

# Maintenance Manual

# X82DF-1.0

Issue 002 2021-07

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## 1.1 Maintenance Manual - change record

Tab 1-1 Change record

Data module code, issue	Status
Chapter number - technical name Reason for change	
<b>Revised issue 002, 2021-08</b>	
<ul style="list-style-type: none"> <li>- Safety precautions and safety rules: updated</li> <li>- Fuel pump: updated for X4 fuel pump</li> <li>- Injection valve: appendix added</li> <li>- iGPR: procedures added</li> <li>- Gas admission valve: appendix added</li> <li>- Gas admission valve: appendix added</li> <li>- Pressure relief valve: updated</li> <li>- Updated various tightening values for new tools</li> <li>- Crankshaft: added new procedure for checking crank deflection</li> <li>- Tightening instructions: updated</li> <li>- Maintenance overview: updated</li> <li>- Tool lists: updated</li> <li>- Various other updates and improvements</li> </ul>	
<b>New issue 001, 2020-11</b>	
All data modules	
n/a	
Initial issue of the Maintenance Manual	

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## 1.2 Preface

This manual is for use only for the related type of engine (the engine described in this manual).

Make sure that you know the inspection and overhaul intervals before you operate the engine.

Also obey the items that follow:

- **Safety**

Make sure that you read carefully this manual before you start work on the engine.

Make sure that you read carefully and obey the data given in chapter safety.

- **Data**

The specifications and recommendations of the classification societies are included in the design of the engine.

The data, instructions, graphics and illustrations etc in this manual are related to drawings from WinGD. These data relate to the date of issue of the manual (the year of the issue is shown on the title page and on the footer). All instructions, graphics and illustrations etc can change because of continuous new development and modifications.

- **Equipment and tools**

Keep all equipment and tools for maintenance and operation serviceable and in good condition.

- **Spare parts**

Use only original spare parts and components to make sure that the engine will continue to operate satisfactorily.

- **Personnel**

Only qualified personnel that have the applicable knowledge and training may do work on the engine, its systems and related auxiliary equipment.



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## 1.3 Technical documentation set

Because of the continuous development of the engine, the technical documentation for the engine changes and is regularly updated. The change record shows all changes.

Important data and changes are given directly to the customer in the service bulletins.

To order technical documents, the data that follows is necessary:

- Engine type, year of manufacture and engine manufacturer
- Name of ship or site of installation
- Cylinder or engine number
- Special equipment
- Document type (printed manuals, CD or Shipdex dataset).

The technical documentation set for this engine includes the publications that follow.

### 1.3.1 Operation Manual

The Operation Manual (OM) contains data about engine operation, the necessary operating media (oil, water, fuel etc) and descriptions of the components and systems. The manual also gives troubleshooting procedures.

The manual gives data about the standard engine with all cylinder numbers, alternative designs and special equipment.

In this manual the engine connections (refer to the pipe connection plan) are the interface of the description. For a description of the plant supply systems refer to the Marine Installation Manual.

### 1.3.2 Maintenance Manual

The Maintenance Manual (MM) contains data about disassembly / assembly procedures that are necessary for the engine maintenance. The manual includes the maintenance schedule, a clearance table, tightening values for important screw connections and a tool list.

### 1.3.3 Spare Parts Catalogue

In the Spare Parts Catalogue (SPC, or code book) all spare parts of the engine are marked with a unique code number. You can order spare parts only with the code number from the Spare Parts Catalogue. Order spare parts from one of the suppliers that follow:

- CSSC Marine Service Co., Ltd.
- Wärtsilä Services Switzerland Ltd.
- Engine supplier.

### **1.3.4 External supplier documentation**

The documentation from external suppliers gives data about the parts of the engine that are not supplied by WinGD, such as turbocharger, automatic filter or damper. Most of this documentation also contains data about spare parts.

### **1.3.5 Records and drawings**

The setting tables, shop trial documents, schematic diagrams and survey certificates of the related engine are given with the first supply of the documentation.

### **1.3.6 Marine Installation Manual**

The Marine Installation Manual (MIM) contains data for design engineers and naval architects, enabling them to optimize plant items and machinery space, and to do installation design work.

## 1.4 Data module codes (procedural data)

This manual is divided into several data modules. Each data module is identified with a unique data module code, refer to [Table 1-2 - Data module codes \(procedural data\)](#). The structure of the data module codes is as follows:

- ??## ##### ##???-###?-? (structure)
- AA00-5556-00AAA-520A-A (example).

**Tab 1-2 Data module codes (procedural data)**

Code	Description	Length/type	Property	Example
?? <sup>1</sup>	Alternative versions/designs of items. Used when two or more items could be installed in the engine as alternatives for the same function (for example turbochargers from different suppliers)	2 alphabetic characters [A-Z]	sequential, starts with AA	AA
## <sup>2</sup>	Applicability related to cylinder number. 00 = applicable to all engines independent of the number of cylinders; ## = applicable only to engines with that specific number of cylinders.	2 numeric characters [0-9]	arbitrary	00
#### <sup>2</sup>	WinGD design group number	4 numeric characters [0-9]	arbitrary	5556
## <sup>2</sup>	Used for sequential numbering for the physical breakdown of components; 00 = complete component, 01 = first breakdown; for illustrated parts (tools) it is used for sequential numbering of data modules.	2 numeric characters [0-9]	sequential, starts with 00	00
??? <sup>1</sup>	Used for alternative items differing in design but not enough to change the variant code (for example AAA = Bearing shell No.1; AAB = Bearing shell No. 2 to #)	3 alphabetic characters [A-Z]	sequential, starts with AAA	AAA
### <sup>2</sup>	Shipdex information code, for example 520 = Remove procedure	3 numeric characters [0-9]	Shipdex specific	520
? <sup>1</sup>	Shipdex information code variant. Used to differentiate different procedures defined by the same information code for the same DMC/Hardware section.	1 alphabetic character [A-Z]	variable	A

Code	Description	Length/type	Property	Example
? <sup>1</sup>	Shipdex item location code. A = information related to items installed on the product; B = information related to items installed on a major assembly removed from the product; C - information related to items on the bench. In this context, it does not matter, for example, whether an item has been removed from the product; D - information related to all three locations A, B, and C. No other combinations are allowed.	1 alphabetic character [A-D]	Shipdex specific	A

1 Placeholder symbol for alphabetic characters.

2 Placeholder symbol for numeric characters.

**NOTE:** For the full list of available Shipdex information codes and more data about the Shipdex specification, refer to [www.shipdex.org](http://www.shipdex.org).

## 1.5 Data module codes (descriptive data)

This manual is divided into several data modules. Each data module is identified with a unique data module code, refer to [Table 1-3 - Data module codes \(descriptive data\)](#). The structure of the data module codes is as follows:

- ??## ##### ##???-###?-? (structure)
- AA00-5551-00AAA-043A-A (example).

**Tab 1-3 Data module codes (descriptive data)**

Code	Description	Length/type	Property	Example
?? <sup>1</sup>	Alternative versions/designs of items. Used when two or more items could be installed in the engine as alternatives for the same function (for example turbochargers from different suppliers)	2 alphabetic characters [A-Z]	sequential, starts with AA	AA
## <sup>2</sup>	Applicability related to cylinder number. 00 = applicable to all engines independent of the number of cylinders; ## = applicable only to engines with that specific number of cylinders.	2 numeric characters [0-9]	arbitrary	00
#### <sup>2</sup>	WinGD design group number	4 numeric characters [0-9]	arbitrary	5551
## <sup>2</sup>	Used for sequential numbering of data modules.	2 numeric characters [0-9]	sequential, starts with 00	00
??? <sup>1</sup>	Used for alternative items differing in design but not enough to change the variant code.	3 alphabetic characters [A-Z]	sequential, starts with AAA	AAA
### <sup>2</sup>	Shipdex information code, for example 043 = description of function attributed to the crew (functional breakdown)	3 numeric characters [0-9]	Shipdex specific	043
? <sup>1</sup>	Shipdex information code variant. Used for sequential numbering	1 alphabetic character [A-Z]	sequential, starts with A	A
? <sup>1</sup>	Shipdex item location code, for example A = information related to items installed on the product	1 alphabetic character [A-D]	Shipdex specific, default is A	A

1 Placeholder symbol for alphabetic characters.

2 Placeholder symbol for numeric characters.

**NOTE:** For the full list of available Shipdex information codes and more data about the Shipdex specification, refer to [www.shipdex.org](http://www.shipdex.org).

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## 1.6 Data module codes (illustrated parts data)

This manual is divided into several data modules. Each data module is identified with a unique data module code, refer to [Table 1-4 - Data module codes \(illustrated parts data\)](#). The structure of the data module codes is as follows:

- ??## ##### ##???-###?-? (structure)
- AA05-5562-01AAA-941A-A (example).

**Tab 1-4 Data module codes (illustrated parts data)**

Code	Description	Length/type	Property	Example
?? <sup>1</sup>	Alternative versions/designs of items. Used when two or more items could be installed in the engine as alternatives for the same function (for example turbochargers from different suppliers)	2 alphabetic characters [A-Z]	sequential, starts with AA	AA
## <sup>2</sup>	Applicability related to cylinder number. 00 = applicable to all engines independent of the number of cylinders; ## = applicable only to engines with that specific number of cylinders.	2 numeric characters [0-9]	arbitrary	05
#### <sup>2</sup>	WinGD design group number	4 numeric characters [0-9]	arbitrary	5562
## <sup>2</sup>	Used for sequential numbering of data modules.	2 numeric characters [0-9]	sequential, starts with 01	01
??? <sup>1</sup>	Used for alternative items differing in design but not enough to change the variant code (for example AAA = ISO; AAB = JIS)	3 alphabetic characters [A-Z]	sequential, starts with AAA	AAA
### <sup>2</sup>	Shipdex information code. 941 = illustrated parts data	3 numeric characters [0-9]	default is 941	941
? <sup>1</sup>	Shipdex information code variant. A = spare part	1 alphabetic character [A-Z]	default is A	A
? <sup>1</sup>	Shipdex item location code. A = information related to items installed on the product	1 alphabetic character [A-D]	Shipdex specific, default is A	A

1 Placeholder symbol for alphabetic characters.

2 Placeholder symbol for numeric characters.

**NOTE:** For the full list of available Shipdex information codes and more data about the Shipdex specification, refer to [www.shipdex.org](http://www.shipdex.org).



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## 1.7 About this book

In the sections that follow you find the definitions of WinGD for this book.

### 1.7.1 Definitions for general text

For general text in this book the definitions that follow are applicable:

- **ASD Simplified Technical English**

The text in this book obeys the rules for ASD Simplified Technical English.

- **Illustrations**

The items in an illustration are shown, if possible, in clockwise direction, for example 001, 002, 003.

**NOTE:** Illustrations are usually generic or are shown as example. Thus some items can be different on the current engine.

- **Cross references**

A cross reference to a different section of this book has the number and the title of the section, for example “refer to section [1.2 Preface](#)”. In the electronic version, a mouse click on the blue text shows the related section.

**NOTE:** The text “[[section not applicable for this engine](#)]” shows, that this cross reference and the related section are not applicable for this book.

- **Instructions**

Instructions in the procedures are given as steps, for example 1, 2, 3. These steps can be divided into sub-steps, for example 1.1, 1.2, 1.3 or also sub-sub-steps, for example 1.1.1, 1.1.2, 1.1.3.

- **Notes**

Notes give more data to help you do a task, or they give data about the related item. Notes come immediately before or after the related paragraph.

- **Decimal separator**

In this book a full stop (.) is used as decimal separator, for example 3.21 bar.

## 1.7.2 Warnings

Warnings in procedures give data about a hazard.

Warnings have the basic structure that follows:

- **Signal word**

The signal words that follow are applicable:

- WARNING
- CAUTION

- **Hazard**

The hazard data gives the dangerous situation.

- **Procedure**

The procedure gives data of how to prevent the dangerous situation.

The signal words have the different hazard levels that follow:

- **WARNING**

The signal word WARNING gives a dangerous situation at which death or large injury are possible. Do the related procedure to prevent this.

- **CAUTION**

The signal word CAUTION gives a dangerous situation at which moderate or small injury to personnel or damage to equipment are possible. Do the related procedure to prevent this.

## 1.8 About the engine

In the sections that follow you find the definitions of WinGD for the engine.

### 1.8.1 Groups of components

Each component of the engine has a four-digit material number. WinGD has divided these components related to the first digit of the number into 9 groups:

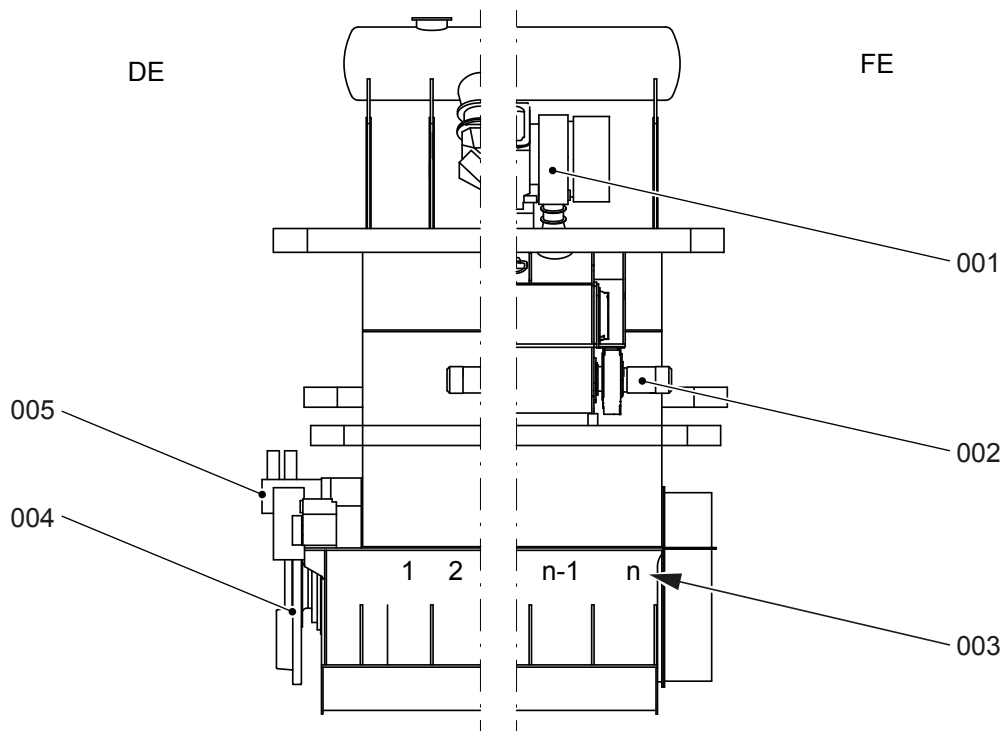
- Group 1 - Engine frame and bearings
- Group 2 - Cylinder
- Group 3 - Crankshaft, connecting rod and piston
- Group 4 - Supply unit drive and control components
- Group 5 - Supply unit, pumps and control valves
- Group 6 - Scavenge air components
- Group 7 - Cylinder lubrication and balancer
- Group 8 - Pipes
- Group 9 - Monitoring instruments.

## 1.8.2 Engine sides and ends - names

The sides and ends of the engine have the names and abbreviations that follow (refer to [Figure 1-1](#)):

- DE - Driving End (end that has a flange to attach the propeller shaft)
- FS - Fuel Side (side that has the equipment for the supply of fuel and other operating media)
- FE - Free End (end that is closed with a cover)
- ES - Exhaust Side (side that has the equipment for the discard of the exhaust gas and for the supply of scavenge air).

**Fig 1-1 Side view (generic)**



### Legend

FE	Free end	DE	Driving end
001	Turbocharger	004	Flywheel
002	Auxiliary blower	005	Supply unit
003	Main bearing number		

## 1.8.3 Standard and LEFT engine

An engine is one of two types:

- A standard engine has the exhaust side (ES) on the right side of the engine (seen from the driving end).

- A LEFT engine has the exhaust side (ES) on the left side of the engine (seen from the driving end).

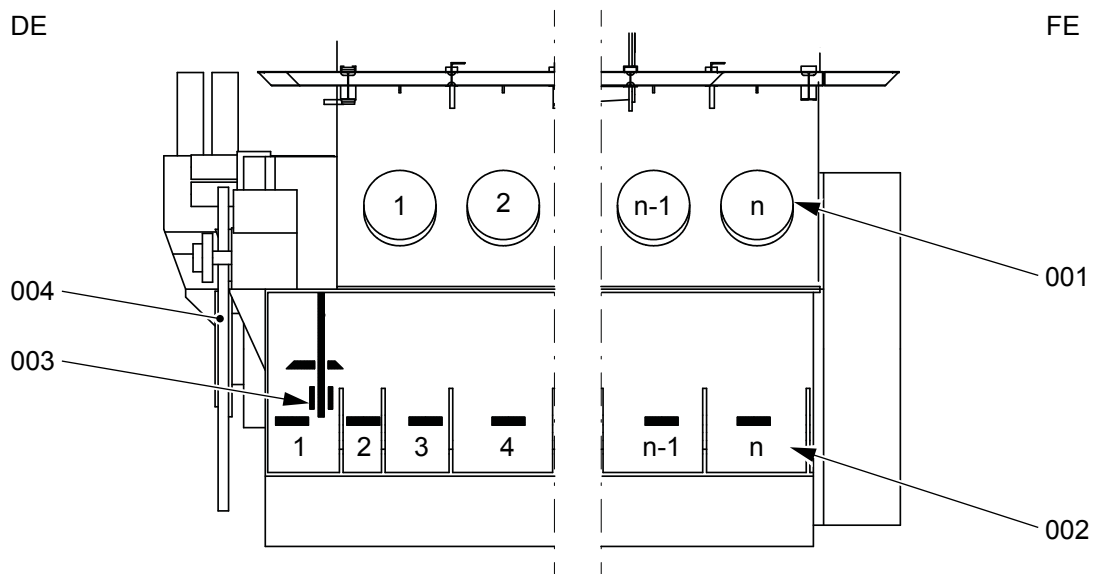
**NOTE:** In the Spare Parts Catalogue parts that have the mark (LEFT) are only applicable for a LEFT engine. Parts that are applicable for the two engines types (Standard and LEFT) have no mark.

### 1.8.4 Numbering of items

WinGD uses the definitions for the numbering of items as follows (refer to [Figure 1-2](#)):

- In axial direction the numbering starts from the flywheel.
- In radial direction the numbering starts from the center of the flywheel.

**Fig 1-2 Engine numbering (generic)**



#### Legend

FE	Free end	DE	Driving end
001	Cylinder number	003	Thrust bearing
002	Main bearing number	004	Flywheel

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## 1.9 List of abbreviations

**Tab 1-5 List of abbreviations and acronyms**

Short form	Full form, meaning
ACM	Angle Calculation Module
ADA	crank Angle Determination Algorithm
AHD	ahead
ALM	alarm
AMS	Alarm and Monitoring System
A/R	as required
AST	astern
ASTM	American Society for Testing and Materials
BDC	Bottom Dead Center
BN	Base Number
BSEC	Brake Specific Energy Consumption
BSFC	Brake Specific Fuel Consumption
BSGC	Brake Specific Gas Consumption
BSPC	Brake Specific Pilot fuel Consumption
CAN	Controller Area Network
CCAI	Calculated Carbon Aromaticity Index
CCM	Cylinder Control Module
CCU	Cylinder Control Unit
CCW	counterclockwise
CMCR	Contract Maximum Continuous Rating
COC	Cleveland Open Cup
CPP	Controllable Pitch Propeller
CS	crankshaft
CW	clockwise
Cyl.	cylinder
DBT	Delta Bypass Tuning
DCC	Dynamic Combustion Control
DE	Driving End
DENIS	Diesel Engine coNtrol and optlmizing Specification
DF	Dual Fuel



Short form	Full form, meaning
ECA	Emission Control Area
ECR	Engine Control Room
ECS	Engine Control System
eg or e.g.	for example (exempli gratia)
EGR	Exhaust Gas Recirculation
ELBA	ELectrical BALancer
ES	Exhaust Side
ESS	Engine Safety System
FAME	Fatty Acid Methyl Esters
FAST	Fuel Actuated Sacless Technology
FCM	Flex Control Module
FCV	Forged Crankshaft Version
FE	Free End
FGSS	Fuel Gas Supply System
FLV	Flow Limiting Valve
FPP	Fixed Pitch Propeller
FQS	Fuel Quality Setting
FS	Fuel Side
FZG	Forschungsstelle für Zahnräder und Getriebebau (gear research center)
GAV	Gas Admission Valve
GSS	Gas Safety System
GTD	General Technical Data
GTU	GaTeway Unit
GVU	Gas Valve Unit
HFO	Heavy Fuel Oil
HFR	High Feed Rate
HP	High Pressure
HT	High Temperature
IACS	International Association of Classification Societies
iCAT	integrated Cylinder lubricant Auto Transfer
ICC	Intelligent Combustion Control
ICM	Intelligent Combustion Monitoring

Short form	Full form, meaning
ICU	Injection Control Unit
ie or i.e.	that is (id est)
iELBA	integrated ELectrical BALancer
iGPR	integrated Gas Pressure Regulation
IMO	International Maritime Organization
Ind.	Indenture
IOM	Input Output Module
ISO	International Standard Organization
JIS	Japanese Industrial Standard
KOH	Potassium hydroxide
LDU	Local Display Unit
LED	Light Emitting Diode
LEL	Lower Explosive Level
LFR	Low Feed Rate
LHV	Lower Heating Value
LLT	Low-Load Tuning
LNG	Liquefied Natural Gas
LP	Low Pressure
LT	Low Temperature
MARPOL	International Convention for the Prevention of Pollution from Ships (MARine POLLution)
MCM	Main Control Module
MCP	Manual Control Panel
MCR	Maximum Continuous Rating
MCU	Main Control Unit
MDO	Marine Diesel Oil
MEG	MonoEthylene Glycol
MEP	Mean Effective Pressure
MGO	Marine Gas Oil
MIM	Marine Installation Manual
MM	Maintenance Manual
Modbus	serial communications protocol published by Modicon
MPG	MonoPropylene Glycol

Short form	Full form, meaning
N/A	not applicable
nil	not illustrated
No.	number
OAT	Organic Acid Technology
OM	Operation Manual
OPI	OPERator Interface (user interface in the engine control room)
PCS	Propulsion Control System
PCV	Pressure Control Valve
PMCC	Pensky Martens Closed Cup method
Pos.	position
PU	Piston Underside
RCS	Remote Control System
REF	Reference
rpm	revolutions per minute
SAC	Scavenge Air Cooler
SAE	Society of Automotive Engineers
SCR	Selective Catalytic Reduction
SCS	Speed Control System
SHD	shutdown
SLD	slowdown
SOI	Start Of Injection
SPC	Spare Parts Catalogue
SPC	Steam Production Control
TC	TurboCharger
TDC	Top Dead Center
UNIC	UNified Controls
USB	Universal Serial Bus
VCU	exhaust Valve Control Unit
VEC	Variable Exhaust valve Closing
VEO	Variable Exhaust valve Opening
VIT	Variable Injection Timing
WECS-9520	WinGD Engine Control System 9520

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Short form	Full form, meaning
WHR	Waste Heat Recovery
WiCE	WinGD Integrated Control Electronics
WinGD	Winterthur Gas & Diesel Ltd.
WLL	Work Load Limit

## 2 Safety

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2.2	Safety precautions and safety rules for natural gas. ....	50

## 2.1 Safety precautions and safety guidelines

### 2.1.1 General safety precautions

Use the data given below as a guide to the personnel.

- **Lighting**

Make sure that there is good permanent lighting in the engine room. Have a sufficient number of hand lamps available at different locations in the engine room.

- **Clean areas**

Keep the engine as clean as possible. Keep the electronic control boxes on the rail unit clean and dry. Make sure that no dust, sand or chemical vapor can go into the engine room.

This will help to prevent a fire in the engine room.

- **Fire**

Make sure that fire-fighting equipment is available in the engine room. Keep covers and casings of the engine closed until the engine is sufficiently cool.

Make sure that no fire extinguisher gases can be automatically released when personnel are in the engine room.

Make sure that the emergency exits are clearly marked.

Make sure that personnel do not smoke in the engine room.

- **Tools**

Put hand-tools in locations where you can easily get access to them. Put special tools and devices in positions in the engine room near the area where you use them.

Make sure that all tools have protection from corrosion.

Make sure that all tools are fixed to prevent from unwanted movement and from damage.

- **Spare parts**

Keep large spare parts as near as possible to the position where they will be installed and near the engine room crane.

Make sure that the spare parts have protection from corrosion.

Make sure that the spare parts are fixed to prevent from unwanted movement and from damage.

Replace used spare parts as soon as possible.

- **Temperature**

Parts of the engine become hot during operation. Be careful and use gloves when you have to touch hot parts with your hands.

- **Frost hazard**

If the ambient air temperature decreases below 0°C and the engine is not in operation, the water in the pipe systems can freeze. To prevent this, drain the pipe systems or increase the temperature in the engine room.

## 2.1.2 General safety guidelines

If you do work at or near the engine, obey the guidelines that follow to prevent risks of harm or damage to personal, to equipment, or to environment.

- **Guidelines for personnel**

Put on the correct safety and protective equipment.

Use fall protection equipment when you work in a height of more than one meter.

Make sure that you know the fire-fighting procedures.

Make sure that you know the health and general safety data and the environment protection data.

Prevent direct contact with operating media or with hot parts.

Only stay on areas that are intended for this.

Do not stay on pipes, valves or fittings.

Do not stay under hanging loads.

Do not put hands or feet under hanging loads.

Keep away from the running engine.

Keep ignition sources away from the engine.

Carry out all work carefully.

- **Guidelines for operation**

Start the engine only if the engine is in good condition.

Keep the safety signs on the engine clean.

Keep unauthorized persons away from the engine.

Clean walk ways and stays regularly.

Open valves and shut-off devices carefully to prevent injury from released media.

Do not use water or cleaning fluid to clean the electronic components and control boxes.

Do not open the relief valve to release pressure during engine operation.

- **Guidelines for service and maintenance**

Keep the tools serviceable, for example calibrate gauges regularly.

Use the correct tools in a correct way, for example lifting devices and ropes.

Protect lifted parts with applicable materials.

Do work inside the engine with a safety person on the outside.

Put covers or protection on opened openings or on removed sealing faces.

Attach removed parts in the engine room to prevent movement of the parts.

Replace O-rings during an overhaul of components.

Make sure that after installation all pipes and items are fixed correctly.

Use lock wires, tab washers, and lock plates one time only.

Before you assemble screws and studs in very hot areas, apply on the threads a lubricant that is resistant to high temperatures.

- **Guidelines for hot work: General**

Hot work means any work requiring the use of electric arc or gas welding equipment, cutting burner equipment or other forms of naked flame, as well as heating or spark generating tools, regardless of where it is carried out on board.

The Safety Management System (SMS) on board must include guidance on control of hot work and which must ensure compliance.

Always use safe workspaces to perform any hot work.

Hot work performed outside of safe workspaces must respect the guidelines below:

- **Guidelines for hot work: Outside of safe workspaces**

The safety officer ensures that the hot work is carried out safely.

The safety officer provides a permit to everybody related to hot work.

Hot work procedures must follow national laws, regulations and any other national safety and health regulations.

Another safety officer must ensure that safety procedures are followed.

All officers follow a written instruction plan.

The work area must be completely isolated before the hot work starts.

Review the fire safety precautions. This includes: firefighting equipment preparations, designation of a fire watch in all nearby areas and fire-extinguishing measures.

Continue the isolation of the workspaces and the fire safety precautions until the risk of fire no longer exists.

Protect components like the turbocharger silencer, ECS electronic control boxes and cables, with a cover.

- **Guidelines for hot work: inside the engine room**

Stop the engine before doing an electric welding.

Set the engine room fire extinguisher to Manual mode.

Isolate the work area.

Make sure that emergency exits are open and cleared.

Make sure that telecommunication or radio communication operates correctly.

Set to OFF the electronic module system and wait for one minute.

Disconnect the electronic modules and sensors near the work area.

Make sure that there are no explosive fluids or gases in the work area.

Put the earthing connection as near as possible to the work area.

Make sure that welding cables have no loops.

Make sure that welding cables lie parallel to the cables of electronic units.

Only use DC power supply and OCV below 70 volts.

Make sure that the connection clamp is near to the work area.

Make sure that electronic parts have protection to prevent damage from sparks and heat.



- **Guidelines for work with hydraulic tools**

Always use personal protection safety goggles and safety gloves while operating hydraulic tools.

Check high pressure double walled hydraulic hoses for any damages before operation.

Check all connection points from the pump to the hydraulic tool for leaks during pressure build-up.

Make sure the pressure gauges are properly calibrated before operation. Applied oil pressure must be within a range of +/-5 bar of the specified pressure for each stud type and size.

## 2.2 Safety precautions and safety rules for natural gas

### 2.2.1 General

High concentrations of natural gas can cause dizziness and there is a risk of suffocation. Make sure that all related spaces have good airflow.

Natural gas in low concentration is not dangerous to personnel.

Natural gas can be dangerous in a gas engine installation. Gas leakage into the engine room can cause fires and explosions.

An explosion also can occur, if unburned gas flows into the exhaust gas system.

### 2.2.2 Definition of gas hazardous zones

The definitions of hazardous zones refer to IEC 600092-502:1999 and are as follows:

- **Zone Z0**

This is an area in which an explosive gas atmosphere is continuously present or is present for long periods.

Examples - Combustion chamber, gas pipes

- **Zone Z1**

This is an area in which an explosive gas atmosphere can be present during usual operation or during unusual operating conditions.

Examples - Piston under side, space of double wall pipe

- **Zone Z2**

This is an area in which an explosive gas atmosphere usually is not present or is present only for short periods, for example if a leakage occurs.

Examples - Exhaust gas system

The engine room and the engine crankcase are given as gas safe non-hazardous areas. Thus they do not refer to the definitions of hazardous zones.

### 2.2.3 Precautions for work in gas hazardous zones

If you do work in a gas hazardous zone, obey the rules that follow to prevent risks of harm or damage to personal, to equipment, or to environment:

- Make sure that you have completed the safety training.
- Make sure that you have the necessary qualification.
- Make sure that you have the permission of the safety officer.
- Ask for the aid of one more person.
- Make sure that the fuel gas system has no pressure.
- Make sure that the remaining gas in the fuel gas system is replaced with inert gas (for example nitrogen).
- Make sure that the airflow is sufficient for the work area.
- Make sure that related systems are prevented from an unwanted start. Use the lock-out and tag-out practice.
- Use a handheld gas detector.
- Do not use systems and devices that can cause a spark, for example a cigar lighter, matches, etc.
- Do not smoke or start a fire.
- Put on antistatic clothes.
- Make sure that your safety shoes are in good condition. Steel toe caps can cause sparks.
- Use only approved tools that do not cause sparks and test equipment that will not cause an explosion.
- Do not use digital cameras, mobile phones or other electronic devices (for example radios, CD-players).
- Use only intrinsically safe and approved MSHA two-way radios and transceivers.
- Use only approved light sources (safety flashlights).
- If you do welding, obey the instructions of the responsible safety officer and the primary contractor. Make sure that the responsible safety officer does checks during the welding work.
- Read and obey the safety procedures for the ship or for the engine room (for example security plan, warnings, life-saving devices, escape routing, meeting point, gas hazardous zones, special instructions on the safety notice board).
- Keep your work area clean. Remove flammable material immediately.

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## 3 General data for maintenance

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## 3.1 Lifting tools

The permissible capacities of the engine crane, lifting tools, ropes, chains, lifting eye bolts, etc. must always correspond with the weights of the parts to be lifted.

**NOTE:** The admissible lifting (max. loading) capacity in kg corresponds to the WLL = Working Load Limit.

For fitting and removal of engine components or their transportation, only the tools which are in perfect condition and intended for this purpose may be used. Ropes which have begun tearing or otherwise are defective and tools which are damaged have to be exchanged.

For safe and proper handling of crane, suspension tools or transport of loads we recommend to proceed as follows for safety reasons:

- Determination of the weight of load
- Determination of the suspension centres and weight distribution
- Choice of attachment elements
- Attaching and disconnecting.

### CAUTION

**If tools are combined (for example beams with shackles, RUD-eye bolts or RUD-swivel lugs and ropes, etc.), it is always the weakest element which determines the maximum lifting capacity.**

### 3.1.1 Wire rope slings

The lifting capacity of the wire rope slings is listed under their tool number in the tools list.

### 3.1.2 Span-sets (round slings)

Span-sets have the advantage of easy and simple handling. The code and the color normally indicate the maximum admissible total load. Loops and knots in the span-sets reduce their lifting capacity by one third.

### 3.1.3 Eye bolts and eye nuts

Only those eye bolts and eye nuts may be used which are in accordance with DIN 580 & 582:2003-08 or which fulfil or exceed these values, including the safety factor.

All calculations for components and tools where eye bolts and eye nuts are used are laid out accordingly and based on the mentioned standards.

**Tab 3-1 Lifting capacities (for information only)**

Thread size	Lifting capacity [kg]	
	single-strand	double-strand (45 degree) <sup>1</sup>
M8	140	100
M10	230	170
M12	340	240
M16	700	500
M20	1200	860
M24	1800	1290
M30	3200	2300
M36	4600	3300
M42	6300	4500
M48	8600	6100
M56	11500	8300

- <sup>1</sup> Full load is only permissible in the direction of the ring, thus the eye bolts or eye nuts must be put to the right position, if necessary by using distance rings.

The details listed in the table above are based on DIN 580 & 582:2003–08. The values are only applicable, if the eye bolt or the eye nut obeys the rules that follow:

- It is completely turned in or screwed down.
- It is flat and fully on the seating surface.
- You have checked it for visible damages (for example corrosion, deformation) before you use it.

Also obey the data that follows:

- If there are through holes, a washer should be placed from the opposite side under the nut or screw head.
- Whenever possible, do not apply an angle of inclination bigger than 45° (in all directions with regard to the ring level), and especially avoid lateral pulling.
- For varying use on different objects to be carried, eye nuts or eye bolts with thread diameters one size higher should be used.

### 3.1.4 RUD-eye bolts and RUD-swivel lugs

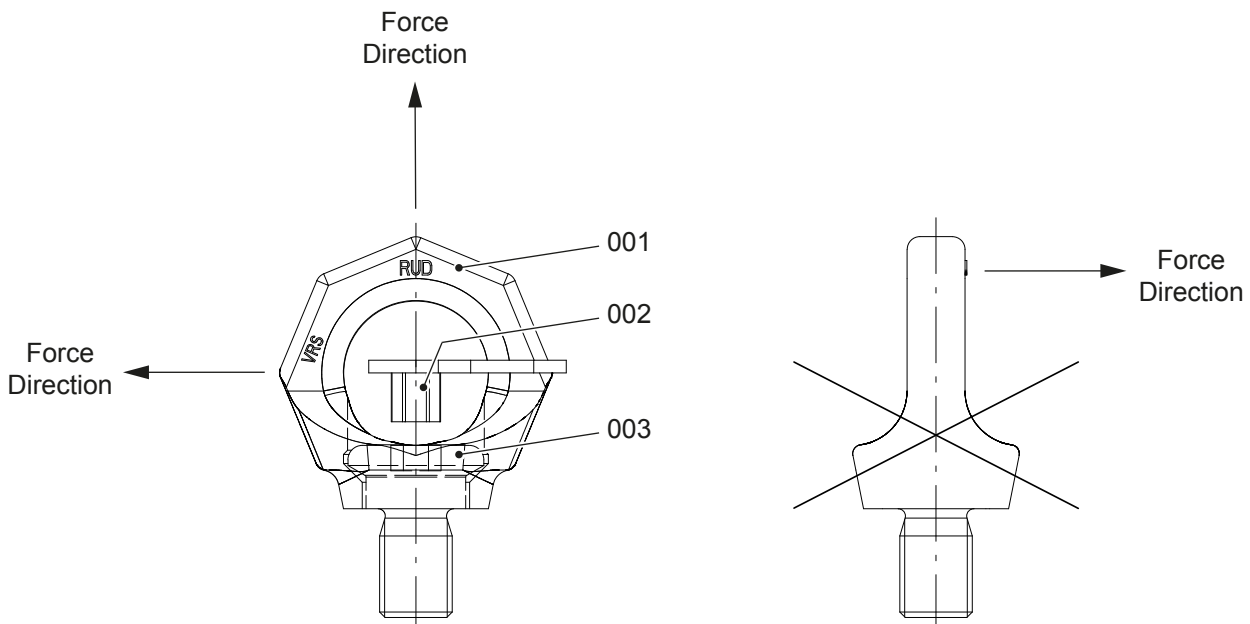
Only those RUD-eye bolts and RUD-swivel lugs may be used with a safety factor 4.

**NOTE:** For more data refer to the documentation of the manufacturer (RUD Ketten Rieger & Dietz GmbH u. Co, Friedensinsel, D-73432 Aalen, Germany, [www.rud.com](http://www.rud.com)).

### 3.1.4.1 Use of RUD-eye bolts

- The RUD-eye bolts must be completely screwed down, lying fully on the seating surfaces.
- The RUD-eye bolts are hand-screwed with their own star-profile wrenches (do not use any extension).
- In order that after tightening the ring of the RUD-eye bolt can freely turn, the star-profile wrench must be removed from the inner hexagon of the screw.
- Prior to loading the RUD-eye bolt adjust it in force direction (RUD-eye bolts are not suitable to be turned under load).
- Lateral loading is permitted in no circumstances (see [Figure 3-1](#)).

**Fig 3-1 RUD-eye bolts**



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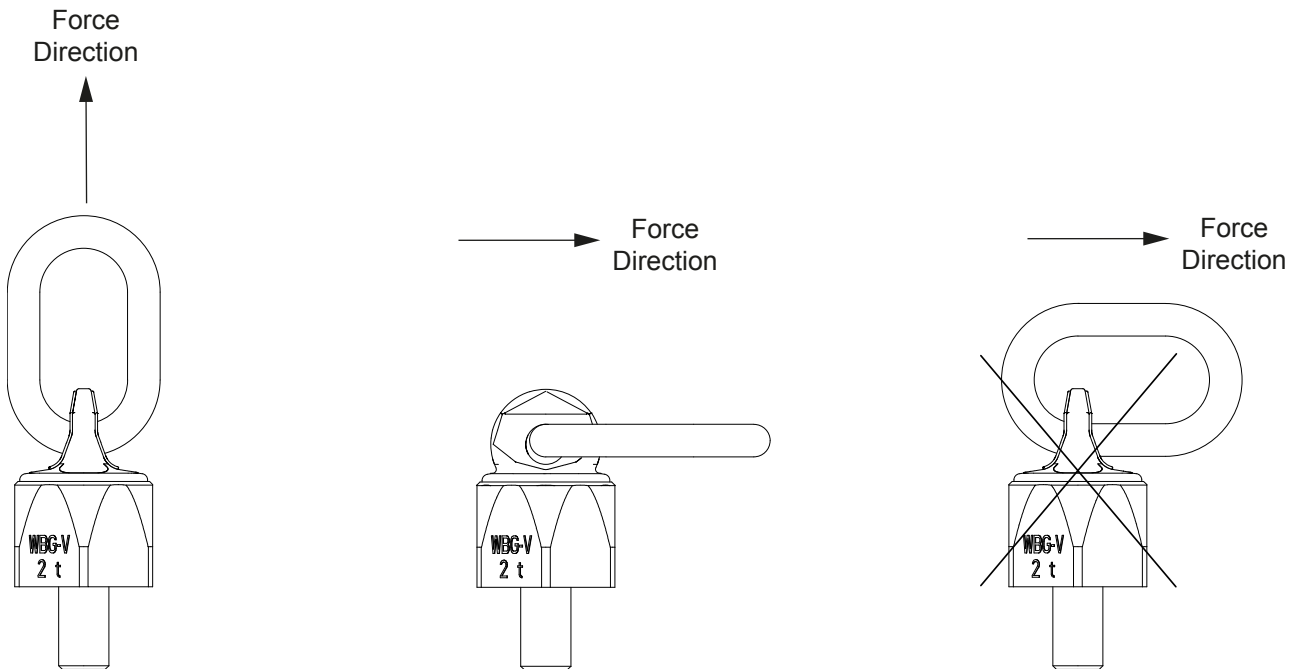
#### Legend

- |     |                     |     |       |
|-----|---------------------|-----|-------|
| 001 | Ring                | 003 | Screw |
| 002 | Star-profile wrench |     |       |

### 3.1.4.2 Use of RUD-swivel lugs

- The RUD-swivel lugs must be completely screwed down, lying fully on the seating surfaces.
- The RUD-swivel lugs are hand-screwed with an open end wrench.
- Prior to loading the RUD-swivel lug adjust it in force direction.
- Loading as shown in [Figure 3-2](#) should be avoided if possible.



**Fig 3-2 RUD-swivel lugs**

00285

### 3.1.5 Shackles

Only those shackles may be used which are in accordance with American Standard RR-C-271A or which fulfil or exceed these values, including the safety factor.

All calculations for components and tools where shackles are used are laid out accordingly and based on the mentioned standards.

Normally, the permissible lifting capacity of the shackles is specified for one single strand.

## 3.2 Jointing compounds

Tab 3-2 Jointing compound

Jointing compound	Hardener	Adhesive primer	Manufacturer
Elastosil RT 622 A	RT 622 B	G 790	Wacker-Chemie GmbH Geschäftsbereich Silicone Hanns-Seidel-Platz 4 D-81737 München
Silcoset 105 RTV	Silcoset Curing Agent A	Silcoset Primer	Ambersil House Ltd. Wylds Road Bridgwater Somerset TA6 4DD England

**NOTE:** Use only the data in the related manufacturer's instructions to mix and apply the jointing compounds, hardeners and adhesive primers.

Materials from other manufacturers are permitted, but must have the qualities as follows:

- The materials must not contain acid.
- The materials must be resistant to oil, marine diesel oil, heavy fuel oil and water at a temperature of 100°C.
- A short age-hardening time is necessary, that is not more than 24 hours (refer to the data in the ISO standard reference conditions).
- The materials must flow easily to fill the area around the sealing surface (that is no air pockets).
- The materials must have good adhesion qualities on primed metal surfaces.
- The materials must be easy to prepare and combine.
- The surface shrinkage must be very small, or none.
- The jointing compound must stay in an elastic condition. This will help you if it becomes necessary to remove the elastic studs.

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### 3.3 Clearances - general

The chapter that follows gives the values for each group of components.

The values given in the columns "Nominal dimension" in the tables that follow are related to design and manufacturing values, or to the settings on a new engine.

The values given in the columns "Maximum dimension" are the possible results after a long period of operation. The differences in the clearances must not be less than or more than those given.

On components where the clearance is adjustable (changed thickness of shims, discs, spacers etc.) the values must be those given in column "Nominal dimension". If this is not possible, you must replace worn parts with standard new parts, or reconditioned parts with applicable material build-up.

If, during an overhaul, clearances are measured that are almost at the permitted limit, personnel has two alternatives:

- Replace the item immediately.
- Let the item stay installed until the next overhaul.

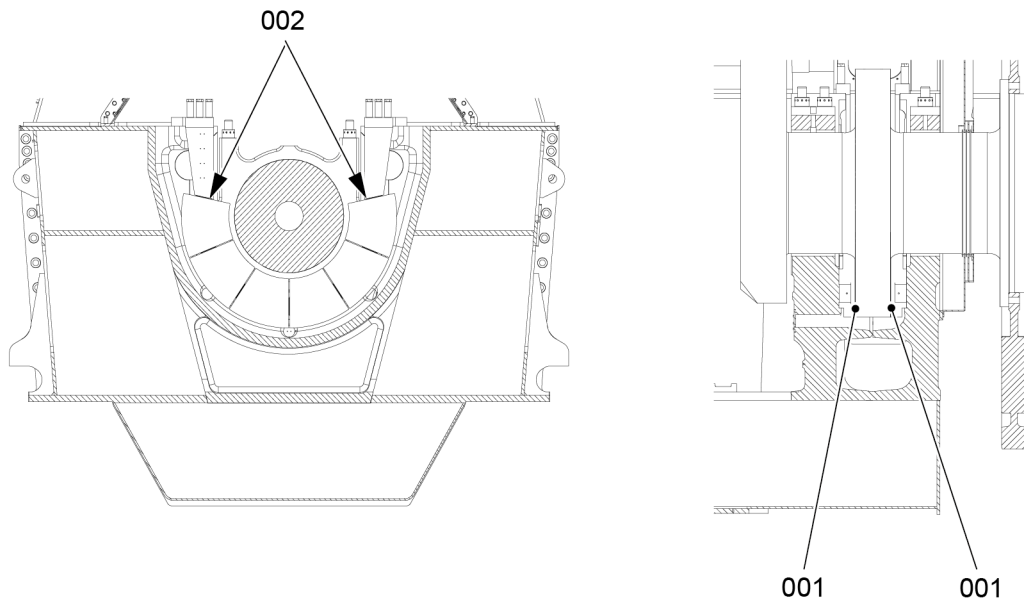
This is related, for example, on the length of the next operation period until the next overhaul and the possible wear of components.

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### 3.4 Clearances

#### 3.4.1 Crankshaft and thrust bearing

Fig 3-3 Crankshaft and Thrust Bearing



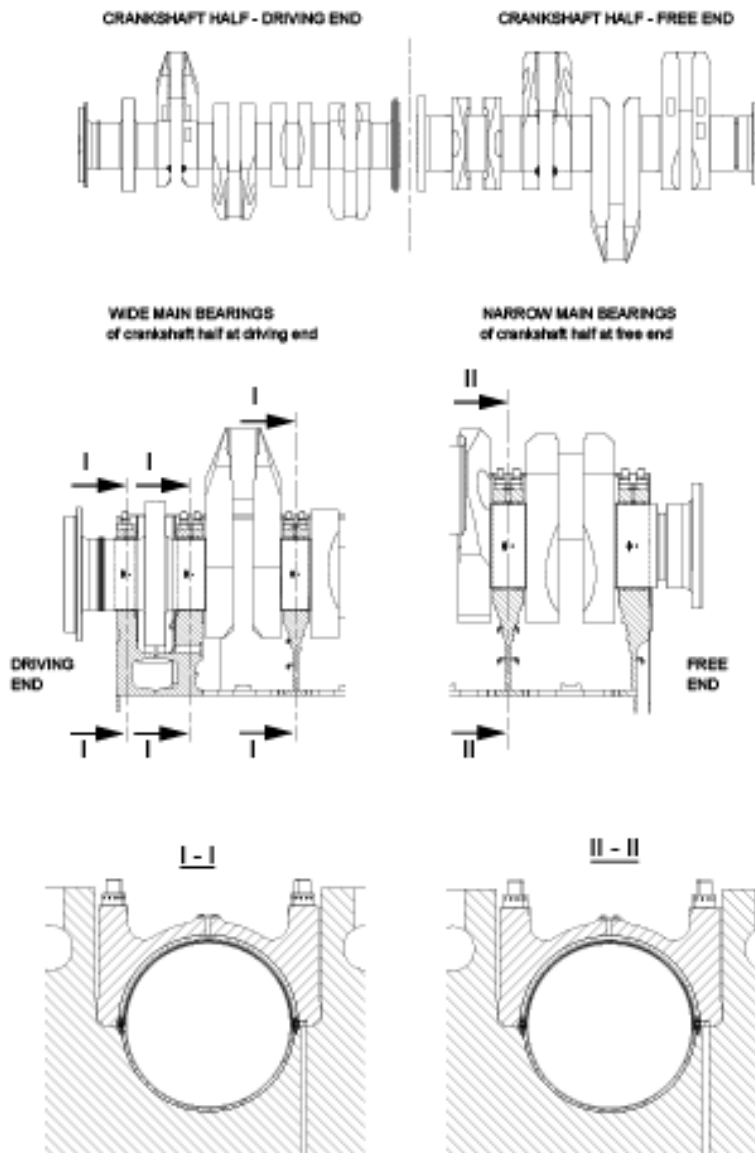
00635

Tab 3-3 Crankshaft and thrust bearing - clearances

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
1203		Thrust bearing			
1224		Thrust bearing pad	Thickness	130 <sup>-0.5</sup> <sub>-0.6</sub>	
	001	Thrust bearing clearance	Axial (total)	0.8 to 1.3	2.5
	002	Clearance between thrust pad and bracket	Each side	3.0	

### 3.4.2 Crankshaft and main bearings

Fig 3-4 Crankshaft and Main Bearing



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**Tab 3-4 Crankshaft and main bearings**

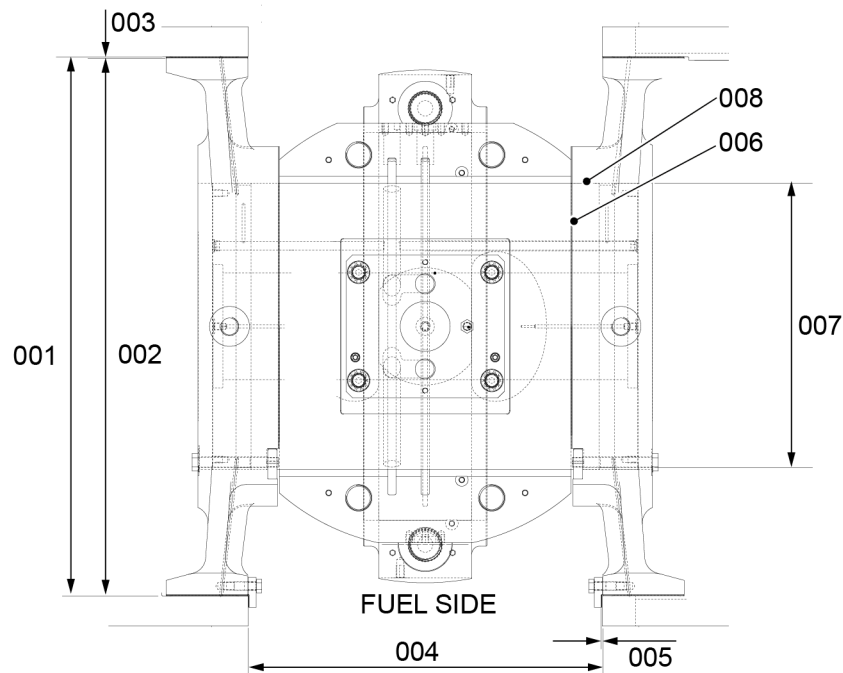
Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
1132		Narrow main bearings of crankshaft half at free end			
	001	Bearing clearance	Vertical	+0.40 to +0.75	0.95
1132		Wide main bearing of crankshaft half at driving end			
	002	Bearing clearance	Vertical	+0.40 to +0.75	0.95

**NOTE:** All main bearing clearances are only applicable when the tie rods studs are tight.



### 3.4.3 Crosshead guide

Fig 3-5 Crosshead Guide



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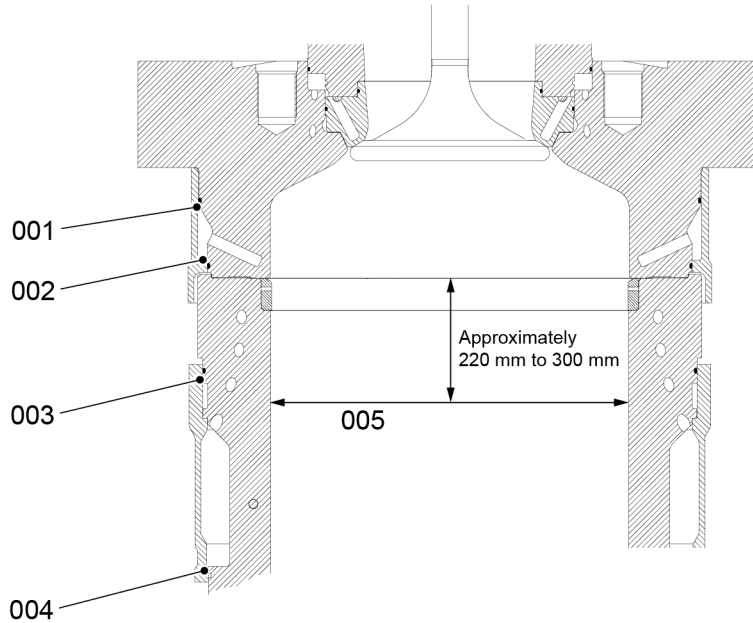
Tab 3-5 Crosshead guide

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
3326		Crosshead guide			
	*003	Guide-way clearance		0.20 to 1.35	1.50
	005	Guide rail, lateral clearance	Total	0.60 to 2.00	2.5
	006	Guide shoe, lateral clearance	Total	0.10 to 0.60	
	007	Crosshead pin	Outer diameter	820 <sup>0</sup> <sub>-0.09</sub>	
	008	Bearing clearance	Radial	0.09 to 0.22	0.25

**NOTE:** For the instructions to measure the clearances, refer to the related procedure. The clearance \*003 is applicable only when the tie rods are correctly tightened.

3.4.4 Cylinder liner

Fig 3-6 Cylinder Liner



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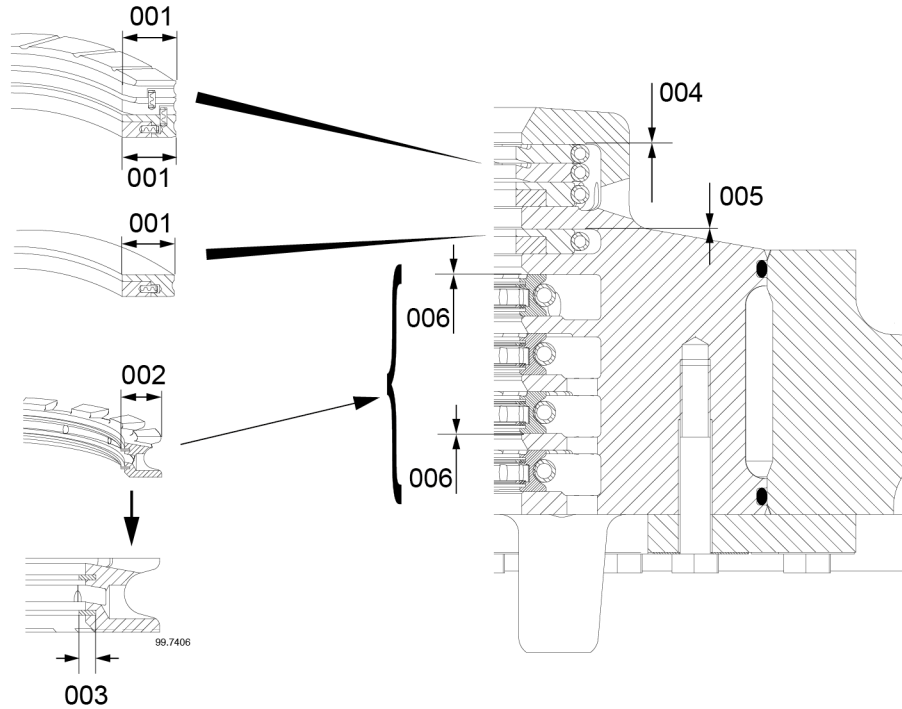
Tab 3-6 Cylinder liner

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
2130		Water guide jacket on cylinder cover			
	001	Clearance	Total	0.60 to 1.00	
	002	Clearance	Total	1.60 to 2.00	
	003	Clearance	Total	0.30 to 0.70	
	004	Clearance	Total	0.60 to 1.00	
2124		Cylinder liner			
	*005	Cylinder liner bore	Radial	820	825.7

**NOTE:** \* = Measure the cylinder liner bore at the location shown.

### 3.4.5 Piston rod gland

Fig 3-7 Piston rod gland



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Tab 3-7 Piston rod gland

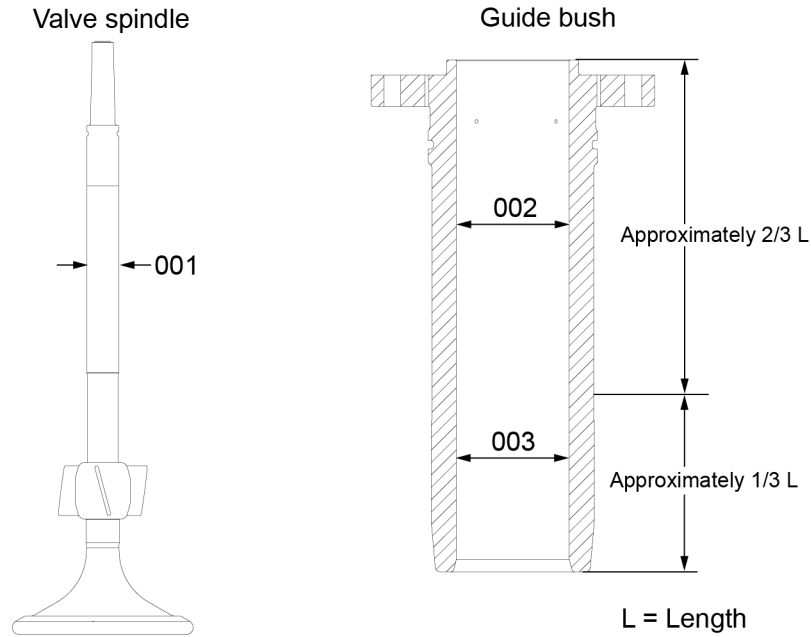
Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
2303		Piston rod gland			
	*001	Ring width	Radial	31	Minimum 25
	*002	Ring width	Radial	24	Minimum 22.20
	*003	Ring width	Radial	5	Minimum 3.20
	004	Ring clearance	Axial	0.05 to 0.19	0.40
	005	Ring clearance	Axial	0.05 to 0.13	0.40
	006	Ring clearance	Axial	0.10 to 0.17	0.40

**NOTE:** \* = ring wear

The different values between the nominal dimension and maximum wear is equal for all rings. Also for rings that are less than the nominal dimension.

3.4.6 Exhaust valve

Fig 3-8 Exhaust valve



00640

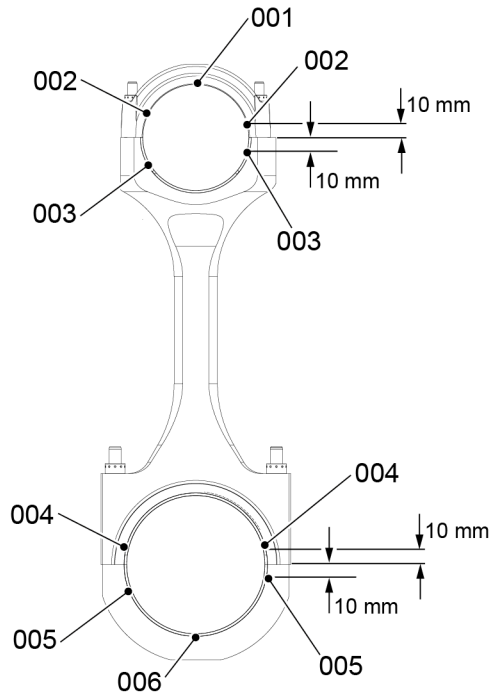
Tab 3-8 Exhaust valve - spindle and guide bush

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
2754		Valve spindle			
	001	Spindle	Outer diameter	75 <sup>-0.29</sup> <sub>-0.33</sub>	79.50
2751		Guide bush			
	*002	Bore	Inner diameter	75 <sup>+0.03</sup> <sub>-0</sub>	75.45
	*003	Bore	Inner diameter	75 <sup>+0.03</sup> <sub>-0</sub>	76.45

NOTE: \* = Measure the guide bush bore at the locations shown.

**3.4.7 Connecting rod - top and bottom end bearings**

**Fig 3-9 Connecting rod - top and bottom end bearings**



00641

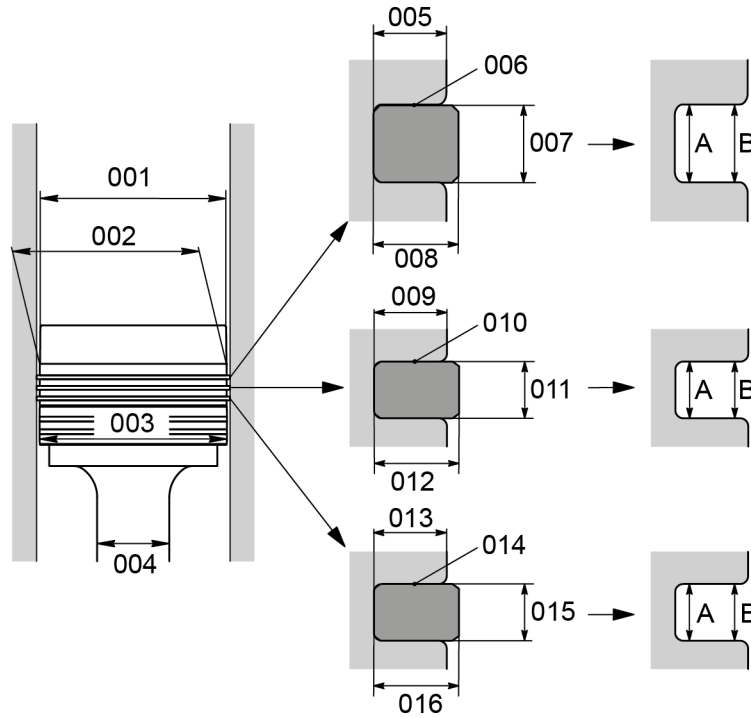
**Tab 3-9 Connecting rod - top and bottom end bearings**

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
3303, 3326		Top end bearing			
	001	Bearing clearance	Vertical	0.55 to 0.85	1.0
	*002	Lateral clearance	Total	0.60 to 0.85	
	*003	Lateral clearance	Total	0.50 to 0.75	
3303		Bottom end bearing			
	004	Bearing clearance	Vertical	0.60 to 0.90	1.05
	*005	Lateral clearance	Total	0.70 to 1.00	
	*006	Lateral clearance	Total	0.70 to 1.00	

**NOTE:** \* = Measure the lateral clearances at the locations shown.

### 3.4.8 Piston and piston rings

Fig 3-10 Piston and piston rings



00643

Tab 3-10 Piston and piston rings

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
3406		Piston head - ring grooves			
	007	Top groove - height	Vertical	24 <sup>+0.60</sup> <sub>+0.55</sub>	
	011	Middle groove - height	Vertical	16 <sup>+0.50</sup> <sub>+0.45</sub>	
	015	Bottom groove - height	Vertical	16 <sup>+0.50</sup> <sub>+0.45</sub>	
	005	Top groove - depth	Radial	27 <sup>+0.2</sup> <sub>+0</sub>	
	009	Middle groove - depth	Radial	27 <sup>+0.2</sup> <sub>+0</sub>	
	013	Bottom groove - depth	Radial	27 <sup>+0.2</sup> <sub>+0</sub>	
3409		Piston skirt			
	003	Skirt	Outer diameter	817.1 <sup>-0</sup> <sub>-0.2</sub>	Minimum 814.9

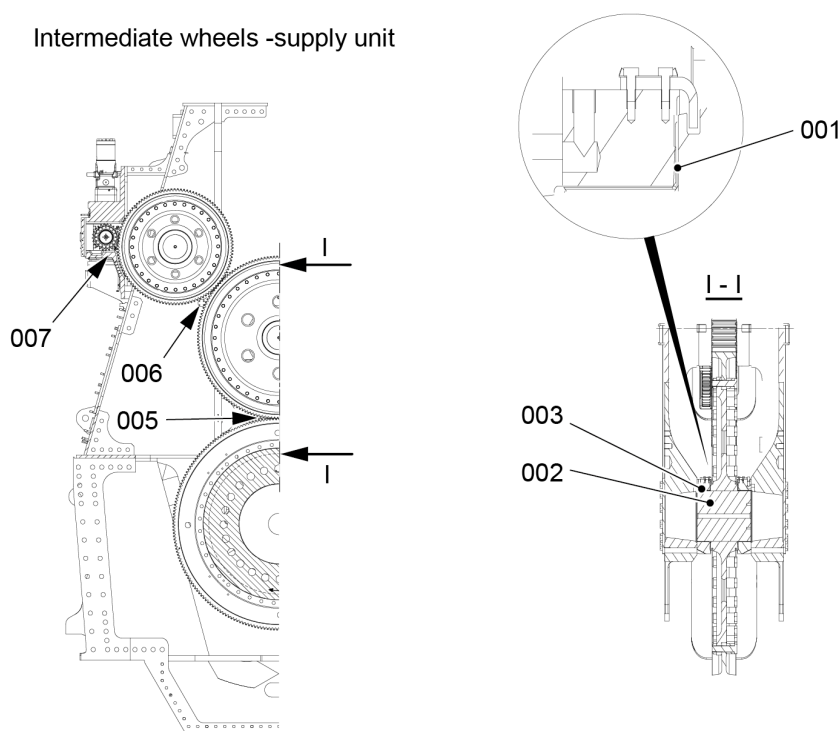
Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
3415		Piston rod			
	004	Rod	Outer diameter	$324^{+0.062}_{-0.119}$	Minimum 322.9
3425		Piston rings			
	007	Top ring - height	Vertical	$24^0_{-0.05}$	
	011	Middle ring - height	Vertical	$16^0_{-0.03}$	
	015	Bottom ring - height	Vertical	$16^0_{-0.03}$	
	006	Top ring - clearance	Vertical	0.50 to 0.58	Point A - 0.80 Point B - 1.00
	010	Middle ring - clearance	Vertical	0.45 to 0.53	Point A - 0.75 Point B - 0.95
	014	Bottom ring - clearance	Vertical	0.45 to 0.53	Point A - 0.75 Point B - 0.95
	008	Top ring - width	Radial	$26 \pm 0.25$	
	012	Middle ring - width	Radial	$26 \pm 0.40$	
	016	Bottom ring - width	Radial	$26 \pm 0.40$	

**NOTE:** Piston rings that were installed before can be installed again if they will stay in their minimum ring width until the next overhaul. If the same piston rings and piston head will be installed again, you can find estimates of wear in the related sections.

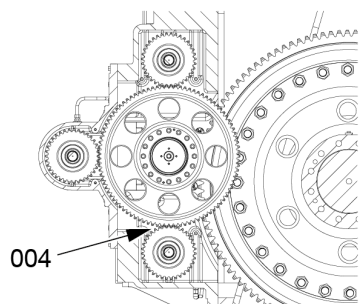
### 3.4.9 Supply unit - drive wheels

Fig 3-11 Supply unit - drive wheels

Intermediate wheels -supply unit



Intermediate wheel - servo pump unit



00644



Tab 3-11 Supply unit - drive wheels

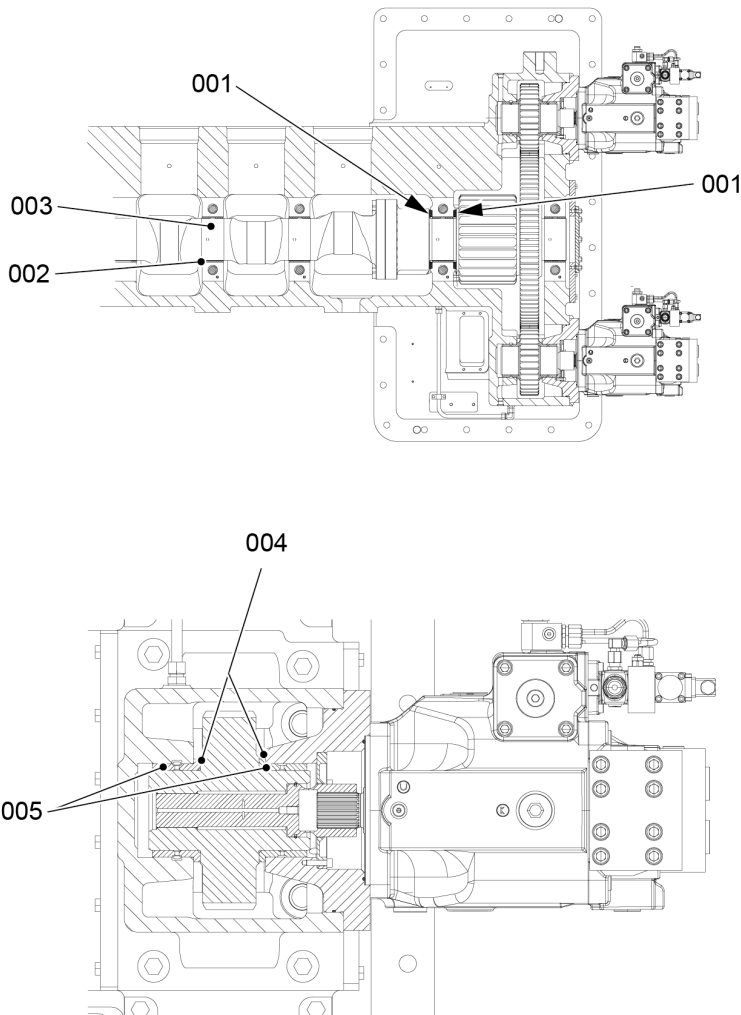
Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Nominal dimension (usual, new) [mm]
4104		Intermediate wheel			
	001	Axial clearance	Total	0.60 to 1.10	1.5
	003	Bearing clearance	Vertical	*0.096 to 0.170	0.27
	004	Tooth backlash		0.24 to 0.39	0.61
	005	Tooth backlash		0.24 to 0.39	0.59
	006	Tooth backlash		0.33 to 0.53	0.76
	007	Tooth backlash		0.33 to 0.52	0.75

**NOTE:** The backlash must be measured longitudinally along the tooth crown.

**NOTE:** \* = This clearance can only be measured when the intermediate wheel is disassembled.

**3.4.10 Fuel and servo pump units**

**Fig 3-12 Fuel and servo pump units**



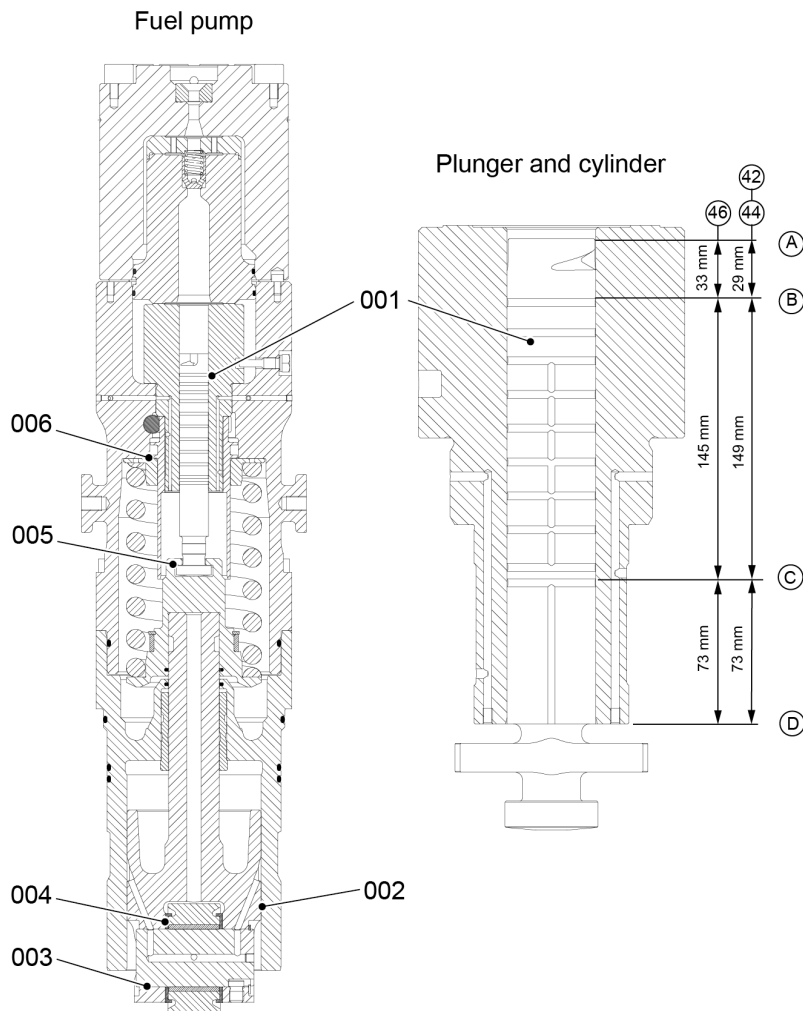
00645

**Tab 3-12 Fuel and servo pump units**

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
5581		Fuel pump unit			
	001	Axial clearance	Total	0.30 to 0.65	0.81
	002	Bearing clearance	Radial	0.153 to 0.237	0.33
5591		Servo pump unit			
	004	Axial clearance	Total	0.30 to 0.70	0.90
	005	Axial clearance	Total	0.25 to 0.54	0.74

3.4.11 Fuel pump

Fig 3-13 Fuel pump



00647

Tab 3-13 Fuel pump

Location code	Key	Item	Measured direction	Nominal dimension (usual, new) [mm]	Maximum clearance dimension (because of wear) [mm]
5556		Fuel pump			
		Plunger (diameters 40 mm, 44 mm and 46 mm)			
	001	Clearance (plunger / cylinder) A-B	Radial	0.035 to 0.038	0.045
		Clearance (plunger / cylinder) B-C	Radial	0.025 to 0.028	0.035
		*Clearance (plunger / cylinder) D	Radial	0.040 to 0.043	0.5
		Clearance	Radial	0.22 to 0.68	0.8
	005	Piston/bottom spring carrier	Axial	0.12 to 0.24	0.3
	006	Regulating sleeve / top spring carrier	Axial	0.5 to 0.7	0.8
5556		Roller guide			
	003	Pin	Outer diameter	$80^{0}_{-0.013}$	
		Guide piston (bore)	Inner diameter	$80^{+0.04}_{+0.01}$	
		Clearance	Radial	0.010 to 0.053	0.08
	004	Total clearance between the guide piston and the roller with pressure discs	Axial	0.26 to 0.54	0.7

**NOTE:** The plunger is machined in the range C to D, thus there is an increase of 0.015 mm in diameter.

### 3.5 Torque values - standard screws

WinGD highly recommends to use the torque values given in [Table 3-15 - Torque values - standard screws](#) for all standard metric screws of grade 8.8.

