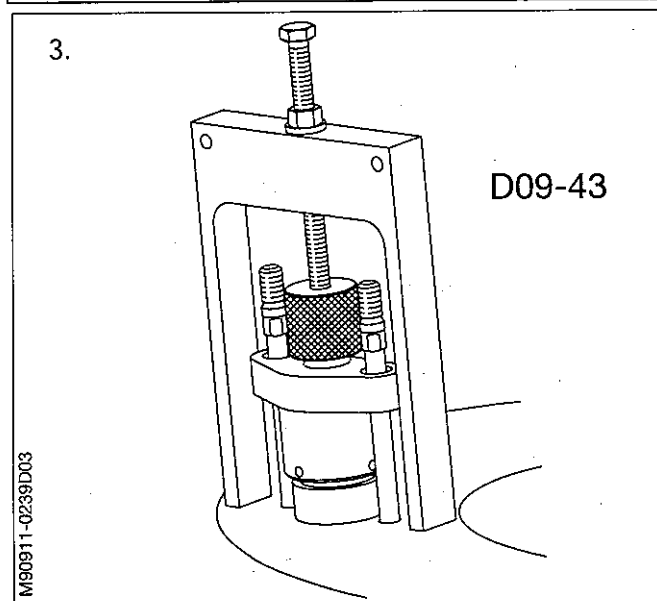
See Procedure 909-14.2.

Disconnect the return oil pipe from the fuel valve.



2. Remove the nuts and the spring housings.
3. Take out the valve. If the valve is sticking, use the fuel valve dismantling tool to pull the fuel valve clear of the top cover.

If the valve is not to be overhauled immediately, the valve should be placed immersed in diesel oil until overhauling.

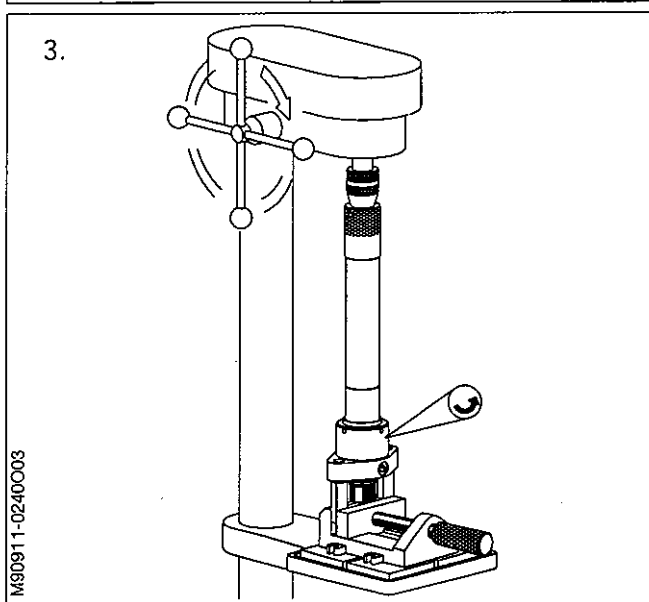
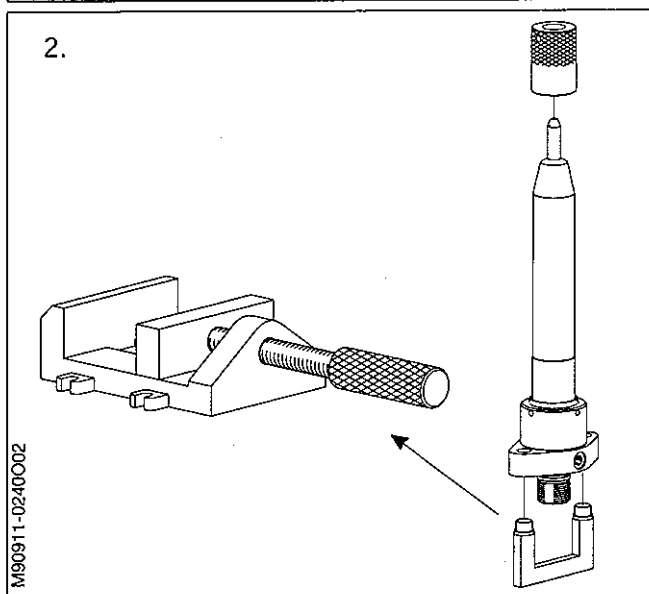
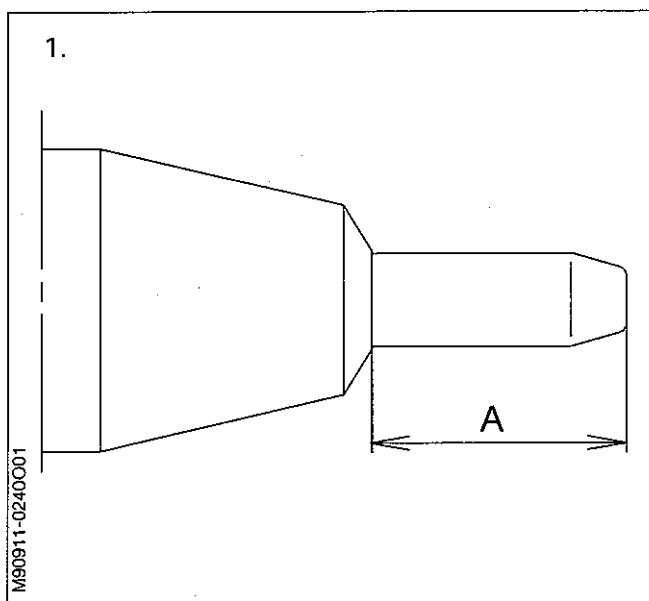


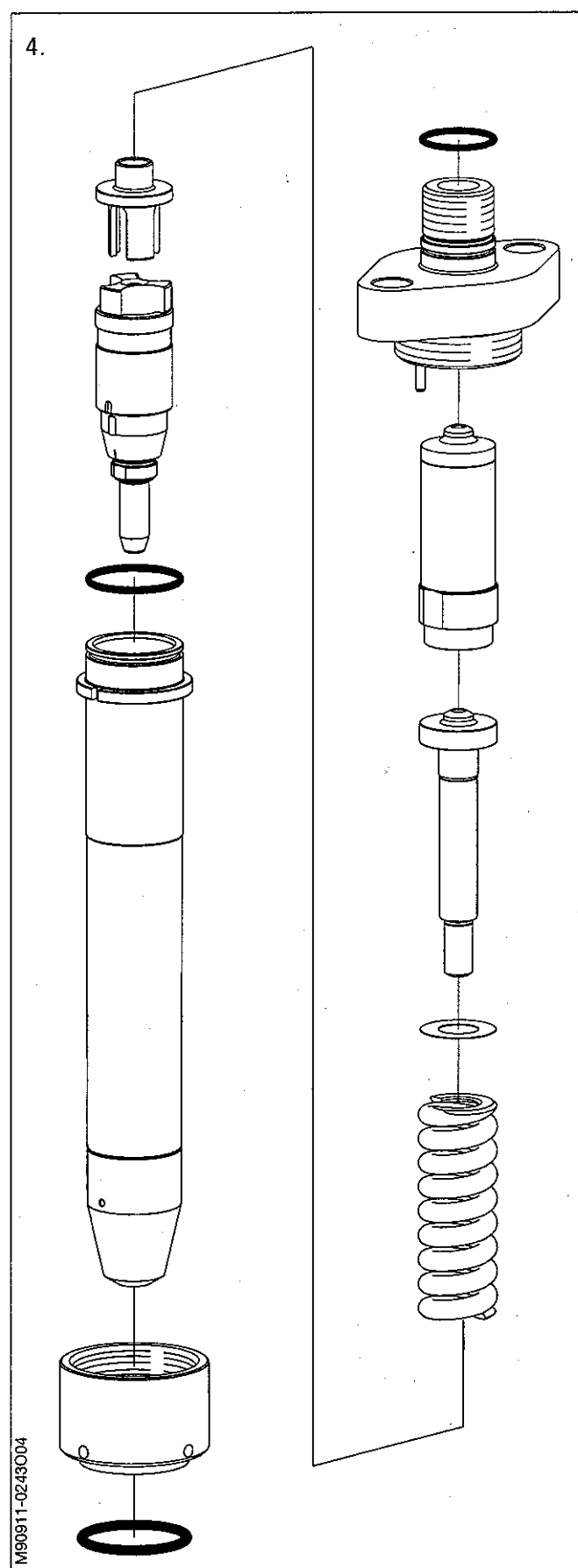
When fuel valves are overhauled, all parts should be handled carefully and be kept clean.

Use only clean, non-fluffy rags for wiping purposes. Make sure to remove all liquid or solid impurities. Whenever fuel valves are overhauled, all sealing rings should be discarded and replaced by new, faultless sealing rings before reassembly.

1. Measure the length A of the protruding part of the nozzle, and write down the result for correct re-assembling of the valve.
2. Place the valve holder in a machine vice, mount the fuel valve in the holder and fit the valve with the guide disc from the grinding tool.
3. Compress the fuel valve and the spring inside, by means of a drilling machine, to avoid seizures in the union thread. Hold the fuel valve compressed and unscrew the union nut with a hook spanner.

Remove the valve from the valve holder.





4. Pull the valve head clear of the valve housing.

Remove the:

- Non return valve
- Thrust spindle parts
- Thrust foot
- Spindle guide and fuel nozzle

from the valve housing.

Remove and discard all the O-rings.

5. Carefully clean and examine all surfaces of the:

- Fuel valve housing
- Fuel valve head
- Thrust spindle

If necessary, grind the seating surfaces by means of the grinding mandrels supplied and a fine-grain abrasive (such as Carborundum No. 500).

This grinding must only be carried out manually.

After the grinding, wash the parts in gas oil and blow clean by means of compressed air to remove any remains of the grinding compound.

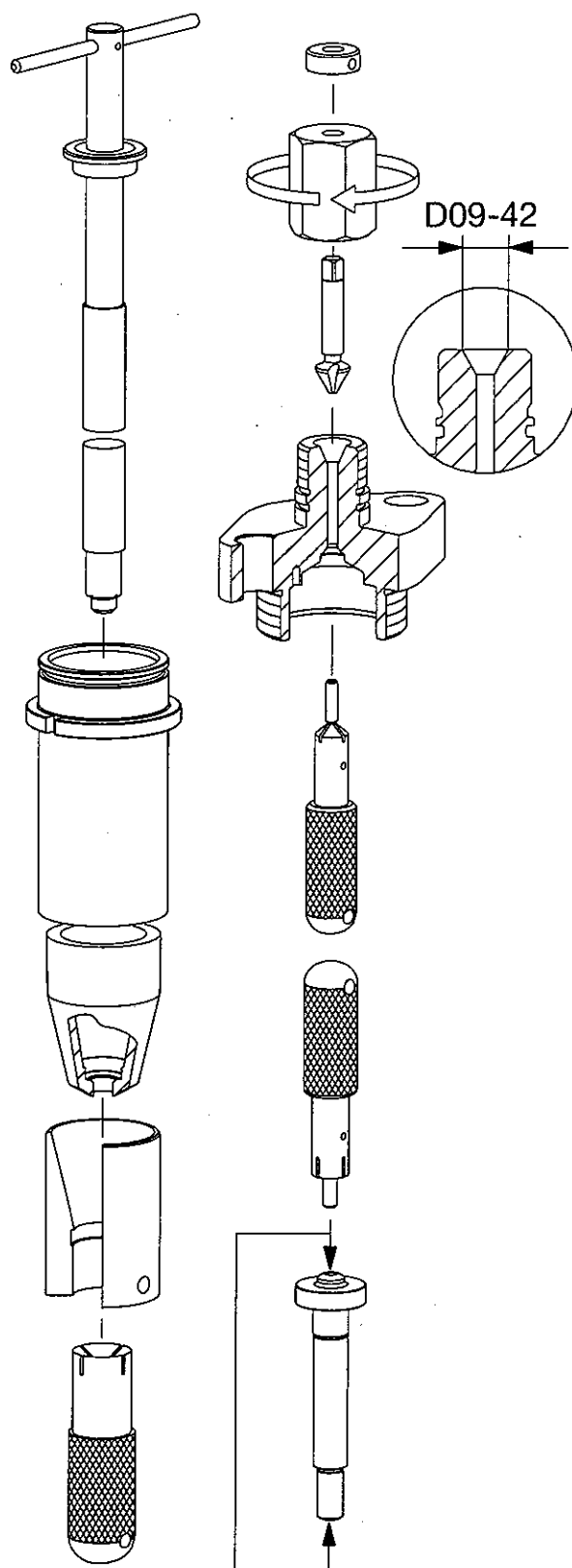
In the event of more serious damage to the seating surface for the high-pressure pipe in the valve head, the milling tool can be used.

Normally, the milling tool is turned by hand, but it may be fitted in the chuck of a column-type drilling machine provided that the number of revolutions is kept at a minimum (not exceeding approx. 100 r/min). An ample supply of cutting emulsion must be used.

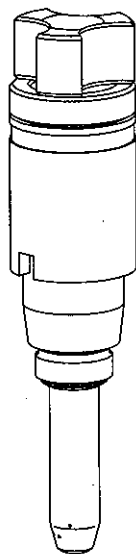
Note!

Take care not to exceed the maximum diameter of the seat, see *Data*.

5.



6.



M90911-0240005

6. The complete spindle guide, including the fuel nozzle, should be sent to an authorised MAN B&W repair shop for overhaul. If this is not possible, the spindle guide may be overhauled on board.

See Procedure 909-12.3.

Note!

Do **not** attempt to remove the fuel nozzle from the spindle guide unless the spindle guide has been dismantled. Otherwise the cut-off slide on the spindle may be damaged.

The non-return valve should be sent to an authorised MAN B&W repair shop for overhaul. If this is not possible, the non-return valve may be overhauled on board.

See Procedure 909-13.3.

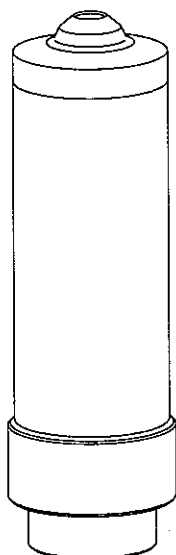
Mount the complete spindle guide, including the fuel nozzle, in the fuel valve housing.

Carefully slide the spindle guide down into the valve holder, and turn the nozzle until the spindle guide engages correctly with the guide pin. Check that distance A corresponds to the measurement taken before the valve was disassembled.

Note!

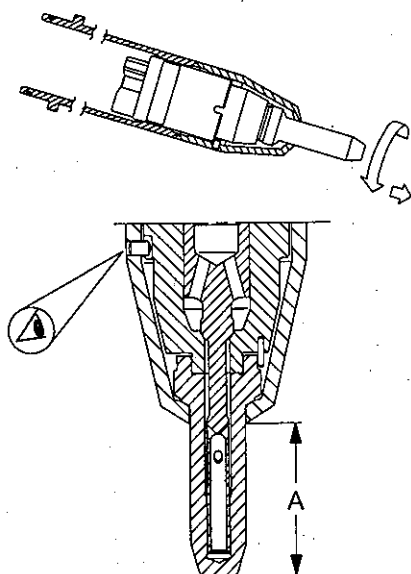
Make sure that the fuel nozzle and spindle guide engage correctly with the guide pin in the fuel valve housing. This can be ascertained by attempting to turn the nozzle after mounting. It must **not** be possible to turn the nozzle.

7.



M90911-0240006

8.



M90911-0240008

9. Mount:

- the thrust foot
- the parts of the thrust spindle
- the non-return valve

in the fuel valve housing.

Mount a new O-ring in the uppermost groove of the fuel valve housing.

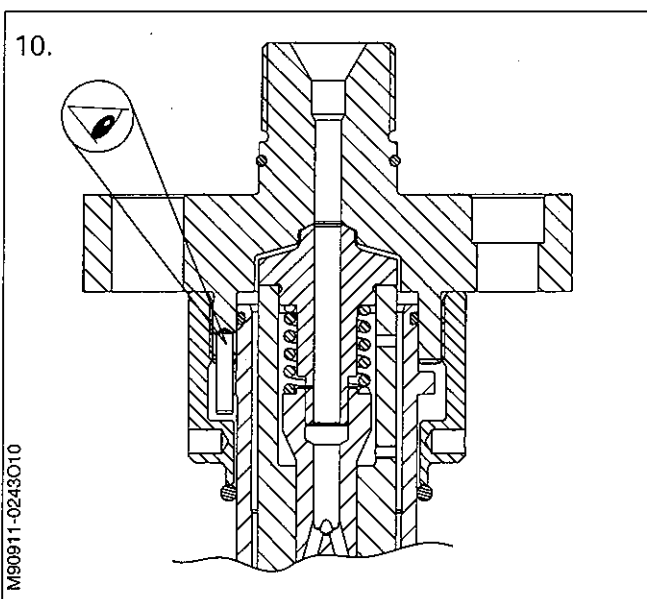
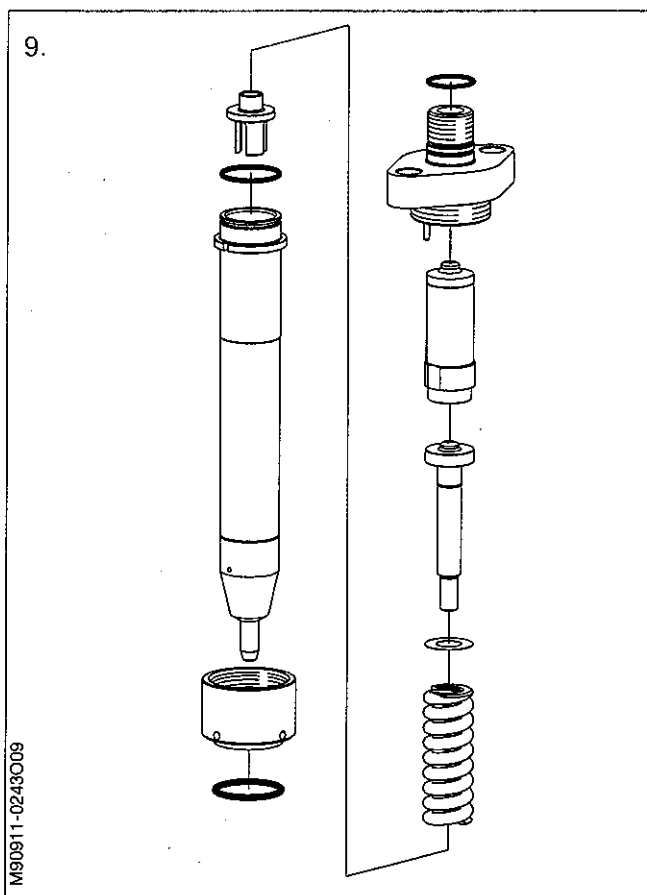
Lubricate the thread of the valve head with molybdenum disulphide (MoS_2).

For the correct use of this lubricant, see Procedure 913-11.

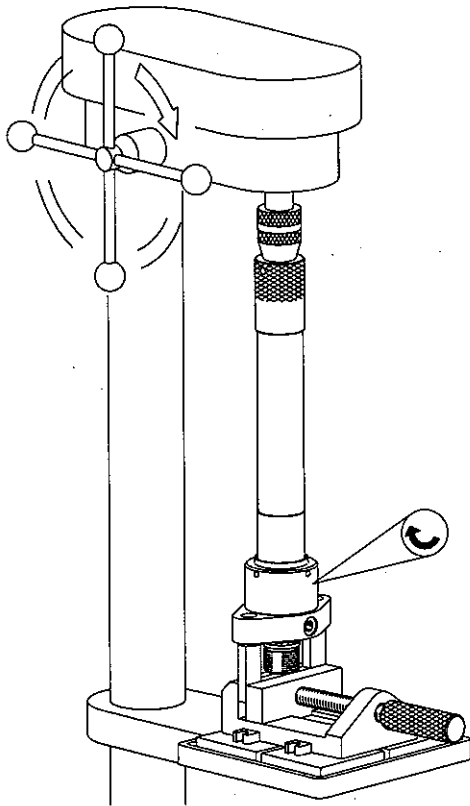
Fit the valve head with a new O-ring.

10. Make sure that the guide pin between valve housing and valve head is intact, and press the valve head down into the valve housing.

See that the guide pin between valve housing and valve head engages correctly so as to prevent relative turning of the parts.



11.



M90911-0240010

11. Assemble the valve by means of the union nut.

Place the valve in the valve holder in a drilling machine.

Compress the fuel valve and the spring inside. Keep the valve compressed and tighten the union nut with a hook spanner.

After overhaul, the fuel valve must be tested in the test rig.

See *Procedure 909-11.1*.

12. If the fuel valve is not to be mounted in the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

1. Before mounting the fuel valve, thoroughly clean the valve bore in the cylinder cover and check the seating in the bore for marks which, if any, must be eliminated.
(For reconditioning of the valve bores in the cylinder cover, see Procedure 901-1.3).

If not already done, mount new O-rings on the fuel valve. Lubricate the valve with molybdenum Disulphide (MoS_2).

2. Mount the valve in position in the cylinder cover.

Mount the spring housings and the nuts. Tighten the nuts until the top face of the pressure disc is flush with the top face of the spring housing. This must be done with great care, as the spring tension in the housing determines the correct tightening of the fuel valve to the cylinder cover as well as the correct compression of the fuel valve.

3. Lubricate the thread on the union nipple of the fuel oil pipe with a heat resistant anti seize grease before mounting.

Note!

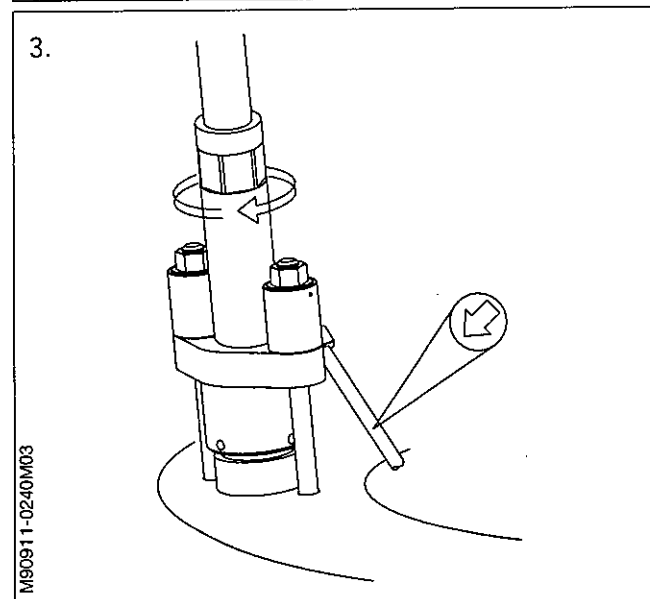
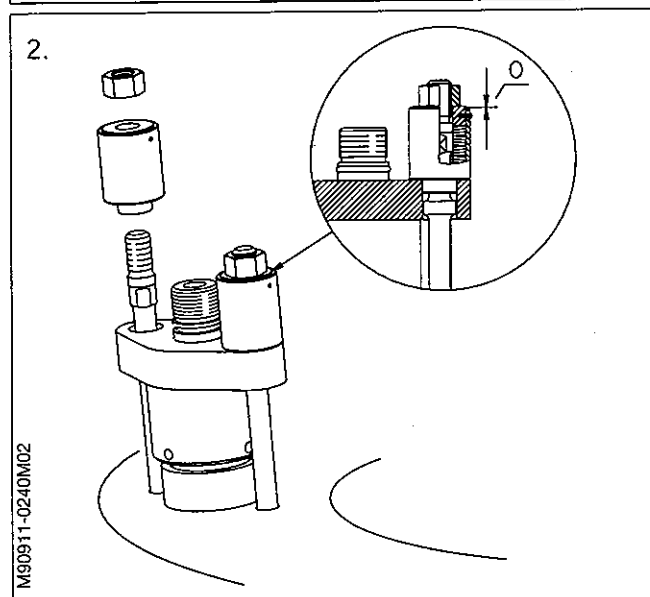
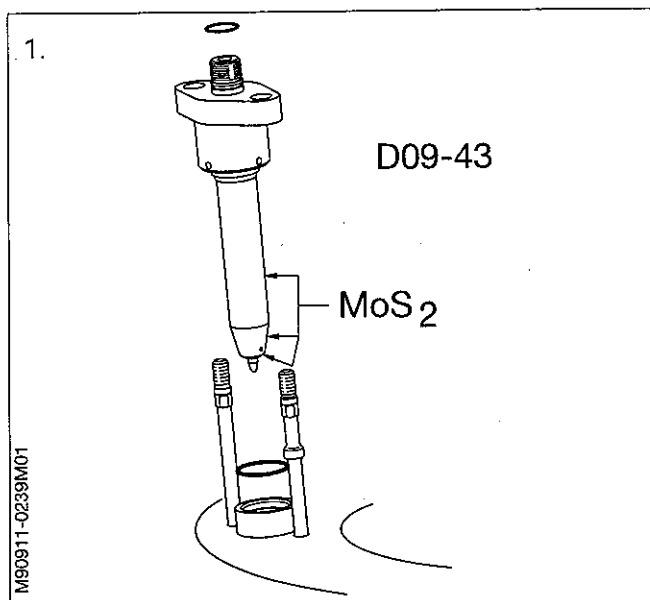
It is recommended to overhaul the fuel oil high-pressure pipe before mounting.
See Procedure 909-14.3.

As a minimum, the distance between the fuel oil pipe ends and the thrust bushings **must** be checked and, if necessary, adjusted.

Mount the overhauled fuel oil high-pressure pipe and the return oil pipe.
See Procedure 909-14.4.

Note!

All fuel valves must be function-tested before being mounted in the cylinder cover, see Procedure 909-11.1.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

- ☐ Stopped engine
- ☐ Shut off starting air supply – *At starting air receiver*
- ☐ Block the main starting valve
- ☐ Shut off starting air distributor/distributing system supply
- ☐ Shut off safety air supply – *Not ME engines*
- ☐ Shut off control air supply
- ☐ Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
- ☐ Engage turning gear
- ☐ Shut off cooling water
- ☐ Shut off fuel oil
- ☐ Stop lubricating oil supply
- ☐ Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit																																																																																										
D09-70	Nozzel spray hole cleaning tool table																																																																																												
	<table><tr><th>Nozzel spray hole</th><th>Cleaning drill</th><th>Test pin</th><th>Nozzel spray hole</th><th>Cleaning drill</th><th>Test pin</th></tr><tr><td>0.90</td><td>0.85</td><td>0.94</td><td>1.60</td><td>1.55</td><td>1.65</td></tr><tr><td>0.95</td><td>0.90</td><td>0.99</td><td>1.65</td><td>1.60</td><td>1.70</td></tr><tr><td>1.00</td><td>0.95</td><td>1.04</td><td>1.70</td><td>1.65</td><td>1.74</td></tr><tr><td>1.05</td><td>1.00</td><td>1.09</td><td>1.75</td><td>1.70</td><td>1.80</td></tr><tr><td>1.10</td><td>1.05</td><td>1.14</td><td>1.80</td><td>1.75</td><td>1.85</td></tr><tr><td>1.15</td><td>1.10</td><td>1.20</td><td>1.85</td><td>1.80</td><td>1.89</td></tr><tr><td>1.20</td><td>1.15</td><td>1.24</td><td>1.90</td><td>1.85</td><td>1.94</td></tr><tr><td>1.25</td><td>1.20</td><td>1.30</td><td>1.95</td><td>1.90</td><td>1.99</td></tr><tr><td>1.30</td><td>1.25</td><td>1.34</td><td>2.00</td><td>1.95</td><td>2.05</td></tr><tr><td>1.35</td><td>1.30</td><td>1.39</td><td>2.05</td><td>2.00</td><td>2.09</td></tr><tr><td>1.40</td><td>1.35</td><td>1.44</td><td>2.10</td><td>2.05</td><td>2.14</td></tr><tr><td>1.45</td><td>1.40</td><td>1.49</td><td>2.15</td><td>2.10</td><td>2.19</td></tr><tr><td>1.50</td><td>1.45</td><td>1.54</td><td>2.20</td><td>2.15</td><td>2.24</td></tr><tr><td>1.55</td><td>1.50</td><td>1.59</td><td>2.25</td><td>2.20</td><td>2.29</td></tr></table>	Nozzel spray hole	Cleaning drill	Test pin	Nozzel spray hole	Cleaning drill	Test pin	0.90	0.85	0.94	1.60	1.55	1.65	0.95	0.90	0.99	1.65	1.60	1.70	1.00	0.95	1.04	1.70	1.65	1.74	1.05	1.00	1.09	1.75	1.70	1.80	1.10	1.05	1.14	1.80	1.75	1.85	1.15	1.10	1.20	1.85	1.80	1.89	1.20	1.15	1.24	1.90	1.85	1.94	1.25	1.20	1.30	1.95	1.90	1.99	1.30	1.25	1.34	2.00	1.95	2.05	1.35	1.30	1.39	2.05	2.00	2.09	1.40	1.35	1.44	2.10	2.05	2.14	1.45	1.40	1.49	2.15	2.10	2.19	1.50	1.45	1.54	2.20	2.15	2.24	1.55	1.50	1.59	2.25	2.20	2.29		
	Nozzel spray hole	Cleaning drill	Test pin	Nozzel spray hole	Cleaning drill	Test pin																																																																																							
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The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90966		Fuel Valve Nozzle - Tools

Note!

This instruction is only valid for spindle guides of the slide valve design.

Extreme care and accuracy should be exercised when carrying out this operation.

Based on service experience it is recommended to replace the complete spindle guide after 16000 hours of operation.

1. Clean the outside of the spindle guide in pure gas oil or similar. The individual parts of the spindle guide are not interchangeable, therefore only one guide is to be disassembled at a time.

Note!

The spindle guide, thrust piece and spindle are matched parts and may not be re-placed individually.

2. Place the spindle guide in a bench vice provided with "soft" jaws, and use the brass mandrel as shown to disassemble the spindle guide.
3. Mount the pulling tool around the fuel nozzle on the spindle guide. Turn the nut to pull the fuel nozzle off the spindle guide.

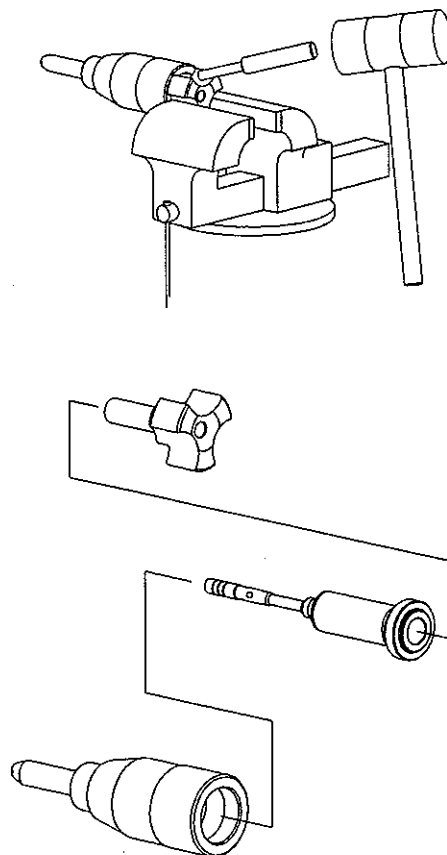
Note!

The pulling tool is not standard for all engines, but may be delivered as an optional extra.

4. If no pulling tool is available, the fuel nozzle can be dismantled from the spindle guide using two screwdrivers.

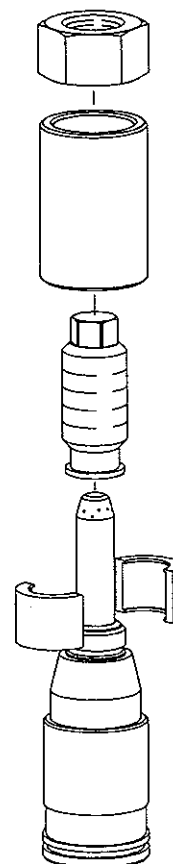
Place the screwdrivers opposite each other in the small gap between the fuel nozzle and the spindle guide and very carefully force the fuel nozzle off the spindle guide.

2.

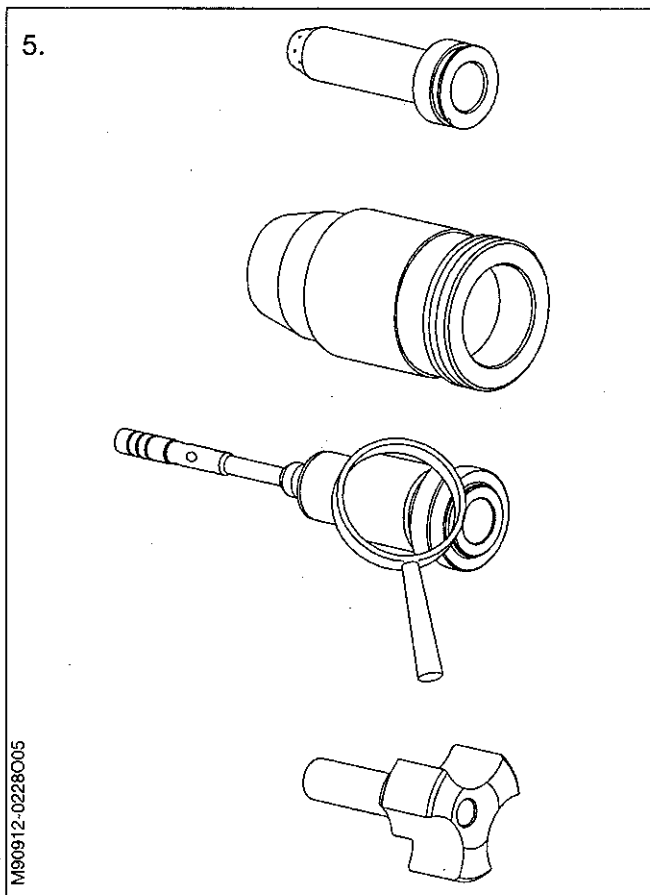


M90912-0228002

4.



M90912-0228004



5. Clean all the parts of the spindle guide in gas oil and wipe dry with a clean piece of cloth.

Clean all parts again in gas oil or 'Electrocleaner' and wipe dry with a clean piece of cloth.

Place all the parts on a clean, soft, lint-free cloth and examine them through an 8-10 times magnification magnifying glass and an inspection lamp.

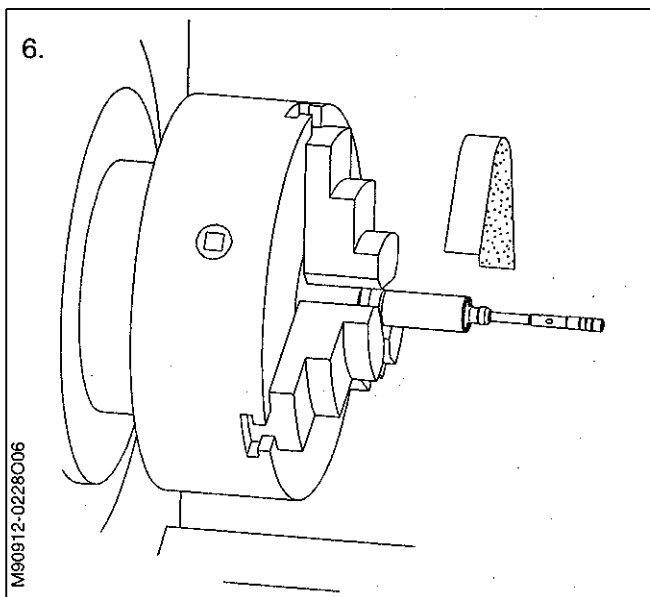
During the examination, pay special attention to the seating surfaces and sliding surfaces of the parts.

6. Remove any deposits or very fine scratches by placing the spindle, thrust piece or spindle guide respectively in a lathe, as shown, and polishing with a very fine conventional polishing linen 'grade 360'.

Use also a little oil for the polishing (a coarser polishing linen must **absolutely not** be used).

Note!

The sliding surface of the cut-off slide may only be polished **VERY** carefully. The sliding surface must not be damaged.



After polishing, clean the parts again and re-check the seat on thrust piece/spindle, the seat on slide valve/spindle, and the seat on spindle/guide. Use an inspection lamp and an 8-10 times enlargement magnifying glass.

If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

7. Clean any carbon deposits from the central bore of the fuel nozzle by means of the special brass brush. Clean the fuel nozzle with gas oil and wipe dry with a clean cloth.
8. Read the nominal hole size on the cylindrical part of the nozzle, as shown in the figure. The hole size is given in 1/100 mm. Depending on the engine model, there can be one or more different sizes of the holes. Find the correct drill size and matching test pin in the table, *D09-70, on the data sheet*, via the nominal hole size.

Clean the spray holes, using gas oil and the special drills supplied.

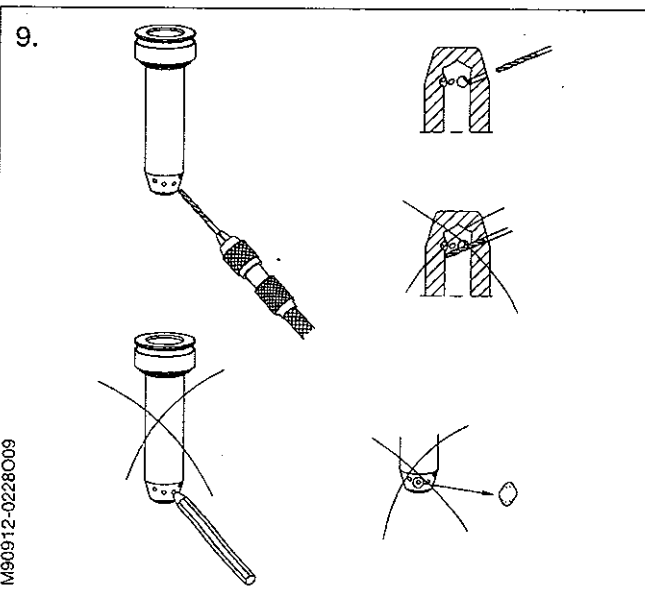
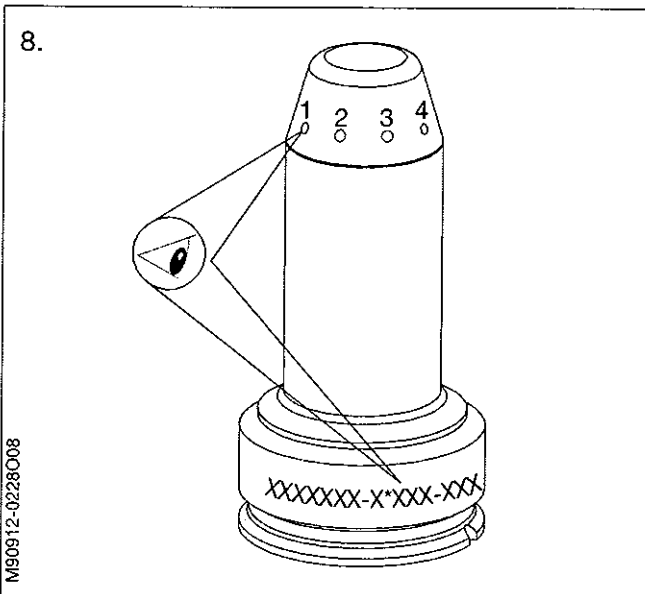
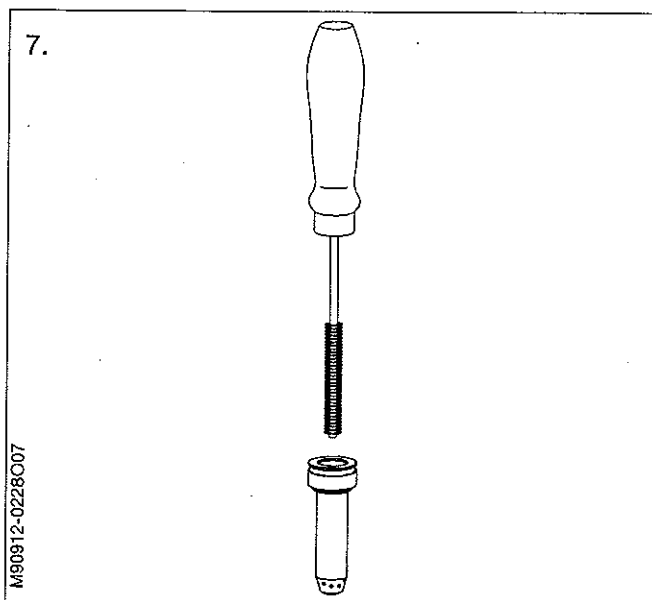
Note!

During this operation be very careful not to push the drill too far to avoid scratching the snug-fit surface on the inside of the fuel nozzle.

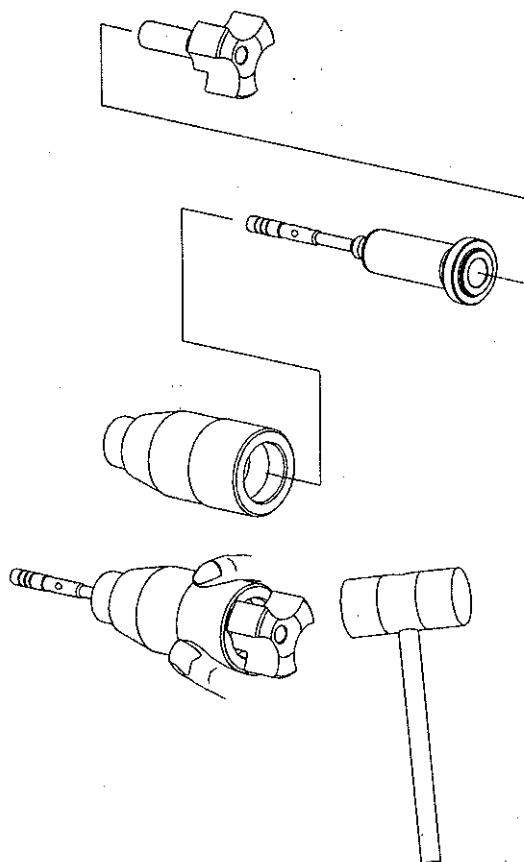
Then test the spray holes with the test pin. If the test pin is able to enter just one of the holes, the fuel nozzle must be discarded.

This also applies to nozzles with oval holes (can be ascertained with a magnifying glass).

Check the fuel nozzle before mounting on the spindle guide, the cut-off slide must be able to move freely inside the nozzle.



11.

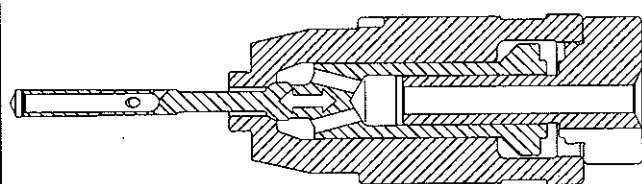


10. Lubricate the spindle and the thrust piece with the cut-off slide with a little Molybdenum Disulphide (MoS_2), see *Procedure 913-11*.

11. Assemble the thrust piece, the spindle and the spindle guide and carefully knock the parts together using a soft hammer.

12. Shake the spindle guide back and forth. The spindle with the cut-off slide must be able to slide freely back and forth inside the spindle guide, with a 'clicking' sound.

12.



13. Lubricate the sliding surfaces of the nozzle and the spindle with a little Molybdenum Disulphide (MoS_2). See Procedure 913-11.

Mount the nozzle on the spindle guide.

Make sure that the half-circle shaped groove on the nozzle and the spring pin are in line.

If nozzle and spindle guide are provided with scratch marks opposite the spring pin, they must be in line.

Place the parts on the plane of a drilling machine or hydraulic press and position the mounting tool over the parts. Make sure that all the parts are perfectly aligned.

Press the nozzle on to the spindle guide.

Note!

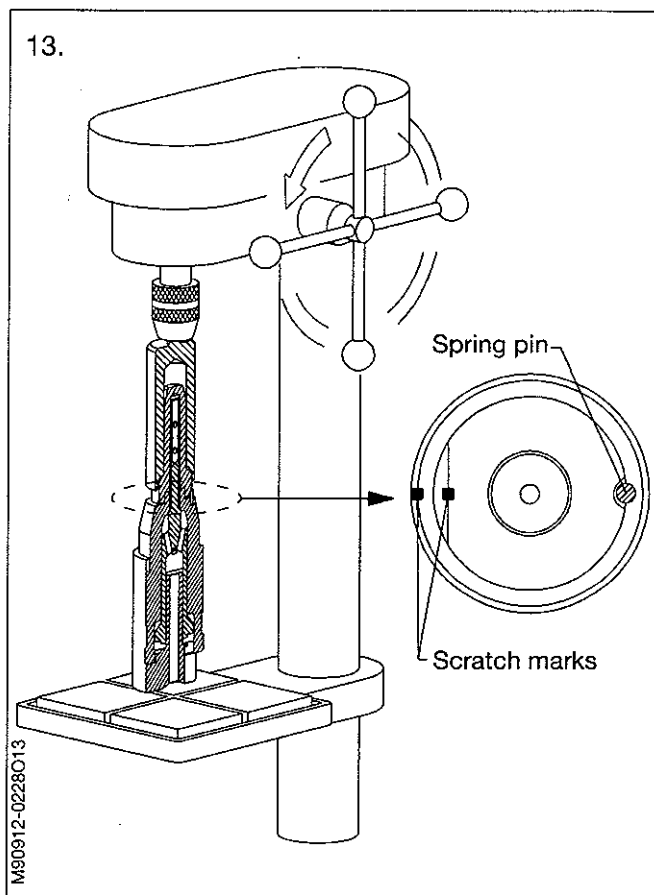
The mounting tools are not standard for all engines but may be delivered as optional extras.

If no mounting tools are available, the nozzle can be mounted on the spindle guide using a short piece of pipe.

Place the pipe around the nozzle, so that the lower end of the pipe rests on the 'foot' of the fuel nozzle. Then press the parts together the same way as when using the mounting tools.

Check that the spindle inside the spindle guide is able to move freely as in step 10.

14. If the spindle guide is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the spindle guide with plastic to prevent dirt from entering the spindle guide during storage.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

- ☐ Stopped engine
- ☐ Shut off starting air supply – *At starting air receiver*
- ☐ Block the main starting valve
- ☐ Shut off starting air distributor/distributing system supply
- ☐ Shut off safety air supply – *Not ME-engines*
- ☐ Shut off control air supply
- ☐ Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
- ☐ Engage turning gear
- ☐ Shut off cooling water.
- ☐ Shut off fuel oil
- ☐ Stop lubricating oil supply
- ☐ Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90951 P90968	153	Flange for dismantling of non return valve Fuel Valve - Inspection Tools

Note!

Extreme care and accuracy should be exercised when carrying out this operation.

1. Clean the outside of the non-return valve with pure gas oil. The individual parts are not interchangeable, therefore only one guide is to be disassembled at a time.

Note!

Except for the slide valve spring, defective parts cannot be replaced individually by new ones.

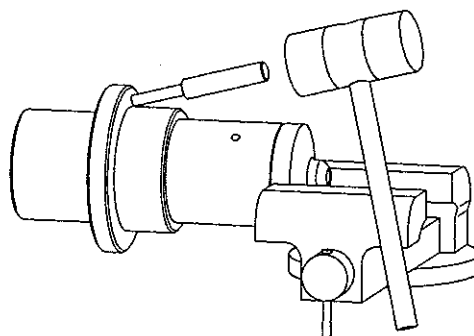
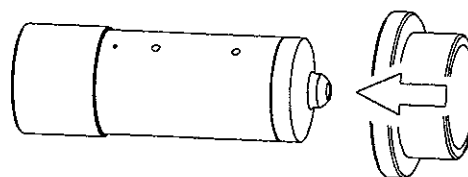
Place the non-return valve as shown in Fig. 1 in a bench vice provided with "soft" jaws, and disassemble the non-return valve, using the disassembling tool and a hammer as shown.

2. Clean all the parts for the spindle guide in gas oil and then blow clean.

Finally, clean in either gas oil, kerosene or 'Electrocleaner', and blow the parts dry with compressed air as shown in Fig. 2.

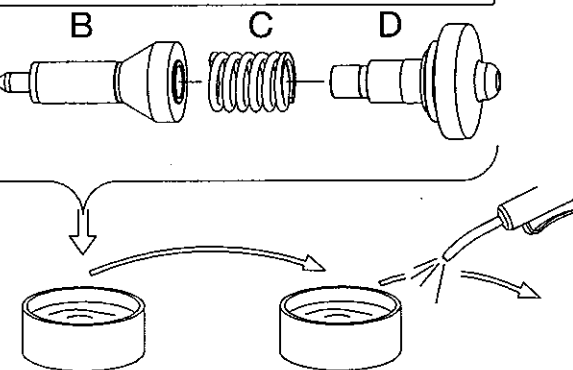
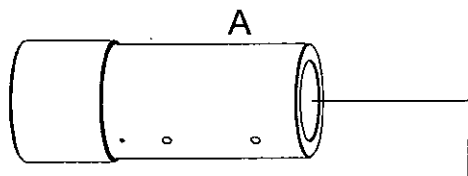
3. Now place the parts on clean, lint-free rags and examine with an 8-10 times enlargement magnifying glass, and an inspection lamp with magnifying glass as shown in Fig. 3.

1.



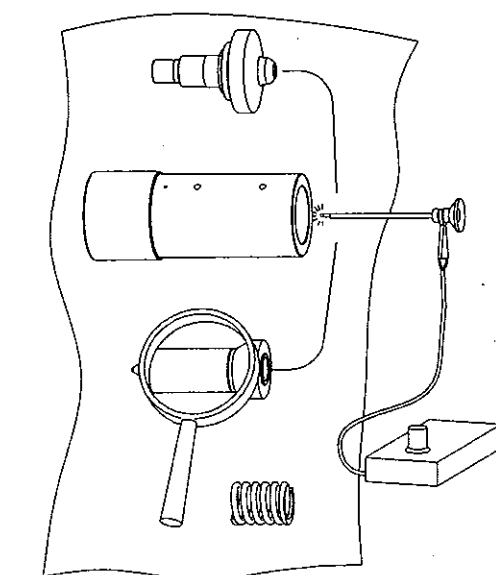
M90913-0207001

2.

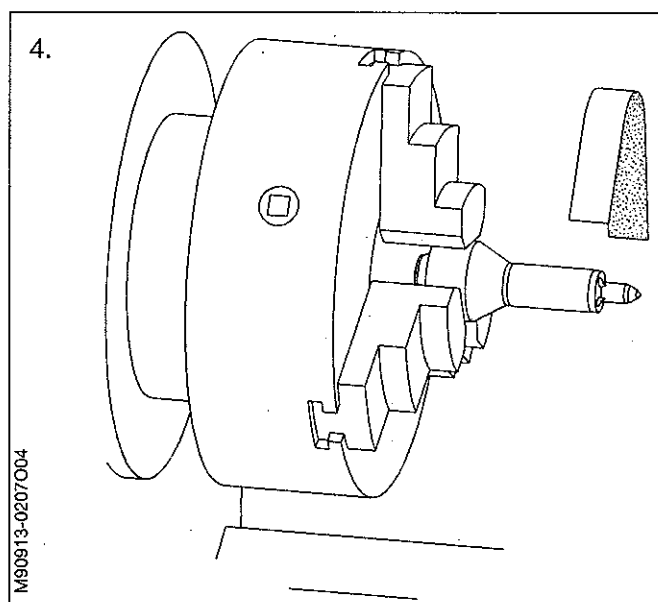


M90913-0208002

3.



M90913-0207003



4. Examine the slide faces of movable parts for coating. Vent slide **B**/housing **A** will be too tight if there is a coating. (The letters **A-D** refer to the letters/parts in Fig. 2).

Fix vent slide **B** and, subsequently, housing **A** in a lathe as shown in Fig. 4 and remove the coating by means of very fine conventional polishing linen 'grade 360'.

Also a little oil should be used (a coarser polishing linen must **absolutely not** be used).

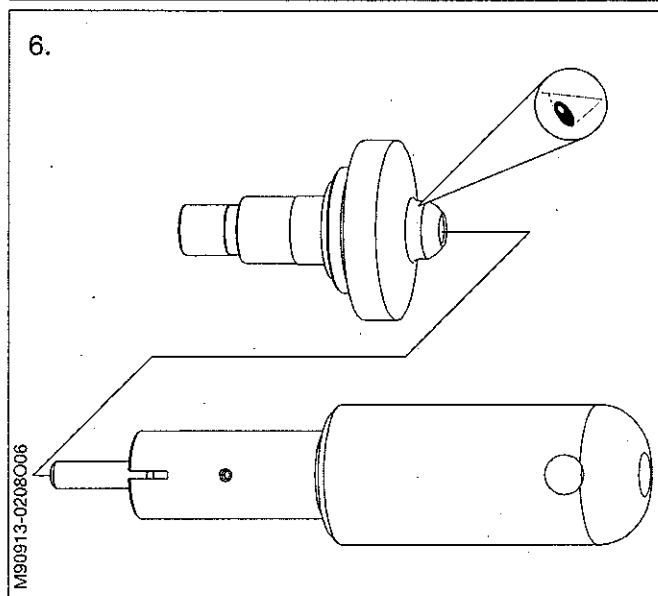
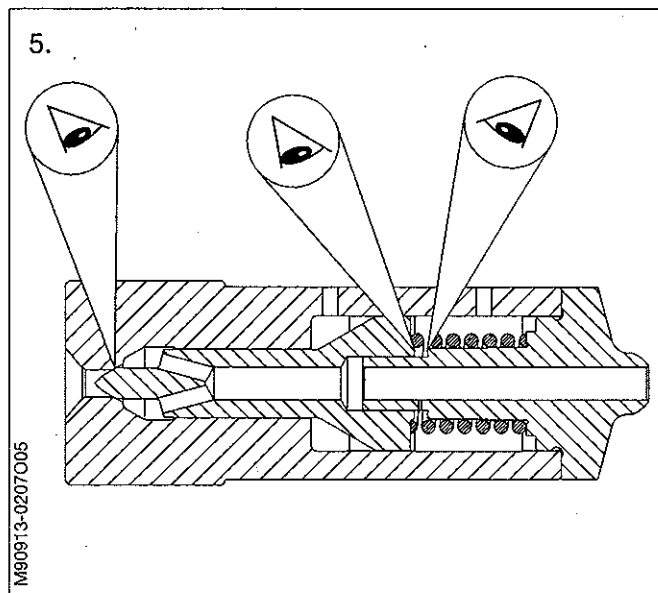
5. Check spring **C** for the thrust piece for inside wear marks. If defective, it should be exchanged.

Check the seat on thrust piece **D**/vent slide, and the seat on vent slide/housing. Use an inspection lamp and an 8-10 times enlargement magnifying glass.

If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

6. Check the outside sealing face on the thrust piece **D**.

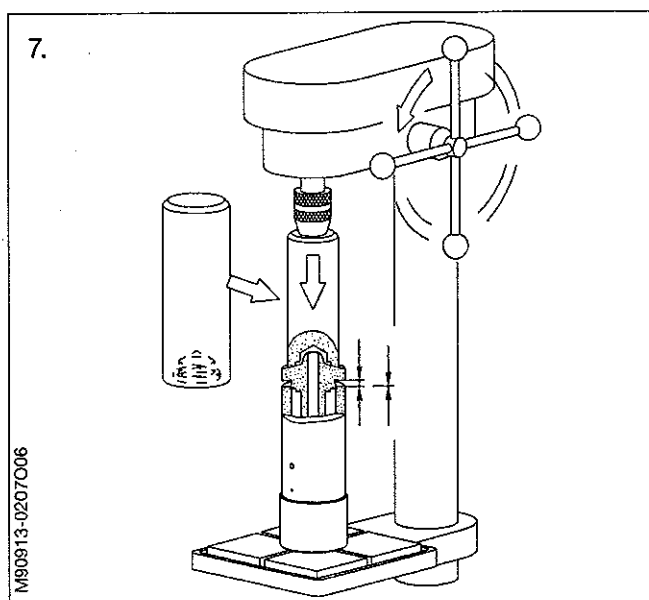
If necessary, grind the seating surfaces by means of the grinding mandrel, found on tool panel 909, and a fine-grain abrasive (such as Carborundum No. 500).



7. Mount the non-return valve as follows:

- Lubricate all movable parts with molybdenum disulphide (MoS_2).
- Place the loosely-assembled non-return valve on the plane of a drilling machine, with the tool positioned as shown in Fig. 6.
- Make sure that the thrust piece and the other parts are perfectly aligned and that the thrust piece is guided in the vent slide.
- Press the handle until the housing and thrust piece meet.

8. If the non-return valve is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the non-return valve with plastic to prevent dirt from entering the valve during storage.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-81	Booster complete	640	kg
D09-82	Booster housing	260	kg
D09-83	Hydraulic plunger	48	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P90862		Exhaust Valve - Hydraulic Tools
P90951	69	Lifting tool for fuel pump
P90951	368	Lifting tool for hydraulic plunger
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	105	3-way distributor block, complete

1. Mount a pressure gauge at "minimess" point No. 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block. Check that the hydraulic cylinder unit is pressure free.

2. Close the fuel oil inlet valve.

Open the fuel oil drain.

Remove the fuel oil high pressure pipes, see *Procedure 909-14.2*.

Disconnect the electrical sensor connection.

Remove the fuel oil inlet pipe.

Remove all drain pipes connected to the fuel oil pressure booster.

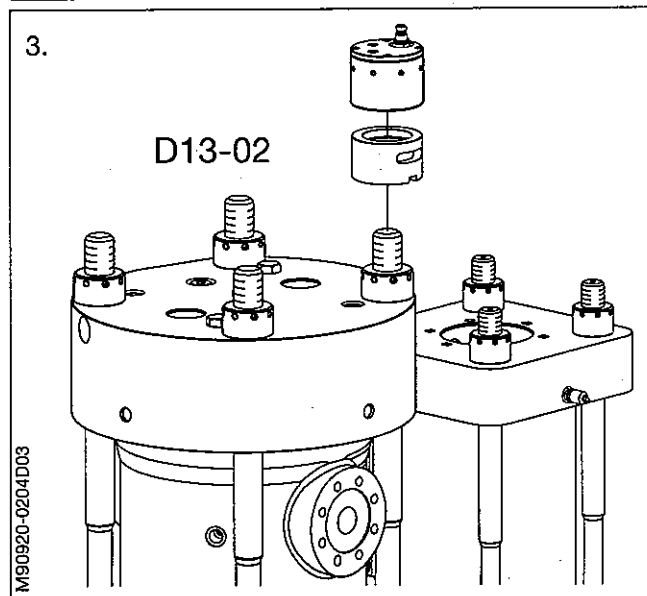
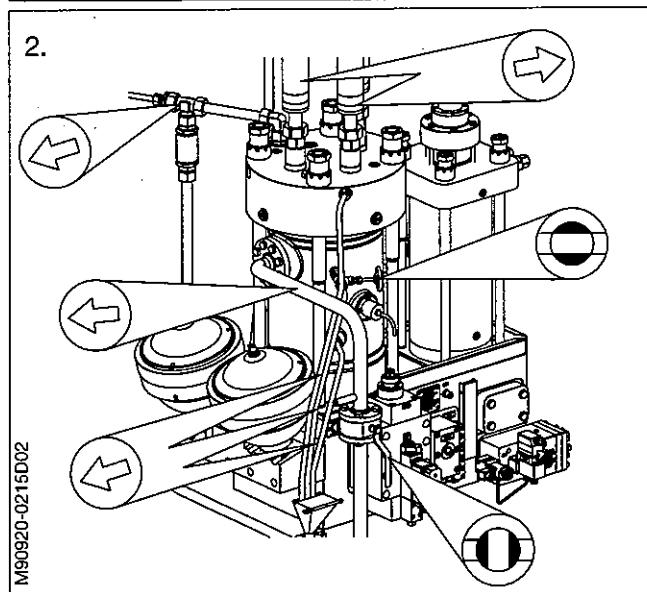
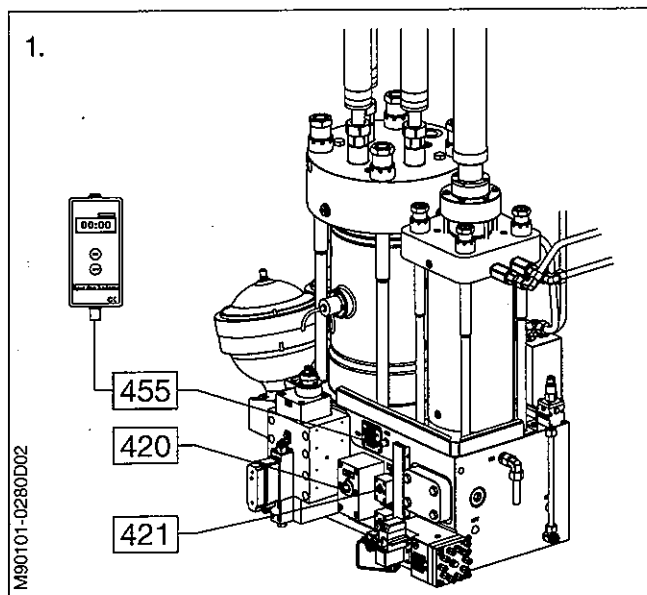
Note!

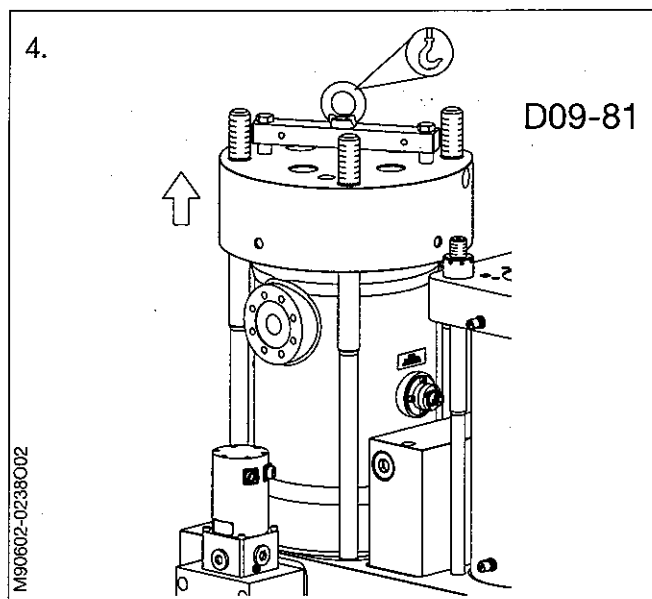
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

3. Loosen the nuts, two at a time, diagonally.

Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in Data. Loosen and remove the nuts.

For use of hydraulic tools, see also Procedure 913-1.





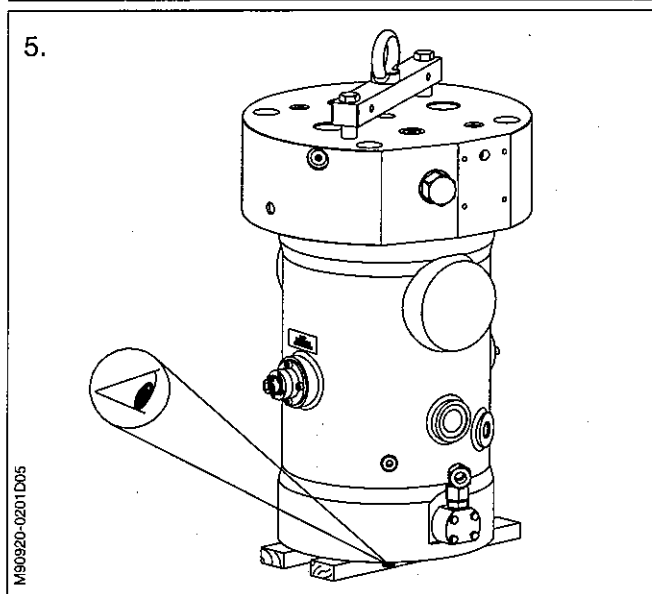
4. Mount the lifting tool on top of the fuel oil pressure booster.

See Procedure 909-21.2.

Carefully lift the fuel oil pressure booster clear of the hydraulic block and the fuel oil pressure booster studs.

Cover the hole in the hydraulic block, to keep the hydraulic high pressure system clean.

5. Land the fuel oil pressure booster on a wooden support and take care not to damage the drain oil bushing.



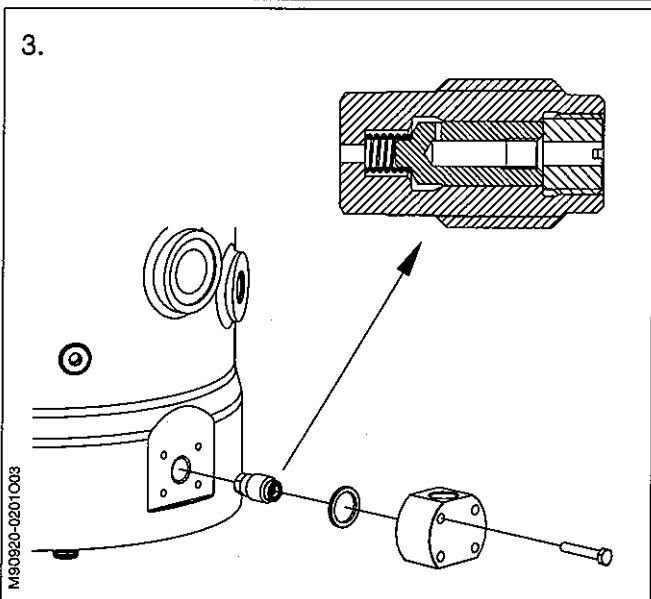
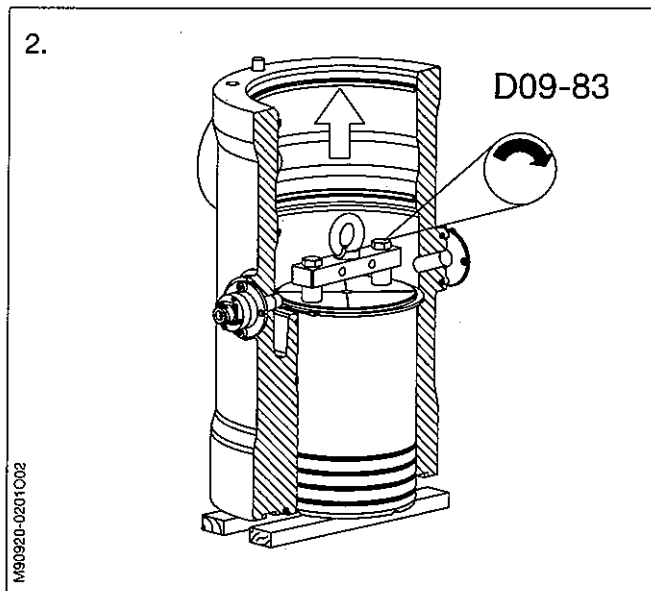
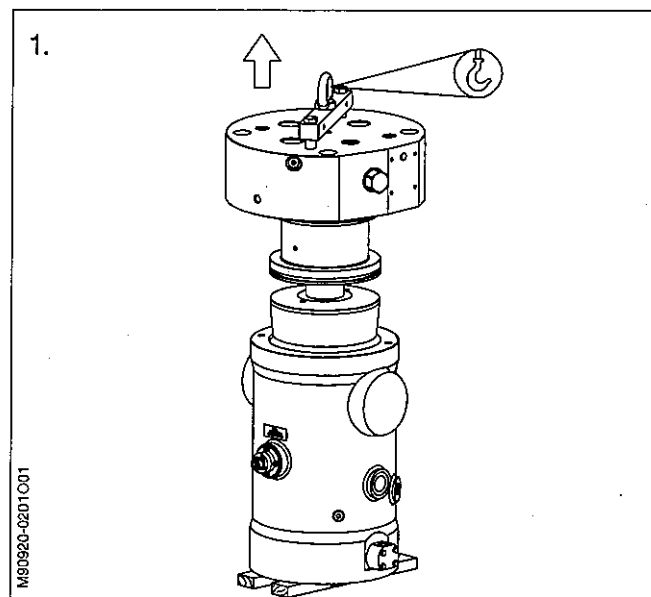
1. Place the fuel oil pressure booster on a wooden support.

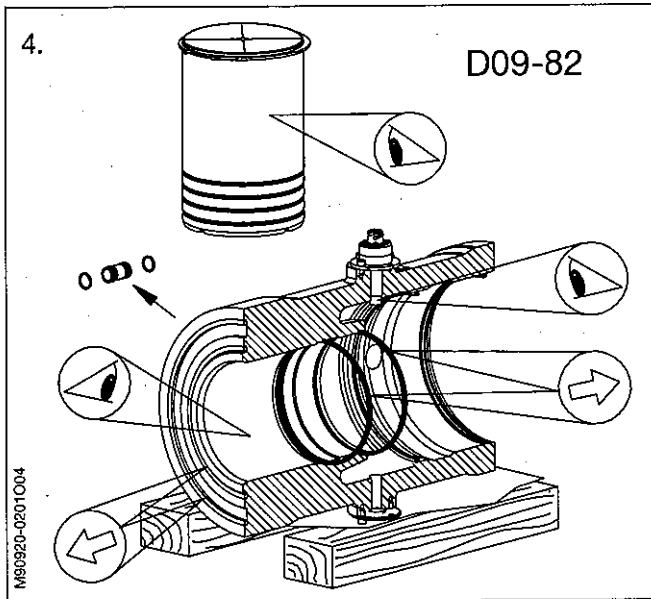
Remove the booster top cover, see Procedure 909-21.2.

2. Mount the lifting tool in the top of the hydraulic plunger.

Lift up the plunger.

3. Unscrew the flange for the throttle valve. Screw out the throttle valve, clean the valve in gas oil and blow through with compressed air.





4. Clean the booster housing and the hydraulic plunger with kerosene or gas oil.

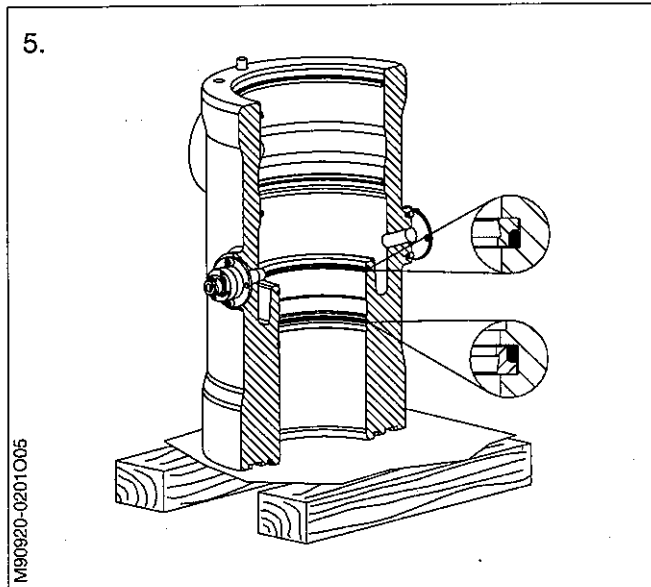
Place the booster housing on one side.

Remove the two sealing rings from the cylindrical part of the booster housing and the sealing ring from the bottom. Discard the sealing rings.

Carefully clean the bottom of the booster housing.

Inspect the hydraulic cylinder surface and the hydraulic piston for wear and seizures.

Check the position sensor tip for damage. The position sensor should only be renewed if it is not working properly.



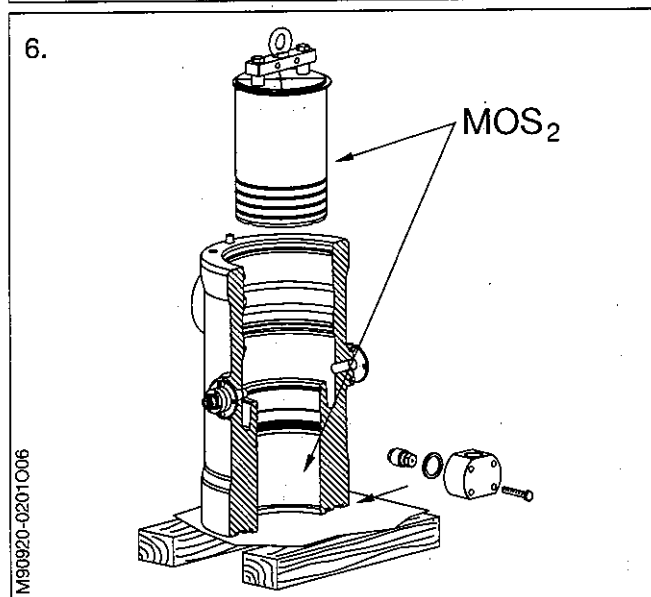
Pull out the drain oil bushing and discard the two sealing rings. Clean the hole and the bushing.

Mount the bushing with new sealing rings.

5. Mount new sealing rings in the hydraulic cylinder.

For correct mounting, see the sketch.

Turn the booster housing to an upright position and place it on a clean piece of oil paper.



6. Lubricate the cylinder (lower part) and the hydraulic piston with proactive oil.

Mount the hydraulic piston.

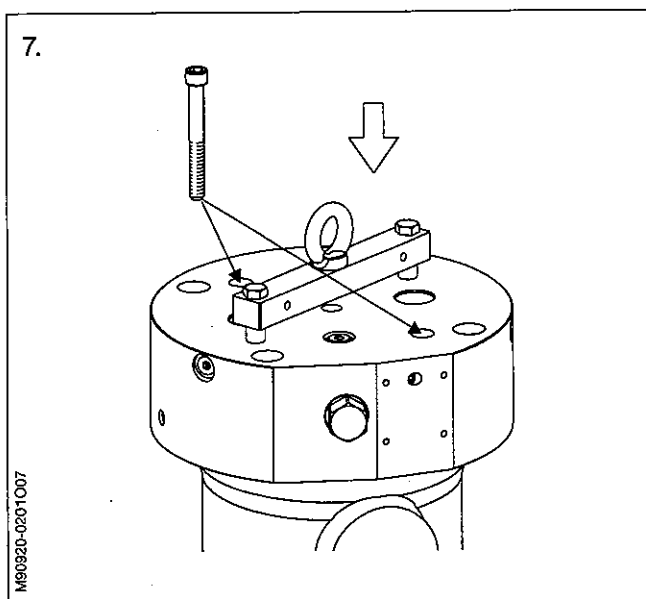
Note!

All parts of the hydraulic high pressure system must be kept absolutely clean and free of impurities.

In this case, pay particular attention to the hydraulic piston and the lower part of the booster housing.

Mount the throttle valve and the flange.

7. Mount the booster top cover and tighten the top cover screws. See *Procedure 909-21.4*.
8. If the booster is stored before use, cover all openings with plastic and apply preservation oil to all machined surfaces to prevent corrosion.



Note!

Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

1. If the fuel oil pressure booster has been preserved for storage, remove all preservation and plastic covers.

Mount the lifting tool in the top of the fuel oil pressure booster.

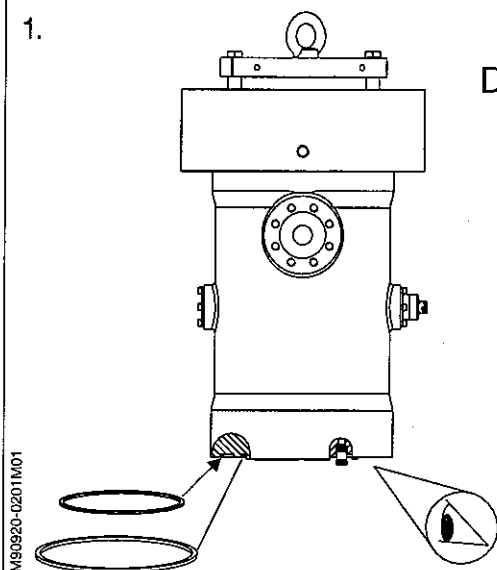
Lift up the fuel oil pressure booster, and check if the bottom surface is clean and free of impurities.

Mount new sealing rings if not already done.

2. Check that the face on the hydraulic block is completely clean.
3. Land the fuel oil pressure booster on the hydraulic block.

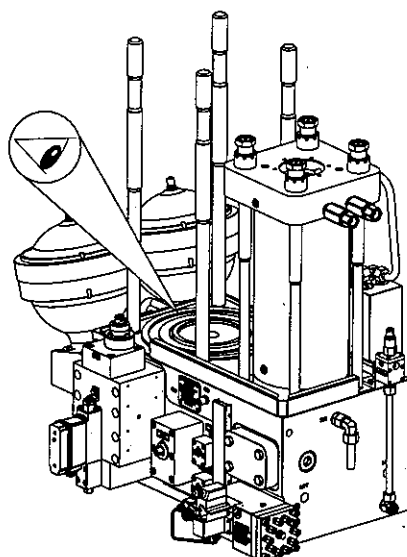
Remove the lifting tool.

1. D09-81



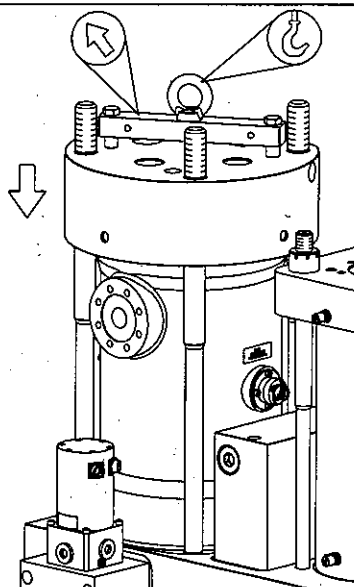
M90920-0201M01

2.



M90920-0215M02

3.



M90602-0238M03

Mounting

4. Mount the nuts on the fuel oil pressure booster studs and screw down.

Tighten two nuts at a time, diagonally.

Screw the nuts on to the two studs. Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the jacks to the tightening pressure, as specified in Data. Tighten the nuts and remove the hydraulic jacks and the spacer rings.

5. Mount and tighten all drain pipes to the fuel oil pressure booster.

Mount the fuel oil inlet pipe.

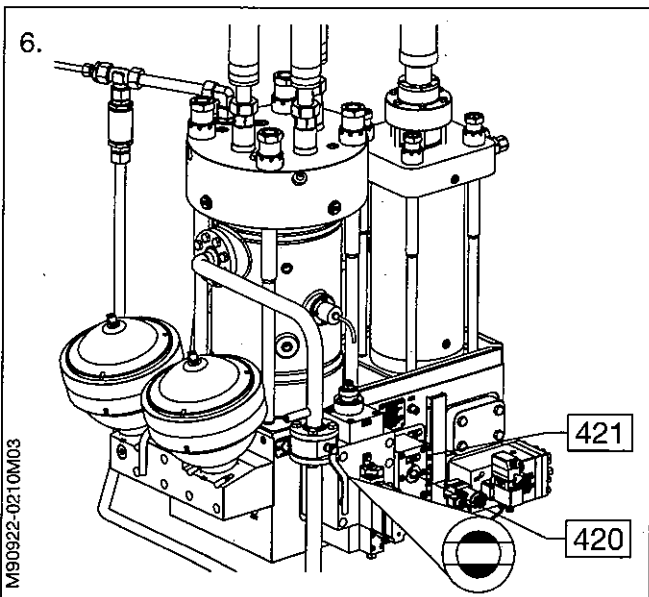
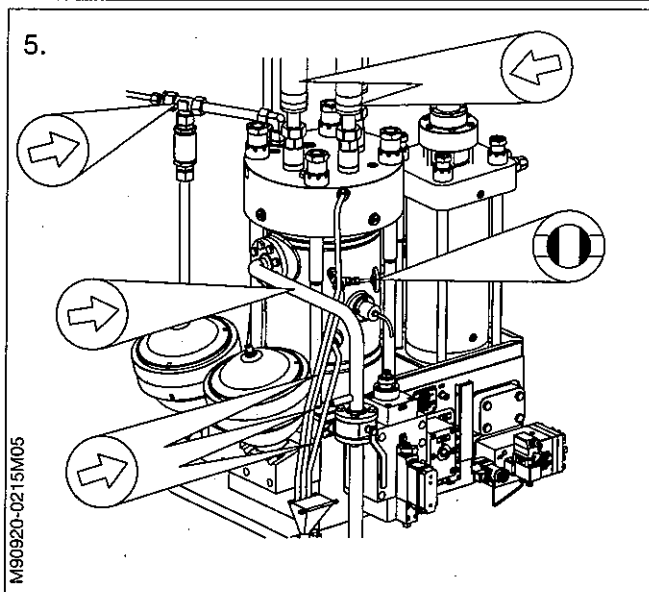
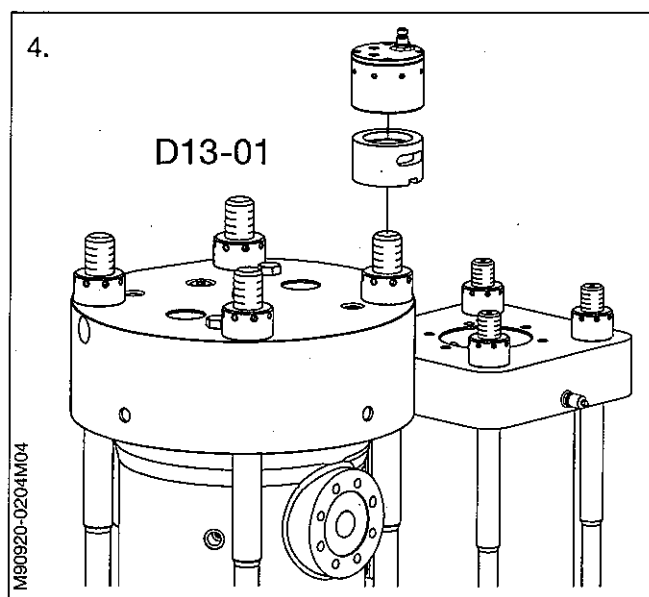
Mount the fuel oil high pressure pipes, see Procedure 909-14.4.

Close the fuel oil drain valve.

Mount the electrical sensor plug.

6. Open valve 420 and close valve 421 on the hydraulic block.

Open the fuel oil inlet valve.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-86	Fuel outlet seat, max.grinding diameter	30	mm
D09-87	Booster top cover	330	kg
D09-88	Fuel plunger	30	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. P90951 refers to chapter 909.

Plate	Item No.	Description
P90862		Exhaust Valve - Hydraulic Tools
P90951	69	Lifting tool for fuel pump
P90981		Mounting Tools - Top Cover Seals
P90951	320	Plunger locking tool
P91351	10	Hydraulic pump, pneumatically operated
P91351	46	Hose with unions (1500mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	105	3-way distributor block, complete

1. Close the fuel oil inlet valve.

Mount a pressure gauge at "minimess" point No. 455. Check the pressure.

Close valve 420 and open valve 421 on the hydraulic block.

