Warning!
It is important that all MAN Diesel A/S engines are operated within the given specifications and performance tolerances specified in the engines' Technical Files and are maintained according to the MAN Diesel A/S maintenance instructions in order to comply with given emissions regulations. In accordance with Chapter I of the Code of Federal Regulations, Part 94, Subpart C, §94.211 NOTICE is hereby given that Chapter I of the Code of Federal Regulations, Part 94, Subpart K, §94.1004 requires that the emissions related maintenance of the diesel engine shall be performed as specified in MAN Diesel A/S instructions, including, but not limited to, the instructions to that effect included in the Technical File.

MAN Diesel

K98ME

DS 09092965

VOLUME II

MAINTENANCE

900 - Introduction

Documents in this Chapter

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Volume II - Maintenance

Table of Contents

Volume II - Maintenance

Instructions for Main Engines

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

Vol. I OPERATION
Vol. II MAINTENANCE
Vol. III COMPONENTS, 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 an MAN B&W main diesel engine. 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:

Name of vessel
Engine No. built by
Plate No.
Part No.
Quantity required (and description)

Example: M/S Nybo – 7730 B&W – P90201-0036 – 059
10 off (piston ring)

To ensure optimum efficiency, reliability and lifetime of the engine and its components, only original spare parts should be used when replacing parts on the engine.

When used in texts and illustrations, the designation "D" refers to the information given on the data sheets inserted in the respective books.

Reliable and economical operation of the diesel engines is conditional upon its correct operation and maintenance in accordance with MAN Diesel' instructions. Emissions related maintenance of the diesel engine shall be performed as specified in MAN Diesel' instructions and any additional instructions to that effect included in the Technical File. Consequently, it is essential that the engine room personnel are fully acquainted with the contents of this book and, in respect of instructions on emissions related maintenance of the diesel engine, also the additional instructions to that effect set out in the Technical File.

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A90023-0028

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”
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

			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**															
-1	Cylinder cover										C*			O		** Check whenever exhaust valve is removed*
	Indicator cock													O		
902	**Piston with Rod and Stuffing box**															
-1	Piston										C,O					
	Inspection through scavenge ports				C										V	
-2	Piston rod stuffing box										C*			O		** Check clearances without dismantling segments*
903	**Cylinder Liner and Cylinder Lubrication**															
-1	Cylinder liner													O		
	Inspection through scavenge ports				C											
	Measuring wear inside liner										C					
-2	Cylinder lubricators										C			A	V,M	*Bearings should only be opened if bearing material fragments fall out.*
	Accumulators nitrogen pressure										C			A		
	Lubricator level sensor						C							O	V,M	*Vol. I Chapter 702-01*
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**															
-2	Main bearing	C							C					C,O	V	*Bearings should only be opened if bearing material fragments fall out.*
-3	Thrust bearing	C							C					C,O		
-3	Guide bearing	C							C					C,O		
-4	Journal bearing	C							C					C,O	V	

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

M : See maker’s instructions
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H : Check new/overhauled parts after 500-1500 hours

R : Parts to be replaced
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			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*
-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	

When referring to this page, please quote Maintenance Schedule A90050 Edition 0293

V : See Volume I “Operation”
A : Adjustment to be carried out
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			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*
907	**Starting Air System**															
-2	Starting air valve		C*							C,O					V	* *Vol. I, Chapter 702-01*
	Main starting valve pilot valve		C*												V	*After arrival in port*
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**															
-1	Air cooler		C											O	V	*Check Δp and Δt*
-2	Non-return valve				C									O		*Check at every port inspection*
-3	Auxiliary blower													O		
-4	Butterfly valves				C									O		*Check at every port inspection*
-5	Turbocharger turbine		C*						C					C,O	V,M	* *Dry cleaning daily*

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

			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*
	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*

When referring to this page, please quote Maintenance Schedule A90050 Edition 0293

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

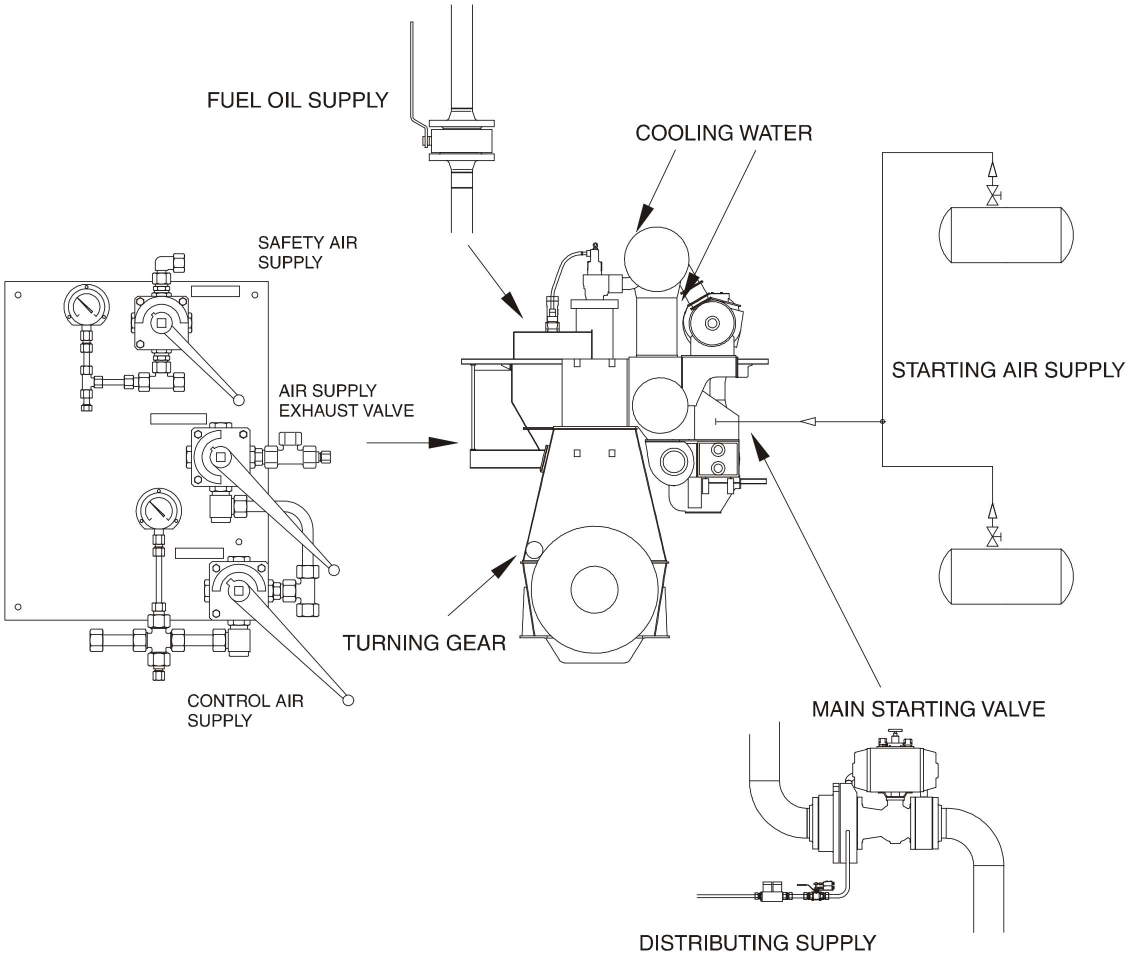
			Regular Checks			Service interval (x 1000 hours of operation)										
No.	Procedure	H	Daily	Weekly	Monthly	2	4	6	8	12	16	24	32	B	P	*Remarks*
913	**General Tools**															
-1	Hydraulic tools								C					O	M	

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 – *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 with stopped lubriating oil pumps*
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:



901 - Cylinder Cover

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubricating oil pumps*
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
D01-01	Exhaust valve stud, screwing-in torque	600	Nm
D01-02	Starting valve stud, screwing-in torque	110	Nm
D01-03	Fuel valve stud, screwing-in torque	140	Nm
D01-05	Cylinder cover stud, check distance	196.5 - 197.5	mm
D01-06	Cylinder cover, complete	11000	kg
D01-07	Cylinder cover without valves	7600	kg
D01-08	Cooling jacket	310	kg
D01-09	Exhaust valve stud	210	kg
D01-10	Cylinder cover stud	205	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
P90151	142	Lifting Tool for Gas Compensator
P90161		Cylinder cover tightening tool
P90165		Cylinder Cover - Lifting Tools
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.

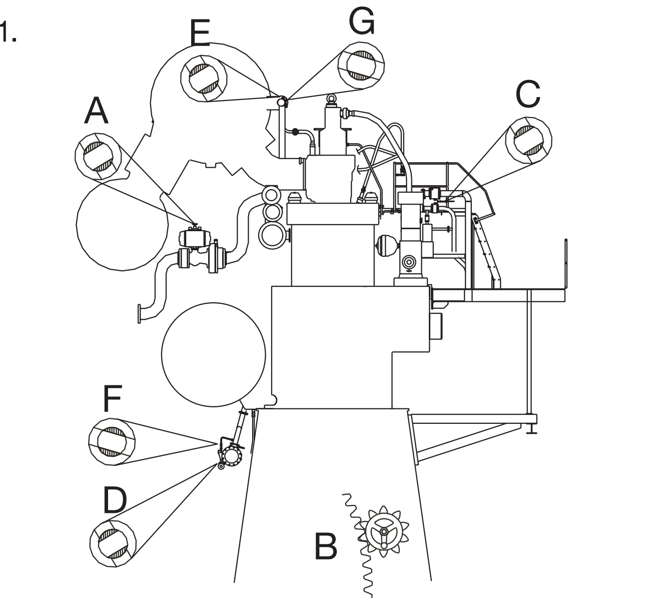
   Check the pressure.

   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.

1.



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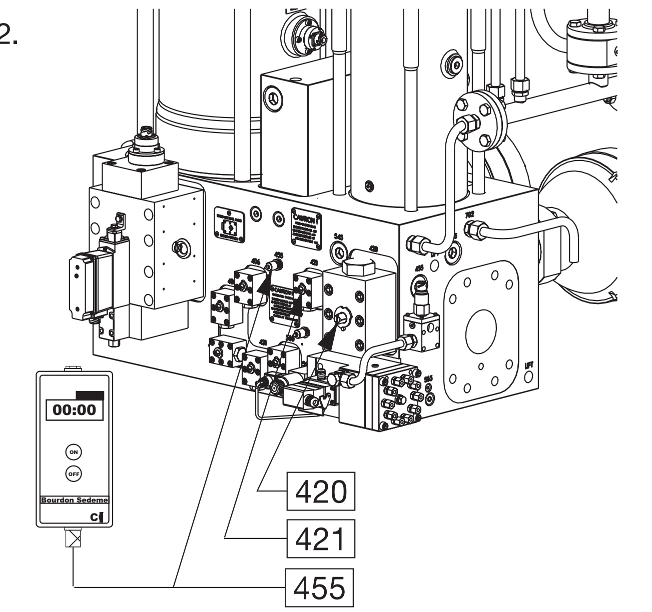

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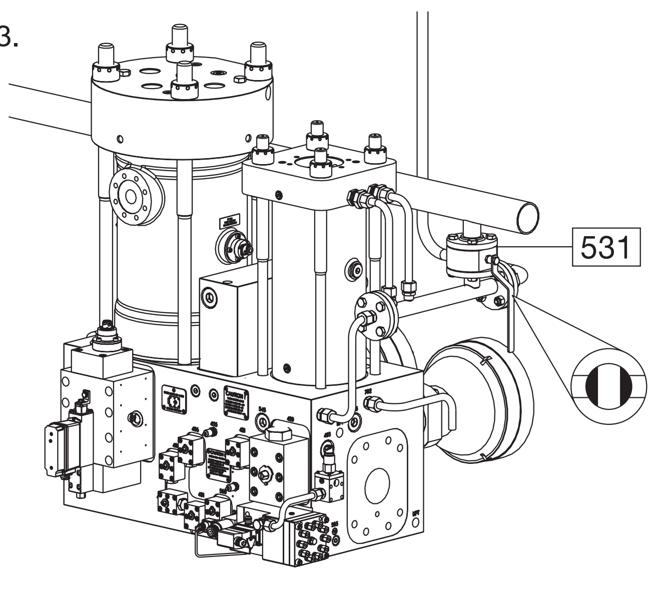

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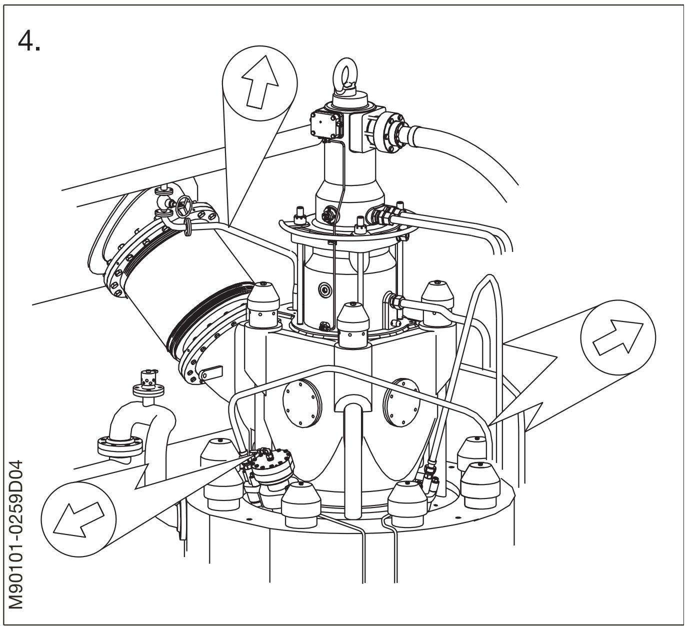

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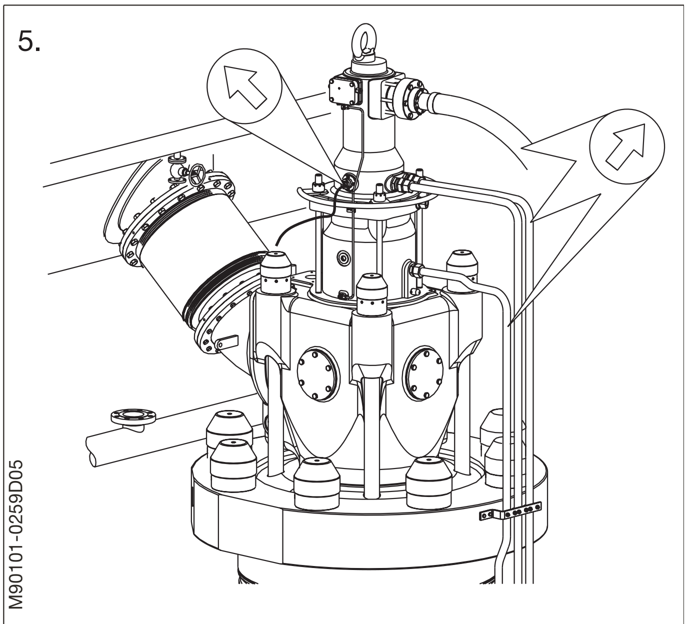


4. Remove the cooling water outlet pipe from the exhaust valve.

   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.

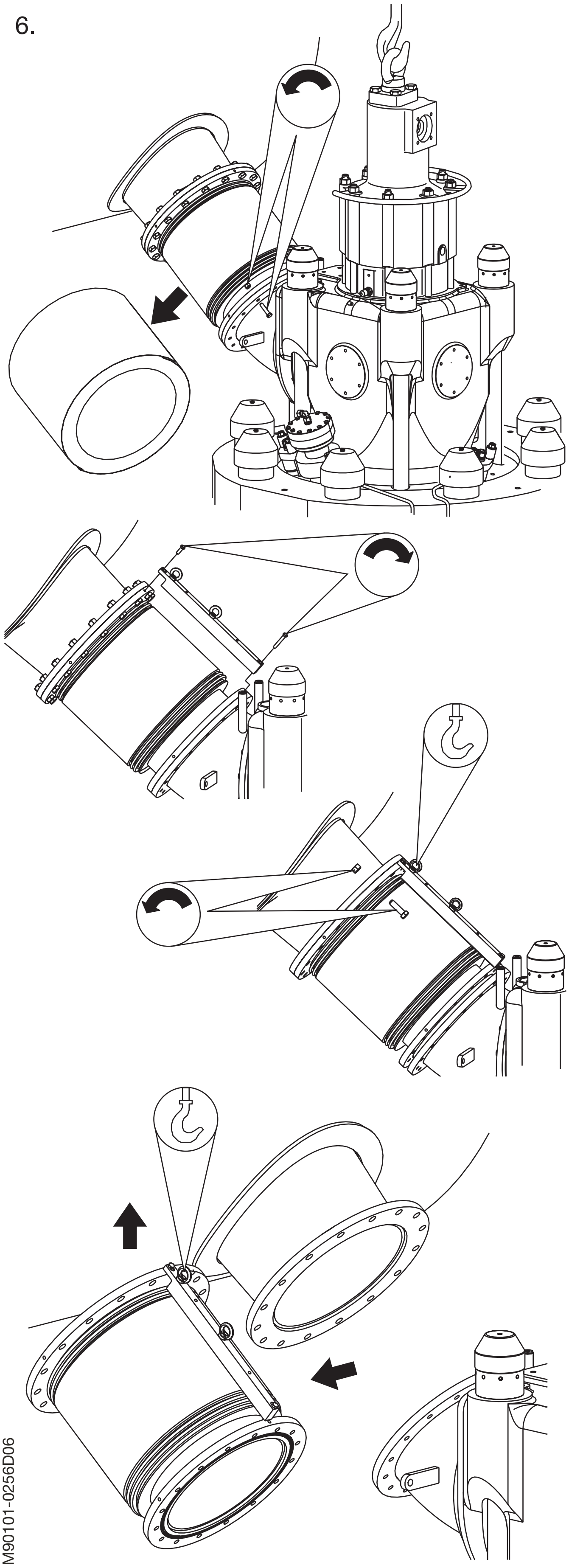
   Fit the lifting tool as shown in the sketch.

   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.

6.



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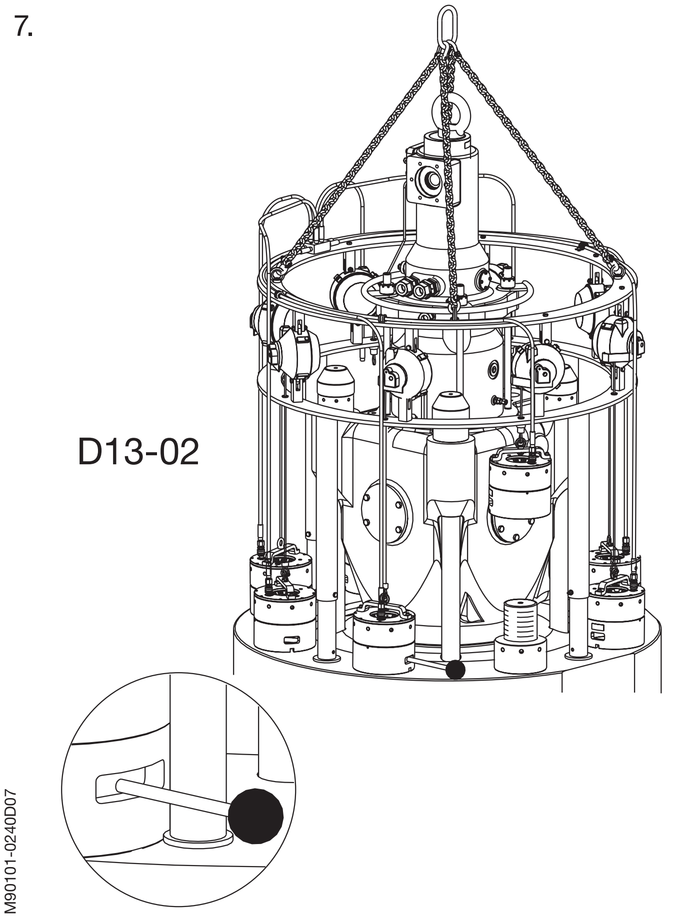

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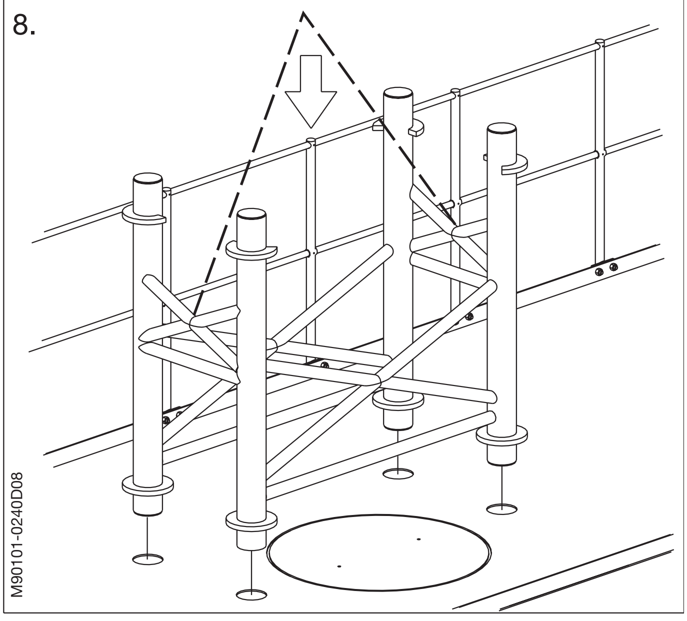


7. Remove the protective caps from the cylinder cover nuts.

   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.

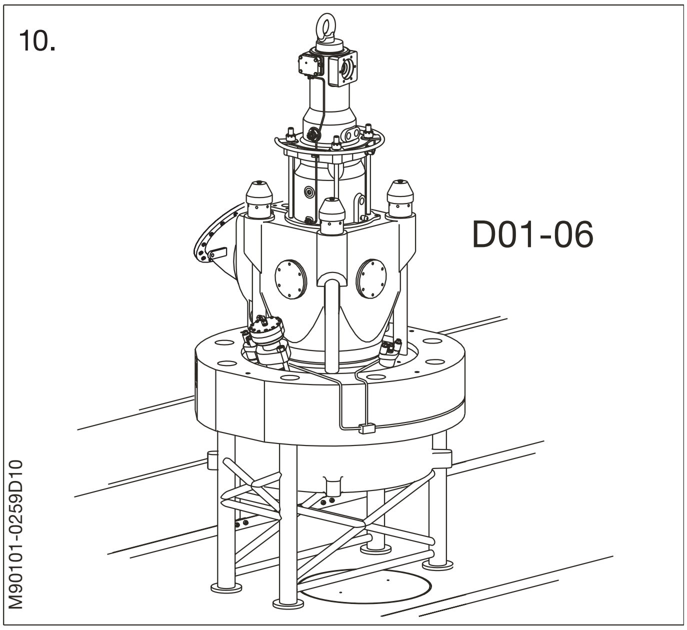
   Lift away the cylinder cover complete.

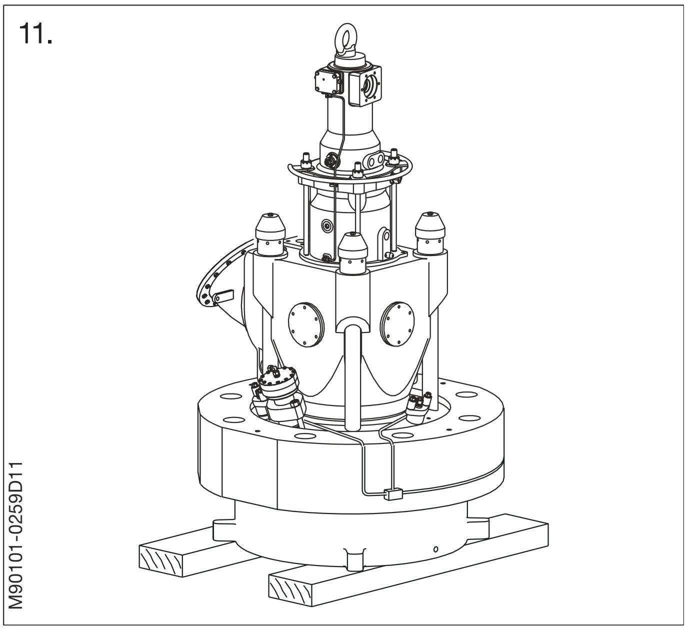
10. Land the cylinder cover on the support tool.

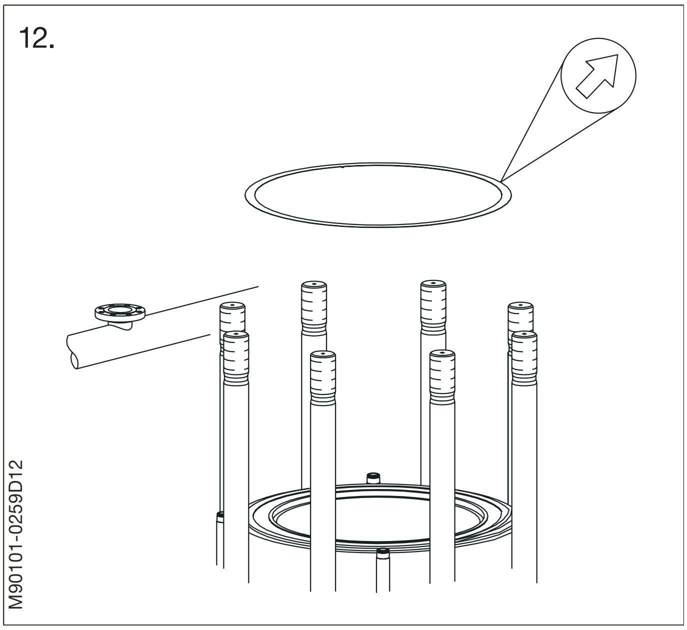
Note!
The cylinder cover support tool should only be used when the ship is in port.

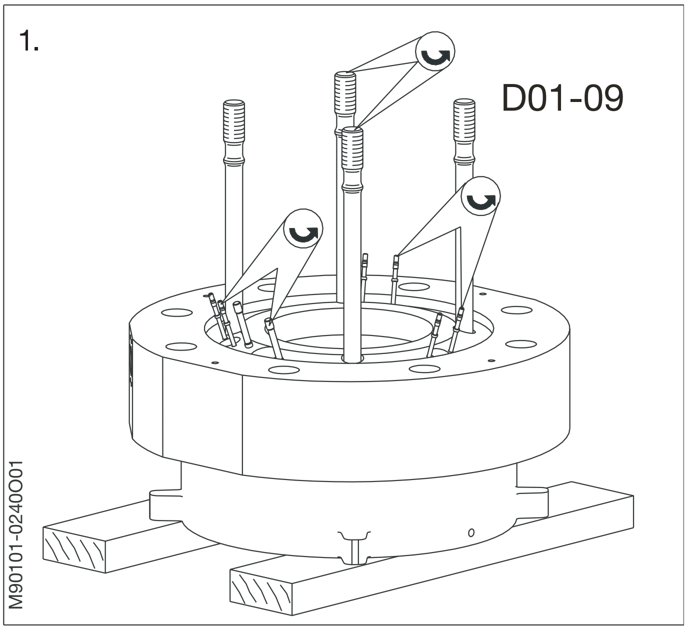
11. If the cylinder cover is to be overhauled it is recommended instead to land the cylinder cover on a couple of wooden planks.

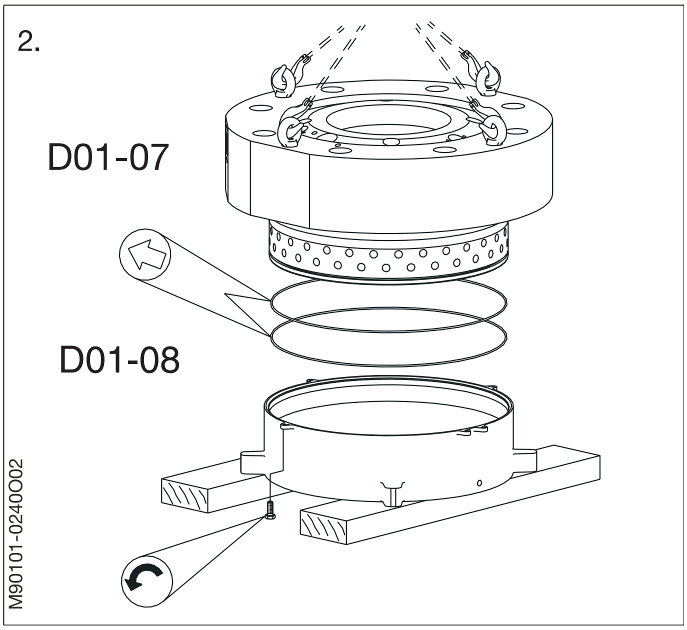
12. Remove and discard the sealing ring between cylinder cover and cylinder liner.

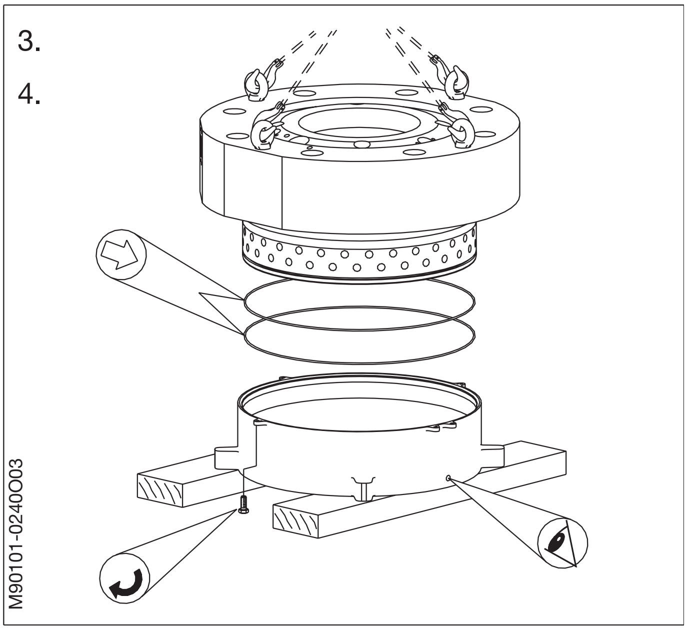












1. Dismount all valves and pipes on the cylinder cover. *See Procedure 907-2.2, 908-2.2 and 909-11.2.*

   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.

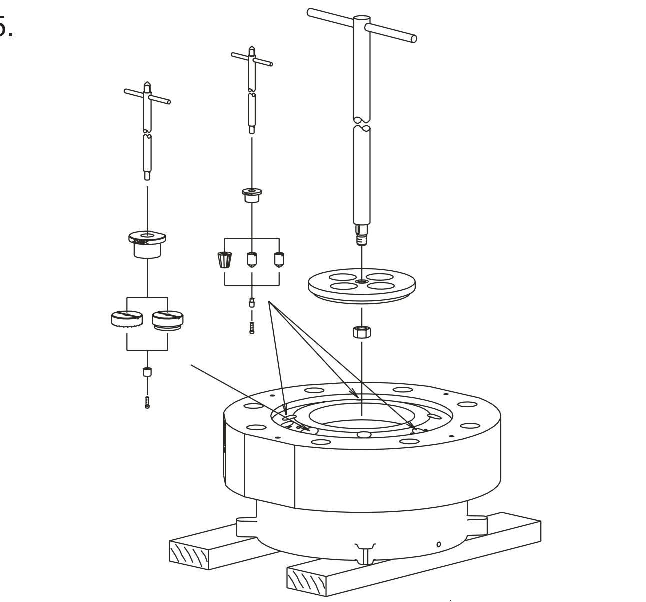
Exhaust valve bore

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.

5.



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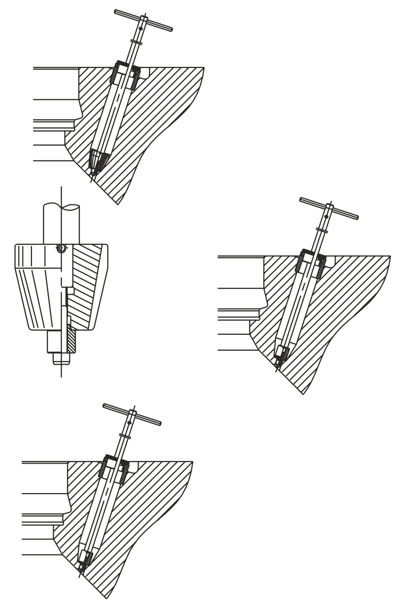

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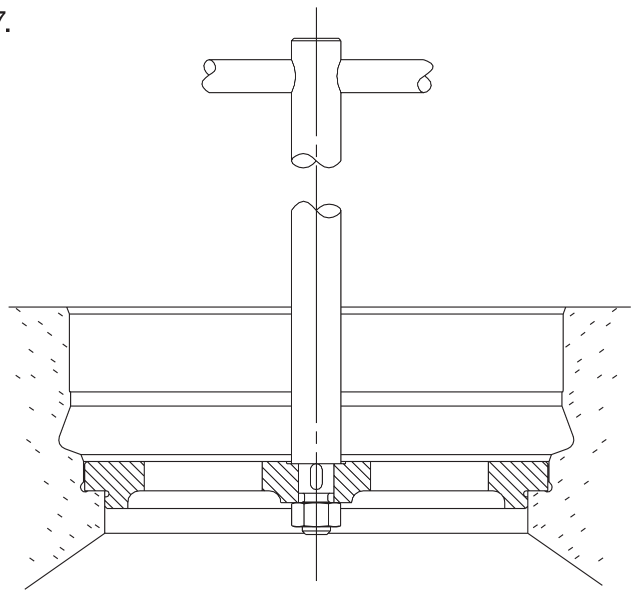

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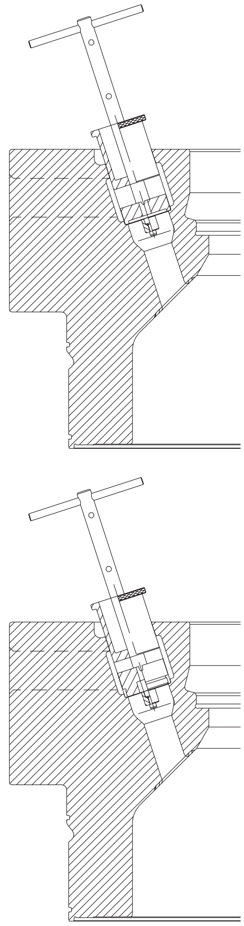

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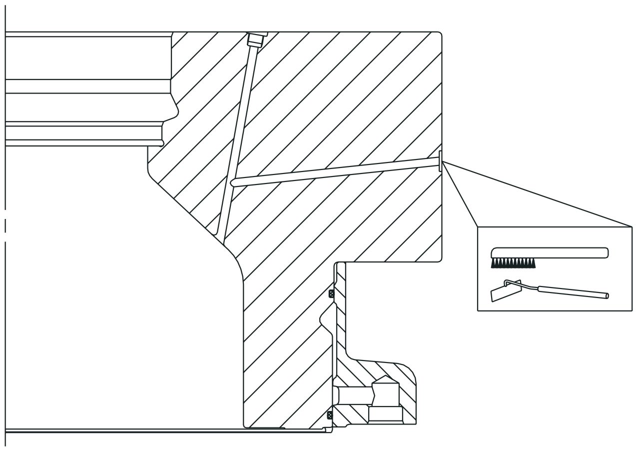

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Starting valve bore

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.

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

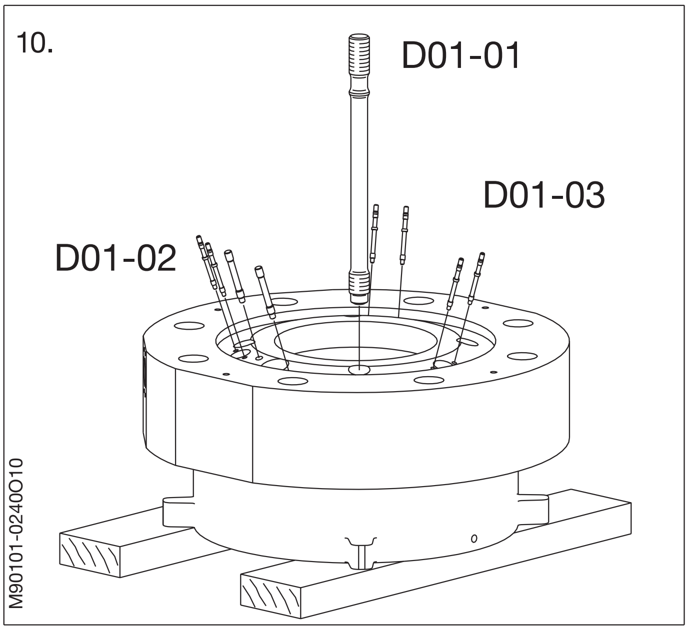
    Tighten up the studs in accordance with the screwing-in torque stated on the data sheet.

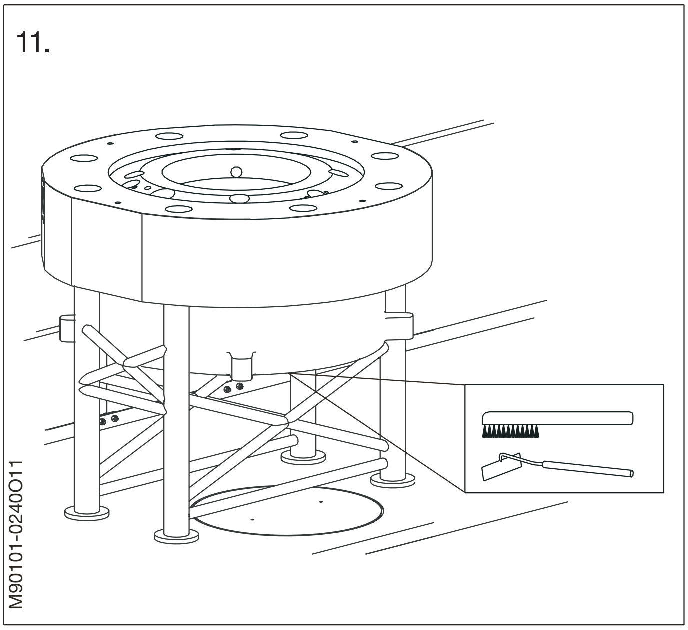
    Fill up the grooves between the valve studs and the bores for the valve studs with permatex to prevent water or oil from entering the bores during operation of the engine.

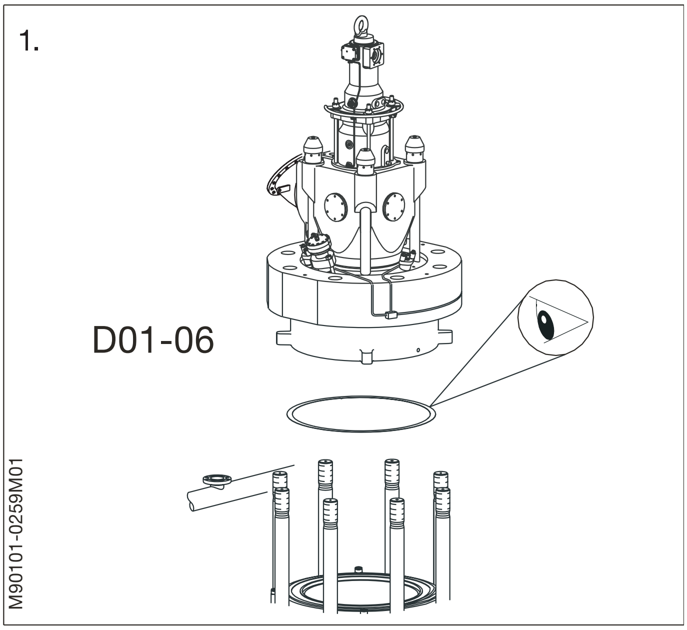
    Provide the water connection flange with a new gasket, and keep the cylinder cover ready for replacement.

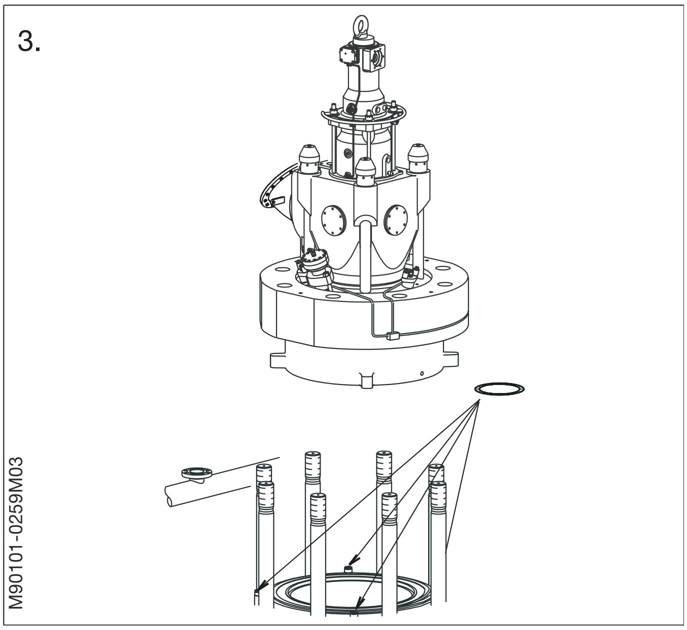
    Always fit new or overhauled valves before a cylinder cover is mounted on the engine.

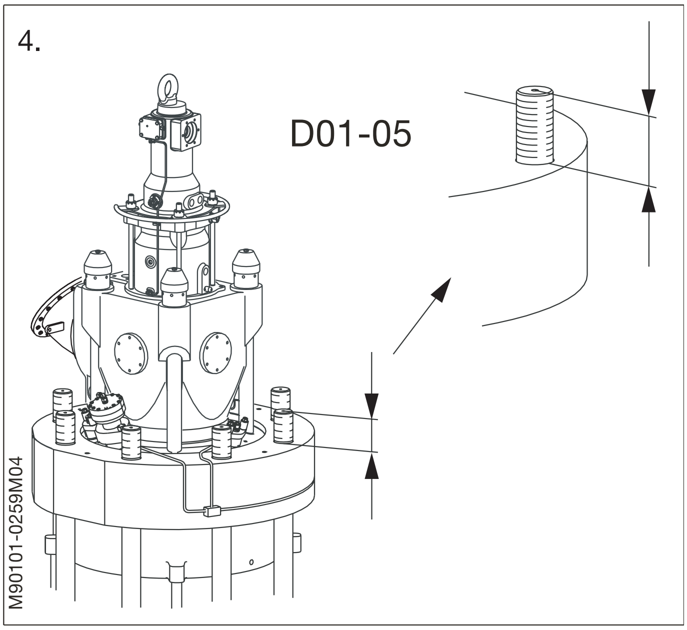
11. For examination/cleaning of the underside or the inside of the cylinder cover the cylinder cover support tool must be used.











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

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.

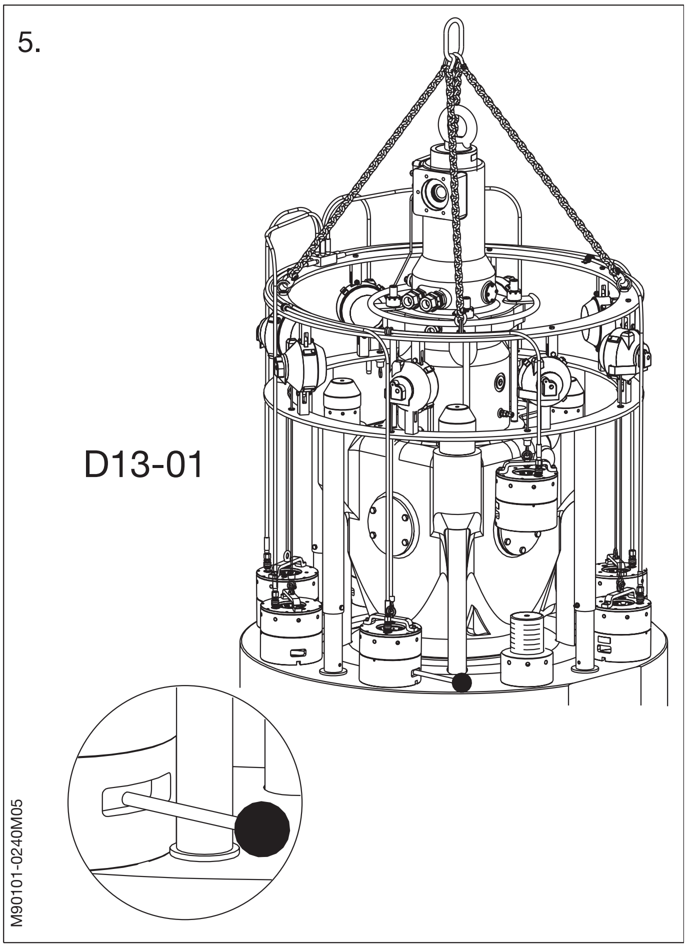
   Position the cylinder cover tightening tool over the cylinder cover.

   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.



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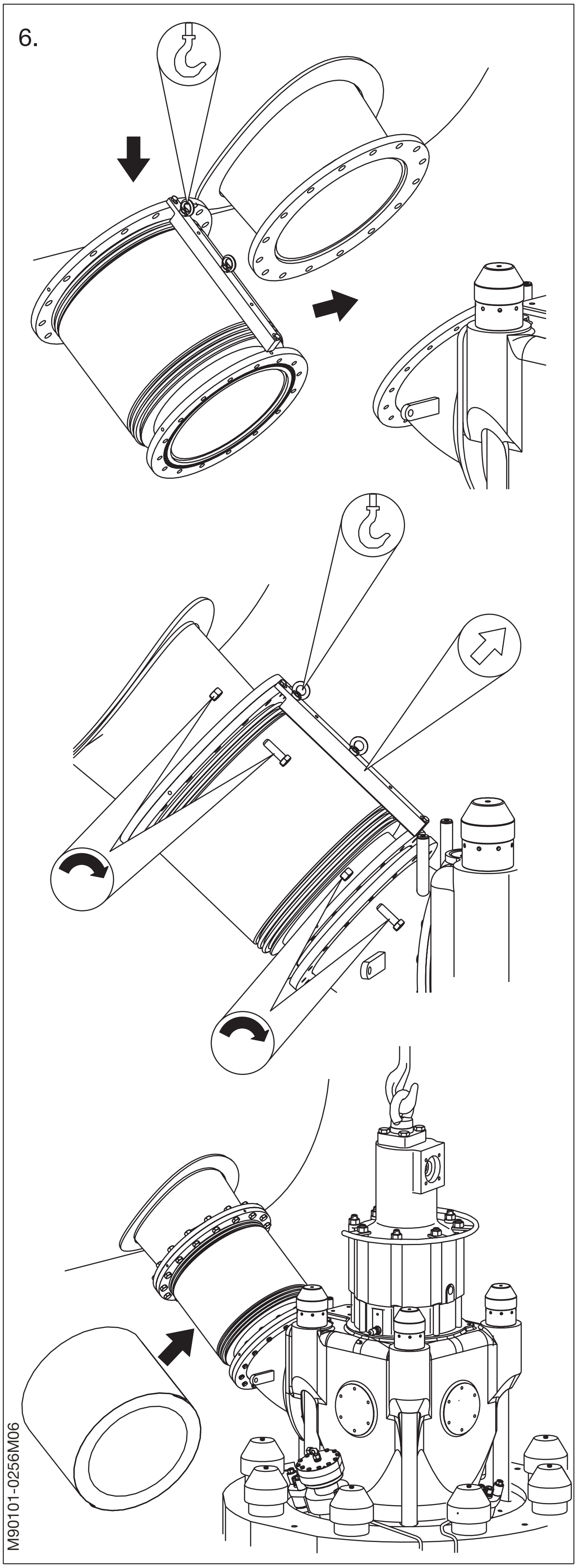

6. Mount the exhaust gas compensator.

   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.

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 elctrical 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.

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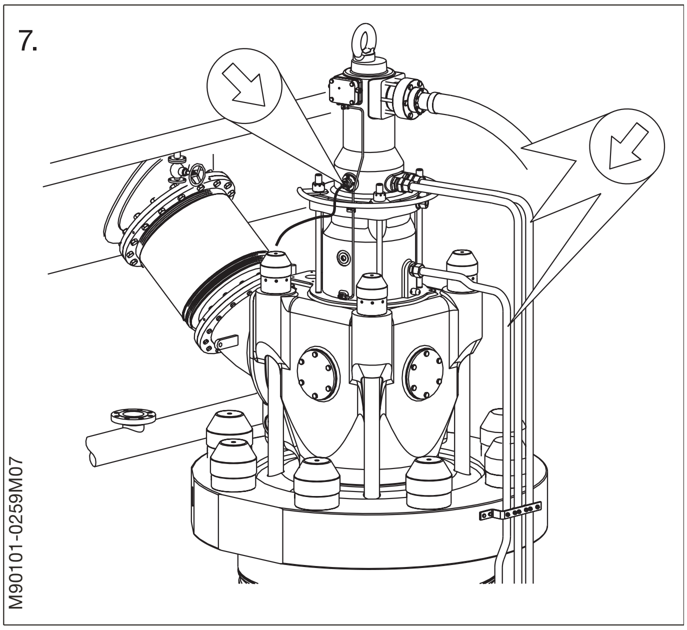

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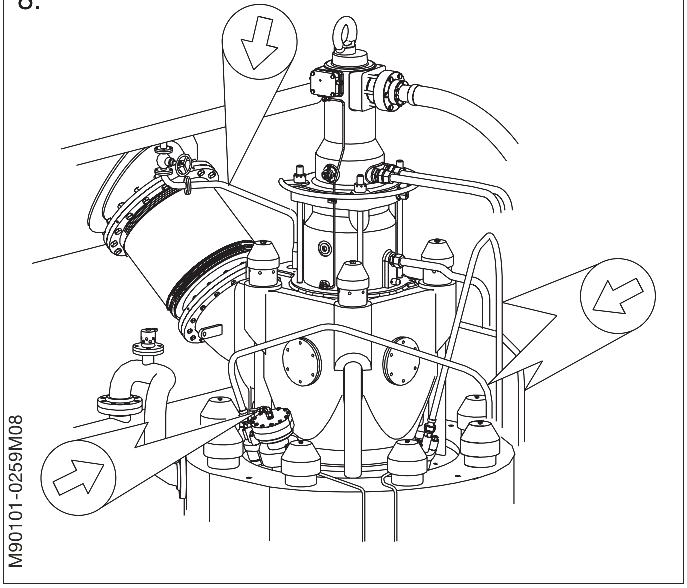

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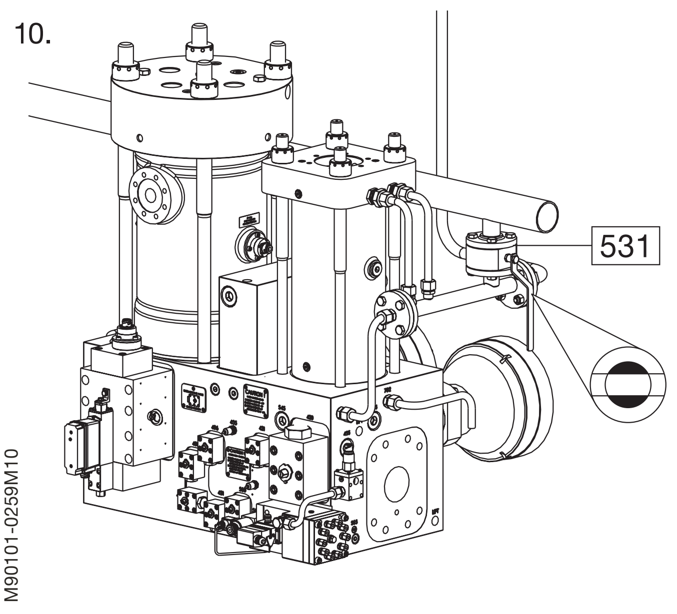

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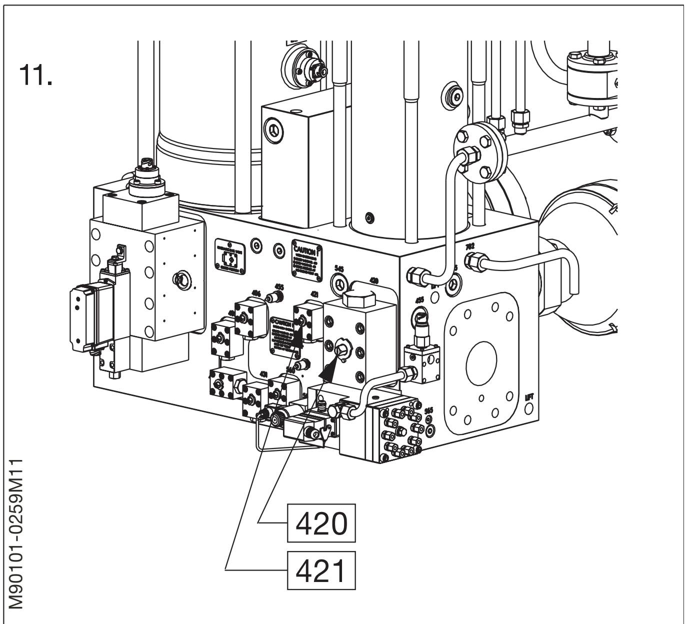


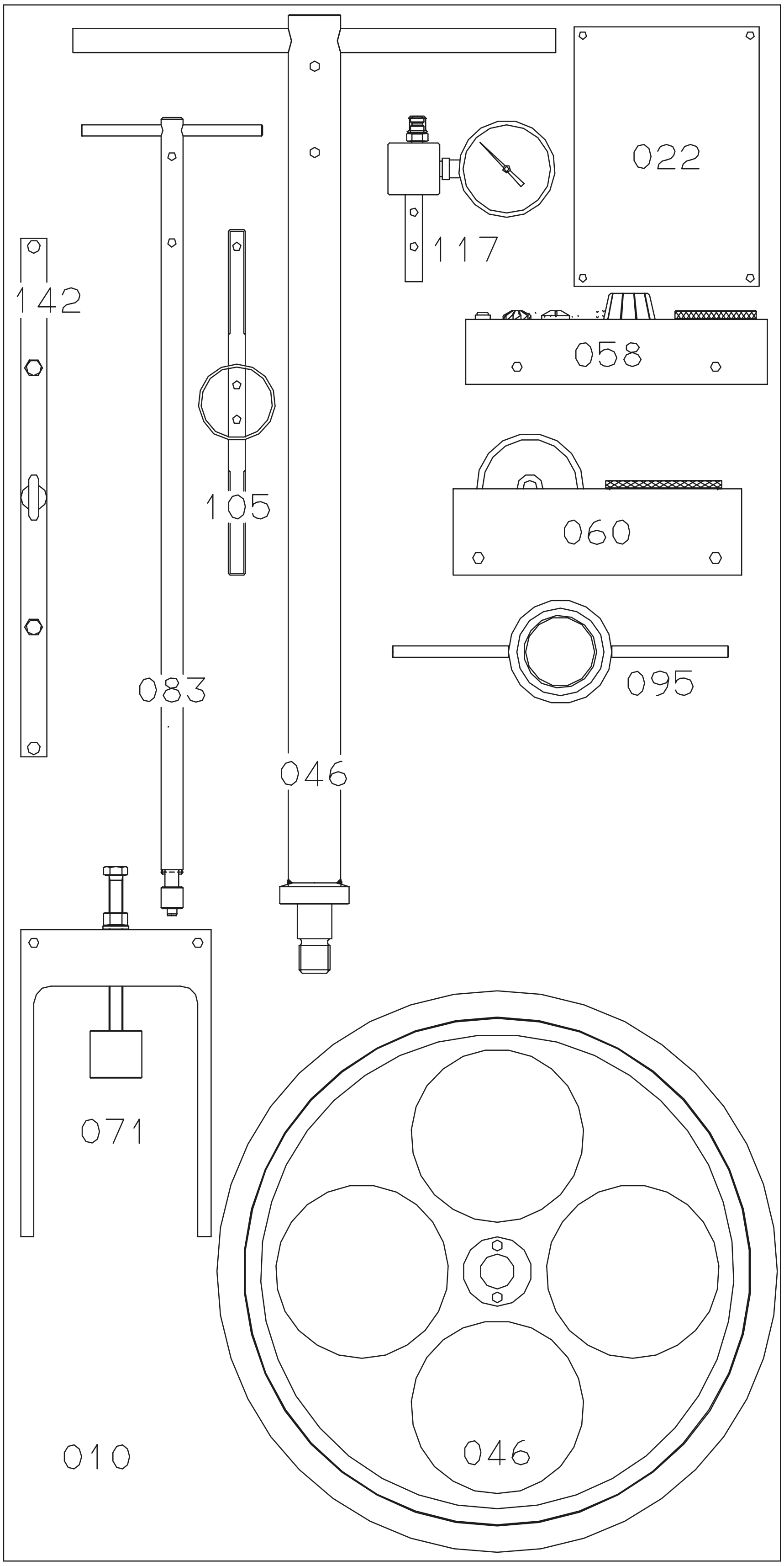
9. If the lubricating oil pumps have been started before the exhaust valve pneumatic springs are pressurised:

   - 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.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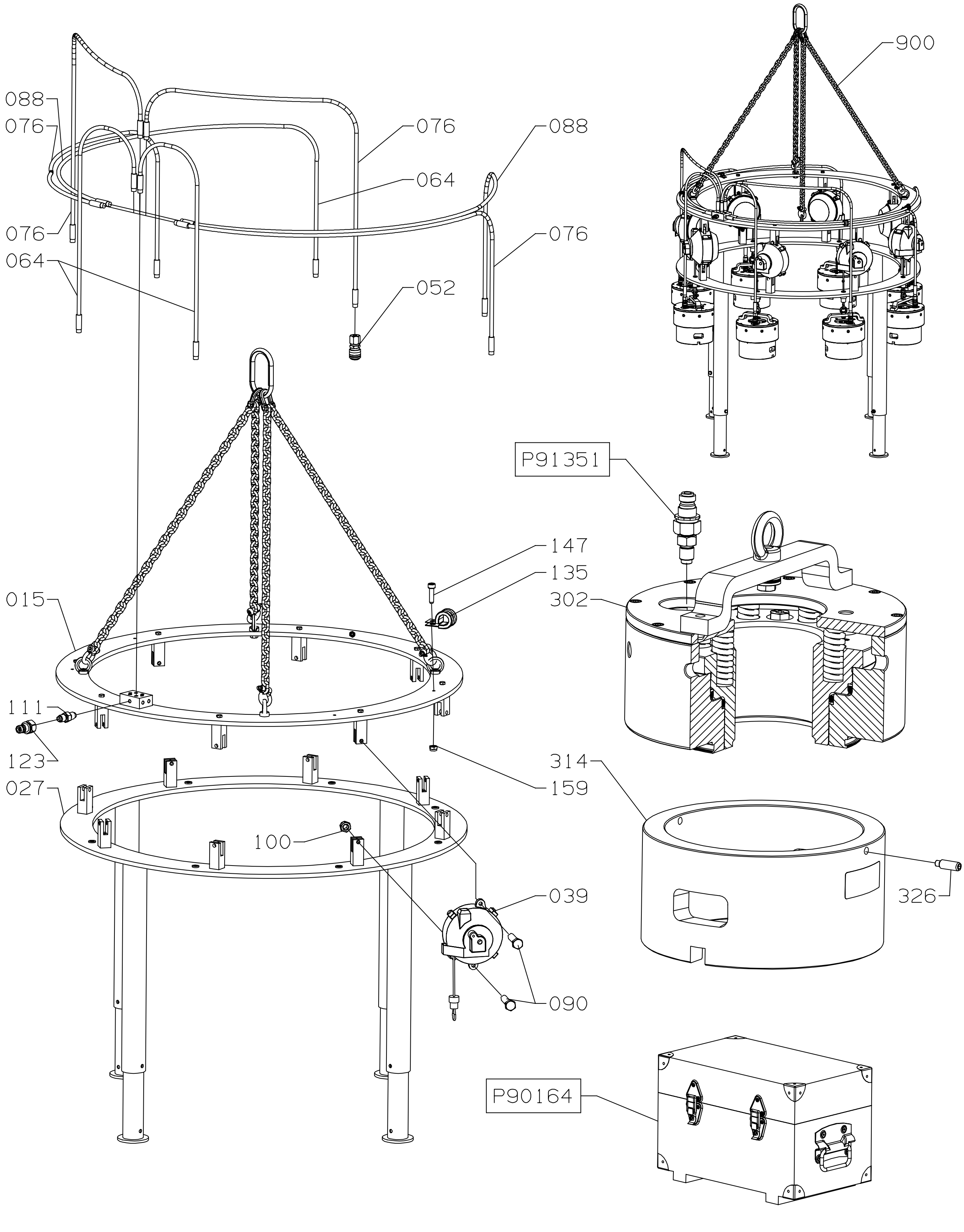
Cylinder Cover Panel

Item No.	Item Description
010	Panel for tools
022	Name plate
046	Grinding tool, exhaust valve seat
058	Milling and grinding wheel, fuel valve
060	Milling and grinding wheel, starting valve
071	Dismantling lever, fuel valve
083	Handle, grinding tools
095	Grinding ring, starting valve
105	Pin spanner, starting valve
117	Test equipment, combined safety valve
142	Lifting tool for compensator

Item No.	Item Description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039
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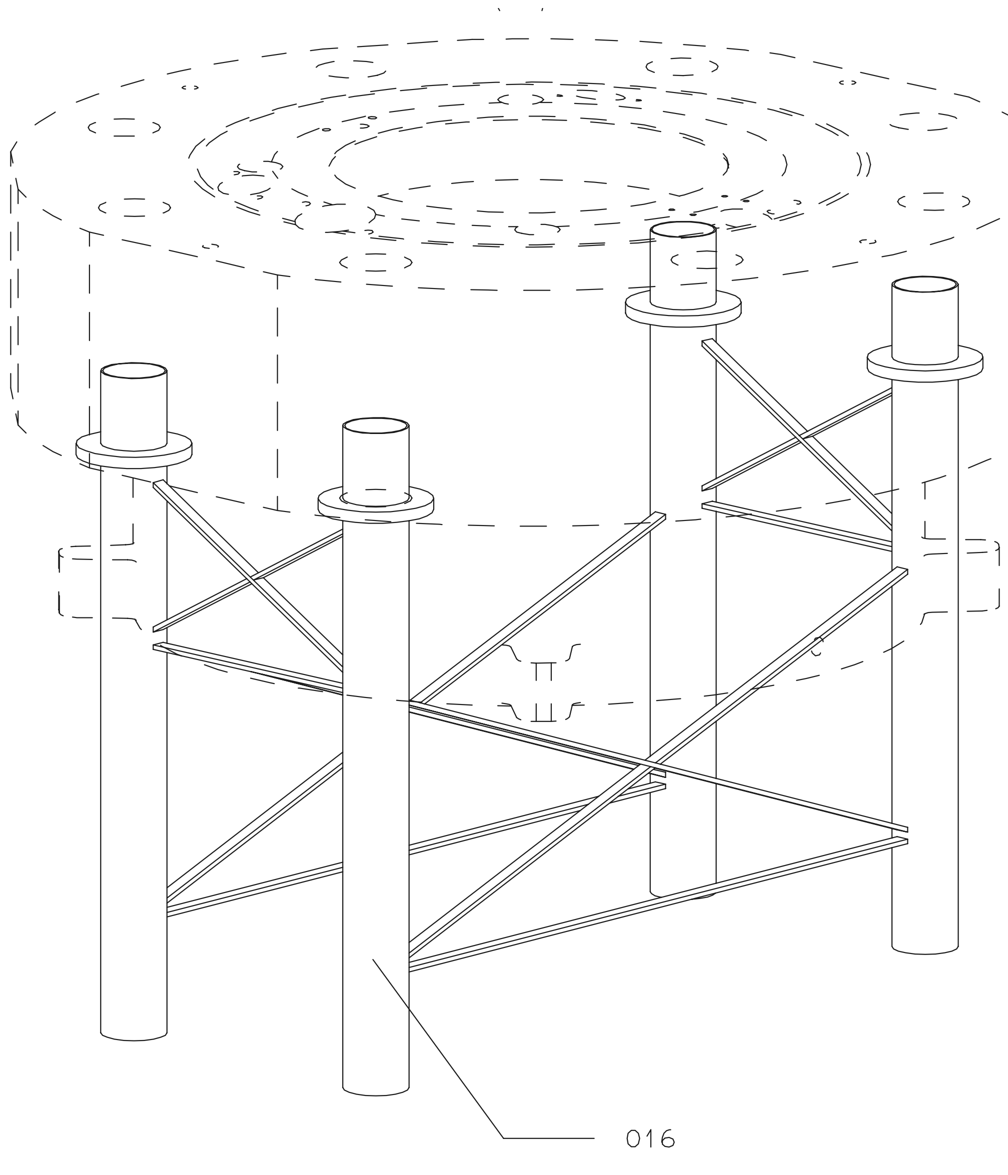
P90164

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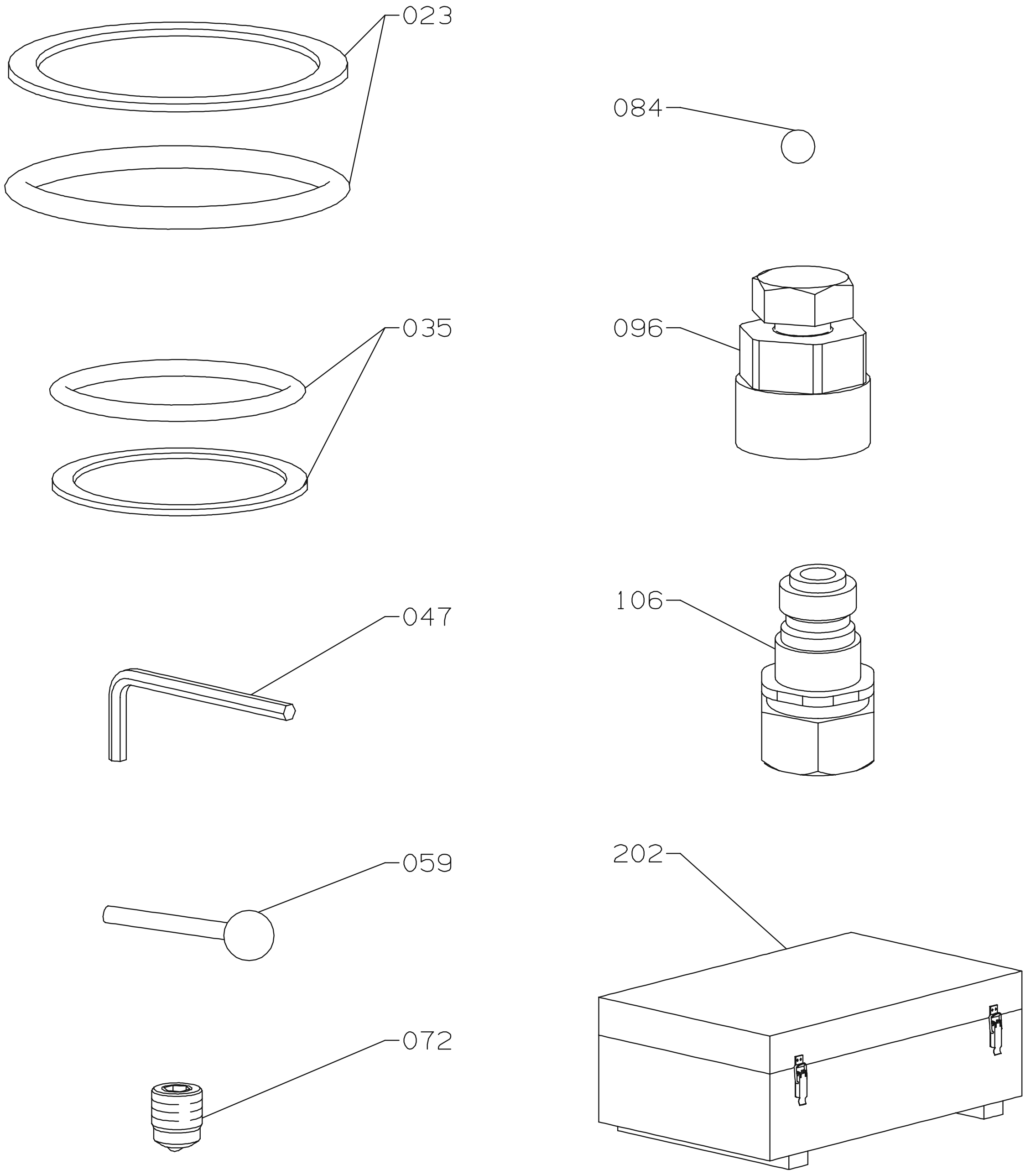
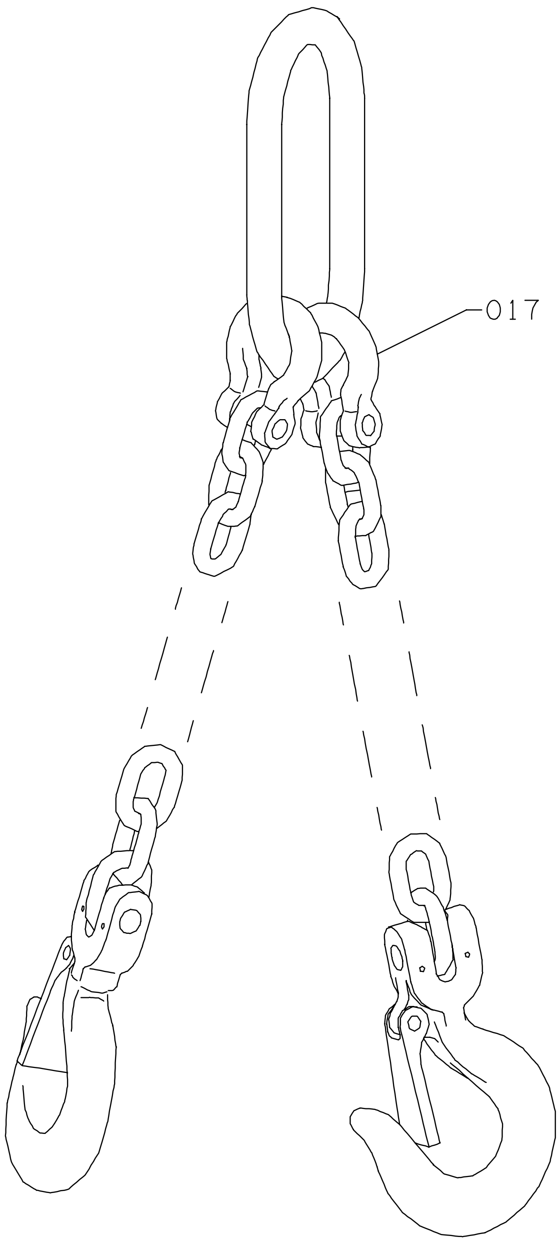
Item No.	Item Description	Item No.	Item Description
016	Cylinder cover rack		

Cylinder Cover - Hydraulic Jack Spares



Cylinder Cover - Hydraulic Jack Spares

Item No.	Item Description	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		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Item No.	Item Description	Item No.	Item Description
017	Lifting chains for cylinder cover		

902 - Piston with Rod & Stuffing Box

Documents in this Chapter

SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D01-05	Cylinder cover stud, check distance	196.5-197.5	mm
D02-01	Test pressure	7	bar
D02-04	Piston rod/crown stud, screwing-in torque	450	Nm
D02-05	Piston skirt, tightening torque	650	Nm
D02-06	Cooling oil pipe, tightening torque	190	Nm
D02-08	Piston ring new, radial width	30.5	mm
D02-09	Piston ring worn, min. radial width	26	mm
D02-10	Groove No.1, max. vertical height	22.8	mm
D02-11	Groove Nos. 2, 3 and 4, max. vertical height	16.8	mm
D02-12	Piston top, max. permissible burn-away	10	mm
D02-15	Minimum free ring gap (before dismantling)	60	mm
D02-16	Minimum ring gap, ring No. 1 (new ring in new liner)	6.9	mm
D02-17	Minimum ring gap, ring Nos. 2, 3 and 4 (new ring in new liner)	4.9	mm
D02-18	Vertical clearance, new parts	0.6	mm
D02-19	Vertical clearance, worn parts, max.	1.0	mm
D02-20	Piston complete	5550	kg
D02-21	Piston crown	1600	kg
D02-22	Piston rod	3100	kg
D02-23	Piston skirt	380	kg
D02-24	Piston cooling pipe	70	kg
D02-25	Lifting tool, tightening torque	150	Nm
D02-27	Stuffing box flange, inner screws tightening torque	350	Nm
D02-46	CPR ring CL groove, min. depth	2.2	mm
D13-01	Hydraulic pressure, mounting	1500	bar
D13-02	Hydraulic pressure, dismantling	1400-1650	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. P**909**51 refers to chapter 909.

Plate	Item No.	Description
P90251	40	Lifting tool for piston rod foot
P90251	51	Lifting tool for cylinder liner
P90251	75	Template for piston top
P90251	87	Distance piece for stuffing box
P90251	99	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
P90264		Tools for tilted lift
P90265		Support for piston
P90266		Piston - Lifting Tools
P90451	118	Rubber cover for crosshead
P90451	120	Rubber cover for crosshead
P91356		Lifting Tools, Etc.
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

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.

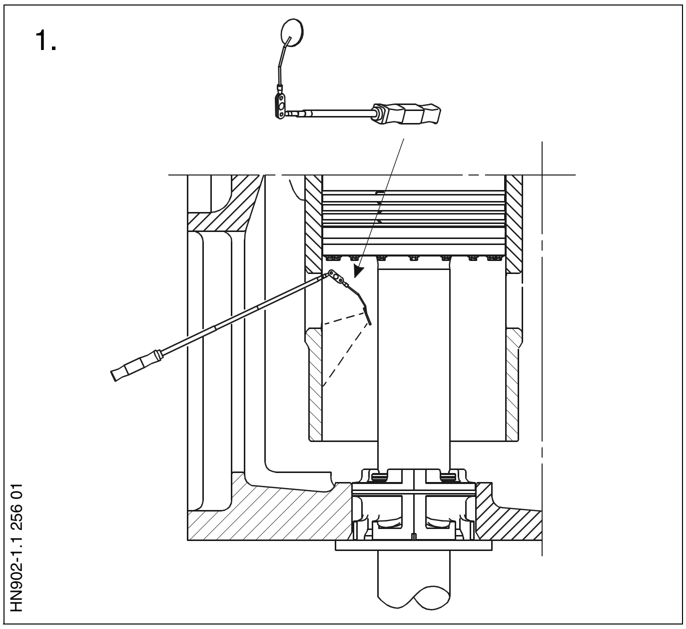
1. The scavenge port inspection is carried out from the scavenge air receiver. An additional view of the rings is possible through the cleaning cover on the manoeuvring side.

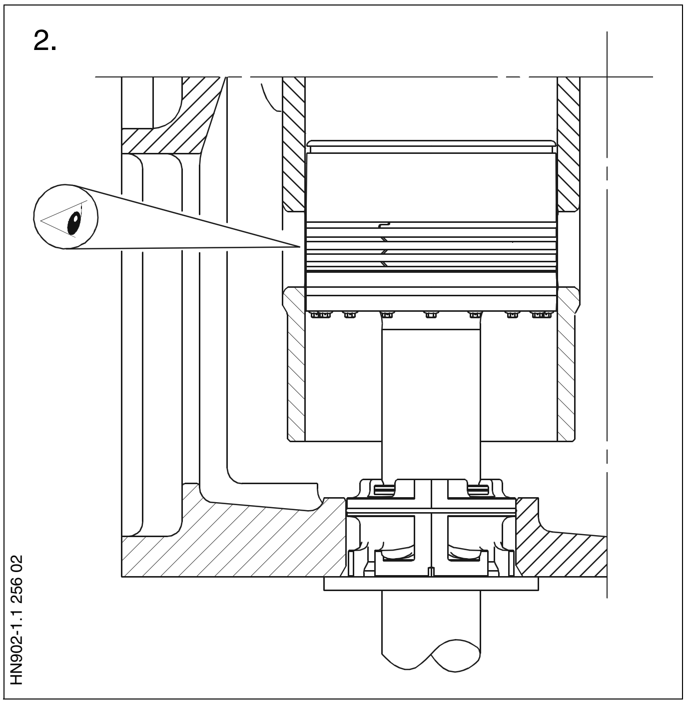
   Turn the engine at least ½ a revolution and start with a unit arriving downwards, just above the scavenge air ports.

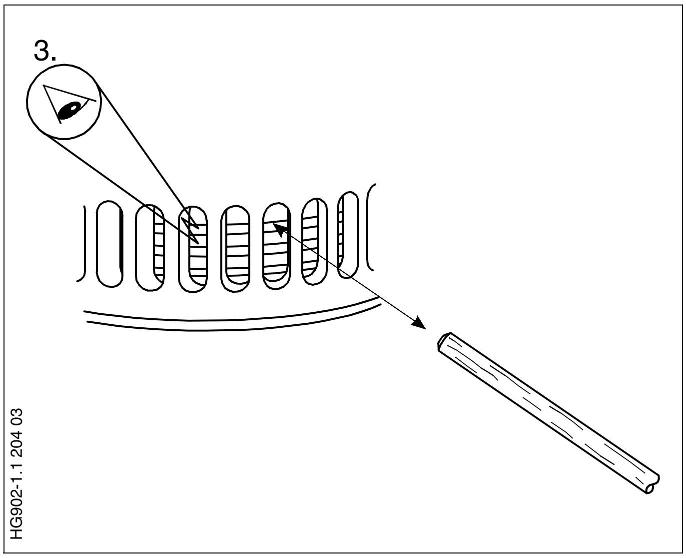
   Inspect the piston rod and the lower part of the cylinder wall. While the piston is passing downwards, inspect the piston skirt, all the piston rings, the ringlands and the piston top.

2. Inspect the rings, one at a time, and note down the results. *See Volume I, Operation, Chapter 707.*

3. Check the movability and the tension of the piston rings, by pressing against them with a wooden stick.







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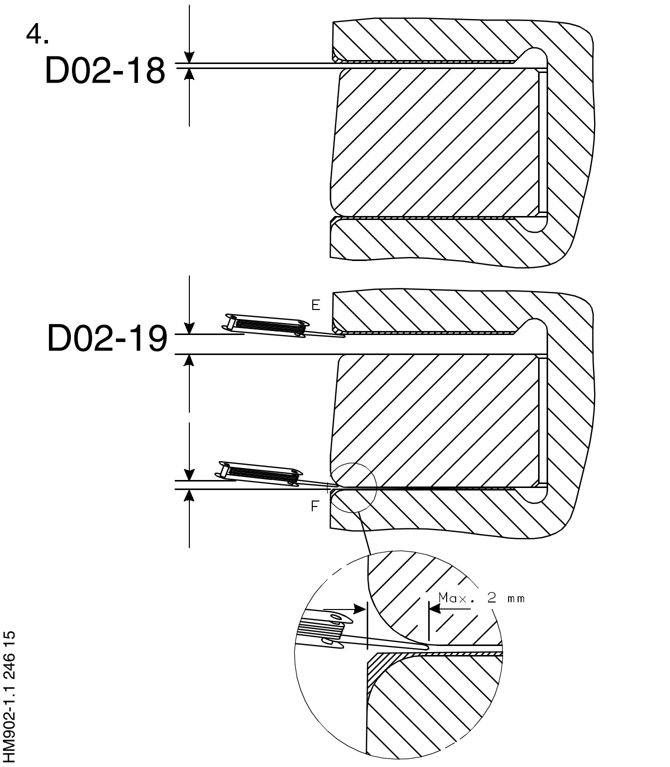

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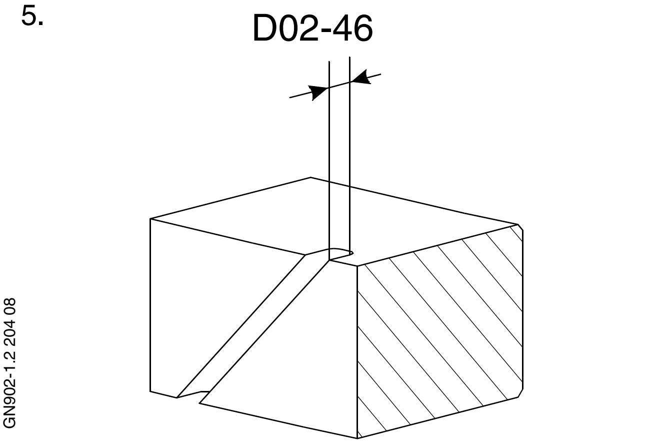

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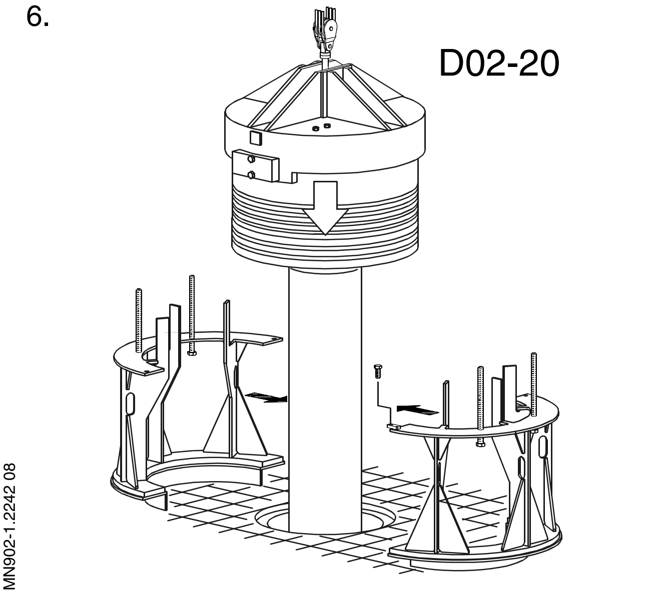


4. Ring grooves:
   Measure the total clearance between the piston rings and the ring grooves.

   The total clearance *must not* exceed the value stated in Data.

   Measurements are to be taken at the top (E) and bottom (F) between the piston ring and piston ring groove.

   Total clearance = E + F.

5. Uppermost piston ring:
   If possible, measure the depth of the pressure relief grooves with a caliper.

   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 of piston rings and piston crown, in connection with piston overhaul:

6. Remove the piston from the cylinder and place it on the piston support.
   See Procedure 902-1.2.

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

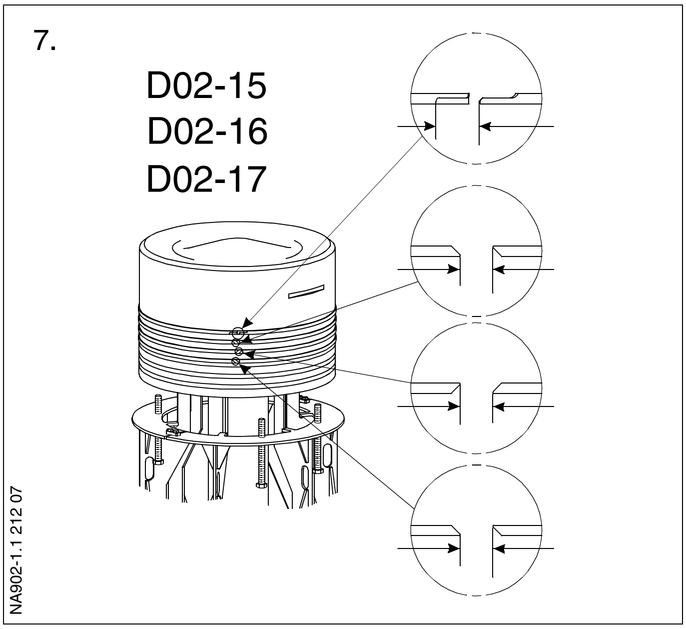
For evaluation of the rings, see Volume I, Chapter 707.

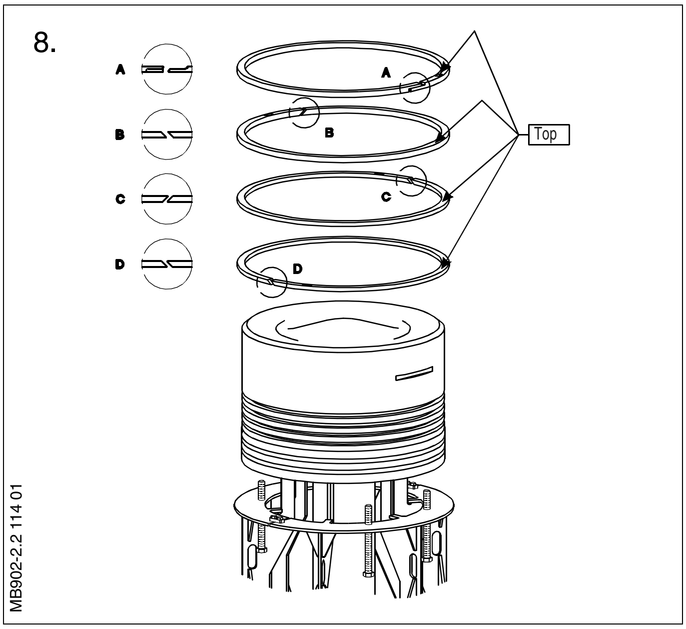
7. Before dismantling the piston rings, measure the free ring gap of all the piston rings.

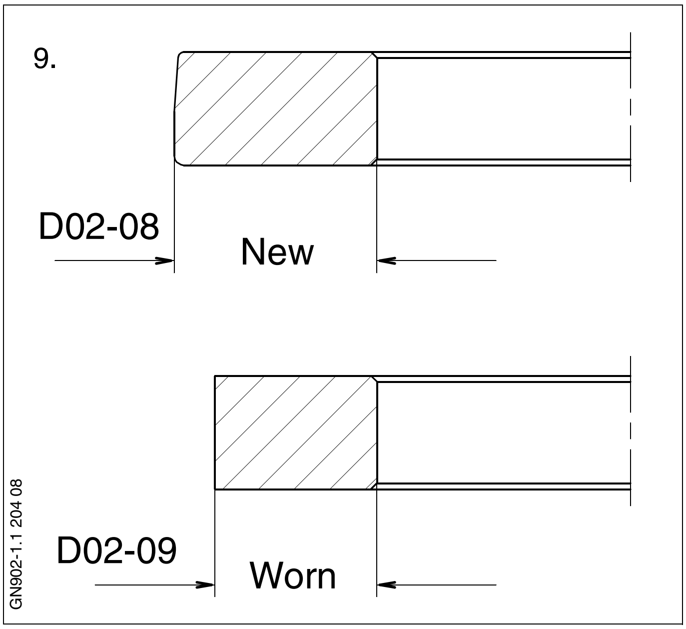
8. Take off the piston rings by means of the ring expander.

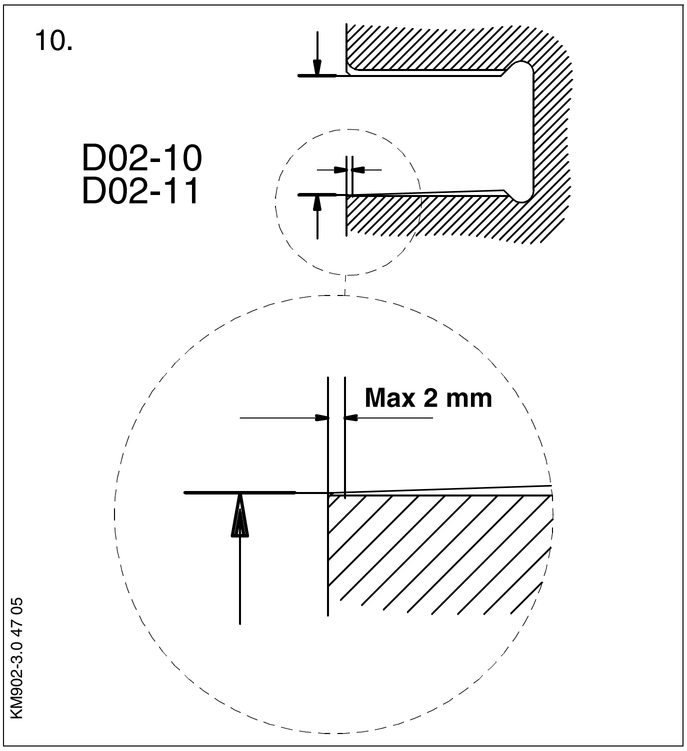
   Clean and inspect the rings.

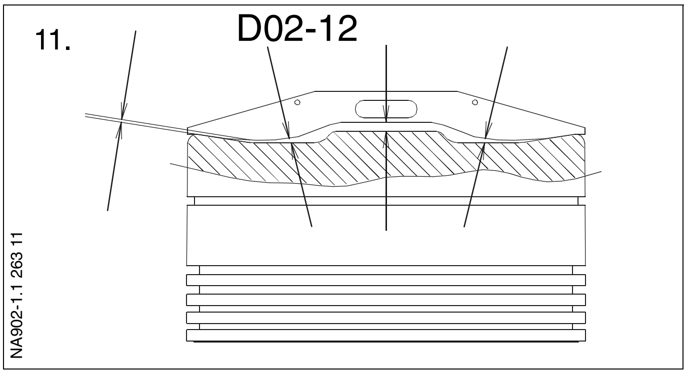
9. Measure the radial width of the rings. Note down the results
   See Volume I, Operation, Chapter 707.

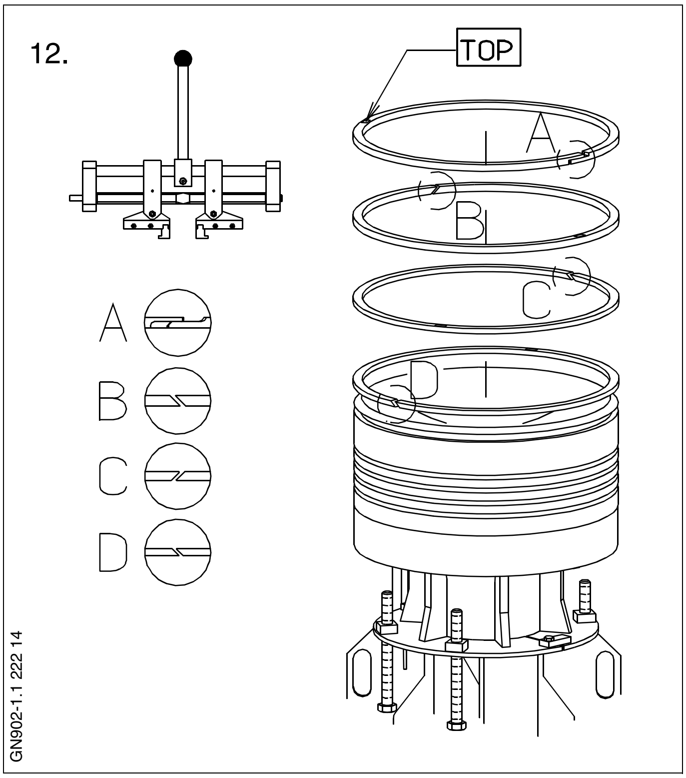












10. Clean the ring grooves and check them for burn marks or other deformation.

    Measure the ring grooves with a caliper 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.

11. Clean the piston crown and check the burn-away by means of the template.
    For maximum permissible burn-away value, see Data.

    Check the burn-away on the whole circumference of the piston crown. Note down the results for later reference.

12. 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 expander to prevent unintended deformation of the rings.

    Do not expand the rings more than necessary. The uppermost ring (CPR-ring) should not be expanded more than to the milled mark on the ring expander.

1. Turn the crosshead down far enough to give access to the piston rod stuffing box and the piston rod nuts.

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

3. 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.

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

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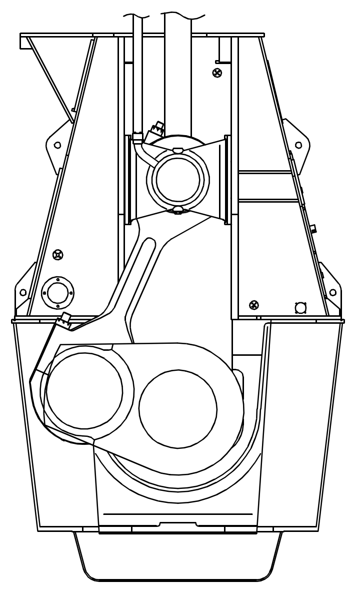

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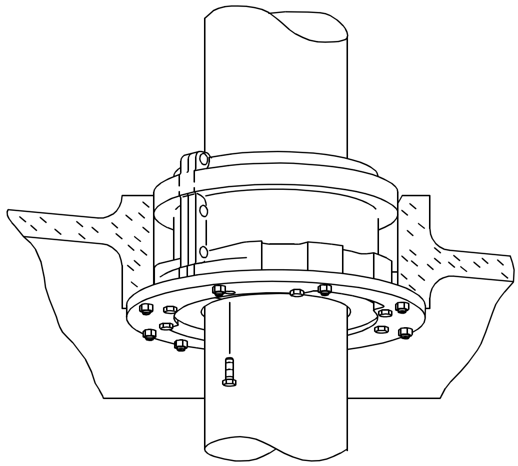

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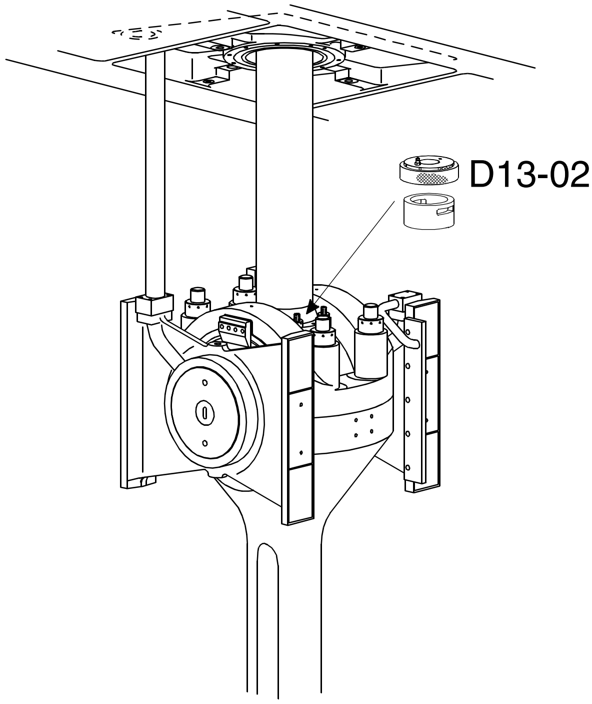

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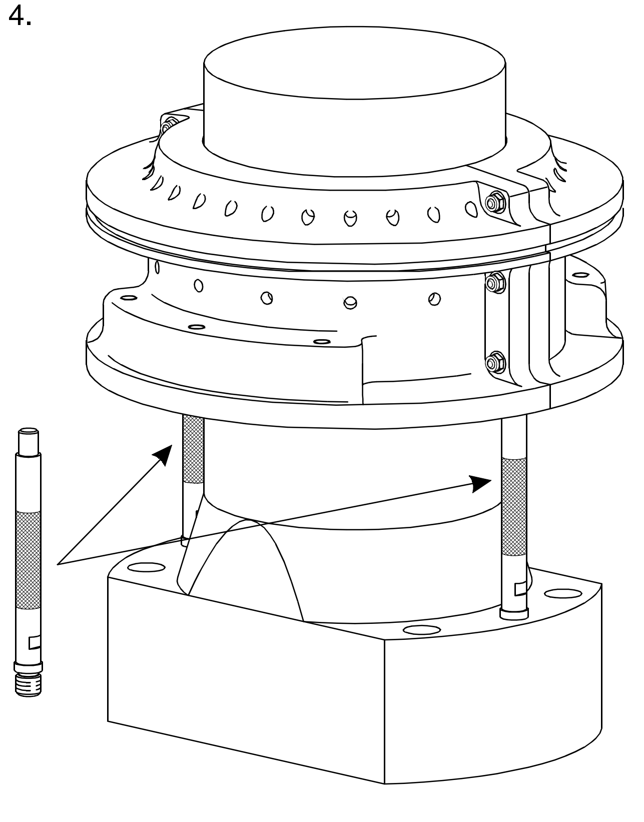

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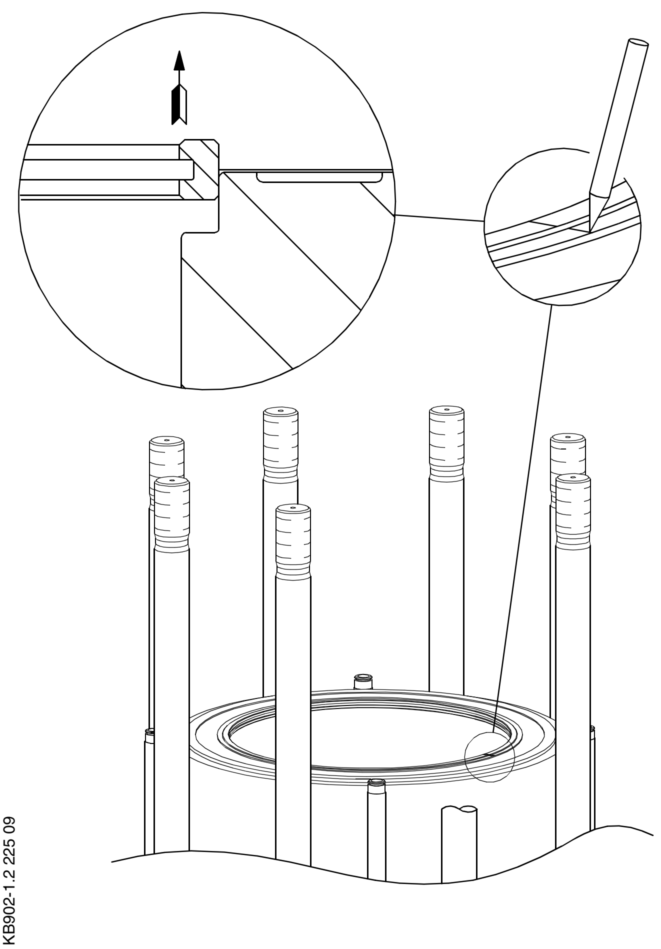


4. Mount the two distance pieces on the piston rod foot to protect the lower scraper ring and to guide the stuffing box.

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

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

   Remove the piston cleaning ring.

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

7. Turn the piston to TDC.

   The top of the piston is now free of the cylinder liner.

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

   If necessary, remove one or two cylinder cover studs, using a stud setter.

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

8. Place the two halves of the support around one of the openings in the platform.

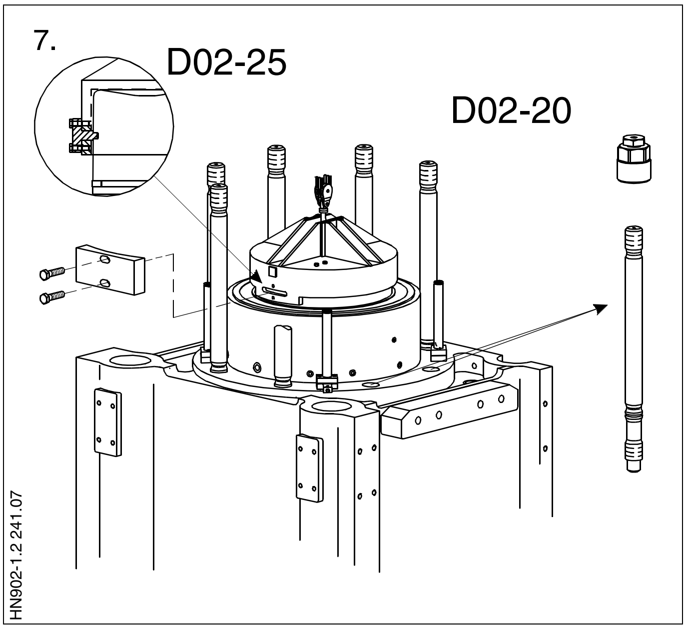
   Lift the piston out of the cylinder and lower the piston rod foot and stuffing box through the opening in the platform.

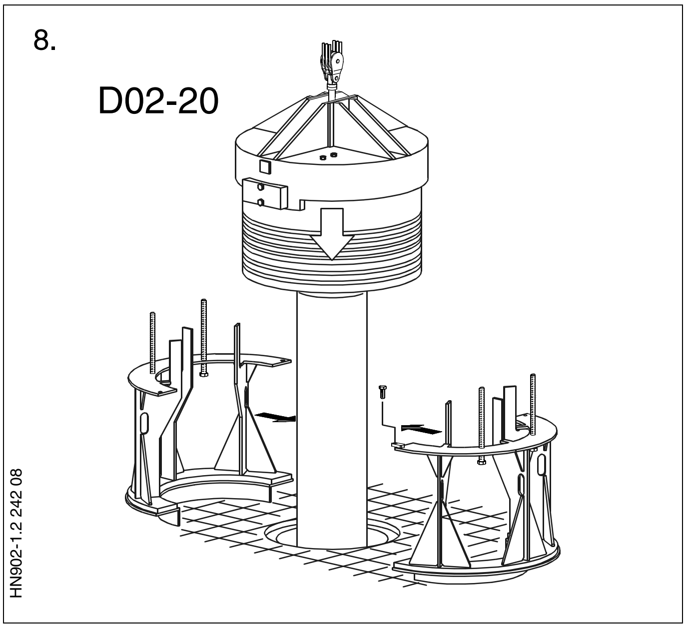
   Place the two halves of the support around the piston rod and secure the two halves with screws.

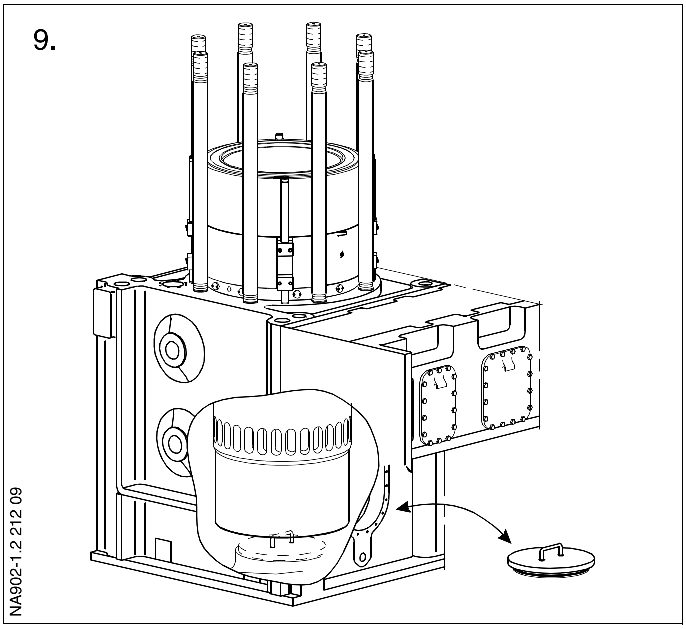
9. Place a cover over the opening for the piston rod stuffing box in the bottom of the cylinder unit.

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

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.







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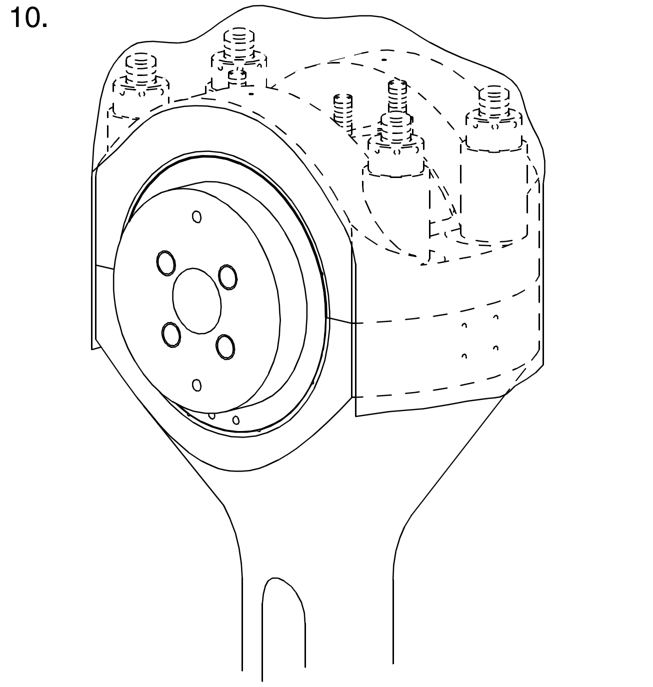

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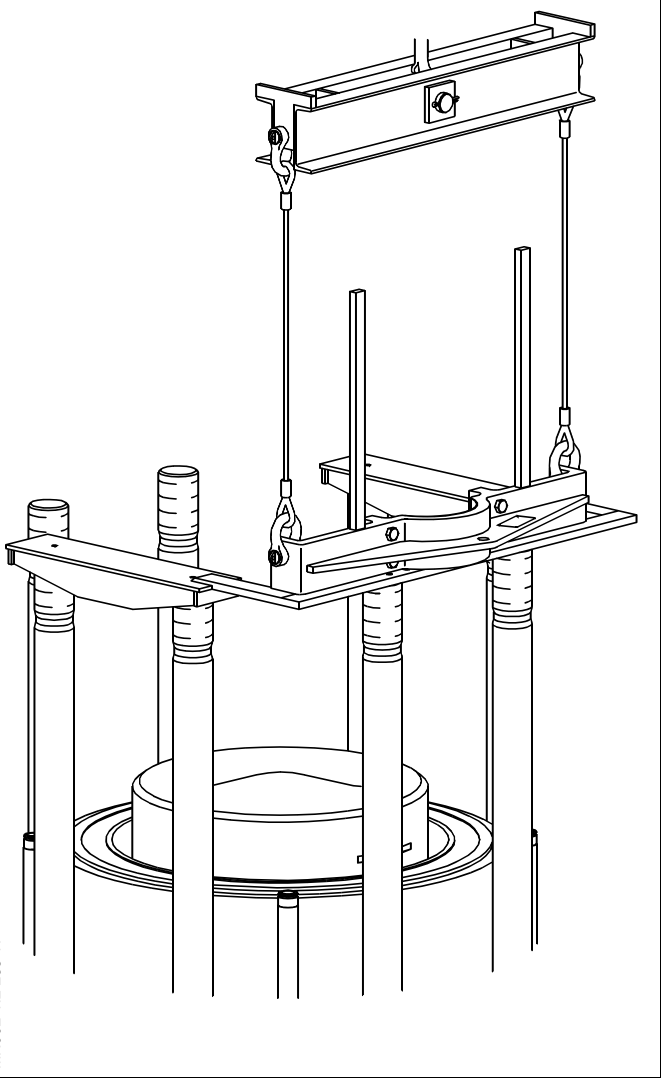

10. Turn the crosshead down far enough to permit mounting of the protective rubber cover on the crosshead bearing cap.

    The protective rubber cover should remain in place to protect the crosshead bearing journal from impurities until the piston is remounted.

Low lifting height

11. Turn the piston to TDC.

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

    Remove the crossbar.

12. 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.

13. Remove the upper piston lifting tool, and attach the wire ropes from the tilting tool to the crossbar.

    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.

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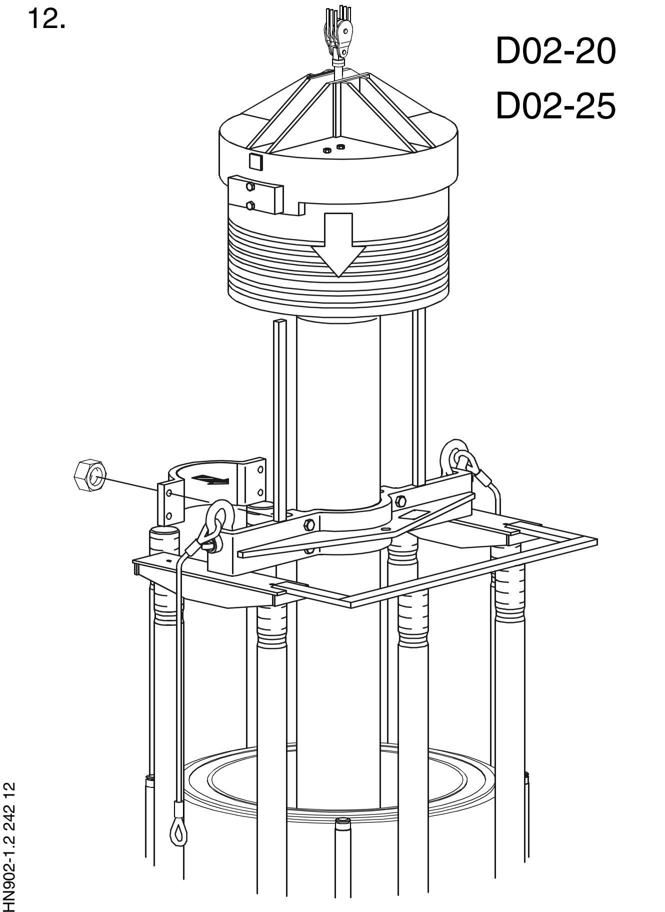

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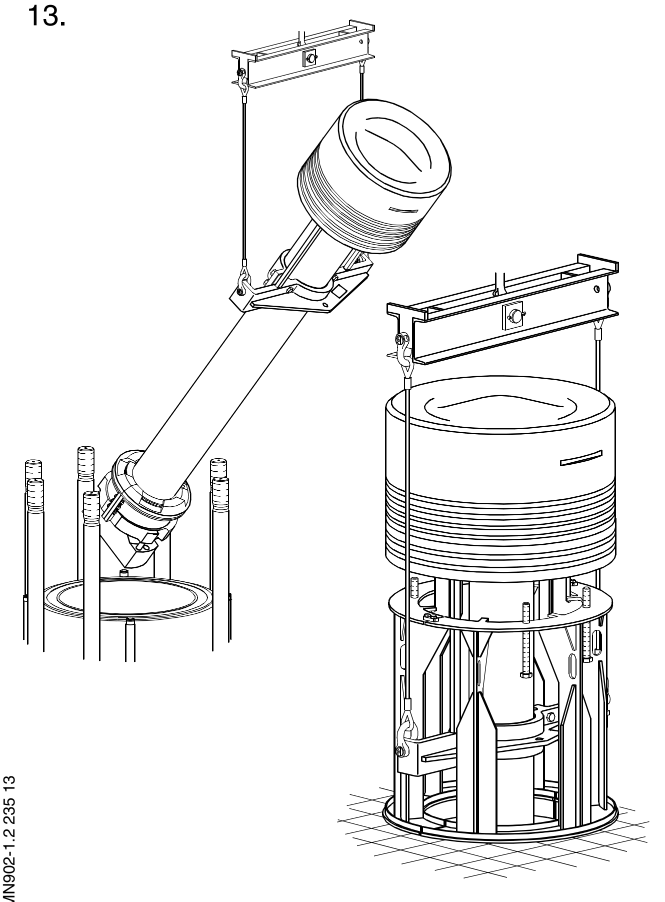
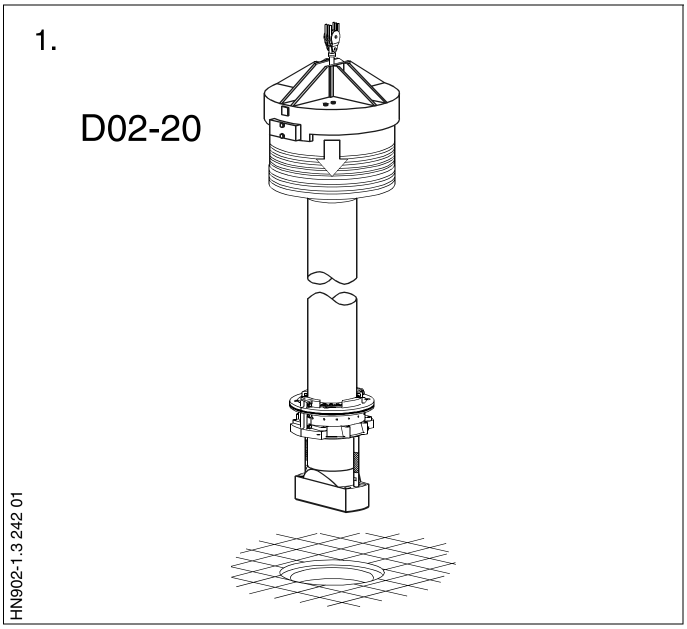
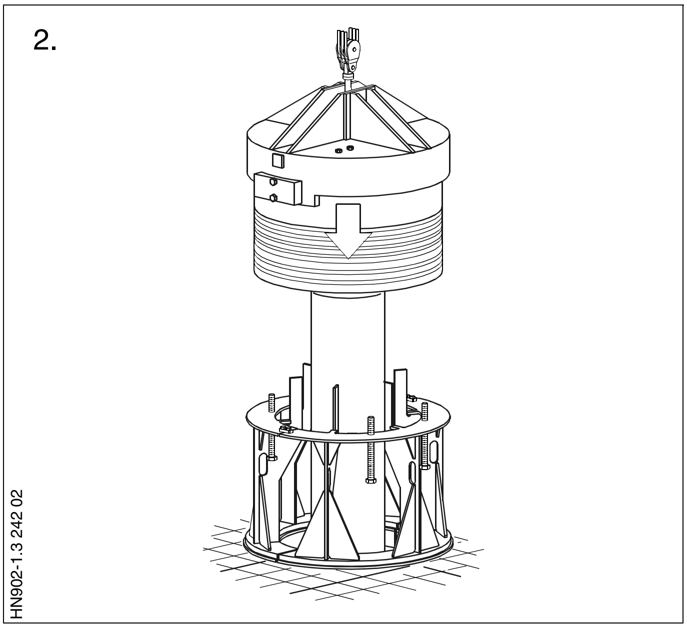
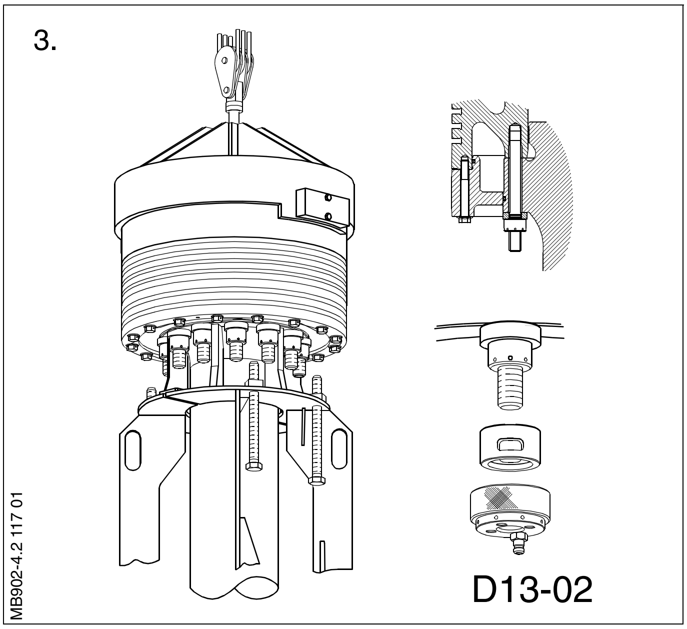








1. Ease the piston down so that the stuffing box is below the floor.

2. Assemble the two halves of the piston support around the piston rod.

   Remove the piston rings.
   See Procedure 902-1.1.

3. Dismount the hydraulic nuts between the rod and the piston crown. *See Data*.

4. Screw the support screws up to contact with the piston skirt.

   Dismount the locking wires and the screws of the piston skirt.

   Land the piston skirt on the piston support.

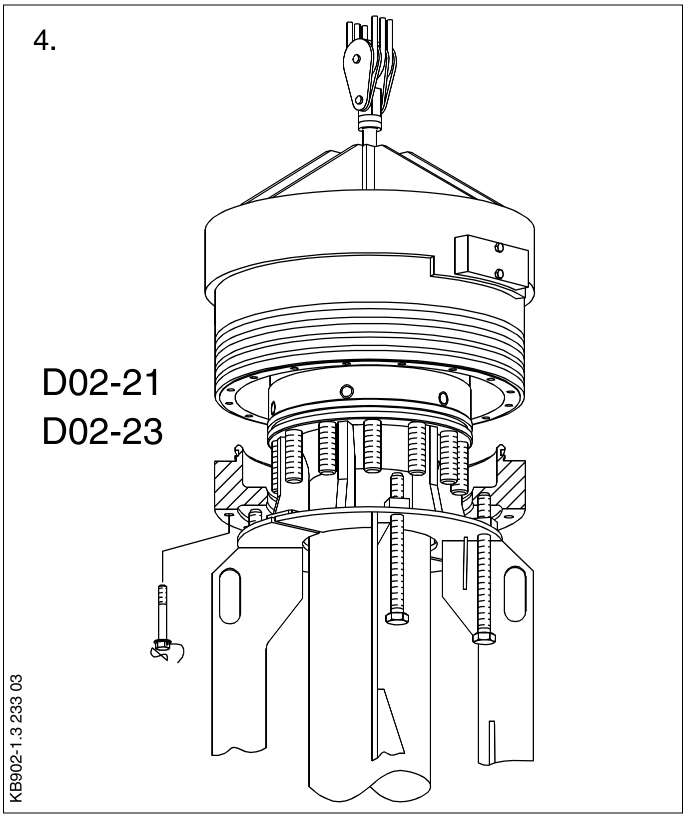
5. Lift away the piston crown.
   Lift away the piston skirt.

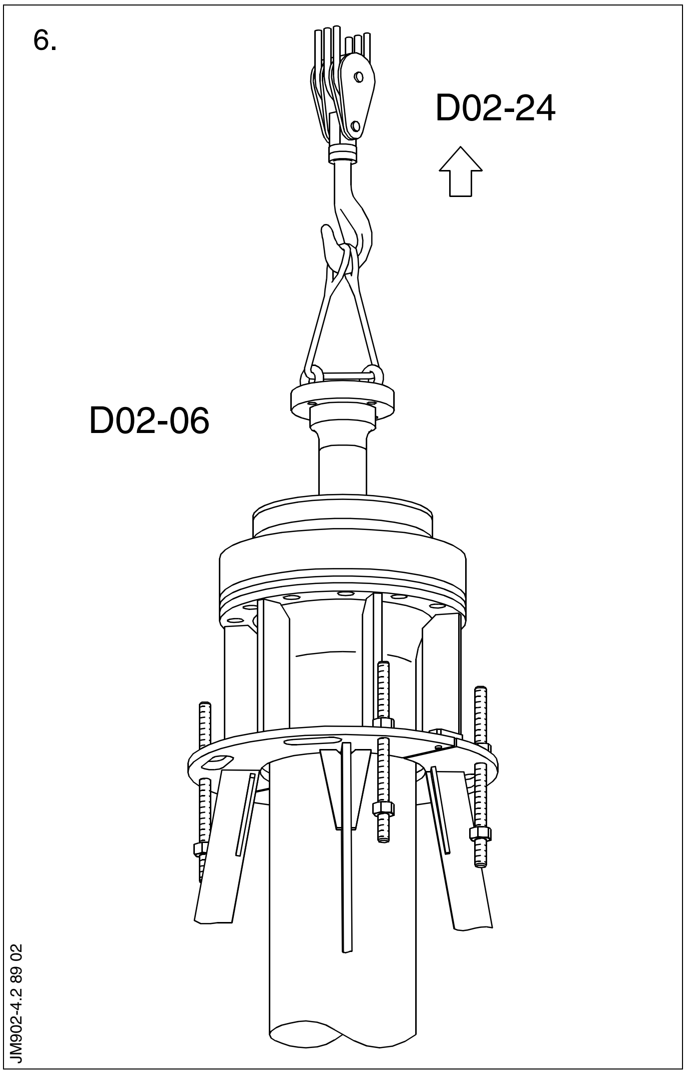
   Thoroughly check the cooling spaces of the piston crown for coke deposits. Any coke deposits found must be removed, *see step 12.*

6. Dismount the screws of the cooling oil pipe flange.

   Mount the eye bolts and lift out the cooling oil pipe.

   Clean and inspect, then re-mount the cooling oil pipe.





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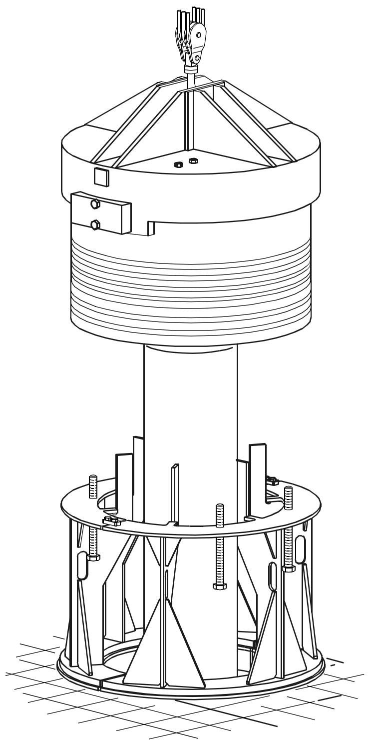

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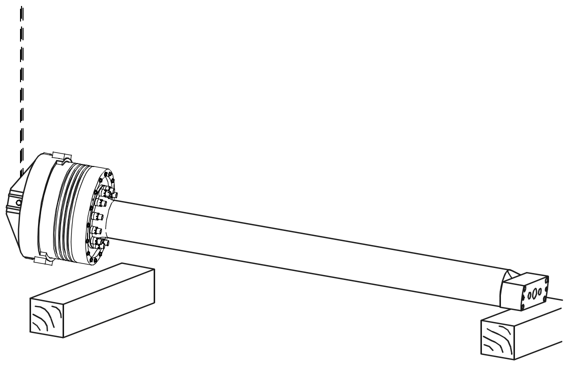

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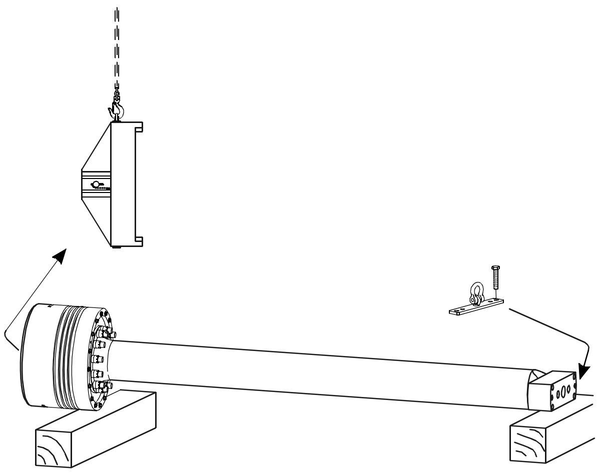


Alternatively, the piston can be dismantled in the following way:

7. With the piston standing in the piston support tool, remove the piston rod stuffing box.
   See Procedure 902-2.3.

8. 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.

9. 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.

10. 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.

Note!
During the lift, follow with the crane to keep the crane positioned vertically above the piston crown.

11. Lift the piston rod foot clear of the wooden block.

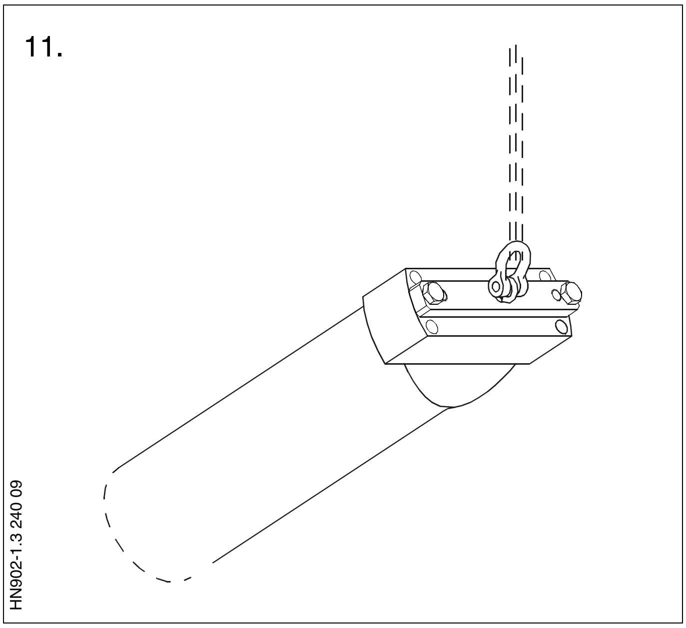
Note!
During the lift, follow with the crane to keep the crane positioned vertically above the piston rod foot.

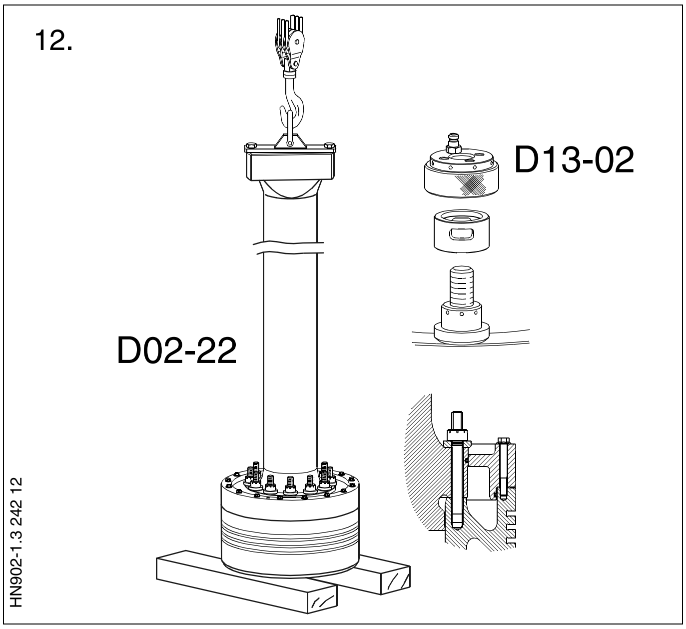
Keep lifting until the piston rod is in a vertical position.

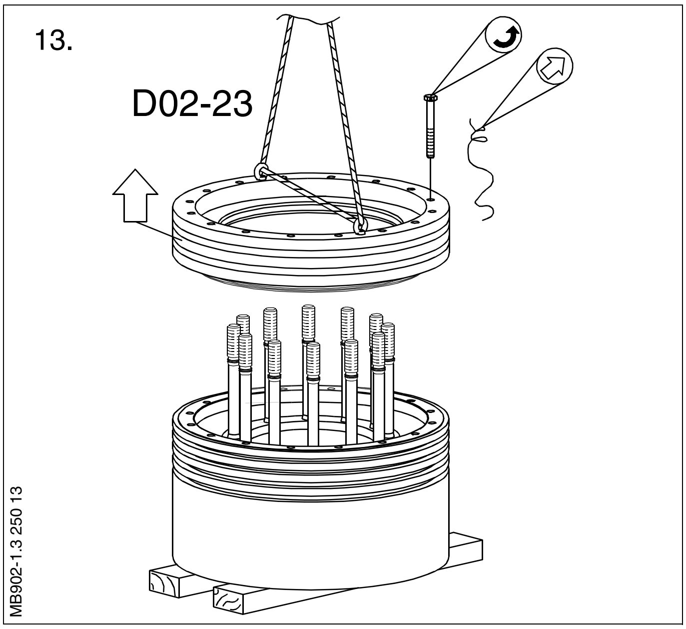
12. Place the piston in an upright position with the piston crown resting on wooden planks.

Dismount the hydraulic nuts. Lift the piston rod away and land it in a horizontal position on a couple of wooden planks.

13. Remove the locking wire and the screws in the skirt and mount two eye bolts in the holes intended for dismantling screws. Lift the skirt and land it on a couple of planks.







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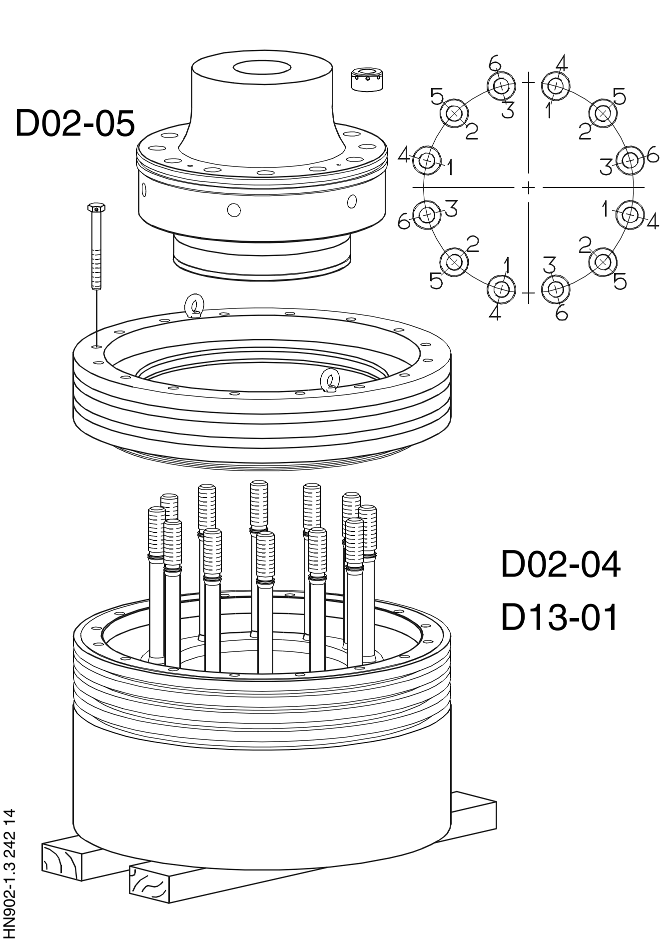

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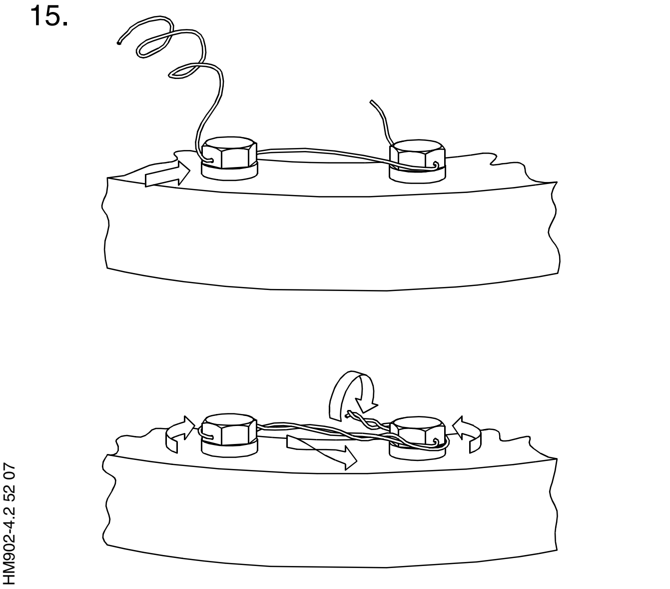


14. Thoroughly clean and inspect all parts of the piston.

    If coke deposits are found in the cooling spaces of the piston crown, the piston crown cooling spaces 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.
    Regarding check of the piston crown, see Procedure 902-1.1.

    Replace all sealing rings on the piston. All the new sealing rings must be coated with lubricating oil before the piston is assembled.

    Coat all screws with Molybdenum Disulphide (MoS_2).

    Assemble the piston in the reverse order to disassembly.

    If the piston crown is renewed, the piston crown studs must be tightened to torque D02-04.

    Tighten all the hydraulic nuts to the tightening pressure stated in Data.
    For correct tightening sequence, see the sketch.

15. Lock the screws with locking wire.

    Mount the locking wire in such a way that the wire is tightened if one of the screws works loose.
    See Procedure 913-7.

16. Fill the piston and piston rod with lubricating oil.

    Mount the pressure-testing tool around the base of the piston rod.

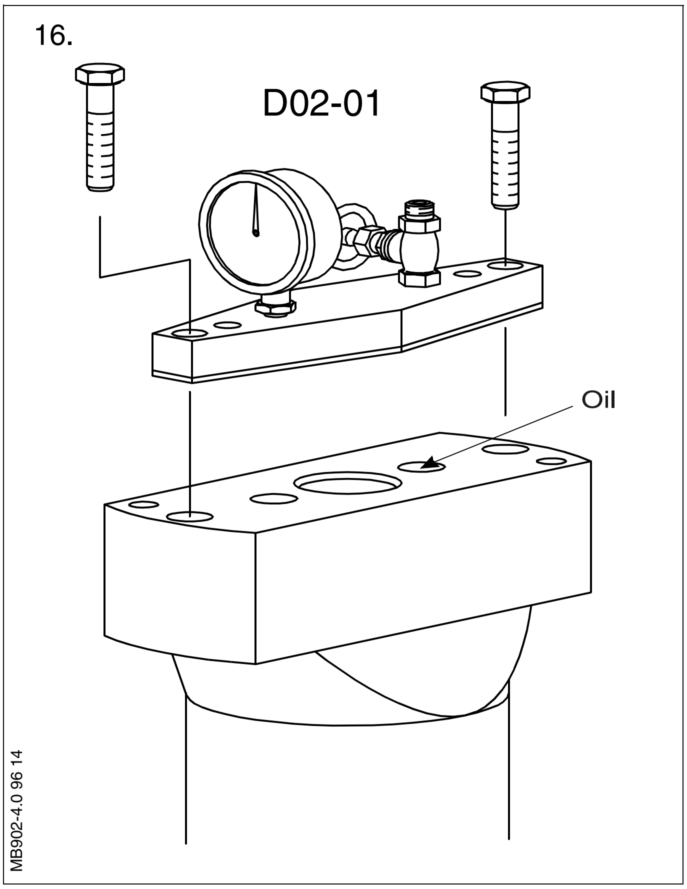
    Pressure-test the piston at the pressure stated on the data sheet.

    Check the contact surfaces of the piston and the sealing rings for tightness.

    Check that there are no cracks in the piston crown.

17. Drain the piston of oil.

    Place the piston in the piston support tool and mount the piston rod stuffing box.
    See Procedure 902-2.3.



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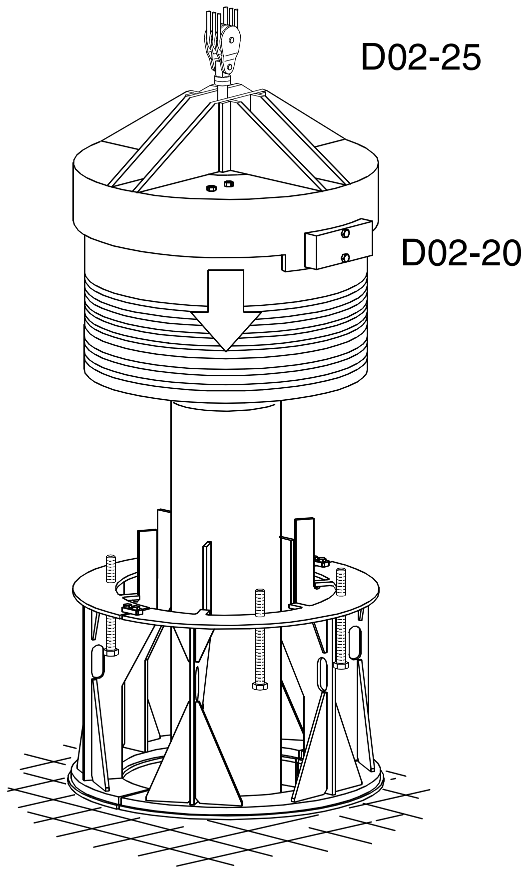

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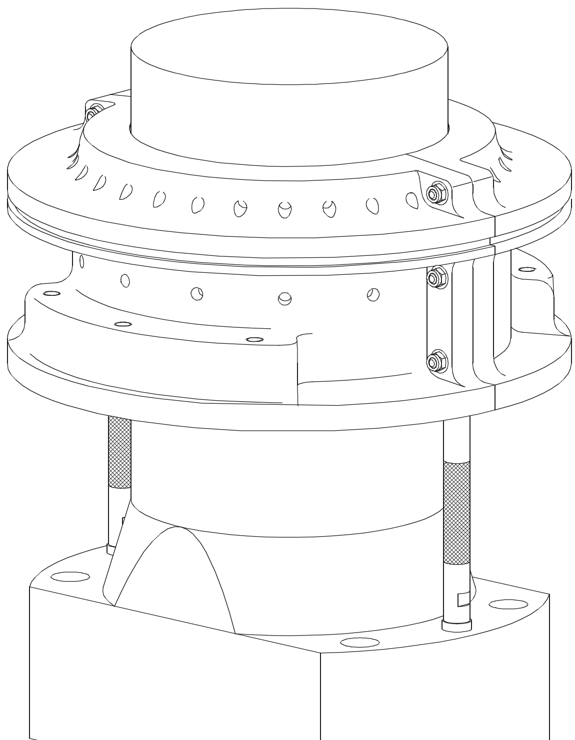


1. Check the piston rings and piston crown in accordance with Procedure 902-1.1.

2. Mount the lifting tool on the piston crown.

3. Ensure that the stuffing box is correctly positioned over the guide pins in the distance pieces mounted on the piston rod foot.

4. Coat the O-rings of the stuffing box with oil. Remove the cover from the piston rod stuffing box opening in the bottom of the cylinder unit. Clean the stuffing box flange.

   Remove the protective rubber cover from the crosshead.

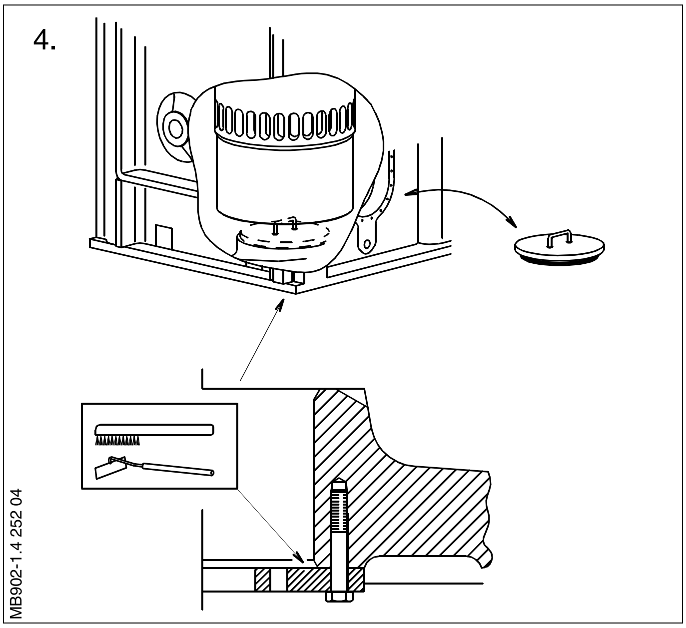
5. Turn the crosshead to a position 45° from TDC.

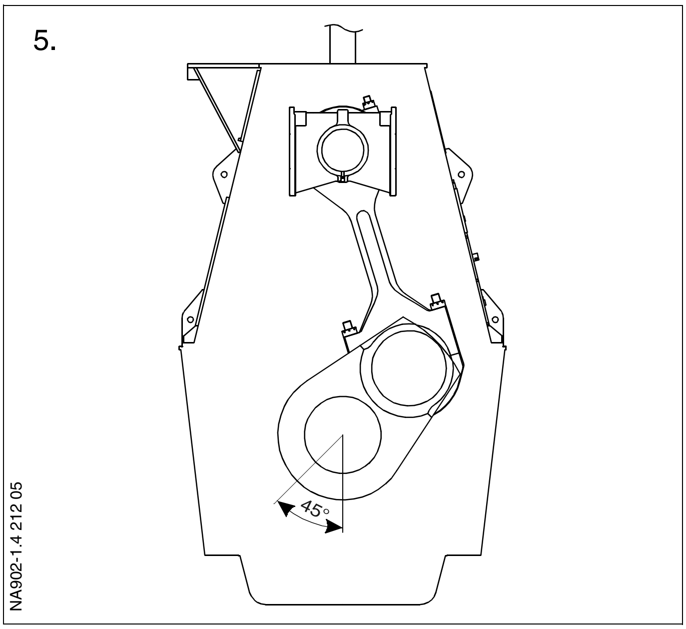
6. Coat the piston rings, piston rod and cylinder liner with lubricating oil.

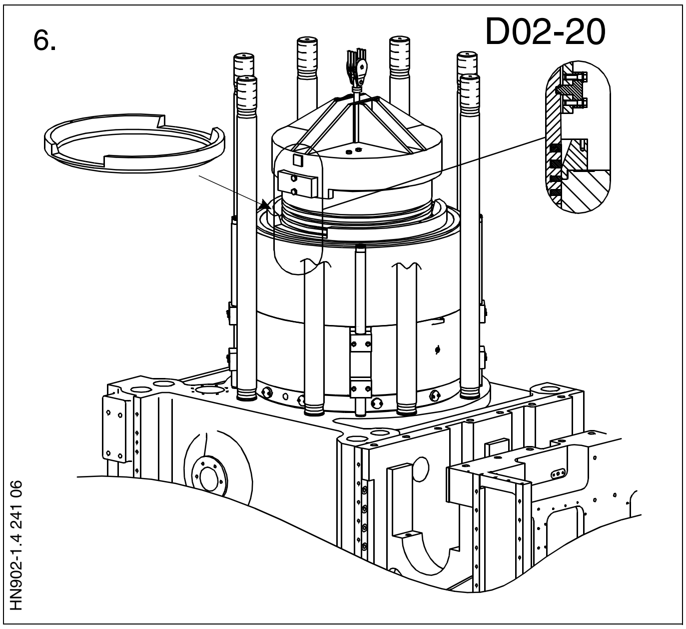
   Coat the O-rings of the stuffing box with oil.

   Mount the guide ring for piston rings on the cylinder liner.

   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.







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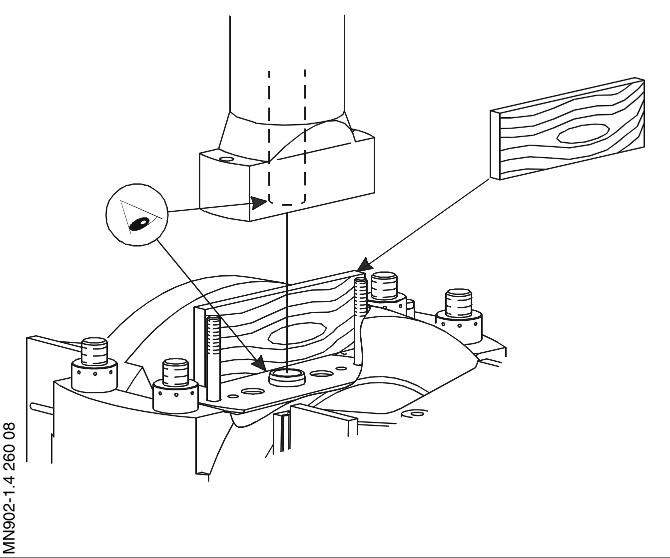

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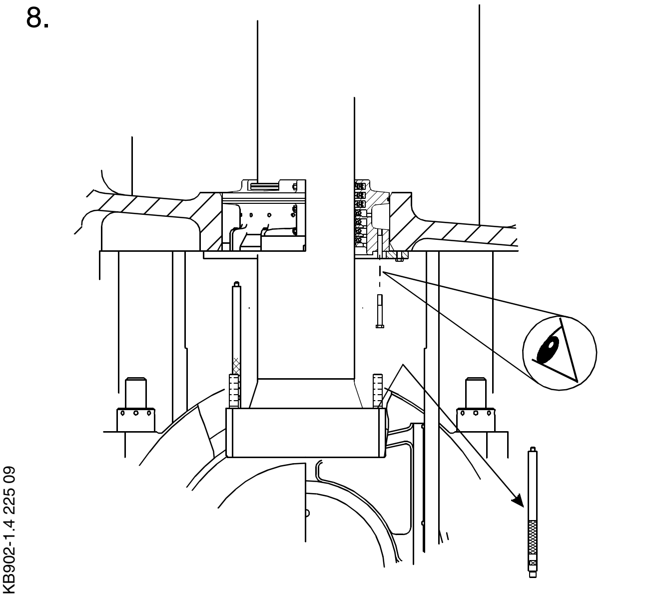

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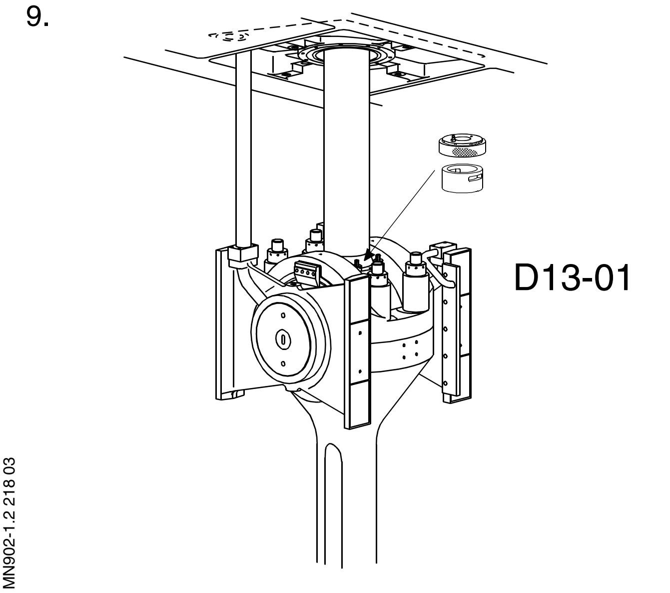


7. Turn the crosshead almost to TDC.

   If necessary:

   Place a 2” wooden plank on the crosshead face, taking care not to cover the guide ring. The plank must be dimensioned so that it is higher than the piston foot studs.

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

   Lower the crosshead just enough to enable the plank to be removed.

   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 adjustable claw of the lifting tool and pull the lifting tool free of the lifting groove in the piston

   Remove the lifting tool and the guide ring for piston rings.

8. 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.

   Remove the distance pieces from the piston rod foot.

9. Mount and tighten the piston rod nuts, using the hydraulic jacks.
   See Data.

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

10. Tighten down the piston rod stuffing box by means of the screws, through the inner holes in the stuffing box flange

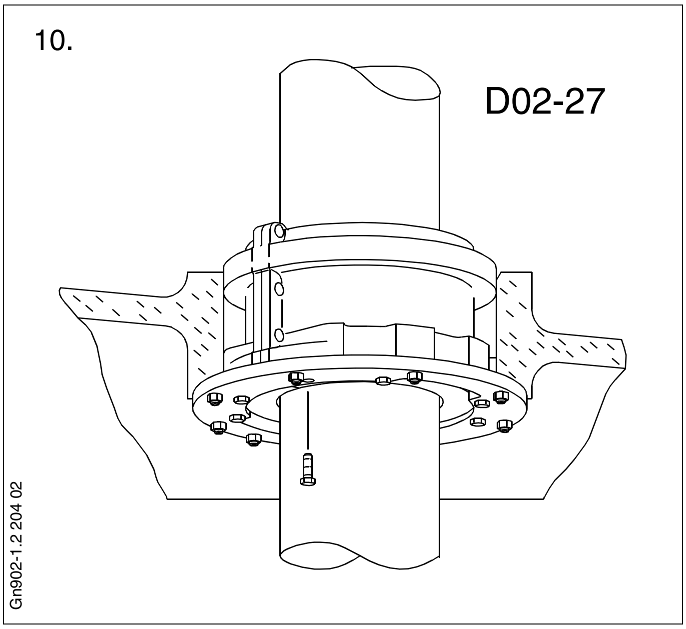
11. Mount the piston cleaning ring according to the scratch mark.

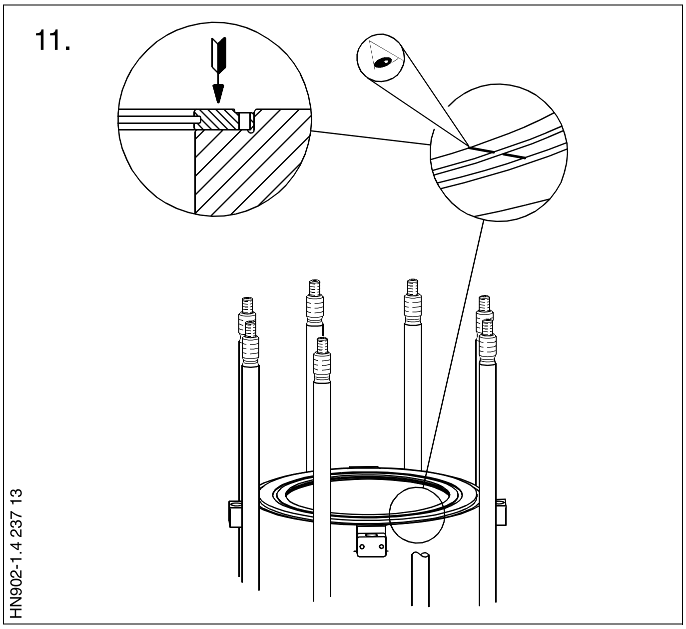
    If the PC-ring is damaged (broken or cracked), it must be replaced by another ring. *See Procedure 903-1.*

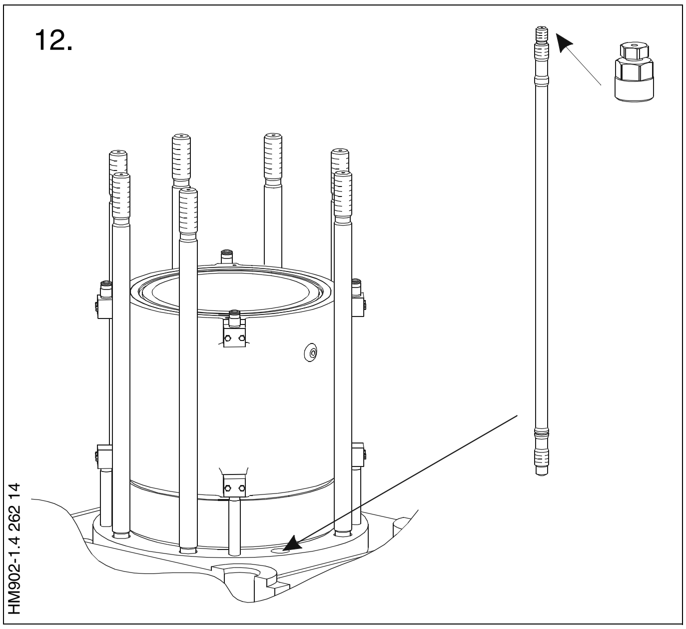
12. If the cylinder cover studs have been removed, remount them.

    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.







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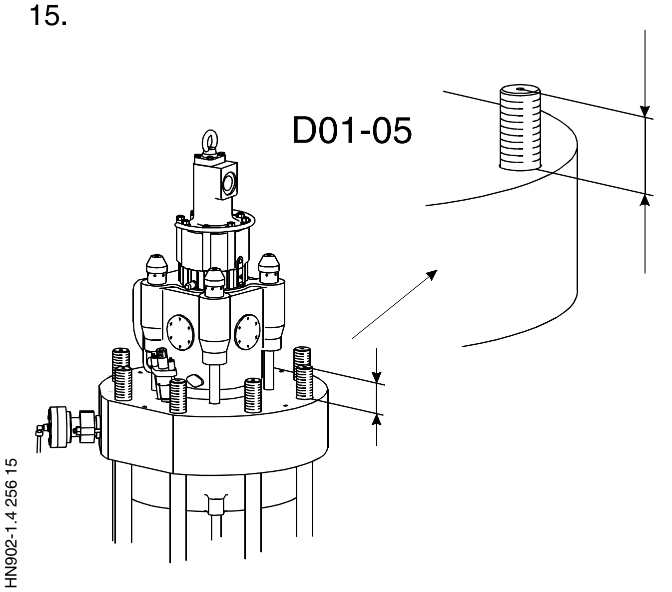


13. Land the cylinder cover on the liner and check the distance the stud is protruding from the cylinder cover.

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

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

    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 number of revolutions corresponding to very slow.

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

SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
Data #	Description		Unit
D02-26	Stuffing box flange, outer screws tightening torque	350	Nm
D02-27	Stuffing box flange, inner screws tightening torque	350	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
D02-33	Check length for the six uppermost springs:		
D02-34	– F 0 = 0 N................. L 0 =	889	mm
D02-35	– F 1 = 153 +/– 7 N....... L 1 =	1278	mm
D02-36	– F 2 = 163 +/– 10 N..... L 2 =	1352	mm
D02-37	Check length for the four lowermost springs:		
D02-38	– F 0 = 0 N................. L 0 =	839	mm
D02-39	– F 1 = 150 +/– 7 N....... L 1 =	1217	mm
D02-40	– F 2 = 200 +/– 10 N..... L 2 =	1263	mm
D02-44	Stuffing box complete	300	kg
D02-45	Stuffing box half	105	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. P**909**51 refers to chapter 909.

Plate	Item No.	Description
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.*

   <u>Uppermost scraper ring and sealing rings</u>

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

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

   <u>Lowermost scraper rings</u>

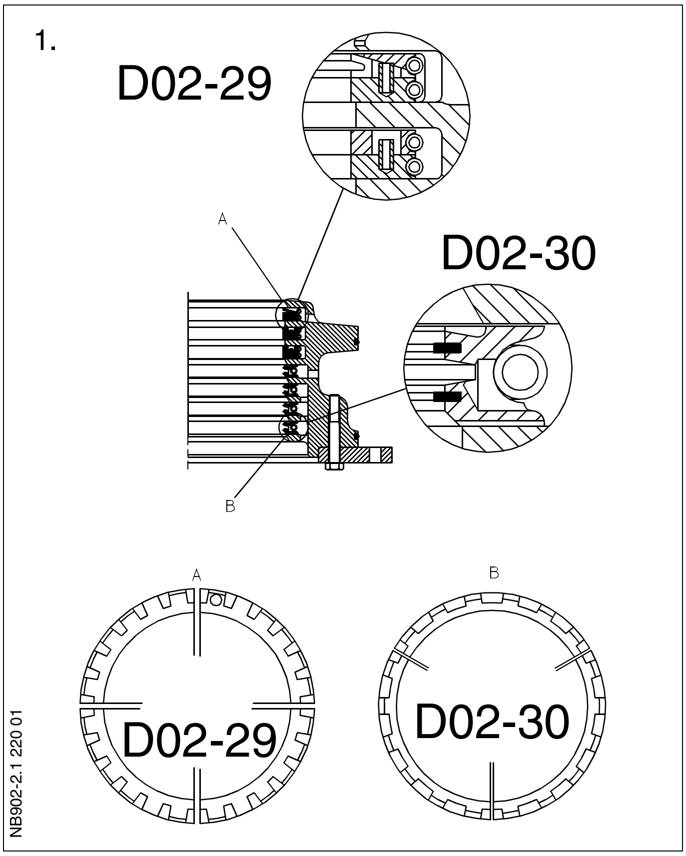
   Clearance at ring ends.
   Total clearance. (D02-30)

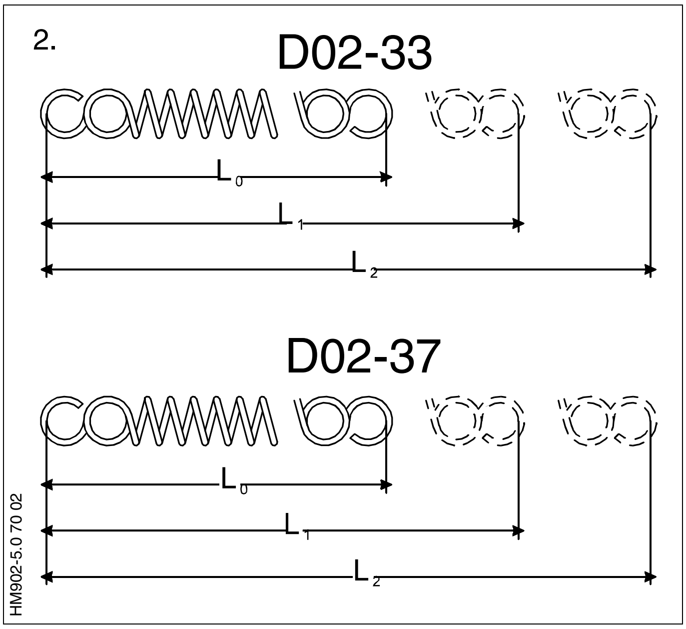
   The ring clearances stated in Data apply to new rings.

   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. Check the length of the springs at different loads. Adjust the loads to achieve the lengths stated in Data.

   If the loads necessary are outside the limits stated in Data, the springs must be discarded.





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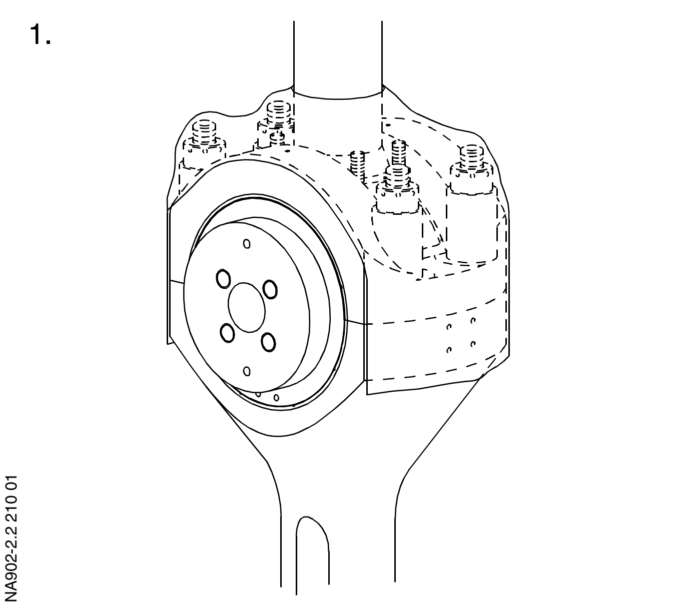

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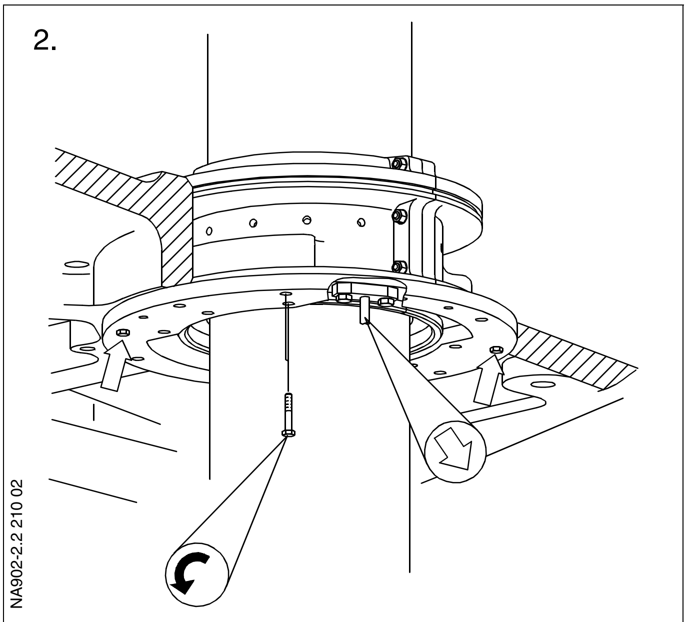

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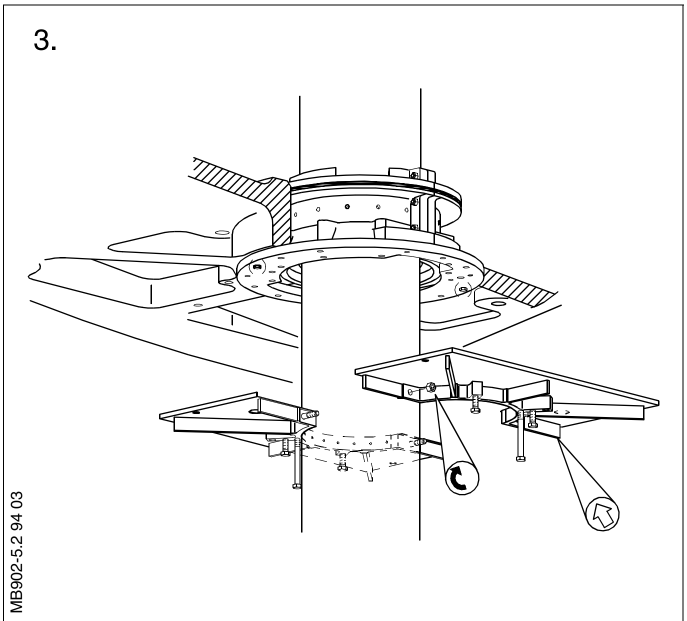

If, in the period between piston overhauls, it becomes necessary to inspect the piston rod stuffing box, proceed as follows:

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. 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.

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.
   For overhauling the stuffing box, see Procedure 902-2.3.

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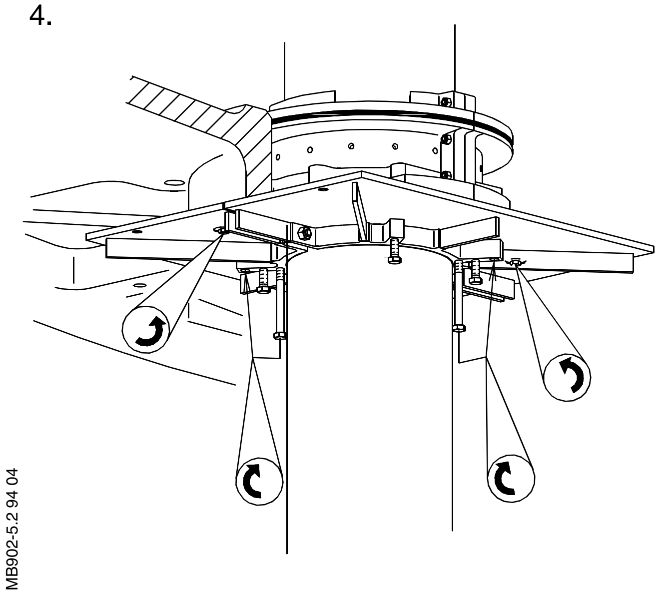

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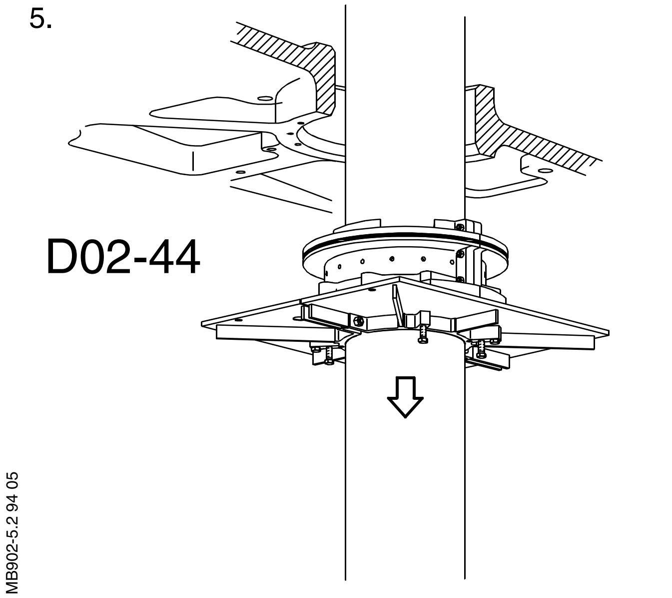

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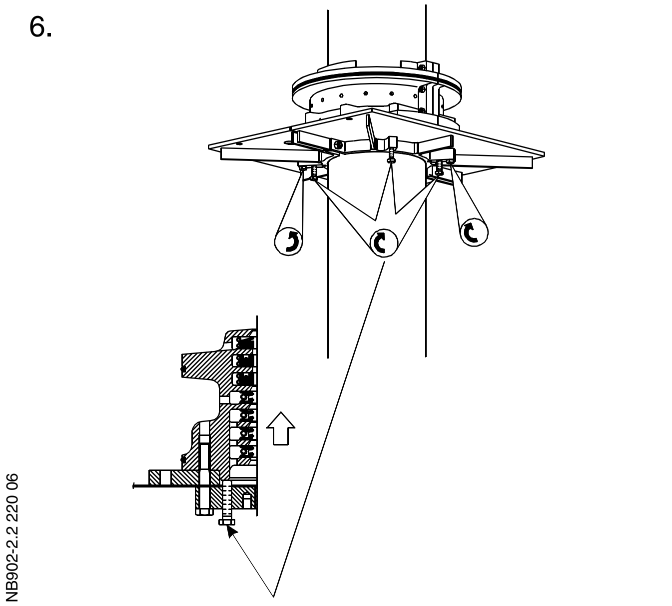

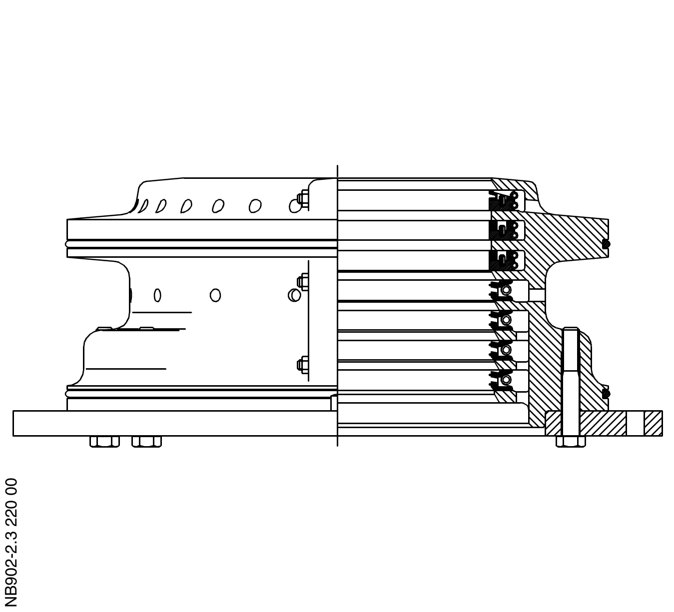

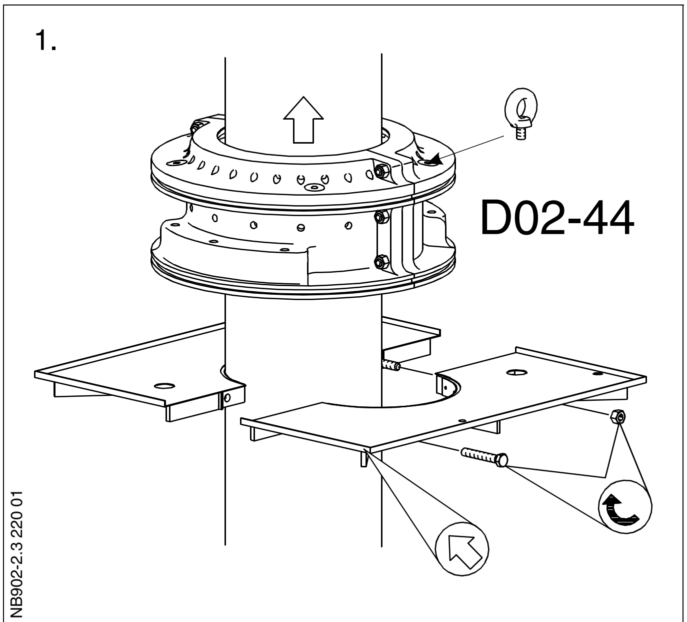

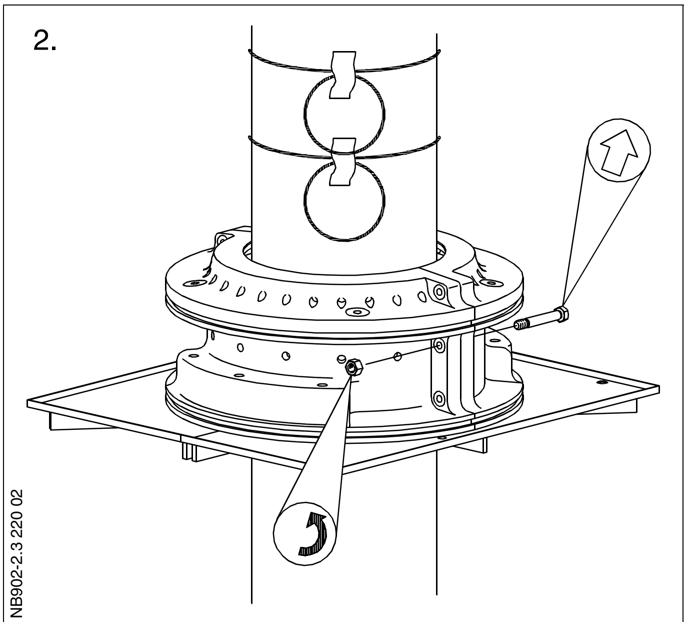

Outside the engine

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.

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.

   Mount two eye bolts on the stuffing box half and remove it from the worktable.

4. Using a feeler gauge, measure the vertical clearance of the rings.
   See Procedure 902-2.1.

5. Remove the remaining stuffing box half and press all sealing rings and scraper rings down against the worktable.

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.

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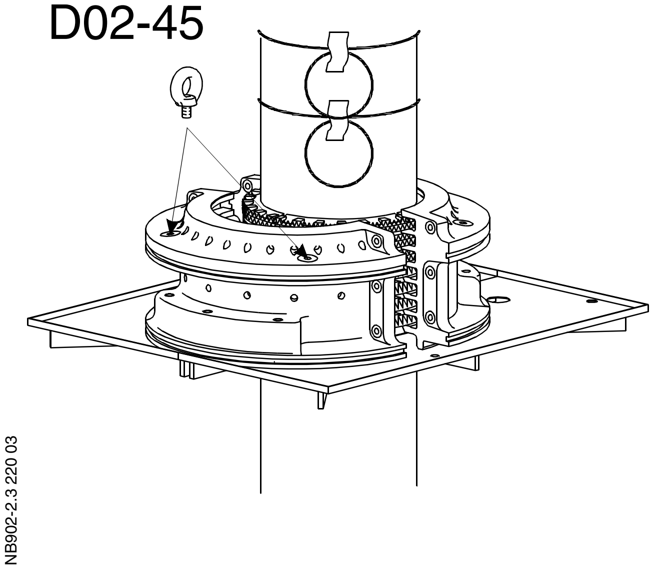

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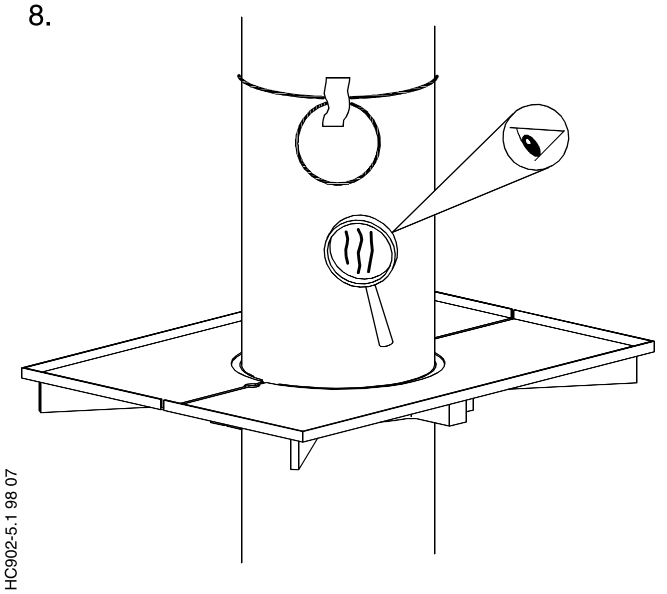

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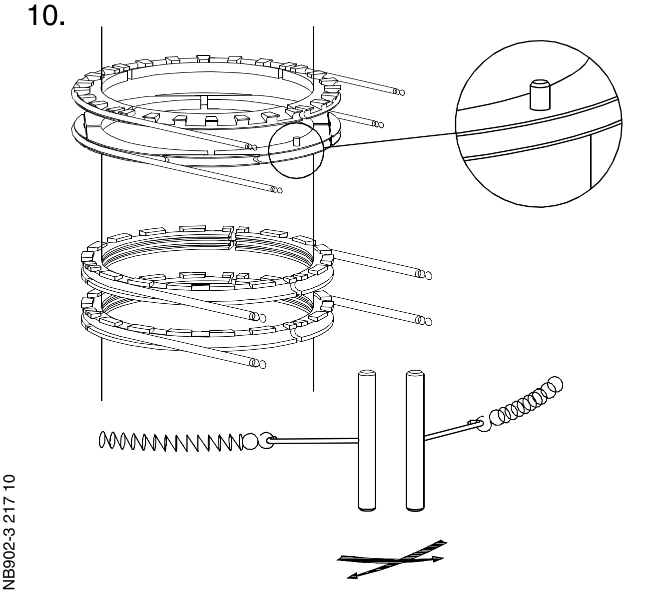

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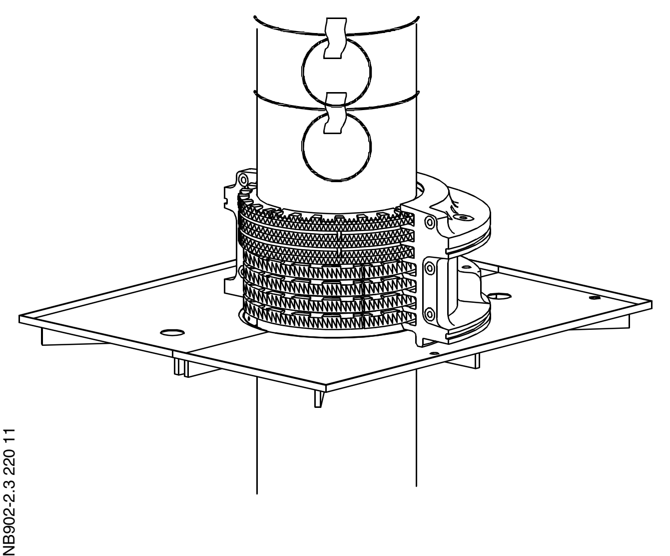


10. Lubricate the piston rod (in the area where all the ring units in the stuffing box will be positioned) with molybdenum disulphide (MoS_2).

    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).

11. 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.

12. 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.

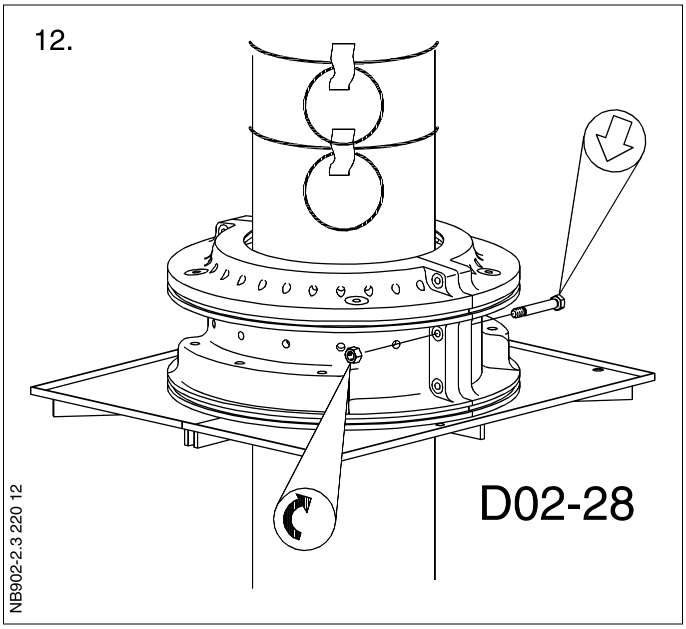
    Mount and tighten up the fitted bolts to the torque specified on the Data Sheet.

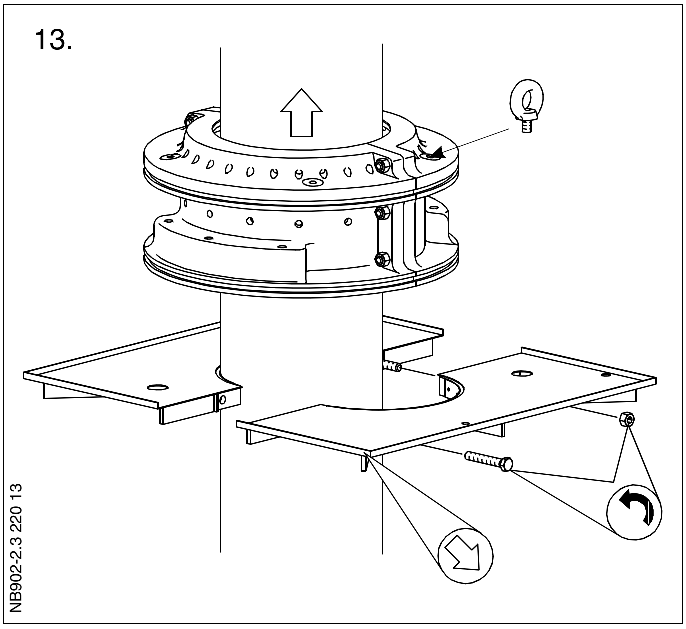
    Mount the O-rings in the stuffing box grooves.

13. 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.





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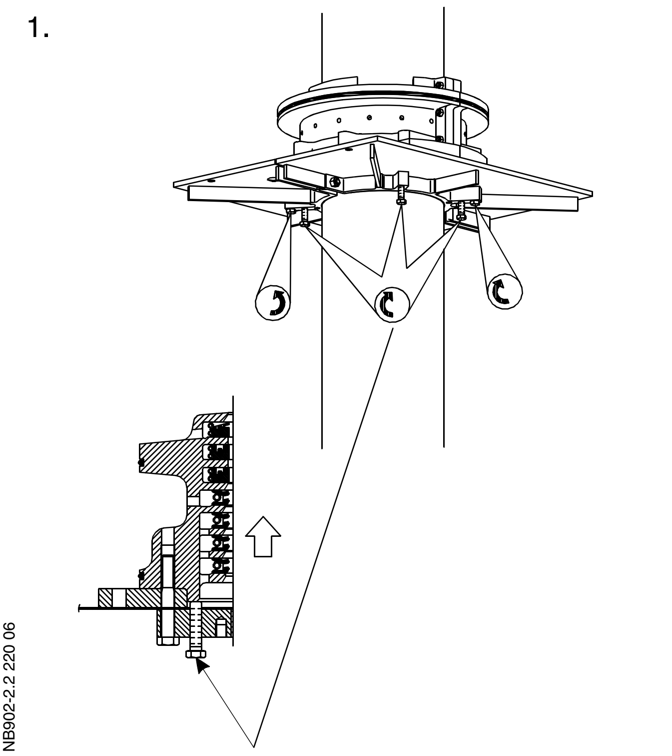

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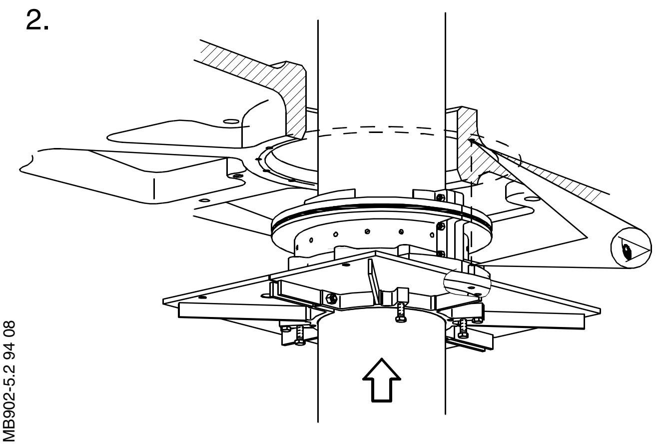

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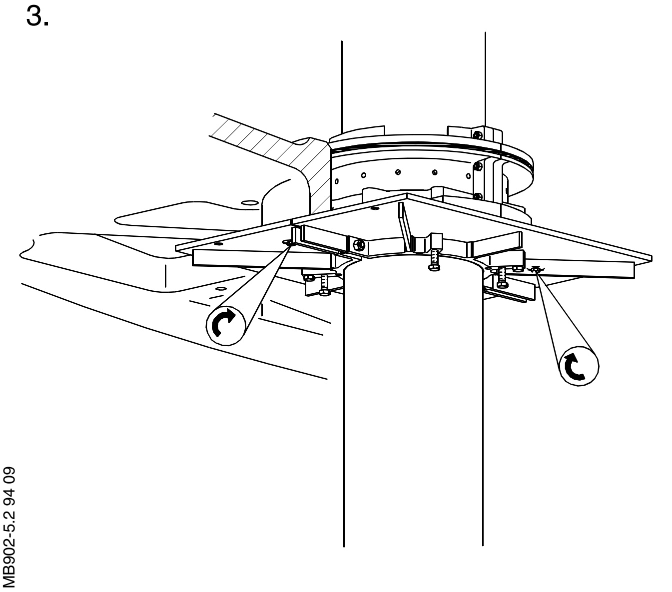

1. After overhauling, assemble the stuffing box halves on top of the four screws.

   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.

   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.

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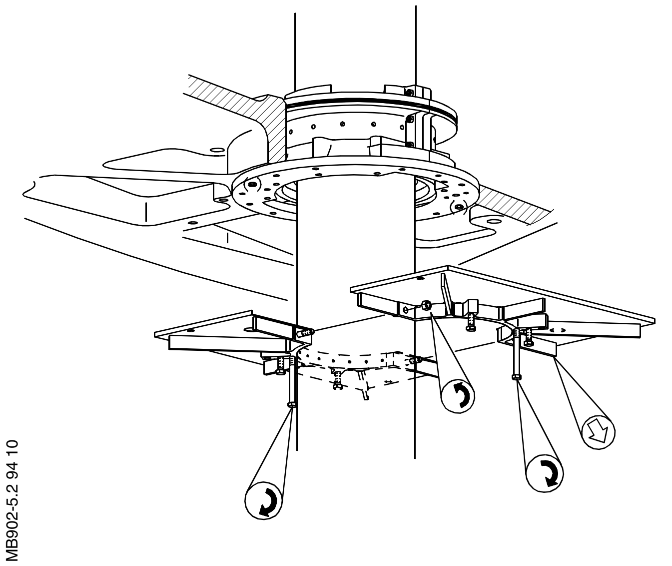

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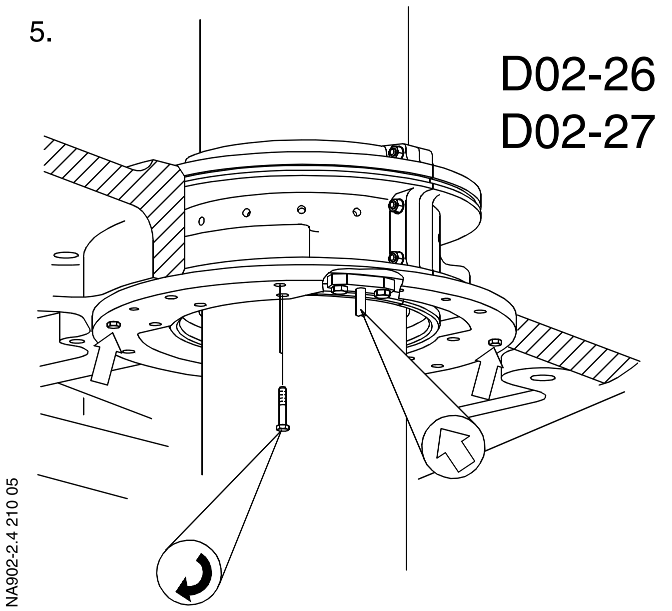

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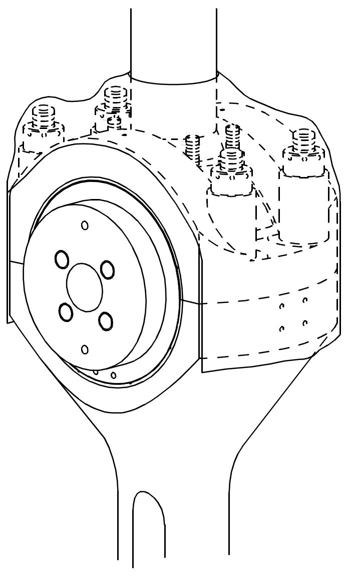
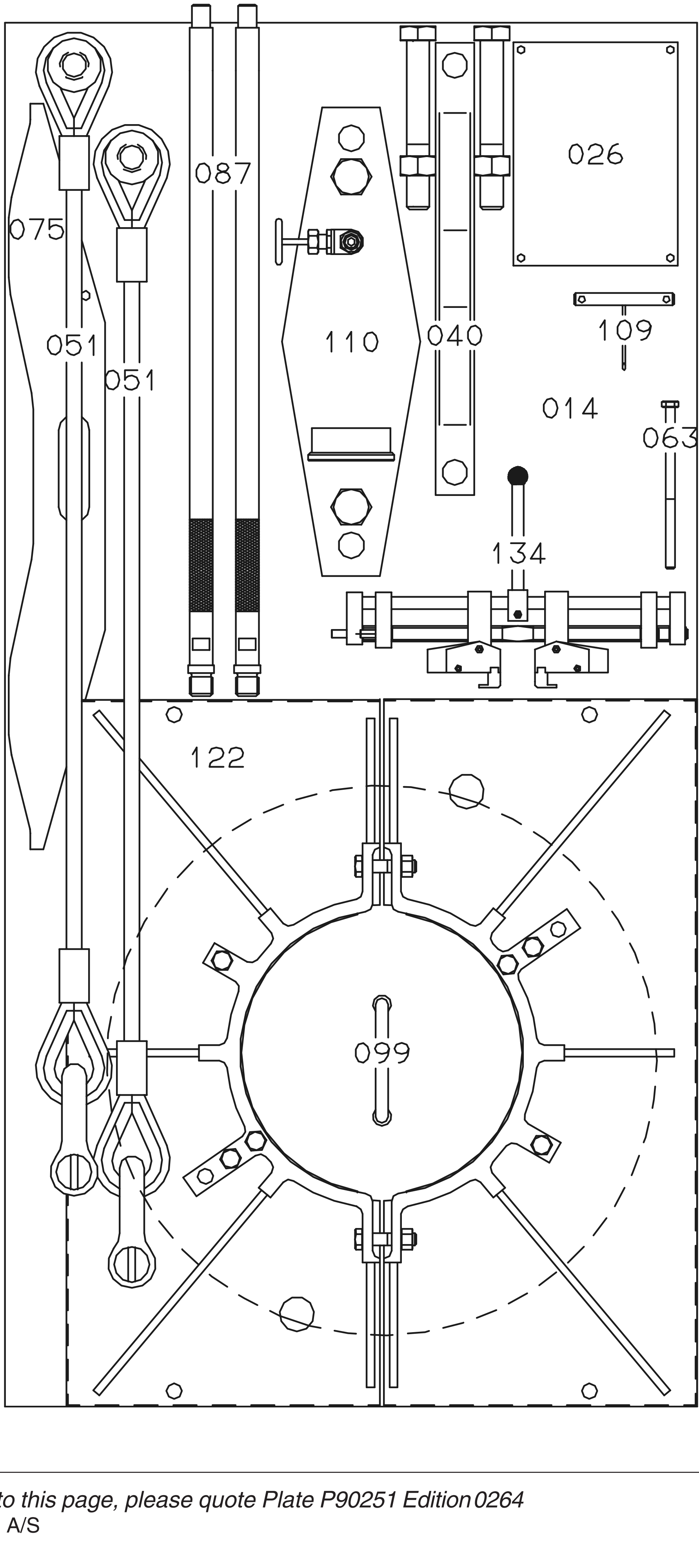
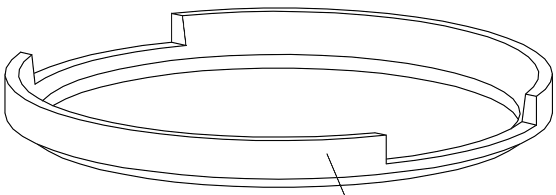



026
087
075
110
040
109
051
051
014
063
134
122
099

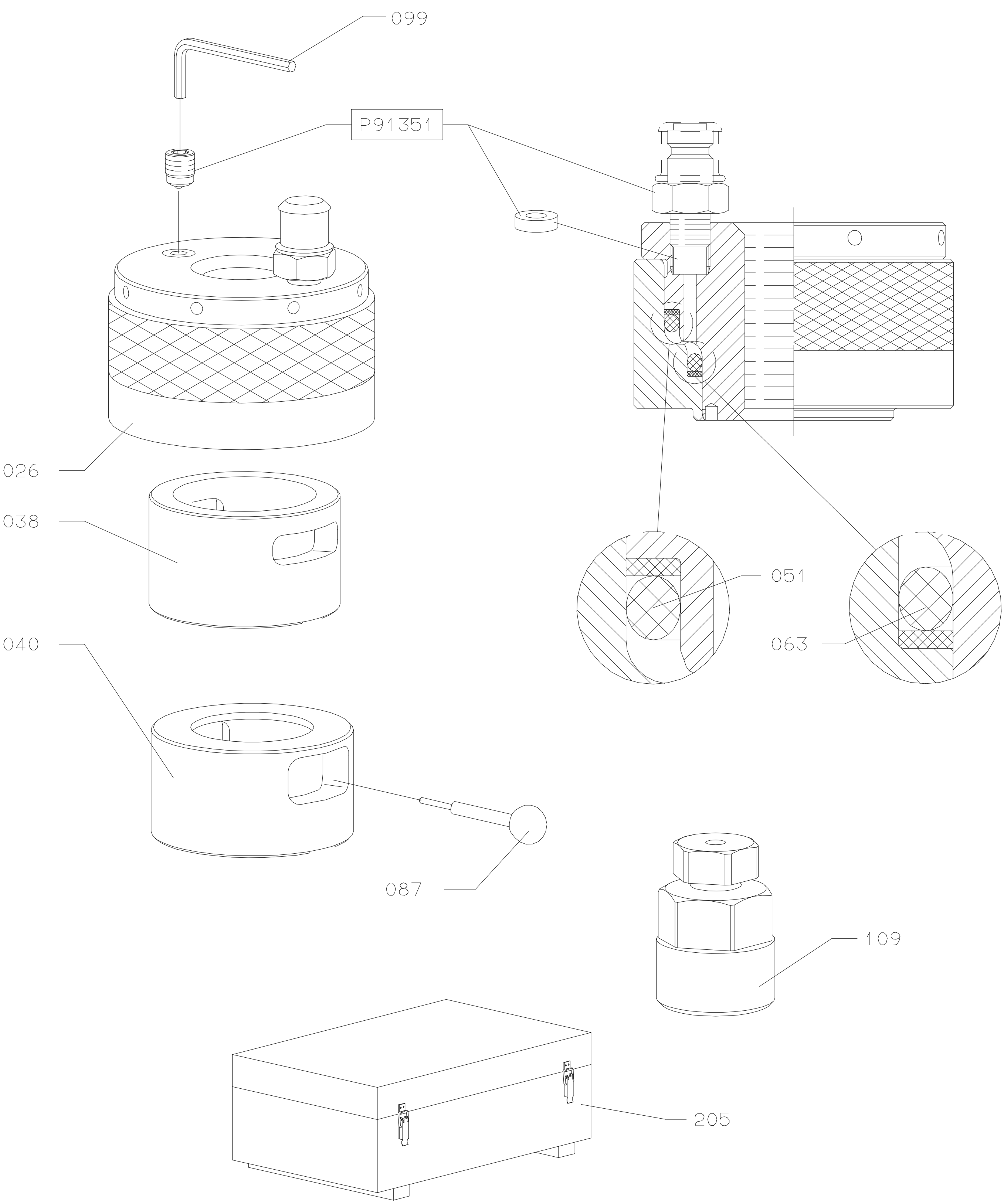
Piston and Piston Rod Panel

Item No.	Item Description
014	Panel for tools
026	Name plate
040	Lifting tool, piston rod foot
051	Lifting tool, cylinder liner
063	Screw, lifting and tilting
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

Item No.	Item Description

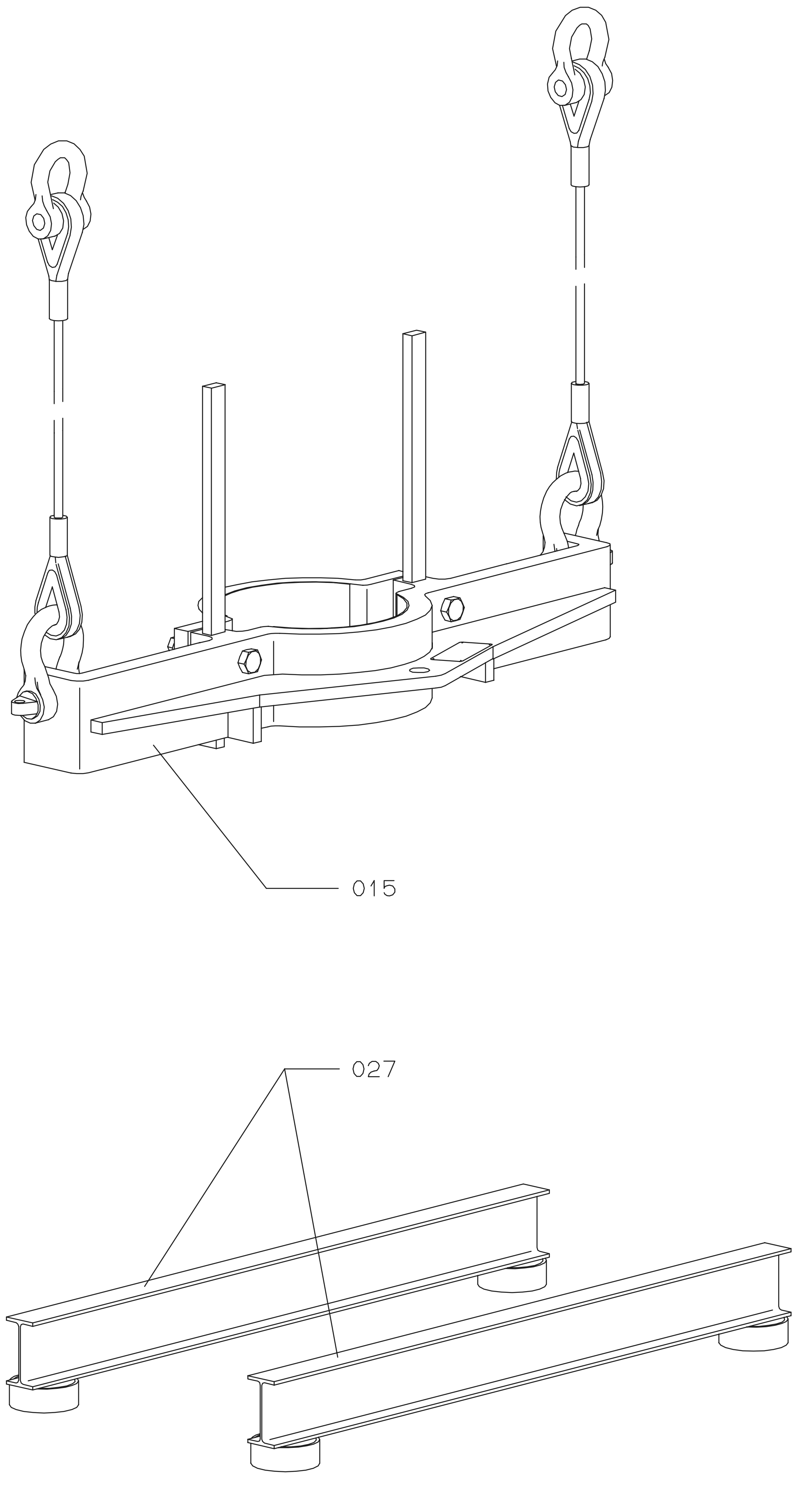

019

Item No.	Item Description	Item No.	Item Description
019	Guide ring for piston		


099
P91351
026
038
040
087
051
063
109
205

Piston and Piston Rod - Hydraulic Tools

Item No.	Item Description
026	Hydraulic jack, complete
038	Support
040	Support
051	O-ring with back-up ring
063	O-ring with back-up ring
087	Tommy bar
099	Spanner
109	Stud setter
205	Hydraulic tool set, complete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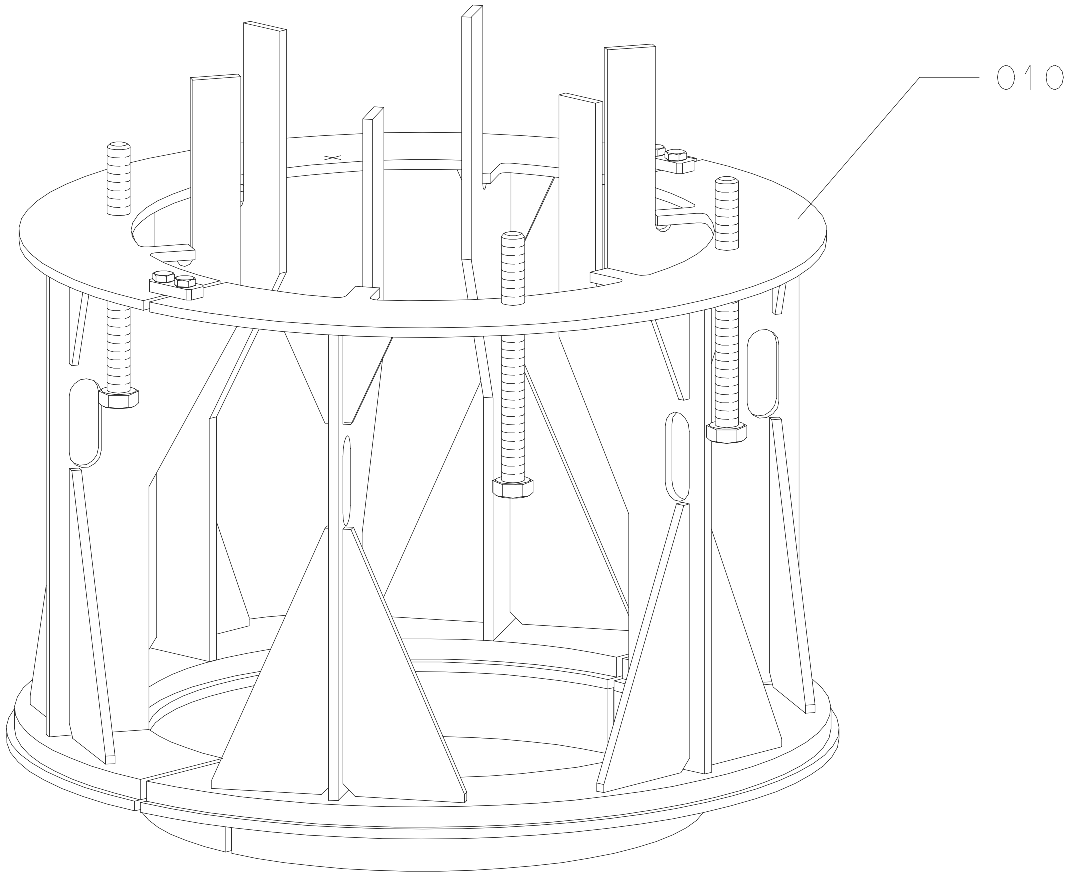
027

Item No.	Item Description	Item No.	Item Description
015	Collar ring for piston		
027	Support for tilting tool		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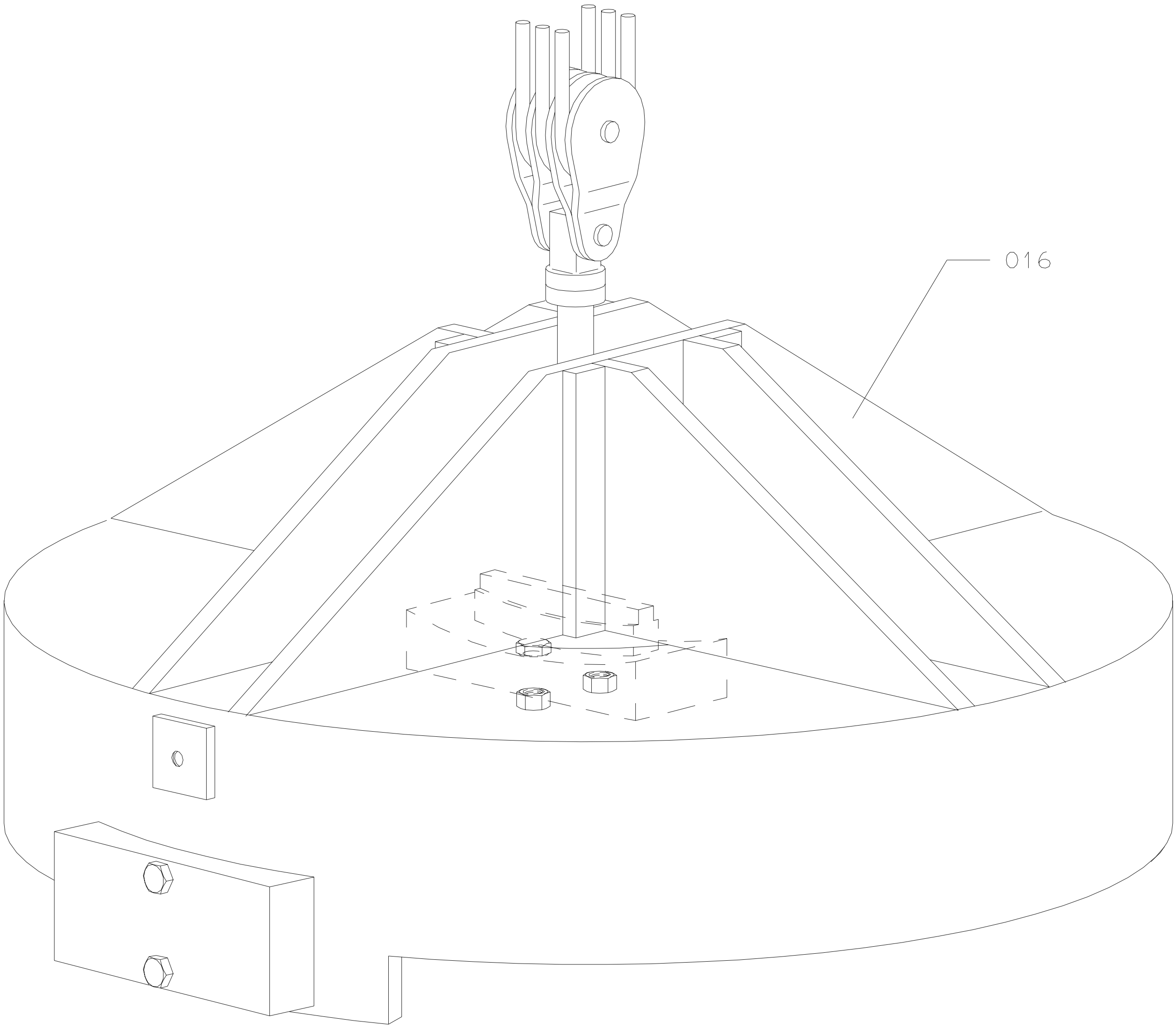
Piston and Piston Rod - Support Tools

Item No.	Item Description	Item No.	Item Description
010	Support iron for piston		


016

Item No.	Item Description	Item No.	Item Description
016	Lifting tool, piston		

903 - Cylinder Liner and Cylinder Lubrication

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubriating oil pumps*
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
D01-10	Cylinder cover stud	205	kg
D03-02	Lifting tool bolts, screwing-in torque	200	Nm
D03-03	Cylinder diameter, new	980	mm
D03-04	Piston cleaning ring diameter, new	977.8	mm
D03-05	Cylinder liner, complete	9000	kg
D03-06	Cooling jacket	335	kg
D03-16	Piston cleaning ring radial width, new	21.1	mm
D03-17	PC-ring/Liner max. wear deviation	0.98	mm
D03-18	PC-rings replacement criteria:		

Liner diameter: 980 mm	
Liner wear:	Install:
0 – 0.98 mm	Standard PC-ring (new max. diameter wear of 0.98 mm
0.98 – 1.96 mm	Oversize PC-ring
> 1.96 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.

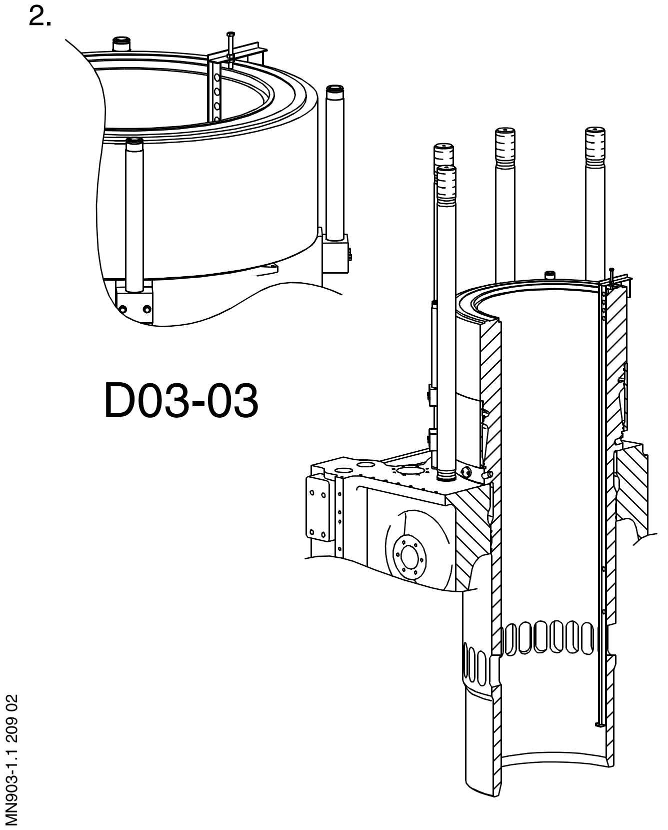
3. Carefully scratch over any scores or marks and grind away the wear ridges.
   See Procedure 903-1.3.

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.

2.



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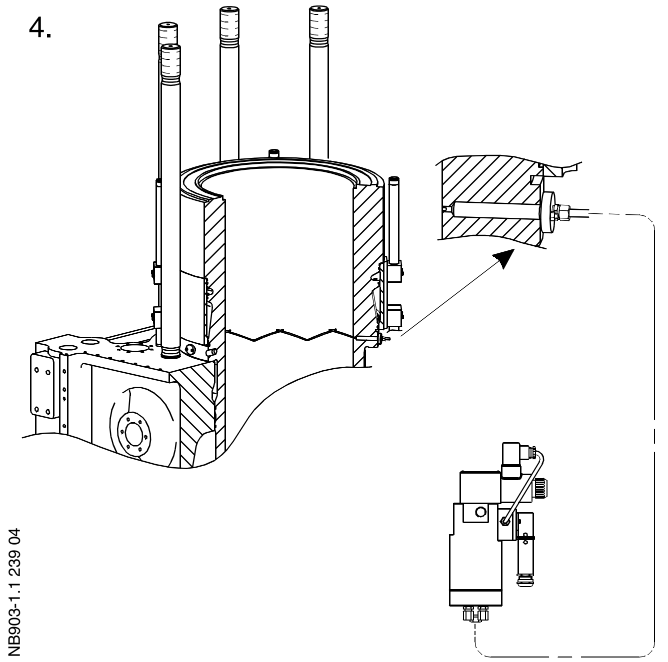

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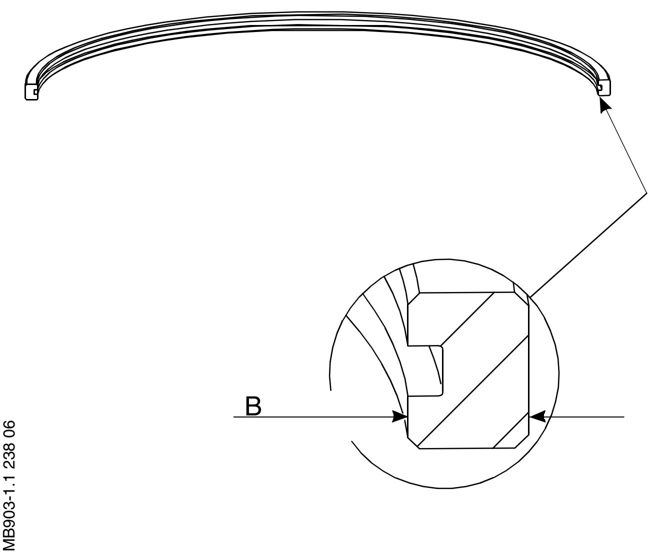


5. Piston cleaning (PC) ring:

   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.

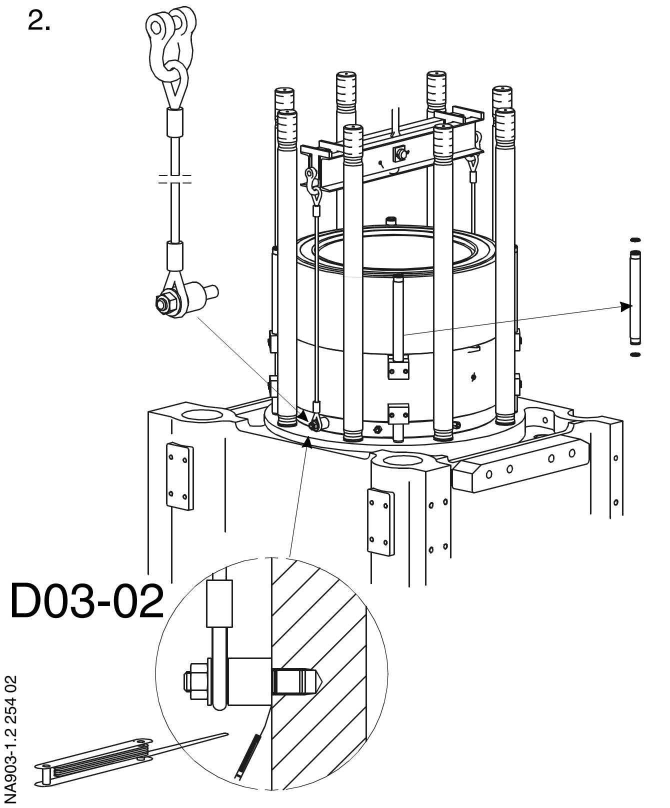
   Dismount the piston cleaning ring and the piston.
   See Procedure 902-1.2.

2. 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.

2.



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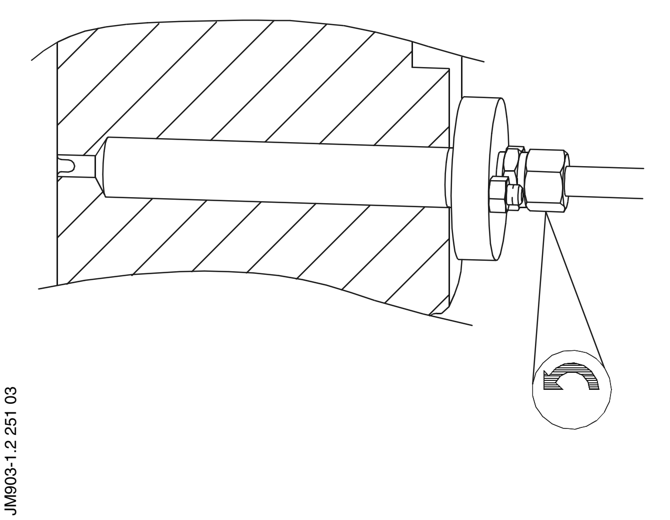

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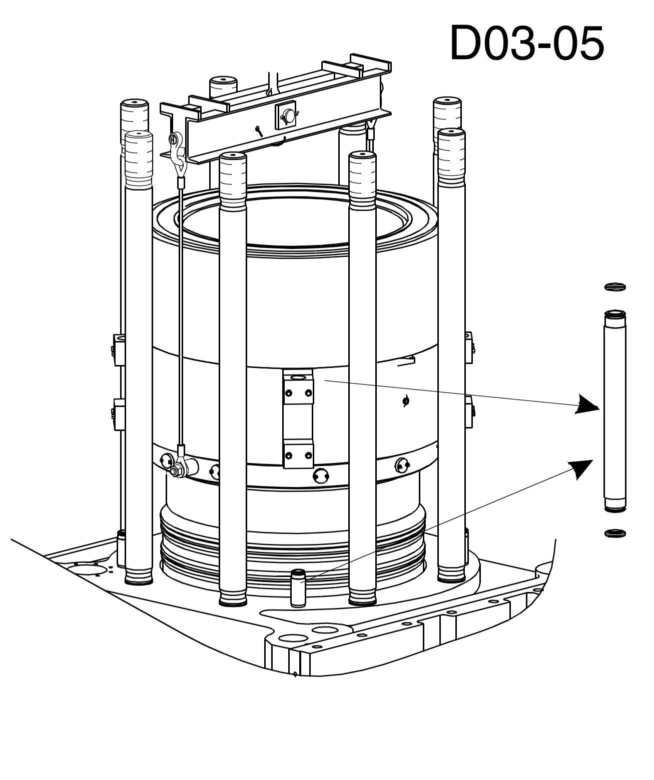

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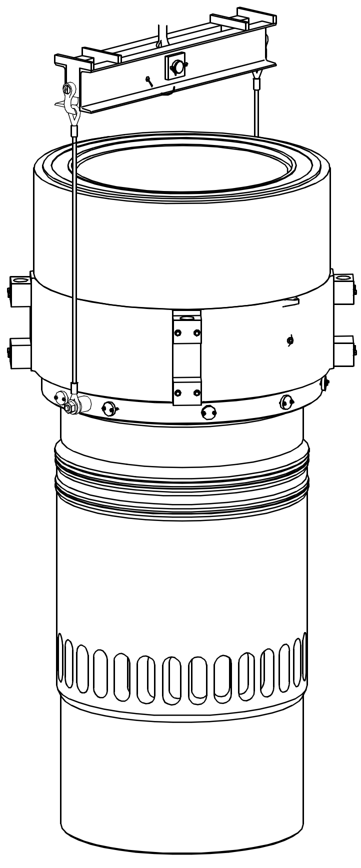


4. Dismount the four cooling water pipes – between the cooling jacket and cylinder cover and discard the O-rings from the pipes – and clean them carefully.

   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.

   Remove the cooling water pipes and discard the O-rings.

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

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

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

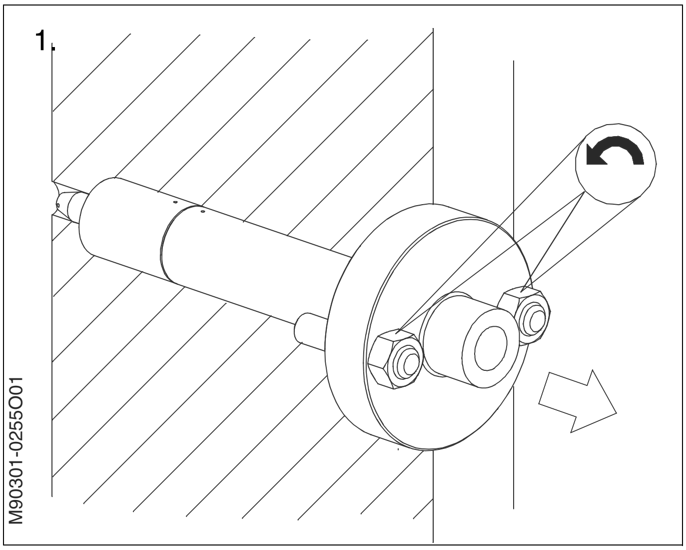
   Clean and inspect the non-return valves.

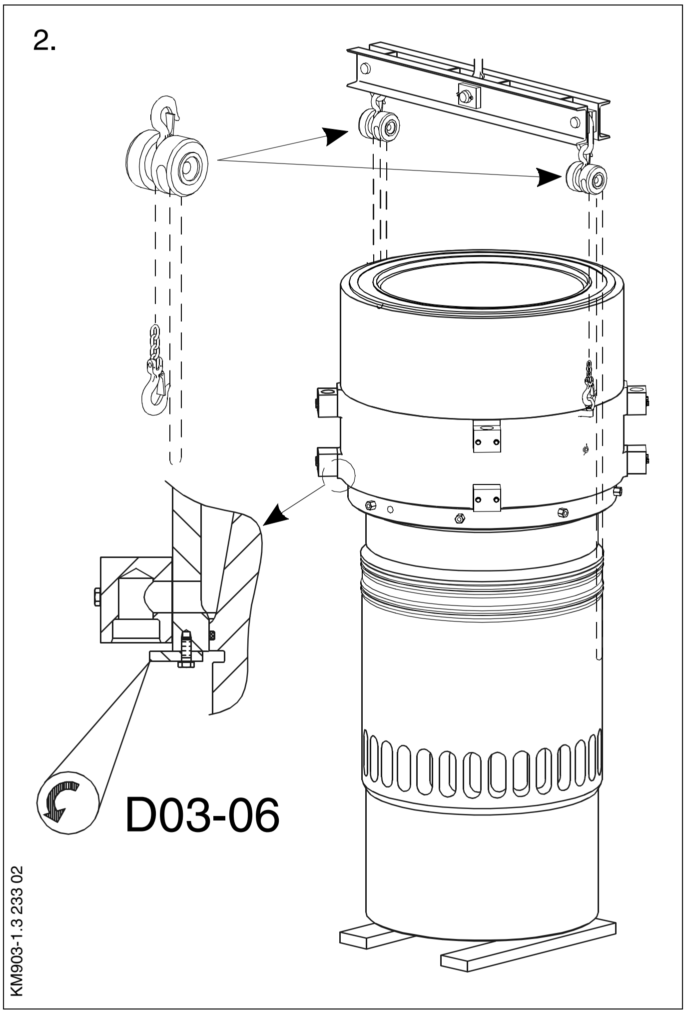
2. Attach two tackles to the crossbar, as shown.

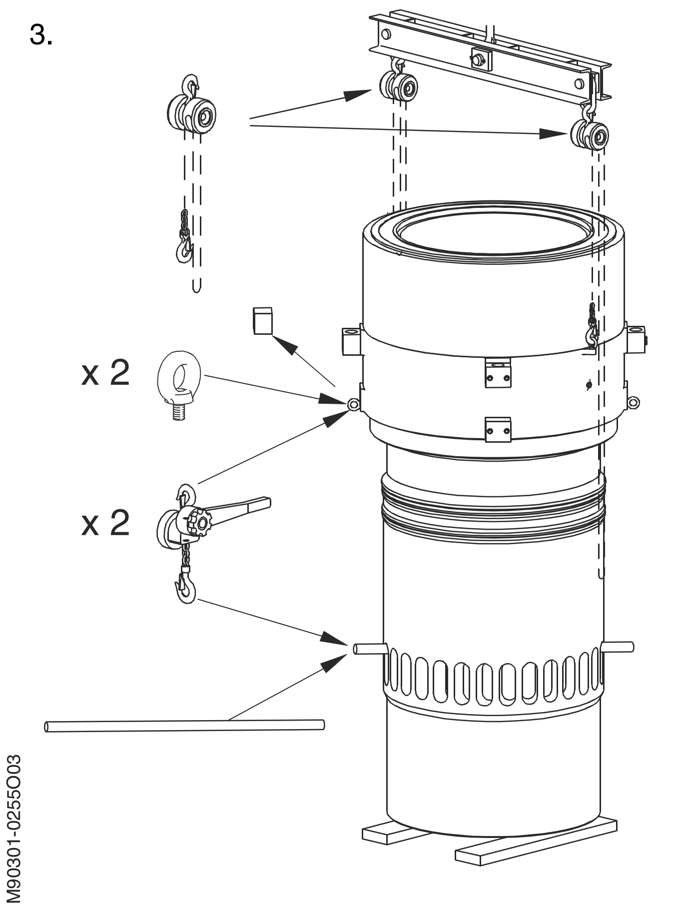
   Mount two lifting eye bolts in the cooling jacket.

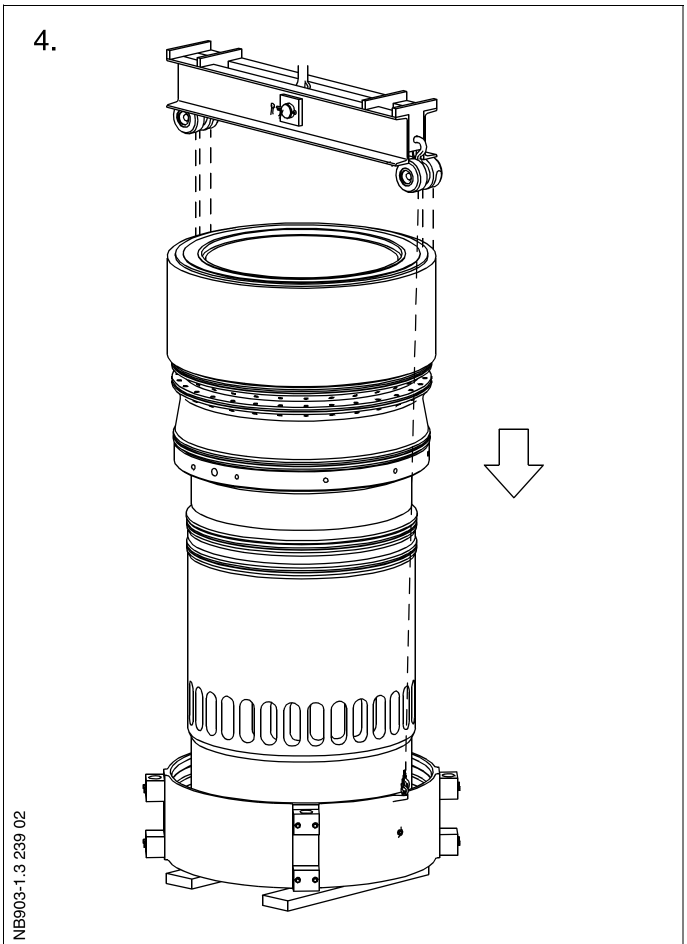
   Hook the tackles on to the lifting eye bolts on the cooling jacket and haul tight.

   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 a piece of pipe in the scavenge air ports and attach two tackles to the pipes 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.

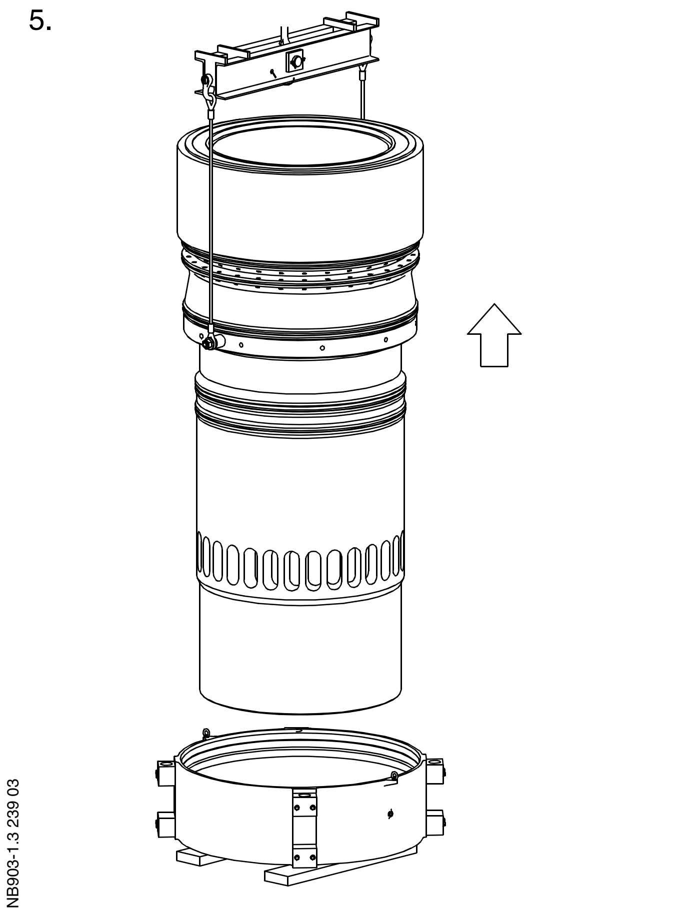
   Clean the cooling jacket internally.

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.



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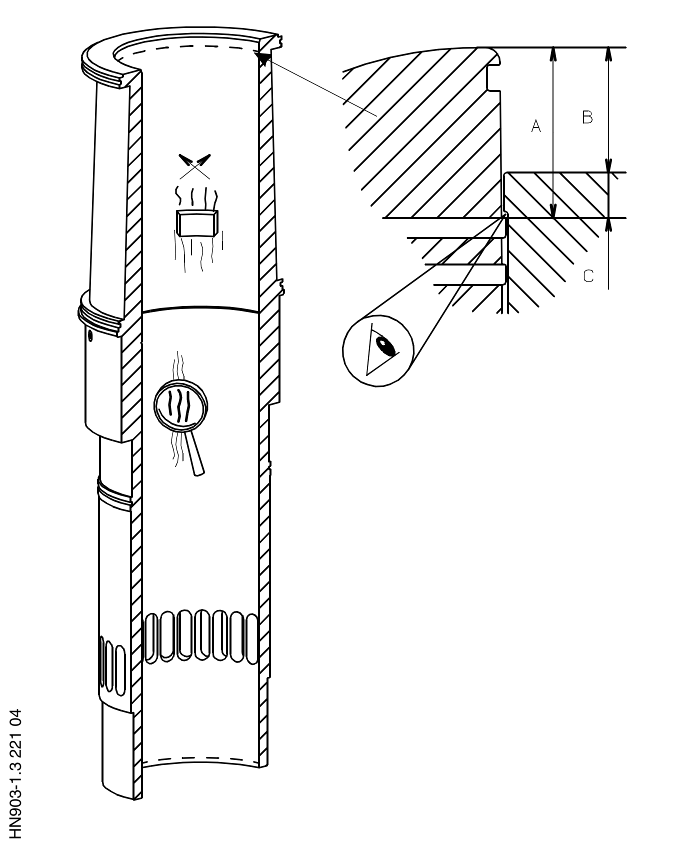

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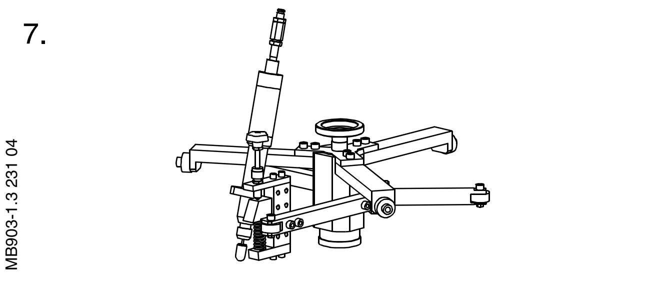

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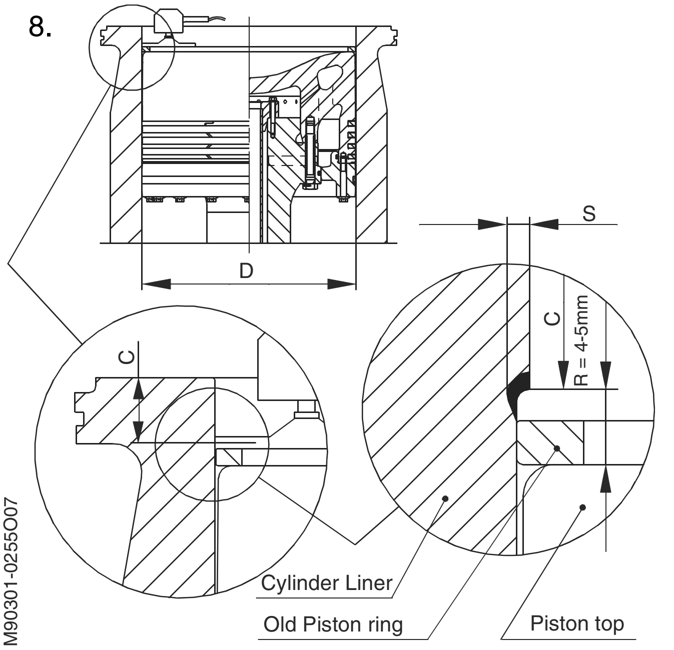


7. It is recommended to use a wear ridge milling machine to create the groove. *For use of the milling machine, see supplier's instruction.*

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.

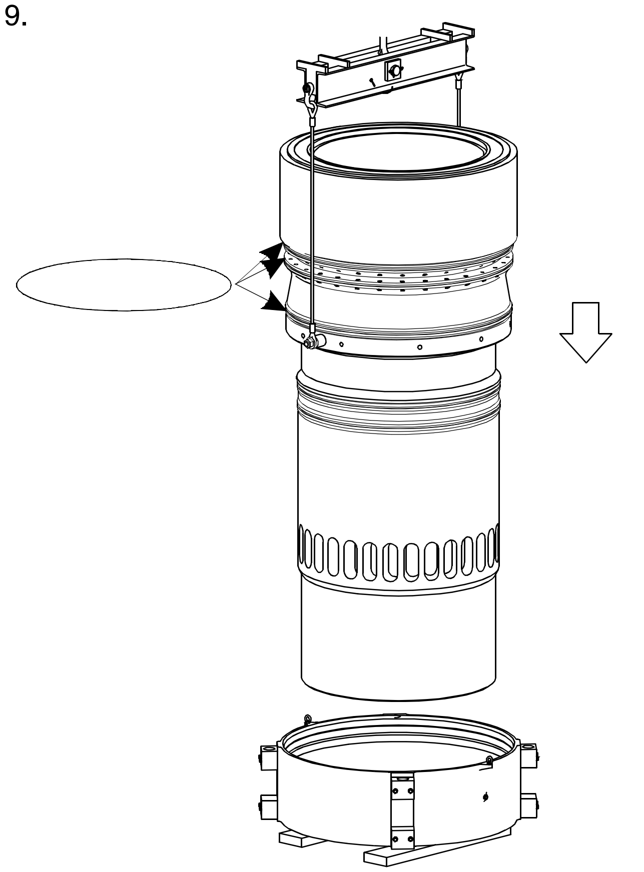
Apply a thin layer of grease on the contact surface for the cooling jacket on the liner.