Lubricate the threads and base of the head of the screws with oil SAE 30.

For the screws in high temperature areas (exhaust pipes, expansion pieces etc.), use a heat resistant lubricant, for example Never Seez NSBT8. Then you have to decrease the torque values, refer to [Table 3-14 - Torque value - applicable decrease](#).

These torques values do not apply to turbocharger installations. Refer to the documents of the turbocharger manufacturer for the correct torque values.

**Tab 3-14 Torque value - applicable decrease**

Lubricant	Applicable torque decrease
Molyslip copaslip	8% (0% to 15%)
Never Seez regular grade (NSBT8)	24% (17% to 30%)
Molykote paste G-n Plus	27% (20% to 33%)

**Tab 3-15 Torque values - standard screws**

Standard thread - Grade 8.8	Fine thread - Grade 8.8	Torque value [Nm]
M3	M3 x 0.35	0.9
M4	M4 x 0.5	2.1
M5	M5 x 0.5	4.2
M6	M6 x 0.75	7.2
M8	M8 x 1	18
M10	M10 x 1.25	35
M12	M12 x 1.25	60
M14	M14 x 1.5	94
M16	M16 x 1.5	145
M18	M18 x 1.5	200
M20	M20 x 1.5	280
M22	M22 x 1.5	380
M24	M24 x 2	490
M27	M27 x 2	720
M30	M30 x 2	980
M33	M33 x 2	1300
M36	M36 x 3	1700
M39	M39 x 3	2200
M42	M42 x 3	2700
M45	M45 x 3	3400
M48	M48 x 3	4100
M52	M52 x 3	5300
M56	M56 x 4	6600
M60	M60 x 4	8100

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## 4 General maintenance procedures

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4.3	Loosen a round nut with a pre-tensioner. ....	88
4.4	Do a check of the pre-tension. ....	92

## 4.1 Do maintenance work - general procedure

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to the Operation Manual.

## PROCEDURE

- 1 Make sure that the pressure in all pipes is released.
- 2 Make sure that you know the procedure for the access to engine spaces, refer to the Operation Manual.
- 3 Make sure that no personnel and components are in the danger areas (crankcase, piston underside, propeller shaft, etc.).
- 4 Prevent the crankshaft from turning.
  - 4.1 Engage the turning gear and make sure that the lever is locked.
  - 4.2 If necessary, do more related work.

**NOTE:** Water current (for instance if the ship is tugged) can cause the propeller shaft to turn.
- 5 Make sure the all related spaces have good airflow, for example if CO<sub>2</sub> was used to extinguish a fire.
- 6 If necessary, install the work platforms in the crankcase.
  - 6.1 Install the platform (94143) on the longitudinal beam of the column door and the crank.
  - 6.2 Install the adjustable platform (94142) at the applicable height on the steps in the columns.

## CLOSE UP

- None

## 4.2 Tighten a round nut with a pre-tensioner

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
HP oil pump	94931		pc 1
HP hose	A/R		pc 1
Hydraulic unit	94942		pc 1
Round bar - kit	94005		pc 1
Pre-tensioner	A/R		A/R

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

## PRELIMINARY OPERATIONS

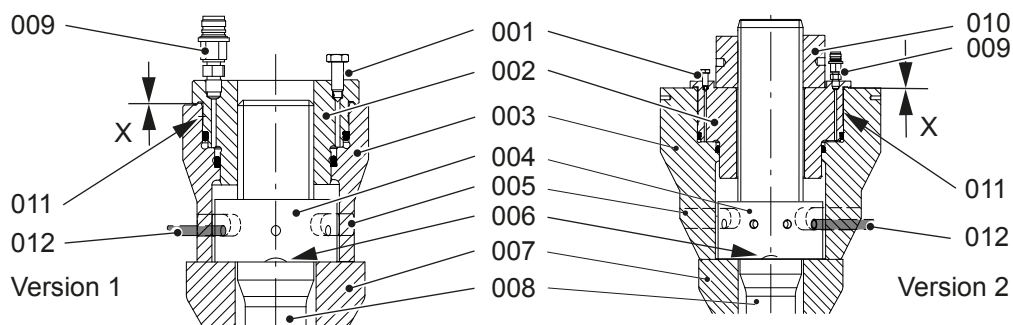
- The engine must be stopped.

## PROCEDURE

- 1 Make sure that the threads of the elastic stud (008, [Figure 4-1](#)), of the round nut (004) and of the pre-tensioner are smooth and clean.
 

**NOTE:** If you have to install the complete set of elastic studs, obey the sequence given in the related figures (refer to section [16.1 Tightening instructions](#)).
- 2 Apply the applicable lubricating agent to the thread of the elastic stud (008) and surfaces that touch on the plate (007), refer to section [16.1 Tightening instructions](#).
- 3 Turn the round nut (004) moderately down to the plate (007).
- 4 If necessary, put one reference mark on the round nut (004) and one on the plate (007).
- 5 Put the applicable pre-tensioner on the elastic stud (008).
  - 5.1 If the piston (002) is attached directly on to the elastic stud (008) (version 1), do the steps that follow:
    - 5.1.1 Turn the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 5.1.2 Make sure that there is no clearance at X.
  - 5.2 If the piston (002) is attached with the nut (010) to the elastic stud (008) (version 2), do the steps that follow:
    - 5.2.1 Put the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 5.2.2 Turn the nut (010) on the elastic stud (008) down to the piston (002).
    - 5.2.3 Make sure that there is no clearance at X.

**Fig 4-1 Tighten a round nut (examples)**



00533

- 6 If necessary, turn back the cylinder (003) a small distance to get good access to the applicable slot (005) of the pre-tensioner.
- 7 Connect the pre-tensioner to the HP oil pump or to the hydraulic unit at the connection (009).
- 8 Fill the pre-tensioner with oil.
  - 8.1 Open the vent screw (001) on the pre-tensioner.
  - 8.2 Operate the HP oil pump or the hydraulic unit until oil that has no air flows out at the vent screw (001).
  - 8.3 Stop the HP oil pump or the hydraulic unit to prevent injury.
  - 8.4 Carefully close the vent screw (001) on the pre-tensioner.
- 9 Slowly increase the pressure to get the related tightening value (refer to the name plate on the pre-tensioner).

**NOTE:** Make sure that the piston (002) does not move above the limit of the red groove (011).

**NOTE:** If you have to install the complete set of elastic studs, do the procedure in two steps as noted.

- 10 Keep the applied pressure constant.
- 11 Tighten the round nut (004).
  - 11.1 Get the applicable round bar (012) from the round bar kit.
  - 11.2 Put the round bar (012) through the slot (005) into a hole of the round nut (004).
  - 11.3 Turn the round nut (004) moderately down to the plate (007).
  - 11.4 Put the feeler gauge through the groove (006) to make sure that there is no clearance between the round nut (004) and the plate (007).
  - 11.5 If there is a clearance, turn the round nut (004) more down.
  - 11.6 Remove the round bar (012).
- 12 Release the pressure on the HP oil pump or on the hydraulic unit to zero.
- 13 Disconnect the pre-tensioner from the HP oil pump or from the hydraulic unit.
- 14 Remove the pre-tensioner from the elastic stud (008).
- 15 If necessary, compare the angle between the reference marks and the control value in the related table (refer to section [16.1 Tightening instructions](#))).

**NOTE:** For the tie rod you compare the difference in the lengths.
- 16 If there is a large difference, find the cause and eliminate the fault.

## CLOSE UP

- None

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## 4.3 Loosen a round nut with a pre-tensioner

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
HP oil pump	94931		pc 1
HP hose	A/R		pc 1
Hydraulic unit	94942		pc 1
Round bar - kit	94005		pc 1
Pre-tensioner	A/R		A/R

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

## PRELIMINARY OPERATIONS

- The engine must be stopped.



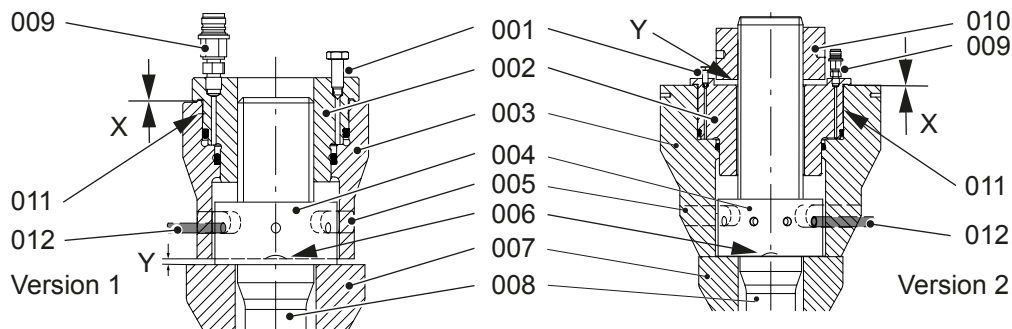
## PROCEDURE

- 1 Make sure that the threads of the elastic stud (008, [Figure 4-2](#)) and of the pre-tensioner are smooth and clean.
- 2 Put the applicable pre-tensioner on the elastic stud (008).
  - 2.1 If the piston (002) is attached directly on to the elastic stud (008) (version 1), do the steps that follow:
    - 2.1.1 Turn the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 2.1.2 Make sure that there is no clearance at X.
    - 2.1.3 Turn back the pre-tensioner with the related number of turns (refer to the name plate on the pre-tensioner) to get a clearance at Y.

**NOTE:** This prevents problems when you remove the pre-tensioner.
  - 2.2 If the piston (002) is attached with the nut (010) to the elastic stud (008) (version 2), do the steps that follow:
    - 2.2.1 Put the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 2.2.2 Turn the nut (010) on the elastic stud (008) down to the piston (002).
    - 2.2.3 Make sure that there is no clearance at X.
    - 2.2.4 Turn back the nut (010) with the related number of turns (refer to the name plate on the pre-tensioner) to get a clearance at Y.

**NOTE:** This prevents problems when you remove the pre-tensioner.

**Fig 4-2** Loosen a round nut (examples)



00539

- 3 If necessary, turn back the cylinder (003) a small distance to get good access to the applicable slot (005) of the pre-tensioner.
- 4 Connect the pre-tensioner to the HP oil pump or to the hydraulic unit at the connection (009).
- 5 Fill the pre-tensioner with oil.
  - 5.1 Open the vent screw (001) on the pre-tensioner.
  - 5.2 Operate the HP oil pump or the hydraulic unit until oil that has no air flows out at the vent screw (001).
  - 5.3 Stop the HP oil pump or the hydraulic unit to prevent injury.
  - 5.4 Carefully close the vent screw (001) on the pre-tensioner.
- 6 Slowly increase the pressure to get approximately 20 bar to 30 bar more than the related tightening value (refer to the name plate on the pre-tensioner).

**NOTE:** Make sure that the piston (002) does not move above the limit of the red groove (011).

- 7 Keep the applied pressure constant.
- 8 Loosen the round nut (004).
  - 8.1 Get the applicable round bar (012) from the round bar kit.
  - 8.2 Put the round bar (012) through the slot (005) into a hole of the round nut (004).
  - 8.3 Turn the round nut (004) back the related number of turns.
  - 8.4 Remove the round bar (012).
- 9 Release the pressure on the HP oil pump or on the hydraulic unit to zero.
- 10 Disconnect the pre-tensioner from the HP oil pump or from the hydraulic unit.
- 11 Remove the pre-tensioner from the elastic stud (008).
- 12 If necessary, fully remove the round nut (004) from the elastic stud (008).

## CLOSE UP

- None

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## 4.4 Do a check of the pre-tension

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
HP oil pump	94931		pc 1
HP hose	A/R		pc 1
Hydraulic unit	94942		pc 1
Round bar - kit	94005		pc 1
Pre-tensioner	A/R		A/R

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

## PRELIMINARY OPERATIONS

- The engine must be stopped.

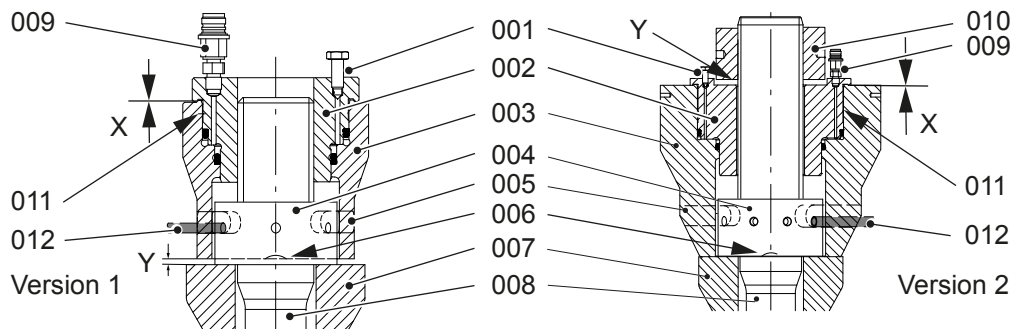
## PROCEDURE

- 1 Make sure that the threads of the elastic stud (008, [Figure 4-3](#)) and of the pre-tensioner are smooth and clean.
- 2 Put the applicable pre-tensioner on the elastic stud (008).
  - 2.1 If the piston (002) is attached directly on to the elastic stud (008) (version 1), do the steps that follow:
    - 2.1.1 Turn the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 2.1.2 Make sure that there is no clearance at X.
    - 2.1.3 Turn back the pre-tensioner with the related number of turns (refer to the name plate on the pre-tensioner) to get a clearance at Y.

**NOTE:** This prevents problems when you remove the pre-tensioner.
  - 2.2 If the piston (002) is attached with the nut (010) to the elastic stud (008) (version 2), do the steps that follow:
    - 2.2.1 Put the pre-tensioner on the elastic stud (008) until the cylinder (003) touches the plate (007).
    - 2.2.2 Turn the nut (010) on the elastic stud (008) down to the piston (002).
    - 2.2.3 Make sure that there is no clearance at X.
    - 2.2.4 Turn back the nut (010) with the related number of turns (refer to the name plate on the pre-tensioner) to get a clearance at Y.

**NOTE:** This prevents problems when you remove the pre-tensioner.

**Fig 4-3 Do a check of the pre-tension (examples)**



- 3 If necessary, turn back the cylinder (003) a small distance to get good access to the applicable slot (005) of the pre-tensioner.
- 4 Connect the pre-tensioner to the HP oil pump or to the hydraulic unit at the connection (009).
- 5 Fill the pre-tensioner with oil.
  - 5.1 Open the vent screw (001) on the pre-tensioner.
  - 5.2 Operate the HP oil pump or the hydraulic unit until oil that has no air flows out at the vent screw (001).
  - 5.3 Stop the HP oil pump or the hydraulic unit to prevent injury.
  - 5.4 Carefully close the vent screw (001) on the pre-tensioner.
- 6 Slowly increase the pressure to get the related tightening value (refer to the name plate on the pre-tensioner).

**NOTE:** Make sure that the piston (002) does not move above the limit of the red groove (011).

- 7 Keep the applied pressure constant.
- 8 Make sure that there is no clearance between the round nut (004) and the plate (007).
  - 8.1 Put the feeler gauge through the groove (006).
  - 8.2 If there is a clearance, do the steps that follow:
    - 8.2.1 Get the applicable round bar (012) from the round bar kit.
    - 8.2.2 Put the round bar (012) through the slot (005) into a hole of the round nut (004).
    - 8.2.3 Turn the round nut (004) down to the plate (007).
    - 8.2.4 Remove the round bar (012).
- 9 Release the pressure on the HP oil pump or on the hydraulic unit to zero.
- 10 Disconnect the pre-tensioner from the HP oil pump or from the hydraulic unit.
- 11 Remove the pre-tensioner from the elastic stud (008).

## CLOSE UP

- None

# 5 Maintenance schedule

5.1	Maintenance schedule.....	96
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## 5.1 Maintenance schedule

The maintenance intervals are given in each procedure related to the recommendations of WinGD. The shown operating hours (or working hours) are always the total running hours of the engine.

Data found during operation will show if it is possible to increase or decrease these maintenance intervals. Reasons for a change of the intervals can be the items that follow:

- Environmental and operation conditions
- Heavy fuel oil and lubricating oil qualities
- Engine load
- Cooling water quality
- Original spare parts used
- Requirements of classification societies.

For an overview of the maintenance tasks refer to section [17.1 Maintenance overview](#).



## 6 Group 1 - Engine frame and bearings

<b>6.1</b>	<b>Foundation bolts</b>	
6.1.1	Bedplate - do a check of the foundation bolts. ....	98
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<b>6.3</b>	<b>Main bearing - bearing shell number 2 to #</b>	
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6.3.2	Main bearing - bearing shell - No. 2 to # - remove. ....	122
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## 6.1 Foundation bolts

### 6.1.1 Bedplate - do a check of the foundation bolts

#### Periodicity

Description	
One Time - after first working hours	1 500
Working hours	12 000
Duration for performing preliminary requirements	1.0 man-hours
Duration for performing the procedure	3.0 man-hours
Duration for performing the requirements after job completion	0.5 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	2

#### Support equipment

Description	Part No.	CSN	QTY
Feeler gauge			1
Pre-tensioner			1
HP oil pump			1
Hydraulic distributors			2
HP hose			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

### PRELIMINARY OPERATIONS

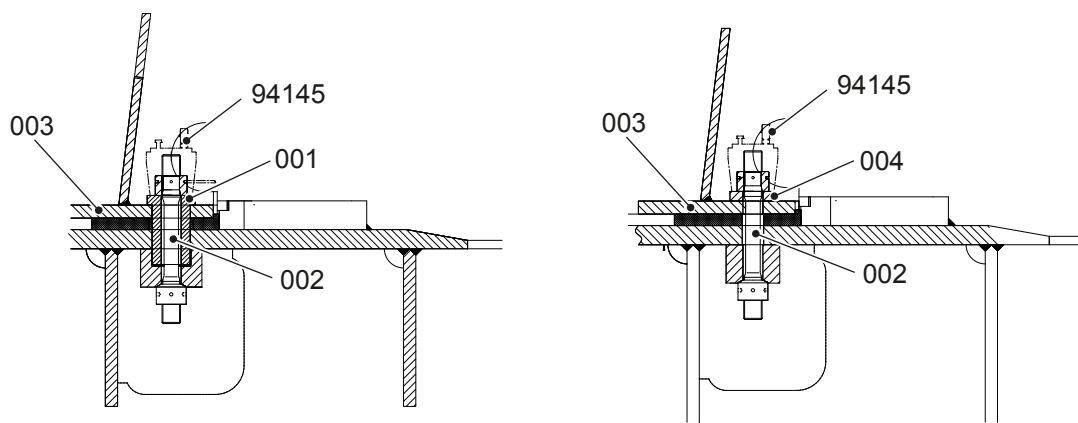
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Do a check of the pre-tension of the foundation bolts, refer to section [4.4 Do a check of the pre-tension](#).

**NOTE:** In the area of the thrust bearing, the bedplate (003, [Figure 6-1](#)) and the foundation must be attached with the foundation bolts (002) and the long bushes (001).  
The remaining area is attached with the foundation bolts (002) and the short bushes (004).

**Fig 6-1** Foundation bolts



## CLOSE UP

- None

## 6.2 Main bearing - bearing shell number 1

### 6.2.1 Main bearing - bearing shell - No. 1 - prepare before removal

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

### PRELIMINARY OPERATIONS

- The engine must be stopped.

## PROCEDURE

- 1 Read the data in [3.1 Lifting tools](#) General Guidelines for Lifting Tools.
- 2 Operate the turning gear to turn the crank to the exhaust side approximately 90° after TDC.
- 3 Lock the turning gear to prevent movement.
- 4 Install the platform, refer to the related procedure.
- 5 Set to off the main oil supply pumps.
- 6 Close the oil lubrication to the main bearing.

## CLOSE UP

- Remove the No. 1 bearing shell, refer to [6.2.2 Main bearing - bearing shell - No. 1 - remove](#)

## 6.2.2 Main bearing - bearing shell - No. 1 - remove

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

### Support equipment

Description	Part No.	CSN	QTY
Spur-gear chain block	94017-2.5-5.4		2
Shackle (WLL 2000 kg)	94019G		1
Lifting plate	94119		1
Turning-out device	94118B		1
Lifting tool - bearing shell	94116A		1
Dial gauge	N/A		1
Hydraulic ram	94936		3
HP oil pump	94931		1
Pressure gauge	94934A		1
Steel beam	N/A		1
Steel plate	N/A		1
Bracket	94141		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

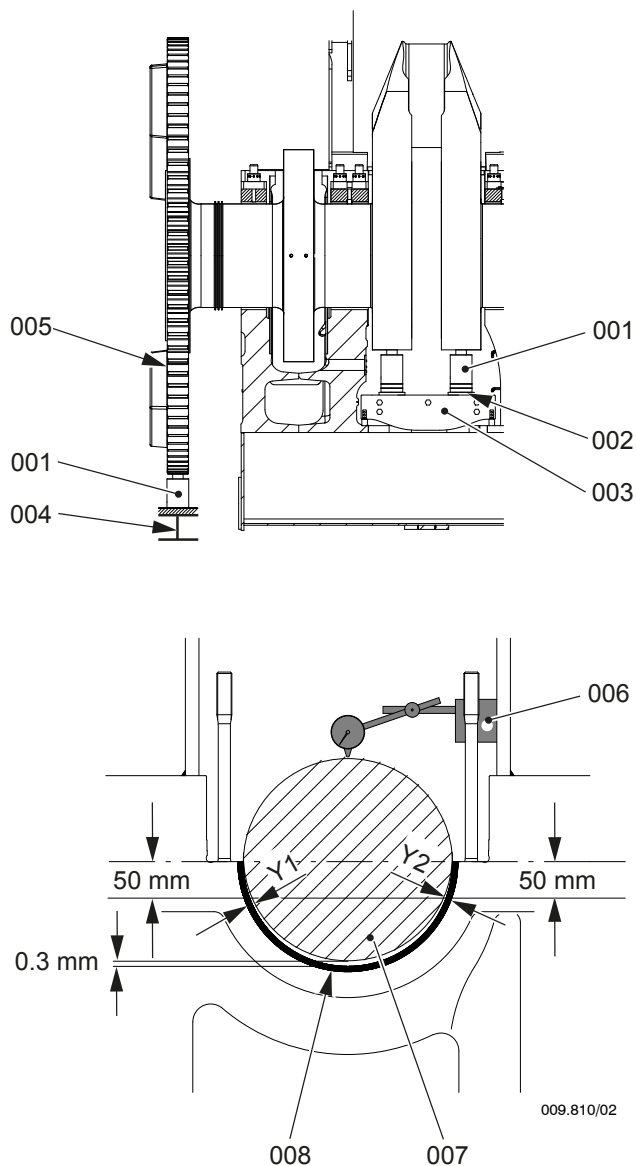
- None

### PRELIMINARY OPERATIONS

- The engine must be stopped.
- The bearing cover must be removed, refer to [6.4.1 Main bearing cover - No.1 - remove](#)

## PROCEDURE

- 1** Hydraulic rams - install
  - 1.1** Put the chain block 94017-2.5-5.4 (003, ) on the main bearing girder as shown.
  - 1.2** Put the two hydraulic rams (001) on the bracket (003) as shown.
  - 1.3** Put the steel beam (004) in position as shown below the flywheel (005).
  - 1.4** Put the other hydraulic ram (001) on the beam (004).
  - 1.5** Put the steel plate on top of the hydraulic ram (001).
  - 1.6** Connect the hydraulic rams (001) to the HP oil pump.
  - 1.7** Put the dial gauge (006) in position on the crankshaft (007) in the vertical axis.
  
- 2** Crankshaft - lift
  - 2.1** Record the values of the lateral clearances (y1 and y2,) between the crankshaft (007) and the main bearing shell (008) at approximately 50 mm below the bearing.
  - 2.2** Set to zero the dial gauge (006).
  - 2.3** Operate the HP oil pump to lift the crankshaft (007) to 0.3 mm.
  - 2.4** Make sure that the value on the dial gauge (006) is 0.3 mm.
  - 2.5** Make sure that there is no clearance between the adjacent bearing cover and the crankshaft (007).
  - 2.6** Keep the pressure constant.
  - 2.7** Measure the lateral bearing clearances y1 and y2. Compare these values with the values recorded in [Step 2.1](#).
  - 2.8** If the value of the lateral bearing clearance is more than 0.1 mm, lower the crankshaft and do [Step 2.8.1](#) to [Step 2.8.3](#):
    - 2.8.1** Install the hydraulic rams (001) in position where the lateral bearing clearance is smaller.
    - 2.8.2** Operate the HP oil pump.
    - 2.8.3** Lift the crankshaft (007) to 0.3 mm.

**Fig 6-2** Crankshaft and flywheel - lift

00606

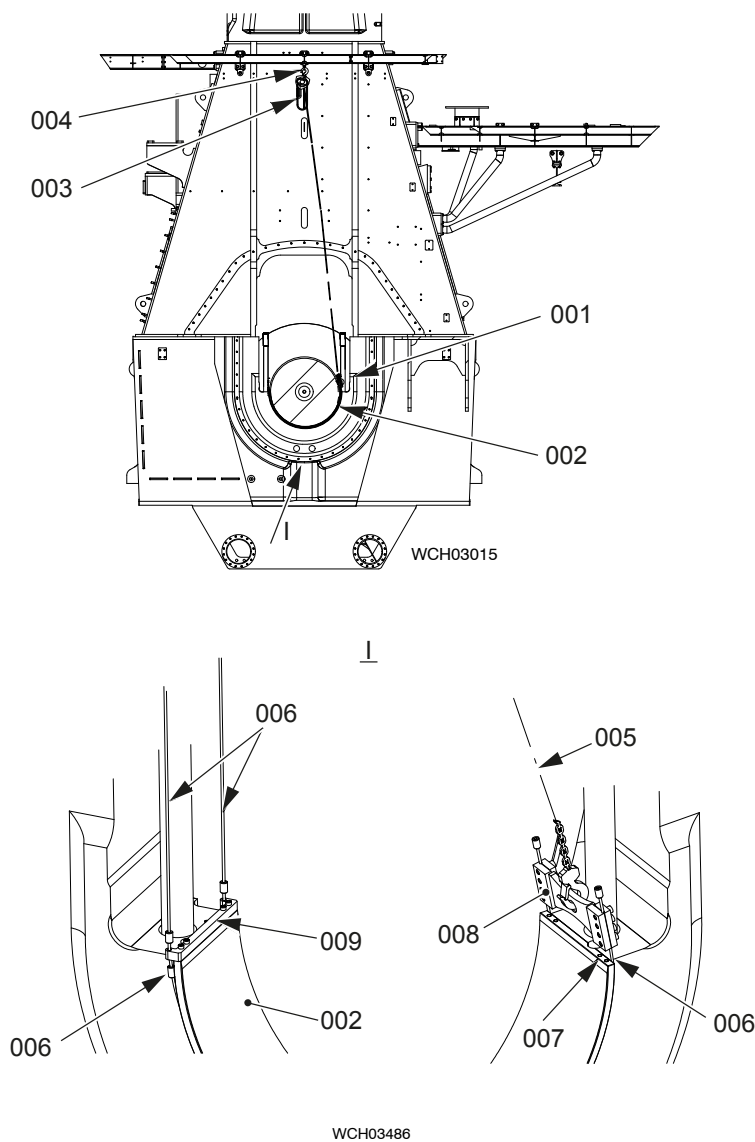
**3** Bearing shell - remove

- 3.1** Attach the shackle (WLL 2000 kg) (004, [Figure 6-3](#)) to the position shown.
- 3.2** Attach the (003) to the shackle (004).



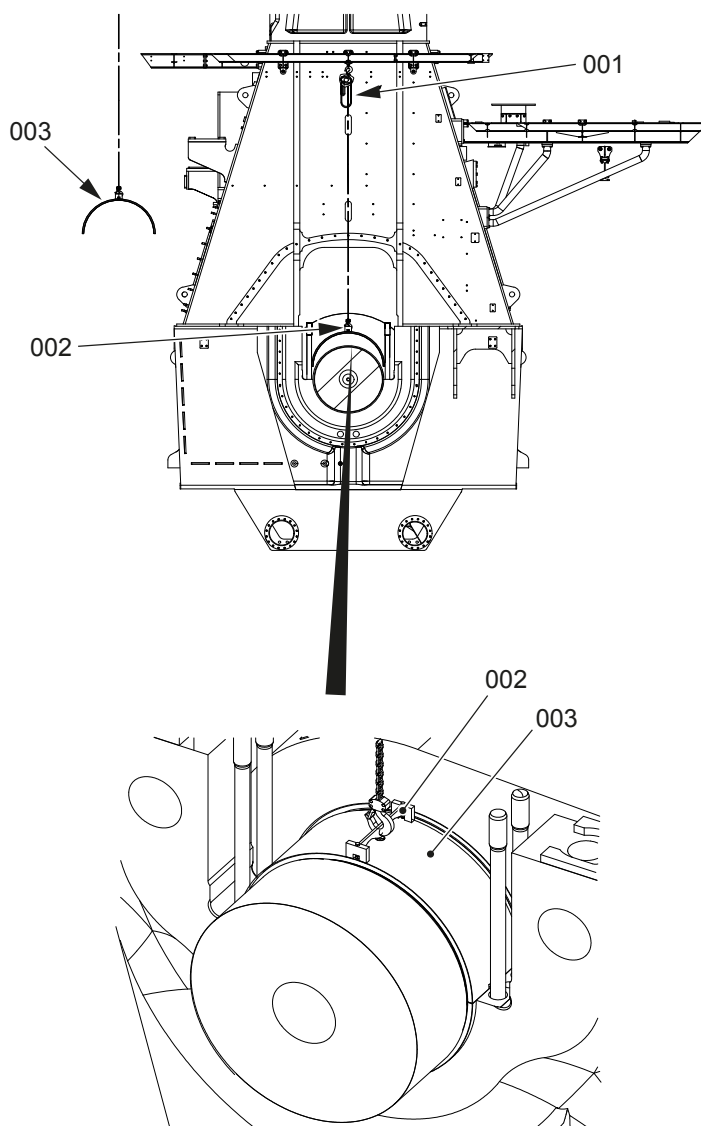
- 3.3** Remove the two Allen screws (007) from the top of the bearing shell (002).
- 3.4** Attach the turning out device (009) to the bearing shell (002).
- 3.5** Put the wire ropes (006) around the edges of the main bearing shell (002). Attach the wire ropes to the lifting plate (008).
- 3.6** Attach the chain block (003) to the middle hole in the lifting plate (008).
- 3.7** Operate the chain block (003) to turn the bearing shell (002) a sufficient distance to attach the lifting tool.
- 3.8** Remove the chain block (003) from the lifting plate (008).
- 3.9** Remove the turning out device (009) and the lifting plate (008).

**Fig 6-3 Bearing shell - remove**



00607

**3.10** Attach the lifting tool (002, [Figure 6-4](#)) to the bearing shell (003).

**Fig 6-4** Bearing shell - lift

00608

- 3.11** Turn the bearing shell (003) sufficiently to attach the chain block (001).
- 3.12** Attach the chain block (001) to the lifting tool (002).
- 3.13** Operate the chain block (001) to lift the bearing shell (003) a small distance.

- 3.14** Attach the engine room crane to the lifting tool (002).
- 3.15** Operate the engine room crane and the chain block (001) to lift and move the bearing shell (003) out of the engine.
- 3.16** Remove the chain block (001).
- 3.17** Operate the engine room crane to move the bearing shell (003) to an applicable area.

## **CLOSE UP**

- Do an inspection of the bearing shell, refer to [6.2.3 Main bearing shell - No.1 - do a check](#)

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### 6.2.3 Main bearing shell - No.1 - do a check

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.25 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Scotchbrite™	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- The bearing shell must be removed, refer to [6.2.2 Main bearing - bearing shell - No. 1 - remove](#)

## PROCEDURE

- 1 Use a soft cloth to clean the bearing shell.
- 2 Examine the bearing shell for damage e.g. breakouts or cracks.

### CAUTION

**Damage Hazard: Do not use a scraper in the running area of the bearing shell. Damage to the bearing shell will occur.**

- 3 Use Scotchbrite to remove small scratches and running marks.
- 4 If the running marks are not symmetrical (axial or radial) speak to, or send a message to WinGD.
- 5 If necessary, replace the bearing shells.
- 6 Do an inspection of the surface of the bearing pin. If necessary, repair the surfaces that have scratches.

## CLOSE UP

- Install the bearing shell, refer to [6.2.4 Main bearing - bearing shell - No. 1 - install](#)

## 6.2.4 Main bearing - bearing shell - No. 1 - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

### Support equipment

Description	Part No.	CSN	QTY
Spur-gear chain block	94017-2.5-5.4		2
Shackle (WLL 2000 kg)	94019G		1
Lifting plate	94119		1
Turning-out device	94118B		1
Lifting tool - bearing shell	94116A		1
Dial gauge	N/A		1
Hydraulic ram	94936		3
HP oil pump	94931		1
Pressure gauge	94934A		1
Steel beam	N/A		1
Steel plate	N/A		1
Bracket	94141		1

### Supplies

Description	QTY
Molykote paste G	A/R
Engine oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Bearing shell			1

## SAFETY PRECAUTIONS

### WARNING

**Injury and Damage Hazard: Do not turn the crankshaft when the platforms, tools and/or supports, are installed. This will cause injury to personnel and damage to equipment.**



## PRELIMINARY OPERATIONS

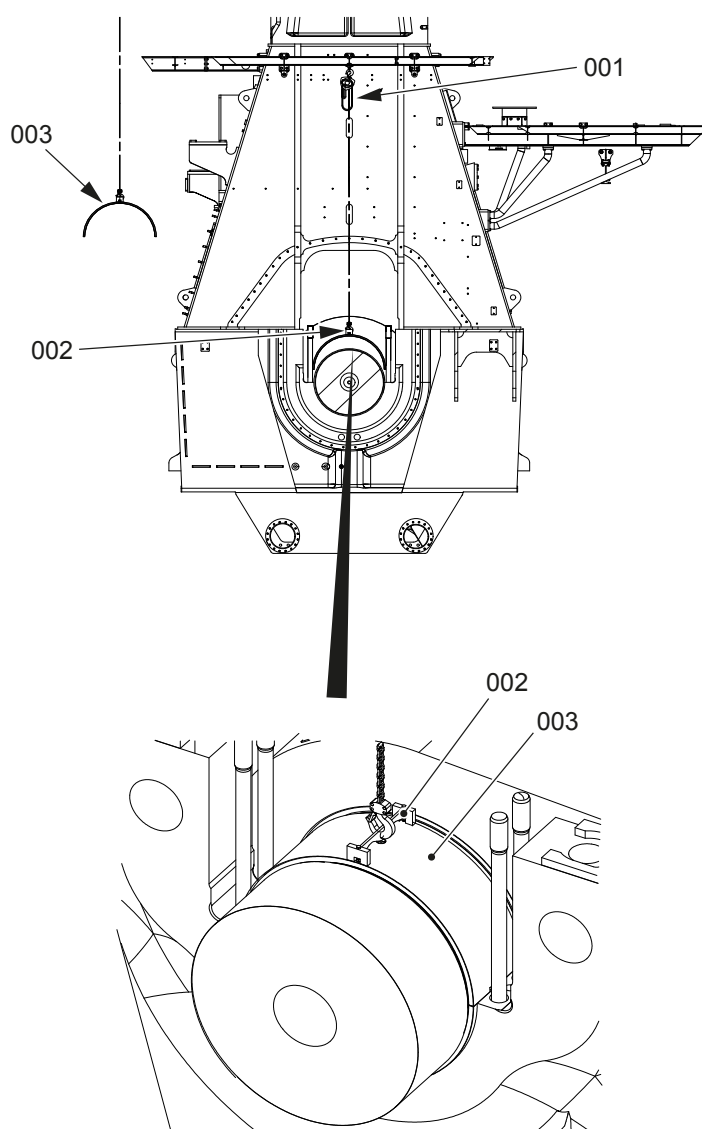
- None

## PROCEDURE

- 1 Bearing shell - install
  - 1.1 **NOTE:** The bearing shell has the mark DRIVING END and must be installed in the correct position.

Make sure that the items that follow are clean and in good condition:

    - The crankshaft pin
    - The girder bore for the bearing shell
    - The bearing shell.
  - 1.2 Apply a very thin layer of Molykote paste G to the rear face of the bearing shell (003, [Figure 6-5](#)).
  - 1.3 Make sure that the crankshaft and the running surface of the bearing shell (003) are clean and fully lubricated with clean engine oil.
  - 1.4 Attach the lifting tool (002) to the bearing shell (003).
  - 1.5 Attach the engine room crane to the lifting tool (002).
  - 1.6 Operate the engine room crane to move the bearing shell (003) to a position near the driving end of the crankshaft.
  - 1.7 Attach the chain block 94017-2.5-5.4 (001) to the lifting tool (002).
  - 1.8 Operate the engine room crane and the chain block (001) to move the bearing shell (003) to a position above the crankshaft.

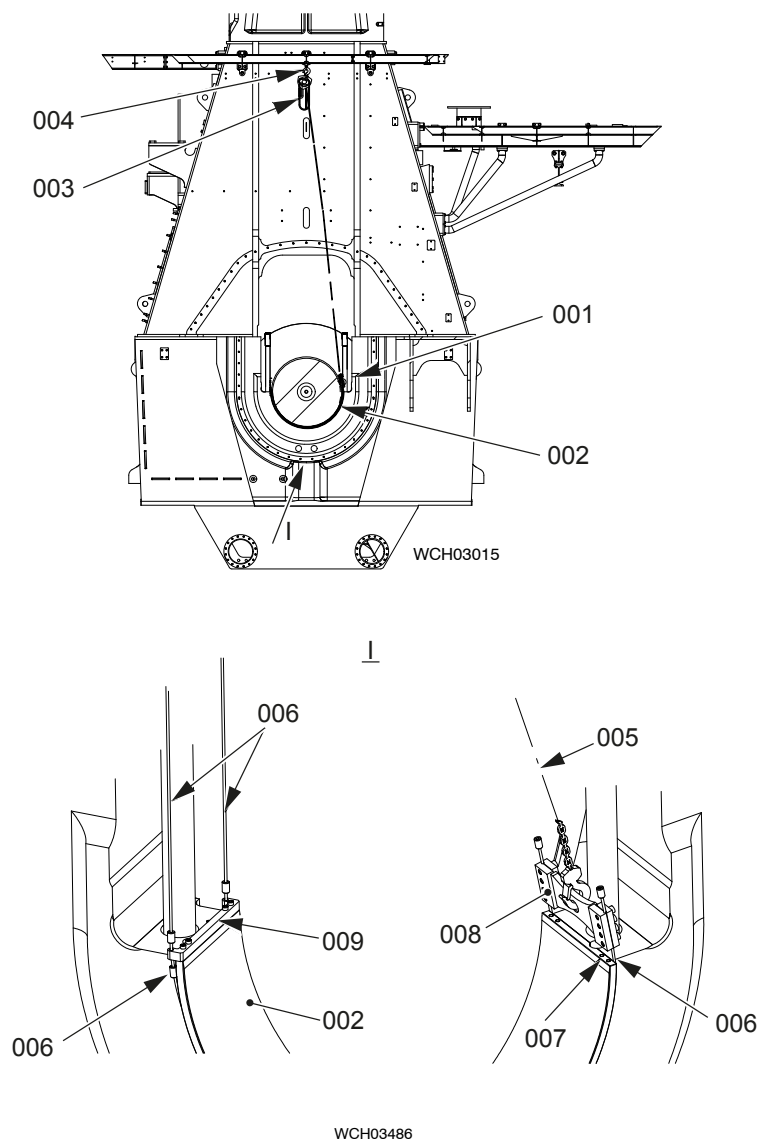
**Fig 6-5** Bearing shell - lift

00608

- 1.9** Remove carefully the engine room crane from the lifting tool (002).
- 1.10** Operate carefully the chain block (001) to lower the bearing shell (003) on to the crankshaft.

- 1.11** Remove the chain block (001) and the lifting tool (002).
- 1.12** Put the wire ropes (006) of the turning-out device (006, [Figure 6-6](#)) over the bearing shell (002) and under the crankshaft.
- 1.13** Attach the wire ropes of the device (009) to the lifting plate (008).
- 1.14** Attach the chain block (004) to the lifting plate (008).
- 1.15** Operate carefully the chain block (001) to move the bearing shell (002) into the bearing girder on the fuel side.
- 1.16** Make sure that the bearing shell (002) is level.
- 1.17** Remove the lifting plate (008) and the device (009).
- 1.18** Attach the bearing shell (002) with the four Allen screws (007).

Fig 6-6 Bearing shell - move



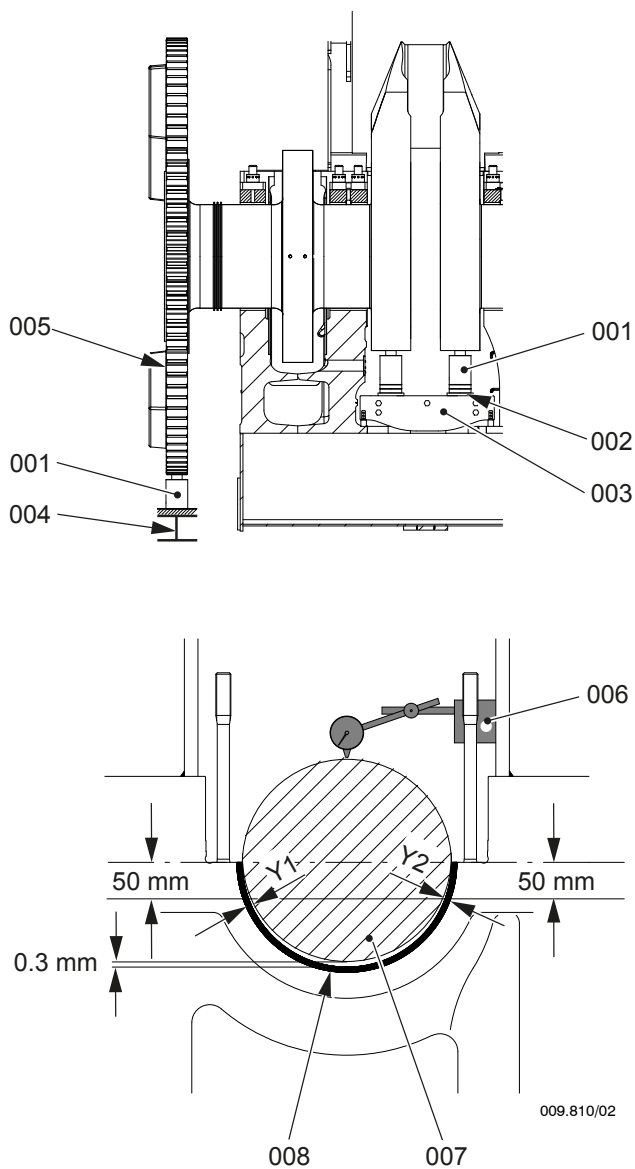
00607

## 2 Crankshaft - lower

- 2.1 On the HP oil pump, release the pressure to fully lower the crankshaft.
- 2.2 Remove the hydraulic rams (001, [Figure 6-7](#)) and the HP oil pump.

2.3 Remove the bracket (004) and steel plate.

Fig 6-7 Crankshaft and flywheel - lift



00606

**CLOSE UP**

- Install the No.1 bearing cover, refer to [6.4.2 Main bearing cover - No.1 - install](#)

## 6.3 Main bearing - bearing shell number 2 to #

### 6.3.1 Main bearing - bearing shell - No. 2 to # - prepare before removal

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

### PRELIMINARY OPERATIONS

- The engine must be stopped.



## PROCEDURE

- 1 Read the data in [3.1 Lifting tools](#) General Guidelines for Lifting Tools.
- 2 Operate the turning gear to turn the crank to the exhaust side approximately 90° after TDC.
- 3 Lock the turning gear to prevent movement.
- 4 Install the platform, refer to the related procedure.
- 5 Set to off the main oil supply pumps.
- 6 Close the oil lubrication to the main bearing.

## CLOSE UP

- Remove the applicable bearing shell No. 2 to No. #, refer to [6.3.2 Main bearing - bearing shell - No. 2 to # - remove](#)

## 6.3.2 Main bearing - bearing shell - No. 2 to # - remove

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

### Support equipment

Description	Part No.	CSN	QTY
Dial gauge	N/A		1
Hydraulic ram	94936		3
HP oil pump	94931		1
Pressure gauge	94934A		1
Steel beam	N/A		1
Steel plate	N/A		1
Bracket	94141		1
Roller support	94117A		1
Shackle 8500kg	94019L		1
Lever chain hoist	94016-0.8-5.5		1
Turning-out device	94118B		1
Lifting plate	94119A		1
Turning-out device	94118C		1
Deviation pipe	94117B		1
Deviation pipe	94117C		1
Lifting tool	94116A		1
Eye bolt	94045-M56		1
Spur geared chain block	94017-2.5-5.4		2
Spur geared chain block	94017-2.5-6.5		1
Sling	94039-015		1
Shackle	94019P		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

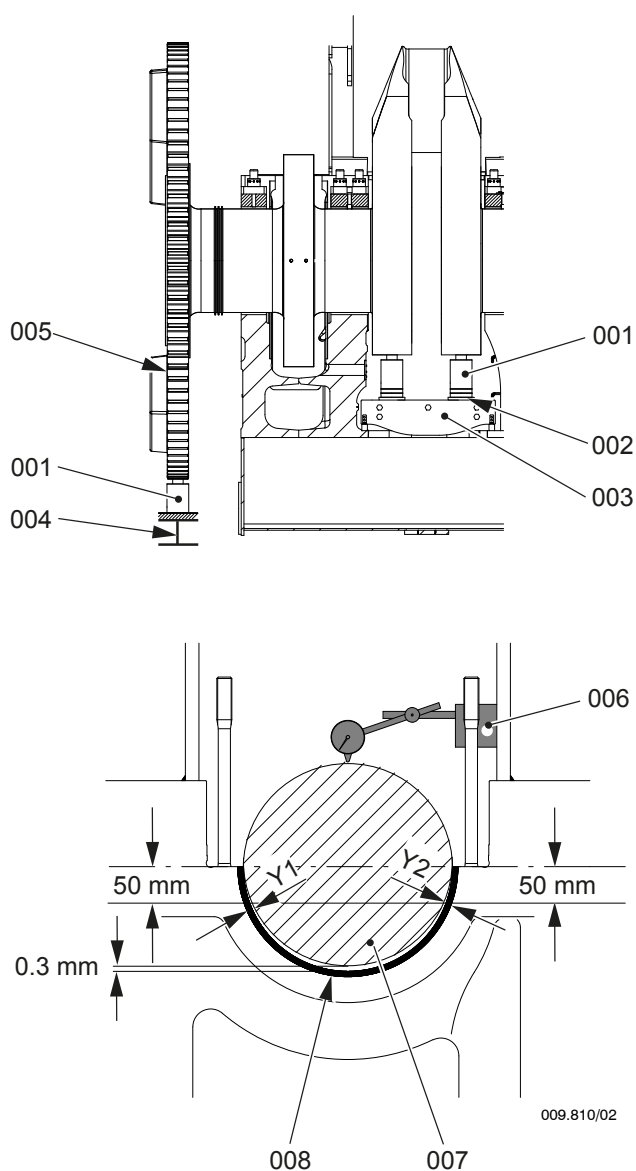
**Damage Hazard: Do not remove two adjacent main bearing shells at the same time. Damage can occur to the bearing shells.**

### PRELIMINARY OPERATIONS

- Remove the applicable bearing cover, refer to [6.5.1 Main bearing cover - No. 2 to # - remove](#)

## PROCEDURE

- 1 Hydraulic rams - install
  - 1.1 Put the bracket 94141 (003, [Figure 6-8](#)) on the main bearing girder as shown.

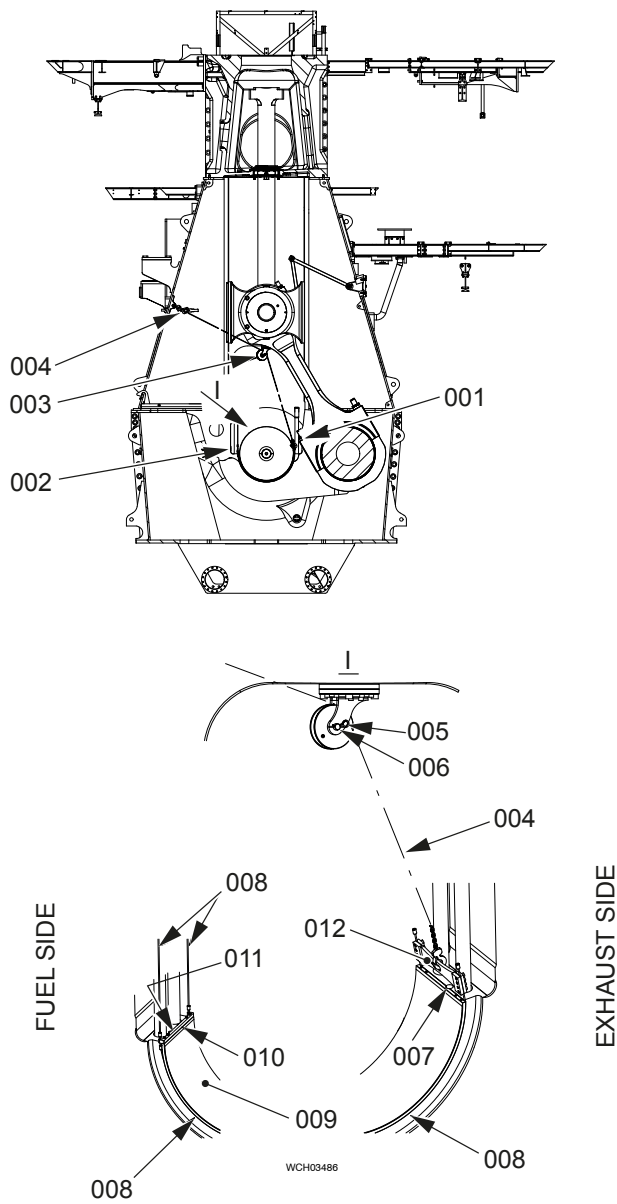
**Fig 6-8 Crankshaft and flywheel - lift**

00606

- 1.2** Put the two hydraulic rams 94936 (001) on the bracket (003) as shown.
- 1.3** Put the steel beam (004) in position as shown below the flywheel (005).
- 1.4** Put the other hydraulic jack (001) on the beam (004).

- 1.5 Put the steel plate on top of the hydraulic ram (001).
  - 1.6 Connect the hydraulic jacks (001) to the [HP oil pump](#).
  - 1.7 Put the dial gauge (006) in position on the crankshaft (007) in the vertical axis.
- 2** Crankshaft - lift
- 2.1 Record the values of the lateral clearances (y1 and y2,) between the crankshaft (007) and the main bearing shell (008) at approximately 50 mm below the bearing.
  - 2.2 Set to zero the dial gauge (006).
  - 2.3 Operate the HP oil pump 94931 to lift the crankshaft (007) to 0.3 mm.
  - 2.4 Make sure that the value on the dial gauge (006) is 0.3 mm.
  - 2.5 Make sure that there is no clearance between the adjacent bearing cover and the crankshaft (007).
  - 2.6 Keep the pressure constant.
  - 2.7 Measure the lateral bearing clearances y1 and y2. Compare these values with the values recorded in [Step 2.1](#).
  - 2.8 If the value of the lateral bearing clearance is more than 0.1 mm, lower the crankshaft and do [Step 2.8.1](#) to [Step 2.8.3](#):
    - 2.8.1 Install the hydraulic rams (001) in position where the lateral bearing clearance is smaller.
    - 2.8.2 Operate the HP oil pump.
    - 2.8.3 Lift the crankshaft (007) to 0.3 mm.
- 3** Bearing shell - remove
- 3.1 Attach the lever chain hoist 94016-0.8-5.5 (004, [Figure 6-9](#)) to the column.
  - 3.2 Attach the roller support 94117A (003) to the column above the main bearing. Make sure that the spring clip (005) locks the pin (006) in position.
  - 3.3 Remove the Allen screws (011) from the bearing girder.
  - 3.4 Attach the lever chain hoist (004) to the middle hole in the [Lifting plate](#) (012).
  - 3.5 Attach the turning out device 94118B (010) to the main bearing shell (009) with four screws.
  - 3.6 Attach the wire ropes to the lifting plate (012).

Fig 6-9 Bearing shell No\_2\_to\_n



00609

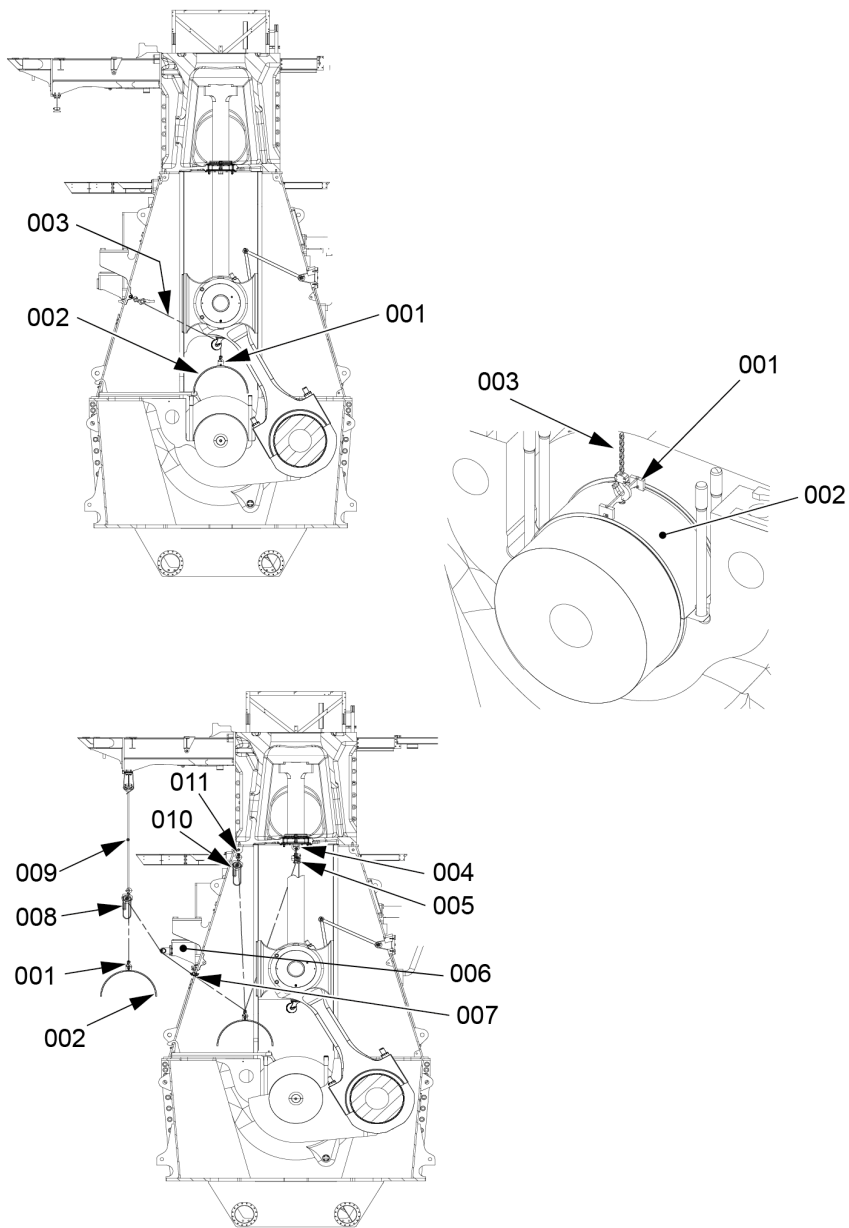
- 3.7 Attach the deviation pipes 94117B and 94117C (006 and 007, [Figure 6-10](#)) to the column as shown.
- 3.8 Operate the lever chain hoist (003) to turn the bearing shell (002) until the center of the bearing shell is in a vertical position.

**NOTE:** If the bearing shell (002) does not move freely during the removal procedure, you must attach the lifting plate to the other side of the turning out device. You must move the bearing shell back to its initial position and do the removal procedure again.

- 3.9** Remove the turning out device, lifting plate and lever chain hoist from the bearing shell.
- 3.10** Attach the lifting tool 94116A (001) to the bearing shell (002).
- 3.11** Attach the lever chain hoist (003) to the lifting tool (001).
- 3.12** Operate the lever chain hoist (003) to lift the bearing shell (002).
- 3.13** Attach the eye bolt 94045-M56 (004) to the roof of the column.
- 3.14** Attach the chain block 94017-2.5-5.4 (005) to the eye bolt (004) and the lifting tool (001).
- 3.15** Operate the chain block (005) to hold the weight of the bearing shell (002).
- 3.16** Attach the shackle 94019P (011) to the column.
- 3.17** Attach the other chain block (010) to the shackle (011) and the lifting tool (001).
- 3.18** Operate the chain block (010) to hold the weight of the bearing shell (002).
- 3.19** Remove the lever chain hoist (003) from the column wall and the lifting tool (001).
- 3.20** Attach the sling 94039-015 (009) to the gallery.
- 3.21** Attach the chain block 94017-2.5-6.5 (008) to the sling (009).
- 3.22** Operate the chain blocks (005, 010) to move the bearing shell a small distance to the fuel side.
- 3.23** Attach the chain block (008) to the lifting tool (001).
- 3.24** Operate the chain block (008) to hold the weight of the bearing shell (002).
- 3.25** Remove the chain block (005) from the lifting tool (001).
- 3.26** Operate the chain blocks (010, 008) to move the bearing shell (002) through the opening in the column.
- 3.27** Lower the bearing shell (002) on to an applicable surface.



Fig 6-10 Bearing shell\_move



00610

**CLOSE UP**

- Install the bearing shell, refer to [6.3.4 Main bearing - bearing shell - No. 2 to # - install](#)

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### 6.3.3 Main bearing shell - No.2 to # - examine

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.25 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Scotchbrite™	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- The bearing shell must be removed, refer to [6.3.2 Main bearing - bearing shell - No. 2 to # - remove](#)

## PROCEDURE

- 1 Use a soft cloth to clean the bearing shell.
- 2 Examine the bearing shell for damage e.g. breakouts or cracks.

### CAUTION

**Damage Hazard: Do not use a scraper in the running area of the bearing shell. Damage to the bearing shell will occur.**

- 3 Use Scotchbrite to remove small scratches and running marks.
- 4 If the running marks are not symmetrical (axial or radial) speak to, or send a message to WinGD.
- 5 If necessary, replace the bearing shells.
- 6 Do an inspection of the surface of the bearing pin. If necessary, repair the surfaces that have scratches.

## CLOSE UP

- Install the bearing shell, refer to [6.3.4 Main bearing - bearing shell - No. 2 to # - install](#)

### 6.3.4 Main bearing - bearing shell - No. 2 to # - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	3

#### Support equipment

Description	Part No.	CSN	QTY
Roller support	94117A		1
Shackle 8500kg	94019L		1
Lever chain hoist	94016-0.8-5.5		1
Turning-out device	94118B		1
Lifting plate	94119A		1
Turning-out device	94118C		1
Deviation pipe	94117B		1
Deviation pipe	94117C		1
Lifting tool	94116A		1
Eye bolt	94045-M56		1
Spur geared chain block	94017-2.5-5.4		2
Spur geared chain block	94017-2.5-6.5		1
Sling	94039-015		1
Shackle	94019P		1

#### Supplies

Description	QTY
Molykote paste G	A/R
Engine oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Bearing shell			1

## SAFETY PRECAUTIONS

### WARNING

**Injury and Damage Hazard: Do not turn the crankshaft when the platforms, tools and/or supports, are installed. This will cause injury to personnel and damage to equipment.**

## PRELIMINARY OPERATIONS

- None

## PROCEDURE

### 1 Bearing shell - install

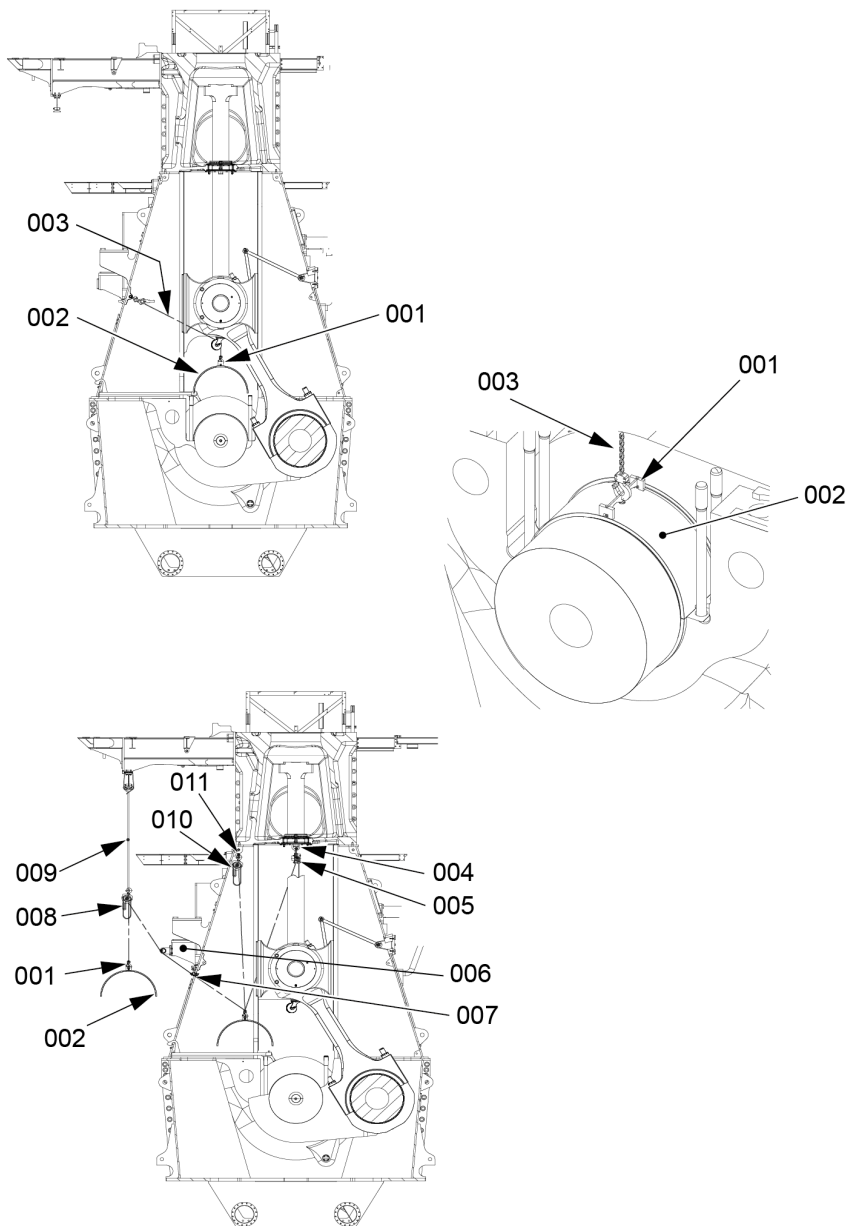
- 1.1 NOTE:** The bearing shell has the mark DRIVING END and must be installed in the correct position.

Make sure that the items that follow are clean and in good condition:

- The crankshaft pin
- The girder bore for the bearing shell
- The bearing shell.

- 1.2** Apply a very thin layer of Molykote paste G to the rear face of the bearing shell (002, [Figure 6-11](#)).



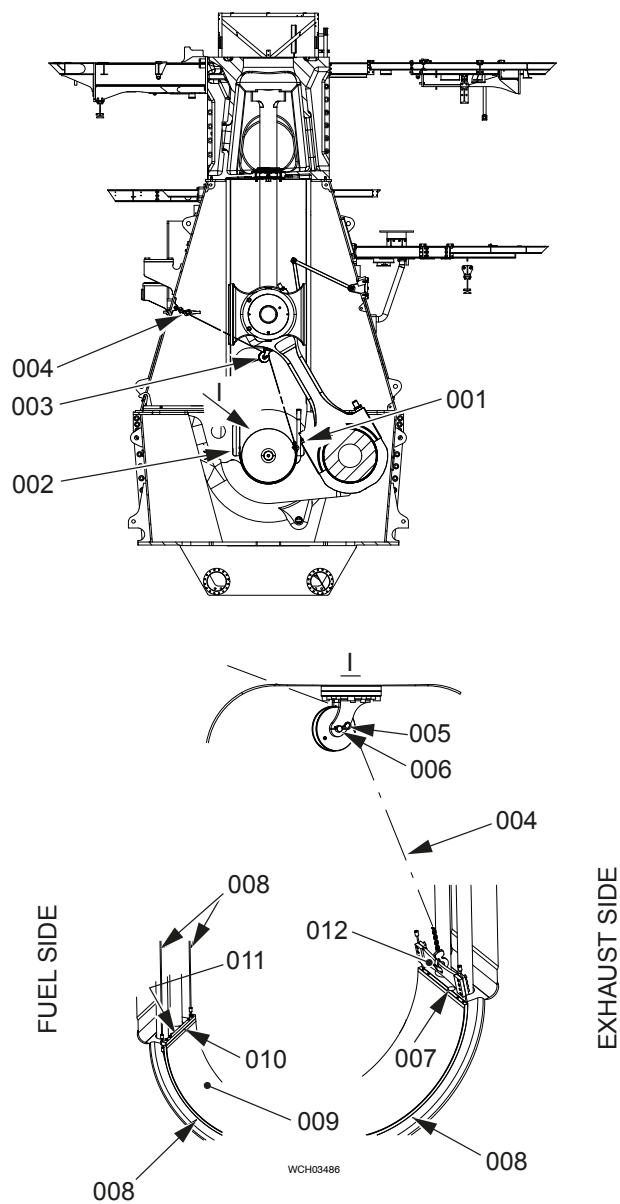
**Fig 6-11 Bearing shell - move**

00610

- 1.3 Make sure that the crankshaft and the running surface of the bearing shell (002) are clean and fully lubricated with clean engine oil.
- 1.4 Attach the lifting tool (001) to the bearing shell (002).

- 1.5** Attach the engine room crane to the lifting tool (001).
- 1.6** Operate the engine room crane to move the bearing shell (002) to an applicable position.
- 1.7** Lower the bearing shell on to an applicable surface.
- 1.8** Remove the engine room crane from the lifting tool (001).
- 1.9** Attach the spur-gear chain blocks 94017-2.5-5.4 and 94017-2.5-6.5 (005, 008) to the lifting tool (001).
- 1.10** Operate the chain blocks (005, 008) to move the bearing shell (002) to a position above the crankshaft.
- 1.11** Remove carefully the chain block (008) from the lifting tool (002).
- 1.12** Operate carefully the chain block (005) to lower the bearing shell (002) on to the crankshaft.
- 1.13** Remove the chain block (005) and the lifting tool (002).
- 1.14** Put the wire ropes (008) of the turning-out device (010, [Figure 6-12](#)) over the bearing shell (002) and under the crankshaft.
- 1.15** Attach the wire ropes of the device (010) to the lifting plate (008).
- 1.16** Attach the chain block (004) to the lifting plate (012).
- 1.17** Operate carefully the chain block (004) to move the bearing shell (009) into the bearing girder on the fuel side.
- 1.18** Make sure that the bearing shell (009) is level.
- 1.19** Remove the lifting plate (012) and the device (010).
- 1.20** Attach the bearing shell (009) with the four Allen screws (007).

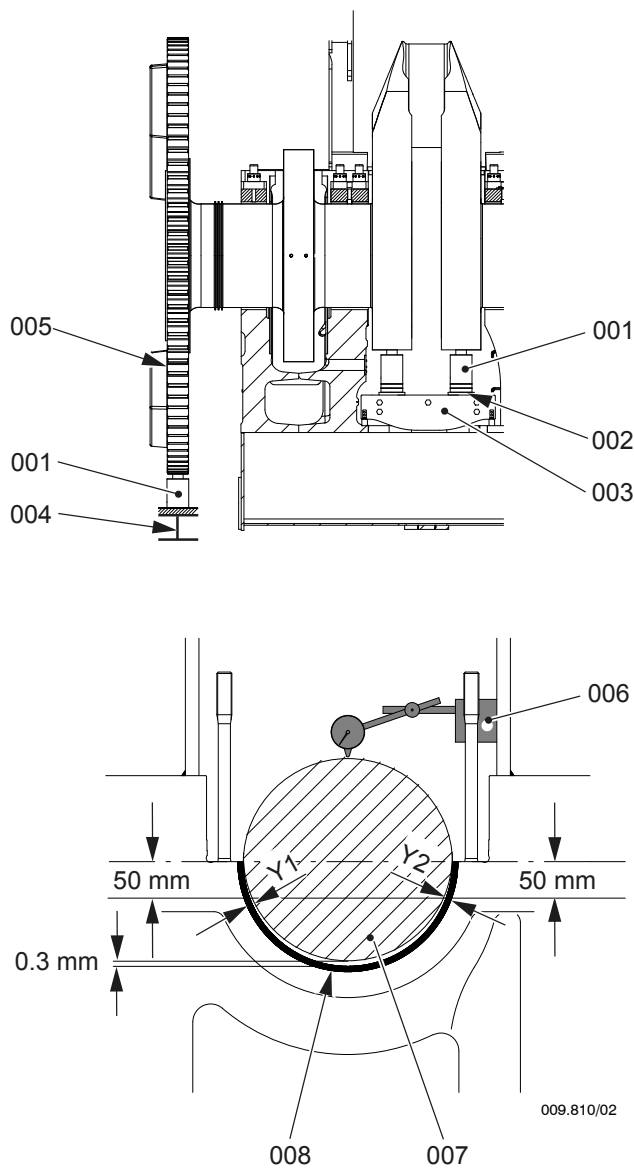
Fig 6-12 Bearing shell No\_2\_to\_n



00609

- 2** Crankshaft - lower
- 2.1** On the HP oil pump, release the pressure to fully lower the crankshaft.
- 2.2** Remove the hydraulic rams (001, [Figure 6-13](#)) and the HP oil pump.