Check that the hydraulic cylinder unit is pressure free.

2. Remove the fuel oil high pressure pipes, see Procedure 909-14.2.

Drain the fuel oil pressure booster for oil.

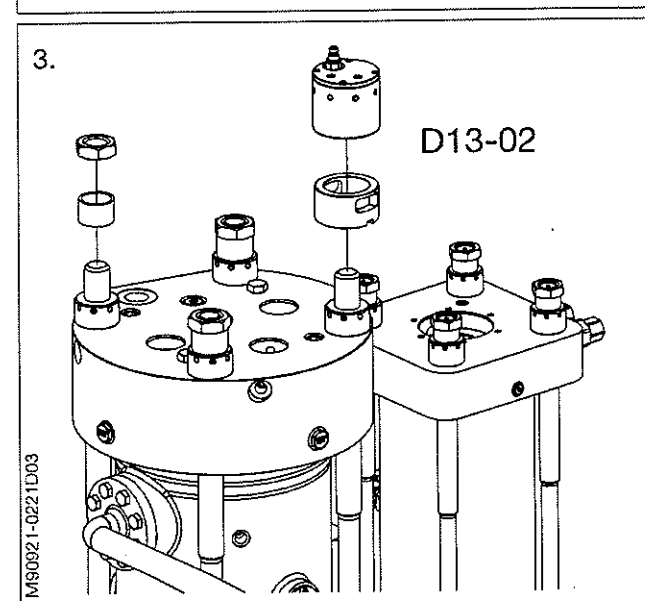
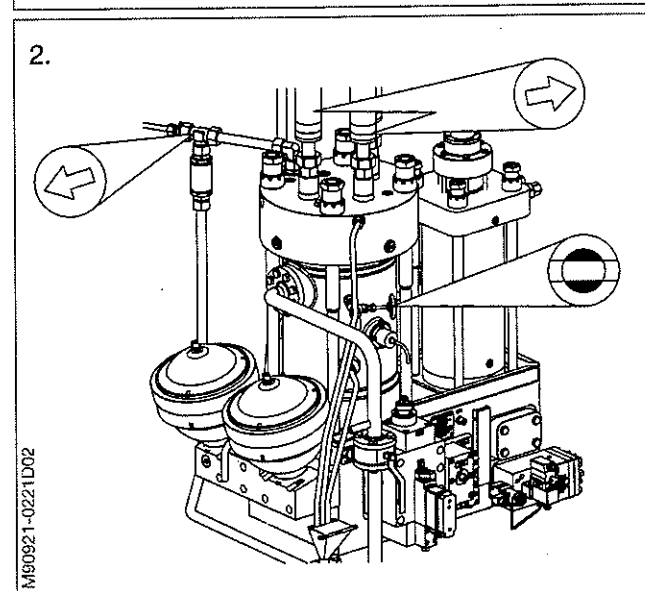
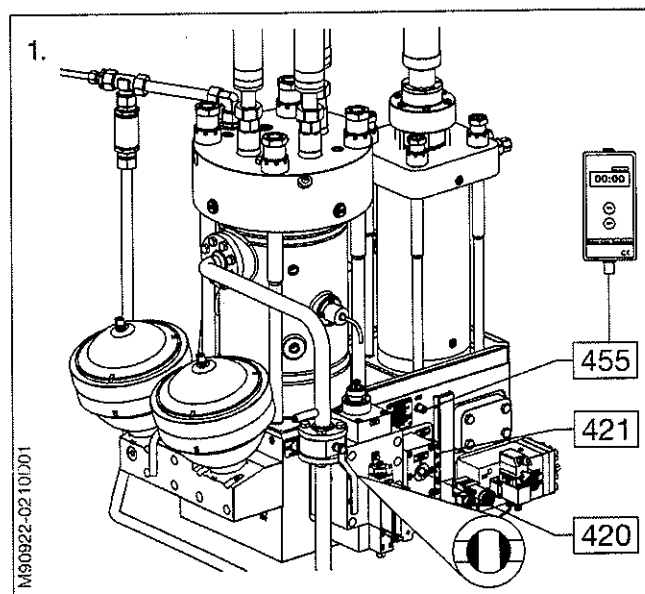
Remove the drain oil pipe from the top cover.

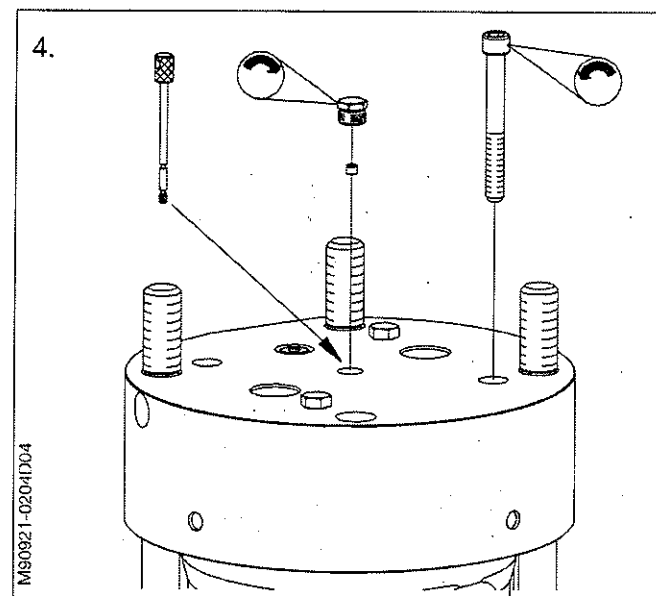
3. Remove the thread protective caps.

Loosen the hydraulic nuts, two at a time, diagonally.

Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in Data. Loosen and remove the nuts.

For operation of the hydraulic tools, see Procedure 913-1.





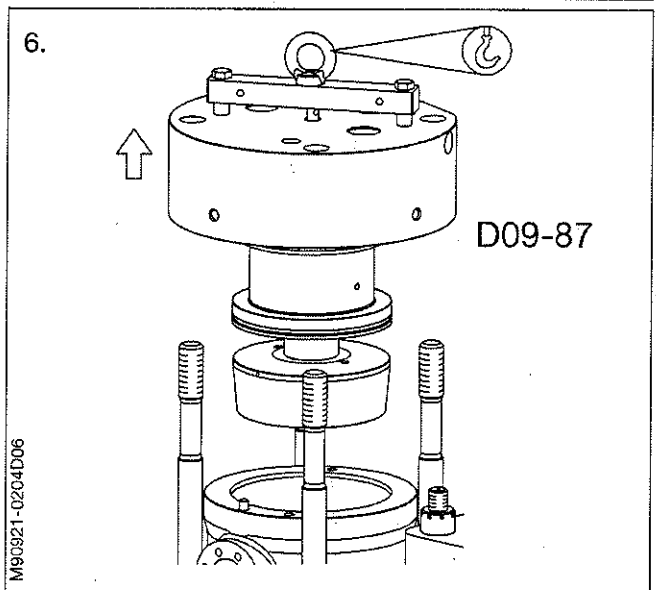
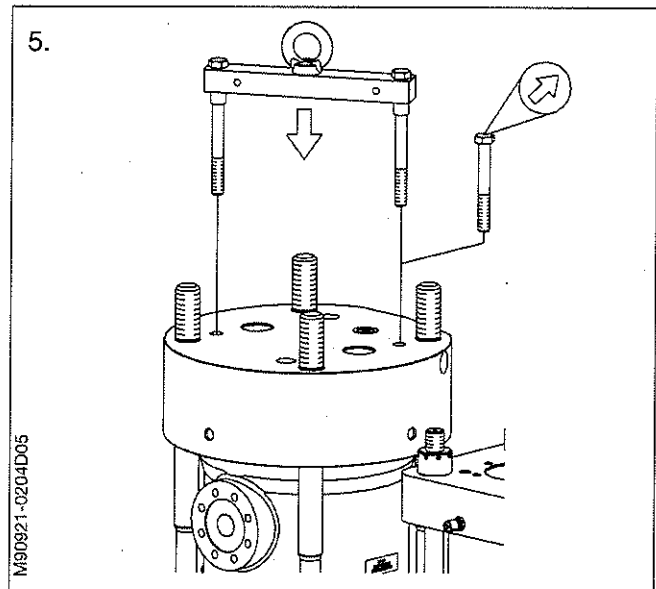
4. Unscrew the centre plug screw with lefthanded thread and remove the small disc.

Mount the retaining tool for the fuel plunger.

Remove the two Allen screws.

5. Remove the two hexagon head screws and mount the lifting tool in the holes.

6. Carefully lift up the top cover assembly, and land it on a wooden support.



1. Land the top cover assembly on a wooden support.

Unscrew the retaining tool for the fuel plunger.

Carefully lift the booster top cover clear of the plunger.

Remove and discard the sealing rings.

2. Remove the lifting tool and the retaining tool from the top cover.

Unscrew and remove the suction valve from the top cover.

See Procedure 909-22.2.

3. Carefully clean and examine the top cover.

Reconditioning of the seatings for the high-pressure pipes is carried out by milling according to the following procedure:

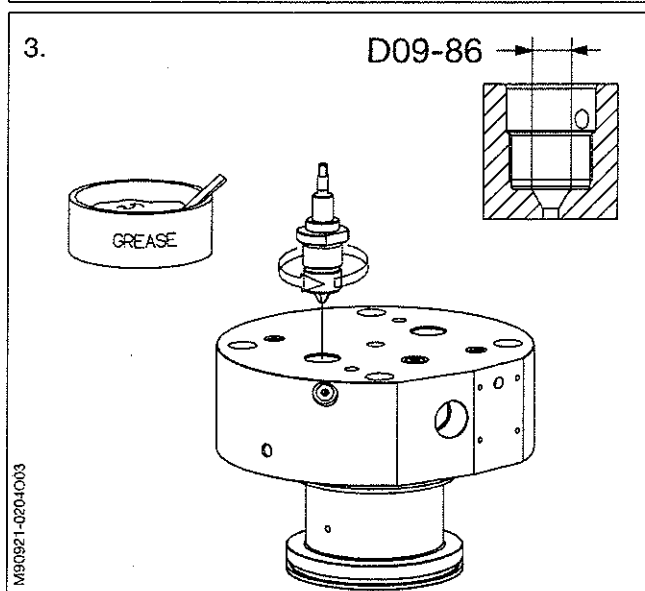
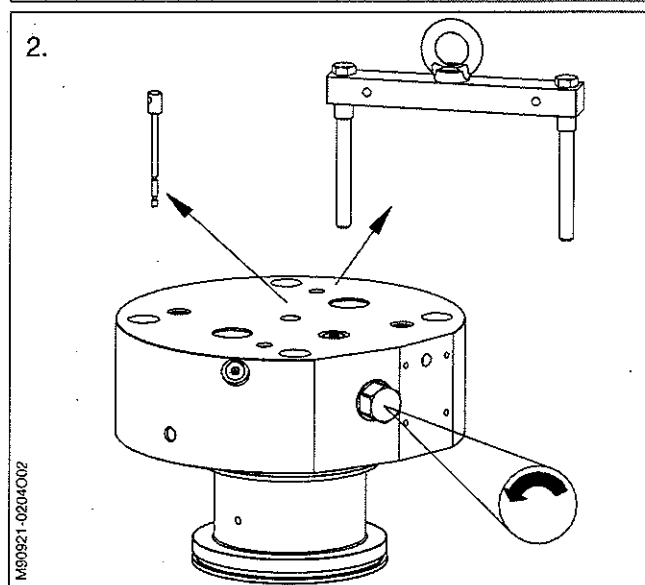
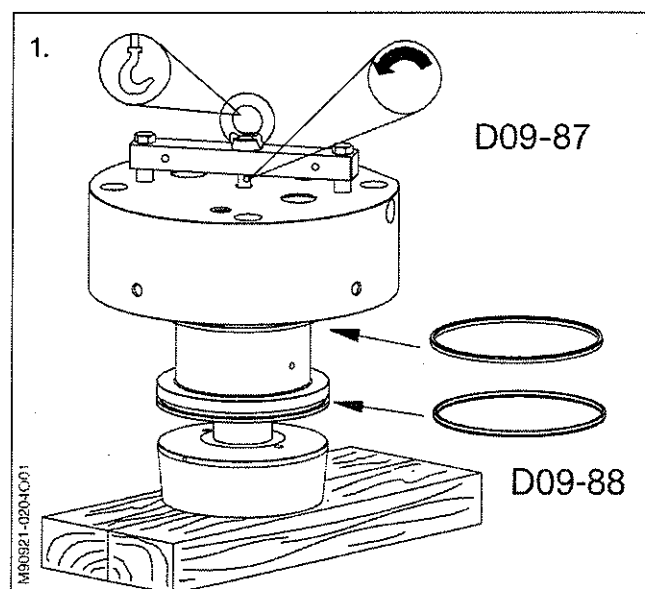
Fill the oil ducts in the top cover with Vaseline or heavy grease.

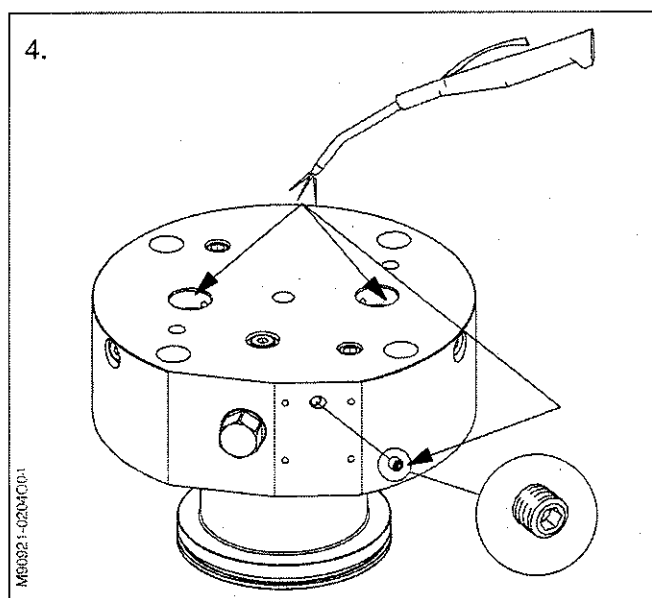
During the work the miller is guided by the guide screwed into the thread for the high-pressure pipe.

Turn the miller by means of, e.g. a tap wrench, while tightening the guide screw lightly to provide a suitable pressure between miller and seat.

During the milling, add drilling oil emulsion liberally.

For the max. milling/grinding diameter of the seat, see Data D09-86.





4. After completing the milling, blow out the Vaseline/grease from the oil ducts by means of compressed air.

Warning!

Always use eye protection when working with compressed air.

Clean the top cover with gas oil, and blow dry with compressed air.

Unscrew the orifice plug for return oil. Clean the plug and remount it.

5. Place the top cover on one side and clean the bore for the fuel plunger in clean kerosene. Inspect the bore and plunger.

For evaluation of the fuel plunger/top cover assembly, see *Volume I, chapter 706*.

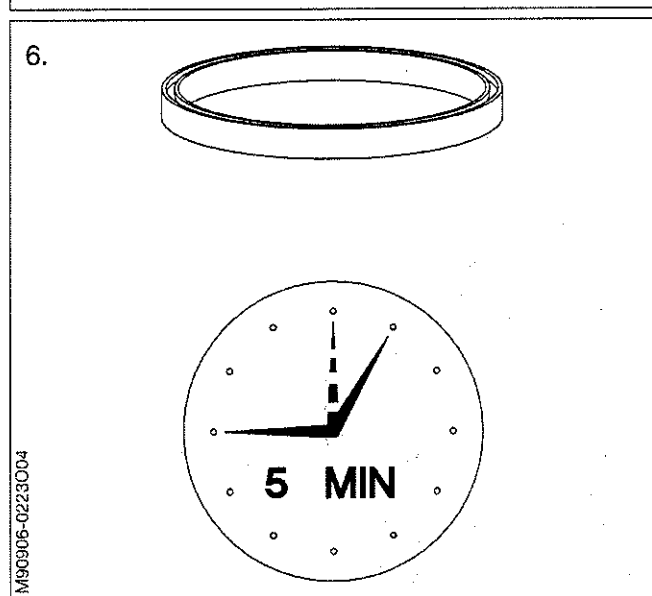
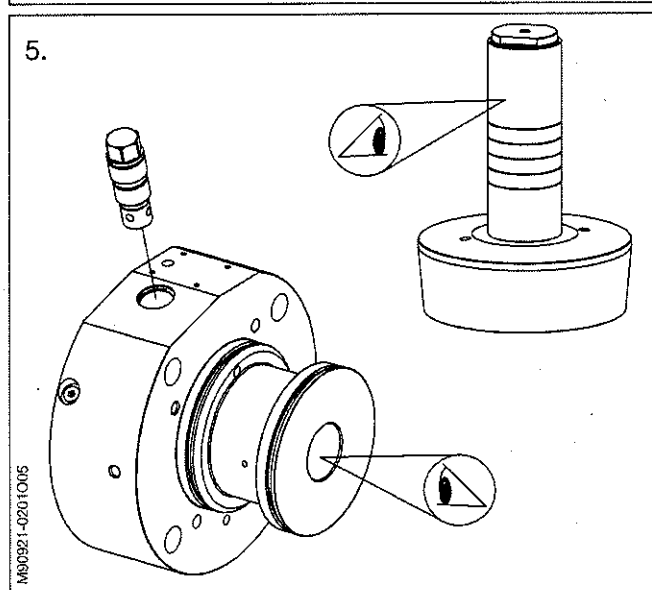
Mount the suction valve, see *Procedure 909-22.4*.

The top cover and fuel plunger are matched parts and must only be renewed as a set.

6. Before fitting new sealing rings on the top cover, heat them to 160-220°C for at least five minutes.

Note!

Take care not to exceed the temperature limit.



7. Fit the sealing rings as shown in the sketch. Place the cone on the top cover and fit the uppermost ring first.

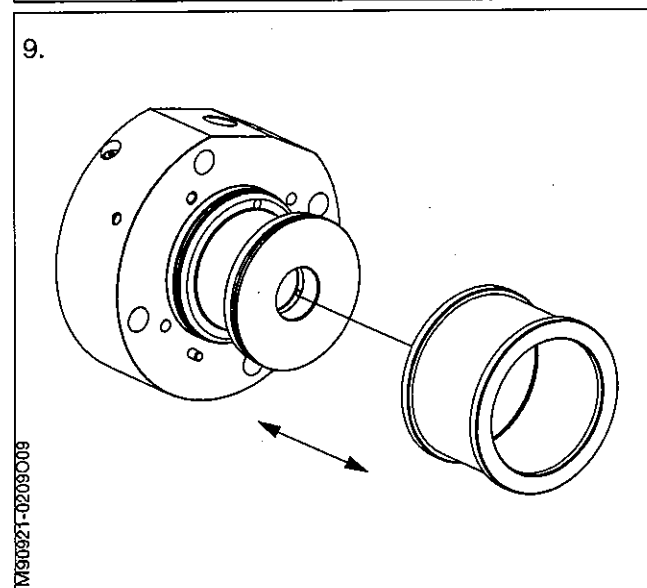
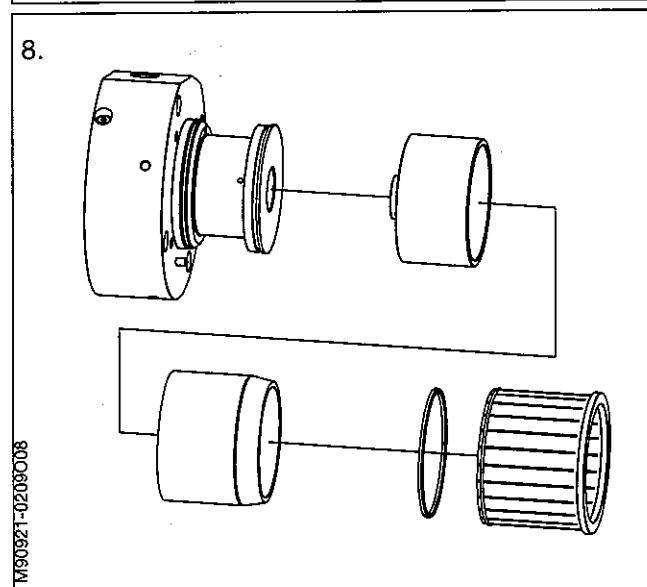
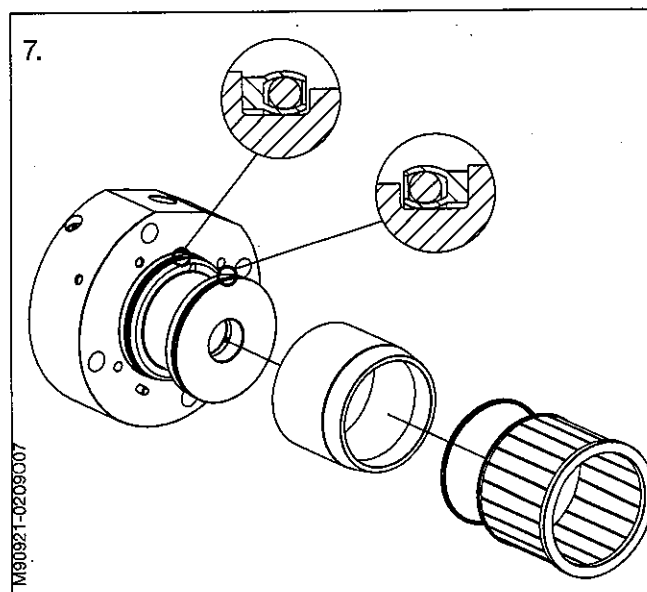
Push the sealing ring in place with the pushing tool.

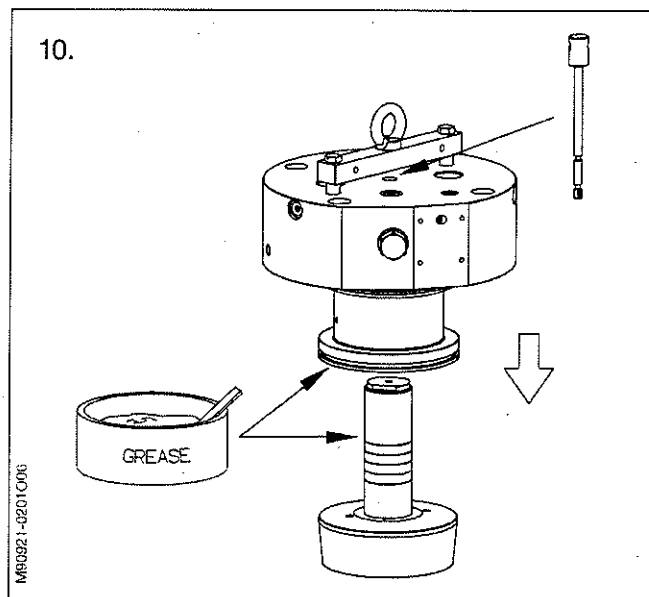
8. Remove the cone from the top cover and place the spacer ring tap in the hole for the plunger.

Place the cone on the top cover and on the spacer ring.

Fit the sealing ring in the lowermost groove by use of the pushing tool.
Remove the cone and the spacer ring.

9. Compress the sealing rings with the compression tool.





10. Turn the top cover to an upright position. Place the retaining tool for the fuel plunger in the centre hole and mount the lifting tool.

Place the plunger on a plane surface.

Apply a little clean grease to the inner hole in the top cover and a thin layer to the plunger.

Carefully lower the top cover onto the fuel plunger, until the top cover rests on the plunger.

Screw the retaining tool into the fuel plunger, to lock the plunger in position.

1. Mount the lifting tool on the new or over-hauled top cover assembly.

Lift the top cover assembly and apply grease to the new sealing rings.

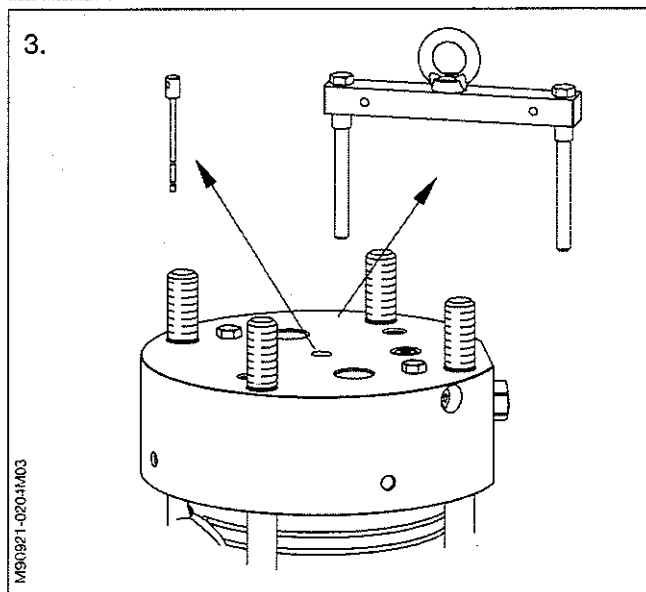
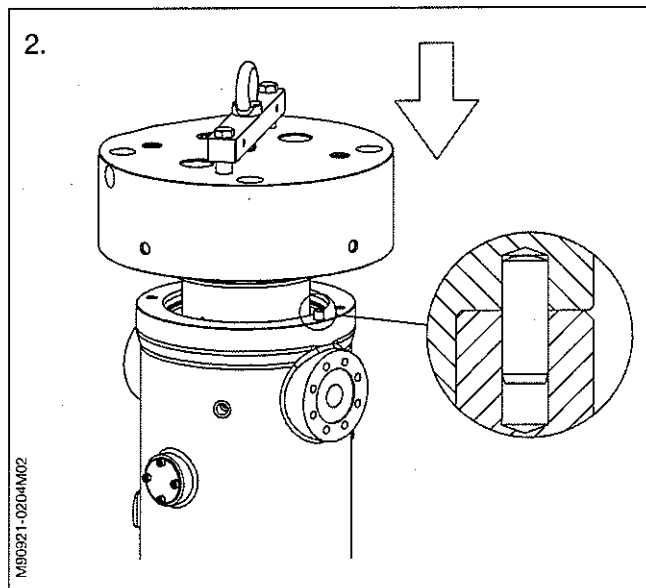
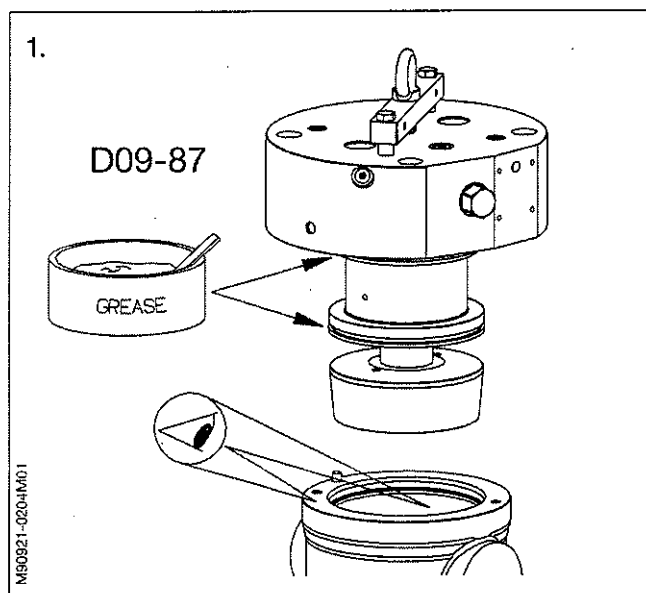
Check that the face on the fuel oil pressure booster housing and the inside cylindrical part are clean and free of fuel oil.

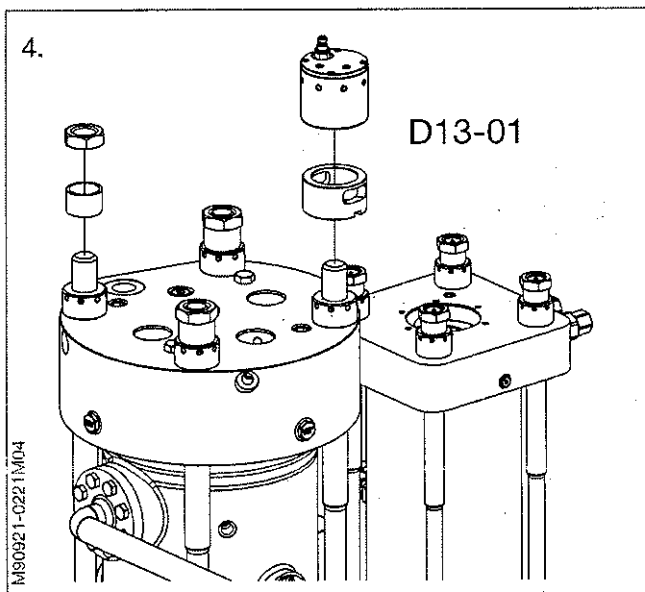
2. Carefully land the top cover on the fuel oil pressure booster.

Check that the guide pin in the top cover is entering the hole in the fuel oil pressure booster housing for correct positioning.

3. Remove the lifting tool from the top cover.

Unscrew and remove the retaining tool for the fuel plunger.





4. Tighten two nuts at a time diagonally.

Screw the nuts on to the studs. Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the jacks to the tightening pressure, as specified in Data. Tighten the nuts, and remove the hydraulic jacks and the spacer rings.

For use of hydraulic tools, see also Procedure 913-1.

Mount the thread protective caps.

5. Mount the small disc in the centre hole.

Mount and tighten the centre plug with the left-handed thread.

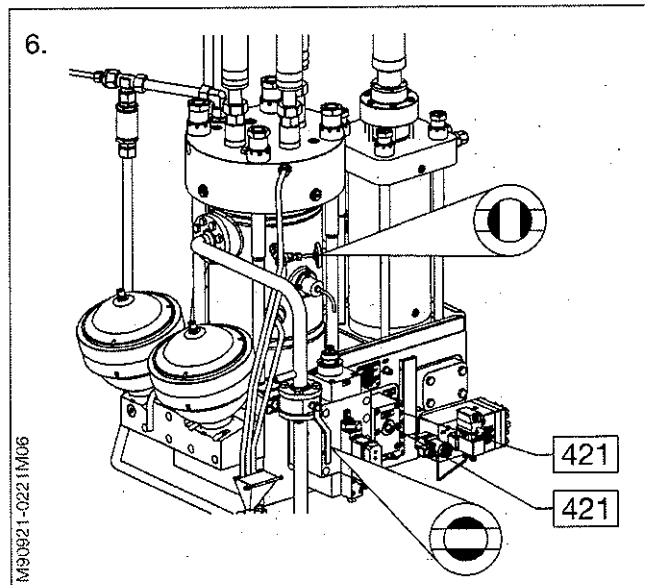
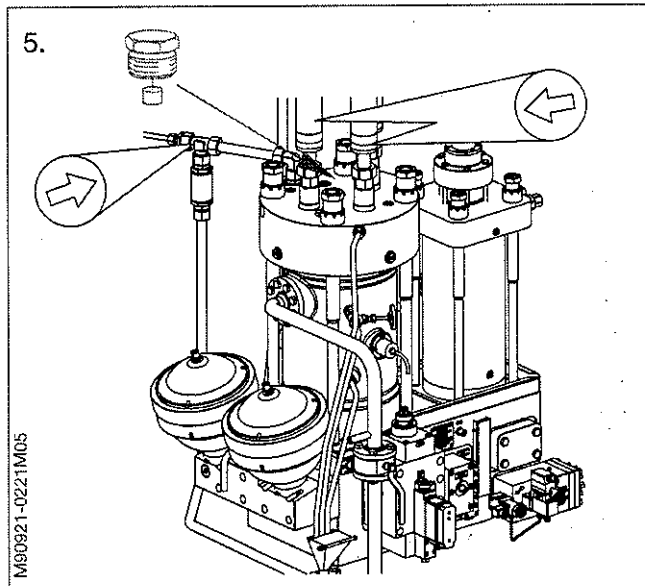
Mount the fuel oil high-pressure pipes, see Procedure 909-14.4.

Mount the return oil pipe.

6. Close valve 421 and open valve 420 on the hydraulic block.

Close the oil drain.

Open the fuel oil inlet valve.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☒	Engage turning gear
☐	Shut off cooling water
☒	Shut off fuel oil
☒	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-89	Fuel suction valve, tightening torque	1165	Nm

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description

Dismantling

1. Shut off the oil supply to the hydraulic actuator.

Install a pressure gauge at "minimess" point No. 455.

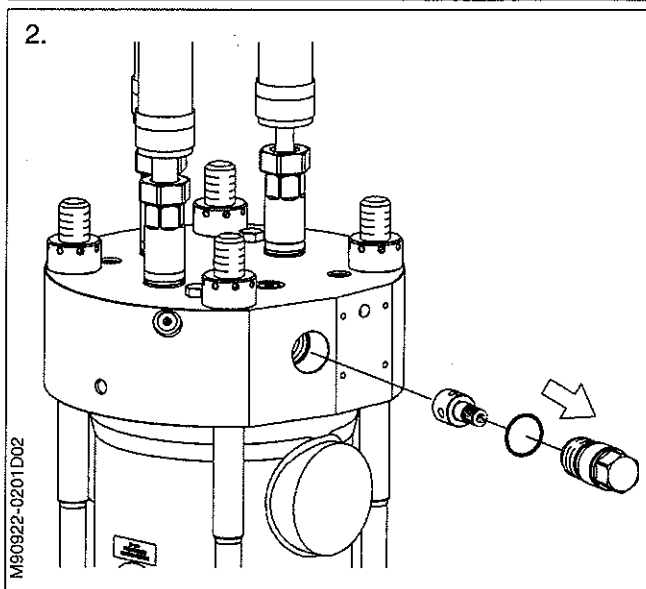
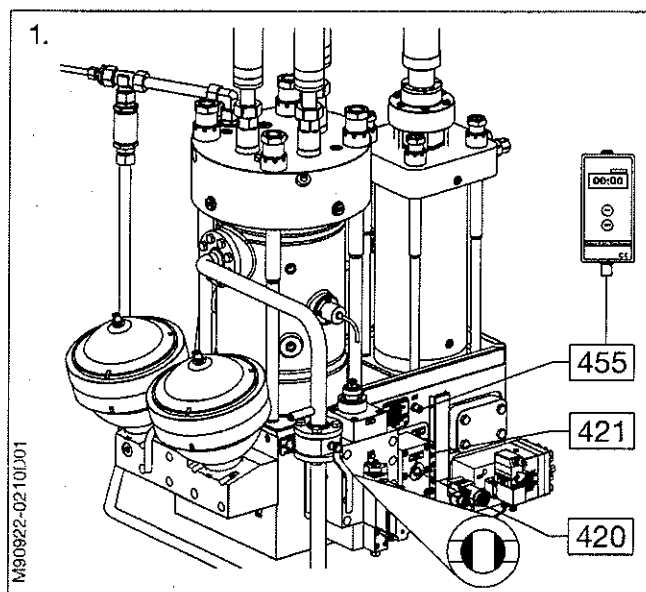
Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

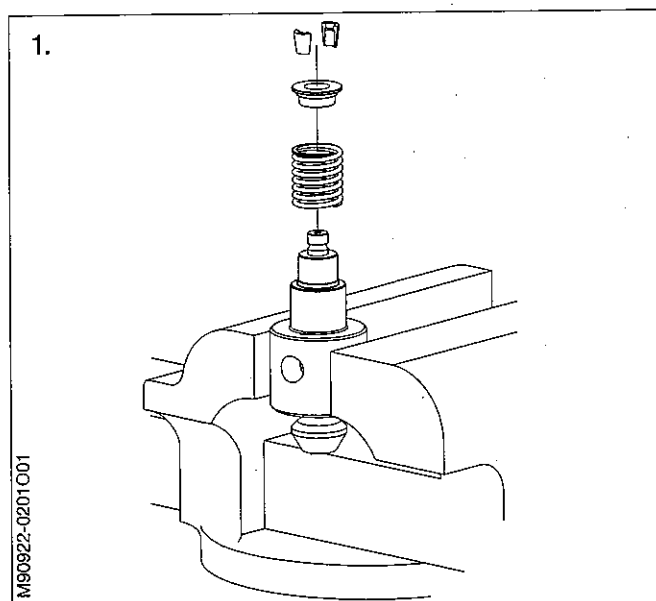
Check that the hydraulic cylinder unit is pressure free.

Shut off the fuel oil supply for the fuel oil pressure booster.

2. Unscrew the union nut for the suction valve, remove and discard the O-ring.

Pull out the suction valve.





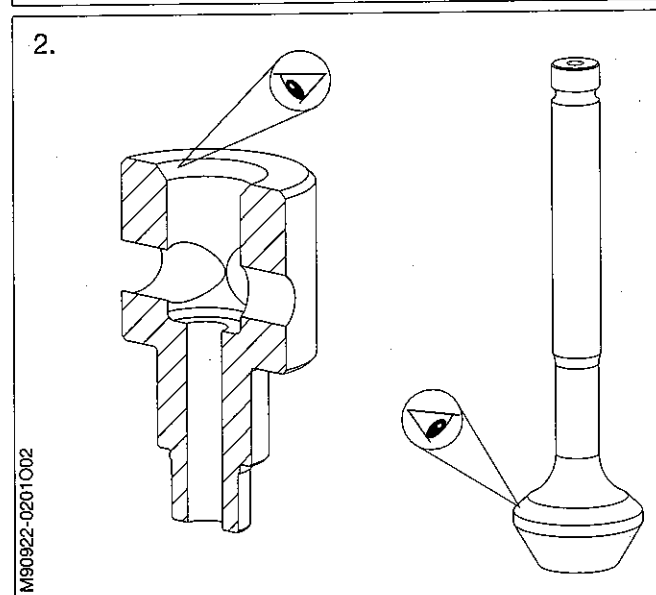
1. Set up the fuel suction valve in a bench vice with "soft" jaws and press down the spring by means of the cone to release the valve spindle from the two-part conical ring.

Clean the parts thoroughly with clean diesel oil and dry carefully.

2. Inspect the seat on the valve spindle and the seat on the valve housing for damage.

If the seats are worn or damaged, a new suction valve must be fitted.

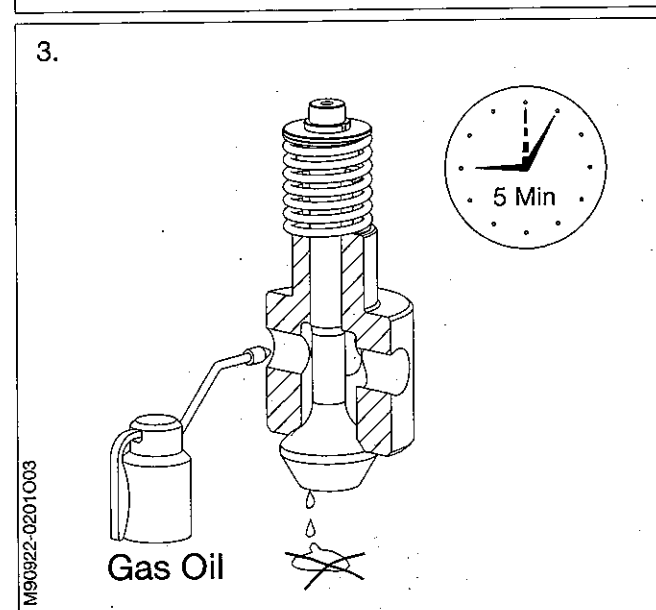
It is not recommended to recondition the valve by lapping. Lapping will damage the seat geometry and lead to very limited running time for the valve.



3. After cleaning and inspecting all the parts, lubricate these with molybdenum disulphide (MoS_2) and assemble the suction valve.

Check the seats for tightness by filling the inlet hole with diesel oil and waiting 5 minutes. No oil may pass through the seats.

4. If the suction valve is not to be fitted on the engine immediately after the overhaul, cover all openings on the valve with plastic to prevent dirt from entering the valve during storage.



1. Check that the face for the suction valve is clean.

Install the overhauled or new suction valve.

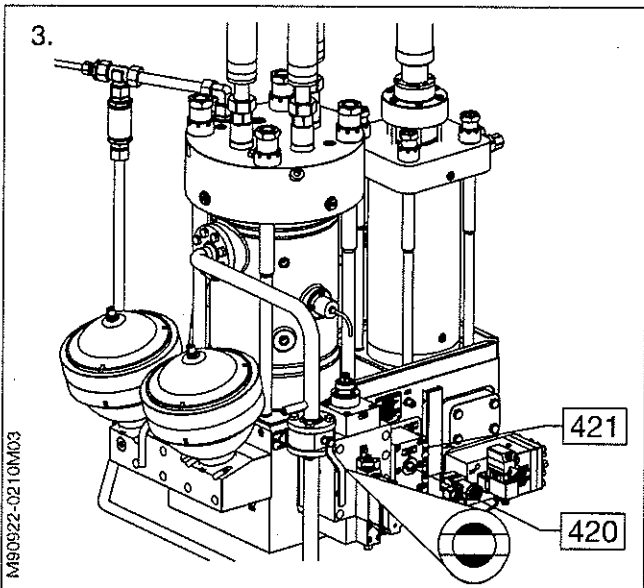
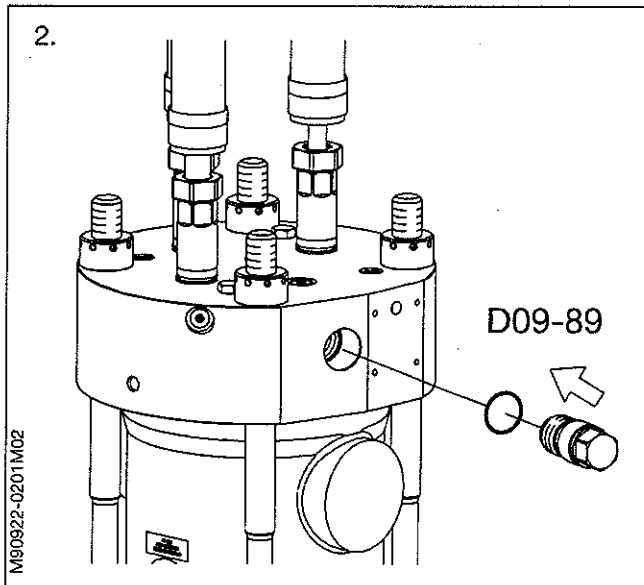
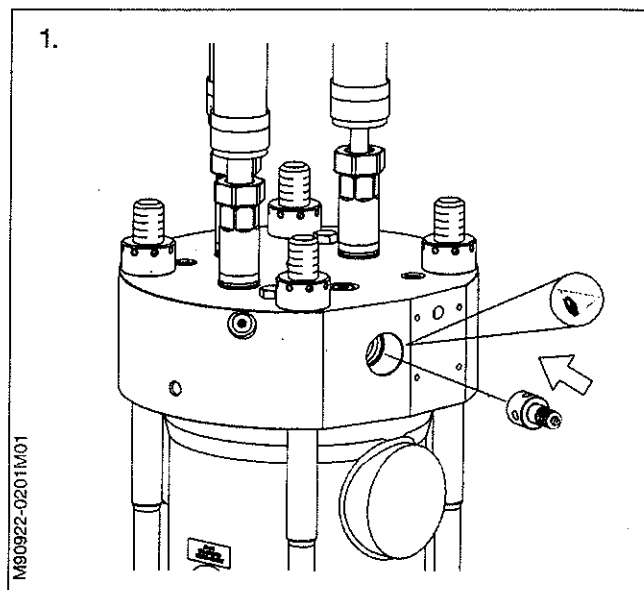
2. Fit a new O-ring on the union nut.

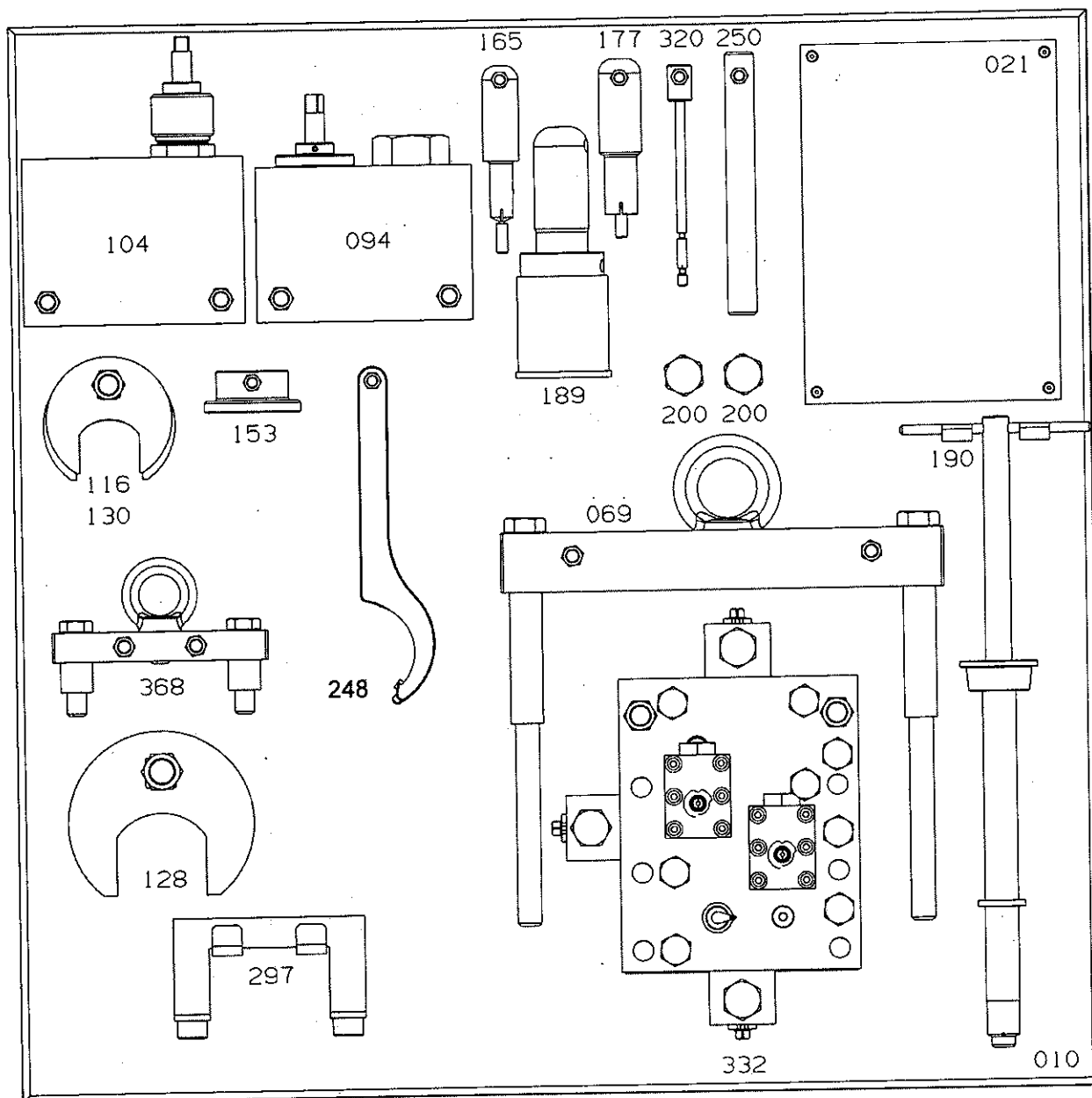
Lubricate the O-ring and the thread on the union nut with molybdenum disulphide (MoS_2) grease.

Assemble and tighten the nut to the specified torque. See *Data*.

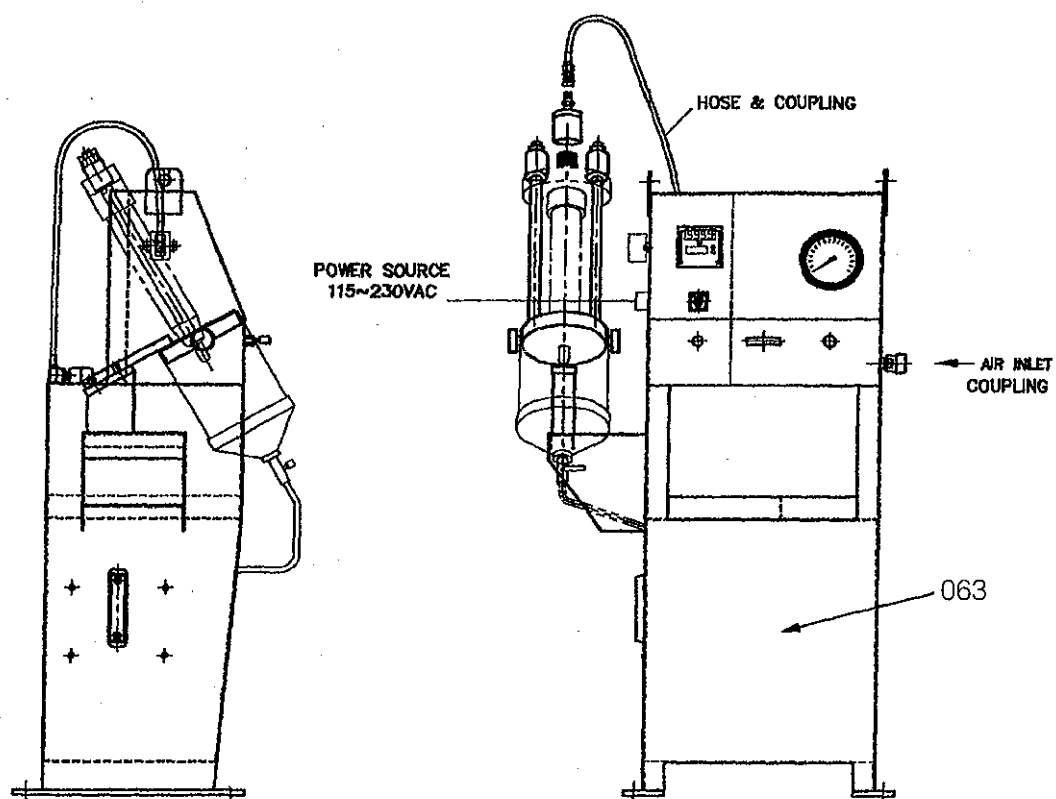
3. Close valve 421 and open valve 420 on the hydraulic block.

Open the fuel oil valve.



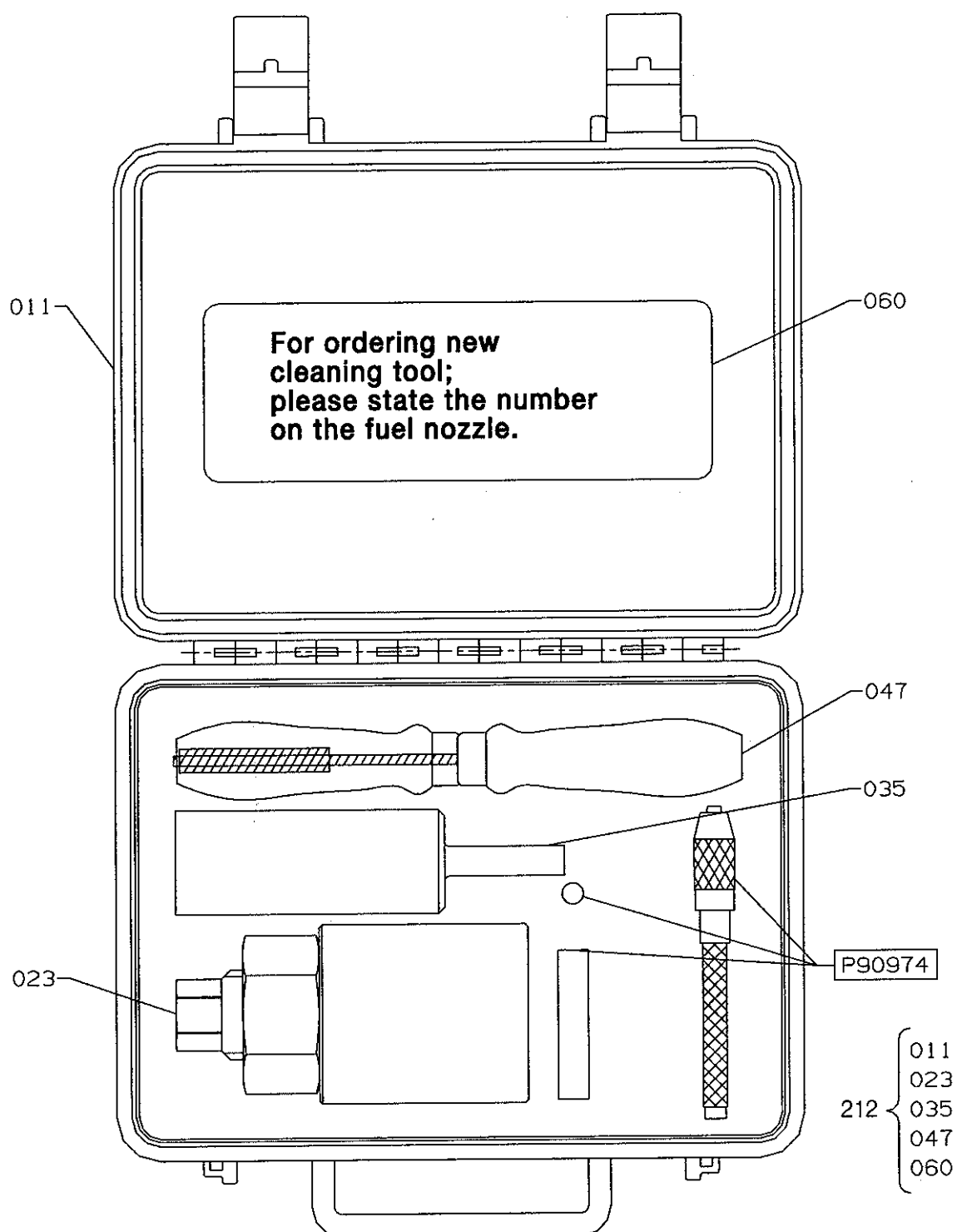


Item No.	Item Description	Item No.	Item Description
010	Panel for tools		
021	Name plate		
069	Lifting tool for fuel pump		
094	Milling tool for fuel oil pipe seat		
104	Milling tool for fuel oil pipe		
116	Crowfoot spanner		
128	Crowfoot spanner		
130	Crowfoot spanner		
153	Flange for dismantling of non return valve		
165	Grinding mandrel, valve head		
177	Grinding mandrel, thrust spindle		
189	Grinding mandrel, holder-outside		
190	Grinding mandrel, holder-inside		
200	Screw		
236	Hook spanner		
248	Hook spanner		
250	Drift for spindle guide		
297	Assembling tool for fuel valve		
320	Locking device		
332	Cleaning tool for NC valve		
368	Lifting tool for hydraulic plunger		



Item No.	Item Description
063	Test rig, complete (Refer to instruction manual)

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
011	Tool box		
023	Extractor for atomizer		
035	Drift for atomizer		
047	Cleaning brush		
060	Instruction plate		
212	Toolset, complete		
	Note:		
	When ordering new cleaning tool, please state P/N on fuel nozzle.		

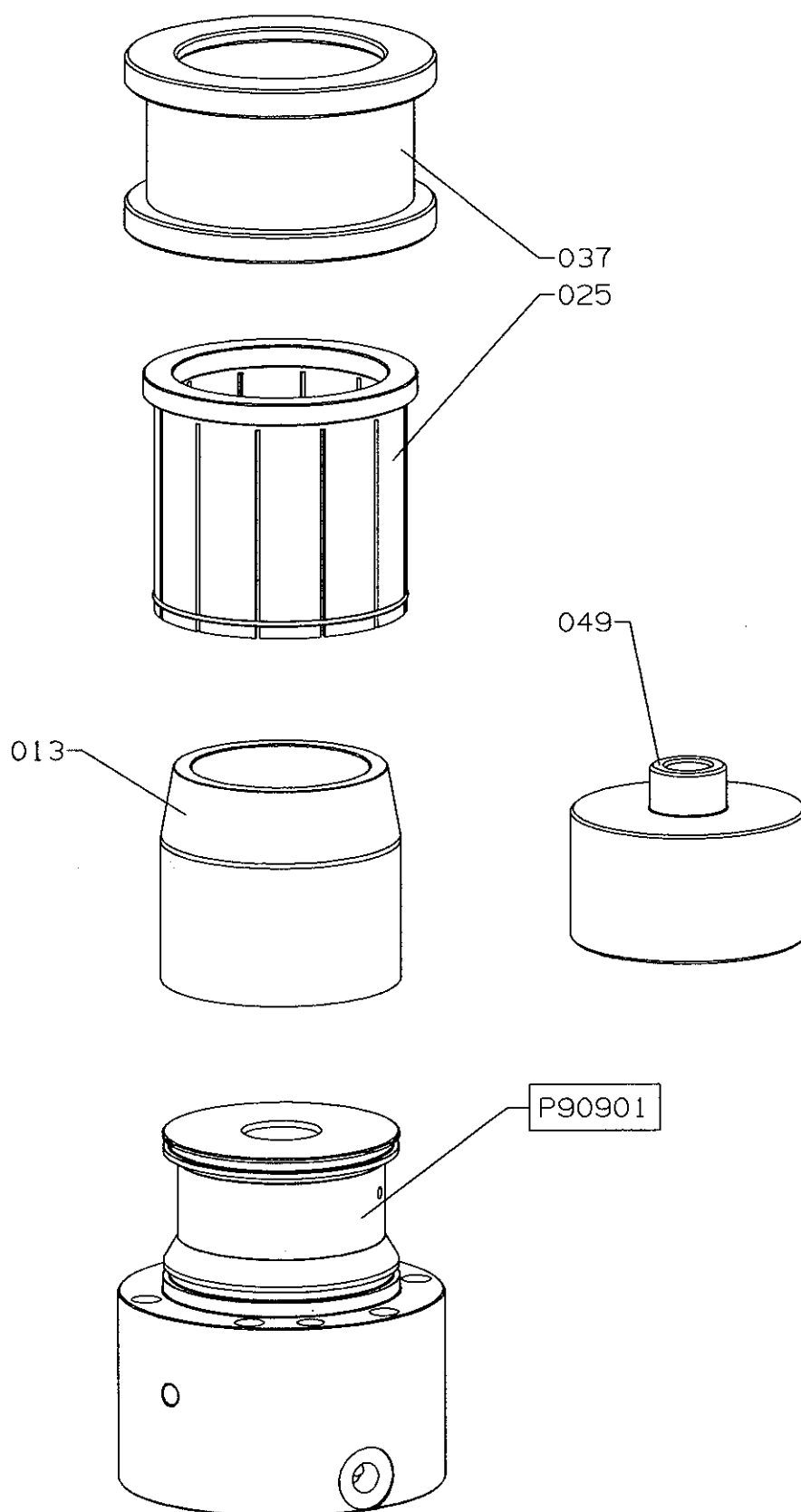
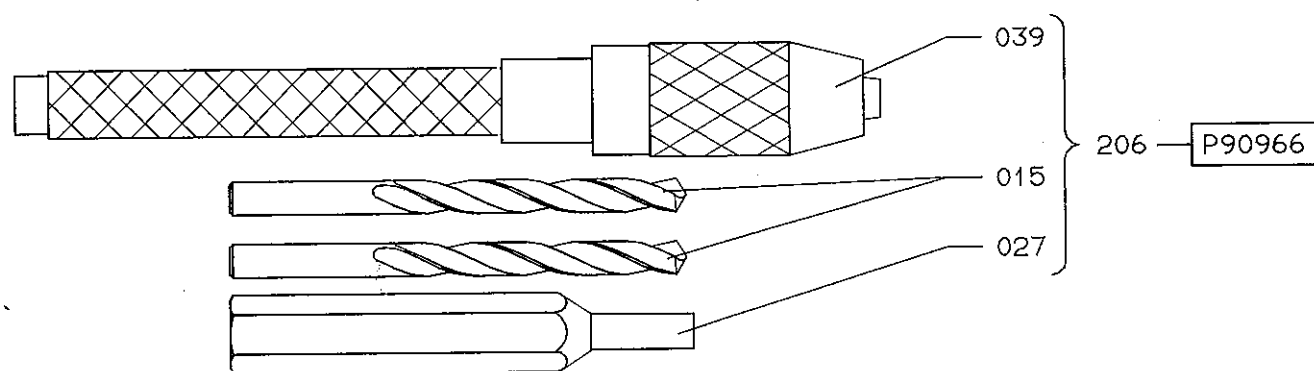


Plate 90981-0001

Mounting Tools - Top Cover Seals

Item No.	Item Description
013	Cone
025	Pushing tool
037	Compression tool
049	Spacer ring

Item No.	Item Description



Item No.	Item Description
015	Drill*
027	Test mandrel*
039	Pin vice*
206	Cleaning tool set, complete
	Note: * When ordering new cleaning tool, please state P/N on fuel nozzle.

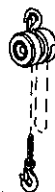
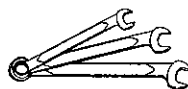
Item No.	Item Description

SAFETY PRECAUTIONS

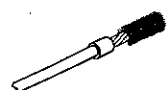
☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☒	Engage turning gear
☒	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Aft end cover	260	kg
D-2	Air cooler element up to	2110	kg
D-3	Front end cover (waterflow reversing chamber)	200	kg

Standard Tools: See Section 913


2 x 3000 kg
2 x 1000 kg



Spare Parts

Plate – Item No.

Description

Qty

See special instructions from air cooler element manufacturer.

1. For the day-to-day checking of the scavenge air cooler, measure the drop in pressure and temperature of the scavenge air across the cooler while the engine is running.

Compare these measurements with the testbed data. *For further evaluation of the measurements, see the OPERATION manual, Volume I, Chapter 706.*

2. An increase in the air pressure drop across the scavenge air cooler indicates fouling of the air side of the cooler.

A decrease in the air temperature drop across the scavenge air cooler indicates fouling of the water side of the cooler.

3. If the measurements indicate fouling of the water side of the air cooler element, the element must be overhauled/cleaned. *See Procedure 910-1.3 – water side.*

If the measurements indicate fouling of the air side of the air cooler element, it is recommended to inspect the air cooler element as follows:

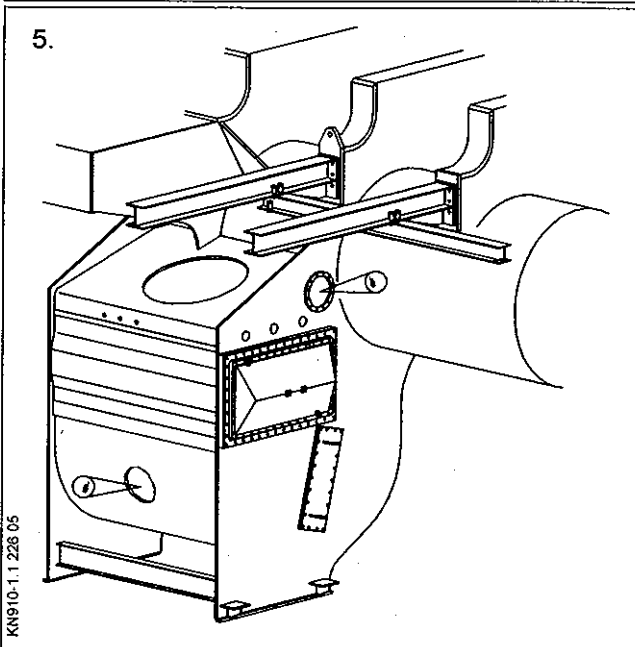
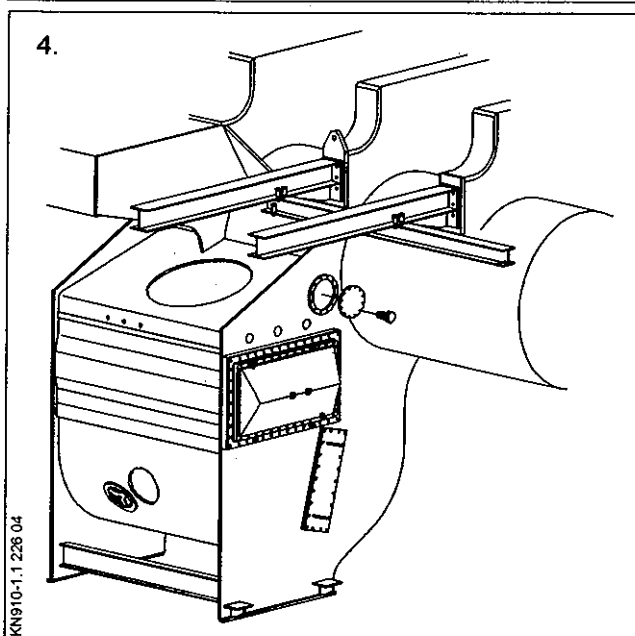
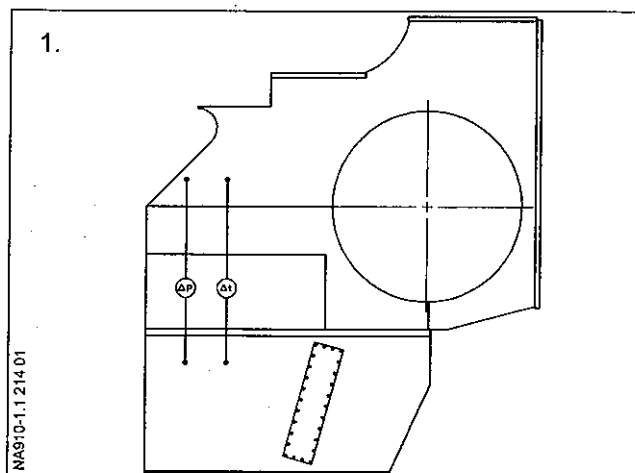
4. Remove the inspection cover from the side of the air cooler.

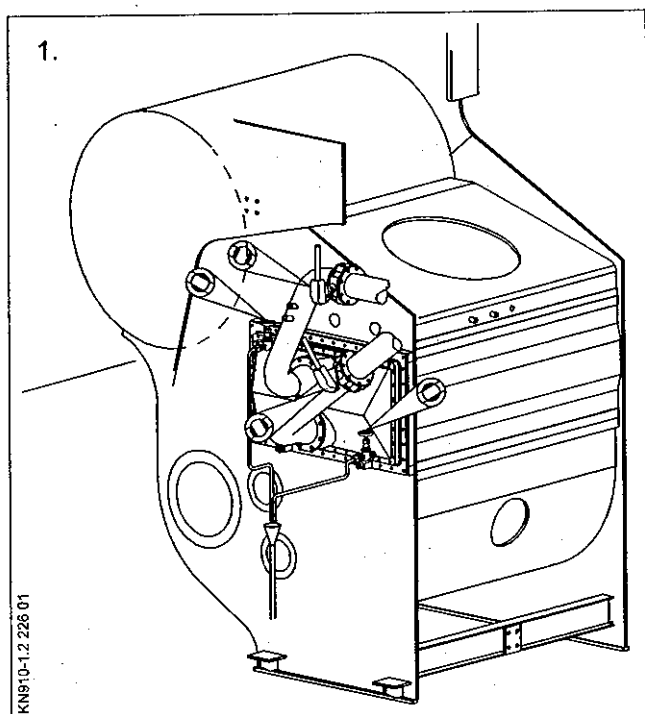
Unlock and swing open the inspection hatch at the bottom of the air cooler.

5. Visually inspect the air cooler element through the openings.

For further information, see the OPERATION manual, Volume I, Chapter 702 "Checks during Standstill Periods".

If the air side of the element is fouled, clean the element using the spray pipe arrangement fitted above the air cooler element. *See Procedure 910-1.3 – air side.*





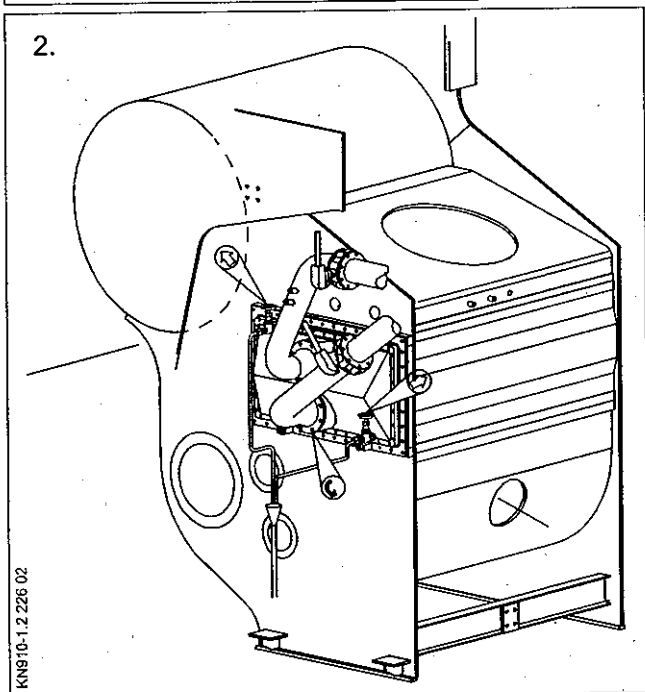
The cooler element normally does not need to be dismantled for inspection purposes. It is only in the event that the cooler element has suffered damage that it has to be dismantled and replaced.

Note!

During dismantling, take care not to damage the cooler element.

1. Close the cooling water inlet and outlet valves. Open the drain cocks to drain off the cooling water. Dismantle the drain pipes.
2. Dismount the screws which fasten the cooling water inlet and outlet flanges to the aft end cover.

Dismount the drain cocks from the aft end cover.



Dismantling

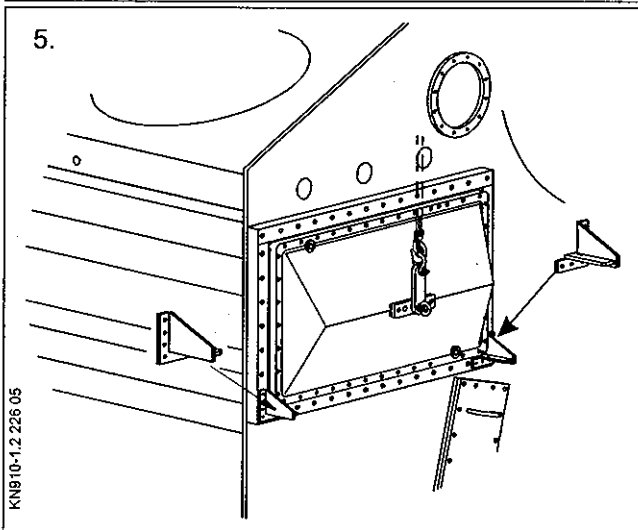
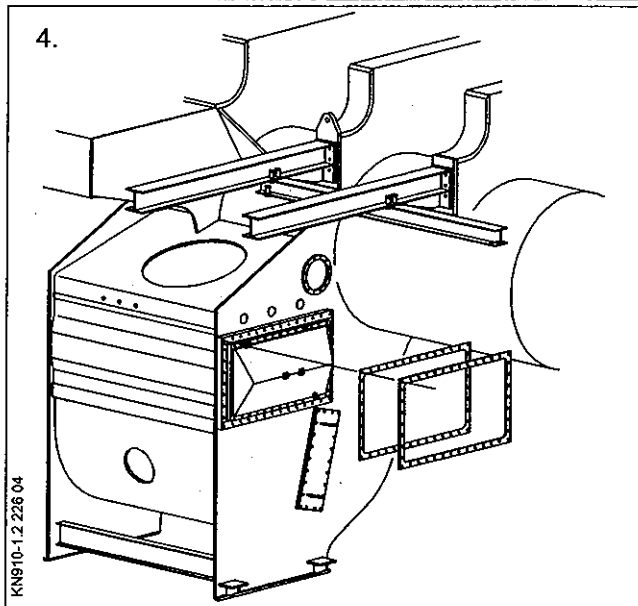
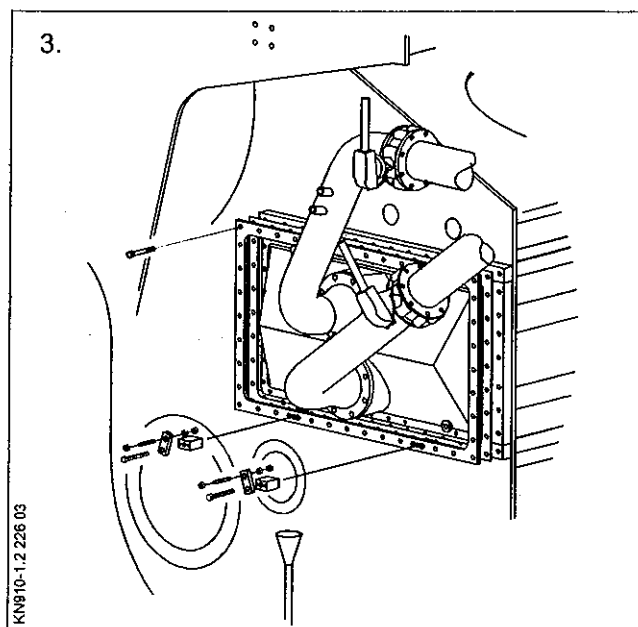
3. Dismount the brackets which control the longitudinal position of the air cooler element.

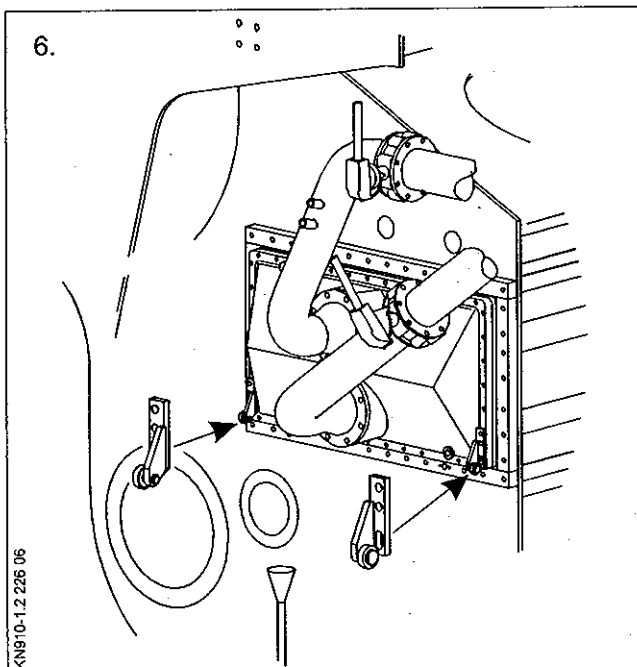
Dismount the sealing flanges around the aft end cover.

For convenience, the sealing flanges may be left hanging on the cooling water pipes during dismantling and mounting of the cooler element.

4. Dismount the sealing flanges around the front end cover.
5. Mount the pair of guide rails on the front of the cooler housing. Mount the lifting bracket on the front end cover of the cooler element.

Mount a travelling trolley on the beam above the front end of the scavenge air cooler. Attach a tackle between the travelling trolley and the lifting bracket, and haul tight.



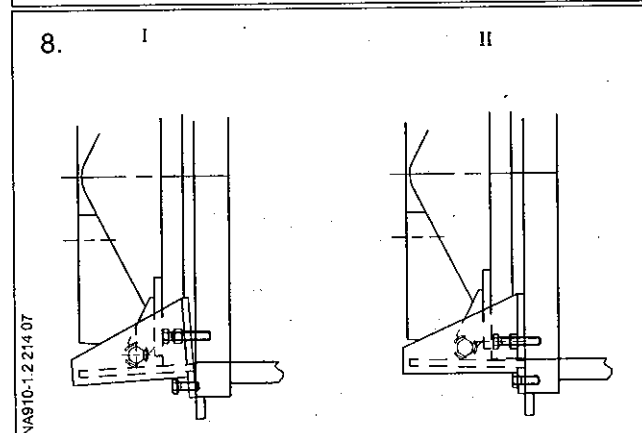
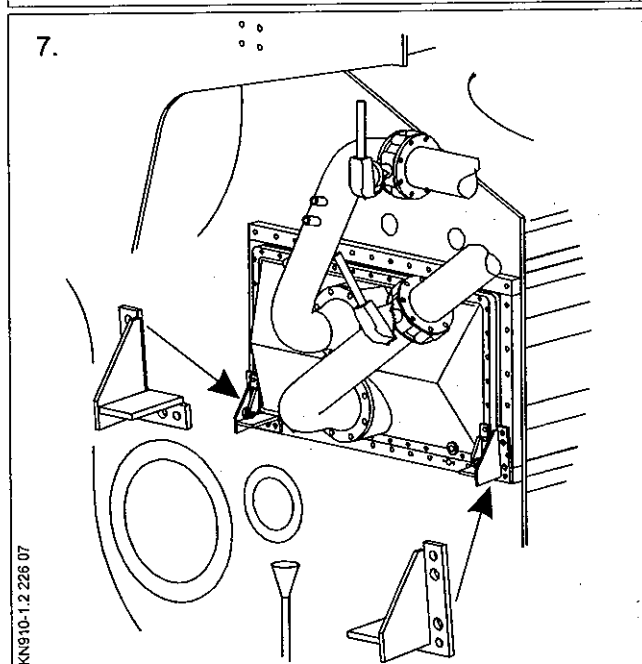


6. Mount the guide wheels on the aft end cover.

7. Mount a pair of guide rails on the aft end of the cooler housing.

8. When mounting the guide rails, hold them up against the wheels of the cooler element and mount, but do not tighten, the lowermost screws. Mount and tighten the uppermost screws.

Tighten the lowermost screws and the thrust nuts on the uppermost screws simultaneously. This results in loosening and lifting the cooler element.



9. Tighten the tackle until the front end of the cooler element comes loose.

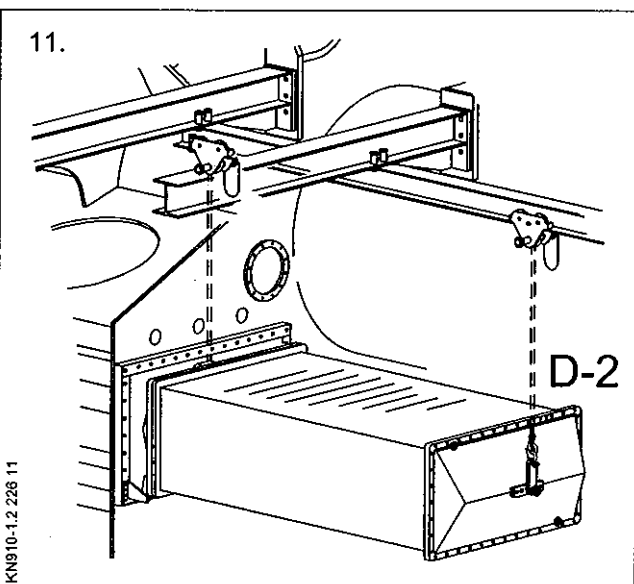
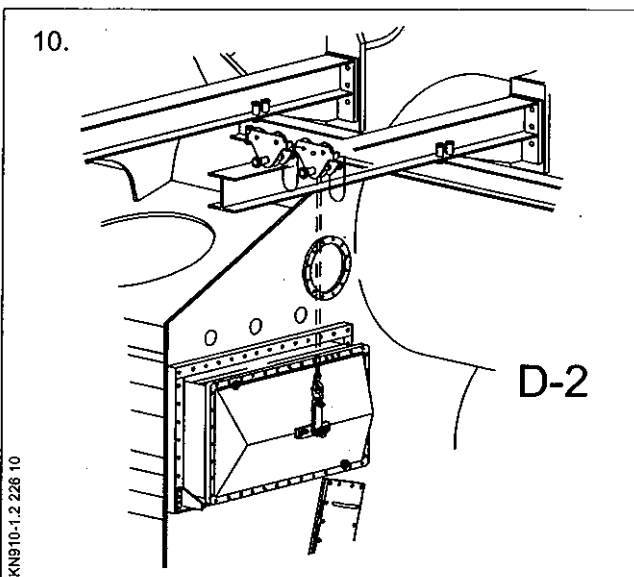
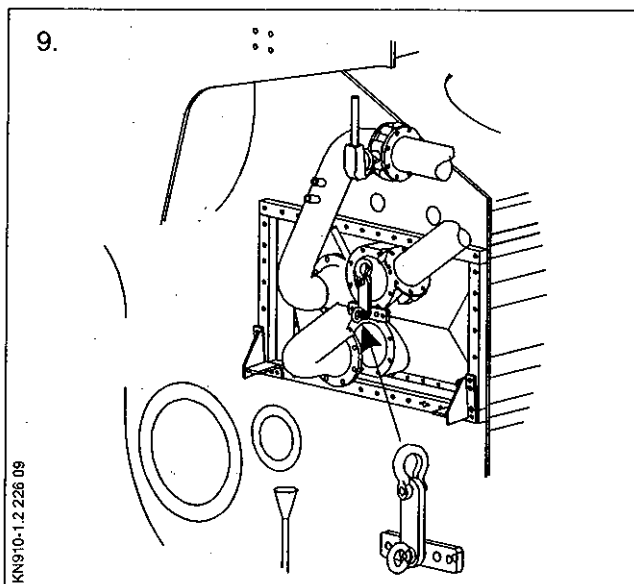
Pull out the cooler element far enough to allow a lifting bracket to be mounted on the aft end cover. Mount the lifting bracket.

10. Pull the cooler element out of the cooler housing by means of a tackle until the wheels engage with the holes in the guide rails on the front of the cooler housing.

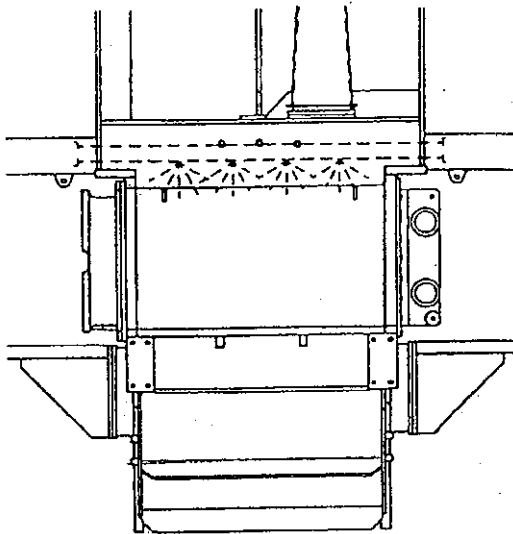
11. Fit a tackle to the lifting bracket on the aft end cover and lift the cooler element away.

Note!

Depending on the engine and the engine room installation, it may be necessary to remove some pipes and floor plates.



1.



GN910-1.3 206 01

Cleaning the air side:

The air side of the cooler is cleaned by injecting a chemical fluid through the spray pipe arrangement fitted to the air chamber above the cooler element.