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 (camshaft side).

9.



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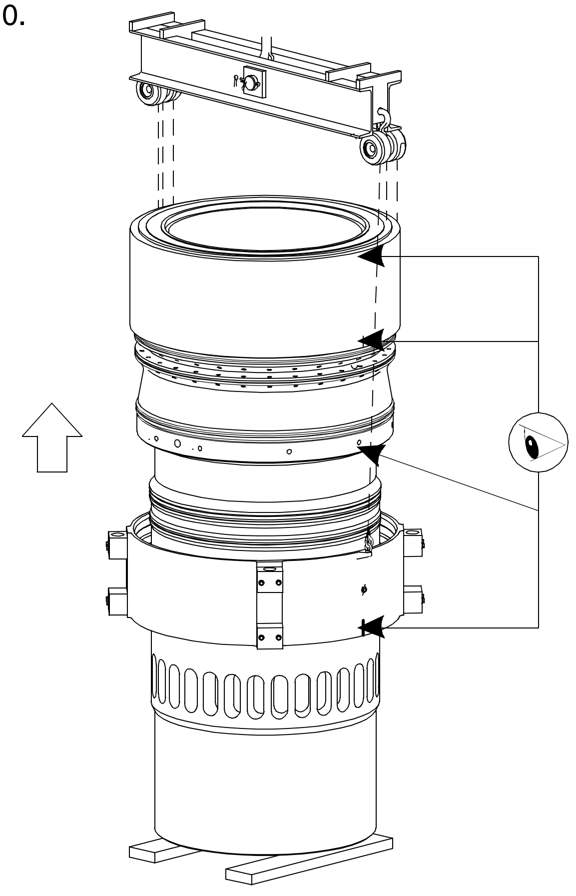

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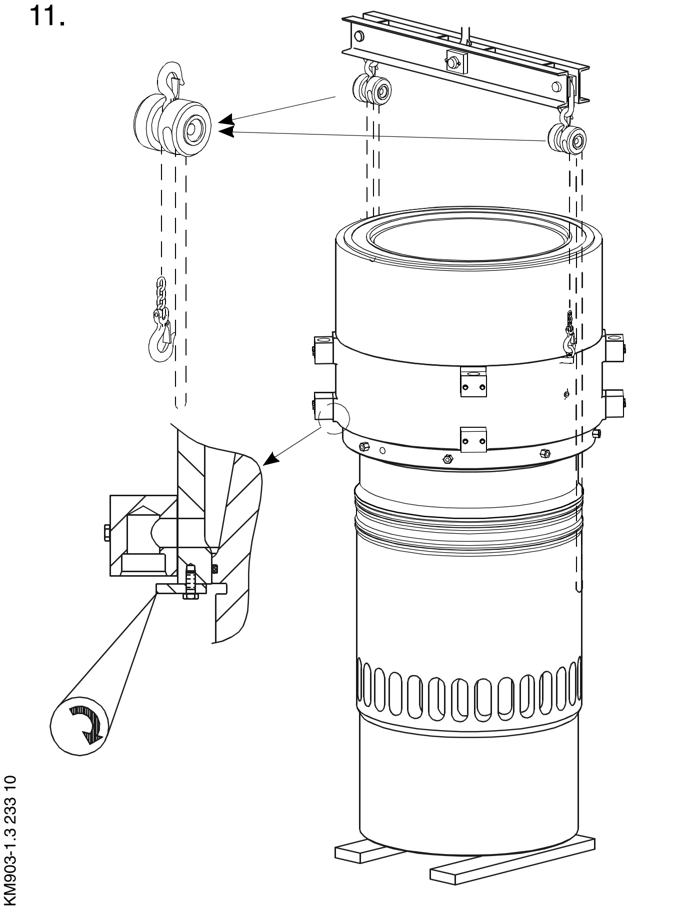
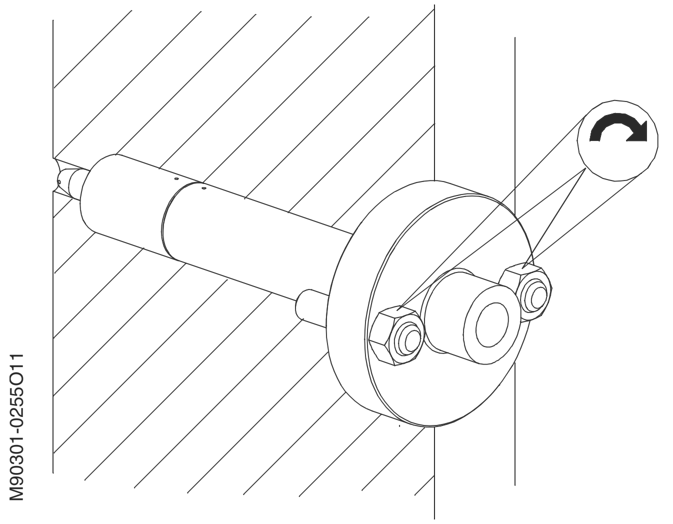


11. Turn the clamps until they fit in the groove of the liner, and tighten the screws.

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

12.



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

1. Loosen the water connections on the cooling jacket.

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

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

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

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

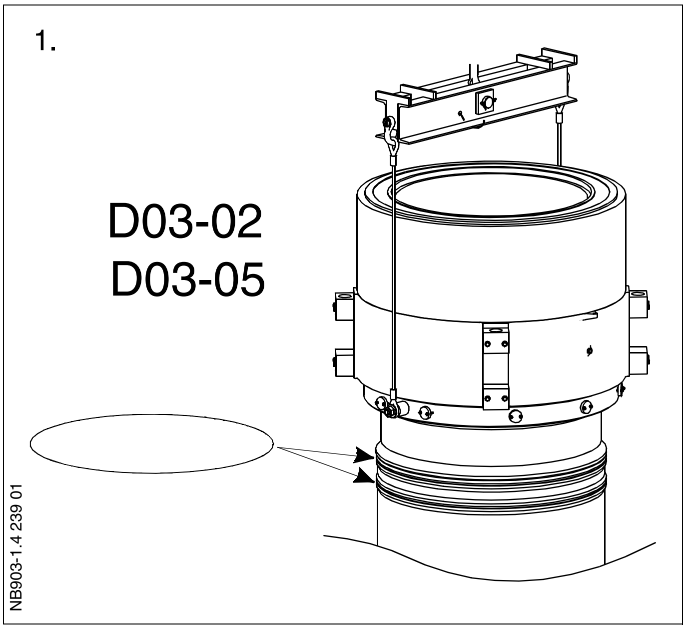
   Coat the joint surfaces with permatex or a similar liquid sealing compound.

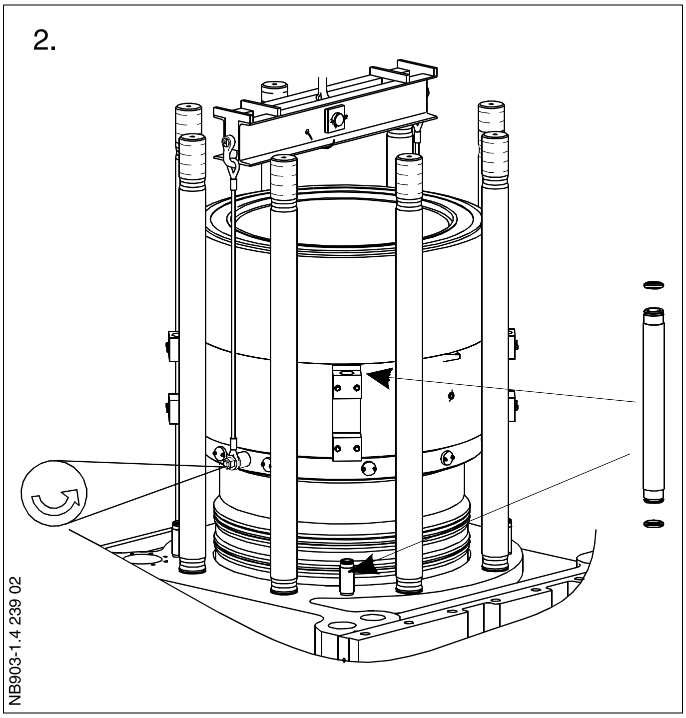
   Mount the cylinder liner in the cylinder frame. Replace the O-rings on the water connections and mount the water connections on the cooling jacket.

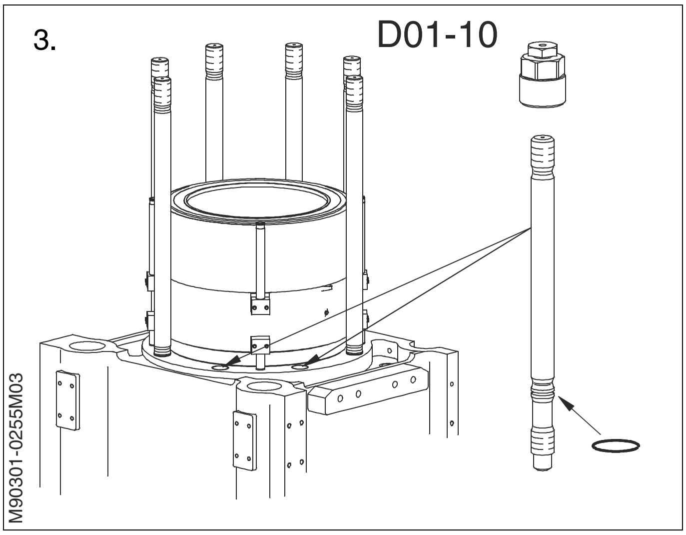
   Remove the cylinder liner lifting tools.

3. If one or more cylinder cover studs have been removed during the dismantling of the cylinder liner, 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.







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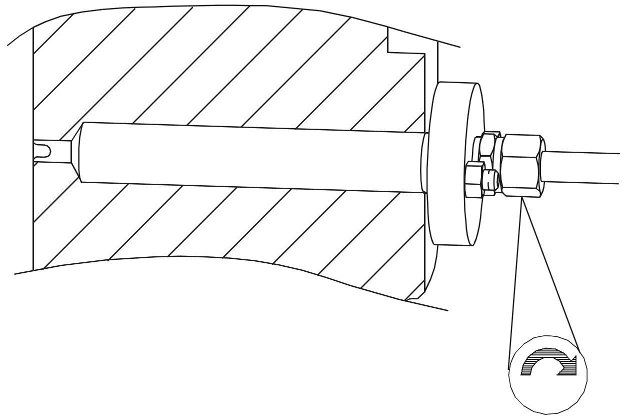

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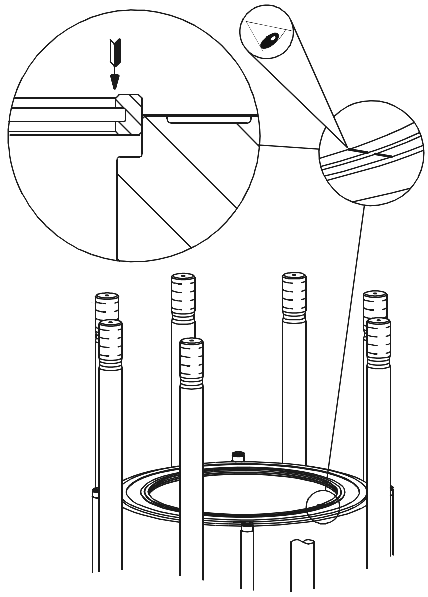
4. Screw the pipes from the lubricator on to the non-return valves, but do not tighten.

   Vent the cylinder lubricating system by manually pumping each individual pipe 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.



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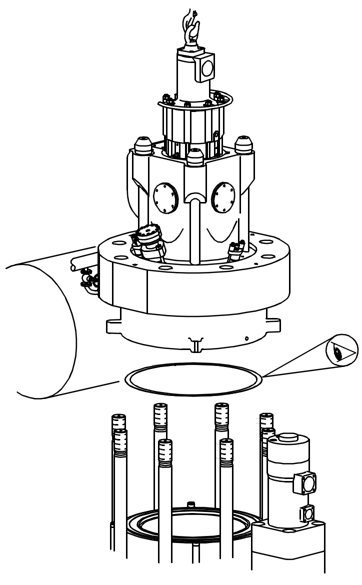
6. Mount the piston cleaning ring.

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

7.



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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*

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D03-14	Cylinder oil feed rate at MCR	0.8 - 1.7	g/kWh

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

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 all lubricators are operating correctly by watching the LEDs on the intermediate boxes next to each lubricator.

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

2. If the cylinder cover or the exhaust valve is removed, check inside the liner that all lubricating points are working properly.

   Otherwise, remove the covers for scavenge port inspection.

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

With running engine:

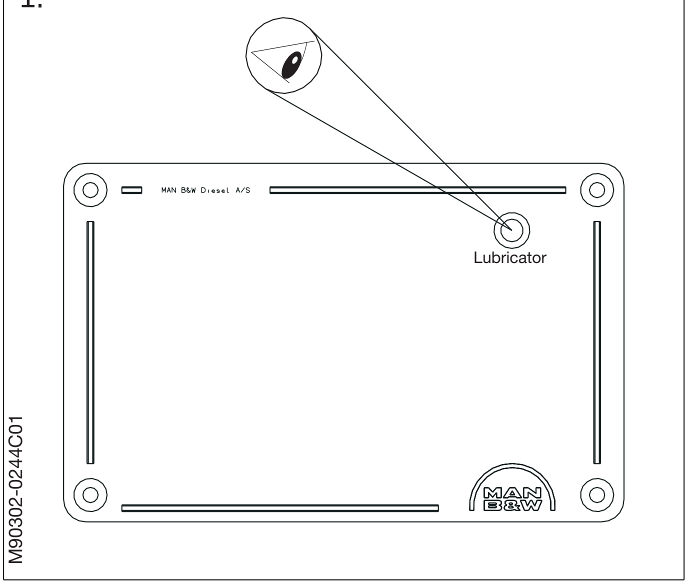
3. Check that all lubricators are operating correctly by watching the LEDs on the intermediate boxes for each lubricator.

   The LEDs give signal when oil is injected.

   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.



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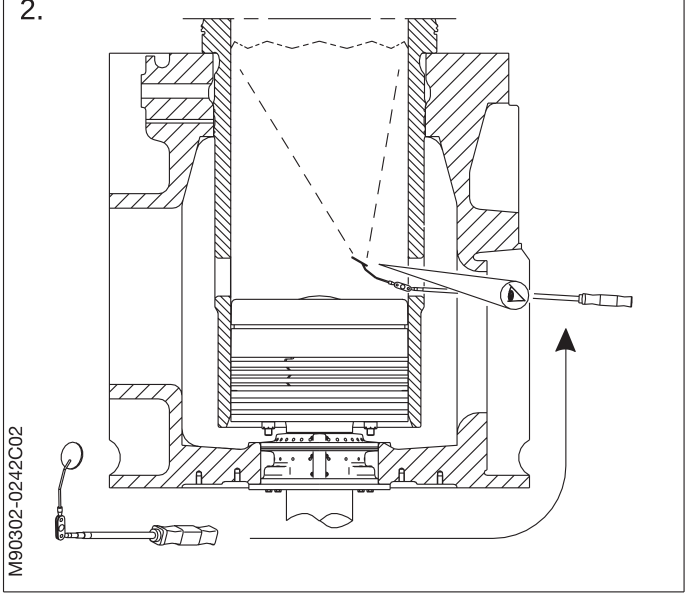

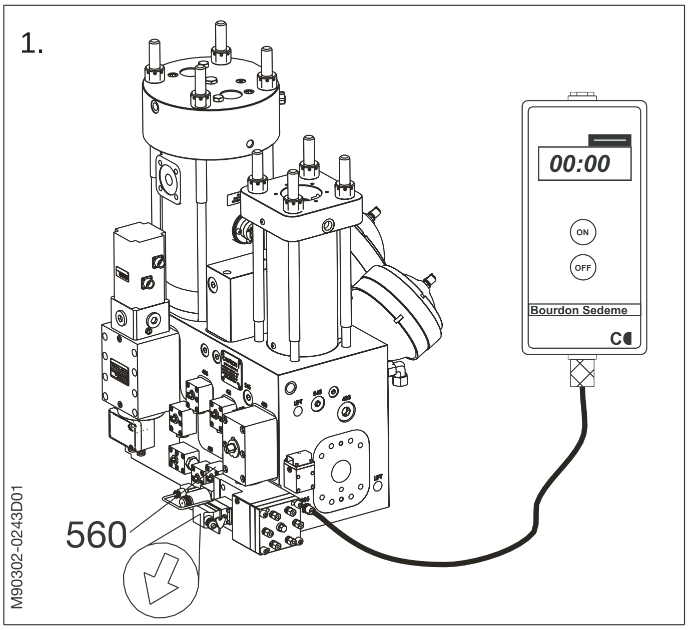

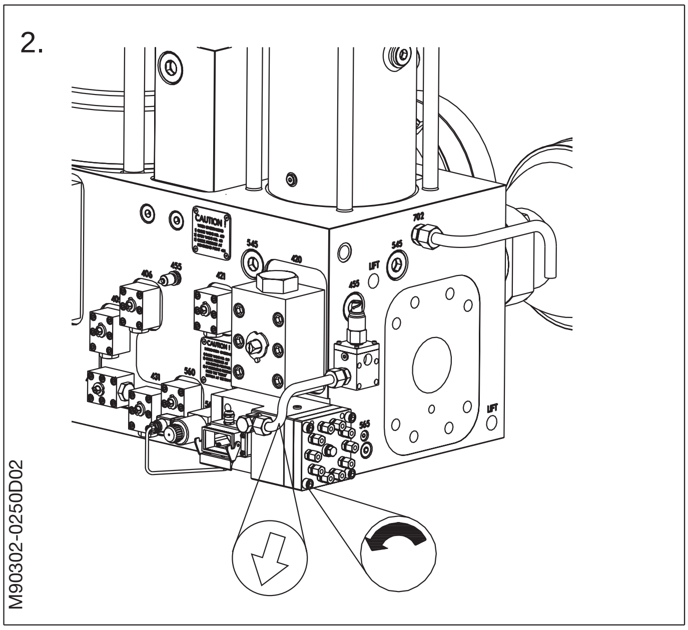

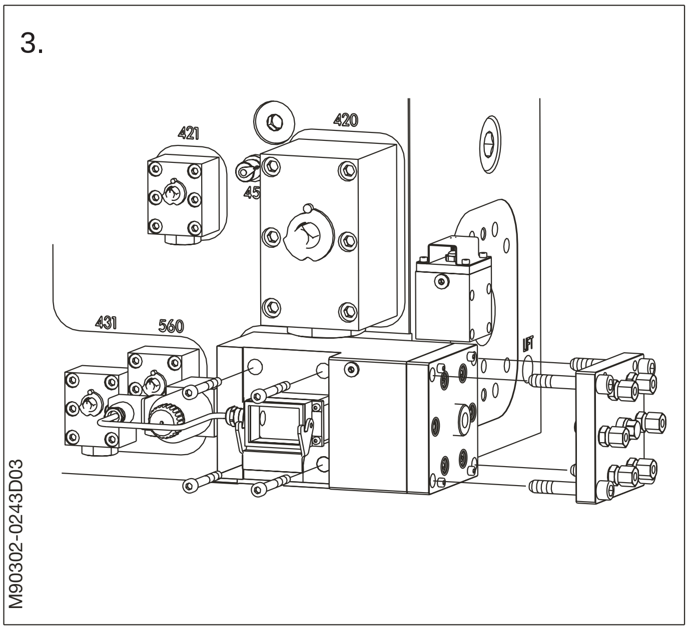

Dismantling of lubricators:

The engine must be stopped and blocked before dismounting a lubricator. Stop the cylinder oil pump station.

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.

   Close the supply valve for cylinder lubricating oil.

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

   Remove the cylinder oil pipe connection.

3. Unscrew the four screws on the side 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 load to below 40% of MCR
- 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 and actuator piston with plungers.

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

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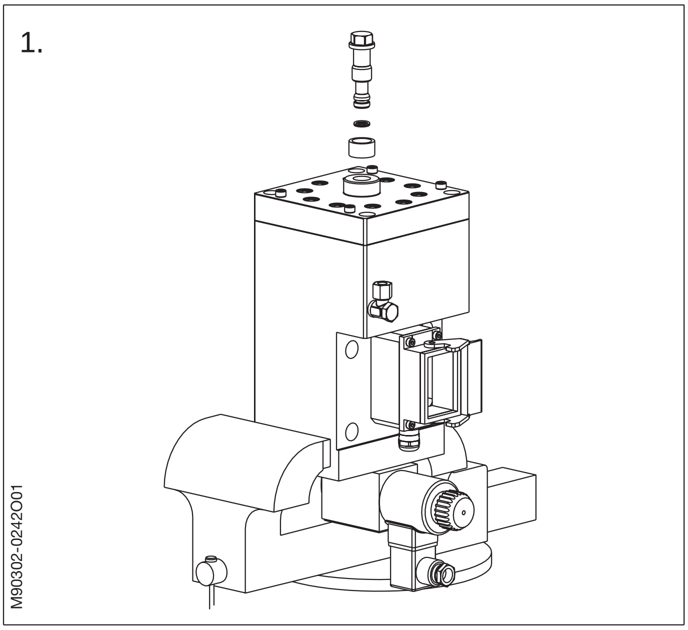

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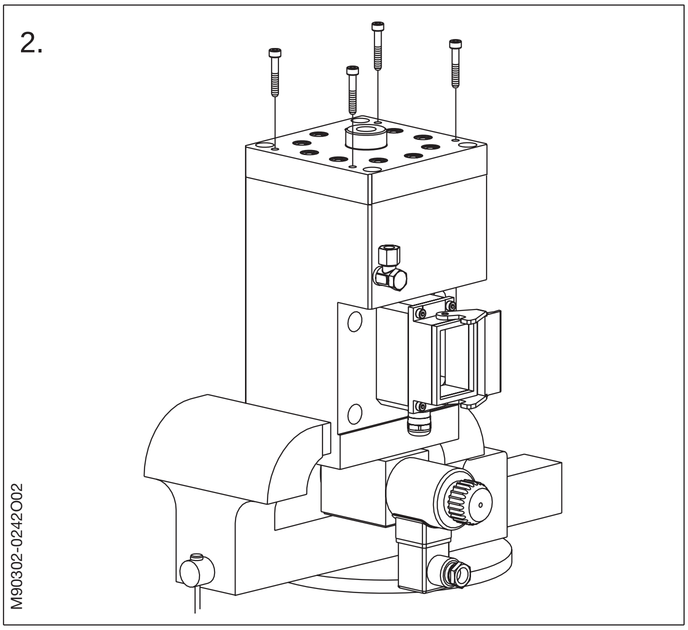

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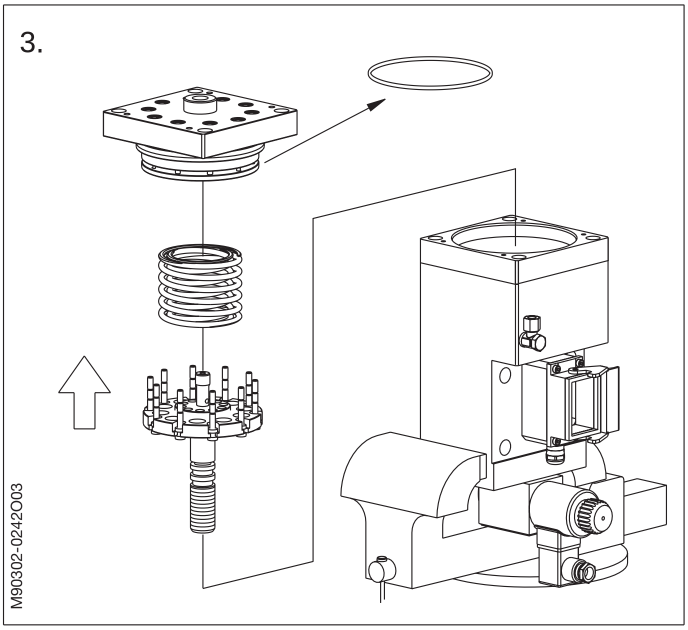

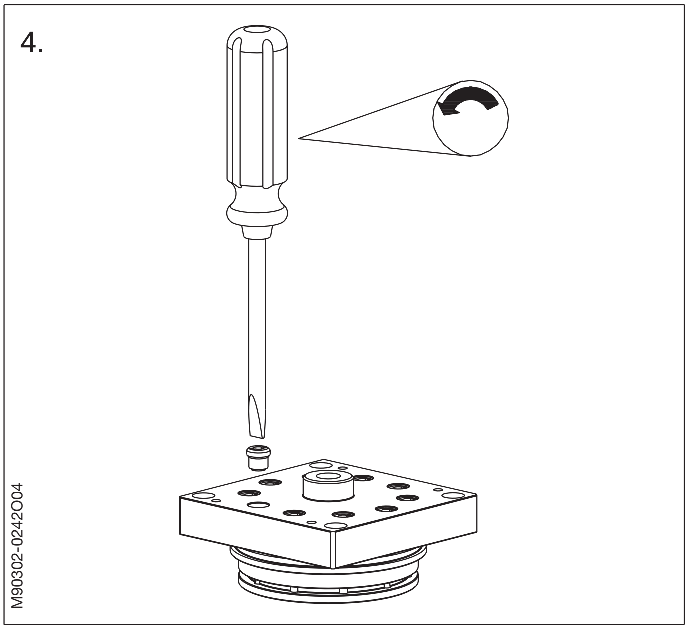

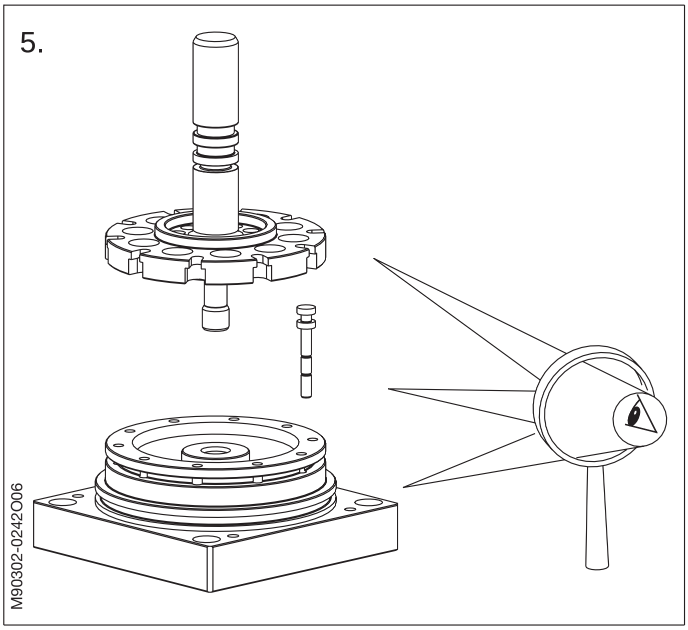

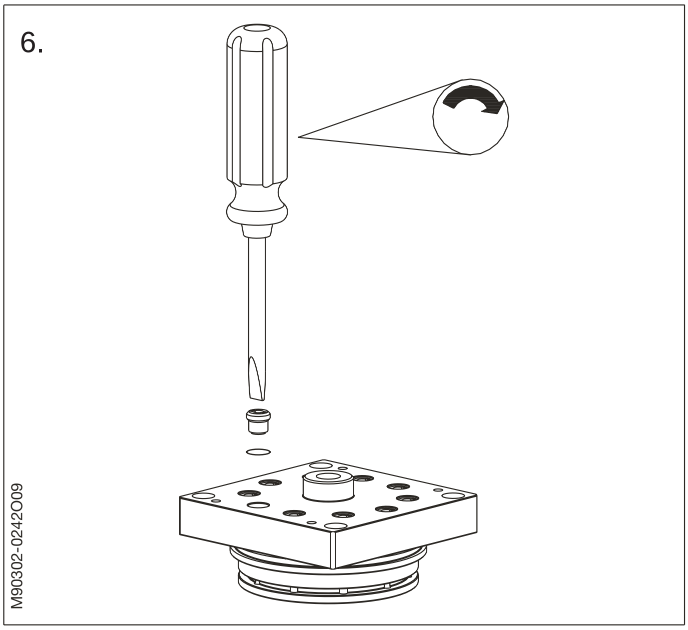

4. Screw out the non-return valves and remove and discard the O-rings.

   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.

   Mount the springs 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.

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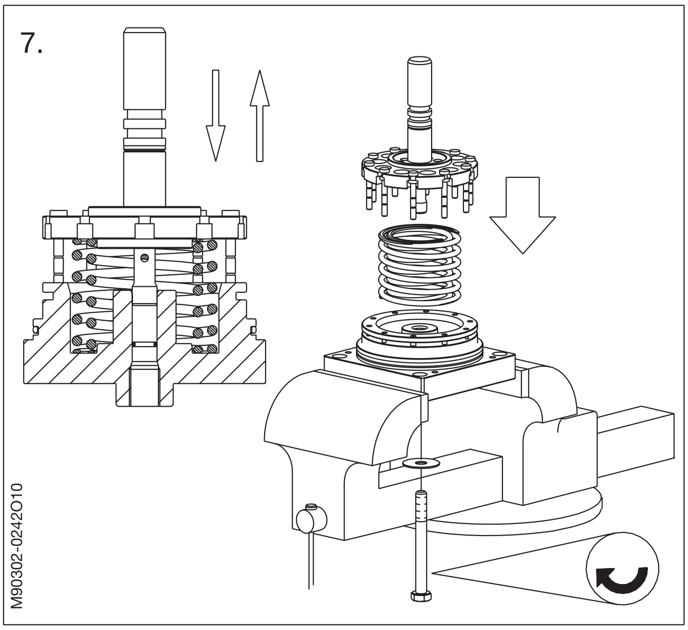

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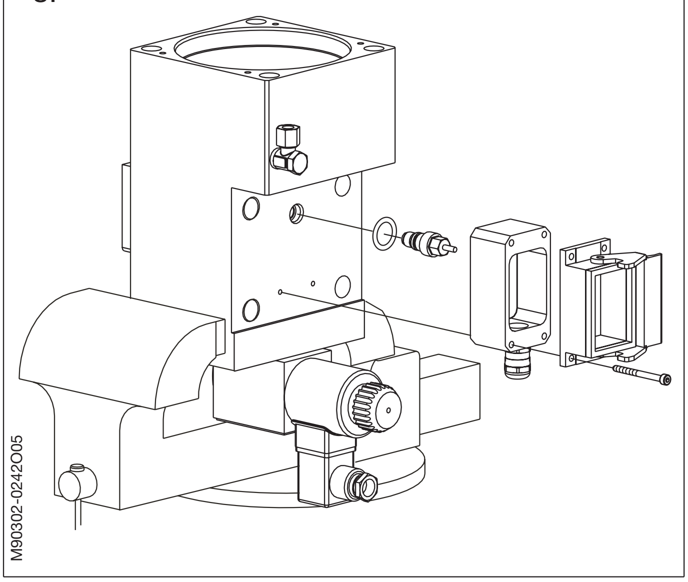

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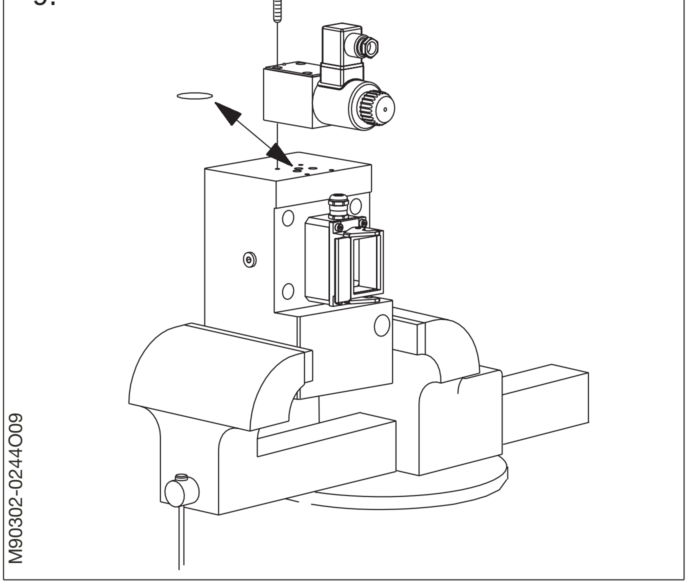

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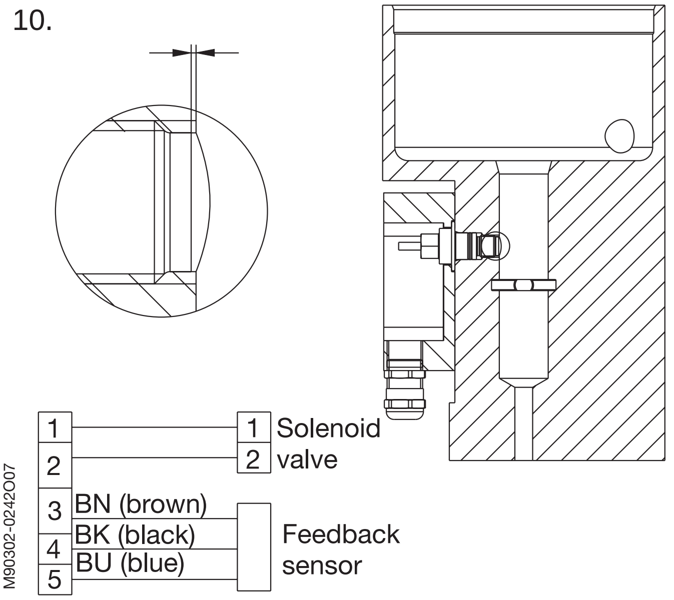

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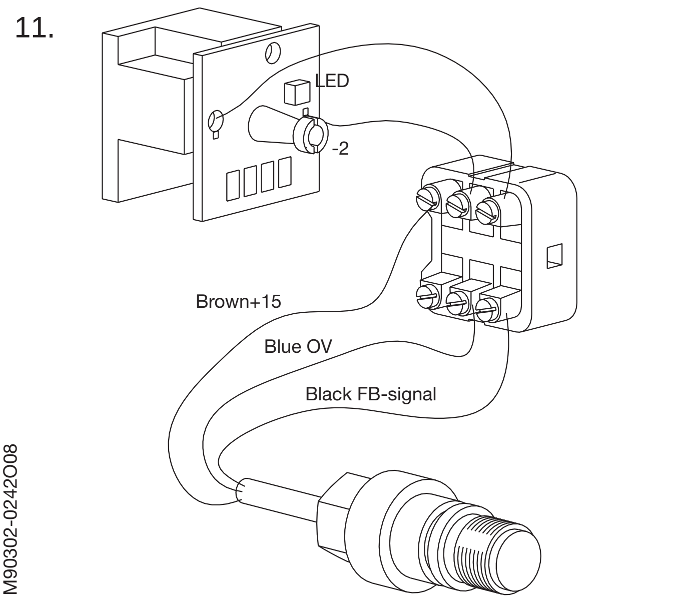

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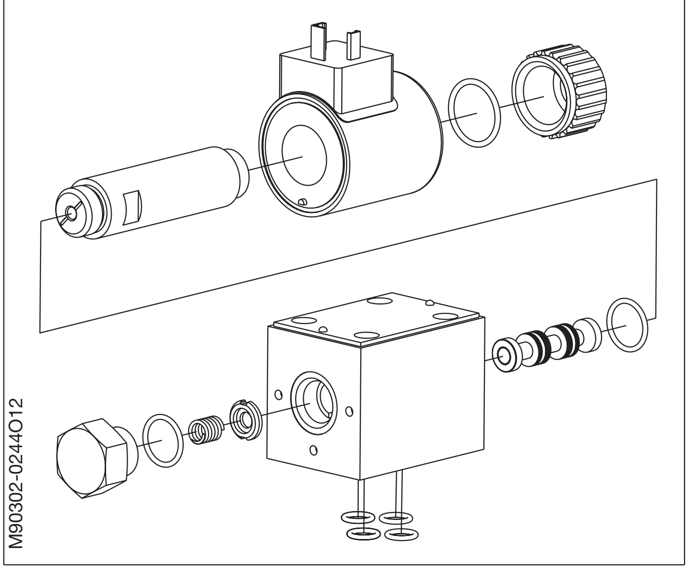

Discard the O-rings

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

    Mount 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. Mount 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. Mount 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 M6 x 60 screw with disc.

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

16. If the lubricator is not to be mounted 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.

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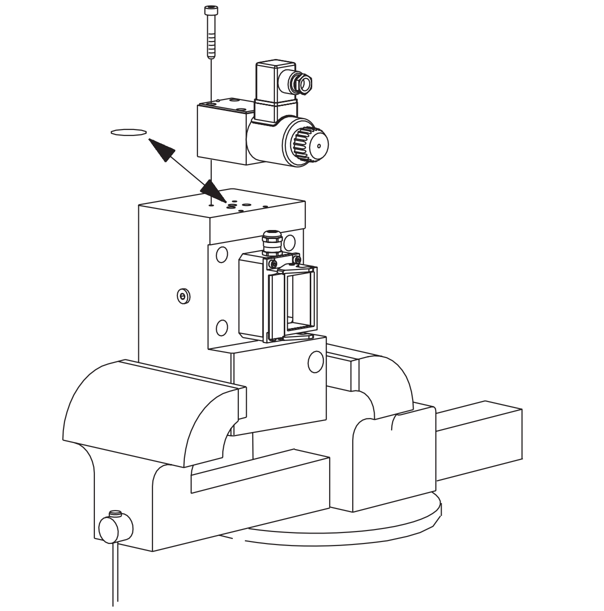

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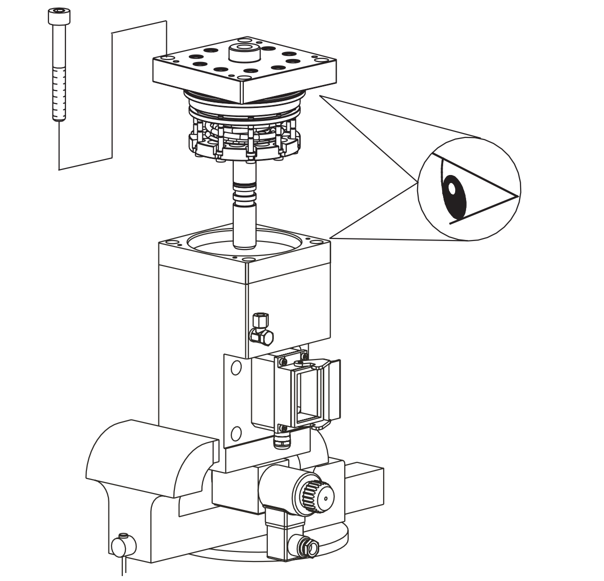

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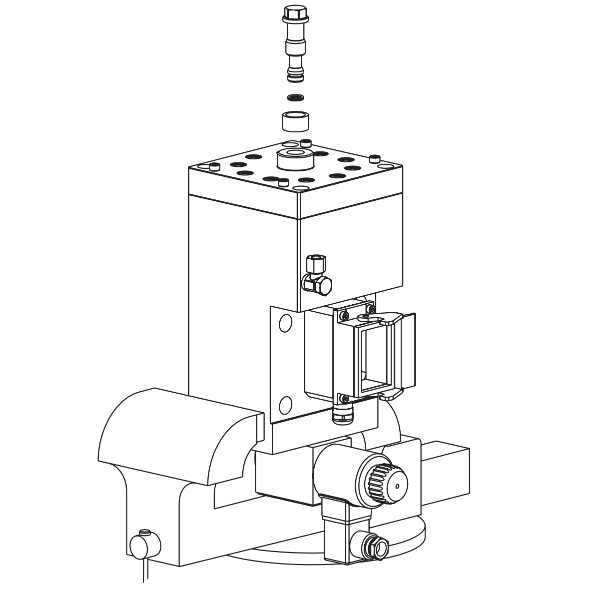

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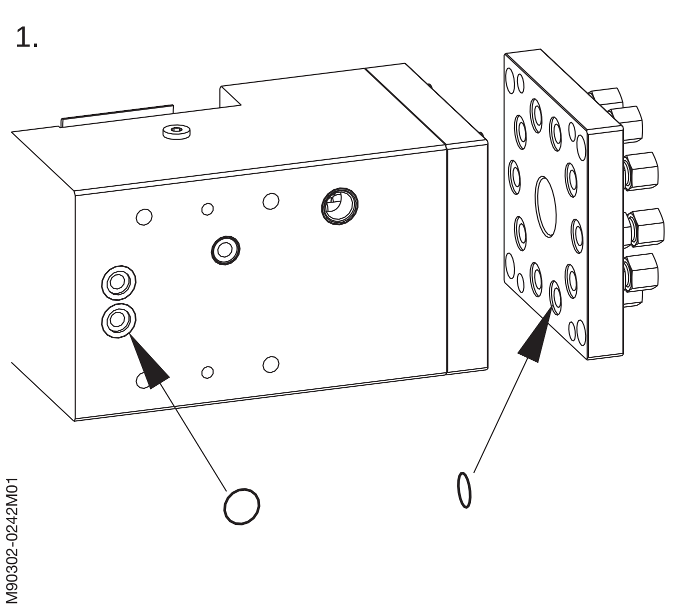
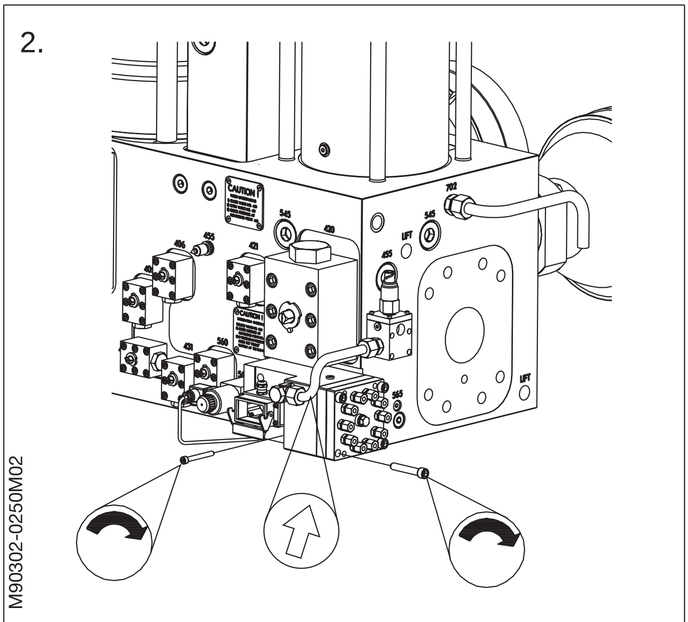
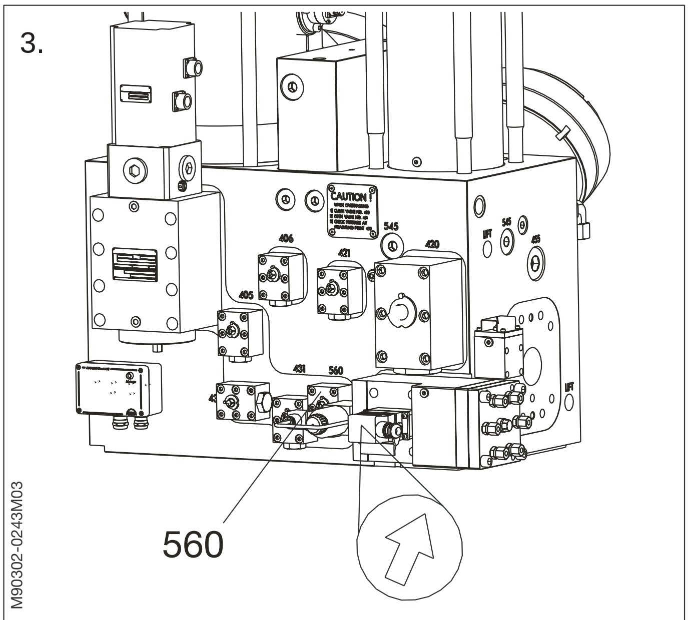






1. Mount new O-rings on the lubricator and on the cover with pipes.

2. Mount the lubricator and tighten the screws on the hydraulic cylinder unit.

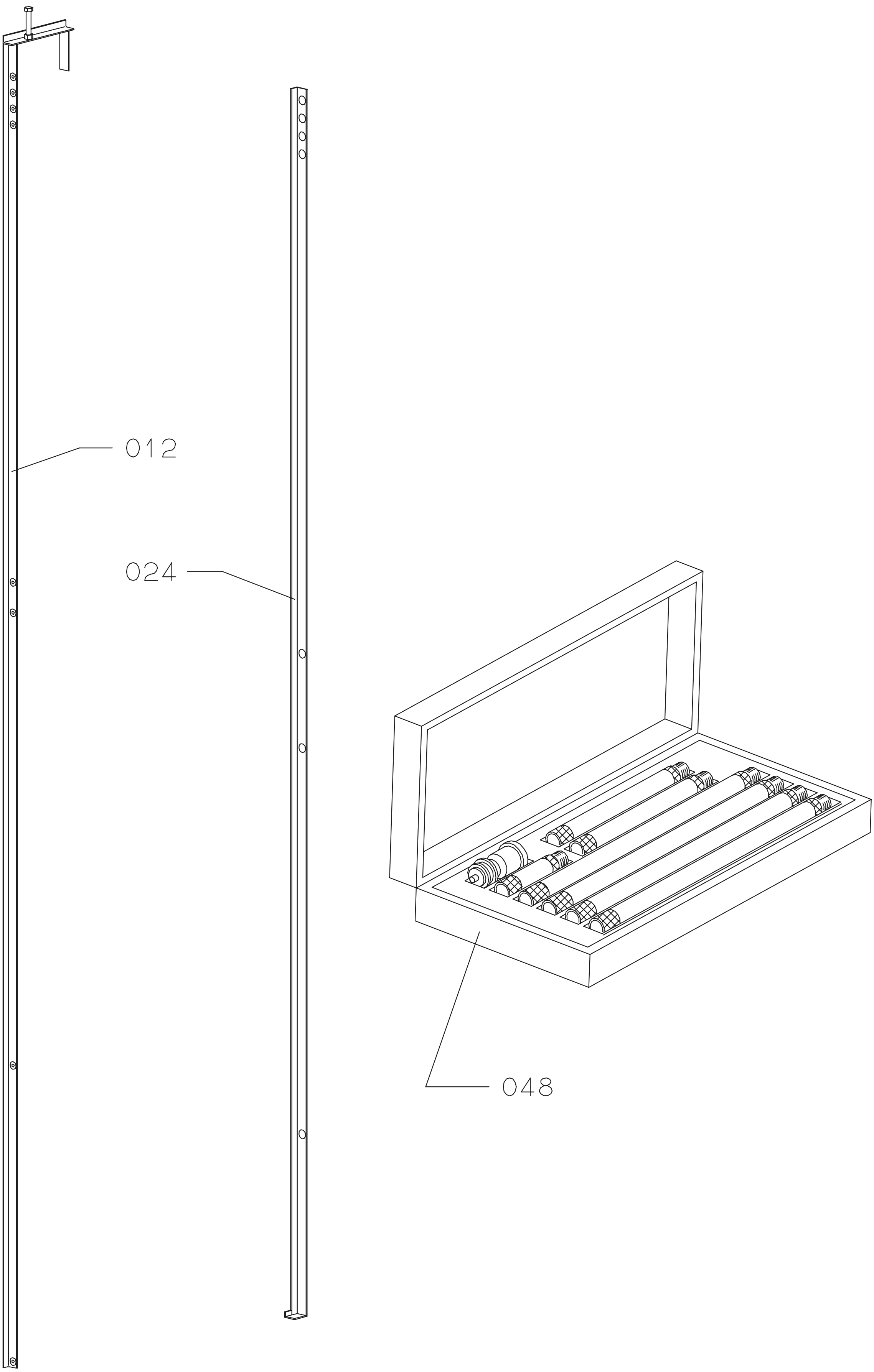
   Tighten the screws in the aft end of the lubricator to the pipe connection.

   Mount the cylinder oil pipe connection.

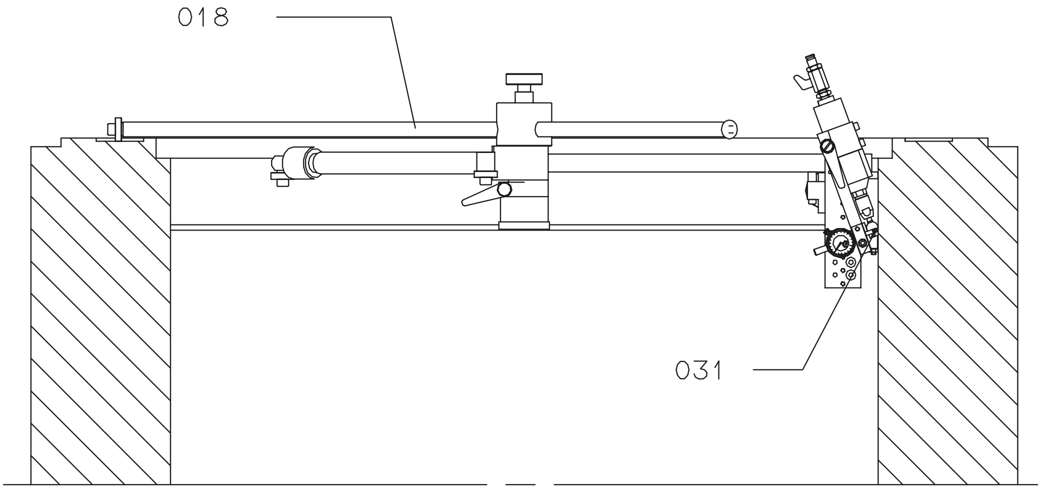
3. Mount the electrical plug. Check the injection of cylinder oil on the feedback LED on the terminal box for the specific lubricator.

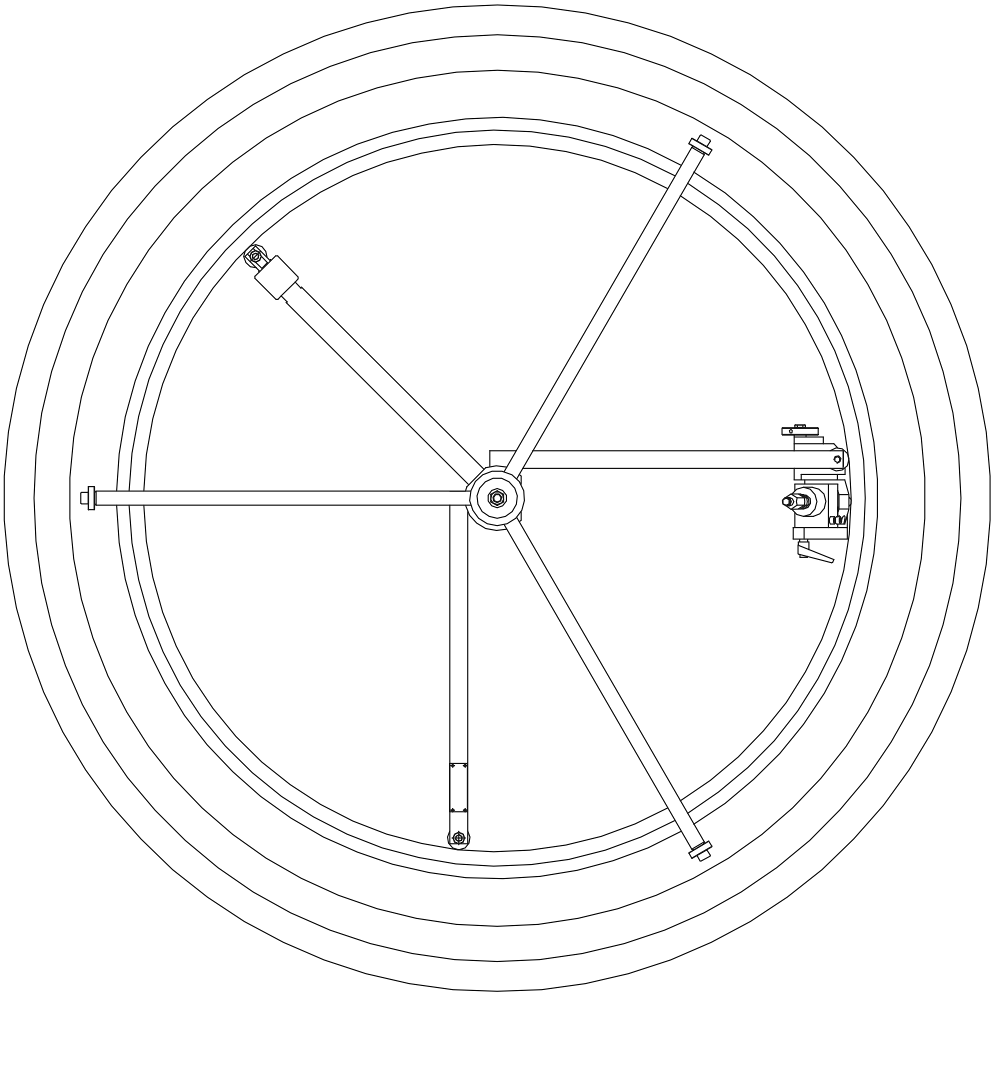
   Open valve 560 for hydraulic oil supply.

   Open the valve for cylinder lubricating oil supply.

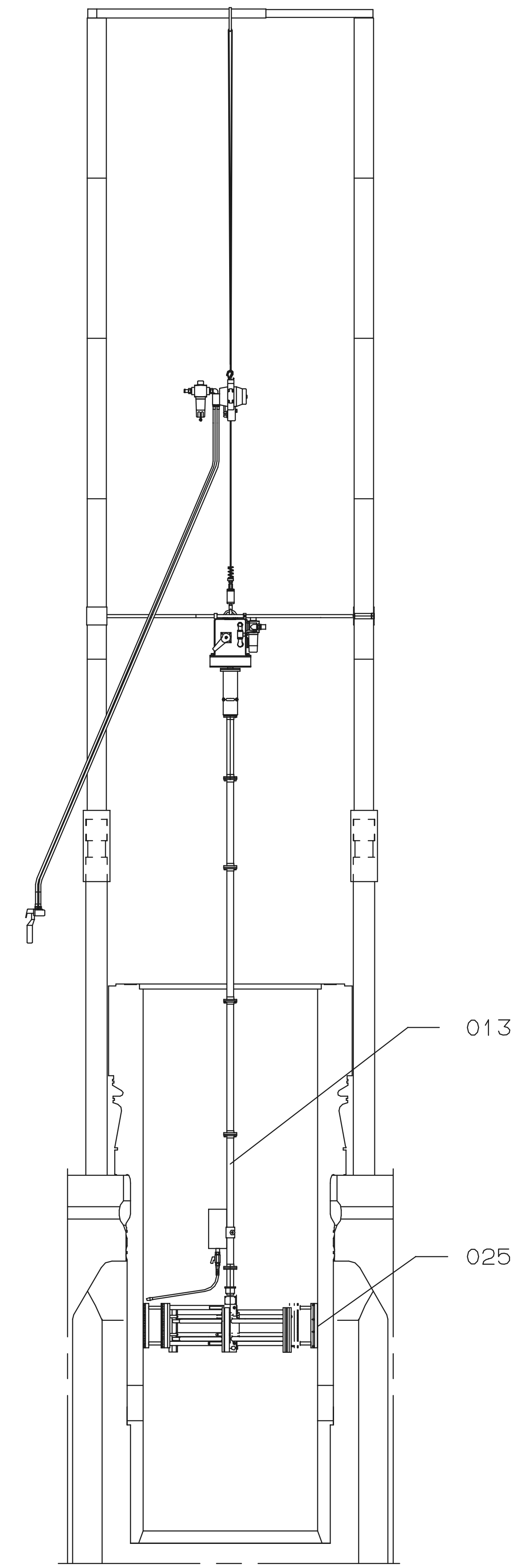

012
024
048

Item No.	Item Description	Item No.	Item Description
012	Measuring rod for cylinder liner, long		
024	Measuring rod for cylinder liner, short		
048	Measuring tool for cylinder liner		

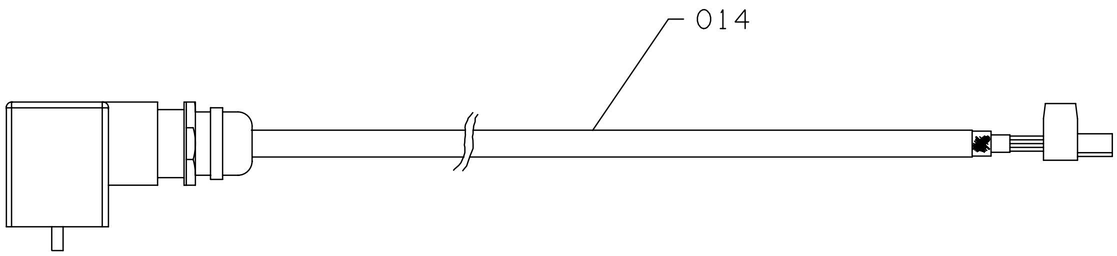

018
031



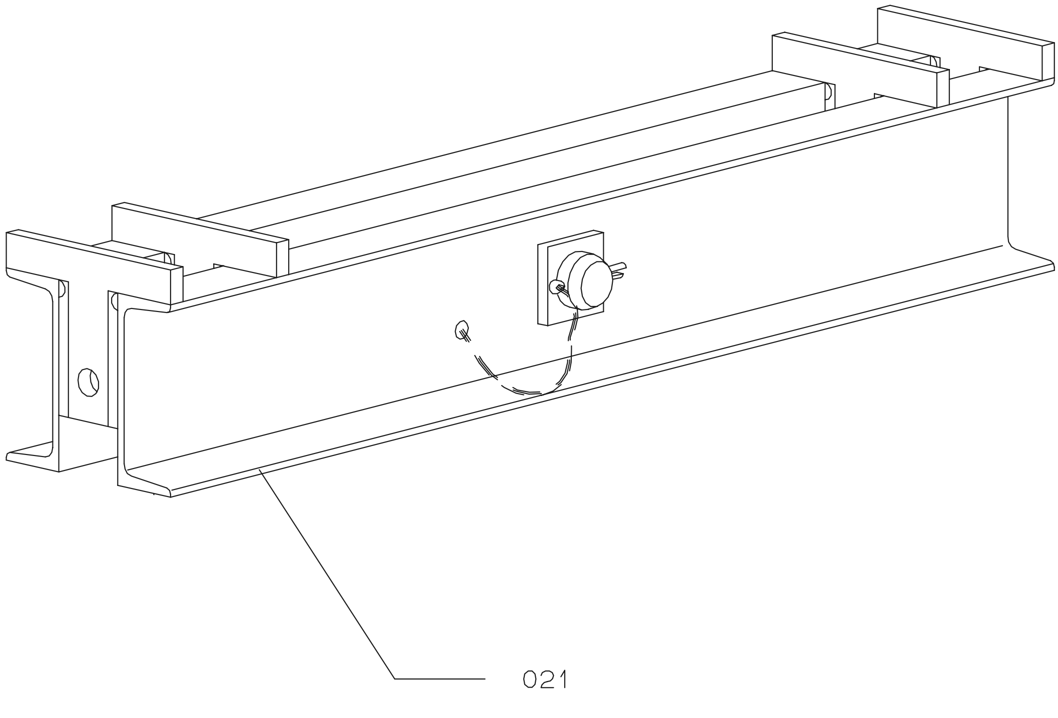
Item No.	Item Description	Item No.	Item Description
018	Wear ridge milling machine		
031	Milling cutter		


013
025

Item No.	Item Description	Item No.	Item Description
013	Honing tool (optional)		
025	Honing stone		


014

Item No.	Item Description	Item No.	Item Description
014	Cable, lenght = 15m		


021

Item No.	Item Description	Item No.	Item Description
021	Cross bar		

904 - Crosshead with Connecting Rod

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-01	Crosshead bearing, top clearance max.	0.6	mm
D04-02	Crosshead bearing, top clearance min.	0.35	mm
D04-03	Oil wedge length, L	20	mm
D04-04	Crosshead bearing cap	1265	kg
D04-05	Crosshead bearing shell, upper	125	kg
D04-06	Crosshead bearing shell, lower	195	kg
D04-07	Crosshead bearing cap with bearing shell	1400	kg
D04-16	Thrust piece, tightening torque	460	Nm
D04-61	Counterweight	460	kg
D04-63	Counterweight,tightening torque	4000	Nm
D04-64	Counterweight,tightening torque/angle	100/55	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
P90451	47	Wire guide
P90451	59	Lifting attachment - connecting rod
P90451	72	Chain for suspending piston
P91351	10	Hydraulic pump, pneumatically operated
P91351	34	Hose with unions (1000 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	117	5-way distributor block, complete
P91366	58	Feeler gauge
P91368		Working Platforms
P91356		Lifting Tools, Etc.
P91359		Torque Spanners
P90464		Crosshead - Hydraulic Tools

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.*

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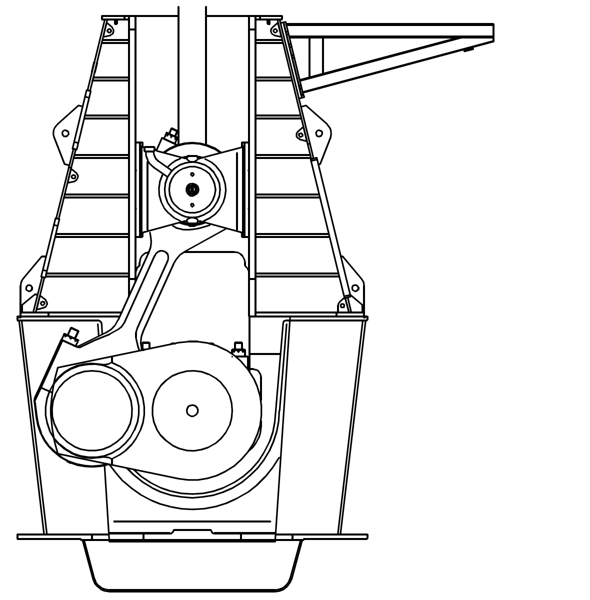

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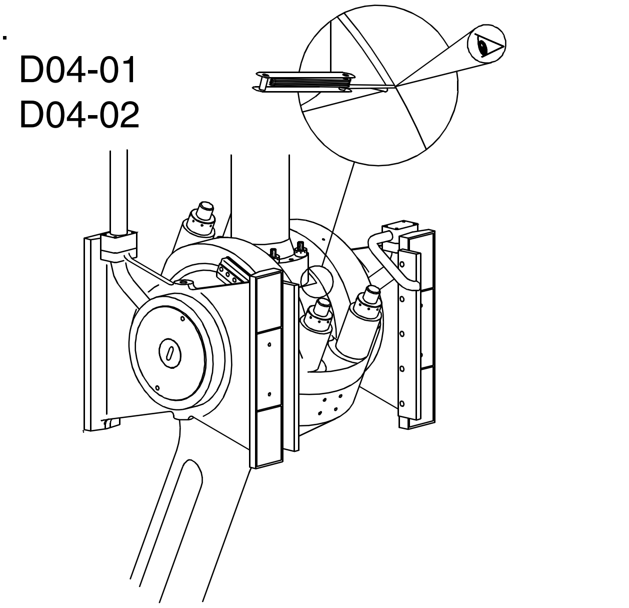

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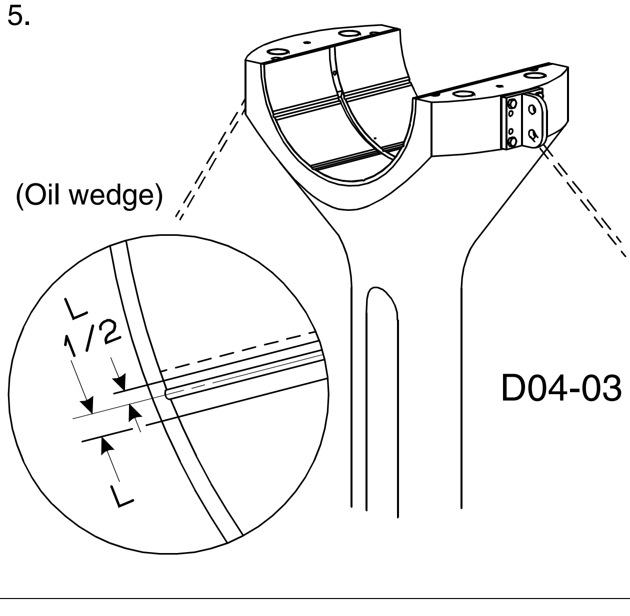

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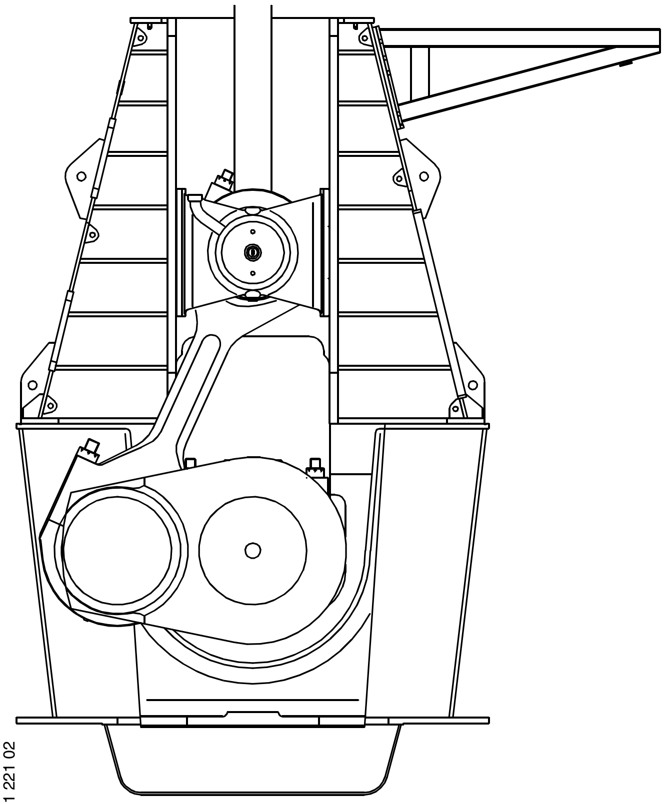

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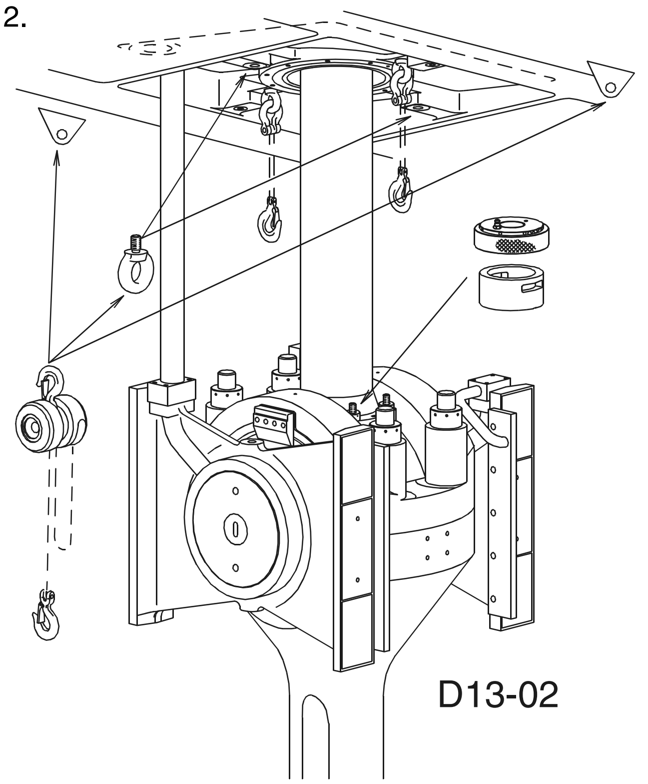

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This procedure applies to the following two dismantling situations:

- 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 athwarthship 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.

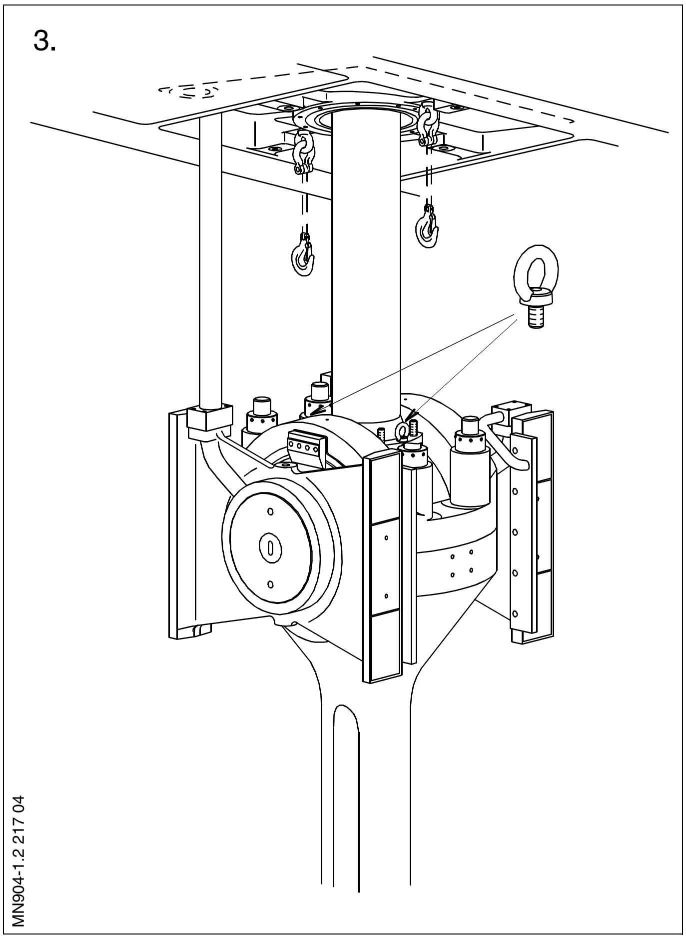
   Loosen the nuts. *For operation of the hydraulic jacks, see Procedure 913-1.*

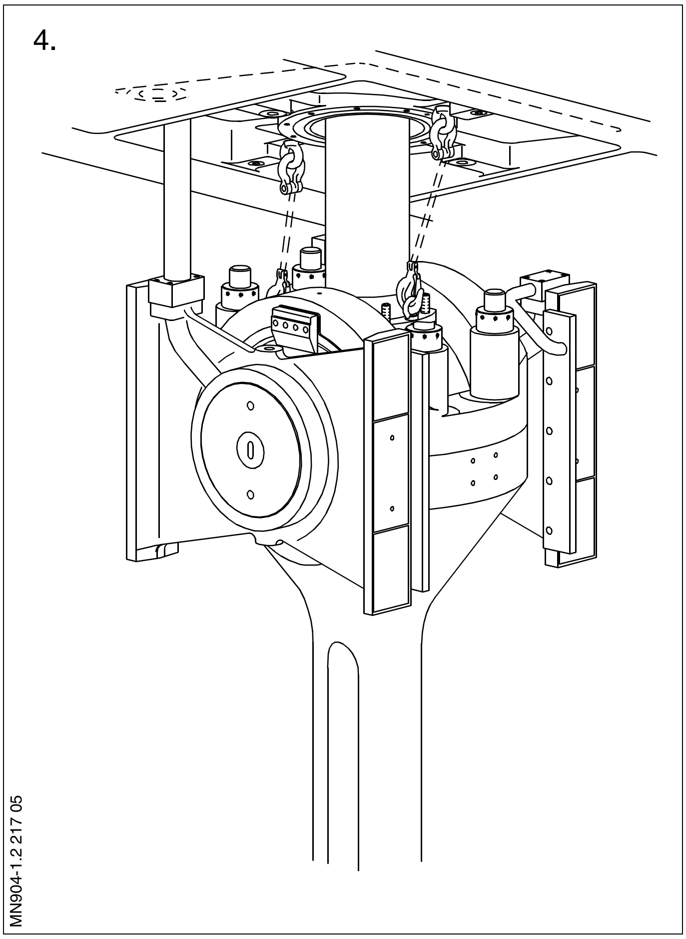
3. Mount a lifting eye bolt on each side of the piston rod.

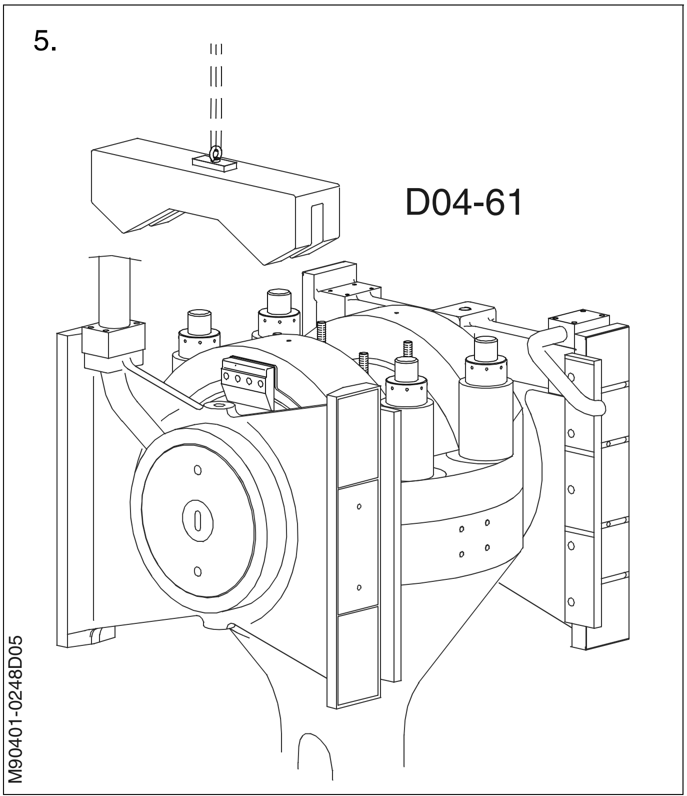
   Turn the crosshead to TDC.

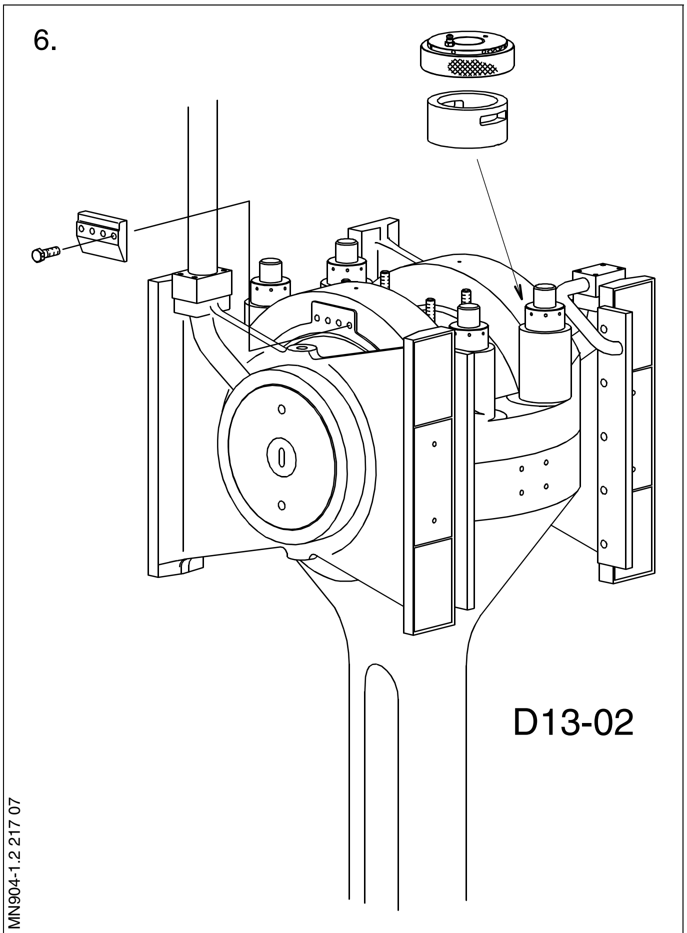
4. Hook the chains to the lifting eye bolts in the piston rod.

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









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.

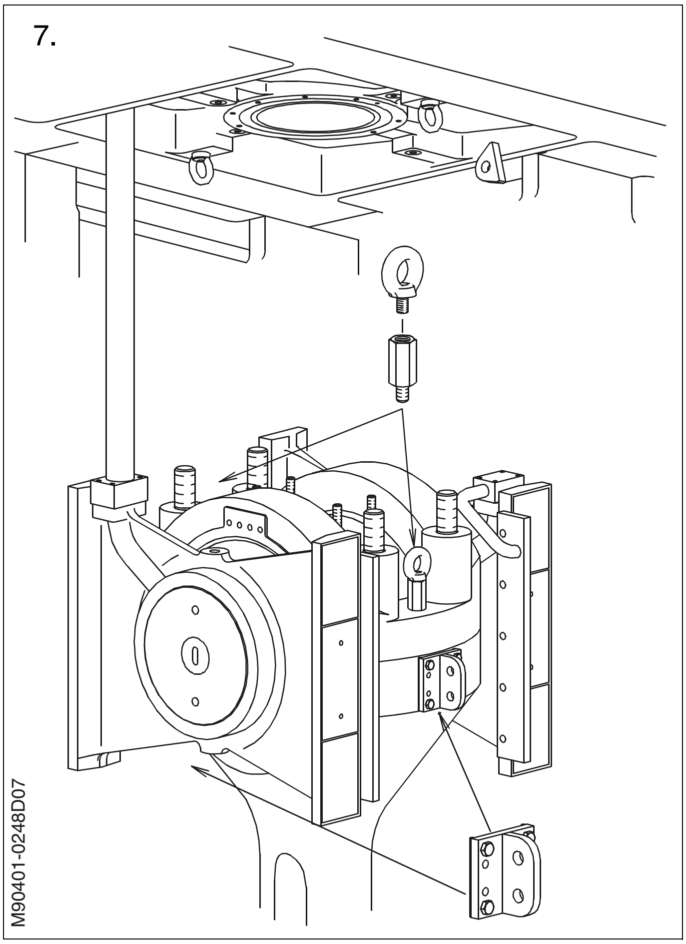
7. Mount the lifting attachments on the head of the connecting rod.

   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.

7.



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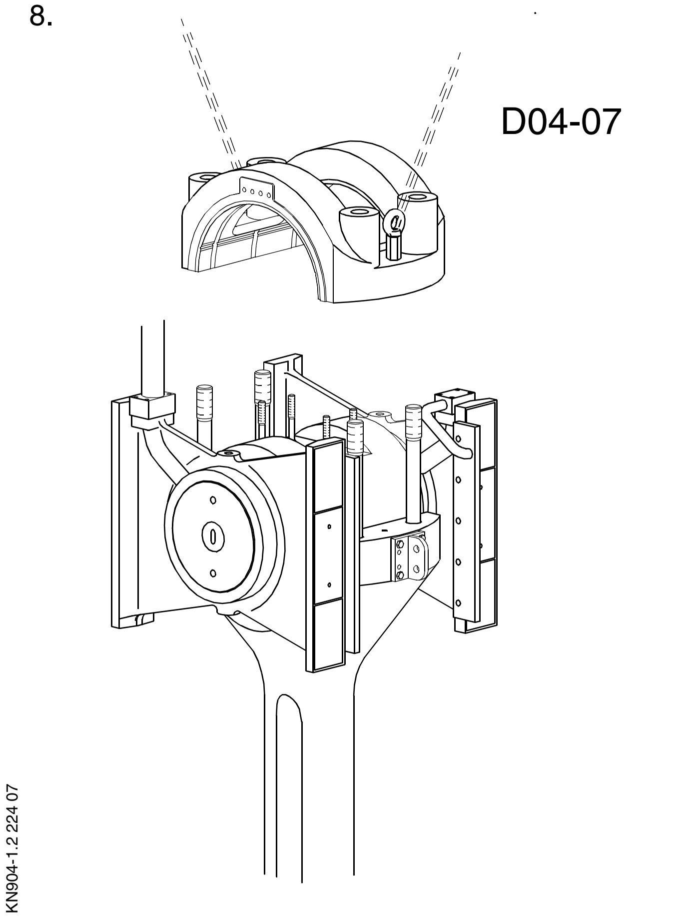

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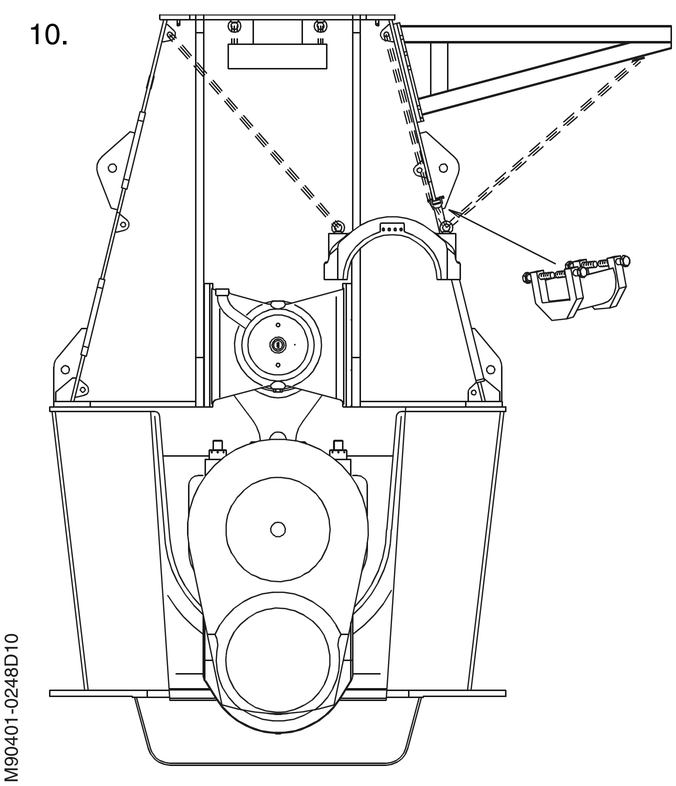

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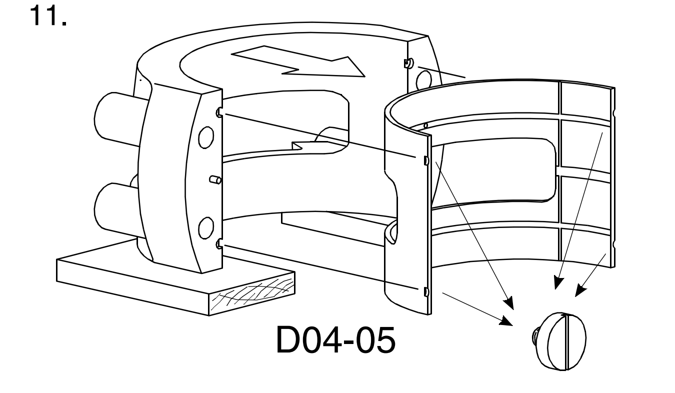

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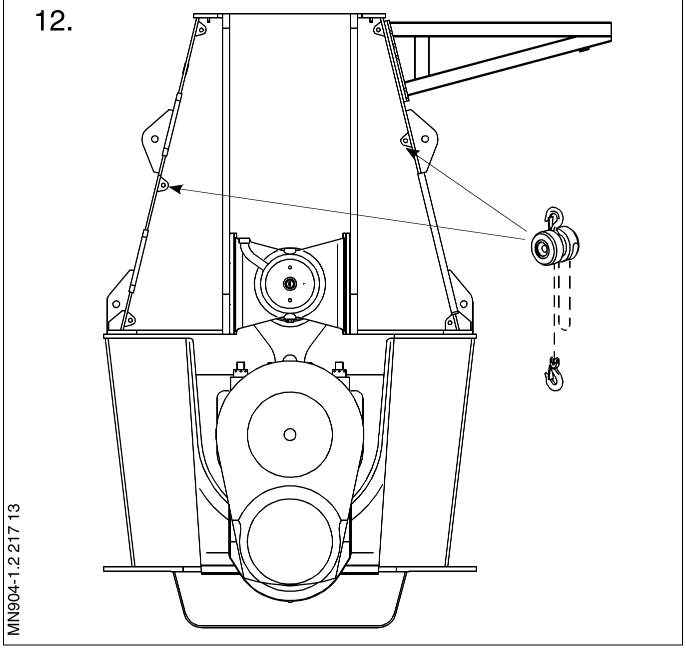


10. Mount the wire guide in the top of the door opening.

    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.

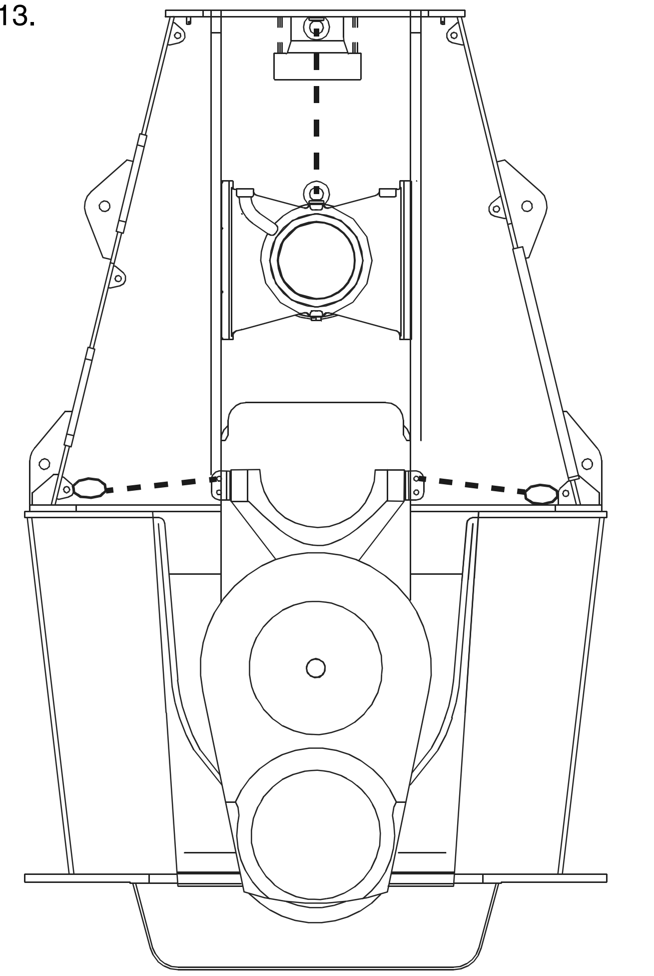
13. Hook the tackles onto the eye bolts in the guide shoes and lift the crosshead to provide access to the crosshead bearing.

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.

13.



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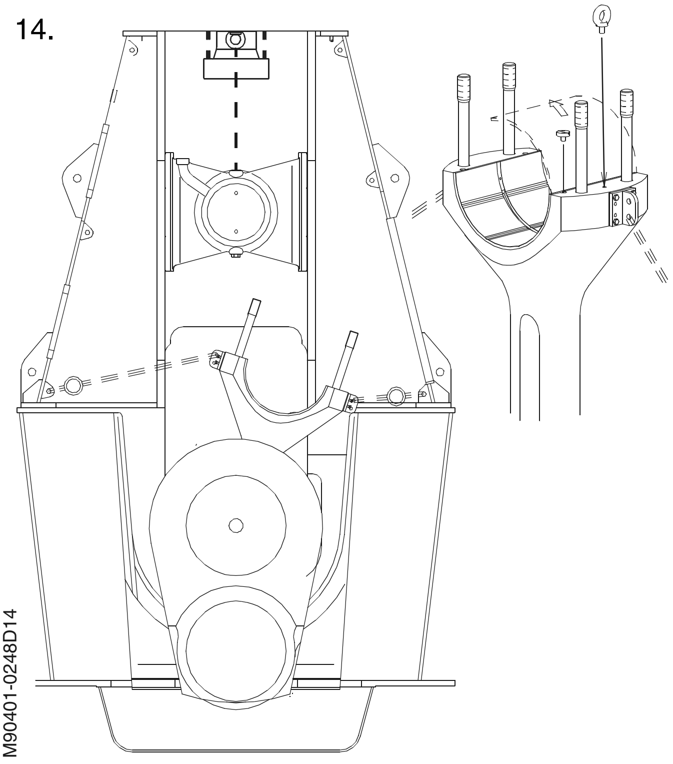
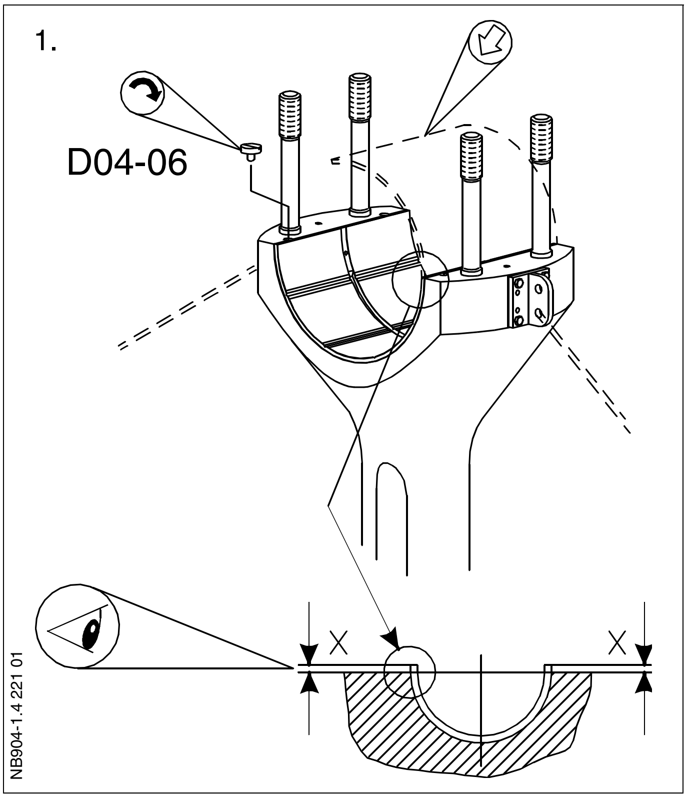
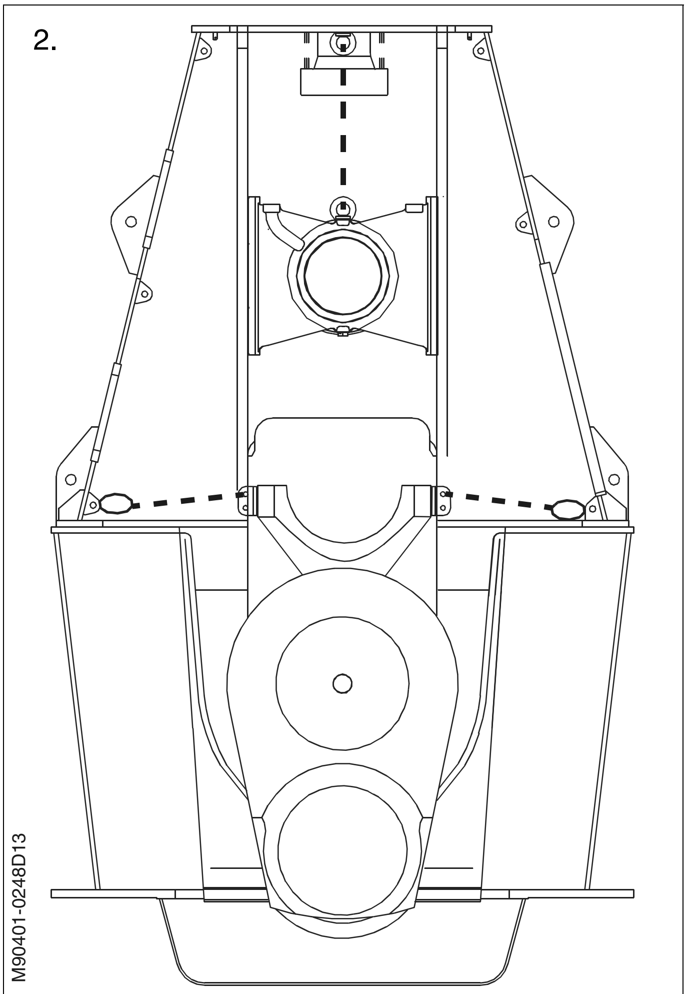






With the piston mounted/
With the piston removed:

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.

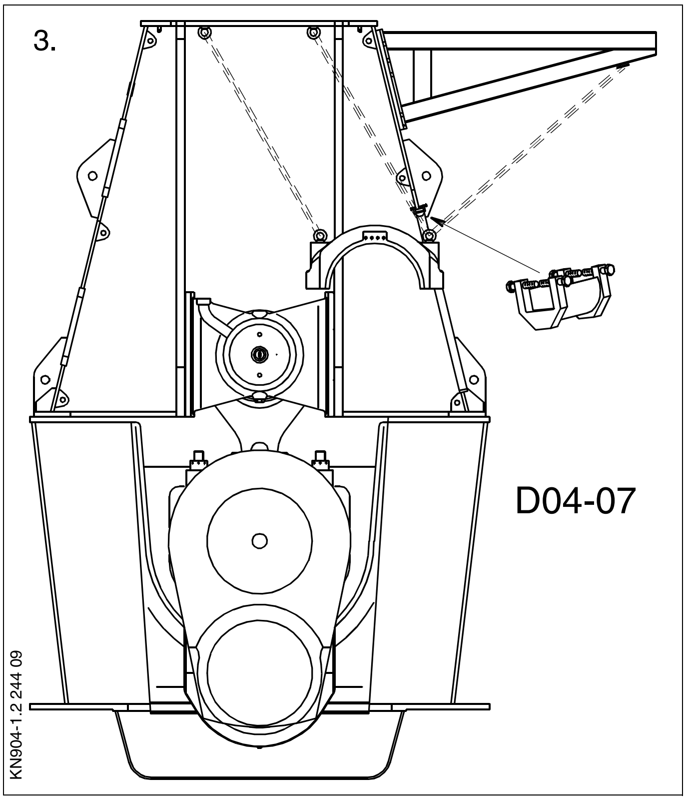
   Remove the lifting attachments from the connecting rod.

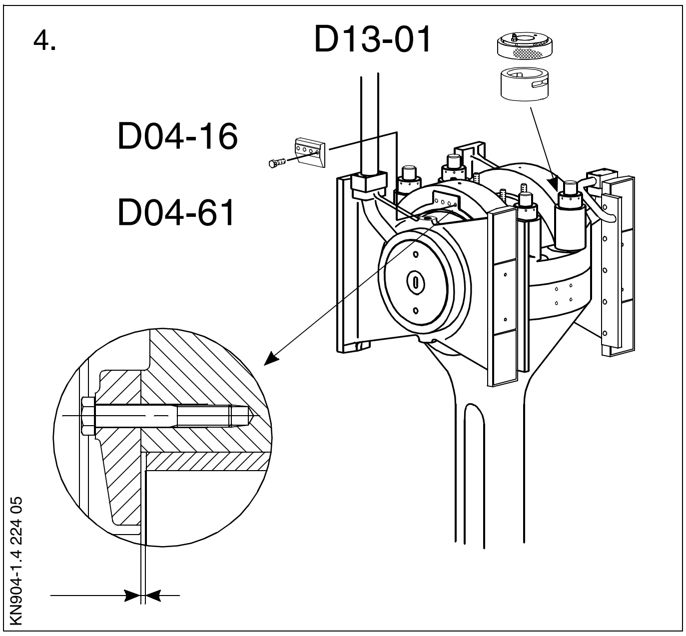
   Remove the wire guide from the engine.

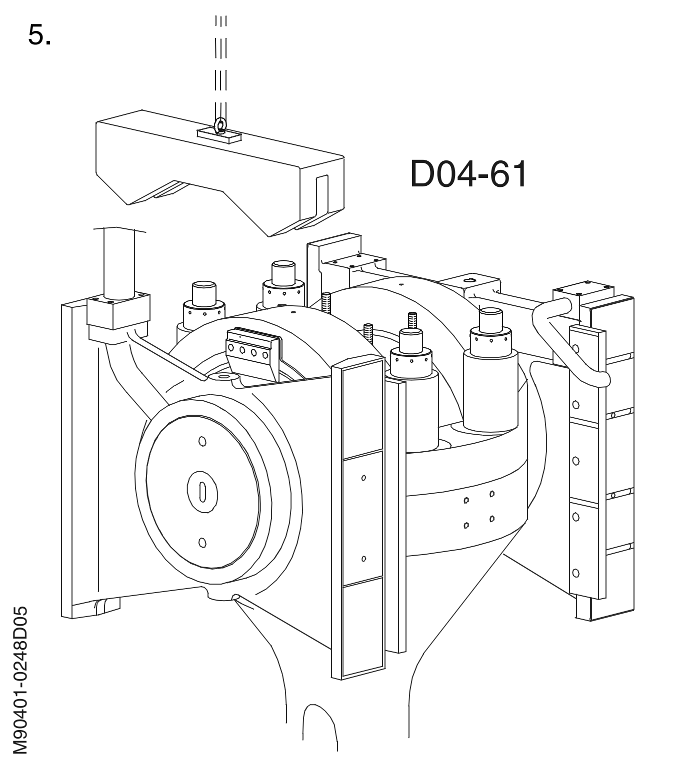
4. Tighten all four crosshead bearing cap nuts simultaneously. *See Data.*
   For operation of hydraulic jacks, see Section 913-1.

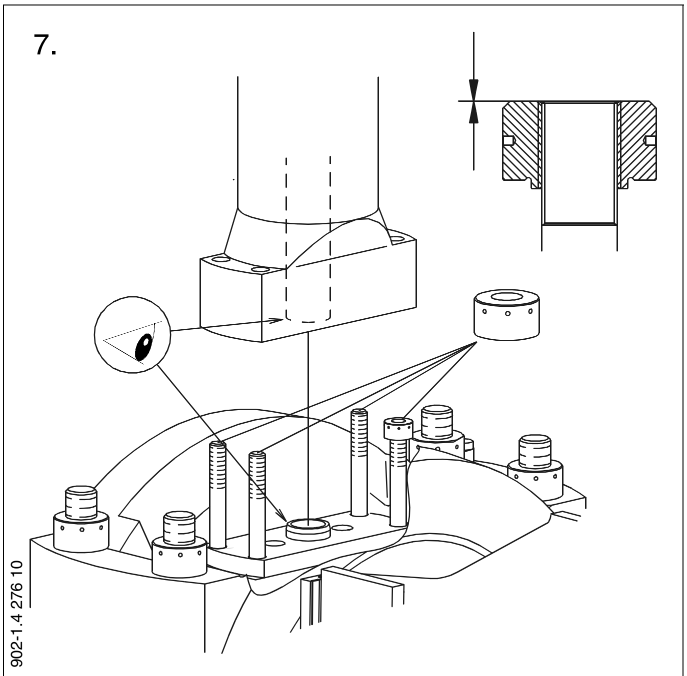
   Mount the thrust pieces on the bearing cap. Tighten the screws to the torque stated in Data.

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.

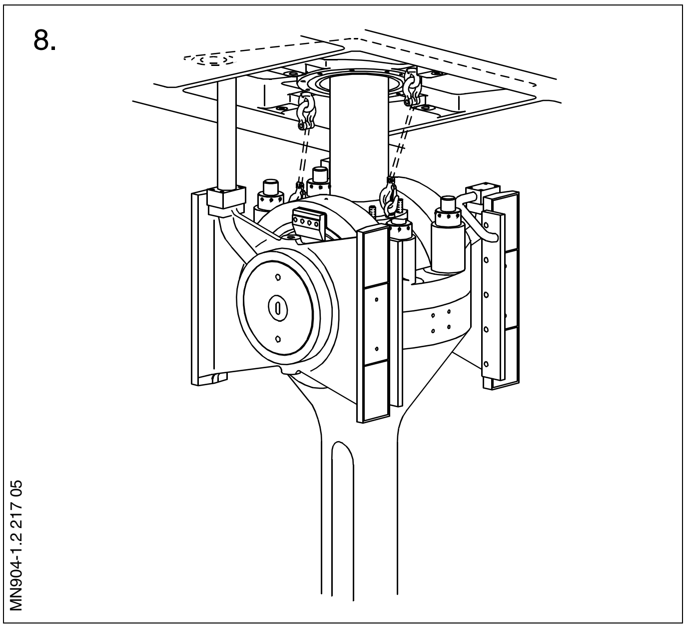
8. Unhook the chains from the lifting eye bolts in the piston rod. Remove the chains and eye bolts from the top of the crankcase, from the piston rod and from the crosshead bearing cap.

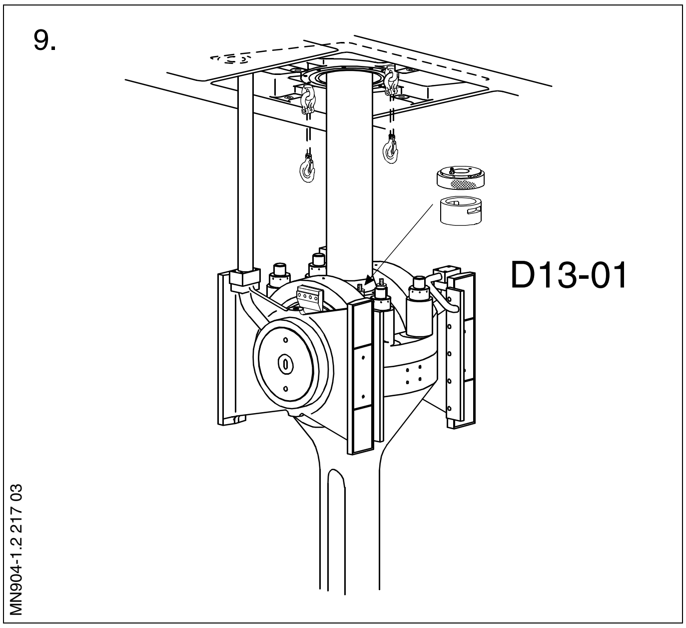
9. Turn down to BDC and mount the hydraulic jacks on the studs. *For operation of the hydraulic jacks, see Procedure 913*-1

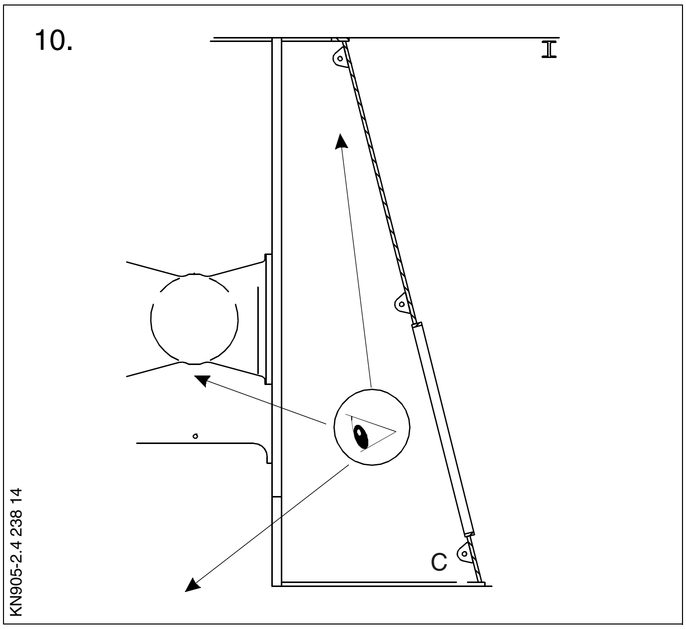
   Tighten the nuts as stated in Data.

10. Remove all tools from the engine.

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







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.

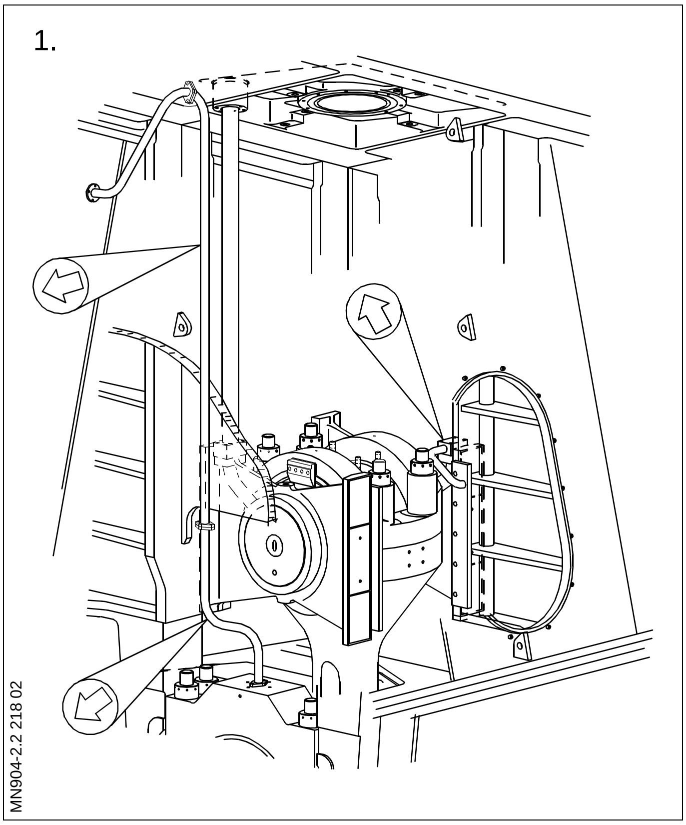
3. Mount the retaining tool for the telescopic pipe on the stuffing box housing for the telescopic pipe.

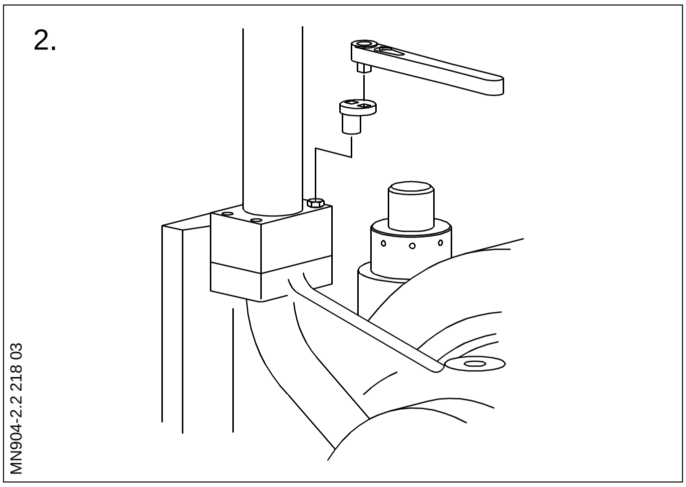
   Turn the crosshead to TDC.

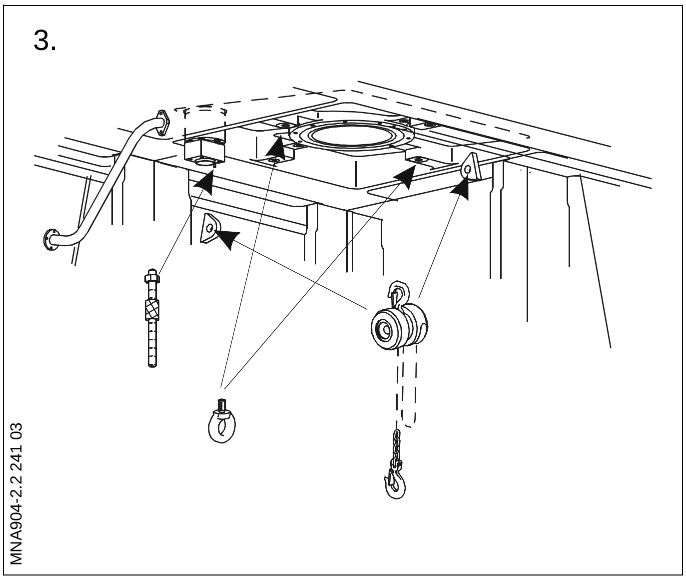
   Suspend the telescopic pipe by means of the tool.

   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.







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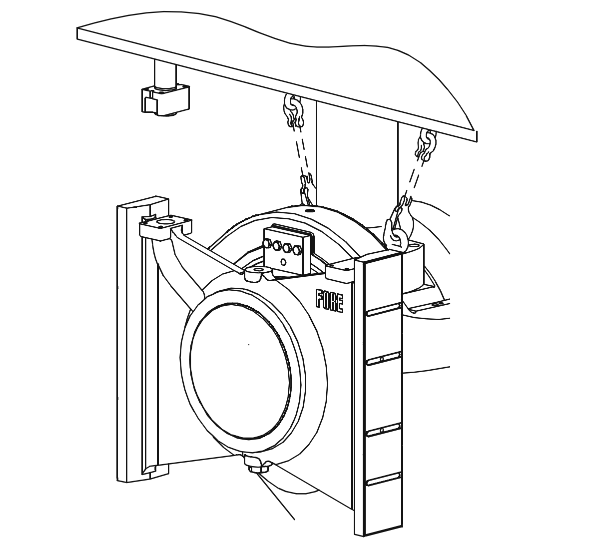

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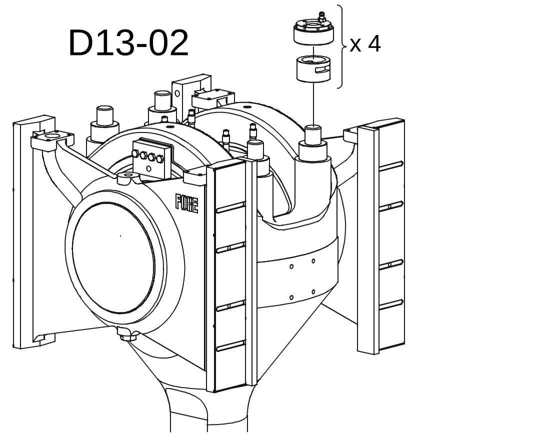

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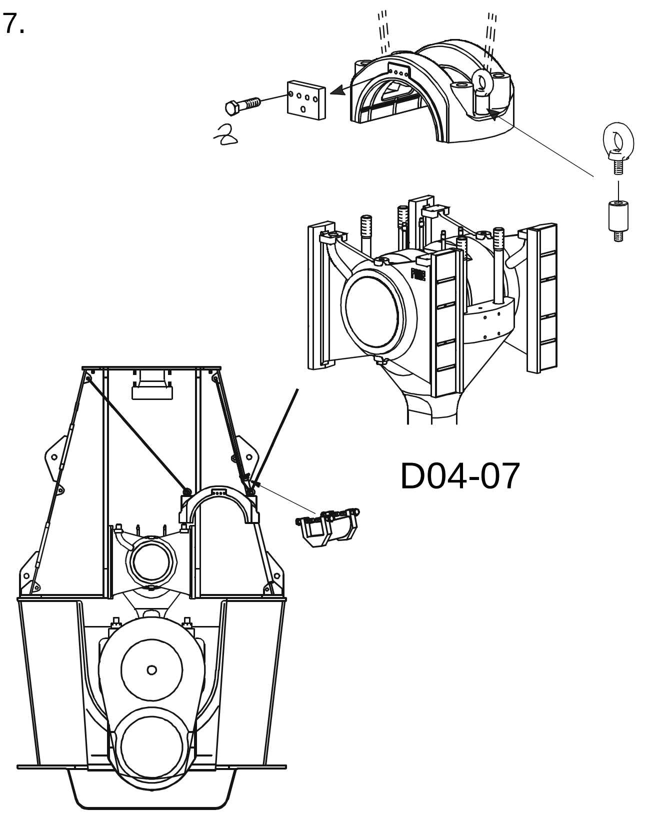

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4. Suspend the piston.
   To suspend piston, see Procedure 904-1.2.

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.

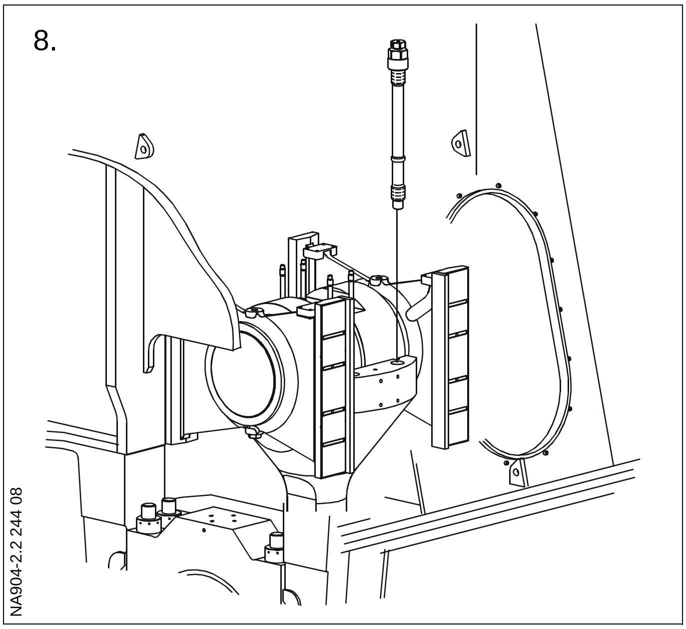
   Fasten two tackles to the eye bolts mounted in the athwartship direction and attach the tackle hooks to two shackles on the lifting tool on the crosshead, and lift the crosshead clear of the connecting rod.

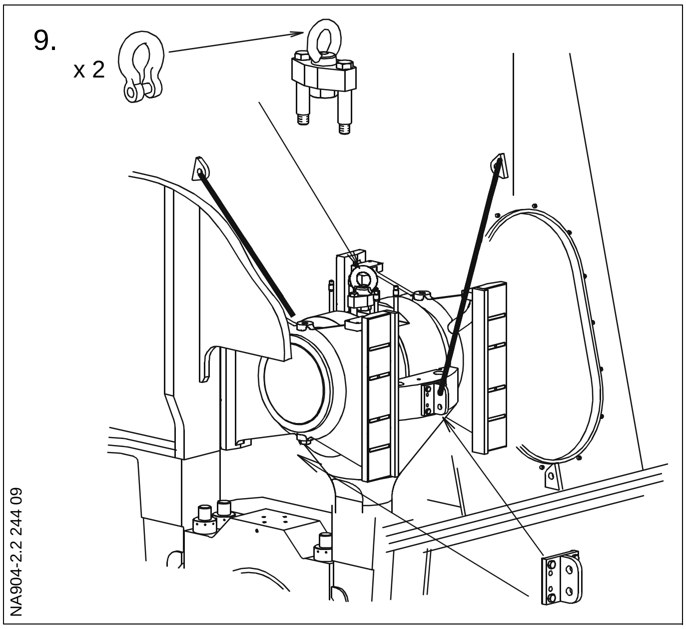
10. Using the tackles, tilt the connecting rod towards the exhaust side, while turning the crankthrow towards the camshaft side.

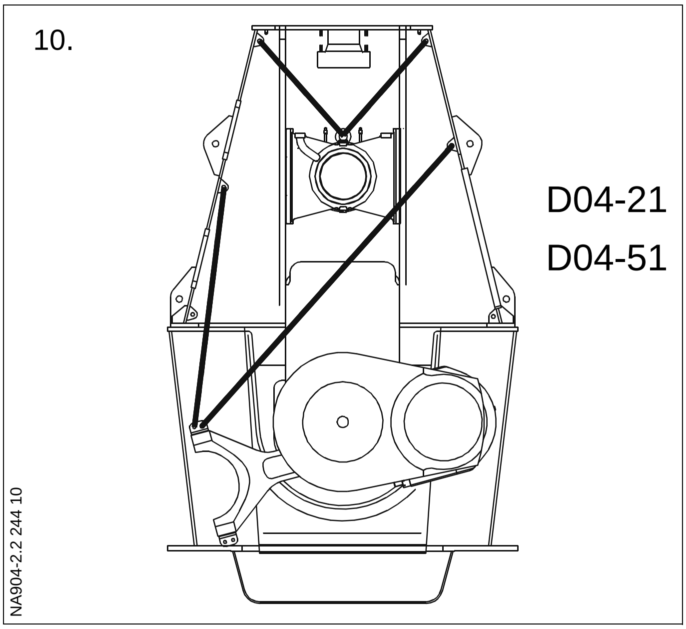
    Transfer the tackles from one lifting attachment to another as necessary.

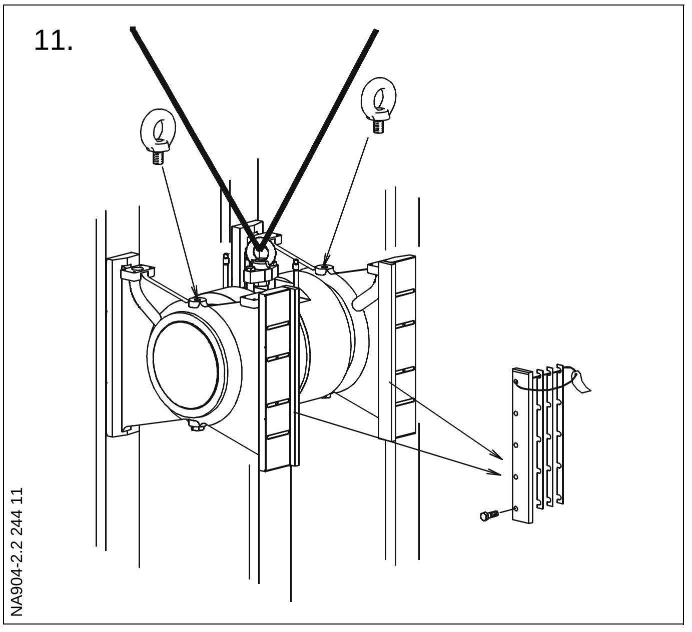
    When the crankthrow is 90° after BDC, stop turning.

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





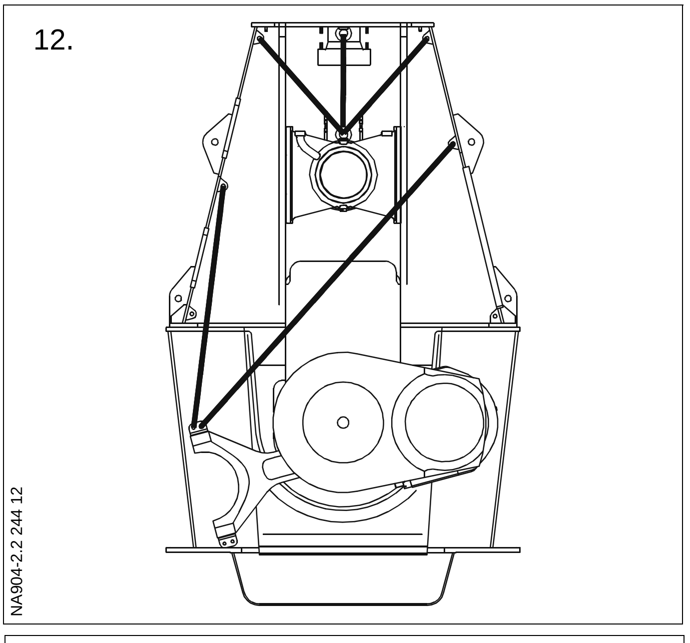




11. Remove the guide strips and the guide screws from the guide shoes.

    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.

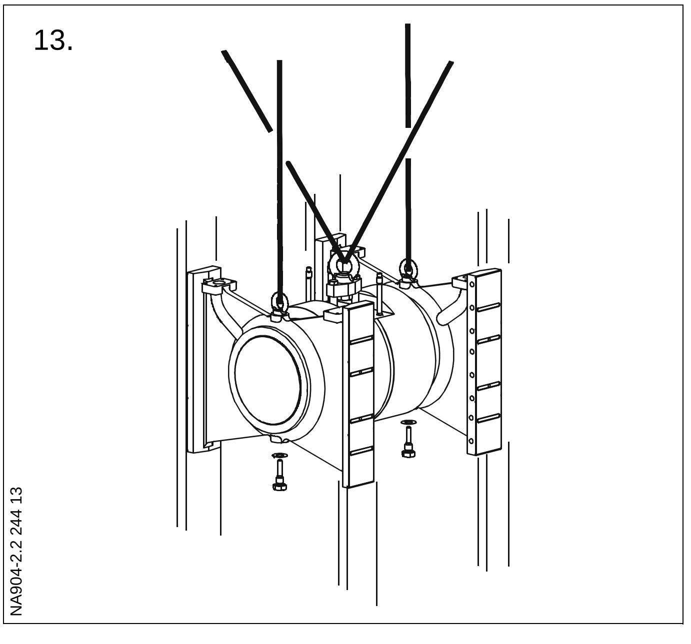


12. Suspend two tackles from the eye bolts in the bottom of the cylinder frame in the fore-and-aft direction.

    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.

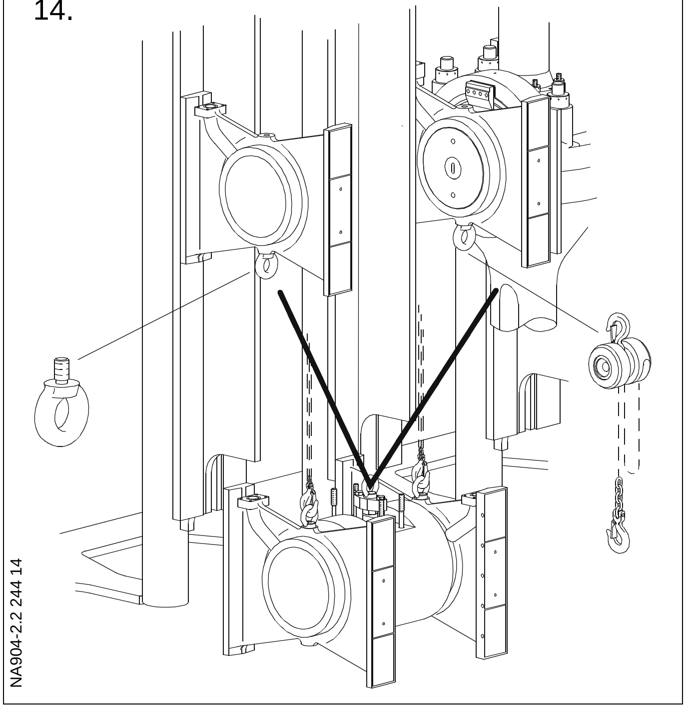
    Remove the guide screws from the bottom of the guide shoes.

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.

14.



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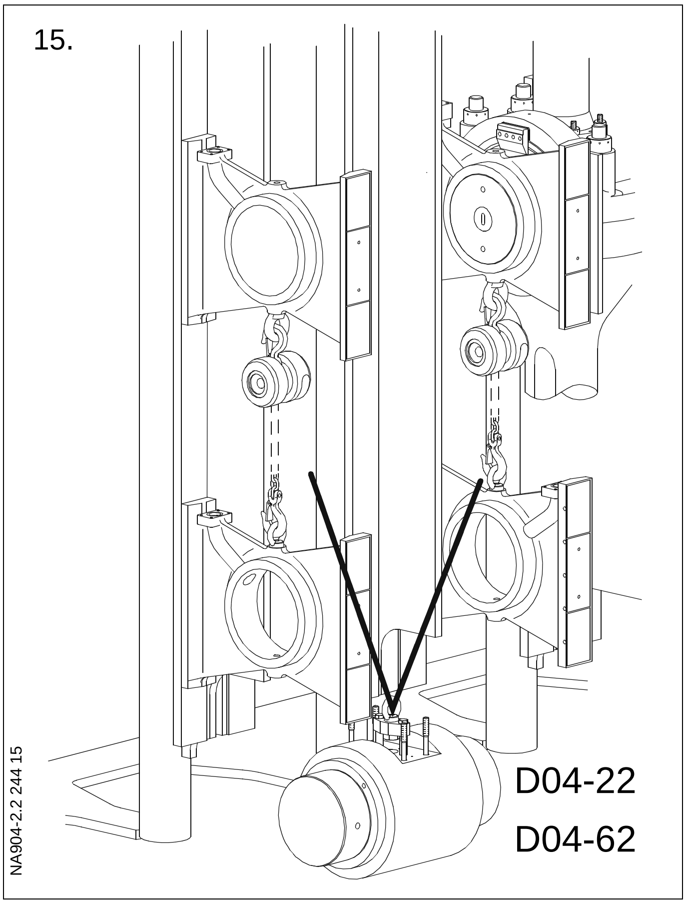

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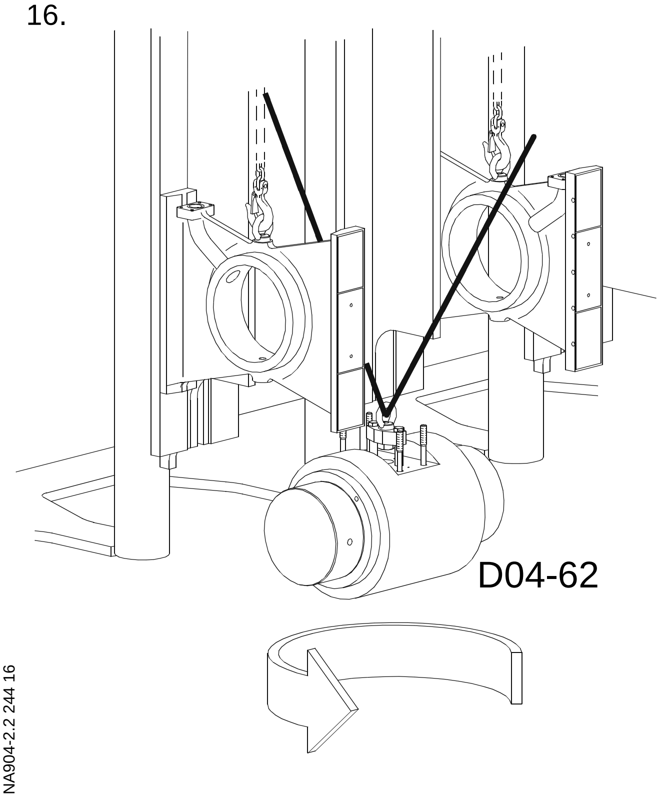

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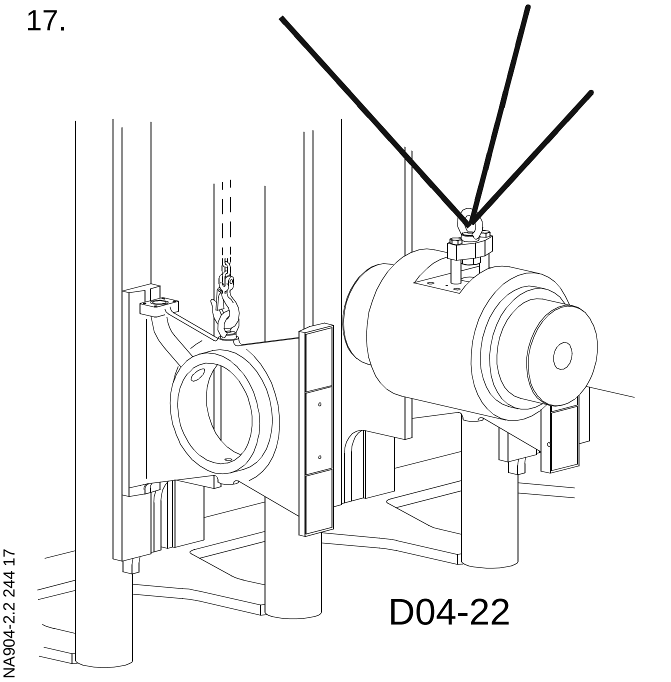


16. Turn the crosshead 90°.

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.

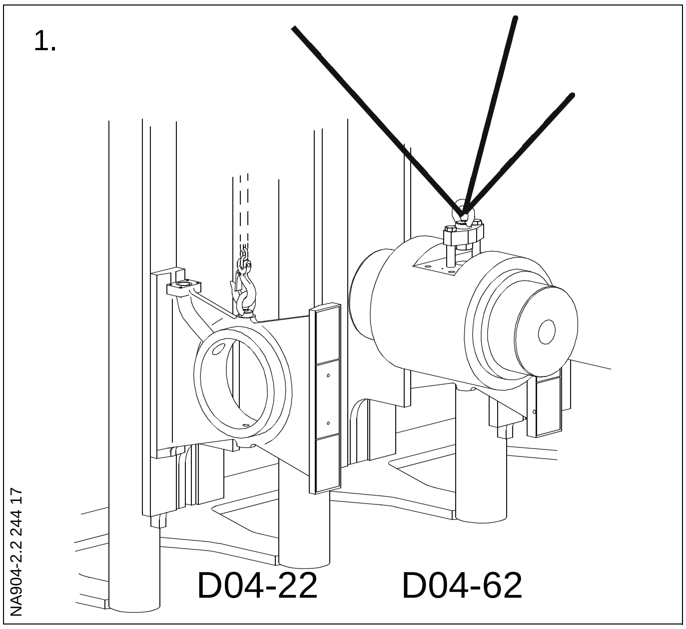
1. Clean the crosshead and mount the lifting bracket.

   Mount the wire guide tool in the framebox door opening.

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

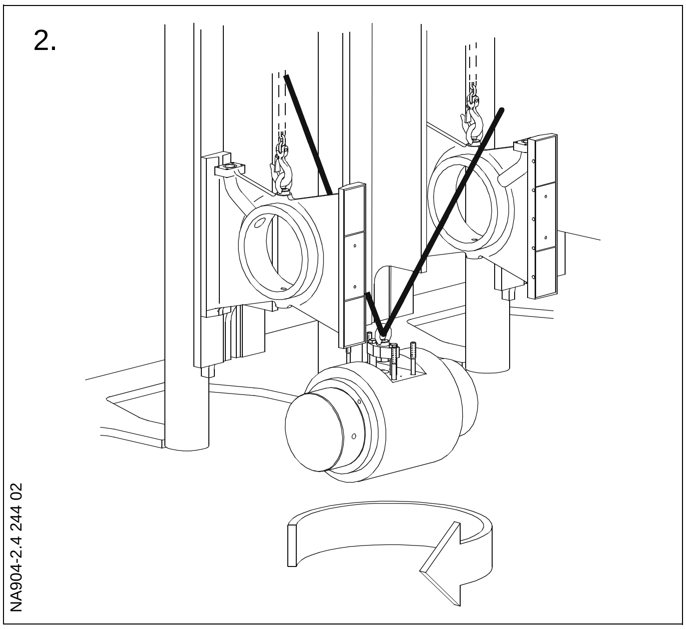
   Mount a tackle outside the engine. Hook a wire rope on to the engine room crane. Lower the wire rope down through the cylinder frame, through the crankcase, and out of the framebox door opening.

   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.



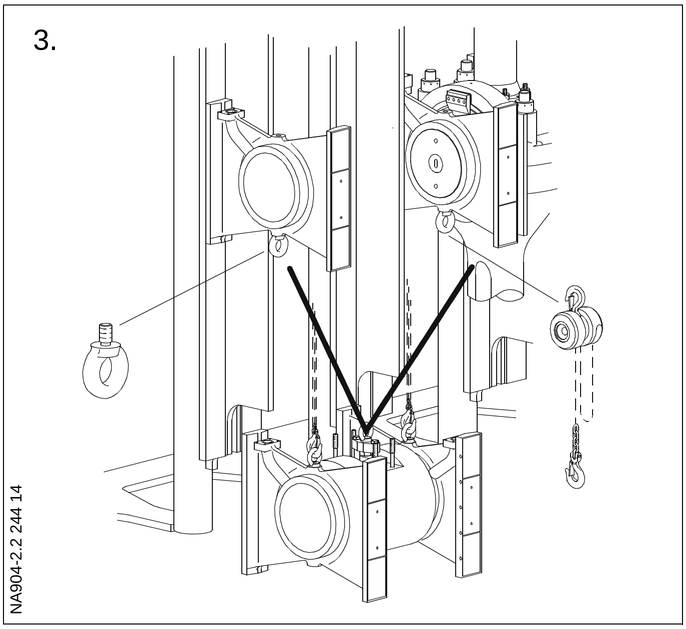
2. Turn the crosshead 90° to enable mounting of the guide shoes. Check that the oil inlet and outlet holes are pointing towards the exhaust side.

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.



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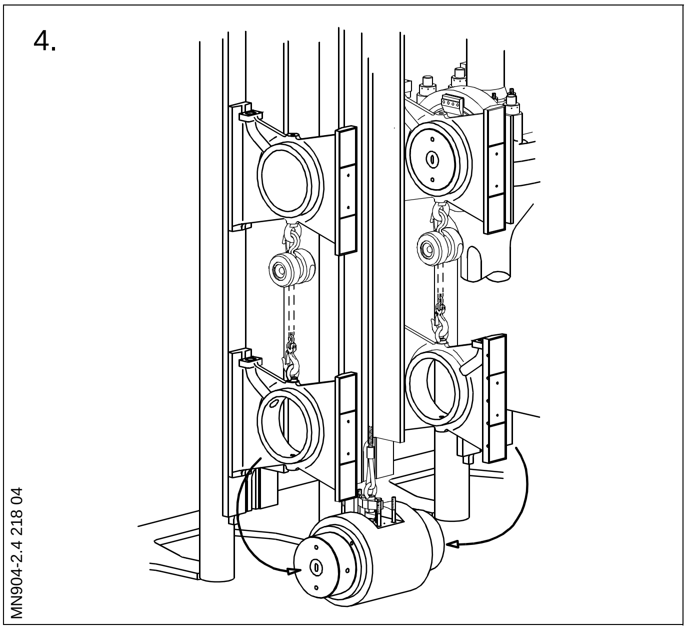

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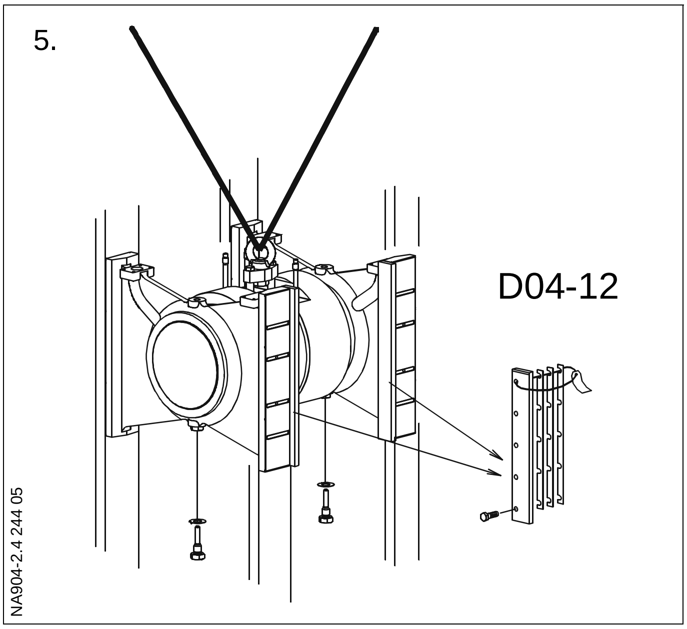

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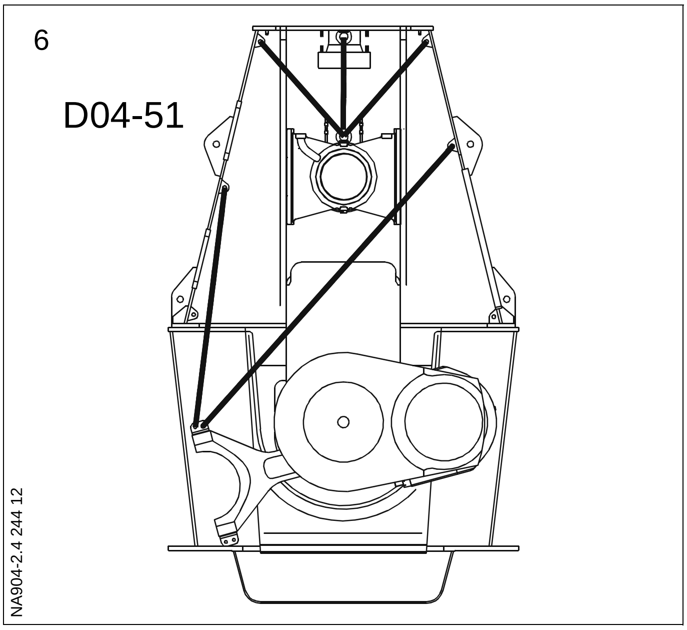


4. Lubricate the sliding surfaces of the guide shoes and the hole for the crosshead with plenty of clean lubricating oil, and push the guide shoes into position through the openings in the side walls.

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.

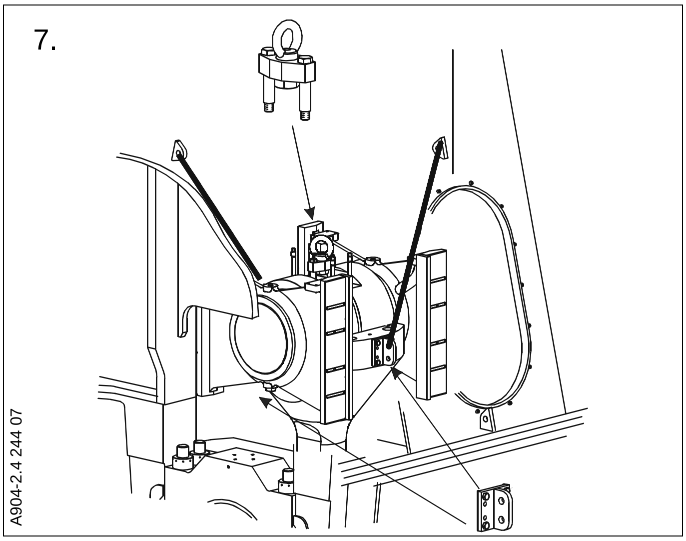
8. Turn the engine to BDC.

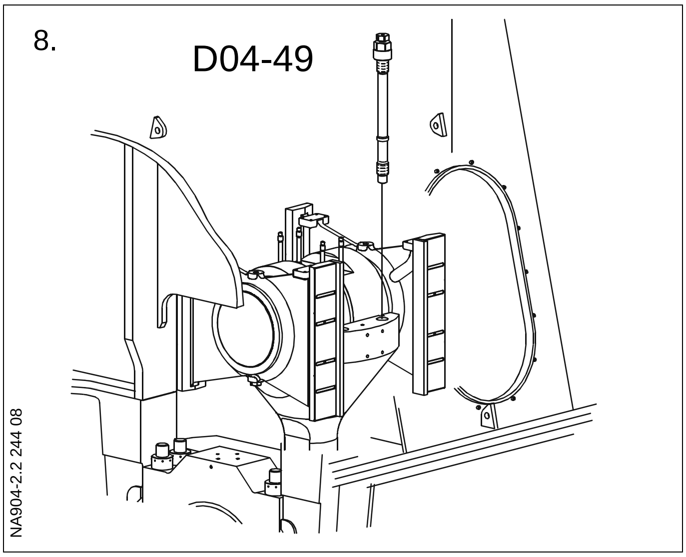
   Mount the studs on the connecting rod. Using the stud setter and a torque wrench, tighten the studs to the torque stated in Data.

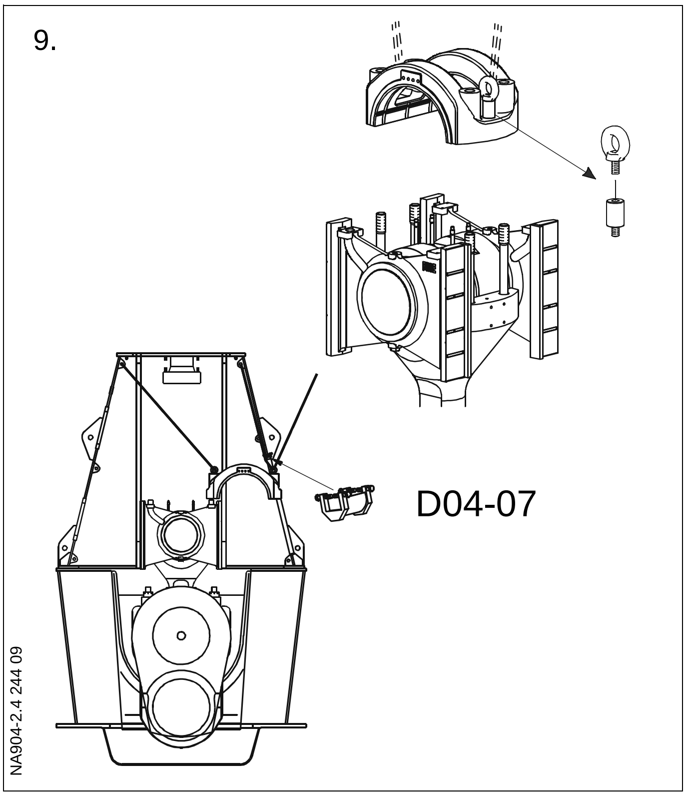
9. Lubricate the crosshead journal with plenty of clean lubricating oil.

   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.







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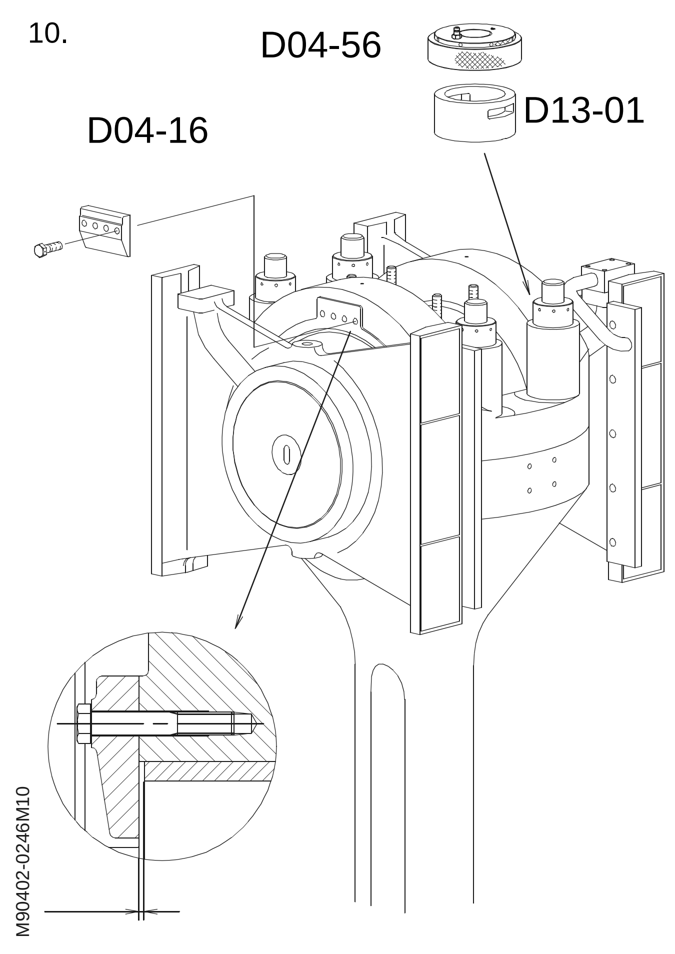

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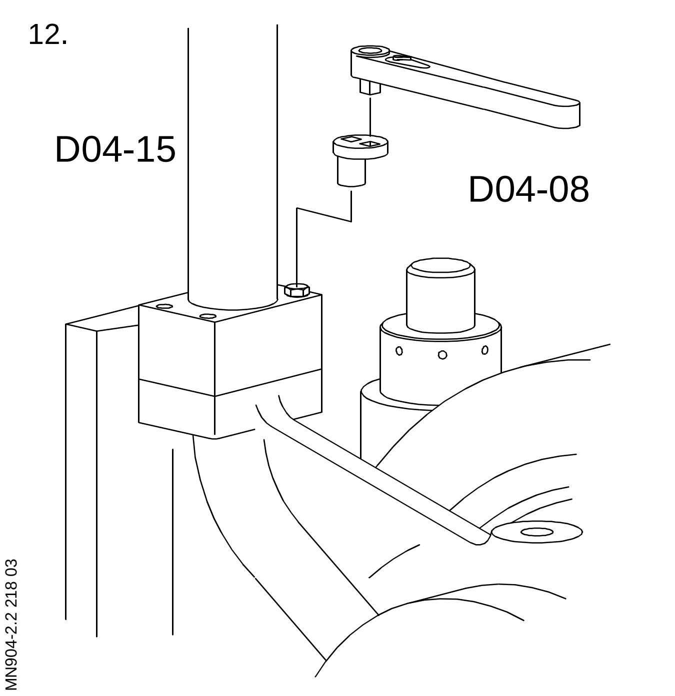


10. Mount and tighten the nuts on the crosshead bearing studs.

    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.

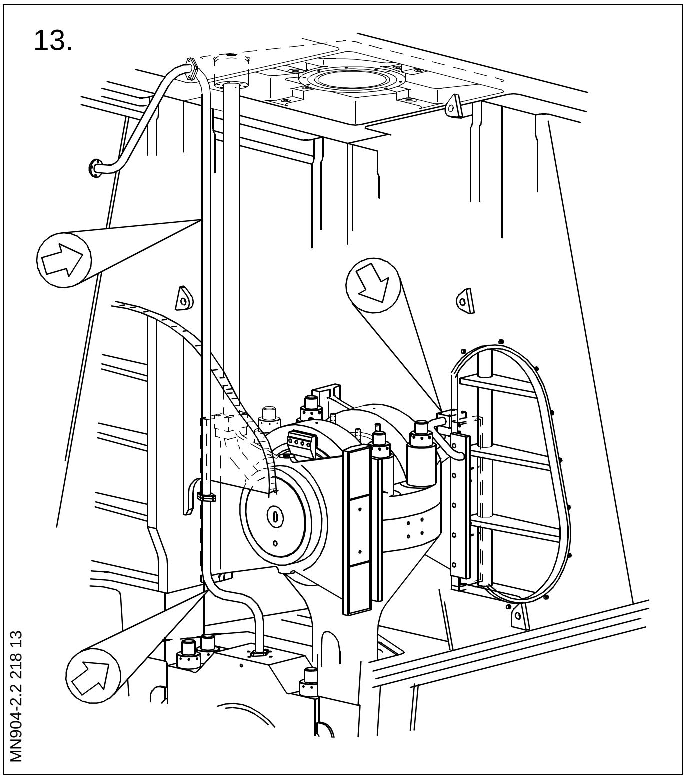
    Mount the cooling oil outlet pipe on the aftmost guide shoe.

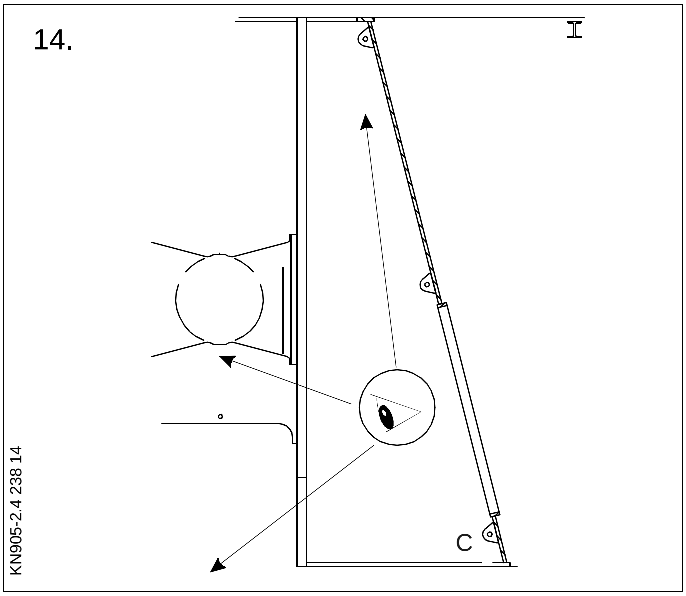
13. Mount the main bearing lubricating oil pipes.

    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.





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

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
	Stop lubricating oil supply
X	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-25	PF+PA, N max.	0.95	mm
D04-26	PF+PA, O max.	1.55	mm
D04-28	E+G, H+F, N max.	0.7	mm
D04-29	E+G, H+F, N min.	0.2	mm
D04-30	E+G, H+F, O max.	1	mm
D04-34	J+X, L+Y, K+X, M+Y, N max.	1.3	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.	1.5	mm
D04-39	QF/QA, O max.	1	mm
D04-41	ZF/ZA O min.	5	mm
D04-42	TF + TA	0.8	mm
	N: New and cold engine with staybolts tightened (less than 100 running hours).		
	O: Engine in service.		

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	58	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.

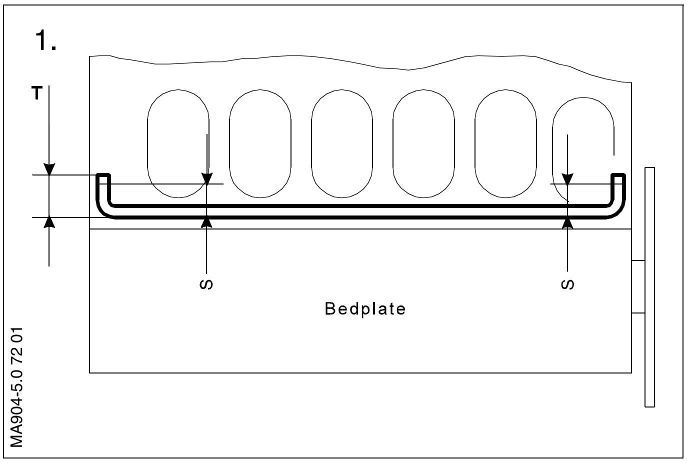
   Measurements are to be taken with a ruler.

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.

1.



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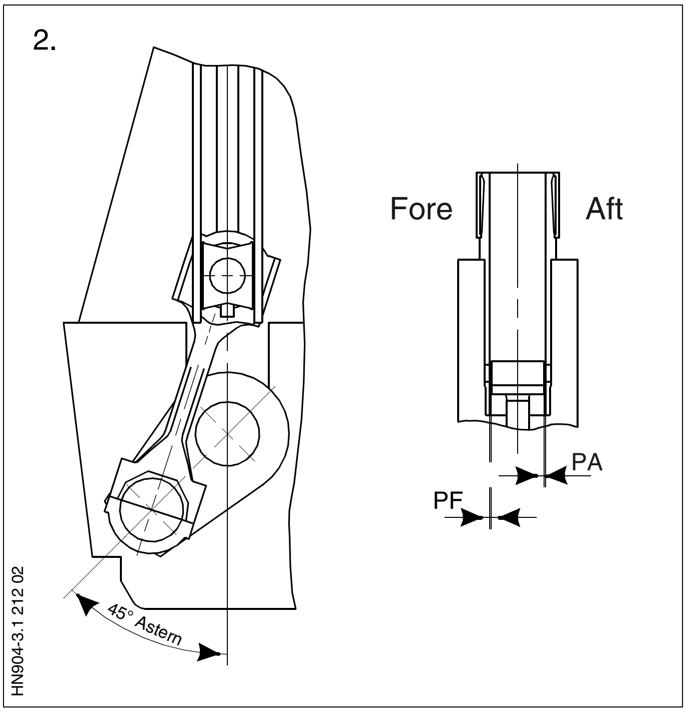

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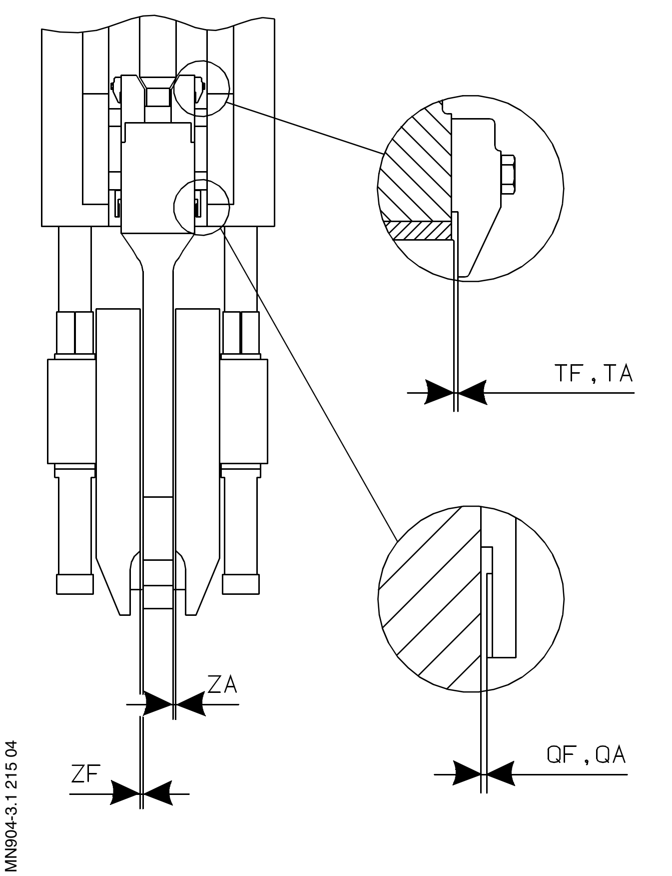

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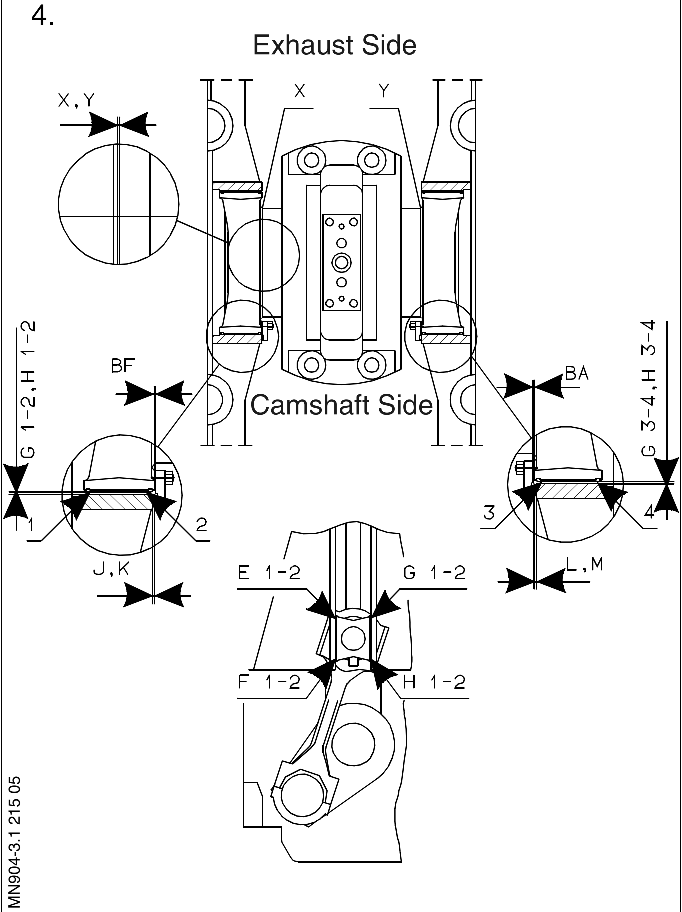


3. Measure the clearance between the crank-throw and the connecting rod.

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				
	J+X				
	L+Y				
	K+X				
	M+Y				
Crosshead Connecting Rod	QF/TF				
	QA/TA				
Crankthrow Connecting Rod	ZF				
	ZA				

MN904-3.1 215 06

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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-43	Crankpin bearing clearance, max.	0.9	mm
D04-44	Crankpin bearing clearance, min.	0.5	mm
D04-45	Crankpin bearing cap complete	900	kg
D04-46	Crankpin bearing, upper shell	88	kg
D04-47	Crankpin bearing, lower shell	82	kg
D04-48	Crankpin bearing cap + shell + bearing studs	1200	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	58	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.

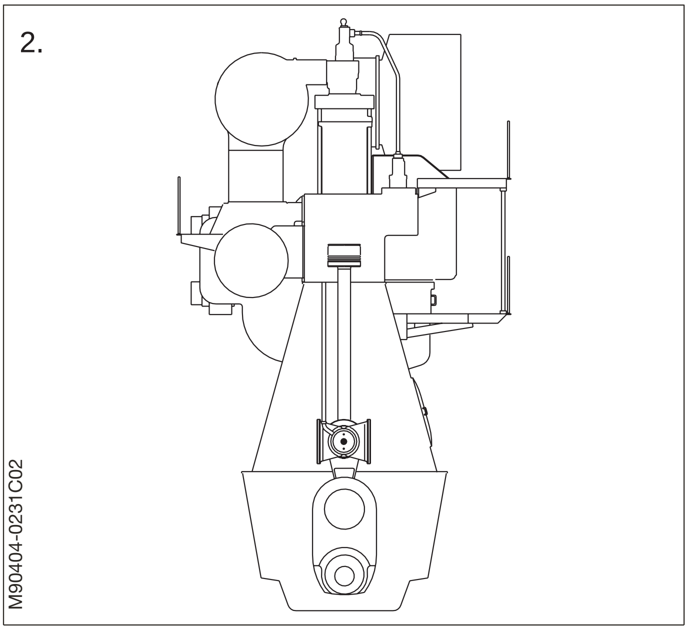
2. Turn the crank concerned to BDC.

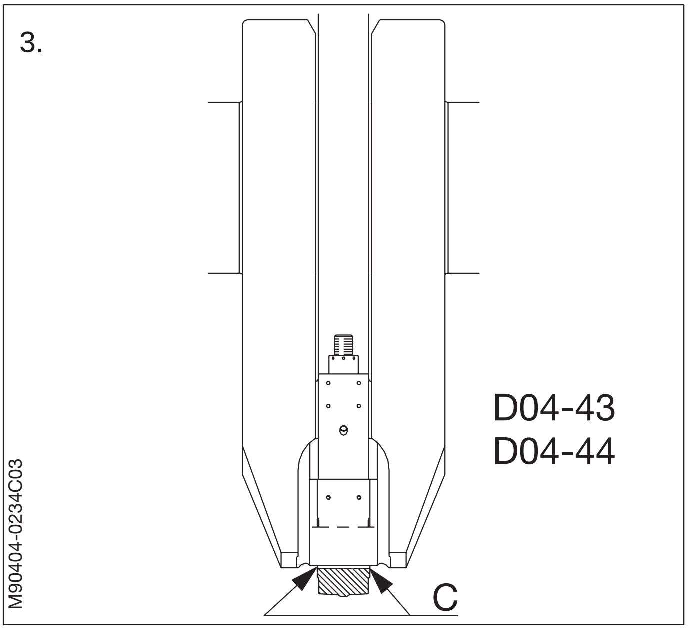
3. Measure the clearance in the crankpin bearing by inserting a feeler gauge at the bottom of the bearing shell in both sides.
   See Data for bottom clearance.

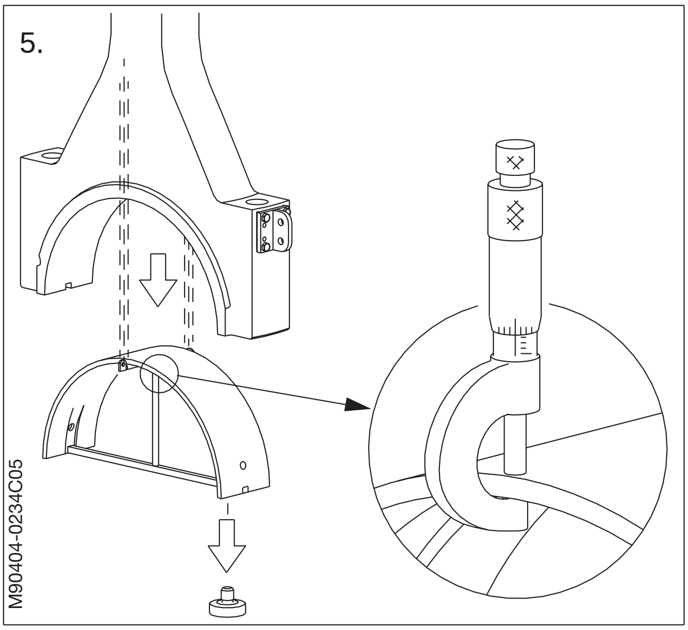
4. The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.05 mm. If so, the crankpin bearing must be disassembled for inspection.
   See Procedure 904-4.2.

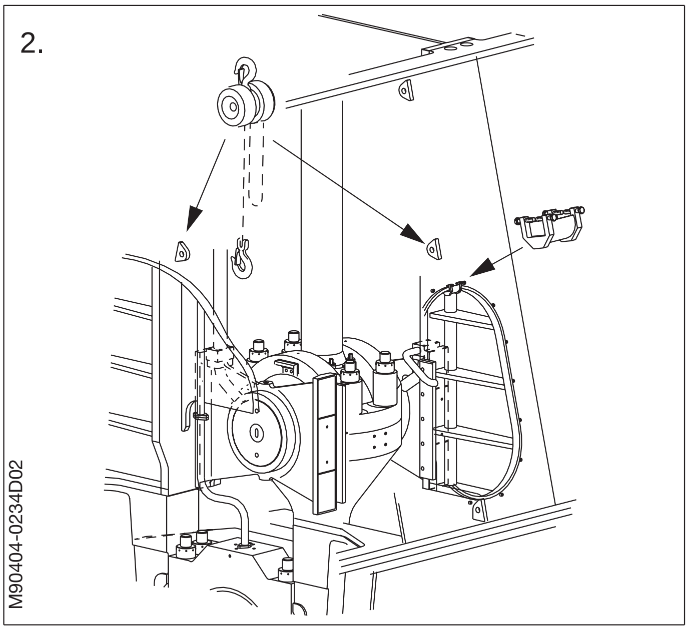
5. The wear limit for the crankpin bearing shells is based on an evaluation of the bearing condition at the time of inspection.

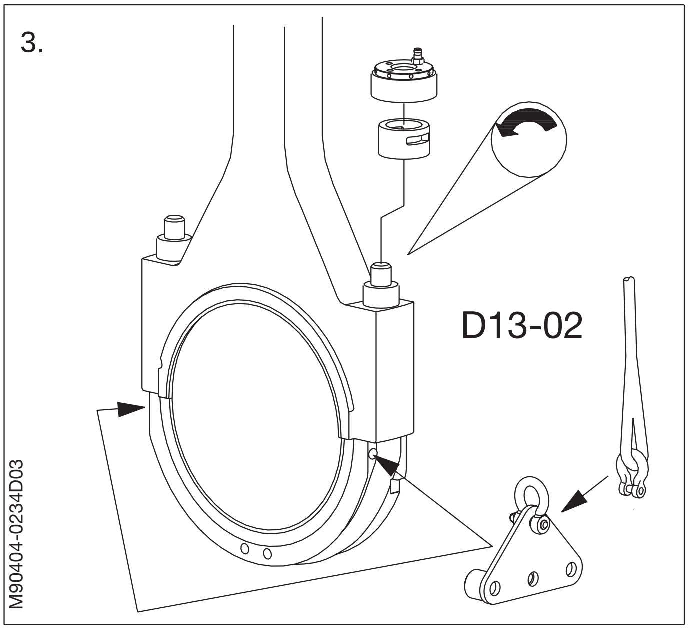
6. *For further external inspection of the crankpin bearing, see Chapter 708 'Bearings' in the instruction book, Volume I, OPERATION.*

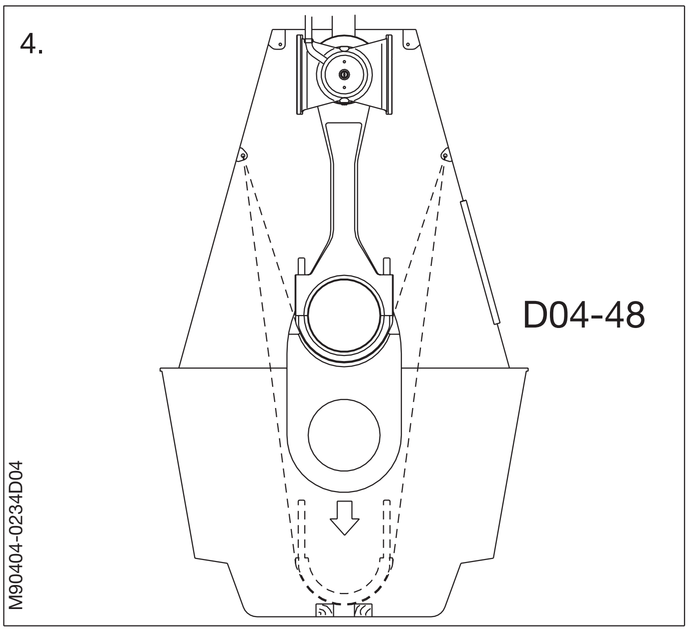












1. Turn the crank to BDC.

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 a crank pin bearing cap lifting tool on 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 mounted in the center hole with a nut on the reverse side 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.

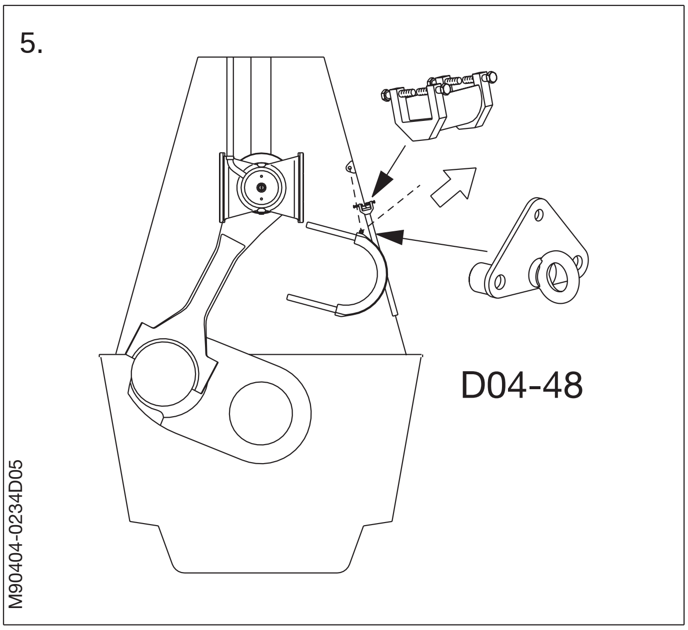
7. Turn to TDC.

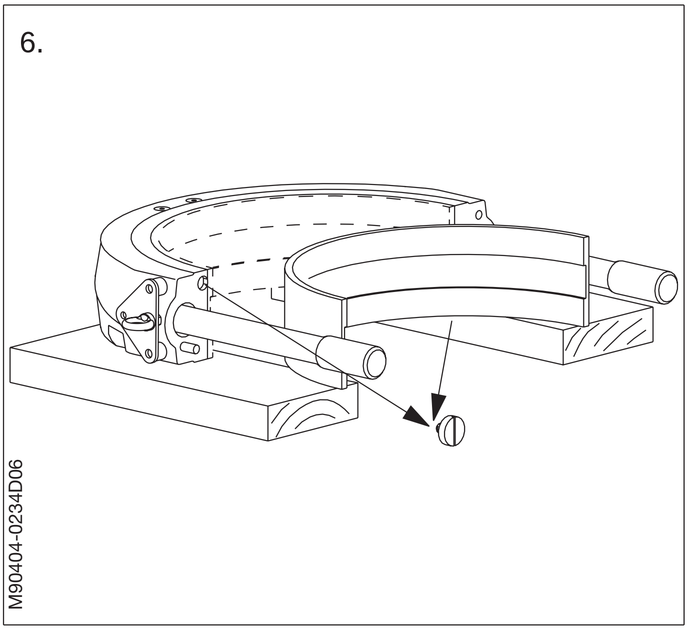
   Mount the four supports for the guide shoes on the crosshead guides.

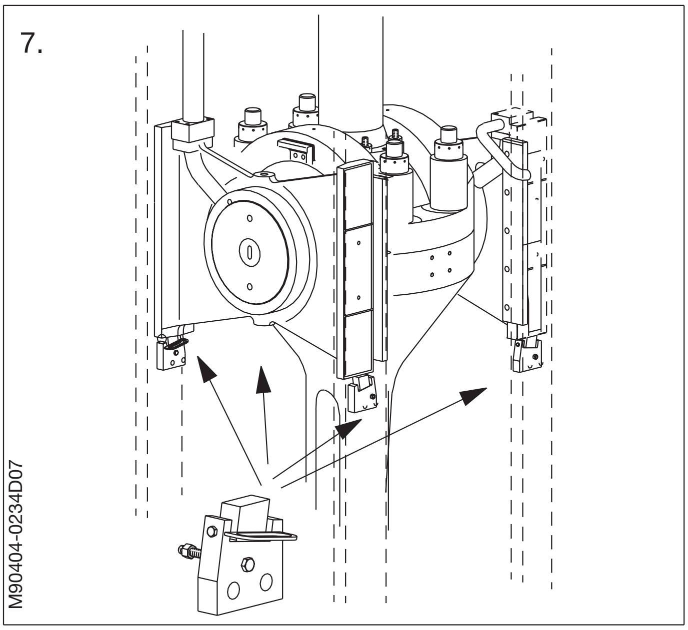
   Adjust the support bracket sledges to their lowest position.

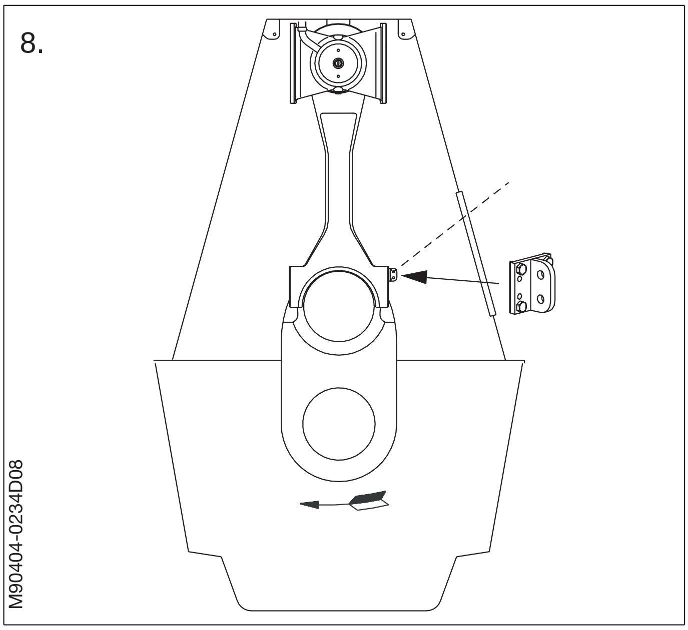
   Carefully turn the crank down until the guide shoes are approx. 1 mm from the support bracket sledges.

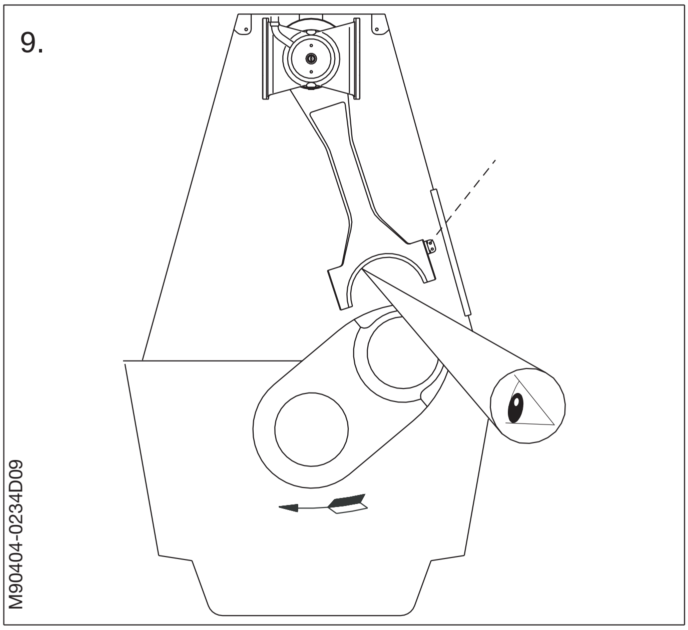
   Adjust the sledges to support the guide shoes so that the weight of the crosshead is evenly distributed on the four supports.

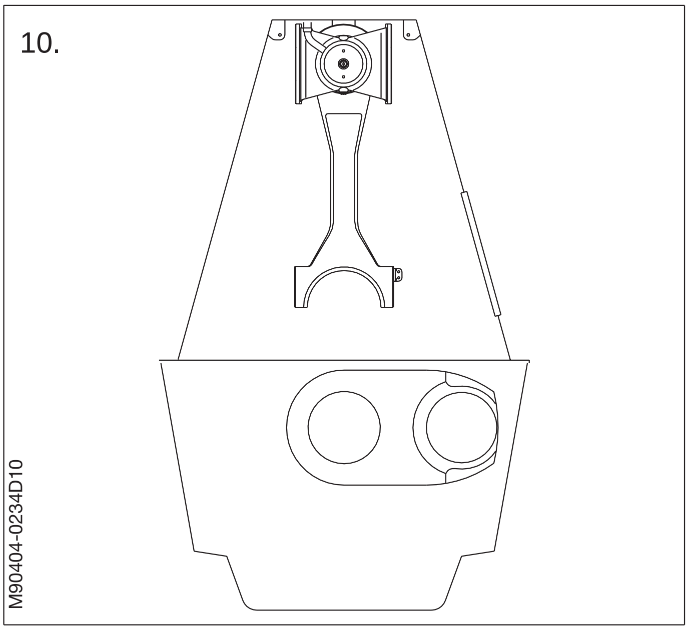












8. Mount a lifting attachment for securing the connecting rod at the lower end, on one side.

   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.

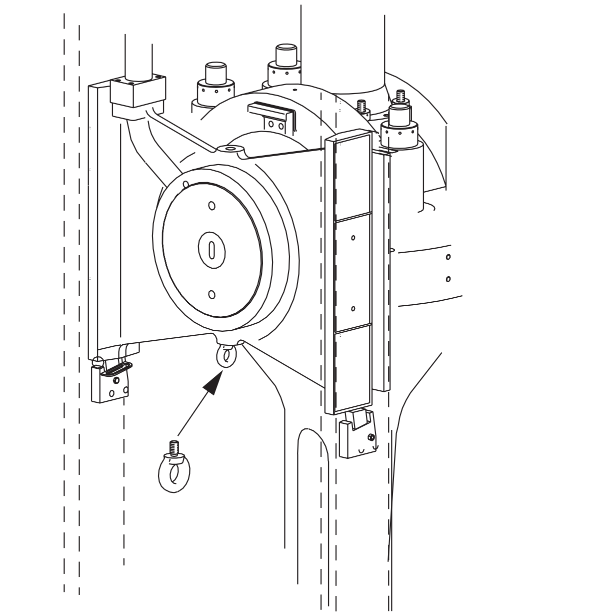
    Mount the tool on the bearing shell in the connecting rod, using the tackles, and haul tight.

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.



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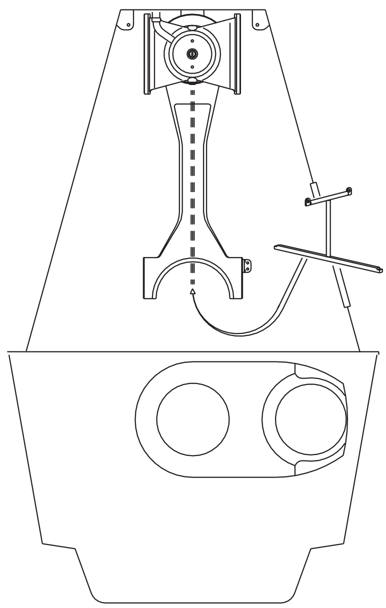

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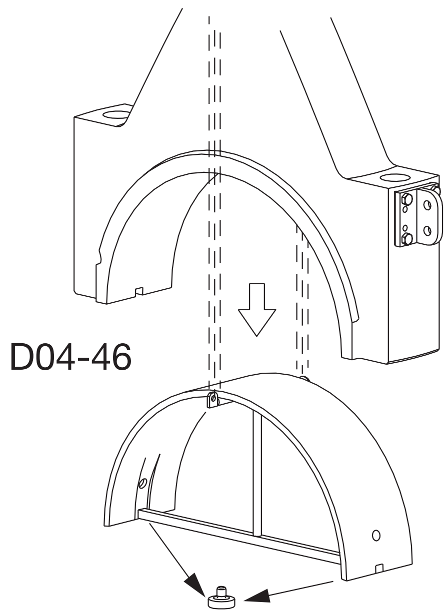

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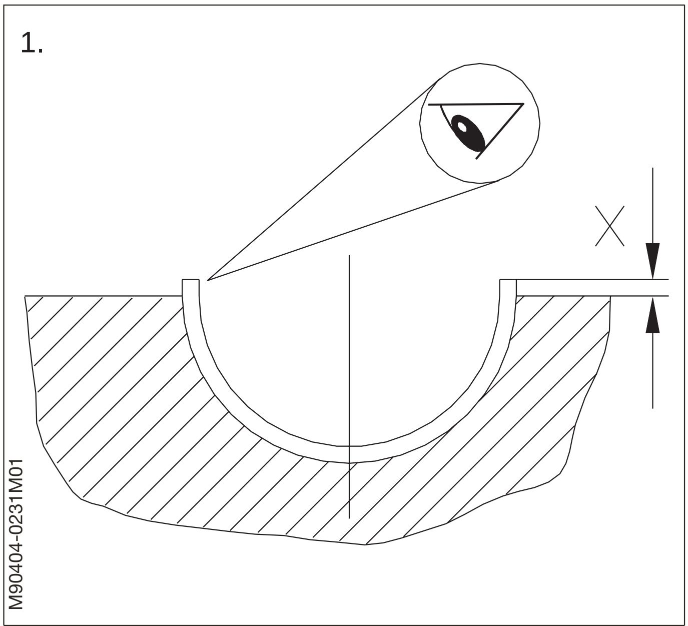

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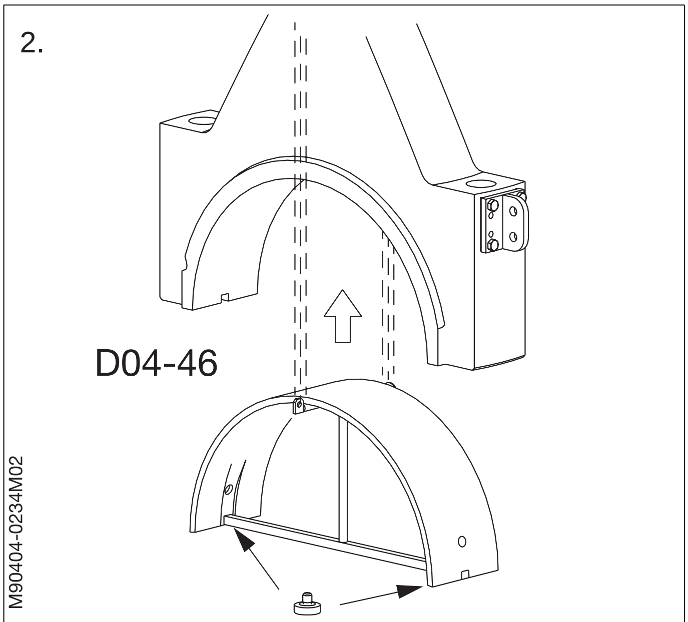

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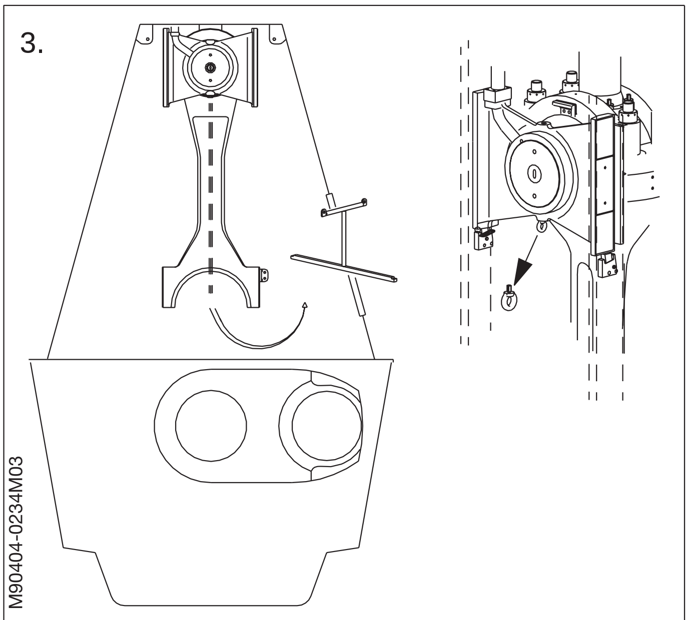


1. If necessary, replace the bearing shells with new ones. The bearing shells **must** be replaced in pairs.

   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.

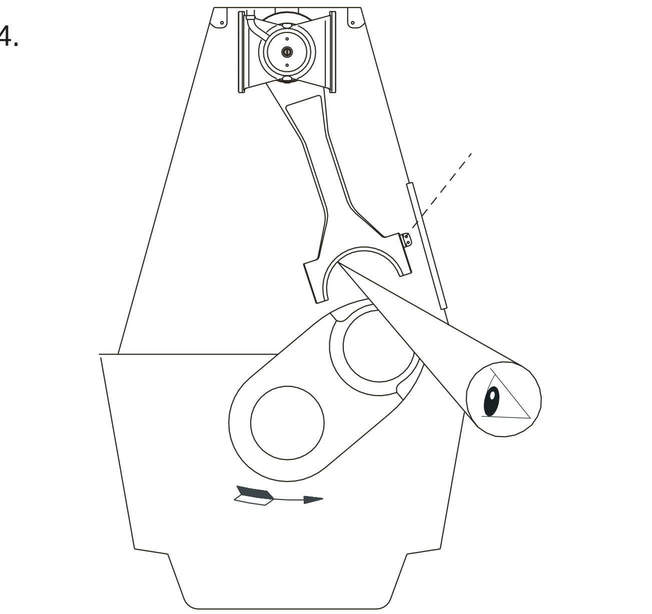
   Carefully turn the crankshaft upwards, while following up with the tackle, making sure that the upper part of the bearing enters the recess in the crankshaft when the parts turn together.

   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.

4.



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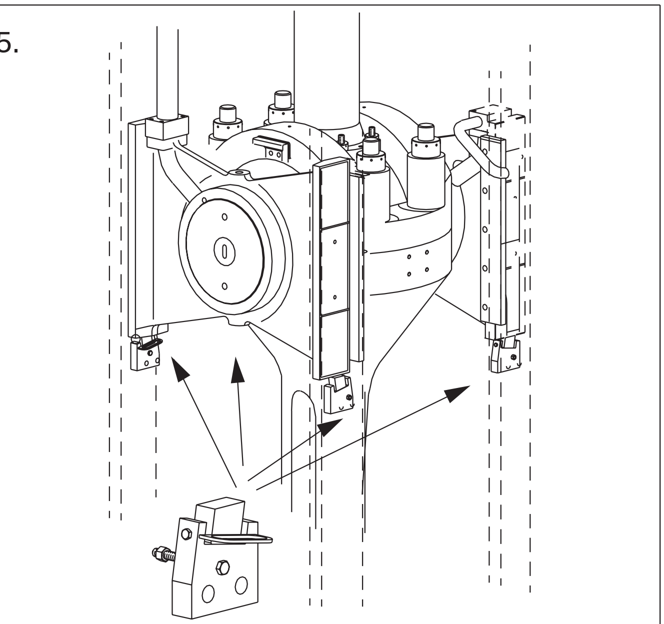

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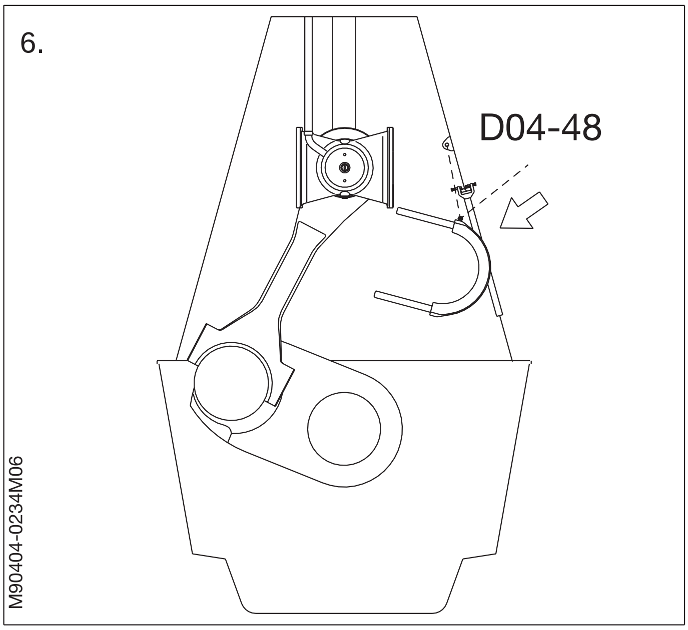

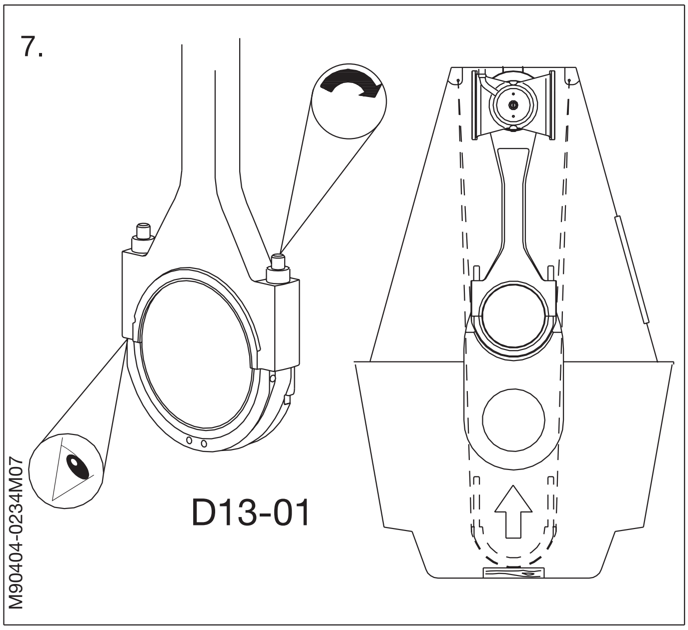

6. Suspend the tackles from the lifting brackets in the top of the frame box.

   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*

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D04-48	Crankpin bearing cap + shell + bearing studs	1200	kg
D04-49	Connecting rod studs , screwing-in torque	680	Nm
D04-50	Connecting rod, without bearing caps	5800	kg
D04-52	Connecting rod stud	38	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	58	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.

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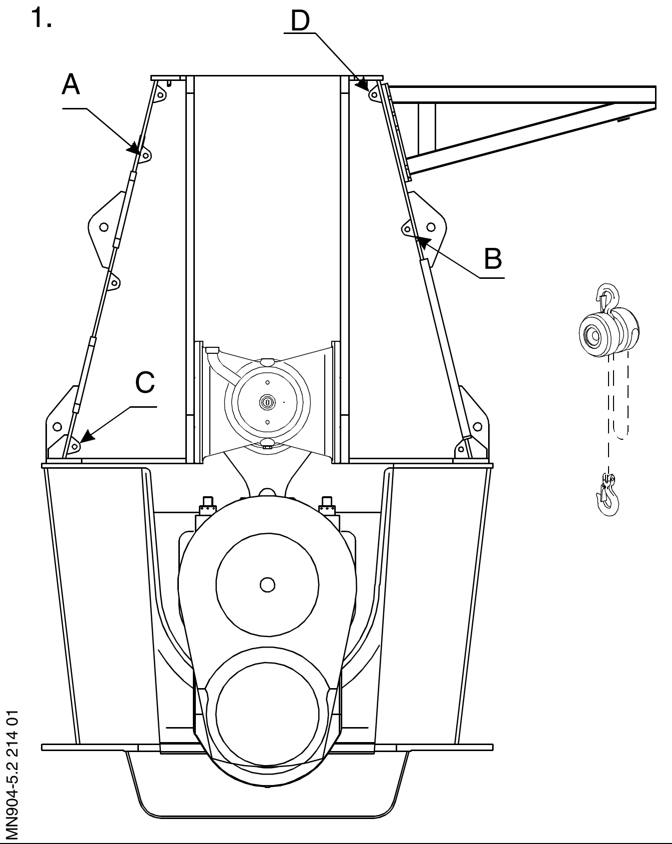

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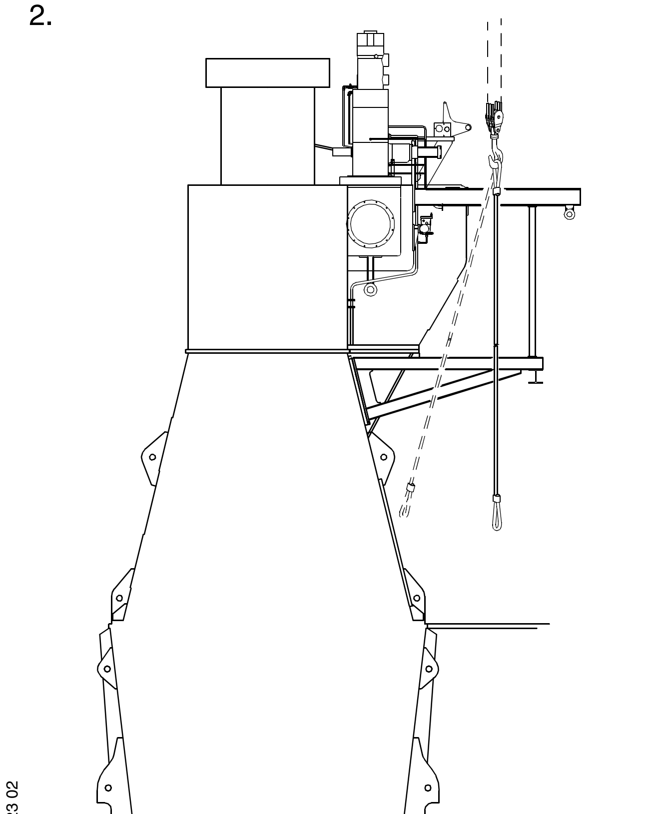

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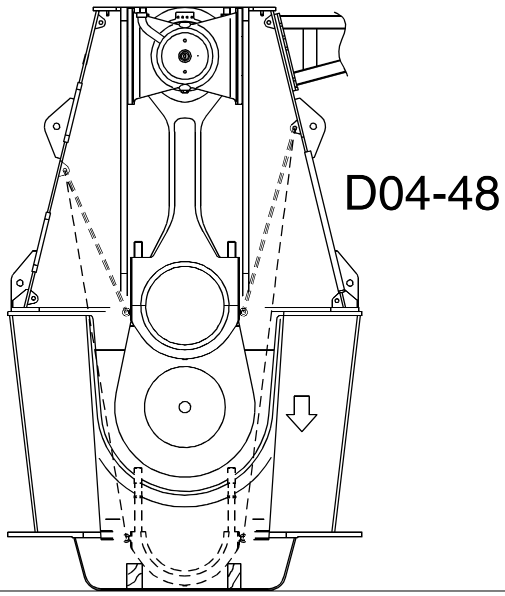

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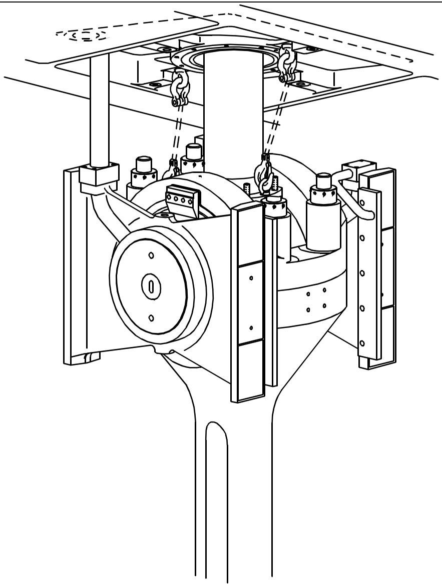

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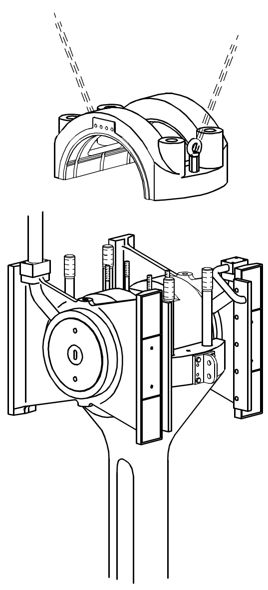

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3. Turn the crankthrow to TDC.

   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.

6. Using the stud setter, dismantle the studs from the connecting rod.

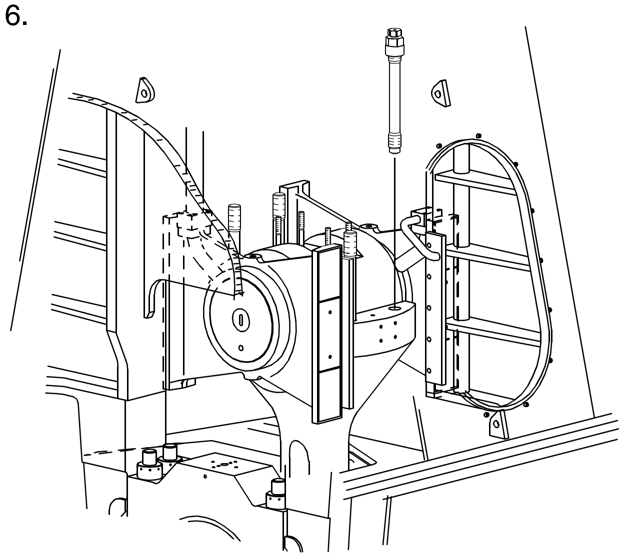
7. Turn the crosshead upwards, until the piston rod foot lands on the crosshead.

   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.

6.



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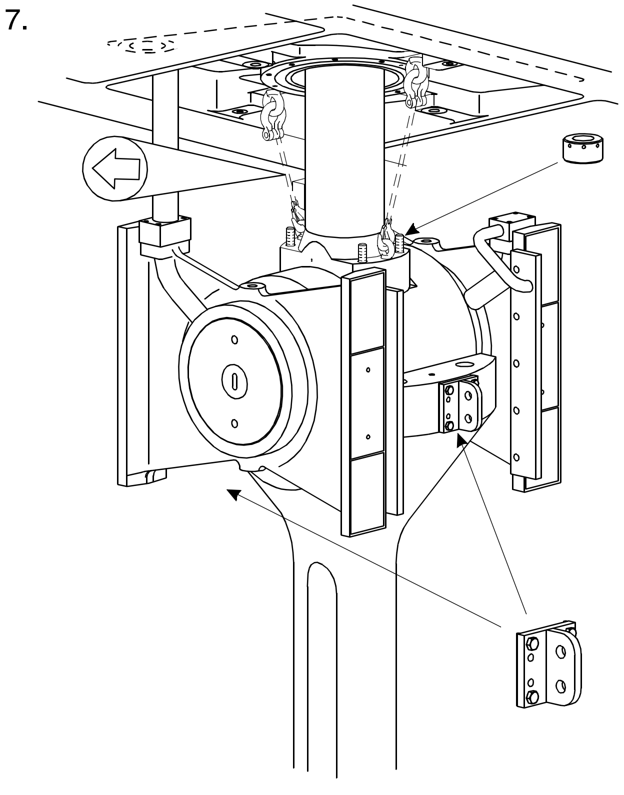

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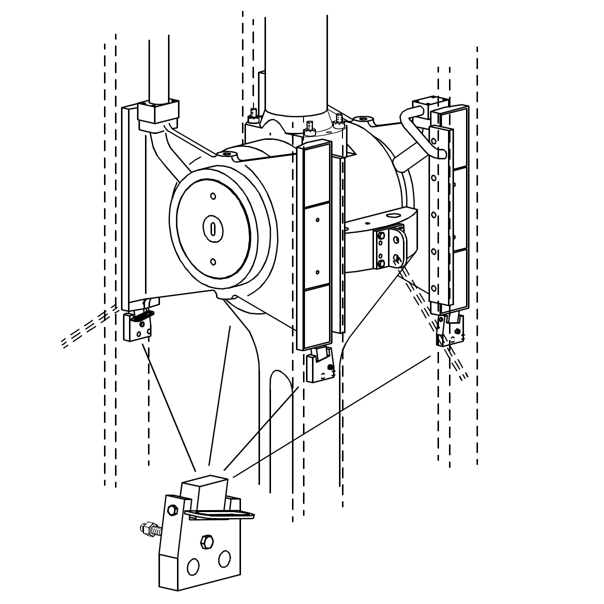

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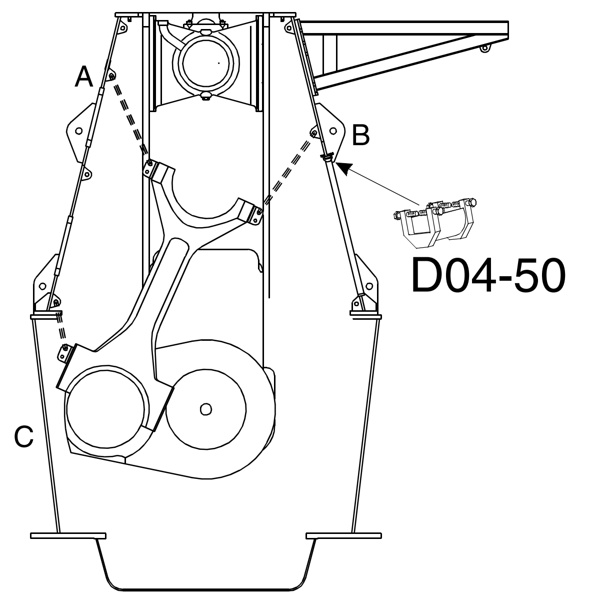

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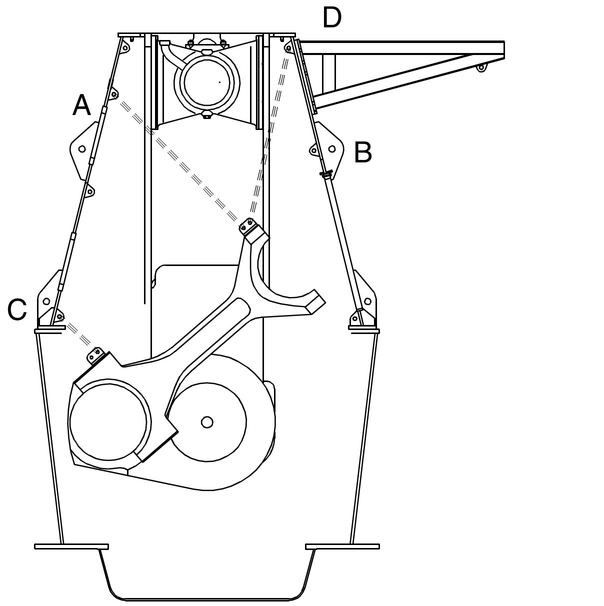


8. Turn the crosshead to TDC. Hook two tackles from points **A** and **B** on to the lifting attachments on the connecting rod head.

   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.

   Carefully turn the crank down towards BDC while 'following' with the tackles, thus continuously supporting the connecting rod.

   Turn the crank until the guide shoes rest on the supports.

   Adjust the support brackets to 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 door way.

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**.

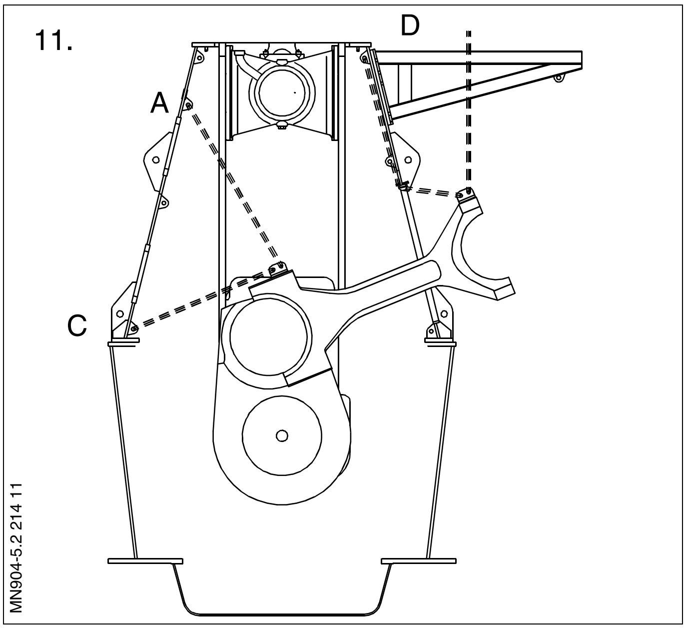
    Shift tackle **D** from the lifting attachment on the connecting rod head to the lifting attachment on the connecting rod foot.

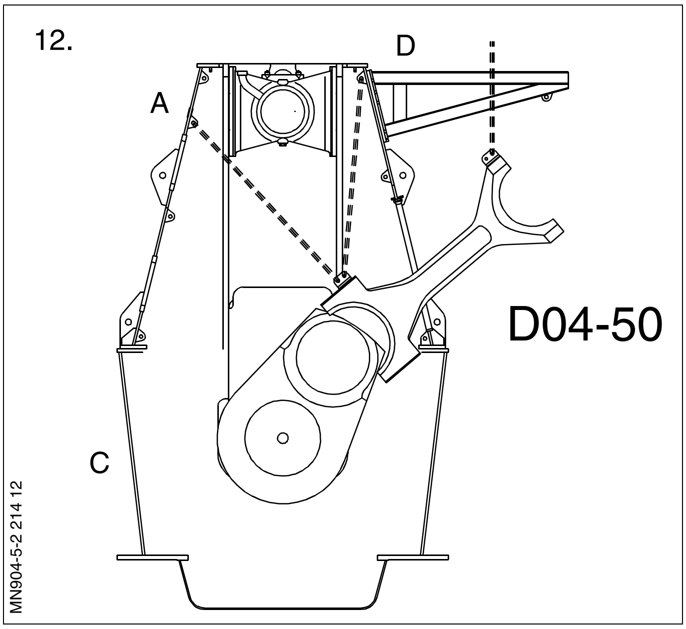
    Turn the engine until the crank is ‘pointing’ towards the doorway, while ‘following’ with the engine room crane and tackles **A** and **D**.

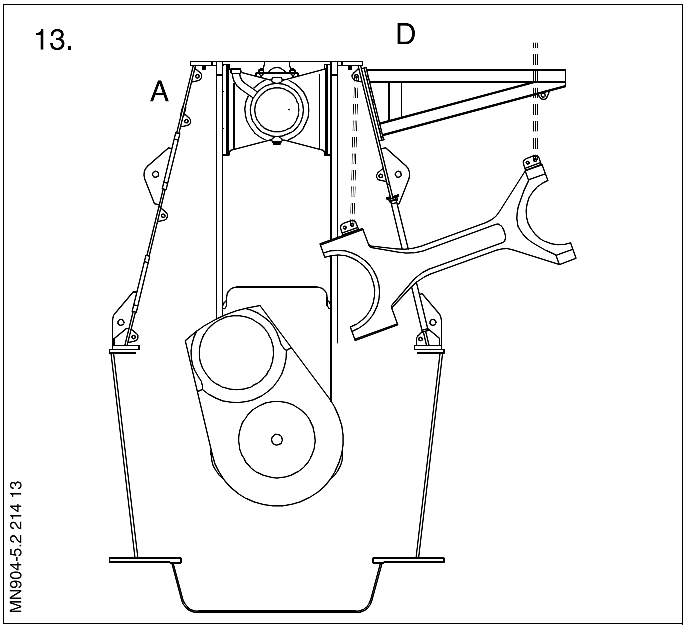
13. Remove tackle **A**. Using tackle **D, carefully** lift the lower end of the connecting rod clear of the bearing journal while, at the same time, turning the crankthrow towards the exhaust side of the engine.

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.







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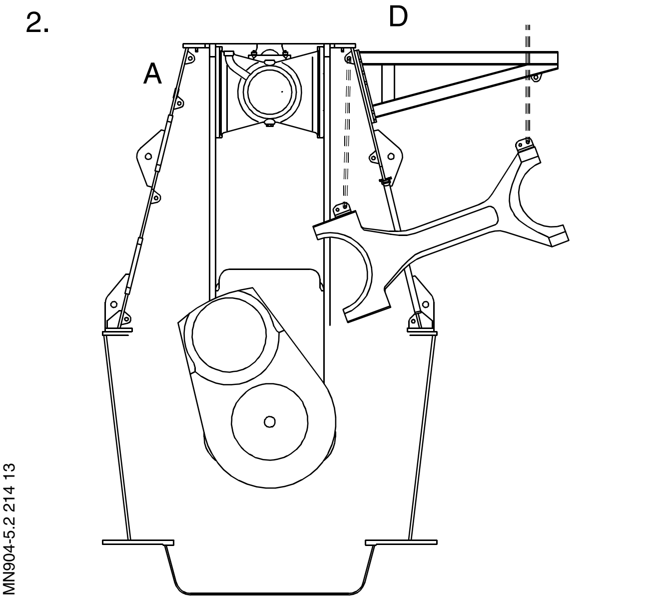

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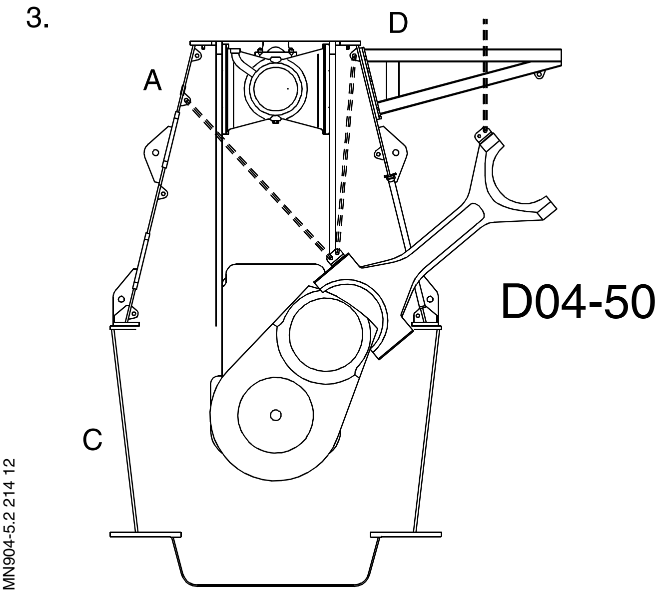

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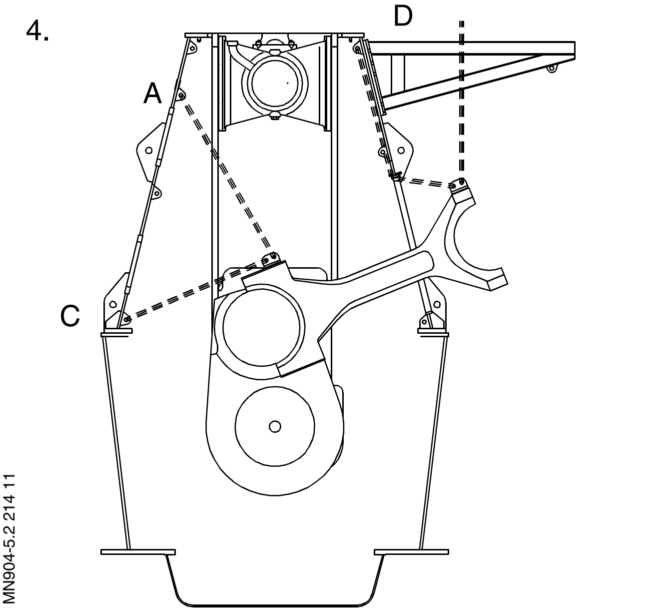


1. Equip the connecting rod with the same lifting attachments as mentioned under dismantling.

   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 door way.

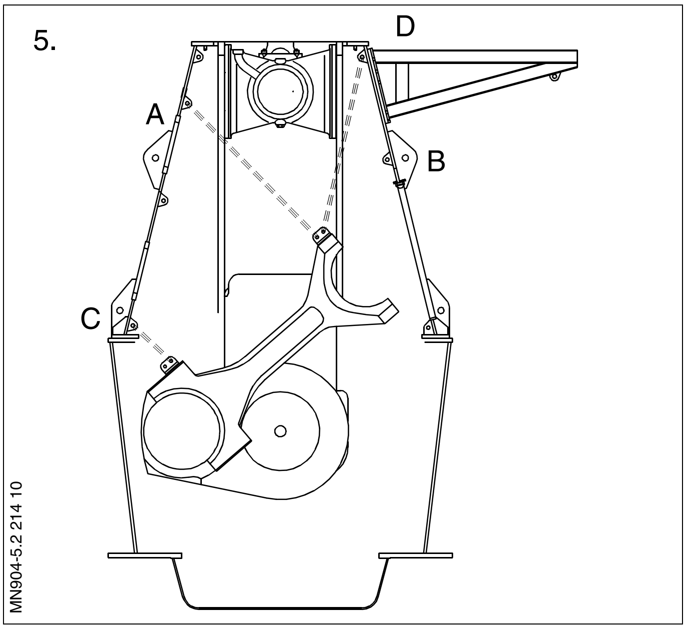
   Mount a tackle in bracket **B** and hook this tackle on to the lifting attachment on the camshaft side of the connecting rod head.

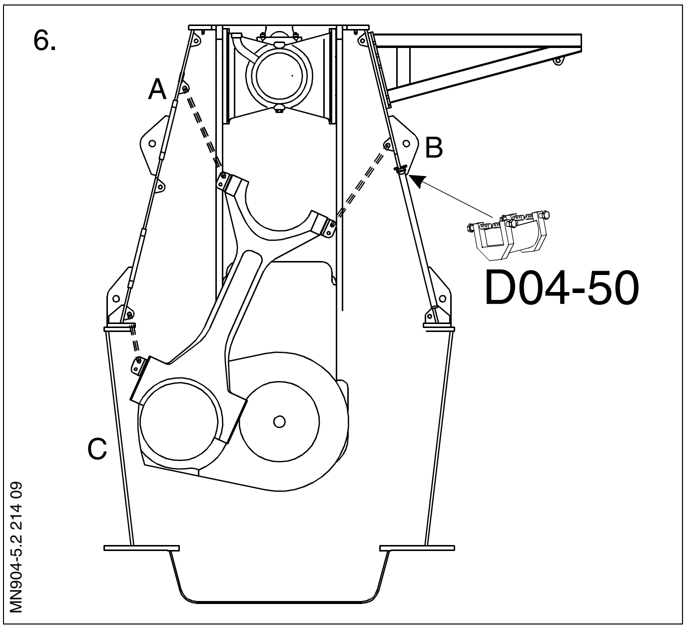
   Remove the tackle in bracket **D**.

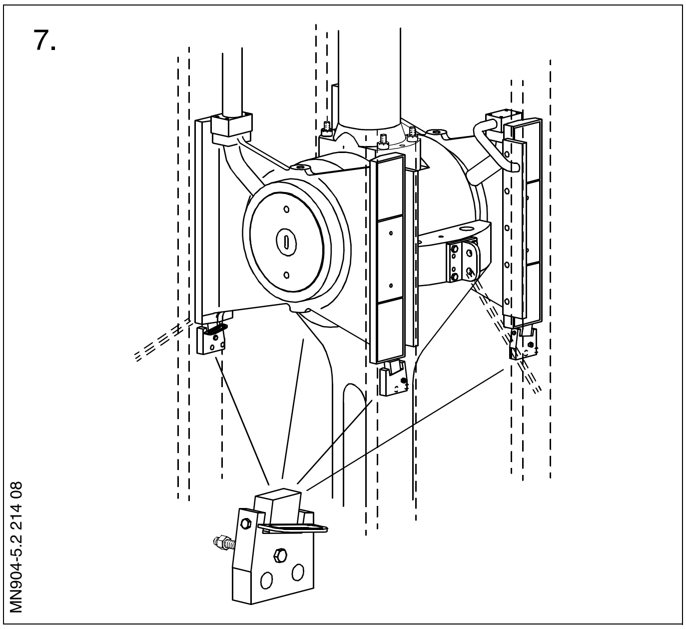
7. Lubricate the crosshead bearing journal and the crosshead bearing shell with plenty of clean lubricating oil.

   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.







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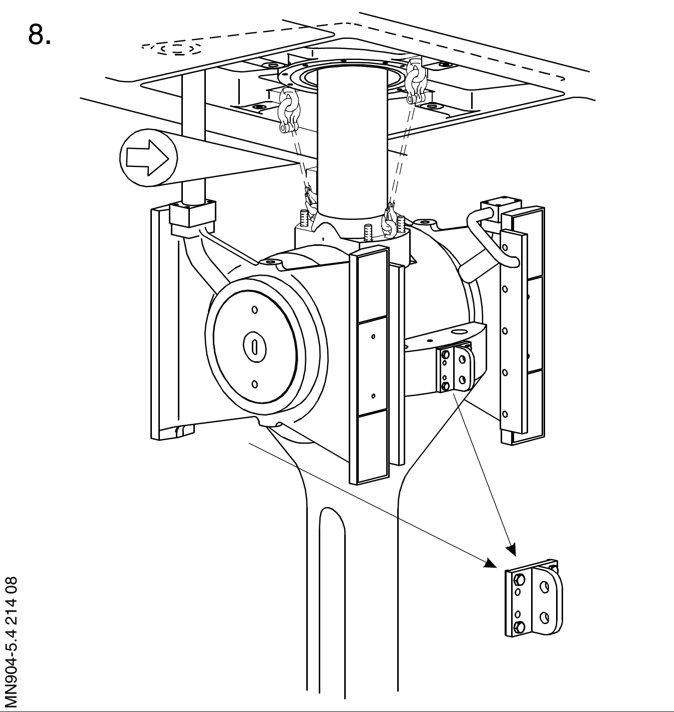

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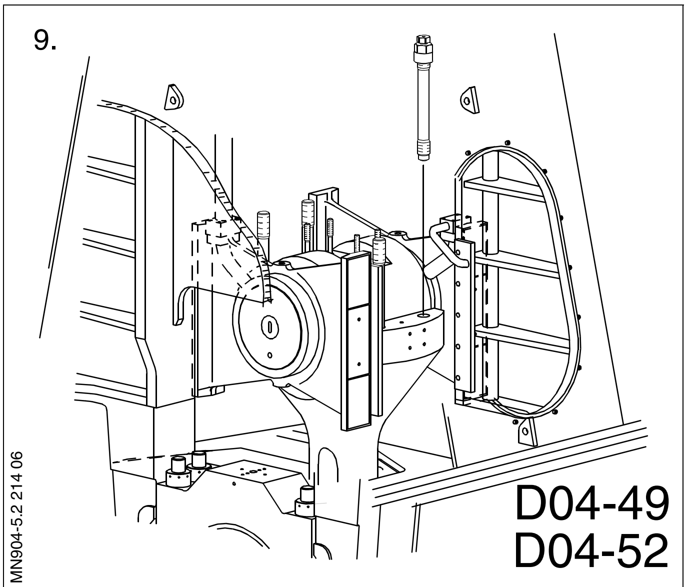

8. Turn the crosshead downwards far enough to enable access to the piston rod nuts.

   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. Re-mount the gallery floor plates.

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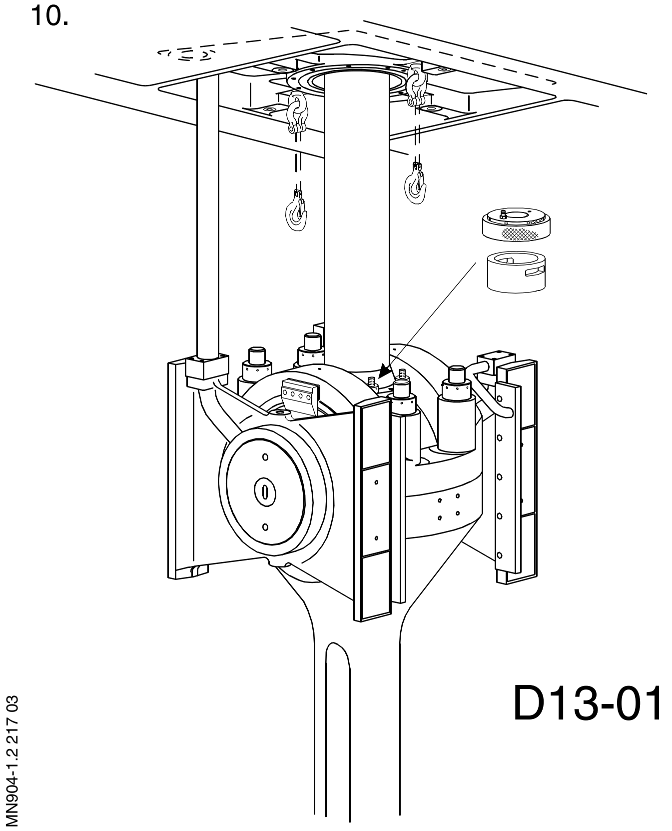

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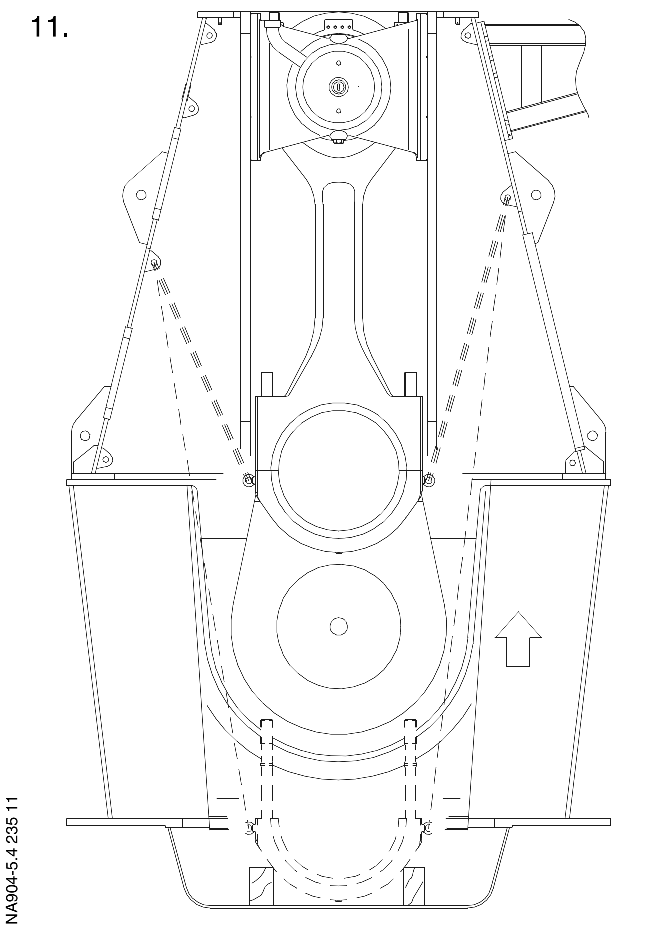

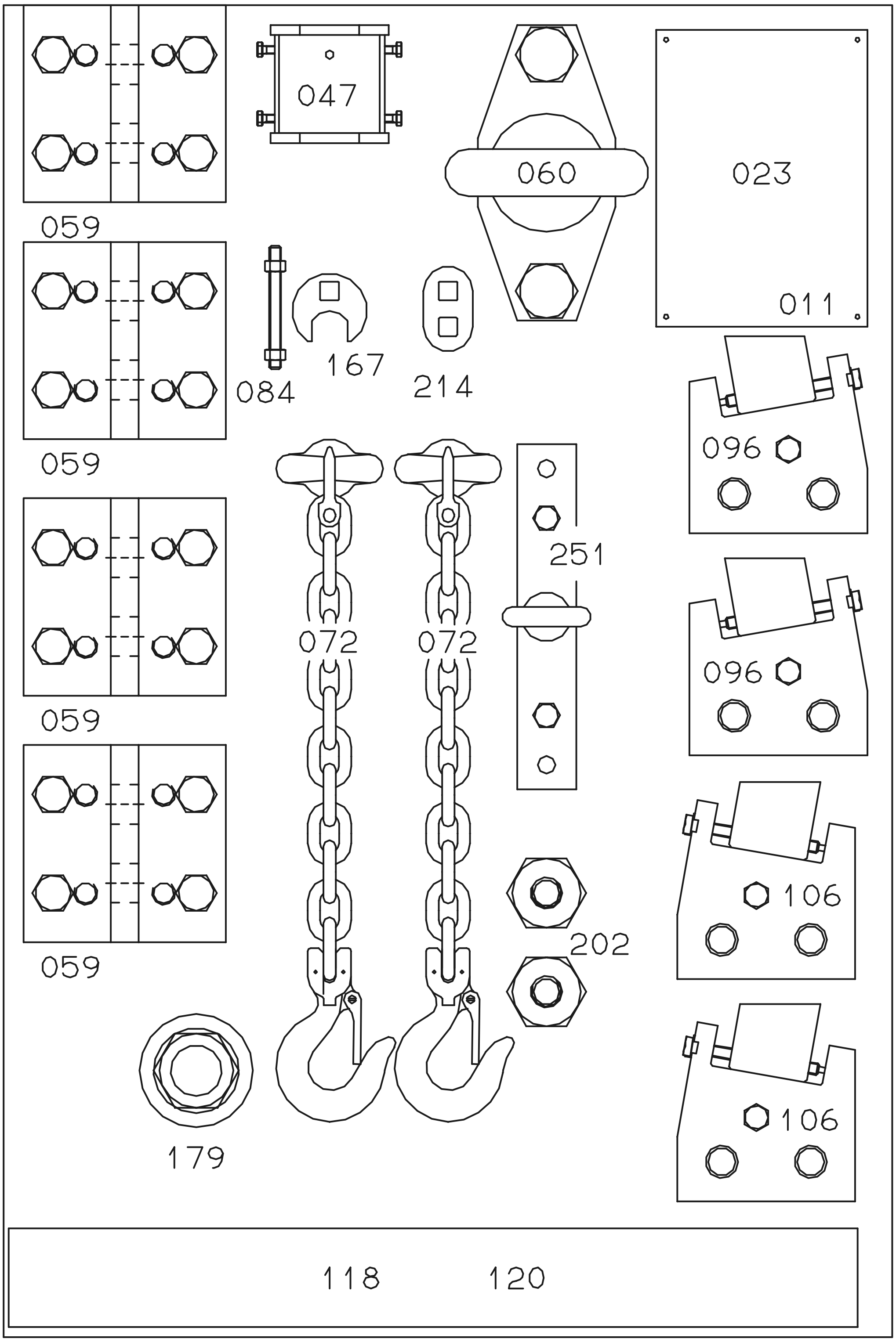
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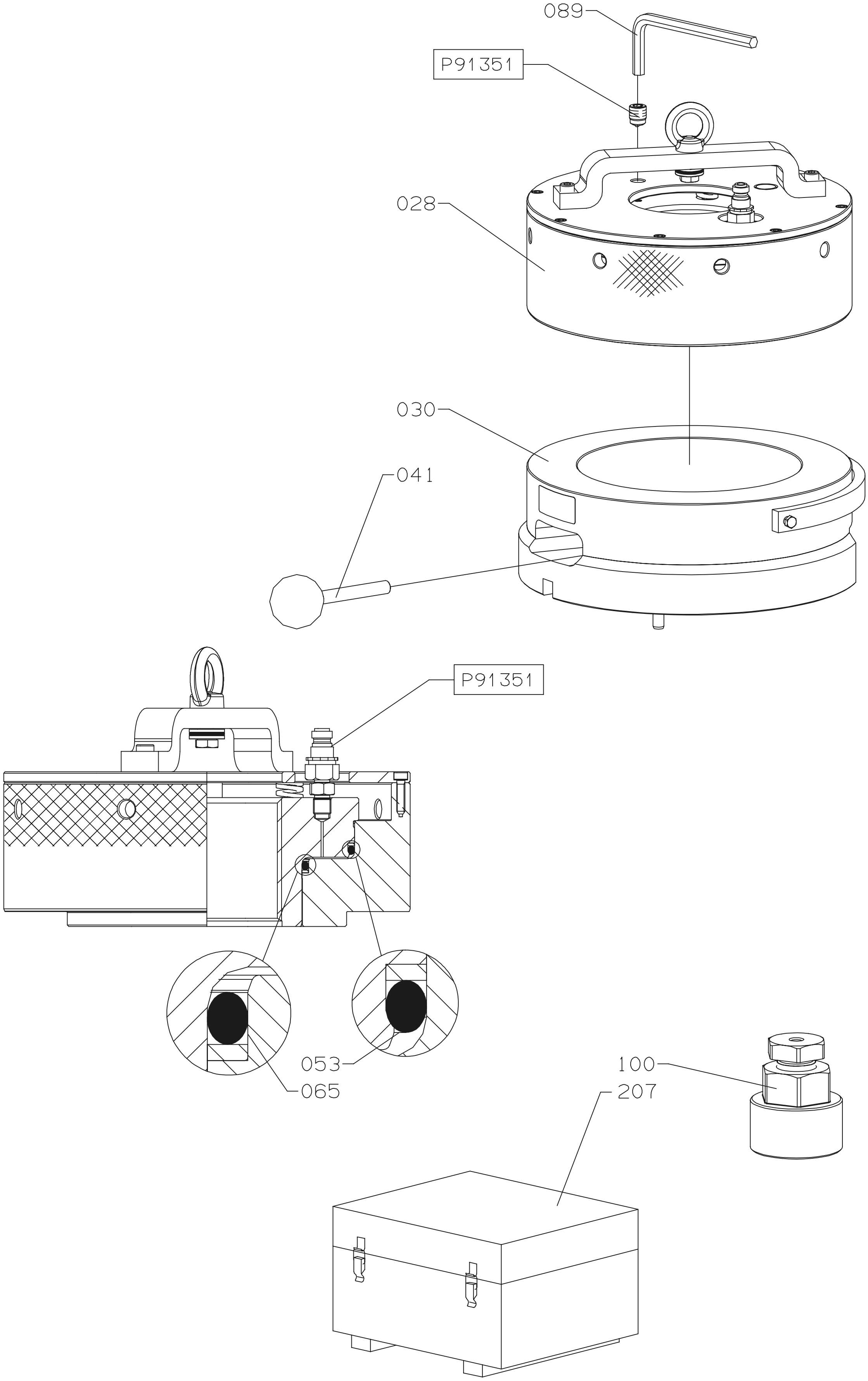
120

Item No.	Item Description	Item No.	Item Description
011	Panel for tools		
023	Name plate		
047	Wire guide, main bearing		
059	Lifting attchment, connecting rod		
060	Lifting tools, crosshead		
072	Chain, suspension of piston		
084	Retaining tool, telescope pipe		
096	Bracket, support of crosshead		
106	Bracket, support of crosshead		
118	Rubber cover, crosshead		
120	Rubber cover with hole, crosshead		
167	Crowfoot spanner		
179	Socket spanner		
202	Extension tool, crosshead cap and piston rod		
214	Offsett tool, torque spanner		
251	Lifting attachment, guide shoe counter-weight		



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P91351
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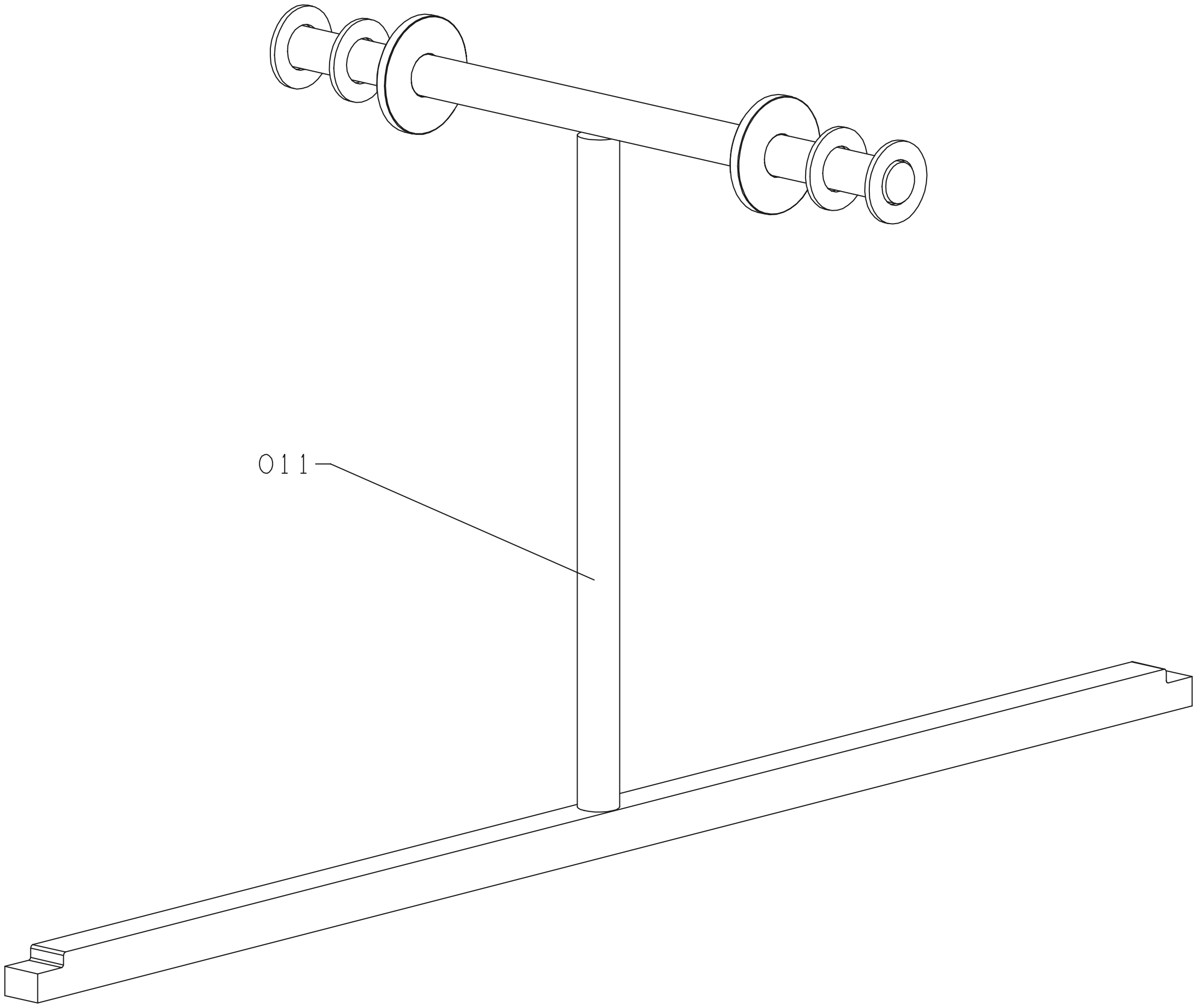
030
041
P91351
053
065
100
207

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		
089	Spanner		
100	Stud setter		
207	Hydraulic toolset, complete		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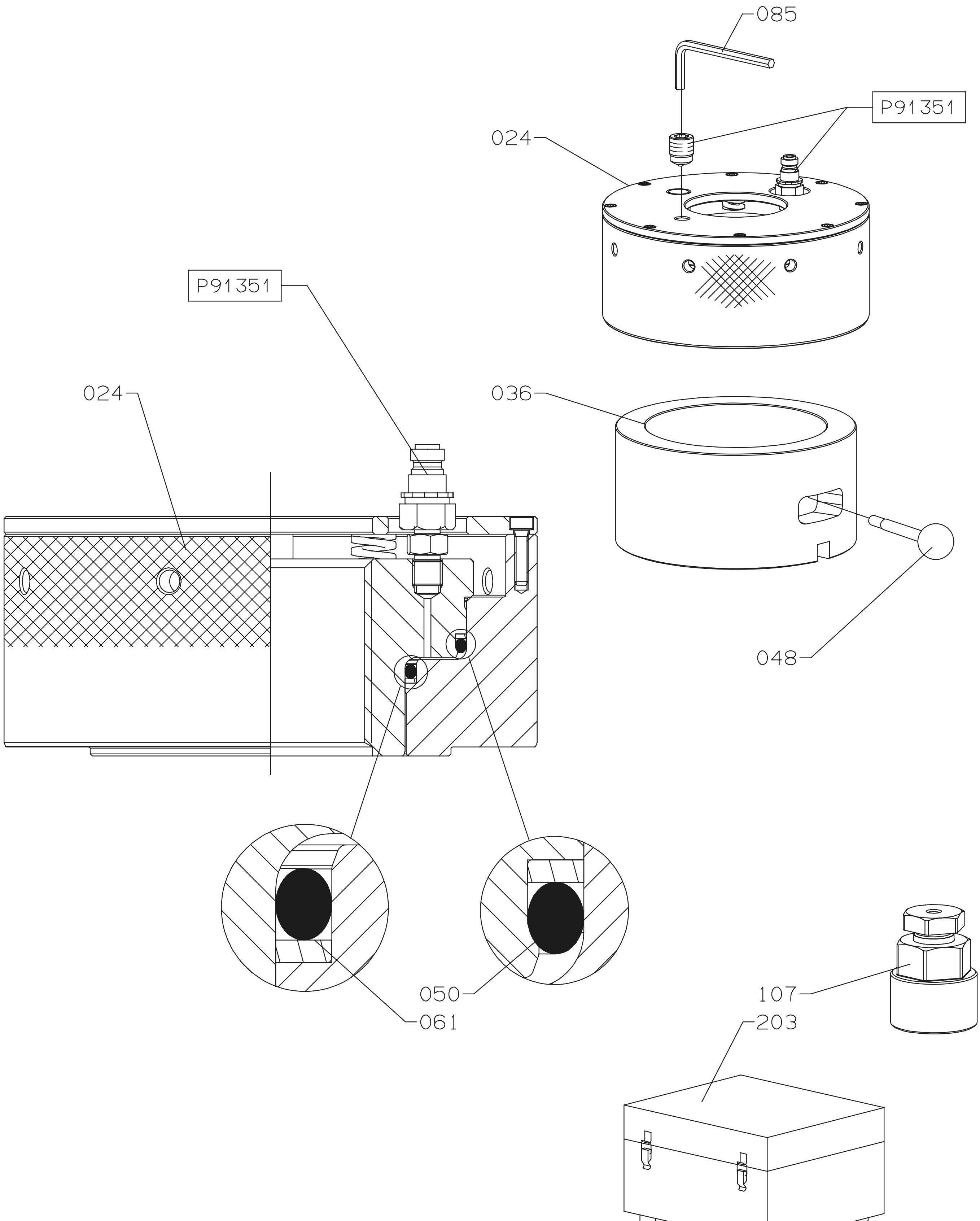
Connecting Rod - Tools

Item No.	Item Description	Item No.	Item Description
011	Lifting tool for crankpin shell		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P91351
024
036
048
050
061
107
203

Crosshead - Hydraulic Tools

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

905 - Crankshaft, Thrust Bearing and Turning Gear

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-01	Main bearing, top clearance max.	0.95	mm
D05-02	Main bearing, top clearance min.	0.50	mm
D05-03	Main bearing cap	1900	kg
D05-04	Main bearing shell, upper	105	kg
D05-05	Main bearing shell, lower	110	kg
D05-30	Main bearing (two aftmost), top clearance max.	1.05	mm
D05-31	Main bearing (two aftmost), top clearance min.	0.5	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
P90451	47	Wire guide
P90551	40	Pulley for wire for main bearing
P90551	76	Lifting tool - main bearing cap
P90551	88	Dismantling tool, main bearing shell
P90551	90	Mounting tool for bearing shell
P90551	123	Retaining tool for main bearing shell
P90551	159	Eye bolt
P90551	172	Mounting tool, thin bearing shell
P90561		Main Bearing - Hydraulic Tools
P90562		Lifting tool for crankshaft
P90565		Main Bearing - Tools
P90571		Main Bearing Shell - Tools
P91351	10	Hydraulic pump, pneumatically operated
P91351	22	Hydraulic pump, hand operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	117	5-way distributor block, complete
P91351	166	Angle union
P91356		Lifting Tools, Etc.
P91366	48	Autolog, measuring tool for crankshaft
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).