Fig 6-13 Crankshaft and flywheel



00606

**CLOSE UP**

- Install the bearing cover, refer to [6.5.2 Main bearing cover - No. 2 to #- install](#)

## 6.4 Main bearing cover - No. 1

### 6.4.1 Main bearing cover - No.1 - remove

#### Periodicity

##### Description

Unscheduled

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block, 2500 kg	94017-028		1
Thrust device	94110		1
Lug	94116C		1
Shackle 6500 kg	94019K		1
Shackle 2000 kg	94019G		1
Thrust device	94110		1
HP oil pump	94931		1

#### Supplies

Description	QTY
Copper paste	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

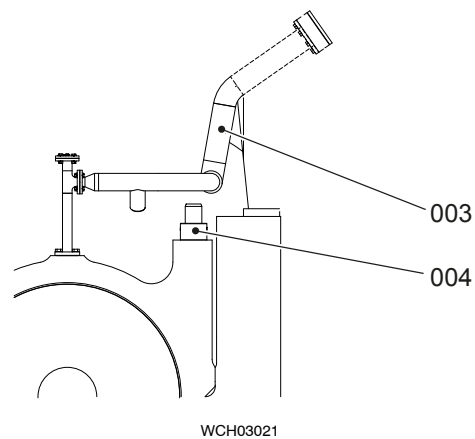
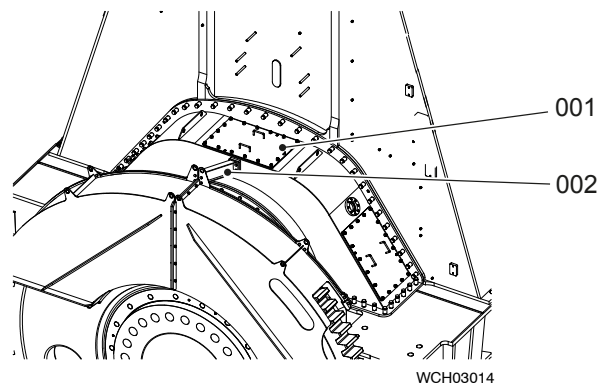
- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped.

**PROCEDURE**

- 1 Remove the cover (001, [Figure 6-14](#)) and the holder (002).
- 2 Remove the oil pipe (003).
- 3 Do a check of the bearing clearance, refer to [3.3 Clearances - general](#).
- 4 Remove the round nuts (004), refer to [4.3 Loosen a round nut with a pre-tensioner](#).

**Fig 6-14** Cover and oil pipe

- 5 Attach the lug (001, [Figure 6-15](#)) to the bearing cover (002).
- 6 Make sure that the thrust device (004) is clean.

00611

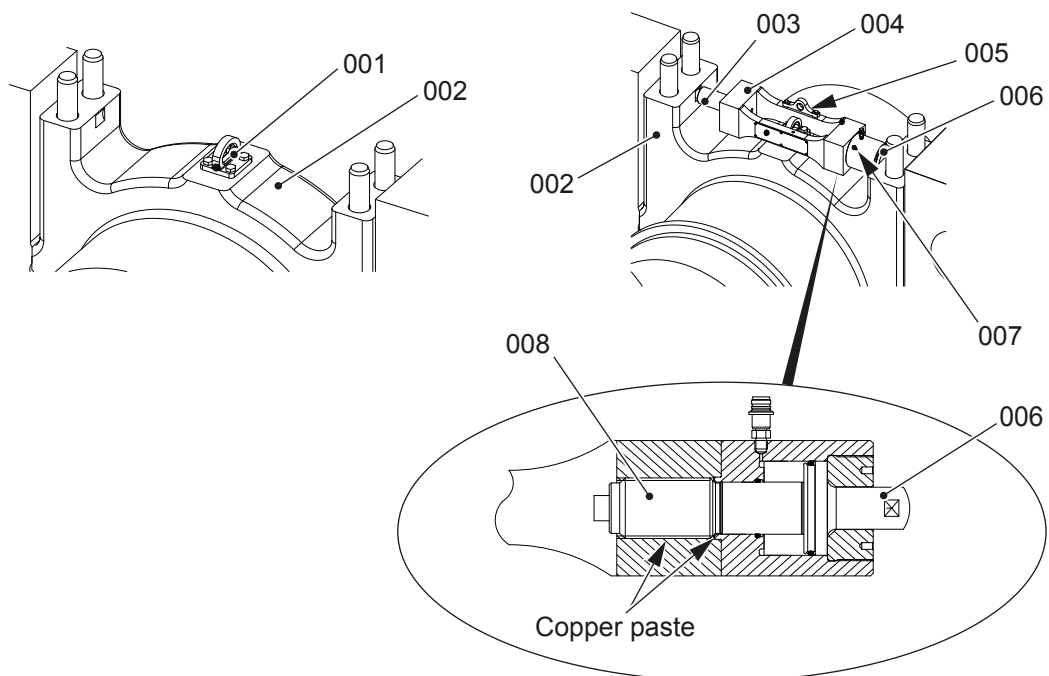


**WARNING**

**Injury Hazard: The thrust device has a WLL of only 70 kg. Do not use the thrust device to lift the bearing cover. Injury to personnel can occur.**

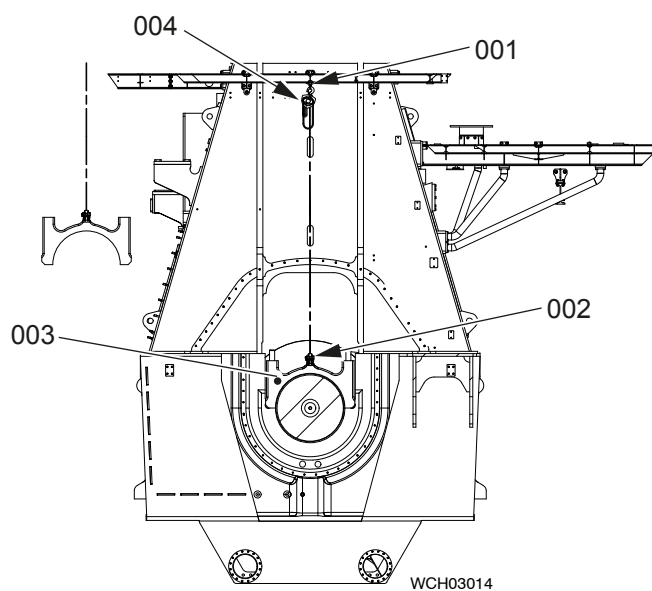
- 7 **NOTE:** Use the lifting plate (005) only to move and install the thrust device (004).
- 8 Put the thrust device (004) in position on the bearing cover (002).
- 9 Move the lifting plate (005) to its stowage position as shown.
- 10 Apply copper paste to the thread and the surface of the screw (008).
- 11 Open the vent screw (007) and make sure that the piston (006) is fully engaged.
- 12 Make sure that the tappet (008) and the piston (006) fully engage with the cutouts in the bearing cover (002).
- 13 Operate the HP oil pump.
- 14 When oil that has no air flows out, close the vent screw (007).
- 15 Slowly increase the pressure to the correct value, refer to the name plate.
- 16 Manually tighten the screw (008).
- 17 Open the relief valve on the HP oil pump to release the pressure to zero.
- 18 Remove the HP hose from the thrust device (004).

**Fig 6-15 Thrust device**



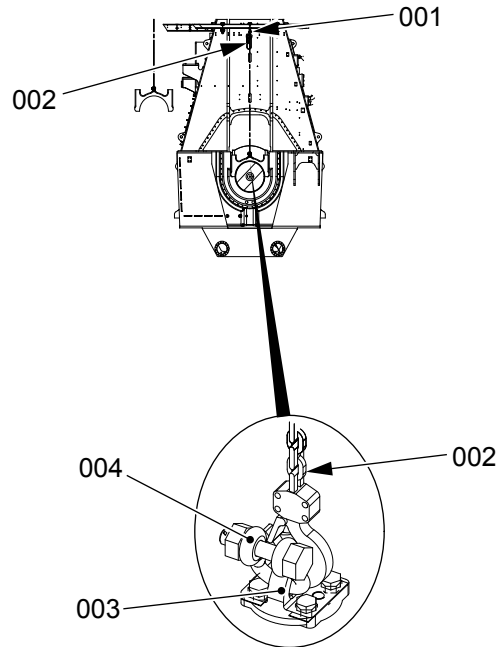
00613

- 19 Attach the shackle 94019G (001, [Figure 6-16](#)) to the platform.
- 20 Attach the chain block (004) to the shackle 94019G (001) and the lug (002).
- 21 Operate the chain block (004) to lift the bearing cover (001).

**Fig 6-16 Bearing cover**

00612

- 22 Attach the shackle 94019K (004, [Figure 6-17](#)) to the lug 94116C (003).
- 23 Attach engine room crane to the shackle 94109K (004).
- 24 Operate the engine room crane to put a light tension on the chain.
- 25 Remove the chain block (002) from the lug 94116C (003).
- 26 Operate the engine room crane to move the bearing cover on to an applicable surface.
- 27 Remove the engine room crane from the shackle (004).

**Fig 6-17 Bearing cover - move**

00614

**CLOSE UP**

- Remove the No. 1 bearing shell, refer to [6.2.2 Main bearing - bearing shell - No. 1 - remove](#)

## 6.4.2 Main bearing cover - No.1 - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block, 2500kg	94017-028		1
Thrust device	94110		1
Lug	94116C		1
Shackle 6500 kg	94019K		1
Shackle 2000 kg	94019G		1
Thrust device	94110		1
HP oil pump	94931		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Main bearing cover			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The bearing shell must be installed, refer to section [6.2.4 Main bearing - bearing shell - No. 1 - install](#)
- The work area and all tools and equipment must be clean and in good condition.

## PROCEDURE

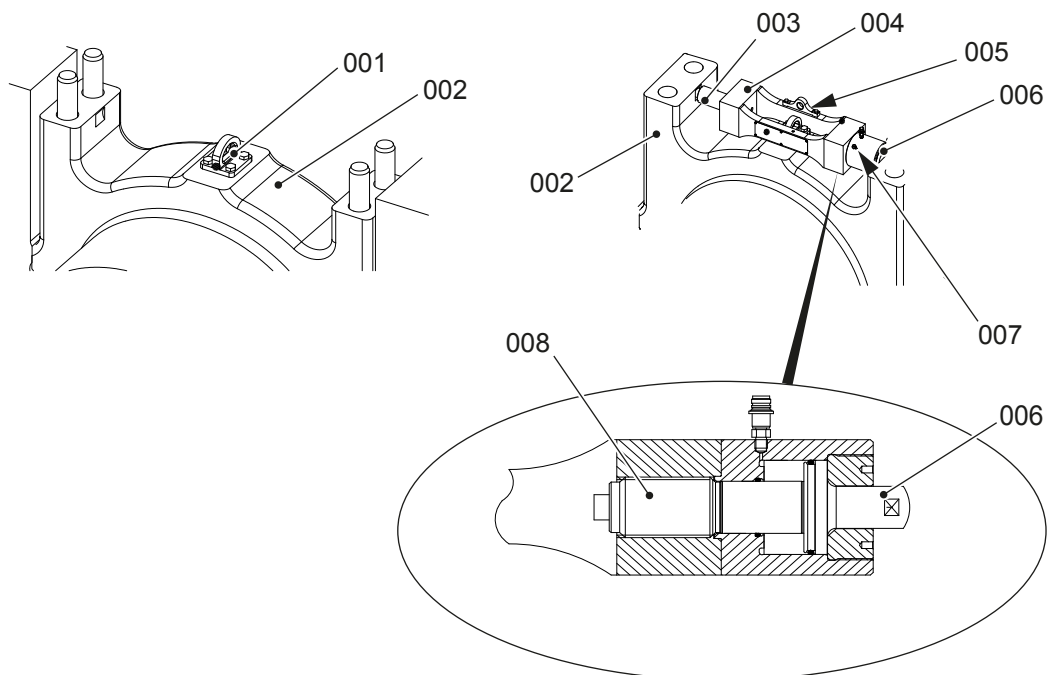
- 1 Clean all surfaces that touch on the bearing cover and bearing girder.
- 2 Make sure that the oil bore in the bearing cover is clear.
- 3 Attach the lug (001, [Figure 6-18](#)) to the bearing cover (002).

### WARNING

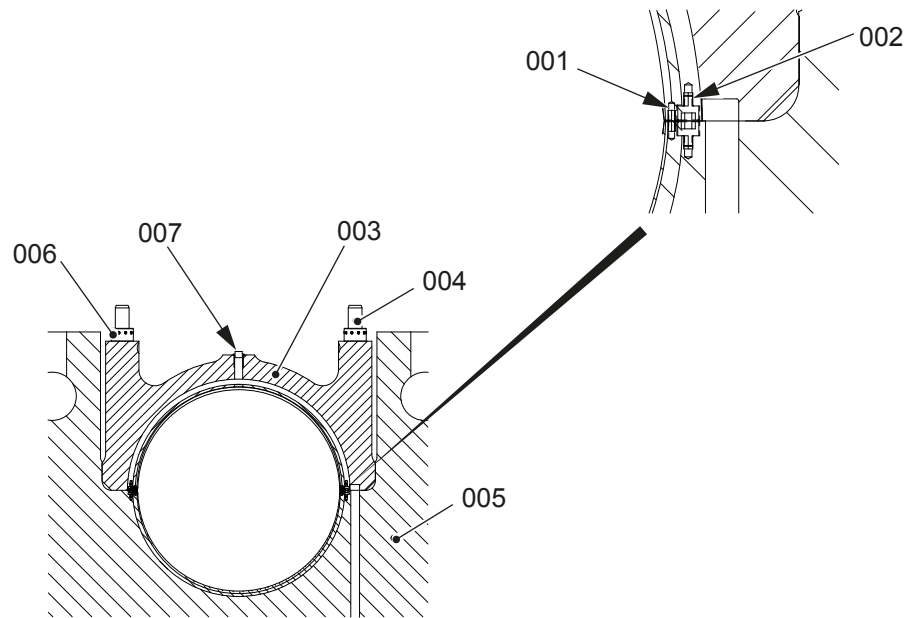
**Injury Hazard: The thrust device has a WLL of only 70 kg. Do not use the thrust device to lift the bearing cover. Injury to personnel can occur.**

- 4 **NOTE:** Put the thrust device (004) in position on the bearing cover (002).  
Use the lifting plate (005) only to move and install the thrust device (004).
- 5 Move the lifting plate (005) to its stowage position as shown.
- 6 Open the vent screw (007) and make sure that the piston (006) is fully engaged.
- 7 Make sure that the tappet (008) and the piston (006) fully engage with the cutouts in the bearing cover (002).
- 8 Operate the HP oil pump.
- 9 When oil that has no air flows out, close the vent screw (007).
- 10 Slowly increase the pressure to the correct value, refer to the name plate.
- 11 Manually tighten the screw (008).
- 12 Open the relief valve on the HP oil pump to release the pressure to zero.
- 13 Remove the HP hose from the thrust device (004).

**Fig 6-18 Thrust device**



00614

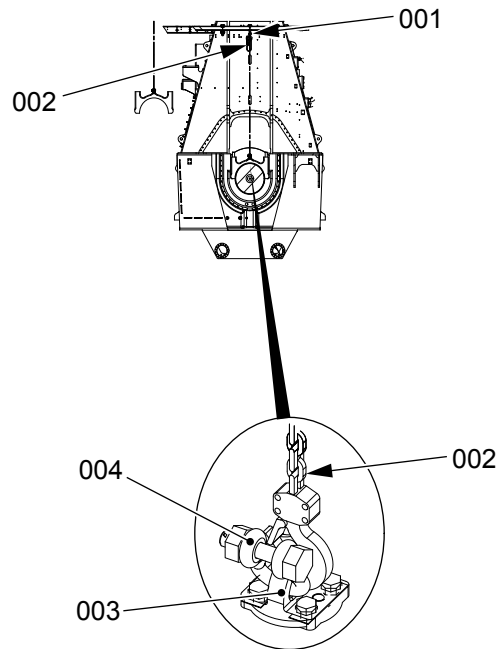
**Fig 6-19 Bearing cover - install**

00616

- 14 Attach the shackle 94019K (004, [Figure 6-20](#)) to the lug 94116C (003).
- 15 Attach engine room crane to the shackle 94109K (004).
- 16 Operate the engine room crane to move the bearing cover to an applicable position on the platform.
- 17 Attach the chain block (002) to the shackle (001) and the lug (003).
- 18 Operate the engine room crane and the chain block (002) to move the bearing cover above the crankshaft.
- 19 **NOTE:** The top bearing shell is attached to the bearing cover (003, [Figure 6-19](#)) with two Allen screws (002). The spring dowel pins (001) help to get the bearing cover in position during installation.

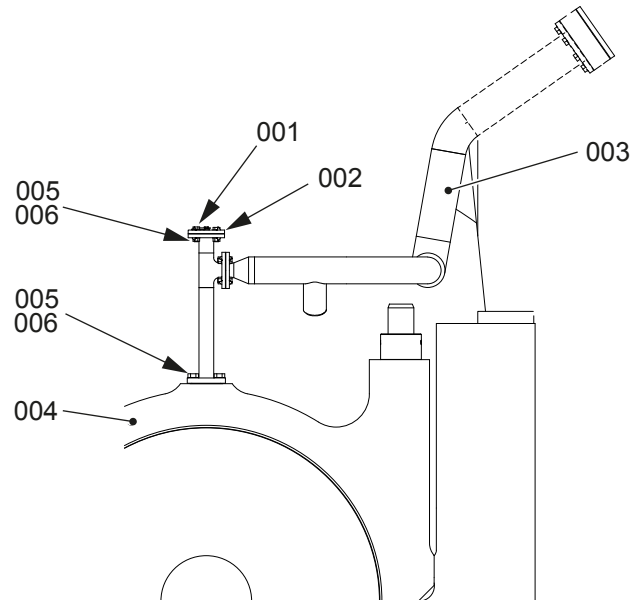
Lower the bearing cover (003) on to the bearing girder (005). Make sure that the two spring dowel pins (001) engage correctly. Make sure that you do not cause damage to the elastic studs (004)

- 20 Install the round nuts (006) on the elastic studs (004), refer to [4.2 Tighten a round nut with a pre-tensioner](#).
- 21 Remove the engine room crane from the shackle (011, [Figure 6-20](#)).
- 22 Remove the shackle (011) from the lug (010).
- 23 Remove the chain block (012) from the lug (010).
- 24 Remove the thrust device.
- 25 Remove the lug (003).

**Fig 6-20 Bearing cover - move**

00614

- 26 Clean the pipes (003, [Figure 6-21](#)).
- 27 Install the pipes (003), their gaskets and new tab washers (006).
- 28 Tighten the screws (005).
- 29 Lock the screws (005) with the new tab washers (006).
- 30 Remove all tools and equipment from the work area.
- 31 Measure the bearing clearance and compare the value measured in [6.2.2 Main bearing - bearing shell - No. 1 - remove](#) with the value in [Clearances 3.3 Clearances - general](#).  
**NOTE:** If the clearance is in the limits given, the bearing can be removed and installed again.
- 32 After each installation of a new bearing shell, measure the crank deflection, refer to the related procedure.
- 33 Do a check of the oil supply to the main bearing.
- 34 Lubricate the main bearing as follows:
  - 34.1 Remove the blank flange (002).
  - 34.2 Remove the screw plug (001).
  - 34.3 Fill the bearing shell with the applicable lubricant. For more data, refer to the Operation Manual.

**Fig 6-21 Bearing cover - oil pipe**

00617

**CLOSE UP**

- None



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## 6.5 Main bearing cover - No. 2 to #

### 6.5.1 Main bearing cover - No. 2 to # - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Roller support	94117		1
Platform	94143		1
Deviation pipe	94117B		1
Thrust device	94110		1
Lug	94116C		1
Manual ratchet	94016-012		1
Eye bolt	94045-M56		1
Spur-gearred chain block, 2500 kg	94017-028		2
Spur-gearred chain block, 2500 kg	94017-029		1
Deviation pipe	94117C		1
Sling	94039-015		1
Shackle 6500 kg	94019K		1
Shackle 13 500 kg	94019P		1
Shackle 8500 kg	94019L		1
Feeler gauge	94123		1

#### Supplies

Description	QTY
Copper paste	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury and Damage Hazard:** Do not turn the crankshaft when the platforms, tools and/or supports, are installed. This will cause injury to personnel and damage to equipment.

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

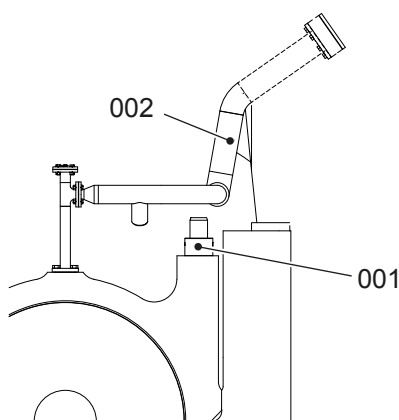
## PRELIMINARY OPERATIONS

- Do the preparation procedure given in [6.3.1 Main bearing - bearing shell - No. 2 to # - prepare before removal](#)

## PROCEDURE

- 1 Use the feeler gauge 94123 to record the bearing clearance, refer to [3.3 Clearances - general](#).
- 2 Remove the oil pipe (002, [Figure 6-22](#)).
- 3 Remove the round nuts (001), refer to [4.3 Loosen a round nut with a pre-tensioner](#).

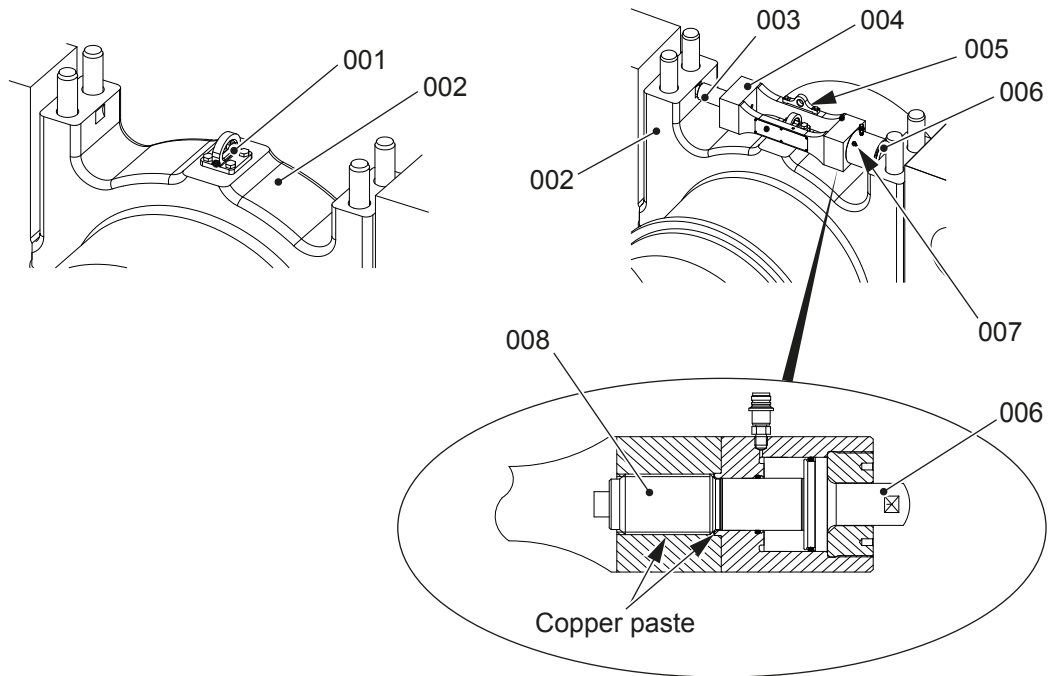
**Fig 6-22 Oil pipe and round nuts**



00618

- 4 Attach the lug 94116C (001, [Figure 6-23](#)) to the main bearing cover (002).
- 5 Make sure that the thrust device 94110 (004) is clean.

Fig 6-23 Thrust device



00613

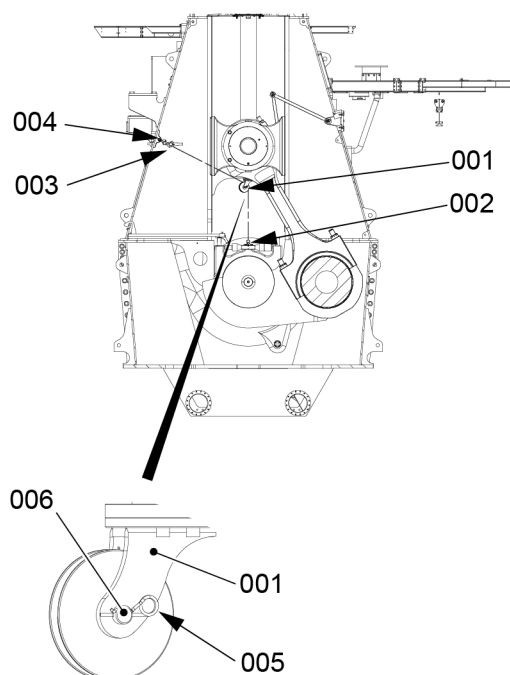
**WARNING**

**Injury Hazard: The thrust device has a WLL of only 70 kg. Do not use the thrust device to lift the bearing cover. Injury to personnel can occur.**

- 6 **NOTE:** Use only the lifting plate (005) to move and install the thrust device (004).  
Put the thrust device (004) in position on the bearing cover (002).
- 7 Move the lifting plate (0055) to its stowage position.
- 8 Apply copper paste to the thread and the surface of the screw (008).
- 9 Open the vent screw (007) and make sure that the piston (006) is fully engaged.
- 10 Make sure that the tappet (003) and the piston (006) fully engage with the cut-outs of the bearing cover (002).
- 11 Connect the HP oil pump 94931 to the thrust device (004).
- 12 Operate the HP oil pump.
- 13 When oil that has no air flows out, close the vent screw (007).
- 14 Slowly increase the pressure to the correct value, refer to the name plate.
- 15 Manually tighten the vent screw (007).
- 16 Release the pressure to zero.
- 17 Remove the HP hose from the thrust device (004).
- 18 Attach the shackle 94019L (004, [Figure 6-24](#)) to the column.
- 19 Attach the manual ratchet 94016-012 (003) to the shackle (004).
- 20 Attach the roller support 94117A (001) to the position shown. Make sure that the spring clip (005) locks the pin (006) in position.
- 21 Put the chain of the manual ratchet (003) through the roller support (001).

- 22 Attach the manual ratchet (003) to the lug (002) on the bearing cover.

**Fig 6-24** Roller support

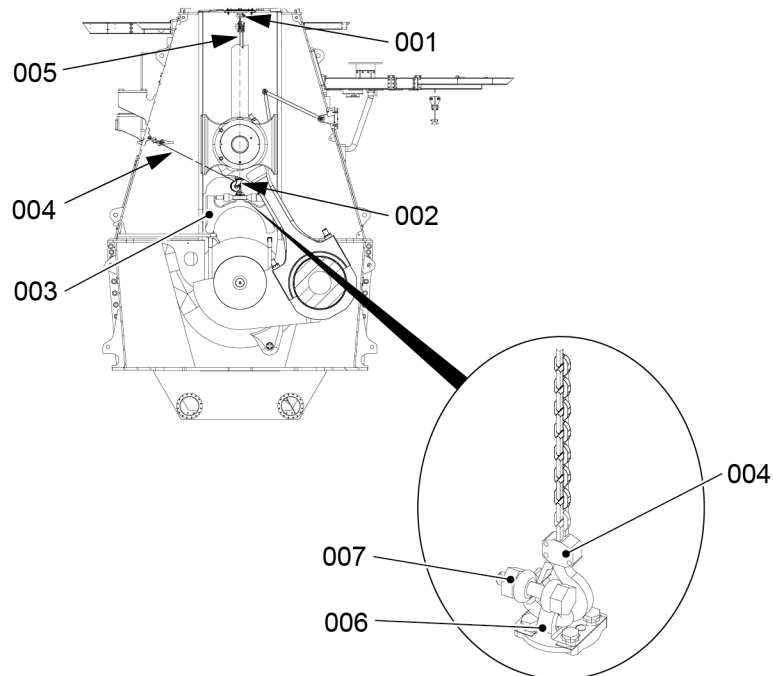


00619

### CAUTION

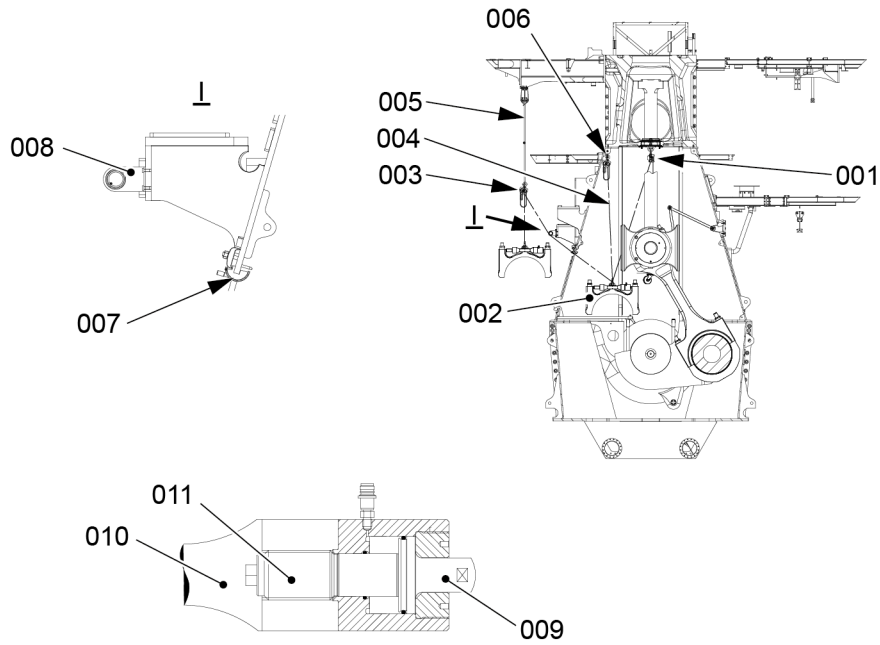
**Damage Hazard:** Use the roller support only as shown on its Warning plate. The maximum permitted load is 16000 N at 45°.

- 23 Operate the manual ratchet (004, [Figure 6-25](#)) to lift the bearing cover (003).  
24 Attach the eye bolt 94045-M56 (005) to the cylinder block.  
25 Attach the shackle 94019K (007) to the lug (006) on the bearing cover (003).  
26 Attach the chain block 94017-028 (005) to the eye bolt (001) and the shackle (007).  
27 Apply tension to the chain block (005).  
28 Remove the roller support (002) and the manual ratchet (004).

**Fig 6-25** Bearing cover No.2 to # - lift and lower

00620

- 29 Attach the sling 94039-015 (005, [Figure 6-26](#)) to the gallery.
  - 30 Attach the chain block 94017-029 (003) to the sling (005).
  - 31 Attach deviation pipes 94117C (007) and 94117B (008) to the column.
  - 32 Attach the shackle 94019P (006) to the column.
  - 33 Attach the chain block 94017-028 (004) to the shackle (006).
  - 34 Operate the chain blocks (004) and (001) to move the bearing cover (002) to the fuel side until the bearing cover hangs vertically on chain block (004).
  - 35 Attach the chain block (003) to the bearing cover (002).
  - 36 Remove the chain block (001) from the bearing cover (002).
  - 37 Operate the chain blocks (004, 003) to move the bearing cover (002) out of the engine.
  - 38 When the bearing cover (002) hangs vertically, remove the chain block (004).
  - 39 Lower the bearing cover (002) on to an applicable surface.
  - 40 Connect the HP oil pump 94931 to the thrust device (010).
  - 41 Operate the HP oil pump to apply 1040 bar pressure to the thrust device.
  - 42 Turn the screw (005) back.
  - 43 Slowly release the pressure to zero in the HP oil pump.
  - 44 Push in the piston (009) and remove the thrust device (010).
- NOTE:** Keep the chain blocks and the sling in position.

**Fig 6-26 Bearing cover No. 2 to # - remove**

00622

**CLOSE UP**

- Remove the applicable bearing shell, [6.5.2 Main bearing cover - No. 2 to #- install](#)



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## 6.5.2 Main bearing cover - No. 2 to #- install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
Roller support	94117		1
Platform	94143		1
Deviation pipe	94117B		1
Thrust device	94110		1
Lug	94116C		1
Manual ratchet	94016-012		1
Eye bolt	94045-M56		1
Spur-gearred chain block, 2500 kg	94017-028		2
Spur-gearred chain block, 2500 kg	94017-029		1
Deviation pipe	94117C		1
Sling	94039-015		1
Shackle 6500 kg	94019K		1
Shackle 13 500 kg	94019P		1
Shackle 8500 kg	94019L		1
Feeler gauge	94123		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Bearing shell			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The bearing shell must be installed, refer to [6.3.4 Main bearing - bearing shell - No. 2 to #- install](#)

- The work area and all tools and equipment must be clean and in good condition.

## PROCEDURE

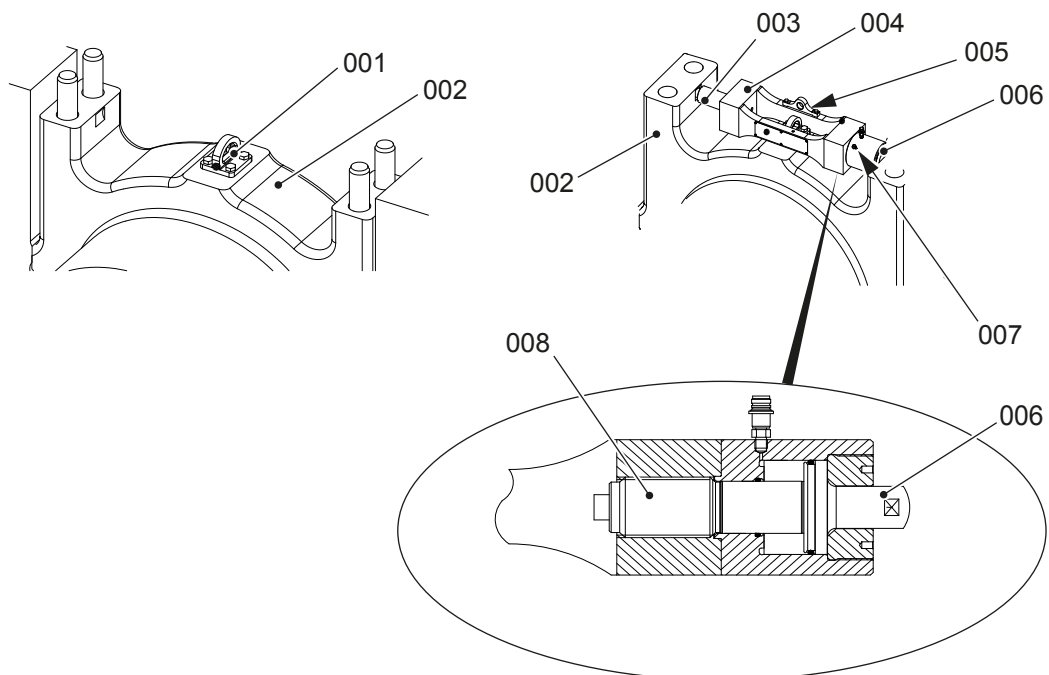
- 1 Clean all surfaces that touch on the bearing cover and bearing girder.
- 2 Make sure that the oil bore in the bearing cover is clear.
- 3 Attach the lug (001, [Figure 6-27](#)) to the bearing cover (002).

### WARNING

**Injury Hazard: The thrust device has a WLL of only 70 kg. Do not use the thrust device to lift the bearing cover. Injury to personnel can occur.**

- 4 **NOTE:** Put the thrust device (004) in position on the bearing cover (002).  
Use the lifting plate (005) only to move and install the thrust device (004).
- 5 Move the lifting plate (005) to its stowage position as shown.
- 6 Open the vent screw (007) and make sure that the piston (006) is fully engaged.
- 7 Make sure that the tappet (008) and the piston (006) fully engage with the cutouts in the bearing cover (002).
- 8 Operate the HP oil pump.
- 9 When oil that has no air flows out, close the vent screw (007).
- 10 Slowly increase the pressure to the correct value, refer to the name plate.
- 11 Manually tighten the screw (008).
- 12 Open the relief valve on the HP oil pump to release the pressure to zero.
- 13 Remove the HP hose from the thrust device (004).

**Fig 6-27 Thrust device**

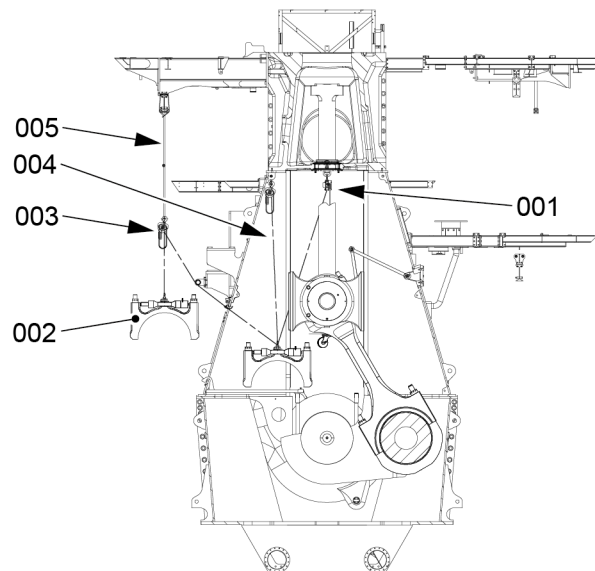


00614

- 14 Attach the chain block (003, [Figure 6-28](#)) to the lug on the bearing cover (002).

- 15 Operate the chain block to lift the bearing cover (002)
- 16 Attach the manual ratchet (004) to the shackle on the bearing cover (002).
- 17 Operate the chain block (003) and the manual ratchet (004) to move the bearing cover into the engine. Make sure that the bearing cover hangs vertically below the manual ratchet.
- 18 Remove carefully the chain block (003).
- 19 Attach the chain block (001) to the shackle on the bearing cover (002).
- 20 Operate the chain block (001) to hold the weight of the bearing cover (002).
- 21 Remove carefully the manual ratchet (004).

**Fig 6-28 Bearing cover No. 2 to #\_move**



00623

- 22 Attach the manual ratchet (004, [Figure 6-29](#)) to the column.
- 23 Put the chain of the manual ratchet (004) through the roller (002). Attach the manual ratchet to the lug (006) on the bearing cover (003).

### CAUTION

**Damage Hazard: Use the roller support only as shown on its Warning plate. The maximum permitted load is 16 000 N at 45°.**

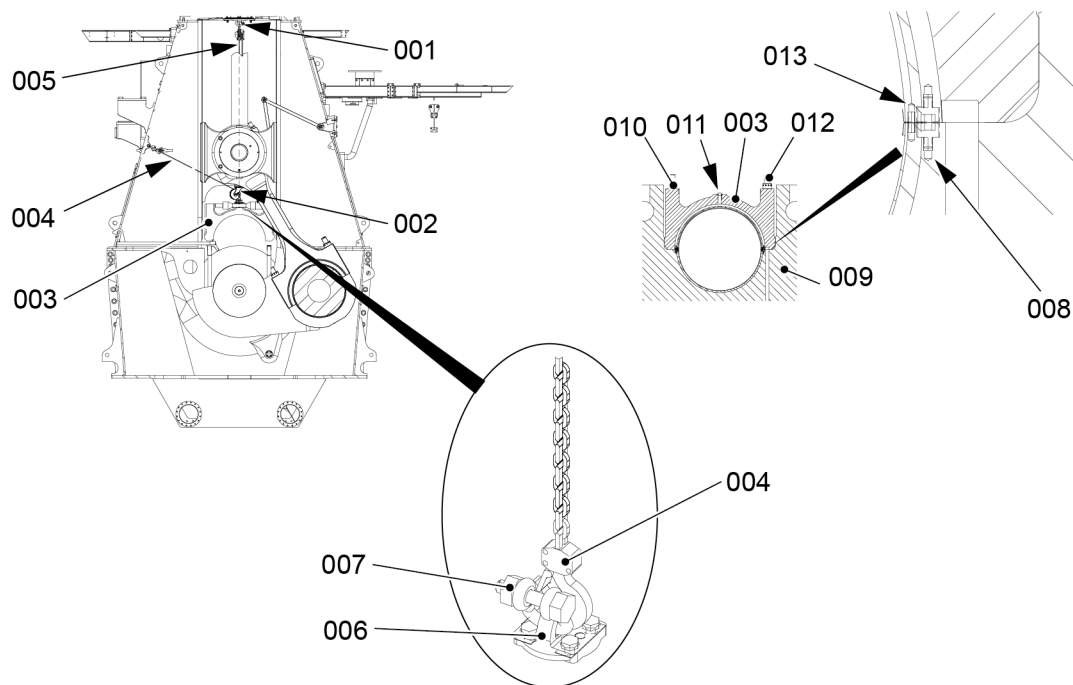
- 24 Operate the manual ratchet (004) to apply tension to the chain.
- 25 Remove the chain block (005).
 

**NOTE:** The top bearing shell is attached to the bearing cover (003) with the two Allen screws (013). The spring dowel pins (008) help to get the bearing cover in position during installation.

Operate the manual ratchet (004) to lower the bearing cover on to the bearing girder. Make sure that the two spring dowel pins (001) engage correctly. Make sure that you do not cause damage to the elastic studs (004).

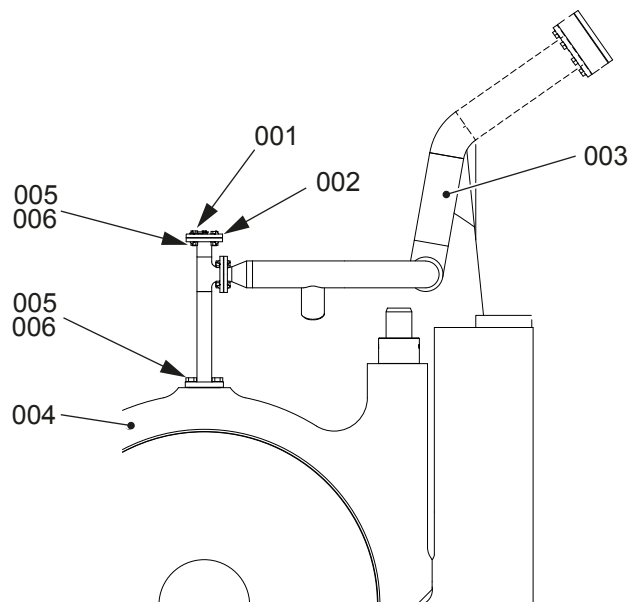
- 26 Remove the thrust device.
- 27 Remove the manual ratchet (004) from the lug (006).
- 28 Remove the shackle (007) from the lug (006).
- 29 Remove the lug (006).
- 30 Install the round nuts (010) on the elastic studs (012), refer to [4.2 Tighten a round nut with a pre-tensioner](#).

**Fig 6-29 Bearing cover No.2 to #- install**



00621

- 31 Clean the pipes (003, [Figure 6-30](#)).
- 32 Install the pipes (003), their gaskets and new tab washers (005).
- 33 Tighten the screws (006).
- 34 Lock the screws (006) with the new tab washers (005).

**Fig 6-30 Bearing cover - oil pipe**

00617

**35** Remove all tools and equipment from the work area.

**36** Measure the bearing clearance and compare the value measured in [6.5.1 Main bearing cover - No. 2 to # - remove](#) with the value given in [3.3 Clearances - general](#).

**NOTE:** If the clearance is in the limits given, the bearing can be removed and installed again.

### CLOSE UP

- None

## 6.6 Thrust bearing

### 6.6.1 Thrust bearing - examine the housing

#### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

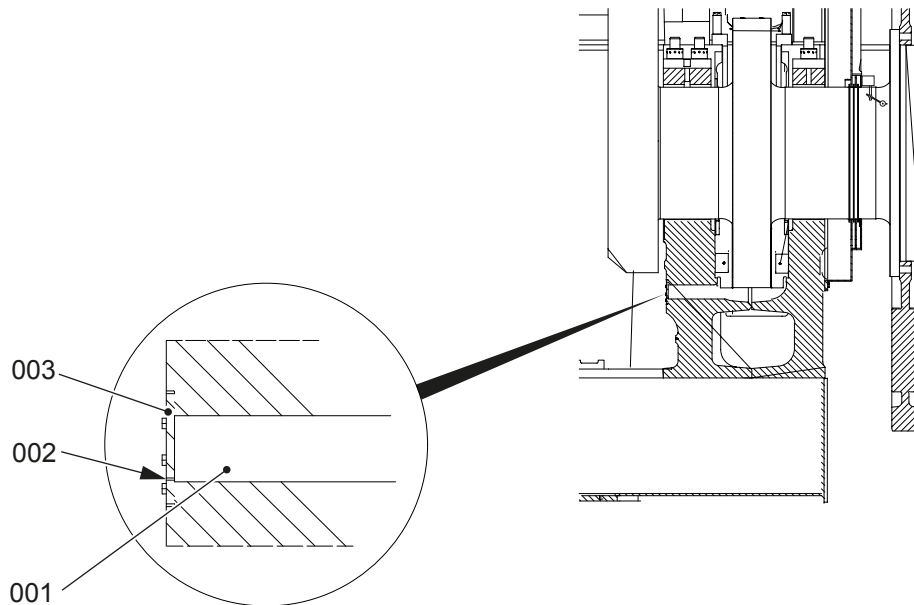
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- Do the procedure after maintenance.



## PROCEDURE

- 1 Remove the cover (003, [Figure 6-31](#)).
- 2 Do a check of the thrust bearing housing.
- 3 If necessary, remove particles from the area (001).
- 4 Make sure th the channel (002) is clear.
- 5 Install the cover (003).

**Fig 6-31 Visual examination**



00624

## CLOSE UP

- None

## 6.6.2 Thrust bearing - do a check of the axial clearance with a dial gauge

### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Dial gauge	N/A		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

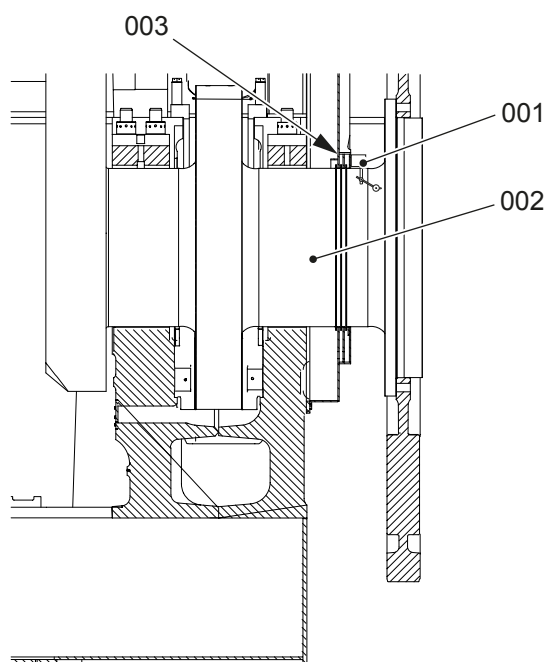
## PROCEDURE

- 1 Start the engine in the direction AHEAD to move the crankshaft (002, [Figure 6-32](#)) fully forward. The crankshaft must touch the thrust pads.
- 2 Stop the engine.
- 3 Put the dial gauge (001) in position on the oil baffle (003) and record the value.
- 4 Remove the dial gauge (001).
- 5 Start the engine in the direction REVERSE to move the crankshaft fully rearward. The crankshaft must touch the thrust pads.
- 6 Stop the engine.
- 7 Put the dial gauge (001) in position on the oil baffle (003) and record the value.
- 8 Remove the dial gauge (001).

- 9 Compare all recorded values with those given in the engine documents on the Check Dimensions page. Refer also to the applicable data in section [3.3 Clearances - general](#).

**NOTE:** If the measured values are more than the nominal values given, the thrust pads are worn. If necessary replace the thrust pads.

**Fig 6-32** Axial clearance



00625

## CLOSE UP

- None

### 6.6.3 Thrust bearing - do a check of the axial clearance with a inside micrometer

#### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Micrometer			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

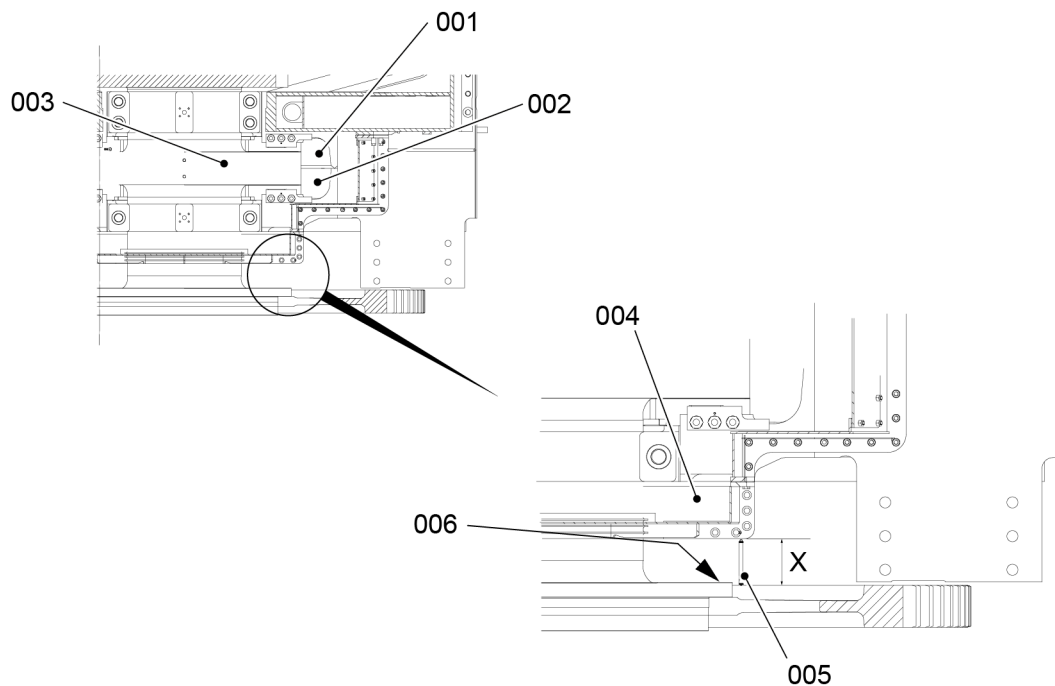
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Start the engine in the direction AHEAD to move the crankshaft fully forward. The crankshaft (003, [Figure 6-33](#)) must touch the thrust pads (002).
  - 2 Stop the engine.
  - 3 Make sure that the crankshaft (003) does not move.
  - 4 Use the micrometer 94101 (005) to measure the distance between the crankshaft flange (006) and the oil baffle (004).
  - 5 Record the value.
  - 6 Remove the micrometer (005).
  - 7 Start the engine in the direction ASTERN to move the crankshaft fully rearward. The crankshaft (003) must touch the thrust pads (001).
  - 8 Stop the engine.
  - 9 Make sure that the crankshaft does not move.
  - 10 Use the micrometer (005) to measure the distance between the crankshaft flange (006) and the oil baffle (004).
  - 11 Record the value.
  - 12 Remove the micrometer (005).
  - 13 Compare all recorded values with those given in the engine documents on the Check Dimensions page. Refer also to the applicable data in section [3.3 Clearances - general](#).
- NOTE:** If the measured values are more than the nominal values given, the thrust pads are worn. If necessary replace the thrust pads.

**Fig 6-33** Axial clearance - micrometer



00626

**CLOSE UP**

- None

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## 6.6.4 Thrust bearing - remove the pads

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Manual ratchet			1
Spur geared chain block WLL 2500 kg			2
Eye bolt			1
Shackle			2
Carrier			1
Link			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

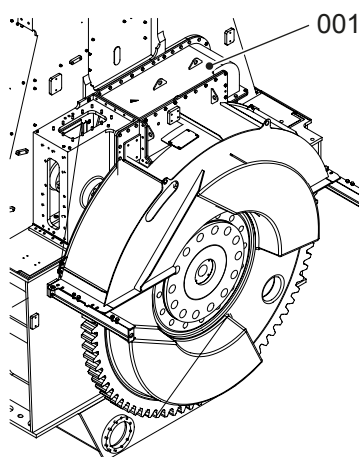
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Read the data in [3.1 Lifting tools](#).
- 2 Remove the cover (001, [Figure 6-34](#)).

**Fig 6-34** Cover - remove



00020

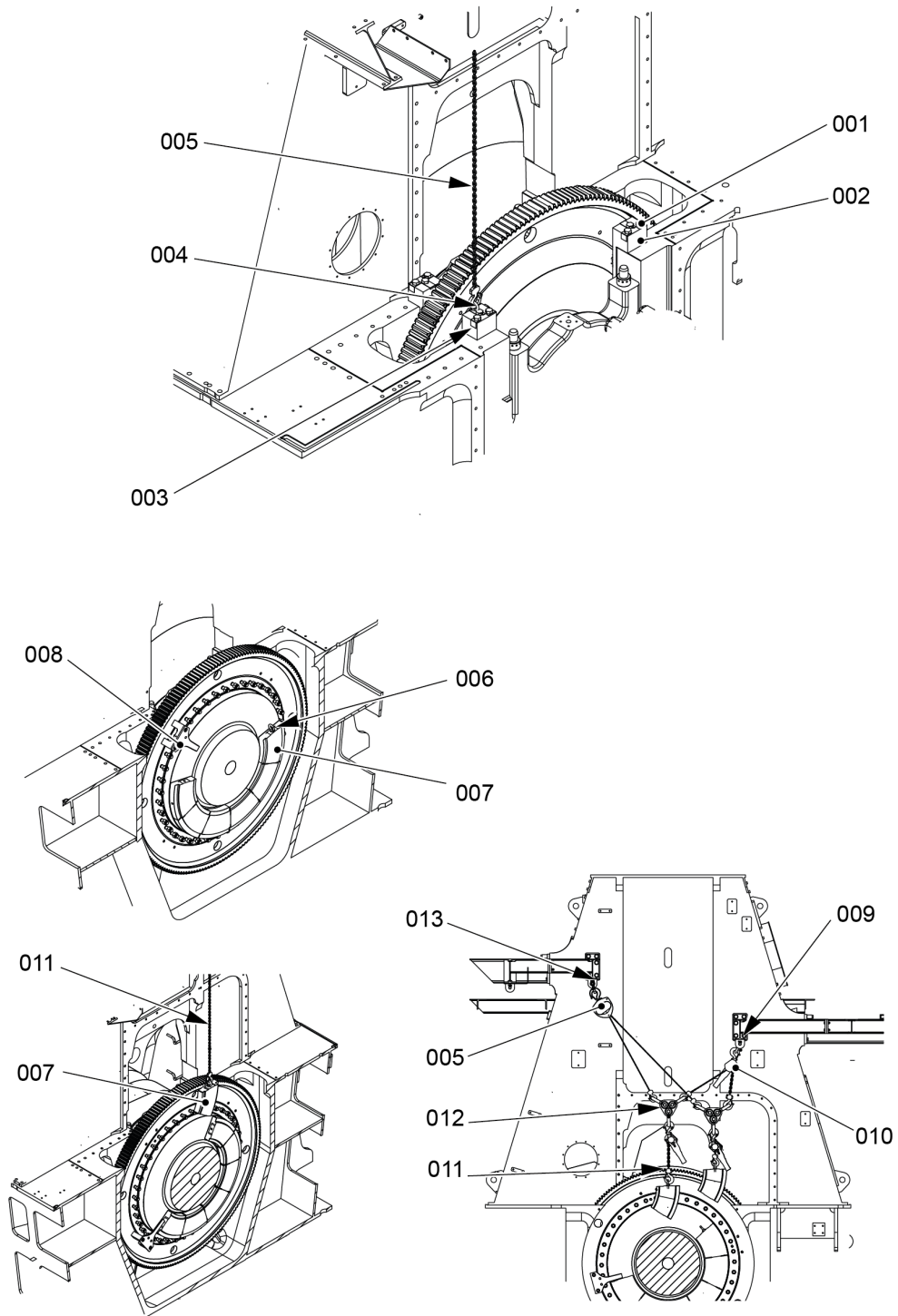
- 3 Record the positions of the thrust bearing pads.
- 4 Remove the three bolts (001, [Figure 6-35](#)) from each of the four arbor supports (002).
- 5 Remove and discard the locking plates (003).
- 6 Attach the eye bolt (004) to the arbor support.
- 7 Attach the two shackles (013) to the gallery.
- 8 Attach the spur-gearred chain block (005) to the shackle (013) and the M12 eye bolt (009).
- 9 Use the chain block (005) to remove the four arbor supports (002).
- 10 Attach the manual ratchet (010) to the other shackle (009).
- 11 Attach the link (012) to the manual ratchet (010) and the chain block (005).
- 12 Attach the other manual ratchet (011) to the link (012).
- 13 Remove the temperature sensors from the thrust pad.
- 14 Attach the carrier (008) to the gear wheel.
- 15 Attach the eye bolt (006) to the top thrust pad (007).

**WARNING**

**Injury hazard. Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.**

- 16** Operate the turning gear to move the crankshaft in the applicable direction.  
**NOTE:** While the gear wheel turns, the carrier (008) moves the thrust pads. The first thrust pad (007) will come out.
- 17** Keep a light tension on the manual ratchet (011) and the chain block (005) while the thrust pad (007) moves up.
- 18** Remove the thrust pad (007).
- 19** Remove carefully the manual ratchet (010).
- 20** Use the chain block (005) and the manual ratchet (011) to move the thrust pad (007) to the exhaust side.
- 21** Lower the thrust pad (007) on to a stable area.
- 22** Do [Step 15](#) to [Step 21](#) for the remaining thrust pads you must remove.

Fig 6-35 Thrust pad - removal



00012

**NOTE:** If some of the thrust pads are removed, the remaining thrust pads will keep the crankshaft in position. If all thrust pads from the same side are removed, for example all the astern pads, the crankshaft can move.

**23** To prevent crankshaft movement, do as follows:

- 23.1 Get a piece of hardwood that has the same dimensions as a thrust pad.
- 23.2 Put the hardwood in the position of the removed thrust pads.

## CLOSE UP

- None

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## 6.6.5 Thrust bearing - install the pads

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Manual ratchet			1
Spur geared chain block WLL 2500 kg			2
Eye bolt			1
Shackle			2
Carrier			1
Link			1

### Supplies

Description	QTY
Engine oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Thrust pad			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

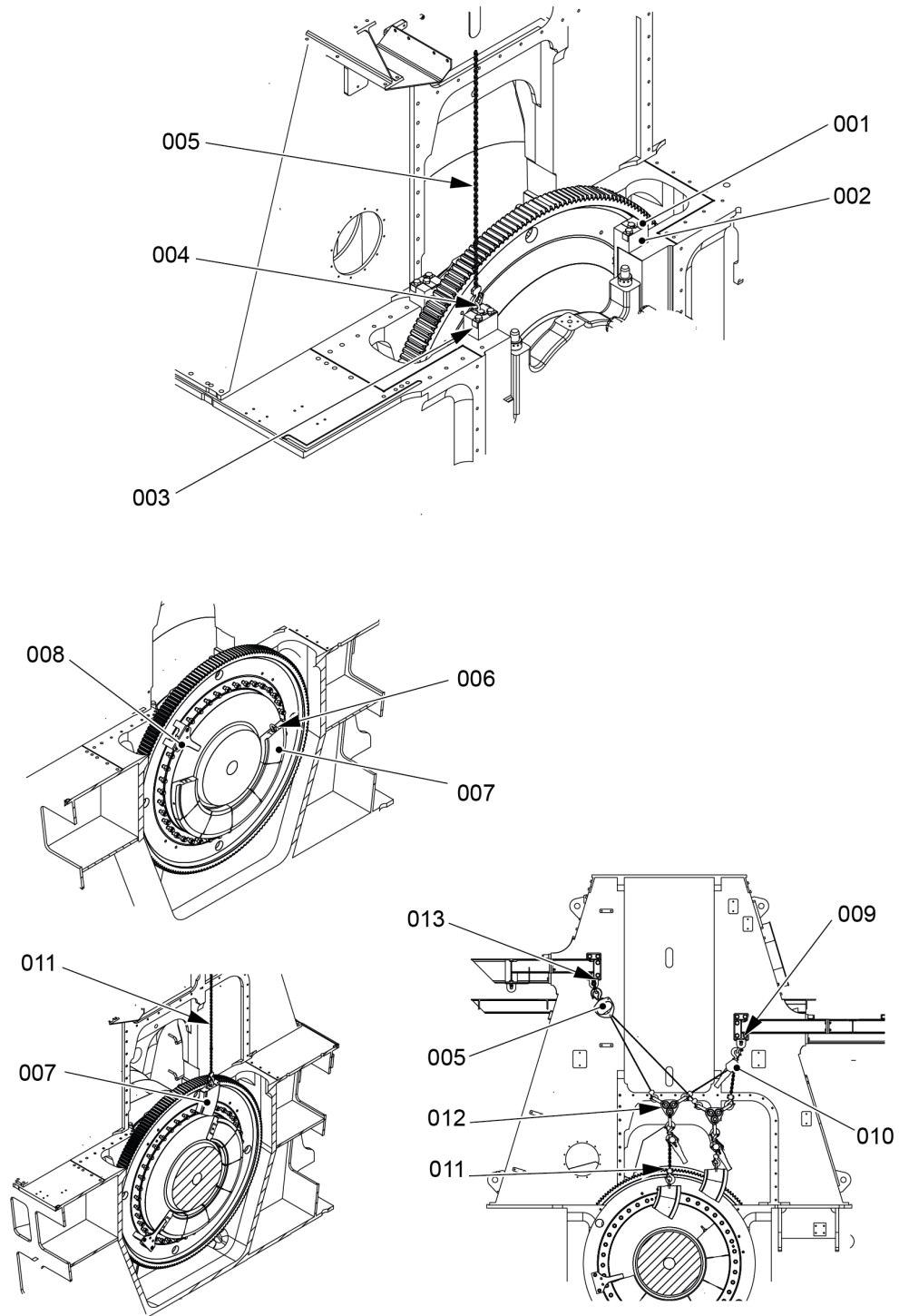
## PROCEDURE

- 1 Make sure that the thrust pads are clean.
- 2 Apply clean engine oil to the thrust pads.  
**NOTE:** You must install thrust pads that you removed before in the same positions.  
Use your recorded notes for the correct positions.
- 3 Attach the eye bolt (006, [Figure 6-36](#)) to the thrust pad (007).
- 4 Attach the manual ratchet (012) to the eye bolt (006).
- 5 Operate the manual ratchet (012) and the spur-gear chain block (005) to lift the thrust pad (007).
- 6 Move the thrust pad (007) into position above the gear wheel.
- 7 Lower the thrust pad (007). Make sure that the thrust pad touches the carrier (008).

## WARNING

**Injury hazard. before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.**

- 8 Operate the turning gear to turn the crankshaft in the applicable direction.
- 9 Put the subsequent thrust bearing pad in position.
- 10 Do [Step 3](#) to [Step 9](#) for each thrust pad.
- 11 When all thrust pads are in position, make sure that the top, outer thrust pads are at equal height.
- 12 Remove the carrier (008).
- 13 Remove the manual ratchets (010, 011) and the link (012).
- 14 Install the arbor supports (002) as follows:
  - 14.1 Attach the eye bolt (004) to the applicable arbor support.
  - 14.2 Attach the chain block spur-gear chain block (005) to the eye bolt (004).
  - 14.3 Operate the chain block (005) to move the arbor support (002) into position.
  - 14.4 Remove the chain block (005) and the eye bolt (004).
  - 14.5 Put new locking plates (003) in position on the arbor support (002).
  - 14.6 Attach the arbor support (002) to the engine with the bolts (001).
  - 14.7 Torque the bolts (001).
  - 14.8 Bend the locking plates (003) to lock the bolts (001).

**Fig 6-36** Thrust pad - install

00012

- 15** Install the temperature sensors removed before.
- 16** Do a check of the clearances between the arbor supports and the thrust pads, refer to section [6.6.2 Thrust bearing - do a check of the axial clearance with a dial gauge](#) or

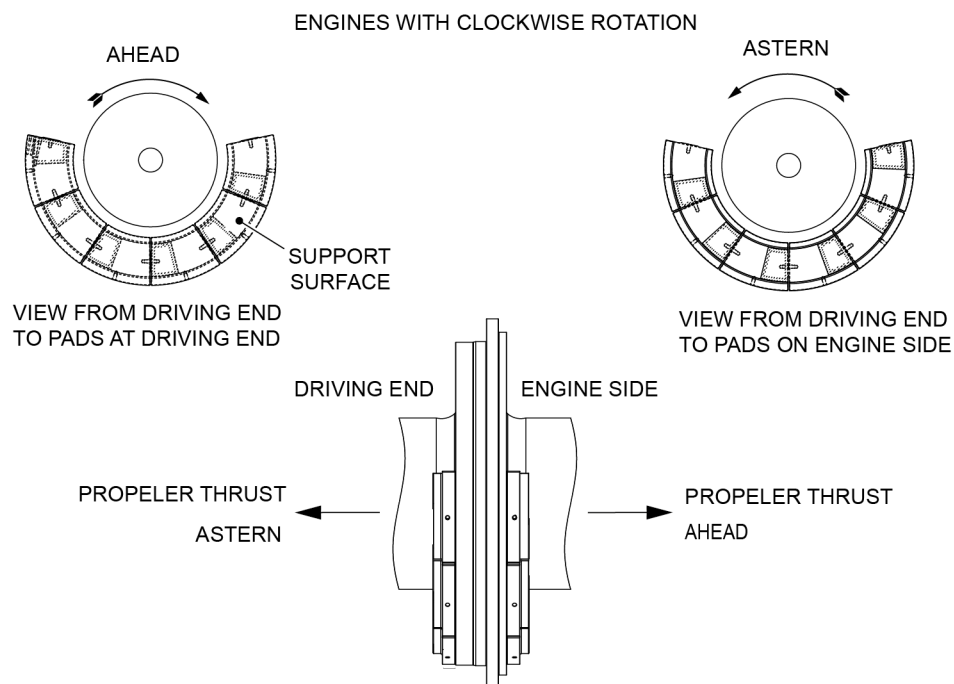


section [6.6.3 Thrust bearing - do a check of the axial clearance with a inside micrometer](#).

**NOTE:** When you replace new thrust pads (or thrust pads that have new metal), you must make sure that the dimensions are the same as the adjacent pad(s).

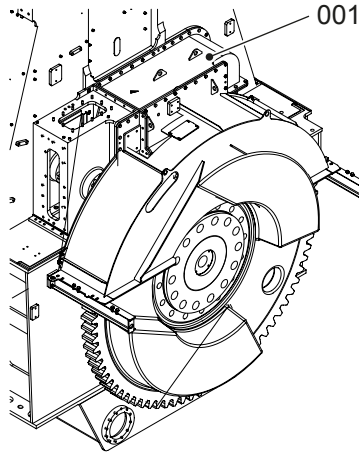
- 17 Adjust the clearances to the original values, refer to section [3.3 Clearances - general](#).
- 18 Do a visual examination of the thrust bearing housing, refer to [6.6.1 Thrust bearing - examine the housing](#).
- 19 For the configuration of the thrust pads, refer to [Figure 6-37](#).

**Fig 6-37 Thrust pads - configuration**



00013

- 20 Attach the cover (001, [Figure 6-38](#)) to the engine.

**Fig 6-38 Cover - install**

00020

**CLOSE UP**

- None

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## 6.7 Engine stays

### 6.7.1 Engine stays (friction shims) - do a check of the pre-tension

#### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	8.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	2

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 For the applicable value for pre-tension refer to section [16.1 Tightening instructions](#).
- 2 Do a check of the pre-tension of the engine stays, refer to section [4.4 Do a check of the pre-tension](#).

## CLOSE UP

- None

## 6.7.2 Engine stays (hydraulic) - do a check of the oil pressure

### Periodicity

Description	
Months	1
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	8.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	2

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

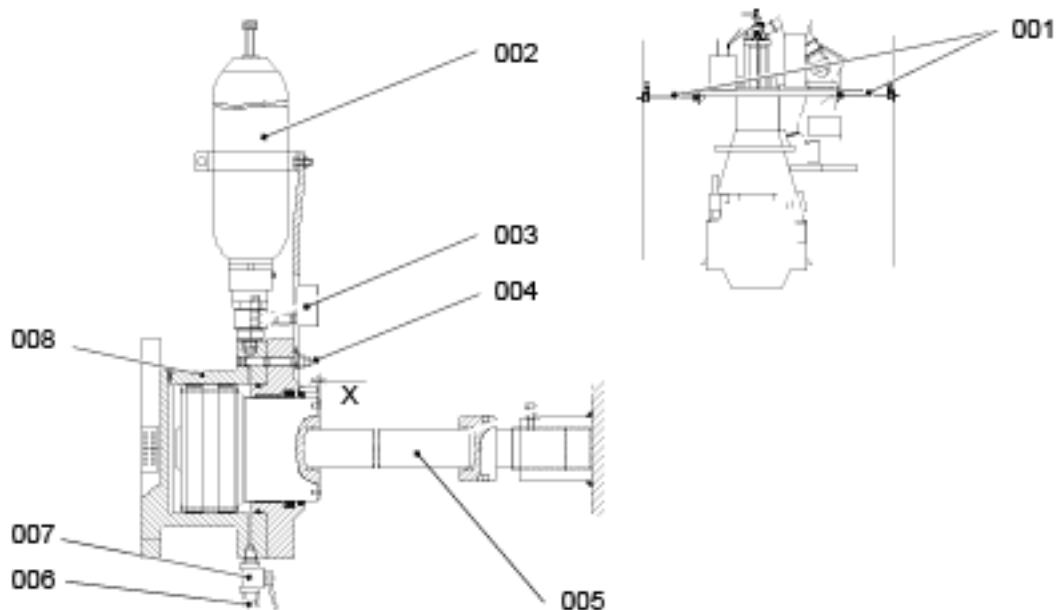
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Do a check of the distance (X) to make sure that the engine is not tilted. The distance (X) must be zero before you do a check of the pressure gauges (007, [Figure 6-39](#)).
- 2 Do a check of the oil pressure values at the gauges (003). If the values of two opposite engines stays added together are less than 120 bar, do as follows:
  - 2.1 Refer to the documentation of the manufacturer.
  - 2.2 Decrease fully the oil pressure.
  - 2.3 Fill the accumulator with nitrogen to a pressure of 40 bar.
  - 2.4 Make sure that the pressure stays constant. If not, there is a leak in the gas system.
  - 2.5 Increase the oil pressure to 80 bar.
  - 2.6 Make sure that the pressure stays constant. If the pressure does not stay constant, change piston seals.
  - 2.7 Make sure that the values on the pressure gauges are the same as the opposite engine stay.

**Fig 6-39 Engine stays - pressure check**



## CLOSE UP

- None

## 6.8 Tie rod

### 6.8.1 Tie rod - do a check of the pre-tension

#### Periodicity

Description	
Working hours	27 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Pre-tensioning jacks			2
Feeler gauge			1

#### Supplies

Description	QTY
Molykote paste G	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

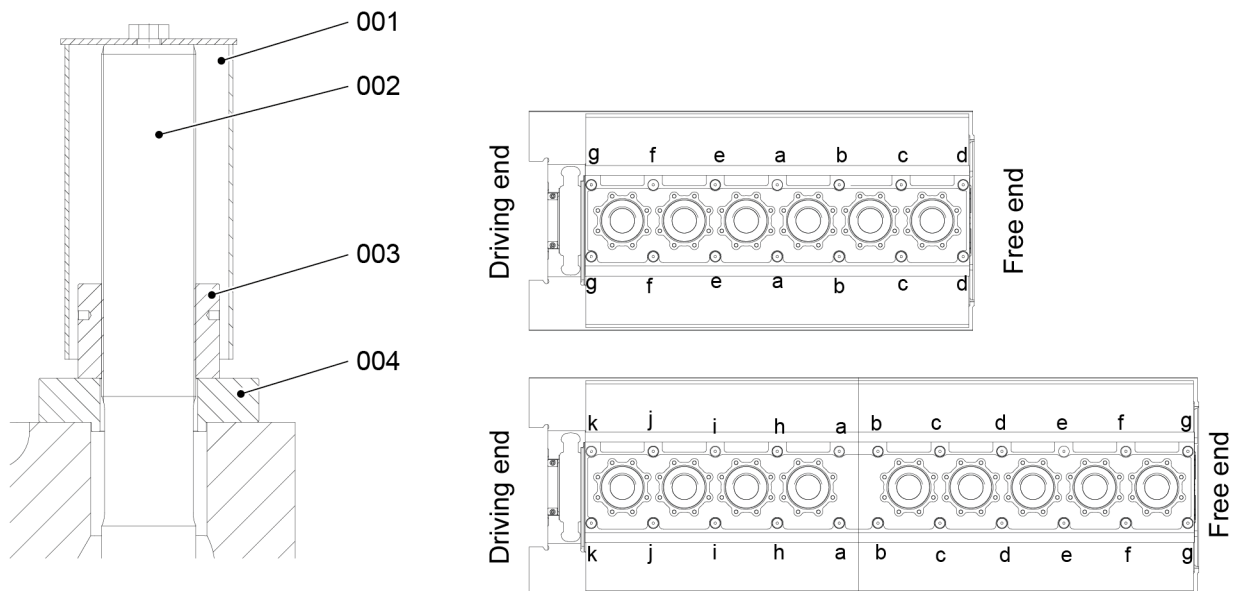
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Remove the protection cover (001, [Figure 6-40](#)) from all tie rods (002).
- 2 Clean the faces of the intermediate rings (004).
- 3 Do a check of the pre-tension of the first pair of tie rods a-a, refer to section [4.4 Do a check of the pre-tension](#).  
**NOTE:** Start with the tie rods in the middle of the engine a-a, then b-b etc.
- 4 Do [Step 3](#) again for the other tie rods.
- 5 Apply a layer of Molykote paste G to the threads of the tie rods (002) to prevent corrosion.
- 6 Attach the protection covers (001).