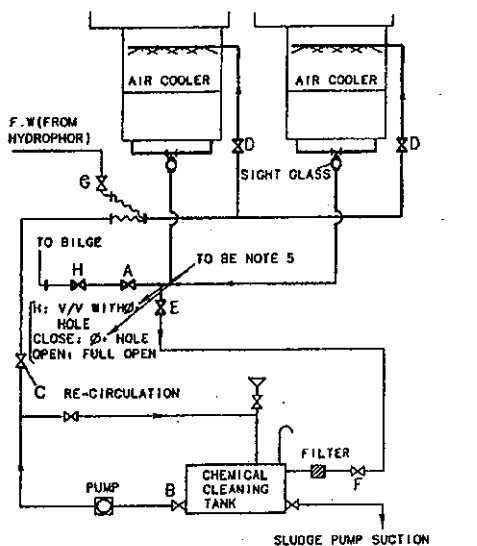
It is recommended to use one of the following cleaning fluids, or a similar product.

- 1) Product: ACC 9, produced by Drew Chemical Corp., New York, USA
- 2) Product: 80B, produced by Vecom Int., Maassluis, Holland

Cleaning should be carried out in the following sequence:

1. Do not start cleaning until the engine has been at a standstill for about 30 minutes. Do not disconnect the compressed air supply to the exhaust valve.
2. Follow the detailed cleaning instructions displayed at the cleaning pipe on the engine. To ensure satisfactory spraying of the cleaning fluid, the circulating pump pressure must be at least 0.7 bar.
3. Continue the cleaning process for at least 30 minutes. The time required depends on the frequency with which cleaning is carried out and on the chemical product used.
4. After cleaning, flush the cooler with clean water until the water appearing in the sight glasses is clean and pure.
5. Inspect the element either by removing the cover on top of the cooler or by dismantling the charging air pipe.

2.

Cleaning condition

- 1) Chemical cleaning
Open: B, C, D, E, F
Close: A, G, H
Start the pump

Water flushing

- 2) Open: A, D, G, H
Close: B, C, E, F

Normal running condition

- 3) Open: A
Close: B, C, D, E, F, G, H
Close the inspection covers on the scavenge air receiver

KE910-5.1 61 02

Cleaning the water side

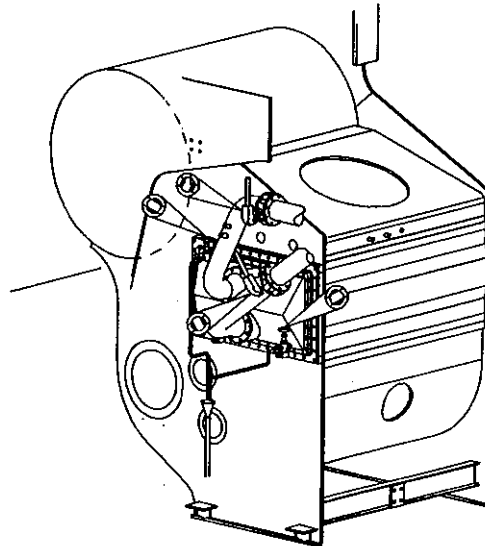
6. Close the cooling water inlet and outlet valves. Remove the plug screws from the front end cover and the aft end cover to drain off the cooling water.
7. Dismount the cooling water inlet and outlet pipes from the aft end cover.
8. Screw two eye bolts into the upper flange of the aft end cover. Mount a lifting wire rope between the eye bolts.

Mount a travelling trolley on the beam above the aft end cover.

Mount a tackle between the travelling trolley and the lifting wire rope. Tighten up the tackle.

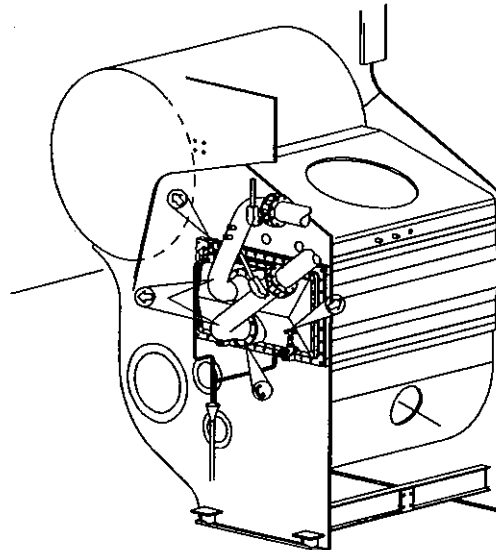
Dismount the brackets which control the longitudinal position of the air cooler element.

6.



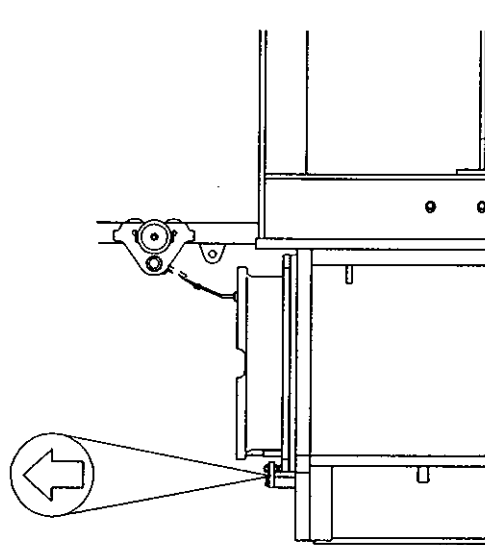
KN910-1.3 226 06

7.

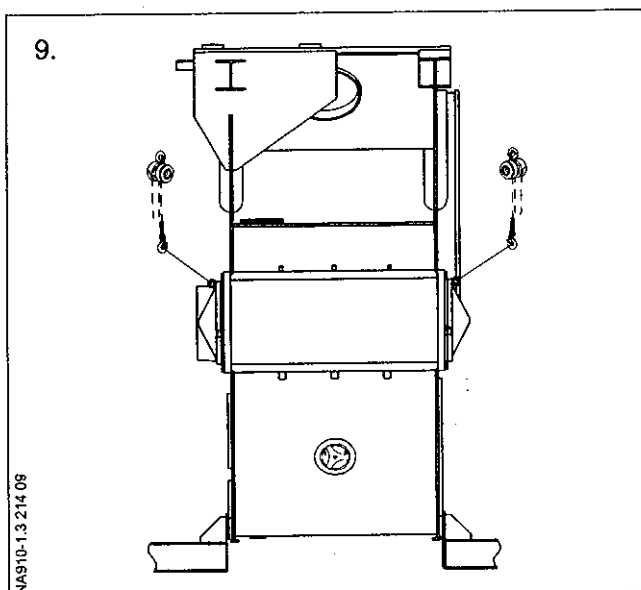


KN910-1.3 226 07

8.



NA910-1.3 214 08



9. Mount a shackle in each of the two lifting eyes on the front end cover.

Mount two tackles above the front end of the air cooler.

Hook the tackles on to the shackles and tighten up.

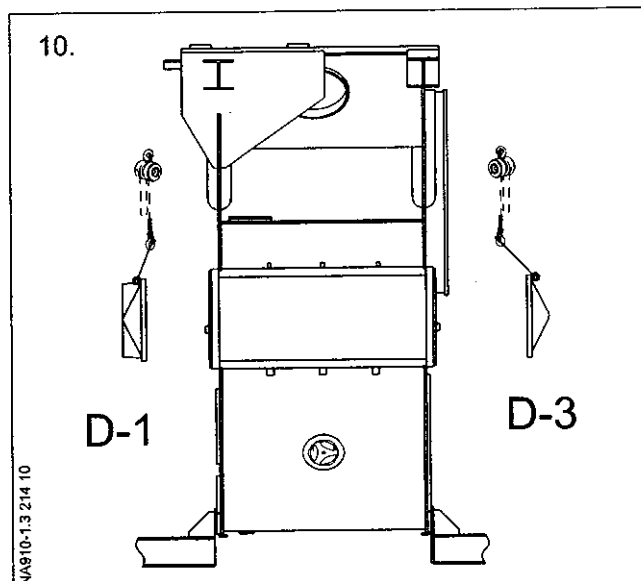
10. Remove the screws of the front end and aft end covers.

Lower both covers and land them on a couple of wooden planks. Discard the gaskets.

11. Clean the inside of the tubes, using the cleaning brush mounted on a drilling machine. In the event of leakages between cooling tube and tube plate, the tubes are rolled with the tube expander.

Clean the front-end and aft-end covers inside with a stiff brush and then rinse with fresh water.

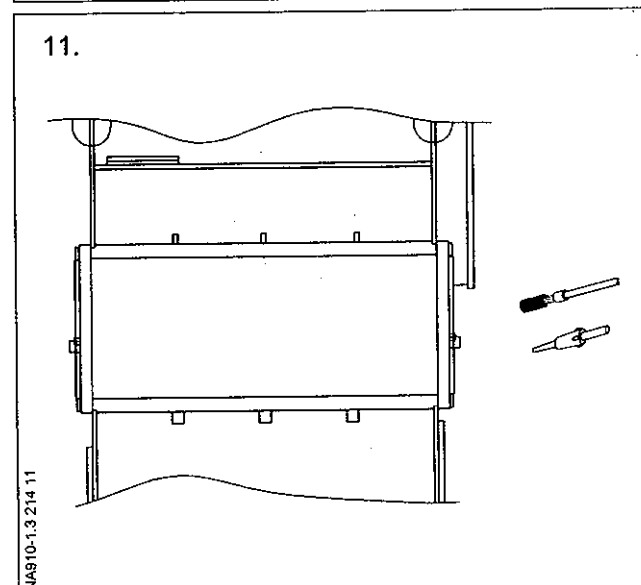
Replace the anti-corrosion blocks, if necessary.



Note!

If damaged, the coating inside the covers is to be repaired with the original coating or a similar product.

12. When cleaning is complete, mount the covers in the reverse order to dismantling.



1. Lift the air cooler element and land the aft end of the element on the guide rails mounted on the front end of the air cooler housing.

Hook a tackle from the travelling trolley on to the lifting bracket on the front end cover of the cooler element.

Remove the tackle from the aft end of the cooler element.

2. Push the air cooler element inwards approx. one metre.

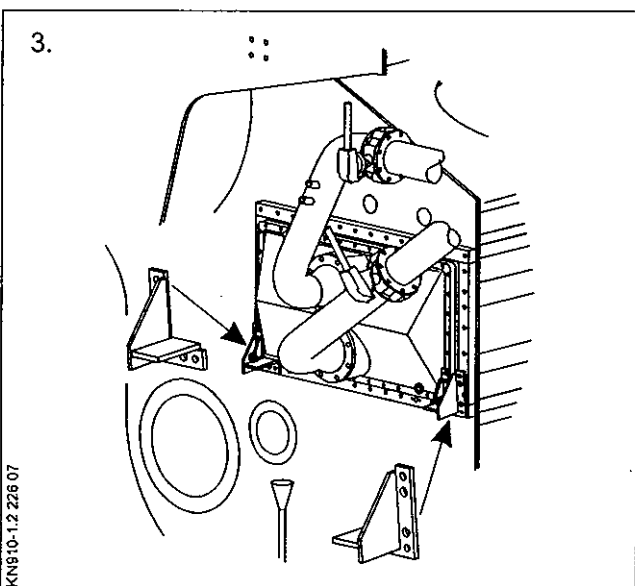
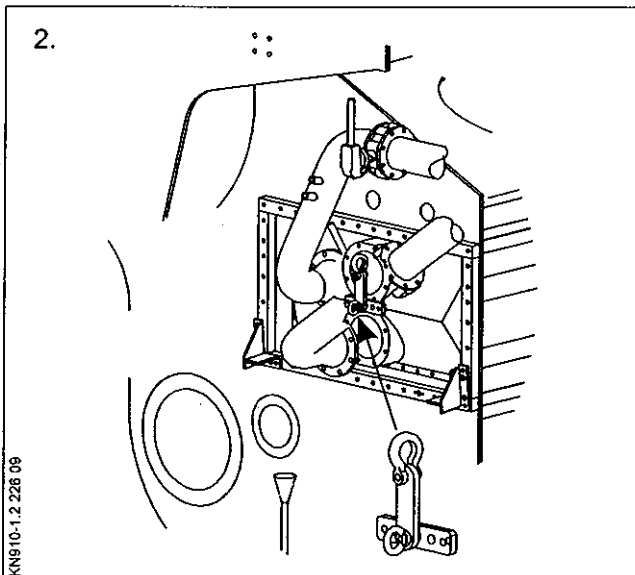
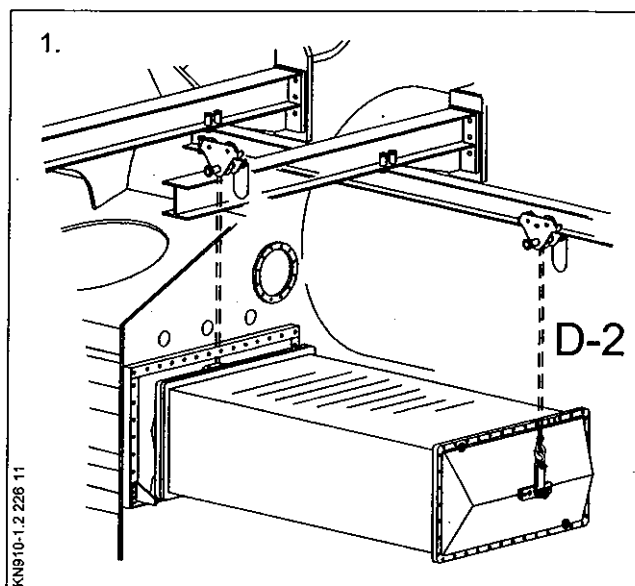
Remove the lifting bracket from the aft end cover.

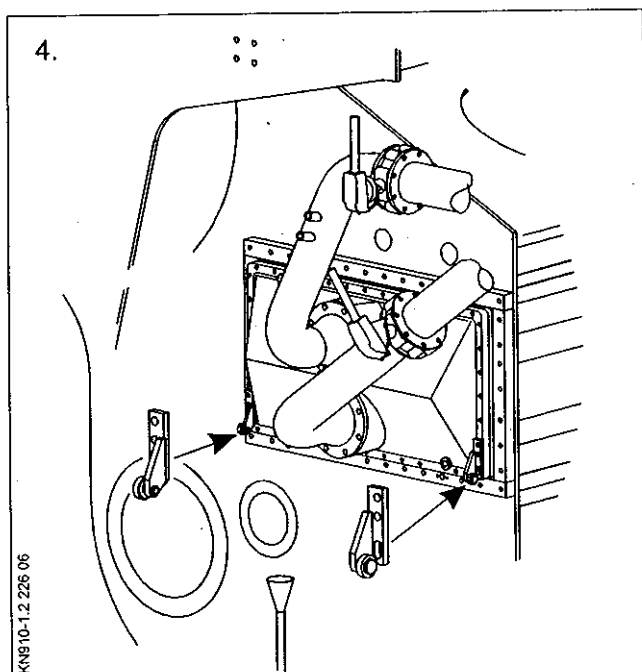
3. Push the air cooler element fully into the air cooler housing

Remove the guide rails from the aft end of the air cooler housing.

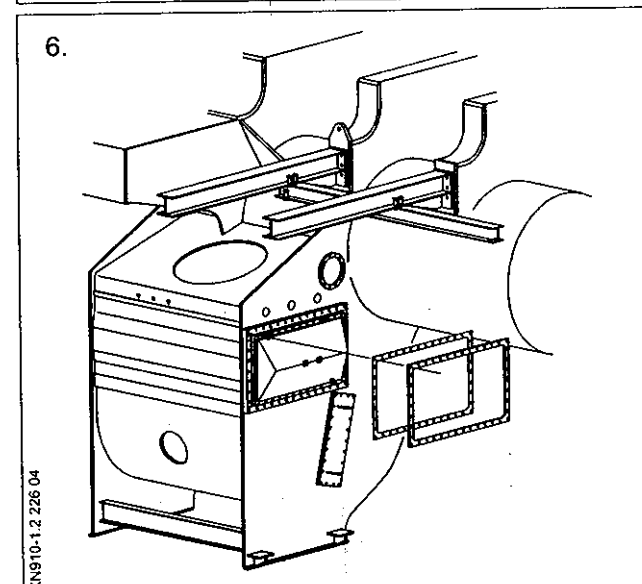
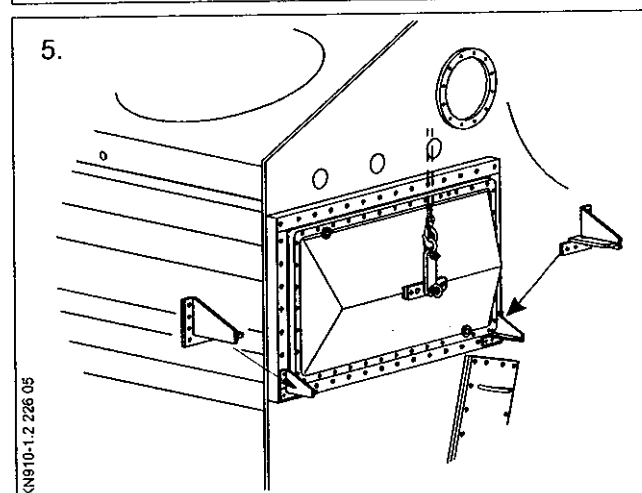
Note!

Before pushing the air cooler element fully in, make sure that the sealing flanges and a new O-ring are in position, hanging on the cooling water pipes.





4. Remove the guide wheels from the aft end cover.
5. Remove the guide rails and the lifting bracket from the front end cover.
6. Mount the sealing plate, a new O-ring and the frame around the front end cover.



7. Mount the sealing plate, a new O-ring and the frame around the aft end cover.

Mount and tighten the brackets which control the longitudinal position of the air cooler element.

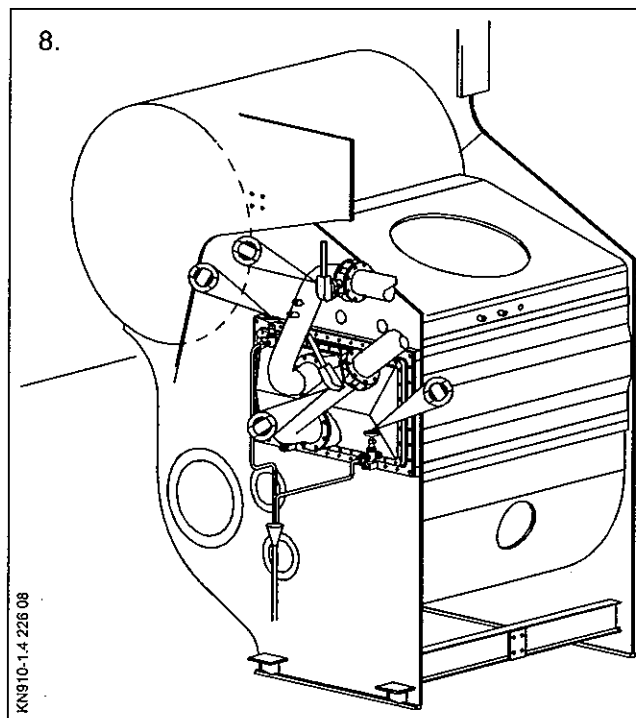
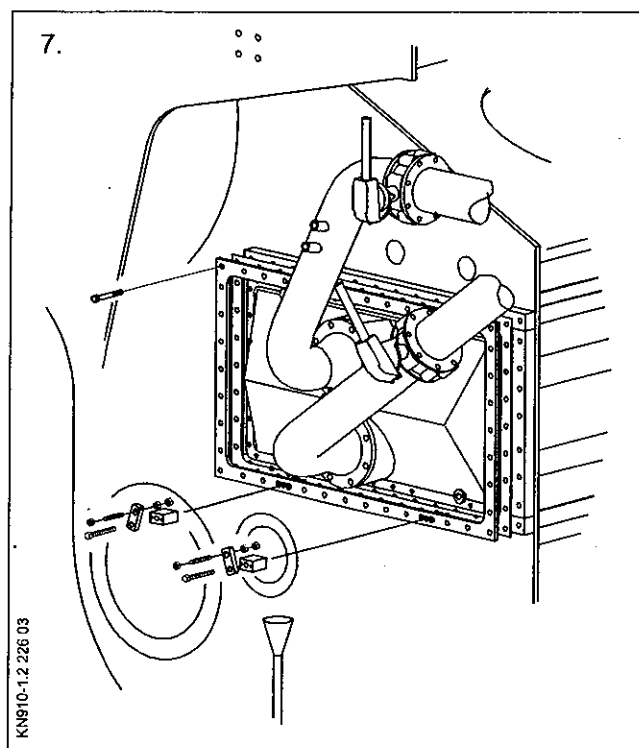
8. Insert new gaskets between the aft end cover and the flanges of the cooling water pipes.

Mount and tighten the screws which fasten the cooling water inlet and outlet pipes to the aft end cover.

Mount the drain pipes, and open the cooling water inlet and outlet valves.

Note!

Remember to vent trapped air from the air cooler element.



SAFETY PRECAUTIONS

☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

Standard Tools: See Section 913



Data

Ref.	Description	Value	Unit
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Spare Parts

Plate – Item No.

Description

Qty

1. Access to the non-return valves in the scavenge air receiver takes place – after the engine has been stopped – through the inspection openings of the receiver.

Warning!

Access to the scavenge air receiver **must not** be attempted until the air in the receiver is clean.

2. Remove the two outermost and middle nuts (which fasten the valve assembly to the housing).

Lift the complete valve assembly out of the air receiver.

3. Remove the spring pin from the valve shaft and knock the valve shaft out of the valve flap.

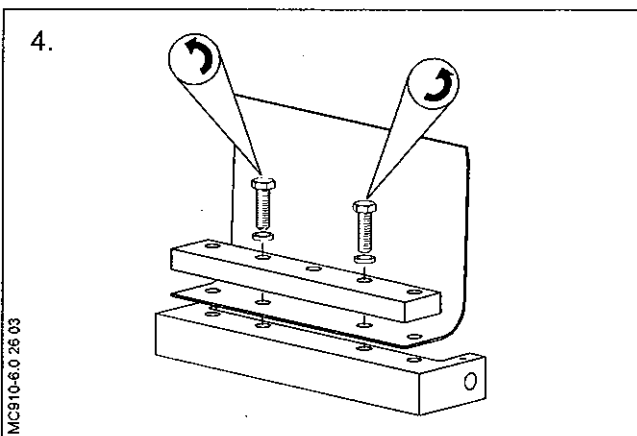
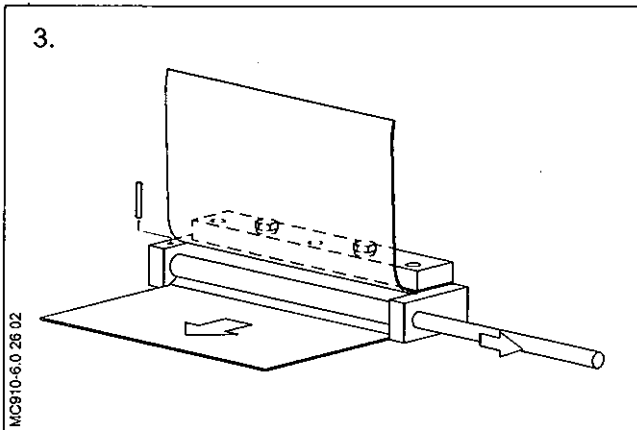
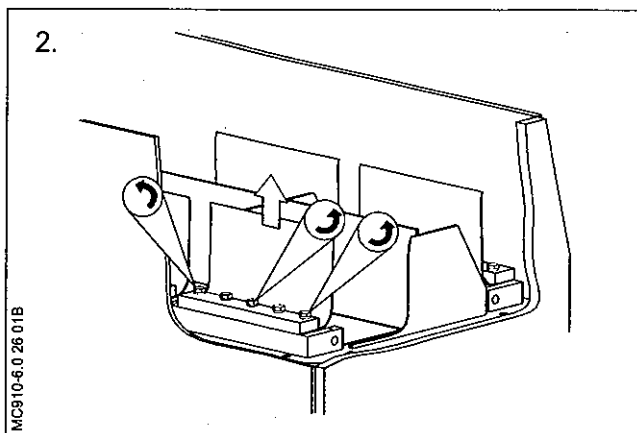
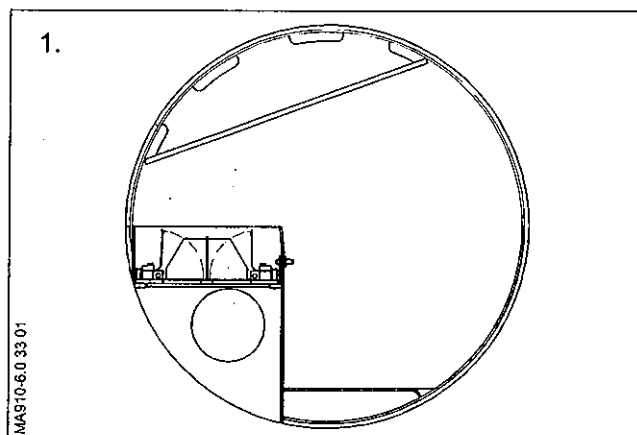
4. For further dismantling, remove the two screws which hold the clamp and the support together as an assembly.

Clean the valve shaft and the slide bearings inside the valve flaps. Lubricate the valve shaft and the slide bearings with molybdenum disulphide (MoS_2).

5. Assemble the valve

After the overhaul, it must be possible to move the valve flap by the light touch of a finger.

6. Re-mount the valve in the scavenge air receiver.



SAFETY PRECAUTIONS

☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Weight of blower unit, complete *)	up to 1300	kg

*) Depending on electric motor type and number of cylinders of engine (size and capacity of auxiliary blower)

Standard Tools: See Section 913



2 x 2000 kg

Spare Parts

Plate – Item No.	Description	Qty
------------------	-------------	-----

1. When cleaning and inspecting the auxiliary blower, disengage the cable connections to the blower motor.

Wire ropes with shackle as well as two tackles suspended from mountings on the gallery bracket are to be hooked onto the blower flange, before removing the screw in the flange.

2. The end cover complete with blower can now be pulled free of the suction pipe by means of the two tackles.

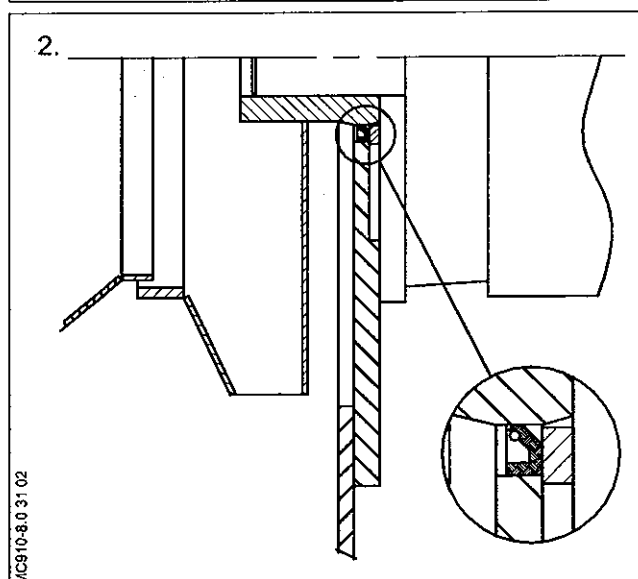
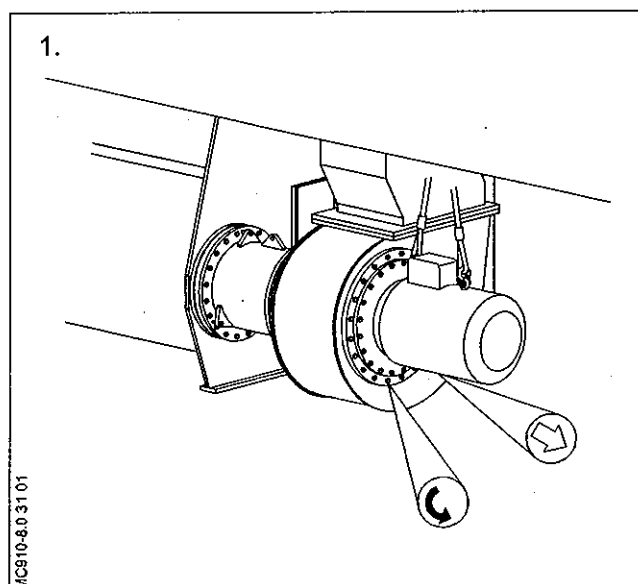
While pulling out the end cover with the blower assembly, make sure that the blower housing disengages from the air pipe without deforming it.

Then inspect and clean the blower wheel as well as the blower housing.

For overhaul of blower wheel and bearings, see blower manufacturer's instructions.

Note!

Exercise care when mounting the electric motor with blower wheel, as the blower wheel is to "catch" the guide in the blower housing.



SAFETY PRECAUTIONS

☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

Standard Tools: See Section 913



Data

Ref.	Description	Value	Unit
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Spare Parts

Plate – Item No.	Description	Qty
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1. It is important that the automatic non-return valves (butterfly valves) are always able to function easily and unimpeded.

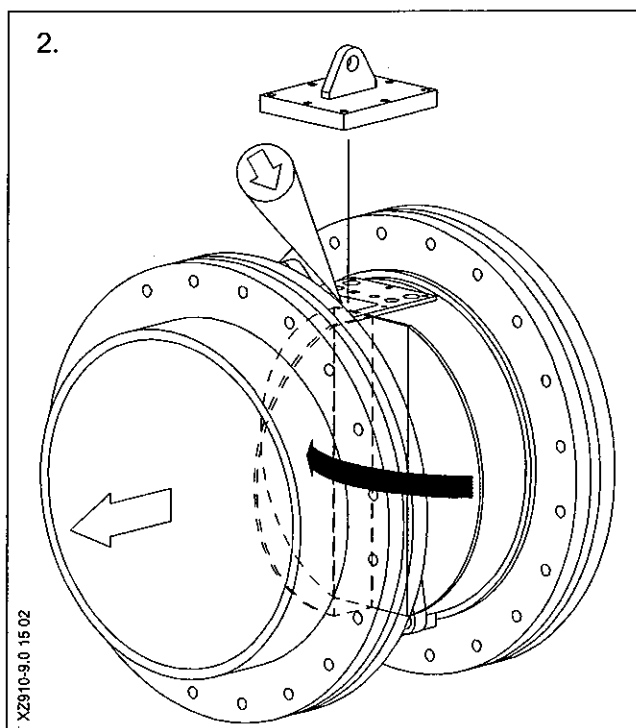
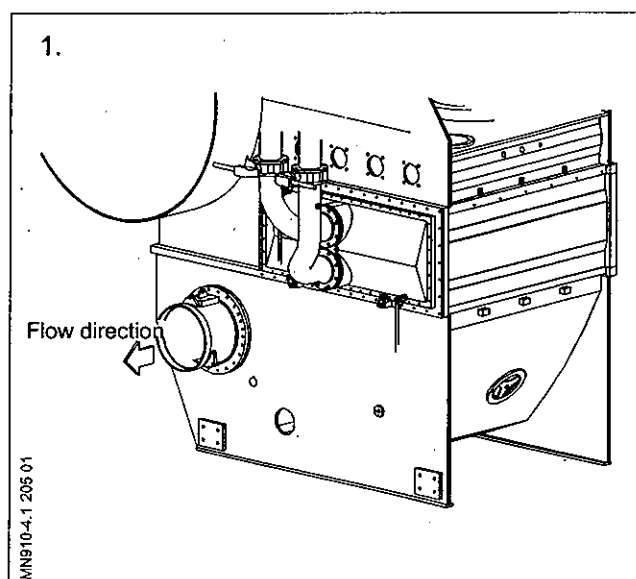
The movability of the valve flaps should therefore be checked at suitable intervals. The valves shall open for the air flow from the scavenge air cooler housings to the auxiliary blowers.

2. To check the valve, remove the cover on the top of the butterfly valve.

Reach down through the opening in the top of the valve and move the valve flaps.

3. If the valve flaps in one of the butterfly valves cannot be moved by a light touch of a fingertip, it must be dismantled and overhauled.

4. Re-mount the cover on the top of the butterfly valve.



SAFETY PRECAUTIONS

- ☐ Stopped engine
- ☐ Block the starting mechanism
- ☐ Shut off starting air supply
- ☐ Engage turning gear
- ☐ Shut off cooling water
- ☐ Shut off fuel oil
- ☐ Shut off lubricating oil
- ☐ Lock turbocharger rotors

Standard Tools: See Section 913

Data

Ref.	Description	Value	Unit
------	-------------	-------	------

Spare Parts

Plate – Item No.	Description	Qty
------------------	-------------	-----

For the turbocharger cleaning in detail,
please refer to the manual for the
turbocharger separately provided.

SAFETY PRECAUTIONS

☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☐	Engage turning gear
☒	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Water mist catcher	260	kg

Standard Tools: See Section 913



2 x M16



2 x 1000 kg

Spare Parts

Plate – Item No.

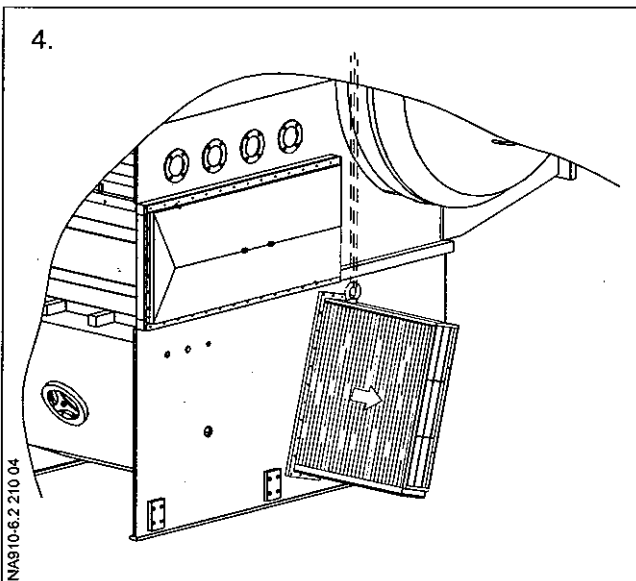
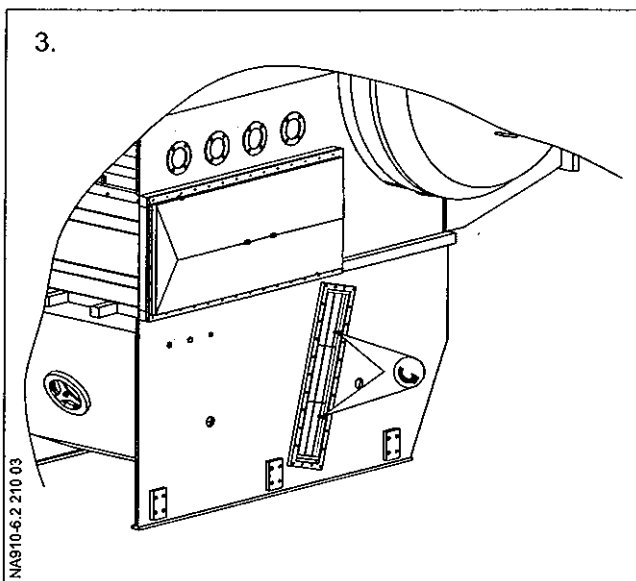
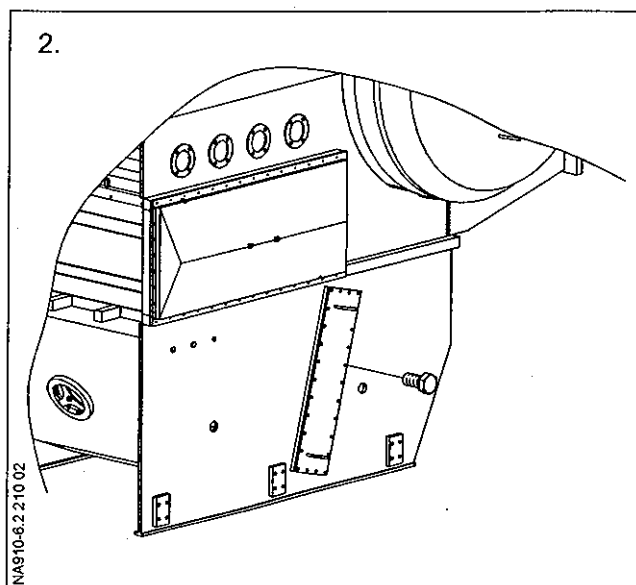
Description

Qty

1. Normally it is not necessary to remove the water mist catcher element from the air cooler housing. If, however, the water mist catcher element has been fouled or damaged, it must be dismantled for cleaning or repair.
2. Dismantle the side covers from the air cooler housing.
3. Loosen the four screws which tighten the water mist catcher to the air cooler frame.
4. Pull the water mist catcher half way out and screw a lifting eye bolt into the top of the water mist catcher.

Attach a tackle to the eye bolt and tighten up the tackle.

5. Pull the water mist catcher fully out of the air cooler housing and land it on a couple of wooden planks.
6. Clean or repair according to manufacturer's instructions.



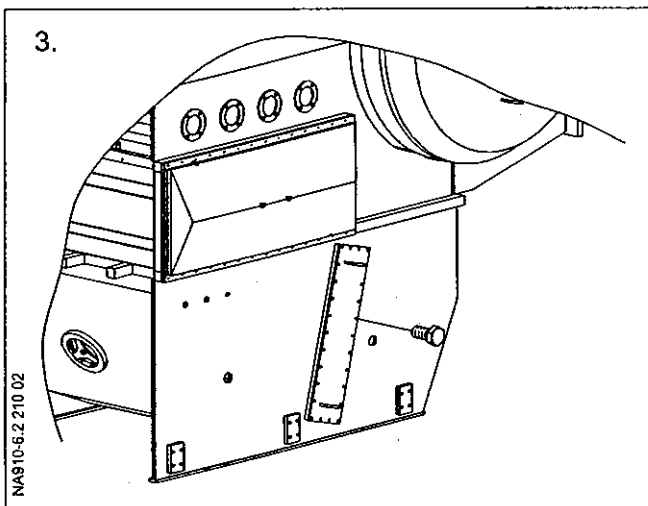
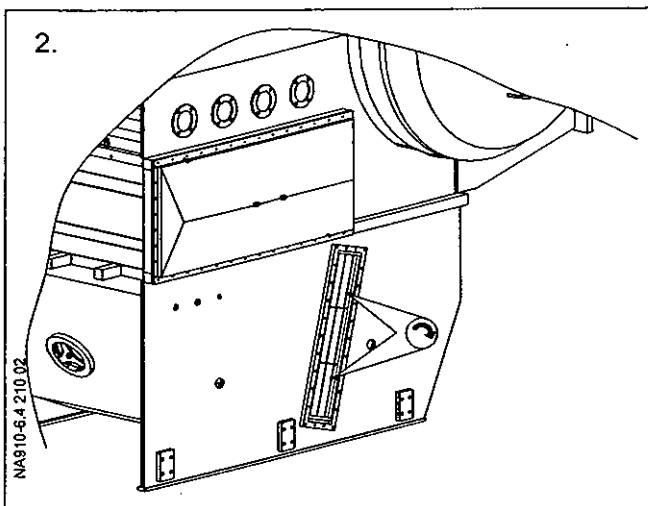
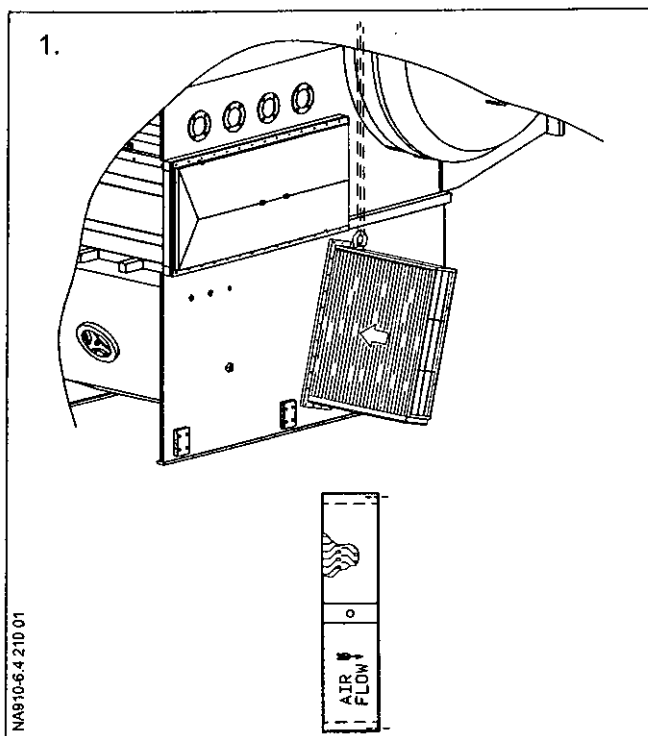
1. Tilt the water mist catcher to the correct angle and slide it into the scavenge air cooler housing.

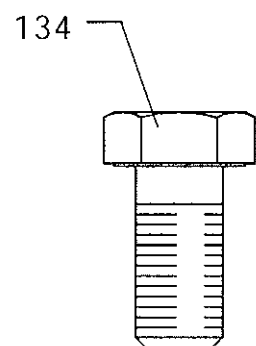
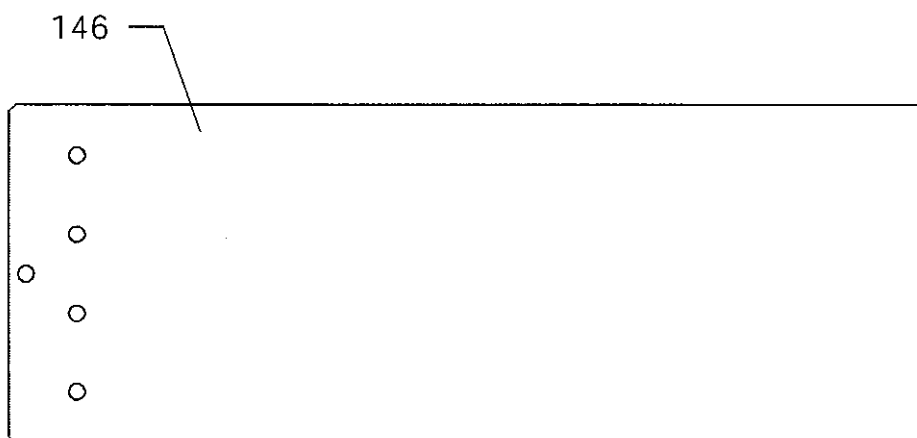
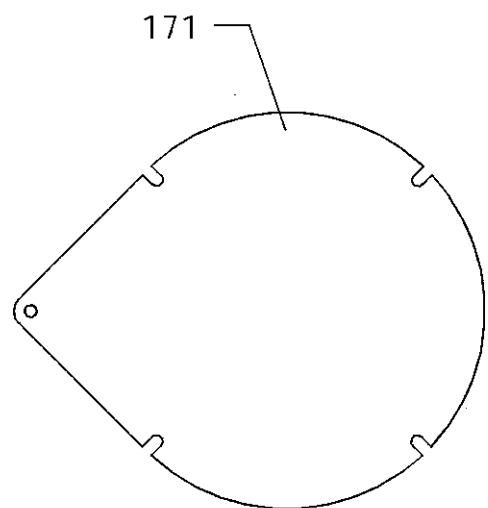
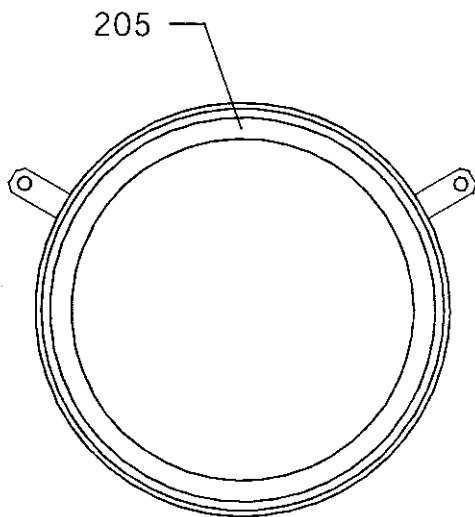
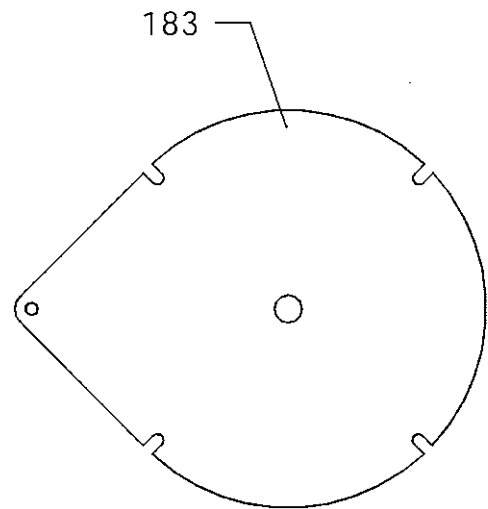
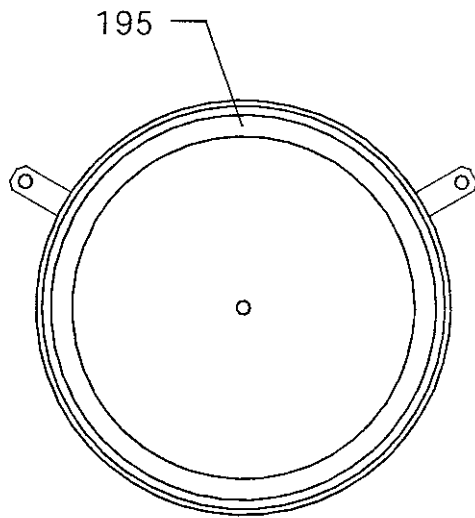
Note!

Make sure the water mist catcher is mounted in the right direction. Check the air flow indicator on the water mist catcher.

When the water mist catcher is half-way in, remove the tackle and the eye bolt, and push the water mist catcher fully into the air cooler housing.

2. Mount the screws which secure the water mist catcher to the air cooler frame.
3. Clean the side covers and apply a thin layer of silicone paste along the edges of the covers. Mount the covers.





Item No.	Item Description
134	Screw
146	Blind plate after turbocharger
171	Blank plate
183	Throttle plate
195	Throttle plate
205	Blank plate

Item No.	Item Description

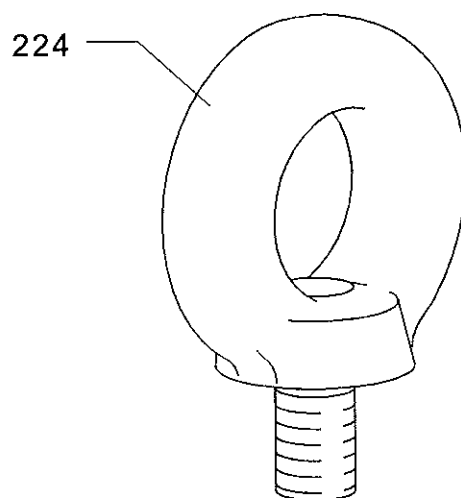
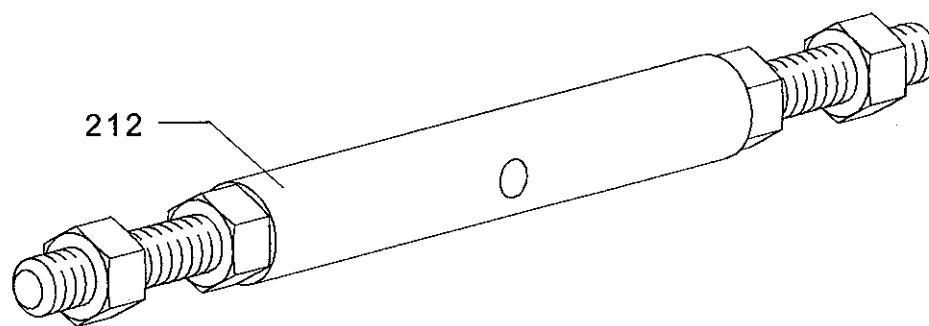


Plate 91061-0071

Turbocharger System - Tools

Item No.	Item Description
212	Pulling tool
224	Lifting eye bolt

Item No.	Item Description

Fore end

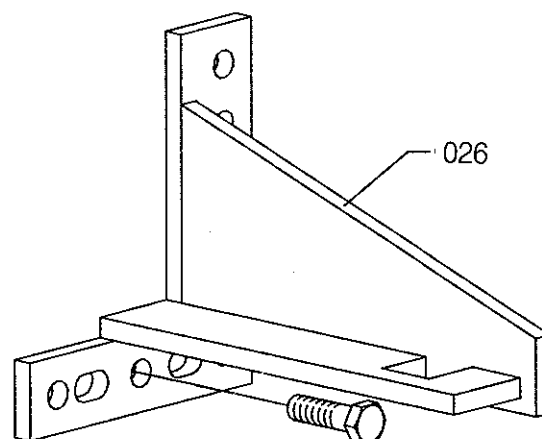
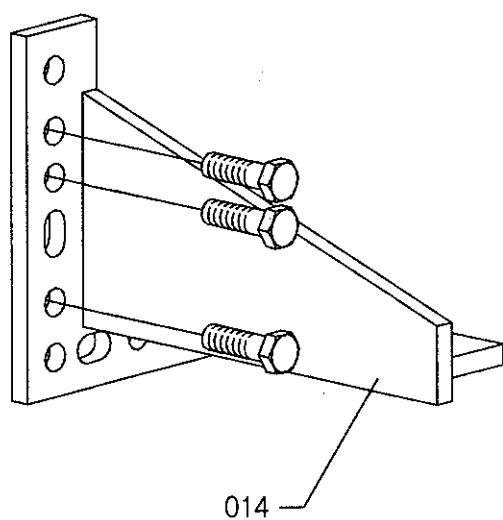
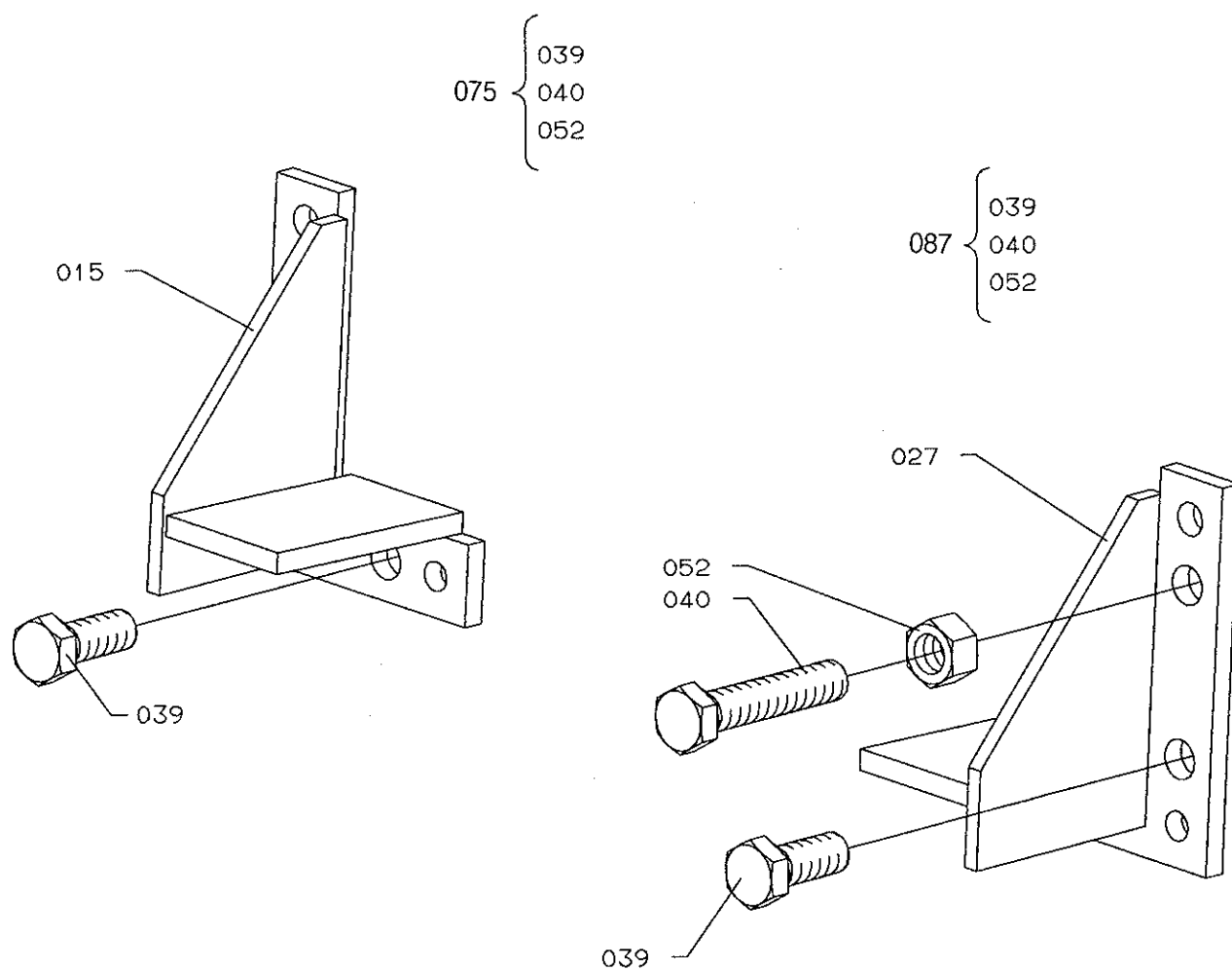


Plate 91063-0017

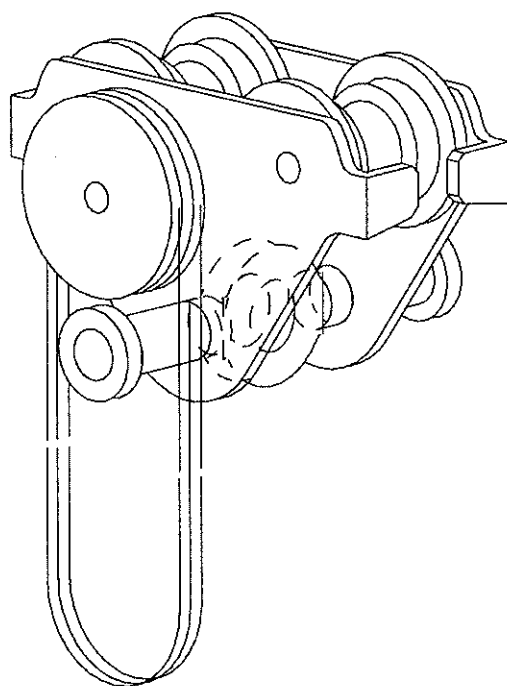
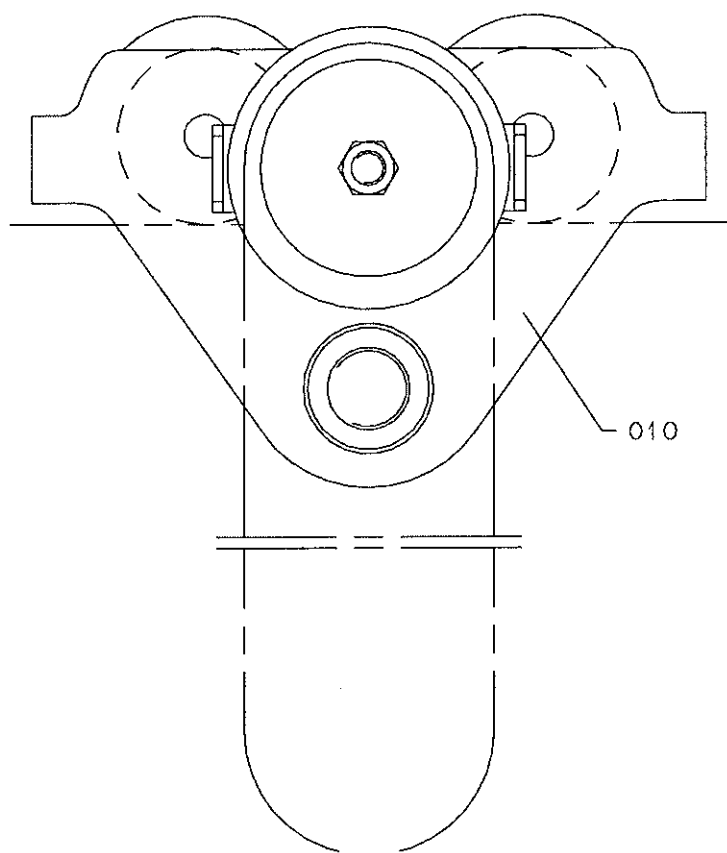
Air Cooler - Tools

Item No.	Item Description
014	Guide rail, air cooler fore end
026	Guide rail, air cooler fore end

Rear end



Item No.	Item Description	Item No.	Item Description
075	Guide rail, rear end		
087	Guide rail, rear		



Item No.	Item Description	Item No.	Item Description
010	Travelling trolley* Note: * When ordering this tool, please state load and track width.		

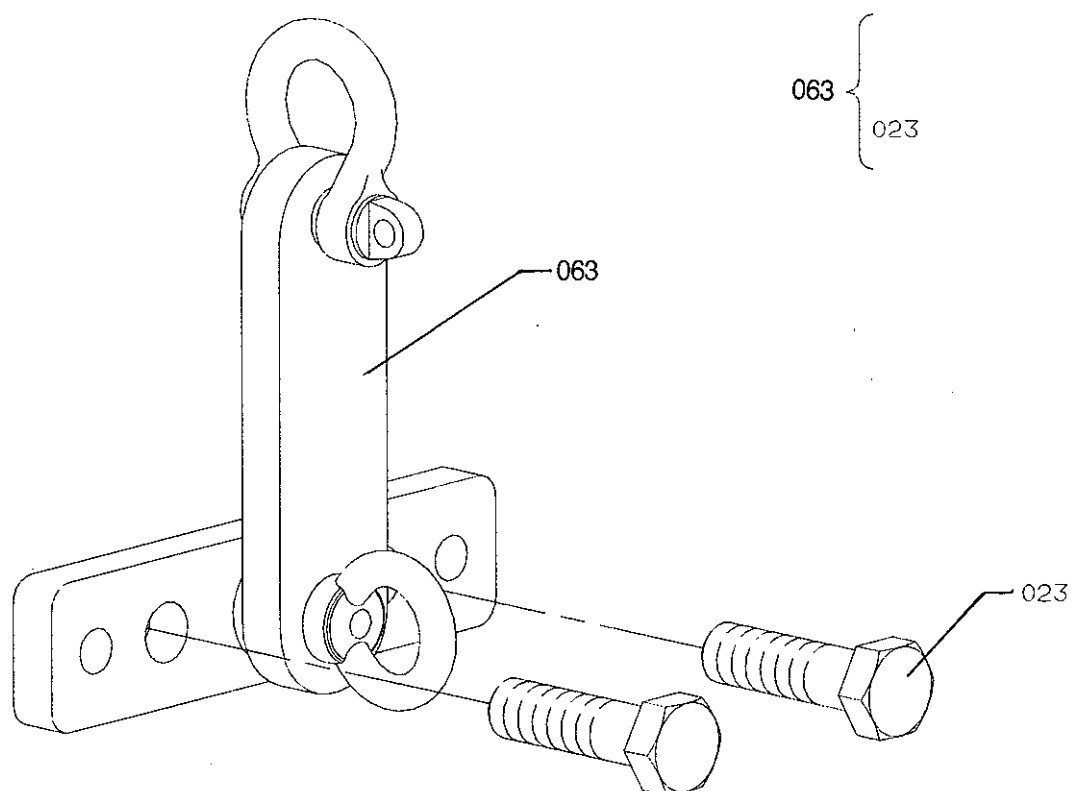


Plate 91066-0002

Air Cooler - Lifting Tools

Item No.	Item Description	Item No.	Item Description
023 063	Screw Lifting attachment air cooler		

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

- ☒ Stopped engine
- ☐ Shut off starting air supply – *At starting air receiver*
- ☐ Block the main starting valve
- ☐ Shut off starting air distributor/distributing system supply
- ☐ Shut off safety air supply – *Not ME-engines*
- ☐ Shut off control air supply
- ☐ Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
- ☐ Engage turning gear
- ☐ Shut off cooling water
- ☒ Shut off fuel oil
- ☐ Stop lubricating oil supply
- ☐ Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description

1. During running of the engine, check if there are any leaks.

If a leak occurs, replace the O-ring inside the relief valve. *See separate instructions from the valve manufacturer.*

2. If work involving risks of mechanical damage to the flame arrester has taken place, a visual inspection of the flame arrester should always be performed before starting the engine.

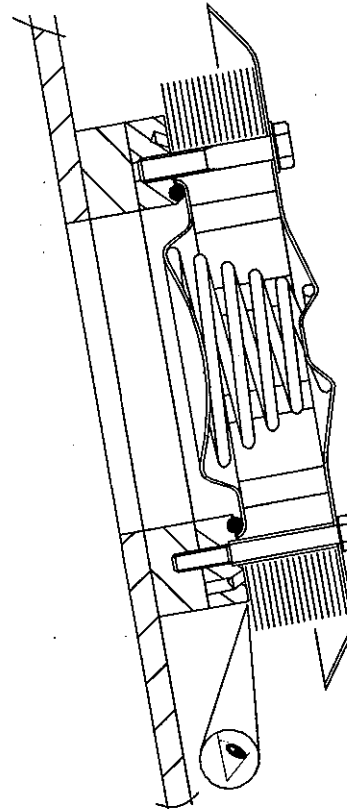
Check on the whole circumference that all the plates in the flame arrester are evenly distributed and that no local openings exist.

If one or more plates in the flame arrester are damaged, the relief valve must be disassembled and the flame arrester replaced. *See separate instructions from the valve manufacturer.*

Note!

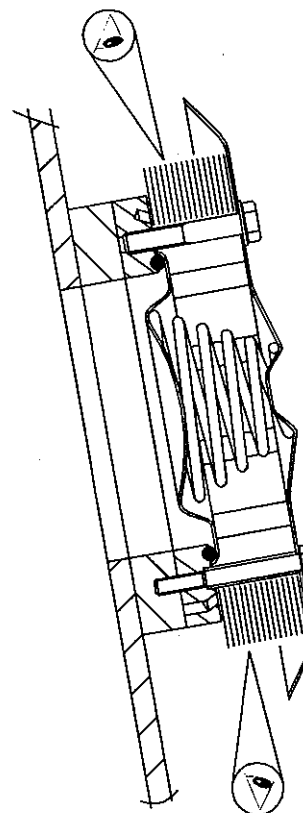
The complete flame arrester has to be replaced after a crankcase explosion.

1.



XZ911-2.1 209 01

2.



XZ911-2.1 207 03

SAFETY PRECAUTIONS

☒	Stopped engine
☒	Block the starting mechanism
☒	Shut off starting air supply
☒	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☒	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit

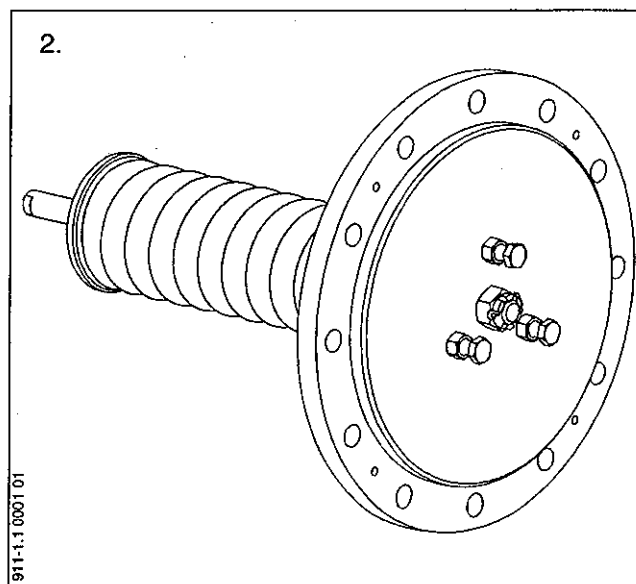
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

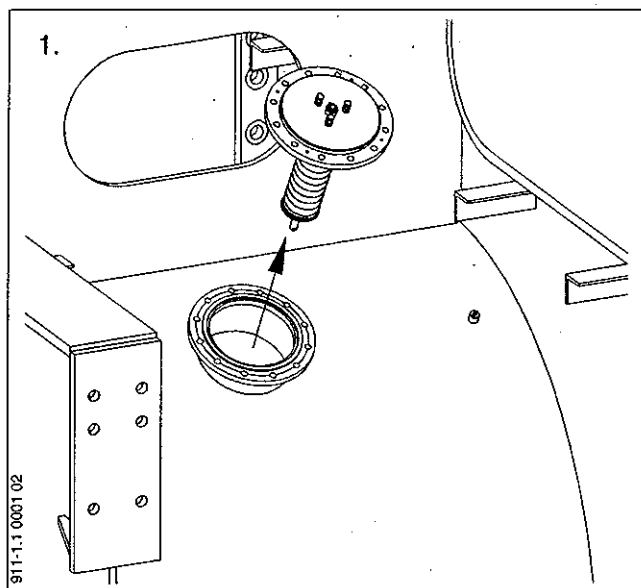
Plate	Item No.	Description

1. The scavenge air receiver safety valve is calibrated at the factory and does not require any adjustment.
2. Check the scavenge air receiver safety valve by loosening the counter nut and turn the forced opening screw to open the valve approx. 10 millimetres.

Use a piece of cloth to wipe out any dirt from the O-ring packing and close the valve again. Tighten the counter nut.

If this operation cannot be performed smoothly, the safety valve must be dismantled and cleaned.





1. Dismount the safety valve from the scavenge air receiver.

1. Remove the split pin.

Unscrew the nut thereby relieving the spring tension.

Remove the nut, spring retainer and washers.

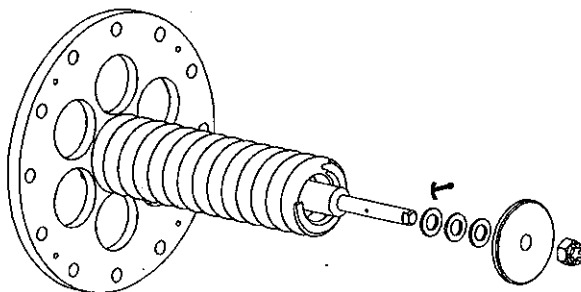
Keep count of the washers.

Pull out the spring.

2. Pull out the valve flap with spindle. If the O-ring seal is damaged remove it without damaging the O-ring groove.

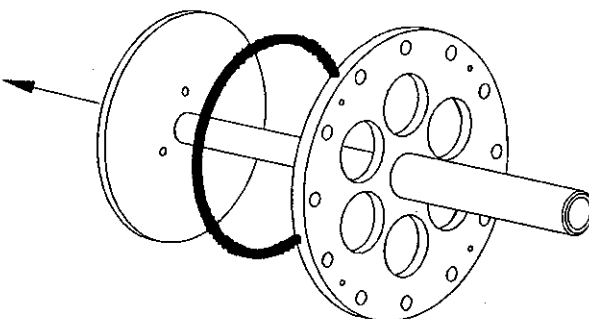
3. Clean the metal surfaces thoroughly.

1.

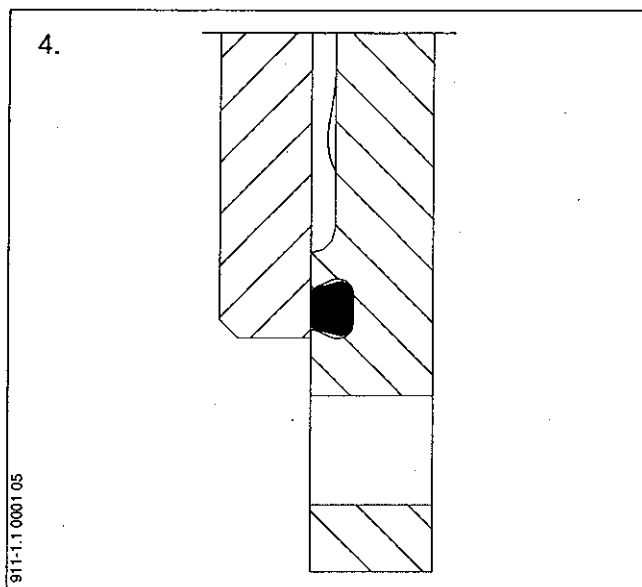


911-1.1 0001 03

2.



911-1.1 0001 04



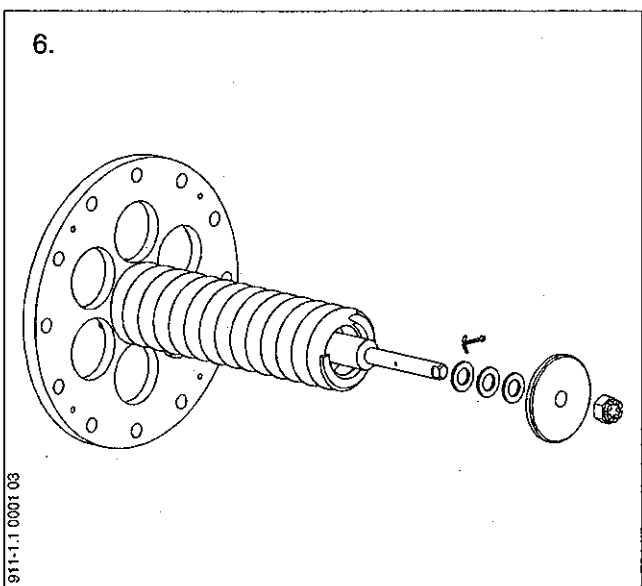
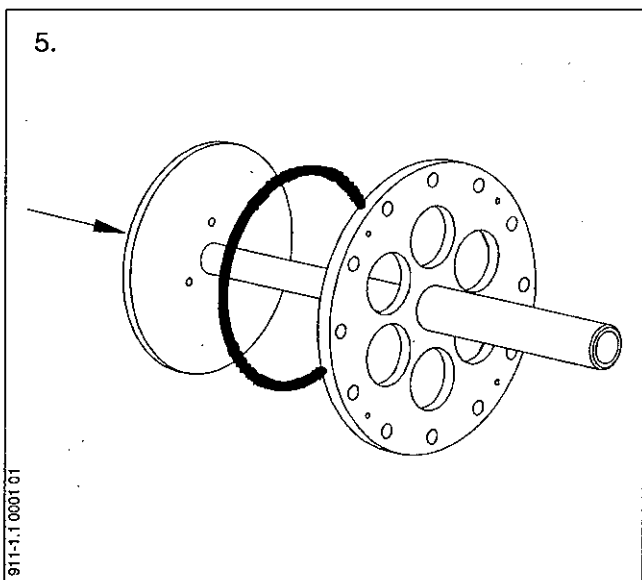
4. If the O-ring seal has been removed mount a new one using Locktite type AVX and Locktite activator type T or similar.

5. Push in the valve flap and spindle while taking care not to damage the O-ring seal.

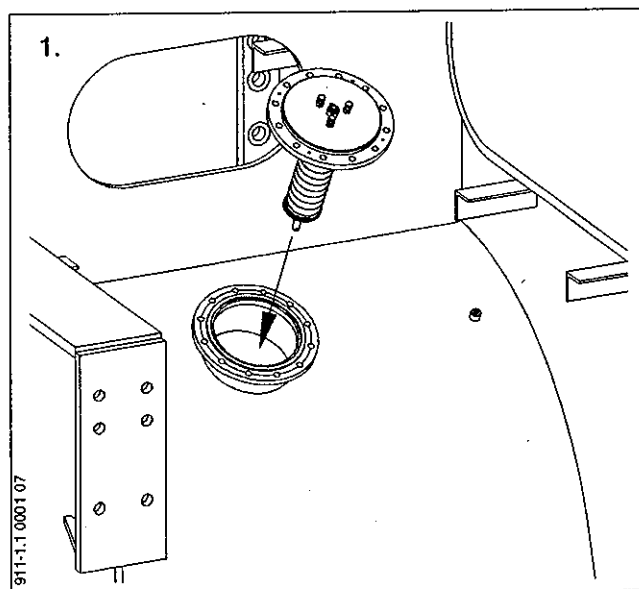
6. Mount the spring, spring retainer and all the washers.

Tighten the nut until the split pin can be mounted.

7. Check the valve according to 91101.1.



1. Mount the safety valve on the scavenge air receiver.



SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☐	Shut off starting air supply – <i>At starting air receiver</i>
☐	Block the main starting valve
☐	Shut off starting air distributor/distributing system supply
☐	Shut off safety air supply – <i>Not ME engines</i>
☐	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D12-02	Check holding down bolts and end chock bolts for correct tightening after the following service hours:		
	1st check	500	hours
	2nd check	1000	hours
	3rd check	2000	hours
	4th check	4000	hours
	5th check	8000	hours
	Subsequent checks at intervals of	8000	hours
D13-01	Hydraulic pressure, mounting	2200	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P91261		Large Parts - Tools
P91351	010	Hydraulic pump, pneumatically operated
P91351	046	Hose with unions (1500 mm), complete
P91351	058	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete

Note!

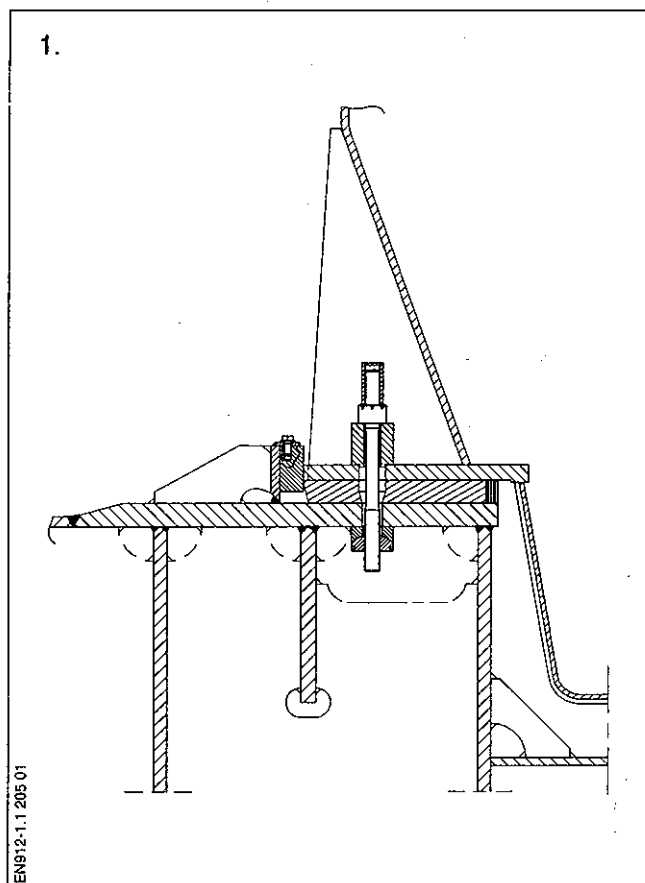
The hydraulic jack used for tightening the holding down bolts is marked with:

For: Holding down bolts

The larger jack used for tightening the end chock bolts is marked with:

For: End chock bolts

Hydraulic tightening of holding down bolts and end chock bolts is carried out as detailed in Section 913-1. The normal tightening pressure is indicated on the Data sheet and is also stamped on the tightening tool.



Checking the Bolt Tightening

1. The holding down bolts and end chock bolts must be checked for correct tightness at the intervals indicated on the Data sheet.

For this purpose, raise the pressure on the hydraulic tool slowly while constantly attempting to loosen the nut with the tommy bar. The oil pressure indicated on the pressure gauge when the nut comes loose ('loosening pressure') is to be noted down in the checking tables, see pages 4 and 5, following which the bolts are tightened to the normal tightening pressure.

The condition of the bolted joints, and thus the general condition of the foundation, can be effectively checked by comparing the tables from successive bolt checks.

If the 'loosening pressure' is below 80 per cent of the tightening pressure, the relative chocks shall always be checked for possible defects. If the chocks are in position and in order, the bolts should be taken out for inspection of threads and contact faces.

Checking of Epoxy Supporting Chocks

2. If a number of measuring pins have been welded to the tanktop, the heights of the epoxy supporting chocks are to be checked immediately after finishing the checking of the loosening pressures of the holding down bolts and the retightening of these.

The distance between the measuring pins and the bedplate is to be measured with a blade gauge and noted down. Any possible settling of the chocks during the intervals between measurements can thereby be followed.

Side Chocks and Side Chock Liners

3. After fitting the liners to an 80 per cent contact area on both sides of the liners, knock the liners a further 3 to 4 mm inward.

The liners located in way of each main bearing on either side of the engine must be fitted and knocked into position simultaneously.

The first time the ship is sailing in a fully-loaded condition after the engine has been operating for 1,000 hours, all side chocks should be checked to see whether the liners can be knocked further inward.

The fit of the side chock liners should be checked with a feeler gauge each time the loosening pressure of the holding down bolts is checked, and thus at the same time intervals.

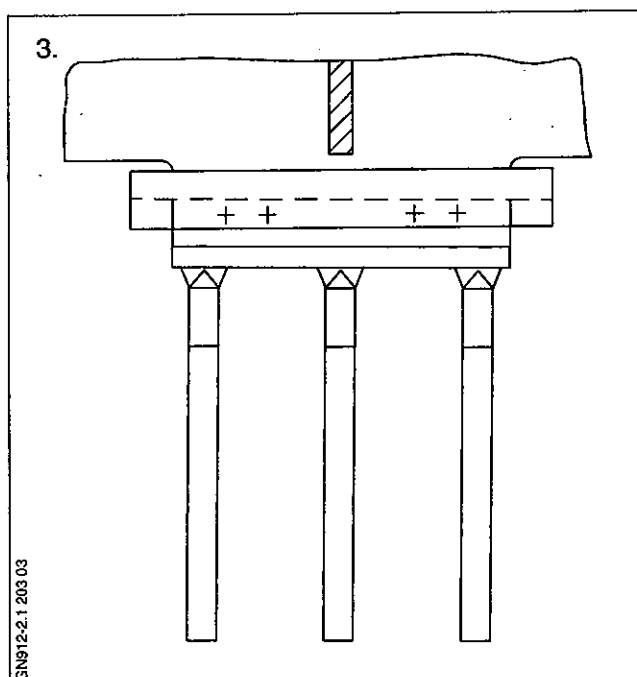
The feeler gauge is applied at the 7 points indicated in the table on page 5, and the measurements found are to be entered in the relevant table. These results are used to determine whether refitting or, possibly, replacement of the liners is necessary.

If the measurements at 3 points or more have increased 5/100 mm or more from the initial results, we recommend that the following procedure is followed:

1. Loosen the hexagon screws.
2. Try to knock the liner further inward.
3. Measure again at the 7 points indicated in the table.

If this procedure does not improve the situation, the liner must be removed, and it must be checked that the actual contact area is more than 80 per cent of the possible contact surface areas on both sides of the liner.

The liners are secured in their correct position by means of hexagon socket set screws with cup point.



GN912-2.1 203 03

Holding Down Bolts

Engine frame No.	Bolt No.	Port side			Cylinder No.	Starboard side			Bolt No.	Engine frame No.
		pressure	% dev.	remarks		pressure	% dev.	remarks		
1	1				1				1	1
	2								2	
	3								3	
	4								4	
2	1				2				1	2
	2								2	
	3								3	
	4								4	
3	1				3				1	3
	2								2	
	3								3	
	4								4	
4	1								1	4
	2								2	
	3								3	
	4								4	
5	1								1	5
	2								2	
	3								3	
	4								4	
6	1								1	6
	2								2	
	3								3	
	4								4	
7	1								1	7
	2								2	
	3								3	
	4								4	
8	1								1	8
	2								2	
	3								3	
	4								4	
9	1								1	9
	2								2	
	3								3	
	4								4	
10	1								1	10
	2								2	
	3								3	
	4								4	
11	1								1	11
	2								2	
	3								3	
	4								4	
12	1								1	12
	2								2	
	3								3	
	4								4	
13	1								1	13
	2								2	
	3								3	
	4								4	
14	1								1	14
	2								2	
	3								3	
	4								4	
	1								1	
	2								2	
	3								3	
	4								4	

Side Chocks and End Chock Bolts

Port side								Starboard side										
Chock No.	Point							Cylinder No.	Point							Chock No.		
	A	B	c	d	e	f	g		A	B	c	d	e	f	g			
1								1 2 3								1		
2																		2
3																		3
4																		4
5																		5
6																		6
7																		7
8																		8
9																		9
10																		10
11																		11
12																		12
13																		13
14																		14

Port side

Ch No.	Bolt No.	Pressure (kp/cm ²) bar	Deviation %	Point				
				a	b	c	d	e
E	1							
	2							

FORE

Starboard side

Point					Deviation %	Pressure (kp/cm ²) bar	Bolt No.	Ch No.
a	b	c	d	e				
							1	E
							2	

AFT

SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

☒	Stopped engine
☒	Shut off starting air supply – <i>At starting air receiver</i>
☒	Block the main starting valve
☒	Shut off starting air distributor/distributing system supply
☒	Shut off safety air supply – <i>Not ME engines</i>
☒	Shut off control air supply
☐	Shut off air supply to exhaust valve – <i>Only with stopped lubricating oil pumps</i>
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Stop lubricating oil supply
☐	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D12-04	Check measurement	210±3	mm
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 - 2400	bar

The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P91261		Large Parts - Tools
P91351	010	Hydraulic pump, pneumatically operated
P91351	046	Hose with unions (1500 mm), complete
P91351	058	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete

1. This check can be performed during several periods of stopped engine, but must be performed on complete twin stay bolt groups at a time, thereby ensuring uniform tension in the affected bearings.

Note!

The first time this check is performed it has to be completed in one operation. The following checks have to be completed within a 500-hour period.