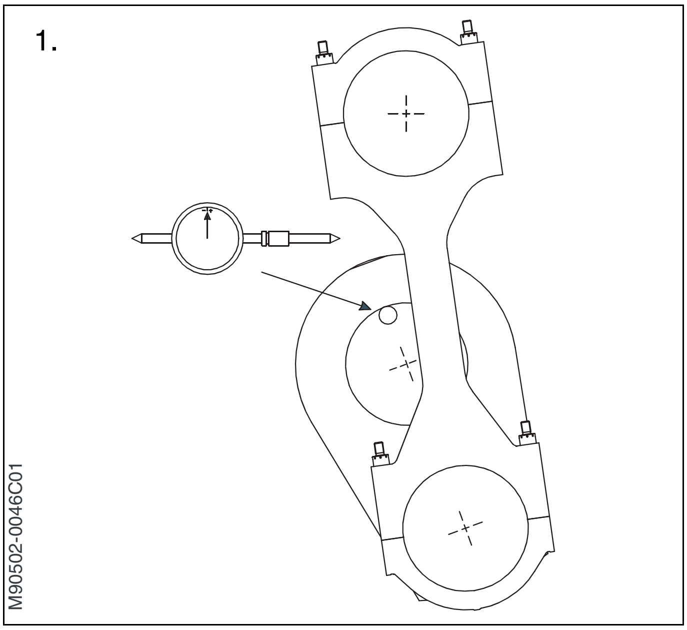
As the alignment is influenced by the engine temperature as well as the loading conditions, deflection measurements should, for comparison purposes, always be made under nearly the same temperature and load conditions.

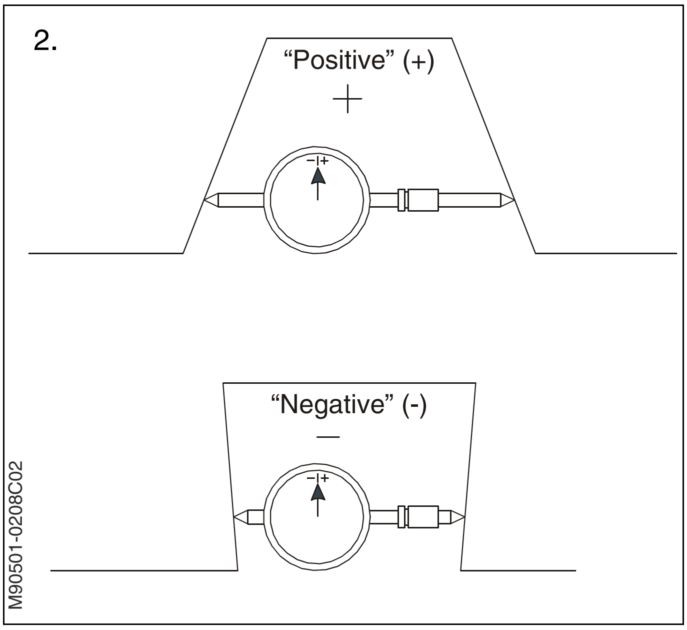
1. Place a dial gauge axially in the crank throw opposite the crankpin, as illustrated on the sketch. The correct mounting position is marked with punch marks on the crank throw. *See also Chapter 708 in Volume I.*

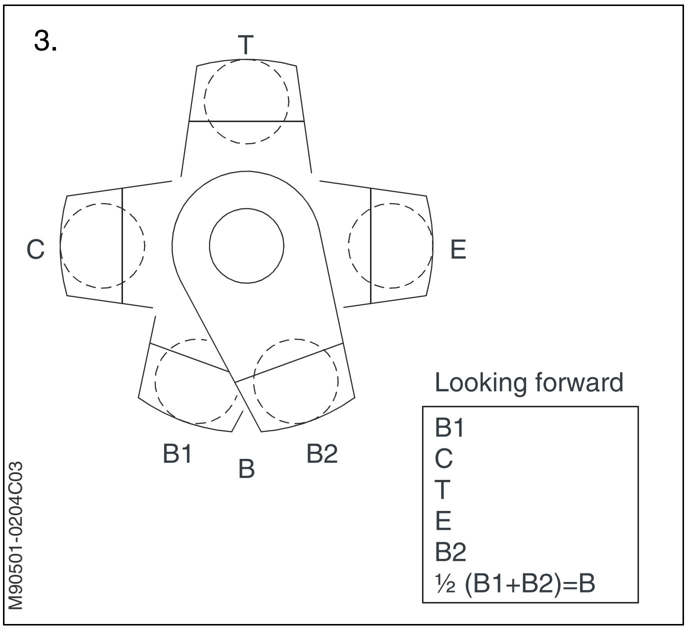
2. “Closing” of the crank throw (compression of the gauge) is regarded as negative (–) and “opening” as positive (+).

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)







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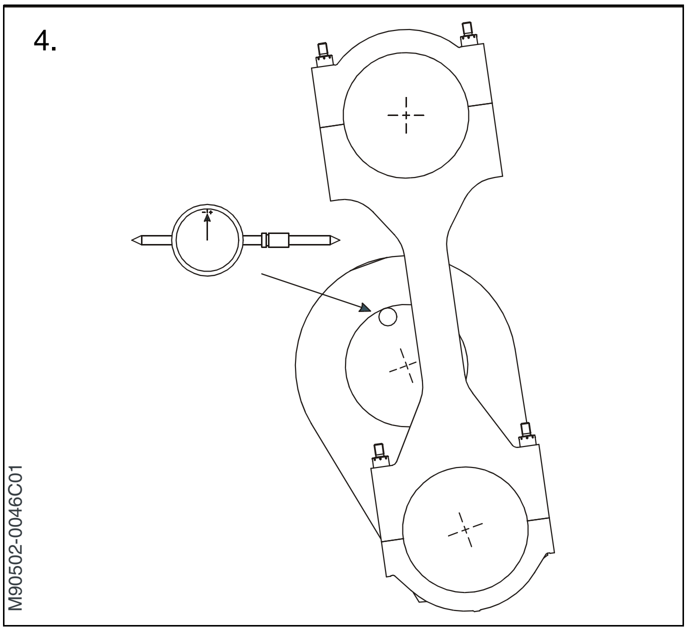

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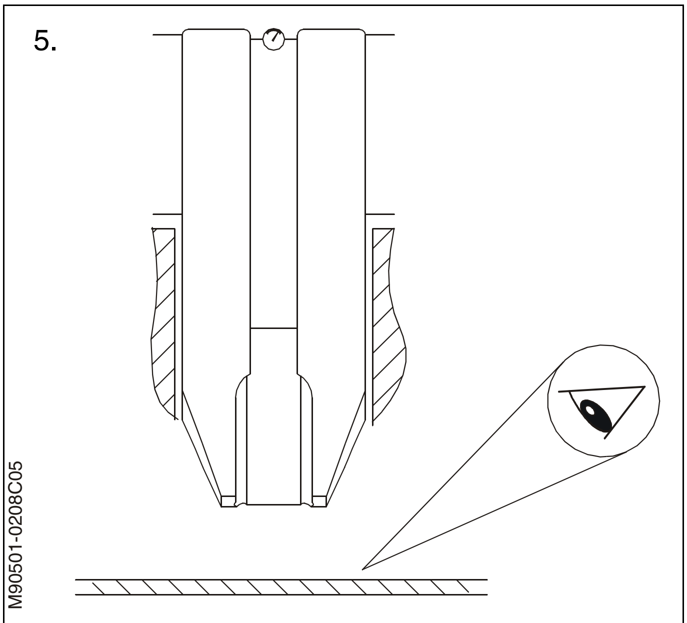


4. When taking deflection readings for the three aftmost cylinders, the turning gear should, at each stoppage, be turned a little backwards to ease off the tangential pressure on the turning wheel teeth. Otherwise, this pressure may falsify the readings.

   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.

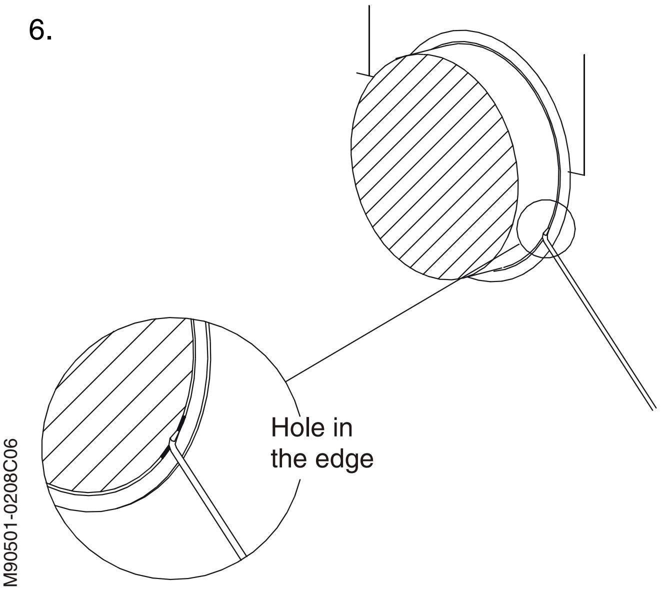
Large, thick pieces will normally be found during a crankcase inspection, and small, thin pieces can enter the filter. A check of the bearing edges together with inspection of the crankcase and the filter normally provides a good indication of the bearing condition.

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.

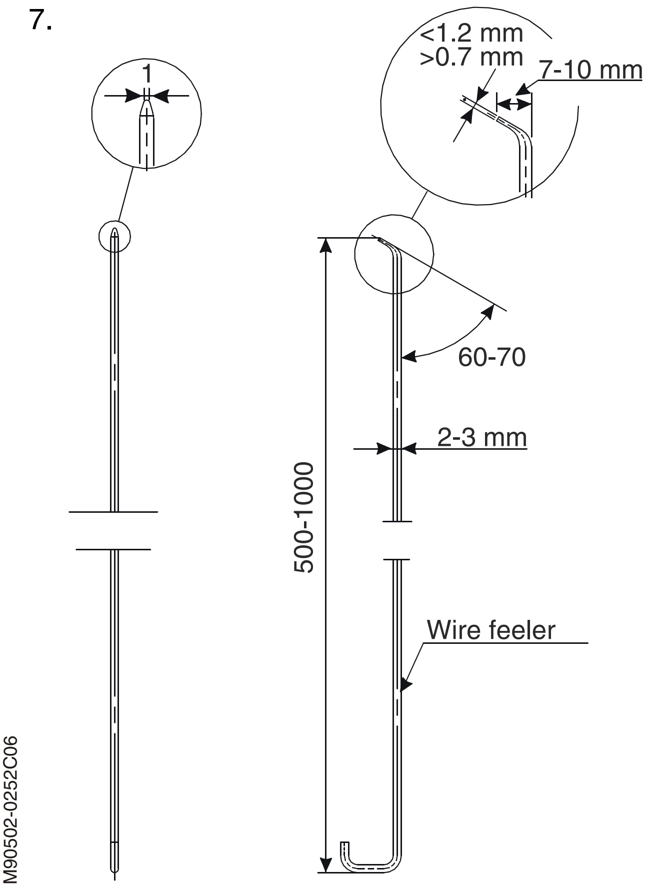
6.



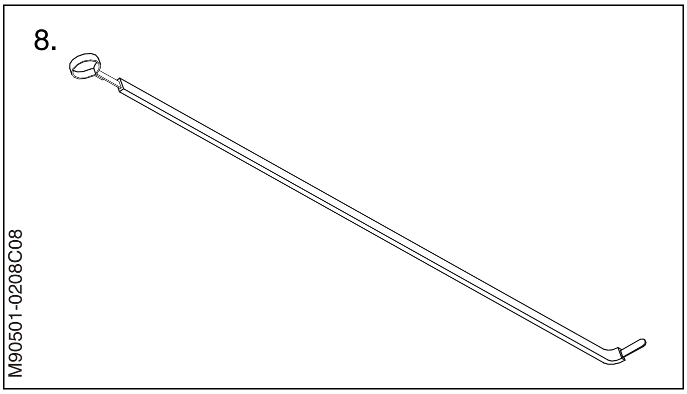
Wire-feeler

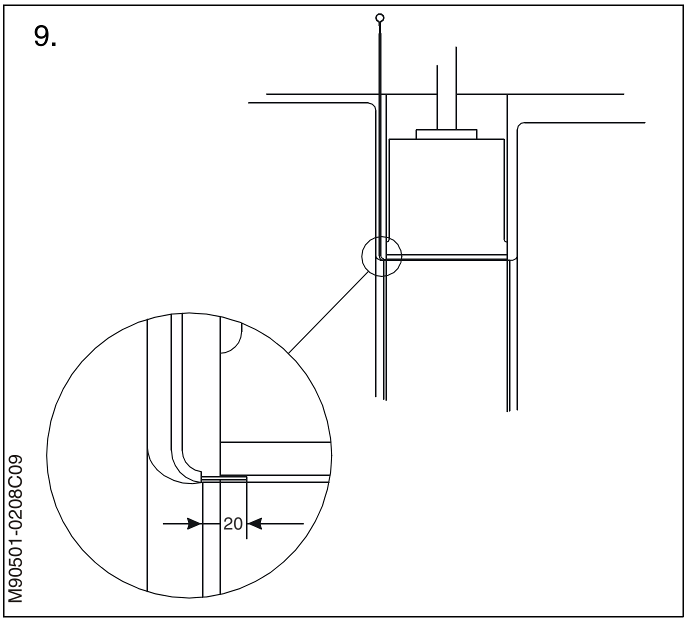
7. It is rather easy to make a feeler (see sketch). The “feeler” should be made from a piece of steel wire (e.g. a welding rod) approx. 0.6 - 1 m long depending on the engine type, and 2 to 3 mm thick. Approx. 7 to 10 mm of the wire should be bent to an angle of approx. 65° to form a “feeler tip”. Grind 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.

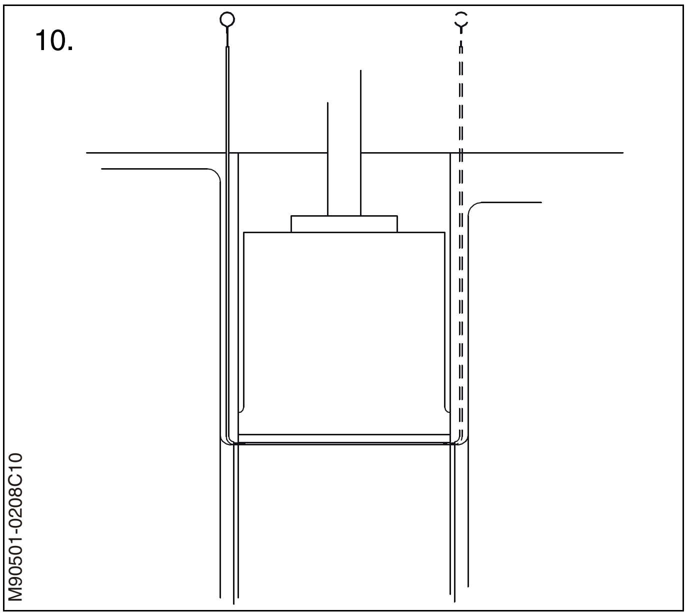
7.



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 = 0.75 mm / No go = 0.8 mm.

   Check the feeler blades after measuring.

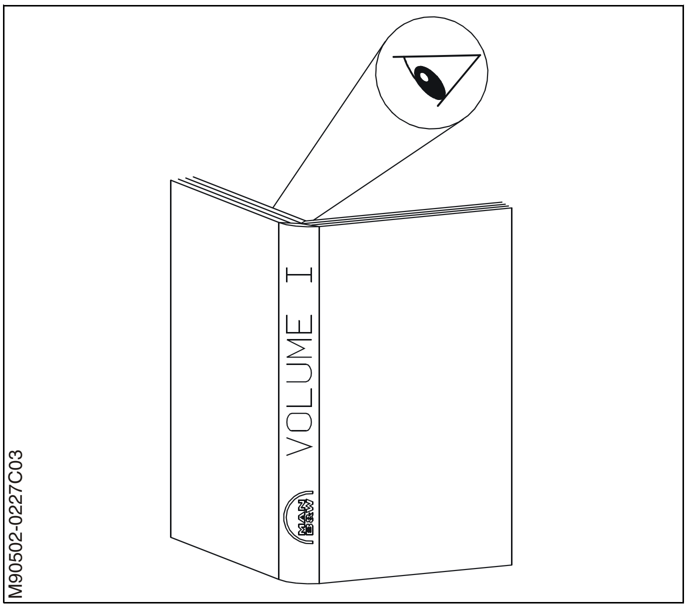
10. The clearance is measured at both the fore and the aft part of the bearing.

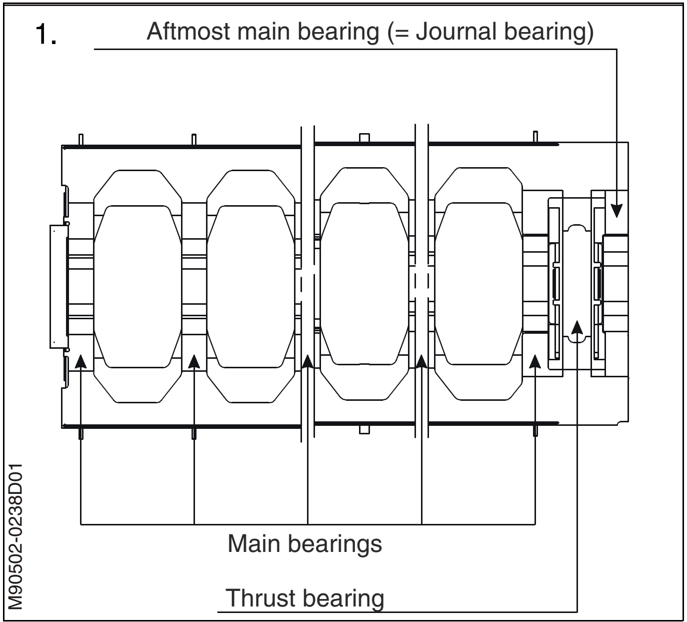
Note!
The bearing clearances for a new bearing stated in Data (*see Data 105-2*) are for guidance purposes only.

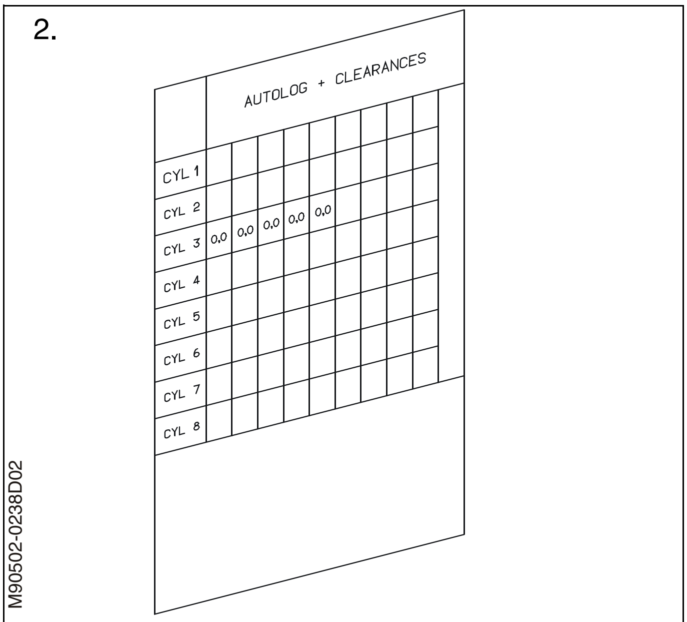
11. The difference between the actual clearance measurement and the measurement recorded in the adjustment sheet (or the clearance noted for a new bearing installed later) must not exceed 0.10 mm. If it does, *see* Volume I, Operation, Chapter 708.

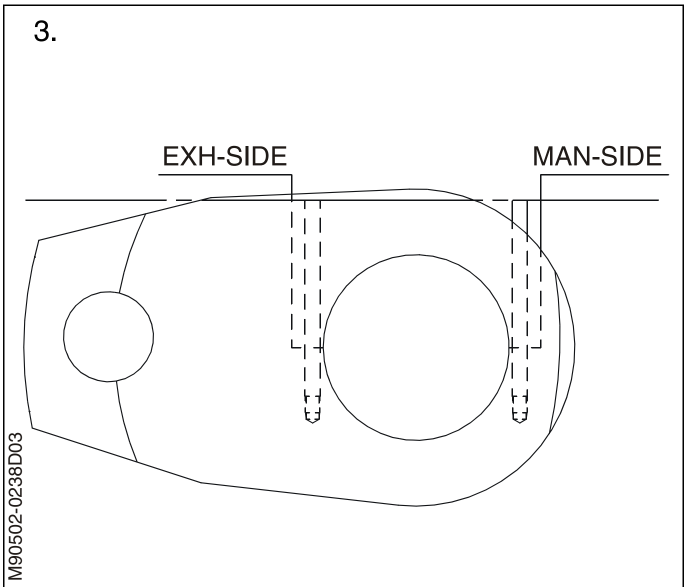
    For evaluation of the bearing, *see Volume I, Operation, Chapter 708.*

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









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.

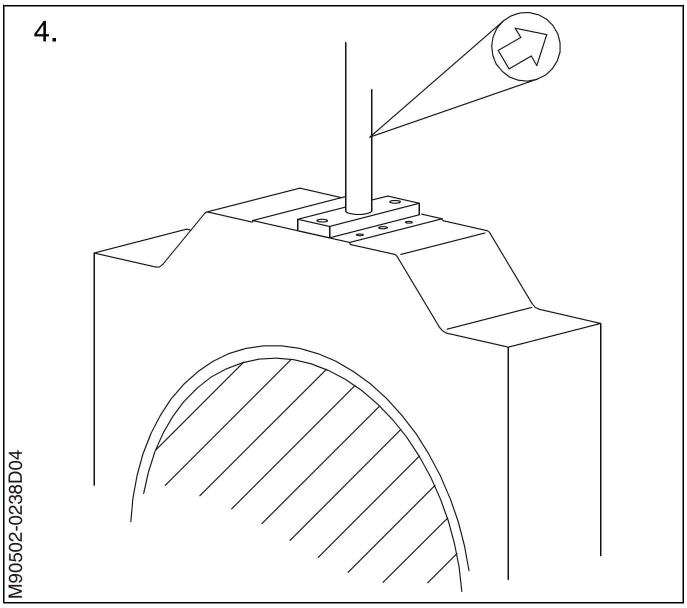
Note!
Be sure that the crosshead for the neighbouring cylinder is in a higher position than for the cylinder you are working on, otherwise it will be impossible to lift the cap.

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.

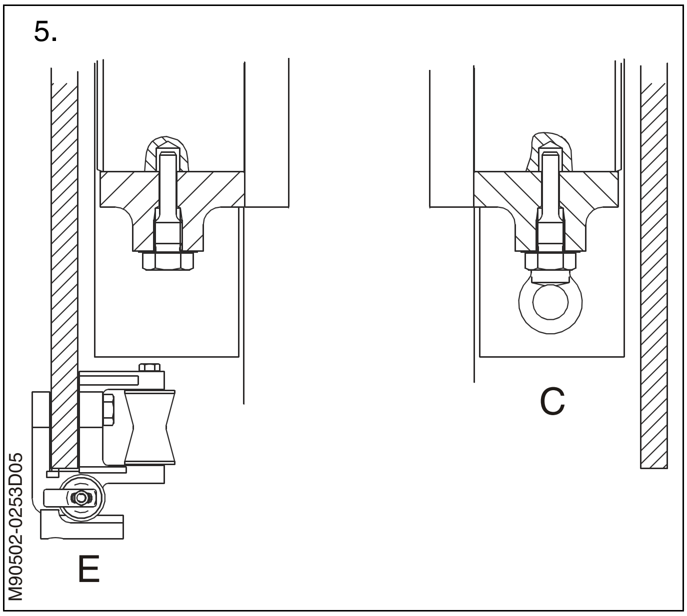
Note!
Some engines have temperature sensors fitted to the main, crosshead, and crank-pin bearings. These sensors must be carefully handled to avoid damaging the equipment.



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.

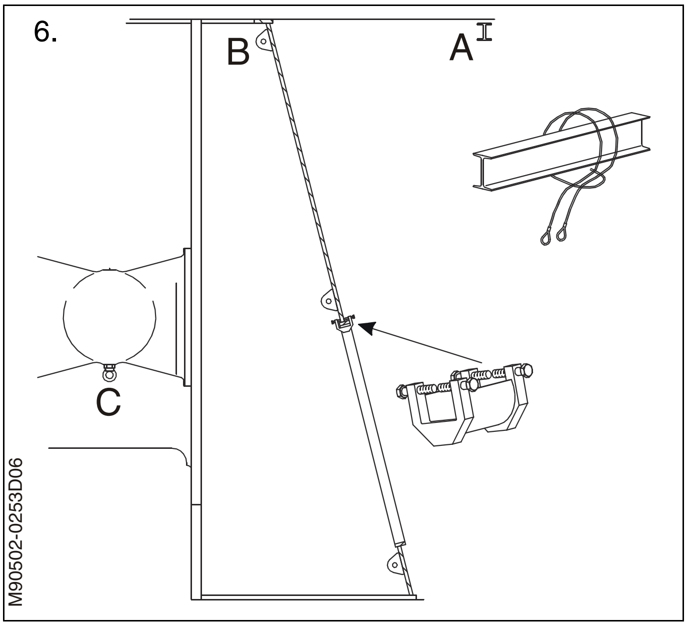


6. Mount the wire guide as shown. Mount tackles in the following positions:

   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



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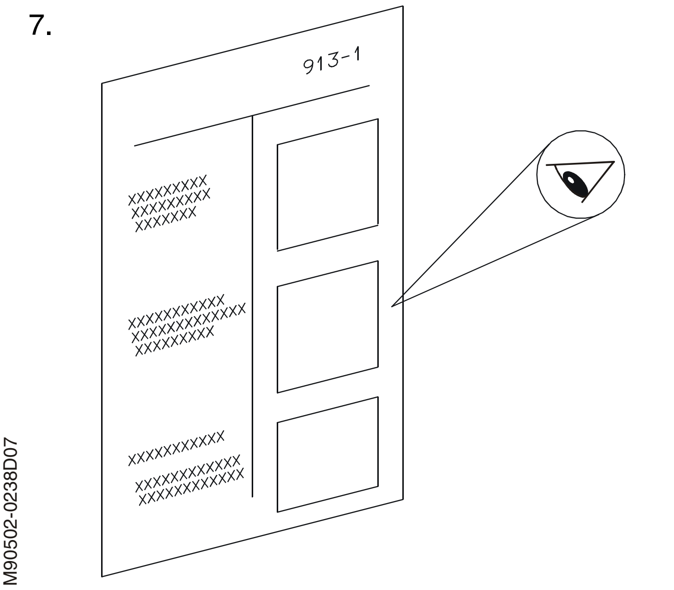

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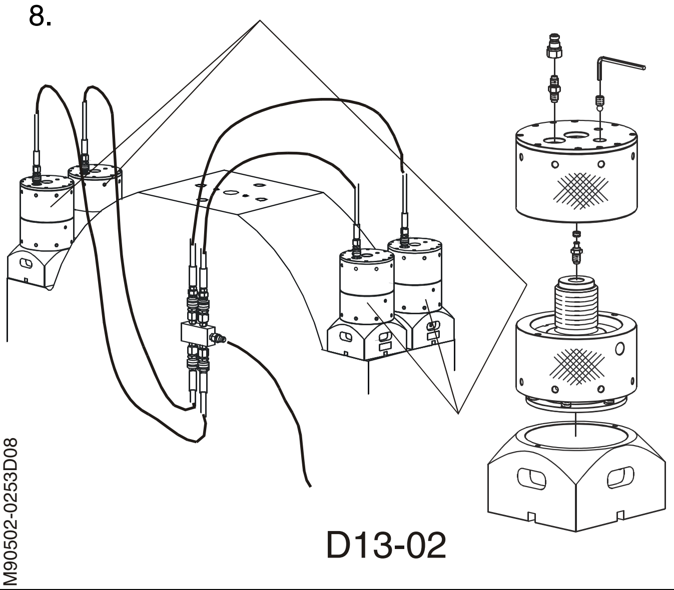


Loosening the nuts

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.

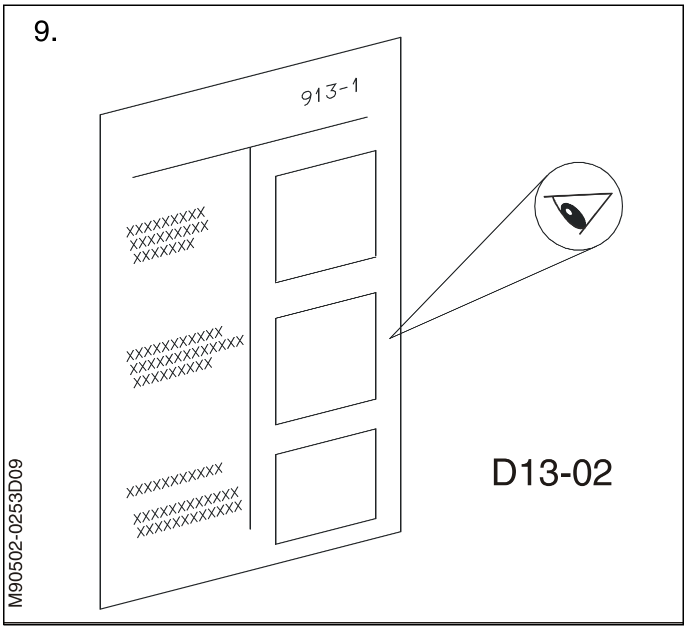
   Remove the hydraulic main bearing tools from the engine.

   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.



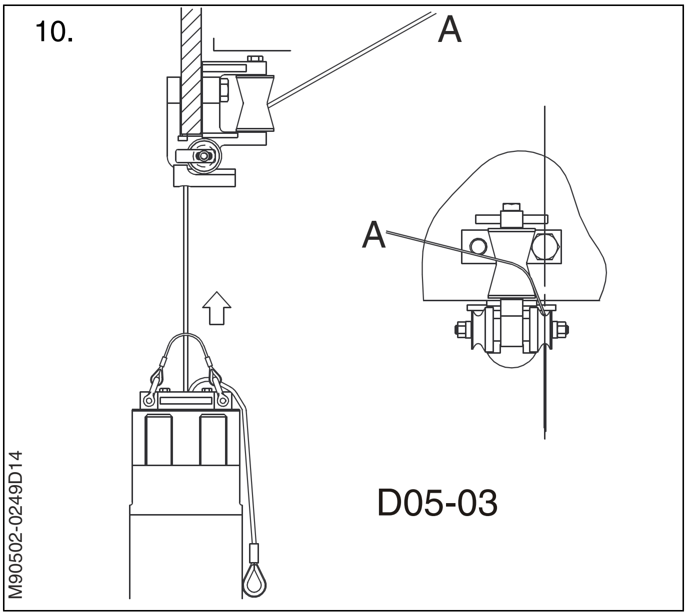
Removal of main bearing cap

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.

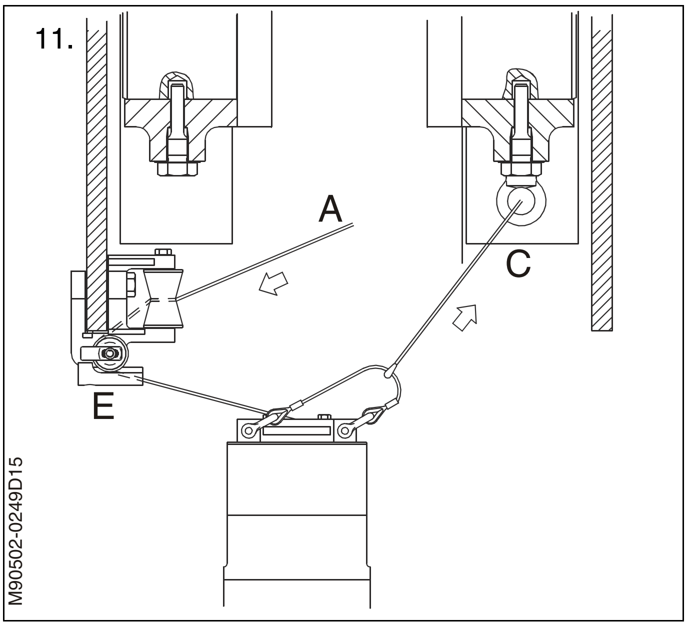
Note!
When tightening up the tackle, be sure that the wire guide is positioned correctly to protect the doorframe.

    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 crosshead guides.



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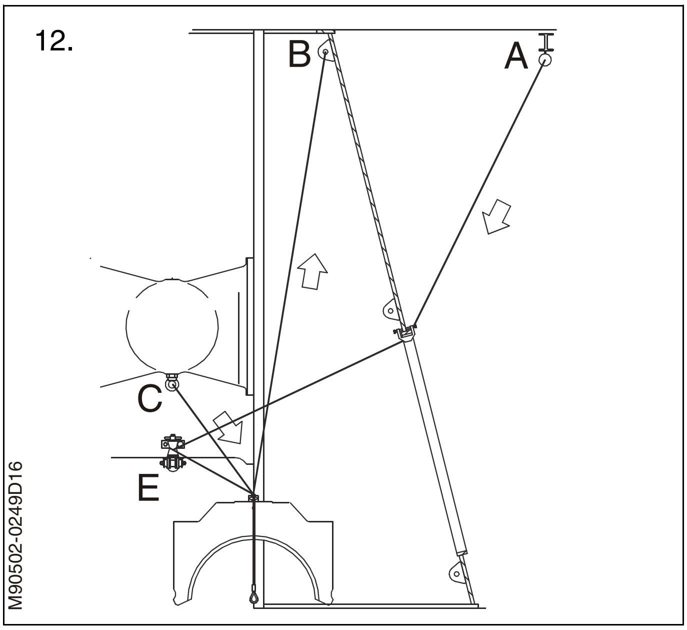

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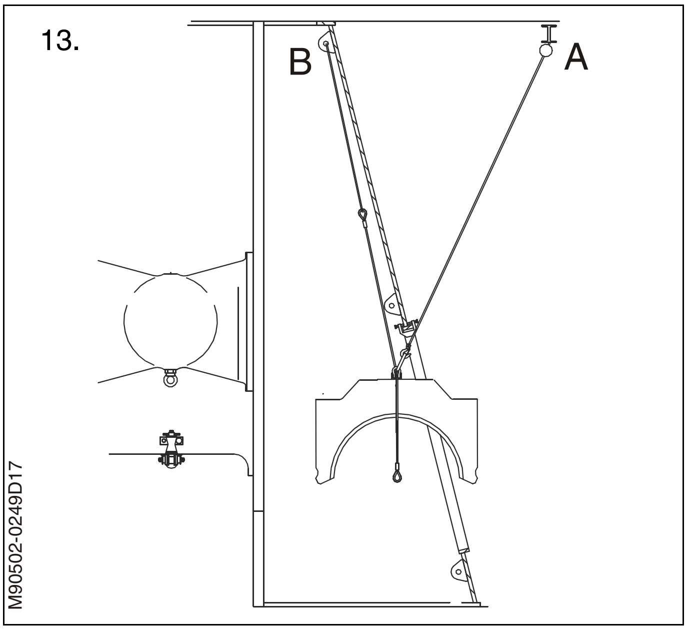

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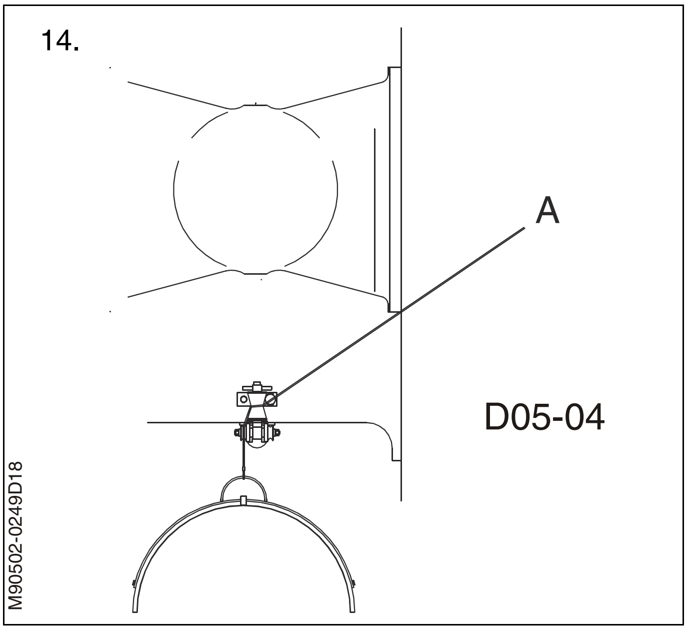

12. Attach tackle **B** to the shortest of the free wire ropes.

    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 dismounted, 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.

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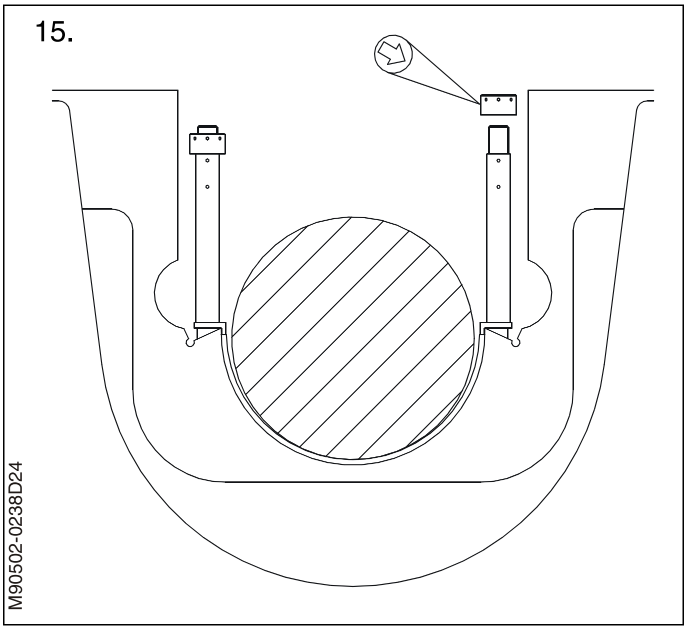

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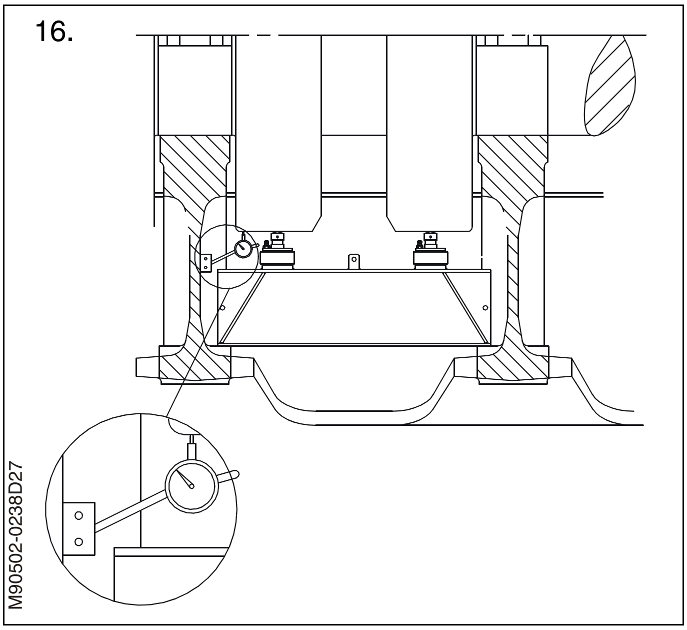

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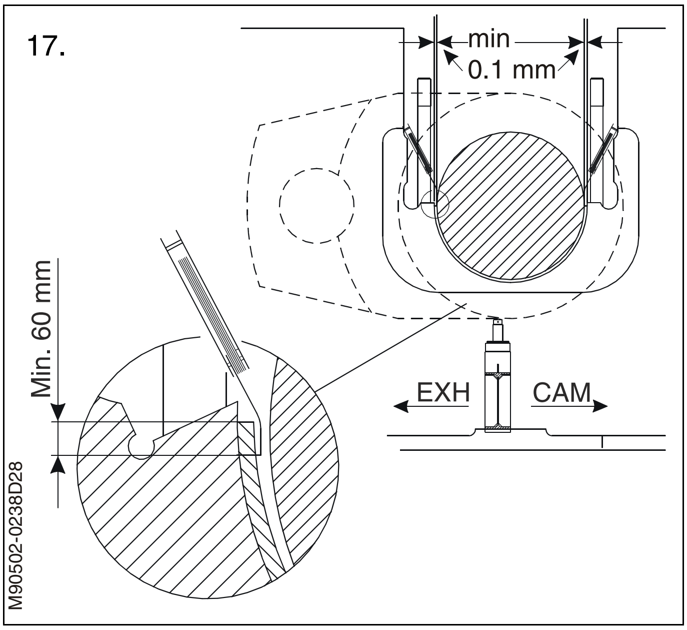

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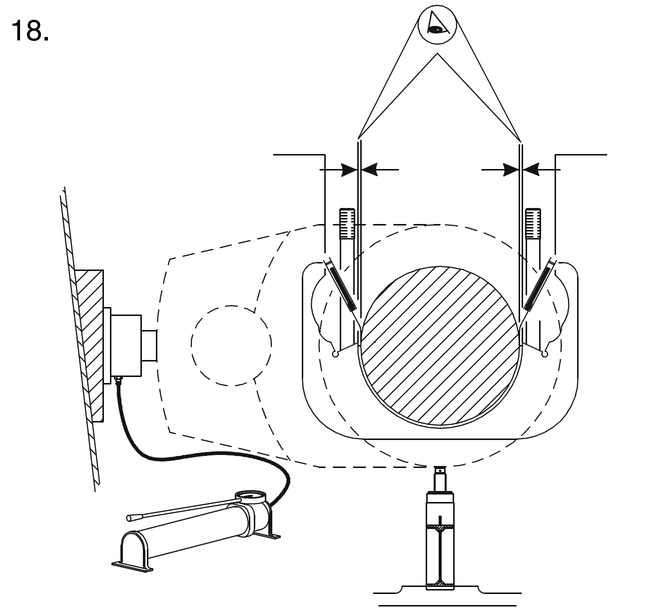

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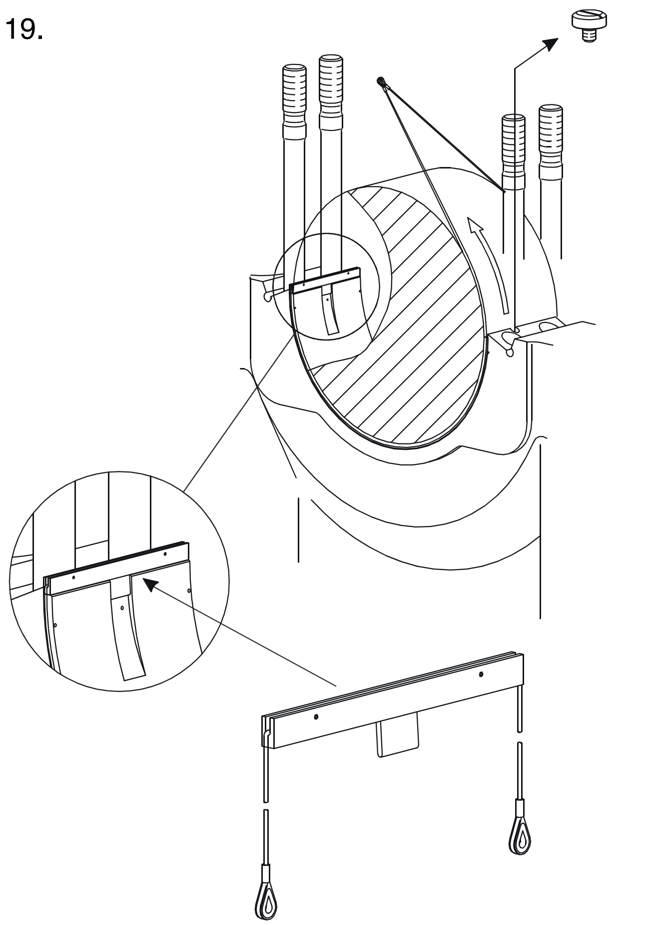
18. If re-positioning of the crosspiece does not ensure a vertical lift, place a 5-tonne jack between the side wall and the crank throw, to correct the journal position in this way.

    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.



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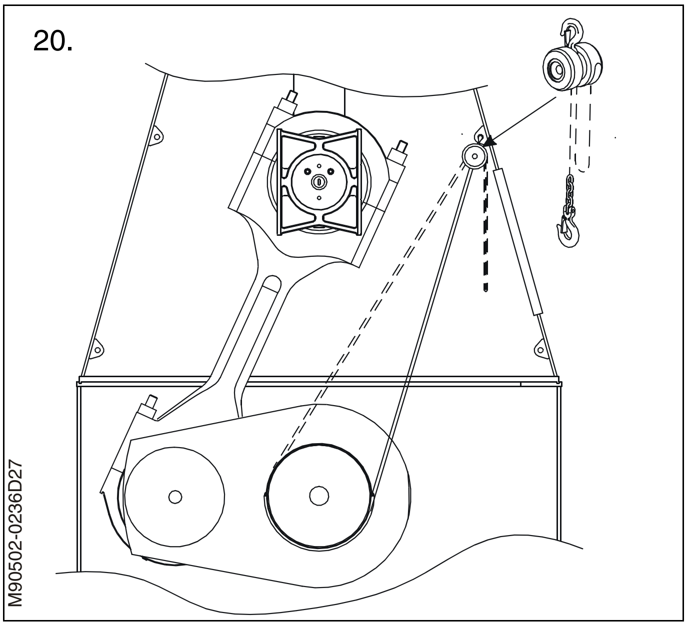
19. Dismount the locking screws.

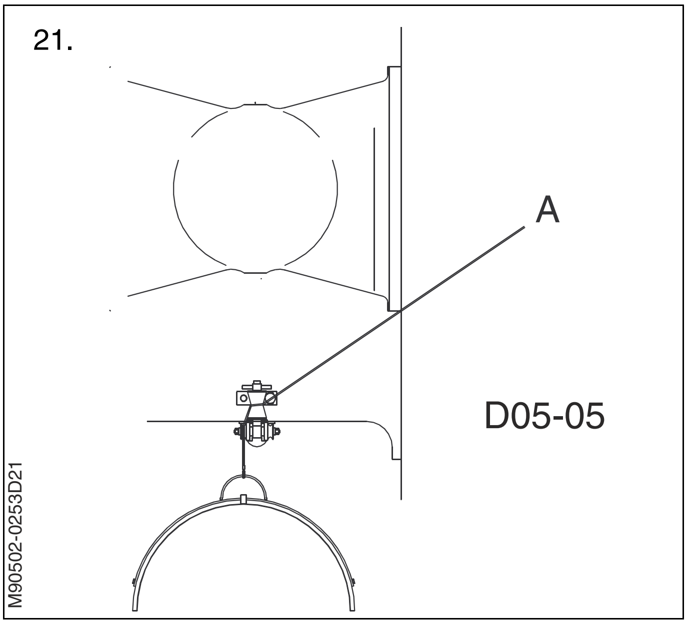
    Place the dismantling tool on top of the lower bearing shell. Make sure that the flap on the dismantling tool enters the oil groove in the bearing shell.

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.





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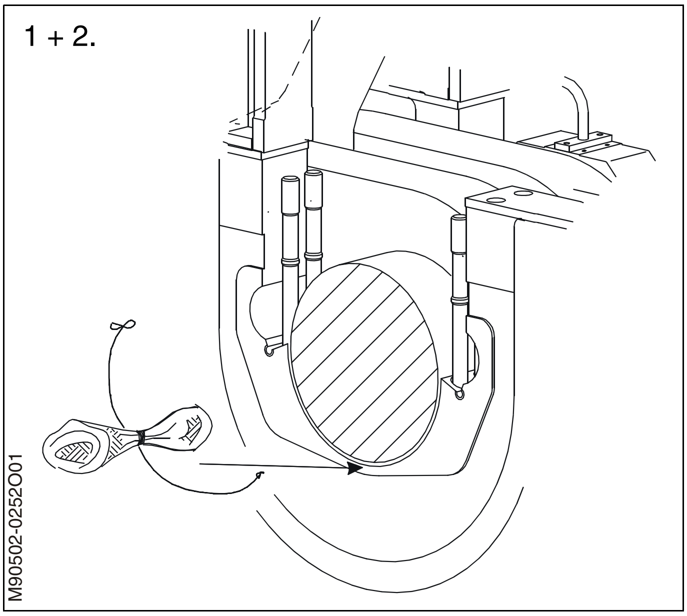


1. Clean and inspect the bearing shells. It is recommended that the main bearing shells be replaced in pairs.

   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 dismounted.

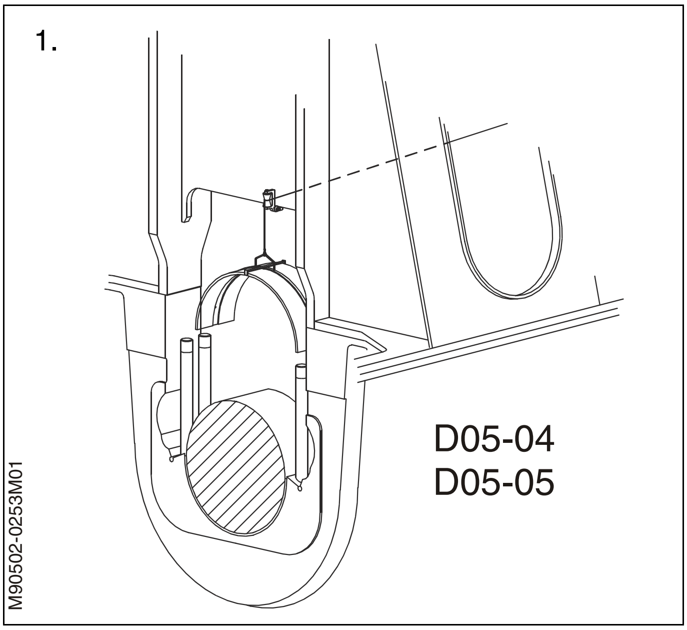
   To ensure that the shell is correctly mounted, check that the distance from the main bearing support to the shell is equal in both sides.

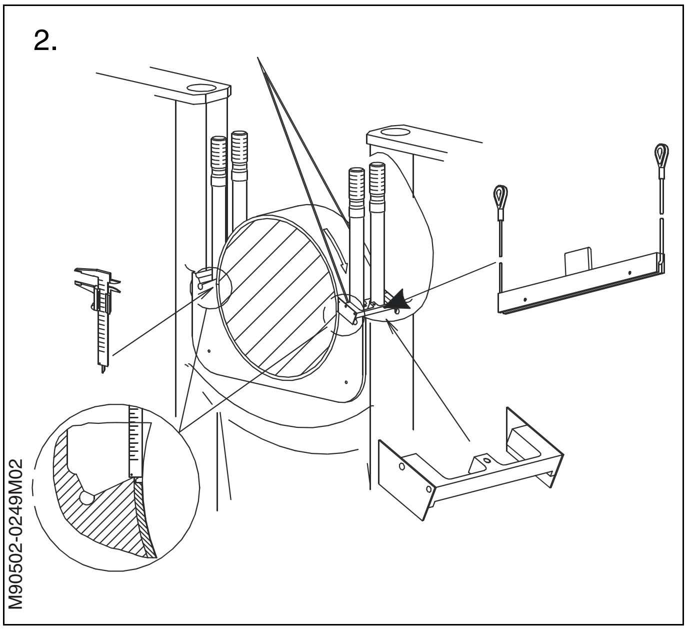
3. Remove the guide tool when the lower bearing shell has been mounted.

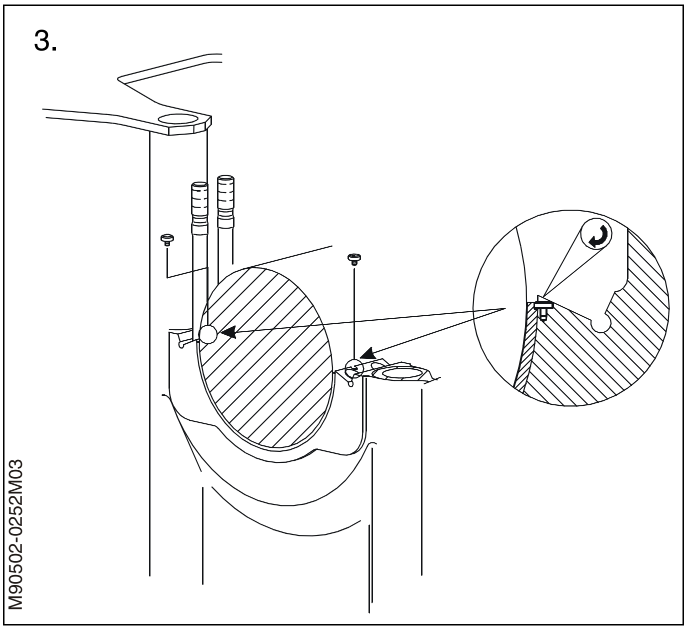
   Mount the locking screws in the bearing support.

   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.







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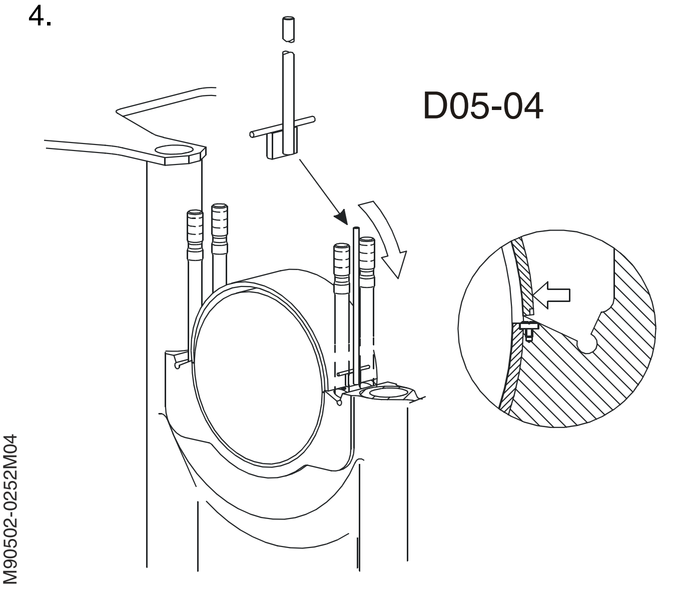

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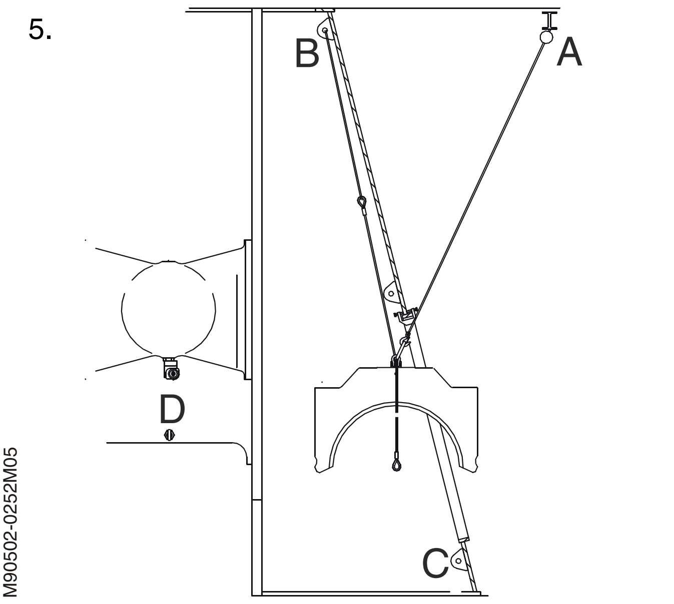


4. Land the upper bearing shell on the main journal in the same way as the lower bearing shell.

   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.

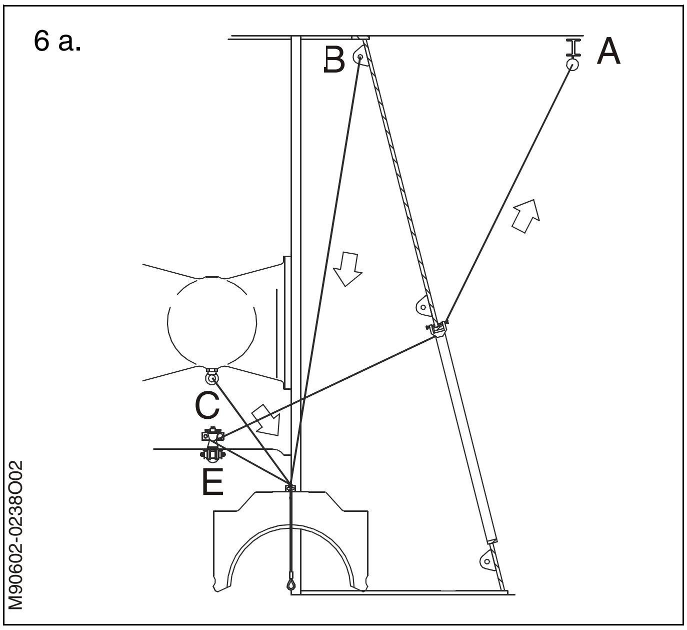
   Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.

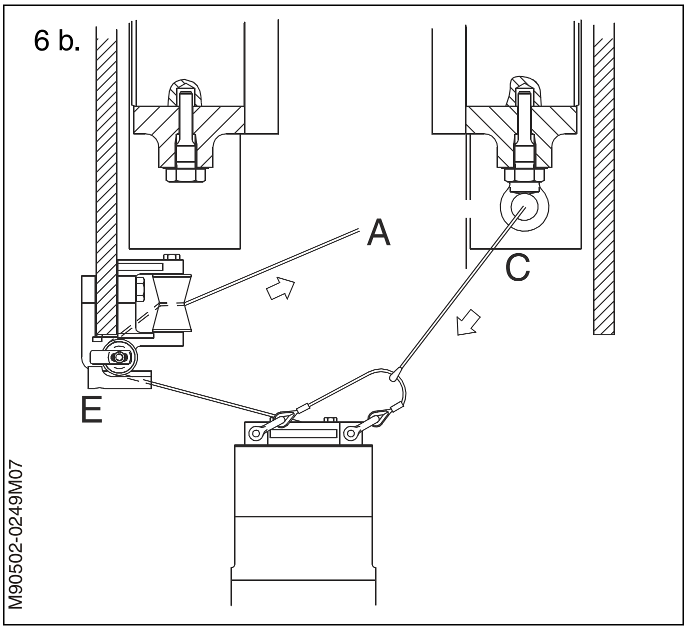
5. Mount the lifting tool on the bearing cap. Using the tackles and wire ropes on the main bearing cap lifting tool, lift the bearing cap into the crankcase in reverse order to dismantling.
   See Procedure 905-2.2, step 17.

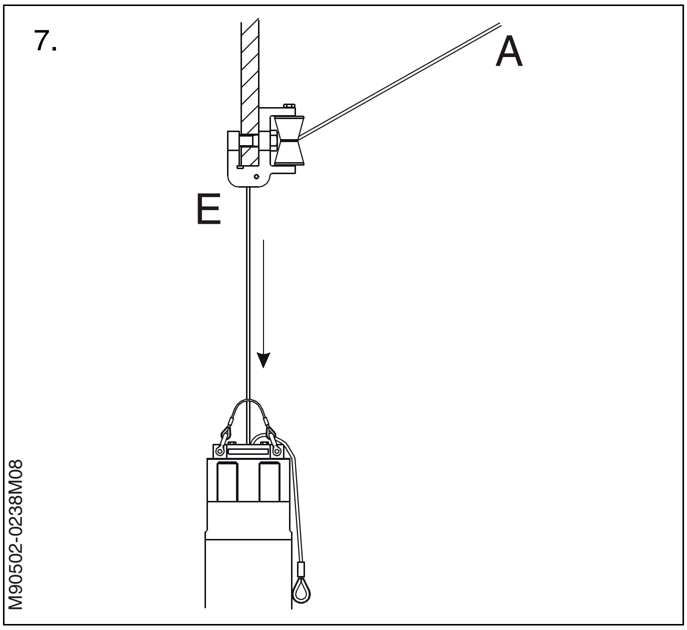
6. Using pulley **E** mounted above the bearing and the pull lift mounted below the opposite guideshoe, move the bearing cap into position vertically above the bearing journal in the reverse order to dismantling.
   See Procedure 905-2.2, steps 16-14.

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.







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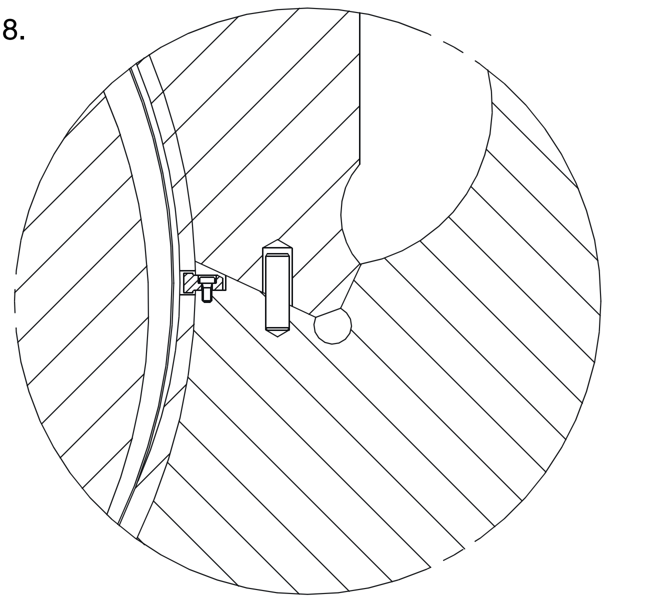

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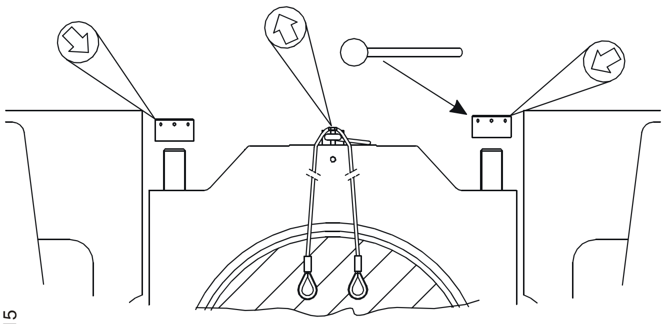

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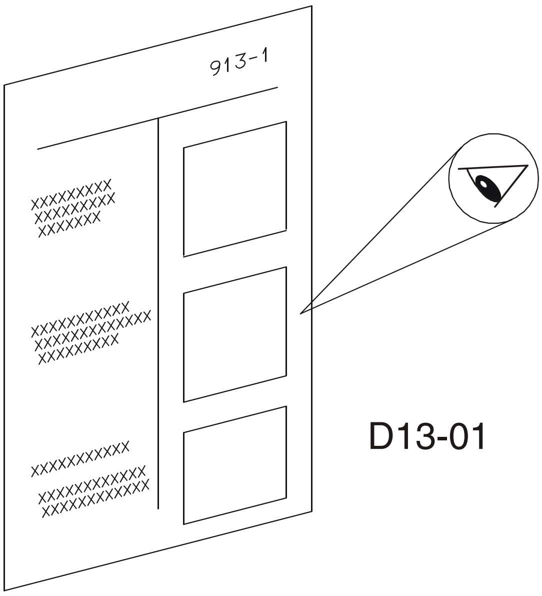

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8.

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.

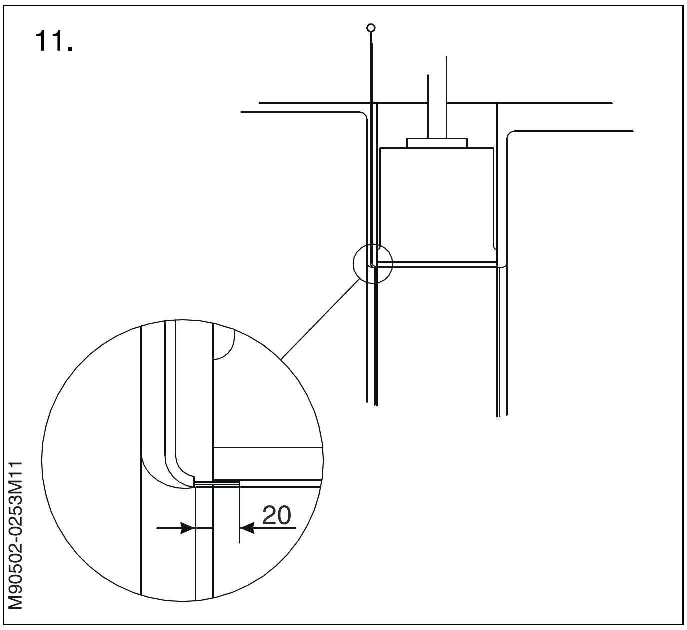
11.

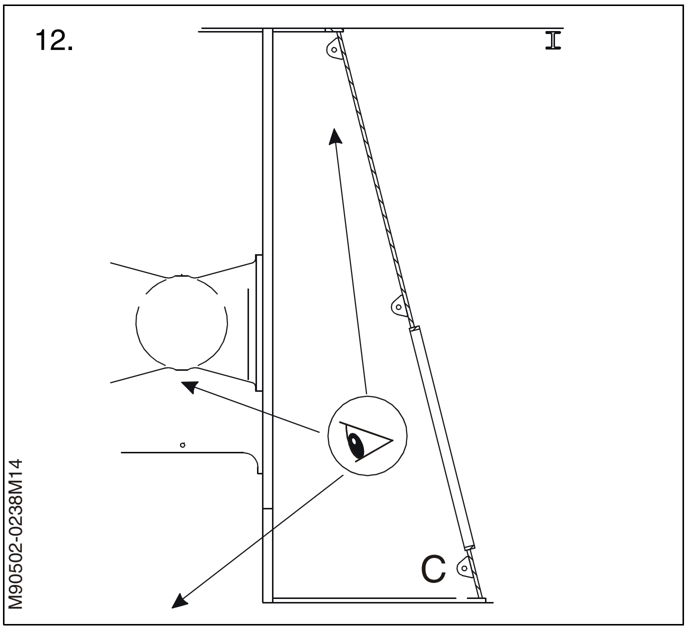
Note!
Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

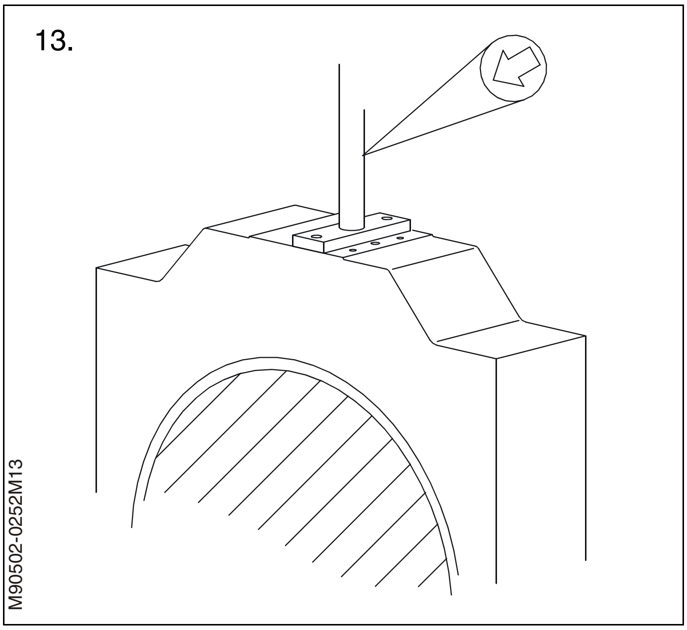
12. Remove all tools from the engine.

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,







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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-06	Thrust bearing segment	238	kg
D05-07	Segment stopper	17	kg
D05-28	Thrust bearing, top cover	860	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
P90551	123	Retaining tool for main bearing shell
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.

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 particles below the thrust bearing.

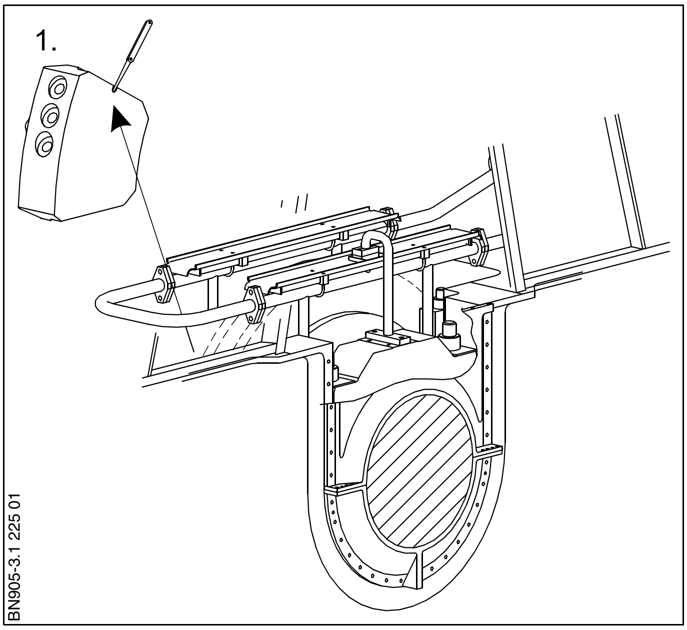
1. A wear groove of 1 mm is positioned in the uppermost thrust segment. (The segment with thermometers).

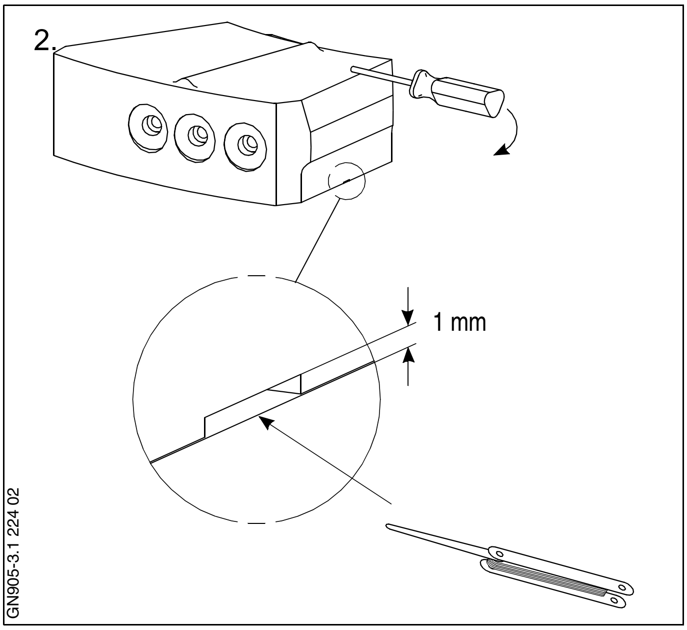
   It is possible to measure the wear from the crankcase, without dismounting the thrust bearing cover

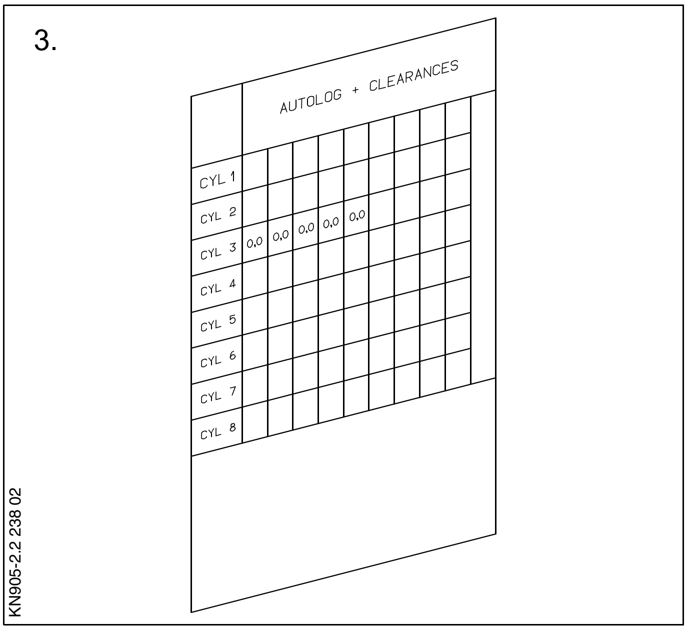
2. To measure the wear, the thrust segment has to be pressed against the thrust cam, to eliminate any gap, i.e. by using a suitable crowbar on the back of the segment.

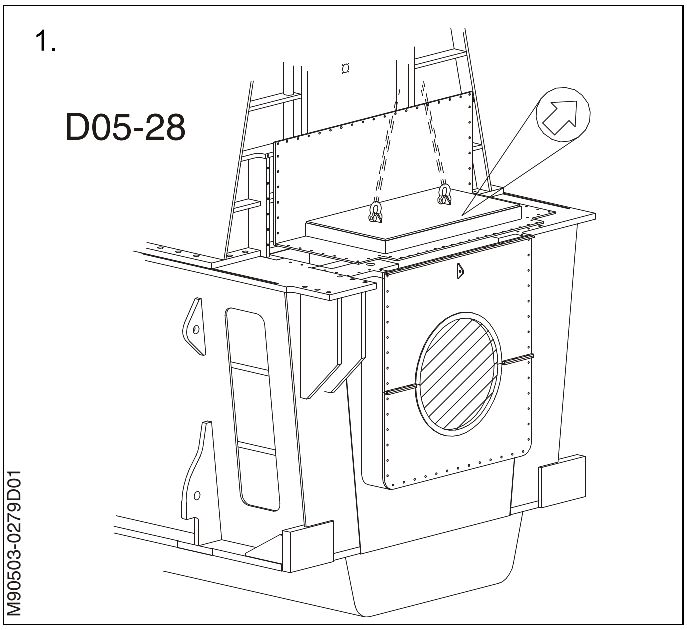
   If a feeler gauge of 0.1 mm is **not** able to enter the groove (the wear is more than 0.9 mm), the thrust bearing must be overhauled.

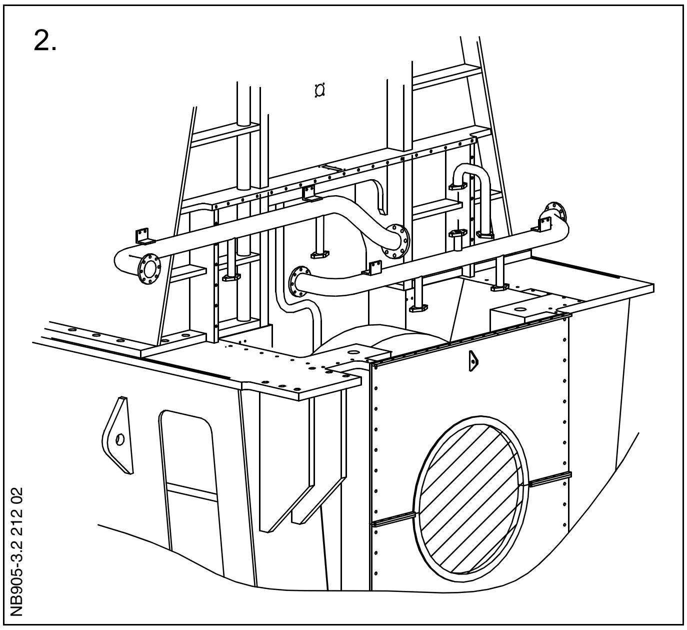
3. Note down the wear for later reference.

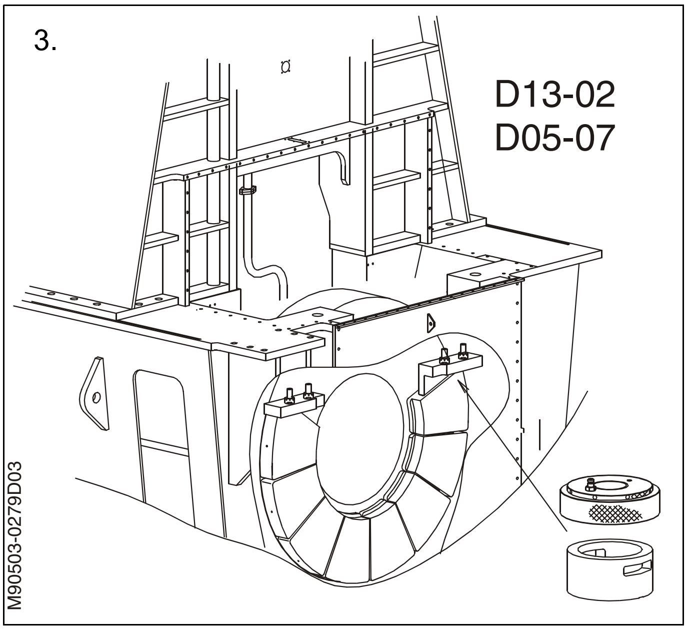












1. Remove the cover above the thrust bearing.

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

   Remove the lub. oil pipe above the thrust segments.

3. 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.

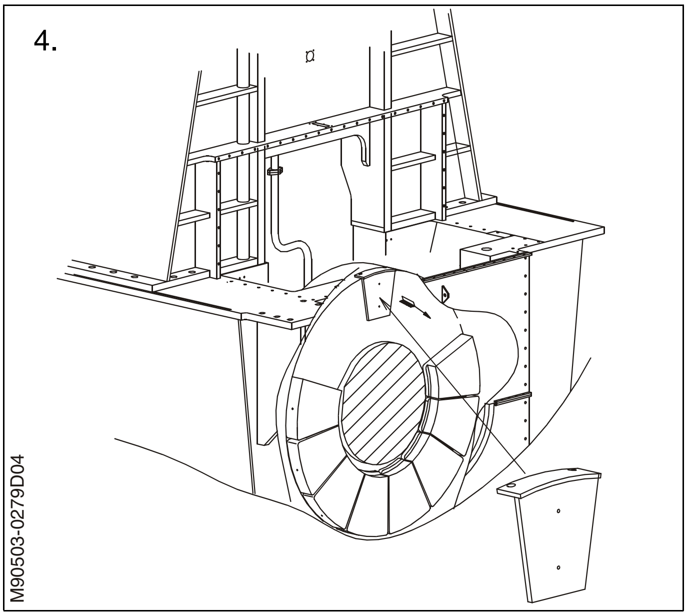
   Remove the stoppers from the chain drive above the thrust segments (AHEAD or ASTERN) that are to be taken out.

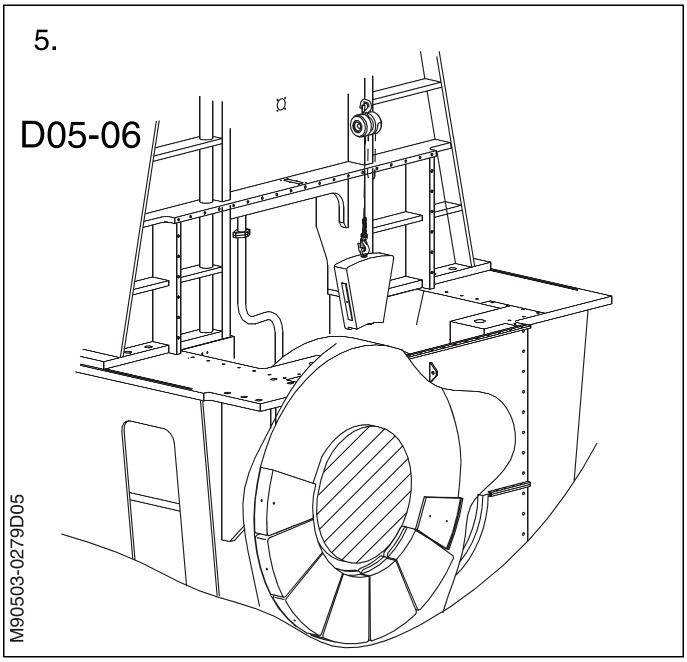
4. Suspend a tackle above the segments which are to be removed.

   For turning-up the thrust segments, mount the segment tool on the chainwheel.

5. Turn up the segments, one at a time, by turning the engine, and remove the segment from the engine. 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.





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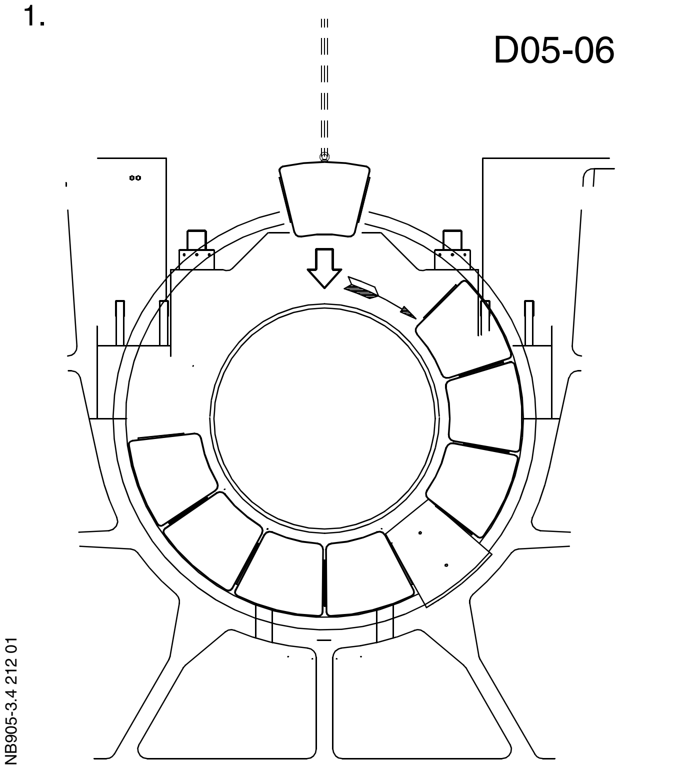


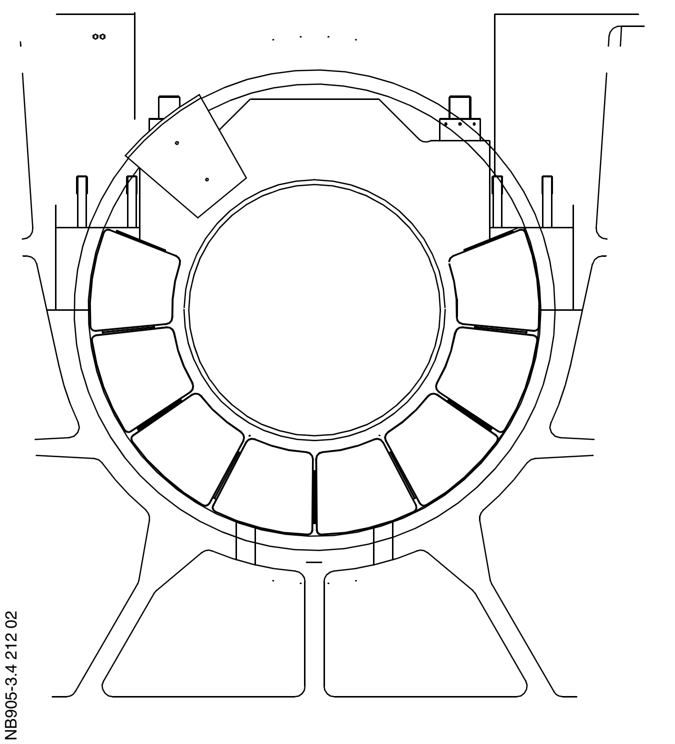
1. Suspend a tackle above the segments which are to be mounted.

   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.

2.



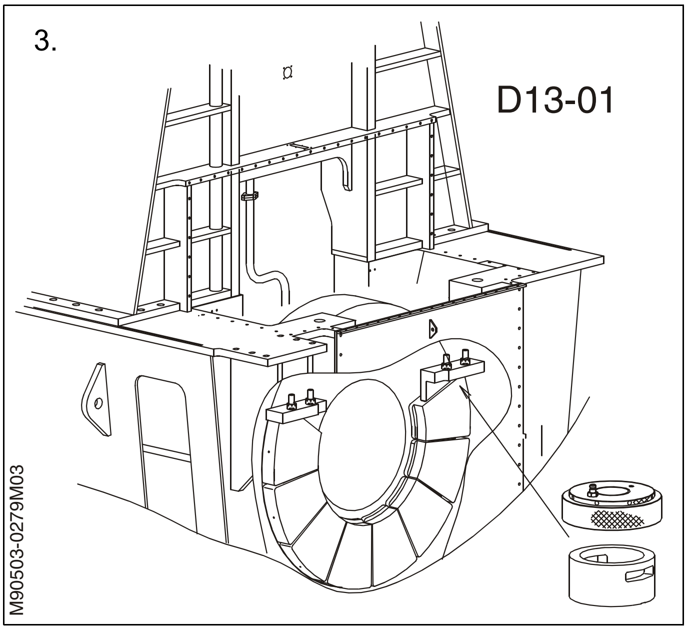
3. Mount the segment stoppers and the nuts.

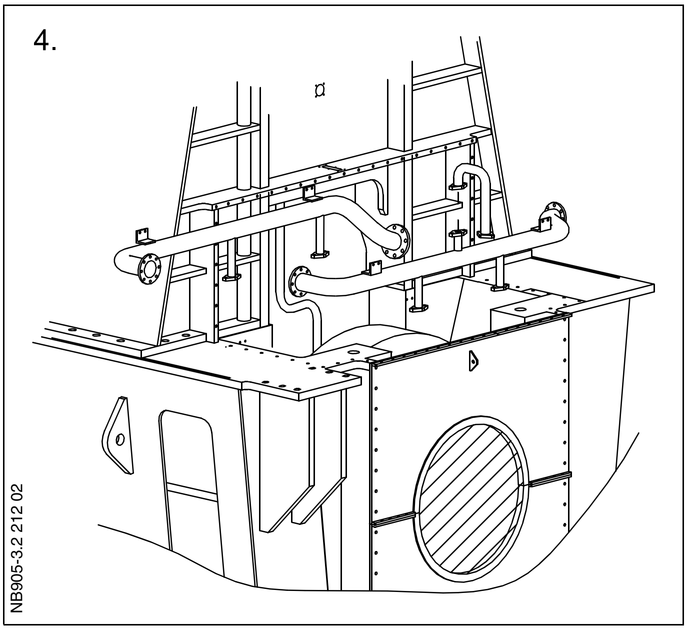
   Mount the hydraulic jacks and tighten the nuts on the stoppers. *See Data.*

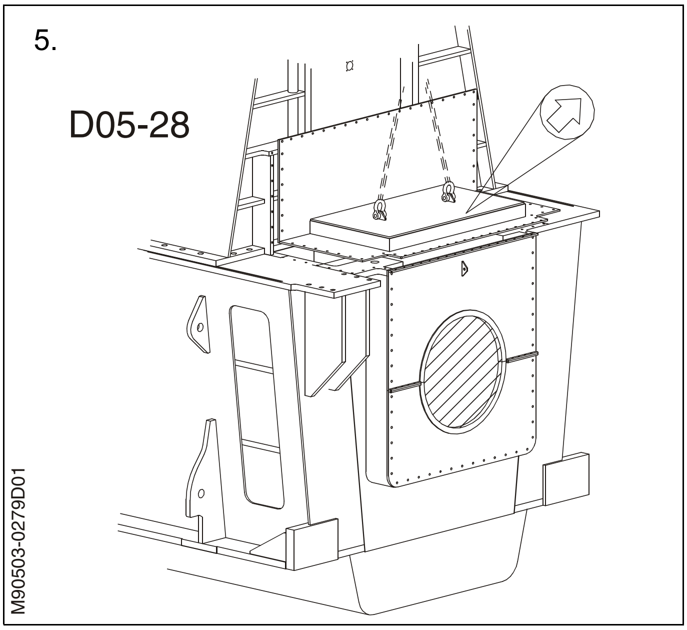
4. Mount the lub. oil pipe for the thrust segments.

   Mount the lub. oil pipe for the aftmost main bearing.

5. Mount the cover above the thrust bearing.







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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D05-11	Min. bearing clearance	0.5	mm
D05-12	Max. bearing clearance	1.05	mm
D05-13	Journal bearing cap	1900	kg
D05-14	Upper bearing shell	105	kg
D05-15	Lower bearing shell	110	kg
D05-28	Thrust bearing, top cover	860	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000-2400	bar

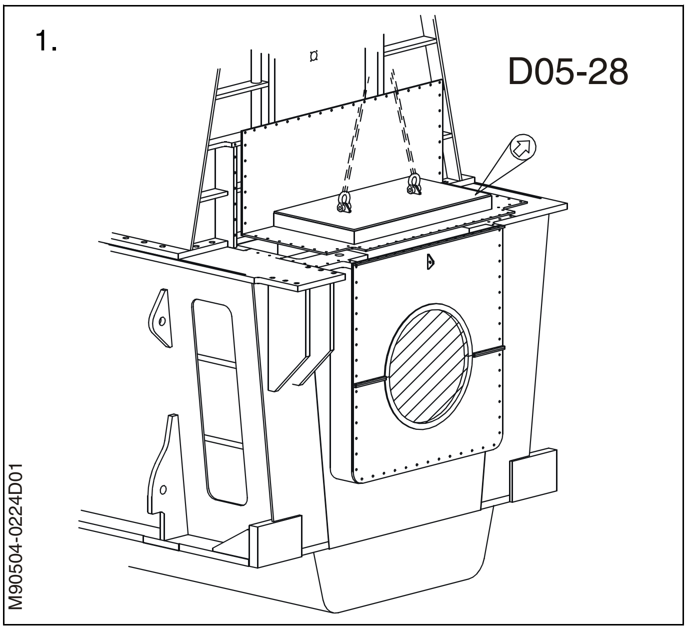
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

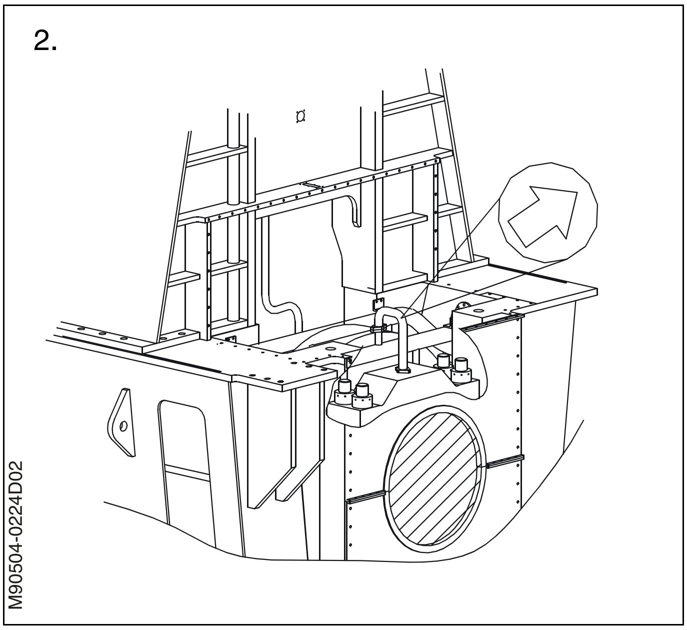
Plate	Item No.	Description
P90551	76	Lifting tool - main bearing cap
P90551	88	Dismantling tool, main bearing shell
P90551	90	Mounting tool for bearing shell
P90551	160	Wire
P90551	172	Mounting tool, thin bearing shell
P90561		Main Bearing - Hydraulic Tools
P90562		Lifting tool for crankshaft
P90571		Main Bearing Shell - Tools
P90572		Main Bearing - Measuring Tools
P91351	10	Hydraulic pump, pneumatically operated
P91351	22	Hydraulic pump, hand 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	58	Feeler gauge
P91368		Working Platforms

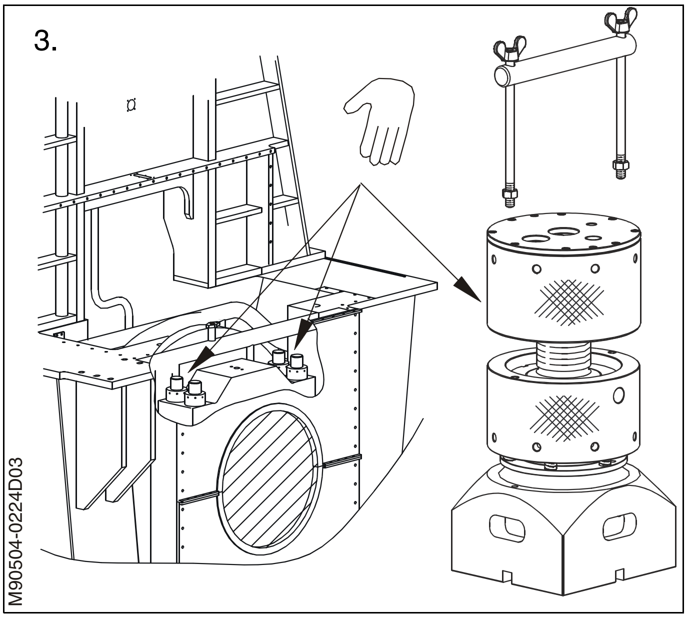
1. Remove the screws from the cover placed over the thrust bearing. Mount an eye bolt, shackles and wire rope on the cover. Hook on a tackle and lift the cover away.

2. Disconnect the lubricating oil pipe used for lubricating the bearing.

3. Mount the main bearing hydraulic jacks or the journal bearing studs.







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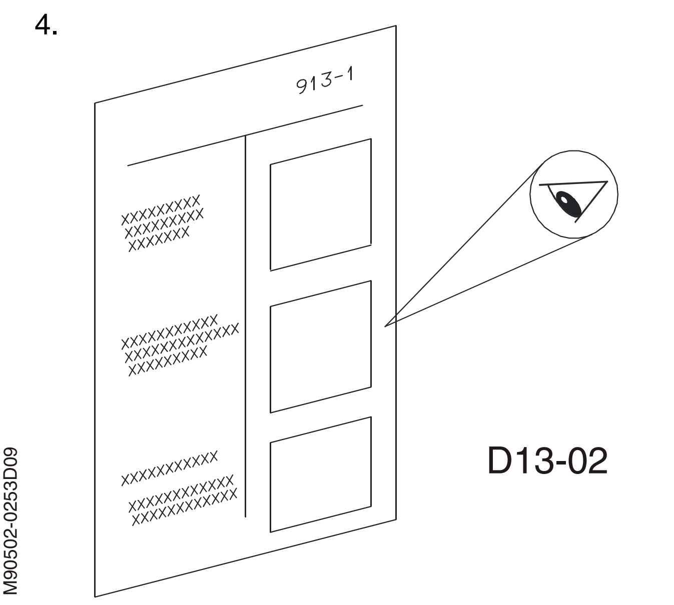

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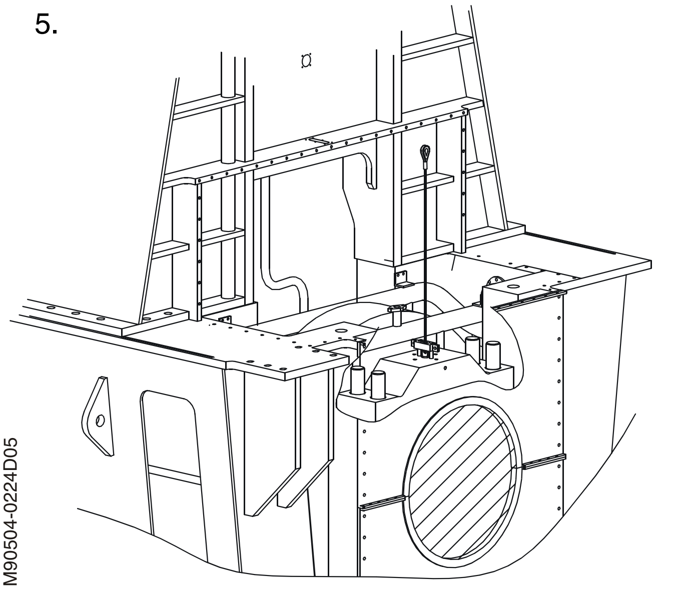


4. *For operation of the hydraulic tools, see Procedure 913-1.*

5. Mount the lifting tool on the bearing cap.

   Hook on the tackle above the bearing to the wire rope of the lifting tool.

6. Lift the journal bearing cap.

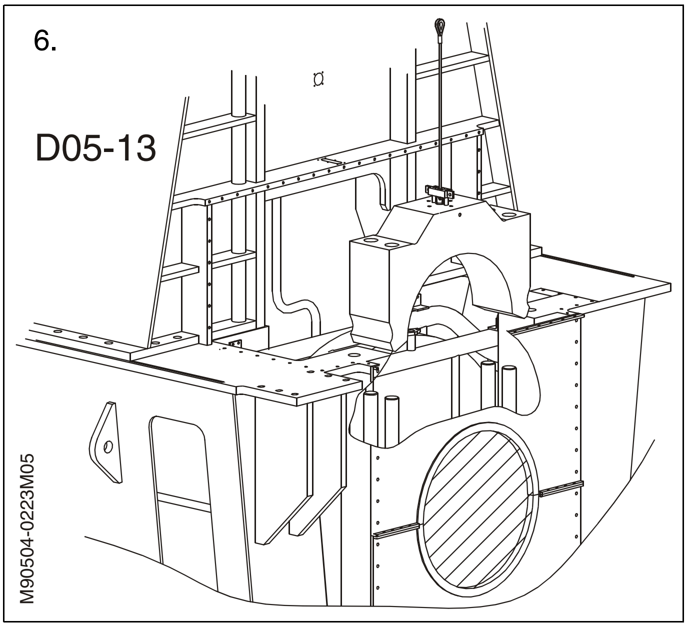
   Using another tackle, lift the bearing cap away from the engine.

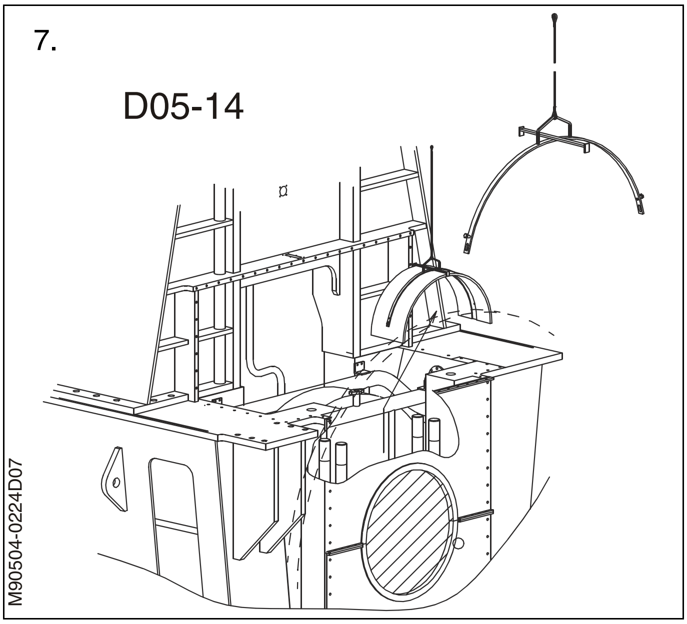
7. Mount the bearing shell lifting tool on the upper bearing shell, and remove the upper bearing shell from the engine.

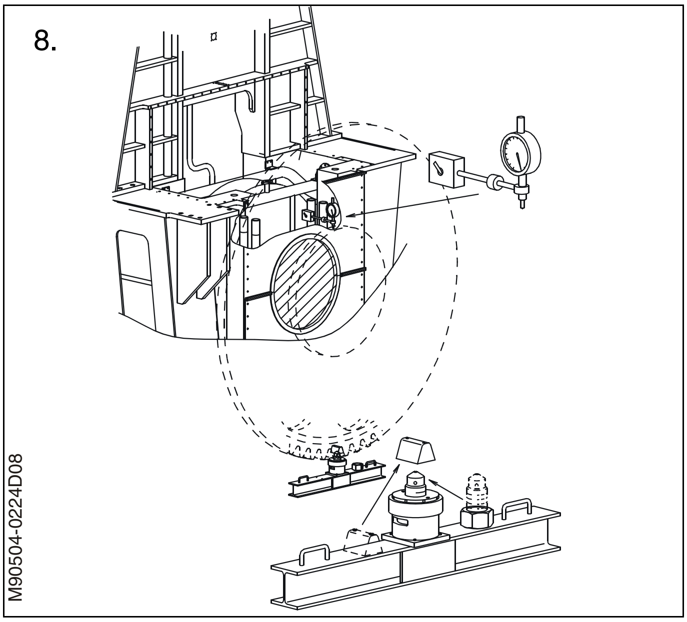
8. Place the crosspiece under the turning wheel as shown. Mount a dial gauge to measure the lift of the crankshaft.

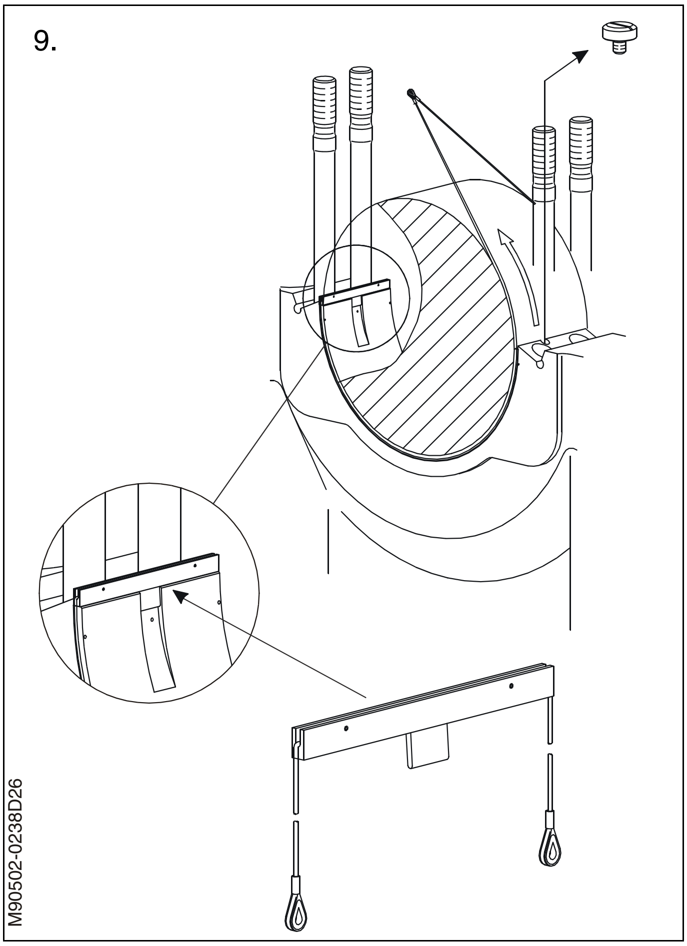
   Tighten the screw against the turning wheel and compress the jacks.

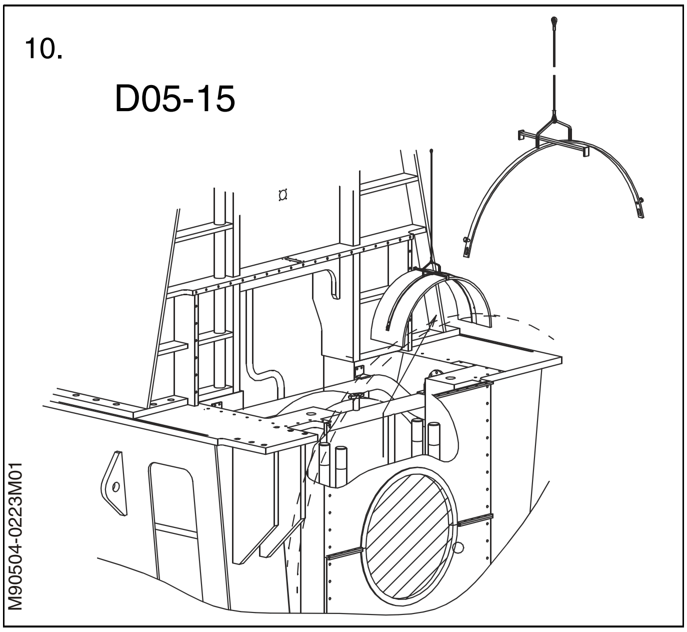
   Connect the hydraulic jacks to the high-pressure pump, and raise the pressure until the crankshaft has been lifted 0.2-0.5 mm, but max. the clearance in the adjacent bearing.











9. Dismount the locking screws.

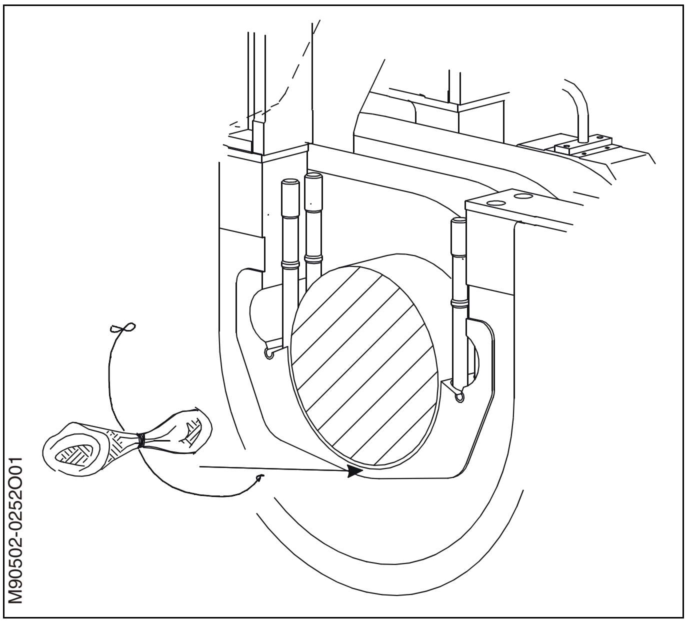
   Place the dismantling tool on top of the lower bearing shell. Make sure that the flap on the dimantling tool enters the oil groove in the bearing shell.

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

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.

10. Take out the lower shell from the crankcase in the same way as the upper shell.

Note!
Never remove the tools for lifting the crankshaft before the lower bearing shell has been remounted.



1. Clean and inspect the bearing shells. It is recommended that the 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 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.

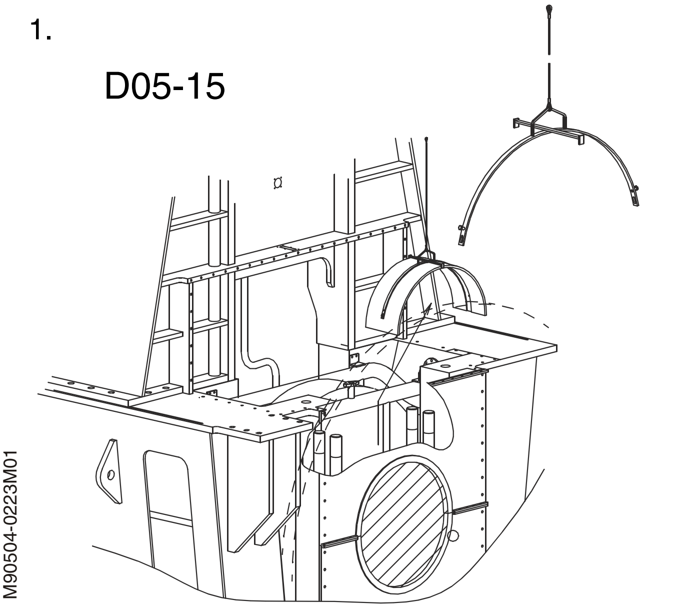
2. Before remounting:

   - 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 a non-fluffy cloth to clean between the journal and bearing support.

   - Lubricate the bearing journal, the bearing support and the back of the shell, with main engine lubricating oil.

1.



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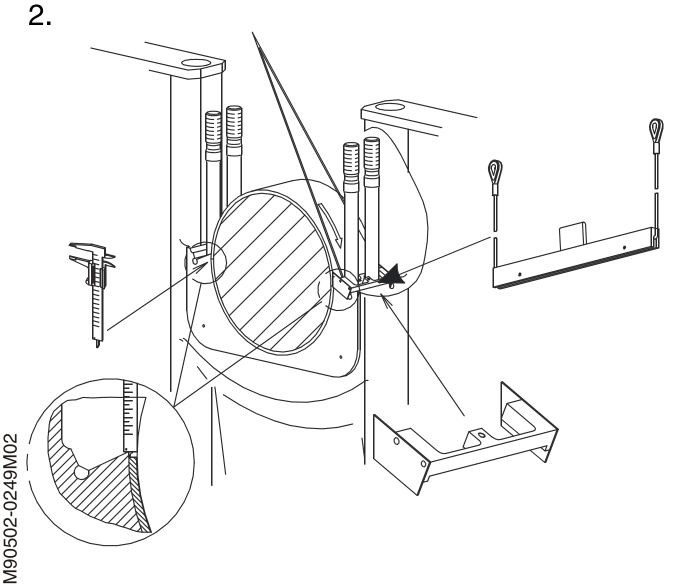

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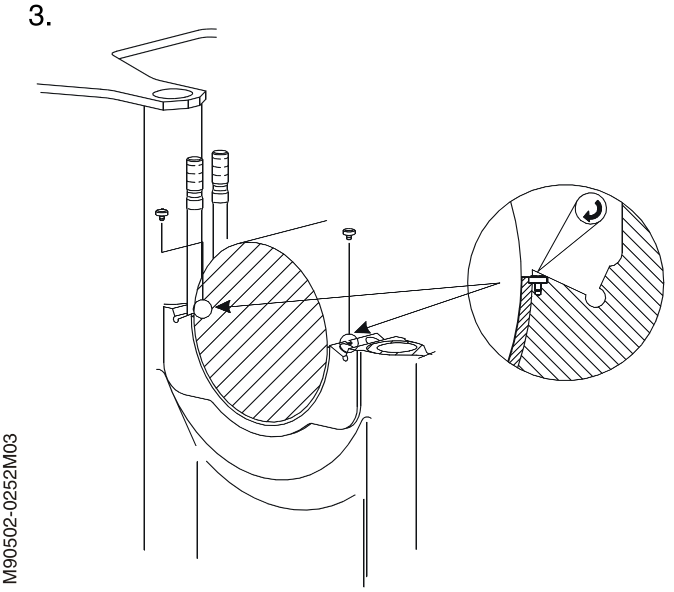


1. Using the bearing shell lifting tool, the pulleys and tackles, lift the lower bearing shell into the crankcase and land it on the crankshaft journal.

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 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 bearng 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 dismounted.

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 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.

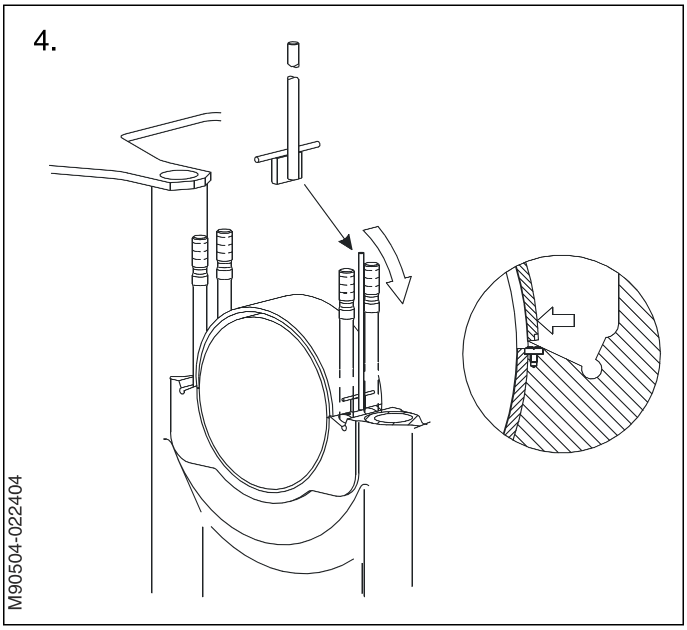
   If necessary, place the special tool between the studs and press the shell into place.

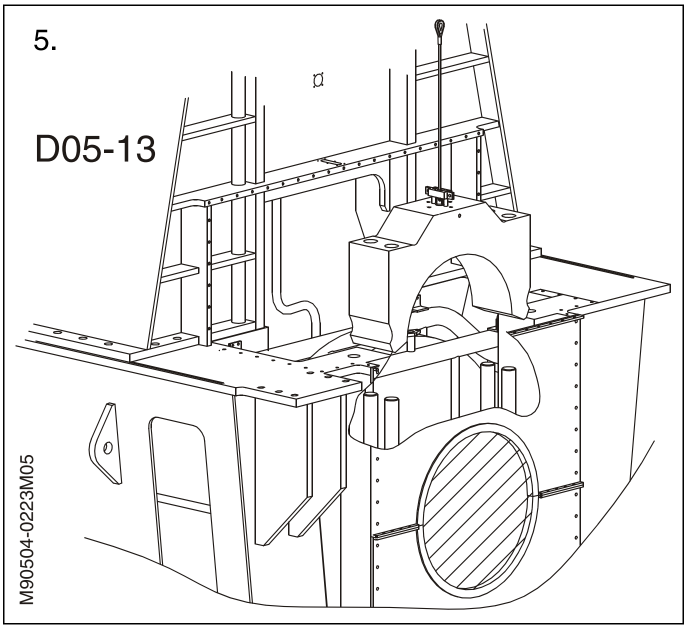
   Clean the contact surfaces between the bearing support and the bearing cap. Make sure that no oil is left on the contact surfaces.

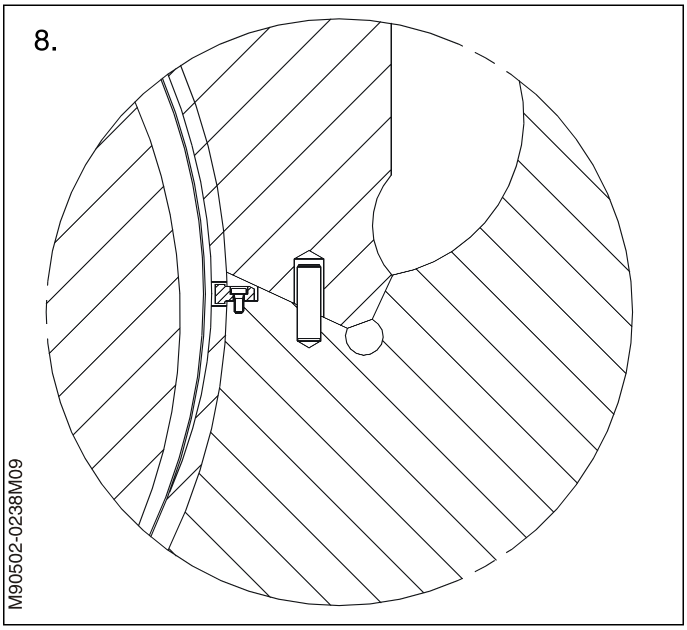
5. Mount the lifting tool on the bearing cap. Using the lifting tool and the tackles, lift the bearing cap into the crankcase in reverse order to dismantling.
   See Procedure 905-4, steps 9-8.

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.







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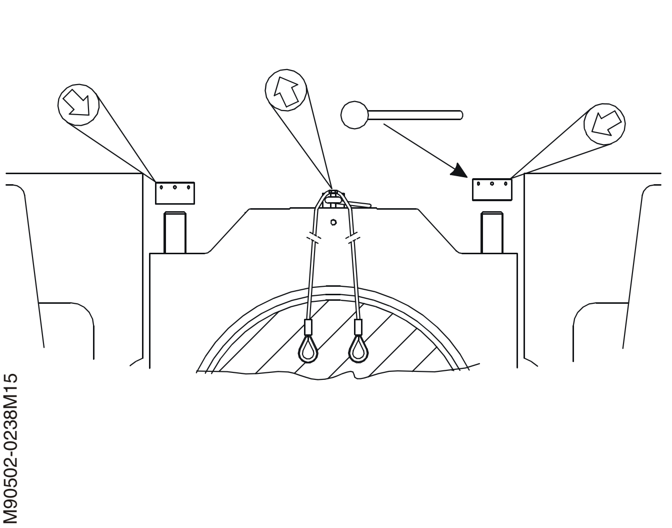


7. Remove the bearing cap lifting tool.

   Screw the nuts on to the bearing studs.

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

8. Mount the hydraulic jacks in the same way as described for dismantling.
   See Procedure 905-4.2, steps 3.

9. Use the hydraulic jacks to fully tighten the nuts on both sides of bearing cap.

   For tightening pressure, *see Data D13-01.*

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

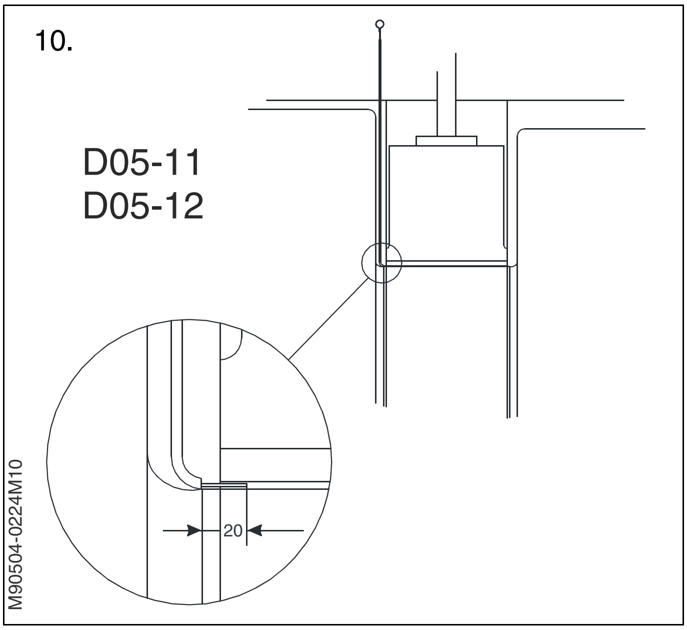
10.

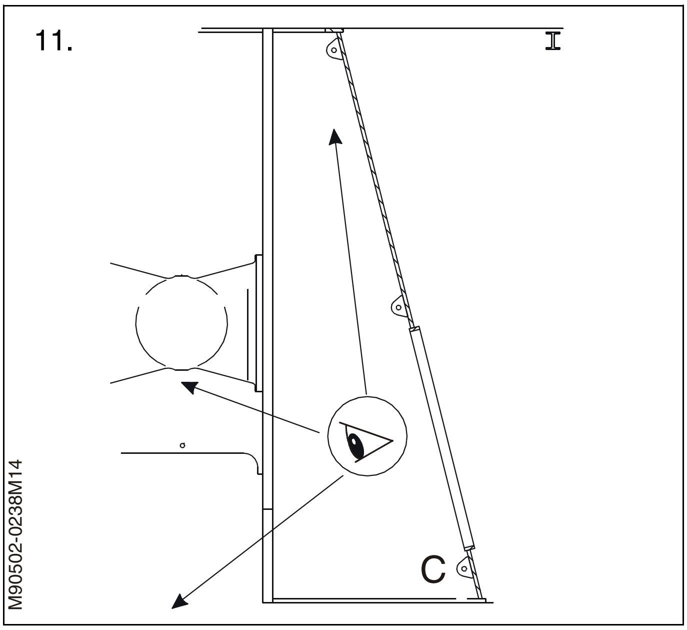
Note!
Before removing the hydraulic jacks, check the top clearance between the upper bearing shell and the journal.

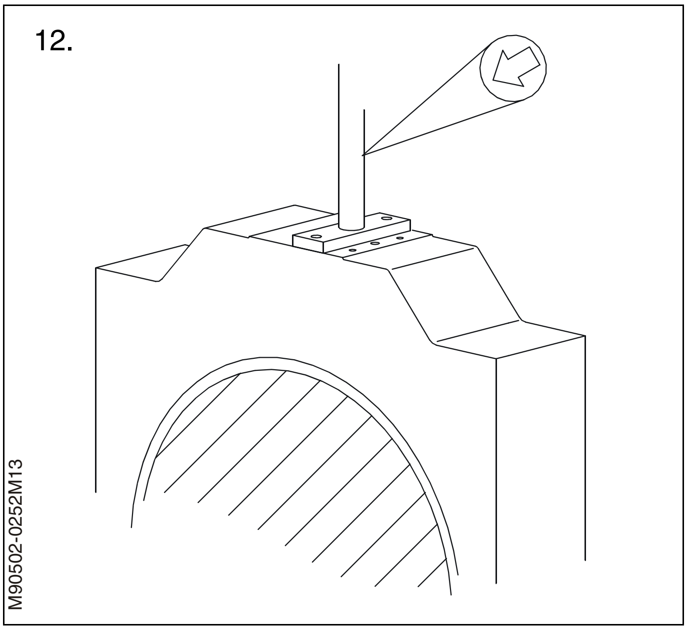
11. Remove all tools from the engine.

Note!
Search the thrust bearing and the crank-case to ensure that there are no tools, shackles or rags left behind.

12. Mount the lubricating oil pipe on the bearing cap, and mount the end cover.







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

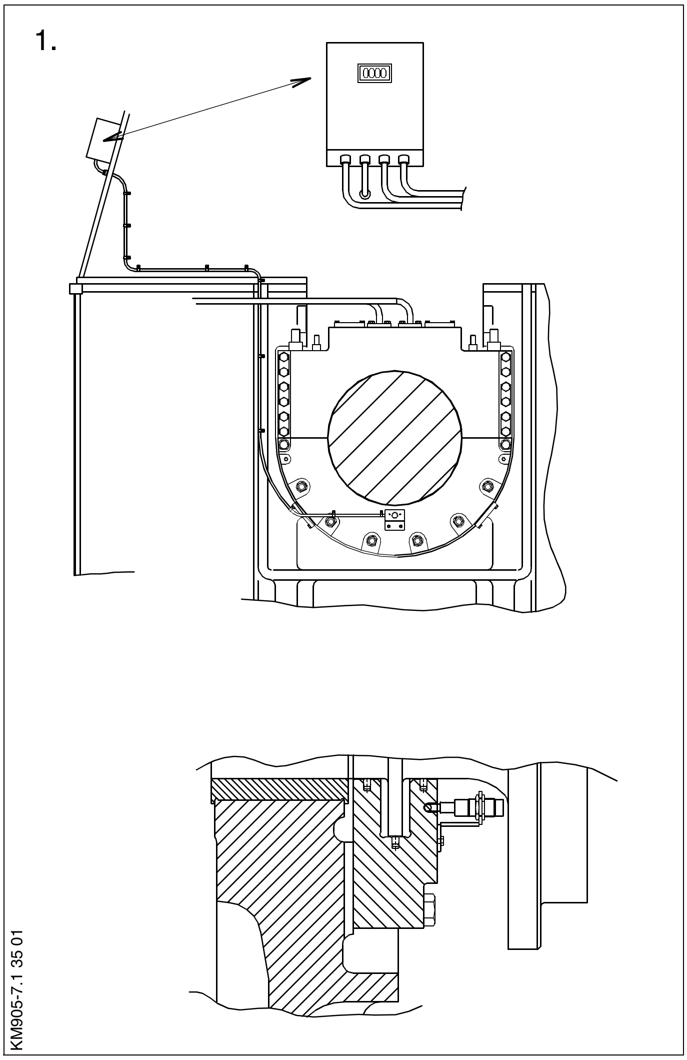
X	Stopped engine
X	Shut off starting air supply – *At starting air receiver*
X	Block the main starting valve
X	Shut off starting air distributor/distributing system supply
X	Shut off safety air supply – *Not ME-engines*
X	Shut off control air supply
X	Shut off air supply to exhaust valve – *Only with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

Data

Ref.	Description	Value	Unit
D05-22	Outer studs, screwing-in torque	140-180	Nm
D05-24	Horizontal screws, tightening torque/angle	100/35	Nm/°
D05-25	Damper housing, upper part	2250	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
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 may be mounted on the specific engines, the checking procedure describes three different systems:

A: Electronic, with Axial Vibration Monitor

B. Mechanical, (without angle encoder fore)

C: Mechanical, with angle encoder fore.

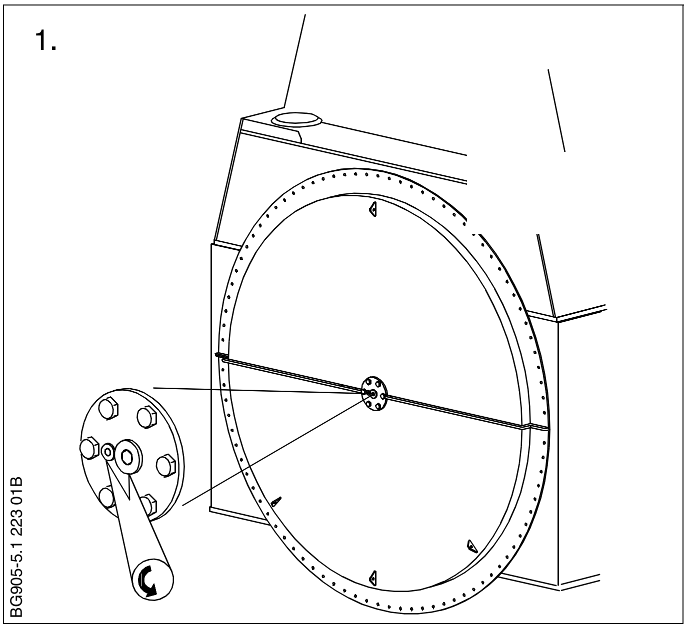
A: Electronic, with Axial Vibration Monitor

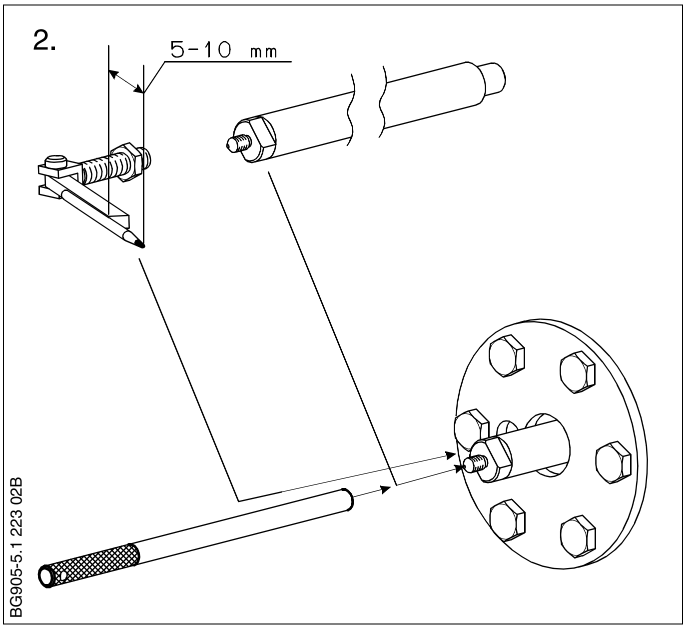
A proximeter probe is built on to the lower part of the damper housing. The probe is connected to a control unit which displays peak-to-peak movements and sends signals to the engine control system.

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 (without 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, using the handle.

   After tightening the shaft, dismount the handle.

   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.

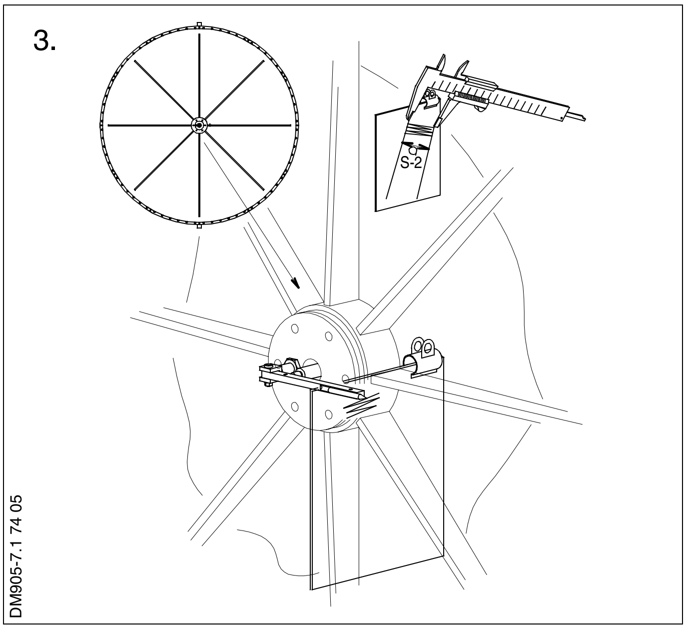
Note!
To obtain a correct measurement, the tip of the pencil should protrude **10 mm** from the end of the arm.

3. 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.



4. 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.

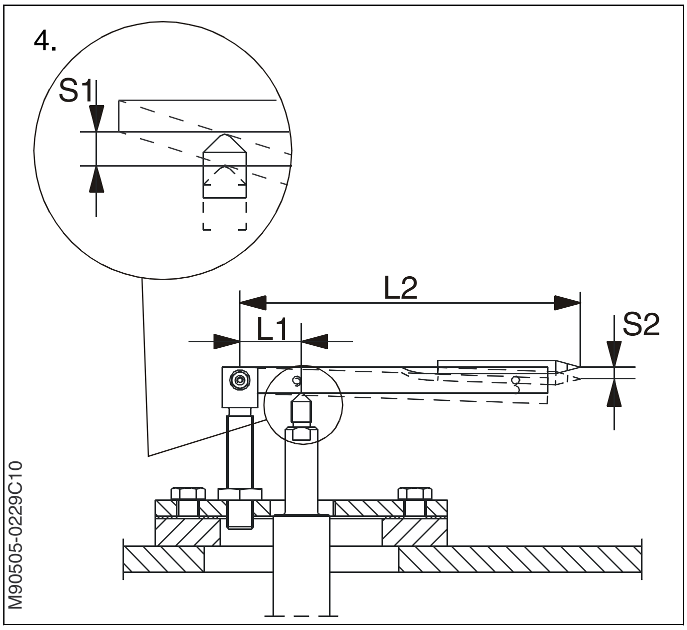
   For a standard measuring tool (L_1 = 38 mm and L_2 = 200 mm), the ratio is 5.3. Therefore, the S1 can be calculated as follows:

$$S1 = \frac{S2}{5.3}$$

   If a non-standard tool is used, S1 can be calculated as follows:

$$S1 = S2 \times \frac{L_1}{L_2}$$

   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*.



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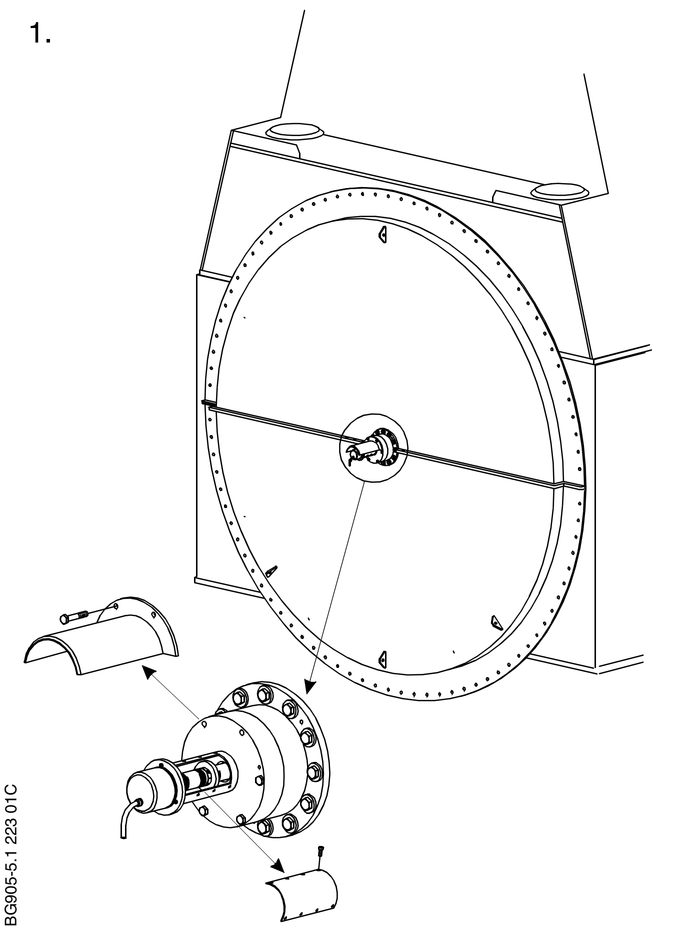

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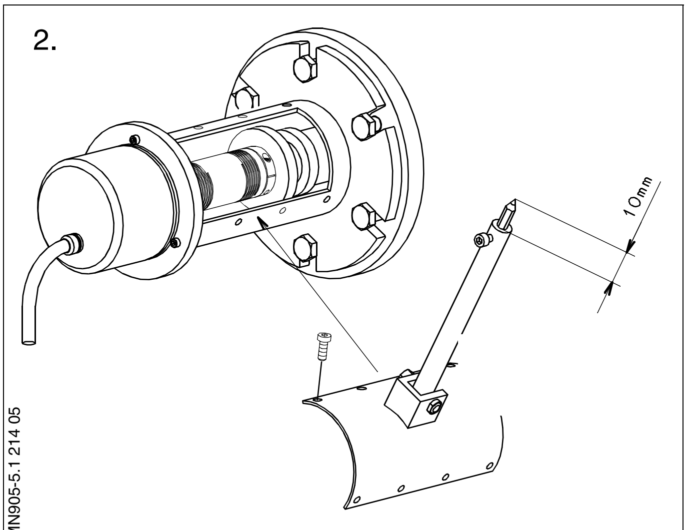


C: Mechanical, with angle encoder fore

For engines with angle encoder fore, a measuring tool is available for mounting on the angle encoder housing.

1. Stop the engine.

   Dismount the protection shield over the angle encoder. (Not always on engine).

   Dismount the cover on the angle encoder housing.

   Apply some Molycote^{TM} on the fore side of the shaft cam.

2. Mount the axial vibration measuring tool, using the screws from the cover.

Note!
To obtain a correct measurement, the tip of the pencil should protrude **10 mm** from the end of the arm.

3. 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, pull the measuring arm against the shaft cam with one hand. With the other hand, move a sheet/block of paper, clipped onto a solid backing plate, lightly sidewards 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.

4. 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 (L_1 = 35 mm and L_2 = 178 mm), the ratio is 5.1. Therefore, S1 can be calculated as follows:

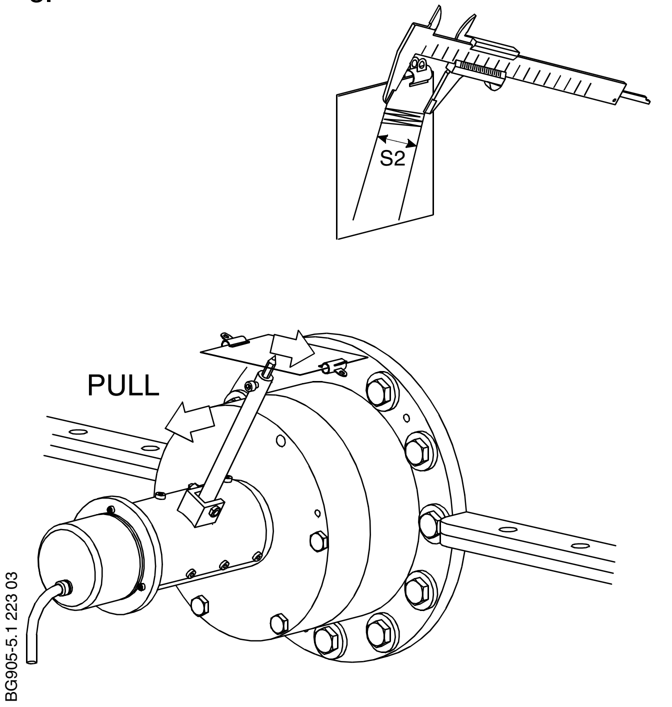
$$S1 = \frac{S2}{5.1}$$

   If a non-standard tool is used, S1 can be calculated as follows:

$$S1 = S2 \times \frac{L_1}{L_2}$$

   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*.

3.



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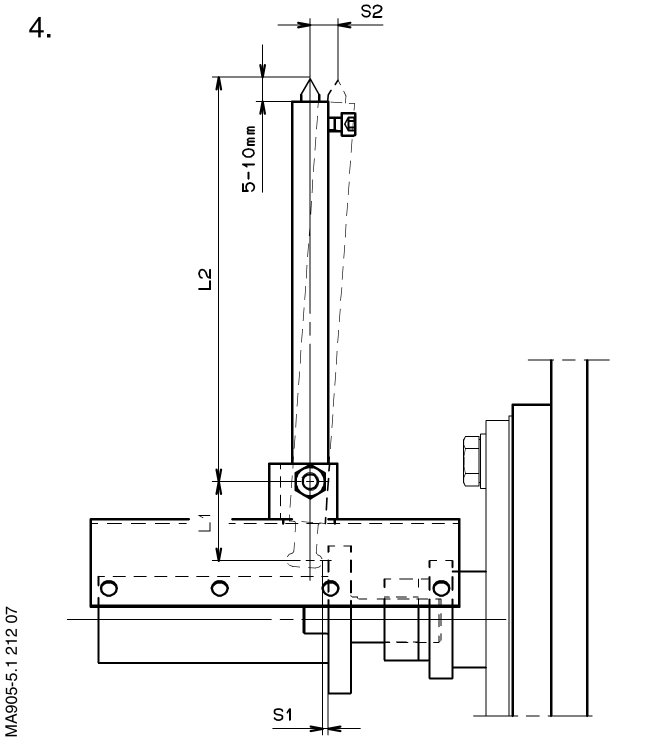
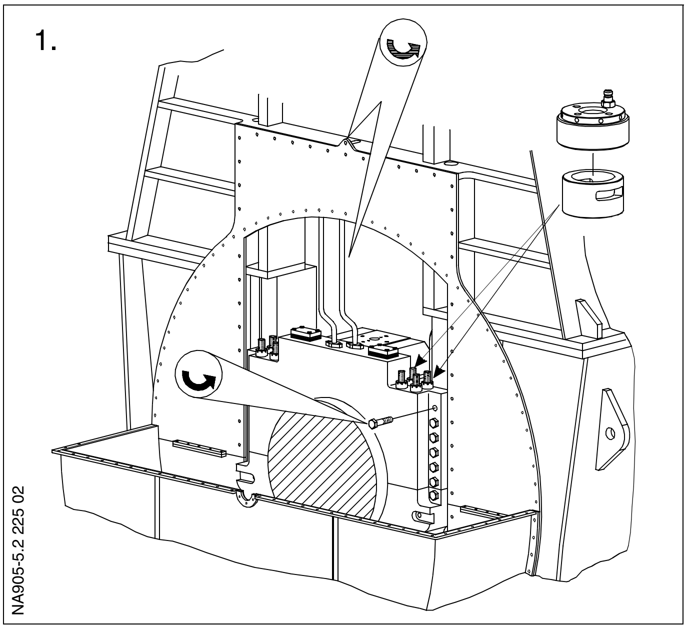
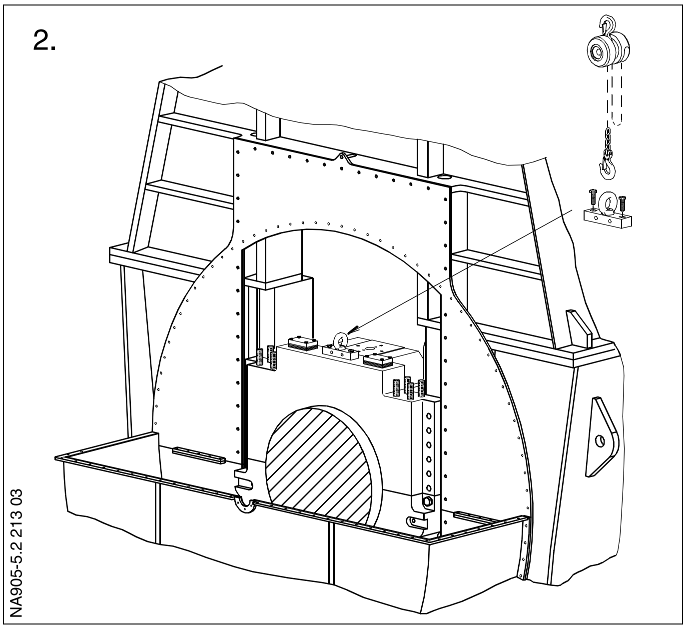
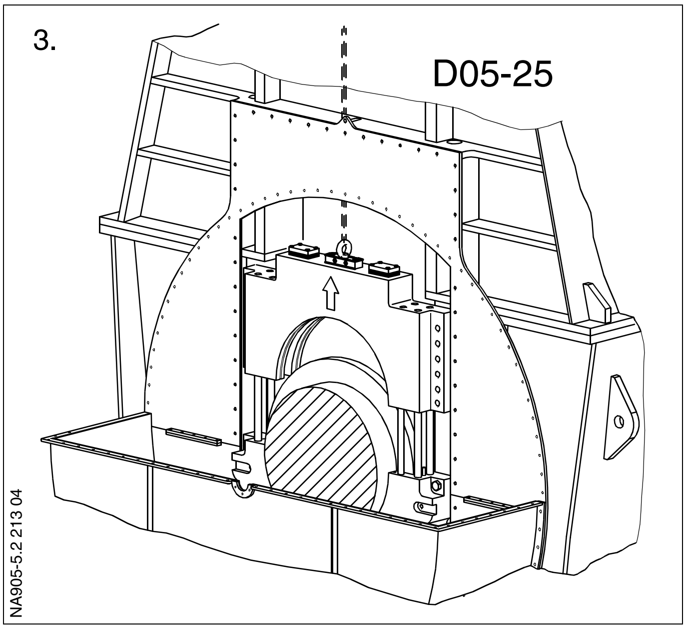








Dismantling of the axial vibration damper is carried out from the crankcase of cyl. No. 1.

1. Turn the engine to a position where it is possible to enter the flyweight housing on the fore end of the engine

   Dismount the lubricating oil pipes for the main bearing and axial vibration damper.

2. Loosen and remove the horizontal screws on the upper part of the damper.

   On some engines, due to the position of the flyweight, it is necessary to turn the engine before loosening the one or the other side of the axial vibration damper.

   Loosen and remove the hydraulic nuts from the studs. *For operation of the hydraulic tools, see Procedure 913-1.*

   Only the upper part of the housing needs to be removed, while the lower half remains mounted on the bedplate.

3. Mount the lifting tool on top of the upper part.

   By means of the tackle and wire rope, separate and raise the upper part of the damper housing to a position in which it is possible to change the oil seals and springs.

Note!
Before starting work under the suspended upper part, secure the upper part with, e.g. a wire rope or another tackle.

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.

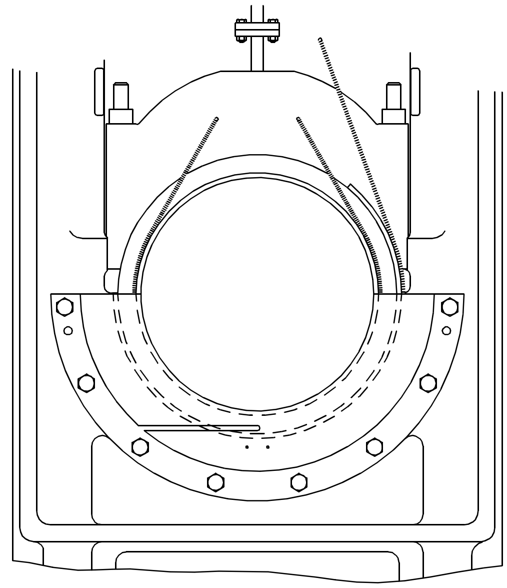
   Then press the tension springs into the groove between the oil sealing ring half and the housing.

2. Mount all the upper halves of the oil sealing rings in such a way that the clearance at both 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.



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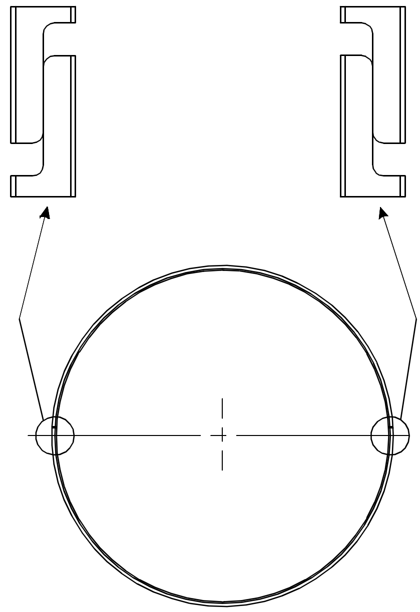

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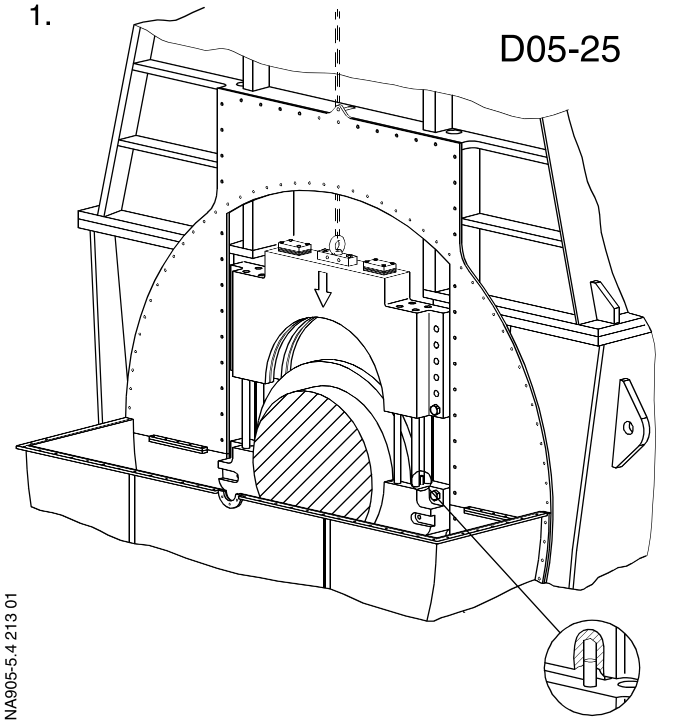

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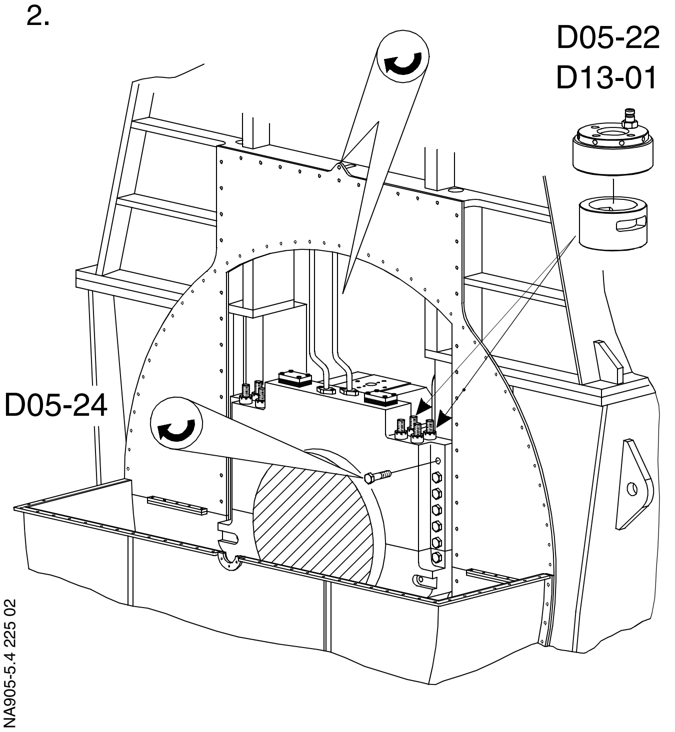


1. Release and carefully lower the upper part of the damper housing.

   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. Mount and tighten the hydraulic nuts. *For operation of the hydraulic tools, see Procedure 913-1.*

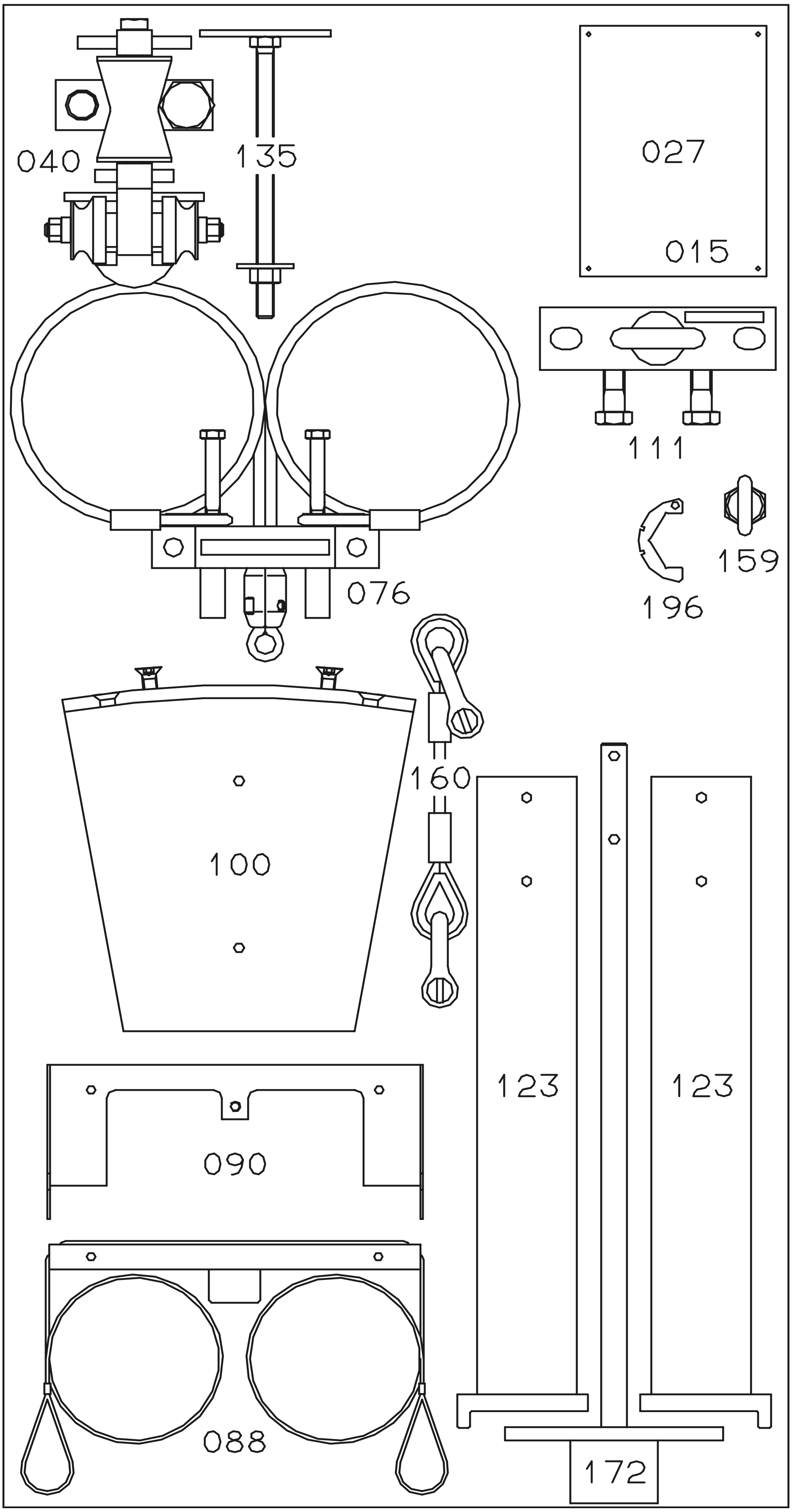
   Mount and tighten the horizontal screws. See Data.

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

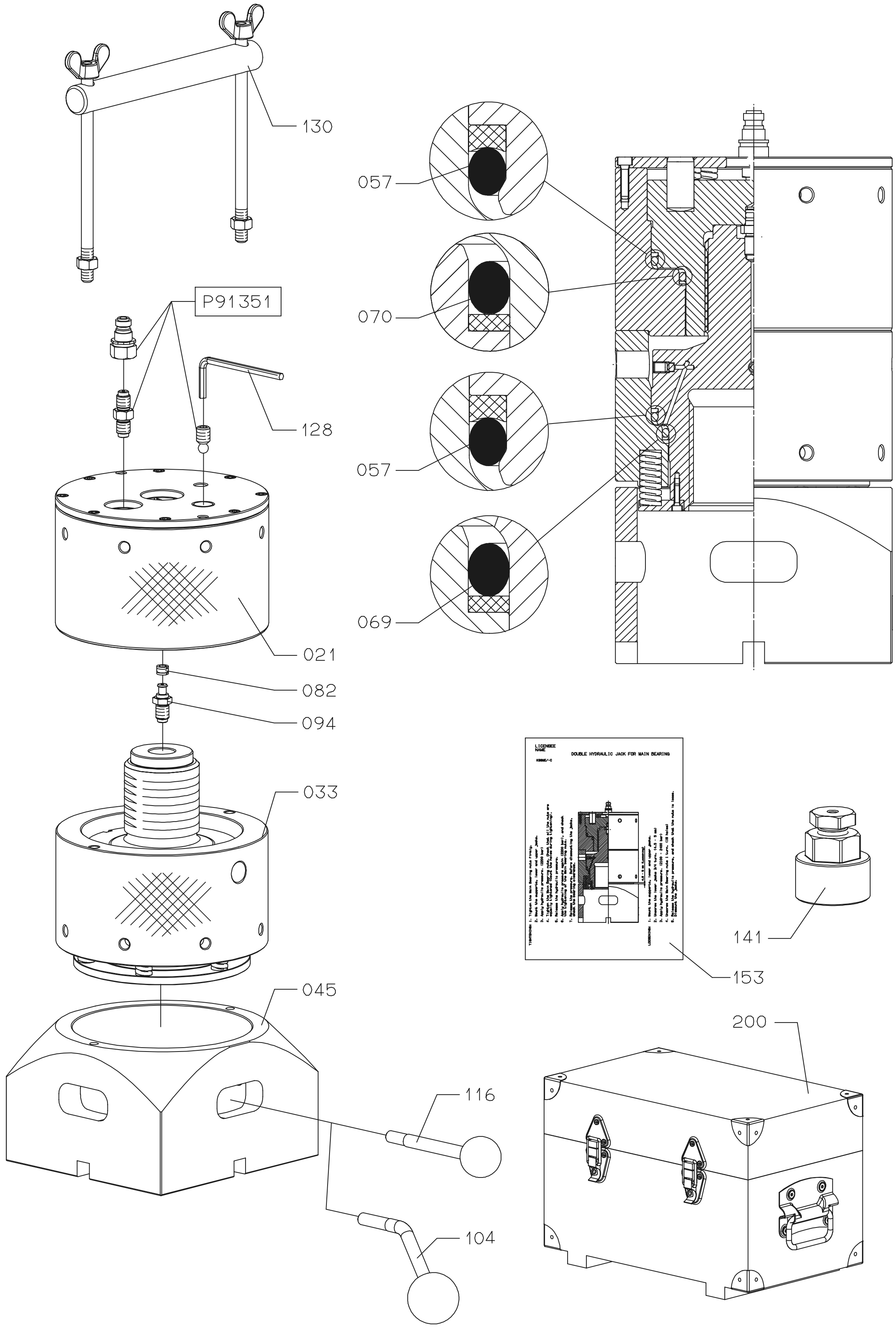
Mount the lubricating oil pipes.

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.*


040
135
027
015
111
159
196
076
160
100
123
123
090
088
172

Item No.	Item Description	Item No.	Item Description
015	Panel for tools		
027	Name plate		
040	Wire pulley, main bearing		
076	Lifting tool, main bearing cap		
088	Dismantling tool, main bearing shell		
090	Mounting tool, thin bearing shell		
100	Tool, turning out segments		
111	Lifting tool, axial vibration damper and journal bearing		
123	Retaining tool, main bearing shell		
135	Lifting tool, relief valve		
159	Eye bolt		
160	Wire		
172	Mounting tool, thin bearing shell		
196	Tightening template, axial vibration damper		

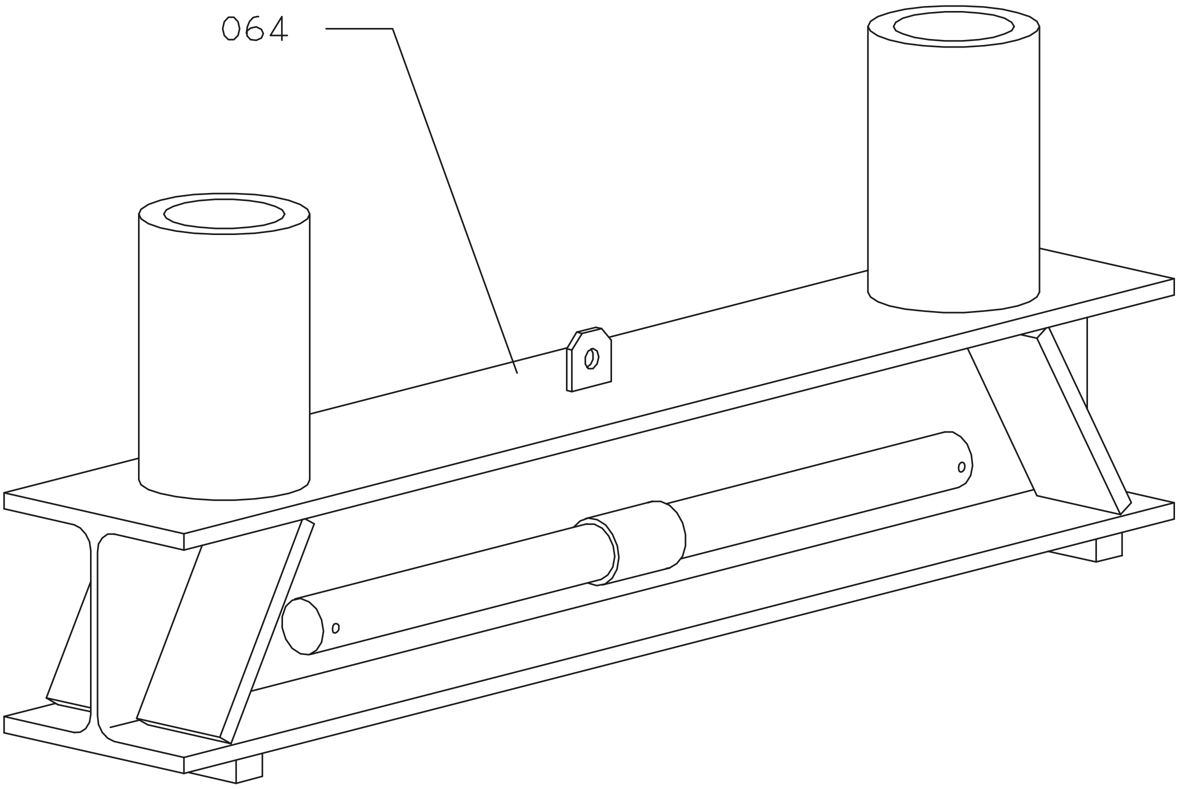


130
P91351
128
021
082
094
033
045
116
104
057
070
057
069
DOUBLE HYDRAULIC JACK FOR MAIN BEARING
141
153
200

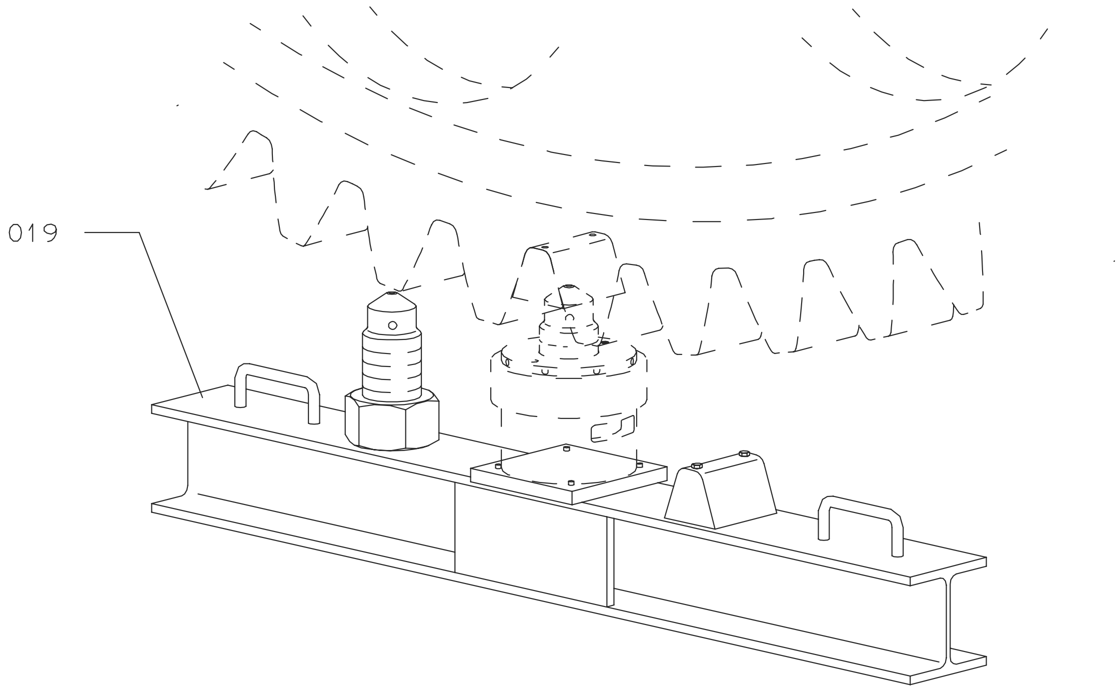
Main Bearing - Hydraulic Tools

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

Item No.	Item Description

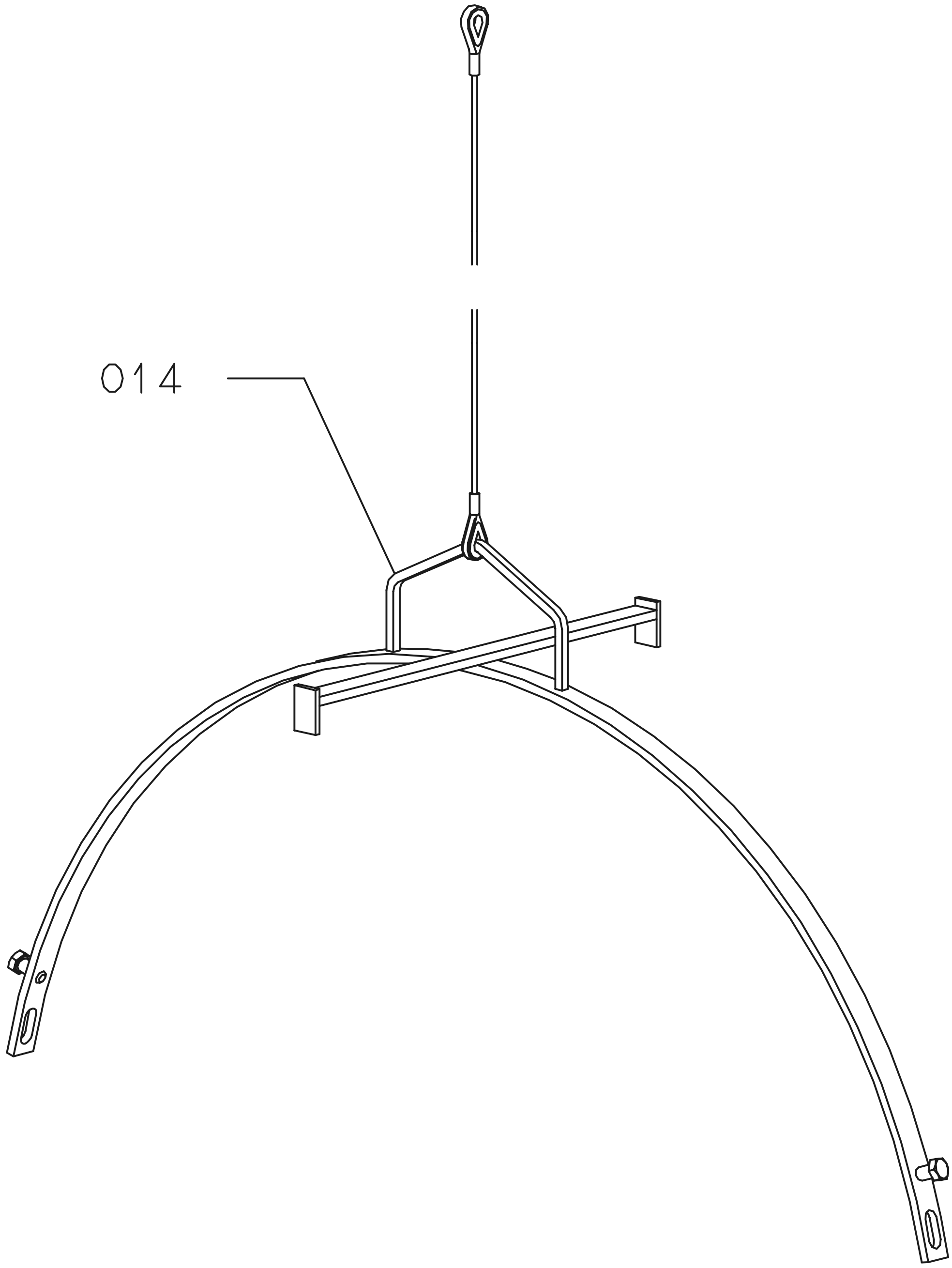

064

Item No.	Item Description	Item No.	Item Description
064	Lifting tool for crankshaft		


019

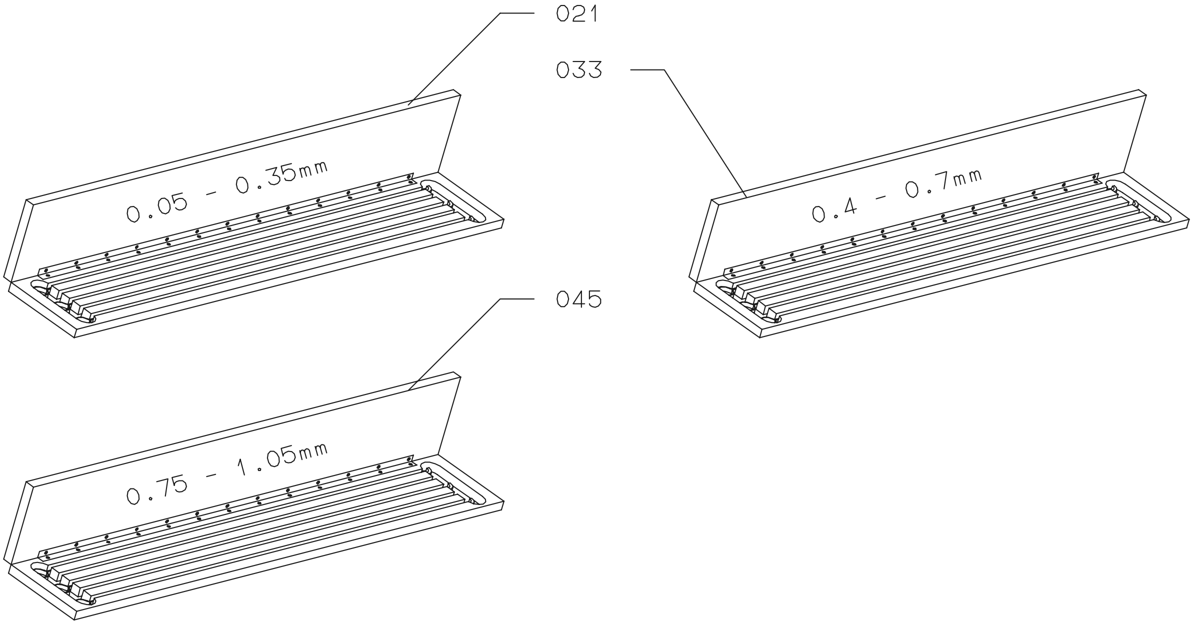
Thrust Shaft - Tools

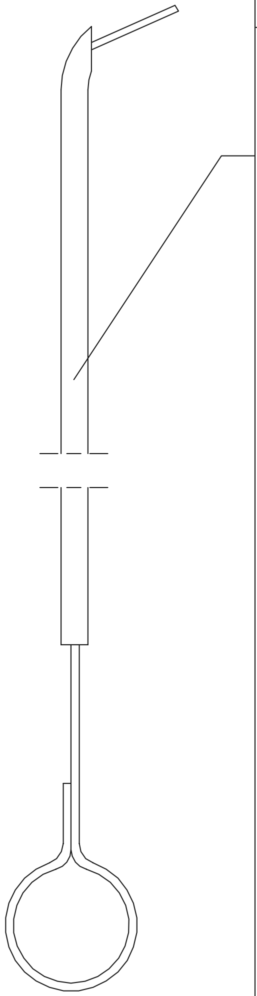
Item No.	Item Description
019	Lifting tool for thrust shaft



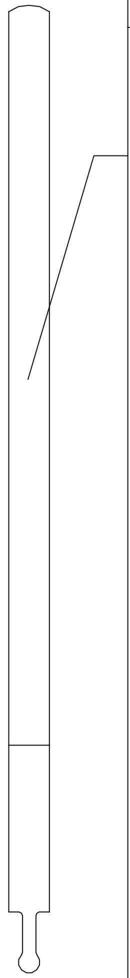
014

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		

906 - Control Gear

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	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)*.

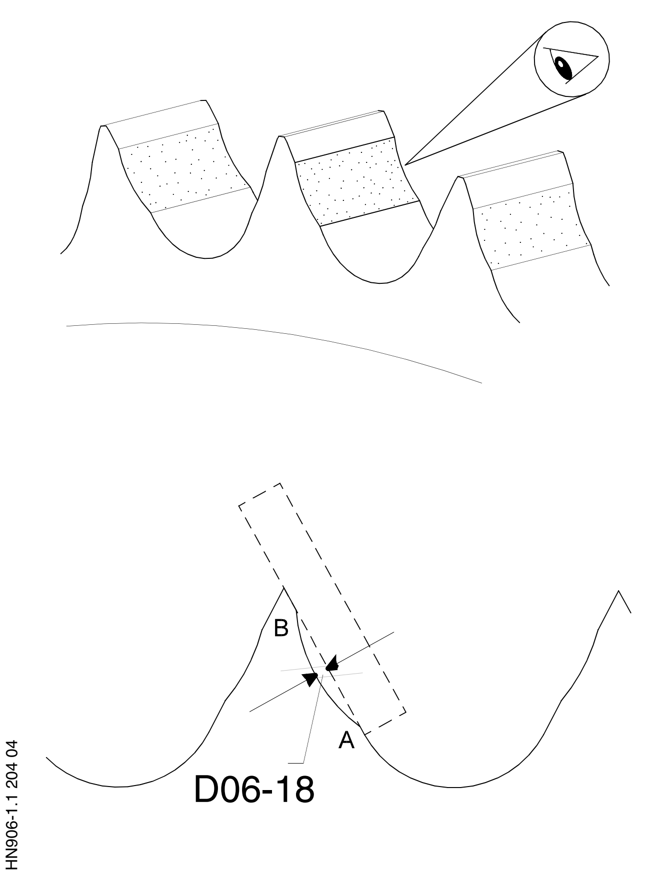
   Measurements are best taken by placing a short straight-edge over points **A** and **B** and then measuring the distance D06-18.

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.

   For assessing the measurement results, contact MAN B&W 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.

4.



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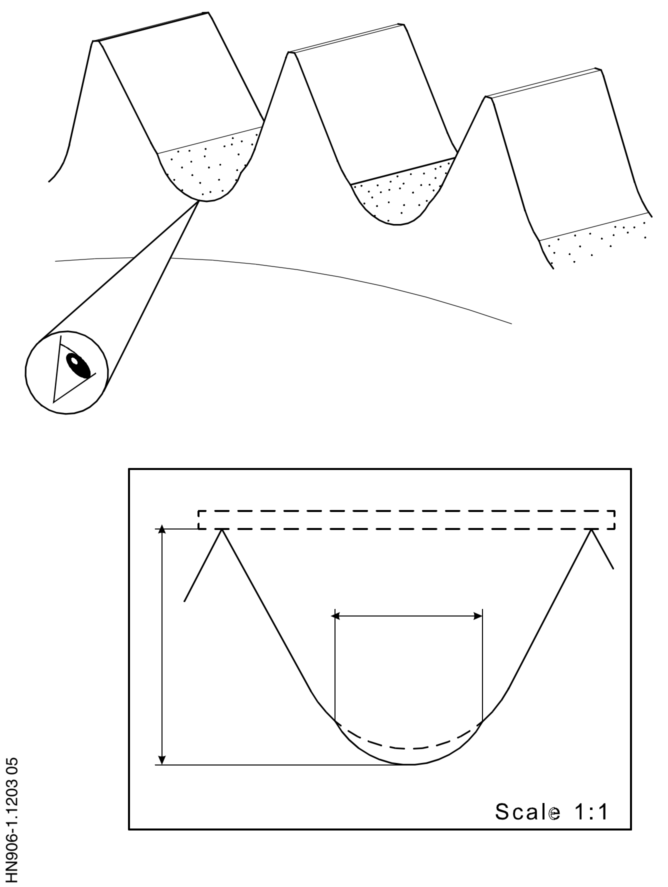

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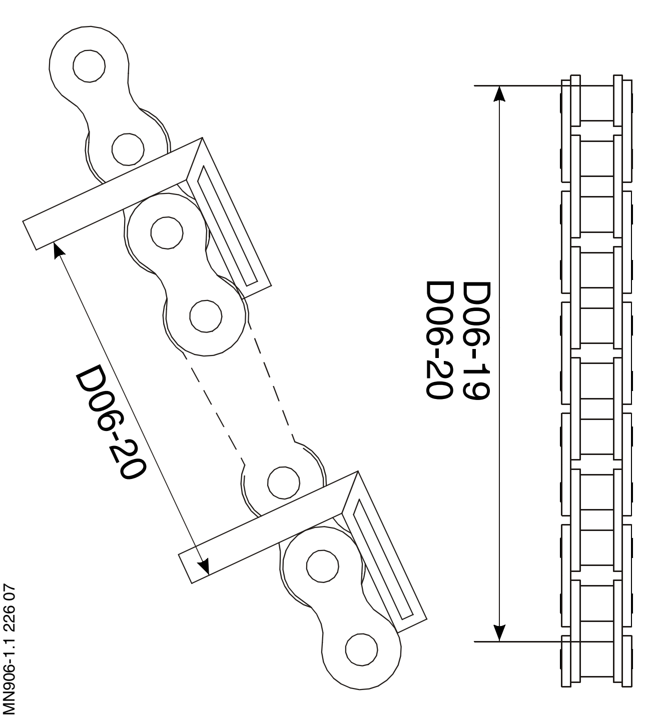


6. The chains for the camshaft drive are matched together to ensure an even load distribution.

   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 1C, 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 values given in Data.

   If necessary, adjust the chain tightener.
   See Procedure 906-2.3.

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.

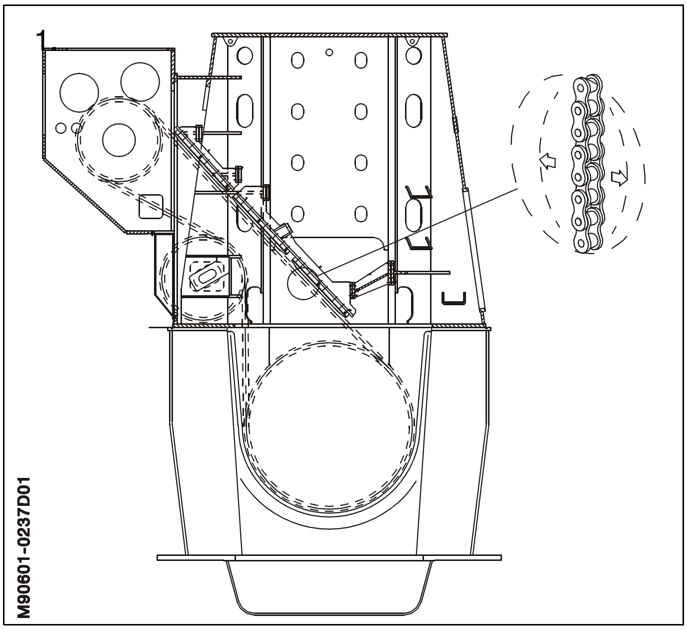
2. Mount a wire round the link rollers a short distance from the disassembly point, and tighten the wire lightly with a tackle.

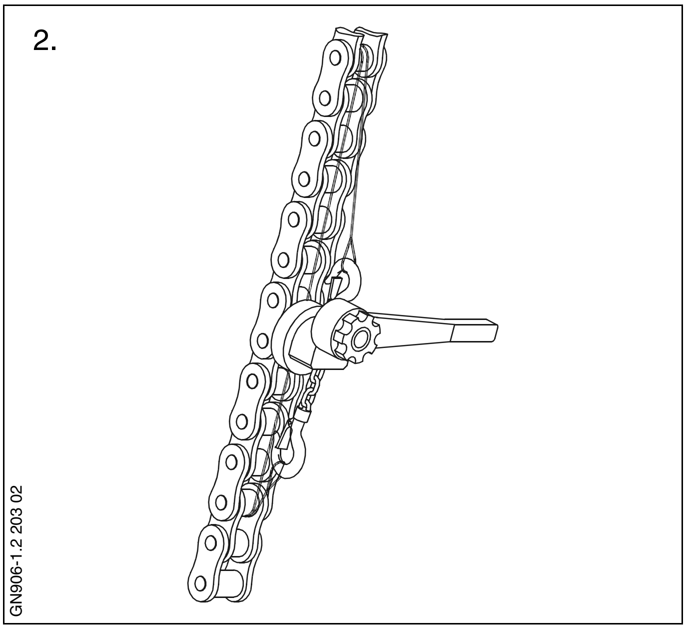
Protect the link rollers over which the wire is wrapped.

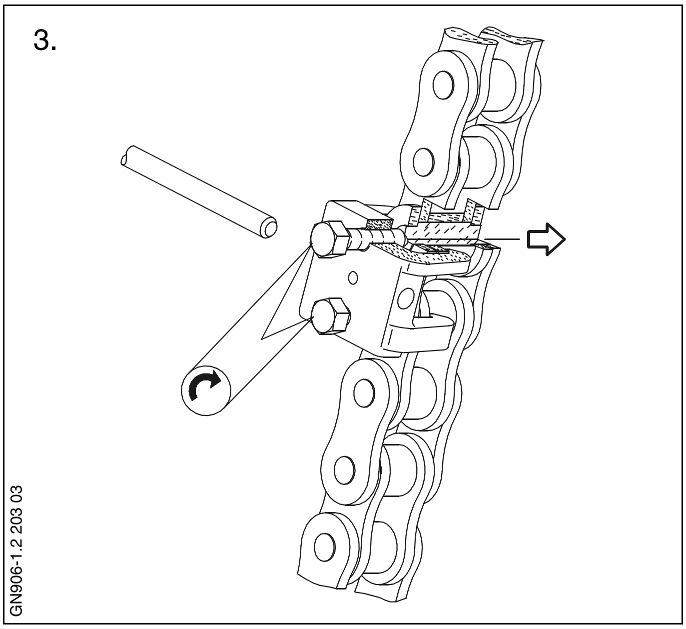
Note!
If the chain is to be completely removed, contact MAN B&W Diesel for further information.

The riveting of the pins that are to be pressed out is to be chiselled or ground away.

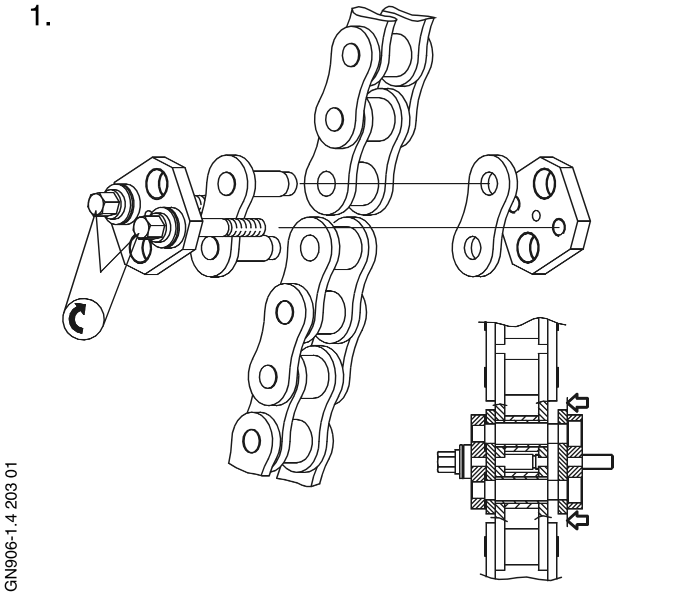
3. Place the chain bursting tool over the outer chain link, and dismantle the link by alternately tightening the screws on the tool.







1.



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*

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	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
P91268		Hydraulic Tools - End-Chock Bolts (Iron Chocks)
P91351	10	Hydraulic pump, pneumatically operated
P91351	22	Hydraulic pump, hand operated
P91351	46	Hose with unions (1500 mm), complete
P91351	58	Hose with unions (3000 mm), complete
P91351	105	3-way distributor block, complete

1. Turn the engine in the AHEAD direction.

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.

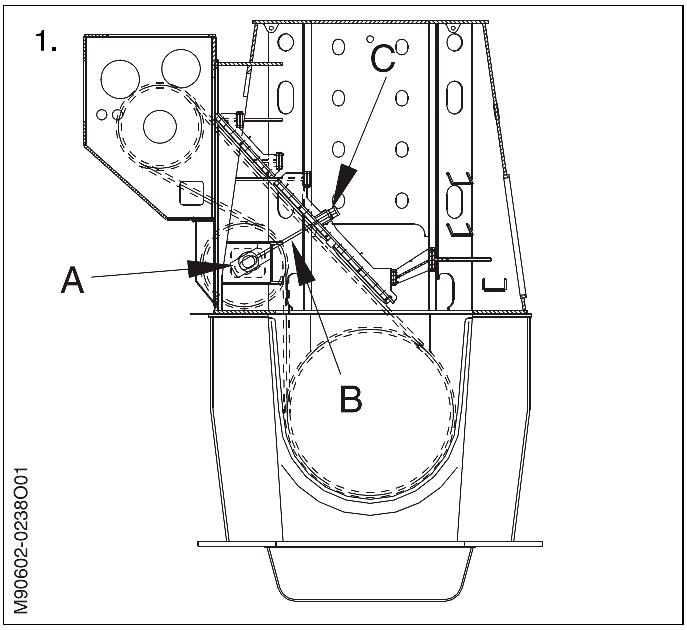
4. Mount the chain tightener tool hydraulic jacks on the studs C and tighten both simultaneously to the value stated in Data D13-01.

   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.

1.



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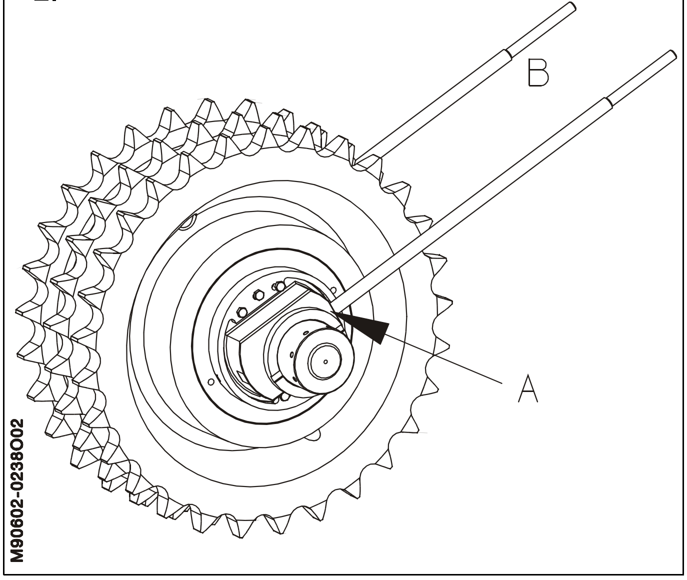

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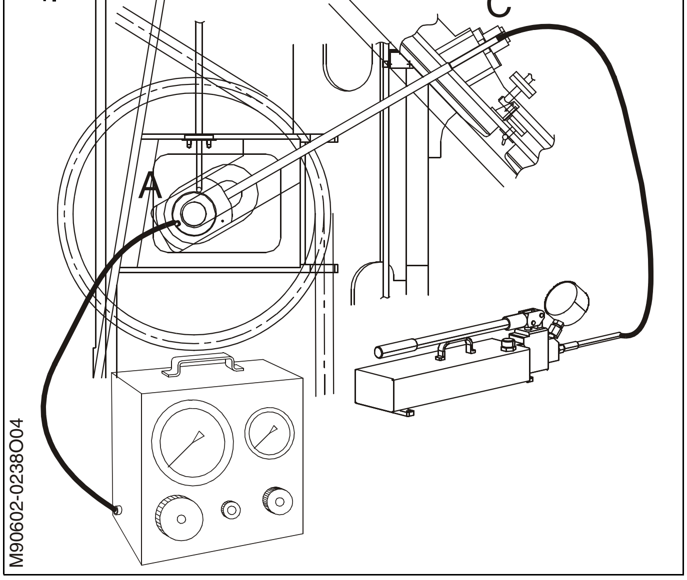


SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors
X	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.

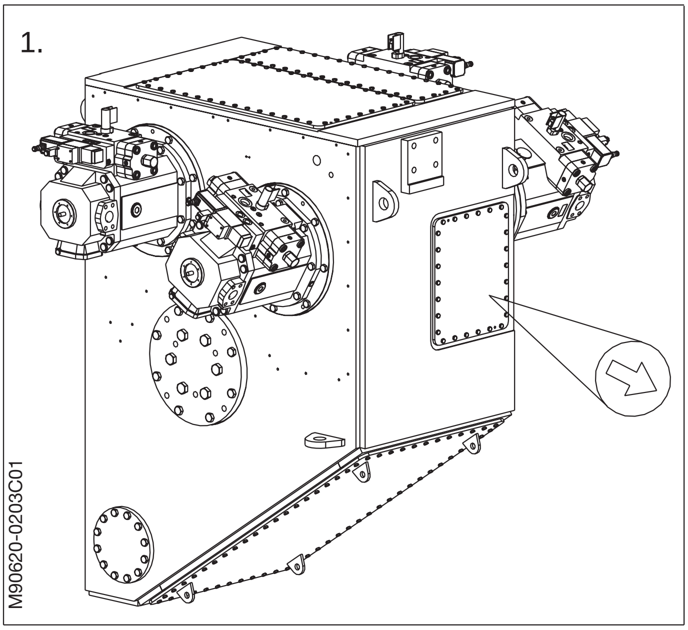
1. Remove the cover on the manoeuvring side of the chain drive.

   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.

1.



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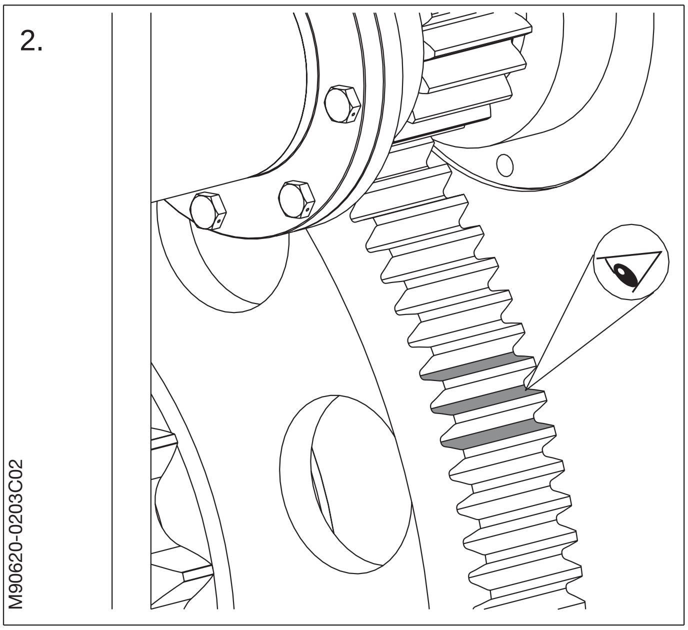

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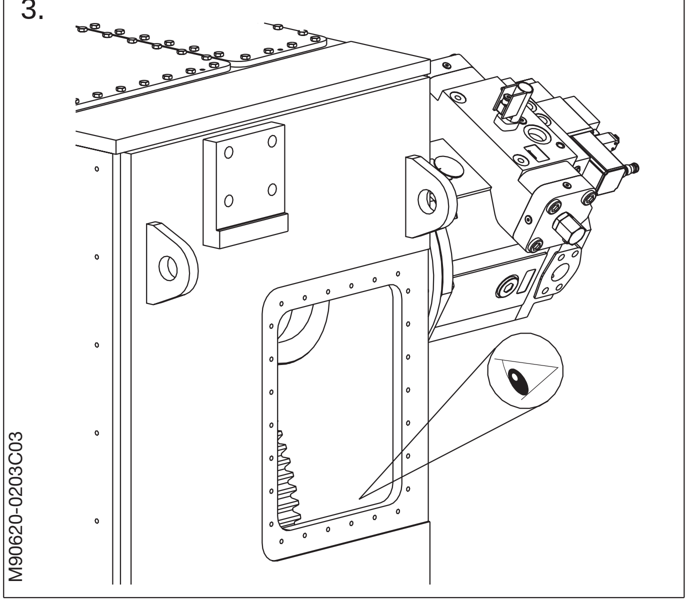
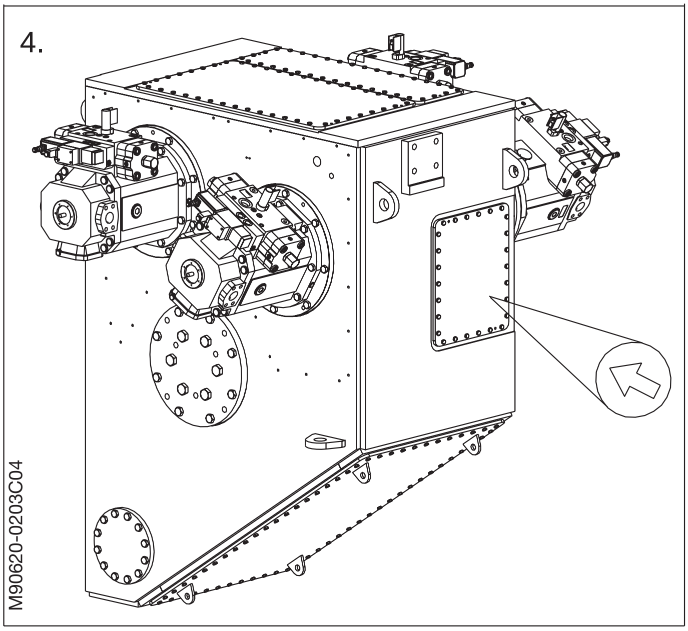




4. Mount the cover on the manoeuvring side of the chain drive.

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

X	Stopped engine
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
	Shut off safety air supply – *Not ME engines*
X	Shut off control air supply
X	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D06-206	Hydraulic Pump	460	kg
D06-210	Internal drive shaft	85/28	kg
D06-214	Shear Nut tightening torque	800	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
P90672		Hydraulic Power Supply Tools
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. Remove the floor plate from the gallery above the hydraulic pumps.

   Mount a tackle on the gallery and the front cover of the spray protection shield.

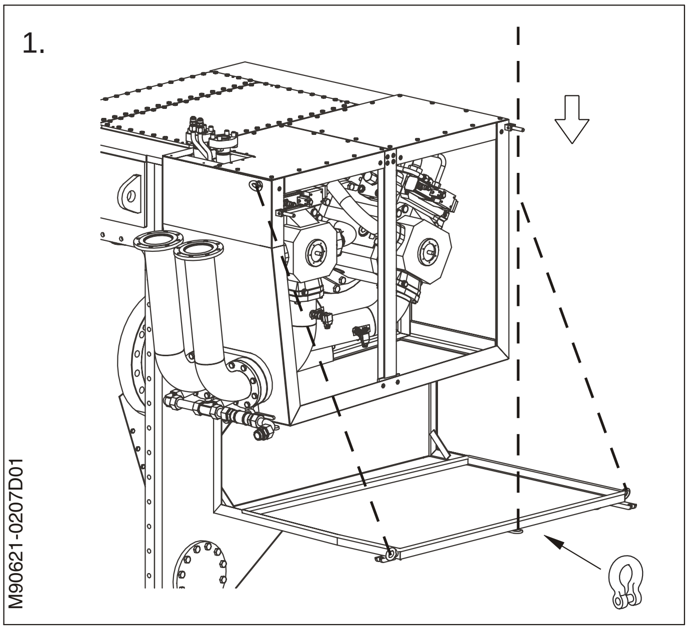
   Open the cover and use the tackle to lower it into the horizontal position.

2. The access ladder can be mounted from above or below the spray protection shield cover.

3. Close the suction valve for the relevant pump.

   Remove the cover and cross member over the relevant pump.

1.



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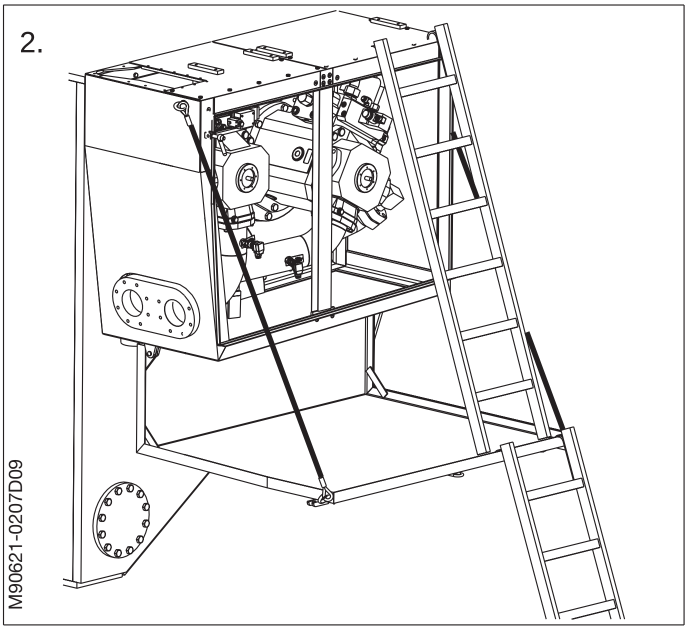

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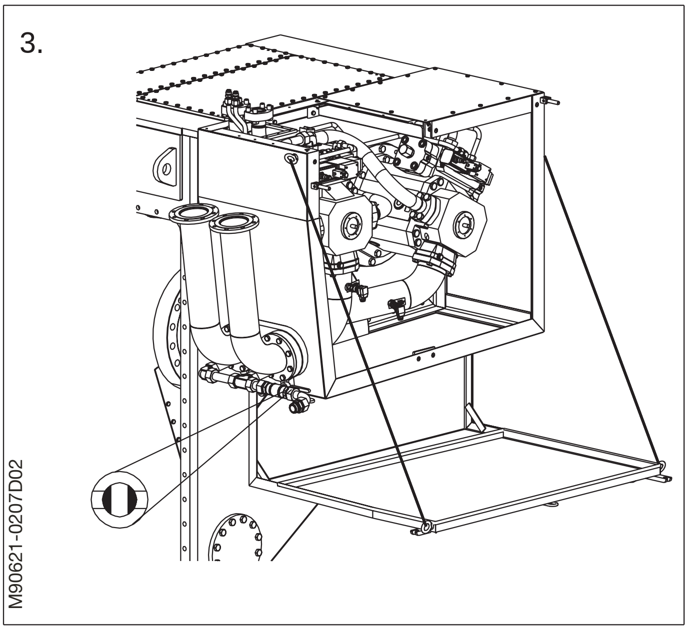

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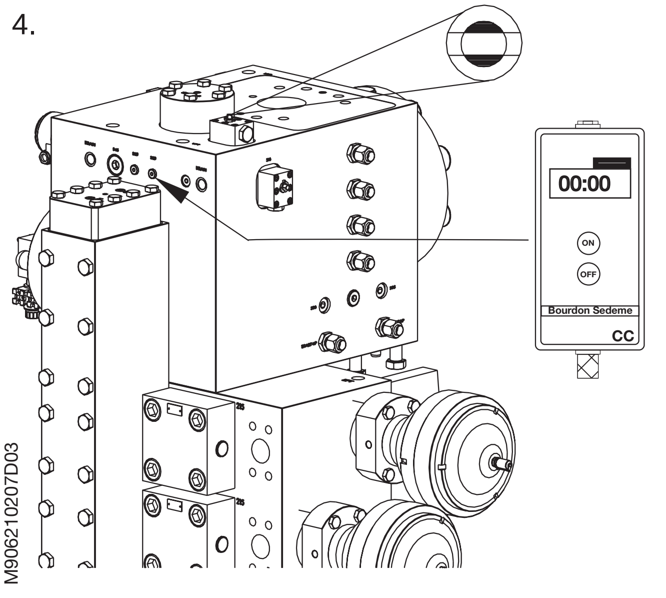

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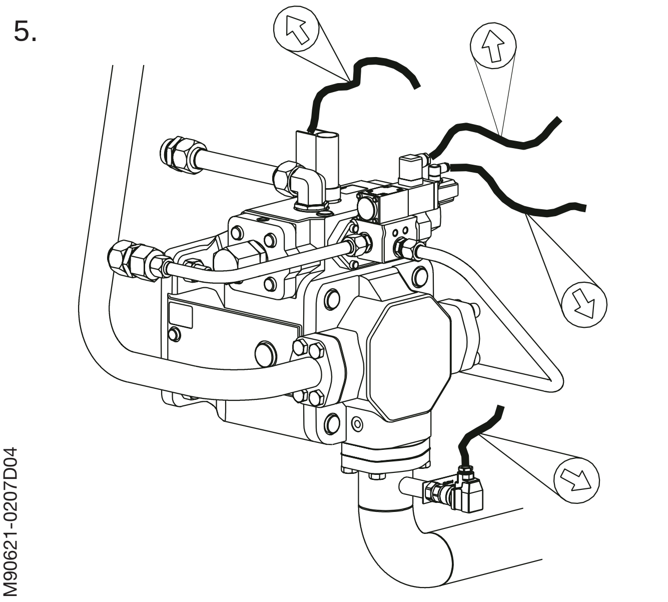

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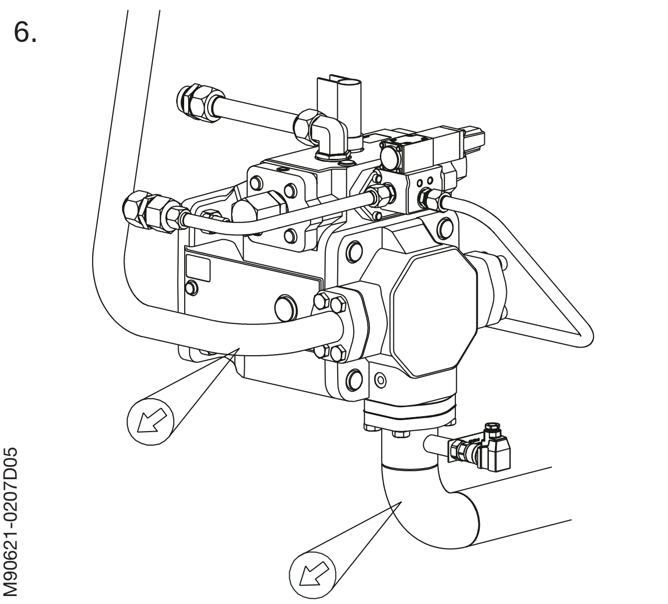


4. Mount a pressure gauge on the "minimess" coupling No. 339. Check the pressure.

   Open valve 315 to release the hydraulic pressure from the system.

   Check on the pressure gauge that the system is pressure free.

5. Remove the electrical connections to the solenoid valves.

6. Unscrew the bolts from the flange on the suction pipe.

   Unscrew the bolts from the discharge pipe and remove the pipe.

7. Unscrew the servo oil pipes.

8. 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.

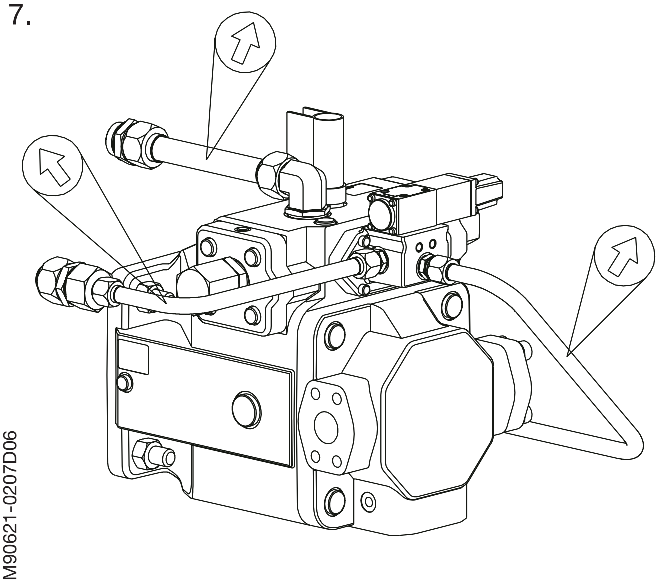
   Unscrew the four screws in the end-flange.

9. Carefully pull out the pump and the internal drive shaft. *See Data.*

   For overhaul of the pump, send it to an authorized MAN B&W workshop.

   The internal drive shaft also functions as an overload protection. If it is necessary to renew the drive shaft, contact MAN B&W Diesel for advice.

7.



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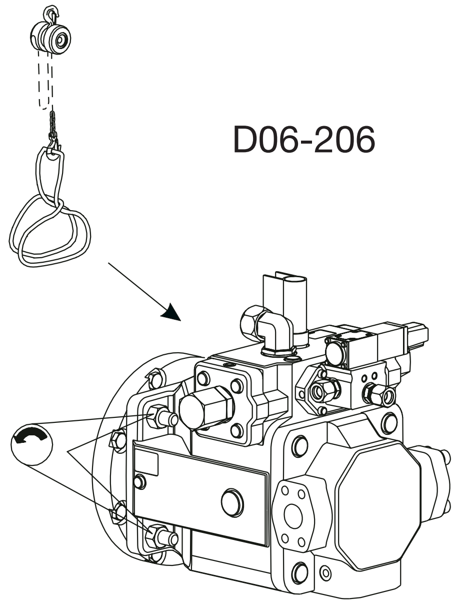

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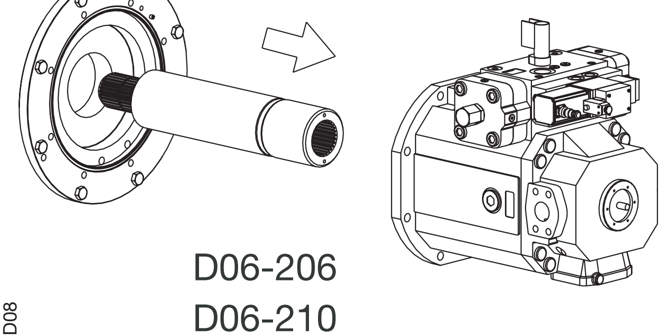

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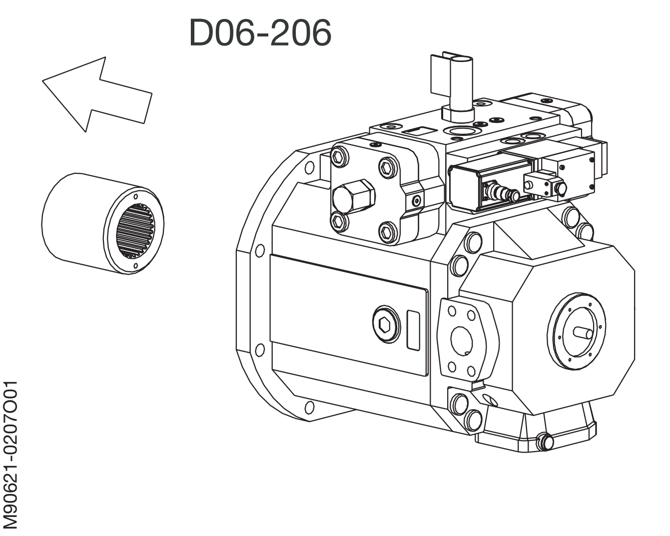
1.



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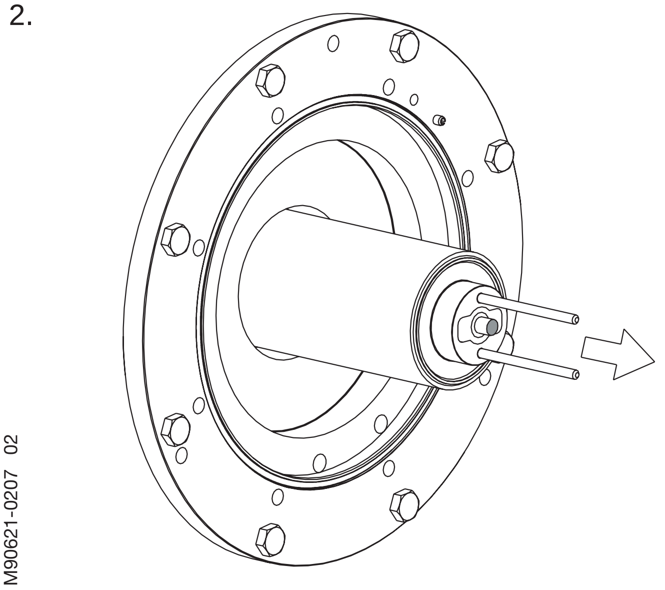


When the internal drive shaft has been overloaded, it must be taken out for overhaul.

1. Dismantle the hydraulic pump.

   Remove the broken end of the internal drive shaft.

2. Screw two pieces of threaded rod into the threaded holes in the drive shaft and pull it out.

3. Inspect the internal drive shaft parts and renew as necessary.

   During assembly of the drive shaft, the following must be observed:

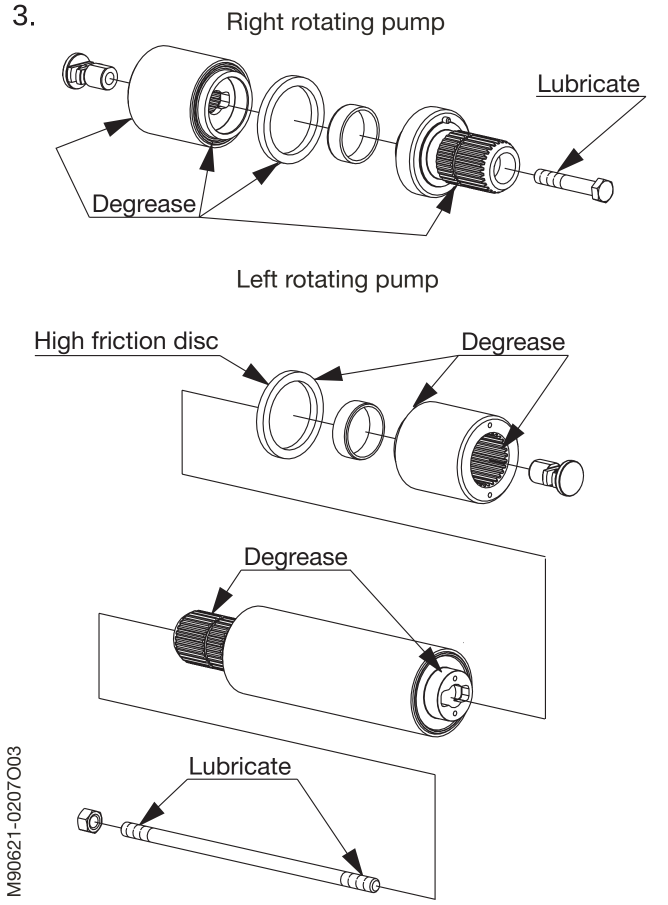
   The contact surfaces on the drive shaft must be degreased before fitting the high friction disc.

   The splines on the shaft must be degreased before mounting.

   The thread and contact face of the center bolt must be slightly lubricated with Molycote ®.

4. Use a torque wrench to tighten the screw or nut on the shear nut to assemble the internal drive shaft. *See data D06-214.*

3.



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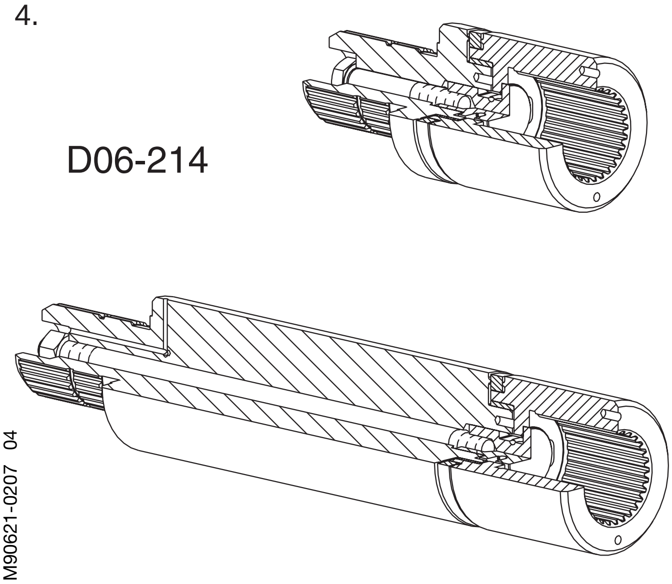

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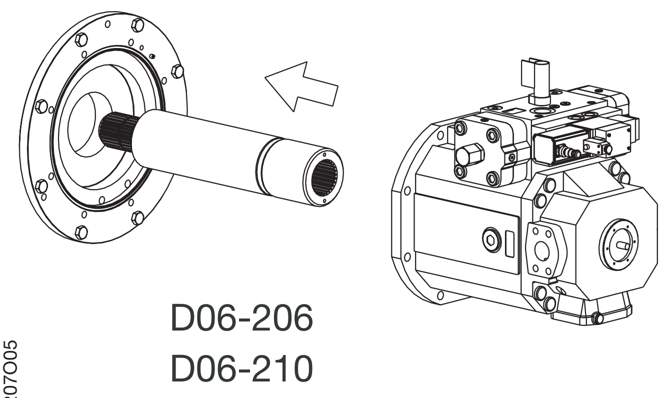


5. Mount the internal drive shaft and the hydraulic pump.

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. Mount the intermediate shaft in the gear-box. Suspend a tackle above the gear box and put a strap around the hydraulic pump.

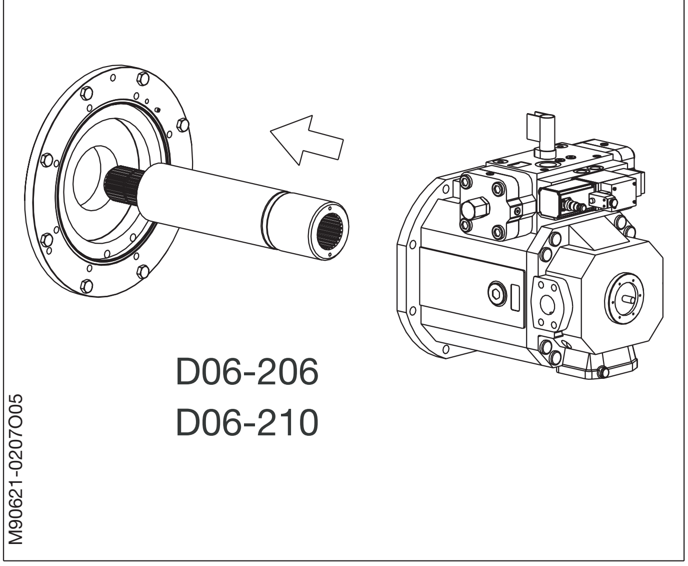
   Lift up the pump in position, and carefully push in the pump to engage the pump shaft with the drive shaft.

2. Mount and tighten the screws on the pump flange.

3. Mount the bolts in the flange on the suction pipe.

   Mount the discharge pipe and tighten the bolts.

1.



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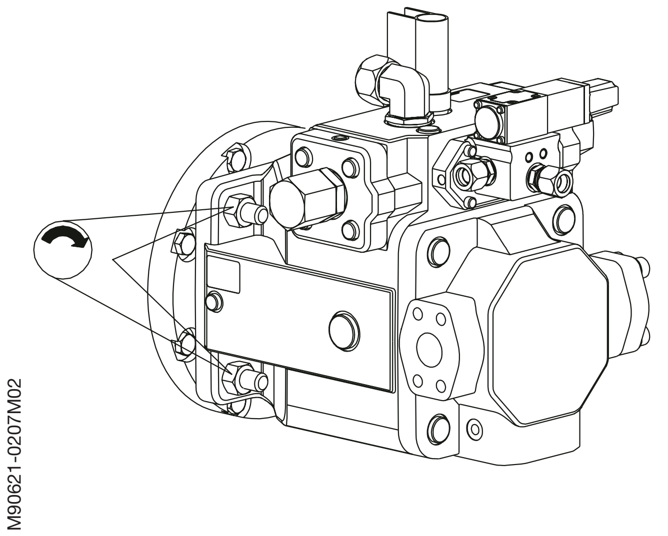

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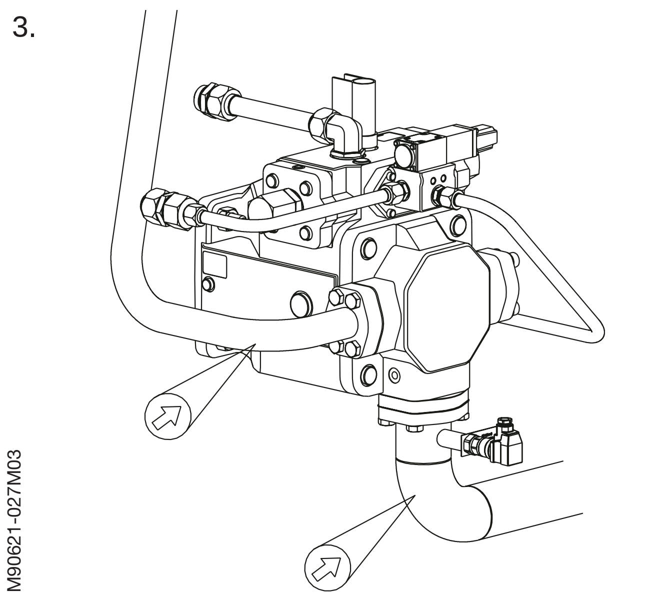

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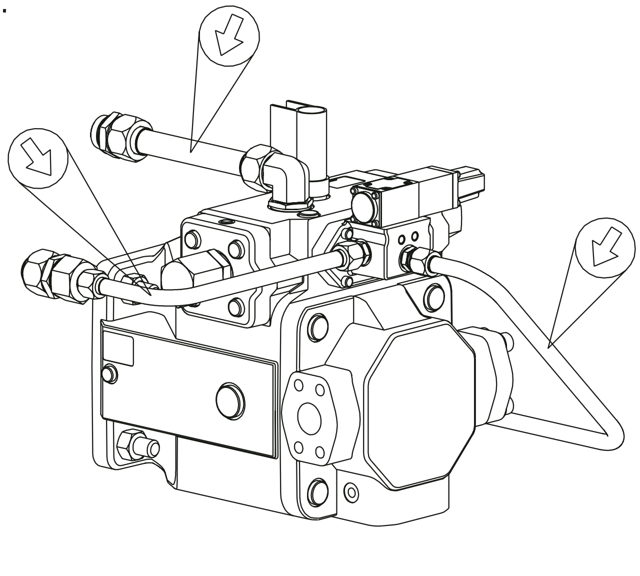

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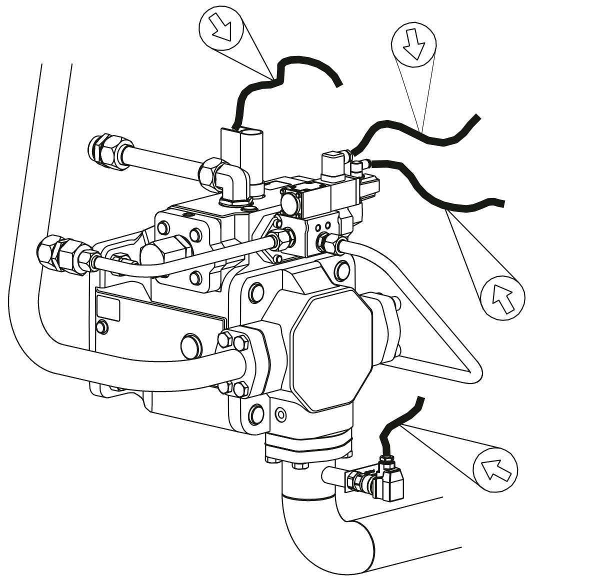

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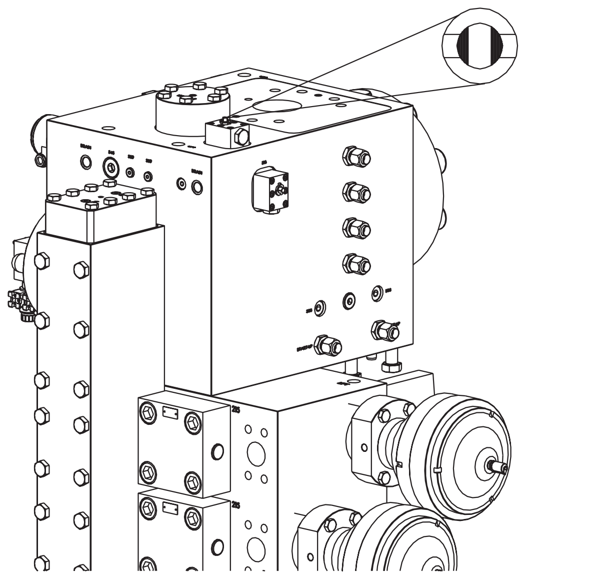

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4. Mount the servo oil pipes.

5. Mount the electrical connections to the solenoid valves and to the angle encoder.

6. Close valve 315 on the hydraulic block.

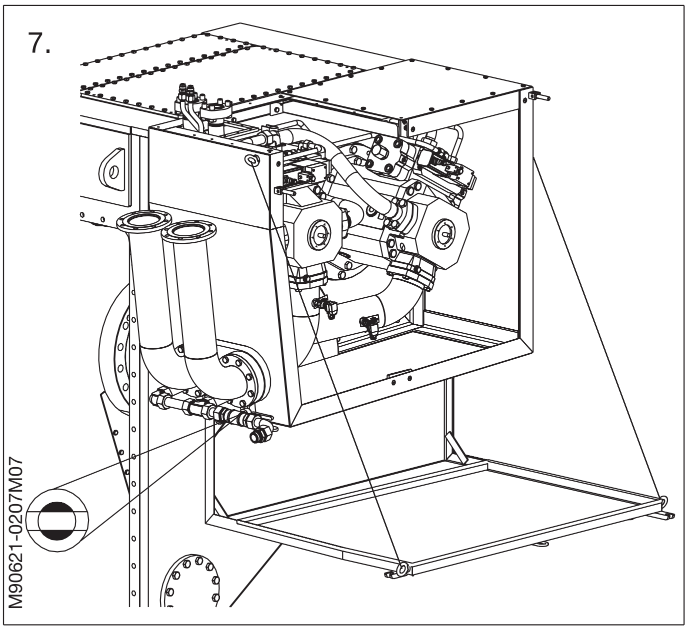
7. Open up the suction valve for the relevant pump.

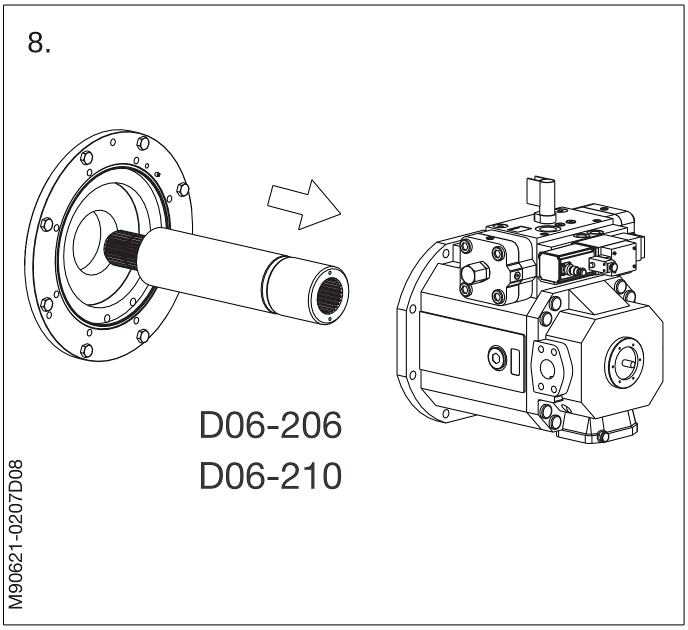
   Remount the cover and cross member.

   Remove the ladder.

8. Use the tackle to close the cover.

   Remount the floor plating on the gallery.





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

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors
X	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
D06-209	Hydraulic flange tightening torque	650	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
P90951	332	Cleaning tool for NC valve
P90951	356	Flange extractor tool
P91359		Torque Spanners

Procedure for test of double-walled pipe and alarm sensors for flow and pressure.

1. Check that flow alarm and pressure alarm are normal.
2. Open valve number 333 on the accumulator block.
3. Start one start-up pump.
4. Wait until flow alarm is activated - normally after approx. one minute.
5. Start the second start-up pump.
6. Wait until pressure alarm is activated and the flow alarm is gone.
7. During pressure build-up, check double-walled pipe for leaks.
8. Stop pumps and observe pressure drop to supply pressure (approx. 2 bar).
9. Check that pressure alarm is gone.
10. Start one start-up pump.
11. Wait until flow alarm is activated.
12. Stop pumps. Wait until pressure is low, and close valve number 333.
13. Wait until flow alarm is gone - time may be up to one hour.