**Fig 6-40 Pre-tension checks**



00924

## CLOSE UP

- None

## 6.8.2 Tie rod - remove

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Pre-tensioning jacks			2
Eye bolt			A/R

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### CAUTION

Use the correct equipment for removal to prevent injury to personnel.

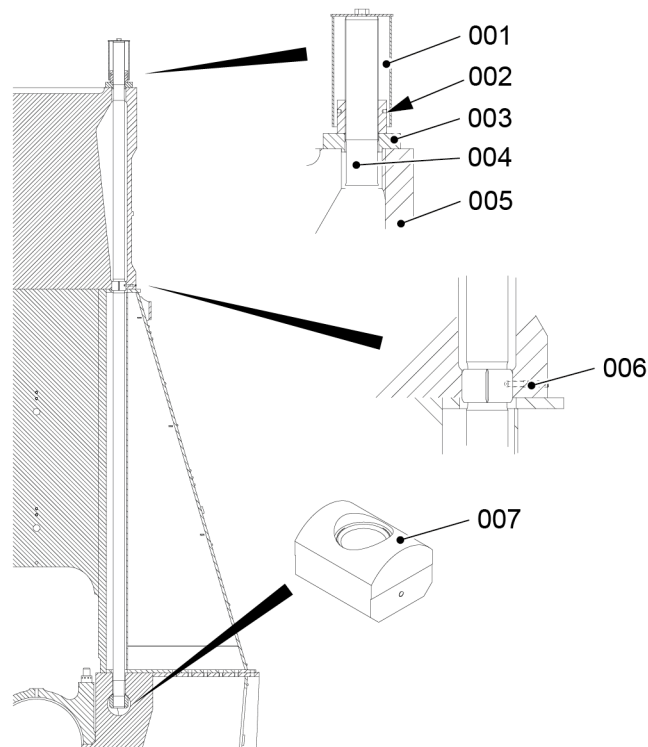
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the protection cover (001, [Figure 6-41](#)) from the tie rods (004).
- 2 Clean the surface of the intermediate ring (003).
- 3 Attach the two pre-tensioning jacks to the applicable tie rod (004).
- 4 Remove the round nut (002), refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 5 Loosen the two set screws (006).
- 6 Use two round nuts to remove the tie rod (004) from the nut (007).
- 7 Attach an eye bolt to the tie rod (004).
- 8 Attach the engine room crane to the eye bolt.
- 9 Operate the engine room crane to lift the tie rod (004) from the cylinder jacket (005).
- 10 Move the tie rod (004) to an applicable area.

**Fig 6-41** Tie rod - removal



00925

## CLOSE UP

- None

### 6.8.3 Tie rod - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Pre-tensioning jacks			2
Eye bolt			A/R

#### Supplies

Description	QTY
Molykote paste G	A/R
Loctite 577	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Tie rod			A/R

#### SAFETY PRECAUTIONS

##### CAUTION

Use the correct equipment for removal to prevent injury to personnel.

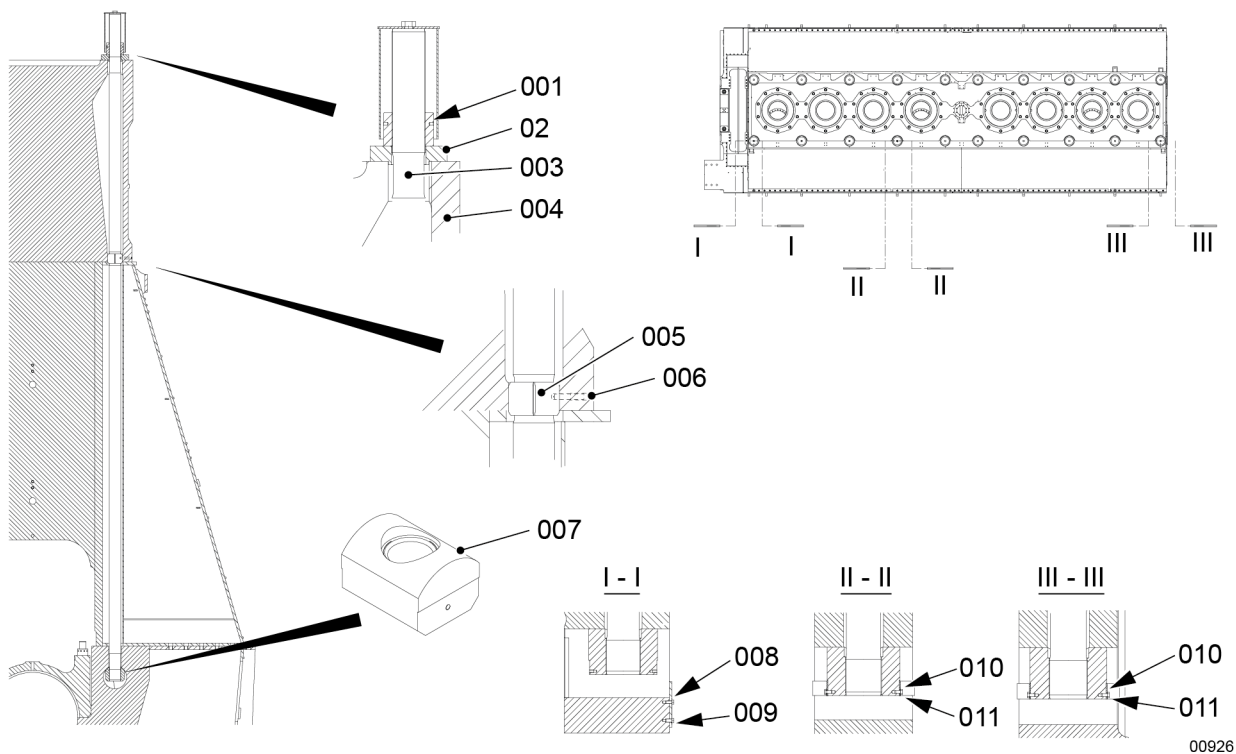
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the applicable holder (008 or 010, [Figure 6-42](#)).
  - 2 Make sure that the nut (007) is correctly attached.
  - 3 Apply Molykote paste G to the bottom thread of the tie rod (003).
  - 4 Clean the top surfaces of the cylinder jacket (004).
  - 5 Make sure that the bush (005) is installed.
  - 6 Attach an eye bolt to the top of the tie rod (003).
  - 7 Attach the engine room crane to the eye bolt.
  - 8 Operate the engine room crane to lift and move the tie rod (003) into position.
  - 9 Operate the engine room crane to lower the tie rod (003) into the cylinder jacket (004).
  - 10 Turn the tie rod (003) until the bottom is flush with the bottom of the nut (007).
  - 11 Attach the intermediate ring (002) to the tie rod (003).
  - 12 Apply Molykote paste G to the top thread of the tie rod (003) and to the top surface of the intermediate ring (002).
  - 13 Attach the round nut (001) to the tie rod (003).
  - 14 Operate the engine room crane to lift the tie rod (003), then fully tighten the round nut (001).
  - 15 Make sure that the nut (007) is fully up.
  - 16 Install the applicable holder (008 or 010).
- NOTE:** The tie rod at the first cylinder (driving end) has only one holder (008).

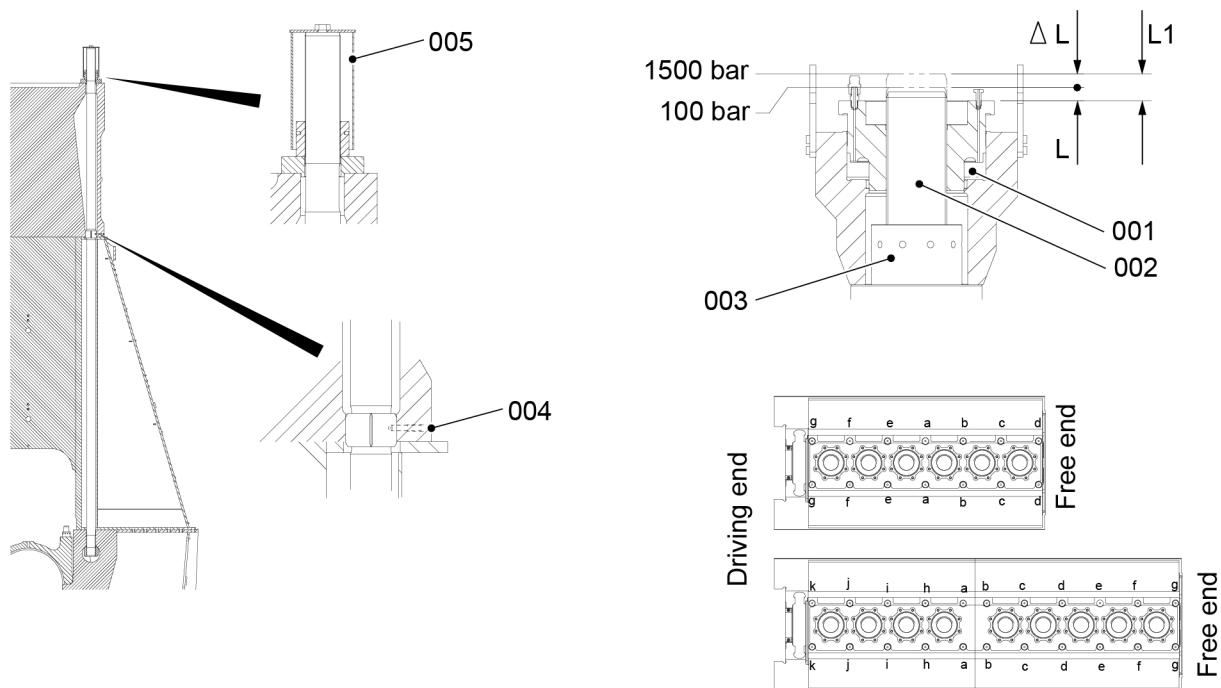
**Fig 6-42 Tie rod - install**



- 17 Attach the pre-tensioner (003) to the tie rod (002, [Figure 6-43](#))

- 18 Apply a tension of 100 bar to the tie rod (002), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 19 Record the length of the tie rod (002) at L.
- 20 Apply a tension of 1800 bar to the tie rod (002), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 21 Record the extension of the tie rod (002) at L1.
- 22 Make sure that the extension  $\Delta L (= L1 - L)$  of the tie rod (002) is in the limit, refer to section [16.1 Tightening instructions](#).
- 23 Tighten the round nut (003) and remove the pre-tensioner (001), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 24 Apply Loctite 577 to the threads of the two set-screws (004).
- 25 Put the two set-screws (004) in position.
- 26 Tighten the two set-screws (004).
- 27 Apply a layer of Molykote paste G to prevent corrosion.
- 28 Install the protection covers (005) to the tie rods (002).

**Fig 6-43 Tie rod - apply tension**



00927

## CLOSE UP

- None

## 7 Group 2 - Cylinder

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## 7.1 Cylinder liner

### 7.1.1 Cylinder liner - do a check of the bore

#### Periodicity

Description	
Unscheduled	After each piston removal and installation
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	2

#### Support equipment

Description	Part No.	CSN	QTY
Inside micrometer			1
Ladder			1
Gauge			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Gas Hazard: Poisonous gas can stay in the cylinder liner. There is a risk of suffocation. You must make sure that poisonous gas is removed before you go into the cylinder liner. You must put on a harness attached to a safety person before you do work in cylinders where gas can stay.**

#### WARNING

**Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.**

**CAUTION**

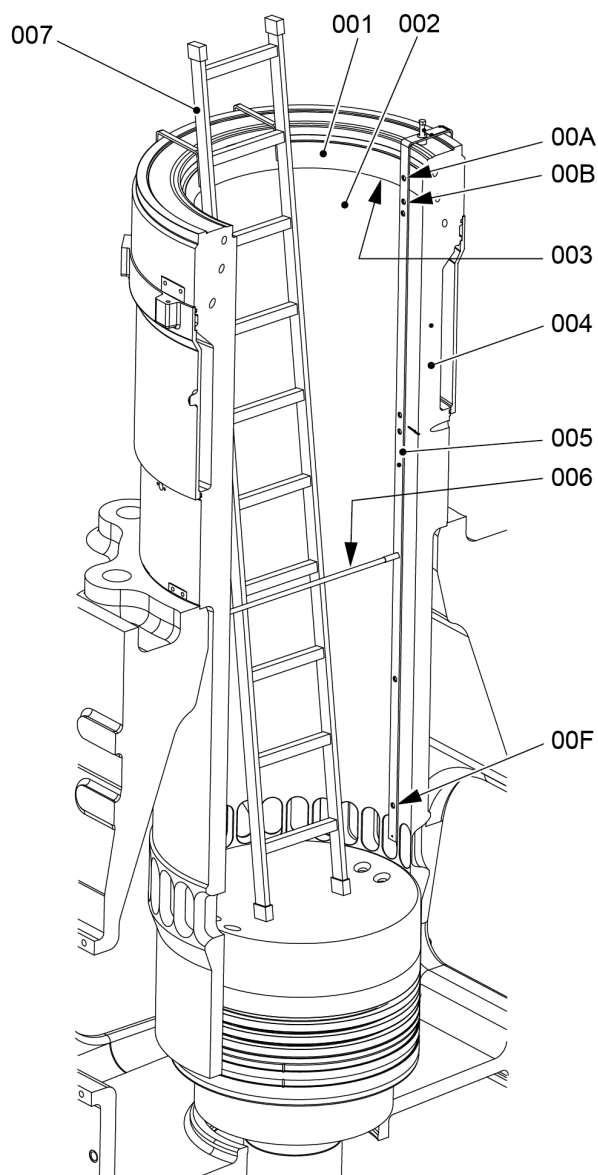
**Injury Hazard: Hot parts can cause injury to personnel. Be careful when you do work in areas where there are hot parts.**

**PRELIMINARY OPERATIONS**

- The cylinder cover must be removed, refer to section [7.5.1 Cylinder cover - remove](#)

**PROCEDURE**

- 1 Operate the turning gear to move the piston to BDC.
- 2 Lock the lever of the cooling water valve in the closed position.
- 3 Put the ladder (007, [Figure 7-1](#)) in position in the cylinder liner (004).

**Fig 7-1 Cylinder liner - dimension check**

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00181

- 4** Clean the area (001) above the running surface (002).
- 5** Remove the bottom part of the measuring gauge (005).

- 6 Put the measuring gauge (005) in position on the top face of the cylinder liner (004) in line with the longitudinal axis of the engine.
  - 7 Make sure that the top hole (00A) is above the ridge (003) in the non-running surface of the cylinder liner (004).
  - 8 Put the inside micrometer (006) in the top hole (00A) to measure the distance. Record the value.
  - 9 Do [Step 8](#) again for the other holes.
  - 10 Move the gauge (005) for an angle of 90° (in line with the transverse axis of the engine).
  - 11 Do [Step 8](#) and [Step 9](#) again in the new position of the gauge (005).
  - 12 Read the values from when the bore was measured before. Compare these values with the new values.
  - 13 Use the formula shown below to calculate the wear rate with the values as follows:
    - WR = Wear rate (mm/1000 hours)
    - T1 = Total running hours (h)
    - D1 = Maximum liner diameter of running surface (point 00B and below) (mm)
    - D2 = Liner diameter of non-running surface (point 00A) (mm).
- $$WR = \frac{(D1 - D2) \times 1000}{(T1)}$$
- 14 For the maximum permitted inner diameter, refer to section [3.3 Clearances - general](#).
  - 15 Remove all waste particles from the cylinder liner (004).
  - 16 Clean the cylinder liner (004).
  - 17 Remove all tools from the cylinder liner (004).

00182

## CLOSE UP

- None

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## 7.1.2 Cylinder liner - remove

### Periodicity

Description	
Unscheduled	As necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolt			2
Sling			2
Shackle			2
Lifting tool			1
Plate			2
Lifting tool			2
Sling			2

### Supplies

Description	QTY
Molyslip Copaslip	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- The cylinder cover must be removed, refer to section [7.5.1 Cylinder cover - remove](#)
- The lubricating quills must be removed, refer to section [7.2.1 Lubricating quill - remove](#)
- The piston must be removed, refer to section [8.7.3 Piston - remove](#)
- For a DF engine - the gas admission valves must be removed, refer to section [\[section not applicable for this engine\]](#)

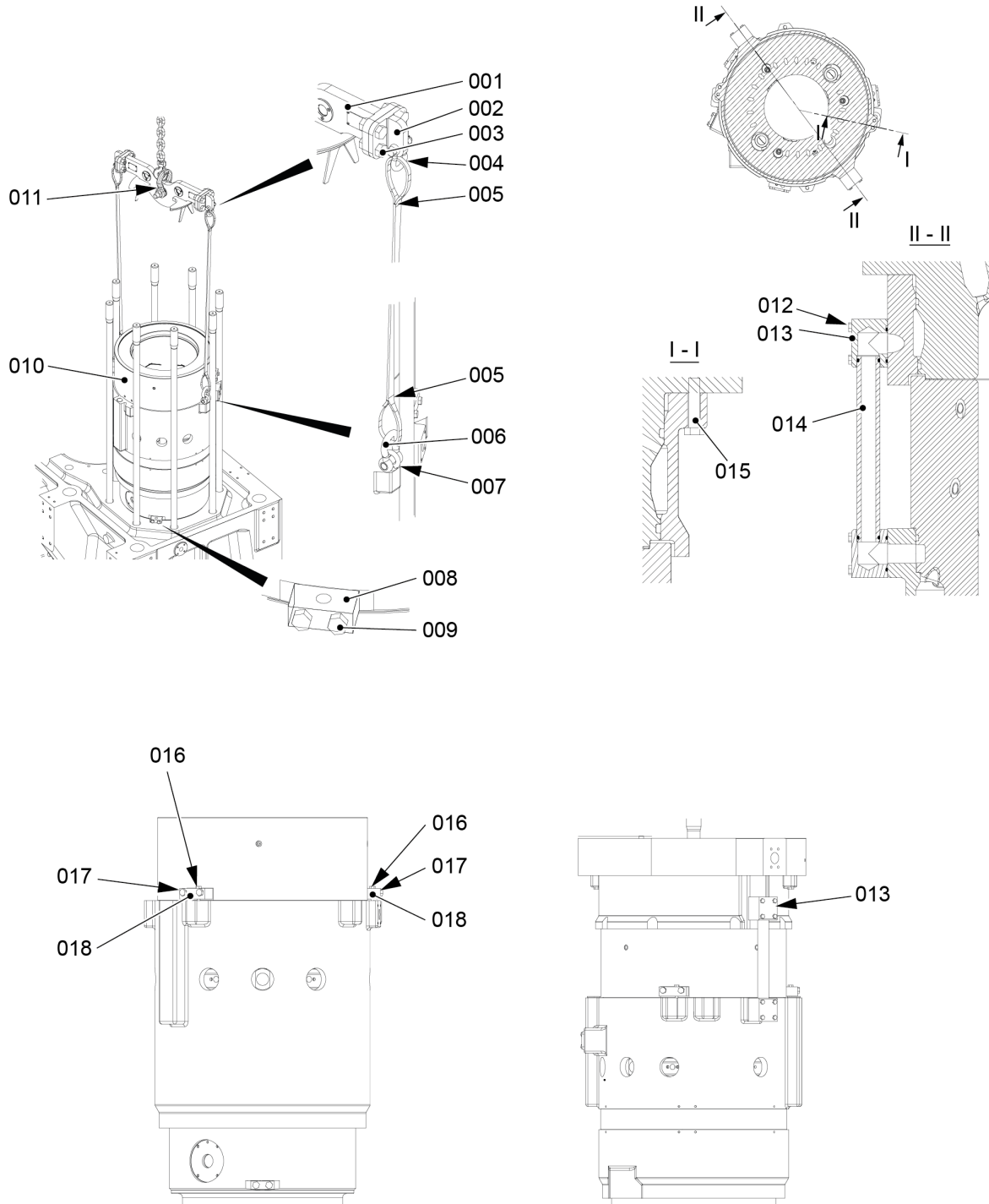


## PROCEDURE

- 1 Remove the water guide jacket.
  - 1.1 If necessary, attach the lifting tools (002, [Figure 7-2](#)) to the lifting tool (001) as follows:
    - 1.1.1 Make sure that the shackle (011) is attached to the middle hole in the lifting tool (001).
    - 1.1.2 Attach the two lifting tools (002) to the lifting tool (001) with the eight nuts and bolts (003).
    - 1.1.3 Tighten the eight nuts and bolts (003).
  - 1.2 Attach the two eye bolts (007) to the water guide jacket (010).
  - 1.3 Attach the two shackles (006) to the eye bolts (007)
  - 1.4 Attach the two slings (005) to the shackles (004).
  - 1.5 Remove the two bolts (015)
  - 1.6 Remove the two bolts (009).
  - 1.7 Remove the holder (008).
  - 1.8 Remove the four bolts (012).
  - 1.9 Remove the pipe connections (013).
  - 1.10 Remove the tubes (014).

**NOTE:** The tubes are a push-fit in the pipe connections (013).
  - 1.11 Attach the engine room crane to the shackle (011) on the lifting tool (001).
  - 1.12 Operate the engine room crane to move the lifting tool (001) into position above the water guide jacket (013).
  - 1.13 Attach the two slings (005) to the shackles (006).
  - 1.14 Operate the engine room crane to hold the weight of the water guide jacket (010).
  - 1.15 Remove the three bolts (016).
  - 1.16 Remove the eight bolts (017) and the three holders (018).
  - 1.17 Operate the engine room crane to lower the water guide jacket (010) on to the cylinder block.

Fig 7-2 Water guide jacket



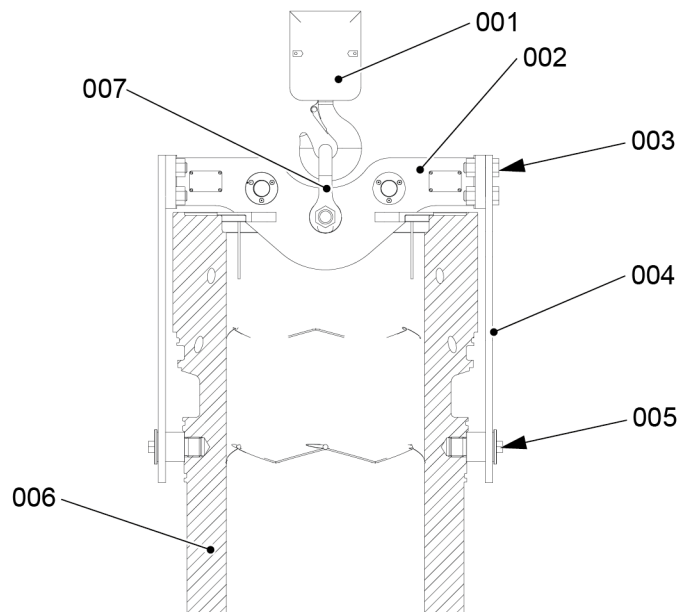
00631

- 2 Remove the pipes to the lubricating quills as follows
  - 2.1 Remove the applicable pipe holders.
  - 2.2 Disconnect the related pipes.

- 2.3 Seal the pipes with applicable seals to prevent contamination.
- 3 Attach the two plates (004, [Figure 7-3](#)) to the lifting tool (002) as follows:
  - 3.1 Remove the two lifting tools from the lifting tool (002).
  - 3.2 Attach the engine room crane (001) to the shackle (007).
  - 3.3 Operate the engine room crane (001) to lift the lifting tool (002) to a sufficient height.
  - 3.4 Apply Molyslip Copaslip to the threads and surfaces that touch on the special screw (005) and the eight M27 bolts and nuts (003).
  - 3.5 Attach the two plates (004) in position on the lifting tool (002) with the eight M27 nuts and bolts (003).
  - 3.6 Torque the four nuts and bolts (003), refer to section [16.1 Tightening instructions](#).
- 4 Operate the engine room crane (001) to move the lifting tool (002) and plates (004) into position on the cylinder liner (006).

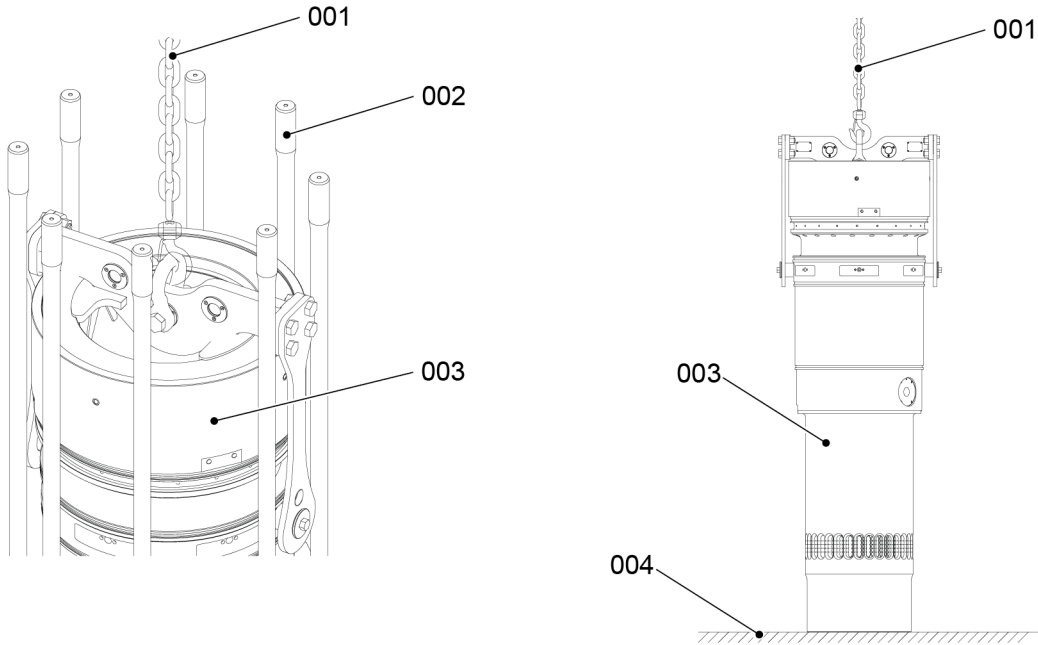
**NOTE:** The connection between the plate (004) and the cylinder liner (006) relates to the engine.
- 5 Torque the special screws (005) to the related value, refer to section [16.1 Tightening instructions](#).

**Fig 7-3 Lifting tool (example)**



00632

- 6 Operate the engine room crane (001, [Figure 7-4](#)) to lift the cylinder liner (003).
- 7 Move the cylinder liner (003) over the elastic bolts (002).
- 8 Lower the cylinder liner on to an applicable wooden underlay (004).
- 9 If necessary, put the cylinder liner (003) into safe storage, refer to section [7.1.3 Cylinder liner - preserve](#).

**Fig 7-4 Cylinder liner (example) - move**

00634

**CLOSE UP**

- None

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### 7.1.3 Cylinder liner - preserve

#### Periodicity

Description	
Unscheduled	As necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Chain			1
Lifting tool			1
Wooden chocks			A/R
Wooden underlay			A/R

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

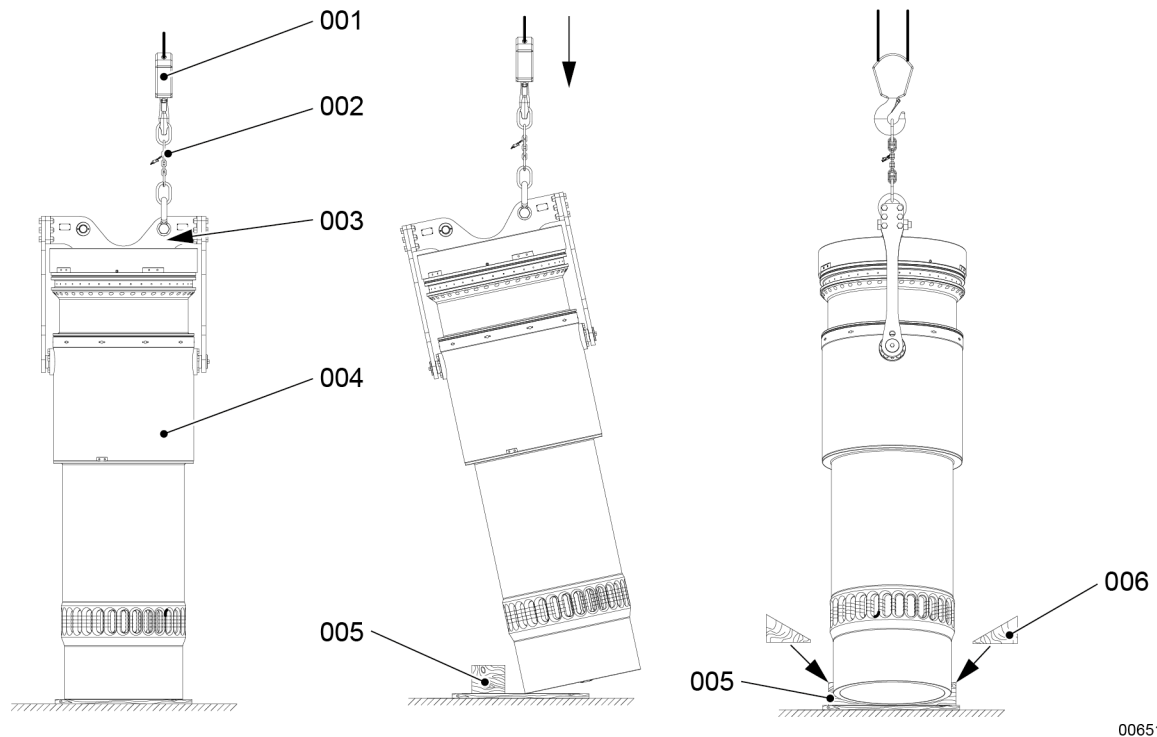
#### PRELIMINARY OPERATIONS

- The cylinder liner must be removed, refer to section [7.1.2 Cylinder liner - remove](#)

## PROCEDURE

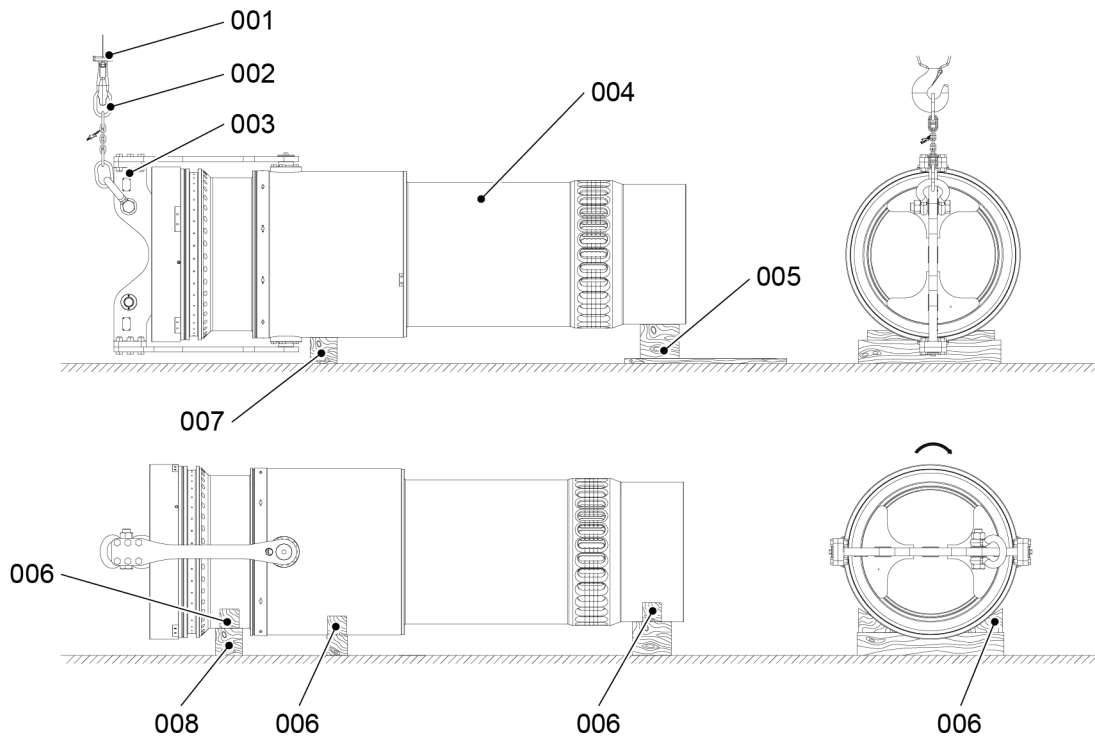
- 1 Attach the chain (002, [Figure 7-5](#)) to the lifting tool (003) and the engine room crane (001) as shown.

**Fig 7-5** Cylinder liner - storage



- 2 Put the wooden underlay (005, 007) and the wooden chocks (006) in position as shown in [Figure 7-6](#).
- 3 Lift the cylinder liner (004) a small distance to tilt the cylinder liner.
- 4 Operate the engine room crane to lower the cylinder liner (004) on to the wooden underlays (005, 007).
- 5 Fully lower the cylinder liner.
- 6 Turn the cylinder liner 90°.
- 7 Put the wooden chocks (006) in position to prevent movement.
- 8 Remove the lifting tool (003).
- 9 Put one more wooden chock (006) in position as shown.

Fig 7-6 Cylinder liner - storage 2



00652

**CLOSE UP**

- None



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## 7.1.4 Cylinder liner - grind

### Periodicity

Description	
Unscheduled	As necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Grinding device			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The cylinder cover must be removed, refer to section [7.5.1 Cylinder cover - remove](#)

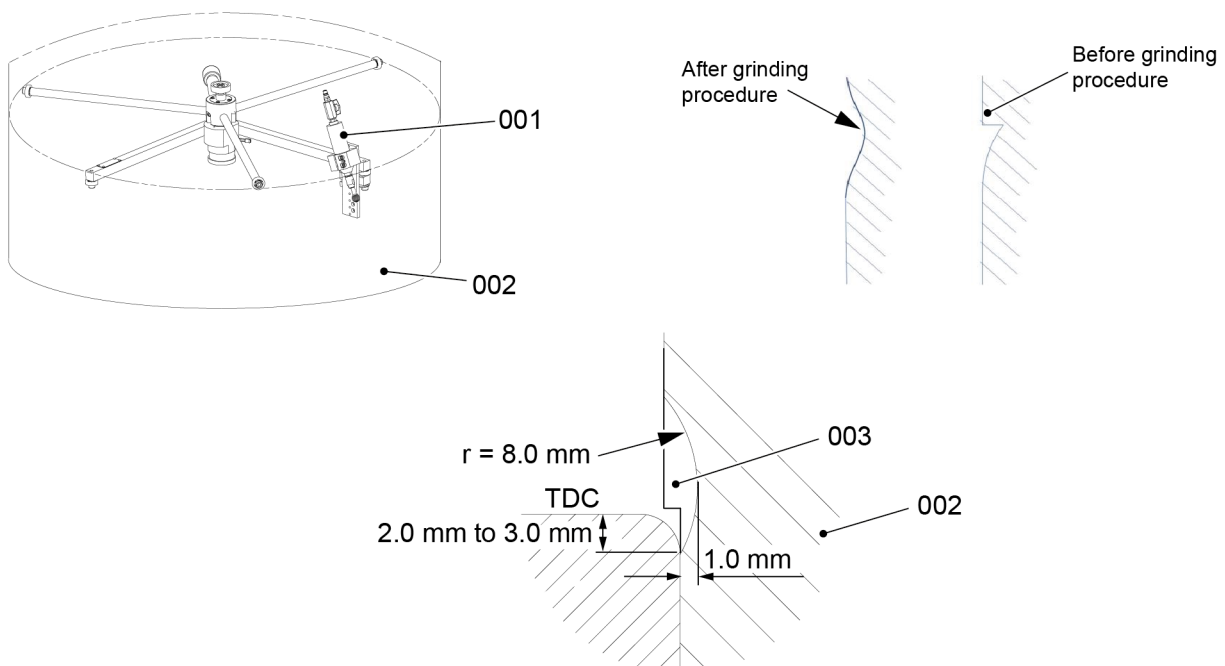
## PROCEDURE

### CAUTION

Make sure that you do not cause damage to the running surface of the cylinder liner when you operate the grinding device.

- 1 Put applicable protection below the cylinder liner to keep particles out of the area.
- 2 Attach the grinding device (001) to the cylinder liner (002) (refer to the Manufacturer's Instruction Manual and [Figure 7-7](#)).
- 3 Attach an applicable air supply to the grinding tool (001).
- 4 Use the grinding tool to carefully remove the unwanted edge (003) from the cylinder liner (002).
- 5 Make sure that you get the radius  $r = 8$  mm as shown.
- 6 Remove waste particles from the scavenge space.
- 7 Clean the cylinder liner bore.

Fig 7-7 Cylinder liner - grind



00653

## CLOSE UP

- None

## 7.1.5 Cylinder liner - grind the lubricating groove

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Oil stone	1
Emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

## PRELIMINARY OPERATIONS

- The cylinder cover must be removed, refer to section [7.5.1 Cylinder cover - remove](#)

## PROCEDURE

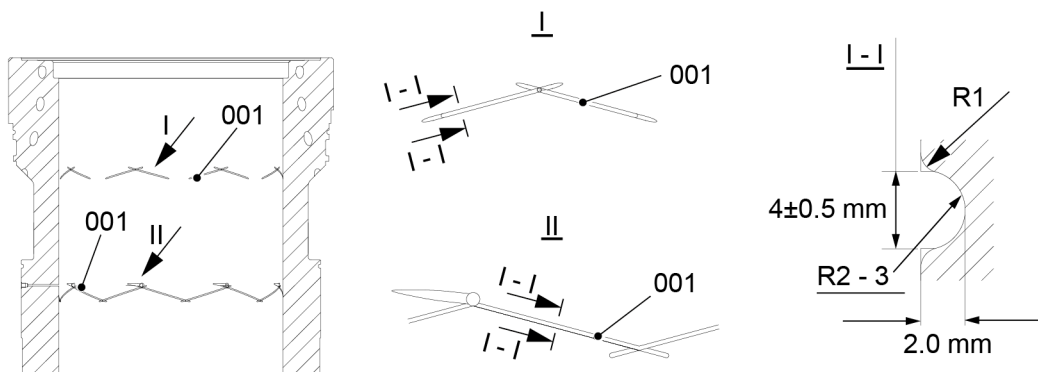
- 1 If necessary, operate the turning gear to move the piston to BDC.
- 2 If the depth of the lubricating grooves (001, [Figure 7-8](#)) has decreased to less than 1.5 mm, do as follows:

### CAUTION

**When you remove sharp edges, make sure that you keep the initial shape of the lubricating grooves.**

- 2.1 Use an oil stone or an emery cloth to get the lubricating grooves back to their initial depth.
- 3 Fully clean the lubricating grooves and the bore of the cylinder liner.
- 4 Remove unwanted particles.
- 5 Manually operate the cylinder lubrication to flush unwanted material from the cylinder liner.

**Fig 7-8 Lubricating grooves - grind**



00654

## CLOSE UP

- None

## 7.1.6 Cylinder liner - grind the scavenge ports

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

### WARNING

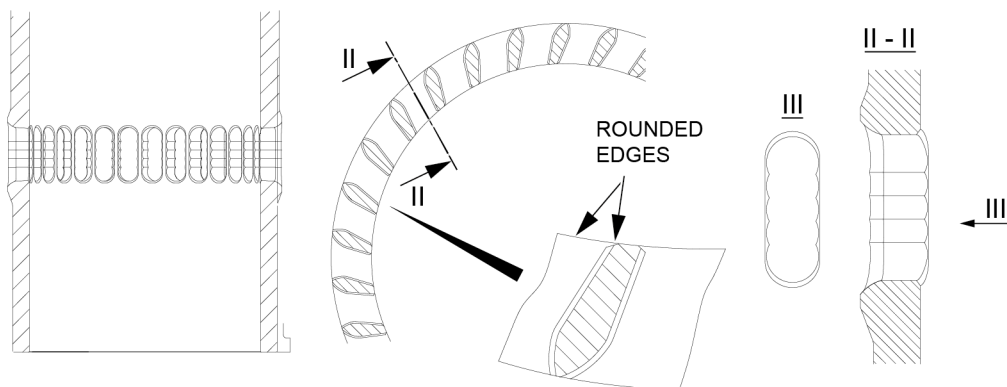
Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

### CAUTION

When you polish the scavenge ports, make sure that you do not cause damage to the running surface of the cylinder liner.

- 1 If necessary, operate the turning gear to move the piston to get access to the scavenge ports.
- 2 Use emery cloth to polish the surfaces of the scavenge ports (Figure 7-9). Make sure that you keep the shape of the scavenge ports the same as those shown.
- 3 Remove unwanted particles from the scavenge space.

Fig 7-9 Scavenge ports - grind



00655

## CLOSE UP

- None

## 7.1.7 Cylinder liner - grind the sealing face for pilot injection valve position

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
grinding tool	94270-02		1
stud bolts	94270F		2
stencil	94270-2D		1
electric drill	N/A		1

### Supplies

Description	QTY
emery cloth	A/R
oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

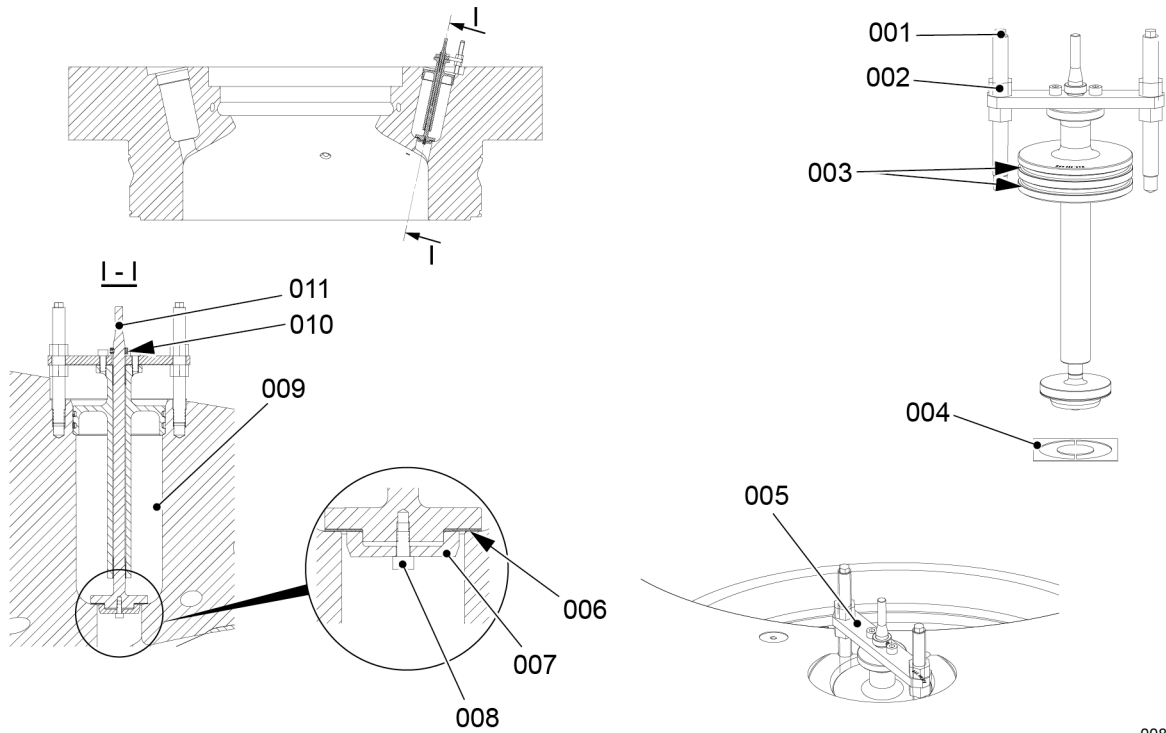
- The pilot injection valve must be removed, refer to section [7.10.1 Pilot injection valve - remove](#)



## PROCEDURE

- 1 Make sure that the stop sleeve (010, [Figure 7-10](#)) is attached to the spindle (011) of the [grinding tool](#) (005).
- 2 Make sure that the two O-rings (003) are serviceable.
- 3 Put the stencil (004) on the [emery cloth](#).
- 4 Use a pencil or a ball-point pen to make the shape (006).
- 5 Cut out accurately the shape (006).
- 6 Attach the shape (006) to the grinding tool (005) with the clamp (007) and the Allen screw (008).
- 7 Torque the Allen screw (008) to 8.0 Nm.
- 8 Apply a thin layer of [oil](#) to the O-rings (003).
- 9 Attach the grinding tool (005) to the cylinder cover with the stud bolts (001) and nuts (002) as shown.
- 10 Attach an [electric drill](#) to the spindle (011).
- 11 **NOTE:** During this step, do not grind more than 1.0 mm from the bottom of the bore (009).  
  
Operate the electric drill at a maximum of 500 rpm.
- 12 Apply a light pressure and start grinding.
- 13 Regularly remove the unwanted material from the grinding tool (005) and the bore (009).
- 14 Make sure that the circular marks around the sealing face of the bore (009) are concentric.
- 15 Change the emery cloth for a smoother grade, then do [Step 3](#) to [Step 14](#) again until you get a smooth finish.
- 16 Remove the grinding tool (005).
- 17 Clean the bore (009).

Fig 7-10 Pilot injection valve position - grind



00896

**CLOSE UP**

- Install the pilot injection valve, refer to section [7.10.7 Pilot injection valve - install](#)

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## 7.1.8 Cylinder liner - grind the sealing face for the prechamber

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
grinding device	94270-03		1
stencil	94270-3D		1
electric drill	N/A		1

### Supplies

Description	QTY
emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

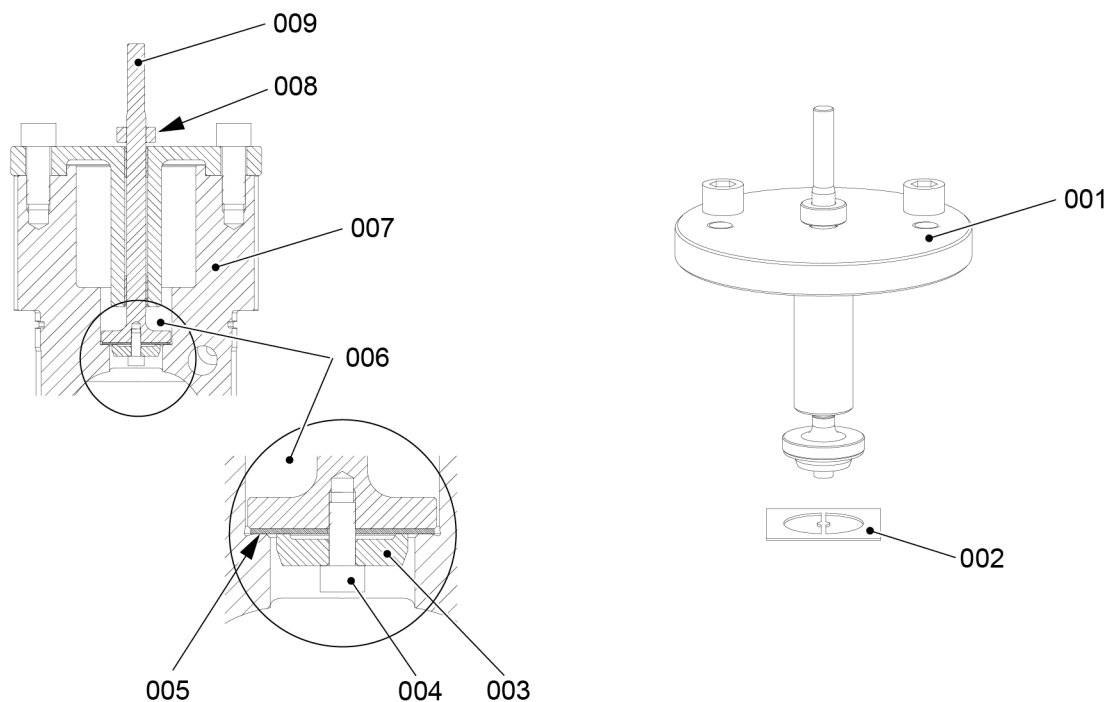
### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Make sure that the stop sleeve (008, [Figure 7-11](#)) is attached to the spindle (009) of the [grinding device](#) (001).
- 2 Use the applicable grade of [emery cloth](#) related to the quantity of metal you want to remove.
- 3 Put the [stencil](#) (002) on the emery cloth.
- 4 Use a pencil or a ball-point pen to make the inner shape (005).
- 5 Cut out accurately the shape (005).
- 6 Attach the shape (005) to the grinding device (001) with the clamp (003) an the Allen screw (004).
- 7 Attach the grinding device (001) to the cylinder cover (007) as shown.
- 8 Attach an [electric drill](#) to the spindle (009).
- 9 Operate the electric drill at a maximum of 500 rpm.
- 10 Apply a light pressure and start grinding.
- 11 Regularly remove the unwanted material from the grinding device (001) and the bore (006).
- 12 Make sure that the circular marks around the sealing face are concentric.
- 13 Change the emery cloth for a smoother grade, then do [Step 3](#) to [Step 12](#) again until you get a smooth finish.
- 14 Remove the grinding tool (001).
- 15 Clean the bore (006).

**Fig 7-11 Prechamber - grind**



00897

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- None

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## 7.1.9 Cylinder liner - install

### Periodicity

Description	
Unscheduled	As necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Shackle			3
Shackle			3
Lifting tool			1
Assembly tool			1
Lever chain hoist			3
Eye bolt			3
Chain			1

### Supplies

Description	QTY
Oil	A/R
Non-hardening sealing compound (for example Hylomar Universal Blue)	A/R
Copper paste	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Cylinder liner			1
O-ring			4
O-ring			2
O-ring			1
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

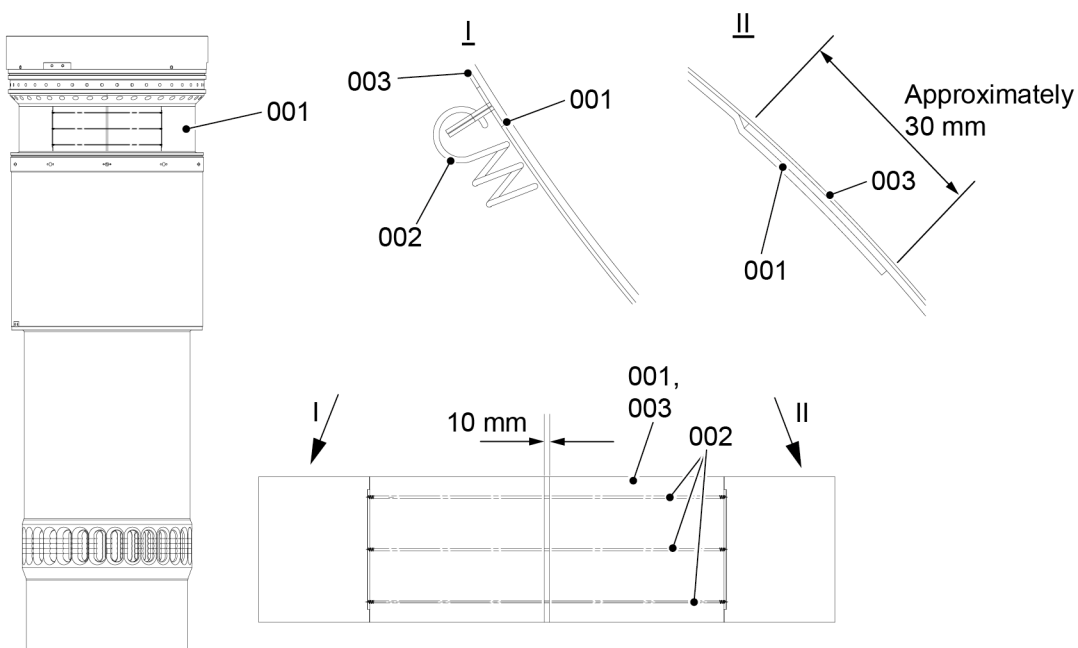
- None



## PROCEDURE

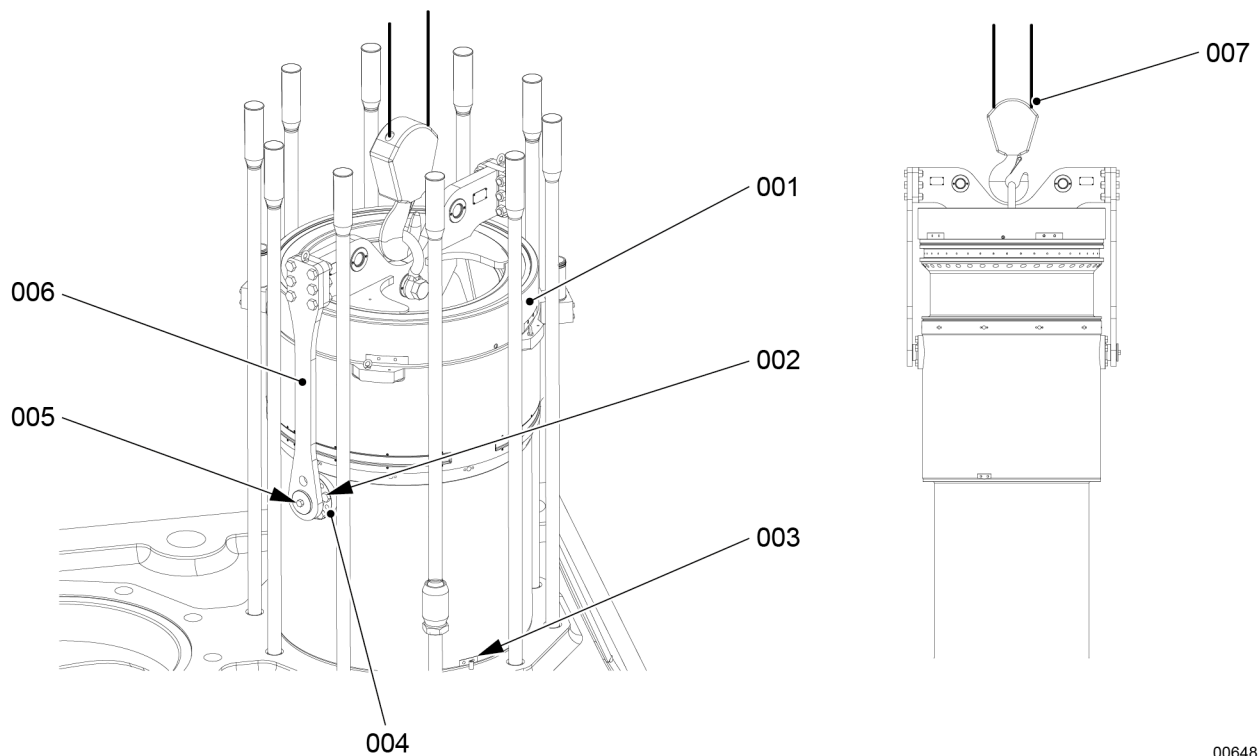
- 1 Put the insulation bandage (001, [Figure 7-12](#)) around the water channel on the cylinder liner.
- 2 Make sure that there is an overlap of approximately 30 mm.
- 3 Put the plate (003) over the insulation bandage (001).
- 4 Use the lever chain hoist to attach the tension springs (002).
- 5 Make sure that there is a clearance of 10 mm between the ends of the plate (003).

**Fig 7-12 Insulation bandage**



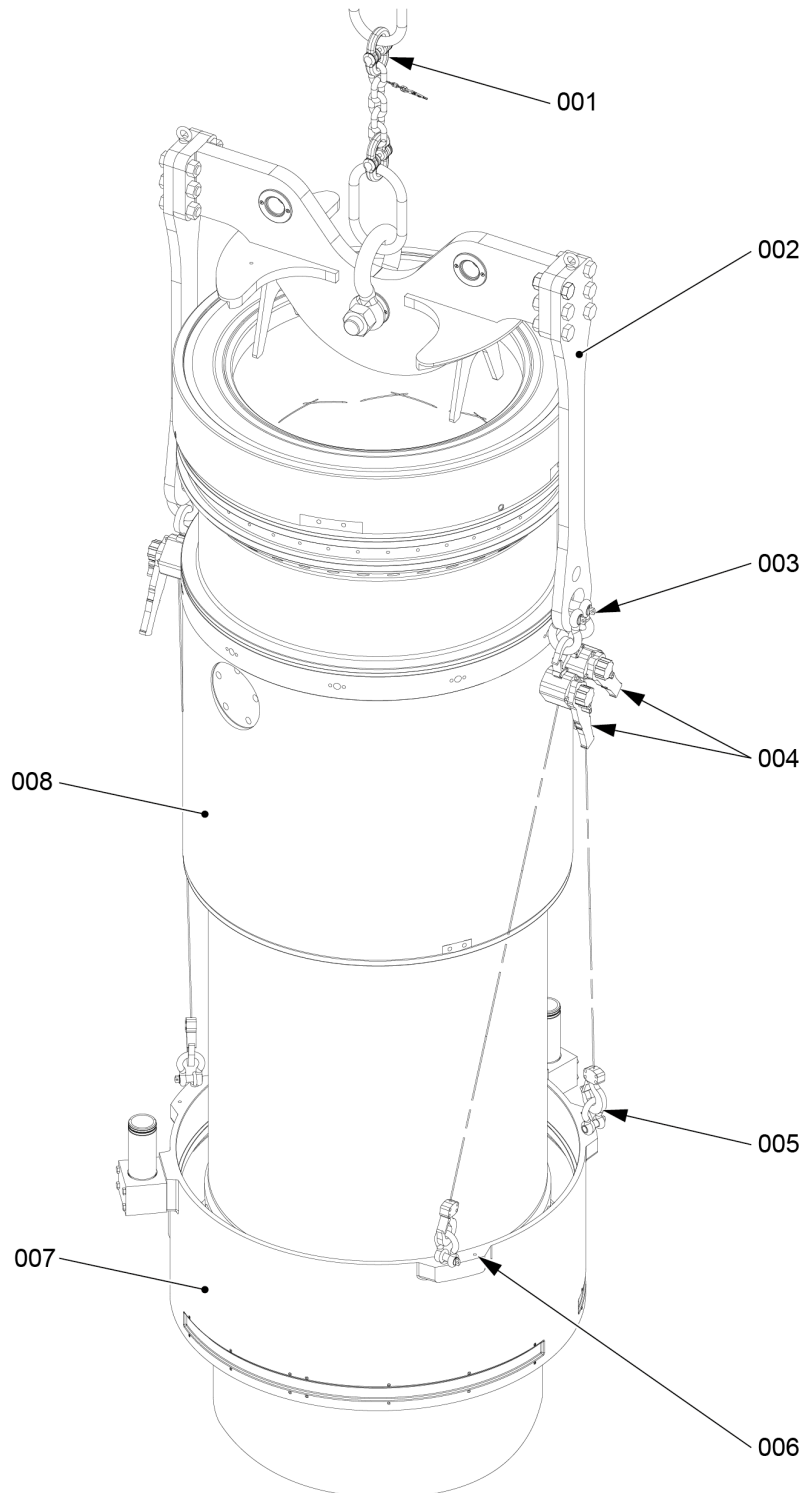
00650

- 6 Attach the flanges (004, [Figure 7-13](#)) (part of the lifting tool) (006) to the cylinder liner (001) with the screws (002).
- 7 Operate the engine room crane (007) to lower the lifting tool (006) on to the cylinder liner (001).
- 8 Apply copper paste to the threads of the screws (005).  
**NOTE:** The connection between the lifting tool (006) and the cylinder liner (001) relates to the engine.
- 9 Torque the screws (005) to the related value, refer to section [16.1 Tightening instructions](#).
- 10 Apply oil to all new O-rings.
- 11 Attach the new O-rings to their applicable positions.

**Fig 7-13 Cylinder liner (example)**

00648

- 12 Attach the chain (001, [Figure 7-14](#)) to the shackle on the lifting tool (002).
- 13 Operate the engine room crane to lift the cylinder liner (008) into the bottom water guide jacket (007).
- 14 Remove the flanges (004, [Figure 7-13](#)).
- 15 Attach the lever chain hoists (004, [Figure 7-14](#)) to the shackle (003) and the shackle (005) as shown.
- 16 Operate the lever chain hoists (004) to lift the water guide jacket (007).
- 17 Attach the water guide jacket (007) to the cylinder liner (008) with the bolts (006).
- 18 Remove the lever chain hoists (004) and the shackles (003 and 005).

**Fig 7-14 Water guide jacket (example)**

00648

- 19** Attach the flanges (004, [Figure 7-13](#)) to the cylinder liner with the special screws (005).
- 20** Attach the holder and pin (003) to the cylinder block with the bolts.
- 21** Clean the seating surface on the cylinder liner and cylinder block.

- 22** Apply a non-hardening sealing compound to the cylinder block.
- 23** Operate the engine room crane to lift and move the cylinder liner into position above the cylinder block.
- 24** Operate the engine room crane to lower the cylinder liner into the cylinder block. Make sure that the pin (003) engages with the hole in the holder.
- 25** Remove the lifting tool (006).
- 26** Install the pipes to the lubricating quills as follows:
  - 26.1** Remove the protection from the pipes.
  - 26.2** Connect the pipes.
  - 26.3** Attach the holders to the pipes.

## **CLOSE UP**

- None

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## 7.2 Lubricating quill

### 7.2.1 Lubricating quill - remove

#### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

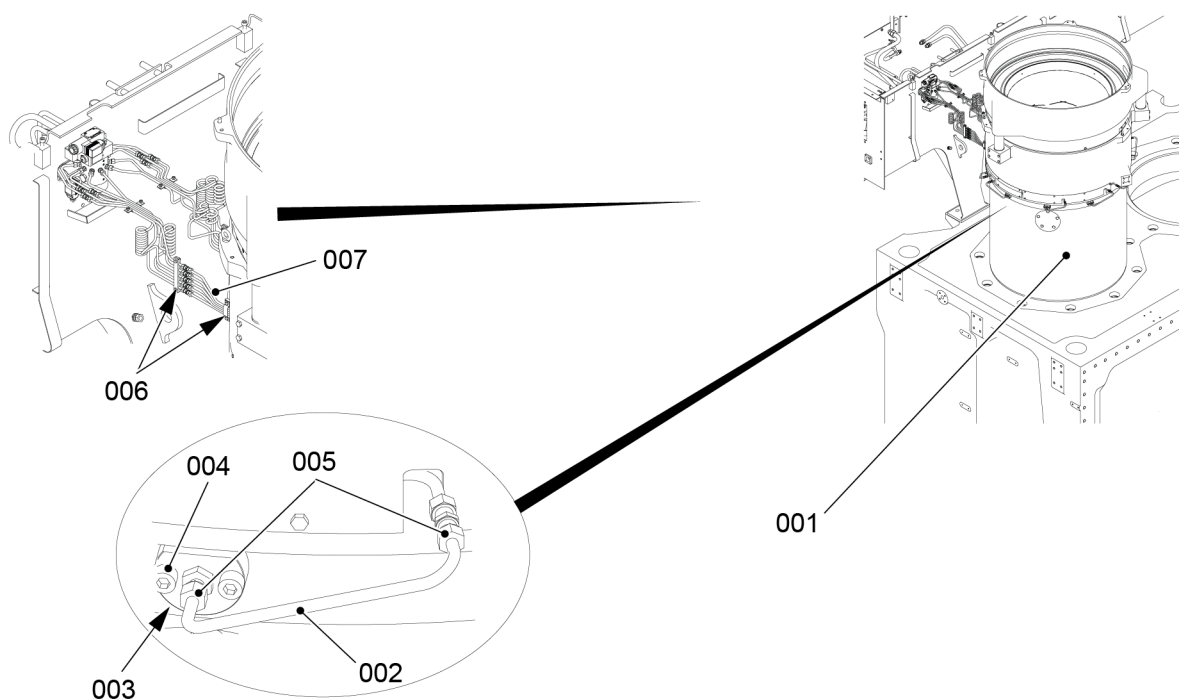
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Loosen the nuts (005, [Figure 7-15](#)) of the unions.
- 2 Carefully remove the pipe (002) from the lubricating quill (003).
- 3 Seal the pipe (002) with an applicable plug to prevent contamination.
- 4 Remove two the bolts (004).
- 5 Remove the lubricating quill (003).
- 6 If necessary, do a function check of the lubricating quills, refer to [7.2.2 Lubricating quill - do a functional test](#).

**Fig 7-15** Lubricating quill (example)



00656

## CLOSE UP

- None

## 7.2.2 Lubricating quill - do a functional test

### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.25 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
HP oil pump			1
Distributing piece			1
Pressure gauge			1
Connection nipple			1
HP hose			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.**

## PRELIMINARY OPERATIONS

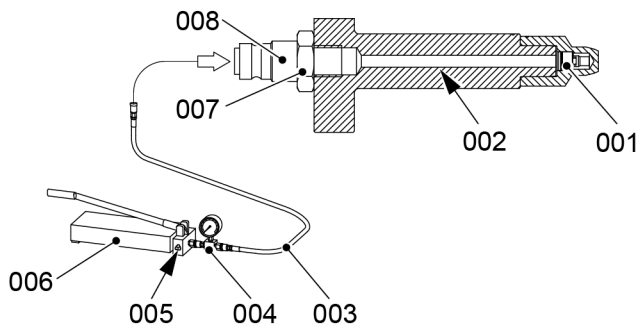
- The lubricating quill must be removed, refer to section [7.2.1 Lubricating quill - remove](#)
- During this procedure, use oil SAE50 at 40°C (approximately 200 cSt) or SAE30 at 25°C (approximately 190 cSt).
- During this procedure, contamination of the non-return valve with dirty or metal chips must be prevented.



## PROCEDURE

- 1 If necessary, remove the union (007, [Figure 7-16](#)) on the lubricating quill (002).

**Fig 7-16 Lubricating quill**



00212

- 2 Attach the distributing piece (004) to the HP oil pump (006).
- 3 Attach the connection nipple (008) to the lubricating quill (002).
- 4 Connect the HP hose (003) to the nipple (008) and to the distributing piece (004).
- 5 Hold the lubricating quill (002) so that the non-return valve (001) points up and points away from your body.
- 6 Operate the HP oil pump (006) until oil that has no air flows out.
- 7 Open the relief valve (005) to decrease the pressure to 2.0 bar.
- 8 Close the relief valve (005).
- 9 Hold the lubricating quill (002) in a horizontal position so that it points away from your body.
- 10 Operate the HP oil pump (006) to increase the pressure in steps of 1.0 bar until the non-return valve (001) opens.
- 11 Record the pressure shown on the pressure gauge (004).
 

**NOTE:** The minimum permitted pressure to open the non-return valve is 4.25 bar. If necessary, replace the defective lubricating quill (002).
- 12 Open the relief valve (005) to release the pressure to zero.
- 13 Remove the nipple (008) and the HP hose (003) from the lubricating quill (002).

## CLOSE UP

- None

## 7.2.3 Lubricating quill - install

### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Lubricating quill			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- None

## PROCEDURE

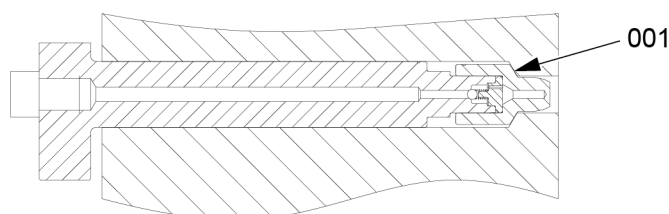
### CAUTION

**Damage Hazard:** The surfaces of the cylinder liner and the nozzle tip make a metallic seal. The seat angles in the cylinder liner and on the nozzle tip are different. Do not use a gasket between the cylinder liner and the nozzle tip. This could cause damage to the equipment.

- 1 Make sure that the sealing surfaces (001, [Figure 7-17](#)) are clean and have no damage.

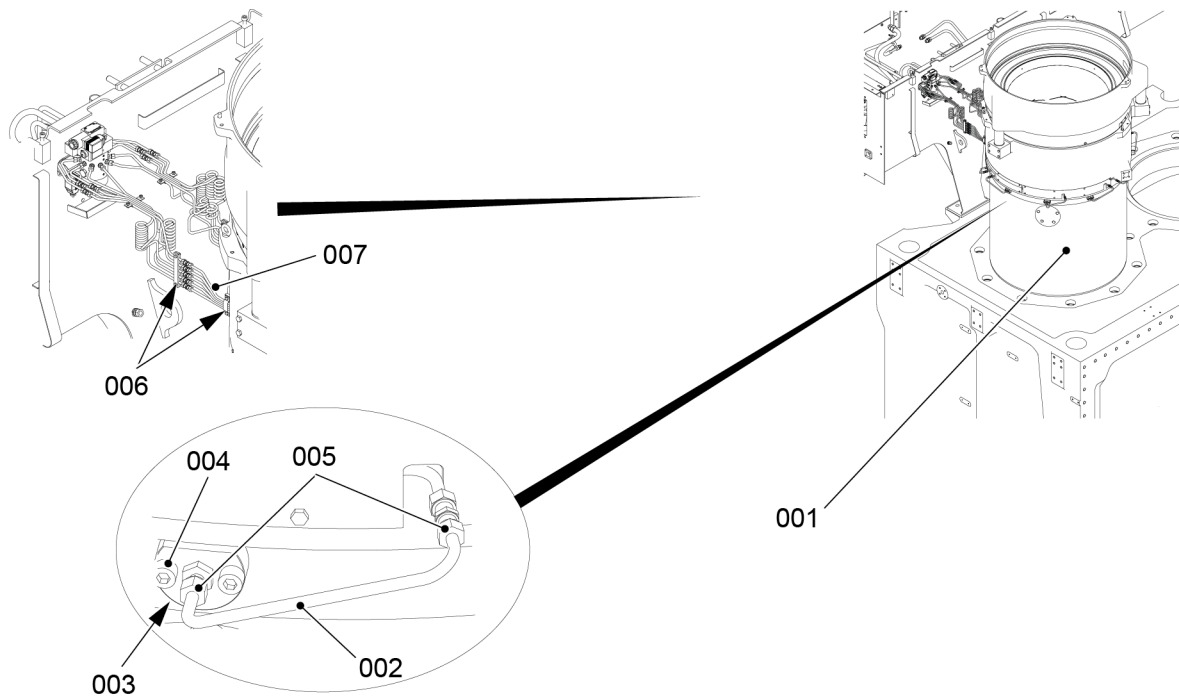
**NOTE:** If a component of the lubricating quill is defective, you must replace all components of the lubricating quill.

**Fig 7-17** Sealing surface



00657

- 2 Apply oil to the threads of the screws (004, [Figure 7-18](#)).
- 3 Attach the lubricating quill (003) to the cylinder liner (001) with the screws (004).
- 4 Torque the screws (004) to the related value, refer to section [16.1 Tightening instructions](#).
- 5 Remove the plugs from the pipe (002).
- 6 Attach the pipe (002) to the lubricating quill (003).
- 7 Tighten the nuts (005) of the unions.