2. Before retightening the stay bolts, remove the protective caps.
3. Check for loose staybolt nuts with the tommy bar.

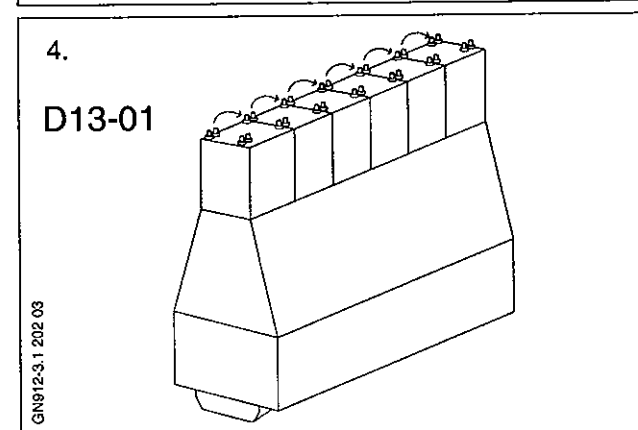
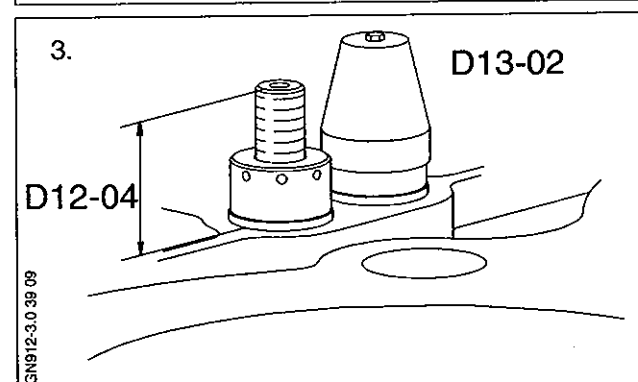
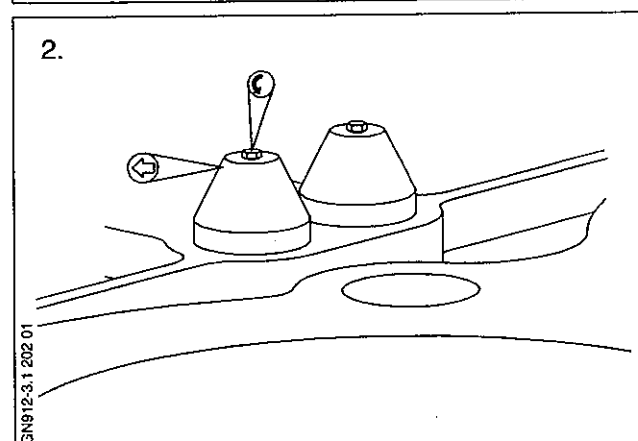
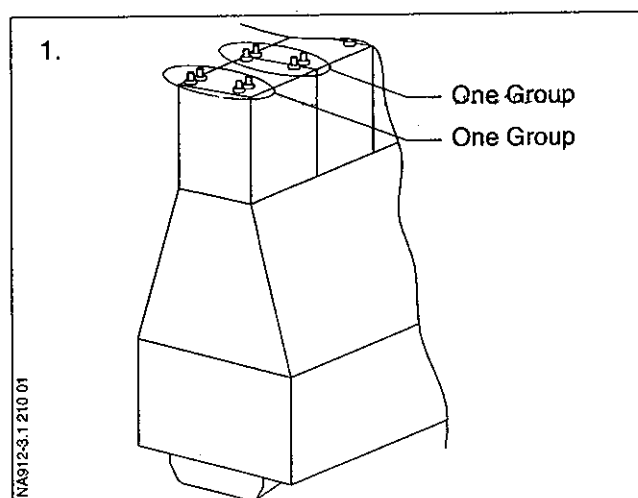
If a loose nut is found, unscrew the nut until a gap occurs between cylinder frame and nut.

Loosen and unscrew the nut on the opposite stay bolt.

Check for the correct mounting of the stay bolt by comparing with the check measurement on the Data Sheet.

If the check measurement is not reached, indicating that the stay bolt is not screwed properly down in the thread of the bedplate, apply a screw and a conternut in the thread in the top of the stay bolt, and turn the stay bolt until the check measurement data is met.

4. Retighten the stay bolts in pairs (athwart-ship), working from fore to aft of the engine.



5. Clean the contact faces and mount the hydraulic tools on a pair of stay bolts positioned opposite each other.

Connect the high-pressure pump by means of the high-pressure hoses, so that the two stay bolts are tightened in one operation.

6. Maintain the mounting pressure, and retighten the stay bolt nuts with a tommy bar. Before relieving the system of pressure, check with a feeler gauge that the nuts bear against their contact faces.
7. When all stay bolts have been retightened, reconnect the hydraulic tools to the pair of stay bolts first tightened. Tighten to 10% below the mounting pressure and check whether the nut is loose.

If the nut is **not** loose:

Tighten the stay bolts concerned to the mounting pressure.

If the nut is loose:

Tighten **all** stay bolts once again to the mounting pressure.

8. After completing the retightening procedure, mount the protective caps.

5.

D13-01

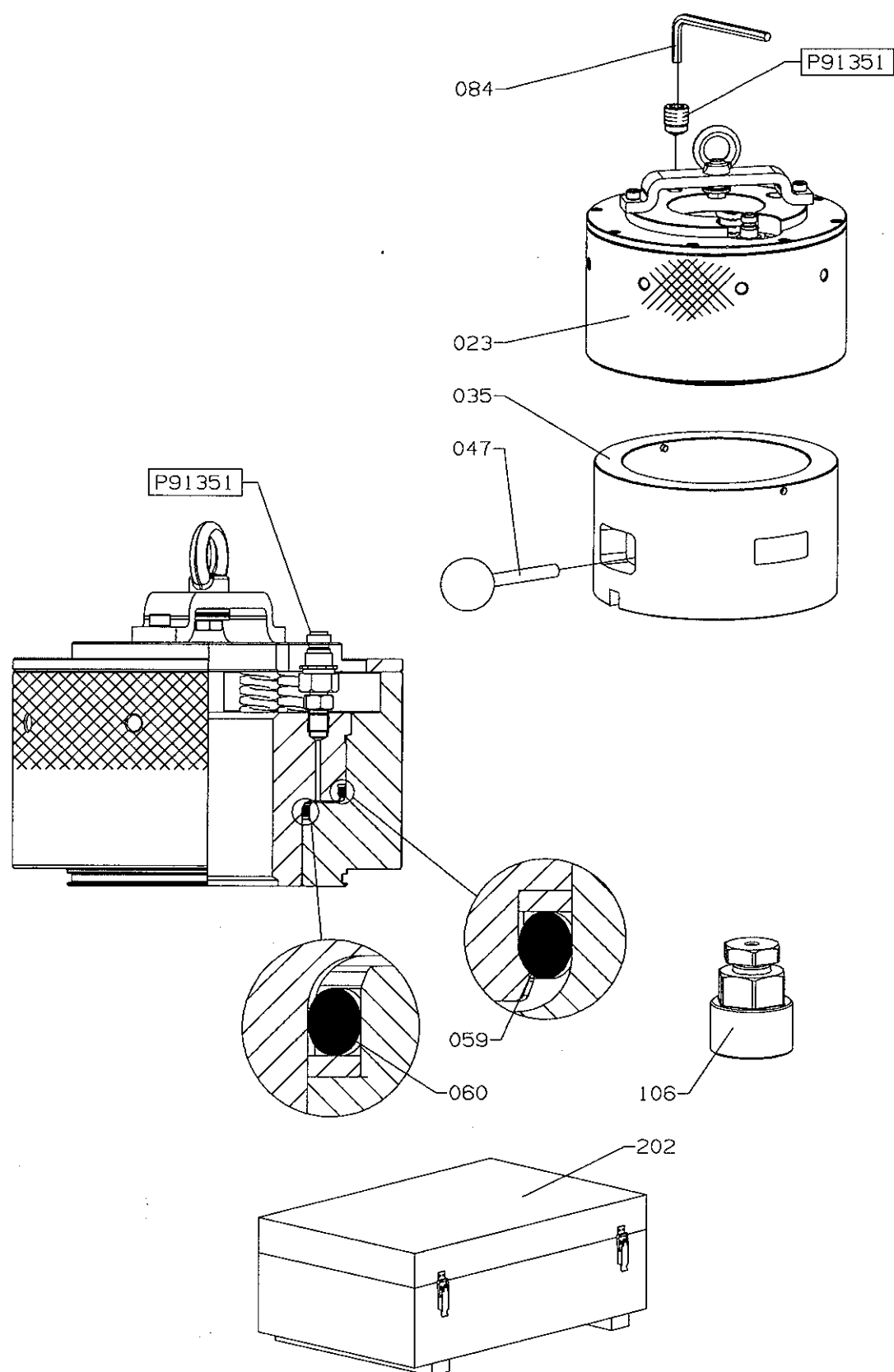
NF912-3.1 214 05

6.

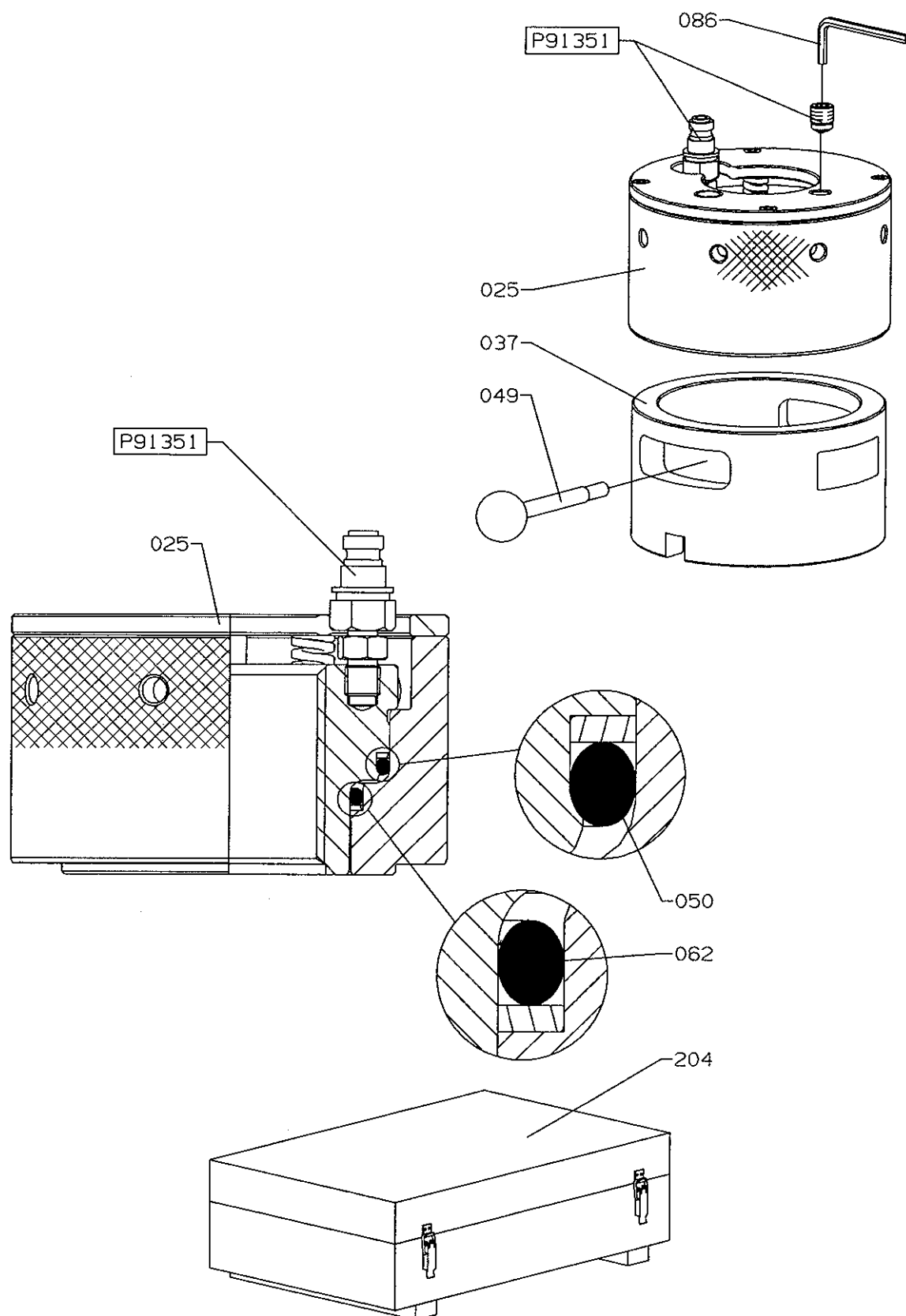
NF912-3.1 214 06

7.

NF912-3.1 214 07



Item No.	Item Description	Item No.	Item Description
023	Hydraulic jack, complete		
035	Support		
047	Tommy bar		
050	Sealing ring with back-up ring		
060	Sealing ring with back-up ring		
084	Spanner		
106	Stud setter		
202	Hydraulic tool set, complete		



**Plate 91265-0004 Hydraulic Tools - Holding Down Bolts
(Epoxy Chocks)**

Item No.	Item Description	Item No.	Item Description
025	Hydraulic jack, complete		
037	Support		
049	Tommy bar		
050	O-ring with back-up ring		
062	O-ring with back-up ring		
086	Spanner		
204	Hydraulic toolset, complete		

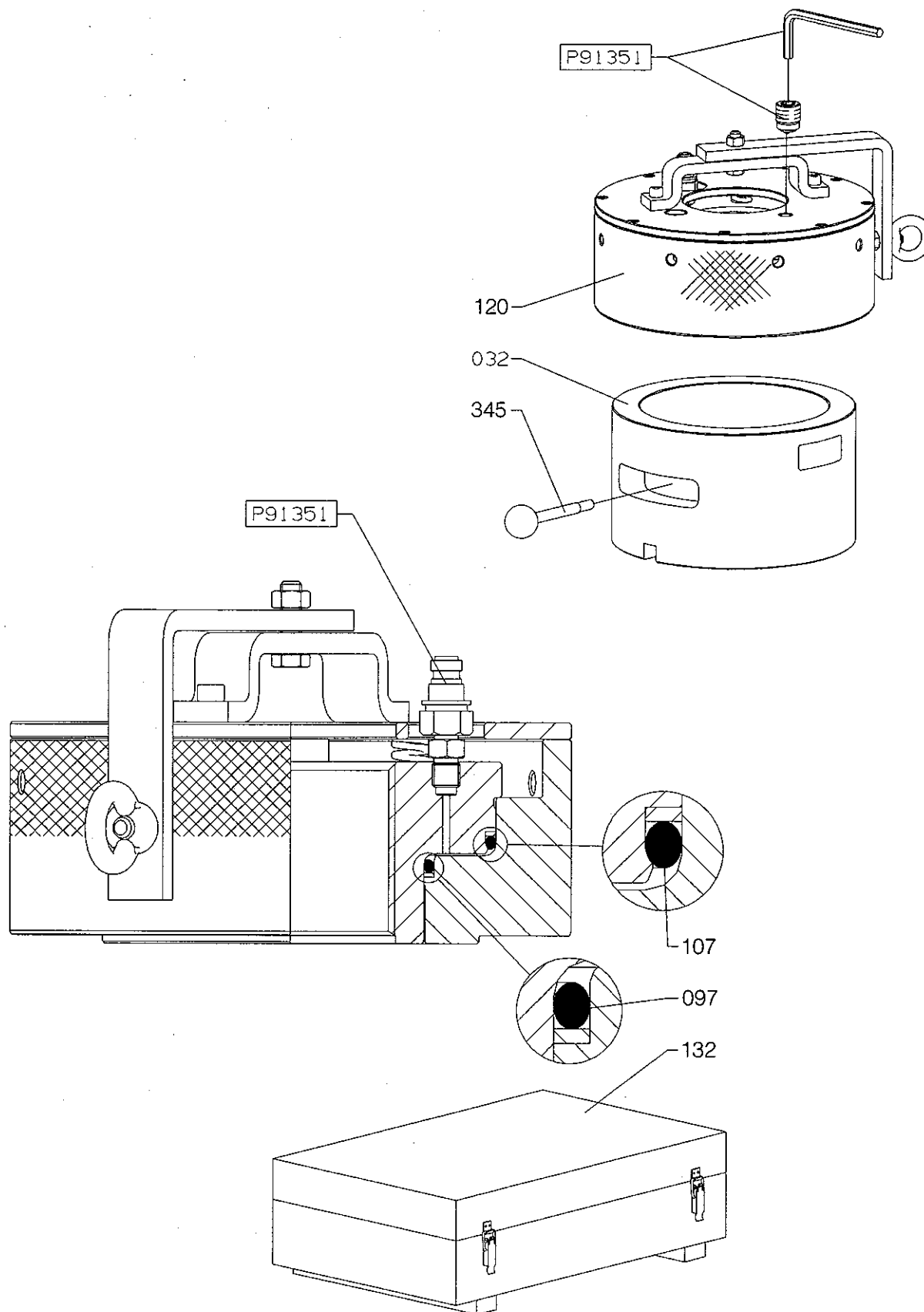


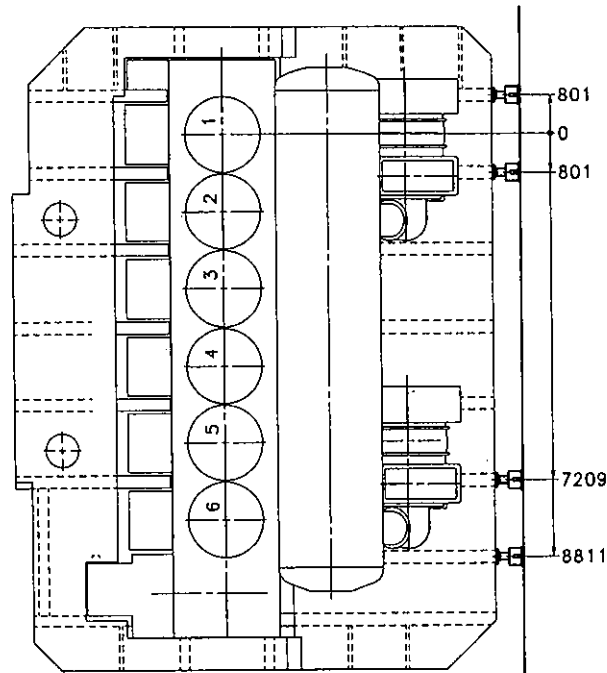
Plate P91266-0003

**Hydraulic Tools - End Chock Bolts
(Epoxy Chocks)**

Item No.	Item Description
032	Support
097	O-ring with back-up ring
107	O-ring with back-up ring
120	Hydraulic jack, complete
132	Steel box
345	Tommy bar

Item No.	Item Description

Viewed from B.

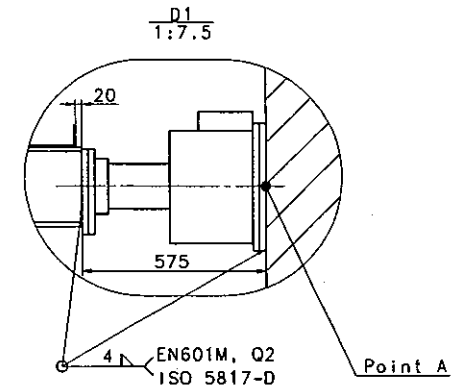
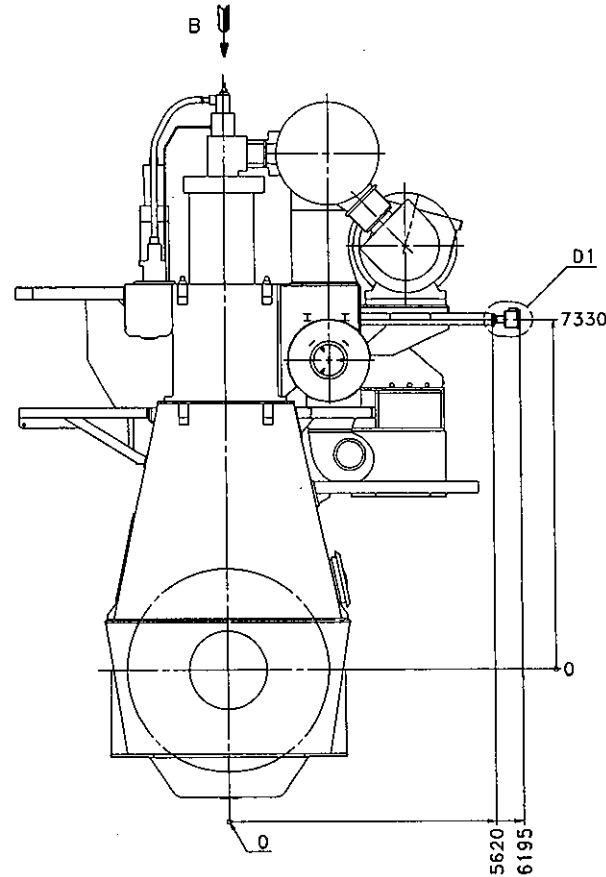


As the rigidity of the casing structure to which the top bracing is attached is most important, it is recommended that the top bracing is attached directly into a deck.

Required rigidity of the casing side point A:

In the axial direction of the hydraulic top bracing
Force per bracing : 127 kN
Max. corresponding deflection of casing side : 0.51 mm

In the horizontal and vertical direction of the hydraulic top bracing
Force per bracing : 22 kN
Max. corresponding deflection of casing side : 2.00 mm



The hydraulic cylinders must be turned so that the relief v/v block is positioned as high as possible.

*유압실린더의 Relief v/v가 상단방향으로 향하도록 유압실린더를 설치할 것.

*용접품질기준

1. 용접각목 4mm기준 잔류용접
2. Fit-up 최대허용값 : 3mm이하
3. 용접부작물허
4. 기타세부사항은 EN601M, Q2 또는 ISO5817-D 용접등급에 따를 것.

*Top Bracing이 설치되는쪽의 Casing Structure강성의 중요성때문에 Top Bracing은 Deck에 직접설치되어야 함.

*Casing Side Point A에 요구되는 강성

1. Top Bracing axial방향
- bracing용 작용력: 127kN
- casing side의 최대변형률: 0.51mm
2. Top Bracing의 수직/수평방향
- bracing용 작용력: 22kN
- casing side의 최대변형률: 2.0mm

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STANDARD FOR WELDING CONVENTION											
Class No.	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Welding	0.025	0.05	0.1	0.2	0.4	0.6	1.0	1.5	2.0	3.0	5.0

STANDARD FOR DIMENSIONS CONVENTION											
Class No.	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Dimension	0.025	0.05	0.1	0.2	0.4	0.6	1.0	1.5	2.0	3.0	5.0

Supplement Drawing No.:		Project No.:		Revision / Break:	
Date:		Rev.:		Rev.:	
07/24/24-1.0		A92		1/1/24	
Revised by: HMI, M.V.		Checked by: HMI, M.V.		Drawn by: HMI, M.V.	
03/2/2024		03/2/2024		03/2/2024	
384625		6590MC-C/ME-C		01 (01)	
HYDRAULIC TOP BRACING ARR.		A11-245433-3		A11-245433-3	

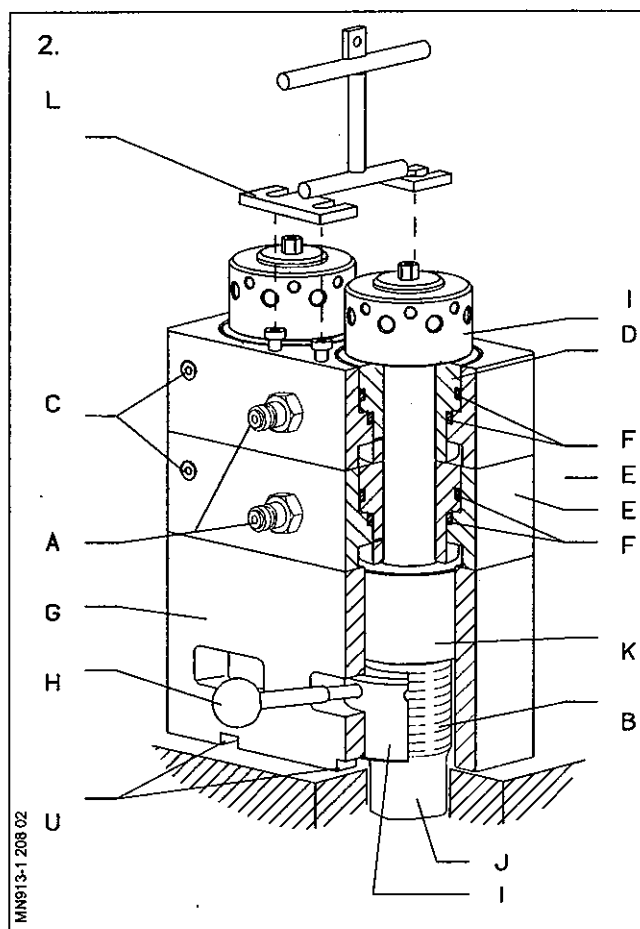
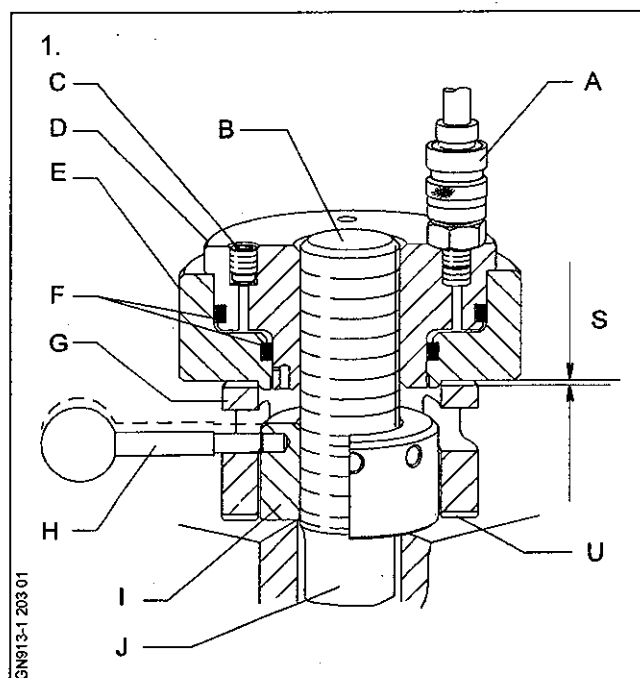
- A. Snap-on coupling
- B. Tool attachment thread
- C. Bleed screw
- D. Piston
- E. Cylinder
- F. Sealing rings
- G. Spacer ring
- H. Tommy bar
- I. Nut
- J. Stud or bolt
- K. Extension stud
- L. Lifting tool
- S. Clearance
- U. Milled recess for feeler gauge

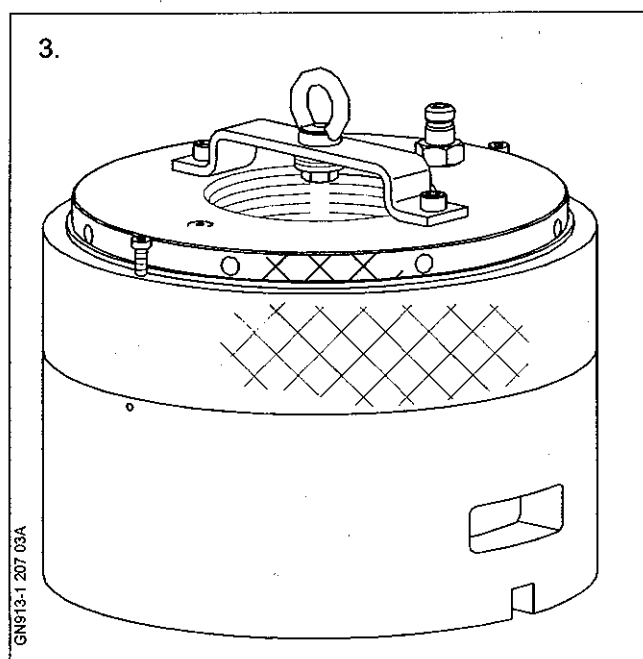
Studs or bolts provided with threads for attaching hydraulic tools and with circular nuts must only be loosened and tightened up by means of the hydraulic tools supplied.

The jack(s) is/are connected, via a distributor block, to a high-pressure pump, which is set to deliver hydraulic oil at the pressure indicated on the jack and on the data sheet in the relevant section of this instruction book. The stud or bolt concerned is thereby lengthened relative to the oil pressure applied and the piston area, and the nut can be loosened or tightened, as required, with the aid of a tommy bar.

The jacks must never be overloaded or exposed to blows or impacts. They are marked with a "Max. lift", which must not be exceeded.

1. The hydraulic tools, except those for the main bearings and the cylinder cover, consist of a jack with an internal thread to suit the tool attachment thread on the stud or bolt, and a spacer ring which is to be placed under the jack and around the nut that is to be loosened or tightened.
2. For the main bearings, the hydraulic tool consists of a double jack with two extension studs. This jack is designed for the simultaneous dismantling of both nuts on one side of the main bearing.





3. For the cylinder cover, the hydraulic tool consists of eight individual jacks suspended from a common lifting tool. A spacer ring is mounted below each jack using two spring pins.

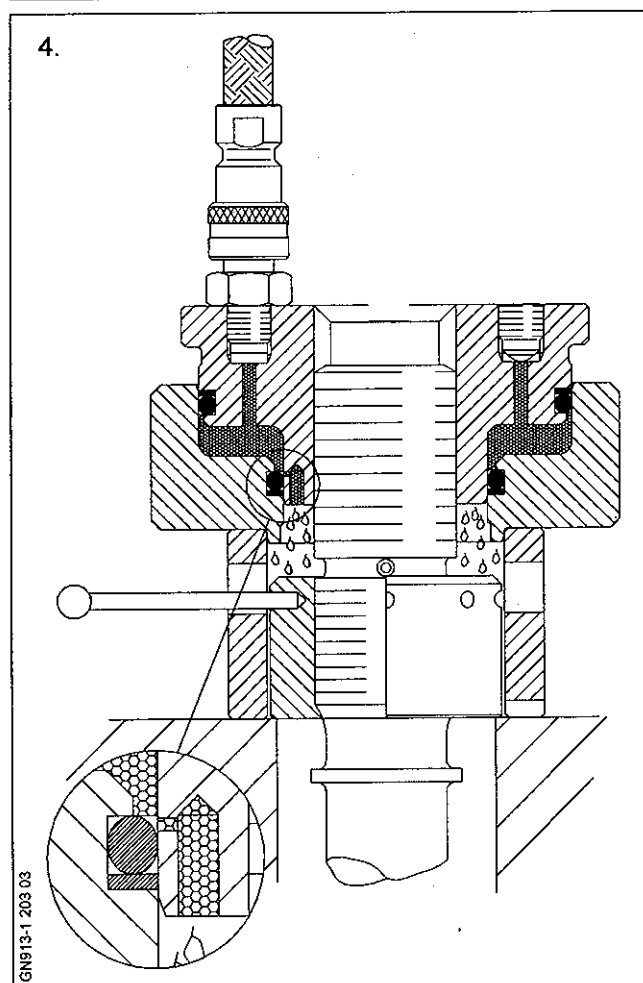
Operation of the cylinder cover jacks is identical to the operation of the single hydraulic jacks.

4. The hydraulic jacks are so designed that, in the event that the "Max. lift" limit is exceeded, the pressure is relieved at the bottom of the pressure chamber and the oil will be pressed out into the space between the stud and the spacer ring.

When the pressure is relieved in this way, the lowermost sealing ring will in most cases be damaged. Therefore inspect and, if necessary, replace this sealing ring.

The oil used must be pure hydraulic oil or turbine oil (with a viscosity of about SAE 20). Oils such as, for instance, lubricating oil (system oil) or cylinder lubricating oil must **not** be used, as these oils are normally alkaline and can thus damage the back-up rings.

The following instructions must be closely followed to prevent accidents or damage, and after use the jacks should be cleaned and kept in the wooden boxes supplied.



Warning!

Eye protectors and gloves **must be** used when using hydraulic tools.

Single Hydraulic Jack

1. Carefully clean the tool attachment thread, the nut and the surrounding parts.

Grease the tool attachment thread with molybdenum disulphide grease or with graphite and oil or similar.

Place the spacer ring around the nut in such a position that the tommy bar can be applied through the slot when the nut is to be loosened.

2. Screw the jack on to the tool attachment thread of the bolt/stud, until the cylinder of the jack bears firmly against the spacer ring.

Connect the hydraulic jack, the distributor block and the high pressure pump by means of high pressure hoses.

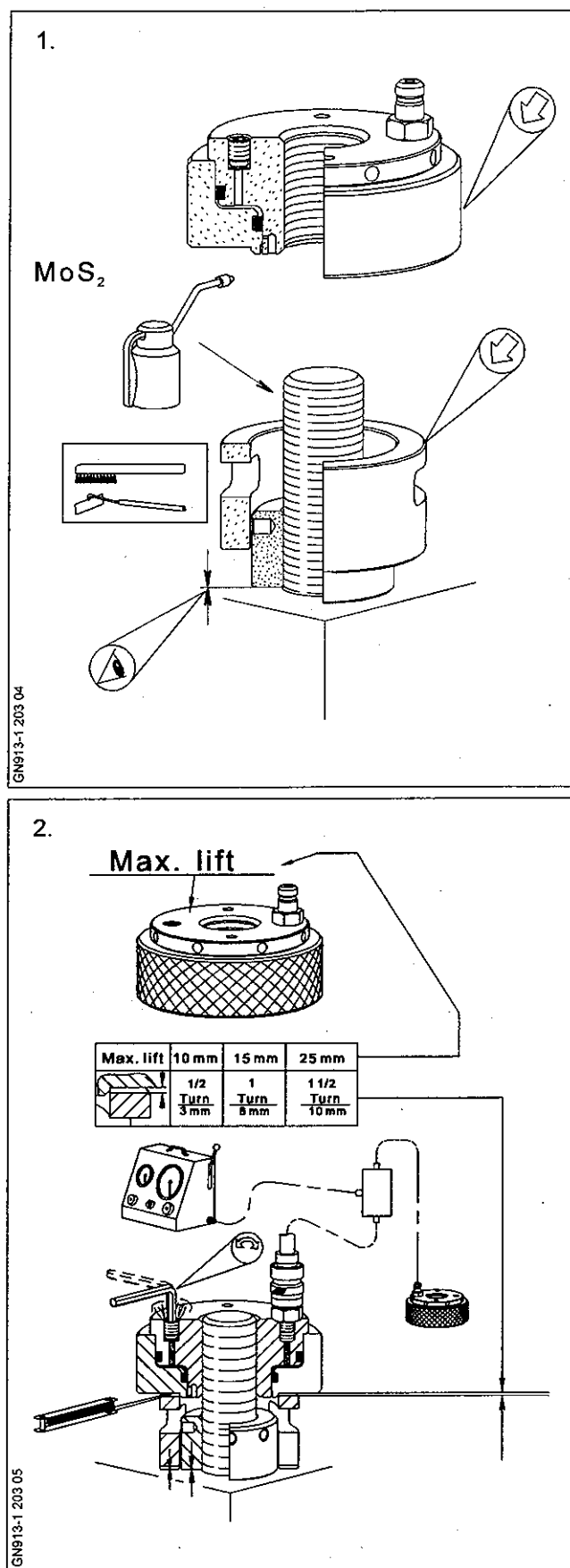
Unscrew the jack to create a clearance between the jack and spacer ring. *See sketch.*

Loosen the bleed screw in the jack and fill up the system with oil until oil without bubbles, flows out of the bleed hole. Then tighten the bleed screw again.

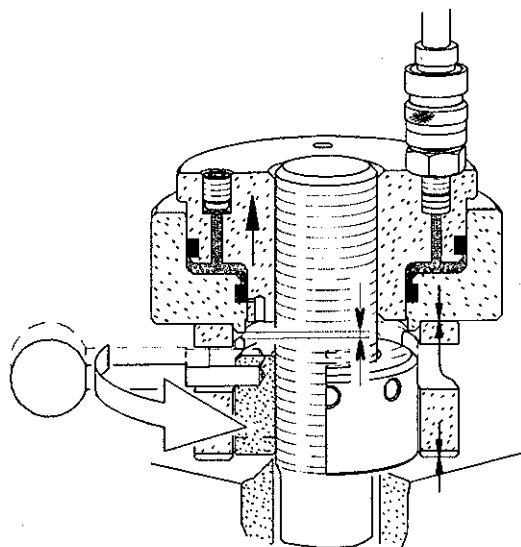
When loosening nuts on very long bolts (e.g. staybolts) it is recommended to unscrew the jack an additional half turn.

The clearance between the jack and spacer ring ensures dismantling of the jack after loosening the nut.

After adjustment, check that the parts are guided correctly together and that there is no clearance between the piston and cylinder of the jack.



3.



3. Increase the oil pressure to the prescribed value. If the nut does not come loose, the pressure may be increased by approx. 150 bar.

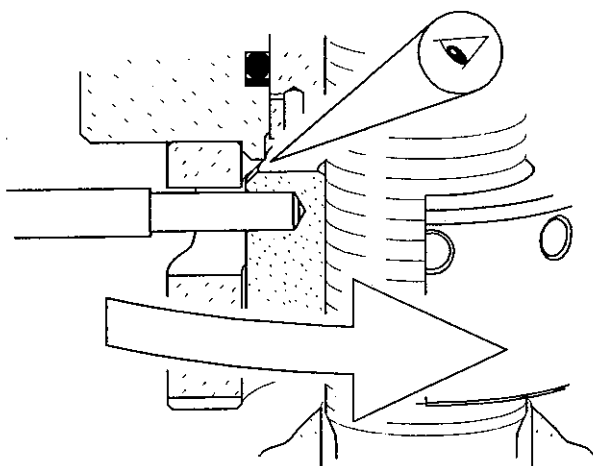
4. Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.

5. Relieve the system of pressure, disconnect the high-pressure pump, and remove the hydraulic tools.

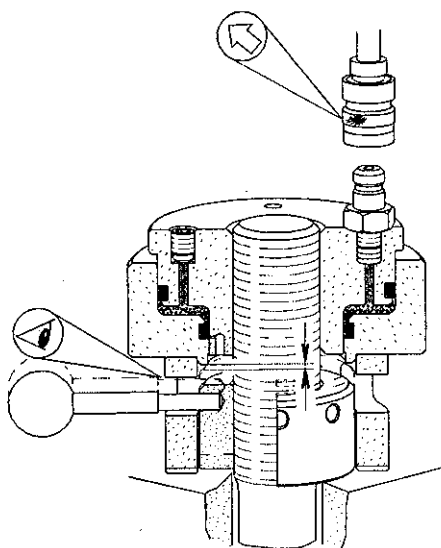
Note!

Make sure **not** to exceed the "max lift" stamped on the jack.

4.



5.



Double Hydraulic Jack

6. Assemble the main bearing tightening tools, using the wooden box as a guide for correct assembling.
7. Using the lifting tool, lift the two main bearing jacks into the crankcase.
See also Procedure 905-2.2.

Carefully clean the main bearing studs, the nuts and the surrounding parts.

Lower the jacks on to the nuts of the main bearing, and screw the extension studs on to the main bearing studs.

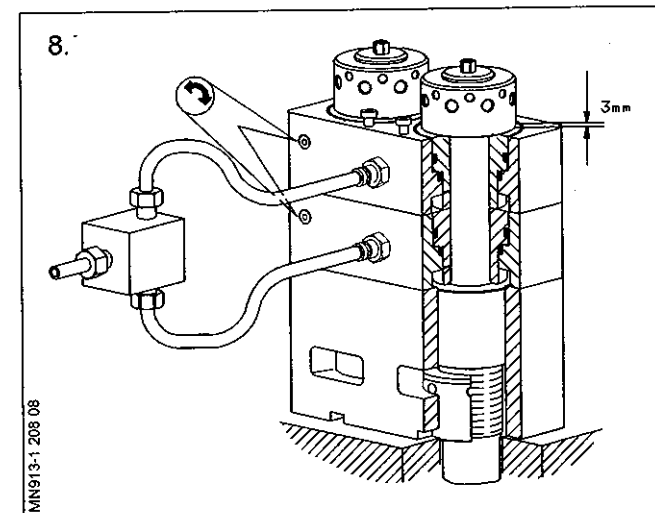
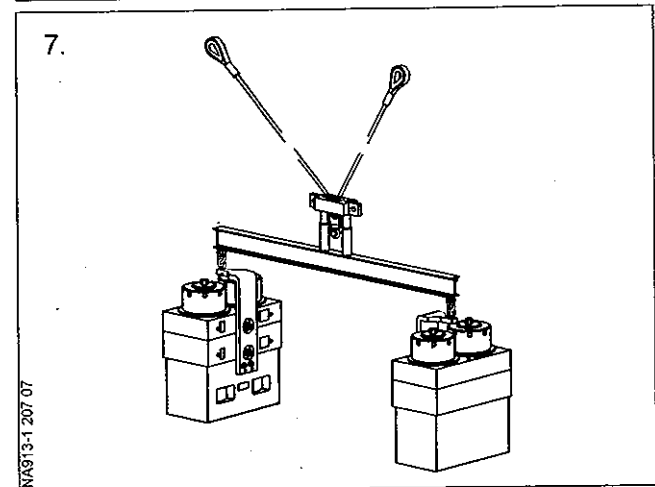
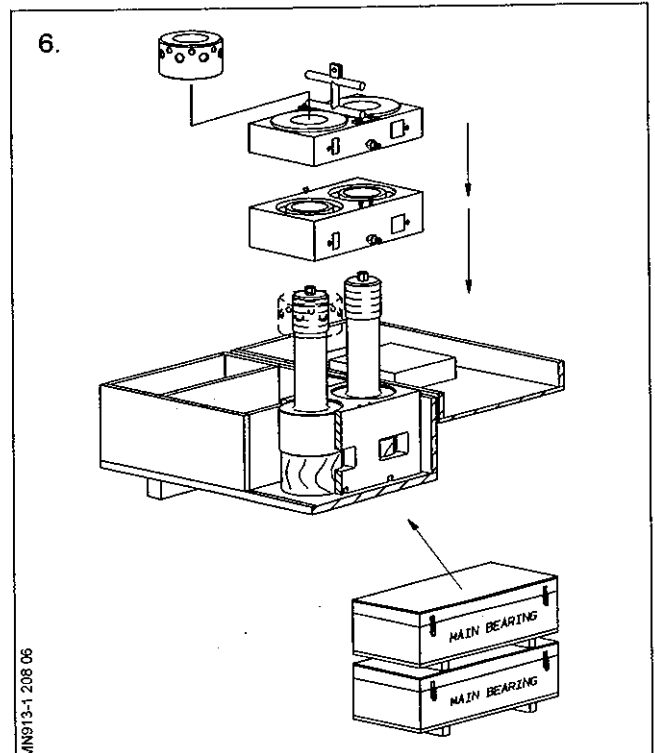
8. The clearance between the pistons and the cylinder of the top jack is adjusted by unscrewing the upper nuts 1 turn $\approx$ 3 mm.

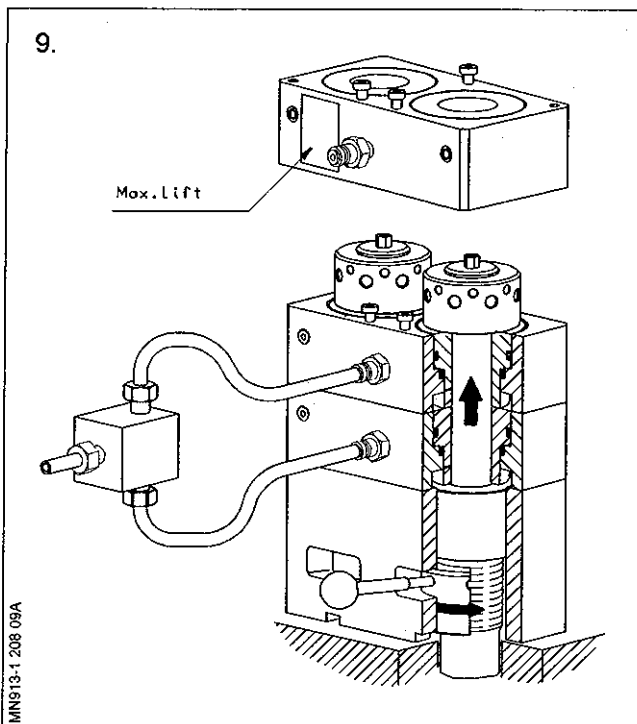
The clearance between the jack and spacer ring ensures dismantling of the jack after loosening the nut.

Connect the hydraulic jacks, the distributor block and the high pressure pump by means of high pressure hoses.

Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

Re-tighten the bleed screws.





9. Increase the oil pressure to the prescribed value. If the nut does not come loose, the pressure may be increased by up to 10% of the normal dismantling pressure.

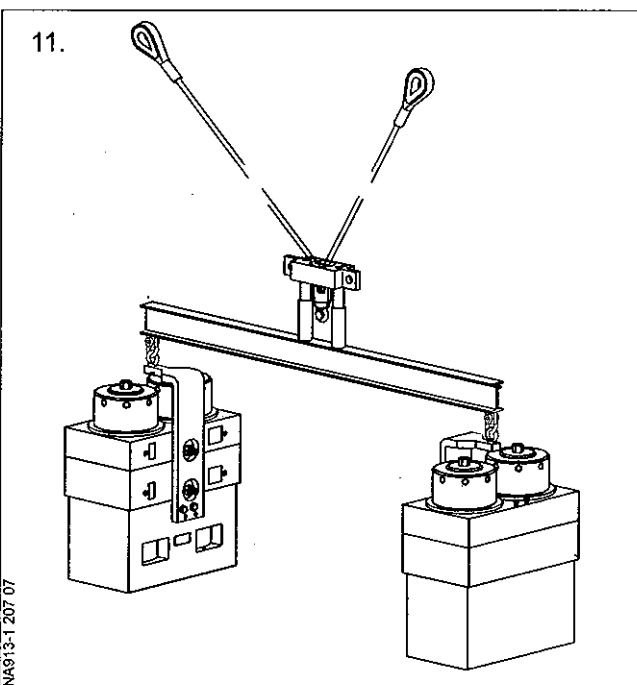
Note!

Make sure **not** to exceed the "max lift" stamped on the jack.

Unscrew the lower nuts $1\frac{1}{2}$ turns with the tommy bar, making sure that the nuts are not screwed up against the extension stud.

10. Relieve the system of pressure, disconnect the high-pressure pump, and unscrew the extension studs from the main bearing studs.

11. Using the lifting tool, remove the hydraulic jacks from the crankcase.



Single Hydraulic Jack

1. Thoroughly clean the nut, the thread, the contact faces, and the surrounding parts.

Clean and lubricate the tool attachment thread and the thread in the nut with molybdenum disulphide grease or with graphite and oil or similar.

Fit the round nut on the thread and tighten it with the tommy bar.

Check with a feeler gauge that the contact face of the nut bears on the entire circumference.

Place the spacer ring around the nut in such a position that the tommy bar can be applied through the slot for the purpose of tightening the nut.

2. Press the piston and the cylinder of the jack firmly together.

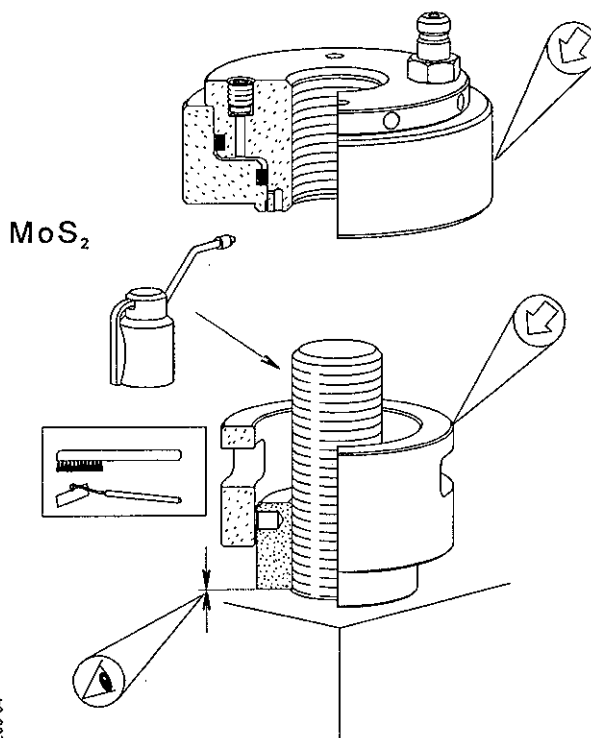
Screw the hydraulic jack on to the tool attachment thread.

Make sure that the cylinder of the jack bears firmly against the spacer ring and that the parts are guided correctly together.

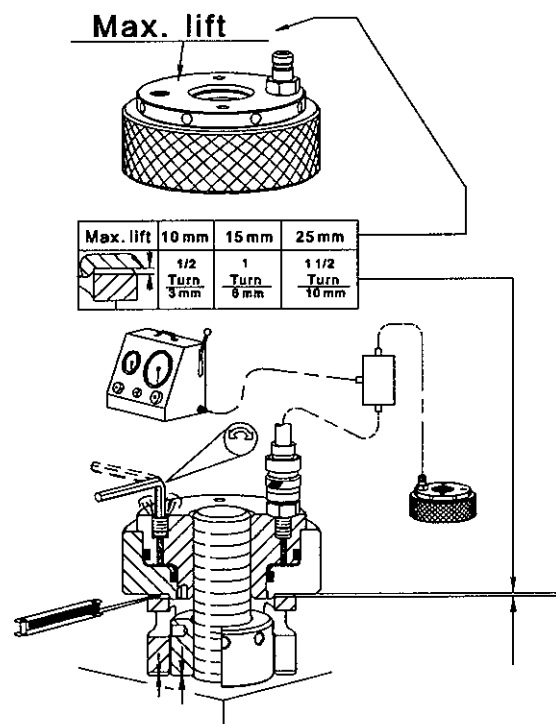
Connect the hydraulic jack, the distributor block and the high-pressure pump by means of high-pressure hoses.

Loosen the bleed screw in the jack and fill up the system with oil, until oil without bubbles flows out of the bleed hole.

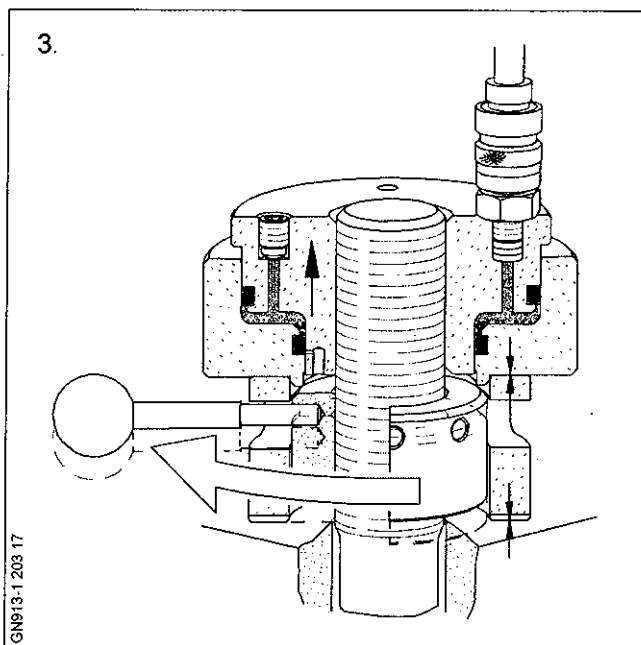
Re-tighten the bleed screw.

1.


GN913-1 203 04

2.


GN913-1 203 05

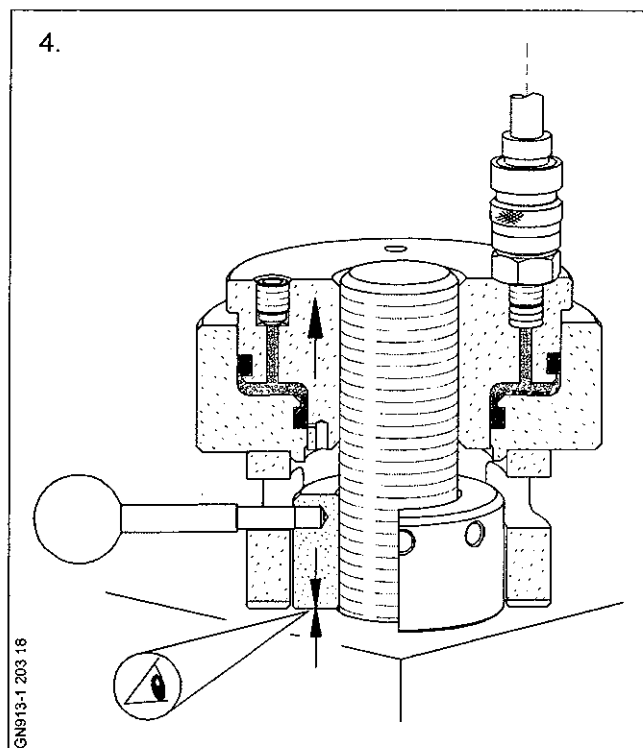


3. Increase the oil pressure to the prescribed value, and tighten the nut by means of the tommy bar applied through the slot of the spacer ring.

4. While maintaining the pressure, check with a feeler gauge introduced through the recess at the bottom of the spacer ring that the nut bears against the contact face.

5. Relieve the system of pressure, disconnect the pump, and remove the hydraulic jack.

6. When new studs, bolts or nuts are tightened for the first time, do not remove the jacks, but loosen the nut as described under 'Loosening', points 2-5, and then tighten the nut again according to the procedure under 'Tightening', points 2-5.



Double Hydraulic Jack

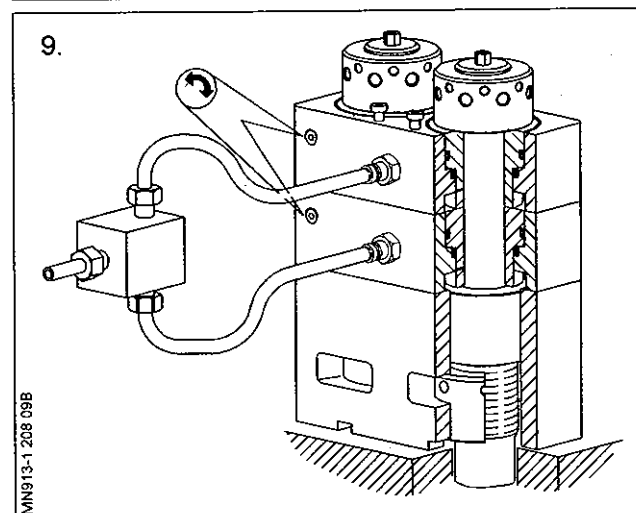
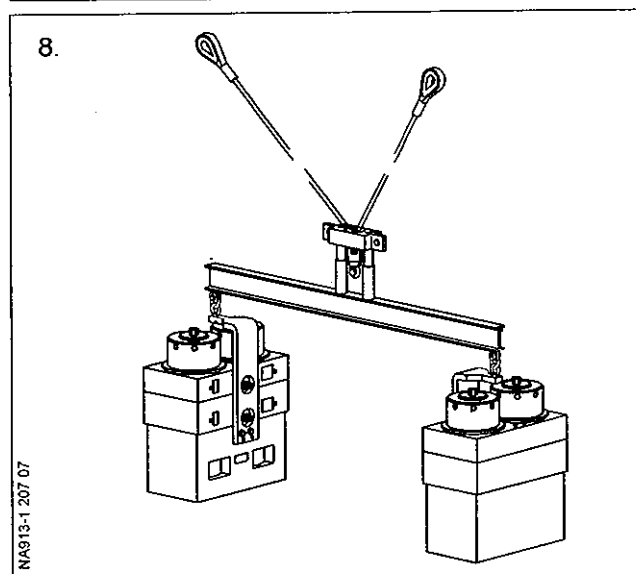
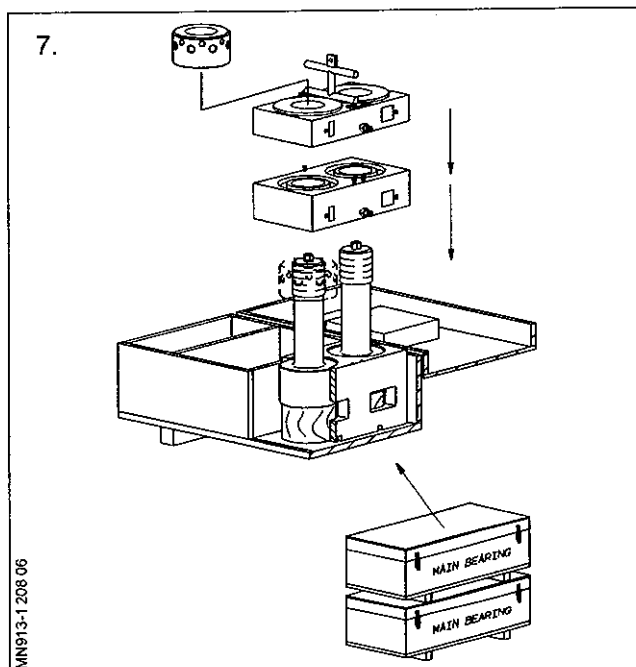
7. Assemble the main bearing tightening tools, using the wooden box as a guide for correct assembling.
8. Using the lifting tool, lift the two main bearing jacks into the crankcase.
See also Procedure 905-2.2.
9. Carefully clean the main bearing studs, the nuts and the surrounding parts.

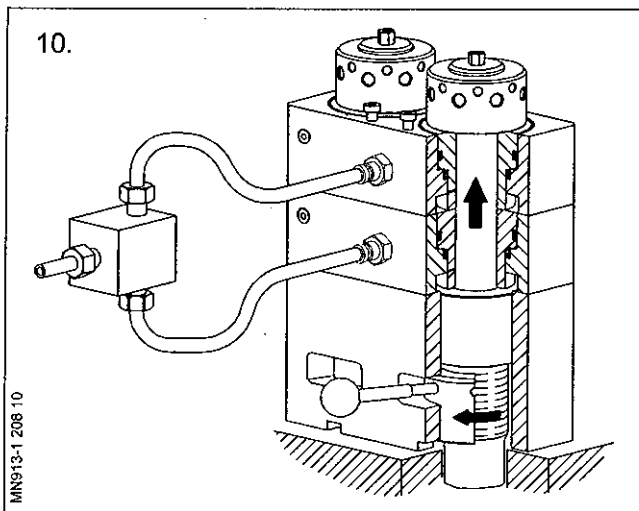
Lower the jacks on to the nuts of the main bearing and screw the extension studs on to the main bearing studs.

Connect the hydraulic jacks, the distributor block and the high pressure pump by means of high pressure hoses.

Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

Re-tighten the bleed screws.





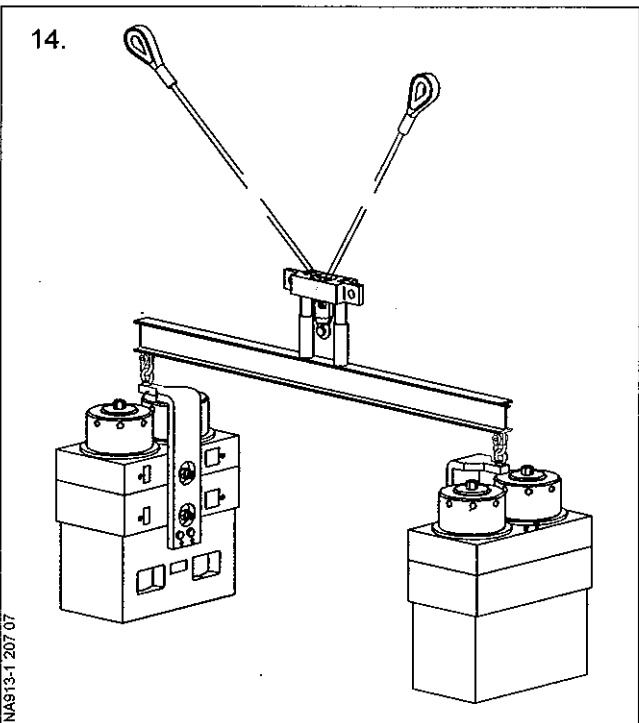
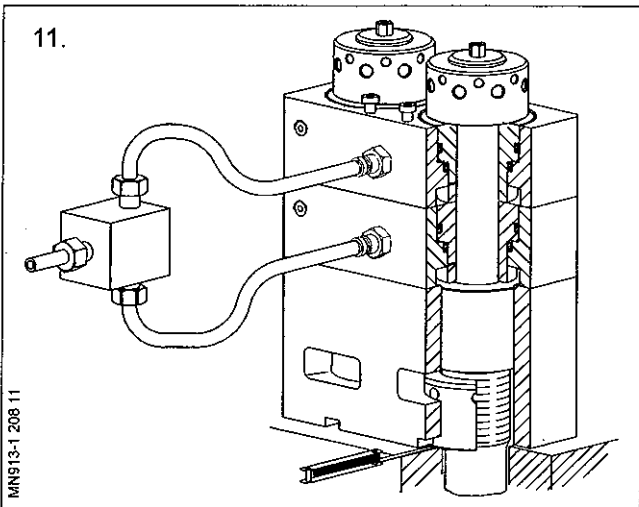
10. Increase the oil pressure to the prescribed value, and tighten the nuts by means of the tommy bar applied through the slots of the spacer ring.

11. While maintaining the pressure, check with a feeler gauge introduced through the recesses at the bottom of the spacer ring that the nuts bear against the contact face.

12. Relieve the system of pressure, disconnect the pump, and unscrew the extension studs from the main bearing studs.

13. When new studs, bolts or nuts are tightened for the first time, do not remove the jacks, but loosen the nuts as described under 'Loosening', points 7-11, and then tighten the nuts again according to the procedure under 'Tightening', points 8-12.

14. Using the lifting tool, remove the hydraulic jacks from the crankcase.



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 compressed air.

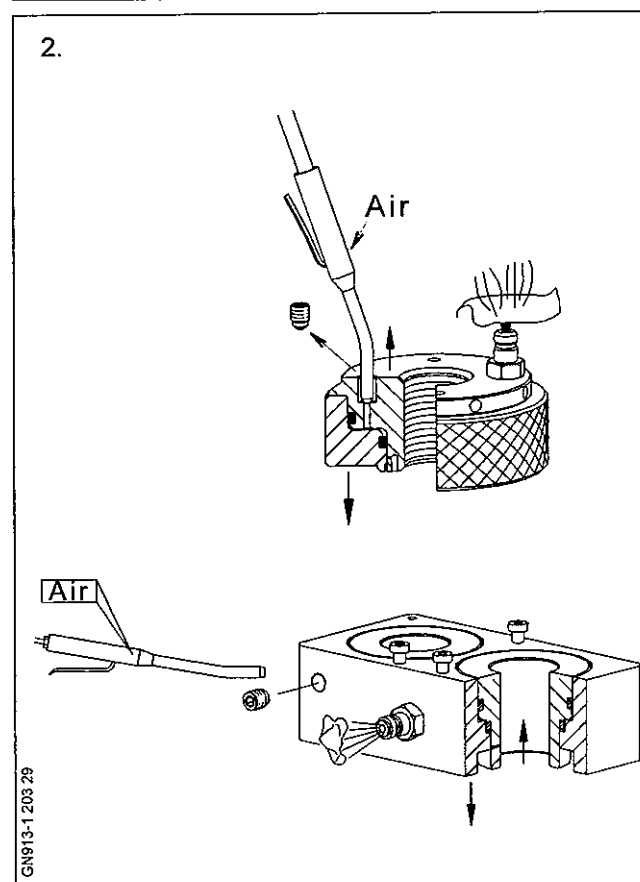
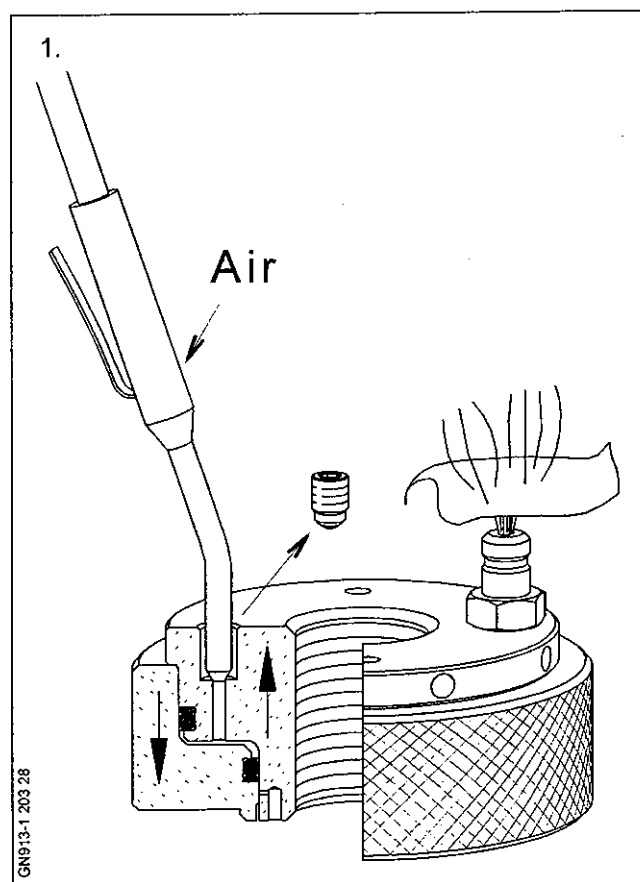
Warning!

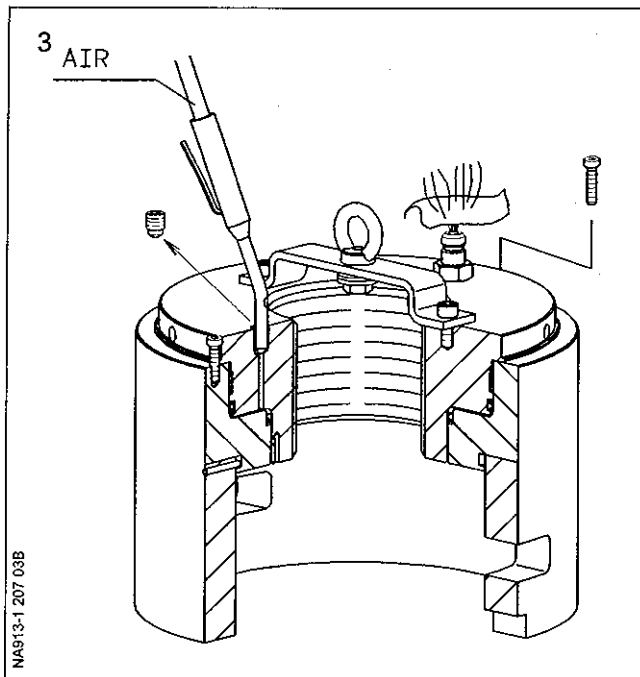
Always use eye protection when working with compressed air.

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.

Keep the sliding surfaces and threads coated with acid-free grease or molybdenum disulphide grease.

2. The pistons and cylinders of the double jacks are separated in the same easy way as described for the single jack.





3. The piston and cylinder of the cylinder cover jacks are separated in the same way as described for the single jack.

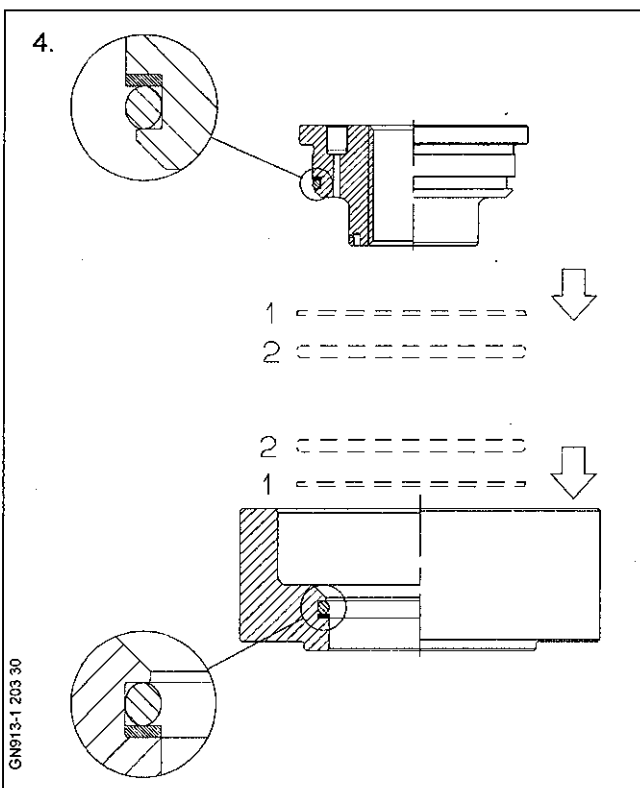
Note!

Remember to remove the screws before separating the piston from the cylinder.

4. When changing the sealing rings, first mount the back-up ring and then the O-ring.

Note!

The back-up ring (1) **must** be away from the pressure chamber and the O-ring (2) close to the pressure chamber.



See the sketch for the correct mounting of both the upper and the lower sealing rings. The same principle applies to all the jacks.

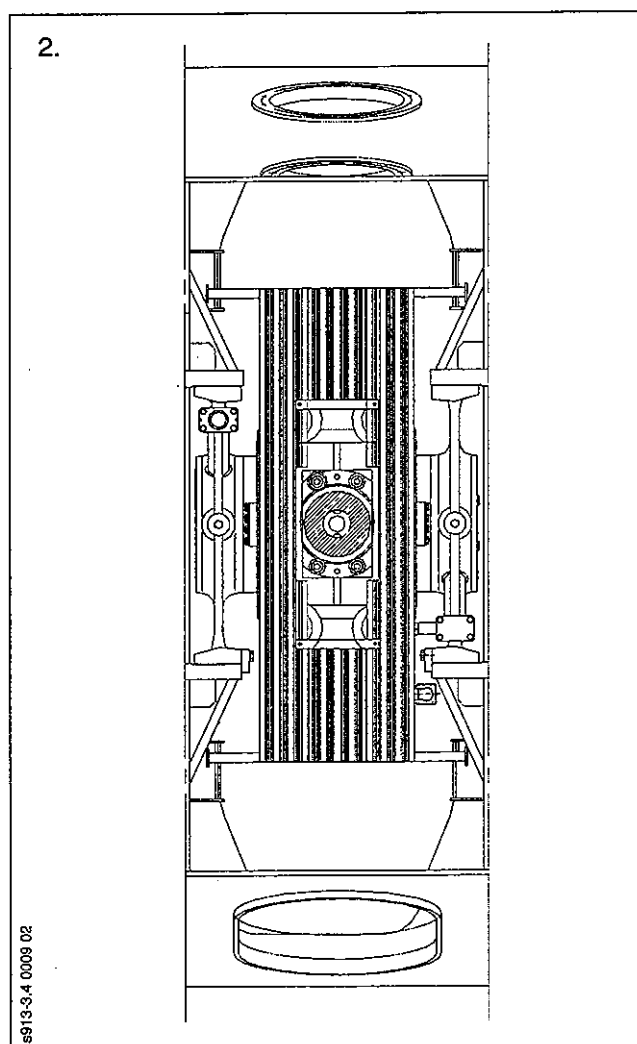
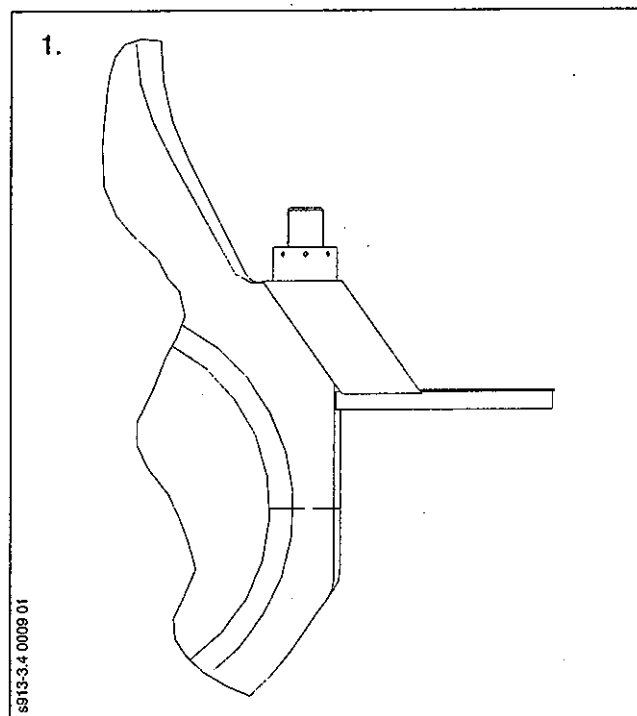
5. After fitting the sealing rings, coat the piston and cylinder with molybdenum disulphide grease and press the piston and cylinder together. See that the rings do not get stuck between the piston and cylinder.

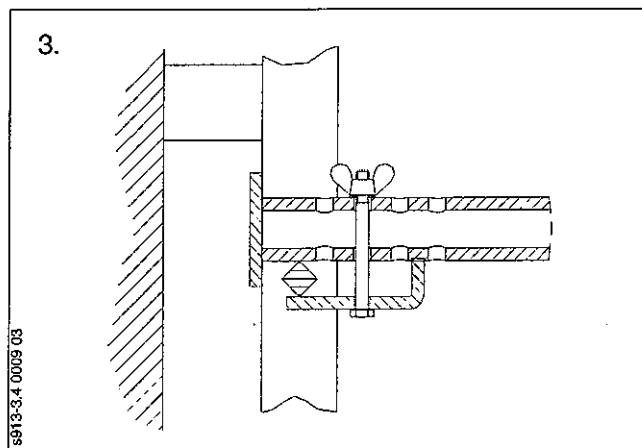
Before carrying out the checking and overhaul procedures underlined below in Items 1, 2 and 4, platform boards should be mounted inside the engine crankcase.

During mounting of the platforms, always use the harness, lanyard and fall arrester. It is always recommended to clean and wipe off oil from steps, crankthrow, doorways and assembling surfaces.

The platform boards are placed inside the engine as shown in the following.

1. Checking the crankshaft alignment, using an Autolog: Turn the engine into a position where it is possible to place the ladder on the crankpin bearing stud nuts.
2. Piston rod stuffing box and telescopic pipe: Put in the standard platform board as a floor as shown on the sketch. Turn the engine to BDC. Mount the platform board from the exhaust side of the engine as shown.





3. The working platform support is mounted as shown in sketch 3.

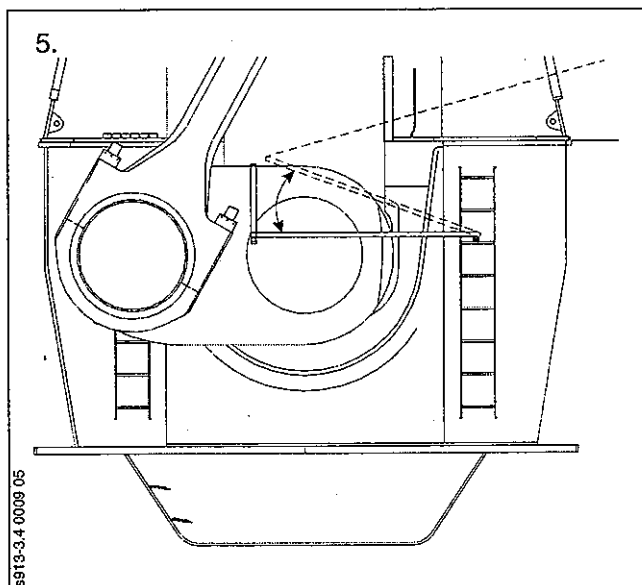
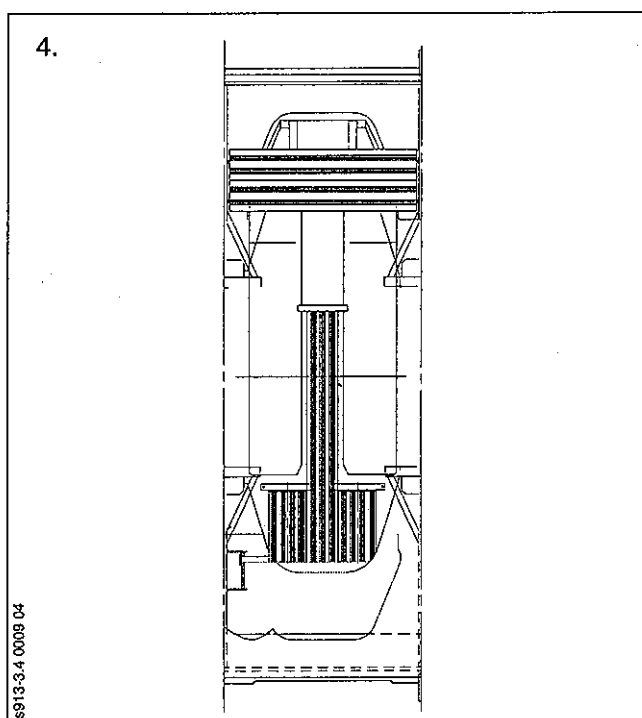
4. Main bearing dismantling: Turn the engine to 80° after TDC. Mount the platform support in a longitudinal direction on the steps in the bedplate.

5. Mount the longest platform board, with the ladder attached, on the support and, by means of a rope, lower the platform support ladder into place on the crankthrow.

The double platform board can now be placed on the support and the long platform board.

Note!

Always remember to remove the platform boards on completion of each working procedure or before turning the engine.



When tightening screws or nuts for which no torque is specified in the instruction procedure or the related data sheet, the standard torques specified in this procedure are to be applied.

1. Standard screws and nuts lubricated with a Molybdenum Disulphide (MoS_2) based lubricant.

Thread	Tightening torque	Thread	Tightening torque
M8	17 Nm	M22	400 Nm
M10	35 Nm	M24	460 Nm
M12	50 Nm	M27	610 Nm
M14	80 Nm	M30	950 Nm
M16	135 Nm	M33	1200 Nm
M18	190 Nm	M36	1650 Nm
M20	260 Nm	M39	2100 Nm

2. Self-locking nuts.

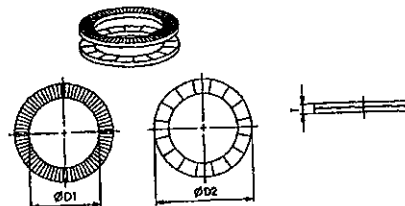
Thread	Tightening torque	Thread	Tightening torque
M8	20 Nm	M22	430 Nm
M10	40 Nm	M24	490 Nm
M12	60 Nm	M27	650 Nm
M14	90 Nm	M30	1000 Nm
M16	150 Nm	M33	1250 Nm
M18	210 Nm	M36	1700 Nm
M20	290 Nm	M39	2200 Nm

3. Screws and nuts locked with glue/Loctite.

Thread	Tightening torque	Thread	Tightening torque
M8	23 Nm	M22	580 Nm
M10	50 Nm	M24	680 Nm
M12	70 Nm	M27	900 Nm
M14	115 Nm	M30	1350 Nm
M16	190 Nm	M33	1700 Nm
M18	270 Nm	M36	2350 Nm
M20	380 Nm	M39	3000 Nm

4. Screws and Nuts with Cam Lock Washer

Thread	Tightening torque	Thread	Tightening torque
M8	20 Nm	M33	1500 Nm
M10	40 Nm	M36	1900 Nm
M12	70 Nm	M39	2500 Nm
M14	110 Nm	M42	3100 Nm
M16	165 Nm	M45	4000 Nm
M18	230 Nm	M48	4700 Nm
M20	320 Nm	M52	5600 Nm
M22	470 Nm	M56	6000 Nm
M24	550 Nm	M60	7100 Nm
M27	800 Nm	M64	8500 Nm
M30	1100 Nm		



Before screwing the nuts on, the threads and the contact faces should be greased with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient $\mu = 0.1-0.12$ (e.g. MOLYKOTE paste type G).

The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

In the case of new nuts and studs, the nuts are to be tightened and loosened two or three times so that the thread may assume its definite shape; thus obviating the risk of loose nuts.

Nuts secured with a split pin are to be tightened to the stated torque and then to the next split-pin hole.

The torque spanner must not be used for torques higher than those stamped on it, and it must not be damaged by hammering on it or the like.

Rahsol Torque Spanner

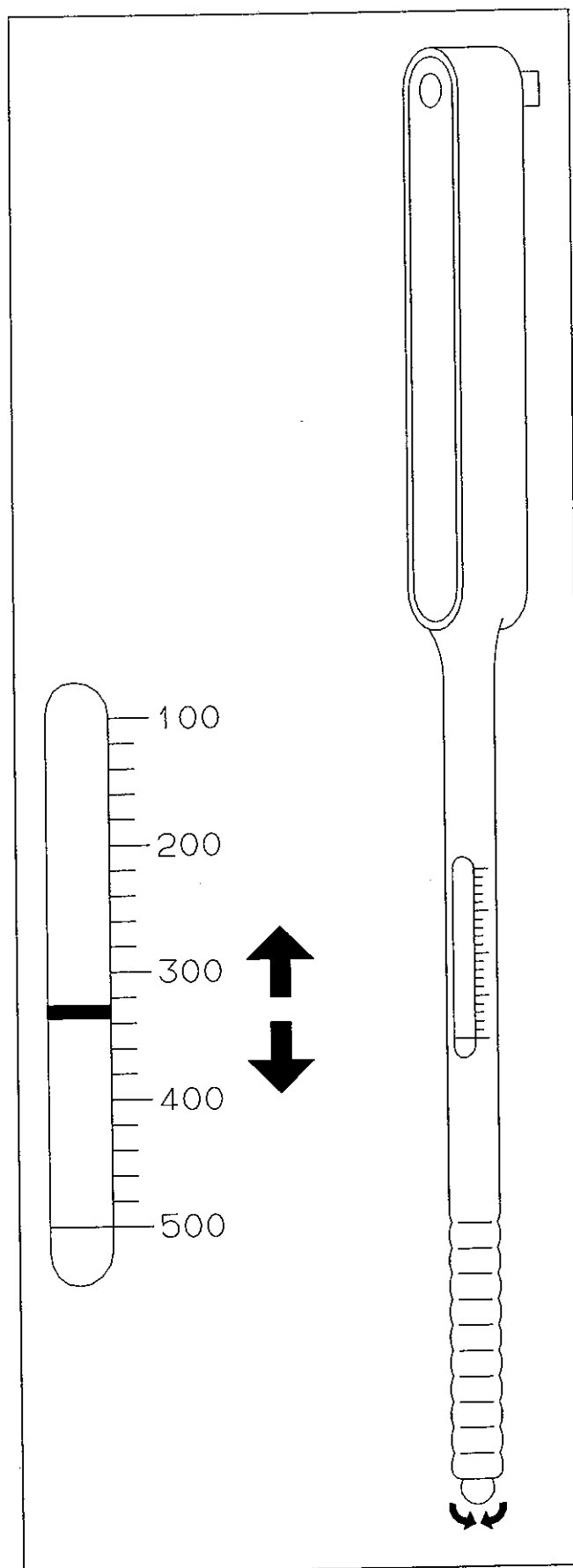
The handle of the torque spanner is provided with a scale indicating the torques at which the spanner can be set.

For setting the spanner at the required torque, there is a ball on a small arm at the end of the handle.

When the ball is pulled, a small crank handle appears. A spring-loaded slide in the handle is provided with a mark which, when the crank handle is turned, can be set at the required torque on the scale. The torque spanner works as follows:

The above-mentioned spring acts on a pawl system in the handle. When the pre-set torque has been reached, the pawl system is released, at which moment a small jerk is felt in the spanner, and a small click is heard.