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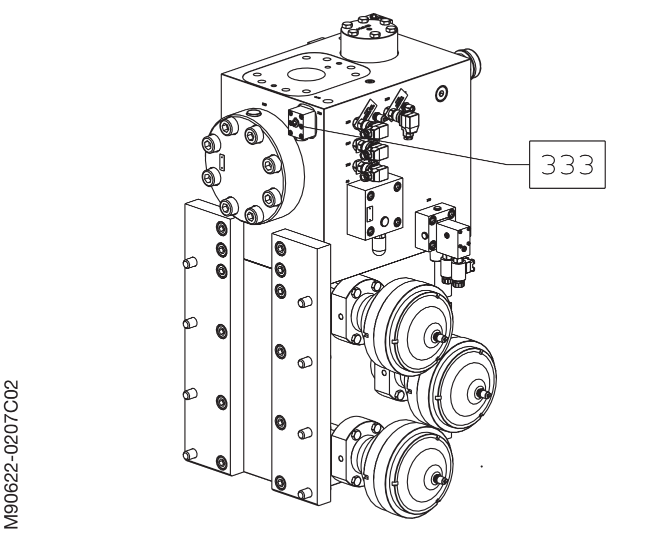

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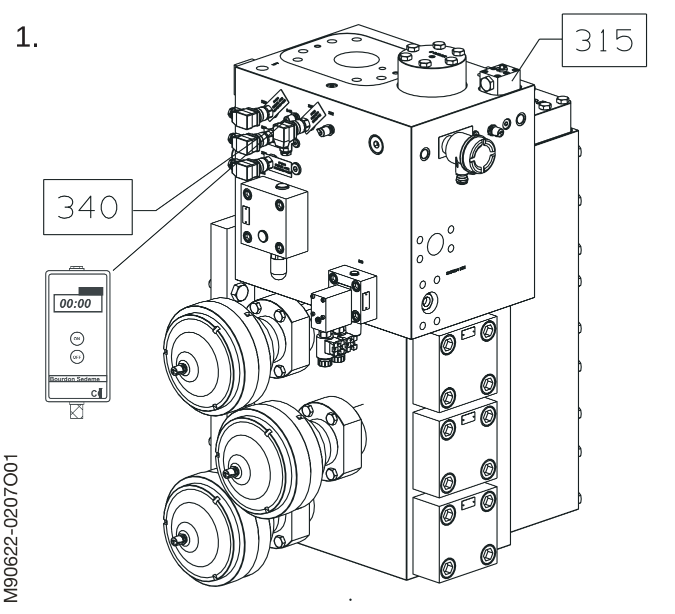

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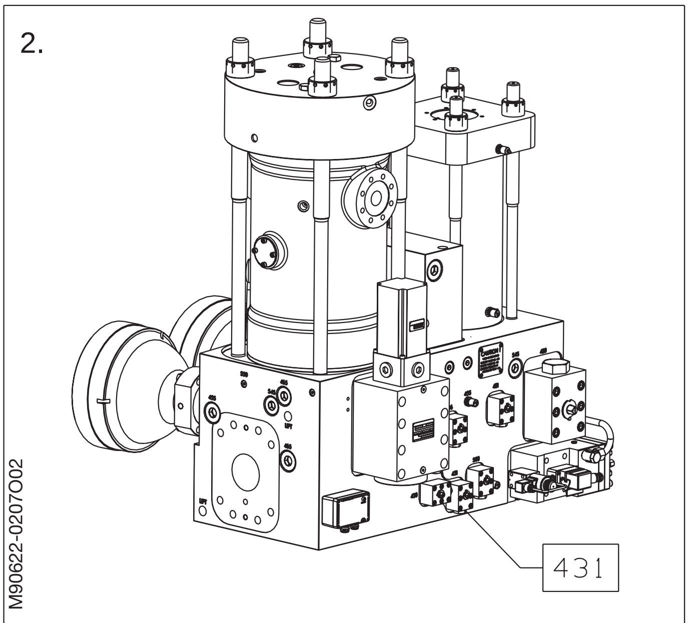

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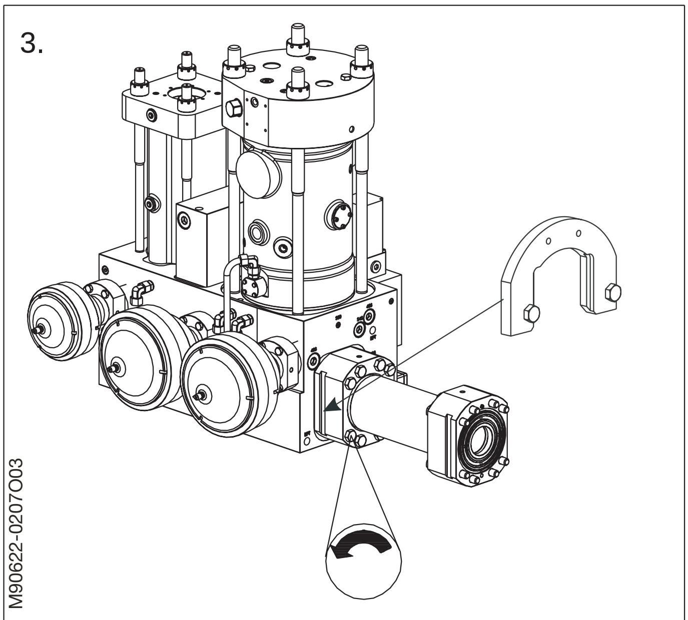

Check that the hydraulic power pumps are stopped before any part of the hydraulic system is disassembled.

Note!
Always ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

Hydraulic High-Pressure Pipes

1. Mount a pressure gauge on the “minimess” coupling 340. Check the pressure.

   Open valve 315 on the hydraulic block next to the hydraulic high-pressure pumps, to relieve the system of hydraulic pressure. Check on the pressure gauge that the system is pressure-free.

2. Open valve 431 on the hydraulic block next to the high-pressure pipe concerned, to the space between the inner and outer pipes.

3. Unscrew the screws in both flanges on the pipe concerned.

   Mount the dismantling tool in one side and pull one flange clear of the hydraulic block by means of the two screws.

4. Lift out the hydraulic double pipe.

5. Pull off both flanges.

6. Remove all sealing rings from the flanges, discard the rings.

   Clean the pipes and flanges, check the sealing surfaces.

Note!
Always ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

Mount new sealing rings, lubricate the rings with engine lube oil, before mounting the flanges on the double pipe.

For correct mounting of the sealing rings, see the sketch.

Push the flanges on to the double pipe.

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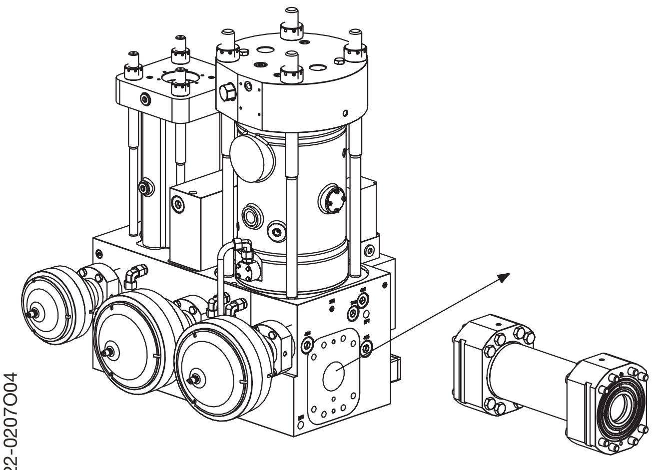

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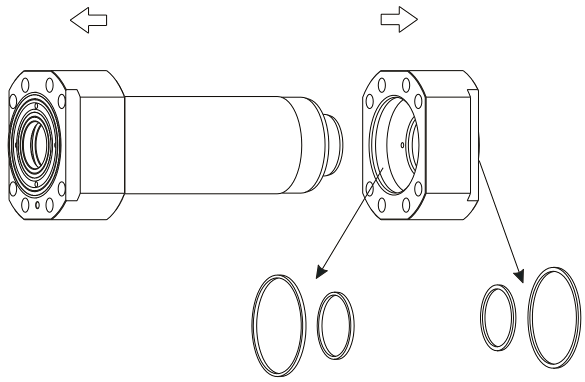

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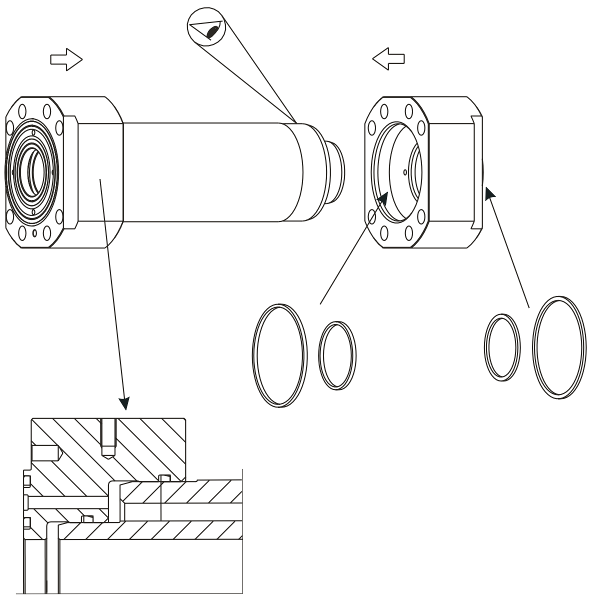

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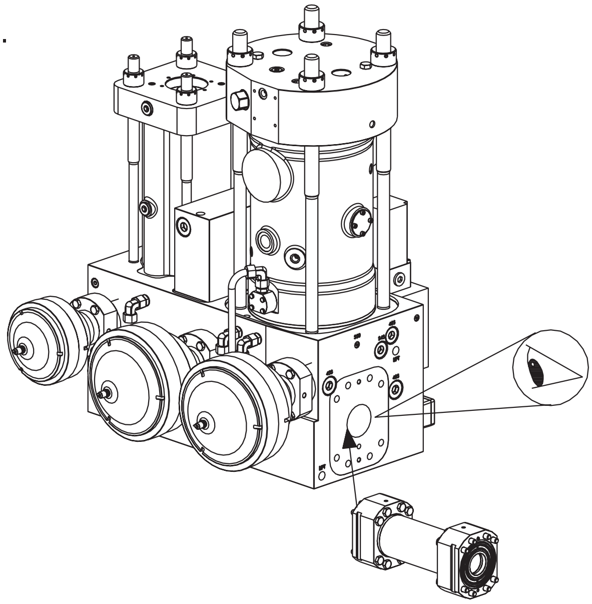

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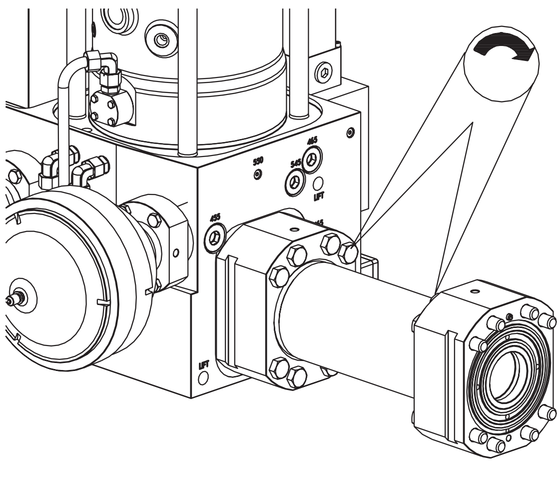

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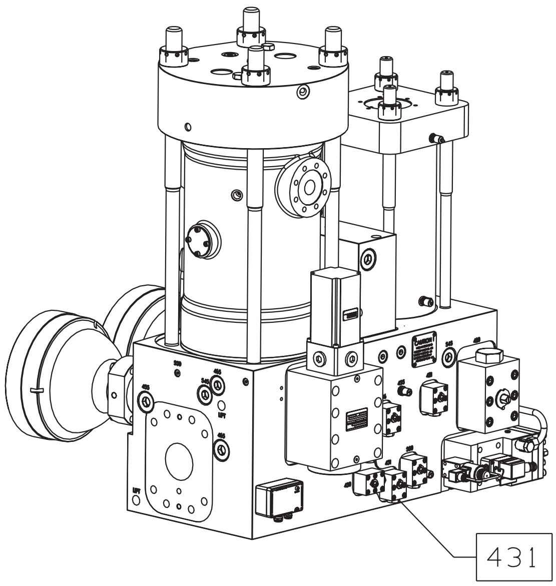

7. Before remounting the hydraulic high-pressure pipe, check that the faces on the hydraulic blocks are clean.

   Mount the hydraulic high-pressure pipe.

8. Mount the screws in the flanges and tighten to the specified torque, see Data.

9. Close valve 431 on the hydraulic block next the high-pressure pipe concerned.

10. Close valve 315 on the hydraulic block next to the hydraulic high-pressure pumps.

    After renewing sealing rings on the high-pressure pipes between the HCU, it is recommended to pressure test the pipes, *see Procedure 906-22.1.*

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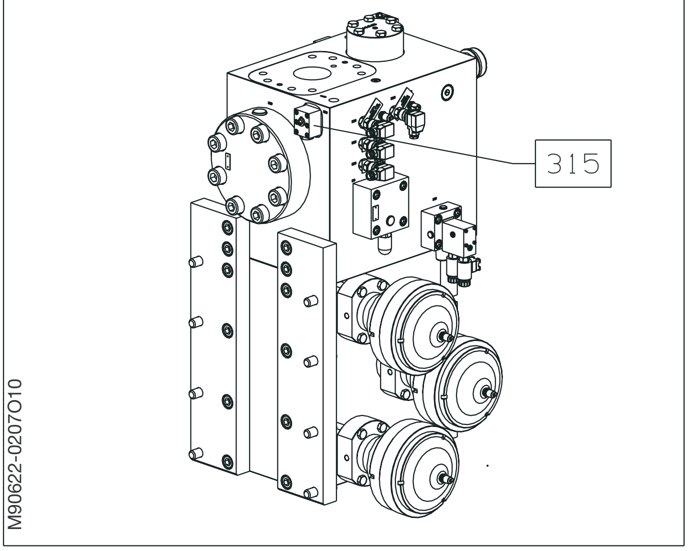


11. **Flushing of hydraulic high-pressure system**

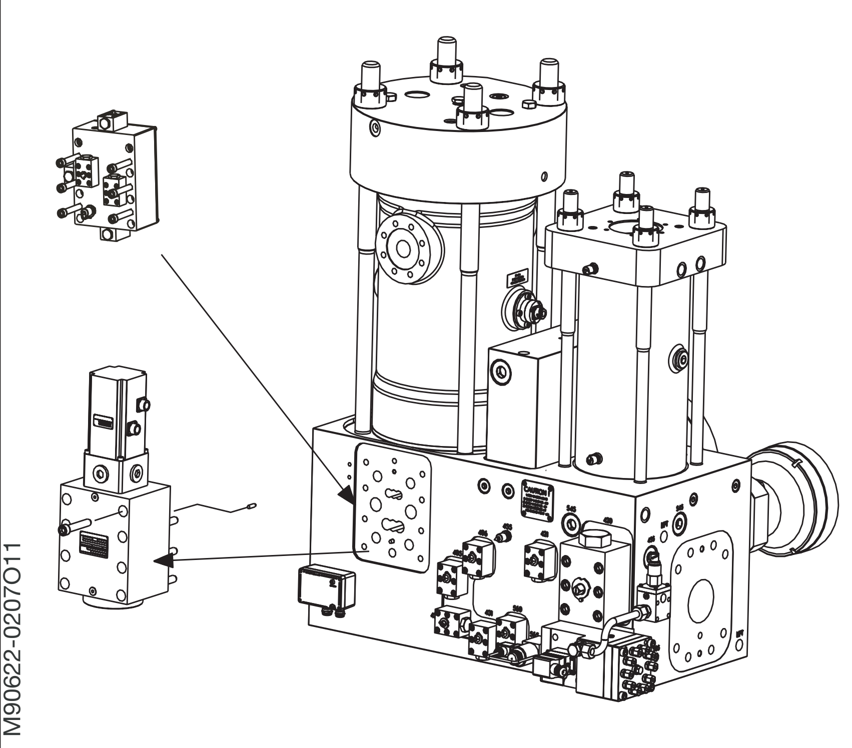
If large components in the hydraulic high-pressure system have been renewed, or if a major overhaul has been carried out on the system, it is recommended to flush the system or parts of the system.

The valve numbers in the system are shown in the figure on the last page in this procedure.

Before flushing, remove the FIVA control valve from the hydraulic cylinder unit (HCU) concerned. *See Procedure 906-24.2.*

Mount the cleaning tools, for correct tools see data.

11.



12. **Flushing of high-pressure line**

Start the electrically driven pumps and increase the pressure to normal working pressure, 175 - 210 bar.

Check the system for leaks.

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Closed	Open	Closed	Closed

	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Closed	Closed	Closed	Closed	Closed

Start with the HCU nearest the accumulator block and pump station, if more than one HCU is flushed. Open valve 420, then open and close valve 421 several times. Wait for the pressure to build up to normal before repeating. Repeat the procedure for each relevant cylinder.

13. **Flushing of bores inside distributor blocks ("Fuel Injection" side)**

When repeating the procedure, it is important to ensure that the pressure does not fall below 120 bar.

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Closed	Open	Closed	Open

ELFI Tool	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Closed	Closed	Closed	Closed	Closed

Start with the cylinder nearest the accumulator block. Open valves 420 and 14, then open and close valve 18 several times. Repeat the procedure for each cylinder concerned.

14. **Flushing of bores inside distributor blocks (“Valve Activation” side)**

When repeating the procedure, it is important to ensure that the pressure does not fall below 120 bar.

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Closed	Open	Closed	Open

	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Closed	Closed	Closed	Closed	Closed

Start with the cylinder closest to the accumulator block. Open valves 420 and 14, then open and close valve 17 several times. Repeat the procedure for each relevant cylinder.

15. **Flushing of fuel oil pressure booster actuator side (“Fuel Injection” side)**

When repeating the procedure, it is important to ensure that the pressure does not fall below 120 bar.

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Closed	Open	Closed	Open

	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Closed	Closed	Closed	Closed	Closed

The fuel oil system must be running normally at operating pressure.

Start with the cylinder closest to the accumulator block.

Open valves 14 and 16, then carefully open valve 420, and check that the fuel oil pressure booster pump moves slowly upwards to the end position.

Close valve 420 and open valve 14. Open valve 18 and see that the fuel pump moves back to the start position.

Repeat 2-3 times. Carry out the procedure for each relevant cylinder.

Note! Due to the high pressure in the system, some valves may be difficult to operate.

Release the pressure by opening valve 17 or 18. The pressure can be observed by mounting a pressure gauge at the relevant “minimess” valve. To avoid too much fuel oil on top of the piston, the fuel oil pressure booster pump may only be activated 2-3 times.

16. **Flushing of exhaust actuator ("Valve Activation" side)**

When repeating the procedure, it is important to ensure that the pressure does not fall below 120 bar.

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Closed	Open	Closed	Open

	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Closed	Closed	Closed	Closed	Closed

Air must be supplied to the exhaust valve air spring and oil supplied to the exhaust valve damper and exhaust actuator.

Open valves 14 and 15, then carefully open valve 420, and the exhaust valve actuator will move slowly upwards to the end position.

Close valve 14 and open valve 17, and the exhaust actuator will move back to the start position. Repeat several times. Carry out the procedure for each relevant cylinder.

Release the pressure by opening valve 17 or 18. The pressure can be observed by mounting a pressure gauge at the relevant "minimess" valves.

Check the cleanliness of the oil, e.g. at sample point "minimess" valve 425.

Flushing of the high-pressure hydraulic system is considered as finished at this stage.

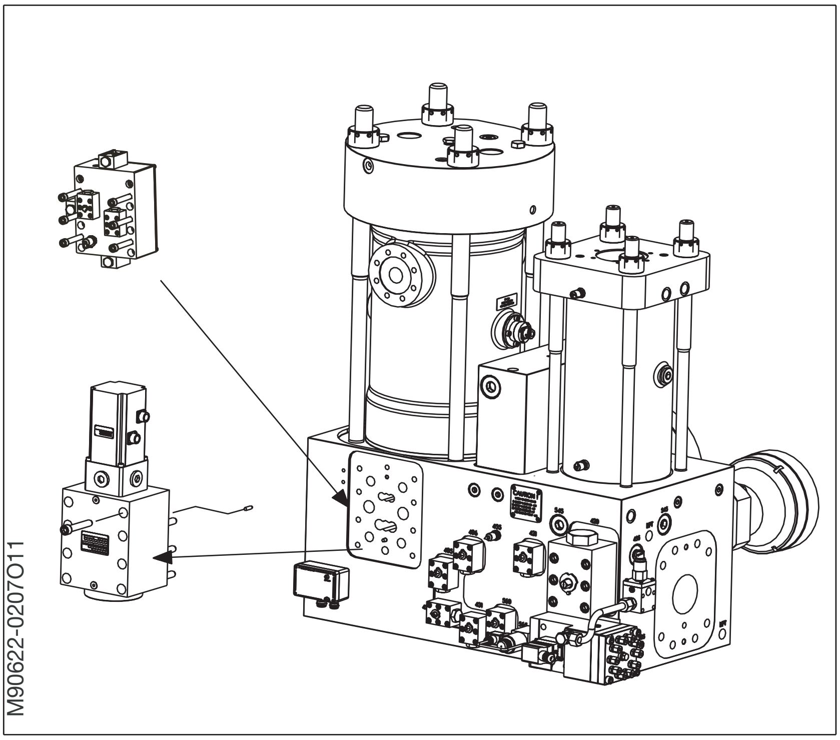
17. **Dismantling of temporary flushing components**

Valve/filter pos. No.	405/406	420	421	430	431	531
Open/closed pos.	Closed	Closed	Open	Open	Closed	Open

	FIVA Tool				
Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Open	Open	Open	Open	Open

Close valve 420 and then open valves 421, 405, 8, 9, 10, 11, 12 and 13. To be carried out on all cylinders.

Remove the cleaning tools and mount the ELFI and ELVA valves on the relevant cylinders.
See procedure 906-24.4.



18. **Basic position of valves during normal running of the Engine**

Valve/filter pos. No.	101	103	105	106	109	115
Open/closed pos.	Open	Open	Blocked	In use	Open	Closed

Valve/filter pos. No.	230	285	405/406	420	421	430	431	531
Open/closed pos.	Open	Open	Closed	Open	Closed	Open	Closed	Open

Valve/filter pos. No.	14	15	16	17	18
Open/closed pos.	Replaced by FIVA valve				

Valve 430 normally open. To be used for detection of leaks.

Valve 431 normally closed.

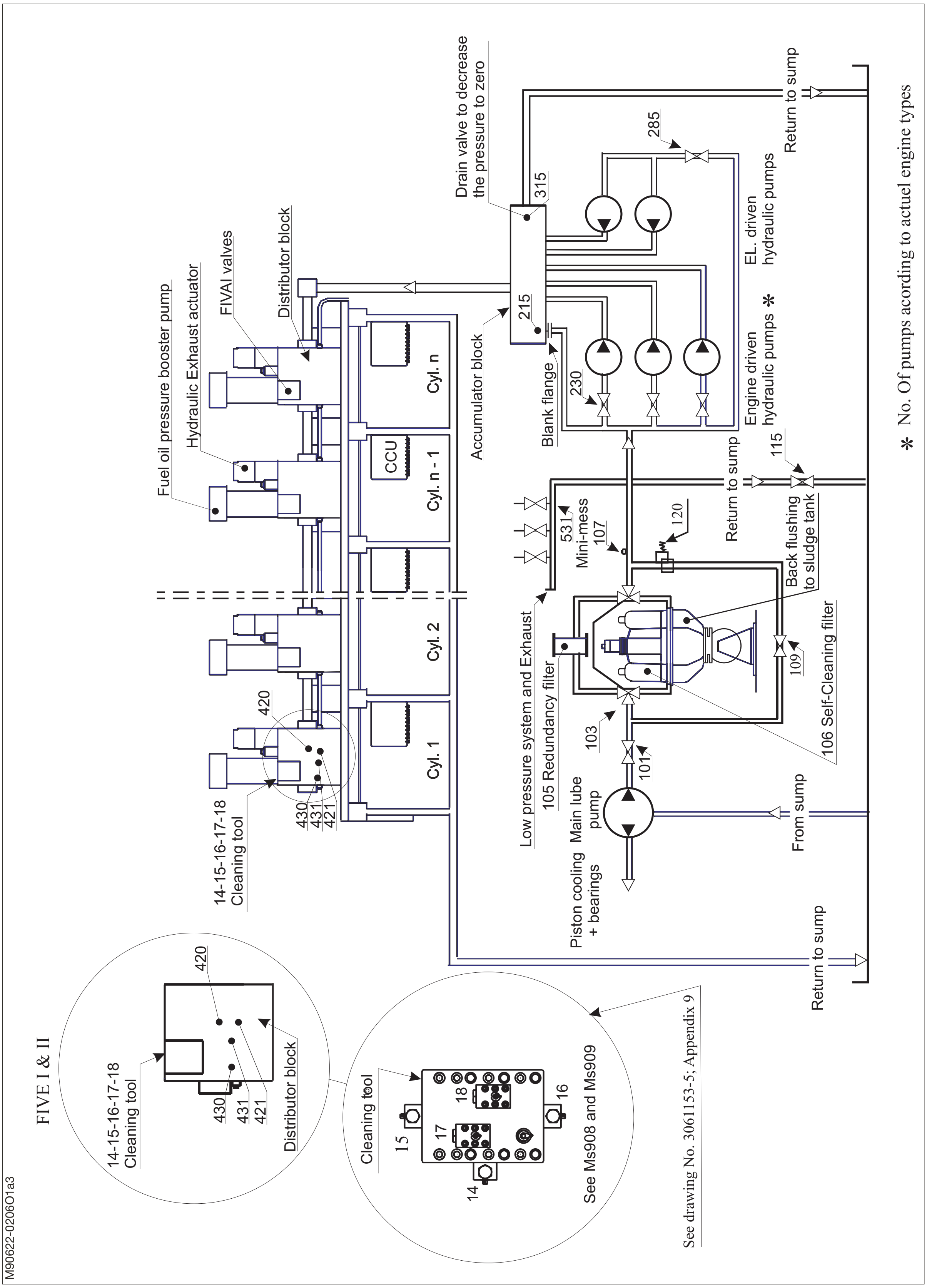
Oil samples should be taken in order to record the contamination level. These should be taken at suitable intervals, e.g. at start-up and after the oil has circulated in the system for some minutes. The samples should be taken at a position where the oil flow is turbulent.

A flushing of 4 – 6 hrs. is considered as sufficient, depending on the system cleanliness.

19. **Venting**

To vent the system, connect a “minimess” hose between 425 and 550 at each HCU concerned.

Start the start-up pumps and let the pumps run for approximately 10 min. Stop the pumps and remove the “minimess” hose. The system has now been vented.



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

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
X	Lock the turbocharger rotors

Data

Ref.	Description		Value	Unit
D06-201	Accumulator		24	kg
D06-202	N2 Charging pressure		104.3	bar at 20°
D06-203	Accumulator flange tightening torque		60	Nm
D06-204	Pressure Adjustment Table			
	Accumulator temperature	t °C		bar
		0	97.2	
		10	100.7	
		20	104.3	
		30	107.9	
		40	111.4	
		50	115.0	
		60	118.5	
		70	122.1	
		80	125.7	
		90	129.2	
		100	132.8	
	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

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 Alpha-Lubricator
P90653		Tools for Accumulator
P91356		Lifting Tools, etc.
P91359		Torque Spanners
P91366		Instruments

Check of Accumulators on Hydraulic Cylinder Unit

1. Checking the hydraulic accumulator can be done with running engine at reduced speed. *See Volume I, Operation.*

   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 3.

Check of Accumulators on Hydraulic Power Supply Unit

2. Check of accumulators on the accumulator block 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. Check the pressure.

   Open valve 315 to release the hydraulic pressure from the system and drain all oil out of the accumulators.

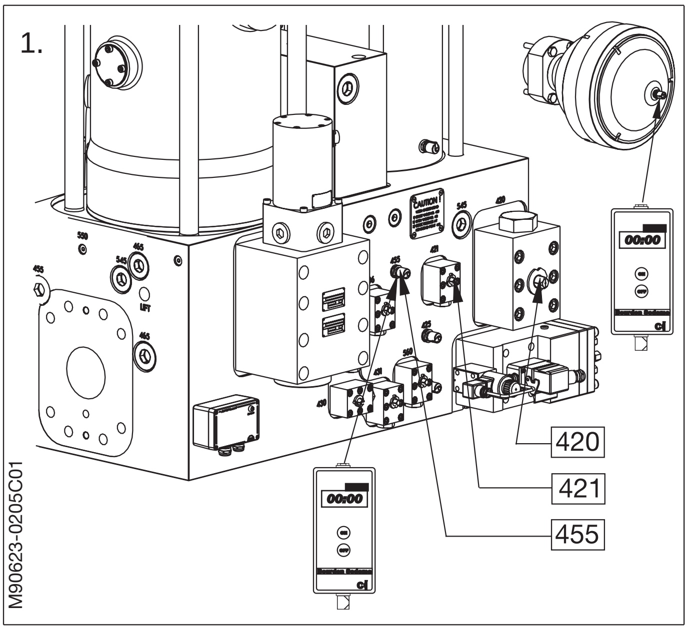
   Check on the pressure gauge that the system is pressure free.

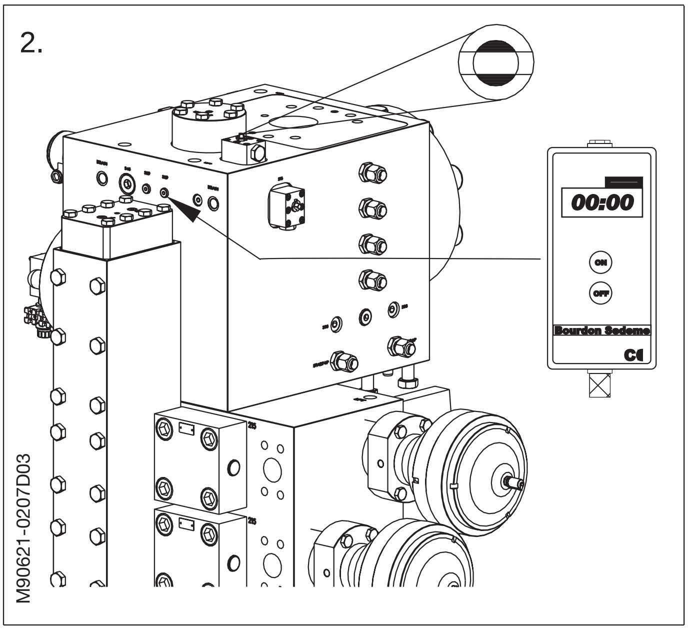
   Mount the pressure gauge connected with a “minimess” hose on the accumulator.

   Check the nitrogen pressure.

   For correct pressure, see Data D06-204.

   For use of pressure setting tool, see step 3.





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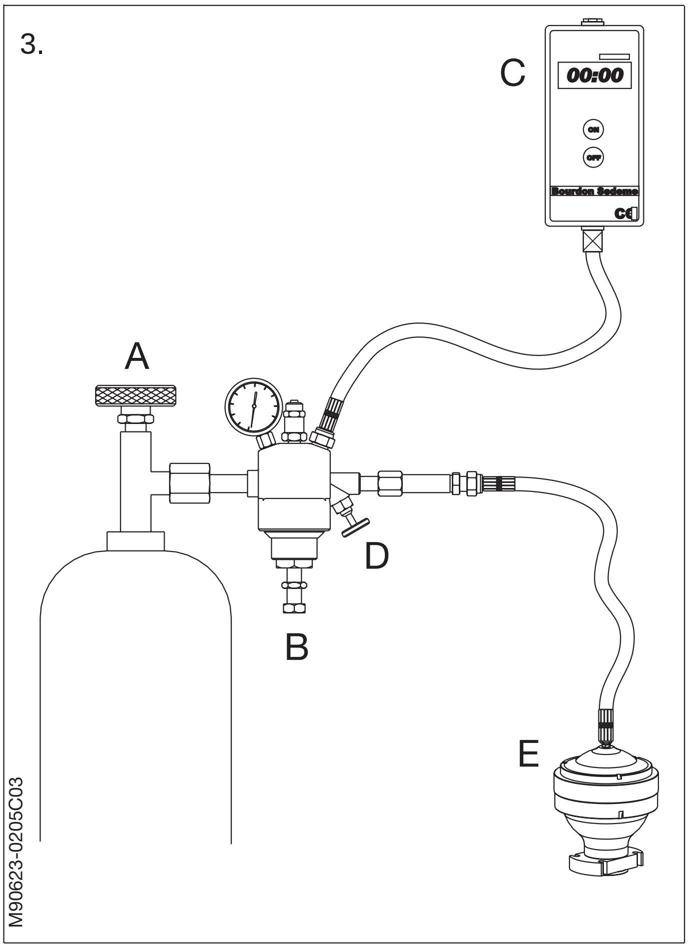

Use of Reducing Valve as Pressure Setting Tool

3. 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.

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

1. This can be performed on a running engine at reduced speed. *See Volume I, Operation.*

   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.

2. Dismount the accumulator flange from the hydraulic cylinder unit.

   Dismount the accumulator flange from the accumulator.

Dismantling of Accumulators from Hydraulic Power Supply Unit

3. Dismantling of accumulators from the accumulator block 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. 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.

   The accumulators on the hydraulic power supply unit are dismounted in the same way as on the hydraulic cylinder unit.

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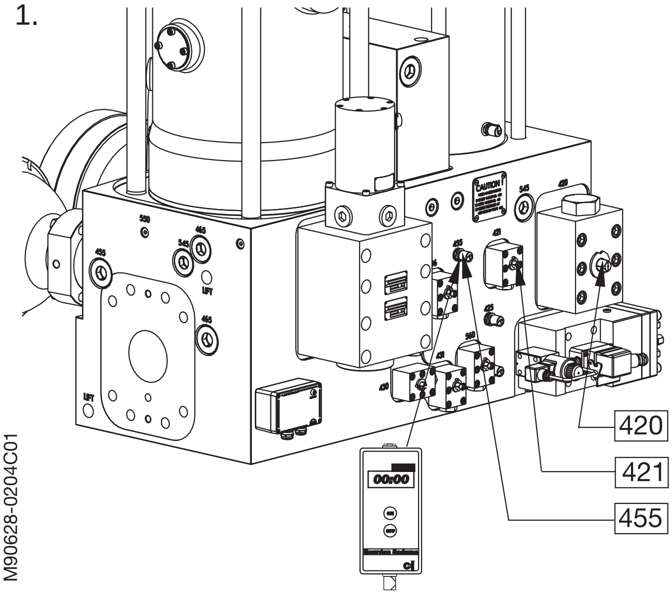

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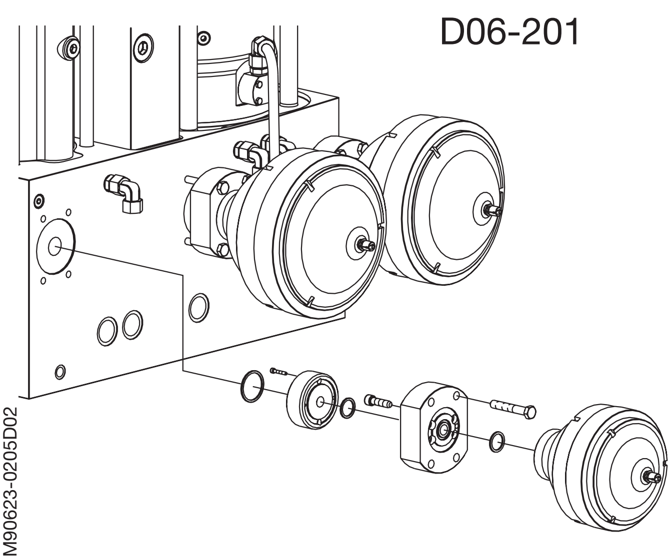

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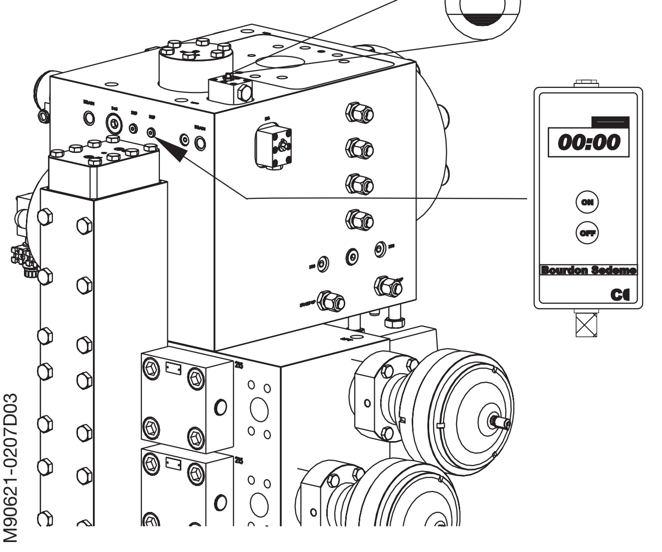

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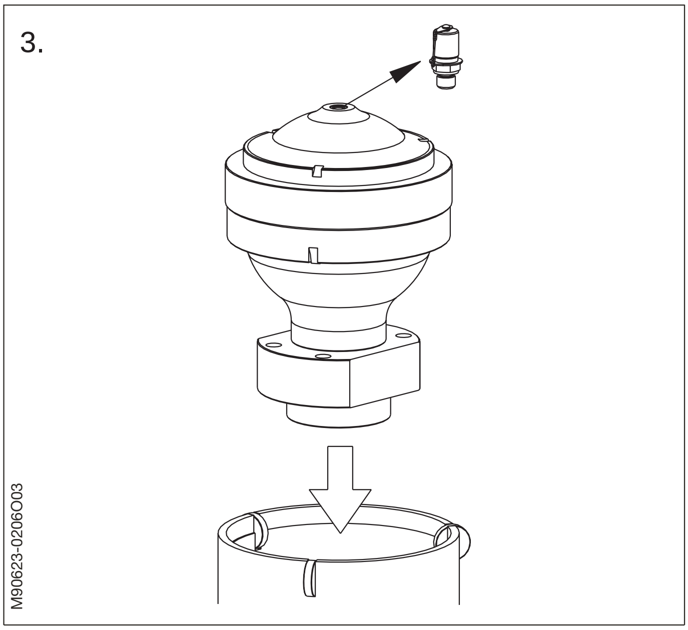

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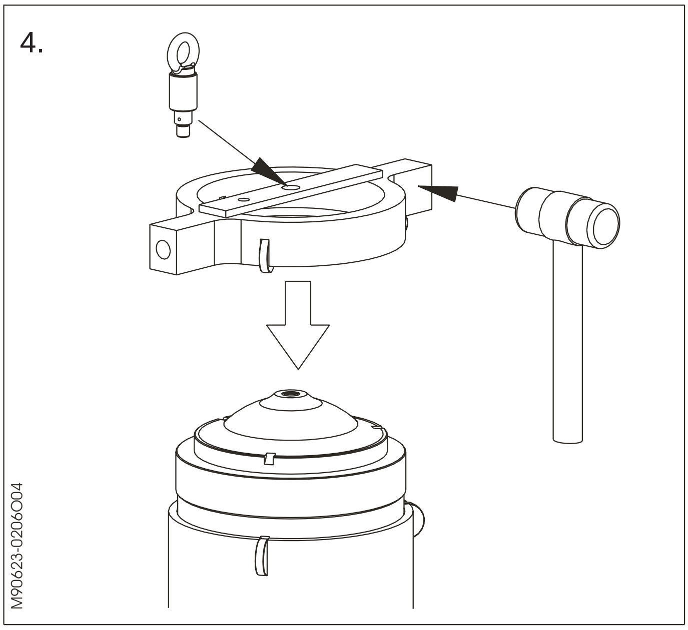

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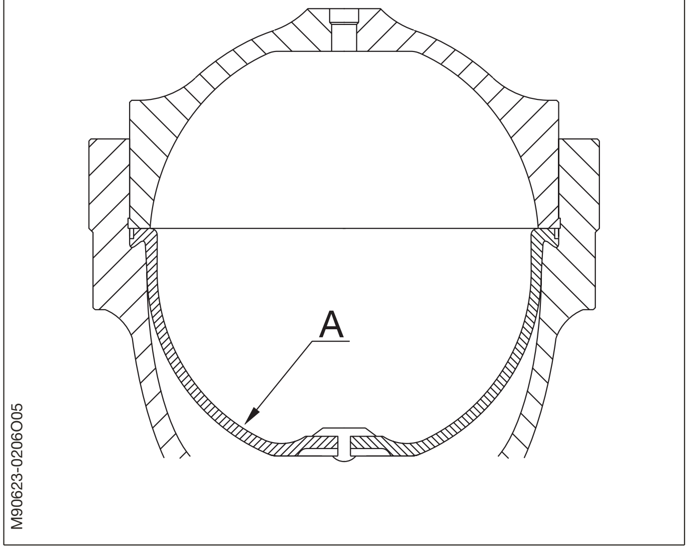


1. Remove the accumulator with the accumulator flange. *See Procedure 906-23.2.*

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.

   Mount the accumulator in the bottom half of the accumulator tool. Make sure that the guides on the tool fit into the slots on the accumulator.

4. Mount the upper half of the accumulator tool and screw the dowel pin with lifting eye into the accumulator top. Make sure that the guides on the tool fit into the slots on the accumulator.

   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. Remove the defective diaphragm “A”

6. Clean both accumulator halves throroughly, especially the threads, and make sure that the parts are dry afterwards.

7. Assemble the two accumulator halves without fitting the diaphragm. Tighten until the halves are in contact.

   Mark the relative position of the accumulator halves.

8. 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.

9. Lubricate the upper part of the diaphragm lip and the accumulator threads with molyb-denum disulphide grease.

10. Assemble the accumulator. Tighten until the marks made in section 7 are off-set according to D06-216.

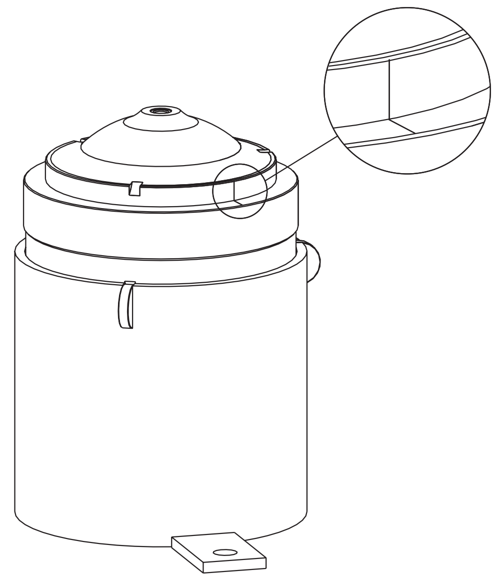
11. Mount the “minimess” valve, by using a new O-ring.

    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.

7.



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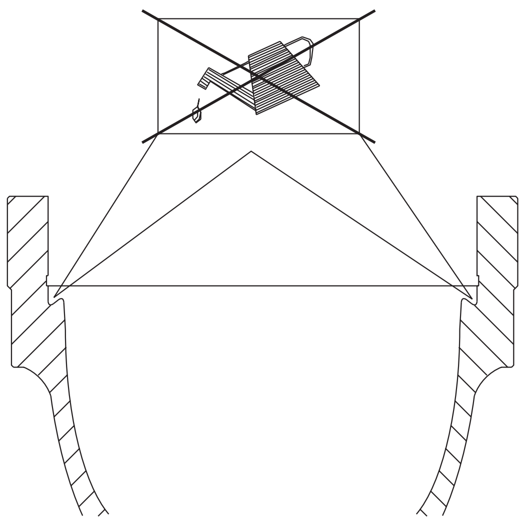

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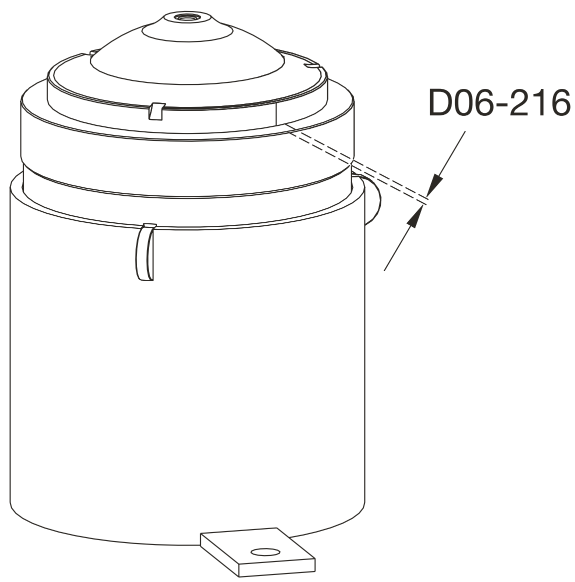

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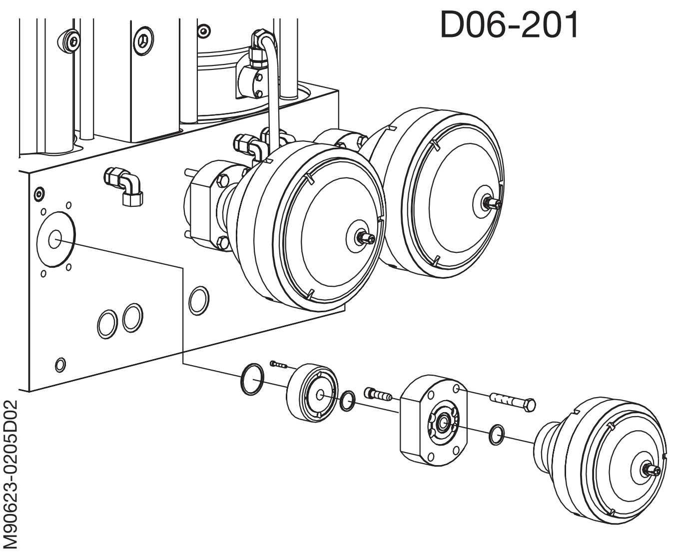

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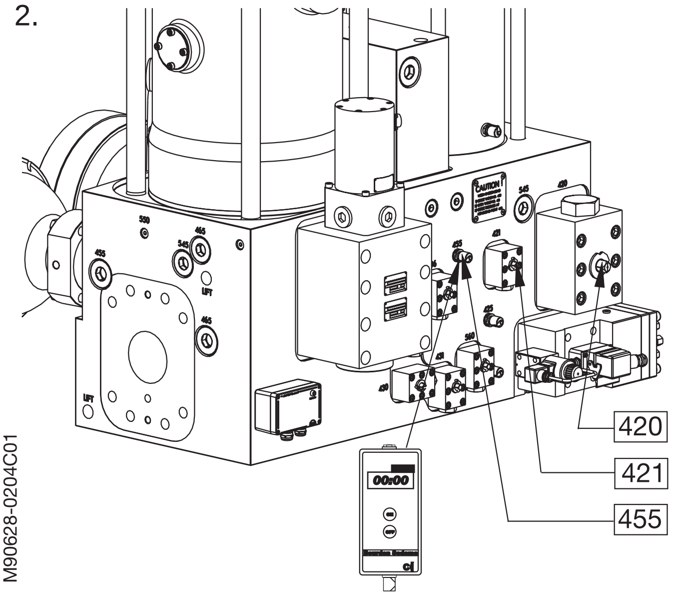

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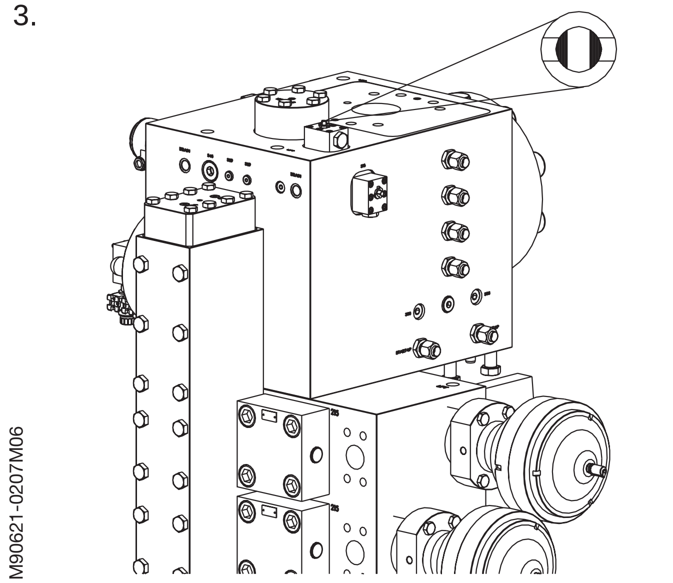

Note!
Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

Mounting of Accumulators on Hydraulic Cylinder Unit

1. This can be performed on a running engine at reduced speed. *See Volume I, Operation.*

   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 and booster pumps.

   The accumulators on the hydraulic power supply unit are mounted in the same way as on the hydraulic cylinder unit.

   Close valve 315.

   Mount a pressure gauge on the "minimess" coupling No. 339. Check the pressure.

   Close valve 315.

   Check on the pressure gauge that the system is pressurised.

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

X	Stopped engine
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 with stopped lubriating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors
X	Shut down hydraulic power supply

Data

Ref.	Description	Value	Unit
D06-215	FIVA Control Valve	60	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

1. The function of the **F**uel **I**njection and the **V**alve **A**ctivation 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 B&W Diesel.

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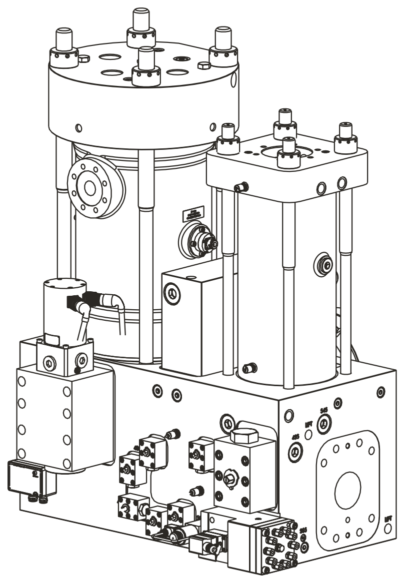

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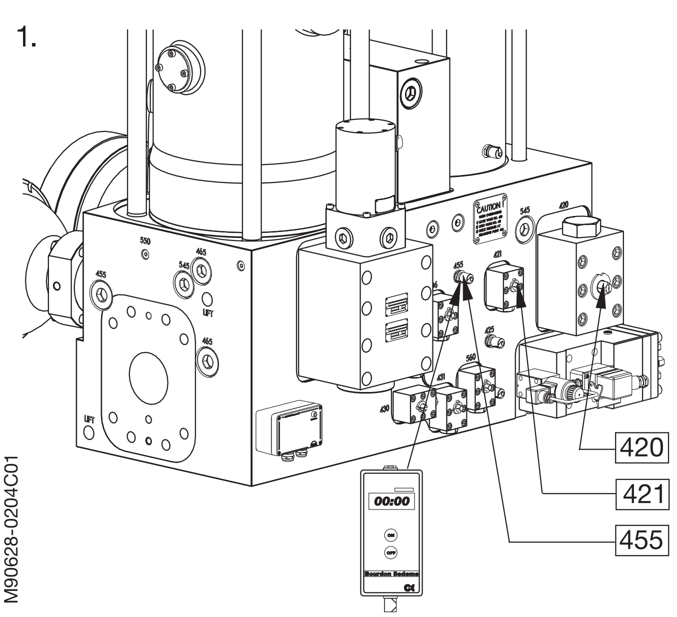

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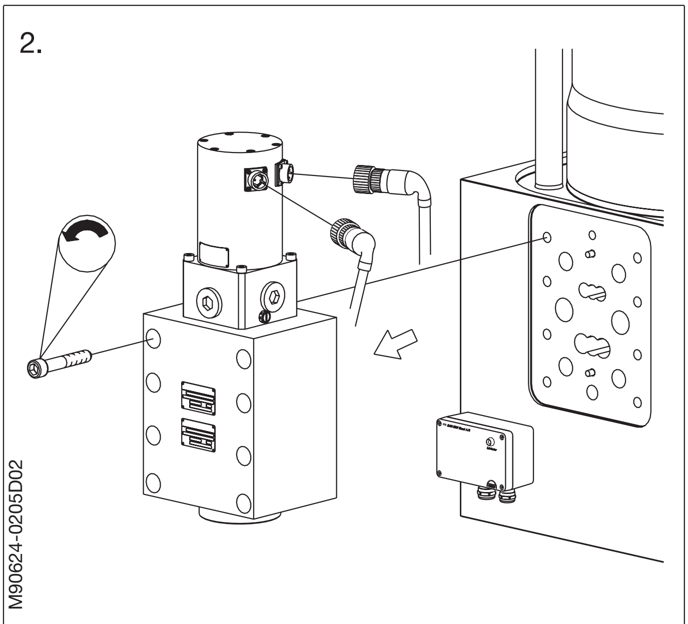


Note!

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.

   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.

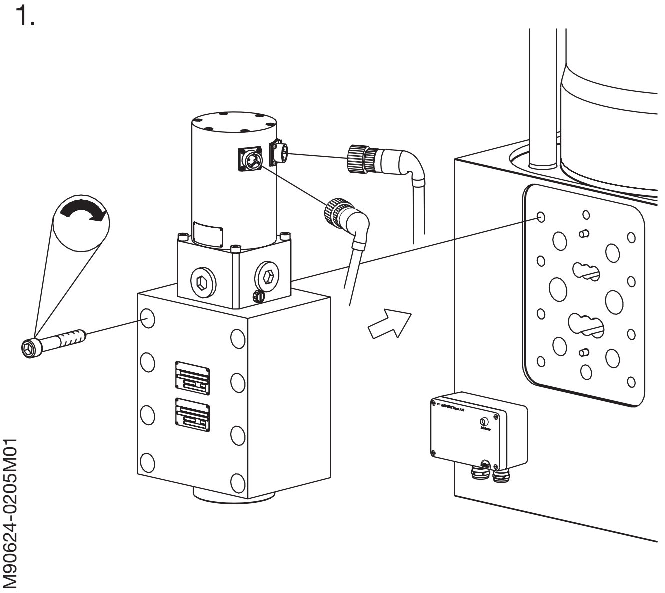
1. Mount new square section sealing rings in the control valve.

   Mount the control valve on the two guide pins and tighten the four screws.

2. Close the high pressure outlet valve 421 and open the high pressure inlet valve 420.

3. Connect the electrical connections

1.



M90624-0205M01

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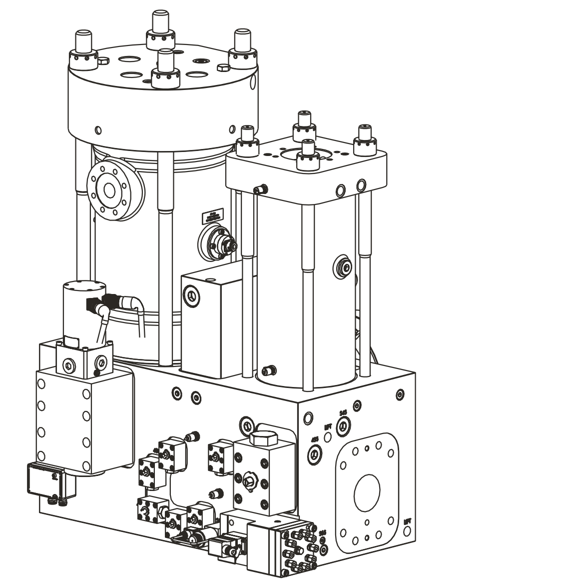

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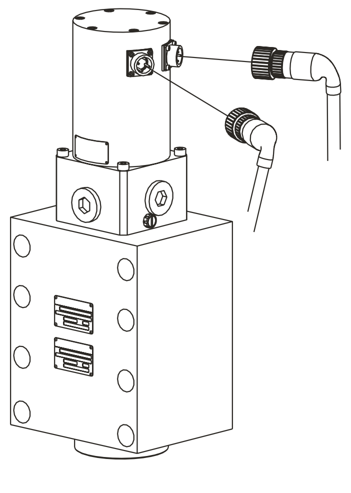


M90624-0205M03

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

X	Stopped engine
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
	Shut off safety air supply – *Not ME engines*
X	Shut off control air supply
X	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D06-218	Angle Encoder cover	20/42	kg
D06-219	Angle Encoder bracket	47	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.

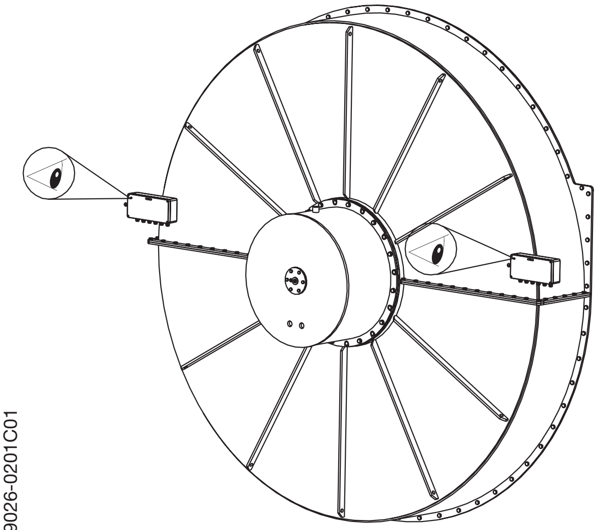
Plate	Item No.	Description
P91356		Lifting Tools, Etc.
P91366	73	Dial Gauge and Stand Tool

1. Check that power is supplied to the **T**acho **S**ignal **A**mplifier 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.

1.



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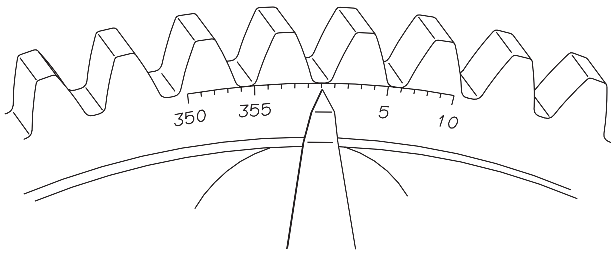

M90626-0201C02

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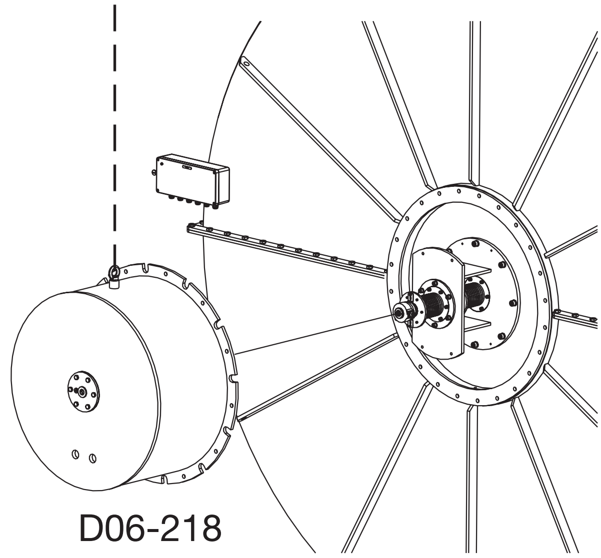

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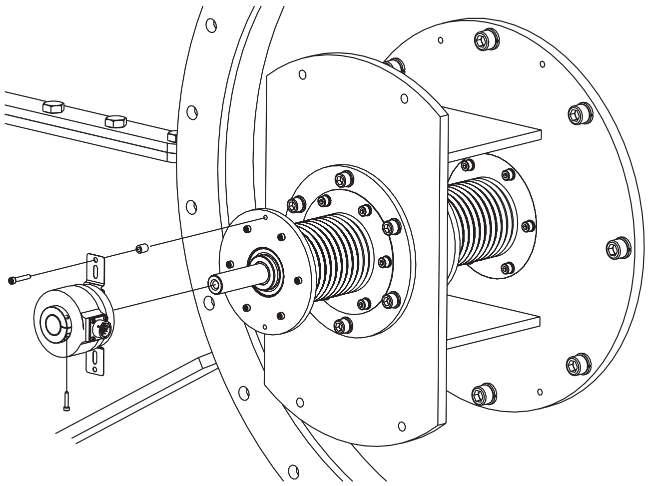

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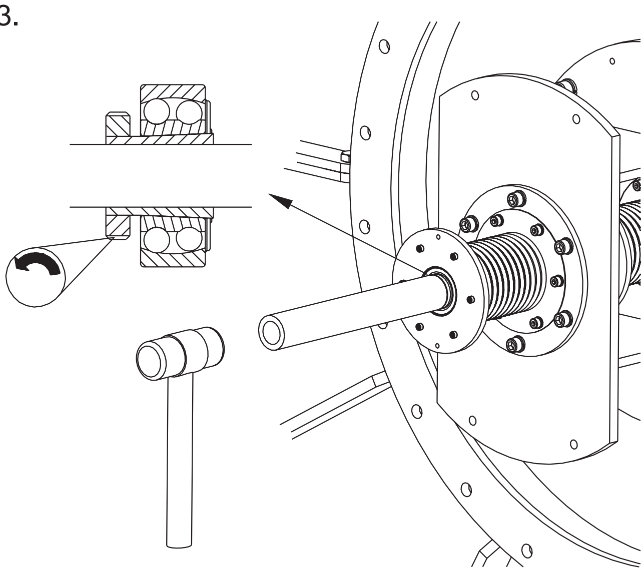


M90626-0201D03

1. Use a tackle to lift off the angle encoder cover where applicable.

2. Tag the electical 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 axle. 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 compesator.

5. The inner encoder and compensator is dismantled in the same way as the outer encoder and compensator.

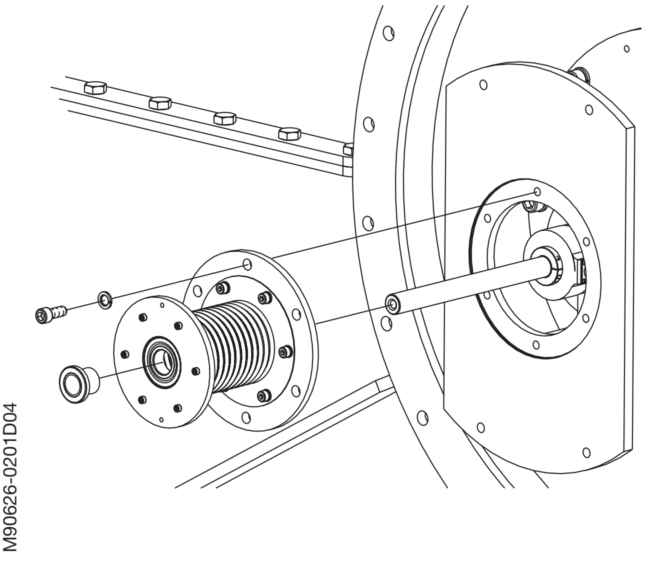
6. If it is necessary the mounting bracket can be dismantled.

   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 dismounted when it is absolutely necessesary.

4.



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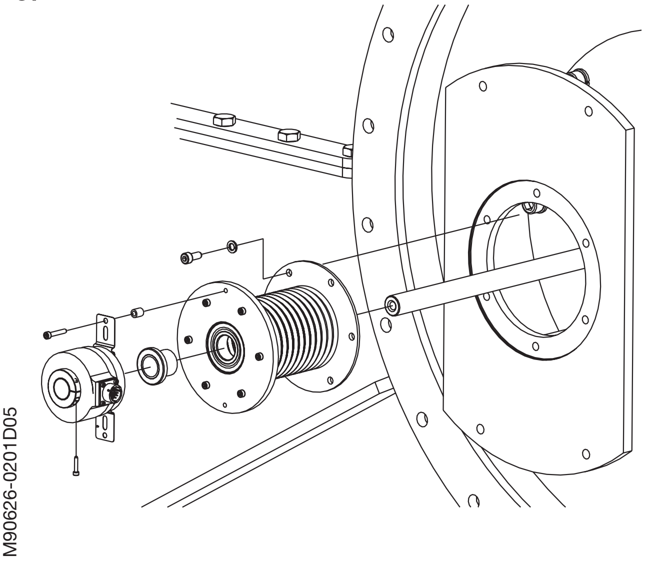

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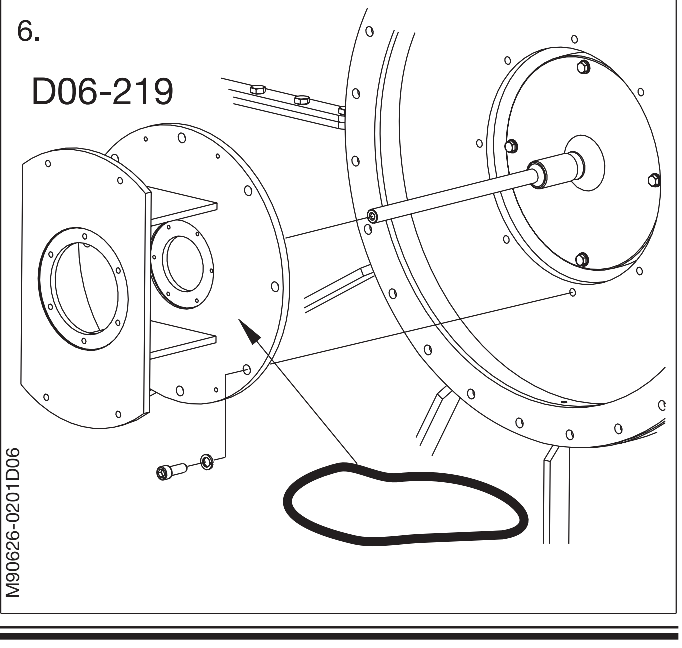

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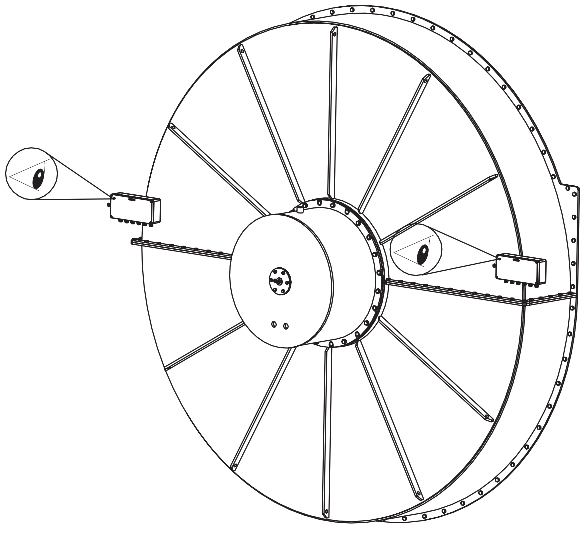

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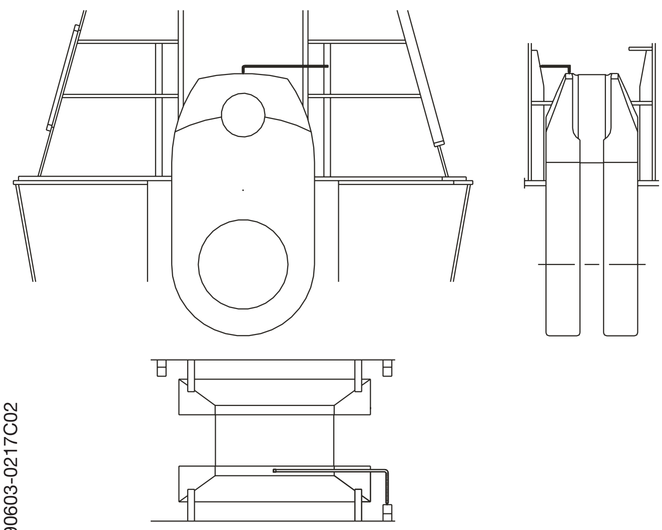

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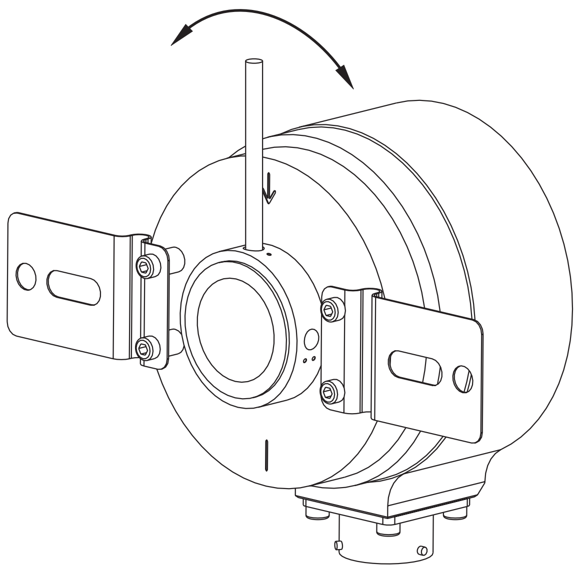


1. Use a tackle to lift off the angle encoder cover where applicable.

2. Turn the crankthrow for cylinder 1 to TDC.

3. Check the TDC position with the pin gauge on the cranckthrow.

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. (TSA-A).

5. Use a mandrel or a drill to turn the encoder hollow shaft in the ahead direction until the indicator light turns on.

   If the indicator light is already on, turn in the ahead direction until it goes off and then 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. (TSA-B).

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 dial gauge to ensure a maximum deviation from “X” of ± 0.3 mm around the center shaft.

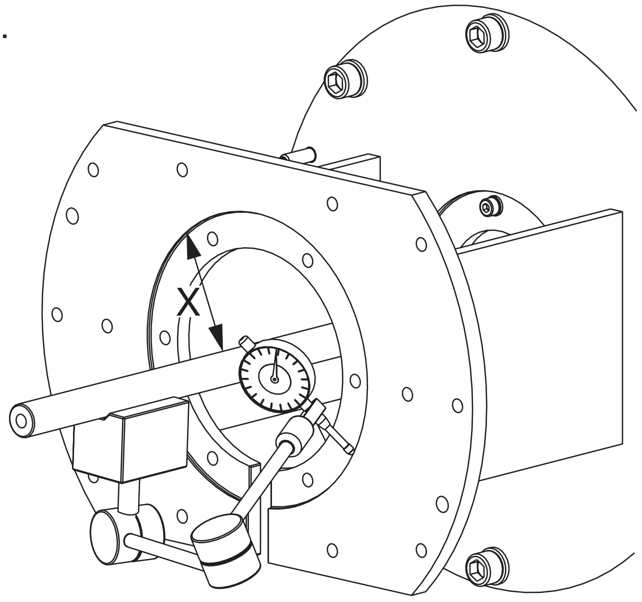
   “X” is the distance between the centre shaft and the rim of the compensator mounting recess.

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-

1.



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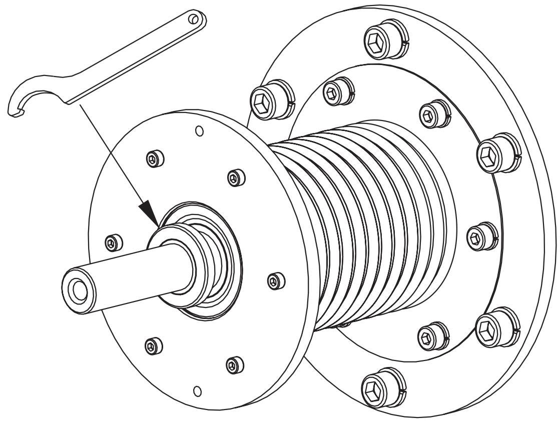

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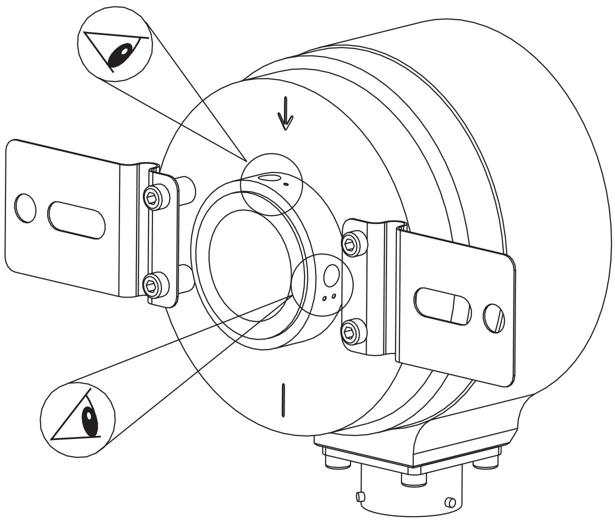

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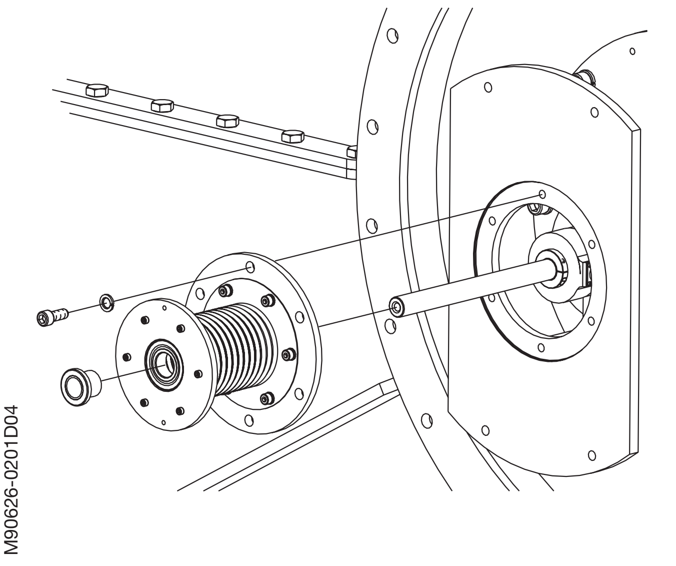

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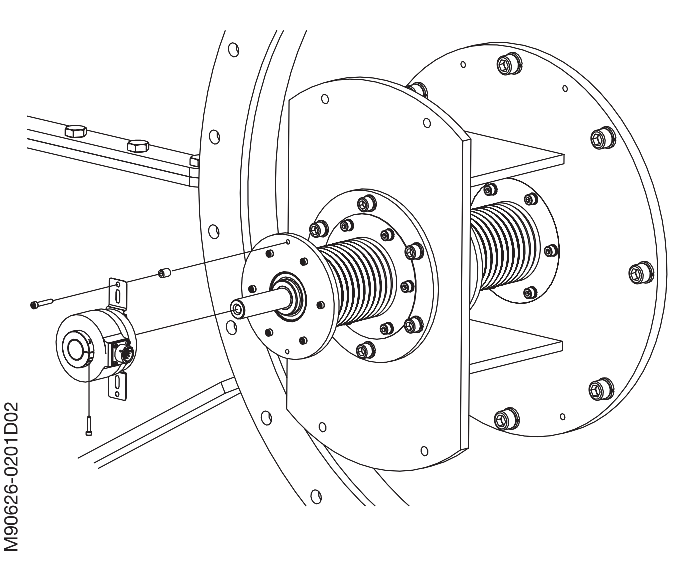


wise turning engine or the two dots in case of a counter clockwise turning engine, are in line with the arrow.

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*

X	Stopped engine
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
	Shut off safety air supply – *Not ME engines*
X	Shut off control air supply
X	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
	Stop lubricating oil supply
	Lock the turbocharger rotors
X	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		Equipment for special running
P90851	124	Tool for emergency open exhaust valve
P91366		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.

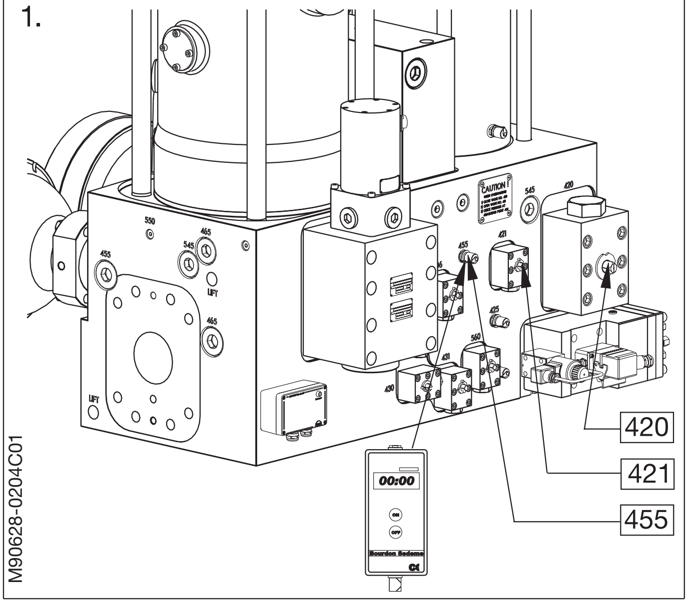
2. Shut off the oil damper oil supply by closing valve 531 on the hydraulic cylinder unit.

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.

1.



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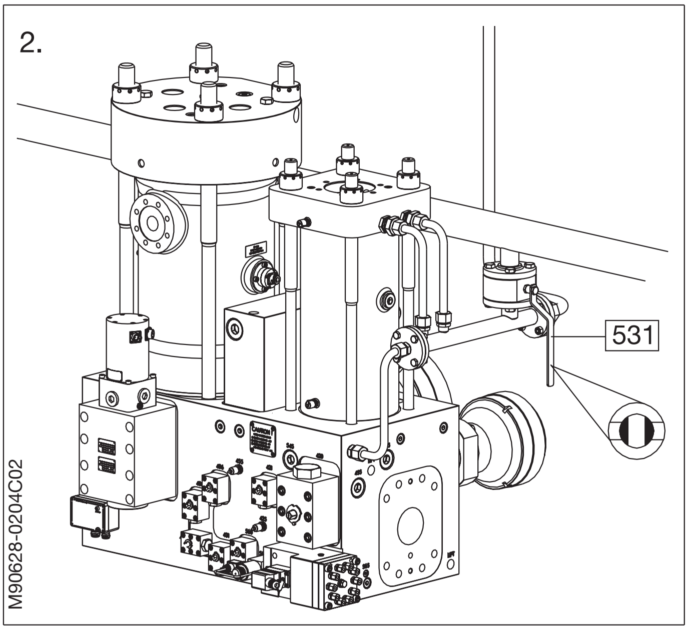

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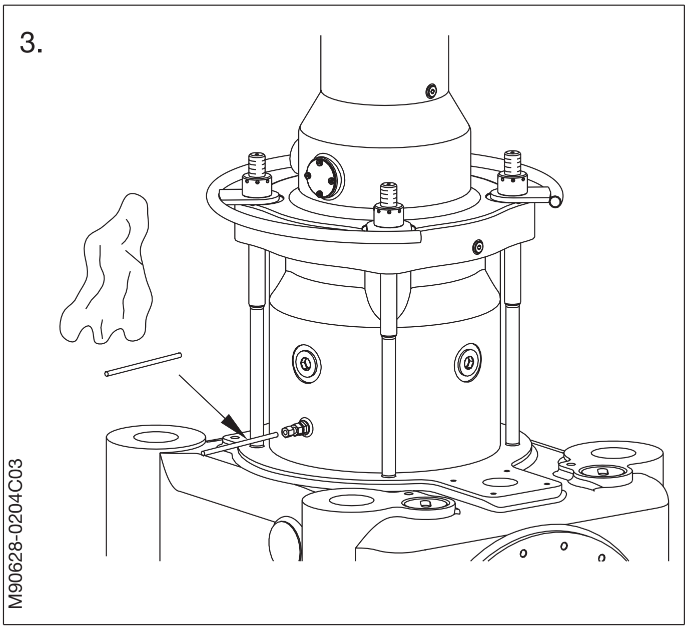
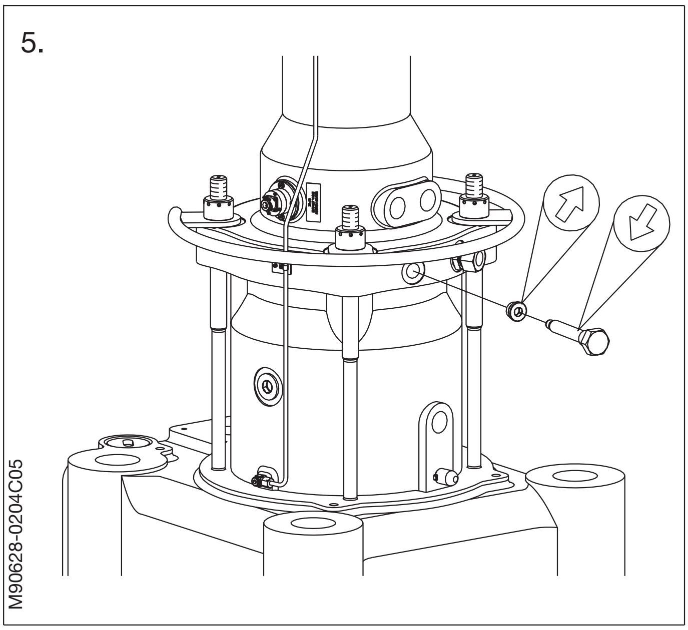
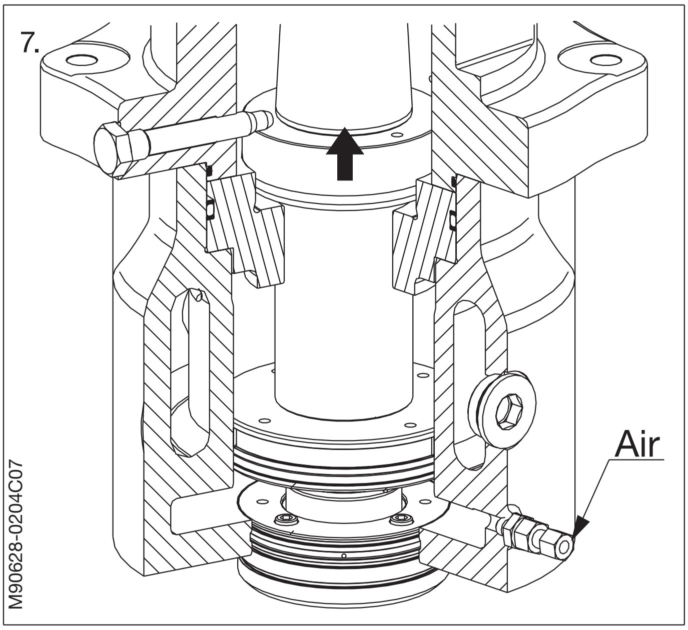




5. Remove the plug screw and mount the tool for emergency opening of exhaust valve.

6. Open the oil damper oil supply by opening valve 531 on the hydraulic block.

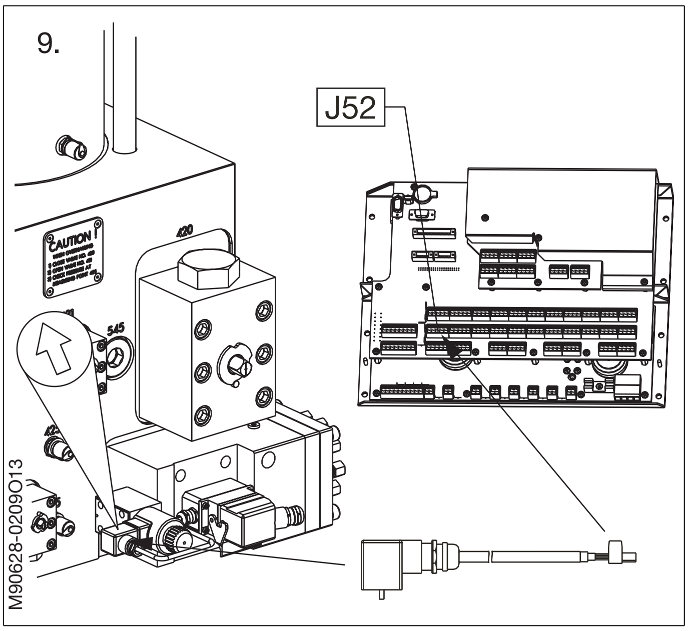


7. Reconnect the exhaust valve air supply.

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. 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.

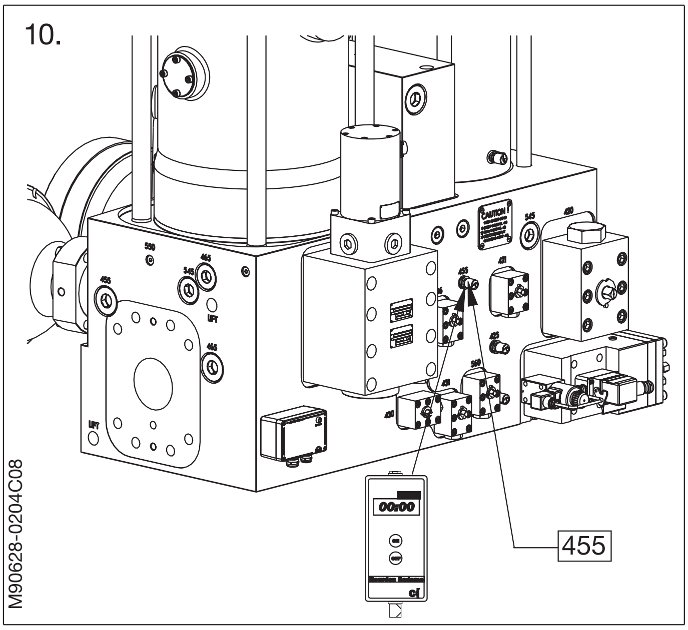
11. Shut off and disconnect the exhaust valve air supply.

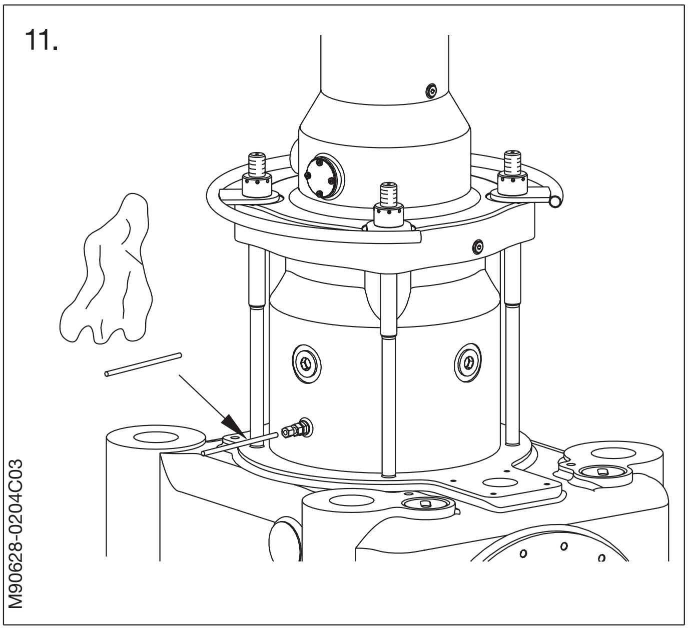
    Use a mandrel to puncture the non-return valve. Cover the valve with a cloth to protect against oil spray.

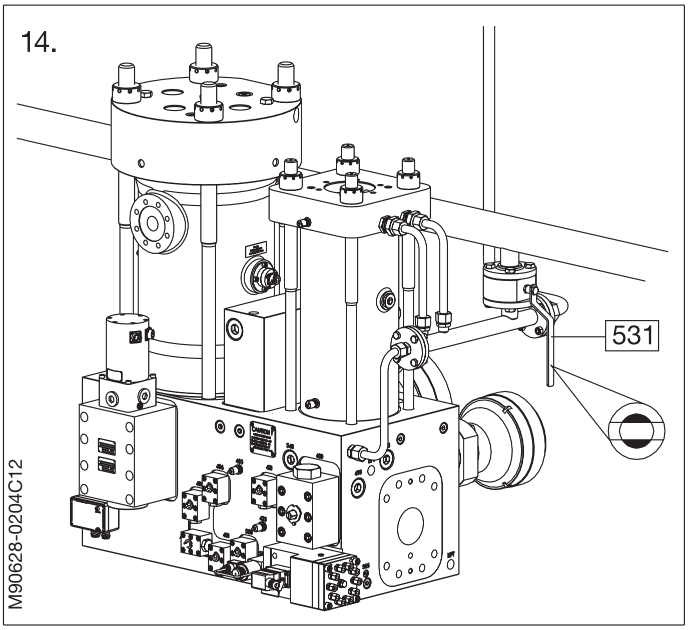
12. Check that the exhaust valve spindle has moved to the open position.

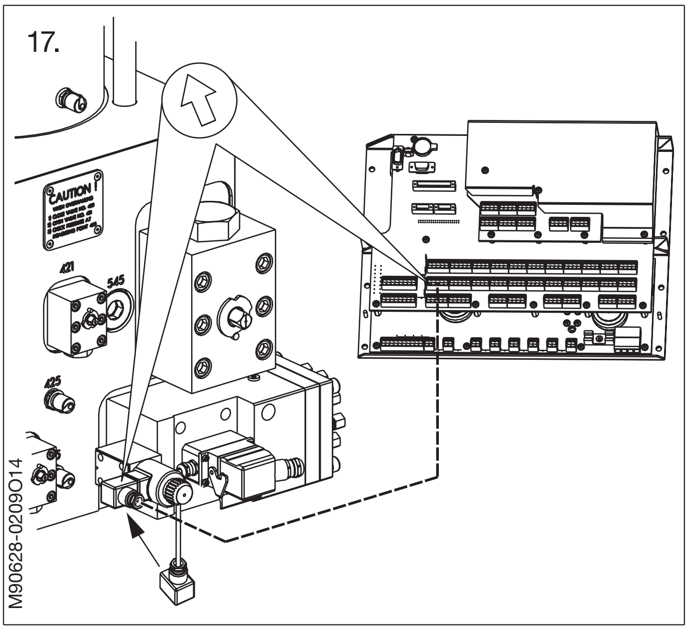
13. Remove the tool for emergency opening of exhaust valve and remount the plug screw.

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.

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

X	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

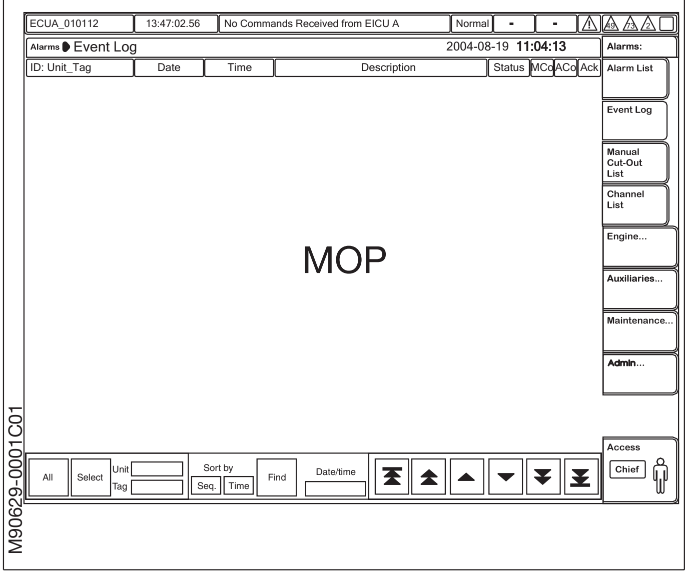
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description

1. Multi Purpose Controllers are used in CCU, ACU, ECU and EICU panels. Checking of the MPC is continuously performed by the MOP units.

   See Volume I, Chapter 703 for a detailed view of the MOP panel screens.

1.



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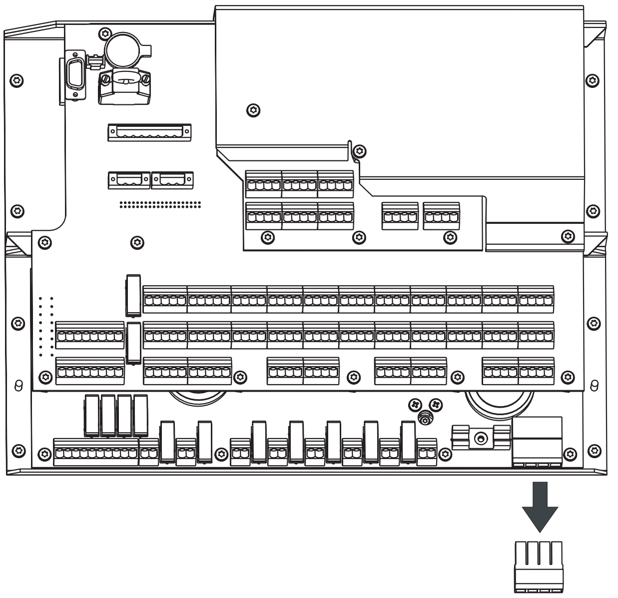

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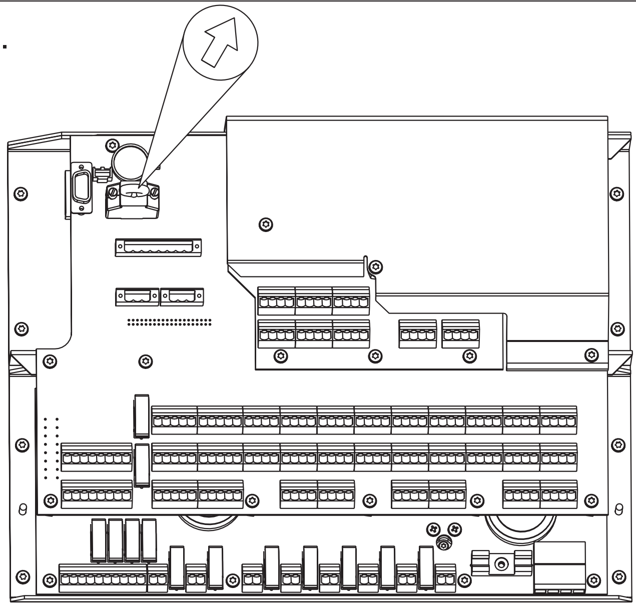

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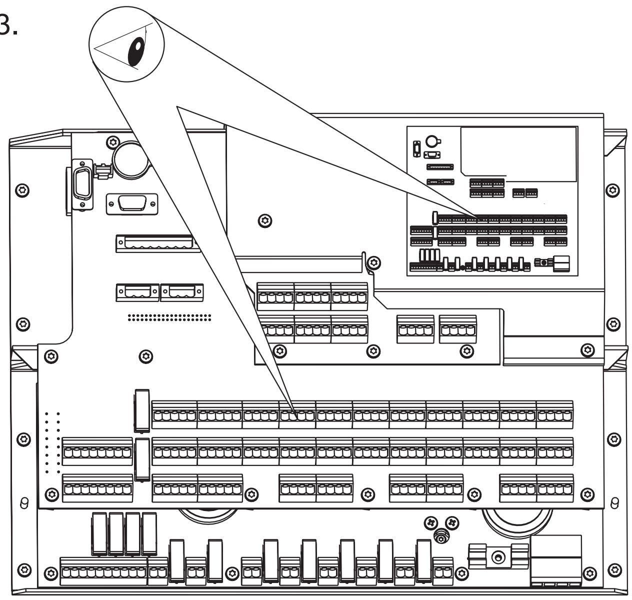
3.



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Dismantling of MPC board

1. Disconnect the power connector.
2. Disconnect the ID-key.
3. Check placement of connectors according to the table shown on the metal plate on the MPC board. If necessary, note down connector placement.
4. Disconnect all connectors on the MPC board.

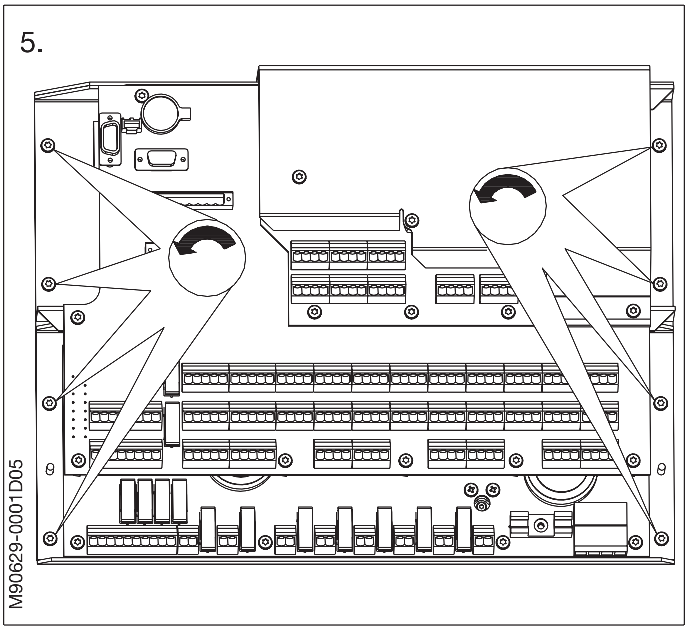
5. Dismount the screws retaining the MPC board and remove it from the panel.

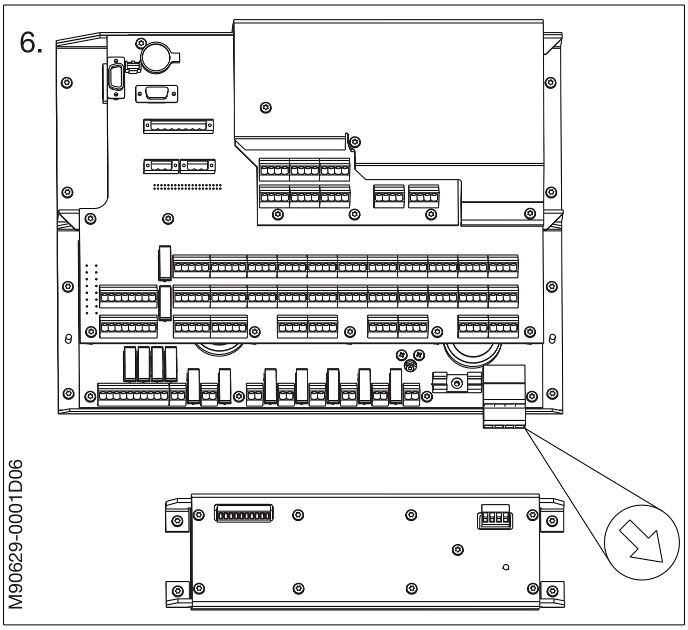
Dismantling of Amplifier

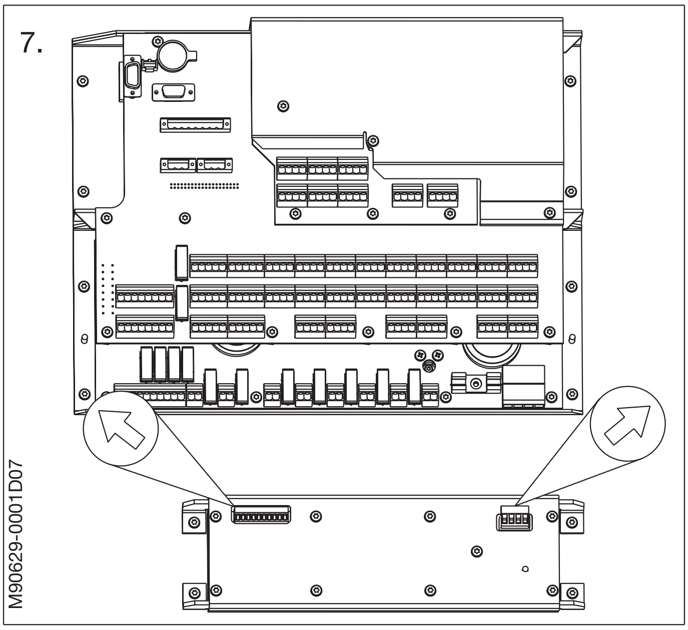
In the CCU and ACU panels amplifiers are mounted below the MPC board.

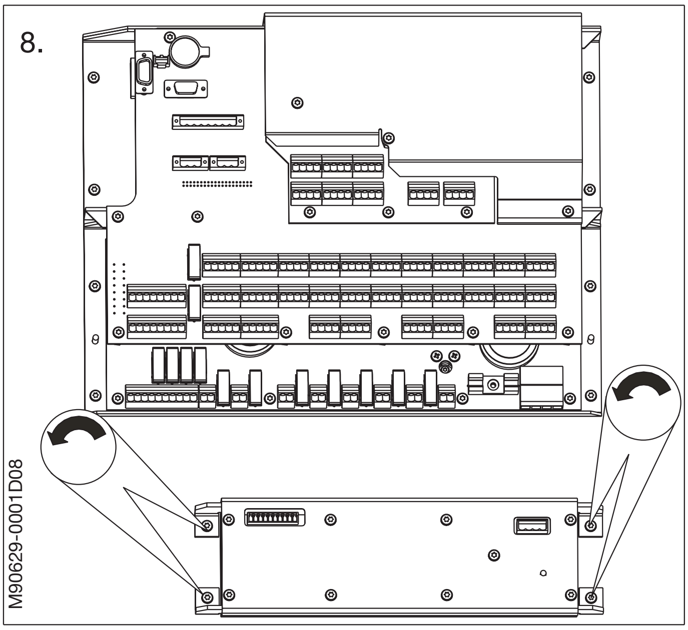
6. Unplug the power connector from the bottom of the MPC board.

7. Unplug the two connectors on the amplifier.









8. Dismount the screws retaining the amplifier and remove it from the panel.

Mounting the MPC board

1.

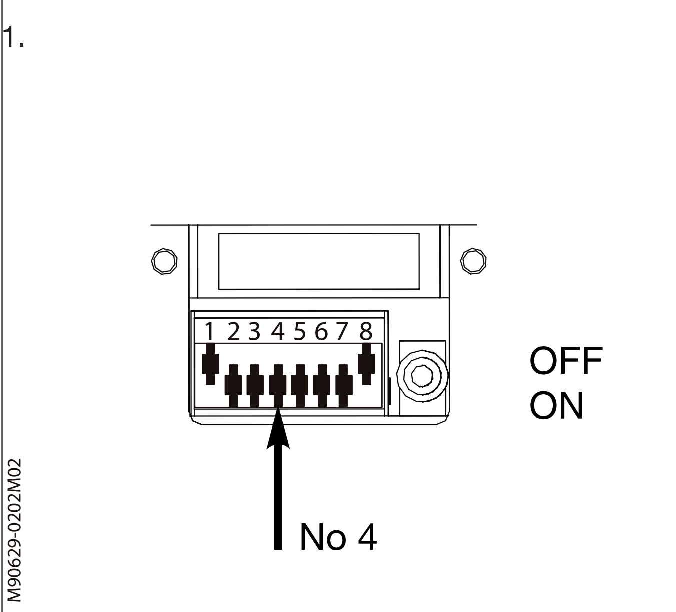
Warning!
If a spare MPC board has been used previously on another engine it is necessary to force the MPC to update software from the MOP panel. This is done in the following way: Set the yellow dip switch No. 4 on the side of the replacement MPC to OFF. Mount the MPC as described. Power on the MPC and let the MPC finish downloading. When the MPC LED flashes 2 red and 3 green (APPLOAD_DIP see appendix), set the yellow dip switch No. 4 to ON.

Note!
Do not mount an MPC board unless the backup battery is installed.

Warning!
Changing the battery of the Multi-Purpose Controller (MPC) may cause a reset and restart of the MPC. Therefore, only change the battery while: • the ship is in harbour with engine stopped, or • when sailing in unrestricted areas, where a restart of an MPC does not imply any risk for the ship or the engine. The battery only serves as back-up supply for the built-in clock of the MPC, and a low battery level for several days until entering port is of no consequence to the safe operation of the engine.

2. Check that the back-up battery is mounted and that the DIP switch S1 is in neutral position. This means all switches are in the »off« position. This is also known as binary »0«.

1.



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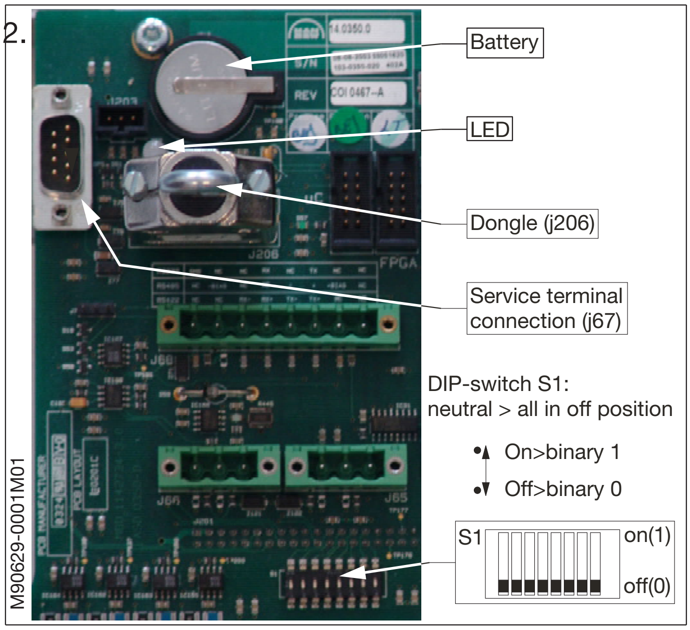

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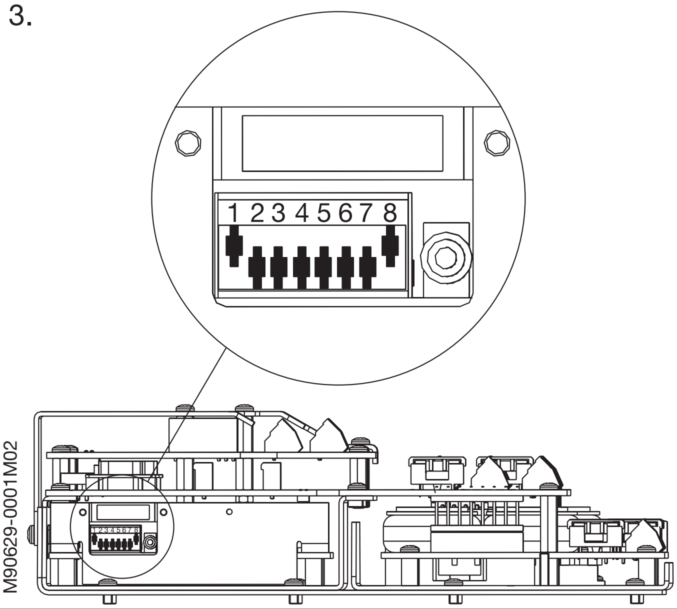

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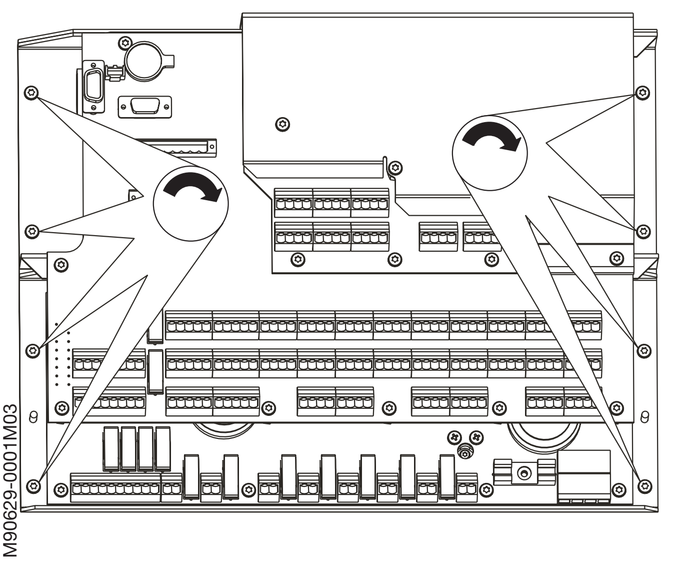

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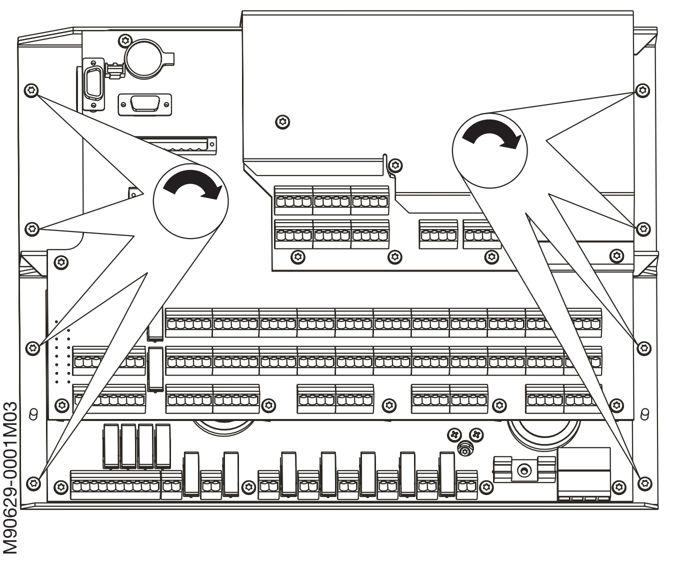


3. Check that the coloured DIP switches 1 and 8 on the side of the MPC board are set to the »off« position.

4. Mount the MPC board in the panel.

5. Mount the connectors according to the table shown on the metal plate on the MPC board.

6. Mount the ID-key.

7. Mount the power connector.

8. During the start-up process, the LED will flash and the MPC board will reboot several times.

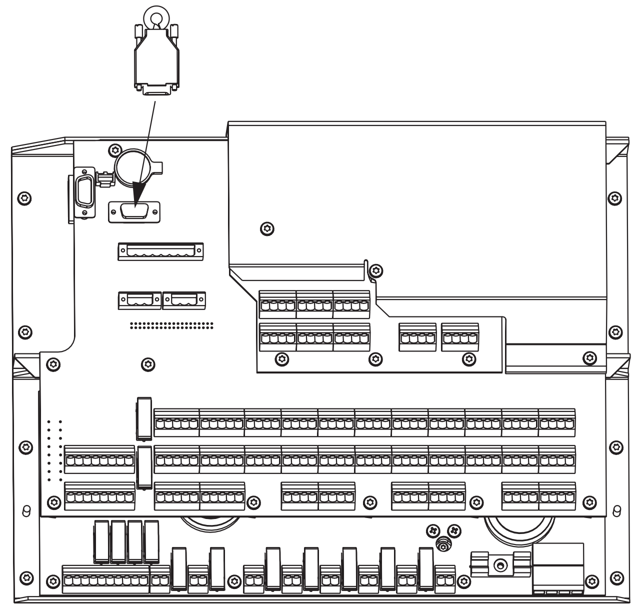
   During start-up, the MPC verifies if the ID-key is connected. It reads the ID number and checks if the key ID is in the correct format and has a valid range, it reads the DIP-switch S1 value and verifies if it is 0 (Off). A new MPC board will download software and settings from the MOP panel during this process.

   The program completes the ID-key verification and is now ready to continue the boot sequence. Any deviations will send an error message via the LED. The start-up time of a new MPC board may vary but will take about 15 minutes.

   When the LED shows green, the MPC board is running normally.

   The MPC LED indications are shown on the appendix in this procedure.

6.



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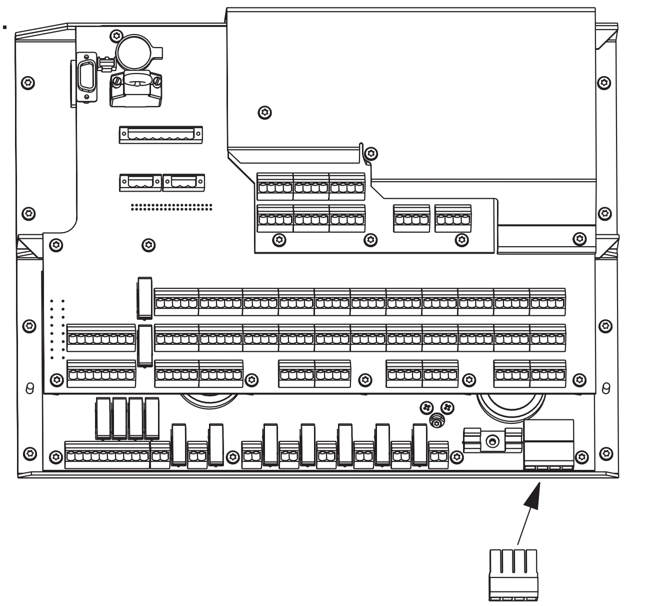

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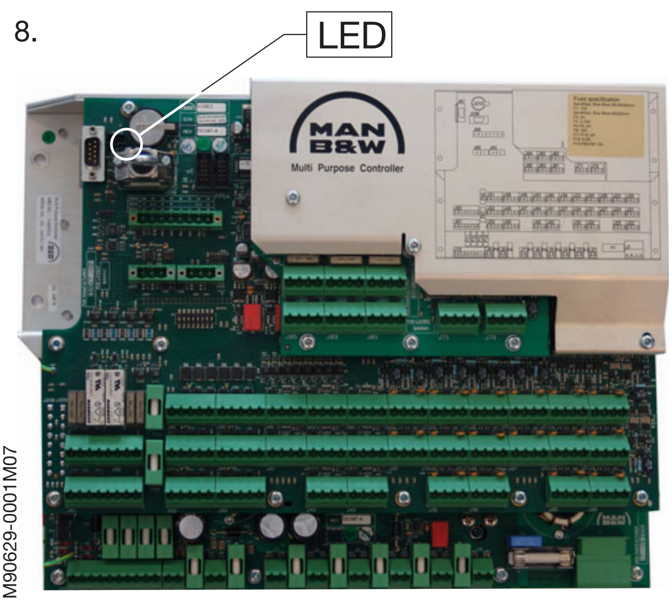

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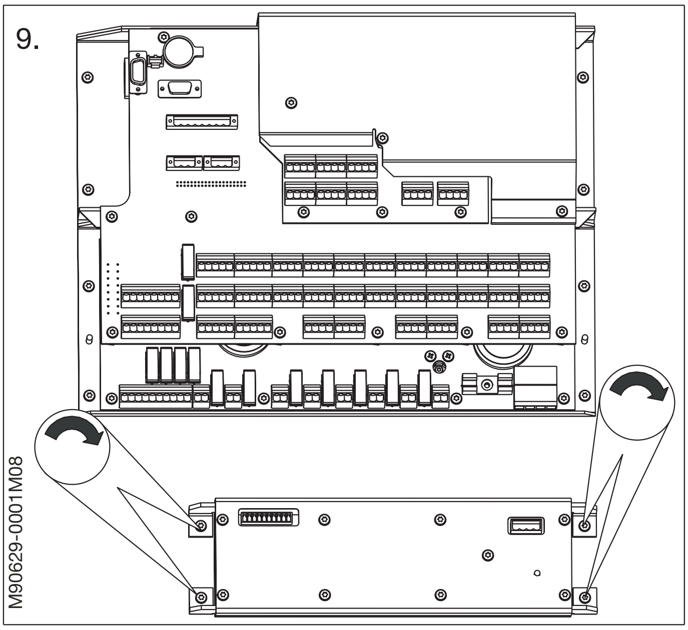
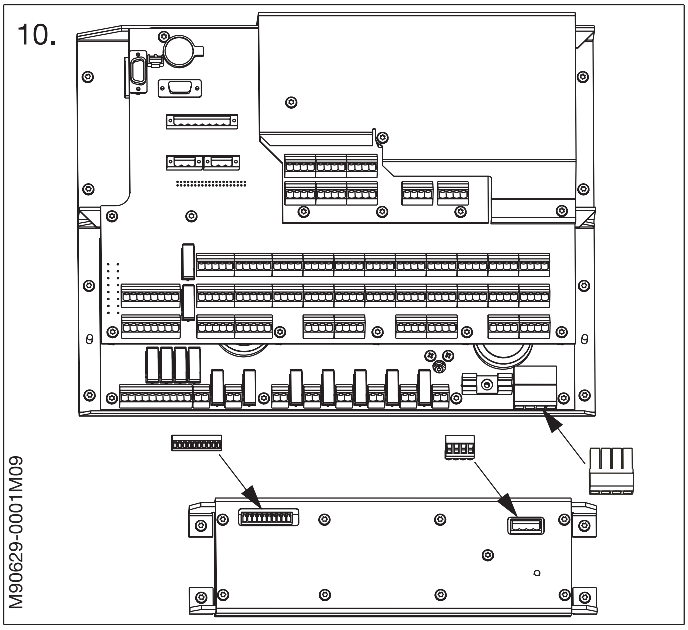




9. Mounting of amplifier.

   Mount the amplifier using the two screws.

10. Connect the two connectors on the amplifier and the power connector on the MPC board.

The MPC LED flashes different sequences according to the process performed.

Some of these indications are for normal use and some are for service personnel use.

All of the LED indication sequences are shown in the diagram below.

This is to facilitate communication with MAN Diesel A/S service personnel if needed.

MPC LED Indication

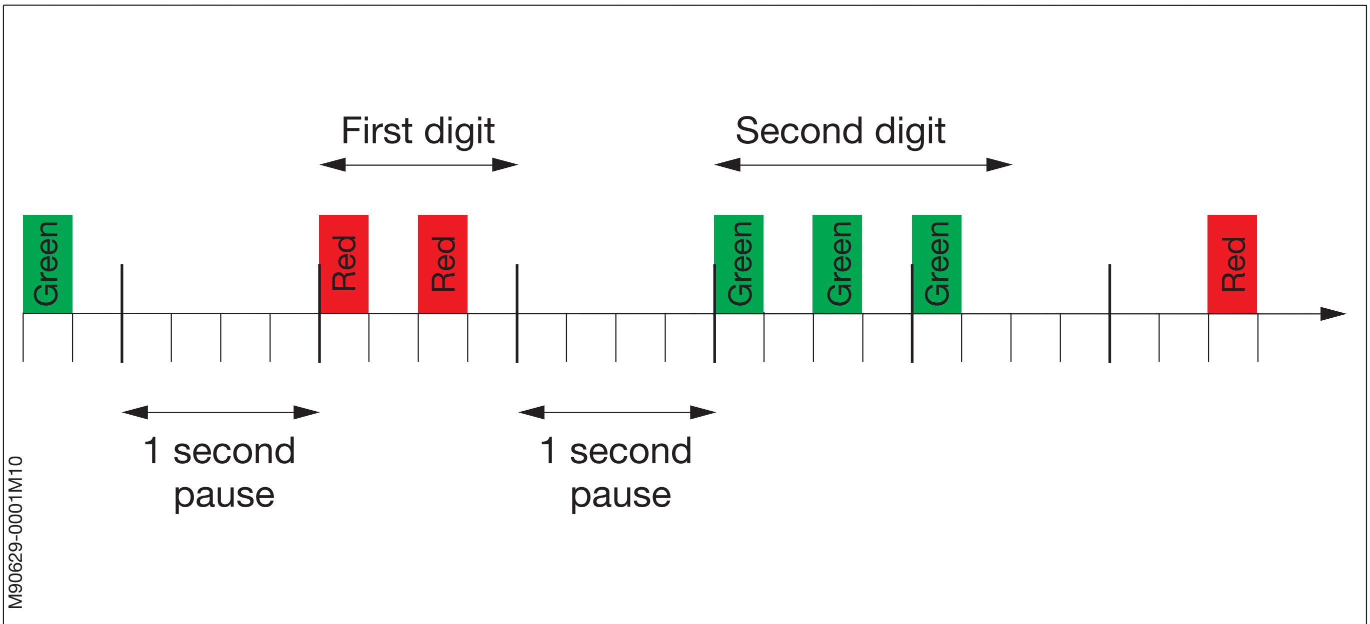
Description

The first part of the document describes the syntax of the LED indication and assigns a short description to each of the used indications. The second part presents a more detailed description of the different indications.

Syntax

The MPC LED may be issuing indications by either emitting constant light or by flashing. The LED indications are uniquely identified by the colour that the MPC LED emits.

A flashing LED indication consists of two pulse trains separated in time by a 1-second pause. Each of these pulse trains represents an integer. All pulses are set against a yellow background. The first pulse train will alternate between the yellow background and a red foreground, while the second will use green as foreground.



For identification of the indication the user must therefore note the number of red and green pulses. The first digit is the number of red pulses and the second digit is the number of green pulses. In the illustration above, the indication code would thus be (2,3).

Indications

Constant

Colour	Short name	Short description
Red	ERROR	Either early initialisation or fatal error
Orange	INIT	Initialisation, no parameters available or non-normal node mode
Green	NORMAL	Application up and running

Flashing

Digits		Short name	Short description
Red	Green		
1	1	CTRL_PRG	Onboard control programming in progress
2	1	APPLOAD_SCAN	Application download in progress – scanning for server
2	2	APPLOAD_DOWNLOAD	Application download in progress – downloading program
2	3	APPLOAD_DIP	Application download completed – reset yellow DIP set to ON
3	1	BOOTLOAD_SCAN	Bootloader download in progress – scanning for server
3	2	BOOTLOAD_DOWNLOAD	Bootloader download in progress – downloading program
4	1	DONGLE_VERIFY	Checking node ID-key
4	2	DONGLE_ERROR	ID-key error – missing, broken or not programmed
4	3	DONGLE_DIP	Node ID DIP switch not correctly reset – reset it to 0x00

Detailed description of LED indications

ERROR (Red)

This code is used primarily for indicating if the MPC has experienced a fatal error. However, the MPC will also use this indication during early initialisation. Therefore, the user should only take this code as an indication of error if it persists more than 10 seconds.

INIT (Orange)

Generally, this code is used for indicating initialisation, but the MPC may also use this indication to signal one of the following conditions:

No parameters: No valid parameters are available to the application software.
Configuration or test mode: The MPC is in a non-normal node mode.
Generally, if the INIT code is shown longer than 10 seconds this would indicate one of the latter conditions.

NORMAL (Green)

Application is up and running.

CTRL_PGM (1,1)

One of the on-board micro controllers is being programmed. This is a part of the MPC initialization process.

APPLOAD_SCAN (2,1)

The application software download program (bootloader) is trying to find a server from which it can download its application program. If this code persists it indicates either that no application program server is connected to the network or the network is broken.

APPLOAD_DOWNLOAD (2,2)

An application program is being downloaded.

APPLOAD_DIP (2,3)

The yellow DIP-switch on the MPC CPU board can be used for forcing download of new application software. To avoid looping it is therefore required that the yellow DIP-switch be reset on completion of such a forced download. Reset it to ON/down.

BOOTLOAD_SCAN (3,1)

This indication is analogous to the APPLOAD_SCAN indication except that this code indicates that there is not server available from which the MPC can download a new bootloader. This code should only be indicated if attempts are being made to update the bootloader using the special update program.

BOOTLOAD_DOWNLOAD (3,2)

A new bootloader program is being downloaded and programmed.

DONGLE_VERIFY (4,1)

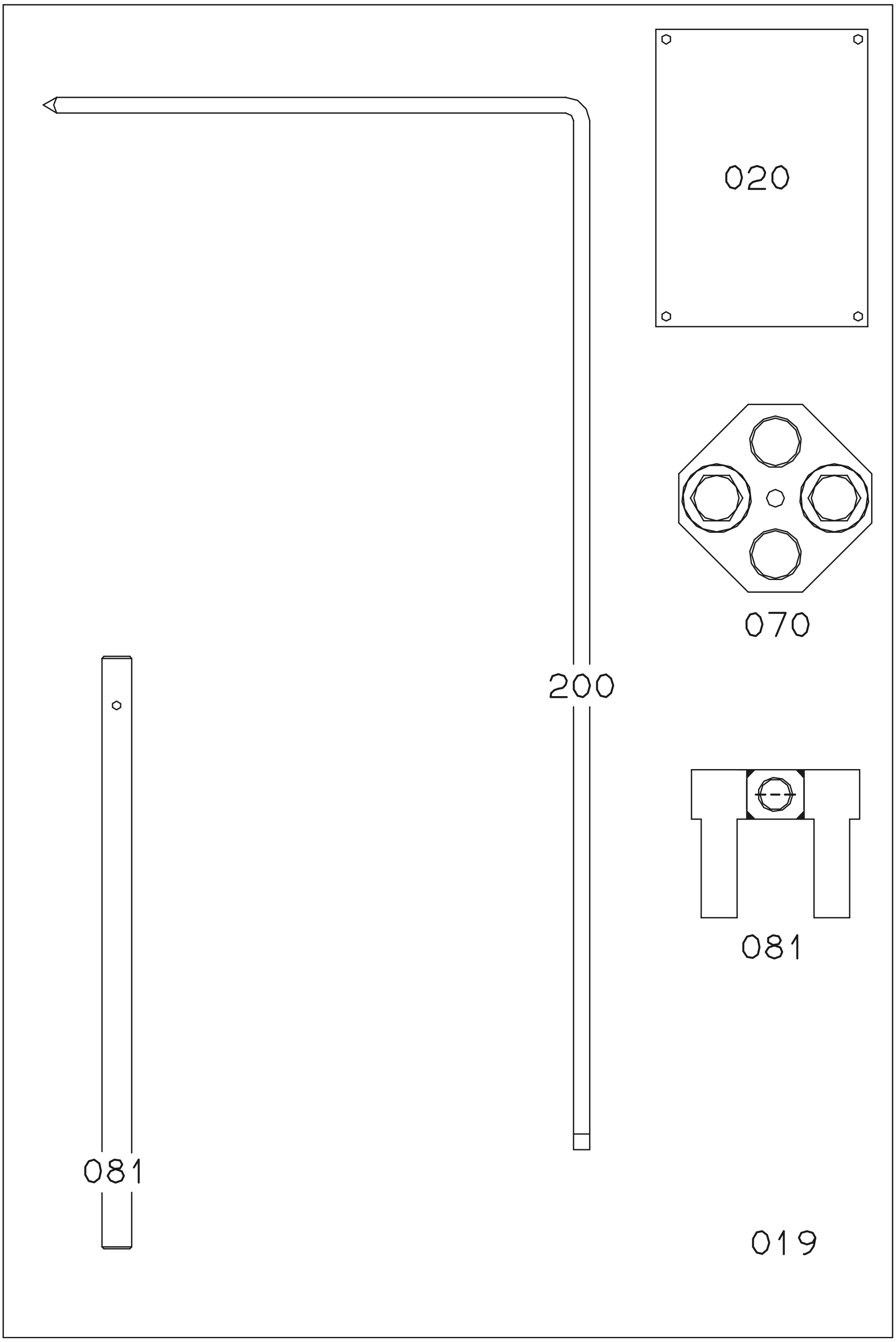
The ID-key is being checked. This should only take a couple of seconds.

DONGLE_ERROR (4,2)

A ID-key error has been identified. Either the ID-key is missing, broken or holds an invalid value. Try to reprogram it.

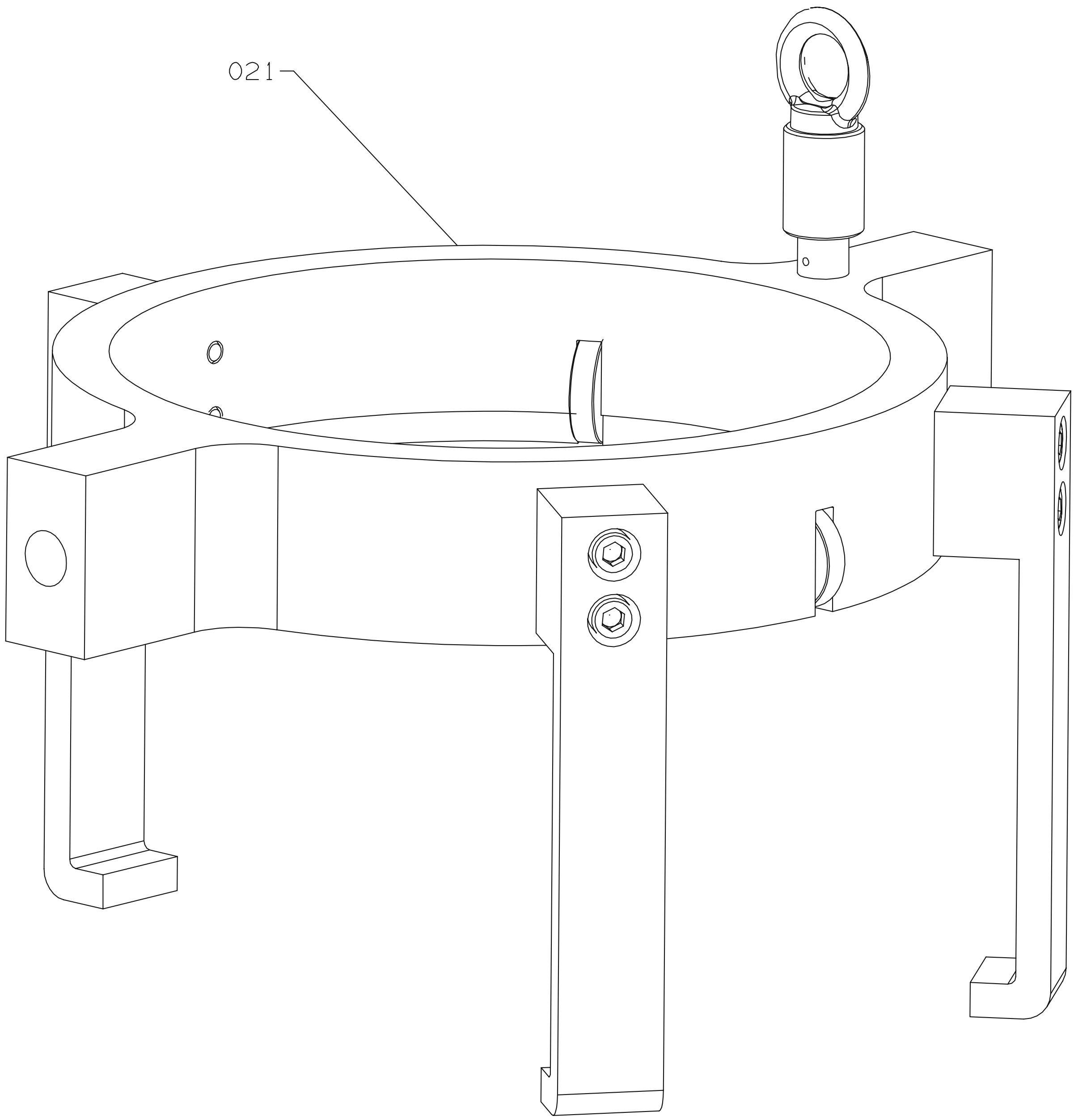
DONGLE_DIP (4,3)

The DIP-switch mounted on the CMI/O board is used for programming the ID-key. The programming process requires that this DIP-switch be reset before completing. This code is used for indicating this to the user. Reset the CMI/O board DIP switches to OFF/down.


020
070
200
081
081
019

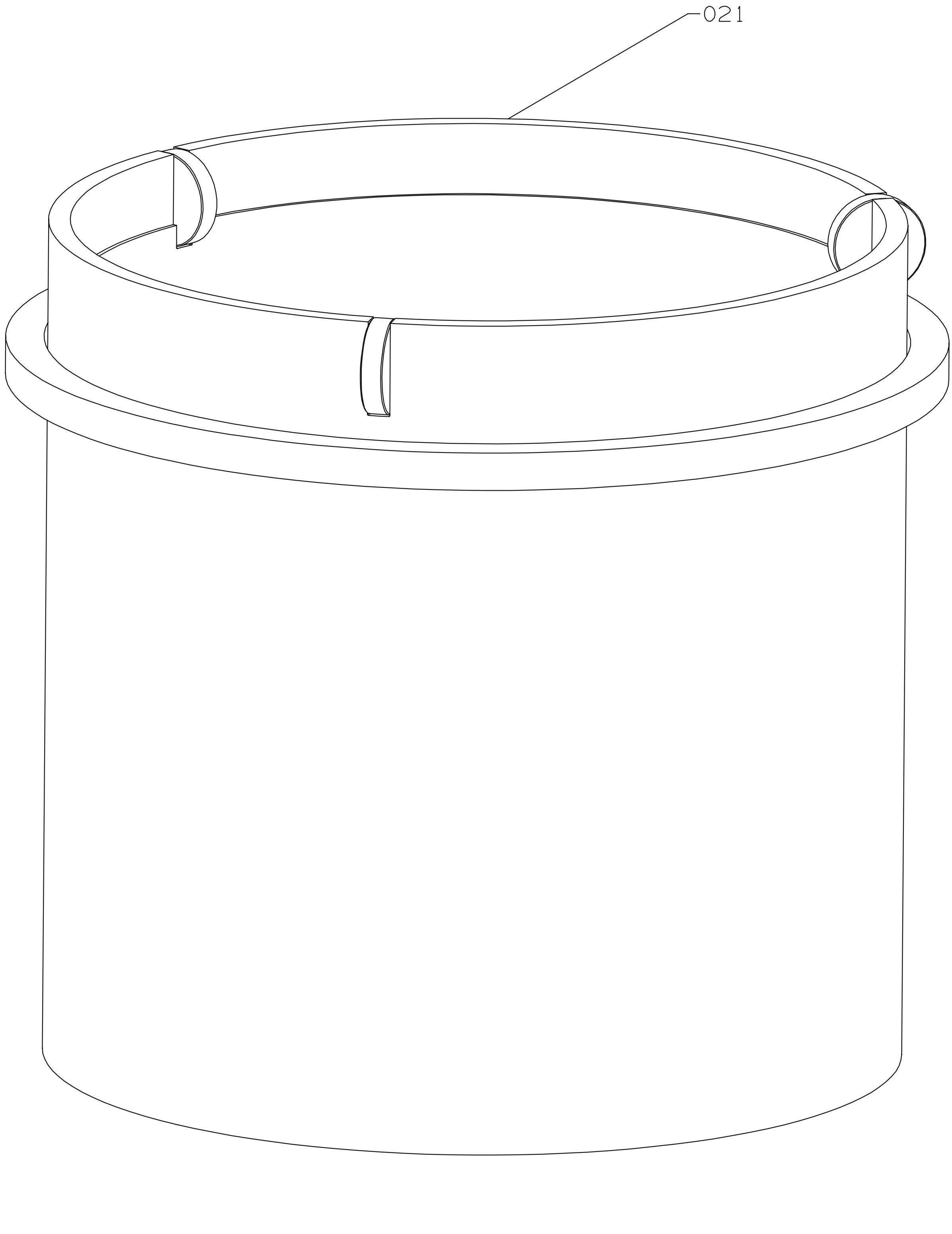
Chain Drive and Camshaft Panel

Item No.	Item Description
019	Panel for tools
020	Name plate
070	Assembling tool, chain
081	Disassembling tool, chain
200	Pin gauge, crankshaft

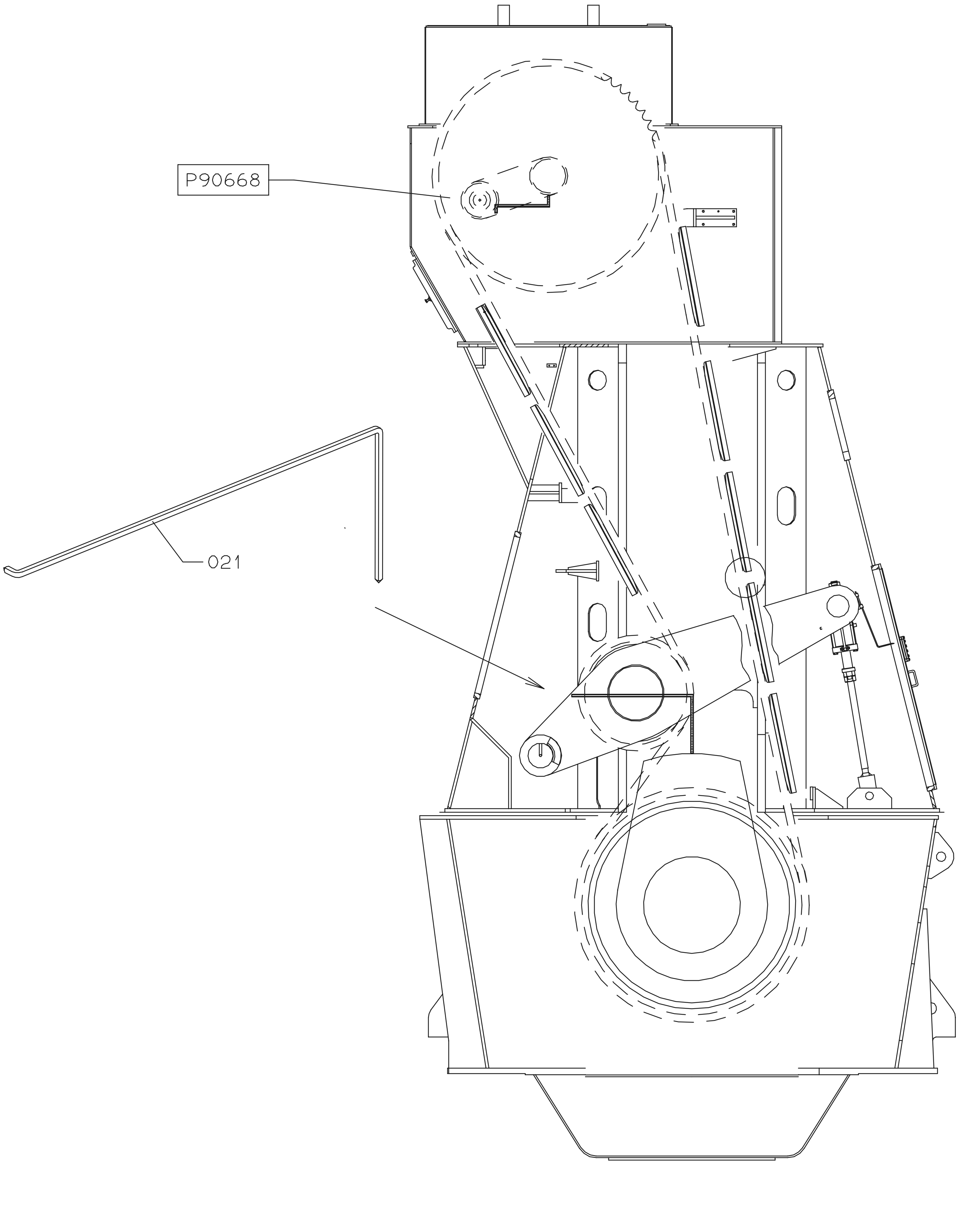

021

Tools for Accumulator

Item No.	Item Description	Item No.	Item Description
021	Hook spanner* **Note:** * When ordering, please state size of accumulator.		

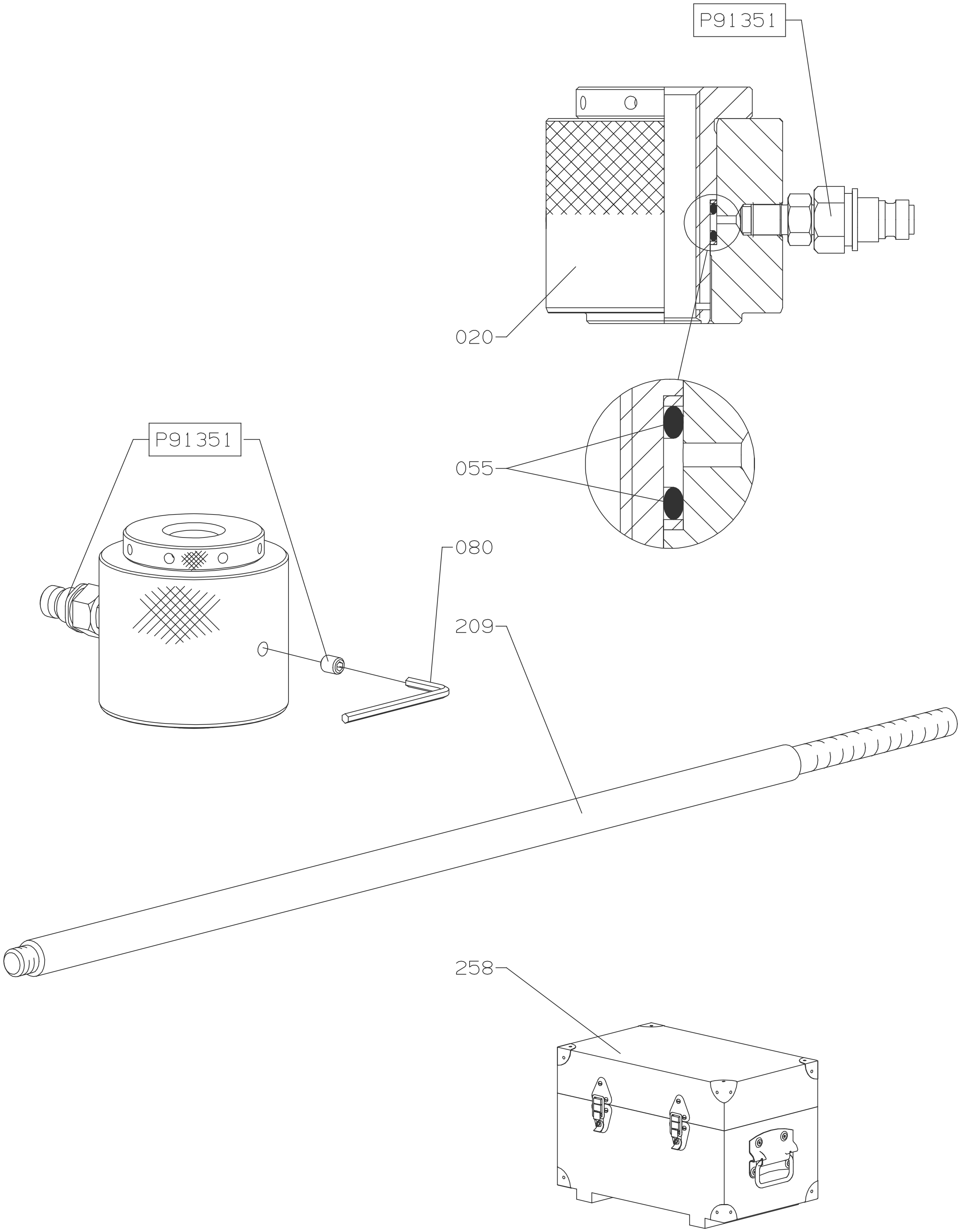

021

Item No.	Item Description	Item No.	Item Description
021	Pin wrench-special* **Note:** * When ordering, please state size of accumulator.		


P90668
021

Crankshaft - Pin Gauge

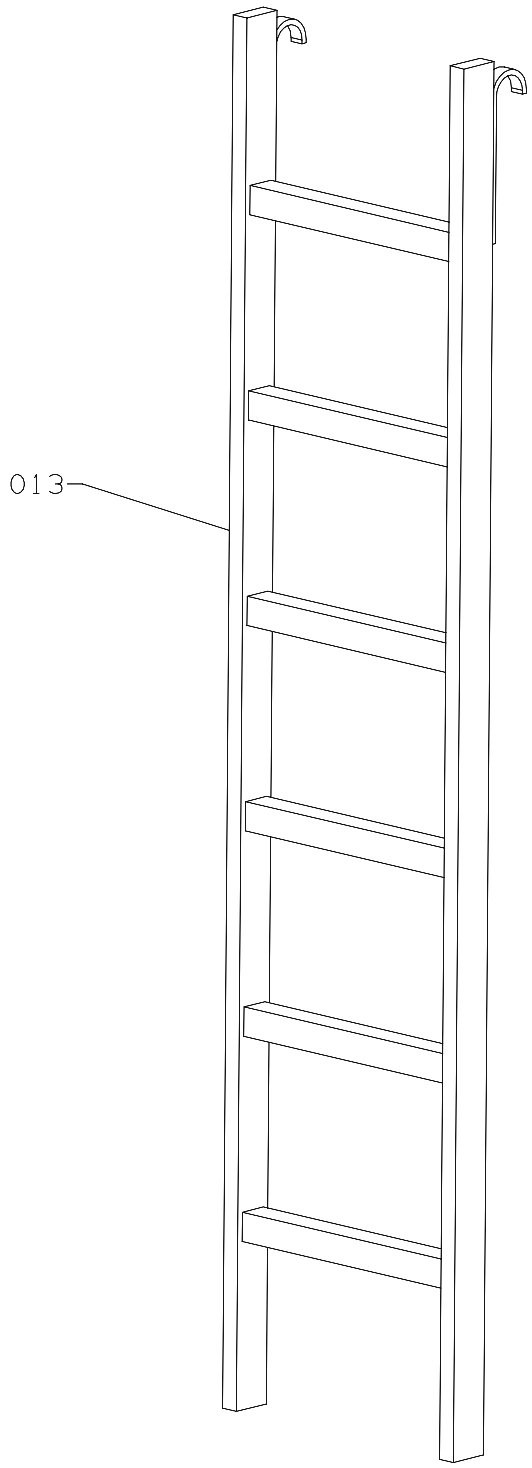
Item No.	Item Description	Item No.	Item Description
021	Pin gauge for crankshaft		


P91351
020
055
P91351
080
209
258

Hydraulic Tools - Chain Tightener

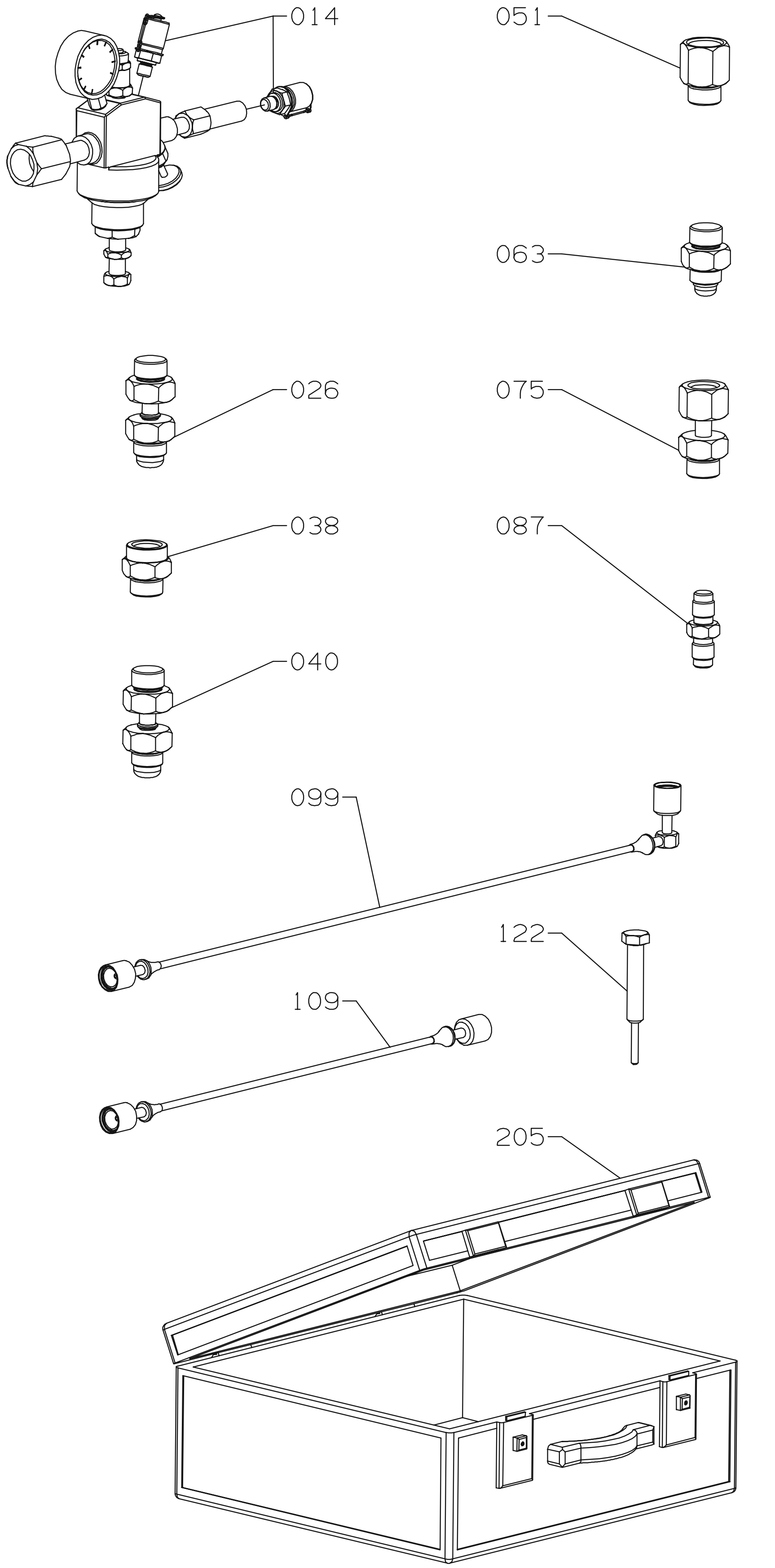
Item No.	Item Description
020	Hydralic jack, complete
055	Sealing ring with back-up ring
080	Spanner
209	Stud
258	Hydraulic tool set, complete

Item No.	Item Description


013

Item No.	Item Description	Item No.	Item Description
013	Ladder		

Test Equipment for Accumulators



Test Equipment for Accumulators

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, Minimess		
109	Quick coupling, Minimess		
122	Special screw		
205	Test equipment for accumulators set, complete		

907 - Starting Air System

Documents in this Chapter

SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	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
D07-11	Valve tightening angle	60	°
D07-12	Starting air valve	55	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. P**909**51 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.

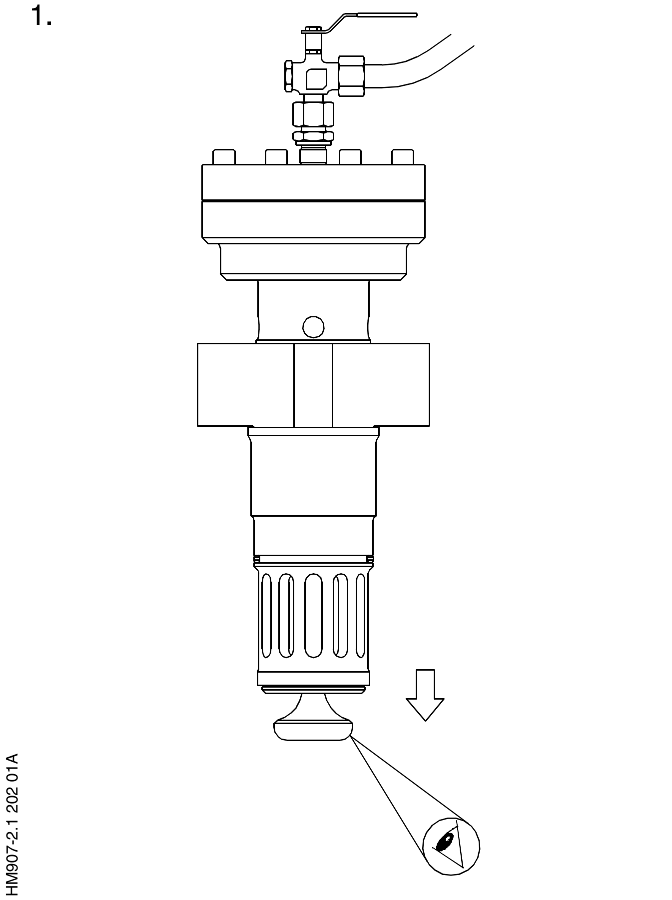
   Check that the valve opens approx. 15-20 mm.

2. Shut off the air supply

   Check that the valve closes fully.

3. Repeat steps 1 and 2 a couple of times.

1.



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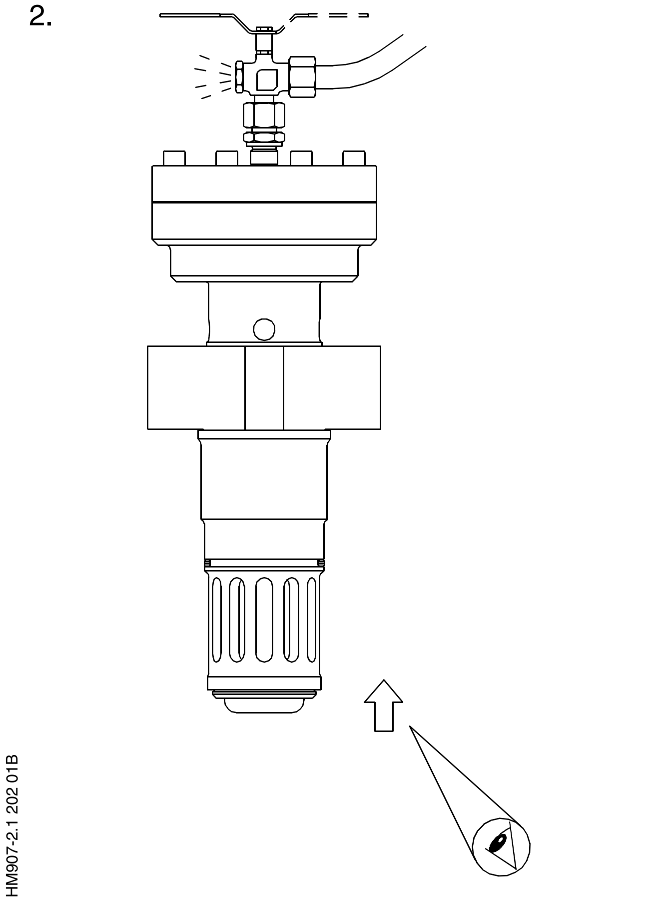
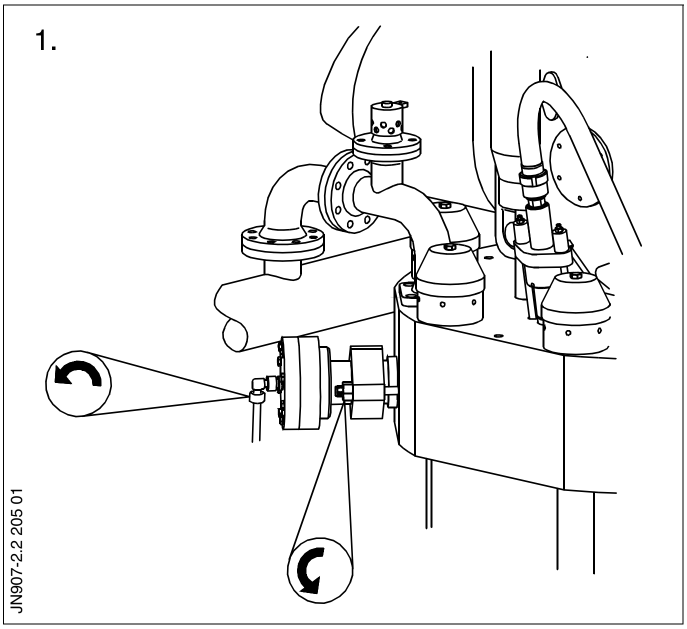


1.



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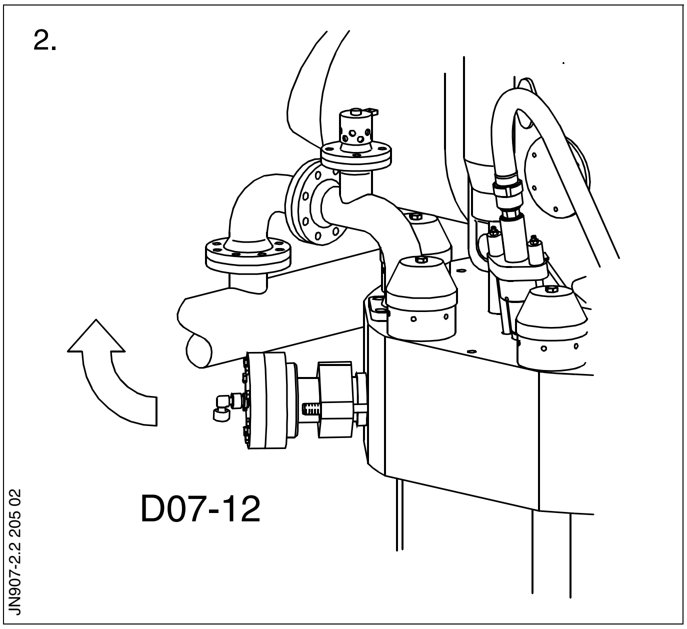


1. Shut off the starting air and control air inlet.

   Dismount the control air pipe.

   Hook a lifting wire around the starting valve and attach the crane hook to the wire.

   Unscrew the fixing nuts of the starting valve flange.

2. Pull the starting air valve out of the cylinder cover and remove it from the engine.

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.

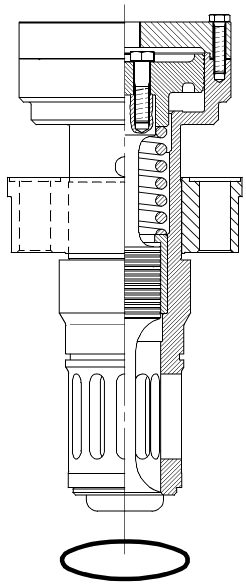
   Dismount the top cover.

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.

1.



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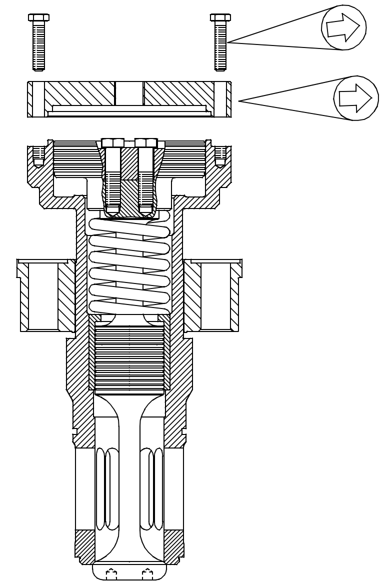

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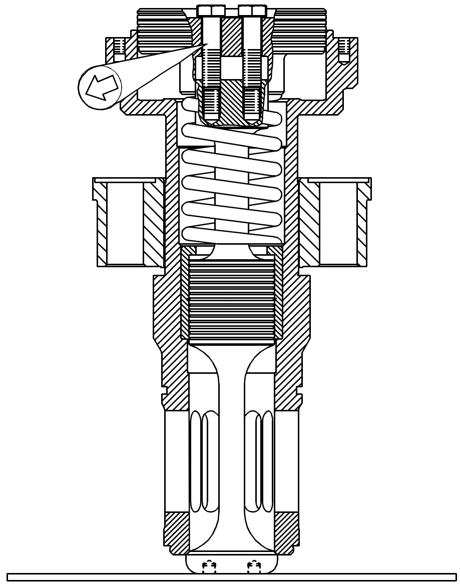

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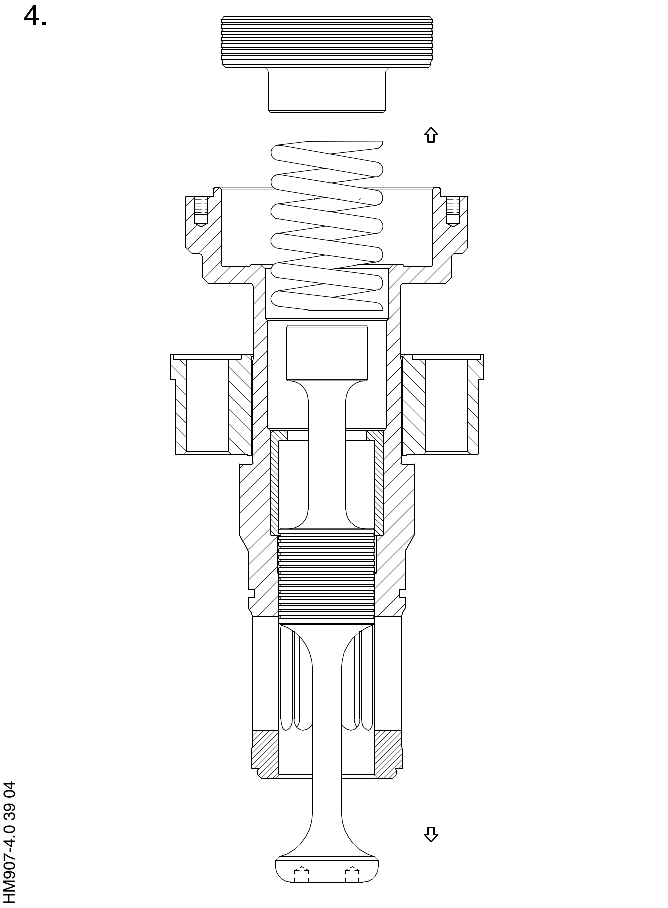

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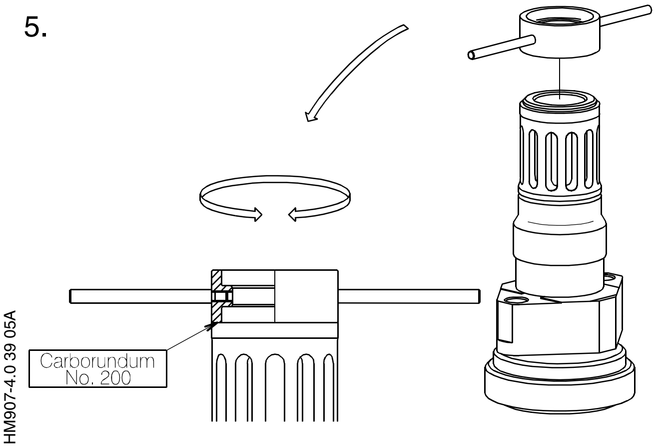

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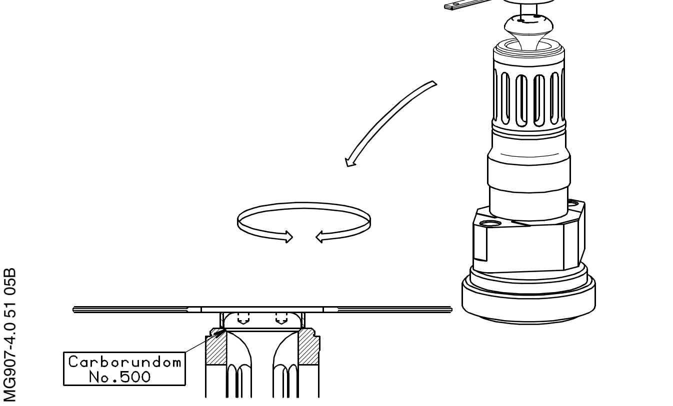


4. Remove the piston from the top end of the valve housing.

   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, MoS_2.

   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.

   Lock the screws with locking device.
   For correct use of locking device, see Procedure 913-7.

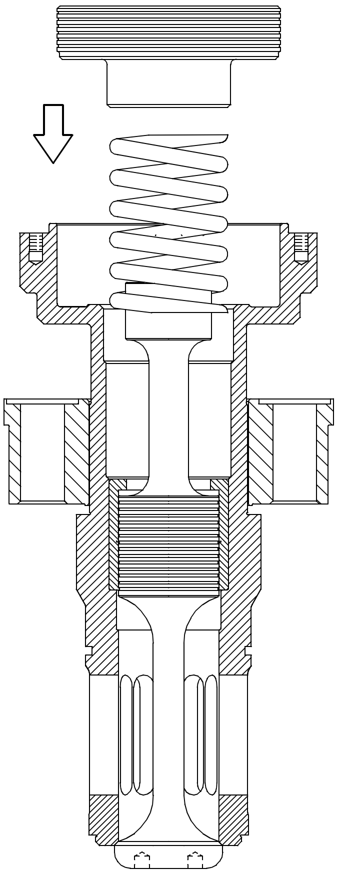
9. Mount and tighten the top cover.

   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.

7.



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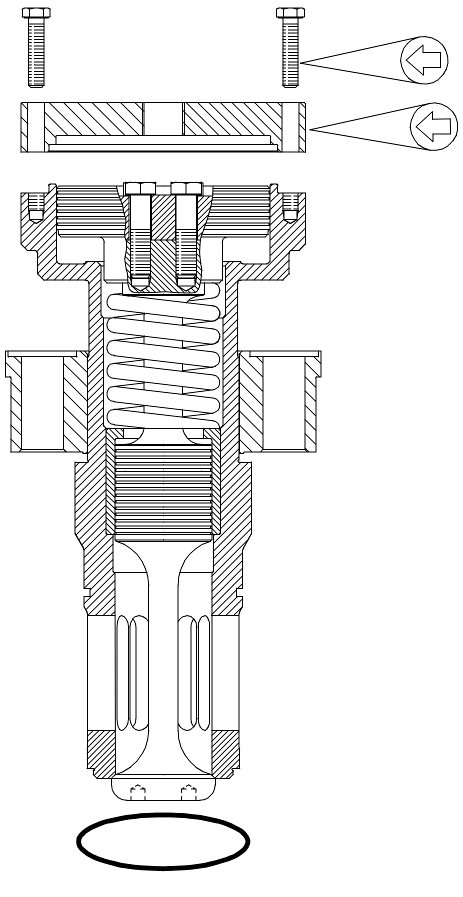

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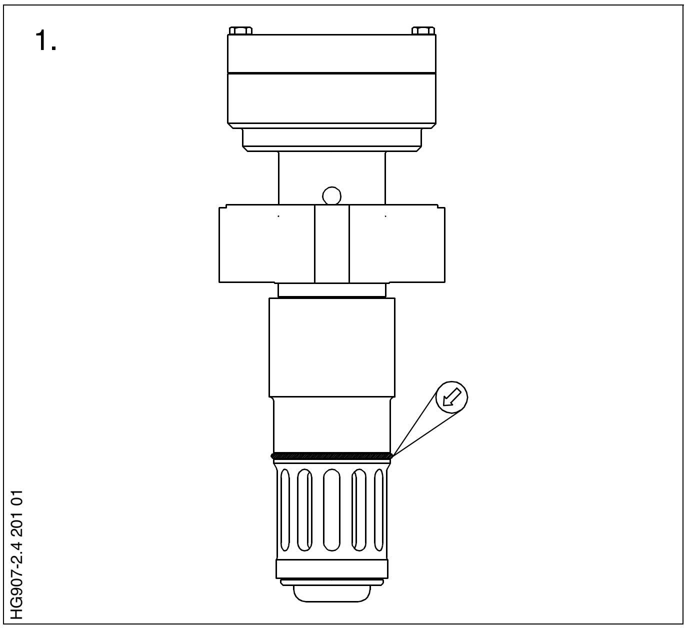
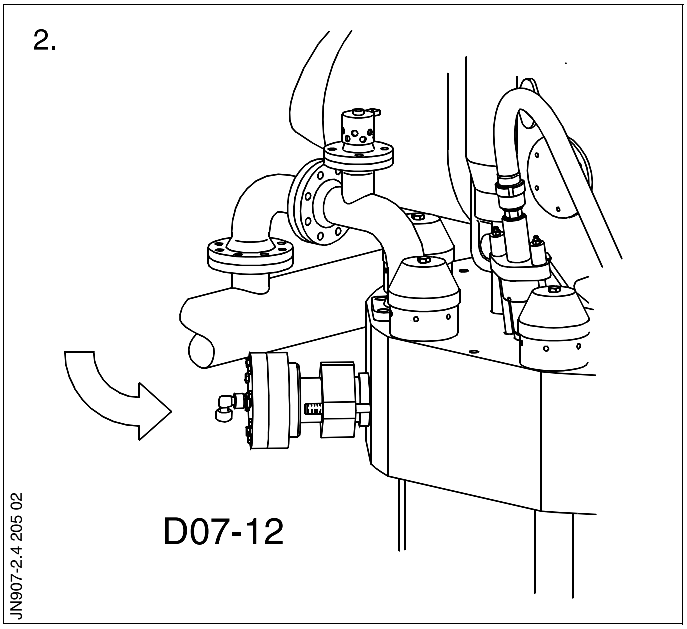
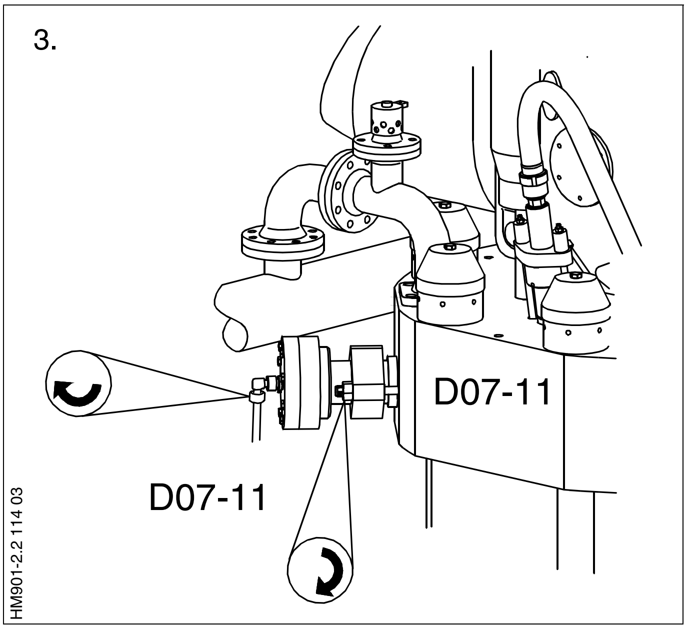






1. Carefully clean the starting valve bore in the cylinder cover and, if necessary, recondition the seat for the starting valve in the bore, *see Procedure 901-1.3.*

   If not already done, fit a new O-ring on the overhauled valve and lubricate with 'Never Seize' or Molybdenum Disulphide, MoS_2. *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.

908 - Exhaust Valve

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubricating oil pumps*
	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-01	High-pressure pipe, tightening torque	85	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.

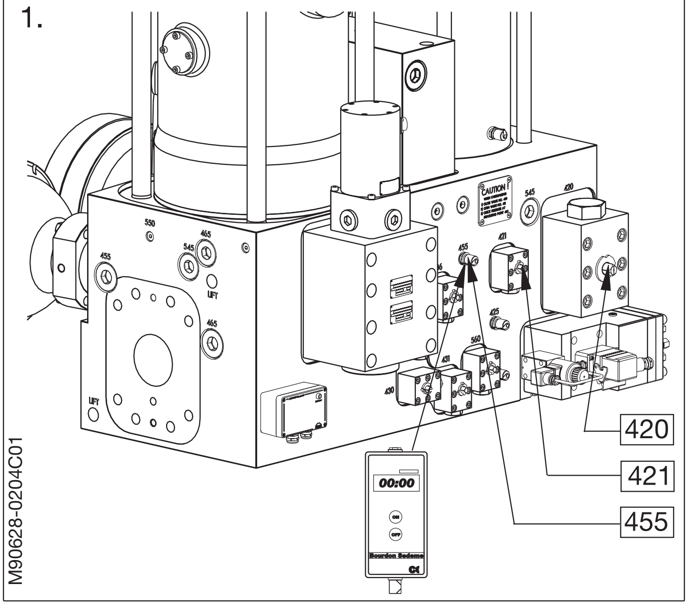
   Connect a pressure gauge at “minimess” point 455. Check the pressure.

   Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

   Check that the system is pressure free.

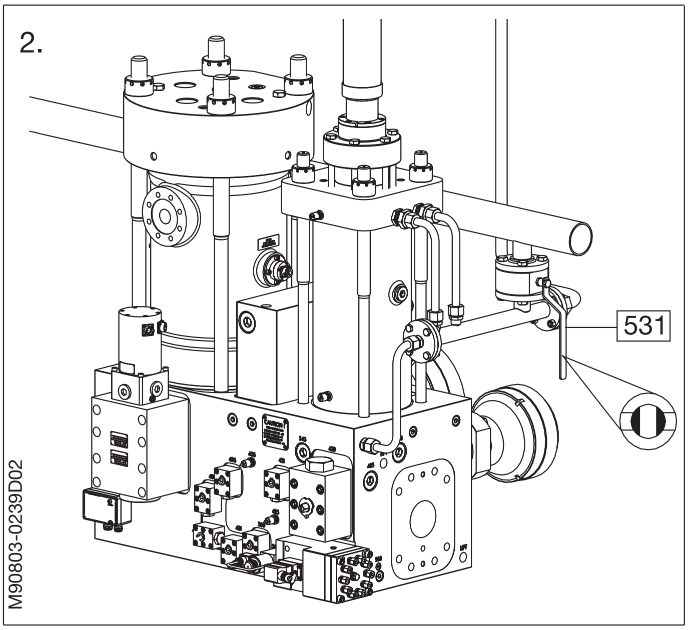
Note!
Great care must be taken to ensure that the area around the workplace is clean before and during any dismantling of the hydraulic system.

1.



2. Close the valve 531 for the actuator oil supply.

2.



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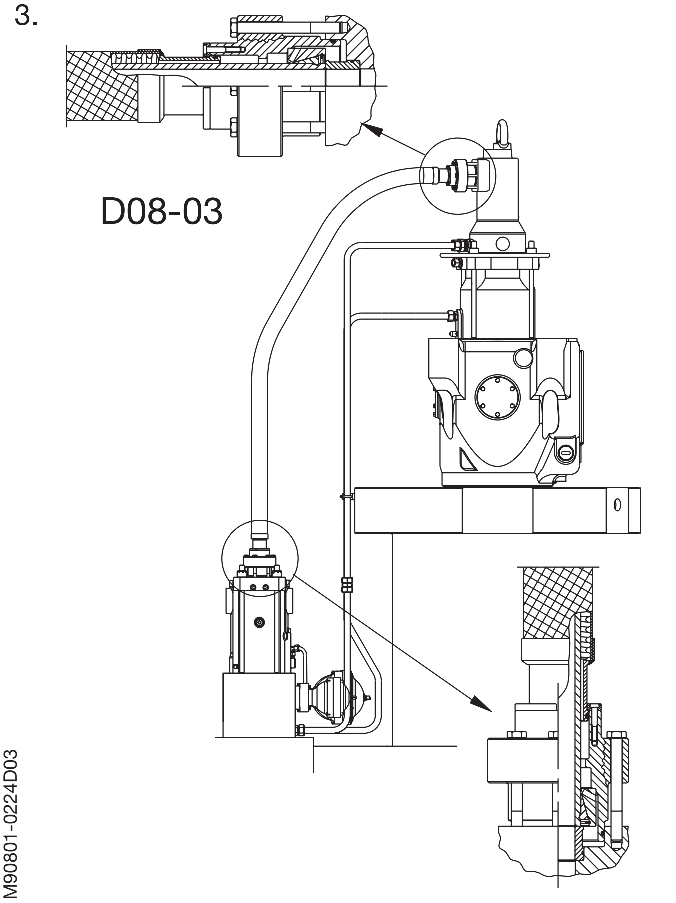

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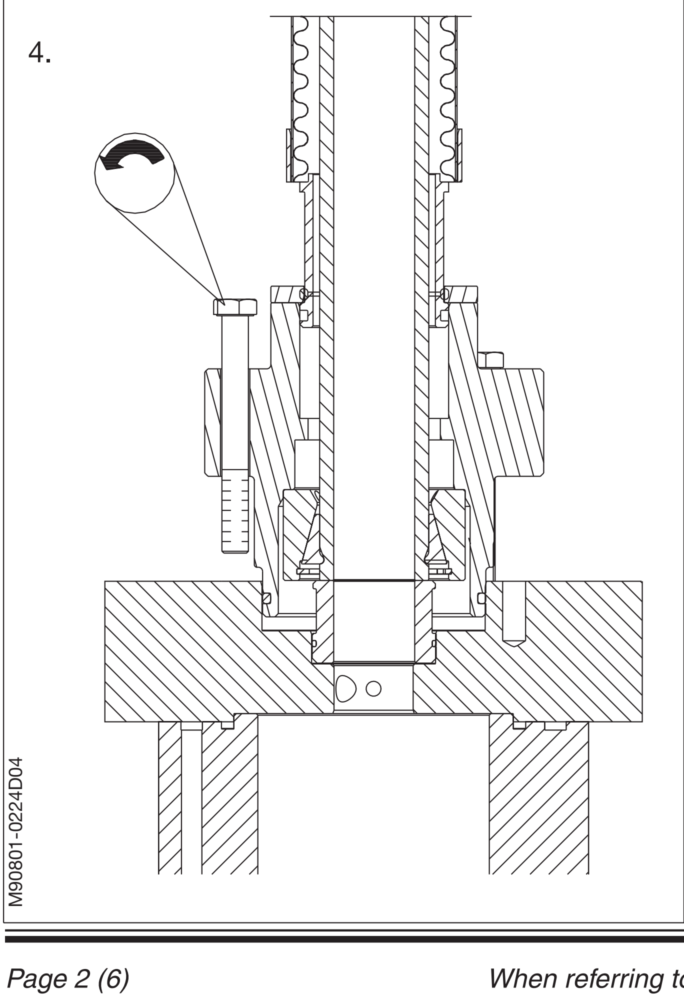


3. When replacing the hydraulic high-pressure pipe, the exhaust valve or the hydraulic actuator, check the high-pressure pipe sealing surfaces.

   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.

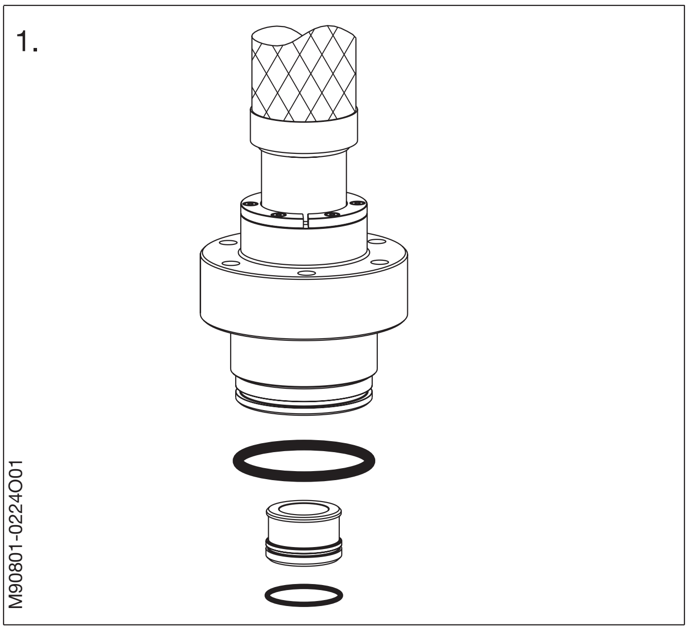
Note!
The two halves of the conical locking ring are matched parts. Check that the halves are marked, as a set, for refitting.

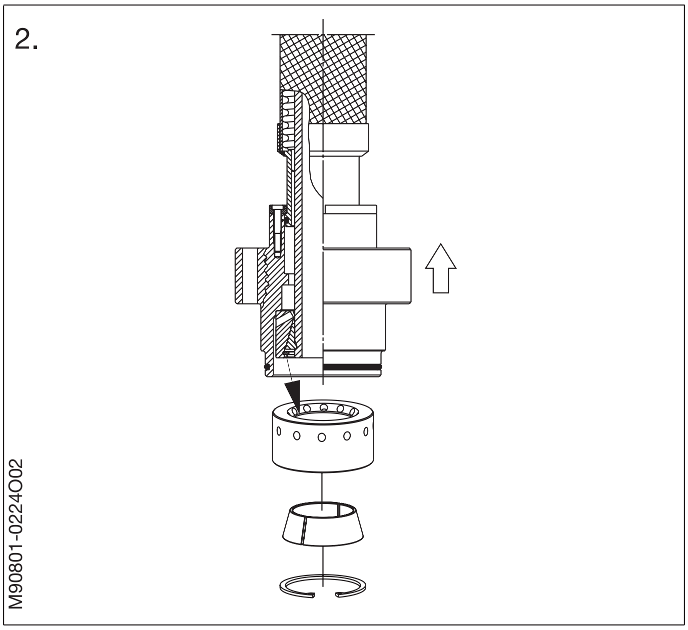
   Pull the sleeve off the pipe.

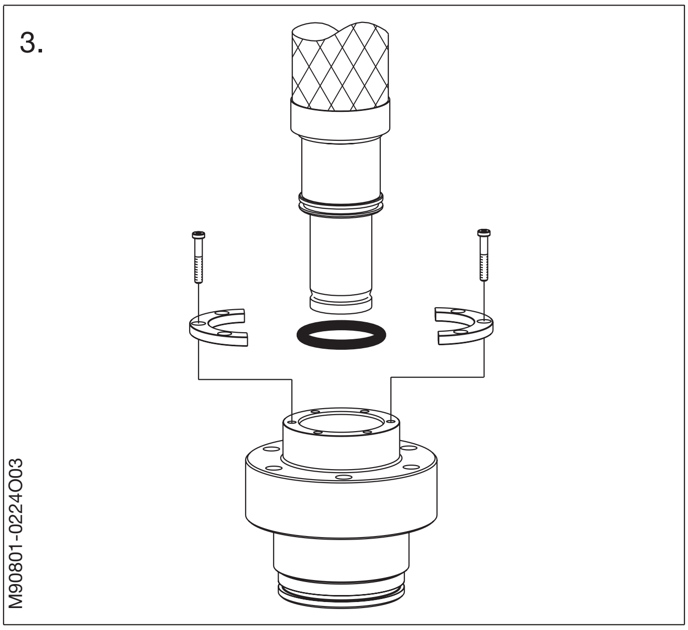
3. Remove the screws and the two-part disc from the thrust flange.

   Pull the thrust flange off the pipe.

   Remove and discard the O-ring.







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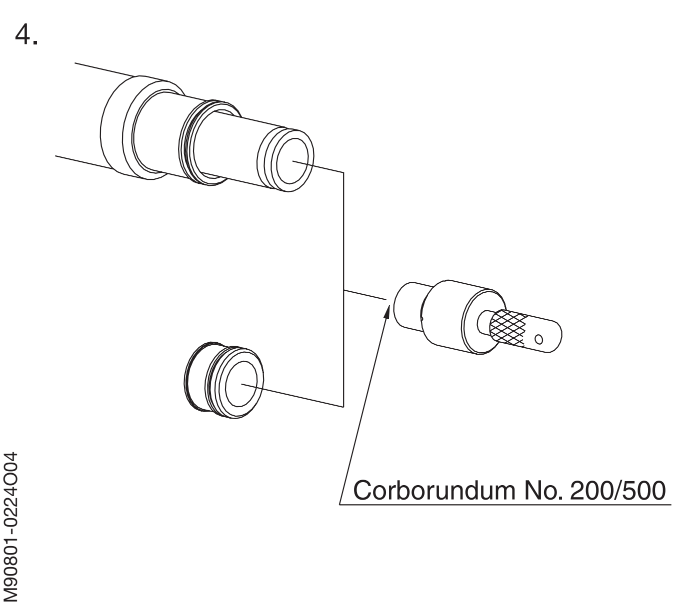

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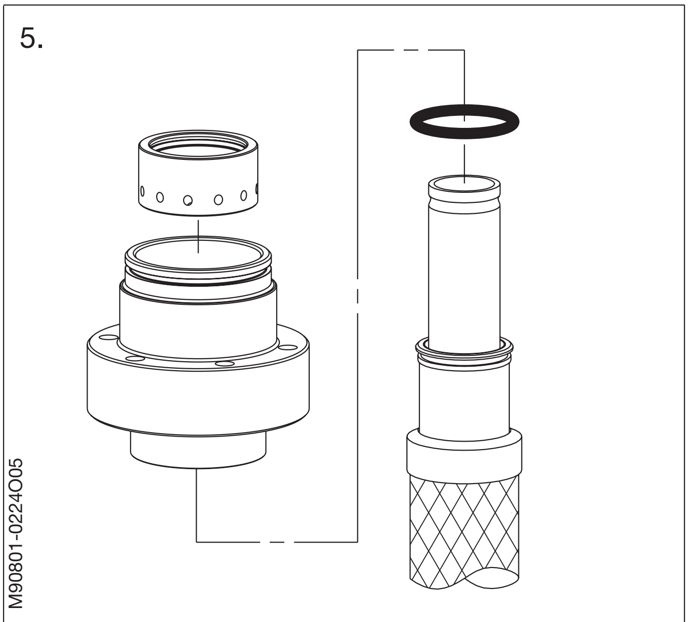

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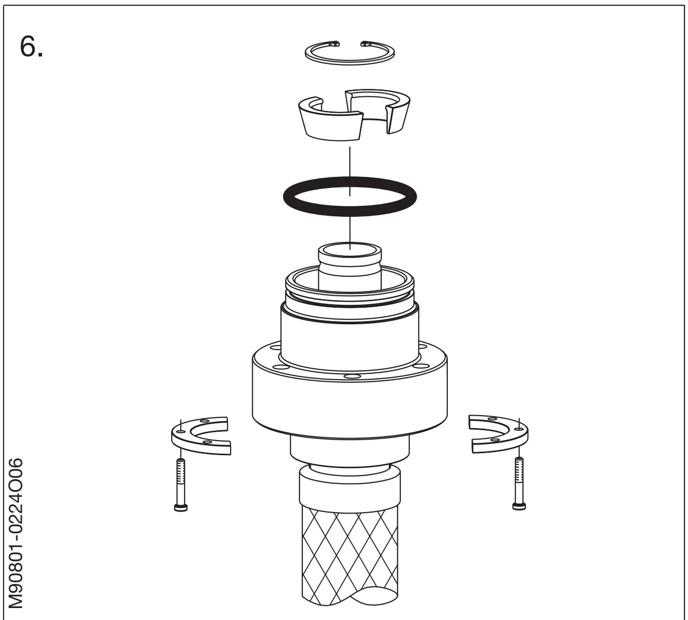


4. Clean and inspect the contact surfaces of the high-pressure pipe and the thrust piece.

   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.

Note!
The two halves of the conical locking ring ae matched parts. Check that the halves are marked as a set, and refit.

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.

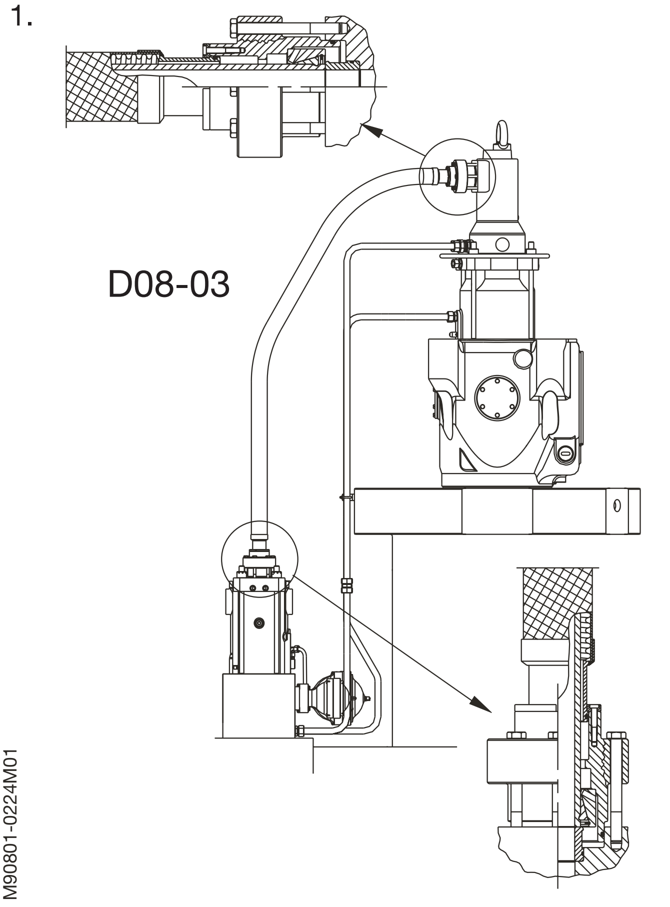
Note!
When mounting the high-pressure pipe, take care not to damage the sealing surfaces of the pipe/thrust pieces.

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.

1.



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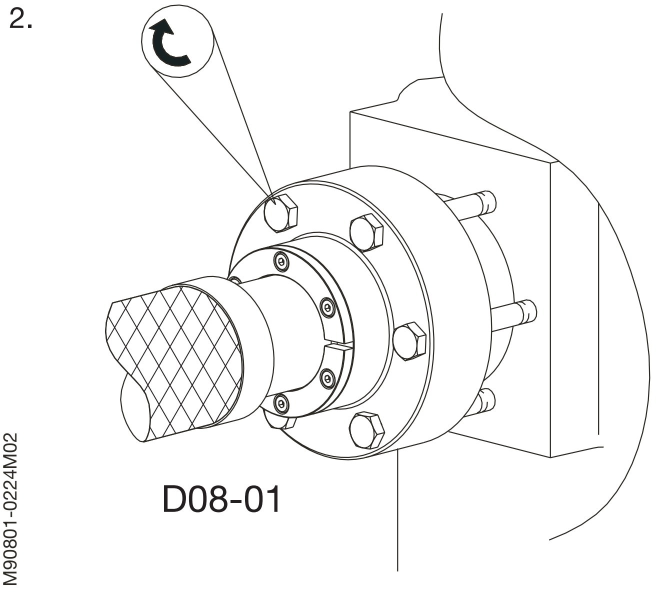

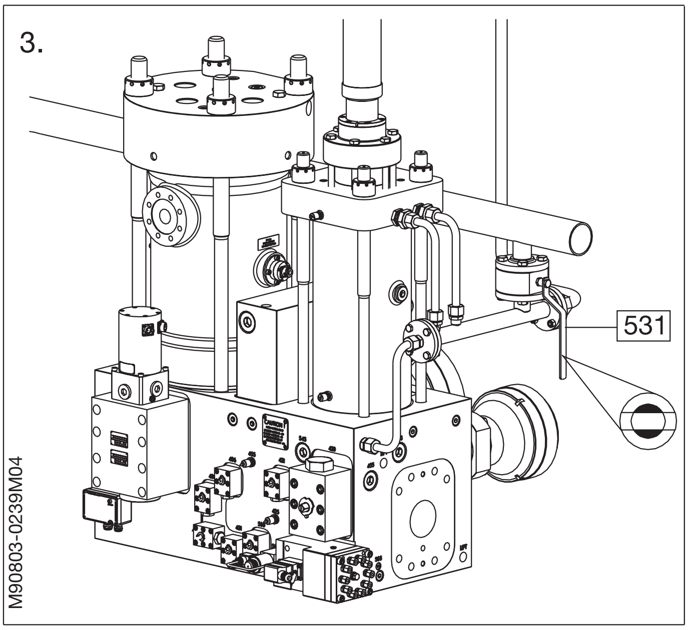

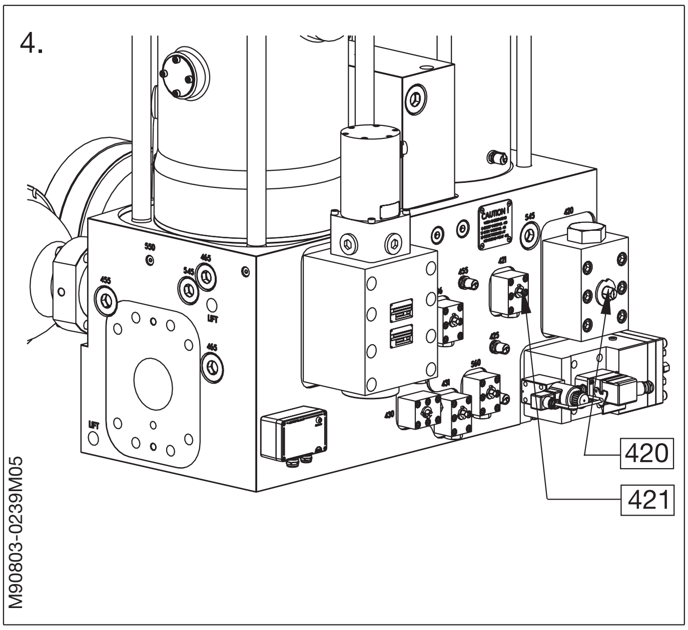

3. Open the valve 531 for actuator oil supply.

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

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

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
X	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
X	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-04	Safety valve, opening pressure	21	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	14.0	mm
D08-14	Spindle, max. grinding	2.0	mm
D08-15	Spindle stem, measuring area, min.	700	mm
D08-16	Spindle stem, measuring area, max.	870	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	140.2	mm
D08-21	Piston rings, min. thickness	5.2	mm
D08-22	Damper piston, min. distance	36.2	mm
D08-23	Damper piston, max. distance	39.2	mm
D08-24	Exhaust valve, complete	3000	kg
D08-25	Exhaust valve housing	1900	kg
D08-26	Oil cylinder	350	kg
D08-27	Air cylinder	230	kg
D08-28	Spindle	270	kg
D08-29	Bottom piece	190	kg
D08-30	Air piston	13	kg
D08-45	Damper piston	32	kg
D08-46	Damper flange	45	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	232	Retaining tool for bottom piece
P90851	268	Air coupling
P90851	281	Cone, for sealing ring
P90851	293	Pliers for retaining ring
P90861		Exhaust Valve - Tools
P90862		Exhaust Valve - Hydraulic Tools
P90863		Exhaust Valve - Extra Tools
P90864		Exhaust Valve - Extractor Tool
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

1. Before mounting an overhauled exhaust valve in the engine, it is recommended that the valve be checked as follows:

   - Fit the retaining tools for the bottom piece.
   - Lift up the valve with the engine room crane (which makes the valve open).
   - Connect compressed air to the air cylinder. The valve should now close.
   - Check that a 1.0 mm feeler gauge can be inserted about 15 mm into gap G 3, to ensure that there is a clearance between the outer parts of the seating faces of valve housing and spindle. *See Procedure 908-2.3.*
   - After shutting-off the compressed air supply and releasing the vent plug screw located just above the ball cock on the air cylinder, the exhaust valve should open.
   - After doing this a couple of times, leave the valve closed and shut-off the compressed air. The valve should remain closed for at least fifteen minutes.

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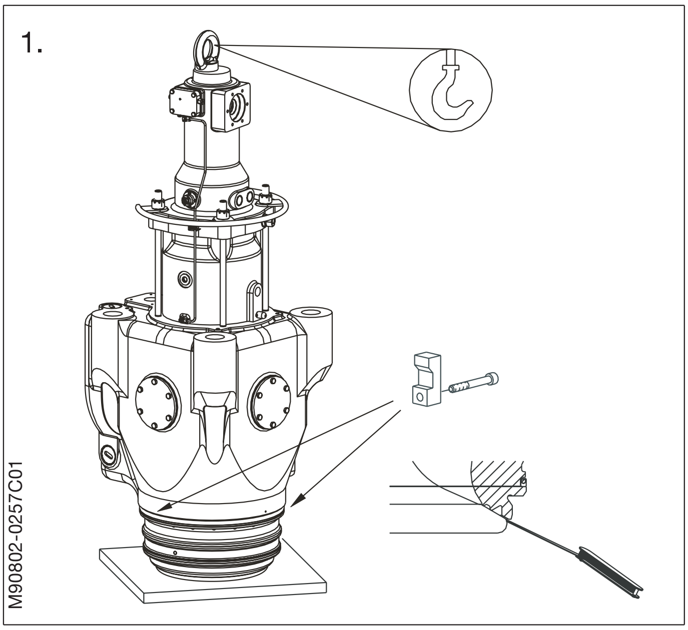

Check of sealing oil unit

2. Check of the sealing oil unit is carried out with running engine. Check that the injection indicator moves regularly with the valve opening. Alternatively, unscrew the sealing oil pipe, and check that oil is coming out (very small quantity).

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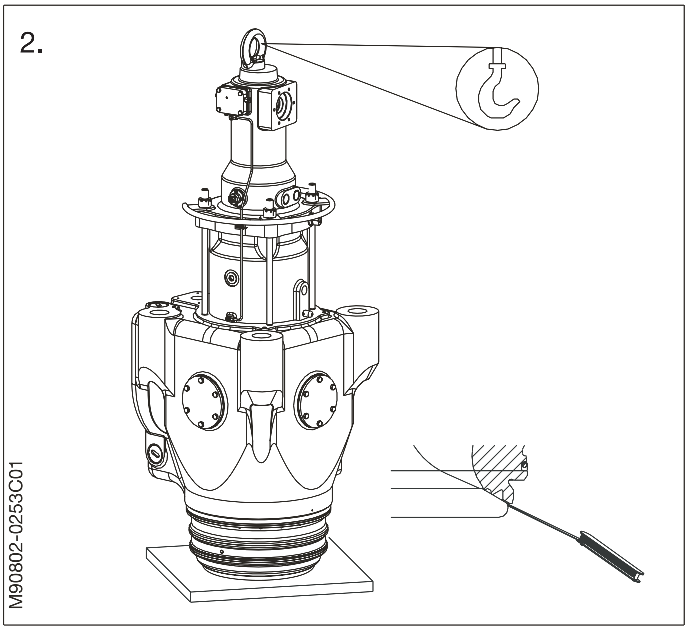

3. When the exhaust valve is mounted in the cylinder cover, and the cooling water inlet to the cylinder cover and exhaust valve is open, check the tightness of the sealing ring between the bottom piece and the cylinder cover by ensuring that water does not flow from the small bore on the top side of the bottom piece.

   If water does flow from one or both of these bores, the exhaust valve must be dismounted and the sealing rings replaced.

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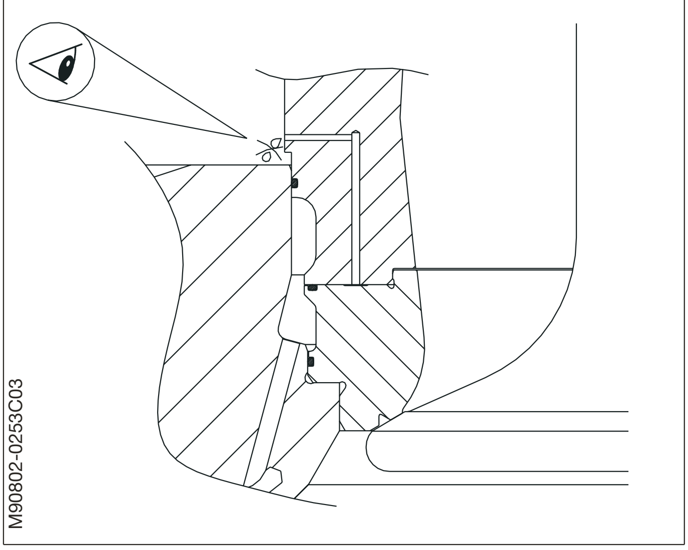

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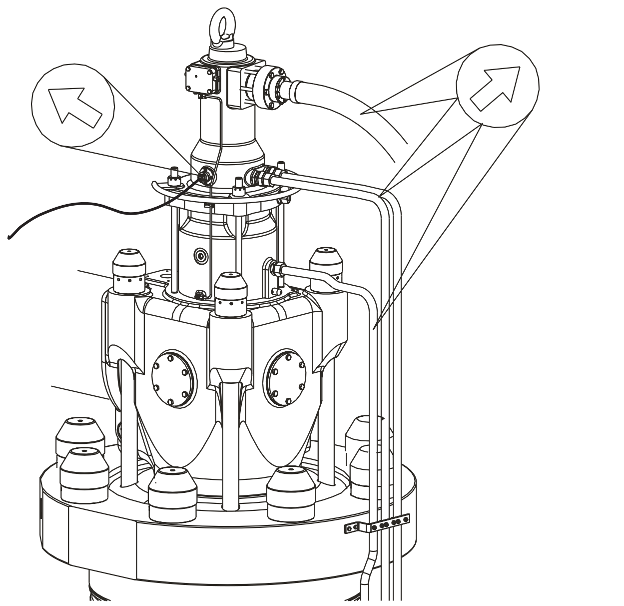
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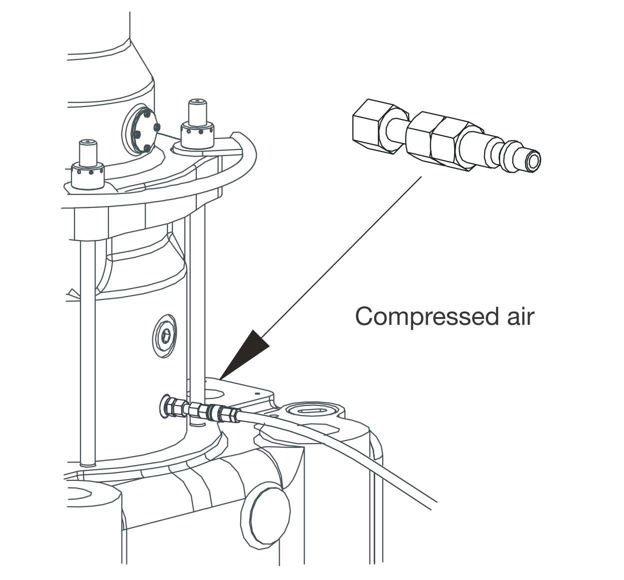

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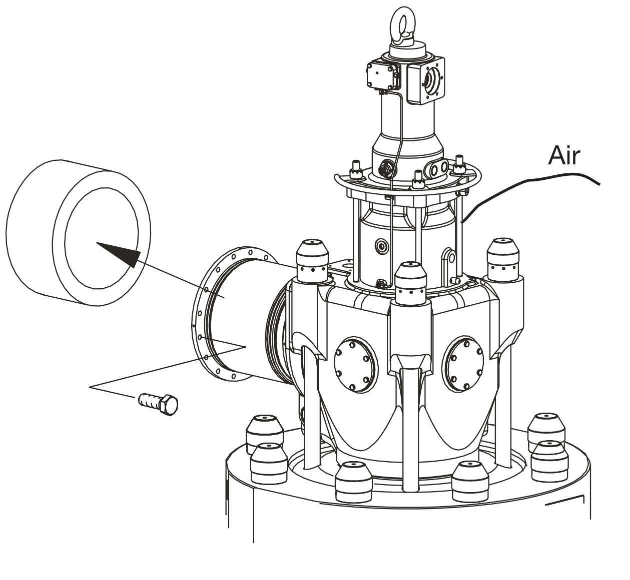

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1. Close the cooling water inlet and outlet, and drain the exhaust valve.

   Dismount the high-pressure pipe for the hydraulic valve actuation. *See Procedure 908-1.2.*

   Disconnect the cooling water outlet pipe from the exhaust valve.

   Dismount the return oil pipe and oil supply pipe from the exhaust valve.

   Disconnect the electrical plug for the valve position sensor.

2. Dismount the air pipe for pneumatic closing of the exhaust valve.

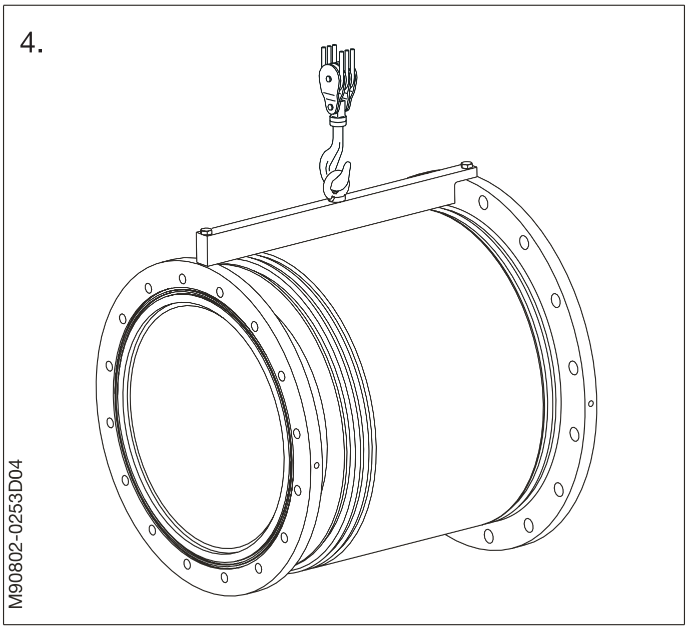
   Mount the adaptor tool on the non-return valve for air spring. The adaptor tool is found on the tool panel.

   Connect 7 bar working air to the coupling assembly, thereby keeping the valve closed when it is removed from the engine.

3. Remove the plate jacket with insulation from the intermediate pipe and remove the screws which attach the intermediate pipe to the inlet pipe of the exhaust receiver.

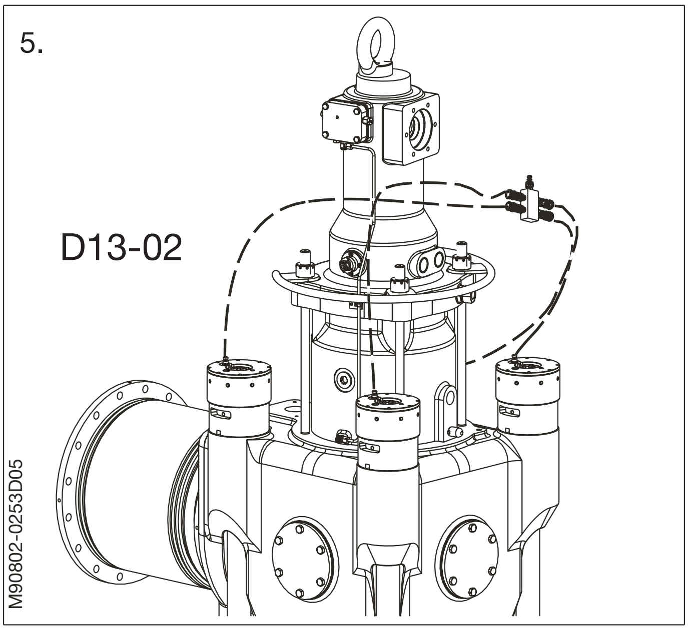
   Alternatively, support the intermediate pipe by a chain block and remove the screws which attach the intermediate pipe to the exhaust valve housing.

4. If necessary to lift the intermediate pipe (compensator) alone, use the special tool from tool panel 901.



5. 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.



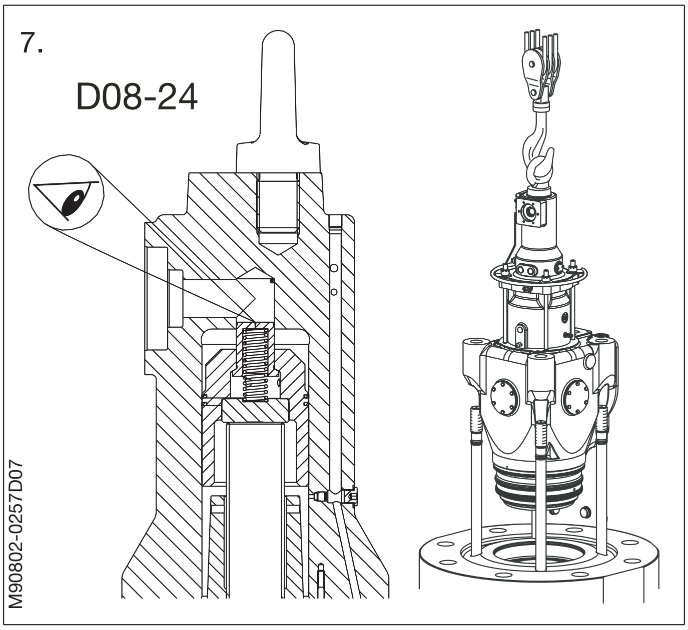
6. Bleed the hydraulic system and raise the pressure as stated in Data.

   Then loosen and remove the nuts.
   See Procedure 913-1.

7. 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.



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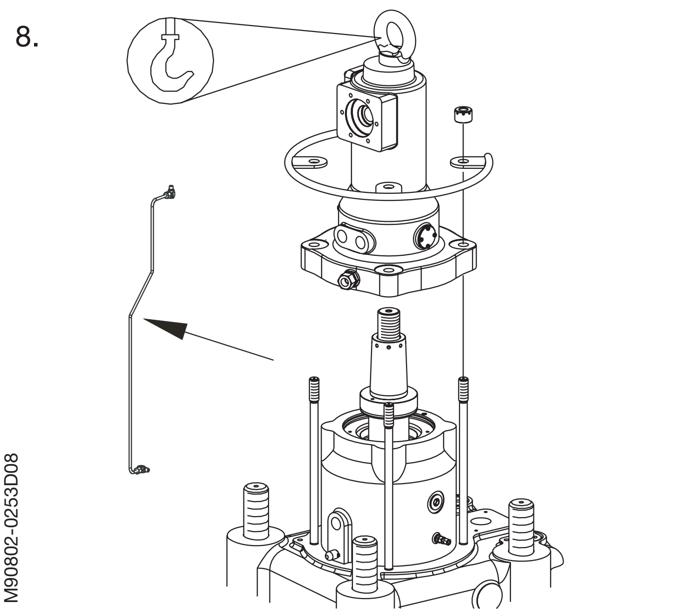

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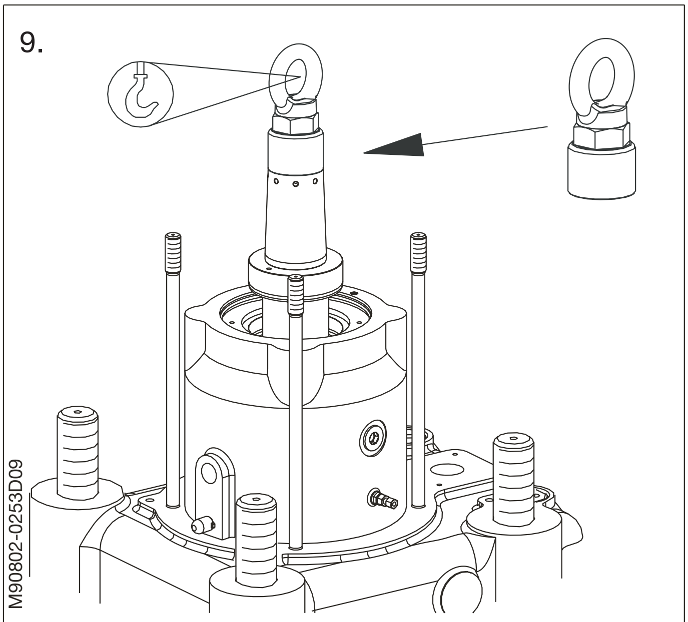


Disconnect the 7 bar working air hose.

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. Remove the four hydraulic nuts and the safety strap from the oil cylinder.

   Remove the sealing oil pipe.

   Attach the crane hook to the oil cylinder. Lift the oil cylinder away and place it on a wooden support.

9. 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.

1. Place the exhaust valve on a wooden support on the platform.

   Loosen the nuts, two at a time, diagonally.

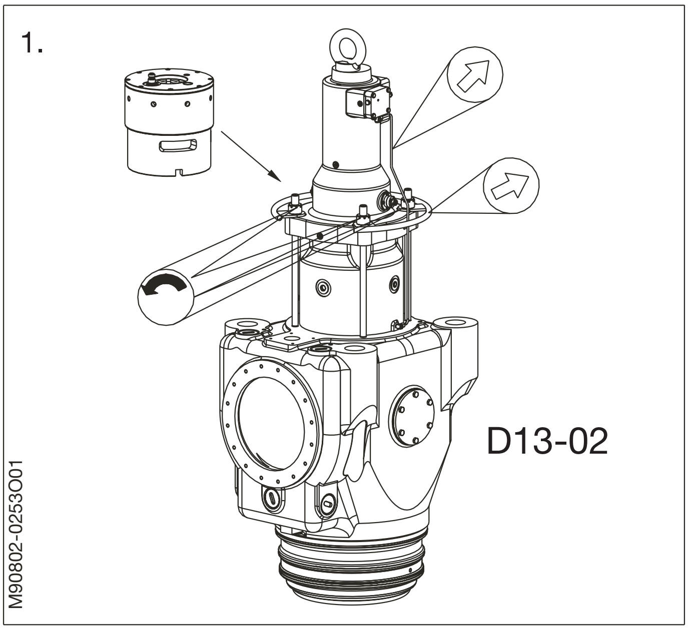
   Mount the spacer rings and the hydraulic jacks over the nuts. Pump up the hydraulic jacks to the dismantling pressure, as specified in Data. Loosen and remove the nuts.

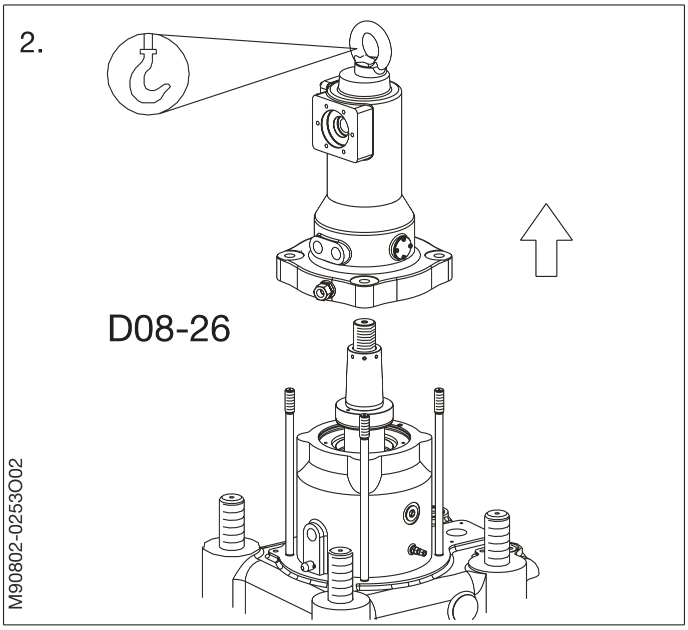
   For use of hydraulic tools, see also Procedure 913-1.

   Remove the the safety strap from the oil cylinder.

   Remove the oil pipe for the valve spindle oil sealing.

2. Lift away and place the oil cylinder on a wooden support.





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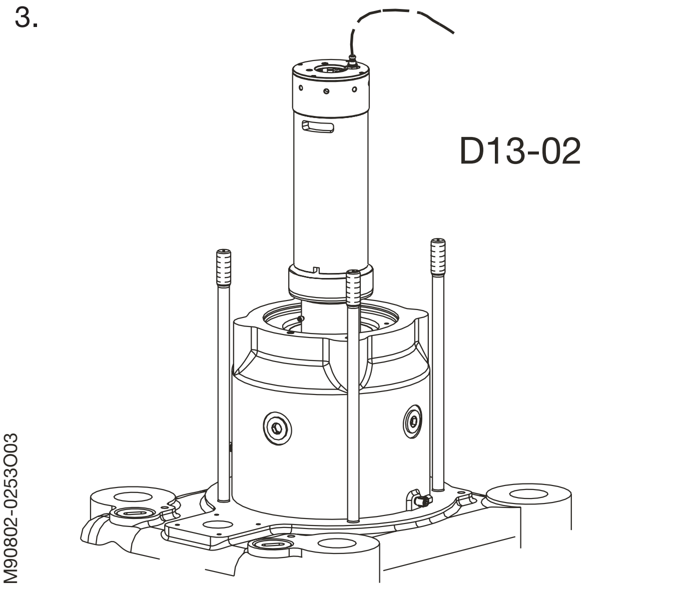

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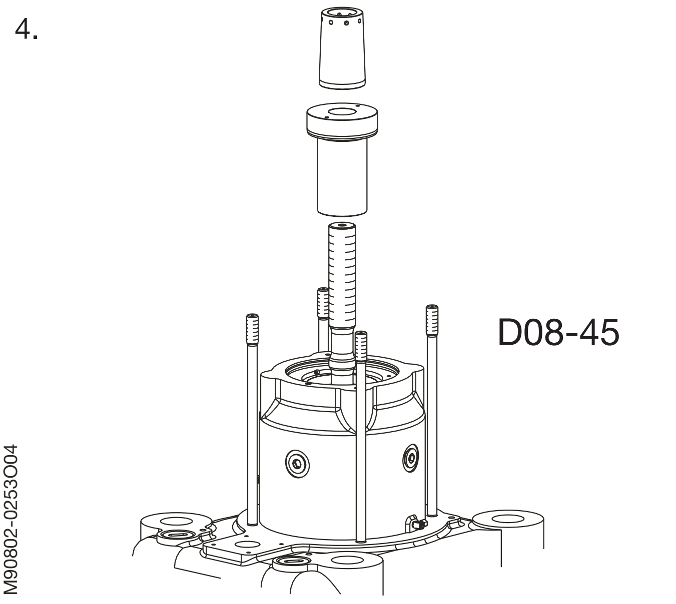


3. Mount the support and the hydraulic jack for the conical nut on the valve spindle.

   Check that the jack is fully compressed and tightened to full face contact, unscrew the jack ½ a revolution.

   Connect the high-pressure pump to the jack. Bleed the hydraulic system and raise the pressure as stated in Data. Then loosen the nut. *See Procedure 913-1.*

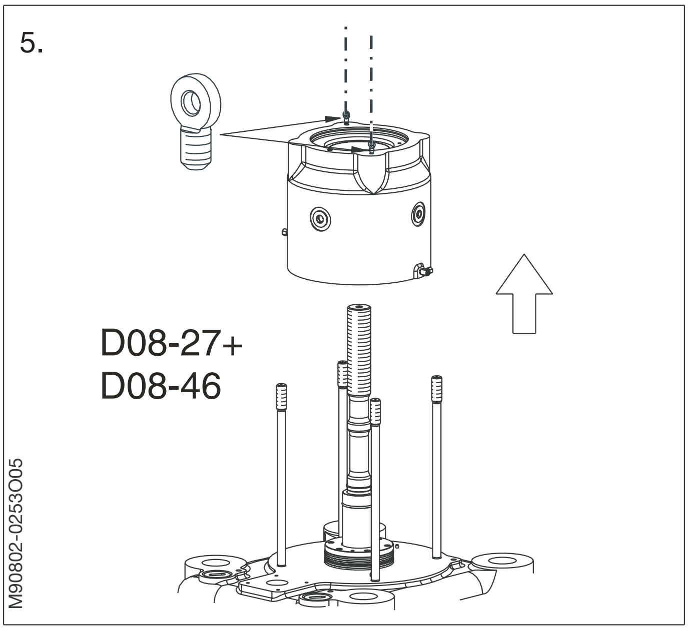
4. Remove the conical nut and the damper bushing.

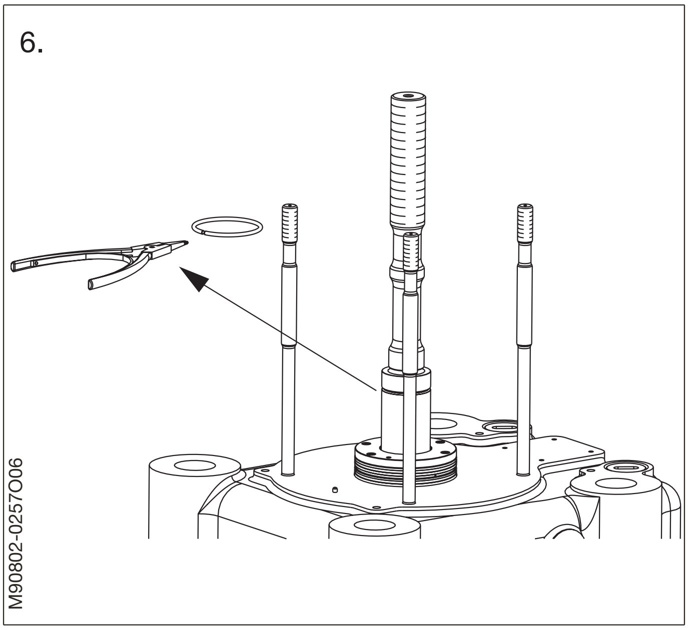
5. Mount two eye bolts in the top of the air cylinder. Lift the air cylinder with damper flange and air piston.

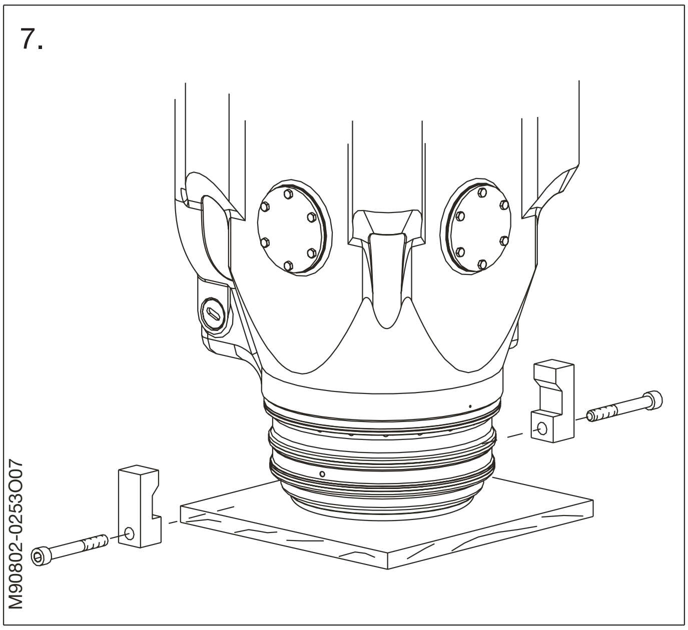
   Land the air cylinder on a wooden support.

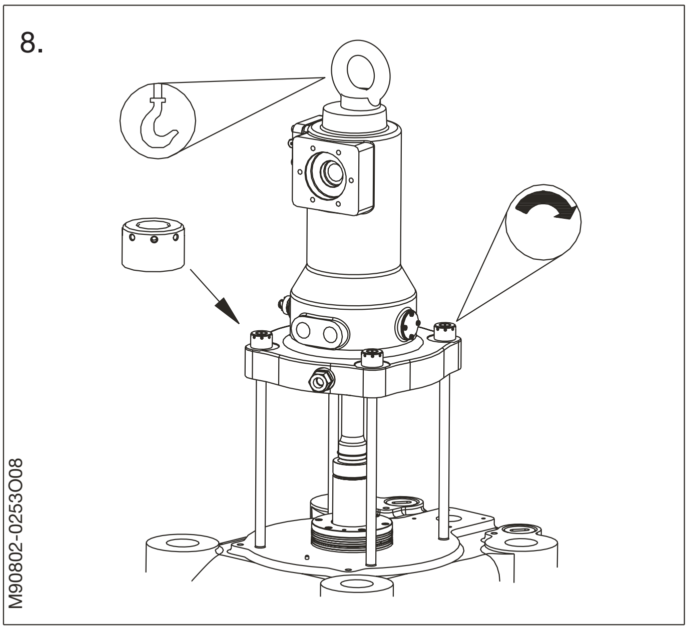
6. Remove the retaining ring from the spindle shaft using the special pliers from Panel 908.

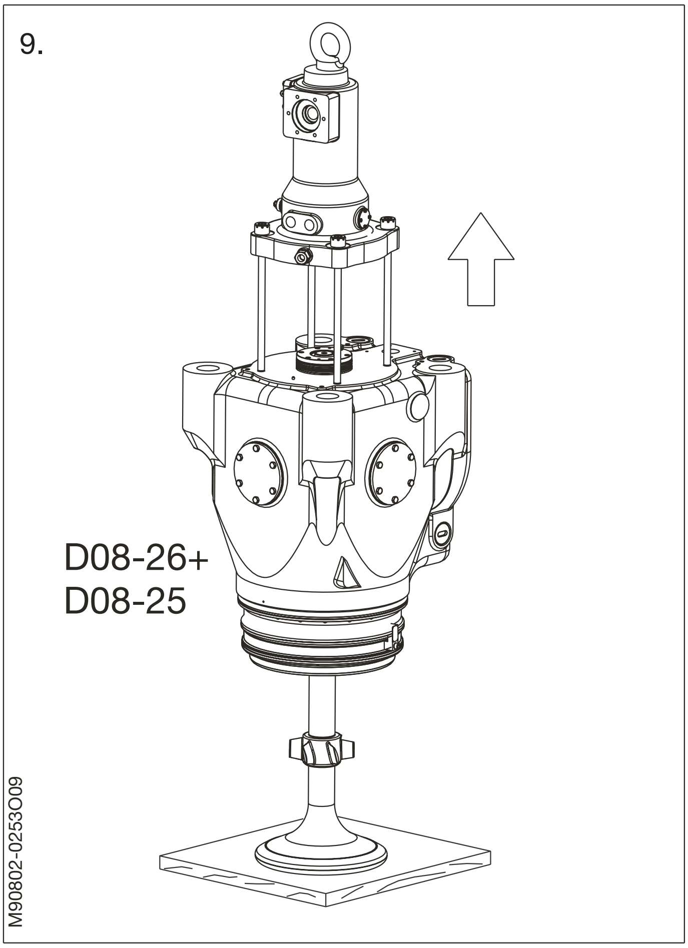
7. Mount a retaining tool for the bottom piece.











8. 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.

9. Lift the oil cylinder and the valve housing clear of the exhaust valve spindle.

10. Land the valve housing on a wooden support and let the oil cylinder hang in the crane.

11. Unscrew and remove the special tool which retains the bottom piece. Lift the valve housing approx. 10 mm.

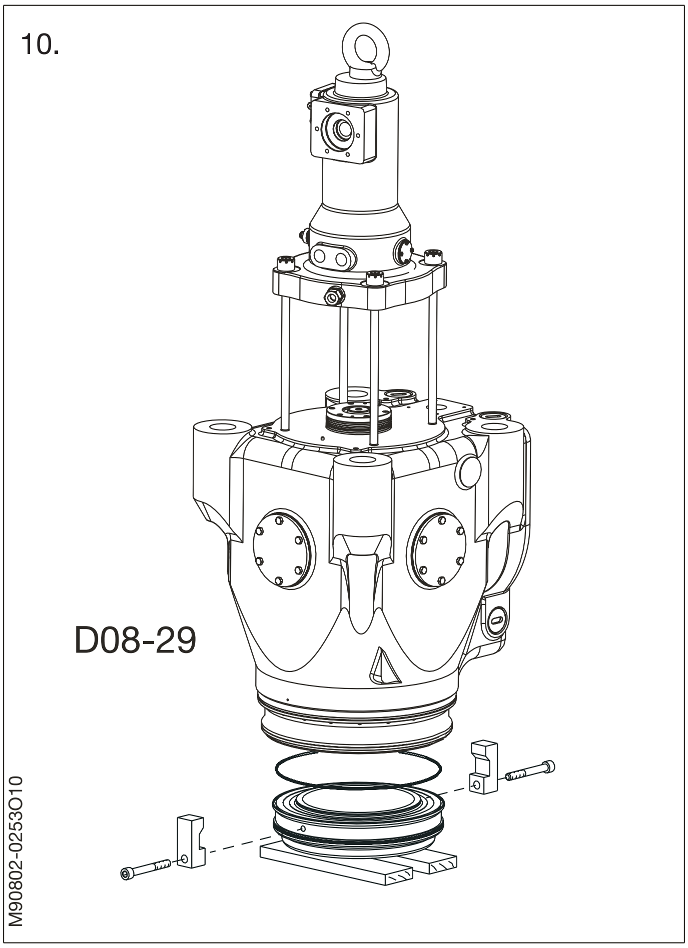
    If the bottom piece has become stuck, use a tin hammer to release it. Lift the valve housing away and land it on a couple of wooden planks.

    Remove and discard the O-ring from the groove in the top of the bottom piece.

    Remove the oil cylinder.

12. Remove and discard the O-rings and the inside sealing ring.

10.



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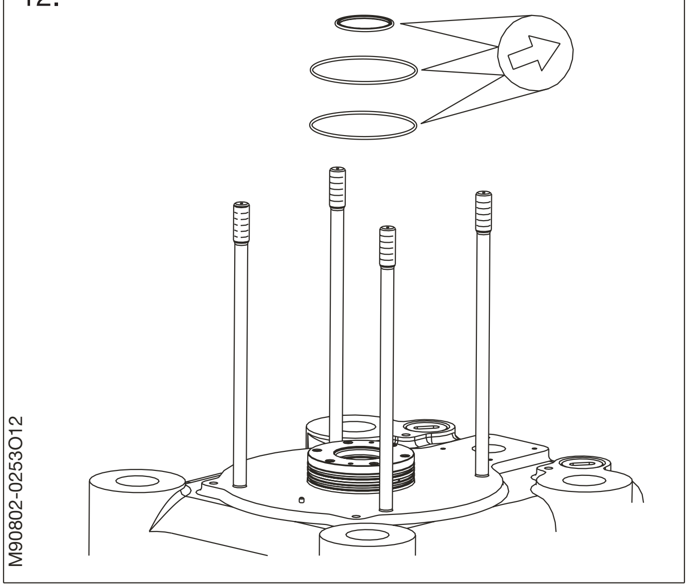

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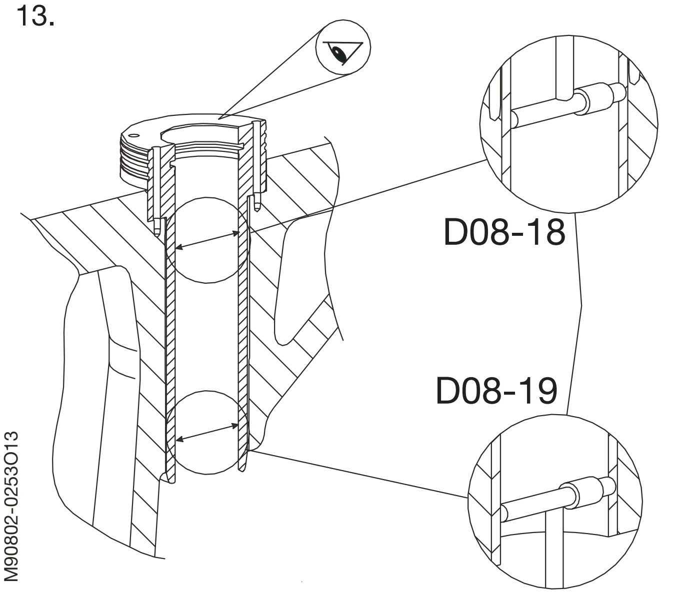

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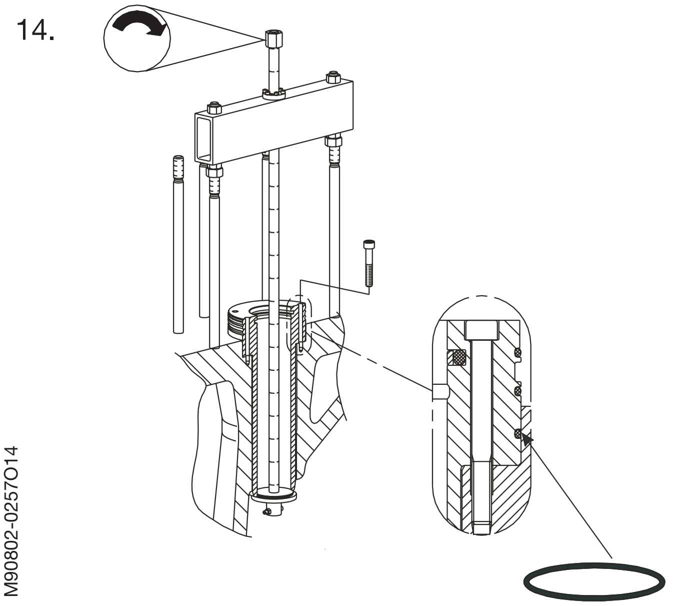


13. Inspect the bushing in the spindle guide for wear and measure the top and bottom diameters. *See Data.*

14. 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, mount a new O-ring for sealing between bushing and exhaust valve housing.