**Fig 7-18 Lubricating quill (example)**

00656

**CLOSE UP**

- Bleed the cylinder lubrication system, refer to [12.1.2 Cylinder lubrication system - bleed](#)

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## 7.3 Gas admission valve

### 7.3.1 Gas admission valve - do a check of the oil leakage flow

#### Periodicity

Description	
Working hours	6000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Measuring tool			1
Pressure reducing valve			1

#### Supplies

Description	QTY
Lubricating oil (SAE 30)	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

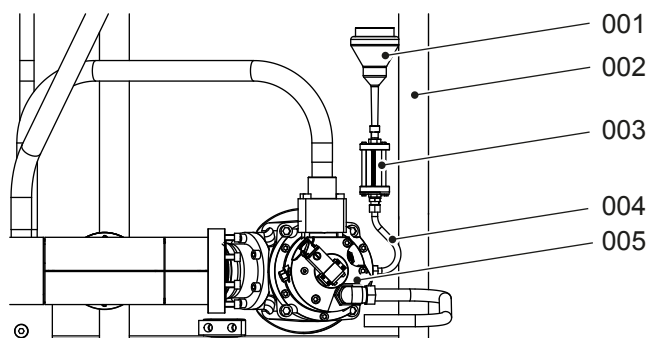
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Install the measuring tool (003, [Figure 7-19](#)) as follows:
  - 1.1 Carefully remove the connection for sealing oil supply on the gas admission valve (GAV) (005).
  - 1.2 If possible, fill the hose (004) with oil to prevent unwanted air in the system.
  - 1.3 Attach the hose (004) to the connection for sealing oil supply on the GAV.
  - 1.4 Attach the measuring tool (003) to the hose (004).
  - 1.5 Install the funnel (001) to the measuring tool (003).
  - 1.6 Fill the measuring tool (003) with clean lubricating oil (SAE 30) to the top mark.
  - 1.7 Make sure that there is no air in the system.
  - 1.8 Remove the funnel (001).
  - 1.9 Connect the measuring tool (003) to a pressurized air supply at a pressure of 15 bar.  
**NOTE:** You can use the pressure reducing valve 94214B.

**Fig 7-19 GAV - do a check of the oil leakage flow**



- 2 Do a check of the oil leakage flow as follows:
  - 2.1 Read the oil level on the scale of the measuring tool (003).
  - 2.2 Start the pressurized air supply.
  - 2.3 Wait 15 minutes.
  - 2.4 Stop the pressurized air supply.
  - 2.5 Read the oil level on the scale of the measuring tool (003).
- 3 Remove the measuring tool (003) as follows:
  - 3.1 Remove the pressurized air supply.
  - 3.2 Remove the hose (004) from the connection for sealing oil supply.
  - 3.3 Drain the oil into an applicable container.
  - 3.4 Attach the sealing oil supply to the GAV.
- 4 Make an estimate of the temperature of the GAV.
- 5 Compare the oil leakage flow with the values given in [Table 7-1 - GAV - usual values of oil leakage flow at 25°C](#).

**Tab 7-1 GAV - usual values of oil leakage flow at 25°C**

Engine type	Oil leakage flow in 15 minutes
X40DF	0.4 to 3 ml
X52DF (and RT-flex50DF)	1 to 8 ml
X62DF	3 to 15 ml
X72DF	3 to 15 ml
X82DF	5 to 30 ml
X92DF	5 to 30 ml

**NOTE:** Related to the temperature of the GAV the oil leakage flow changes.

- 6** If the oil leakage flow is more than the given range, do as follows:
- 6.1** Check the O-rings of the GAV for unwanted material or for damage.
  - 6.2** If necessary, clean or replace the O-rings.
  - 6.3** Check the spindle of the GAV for damage.
  - 6.4** If necessary, replace the GAV.
- 7** If the oil leakage flow is less than the given range, do as follows:
- 7.1** Check the spindle of the GAV for unwanted material or for damage.
  - 7.2** If necessary, clean the spindle.
  - 7.3** If necessary, replace the GAV.
- 8** Do [Step 1](#) to [Step 7](#) again for the other gas admission valves.

## CLOSE UP

- None



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## 7.3.2 Gas admission valve - Appendix

For maintenance information about the gas admission valve, refer to [18.1 Appendix](#)

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## 7.4 Piston rod gland

### 7.4.1 Piston rod gland - remove

#### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Assembly tool			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

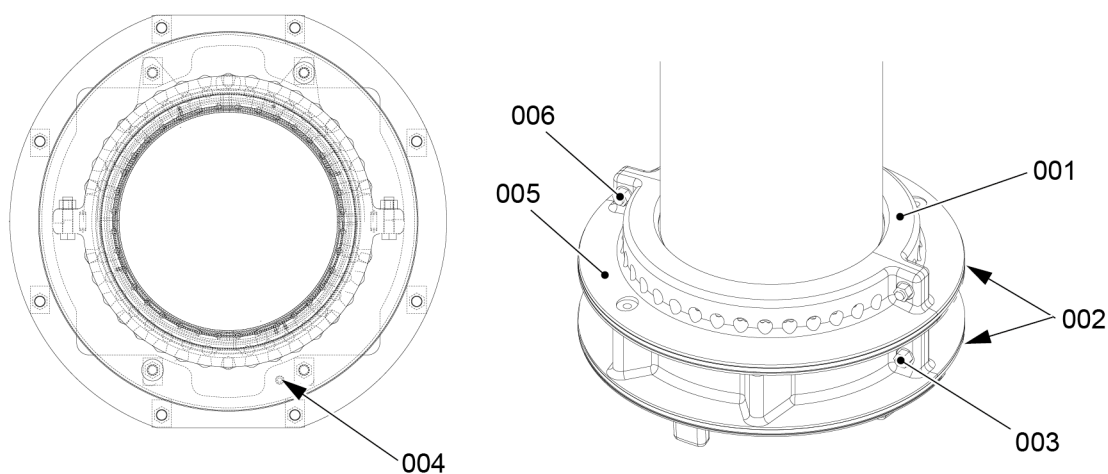
#### PRELIMINARY OPERATIONS

- The piston must be removed, refer to the related procedure.

## PROCEDURE

- 1 Remove the piston rod gland together with the piston, refer to the related procedure.
- 2 Remove and discard the two O-rings (002, [Figure 7-20](#)).
- 3 Remove the four screws and nuts (003, 006).
- 4 Push the two parts of the housing (001, 005) away from the piston rod.
- 5 Remove the two parts of the housing (001, 005).

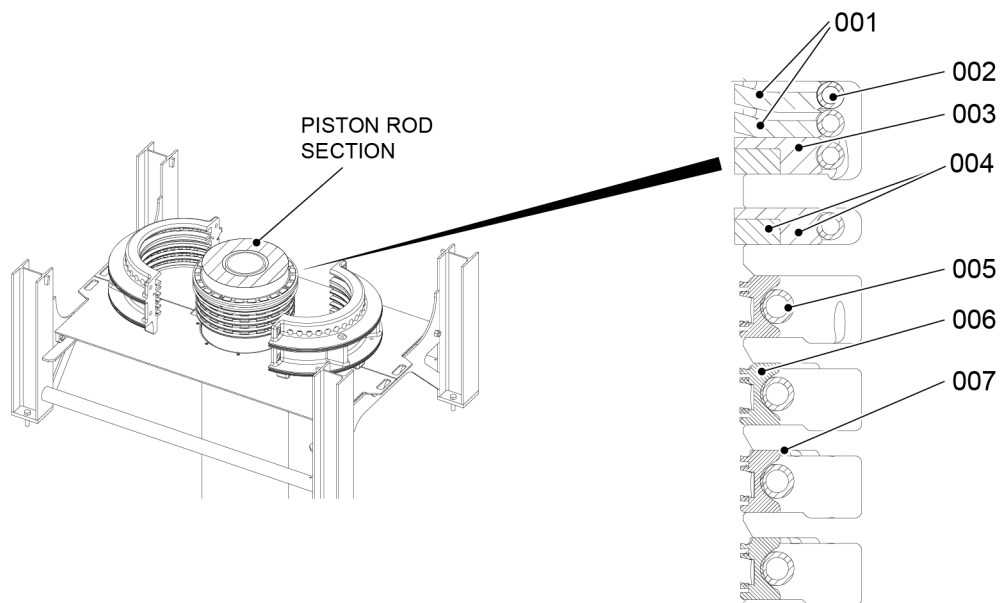
**Fig 7-20** Piston rod gland - remove and install



- 6 Remove the parts that follow:
  - Tension springs (002 and 005, [Figure 7-21](#))
  - Scraper rings (001, 007)
  - Gaskets (003, 004)
  - Ring supports (006).

00660

**Fig 7-21** Piston rod gland - disassemble



00659

**CLOSE UP**

- None

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## 7.4.2 Piston rod gland - do a check of the wear

### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

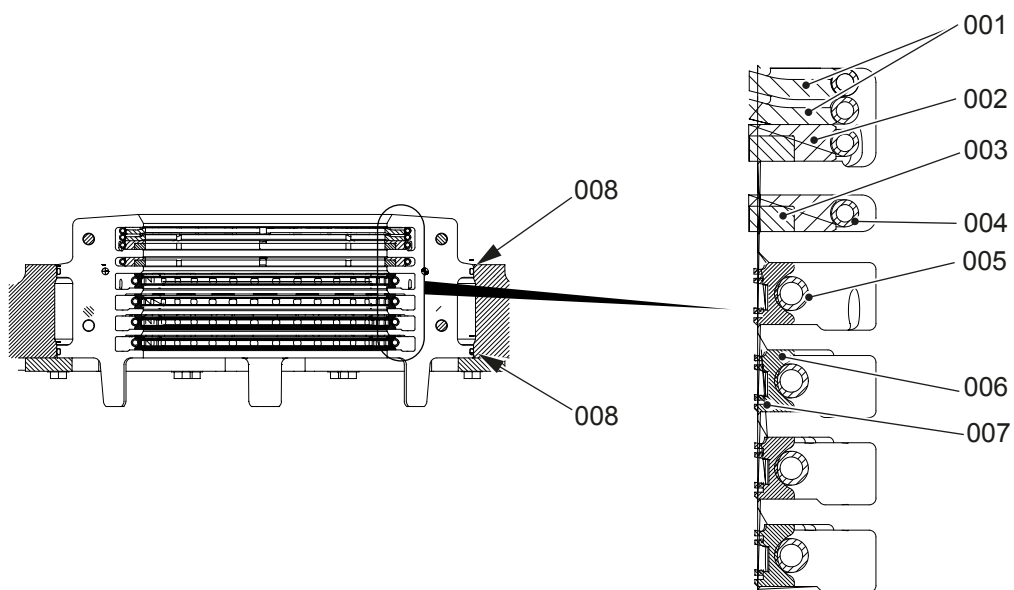
- The piston must be removed, refer to the related procedure.
- The piston rod gland must be removed, refer to section [7.4.1 Piston rod gland - remove](#)



## PROCEDURE

- 1 Compare the wear of the parts that follow with the maximum permitted dimensions given in section [3.3 Clearances - general](#).
  - Scraper rings (001, 007, [Figure 7-22](#))
  - Gaskets (002, 003).
- 2 Make sure that the springs (004, 005) and the O-rings (008) are serviceable.
- 3 If necessary, replace the worn or the unserviceable parts.

**Fig 7-22** Piston rod gland



### Legend

001	4-part scraper ring	005	Spring
002	4-part gasket	006	Ring support
003	4-part gasket	007	3-part scraper ring
004	Spring	008	O-ring

### CLOSE UP

- None

### 7.4.3 Piston rod gland - install

#### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Assembly tool			1
2- part clamp ring			1
Distance piece 12 mm			1
Distance piece 11 mm			1
Distance piece 9 mm			1
Template			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
Scraper ring 4-part			1
Scraper ring 4-part (with dowel pin)			1
Gasket 4-part			1
Gasket 4-part			1
Gasket 4-part			2
Ring support			4
Scraper ring 3-part			8
Spring			4
Spring			4
O-ring			2

#### SAFETY PRECAUTIONS

- None

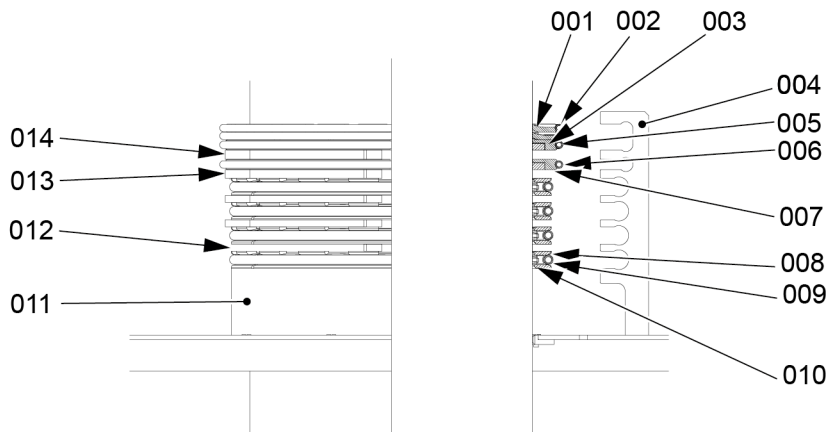
## PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Attach the two parts of the clamp ring 94231A (011, [Figure 7-23](#)) to the piston rod.
- 2 Put the three parts of the ring support (010) and the scraper ring 3-part (008) on the clamp ring (011).
- 3 Use the assembly tool to attach the spring (009) to the ring support (010).
- 4 Put the two parts of the distance piece (012) on the ring support (010).

**Fig 7-23** Piston rod gland - assemble

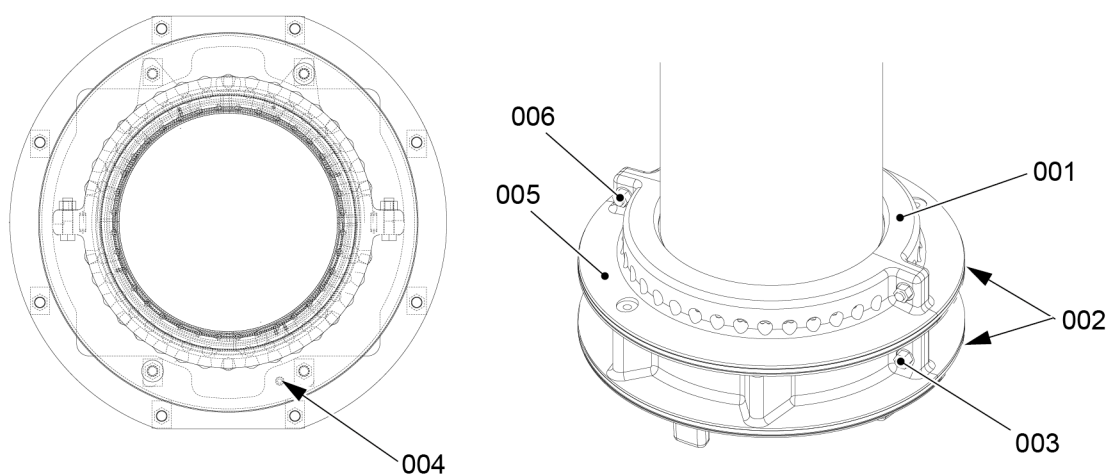


00661

- 5 Put the next three parts of the ring support (010) and the scraper rings (008) on the distance piece. Make sure that there is an equal distance between the three parts.
- 6 Use the assembly tool to attach the tension spring (009) to the ring support (010).
- 7 Remove the distance piece (012).
- 8 Do [Step 4](#) to [Step 7](#) again until the four ring supports (010) are attached to the piston rod.
- 9 Put the two parts of the distance piece (013) on the top ring support (010).
- 10 Put the gasket 4-part and the gasket 4-part (007) on the distance piece (013).
- 11 Use the assembly tool to attach the spring (006).
- 12 Remove the distance piece (013).
- 13 Put the two parts of the distance piece 94231B (014) on the gasket 4-part (007).
- 14 Put the gasket 4-part (003) on the distance piece 94231B. Make sure that there is an equal distance between the four parts.
- 15 Put the scraper ring 4-part (with dowel pin) (002) on the gasket 4-part (003). Make sure that there is an equal distance between the four parts. Make sure that the spring dowel pin (not shown) is correctly installed.
- 16 Use the assembly tool 94233 to attach the spring (005).

- 17 Put the scraper ring 4-part (001) on the top of the scraper ring (003). Make sure that there is an equal distance between the four parts.
- 18 Use the assembly tool to attach the tension spring (002).
- 19 Remove the distance piece (014).
- 20 Remove the clamp ring (011).
- 21 Put the template (004) over the assembly. Make sure that all parts are in the correct position. If necessary, correct the position.
- 22 Apply bearing oil to the piston rod and the assembly.
- 23 Push the two parts of the housing (001 and 005, [Figure 7-24](#)) over the assembled rings. Make sure that the dowel pins (004) are correctly installed.
- 24 Attach the bolts and nuts (003, 006) to the housing (001, 005).
- 25 Torque the bolts (003) to the value given in section [3.5 Torque values - standard screws](#).
- 26 Put oil on the new O-rings (002).
- 27 Attach the O-rings (002) to the housing (005).
- 28 Install the piston rod gland together with the piston, refer to section [7.4.3 Piston rod gland - install](#).

**Fig 7-24 Piston rod gland - remove and install**



00660

## CLOSE UP

- None

## 7.5 Cylinder cover

### 7.5.1 Cylinder cover - remove

#### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	4.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Pre-tensioning jacks			10
Cylinder cover support			1
Hydraulic unit			1
Pressure gauge			1
HP hose			1
Flexible hose			10
Lifting tool			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** You must put on safety goggles and gloves when you do work on hot components. Oil can come out as a spray and cause injury.

#### CAUTION

**Injury Hazard:** Use the correct equipment to lift and move the cylinder cover.

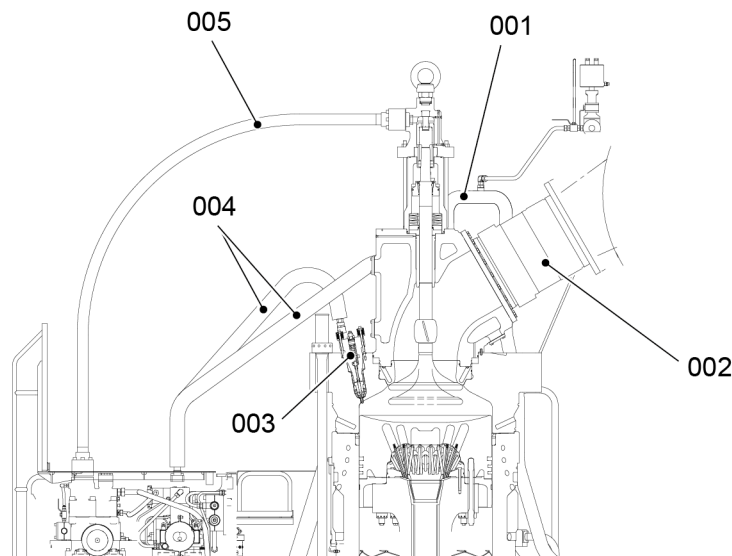
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the applicable hydraulic pipe (005, [Figure 7-25](#)), refer to the related procedure.
- 2 Remove the applicable HP fuel pipes (004), refer to the related procedure.
- 3 Remove the applicable injection valves (003), refer to the related procedure.
- 4 For a DF engine, remove the applicable pilot injection valves (not shown), refer to the related procedure.
- 5 Do the applicable steps to remove the expansion piece (002), refer to the related procedure.
- 6 Remove the cooling water pipe (001).

**Fig 7-25 Cylinder cover - pipes and expansion piece (example)**

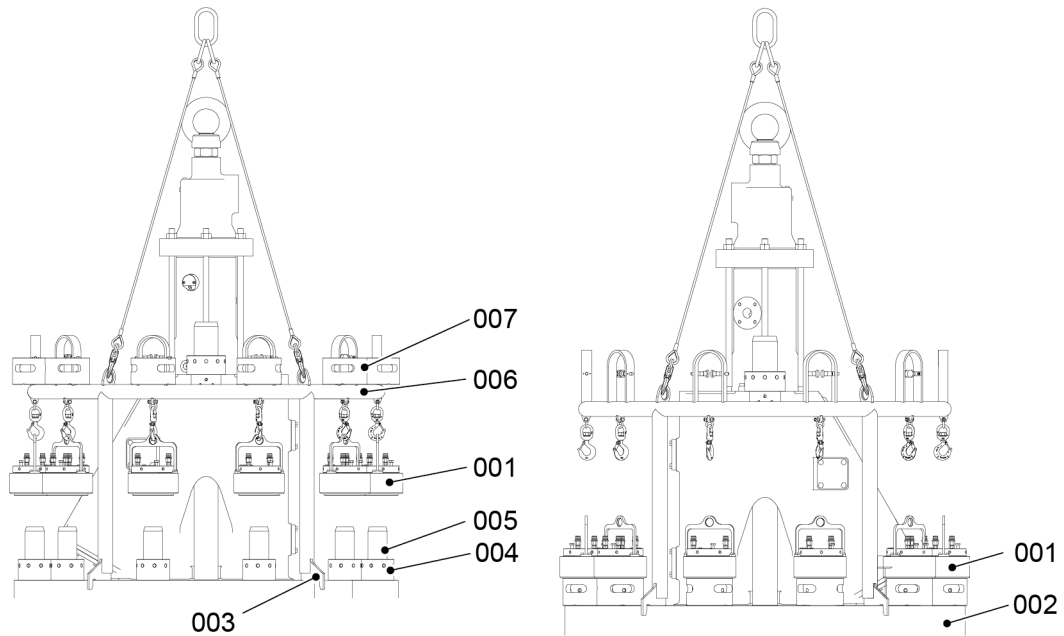


Note: Some parts can look different.

00895

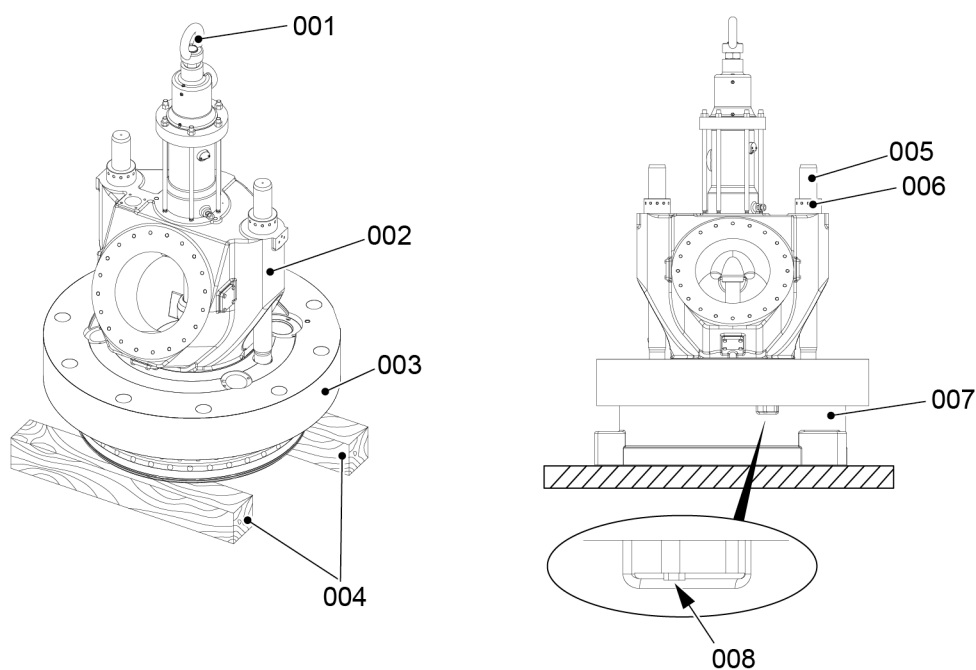
- 7 Close the starting air valve.
- 8 Remove the starting air pipe from the cylinder cover.
- 9 Disconnect all other connections to the cylinder cover and to the exhaust valve.
- 10 Operate the engine room crane to put the lifting tool (006, [Figure 7-26](#)) and the pre-tensioners in position above the cylinder cover (002).
- 11 Slowly lower the lifting tool (006) until the four brackets (003) are on the cylinder cover (002).
- 12 Put the top and bottom parts (001, 007) of the pre-tensioners in position on the elastic studs (005).
- 13 Connect the pre-tensioners together and to the hydraulic unit.
- 14 Loosen the round nuts, refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 15 Operate the engine room crane to remove the lifting tool (007).
- 16 Remove the pre-tensioners (001).
- 17 Remove the round nuts (004).



**Fig 7-26 Lifting tool - pre-tensioner (example)**

00662

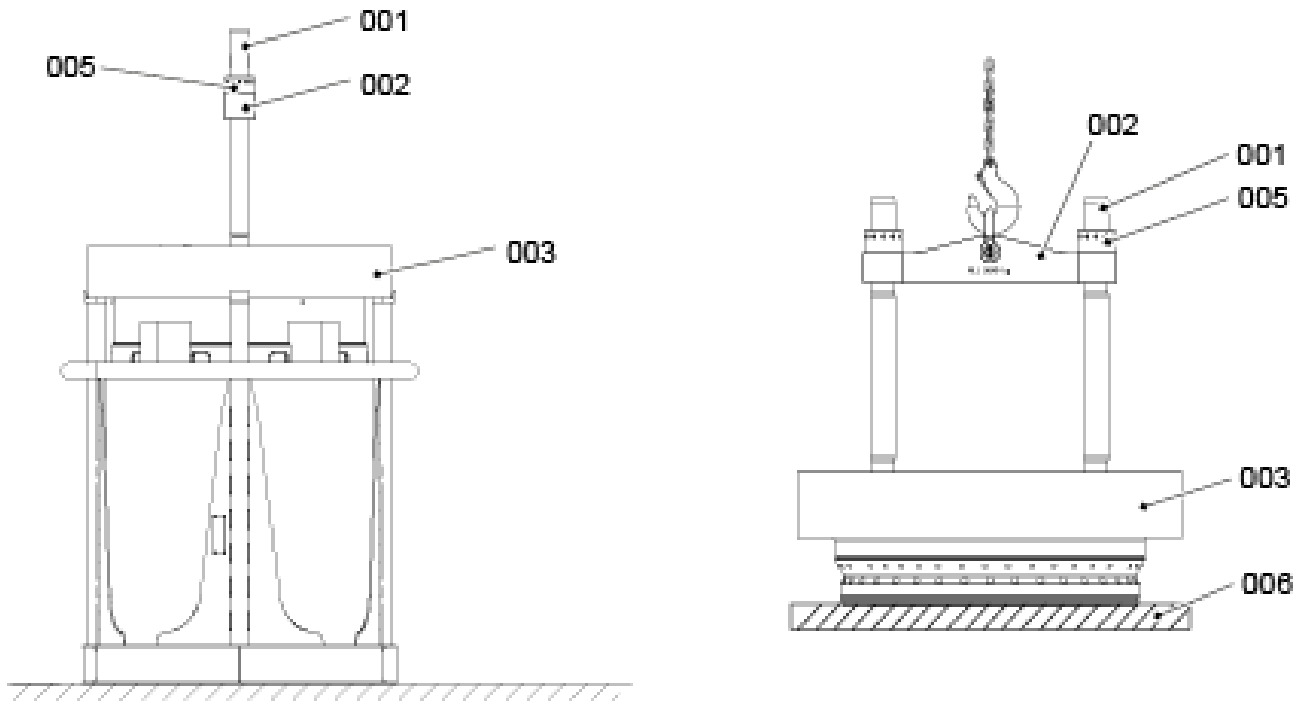
- 18** Attach the engine room crane to the eye bolt (001, [Figure 7-27](#)) on the exhaust valve (002).
- 19** Operate the engine room crane to lift the cylinder cover (003) together with the exhaust valve (002) and top water guide jacket (007).
- 20** Put the cylinder cover, together with the exhaust valve and the top water guide jacket, on to the wooden support (004).
- 21** Remove the screws (008) of the water guide jacket.
- 22** Operate the engine room crane to lift the cylinder cover (003).
- 23** Put the cylinder cover together with the exhaust valve on to a wooden support.
- 24** Remove the loosened round nuts (006) from the elastic studs (005).
- 25** Operate the engine room crane to lift the exhaust valve (002).
- 26** Move the exhaust valve (002) to an applicable area.
- 27** Remove the engine room crane from the exhaust valve.

**Fig 7-27** Cylinder cover, exhaust valve cage and water guide jacket (example)

00663

- 28 Attach the engine room crane to the lifting tool (002, [Figure 7-28](#)).
- 29 Operate the engine room crane to lift the lifting tool (002).
- 30 Lower the lifting tool (002) on to the elastic studs (001).
- 31 Attach the lifting tool (002) to the elastic studs (001) with the round nuts (005).
- 32 Operate the engine room crane to lift and move the cylinder cover (003) to an applicable area.
- 33 Lower the cylinder cover (003) on to an applicable support (006).

Fig 7-28 Cylinder cover and exhaust valve cage



**CLOSE UP**

- None

## 7.5.2 Cylinder cover - grind the sealing face for injection valve

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Grinding device			1
Stencil			1
Electric drill			1

### Supplies

Description	QTY
Emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

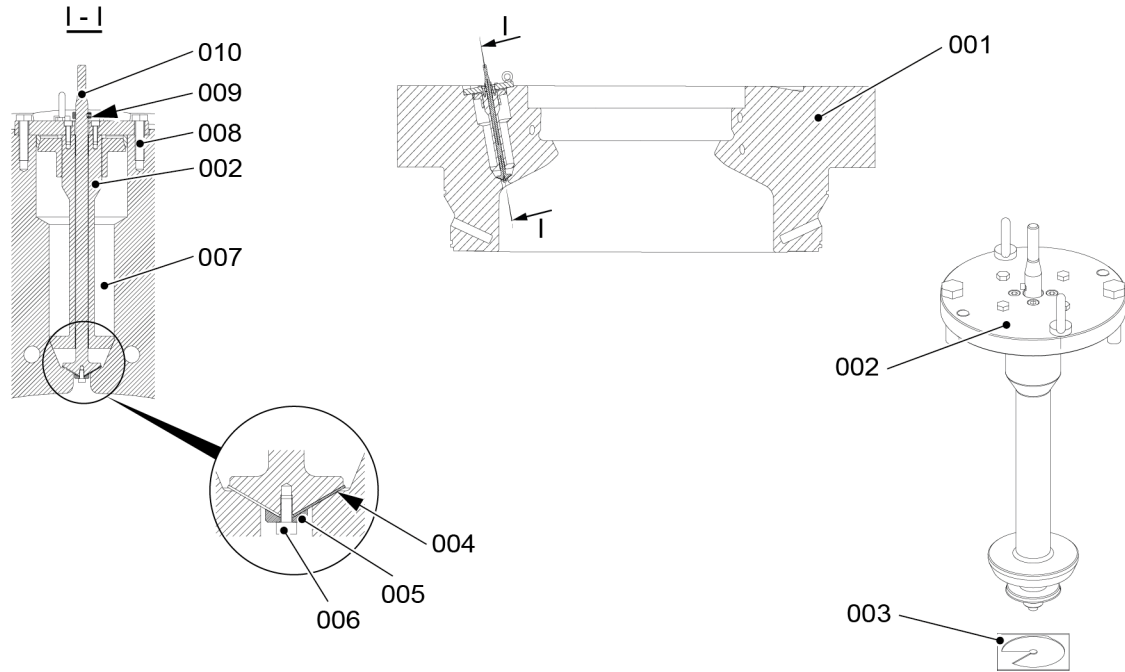
### PRELIMINARY OPERATIONS

- The injection valve must be removed, refer to the related procedure.

## PROCEDURE

- 1 Clean the bore (007, [Figure 7-29](#)).
- 2 Make sure that the stop sleeve (009) is attached to the spindle (010) of the grinding device (002).
- 3 Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
- 4 Put the stencil (003) on the emery cloth.
- 5 Use a pencil or a ball-point pen to make the inner shape (004).
- 6 Cut out accurately the shape (004).
- 7 Attach the shape (004) to the grinding device (002) with the clamp (005) and the screw (006).
- 8 Torque the screw (006) to 4.0 Nm.
- 9 Attach the grinding device (002) to the cylinder cover with the bolts (008).
- 10 Torque equally the two bolts (008) to 1.0 Nm. Make sure that the grinding tool is in the center of the bore (007).
- 11 Torque equally the bolts (008) to 6.0 Nm.
- 12 Attach an electric drill to the spindle (010).
- 13 Operate the electric drill at a maximum speed of 500 rpm.
- 14 Apply a light pressure and start grinding.
- 15 Regularly remove the unwanted material from the grinding device (002) and from the bore (007).
- 16 Make sure that the circular marks around the sealing face are concentric.
- 17 Change the emery cloth for a smoother grade, then do [Step 4](#) to [Step 16](#) again until you get a smooth finish.
- 18 Remove the grinding tool (002).
- 19 Clean the bore (007).

Fig 7-29 Sealing face for injection valve - grind (example)



00899

**CLOSE UP**

- None

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### 7.5.3 Cylinder cover - grind the sealing face for pilot injection valve

#### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Grinding device			1
Stencil			1
Stud bolts			2

#### Supplies

Description	QTY
Emery cloth	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

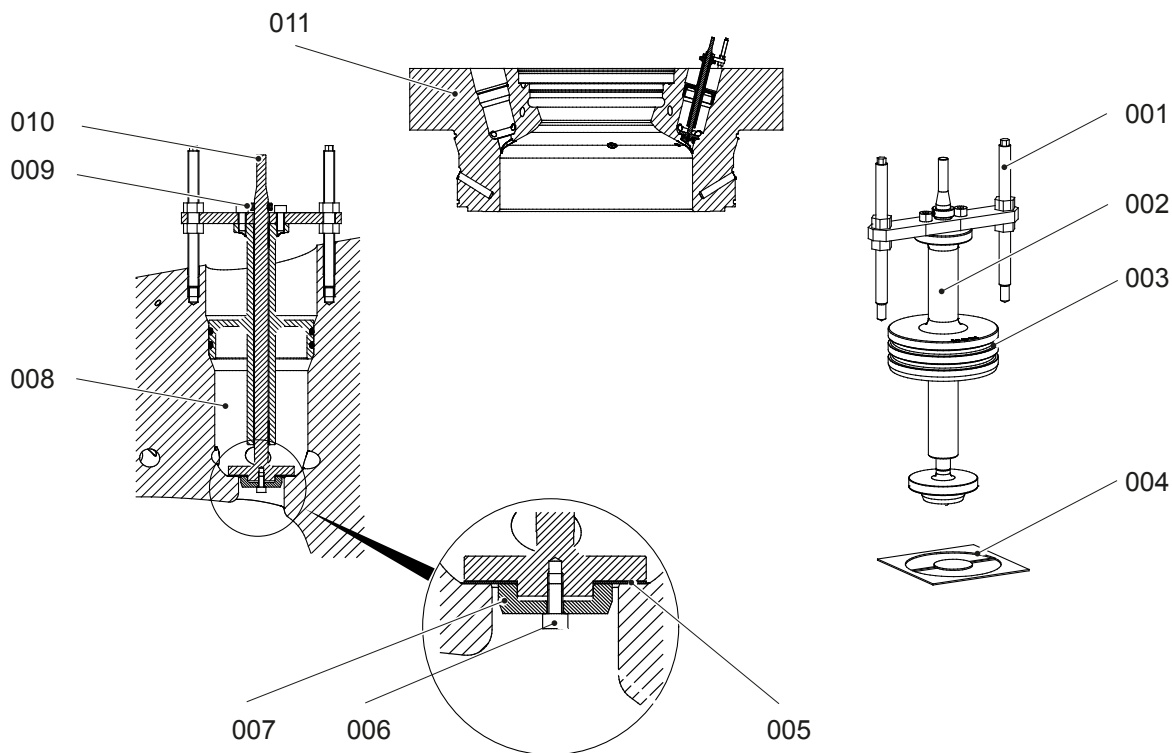
- The pilot injection valve must be removed, refer to the related procedure.



## PROCEDURE

- 1** Make sure that the stop sleeve (009, [Figure 7-30](#)) is attached to the spindle (010) of the grinding device (002).
- 2** Make sure that the two O-rings (003) are serviceable.
- 3** Apply a thin layer of oil to the O-rings (003).
- 4** Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
- 5** Put the stencil (004) on the emery cloth.
- 6** Use a pencil or a ball-point pen to make the inner shape (005).
- 7** Cut out accurately the shape (005).
- 8** Attach the shape (005) to the grinding device (002) with the clamp (007) and the Allen screw (006).
- 9** Torque the Allen screw (006) to 8.0 Nm.
- 10** Attach the grinding device (002) to the cylinder cover (011) with the two stud bolts (001).
- 11** Attach an electric drill to the spindle (010).
- 12** Operate the electric drill at a maximum speed of 500 rpm.
- 13** Apply a light pressure and start grinding.
- 14** Regularly remove the unwanted material from the grinding device (002) and the bore (008).
- 15** Make sure that the circular marks around the sealing face are concentric.
- 16** Change the emery cloth for a smoother grade, then do [Step 4](#) to [Step 15](#) again until you get a smooth finish.
- 17** Remove the grinding tool (002).
- 18** Clean the bore (008).

**Fig 7-30 Grind the sealing face for pilot injection valve**



**CLOSE UP**

- None

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## 7.5.4 Cylinder cover - grind the sealing face for prechamber

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Grinding device			1
Stencil			1

### Supplies

Description	QTY
Emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

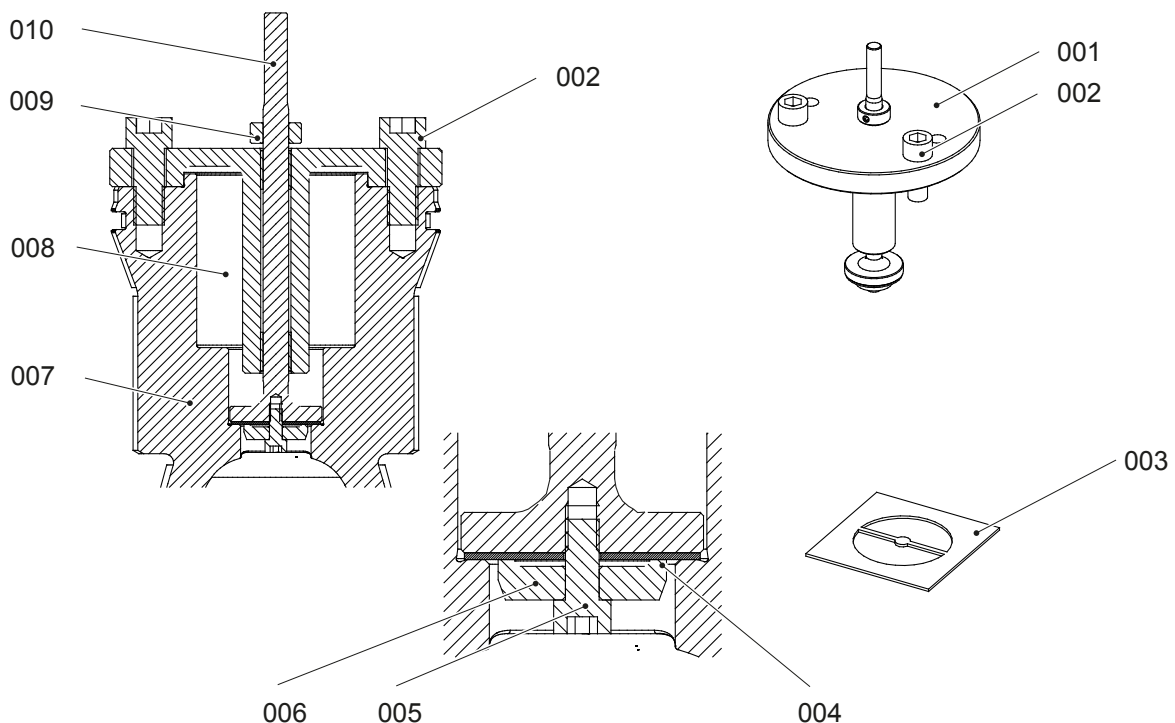
### PRELIMINARY OPERATIONS

- The pilot injection valve and the prechamber must be removed, refer to the related procedure.

## PROCEDURE

- 1 Make sure that the stop sleeve (009, [Figure 7-31](#)) is attached to the spindle (010) of the grinding device (001).
- 2 Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
- 3 Put the stencil (003) on the emery cloth.
- 4 Use a pencil or a ball-point pen to make the inner shape (004).
- 5 Cut out accurately the shape (004).
- 6 Attach the shape (004) to the grinding device (001) with the clamp (006) and the Allen screw (005).
- 7 Torque the Allen screw (006).
- 8 Attach the grinding device (001) to the prechamber (007) with the two bolts (002).
- 9 Attach an electric drill to the spindle (010).
- 10 Operate the electric drill at a maximum speed of 500 rpm.
- 11 Apply a light pressure and start grinding.
- 12 Regularly remove the unwanted material from the grinding device (001) and the bore (008).
- 13 Make sure that the circular marks around the sealing face are concentric.
- 14 Change the emery cloth for a smoother grade, then do [Step 2](#) to [Step 13](#) again until you get a smooth finish.
- 15 Remove the grinding tool (001).
- 16 Clean the bore (008).

**Fig 7-31 Grind the sealing face for prechamber**



**CLOSE UP**

- None

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## 7.5.5 Cylinder cover - install

### Periodicity

Description	
Unscheduled	at each piston removal
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Pre-tensioner			10
Cylinder cover support			1
Hydraulic unit			1
Pressure gauge			1
HP hose			1
Flexible hose			10
Lifting tool			1

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Cylinder cover			1
O-ring			1
O-ring			1

### SAFETY PRECAUTIONS

#### CAUTION

**Injury Hazard: Use the correct equipment to lift and move the cylinder cover.**

### PRELIMINARY OPERATIONS

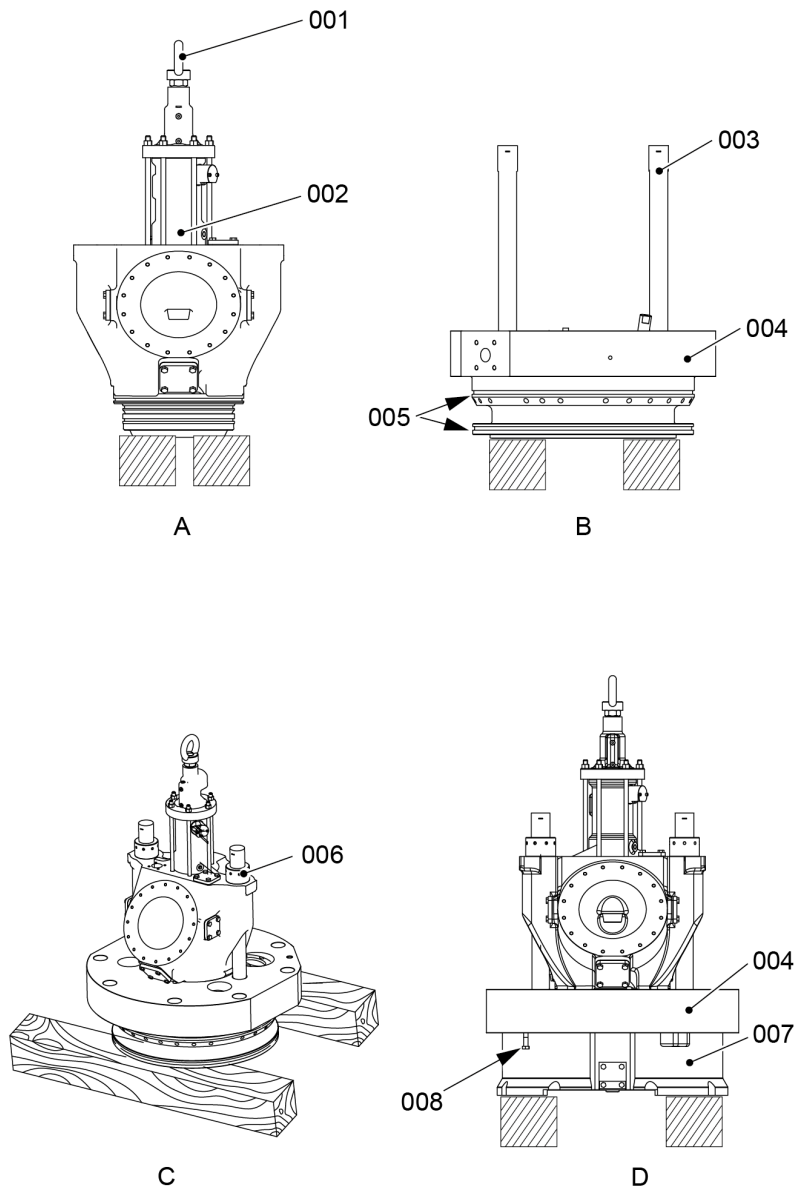
- None



## PROCEDURE

- 1 Clean the items that follow:
  - O-ring grooves (005, [Figure 7-32](#))
  - Sealing surfaces of the cylinder cover (004).
- 2 Put oil on the O-rings.
- 3 Clean the threads of the two elastic studs (003).
- 4 Put oil on the threads of the elastic studs (003).
- 5 Attach the engine room crane to the eye bolt (001) on the exhaust valve (002).
- 6 Operate the engine room crane to lift the exhaust valve (002).
- 7 Carefully lower the exhaust valve (002) into the cylinder cover (004).
- 8 Attach the round nuts (006) to the elastic studs (003).
- 9 Tighten the round nuts (006), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 10 Operate the engine room crane to lift the cylinder cover (004) together with the exhaust valve (002).
- 11 Carefully lower the cylinder cover (004) on to the top water guide jacket (007).
- 12 Attach the top water guide jacket (007) to the cylinder cover (006) with the two screws (008).
- 13 Operate the engine room crane to lift the cylinder cover (006) together with the exhaust valve (002) and top water guide jacket (007).

Fig 7-32 Assemble before installation (example)



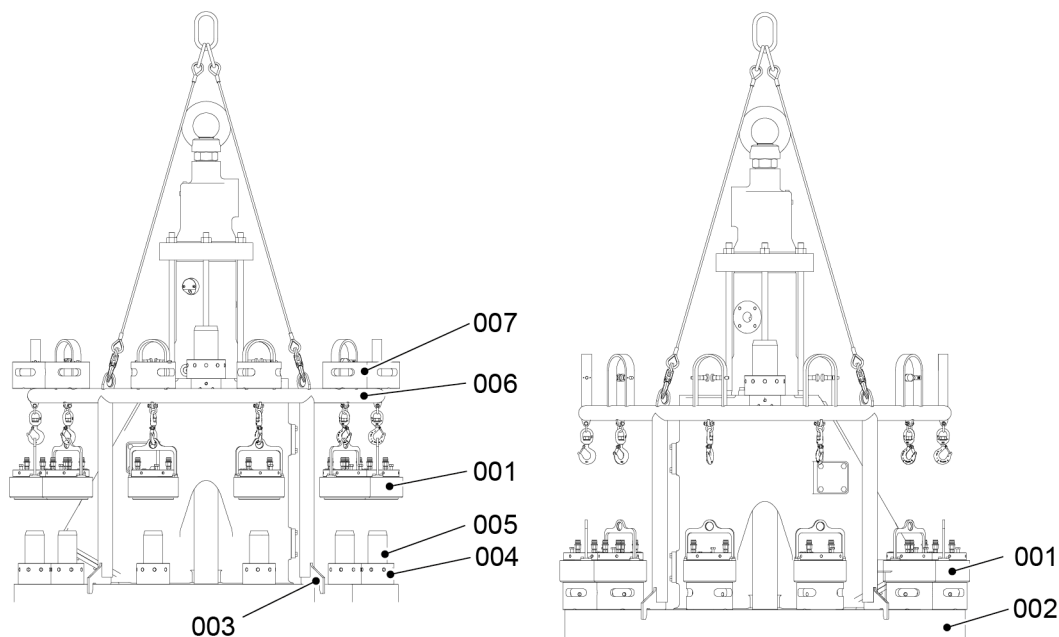
00231

- 14 Lower the cylinder cover together with the exhaust valve and top water guide jacket on to the cylinder liner.

**NOTE:** Related to the engine type the connection between the top water guide jacket and the bottom water guide jacket is different.

- 15 Remove the engine room crane from the eye bolt from the exhaust valve.
- 16 Put the round nuts (004, [Figure 7-33](#)) on the elastic studs (005).
- 17 Attach the engine room crane to the lifting tool (006).
- 18 Operate the engine room crane to move the lifting tool (006) and the pre-tensioners above the cylinder cover (002).
- 19 Slowly lower the lifting tool (006) until the four plates (003) are on the cylinder cover (002).
- 20 Connect the applicable flexible hose between each pre-tensioner.
- 21 Put the top and bottom parts (001, 007) of the pre-tensioners in position on the elastic studs (005).
- 22 Put the pre-tensioners (001) on the round nuts (004).
- 23 Tighten the round nuts (004), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 24 Remove the pre-tensioners (001).
- 25 Operate the engine room crane to remove the lifting tool (006).

**Fig 7-33 Lifting tool - pre-tensioner (example)**



00662

- 26 Attach the cooling water pipe.
- 27 Connect all other connections removed before to the cylinder cover and to the exhaust valve.
- 28 Install the hydraulic pipe, refer to the related procedure.
- 29 Install the HP fuel pipes, refer to the related procedure.
- 30 For a DF engine, install the pilot injection valves, refer to the related procedure.
- 31 Attach the cooling water pipe to the cylinder cover.
- 32 Install the expansion pipe, refer to the applicable steps in the related procedure.
- 33 Remove all tools and equipment from the work area.

**CLOSE UP**

- None

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## **7.6 Injection valve**

### **7.6.1 Injection valve - Appendix**

For maintenance information about the injection valve, refer to [18.1 Appendix](#).

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## 7.7 Starting air valve

### 7.7.1 Starting air valve - remove

#### Periodicity

Description	
Working hours	12 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Support equipment

Description	Part No.	CSN	QTY
Long special screw (recommended)	942719B		2
Short special screw (recommended)	942719C		2
Cap (recommended)	942719D		2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

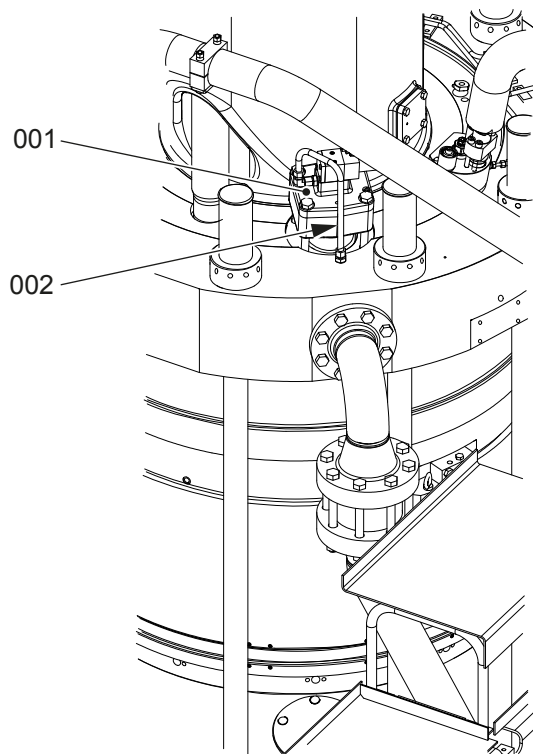
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Make sure that the pressure in the starting air system is released.
- 2 Remove the air pipe (002, [Figure 7-34](#)) from the starting air valve (001).

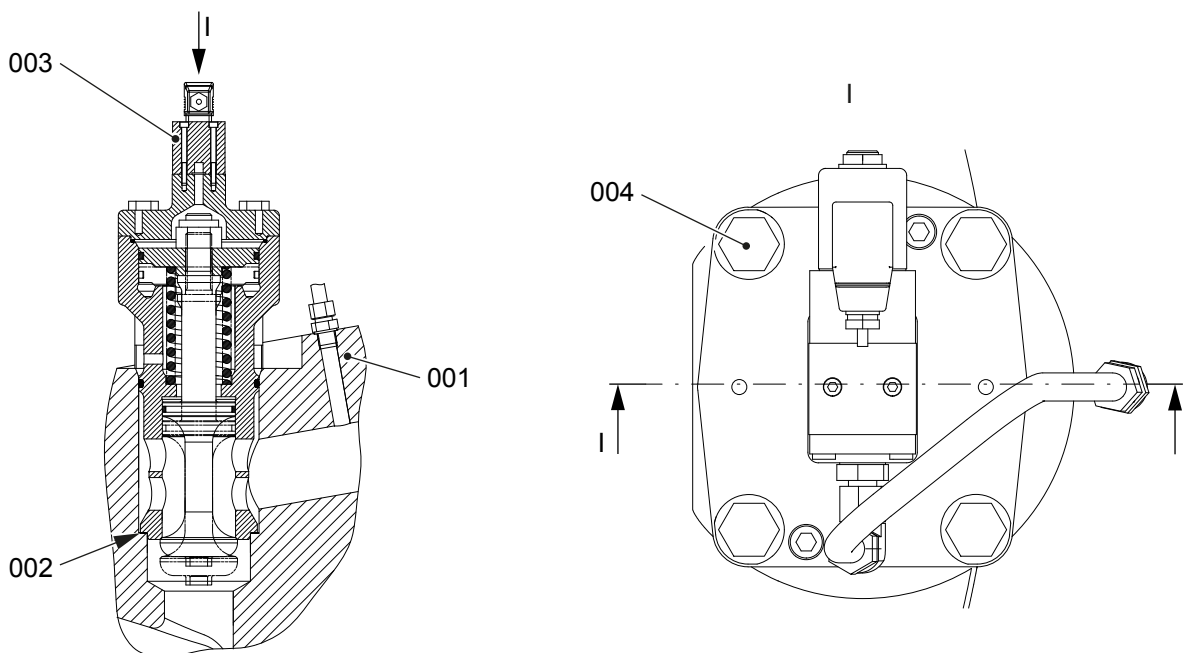
**Fig 7-34 Starting air valve - preparation**



00709

- 3 Disconnect the electrical connection from the 3/2-way solenoid valve (003, [Figure 7-35](#)).
- 4 Remove the four screws (004).
- 5 Carefully remove the starting air valve from the cylinder cover (001).  
**NOTE:** If available you can use the long special screws 942719B to remove the starting air valve.
- 6 Remove and discard the gasket (002).
- 7 Put protection over the opening in the cylinder cover (001).

Fig 7-35 Starting air valve - removal



00710

**CLOSE UP**

- None

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## 7.7.2 Starting air valve - disassemble

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

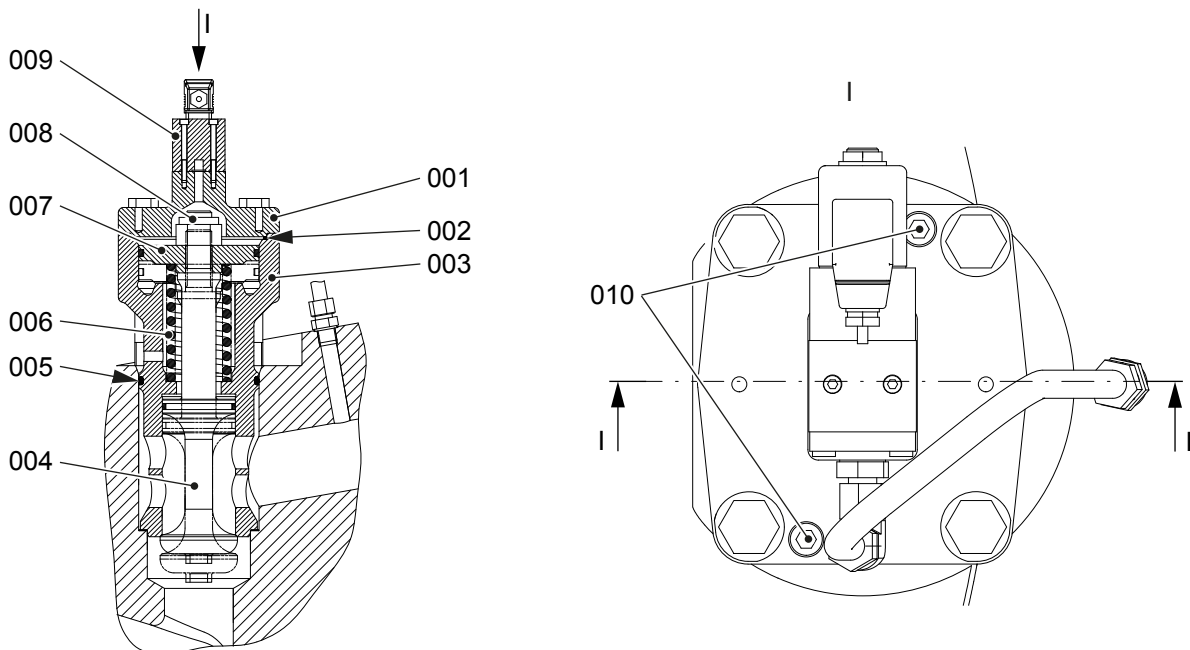
### PRELIMINARY OPERATIONS

- The starting air valve must be removed, refer to [7.7.1 Starting air valve - remove](#)

## PROCEDURE

- 1 Put the starting air valve in a vice. Make sure that the vice jaws do not cause damage the starting air valve.
- 2 Remove the two screws (010, [Figure 7-36](#)).
- 3 Remove the cover (001) together with the 3/2-way solenoid valve (009).
- 4 Remove the hexagon nut (008).
- 5 Remove the piston (007) from the valve spindle (004).
- 6 Remove the compression spring (006) from the housing (003).
- 7 Remove the valve spindle (004) from the housing (003).
- 8 Remove and discard the O-rings (002, 005).

**Fig 7-36 Starting air valve - disassemble**



00712

## CLOSE UP

- Assemble the starting air valve, refer to [7.7.4 Starting air valve - assemble](#)

### 7.7.3 Starting air valve - grind

#### Periodicity

##### Description

Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

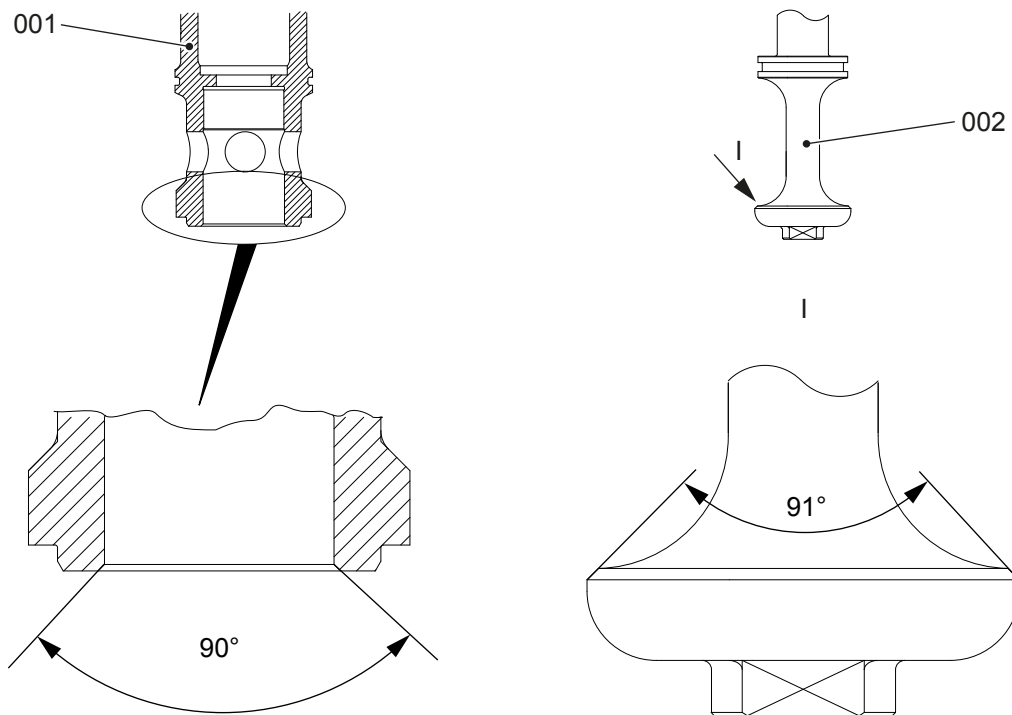
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 If the seating faces of the housing (001, [Figure 7-37](#)) and of the valve spindle (002) only have minimum damage, do as follows:
  - 1.1 Use an applicable tool to manually grind the seating faces of the housing (001) and of the valve spindle (002).
  - 1.2 Make sure that you keep each radius to the values given.
- 2 If the seating faces of the housing (001) and of the valve spindle (002) have more than minimum damage, do as follows:
  - 2.1 Use an applicable machine tool to grind the seating faces of the housing (001) and of the valve spindle (002).
  - 2.2 Use an applicable tool to manually grind the seating faces of the housing (001) and of the valve spindle (002) to get a good finish.
  - 2.3 Make sure that you keep each radius to the values given.

**Fig 7-37 Starting air valve - grind**



00711

## CLOSE UP

- None

## 7.7.4 Starting air valve - assemble

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

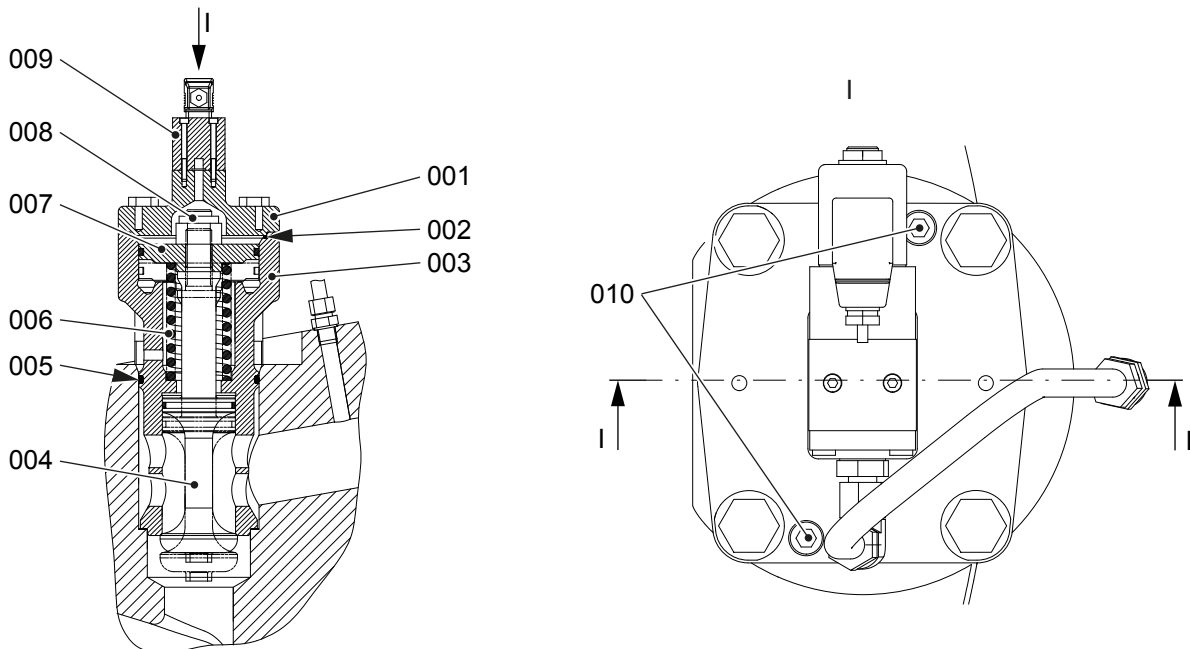
- None



## PROCEDURE

- 1 Clean all the parts of the starting air valve.
  - 2 **NOTE:** Do not apply lubricant to the synthetic locking ring of the Allen screw (008, [Figure 7-38](#)).
- Apply a thin layer of oil to all the parts of the starting air valve.
- 3 Apply a thin layer of oil to the O-rings DX 27296 (002) and DX 27295 (005).
  - 4 Attach the O-rings (002, 005) to the housing (003).
  - 5 Put the valve spindle (004) in the housing (003).
  - 6 Put the compression spring (006) into the housing (003).
  - 7 Put the piston (007) in position on the valve spindle (004).
  - 8 Attach the hexagon nut (008) to the valve spindle (004).
  - 9 Torque the hexagon nut (008) to 600 Nm.
  - 10 Tap the top of the valve spindle (004) with a soft mallet. The valve spindle must spring back to its initial position.
  - 11 Attach the cover (001), together with the solenoid valve (009), to the housing (003) with the two M12 Allen screws (010).
  - 12 Torque the two M12 Allen screws to the value given in [3.5 Torque values - standard screws](#).

Fig 7-38 Starting air valve - assemble



00712

## CLOSE UP

- Install the starting air valve, refer to [7.7.5 Starting air valve - install](#)

## 7.7.5 Starting air valve - install

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Starting air valve			1
Gasket			1

### SAFETY PRECAUTIONS

- None

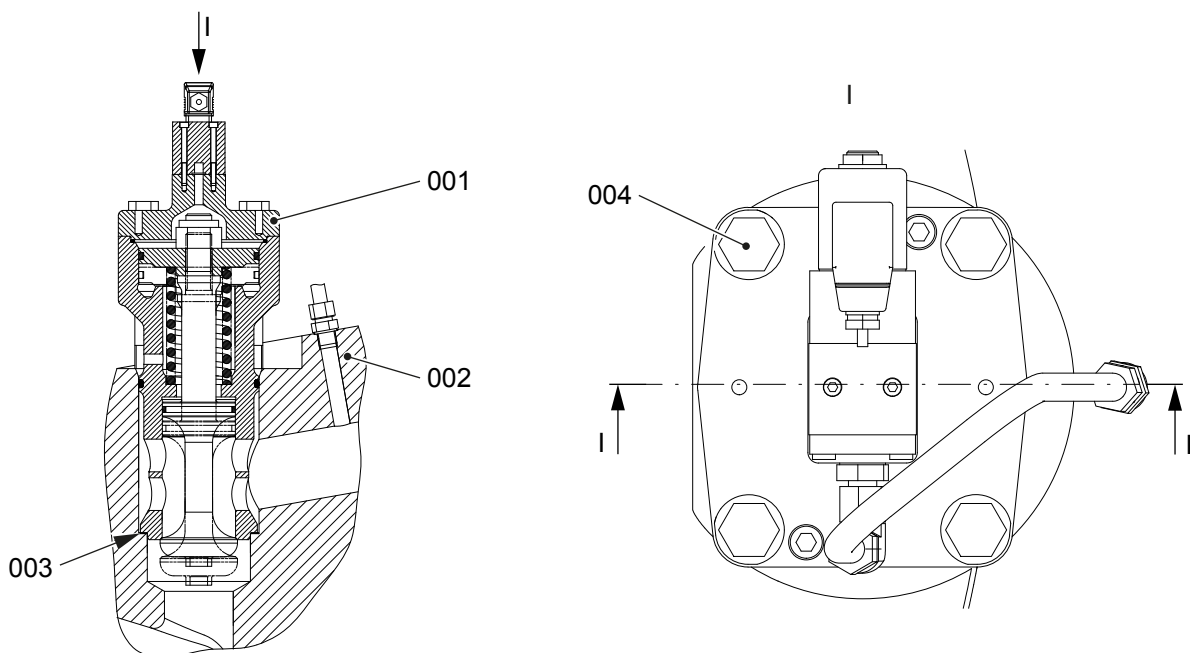
### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Put a new gasket (003) in the bore of the cylinder cover (002)
- 2 Apply a thin layer of oil to the bore of the cylinder cover (002).
- 3 Carefully attach the starting air valve to the cylinder cover (002) with the four M20 bolts (004).
- 4 Torque symmetrically the four M20 bolts (004) to the value given in [3.5 Torque values - standard screws](#).

Fig 7-39 Starting air valve - installation



00713

## CLOSE UP

- None

## 7.8 Relief valve combustion chamber

### 7.8.1 Relief valve combustion chamber - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

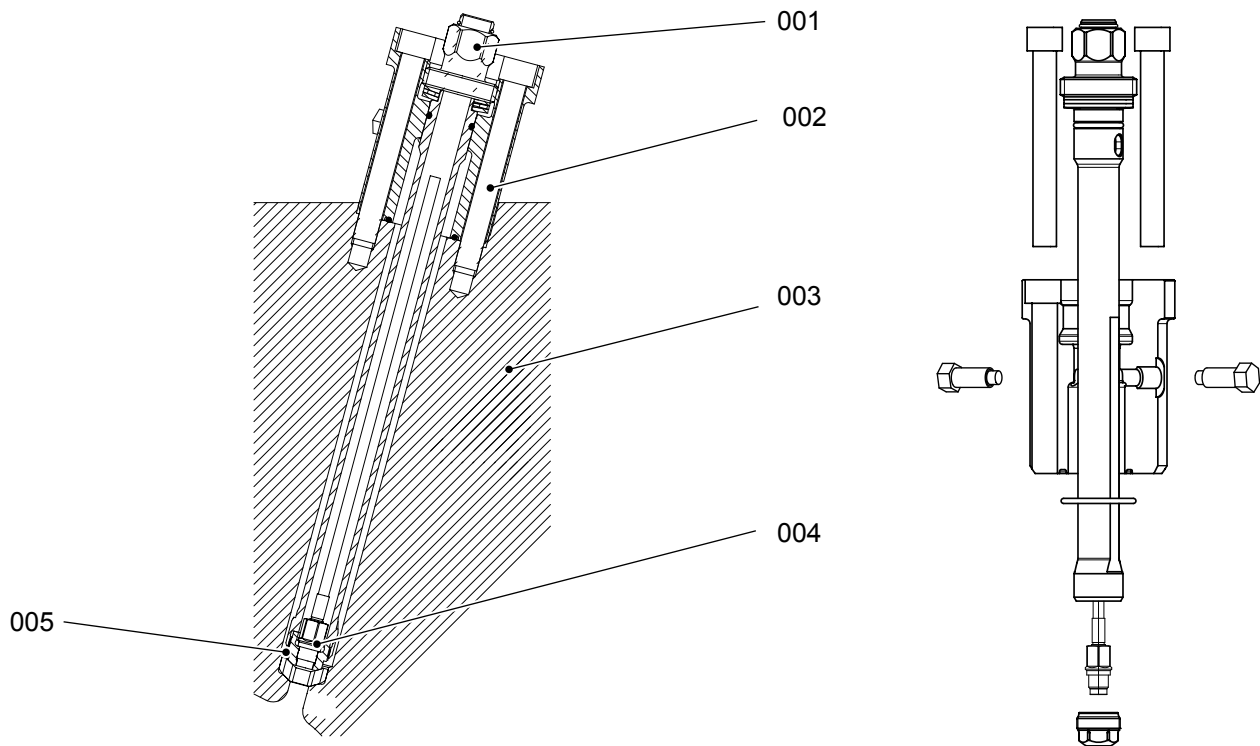
- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- The engine must become cold before you do work.

**PROCEDURE**

- 1 Open the relief valve with the spindle (001, [Figure 7-40](#)).
- 2 Disconnect the electrical cable from the connector.
- 3 Remove the two screws (002).
- 4 Remove the relief valve from the cylinder cover (003).
- 5 Remove the spindle from the flange.
- 6 Remove and discard the O-rings.

**Fig 7-40 Relief valve combustion chamber**

- 7 If necessary remove the sensor (004).
  - 7.1 Clamp the spindle at the flat machined surfaces in a bench vice.
  - 7.2 Remove the holder (005) from the spindle.