When the torque spanner is not in use, the spring inside should be released by adjusting to minimum torque.



Preparations

Before screwing on the nuts, grease the threads and the contact faces with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient.

$\mu = 0.1-0.12$ (e.g. MOLYKOTE paste type G)

The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

Pre-tightening with a torque spanner

Before tightening the nuts according to a tightening gauge or tightening angle, they must be pre-tightened with a torque spanner.

See Procedure 913-5.

Apply a pre-tightening torque of:

- thread M8 – M20 = 50 Nm
- thread M22 – M27 = 100 Nm
- thread M30 – M39 = 150 Nm
- thread M42 – M48 = 200 Nm

This is in order to ensure a uniform basis for the subsequent tightening with gauge or tightening angle.

Tightening with a tightening gauge

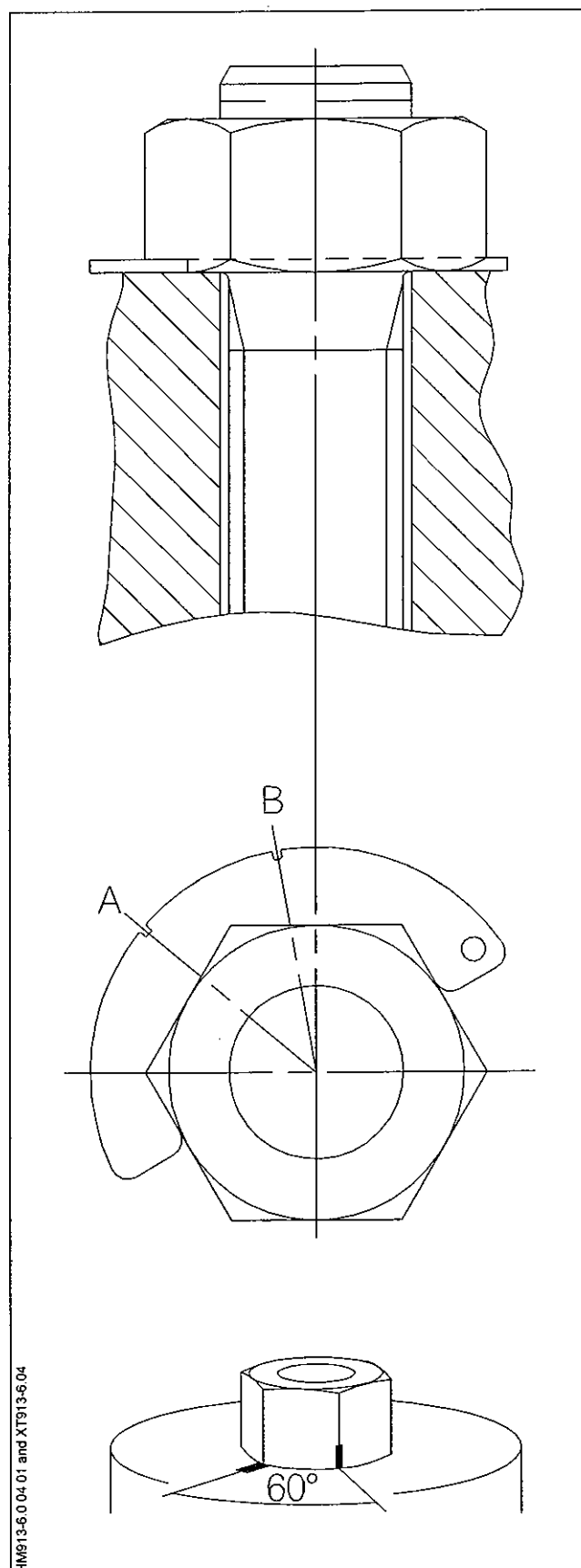
After pre-tightening, place the tightening gauge round the nut, and mark off with chalk on the nut at slot **A** on the tightening gauge, and make another chalk mark on the contact face at slot **B**. Then tighten the nut until the two chalk marks coincide.

Tightening without a tightening gauge

For tightening angles of e.g. 30°–45° and 60°, we usually do not deliver a tightening gauge. Therefore, after pre-tightening, mark the angle on a corner of the nut and on the contact face, respectively. Then tighten the nut until the two marks coincide.

When tightening new studs or bolts for the first time, loosen again and repeat the procedure – including pre-tightening with a torque spanner, to allow the parts to settle.

See Procedure 913-5.



Some screwed and bolted connections on the engine, as well as some movable joints, are secured against untimely loosening by means of different types of locking devices.

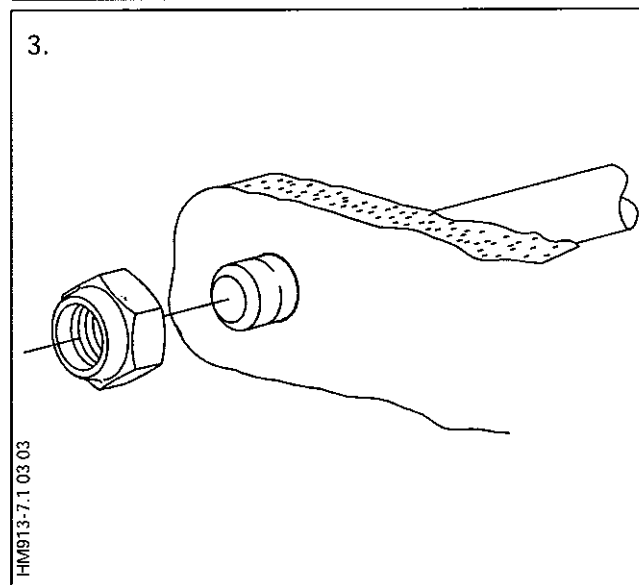
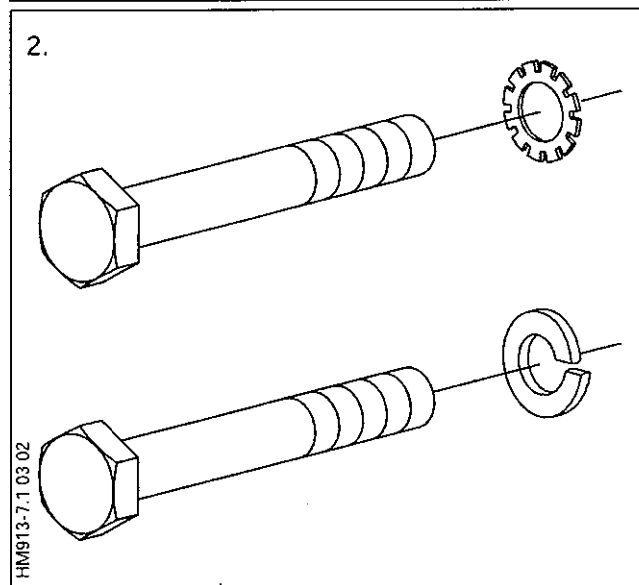
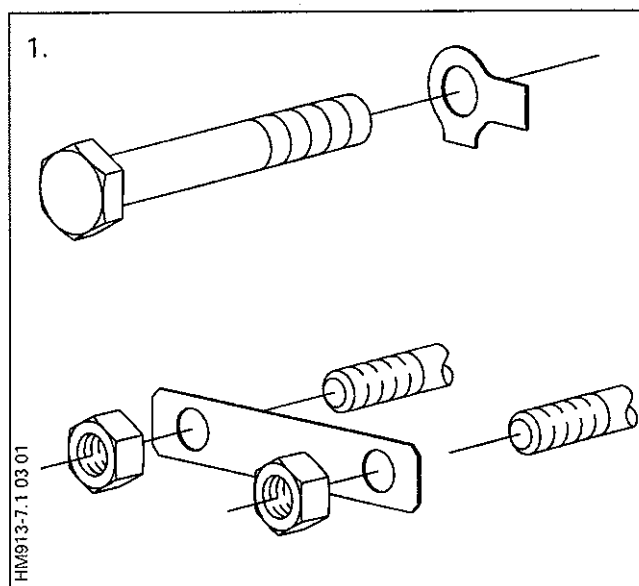
When reassembling the engine after overhauls, it is vital that all such screws and nuts are again locked correctly.

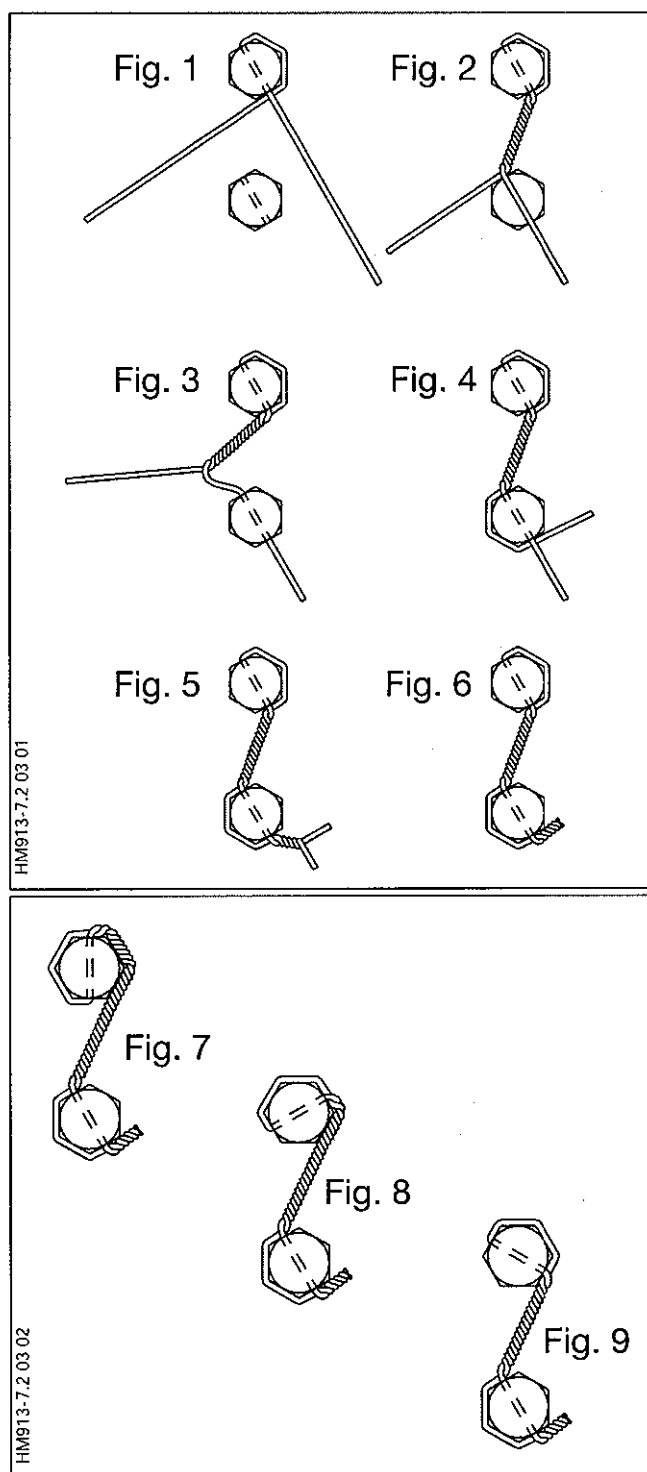
Note!

Make sure only to mount locking devices on nuts and screws which have been mounted with locking devices by the engine manufacturer.

1. **Lock washers**, tab washers, locking plates, etc., must always be replaced. The tab-like projections, etc., on the washers are to be bent back over one of the flats of the screw or nut concerned.
2. Used **spring washers** must be replaced.
3. **Self-locking nuts** may only be used five times. Therefore, give the nut a centre punch mark each time it is loosened.

To tighten a self-locking nut to a specific torque, first measure the torque required to turn the nut itself, and then add this torque to the torque value stated on the data sheet of a procedure.





Locking wire should be fitted after the screws or nuts have been tightened to the correct torque. Do not overtighten or loosen the units to get a correct alignment of the wire holes. Always fit new wire after tightening-up the units.

Any tendency of the screws or nuts to loosen will be counteracted by a tightening of the locking wire. Do not secure more than four units in a series, unless otherwise specified.

Fig. 1: Insert wire, grasp the upper end of the wire and bend it around the head of the screw, then under the other end of the wire, be sure that the wire is tight around the head.

Fig. 2: Twist the wire **clockwise** until it is just short of the hole in the second screw. Keeping the wire under tension, twist it until tight. When the wire is tight, the wire shall have approximately 7-10 twists per 25 mm. One twist is a twist of the wires through an arc of 180°, equal to half of a complete turn.

Fig. 3: Insert the uppermost wire in the second screw, and pull it tight.

Fig. 4: Bend the lower wire around the screw, and under the end protruding from the screw.

Fig. 5: Keeping the wire under tension, twist it min. 3 twists, **counterclockwise** until tight.

Fig. 6: During the final twisting motion, bend the wire along the screw head. Cut off excess wire.

Fig. 7-9: Show the preferred ways of mounting the locking wire on screws with wire holes oriented in different angles.

Fig. 10: Shows how to route the locking wire on screws in different planes.

Fig. 11: Wire that passes over the top of a nut is an acceptable alternative only if it routes around the protruding screw thread.

Fig. 12: Wire that passes over the top of a nut is also an acceptable alternative if the hole is located as shown in the figure.

Fig. 13: Where drilling of locking wire holes has caused a thin wall section, route the wire as shown in the figure, to prevent damage to the nut.

Fig. 14: Locking wire can be mounted to any other part of the assembly if nothing else is possible.

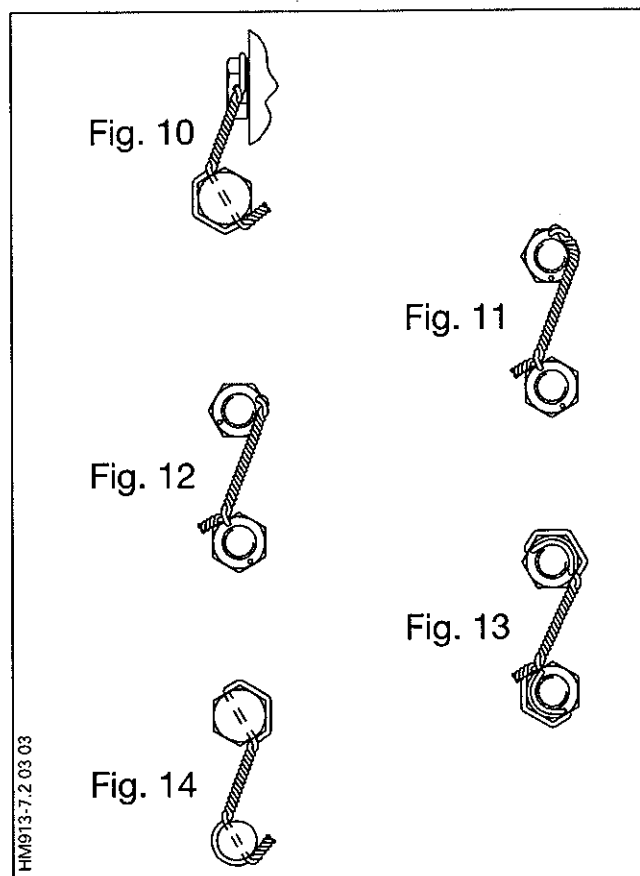
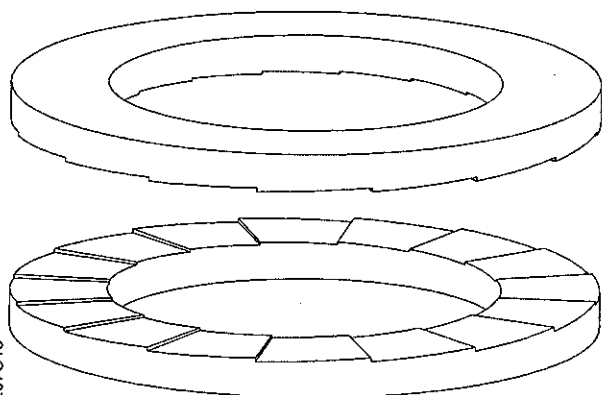


Fig. 15



M91307-0207/C15

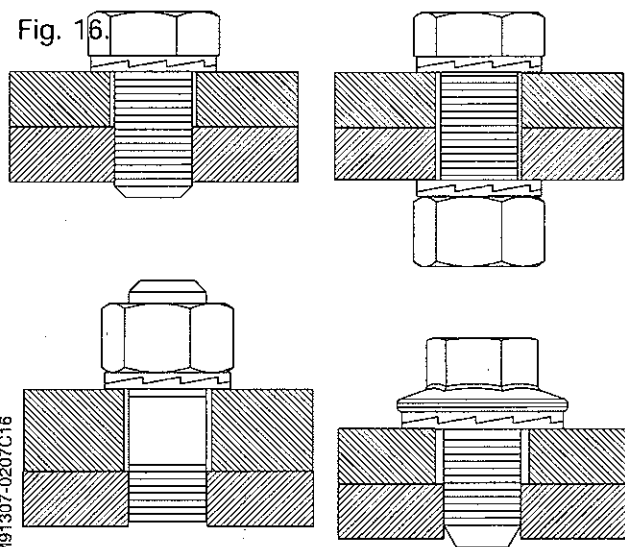
Cam Lock Washers with rising cams on one side and radial teeth on the other.

Fig. 15: The washers are installed in pairs, cam face to cam face. When the bolt and/or nut is tightened the teeth grip and seat the mating surfaces. The cam lock washer is locked in place, allowing movement only across the face of the cams. Any attempt from the bolt/nut to rotate loose is blocked by the wedge effect of the cams.

Fig. 16: Different uses of the cam lock washers.

Fig. 17: Don not use the cam lock washers in conjunction with other loose washers.

Fig. 16.

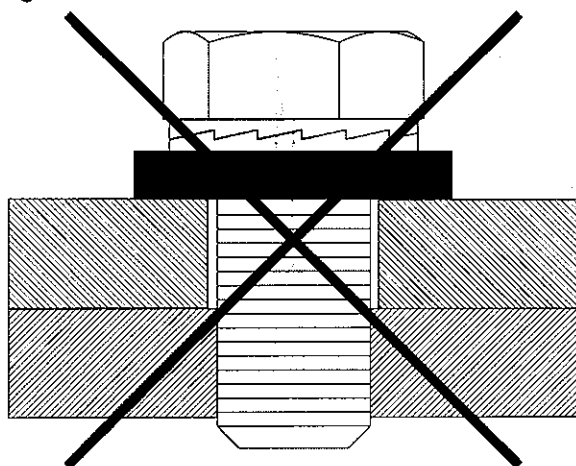


M91307-0207/C16

Note!

Cam lock washers must be installed in pairs and are not to be substituted by other typers of washers.

Fig. 17



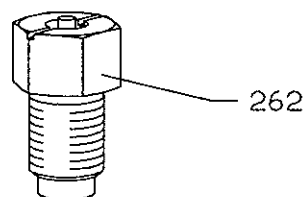
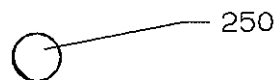
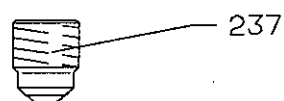
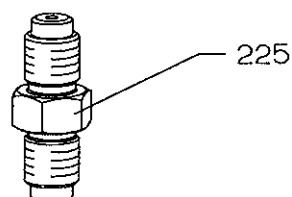
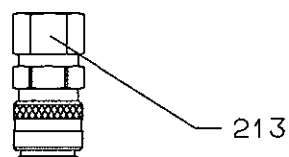
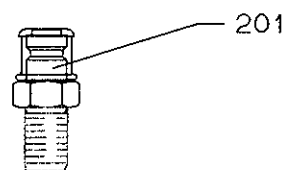
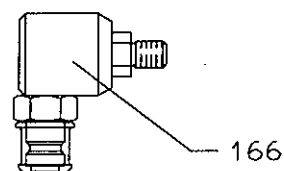
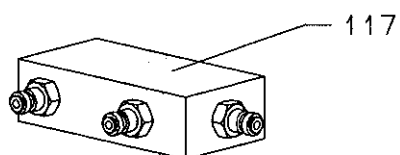
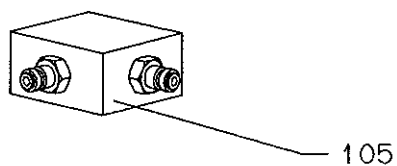
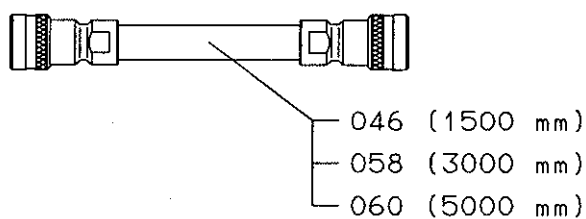
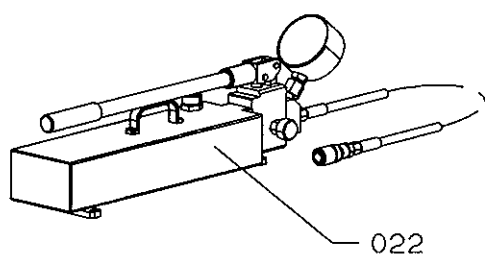
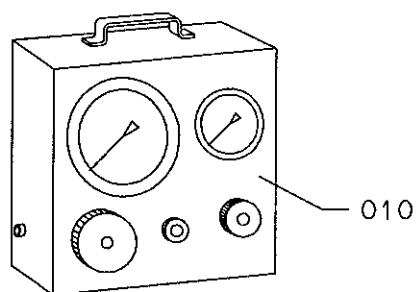
M91307-0207/C17

Molybdenum Disulphide (MoS₂)

The following procedure is to be followed prior to the mounting of metal surfaced parts which are to function as seals.

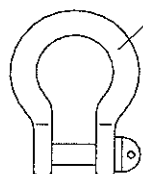
- Clean the surface with a cleaning fluid and ensure that the entire surface is completely free of grease.
- Allow 5 minutes for the cleaning fluid to evaporate.
- With a clean leathercloth, and using circular movements, rub a mixture of fine-grained particles of Molybdenum Disulphide (MoS₂) and mineral oil (e.g. Moly-cote G-n Plus, or the like) hard onto the metal surface.
- Remove any excessive paste and ensure that the metal surface is only coated with a thin, uniform, layer of the above mixture.
- Protect the wet paste and cloth from dust or other foreign particles.

Working Pressure 2200 Bar



Item No.	Item Description
010	Hydraulic pump, pneumatic operated
022	Hydraulic pump, hand operated
046	Hose with unions (1500mm), complete
058	Hose with unions (3000mm), complete
060	Hose with unions (5000mm), complete
105	3-way distributor block, complete
117	5-way distributor block, complete
166	Elbow coupling
201	Quick coupling, male
213	Quick coupling, female
225	Nipple
237	Screw
250	Steel ball
262	Blow-off valve

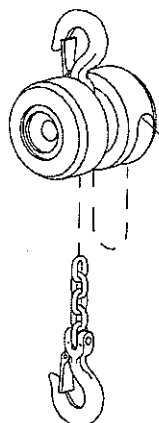
Item No.	Item Description



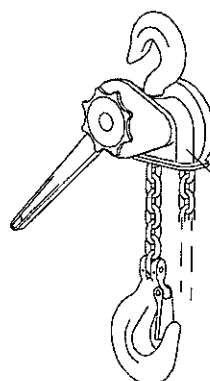
Item	Size
020	M10
031	M12
043	M16
055	M20
067	M24
079	M30
080	M33
092	M42



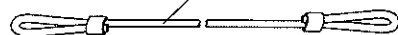
Item	Size
114	M10
126	M12
138	M16
140	M20
151	M24
163	M30
175	M36
197	M42
199	M48



Item	Max.Load (kg)
079	1000
080	3000
092	5000
102	8000



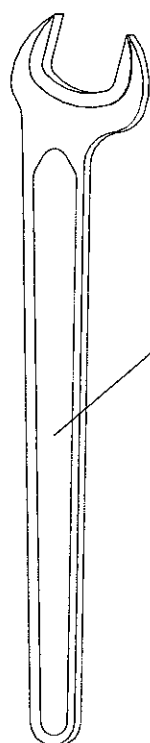
Item	Max.Load (kg)
114	3000



Item	Length (m)
305	6.0

Item No.	Item Description
020	Forged-bent screw shackle, 10mm
031	Forged-bent screw shackle, 12mm
043	Forged-bent screw shackle, 16mm
055	Forged-bent screw shackle, 20mm
067	Forged-bent screw shackle, 24mm
079	Forged-bent screw shackle, 30mm
080	Forged-bent screw shackle, 33mm
092	Forged-bent screw shackle, 42mm
114	Lifting eye bolts, 10mm
126	Lifting eye bolts, 12mm
138	Lifting eye bolts, 16mm
140	Lifting eye bolts, 20mm
151	Lifting eye bolts, 24mm
163	Lifting eye bolts, 30mm
079	Chain tackle, 1000kg
080	Chain tackle, 3000kg
092	Chain tackle, 5000kg
102	Chain tackle, 8000kg
114	Pull lift, 3000kg
197	Lifting eye bolts, 42mm
305	Wire rope, 6m

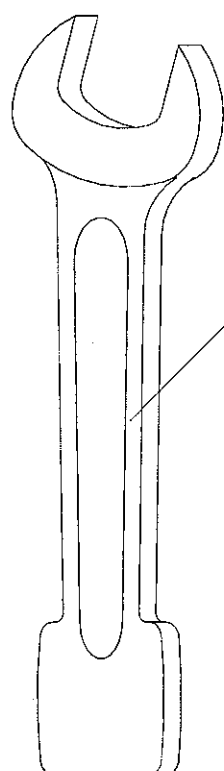
Item No.	Item Description



Item	Size (mm)
013	65
037	75
049	80
050	85
074	95
098	105
000	070
000	115

Item No.	Item Description
013	Open-ended spanner, size NV65mm
037	Open-ended spanner, size NV75mm
049	Open-ended spanner, size NV80mm
050	Open-ended spanner, size NV85mm
074	Open-ended spanner, size NV95mm
098	Open-ended spanner, size NV105mm
000	Open-ended spanner, size NV70mm
000	Open-ended spanner, size NV115mm

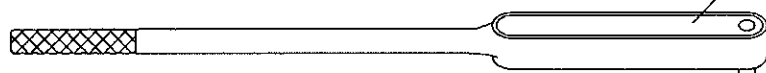
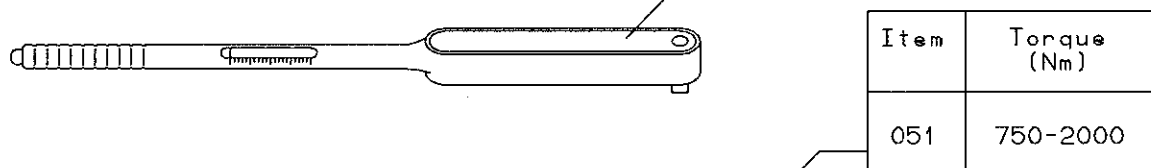
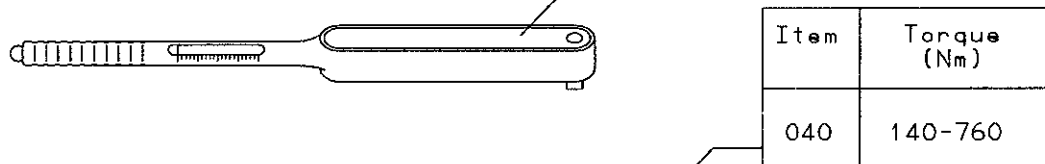
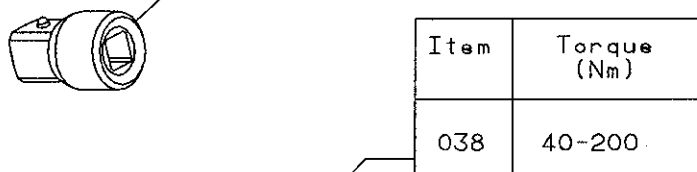
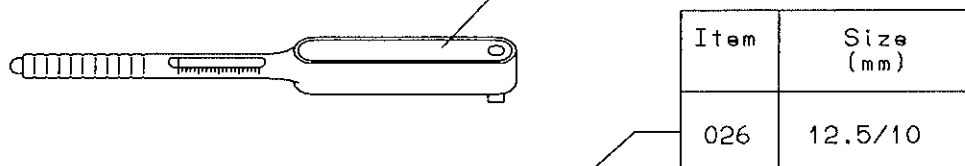
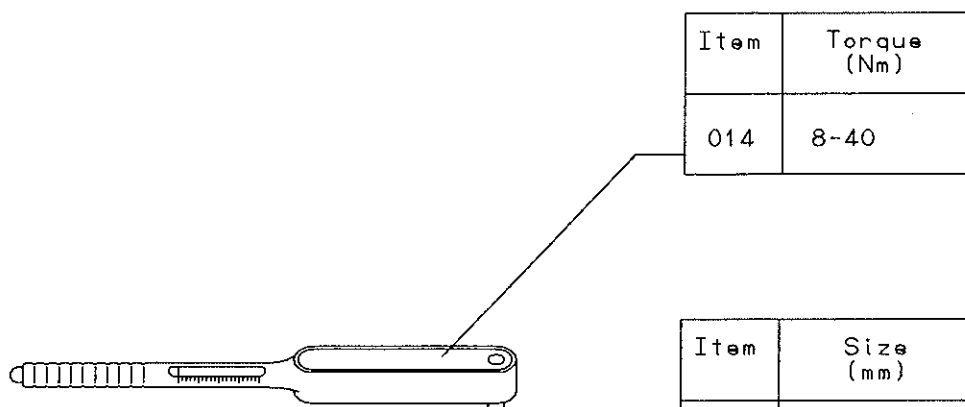
Item No.	Item Description



Item	Size (mm)
223	105
	30
	32
	36
	41
	46
	50
	55
	60
	65
	70
	75
	80
	85
	95
	115

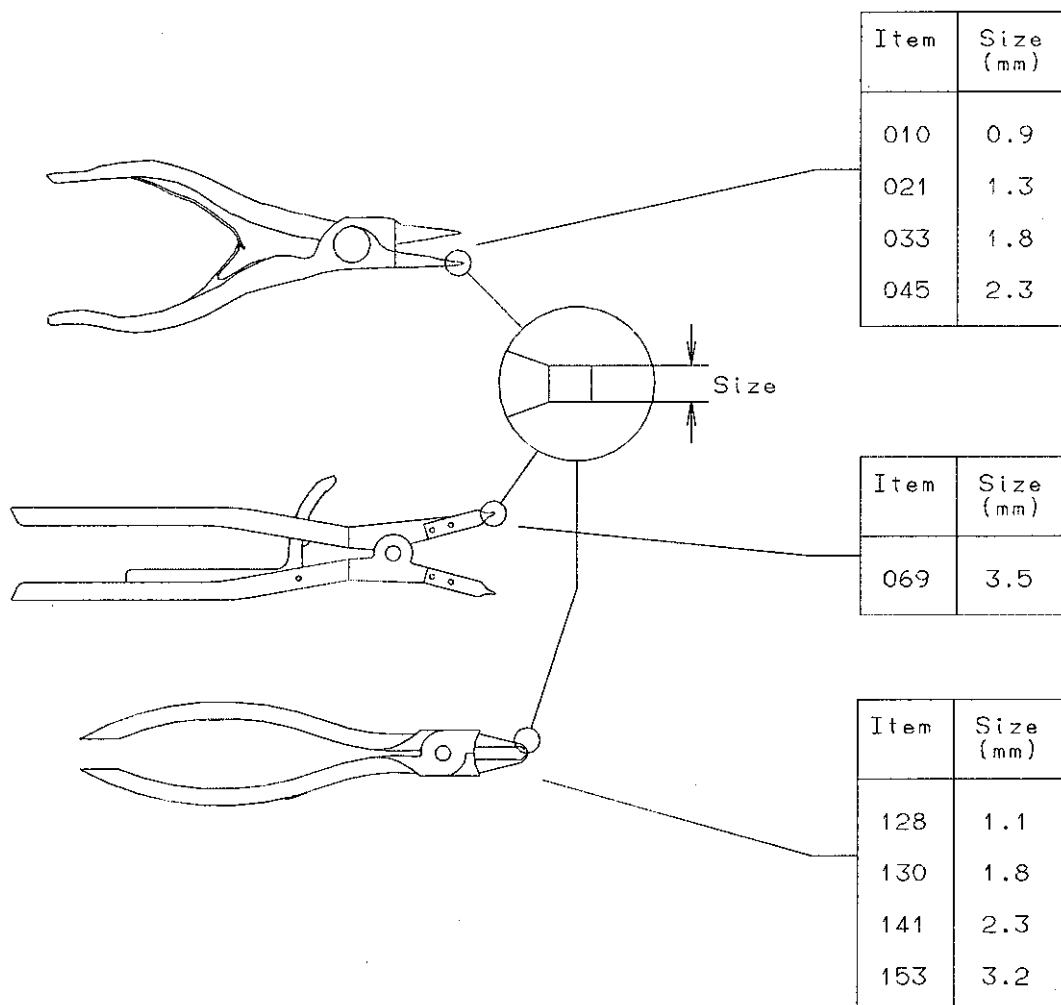
Item No.	Item Description
223	Open-ended slugging spanner, size NV105mm Open-ended slugging spanner, size NV30mm Open-ended slugging spanner, size NV32mm Open-ended slugging spanner, size NV36mm Open-ended slugging spanner, size NV41mm Open-ended slugging spanner, size NV46mm Open-ended slugging spanner, size NV50mm Open-ended slugging spanner, size NV55mm Open-ended slugging spanner, size NV60mm Open-ended slugging spanner, size NV65mm Open-ended slugging spanner, size NV70mm Open-ended slugging spanner, size NV75mm Open-ended slugging spanner, size NV80mm Open-ended slugging spanner, size NV85mm Open-ended slugging spanner, size NV95mm Open-ended slugging spanner, size NV115mm

Item No.	Item Description

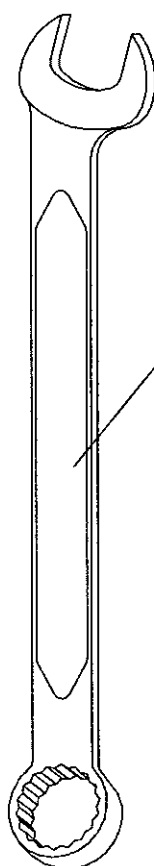


Item No.	Item Description
014	Torque wrench, 8 - 40Nm
026	Adapter for socket wrench, 10 x 12.5 mm
038	Torque wrench, 40 - 200Nm
040	Torque wrench, 140 - 760Nm
051	Torque wrench, 750 - 2000Nm

Item No.	Item Description



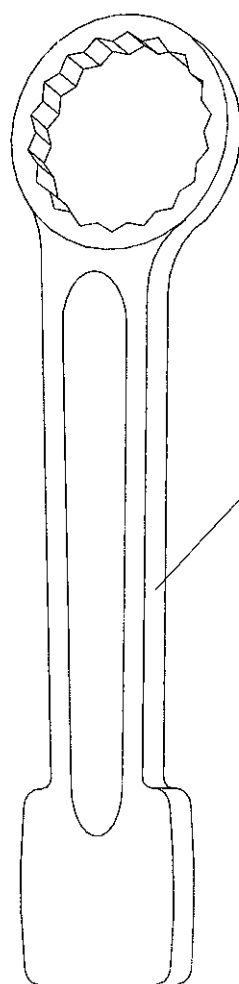
Item No.	Item Description	Item No.	Item Description
010	Pliers for retaining ring, size 0.9mm		
021	Pliers for retaining ring, size 1.3mm		
033	Pliers for retaining ring, size 1.8mm		
045	Pliers for retaining ring, size 2.3mm		
057	Pliers for retaining ring, size 3.2mm		
069	Pliers for retaining ring, size 3.5mm		
128	Pliers for retaining ring, size 1.1mm		
130	Pliers for retaining ring, size 1.8mm		
141	Pliers for retaining ring, size 2.3mm		
153	Pliers for retaining ring, size 3.2mm		



Item	Size (mm)
015	10
027	11
039	12
040	13
052	14
064	15
076	16
088	17
090	18
100	19
111	21
123	22
135	24
147	27
159	30
160	32
172	34
184	36
196	41
206	46
218	50
220	55
231	60

Item No.	Item Description
015	Combination spanners, size NV10mm
027	Combination spanners, size NV11mm
039	Combination spanners, size NV12mm
040	Combination spanners, size NV13mm
052	Combination spanners, size NV14mm
064	Combination spanners, size NV15mm
076	Combination spanners, size NV16mm
088	Combination spanners, size NV17mm
090	Combination spanners, size NV18mm
100	Combination spanners, size NV19mm
111	Combination spanners, size NV21mm
123	Combination spanners, size NV22mm
135	Combination spanners, size NV24mm
147	Combination spanners, size NV27mm
159	Combination spanners, size NV30mm
160	Combination spanners, size NV32mm
172	Combination spanners, size NV34mm
184	Combination spanners, size NV36mm
196	Combination spanners, size NV41mm
206	Combination spanners, size NV46mm
218	Combination spanners, size NV50mm
220	Combination spanners, size NV55mm
231	Combination spanners, size NV60mm

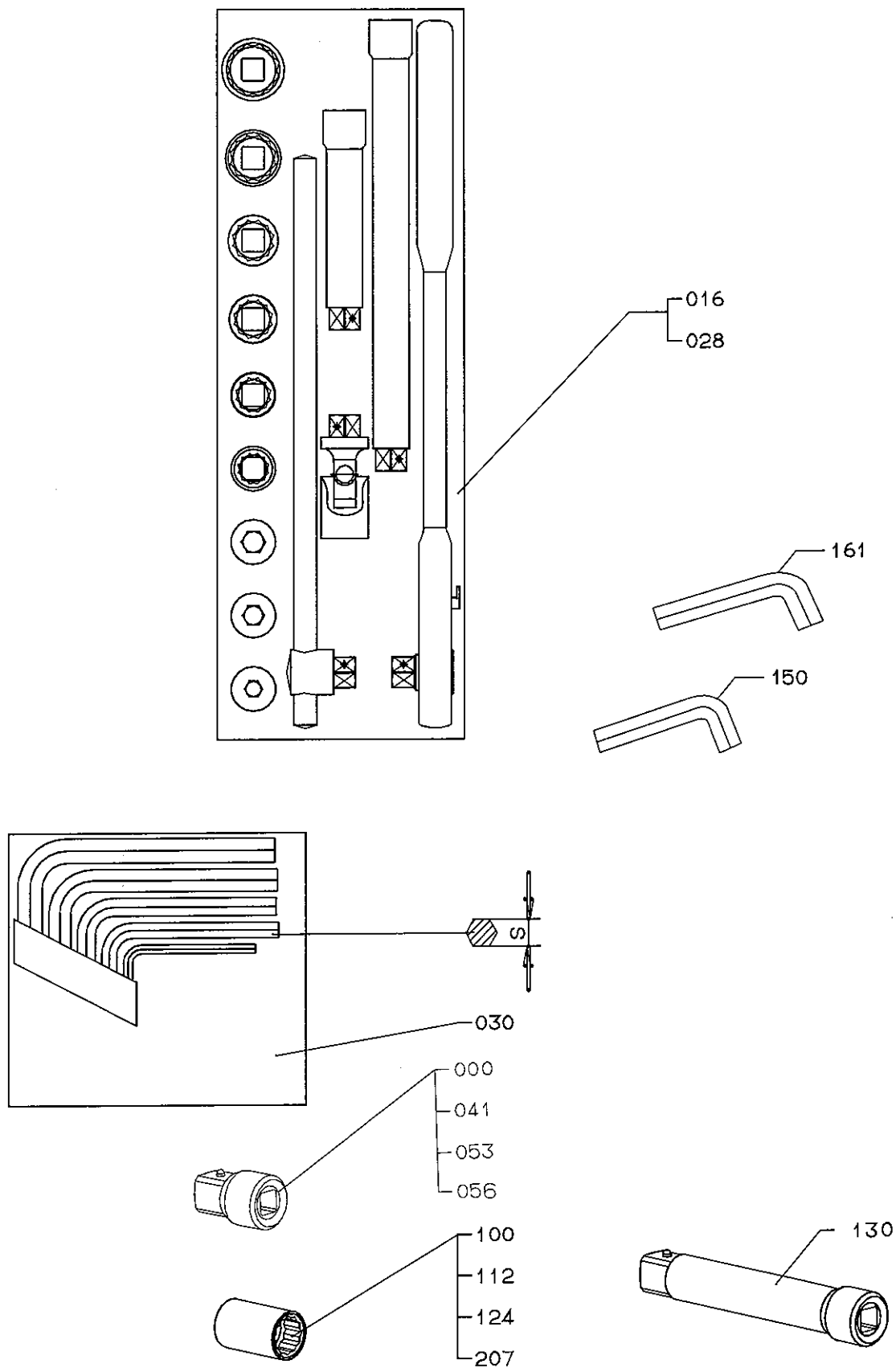
Item No.	Item Description



Item	Size (mm)
022	30
034	32
046	34
058	36
060	41
071	46
083	50
095	55
117	65
130	75
142	80
154	85
178	95
180	100
191	105
213	115
225	120
120	70
164	90

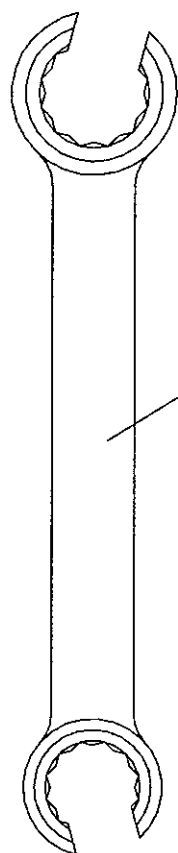
Item No.	Item Description
022	Slugging spanners, ring size NV30mm
034	Slugging spanners, ring size NV32mm
046	Slugging spanners, ring size NV34mm
058	Slugging spanners, ring size NV36mm
060	Slugging spanners, ring size NV41mm
071	Slugging spanners, ring size NV46mm
083	Slugging spanners, ring size NV50mm
095	Slugging spanners, ring size NV55mm
105	Slugging spanners, ring size NV60mm
117	Slugging spanners, ring size NV65mm
130	Slugging spanners, ring size NV75mm
142	Slugging spanners, ring size NV80mm
154	Slugging spanners, ring size NV85mm
178	Slugging spanners, ring size NV95mm
180	Slugging spanners, ring size NV100mm
191	Slugging spanners, ring size NV105mm
213	Slugging spanners, ring size NV115mm
225	Slugging spanners, ring size NV120mm
120	Slugging spanners, ring size NV70mm
164	Slugging spanners, ring size NV90mm

Item No.	Item Description



Item No.	Item Description
016	Tool set, complete
028	Tool set, complete
030	Hexagon key set, complete
041	Adaptor for socket spanner
053	Adaptor for socket spanner
100	Socket spanner, sq. drive
112	Socket spanner, sq. drive
124	Socket spanner, sq. drive
130	Extension bar
150	Spanner
161	Spanner
207	Socket spanner, sq. drive
000	Adaptor for socket spanner
056	Adaptor for socket spanner

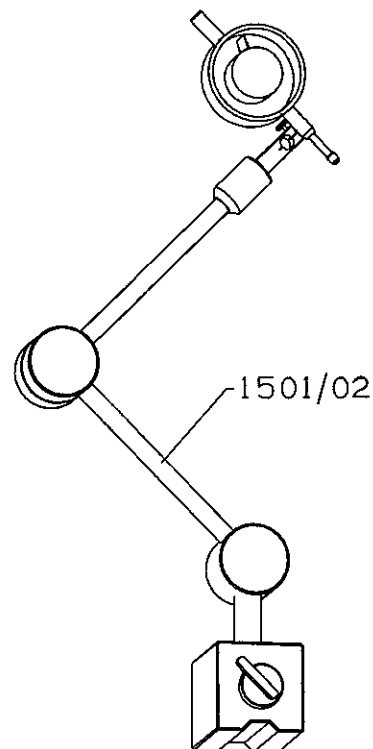
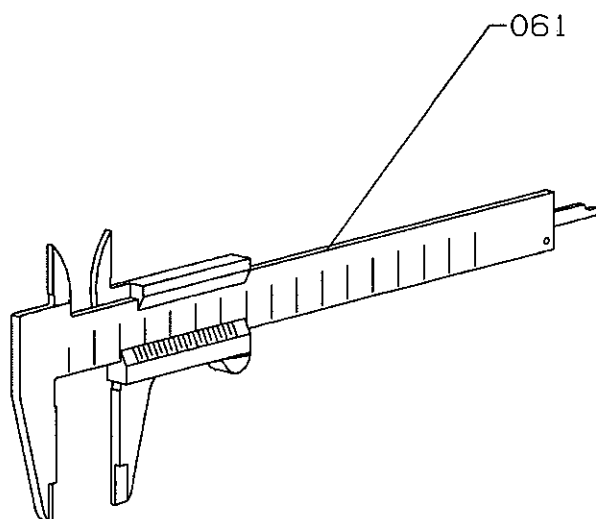
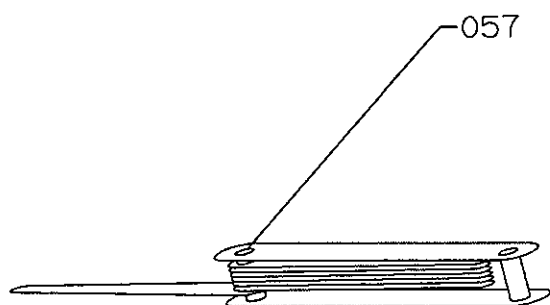
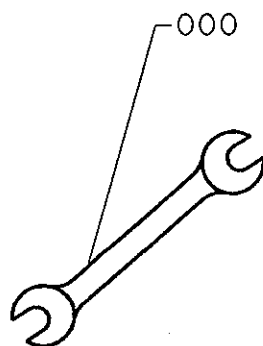
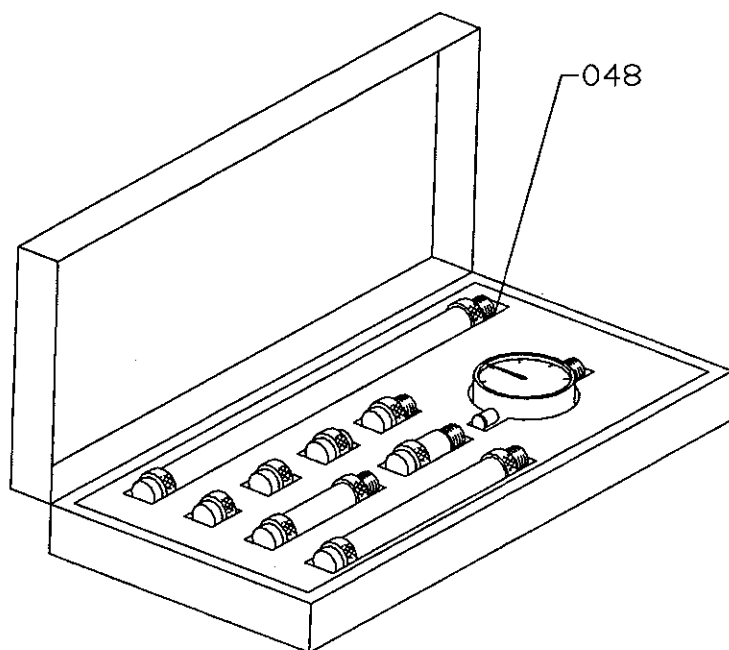
Item No.	Item Description



Item	Size (mm)
011	14/17
023	19/22

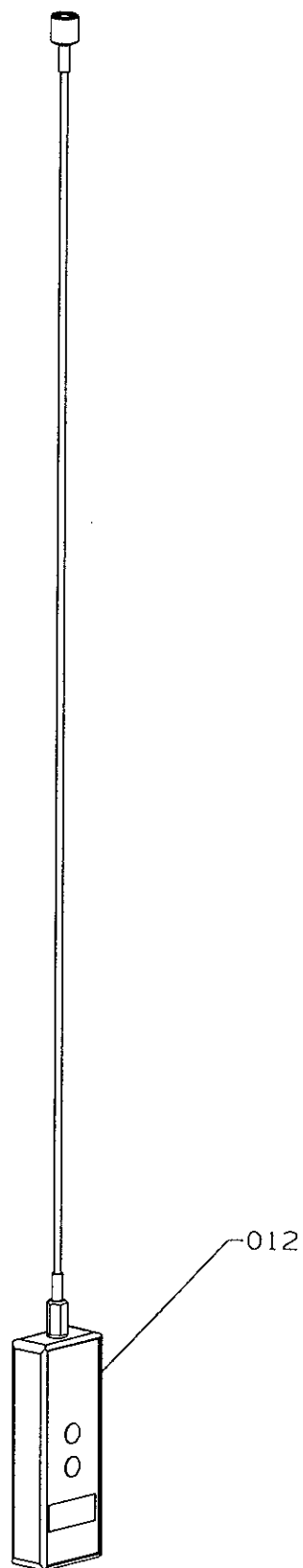
Item No.	Item Description
011	Open ring wrench, 14 - 17mm
023	Open ring wrench, 19 - 22mm

Item No.	Item Description

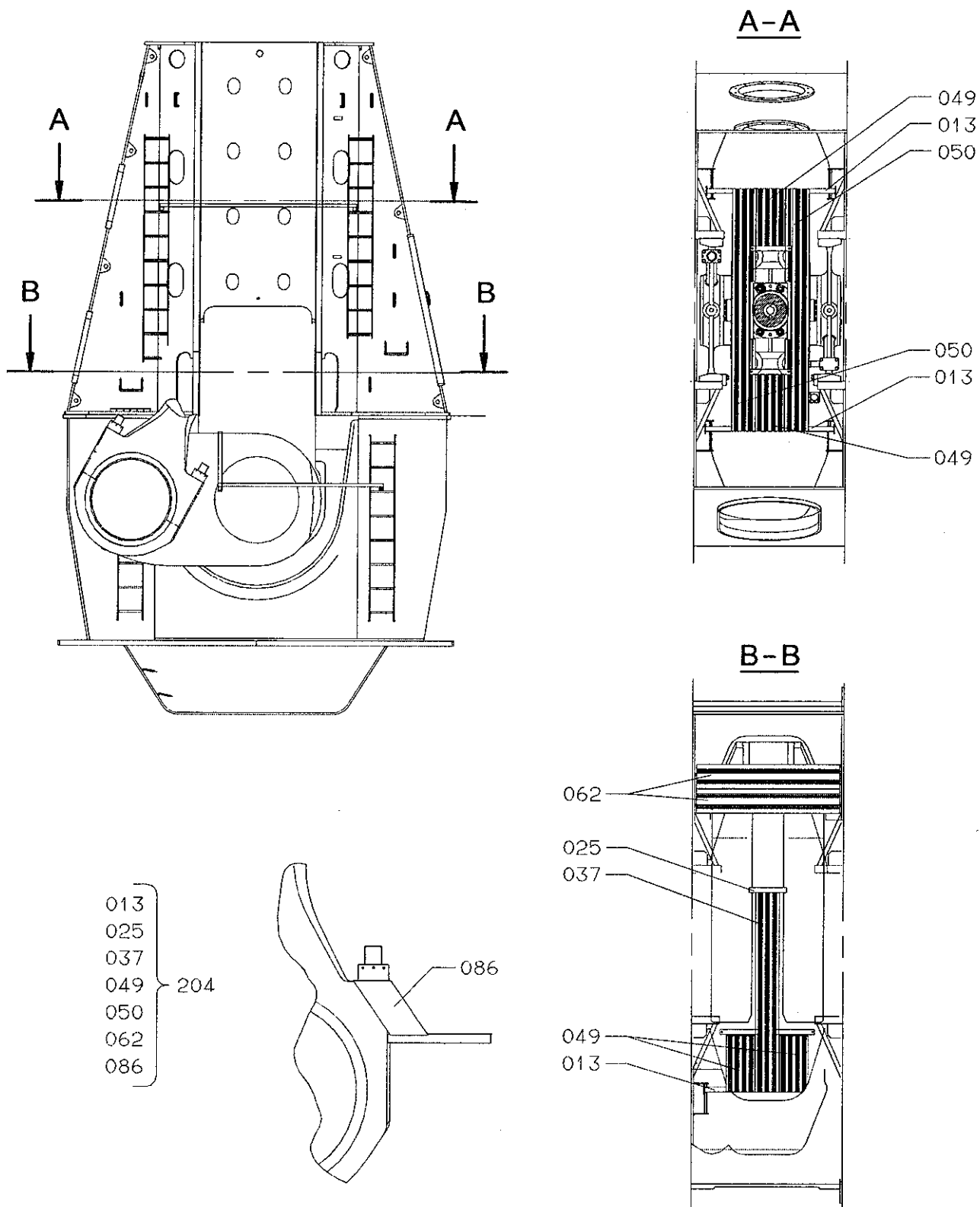


Item No.	Item Description
048	Autolog, measuring tool for crankshaft
057	Feeler gauge
061	Slide caliper
1501/02	Dial gauge and stand tool
000	Double head open ended spanner 6x7
	Double head open ended spanner 8x10
	Double head open ended spanner 12x14
	Double head open ended spanner 13x17
	Double head open ended spanner 16x18
	Double head open ended spanner 19x22
	Double head open ended spanner 24x30
	Double head open ended spanner 27x32
	Double head open ended spanner 36x41
	Double head open ended spanner 46x50
	Double head open ended spanner 55x60

Item No.	Item Description



Item No.	Item Description	Item No.	Item Description
012	Pressure gauge		



Item No.	Item Description	Item No.	Item Description
013	Working platform support		
025	Working platform support		
037	Platform board		
049	Platform board		
050	Platform board		
062	Platform board		
086	Ladder		
204	Working platform, complete		

INDEX

GRINDING MACHINE FOR EXHAUST VALVE

TESTING TOOL FOR FUEL VALVE

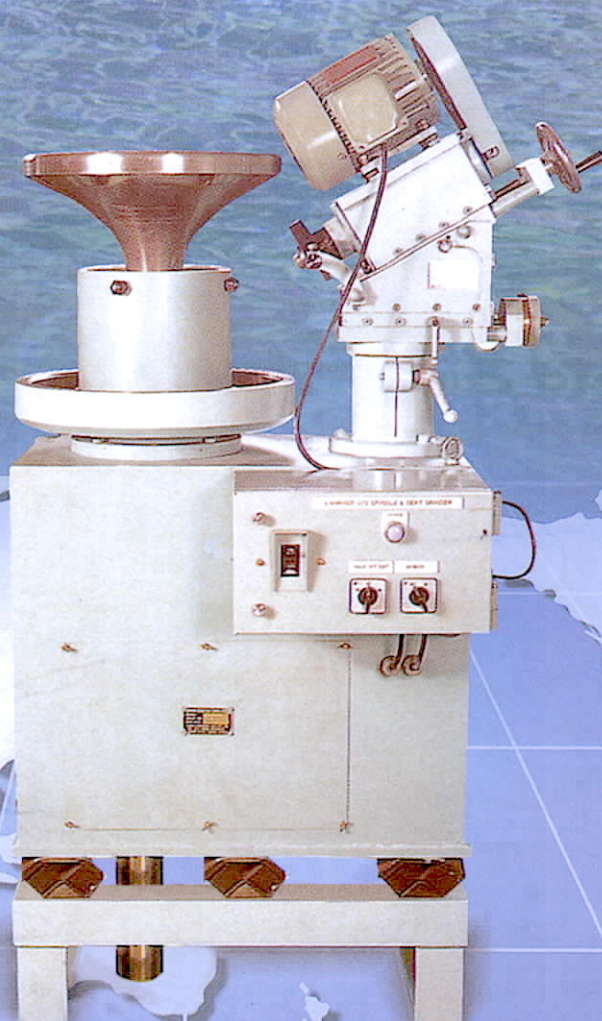
PNEUMATIC-HYDRAULIC HIGH PRESSURE PUMP

HAND PUMP

TOP BRACING

GRINDING MACHINE FOR EXHAUST VALVE

KOKACO SYSTEM EXH' VALVE SPINDLE & BOTTOM PIECE GRINDING MACHINE

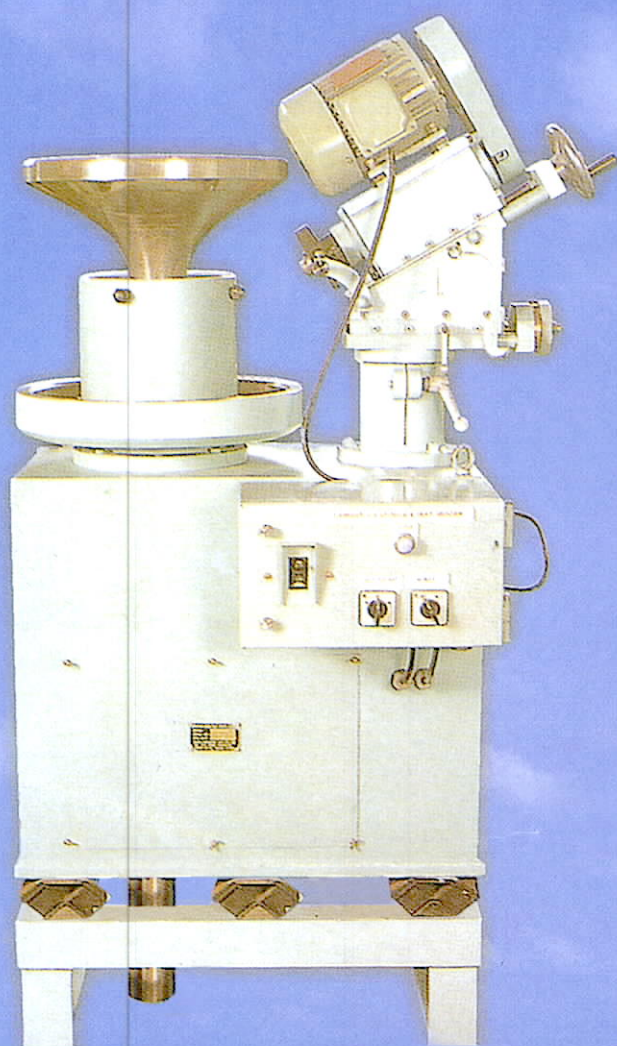


OPERATION MANUAL (MODEL : NKK - TYPE)



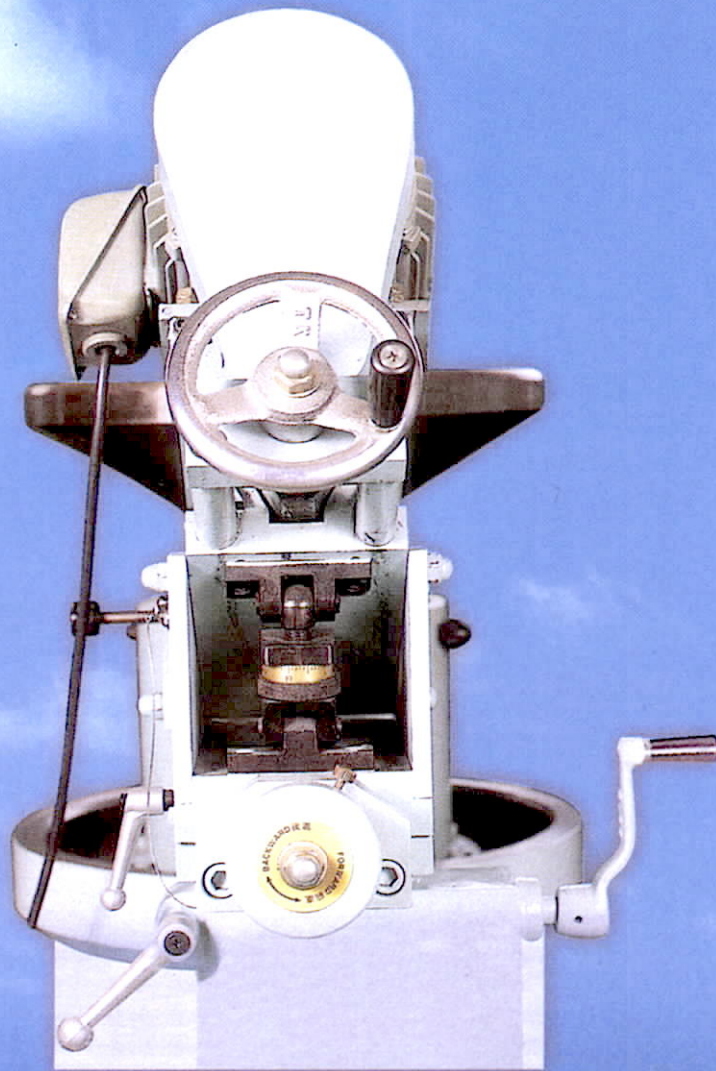
BEST QUALITY
KOKACO CO., LTD.

KOKACO



CO., LTD.

KOKACO



BRIEF HISTORY

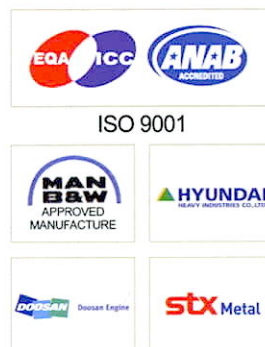
Dec. 27, 1988	Founded Korea Kawamura Seiki Co., Ltd.
Feb. 1, 1989	Exported to Japan Kawamura Seike Seisakusho Co., Ltd.
Jul. 20, 1989	Supplied Grinding M/Cs to Ssangyong Heavy Industry Co., Ltd.
Dec. 24, 1990	Developed the EXH' Valve/Seat Grinder and designated by the Ministry of Commerce & Industry.
Jun. 26, 1991	Supplied Grinding M/Cs to Hyundai Heavy Industry Co., Ltd.
Nov. 27, 1991	Supplied Grinding M/Cs to Korea Heavy Industry Co., Ltd.
Feb. 13, 1992	Patented Fuel Valve Lapping M/Cs.
Mar. 9, 1992	Started Fuel Valve Reconditioning & Repairs.
Jan. 10, 1993	Started F.O. Pump & Plunger, Barrel Repairs.
Jul. 4, 1997	Supplied Grinding M/Cs to Samsung Heavy Industry Co., Ltd.
Feb. 1, 2000	Transferred into Korea Kwawamura Co., Ltd.
Dec. 19, 2000	Optained Approval of Manufacture from MAN B&W.
Jul. 1, 2001	Transferred into KOKACO Co., Ltd.
Apr. 4, 2001	Patented EXHAUST VALVE SPINDLE/SEAT GRINDING MACHINE(NKK-TYPE)
Apr. 30, 2001	Achieved Company-ISO 9002:1994 Certification
May. 17, 2003	Achieved Company-ISO 9001:2000 Certification

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E-MAIL : kksco@unitel.co.kr



Entrust EXH'V SPINDLE & BOTTOM PIECE GRINDING
M/Cs from small engine to Extra large Engine to
KOKACO Co., Ltd. from today.

ENGINE TYPE	
HANSHIN, B&W, MAKITA, NIIGATA, UEC, YANMAR, AKASAKA	
B&W 26MC	B&W 60MC/ME
B&W 35MC	B&W 70MC/ME
B&W 42MC/ME	B&W 80MC/ME
B&W 46MC/ME	B&W 90MC/ME
B&W 50MC/ME	B&W 98MC/ME
PC2-2, PC2-5, PC4, MITSUBI M42, KAWASAKI MAN, MITSUBISHI MAN	
SULZER RTA48	SULZER RTF 50
SULZER RTA52	SULZER RTF 58
SULZER RTA62	SULZER RTF 60
SULZER RTA72	SULZER RTF 68
SULZER RTA84	SULZER RTF 84
SULZER RTA96	SULZER RTF 96
VALVE SEAT Ø38~160mm, VALVE STEM Ø10~25mm PC, MAN, GENERATOR FOR SHIP	
VARIOUS TYPES OF FUEL INJECTOR	

• We have already developed the Pneumatic Type most recently.

Technical Information

The KOKACO grinding machine is air driven or electrically driven.

Patented anti-vibration system and adjustable grinding angles system.

This KOKACO grinding machine is designed and manufactured to simply adjust to operating work with effort to safely and trust for high quality grinding successfully.

The machine is used for grinding of valve spindle seat and bottom piece of large bore diesel engines.



1. GRINDING ACCURACY

① angle accuracy	± 0.2 minutes
② eccentricity	max 0.02mm
③ ovality	max 0.003mm
④ surface fineness	N6 = Ra 0.8 μ m.
⑤ run out	0.02mm

2. MACHINE DATA

① machine capacity	: up to 700mm diameter an valve spindle & bottom piece.
② grinding stone size	: rough grinding stone : $\varnothing 100 \times \varnothing 32 \times 13$ mm fine grinding stone : $\varnothing 100 \times \varnothing 32 \times 15$ mm
③ normal grinding time	: 50 ~ 60 minutes
④ weight	: 300 ~ 570 kgs
⑤ power supply	: 3ph 220 ~ 440V 50/60hz
⑥ grinding stone speed	: 2355m/MIN
⑦ grinding object speed	: 3.0 ~ 4.0 rpm.

Warning – Read these instruction carefully

Transportation and installation

- ① Ensure that the machine is transported safely, and do not carry loads above people.
- ② The machine has prepared holes for four lift eye bolts.
Always use these when the machine is lifted.
- ③ Make sure the lift eye bolts are undamaged and adequately fastened.
- ④ Only use undamaged and correctly sized lifting equipment.

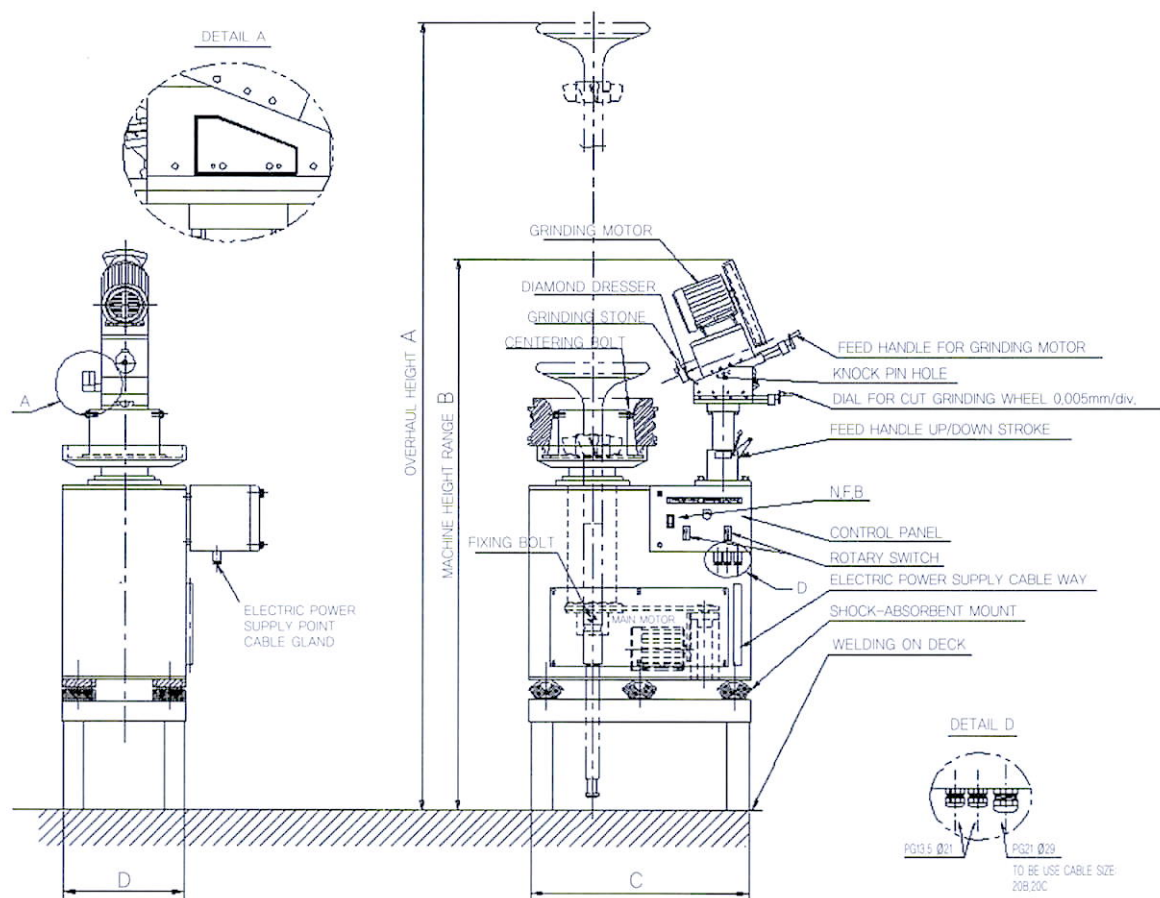
Installation

At delivery the grinding machine is assembled all parts and metal parts are coated to prevent corrosion.

1) LOCATION FOR THE EQUIPMENT

Carefully consider the following points when deciding where to install the KOKACO NKK-TYPE grinding machine

- ① Avoid any area with excessive engine vibrations 8mm/s or 286mm/s in a RMS of ISO regulation.
- ② Availability of lifting facilities and necessary lifting headroom.
- ③ KOKACO NKK-TYPE grinding machine has been installed angle bed on grinding machine for struture welding work use.



Specification

ELECTRIC MAIN POWER SOURCE : AC 440V, 60Hz, Ø3

TURNING MOTOR : AC 440V, 60Hz, Ø3, 400W(*JP44, INS.CLASS "F")

*EQUIVALENT TO JP44 = IP44

AMBIENT TEMP : 50°C

GRINDING MOTOR : AC 440V, 60Hz, 750W, 3350RPM

GRINDING RATE : 0.005 mm/div

WHEEL INCLINING ANGLE RANGE : FIXED TYPE

WHEEL SIZE : Ø100 × W13 × Ø32

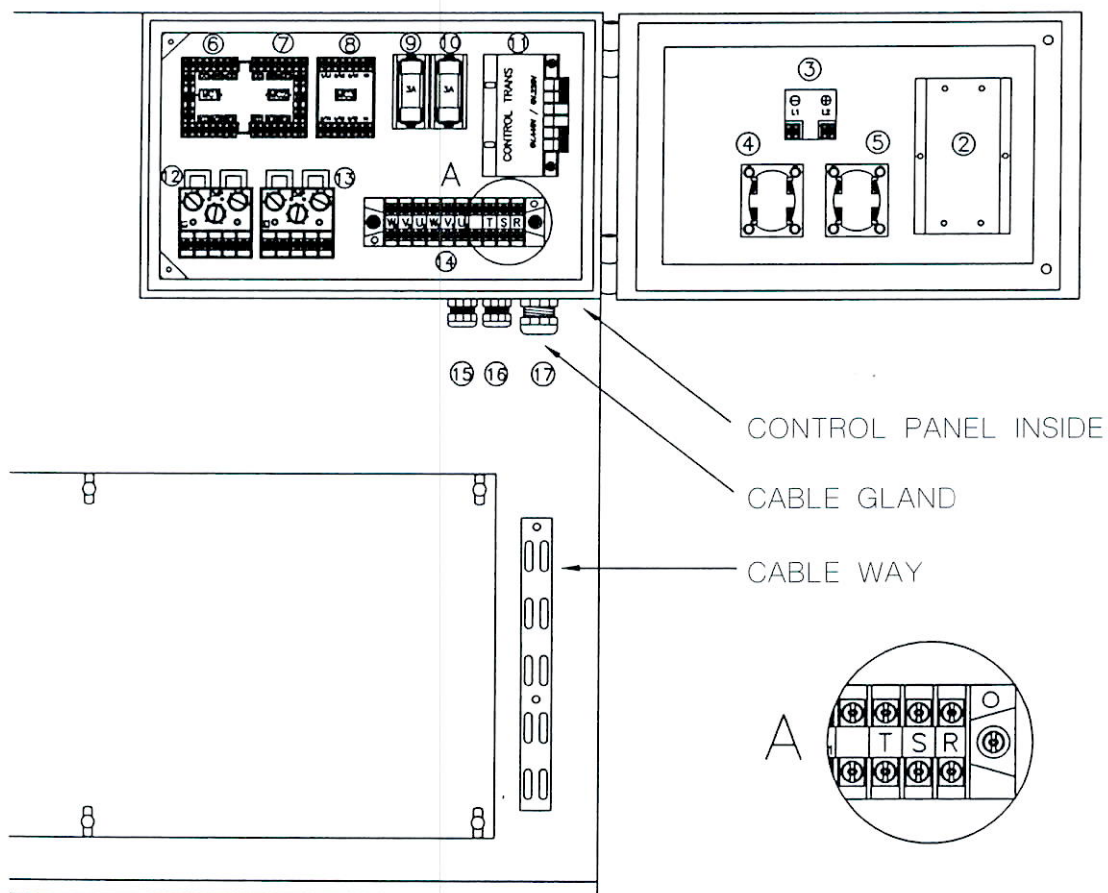
PAINT COLOR : MAKER STANDARD(7.5BG 7/2)

MAIN MOTOR : RATING CURRENT 1.2A, STARTING CURRENT 5A

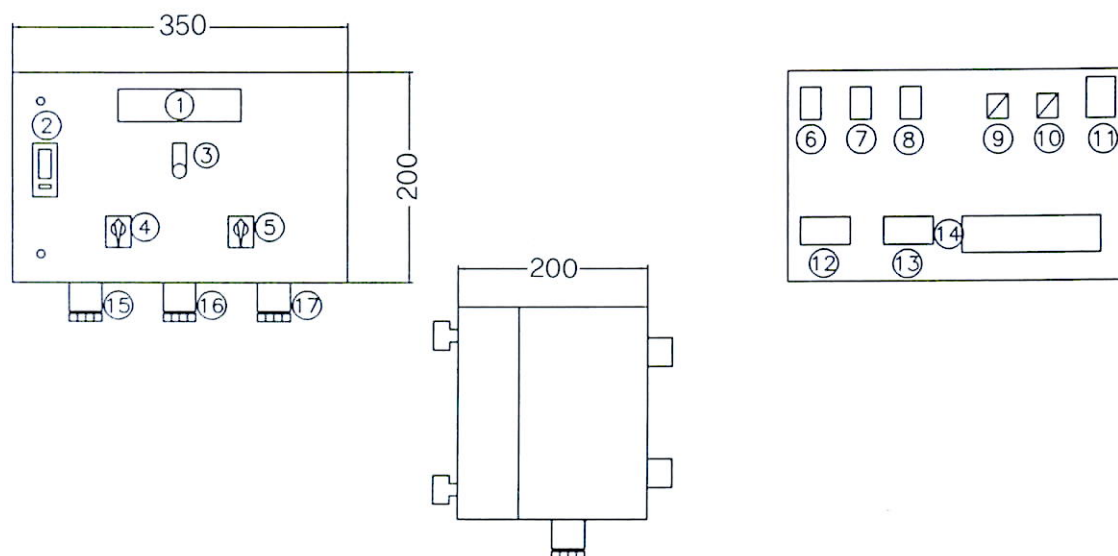
GRINDING MOTOR : RATING CURRENT 1.45A, STARTING CURRENT 8A

ENGINE MODEL	A	B	C	D	WEIGHT	ENGINE MODEL	A	B	C	D	WEIGHT
						B&W 40ME/-C	1855mm	1530mm	680mm	390mm	300kg
B&W 42MC/-C	1997mm	1530mm	680mm	390mm	300kg	B&W 42ME/-C					
B&W 46MC/-C	1930mm	1530mm	680mm	390mm	300kg	B&W 46ME/-C	1930mm	1530mm	680mm	390mm	300kg
B&W 50MC/-C	1970mm	1530mm	680mm	390mm	300kg	B&W 50ME/-C	2180mm	1635mm	666mm	376mm	310kg
B&W 60MC/-C	2236mm	1660mm	666mm	376mm	310kg	B&W 60ME/-C	2618mm	1850mm	666mm	376mm	320kg
						B&W 65ME/-C	2720mm	1920mm	680mm	390mm	320kg
B&W 70MC/-C	2571mm	1835mm	666mm	376mm	320kg	B&W 70ME/-C	2918mm	2005mm	666mm	376mm	330kg
B&W 80MC/-C	2903mm	1995mm	776mm	476mm	450kg	B&W 80ME/-C	3280mm	2190mm	776mm	476mm	460kg
B&W 90MC/-C	3351mm	2260mm	846mm	556mm	550kg	B&W 90ME/-C	3672mm	2420mm	846mm	556mm	560kg
B&W 98MC/-C	3522mm	2364mm	846mm	556mm	570kg	B&W 98ME/-C	3953mm	2580mm	846mm	556mm	580kg

POWER CONNECTION



*Connect the power cable from on cable way to terminal A,
The power supply with 3ph 220V 50/60Hz, or 3ph 440V 50/60Hz

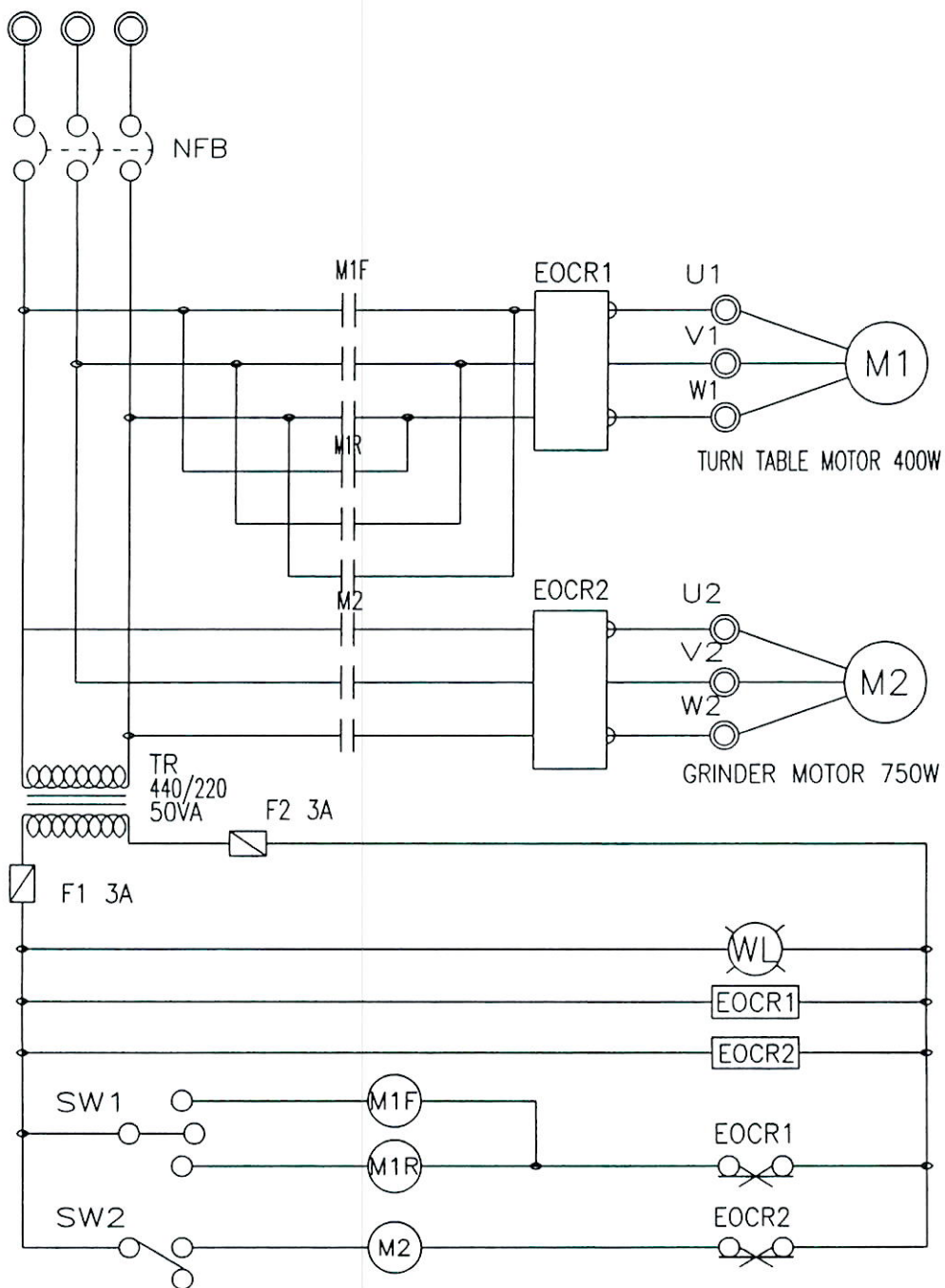


17	CABLE GLAND	PG 21	
16	CABLE GLAND	PG 13.5	
15	CABLE GLAND	PG 13.5	
14	TERMINAL	20A 10P	
13	ELEC. OVER CURRENT RELAY(EOCR2)	HME-S05 0.5-6.5A 220V	
12	ELEC. OVER CURRENT RELAY(EOCR1)	HME-S05 0.5-6.5A 220V	
11	TRANSFORMER	440/220V 50VA	
10	FUSE	3A	
9	FUSE	3A	
8	MAGNETIC CONTACTOR (M2)	DMC12 220V	
7	MAGNETIC CONTACTOR (M1R)	DMH10 220V	
6	MAGNETIC CONTACTOR (M1F)	DMH10 220V	
5	ROTARY SWITCH	Ø25 2 DAN 1a1b	
4	ROTARY SWITCH	Ø25 3 DAN 1a1b	
3	SOURCE LAMP	Ø25 220V	
2	NO FUSE BRAKE	33C 30/10A	
1	NAME PLATE		
NO	DESCRIPTION	TYPE	REMARKS

CONTROL PANEL

	DRAW	CHECKD	APPRVD	DESCRIPTION
TITLE CONTROL PANEL				
KOKACO CO., LTD.				DWG. NO. NKK - BG - 2

R S T



W2	V2	U2	E	W1	V1	U1	T	S	R
----	----	----	---	----	----	----	---	---	---

	DRAW	CHECKD	APPRVD	DESCRIPTION
TITLE CONTROL PANEL				
KOKACO CO., LTD.			DWG NO.	NKK - BG - 1

Important safety guide for grinding machine users

DO...

1. Do always handle and store grinding stone in a careful manner.
2. Do visually inspect all grinding stone before mounting to grinding machine.
3. Do check maximum operating speed worked on for grinding stone against machine speed.
4. Do check mounting flanges for equal and correct diameter.
5. Do be sure work rest for floor stand grinder is properly adjusted
6. Do allow newly mounted grinding stone to run at operating speed with guard in place for at least one minute before grinding.
7. Do always wear safety glasses or some type of eye protection when grinding.

DON'T...