    Mount and tighten the screws for the bushing.

Bottom piece:

15. Inspect the seating of the bottom piece **carefully** for damage and check with the bottom piece template.

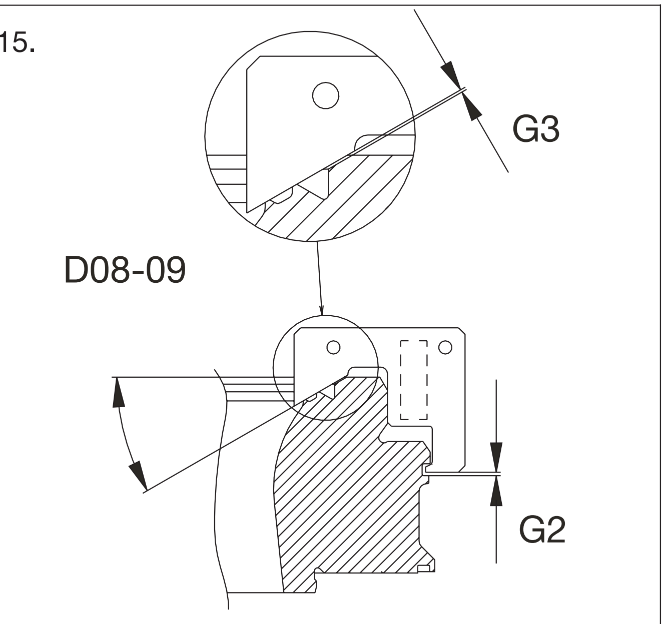
Note!
Before using the bottom piece template, thoroughly clean the contact faces on the valve housing w-seat with a steel brush. All measurements should be taken at four diametrically opposite points on the circumference of the bottom piece seating. Small dent marks in the bottom piece seating are acceptable 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.

15.



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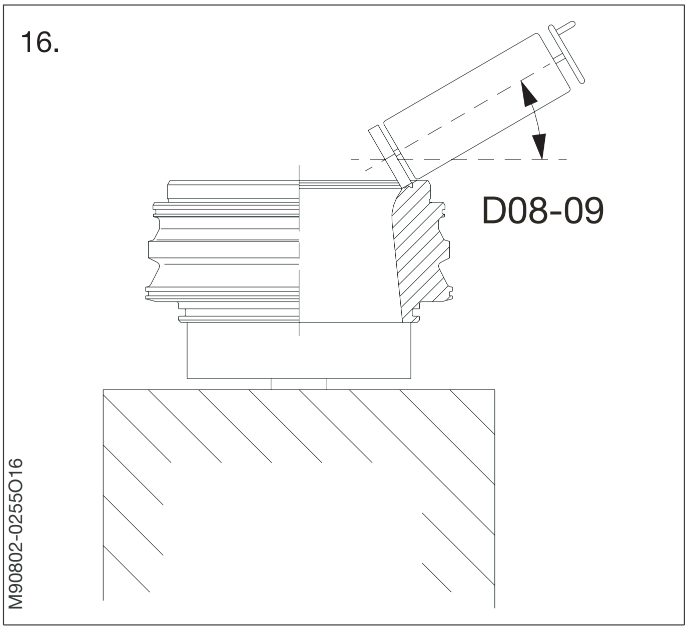

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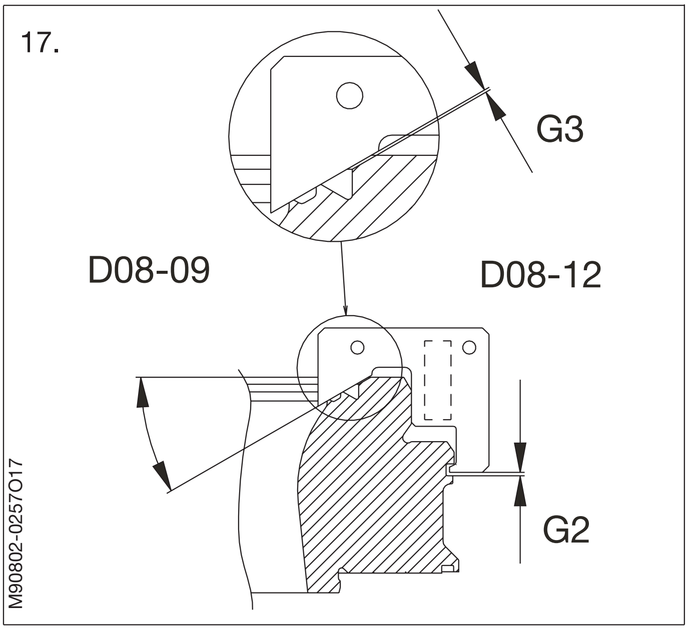

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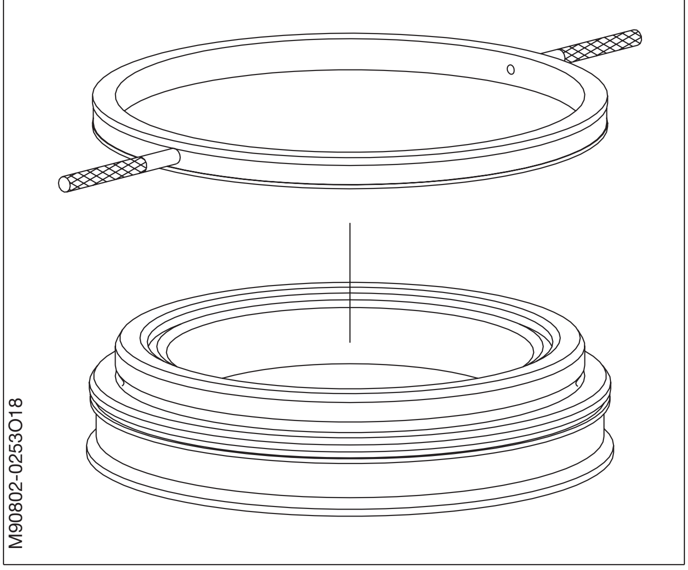


16. If it is necessary to grind the seating, proceed as follows:

    Before placing the bottom piece on the grinding machine, turn the grinding head away from the grinding table.

    Mount 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.

17. 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.

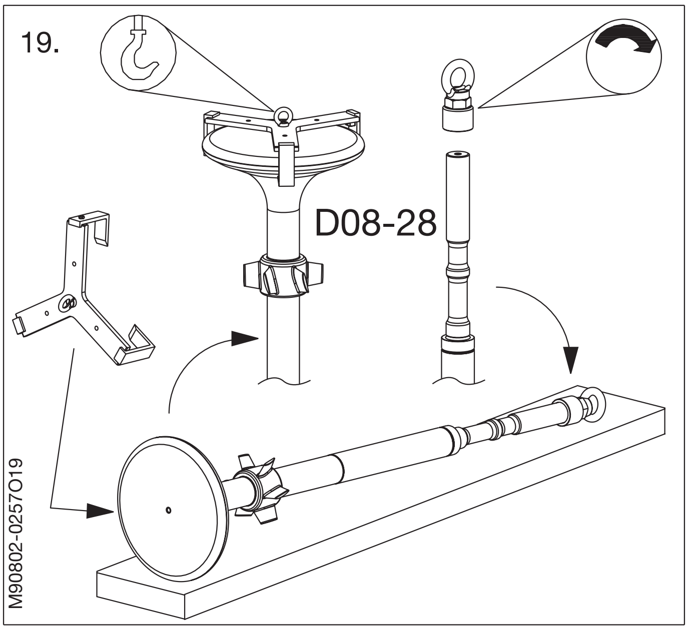
    Grind the recess so that gap G3 equals D08-12 as stated on the Data sheet.

18. 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.

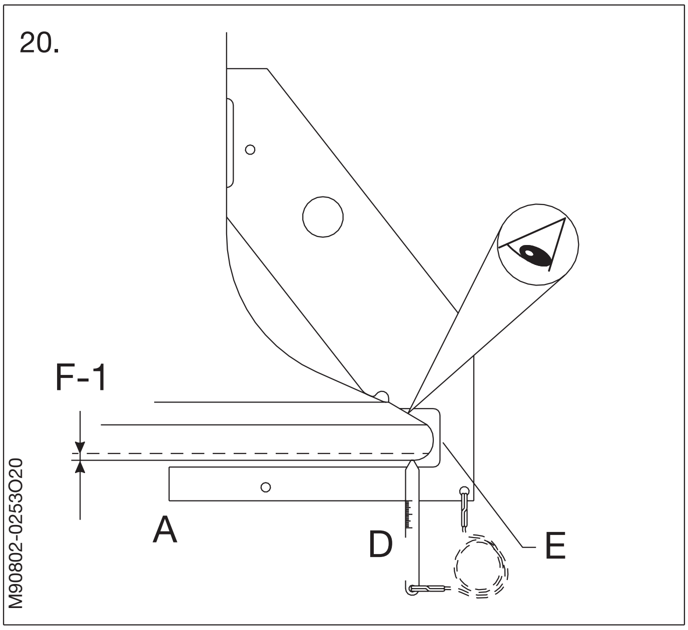
Valve spindle



19. 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).

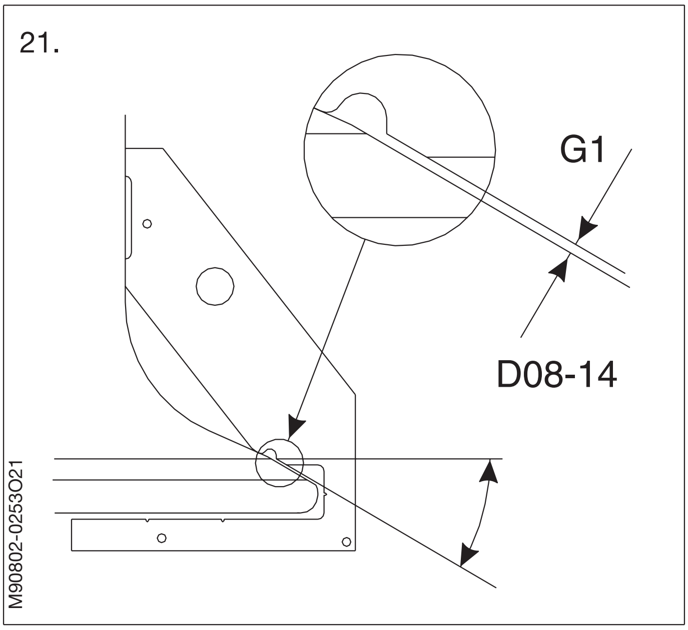
    Mount the large lifting tool designed for the bottom of the spindle. Lift up the valve spindle as shown in the sketch.



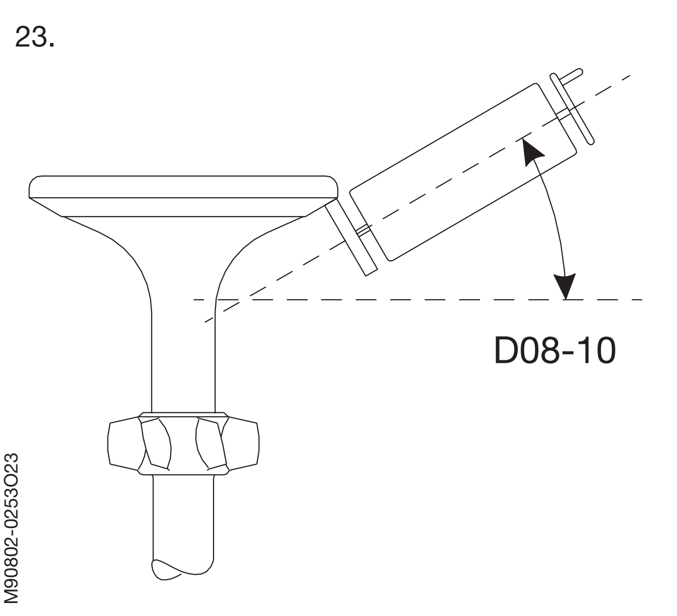
20. Inspect the seating of the valve spindle for burn marks.

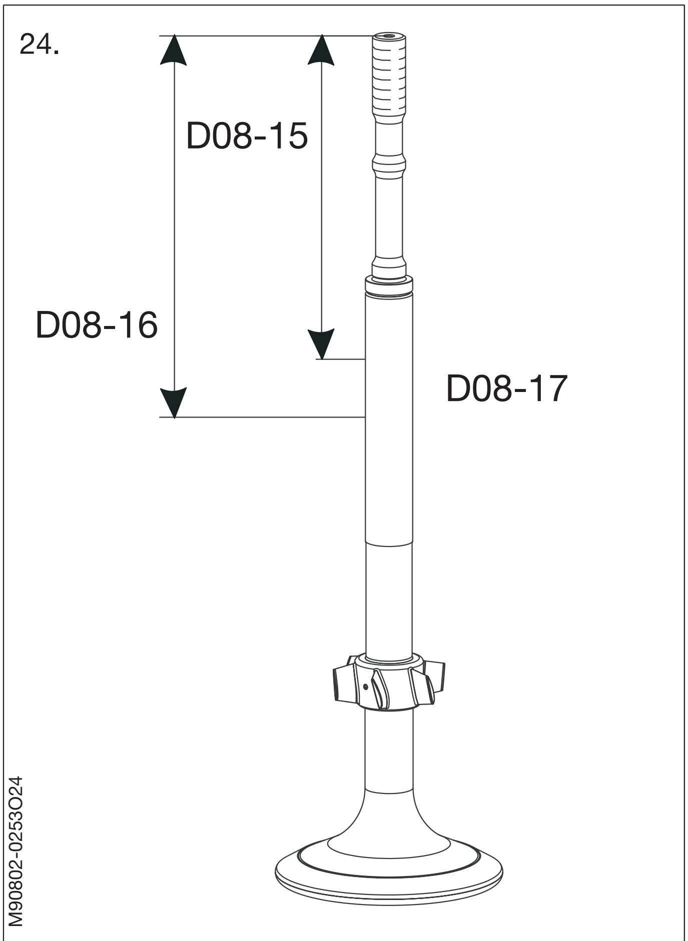
    Check the burn-off F1 of the valve spindle by measuring along the spindle template from point A to point D and in point E.

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.*



21. Measure the gap G1 between the spindle template and the seating of the spindle.





22. 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 B&W Diesel for advice on reconditioning.

23. 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 G 1 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 B&W Diesel for advice on reconditioning.

Clean the spindle.

24. 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 B&W Diesel for advice.

25. Mount the O-rings and sealing ring on the spindle stuffing box.

Note!
Make sure to mount the sealing ring correctly, see the sketch.

26. 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.

    Mount and tighten the bottom piece retaining tools.

27. Lubricate the inside of the bushing in the spindle guide with plenty of lubricating oil.

    Mount the guide cone on the exhaust valve spindle, to protect the sealing rings in the stuffing box.

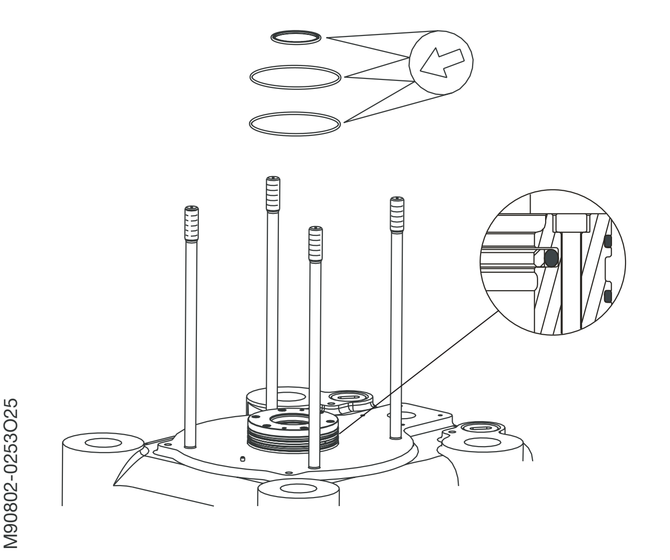
    Carefully land the exhaust valve housing with the bottom piece on the exhaust valve spindle.

    Take care not to damage the sealing rings in the stuffing box.

    Remove the oil cylinder from the exhaust valve.

    Remove the spindle cone from the exhaust valve spindle

25.



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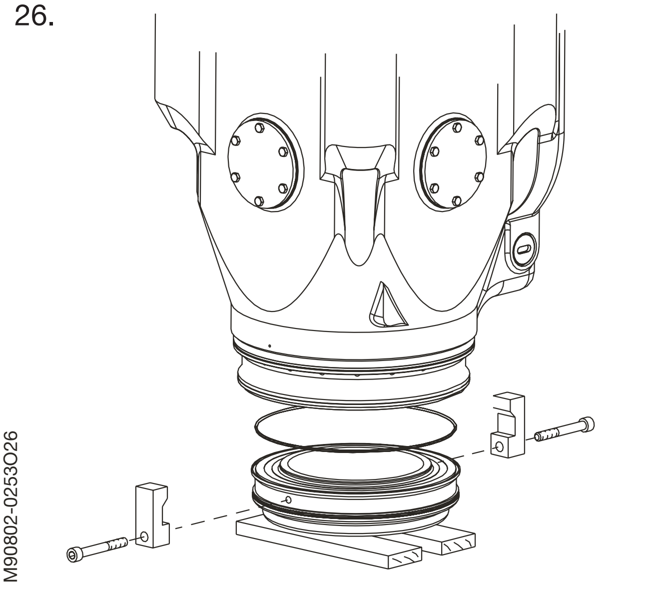

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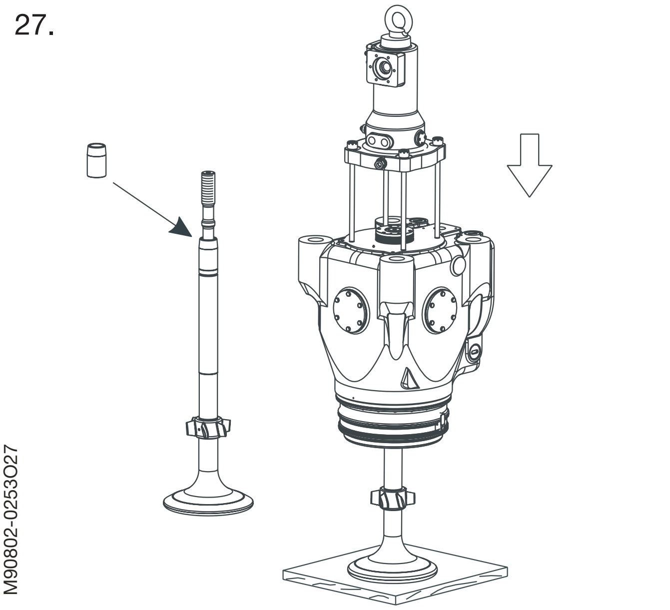

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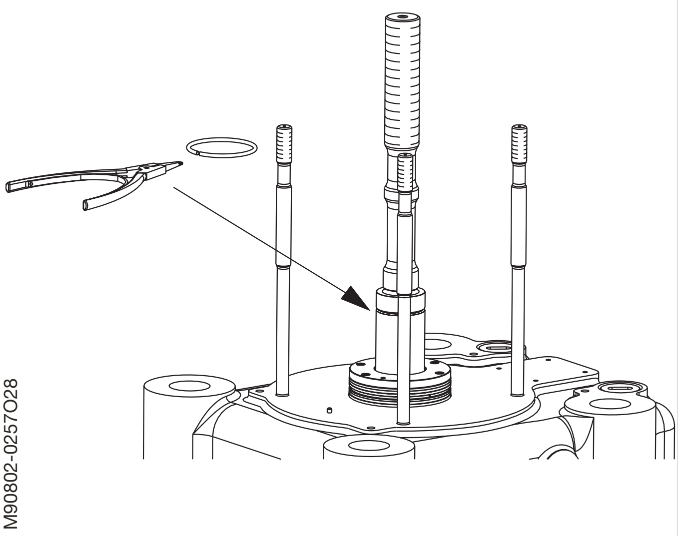

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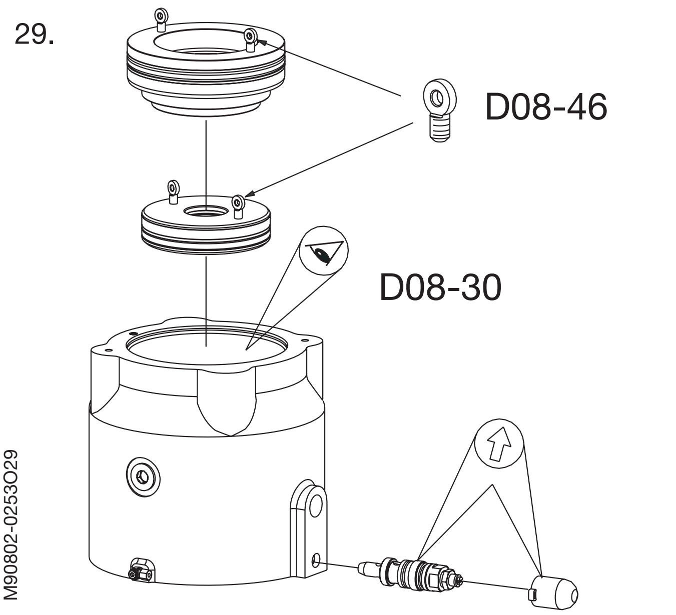

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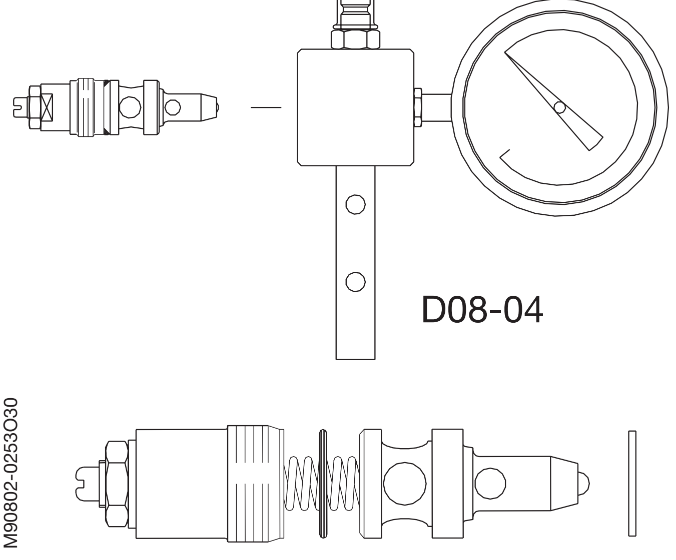

28. Mount the retaining ring on the spindle using the special pliers from Panel 908.

29. Lift up the damper flange and the air piston from the air cylinder.

    Remove the protective cap from the safety valve mounted near the bottom of the air cylinder. Dismount the safety valve from the air cylinder. Clean the machined surfaces and the internal bores.

    Check the running surface for wear or possible scores.

30. Place the safety valve in the pressure testing device.

    Connect the testing device with the high pressure pump for the fuel valves by means of a hose. Check the opening pressure, see Data.

    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.

31. Mount a new gasket and a new O-ring on the safety valve.

    Mount the safety valve in the bore near the bottom of the air cylinder.

    When mounting the safety valve in the air cylinder, use only the machined faces on the valve housing and tighten, see Data.

    Finally, mount the protective cap.

32. 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.

33. Inspect the air piston sealing rings and guide ring. If it is necessary to change the rings, cut them and remove them.

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. Compress the teflon ring by hand, using working gloves.

    Mount the new O-ring in the groove of the air piston.

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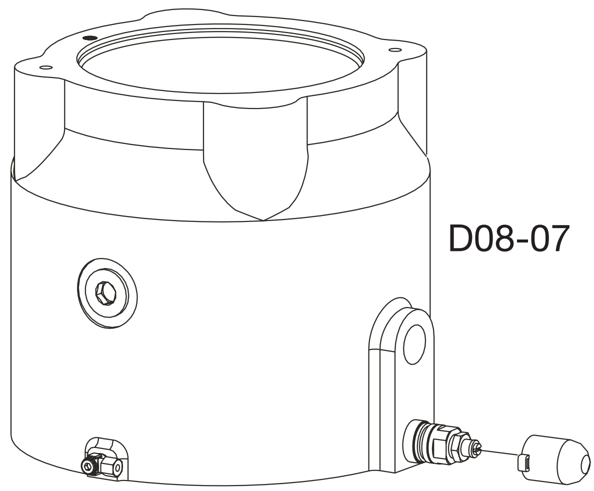

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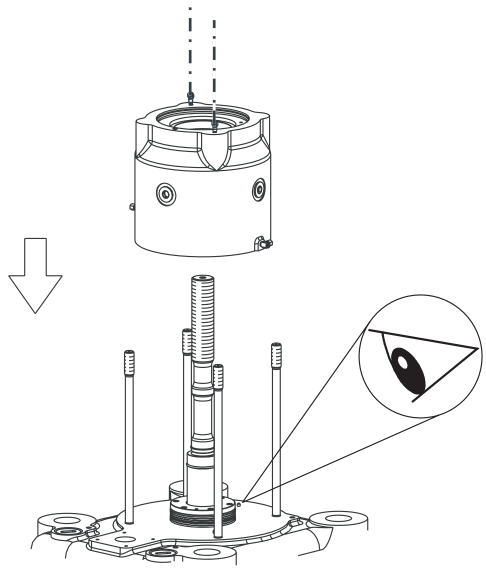

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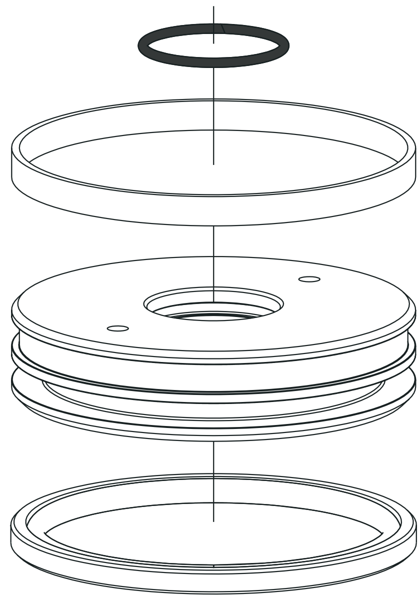

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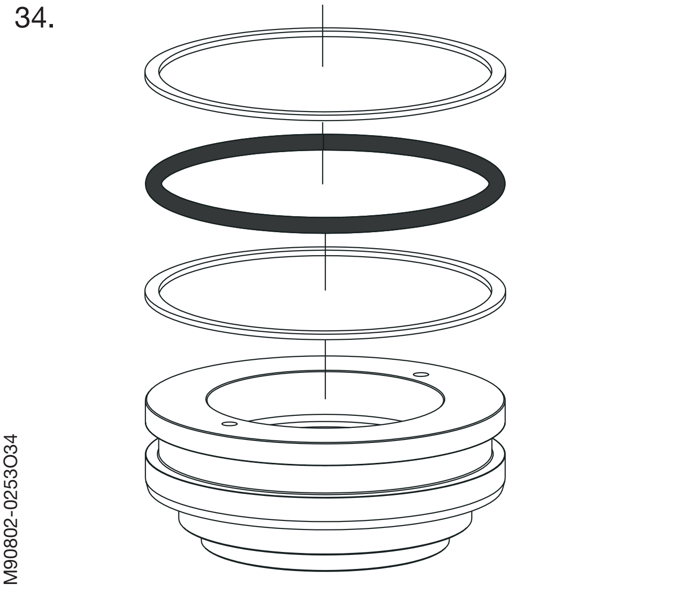

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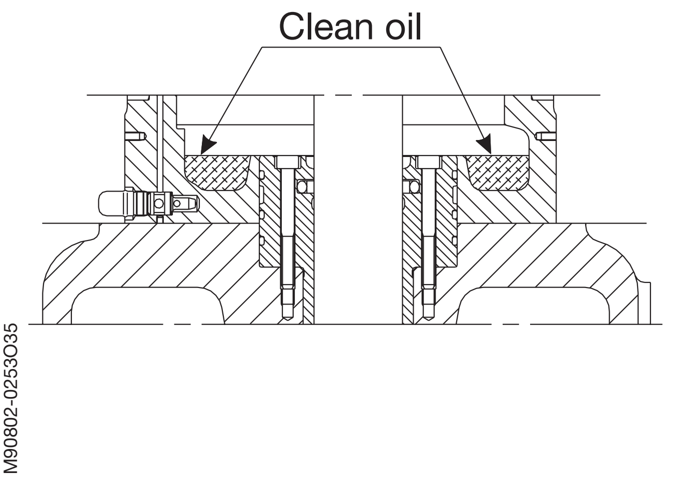

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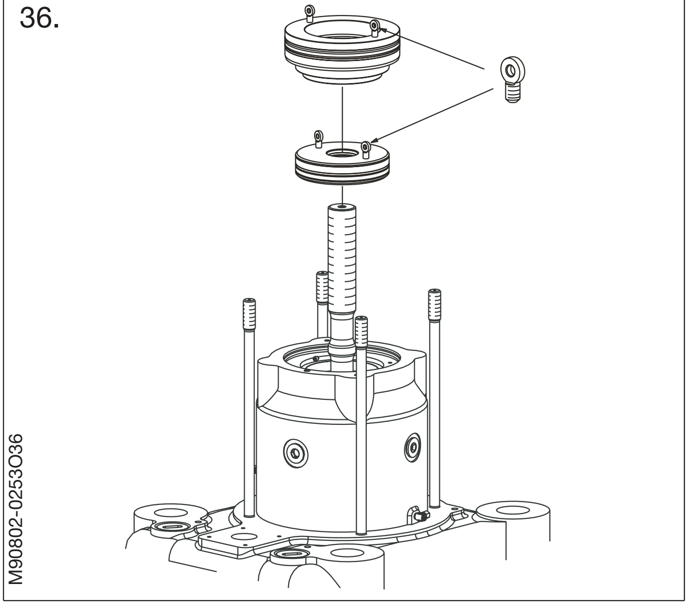

34. Mount new sealing rings on the damper piston flange.

35. Fill the groove on top of the flange and the lower part of the air cylinder with clean lubricating oil (approx. 0.5 litre).

36. Lubricate the running surface of the air cylinder and the surface for the damper piston flange.

    Lower the air piston over the valve spindle down into the air cylinder.

    Lower the damper piston flange over the valve spindle down into the upper groove of the air cylinder.

37. Mount the damper bushing and the conical nut.

38. Mount the support and the hydraulic jack for the conical nut on the valve spindle.

    Check that the jack is fully compressed and tightened to full face contact.

    Connect the high-pressure pump to the jack. Bleed the hydraulic system and raise the pressure as stated in Data. Then tighten the nut. *See Procedure 913-1*.

    Remove the hydraulic jack from the spindle.

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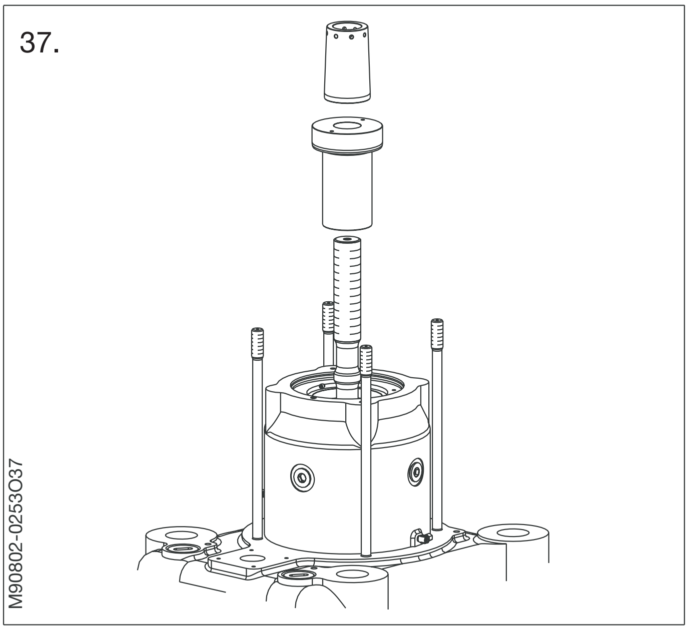

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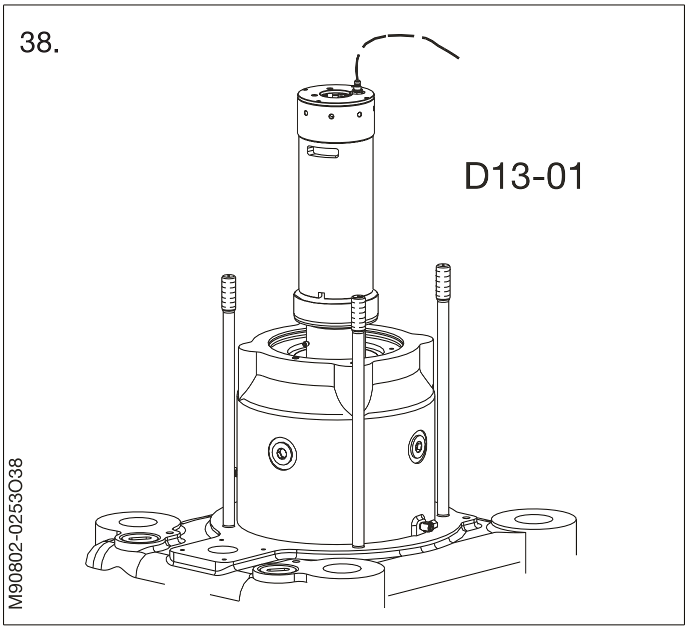

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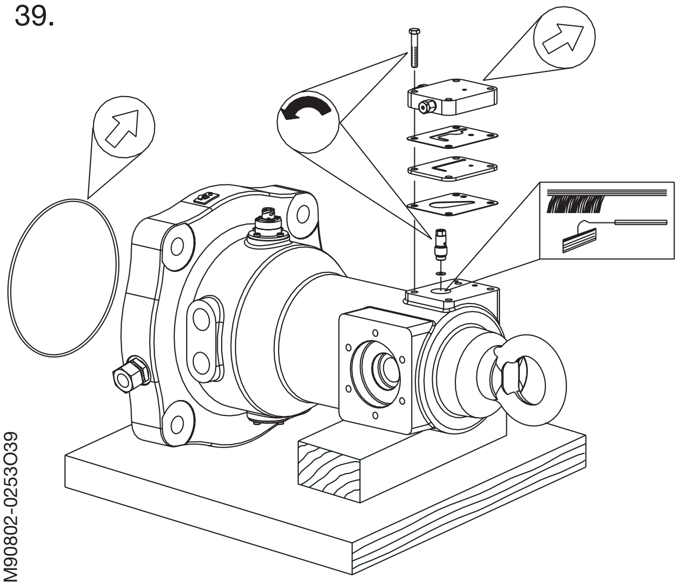

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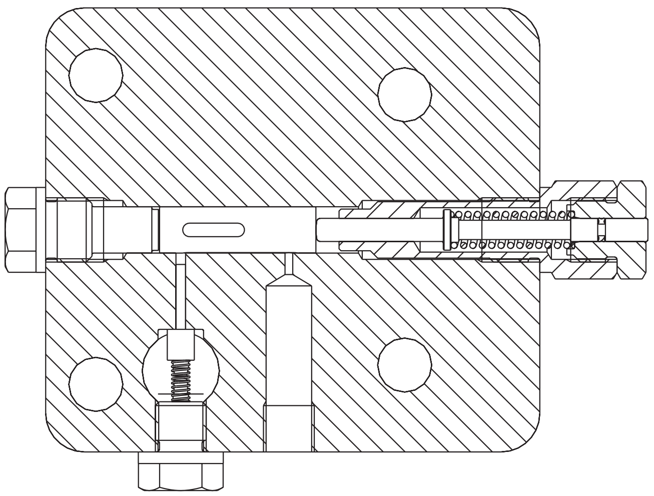

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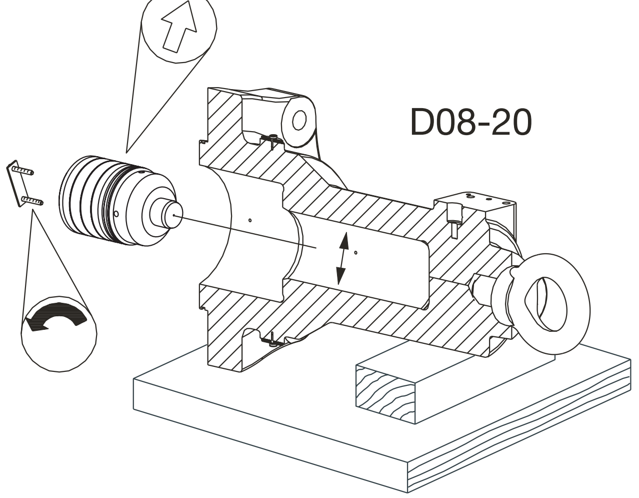


M90802-0257O41

39. Place the oil cylinder in a horizontal position with the sealing oil unit pointing upwards.

    Remove and discard the sealing ring.

    Loosen the screws and remove the sealing oil control unit.

    Unscrew and clean the orifice plug.

    Check and clean the bore for the orifice plug in the top of the oil cylinder.

40. Sealing oil control unit:

    Normally, overhaul of the sealing oil unit should not be necessary.

    Check the unit according to Procedure 908-2.1

    Before remounting the unit, carefully clean it on the machined faces. If the unit needs to be overhauled, send it to an authorized MAN B&W repair shop.

    Mount the orifice plug and the sealing oil control unit.

41. Remove the flange and take out the piston.

    Clean the oil cylinder and inspect the bore of the oil cylinder for scoring and check its measurements.

    If the diameter of the bore exceeds the value stated in Data, send the oil cylinder to an MAN B&W authorized workshop for repair.

42. 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 mount new ones.

    Check that the TOP mark on the piston rings faces upwards, when mounting.

43. Mount 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.

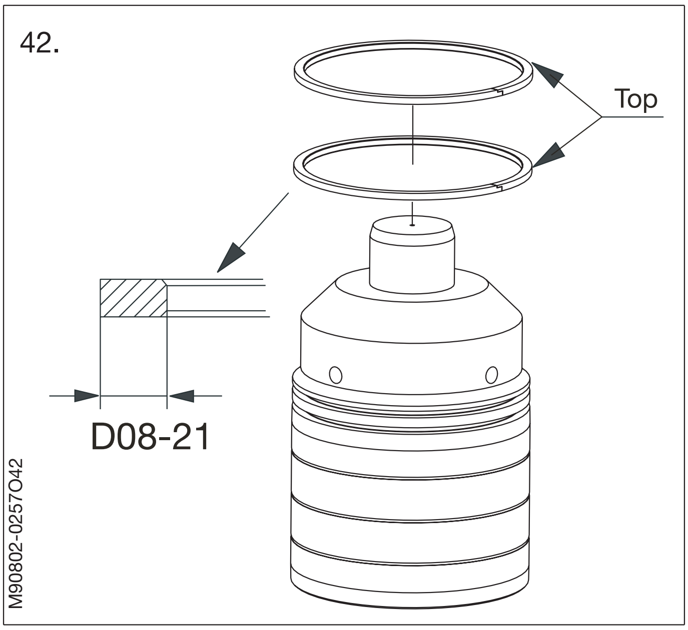
    Connect compressed air supply to the space below the air piston, in order to keep the valve closed, and to keep the air cylinder in close contact with the valve housing.

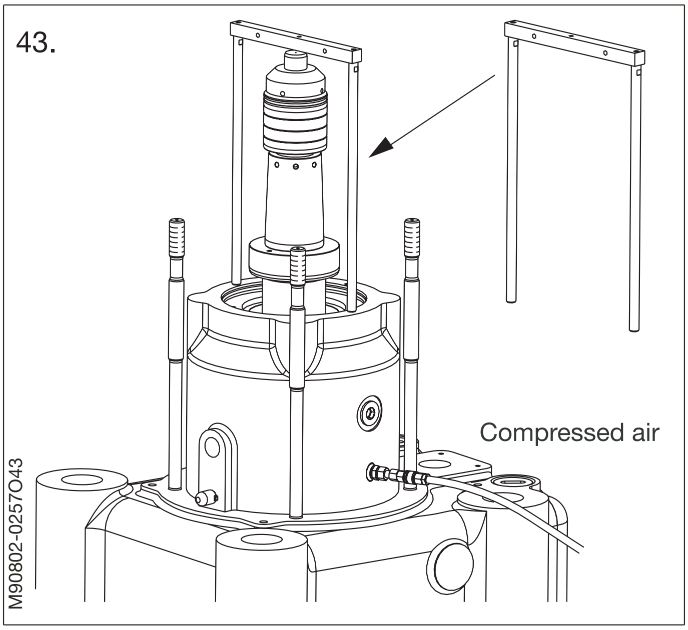
    Place the measuring tool on the air cylinder across the piston.

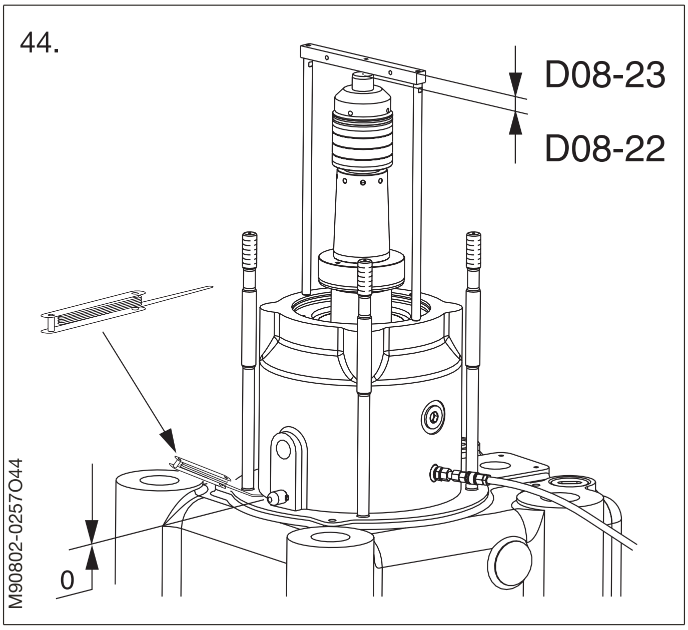
44. Check the mesh of the damper piston by checking the distance from the upper edge of the crossbar to the top of the damper piston. *See Data*.

    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:

45. Place the piston in the special tool.







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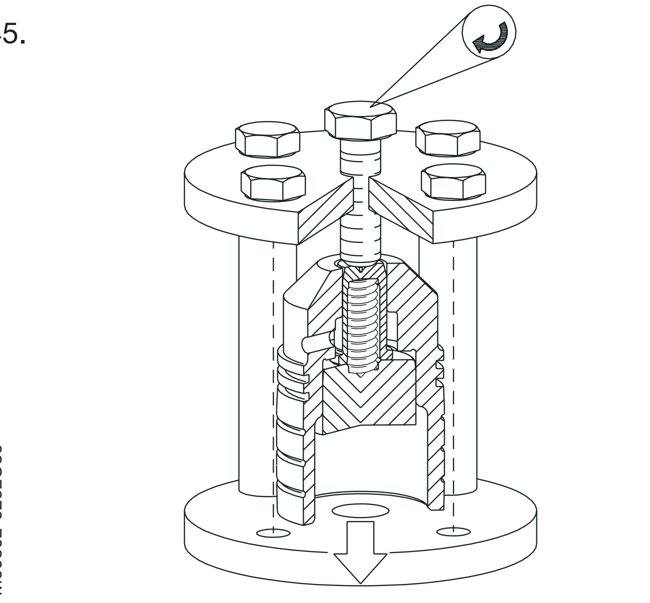

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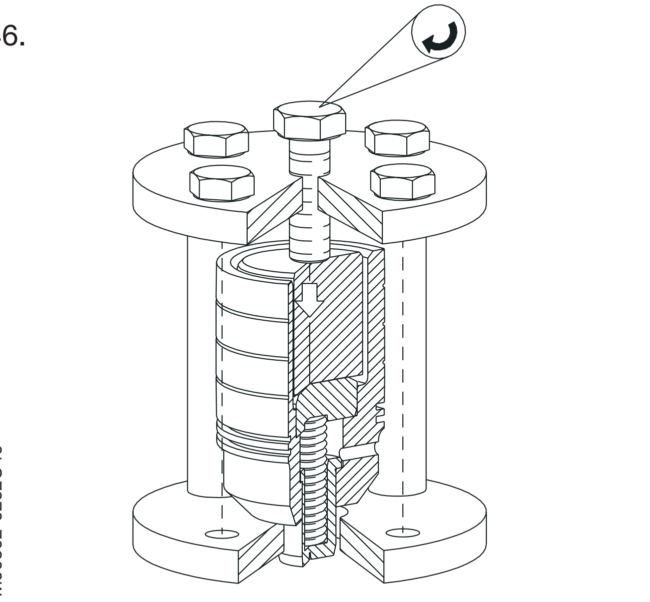

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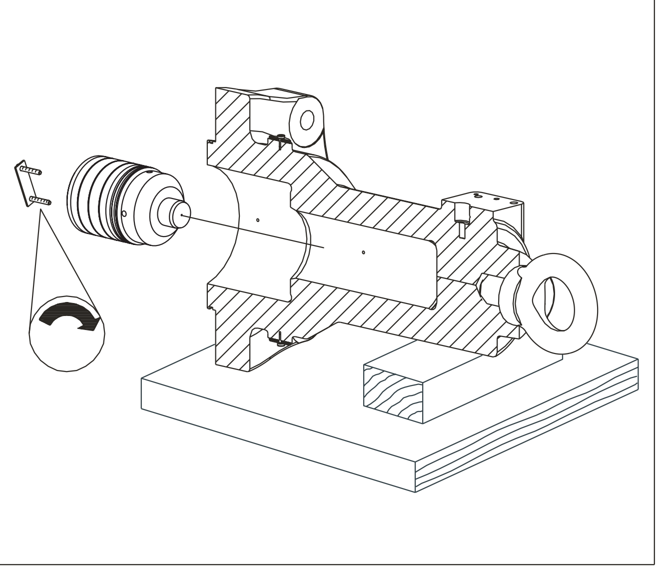


M90802-0257O47

Press out the disc with the centre screw.

If necessary, replace also the spring and the piston.

46. 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.

47. Mount the oil piston and the flange in the oil cylinder and mount a new O-ring in the outside groove.

48. Mount the oil cylinder and the safety strap.

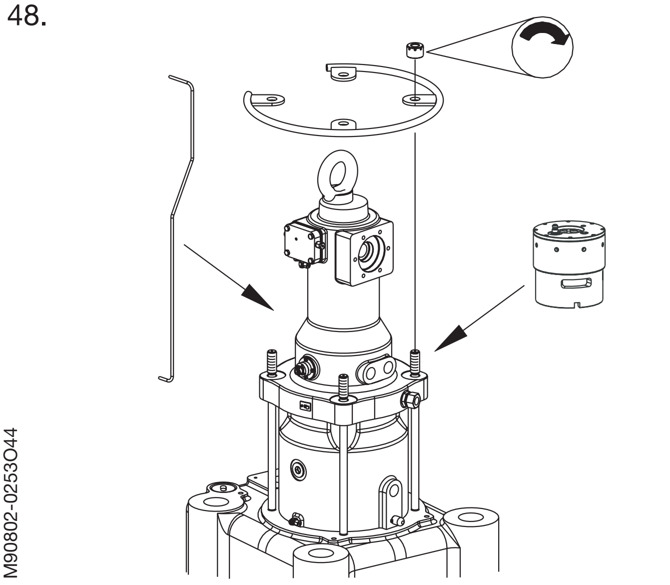
Tighten two nuts at a time diagonally.

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.

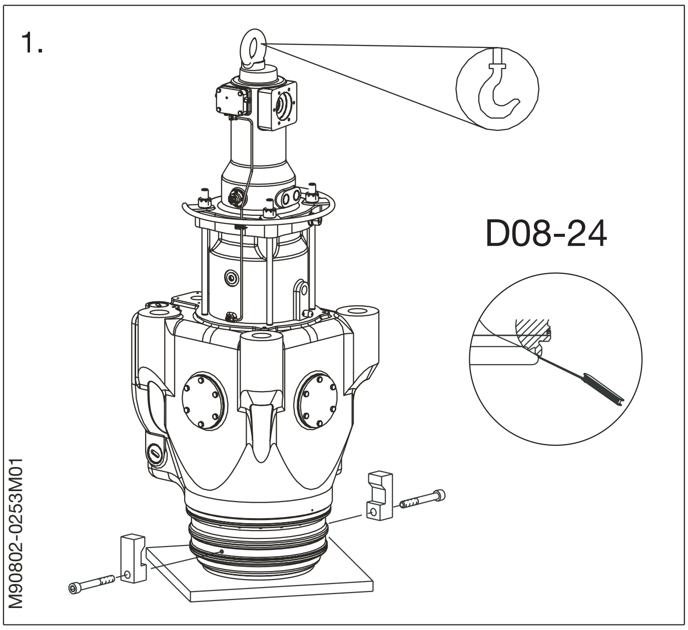
For the use of hydrauliv tools, see also Procedure 913-1.

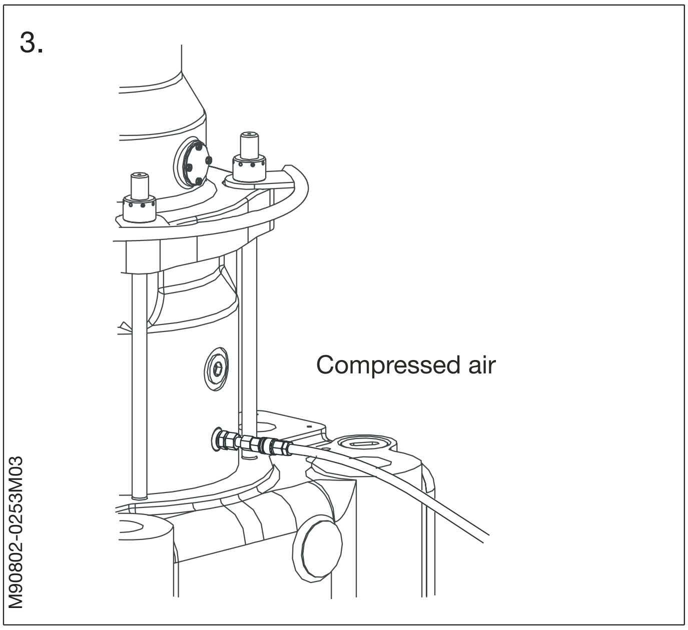
Mount the oil pipe for sealing oil.

48.



Check before mounting





Before mounting an overhauled exhaust valve in the engine, it is recommended to check and prepare the valve as follows:

1. Mount the bottom piece retaining tools.

2. Lift up the valve with the engine room crane (whereby the valve may open).

3. Connect compressed air to the air cylinder to close the valve:

   - 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. *See Procedure 908-2.3.*

   - After shutting-off the compressed air supply and releasing the air through the non-return valve on the air cylinder, the exhaust valve should open.

Hint!

Use a small screwdriver to press the ball into the non-return valve, and cover it with a rag to catch the oil drops.

   - After doing this a couple of times, leave the valve closed, and shut-off the compressed air.

   If the exhaust valve opens within 15 minutes, check for air leakages around the air spring.

   Connect compressed air to the air spring.

   Check:

   - Air piston sealing (air coming out of drain oil hole)

   - Stem sealing (air coming out along spindle stem in exhaust gas duct)

4.

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.

Mount a new O-ring in the groove on the bottom piece and an O-ring in the groove on the exhaust valve housing.

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 flange.

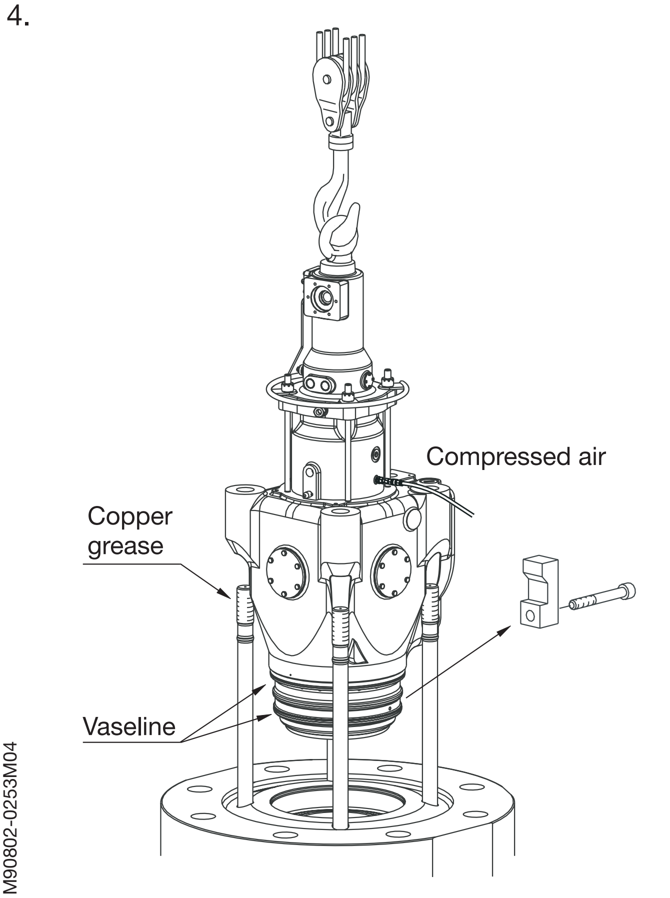
5. Mount the nuts and the hydraulic jacks. Raise the pressure to the value stated in Data and tighten the nuts.

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

   Relieve the system of pressure, remove the hydraulic jacks and high-pressure hoses, and fit the protective caps.

6. Connect the intermediate pipe to the flange

4.



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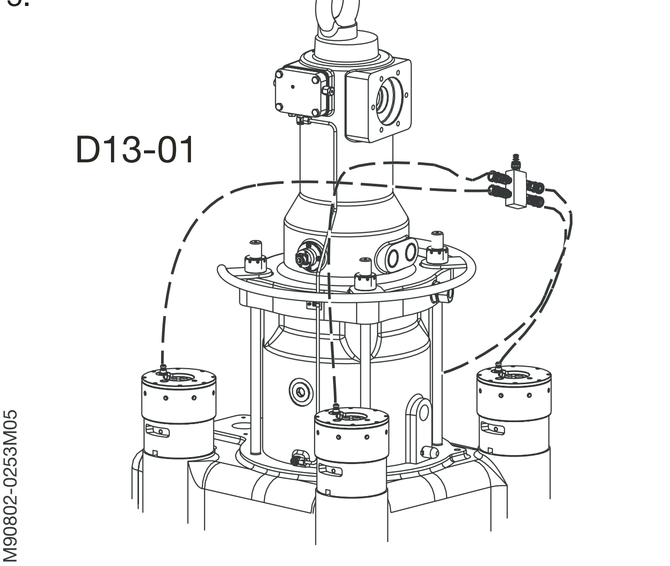

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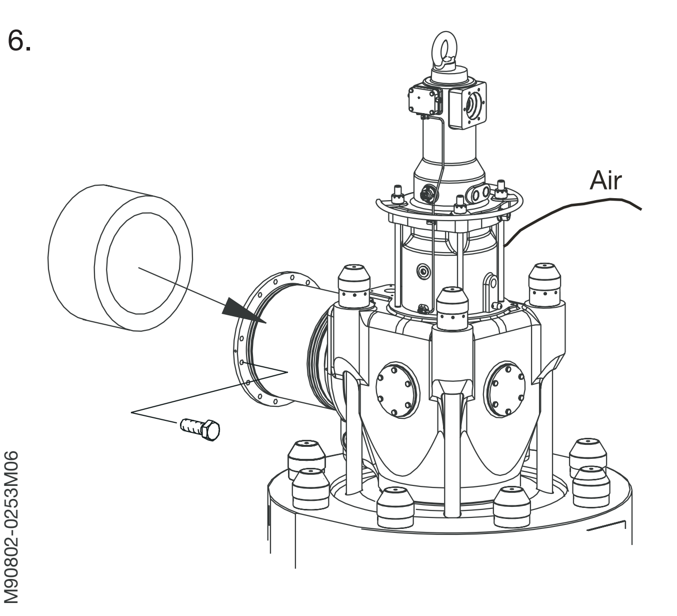

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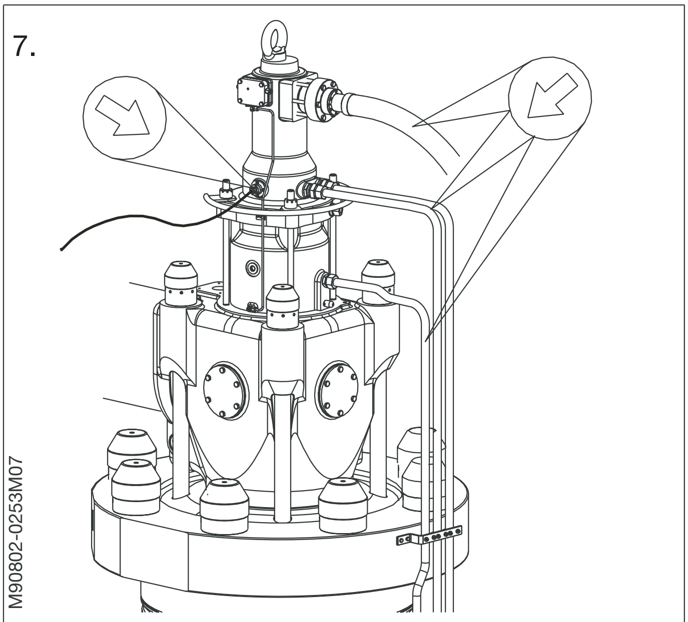

at the exhaust valve, mount and tighten the screws.

Attach the insulation jacket.

7. Mount the cooling water outlet pipe on the exhaust valve.

   Mount the high-pressure pipe and the return oil pipe, *see Procedure 908-1.4.*

   Mount the air pipe for the sealing air control unit.

   Connect the electrical plug for the position sensor.

   Disconnect the compressed air and connect the normal air supply.

   Open the lub. oil supply and the cooling water supply to the exhaust valve.

Caution!
The air supply to the exhaust valve must always be connected before turning on the oil supply to the exhaust valve actuator.

8. Check the tightness of the sealing ring between the bottom piece and the exhaust valve housing. *See Procedure 908-1.1.*

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

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D08-35	Hydraulic actuator	250	kg
D08-47	Top flange	56	kg
D08-48	Actuator piston	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
P91351	10	Hydraulic pump, pneumatically operated
P91351	34	Hose with unions (1000 mm), 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 pipes from the aft side of the top flange.

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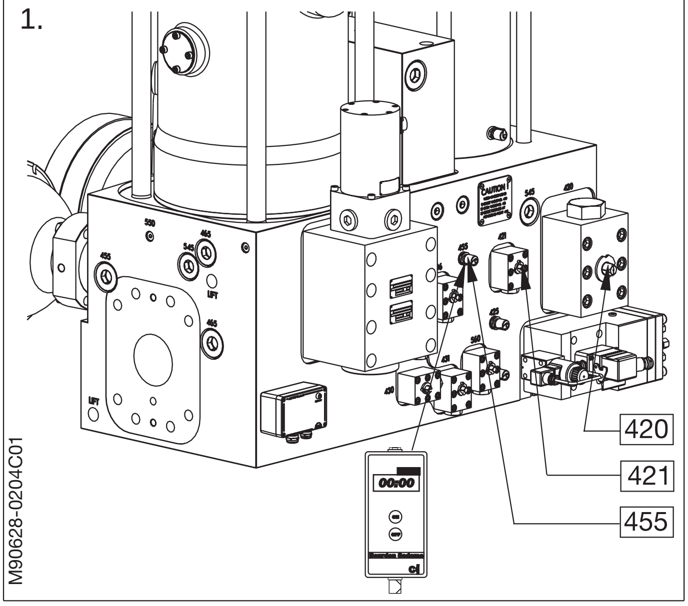

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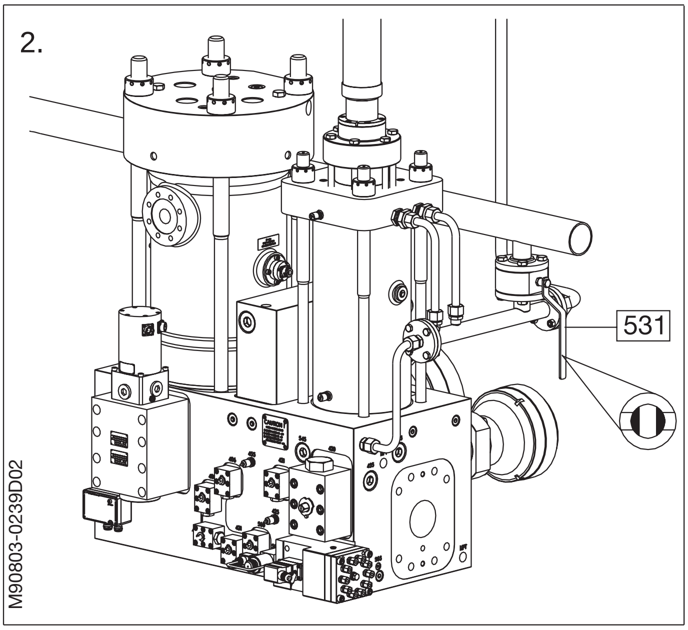

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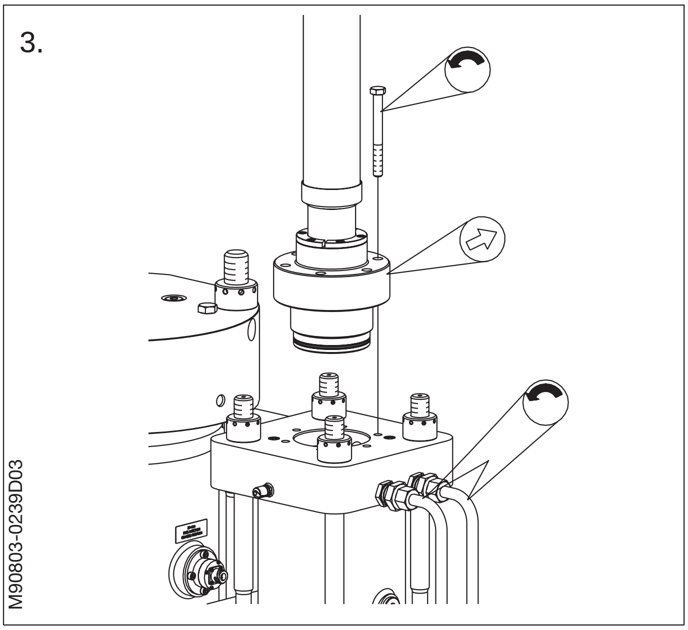
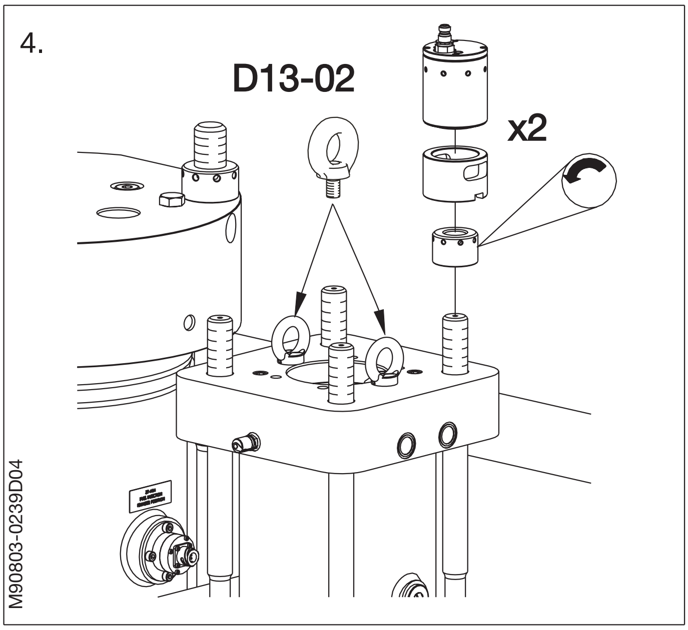
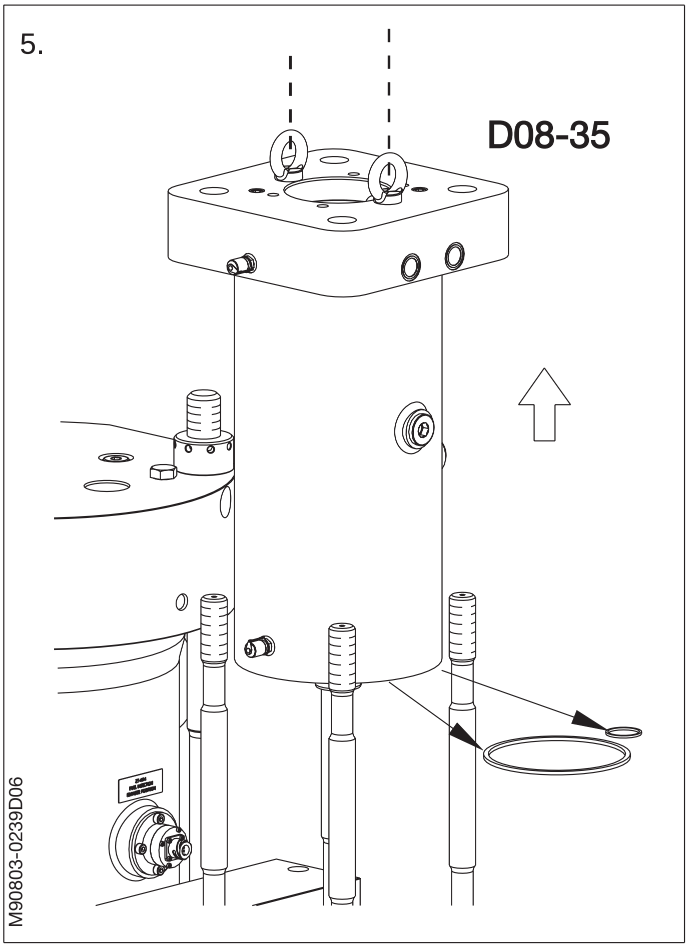






4. Loosen the nuts, two at a time, diagonally.

   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.

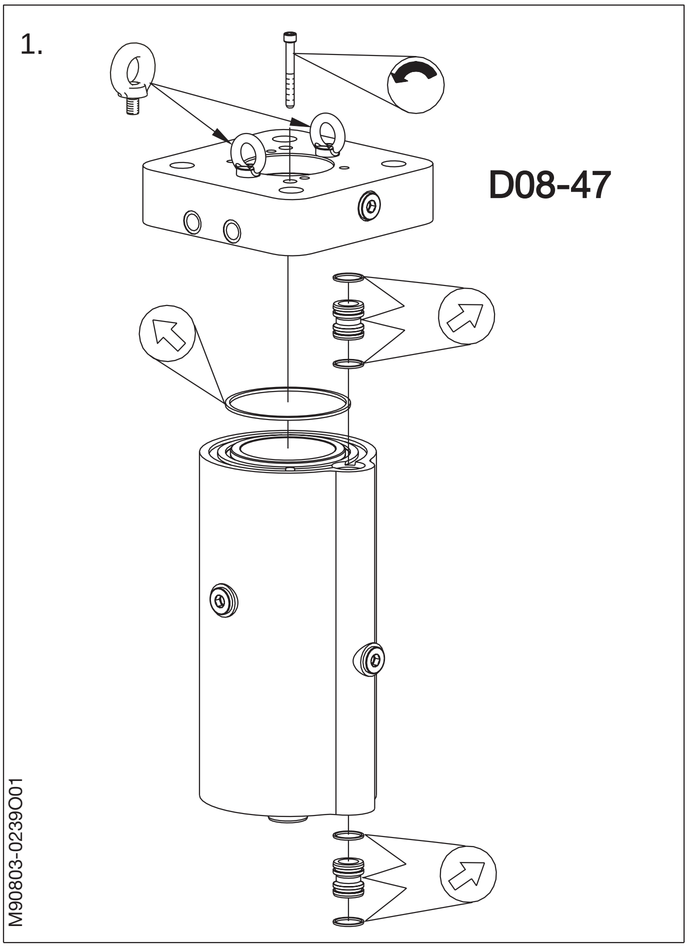
5. Lift the actuator unit clear of the actuator block.

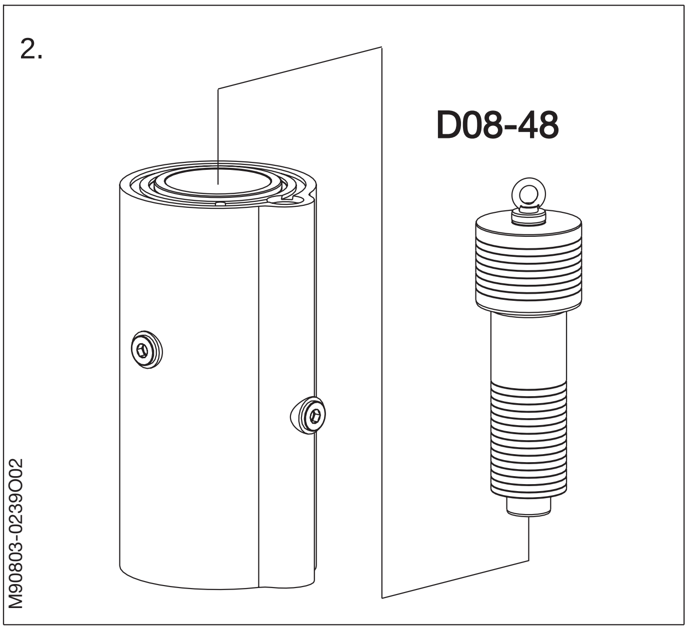
   Remove the sealing rings from the bottom and discard them.

1. Remove the two screws which retain the top flange to the cylinder unit.

   Mount two eye bolts in the top flange and lift away the top flange. Pull out the bushing for drain oil, discard the sealing rings.

2. Mount an eye bolt in the top of actuator piston. Lift out the piston.





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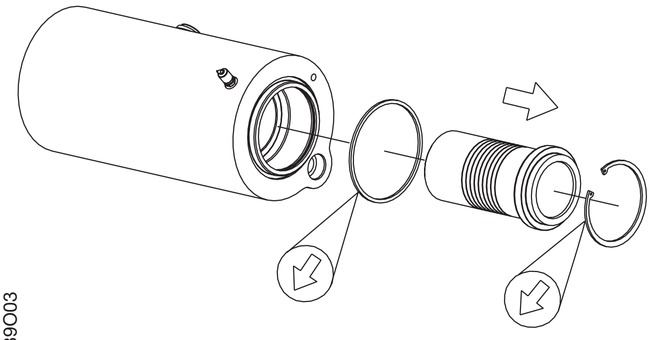

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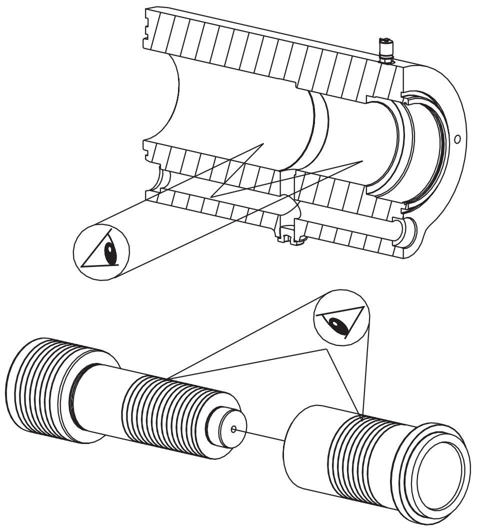

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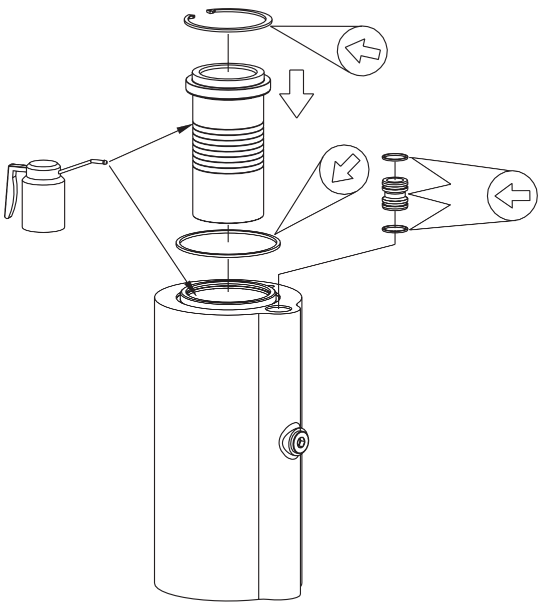

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3. Place the actuator on the side.

   Remove the retaining ring from the bottom flange of the oil cylinder.

   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 the retaining ring.

   Mount a new sealing ring.

   Mount the bushing for drain oil with new sealing rings.

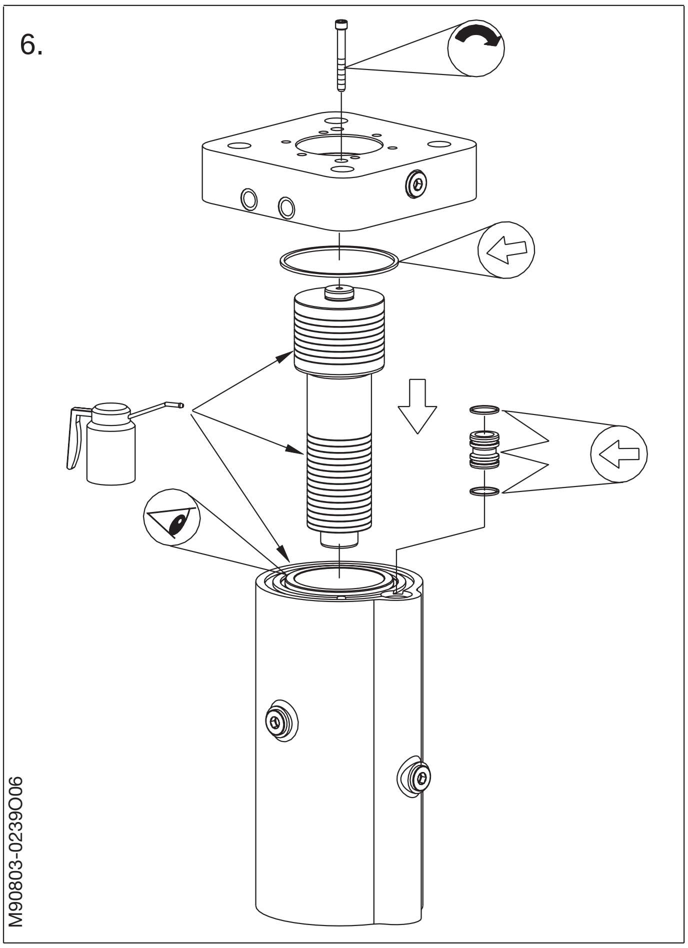
6. Lubricate the actuator piston on all sliding surfaces.

   Mount the piston from the top side of the cylinder.

   Mount a new sealing ring.

   Mount the bushing for drain oil with new sealing rings.

   Mount the top flange and tighten the screws.



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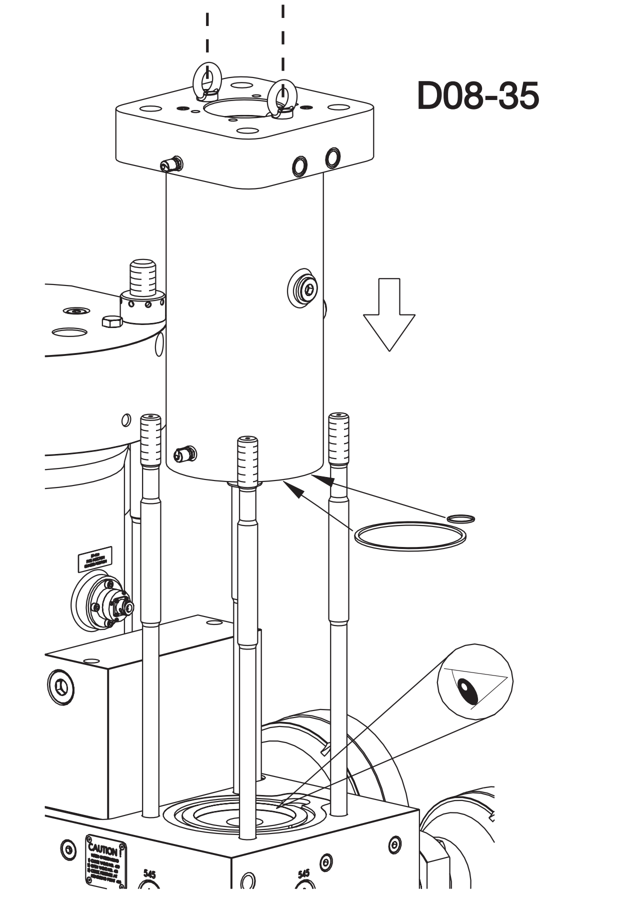

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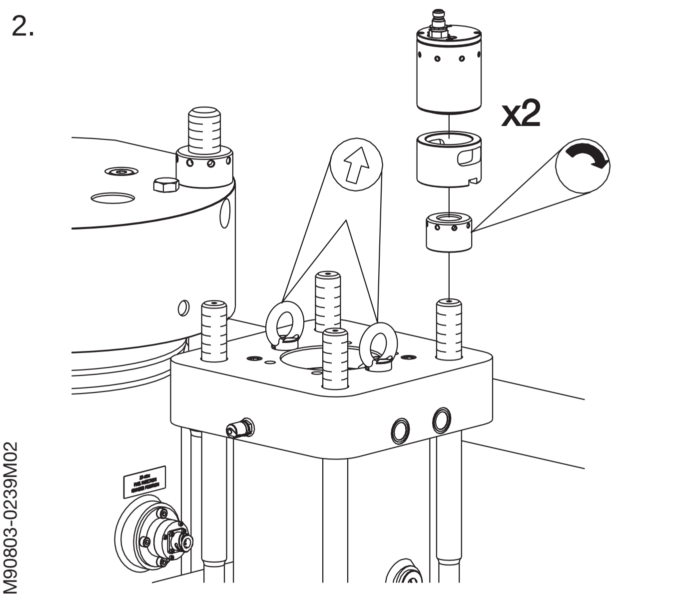


Note!
Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

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 eye bolts 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 eye bolts 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.

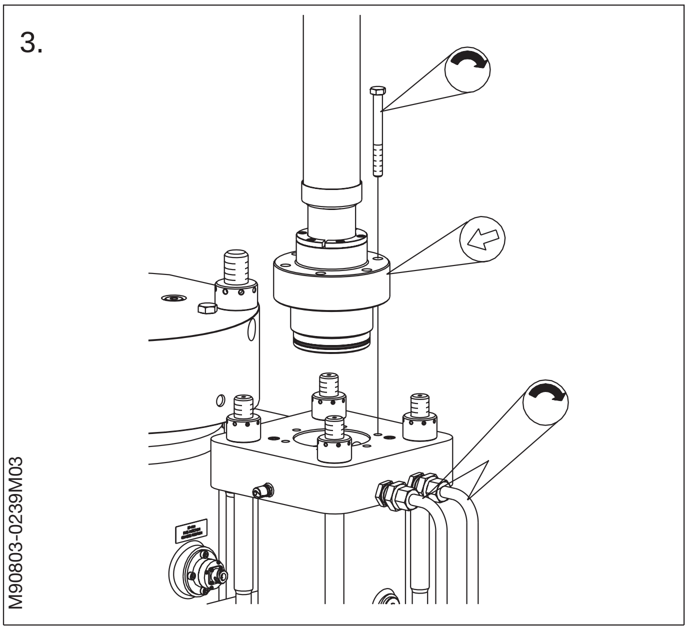
   For use of hydraulic tools, see also Procedure 913-1.

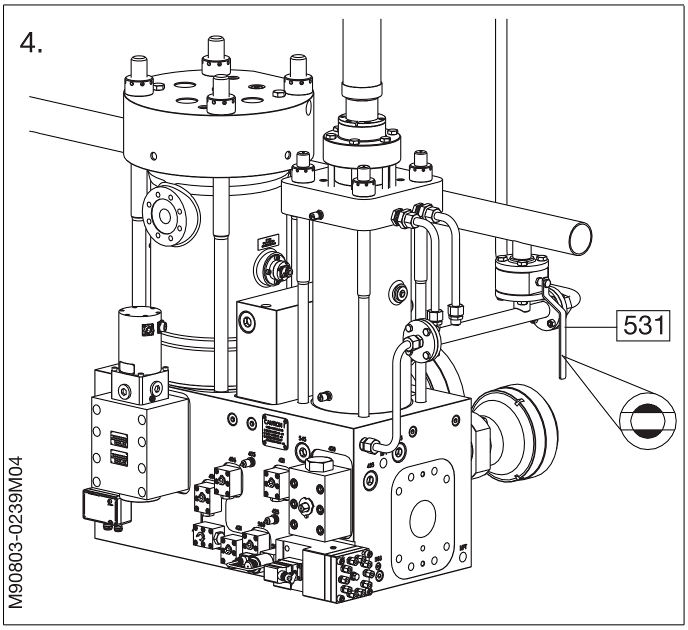
3. Mount and tighten the oil pipes for oil supply.

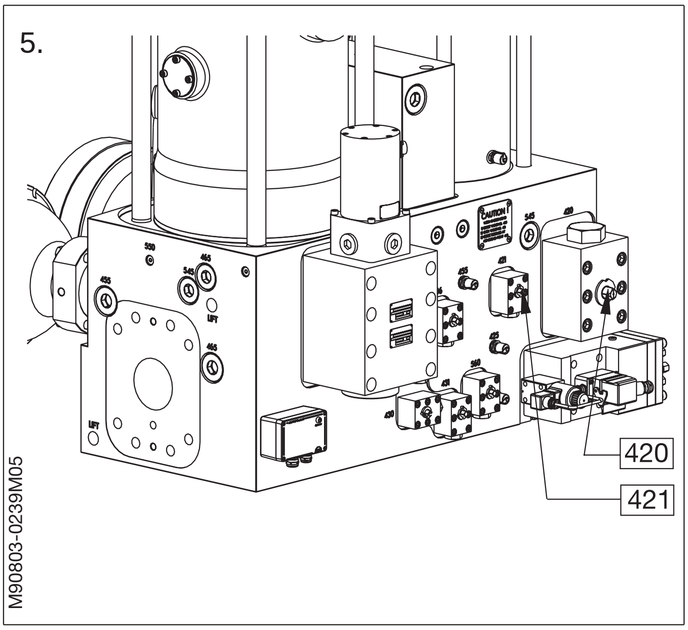
   Mount the hydraulic high pressure pipe, *see Procedure 908-1.4.*

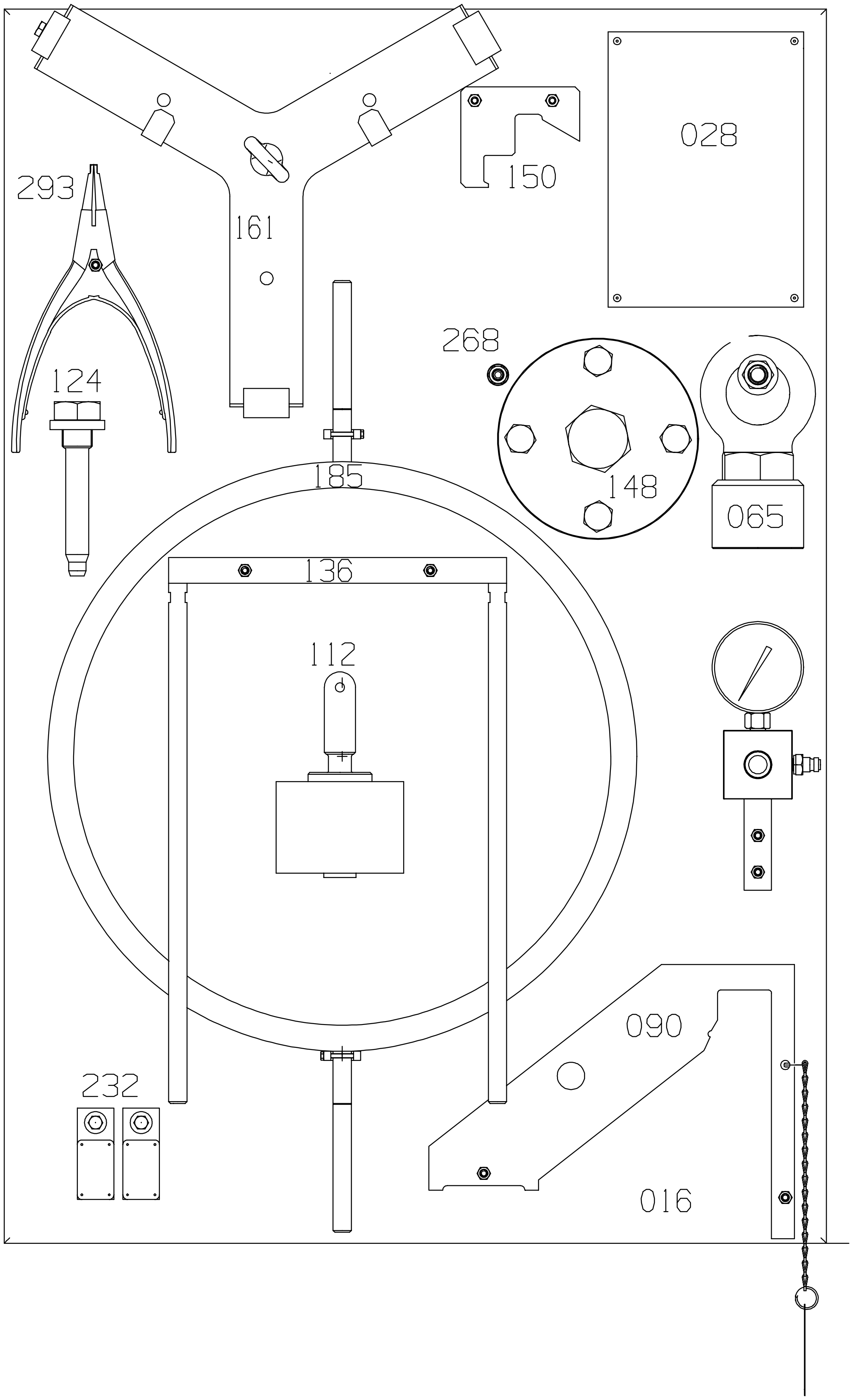
4. Open valve 531 for actuator oil supply.

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

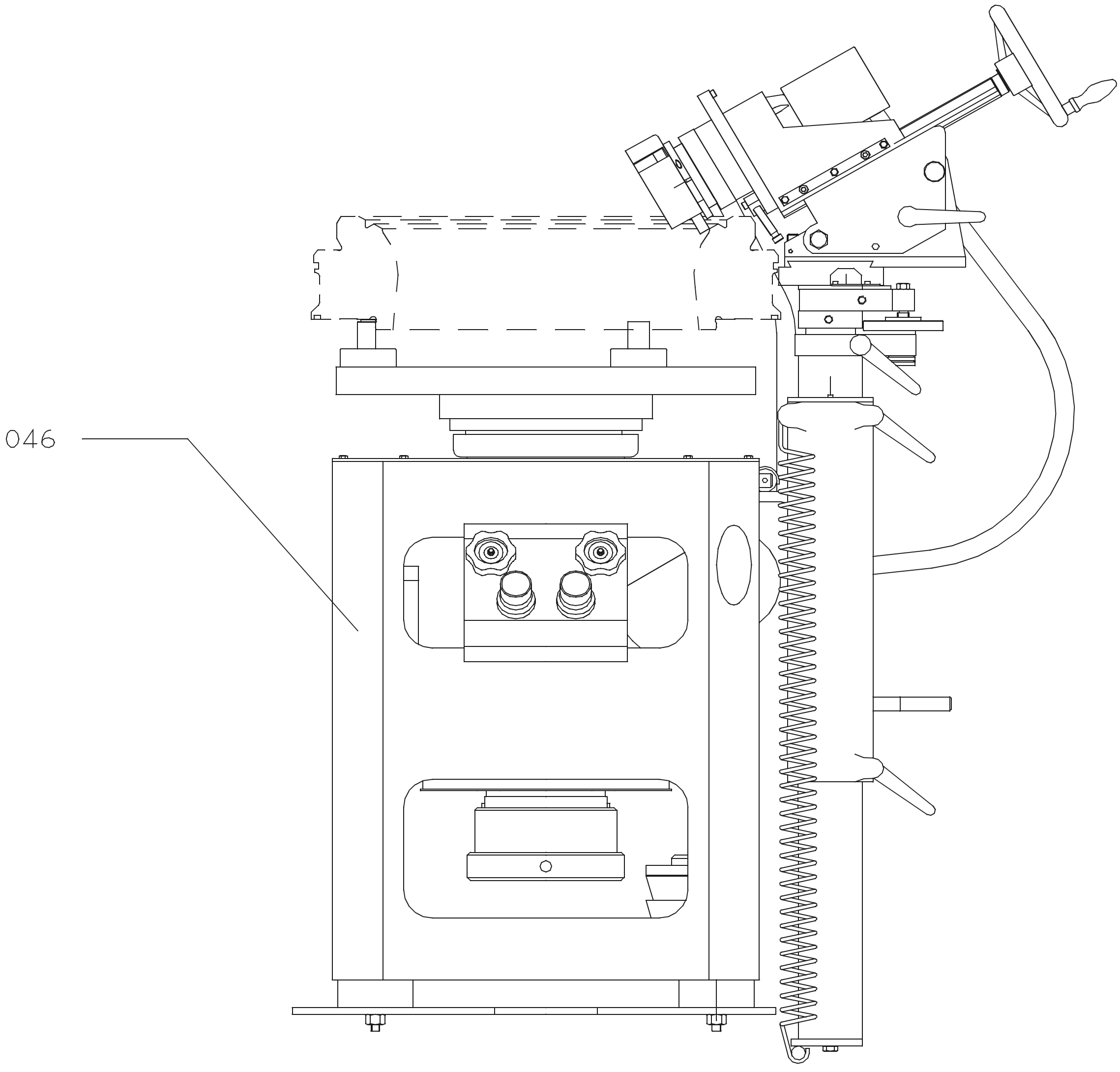







293
161
150
028
124
268
185
148
065
136
112
090
232
016

Item No.	Item Description	Item No.	Item Description
016	Panel for tools		
028	Name plate		
065	Lifting tool for exhaust valve		
089	Test equipment for exhaust valve		
090	Gauge for exhaust valve spindle		
112	Grinding mandrel, high-pressure pipe		
124	Tool, 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		
232	Retaining tool		
268	Coupling for exhaust valve spring air		
281	Cone for sealing ring		
293	Pliers for retaining ring		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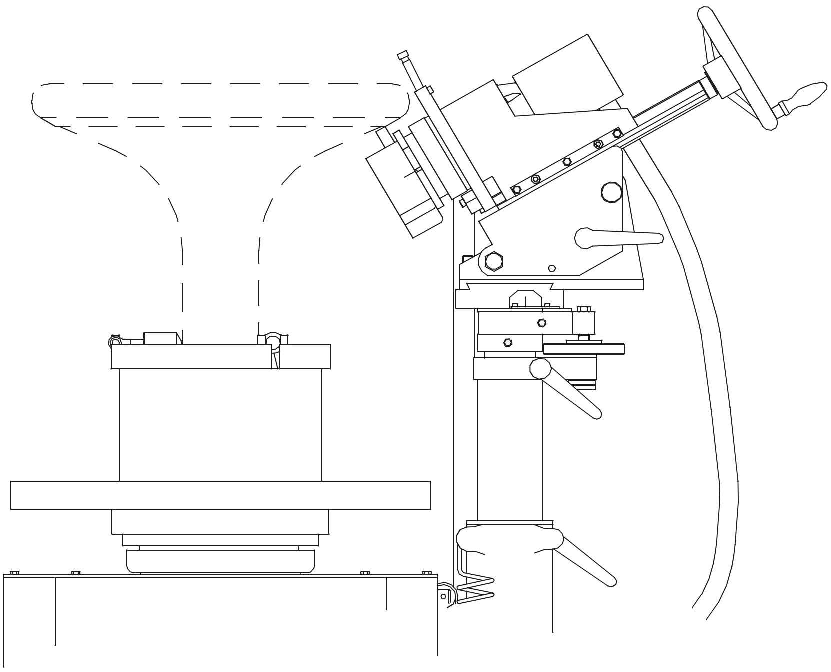
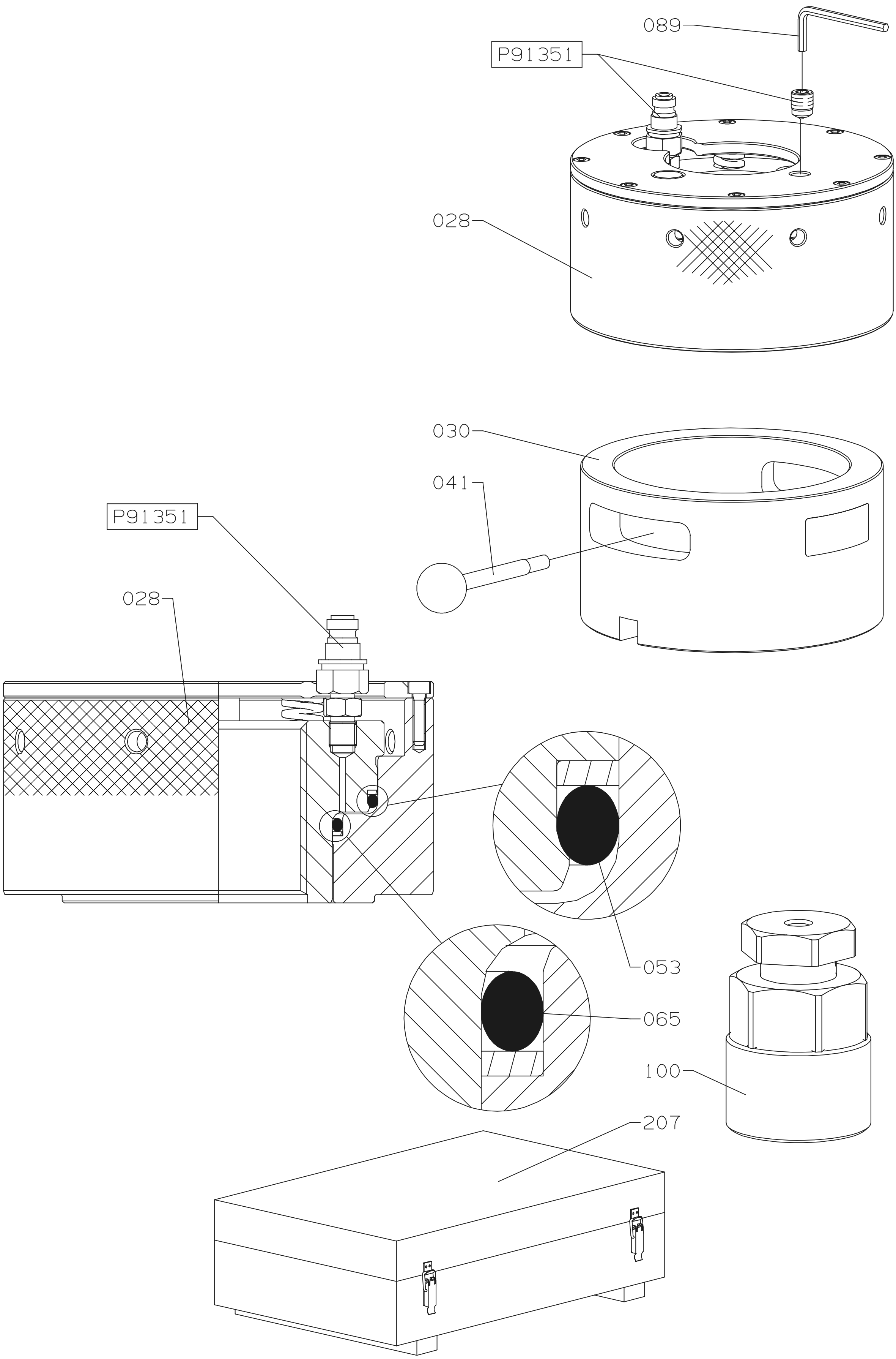


Exhaust Valve - Tools

Item No.	Item Description
046	Grinding machine, complete

Item No.	Item Description

Notes: When ordering spare parts, please refer to the Chris Marine manual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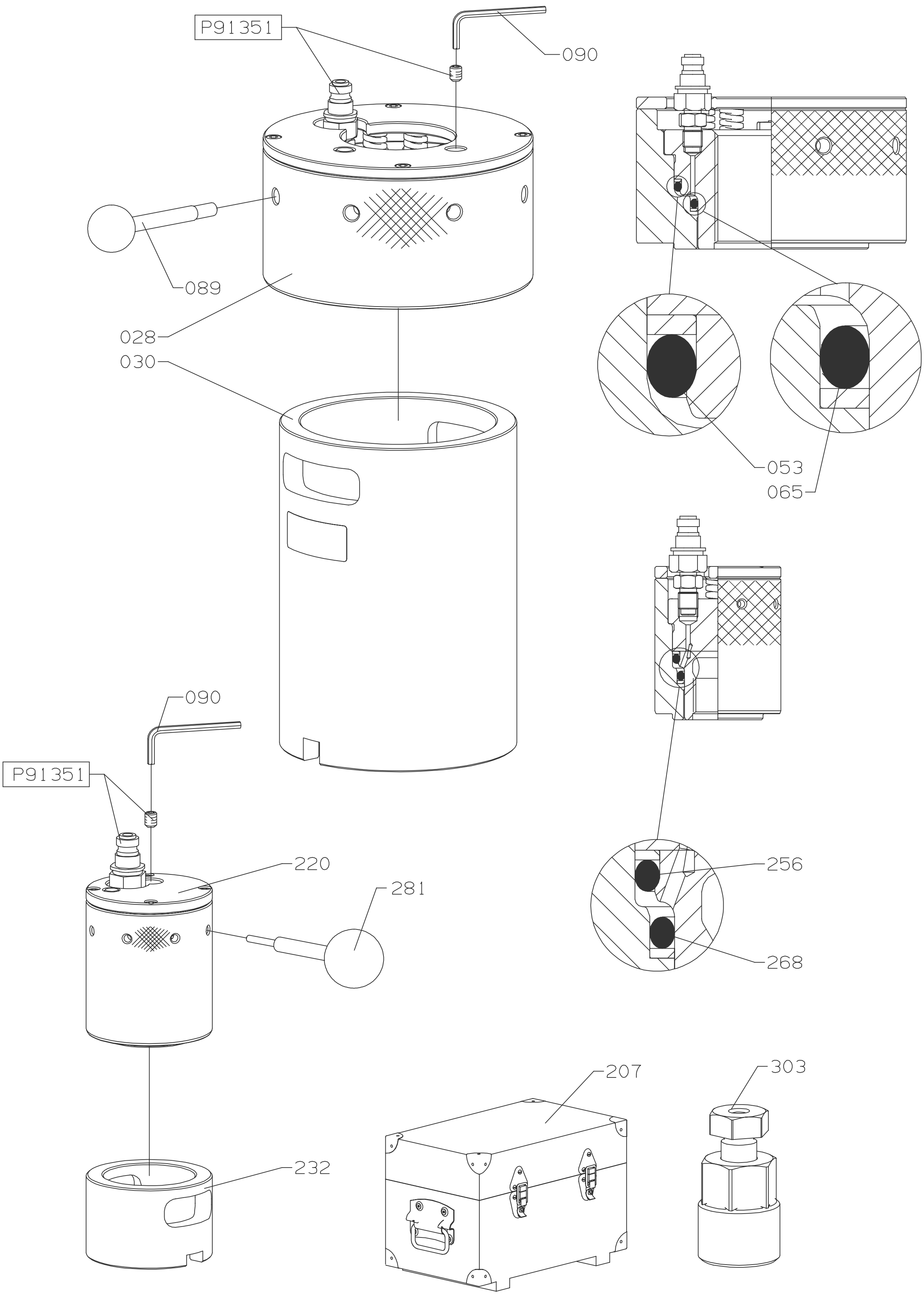
030
041
P91351
028
053
065
100
207

Exhaust Valve - Hydraulic Tools

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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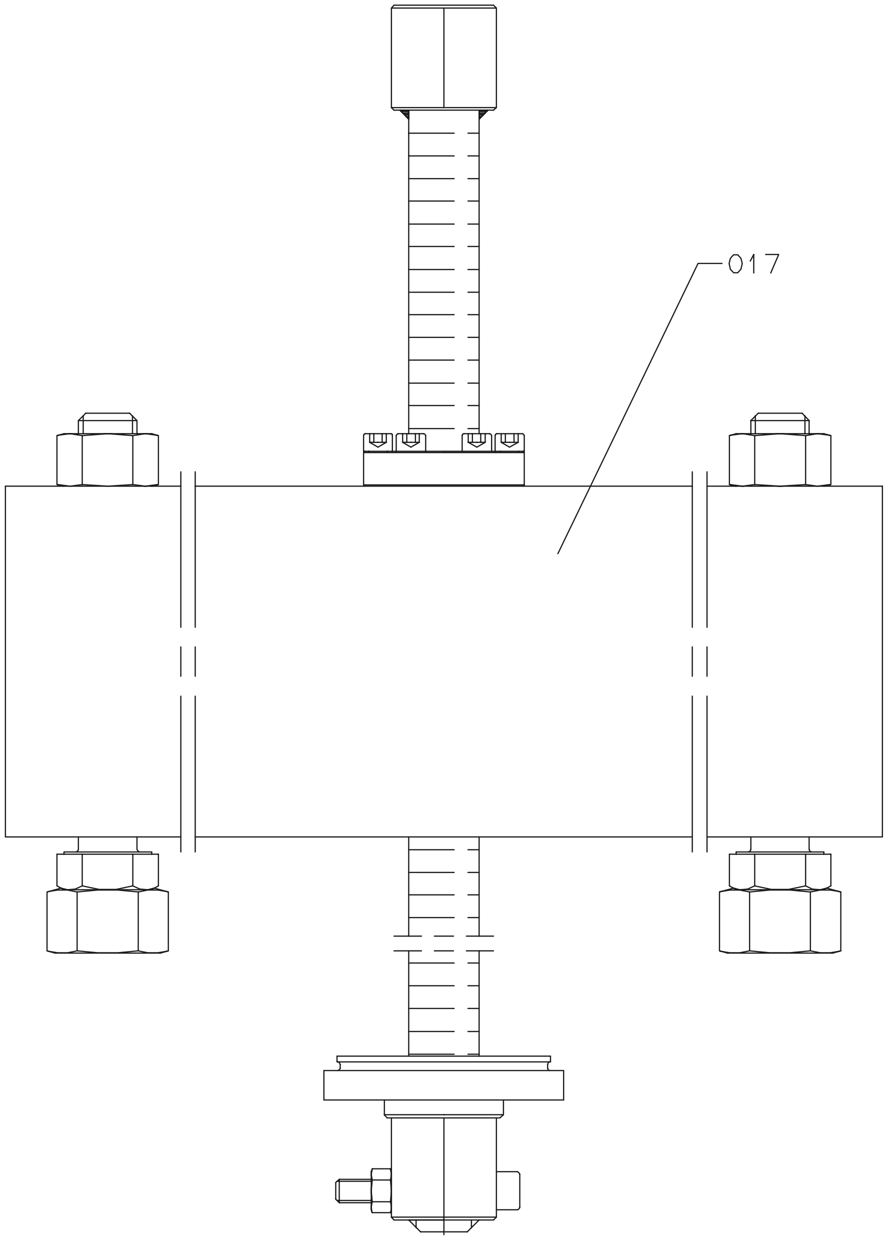
090
089
028
030
053
065
090
P91351
220
281
256
268
207
303
232

Item No.	Item Description	Item No.	Item Description
028	Hydraulic jack, complete		
030	Support		
053	O-ring with back-up ring		
065	O-ring with back-up ring		
089	Tommy bar		
090	Spanner		
207	Hydraulic toolset, complete		
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		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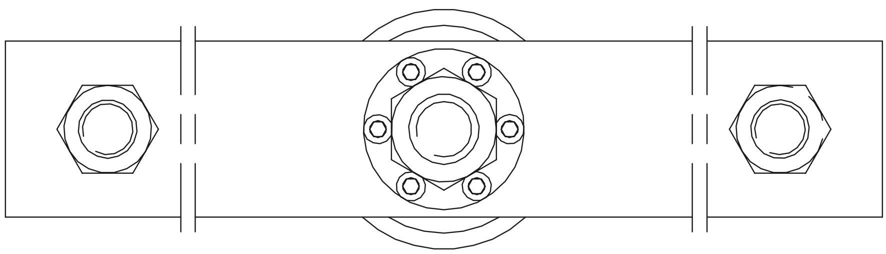

Exhaust Valve - Extractor Tool

Item No.	Item Description
017	Extractor tool, complete

Item No.	Item Description

909 - Fuel Oil System

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubricating oil pumps*
	Engage turning gear
	Shut off cooling water
X	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	25	mm
D09-43	Fuel valve	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
P90151	71	Dismantling tool for fuel valve
P90951	94	Milling tool for fuel oil pipe seats
P90951	165	Grinding mandrel for valve head
P90951	189	Grinding mandrel for holder - outside
P90951	190	Grinding mandrel for holder - inside
P90951	297	Assembling tool for fuel valve
P90961	14	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.

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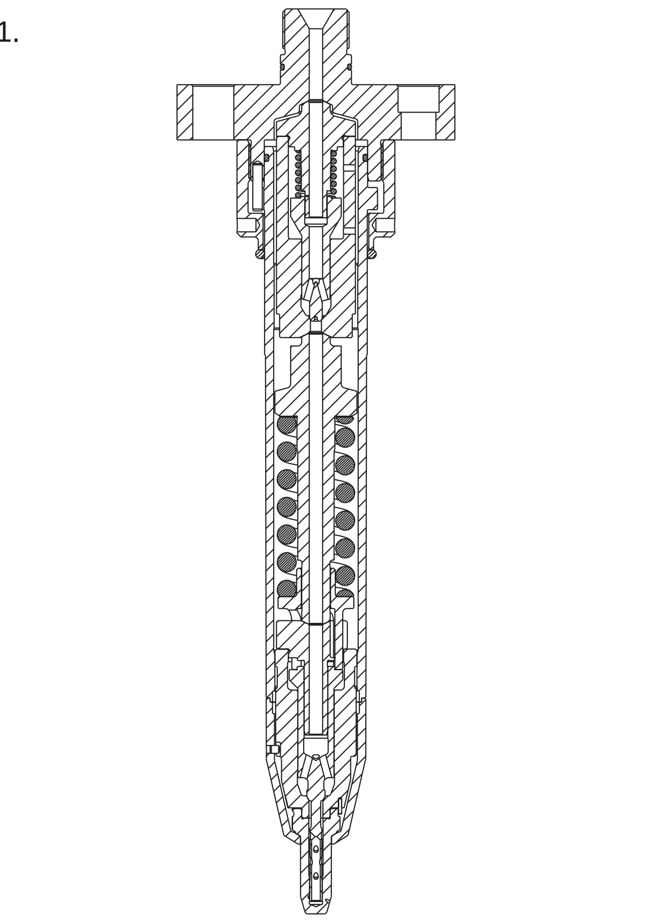

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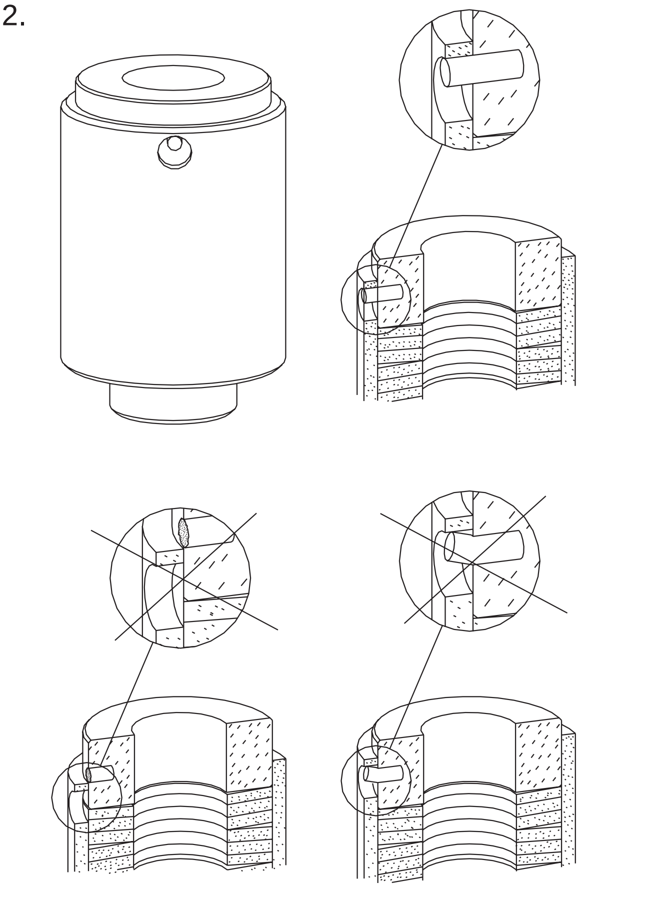

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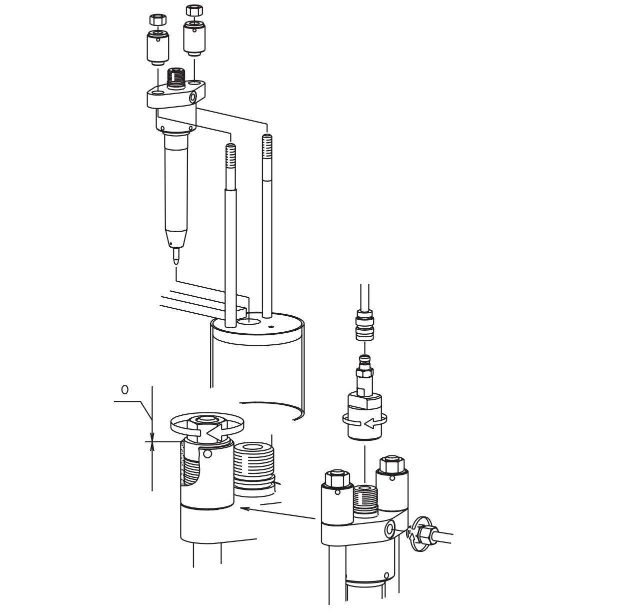

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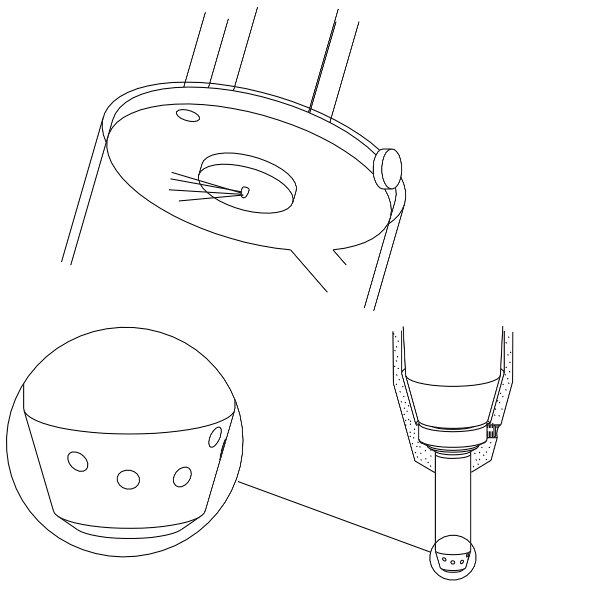

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3. Setting-up the fuel valve

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 valvs, as this may damage the cut-off slide and nozzle.

Cause of fault:

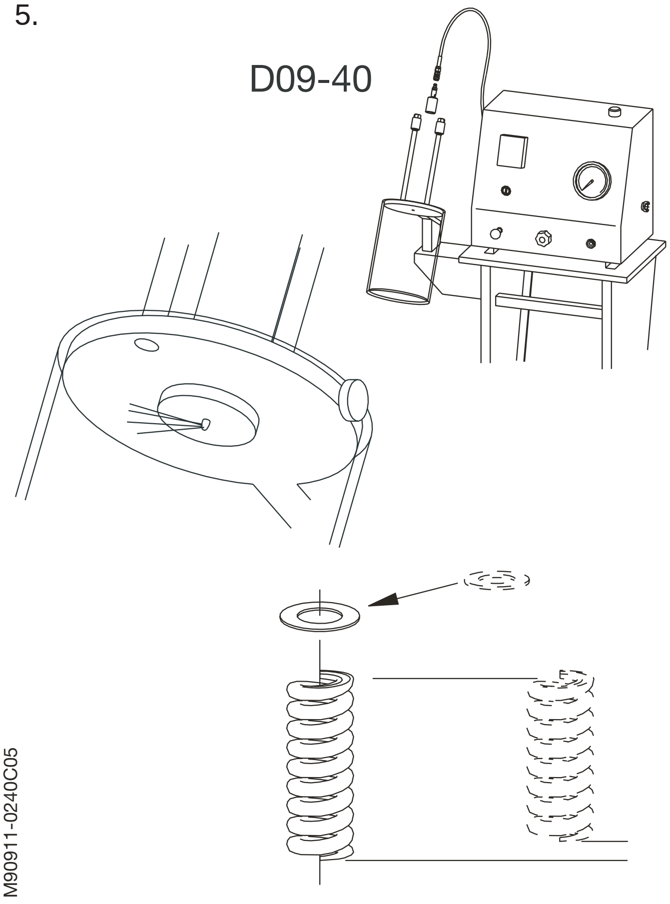
If the opening pressure is higher than specified in D09-40, the cause may be that a wrong type of spring is used - replace the spring on the thrust spindle, if necessary, replace the complete thrust spindle.

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.

5.



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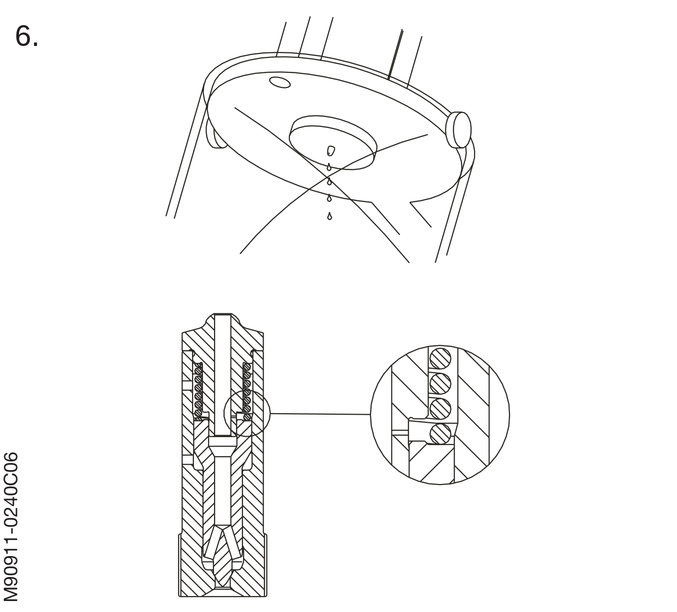


6. Sealing test and sliding function

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.

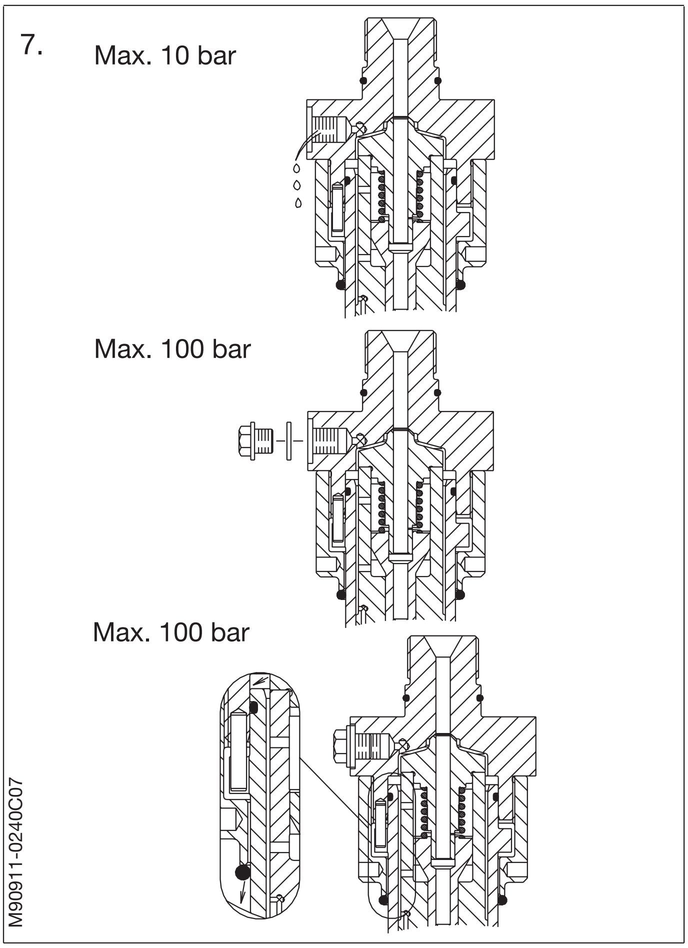
Increase the working pressure to about 100 bar.

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.

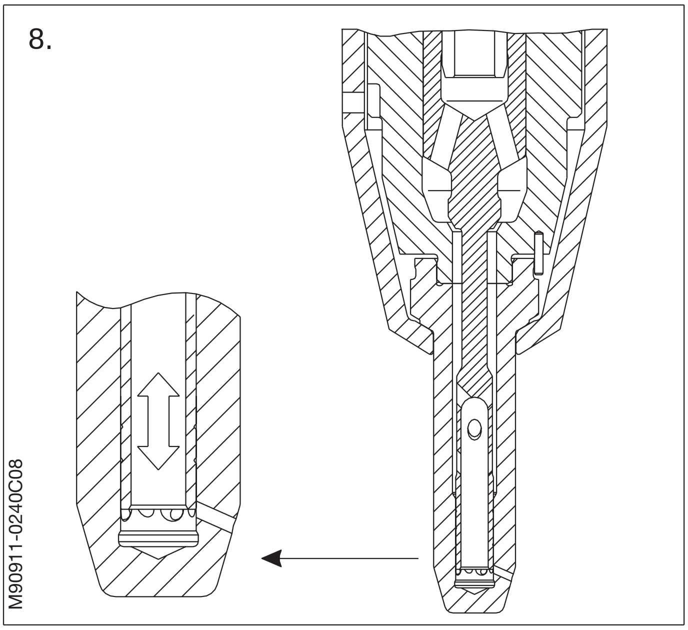


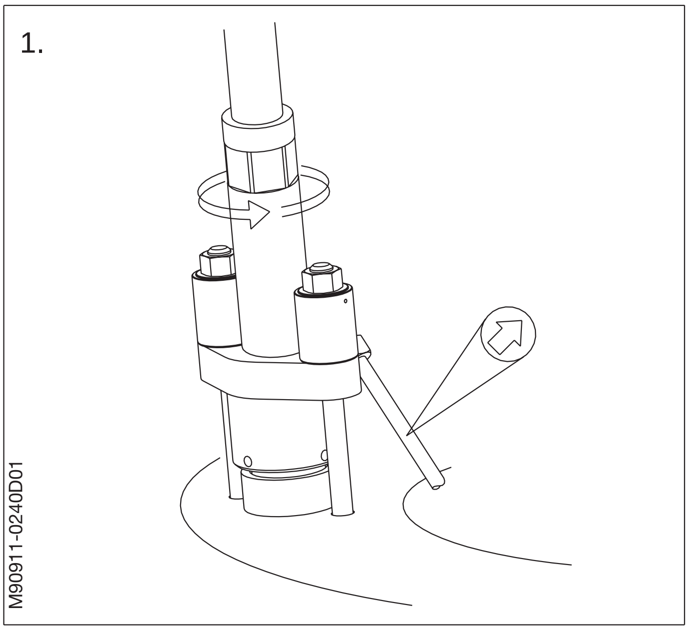
8. Atomization test

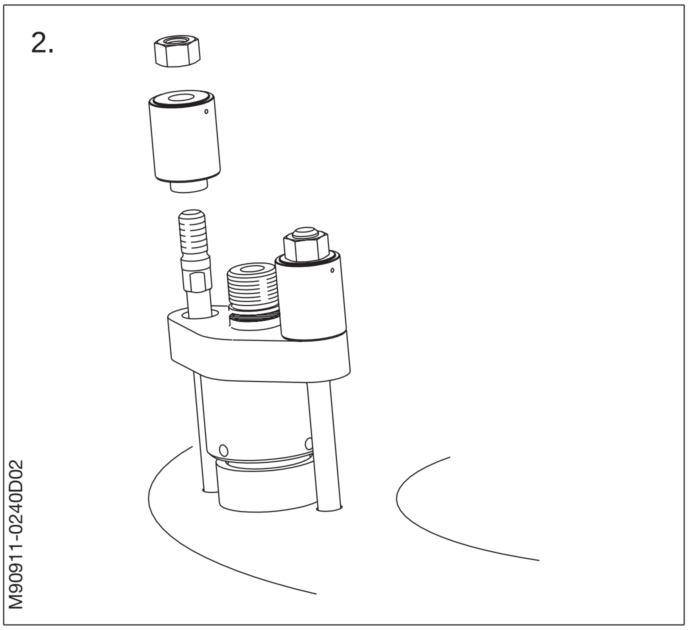
Note!
Do **NOT** attempt to carry out an atomization test on slide type fuel valves, as this may damage the cut-off slide and nozzle.

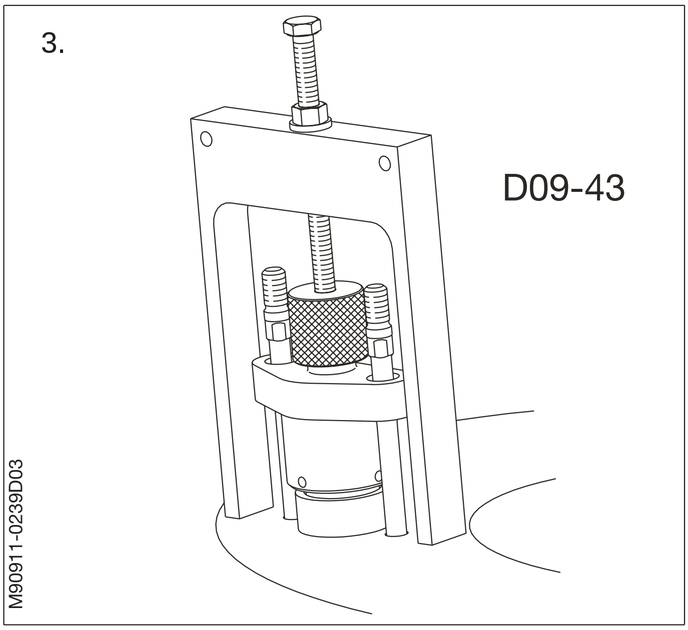
The atomization test may damage the valve because it makes the needle oscillate, with a small lift at a very high frequency. The high pressure drop across the cut-off edge and the high contact pressure between slide and fuel nozzle, in combination with the poor lubricity of the test oil, increase the 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.

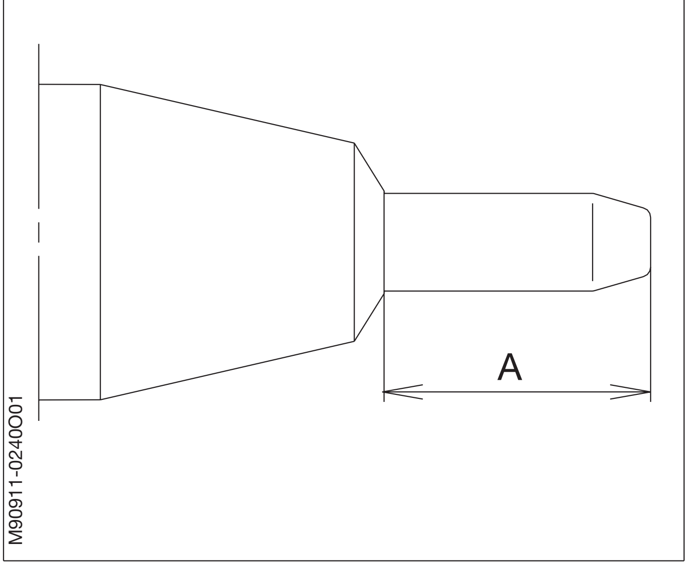
1. Measure the length A of the protruding part of the nozzle, and write down the result for correct re-assembling of the valve.

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.

1.



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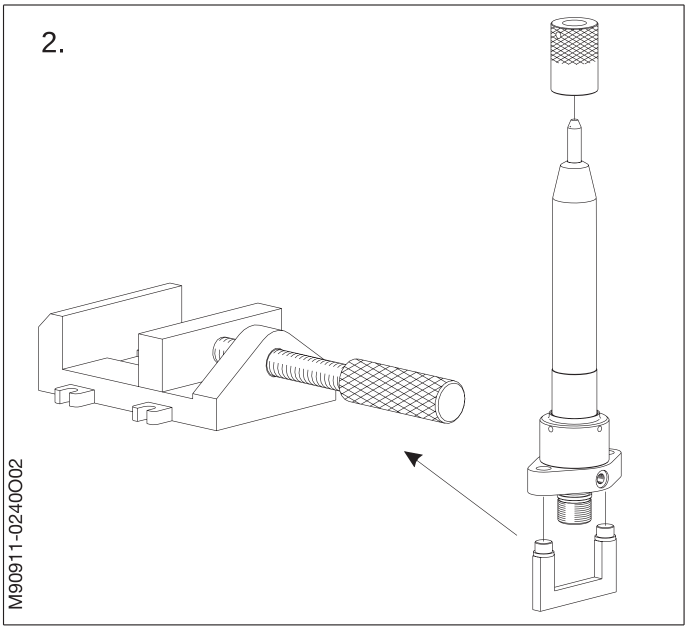

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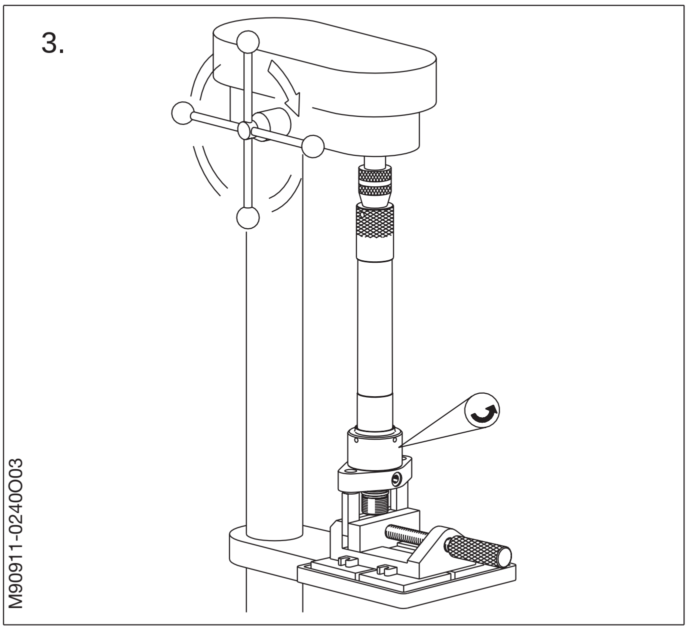
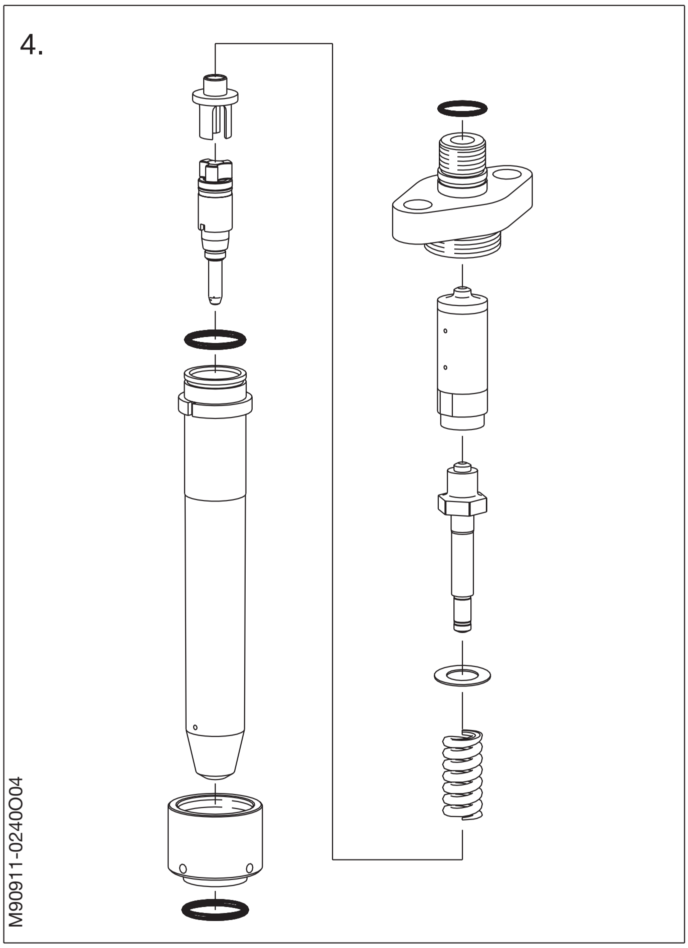




Pull the valve head clear of the valve housing.

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.

4. 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).

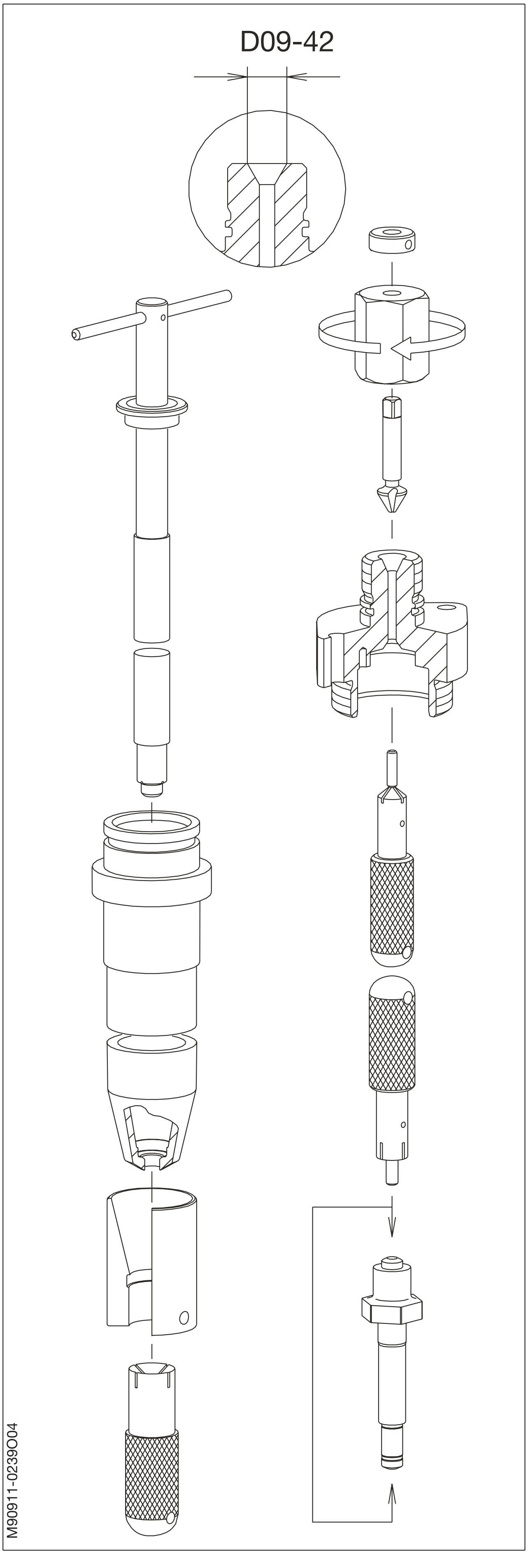
This grinding must only be carried out manually.

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.*



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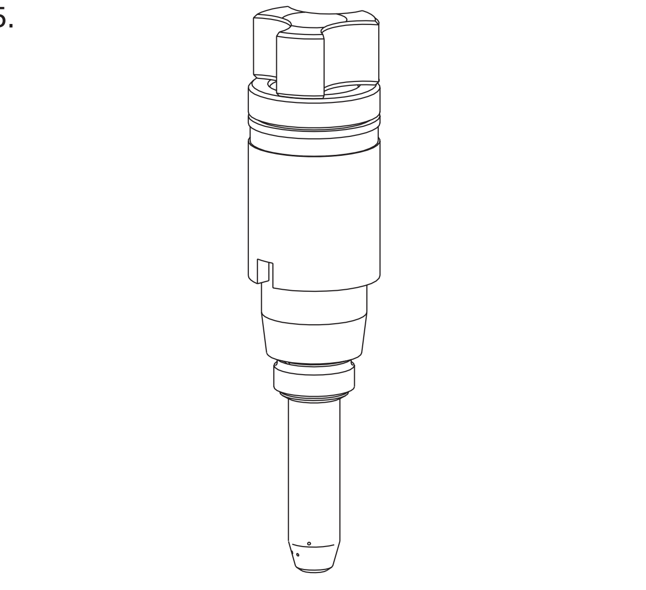

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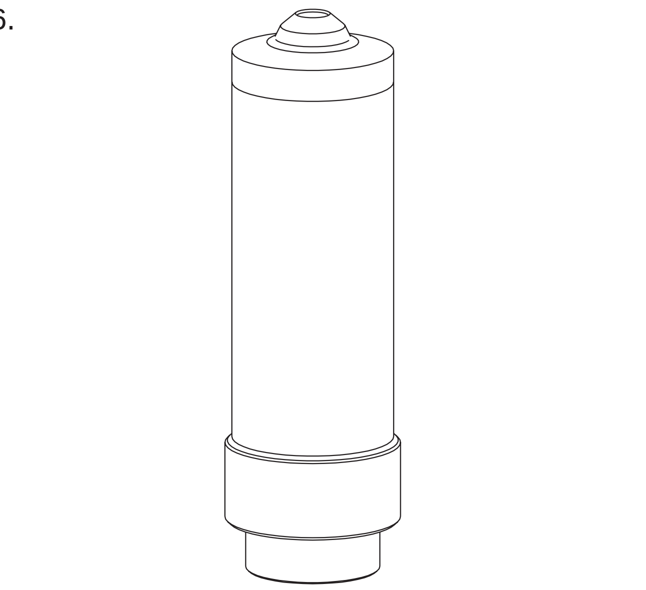

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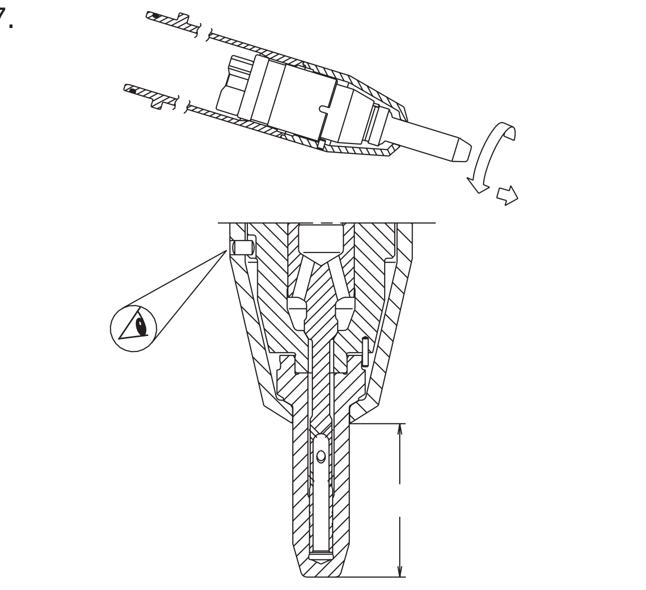


5. The complete spindle guide, including the fuel nozzle, should be sent to an authorised MAN B&W repair shop for overhaul. If this is not possible, the spindle guide may be overhauled on board. *See Procedure 909-12.3.*

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.

6. 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.

7. 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.

8. 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 (MoS2).

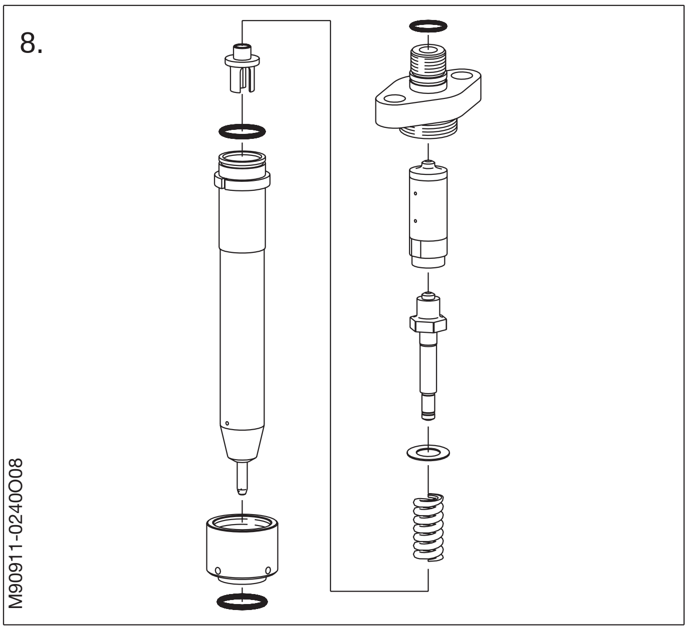
   For the correct use of this lubricant, *see Procedure 913-11.*

   Fit the valve head with new O-rings.

9. 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.

8.



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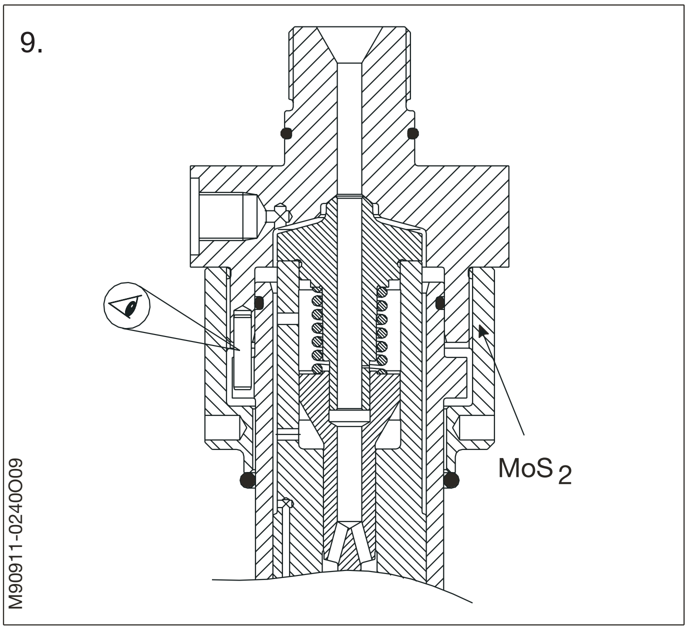

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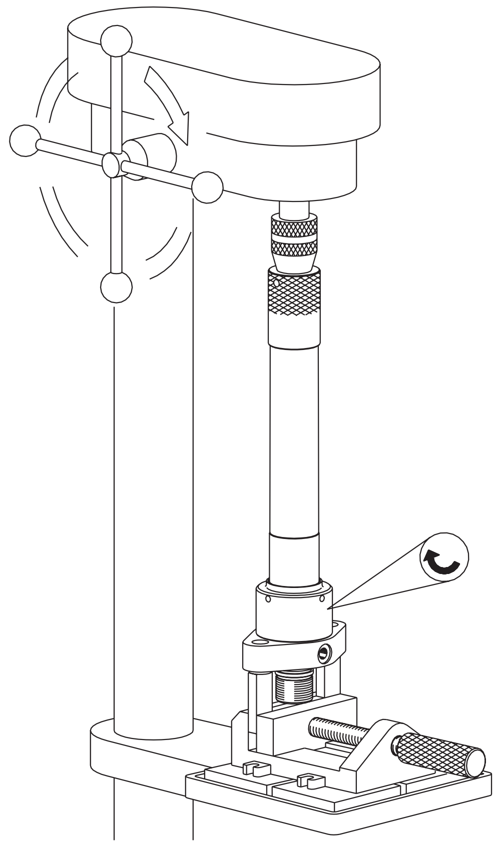


10. Assemble the valve by means of the union nut.

    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.

11. 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 (MoS2).

2. Mount the valve in position in the cylinder cover.

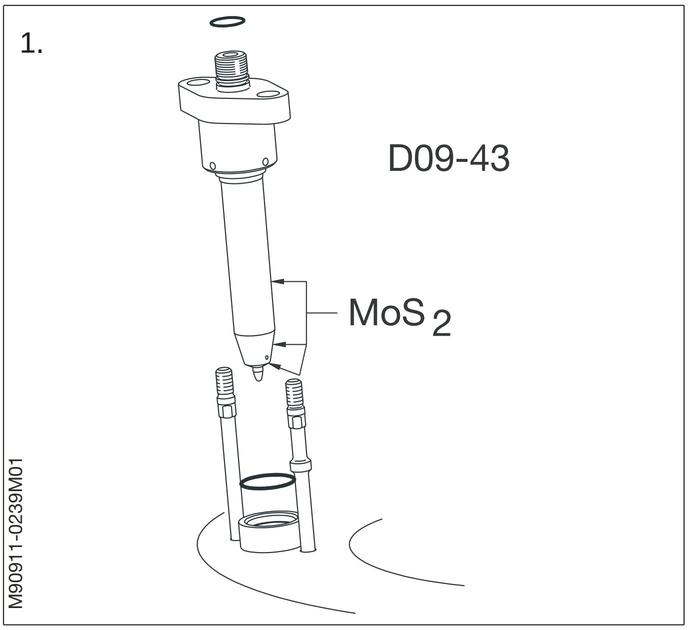
   Mount the spring housings and the nuts. Tighten the nuts until the top face of the pressure disc is flush with the top face of the spring housing. This must be done with great care, as the spring tension in the housing determines the correct tightening of the fuel valve to the cylinder cover as well as the correct compression of the fuel valve.

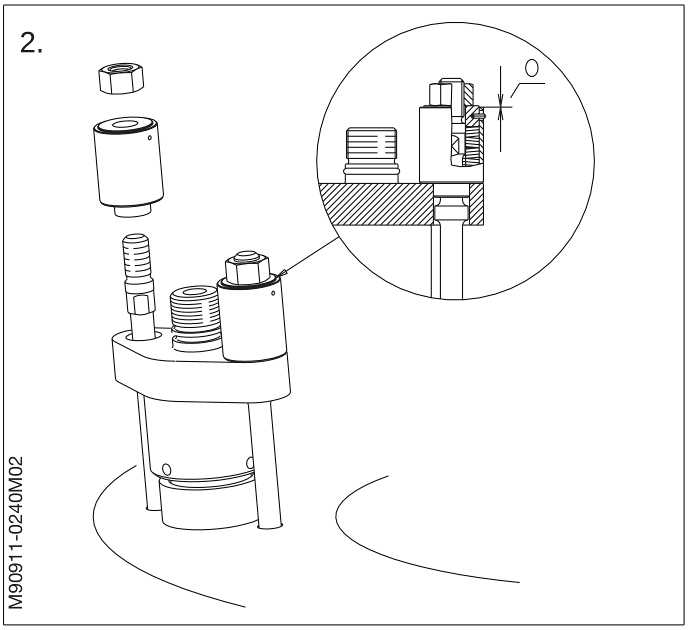
3. Lubricate the thread on the union nipple of the fuel oil pipe with a heat resistant anti seize grease before mounting.

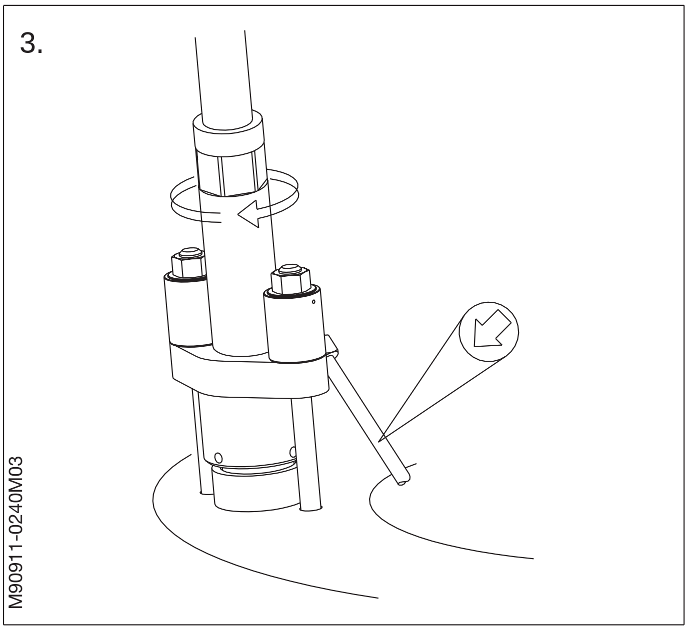
Note!
It is recommended to overhaul the fuel oil high-pressure pipe before mounting. *See Procedure 909-14.3.* As a minimum, the distance between the fuel oil pipe ends and the thrust bushings **must** be checked and, if necessary, adjusted.

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	Nozzle spray hole cleaning tool table		

Nozzle spray hole	Cleaning drill	Test pin
1.40	1.35	1.44
1.45	1.40	1.49
1.50	1.45	1.54
1.55	1.50	1.59
1.60	1.55	1.65
1.65	1.60	1.70
1.70	1.65	1.74
1.75	1.70	1.80
1.80	1.75	1.85
1.85	1.80	1.89
1.90	1.85	1.94
1.95	1.90	1.99
2.00	1.95	2.05

Ref.	Description	Value	Unit
D09-71	Nozzle spray hole diameter	1.65	mm
D09-72	Nozzle spray hole diameter	1.65	mm
D09-73	Nozzle spray hole diameter	1.8	mm
D09-74	Nozzle spray hole diameter	1.8	mm
D09-75	Nozzle spray hole diameter	1.5	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
P90966		Fuel Valve Nozzle - Tools
P90968		Probe light with magnifier, complete
P90974		Fuel Valve Nozzle - Cleaning 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 replaced 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.

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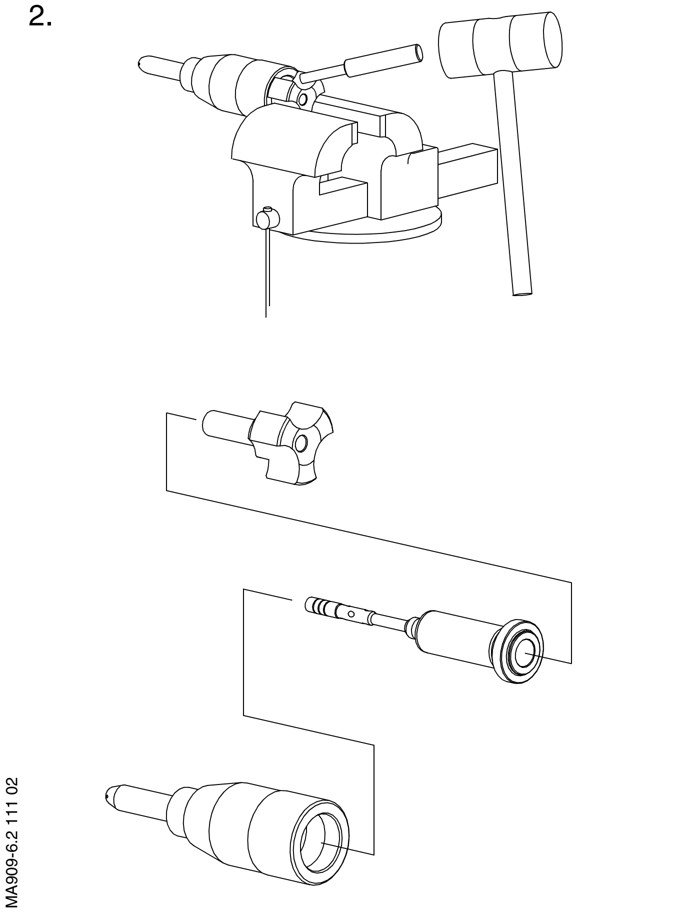

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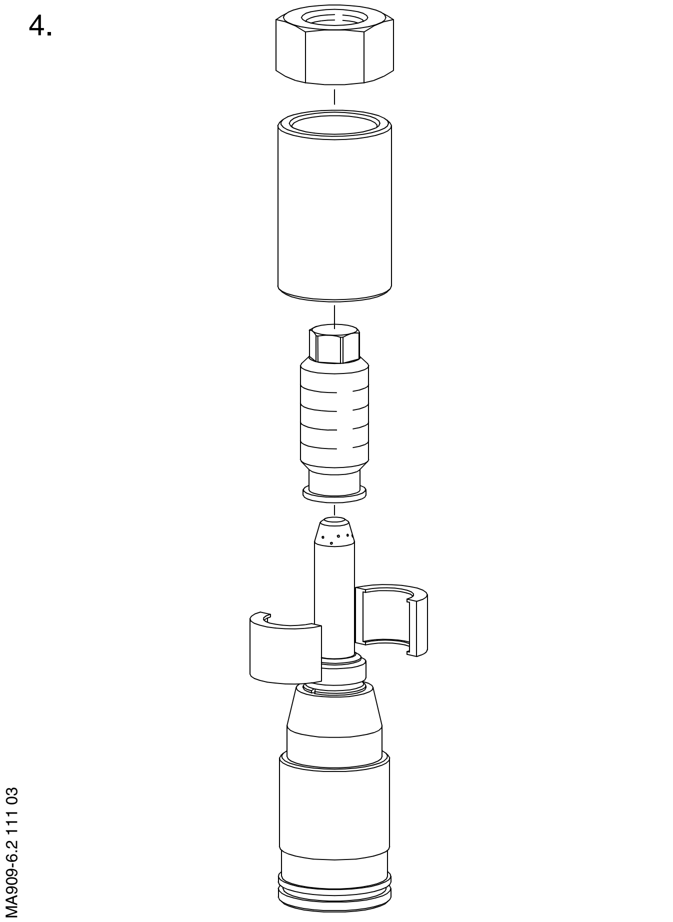

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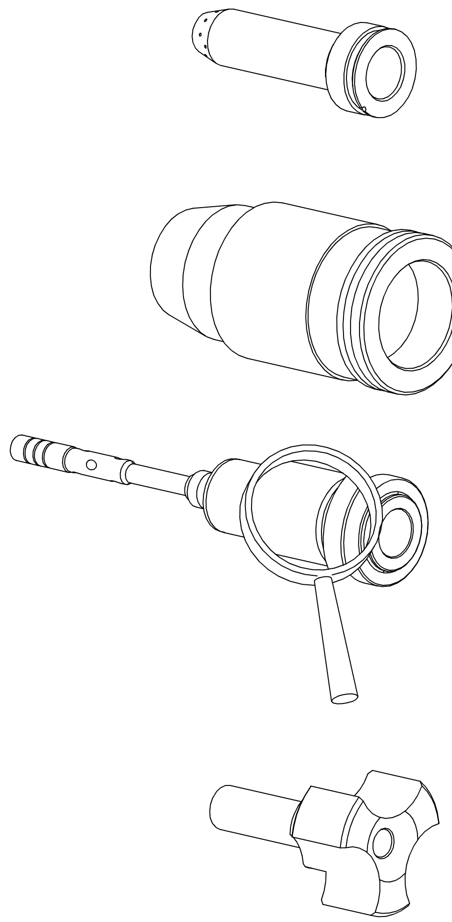

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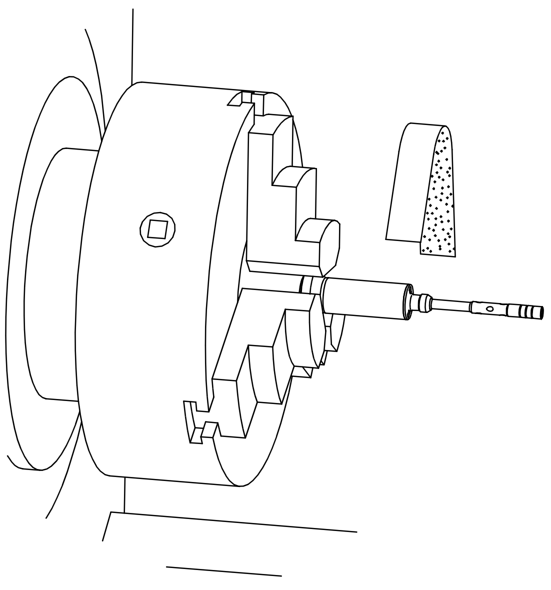

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5. Clean all the parts of the spindle guide in gas oil and wipe dry with a clean piece of cloth.

   Clean all parts again in gas oil or ‘Electro-cleaner’ 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. *See Data* for nominal spray hole size, and compare with the sketch for correct hole position. Find correct drill size and matching test pin in the table, *D09-70, on the data sheet*, via the nominal hole size.

9. 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.

Note!
It is recommended that the fuel nozzle is changed whenever the spindle guide is being overhauled or at maximum 8000 running hours.

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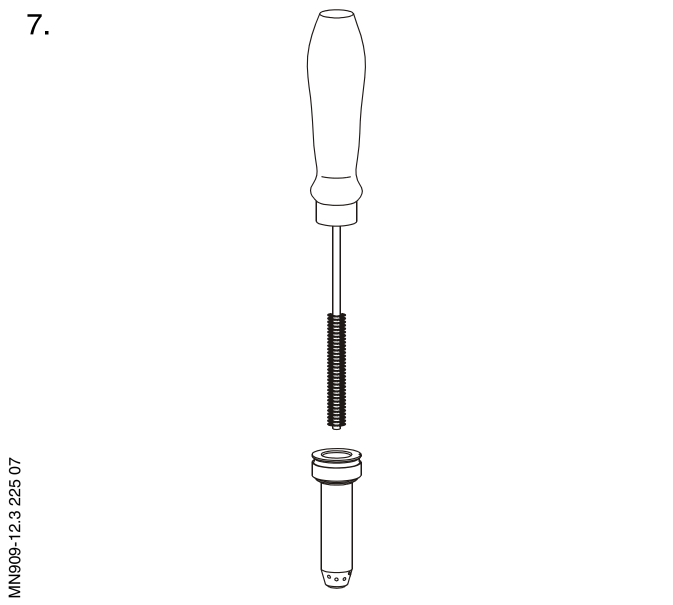

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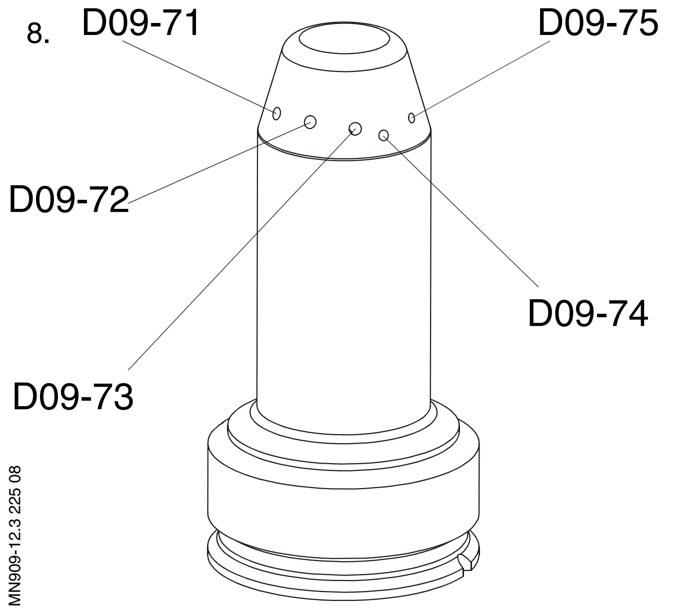

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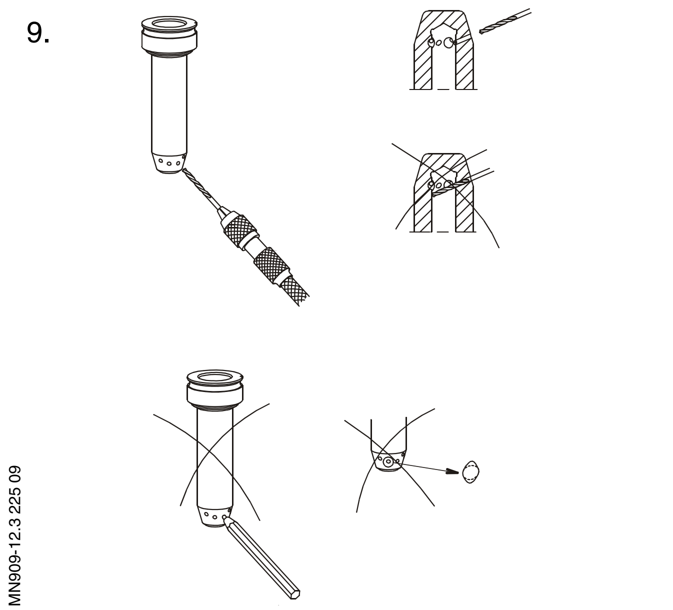

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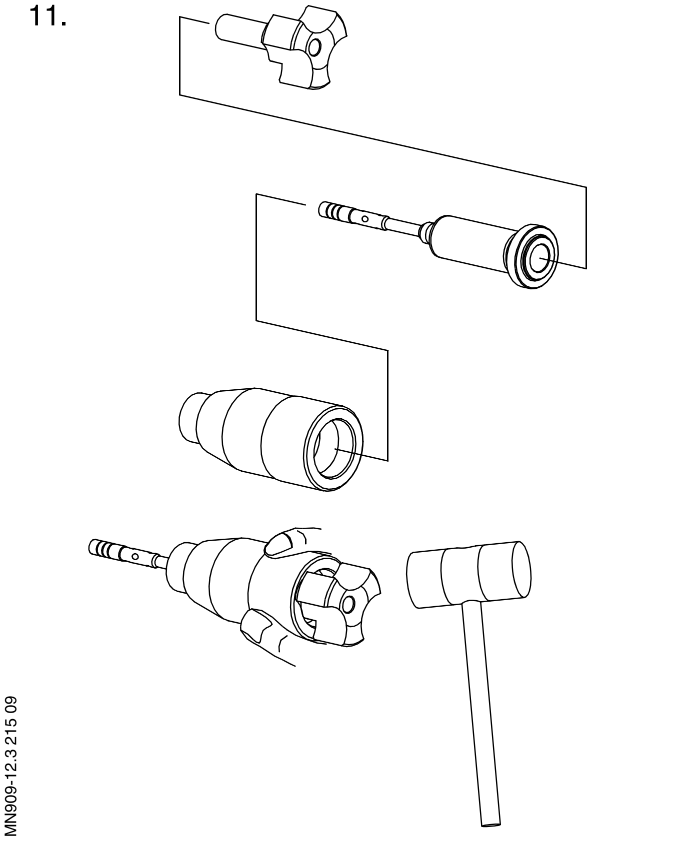

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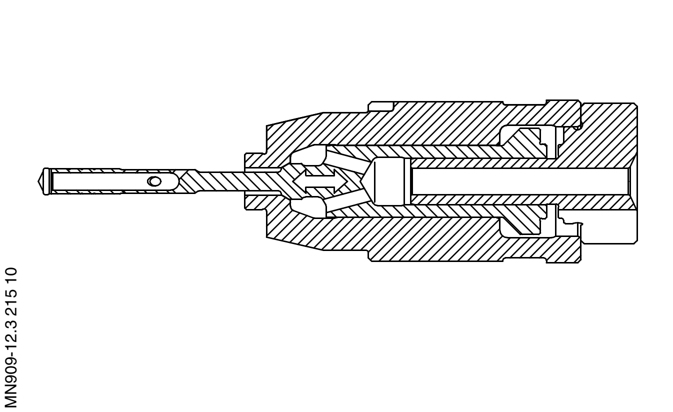


10. Lubricate the spindle and the thrust piece with the cut-off slide with a little Molybdenum Disulphide (MoS_2), *see Procedure 913-11.*

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.

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.

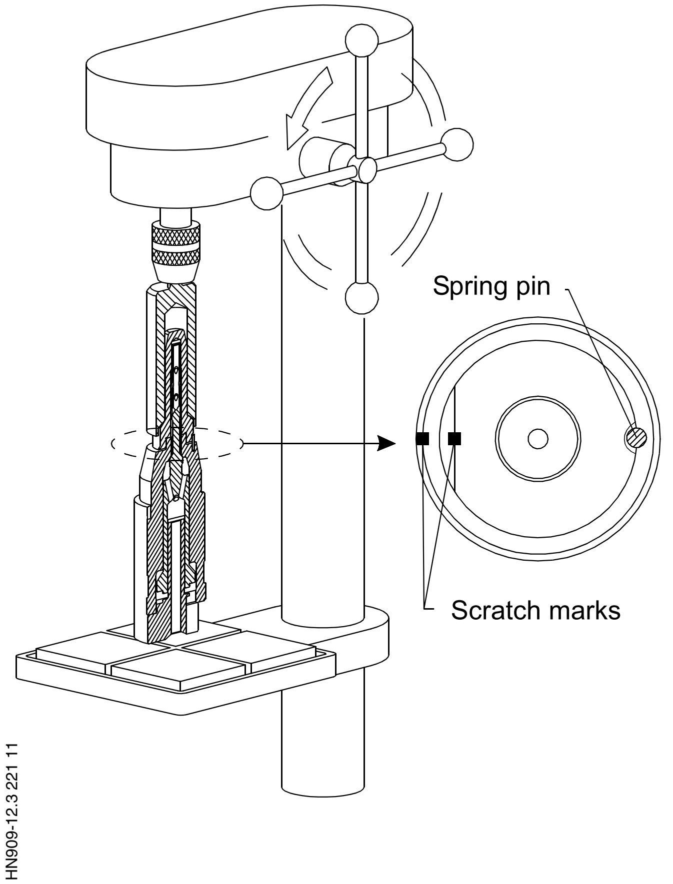
    If no mounting tools are available, the nozzle can be mounted on the spindle guide using a short piece of pipe.

    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.

13.



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 lubriating 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	153	Flange for dismantling of non return valve
P90968		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.

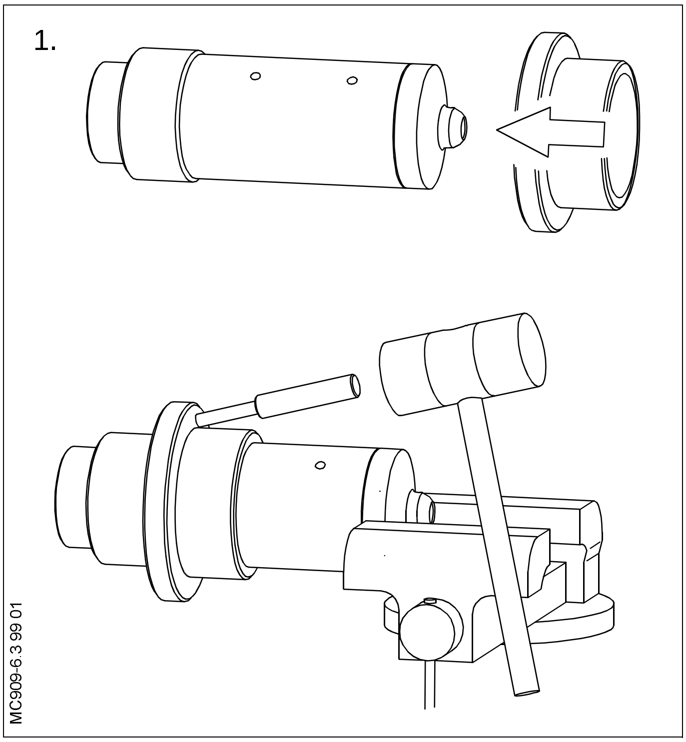
Note!
Except for the slide valve spring, defective parts cannot be replaced individually by new ones.

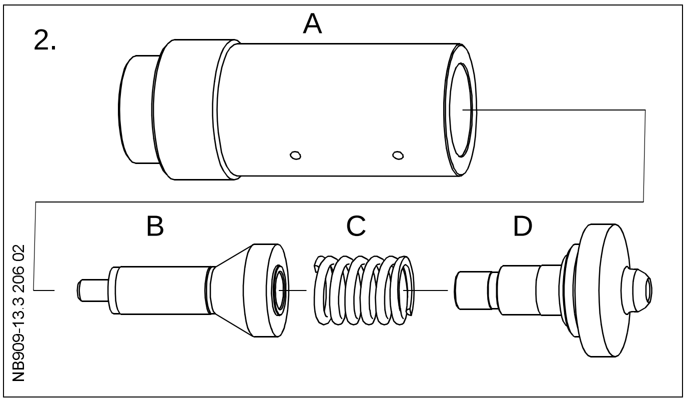
   Place the non-return valve as shown in Fig. 1 in a bench vice provided with “soft” jaws, and disassemble the non-return valve, using the disassembling tool and a hammer as shown.

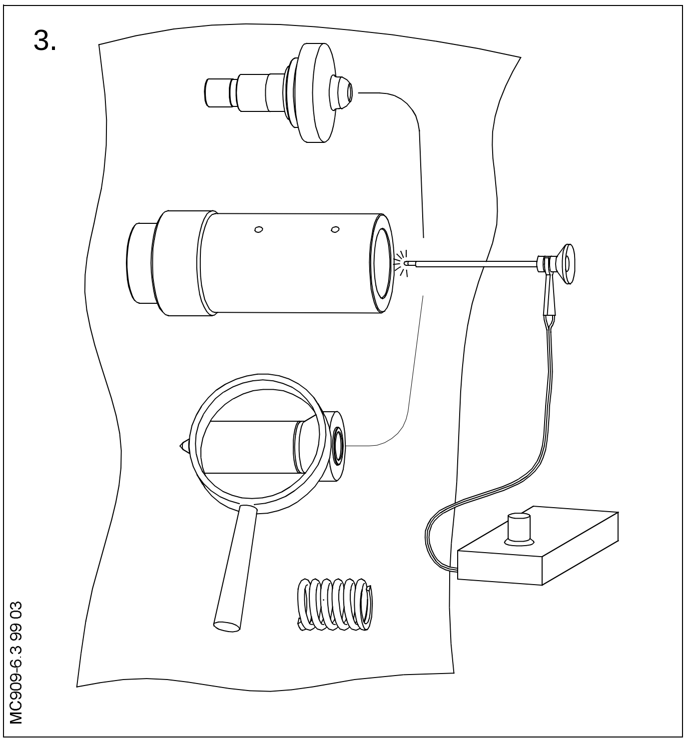
2. Clean all the parts for the spindle guide in gas oil and wipe them dry with a clean piece of cloth.

   Finally, clean in either gas oil, kerosene or ‘Electrocleaner', and wipe the parts dry with a clean piece of cloth.

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.







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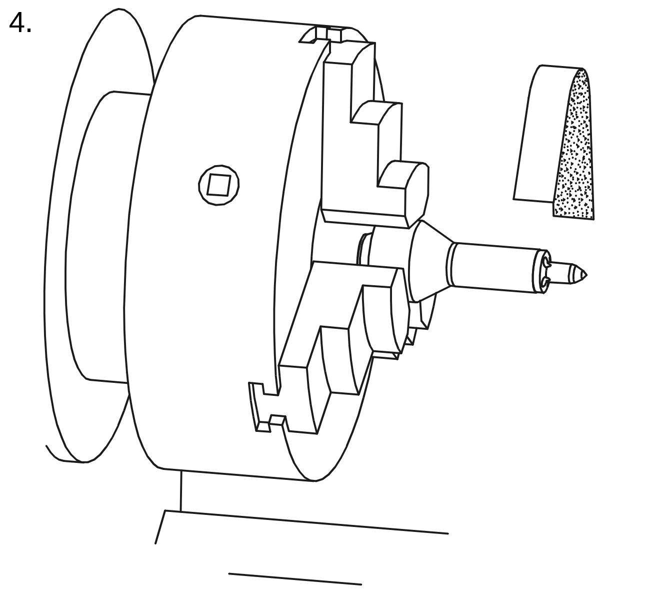

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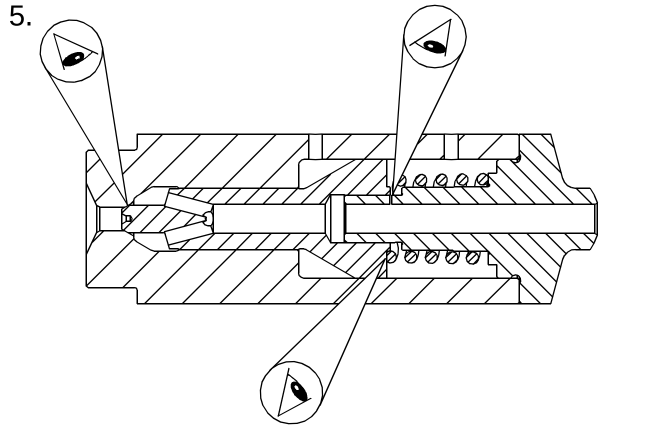

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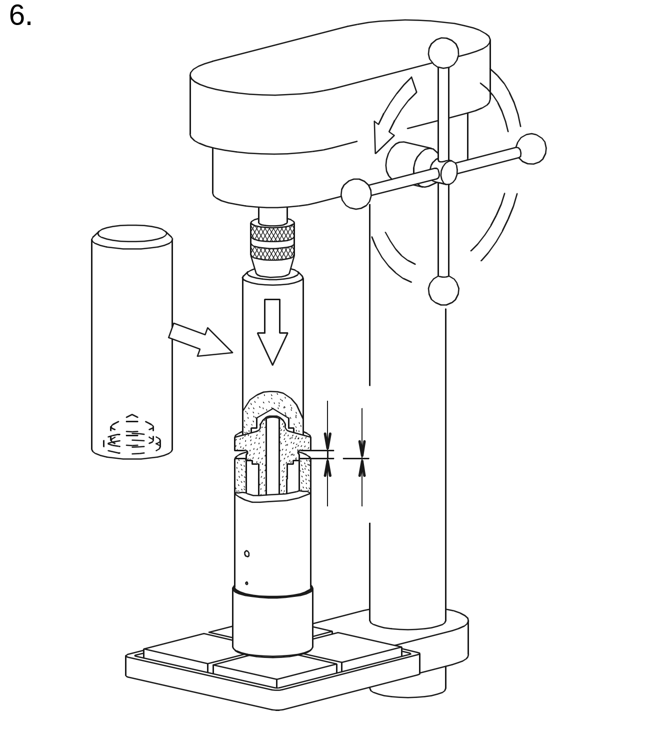

4. Examine the slide faces of movable parts for coating. Vent slide **B**/housing **A** will be too tight if there is a coating. (The letters **A**-**D** refer to the letters/parts in Fig. 2).

   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 outside 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. 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.

7. 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*

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-47	Fuel oil high-pressure pipe, tightening torque	300	Nm
D09-50	Union nuts, tightening torque	55	Nm
D09-52	Fuel oil pipe	25	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
P90951	104	Milling tool for fuel oil pipe
P90951	116	Crowfoot spanner
P90951	128	Crowfoot spanner

High-Pressure Pipe with Double Pipe

1. Close the fuel oil inlet and outlet valves.

2. Unscrew the union nut at the fuel valve end of the high-pressure pipe.

   Pull the union nut clear of the union nipple.

   Unscrew the union nipple from the fuel valve.

3. Unscrew the union nut at the fuel oil pressure booster end of the high-pressure pipe.

   Pull the union nut clear of the union nipple.

   Unscrew the union nipple from the fuel pump.

4. Lift the pipe ends clear of the fuel valve/ fuel pump, and remove the high-pressure pipe from the engine.

Note!
It is recommended always to overhaul the high-pressure pipe before remounting it on the engine. *See Procedure 909-14.3.* The overhaul should preferably take place immediately after the high-pressure pipe has been dismantled.

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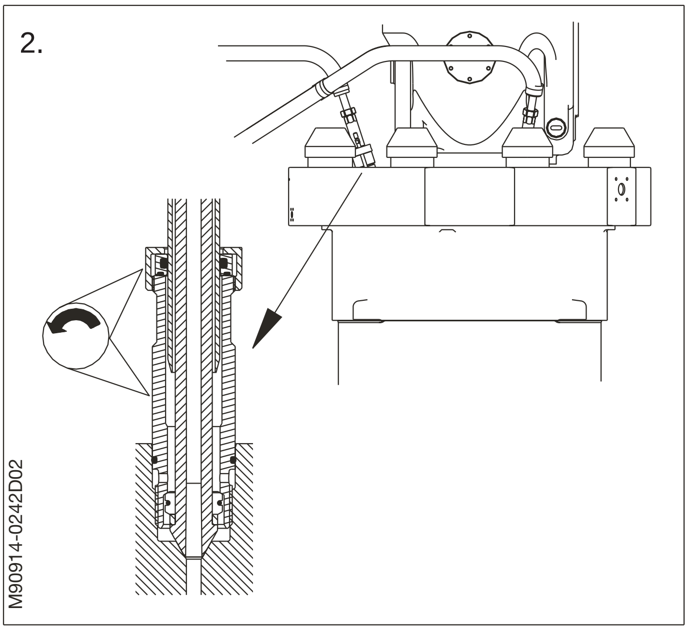

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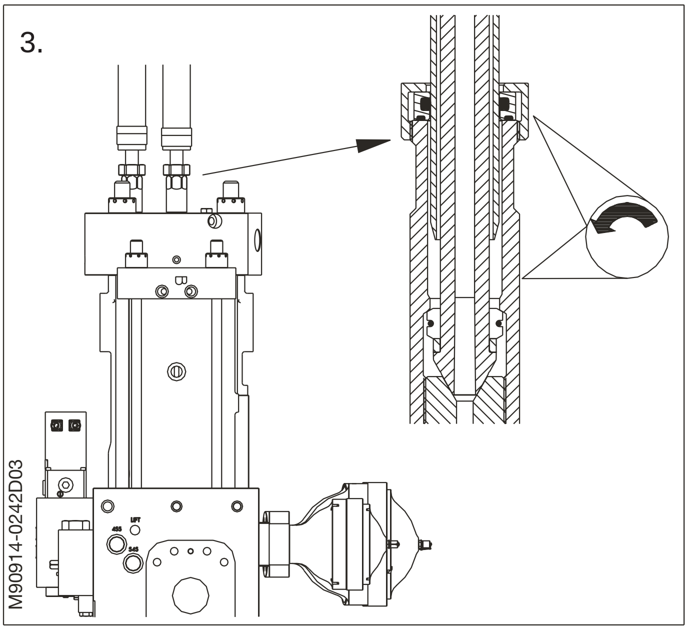

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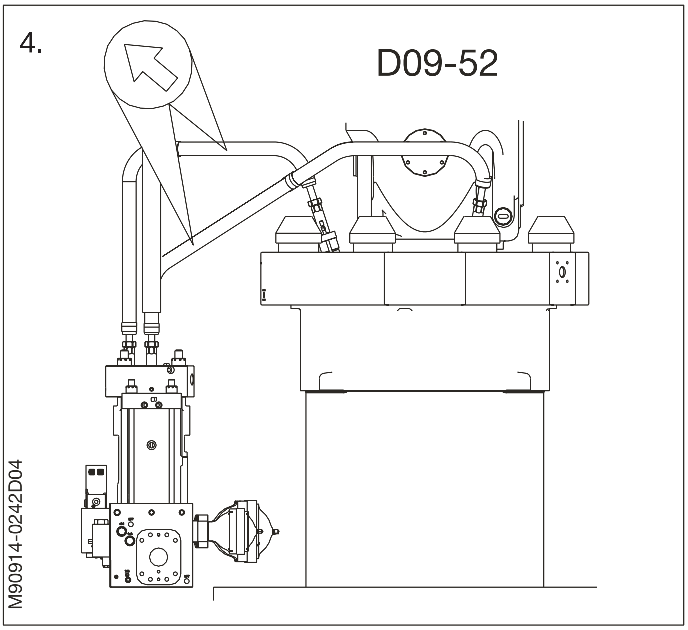

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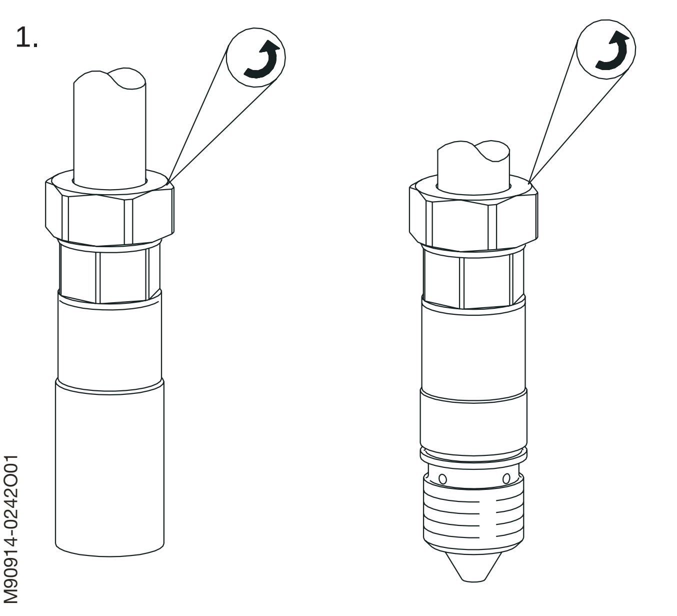

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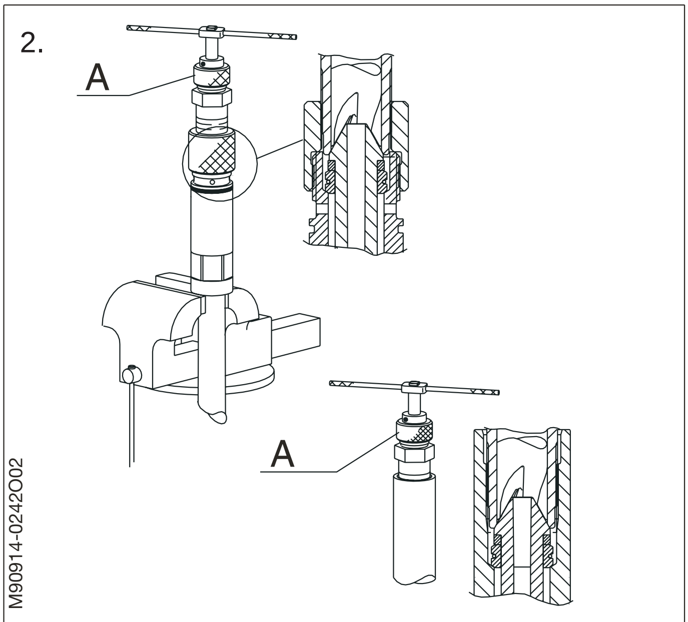

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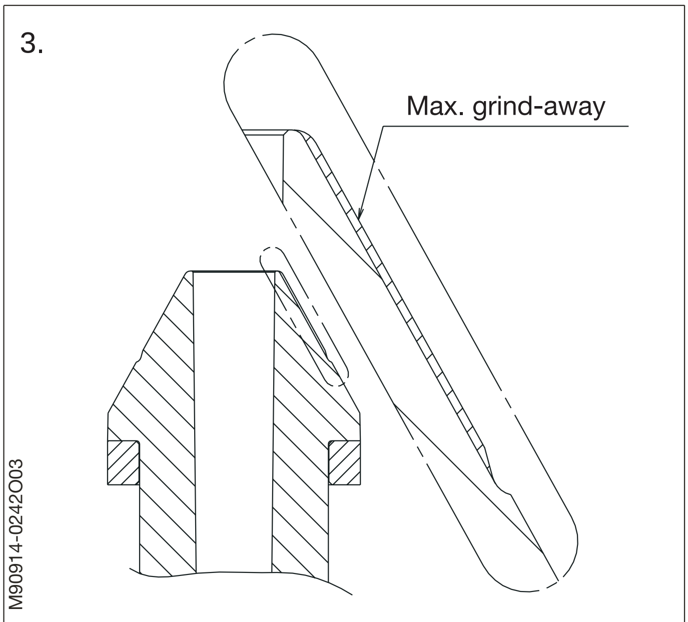


Whenever the fuel oil high-pressure system has been dismantled, it is necessary, before remounting the high-pressure pipes, to carefully inspect the tapered contact surfaces of the pipe ends, together with their seats in fuel valves and fuel oil pressure booster top cover.

If the pipe ends require reconditioning, proceed as follows:

1. If not already done, unscrew the union nuts from the union nipples.

2. Fasten the pipe in a vice with soft jaws. Mount the miller on the pipe end.

Note!
The two pipe ends are of different designs – *see sketch.*

Turn the upper tightening ring (A) until the miller presses against the pipe end.

Turn the miller with, for instance, a tap wrench while lightly tightening the upper tightening ring (A) to provide a suitable pressure between the miller and the pipe end.

During the milling process, add drilling oil emulsion liberally.

3. On both pipe ends a small groove has been ground to indicate the maximum allowable grinding of the pipe ends.

The pipe ends may only be ground until the ground surface is flush with the bottom of the groove.

If the pipe ends are still not in order, the pipe must be discarded.

After completing the milling, carefully clean the high-pressure pipe, and blow through the bore with compressed air.

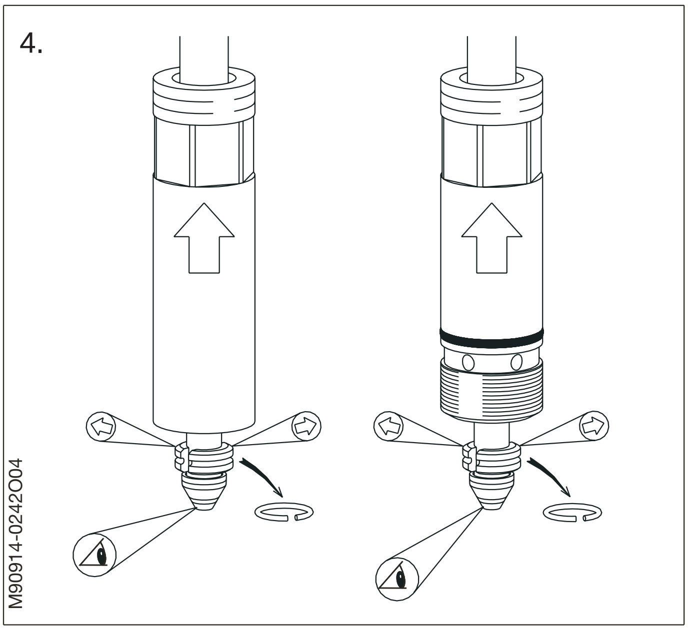
4. Lift up the union nuts and the union nipples.

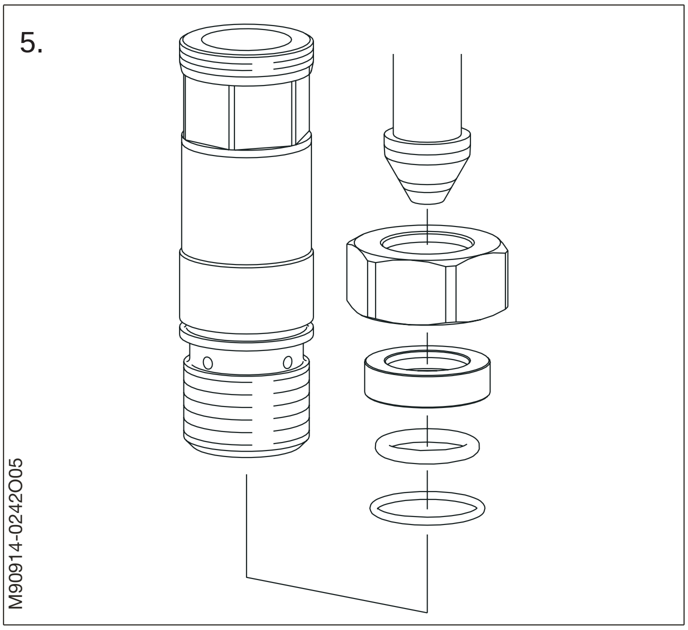
   Remove the spring rings from the two-part sleeves. Remove the sleeves.

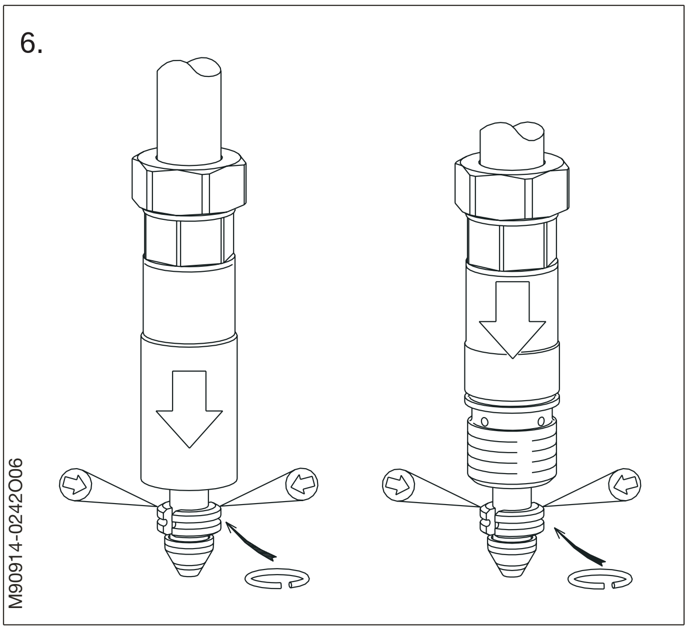
5. Remove the union nipple and union nut from the pipe ends. Clean all parts and replace the O-rings. Remount the union nipple and union nut on both pipe ends.

6. Mount the two-part sleeves and lock the sleeves with the spring rings.

   Screw the union nuts losely (approx. 2 revolutions) on to the union nipples.







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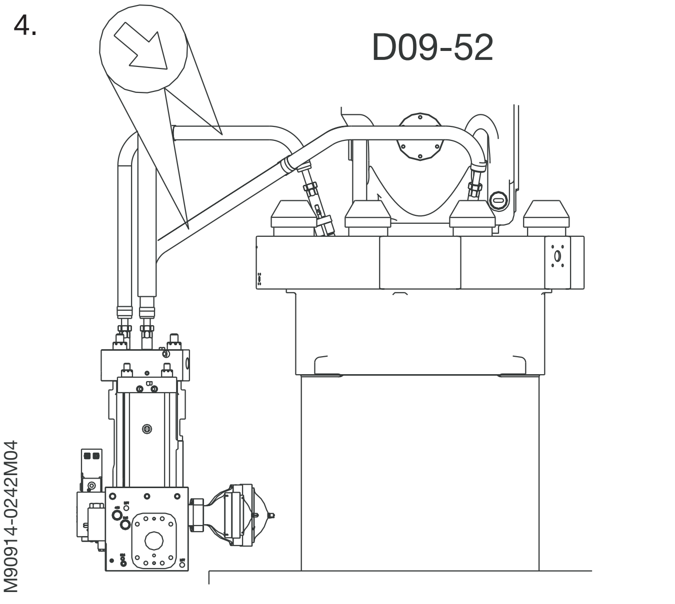

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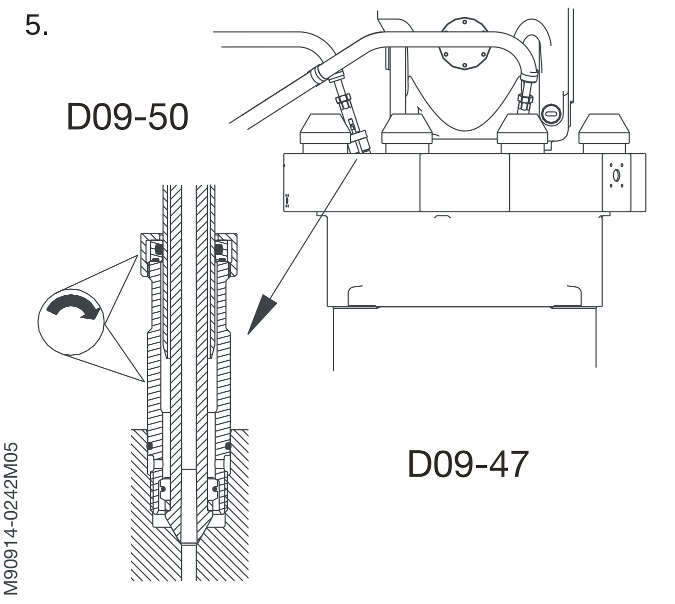

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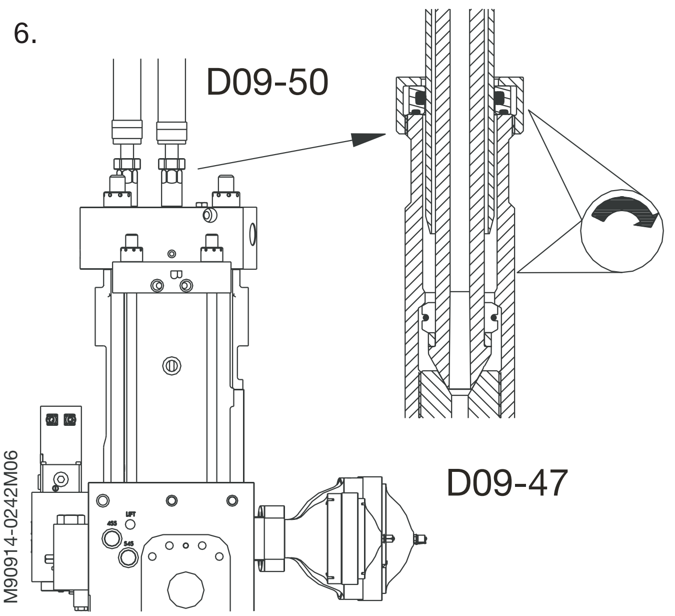


1. Check that the sealing surfaces on both pipe ends are in order without scratches or pressing-in marks.

2. Ensure that the fuel valve is fitted with a new O-ring. Lubricate the thread of the fuel valve with a heat resistant grease.

3. Ensure that the union nipple at the fuel oil pressure booster end of the high-pressure pipe is fitted with a new O-ring. Lubricate the thread on the union nipple with a heat resistant grease.

4. Mount the high-pressure pipe between the fuel valve and the fuel oil pressure booster. Screw the union nipples onto the fuel valve and into the fuel oil pressure booster top cover, by hand.

Note!
The nipples must be screwed by **hand**, as the threads of the union nipples, fuel valve or fuel oil pressure booster top cover might otherwise be damaged. Tightening with a crowfoot wrench should only be done after both of the union nipples have been screwed into position.

5. If not already done, screw the union nut loosely (approx. 2 revolutions) on to the union nipple screwed into the fuel valve.

   Using a crowfoot wrench and torque wrench, tighten the union nipple, then the union nut, to the torques stated in data.

6. Repeat step 5 on the union nipple screwed into the fuel oil pressure booster.

   If dismantled, re-mount the return oil pipe on the fuel valve. Open the fuel oil inlet and outlet valves.

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

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

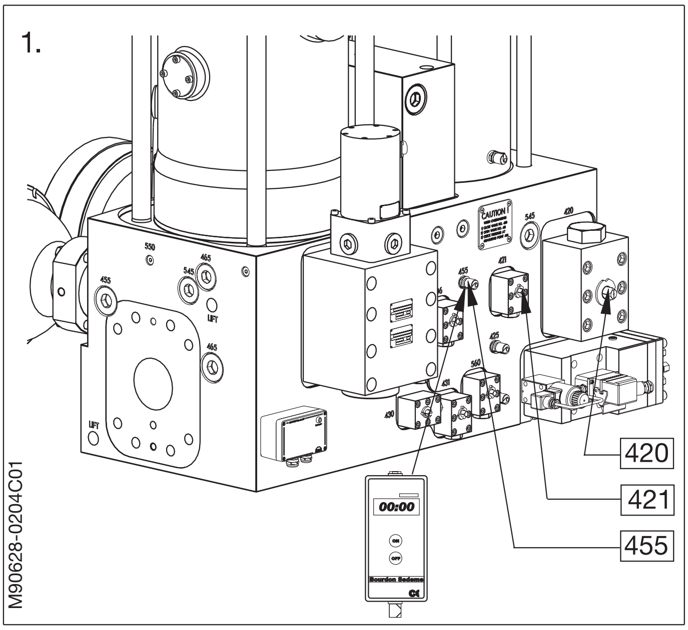
Ref.	Description	Value	Unit
D09-81	Booster complete	700	kg
D09-82	Booster housing	260	kg
D09-83	Hydraulic plunger	70	kg
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	2000 -2400	bar

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
P90951	69	Lifting tool for fuel pump
P90951	82	Lifting tool for fuel pump roller guide
P90262		Piston and Piston Rod - HydraulicTools
P91351	10	Hydraulic pump, pneumatically operated
P91351	34	Hose with unions (1000 mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	117	5-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.

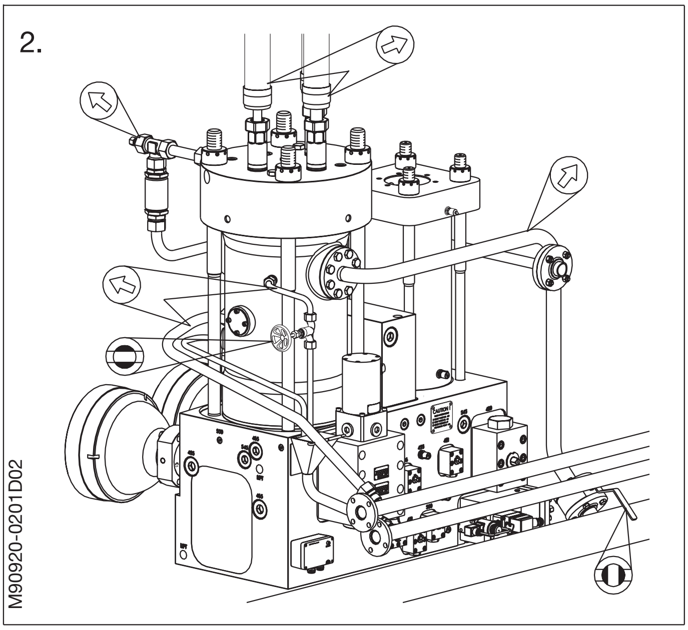
   Remove the fuel oil high pressure pipes, *see Procedure 909-14.2.*

   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. Mount the four extensions on the studs.

   Place four long spacer rings over the nuts of the fuel oil pressure booster and screw the four hydraulic jacks onto the studs.

   Connect the high-pressure pump to the jacks by means of the distributor block and the high-pressure hoses.

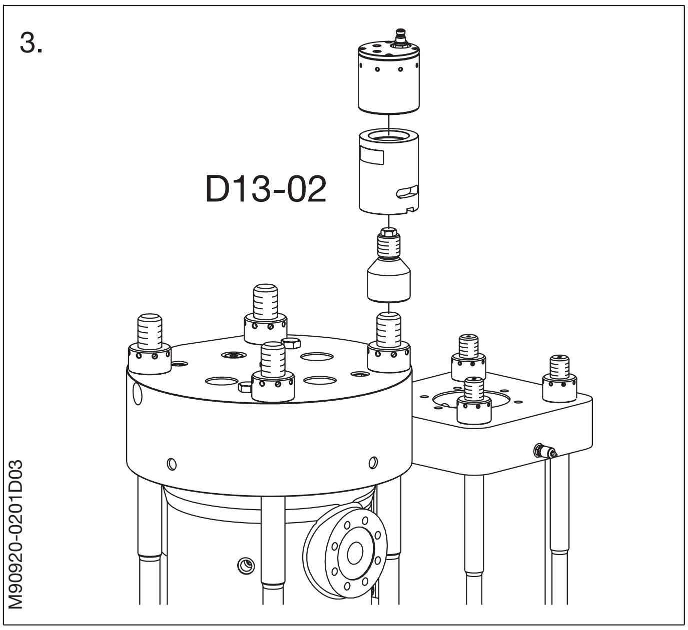
   Using the vent screws of the hydraulic nuts, vent the system and increase the pressure as stated in Data. *For operation of the hydraulic tools, see Procedure 913-1.*

   Loosen the nuts by applying the tommy bar through the slots in the spacer rings.

   Relieve the system of pressure.

   Disconnect the high-pressure hoses from the jacks.

   Finally, remove the hydraulic jacks and spacer rings, and unscrew the nuts.



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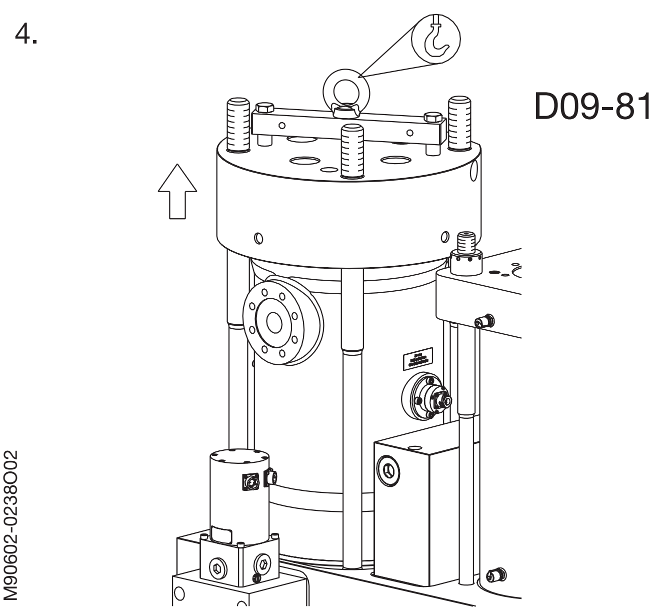

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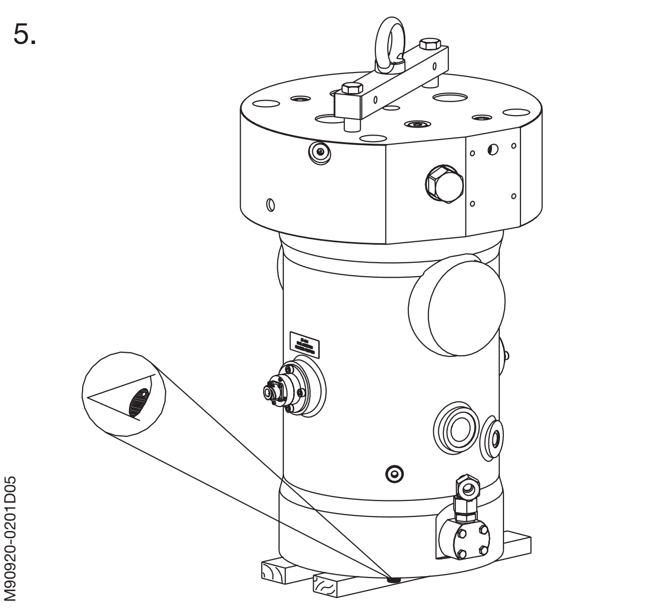


4. Mount the lifting tool on top of the fuel oil pressure booster.

   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.

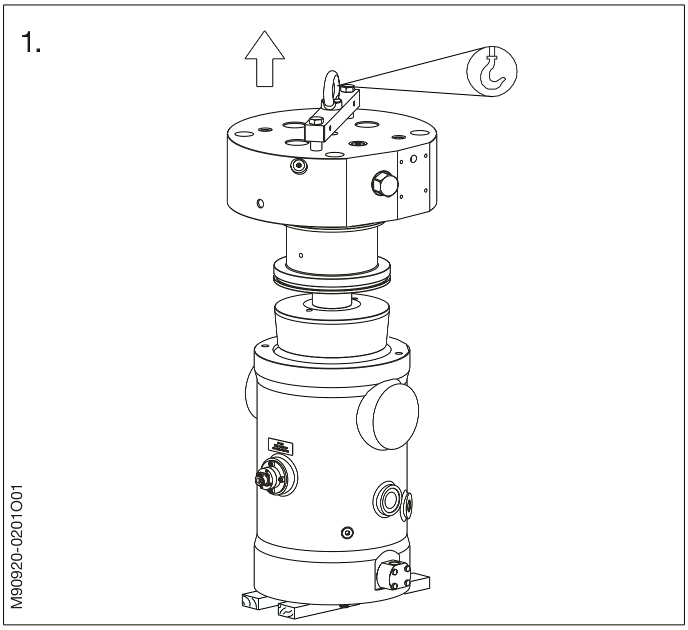
1. Place the fuel oil pressure booster on a wooden support.

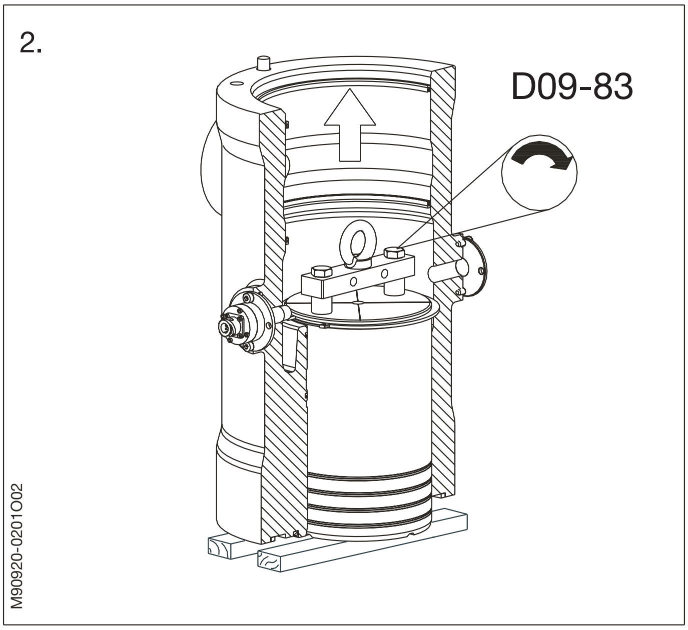
   Remove the booster top cover, *see Procedure 909-21.2.*

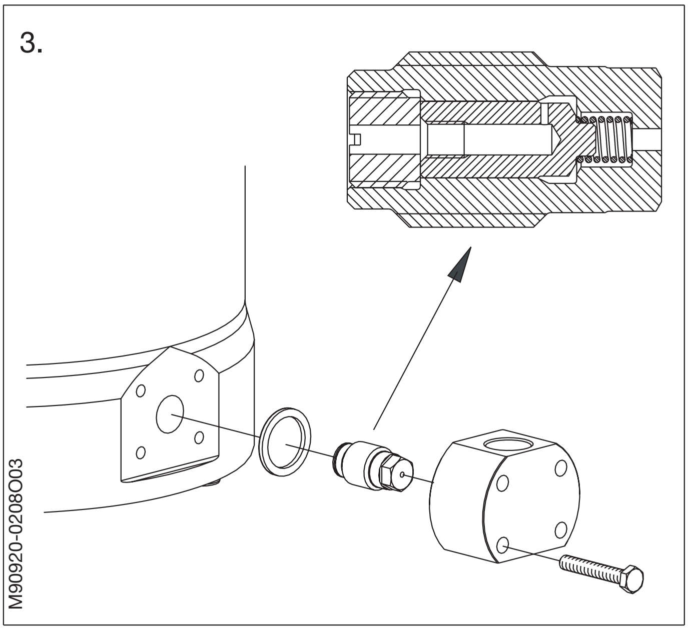
2. Mount the lifting tool in the top of the hydraulic plunger.

   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.







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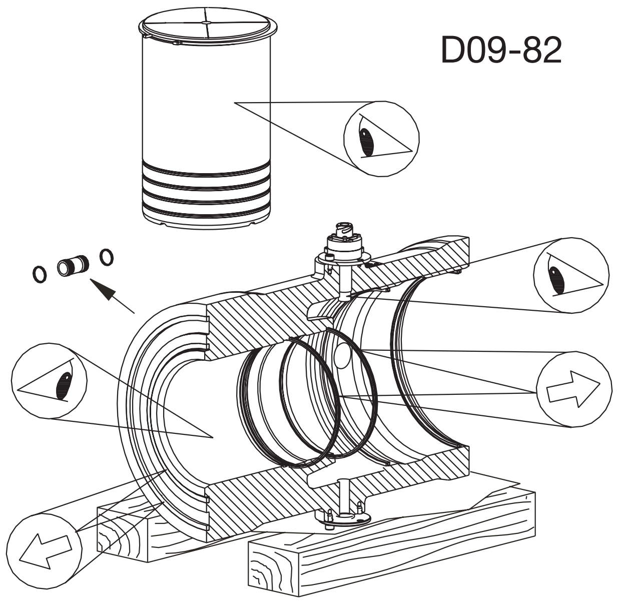

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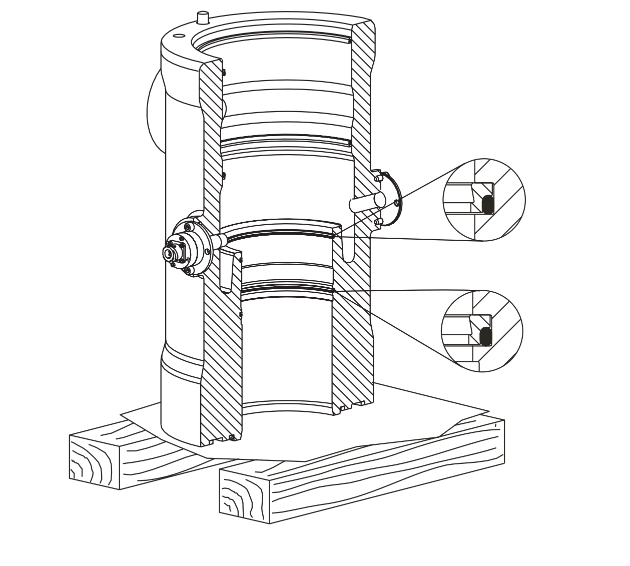

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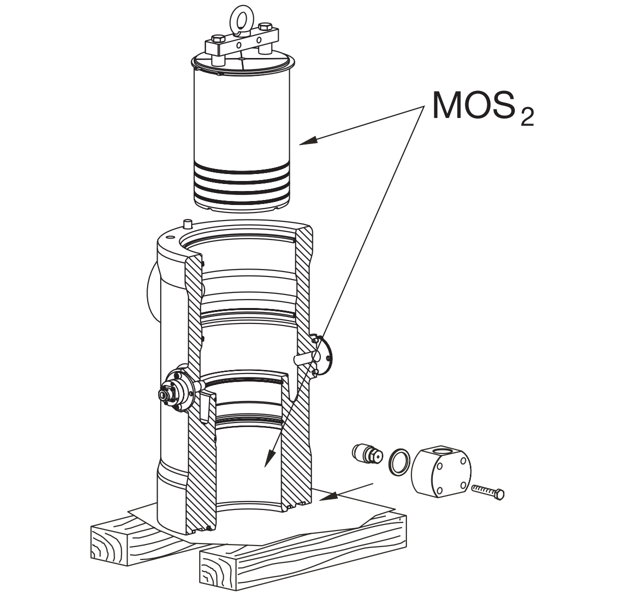


4. Clean the booster housing and the hydraulic plunger with kerosene or gas oil.

   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.

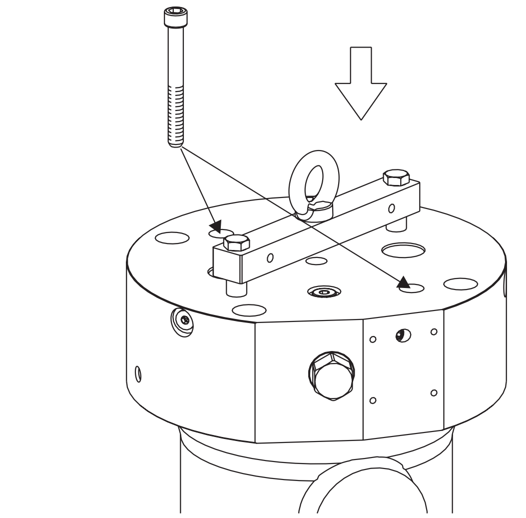
Note!
All parts of the hydraulic high pressure system must be kept absolutely clean and free of impurities. In this case, pay particular attention to the hydraulic piston and the lower part of the booster housing.

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.

7.



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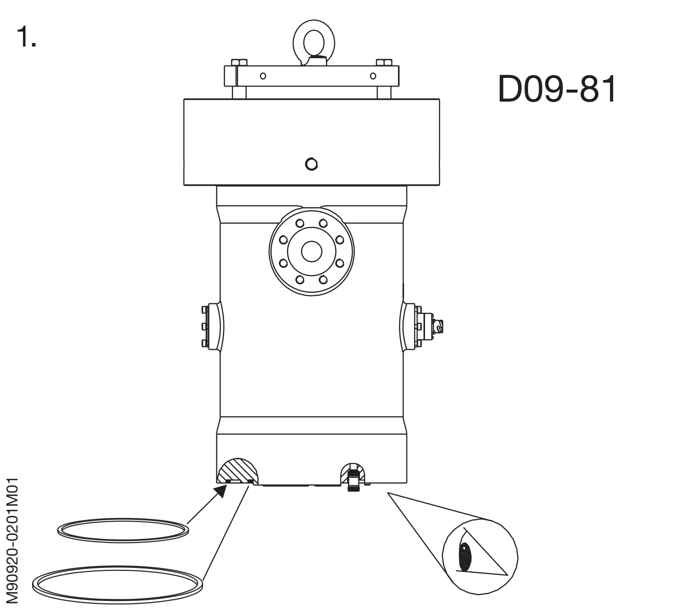

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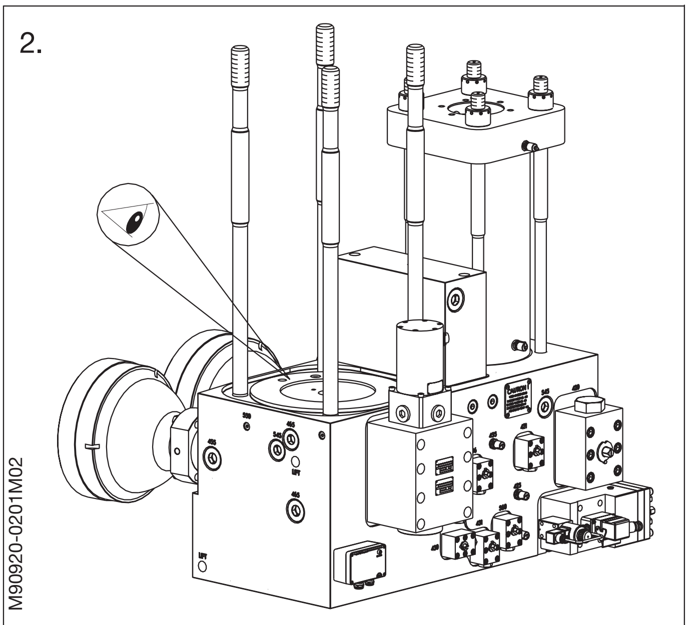

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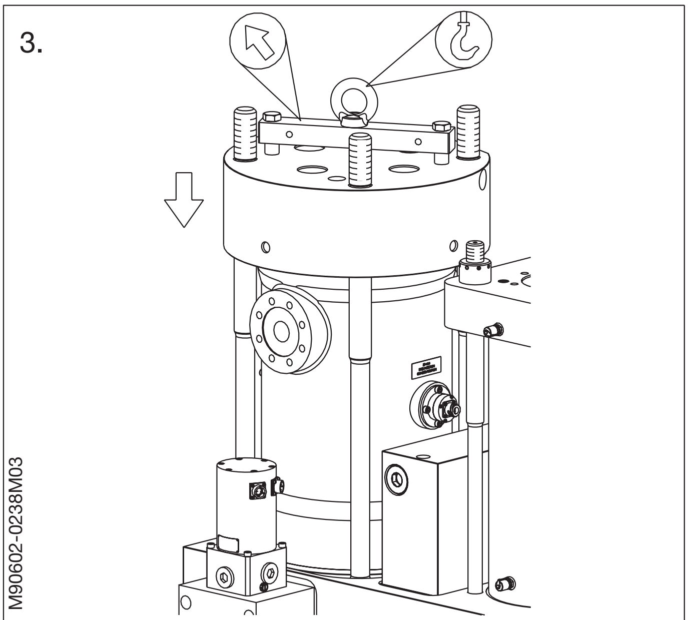


Note!
Great care must be taken to ensure that the area around the workplace is clean before and during assembly of the hydraulic system.

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.

4. Mount the nuts on the fuel oil pressure booster studs and screw down.

   Mount the four extensions on the studs.

   Place the long spacer rings, one around each nut, and mount the hydraulic jacks on the studs.

   Connect the high-pressure pump to the jacks by means of the distributor block and the high-pressure hoses.

   Use the vent screws of the hydraulic jacks to vent the system, and then increase the pressure as stated in Data.

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

   Tighten the nuts by applying the tommy bar through the slots in the spacer rings.

   Relieve the system of pressure.

   Finally, remove the hydraulic jacks and spacer rings from the nuts.

5. Mount and tighten all drain pipes to the fuel oil pressure booster.

   Mount the fuel oil inlet pipe.

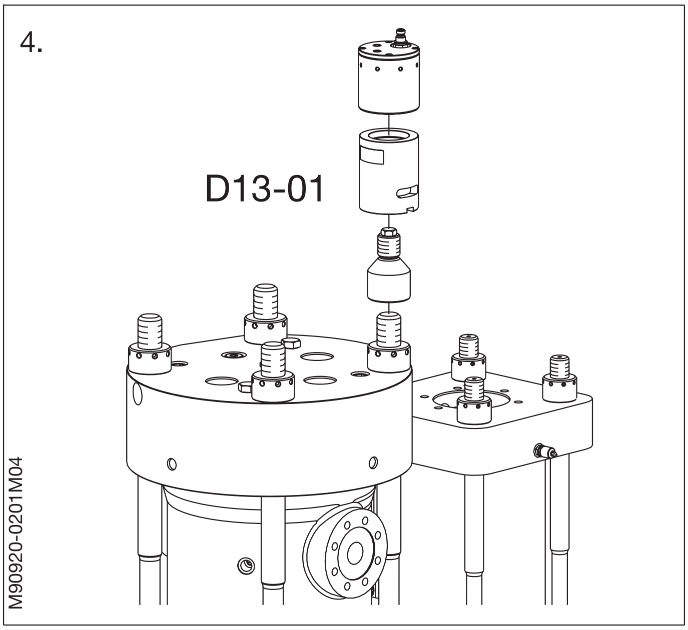
   Mount the fuel oil high pressure pipes, *see Procedure 909-14.4.*

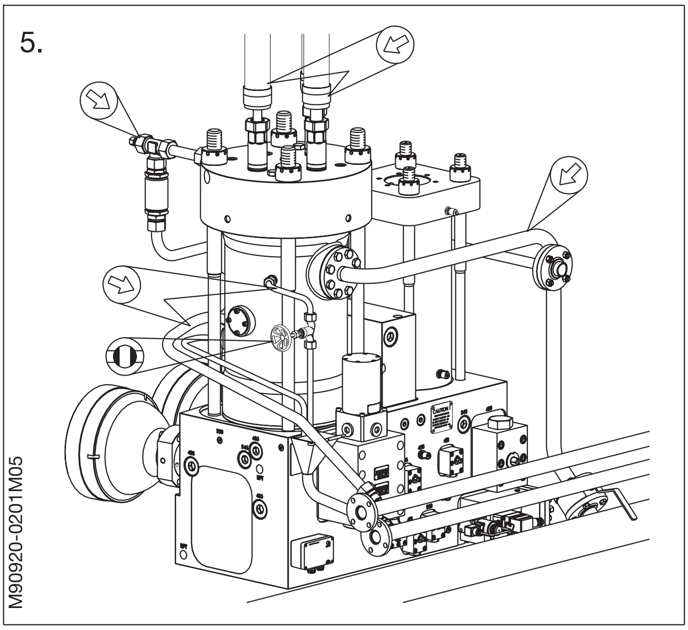
   Close the fuel oil drain valve.

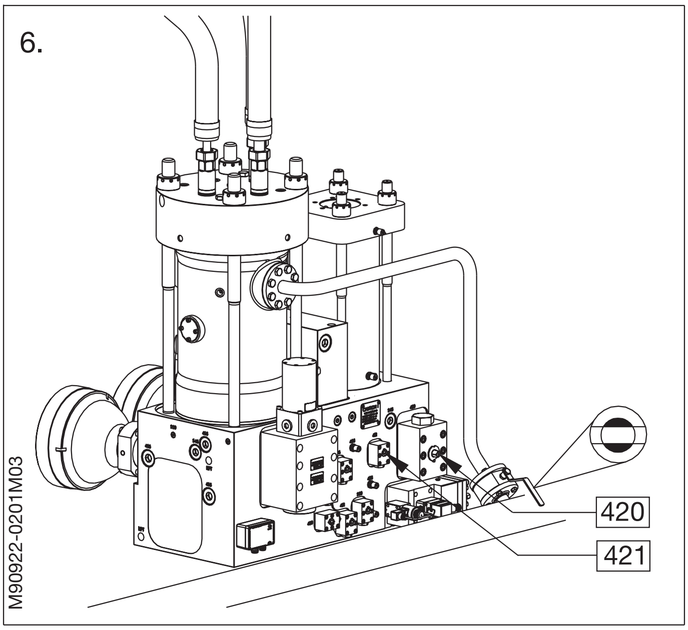
   Mount the electrical sensor plug.

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*

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
X	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D09-86	Fuel outlet seat, max.grinding diameter	26	mm
D09-87	Booster top cover	260	kg
D09-88	Fuel plunger	35	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.

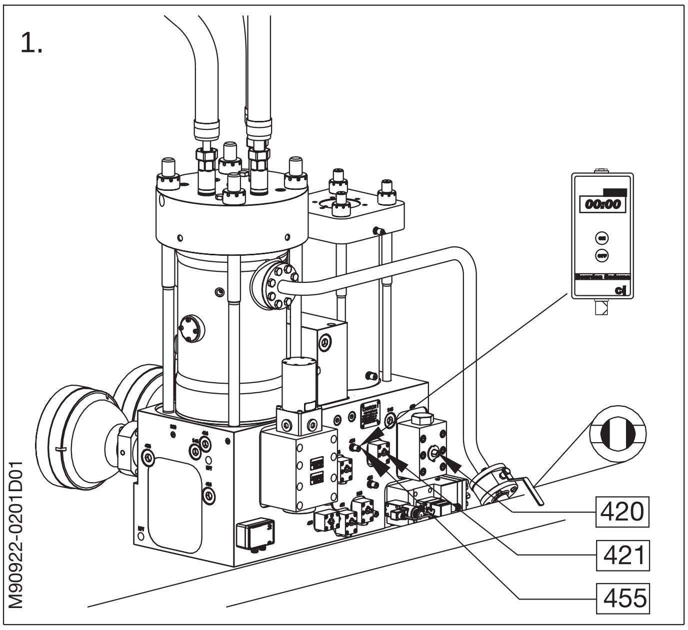
Plate	Item No.	Description
P90951	69	Lifting tool for fuel pump
P90951	320	Plunger locking tool
P90262		Piston and Piston Rod - HydraulicTools
P91351	10	Hydraulic pump, pneumatically operated
P91351	34	Hose with unions (1000 mm), complete
P91351	60	Hose with unions (5000 mm), complete
P91351	117	5-way 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.

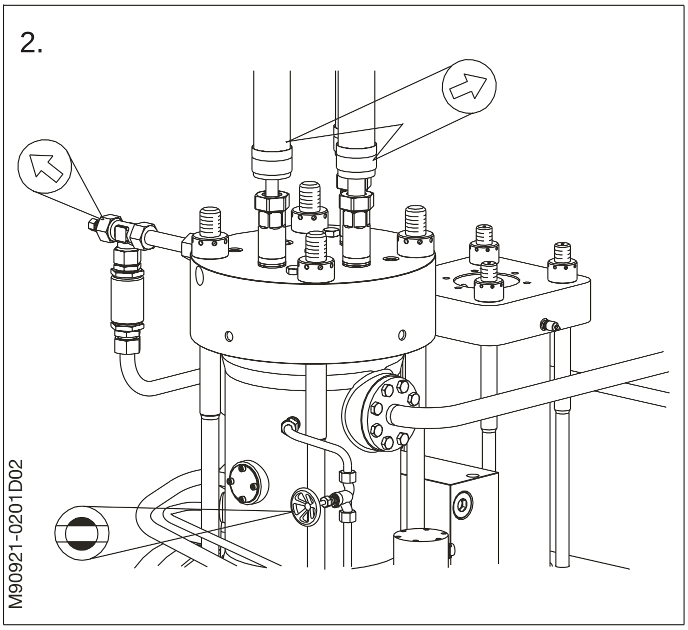
   Check that the hydraulic cylinder unit is pressure free.



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. Mount the four extensions on the studs.

   Place four long spacer rings over the nuts of the fuel oil pressure booster and screw the four hydraulic jacks onto the studs.

   Connect the high-pressure pump to the jacks by means of the distributor block and the high-pressure hoses.

   Using the vent screws of the hydraulic nuts, vent the system and increase the pressure as stated in Data.

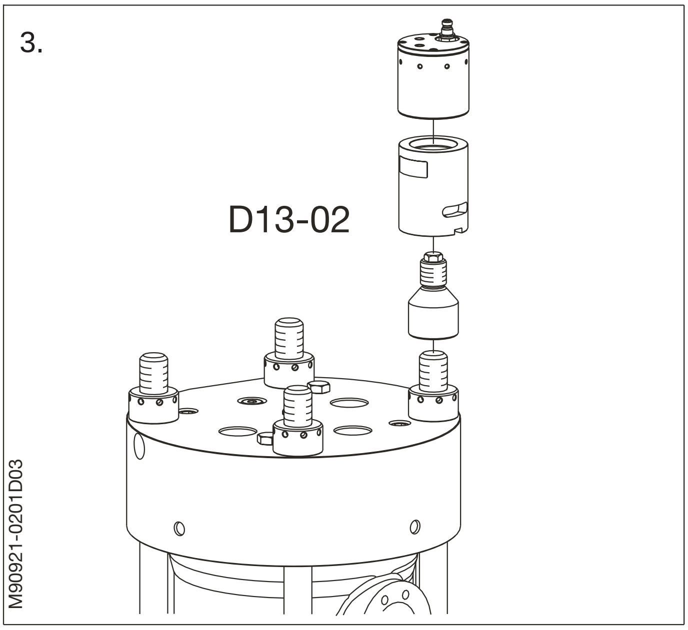
   For operation of the hydraulic tools, see Procedure 913-1.

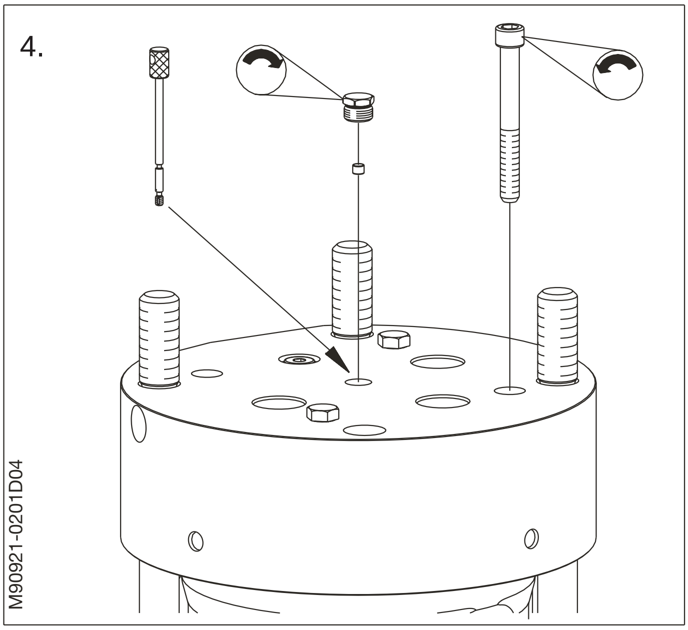
   Loosen the nuts by applying the tommy bar through the slots in the spacer rings.

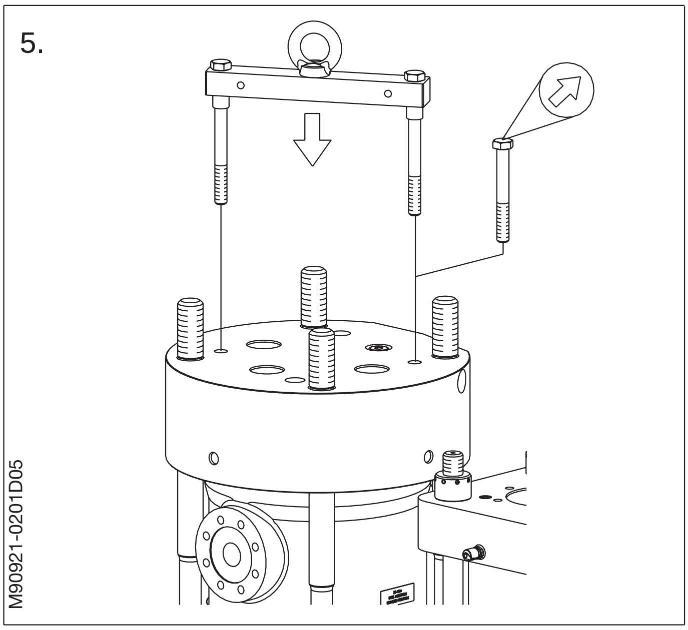
   Relieve the system of pressure.

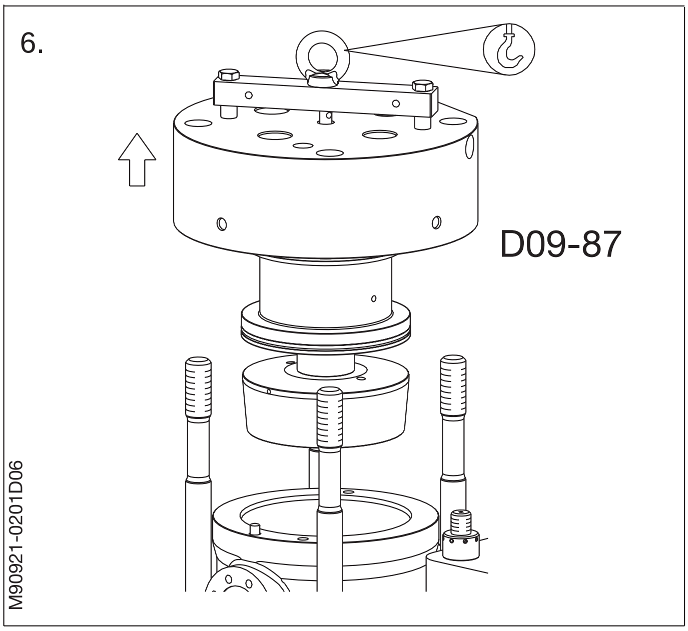
   Disconnect the high-pressure hoses from the jacks.

   Finally, remove the hydraulic jacks, the spacer rings and the extensions. Unscrew the nuts.