7.3 Remove the sensor (004) from the holder (005).

### **CLOSE UP**

- None

## 7.8.2 Relief valve combustion chamber - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Never Seez NSBT	A/R
Never Seez High Temperature Stainless	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Relief valve combustion chamber			1
Sensor complete			1
O-ring			2

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

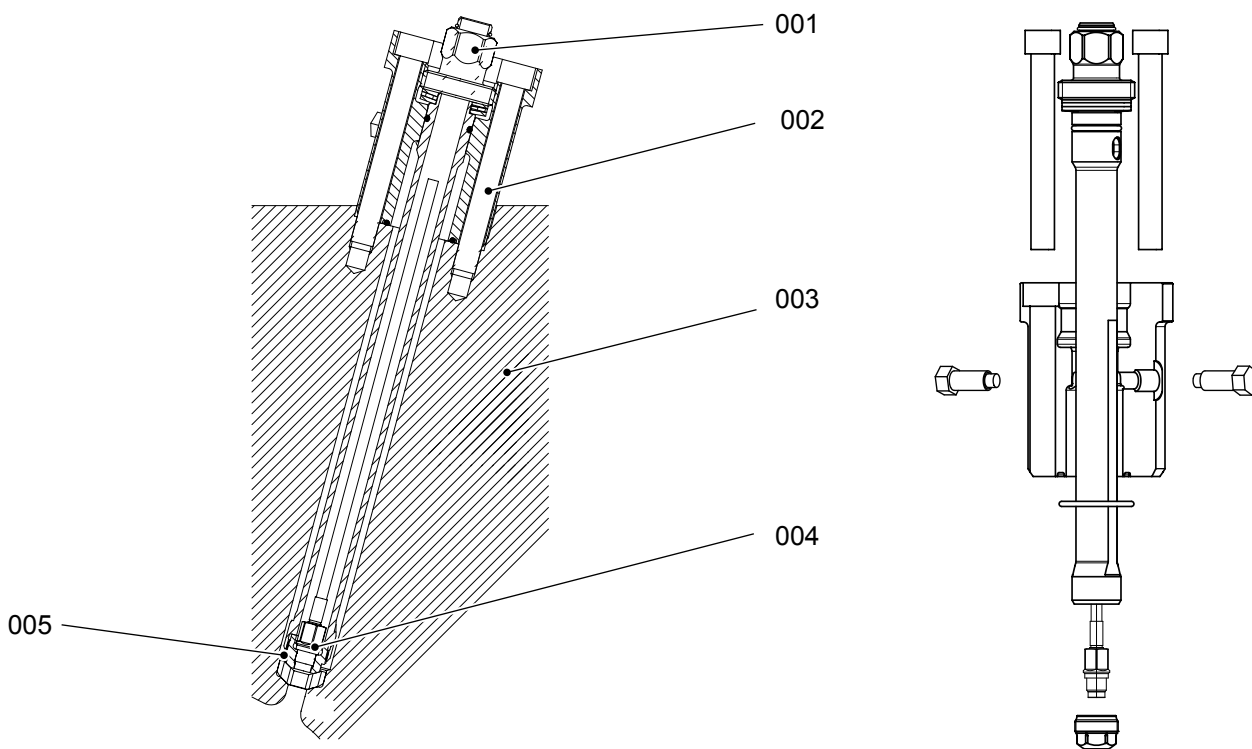
- The relief valve must be removed, refer to section [7.8.1 Relief valve combustion chamber - remove](#)



## PROCEDURE

- 1 If the sensor (004, [Figure 7-41](#)) has been removed, install the sensor (004).
  - 1.1 Guide the sensor (004) with the cable through the spindle.
  - 1.2 Connect the sensor tip to the holder (005) and spindle.
  - 1.3 Apply a thin layer of Never Seez High Temperature Stainless to the thread of the sensor (004).
  - 1.4 Apply a thin layer of Never Seez High Temperature Stainless the thread and the front face of the holder (005).
  - 1.5 Put the holder (005) to the sensor (004) and torque the sensor (004) to 15 Nm.
  - 1.6 Put the holder (005) with the sensor (004) to the relief valve and torque the holder (005) to 50 Nm.
- 2 Apply oil to the new O-rings.
- 3 Put the O-rings in the grooves of the relief valve.
- 4 Apply a thin layer of Never Seez to the contact surface of the relief valve.
- 5 Turn the spindle nut (001) to the upper position to get the open position.
- 6 Put the relief valve in position of the cylinder cover (003).
- 7 Apply a thin layer of Never Seez to the thread of the bolts (002).
- 8 Torque the bolts (002) to 50 Nm.
- 9 Turn in the spindle nut (001) until contact.
- 10 Turn in the spindle nut (001) 1/4 turn further. Refer to section [16.1 Tightening instructions](#).

Fig 7-41 Relief valve combustion chamber



**CLOSE UP**

- None

## 7.9 Exhaust valve

### 7.9.1 Exhaust valve - remove

#### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Sling			2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

To prevent injury to personnel and damage to equipment, use only the correct lifting equipment to lift and move the expansion piece.

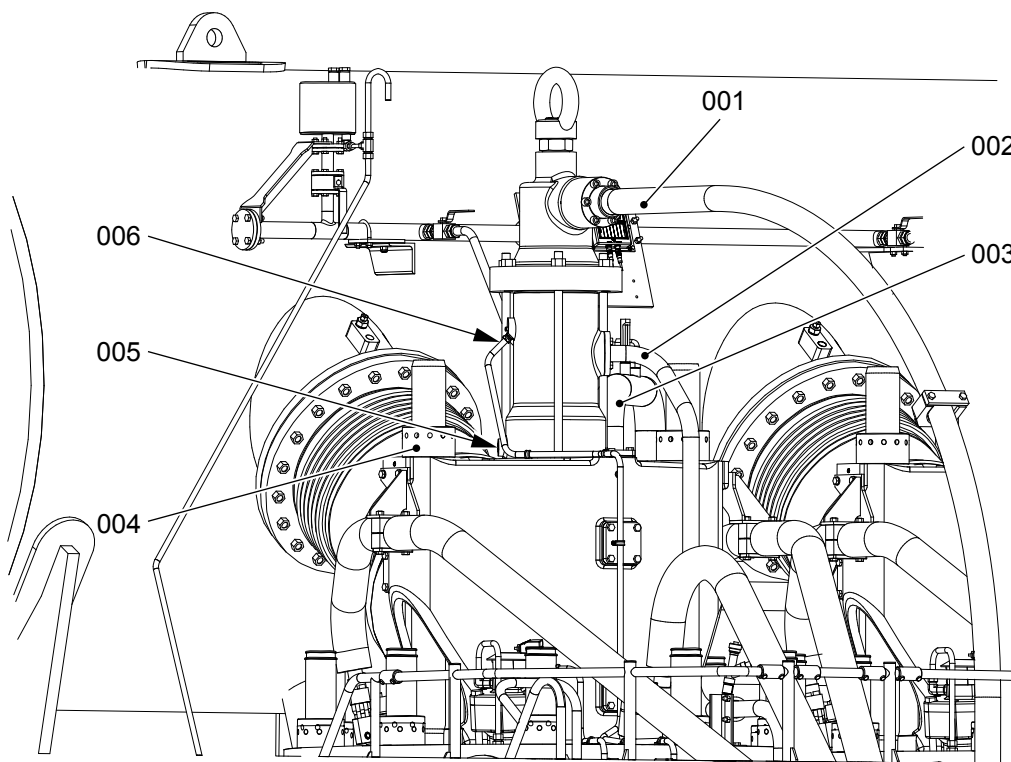
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Prepare the exhaust valve for removal.
  - 1.1 Remove the hydraulic pipe (001, [Figure 7-42](#)) from the exhaust valve, refer to [13.2.1 Hydraulic pipe exhaust valve - remove](#).
  - 1.2 Remove all other pipes from the exhaust valve.
  - 1.3 Disconnect the plug (005) from the valve stroke sensor.
  - 1.4 Remove the round nuts (004), refer to [4.3 Loosen a round nut with a pre-tensioner](#).

**Fig 7-42 Exhaust valve - preparation**

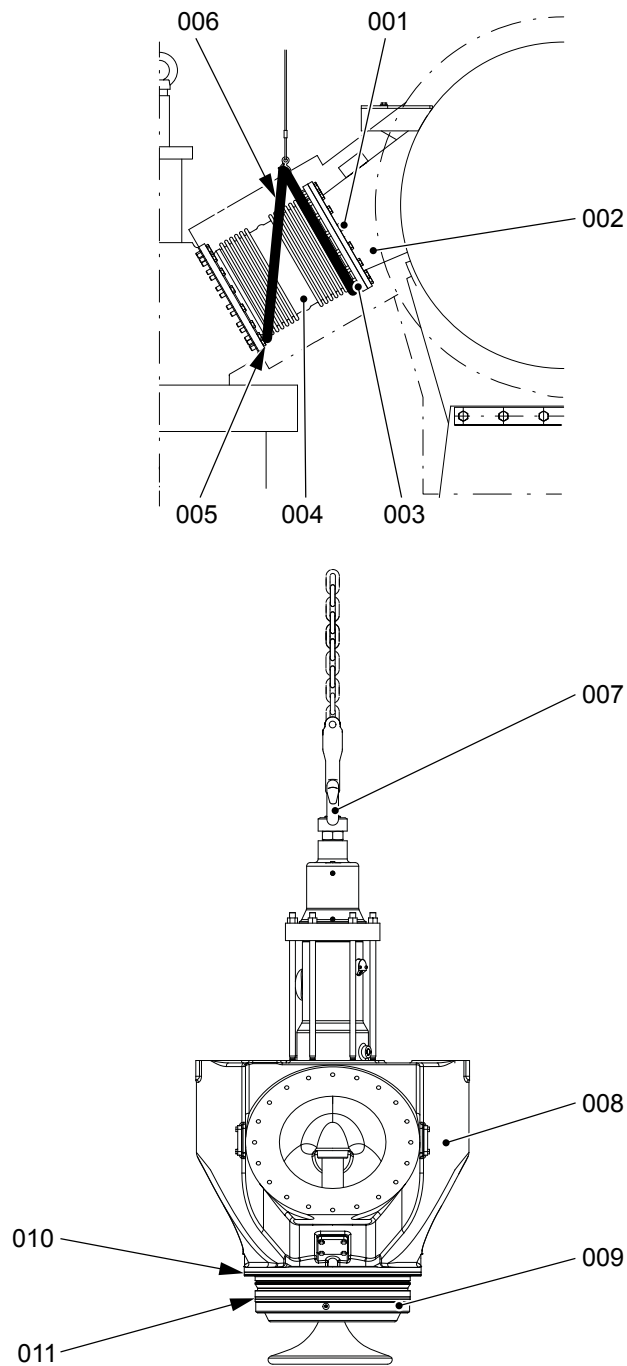


00719

- 2 Remove the expansion piece (004, [Figure 7-43](#)).
  - 2.1 Put the two slings (006) in position around the expansion piece (004) as shown.
  - 2.2 Attach the two slings (006) to the engine room crane.
  - 2.3 Operate the engine room crane to put a light tension on the slings (006).
  - 2.4 Remove the screws (005).
  - 2.5 Remove the nuts (003) and the bolts (001).
  - 2.6 Move the expansion piece (004) to one side.
  - 2.7 Lower the expansion piece on to an applicable surface.
- 3 Remove the exhaust valve.
  - 3.1 Attach the crane hook to the eye bolt (007).
  - 3.2 Operate the engine room crane to lift the exhaust valve (008) from the cylinder cover.
  - 3.3 Carefully lower the exhaust valve on to a wooden support.

- 3.4 Remove and discard the O-rings (010, 011) from the valve cage and valve seat.

Fig 7-43 Exhaust valve - removal



00718

**CLOSE UP**

- None

## 7.9.2 Exhaust valve - disassemble

### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
Jack screws			2
Depth gauge			1
Eye bolts			2
Eye bolts			2
Chain			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

During this procedure, do the work in a clean area. Electrical welding is not permitted. Injury to personnel can occur.

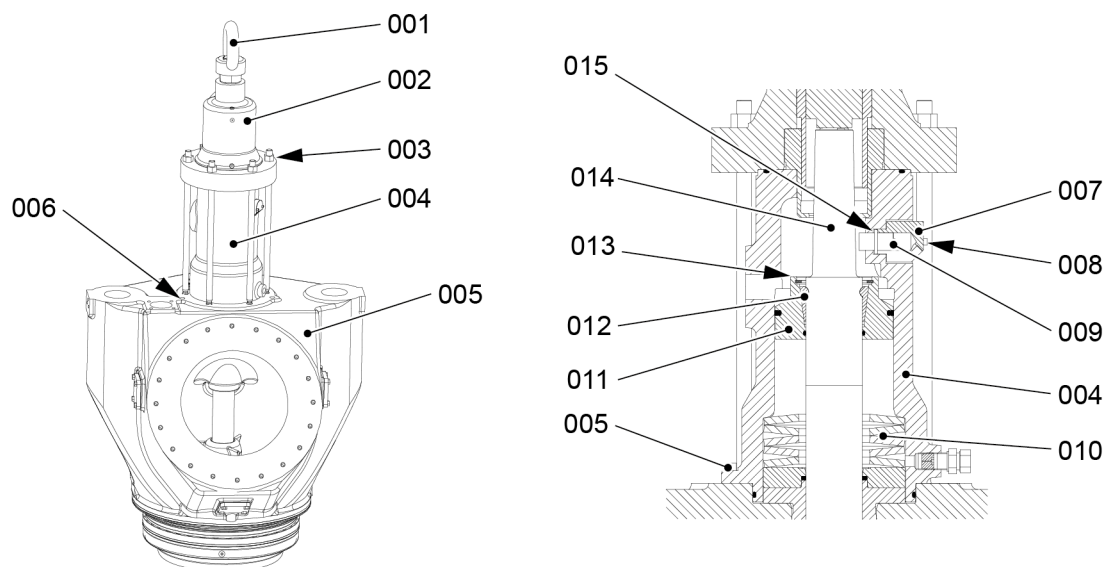
### PRELIMINARY OPERATIONS

- The exhaust valve must be removed, refer to section [7.9.1 Exhaust valve - remove](#)



## PROCEDURE

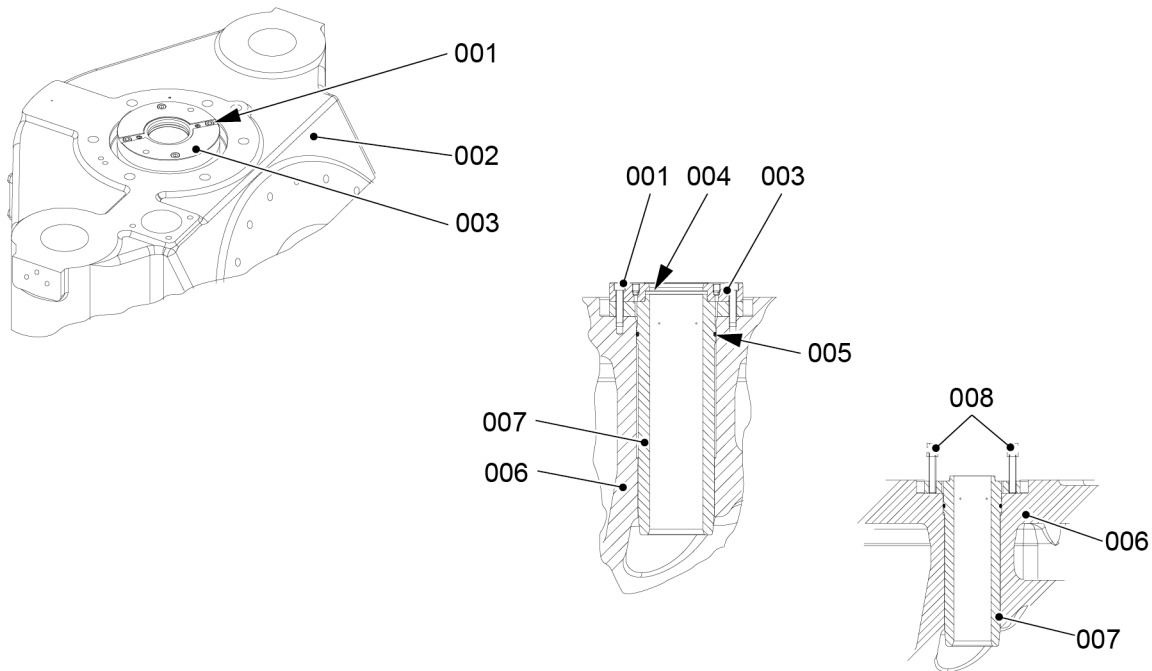
- 1** Disassemble the valve drive.
  - 1.1** Attach the engine room crane to the eye bolt (001, [Figure 7-44](#)).
  - 1.2** Remove the nuts (003).
  - 1.3** Remove the top housing (002).
  - 1.4** Remove the screws (008).
  - 1.5** Remove the transmitter housing (007).
  - 1.6** Remove the valve stroke sensor (009).
  - 1.7** Remove and discard the O-ring (015).
  - 1.8** Remove the Allen screw (006).
  - 1.9** Attach the two eye bolts to the bottom housing (004).
  - 1.10** Attach the chain to the two eye bolts attached before.
  - 1.11** Attach the engine room crane to the chain.
  - 1.12** Operate the engine room crane to remove the bottom housing (004).
  
- 2** Remove the valve spindle.
  - 2.1** Remove the circlip (013).
  - 2.2** Push the piston (011) down, then remove the valve cotters (012).
  - 2.3** Remove the piston (011) from the valve spindle (014).
  - 2.4** Remove the cup springs (010).
  - 2.5** Attach the two eye bolts to the valve cage (005).
  - 2.6** Attach the chain to the eye bolts.
  - 2.7** Attach the engine room crane to the chain.
  - 2.8** Operate the engine room crane to lift the valve cage (005). Make sure that the valve spindle (014) does not move.
  - 2.9** Lower the valve cage (005) on to its side.

**Fig 7-44 Exhaust valve - disassemble**

00677

- 3** Remove the guide bush.
  - 3.1** Remove the Allen screws (001, [Figure 7-45](#)).
  - 3.2** Remove the distance ring (003).
  - 3.3** Remove and discard the rod joint ring (004).
  - 3.4** Put the two jack screws (008) into the two threads of the guide bush flange (003).
  - 3.5** Turn equally the two jack screws (008) to push up the guide bush (007).
  - 3.6** Remove the guide bush (007).
  - 3.7** Measure the inner diameter of the guide bush (007).
  - 3.8** Compare the measurement with the values given in section [3.3 Clearances - general](#).

**Fig 7-45 Guide bush - removal**



00678

**CLOSE UP**

- None

### 7.9.3 Exhaust valve - remove the seat (recommended procedure)

#### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Valve seat tool	94261		1
Wooden support	N/A		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### CAUTION

TO PREVENT INJURY, USE ONLY APPLICABLE LIFTING EQUIPMENT TO LIFT AND MOVE THE VALVE CAGE.

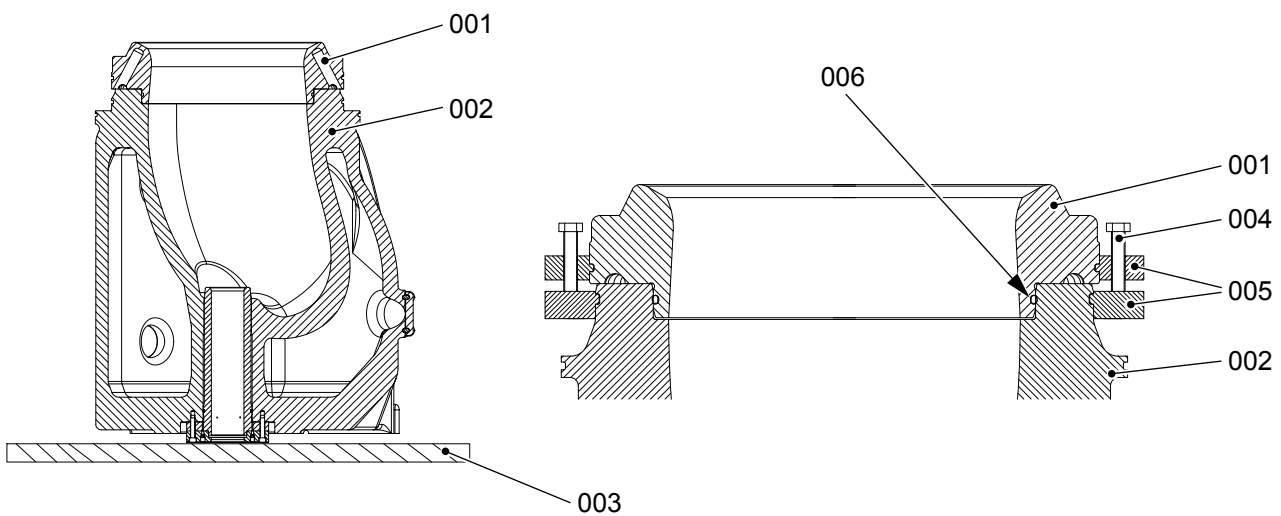
#### PRELIMINARY OPERATIONS

- The exhaust valve must be removed, refer to [7.9.1 Exhaust valve - remove](#)

## PROCEDURE

- 1 Mark the position of the valve seat (001, [Figure 7-46](#)) in the valve cage.
- 2 Turn the valve cage (002) until the valve seat (001) points up.
- 3 Carefully put the valve cage (001) on to an applicable wooden support (003).
- 4 Install the top two halves of the valve seat tool (005) into the groove of the valve seat (001).
- 5 Install the bottom two halves of the valve seat tool (005) into the groove of the valve cage (002).
- 6 Turn equally the three jack screws (004) to push out the valve seat (001) from the valve cage (002).
- 7 Remove and discard the O-ring (006).
- 8 Remove the valve seat tool (005).

**Fig 7-46** Valve seat - remove



00726

## CLOSE UP

- None

## 7.9.4 Exhaust valve - remove the seat (alternative procedure)

### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolts			2
Valve seat tool			1
Wooden support	N/A		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

TO PREVENT INJURY, USE ONLY APPLICABLE LIFTING EQUIPMENT TO LIFT AND MOVE THE VALVE CAGE.

### PRELIMINARY OPERATIONS

- Do this procedure only, if it is necessary to remove the valve seat when the calve cage must stay in the usual position.

## PROCEDURE

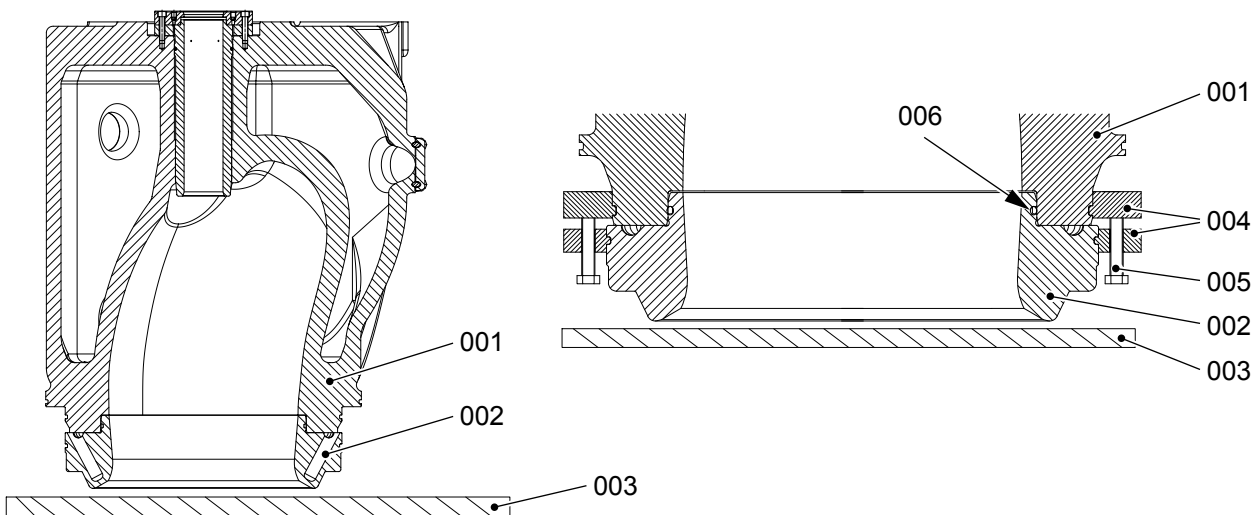
- 1 Attach the two eye bolts to the valve cage (001, [Figure 7-47](#)).
- 2 Attach an applicable chain to the eye bolts and to the engine room crane.
- 3 Operate the engine room crane to move the valve cage to a position immediately above the wooden support (003).
- 4 Install the top two halves of the valve seat tool (004) into the groove of the valve cage (001).
- 5 Install the bottom two halves of the valve seat tool (004) into the groove of the valve seat (002).

## CAUTION

**Injury hazard. Be careful when you do this step.**

- 6 Turn equally the four jack screws (005) until the valve seat (002) falls out of the valve cage (001).
- 7 Lift and move the valve cage (001) away from the valve seat (002).
- 8 Remove and discard the O-ring (006).
- 9 Remove the valve seat tool (004).

**Fig 7-47 Valve seat - alternative procedure**



00727

## CLOSE UP

- None

## 7.9.5 Exhaust valve - do a check of the seat

### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolt			1
Hammer			1
Feeler gauge			1
Wooden block			1
Rope			1

### Supplies

Description	QTY
Engineer's blue paste	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The exhaust valve must be disassembled, refer to section [7.9.2 Exhaust valve - disassemble](#)
- The valve seat must be removed.



## PROCEDURE

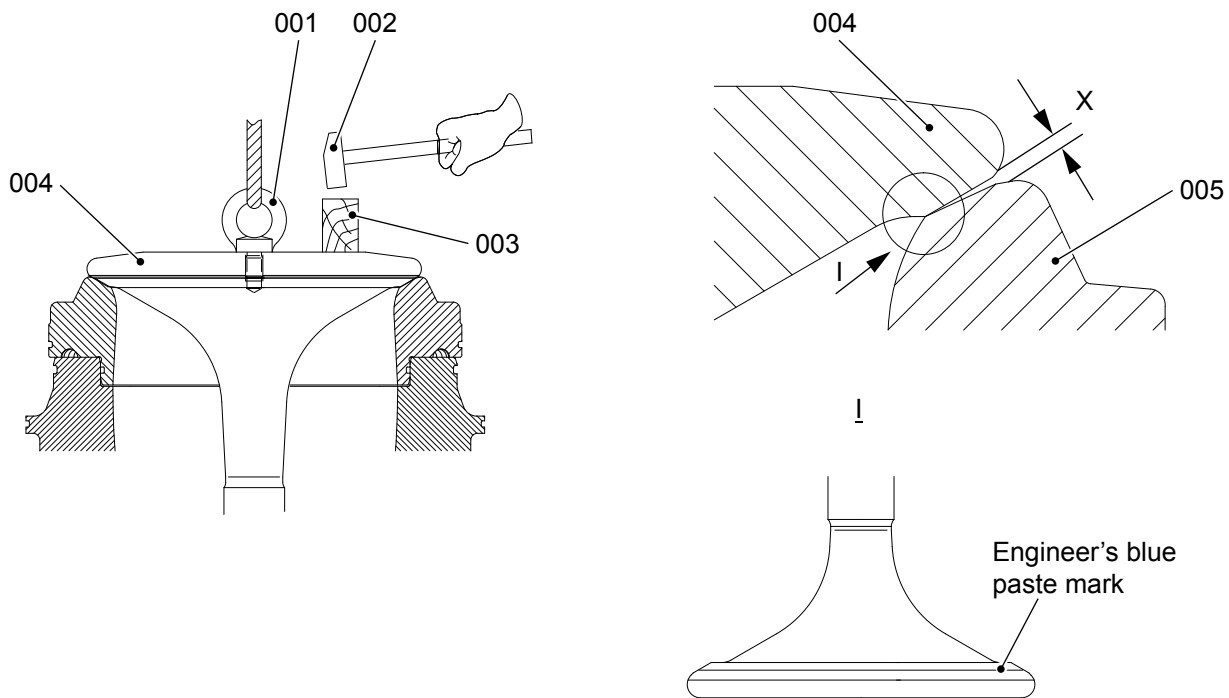
- 1 Attach the eye bolt (001, [Figure 7-48](#)) to the valve spindle (004).
- 2 Attach the rope to the eye bolt (001) and the engine room crane.
- 3 Put a thin layer of engineer's blue paste on the sealing face of the valve spindle (004).
- 4 Put the valve spindle (004) in position in the valve guide bush.
- 5 Put the wooden block (003) on the valve spindle (004).
- 6 Tap the wooden block (003) with the hammer (002) three or four times.  
**NOTE:** During this step, do not turn the valve spindle (004) because this can cause the sealing faces to catch.
- 7 Use the feeler gauge to do a check of the clearance X between the sealing faces of the valve spindle (004) and valve seat (005), refer to [Table 7-2 - Exhaust valve, clearance X](#).

**Tab 7-2 Exhaust valve, clearance X**

Engine type	Clearance X [mm]
X35, X35-B	0.005 to 0.020
X40, X40-B X40DF	0.005 to 0.020
X52 X52DF	0.033 to 0.062
X62, X62-B X62DF	0.054 to 0.070
X72, X72-B X72DF	0.054 to 0.070
X82, X82-B X82DF	0.120 to 0.150
X92, X92-B X92DF	0.120 to 0.150

- 8 Remove the valve spindle (004) from the guide bush.
- 9 Do a check of the engineer's blue paste. The paste must only show on the inner part of the full circumference of the valve spindle.

Fig 7-48 Valve seat clearance



00725

**CLOSE UP**

- None

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## 7.9.6 Exhaust valve - grind the seat

### Periodicity

Description	
Unscheduled	as necessary
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Grinding tool			1
Gauge			1
Feeler gauge			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

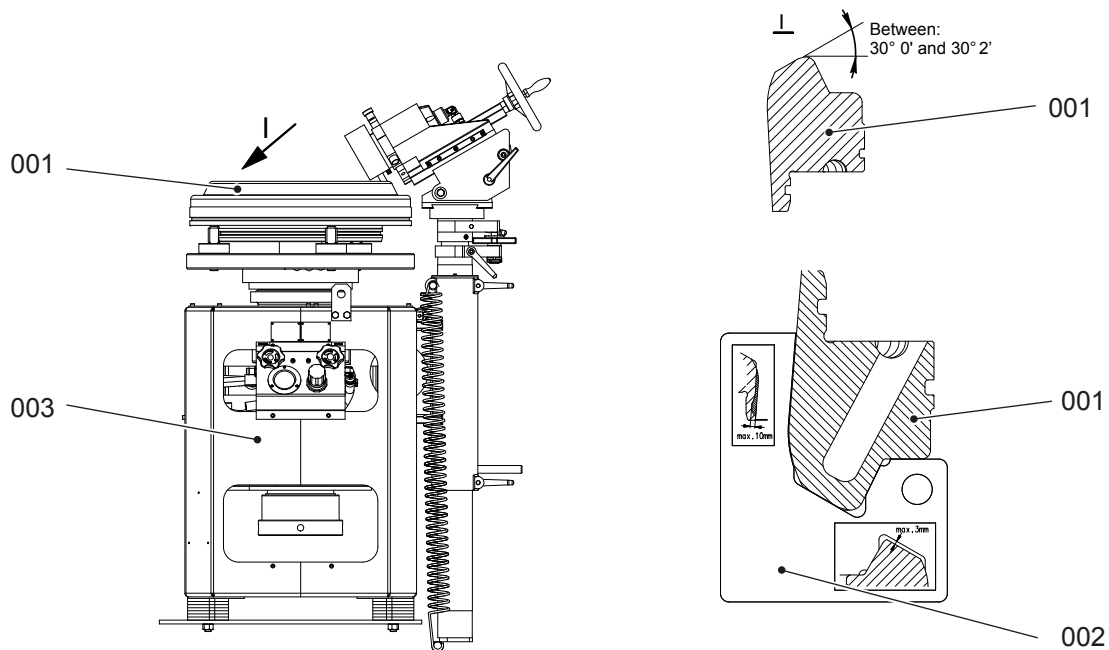
### PRELIMINARY OPERATIONS

- The valve seat must be removed.

## PROCEDURE

- 1 Read the data in the manufacturer's manual for the grinding tool (003, [Figure 7-49](#)).  
**NOTE:** Use only the grinding tool (003) to grind the valve seat (001).
- 2 Put the valve seat (001) in the correct position on the grinding tool (003).
- 3 Put the gauge (002) on the valve seat (001).
- 4 Use the feeler gauge to measure the values.  
**NOTE:** The data on the gauge (002) shows the maximum permitted limits for the valve seat (001).
- 5 If the values are less than the limits given, do as follows:
  - 5.1 Operate the grinding tool (003) to grind the sealing face of the valve seat (001). Make sure that you get a smooth and flat surface.
  - 5.2 Keep the valve seat angle to between  $30^{\circ} 0'$  and  $30^{\circ} 2'$ .

Fig 7-49 Valve seat - grinding tool



## CLOSE UP

- None

## 7.9.7 Exhaust valve - install the seat

### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Valve seat tool			1
Feeler gauge			1

### Supplies

Description	QTY
Oil	A/R
Never-Seez NBST-8	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1

### SAFETY PRECAUTIONS

#### CAUTION

TO PREVENT INJURY, USE ONLY APPLICABLE LIFTING EQUIPMENT TO LIFT AND MOVE THE VALVE CAGE.

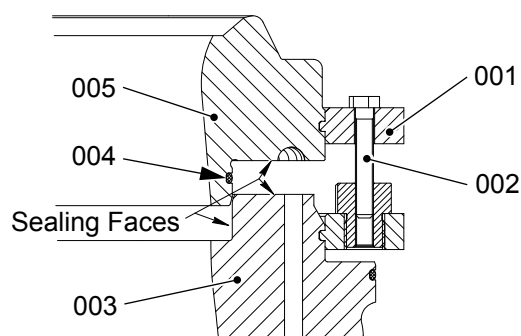
### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Clean the bores and the sealing faces of the valve cage (003, [Figure 7-50](#)) and of the valve seat (005).
- 2 Apply oil or Never-Seez NBST-8 to the bores and to the sealing faces of the valve cage (003) and of the valve seat (005).
- 3 Apply the same lubricant to the new O-ring (004).
- 4 Put the new O-ring (004) on the valve seat (005).
- 5 If the valve seat (005) was removed to replace the O-ring (004), align the marks on the valve seat (005) with the marks on the valve cage (003).
- 6 Put the valve seat (005) into the bore of the valve cage (003).
- 7 Install the top two halves of the valve seat tool (001) into the groove of the valve seat (005).
- 8 Install the bottom two halves of the valve seat tool (001) into the groove of the valve cage (003).
- 9 Turn equally the four jack-screws (002) to fully push the valve seat (005) into the valve cage (003).
- 10 Use the feeler gauge to make sure that there is no clearance between the sealing faces.
- 11 Remove the valve seat tool (001).

**Fig 7-50** Valve seat - install



00730

## CLOSE UP

- Assemble the exhaust valve, refer to section [7.9.8 Exhaust valve - assemble](#)

## 7.9.8 Exhaust valve - assemble

### Periodicity

Description	
One Time - after first working hours	18 000
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Jack screws			2
Depth gauge			1
Eye bolts			2
Eye bolts			2
Chain			1
Feeler gauge			1

### Supplies

Description	QTY
Oil	AR
System oil	AR
Loctite 271	AR

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1
Rod joint ring			1
Piston joint ring			1

### SAFETY PRECAUTIONS

#### CAUTION

Do this work in a clean area. Electrical welding is not permitted. Injury to personnel can occur.

### PRELIMINARY OPERATIONS

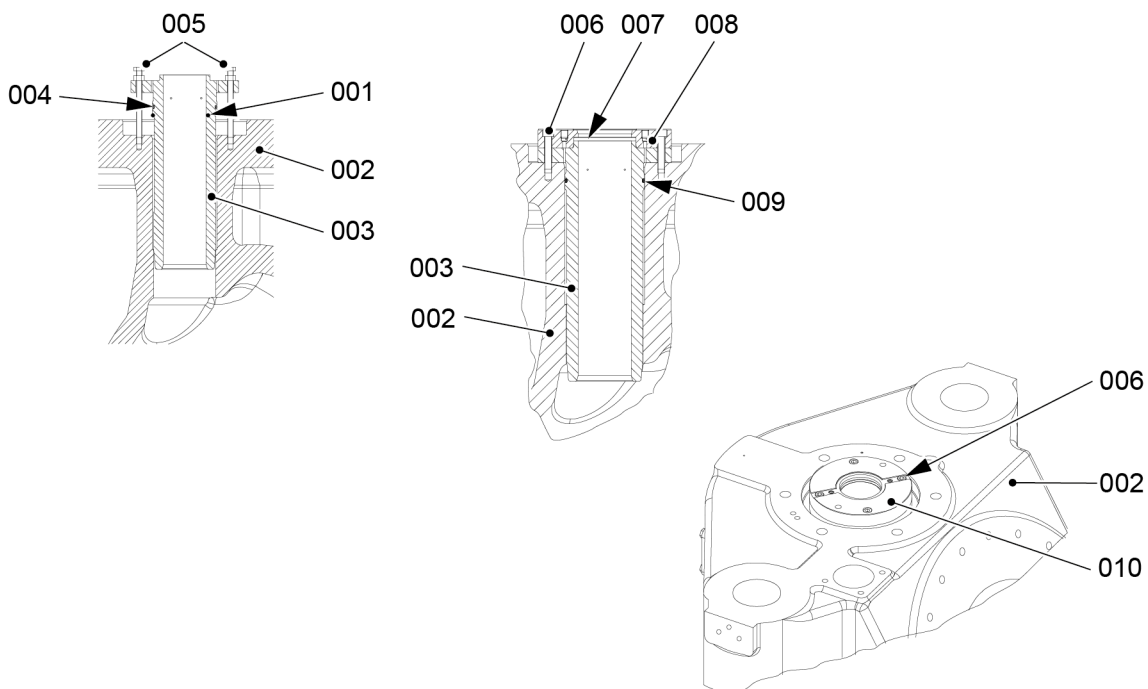
- None



## PROCEDURE

- 1 Install the guide bush.
  - 1.1 Clean the bore in the valve cage (002, [Figure 7-51](#)).
  - 1.2 Clean the guide bush (003).
  - 1.3 Make sure that the oil bores (004) in the guide bush (003) are clear.
  - 1.4 Put oil on the new O-ring (009) and the guide bush (003).
  - 1.5 Put the O-ring (009) on the guide bush (003).
  - 1.6 Put the guide bush (003) in position in the valve cage (002).
  - 1.7 Put the two jack screws (005) into the valve cage (002).
  - 1.8 Turn the jack screws (005) to push the guide bush (003) fully in to the valve cage (002).
  - 1.9 Put oil on the rod joint ring (007).
  - 1.10 Put the rod joint ring (007) in position.

**Fig 7-51 Guide bush - installation**

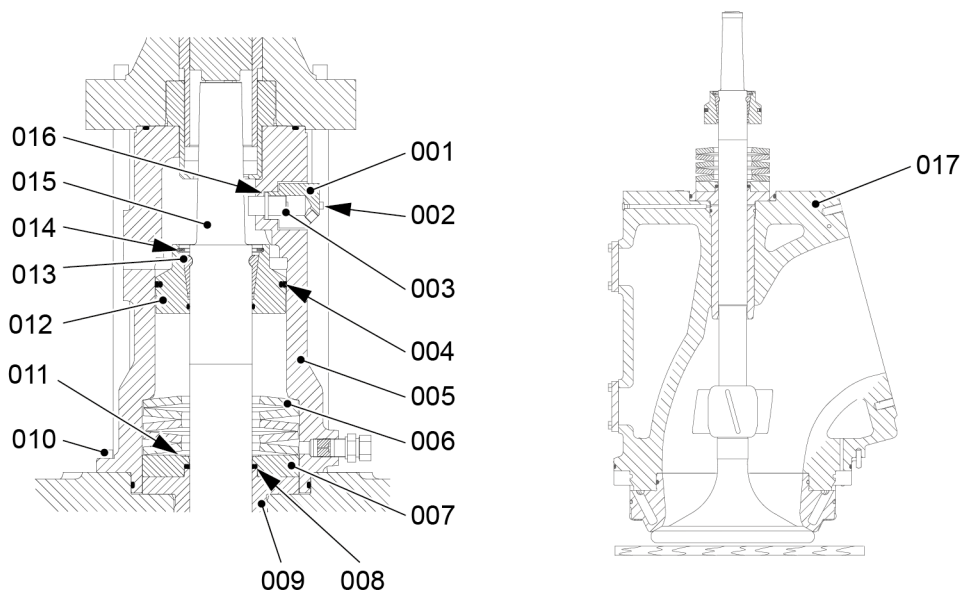


00679

- 2 Install the valve spindle.
  - 2.1 Measure the dimensions of the valve spindle (015, [Figure 7-52](#)).
  - 2.2 Compare the values with those given in section [3.3 Clearances - general](#).
  - 2.3 Make sure that the piston joint ring (004) has no damage. If you find damage, replace with the new piston joint ring.
  - 2.4 Replace all remaining O-rings.
  - 2.5 Put oil on the valve spindle (015).
  - 2.6 Attach the two eye bolts to the valve cage (017).
  - 2.7 Attach the chain to the two eye bolts.

- 2.8** Attach the engine room crane to the chain.
  - 2.9** Operate the engine room crane to lift the valve cage (017).
  - 2.10** Lower the valve cage (017) over the valve spindle (015). Make sure that the valve spindle does not move. Make sure that you do not cause damage to the guide bush (009).
  - 2.11** Put oil on the new rod joint ring (008).
  - 2.12** Put the new rod joint ring (008) in position in the guide bush (009).
  - 2.13** Attach the distance ring (007) with the four Allen screws (006, [Figure 7-51](#)).
- 3** Assemble the valve drive.
- 3.1** Put the cup springs (006, [Figure 7-52](#)) in position.
  - 3.2** Fill the oil bath (011) with system oil.
  - 3.3** Prepare a new piston joint ring (004) for installation as follows:
    - 3.3.1** Put sufficient water in an applicable container.
    - 3.3.2** Apply heat to get the water to 100°C.
    - 3.3.3** Put the new piston joint ring in the 100°C water for some minutes until it becomes soft.
  - 3.4** Put the piston joint ring (004) in the correct position on the piston (012).
  - 3.5** Put the piston (012) on the valve spindle (015).
  - 3.6** Attach the valve cotters (013).
  - 3.7** Push the piston (012) up and attach the circlip (014).
  - 3.8** Attach two eye bolts to the bottom housing (005).
  - 3.9** Attach the chain to the eye bolts and to the engine room crane.
  - 3.10** Operate the engine room crane to lift and lower the bottom housing (005) on to the valve cage (002).
  - 3.11** Install the Allen screw (010) to the bottom housing (005).

Fig 7-52 Valve spindle - installation



00680

- 3.12 Attach the engine room crane to the eye bolt (001, [Figure 7-53](#)).
- 3.13 Operate the engine room crane to lift and lower the top housing (003) on to the bottom housing (006).
- 3.14 Attach the nuts (004) to the elastic studs (005).
- 3.15 Torque symmetrically six nuts (004) to the related value, refer to section [16.1 Tightening instructions](#).

#### 4 Set the damper.

**NOTE:** You set the damper (002) only after you replace a valve spindle or a valve seat, or after the grinding procedure of one of the seating faces.

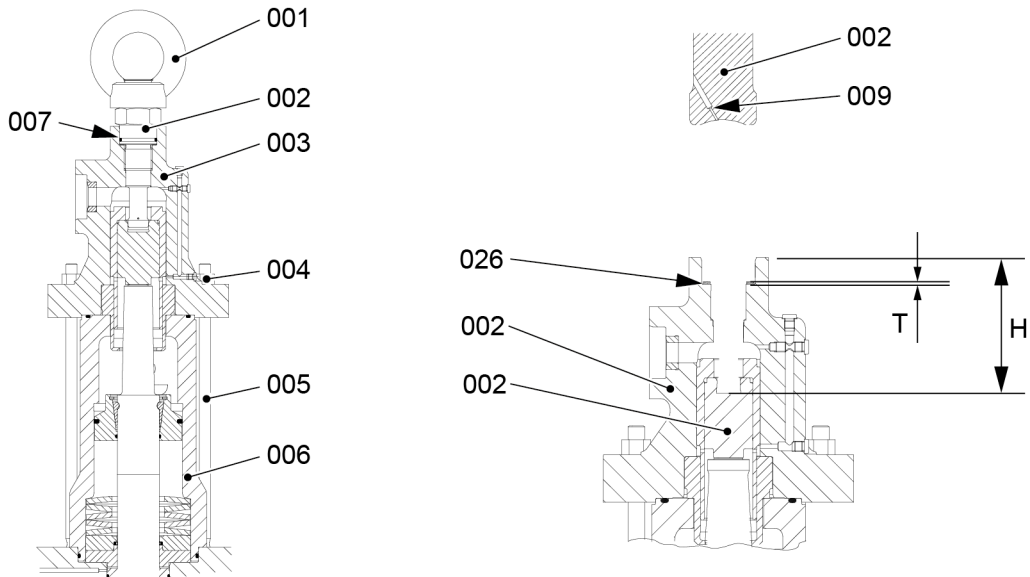
- 4.1 Remove the damper (002).
- 4.2 Make sure that the bores (009) in the damper (002) are clear.
- 4.3 Make sure that the exhaust valve is closed.
- 4.4 Use the feeler gauge to make sure there is no clearance between the valve plate and valve seat.
- 4.5 Use the depth gauge to measure the height H between the top and bottom of the bore in the top housing.
- 4.6 Calculate the number of shims T with the formula that follows:

$$T = H_b - H \pm 0.5 \text{ [mm]}$$

**NOTE:** For example for a X72DF engine, if the measured distance H is 163 mm, you must install two shims. Each shim (007) has a thickness of 1.0 mm ( $T = 165.2 - 163.0 = 1.8$ ).

- 4.7 Install the correct quantity of shims.
- 4.8 Apply Loctite 271 to the threads of the damper (002).
- 4.9 Install the damper (002).

Fig 7-53 Damper setting (example)



00681

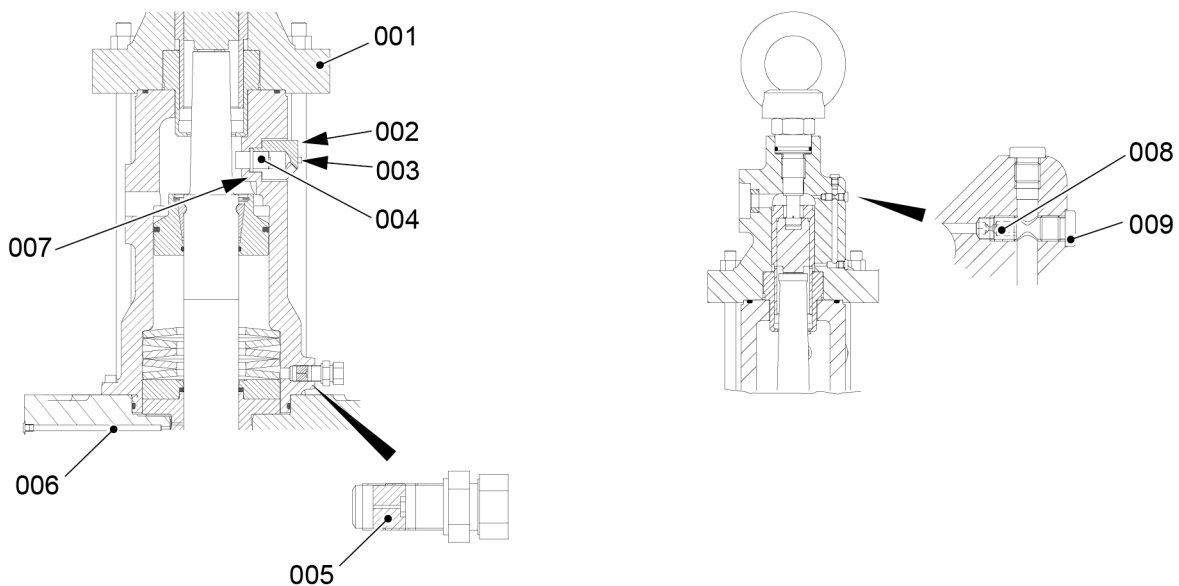
Tab 7-3 Damper settings

Engine type	Basic distance $H_b$ [mm]
X35, X35-B	80.9
X40, X40-B X40DF	90.4
X52 X52DF	140.0
X62, X62-B X62DF	143.7
X72, X72-B X72DF	165.2
X82, X82-B X82DF	175.0
X92, X92-B X92DF	228.7

- 5 Install the valve stroke sensor.
  - 5.1 Clean the parts that follow:

- The valve stroke sensor (004, [Figure 7-54](#))
  - The transmitter housing (002)
  - The bore and collar in the top housing (001).
- 5.2 Put oil on the O-ring (007) and on the valve stroke sensor (004).
  - 5.3 Carefully put the O-ring (007) and the valve stroke sensor (004) into the housing.
  - 5.4 Attach the transmitter (004) and transmitter housing (002) to the top housing (001) with the two screws (003).
  - 5.5 Connect the electrical connection to the valve stroke sensor (003).
- 6 Do a check of the throttle (008).
    - 6.1 Remove the screw plug (009).
    - 6.2 Remove the throttle (008).
    - 6.3 Make sure that the throttle (008) is clean.
    - 6.4 Put oil on the threads of the throttle (008).
    - 6.5 Put the throttle (008) in the housing.
    - 6.6 Torque the throttle (008) to 20 Nm.
    - 6.7 Attach the screw plug (009).
  - 7 Do a check of the non-return valve (005).
    - 7.1 Remove the non-return valve (005) from the housing (001).
    - 7.2 Make sure that the non-return valve (005) operates correctly.
    - 7.3 Install the non-return valve (005) in the housing (001).
  - 8 Make sure that the oil bore to the valve guide (006) is clear.

**Fig 7-54 Valve stroke sensor, throttle and non-return valve**



00682

**CLOSE UP**

- Install the exhaust valve, refer to section [7.9.9 Exhaust valve - install](#)

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## 7.9.9 Exhaust valve - install

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Slings			2

### Supplies

Description	QTY
Oil	A/R
Heat-resistant lubricant	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Gasket			1
O-ring			1
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

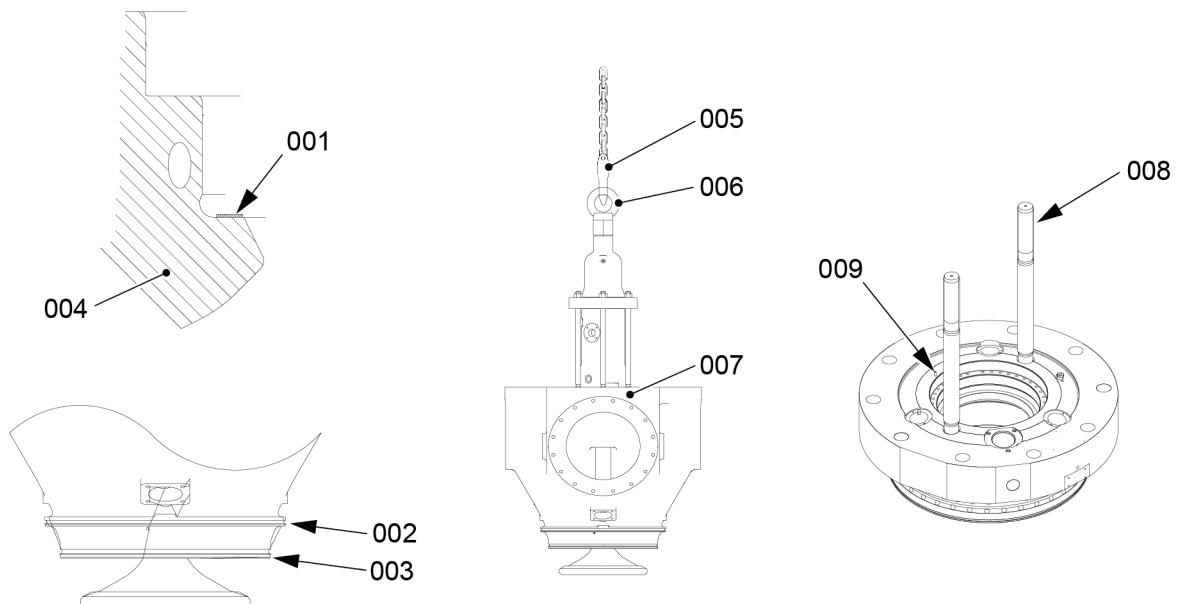
- None



## PROCEDURE

- 1 Clean all the sealing surfaces of the exhaust valve and the cylinder cover.
- 2 Examine the sealing surfaces of the exhaust valve and cylinder cover for damage.
- 3 Remove the gasket (001) from the cylinder cover (004).
- 4 Clean the gasket (001).
- 5 Examine the gasket (001) for damage. Make sure that the dimension of the gasket is correct.
- 6 If the gasket (001) has no damage, and the dimension is correct, put the gasket in position in the cylinder cover.
- 7 If the gasket (001) has damage, or the dimension is not correct, replace with a new gasket.
- 8 Put the new O-rings (002, 003) in the valve cage and valve seat.
- 9 Apply a thin layer of oil to the new O-rings (002, 003).
- 10 Attach the engine room crane (005, [Figure 7-56](#)) to the eye bolt (006).
- 11 Operate the engine room crane to lift and move the exhaust valve (007).
- 12 Put the exhaust valve (007) in the correct position in the cylinder cover. The cylindrical pin (009) in the cylinder cover will help you get the correct position.  
**NOTE:** Make sure that you do not cause damage to the threads of the elastic studs (008).
- 13 Install the round nuts to the elastic studs (008), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).

Fig 7-55 Exhaust valve - installation

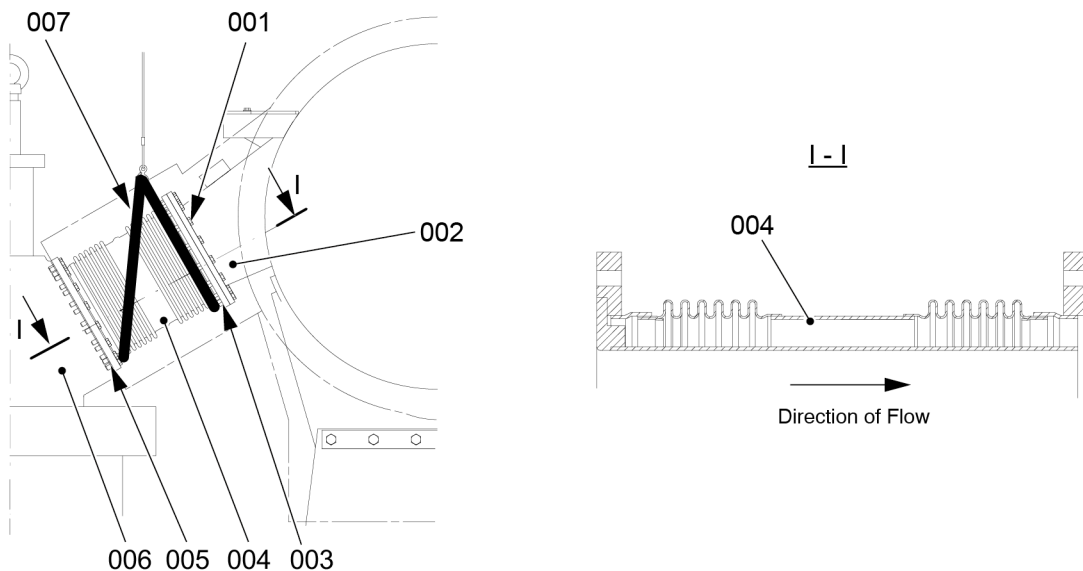


00675

- 14 Clean the sealing surfaces of the expansion piece (004, [Figure 7-56](#)) and the related faces on the valve cage (006) and exhaust pipe (002).

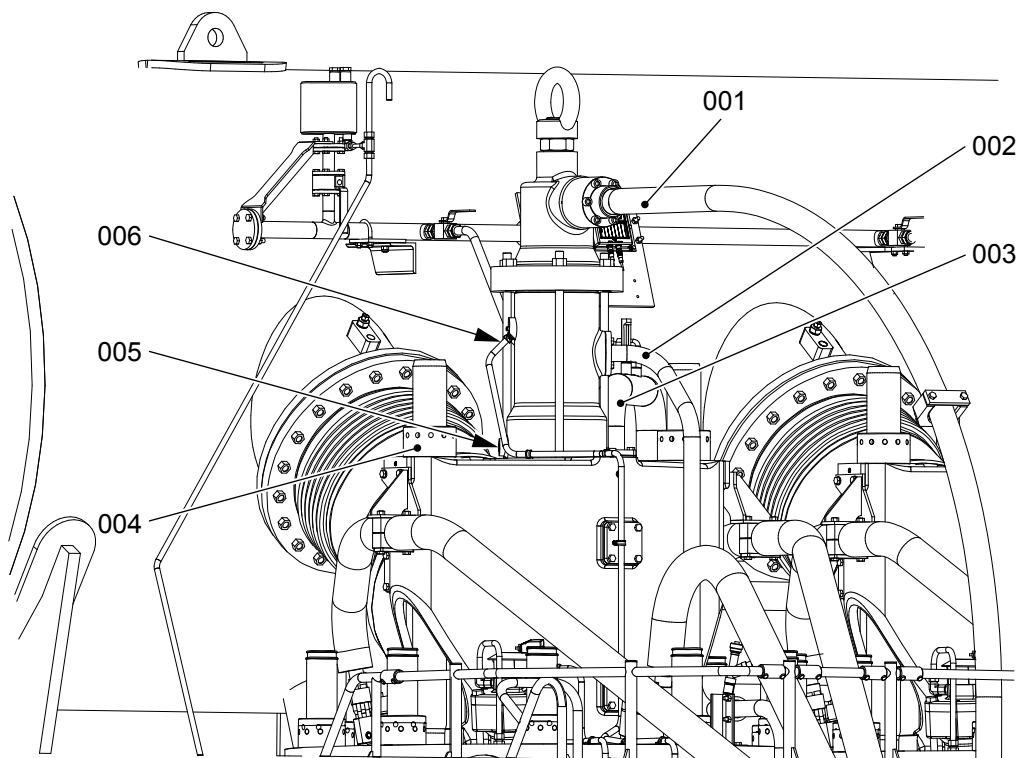
- 15 Apply a thin layer of heat-resistant lubricant to the sealing faces and the screws (001, 005).
- 16 Put the two slings (007) in position on the expansion piece (004).
- 17 Attach the slings (007) to the engine room crane.
- 18 Operate the engine room crane to lift the expansion piece (004).
- 19 Put the expansion piece (004) in position between the valve cage (006) and the exhaust pipe (002). Make sure that the expansion piece is in the correct position.
- 20 Attach the expansion piece (004) to the valve cage (006) and the exhaust pipe (002) with the screws (001, 005) and the nuts (003).
- 21 Remove the two slings (007).

**Fig 7-56 Expansion piece - installation**



00676

- 22 Complete the installation of the exhaust valve.
  - 22.1 Tighten the round nuts (004, [Figure 7-57](#)), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
  - 22.2 Connect the plug (005) to the valve stroke sensor.
  - 22.3 Install the hydraulic pipe (001), refer to section [13.1.3 HP servo oil pipe - install](#).
  - 22.4 Install all other pipes to the exhaust valve.

**Fig 7-57 Exhaust valve - complete the installation**

00719

**CLOSE UP**

- None

## 7.10 Pilot injection valve

### 7.10.1 Pilot injection valve - remove

#### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Plate			1
Stud bolt			2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Danger: Do not weld or grind materials in the area. The sparks from welding equipment and grinding tools can cause a fire.**

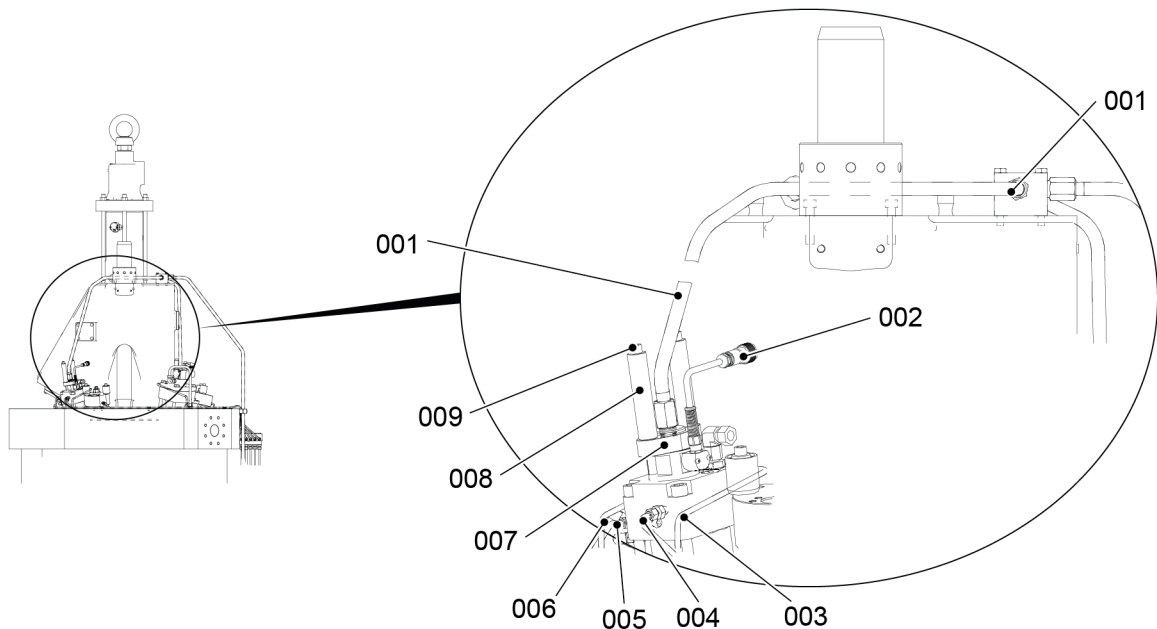
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- The engine must become cool before you do work.

## PROCEDURE

- 1 Make sure that the drain from the pilot injection valve to the sludge tank is open.
- 2 Remove the applicable HP pilot fuel pipe (001, [Figure 7-58](#)), refer to section [13.4.1 HP pilot fuel pipe - remove](#).
- 3 If necessary, remove the pipes (003, 004, 005 and 006).
- 4 Disconnect the electrical cable (002) from the solenoid valve.
- 5 Remove the Allen screws (009) together with the distance pieces (008).
- 6 Remove the flange (007).

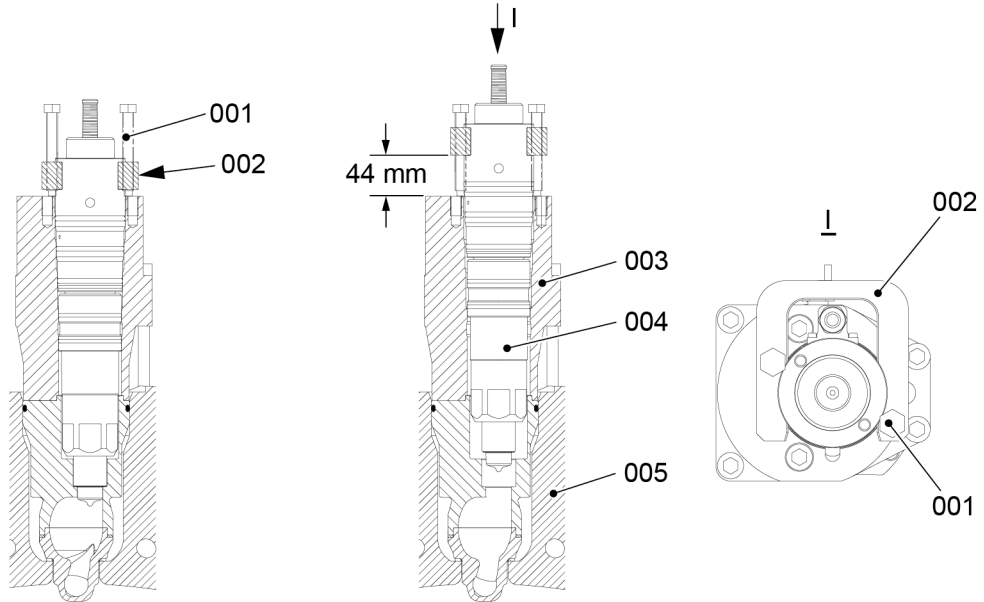
**Fig 7-58 Pilot injection valve**



00899

- 7 Put the plate (002, [Figure 7-59](#)) on the pilot injection valve (004) as shown.
- 8 Put the stud bolts (001) in the plate (002).
- 9 Turn equally the stud bolts (001) until they touch the valve holder (003).
- 10 Turn equally the screws of the stud bolts (001) to lift the pilot injection valve (004) approximately 44 mm.  
**NOTE:** The valve holder (003) stays in the cylinder cover (005).
- 11 Remove the pilot injection valve (004) from the valve holder (003).

Fig 7-59 Pilot injection valve - remove



00606

**CLOSE UP**

- None

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## 7.10.2 Pilot injection valve - remove the injection module

### Periodicity

Description	
Working hours	12 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Test bench	N/A		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

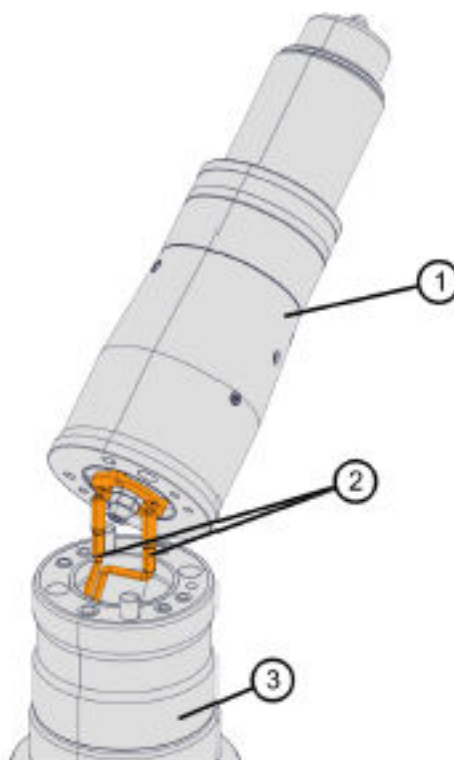
- The pilot injection valve must be removed, refer to section [7.10.1 Pilot injection valve - remove](#)



## PROCEDURE

- 1 Put the pilot injection valve in position in the valve holder of the test bench.  
**NOTE:** For the use of the test bench refer to the related section.
- 2 Attach the pilot injection valve to the valve holder.
- 3 Turn the valve holder through 180° so that the nozzle tip points up.
- 4 Safety the valve holder in that position on the test bench.
- 5 Loosen the nozzle nut of the pilot injection valve.
- 6 Carefully remove the nozzle nut.  
**NOTE:** If necessary you can use an applicable tool to remove the nozzle nut.
- 7 Remove and discard the two O-rings from the inner side of the nozzle nut.
- 8 Carefully lift the injection module (1, [Figure 7-60](#)) some centimeters above the distributor piece (3).
- 9 Disconnect the two cables (2).
- 10 Fully remove and discard the injection module (1).

**Fig 7-60** Pilot fuel valve - remove the injection module



## CLOSE UP

- None

### 7.10.3 Pilot injection valve - install the injection module

#### Periodicity

Description	
Working hours	12 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Test bench	N/A		1
Injection module	N/A		1
O-ring	N/A		2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

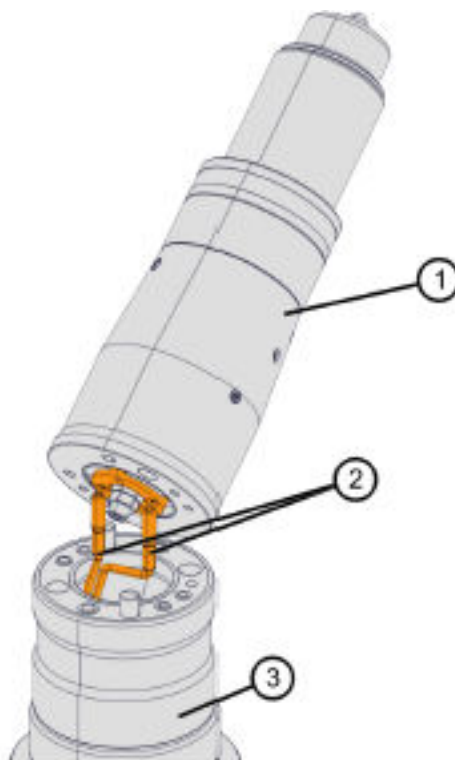
#### PRELIMINARY OPERATIONS

- The distributor piece of the pilot injection valve must be fixed on the test bench, refer to section [7.10.2 Pilot injection valve - remove the injection module](#)

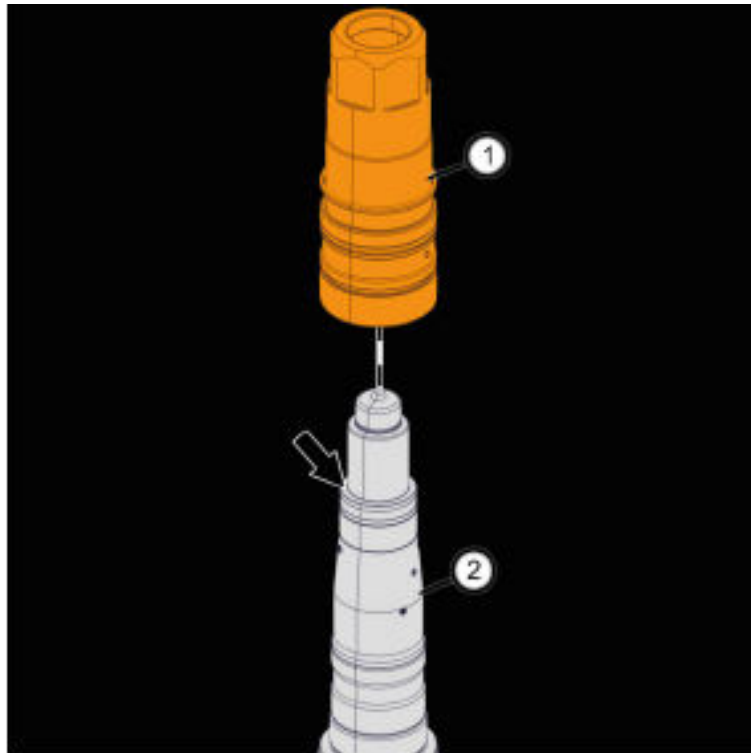
## PROCEDURE

- 1 Clean the contact surfaces of the new injection module (1, [Figure 7-61](#)) and of the distributor piece.
- 2 Clean the inner side of the distributor piece (3).
- 3 Make sure that the contact surfaces and the two cables (2) have no damage.
- 4 Move the injection module (1) some centimeters above the distributor piece (3).  
**NOTE:** Find the correct position related to the two dowel pins.
- 5 Connect the two cables (2) to the injection module (1).  
**NOTE:** You can use one of the two plugs for each cable.

**Fig 7-61** Pilot fuel valve - install the injection module



- 6 Put the injection module onto the distributor piece.  
**NOTE:** Make sure that you not cause damage to the cables.
- 7 Apply a thin layer of oil to the new O-rings.
- 8 Put the new O-rings in the related grooves of the nozzle nut.
- 9 Clean the distributor piece and the injection module.
- 10 Apply an applicable lubricant on the thread of the nozzle nut and on the shoulder of the injection module.
- 11 Install the nozzle nut (1, [Figure 7-62](#)) onto the injection module (2) and tighten it with your hands.
- 12 Tighten the nozzle nut (1) to the correct value, refer to section [16.1 Tightening instructions](#).
- 13 Make sure that the sealing ring is correctly installed.

**Fig 7-62 Pilot fuel valve - install the nozzle nut****CLOSE UP**

- None

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## 7.10.4 Pilot injection valve - do a functional test

### Periodicity

Description	
Working hours	12 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Test bench			1
HP hose			1
Valve holder			1

### Supplies

Description	QTY
Test fluid, ISO 4113	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Danger: Do not put your fingers near the nozzle tip. Fuel can go through your skin and cause injury or kill You.**

### WARNING

**Injury Hazard. Test fluid is dangerous. Always read the manufacturer's safety instructions before you use test fluid.**

**NOTE:** Only trained personnel are permitted to do this procedure.

**NOTE:** If test fluid is not available, you can use clean diesel oil. If you use clean diesel oil, install the injection valve immediately on the engine after you have completed this procedure.

**NOTE:** It is not recommended that diesel oil is used if the injection valve is put into storage after this procedure. Diesel oil can cause corrosion of the injection valve.

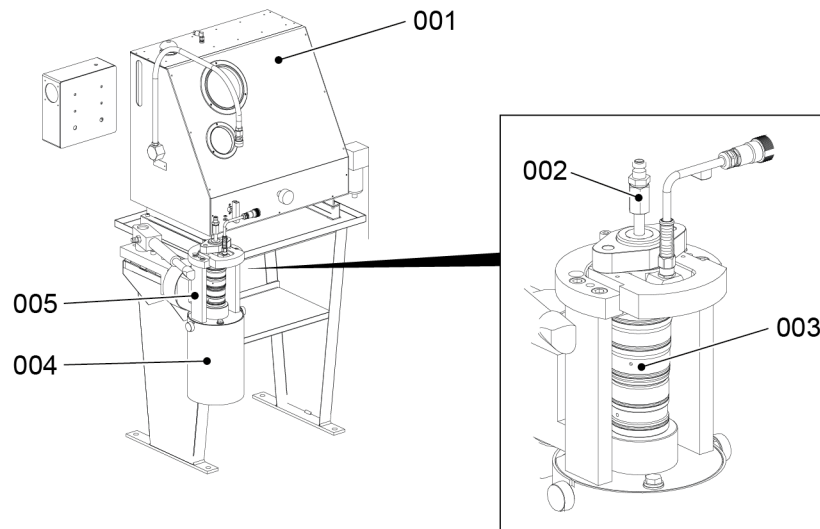
## PRELIMINARY OPERATIONS

- The pilot fuel valve must be removed, refer to section [7.10.1 Pilot injection valve - remove](#)
- You must read the instructions of the test bench manufacturer.