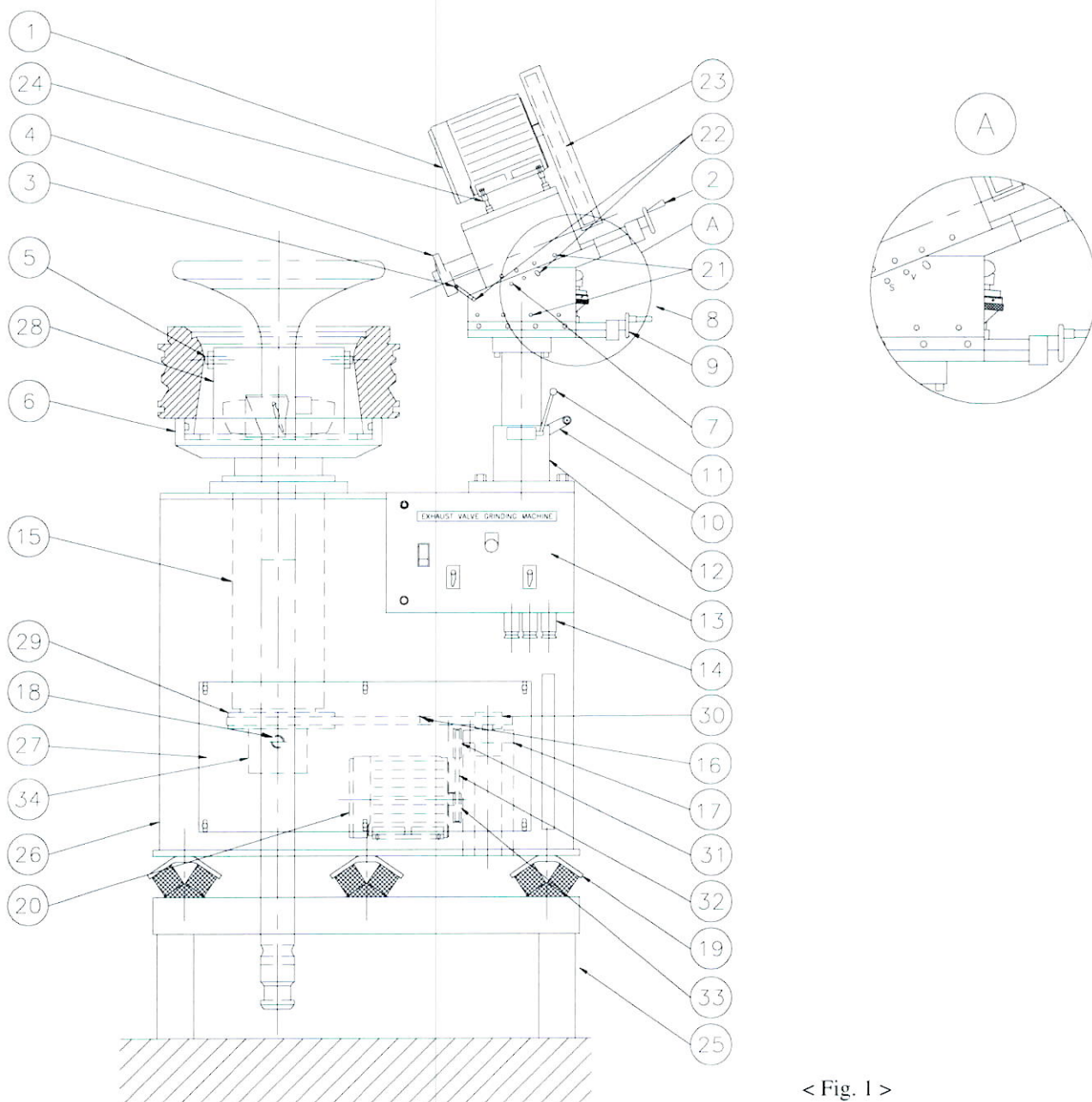
1. Don't use a grinding stone that has been shocked.
2. Don't force a grinding stone onto the machine or alter the size of the mounting hole if wheel won't fit the machine, get one that will.
3. Don't ever exceed maximum operating speed established for the grinding stone.
(Machine's rated speed : 5400r.p.m)
4. Don't use mounting flanges which are warped, nicked, sprung or dirty.
5. Don't tighten the mounting nut excessively. On multiple screw mountings tighten opposite screws to 20 foot-pounds and do this a minute of 3 times. Recheck at the end of 8 hours running.
6. Don't grind the object with the side face of grinding stone.
7. Don't start the machine until the grinding stone guard is in place.
8. Don't stand directly in front of a rotating direction for grinding stone whenever a grinder is started.
9. Don't grind material for which the grinding stone is not designed.

Precaution in operating the grinding machine.

Erroneous operation might be hazardous during grinding generally.

It is advisable to secure safe operation as followings;

1. If possible, the grinding machine has to be placed at safe area where personnels are not endangered even in case of destruction for grinding stone.
2. When a new grinding stone is used, carry out the idle operation for 1 minute at least and check the machine for any abnormality and sound.
3. Before every operation of grinding machine, carry out the idle running for 1 minute at least to check any abnormality.
4. Depth of cutting and feed rate should be kept as specified.
If not, abnormal abrasion of grinding stone and abnormal ground quality on workpiece may be occurred, and, in severe case, grinding stone may be broken to bits.
5. If it is hard to move feed handle, adjust the liner stopper with set screw on upper slide unit.
6. Don't use when a circumferential vibration of Grinding M/C exceeds 8mm/s or 286mm/s² in a RMS of ISO regulation or in a stormy weather voyage.
7. Stop operating in case weather has not an effect on grinding operation.
8. Grinding should be operated by a skilled engineer only who is well aware of this operation manual.
9. Complete works after checking whether a roughness degree of surface is less than N6(Ra 0.8) that is compared with a table RUGO TESTER of roughness after operations.
10. To only reduce dust induced and to make surface roughness good in grinding operation, we recommend to apply cutting oil on a ground surface.

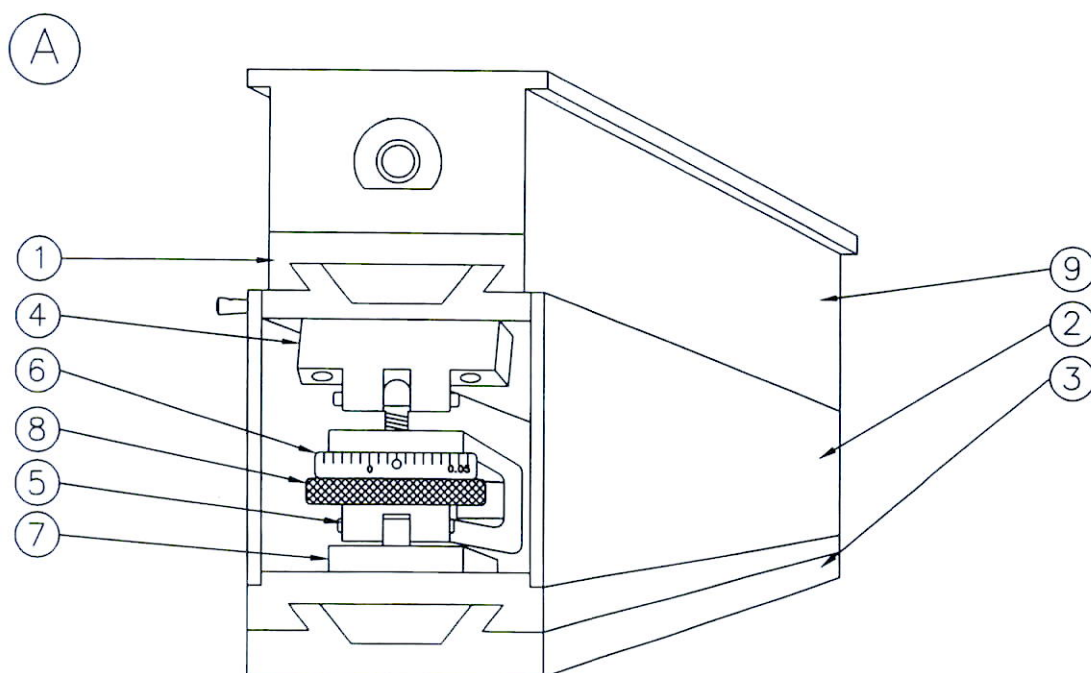


< Fig. 1 >

No	NAME
FIGURE 1	
1	GRINDING MOTOR
2	FEED HANDLE FOR GRINDING MOTOR
3	DIAMOND DRESSER
4	GRINDING STONE
5	CENTERING BOLT
6	TURN TABLE
7	KNOCK PIN HOLE
8	UPPER SLIDE UNIT
9	DIAL PLATE FOR CUT GRINDING STONE 0.005mm/div
10	SLIDE HANDLE UP/DOWN, STROKE-280mm
11	CLAMPING LEVER
12	LOWER SLIDE UNIT
13	CONTROL PANEL
14	GLAND FOR MAIN POWER SOURCE

No	NAME
15	BEARING CASE
16	V-BELT
17	REDUCER
18	FIXING BOLT
19	SHOCK-ABSORBENT MOUNT
20	MAIN MOTOR
21	SCREW
22	FIXING BOLT FOR ANGLE ADJUSTMENT
23	V-BELT
24	SHOCK-ABSORBENT MOUNT FOR MOTOR
25	ANGLE STAND
26	MACHINE BODY
27	FRONT PANEL
28	CENTERING CAP
29	MAIN PULLEY

No	NAME
30	PULLEY FOR REDUCER
31	PULLEY FOR MAIN MOTOR
32	V-BELT
33	MAIN MOTOR PULLEY
34	CENTERING BUSH
FIGURE 2 UPPER SLIDE UNIT	
1	SADDLE FOR SHAFT CASE OF GRINDER
2	SIDE PLATE
3	SADDLE FOR UPPER SLIDE
4	FIX PLATE FOR ANGLE ADJUSTMENT UNIT
5	BODY FOR ANGLE ADJUSTMENT UNIT
6	DIAL MEMORY
7	FIX PLATE FOR ANGLE ADJUSTMENT UNIT
8	HANDLE FOR ANGLE ADJUSTMENT
9	SHAFT CASE OF GRINDER



< Fig. 2 >

SPECIFICATION

ANGLE TABLE

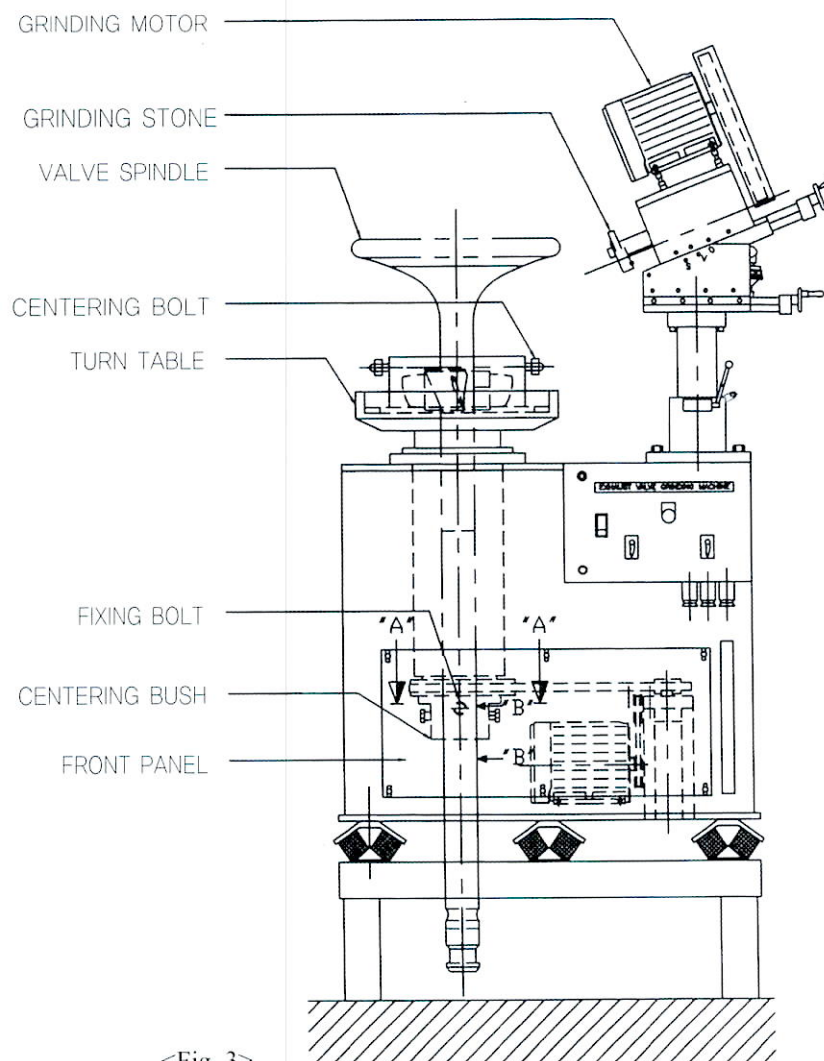
ENGINE MODEL	MODEL NAME	ROTATION OF TURN TABLE	THE ANGLE OF GRINDING		ROTATION OF GRINDER SHAFT	SIZE OF GRINDER STONE	MOTOR	
			VALVE SPINDLE	BOTTOM PIECE			GRINDER	TURN TABLE
B&W 42MC/-C	NKK 42BG	4.0RPM	30.3° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$	3,350RPM	ROUGH Ø100×Ø32×W13 FINE Ø100×Ø32×W15	750W	400W
B&W 46MC/-C	NKK 46BG	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 50MC/-C	NKK 50BG	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
			30.5° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 60MC/-C	NKK 60BG	4.0RPM	30.3° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 70MC/-C	NKK 70BG	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 80MC/-C	NKK 80BG	3.0RPM	30.5° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 90MC/-C	NKK 90BG	3.0RPM	30.7° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 98MC/-C	NKK 98BG	3.0RPM	30.7° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 40ME/-C	NKK 40BG-ME	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 42ME/-C	NKK 42BG-ME							
B&W 46ME/-C	NKK 46BG-ME	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 50ME/-C	NKK 50BG-ME	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
			30.5° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 60ME/-C	NKK 60BG-ME	4.0RPM	30.3° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
			30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 65ME/-C	NKK 65BG-ME	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 70ME/-C	NKK 70BG-ME	4.0RPM	30.4° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 80ME/-C	NKK 80BG-ME	3.0RPM	30.5° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 90ME/-C	NKK 90BG-ME	3.0RPM	30.7° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				
B&W 98ME/-C	NKK 98BG-ME	3.0RPM	30.7° $^{+0.1^{\circ}}_0$	30° $^{0}_{-0.1^{\circ}}$				

GRINDING PROCEDURE

1. VALVE SPINDLE

1-1) MOUNTING THE VALVE SPINDLE ON GRINDING MACHINE:(Refer to fig.3)

- a) Remove the carbon stuck on the valve spindle using Light oil initially.
- b) Detach the front panel No. 27 from the machine.
- c) Confirm the fixing bolt No.18 is loosened in order not to obstruct the insertion of valve spindle.
- d) Insert the valve spindle into Centering Bush No.34 as figure.
- e) Tighten the valve spindle by fixing bolt No.18.
- f) Refer to Fig. 6 on page 13, How the set Run-Out exactly.
- g) Place the dial gauge on the top of machine body and adjust the centering by centering bolt No.5 to obtain run out within 0.02mm.



<Fig. 3>

1-2) GRINDING THE VALVE SPINDLE

- a) Loosen the two bolts for grinding stone cover and place the cover correctly.
- b) Set the grinding angle to V(Valve spindle) with knock-pin.
- c) Set grinding stone for rough grinding. (an installed stone in delivery)
- d) push the "power on" switch on the front of the control panel.
- e) Before grinding the valve spindle, please check the grinding stone condition.
- f) Move grinding stone to the under side of the valve spindle by turning clockwise the feed handle for grinder.
- g) Select the "valve" switch for valve driver. (turn table)
- h) Select the "motor on" switch for grinding driver. (grinding stone)
- i) Raise the upper slide unit No.8 by turning slide handle No.10 clockwise grinding stone come into just contact with valve spindle.

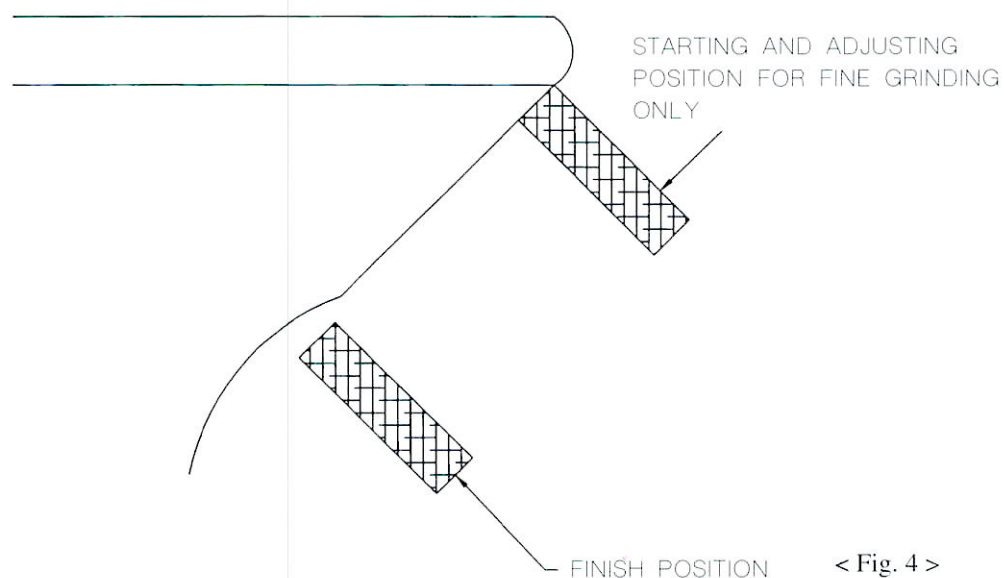
NOTE : After adjustment the height of grinding stone, Lock slide unit (8, 12) with the clamping lever No.11 to prevent any movement during grinding.

- j) Set the scale of dial plate No.9 to zero at the position where grinding stone contact with the valve seat and fix the dial plate by set screw.
- k) The depth of cut scale plate is graduated in 0.005mm/div. Set the depth of cut to 0.02mm(four graduation) or less and perform several coarse grinding by operation of the feed handle for grinder sliding back and forth. During coarse, the feed handle (2) has to turned by 1 revolution per every 1 turning of valve spindle or bottom piece.

NOTE : All cutting operations must be done within the valve seat surface.

- l) When grinding is finished, switch off all motor after whole surface of grinding stone is detached from the valve seat area.
- m) Check the entire seat surface has been coarsely ground.
- n) Replace the Rough Grinding stone with Fine Grinding stone.
- o) Select the power "on" switches for all motor and place the grinding stone to be matched fully with valve spindle. (Refer to following sketch)
- p) Set the depth of cut to 0.01mm(two graduation) or less and perform the fine grinding by slow moving the grinder.

NOTE : For starting the grinding, all width of grinding stone has to be matched with grinding object and finishing has to be done at fully detached state as shown on fig 4.



Attention

To get a good grinding surfaces, we recommend to keep optimum standard feed time of 1 pass with about 5 minutes or more.

For example, 0.2mm cutting of the seat surface:

1. Coarse grinder : 9 passes for 45 minutes
And for fine grinding, the feed handle has to be turned by half(1/2) revolution per every 1 turning of valve spindle or bottom piece.
2. Fine grinding : 3 passes about 15 minutes
3. Total grinding times : about 60 minutes



To grind the valve SPINDLE



To grind the BOTTOM PIECE

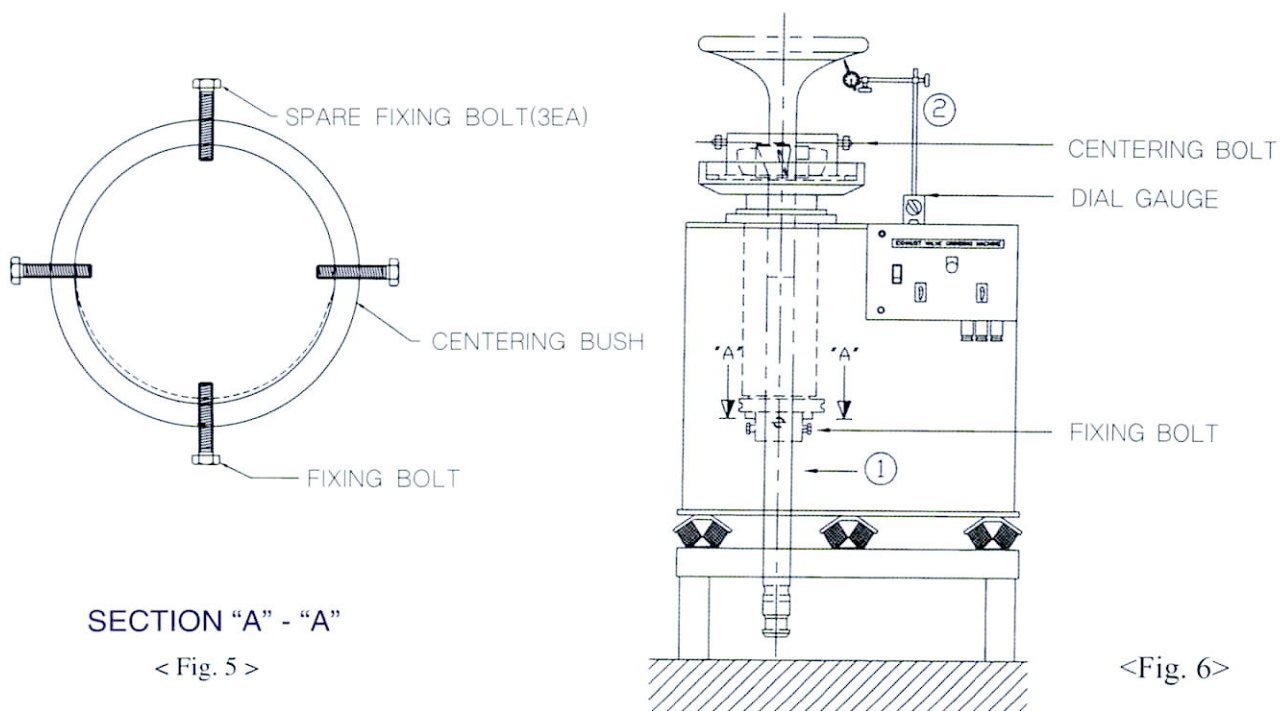
1-3) CONFIRMING THE CENTER DEFLECTION

This machine is designed so that the deflection of core (run out of the stem for valve spindle) is within 0.01mm and delivered after adjustment, but check once more to make sure before grinding as follows:



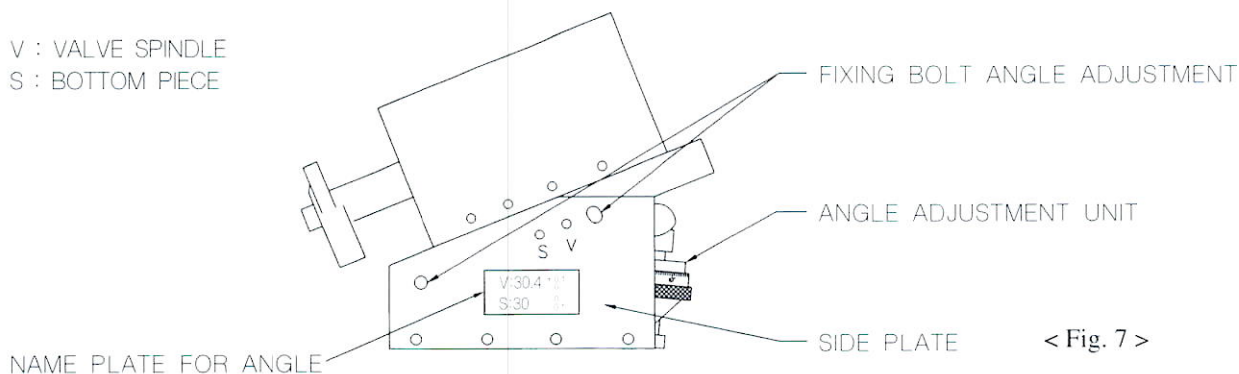
- a) Set the dial gauge at the lower part of valve stem.
(Fig. 6 position ① by dial gauge)
- b) Select the "valve" switch for valve drive(turn table) and check the run out on valve stem.
- c) If the run out is larger than 0.03mm for position ① please adjust the spare fixing bolts into centering bush as shown on the below figure.
- d) Please don't use spare fixing bolts when center deflection(run out) is normal condition.
- e) After setting of position ① below 0.03mm, If the valve exceeds 0.03mm, adjust the run-out by centering bolts of turn table.
- f) After setting of position ① below 0.03mm, check the position ② which measures run-out 0.05mm on valve seat area. If it exceeds 0.3mm, the lopsidedness of valve spindle has problem, then contact with specialized engine manufacturer.

HOW TO CHECK THE RUN OUT OF VALVE SPINDLE



1-4) THE ANGLE OF GRINDING SLIDE TABLE

V : VALVE SPINDLE
S : BOTTOM PIECE



NOTE : The angle of grinding slide table is different between valve spindle and bottom piece.

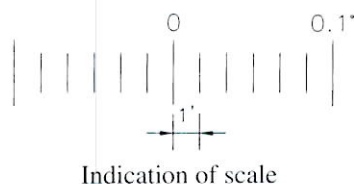
If grinding object is changed, readjust the grinding angle according to following procedure.

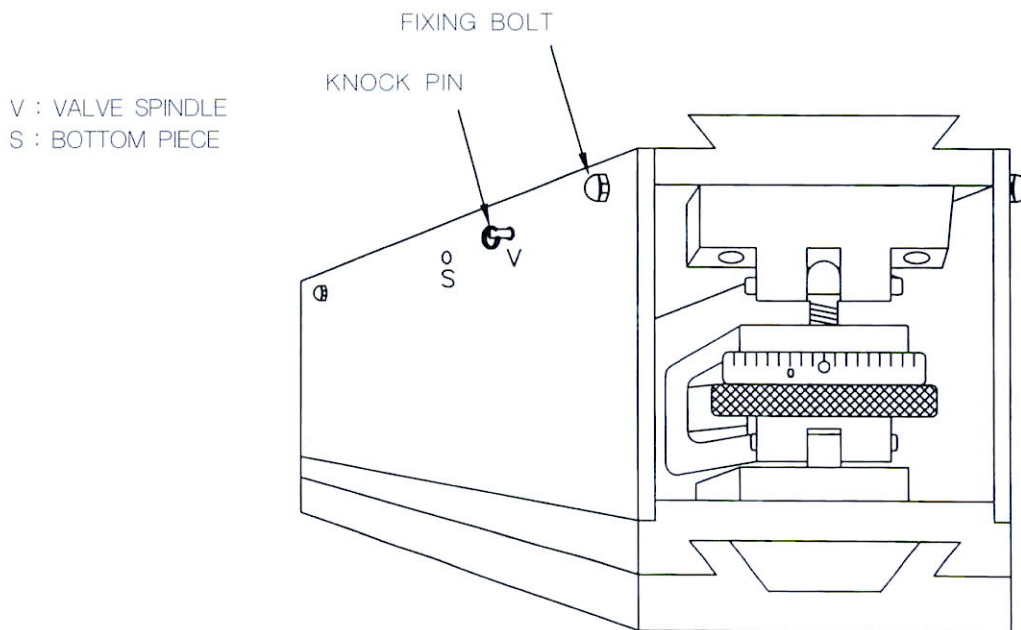
1. Loosen two screws for angle adjustment and lift up the grinder fitting table.
2. Insert the knock pin into hole for V(Valve spindle) or S(Bottom piece).
3. Tighten four screws for angle adjustment.

1-5) METHOD OF ADJUSTMENT FOR GRINDING ANGLE OF VALVE SPINDLE & BOTTOM PIECE

This grinding machine is designed and manufactured to adjust the angle simply to valve spindle and bottom piece mentioned on page 3(SPECIFICATION/Angle Table) with knock pin "V" and "S". If the valve spindle and bottom piece should be adjust with mentioned angle on page 2, below mentioned procedure should be taken.

- 1) Unscrew both fixing bolts on upper slide. (Fig. 8)
- 2) Adjust the saddle to coincide the knock pin hole with the hole on side plate. (Refer to Fig. 8)
- 3) Put the knock pin to the hole with "V" for valve spindle or "S" for bottom piece.
- 4) Tighten both fixing bolts on upper slide.
- 5) Release both fixing bolts fixed on the upper slide. (Fig. 8)
- 6) Check if knock-pin is exactly located at bottom piece or valve spindle.
- 7) Set Dial memory at "O" with set screw when knock-pin is placed at the grinding angle of bottom piece or valve spindle, then pull out knock-pin.
- 8) Turn the dial memory to requested angle.
- 9) A small scale is 1' and a big scale is 0.1°, when turn dial memory to counter-clockwise with a scale at "O" setting point.
- 10) When an adjustment of angle is set, fix and fasten bolts of upper slide
- 11) Limits for the adjustment of angle : 29.0°~31.0°



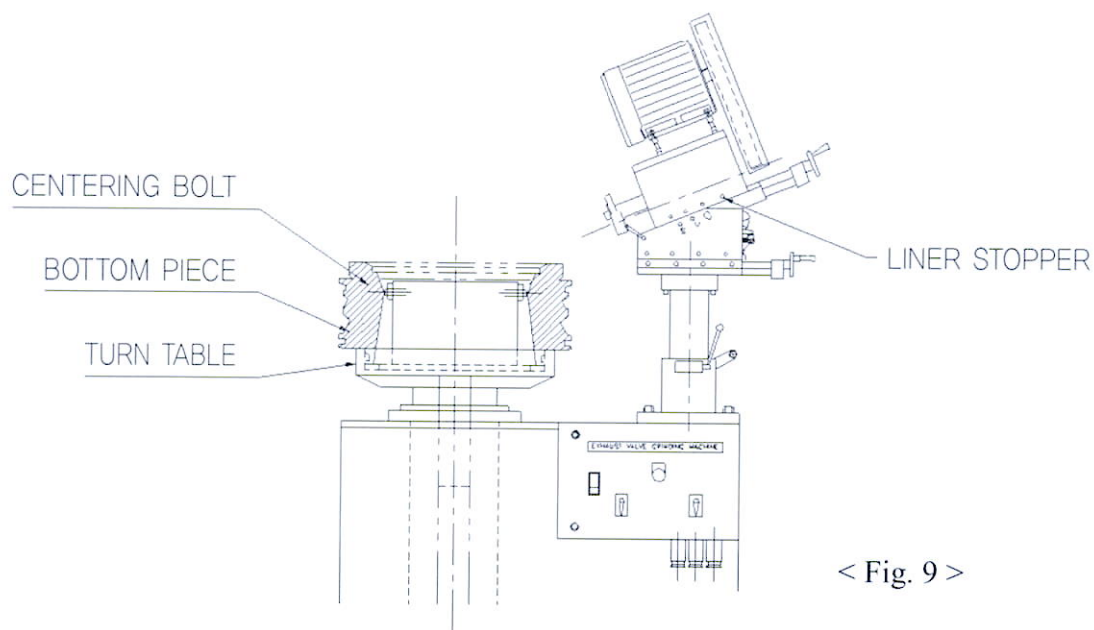


< Fig. 8 >

2. BOTTOM PIECE

2-1) MOUNTING THE BOTTOM PIECE

- a) Clean the Bottom piece thoroughly with light oil.
- b) Mount the Bottom piece on the turn table as shown on below figure. (Fig. 9)
- c) Place the dial gauge on the slide unit and seat area for Bottom Piece and adjust the centering by centering bolts to obtain a run out within 0.02mm.
- d) This machine is designed so that deflection of the core(Run out) for Bottom Piece is within 0.02mm. If deflection(Run out) exceeds 0.02mm, clean the contact area between the Bottom Piece and turn table.



< Fig. 9 >

2-2) GRINDING FOR BOTTOM PIECE

- a) Loosen two bolts for cover of grinding stone and place the cover correctly.
- b) Set the grinding angle to S(Bottom Piece) with knock pin.
- c) Set grinding stone for rough grinding. (An installed stone in delivery)
- d) Push the "power on" switch on the control panel.
- e) Select the "SEAT" switch for turn table.
- f) Select the "motor on" switch for grinder drive. (grinding stone)
- g) Before grinding the Bottom Piece, please check the grinding stone condition.
- h) Move grinding stone to the upper side of seat area for Bottom Piece by turning the feed handle.
- i) Lower the slide by turning slide handle where grinding stone is just contact with seat area and set the dial a zero on the scale.
- j) Set the depth of cut to 0.02mm(four graduations) or less and perform several coarse grinding by operation of the feed handle for grinder sliding back and forth.

NOTE : All cutting operation should be done by moving the grinding stone up the down.

- K) Check the entire seat surface has been coarsely ground.
- l) When grinding is finished, switch off all motor after whole surface of grinding stone is detached from the seat area.
- m) Replace the Rough Grinding stone with the Fine Grinding stone.
- n) Select the switches on all motors and place the grinding stone to be fully contacted with seat area. (Refer to procedure for valve spindle)
- o) Set the depth of cut to 0.01mm(two graduation) or less and perform the fine grinding by moving slowly the grinding stone.

2-3) THE ANGLE OF GRINDING SLIDE TABLE ; PLEASE REFER TO 1-4).

2-4) METHOD OF ADJUSTMENT FOR GRINDING ANGLE ; PLEASE REFER TO 1-5).

3. DRESSING FOR GRINDING STONE

3-1) DRESSING IS REQUIRED IN THE FOLLOWING CASES :

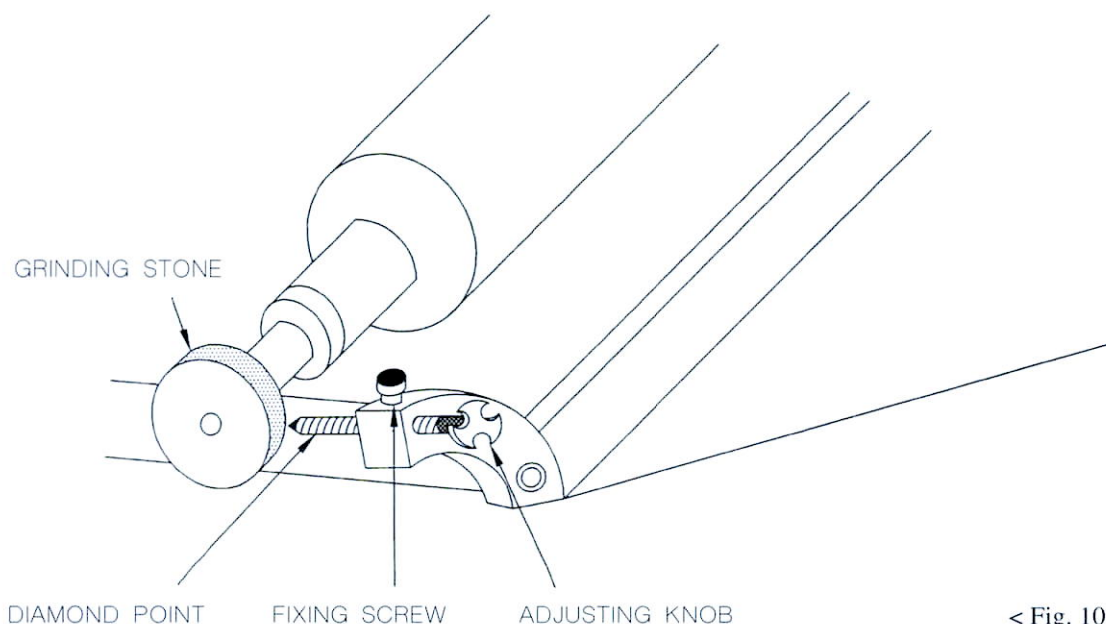
- a) When the grinding stone is changed.
- b) when the grinding stone is retightened.
- c) When the grinding stone becomes blocked.

NOTE : "BLOCKED" means that the grinding surface of stone turned brown for rough stone and clogged for fine stone during grinding.

3-2) DRESSING PROCEDURE :

- a) Move the feed handle for grinder forward.
(Move the grinding stone up to the dresser diamond point)
- b) Adjust the contact of the diamond point and the surface of the grinding stone with the dresser adjusting knob.
- c) Select the grinding motor switch on.
- d) Fix the dresser with the fixing screw, after adjusting the contact.
- e) Turn the feed handle slowly up and down few times.
- f) After dressing, the motor should be "off" and the diamond point should be retarded and locked at original position.

NOTE : Impacts against the diamond point or excess corrective machining allowance will damage the diamond point and cause abnormal wear of the grinding stone.



< Fig. 10 >

4. How to measure an angle with an Angle Tool Piece

Setting an "Angle Tool Piece", measure an exact angle by following methods.
(In case of B & W 70MC)

SPECIFICATION

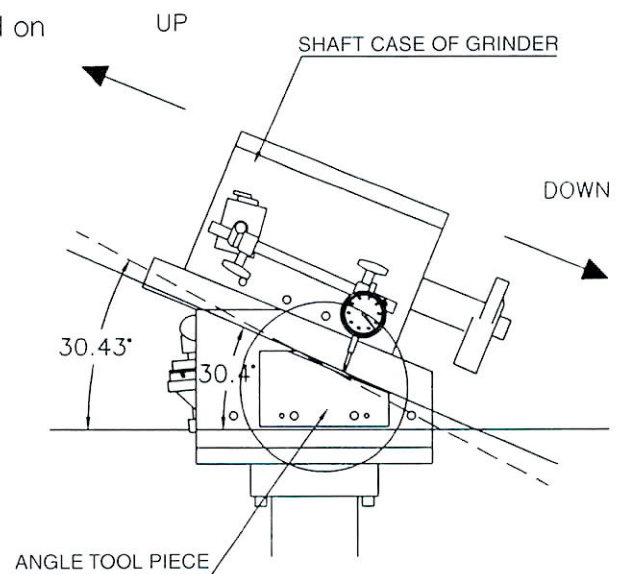
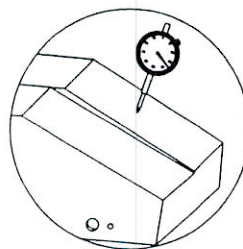
ANGLE TABLE

ENGINE MODEL	MODEL NAME	ROTATION OF TURN TABLE	THE ANGLE OF GRINDING		ROTATION OF GRINDER SHAFT	SIZE OF GRINDER STONE	MOTOR	
			VALVE SPINDLE	BOTTOM PIECE			GRINDER	TURN TABLE
B&W 42MC/-C	NKK 42BG	4.0RPM	30.3° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$	3,350RPM	ROUGH Ø100×Ø32×W13 FINE Ø100×Ø32×W15	750W	400W
B&W 46MC/-C	NKK 46BG	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 50MC/-C	NKK 50BG	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
			30.5° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 60MC/-C	NKK 60BG	4.0RPM	30.3° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 70MC/-C	NKK 70BG	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 80MC/-C	NKK 80BG	3.0RPM	30.5° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 90MC/-C	NKK 90BG	3.0RPM	30.7° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 98MC/-C	NKK 98BG	3.0RPM	30.7° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 40ME/-C	NKK 40BG-ME	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 42ME/-C	NKK 42BG-ME							
B&W 46ME/-C	NKK 46BG-ME	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 50ME/-C	NKK 50BG-ME	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
			30.5° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 60ME/-C	NKK 60BG-ME	4.0RPM	30.3° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
			30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 65ME/-C	NKK 65BG-ME	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 70ME/-C	NKK 70BG-ME	4.0RPM	30.4° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 80ME/-C	NKK 80BG-ME	3.0RPM	30.5° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 90ME/-C	NKK 90BG-ME	3.0RPM	30.7° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				
B&W 98ME/-C	NKK 98BG-ME	3.0RPM	30.7° $\begin{smallmatrix} +0.1^{\circ} \\ 0 \end{smallmatrix}$	30° $\begin{smallmatrix} 0 \\ -0.1^{\circ} \end{smallmatrix}$				

4-1) SPINDLE ANGLE SETTING

The exact angle of "Angle tool piece" is marked on individual product. At first, angle tool piece for valve spindle & Bottom piece should be placed on the position of the view(Fig.1).

Move upper slide by 50mm and then check the difference of indication with dial gauge.



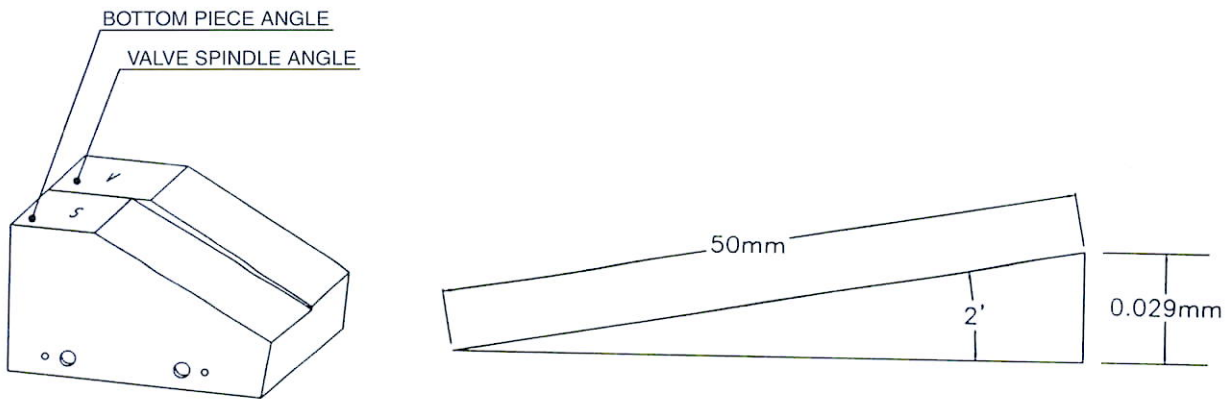
< Fig. 1 >

If the difference is "0" then the up (=grinding angle) inclination is quite same with "angle tool piece".

If the indication with dial gauge at upper position is bigger than lower position, the calculated angle should be added to the angle of "angle tool piece" and vice versa.

For example the tool piece angle is 30.40° and the measuring result is as following, then the angle can be calculated as ;

$$\sin^{-1}(0.029/50) = 0.03323^\circ \div 0.033^\circ$$

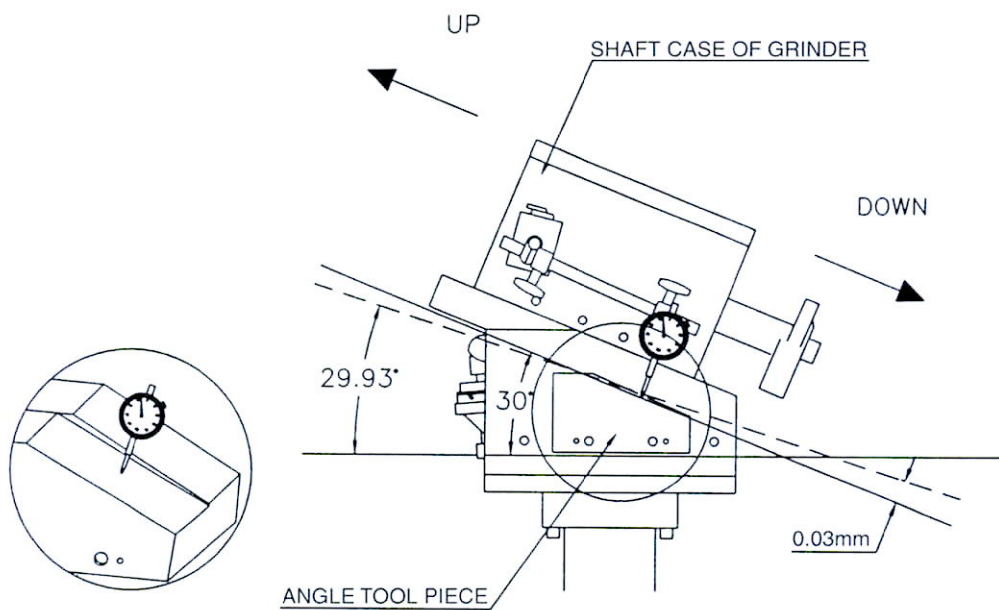


< Fig. II >

Setting angle becomes $30.4^\circ + 0.033^\circ = 30.433^\circ$

4-2) BOTTOM PIECE ANGLE SETTING

: Measuring and calculation method are quite with valve spindle case.

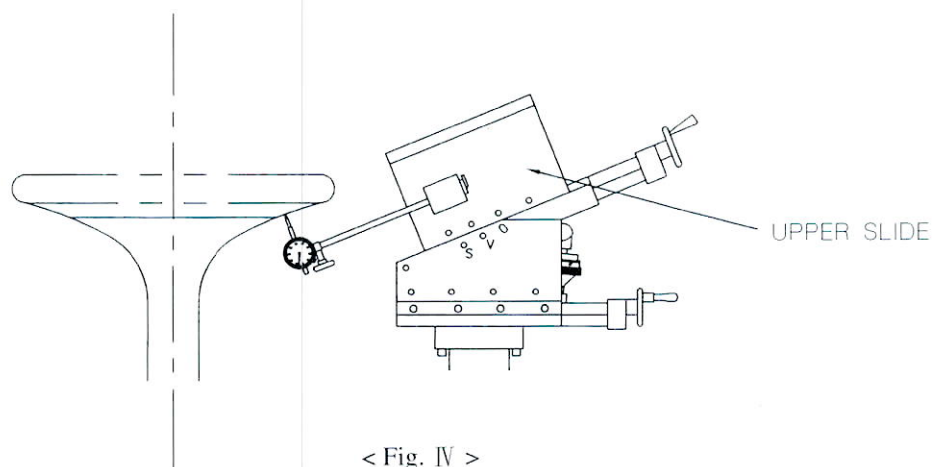


ANGLE TOOL PIECE FOR VALVE SPINDLE

< Fig. III >

5. MEASUREMENT OF FLATNESS

Checking after grinding, using the Dial Gauge. (Refer to Fig.)



After completing all works, install the Dial Gauge Set as Fig. then, check a scale while turning the Upper Slide up and down.

As this point, Do not exceed 0.01mm of scale.

6. CONFIRMATION OF ROUGHNESS

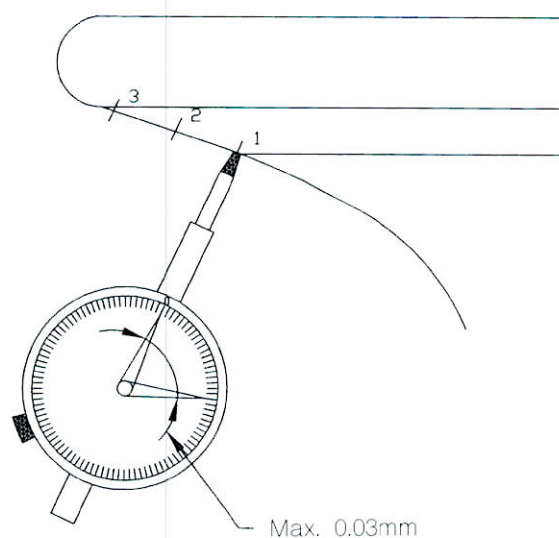
IT should be confirmed by comparing the ground surface and "Rugo tester" supplied.

Surface requirement : R_a 0.8(=N6)

7. MEASUREMENT OF RUN-OUT

Measure while putting V/V Spindle or Bottom Piece on the Grinder and the Dial Gauge on the seat of Spindle or Bottom Piece.

Do adjust between Min. 0.01mm and Max 0.03mm. Refer to Fig. V







BEST QUALITY

KOKACO CO., LTD.

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FAX : +82 - 51 - 403 - 6990

E-MAIL : kksco@unitel.co.kr

TESTING TOOL FOR FUEL VALVE



HANMI POWER

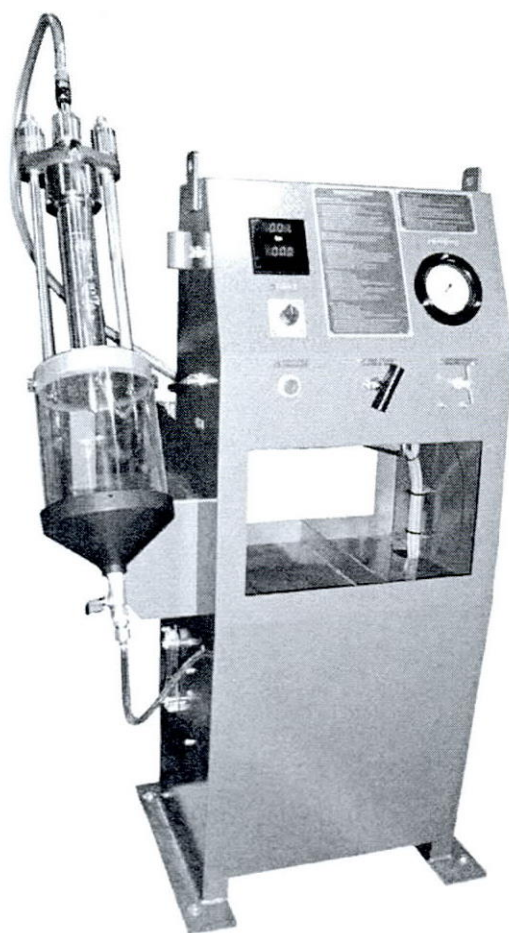
HDFD-1100

MANUAL NO : HDFD-1100-0.13 (2009.12)

INSTRUCTION MANUAL

FUEL VALVE TEST DEVICE

MODEL : HDFD-1100



HANMI HYDRAULIC MACHINERY CO., LTD.
#700-17, Mora-dong, Sasang-ku, Busan, Korea
Tel. +82 51 305 2511-6 / Fax. +82 51 301 1721
E-mail : hm131@kornet.net /



CONTENTS

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B. OPERATION INSTRUCTIONS	PAGE 3
C. TROUBLE-SHOOTING FOR THE HDFD-1100 TEST RIG	PAGE 7
D. OUTLINE OF THE HDFD-1100	PAGE 8
E. OIL CHART	PAGE 9

APPENDIX

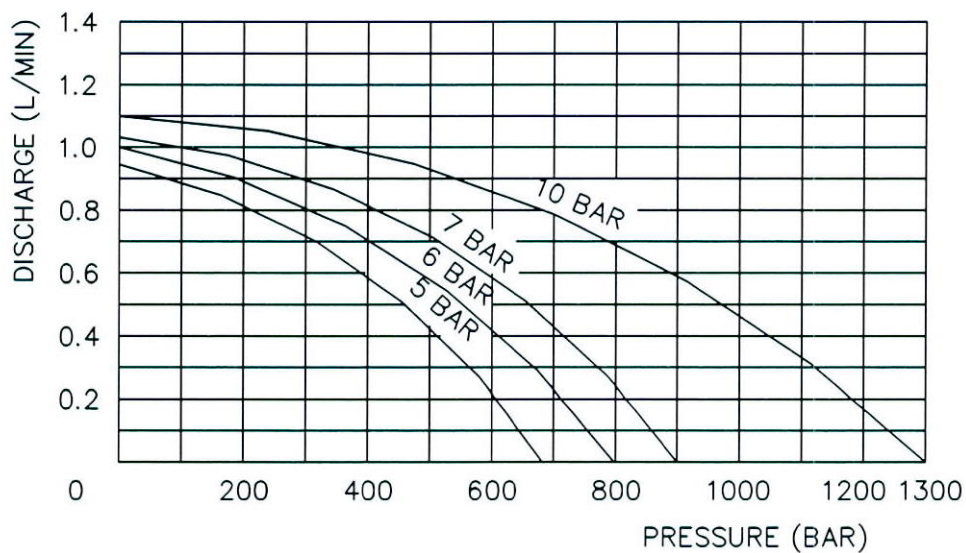
- GENERAL ASSEMBLY	
1)DWG No. M12-7100-0.6(STANDARD).....	PAGE10-1
2)DWG No. M12-7100-2.1(OPTION).....	PAGE10-2
- CIRCUIT DIAGRAM (DWG NO. M12-7100-1).....	PAGE11
- ASSEMBLY DRAWING (DWG NO. M12-1100-0).....	PAGE12
- TOOLS (DWG NO. M12-7112-0).....	PAGE13
- SPARE PARTS (DWG NO. M12-7113-0).....	PAGE14,15



A. SPECIFICATIONS

1. MODEL NO	: HDFD-1100
2. OUTPUT PRESSURE	: 0~1300BAR AT 10BAR AIR INPUT 0~900BAR AT 7BAR AIR INPUT
3. AIR CONSUMPTION	: 60.5LITERS/CYCLE AT 10BAR INPUT 44LITERS/CYCLE AT 7BAR INPUT
4. MAX. FLOW AT NO PRESSURE	: APPROX. 1.2LITERS/MIN AT 7BAR AIR INPUT
5. DISPLACEMENT PER CYCLE	: 17.2cm ³
6. PUMP SPEED	: APPROX. 60 CYCLES/MIN. AT 7BAR AIR INPUT
7. OIL TANK CAPACITY	: 6 LITERS
8. WEIGHT	: ABT. 115kg AT EMPTY
9. DIMENSION	: 885mm X 638mm X 1700mm
10. POWER SUPPLY	: SINGLE PHASE 115~230VAC
11. CLASSIFICATION	: GAUGE-CLASS 1.0, DISPLAY 0.2

PERFORMANCE CURVES





B. OPERATION INSTRUCTIONS

The HDFD-1100 ensures the correct testing of MAN B&W Diesel slide fuel valve.

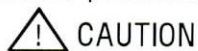
The atomizing test cannot be executed.

The below procedure for fuel-valve testing is to be in compliance with the MAN B&W Diesel A/S guidelines for testing of fuel injection valves. Please refer to the MAN B&W manual for general fuel valve maintenance.

All numbers in the text refer to the numbers found on the HDFD-1100 front panel (see the figure 1, Unit Layout illustrated overleaf.)

Pre-testing preparations :

Before performing any of the tests, the slide-valve must be completely filled with test-oil :



CAUTION

"A coupling is separately packed when a product is supplied"

When a product is supplied, the coupling is separately packed under an unassembled state.

Assemble the coupling packed in tool box to the product.

(see the figure of page 8, No 10 " fuel outlet" coupling)

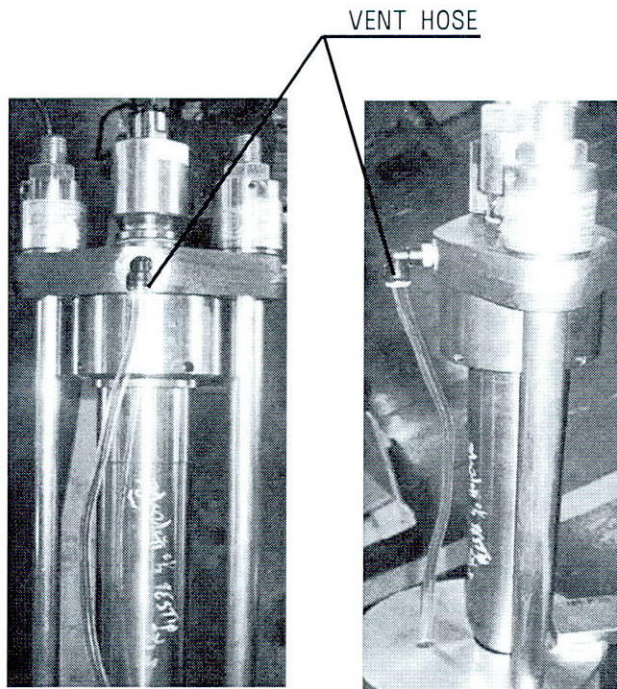
- Turn Switch ⑤ to position OPENING PRESSURE
- Close Pressure Release Valve ② by turning clockwise
- Turn Pressure Control Valve ③ clockwise, until the WORKING PRESSURE Display ④ shows a pressure above zero*
- The valve is now filled with oil. When clear oil without air-bubbles tickles from the venting hole through the breathing-pipe, the valve is full

⚠ Please connect vent hose to valve venting hole in advance. (See next page picture: vent hose)

But in case of O-ring seal test, remove the vent hose, then block vent hole to use plug.

- Turn Pressure Control Valve ③ counter-clockwise to switch off air supply
- Open Pressure Release Valve ② by turning counter-clockwise

* NOTE: The HDFD-1100 FUNCTION may be activated during this process, which stop operation. Turn Switch ⑤ to RESET and back to OPENING PRESSURE to resume pre-testing preparations.



(Figure. VENT HOSE)



In case of following function test please make sure to connect vent hose to fuel valve.

- Venting function.
- Opening pressure.
- Leak test.

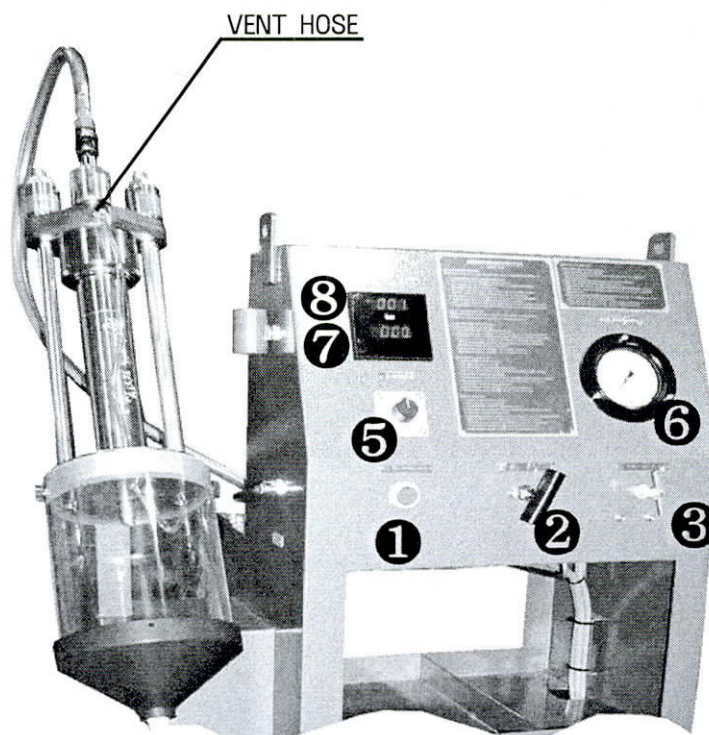


If fuel valve vent hole is blocked by plug Oil is not spray.

Test A : Venting function

Before performing any of the tests, the slide-valve must be completely filled with test-oil, as described in the section "Pre-testing preparations".

- Turn Switch ⑤ to RESET position
- Close Pressure Release Valve ②
- Turn Switch ⑤ to VENTING PRESSURE position
- Slowly adjust Pressure Control Valve ③ until the system automatic turns off the Air pump 150 bar
- The pressure will slowly decrease on the WORKING PRESSURE Display ⑧. When the internal leak slide valve opens, the venting pressure is shown on OPENING + VENTING PRESSURE Display ⑦.
- Close pressure control valve ③ - turn it counter-clockwise
- Open Pressure Release Valve ② - turn it counter-clockwise



(Figure 1, Unit Layout)

- ① Full Stroke Push Button
 - ② Pressure Release Valve
 - ③ Pressure Control Valve
 - ⑤ Switch (VENTING / RESET / OPENING)
 - ⑥ Air Pressure Gauge (0~10bar)
 - ⑦ Pressure Display (VENTING + OPENING PRESSURE)
 - ⑧ Pressure Display (WORKING PRESSURE)
-



Test B : Opening pressure

The atomizing test cannot be executed.

- Turn Switch ⑤ to RESET position.
- Close Pressure Release Valve ②
- Turn Switch ⑤ to OPENING PRESSURE position
- Slowly adjust Pressure Control Valve ③ until WORKING PRESSURE ⑧ is around 150bar
- Press FULL STROKE Push Button ①
- Increase pressure using Pressure Control Valve ③ until opening pressure is reached
- The opening pressure is shown on the OPENING + VENTING PRESSURE Display ⑦ the pump stops automatically
- Close Pressure Control Valve ③ - turn it counter-clockwise
- Open Pressure Release Valve ② - turn it counter-clockwise

Test C : Leak Test

- Turn Switch ⑤ to RESET position
- Close Pressure Release Valve ②
- Turn Switch ⑤ to OPENING PRESSURE position
- Slowly adjust Pressure Control Valve ③ until WORKING PRESSURE ⑧ is around 150bar
- Press FULL STROKE Push Button ①
- Slowly Adjust pressure using Pressure Control Valve ③ until displayed WORKING PRESSURE ⑧ is 10-20bar below the opening pressure measured in Test B
- Close Pressure Control Valve ③ - turn it counter-clockwise
- Open Pressure Release Valve ② - turn it counter-clockwise

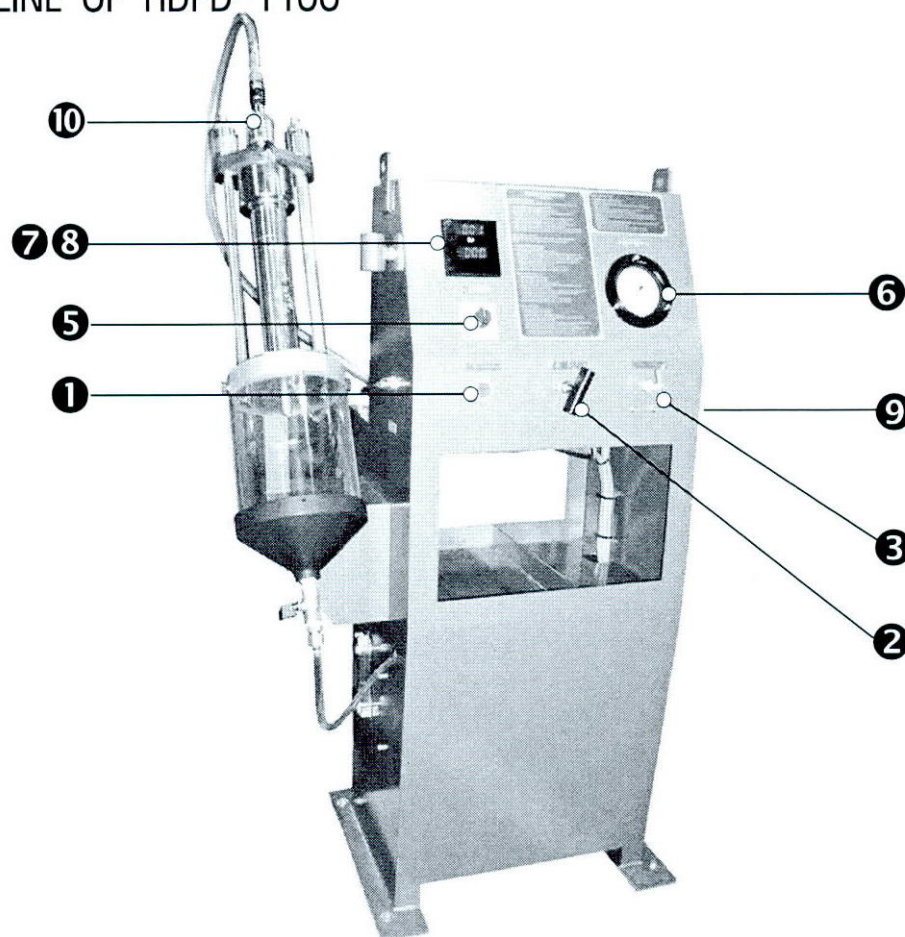
Test D : O-ring Seal Test

- Turn Switch ⑤ to RESET position
- Close Pressure Release Valve ②
- Dismantle breathing pipe from the venting hole in the fuel-injection valve head/fixture
- Plug venting hole with plug supplied with the valve holder
- Turn Switch ⑤ to VENTING PRESSURE position
- Slowly adjust Pressure Control Valve ③ until WORKING PRESSURE ⑧ is around 100bar
- Decrease air pressure using Pressure Control Valve ③ until manometer ⑥ reads 0bar
- Read pressure from WORKING PRESSURE Display ⑧. The displayed pressure should remain stable for a few minutes
- Close Pressure Control Valve ③ - turn it counter-clockwise
- Open Pressure Release Valve ② - turn it counter-clockwise



C. TROUBLE-SHOOTING FOR THE HDFD-1100 TEST RIG

Problem	Possible solution	Explanation	Remark
No tests can be performed Inlet pressure reads 0bar at all times (air pressure gauge ⑥ although air supply is working	Turn Switch ⑤ to RESET and back to OPENING PRESSURE	When the electronic blocking system in the HDFD-1100 is activated, air supply to the unit is blocked. The magnet valve is "released" by resetting the unit.	
Air supply is turned off almost immediately after test is started	Make sure that the valve is filled with oil (clear oil is tickling from venting hole when Pressure Control Valve ③ is turned a few times (clockwise) before attempting to run a test. Follow instruction above test A before attempting to run the desired test again	Air inside the fuel valve results in malfunction of the electronic pressure transmitter.	
Air supply is turned off when Full Stroke Button is pressured	Reset the unit, and start the test again. press the "FULL STROKE" Button ① while the Turn Switch ⑤ to Reset and back to OPENING PRESSURE		
The HDFD-1100 is plugged in and turned on, but air supply is never blocked	Consult with Maker HANMI for maintenance advice.		
The display on the HDFD-1100 box is not working	Check power supply		

**HANMI POWER****HDFD-1100****FUEL VALVE TEST DEVICE****D. OUTLINE OF HDFD-1100**

Pos. 1	Full Stroke Valve (Push Button)	(HM-FD01-01)
Pos. 2	Pressure Release Valve	(HM-FD04-02)
Pos. 3	Pressure Control Valve / pneumatic reducing valve	(HM-FD04-03)
Pos. 4	Pressure transducer (inside HDFD unit)	(HM-FD04-04)
Pos. 5	Switch (VENTING PRESSURE/RESET/OPENING PRESSURE)	(HM-FD04-05)
Pos. 6	Air Pressure Gauge for "Inlet air pressure"(0~10bar)	(HM-FD04-06)
Pos. 7+8	Pressure Display with two displays	(HM-FD04-07)
Pos. 9	Adapter "air inlet"M42x2	
Pos. 10	High Pressure Outlet "fuel outlet"	(HM-FD04-10)
Pos. 11	Filler cap with strainer (inside HDFD unit)	(HM-FD04-11)
Pos. 12	Oil filter (inside oil tank)	(HM-FD04-12)
Pos. 13	2-Way pneumatic valve(inside HDFD unit)	(HM-FD04-13)
Pos. 14	Pump AHP-1100(inside HDFD unit)	(12-1100-0.0)



E. OIL CHART

1. Recommendable Oil for Testing

Rust-preventing hydraulic oil with viscosity of 7-10 cST at 50°C.

2. Initial Filling Quantity

Fill the oil until the level gauge indicates between High and Low.

No further replenishment of the oil is required thanks to the close circuit.

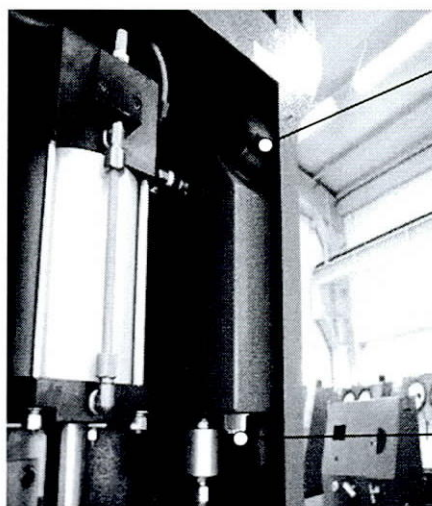
(see figure 2, Oil level gauge)

3. Draining oil

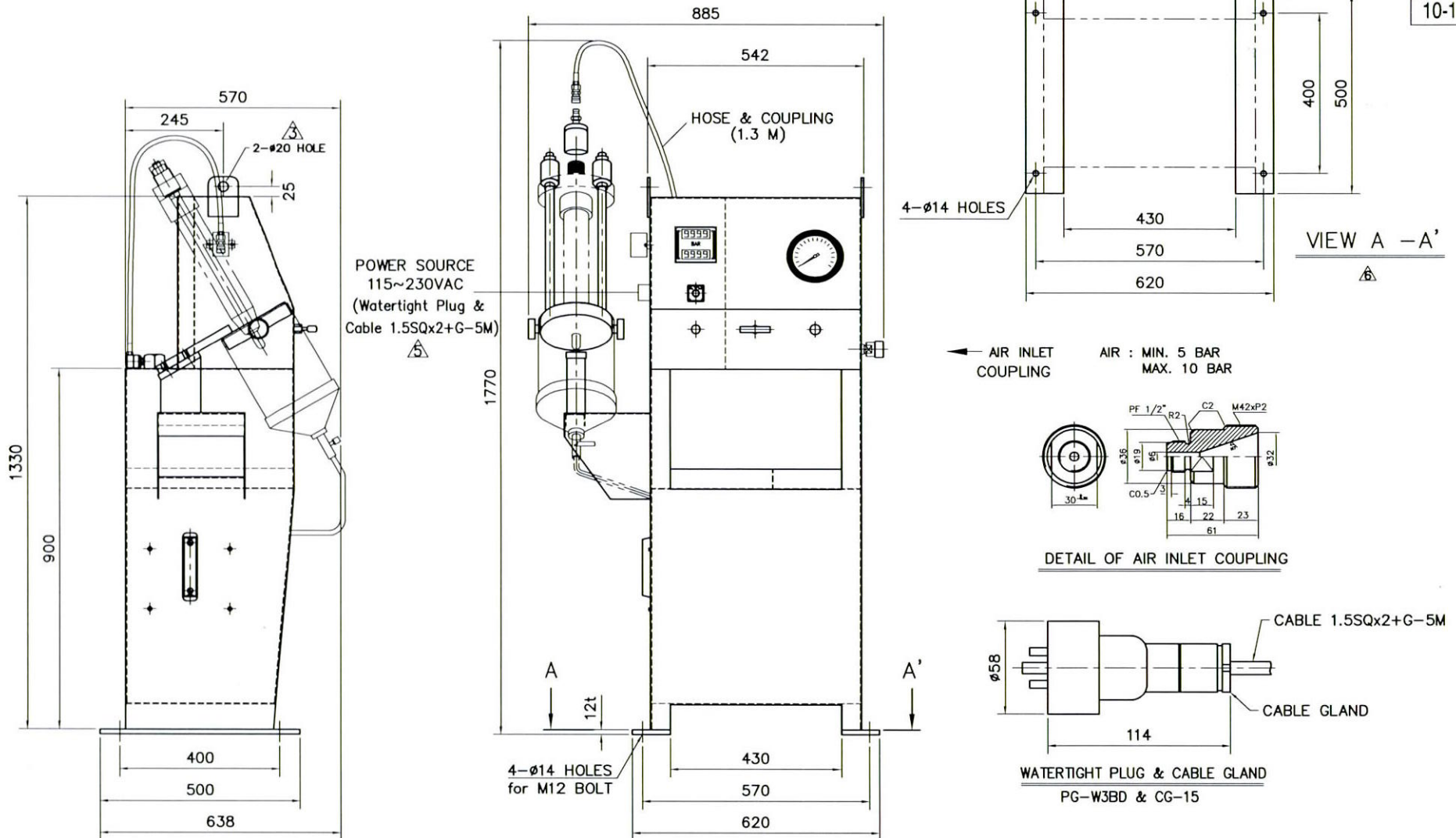
(see figure 3, Oil tank)



(figure 2, Oil level gauge)

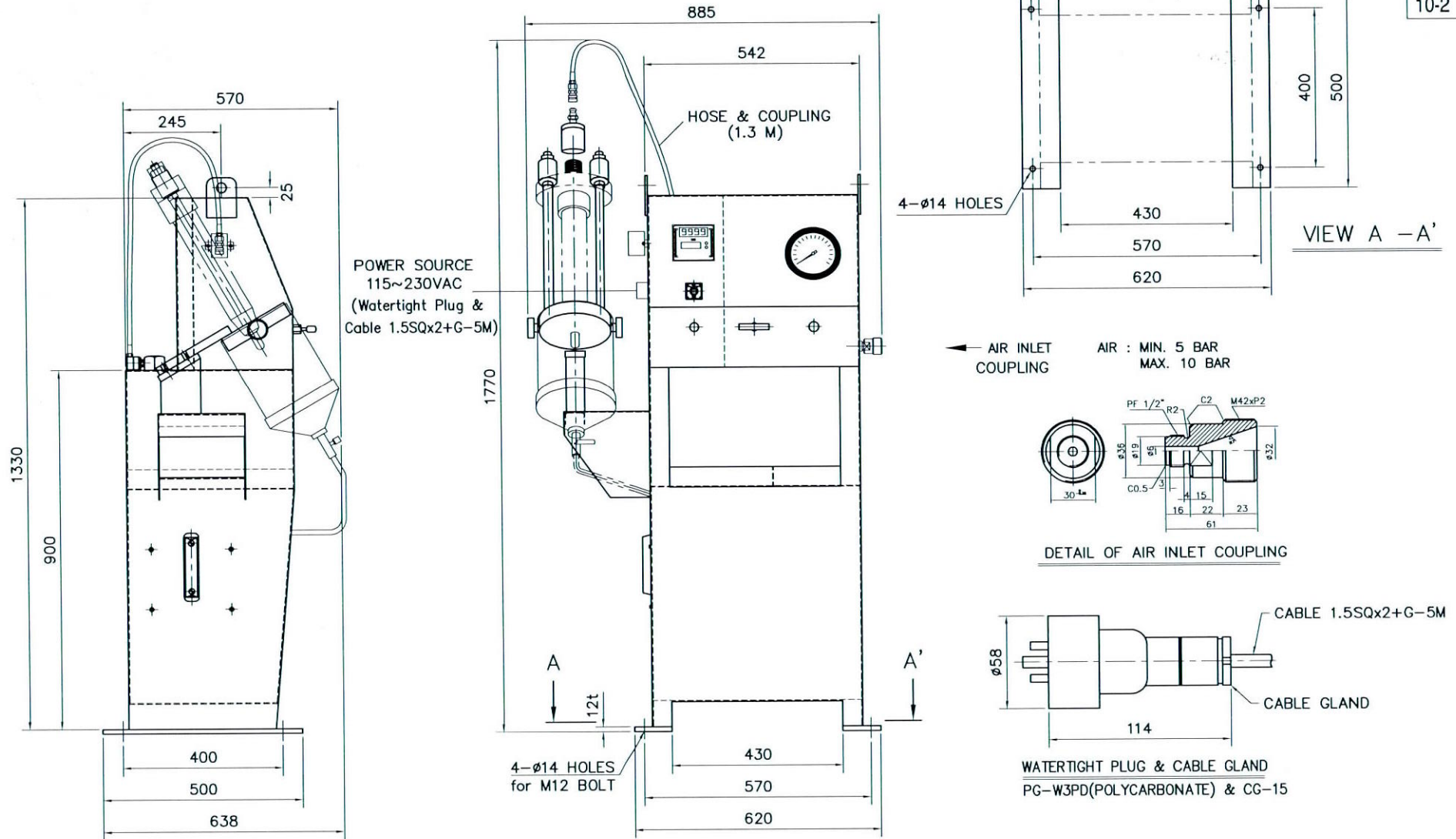


(figure 3, Oil tank)



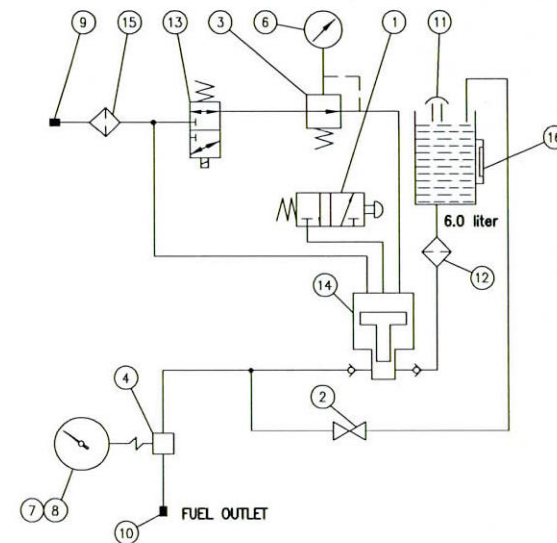
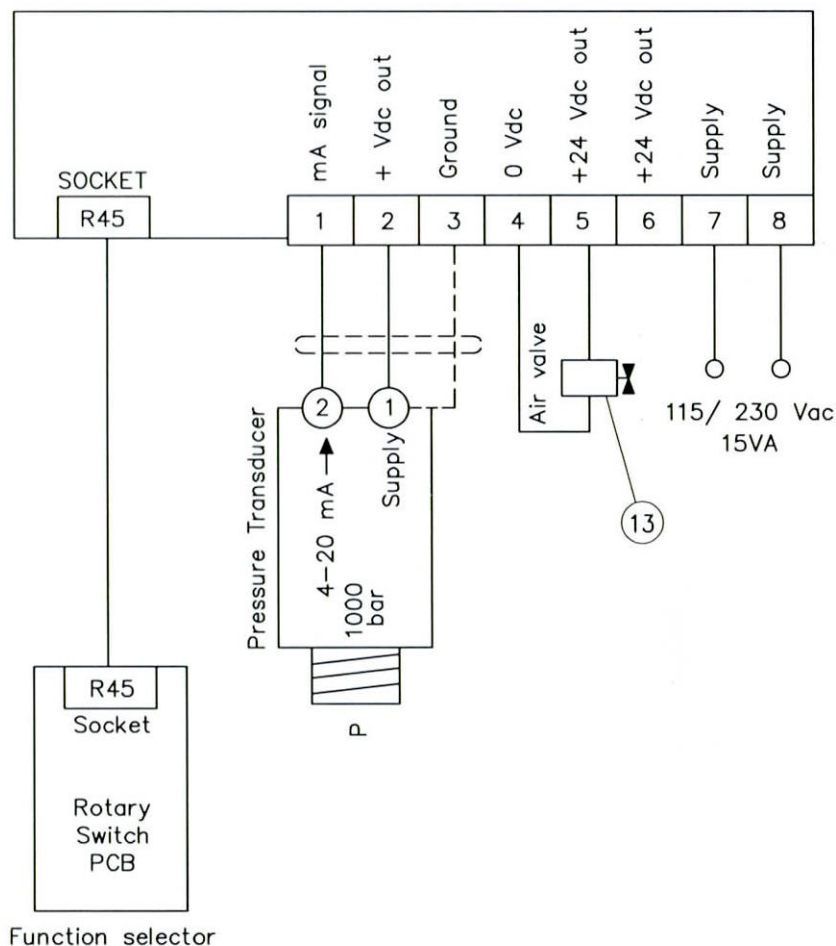
	080618	DEL:  	D.H.KOO	B.C.KIM	M.W.CHOI
	070702	CABLE 2SQ --> 1.5SQ, DEL. 700mm	D.H.KOO	B.C.KIM	M.W.CHOI
	061123	CABLE 1.25SQ --> 2SQ	D.H.KOO	B.C.KIM	M.W.CHOI
	061109	ADDED SUPPORT	D.H.KOO	B.C.KIM	M.W.CHOI
	050217	Revision of controller	D.H.KOO	B.C.KIM	M.W.CHOI
	040920	Addition of mounting plate.	D.H.KOO	D.H.KOO	M.W.CHOI
REV.	DATE	REASON FOR MODIFICATION	REV'D	CHK'D	APP'D

APPROVED M.W.CHOI	SCALE 1 / 10	PROJECT FUEL VALVE TEST DEVICE (HDFD-1100)	PROJECTION
CHECKED D.H.KOO	DATE 040920	TITLE GENERAL ASSEMBLY	
DESIGNED S.Y.CHOI	 HANMI HYDRAULIC MACHINERY CO., LTD.		DRAWING NO. M12-7100-0.6



△	090304	MOUNTING PLATE 삭제.	J.W.JUNG	B.C.KIM	M.W.CHOI
△	070702	APP. HMD	D.H.KOO	B.C.KIM	M.W.CHOI
REV.	DATE	REASON FOR MODIFICATION	REV'D	CHK'D	APP'D