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.*

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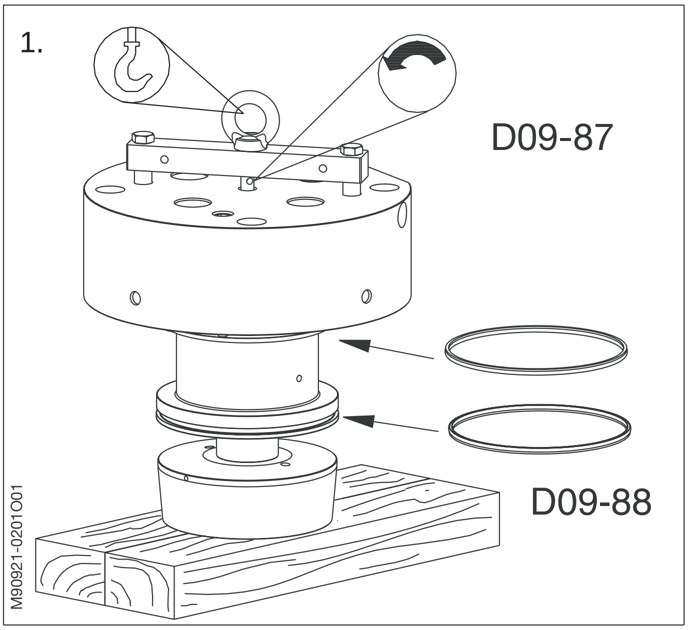

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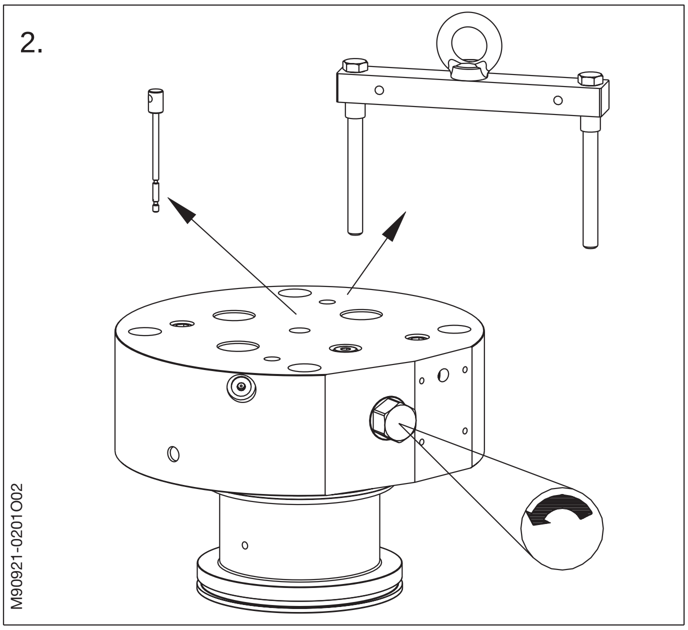

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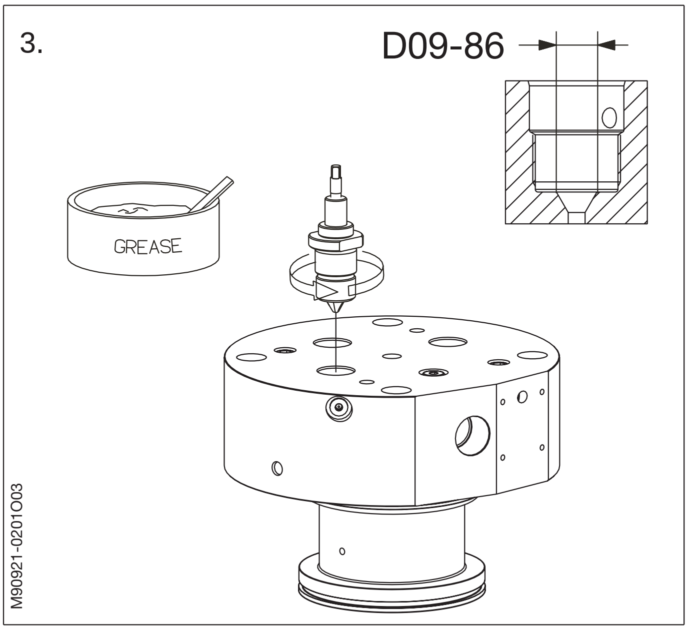
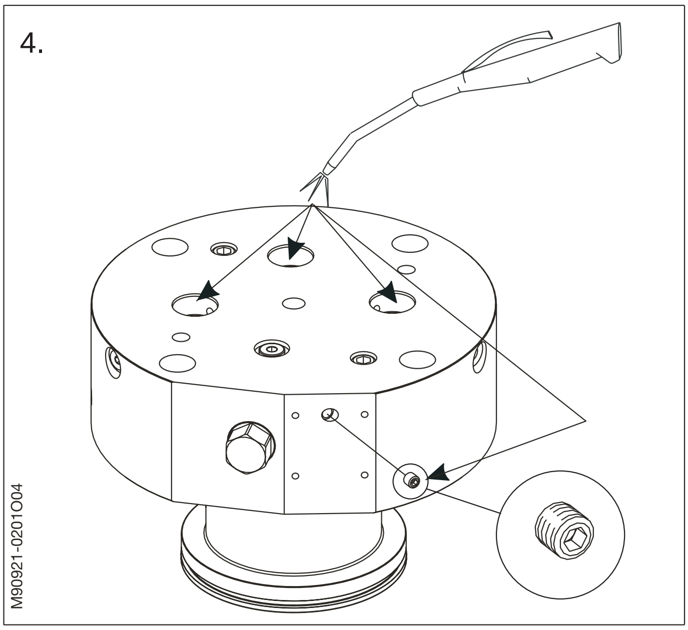


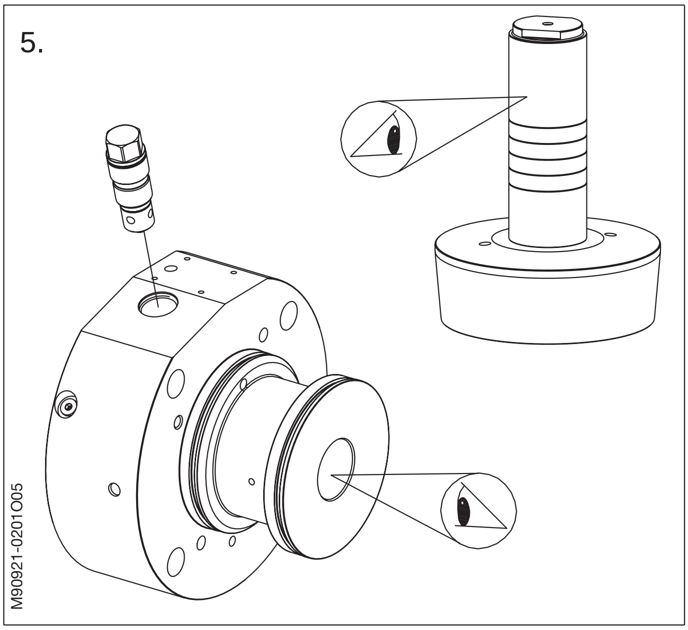


4. After completing the milling, blow out the Vaseline/grease from the oil ducts by means of compressed air.

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.

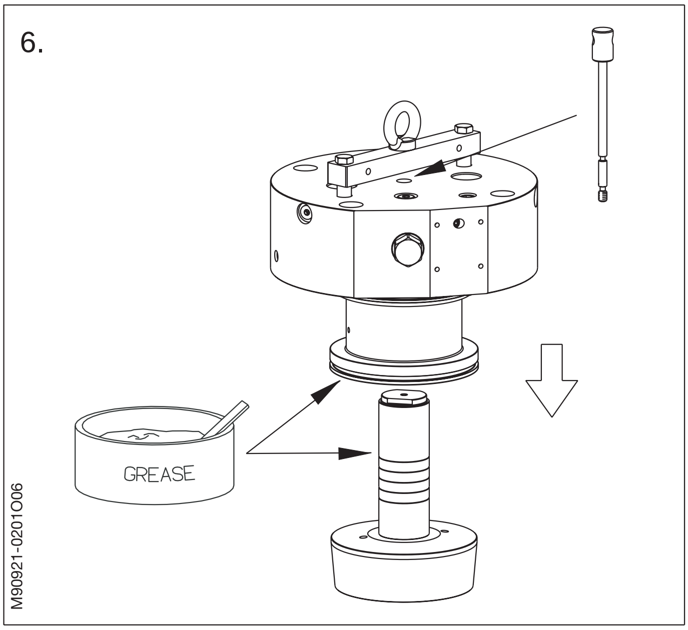


5. Place the top cover on one side and clean the bore for the fuel plunger in clean kerosene. Inspect the bore and plunger.

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. 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.

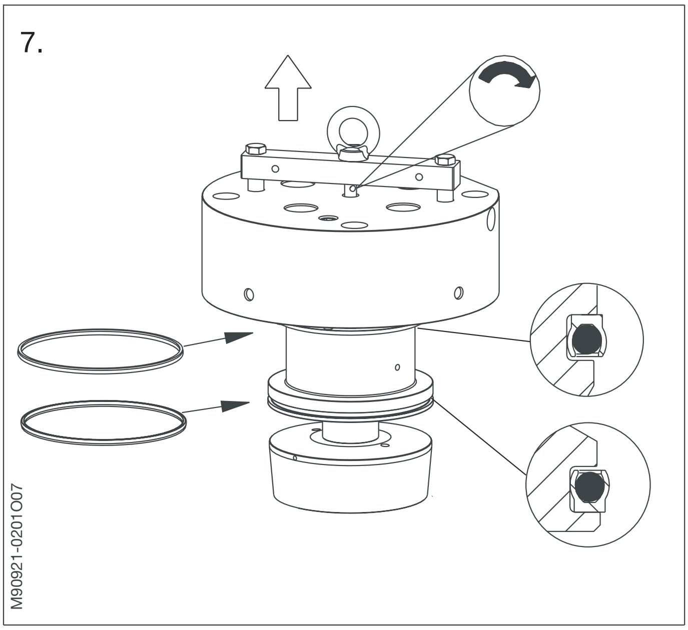
Place the plunger on a plane surface.

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.

7. Screw the retaining tool into the fuel plunger, to lock the plunger in position.

   Lift the top cover and mount two new sealing rings as shown on the sketch.



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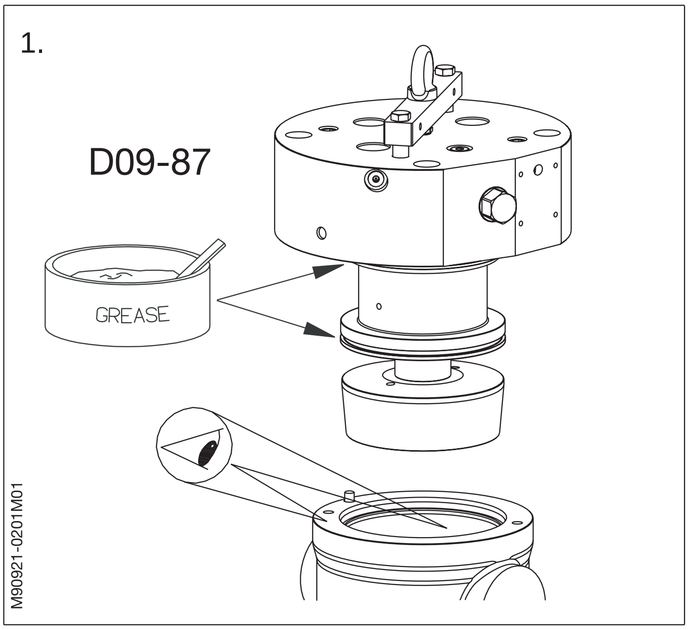

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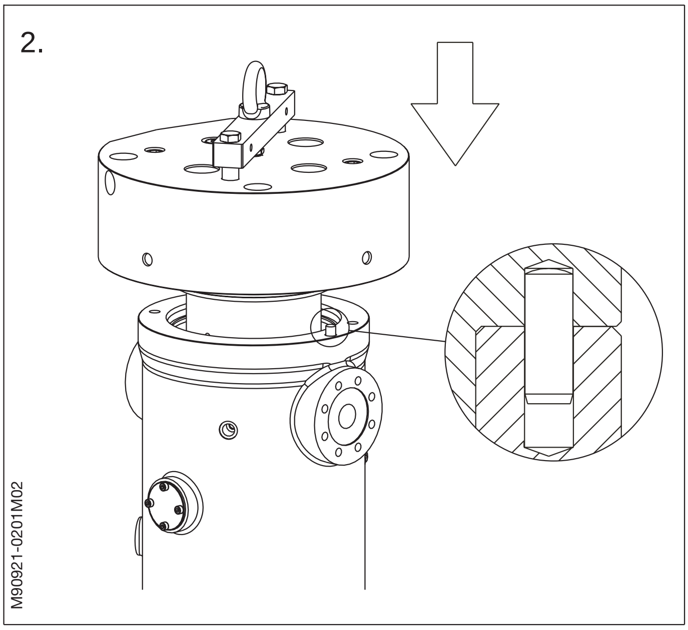

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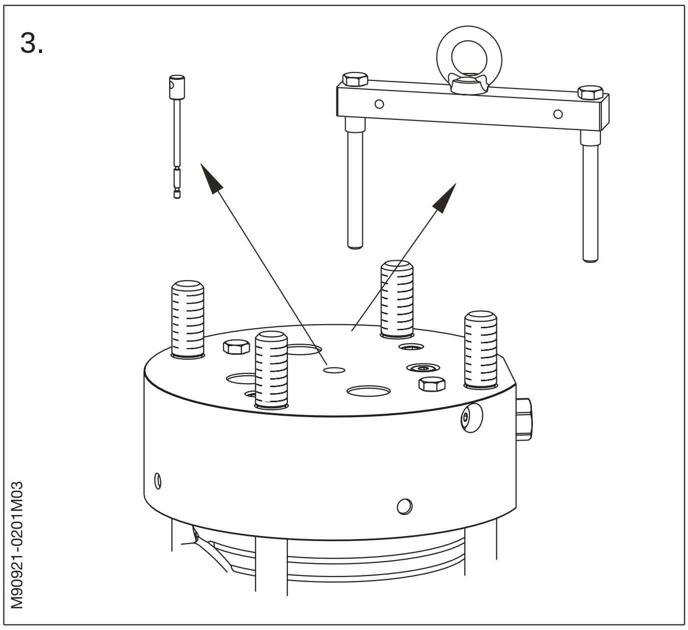


1. Mount the lifting tool on the new or overhauled top cover assembly.

   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. Mount the nuts, the extensions, the spacer rings and two hydraulic jacks. Raise the pressure to the value stated in Data and tighten the nuts.

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

   Relieve the system of pressure, remove the hydraulic jacks and high-pressure hoses, and fit the 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.*

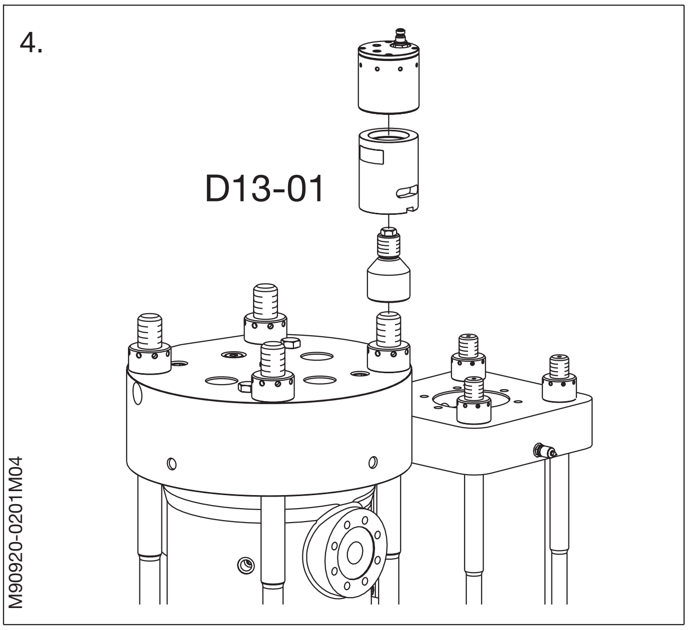
   Mount the return oil pipe.

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

   Close the oil drain.

   Open the fuel oil inlet valve.

4.



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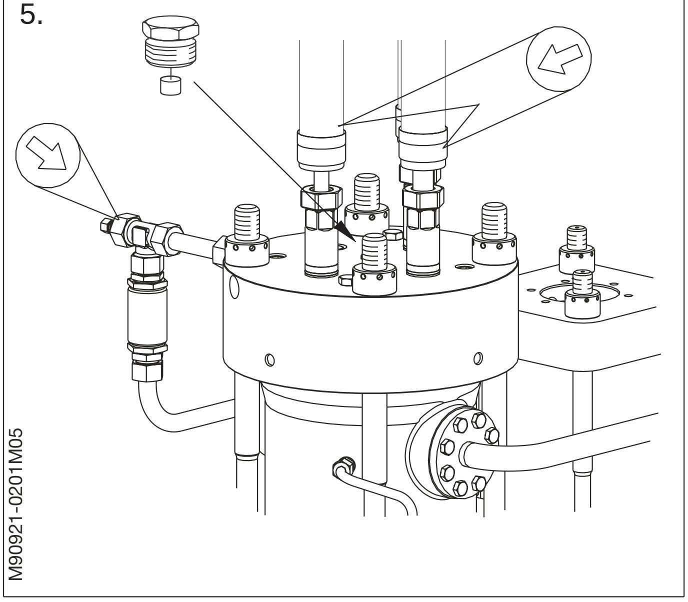

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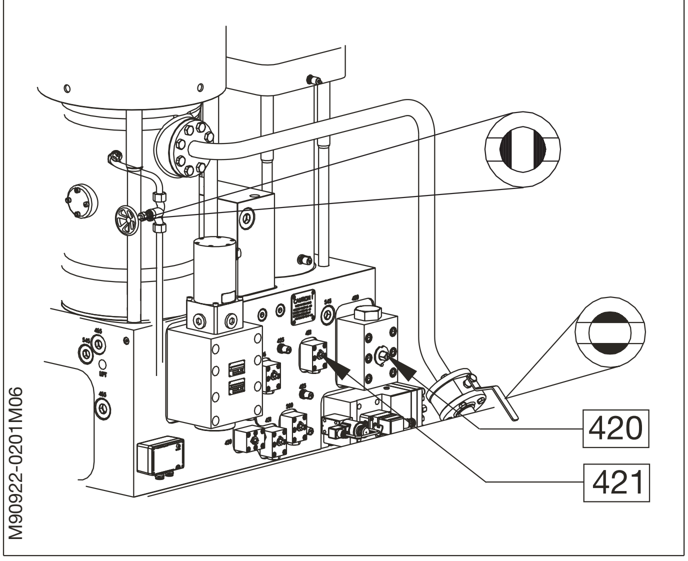


SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

X	Stopped engine
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
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
X	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

1. Shut off the oil supply to the hydraulic actuator.

   Mount a pressure gauge at “minimess” point No. 455.

   Close valve 420 and open valve 421 on the hydraulic block for the cylinder concerned.

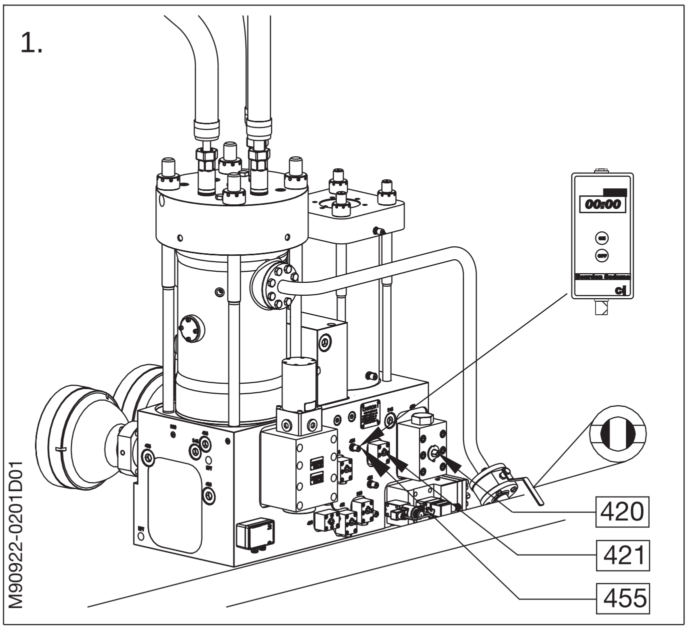
   Check that the hydraulic cylinder unit is pressure free.

   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.



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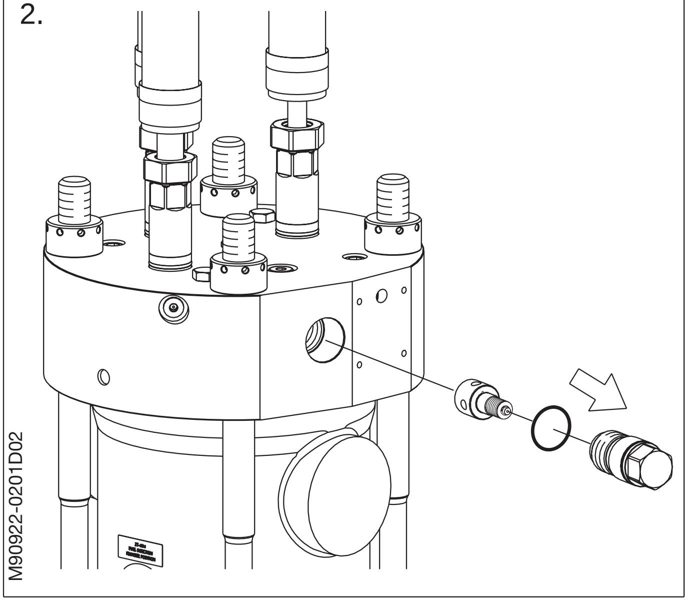

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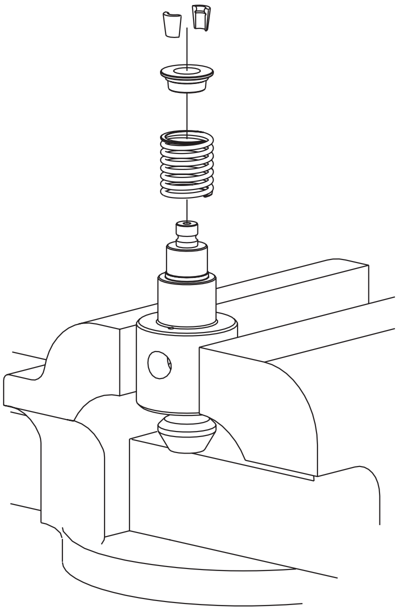

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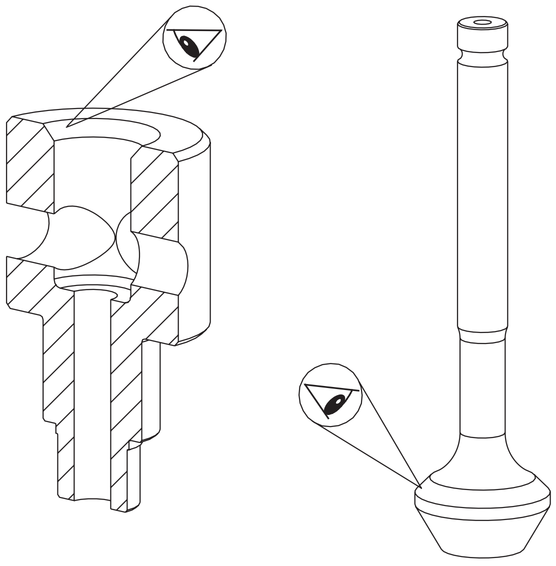

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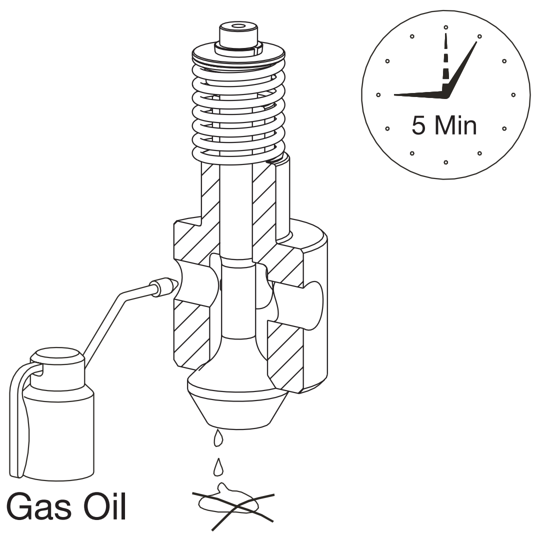

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1. Set up the fuel suction valve in a bench vice with "soft" jaws and press down the spring by means of the cone to release the valve spindle from the two-part conical ring.

   Clean the parts thoroughly in clean diesel oil and carefully dry.

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 mounted on the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve dur-ing storage.

1. Check that the face for the suction valve is clean.

   Mount the overhauled or new suction valve.

2. Mount a new O-ring on the union nut.

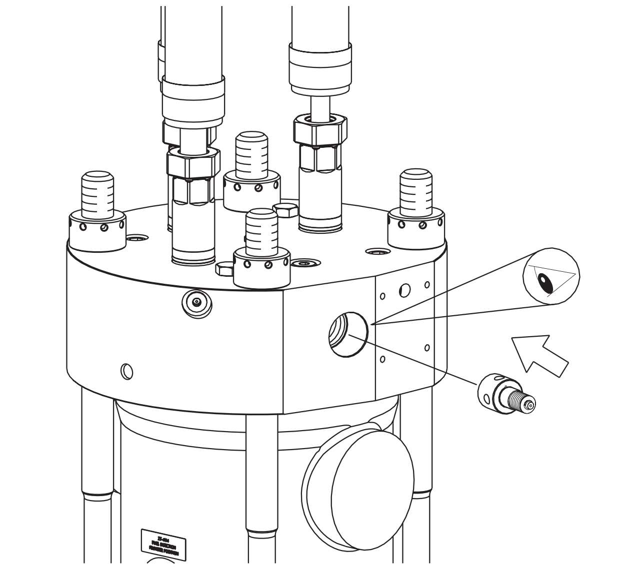
   Lubricate the O-ring and the thread on the union nut with molybdenum disulphide (MoS_2) grease.

   Mount 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.

1.



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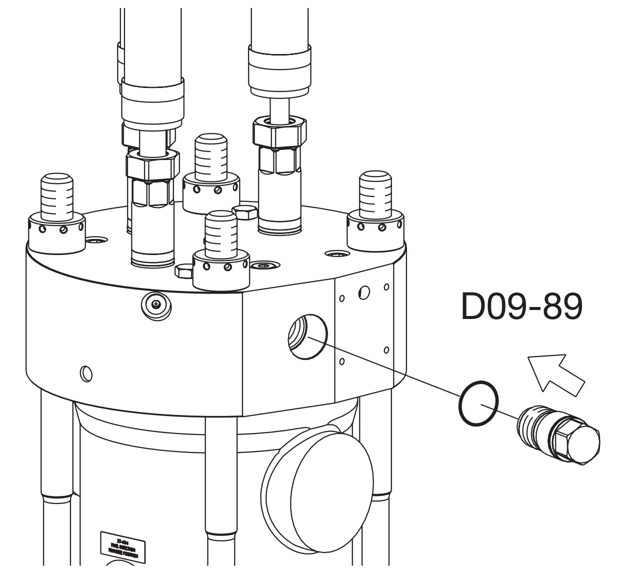

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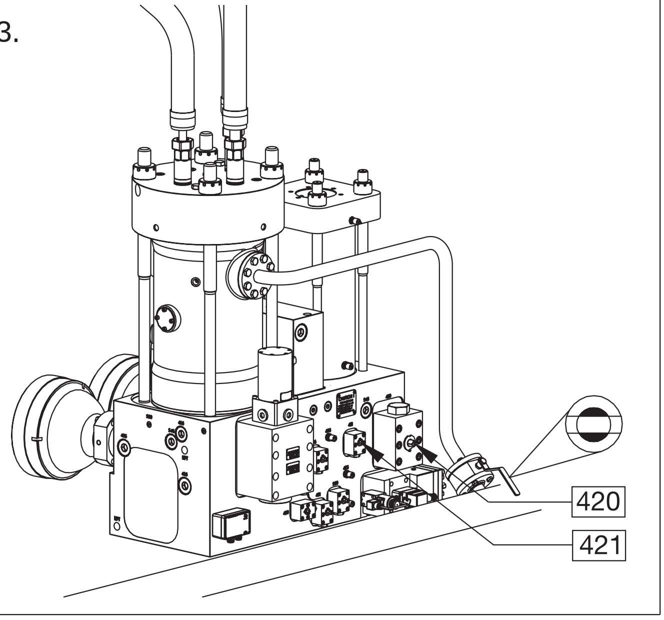

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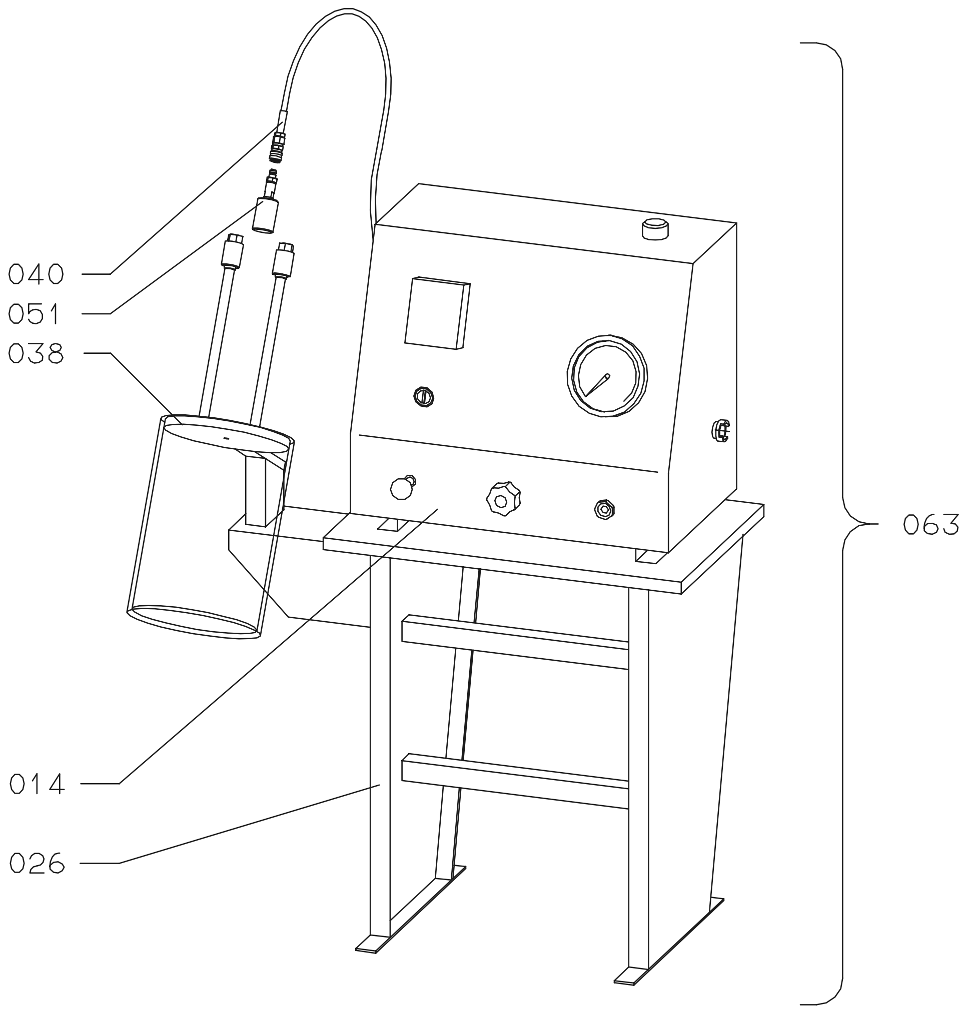
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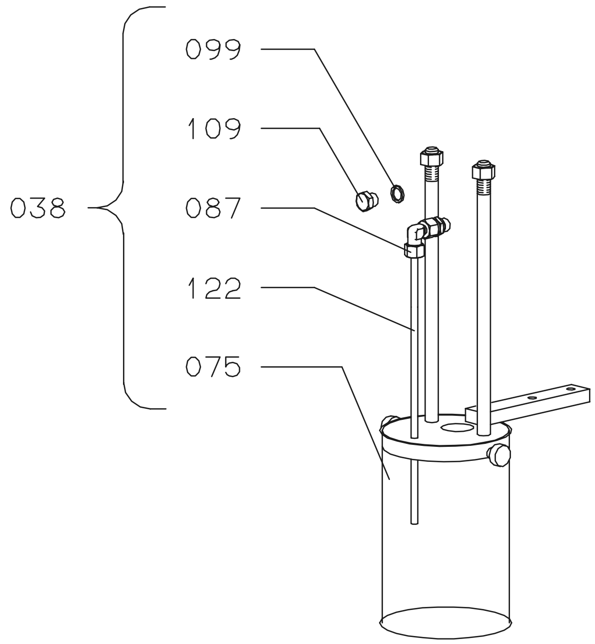
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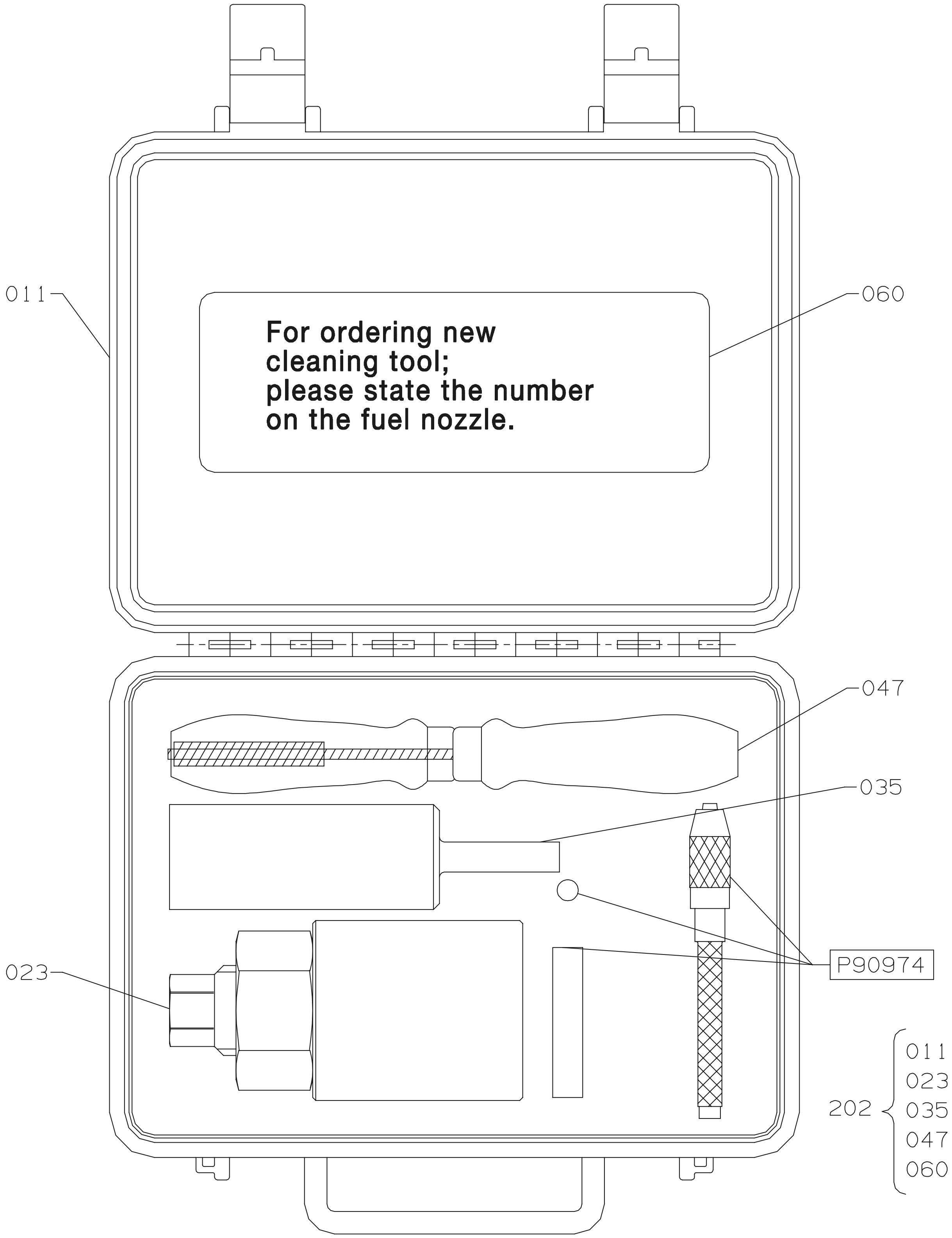
Fuel Valve - Tools

Item No.	Item Description
014	High-pressure pump
026	Table
038	Rig fuel oil valve
040	High-pressure hose
051	Connection piece, M42x2
063	Test rig, complete
075	Cover
087	Angle union
099	Gasket
109	Plug screw
122	Hose

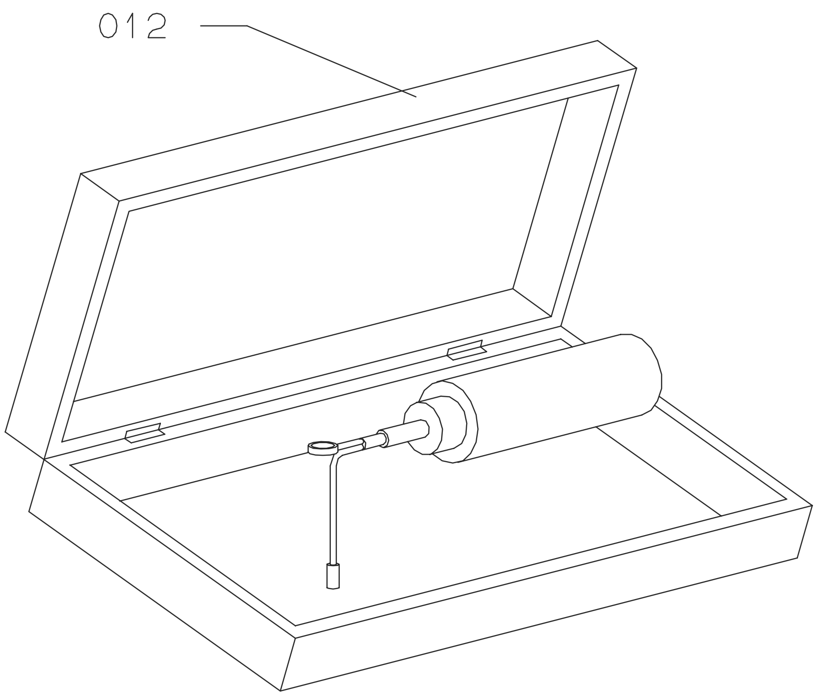
Item No.	Item Description


011
060
For ordering new
cleaning tool;
please state the number
on the fuel nozzle.
047
035
023
P90974
202
011
023
035
047
060

Fuel Valve Nozzle - Tools

Item No.	Item Description
011	Tool box
023	Extractor for atomizer
035	Drift for atomizer
047	Cleaning brush
060	Instruction plate
202	Toolset, complete
	Note:
	When odering new cleaning tool, please state P/N on fuel nozzle.

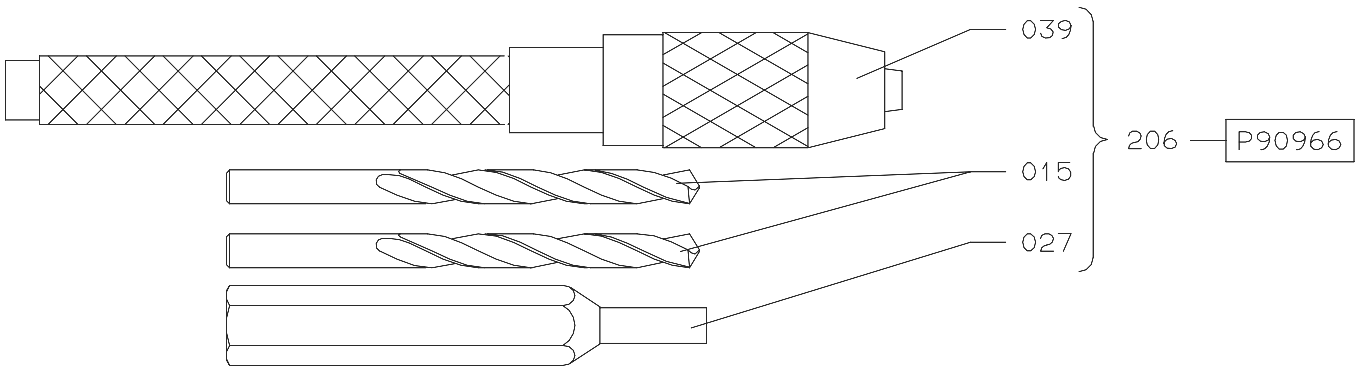
Item No.	Item Description


012

Fuel Valve - Inspection Tools

Item No.	Item Description
012	Probe light with magnifier, complete

Item No.	Item Description


039
206
P90966
015
027

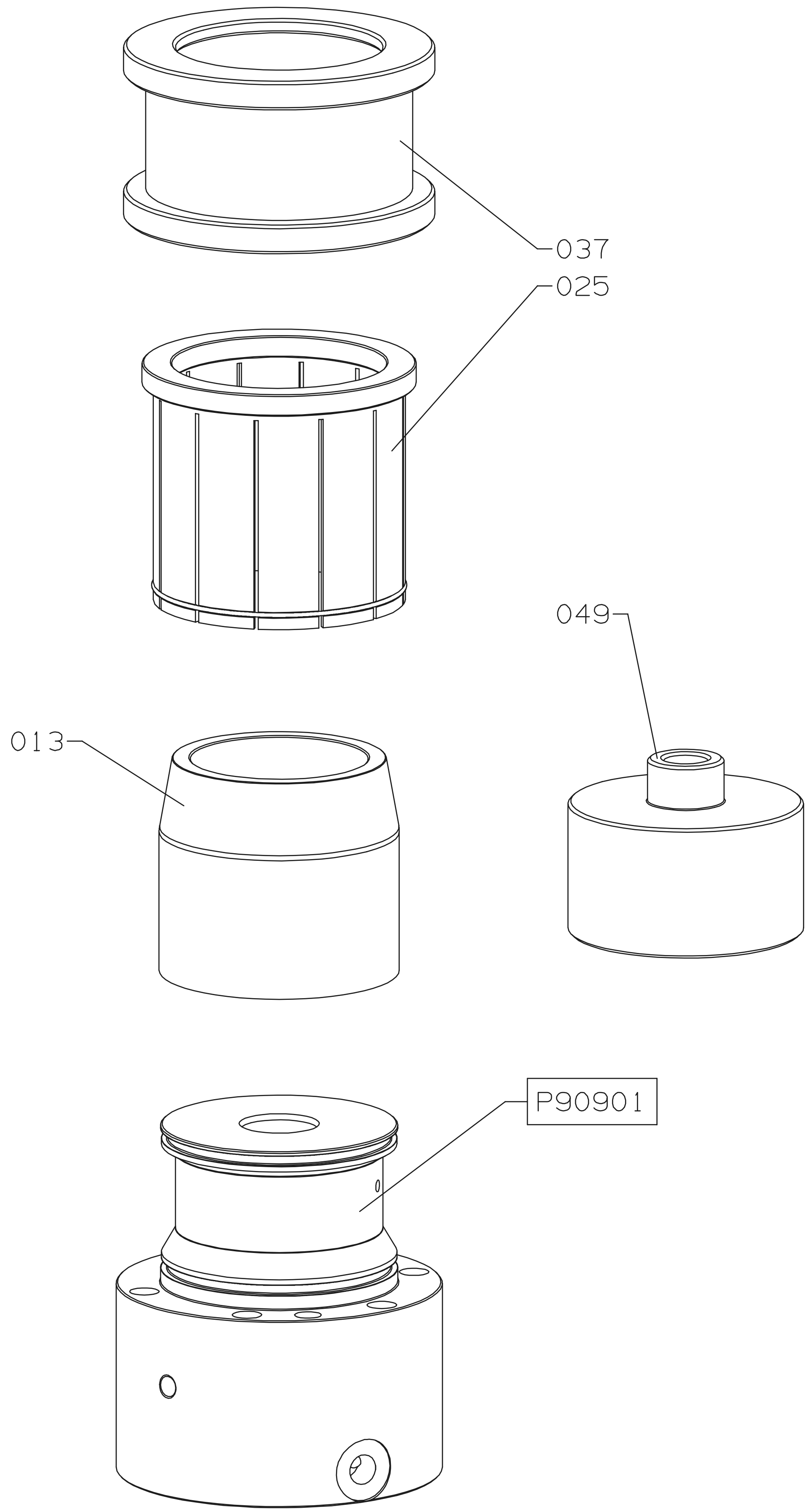
Fuel Valve Nozzle - Cleaning Tools

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


037
025
049
013
P90901

Mounting Tools - Top Cover Seals

Item No.	Item Description
013	Cone
025	Pushing tool
037	Compression tool
049	Spacer ring

910 - Turbocharger System

Documents in this Chapter

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

X	Stopped engine
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 with stopped lubricating oil pumps*
X	Engage turning gear
X	Shut off cooling water
	Shut off fuel oil
	Stop lubricating oil supply
	Lock the turbocharger rotors

Data

Ref.	Description	Value	Unit
D10-01	Bottom cover	350	kg
D10-02	Aft end cover	350	kg
D10-04	Air cooler element, complete with covers, up to	4000	kg
D10-13	Waste Heat Recovery Element	1650	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
P91063		Air Cooler - Tools
P91064		Travelling Trolley
P91066		Air Cooler - Lifting Tools
P91356		Lifting Tools, Etc.

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:

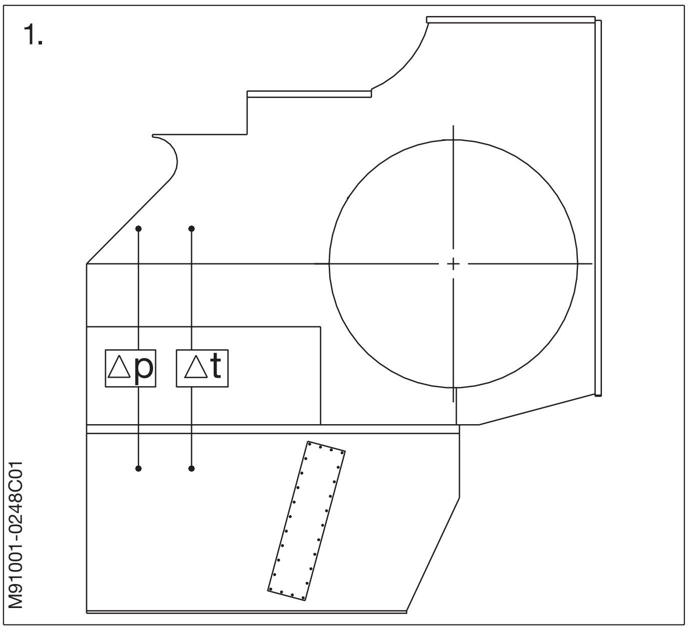
4. Remove the top inspection cover of the air cooler.

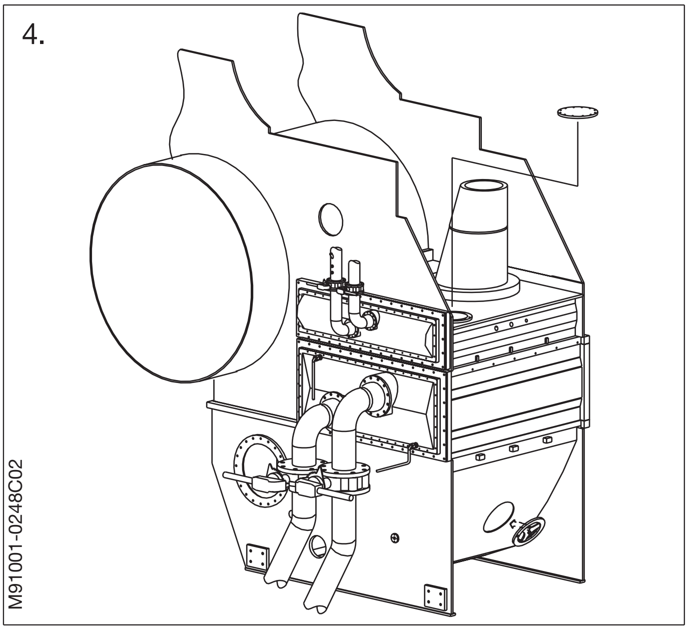
   Unlock and swing open the inspection hatch at the bottom of the air cooler.

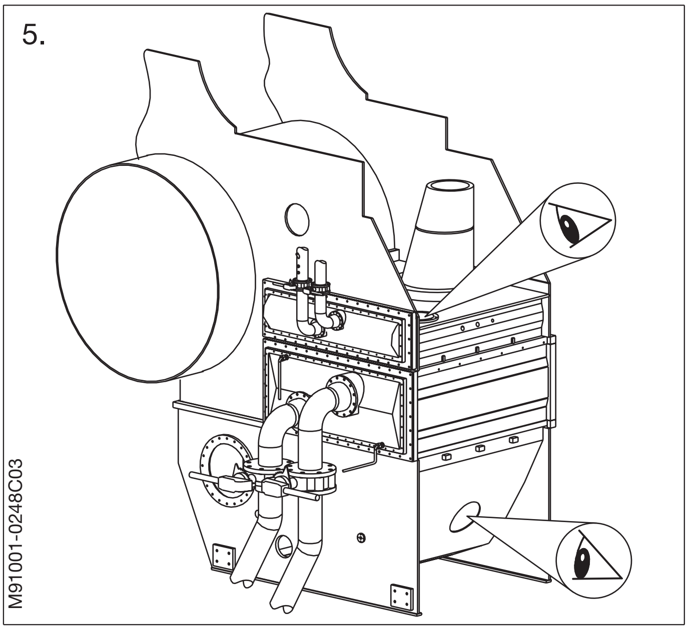
5. Visually inspect the air cooler element through the openings.

   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.*







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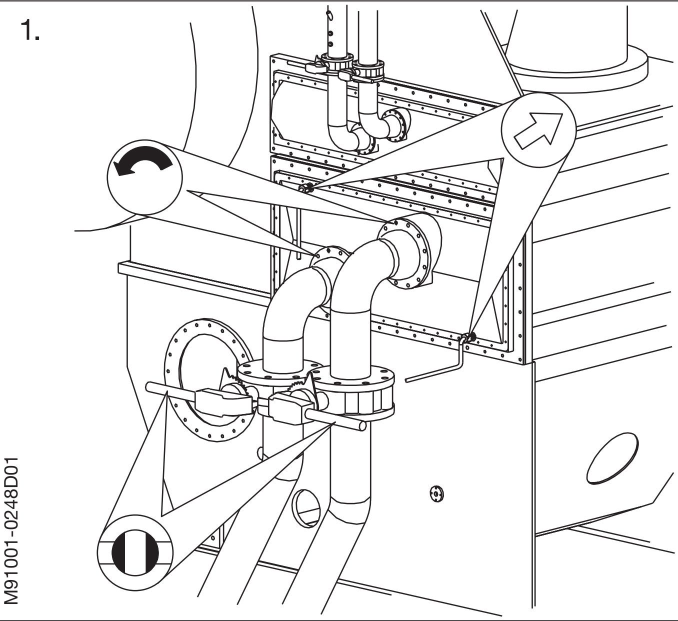

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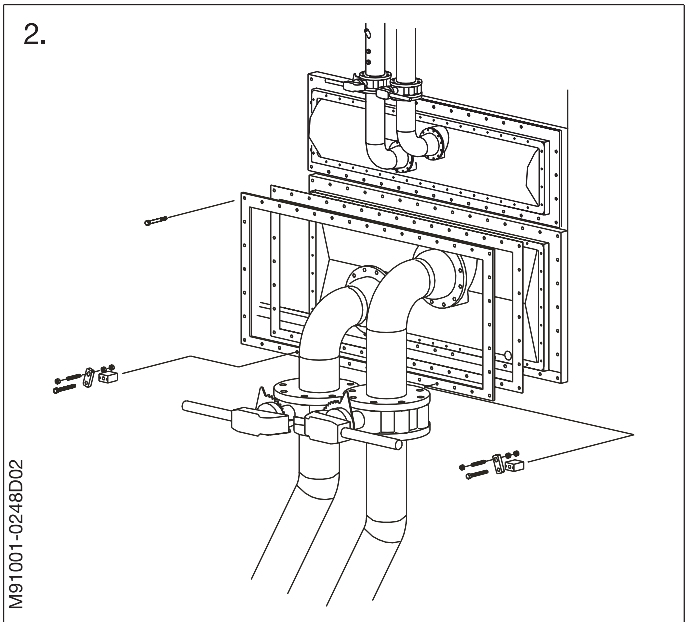

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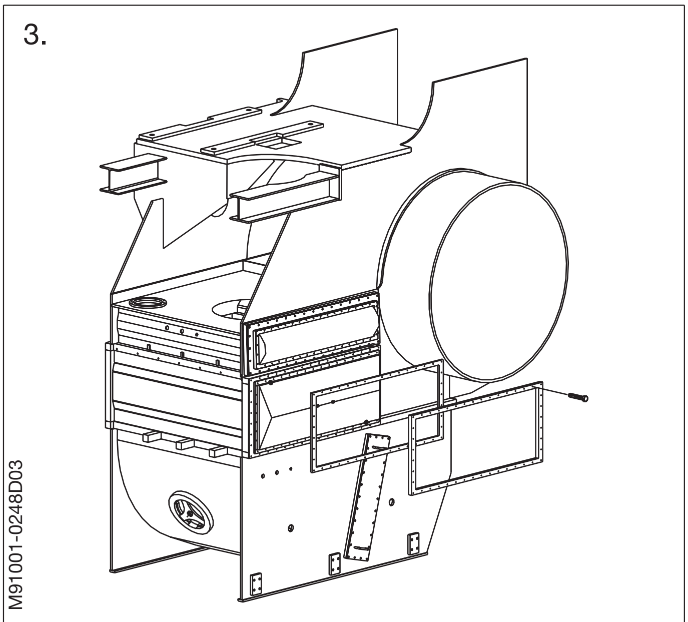


The cooler element normally does not need to be dismantled for inspection purposes. It is only in the event that the cooler element has suffered damage that it has to be dismantled and replaced.

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 and dismantle the drain pipes.

   Dismount the screws which fasten the cooling water inlet and outlet flanges to the aft end cover.

2. 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.

3. Dismount the sealing flanges around the front end cover.

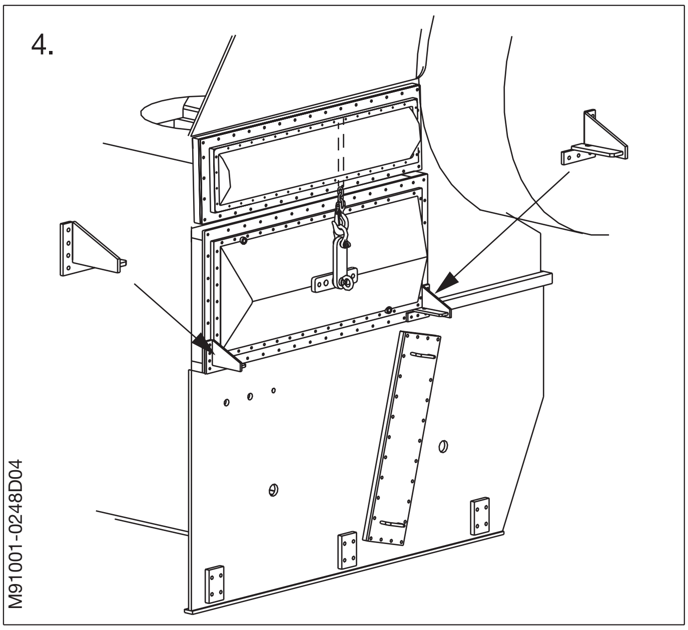
4. Mount the pair of guide rails on the front of the cooler housing. Mount the lifting bracket on the front end cover of the cooler element.

   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.

5. Mount the guide wheels on the aft end cover.

6. Mount a pair of guide rails on the rear end of the cooler housing.

4.



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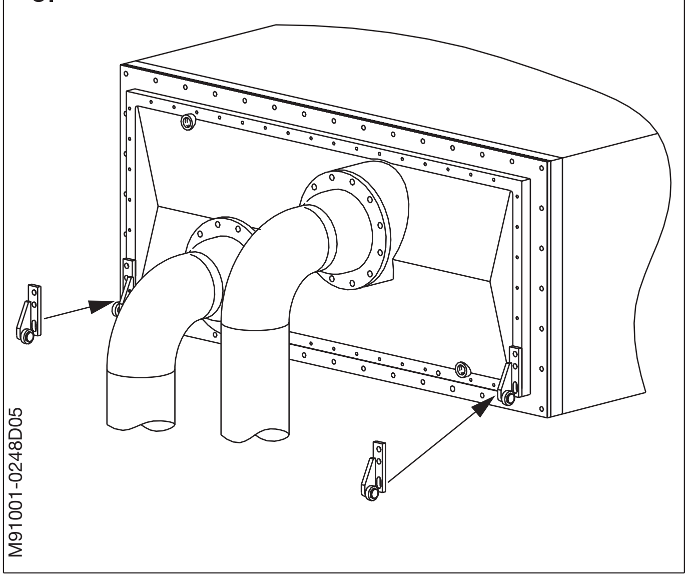

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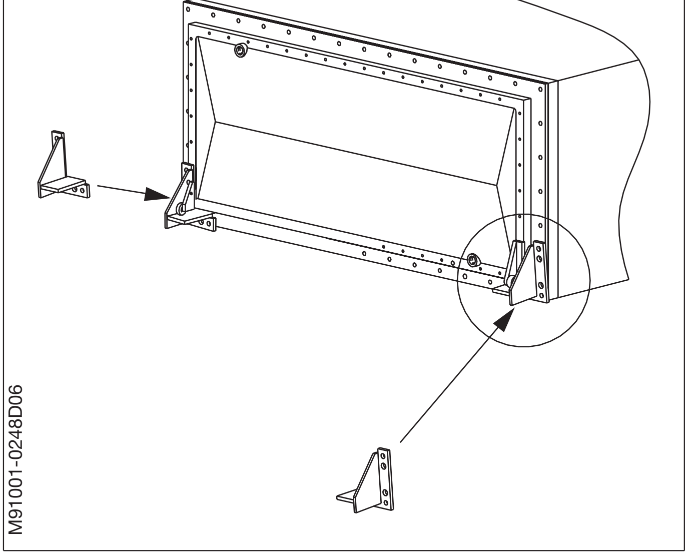
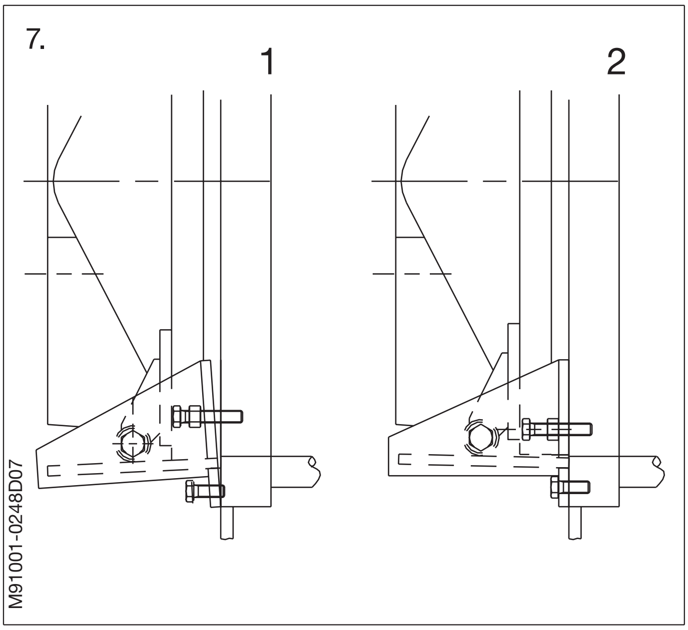
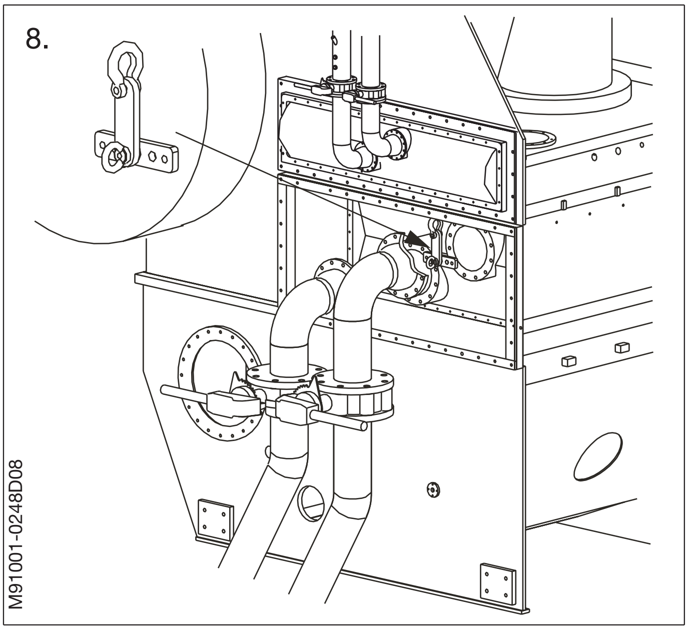
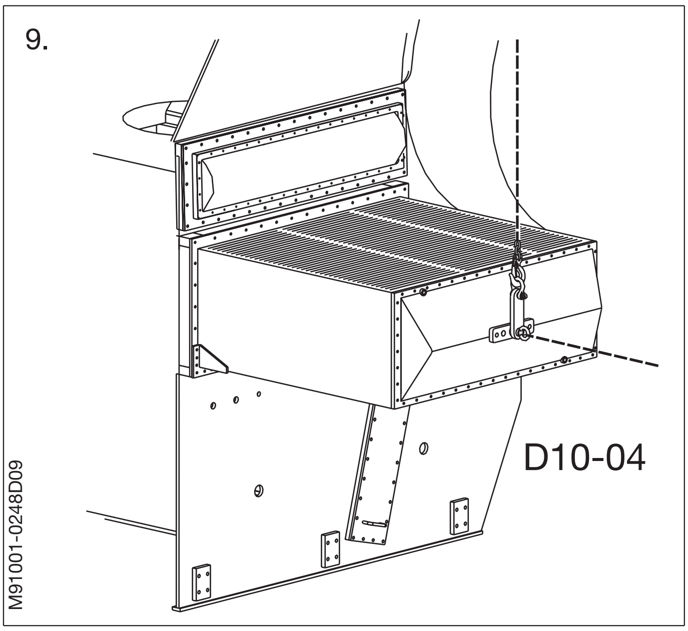








7. When mounting the guide rails, hold them up against the wheels of the cooler element and mount, but do not tighten, the lowermost screws. Mount and tighten the uppermost screws.

   Tighten the lowermost screws and the thrust nuts on the uppermost screws simultaneously. This results in loosening and lifting the cooler element.

8. 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.

9. 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.

10. Fit a tackle to the lifting bracket on the aft end cover and lift away the cooler element.

Note!
Depending on the engine and the engine room installation, it may be necessary to remove some pipes and floor plates.

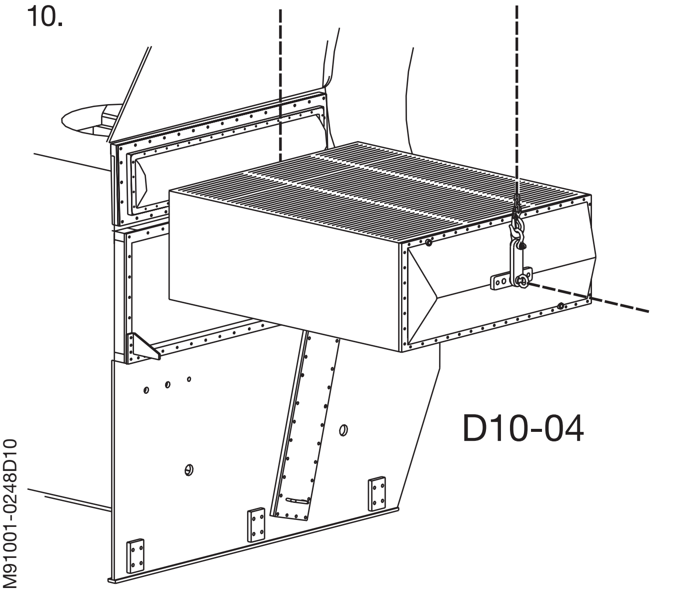
Waste Heat Recovery Element

11. Close the cooling water inlet and outlet valves. Open the drain cocks to drain off the cooling water.

12. Dismount the cooling water inlet and outlet pipes and the drain pipes from the aft end cover.

Note!
On some engines it may be necessary to remove the cooling water pipes of both waste heat recovery elelments to enable dismantling of the waste heat recovery element.

10.



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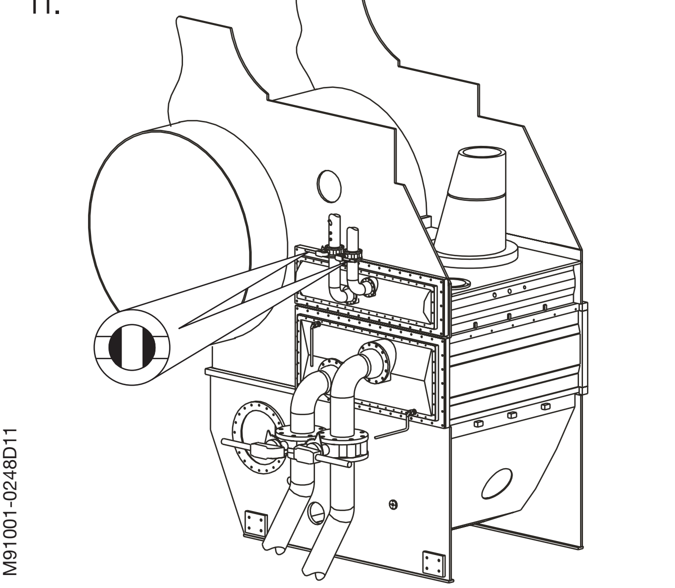

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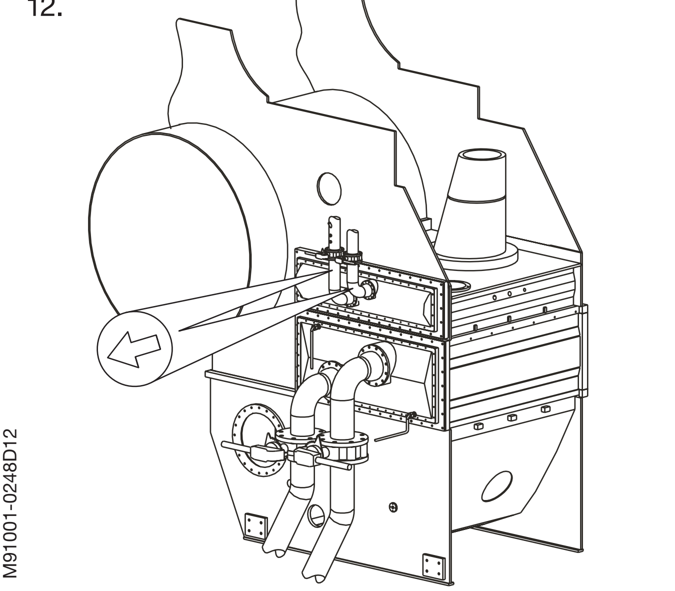
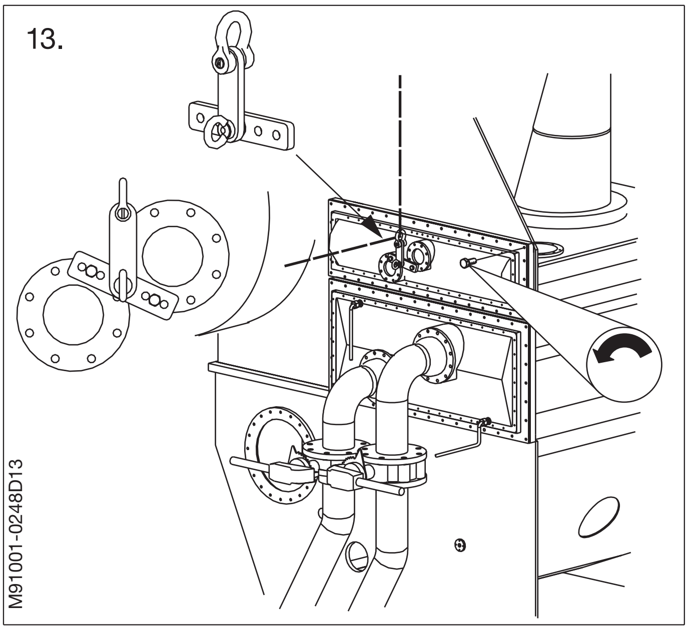




13. Remove the screws that fix the aft end cover to the air cooler housing.

Note!
Do **NOT** remove the screws that fix the alf end cover to the waste heat recovery element.

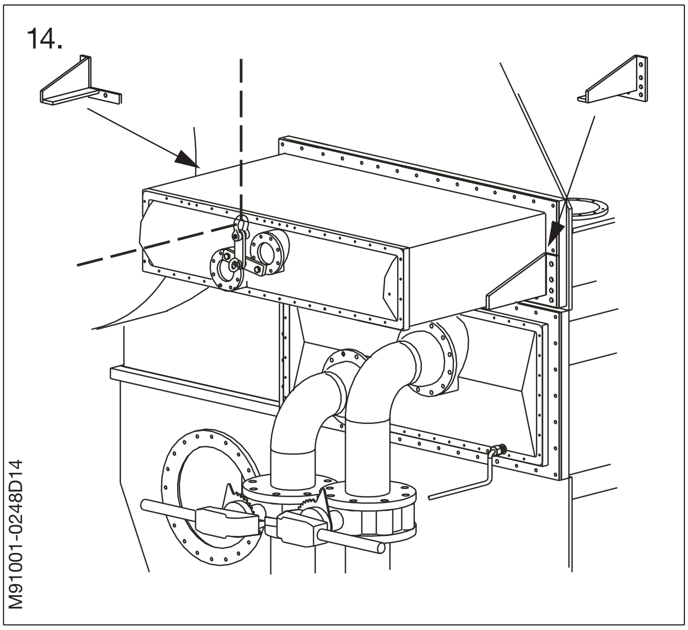
Mount the lifting bracket on the flanges of the aft end cover.

Note!
Due to the placement of the flanges, the lifting bracket must be mounted tilted, as shown on the sketch.

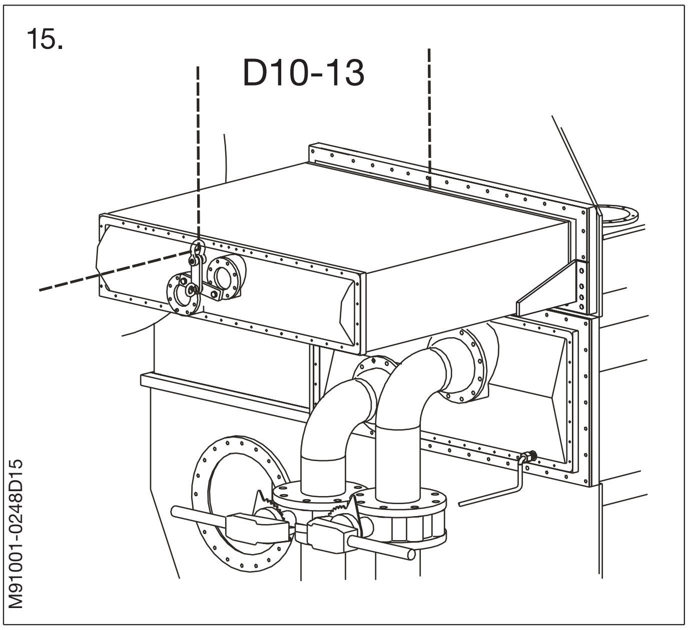
Hook a horizontally placed tackle on to the eye bolt of the lifting bracket.

If the engine is equipped with a beam above the air coolers, mount a travelling trolley on the beam and mount a tackle on the travelling trolley. If no beam is available, mount the tackle in a suitable point above the waste heat recovery element.

Hook the tackle on to the shackle of the lifting bracket, and lift the waste heat recovery element approx. 2-3 mm.



14. Using the horizontally placed tackle, pull out the waste heat recovery element approx. half a metre. Mount the guide rails on the frame around the waste heat recovery element.



15. Pull out the waste heat recovery element until the front of the waste heat recovery element becomes accessible.

Mount a wire rope and a lifting bracket on the front of the waste heat recovery element.

Hook a tackle on to the wire rope and lift the waste heat recovery element away from the engine. Land the waste heat recovery element on a couple of wooden planks.

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.

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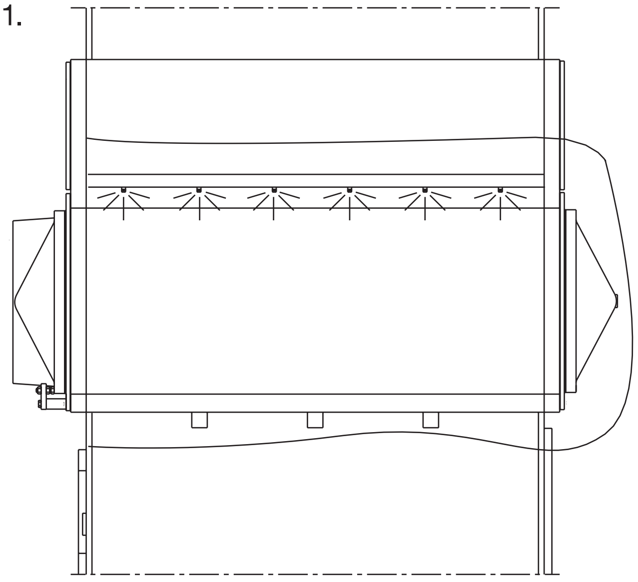

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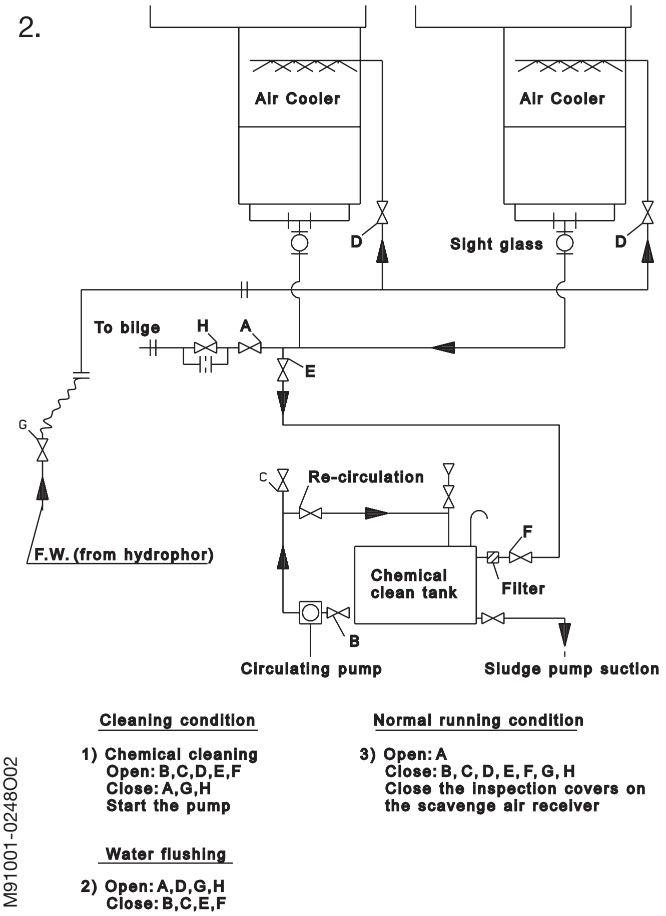

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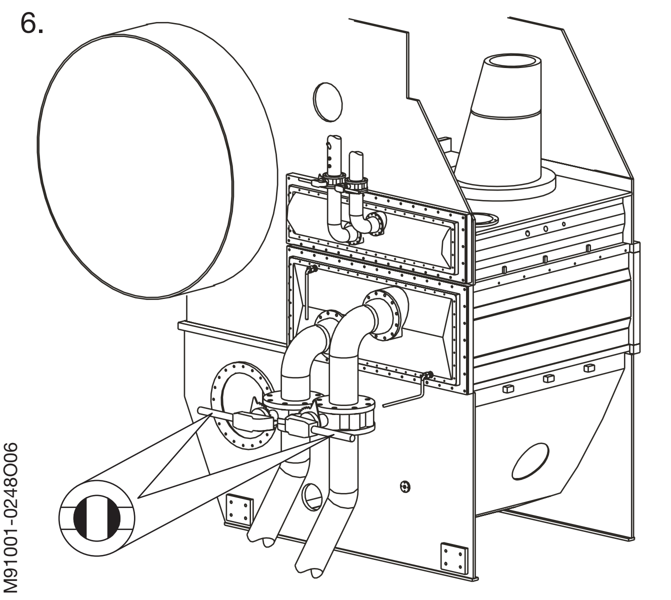

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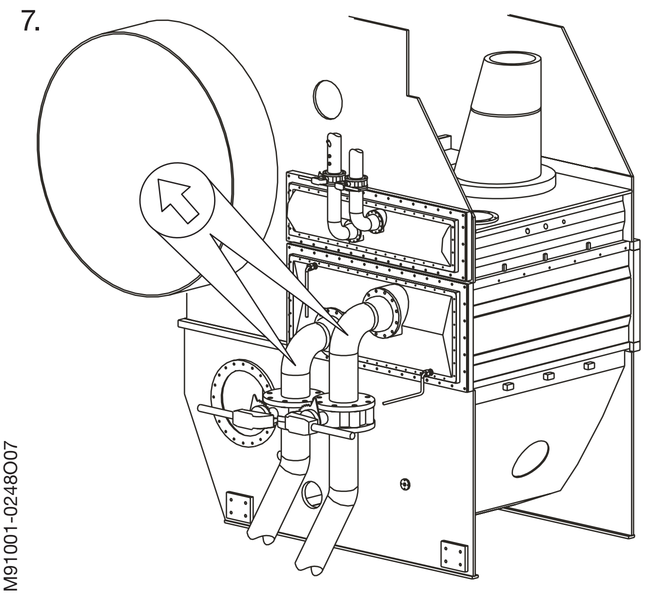

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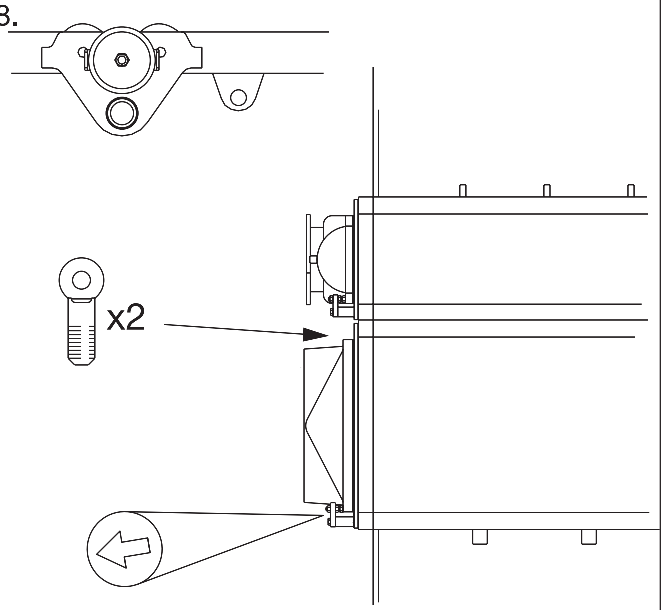

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Cleaning the water side:

Note!
As the cleaning of the water side is identical for the air cooler element and the waste heat recovery element, only the cleaning of the water side of the air cooler element will be described in this procudure.

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.

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 (supplied by the cooler element manufacturer) mounted on a drilling machine. In the event of leakages between cooling tube and tube plate, the tubes are rolled with the tube expander (also supplied by the cooler element manufacturer).

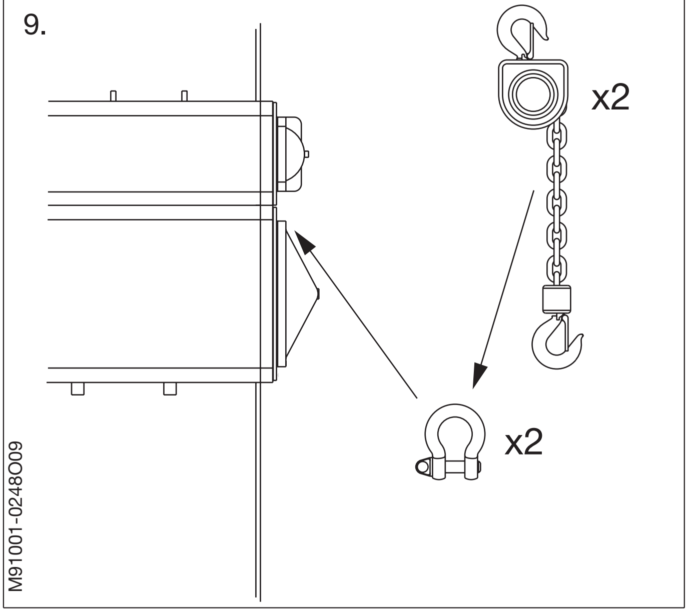
    Clean the front-end and aft-end covers inside with a stiff brush and then rinsed with fresh water.

    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.

9.



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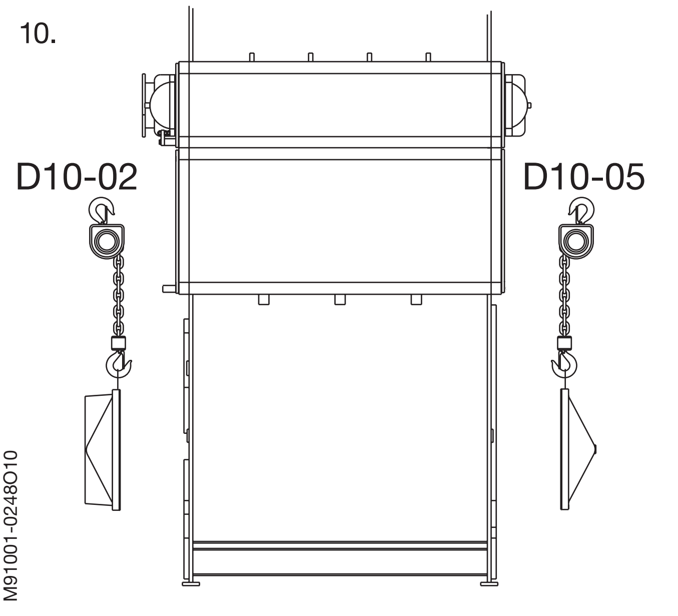

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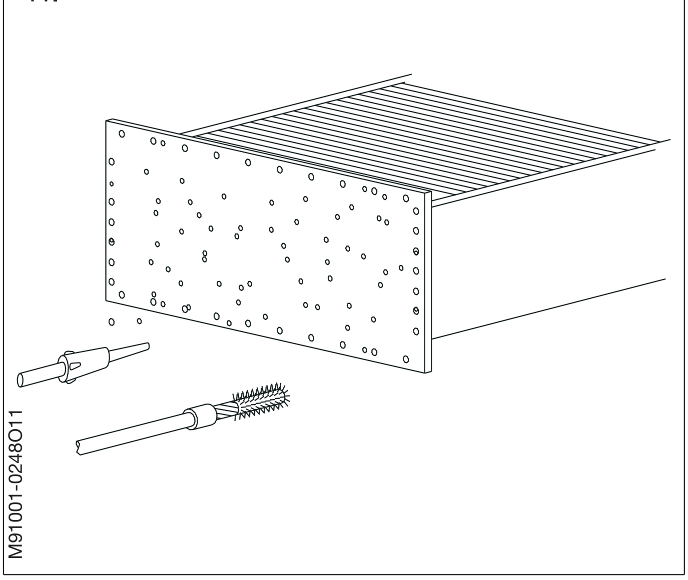
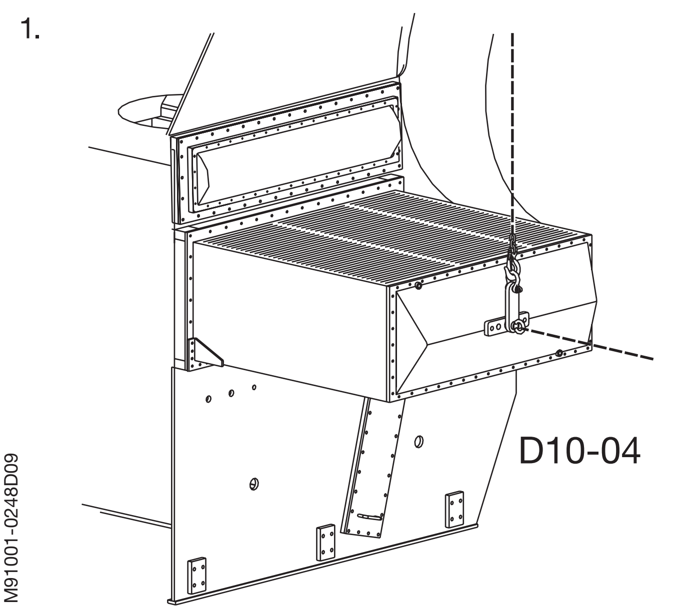
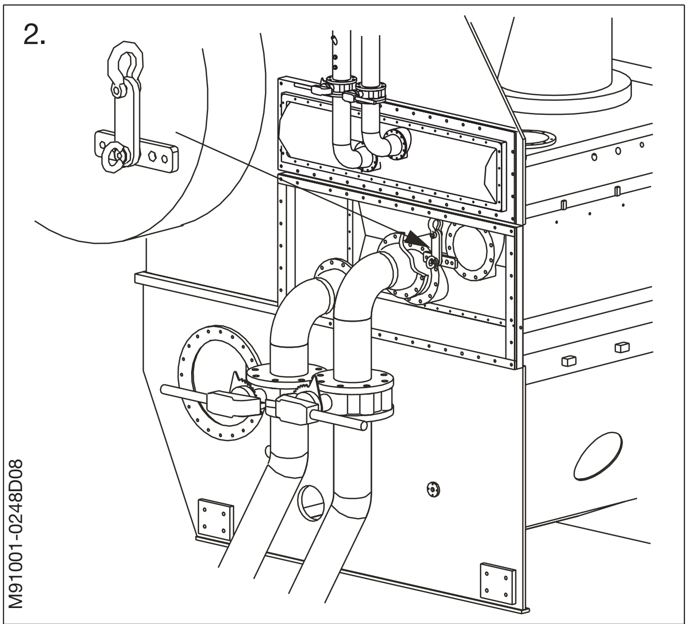
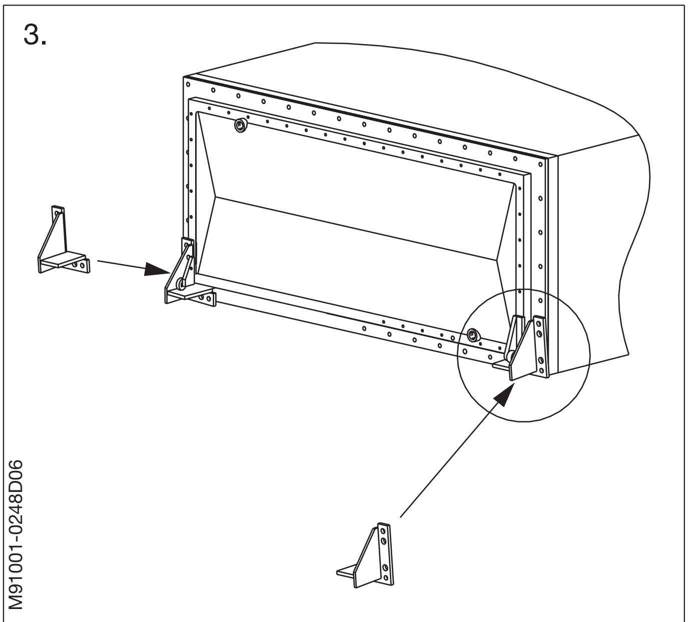








1. Lift the air cooler element and land the aft end of the element on the guide rails mounted on the front end of the air cooler housing.

   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

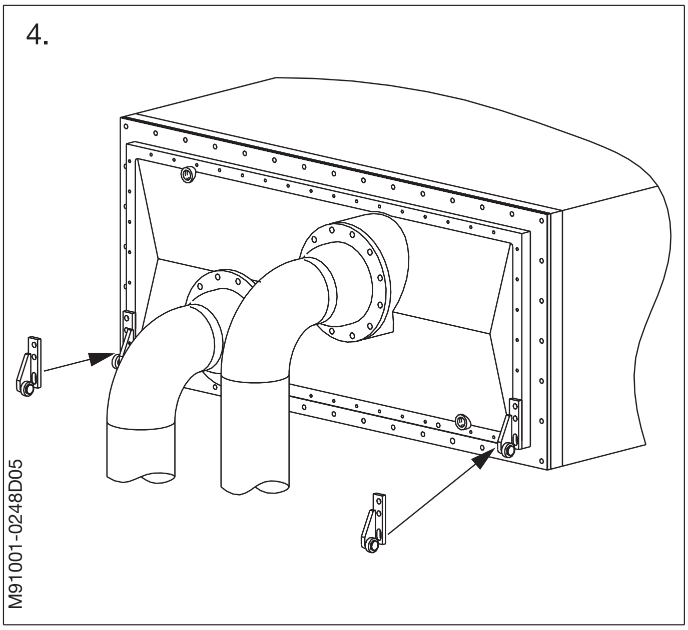
   Remove the guide rails from the aft end of the air cooler housing.

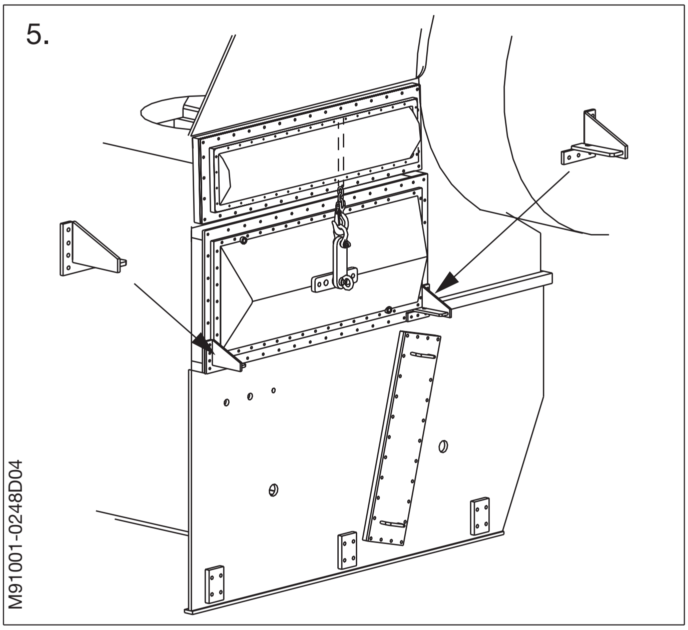
Note!
Before pushing the air cooler element fully in, make sure that the sealing flanges and a new O-ring are in position, hanging on the cooling water pipes.

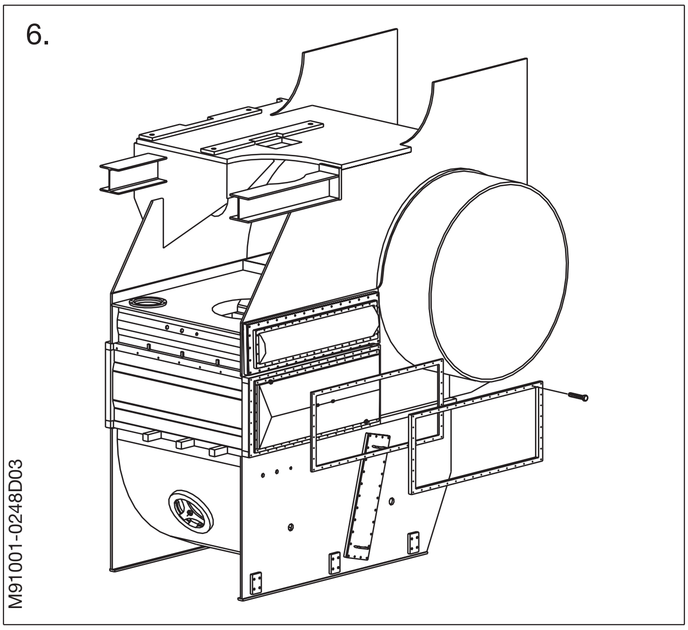
4. Remove the guide wheels from the aft end cover.

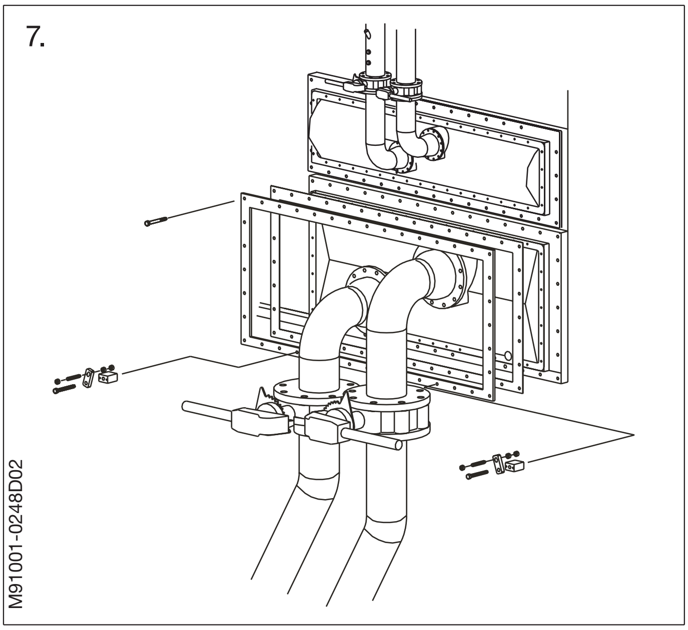
5. Remove the guide rails and the lifting bracket from the front end cover.

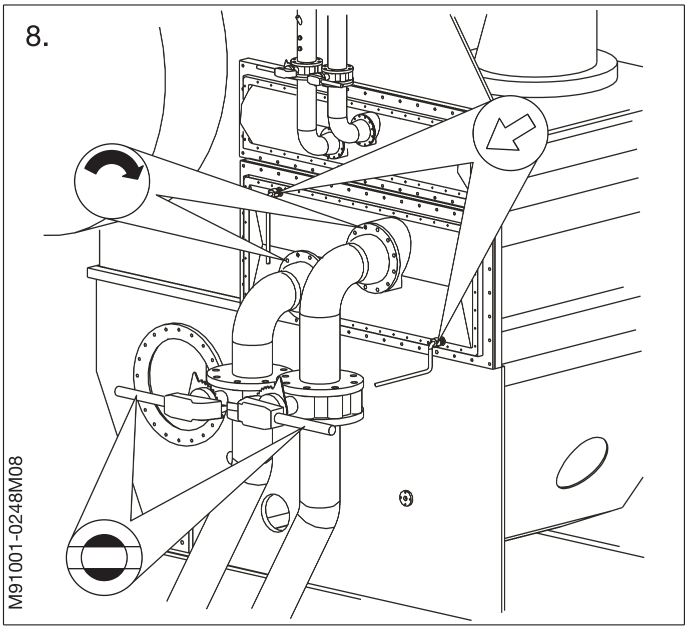
6. Mount the sealing plate, a new O-ring and the frame around the front end cover.











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.

Waste Heat Recovery Element:

9. Lift the WHR element and land the front end of the element on the guide rails mounted on the aft end of the air cooler housing.

10. Remove the tackle, the wire rope and the lifting bracket from the front end of the element.

11. Push the WHR element inwards approx. one metre.

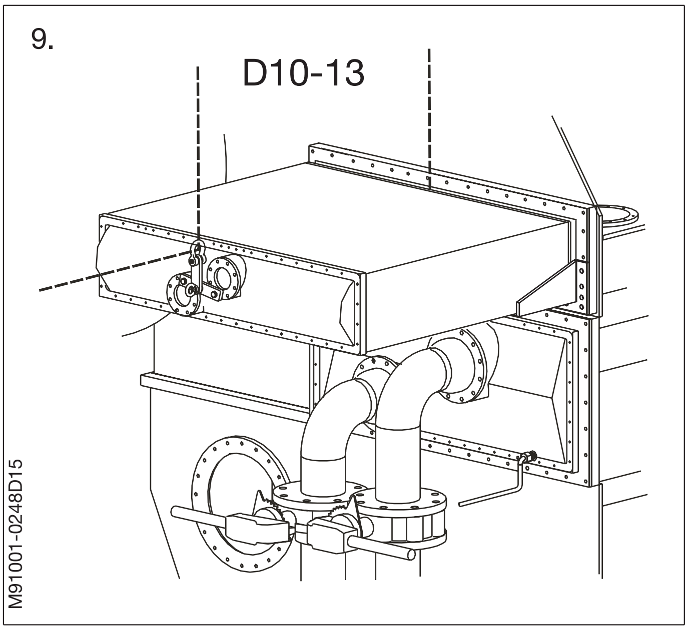
    Remove the guide rails.

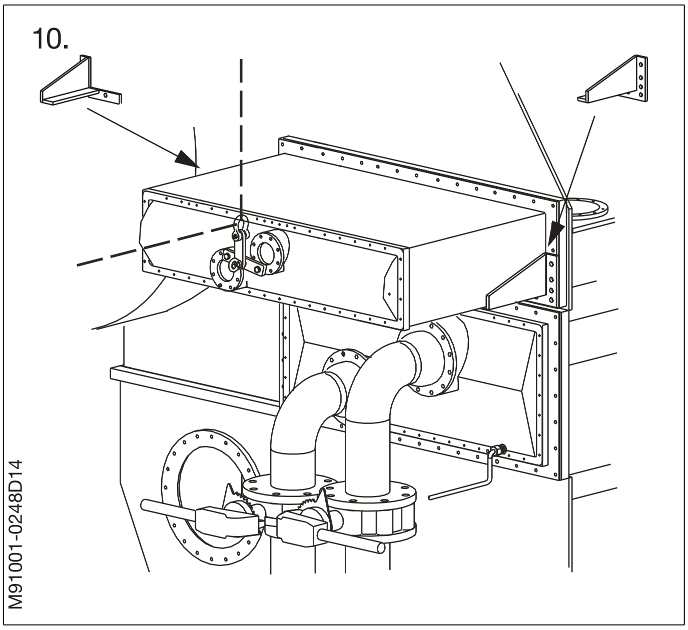
12. Clean the frame around the air cooler element and the contact surface of the aft end cover.

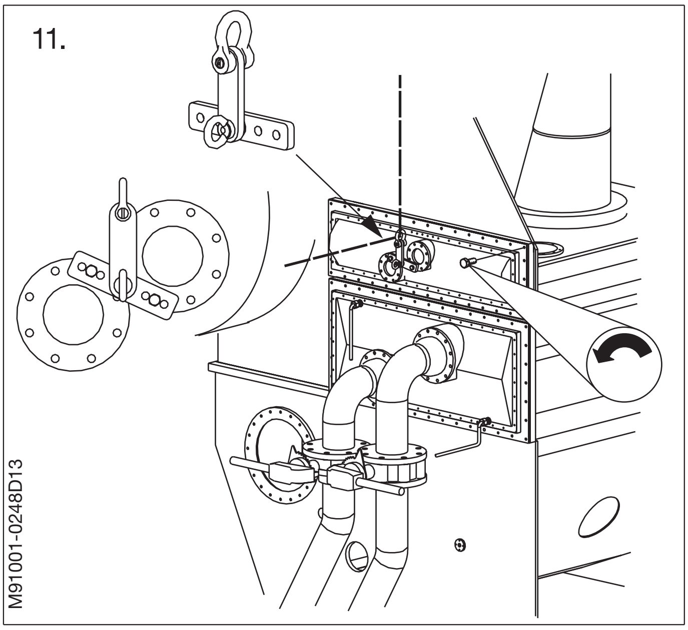
    Apply a thin layer of silicone paste to the frame around the air cooler element and the contact surface of the aft end cover.

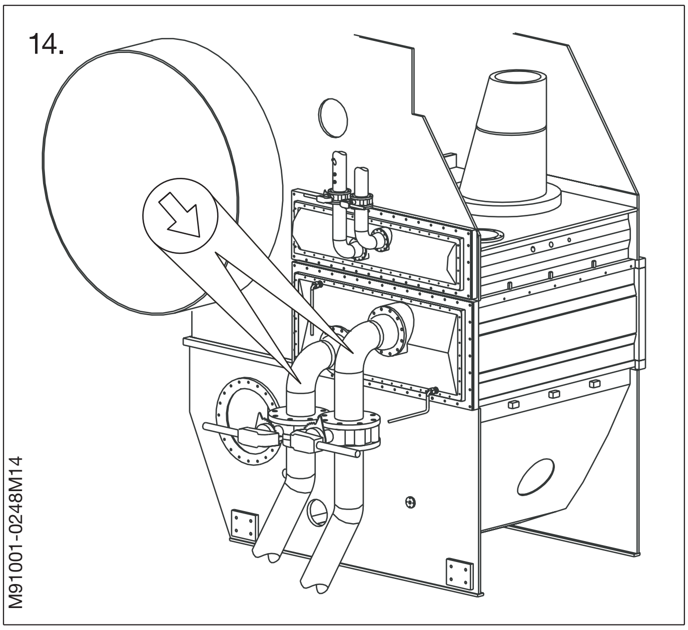
13. Push the air cooler element fully into the air cooler housing.

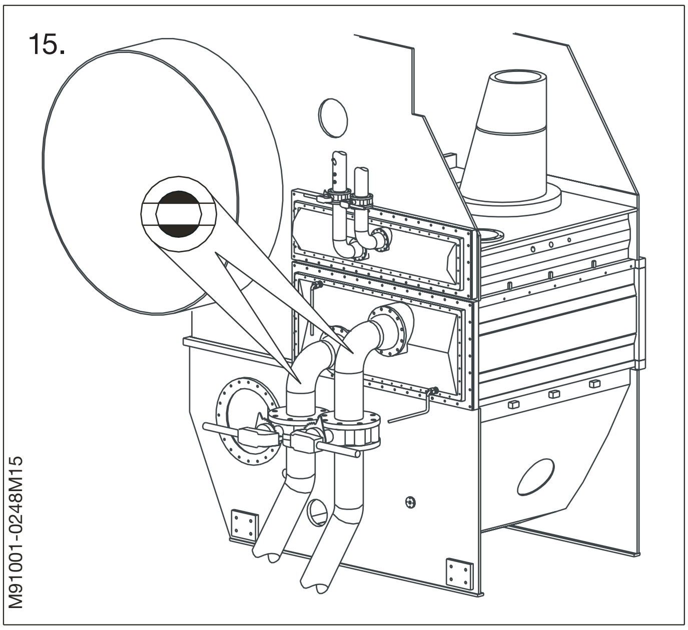
    Remove the tackle and the lifting bracket from the aft end cover.











14. Lift the front end cover into position and mount it on the frame around the air cooler element.

    Remove the tackles and shackles.

15. Mount the cooling water inlet and outlet pipes and the drain pipes on the aft end cover.

16. Close the drain cocks and open the cooling water inlet and outlet valves.

Note!
Remember to vent trapped air from the air cooler element.

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

X	Stopped engine
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 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

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

X	Stopped engine
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 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
D10-12	Electric motor, impeller and motorplate	900	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.

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

X	Stopped engine
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 with stopped lubriating 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

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 lubriating 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

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

X	Stopped engine
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 with stopped lubriating 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
D10-11	Water mist catcher	440	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.

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.

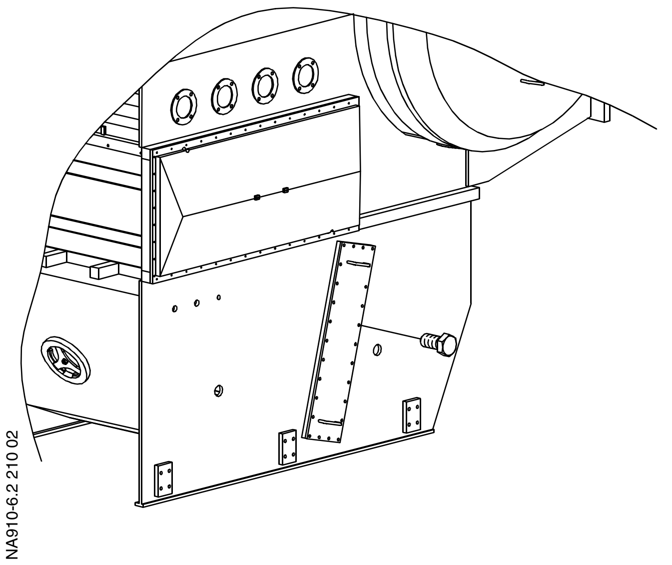
4. Pull the water mist catcher half way out and screw a lifting eye bolt into the top of the water mist catcher.

   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.

2.



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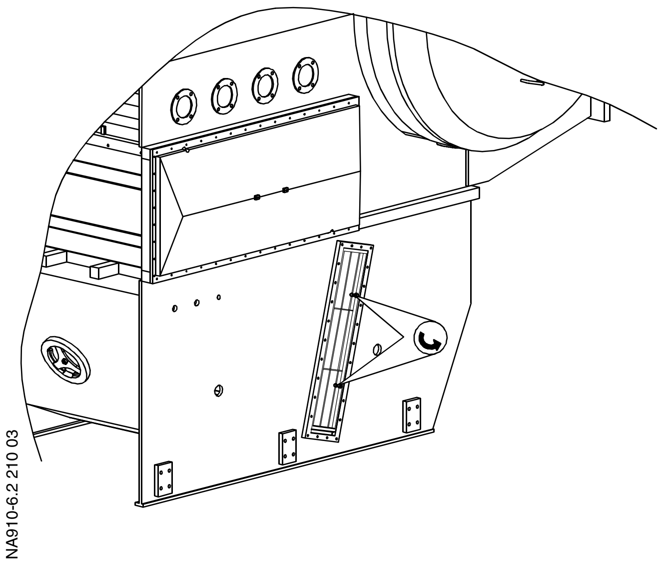

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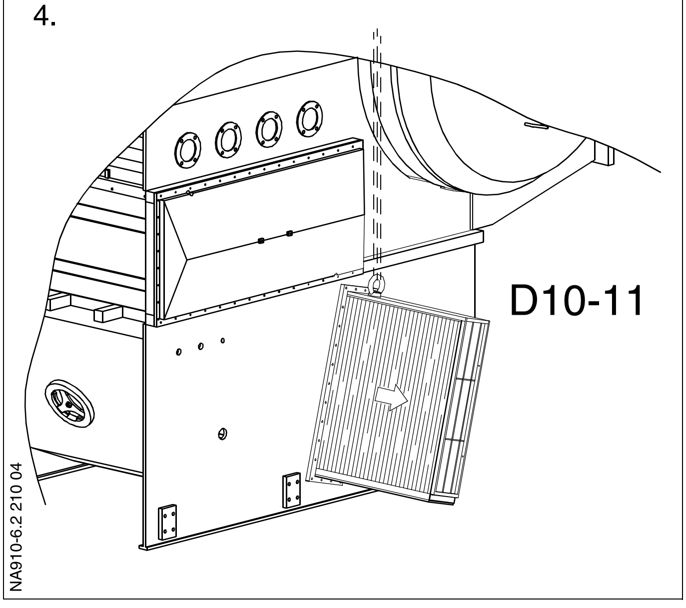
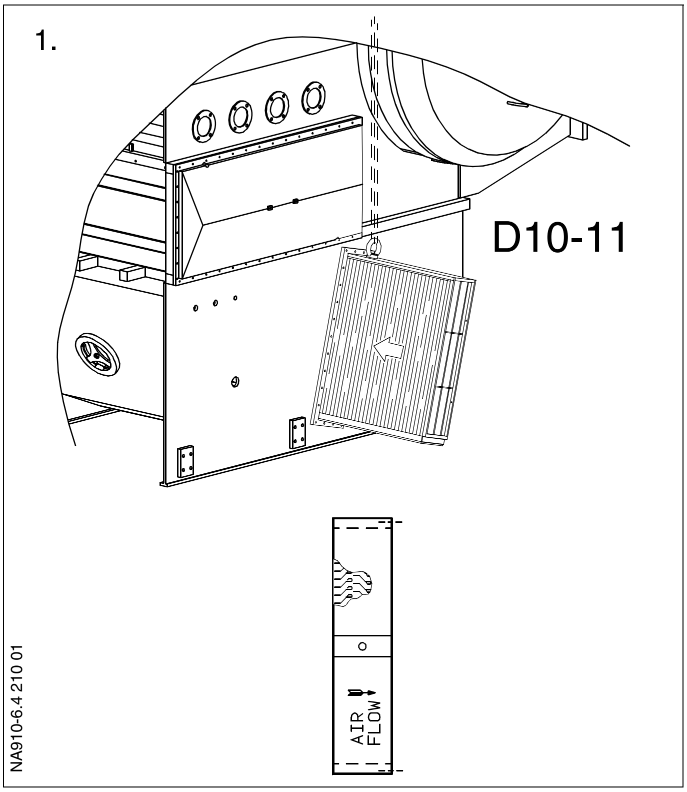
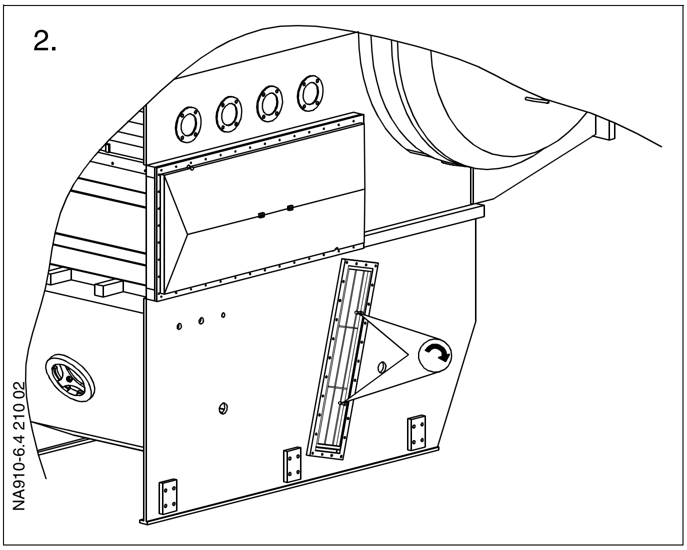
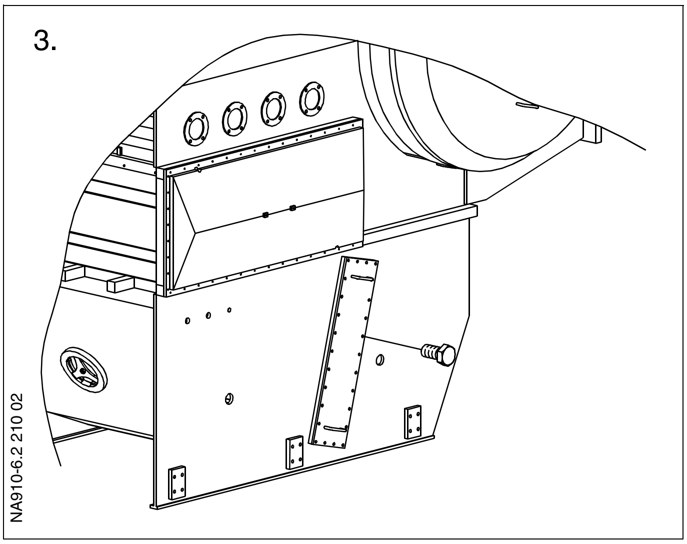








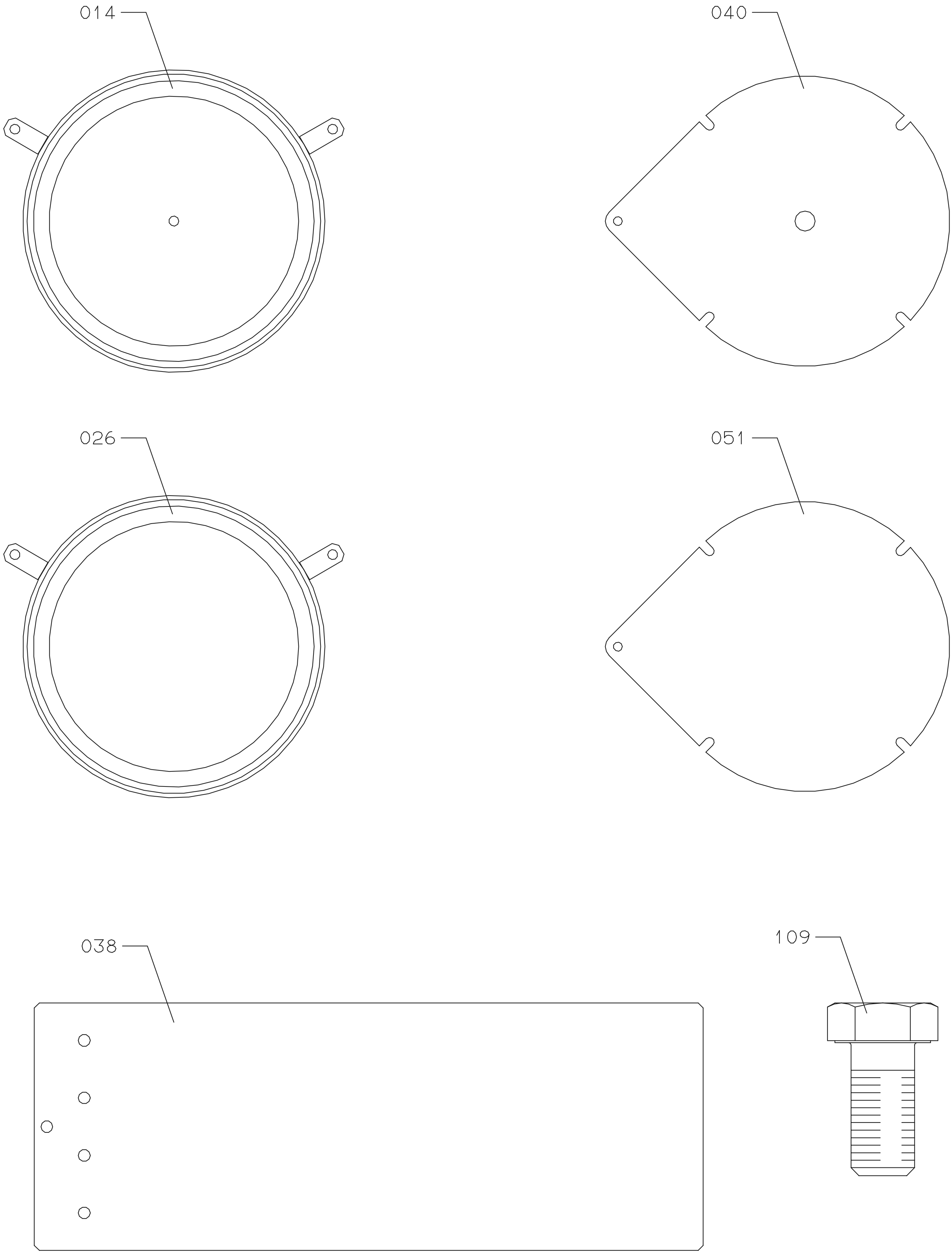
1. Tilt the water mist catcher to the correct angle and slide it into the scavenge air cooler housing.

Note!
Make sure the water mist catcher is mounted in the right direction. Check the air flow indicator on the water mist catcher.

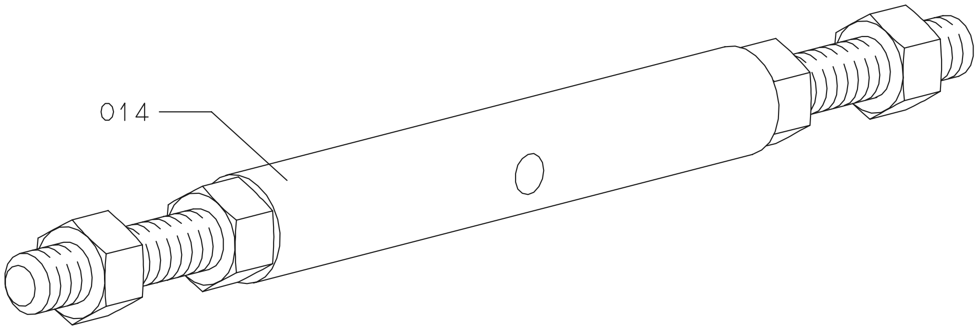
   When the water mist catcher is half-way in, remove the tackle and the eye bolt, and push the water mist catcher fully into the air cooler housing.

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.


014
040
026
051
038
109

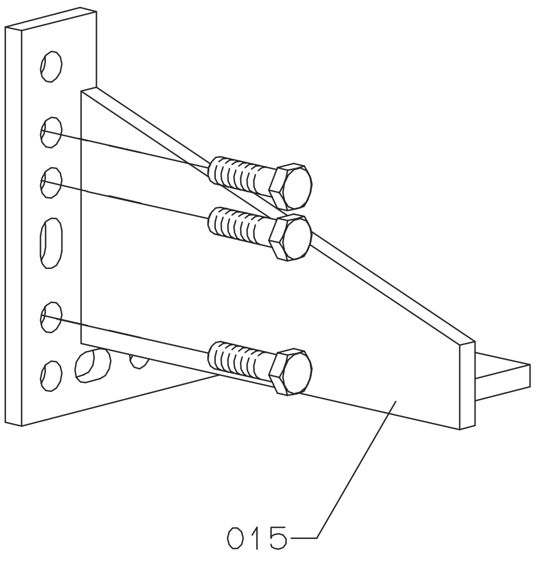
Item No.	Item Description	Item No.	Item Description
014	Throttle plate		
026	Blank plate		
038	Blind plate after turbocharger		
040	Throttle plate		
051	Blank plate		
109	Screw		

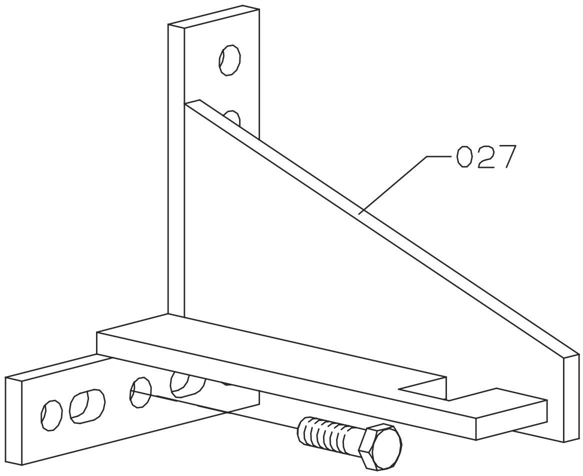

014


026

Item No.	Item Description	Item No.	Item Description
014	Pulling tool		
026	Lifting eye bolt		

Fore end

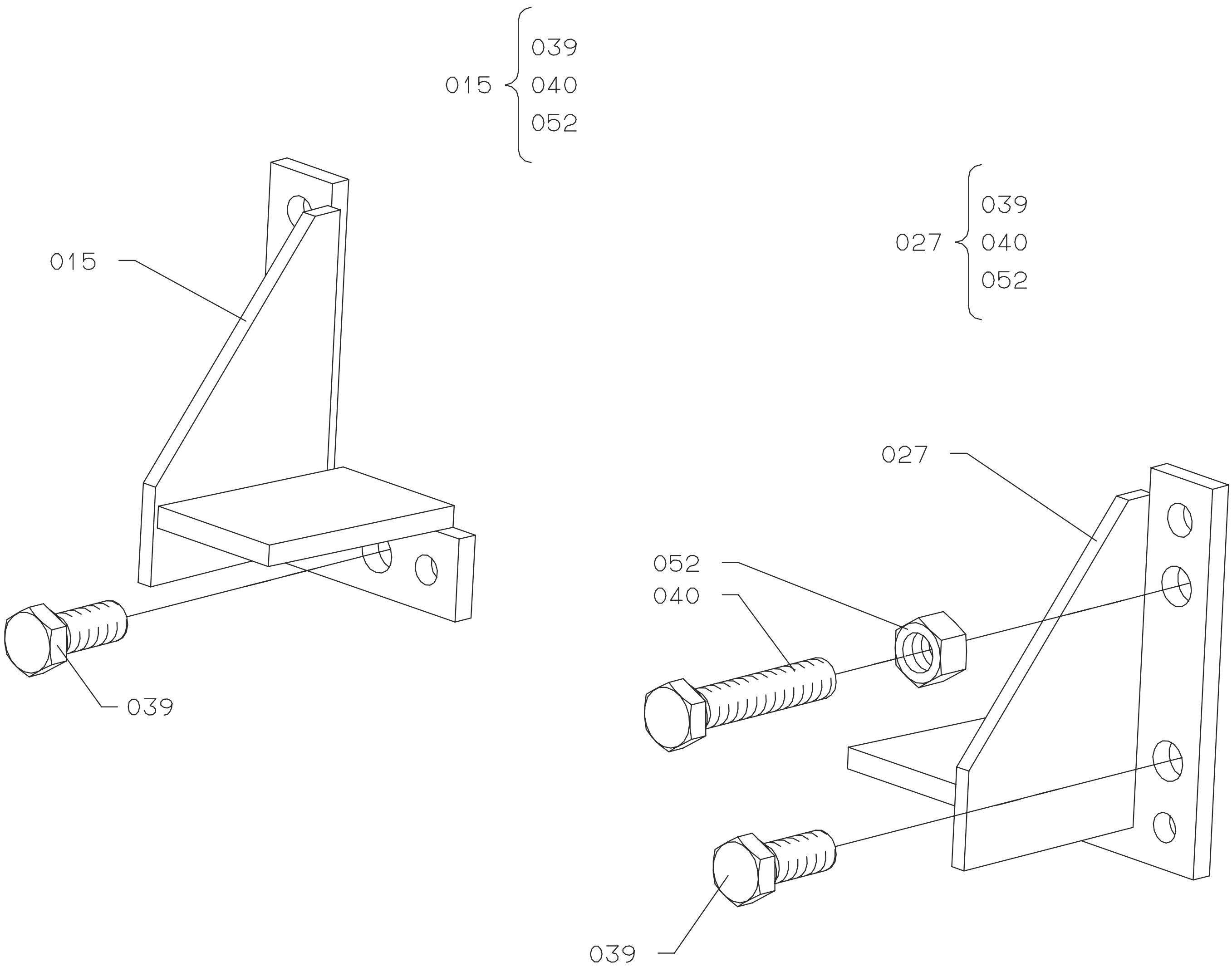




Item No.	Item Description
015	Guide rail, air cooler fore end
027	Guide rail, air cooler fore end

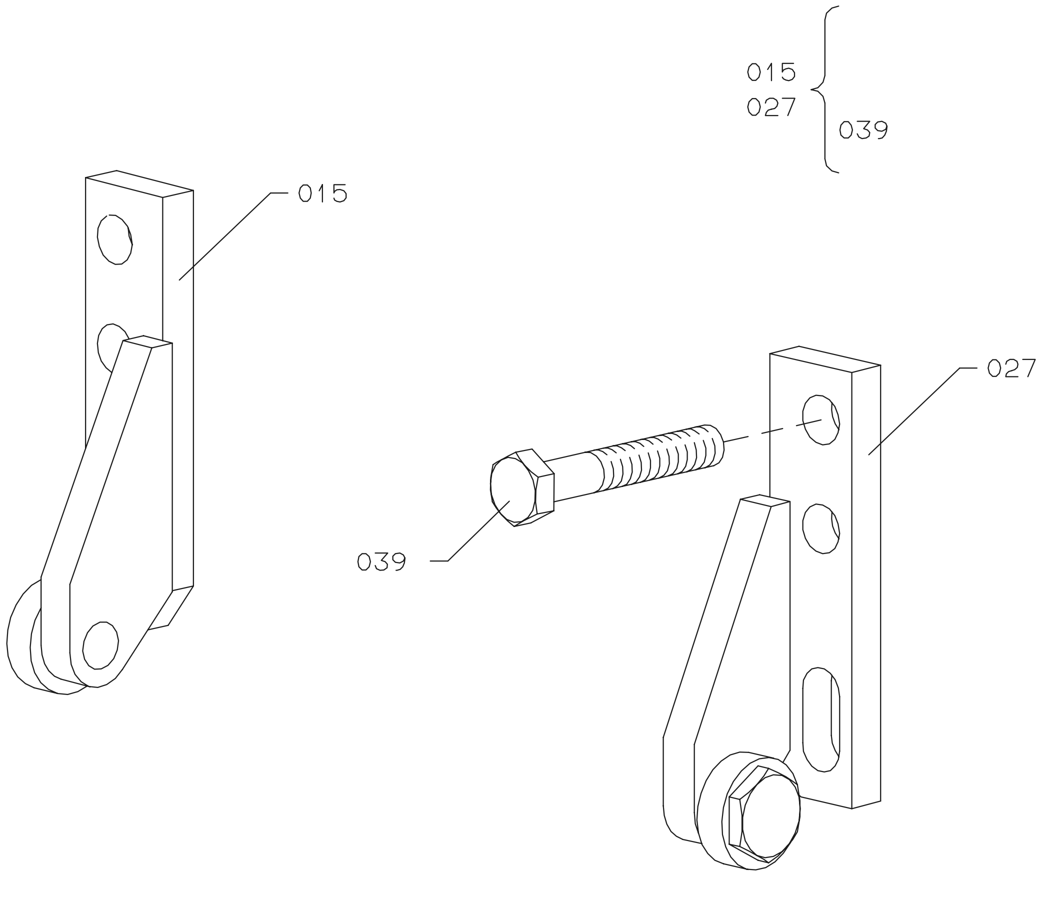
Item No.	Item Description

Rear end



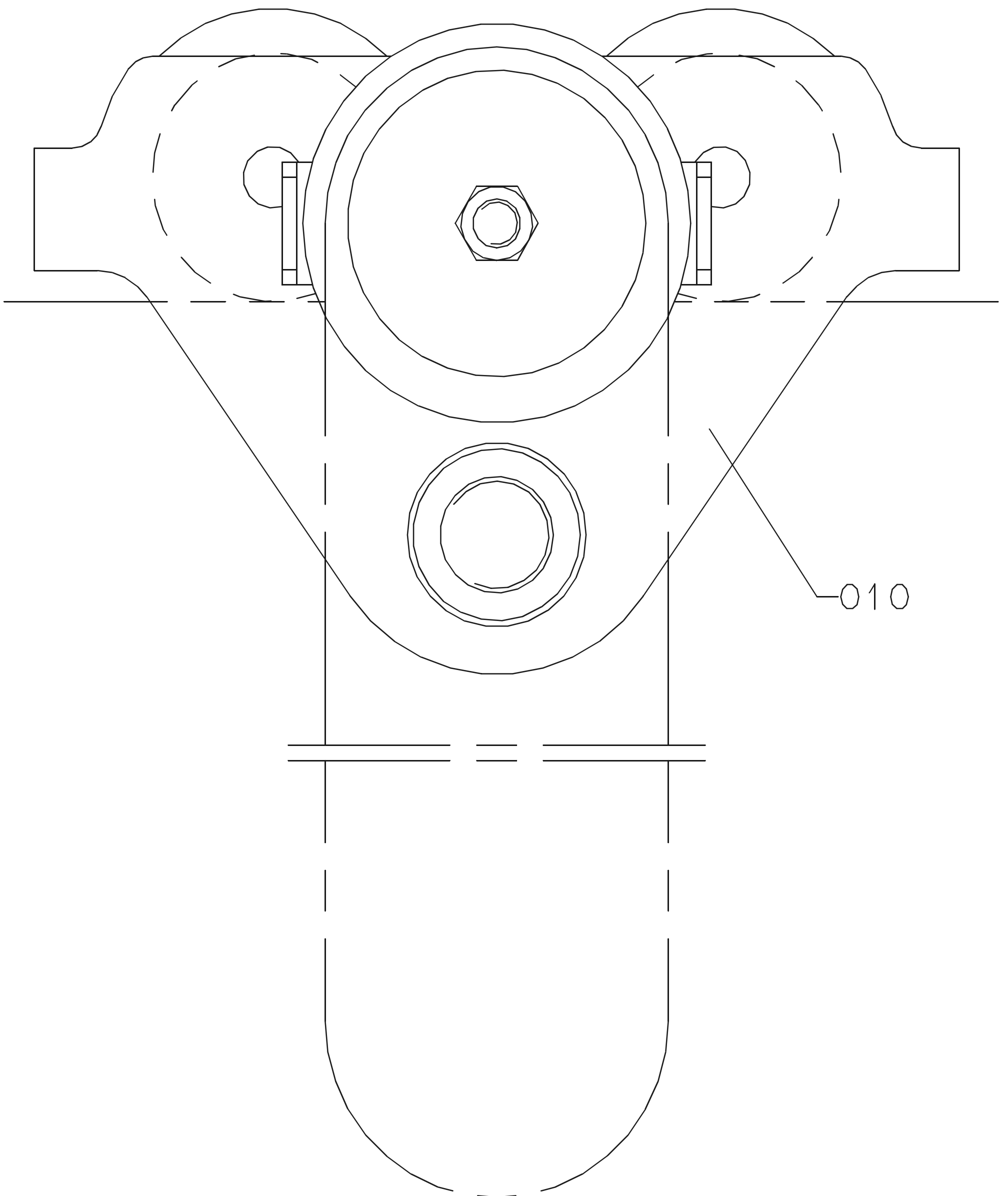
Item No.	Item Description
015	Guide rail, rear end
027	Guide rail, rear

Item No.	Item Description



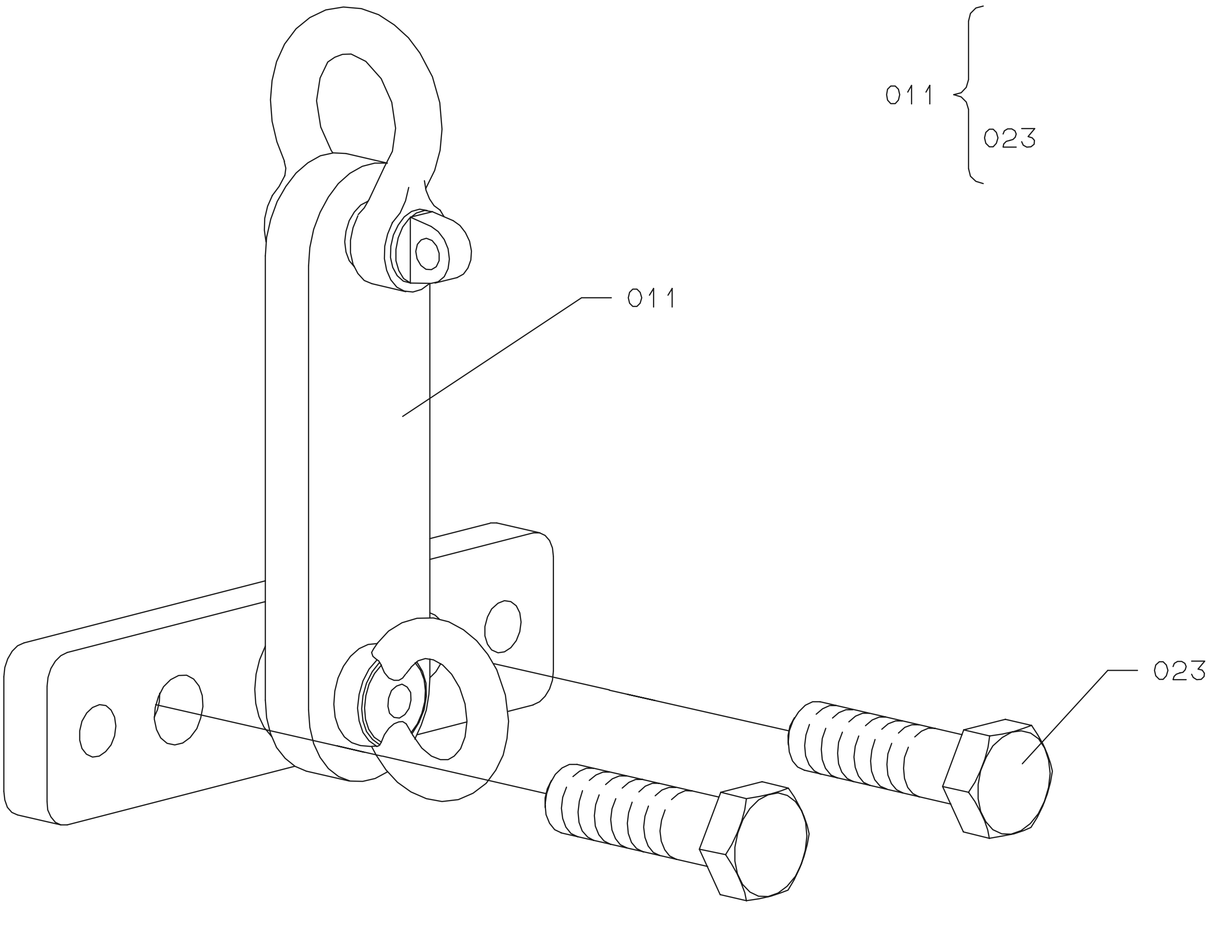
015
027
039
015
027
039

Item No.	Item Description	Item No.	Item Description
015	Wheel for air cooler, left		
027	Wheel for air cooler, right		
039	Screw		


010

Travelling Trolley

Item No.	Item Description
010	Travelling trolley


011
023
011
023

Item No.	Item Description	Item No.	Item Description
011	Lifting attachment air cooler		
023	Screw		

911 - Safety Equipment

Documents in this Chapter

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

X	Stopped engine
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 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
D11-01	Opening pressure	200± 5	bar
D11-02	Valve housing, tightening torque	45	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
P91351	10	Hydraulic pump, pneumatically operated
P91351	58	Hose with unions (3000 mm), complete
P90151	117	Test equipment for combined safety valve
P91359		Torque Spanners

When Side-mounted

1. Remove the guard surrounding the safety valve.

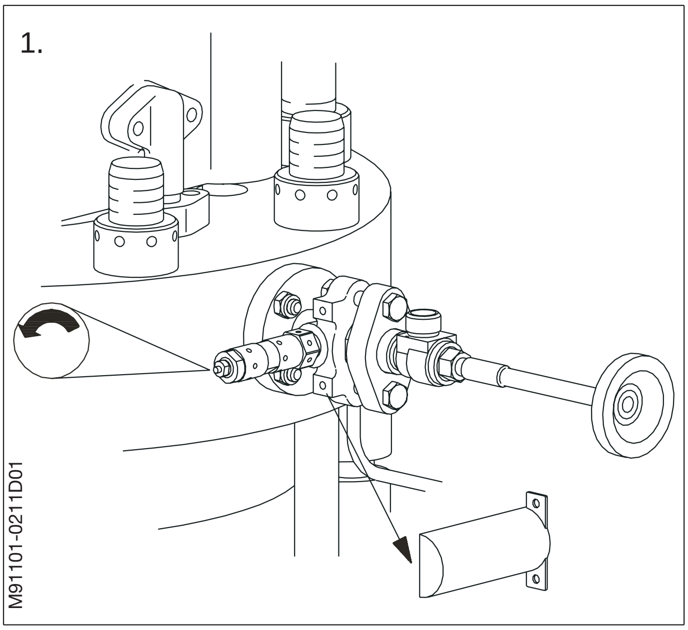
   Unscrew the safety valve from the extension pipe.

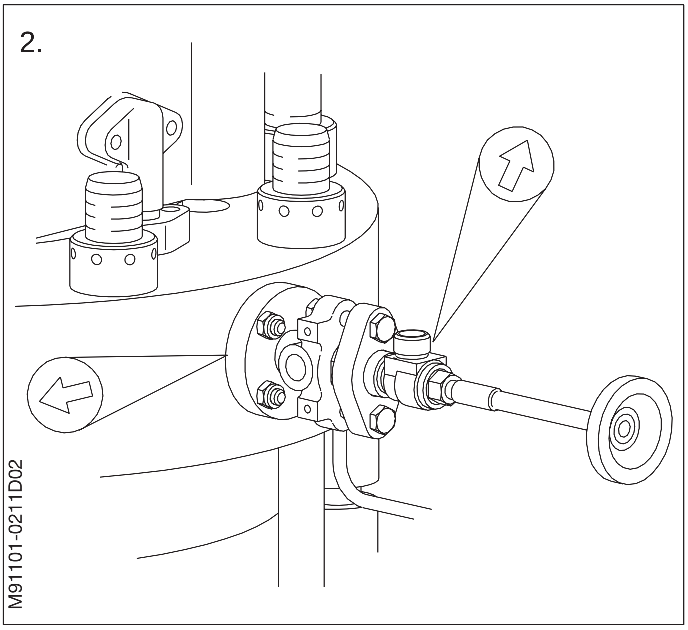
2. Dismantle the indicator cock and the intermediate pipe.

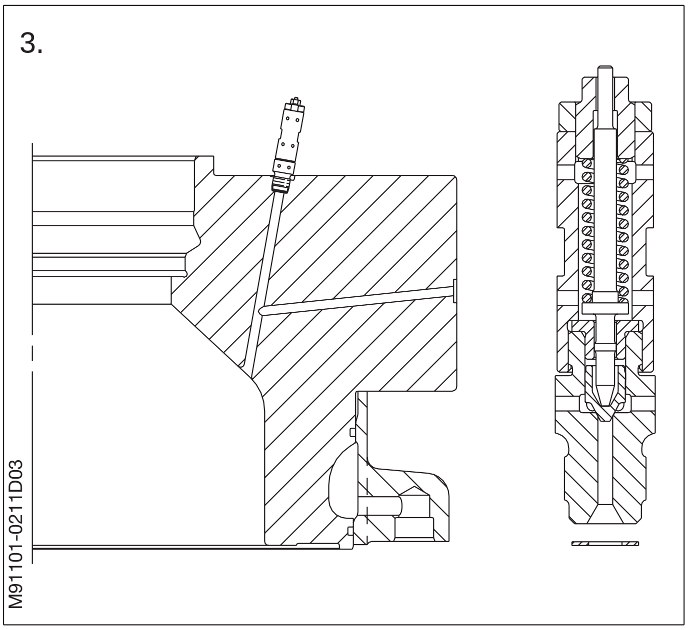
When Top-mounted

3. Unscrew the safety valve from the cylinder cover.

   Remove and discard the mild steel disc.







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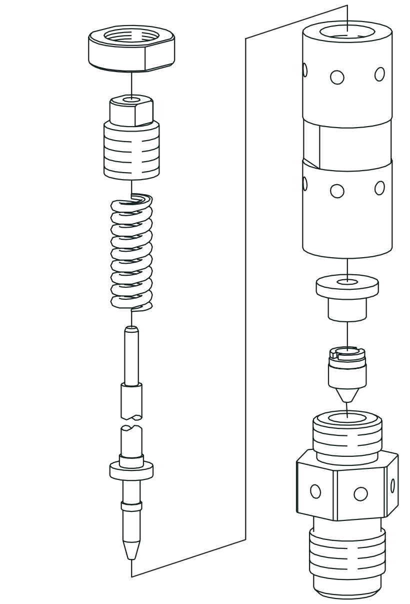
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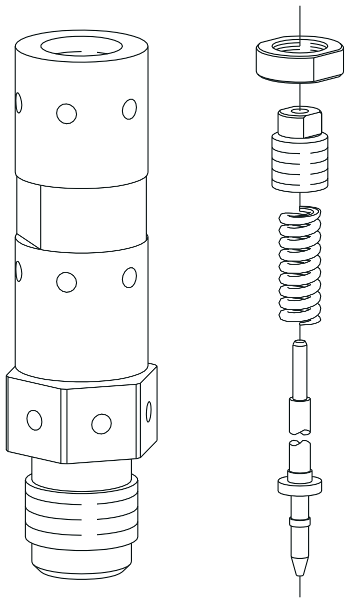
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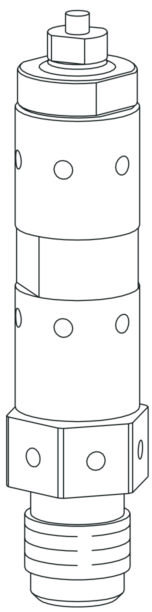

M91101-0211O03

1. If necessary, dismantle the safety valve and clean all the parts in either gas oil, kero-sene, or ‘electro-cleaner’.

2. Assemble the safety valve in two steps:

   - Insert the valve flap and the stop ring in the valve guide and screw on the valve housing.

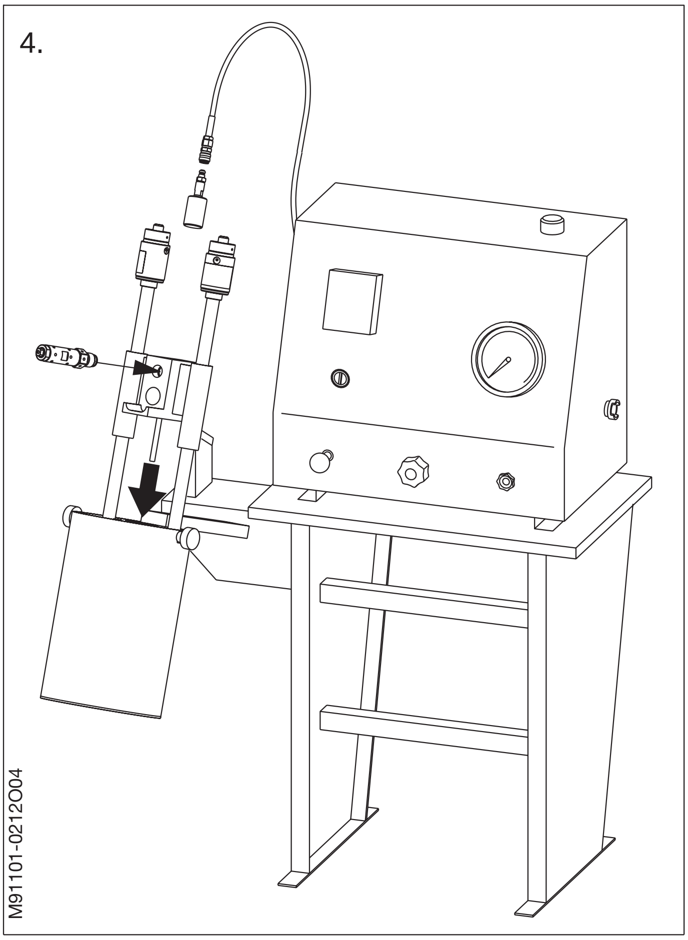
   - Tighten the housing to the torque stated in the data, loosen and tighten again to the torgue stated in the data.

3. Then mount:

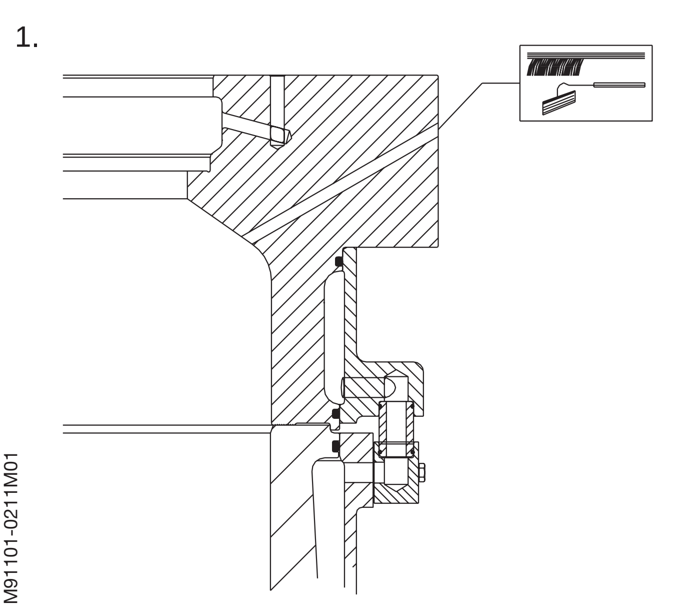
   - the valve spindle
   - the spring
   - the adjusting screw
   - the lock nut

4. To set the safety valve opening pressure:

   - Set up the safety valve in the Fuel valve test rig.
   - Connect the testing device to the hydraulic pump. Alternatively the hydraulic hans pump can be used.
   - Loosen the lock nut on the safety valve.
   - Turn the adjusting screw until the valve just closes.
   - Bleed the valve and hose until oil, without air bubbles, flows out from the openings of the safety valve.
   - Tighten the adjusting screw of the safety valve until the correct pressure is indicated (*see Data*).
   - Tighten the lock nut.
   - Test the opening pressure.
   - Remove the valve from the fuel valve test rig.



1.



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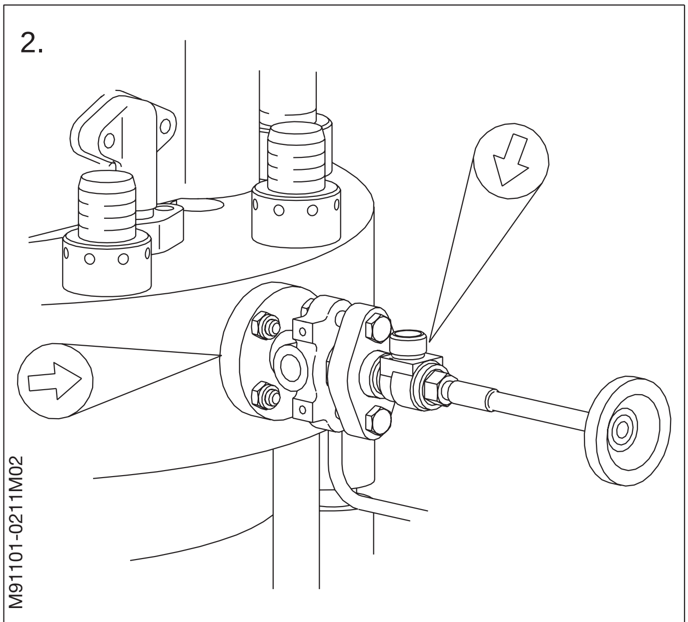

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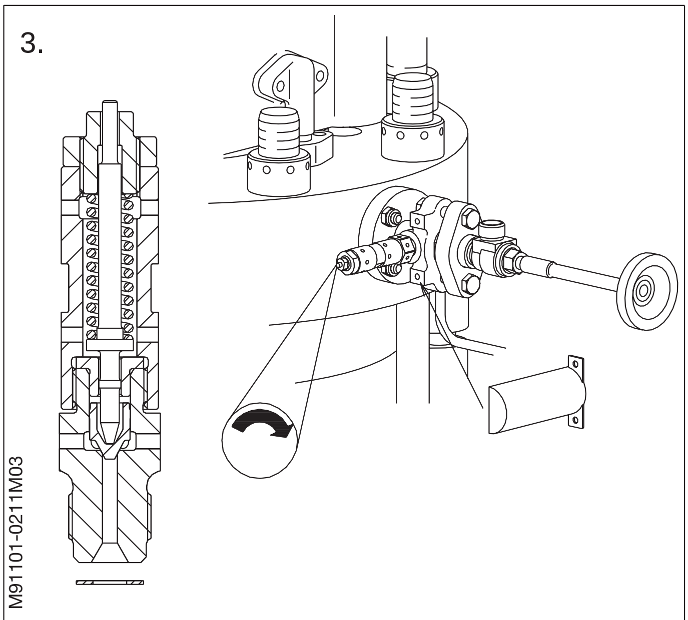


When Side-mounted

1. Pierce the bore in the cylinder cover, and blow it clean.

2. Clean the sealing ring grooves of the indicator cock. Mount the intermediate pipe and the indicator cock.

3. Mount a new sealing ring and a new or overhauled safety valve.

   When mounting the safety valve, apply tools only on the hexagon on the safety valve.

   Mount the guard surrounding the safety valve.

When Top-mounted

4. Pierce the bore in the cylinder cover, and blow it clean.

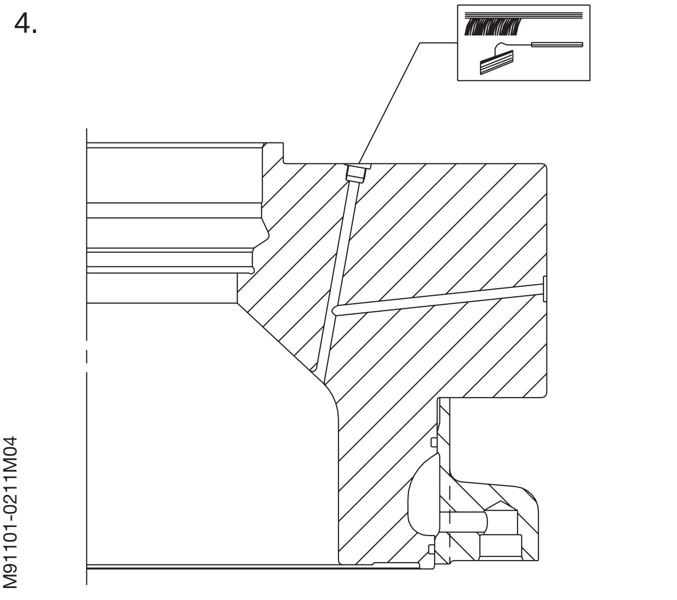
   Clean the thread and the sealing surface.

5. Mount a new or overhauled safety valve.

   Mount a new mild steel disc in the bore.

   When mounting the safety valve on the cylinder cover, apply tools only on the hexagon on the safety valve.

4.



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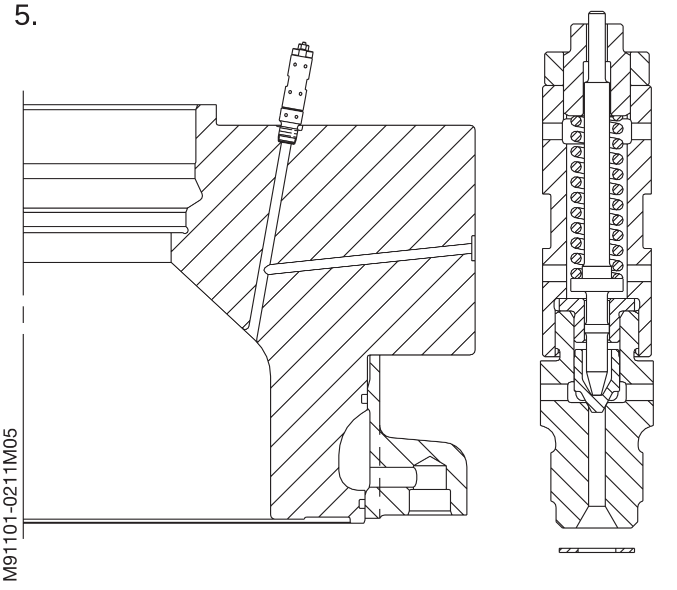


SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

X	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 lubriating oil pumps*
	Engage turning gear
	Shut off cooling water
X	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.*

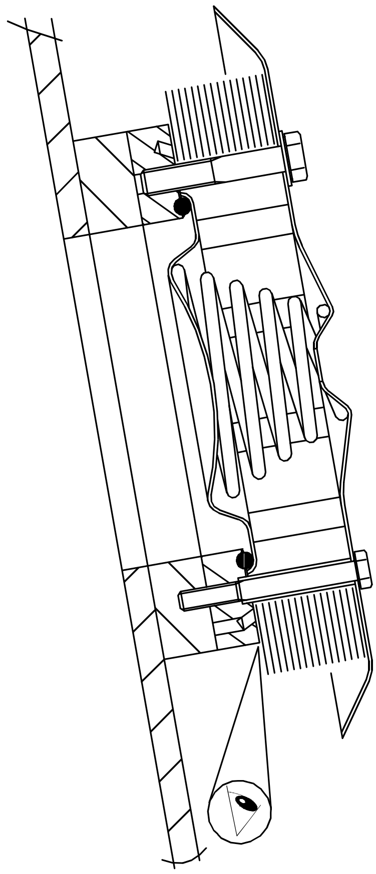
2. If work involving risks of mechanical damage to the flame arrester has taken place, a visual inspection of the flame arrester should always be performed before starting the engine.

   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.



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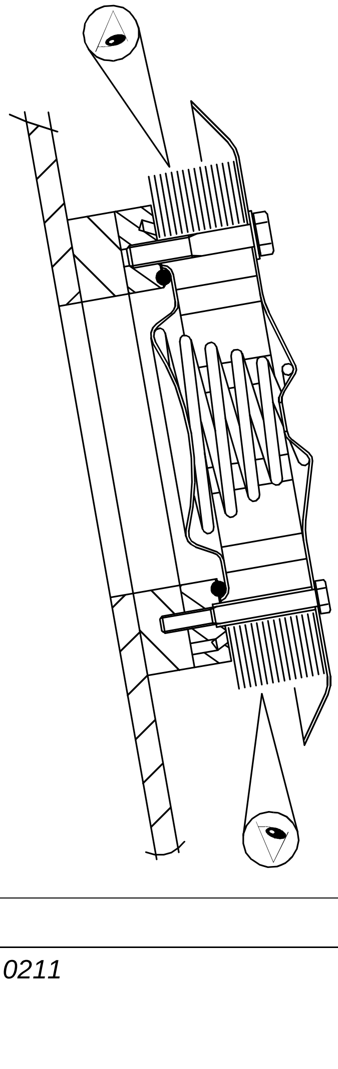

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SAFETY PRECAUTIONS *For detailed sketch, see 900-2*

X	Stopped engine
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
	Shut off safety air supply – *Not ME engines*
X	Shut off control air supply
	Shut off air supply to exhaust valve – *Only with stopped lubricating oil pumps*
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
	Stop lubricating oil supply
X	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

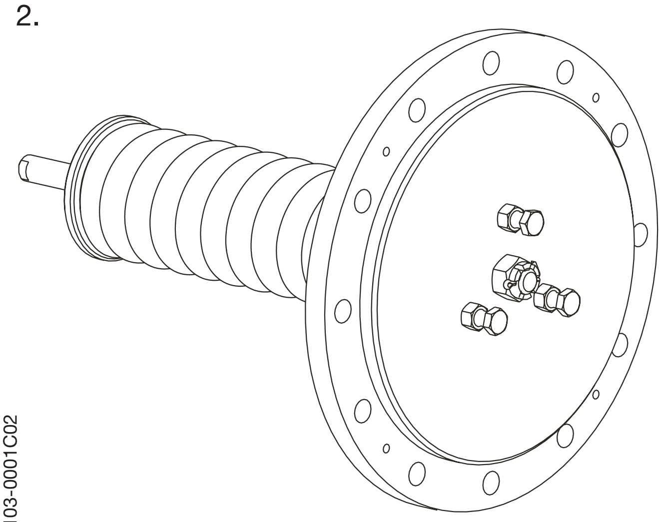
1. The scavenge air receiver safety valve is calibrated at the factory and does not re-quire any adjustment.

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 disman-tled and cleaned.

2.



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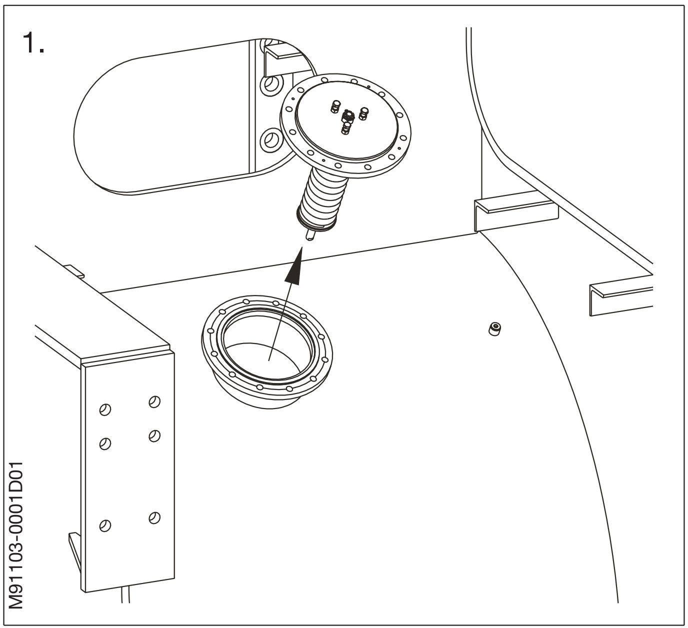
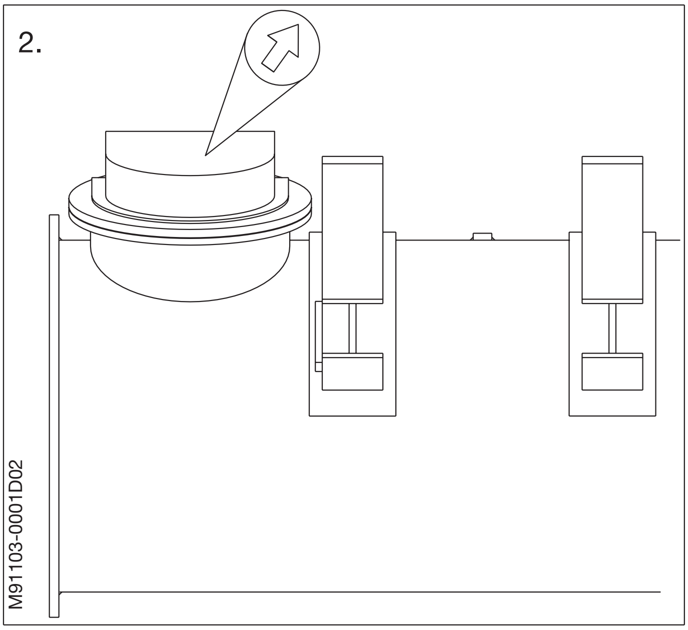




1. Dismount the safety valve from the scavenge air receiver.

2. On some engines, a cover has to be removed in order to gain access to the safety valve.

1. Remove the split pin.

   Unscrew the nut thereby relieving the spring tension.

   Remove the nut, spring retainer and wash-ers.

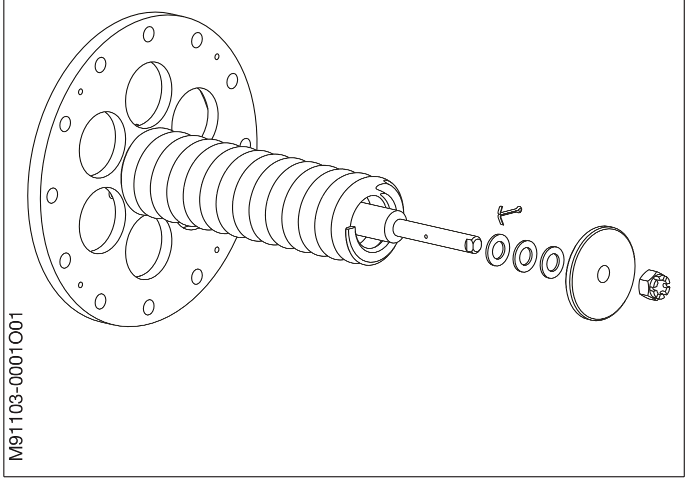
   Keep count of the washers.

   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.



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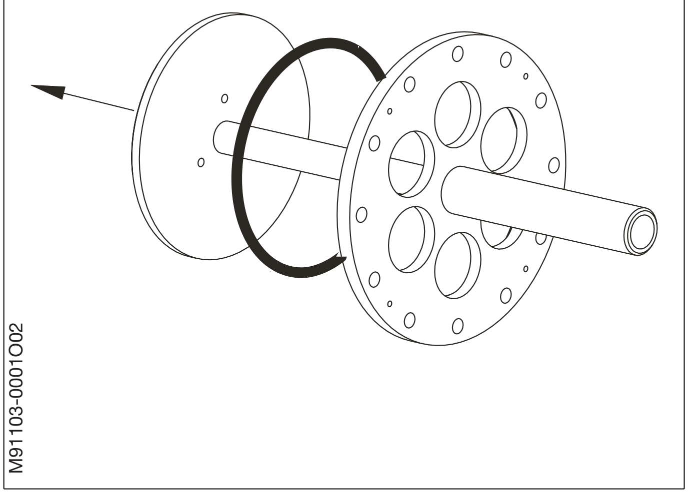

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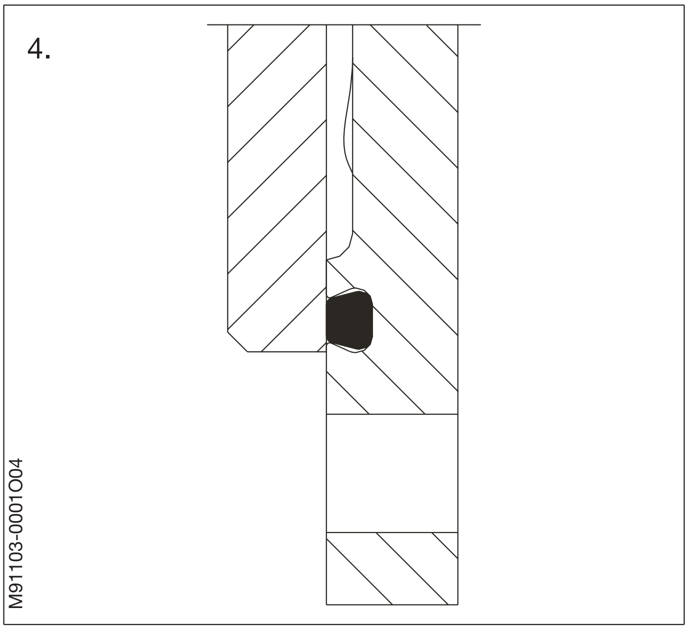

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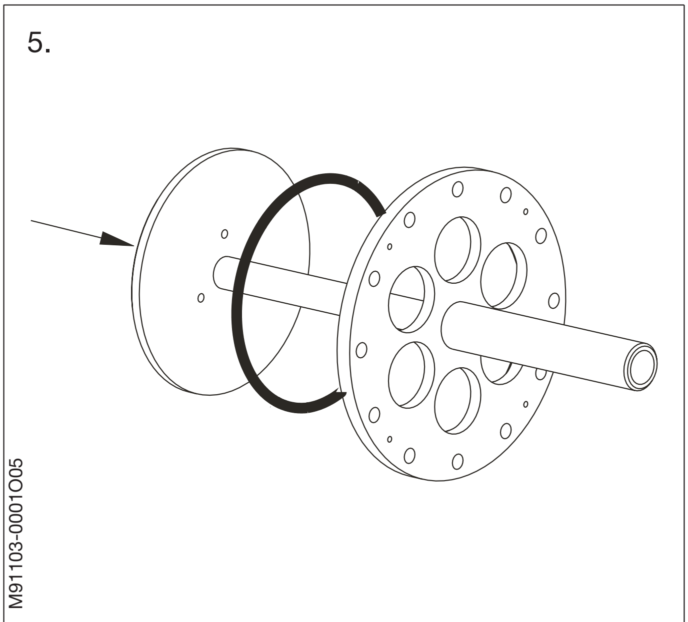

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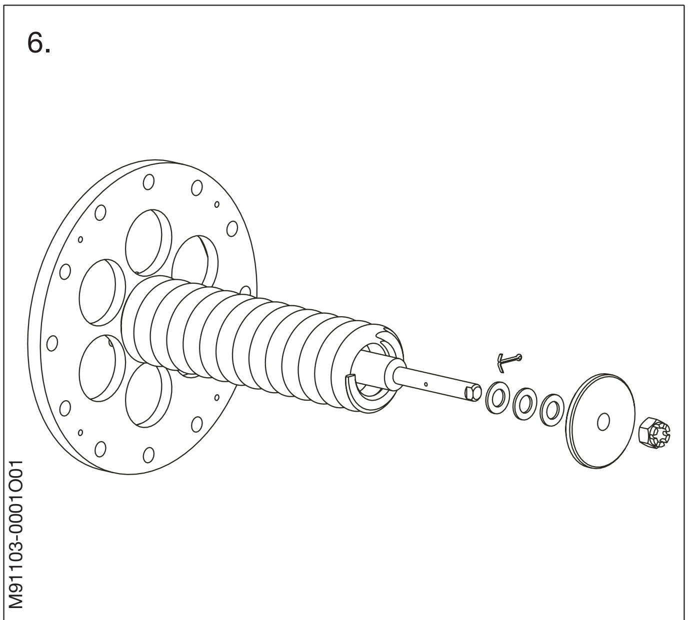


4. If the O-ring seal has been removed mount a new one using Locktite type AVX and Loc-tite activator type T or similar.

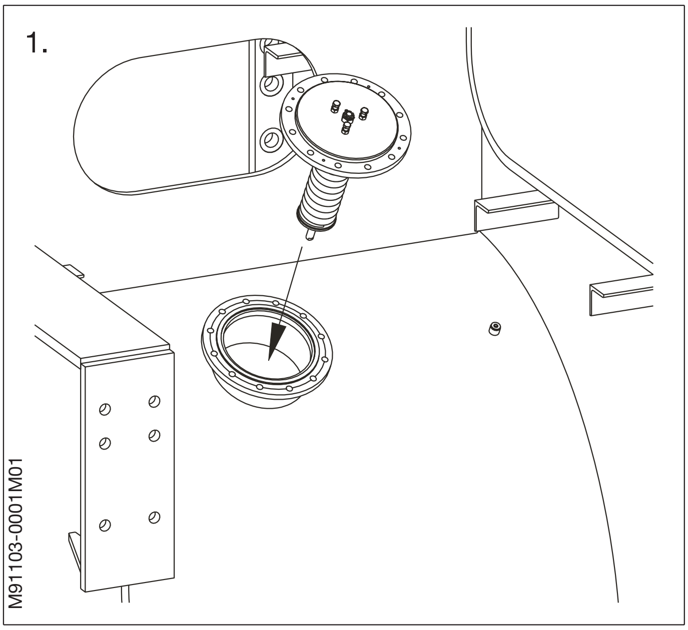
5. Push in the valve flap and spindle while tak-ing care not to damage the O-ring seal.

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 911-3.1.

1. Mount the safety valve on the scavenge air receiver.



912 - Assembly of Large Parts

Documents in this Chapter

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

X	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 lubriating 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
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

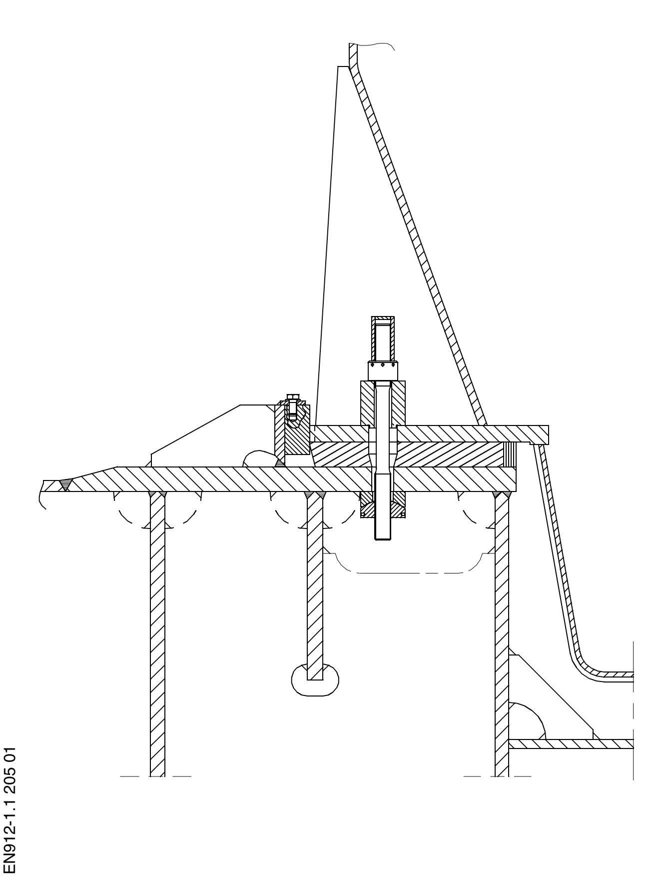
The task-specific tools used in this procedure are shown on the plates at the end of this chapter or in the chapters indicated by the first three digits in the plate number, e.g. **P90951** refers to chapter 909.

Plate	Item No.	Description
P91351	10	Hydraulic pump, pneumatically operated
P91351	60	Hose with unions (5000 mm), complete
P91263		Hydraulic Tools for Holding-Down Bolts and End Chock Bolts, Epoxy

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.

1.



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 inwards.

   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.

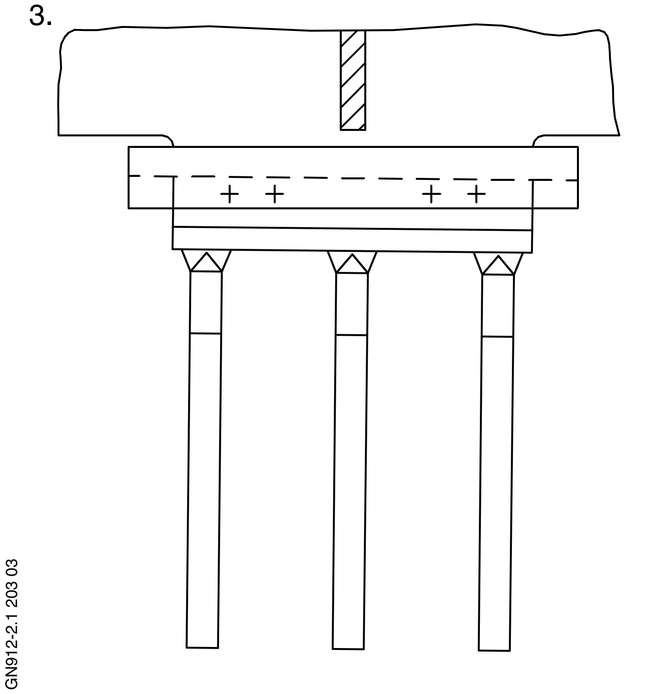
If the measurements at 3 points or more have increased 5/100 mm or more from the initial results, we recommend that the following procedure is followed:

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.

3.



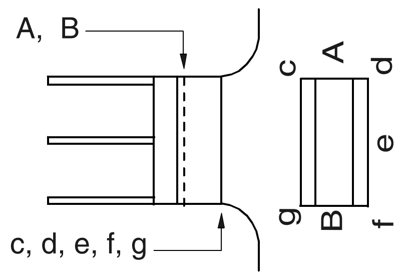
Holding Down Bolts

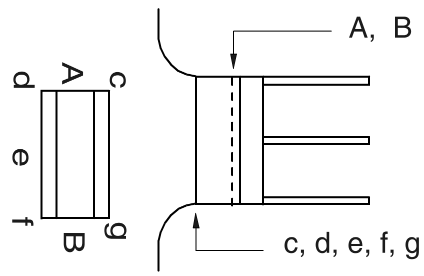
Engine frame No.	Bolt No.	Port side pressure	Port side % dev.	Port side remarks	Cylinder No.	Starboard side pressure	Starboard side % dev.	Starboard side remarks	Bolt No.	Engine frame No.
1	1								1	1
	2								2	
	3								3	
	4				1				4	
2	1								1	2
	2								2	
	3								3	
	4				2				4	
3	1								1	3
	2								2	
	3								3	
	4				3				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	

Side Chocks and End Chock Bolts

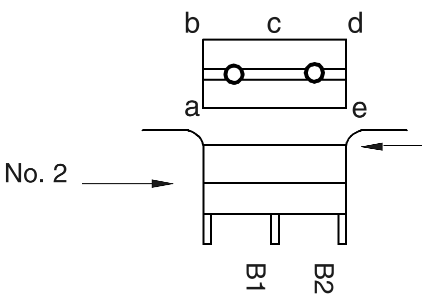
Port side									Starboard side							
Chock No.	Point A	B	c	d	e	f	g	Cylinder No.	Point A	B	c	d	e	f	g	Chock No.
1								1								1
2								2								2
3								3								3
4																4
5																5
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14

FORE

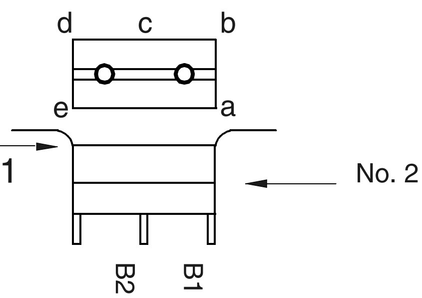




Port side									Starboard side								
Ch No.	Bolt No.	Pres-sure (kp/cm²) bar	Devi-ation %	Point a	b	c	d	e	Point a	b	c	d	e	Devi-ation %	Pres-sure (kp/cm²) bar	Bolt No.	Ch No.
E	1															1	E
E	2															2	E



Contact face No. 1



AFT

SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	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
D12-04	Check measurement	206±3	mm
D13-01	Hydraulic pressure, mounting	2200	bar
D13-02	Hydraulic pressure, dismantling	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. P**909**51 refers to chapter 909.

Plate	Item No.	Description
P91261		Large Parts - 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

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.

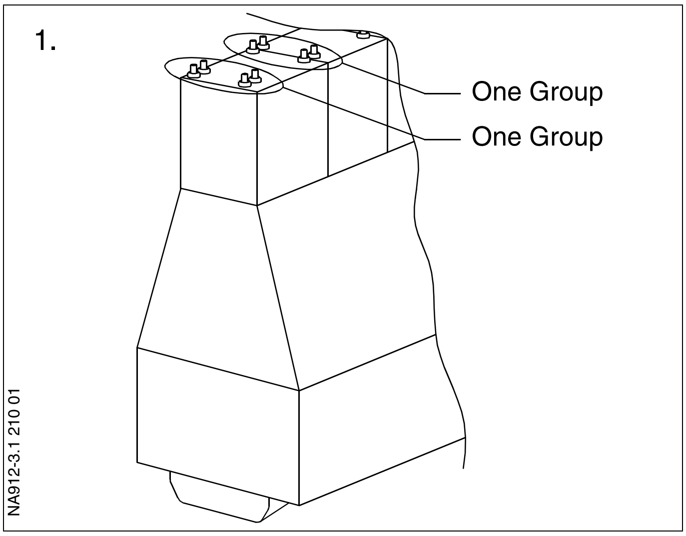
   If a loose nut is found, unscrew the nut until a gap occurs between cylinder frame and nut.

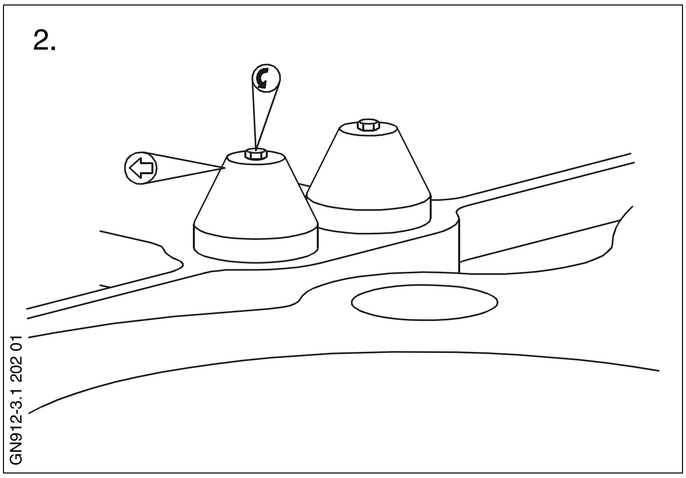
   Loosen and unscrew the nut on the opposite stay bolt.

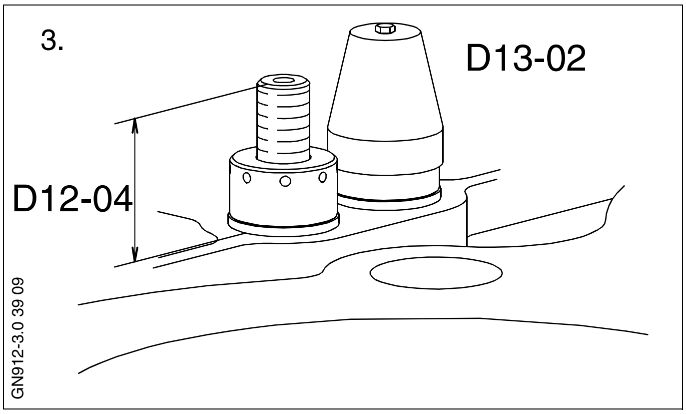
   Check for the correct mounting of the stay bolt by comparing with the check measurement on the Data Sheet.

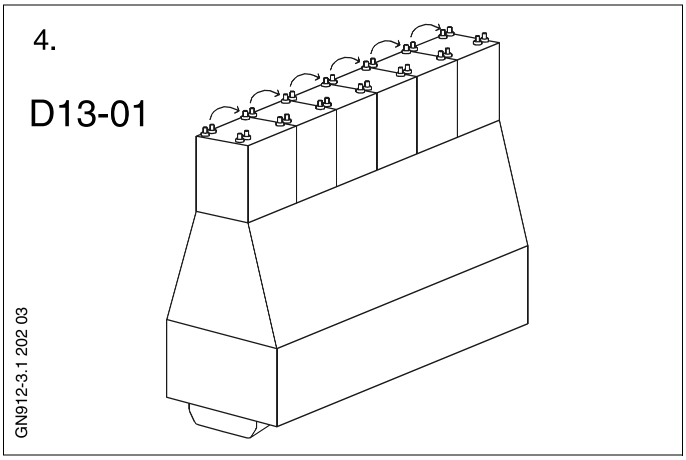
   If the check measurement is not reached, indicating that the stay bolt is not screwed properly down in the thread of the bedplate, apply a screw and a counternut in the thread in the top of the stay bolt, and turn the stay bolt until the check measurement data is met.

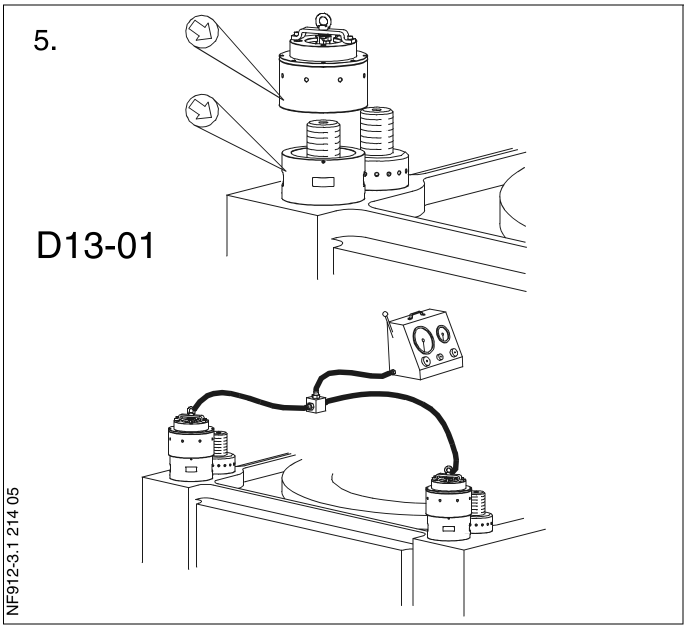
4. Retighten the stay bolts in pairs (athwartship), working from fore to aft of the engine.

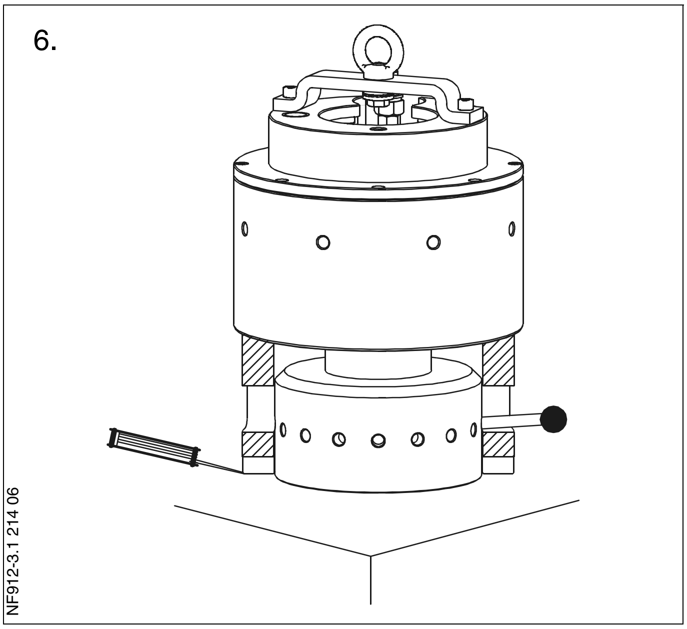


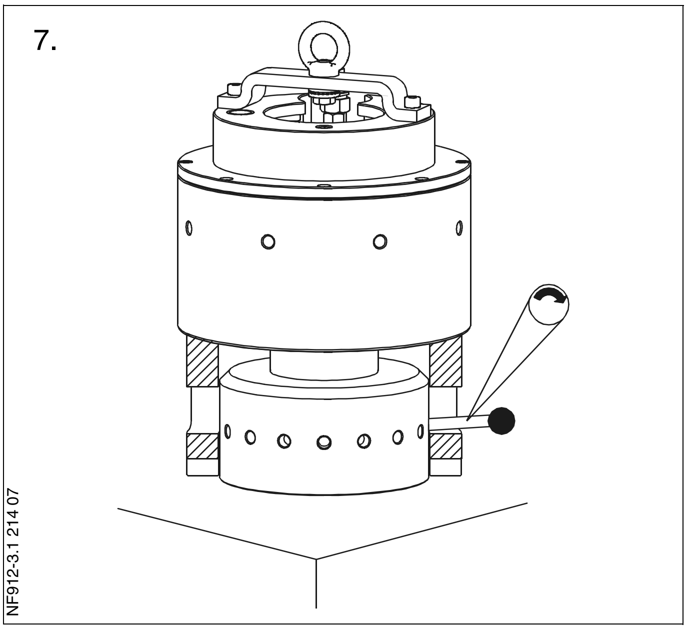












5. Clean the contact faces and mount the hydraulic tools on a pair of stay bolts positioned opposite each other.

   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.

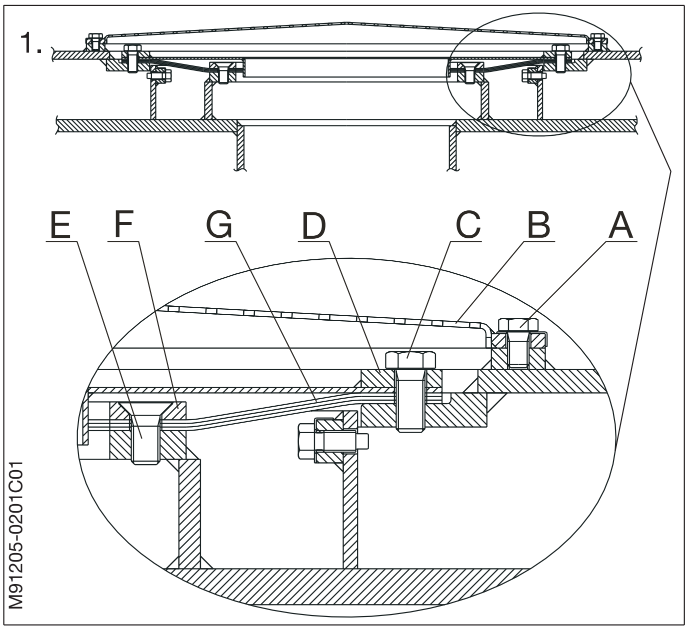
   If the nut is **not** loose:
   Tighten the stay bolts concerned to the mounting pressure.

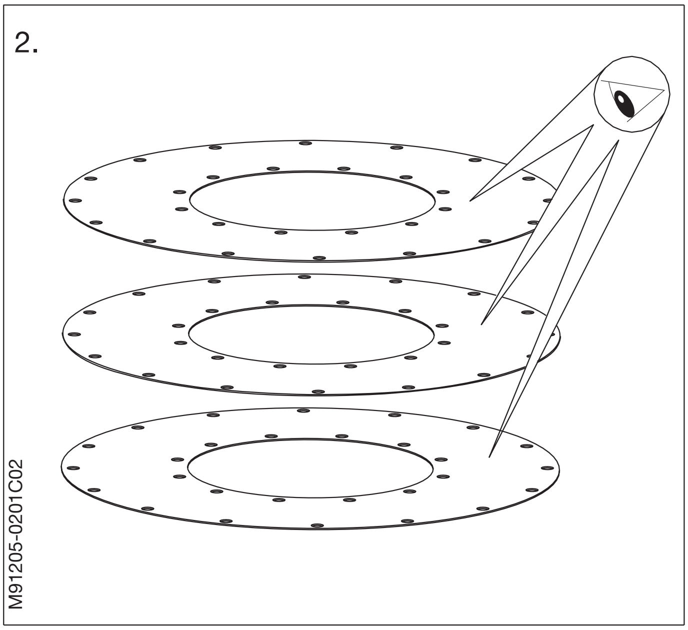
   If the nut is loose:
   Tighten **all** stay bolts once again to the mounting pressure.

8. After completing the retightening procedure, mount the protective caps.

The crankcase oil outlets guide the lubricating oil from the crankcase to the lubricating oil bottom tank. The sealings of the crankcase oil outlets must be checked at regular intervals, for example during dockings. The crankcase oil outlets may be equipped with either rubber diaphragm sealing or metal bellow sealing.

Note!
If the water content of the main engine lube oil is rising, this may indicate that the crankcase oil outlet sealings are fractured.





Rubber diaphragm sealing

1. To access the rubber diaphragm sealing remove:
   Screws A
   Grating B
   Screws C
   Cover plate D
   Screws E
   Steel ring F.

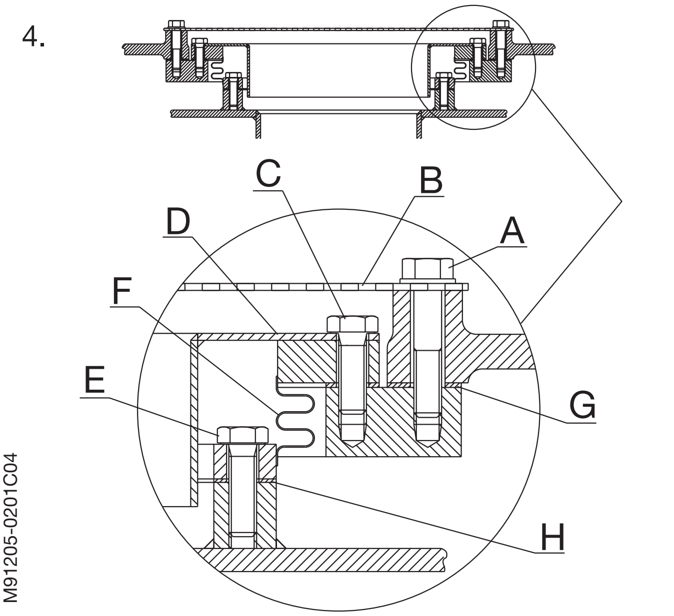
2. Lift away the rubber sealing diaphragms G and examine each diaphragm closely. In case of any rips or tears in the diaphragms, they must be replaced.

Note!
It is strongly recommended to always replace the diaphragms during inspection. If unavailable, new diaphragms may be made from three layers of 2 mm thick oil and temperature resistant rubber.

3. Mount:
   Rubber sealing diaphragms G
   Steel ring F
   Screws E
   Cover plate D
   Screws C
   Grating B
   Screws A.

Note!
Remember to fit new locking plates at screws A.

4.



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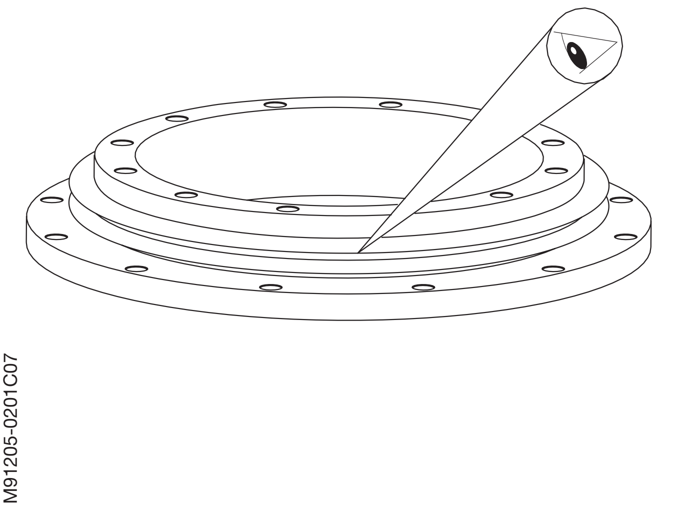


Metal bellow sealing

4. Remove all screws A and grating B.

5. Remount four of the screws A at diametrically opposite positions.

6. Remove:
   Screws C
   Cover plate D
   Screws E.

7. Lift away metal bellow sealing F and examine it closely. If any cracks or punctures are found in the metal bellow sealing, it must be replaced.

Note!
It is recommended to always replace the metal bellow sealing during inspection.

8. Replace gaskets G and H.

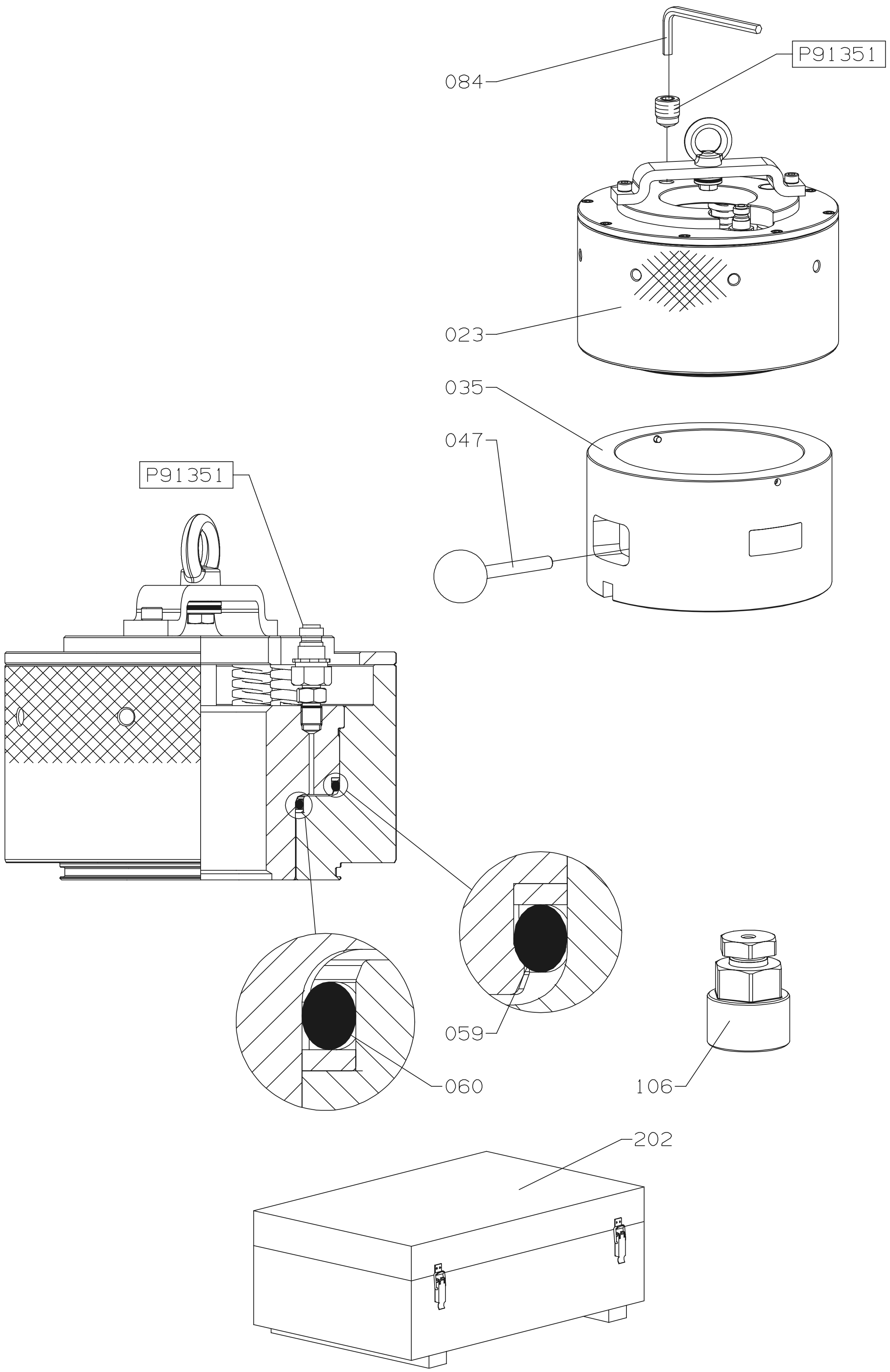
9. Mount metal bellow sealing F.

10. Mount:
    Screws E
    Cover plate D
    Screws C.

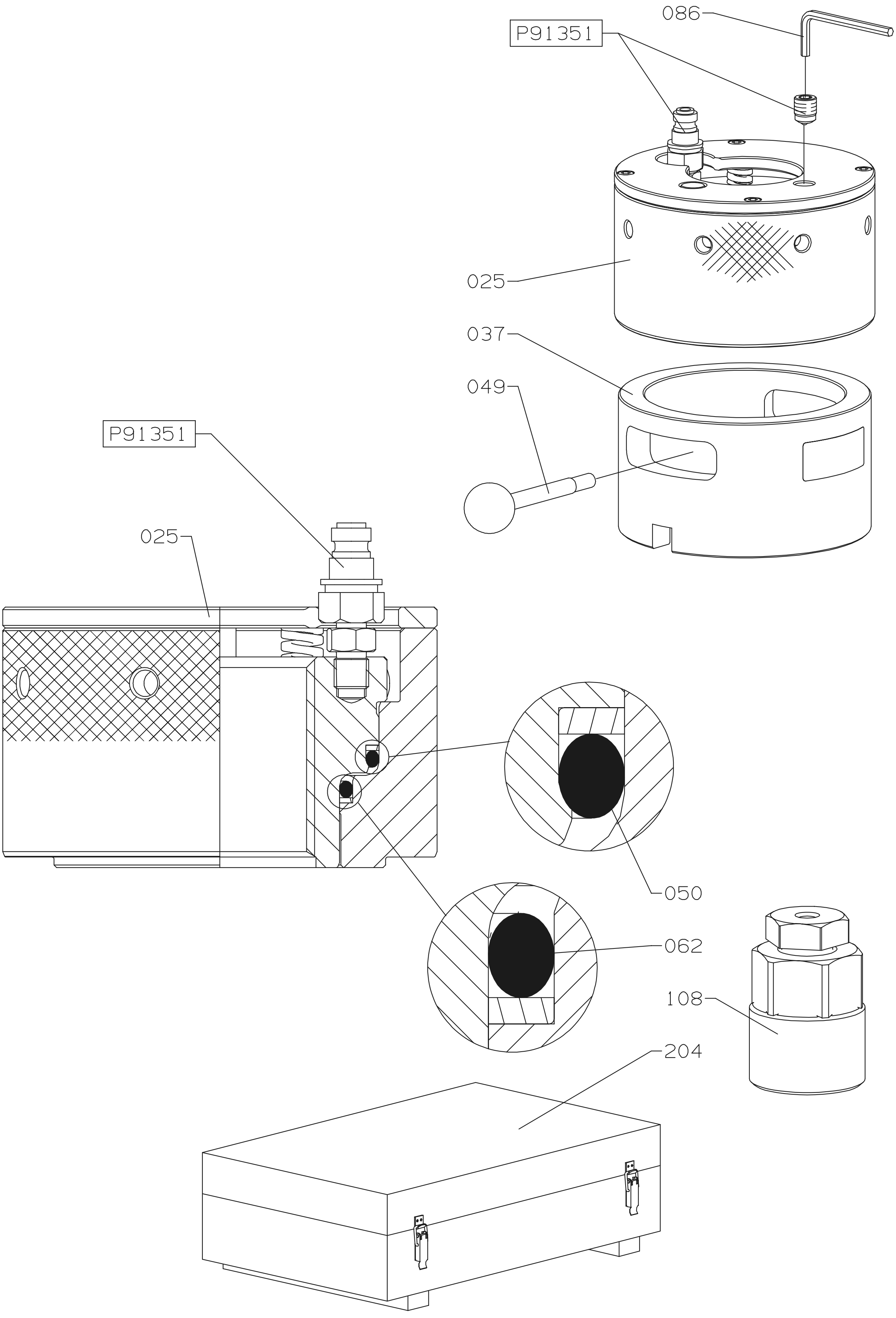
11. Remove the four screws A.

12. Mount grating B.

13. Mount all screws A.


084
P91351
023
035
047
P91351
059
060
106
202

Item No.	Item Description	Item No.	Item Description
023	Hydraulic jack, complete		
035	Support		
047	Tommy bar		
059	Sealing ring with back-up ring		
060	Sealing ring with back-up ring		
084	Spanner		
106	Stud setter		
202	Hydraulic tool set, complete		


086
P91351
025
037
049
P91351
025
050
062
108
204

Hydraulic Tools - Holding Down Bolts (Epoxy Chocks)

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
108	Stud setter
204	Hydraulic toolset, complete

Item No.	Item Description

913 - General Tools

Documents in this Chapter

A. Lifting bracket
B. Cover
C. Snap-on coupling
D. Bleed screw
E. Piston Return Spring
F. Guide pin
G. Overstroke valve
H. Piston
I. Sealing rings
J. Cylinder
K. Support ring
L. Nut
M. Stud
N. Tommy bar
O. Milled recess for feeler gauge
P. Coupling
Q. Guide screw
S. Clearance

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.

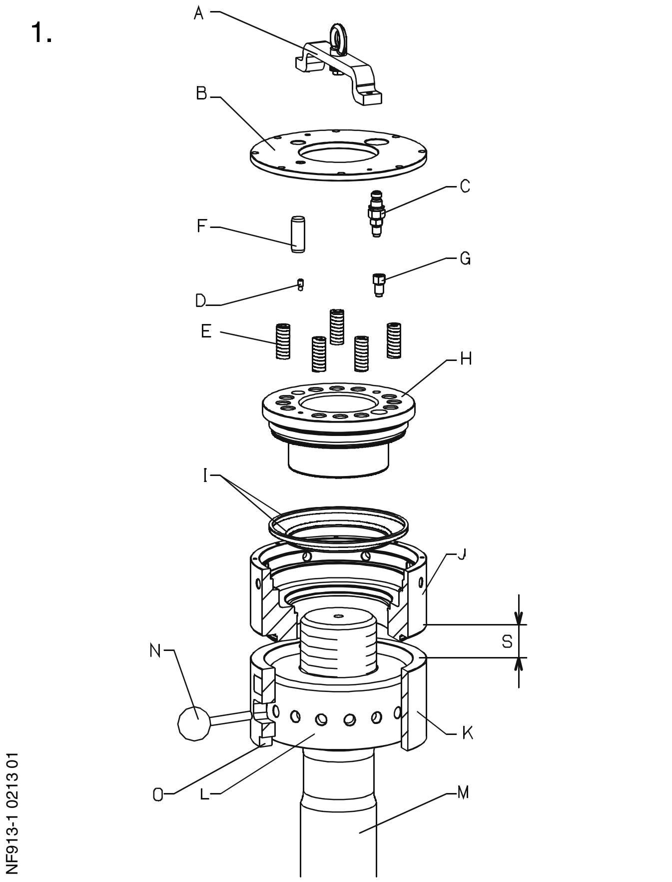
The jack(s) is/are connected, via a distributor block, to a high-pressure pump, which is able to deliver hydraulic oil at the pressure indicated on the jack and on the data sheet in the relevant section of this instruction book. The stud or bolt concerned is thereby lengthened relative to the oil pressure 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 not be exposed to blows or impacts.
The jacks are marked with a “Max. lift”, which can be measured on the protruding guide pin on top of the jack *(see picture 4)*.
The hydraulic jacks are fitted with piston return springs to ensure the correct retraction af the piston when pressure is released.

1. The hydraulic tools consist of a set of jacks with an internal thread to suit the tool attachment thread on the stud or bolt, and a support rings.

2. For the main bearings, the hydraulic tool consists four sets of an upper and a lower jack stacked on top of each other and a support ring.

1.



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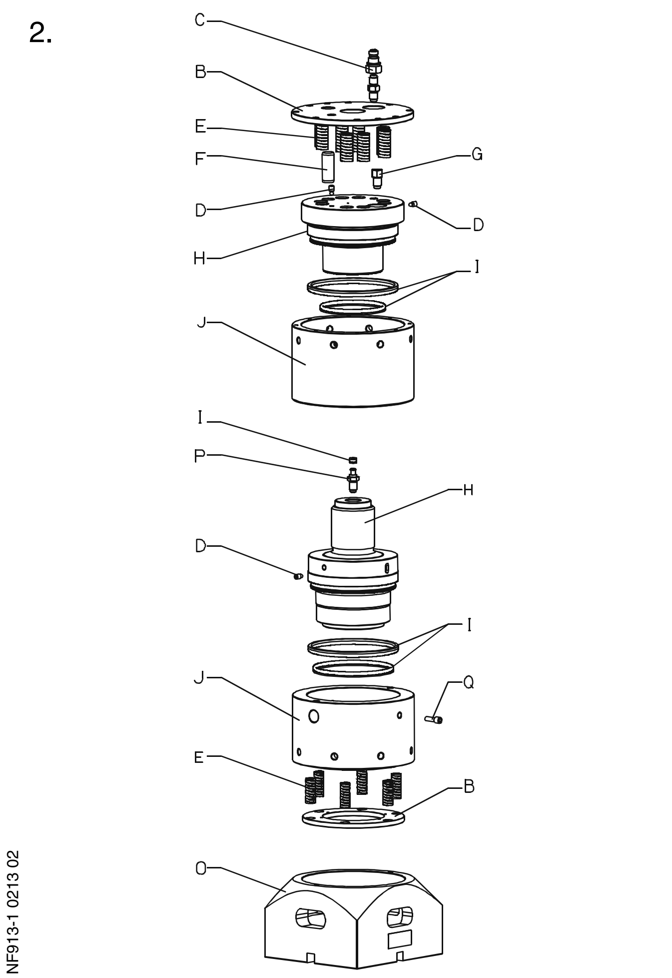

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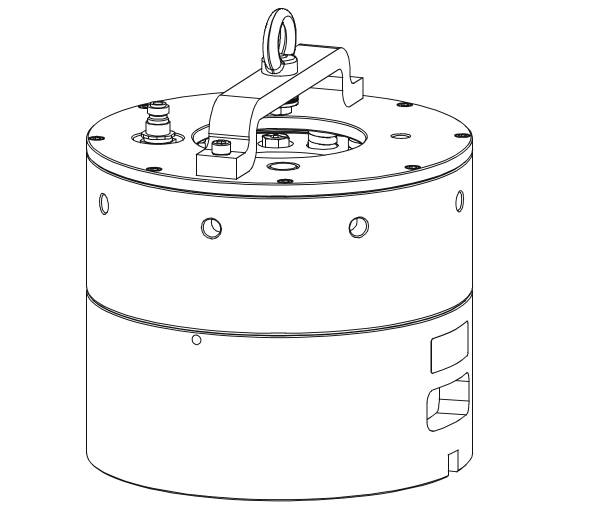

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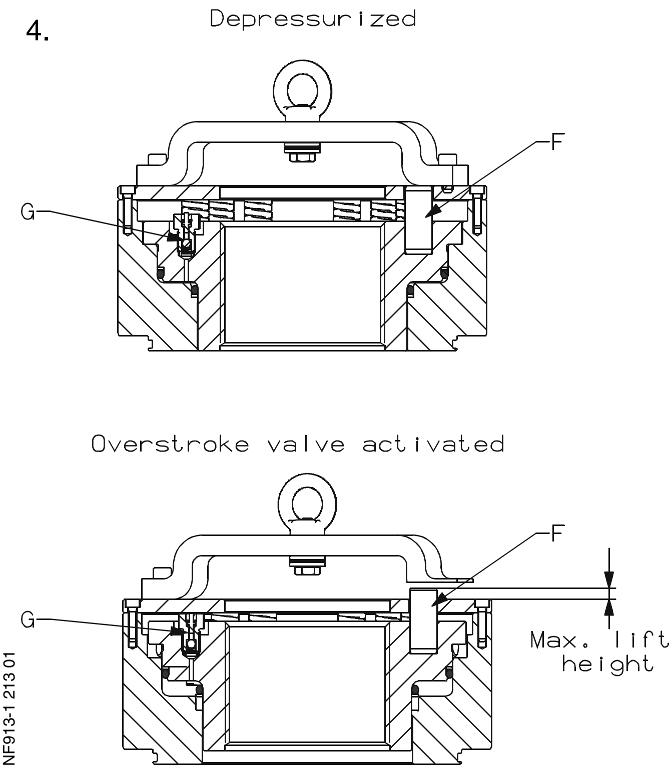


3. For the cylinder cover, the hydraulic tool consists of eight individual jacks suspended from a common lifting tool. The support rings are mounted below each jack using spring pins.

Note!
It is not necessary to dismount the support rings when overhauling the cylinder cover jacks.

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 by an overstroke valve mounted in the piston. The overstroke valve releases the oil pressure into the cavity beneath the cover. The oil can then be seen seeping out of the openings in the jack.

Note!
If the overstroke valve has been activated, it may be necessary to overhaul the valve, *see 913-1.4*.

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

5. 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 support 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.

6. Screw the jack on to the tool attachment thread of the bolt/stud, until the cylinder of the jack bears firmly against the support ring.

   Connect the hydraulic jack, the distributor block and the high pressure pump by means of high pressure hoses.

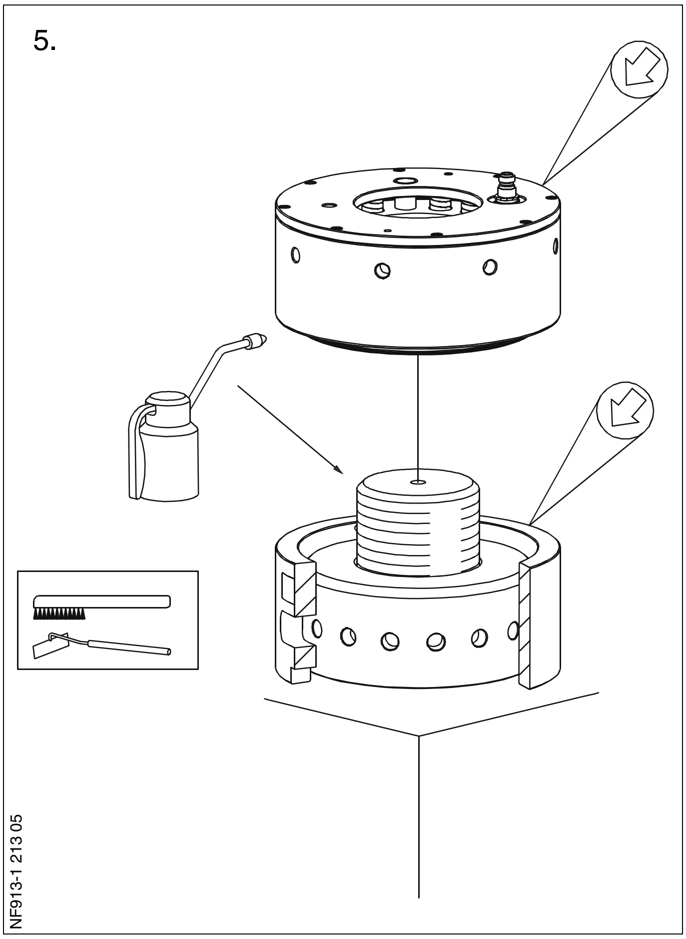
   Unscrew the jack ¾ of a turn to create a clearance between the jack and support ring. When loosening nuts on staybolts it is necessary to unscrew the jack 2,5 turns.

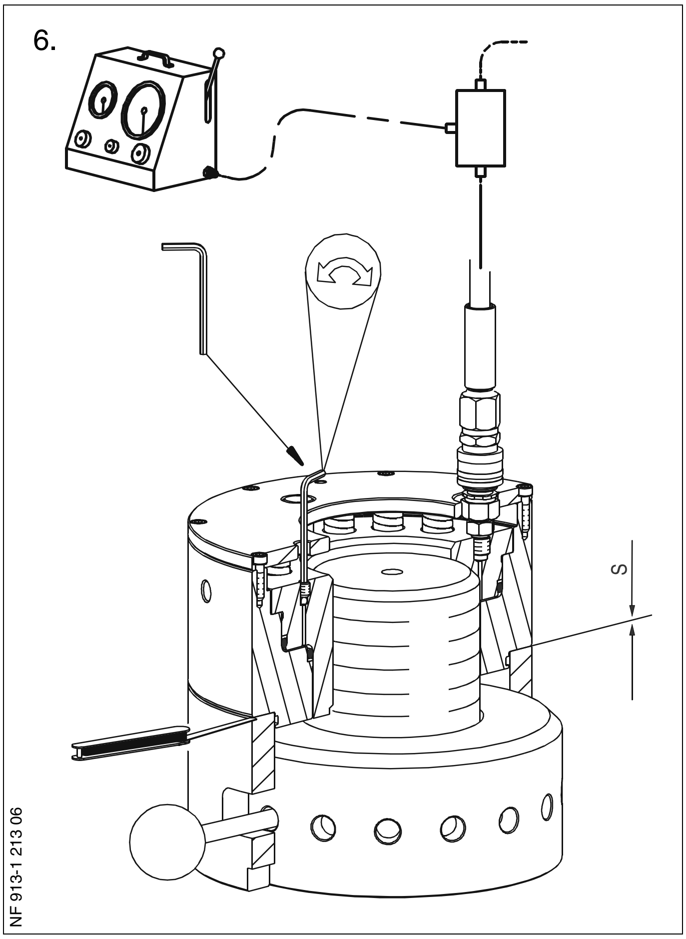
   The clearance between the jack and support ring ensures dismounting of the jack after loosening the nut.

   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.

   The clearance between the jack and support 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.





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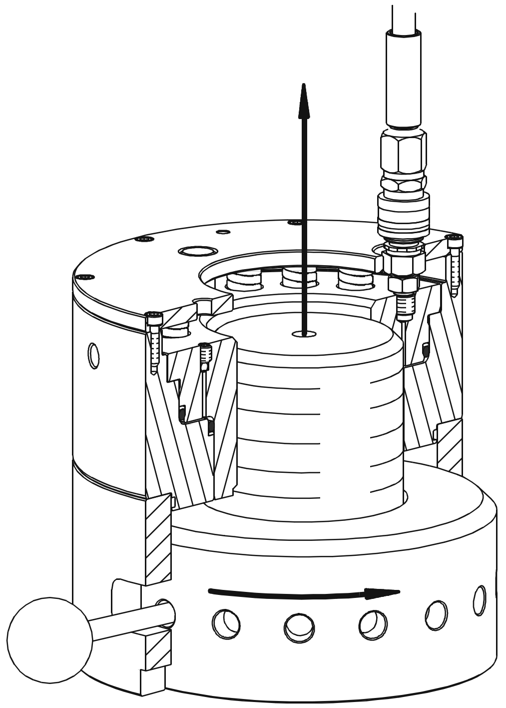

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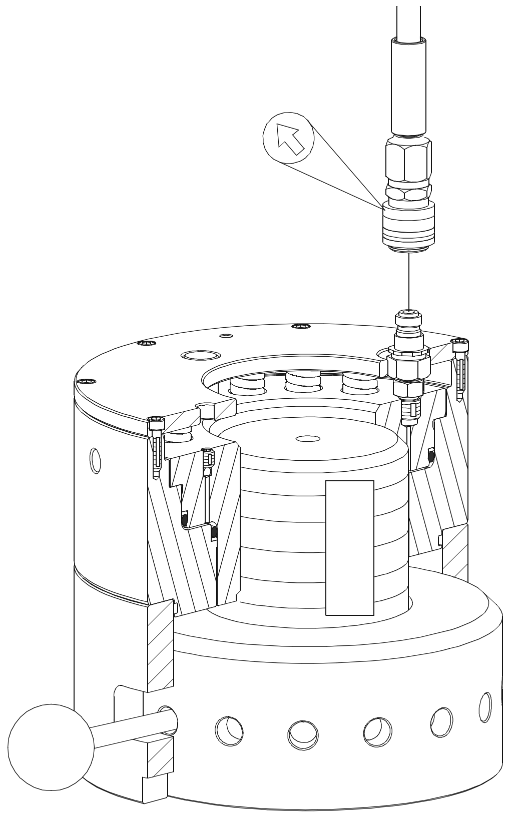

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7. Increase the oil pressure to the prescribed value. Use the tommy bar during the pressure increase to determine when the nut is loose. If the nut does not come loose, the pressure may be increased by 10% of the working pressure marked on the jack.

8. Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.

9. Relieve the system of pressure, disconnect the high-pressure pump, and remove the hydraulic tools.

Double Hydraulic Jack

10. Carefully clean the main bearing studs, the nuts and the surrounding parts. Use the lifting handle to lift the upper and lower jacks and the support onto the main bearing nuts. Take care that the upper and lower jacks are screwed all the way together in order to ensure correct oil flow.

11. Turn the jacks ¾ of a turn back making a clearance "S".

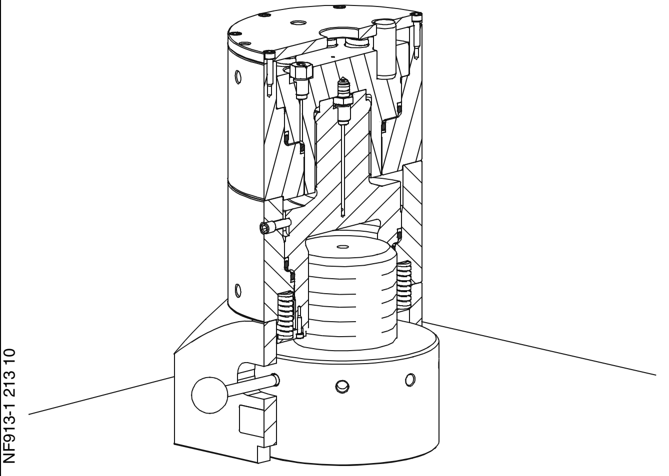
    The clearance between the jack and support ring ensures dismounting of the jack after loosening the nut.

    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.

10.



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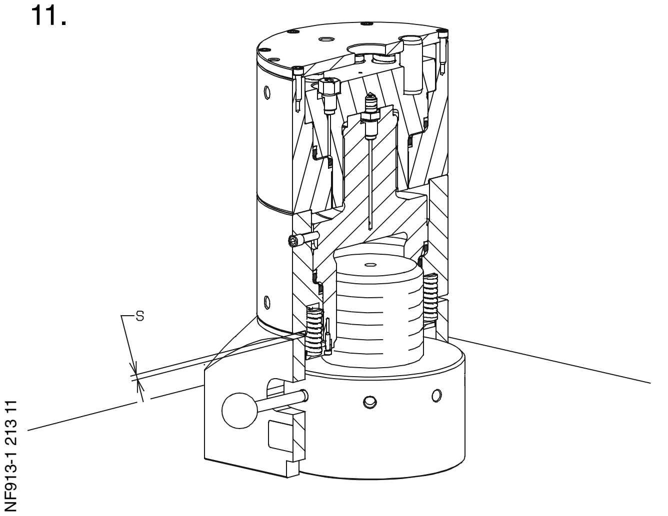

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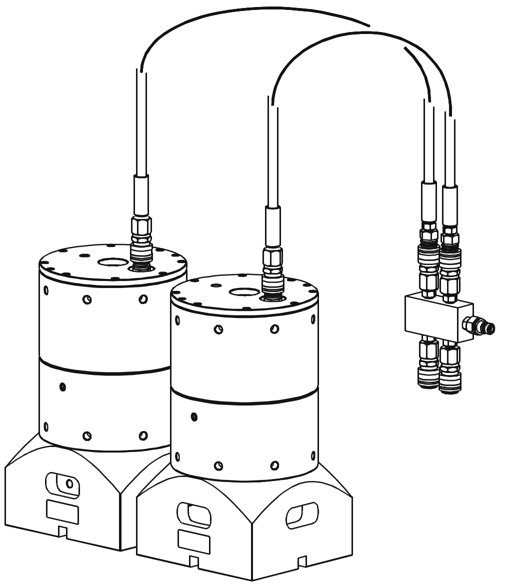

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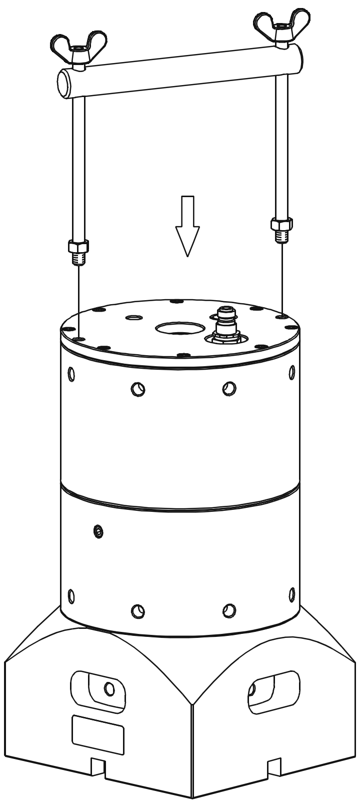

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12. Increase the oil pressure to the prescribed value. Use the tommy bar during the pressure increase to determine when the nut is loose. If the nut does not come loose, the pressure may be increased by 10% of the working pressure marked on the jack.

    Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.

13. Relieve the system of pressure, disconnect the high-pressure pump, and unscrew the hydraulic jack.

14. Disassemble the hydraulic jacks into three parts and use the lifting handle to lift the jacks out of the crankcase.

Single Hydraulic Jack

15. 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.

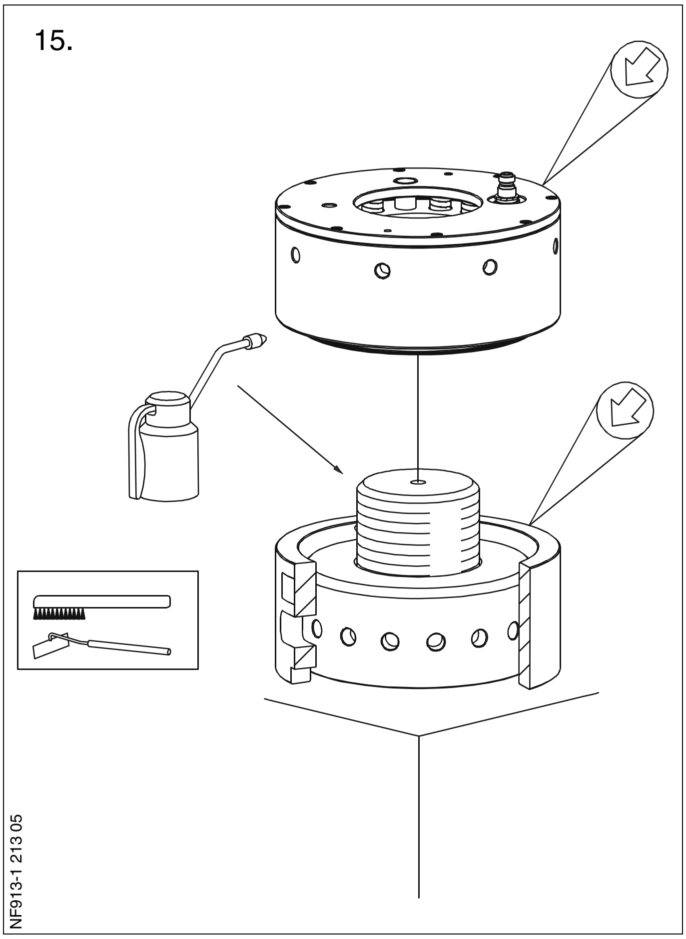
    Place the support ring around the nut in such a position that the tommy bar can be applied through the slot for the purpose of tightening the nut.

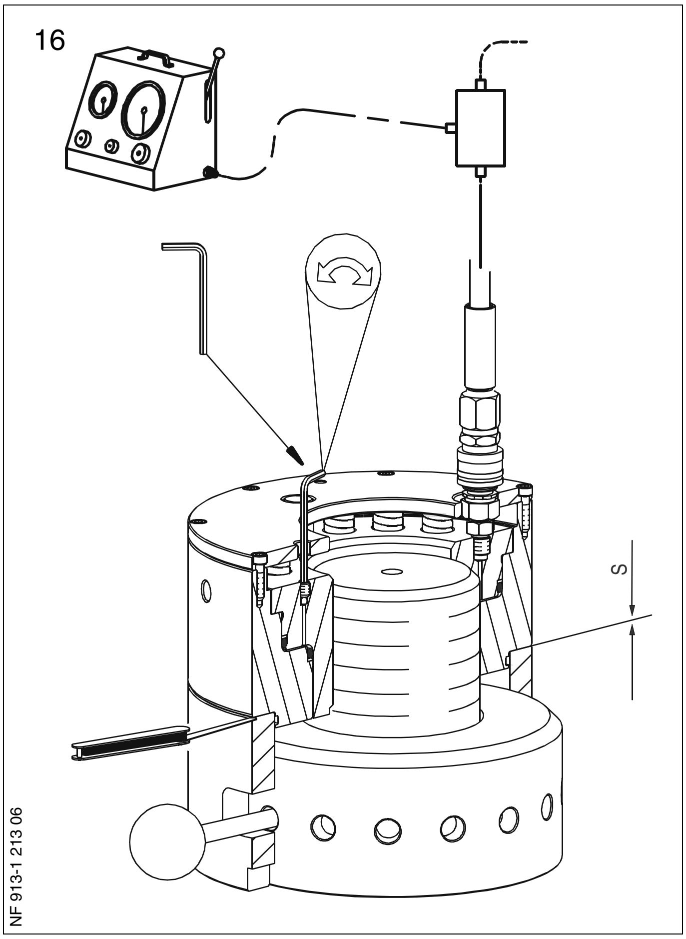
16. Screw the hydraulic jack on to the stud. Make sure that the jack bears firmly against the support ring and that the parts are guided correctly together.

    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.





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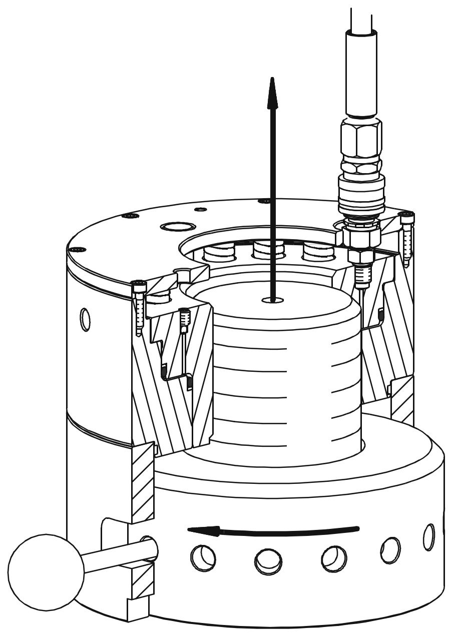

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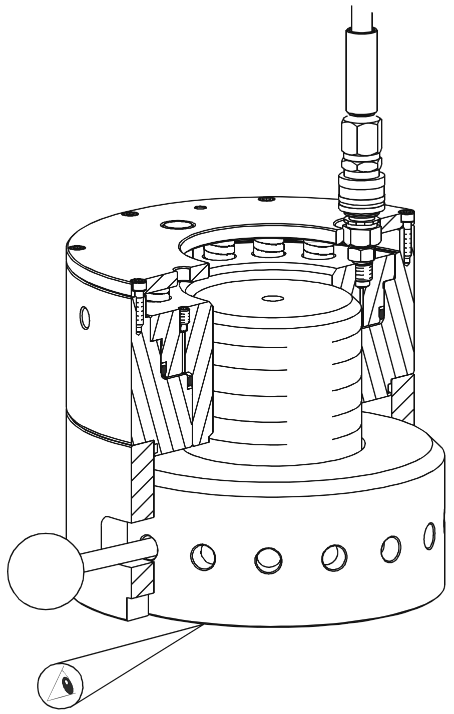

NF913-1 213 18

17. Increase the oil pressure to the prescribed value, and tighten the nut by means of the tommy bar applied through the slot of the support ring. Depressurize and pump up to the prescribed pressure again.

18. While maintaining the pressure, check with a feeler gauge introduced through the recess at the bottom of the support ring that the nut bears against the contact face.

19. Relieve the system of pressure, disconnect the pump, and remove the hydraulic jack.

Double Hydraulic Jack

20. 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. Mount the nuts and tighten till face contact.

21. Use the lifting handle to lift the two main bearing jacks into the crankcase.

22. Lower the jacks on to the nuts of the main bearing. 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.

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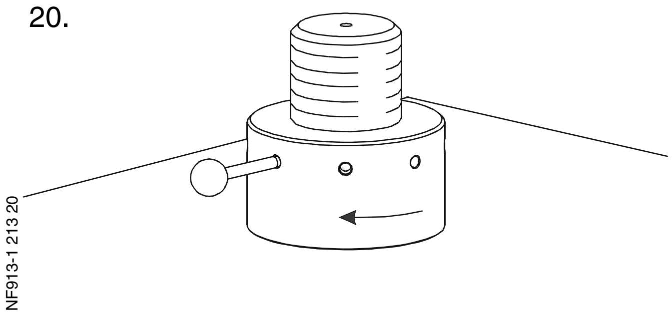

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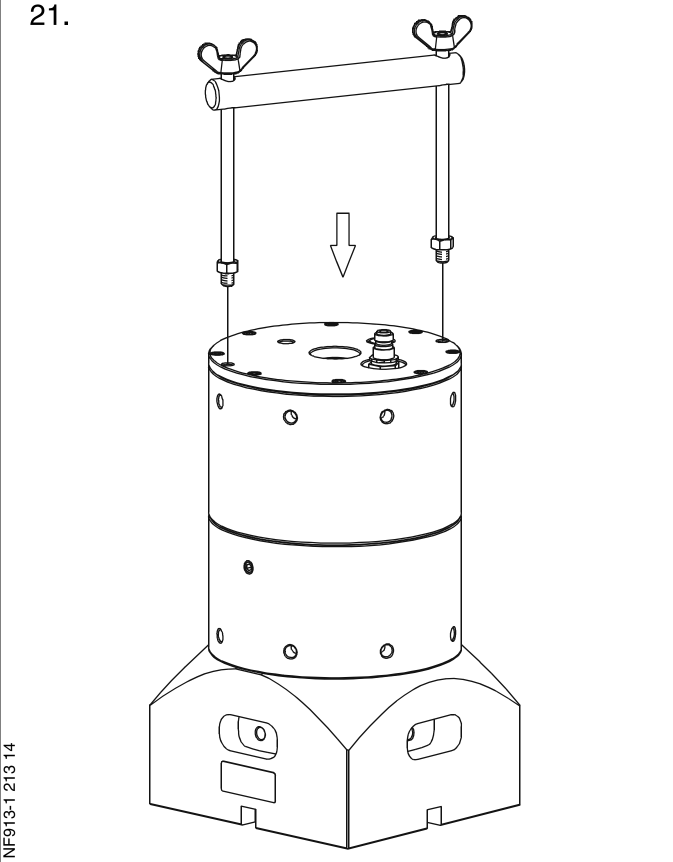

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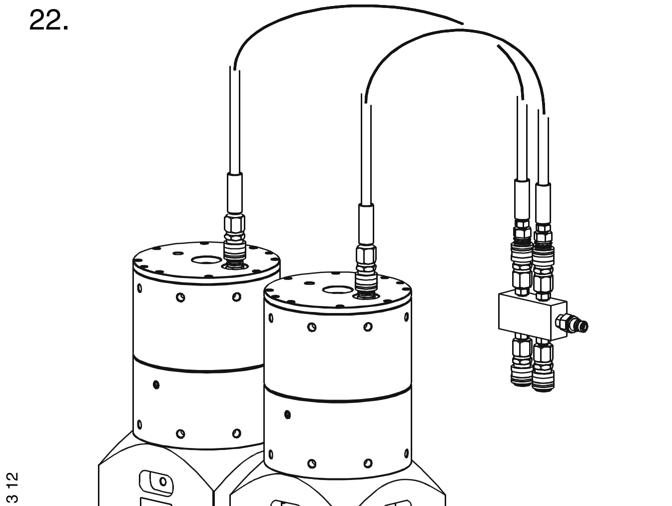

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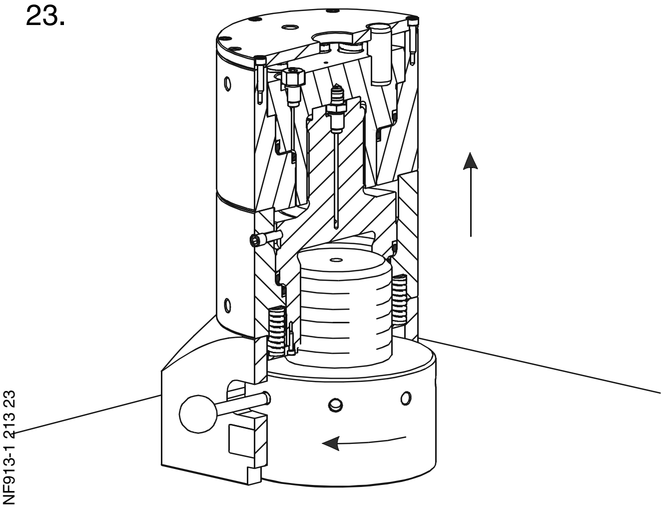

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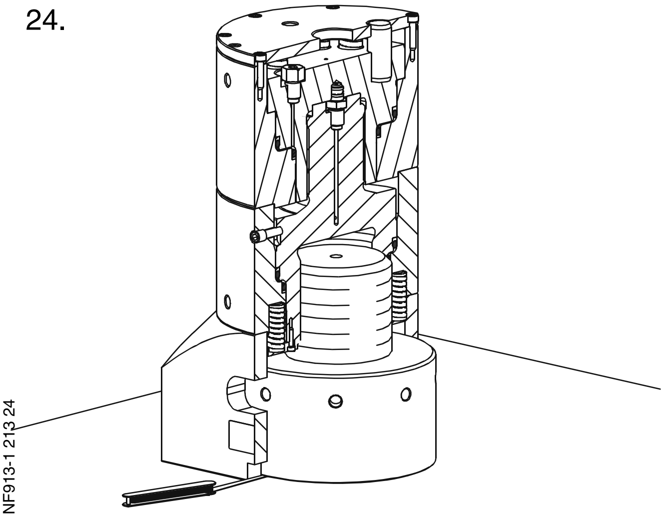


23. Increase the oil pressure to the prescribed value, and tighten the nuts by means of the tommy bar applied through the slots of the support ring. Depressurize and pump up to the prescribed pressure again. Keep count of how many holes the nuts are turned to assure equal tightening

24. While maintaining the pressure, check with a feeler gauge introduced through the recesses at the bottom of the support ring that the nuts bear against the contact face.