## PROCEDURE

- 1 Make sure that the test bench (001, [Figure 7-63](#)) is clean.
- 2 Make sure that the receiver (004) is removed from the valve holder (005).
- 3 Use a brass wire brush to remove combustion particles from the external areas of the nozzle.
- 4 Attach the pilot injection valve (003) to the valve holder (005) with the spring cages and their Allen screws. Make sure that the pilot injection valve points down.
- 5 Attach the HP hose to the connecting piece (002).
- 6 Connect the electrical connection to the test bench.
- 7 Start the test bench in accordance with the manufacturer's instructions.
- 8 Set the pressure of the test bench to 500 bar.
- 9 At regular intervals, use a master pressure gauge to do checks of the pressure gauges on the test bench. If necessary, adjust the pressure gauges.
- 10 Push the INJECT button. Make sure that pilot injection valve operates correctly.
- 11 Do a check of the seating surface between the needle seat and the nozzle as follows:
  - 11.1 Keep the pressure of the test bench constant at approximately 350 bar.
  - 11.2 Monitor the pilot injection valve for 30 seconds. No fuel must come out of the nozzle.
- 12 Do a check of the opening pressure as follows:
  - 12.1 Set the pressure to 280 bar, then push the INJECT button. No fuel must come out of the nozzle.
  - 12.2 Set the pressure to 400 bar, then push the INJECT button. Fuel must come out of the nozzle as a spray.
- 13 For the correct function and to use a pilot injection valve again, read the data below:
  - The pressure to operate the pilot injection valve is between 300 bar and 400 bar, refer to the check given above.
  - Most of the fuel will come out as a spray from the holes in the nozzle tip at the specified opening pressure.
  - At the end of an injection, no fuel must come out of the nozzle.



**Fig 7-63 Pilot injection valve - checks**

00900

**CLOSE UP**

- None

## 7.10.5 Pilot injection valve - remove the pre-chamber

### Periodicity

Description	
Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolts	N/A		2

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

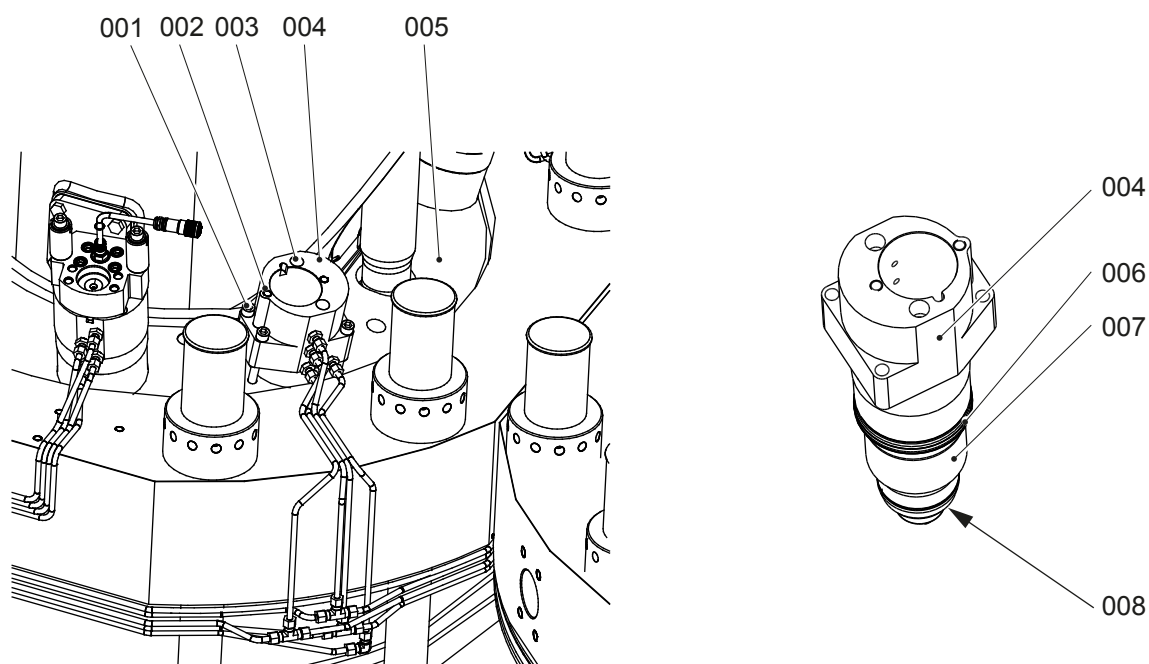
### PRELIMINARY OPERATIONS

- The pilot injection valve must be removed, refer to section [7.10.1 Pilot injection valve - remove](#)

## PROCEDURE

- 1 Make sure that the cooling water in the cylinder cover is drained.
- 2 Remove all pipes from the holder (004, [Figure 7-64](#)).
- 3 Loosen the two screws (003) one turn.
- 4 Remove the screws (001).
- 5 Attach two eye bolts to the threads (002) of the holder (004).
- 6 Carefully lift the holder (004) together with the pre-chamber (007) from the cylinder cover (005).
- 7 Remove the two screws (003) and the pre-chamber (007).
- 8 Remove and discard the O-ring (006) and the seal (008).
- 9 Do a check of the sealing surfaces of the pre-chamber and of the cylinder cover. If necessary, grind the sealing surfaces.

**Fig 7-64 Pilot injection valve - remove the pre-chamber**



## CLOSE UP

- None

## 7.10.6 Pilot injection valve - install the pre-chamber

### Periodicity

Description	
Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolts	N/A		2
Pre-chamber	A/R		1
Seal	N/A		1
O-ring	N/A		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

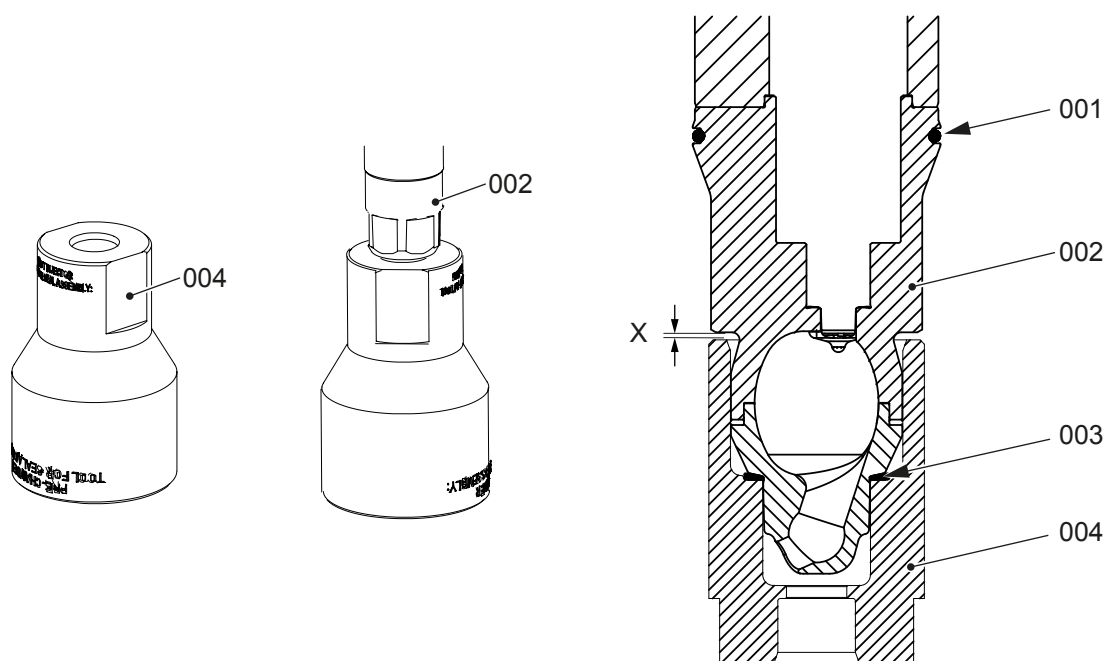
### PRELIMINARY OPERATIONS

- The pilot injection valve must be removed, refer to section [7.10.1 Pilot injection valve - remove](#)

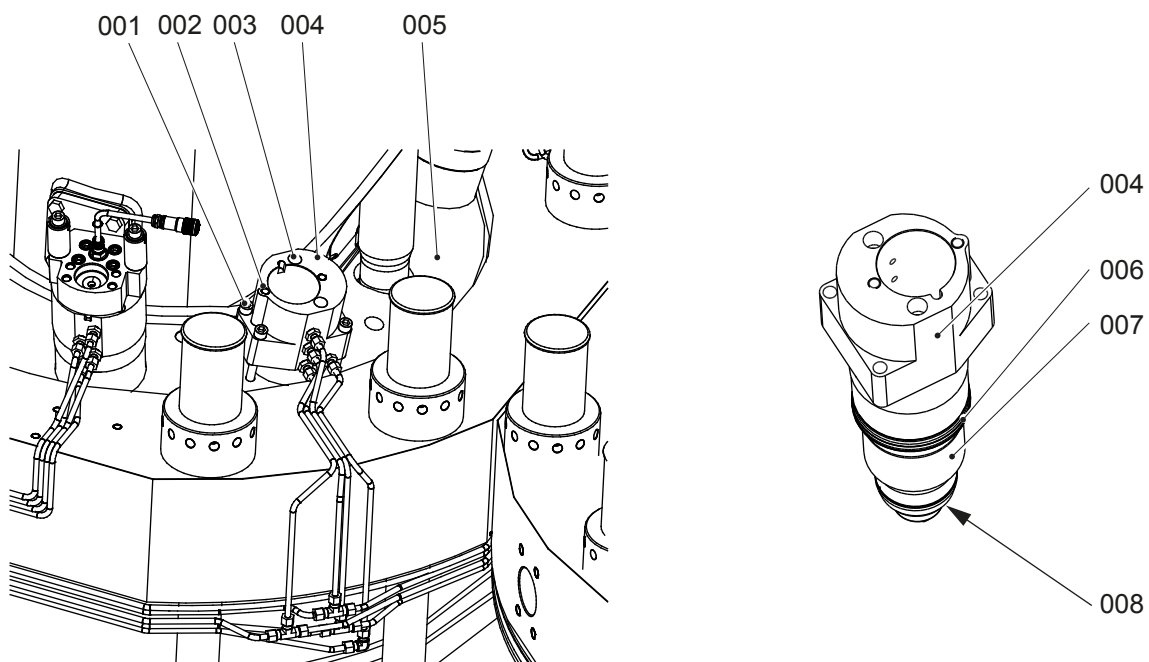
## PROCEDURE

- 1 Make sure that the pre-chamber (002, [Figure 7-65](#)) is internally and externally clean.
- 2 Install the dowel pin.
- 3 Apply a thin layer of oil to the new O-ring (001).
- 4 Attach the new O-ring (001) to the pre-chamber (002).
- 5 Attach the new seal (003) to the pre-chamber (002) with the assembly tool (004).  
**NOTE:** The assembly tool (004) can look different.

**Fig 7-65 Pilot injection valve - install the seal for the pre-chamber**



- 6 Put the pre-chamber to the correct position on the holder (004, [Figure 7-66](#)) with the two screws (003).
- 7 Torque the two screws (003).
- 8 Carefully put the holder (004) together with the pre-chamber into the cylinder cover (005).
- 9 Apply Never Seez NSBT to the screws (001).
- 10 Torque crosswise the screws (001) to the correct value, refer to section [16.1 Tightening instructions](#).
- 11 Install all pipes to the holder (004).

**Fig 7-66 Pilot injection valve - install the pre-chamber****CLOSE UP**

- None

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## 7.10.7 Pilot injection valve - install

### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Assembly tool			1
Stud bolts			2

### Supplies

Description	QTY
White spirit	A/R
Never Seez NSBT	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Pilot injection valve			1
Seal			1
O-rings			4

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The pre-chamber must be installed, refer to section [7.10.6 Pilot injection valve - install the pre-chamber](#)
- The injection module must be installed, refer to section [7.10.3 Pilot injection valve - install the injection module](#)



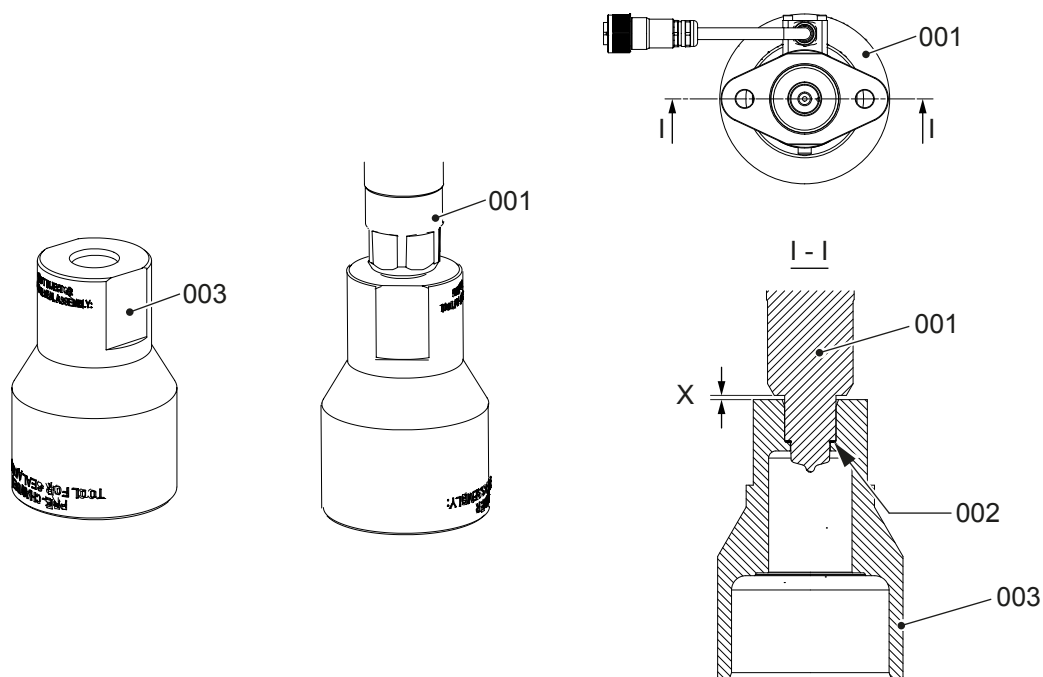
## PROCEDURE

- 1 Make sure that the sealing faces of the pilot injection valve have the conditions that follow:
  - Clean and dry
  - Satisfactory condition
  - No lubricant.
- 2 Put a new seal (002, [Figure 7-67](#)) on the pilot injection valve (001).
- 3 Use the assembly tool (003) to install the seal (002) on to the pilot injection valve (001).
- 4 Make sure that the distance X between the pilot injection valve (001) and the tool (003) is related to [Table 7-4 - Distance X for pre-chamber](#).

**Tab 7-4 Distance X for pre-chamber**

Engine type	Distance X [mm]
X40DF	xxx
X52DF	4.25
X62DF	4.25
X72DF	4.25
X82DF	3.0
X92DF	3.0

**Fig 7-67 Pilot injection valve - assemble the seal**



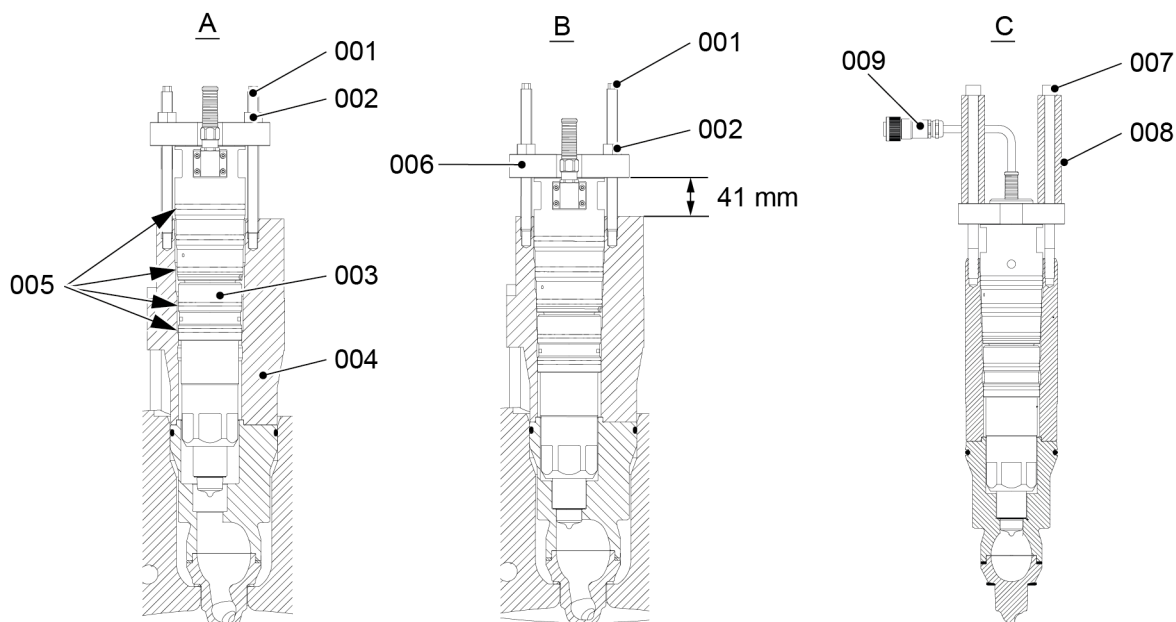
- 5 Remove the tool (003).

### CAUTION

**Injury Hazard: Always put on gloves and safety goggles that have a closed side frame when you do work with white spirit. White spirit can cause damage to your skin and eyes.**

- 6 Clean the pilot injection valve (003, [Figure 7-68](#)) with white spirit (for example Shellsol TD, Shellsol T or Solvent FP68).
- 7 Apply oil to the new O-rings (005).
- NOTE:** The O-rings are part of the spare parts set for the pilot injection valve.
- 8 Put the pilot injection valve (003) into the valve holder (004).
- 9 Put the stud bolts (001) into the valve holder (004) as shown.
- 10 Turn down equally the two nuts (002) until you get a distance of 41 mm between the flange (006) and the valve holder (004).
- 11 Remove the stud bolts (001).
- 12 Apply Never Seez NSBT to the threads and surfaces that touch on the two Allen screws (007).
- 13 Attach the two distance pieces (008) to the pilot injection valve with the two Allen screws (007).
- 14 Torque the two Allen screws (007) to the correct value, refer to section [16.1 Tightening instructions](#).

**Fig 7-68 Pilot injection valve - install**

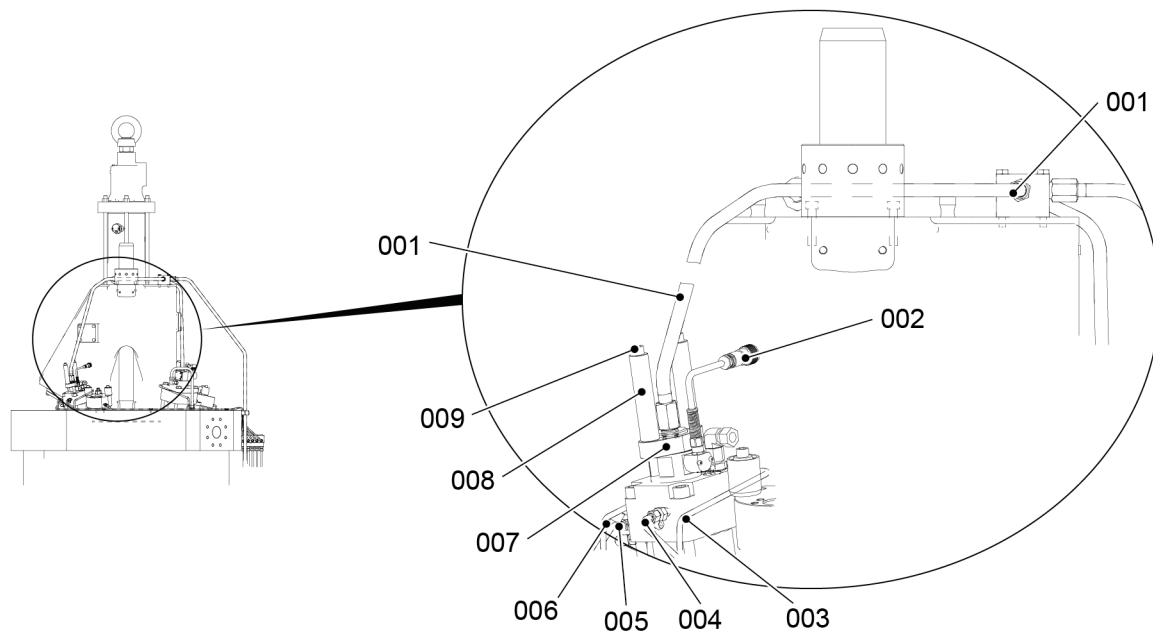


00610

- 15 Install the applicable HP pilot fuel pipe (001, [Figure 7-69](#)), refer to section [13.4.2 HP pilot fuel pipe - install](#).
- 16 If necessary, install the pipes (003, 004, 005 and 006).

- 17 Connect the electrical cable (002) to the solenoid valve.

**Fig 7-69 Pilot injection valve**



00899

### CLOSE UP

- None

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## 8 Group 3 - Crankshaft, connecting rod and piston

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## 8.1 Crankshaft

### 8.1.1 Crankshaft - do a check of the crank deflection

#### Periodicity

Description	
Working hours	6000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	6.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Dial gauge (0.01 mm accuracy)			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

#### WARNING

**Suffocation Hazard:** Ventilate the engine for at least 20 min. before entering the crankcase.

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Do this procedure in the conditions that follow:
  - Related to the intervals given from the owner (related to classification societies)
  - Related to the intervals given from WinGD
  - If temperature alarms of bearings occurred
  - If damage of bearings occurred
  - After the main bearing shells are replaced and again after approximately 100 operation hours
  - If the vessel has hit the sea bed.

**NOTE:** If possible do this procedure if there is no direct sunshine to prevent thermal influence of the measurement.

- 2 Prepare the vessel and the engine for the measurement as follows:

**2.1** Switch off the main lubricating oil pumps and the crosshead pumps.

**2.2** Open the indicator valves.

**2.3** Switch off the following heat sources:

- Heater in main lubricating oil dump tank
- Heaters in other tanks in the engine room double bottom
- Pre-Heater of the main lubricating oil separator

The heat sources mentioned above must be switched off

- In cold condition: 8 hours before measurement
- In warm condition: 4 hours before measurement
- In hot condition: 1 hour before measurement

**2.4** Make sure that the vessel floats freely in a horizontal position.

**NOTE:** You must not charge or discharge the vessel during the measurement.  
You must not do this measurement in the dry-dock.

**2.5** Get access to the crankshaft of the engine.

**NOTE:** Suffocation Hazard: Ventilate the engine for at least 20 min. before entering the crankcase.

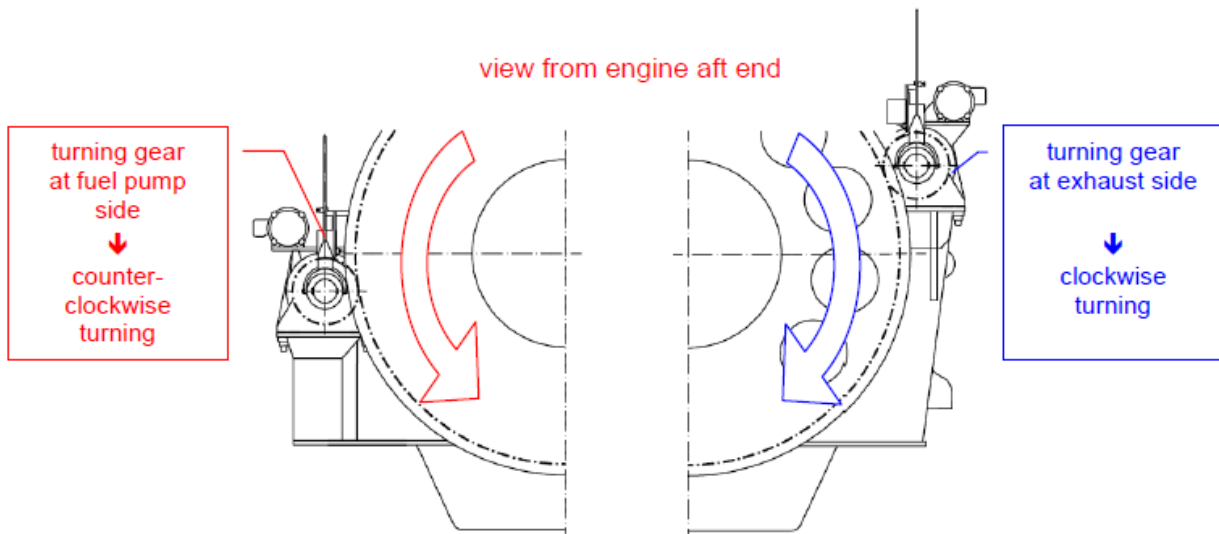
**2.6** Turn the crankshaft at least one revolution to ensure good lubrication.

- 3 Record the general data that follow:

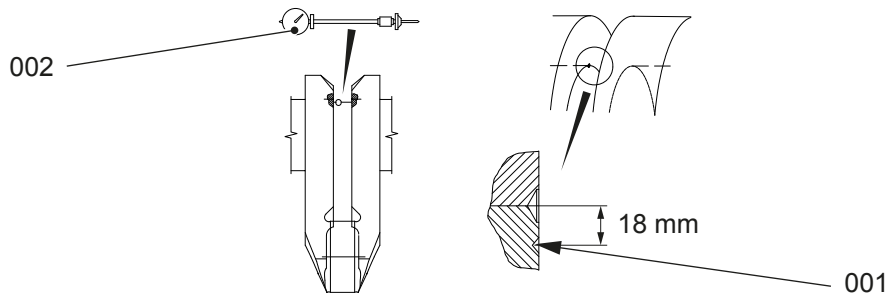
- Load of the engine
- Temperature of the engine
- Temperature of the seawater
- Temperature of the HT water
- Temperature of the system oil
- Draught of the vessel (fore side and aft side)

- 4 Measure the values for the first crank as follows:

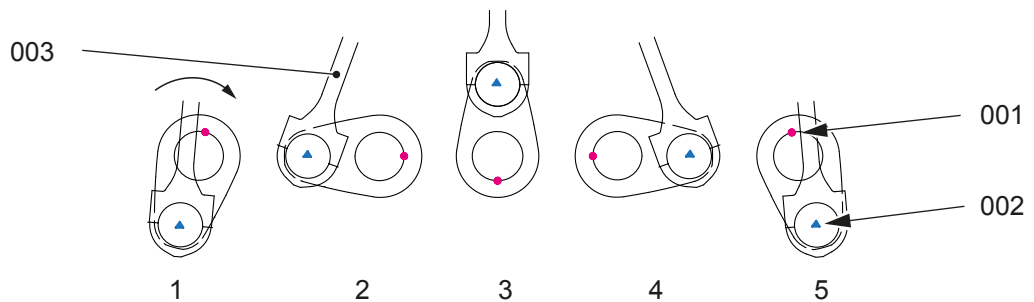
**4.1** Operate the turning gear to turn the engine in the direction related to [Figure 8-1](#) until the crank is in the BDC position.

**Fig 8-1** Definition of turning directions (view from aft end)

- 4.2 Continue to operate the turning gear in the same direction until the punch marks are freely accessible (position 1 in [Figure 8-3](#)).
- 4.3 Put the dial gauge (002, [Figure 8-2](#)) next to the connecting rod in the center punch marks (001). Make sure that the dial gauge (002) goes into the center punch marks (001).

**Fig 8-2** Dial gauge position

- 4.4 Turn the rod of the dial gauge (002) to apply tension.
- 4.5 Set the dial gauge (002) to zero.
- 4.6 Operate the turning gear in the same direction to move the crank to each position of the dial gauge (001, [Figure 8-3](#)).

**Fig 8-3 Crank positions for clockwise direction****Legend**

001 Dial gauge position  
002 Crank pin position

003 Connecting rod

**NOTE:** For an engine with the turning gear on the exhaust side (for twin engine on starboard side), use the clockwise rotation.

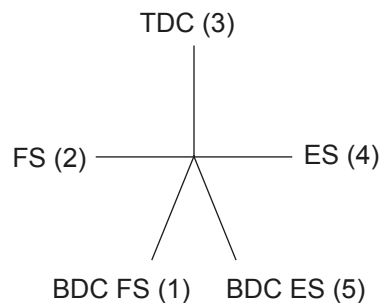
- 4.7** At each measurement position, operate the turning gear in the opposite direction a short time to release pressure between pinion and flywheel.
- 4.8** At each position, record the indication on the dial gauge. For the last position make sure that the connecting rod (003) does not touch the dial gauge.
- 4.9** If the difference between positions 1 and 5 is more than the value related to [Table 8-1 - Maximum permitted difference in mm](#), you must do the measurement again.

**NOTE:** For the definitions of the crank pin positions refer to [Figure 8-4](#).

Tab 8-1 Maximum permitted difference in mm

Engine type	Difference
X35, X35-B	0.03
X40, X40-B X40DF	0.03
X52 X52DF	0.04
X62, X62-B X62DF	0.04
X72, X72-B X72DF	0.05
X82, X82-B, X82-2.0 X82DF	0.06
X92, X92-B X92DF	0.06

Fig 8-4 Definitions of crank pin positions

**4.10** Do also the visual inspections that follow:

- Visually do a check of the crank and the bedplate for unwanted material.
- Visually do a check of the edge for unusual colors.

**5** Repeat step 4 for each crank.

**6** For each crank calculate the vertical deviation  $d_{\text{vert}}$  as follows:

**6.1** Calculate the average value  $d_1$  for position 1 and 5 with the formula

$$d_1 = [d_1 + d_5] / 2.$$

**6.2** Calculate the vertical deviation  $d_{\text{vert}}$  with the formula  $d_{\text{vert}} = d_3 - d_1$ .

**7** For each crank calculate the horizontal deviation  $d_{\text{hor}}$  with the formula  $d_{\text{hor}} = d_2 - d_4$ .

**8** Compare the calculated values with the limits in [Table 8-2 - Crank-web deflection limits in mm](#).

**Tab 8-2 Crank-web deflection limits in mm**

Engine type	Vertical				Horizontal
	Crank No. 1 (Driving End)	Crank No. 2 to the next to last crank	Last crank (Free End)		All cranks
			Note 1	Note 2	
X35, X35-B	0.27	0.19	0.19	0.19	0.09
	-0.27	-0.19	-0.19	-0.27	-0.09
X40, X40-B X40DF	0.32	0.23	0.23	0.23	0.11
	-0.32	-0.23	-0.23	-0.32	-0.11
X52 X52DF	0.45	0.32	0.32	0.32	0.15
	-0.45	-0.32	-0.32	-0.45	-0.15
X62, X62-B X62DF	0.56	0.40	0.40	0.40	0.18
	-0.56	-0.40	-0.40	-0.56	-0.18
X72, X72-B X72DF	0.82	0.58	0.58	0.58	0.27
	-0.82	-0.58	-0.58	-0.82	-0.27
X82, X82-B, X82-2.0 X82DF	0.90	0.64	0.64	0.64	0.29
	-0.90	-0.64	-0.64	-0.90	-0.29
X92, X92-B X92DF	1.08	0.76	0.76	0.76	0.35
	-1.08	-0.76	-0.76	-1.08	-0.35

Note 1 - Applicable for an engine with no more weight at the Free End (that is no torsional vibration damper, no front disc, and no PTO connection)

Note 2 - Applicable for an engine with more weight at the Free End (that is with torsional vibration damper, and/or with front disc, and/or with PTO connection)

- 9** If a minimum any measured value is more than the given limits, contact WinGD for the related procedures.

## CLOSE UP

- None

## 8.1.2 Crankshaft - install the work platform

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.25 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Platform			1
Adjustable platform			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### CAUTION

Do not operate the engine or the turning gear when the platforms are installed. This can cause injury to personnel and damage to equipment.

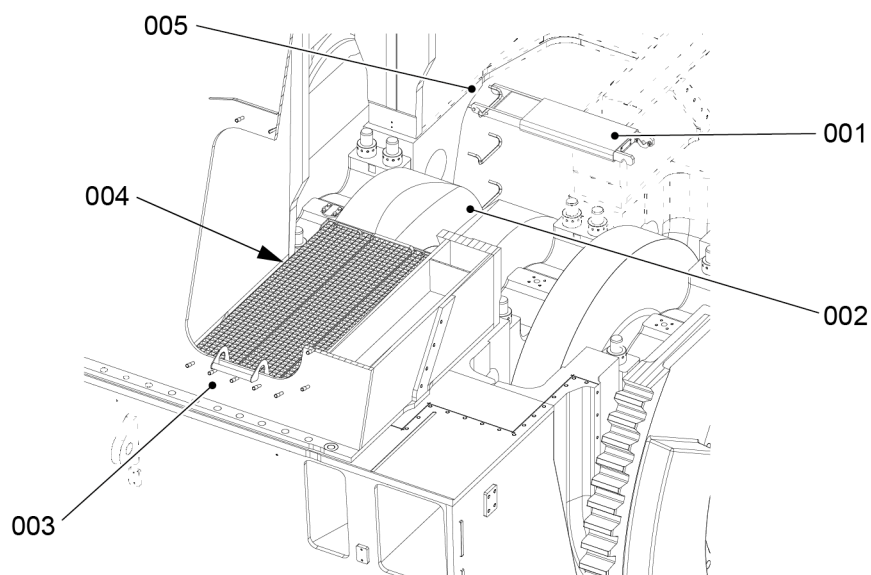
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Attach the platform (004, [Figure 8-5](#)) to the crankshaft (002) and to the longitudinal beam (003).
- 2 Attach the adjustable platform (001) to the applicable position between the columns (005).
- 3 Obey the maximum load of the platforms on the related nameplate.

**Fig 8-5** Platforms



00692

## CLOSE UP

- None

### 8.1.3 Crankshaft - remove the work platform

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.25 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Platform			1
Adjustable platform			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

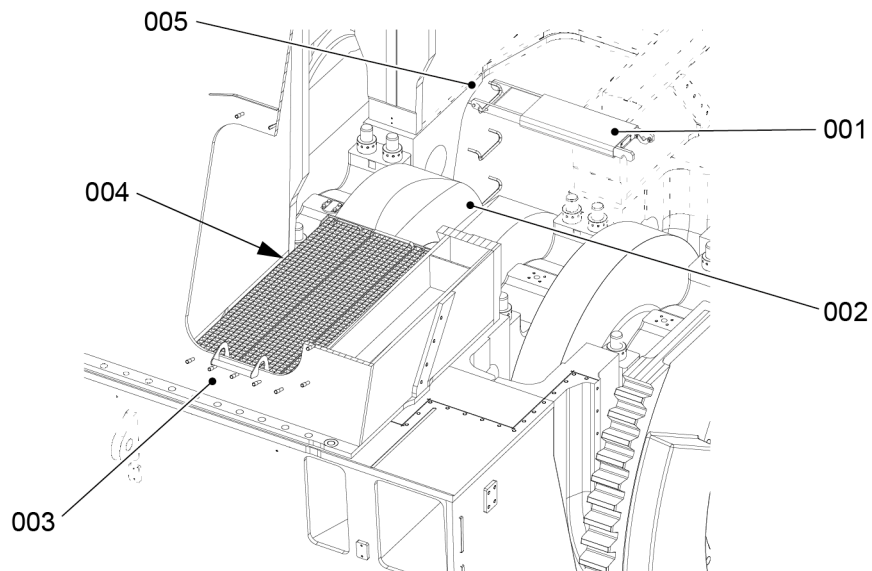
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Remove the adjustable platform (001) from the columns (005).
- 2 Remove the platform (004) from the crankshaft (002) and the longitudinal beam (003).

**Fig 8-6** Platforms



00692

## CLOSE UP

- None

## 8.2 Torsional vibration damper

### 8.2.1 Torsional vibration damper - examine

#### Periodicity

Description	
One Time - after first working hours	16 500
Working hours	refer to manufacturer
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	6.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Related to manufacturer	N/A		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

**PROCEDURE**

- 1 Examine the torsional vibration damper related to the manufacturer's instructions.

**CLOSE UP**

- None

## 8.3 Axial vibration damper

### 8.3.1 Axial vibration damper - disassemble

#### Periodicity

Description	
Working hours	42 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Eye bolts			2
Chain			1
Shackles			2
Sling			2
Link			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

Use only approved lifting equipment to lift and move the top housing. Injury to personnel can occur.

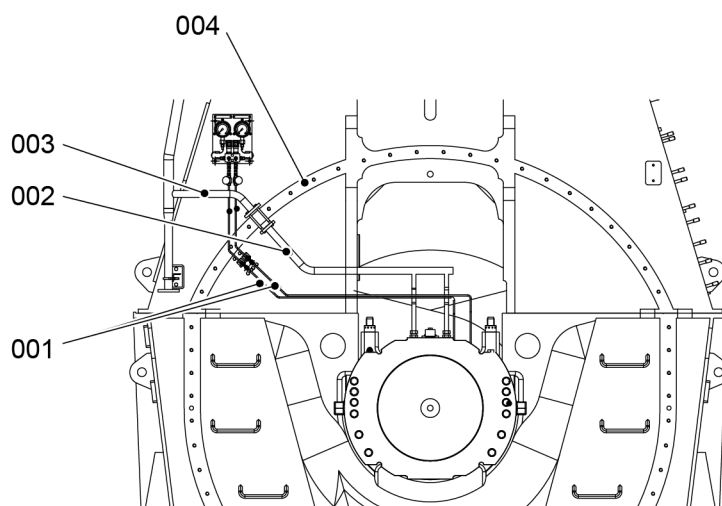
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

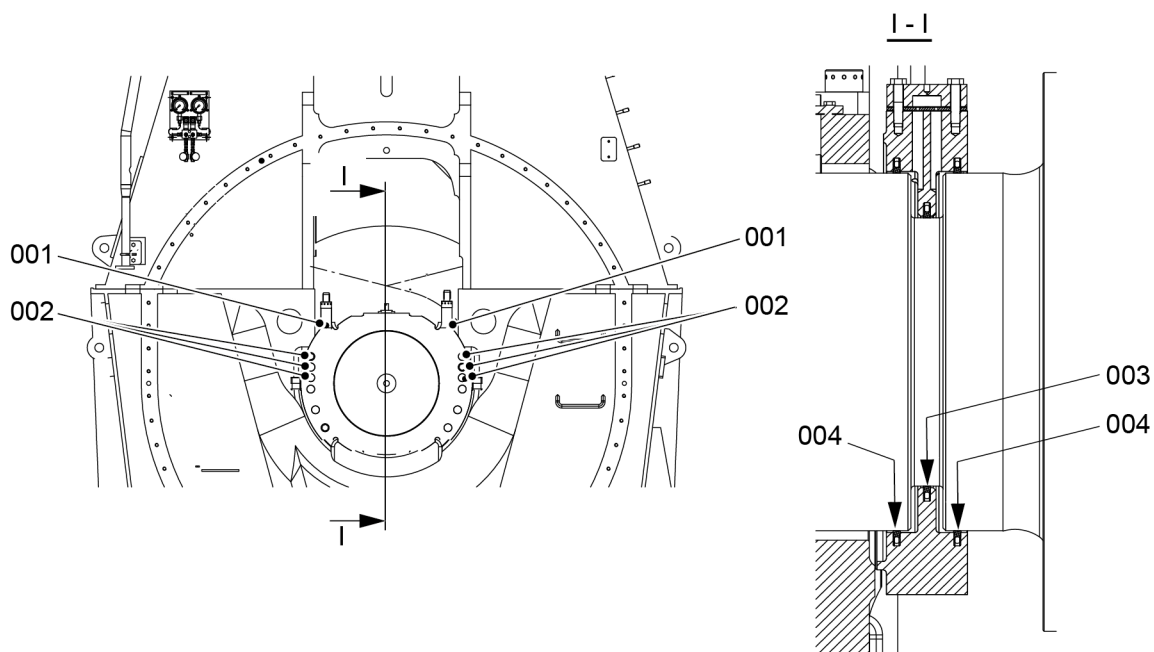
- 1 Prepare the axial vibration damper for removal.
  - 1.1 Read the data in [3.1 Lifting tools](#).
  - 1.2 Remove the oil pipes (002 and 003, [Figure 8-7](#)).
  - 1.3 Remove the two pipes (001).
  - 1.4 Remove the housing (004).

**Fig 8-7** Axial vibration damper - housing and pipes



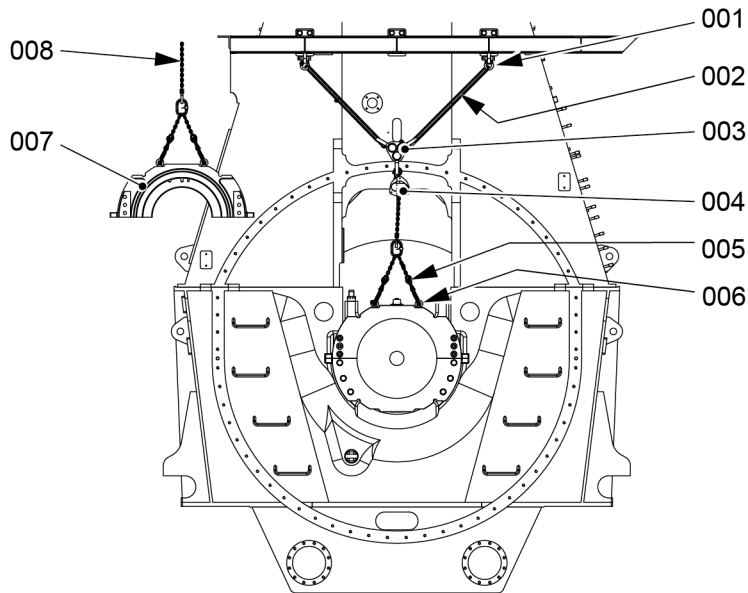
00281

- 2 Remove the four bolts (001, [Figure 8-8](#)) and the six bolts (002) from the top cylinder half.
- 3 Examine the 2-part gaskets (003, 004) for damage and contamination. If necessary, remove and discard the 2-part gaskets.

**Fig 8-8 Axial vibration damper**

00282

- 4 Attach the two eye bolts (006, [Figure 8-9](#)) to the top cylinder half.
- 5 Attach the chain (005) to the eye bolts (006).
- 6 Attach the two shackles (001) to the platform.
- 7 Attach the two slings (002) to the shackles (001) and the link (003).
- 8 Attach the spur-gear chain block (004) to the chain (005) and the link (003).
- 9 Operate the chain block (004) to carefully lift the top cylinder half (007).
- 10 Attach the engine room crane (008) to the chain (005).
- 11 Operate the engine room crane (008) to hold the weight of the top cylinder half (007).
- 12 Remove the chain block (004) from the chain (005).
- 13 Operate the engine room crane (008) to lower the top cylinder half (007) on to an applicable surface.

**Fig 8-9 Axial vibration damper - move**

00283

**CLOSE UP**

- None

## 8.3.2 Axial vibration damper - assemble

### Periodicity

Description	
Working hours	42 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Eye bolt			2
Chain			1
Shackle			2
Sling			2
Link			1

### Supplies

Description	QTY
Oil	A/R
Molykote paste G	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Two-part gasket			2
Two-part gasket			1

### SAFETY PRECAUTIONS

- None

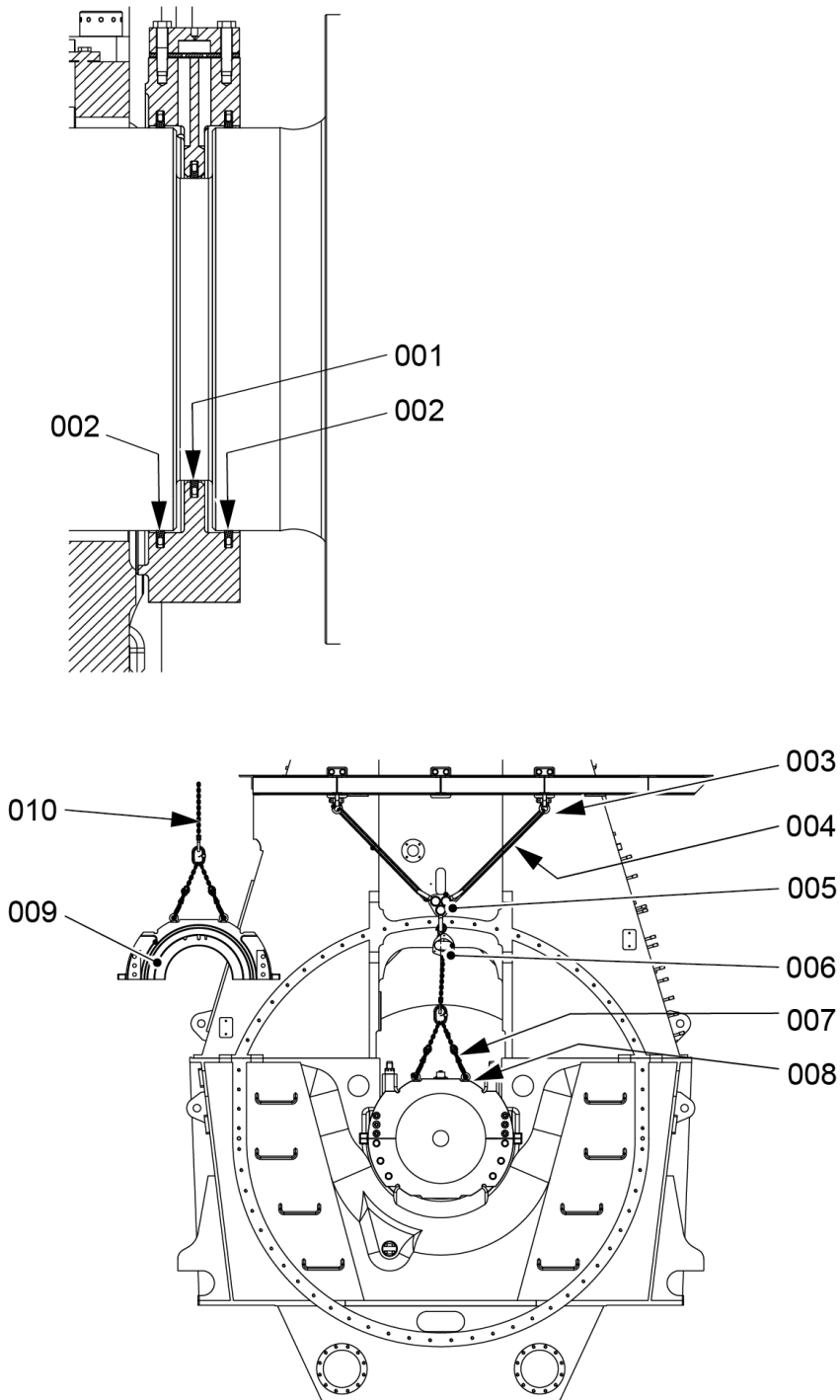
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Apply clean oil to the 2-part gaskets (002, [Figure 8-10](#)) and the 2-part gasket (001).
- 2 Install the 2-part gaskets (002, 001). Make sure that the 2-part gaskets can move freely.
- 3 Attach the two shackles (003) to the platform.
- 4 Attach the two slings (004) to the shackles (003).
- 5 Attach the link (005) to the two slings (004).
- 6 Attach the spur-gear chain-block (006) to the link (005).
- 7 Attach the two eye bolts (008) to the top cylinder half.
- 8 Attach the chain (007) to the eye bolts (008).
- 9 Attach the engine room crane (010) to the chain (007).
- 10 Operate the engine room crane (010) to lift and move the top cylinder half (009) into position above the bottom cylinder half.
- 11 Attach the chain block (006) to the chain (007).
- 12 Operate the chain block (006) to hold the weight of the top cylinder half (009).
- 13 Remove the engine room crane (010) from the chain (007).
- 14 Operate carefully the chain block (006) to lower the top cylinder half (009) on the bottom cylinder half.  
**NOTE:** When you do this step, make sure that you do not cause damage to the 2-part gaskets (001, 002).

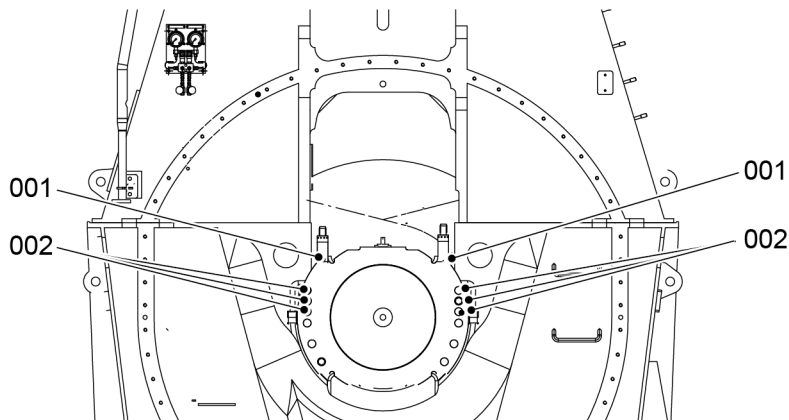
**Fig 8-10** Axial vibration damper - install

00286

- 15 Apply Molykote paste G-n to the threads of the bolts (002, [Figure 8-11](#)).
- 16 Put the bolts (002) in position in the top cylinder half.
- 17 Torque symmetrically the bolts (002) to the correct value, refer to section [16.1 Tightening instructions](#).
- 18 Put the bolts (001) in position in the top cylinder half.

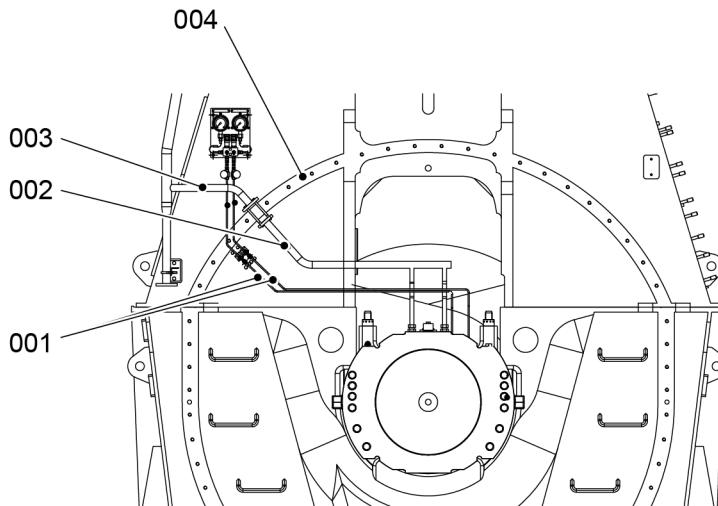
- 19 Torque the bolts (001).

**Fig 8-11 Axial vibration damper - bolts**



00287

- 20 Install the pipes (002, [Figure 8-12](#)).
- 21 Install the oil supply pipe (003).
- 22 Install the two pipes (001).
- 23 Install the housing (004).

**Fig 8-12 Axial vibration damper - housing and pipes**

00281

**CLOSE UP**

- None

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## 8.4 Turning gear

### 8.4.1 Turning gear - do a check of the screwed connections

#### Periodicity

Description	
One Time - after first working hours	8 000
Working hours	12 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

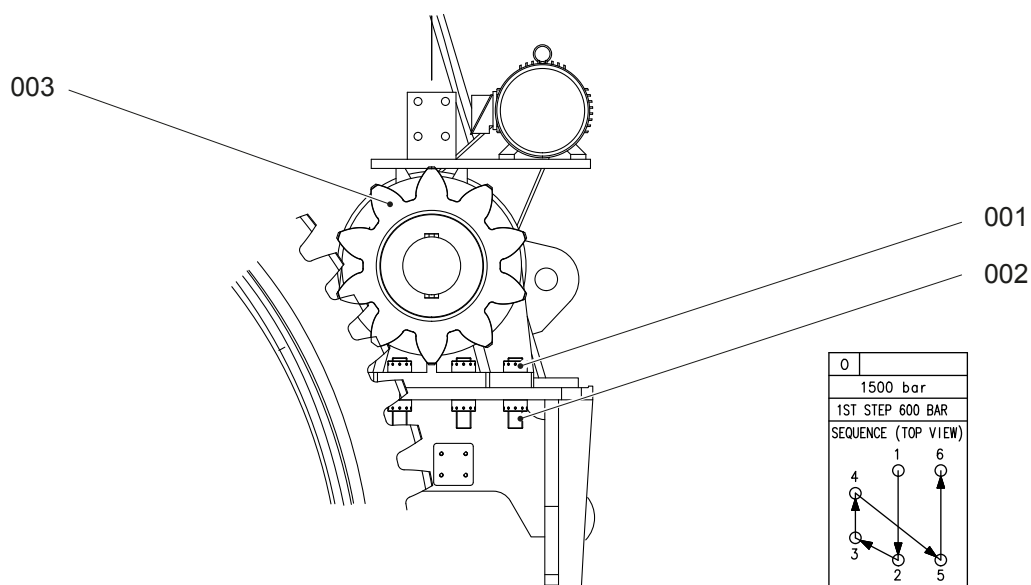
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the round nuts (001, [Figure 8-13](#)) and the bolts (002) of the turning gear (003), refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 2 Clean the threads of the bolts (002).
- 3 Apply oil to the threads of the bolts (002).
- 4 Tighten the round nuts (001) related to the data given in [Figure 8-13](#), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).

**Fig 8-13** Turning gear - do a check



## CLOSE UP

- None

## 8.4.2 Turning gear - lubricate the teeth

### Periodicity

Description	
Working hours	2000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Pyroshield	A/R
Klüberfluid	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

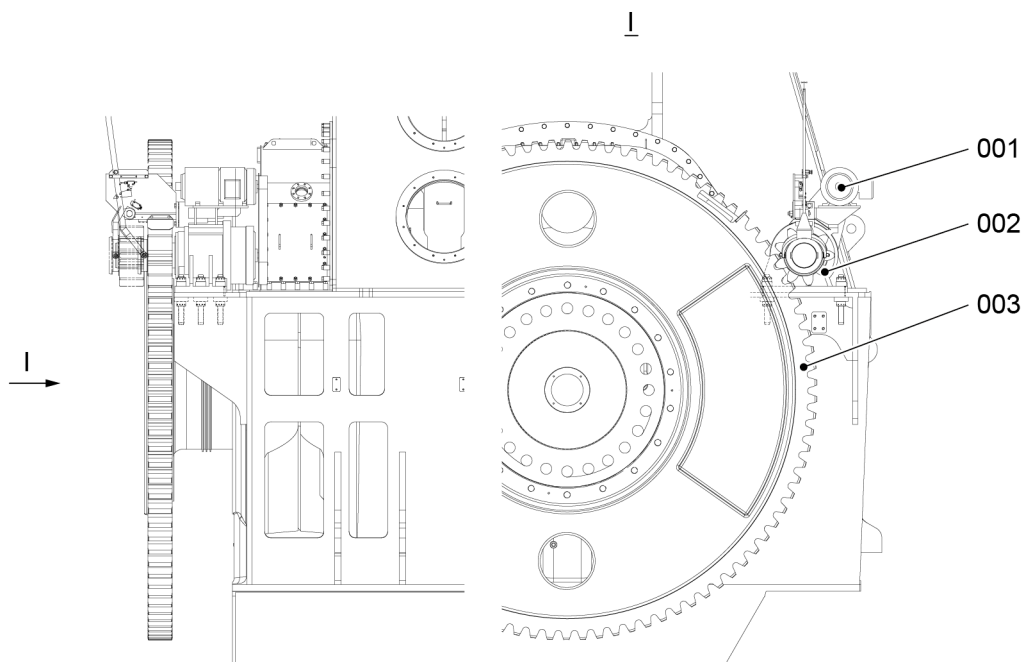
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

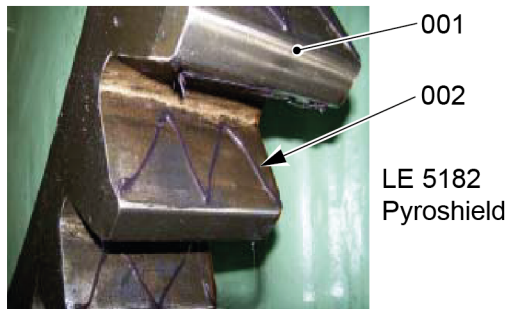
- 1 For the maintenance of the turning gear (001, [Figure 8-14](#)), refer to the manufacturer's instructions.
- 2 Examine the items that follow:
  - Condition of the tooth flanks of the gear wheels
  - Lubrication of the pinion (002)
  - Lubrication of the flywheel (003).

**Fig 8-14** Turning gear and gear wheels

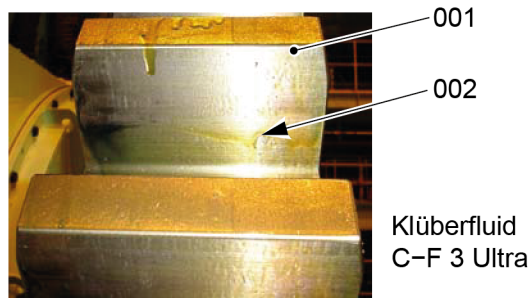


00690

- 3 If the tooth flanks have a minimum of lubricant remaining or are dry, continue the procedure.
- 4 If you use Klüberfluid as lubricant, prepare the lubricant as follows:
  - 4.1 Put an applicable quantity of Klüberfluid into a container.
  - 4.2 Put the container into warm water until the Klüberfluid is at approximately 35°C.
- 5 Apply a thin layer of lubricant to the teeth (001) of the flywheel and of the pinion as shown in [Figure 8-15](#) or in [Figure 8-16](#).

**Fig 8-15 Pyroshield**

00288

**Fig 8-16 Klüberfluid**

00289

- 6 If necessary, examine the teeth more frequently than the interval given above.

**NOTE:** For the recommended suppliers, refer to [Table 8-3 - Recommended suppliers](#)

**Tab 8-3 Recommended suppliers**

Lubrication Engineers Inc. 300 Bailey Avenue Forth Worth Texas 76107 USA <a href="http://www.l Lubricants.com/">http://www.l Lubricants.com/</a> E-mail: <a href="mailto:info@le-inc.com">info@le-inc.com</a>	Klüber Lubrication München KG Geisenhausenerstrasse 7 81379 München Germany <a href="http://www.klueber.com">http://www.klueber.com</a> E-mail: <a href="mailto:info@klueber.com">info@klueber.com</a>
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**CLOSE UP**

- None

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## 8.5 Connecting rod

### 8.5.1 Connecting rod - prepare before removal

#### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	2

#### Support equipment

Description	Part No.	CSN	QTY
Shackles			4
Lever chain hoists			2
Connecting rod tool			1
Stop plate			1
Eye bolt			1

#### Supplies

Description	QTY
Molyslip copaslip	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

Before you operate the turning gear, make sure that no personnel are near the flywheel.

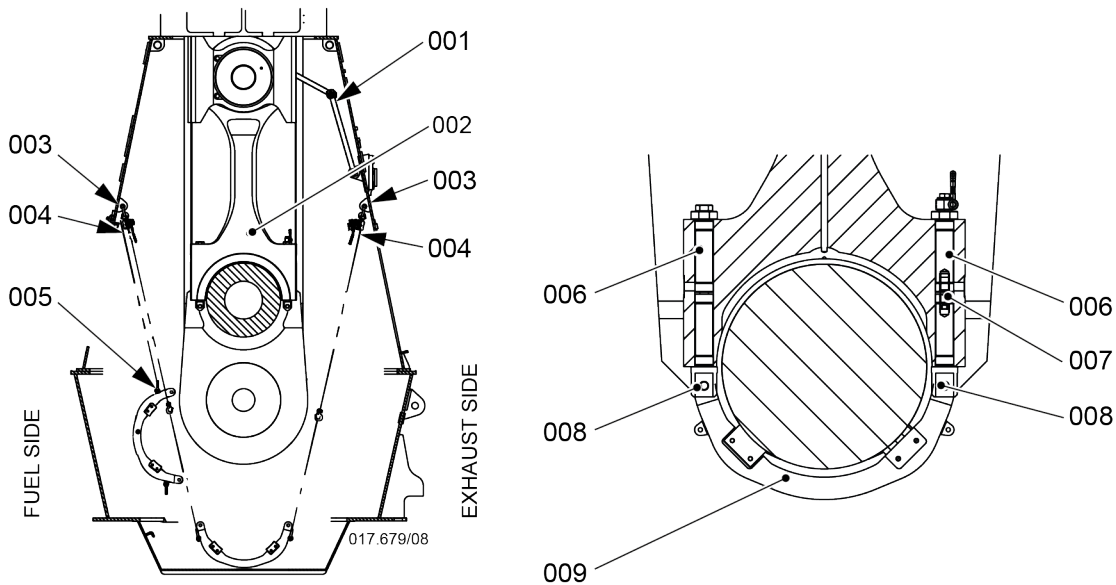
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Attach two shackles (003, [Figure 8-17](#)) to the column.
- 2 Attach the two lever chain hoists (004) to the shackles (003).
- 3 Attach the two lever chain hoists (004) to the shackles (005) on the tool connecting rod (009).
- 4 Apply Molyslip copaslip to the thread of the bolts (007).
- 5 Put the rods (006) into the connecting rod (002).
- 6 Operate the manual ratchets (004) to lift the tool (009) into position on the rods (006).
- 7 Tighten the nuts and bolts (008).
- 8 Torque the rods (006) to the correct value, refer to section [16.1 Tightening instructions](#).

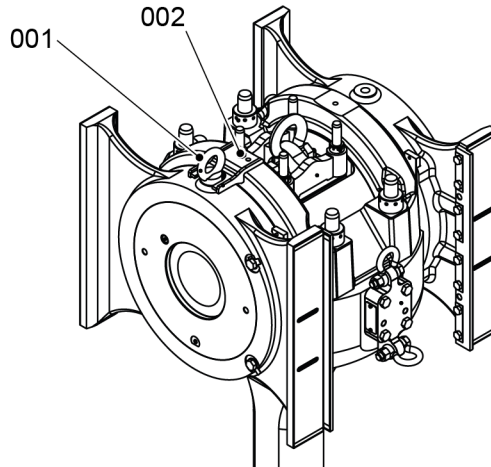
**Fig 8-17 Connecting rod**



Note: Some parts can look different.

00367

- 9 Operate the turning gear and lever chain hoists to lower the crosshead to BDC.
- 10 Attach the stop plate (002, [Figure 8-18](#)) to the bearing cover.
- 11 Attach the eye bolt (001) to the guide shoe.

**Fig 8-18 Stop plate**

00373

- 12 Lift the crosshead.
- 13 Remove the lever chain hoists (004, [Figure 8-17](#)) from the tool (009).
- 14 Remove the toggle lever (001) from the crosshead.
- 15 Put protection on the toggle lever (001) and the crosshead to prevent contamination and damage.

**CLOSE UP**

- None

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## 8.5.2 Connecting rod - remove

### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	10.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Deviation pipe			1
Shackle			1
Spur-gearred chain block			4
Shackles			4
Chain (symmetrical)			1
Tool, connecting rod assembly			1
Chain (asymmetrical)			1

### Supplies

Description	QTY
Copper paste	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard.** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

#### WARNING

**Injury Hazard.** To prevent injury, be careful when you move the connecting rod.



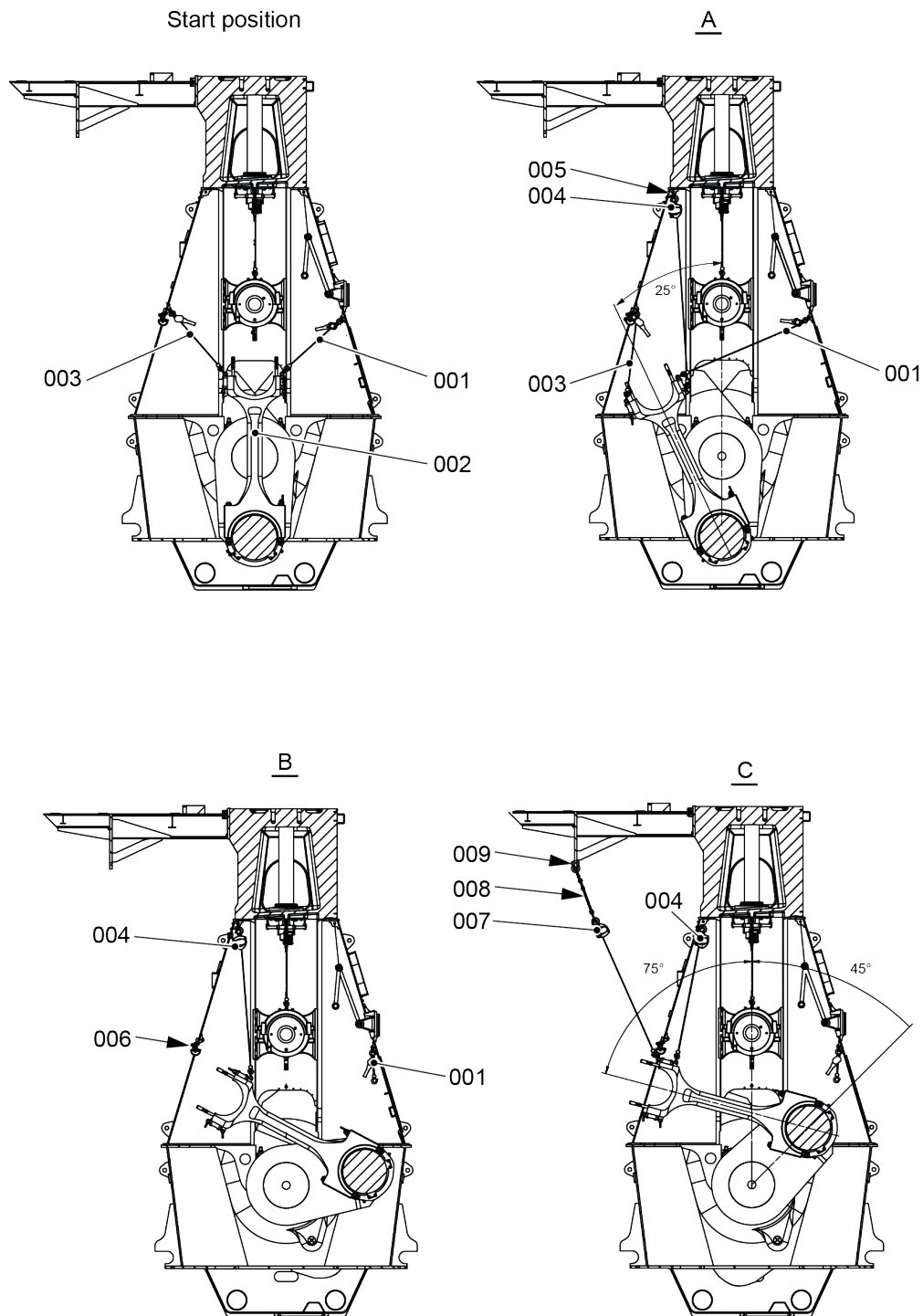
## PRELIMINARY OPERATIONS

- The connecting rod must be prepared for removal, refer to section [8.5.1 Connecting rod - prepare before removal](#)

## PROCEDURE

- 1 Attach an applicable rope to hold the toggle lever up to prevent damage.
- 2 Attach the deviation pipe (006, [Figure 8-19](#)) to the column.
- 3 Operate the lever chain hoists (001, 003) to move the connecting rod (002) to the position shown in view A.
- 4 Attach the shackle (005) to the cylinder block.
- 5 Attach the spur-gear schain block (004) to the shackle (005) and the lifting tool on the connecting rod (002).
- 6 Operate the chain block (004) to hold the weight of the connecting rod (002).
- 7 Remove the lever chain hoists (001, 003).
- 8 Operate the turning gear and the chain block (004) to move the connecting rod (002) counterclockwise to the position shown in view B.
- 9 Continue to operate the turning gear and the chain block (004) until the connecting rod (002) goes through the column door (view C).
- 10 Attach the shackles (009) to the top platform.
- 11 Attach the applicable chain (008) to the two shackles (009).
- 12 Attach the chain block (007) to the chain (008) and the top end of the lifting tool.
- 13 Operate the chain block (007) to hold the weight of the connecting rod (002).
- 14 Remove the chain block (004).

Fig 8-19 Connecting rod - move



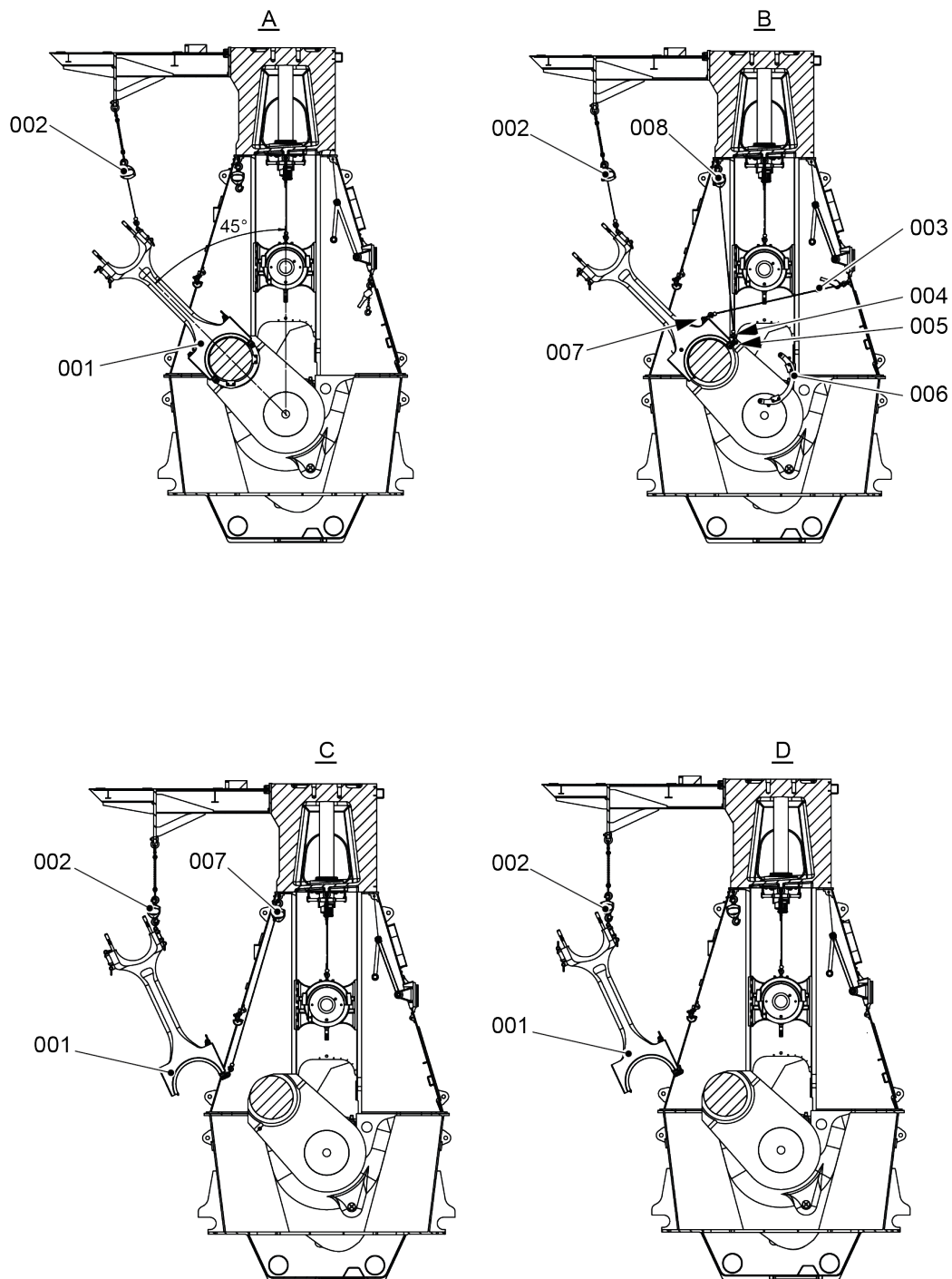
00368

- 15 **NOTE:** During this step, operate the chain block (002, [Figure 8-20](#)) to get the connecting rod to 45°.