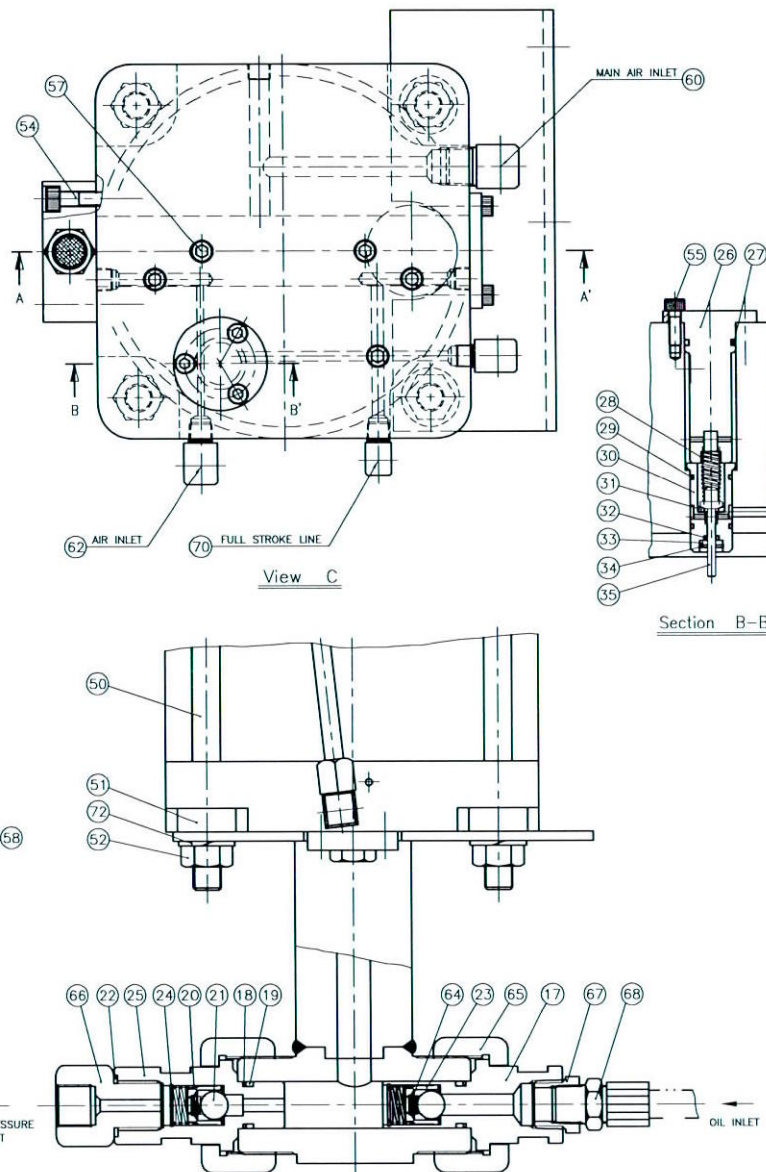
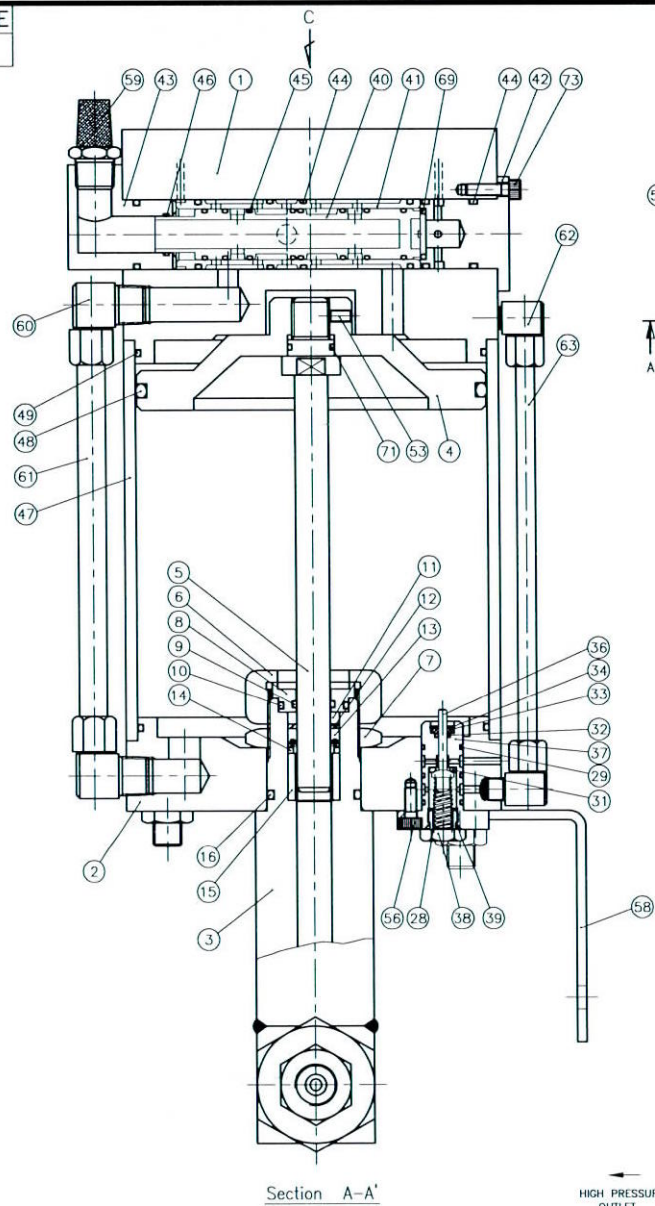
APPROVED M.W.CHOI	SCALE 1 / 10	PROJECT FUEL VALVE TEST DEVICE (HDFD-1100)	PROJECTION
CHECKED D.H.KOO	DATE 070702	TITLE GENERAL ASSEMBLY	
DESIGNED S.Y.CHOI		HANMI HYDRAULIC MACHINERY CO., LTD.	DRAWING NO. M12-7100-2.1



- | | |
|--|-------------|
| 1. FULL STROKE VALVE | HM-FD04-01 |
| 2. PRESSURE RELEASE VALVE | HM-FD04-02 |
| 3. PRESSURE CONTROL VALVE | HM-FD04-03 |
| 4. PRESSURE TRANSDUCER (INSIDE HDFS UNIT) | HM-FD04-04 |
| 5. TURN SWITCH (VENTING PRESSURE/RESET/OPENING PRESSURE) | HM-FD04-05 |
| 6. AIR PRESSURE GAUGE (0~10bar) | HM-FD04-06 |
| 7+8. PROGRAMMABLE DISPLAY | HM-FD04-07 |
| 9. AIR INLET WITH ADAPTER (M42x2P) | |
| 10. HIGH PRESSURE OUTLET | HM-FD04-10 |
| 11. FILLER CAP WITH STRAINER (INSIDE HDFS UNIT) | HM-FD04-11 |
| 12. OIL FILTER (INSIDE OIL TANK) | HM-FD04-12 |
| 13. 2-WAY PNEUMATIC VALVE | HM-FD04-13 |
| 14. PUMP AHP-1100 (INSIDE HDFS UNIT) | 12-1100-0.0 |
| 15. AUTO DRAIN FILTER (INSIDE HDFS UNIT) | HM-FD04-15 |
| 16. OIL LEVEL GAUGE | HM-FD04-16 |

△	050218	Revision of controller.	D.H.KOO	B.C.KIM	M.W.CHOI
△	050201	Revision of power source.	D.H.KOO	B.C.KIM	M.W.CHOI
REV.	DATE	REASON FOR MODIFICATION	REV'D	CHK'D	APP'D

APPROVED M.W.CHOI	SCALE N / S	PROJECT FUEL VALVE TEST DEVICE (HDFS-1100)	PROJECTION
CHECKED D.H.KOO	DATE 04.9.20	TITLE CIRCUIT DRAGRAM	
DESIGNED S.Y.CHOI	HANMI HYDRAULIC MACHINERY CO., LTD.		DRAWING NO. M12-7100-1.3



73	WRENCH BOLT	AP1100-73	12-1173-0	3	
72	SPRING WASHER	AP1100-72	12-1172-0	4	
71	O-RING	AP1100-71	12-1171-0	1	
70	CONNECTOR	AP1100-70	12-1170-0	1	
69	O-RING	AP1100-69	12-1169-0	1	
68	CONNECTOR	AP1100-68	12-1168-0	1	
67	ADAPTER	AP1100-67	12-1167-0	1	
66	ADAPTER	AP1100-66	12-1166-0	1	
65	GLAND NUT	AP1100-65	12-1165-0	2	
64	SPRING	AP1100-64	12-1164-0	2	
63	AIR TUBE	AP1100-63	12-1163-0	1	
62	CONNECTOR	AP1100-62	12-1162-0	3	
61	AIR TUBE	AP1100-61	12-1161-0	1	
60	CONNECTOR	AP1100-60	12-1160-0	3	
59	SILENCER	AP1100-59	12-1159-0	1	
58	BRIDGE	AP1100-58	12-1158-0	1	
57	PLUG	AP1100-57	12-1157-0	7	
56	WRENCH BOLT	AP1100-56	12-1156-0	2	
55	WRENCH BOLT	AP1100-55	12-1155-0	3	
54	WRENCH BOLT	AP1100-54	12-1154-0	2	
53	SET SCREW	AP1100-53	12-1153-0	1	
52	NUT	AP1100-52	12-1152-0	1	
51	WASHER	AP1100-51	12-1151-0	1	
50	TIE ROD	AP1100-50	12-1150-0	4	
49	O-RING	AP1100-49	12-1149-0	2	
48	O-RING	AP1100-48	12-1148-0	1	
47	TUBE	AP1100-47	12-1147-0	1	
46	O-RING	AP1100-46	12-1146-0	1	
45	O-RING	AP1100-45	12-1145-0	8	
44	O-RING	AP1100-44	12-1144-0	7	
43	COVER	AP1100-43	12-1143-0	1	
42	COVER	AP1100-42	12-1142-0	1	
41	SLEEVE	AP1100-41	12-1141-0	1	
40	SPOOL	AP1100-40	12-1140-0	1	
39	O-RING	AP1100-39	12-1139-0	1	
38	PLUG	AP1100-38	12-1138-0	1	
37	UPPER VALVE BODY	AP1100-37	12-1137-0	1	
36	LOWER VALVE	AP1100-36	12-1136-0	1	
35	UPPER VALVE	AP1100-35	12-1135-0	1	
34	SNAP RING	AP1100-34	12-1134-0	2	
33	WASHER	AP1100-33	12-1133-0	2	
32	O-RING	AP1100-32	12-1132-0	2	
31	O-RING	AP1100-31	12-1131-0	2	
30	LOWER VALVE BODY	AP1100-30	12-1130-0	1	
29	O-RING	AP1100-29	12-1129-0	5	
28	SPRING	AP1100-28	12-1128-0	2	
27	O-RING	AP1100-27	12-1127-0	1	
26	VALVE BODY GLAND	AP1100-26	12-1126-0	1	
25	FITTING OUTLET	AP1100-25	12-1125-0	1	
24	SNAP RING	AP1100-24	12-1124-0	2	
23	SPRING CAP	AP1100-23	12-1123-0	2	
22	TREDO JOINT	AP1100-22	12-1122-0	1	
21	BALL	AP1100-21	12-1121-0	2	
20	SPRING	AP1100-20	12-1120-0	2	
19	O-RING	AP1100-19	12-1119-0	2	
18	BACK-UP RING	AP1100-18	12-1118-0	2	
17	FITTING INLET	AP1100-17	12-1117-0	1	
16	O-RING	AP1100-16	12-1116-0	1	
15	BUSHING	AP1100-15	12-1115-0	1	
14	SUPPORT RING	AP1100-14	12-1114-0	1	
13	PACKING SEAL	AP1100-13	12-1113-0	1	
12	BACK-UP RING	AP1100-12	12-1112-0	1	
11	SPACER	AP1100-11	12-1111-0	1	
10	O-RING	AP1100-10	12-1110-0	1	
9	O-RING	AP1100-09	12-1109-0	1	
8	SLEEVE	AP1100-08	12-1108-0	1	
7	NUT	AP1100-07	12-1107-0	1	
6	GLAND NUT	AP1100-06	12-1106-0	1	
5	H.P. PISTON	AP1100-05	12-1105-0	1	
4	AIR PISTON	AP1100-04	12-1104-0	1	
3	H.P. CYLINDER	AP1100-03	12-1103-0	1	
2	BOTTOM CAP	AP1100-02	12-1102-0	1	
1	TOP CAP	AP1100-01	12-1101-0	1	
NO.	DESCRIPTION	OLD DWG. NO.	NEW DWG. NO.	QTY	REMARK
APPROVED	SCALE	PROJECT	AIR DRIVEN HYD' PUMP (AHP-1100)		
M.W. CHOI	N/S	DATE	ASSEMBLY DWG.		
DESIGNED	DATE	DATE			
D.H. KOO	04.9.20				
DRAWN					
S.Y. CHOI					
				DRAWING NO.	
				M12-1100-0.0	

REV.	DATE	REASON FOR MODIFICATION	REV'D	CHK'D	APP'D
△					
△					

QP-052-05 (Rev 0)

(주) 한미유압기계

A3(297x420)

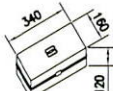
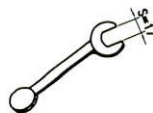
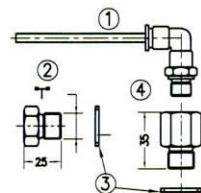
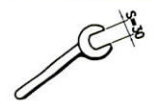
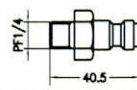
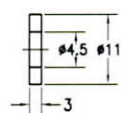
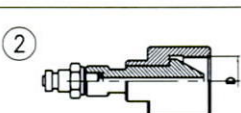
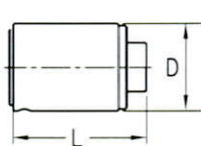
FUEL VALVE TEST DEVICE

TYPE : HDFD-1100

PAGE

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DWG. NO. : M12-7112-0.6

NO.	NAME	SKETCH	MATERIAL	SUPPLY PER SHIP			REMARK																								
				STAND- ARD	ADDI- TION	TOTAL																									
1	BOX		PLASTIC	1	-	1																									
1-1	COMBINATION SPANNER		TOOL STEEL	1	-	1																									
1-2	HEXAGON HEAD PLUG WITH FLANGE AND GASKET		① P.U.R ② STEEL ③ COPPER ④ STEEL	1	-	1	<table><tr><td>"T"</td><td>M16xP1.5</td><td>M18xP1.5</td><td>G 1/4"</td><td>G 3/8"</td></tr><tr><td>S46/50MC-C</td><td>S40ME-B</td><td>S35MC</td><td></td><td></td></tr><tr><td>S50ME-C</td><td>S35ME-B</td><td>S42MC</td><td></td><td>OTHER</td></tr></table> *PRODUCT NO. ④ USE TO S35/40ME-B, S46/50MC-C, S50ME-C ENG.	"T"	M16xP1.5	M18xP1.5	G 1/4"	G 3/8"	S46/50MC-C	S40ME-B	S35MC			S50ME-C	S35ME-B	S42MC		OTHER									
"T"	M16xP1.5	M18xP1.5	G 1/4"	G 3/8"																											
S46/50MC-C	S40ME-B	S35MC																													
S50ME-C	S35ME-B	S42MC		OTHER																											
1-3	SINGLE OPEN ENDED SPANNER		TOOL STEEL	1	-	1																									
1-4	+ DRIVER		-	1	-	1																									
1-5	MALE COUPLER		STEEL	1	-	1																									
1-6	DISC		COPPER	6	-	6																									
1-20	INJECTION NOZZLE	 	STEEL	1	-	1	<table><tr><td></td><td>DIM. (D)</td><td>ENG.</td></tr><tr><td>①</td><td>M24x1.5</td><td>35MC, 42MC, 35ME-B</td></tr><tr><td></td><td>M36x2</td><td>40ME-B, 46MC-C, 50MC, 50MC-C, 50ME-C</td></tr><tr><td>②</td><td>M42x2</td><td>60MC, 60MC-C, 60ME-C, 70MC, 70MC-C, K80MC-C, K90MC-C, K98MC/-C, K98ME</td></tr><tr><td></td><td>M48x3</td><td>S80MC, S80MC-C, S90MC-C, S90ME</td></tr></table>		DIM. (D)	ENG.	①	M24x1.5	35MC, 42MC, 35ME-B		M36x2	40ME-B, 46MC-C, 50MC, 50MC-C, 50ME-C	②	M42x2	60MC, 60MC-C, 60ME-C, 70MC, 70MC-C, K80MC-C, K90MC-C, K98MC/-C, K98ME		M48x3	S80MC, S80MC-C, S90MC-C, S90ME									
	DIM. (D)	ENG.																													
①	M24x1.5	35MC, 42MC, 35ME-B																													
	M36x2	40ME-B, 46MC-C, 50MC, 50MC-C, 50ME-C																													
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	M48x3	S80MC, S80MC-C, S90MC-C, S90ME																													
1-21	SPRING HOUSING		STEEL	2	-	2	<table><tr><td>NO SUPPLY</td><td>46x65L</td><td>46x70L</td></tr><tr><td>40ME-B</td><td>S50MC,</td><td>S80MC,</td></tr><tr><td>35/42MC-MK7</td><td>S60MC,</td><td>K80/K90MC-C,</td></tr><tr><td>35/42MC</td><td>S60MC-C,</td><td>S80/S90MC-C</td></tr><tr><td>S35ME-B</td><td>S60ME-C,</td><td>S90ME</td></tr><tr><td>S50ME-C</td><td>S70MC/-C</td><td>K98MC/-C,</td></tr><tr><td>S46MC-C</td><td></td><td>K98ME</td></tr><tr><td>S50MC-C</td><td></td><td></td></tr></table>	NO SUPPLY	46x65L	46x70L	40ME-B	S50MC,	S80MC,	35/42MC-MK7	S60MC,	K80/K90MC-C,	35/42MC	S60MC-C,	S80/S90MC-C	S35ME-B	S60ME-C,	S90ME	S50ME-C	S70MC/-C	K98MC/-C,	S46MC-C		K98ME	S50MC-C		
NO SUPPLY	46x65L	46x70L																													
40ME-B	S50MC,	S80MC,																													
35/42MC-MK7	S60MC,	K80/K90MC-C,																													
35/42MC	S60MC-C,	S80/S90MC-C																													
S35ME-B	S60ME-C,	S90ME																													
S50ME-C	S70MC/-C	K98MC/-C,																													
S46MC-C		K98ME																													
S50MC-C																															

MANUFACTURER'S NAME



HANMI HYDRAULIC MACHINERY CO., LTD.

SPARE

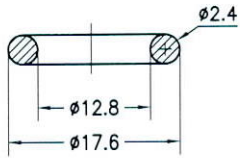
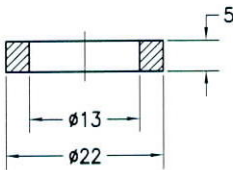
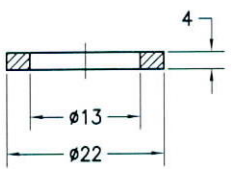
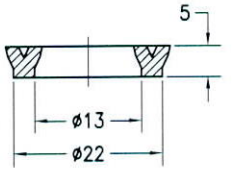
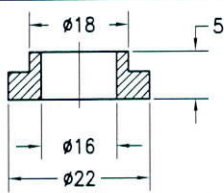
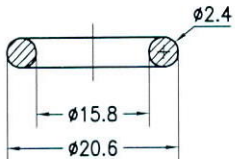
FUEL VALVE TEST DEVICE

PAGE

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TYPE : HDFD-1100

DWG. NO. : M12-7100-0.0 (1/2)

NO.	NAME	SKETCH	MATERIAL	SUPPLY PER SHIP			OLD DWG NO.	NEW DWG NO.	REMARK
				STAND- ARD	ADDITION	TOTAL			
1-7	O-RING		N.B.R	1	-	1	AP1100-09	12-1109-0	
1-8	SPACER		BC3	1	-	1	AP1100-11	12-1111-0	
1-9	BACK-UP RING		TEFLON	1	-	1	AP1100-12	12-1112-0	
1-10	PACKING SEAL		URETANE	1	-	1	AP1100-13	12-1113-0	
1-11	SUPPORT RING		BC3	1	-	1	AP1100-14	12-1114-0	
1-12	O-RING		N.B.R	2	-	2	AP1100-19	12-1119-0	
1-13	BALL		STEEL	2	-	2	AP1100-21	12-1121-0	

MANUFACTURER'S NAME



HANMI HYDRAULIC MACHINERY CO., LTD.

SPARE

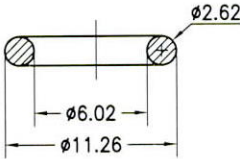
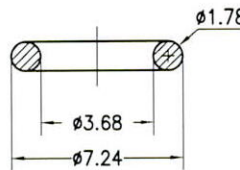
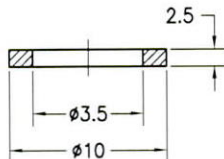
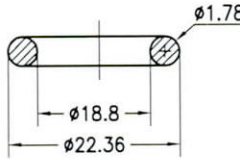
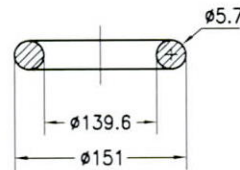
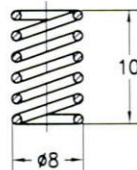
FUEL VALVE TEST DEVICE

PAGE

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TYPE : HDFD-1100

DWG. NO. : M12-7100-0.0 (2/2)

NO.	NAME	SKETCH	MATERIAL	SUPPLY PER SHIP			OLD DWG NO.	NEW DWG NO.	REMARK
				STAND- ARD	ADDIT- ION	TOTAL			
1-14	O-RING		N.B.R	2	-	2	AP1100-31	12-1131-0	
1-15	O-RING		N.B.R	2	-	2	AP1100-32	12-1132-0	
1-16	WASHER		Bc3	2	-	2	AP1100-33	12-1133-0	
1-17	O-RING		N.B.R	8	-	8	AP1100-45	12-1145-0	
1-18	O-RING		N.B.R	1	-	1	AP1100-48	12-1148-0	
1-19	SPRING		SUP10	2	-	2	AP1100-64	12-1164-0	

MANUFACTURER'S NAME



HANMI HYDRAULIC MACHINERY CO., LTD.

**PNEUMATIC-HYDRAULIC HIGH PRESSURE
PUMP**



HANMI POWER

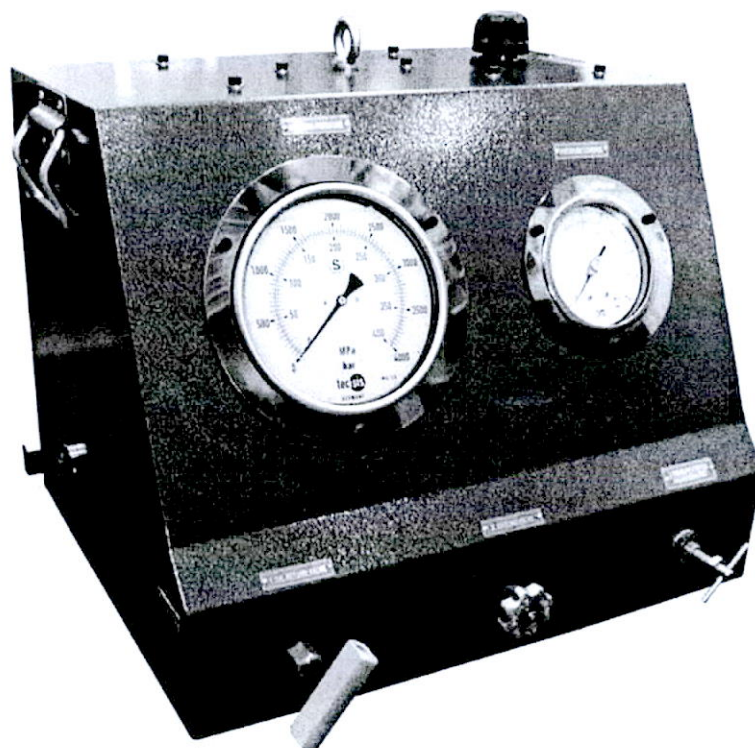
AHP-3500

MANUAL NO : AHP-3500-0.3 (2005.01)

INSTRUCTION MANUAL

AIR DRIVEN HIGH PRESSURE PUMP

MODEL : AHP-3500



HANMI HYDRAULIC MACHINERY CO., LTD.
#700-17, Mora-dong, Sasang-ku, Pusan, Korea
Tel. +82 51 305 2512~4 / Fax. +82 51 301 1721
E-mail : hm131@kornet.net / Hm132@kornet.net



CONTENTS

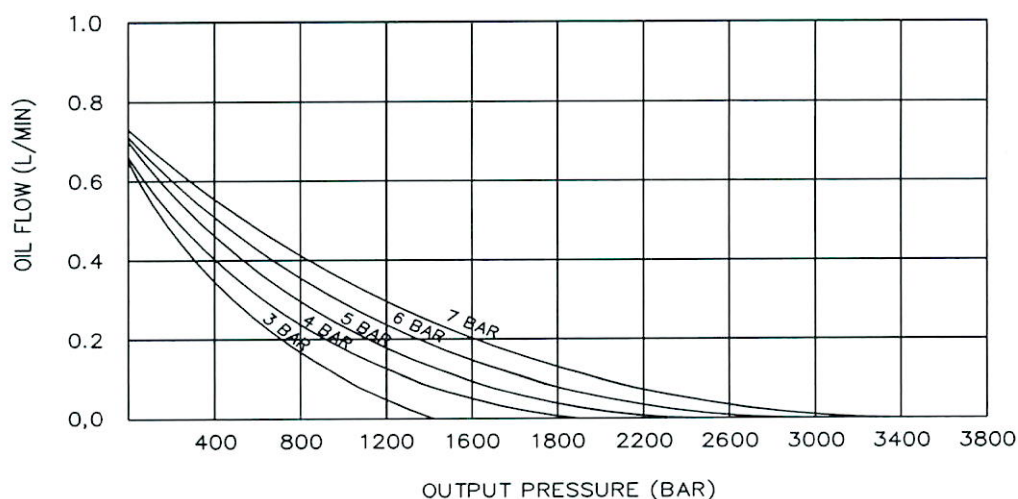
A. SPECIFICATIONS	PAGE 2
B. OUTLINE OF THE AHP-3500	PAGE 3
C. OPERATING MANUAL	PAGE 4
1. BEFORE CONNECTING THE PUMP UNIT	PAGE 4
2. CONNECTION OF PUMP	PAGE 4
3. START OF PUMP	PAGE 4
4. ENDING OF JOB	PAGE 5
5. DATA FOR HIGH PRESSURE	PAGE 5
6. CLEANING OF OIL FILTER	PAGE 5
7. LUBRICATION INSTRUCTION	PAGE 5

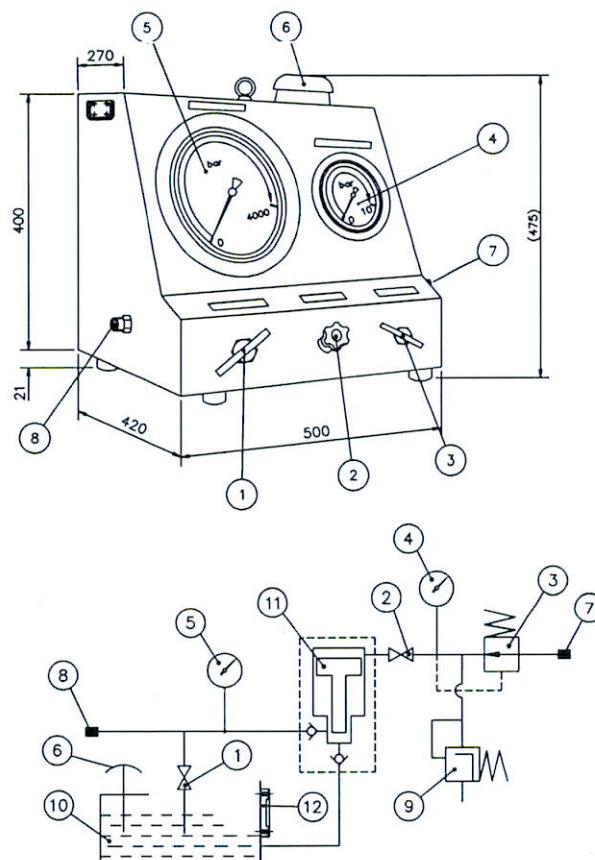
APPENDIX

- ASSEMBLY OF BOOSTER (DWG NO. M10-6100-0.3)
- SPARE PART (DWG NO. M10-6107-0.0)

**HANMI POWER****AHP-3500****HIGH PRESSURE PUMP UNIT****A. SPECIFICATION**

- | | |
|-----------------------------|--|
| 1. MODEL NO. | : AHP-3500 |
| 2. AREA RATIO | : 531 : 1 |
| 3. ACTUAL AREA RATIO | : 500 : 1 |
| 4. AIR CONSUMPTION | : 3200 LITERS/MIN. AT 7 BAR AIR INPUT |
| 5. PUMPING SPEED | : APPROX. 220 CYCLES/MIN. AT 7 BAR AIR INPUT |
| 6. DISPLACEMENT PER CYCLE | : 3.3 cm ³ |
| 7. MAX. FLOW AT N0 PRESSURE | : APPROX. 0.7 LITERS/MIN. AT 7 BAR AIR INPUT |
| 8. TANK CAPACITY | : 8.0 LITER |
| 9. AIR INNER PORT | : 1/2" BSP FEMALE WITH INCREASE TO M42 ADAPTER |
| 10. LIQUID OUTLET PORT | : 1/4" MALE (CEJN 10.125.6203) |
| 11. APPROX. DIMENSION | : 500 x 420 x 475 |
| 12. WEIGHT | : 42 Kg |

PERFORMANCE CURVES

**HANMI POWER****AHP-3500****HIGH PRESSURE PUMP UNIT****B. OUTLINE OF THE AHP-3500**

- | | |
|---|---|
| 1. OIL RETURN VALVE | 8. OIL OUTLET MALE COUPLING
(HIGH PRESSURE OUTLET) |
| 2. AIR STOP VALVE (CYCLING VALVE) | 9. SAFETY VALVE (RELEASE VALVE) |
| 3. AIR PRESSURE CONTROL VALVE | 10. OIL TANK |
| 4. AIR PRESSURE GAUGE FOR PRESSURE CONTROL | 11. PUMP |
| 5. OIL PRESSURE GAUGE FOR WORKING PRESSURE | 12. OIL LEVEL GAUGE |
| 6. AIR BREATHER (FILLER CAP) | |
| 7. AIR INLET (FEMALE COUPLING FOR AIR HOSE) | |



C. OPERATING MANUAL

This instruction has been made to facilitate the understanding of the working principles of the pump unit.

The various control instruments and maneuvering handle are fitted with a number.

These numbers are mentioned in this instruction and are also referring to the numbers found on the drawings showing the complete pump unit.

Furthermore, these numbers are found on the instrument panel of the pump unit.

Please, read this direction of use carefully before using the pump unit and follow the instructions given very carefully.

1. BEFORE CONNECTING THE PUMP UNIT

The tank is filled with oil through the filler cap (6) in the right side of the top panel.

Hydraulic oil : ISO VG22 OF ISO VG32 (MINERAL OIL)

a) Open oil return valve (1) by turning anti-clockwise.

b) The handle of the regulator valve (3) should be turned 4-5 turns anti-clockwise.

This is done to avoid the pump starting at a too high pressure level.

c) Stop valve (2) should be turned clockwise, to close the valve.

This is done to ensure that the pump will not work at will when the primary pneumatic system is connected.

2. CONNECTION OF PUMP

Compressed air is led through a flexible hose and is connected to the stud marked "air inlet" (7) on the right side of the cabinet. This stud has a 1/2" BSP female thread with a 1/4" BSP reduction, accepting either 1/2" or 1/4" hose. To avoid contamination of the pump, it is essential that an effective air filter and water separator is inserted in the air line. A lubro unit should however be avoided - see lubrication instruction on page 4.

The hydraulic system is connected to the stud marked "high pressure outlet" (8) found on the left side of the cabinet. This stud has a 1/4" BSP female thread.

The pump is now ready for use.

3. START OF PUMP

a) Stop valve (2) is turned slowly anti-clockwise, whereby compressed air enters into the pump unit, which commences to work. The stop valve (2) is also acting as a regulator valve for the pumping speed.

b) The regulator valve (3) which is used for adjusting the pressure is now turned clockwise and the hydraulic pressure may now be read on the manometer for pressure control (4)

This manometer shows the hydraulic high pressure in bar.



- c) The oil return valve ① is closed by turning the knob clockwise and the oil will then run from the oil tank into the hydraulic system. When the hydraulic system has been filled, and the pump has stopped operating, the high pressure reached can be read at the manometer for working pressure ⑤ found on the left side of the instrument panel. The pump stops automatically, when the required high pressure has been established and holds it infinitely. The pump starts automatically again if a pressure drop occurs in the hydraulic system.
- d) High pressure may be relieved from the system by opening the oil return valve ① (to be turned anti-clockwise). The excessive oil the secondary high pressure system will thereby return to the oil tank in the pump unit.

4. ENDING OF JOB

To avoid oil spillage, precautions should be taken to see that the oil is taken back into the oil tank before the connections on the high pressure side are disconnected.

This is done by turning the oil return valve ① anti-clockwise.

Simultaneously the pump should be stopped by turning the stop valve ② clockwise, and when this valve has been closed, the air hose may be removed and the pump transferred to another job.

5. DATA FOR HIGH PRESSURE

The pump unit can deliver a maximum pressure of 3500 bar. At an air pressure of 5 bar a safety release valve is in the B+W standard version adjusted to release at a maximum pressure of 2500 bar.

This pressure of 2500 bar (which is preset by the factory) secures the rest of the system from overload or faulty operation. The pump may be re-adjusted to blow off at any desired pressure, but maximum 3500 bar.

The release valve should be set at approx. 10% above the desired working pressure.

6. CLEANING OF OIL FILTER

The filter in the filler cap ⑥ is removed and cleaned when by re-filling the oil starts running through slowly.

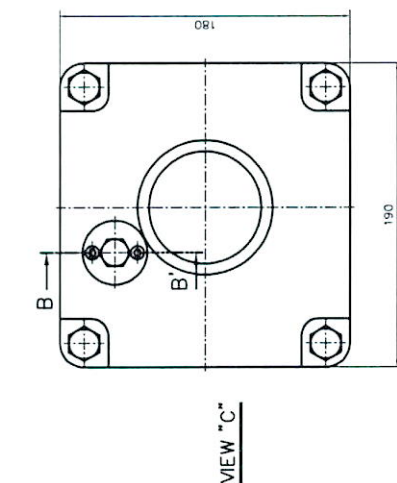
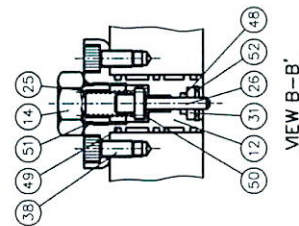
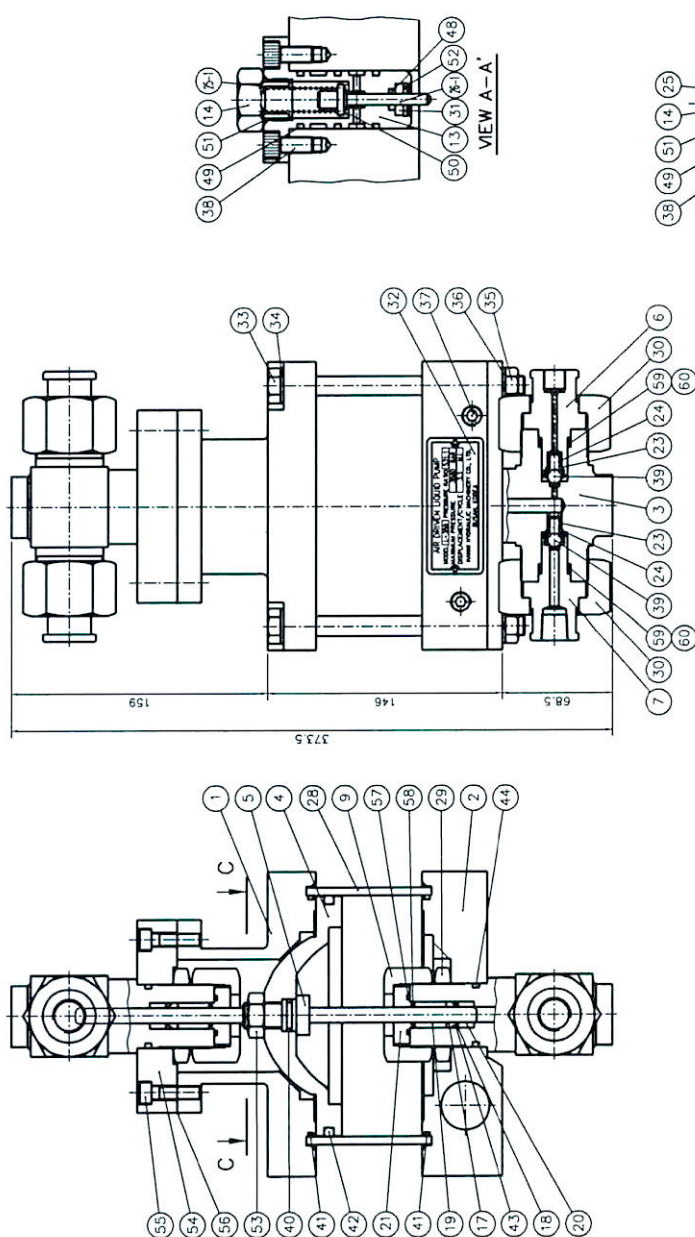
7. LUBRICATION INSTRUCTION

WARNING : AVOID AIR LINE LUBRICATION.

The pump has been pre-lubricated and a lubro unit will decrease the efficiency of the pump. Air valves should be lubricated periodically.

Remove exhaust fittings and valve spool and apply a thin coat of hydraulic grease.

If primary airdrive section is dismantled, always apply a thin coat of hydraulic grease to entire inner surface of cylinder tube plunger O-rings.



NO.	APPROVED	SCALE	N / S	PROJECT	MATERIAL	QTY	REMARK
	M.W. CHOI		DATE	TITLE			
60			03.12.1	PROJECT AIR DRIVEN HYD PUMP (AHP-3500)	10-6160--00	4	
59					10-6158--00	1	
58					10-6158--00	2	
57					10-6157--00	2	
56					10-6156--00	1	
55					10-6155--00	4	
54					10-6154--01	1	
53					10-6153--00	1	
52					SNAP RING	2	
51					O-RING	2	
50					O-RING	2	
49					O-RING	2	
48					O-RING	2	
47					O-RING	6	
46					O-RING	4	
45					O-RING	1	
44					O-RING	1	
43					O-RING	2	
42					O-RING	1	
41					O-RING	2	
40					O-RING	1	
39					O-RING	4	
38					WRENCH BOLT	11	
37					WRENCH BOLT	11	
36					HEX NUT	4	
35					HEX NUT	4	
34					WASHER	4	
33					HEX BOLT	4	
32					NAME PLATE	1	
31					RING	2	
30					GLAND NUT	4	
29					NUT W/SEAL *	2	
28					AIR W/SEAL *	2	
27					PUMP BRACKET	1	
26					PILOT STEW	1	
25					PILOT STEW	1	
24					SPRING	1	
23					SPRING	4	
22					RETAINER	4	
21					FLOW TUBE	1	
20					FLANGE	2	
19					RING	2	
18					RING	2	
17					PACKING SEAL	2	
16					SLEEVE	1	
15					SPOOL	1	
14					PLUG	2	
13					BOTTOM V/V BODY	1	
12					TOP V/V BODY	1	
11					RETAINER	1	
10					RETAINER	1	
9					GASKET	2	
8					FITTING	4	
7					FITTING	4	
6					PISTON	4	
5					PISTON	4	
4					AIR PISTON	1	
3					PUMP BODY	2	
2					BOTTOM CAP	1	
1					TOP CAP	1	

SPARE

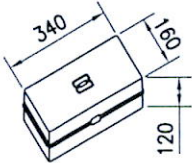
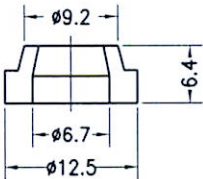
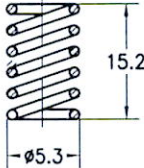
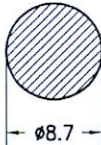
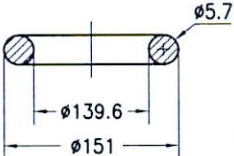
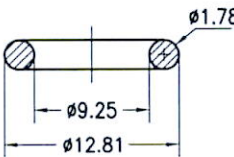
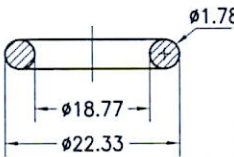
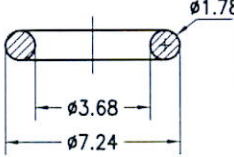
AIR DRIVEN HIGH PRESSURE PUMP

MODEL : AHP-3500

PAGE

7

DWG. NO. M10-6107-0.0

NO.	NAME	SKETCH	MATERIAL	SUPPLY PER SHIP			DRAWING NO.	REMARK (WEIGHT) Kg
				STAND- -ARD	ADDIT- -ION	TOTAL		
1	BOX		PLASTIC	1	-	1		
1-1	PACKING SEAL		UHMWPE	2	-	2	10-6117 -0.0	
1-2	SPRING		SUS304	4	-	4	10-2124 -0.0	
1-3	BALL		STEEL	4	-	4	10-2139 -0.0	
1-4	O-RING		N.B.R	1	-	1	10-2142 -0.0	
1-5	O-RING		N.B.R	2	-	2	10-6143 -0.0	
1-6	O-RING		N.B.R	8	-	8	10-2147 -0.0	
1-7	O-RING		N.B.R	2	-	2	10-2148 -0.0	

MANUFACTURER'S NAME



HANMI HYDRAULIC MACHINERY CO., LTD.

HAND PUMP



HANMI POWER

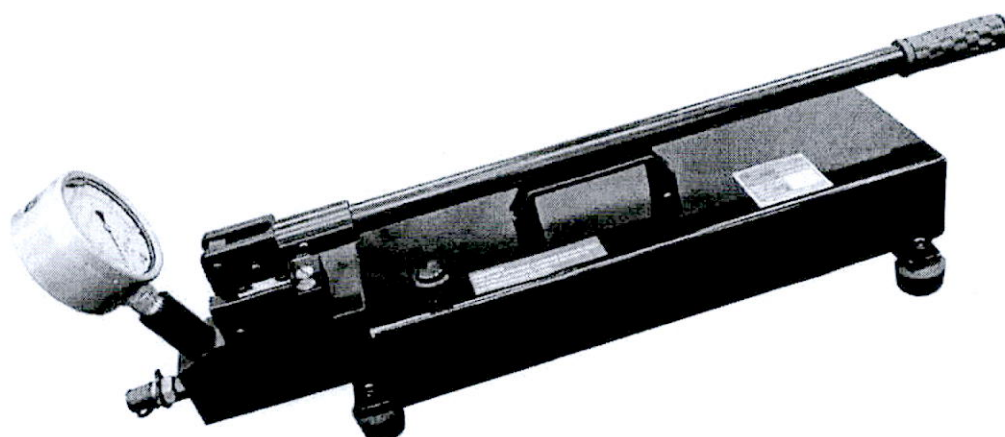
HML-3500

MANUAL NO : HML-3500-0.0(2005.02)

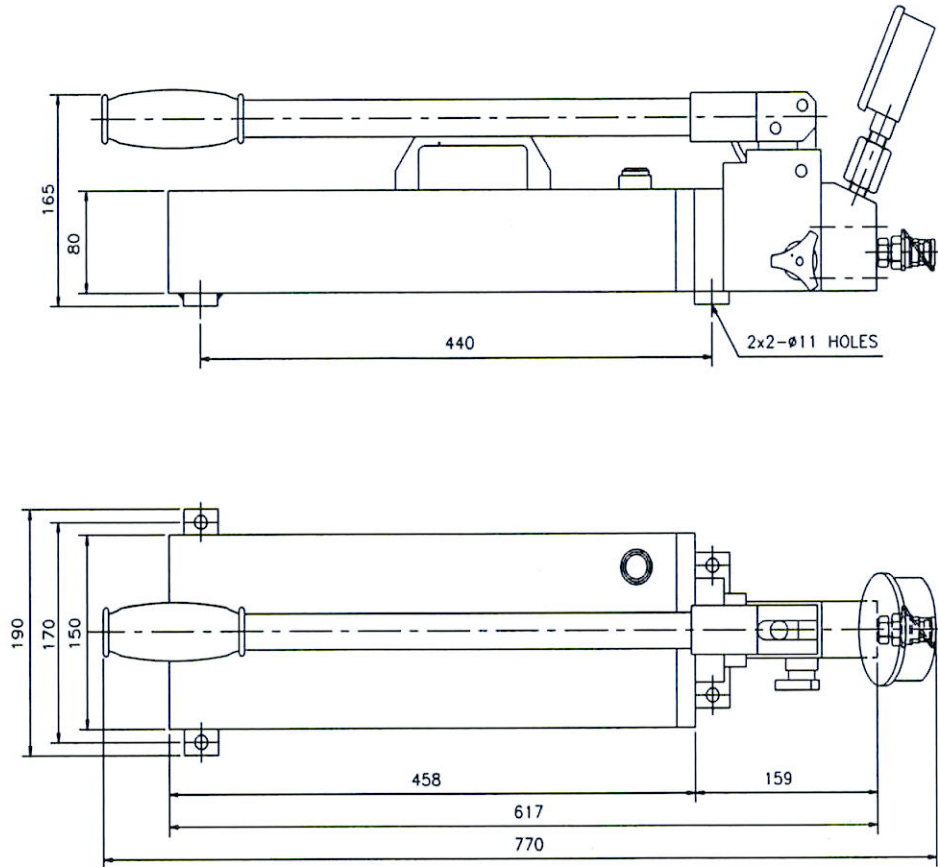
INSTRUCTION MANUAL

HYDRAULIC PUMP HAND OPERATED

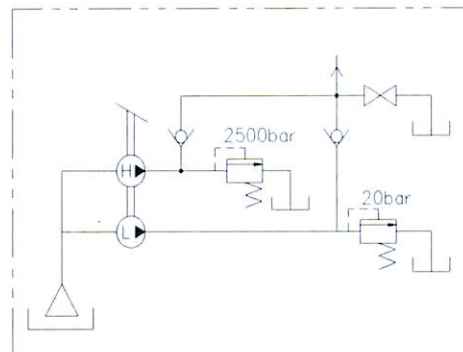
MODEL : HML-3500



HANMI HYDRAULIC MACHINERY CO., LTD.
#715-14, Mora-dong, Sasang-ku, Pusan, Korea
Tel. +82 51 305 2512~4 / Fax. +82 51 301 1721
E-mail : hm131@kornet.net / Hm132@kornet.net

**HANMI POWER****HML-3500****HYDRAULIC PUMP HAND OPERATED****HYD' PUMP HAND OPERATED**

MAKER	HANMI HML-3500
WORKING PRESSURE	
LOW	20BAR
RELIEF / HIGH	Min. 2500bar
OIL OUTPUT	
VOLUME / STROKE	
LOW	32cc
HIGH	0.8cc
RESERVOIR	
OIL VOLUME	4.0L

HYDRAULIC CIRCUIT

**HANMI POWER****HML-3500****HYDRAULIC PUMP HAND OPERATED****HAND PUMPS****IMPORTANT DIRECTIONS ON RECEIVING GOODS**

Always inspect all the components received in order to ascertain any possible damage caused during transportation. If necessary, put forward a complaint to the forwarder.

SAFETY INFORMATIONS

Before starting the pump read carefully the manual, particularly the boldface parts and those indicated by:

WARNING :

and

CAUTION :

HANMI DECLINES ALL LIABILITY FOR DAMAGES DERIVING FROM AN IMPROPER USE OF THE PRODUCT. SHOULD YOU HAVE ANY DOUBT REGARDING APPLICATION DO NOT HESITATE TO CONTACT HANMI.

WARNING: PLEASE REFER TO THE APPENDIX FOR THE LIST OF COMPONENTS FOR ALL KINDS OF HAND PUMPS.

The hand pump reservoir must have a capacity of usable oil sufficient to fill the complete hydraulic system it is connected to (i.e. flexible hoses + cylinders).

WARNING : OIL SHOULD NOT BE ADDED TO THE PUMP RESERVOIR TO COMPLETE THE STROKE OF A CYLINDER WHOSE VOLUME IS GREATER THAN THE PUMP CAPACITY. THIS PRACTISE WILL RESULT IN THE PRESSURIZATION OF THE PUMP RESERVOIR LEADING TO EQUIPMENT DAMAGE AND POSSIBLE INJURY TO PERSONNEL.

"Double stage" or 2-speed pumps' piston features two thrust sections of different diameter. When the load is not present it is the piston wider section that pushes the oil into the circuit so allowing a fast approach to the load. (1st stage at low pressure and high capacity). Under load, the same section is automatically excluded by a specific valve. Continuous pumping with the smaller section achieves the maximum pressure by making a reduced effort on the lever (2nd stage at high pressure and low capacity). The filler cap (HML models) is of the push-button air discharge type to depressurize the reservoir. The pumps can work in a horizontal or vertical position with the pumping head downwards, and are fitted with a threaded hole for the mounting of a gauge (alternatively a gauge adaptor block can be mounted on the oil delivery outlet; both are optional extras). Upon request pumps with reservoirs different from standard, for higher working pressures or working with other fluids can be supplied. For any specific inquiry please contact our Technical Department.



OIL DELIVERY / RETURN

The direction of circulation of the oil from the pump to the hydraulic circuit (delivery) and successively from the circuit to the pump (return) is regulated by the control valve mounted on the hand pump head.

(PICTURE. 1)

The pumps are fitted with a 2-way valve ("by-pass") to operate single acting cylinders either gravity or spring return : the pump head has one only delivery - return port. When the valve handwheel is completely screwed clockwise, repeated action of the lever will introduce oil into pressure to the circuit. By unscrewing it counter-clockwise, oil is allowed to return to the reservoir. In this case it will be useless to operate the lever as the pumped oil will immediately return to the reservoir.

HOW TO CHOOSE THE PUMP

The selected pump must have a 2-way valve for single-acting cylinders either gravity or spring return and a 4-way valve for single-acting oil return cylinders or double acting cylinders.

The reservoir must have a capacity of usable oil sufficient to fill the flexible hose and the cylinder.

If you need a large amount of oil to fill the system and for the approaching of the piston to the load it is advisable to choose a pump with high delivery at low pressure. Hand pumps are recommended for low speed applications. When your application requires higher working speeds it is recommended to choose a hydraulic unit in our wide range of models driven by petrol engines, electric or pneumatic motor.

WARNING : IT IS RECOMMENDED TO MOUNT A GAUGE ON THE PUMP OR ON THE CYLINDER IN ORDER TO PREVENT ANY DAMAGES TO THE EQUIPMENT, WHEN LIFTING LOADS WHOSE WEIGHT IS NOT KNOWN, AND ALSO TO BETTER CHECK ANY SINGLE PHASE OF THE LIFTING OPERATION.

TO ENSURE A CORRECT WORKING AND A LONG LIFE OF HANMI COMPONENTS CAREFULLY FOLLOW ALL THE DIRECTIONS PROVIDED BY THIS MANUAL.

CORRECT USE OF THE PUMP

WARNING : THE PUMP CAN WORK EITHER IN A HORIZONTAL OR VERTICAL POSITION PROVIDED THE HEAD IS DOWNWARDS.

(PICTURE. 2)

The pump must be placed on a stable and still plane to prevent it from turing over during operations.

The BY-PASS valve must be operated esclusively by hand. Do not use mechanical grips.

**AIR IN THE SYSTEM**

Since air can be compressed if it enters a hydraulic system it can prove dangerous. Before putting a cylinder under load it is absolutely necessary to bleed the air from the system. Simply follow the following directions:

(PICTURE. 3)

- pump until the piston is completely extended ;
- invert the cylinder so that the piston head is placed on the bench or on the floor;
- keep the pump higher than the cylinder ;
- open the valve of the pump ;
- press the cylinder bottom to help the piston retract. The air will flow from the cylinder and the hose to enter the oil reservoir where it can stay without causing any inconvenience.

USE

CAUTION : HIGH PRESSURE EQUIPMENT CAN DEVELOP HIGH FORCES IN COMPARISON WITH THEIR DIMENSIONS. DO PAY THE GREATEST ATTENTION WHEN OPERATING.

Before starting any operations check the oil level inside the hand pump reservoir. Such level must usually be about 1 cm from the inlet. Add oil if necessary. **Make sure the reservoir is not completely full so as to prevent the oil from overflowing from the inlet hole, since during operations increases of the oil volume might occur.**

IT IS RECOMMENDED TO USE EXCLUSIVELY HANMI HYDRAULIC OIL : its viscosity and lubrication characteristics grant the maximum use efficiency and a longer life of equipment. If you need to add large quantities of oil to the pump, it is recommended that the reservoir is drained, thoroughly cleaned and filled up with fresh oil.

CAUTION : MAKE SURE THAT ALL THE SYSTEM COMPONENTS ARE SUITABLE FOR THE REQUIRED WORKING PRESSURE.

SPECIFIC DIRECTIONS ON THE USE OF FLEXIBLE HOSES

CAUTION : DO NOT USE FLEXIBLE HOSES FOR CARRYING OR DRAGGING PURPOSES

Hoses must be placed on a straight line with no obstructions. Ensure that the bend radius is greater than 60 mm, that no heavy load is placed over them and avoid any direct contact with sharp objects. Keep them clear of flames or heat sources.

SPECIFIC DIRECTIONS ON CONNECTIONS THROUGH NIPPLES

The threaded end connections are either 1/4 or 3/8 NPT male.

When tightening, do not use spanner extensions as damage to the threads can occur. Wrap thread with teflon tape (do not use tow as its threads can contaminate the oil of the hydraulic system).

**HANMI POWER****HML-3500****HYDRAULIC PUMP HAND OPERATED****SPECIFIC DIRECTIONS ON THE CONNECTIONS THROUGH COUPLERS**

Ingress of foreign materials into the hydraulic system can cause scoring inside the cylinders or damage the valves seats so compromising their seal and the consequent success of the system operation. Therefore :

CAUTION : MAKE SURE THE COUPLINGS ARE CLEAN BEFORE CONNECTING THEM.

Dirt can prevent a correct seal and restrict the oil flow since the two seal balls do not properly repel each other.

WARNING : MANUALLY SCREW TIGHT THE CONNECTING SLEEVE OF THE FEMALE COUPLING TO THE THREADED SPIGOT OF THE MALE COUPLING.

WARNING : ALWAYS SCREW THE PROTECTION CAPS ON THE TWO COUPLING WHEN DISCONNECTED.

EURO PRESS PACK DECLINES ALL LIABILITY FOR DAMAGES OF UNSUCCESSFUL OPERATIONS DERIVING FROM IMPROPER USE, OR USE OF ACCESSORIES AND/OR SPARES OTHER THAN THE ORIGINAL ONES.
FOR ANY INFORMATION OR EXPLANATION DO REFER TO OUR TECHNICAL DEPARTMENT.

WARNING : ANY MAINTENANCE AND/OR REPAIRING INTERVENTIONS MUST BE CARRIED OUT BY QUALIFIED PERSONNEL. WRONG INTERVENTIONS MAY CAUSE THE LOSS OF WARRANTY!

PRESSURE REGULATION - The hand pump safety relief valves are factory set to the maximum working pressure. By requests, this can be set to customer requirements.

WARNING : IT IS ABSOLUTELY FORBIDDEN TO SET SUCH VALVE AT A VALUE HIGHER THAN THE ONE SET IN OUR FACTORY.

TROUBLE SHOOTING

In many cases faults can be determined and EASILY OVERCOME ON SITE, so saving money and time. Please find below a few suggestions for the most common problems. For further details refer to our CUSTOMERS SERVICE.

THE PISTON WILL NOT ADVANCE

- The pump head is not downwards ;
 - The pump valves is open or not properly closed ;
 - There is air in the system or lack of oil in the pump ;
 - Make sure the pump correctly pumps the oil. If it fails to do so the piston cannot advance.
-

**DO NOT OVERLOAD**

- The piston will not advance if the load to be lifted exceeds the capacity of the cylinder in use. In this case the safety valve protects the operator and the equipment by preventing the advance.

THE PISTON DOES NOT MAKE FULL STROKE OR ADVANCES WITH JERKS

- There is air in the system (to eliminate it please refer to "Air in the system").
- The piston could be bent or deformed causing it to bind with the ring nut.
- There is lack of oil in the pump. The piston is limited in its stroke. Refill the oil level in the pump (see "Use").
- The hydraulic cylinder's capacity is higher than that of the reservoir. The pump must be replaced with one with higher capacity.

THE PISTON DOES NOT KEEP THE LOAD

- If when pumping the piston advances, but does not keep its required position, i.e. does not hold pressure, the reason might be found among one of the following causes :
 - 1) The pump does not work properly (check valve).
 - 2) Cylinders seals leak.
 - 3) Oil leakage through the flexible hose connection.

THE PISTON RETURN IS NOT COMPLETE OR SLOWED DOWN

- This is due to the fact that the oil cannot flow back to the reservoir. Make sure that :
 - 1) The pump valve is open.
 - 2) The two couplings are tight so that the two balls repel each other and make the oil flow correctly.
 - 3) The return spring of the cylinder (if fitted) could be broken or loose and the internal walls of the cylinder can be worn.
 - 4) The piston cannot be fully retracted if there is too much oil in the pump. In that case the excess of oil cannot flow from the cylinder to the reservoir. Consequently the piston is not fully retracted.

WARNING : FOR GRAVITY RETURN CYLINDERS IT IS NECESSARY TO MAKE AN EXTERNAL FORCE ON THE TOP OF THE ROD SO AS TO MAKE IT RETRACT.

WARNING : ALWAYS HELP THE PISTON RETRACT BY PRESSING ON THE RESERVOIR RELIEF VALVE ON THE FEEDING CAP IN ORDER TO DEPRESSURIZE THE SAME (only HML models).

OIL LEAKAGE

If there is oil leakage from the piston it means the seals are either broken or worn out. Their replacement is simple and quick and can be carried out on site.

WARNING : IT IS RECOMMENDED TO KEEP IN STOCK A SPARE REPAIR KIT FOR THE PUMP.

**APPENDIX A**

LIST OF HAND PUMPS COMPONENTS SHARED BY THE VARIOUS PUMPS	
A	PUMP RESERVOIR
B	LEVER
C	OIL INLET
D	PRESSURIZED OIL OUTLET
E	ADDITIONAL OIL OUTLET
F	MAX PRESSURE RELIEF VALVE
G	BY-PASS VALVE

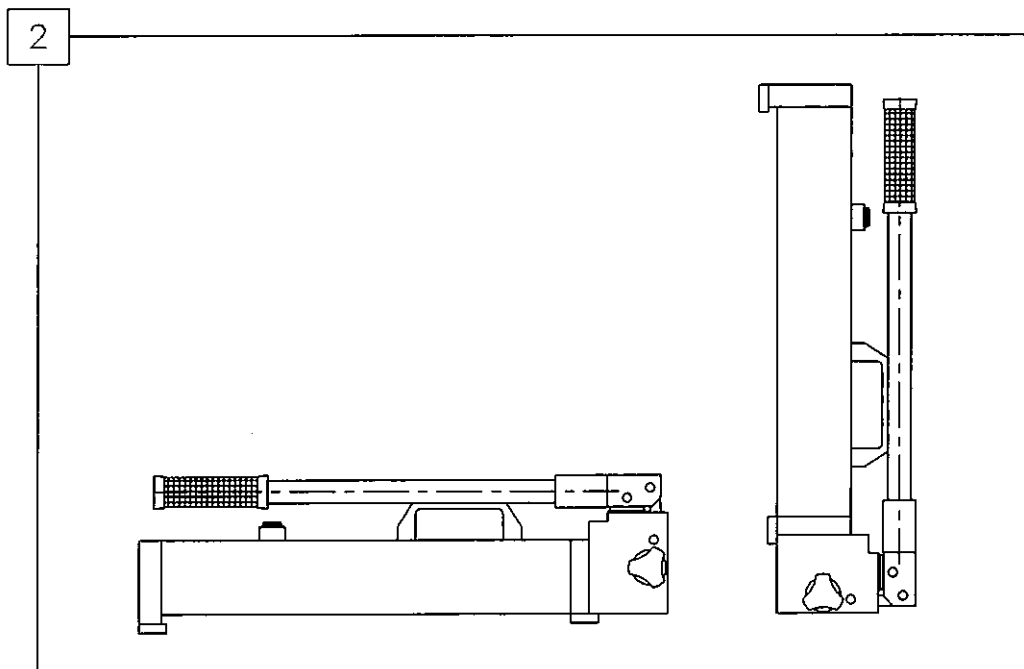
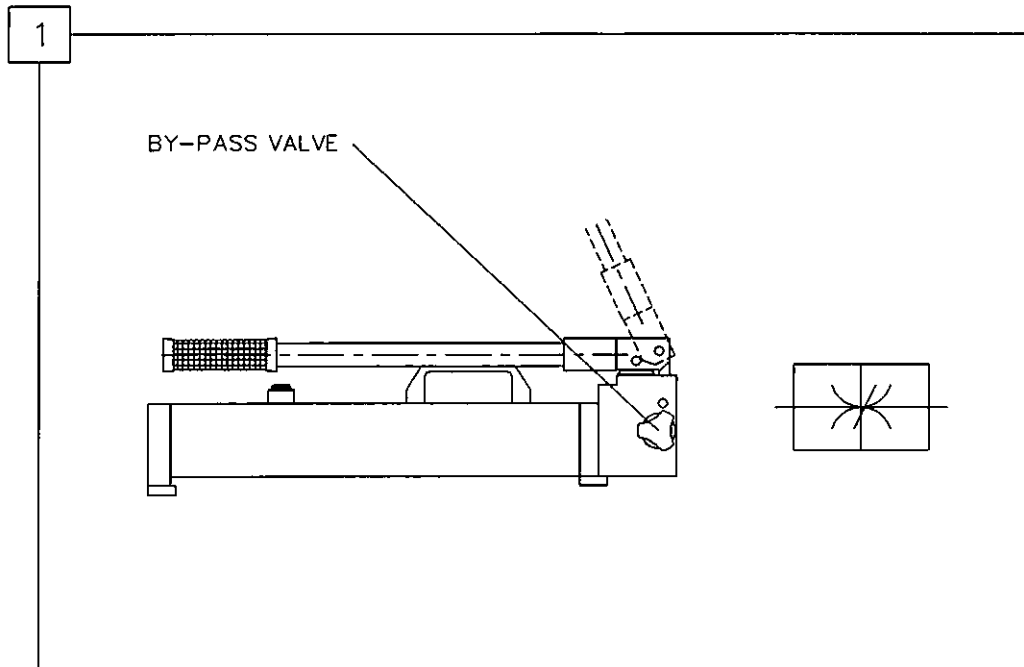
Also valid for MOD. HML-1000
HML-1600, 1600- I 1600N
HML-2500, 2500N
HML-3500



HANMI POWER

HML-3500

HYDRAULIC PUMP HAND OPERATED



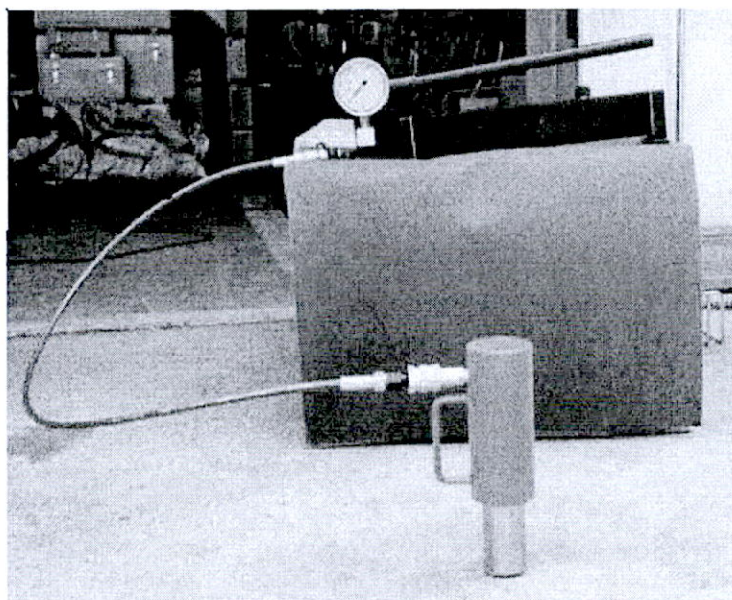


HANMI POWER

HML-3500

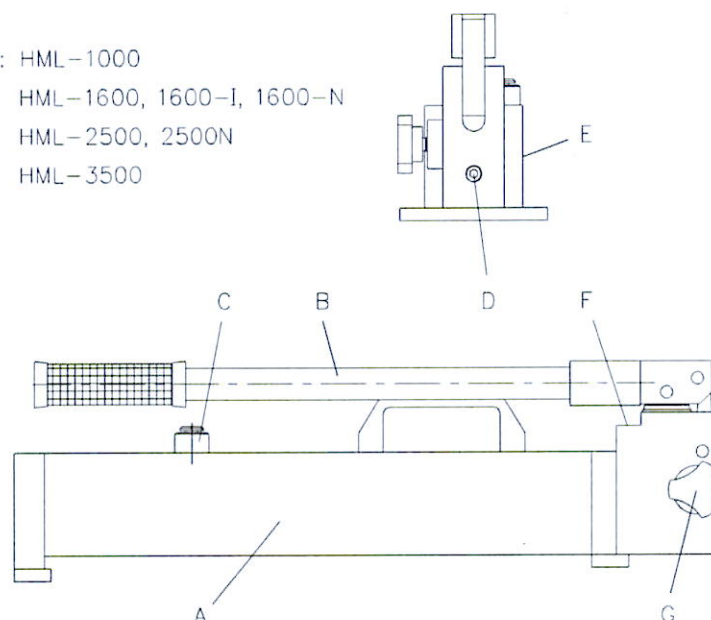
HYDRAULIC PUMP HAND OPERATED

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MOD. : HML-1000
HML-1600, 1600-I, 1600-N
HML-2500, 2500N
HML-3500



TOP BRACING

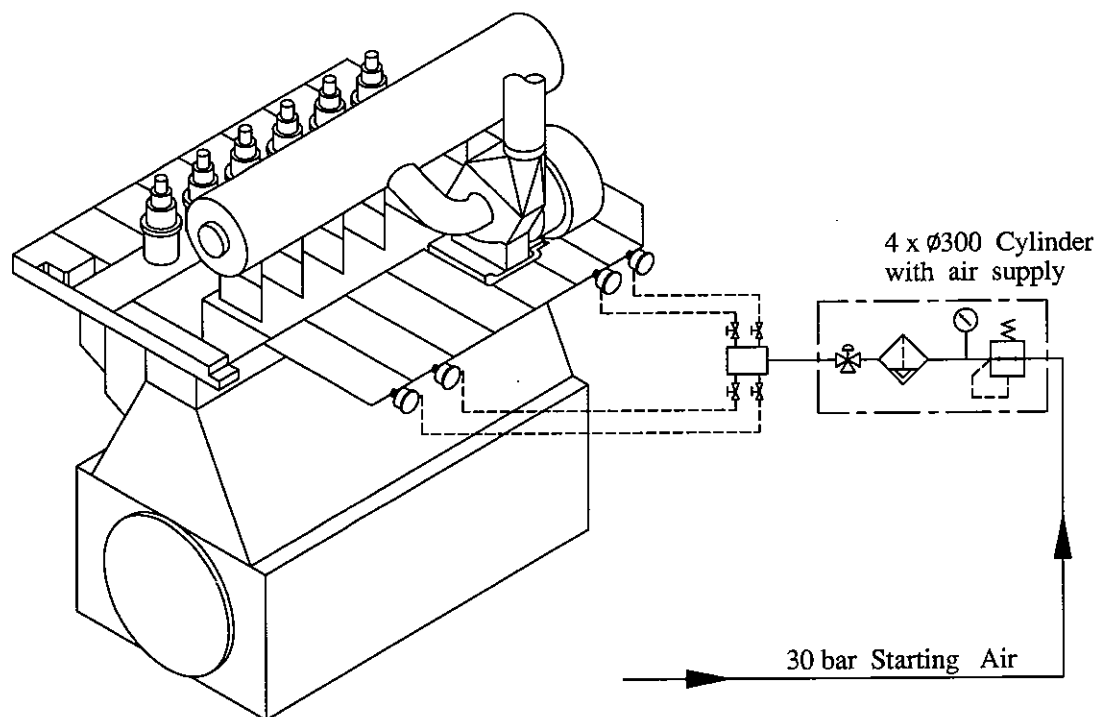
Service manual

MAIN ENGINE HYDRAULIC TOP BRACING

Customer : HYUNDAI HEAVY INDUSTRIES CO., LTD.

Type : AOC-300 (ON-OFF TYPE)

Hull No. :



GREEN & CLEAN TECHNOLOGY Co., Ltd.

Home-page : <http://www.gc-tech.com>

Tel : +82 52 268 ~ 5656 Fax : +82 52 265 ~ 7887

INDEX

NO.	DESCRIPTION	PAGE
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2.	Technical description	4
3.	Function description	5
4.	Installation	6 ~ 8
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6.	Top bracing off setting procedure	9
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	Lay-out of top bracing	13
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	Top bracing(GC-981116)	17
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	Top bracing(GC-981112)	19
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10.	Spares list for hydraulic top bracing	21
11.	Tools for hydraulic top bracing	22
12.	REGULATOR INSTRUCTIONS	23~26
13.	AIR FILTER INSTRUCTIONS	27~30
14.	GAS-FILLING AND CHECKING APPARATUS INSTRUCTIONS	31~33

General specification

1. Type : AOC-300.
2. Assembly drawing : refer to drawing GC-981114.
3. Dimensional drawing with part list : GC-981116.
4. AOC-300 function drawing : GC-981113.
5. Air connection diagram : GC-981115-4.
6. Force to a cushion at 5 ~ 14 bar : 35.3 KN ~ 99 KN (3.6 ~ 10.1 Ton).
7. Max. force at relieving pressure (26 bar) : 183.8 KN (18.7 Ton).
8. Air connection port : $\Phi 10$ copper pipe or $\Phi 10$ steel pipe connector.
9. Foundation bolts : 10 pcs Hex-bolts (M16 x 45L).
10. Valve block : Consists of with 1 relief valve,
1 test coupling and 1 accumulator with stop valve.
11. Type of hydraulic oil : Standard hydraulic oil, ISO VG 32.
(recommend : Mobil DTE 13M)
(Top-bracing is delivered with oil filled condition.)
12. Volume of oil : 6 liter per cylinder.
13. Size of air supply pipe : $\Phi 10$ steel pipe.
14. Weight : Approximately 220 kg/cyl (with oil).
15. Operating temperature : Max. 75 °C.
16. Installation tolerance : Max. ± 25 mm.
17. Accumulator set pressure : 15 bar.
18. Relief valve set pressure : 26 bar.
19. Air regulator set pressure : 12 bar.
20. Paint color : Munsell no. 7.5 BG 7/2.

Technical description

By means of top bracing the main engine, it will in most cases be possible to obtain such a high natural frequency of the system "engine - ship's side - ship's bottom" that annoying vibrations of the engine top or ship's hull will be eliminated.

The so-called guide force moments are caused by the transverse reaction forces acting on the crossheads due to the connecting rod/crankshaft mechanism. When the piston of a cylinder is not exactly in its top or bottom position, the gas force from the combustion, transferred through the connecting rod will have a component acting on the crosshead and the crankshaft perpendicularly to the axis of the cylinder. Its resultant is acting on the guide shoe (or piston skirt in the case of a trunk engine), and together they form a guide force moment.

The moments may excite engine vibrations moving the engine top athwartships and causing a rocking (excited by H-moment) or twisting (excited by X-moment) movement of the engine.

For engines with fewer than seven cylinders, this guide force moment tends to rock the engine in transverse direction, and for engines with seven cylinders or more, it tends to twist the engine. The guide force moments are harmless to the engine, however, they may cause annoying vibrations in the superstructure and /or engine room, if proper countermeasures are not taken.

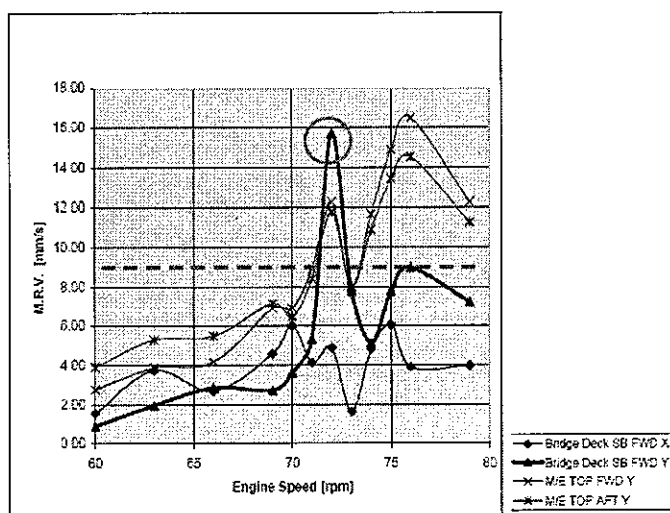
(The guide force moments are harmless except when resonance vibrations occur in the engine/double bottom system.)

As this system is difficult to calculate with adequate accuracy, MAN B&W Diesel strongly recommend that top bracing is installed between the engine's upper platform brackets and the casing side.

The hydraulic top bracing is designed as an adjustable connection which allows adjustment in accordance with the loading conditions of the ship.

High / Low Pressure

Such the preceding reasons, the top bracing is installed to solve vibrations casued by several problems during sailing. However, sometimes in one particular area to cause resonance vibration produces greater due to top bracing. (see the picture below.) This is causing a bigger problem to solve is stop the operation of top bracing in the range.



Function Description (In case of High Pressure) (see Dwg. GC-981113)

The top bracing can be installed :

On one side (exhaust side or camshaft side)

Both side of engine.

On one side with fore or aft and both side with fore or aft.
depending on the circumstances & requirements.

When the force from engine and/or hull is less than 85 KN, top bracing keeps preadjusted condition.

But, the force is between 85 KN and 183.8 KN, oil pressure in primary chamber will increase.

In this case, accumulator absorbs the force.

When the force from engine and/or hull is higher than setting pressure of relief valve(force : 183.8 KN), the relief valve is open. At the same time, oil in primary chamber flows to secondary chamber. During the oil in primary chamber flows to secondary chamber, the secondary piston move backward until the pressure of secondary and air chamber is equal. So, air chamber absorbs the force.

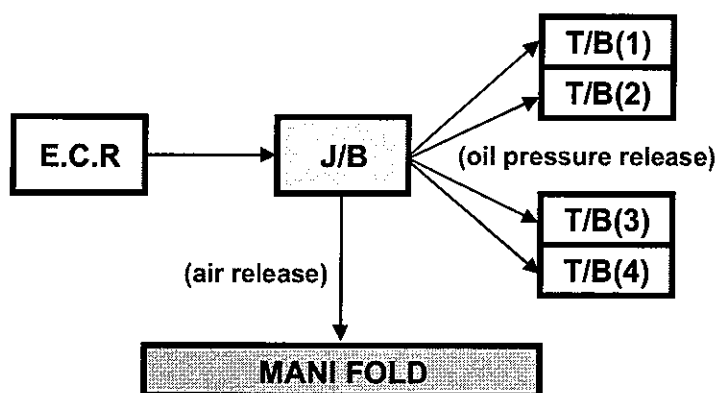
When engine and hull moves away from each other(negative force) the oil pressure in primary chamber is decreased. At the same time, compressed air in air chamber push the secondary piston forward and the oil in secondary chamber flows back to primary chamber through the check valve until the pressure in primary, secondary and air chamber is equal.

Ship's M/E starting air to be fed to all the top bracing installed parallely through a pressure regulating valve.

Function Description (In case of Low Pressure)

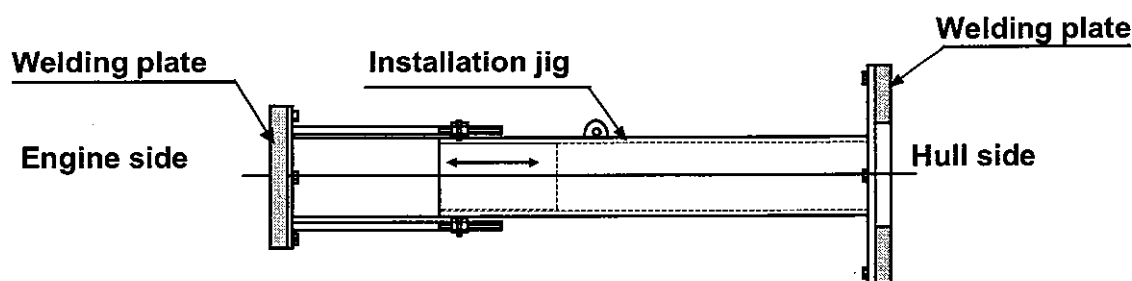
Using the 3-way valve and solenoid valve, the supplied air and oil pressure of top bracing must be turned off to stop operation.

And then, they are working through E.C.R is controlled by signals.

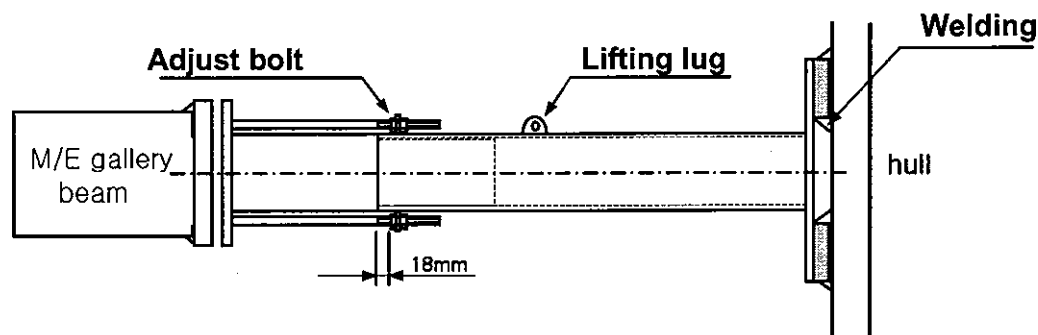


Installation.

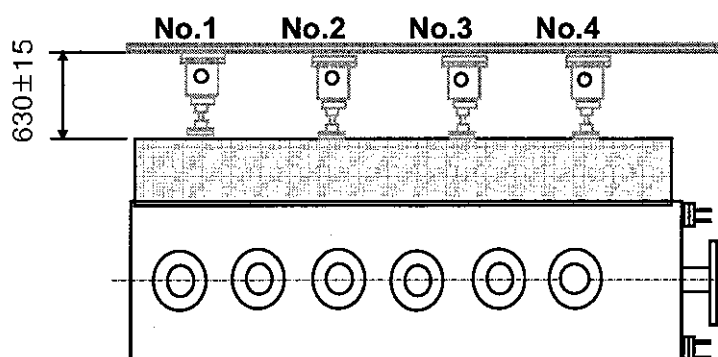
1. It is recommended to study this installation manual before commencing the installation work.
2. Review the drawing of scope of supply with the parts supplied.
Check if they are identical and there are any missing parts.
3. Disassemble the both side welding plate from the top bracing and the plates are to be assembled with the installation jig. (refer to the figure)



4. Measure the distance between beam of hull and gallery beam of engine.
The distance should be within 630 ± 15 mm.
 - a) In case of the distance is too short.
It is recommended to cut the gallery beam to meet the required distance.
 - b) In case of the distance is too long.
It is recommended to apply a adaptable plate on to gallery beam.
5. As shown in the sketch below, adjust bolts must have 18mm adjustable tolerance on installation jig so that easy removal after welding the plates.



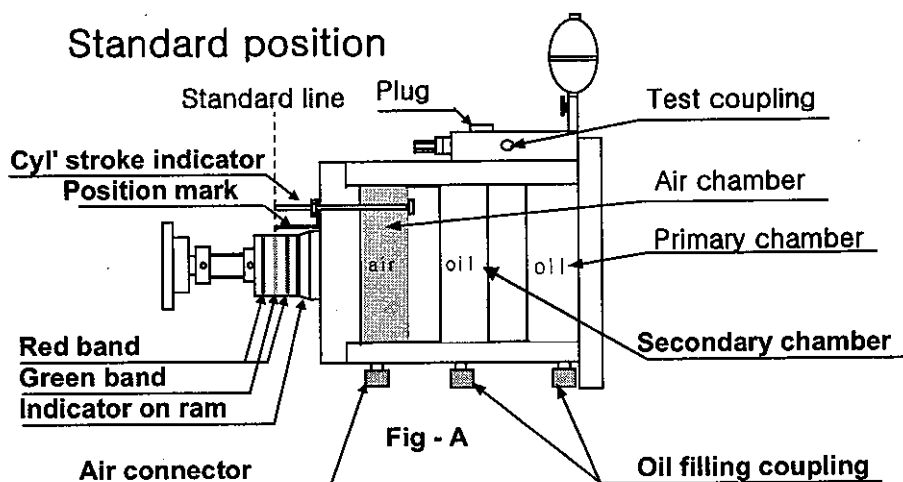
6. Check the leveling of vertical & horizontal direction by using level gauge and weld the plates.
7. Remove the installation jig and weld inside circle of the plates.
8. Do final treatment about welding spartters and painting.
9. Install the top bracing according to the following guide.
 - a) Between center line of cylinder and barrier should be kept as below.



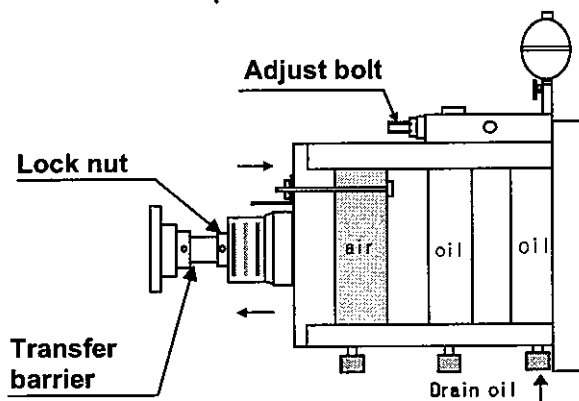
- 1) Tighten the bolts of welding plates. Adjust the transfer barrier and lock nut.
Then tighten the fixing bolt(pos. no. 29) on transfer barrier.
- 2) Install the pipe as shown on the pipe diagram.
Connect the pipe to air connection port.
(refer to drawing GC-981115-4)
- 3) Supply air and adjust to 8 ~ 14 bar.

b) Piston setting and air venting

Standard position

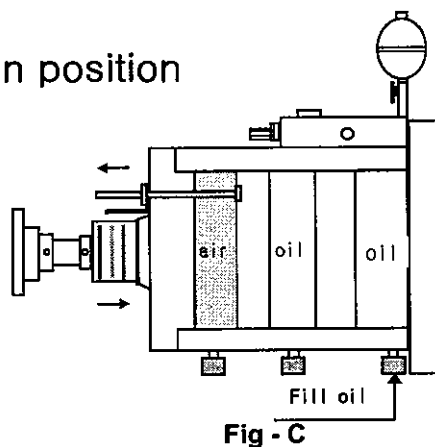


Ram out position



- 1) Stop air supply.
- 2) Connect hyd' hose to test coupling.
- 3) Tighten up the transfer barrier and lock nut until the green band meet position mark. During this work, air will be come out first then oil will be come out through hyd' hose. (primary chamber air venting)
- 4) Disconnect the hyd' hose from test coupling when 3) is done.
- 5) Check the position of secondary piston by cyl' stroke indicator.
- 6) Loosen up the plug a little on the valve block for secondary chamber air venting.
- 7) If cyl' stroke indicator is shorter than the end of position mark, fill oil to secondary chamber until cyl' stroke indicator meet the end of position mark. If cyl' stroke indicator is longer than the top of position mark, supply air to air chamber over 4bar. Do 2) to secondary oil filling coupling then oil will be come out. Drain oil until cyl' stroke indicator meet the end of position mark.

Ram in position



- 1) Connect hyd' hose to primary oil filling coupling and drain off until oil is not coming out.
- 2) Loosen up stoppper and transfer barrier enough.
- 3) Supply air over 4bar, until the green band meet the end of position mark. Then stop air supply.
- 4) Do 3) In order of Fig-B.
- 5) Do 4), 5) In order of Fig-B.