25. Relieve the system of pressure, disconnect the pump, and unscrew the extension studs from the main bearing studs.

26. Use the lifting handle to remove the hydraulic jacks from the crankcase.

27. The hydraulic jacks require no maintenance except cleaning of overstroke valve and 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 off the cover and piston return spring, removing the bleed screw with ball and pressing the parts apart with the help of 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.

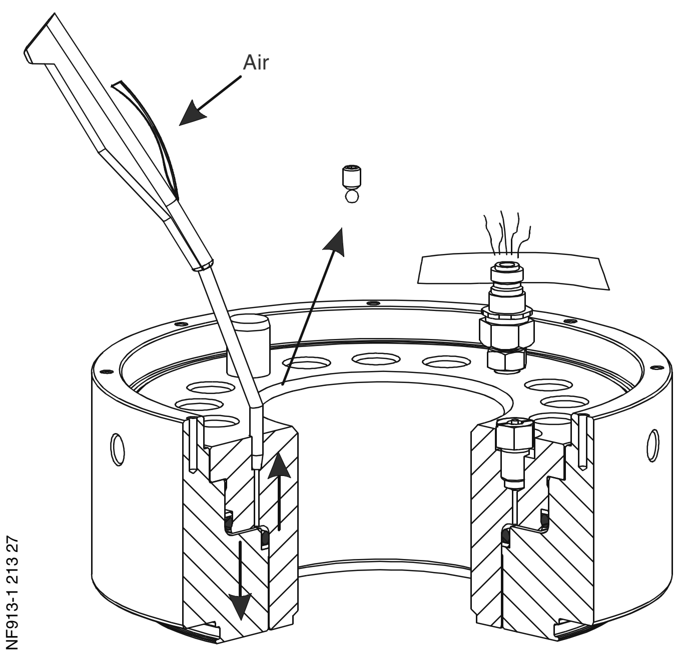
    Keep the sliding surfaces and O-rings coated with molybdenum disulphide grease.

28. If the overstroke valve leaks oil without being activated the hydraulic jack has to be dismounted and disassembled. Disassembly is done by removing the two spring clips. Take care not to loose the ball and spring. Clean the overstroke valve with compressed air. If this does not remedy the fault the Overstroke valve has to be replaced.

    The pistons and cylinders of the double jacks are separated in the same easy way as described for the single jack.

Warning!
Always use eye protection when working with compressed air.

27.



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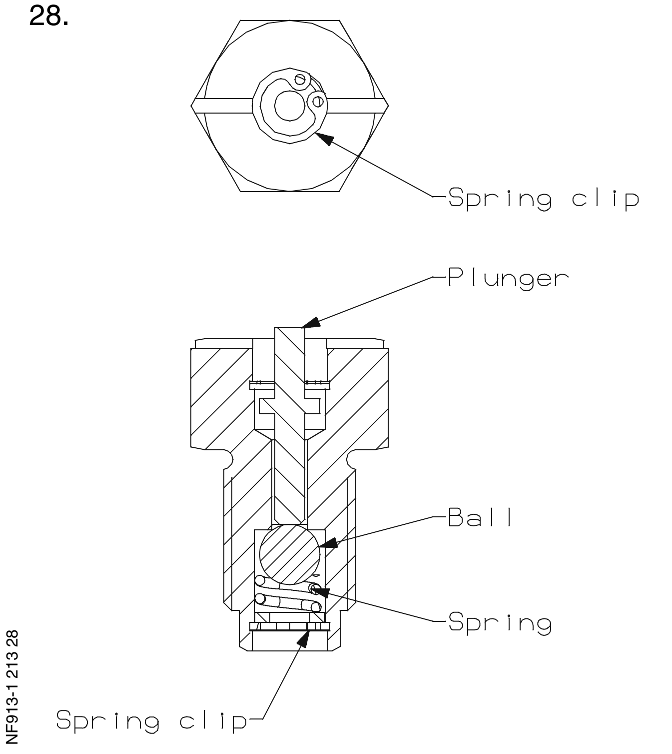

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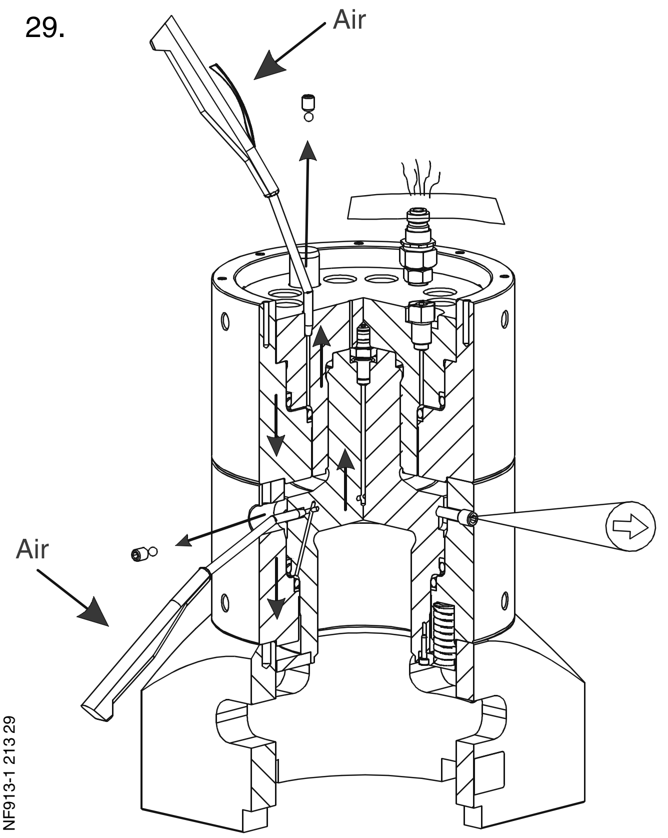

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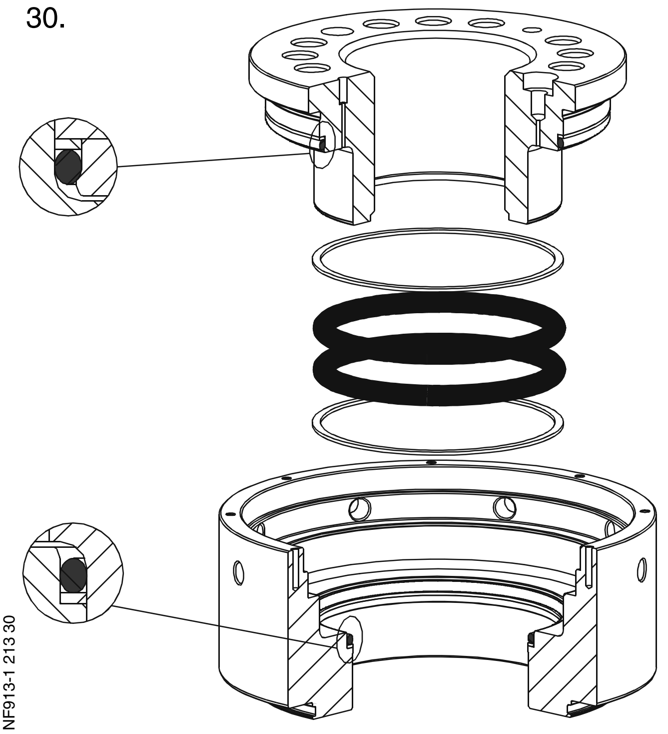


29. The piston and cylinder of the cylinder cover jacks are separated in the same way as described for the single jack.

30. When changing the sealing rings, first mount the back-up ring and then the O-ring.

    See the sketch for the correct mounting of both the upper and the lower sealing rings. The same principle applies to all the jacks.

31. 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.

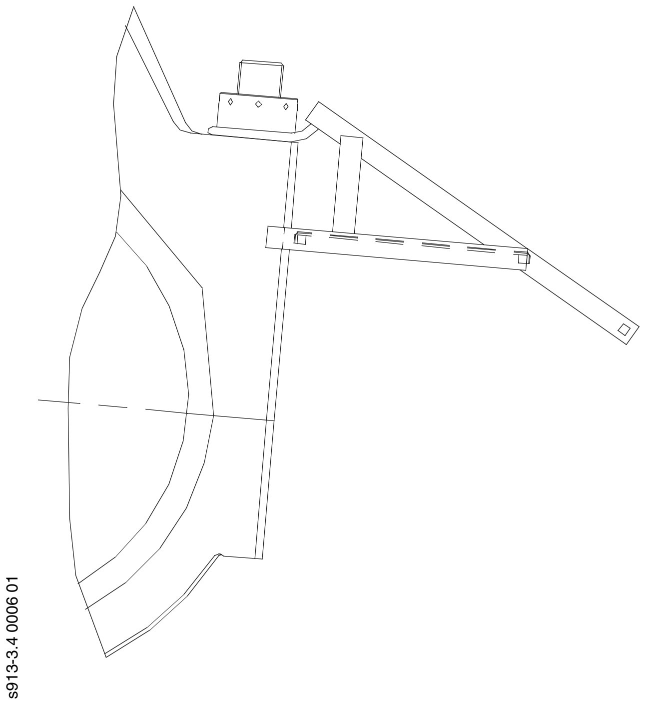
During mounting of the platforms, always use the harness, lanyard and fall arrester. It is always recommended to clean and wipe off oil from steps, crankthrow, doorways and assembling surfaces.

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.

1.



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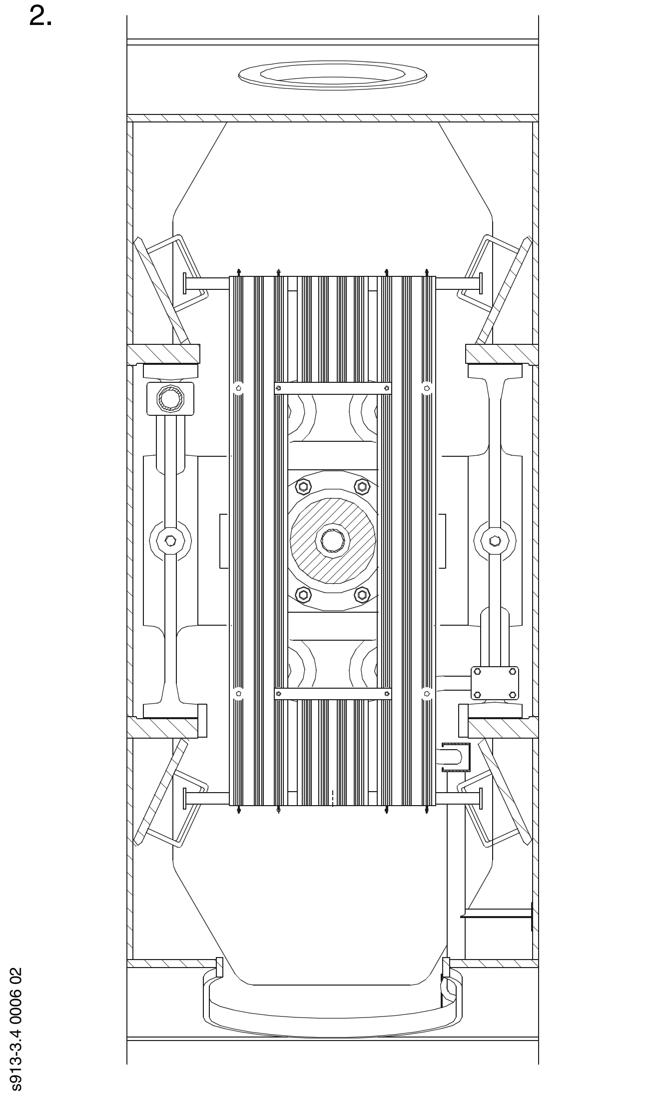

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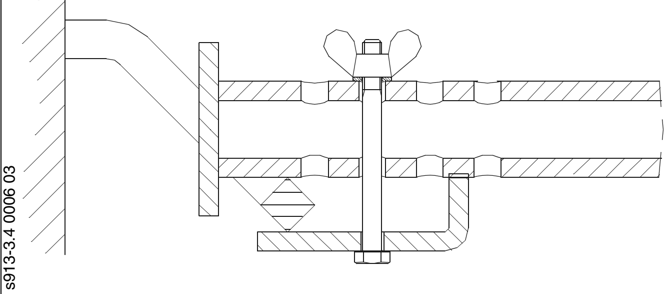

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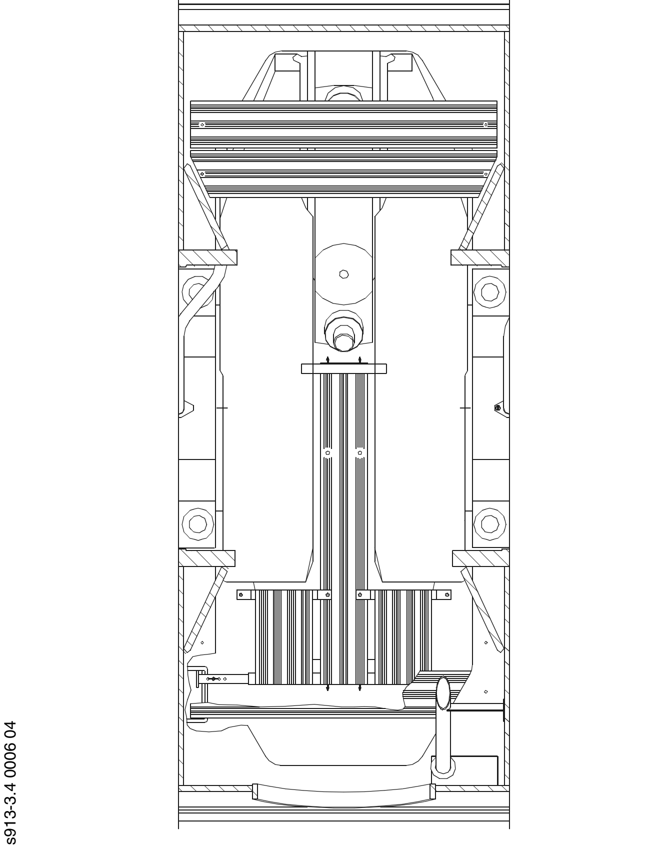

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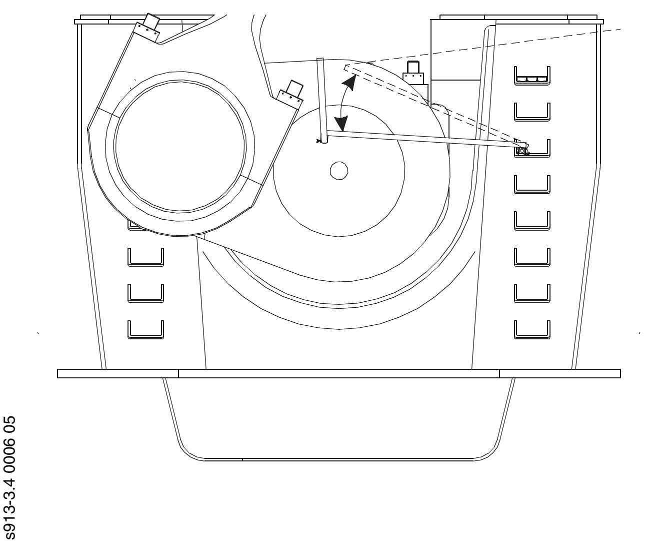


3. The working platform support is mounted as shown in sketch 3.

4. <u>Main bearing dismantling:</u> 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

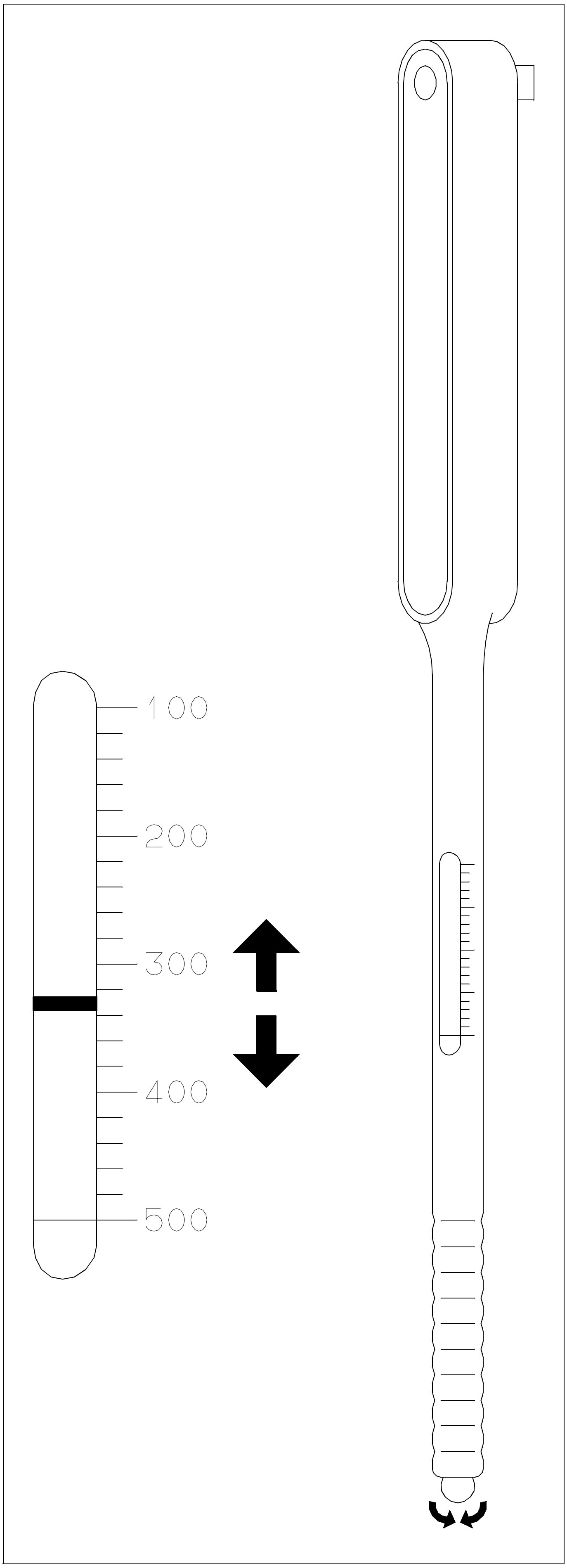
Before screwing the nuts on, the threads and the contact faces should be greased with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient μ = 0.1-0.12 (e.g. MOLYKOTE paste type G).

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

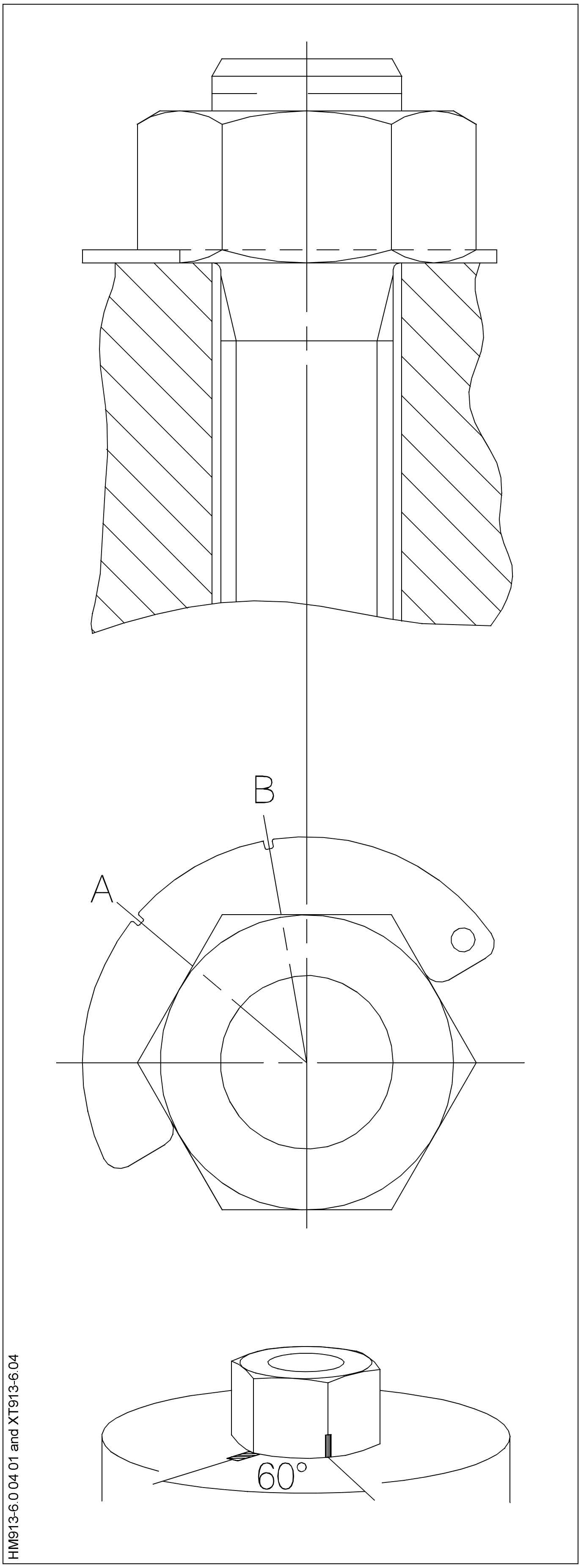
The handle of the torque spanner is provided with a scale indicating the torques at which the spanner can be set.

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.

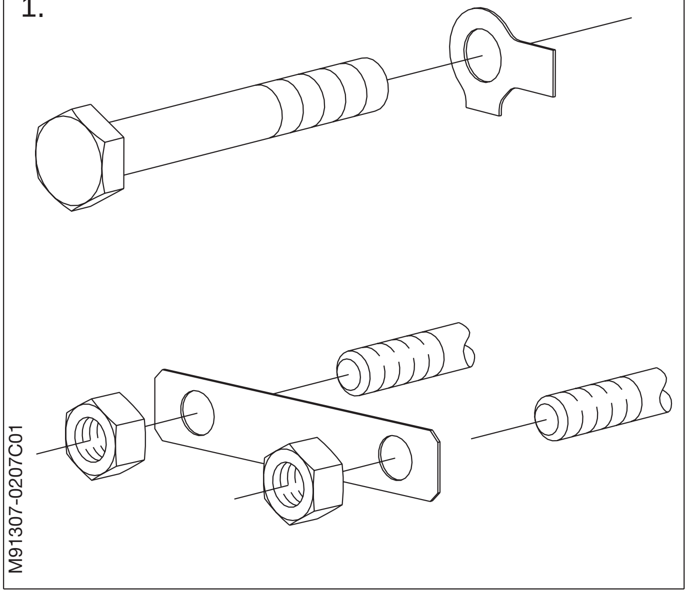
1. **Lock washers**, tab washers, locking plates, etc., must always be replaced. The tab-like projections, etc., on the washers are to be bent back over one of the flats of the screw or nut concerned.

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.

1.



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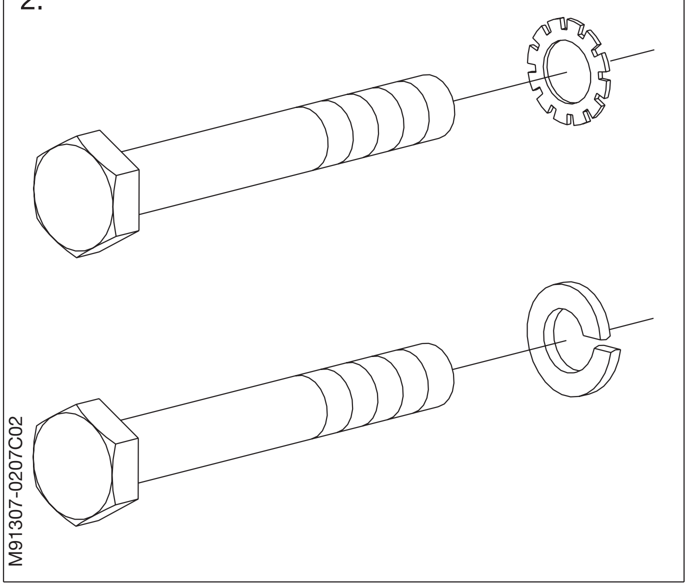

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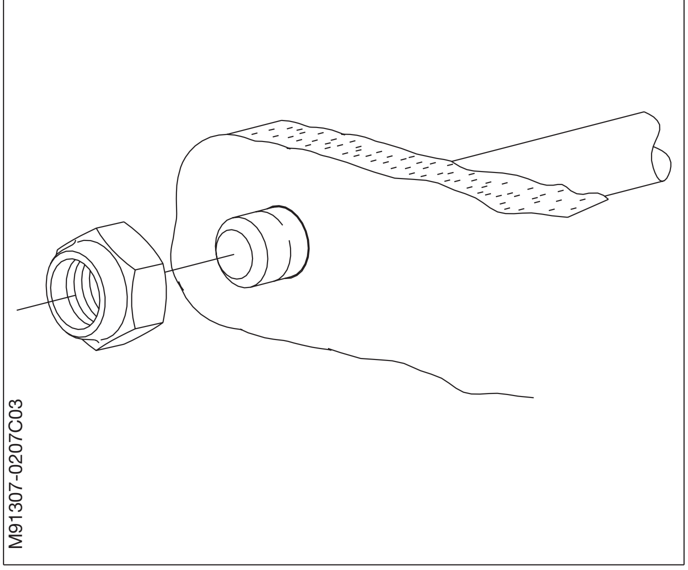
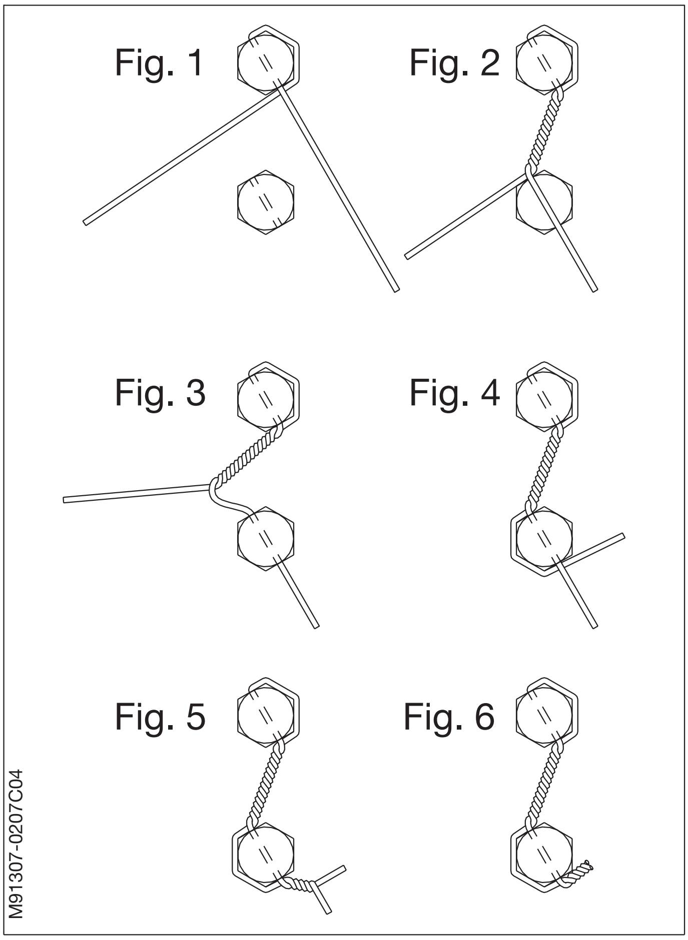
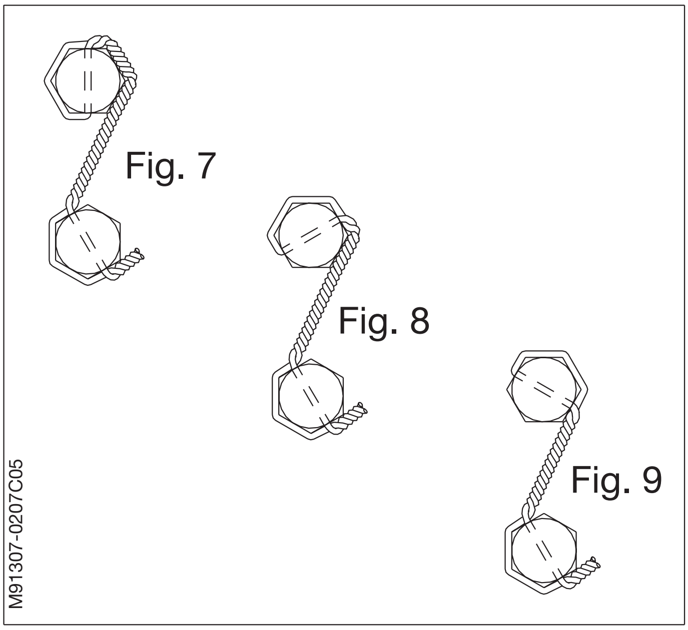






Locking wire should be fitted after the screws or nuts have been tightened to the correct torque. Do not overtighten or loosen the units to get a correct alignment of the wire holes. Always fit new wire after tightening-up the units.

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.

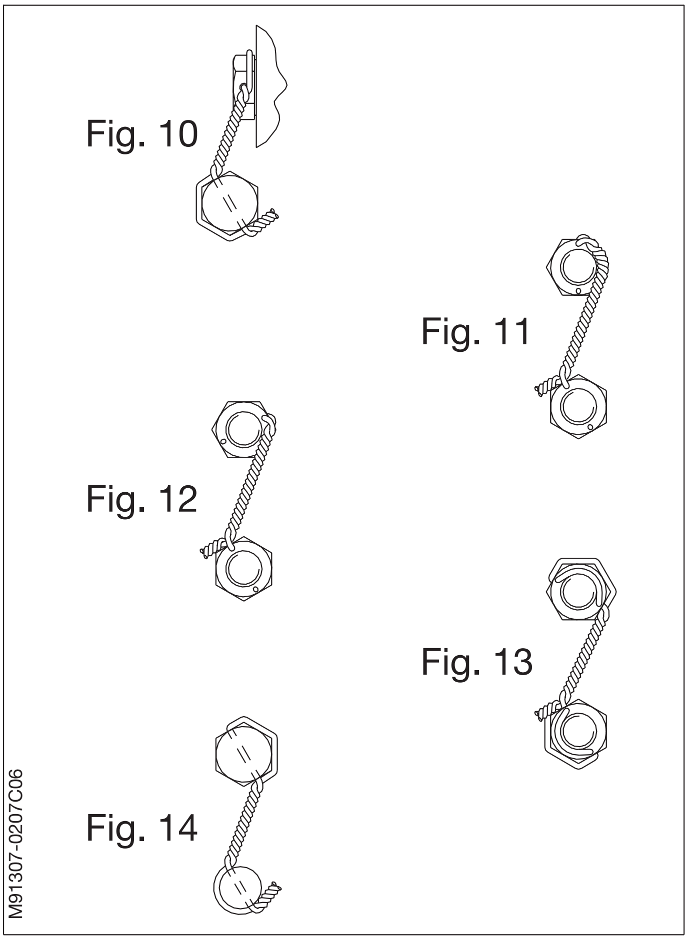


Fig. 15

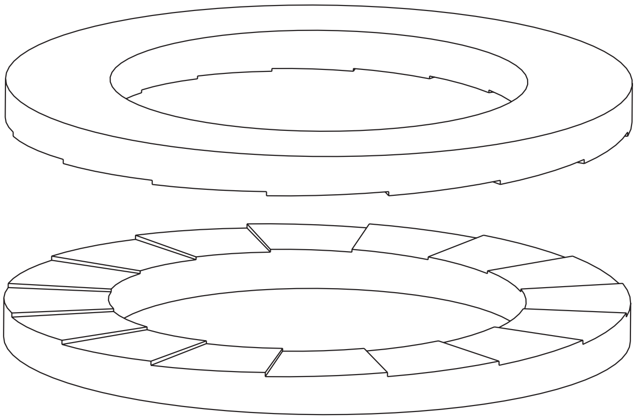


Fig. 16.

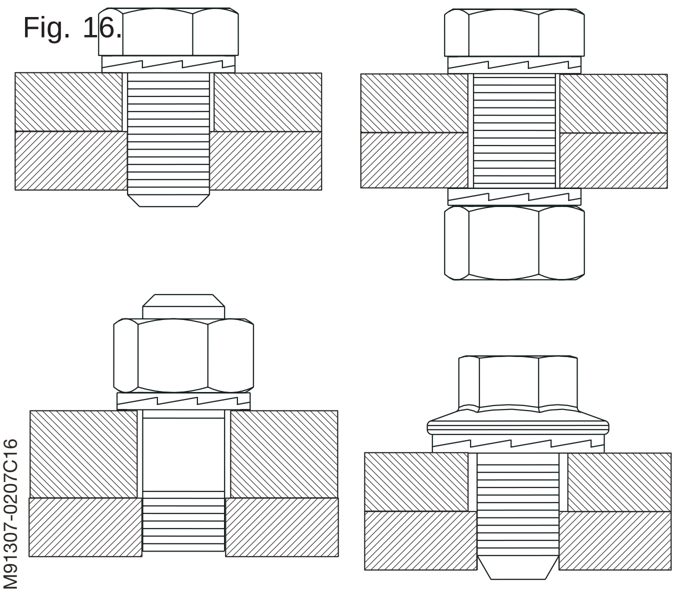
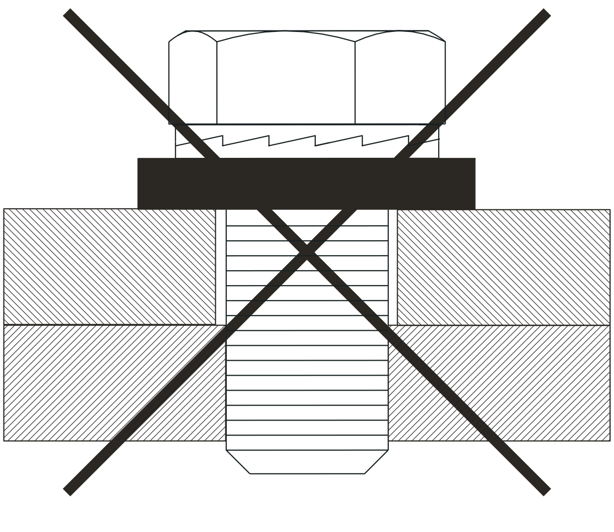


Fig. 17



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 og 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.

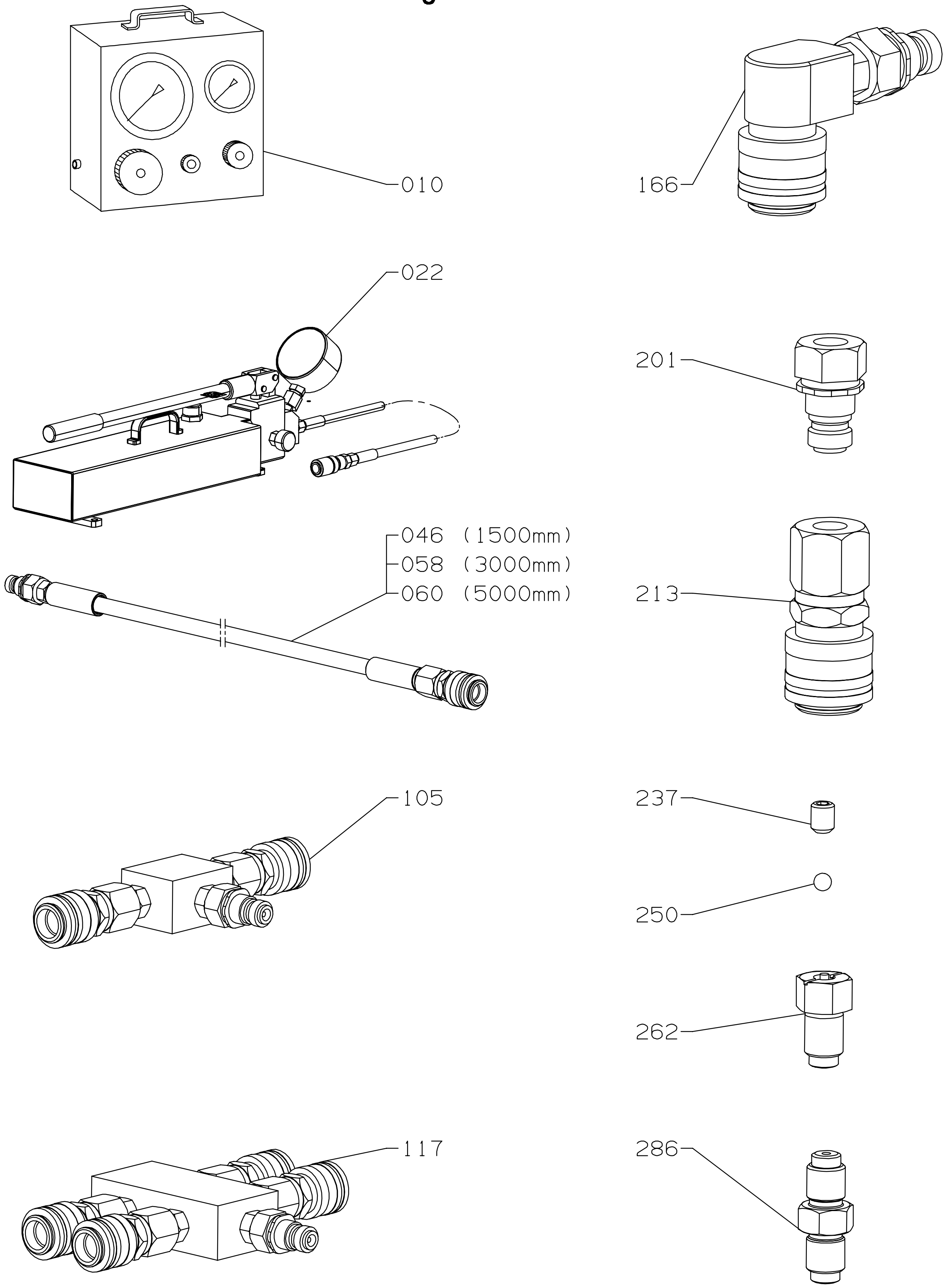
Note!
Cam lock washers must be installed in pairs and are not to be substituted by other typers of washers.

Molybdenum Disulphide (MoS_2)

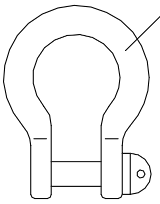
The following procedure is to be followed prior to the mounting of metal surfaced parts which are to function as seals.

- 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 (MoS_2) and mineral oil (e.g. Molycote 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.

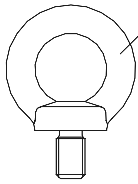
Working Pressure: 2200 Bar



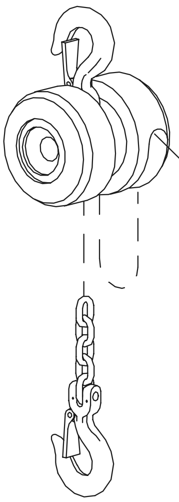
Item No.	Item Description	Item No.	Item Description
010	Hydralic pump, pneumatic operated		
022	Hydralic pump, hand operated		
046	Hose with unions (1500mm), complete		
058	Hose with unions (3000mm), complete		
060	Hose with unions (5000mm), complete		
105	2-way distributor block, complete		
117	4-way distributor block, complete		
166	Angle union		
201	Quick coupling, male		
213	Quick coupling, female		
237	Bleeder screw		
250	Steel ball		
262	Blow-off valve		
274	Nipple		



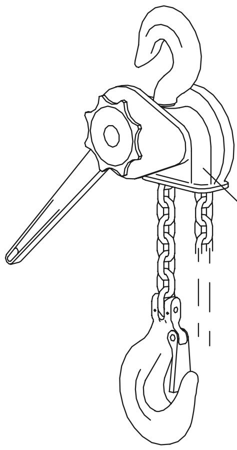
Item	Size
020	M10
031	M12
043	M16
055	M20
067	M24
079	M30
080	M33
092	M42



Item	Size
114	M10
126	M12
138	M16
140	M20
151	M24
163	M30
175	M36
199	M48

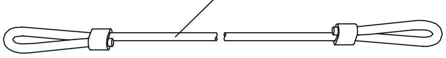


Item	Max.Load (kg)
222	1000
258	3000
260	5000
271	8000

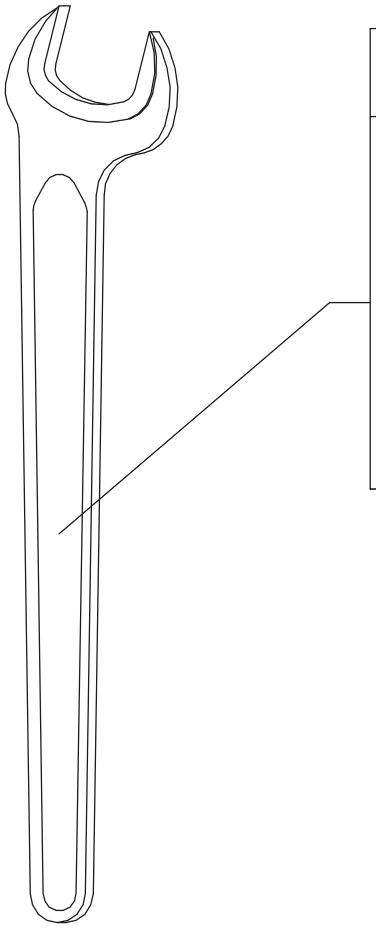


Item	Max.Load (kg)
295	3000

Item	Lenght (m)
305	6.0



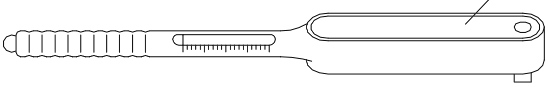
Item No.	Item Description	Item No.	Item Description
020	Forged-bent screw shackle, 10mm		
031	Forged-bent screw shackle, 12mm		
043	Forged-bent screw shackle, 16mm		
055	Forged-bent screw shackle, 20mm		
067	Forged-bent screw shackle, 24mm		
079	Forged-bent screw shackle, 30mm		
080	Forged-bent screw 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		
175	Lifting eye bolts, 36mm		
199	Lifting eye bolts, 48mm		
222	Chain tackle, 1000kg		
258	Chain tackle, 3000kg		
260	Chain tackle, 5000kg		
271	Chain tackle, 8000kg		
295	Pull lift, 3000kg		
305	Wire rope, 6m		



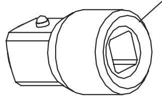
Item	Size (mm)
013	65
037	75
050	85
062	90
074	95
098	105

Item No.	Item Description	Item No.	Item Description
013	Open-ended spanner, size NV65mm		
037	Open-ended spanner, size NV75mm		
050	Open-ended spanner, size NV85mm		
062	Open-ended spanner, size NV90mm		
074	Open-ended spanner, size NV95mm		
098	Open-ended spanner, size NV105mm		

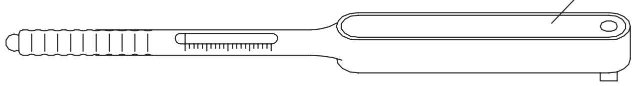
Item	Torque (Nm)
014	8-40



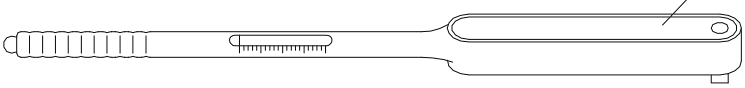
Item	Size (mm)
026	12.5/10



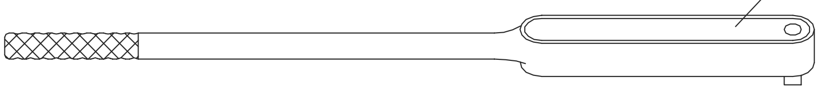
Item	Torque (Nm)
038	40-200



Item	Torque (Nm)
040	140-760



Item	Torque (Nm)
051	750-2000



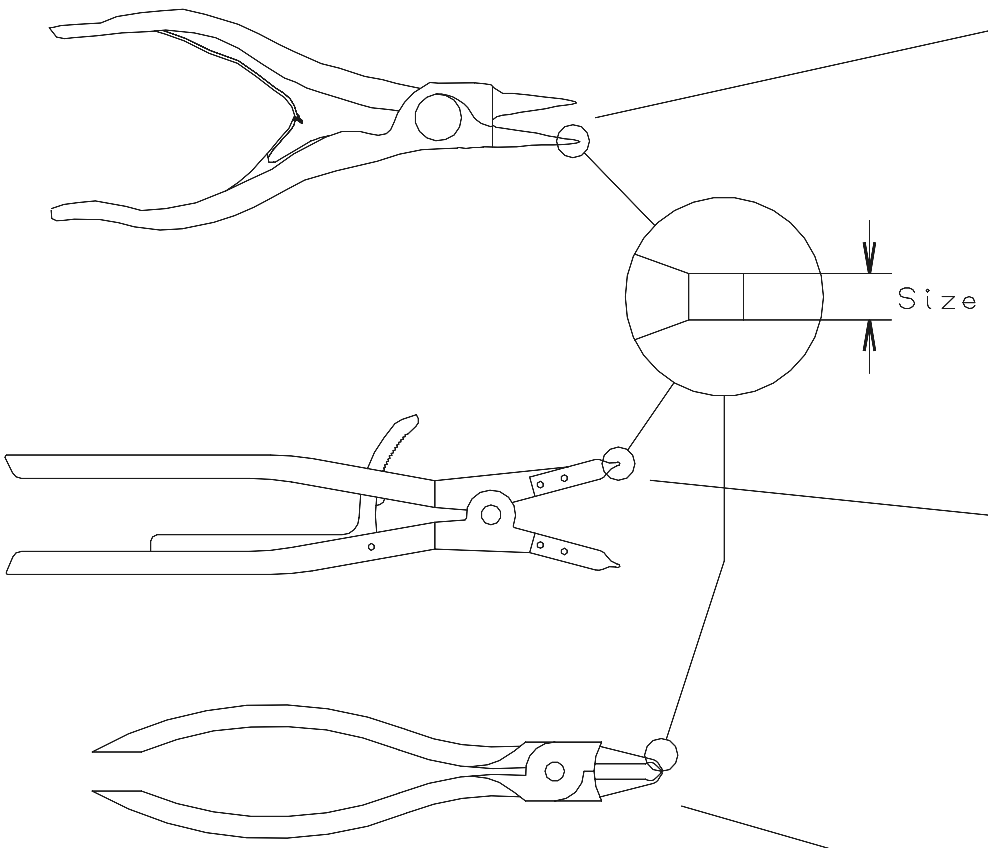
Torque Wrenches

Item No.	Item Description
014	Torque wrench, 8 - 400Nm
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

Pliers

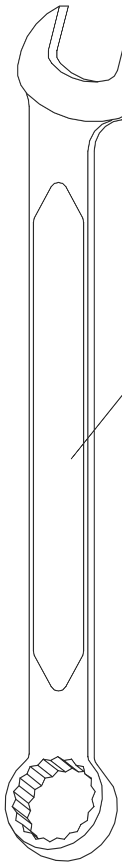
Item	Size (mm)
010	0.9
021	1.3
033	1.8
045	2.3



Item	Size (mm)
069	3.5

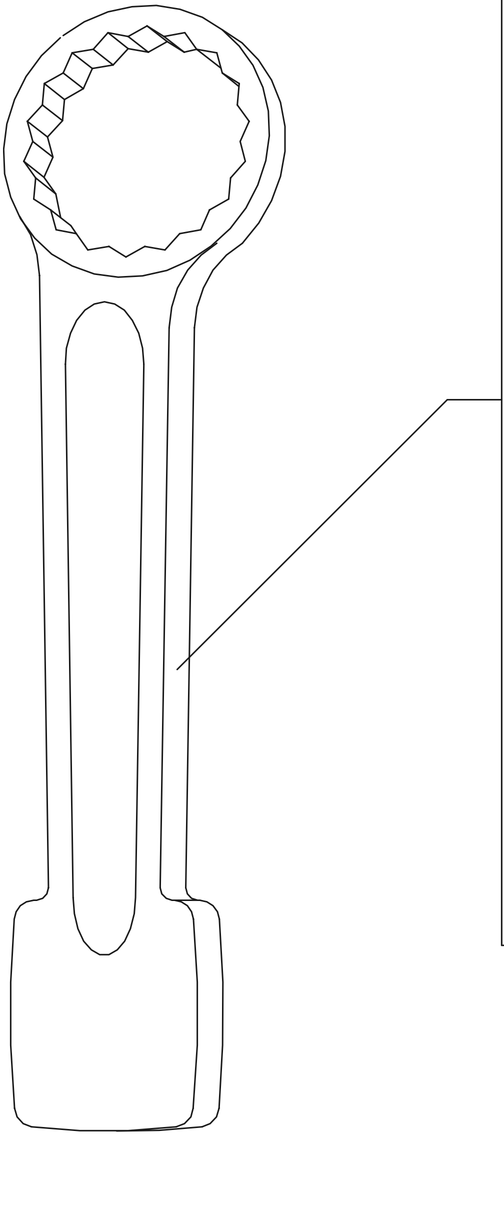
Item	Size (mm)
128	1.1
130	1.8
141	2.3
153	3.2

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		
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	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		

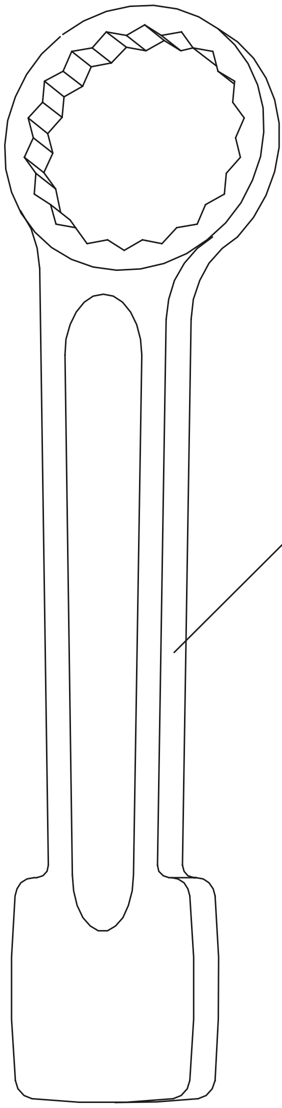


Item	Size (mm)
022	30
034	32
046	34
058	36
060	41
071	46
083	50
095	55
117	65
130	75
142	80
154	85
166	90
178	95
180	100
191	105
213	115
225	120

Ring Slugging Spanner

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
117	Slugging spanners, ring size NV65mm
130	Slugging spanners, ring size NV75mm
142	Slugging spanners, ring size NV80mm
154	Slugging spanners, ring size NV85mm
166	Slugging spanners, ring size NV90mm
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

Item No.	Item Description



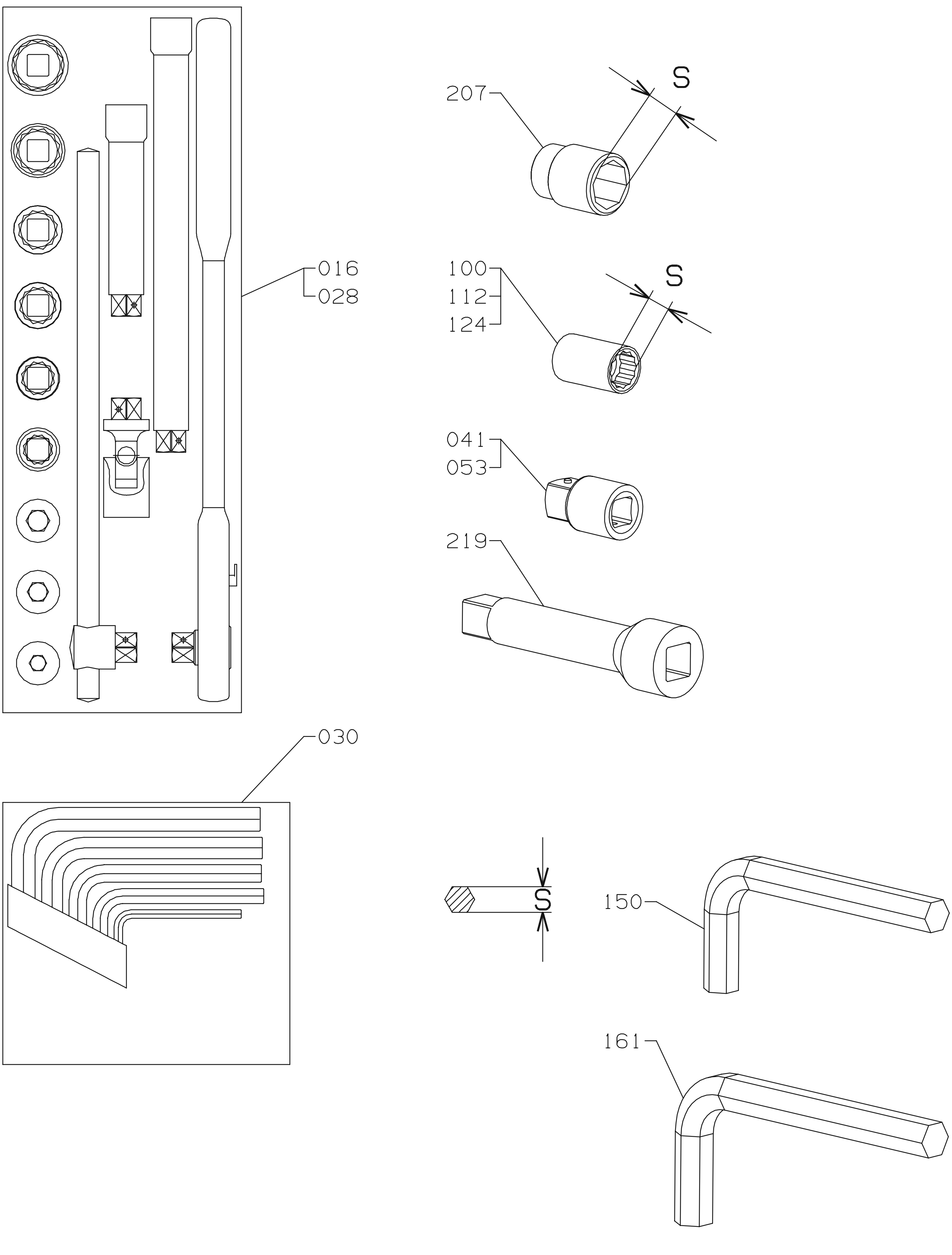
Item	Size (mm)
022	30
034	32
046	34
058	36
060	41
071	46
083	50
095	55
105	60
117	65
129	70
130	75
142	80
154	85
166	90
178	95
180	100
191	105
213	115
225	120

Ring Slugging Spanner

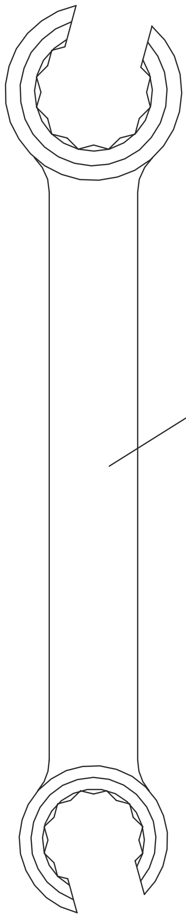
Item No.	Item Description
022	Slugging spanners, ring size NV30mm
034	Slugging spanners, ring size NV32mm
046	Slugging spanners, ring size NV34mm
058	Slugging spanners, ring size NV36mm
060	Slugging spanners, ring size NV41mm
071	Slugging spanners, ring size NV46mm
083	Slugging spanners, ring size NV50mm
095	Slugging spanners, ring size NV55mm
105	Slugging spanners, ring size NV60mm
117	Slugging spanners, ring size NV65mm
129	Slugging spanners, ring size NV70mm
130	Slugging spanners, ring size NV75mm
142	Slugging spanners, ring size NV80mm
154	Slugging spanners, ring size NV85mm
166	Slugging spanners, ring size NV90mm
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

Item No.	Item Description

Spanners



Item No.	Item Description	Item No.	Item Description
016	Tool set, complete, size 10-22 mm		
028	Tool set, complete, size 24-46 mm		
030	Hex key tool set, complete		
041	Adapter for socket wrench, 20->12.5		
053	Adapter for socket wrench, 25->20		
100	Socket spanner, S=46 mm		
112	Socket spanner, S=50 mm		
124	Socket spanner, S=55 mm		
150	Hex key, S=22 mm		
161	Hex key, S=24 mm		
207	Socket wrench, S=33 mm		
219	Extension bar, 200 mm		

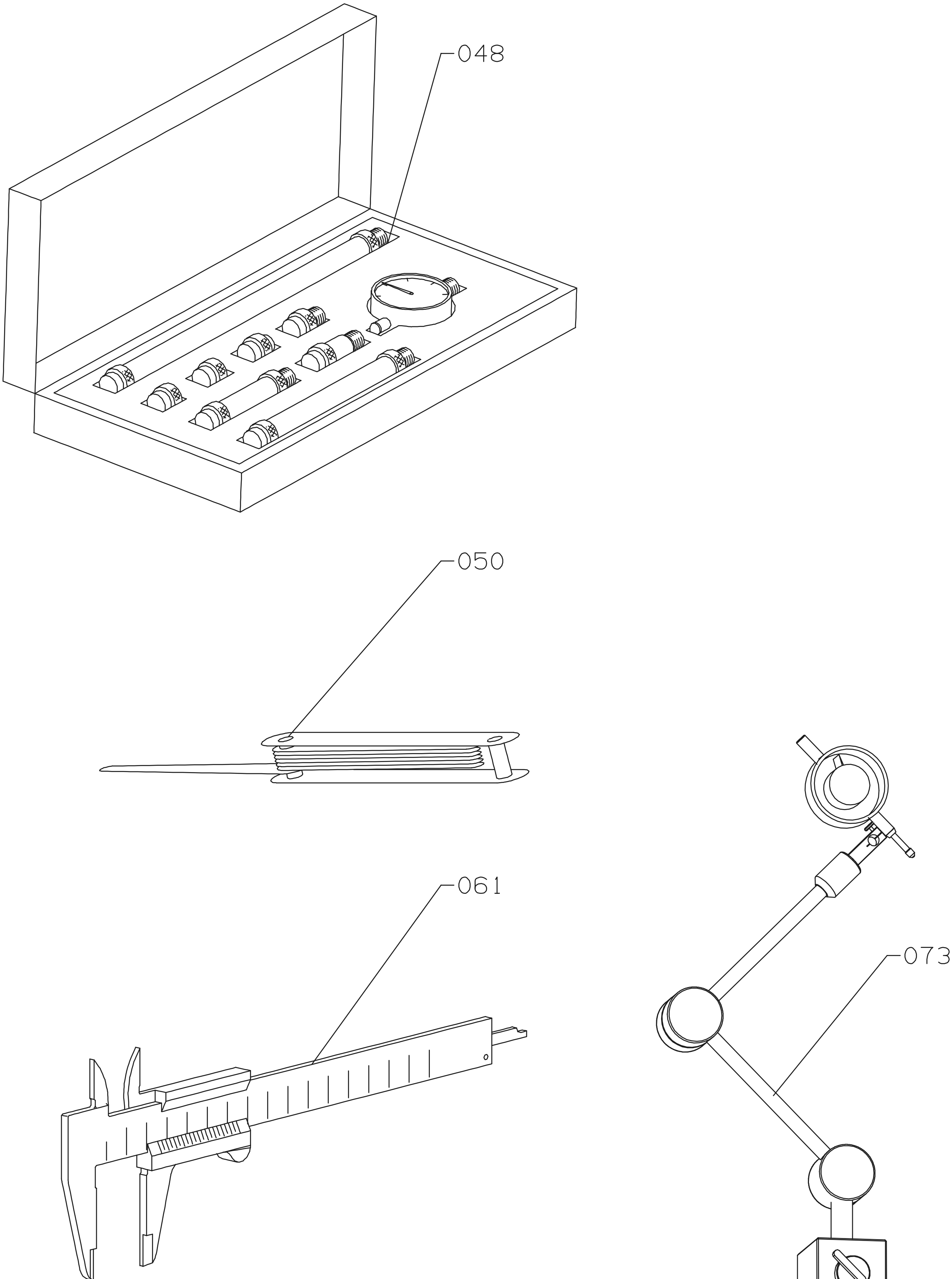


Item	Size (mm)
011	14/17
023	19/22

Open-ended Spanners

Item No.	Item Description
011	Open ring wrench, 14 - 17mm
023	Open ring wrench, 19 - 22mm

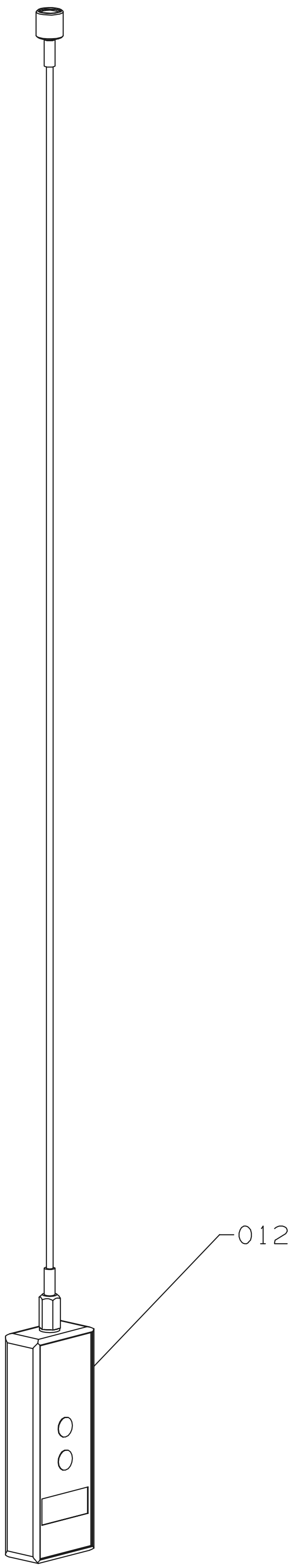
Item No.	Item Description


048
050
061
073

Instruments

Item No.	Item Description
048	Autolog, measuring tool for crankshaft
050	Feeler gauge
061	Slide caliper
073	Dial gauge and stand tool

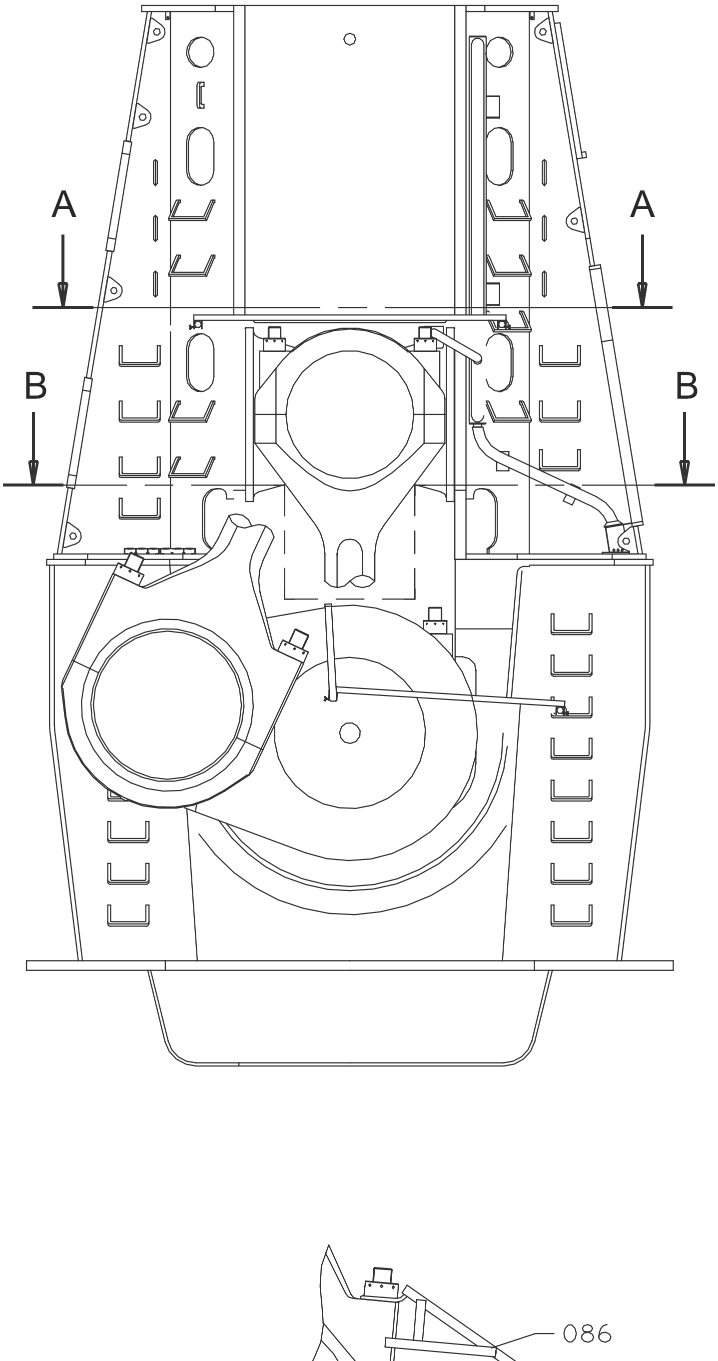
Item No.	Item Description


012

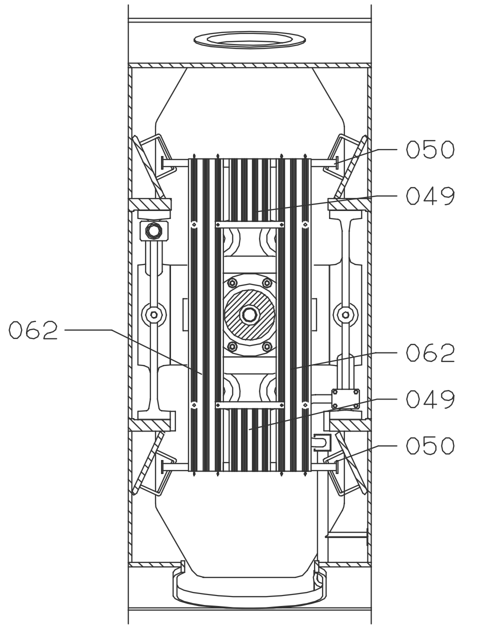
Instruments

Item No.	Item Description
012	Pressure gauge

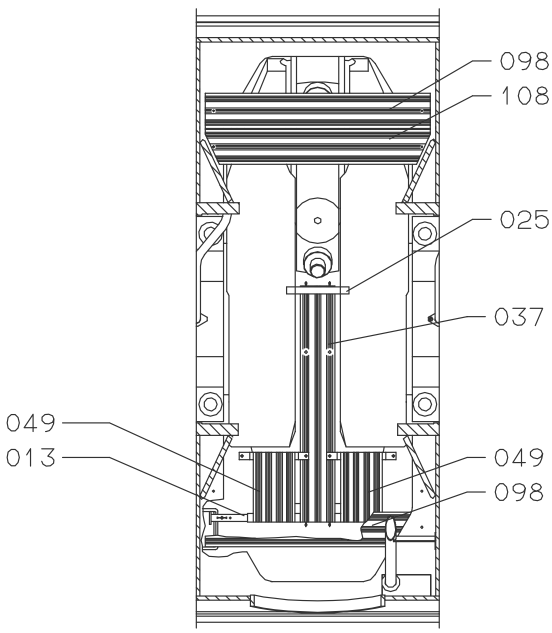
Item No.	Item Description

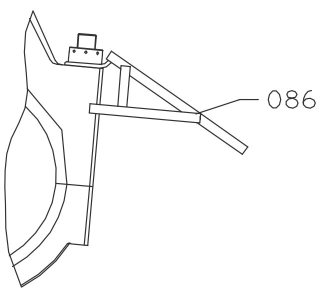


A - A



B - B





Item No.	Item Description	Item No.	Item Description
013	Working platform support		
025	Working platform support		
037	Platform board		
049	Platform board		
050	Working platform support		
062	Platform board		
086	Ladder		
098	Foot grating		
108	Foot grating		

Warning!
It is important that all MAN Diesel A/S engines are operated within the given specifications and performance tolerances specified in the engines' Technical Files and are maintained according to the MAN Diesel A/S maintenance instructions in order to comply with given emissions regulations. In accordance with Chapter I of the Code of Federal Regulations, Part 94, Subpart C, §94.211 NOTICE is hereby given that Chapter I of the Code of Federal Regulations, Part 94, Subpart K, §94.1004 requires that the emissions related maintenance of the diesel engine shall be performed as specified in MAN Diesel A/S instructions, including, but not limited to, the instructions to that effect included in the Technical File.

MAN Diesel

K98ME

DS 09092965

VOLUME III

COMPONENTS

DESCRIPTION

900 - Introduction

Documents in this Chapter

Table of Contents

Volume III - Components Description

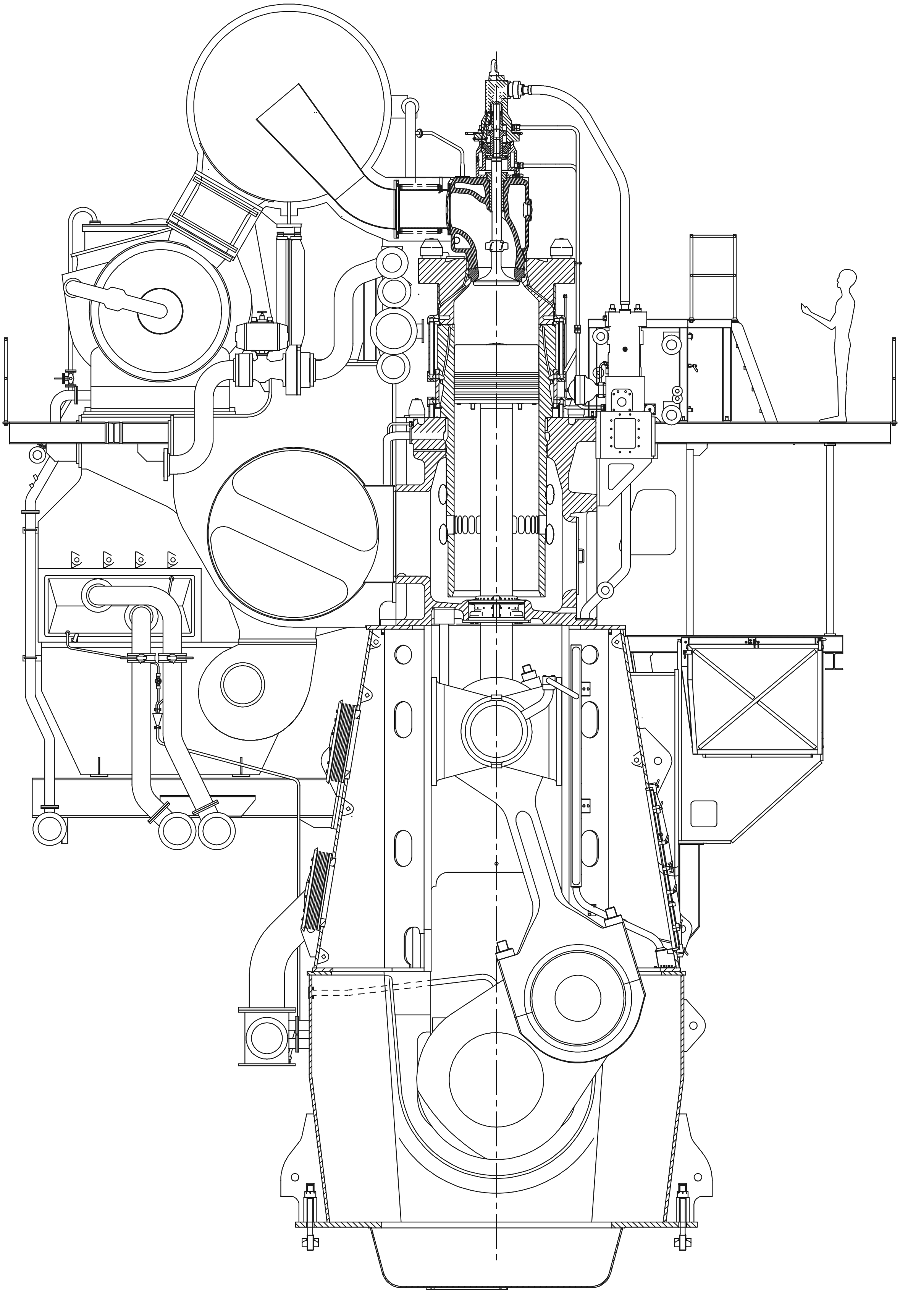


Plate Item no. for part(s) to be insulated P______-____-___*

(For example: P91003-0195-305)

Length: __________mm

Width: __________mm

Height: __________mm

Diameter Ø: __________mm

Special features: ____

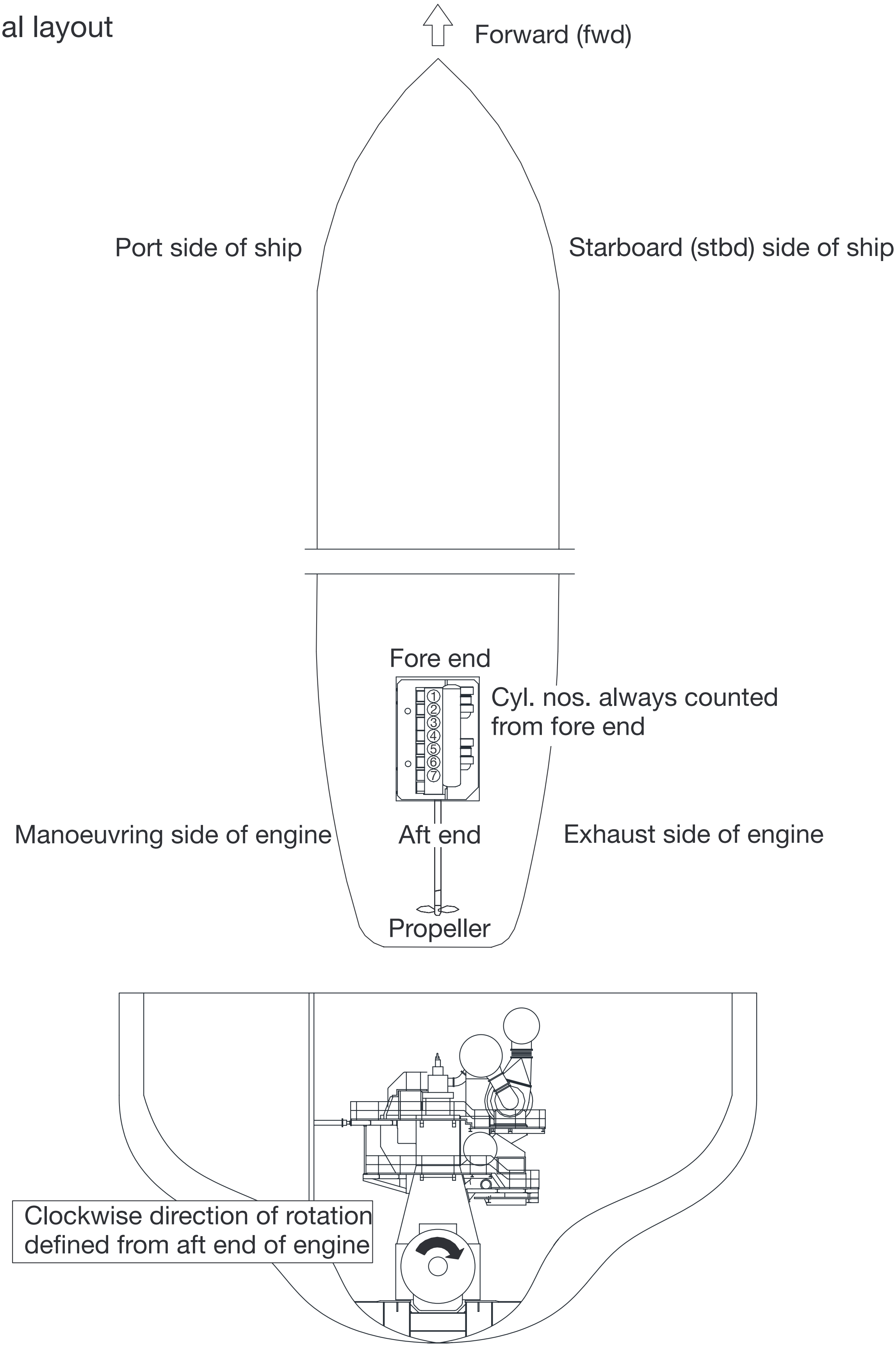
____

____

Sketch:

* Or state manufacturer's part no.: ________________________

Normal layout



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Instructions for Main Engines

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

Vol. I OPERATION
Vol. II MAINTENANCE
Vol. III COMPONENTS, 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 an MAN B&W main diesel engine. 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:

Name of vessel
Engine No. built by
Plate No.
Part No.
Quantity required (and description)

Example: M/S Nybo – 7730 B&W – P90201-0036 – 059
10 off (piston ring)

To ensure optimum efficiency, reliability and lifetime of the engine and its components, only original spare parts should be used when replacing parts on the engine.

When used in texts and illustrations, the designation "D" refers to the information given on the data sheets inserted in the respective books.

Reliable and economical operation of the diesel engines is conditional upon its correct operation and maintenance in accordance with MAN Diesel' instructions. Emissions related maintenance of the diesel engine shall be performed as specified in MAN Diesel' instructions and any additional instructions to that effect included in the Technical File. Consequently, it is essential that the engine room personnel are fully acquainted with the contents of this book and, in respect of instructions on emissions related maintenance of the diesel engine, also the additional instructions to that effect set out in the Technical File.

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CVR No. 39 66 13 14

A90023-0028

901 Cylinder Cover

Cylinder Cover The cylinder cover is made from steel.

On the 65-108ME type engines the cylinder cover is provided with welded-on heat resistant material at the points of fuel oil injection in order to improve the service condition.

Valve bores The cover has a central bore for the exhaust valve, which is attached by means of four studs and nuts.

The cover furthermore has bores for the fuel valves, starting valve, starting air inlet, safety valve, indicator cock and PMI-pick-up.

Cooling A cooling jacket is mounted on the lower part of the cylinder cover, whereby a cooling water space is formed.

Another cooling water space is formed around the exhaust valve seat, when the exhaust valve is installed. These two spaces communicate through a large number of cooling bores in the cover.

The water is supplied from the cooling jacket surrounding the cylinder liner and passes through water connections to the cooling jacket surrounding the cylinder cover and, further on, through the cooling bores, to the space around the exhaust valve seat.

From here the water is discharged to the main cooling water outlet pipe:

On some engine types, an amount of water is also passed directly from the cylinder cover to the exhaust valve housing through a cooling water connection.

Tightening The cylinder cover is tightened against the top of the cylinder liner with nuts and long studs fitted in the cylinder frame. The nuts are tightened with hydraulic tools.

Sealing between the cylinder cover and cylinder liner is obtained by means of a sealing ring of mild steel.

902 Piston with Rod and Stuffing Box

Piston The piston consists of two main parts:

- Piston Crown
- Piston Skirt

The piston crown is tightened to the upper end of the piston rod, and the piston skirt is tightened to the piston crown.

The piston crown is provided with one groove all the way around, or with three smaller grooves for the fitting of lifting tools.

The piston crown is provided with chromium-plated grooves for four piston rings.

Piston ring No. 1 is a Controlled-Pressure Relief ring (CPR).

Piston rings Nos. 2, 3 and 4 have oblique cuts:

• piston ring No. 3 has a right-hand cut,

and

• piston rings Nos. 2 and 4 have left-hand cuts.

On some engines, the piston rings are provided with Alu-coating to improve the running-in stability and to reduce the running-in period.

Handle with care, as impact may cause the coating to crack and peel off.

<u>Stationary Engines:</u>

The CPR ring may have been coated with PM14 on the external surface. Handle with care, as impacts may cause the coating to crack and peel off.

Piston Rod

The piston rod has a through-going bore for the cooling oil pipe, which is secured to the piston rod top.

Cooling oil is supplied through a telescopic pipe connection on the guideshoe or on the crosshead and passed through a bore in the piston rod foot and, through the cooling oil pipe in the piston rod, to the piston crown.

The oil is passed on, through a number of bores in the thrust part of the piston crown, to the space around the cooling oil pipe in the piston rod.

From the bore in the piston rod foot, the oil is led through the crosshead to a discharge spout and to a slotted pipe inside the engine framebox as well as through a control device for checking the flow and temperature.

The piston rod foot rests on a face cut out in the crosshead pin.

A shim is inserted between the piston rod and the crosshead. The thickness of the shim is predetermined to match the actual engine layout.

The piston rod is fastened to the crosshead pin with screws or studs and nuts. The nuts are tightened with hydraulic tools.

Stuffing Box

The bore for the piston rod between the scavenge air space and the crankcase is fitted with a piston rod stuffing box, which is designed to prevent the lubricating oil in the crankcase from being drawn up into the scavenge air space.

The stuffing box also prevents scavenge air (in the scavenge air space) from leaking into the crankcase.

The stuffing box housing consists of two parts, which are bolted together.

Scraper/ sealing rings

The housing is provided with a number of machined ring grooves:

- The uppermost groove holds a scraper ring with oblique edges, which serves to prevent sludge from the scavenge box from being drawn down to the other rings.

Furthermore, a sealing ring is fitted below the scraper ring.

- The ring grooves in the middle are fitted with sealing rings.

- The lowermost ring grooves are fitted with scraper rings which scrape the lubricating oil off the piston rod.

Oil which is scraped off the piston rod is returned to the crankcase through bores in the stuffing box housing.

Through bores in the housing and a pipe, the stuffing box communicates with a control funnel on the outside of the engine, which enables the sealing/scraping performance to be checked.

Gaps at the ends of the ring segments ensure that the rings will bear against the piston rod even in worn condition.

903 Cylinder Liner and Cylinder Lubrication

Cylinder Section

The cylinder section of the engine consists of a number of cylinder frames. The cylinder section is tightened together with the engine framebox and the bed plate by means of stay bolts. Alternativly as a complete welded assembly integrating the scavenge air receiver into the cylinder frame.

Bores and openings

Central bores at the top of the cylinder frame enclose the cylinder liners.

Central bores in the bottom of the cylinder frame enclose the piston rod stuff ing boxes.

On the exhaust side of the cylinder frame there are openings which connect the scavenge air space around the cylinder liner with the longitudinal scavenge air receiver of the engine.

There are also inlet pipes for cooling and lubricating oil. The cylinder frame is provided with cleaning and inspection covers giving access to the scavenge air spaces.

Cylinder cover studs

Studs for fastening the cylinder cover are mounted in the cylinder frame.

Cylinder Liner and Cooling Jacket

The cylinder liner is fitted with a cooling jacket. The cooling water is supplied at the lower part of the cooling jacket.

On slim-type liners, the water continues directly to the upper part of the cool ing jacket, whereas on the bore-cooled type liner, the water first passes through the cooling bores. From the top of the cooling jackets, the water flows through water connections to the cooling jacket on the lower part of the cylinder cover.

Leakage of cooling water is prevented by silicone rubber rings.

The cylinder liner is tightened against the top of the cylinder frame by the tensioning force from the cylinder cover studs being transmitted via the cylinder cover.

Scavenge air ports — The part of the cylinder liner which is located in the scavenge air space of the cylinder frame is provided with a number of scavenge air ports, which are uncovered by the piston when this is in its bottom position. The scavenge air ports are bored at an oblique angle to the axis of the cylinder liner so as to give the scavenge air a rotary movement in the cylinder.

Cylinder lubrication — In the free part of the cylinder liner, between the cooling jacket and the cylinder frame, there are a number of bores with non-return valves for the supply of lubricating oil to the cylinder.

PC-ring — On 80-98ME type engines a piston cleaning (PC) ring is mounted at the top of the cylinder liner. The purpose of the PC-ring is to prevent the building-up of deposits on the piston topland and, in turn, prevent the wiping away of the cylinder lubricating oil. Consequently, the PC-ring contributes to reducing the wear of liners and rings.

Cylinder Lubricators — The engine is equipped with electronically controlled cylinder lubricators for lubrication of the running surface of liners and rings, mounted on the Hydraulic Cylinder Unit (HCU), *see Chapter 906 and 909*.

Regarding the cylinder lubricators proper, reference is made to the special in struction manuals supplied.

See also Volume I, OPERATION, Chapter 707.

904 Crosshead with Connecting Rod

Crosshead — The crosshead is provided with two guide shoes fitted on the crosshead ends.

The centre part of the crosshead is designed as a bearing journal which is housed in the crosshead bearing.

The crosshead bearing cap is provided with a cut-out enabling the piston rod to be assembled with the crosshead journal.

The crosshead is equipped with steel shells lined with bearing metal. The lower shell is provided with an overlayer coating.

See also Volume I, OPERATION, Chapter 708.

Piston rod foot — The piston rod foot is fastened to the crosshead. To match different engine lay outs, a shim of predetermined thickness is inserted between the piston rod and the crosshead.

Lubrication — The crosshead is provided with bores for distributing the oil supplied through the telescopic pipe, partly as cooling oil for the piston, partly as lubricating oil for the crosshead bearing and guide shoes and – through a bore in the connecting rod – for lubricating the crankpin bearing.

The piston cooling oil outlet is led through a control device for each cylinder for the purpose of checking the temperature and flow before the oil is passed on to the lube oil tank.

Guide shoes

The sliding faces of the guide shoes are lined with cast-on bearing metal.

The guide shoes are guided by crosshead guides in the engine framebox and properly secured against displacement by guide strips fastened to the guide shoes.

On some engines, the guide shoes are provided with counterweights.

Tightening

The crosshead bearing is held together by studs and nuts. The nuts are tight ened with hydraulic tools.

The crankpin bearing is fitted with steel shells lined with bearing metal and as sembled in the same way as the crosshead bearing.

905 Crankshaft and Turning Gear

Crankshaft

The crankshaft is either of the semi-built type, where the parts are shrunk to gether, or it is a one-piece forging.

The main bearings are lubricated via a main lubricating oil pipe that branches off to the individual bearings, whereas oil for lubricating the crankpin bearings is supplied from the crossheads through bores in the connecting rods.

The crankshaft is provided with a chain wheel, a step-up gear for the hydraulic pumps and a turning wheel. Furthermore, if deemed necessary by the vibration calculations, a tuning wheel, a torsional vibration damper and a chain wheel drive for 2nd order and 4th order moment compensators are installed. Alternatively, an electrically driven moment compensator can be installed in the steering gear room.

<u>Marine engines (except geared plants):</u>

At the aftmost end of the engine, a thrust bearing is fitted.

The thrust bearing serves the purpose of transmitting the axial thrust of the propeller through propeller shaft and intermediate shafts to the ship’s hull.

The crankshaft is provided with a thrust collar which transmits the thrust to a number of segments mounted in a thrust shoe on either side of the thrust collar.

The thrust shoes rest on surfaces in the thrust bearing housing and are held in place by means of stoppers or cross bars. The segments have white metal cast onto the wearing faces against the thrust collar. *See also Volume I, OPERATION, Chapter 708.*

The thrust bearing is lubricated by the pressure lubrication system of the engine. The oil is supplied between the segments through spray pipes and spray nozzles.

The thrust bearing is provided with alarm, slow-down, and shut-down devices for low lube oil pressure and high segment temperature. *See also Volume I, OPERATION, Chapter 701.*

<u>Stationary engines and geared marine plants:</u>

The crankshaft is provided with a collar for the guide bearing. The purpose of the guide bearing is to keep the crankshaft in its proper position in the axial direction.

Axial Vibration Damper

To counteract heavy axial vibrations, and any resultant adverse forces and vibrations, the crankshaft is provided with an axial vibration damper. *See also Section 912, "Assembly of large parts" further on in this text.*

The damper consists of a 'piston' and a slit-type housing. The 'piston' is made as an integrated collar on one of the main bearing journals, and the housing is mounted on the pertaining main bearing support.

The axial movement is damped as a result of the 'restrictions' incorporated in the bores which interconnect the oil-filled chambers on the two sides of the 'piston'.

Lubricating oil is supplied to both sides of the 'piston' from the main system.

Turning Gear

The turning gear is attached to the engine bedplate and is driven by an electric motor incorporating a disc brake.

Through a planetary gearing, the motor drives a horizontal shaft equipped with a gear wheel which can be axially displaced manually, so as to engage with the turning wheel of the engine.

The turning gear is provided with a safety arrangement consisting of a safety lever which must be lifted before the gear wheel of the turning gear can be made to engage with the turning wheel.

When the safety lever is in its bottom position, it prevents the gear wheel of the turning gear from engaging with the turning wheel.

Immediately the lever is lifted away from the **disengaged** position, an interlock valve inserted in the starting air system of the engine is actuated. This interlock prevents starting air from being supplied to the engine as long as the turning gear is in the **engaged** position.

See also Volume I, OPERATION, Chapter 703.

Warning!	
Dismantling of working parts:	**During any dismantling of working parts of the engine, the turning gear must be in the engaged position in order to prevent outside forces from turning the engine, thus causing injuries to personnel or damage to the machinery.** *See Volume II, MAINTENANCE, 'DATA' pages.*
Pressure testing of starting valves:	**The turning gear must be in the disengaged position during pressure testing of starting valves, as a leaky valve may cause the engine to rotate, and damage the turning gear.** *See Volume I, OPERATION, Chapter 703.*

906 Control Gear

Concept

The ME engine control concept primarily concerns the use of a mechanical/hydraulic system to activate the fuel injection pumps and the exhaust valves, which are electronically controlled by a computer based control system. Also the starting air system is electronically controlled by the ME control system.

The hydraulic fuel injection and exhaust valve activation systems require a hydraulic power supply.

The normal lubricating oil is used as hydraulic medium. The oil is cleaned by a filter unit to the appropriate purity for use in a hydraulic oil system. The oil is then pressurised either by engine-driven pumps when the engine is rotating, or by electrically driven pumps when the engine is at a standstill. In the 'Safety and Accumulator Block', pressurised oil is accumulated to ensure a stable oil supply to the 'Hydraulic Cylinder Units', see also Chapter 908 and 909.

Filter Unit

The main filter in the hydraulic power system is of the multi-cartridge, self-cleaning type, with automatic back-flushing of the cartridges.

The back-flushing of each cartridge is carried out with compressed air on a time basis, but is also activated if the pressure drop across the filter exceeds a certain level.

A redundant filter is mounted in parallel with the main filter and is used during overhaul of the main filter. Switching to the redundant filter and back again is done manually without interrupting the oil flow to the pumps.

Indicator Valve

Each cylinder is fitted with an indicator valve, which communicates with the combustion chamber of the cylinder through a bore.

Operating Instructions

When opening the indicator valve, the spindle must be screwed right back to the stop in order to avoid burns and carbon in the guide.

Note!

For indicator valves of the double-seated design with a spring-loaded closing face:

In order to prevent overstressing, close the valve lightly before starting the engine, and retighten the valve when the engine has reached its normal service temperature.

Electrically driven Pumps

The purpose of the electrically driven pumps is to ensure adequate hydraulic system pressure in situations where the main engine is not rotating and thus not driving the engine-driven pumps. The electrically driven pumps operate when there is no hydraulic oil consumption. Therefore, only a small capacity is needed and the pumps are thus relatively small compared to the engine-driven pumps.

The electrically driven pumps are of the fixed displacement type. They are arranged in two sets each driven by an electric motor. Each set consists of a high-pressure pump for hydraulic oil supply and one low-pressure booster pump for filling and topping-up of the ‘hydraulic push rods’ of the exhaust valves.

Step-up Gear

The engine-driven hydraulic pumps are either mounted on the aft end of the engine and are driven from the crankshaft via a two-stage step-up gear or mounted on the chain box and driven through gear wheels on the chain wheels.

The step-up gear is of the gearwheel type. It is driven by the crankshaft and is permanently connected to the mechanically driven pumps.

The step-up gear is lubricated from the main engine lubricating system.

Engine-driven Pumps

All engine-driven hydraulic oil pumps are of the variable displacement type and are of the same size. The displacement is electronically controlled by the ECS (Engine Control System) via a control valve built on to the pumps. The flow is determined by the actual displacement and rotational speed.

The pumps are designed to have two directions of rotation and two directions of flow. This is needed as most engines are reversible. On reversing of the engine, the displacement control of the ECS must alter the pump to the opposite direction of flow.

Safety and Accumulator Block

The pre-charged accumulators in the ‘Safety and Accumulator Block’ contain high-pressure oil, ensuring a stable, non-fluctuating supply to the cylinder units.

The block also incorporates three pressure relief valves to protect the high-pressure system against excessive pressure.

High-Pressure Piping

The hydraulic oil pipes between the Hydraulic Power Supply (HPS) unit and the Hydraulic Cylinder Units (HCU) employ double-walled piping. Double piping is also used for high-pressure pipes between the individual HCU units. The inner and outer bores of the double piping are connected by separate lines in the distribution block.

The outer pipe is connected to a leak line in which a restriction and a pressure controlled valve are installed. In the event of a small leak from the inner pipe, the flow transmitter will set off an alarm. In the event of a severe leak, the restriction causes a pressure loss leading to increased pressure in the leak line and outer pipe. This pressure increase closes a pressure controlled valve, and the system pressure is now contained by the outer pipe. The pressure transmitter issues an alarm indicating that the outer pipe is now pressurised.

The piping is designed to ensure the safety to personnel and to ensure that a single failure, e.g. a leak from the inner pipe, will not affect the operation of the engine.

Crankshaft Position Sensing

The crankshaft position sensors and the dedicated trigger and marker rings which they sense, are the mechanical parts of the tacho system. The tacho system is used for measuring the actual engine speed and synchronising the control events in relation to the crankshaft position.

The trigger and marker rings are mounted on the turning wheel.

Alternatively an angle decoder can be fitted. The angle decoder is placed on a mounting bracket on the fore-end of the engine. For redundancy reasons the angle decoder has two encoders.

907 Starting Air System

Starting Air System

The starting air system consists of the manoeuvring system and the starting air components, which comprise:

- Main Starting Valve
- Solenoid Valves
- Starting Valves

The manoeuvring system is of electric/pneumatic design. See also Volume I, OPERATION, Chapter 703.

Main Starting Valve

The main starting valve is interposed in the starting air main pipe.

The main starting valve consists of a large ball valve and, optionally, a smaller ball valve for slow-turning prior to starting the engine, which is fitted as a by-pass for the large valve. Both valves are operated by pneumatic actuators.

If the smaller ball valve is installed, an adjusting screw will be mounted for setting the slow-turning speed.

Furthermore, a non-return valve is incorporated to prevent blow-back in the event of excessive pressure in the starting air line.

The main starting valve is equipped with a blocking device consisting of a plate which, by means of a handwheel, can be made to block the actuators.

The ball valves and their actuators are, together with the non-return valve and blocking device, built together to form a unit.

Note!
During all inspections of the engine, the blocking device of the main starting valve must be in the BLOCKED position. The only exception is when the starting valves are being tested for tightness, in which case the blocking device of the main starting valve must be in the working position and the shut-off valve for the solenoid valves must be in the CLOSED position. *See Volume I, operation, Chapter 703, 'Operations after arrival in port'.*

Solenoid Valves

The Engine Control System controls the opening and closing of the starting valves, via one solenoid pilot valve fitted for each cylinder. When actuated by the ECS, the solenoid valve leads control air from the control air system to the starting valve on the individual cylinder cover.

Starting Valves

One starting valve (spring-loaded) is fitted on each cylinder cover. It is controlled by control air from the control air system.

When the main starting valve is open, the chamber below the piston of the starting valve is pressurised through the starting air pipe.

The starting valve is kept closed by the spring. When the chamber above the starting valve piston is pressurised with control air from the control air system, the starting valve opens, and starting air now flows from the starting air pipe to the cylinder.

When the starting period is finished, the chamber above the piston is vented through the vent pipe of the solenoid valve, and the starting valve will close.

The starting air in the chamber below the piston and the starting air pipe is vented slowly through small holes in the starting air pipe.

908 Exhaust Valve

Exhaust Valve

Each cylinder is equipped with an exhaust valve, which is mounted in a central bore in the cylinder cover. The valve housing is attached with four studs and nuts to form a gas-tight seal against a seat in the cylinder cover.

Valve housing

The valve housing has an exchangeable bottom piece.

The bore for the valve spindle is provided with an exchangeable spindle guide liner.

Cooling

The valve housing is water cooled. The cooling water is passed to the valve housing after it has passed the cylinder cover. The water is discharged from the upper part of the valve housing.

On the front of the valve housing there is a cleaning cover through which the cooling water space can be checked and cleaned.

Valve spindle

The part of the spindle stem which travels within the sealing arrangement of the air cylinder is coated with a wear resistant mixture of metal carbide and super alloy, applied by the HVOF process.

On the lower cylindrical part of the valve spindle a vane wheel is fitted which causes the valve spindle to rotate while the engine is running.

Each open and close movement of the exhaust valve spindle is measured via an inductive feeler mounted on the exhaust valve. The movement of the spindle is monitored in the ME-control system.

<u>Pistons</u>

At the top of the spindle, two pistons are fitted:

1. Air piston

The piston serves to close the exhaust valve. The piston is locked to the spindle by a two-piece ring.

2. Hydraulic piston

The piston serves to open the exhaust valve. The hydraulic piston has two piston rings and a damper arrangement, designed to dampen the closing of the valve.

For small bore engine types (50-70ME/ME-C) the damper arrangement is of self-adjusting type.

Note!
For damper arrangements of non-self-adjusting type, it is important to check the damper after the exhaust valve has been overhauled, to avoid knocking. *See Volume II, MAINTENANCE, Procedure 908.*

Air cylinder

The air cylinder is mounted on top of the valve housing. Air for closing the exhaust valve is supplied through a non-return valve to the space below the piston.

A safety valve is mounted in the bottom of the air cylinder. The safety valve is connected to the drain pipe which leads to the crankshaft housing.

Hydraulic cylinder

The hydraulic cylinder is attached with studs and nuts on the air cylinder on top of the exhaust valve housing.

Sealing Oil

A sealing oil arrangement is fitted around the spindle shaft below the air cylinder.

The sealing oil is supplied from a control unit fitted on top of the exhaust valve hydraulic actuator.

During the exhaust valve lifting period, oil escapes from the hydraulic actuator through the restriction chamber to the control unit which, in turn, gives a certain amount of oil (dosage oil) to the exhaust valve spindle.

The sealing oil will prevent the exhaust gas and particles from penetrating upwards and wearing out the running surfaces and polluting the pneumatic system of the valve gear.

The oil improves the service condition of the sealing rings.

Exhaust Valve Actuator

The design of the hydraulically-activated valve is similar to that on the MC engines, i.e. the exhaust valve is opened hydraulically and is closed by an 'air spring'.

The Fuel Injection Valve Actuator system (FIVA) fitted to each HCU consists of the FIVA 'on/off valve' and the two-stage hydraulic exhaust valve activator.

The electronic FIVA 'on/off valve' (controlled by the ECS) opens the oil flow to the two-stage hydraulic actuator.

The exhaust valve is closed by connecting the hydraulic piston to a drain via the FIVA valve and letting the air spring of the exhaust valve drive it to closed position. This movement also drives the pushrod oil back into the exhaust actuator preparing it for the next actuation.

909 Fuel Oil System

Hydraulic Cylinder Unit and Oil Pressure Booster

Each engine cylinder is equipped with its own fuel oil pressure booster, which is mounted corresponding to the cylinder concerned on the HCU.

The booster housing is attached to the housing by studs and nuts.

The Hydraulic Cylinder Unit (one per cylinder) consists of a distributor block, the electronically controlled fuel injection system and electronically controlled exhaust valve actuation. The distributor block serves as a mechanical support for the hydraulically-activated fuel oil pressure booster and exhaust valve actuator, the FIVA valve.

The function of the distributor block is, as its name indicates, to distribute the hydraulic oil to the FIVA control valve mounted on the distributor block.

Fitted on the distributor block are hydraulic accumulators precharged with nitrogen. Their function is to ensure that the necessary hydraulic oil peak flow is available for the injection of fuel oil and actuation of the exhaust valve.

Close to the FIVA valve are two manually operated valves. One valve connects the high-pressure inlet side while the other connects the accumulators to the bedplate (drain).

These manually operated valves are used to isolate individual HCUs during their overhaul, which is also possible with a running engine.

A manually activated valve connects the oil pushrod to its supply. This valve must be closed during overhaul of the exhaust valve.

Electronically controlled Fuel Injection

The electronically controlled fuel injection system consists of the hydraulically activated fuel oil pressure booster, its controlling valve, i.e. FIVA valve and the fuel injection valves.

The FIVA valve (controlled by the ECS) ensures fast and precise control of the oil flow to the fuel oil pressure booster. The oil flow pushes the hydraulic piston and fuel injection plunger, thus generating the injection pressure and hence the injection.

After the injection has finished, the plunger and piston are returned to their starting positions by the piston being connected to a drain and letting the pressure in the fuel supply drive the plunger back. The fuel oil pressure booster is then filled and ready for the next injection sequence.

The fuel system permits continuous circulating of heated heavy fuel oil through the fuel oil pressure booster and fuel valves to keep the system heated during engine standstill.

Fuel Valve

The fuel valve consists of a valve head and a valve housing. Fitted within the valve housing is a non-return valve and a spindle and spindle guide with a pressure spring, and a nozzle.

The spindle may be provided with a cut-off slide. When the fuel valve is fitted in the cylinder cover, the valve parts are tightened together by the pressure from the securing nuts.

Functioning

The functioning of the fuel valve is as follows:

The electrical fuel oil primary pump circulates preheated oil through the fuel oil pressure booster and fuel valve. The fuel oil passes through the fuel valve, leaving through a circulation bore and the return oil pipe on the valve head.

When the pressure at the beginning of the fuel oil pressure booster's delivery stroke has reached the predetermined pressure, the circulating bores is closed.

When the pressure has reached the predetermined opening value for the fuel valve, the spindle will be lifted and oil injected through the nozzle into the engine cylinder.

On completion of the fuel oil pressure booster delivery stroke, the valve spindle is pressed against its seat and injection now ceases. Then the circulating bore is uncovered, and oil starts to recirculate through the valve.

910 Turbocharger System

Air System

The engine is supplied with scavenge air from one or more turbochargers, depending on the engine type and layout.

The engine exhaust gas drives the turbine wheel of the turbocharger and, through a common shaft, the turbine wheel drives the compressor wheel.

The compressor draws air from the engine room, through the air filters. From the compressor outlet, the air passes through the charging air pipe to the charging air cooler where the air is cooled down.

The charging air pipe, with compensator, is insulated.

The air cooler incorporates a water mist catcher, which is designed to separate condensate from the air.
See also 'Charging Air Cooler' further on in this Section.

When the air has passed the water mist catcher, it is pressed into the scavenge air receiver through non-return valves. The non-return valves open by pressure from the turbocharger.

From the scavenge air receiver, the air flows to the cylinder through the scavenge air ports when the piston is in the bottom position. When the exhaust valves open, the exhaust gas is pressed into a common exhaust gas receiver, from where the gas drives the turbine of the turbocharger with an even and steady pressure

Scavenge Air Receiver

The scavenge air receiver is a container having a large volume. The receiver is bolted on to the cylinder frame, or alternatively integrated into the cylinder frame, if welded. *See Chapter 903.*

Scavenge air is collected in the receiver after the air has passed through the cooler, the water mist catcher and the non-return valves.

The receiver and the cylinder frame communicate through large openings.

The scavenge air receiver is provided with man-hole covers and a safety valve.

Auxiliary Blowers

The engine is provided with two or more auxiliary blowers. The suction sides are connected to the space after the water mist catcher. The discharge sides are connected to the scavenge air receiver. Separate non-return valves are installed at the suction side or discharge side of the auxiliary blowers, in order to prevent reversed air flow.
See also item, "Non-return valves", further on.

Electrical panels for auxiliary blower

See special instructions supplied by the engine builder.

Running with auxiliary blowers

During the starting of the engine, and when the engine is running at low load, the turbocharger is not able to supply enough air for the engine process. In these cases a pressure switch will automatically start the auxiliary blowers.

When the auxiliary blowers are operating, they draw air from the engine room through the turbocharger's air filter and compressor side.

Warning!

If the auxiliary blowers do not start during low-load running (because of faults, or because the switch for the blowers is not in "AUTO" position), unburned fuel oil may accumulate on top of the pistons.

This will involve the risk of a **scavenge air box fire**.

In order to avoid such a fire:

– obtain permission to stop the engine

– stop the engine

– remove any unburned fuel oil from the top of the pistons

– re-establish the supply of scavenge air

– start the engine

Note: the switch for the auxiliary blowers should be in

"AUTO" position during all modes of engine control, i.e.:

– remote control

– control from engine side control console.

The non-return valves fitted after the water mist catcher are now closed as a result of partial vacuum and gravitation acting on the valve flaps.

There will be a lack of air supply if the non-return valves do not close.

Non-Return Valves

It is of the utmost importance that the non-return valves of the auxiliary blowers always function correctly and move easily. This can be checked either by moving the valves manually in connection with the regular scavenge port inspections, or via locally placed inspection covers.

The non-return valves protect the blowers and engine during:

- Start-up of the auxiliary blowers
- Running with auxiliary blowers.

Starting the auxiliary blowers:

1. Owing to the relatively high starting current, the blowers start in sequence, with 6-10 seconds in between.

   The non-return valve of the blower that has not yet started must be in the closed position to prevent the blower from rotating backwards. Otherwise, there is a risk that the electric motor will burn out when it starts.

2. If an auxiliary blower fails to start, the non-return valve must be in the closed position. Otherwise, the operating blower will not be able to draw fresh air in through the turbocharger and air cooler. This is due to differences in the air flow resistance.

Running with auxiliary blowers:

If an auxiliary blower fails during running, the non-return valve must close to ensure the continued supply of fresh air to the engine. See ‘Starting the auxiliary blowers‘, Item 2, above.

Exhaust Gas Receiver

From the exhaust valves, the exhaust gas is led to the exhaust gas receiver where the pulsatory pressure from the individual exhaust valves is equalised and led to the turbocharger at a constant pressure.

The exhaust gas receiver is fastened to the seating by flexible supports. Compensators are inserted between the receiver and the exhaust valves, and be tween the receiver and the turbocharger.

Inside the exhaust gas receiver, a protective grating is mounted before the turbocharger.

The exhaust gas receiver and the exhaust pipe are insulated.

Charging Air Cooler

The charging air cooler insert is of the block type. It is mounted in a housing which is welded up of steel plates.

The cooler housing is provided with inspection covers.

The cooler is designed with an air reversing chamber which incorporates a water mist catcher. The water mist catcher is built up of a number of lamellas which separate the condensation water from the scavenge air during the passage of the air flow.

The separated water is collected in the bottom of the cooler housing from which it is removed by a drain system.

Caution!
It is important to check that the drain functions correctly, as otherwise water droplets may enter the cylinders. *See Volume I Operation, Chapter 706, 'Cleaning of Turbochargers and Air Coolers'*.

An alarm device for high water level in the drain system is installed.

911 Safety Equipment

Safety Valves, Cylinder Cover

Each cylinder cover is provided with a spring-loaded safety valve which is set to open at a pressure somewhat higher than the maximum firing pressure in the cylinder.

Relief Valves

On the exhaust side of the engine a number of spring-loaded relief valves are fitted, which will open in the event of excessive pressure in the crankcase/chain casing, for instance as a result of the ignition of oil mist.

Warning!
Keep the areas around the relief valves free of oil, grease, etc. to prevent the risk of fire caused by hot air/gas emitted in the event that the relief valves open.

Regarding how to:

- avoid evaporation of the lubricating oil in the crankcase,
- detect oil mist in the crankcase using an 'Oil Mist Detector'.

see Volume I, OPERATION, Chapter 704.

Warning!
Do not stand near crankcase doors or relief valves – or in corridors near doors to the engine room casing in the event of an **alarm** for: a) oil mist b) high lube oil temperature c) no piston cooling oil flow, or d) scavenge box fire Alarms b, c and d should be considered as pre-warnings of a possible increasing oil mist level. *See also our Service Letter SL97-348/ERO.*

Note!
If there has been a crankcase explosion, the complete flame arrester of the relief valves must be replaced.

Safety Valve, Scavenge Air Receiver

The scavenge air receiver is fitted with a safety valve which is set to open should the pressure in the scavenge air receiver exceed a value somewhat higher than the normal scavenge air pressure of the engine.

In some cases it may be necessary to open the valve manually, *see Volume I, Chapter 704, »Turbocharger Surging«.*

Safety Cap in Starting Air Line

Each starting valve inlet pipe is provided with a safety cap. The safety cap consists of a bursting disc enclosed by a perforated cylinder and a perforated cover in order to protect any bystanders, in the event of a burst.

The cover is provided with a check plate, which shows if the bursting disc has been damaged.

If the bursting disc of the safety cap is damaged by excessive pressure in the starting air line, overhaul or replace the starting valve which caused the burst, and fit a new disc.

If a new disc is not available immediately, turn the cover in relation to the cylinder, in order to reduce the leakage of starting air. Fit a new bursting disc and return the cover to the open position at the first opportunity.

912 Assembly of large Parts

Bedplate

The bedplate is made in one or more sections, depending on the number of cylinders. If there are two or more sections, these are joined together with fitted bolts. The bedplate consists of two welded, longitudinal girders and a number of cross girders which support the main bearings. The main bearings consist of steel shells, lined with bearing metal.
See also Volume I, OPERATION, Chapter 708.

Each main bearing has one or two main bearing caps which are secured by studs and nuts, designed for tightening with hydraulic tools.

The bedplate is fitted with an axial vibration damper. For the design and functioning of the axial vibration damper, see Section 905 “Crankshaft”.

<u>Marine engines (except geared plants):</u>

The aft end of the bedplate incorporates the thrust bearing. *See also Section 905 “Crankshaft”.*

<u>Stationary engines (and geared marine plants):</u>

The bedplate incorporates the guide bearing. *See also Section 905, “Crank shaft”.*

Framebox

A framebox is bolted on to the top of the bedplate. Like the bedplate, the framebox consists of one or more sections. Together, the bedplate and the framebox constitute the crankcase of the engine.

The framebox is fitted with steel-plate doors for access to the crossheads and to the main and crankpin bearings.

For each cylinder, the framebox is equipped with a slotted pipe in which the piston cooling oil outlet pipe fitted to the crosshead or guide shoe is able to travel. From the slotted pipe the cooling oil is, through an outlet pipe, led to the oil tray of the bedplate.

Equipment for local checking of the cooling oil temperature and flow, and for temperature and flow alarms, is installed in conjunction with the outlet pipe.
See also Volume I, OPERATION, Chapter 701.

Staybolts

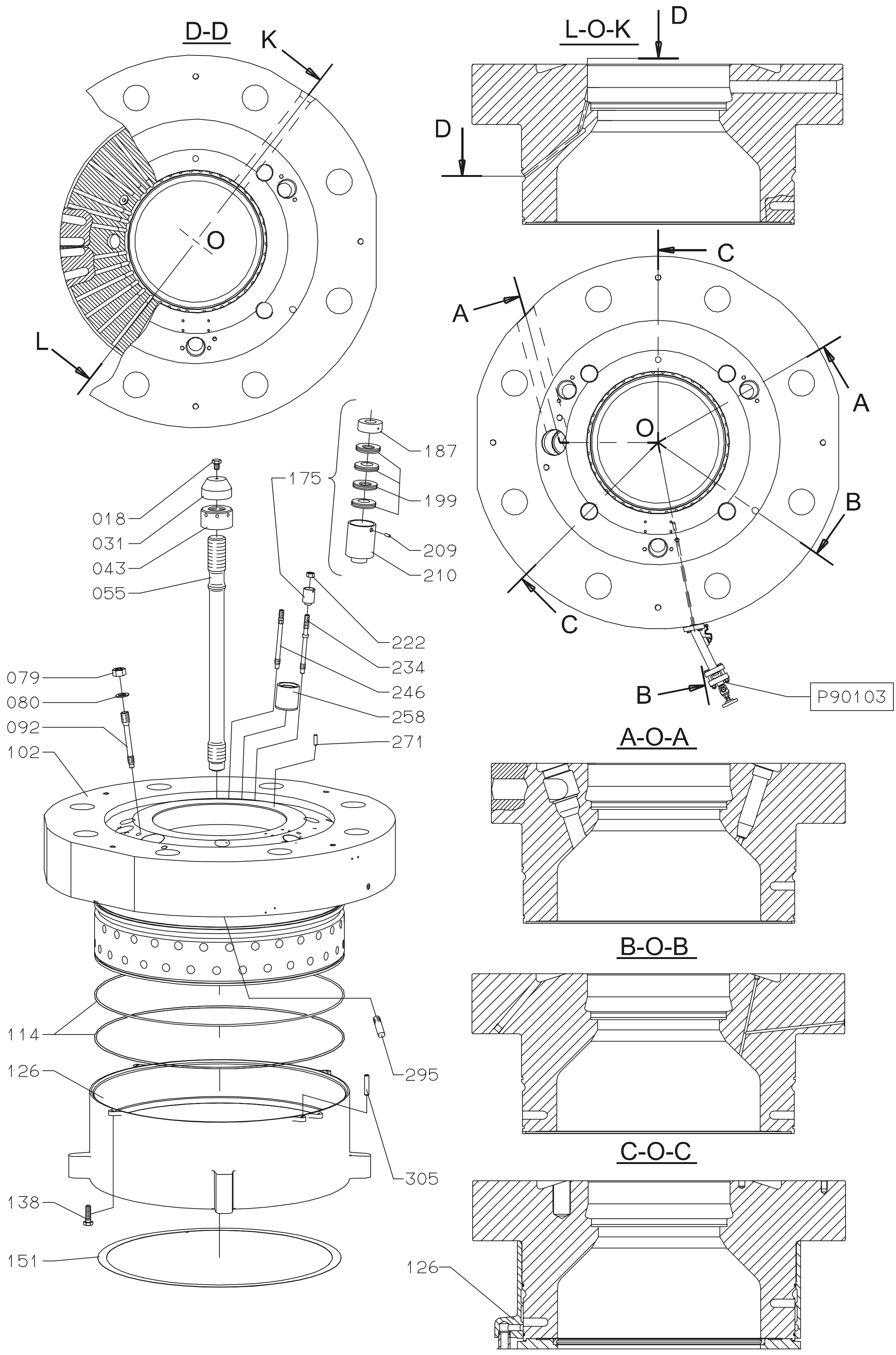
The bedplate, framebox and the cylinder frame are tightened together to form one unit by means of staybolts.

Engine Seating

Regarding the engine seating for the specific engine, see the supplier’s special instructions.

901 - Cylinder Cover

Documents in this Chapter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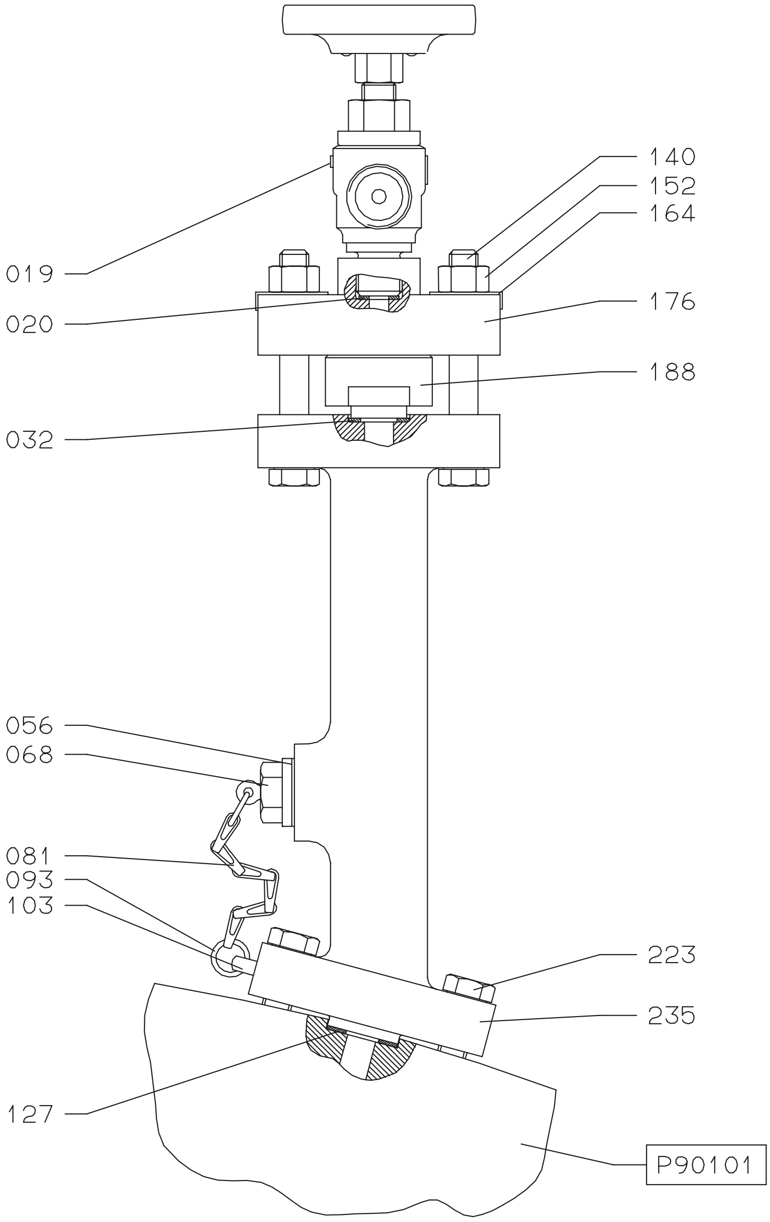
Cylinder Cover

Item No.	Item Description
018	Screw
031	Protective cap
043	Nut
055	Stud for exhaust valve
079	Nut
080	Washer
092	Stud for starting valve
102	Cylinder cover
114	O-ring
126	Cooling jacket
138	Screw
151	Gasket
175	Spring housing, complete
187	Disc special
199	Disc spring
209	Cylindrical pin
210	Spring housing, fuel valve
222	Nut
234	Stud
246	Stud
258	Pipe
271	Guide pin
295	Pipe branch
305	Dowel

Item No.	Item Description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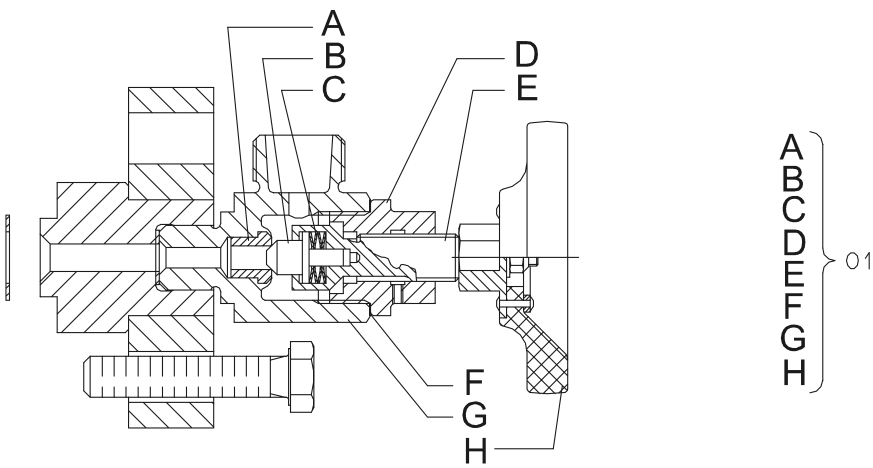
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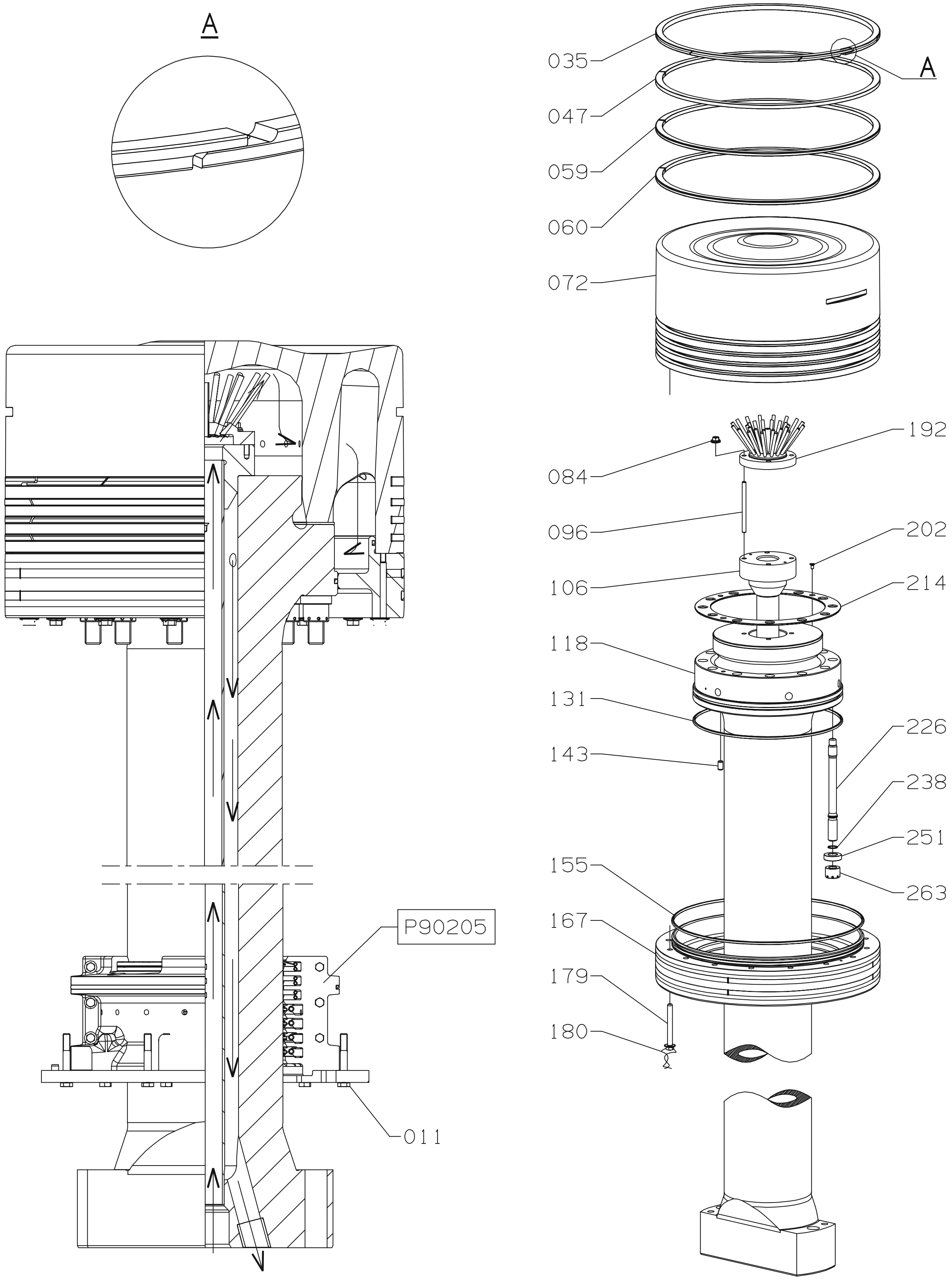
Indicator Cock - Mounting

Item No.	Item Description
019	Indicator cock
020	Packing
032	Packing
056	Disc
068	Plug screw
081	Chain and link
093	Key ring
103	Eye screw
127	Packing
140	Screw
152	Nut
164	Locking plate
176	Flange
188	Extension
223	Screw
235	Extension

Item No.	Item Description

902 - Piston with Rod & Stuffing Box

Documents in this Chapter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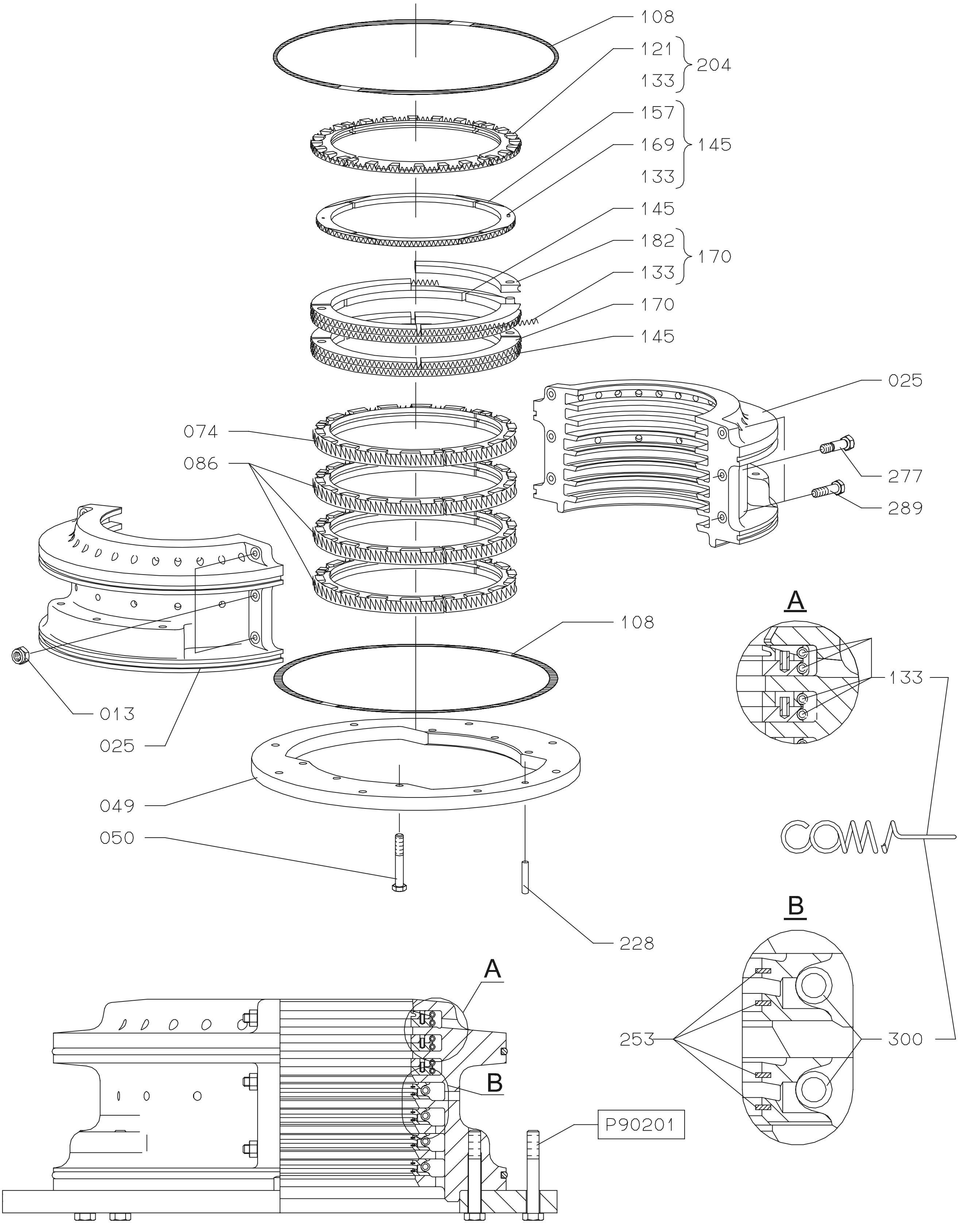
011

Piston and Piston Rod

Item No.	Item Description	Item No.	Item Description
011	Screw		
035	Piston ring no. 1		
047	Piston ring no. 2		
059	Piston ring no. 3		
060	Piston ring no. 4		
072	Piston crown		
084	Cam lock nut		
096	Stud		
106	Pipe for cooling insert		
118	Piston rod		
131	D-ring		
143	Guide pin		
155	D-ring		
167	Piston skirt		
179	Flange screw		
180	Locking wire		
192	Cooling insert		
202	Screw		
214	Intermediate disc		
226	Stud		
238	Sealing ring		
251	Disc		
263	Nut for hydraulic tightening		
	Note:		
	*		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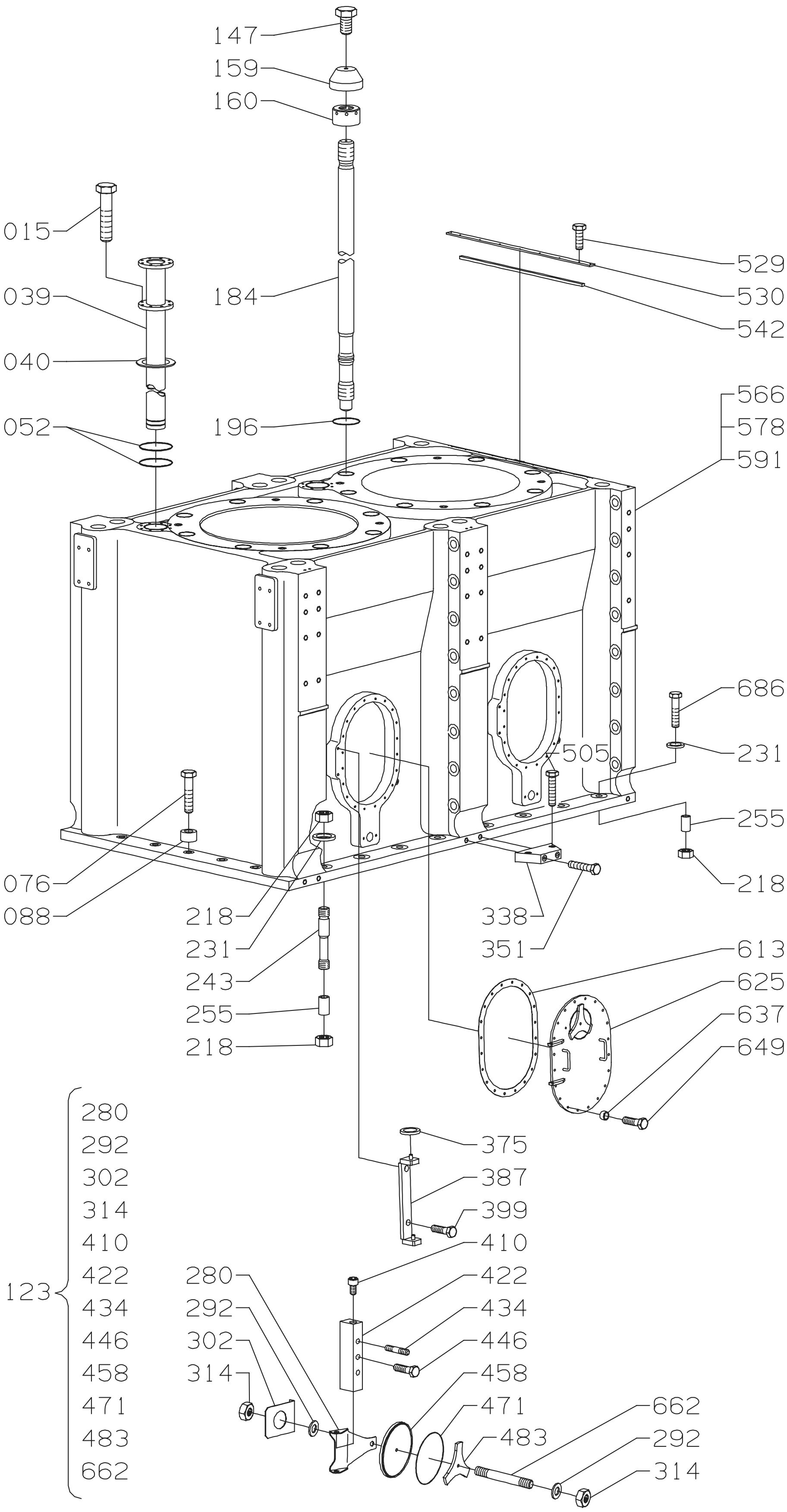
Item No.	Item Description	Item No.	Item Description
013	Nut		
025	Housing for stuffing box, complete		
049	Flange		
050	Screw		
074	Scraper ring		
086	Scraper ring		
108	O-ring		
121	Scraper ring		
133	Tension spring		
145	Sealing ring		
157	Sealing ring		
169	Spring pin		
170	Sealing ring		
182	Sealing ring		
204	Scraper ring		
228	Guide pin		
253	Lamella		
277	Fitted bolt		
289	Screw		
300	Tension spring		

903 - Cylinder Liner and Cylinder Lubrication

Documents in this Chapter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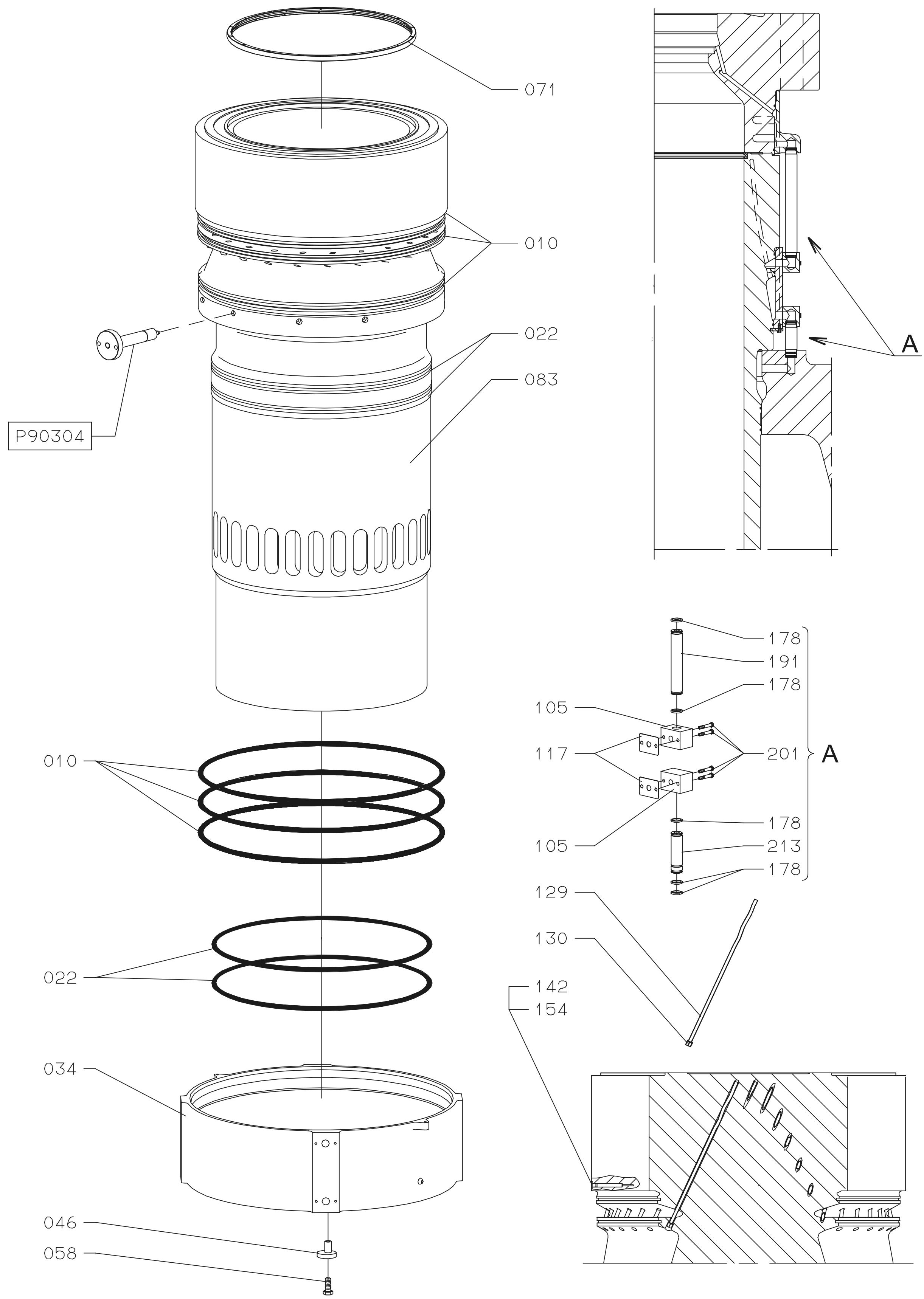
637
649
123
280
292
302
314
410
422
434
446
458
471
483
662
375
387
399
410
422
434
446
458
471
483
280
292
302
314
662
292
314

Item No.	Item Description	Item No.	Item Description
015	Screw		
039	Protective tube		
040	Packing		
052	Sealing ring		
076	Screw		
088	Spacer, tubular		
123	Cleaning cover, complete		
147	Screw		
159	Protective cap		
160	Nut		
184	Stud		
196	Sealing ring		
218	Nut		
231	Spacer, tubular		
243	Fitted stud		
255	Spacer, tubular		
280	Hinge		
292	Washer		
302	Locking plate		
314	Nut		
338	Plate		
351	Screw		
375	Washer		
387	Hinge		
399	Screw		
410	Screw		
422	Support		
434	Spring pin		
446	Screw		
458	Cover		
471	Sealing ring		
483	Cross member		
505	Screw		
529	Screw		
530	Rail for sealing		
542	Packing		
566	Cylinder frame, fore		
578	Cylinder frame, intermediate		
591	Cylinder frame, aft		
613	Packing		
625	Cleaning cover		
637	Distance pipe		
649	Screw		
662	Stud		
686	Screw		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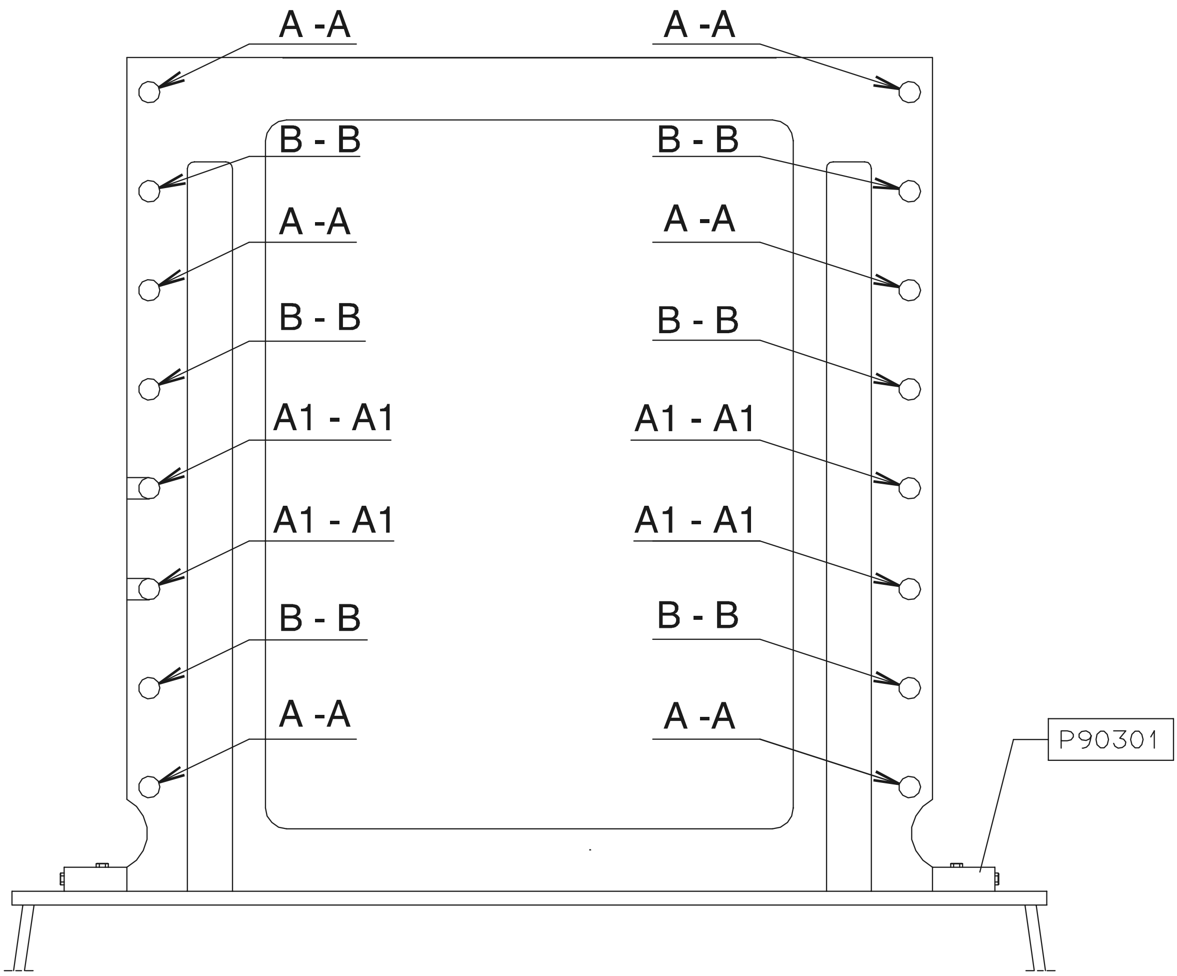
010
022
083
P90304
A
178
191
178
105
117
201
A
105
178
213
178
129
130
142
154
010
022
034
046
058

Cylinder Liner and Cooling Jacket

Item No.	Item Description
010	O-ring
022	O-ring
034	Cooling jacket
046	Clamp
058	Screw
071	Piston cleaning ring
083	Cylinder liner
105	Cooling water connection
117	Packing
129	Pipe
130	Spring pin
142	Plug screw
154	Packing ring
178	Sealing ring
191	Cooling water connection
201	Screw
213	Cooling water connection

Item No.	Item Description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B - B
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A -A
B - B
B - B
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A1 - A1
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B - B
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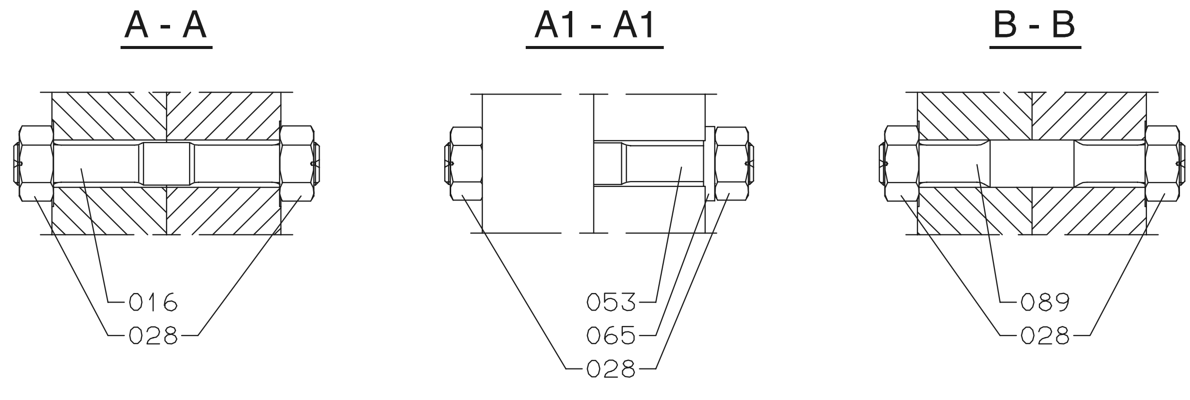
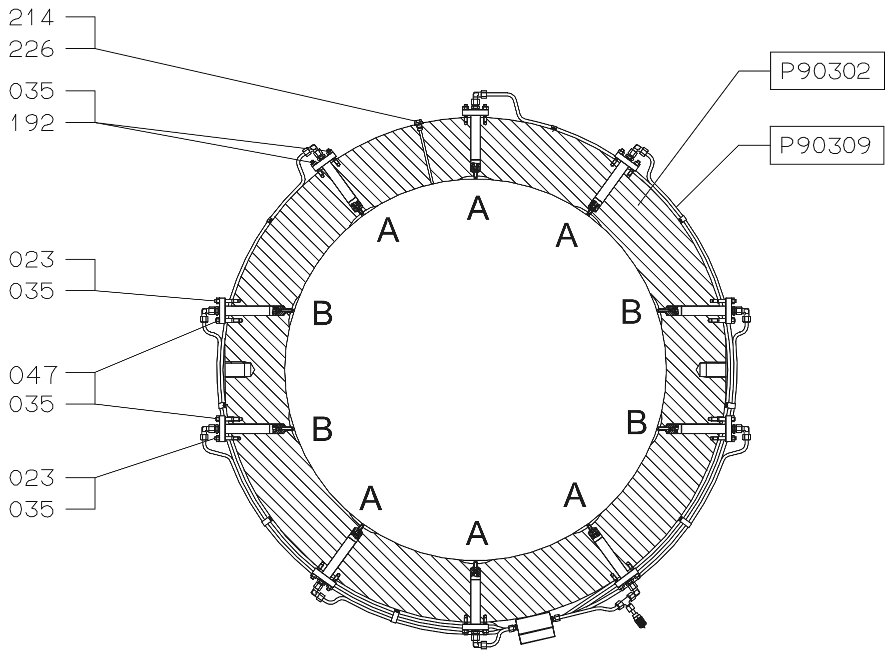
A -A
A -A
P90301


A - A
A1 - A1
B - B
016
028
053
065
028
089
028

Item No.	Item Description
016	Stud
028	Nut
053	Stud
065	Distance piece
089	Fitted stud


214
226
035
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P90302
P90309
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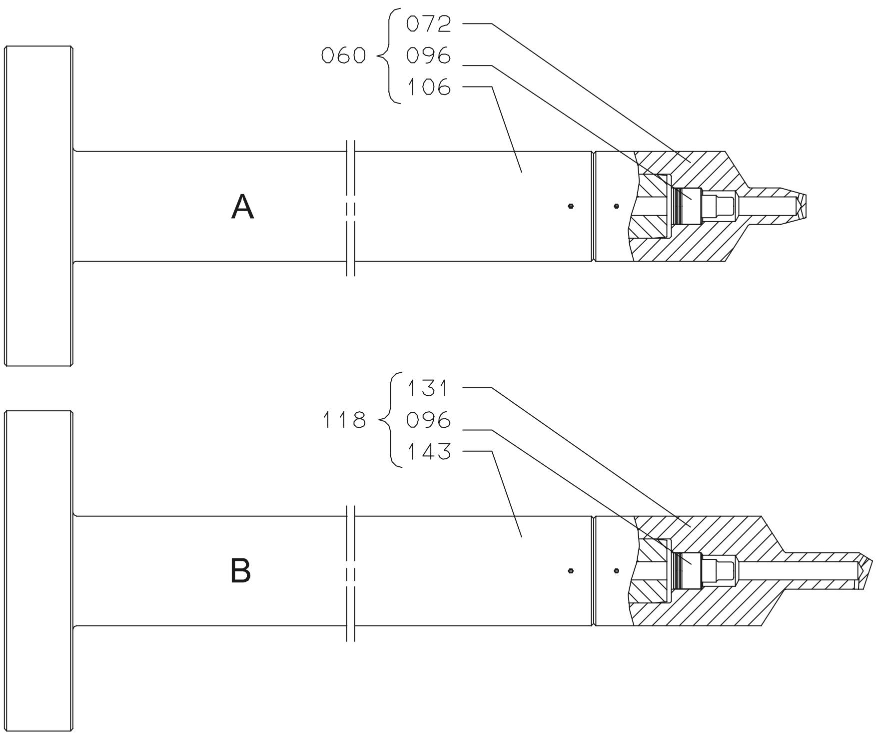
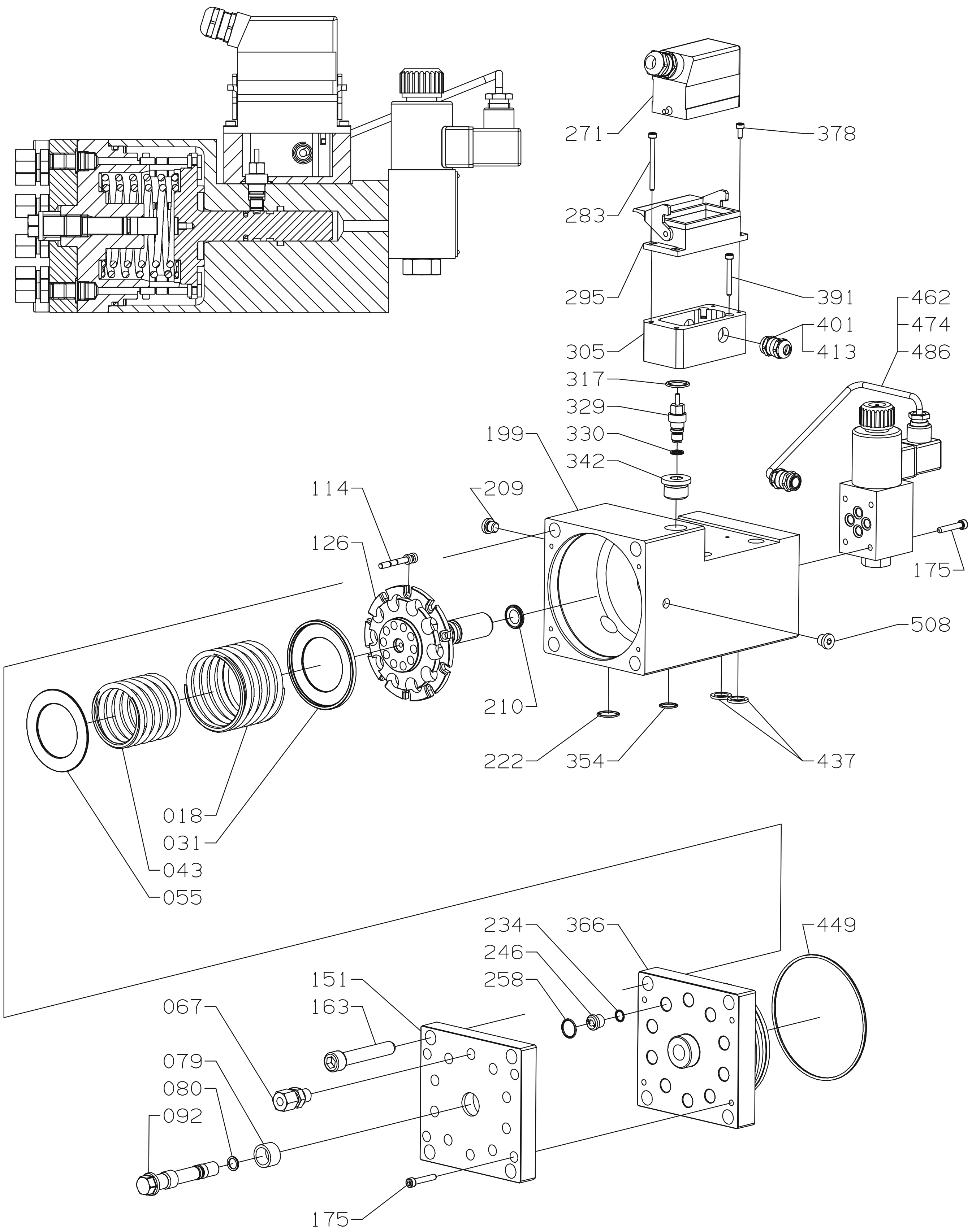
A


060
072
096
106
A
118
131
096
143
B

Cylinder Liner - Details

Item No.	Item Description
023	Stud
035	Nut
047	Pin
060	Non-return valve “A” complete
072	Valve housing
096	Valve
106	Valve head
118	Non-return valve “B” complete
131	Valve housing
143	Valve head
192	Stud
214	Packing
226	Screw

Item No.	Item Description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378
283
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391
462
474
486
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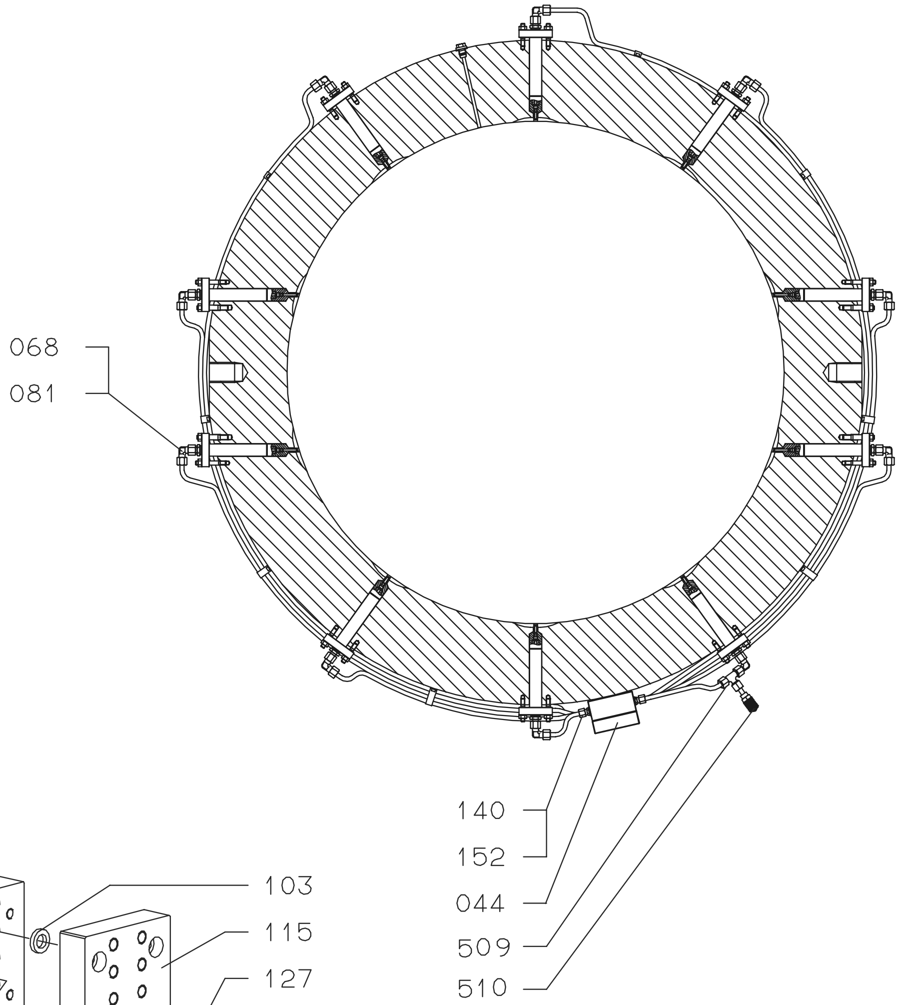
401
413
317
329
199
330
342
114
209
126
175
508
210
222
354
437
018
031
043
055
234
366
449
246
151
258
067
163
079
080
092
175

Item No.	Item Description	Item No.	Item Description
018	Spring		
031	Disc, special		
043	Spring		
055	Disc, special		
067	Straight stud coupling		
079	Spacer, tubular		
080	O-ring		
092	Adjusting screw		
114	Plunger		
126	Actuator piston		
151	Cover		
163	Screw		
175	Screw		
199	Cylinder housing		
209	Plug screw		
210	Sealing ring		
222	O-ring		
234	Sealing ring		
246	Non-return valve		
258	O-ring		
271	Plug		
283	Screw		
295	Plug		
305	Housing		
317	O-ring		
329	Inductive sensor		
330	Sealing ring		
342	Plug screw		
354	O-ring		
366	Cylinder block		
378	Screw		
391	Screw		
401	Cable gland, complete		
413	Cable		
437	Sealing ring		
449	Sealing ring		
462	Cable gland, complete		
474	4/2-way solenoid valve		
486	Cable		
508	Plug screw		
	Note:		
	*		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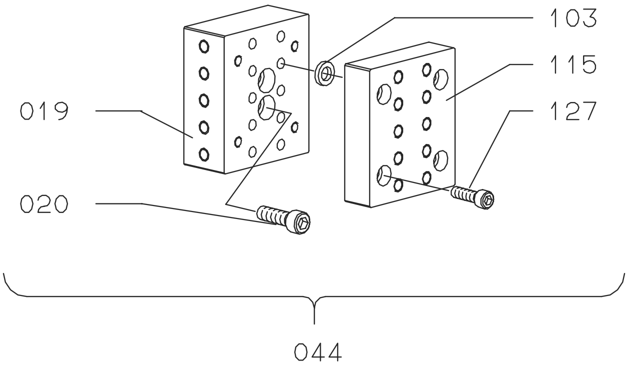
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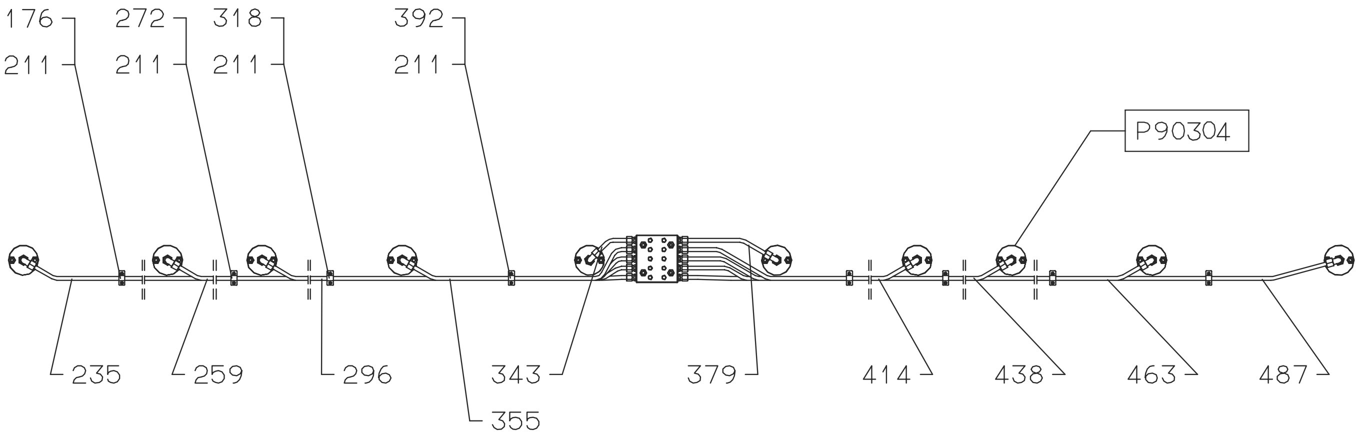
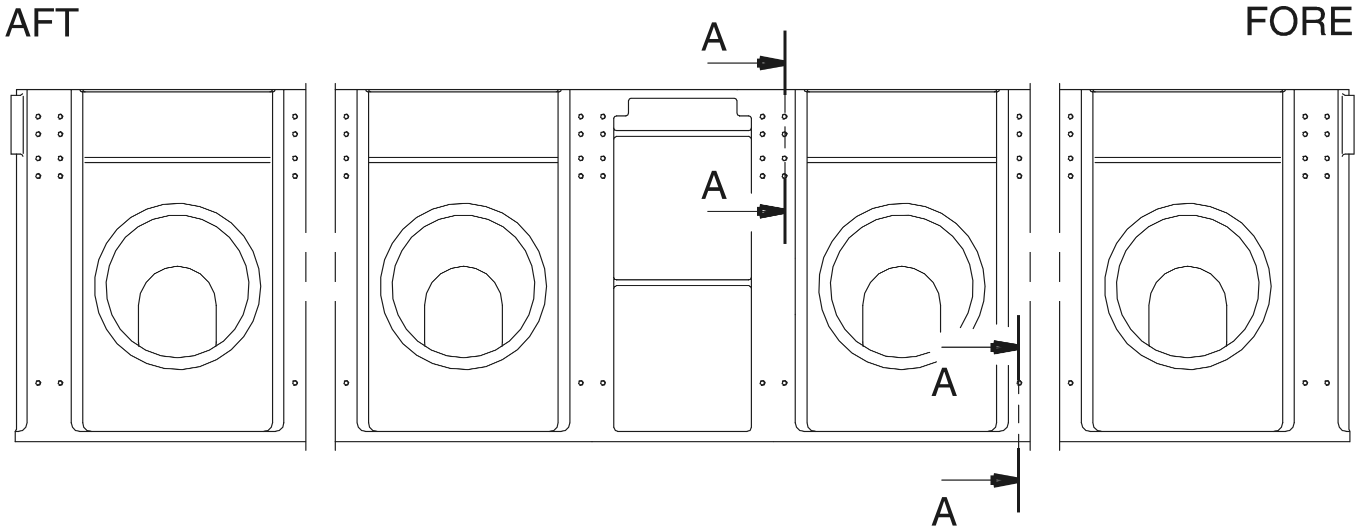
020
044


176
211
272
211
318
211
392
211
P90304
235
259
296
343
379
414
438
463
487
355

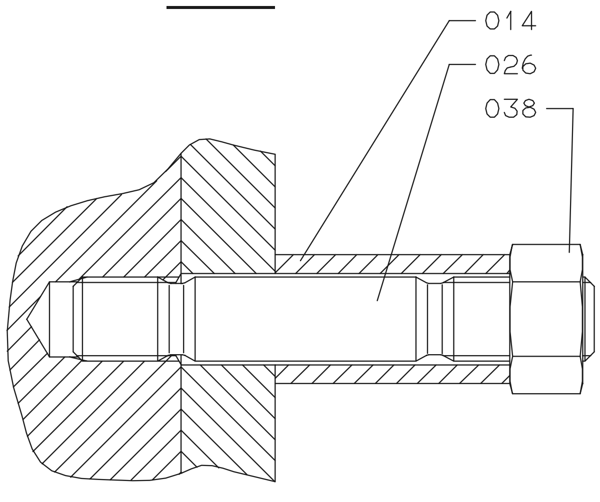
Cylinder Lubrication System - Details

Item No.	Item Description
019	Distributor block
020	Screw
044	Distributor block
068	Coupling
081	Packing ring
103	Sealing ring
115	Distributor block
127	Screw
140	Coupling
152	Packing ring
176	Steel bar
211	Screw
235	Steel pipe
259	Steel pipe
272	Steel bar
296	Steel pipe
318	Steel bar
343	Steel pipe
355	Steel pipe
379	Steel pipe
392	Steel bar
414	Steel pipe
438	Steel pipe
463	Steel pipe
487	Steel pipe
509	Screw connection
510	Coupling

Item No.	Item Description



A - A

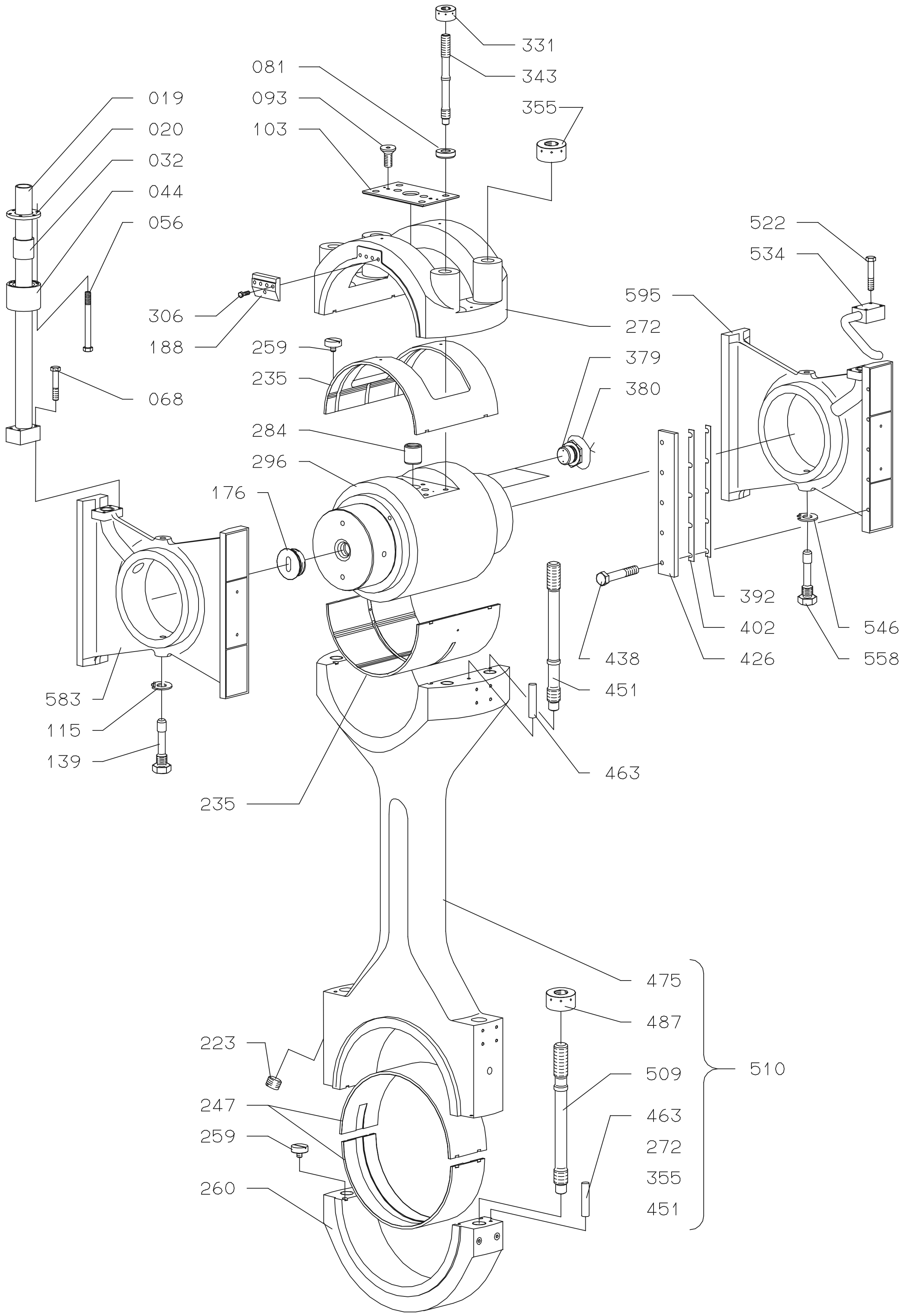


Cylinder Frame, Studs on Exhaust Side

Item No.	Item Description
014	Distance pipe
026	Stud
038	Nut

904 - Crosshead with Connecting Rod

Documents in this Chapter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343
355
081
093
103
019
020
032
044
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534
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235
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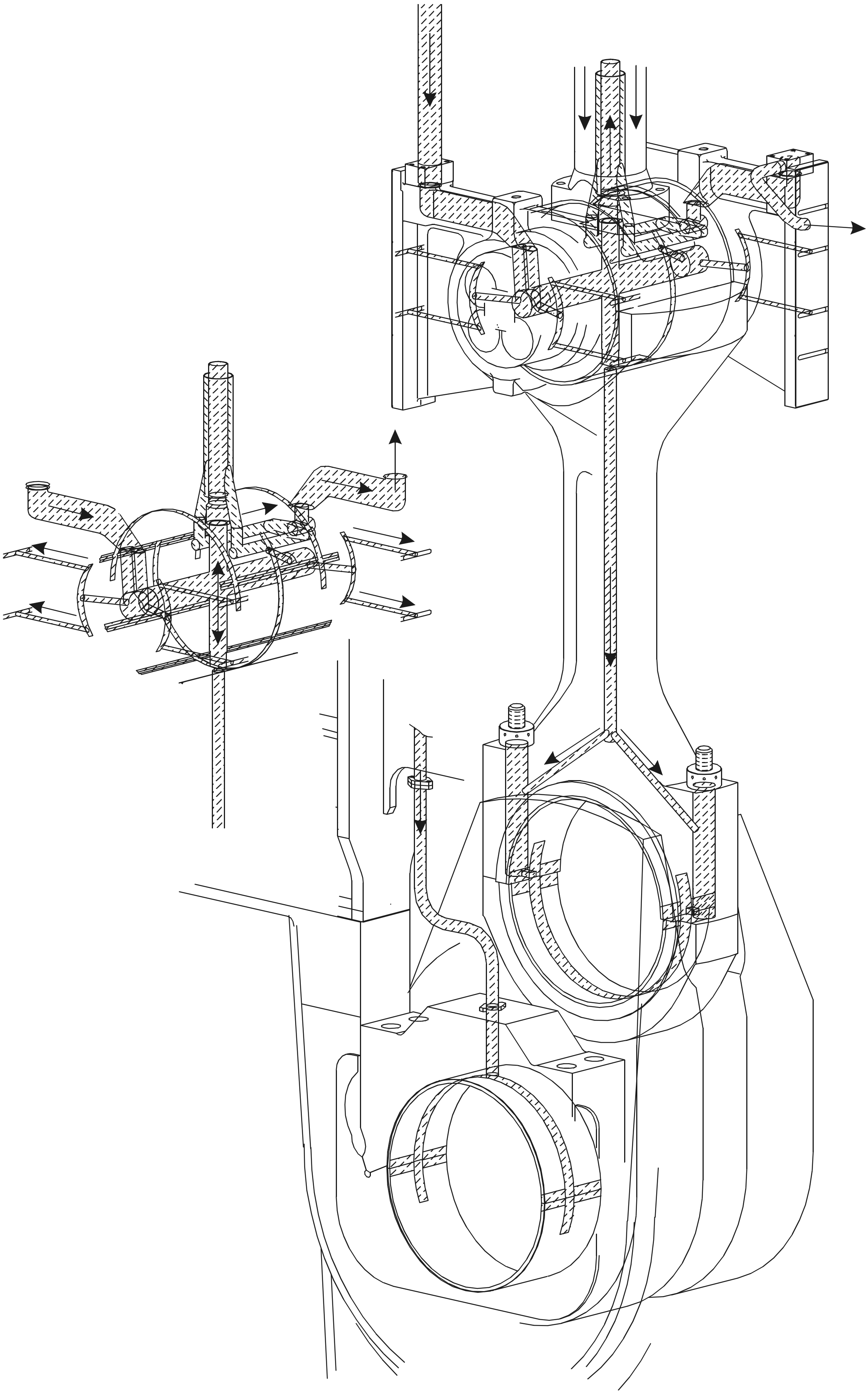
068
284
296
176
392
402
426
546
558
438
451
583
115
139
463
235
475
487
510
509
223
247
259
260
463
272
355
451

Connecting Rod and Crosshead

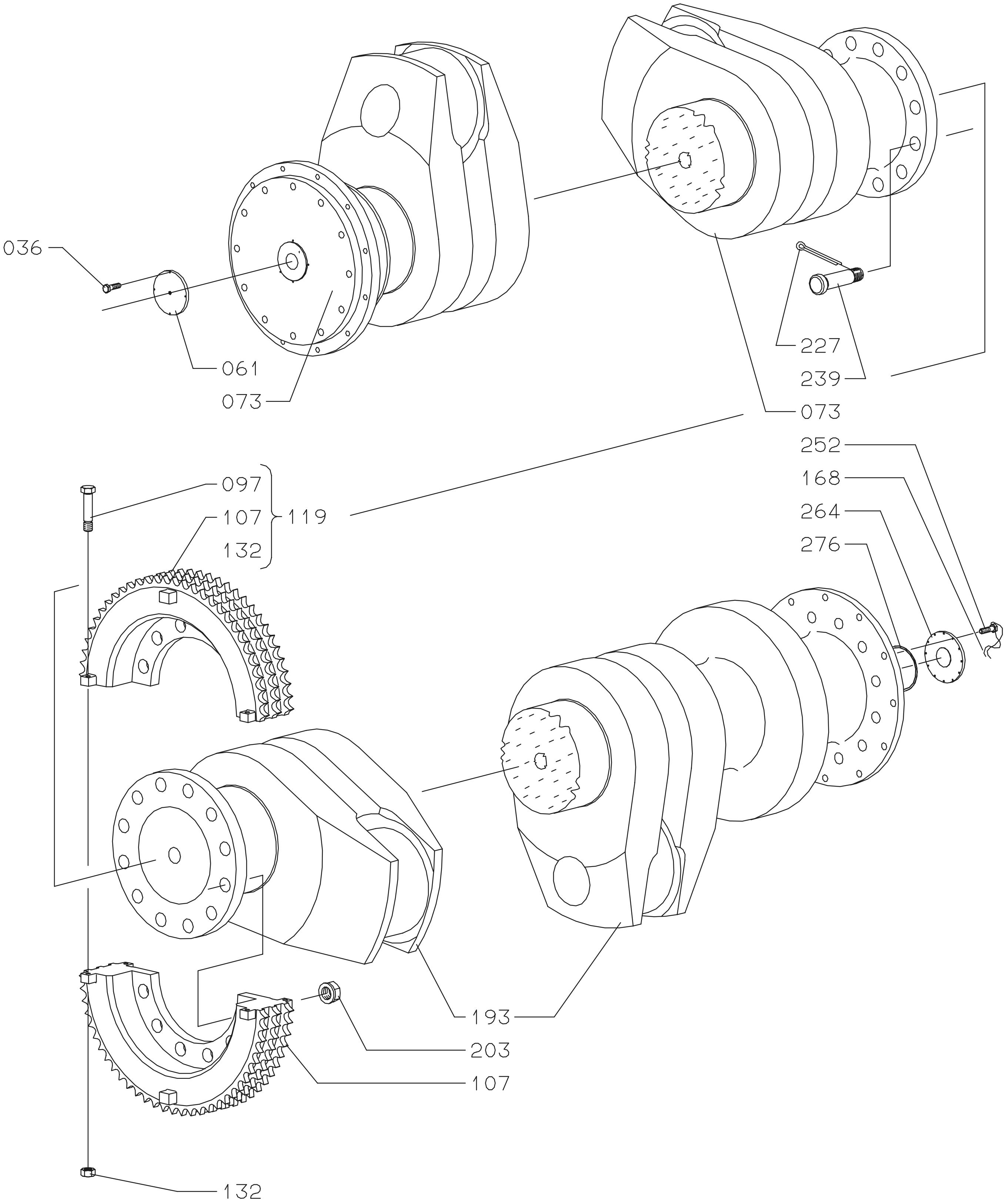
Item No.	Item Description
019	Telescope pipe
020	Distance pipe
032	Bushing
044	Housing
056	Screw
068	Screw
081	Washer
093	Screw
103	Shim*
115	Washer
139	Stop screw
176	Plug
188	Thrust piece
223	Plug screw
235	Bearing shell, complete
247	Bearing shell, complete
259	Screw
260	Bearing cap
272	Bearing cap
284	Guide ring
296	Crosshead
306	Screw
331	Nut
343	Stud
355	Nut
379	Plug
380	Locking wire
392	Shim*
402	Shim*
426	Guide strip
438	Screw
451	Stud
463	Guide pin
475	Connecting rod
487	Nut
509	Stud
510	Connecting rod
522	Screw
534	Outlet pipe
546	Locking washer
558	Stop screw
583	Guide shoe
595	Guide shoe
	Note:
	*When ordering, please state thickness of shim.

Item No.	Item Description



905 - Crankshaft, Thrust Bearing and Turning Gear

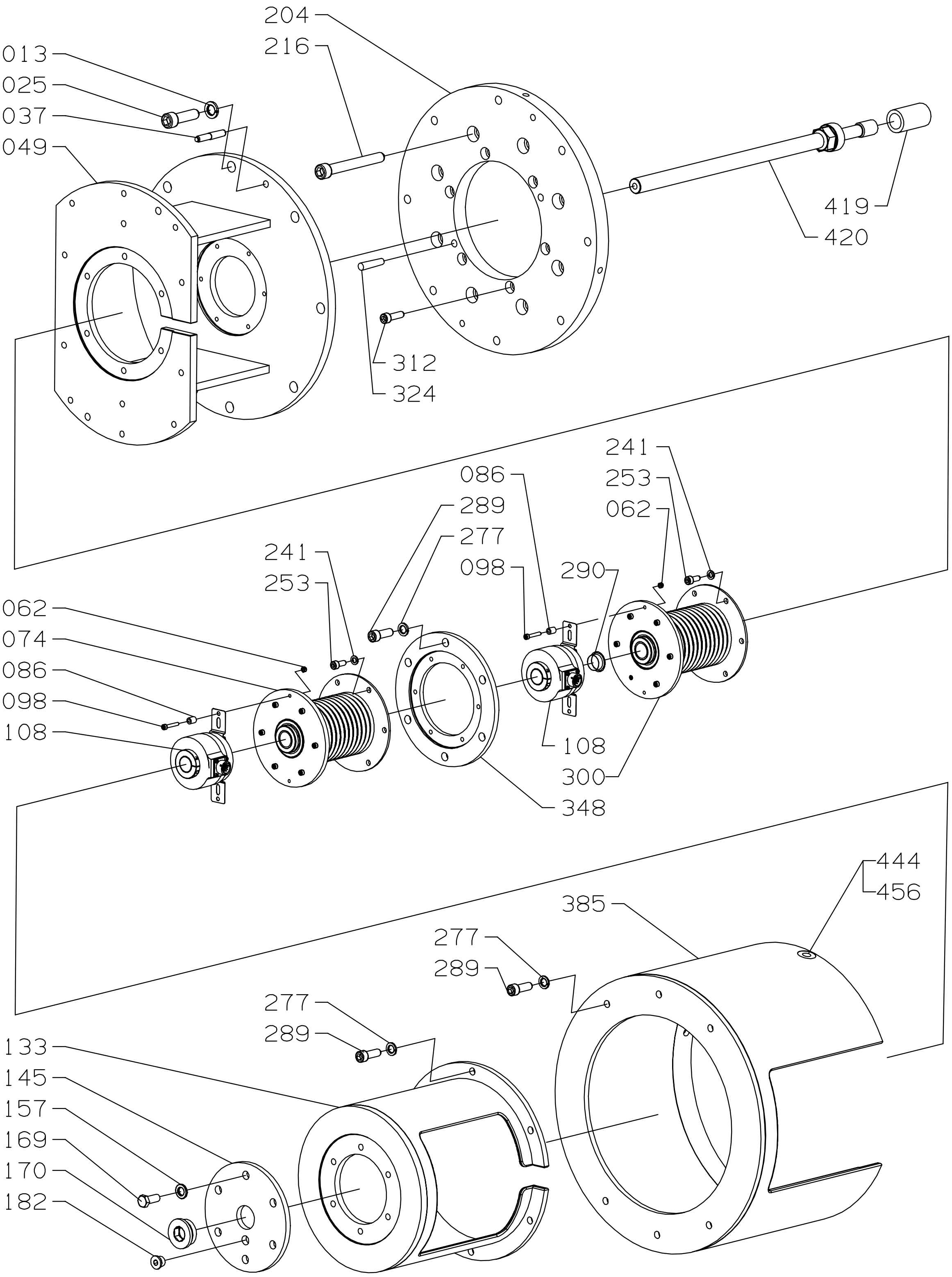
Documents in this Chapter


036
061
073
227
239
073
252
168
264
276
097
107
132
119
193
203
107
132

Crankshaft

Item No.	Item Description
036	Screw
061	Flange
073	Crankshaft
097	Fitted bolt
107	Chain wheel
119	Chain wheel, complete
132	Nut
168	Locking wire
193	Crankshaft
203	Nut
227	Split pin
239	Fitted bolt
252	Screw
264	Cover
276	Packing

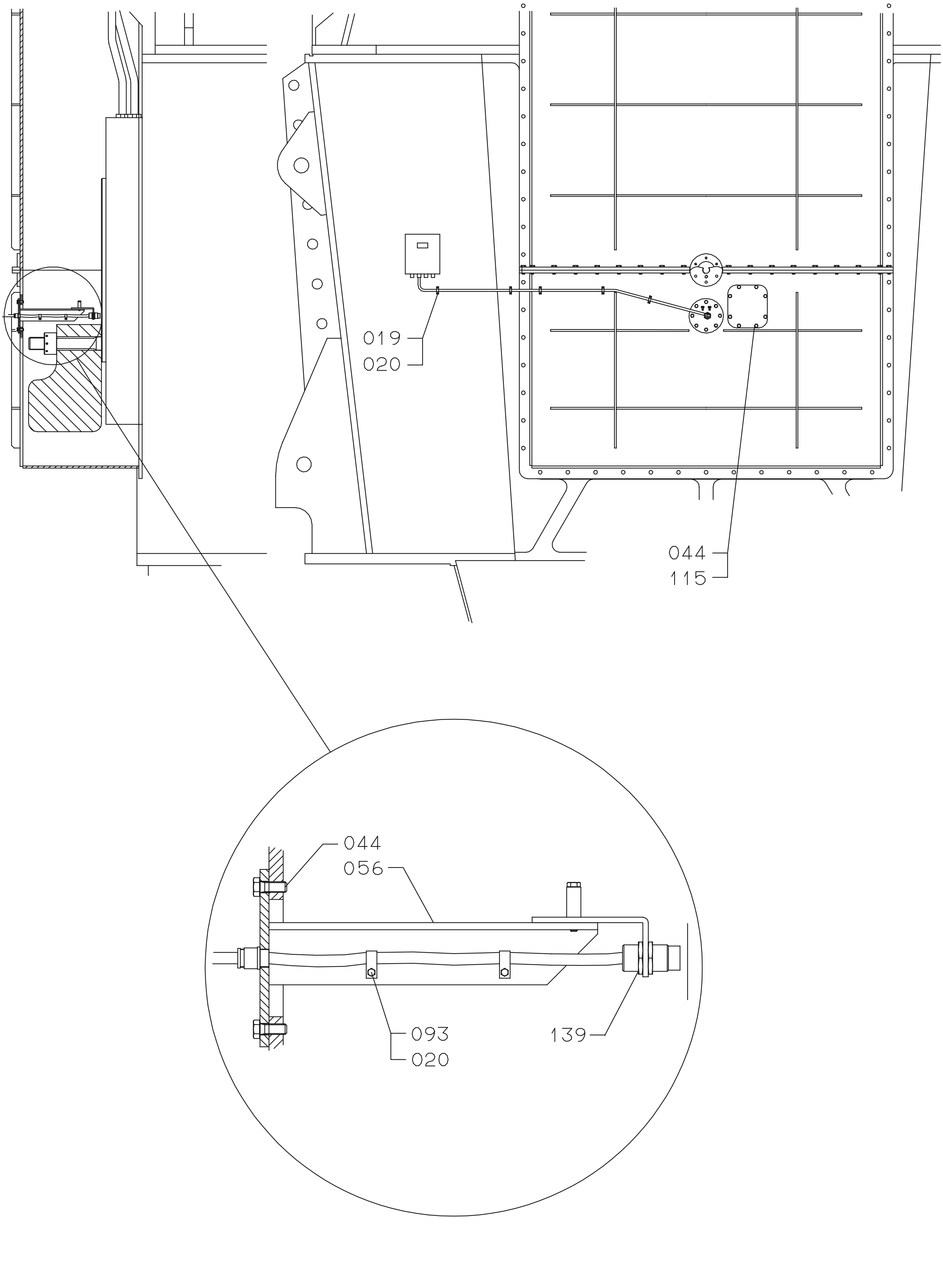
Item No.	Item Description



204
216
013
025
037
049
419
420
312
324
241
253
062
086
289
277
098
290
241
253
062
074
086
098
108
108
300
348
444
456
385
277
289
277
289
133
145
157
169
170
182

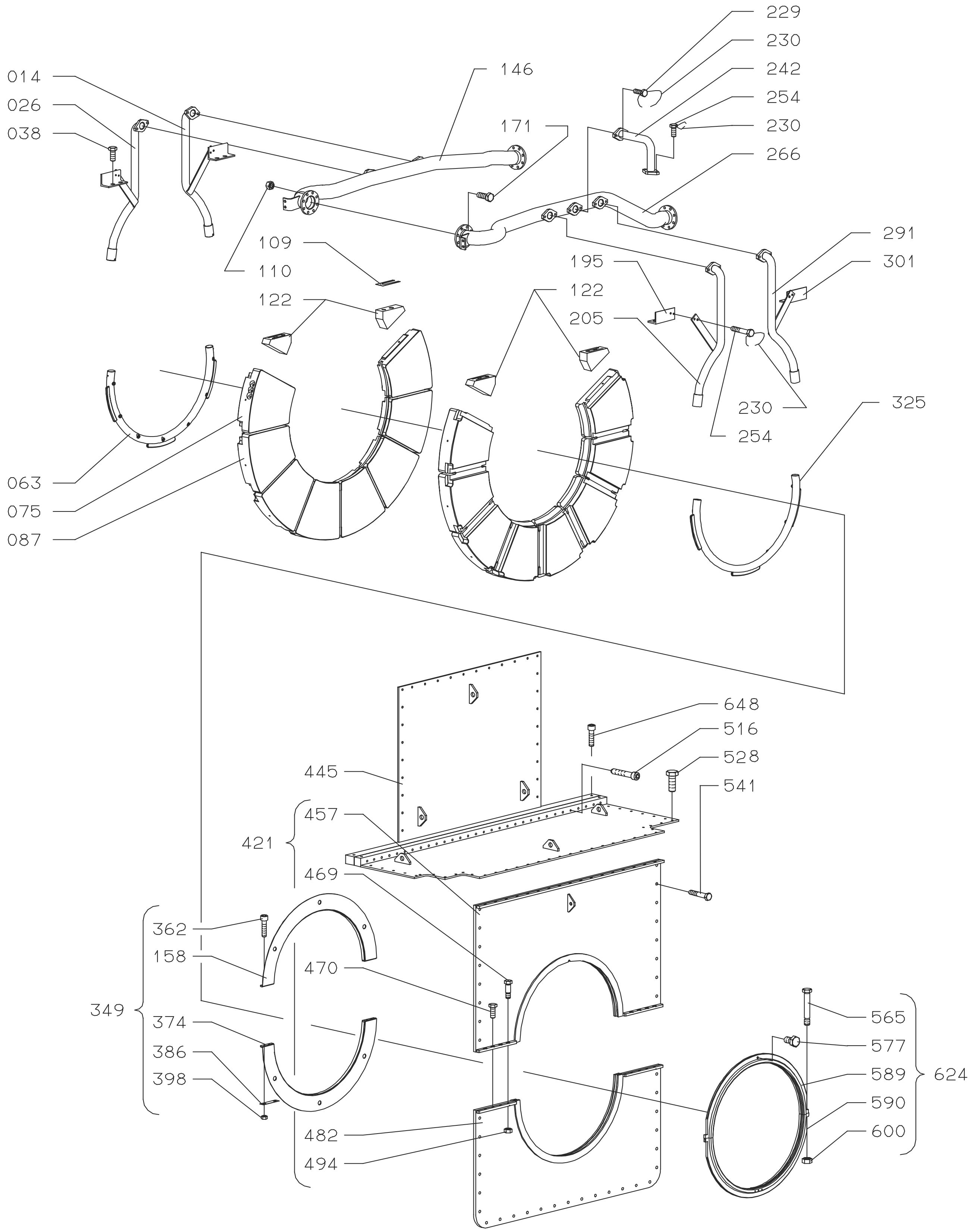
Arrangement of Angle Encoder

Item No.	Item Description	Item No.	Item Description
013	Spring lock		
025	Screw		
037	Guide pin		
049	Bracket		
062	Nut, self-locking		
074	Bearing, complete		
086	Distance ring		
098	Screw		
108	Angle encoder		
133	Cover		
145	Cover		
157	Washer, hardened		
169	Screw		
170	Plug screw		
182	Plug screw		
204	Flange		
216	Screw		
241	Spring lock		
253	Screw		
277	Spring lock		
289	Screw		
290	Sleeve		
300	Bearing, complete		
312	Screw		
324	Guide pin		
348	Flang		
385	Cover		
419	Distance pipe		
420	Shaft		
444	Washer, hardened		
456	Screw		
	Note:		
	*		


019
020
044
115
044
056
093
020
139

Axial Vibration Monitor

Item No.	Item Description
019	Pipe holder
020	Screw
044	Screw
056	Bracket
093	Pipe holder
115	Cover
139	Vibration monitor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230
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230
266
014
026
038
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171
109
110
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122
205
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301
230
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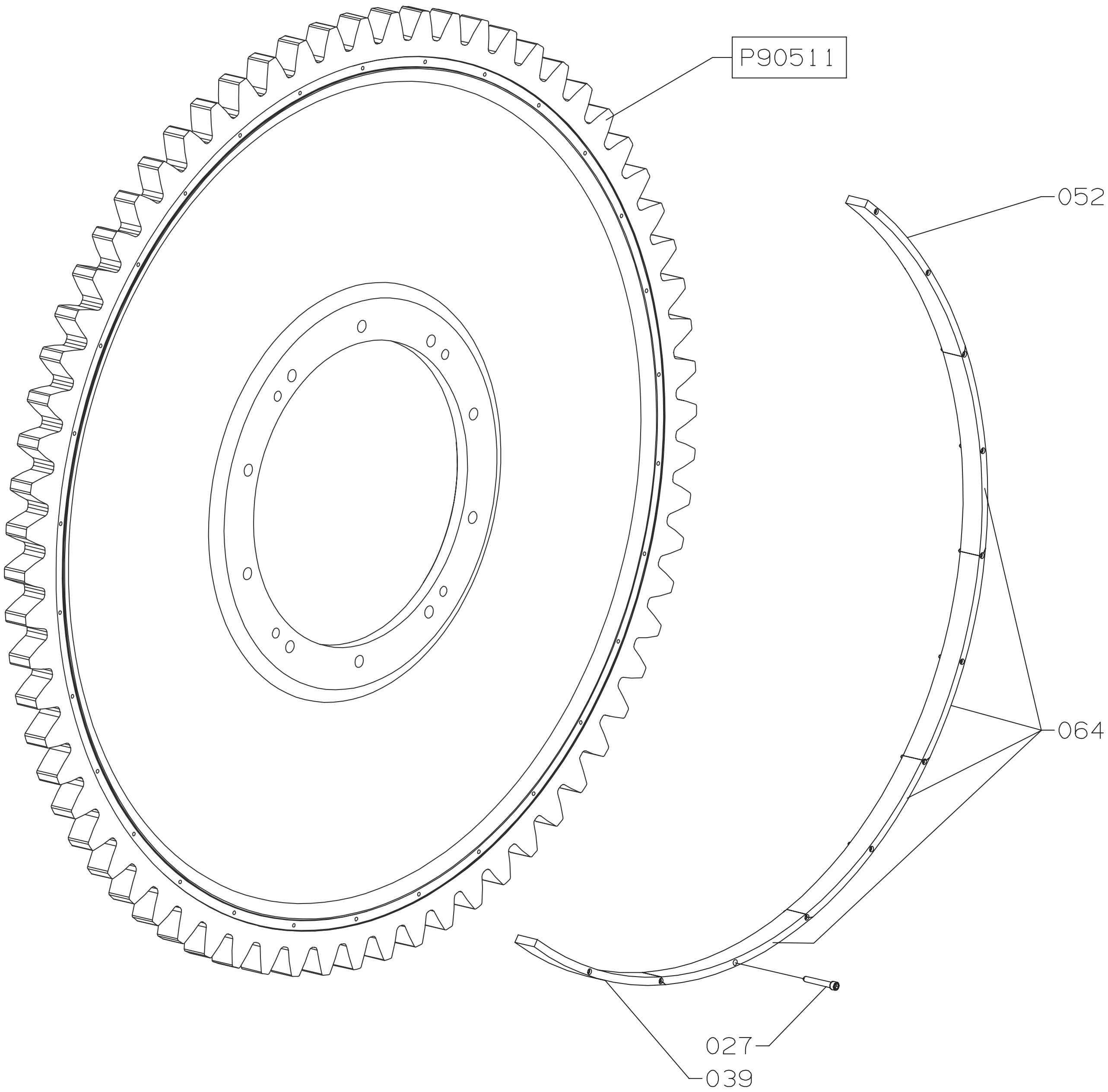
325
063
075
087
648
516
528
541
445
457
421
469
362
158
470
349
374
386
398
482
494
565
577
589
624
590
600

Thrust and Guide Bearing

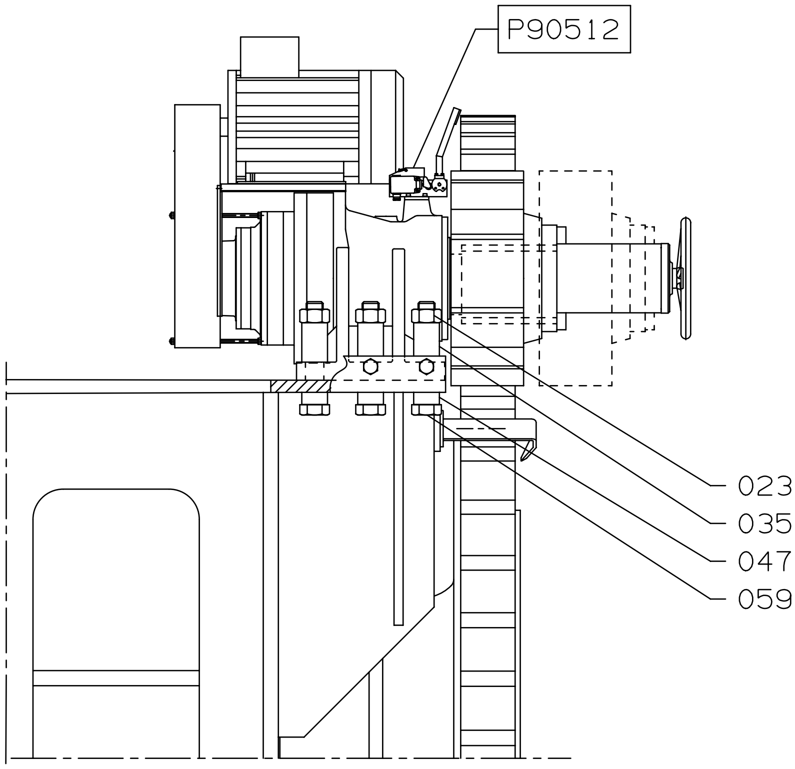
Item No.	Item Description
014	Lubricating oil pipe
026	Lubricating oil pipe
038	Screw
063	Spray pipe
075	Segment stopper
087	Segment
109	Shim
110	Nut
122	Segment stopper
146	Lubricating oil pipe
158	Plate
171	Screw
195	Support
205	Lubricating oil pipe
229	Screw
230	Locking wire
242	Lubricating oil pipe
254	Screw
266	Lubricating oil pipe
291	Lubricating oil pipe
301	Support
325	Spray pipe
349	Oil throwring, complete
362	Screw
374	Plate
386	Locking plate
398	Nut
421	Scraper ring housing, complete
445	Cover
457	Scraper ring housing, upper part
469	Fitted bolt
470	Screw
482	Scraper ring housing, lower part
494	Nut
516	Screw
528	Screw
541	Screw
565	Fitted bolt
577	Screw
589	Scraper ring, upper
590	Scraper ring, lower
600	Nut
624	Scraper ring, complete
648	Screw

Item No.	Item Description



P90511
052
064
027
039

Item No.	Item Description	Item No.	Item Description
027	Screw		
039	TDC indicator		
052	TDC indicator		
064	TDC indicator		
	Note:		
	*		



P90512
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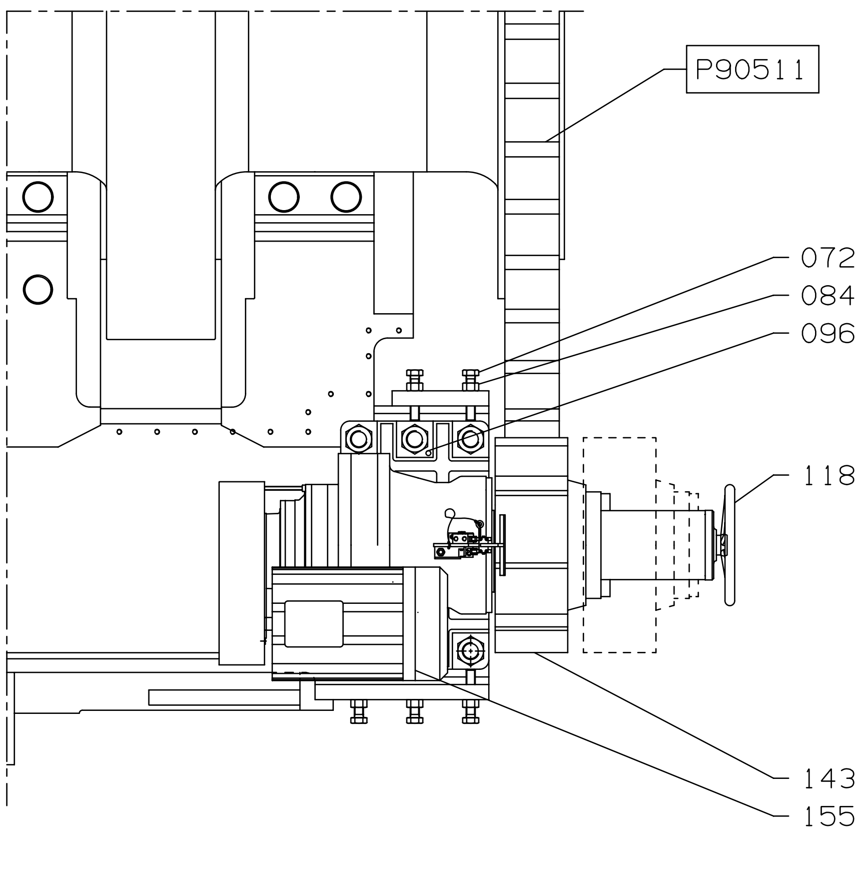
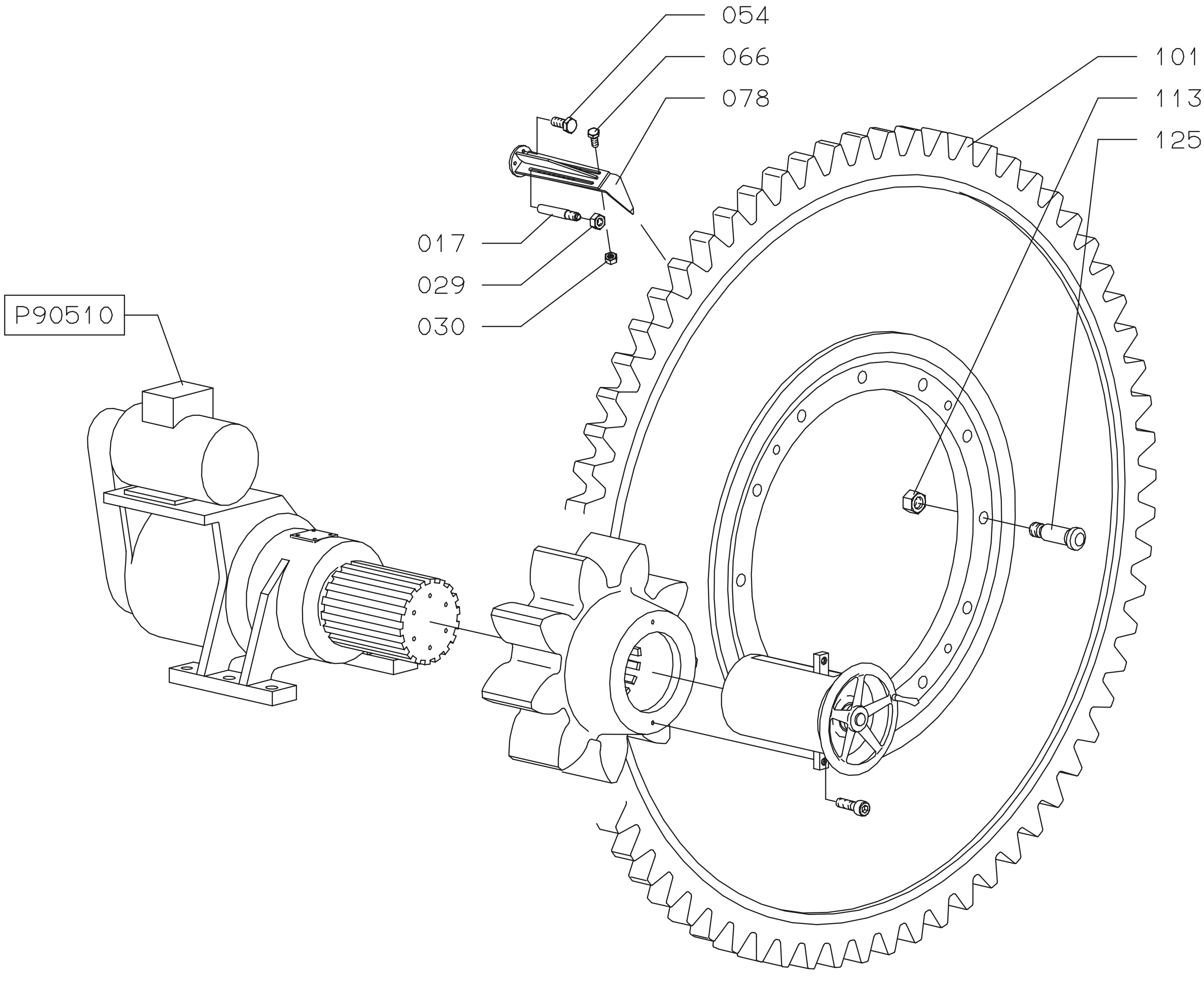
035
047
059



P90511
072
084
096
118
143
155

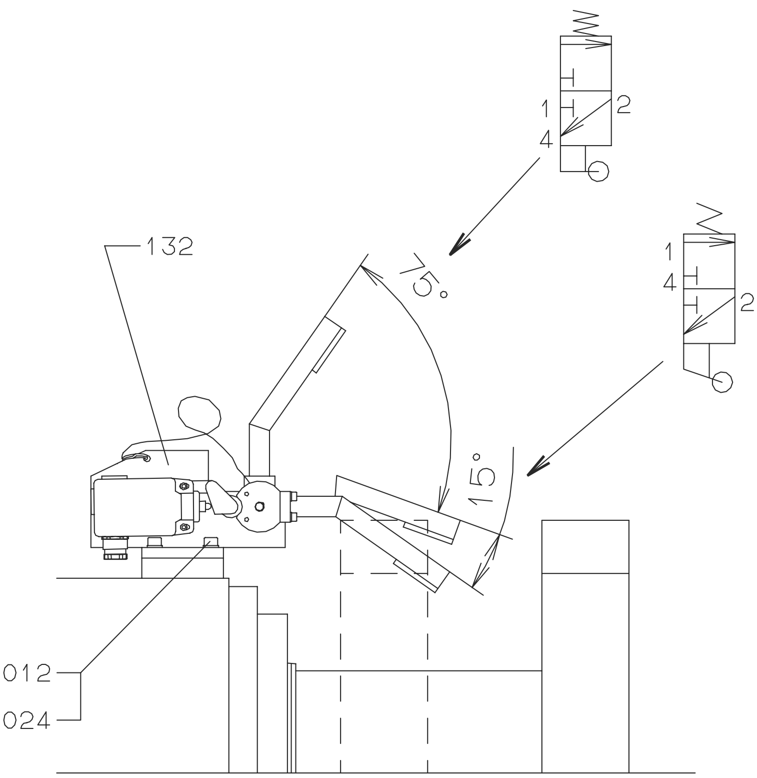
Item No.	Item Description	Item No.	Item Description
023	Screw		
035	Spacer tubular		
047	Spacer tubular		
059	Nut		
072	Screw		
084	Nut		
096	Guide pin		
118	Disengaging device, complete		
143	Gear wheel		
155	Planet gear		


054
066
078
101
113
125
017
029
030
P90510

Turning Wheel

Item No.	Item Description
017	Guide pin
029	Nut
030	Nut
054	Screw
066	Screw
078	Dead centre pointer
101	Turning wheel
113	Nut
125	Fitted bolt

Item No.	Item Description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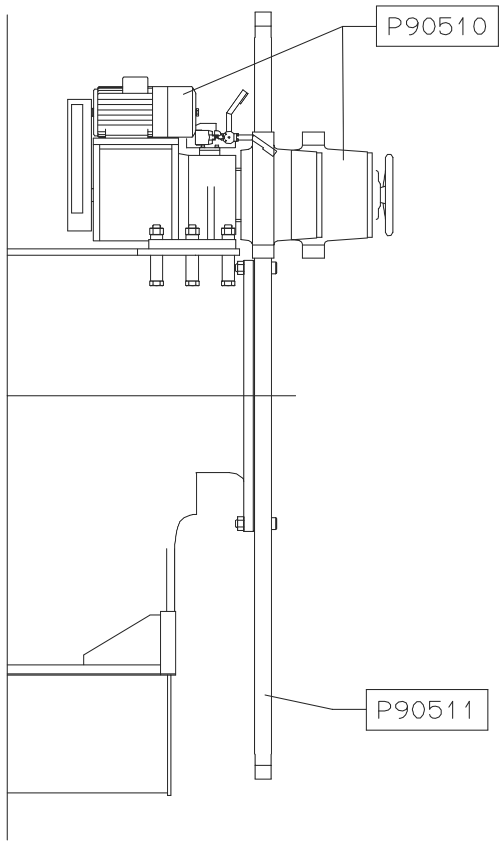
2
4
1
4
2
132
75°
15°
012
024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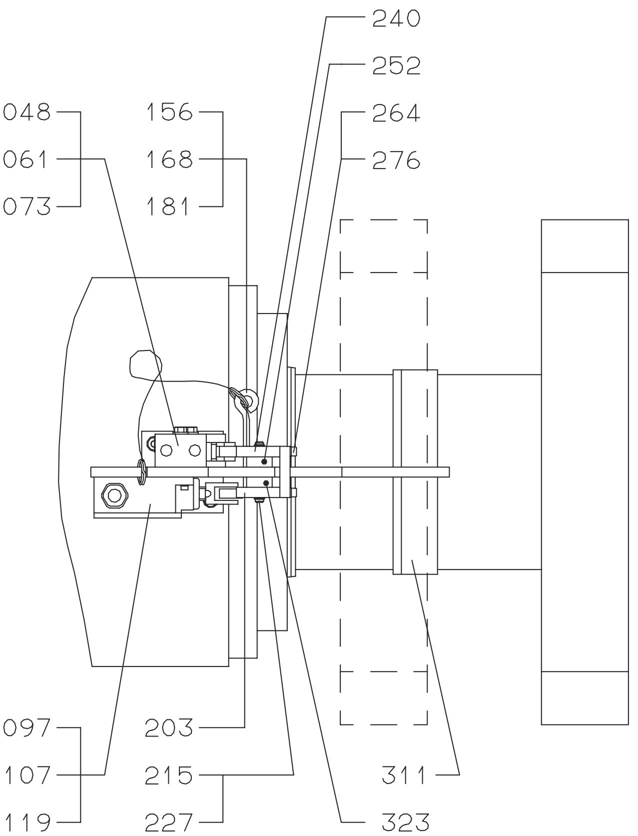
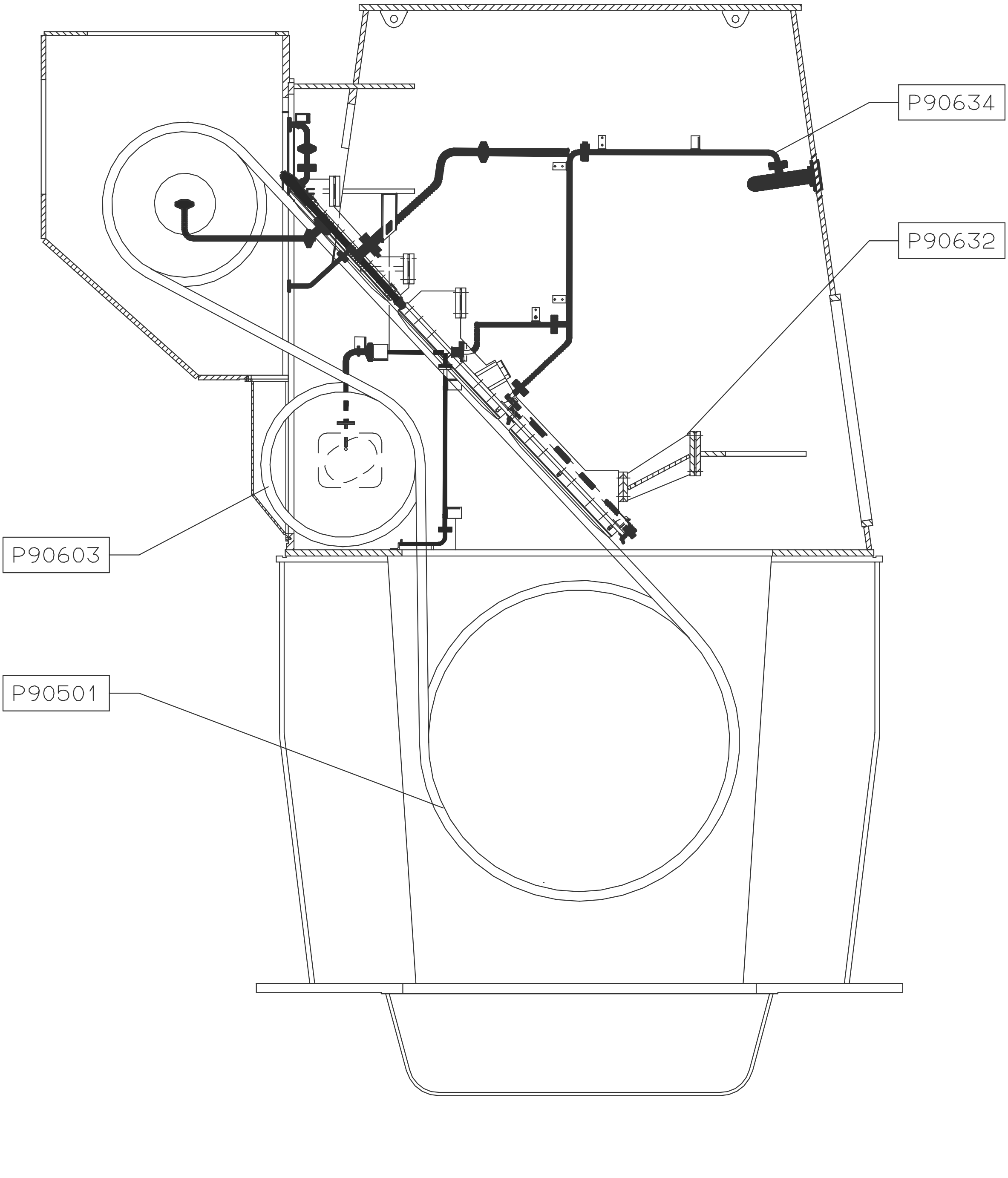
P90511


240
252
264
276
048
061
073
156
168
181
097
107
119
203
215
227
311
323

Item No.	Item Description	Item No.	Item Description
012	Screw		
024	Spring washer		
048	3/2-way valve		
061	Screw		
073	Spring washer		
097	Switch 0-110 volts		
107	Screw		
119	Spring washer		
132	Bracket		
156	Eye screw		
168	Key ring		
181	Chain		
203	Disc with inicision		
215	Stud with groove		
227	Circlip		
240	Disc with inicision		
252	Sleeve		
264	Screw		
276	Spring washer		
311	Lever		
323	Bush		

906 - Control Gear

Documents in this Chapter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P90632
P90603
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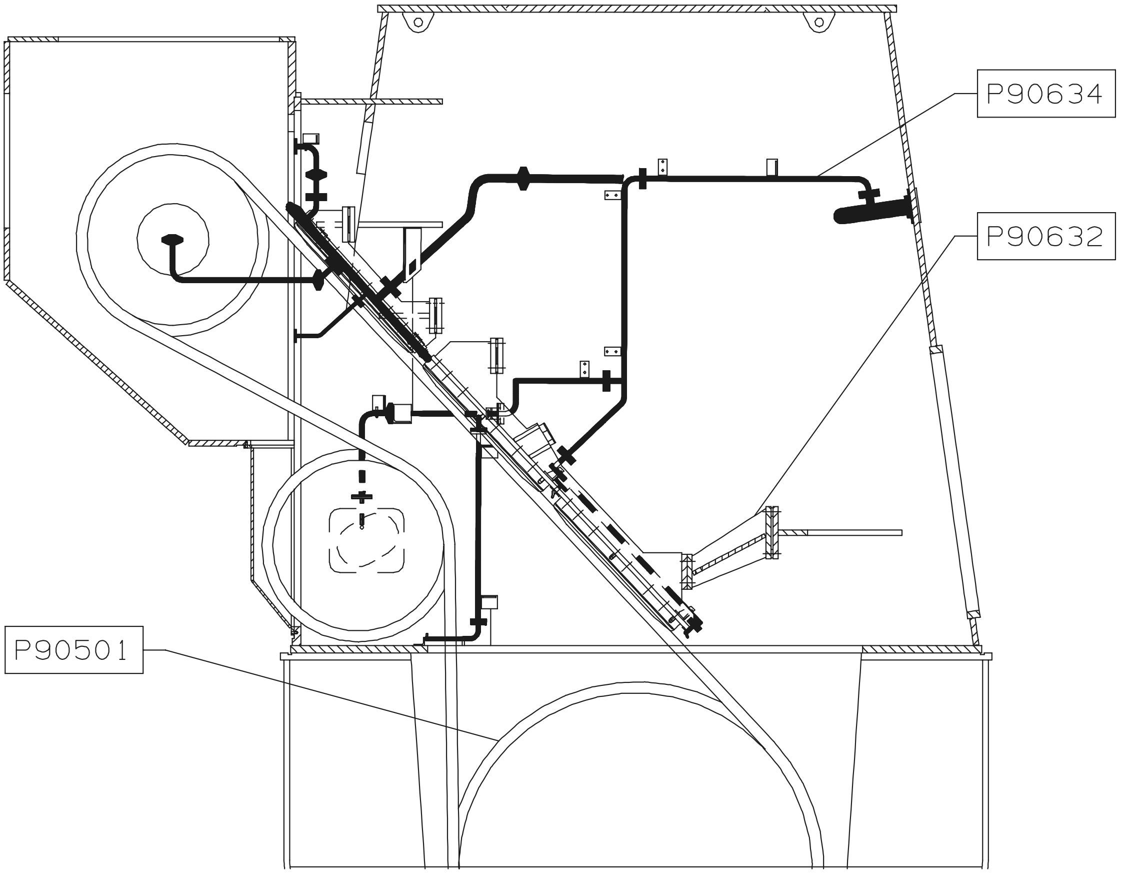
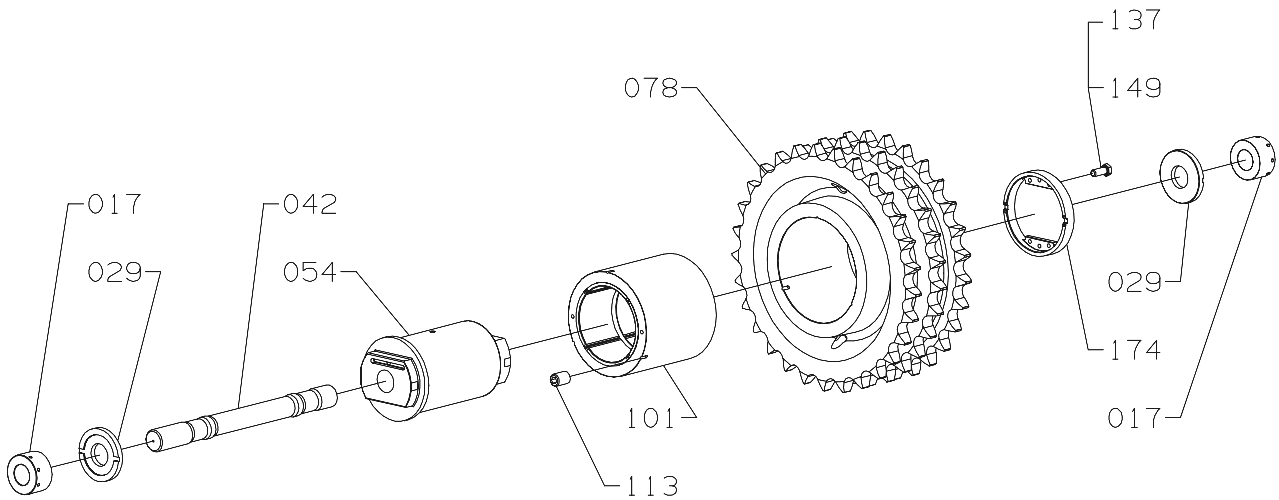
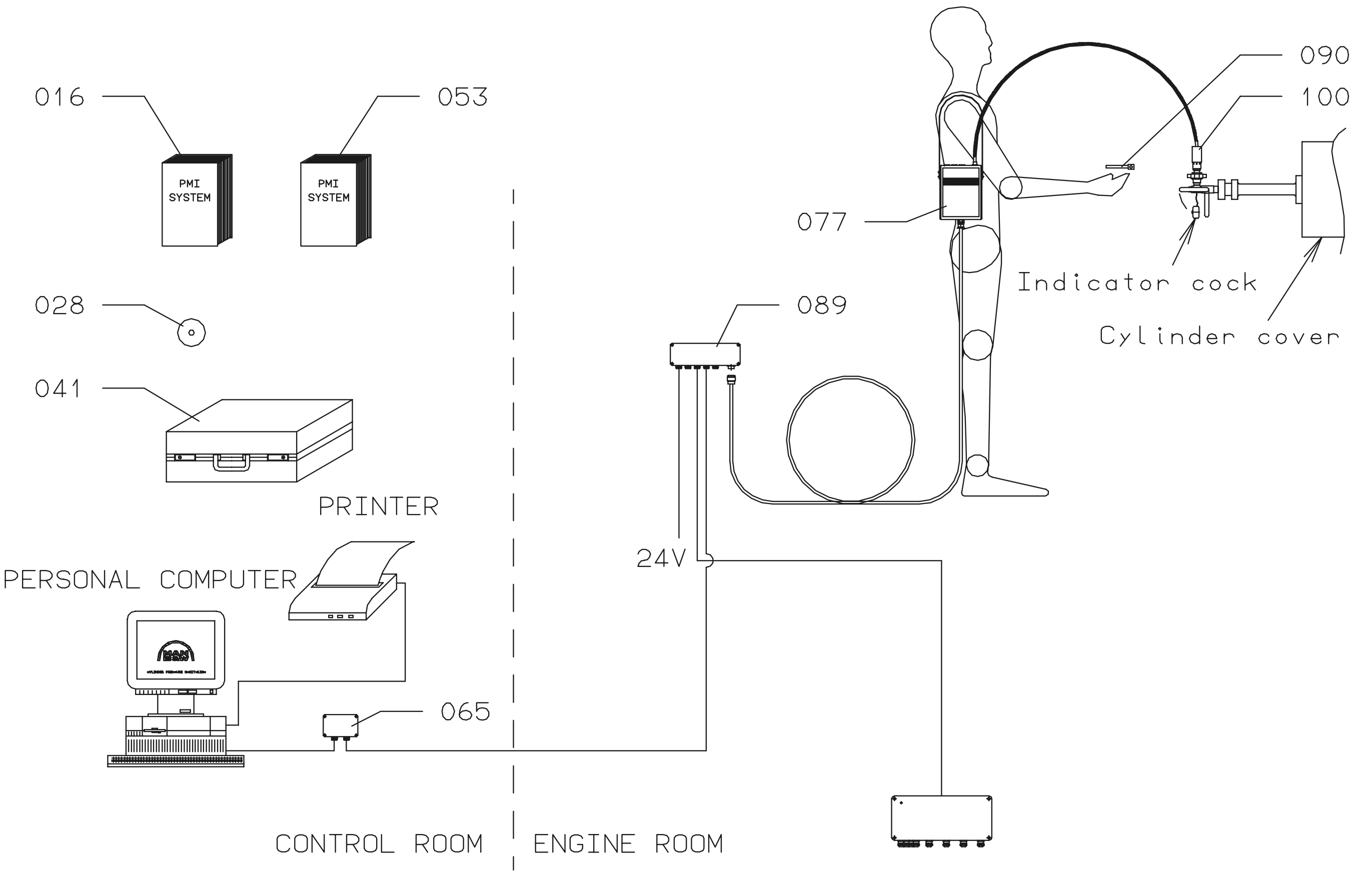

P90634
P90632
P90501


137
149
078
017
029
042
054
101
113
029
174
017

Chain Tightener

Item No.	Item Description
017	Nut
029	Disc
042	Stud
054	Shaft
078	Chain tightener wheel
101	Bushing
113	Screw
137	Screw
149	Locking wire
174	Bushing

Item No.	Item Description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053
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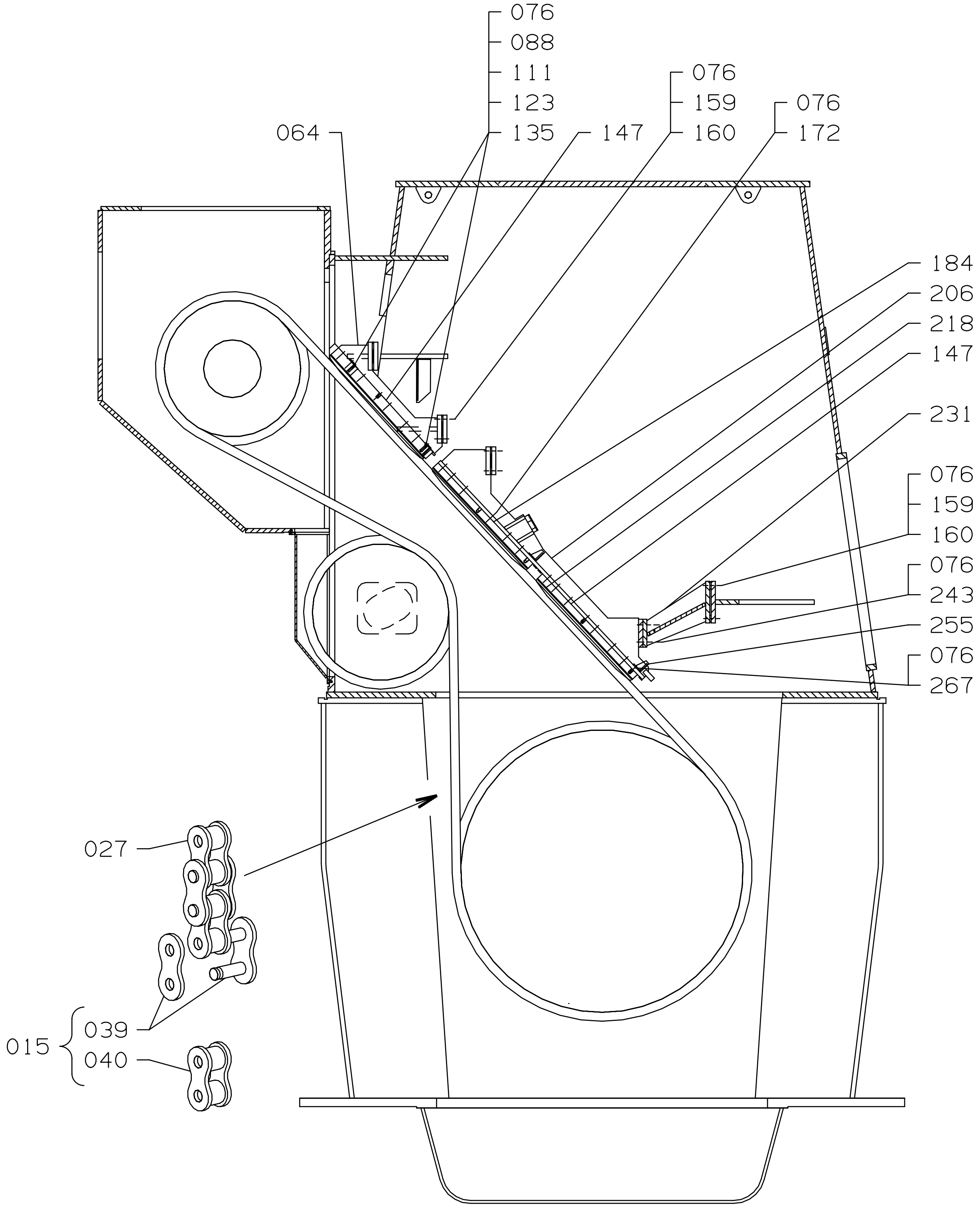
PMI SYSTEM
028
041
PRINTER
PERSONAL COMPUTER
065
CONTROL ROOM
ENGINE ROOM
24V
089
077
090
100
Indicator cock
Cylinder cover

Arrangement of Indicator System

Item No.	Item Description
016	PMI system users manual
028	PMI software
041	Storage case
053	PMI install and start-up manual
065	Converter box
077	PMI controller box, complete
089	Junction box
090	Handle
100	Pressure transducer, complete

Item No.	Item Description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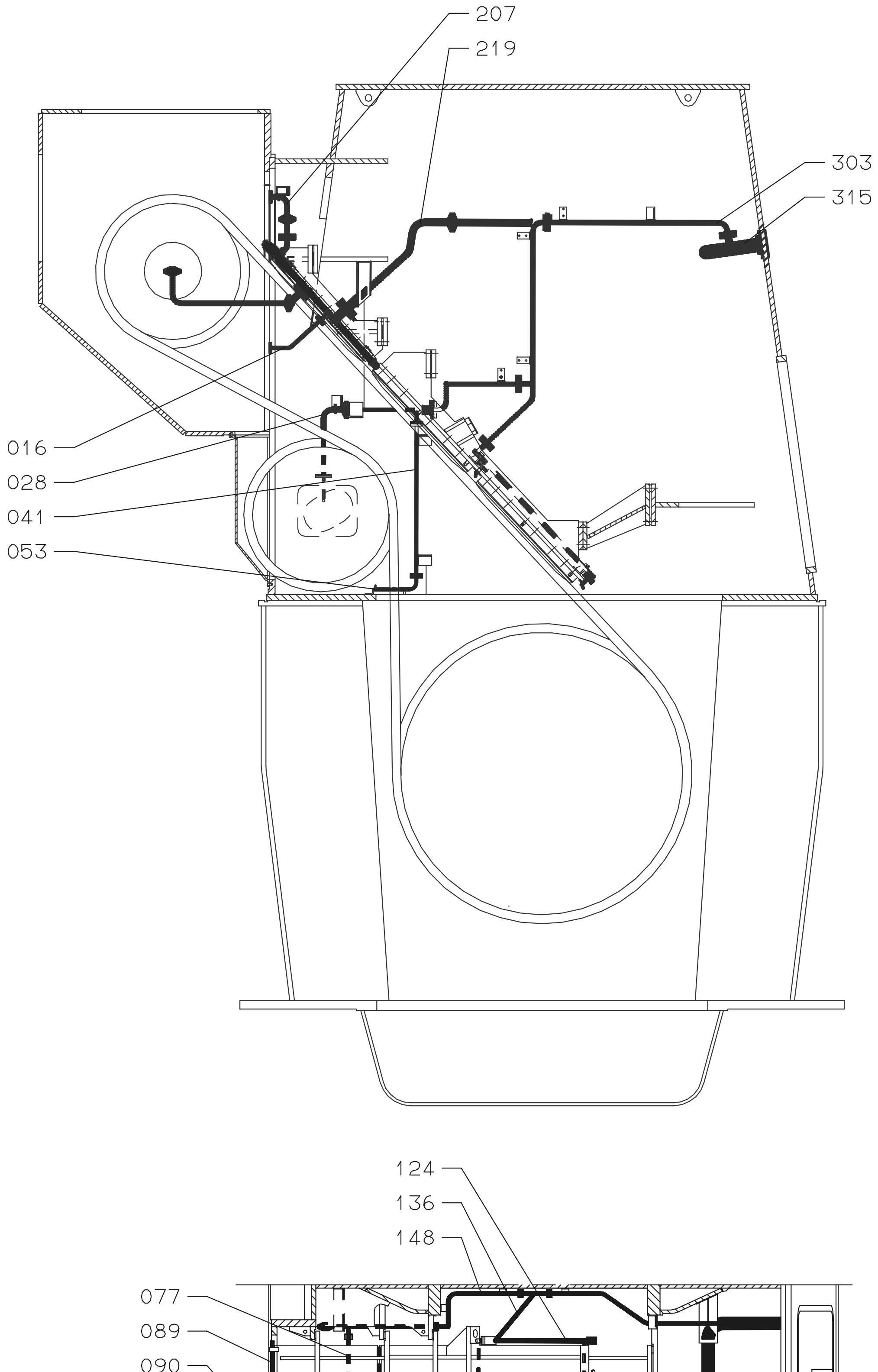
076
172
184
206
218
147
231
076
159
160
076
243
255
076
267
027
015
039
040