Top bracing operating procedure

1. Before top-bracing operating, confirm the following works which should be completed to activate top-bracing.
 - 1) Pipes for air supply are connected to top-bracing.
 - 2) Ready to use starting air(30bar).
 - 3) Piston position setting is completed.
(Refer to piston setting and air venting)
2. Loosen up the transfer barrier and lock nut by using torque bar until they are tight each other.(Make the position of key way and fixing bolt hole to fix the distance of the transfer barrier and lock nut)
3. Tighten up the fixing bolt.
4. Set the air supply pressure 12 bar.
5. Check the piston position.
(If the position of piston are on standard line after air venting , top-bracing activation is finished. But, if there is a change in position of pistons, refer to piston setting and air venting to adjust piston position)

Top bracing off setting procedure

1. Close the shut off valve in supply line from starting air line.
2. Stop air supply by using air regulator.
(Air regulator will vent out all air in pipe and top bracing)
3. Close the stop valve below the accumulator.
4. If you want to activate top-bracing again, set the air pressure 12 bar. Then open the stop valve below the accumulator.
5. Check the piston position.
(If there is a change in piston position, refer to piston setting and venting to adjust piston position)

Maintenance (Refer to as following before any action.)

Service in shop

Step 1 To remove the top bracing from place of installation

- a) Open the air-port on the side of the top bracing. This release the top bracing air pressure and prevent the elongation of the top bracing cylinder when taken off the flange. Loose the adjustment nut.
- b) Secure the barrier flange jig (Tool No.1-2) between cylinder cover & bearing cover. And sling on eye bolt & hoist it away.

NOTE: The top bracing weight approximately 220kg.

The top bracing should be taken to avoid a drop. Do not lift the transfer barrier & lock nut when pulling the top bracing away from the flange.

Step 2 Opening the top bracing cover.

- a) Open all oil filling & bleeder ports and drain for oil and fit a compressed air hose to the air inlet and pressurize to approximately 1bar, as this will push the secondary piston down/squeezing any remaining oil out of the cylinder.

Step 3 Open the cylinder as following instruction and check with the drawing.

- a) Remove the cylinder cover
- b) Apply 1 bar air into primary chamber to lift up complete inner construction.
- c) The secondary piston can be removed by hand lifting.
- d) Remove all bearing and seals and fit new ones from the seal kits.
- e) Check for damage to all chromium coated surfaces and report if any surface looks worn but usable if scratches look too deep, the part should be replaced.

Maintenance Period

Item	Period
Piston position	1 Month
Oil	6 Months
Accumulator	6 Months
Seal	12 Months

Assembly

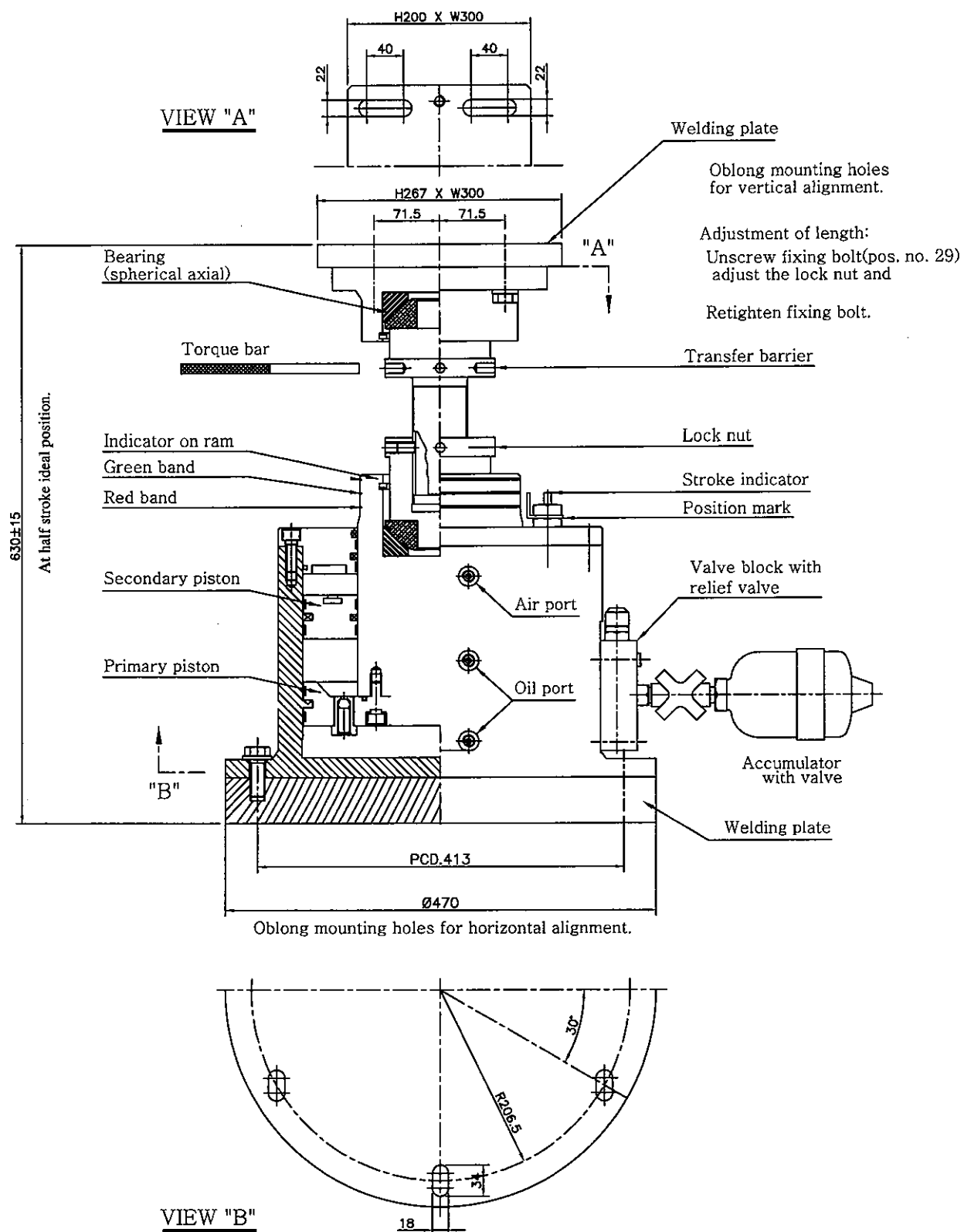
- a) Assemble secondary piston into ram.
- b) Insert complete inner construction into cylinder.

Use the jig provided to insert the inner complete construction specially when the wear ring are renewed.

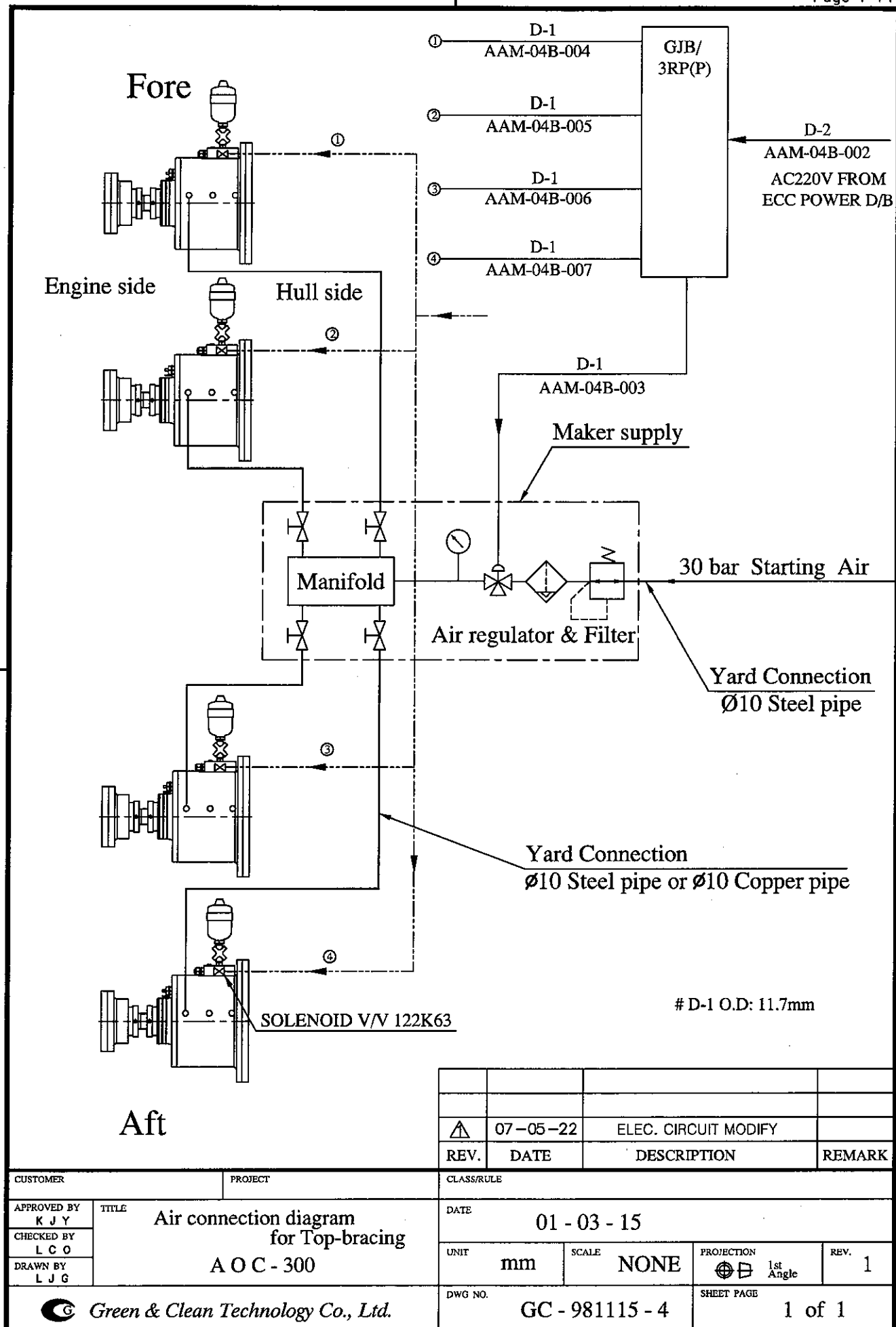
- c) Close the cylinder cover and tighten hex bolts.

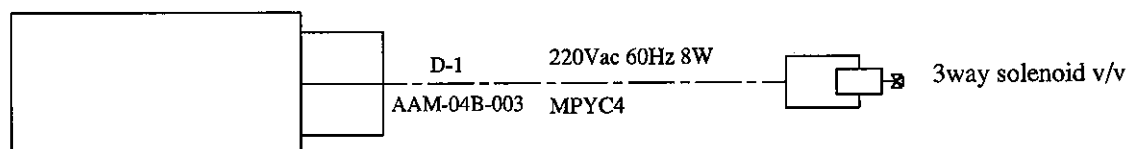
DRAWINGS

DRAWING NO.	TITLE	REV.
GC-981114	Lay-out of Top-bracing	0
GC-981115-4	Air connection diagram for Top-bracing	1
GC-981115A	Electric diagram for Top-bracing	3
GC-981117	Diaphragm hydropneumatic accumulator	0
GC-981116	Top-bracing (Part List)	1
GC-981113	Top-bracing (Function Description)	0
GC-981112	Top-bracing (Dismantling Drawing)	0
GC-981118-4	Manifold & air regulator	0



REV.		DATE	DESCRIPTION	REMARK
CUSTOMER		PROJECT		
APPROVED BY		DATE		
K J Y		02 - 01 - 07		
CHECKED BY		UNIT	SCALE	PROJECTION
L C O		mm	NONE	1st Angle
DRAWN BY		DWG NO.	SHEET PAGE	REV.
L J G		GC - 981114	1 of 1	0
Green & Clean Technology Co., Ltd.				





D-1 220Vac 60Hz 8W
AAM-04B-004 1.0m X 3C NO.1 T/B SOLENOID V/V 121K63

D-1 220Vac 60Hz 8W
AAM-04B-005 1.0m X 3C NO.2 T/B SOLENOID V/V 121K63

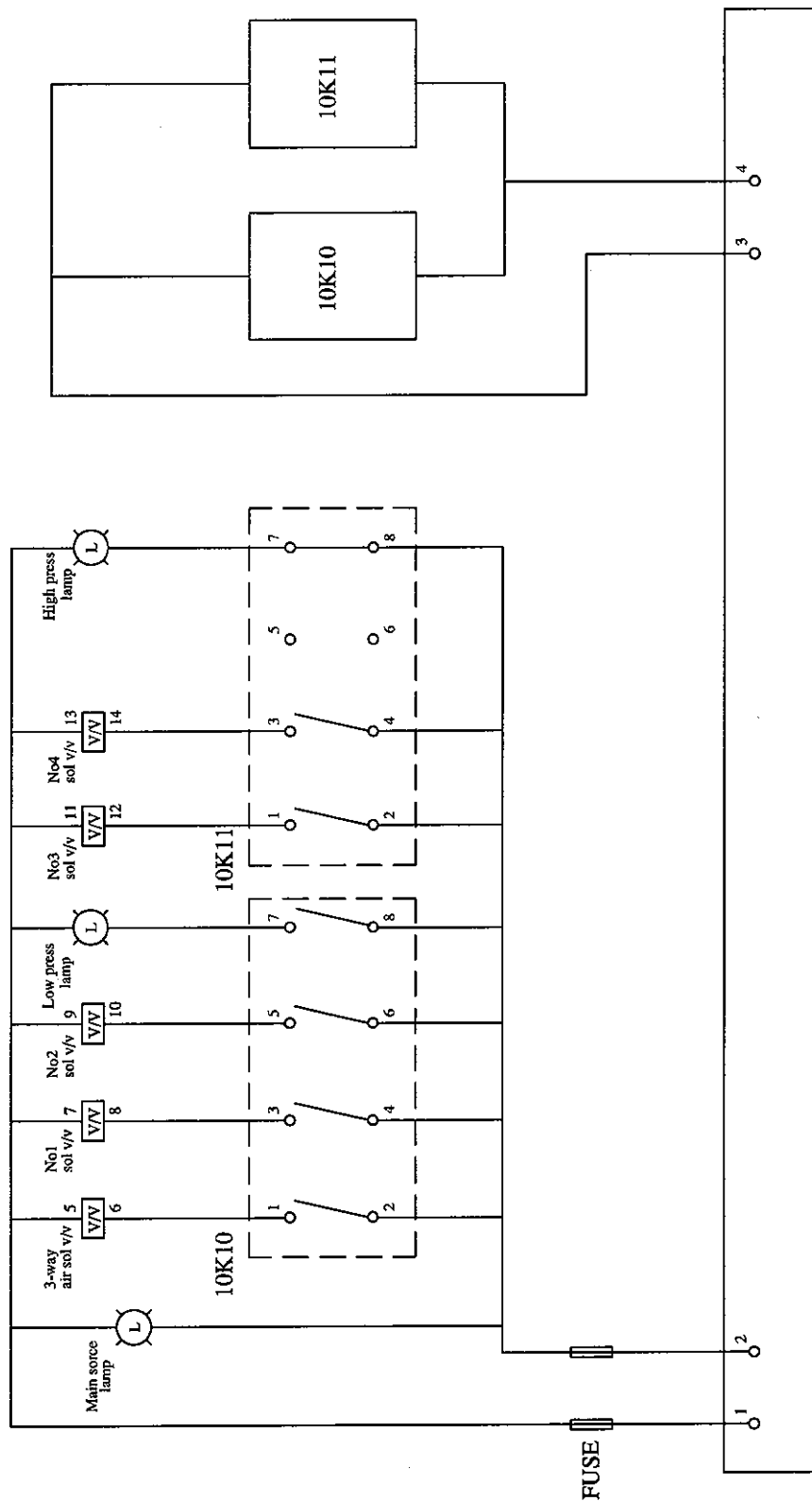
D-1 220Vac 60Hz 8W
AAM-04B-006 1.0m X 3C NO.3 T/B SOLENOID V/V 121K63

D-1 220Vac 60Hz 8W
AAM-04B-007 1.0m X 3C NO.4 T/B SOLENOID V/V 121K63

————— Supplier's installation
- - - - - Yard installation

△	07-12-04	MODIFICATION SOL V/V TYPE	
△	07-06-12	RECORD SOL. V/V POWER CONSUMPTION	
△	04-09-01	ELEC. CIRCUIT MODIFY	
REV.	DATE	DESCRIPTION	REMARK

CUSTOMER		PROJECT		CLASS/RULE			
APPROVED BY K J Y	TITLE Electric diagram for Top-bracing A O C - 300	DATE 02 - 01 - 07					
CHECKED BY L C O		UNIT mm	SCALE NONE	PROJECTION 1st Angle	REV. 3		
DRAWN BY L J G		DWG NO. GC - 981115A		SHEET PAGE 1 of 1			
Green & Clean Technology Co., Ltd.							



E.C.R
Sol v/v control s/w
24VDC

Power supply
220Vac, 60Hz

_____ Maker installation
_____ Yard installation

REV. NO.	DATE	DESCRIPTION	DWN.	CHK.	APPR.	TITLE	DWG NO.	SHEET PAGE	A4
3						Electric diagram for Top-bracing A O C - 300	GC-981115B	1 of 1	A4
2									
1									
0	02-01-07		L J G	L C O	K J Y				

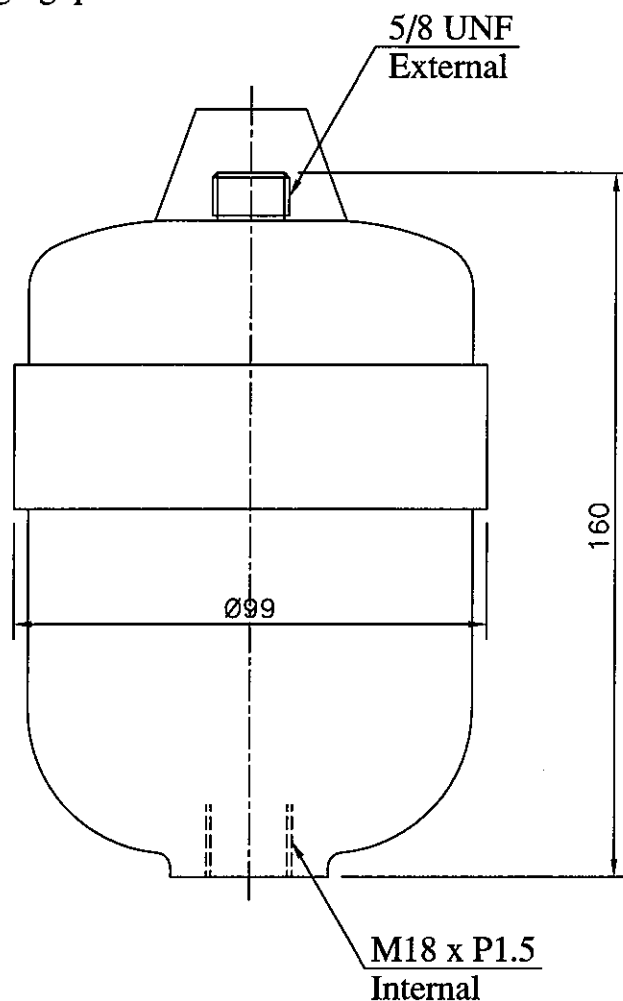
Green & Clean Technology co., Ltd

A4 (297mm x 210mm)

This drawing and design is our property and must not be disclosed to any third person with permission.

Specification

1. Gas filling : Nitrogen exclusively, Max. 90% of operating pressure.
2. $\frac{\text{Max. using pressure}}{\text{Gas changing pressure}} \leq 6$
3. Gas charging pressure : 15 bar



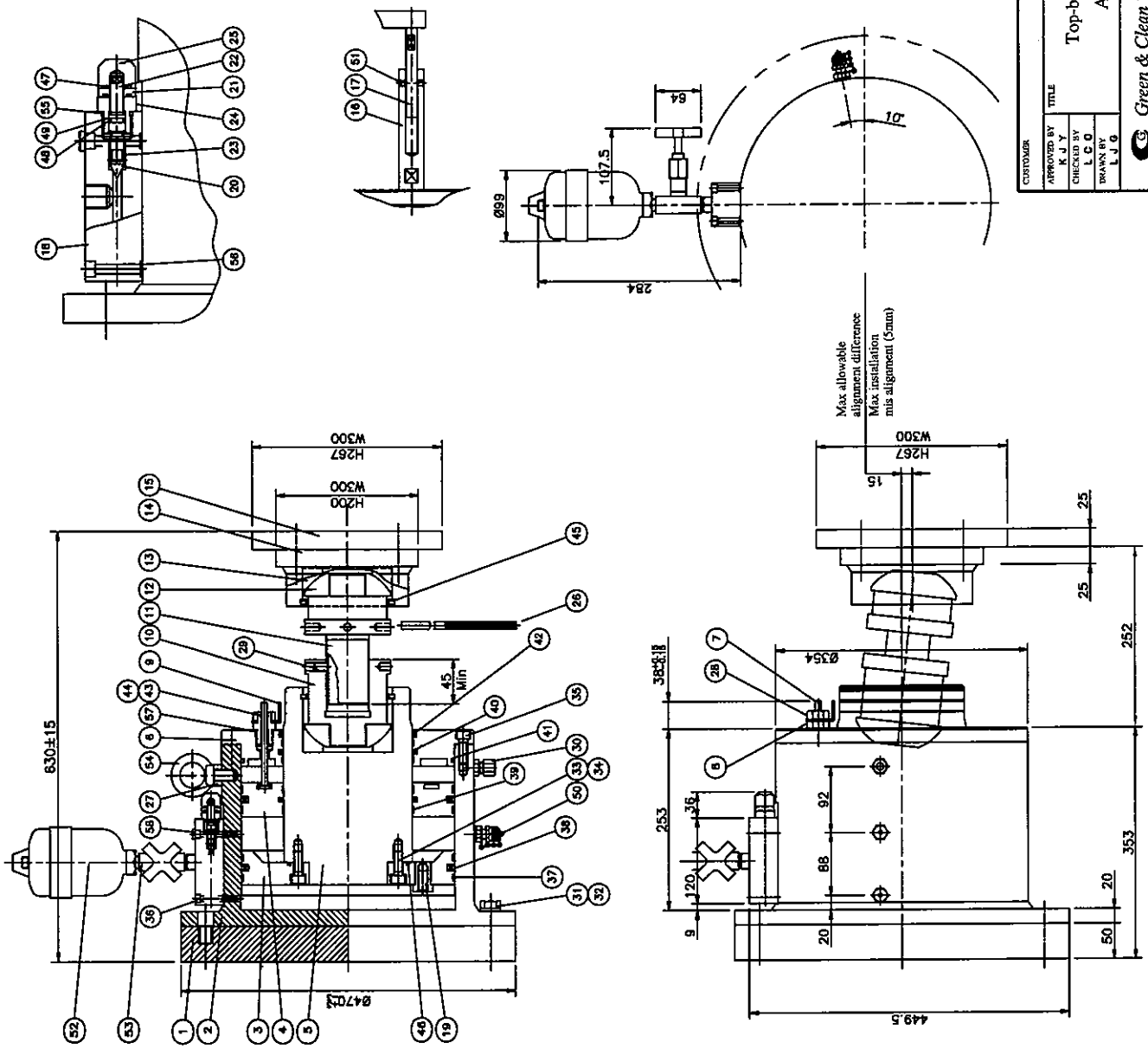
Model	Serial No.	Volume Cm ³	Max. Work. Press. bar	Work. temp. °C	Weight Kg
L 0,35	SA-0006	350	210	-15 ~+80	2.6

Maker : SAIP (ITALY)

CUSTOMER		PROJECT		REV.	DATE	DESCRIPTION	REMARK
APPROVED BY K J Y		TITLE Diaphragm Hydropneumatic Accumulator A O C - 300		CLASS/RULE			
CHECKED BY L C O				DATE 02 - 01 - 07			
DRAWN BY L J G				UNIT mm	SCALE NONE	PROJECTION 1st Angle	REV. 0
Green & Clean Technology Co., Ltd.				DWG NO. GC - 981117		SHEET PAGE 1 of 1	

Pos. No.	Drawing No.	Description	Material	Qty	Remarks
1	AOC30-1	WELDING PLATE	SS 400	1	
2	AOC30-2	CYLINDER	SS 400	1	
3	AOC30-3	PRIMARY PISTON	SS 400	1	
4	AOC30-4	SECONDARY PISTON	SS 400	1	
5	AOC30-5	NOZZLE ON PUMP	SS 400	1	
6	AOC30-6	CYLINDER COVER	SS 400	1	
7	AOC30-7	CYLINDER COVER	SS 400	1	
8	AOC30-8	CYLINDER COVER	SS 400	1	
9	AOC30-9	CYLINDER COVER	SS 400	1	
10	AOC30-10	POSITION MARK	SS 400	1	
11	AOC30-11	LOCK NUT	SS 400	1	
12	AOC30-12	TRANSFER BAR	SS 400	1	
13	AOC30-13	BEARING	SS 400	1	
14	AOC30-14	BEARING COVER	SS 400	1	
15	AOC30-15	WELDING PLATE	SS 400	1	
16	AOC30-16	SUPPORT BAR	SS 400	1	
17	AOC30-17	SUPPORT BAR	SS 400	1	
18	AOC30-18	VALVE BLOCK	SS 400	1	
19	AOC30-19	CHECK VALVE	SS 400	1	
20	AOC30-20	SPRING	SS 400	1	
21	AOC30-21	LOCKER	SS 400	1	
22	AOC30-22	ADJUST BOLT	SS 400	1	
23	AOC30-23	SPRING	SS 400	1	
24	AOC30-24	PLATE	SS 400	1	
25	AOC30-25	LOCKER	SS 400	1	
26	AOC30-26	TORQUE BAR	SS 400	1	
27	AOC30-27	WASHER	SS 400	1	
28	AOC30-28	LOCKER	SS 400	1	
29	AOC30-29	WASHER	SS 400	1	
30	AOC30-30	WASHER	SS 400	1	
31	AOC30-31	WASHER	SS 400	1	
32	AOC30-32	WASHER	SS 400	1	
33	AOC30-33	WASHER	SS 400	1	
34	AOC30-34	WASHER	SS 400	1	
35	AOC30-35	WASHER	SS 400	1	
36	AOC30-36	WASHER	SS 400	1	
37	AOC30-37	WASHER	SS 400	1	
38	AOC30-38	WASHER	SS 400	1	
39	AOC30-39	WASHER	SS 400	1	
40	AOC30-40	WASHER	SS 400	1	
41	AOC30-41	WASHER	SS 400	1	
42	AOC30-42	WASHER	SS 400	1	
43	AOC30-43	WASHER	SS 400	1	
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96	AOC30-96	WASHER	SS 400	1	
97	AOC30-97	WASHER	SS 400	1	
98	AOC30-98	WASHER	SS 400	1	
99	AOC30-99	WASHER	SS 400	1	
100	AOC30-100	WASHER	SS 400	1	

When ordering spare parts, use correct Pos. No.



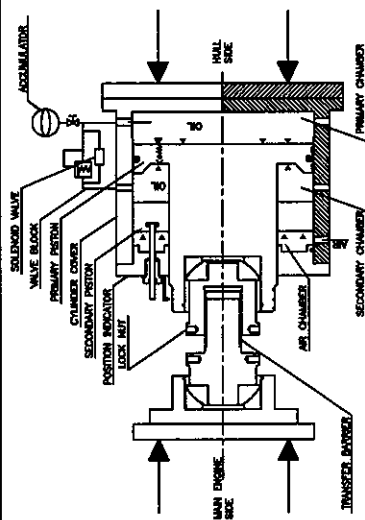
REV.	DATE	Pos. No. Modification	DESCRIPTION	REMARK
1.	2005.12.21			

CUSTOMER	PROJECT	DATE	01-11-09
APPROVED BY	TITLE	Top-bracing (Part List)	
CHECKED BY	AOC-300		
DRAWN BY			
UNIT	mm	SCALE	NONE
PROJECTION	1st Angle		
REV.	1		
DWG. NO.	GC-981116		
SHEET PAGE	1 of 1		

Green & Clean Technology Co., Ltd.

Range of activate

Function description

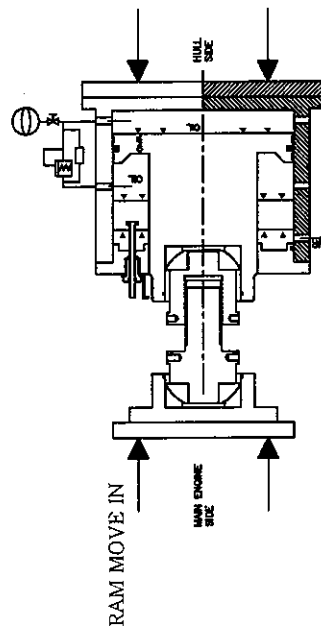


LOW LOAD

1. Static condition
2. Light load

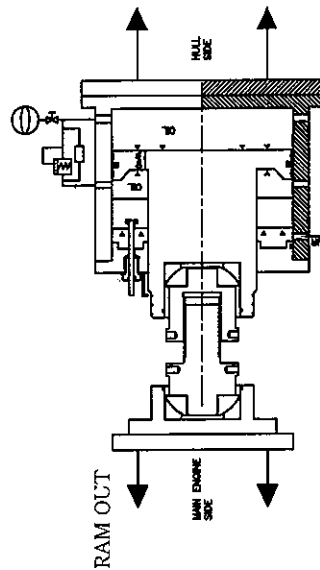
When the force from engine and/or hull is less than 85 KN, top bracing keeps preadjusted condition.
But, the force is between 85 KN and 183.8 KN, oil pressure in primary chamber will increase.
In this case, accumulator absorbs the force.

* Relief valve set pressure : 26 bar
Accumulator set pressure : 15 bar
Air regulator set pressure : 12 bar
(Remark : It is changeable depend on ship's condition.)



HEAVY LOAD

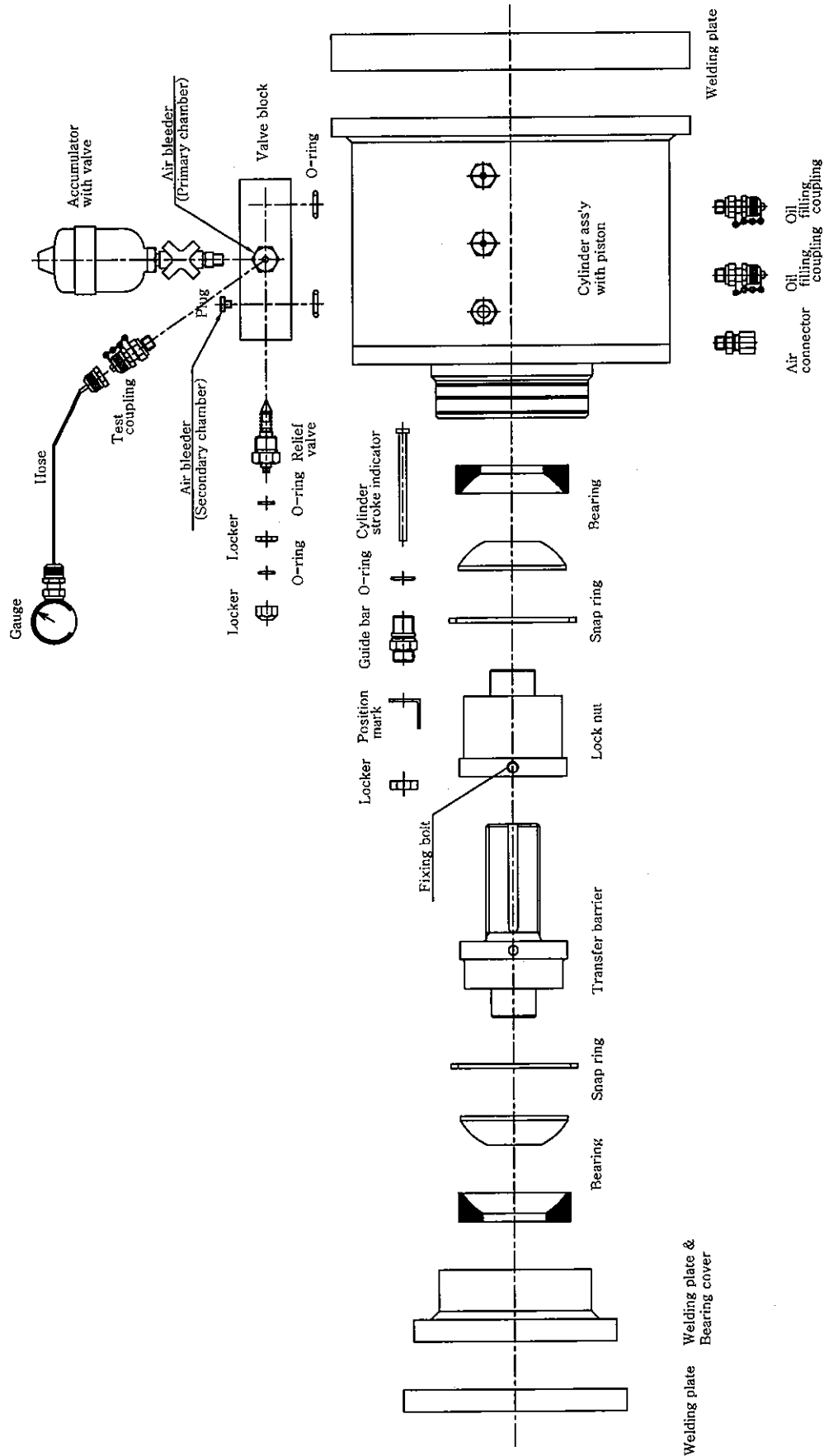
When the force from engine and/or hull is higher than setting pressure of relief valve(force : 183.8 KN), the relief valve is open.
At the same time, oil in primary chamber flows to secondary chamber.
During the oil in primary chamber flows to secondary chamber, the secondary piston move backward until the pressure of secondary and air chamber is equal.
So, air chamber absorb the force.



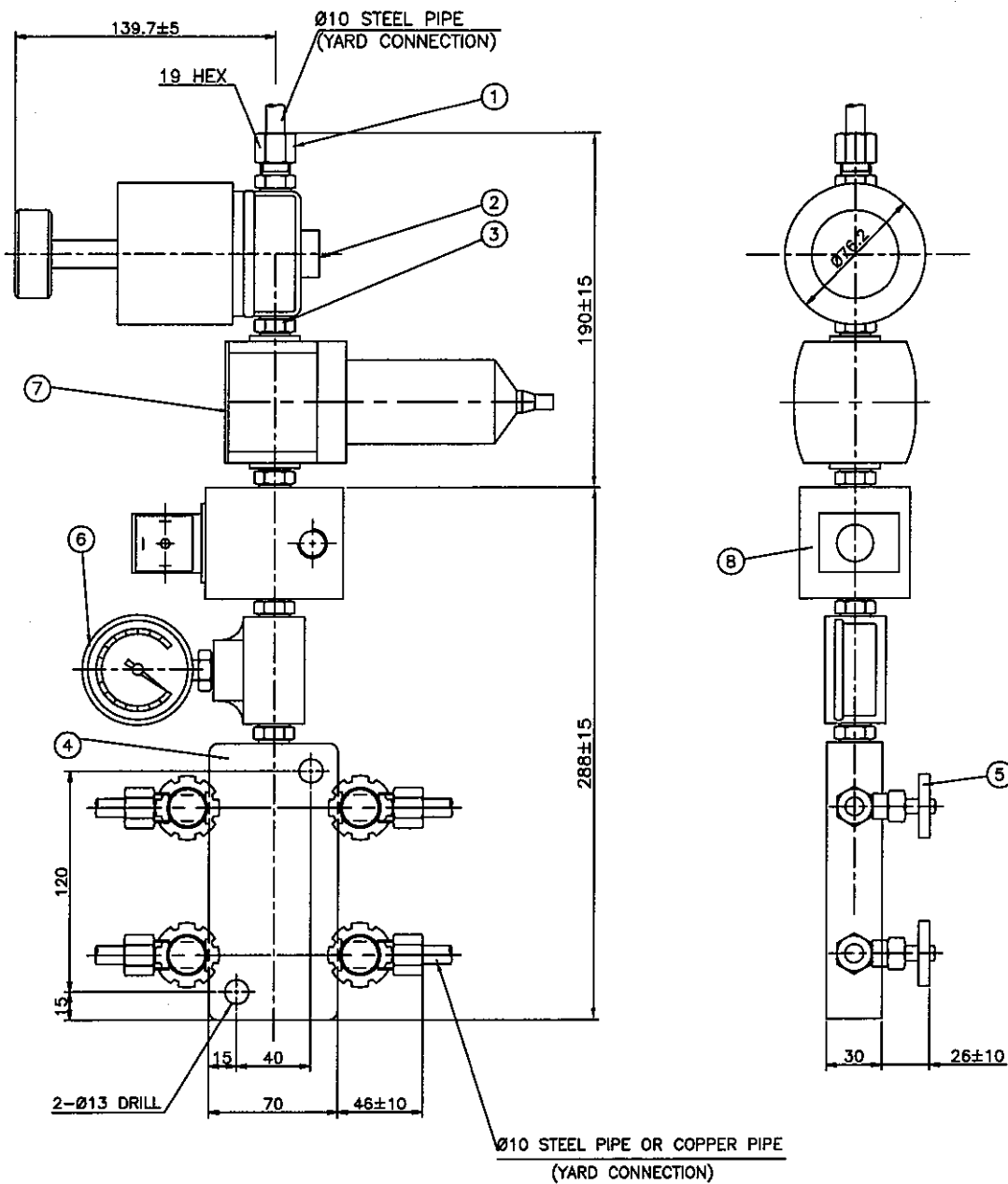
REVERSE LOAD (Negative force)

When engine and hull moves away from each other the oil pressure in primary chamber is decreased.
At the same time, compressed air in air chamber push the secondary piston forward and the oil in secondary chamber flows back to primary chamber through the check valve until the pressure in primary, secondary and air chamber is equal.

CUSTOMER		PROJECT		REV.	DATE	DESCRIPTION	REMARK
APPROVED BY K J Y		TITLE Top-bracing (Function Description)		CLASSICLE			
CHECKED BY L J G		A O C - 300		DATE 02 - 01 - 07			
DRAWN BY L J G		SCALE mm		UNIT mm		PRODUCTION Is Angle	
		TWO NO.		GC - 981113		REV. 0	
		Green & Clean Technology Co., Ltd.				SHEET PAGE 1 of 1	

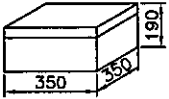
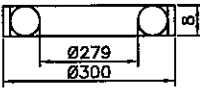
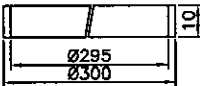
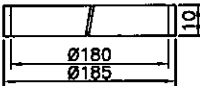
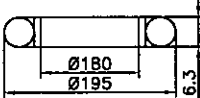
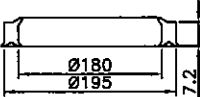
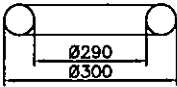
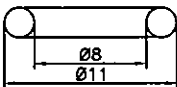
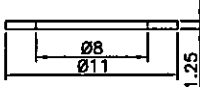


REV.	DATE	DESCRIPTION	REMARK
CLASSMATE			
DATE 02-01-07			
TITLE Top-bracing (Dismantling Drawing)			
PROJECT A O C - 300			
APPROVED BY K. J. V.	UNIT mm	SCALE NONE	REV. 0
CHECKED BY L. G. D.			
DRAWN BY L. J. S.			
DWG NO. GC-98112			SHEET PAGE 1 of 1
Green & Clean Technology Co., Ltd.			



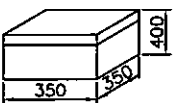
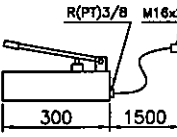
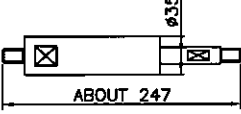
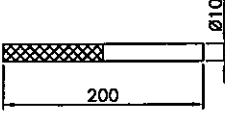
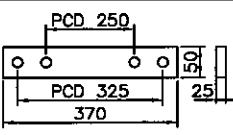
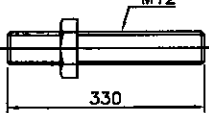
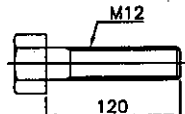
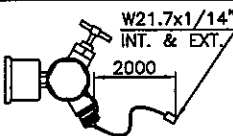
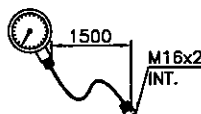
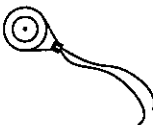
9	Tee (PTF 3/8)		1	
8	Solenoid valve(3-way)	E332 B11	1	Max. Pressure 15 bar
7	Filter (NPT 3/8)	AF18-T3-SH00	1	Max. Pressure 17.2 bar
6	Pressure gage (G 1/4)		1	Range 0~25 Kg/Cm ²
5	Stop valve (R 3/8)		4	
4	Manifold	SS 400	1	
3	Nipple (NPT 3/8)		3	
2	Air regulator (NPT 3/8)	10 2 7 3	1	Max. Output Range 14 bar
1	Connector (R 3/8)		1	
No.	Description	Material	Q'ty	Remark

CUSTOMER		PROJECT	CLASS/RULE				
APPROVED BY K J Y	TITLE Manifold & Air Regulator A O C - 300		DATE 02 - 01 - 07				
CHECKED BY L C O			UNIT mm		SCALE NONE	PROJECTION  1st Angle	REV. 0
DRAWN BY L J G							
 Green & Clean Technology Co., Ltd.			DWG NO. GC - 981118 - 4		SHEET PAGE 1 of 1		

SHIP NO. :					
SPARES LIST FOR HYDRAULIC TOP BRACING					
NO.	DESCRIPTION	SKETCH	SUPPLY PER SHIP		REMARK
			WORKING	SPARE	
1	SPARE BOX			1	STEEL BOX 11.2 Kg
1-1	GLYD RING		8	2	Busak-Luyken 0.15 Kg
1-2	WEAR RING		16	4	Busak-Luyken 0.1 Kg
1-3	WEAR RING		16	4	Busak-Luyken 0.05 Kg
1-4	STEP SEAL		8	2	Busak-Luyken 0.1 Kg
1-5	DUST SEAL		4	1	UREATHAN 0.01 Kg
1-6	O - RING		4	1	NBR 0.01 Kg
1-7	O - RING		12	1	NBR 0.001 Kg
1-8	BACK UP RING		12	1	TEFLON 0.001 Kg

SHIP NO. :

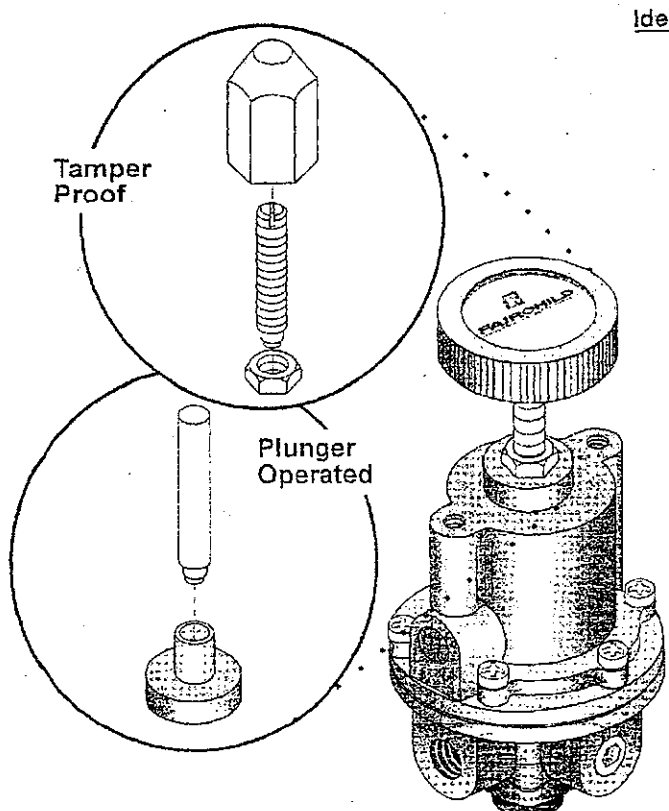
TOOLS FOR HYDRAULIC TOP BRACING

NO.	DESCRIPTION	SKETCH	SUPPLY PER SHIP		REMARK
			WORKING	SPARE	
1	TOOL BOX			1	STEEL BOX 12.1 Kg
1-1	HAND PUMP WITH HOSE			1	MAX. PRESSURE 70 Kg/Cm ² 10.5 Kg
1-2	BARRIER FLANGE JIG			2	2.6 Kg
1-3	TORQUE BAR			2	0.1 Kg
1-4	PISTON INSTALLATION JIG			1	3.6 Kg
1-5	INSTALLATION JIG BOLT WITH NUT			2	0.6 Kg
1-6	INSTALLATION JIG BOLT			2	0.2 Kg
1-7	N ₂ GAS REGULATOR WITH HOSE			1	PRESSURE GAUGE RANGE : 0 ~ 25 Kg/Cm ² 2.2 Kg
1-8	PRESSURE GAUGE WITH HOSE			1	PRESSURE GAUGE RANGE : 0 ~ 40 Kg/Cm ² 0.4 Kg
1-9	SOLENOID VALVE			1	MAX. PRESSURE 34 bar 1.2 Kg
1-10	COIL			1	220V / 8W 0.7 Kg

FAIRCHILD MODEL 10 PNEUMATIC PRECISION REGULATOR

Page 23

Installation, Operation and Maintenance Instructions



Tamper Proof

Plunger Operated

Identification Number **10 2** ☐ ☐ ☐

Pressure Range

psig	[BAR]	(kPa)	
0-2	[0-.15]	(0-15)	(1)
0-10	[0-0.7]	(0-70)	(2)
0-20	[0-1.5]	(0-150)	(0)
5-30	[.03-2]	(3-200)	(3)
1-60	[.10-4]	(10-400)	(4)
2-150	[.15-10]	(15-1000)	(6)
3-200	[.20-14]	(20-1400)	(7)
5-300	[.35-21]	(35-2100)	(8)
5-400	[.35-28]	(35-2800)	(9)

Pipe Size ☐ ☐ ☐

1/4" NPT (2)

3/8" NPT (3)

1/2" NPT (4)

Options

Compatibility

	T	E	L	R	N	B	C	A	J	U	H
Tamper Proof	(T)	-	Y	Y	N	Y	Y	Y	Y	Y	Y
Tapped Exhaust	(E)	Y	-	Y	N	Y	Y	Y	Y	Y	Y
Low Flow	(L)	Y	Y	-	Y	N	N	Y	Y	Y	Y
Plunger Operated	(R)	N	N	Y	-	Y	Y	Y	Y	Y	Y
Non-Relieving	(N)	Y	Y	N	Y	-	N	N	Y	Y	Y
Low Bleed	(B)	Y	Y	N	Y	N	-	N	Y	Y	Y
Check Valve ¹	(C)	Y	Y	Y	Y	N	N	-	Y	Y	Y
Silicone Elastomers ²	(A)	Y	Y	Y	Y	Y	Y	-	N	Y	Y
Viton Elastomers	(J)	Y	Y	Y	Y	Y	Y	N	-	Y	Y
BSPT (Tapered)	(U)	Y	Y	Y	Y	Y	Y	Y	Y	-	-
BSPP (Parallel) ³	(H)	Y	Y	Y	Y	Y	Y	Y	Y	N	-

Y = Available N = Not Available

¹ Maximum Supply Pressure - 250 psig [17.0 BAR] (1700 kPa)

² Maximum Supply Pressure - 75 psig [5.0 BAR] (500 kPa)

³ BSPP Threads in Inlet & Outlet Ports Only. Others BSPT.

Figure 1. Model 10 Pneumatic Pressure Regulator Identification Number System.

GENERAL INFORMATION

The Model 10 is a high capacity regulator that provides a uniform output pressure independent of supply pressure variation.

ADJUSTMENTS

The Model 10 Regulator does not require field adjustments.

SPECIFICATIONS

Functional Specifications			
Supply Pressure	psig	[BAR]	(kPa)
Maximum (A Option)	500	[35]	(3500)
	75	[5.0]	(500)

Specifications (continued)

Flow Capacity (Nominal)	40 SCFM (68m ³ /HR) @ 100 psig [7 BAR] (700 kPa) Supply & 20 psig [1.5 BAR] (150 kPa) Set.
Exhaust Capacity	5 1/2 SCFM (9.4m ³ /HR) @ downstream pressure 5 psig [.35 BAR] (35 kPa) above 20 psig [1.5 BAR] (150 kPa) Set Pressure.
Sensitivity	Less than 0.125" (.32 cm) Water Column
Ambient Temperature Limits	-40°F to +200°F (-40°C to +93.2°C)
Performance Specifications	
Supply Pressure Effect	Less than .1 psig [.007 BAR] (.7 kPa) for 100 psig [7 BAR] (700 kPa) Change.
Materials of Construction	Body and Housing Aluminum Trim Stainless Steel Brass, Zinc Plated Steel Diaphragms Buna N on Dacron (Standard Unit Only)

Clean all pipelines to remove dirt and scale before installation.

Apply a minimum amount of pipe compound to the male threads of the fitting only. Start with the third thread back and work away from the end of the fitting to avoid the possibility of contaminating the regulator. Install the regulator in the air line.

The regulator can be mounted in any position without affecting its operation. It can be wall mounted by using Mounting Bracket EA-09921 shown in Figure 3.

The inlet and outlet connections are labeled on the underside of the regulator with the arrows pointing in the direction of the flow. Tighten connections securely. Avoid undersized fittings that will limit the flow through the regulator and cause a pressure drop downstream. For more information, see Figure 2. "Outline Dimensions".

NOTE: Oil free air must be applied to the regulator. Use a filter to remove dirt and entrained liquid in the air line ahead of the regulator. If an air line lubricator is used, it **MUST** be located downstream of the regulator, to avoid interference with regulator performance.

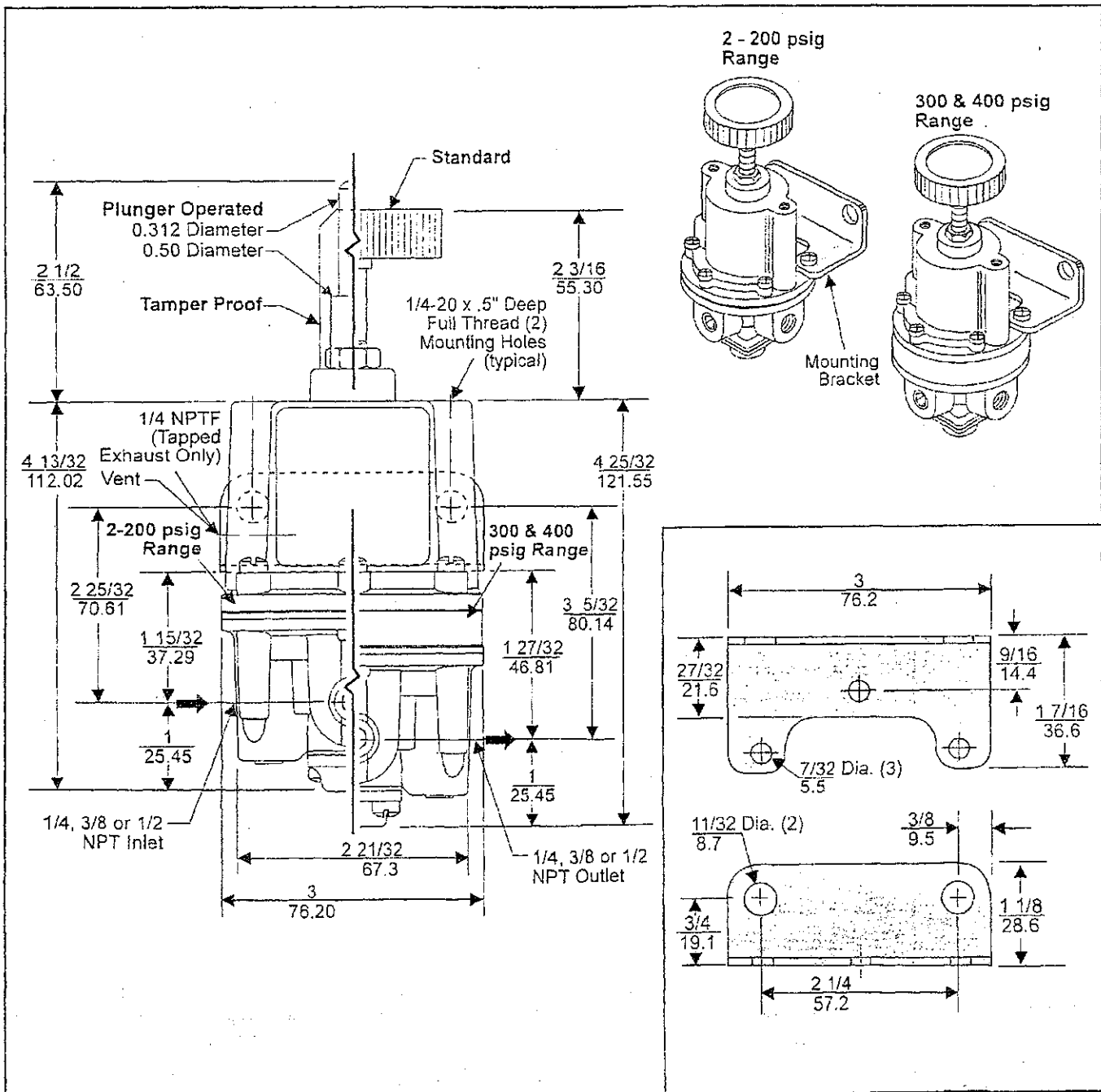


Figure 2. Outline Dimensions

Figure 3. Mounting Bracket EB-09921

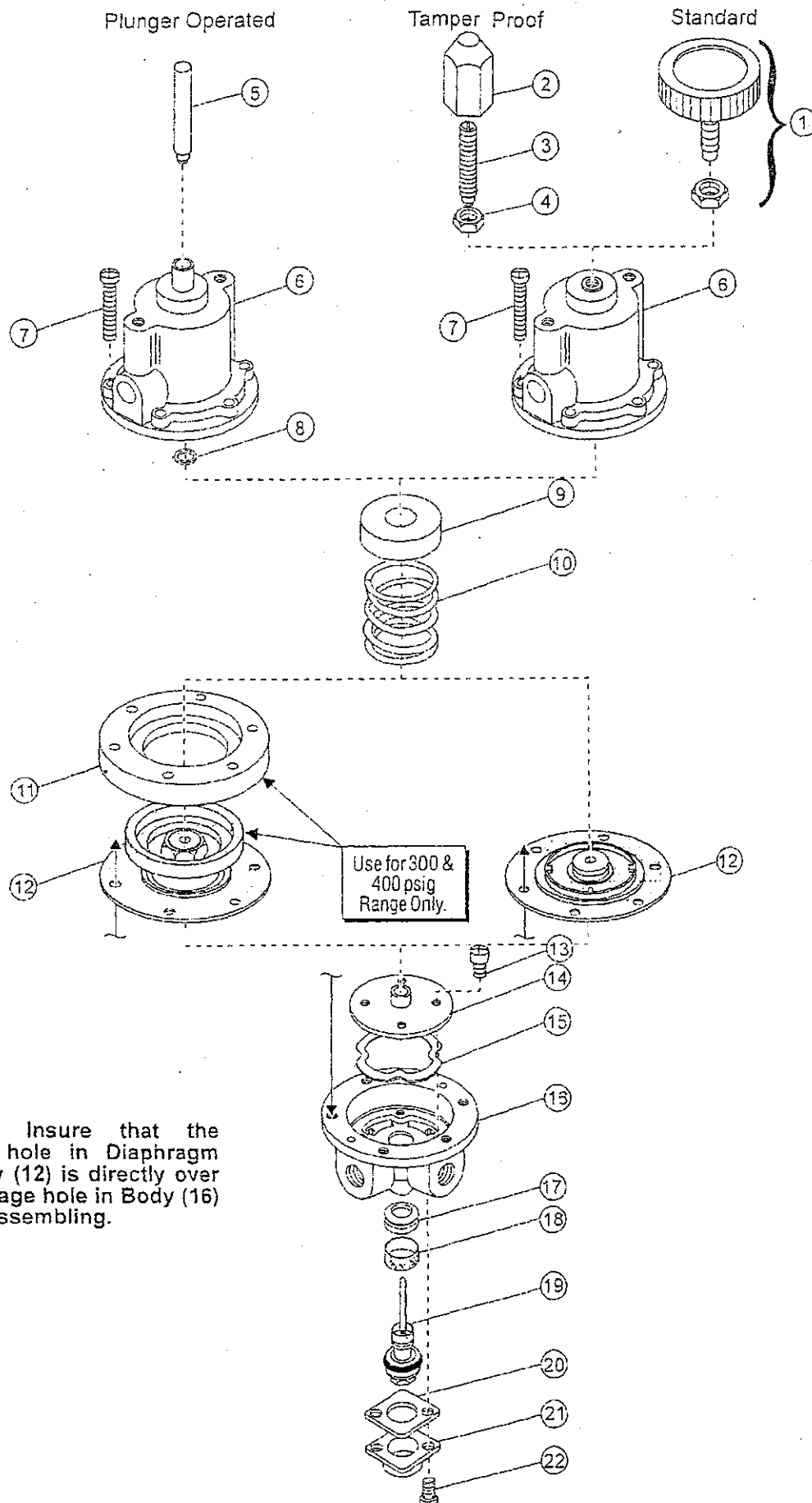


Figure 4. Exploded Drawing

To clean the Model 10, use the following procedure:

1. Before disassembly, shut off the valve that is supplying air to the regulator. This is to prevent air from escaping. It is not necessary to remove the regulator from the air line.
2. Remove the two Screws (22) from bottom of the unit.
3. Pull out the Inner Valve Assembly (19). Wash the Seat on the Inner Valve Assembly carefully.
4. Wipe off any particles that may be attached to rubber Seat Ring (17) in Body.
5. Replace the assembly carefully.
6. Keep the vent hole in the Bonnet clear for proper regulator operation. Lubricate the adjusting screw with Molycote "G". For more information, see Figure 4. "Exploded Drawing" on page 3.

NOTES: Avoid such solvents as acetone, carbon tetrachloride and trichlorethylene.

If the standard maintenance procedure does not correct the trouble, install service kit.

TROUBLE-SHOOTING

Table 1. Trouble-Shooting	
Problem	Solution (check)
Leakage	Check Body Screw tightness. Check Diaphragm.
High Bleed	Check Relief Pintle and Relief Seat for damage or contamination.
Valve Chatter	Check Seal Ring lubrication.

Table 2. Model 10 Components

Item	Qty.	Description
1	1	Knob Assembly
2	1	Cap Nut
3	1	Slotted Set Screw
4	1	Lock Nut
5	1	Plunger
6	1	Bonnet Assembly
7	6	Screw
8	1	Snap Ring
9	1	Spring Seat
10	1	Spring
11	1	Spacer Ring
12 1	1	Diaphragm Assembly
12 2	1	Diaphragm Assembly
12 3	1	Diaphragm Assembly
12 4	1	Diaphragm Assembly
12 5	1	Diaphragm Assembly
13	4	Screw
14	1	Seal Plate Assembly
15 6	1	Seal Plate Gasket
16	1	Body
17 7	1	Seat Ring Assembly
17 4	1	Seat Ring Assembly
17 8	1	Seat Ring Assembly
18 6	1	Screen
19 7	1	Inner Valve Assembly
19 4	1	Inner Valve Assembly
19 8	1	Inner Valve Assembly
20	1	Retainer Plate
21	1	Retainer Cap
22	2	Screw

¹ EA-12125 Service Kit Components Only.
0-2, 0-10, 0-20, .5-30, 1-60, 2-150, 3-200 psig
[0-15, 0-7, 0-1.5, .03-2, 0.1-4, .15-10, .20-14 BAR]
(0-15, 0-70, 0-150, 3-200, 10-400, 15-1000, 20-1400 kPa)

² EA-12126 Service Kit Components Only.
5-300, 5-400 psig
[.35-21, .35-28 BAR]
(35-2100, 35-2800 kPa)

³ EA-12495 Service Kit Components Only. (Viton)
0-2, 0-10, 0-20, .5-30, 1-60, 2-150, 3-200 psig
[0-15, 0-7, 0-1.5, .03-2, 0.1-4, .15-10, .20-14 BAR]
(0-15, 0-70, 0-150, 3-200, 10-400, 15-1000, 20-1400 kPa)

⁴ EA-12556 Service Kit Components Only. (Silicone)
0-2, 0-10, 0-20, .5-30, 1-60, psig
[0-15, 0-7, 0-1.5, .03-2, 0.1-4, BAR]
(0-15, 0-70, 0-150, 3-200, 10-400, kPa)

⁵ EA-18017 Service Kit Components Only. (Viton)
5-300, 5-400 psig
[.35-21, .35-28 BAR]
(35-2100, 35-2800 kPa)

⁶ For All Service Kits.

⁷ EA-12125 & EA-12126 Service Kits Only.

⁸ EA-12495 & EA-18017 Service Kits Only.

ISO 9002
Certified



FAIRCHILD
INDUSTRIAL PRODUCTS COMPANY

3920 WEST POINT BLVD. WINSTON-SALEM, NC 27103-6708
TEL 336-659-3400 FAX 336-659-9323



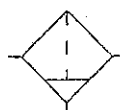
FM NO. 25571

IS-10000010
Litho in USA
Rev. O 9/99

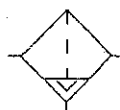
Filter / AF08, AF18, AF28 Series

Page 27

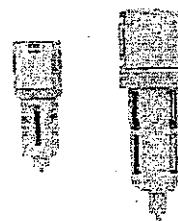
Symbol



Manual



Auto



ORDER KEY

AF 18 - T 3 - S K 0 0

Series

AF	Filter
----	--------

Body Size

08	1/8", 1/4"
18	1/4", 3/8", 1/2"
28	3/8", 1/2", 3/4"

Thread type

T	Rc(PT)
0	NPT
C	BSPP ²

Port Size

1	1/8"
2	1/4"
3	3/8"
4	1/2"
6	3/4"

Filter element

S	5 μ m
---	-----------

Option

0	None
L	Differential pressure indicator ¹
V	Fluorocarbon seal

Option

0	None
L	Differential pressure indicator ¹
V	Fluorocarbon seal

Option

BOWLS	PLASTIC W/GUARD DRAINS	METAL W/NO SIGHT GLASS ¹	METAL W/ SIGHT GLASS ³
NONE	C	-	D
1/8 NPT FEMALE ¹	E	U	F
STD AUTO. DRAIN ^{2,5}	G	-	H
MANUAL DRAIN	K	-	L
LOW FLOW AUTO. DRAIN ^{4,5}	N	-	P
PISTON DRAIN (08 Series Only)	R	-	S
FLEX DRAIN (18&28 Series Only)	T	-	-

1. Not available on 08 series.

2. ISO, R228 (G SERIES)

3. AF08 filter has an all metal bowl (no sight glass).

4. Except 08 Series.

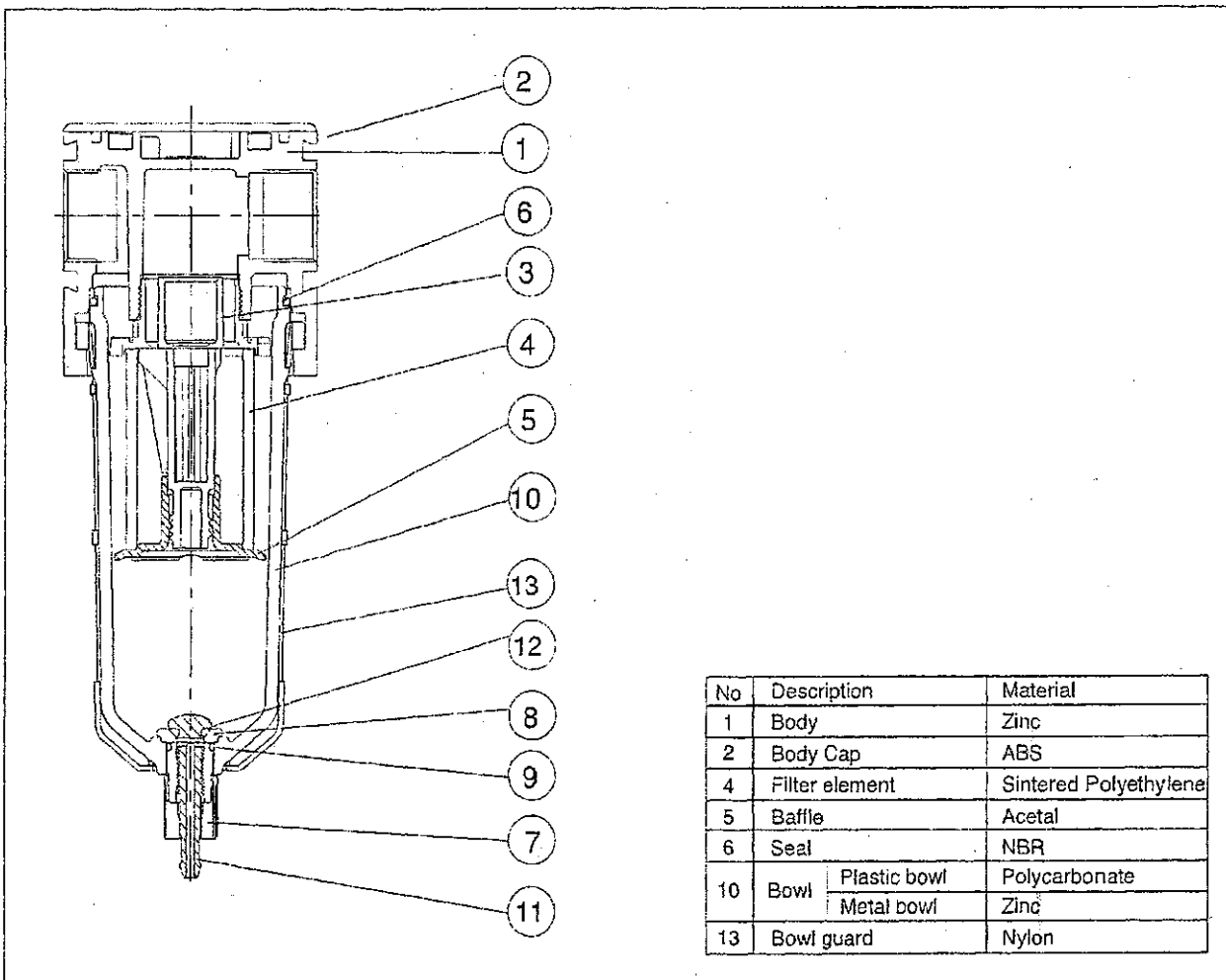
5. Operating Range 1.14 bar.

Specifications

Model No	Unit	AF08		AF18			AF28		
Port Size		1/8"	1/4"	1/4"	3/8"	1/2"	3/8"	1/2"	3/4"
Flow capacity	l/min (ANR)	714	1,429	3,143	3,428	4,143	4,114	4,571	4,714
Fluid		Air							
Standard filtration	μm	5							
Max. Operating Pressure	Plastic bowl	MPa(bar)							
	Metal bowl								
		1(10.3)							
		1.7(17.2)							
Max. Operating Temperature	Plastic bowl	$^{\circ}\text{C}$							
	Metal bowl								
		52.0							
		85.5							
Useful retention	cm^3	12.0		50.9			84.9		
Weight	kg	0.2		0.5			0.77		

Note) Inlet pressure 10.3 bar. Pressure drop 0.3 bar

Constructions

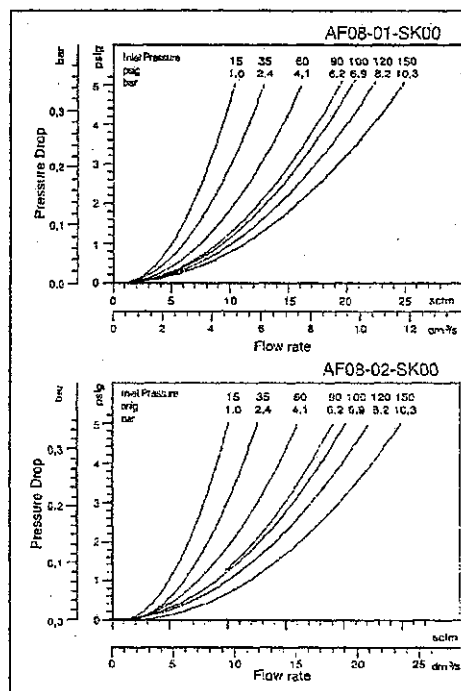


Filter / AF08, AF18, AF28 Series

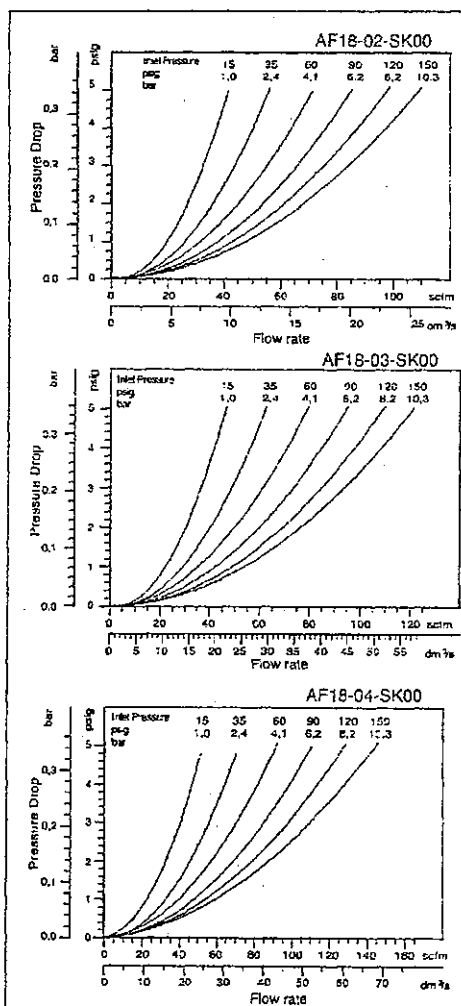
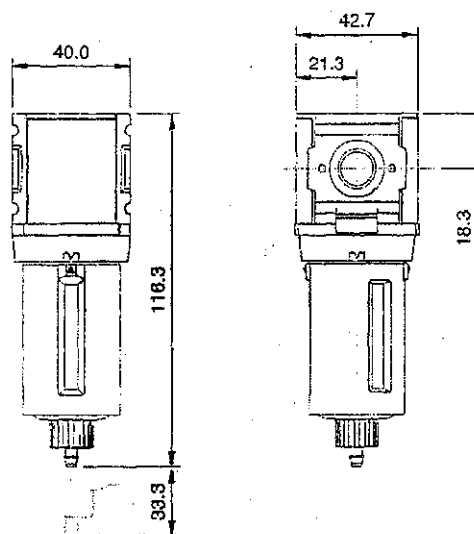
Flow Characters

Dimensions

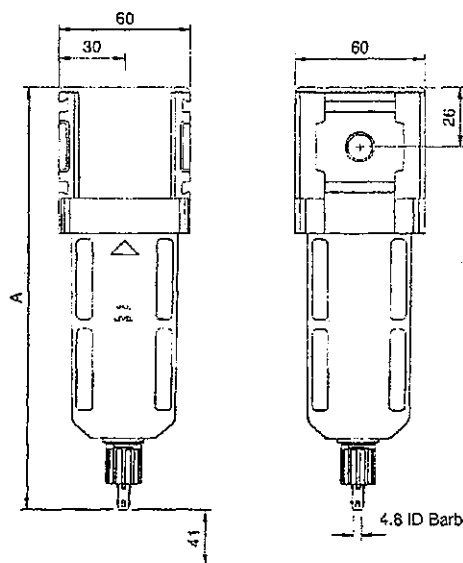
(Unit : mm)



AF08



AF18



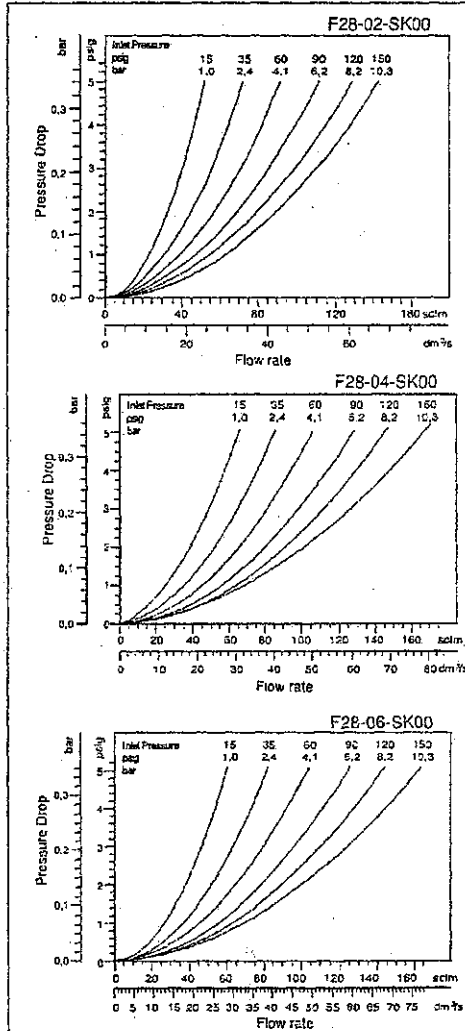
	A
Manual drain	188
Auto drain	179
Differential pressure indicator	209
Metal bowl and auto drain	179
Metal bowl and manual drain	188

Note) scfm=0.035 × l/min

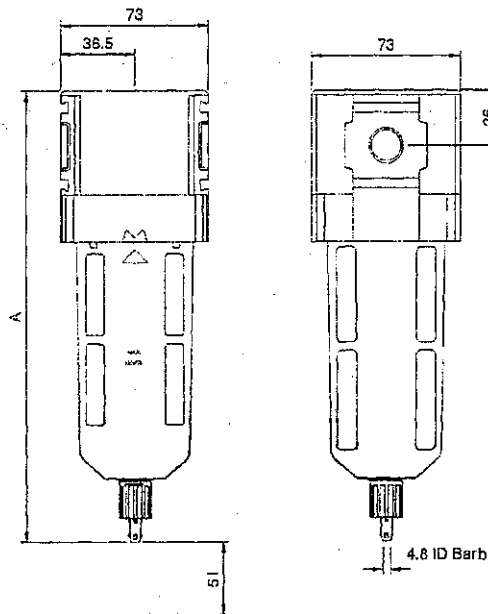
Flow Characters

Dimensions

(Unit : mm)



AF28



	A
Manual drain	213
Auto drain	204
Differential pressure indicator	235
Metal bowl and auto drain	204
Metal bowl and manual drain	213

Note) scfm=0.035 × l /min



Istruzioni per la precarica di accumulatori
idropneumatici

Instructions for precharge and control of the
hydropneumatic accumulators

Instructions pour le dispositif de précharge pour
accumulateurs hydropneumatique

Bedienungsanleitung zur Vorspannung von
Druckspeichern

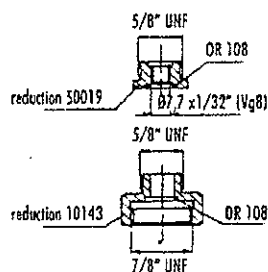
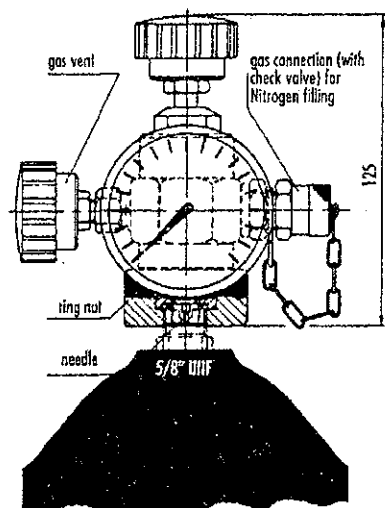
Smontaggio e manutenzione accumulatori
idropneumatici SAIP

Dismantling a SAIP hydropneumatic
accumulator

Démontage des accumulateurs
hydropneumatiques SAIP

Wartung und Instandsetzung von SAIP
Hydropneumatischen Druckspeichern

GAS-FILLING AND CHECKING APPARATUS



General

This device is used to check and refill the accumulator periodically, after changing the diaphragm or bag and to adjust the gas-filling pressure. Use industrial-nitrogen bottles having a higher pressure than the filling pressure.

Description

The Standard Version consists of:

- * A pressure-reading unit, fitted with a ringnut for connection to the accumulator's gas valve, a pressure gauge, vent and check valve with quick fitting to the hose.
- * A 3-m long high-pressure hose with fitting suitable for Italian gas bottles
- * A set of spare gaskets
- * A carrying case

Optional attachments:

- * Adapters for non-standard fittings
- * Fittings for non-Italian gas bottles
- * Hose of lengths other than 3 m

Technical data

	DP 100	DP 200
Max. pressure :	360 Bar	360 Bar
Accumulator fitting :	M28x1,5	5/8" UNF (standard) 7/8" UNF (optional) Ø 7,7x1/32" (Vg 8) - (opt.)
Bottle fitting :	Standard W21,7x1/14" ext. (Italy) W24,32x1/14" int. (D-CH-NL-S-FL-B-CSI) Optional W21,7x1/14" int. (F) W5/8" ext. (G)	Designation: The example is for a gas-filling and checking apparatus with pressure gauge, 5/8" UNF accumulator fitting, bottle fitting to Italian standards, complete with 3-m long hose and carrying case.
Pressure gauges :	• Ø 63 1/4 NPT • Full scale: 6-10-60-100-160-250-400	
Weight :	2 kg (with case)	

Type	Pressure gauges (bar full scale)	Accumulator fitting	Bottle fitting (to local standards)	Hose (metres)
DP 100	6 10 60 100	- = 5/8" UNF A = Ø 7,7x1/32" (Vg 8) (reduction 50019)	- = Italy D = Germany - Switzerland - Holland - Sweden - Finland - Belgium - Russia	- = 3m (standard) 2-4-5-6 (optional)
DP 200	160 250 400	B = 7/8" UNF (reduction 10143) C = M28x1,5	F = France G = Great Britain	

Modifications excepted

Instructions for precharge and control of the hydropneumatic accumulators (see drawing)

Control or reduction of the precharge pressure.

For this operation, the hose is not needed. Discharge the pressure of the pump system and take off or cut out the accumulator, remove the protection cap of the precharge valve and apply the precharging device by screwing the fixing ring (1) on the valve of the accumulator, screw the handwheel (4) gently and read the pressure on the gauge (3). If it is too high, open the bleed screw (2) slightly, unscrew the handwheel (4), remove the device and replace the protection cap on the precharge valve.

Increase of the precharge pressure.

To precharge or increase the precharge pressure of the accumulator remove the cap, apply the device by screwing for fixing ring (1), leaving the handwheel (4) unscrewed and the bleed screw (2) tightly screwed. Take off the cap (5) and connect the precharge device to a nitrogen bottle connection (7) with the hose (6).

Screw the handwheel (4) gently and open the faucet of the nitrogen bottle slowly; check the pressure gauge (3) and increase the pressure till a slightly higher pressure value than the one needed is reached. Close the faucet of the bottle, bleed by opening and closing the bleed screw (2) and

wait for a few minutes. Screw the handwheel (4) and read the pressure; if the precharge is right, unscrew the handwheel (4) and remove the device and the hose (6). If it is wrong, reduce or increase the precharge pressure according to the given instructions.

General notes

- use nitrogen only as precharge gas;
- standard diaphragms are made of nitrile, butyl-rubber or viton;
- precharging pressure must be higher than 1/4 of the max. and lower than 9/10 of the min. operating pressure of the pump;
- check the precharge pressure every 2 or 3 months and, if necessary, recharge the accumulator.

Dismantling a SAIP hydropneumatic accumulator

- 1 - Release pressure in hydraulic system.
- 2 - Check that accumulator is completely empty of gas, with infilling-clocking instrument. If no instrument is available depress checkvalve with screwdriver until no more gas escapes.
- 3 - Unscrew and remove complete refilling valve.
- 4 - Unscrew upper cap with band-key.
- 5 - Remove diaphragm.
- 6 - Thoroughly clean accumulator inside.
- 7 - Snear seat of new diaphragm with grease.
- 8 - Insert new diaphragm.
- 9 - Discard and replace O-ring.
- 10 - Thoroughly tighten upper cap.
- 11 - Fill new refilling valve.
- 12 - Pressurize accumulator to required value (with prefilling device).

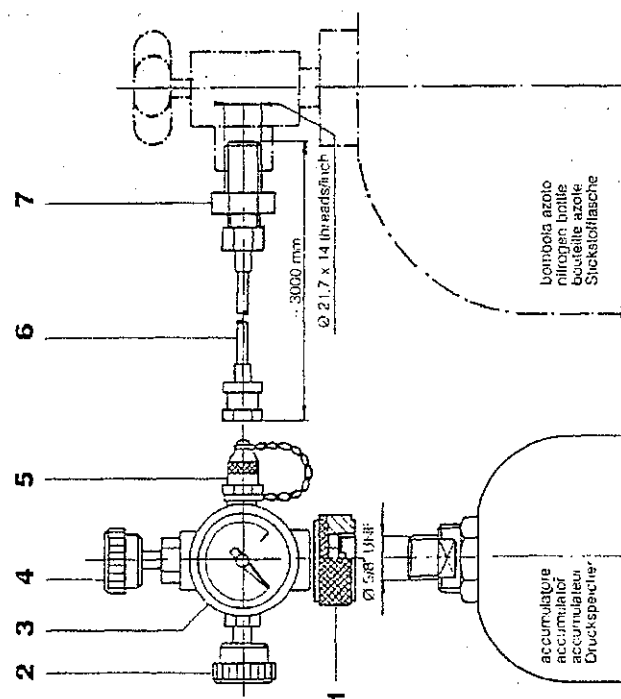
Warning: Use NITROGEN-Gas exclusively, to prevent explosions!

Before checking gas precharge or increasing/decreasing pressure, make sure that accumulator is completely empty on the liquid side. When replacing the diaphragm, wet seal walls with the pumped or other compatible liquid to facilitate adhesion of the new diaphragm.

Dispositivo di precarica per accumulatori Precharge device for accumulators

Dispositif de précharge pour accumulateurs

Vorspannungsvorrichtung für Druckspeicher



5 raccordo di precarica con cappello
precharge connection with cap
raccord de précharge avec chapeau
Vorspannungsverschraubung mit
Kappe

6 tubo flessibile (max. 600 bar)
hose
flexible
Schlauch

7 raccordo bombola
bolle connection
raccord bouteille
Flaschenverschraubung

1 ghiera di fissaggio
fixing ring
collier de serrage
Beleisungsschwinde

2 valvola di scarico
bleed screw
vis d'échappement
Abblaseventil

3 manometro
pressure gauge
manomètre

4 volante apertura valvola
volant d'ouverture soupape
Handrad für Ventilöffnung