Item No.	Item Description	Item No.	Item Description
015	Chain link, complete		
027	Chain, complete		
039	Outer link		
040	Inner link		
064	Beam for guidebar		
076	Locking wire		
088	Support		
111	Screw		
123	Nut, self-locking		
135	Clamp		
147	Shim		
159	Screw		
160	Disc		
172	Screw		
184	Shim		
206	Beam for guidebar		
218	Guidebar		
231	Bracket for guideway		
243	Screw		
255	Support		
267	Screw		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219
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028
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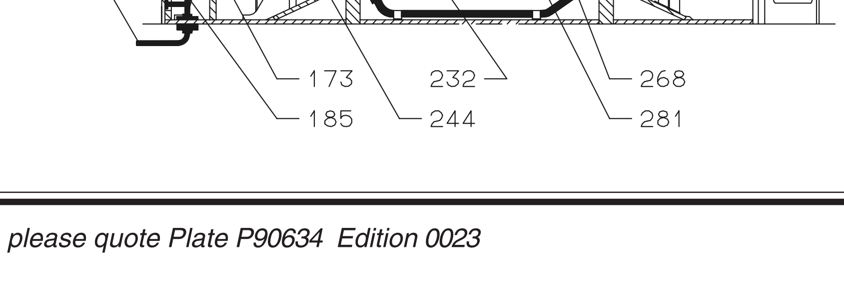
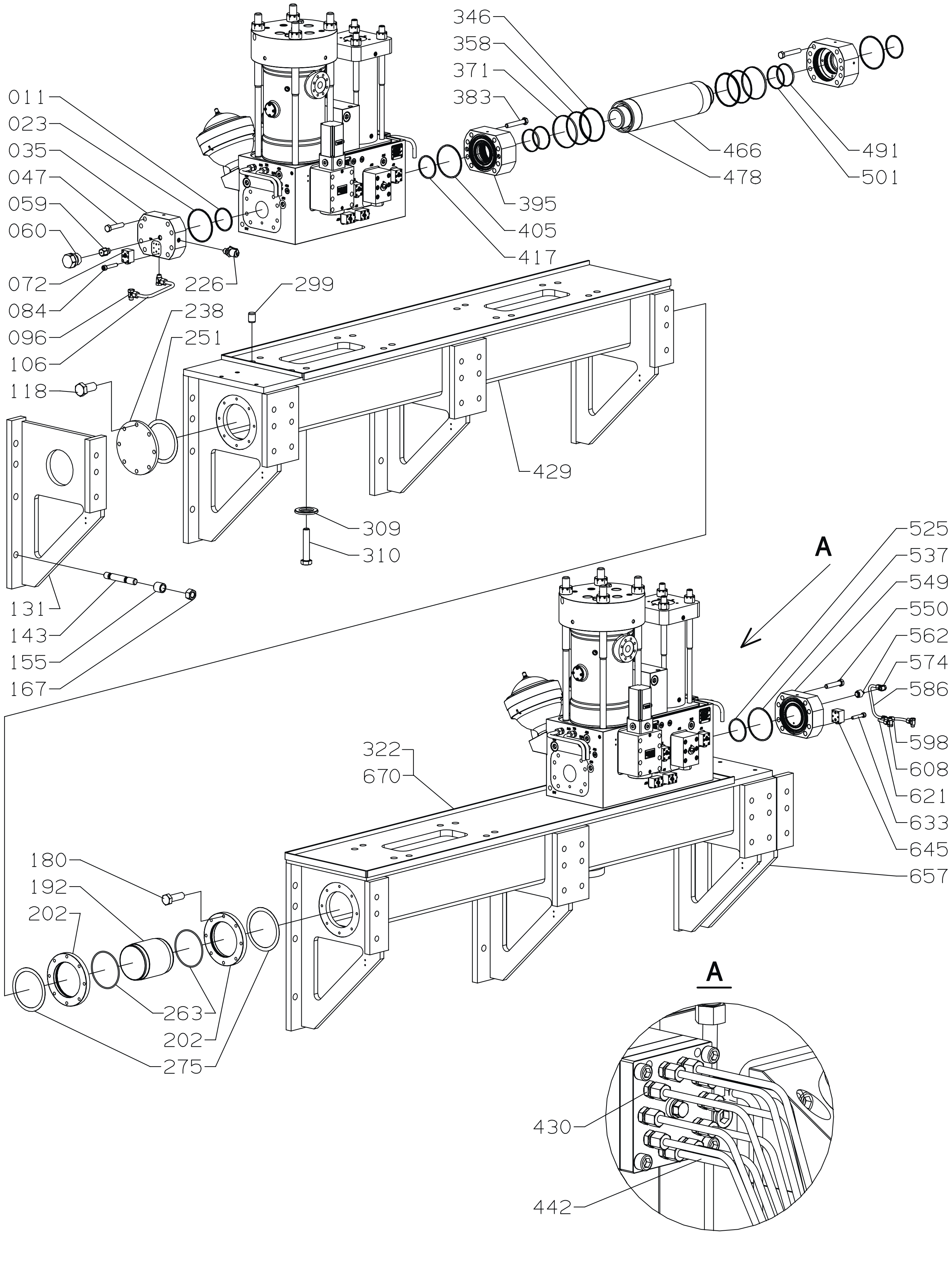
053


124
136
148
077
089
090
100
173
232
268
185
244
281

Item No.	Item Description	Item No.	Item Description
016	Lubricating pipe		
028	Lubricating pipe		
041	Lubricating pipe		
053	Spray pipe		
077	Spray pipe		
089	Spray pipe		
090	Lubricating pipe		
100	Lubricating pipe		
124	Lubricating pipe		
136	Lubricating pipe		
148	Lubricating pipe		
173	Lubricating pipe		
185	Lubricating pipe		
207	Lubricating pipe		
219	Lubricating pipe		
232	Spray pipe		
244	Spray pipe		
268	Lubricating pipe		
281	Spray pipe		
303	Lubricating pipe		
315	Lubricating pipe		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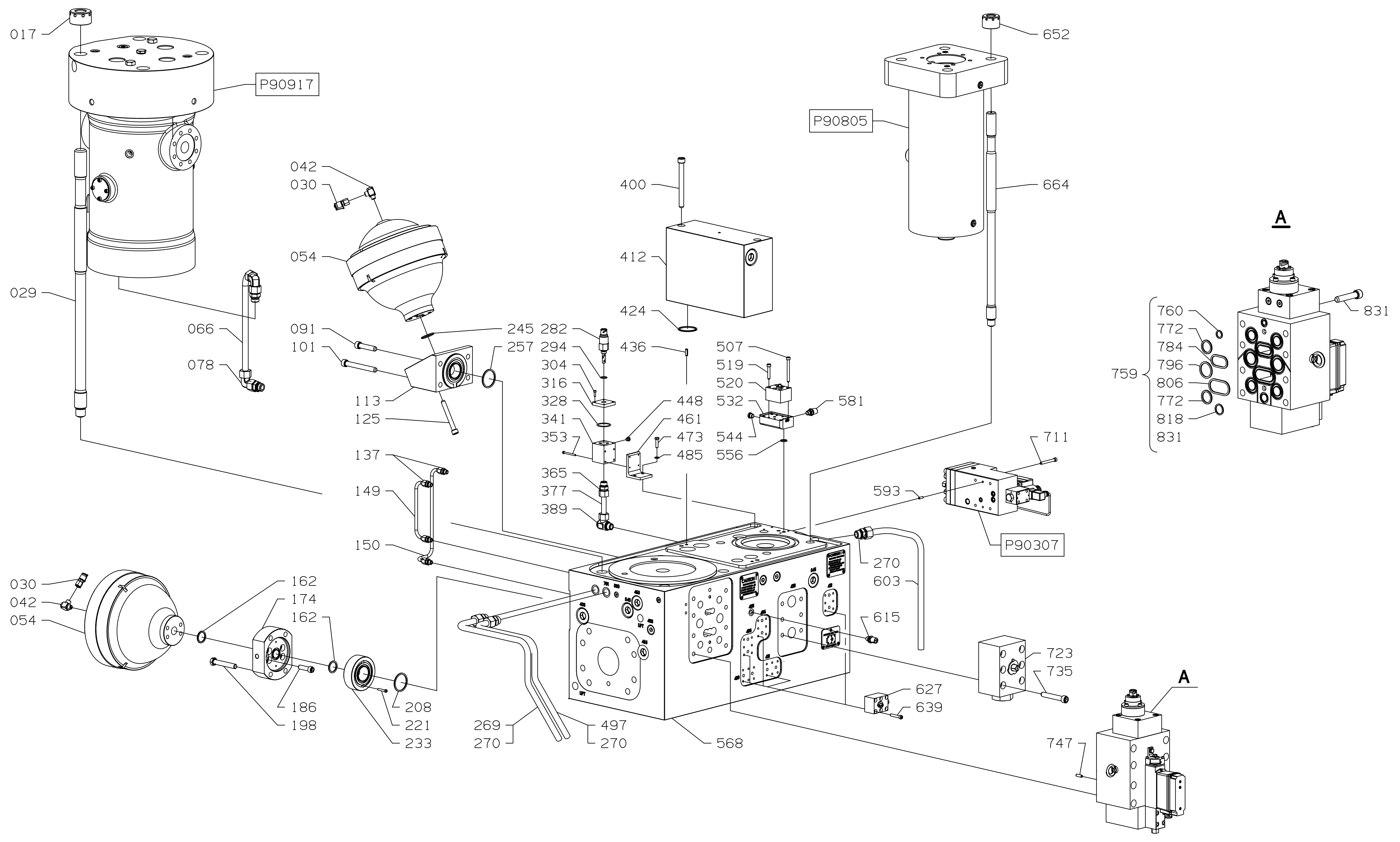
Item No.	Item Description	Item No.	Item Description
011	Sealing ring	608	Banjo coupling
023	Sealing ring	621	Steel pipe
035	Flange	633	Screw
047	Screw	645	Ball valve
059	Plug	657	Bracket
060	Plug screw	670	Filter screen
072	Ball valve		
084	Screw		**Note:**
096	Banjo coupling		
106	Steel pipe		*
118	Screw		
131	Bracket		
143	Stud		
155	Spacer, tubular		
167	Nut		
180	Screw		
192	Pipe		
202	Bush		
226	Quick coupling		
238	Flange		
251	Packing ring		
263	Sealing ring		
275	Packing ring		
299	Guide pin		
309	Washer		
310	Screw		
322	Base plate		
346	Sealing ring		
358	Sealing ring		
371	Sliding bearing		
383	Screw		
395	Flange		
405	Sealing ring		
417	Sealing ring		
429	Base plate		
430	Straight stud coupling		
442	Steel pipe		
466	High pressure pipe		
478	High pressure pipe		
491	Sliding bearing		
501	Sealing ring		
525	Sealing ring		
537	Sealing ring		
549	Flange		
550	Screw		
562	Non-return valve		
574	Banjo coupling		
586	Steel pipe		
598	T-coupling		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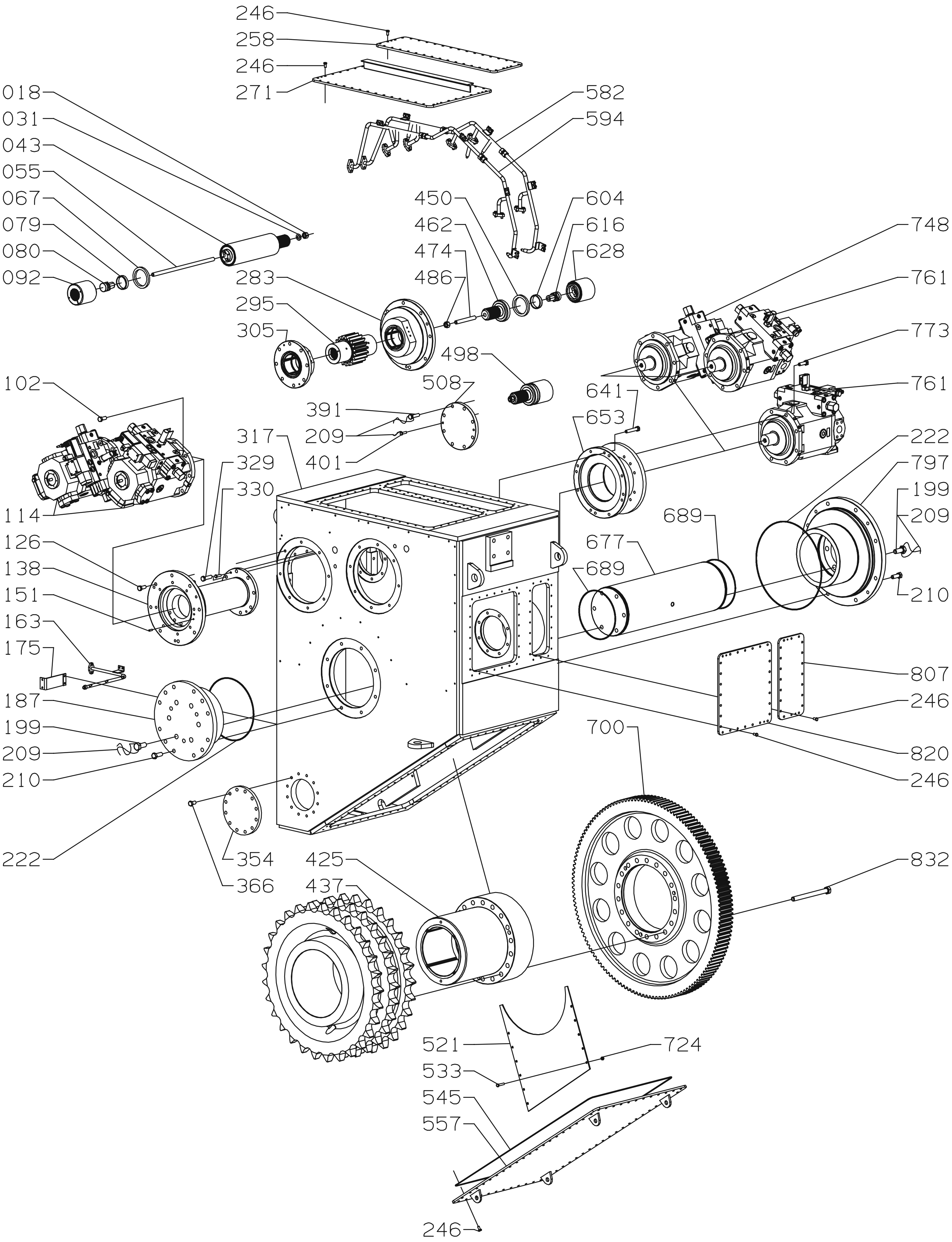
Item No.	Item Description	Item No.	Item Description
017	Nut	556	Sealing ring
029	Stud	568	Distributor block
030	Quick coupling	581	Quick coupling
042	Banjo coupling	593	Guide pin
054	Membrane accumulator	603	Steel pipe
066	Steel pipe	615	Quick coupling
078	Elbow coupling	627	Ball valve
091	Screw	639	Screw
101	Screw	652	Nut
113	Flange	664	Stud
125	Screw	711	Screw
137	Stud coupling	723	Ball valve
149	Steel pipe	735	Screw
150	Steel pipe	747	Guide pin
162	Sealing ring	759	Multi-way valve
174	Flange	760	Sealing ring
186	Screw	772	Sealing ring
198	Screw	784	Sealing ring
208	Sealing ring	796	Sealing ring
221	Screw	806	Sealing ring
233	Flange	818	Sealing ring
245	Sealing ring	831	Screw
257	Sealing ring		
269	Steel pipe		
270	Stud coupling		
282	Level switch		
294	Packing ring		
304	Screw		
316	Plate		
328	Sealing ring		
341	Plate		
353	Screw		
365	Stud coupling		
377	Steel pipe		
389	Banjo coupling		
400	Screw		
412	Return oil standpipe		
424	Sealing ring		
436	Spring pin		
448	Plug screw		
461	Sectional iron		
473	Screw		
485	Washer		
497	Steel pipe		
507	Screw		
519	Screw		
520	Ball valve		
532	Flange		
544	Plug screw		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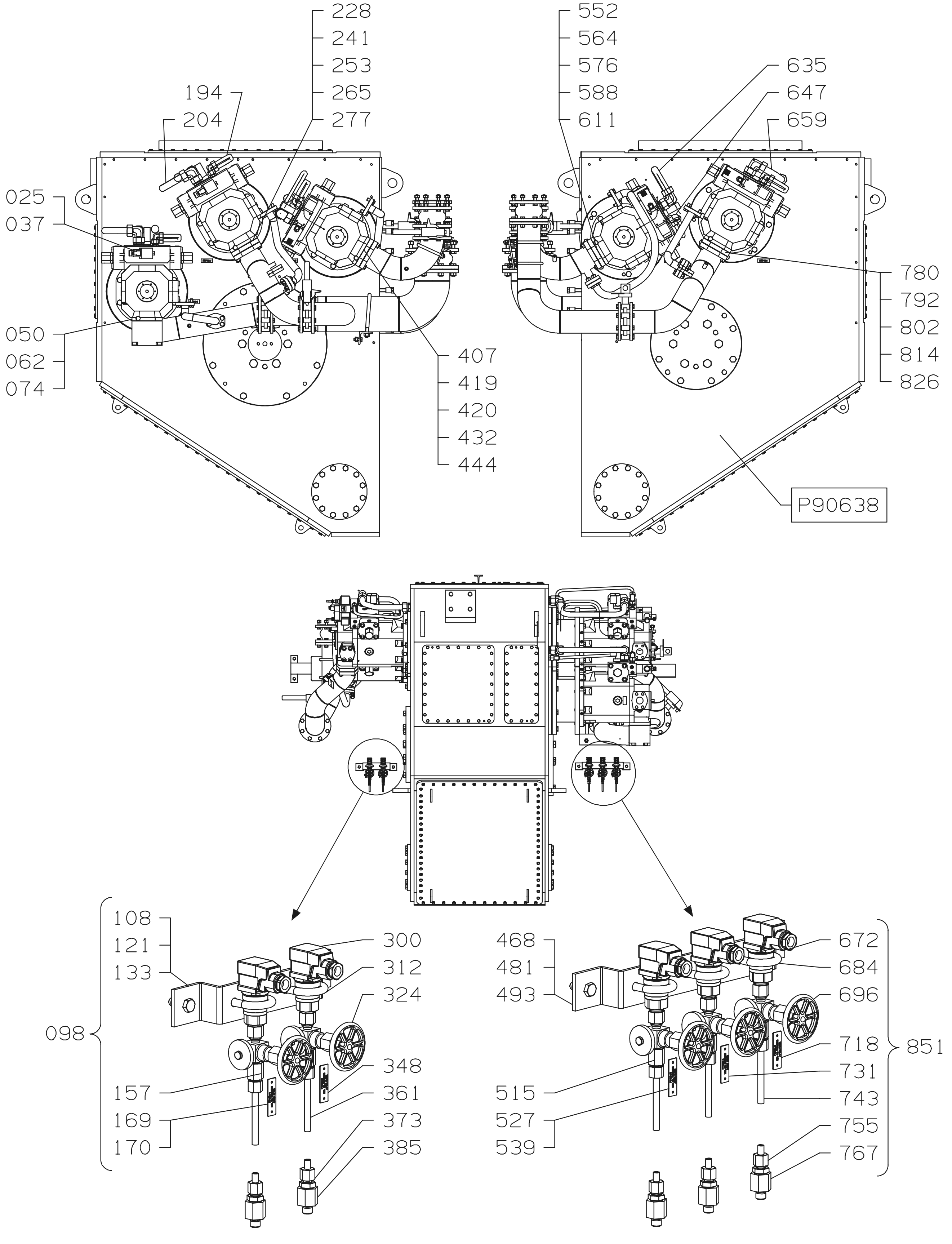
246

Item No.	Item Description	Item No.	Item Description
018	Nut	628	Drive shaft
031	Washer	641	Screw
043	Drive shaft	653	Connecting flange
055	Stud	677	Shaft
067	Disc	689	Glued sealing ring
079	Sealing ring	700	Gearwheel
080	Shear nut	724	Nut, self-locking
092	Drive shaft	748	Hydraulic oil pumps
102	Screw	761	Hydraulic oil pumps
114	Hydraulic oil pumps	773	Screw
126	Screw	797	Flange bearing
138	Connecting flange	807	Cover
151	Spring pin	820	Cover
163	Spray pipe	832	Screw
175	Support		
187	Flange bearing		
199	Screw		
209	Locking wire		
210	Screw		
222	Glued sealing ring		
246	Screw		
258	Cover		
271	Cover		
283	Connecting flange		
295	Gearwheel, drive shaft		
305	Connecting flange		
317	Gearbox		
329	Screw		
330	Screw		
354	Blank flange		
366	Screw		
391	Screw		
401	Screw		
425	Bushing		
437	Gearwheel		
450	Disc		
462	Drive shaft		
474	Stud		
486	Nut		
498	Friction coupling, complete		
508	Cover		
521	Plate, shaped		
533	Screw		
545	Sealing ring		
557	Cover		
582	Spray pipe		
594	Spray pipe		
604	Sealing ring		
616	Shear nut		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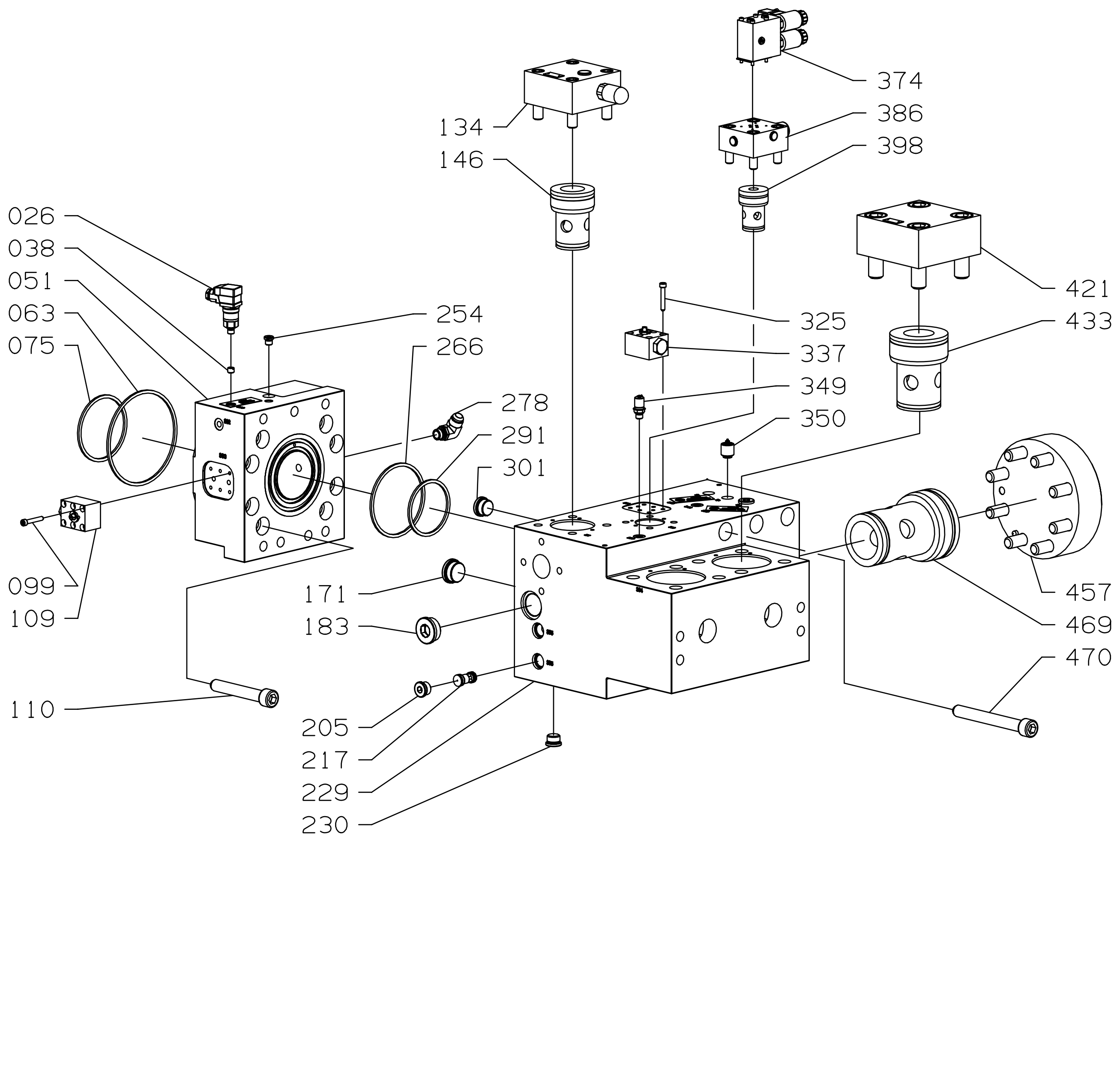
Hydraulic Power Supply - Drive, Details

Item No.	Item Description	Item No.	Item Description
025	4/2-way solenoid valve*	696	Valve, needle with test flange
037	4/2-way solenoid valve*	718	Name plate
050	Flange	731	Name plate
062	Screw	743	Steel pipe with certificate
074	Packing, rectangular	755	Straight stud coupling
098	Pressure switch, complete	767	Pressure equalizer
108	Support	780	Nut
121	Nut, self-locking	792	Flange, rectangular
133	Screw	802	Packing, rectangular
157	Straight coupling	814	Screw
169	Name plate	826	Stud
170	Locking wire	851	Pressure switch, complete
194	High pressure pipe		
204	High pressure pipe		**Note:**
228	Nut		
241	Flange, rectangular		* Optional extras.
253	Packing, rectangular		
265	Screw		
277	Stud		
300	Pressure transducer		
312	Clamp		
324	Valve, needle with test flange		
348	Name plate		
361	Steel pipe with certificate		
373	Straight stud coupling		
385	Pressure equalizer		
407	Flange, rectangular		
419	Packing, rectangular		
420	Screw		
432	Stud		
444	Nut		
468	Support		
481	Nut, self-locking		
493	Screw		
515	Straight coupling		
527	Name plate		
539	Locking wire		
552	Nut		
564	Flange, rectangular		
576	Packing, rectangular		
588	Screw		
611	Stud		
635	High pressure pipe		
647	High pressure pipe		
659	High pressure pipe		
672	Pressure transducer		
684	Clamp		



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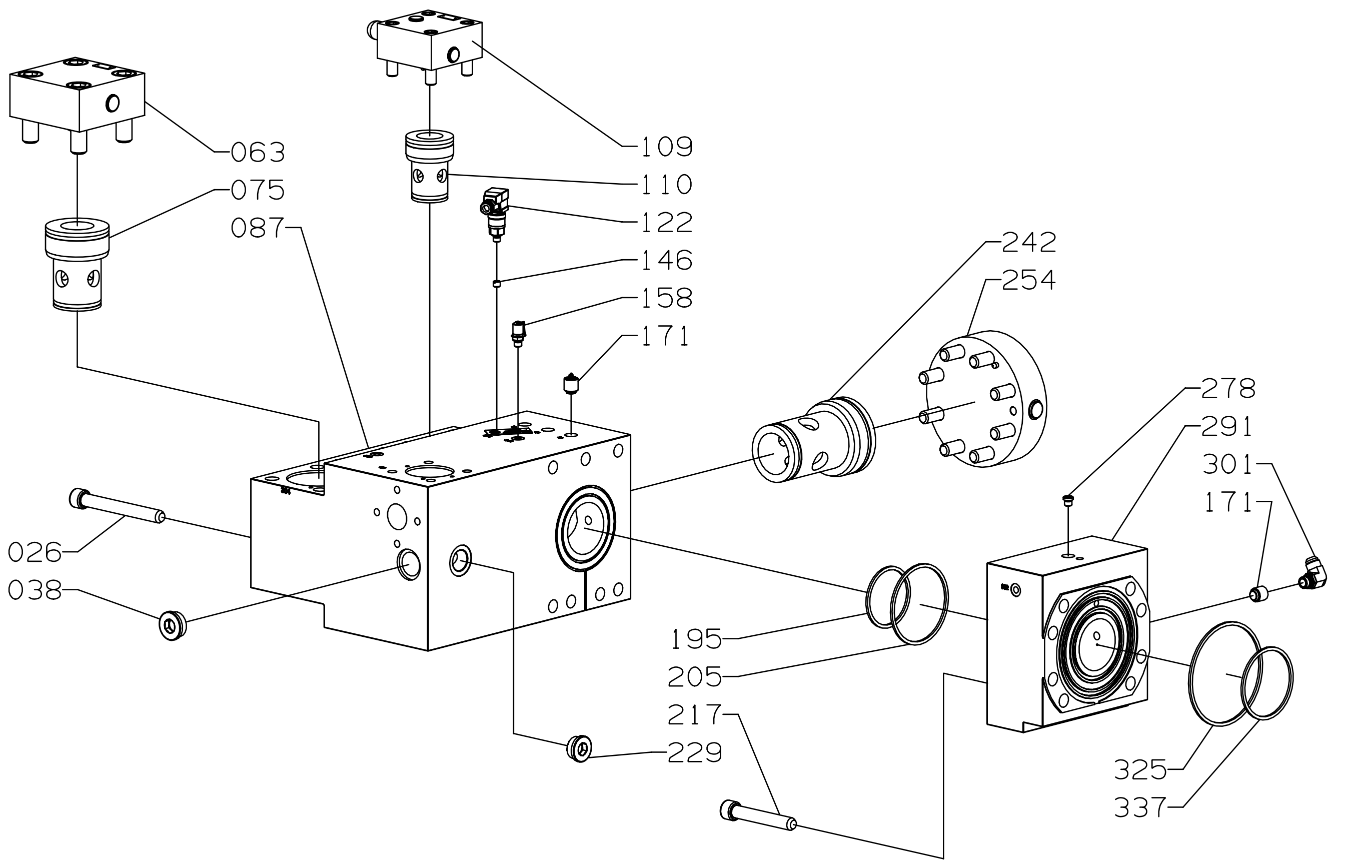
Item No.	Item Description	Item No.	Item Description
026	Pressure transducer		
038	Orifice plate		
051	Hydraulic safety block		
063	Sealing ring		
075	Sealing ring		
099	Screw		
109	Ball valve		
110	Screw		
134	Control cover		
146	Cartridge valve		
171	Plug screw		
183	Plug screw		
205	Plug screw		
217	Cartridge valve		
229	Accumulator block		
230	Plug screw		
254	Plug screw		
266	Sealing ring		
278	Elbow connection		
291	Sealing ring		
301	Plug screw		
325	Screw		
337	Ball valve		
349	Quick coupling, minimess		
350	Non-return valve		
374	Cartridge valve, 2-way		
386	Control cover		
398	Cartridge valve		
421	Control cover		
433	Cartridge valve		
457	Control cover		
469	Cartridge valve		
470	Screw		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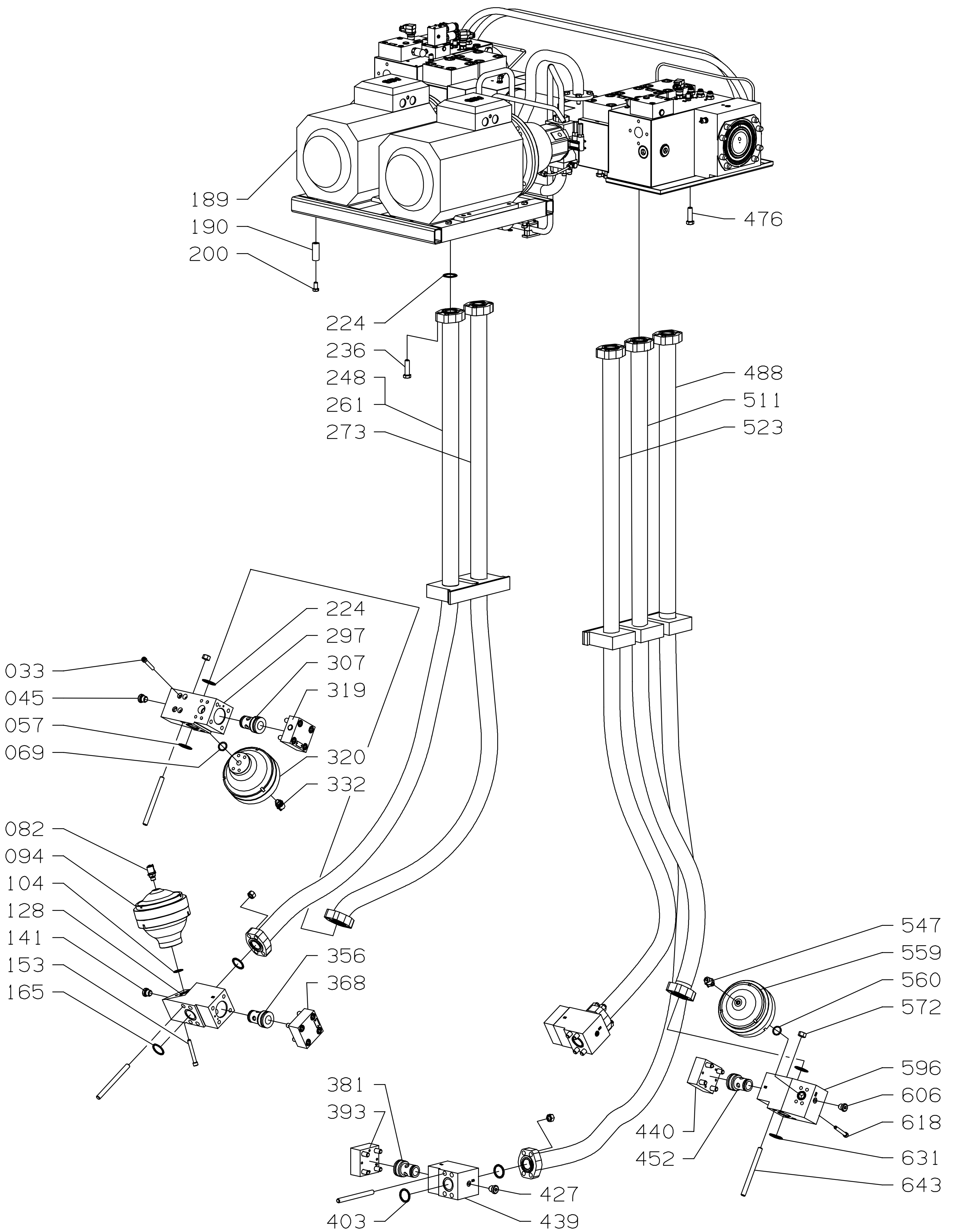
Item No.	Item Description	Item No.	Item Description
026	Screw		
038	Plug screw		
063	Control cover		
075	Cartridge valve		
087	Accumulator block		
109	Control cover		
110	Cartridge valve		
122	Pressure transducer		
146	Orifice plate		
158	Quick coupling, minimess		
171	Non-return valve		
195	Sealing ring		
205	Sealing ring		
217	Screw		
229	Plug screw		
242	Cartridge valve		
254	Control cover		
278	Plug screw		
291	Flange		
301	Elbow connection		
325	Sealing ring		
337	Sealing ring		



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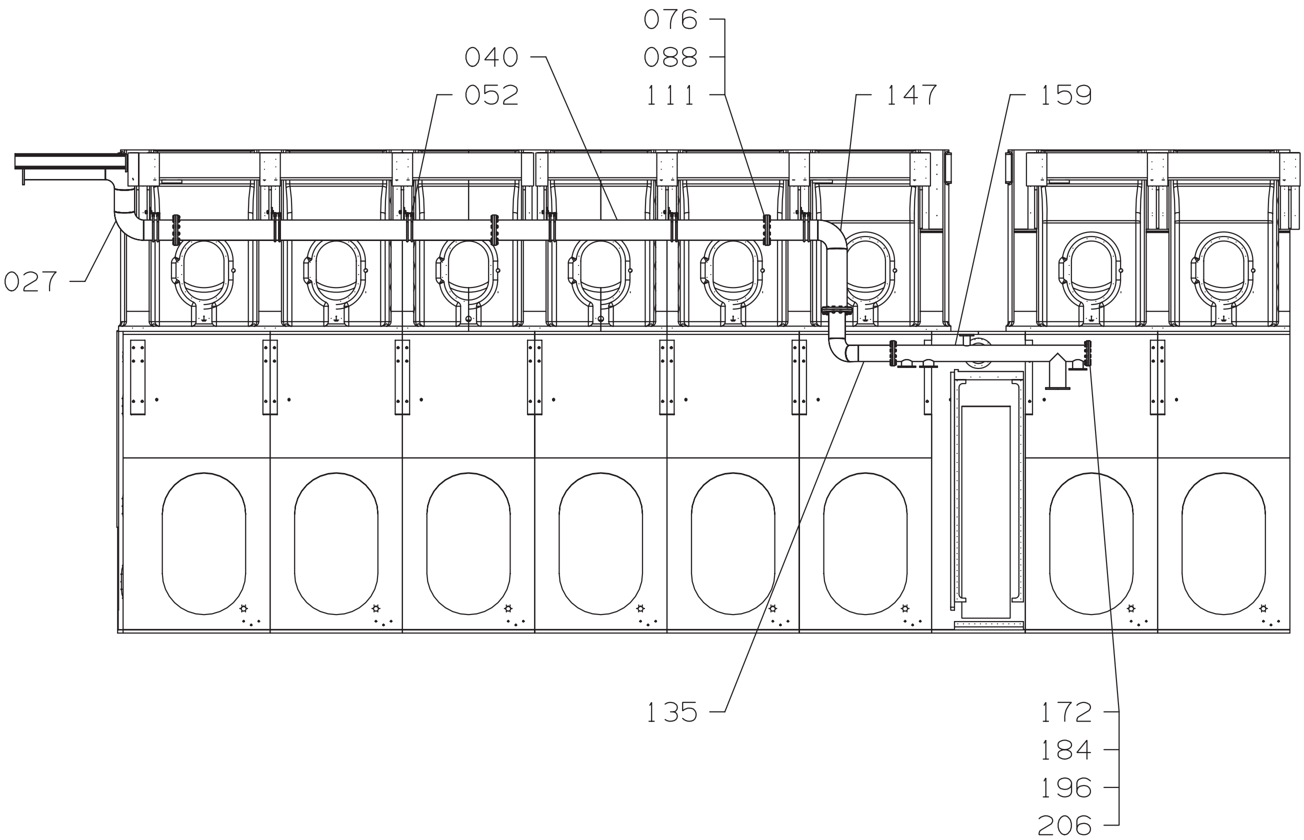
403

Item No.	Item Description	Item No.	Item Description
033	Screw		
045	Plug screw		
057	Gasket		
069	Sealing ring		
082	Quick coupling, minimess		
094	Membrane accumulator		
104	Sealing ring		
128	Accumulator block		
141	Plug screw		
153	Screw		
165	Gasket		
189	Hydraulic pump station		
190	Round iron		
200	Screw		
224	Gasket		
236	Screw		
248	Hose with 2 couplings		
261	Flexible steel tube		
273	Hose with 2 couplings		
297	Accumulator block		
307	Cartridge valve		
319	Control cover		
320	Membrane accumulator		
332	Quick coupling, minimess		
356	Cartridge valve		
368	Control cover		
381	Cartridge valve		
393	Control cover		
403	Gasket		
427	Plug screw		
439	Accumulator block		
440	Control cover		
452	Cartridge valve		
476	Screw		
488	Hose with 2 couplings		
511	Hose with 2 couplings		
523	Hose with 2 couplings		
547	Quick coupling, minimess		
559	Membrane accumulator		
560	Sealing ring		
572	Nut		
596	Accumulator block		
606	Plug screw		
618	Screw		
631	Gasket		
643	Stud		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027
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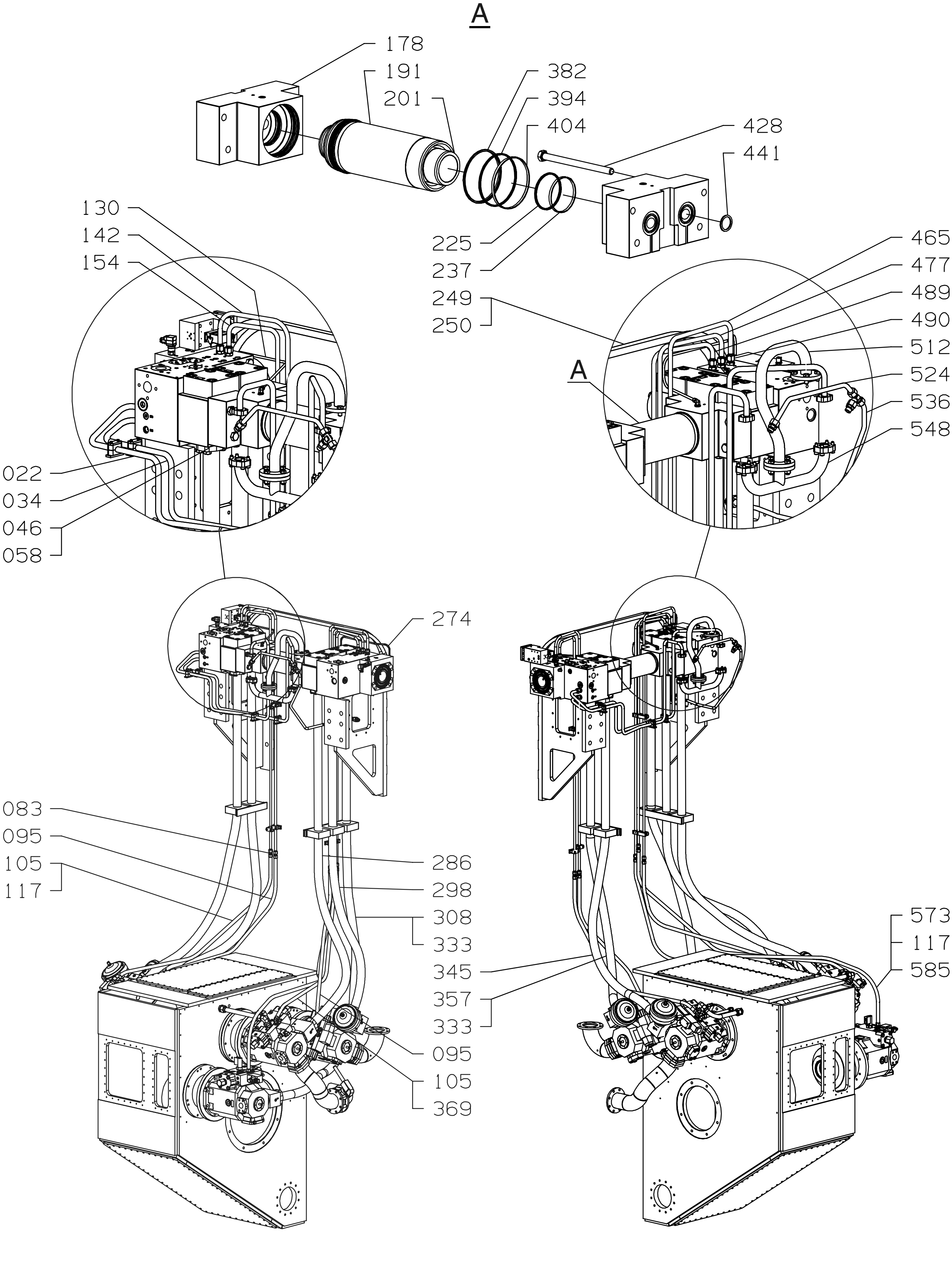
206

Hydraulic Supply System, Low pressure

Item No.	Item Description	Item No.	Item Description
027	Steel pipe		
040	Steel pipe*		
052	Support		
076	Packing		
088	Screw		
111	Nut		
135	Steel pipe		
147	Steel pipe		
159	Steel pipe		
172	Packing		
184	Flange		
196	Screw		
206	Nut		
	Note:		
	* Screws, nuts, packing, etc., included.		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046
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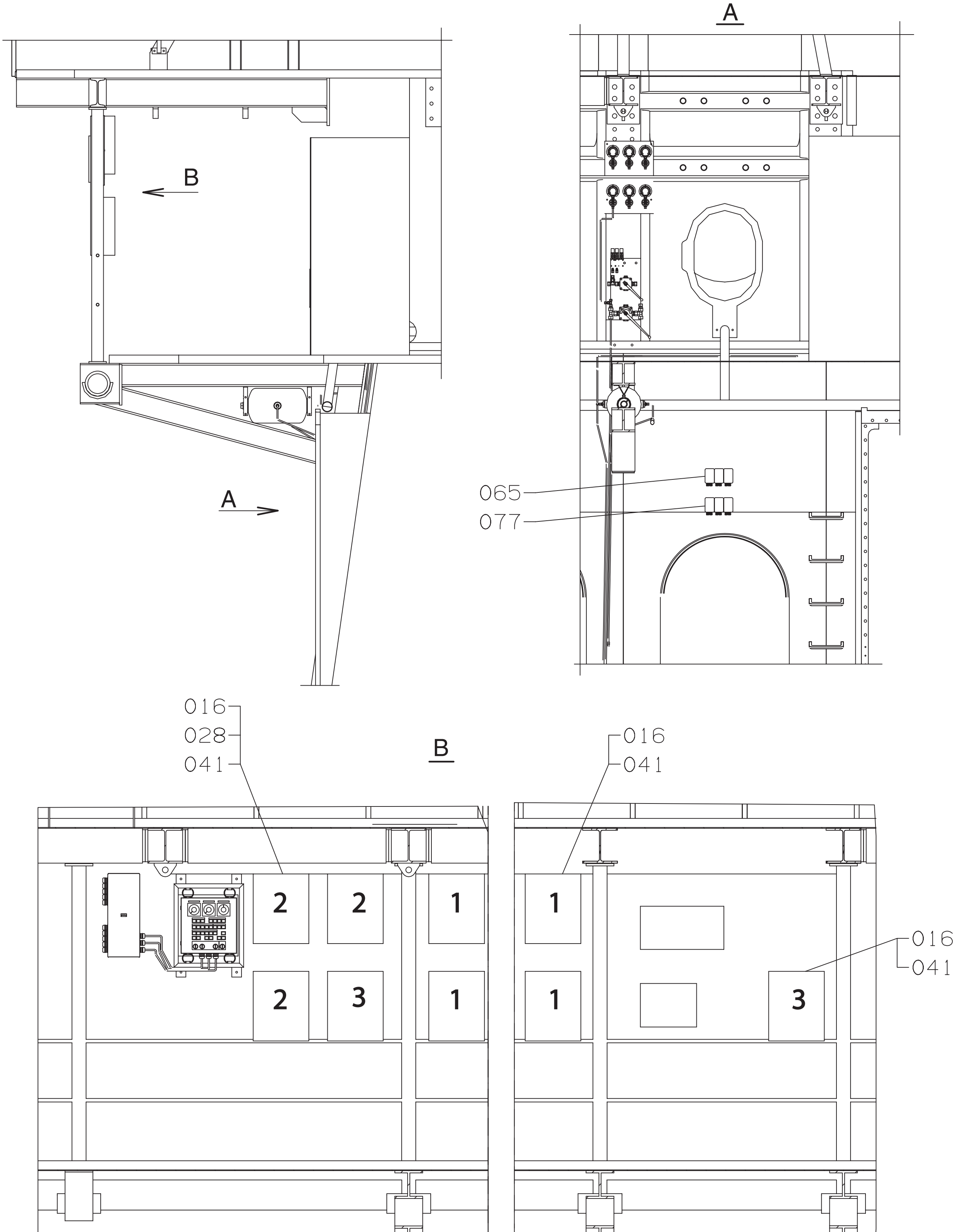
274
083
095
105
117
286
298
308
333
345
357
333
095
105
369
573
117
585

Item No.	Item Description	Item No.	Item Description
022	High pressure pipe		
034	High pressure pipe		
046	Gasket		
058	Screw		
083	Adapter, straight, male/male		
095	Hose with 2 couplings		
105	Hose with 2 couplings		
117	Flexible protector spiral		
130	High pressure pipe		
142	High pressure pipe		
154	High pressure pipe		
178	Flange		
191	High pressure pipe		
201	High pressure pipe		
225	Sealing ring, with reinforcement		
237	Sliding bearing		
249	Hose with 2 couplings		
250	Elbow connection		
274	High pressure pipe		
286	Hose with 2 couplings		
298	Hose with 2 couplings		
308	Hose with 2 couplings		
333	Flexible protector spiral		
345	Hose with 2 couplings		
357	Hose with 2 couplings		
369	Elbow connection		
382	Sealing ring		
394	Sealing ring, with reinforcement		
404	Sliding bearing		
428	Screw		
441	Sealing ring		
465	High pressure pipe		
477	High pressure pipe		
489	High pressure pipe		
490	Adapter, straight, male/male		
512	Hydraulic oil inlet, low press		
524	Hydraulic oil inlet, low press		
536	Hydraulic oil inlet, low press		
548	Hydraulic oil inlet, low press		
573	Hose with 2 couplings		
585	Adapter, straight, male/male		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041
B
016
041
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2
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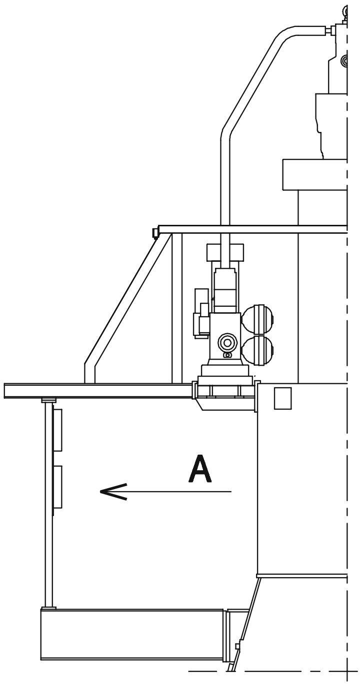
1
2
3
1
1
3
016
041

Item No.	Item Description	Item No.	Item Description
016	Multi purpose controller		
028	Amplifier		
041	Printed circuitboard assy		
065	Amplifier		
077	Amplifier		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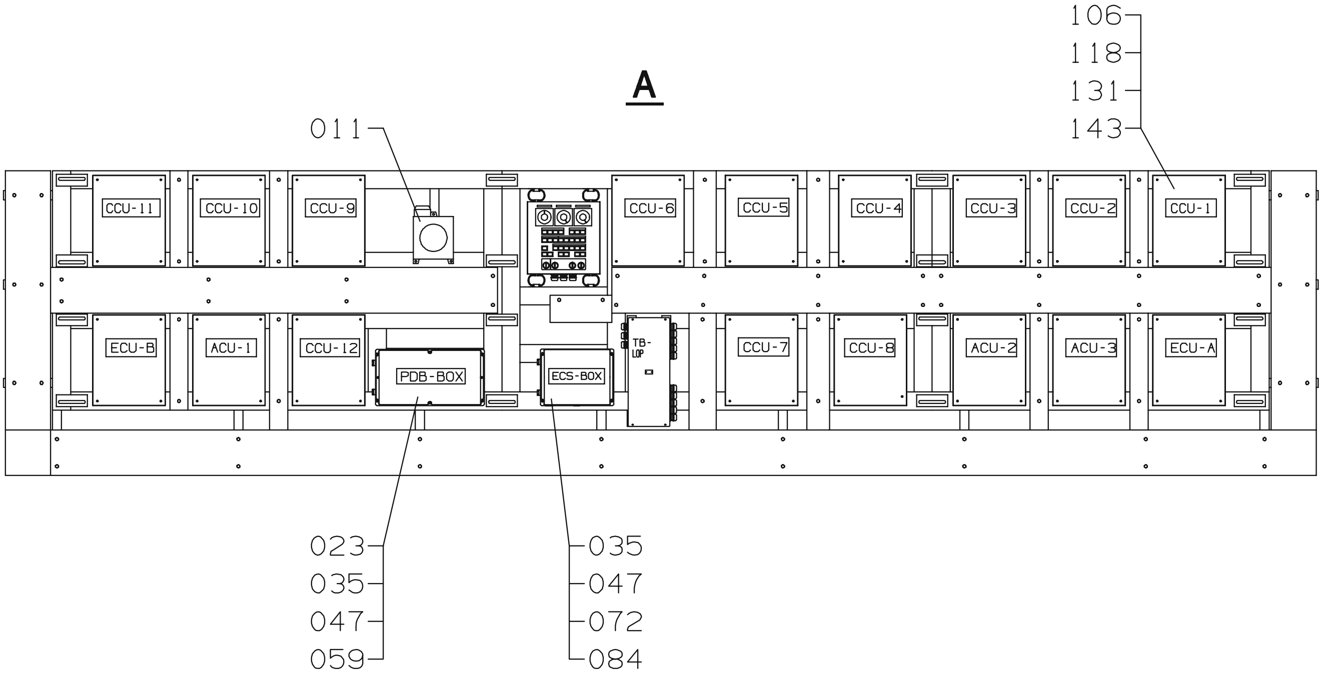
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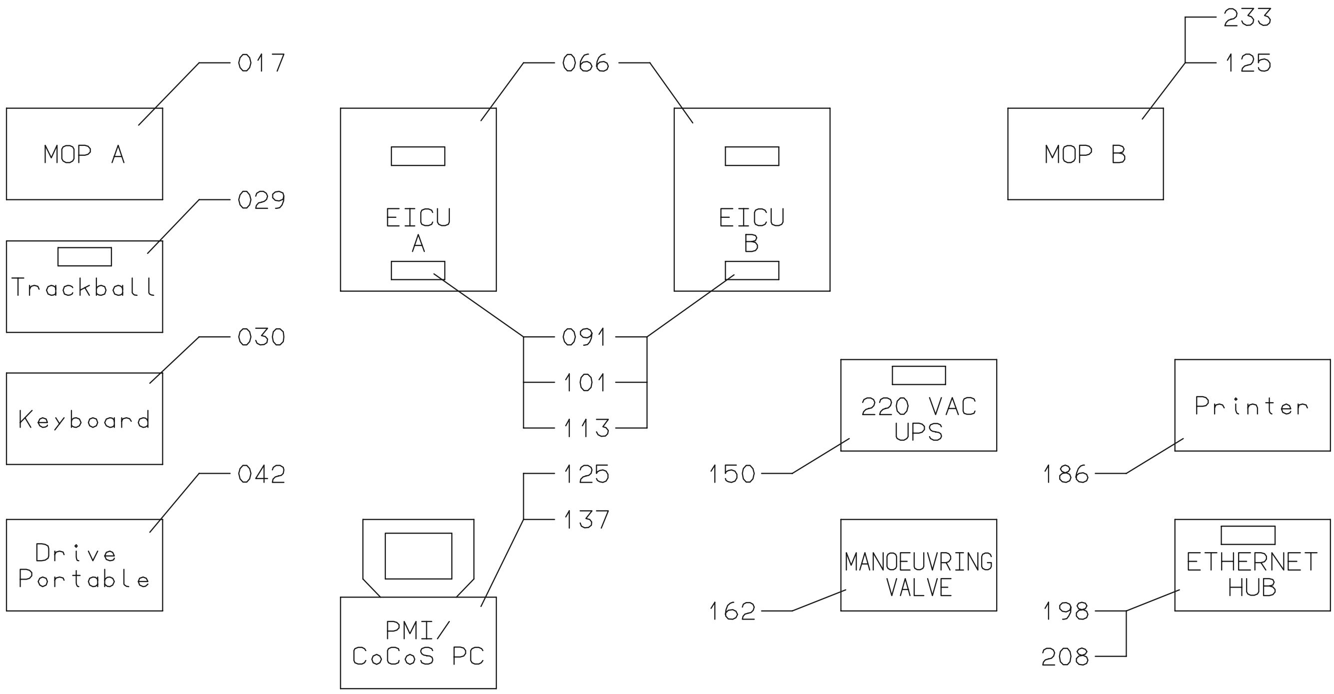
CCU-2
CCU-1
ECU-B
ACU-1
CCU-12
PDB-BOX
ECS-BOX
TB-
LOP
CCU-7
CCU-8
ACU-2
ACU-3
ECU-A
023
035
047
059
035
047
072
084

Item No.	Item Description	Item No.	Item Description
011	Engine control system		
023	Enclosure, complete		
035	Screw		
047	Nut		
059	Engine control system		
072	Enclosure, complete		
084	Engine control system		
106	Enclosure, complete*		
118	Connector kit*		
131	Screw*		
143	Nut, self-locking*		
	Note:		
	* Applies to all ACU, CCU and ECU's, when ordering please specify no. of cylinders.		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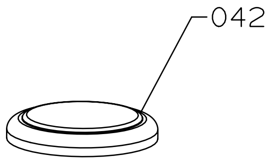
Trackball
029
Keyboard
030
Drive Portable
042
EICU A
EICU B
066
091
101
113
PMI/ CoCoS PC
125
137
220 VAC UPS
150
MANOEUVRING VALVE
162
MOP B
233
125
Printer
186
ETHERNET HUB
198
208

Engine Control Room - Components

Item No.	Item Description
017	HMI panel
029	PC hardvare
030	PC hardvare
042	PC hardvare
066	Enclosure, complete
091	Multi purpose controller
101	Printer circuitboard assy
113	Connector - PCB, kit
125	PC hardvare *
137	PC hardvare *
150	PC hardvare
162	Regulating handle
186	Printer
198	PC hardvare
208	Cabel
233	PC hardvare
	Note:
	*Only for CoCoS

Item No.	Item Description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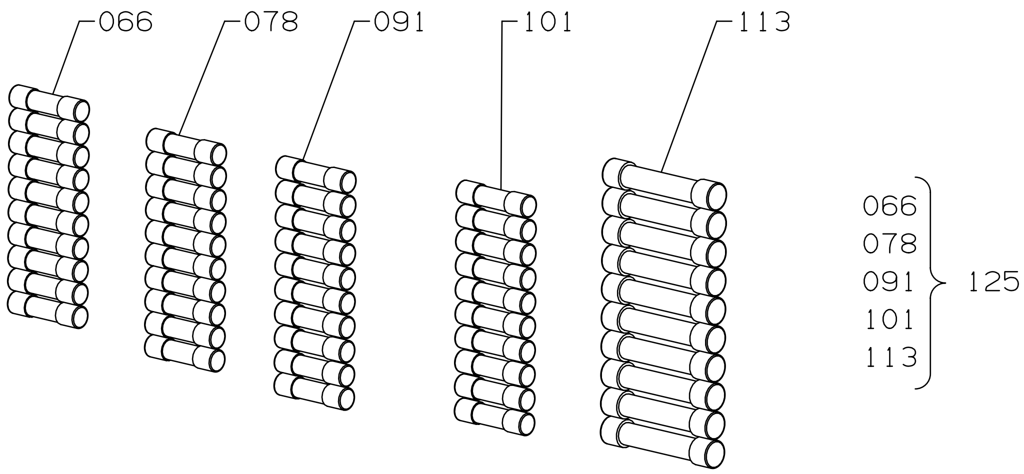
066
078
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101
113
066
078
091
101
113
125

Engine Control Room - Components

Item No.	Item Description	Item No.	Item Description
042	Battery for multi purpose controller		
066	Fuse cartridge, 6.3a slow blow		
078	Fuse cartridge, 10.0a slow blow		
091	Fuse cartridge, 3.15a slow blow		
101	Fuse cartridge, 2.0a slow blow		
113	Fuse cartridge, 12.5a slow blow		
125	Fuse cartridge set, complete		

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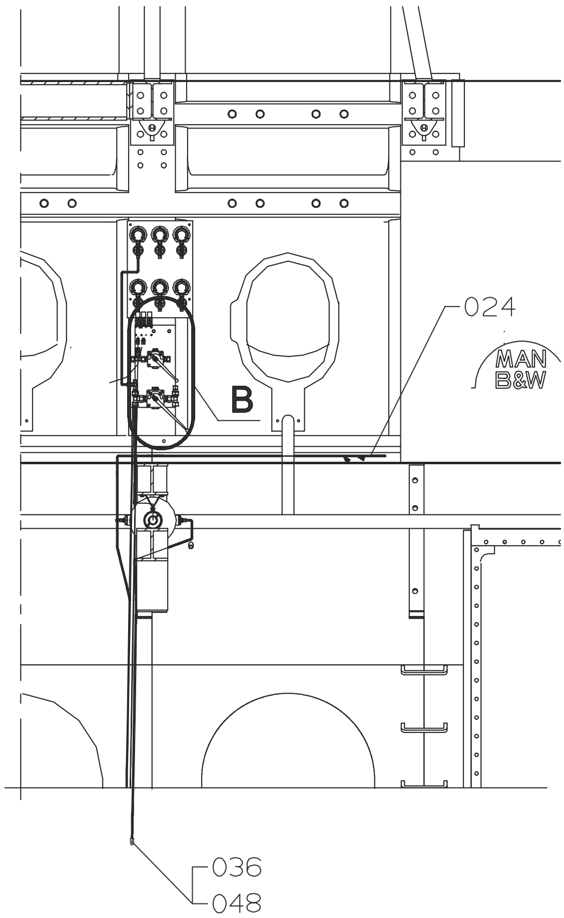
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B
MAN
B&W
036
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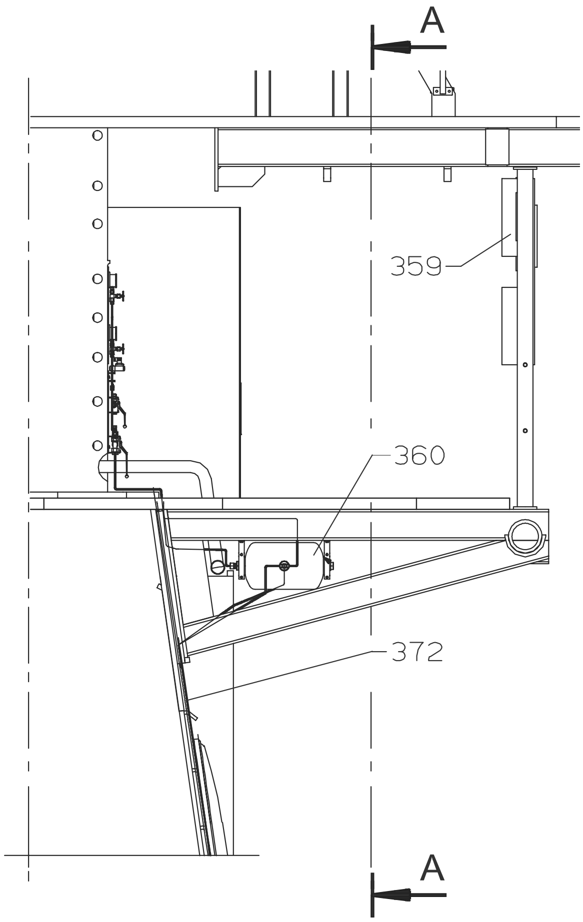
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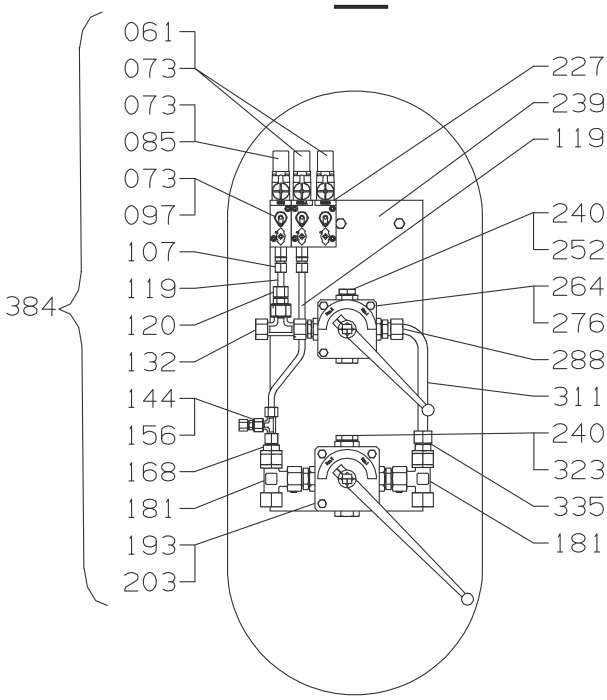
B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252
264
276
288
311
240
323
335
181

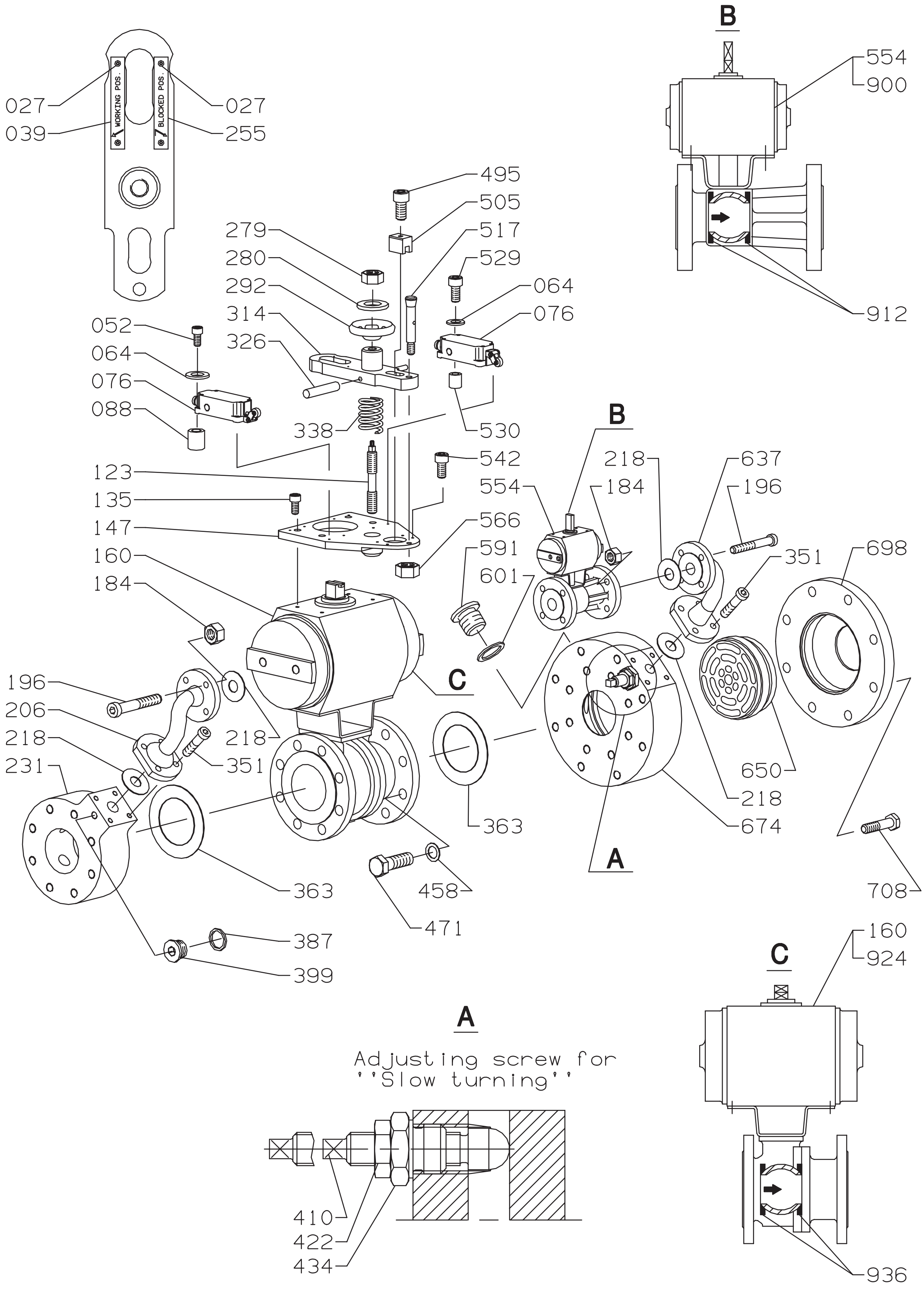
Pneumatic Components

Item No.	Item Description
024	Control air pipe
036	Ball valve
048	Coupling
061	Pressure transducer
073	Screw
085	Pressure transducer
097	Distributor block
107	Coupling
119	Copper pipe
120	Reducing connection
132	Coupling
144	Reducing connection
156	Coupling
168	Reducing connection
181	Coupling
193	Ball valve
203	Screw
227	Distributor block
239	Plate for pneumatics
240	Silencer
252	Reducing adaptors
264	Ball valve
276	Screw
288	Coupling
311	Copper pipe
323	Reducing adaptors
335	Reducing connection
359	Local control box
360	Air reciever
372	Copper pipe
384	Plate with pneumatics, complete

Item No.	Item Description

907 - Starting Air System

Documents in this Chapter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039
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WORKING POS.
BLOCKED POS.
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351
C
363
363
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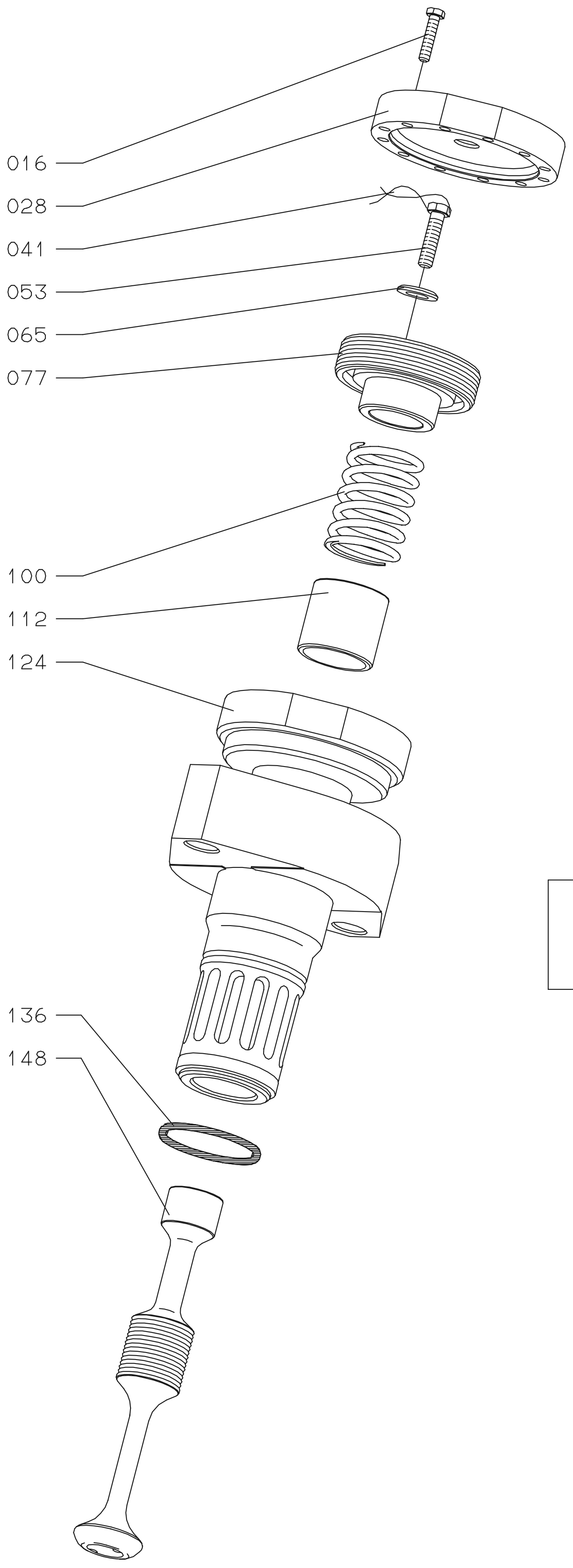
471
650
218
674
A
708
387
399
C
160
924
A
Adjusting screw for
''Slow turning''
410
422
434
936

Item No.	Item Description	Item No.	Item Description
027	Screw	900	Repair kit, slave actuator,slow turning*
039	Name plate »working«	912	Repair kit, slave ball actuator, slow turning*
052	Screw		
064	Washer	924	Repair kit, main actuator,slow turning*
076	Switch	936	Repair kit, main ball valve, slow turning*
088	Distance pipe		
123	Spindle		**Note:**
135	Screw		
147	Plate		* When ordering spare parts for this item, please state manufacturer's part no.
160	Ball valve with actuator*		
184	Nut		
196	Screw		
206	Starting air pipe		
218	Gasket		
231	Intermediate piece		
255	Name plate »blocked«		
279	Nut		
280	Washer		
292	Hand wheel		
314	Securing plate		
326	Pin		
338	Spring		
351	Screw		
363	Gasket		
387	Gasket		
399	Plug screw		
410	Adjusting screw		
422	Nut		
434	Adapter		
458	Washer		
471	Screw		
495	Screw		
505	Guide		
517	Guide pin		
529	Screw		
530	Distance pipe		
542	Screw		
554	Ball valve with actuator*		
566	Nut		
591	Plug screw		
601	Gasket		
637	Starting air pipe		
650	Non-return valve		
674	Housing		
698	Housing		
708	Screw		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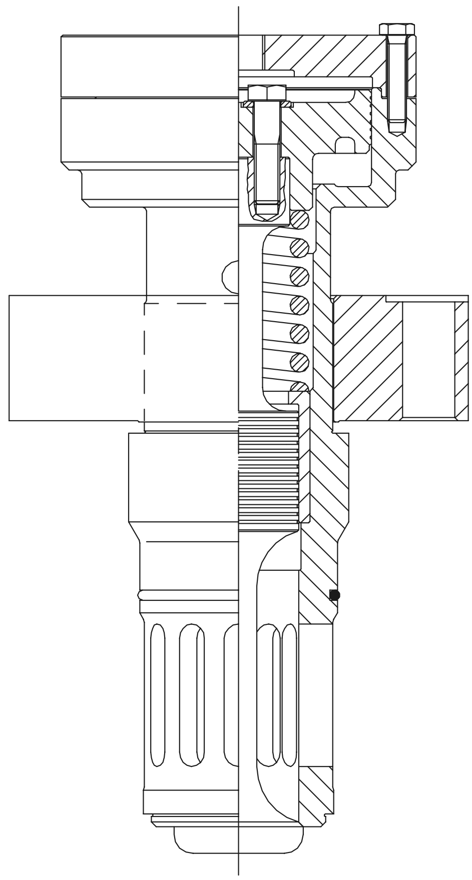


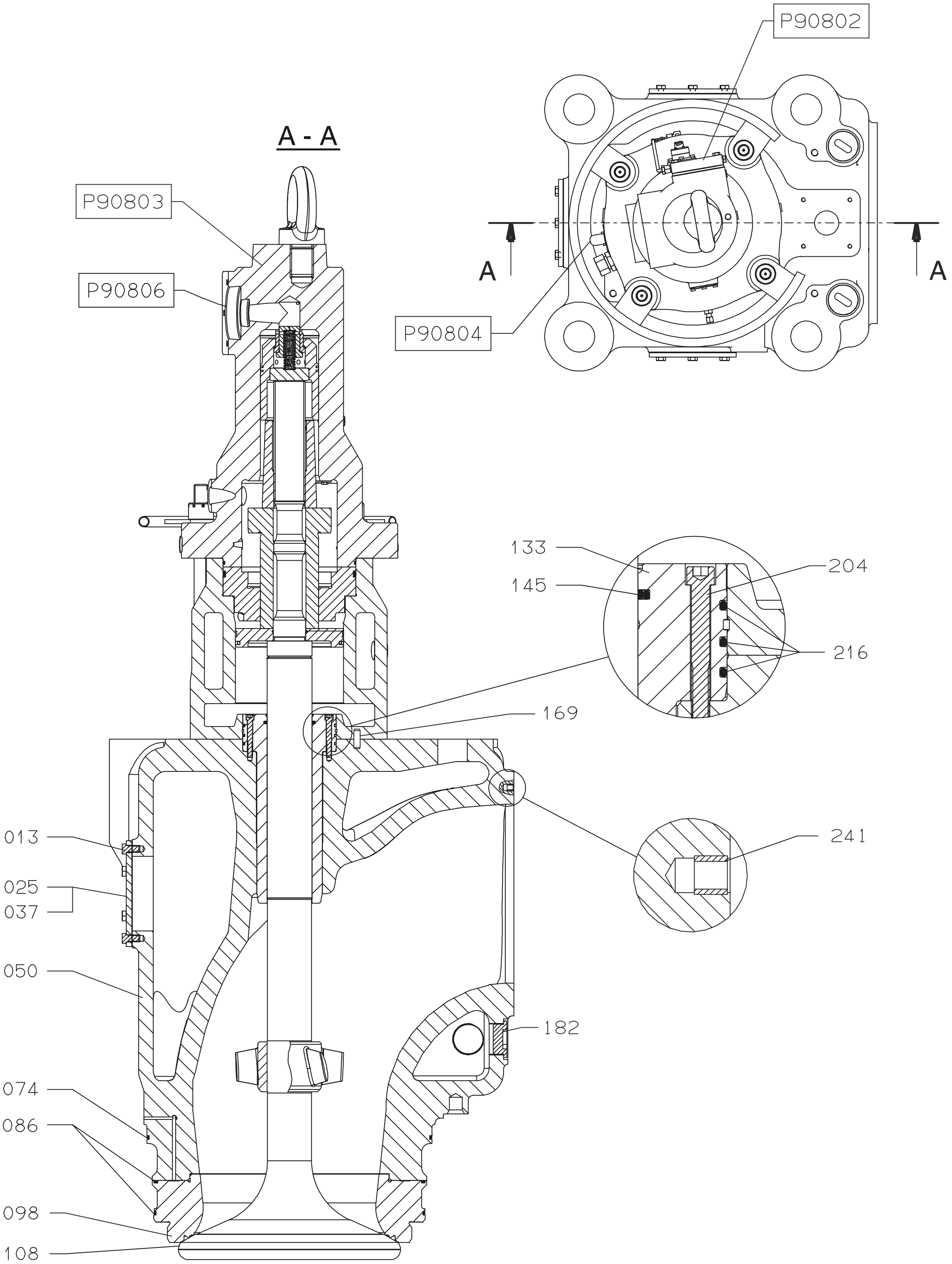
Starting Valve

Item No.	Item Description
016	Screw
028	Cover
041	Locking wire
053	Screw
065	Washer
077	Piston
100	Spring
112	Bushing
124	Valve housing
136	Sealing ring
148	Valve spindle

Item No.	Item Description

908 - Exhaust Valve

Documents in this Chapter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241
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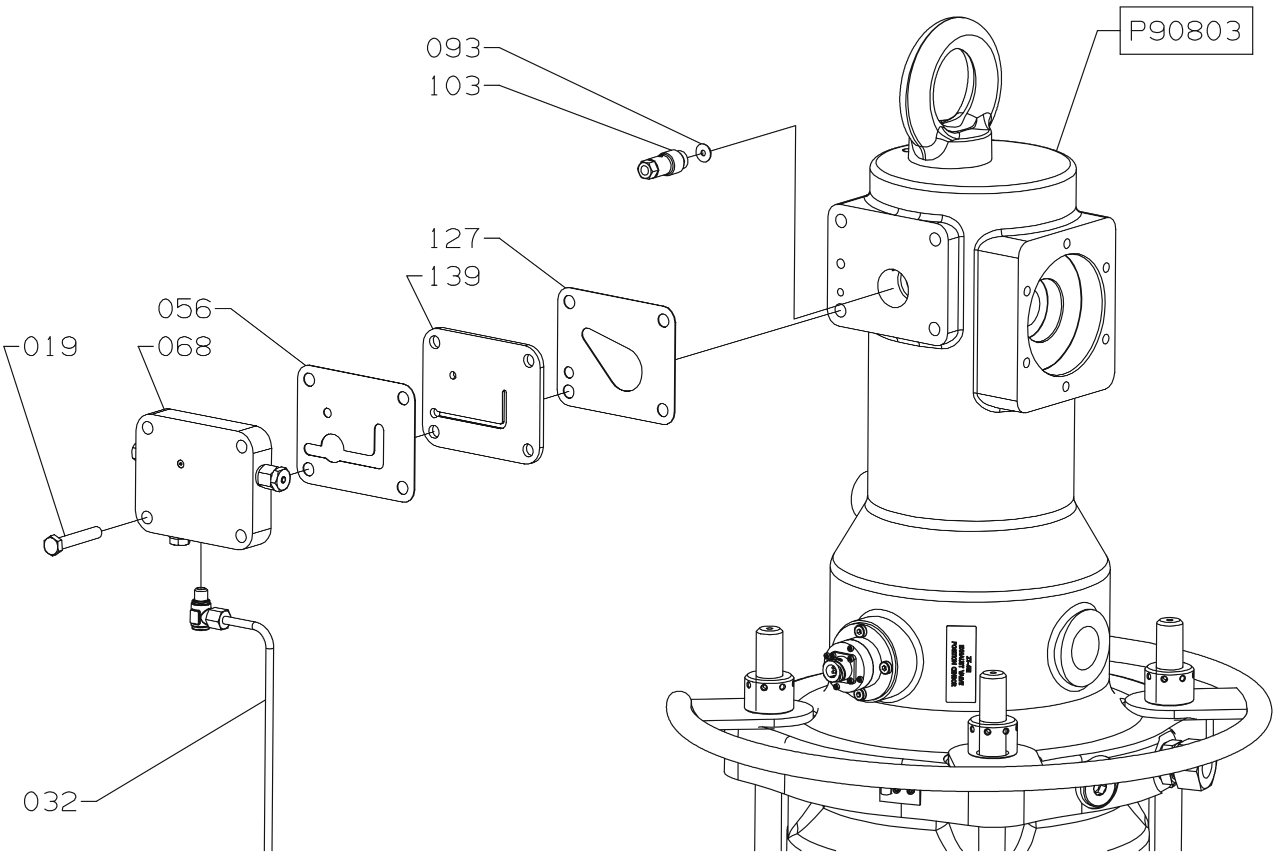
074
086
098
108

Exhaust Valve - Lower Parts

Item No.	Item Description
013	Screw
025	Packing
037	Cover
050	Exhaust valve housing, complete
074	O-ring
086	O-ring
098	Bottom piece
108	Exhaust valve spindle
133	Spindel guide
145	Sealing ring
169	Spring pin
182	Plug
204	Screw
216	Sealing ring
241	Thread insert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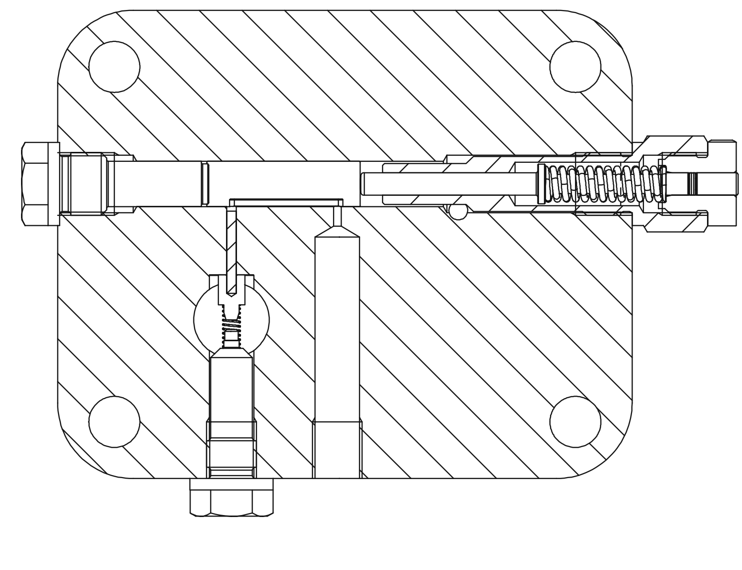
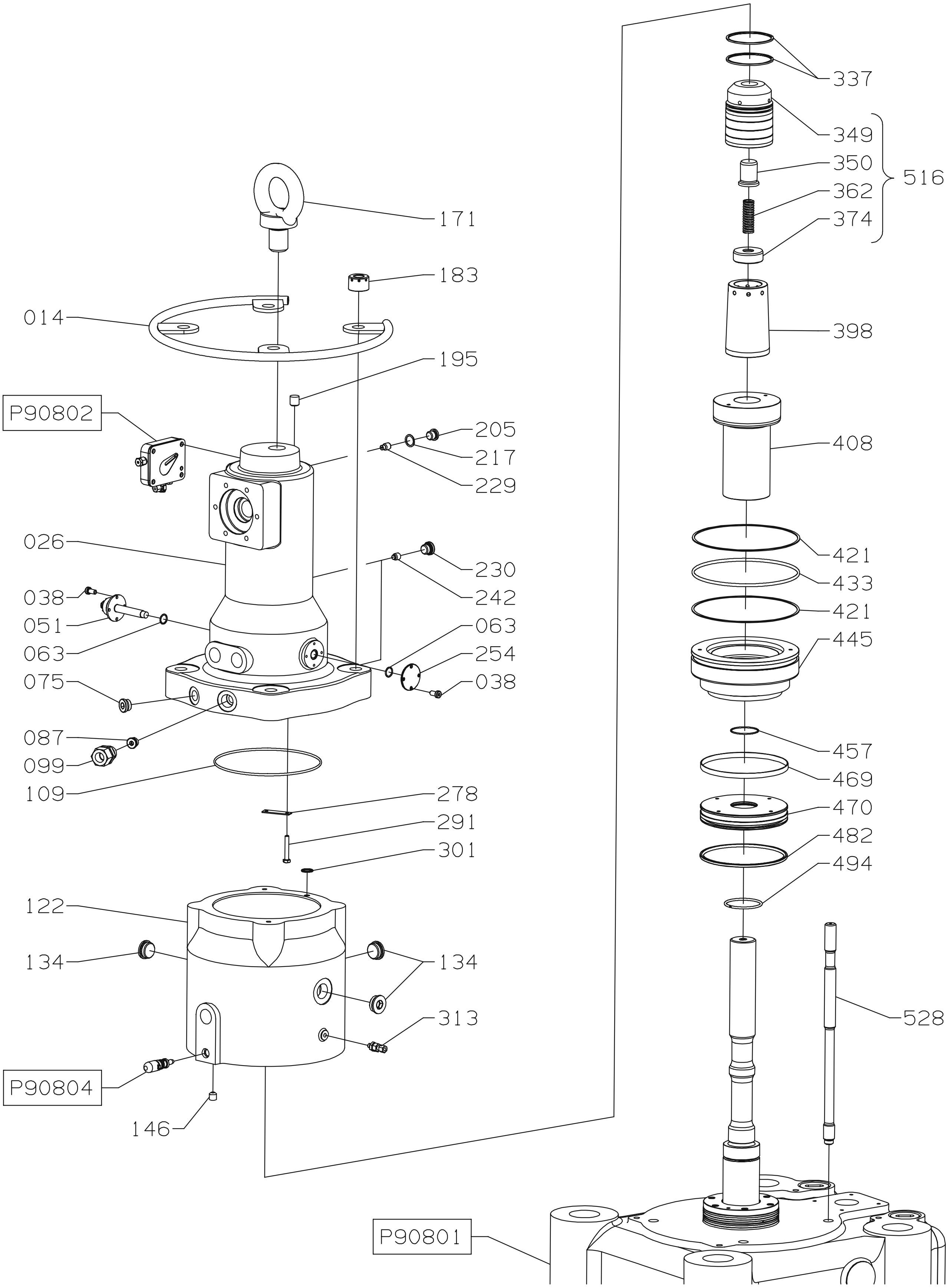


Item No.	Item Description	Item No.	Item Description
019	Screw		
032	Sealing oil pipe, complete		
056	Packing		
068	Sealing oil controle unit		
093	Disc		
103	Orifice plug		
127	Packing		
139	Plate		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063
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087
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278
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P90804
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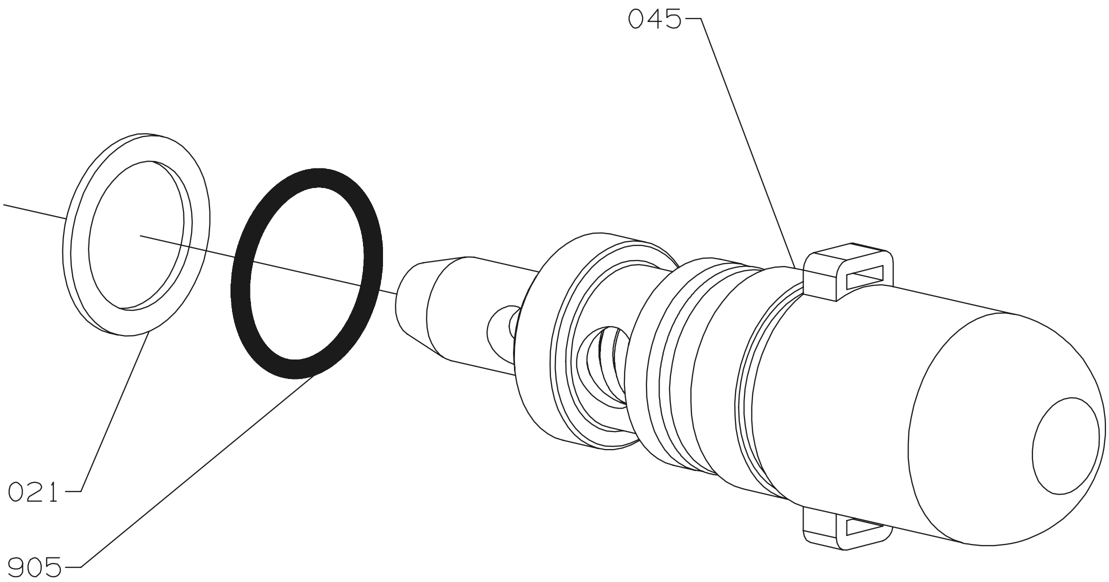
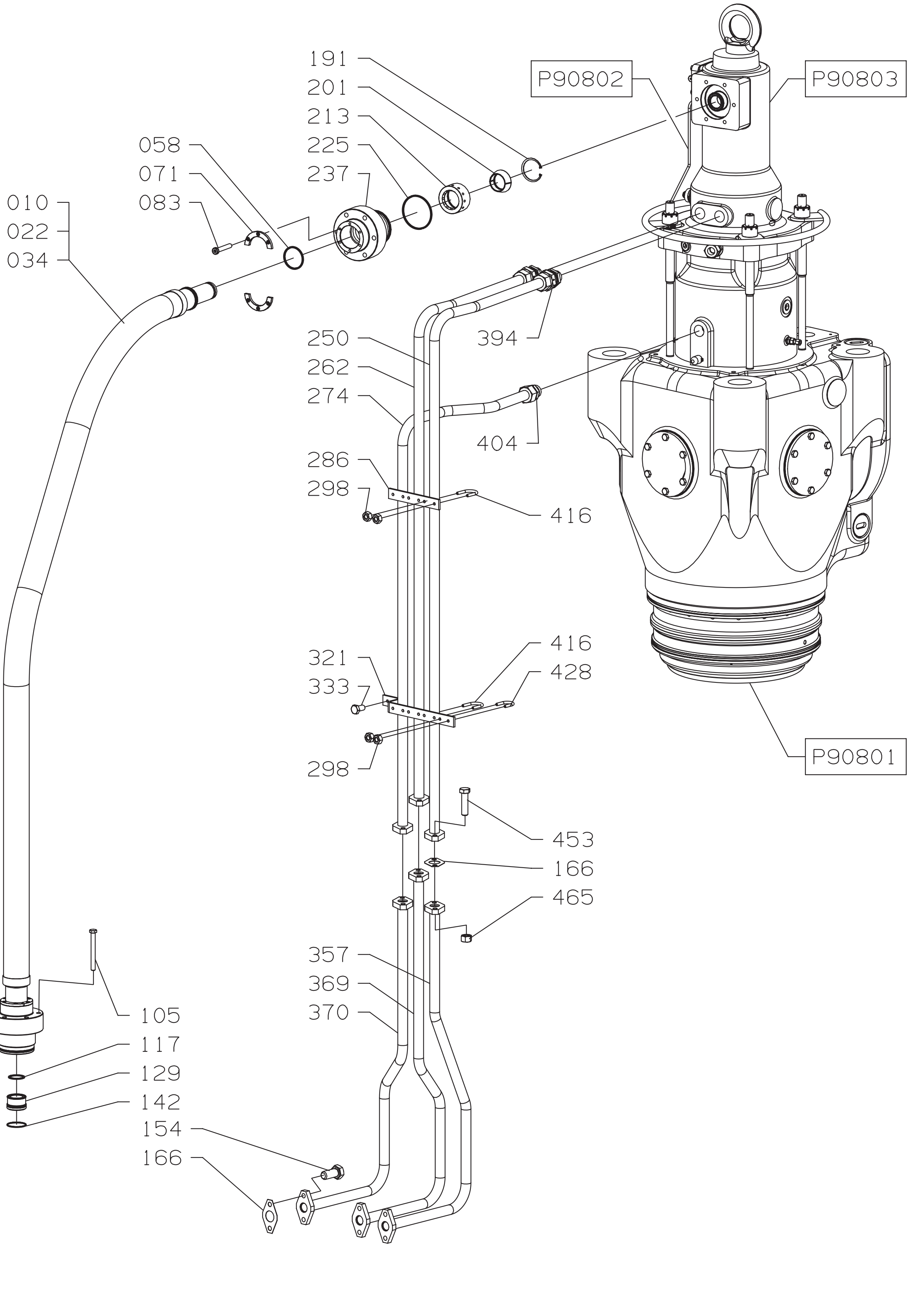
P90801

Exhaust Valve - Upper Parts

Item No.	Item Description	Item No.	Item Description
014	Safety handrail		
026	Oil cylinder		
038	Screw		
051	Inductive sensor		
063	Sealing ring		
075	Plug screw		
087	Plug screw		
099	Coupling		
109	Sealing ring		
122	Air cylinder		
134	Plug screw		
146	Plug		
171	Eye bolt		
183	Nut		
195	Plug		
205	Plug screw		
217	Packing ring		
229	Orifice plug		
230	Plug screw		
242	Orifice plug		
254	Cover		
278	Disc		
291	Screw		
301	Sealing ring		
313	Non-return valve		
337	Piston ring		
349	Piston, actuator		
350	Piston		
362	Spring		
374	Disc		
398	Cone		
408	Piston, actuator		
421	Back-up ring		
433	O-ring		
445	Flange		
457	O-ring		
469	Guide ring for piston		
470	Piston, air cylinder		
482	Sealing ring		
494	Retaining ring		
516	Piston, actuator		
528	Stud		
	Note:		
	*		


045
021
905

Item No.	Item Description	Item No.	Item Description
021	Gasket		
045	Safty valve, with o-ring		
905	O-ring*		
	Note:		
	* Optional extras		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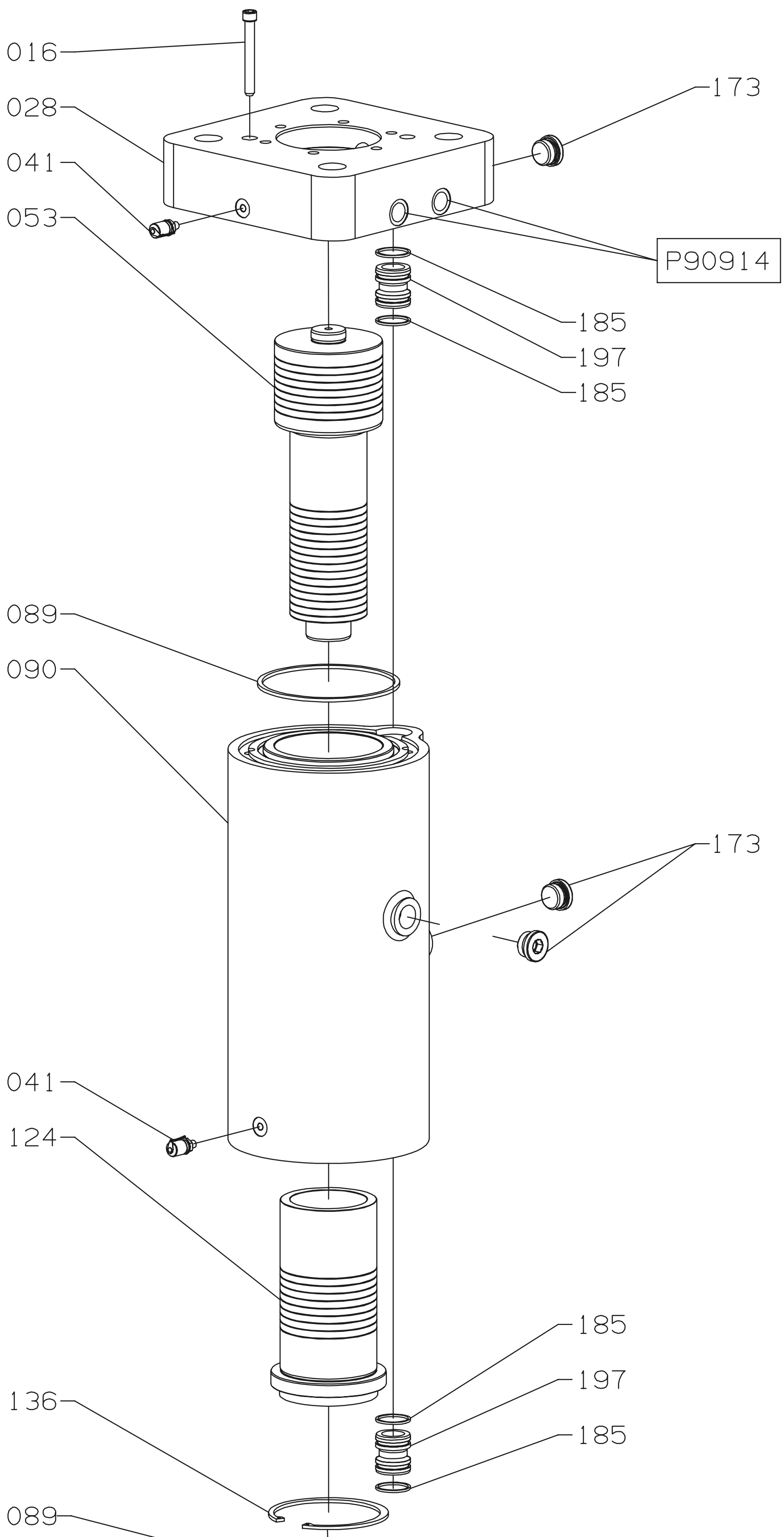
Item No.	Item Description	Item No.	Item Description
010	Protective pipe		
022	Hose complete		
034	Hydraulic pipe		
058	Sealing ring		
071	Disc with incision		
083	Screw		
105	Screw		
117	Gasket		
129	Disc		
142	Sealing ring		
154	Screw		
166	Packing		
191	Retaining ring for boring		
201	Cone		
213	Cone		
225	Sealing ring		
237	Thrust flange		
250	Drain pipe		
262	Drain pipe		
274	Drain pipe		
286	Support, plate		
298	Nut		
321	Support, plate		
333	Screw		
357	Drain pipe		
369	Drain pipe		
370	Drain pipe		
394	Non-return valve		
404	Straight stud coupling		
416	Clamp		
428	Clamp		
453	Screw		
465	Nut		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089
090
173
041
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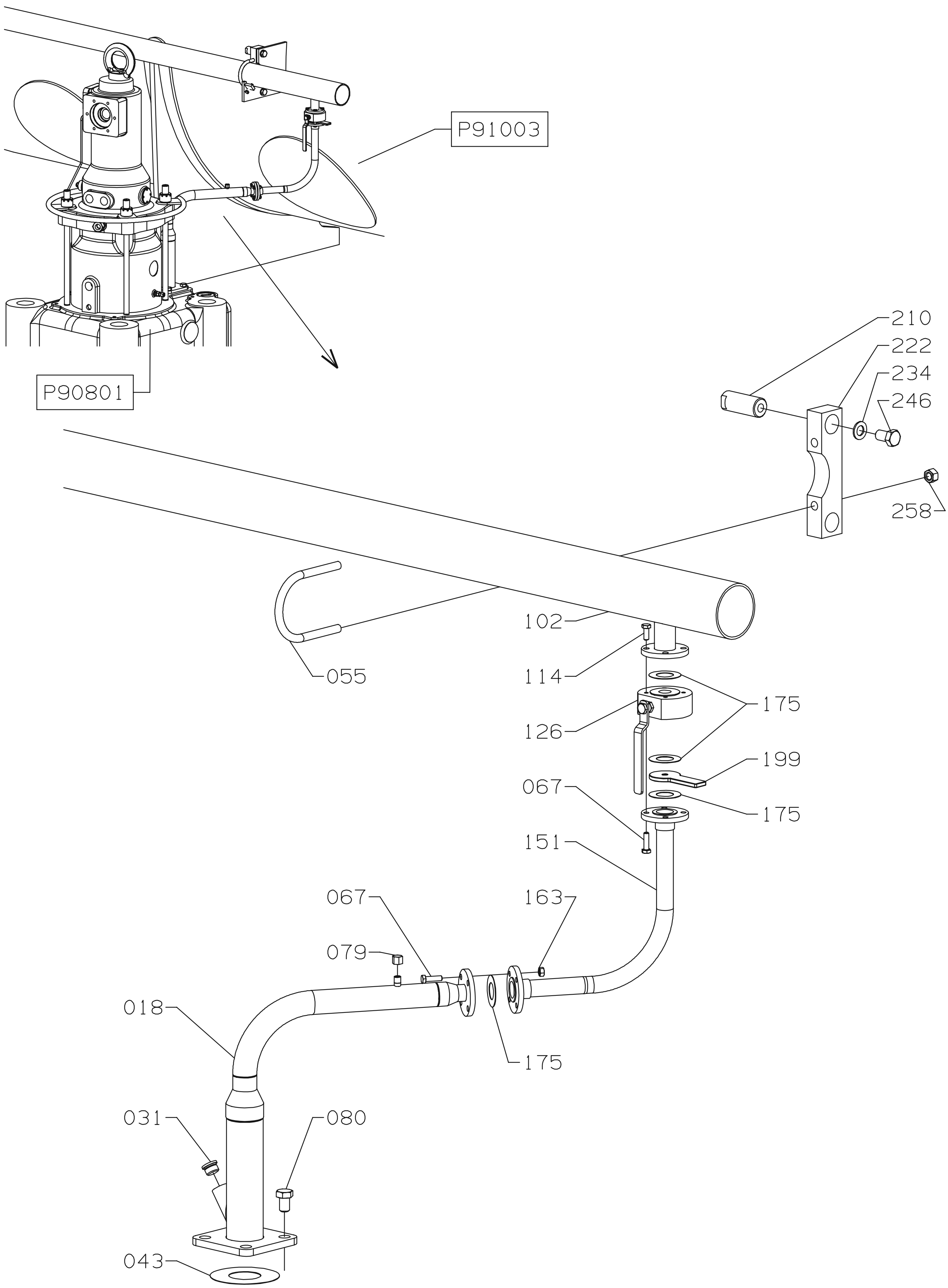
185
197
136
185
089

Exhaust Valve Actuator

Item No.	Item Description	Item No.	Item Description
016	Screw		
028	Top piece		
041	Quick coupling		
053	Piston		
089	Sealing ring		
090	Oil cylinder		
124	Piston		
136	Circlip		
173	Plug screw		
185	Sealing ring		
197	Bushing		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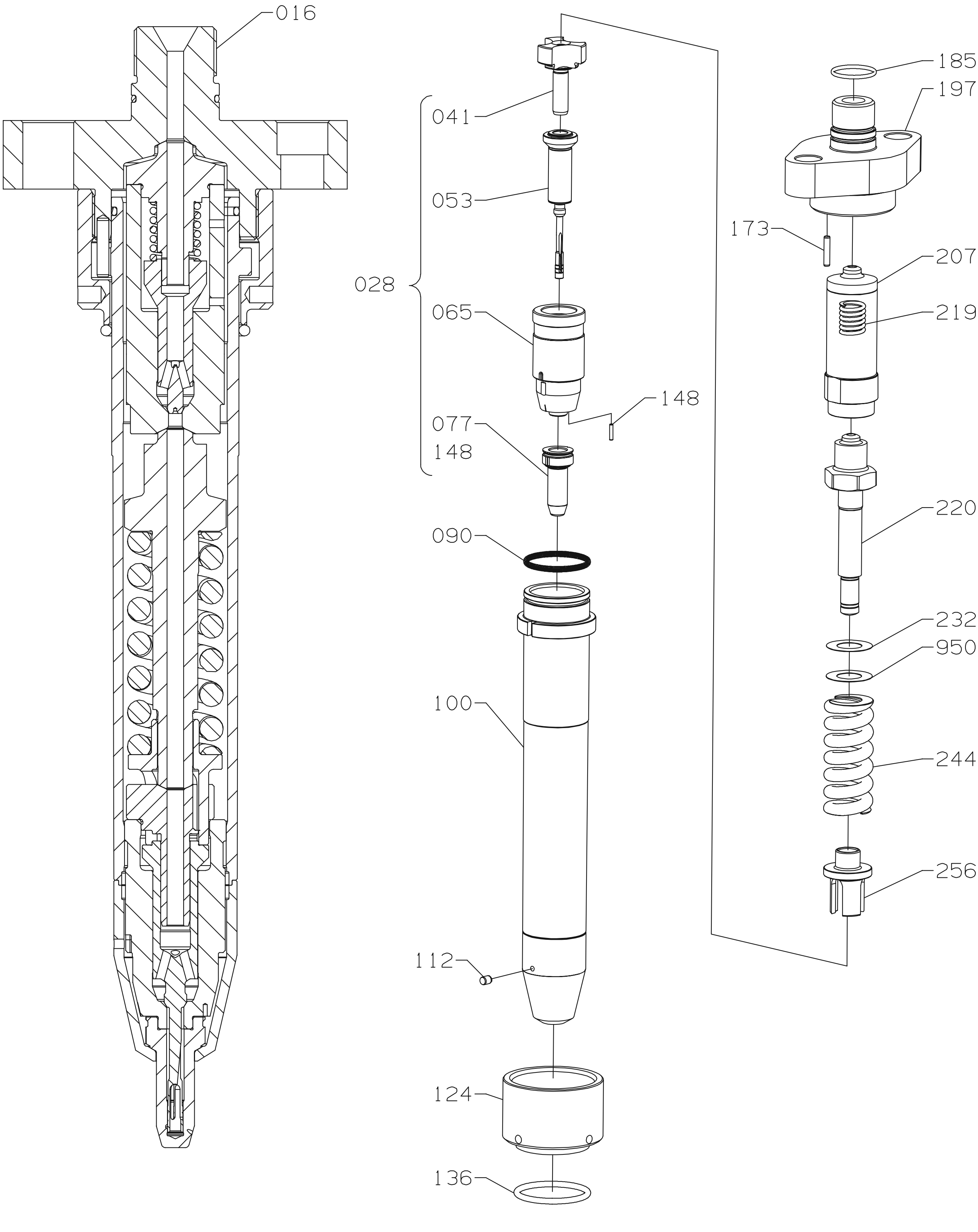
163
079
018
175
031
080
043

Item No.	Item Description	Item No.	Item Description
018	Steel pipe		
031	Plug screw		
043	Packing, round		
055	Clamp		
067	Screw		
079	Cap nut		
080	Screw		
102	Main pipe		
114	Screw		
126	Ball valve		
151	Steel hose		
163	Nut		
175	Packing ring		
199	Orifice plate		
210	Bushing		
222	Steel bar		
234	Washer		
246	Screw		
258	Nut		

909 - Fuel Oil System

Documents in this Chapter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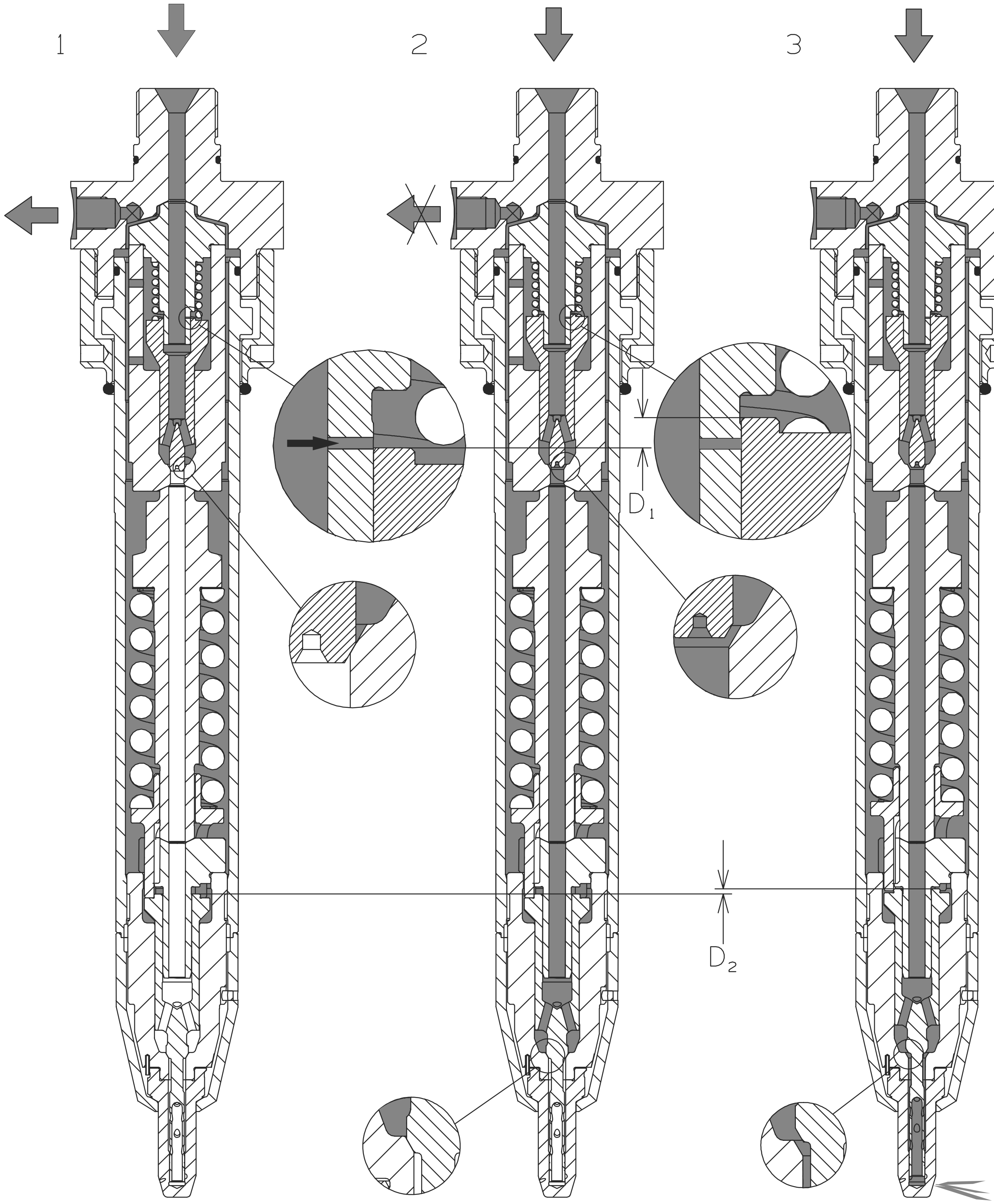
244
256

Item No.	Item Description	Item No.	Item Description
016	Fuel valve, complete		
028	Spindle guide, complete		
041	Thrust piece		
053	Cut-off shaft		
065	Spindle guide		
077	Fuel nozzle		
090	O-ring		
100	Holder		
112	Guide pin		
124	Union		
136	Sealing ring		
148	Spring pin		
173	Guide pin		
185	Sealing ring		
197	Fuel valve head		
207	Non-return valve		
219	Spring		
220	Thrust spindle		
232	Disc		
244	Spring		
256	Thrust foot		
950	Disc*		
	Note:		
	* Optional extras		


1
2
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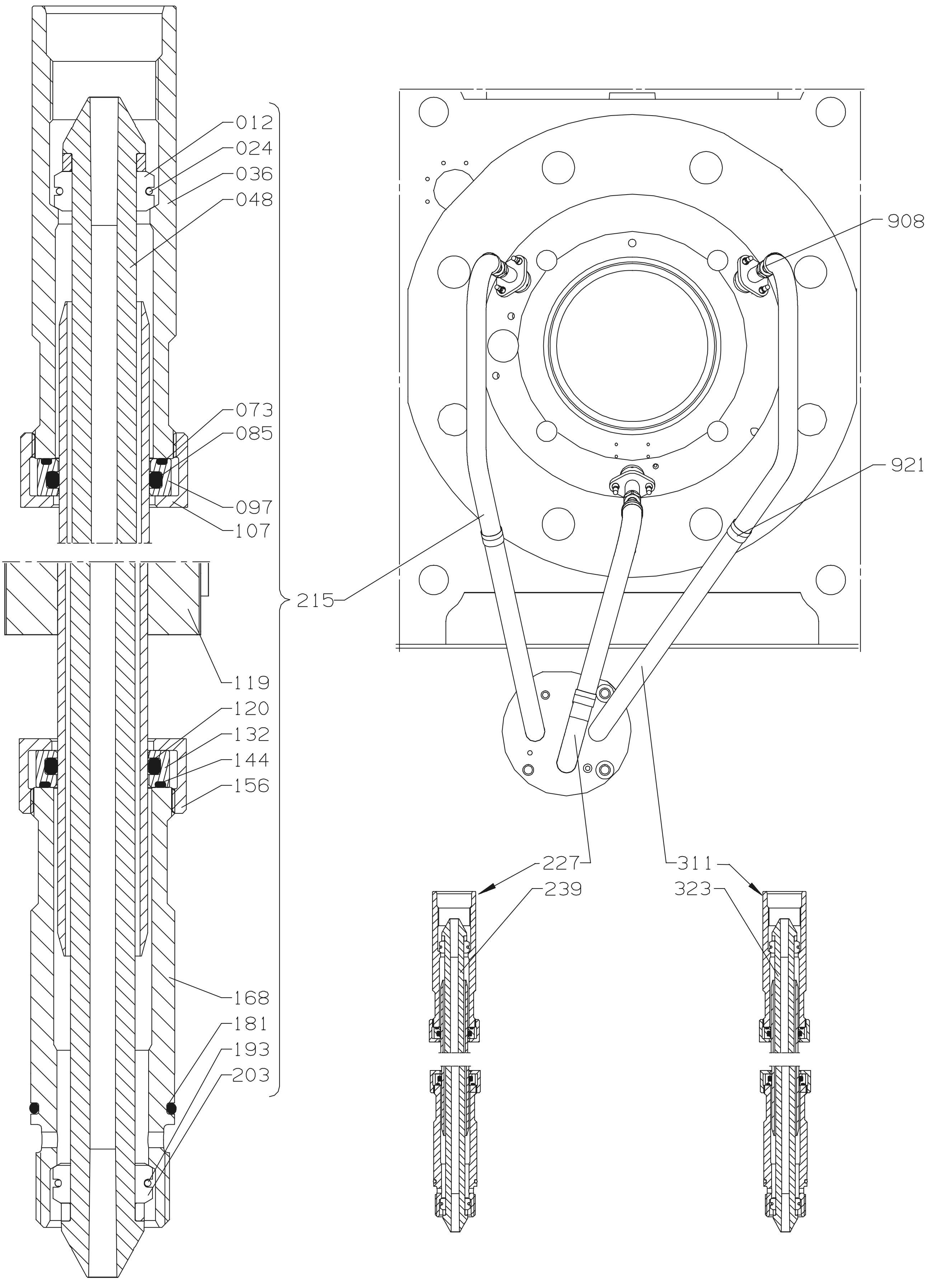
D1
D2

Fuel Valve Function

Item No.	Item Description	Item No.	Item Description
	Note: D1 = Predetermined closing value for non-return valve D2 = Predetermined opening value for cut-off spindle		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921
227
239
311
323

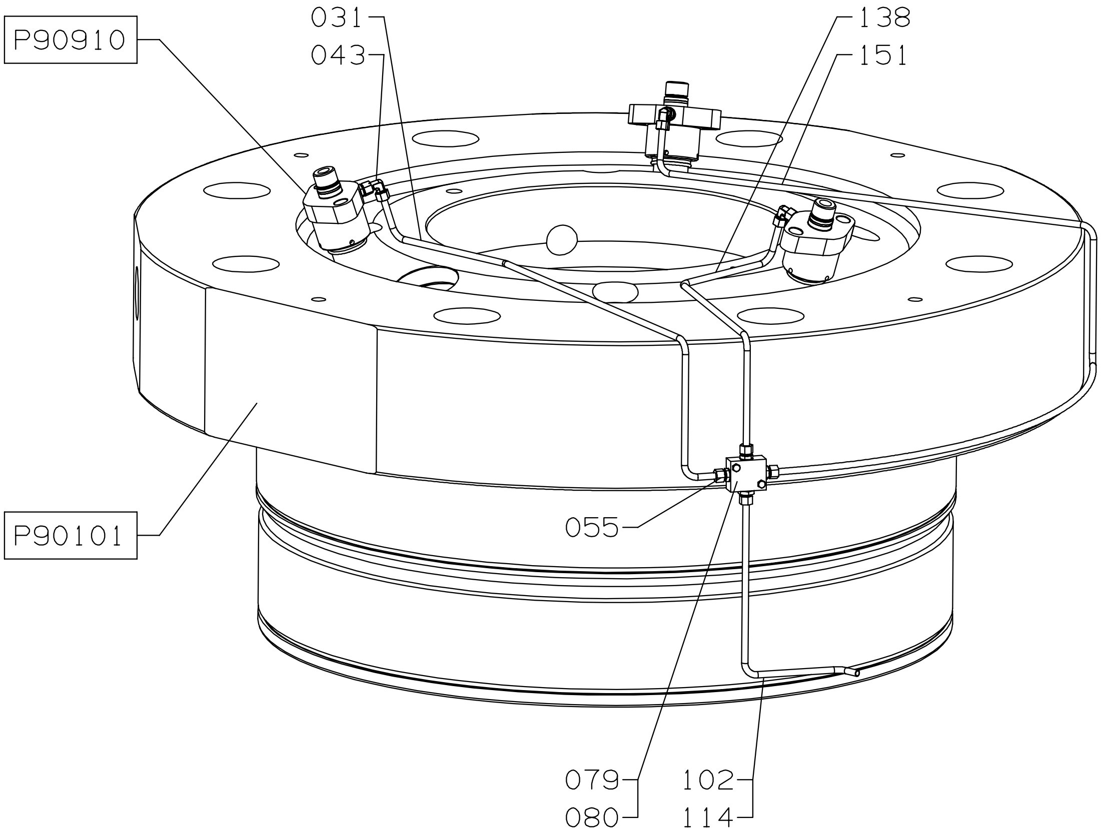
High-Pressure Pipes

Item No.	Item Description
012	Sleeve in 2/2
024	Retaining ring
036	Union nipple
048	High-pressure pipe
073	O-ring
085	O-ring
097	Housing
107	Union nut
119	Insulation of pipe*
120	O-ring
132	Housing
144	O-ring
156	Union nut
168	Union nipple
181	O-ring
193	Retaining ring
203	Sleeve in 2/2
215	High-pressure pipe, complete
227	High-pressure pipe, complete
239	High-pressure pipe
311	High-pressure pipe, complete
323	High-pressure pipe
908	Pipe end insulation sleeve, roll**
921	Tape, roll**

Note:

* Pipe end insulation sleeve and tape is not included

** Optional extras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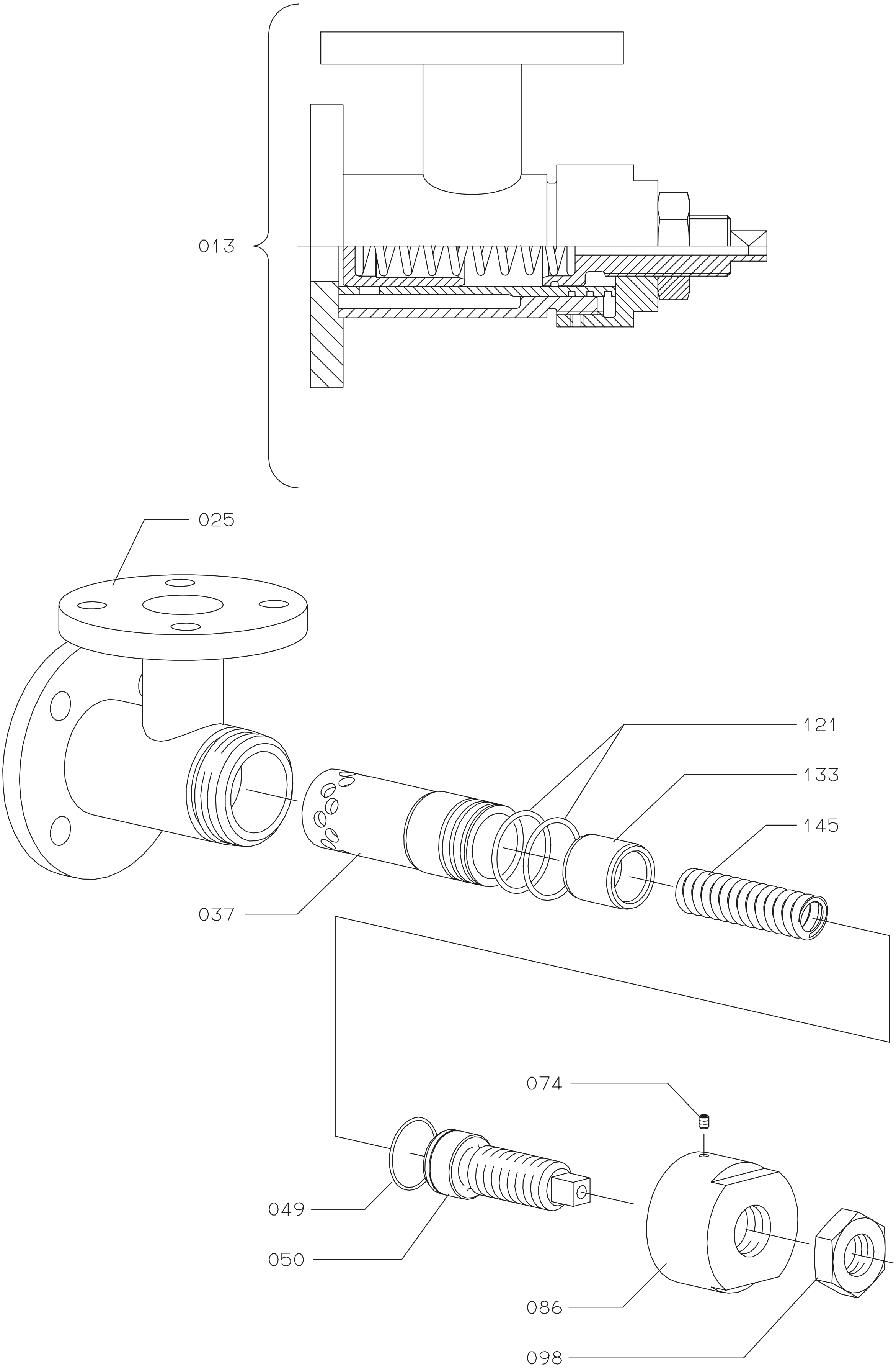
Item No.	Item Description	Item No.	Item Description
031	Steel pipe		
043	Adjustable elbow coupling		
055	Straight stud coupling		
079	Distributor piece		
080	Screw		
102	Steel pipe		
114	Straight stud coupling		
138	Steel pipe		
151	Steel pipe		
	Note:		
	*		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025
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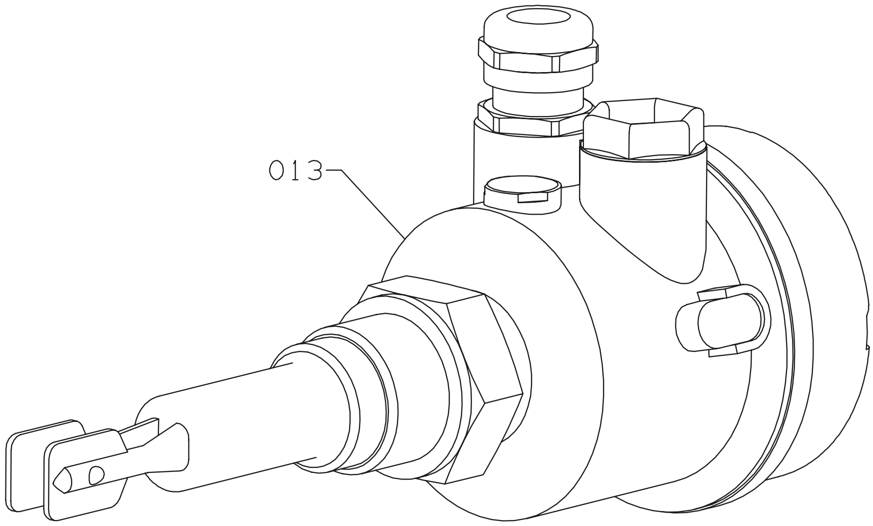
098

Fuel Oil System - Details

Item No.	Item Description
013	By-pass valve, complete
025	Valve housing
037	Valve housing
049	Sealing ring
050	Spring guide
074	Screw
086	Union nut
098	Nut
121	Sealing ring
133	Piston
145	Spring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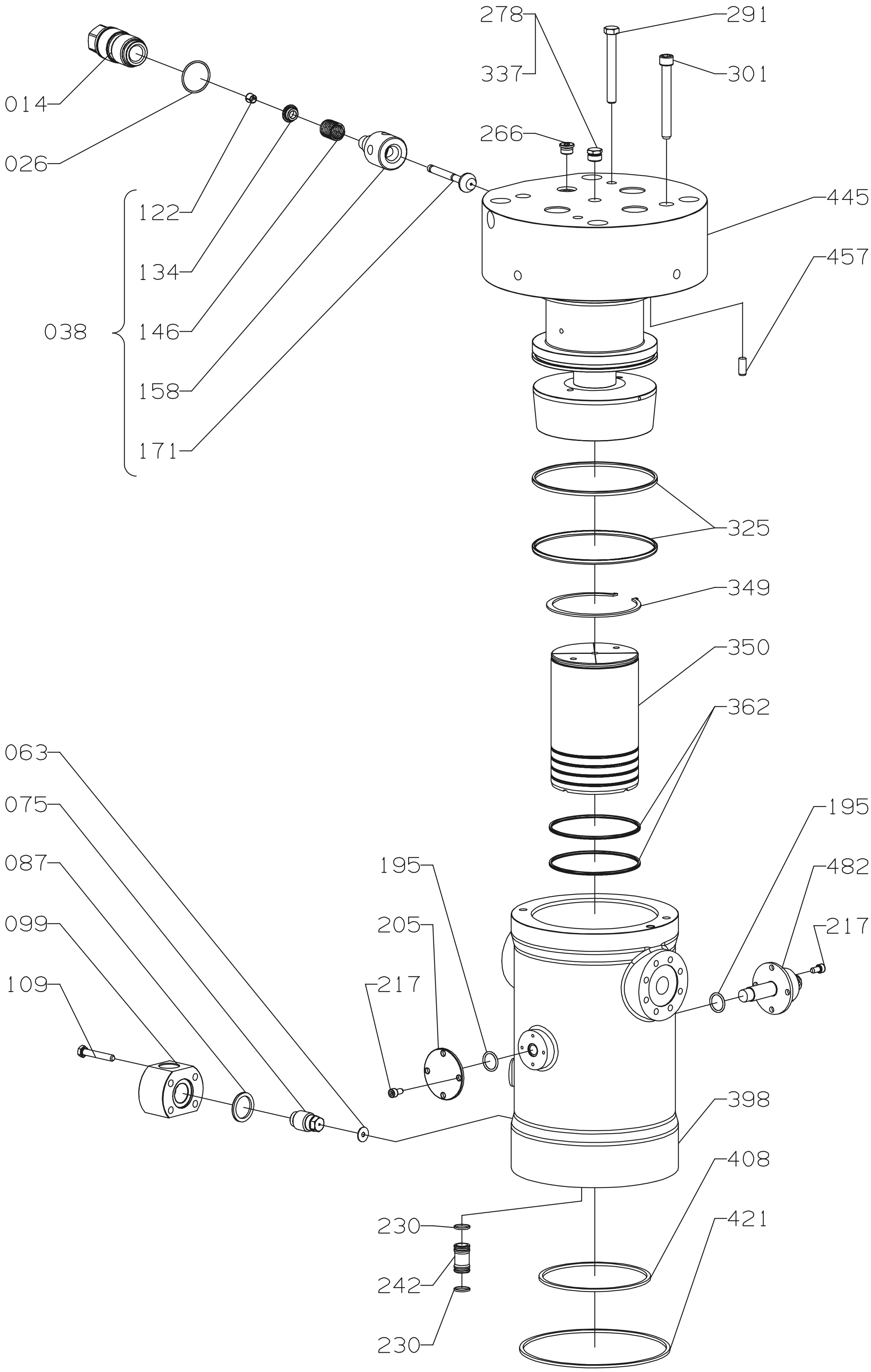
Item No.	Item Description	Item No.	Item Description
013	Level switch		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087
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482
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398
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421
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230

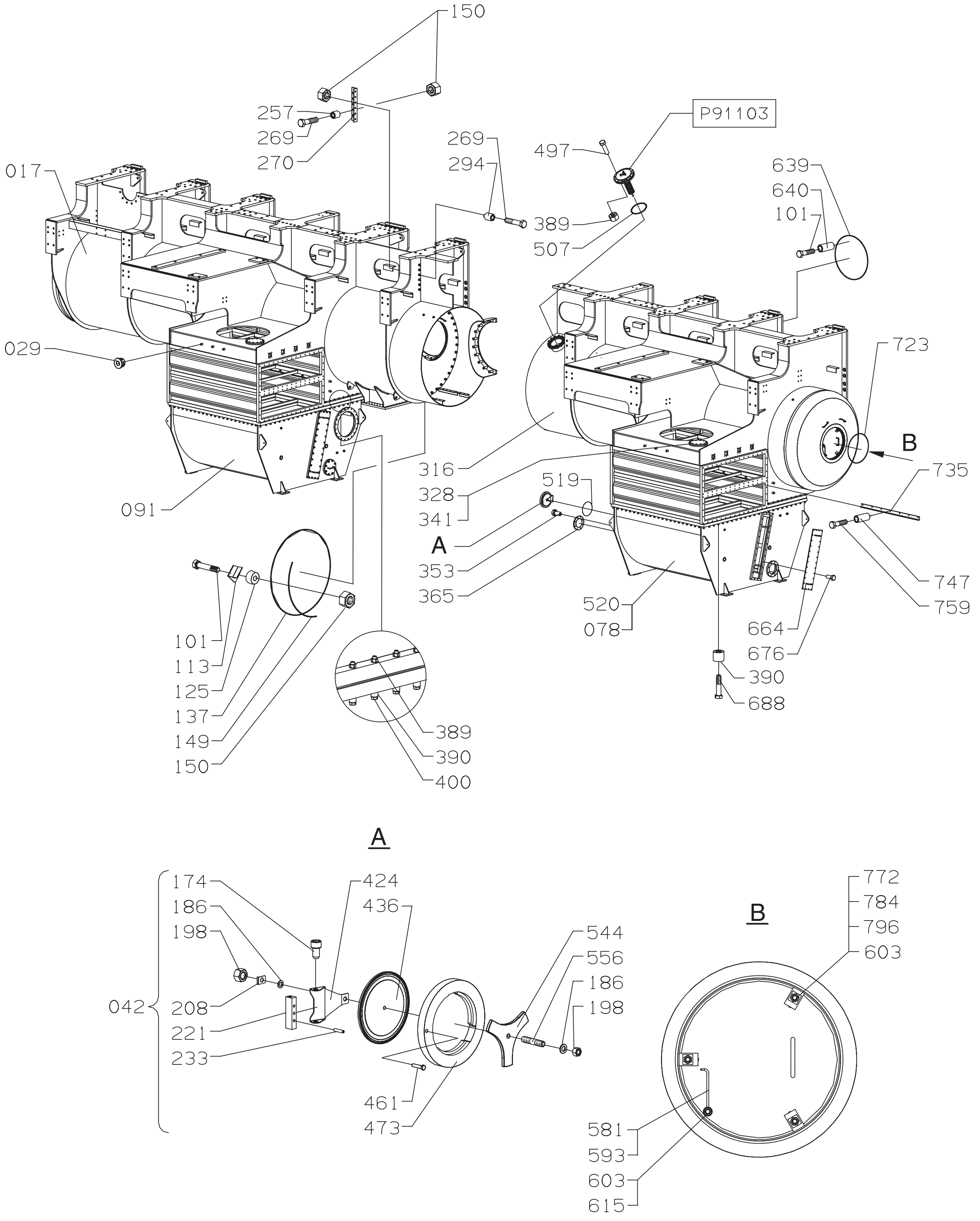
Fuel Oil Pressure Booster

Item No.	Item Description
014	Union nut
026	Sealing ring
038	Suction valve, complete
063	Disc
075	Throttle valve
087	Sealing ring
099	Flange
109	Screw
122	Conical ring 2/2
134	Cone
146	Spring
158	Housing
171	Spindle
195	Sealing ring
205	Cover
217	Screw
230	Sealing ring
242	Bushing
266	Plug screw
278	Plug screw
291	Screw
301	Screw
325	Sealing ring
337	Disc
349	Circlip
350	Hydraulic plunger
362	Sealing ring
398	Housing
408	Sealing ring
421	Sealing ring
445	Top cover
457	Pin
482	Inductive sensor

Item No.	Item Description

910 - Turbocharger System

Documents in this Chapter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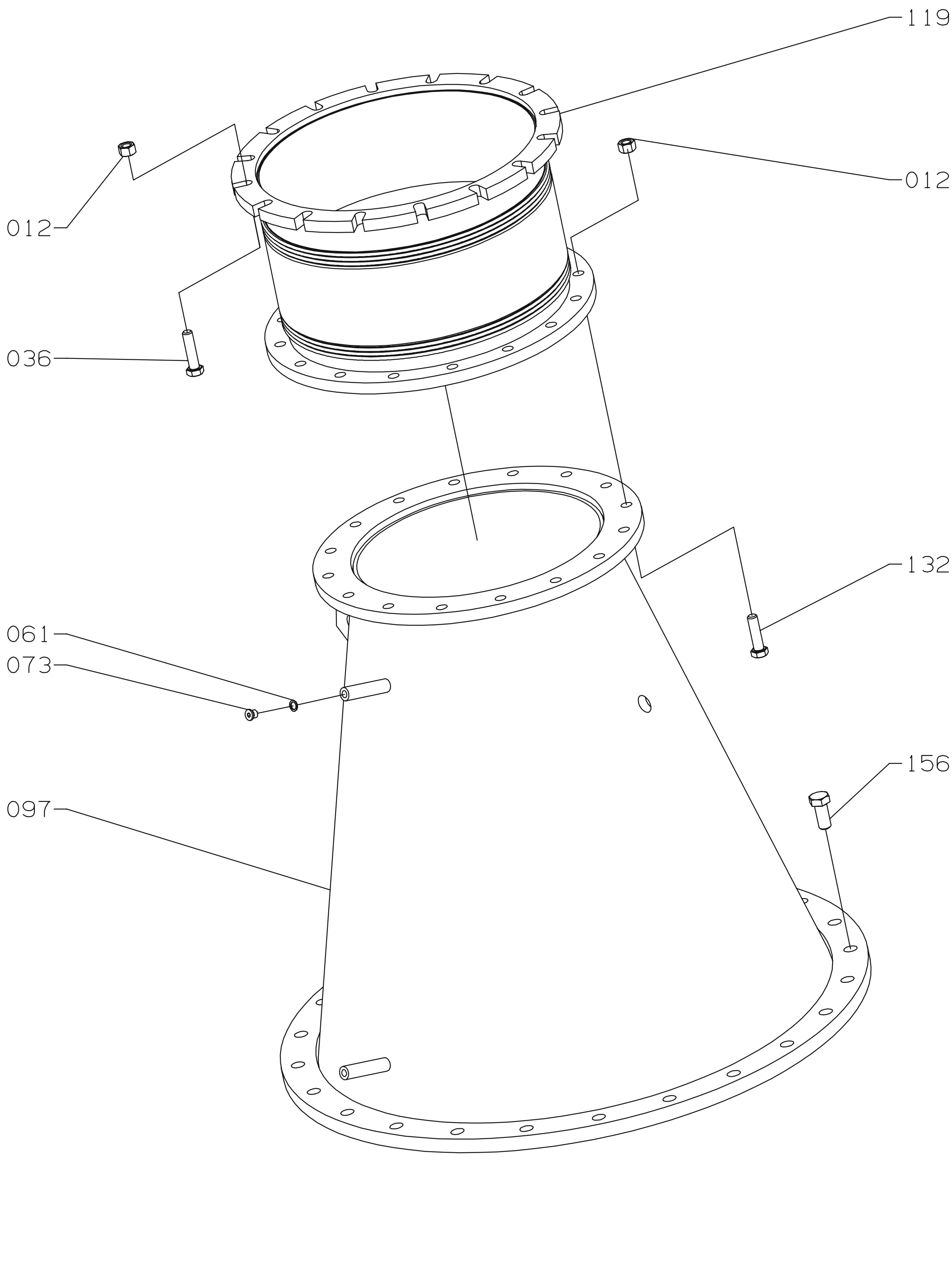
615

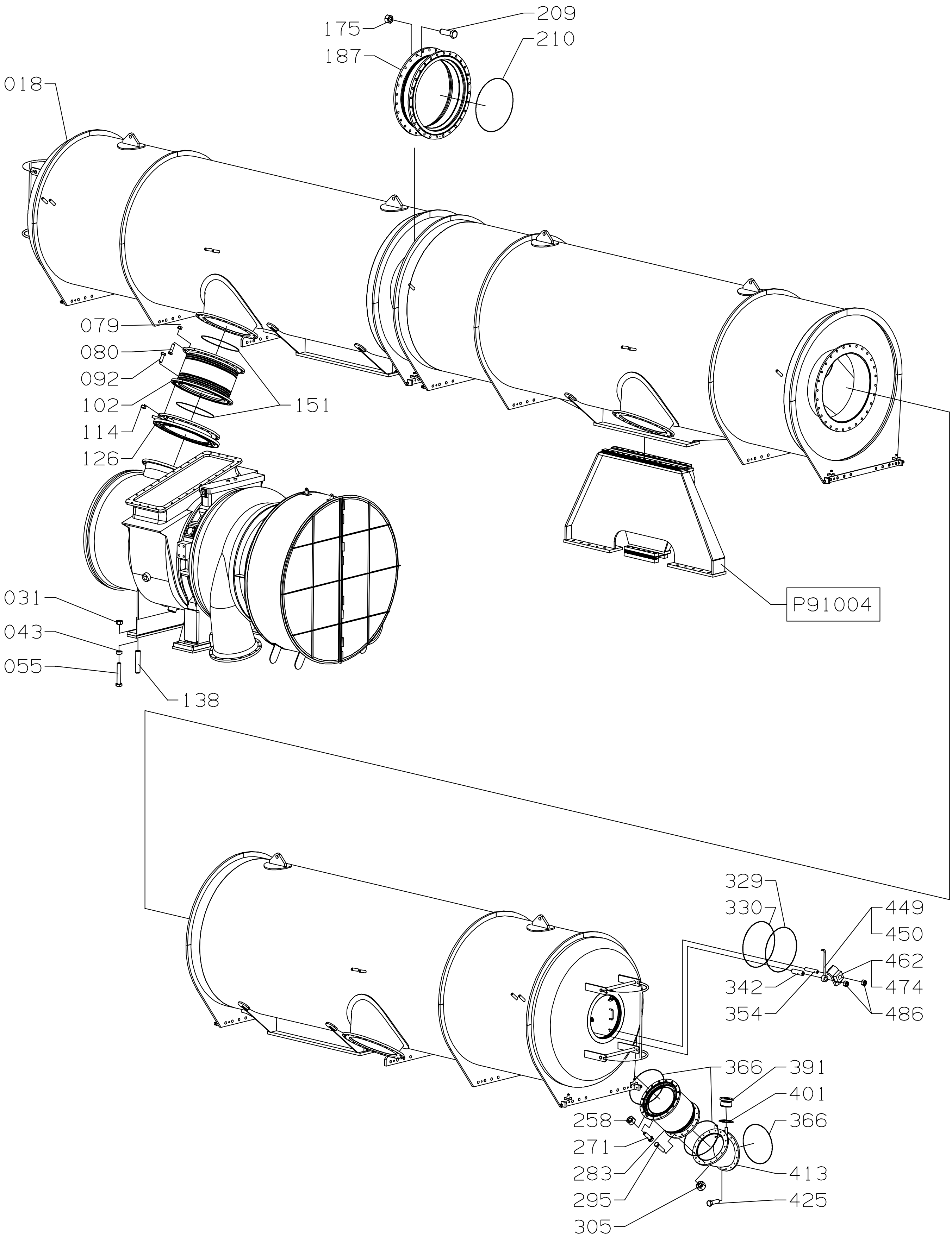
Item No.	Item Description	Item No.	Item Description
017	Scavenge air reciever, aft	688	Screw
029	Plug screw	723	O-ring
042	Inspection cover, complete	735	Air cooler housing sealing
078	Packing	747	Distance pipe
091	Airflow reversing chamber	759	Screw
101	Screw	772	Plate
113	Locking plate	784	Plate
125	Distance pipe	796	Stud
137	O-ring		
149	Distance piece		
150	Nut		
174	Screw		
186	Washer		
198	Nut		
208	Locking plate		
221	Support		
233	Spring pin		
257	Distance pipe		
269	Screw		
270	Sectional iron		
294	Distance pipe		
316	Scavenge air reciever, fore		
328	Cover		
341	Screw		
353	Screw		
365	Cover		
389	Nut		
390	Distance pipe		
400	Screw		
424	Hinge		
436	Cover		
461	Screw		
473	Flange		
497	Screw		
507	Packing		
519	O-ring		
520	Airflow reversing chamber		
544	Cross member		
556	Stud		
581	Sectional iron		
593	Sectional iron		
603	Nut		
615	Stud		
639	O-ring		
640	Distance pipe		
664	Cover		
676	Screw		

Arrangement of Charging Air Pipe



Arrangement of Charging Air Pipe

Item No.	Item Description	Item No.	Item Description
012	Nut		
036	Screw		
061	Packing		
073	Plug screw		
097	Charging air pipe		
119	Compensator, gas type		
132	Screw		
156	Screw		
	Note:		
	*		



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283
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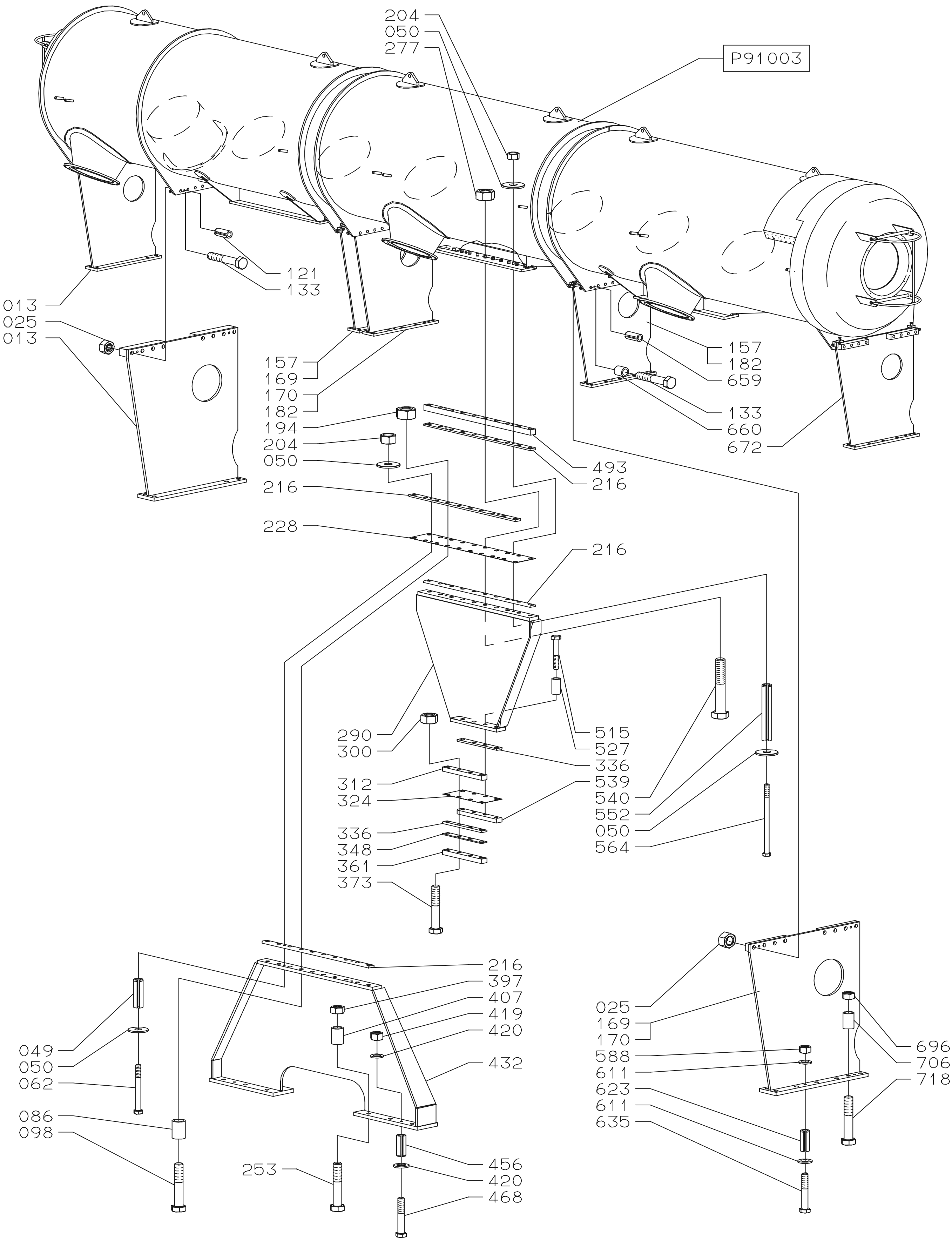
425

Item No.	Item Description	Item No.	Item Description
018	Exhaust reciever		
031	Nut		
043	Distance pipe		
055	Screw		
079	Nut		
080	Screw*		
092	Screw*		
102	Compensator		
114	Nut		
126	Gas inlet		
138	Guide pin		
151	Sealing ring		
175	Nut		
187	Compensator		
209	Screw*		
210	Sealing ring		
258	Nut		
271	Screw*		
283	Compensator		
295	Screw*		
305	Nut		
329	Sealing ring		
330	Sealing ring		
342	Stud		
354	Stud		
366	Sealing ring		
391	Plug		
401	Washer		
413	Pipe bend		
425	Screw*		
449	Sectional iron		
450	Sectional iron		
462	Plate		
474	Plate		
486	Nut		
	Note:		
	* These screws are special screws for hot joints, they are marked with a “T”, and MUST NOT be used elsewhere !		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696
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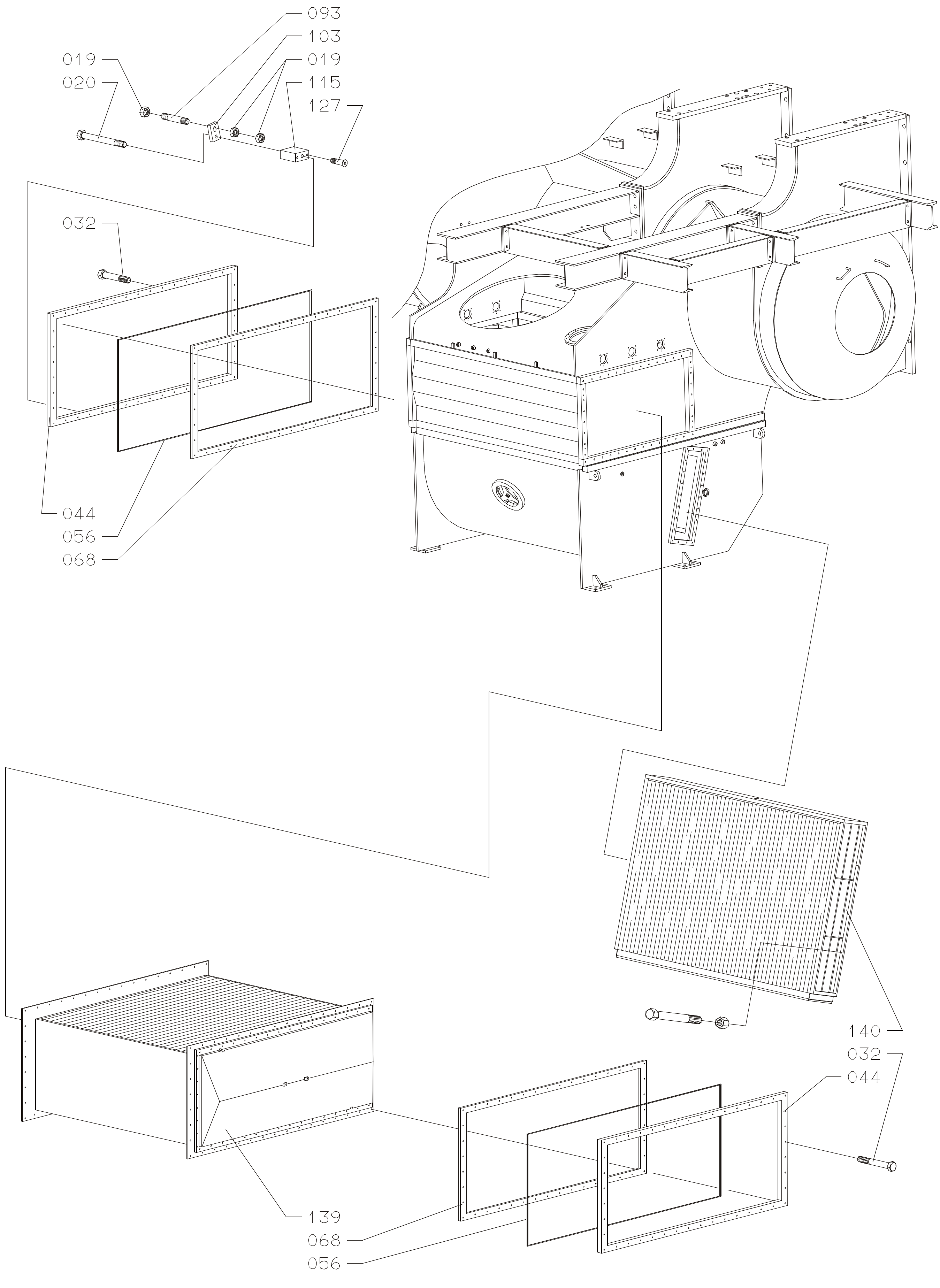
718

Exhaust Receiver - Details

Item No.	Item Description
013	Support
025	Nut
049	Spring pin
050	Washer
062	Screw
086	Distance pipe
098	Screw
121	Spring pin
133	Screw
157	Support
169	Shim
170	Support
182	Shim
194	Nut
204	Nut
216	Clamp
228	Spring plate
253	Screw
277	Nut
290	Support
300	Nut
312	Clamp
324	Spring plate
336	Clamp
348	Shim
361	Clamp
373	Screw
397	Nut
407	Distance pipe
419	Nut
420	Washer
432	Support
456	Spring pin
468	Screw
493	Clamp
515	Screw
527	Distance pipe
539	Clamp
540	Screw
552	Spring pin
564	Screw
588	Nut
611	Washer
623	Spring pin
635	Screw
659	Spring pin
660	Distance pipe
672	Support
696	Nut
706	Distance pipe
718	Screw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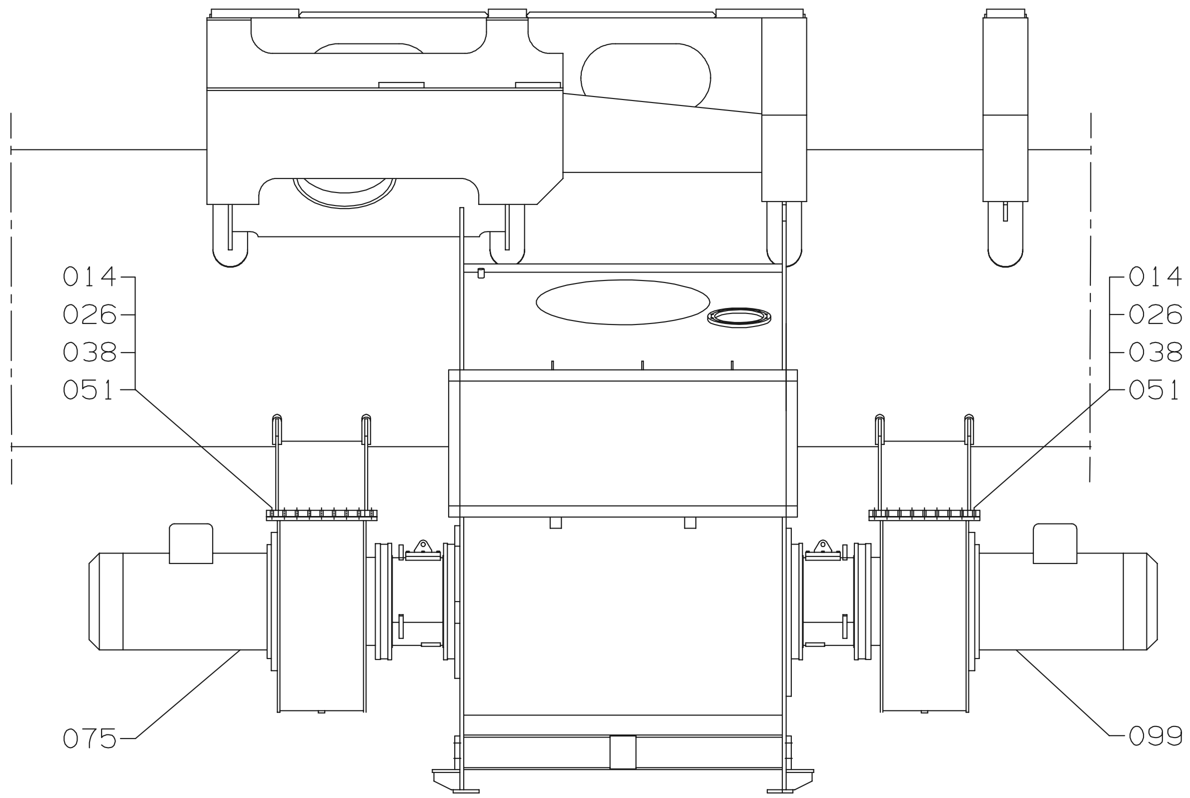
068
056

Air Cooler

Item No.	Item Description
019	Nut
020	Screw
032	Screw
044	Frame
056	O-ring
068	Frame
093	Stud
103	Support
115	Support
127	Screw
139	Cooler insert
140	Water mist catcher

Item No.	Item Description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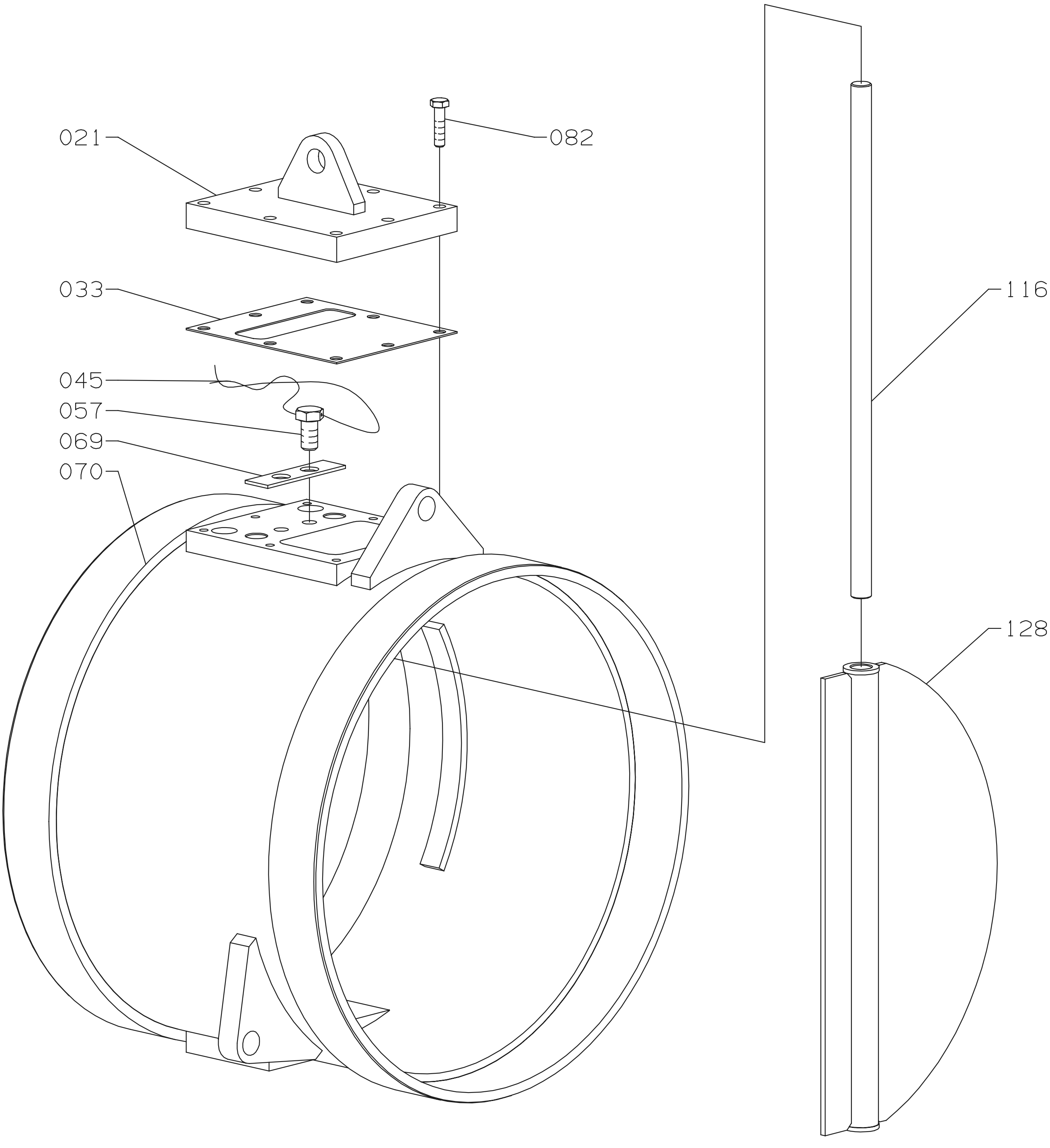
014
026
038
051
075
099

Arrangement of Auxiliary Blower

Item No.	Item Description
014	Packing
026	Distance pipe
038	Screw
051	Nut
075	Auxiliary blower*
099	Auxiliary blower*
	Note:
	* When ordering spare parts for this item, please state manufacturer's Part No.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069
070
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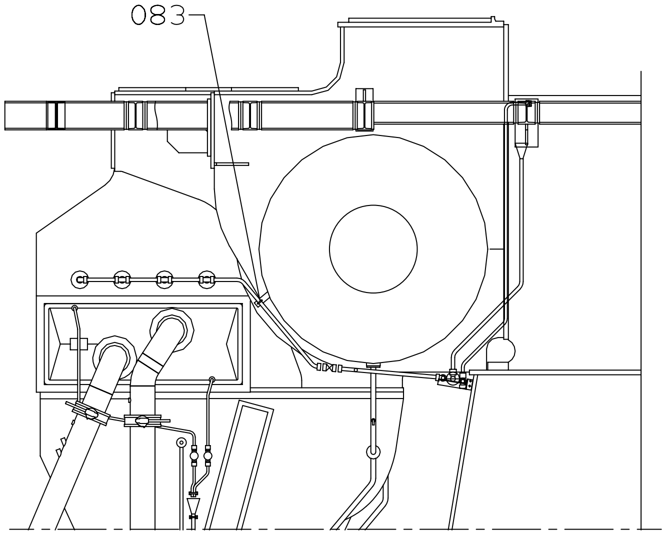
128

Butterfly Valve

Item No.	Item Description
021	Cover
033	Packing
045	Locking wire
057	Screw
069	Locking plate
070	Housing
082	Screw
116	Shaft
128	Flap

Item No.	Item Description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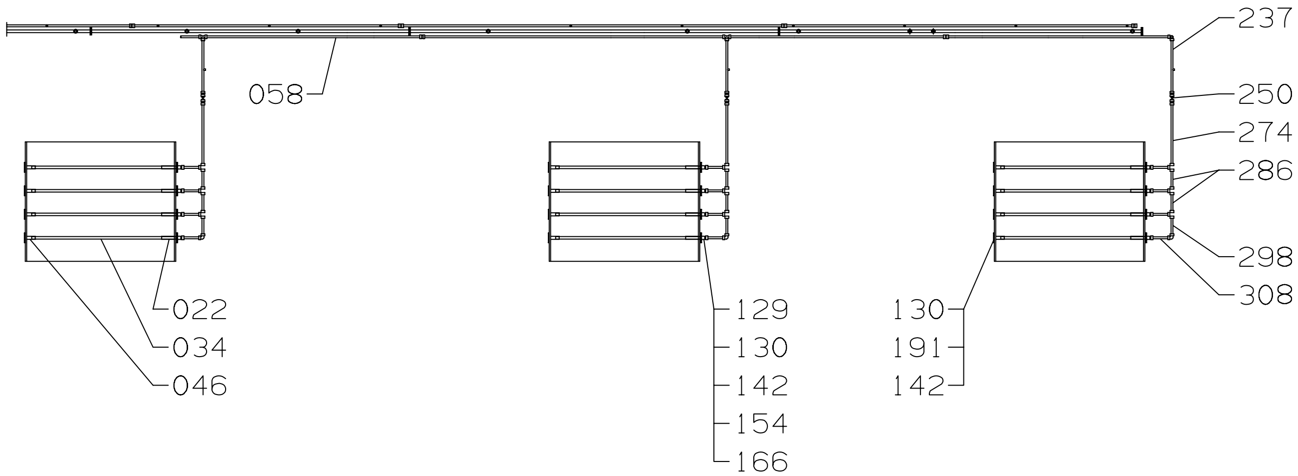
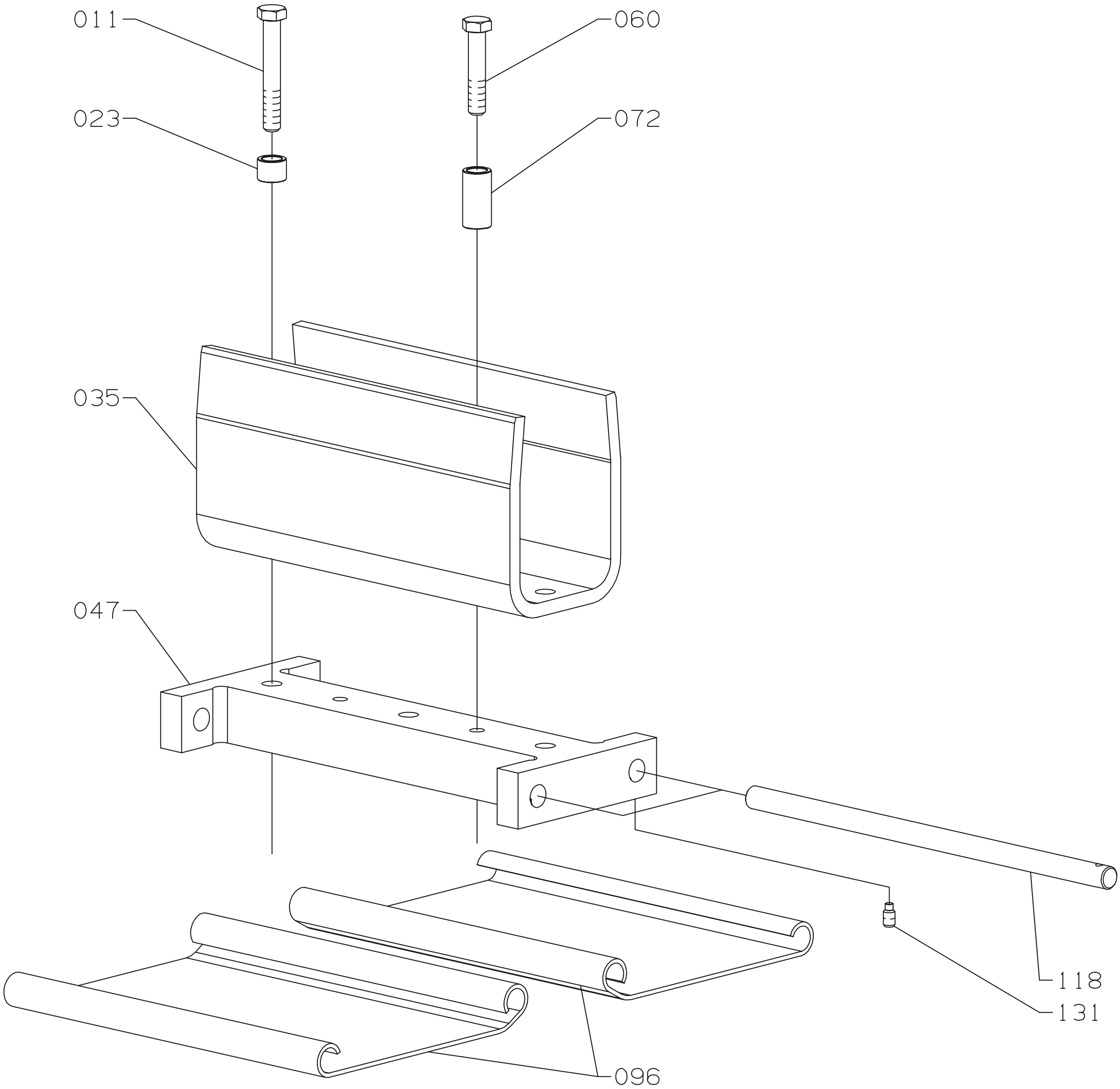

237
058
250
274
286
298
308
022
034
046
129
130
142
154
166
130
191
142

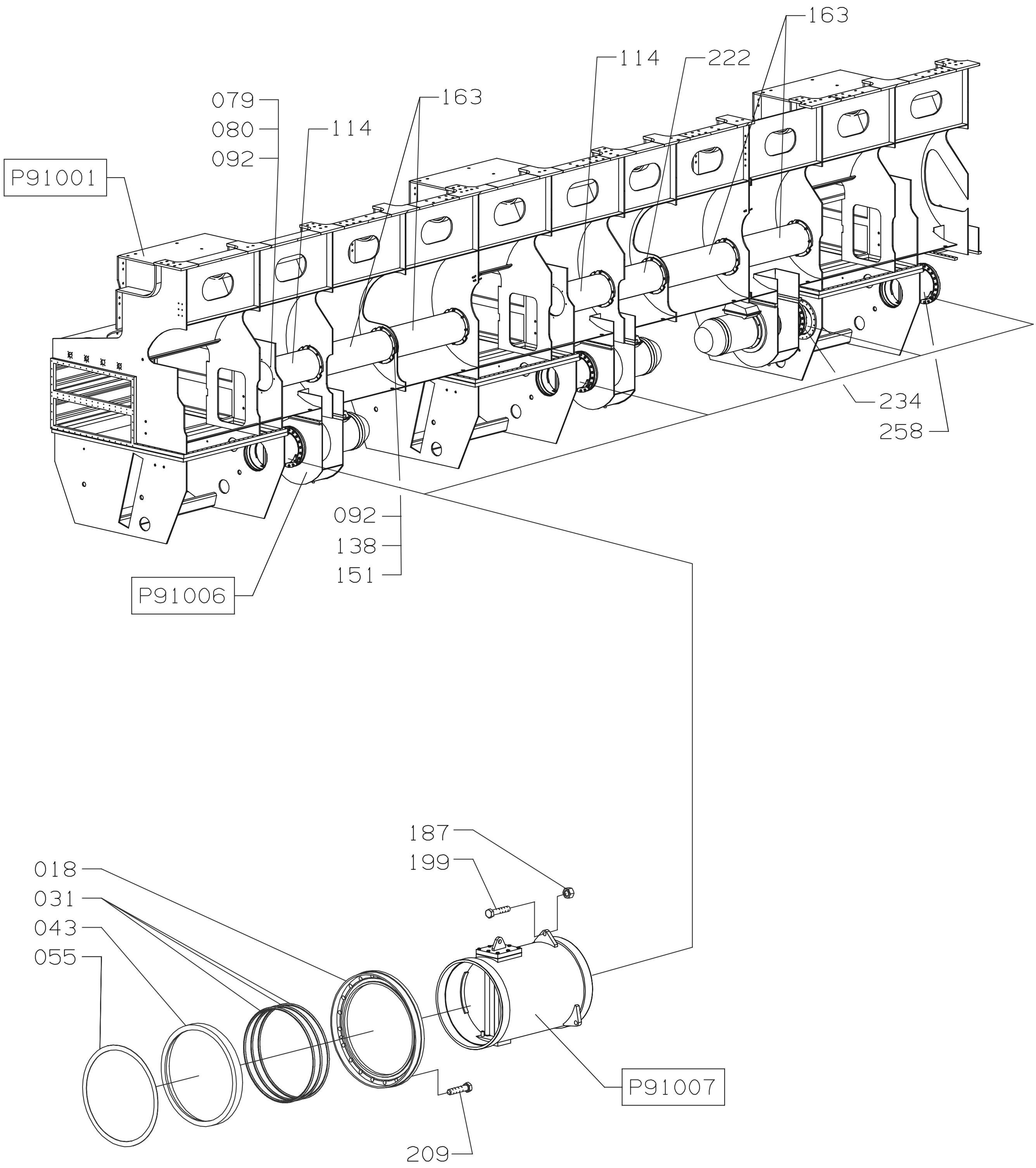
Item No.	Item Description	Item No.	Item Description
022	Guide		
034	Cleaning pipe		
046	Guide		
058	Main pipe, complete		
083	Support		
129	Stud		
130	Nut		
142	Packing		
154	Stud		
166	Nut		
191	Stud		
237	Cleaning pipe		
250	Valve		
274	Cleaning pipe		
286	Cleaning pipe		
298	Cleaning pipe		
308	Cleaning pipe		


011
060
023
072
035
047
118
131
096

Arrangement of Non-return Valve

Item No.	Item Description
011	Screw
023	Distance pipe
035	Stop for valve
047	Support
060	Screw
072	Distance pipe
096	Valve flap
118	Shaft
131	Screw

Item No.	Item Description


163
114
222
079
080
092
163
114
P91001
234
258
092
138
151
P91006
187
199
018
031
043
055
P91007
209

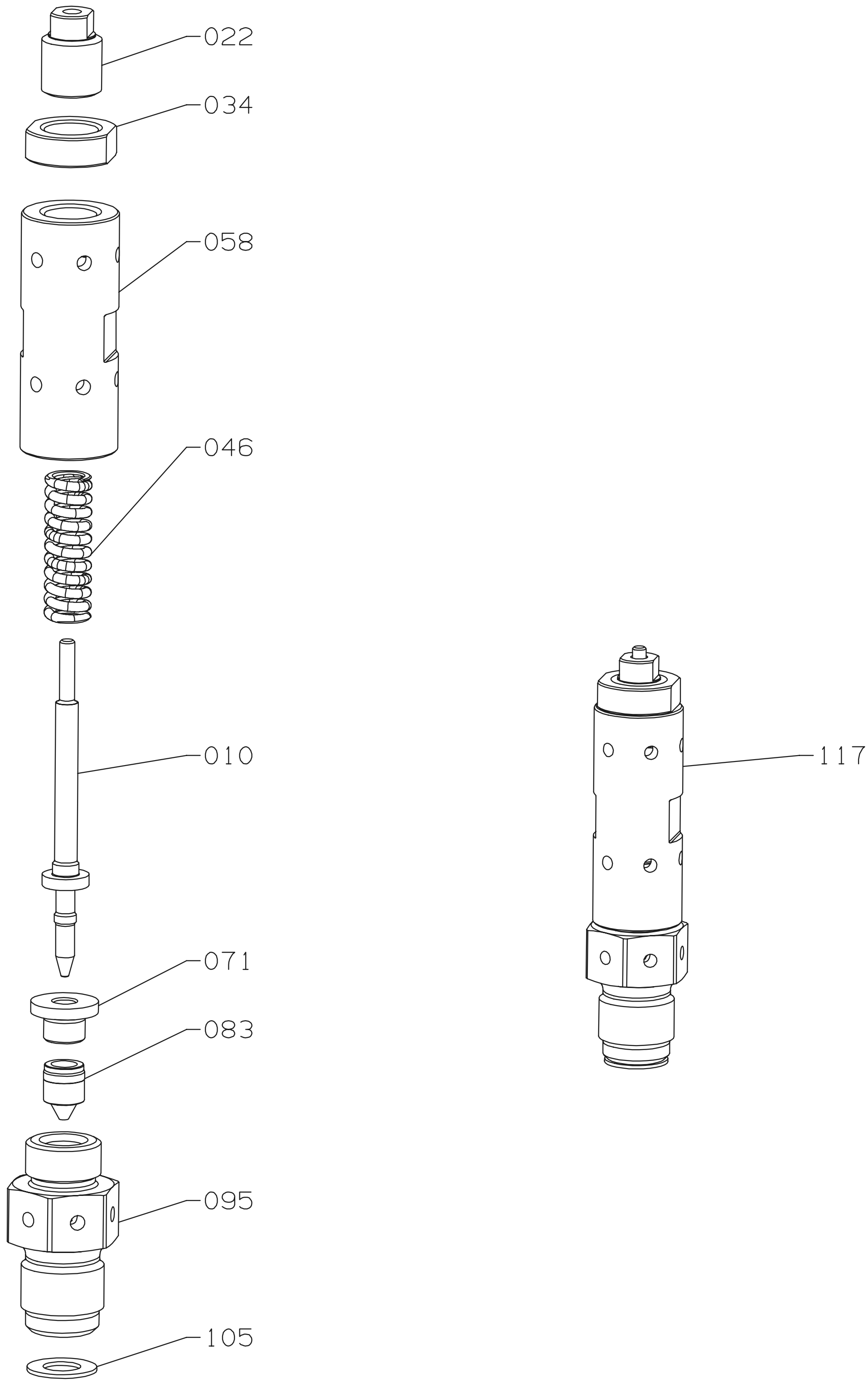
Arrangement of Suction Pipe

Item No.	Item Description
018	Flang
031	O-ring
043	Disc
055	Packing
079	Distance pipe
080	Screw
092	Disc
114	Pipe
138	Nut
151	Screw
163	Pipe
187	Nut
199	Screw
209	Screw
222	Pipe
234	Butterfly valve
258	Butterfly valve

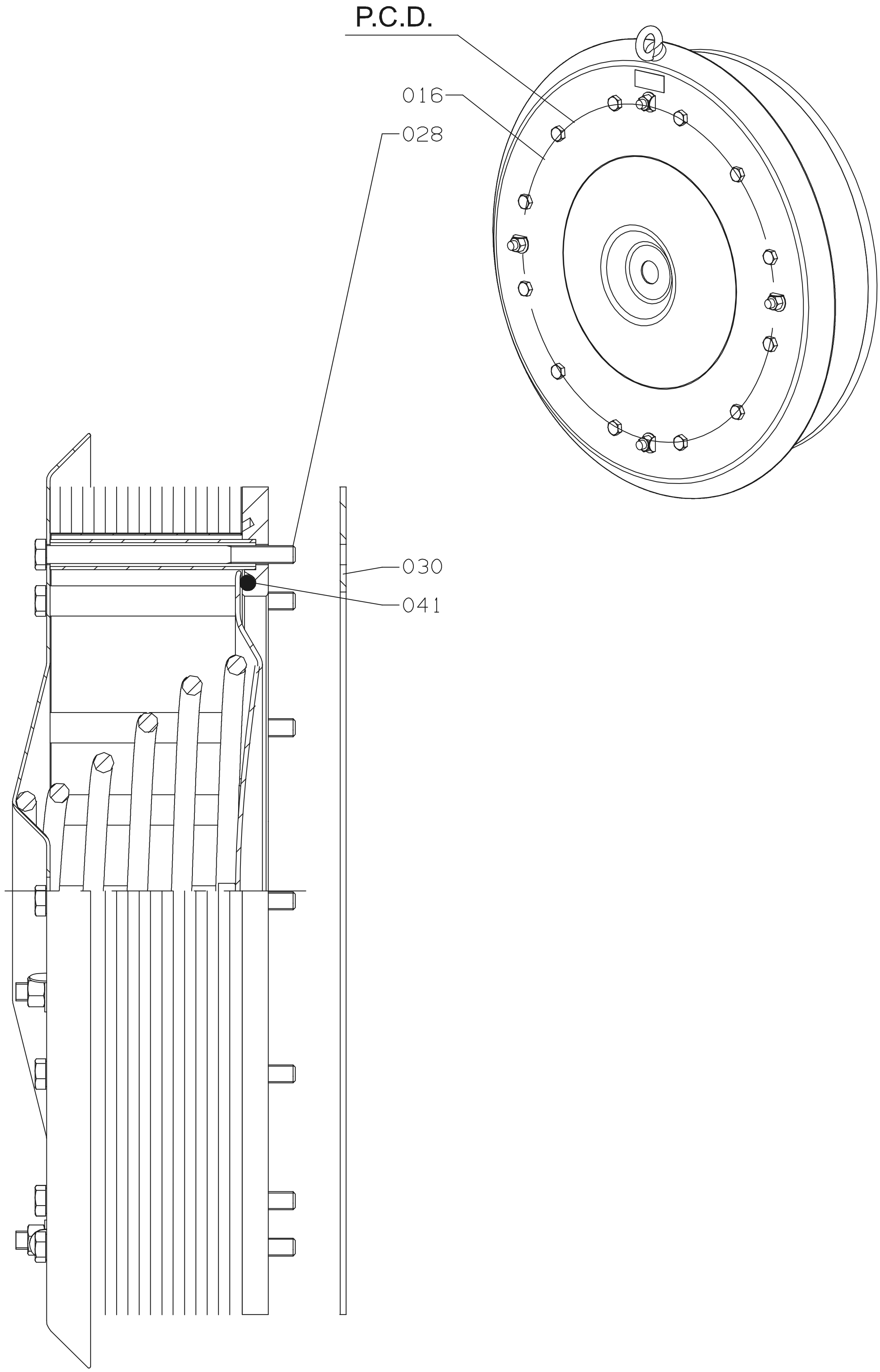
Item No.	Item Description

911 - Safety Equipment

Documents in this Chapter


022
034
058
046
010
071
083
095
105
117

Item No.	Item Description	Item No.	Item Description
010	Spindle		
022	Spring retainer		
034	Lock nut		
046	Spring		
058	Valve housing		
071	Stop ring		
083	Valve flap		
095	Valve guide		
105	Gasket		
117	Safety valve, complete		


P.C.D.
016
028
030
041

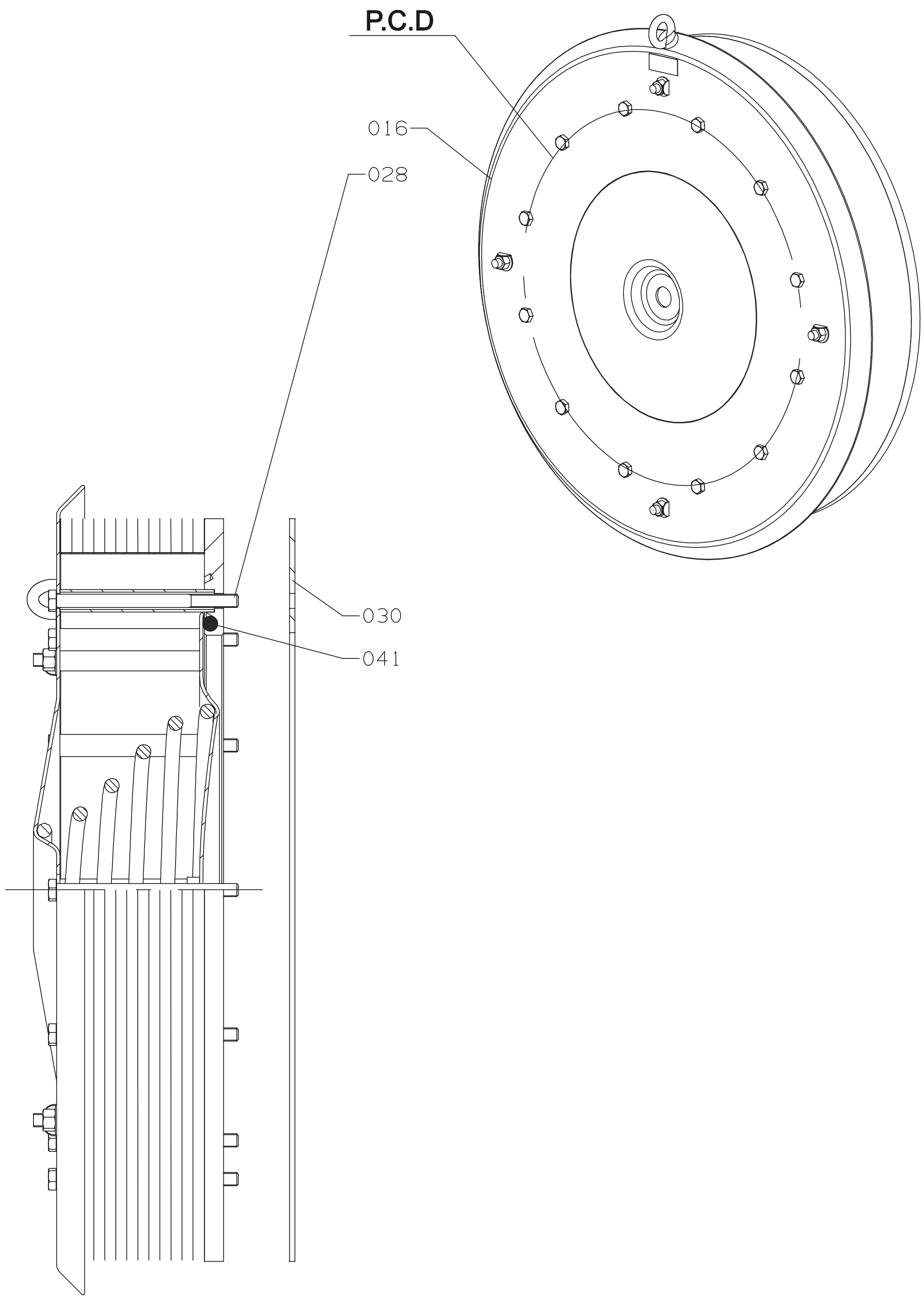
Relief Valve

Item No.	Item Description
016	Relief valve (P.C.D. 615mm) *
028	Screw*
030	Packing*
041	O-ring*

Note:

*When ordering, please state manufacturer of Relief Valve and P.C.D. xxx mm

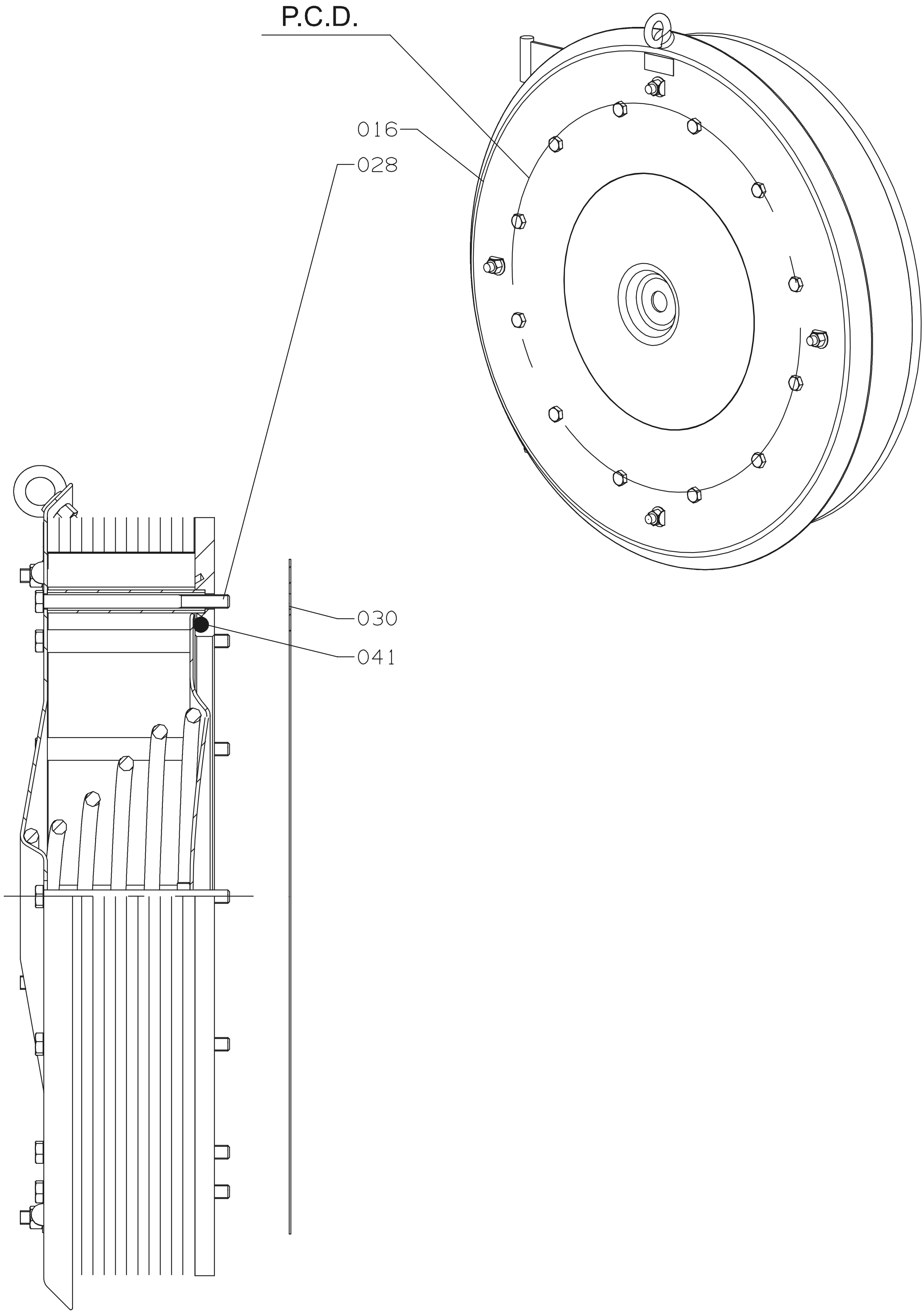
Item No.	Item Description


P.C.D
016
028
030
041

Relief Valve

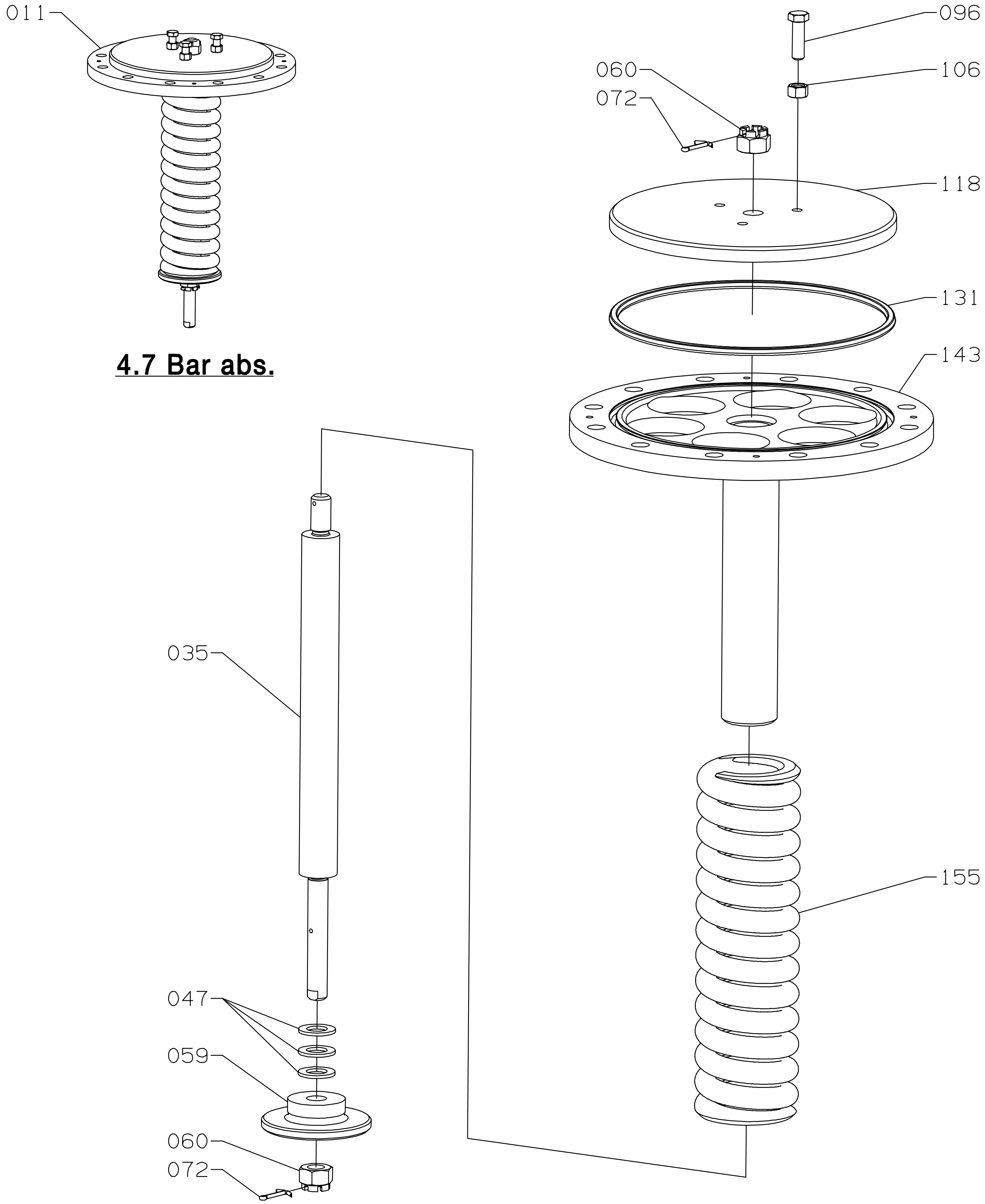
Item No.	Item Description
016	Relief valve (P.C.D. 700mm) *
028	Screw *
030	Packing *
041	O-ring *
	Note:
	*When ordering, please state manufacturer of Relief Valve and P.C.D. xxx mm

Item No.	Item Description


P.C.D.
016
028
030
041

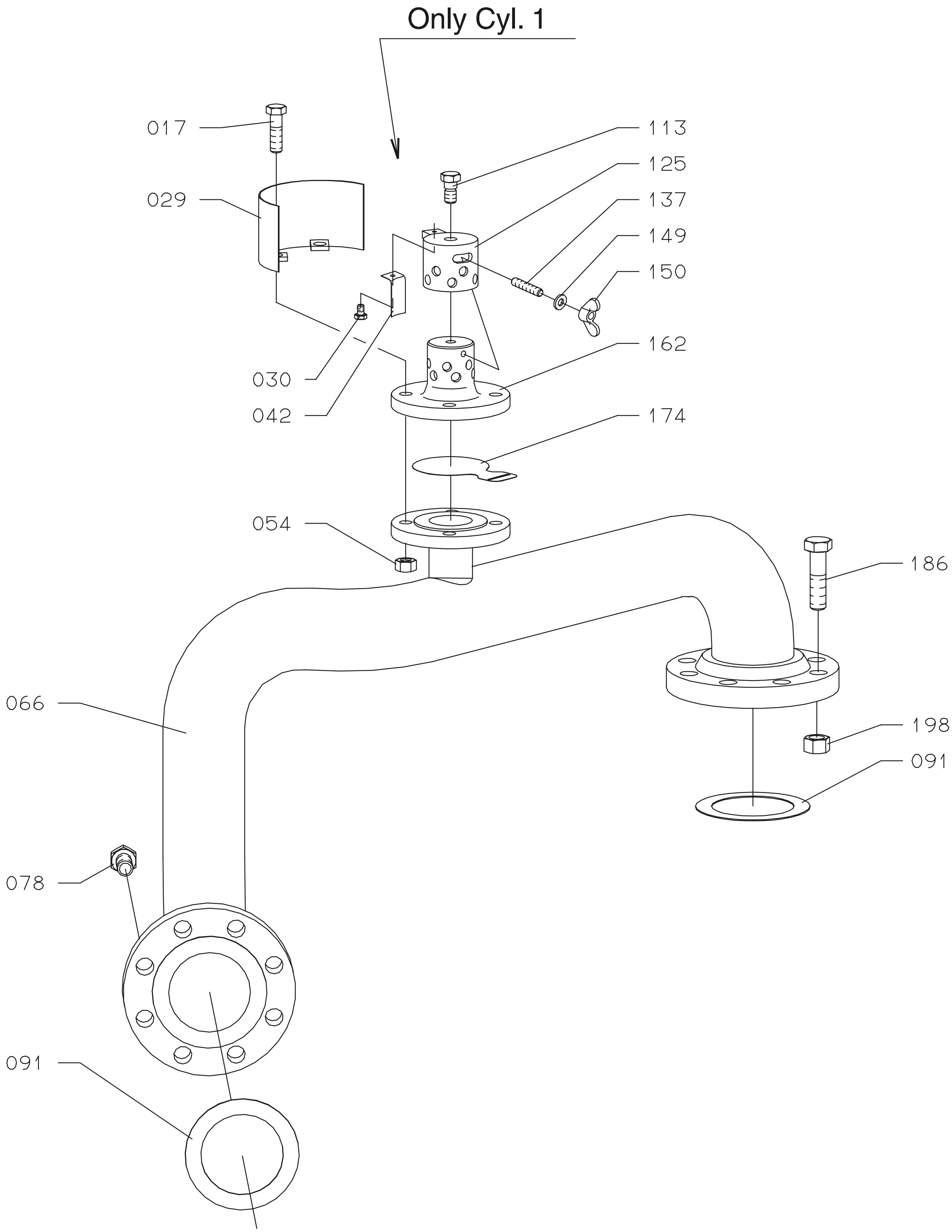
Relief Valve

Item No.	Item Description
016	Relief valve (P.C.D. 700mm) *
028	Screw *
030	Packing *
041	O-ring *
	Note:
	*When ordering, please state manufacturer of Relief Valve and P.C.D. xxx mm


011
4.7 Bar abs.
096
060
106
072
118
131
143
035
155
047
059
060
072

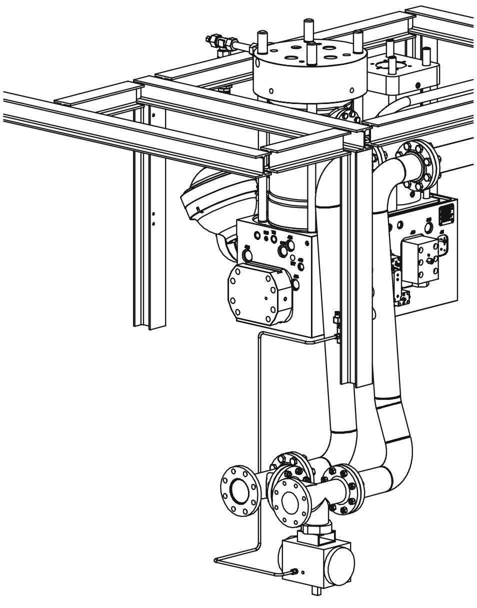
Safety Valve - Scavenge Air System

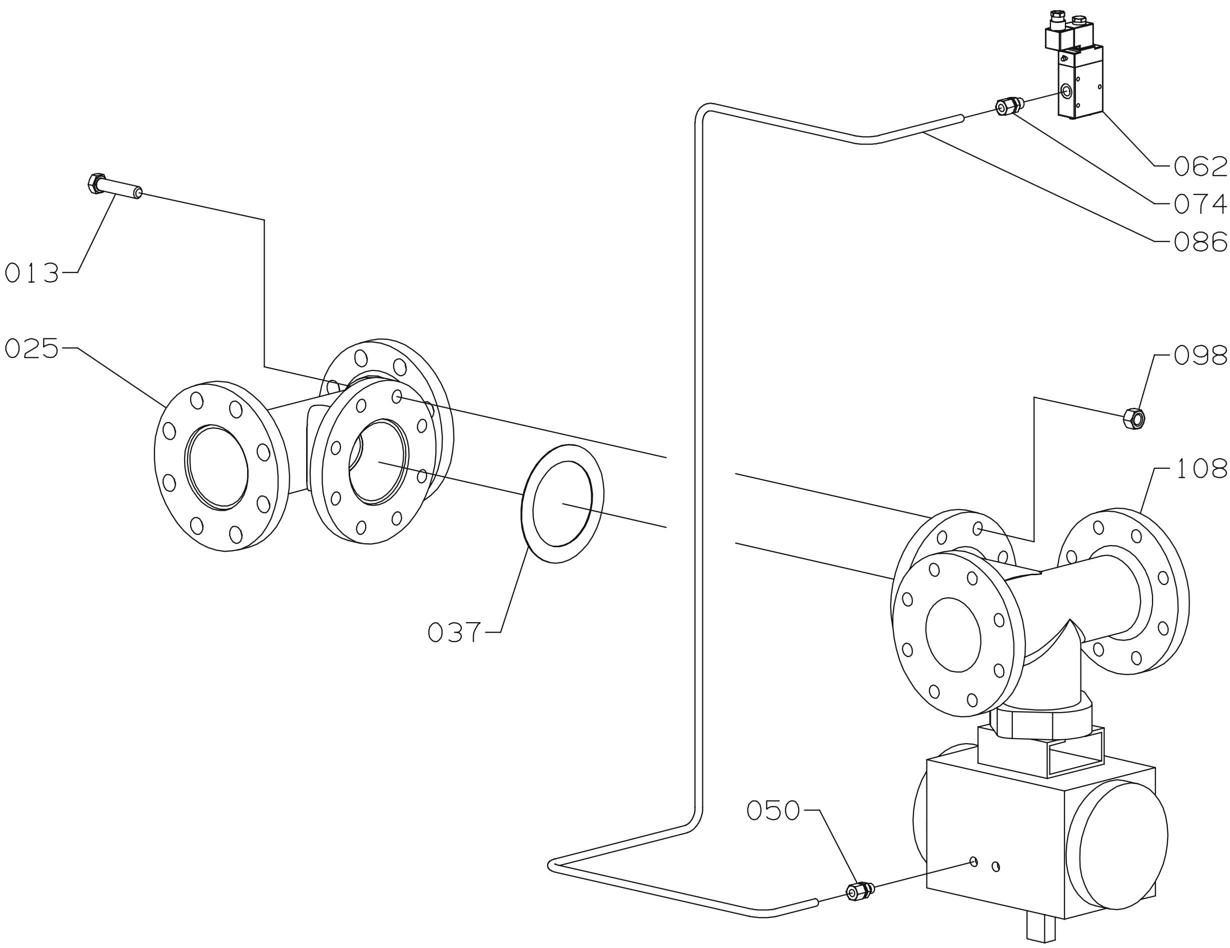
Item No.	Item Description	Item No.	Item Description
011	Safety valve, complete		
035	Spindle		
047	Washer		
059	Spring retainer		
060	Castle nut		
072	Split pin		
096	Screw		
106	Nut		
118	Valve flap		
131	Seal		
143	Valve seat		
155	Spring		


Only Cyl. 1
017
113
125
029
137
149
150
162
030
042
174
054
186
066
198
091
078
091

Arrangement of Safety Cap

Item No.	Item Description
017	Screw
029	Protecting guard
030	Screw
042	Check plate
054	Nut
066	Starting air pipe
078	Screw
091	Gasket
113	Fitted bolt
125	Bursting cap cover
137	Stud
149	Washer
150	Wing nut
162	Perforated cylinder
174	Bursting disc
186	Screw
198	Nut



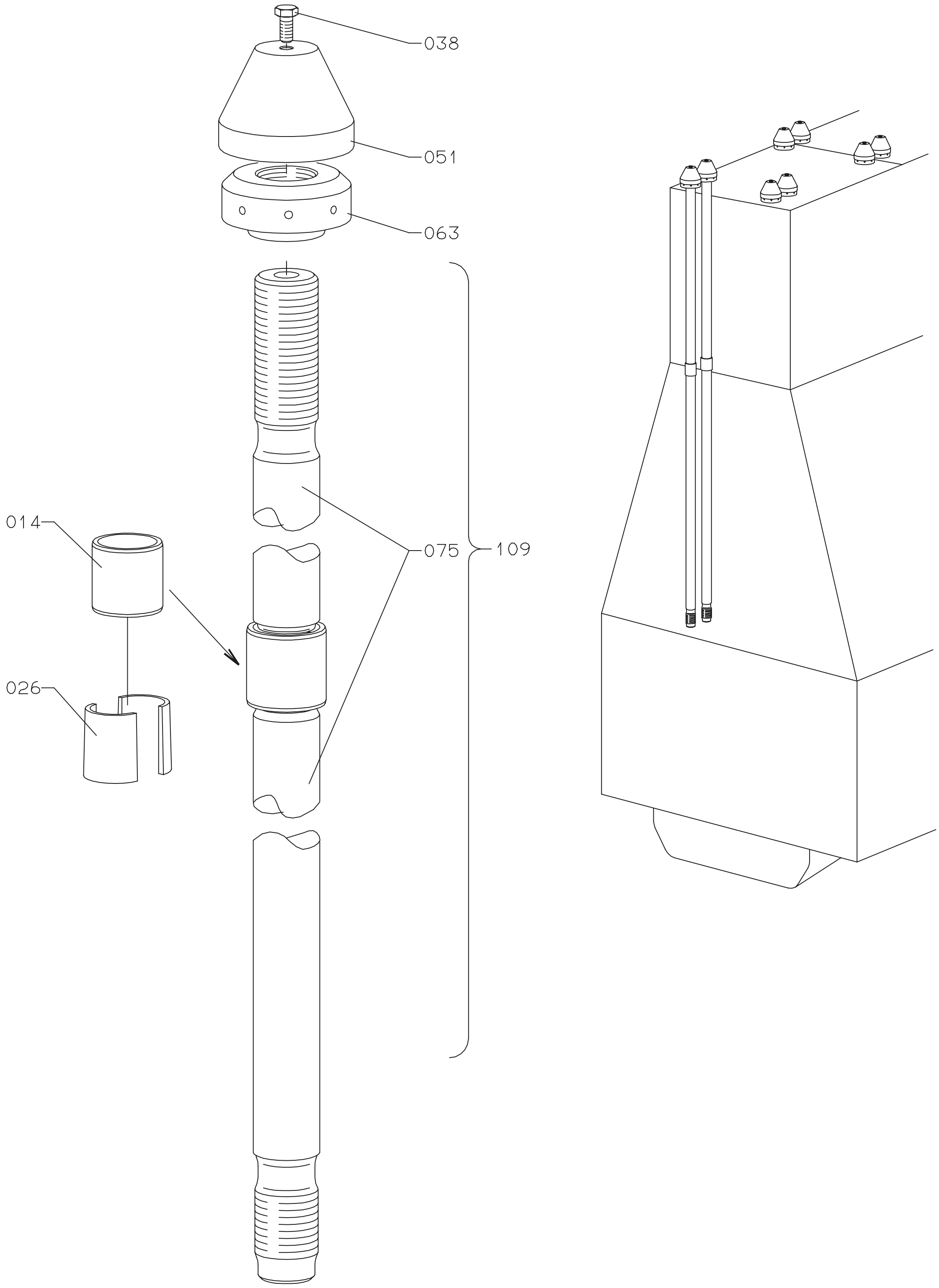

062
074
086
013
025
098
108
037
050

Item No.	Item Description	Item No.	Item Description
013	Screw		
025	Main pipe fuel oil outlet		
037	Packing ring		
050	Coupling		
062	3/2-way valve		
074	Coupling		
086	Steel pipe		
098	Nut		
108	Ball valve with actuator		
	Note:		
	*		

912 - Assembly of Large Parts

Documents in this Chapter

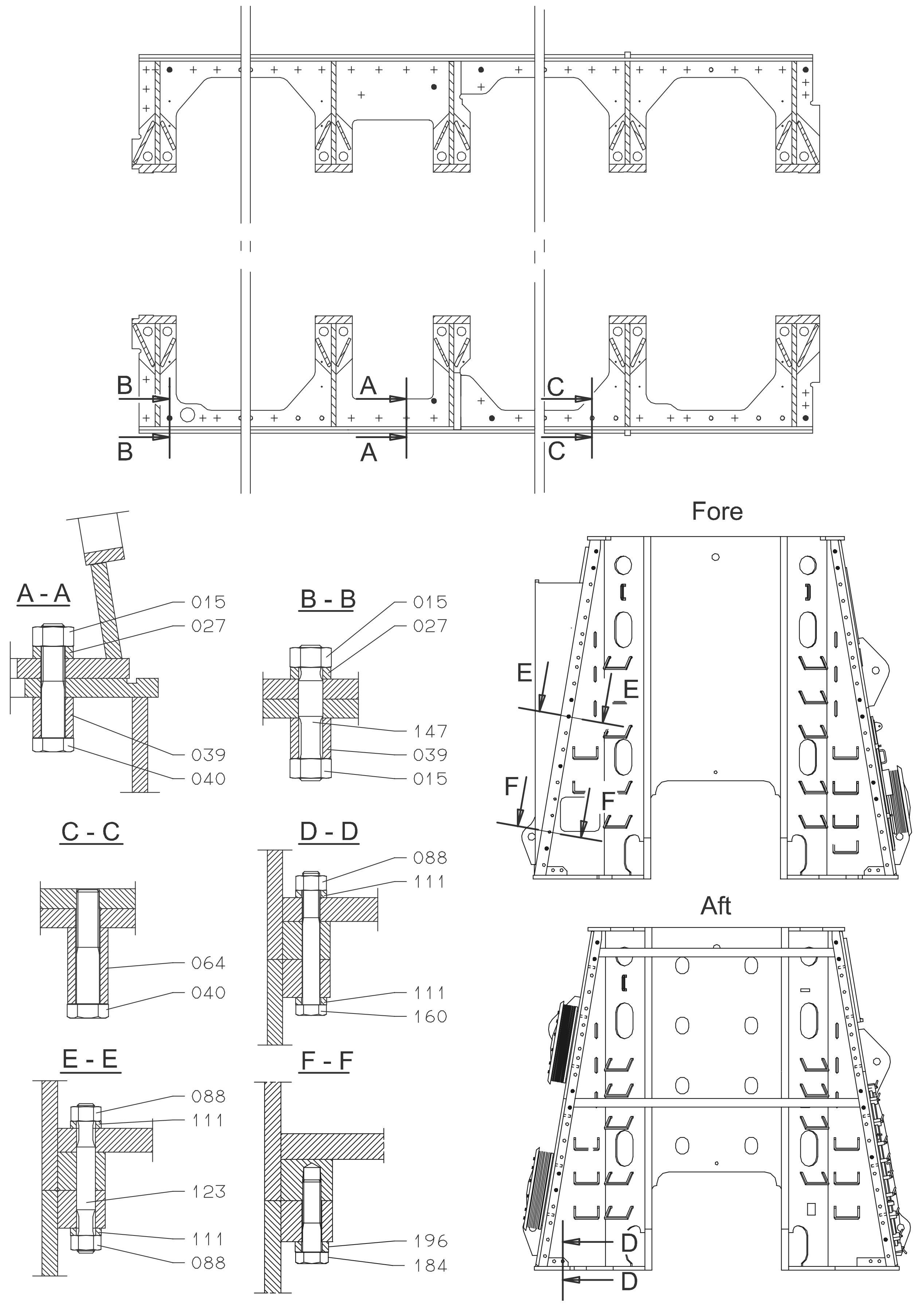
Arrangement of Stay Bolts



Arrangement of Stay Bolts

Item No.	Item Description
014	Guide bushing
026	Guide bushing
038	Screw
051	Protective cap
063	Nut
075	Stay bolt
109	Asembling of stay bolt

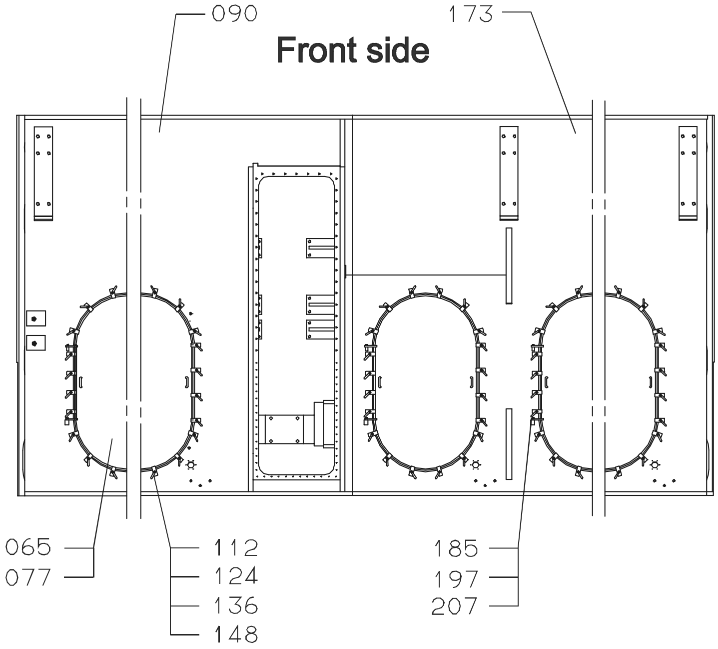
Item No.	Item Description


B
B
A
A
C
C
A - A
015
027
039
040
B - B
015
027
147
039
015
C - C
064
040
D - D
088
111
111
160
E - E
088
111
123
111
088
F - F
196
184
Fore
E
E
F
F
Aft
D
D

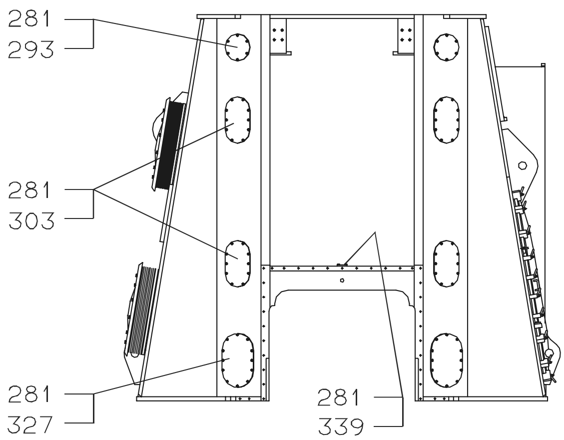
Frame Box - Details

Item No.	Item Description
015	Nut
027	Distance piece
039	Distance piece
040	Screw
064	Distance piece
088	Nut
111	Distance piece
123	Fitted stud
147	Fitted stud
160	Screw
184	Screw
196	Distance piece

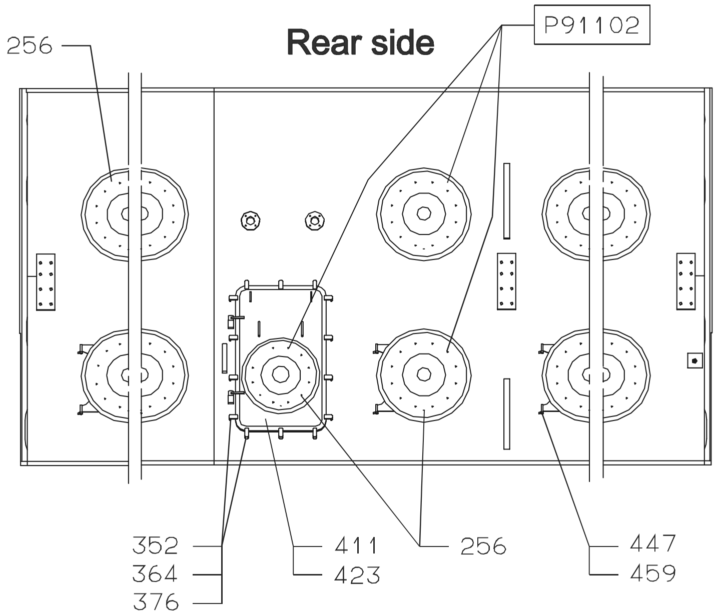
Front side



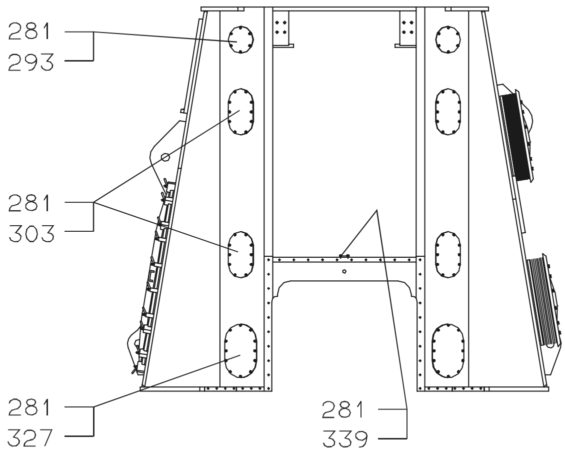
Fore end



Rear side



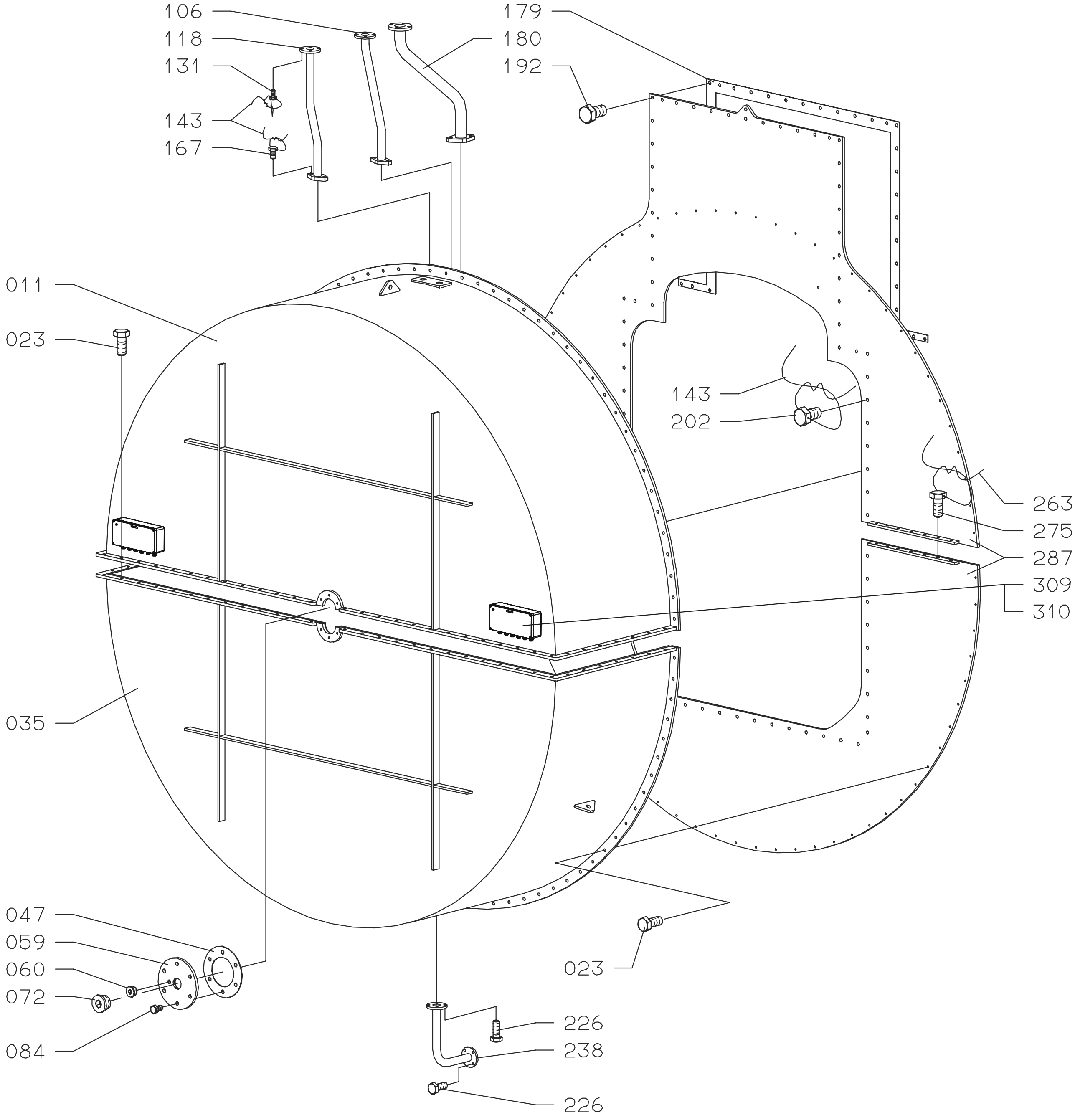
Aft end



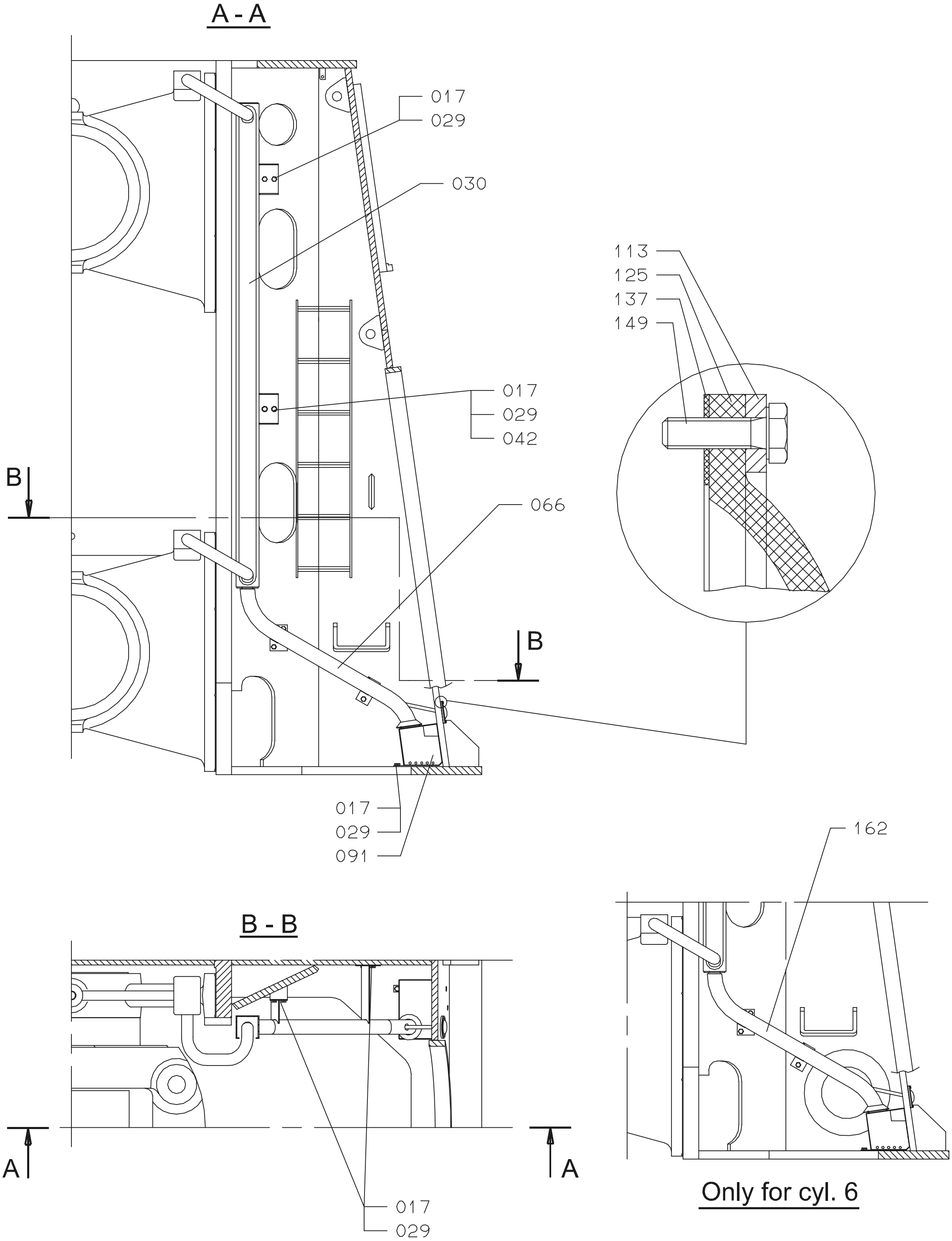
Frame Box

Item No.	Item Description
065	Frame box door
077	Sealing material
090	Frame box, fore
112	Door fastener
124	Wing nut
136	Stud
148	Pressure spring
173	Frame box, aft
185	Locking pin
197	Pressure spring
207	Key ring
256	Drain pipe
281	Screw
293	Cover
303	Cover
327	Cover
339	Cover
352	Door fastener
364	Stud
376	Nut
411	Frame door
423	Packing
447	Washer
459	Bush

Item No.	Item Description


106
118
131
143
167
179
180
192
011
023
143
202
263
275
287
309
310
035
047
059
060
072
084
023
226
238
226

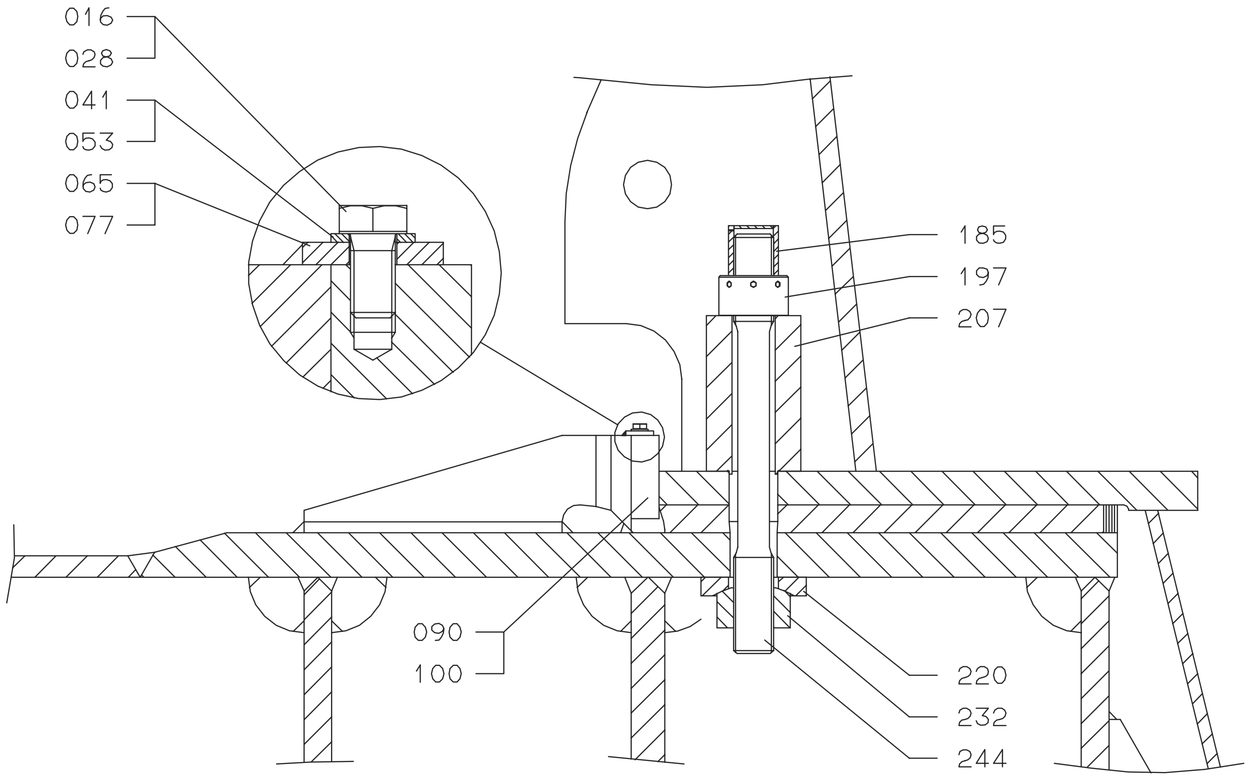
Item No.	Item Description	Item No.	Item Description
011	Shield upper		
023	Screw		
035	Shield lower		
047	Packing		
059	Cover		
060	Plug screw		
072	Plug screw		
084	Screw		
106	Damper, oil pipe		
118	Damper, oil pipe		
131	Screw		
143	Locking wire		
167	Screw		
179	Gasket		
180	Lubricating oil pipe		
192	Screw		
202	Screw		
226	Screw		
238	Drain pipe		
263	Locking wire		
275	Screw		
287	Shield fore		
309	Amplifier		
310	Screw		
	Note:		
	*		

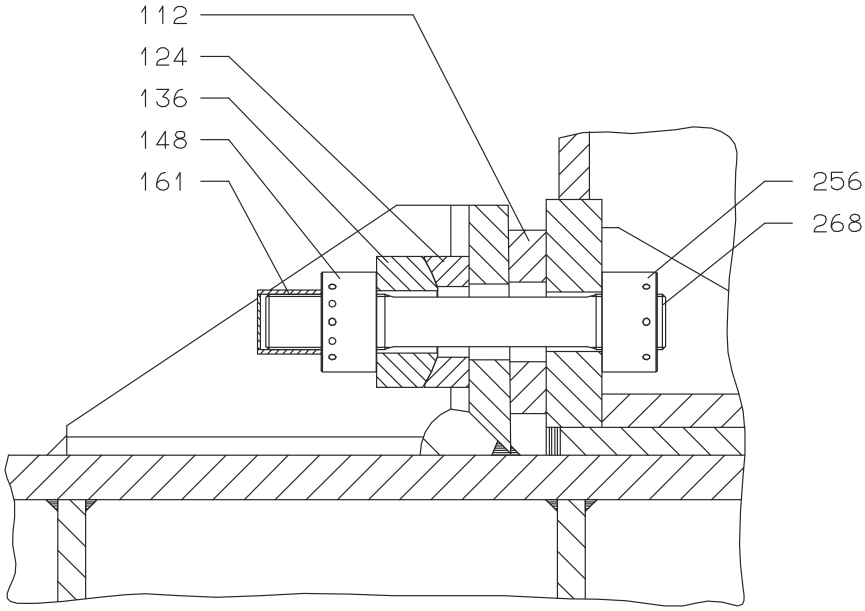

A - A
017
029
030
113
125
137
149
017
029
042
B
066
B
017
029
091
162
B - B
A
A
017
029
Only for cyl. 6

Arrangement of Piston Cooling

Item No.	Item Description
017	Screw
029	Locking Wire
030	Drain pipe-piston cooling
042	Washer
066	Drain pipe-piston cooling
091	Drain box
113	Flange
125	Sight glass
137	Packing
149	Screw
162	Drain pipe-piston cooling

Item No.	Item Description


016
028
041
053
065
077
185
197
207
090
100
220
232
244


112
124
136
148
161
256
268

HoldingDown Bolts and End Chock Bolts (Epoxy Chocks)

Item No.	Item Description	Item No.	Item Description
016	Screw		
028	Screw		
041	Washer		
053	Washer		
065	Locking plate		
077	Locking plate		
090	Liner for side chock, port side		
100	Liner for side chock, starboard		
112	Liner for end chock		
124	Spherical washer		
136	Spherical washer		
148	Nut		
161	Protecting cap		
185	Protective cap		
197	Nut		
207	Distance pipe		
220	Washer		
232	Nut		
244	Holding down bolt		
256	Nut		
268	Stud for end chock bolt		