Operate the turning gear to move the crank counterclockwise to the position shown in view A.

- 16** Attach the lever chain hoist (003) to the lug (007) and tighten lightly the chain.
- 17** Attach the tool connecting rod (004) to the tool (005).
- 18** Attach the chain block (007) to the lifting tool (004) and tighten lightly the chain (view B).
- 19** Remove the connecting rod tool (006).
- 20** Remove the lever chain hoist (003).
- 21** Operate the chain blocks (002, 007) to move the connecting rod (001) away from the crank and through the column door.
- 22** Remove the chain block (007).

Fig 8-20 Connecting rod - remove



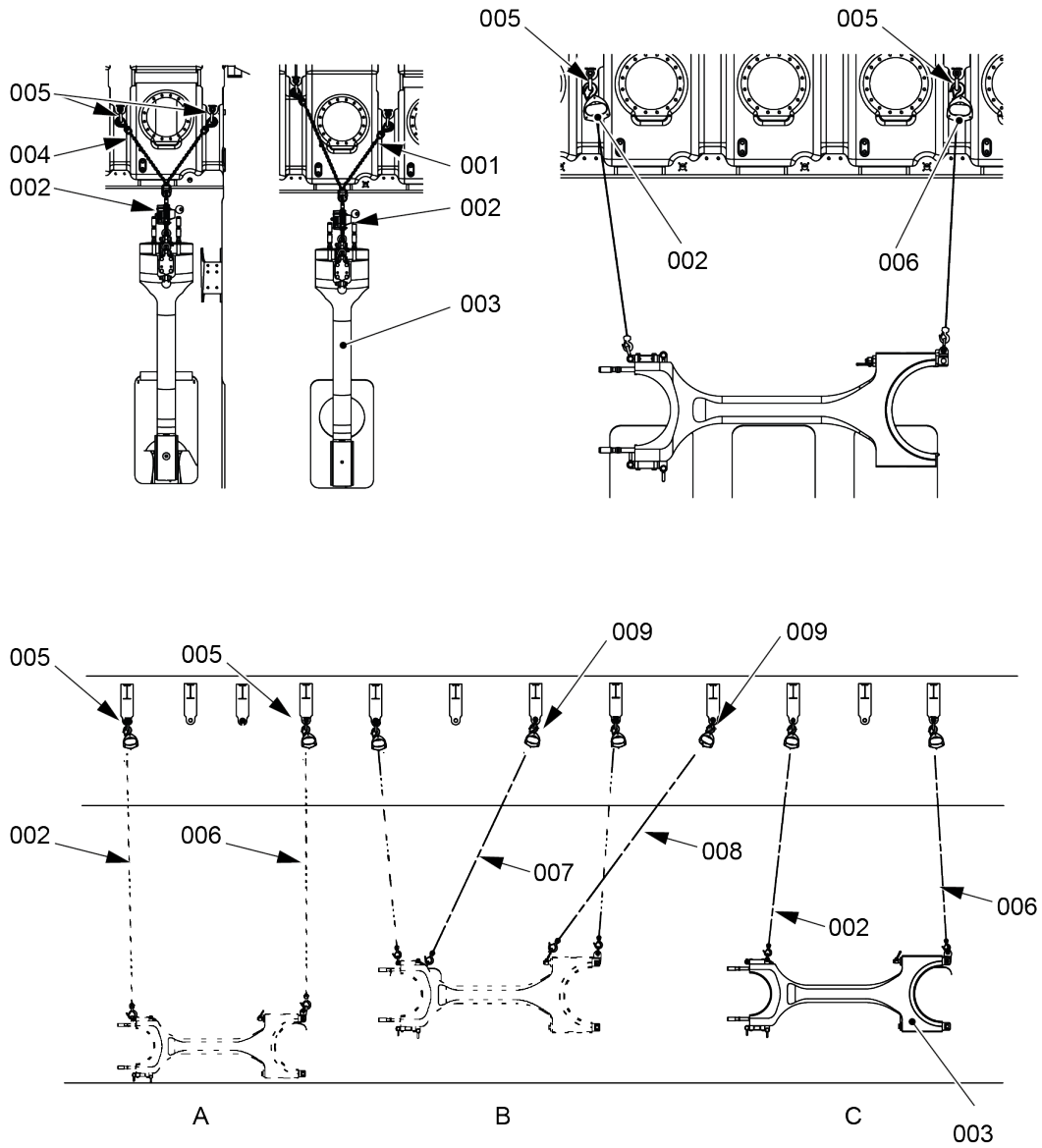
00369

**23** If it necessary to move the connecting rod away from the area, do [Step 23.1](#) to [Step 23.14](#):

**23.1** Read the applicable safety precautions.

- 23.2** Put on the applicable personal protective equipment.
- 23.3** Operate the chain block (002) to lower the connecting rod (001) to the floor.
- 23.4** Remove the chain.
- 23.5** Attach the two chain blocks (002 and 006, [Figure 8-21](#)) to the connecting rod (003) and the shackles (005).
- 23.6** Lift the connecting rod (003) a small distance.
- 23.7** Attach two more shackles (009) to the top platform.
- 23.8** Attach two more chain blocks (007, 008) to the connecting rod (003) and shackles (009) as shown in step B.
- 23.9** Operate carefully the chain blocks (002, 006, 007, 008) to move the connecting rod.
- 23.10** Attach and remove the chain blocks (002, 006, 007, 008) and shackles (005, 009) as given in [Step 23.9](#) to continue to move the connecting rod a sufficient distance (step C).
- 23.11** Lower the connecting rod (003) to the floor.
- 23.12** Attach the engine room crane to the connecting rod (003).
- 23.13** Remove the chain blocks (002, 006, 007, 008) and shackles (005, 009).
- 23.14** Operate the engine room crane to lift and move the connecting rod to an applicable area, for example into storage.

Fig 8-21 Connecting rod - move 2



00370

**CLOSE UP**

- None



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### 8.5.3 Connecting rod - install

#### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	10.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Deviation pipe			1
Shackle			1
Spur-gearred chain block			4
Shackles			4
Chain (symmetrical)			1
Tool, connecting rod assembly			1
Chain (asymmetrical)			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
Connecting rod			1

#### SAFETY PRECAUTIONS

##### WARNING

Injury Hazard. Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

##### WARNING

Injury Hazard. To prevent injury, be careful when you move the connecting rod.

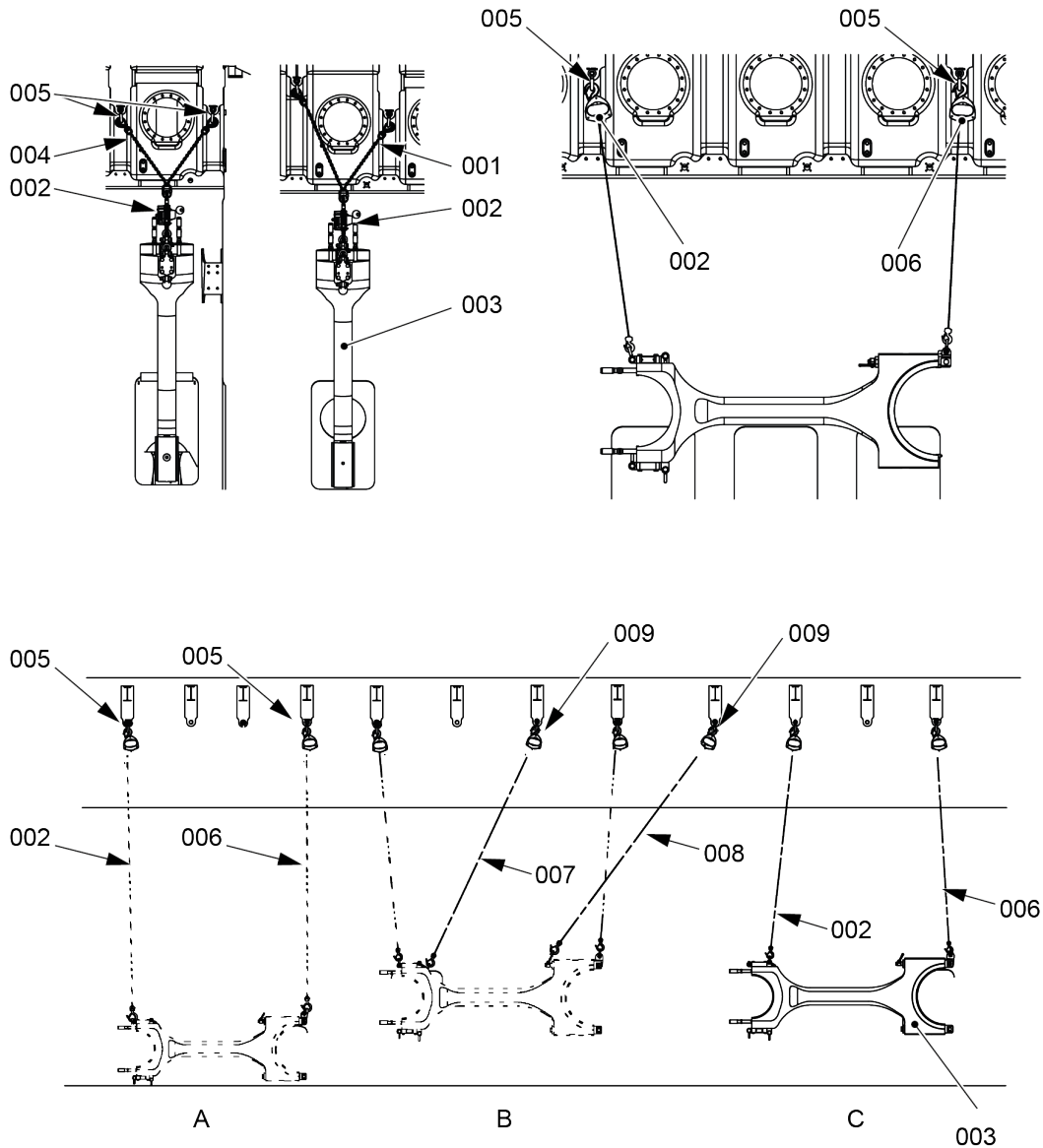
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 If it necessary to move the connecting rod away from the area, do [Step 1.5](#) to [Step 1.15](#):
  - 1.1 Read the applicable safety precautions.
  - 1.2 Put on the applicable personal protective equipment.
  - 1.3 Attach two shackles (005, [Figure 8-22](#)) to the positions shown.
  - 1.4 Attach the spur-gear chain block (002, 006) to the connecting rod (003) and the engine room crane.
  - 1.5 Operate the engine room crane to lift and move the connecting rod to the applicable area.
  - 1.6 Lower the connecting rod (003) on to the floor.
  - 1.7 Remove the engine room crane from the chain blocks (002, 006)
  - 1.8 Attach the two chain blocks (002 and 006) to the top platform and the shackles (005).
  - 1.9 Lift the connecting rod (003) a small distance.
  - 1.10 Attach two more shackles (009) to the top platform.
  - 1.11 Attach two more chain blocks (007, 008) to the connecting rod (003) and shackles (009) as shown in step B.
  - 1.12 Attach and remove the chain blocks (002, 006, 007, 008) and shackles (005, 009) as given in [Step 1.11](#) to continue to move the connecting rod to the applicable position for installation (step C).
  - 1.13 Lower the connecting rod (003) on to the floor.
  - 1.14 Remove the chain blocks and the shackles.
  - 1.15 Continue the installation procedure from [Step 2](#).

Fig 8-22 Connecting rod - move 2

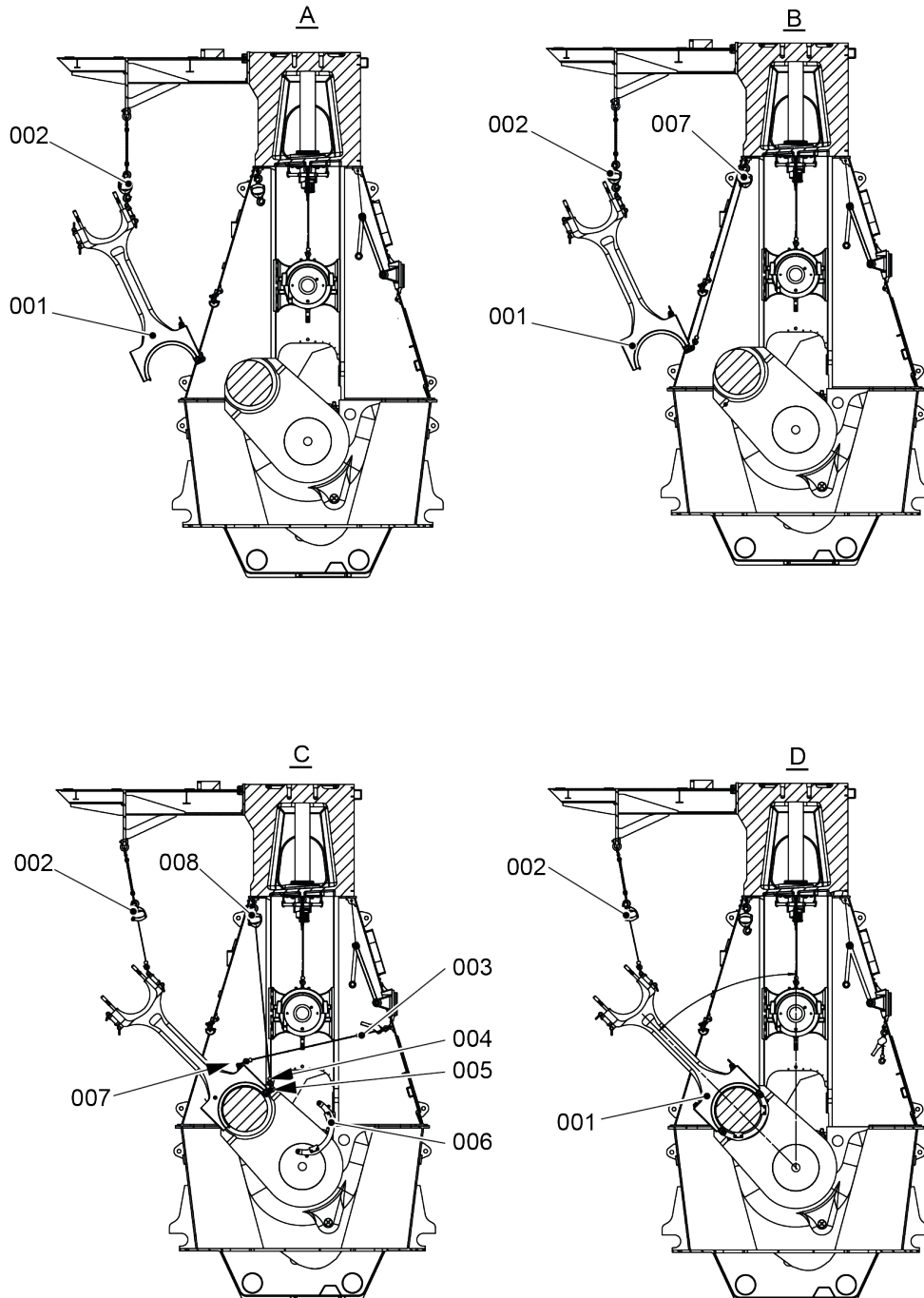


00370

- 2 Attach the shackles (005) to the platform at the applicable installation position.
- 3 Clean the bearing shell and the crank pin.
- 4 Put oil on the bearing shell and the crank pin.

- 5** Attach the applicable chain (001 or 004) to the shackles (005).
- 6** Attach the chain block (002) to the chain (001 or 004).
- 7** Operate the chain block (002, [Figure 8-23](#)) to lift the connecting rod (001) to sufficient height.
- 8** Attach the chain block (007) to the connecting rod (001).
- 9** Operate the chain blocks (002, 007) to move the connecting rod (001) into the position shown in view C.
- 10** Attach the lever chain hoist (004) to the lug (005).
- 11** Attach the chain block (008) to the plate (006).
- 12** Operate the chain block (880) to lift the plate (006) up to the crosshead.
- 13** Attach the plate (006) to the rod with the two bolts and nuts.
- 14** Remove the chain block (008) from the plate (006).
- 15** Remove the lever chain hoist (003).

Fig 8-23 Connecting rod - install 1

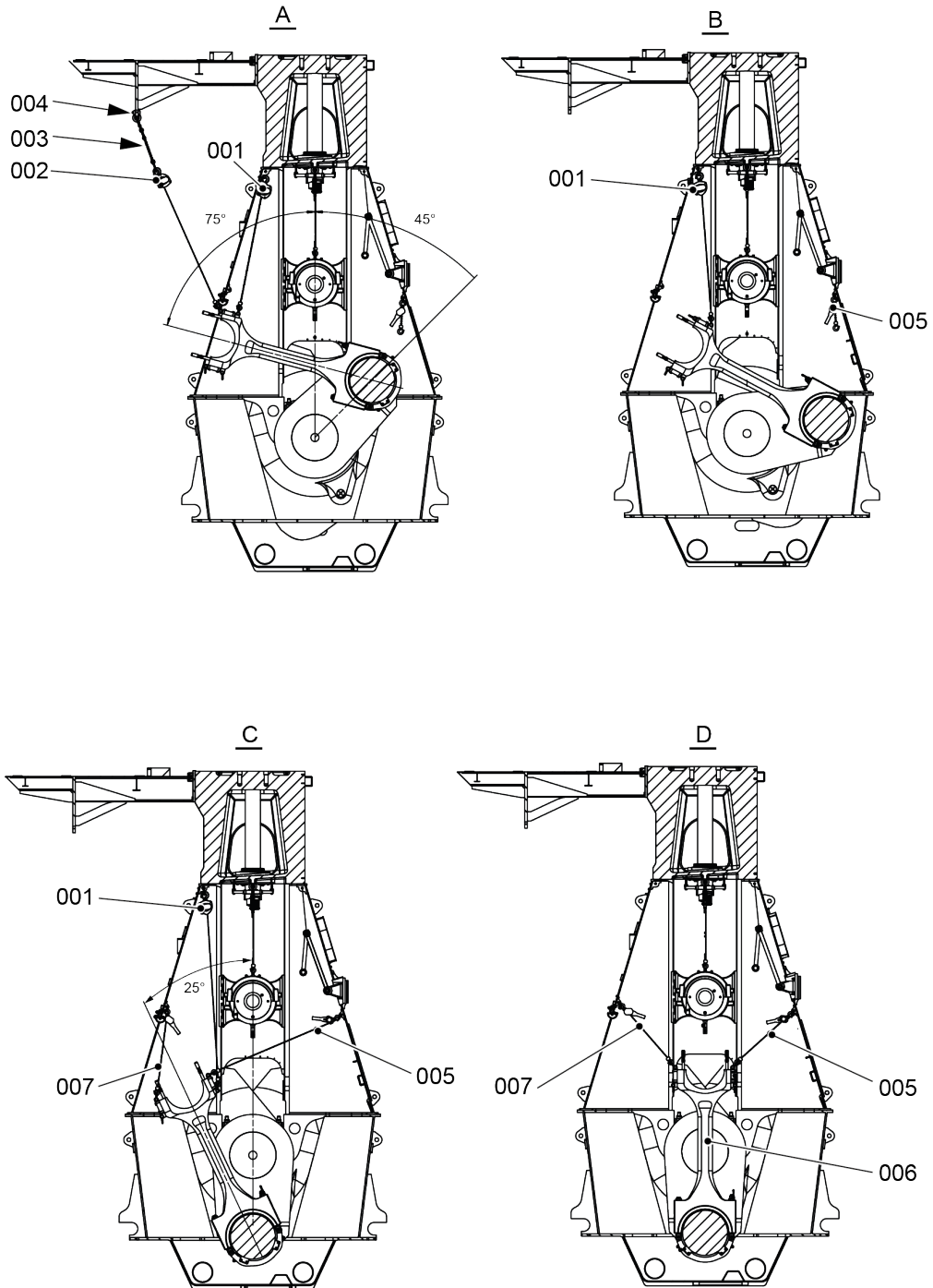


00371

- 16 Operate the turning gear and the chain block (002, [Figure 8-24](#)) to move the connecting rod clockwise to the position shown in view A.
- 17 Attach the chain block (001) to the bottom shackle on the lifting tool.

- 18** Remove the chain block (002), the chain (003) and the shackle (004).
- 19** Operate the turning gear and the chain block (001) to move the connecting rod clockwise to the position shown in view B.
- 20** Attach the lever chain hoists (005, 007) to the lifting tool on the connecting rod (006) as shown in view C.
- 21** Remove the chain block (001).
- 22** Operate the turning gear and the lever chain hoists (005, 007) to move the connecting rod clockwise into the position shown in view D.

Fig 8-24 Connecting rod - install 2

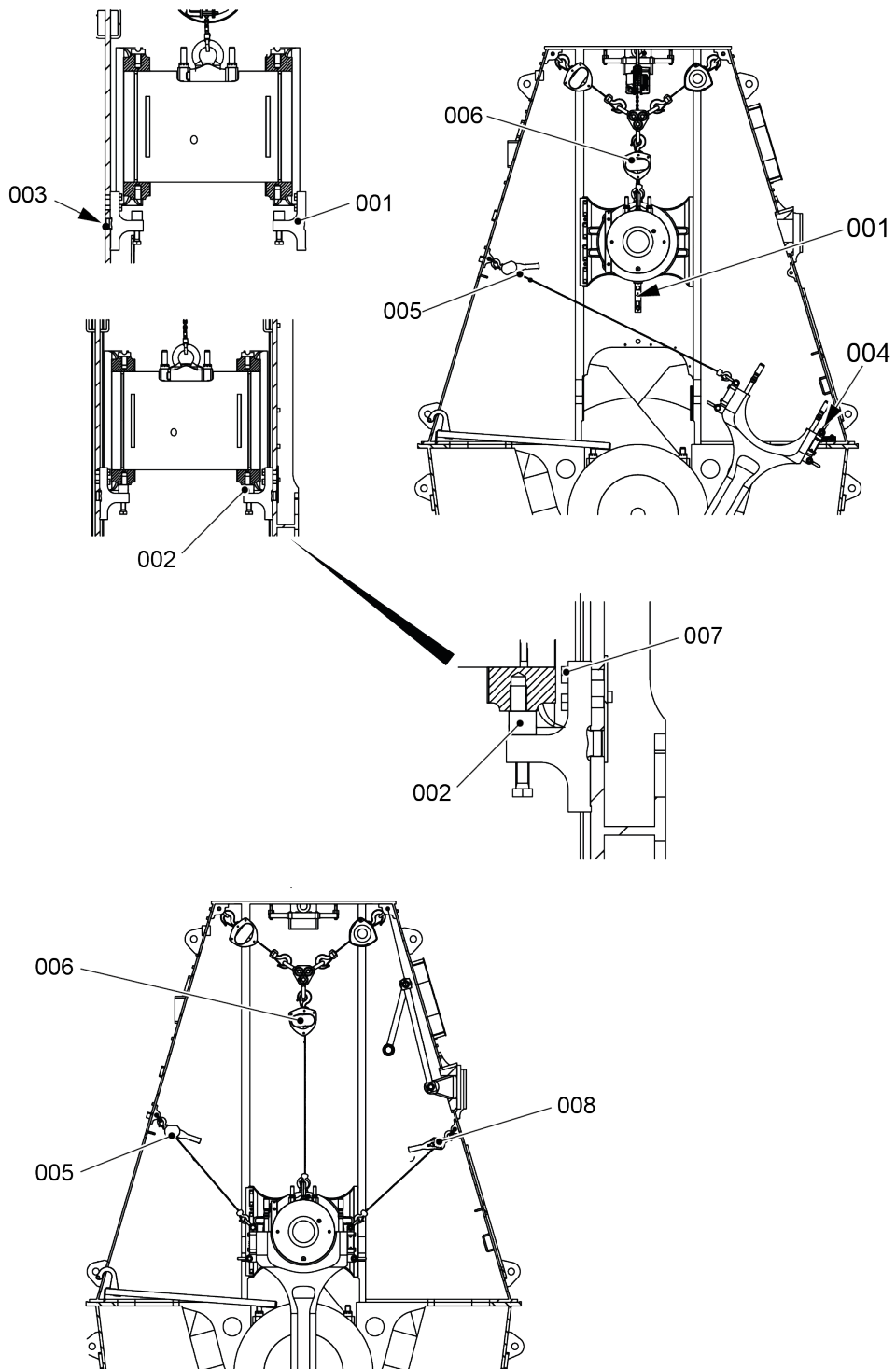


00372

- 23 Operate the chain block (006, [Figure 8-25](#)) to lift the crosshead a small distance.
- 24 Remove the two supports (001).



- 25**    **NOTE:** During this step, make sure that the elastic bolts in the connecting rod align with the holes in the crosshead.
- Operate the chain block (006) to lower carefully the crosshead on to the connecting rod.
- 26**    Remove the chain block (006).

**Fig 8-25 Crosshead - install**

00364

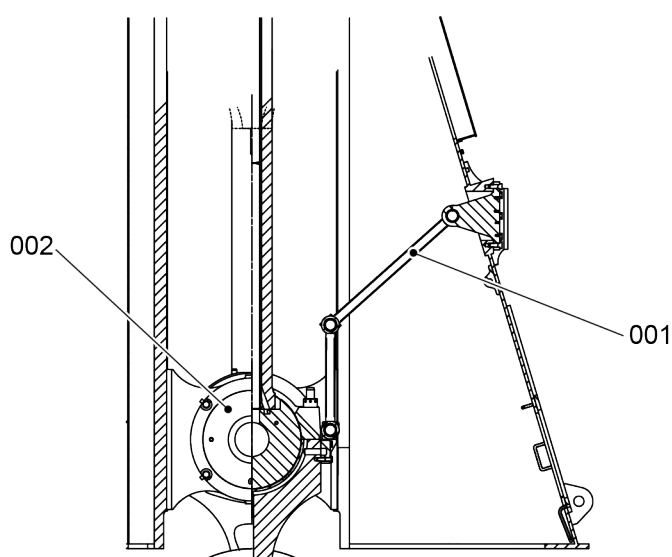
- 27** Remove all lever chain hoists, chain blocks, eye bolts, shackles and other equipment.
- 28** Remove the protection from the crosshead pin.

**CAUTION**

**Damage Hazard.** Damage will occur to an incorrectly connected toggle lever. Make sure that you connect the toggle lever correctly.

- 29 Connect the toggle lever (001, [Figure 8-22](#)) to the crosshead (002). Make sure that the toggle lever is in the position shown.

**Fig 8-26** Toggle lever - attach

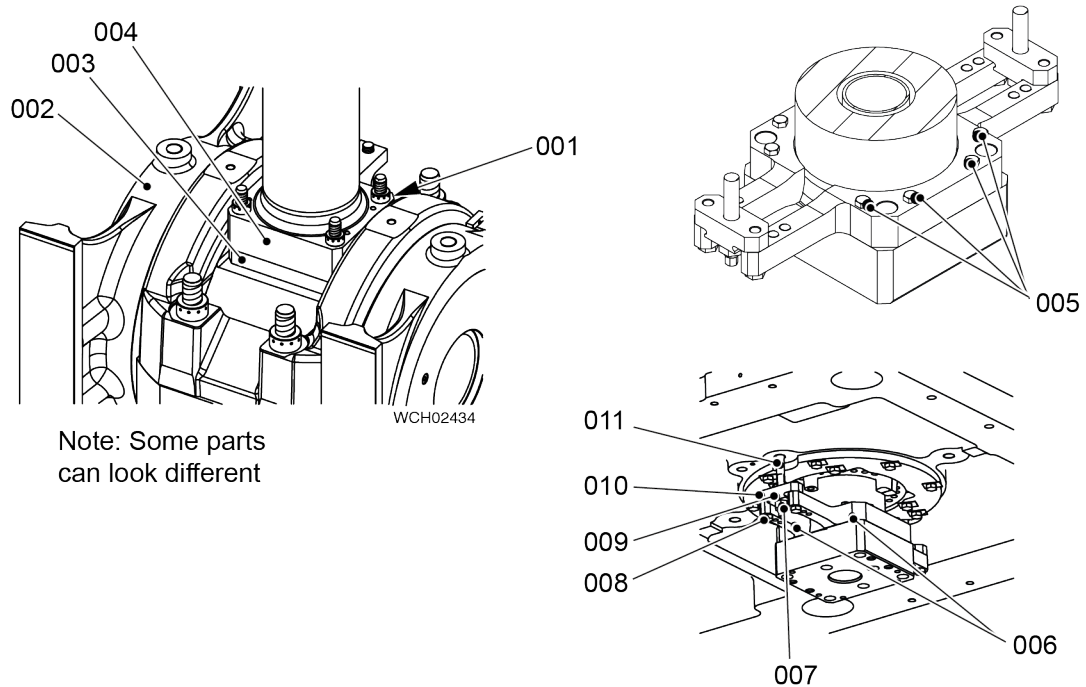


Note: The crank is at BDC

00365

- 30 Remove the platform, refer to section [8.1.3 Crankshaft - remove the work platform](#).
- 31 Do the a check of the clearances, refer to section [8.6.2 Crosshead - do a check of the clearances](#).
- 32 Make sure that the piston rod foot (004, [Figure 8-27](#)) is clean and has no damage.

Fig 8-27 Piston - attach



- 33** Make sure that the compression shim (003) is clean and has no damage.  
**34** Unlock the turning gear.

### WARNING

**Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.**

- 35** Operate the turning gear to move the crank to TDC. Make sure that the crosshead touches the piston rod foot.  
**36** Loosen the two nuts (007).  
**37** Remove the two bolts (011) from the cylinder jacket.  
**38** Remove the four bolts (008), then remove the holders (010) from the plates (006).  
**39** Remove the eight bolts (005), then remove the plates (006).  
**40** Tighten the round nuts (001) to the correct value, refer to section [16.1 Tightening instructions](#).

### CLOSE UP

- None

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## 8.5.4 Connecting rod - remove the top end bearing

### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Lever chain hoist			2
Chain			1
Brackets			2
Deviation pipe			1
Sling			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

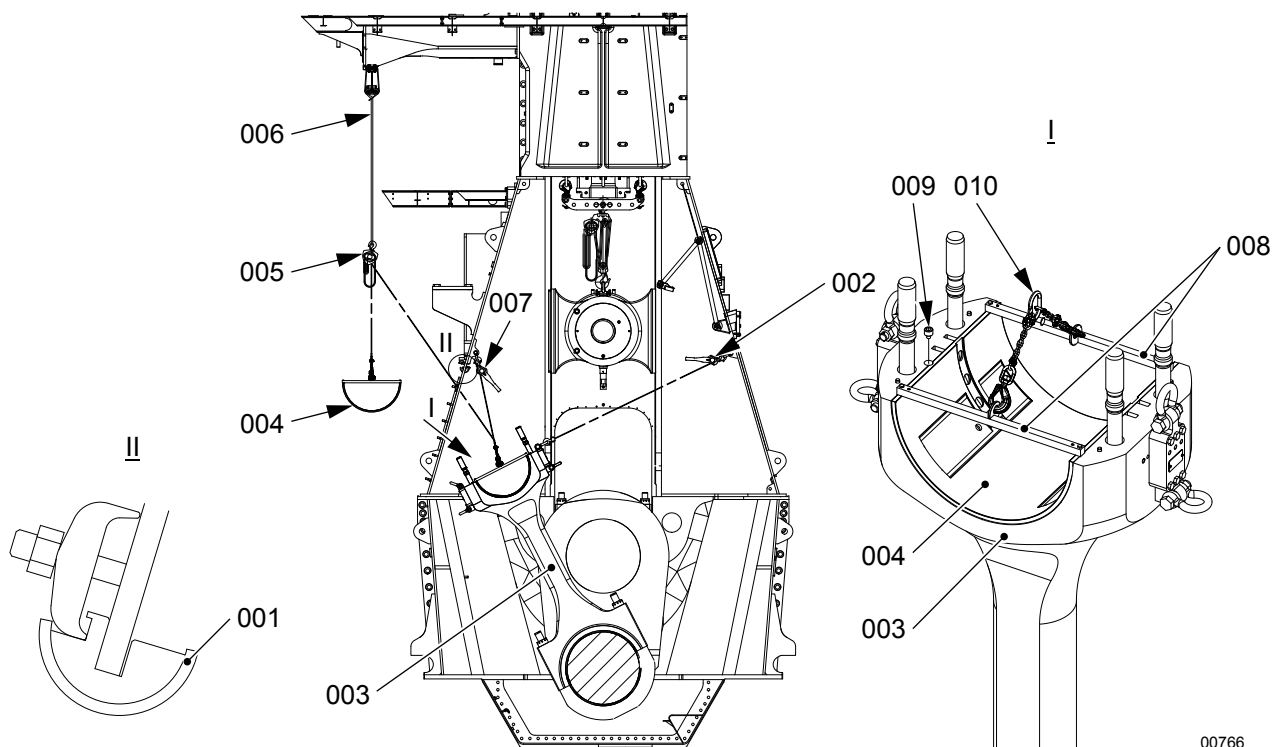
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Make sure that the platform is installed.
- 2 Operate carefully the lever chain hoists (002 and 007, [Figure 8-28](#)) to move the connecting rod (003) to the fuel side.
- 3 Remove the lever chain hoist (007) from the lifting tool on the connecting block.
- 4 Install the brackets (008) on the bearing shell (004). Make sure that the lugs face in.
- 5 Attach the chain (010) to the brackets (008).
- 6 Attach the lever chain hoist (007) to the chain (010).
- 7 Attach the deviation pipe (001) to the column.
- 8 Attach the sling (006) to the gallery.
- 9 Attach the spur-gearred chain block (005) to the sling (006) and to the chain (010).
- 10 Remove the screws (009).
- 11 Operate the lever chain hoist (007) and the chain block (005) to remove the bearing shell (004) from the connecting rod (003).
- 12 Operate the lever chain hoist (007) and the chain block (005) to move the bearing shell (004) through the column door.
- 13 Lower the bearing shell (004) on to an applicable surface.

**Fig 8-28 Top end bearing - remove**



## CLOSE UP

- None

## 8.5.5 Connecting rod - remove the bottom end bearing

### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Lever chain hoist			1
Lever chain hoists			2
Eye bolt			4
Eye bolt			1
Shackles			2
Shackles			4
Shackles			2
Sling			1
Deviation pipe			1
Chain			1
Console frame			1
Support			1
Support			1 or 2

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel.



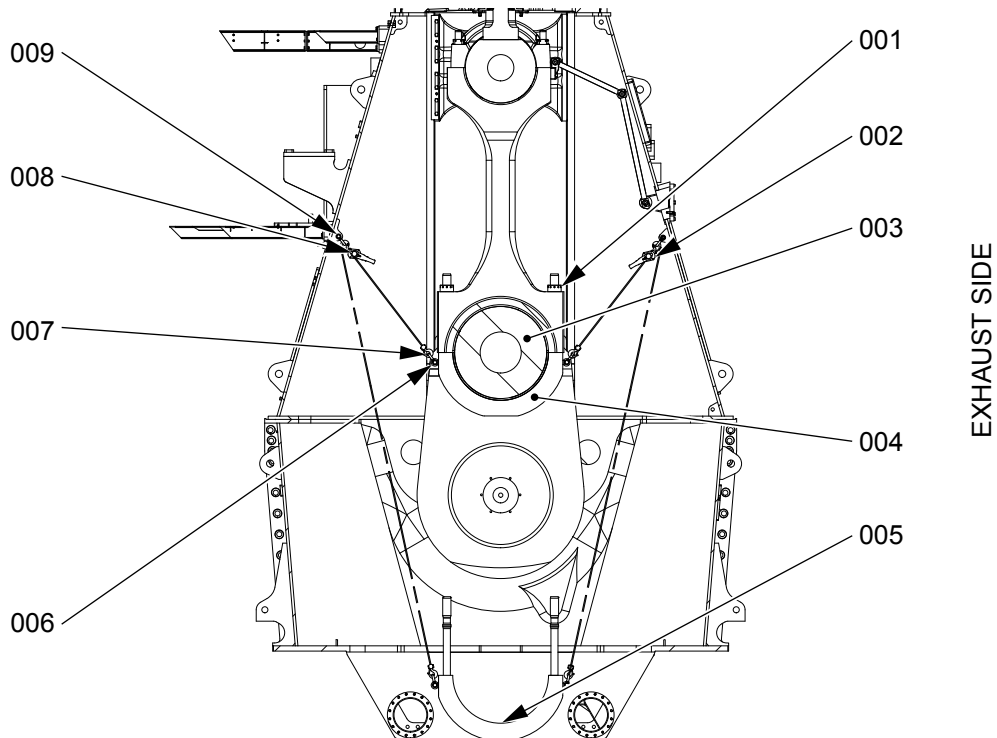
## PRELIMINARY OPERATIONS

- The top end bearing must be removed, refer to section [8.5.4 Connecting rod - remove the top end bearing](#)

## PROCEDURE

- 1 Remove the bearing cover.
  - 1.1 Operate the turning gear to move the crankshaft until the applicable crank pin (003, [Figure 8-29](#)) is at TDC.
  - 1.2 Lock the turning gear.
  - 1.3 Attach the eye bolts (006) to the bearing cover (004).
  - 1.4 Attach the shackles (009) to the column.
  - 1.5 Attach the lever chain hoist (008) and the lever chain hoists (002) to the shackles (009).
  - 1.6 Attach the eye bolts (006) to the bearing cover (004).
  - 1.7 Operate the lever chain hoists (002, 008) to put a light tension on their chains.
  - 1.8 Remove the round nuts (001), refer to [4.3 Loosen a round nut with a pre-tensioner](#).
  - 1.9 Operate the lever chain hoists (002, 008) to lower the bearing cover (004).
  - 1.10 Do an inspection of the bearing shell (005).
  - 1.11 If the bearing shell (005) is in good condition, do as follows:
    - 1.11.1 Lower the bearing cover (004) to the bottom of the crankcase.
    - 1.11.2 Remove the lever chain hoists (002, 008).

**Fig 8-29 Bottom end bearing cover - move**

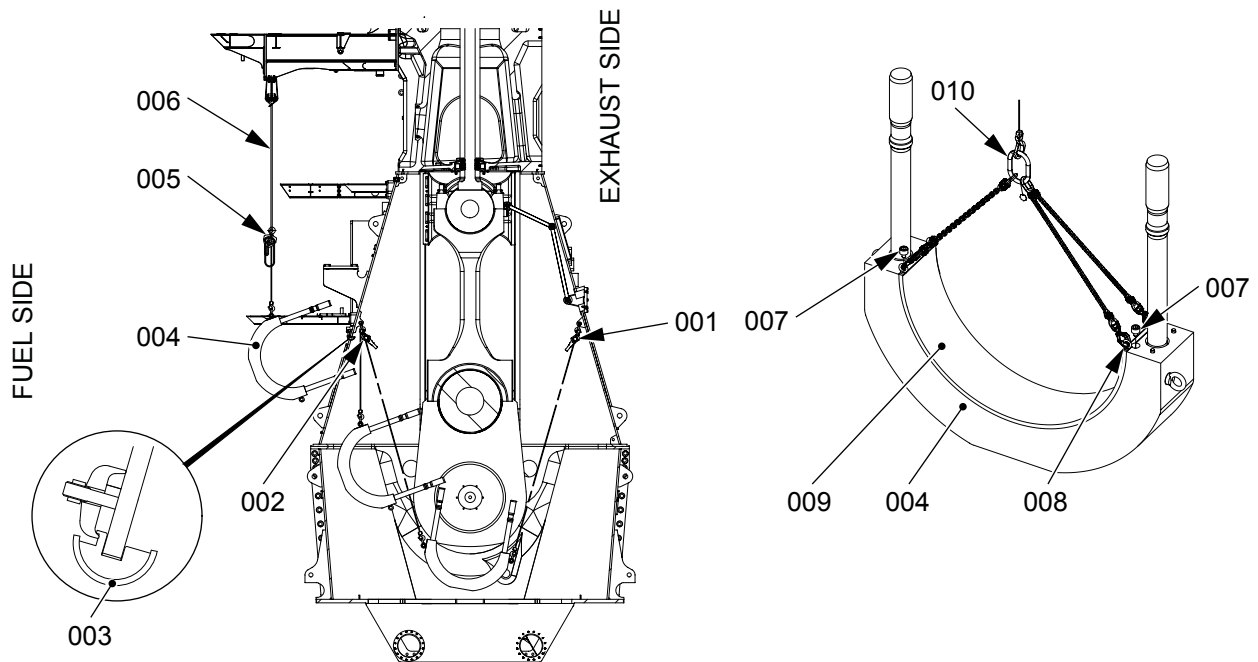


00770

- 1.12 Attach the sling (006, [Figure 8-30](#)) to the gallery.
- 1.13 Attach the spur-gear chain block (005) to the sling (006).
- 1.14 Install the deviation pipe (003) to the column door frame.

- 1.15 Operate the lever chain hoists (001, 002) to move the bearing cover (004) to the fuel side.
- 1.16 Remove the lever chain hoist (001) from the bearing cover (004).
- 1.17 Attach the chain block (005) to the bearing cover (004).
- 1.18 Operate the lever chain hoist (002) and the chain block (005) to move the bearing cover (004) from the crankcase.
- 1.19 Lower the bearing cover (004) on to an applicable surface.
- 2 Remove the bottom bearing shell.
  - 2.1 Remove the two screws (007).
  - 2.2 Attach the four eye bolts (008) to the bearing cover (004).
  - 2.3 Attach the chain (010) to the four eye bolts (008).
  - 2.4 Attach the chain block (005) to the chain (010).
  - 2.5 Operate the chain block to lift the bearing shell (009) out of the bearing cover (004).
  - 2.6 Lower the bearing cover on to an applicable surface.

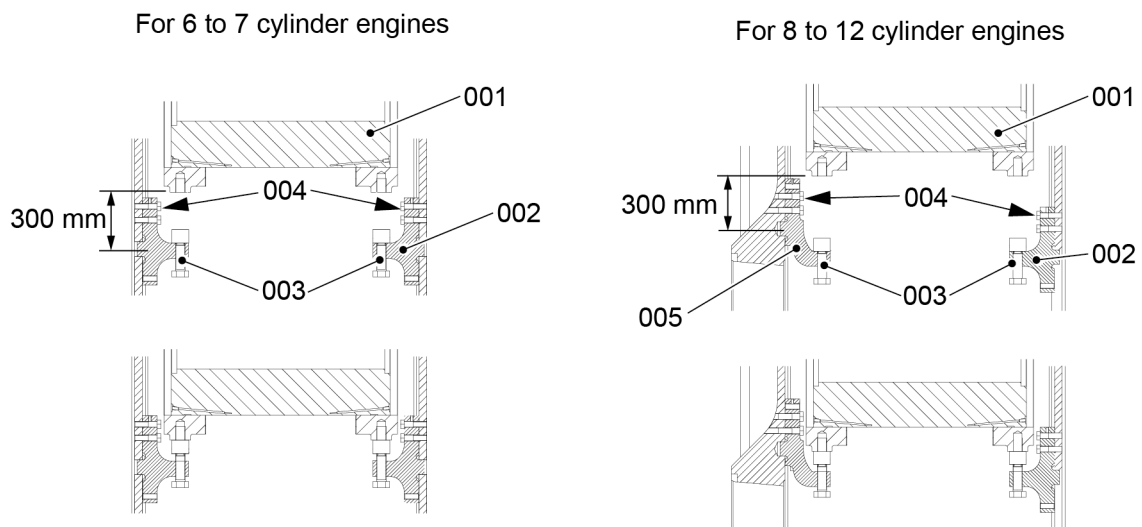
**Fig 8-30 Bottom end bearing shell - remove**



00767

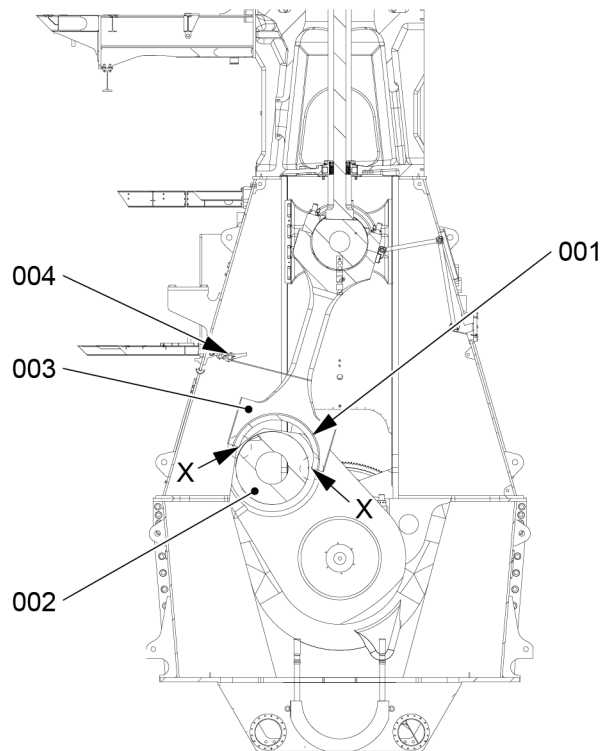
- 3 Remove the top bearing shell.
  - 3.1 Unlock the turning gear.
  - 3.2 Operate the turning gear to move the crank to the fuel side until the crosshead (001, [Figure 8-31](#)) is approximately 300 mm above the plug bore.
  - 3.3 Put oil on the four bolts (004).
  - 3.4 Attach the supports (002, 005) as follows:
    - 3.4.1 For 6-7 Cylinder engines: Attach the two supports (002) with the four bolts (004).

- 3.4.2** For 8 to 12 cylinder engines: Attach the support (005) and the support (002).
- 3.5** Tighten the special screws (003).
- 3.6** Operate the turning gear to lower the crosshead (001) on to the special screws (003).

**Fig 8-31 Supports**

00803

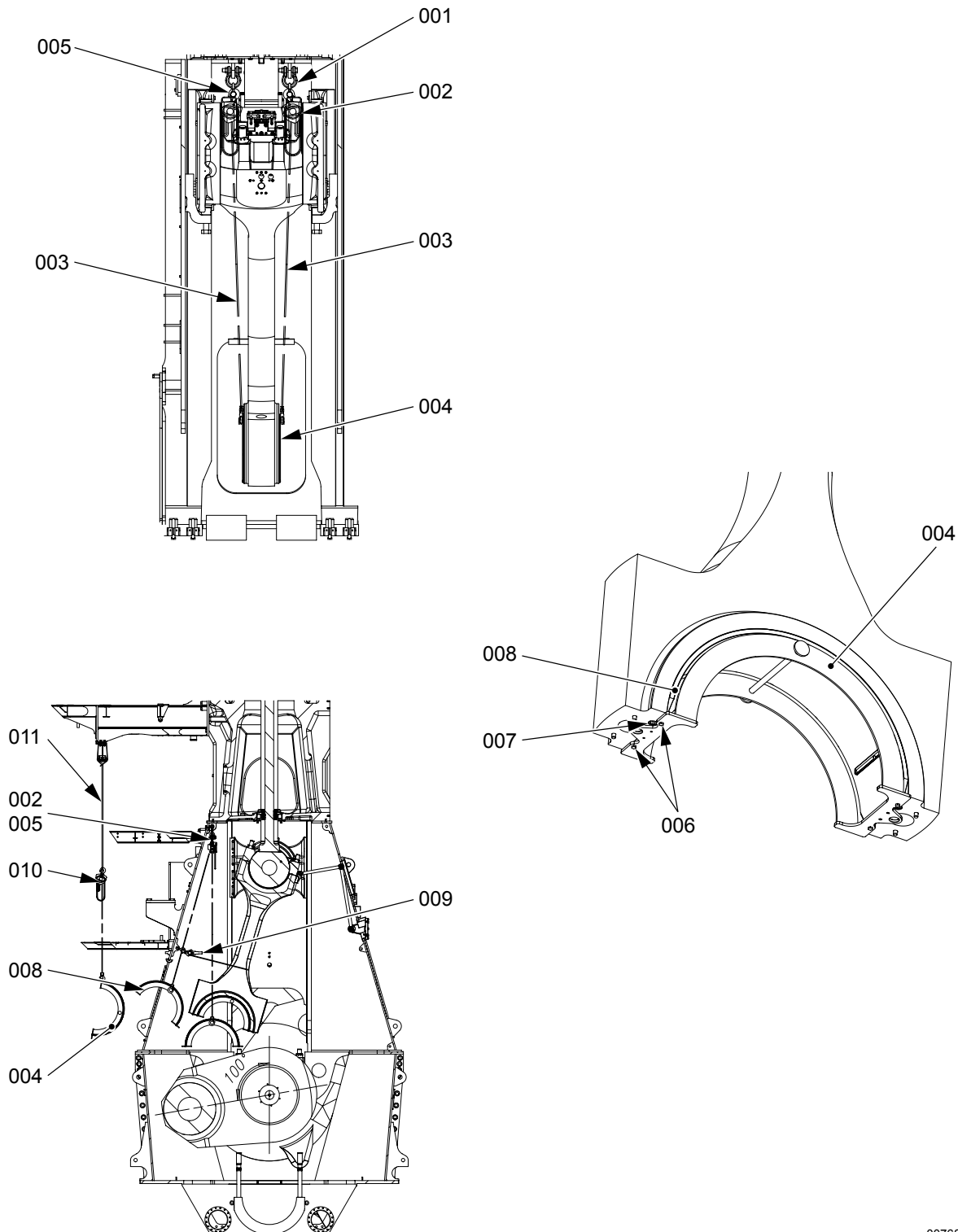
- 3.7** Put the chain of the lever chain hoist (004, [Figure 8-32](#)) around the connecting rod (003).
- 3.8** Operate the turning gear to move the crank (002) to the fuel side. At the same time, operate the lever chain hoist (004) to keep tension on the chain.
- NOTE:** Make sure that there is no load on the corners (X) of bearing shell (001).
- 3.9** Operate the turning gear to move the crank to 100° after TDC.
- 3.10** Do an inspection of the bottom end bearing shell, refer to section [8.5.6 Connecting rod - examine the bearing shells](#).

**Fig 8-32 Bottom end bearing**

00698

- 3.11** Attach the shackles (001, [Figure 8-33](#)) to the column.
- 3.12** Attach the shackles (005) to the shackles (001).
- 3.13** Attach the lever chain hoists (002) to the shackles (005).
- 3.14** Attach the console frame (004) to the bearing shell (008) with the four screws (006).
- 3.15** Attach the lever chain hoists (002, 005) to the console frame (004).
- 3.16** Operate the lever chain hoists (002) to apply a light tension on their chains (003).
- 3.17** Remove the two screws (007).
- 3.18** Operate the lever chain hoists (002) to lower the console frame (004) together with the bearing shell (008).
- 3.19** Attach the chain block (010) to the eyelet on the console frame (004).
- 3.20** Operate the chain block (010) and the lever chain hoists (002) to move the console frame (004) through the column door.
- 3.21** Remove the lever chain hoists (002).
- 3.22** Operate the chain block (010) to lower the console frame (004) on to an applicable surface.
- 3.23** Remove the chain block (010).
- 3.24** Remove the console frame (004).

Fig 8-33 Top bearing shell - remove



00768

**CLOSE UP**

- None

## 8.5.6 Connecting rod - examine the bearing shells

### Periodicity

Description	
Working hours	70000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

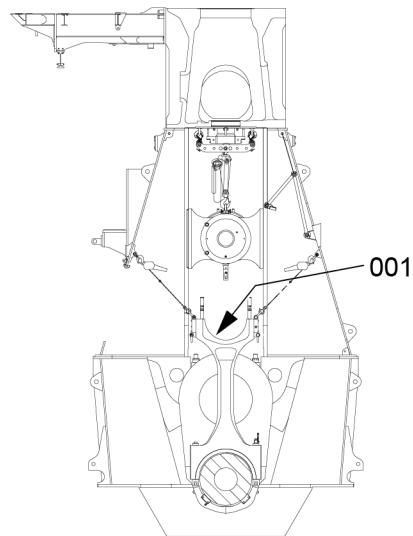
- Do the procedures given in section [8.5.4 Connecting rod - remove the top end bearing](#)



## PROCEDURE

- 1 Do an inspection of the related bearing shell (001, [Figure 8-34](#)).
- 2 If you find damage, remove the bearing shell (001), refer to section [8.5.2 Connecting rod - remove](#).

**Fig 8-34** Visual examination



00606

## CLOSE UP

- None

## 8.5.7 Connecting rod - install the bottom end bearing

### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Lever chain hoist			1
Lever chain hoists			2
Eye bolt			4
Eye bolt			1
Shackle			1
Shackle			4
Shackle			2
Sling			1
Deviation pipe			1
Chain			1
Console frame			1
Support			1
Support			1 or 2

### Supplies

Description	QTY
Oil	A/R
Steam engine cylinder oil, ISO VG 1000/1500	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Bearing shell - crank pin			1
Bearing shell - crank pin			1

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel.

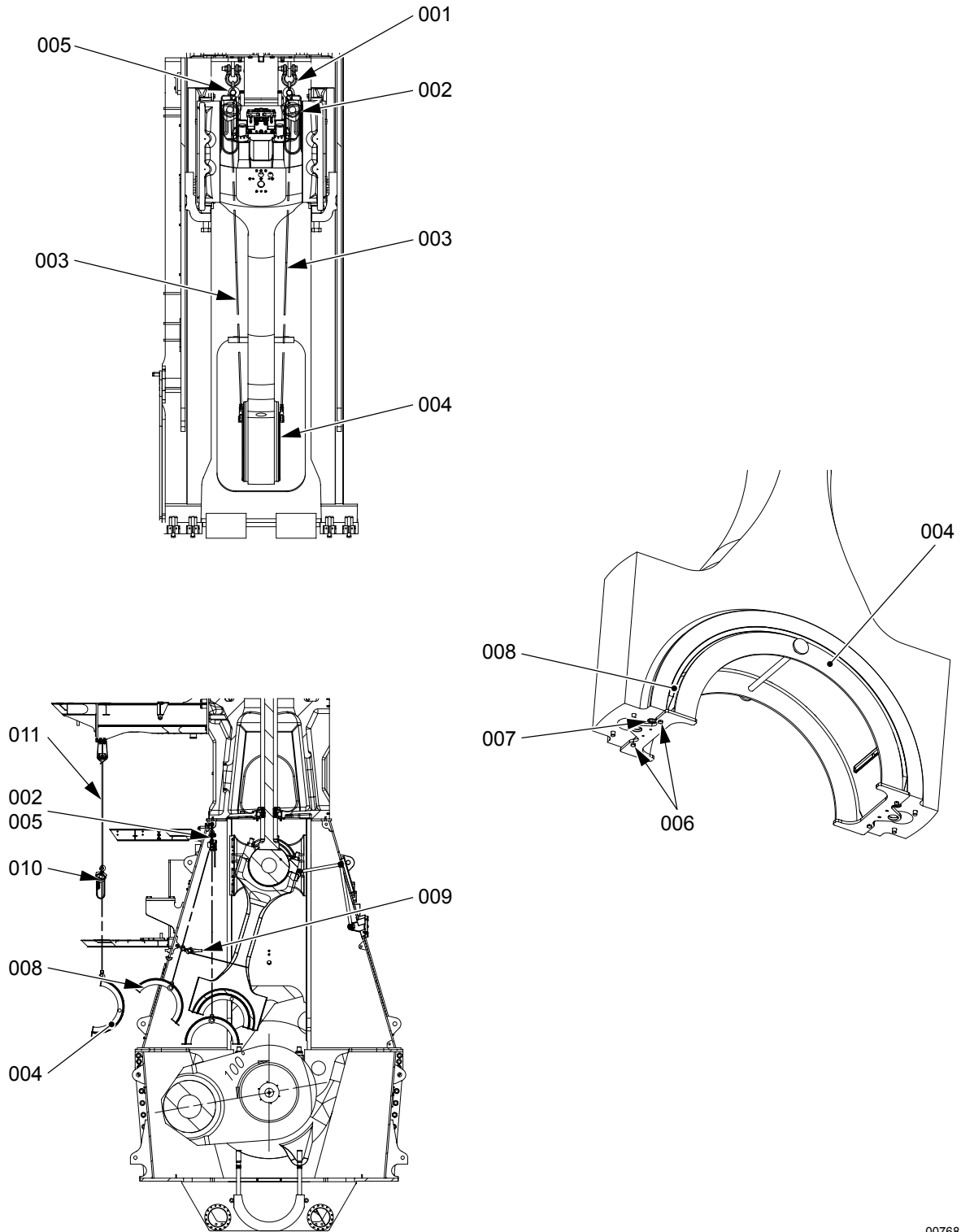
## PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Clean the seating surface of the bearing shell.
- 2 Attach the bearing shell - crank pin (008, [Figure 8-35](#)) to the console frame (004) with the four screws (006).
- 3 Clean the seating surface of the connecting rod and the bearing shell (008).
- 4 Attach the spur-gear chain block (010) to the sling (011) and to the console frame (004).
- 5 Operate the chain block (010) to lift the console frame (004) into position.
- 6 Attach the spur-gear chain block (002) to the console frame (004).
- 7 Remove the chain block (010).
- 8 Put oil on the surface of the bearing shell (008).
- 9 Operate the lever chain hoists (002) move the console frame (004) and bearing shell (008) into position.  
**NOTE:** Make sure that the distance between each end of the bearing shell and the connecting rod is the same.
- 10 Attach the bearing shell (008) to the connecting rod with the two screws (007).
- 11 Remove console frame (004).
- 12 Make sure that the surface of the crank pin is in a satisfactory condition.
- 13 Put oil on the crank pin.

Fig 8-35 Top bearing shell - move

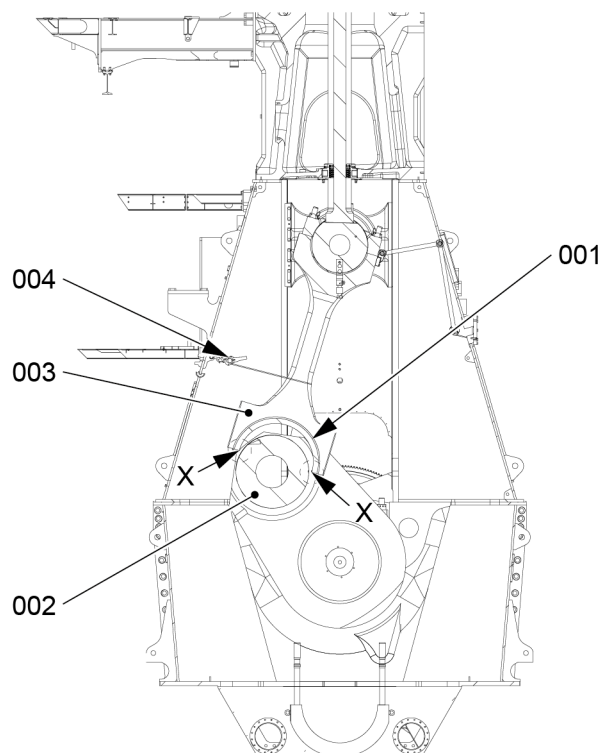


00768

- 14 Operate the turning gear to move the crank (002, [Figure 8-36](#)) to the position shown.
- 15 Make sure that there is no load on the points (X) between the connecting rod (003) and the crank pin (002).

- 16 If necessary, operate the chain block (004) to move the connecting rod (003).

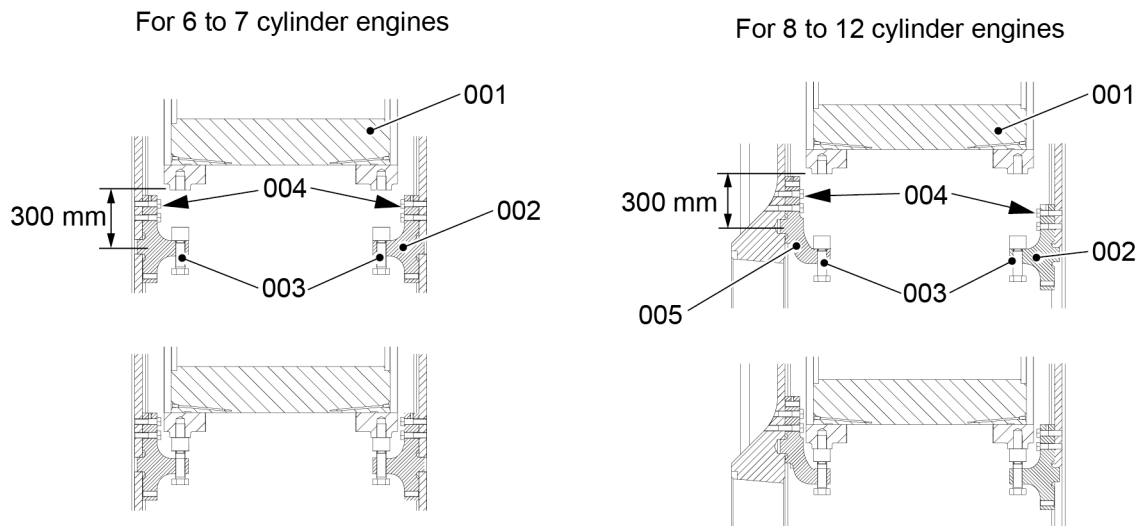
**Fig 8-36 Bottom end bearing**



00698

- 17 Loosen the screws (003, [Figure 8-37](#)).
- 18 Remove the four bolts (004).
- 19 Remove the two supports (002 and or 005).
- 20 Remove the lever chain hoist from the connecting rod.

Fig 8-37 Supports



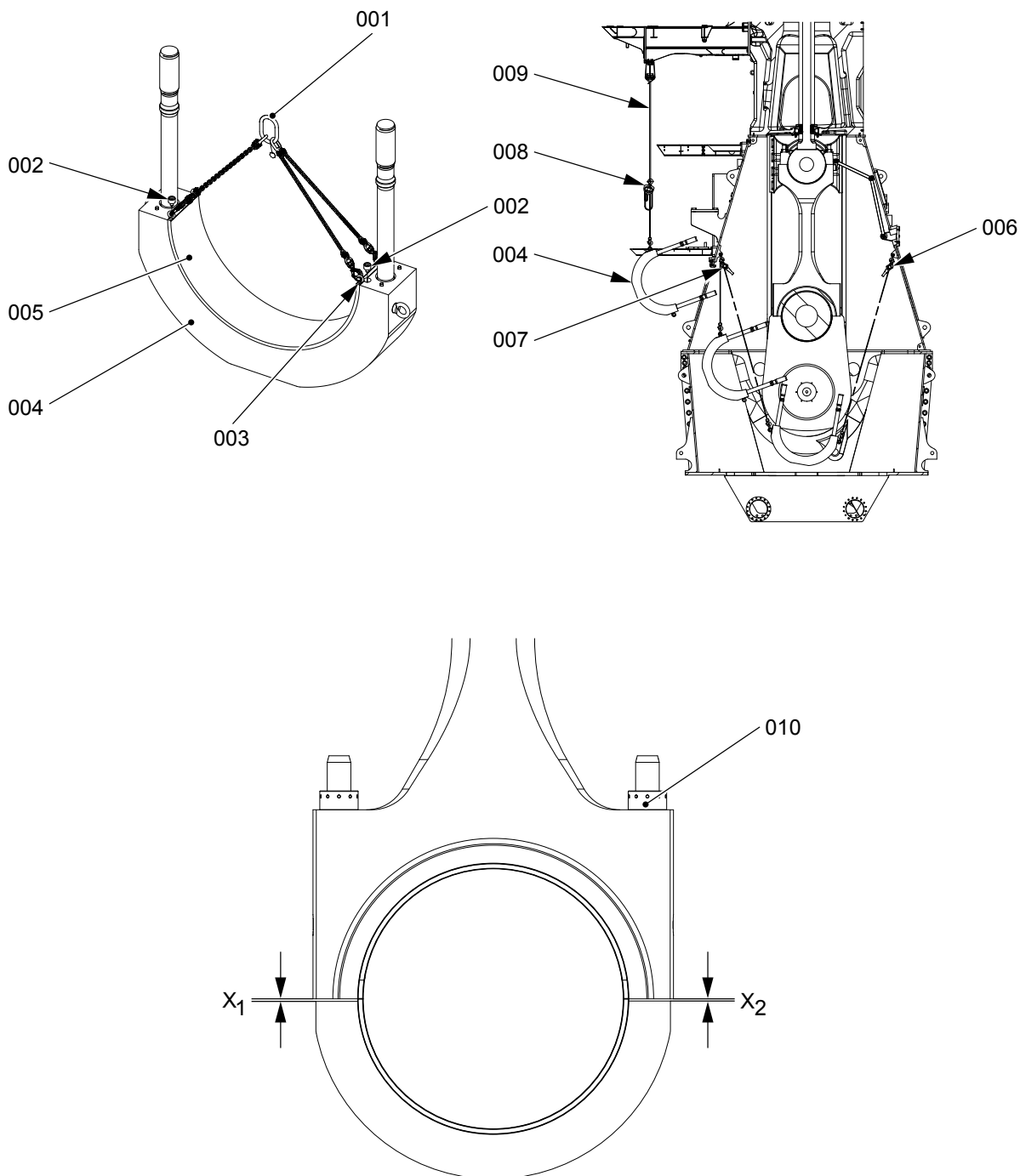
00803

- 21 Attach the four eye bolts (003, [Figure 8-38](#)) to the bearing shell - crank pin (005).
- 22 Attach the chain (001) to the four eye bolts (003).
- 23 Attach the chain block (008) to the chain (001) and the sling (009).
- 24 Operate the chain block (008) to lift the bearing shell (005).
- 25 Clean the seating surface of the bearing cover (004) and the bearing shell (005).
- 26 Apply a small quantity of clean oil to the surface of the bearing shell (005).
- 27 Lower the bearing shell (005) into the bearing cover (004).
- 28 Attach the bearing shell (005) to the bearing cover (004) with the four screws (002).  
**NOTE:** During this step, make sure that the distance between each end of the bearing shell and the connecting rod is the same.
- 29 Remove the chain (001) and the four eye bolts (003).
- 30 Attach the chain block (008) to eye bolt on the bearing cover (004).
- 31 Operate the chain block (005) to lift the bearing cover (004).
- 32 Attach the lever chain hoist (007) to the bearing cover (004).
- 33 Operate the chain block (008) and the lever chain hoist (007) to move the bearing cover (004) through the column door frame.
- 34 Attach the lever chain hoist (006) to the bearing cover (004).
- 35 Remove the chain block (008).
- 36 Put bearing oil on the surface of the bearing shell (005) as follows:
  - 36.1 If you start the engine immediately after completion of this procedure, use only bearing oil.
  - 36.2 If the engine has stopped for some days, use a mixture of steam engine cylinder oil and bearing oil. A list of suppliers for high viscosity oils is given in [Table 8-4 - ISO VG 1000/1500 suppliers](#).

- 37** Operate the lever chain hoists (006, 007) to lift the bearing cover (004) into position on the crank pin.
- 38** Put the round nuts (010) on the elastic studs.
- 39** Use a round bar to tighten equally the round nuts (010).
- 40** Measure the distance (X1, X2) between the edges of the bearing shells (002, 003) and the bearing cover (004).
- 41** For new bearing shells, the dimensions X1 plus X2 must be between 1.18 mm and 1.34mm.
- 42** Tighten the round nuts (010), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).



Fig 8-38 Bottom end bearing - install



00773

**Tab 8-4 ISO VG 1000/1500 suppliers**

Supplier	Type	Viscosity at 40°C [mm <sup>2</sup> /s]	Viscosity at 100°C [mm <sup>2</sup> /s]	Weight at 15°C [g/ml]
BP	Energol DC 1000	980	49.0	0.913
BP	Energol DC 1000	920	40.0	0.913
Chevron	Cylinder oil 1000	1000	43.1	0.937
Exxon/Esso	Cylessso 1000	950	44.0	
Exxon/Esso	Cylessso TK1000	925	46.7	
Mobil	Extra Hecla super cylinder oil	680	39.0	0.905
Shell	Fiona oil 1500	1500	37.0	0.958
Shell	Valvata oil 1000	1000	45.4	0.924
Texaco	650T mineral oil	985	44.0	0.919

**CLOSE UP**

- None

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## 8.5.8 Connecting rod - install the top end bearing

### Periodicity

Description	
Working hours	70000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			1
Lever chain hoist			2
Chain			1
Bracket			2
Deviation pipe			1
Sling			1
Platform			1
Flange			1
Lever chain hoist			2

### Supplies

Description	QTY
Bearing oil	A/R
Steam engine cylinder oil, ISO VG 1000/1500	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Bearing shell			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

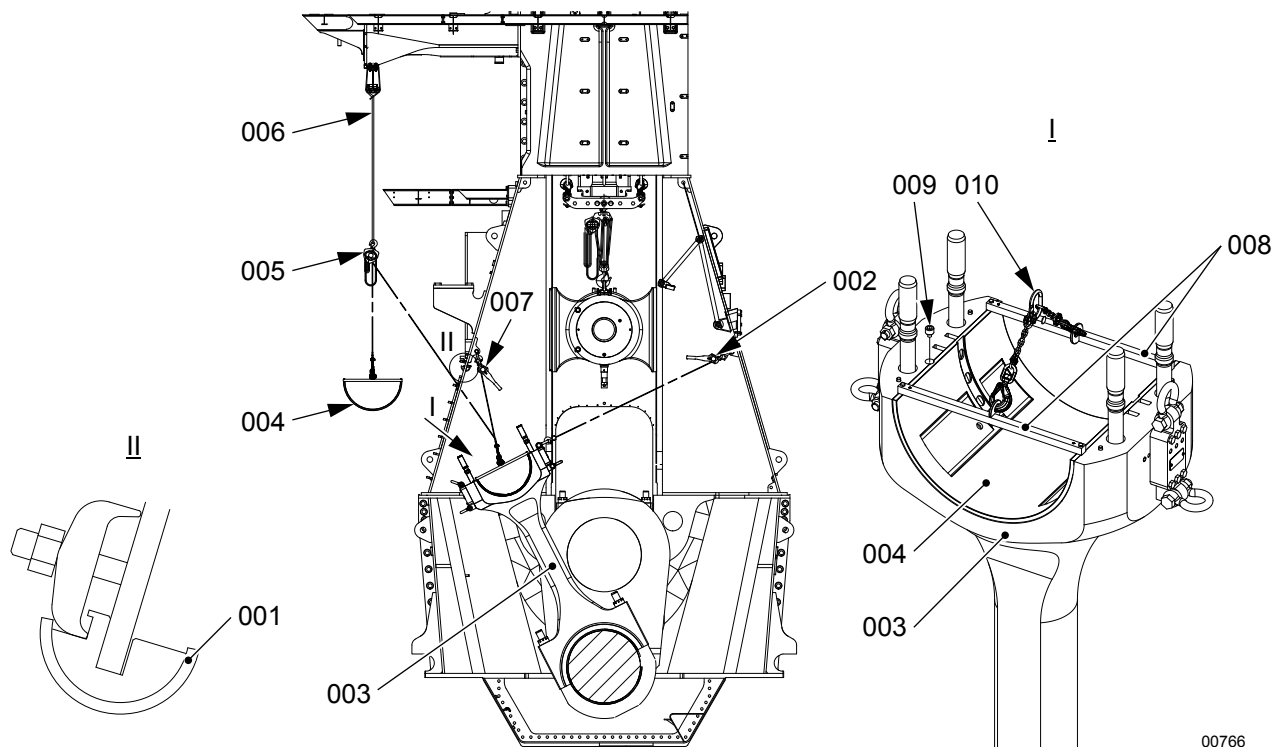
- 1 Clean the seating surface of the bearing shell (004, [Figure 8-39](#)).
- 2 Put bearing oil on the surface of the bearing shell (004) as follows:
  - 2.1 If you start the engine immediately after completion of this procedure, use only system oil.
  - 2.2 If the engine has stopped for some days, use a mixture of steam engine cylinder oil (high viscosity oil) and bearing oil.
 

**NOTE:** The ratio is two thirds ISO VG 1000/1500 to one third bearing oil. A list of suppliers for high viscosity oils is given in [Table 8-5 - ISO VG 1000/1500 suppliers](#) below.

**Tab 8-5 ISO VG 1000/1500 suppliers**

Supplier	Type	Viscosity at 40°C [mm <sup>2</sup> /s]	Viscosity at 100°C [mm <sup>2</sup> /s]	Weight at 15°C [g/ml]
BP	Energol DC 1000	980	49.0	0.913
BP	Energol DC 1000	920	40.0	0.913
Chevron	Cylinder oil 1000	1000	43.1	0.937
Exxon/Esso	Cylessso 1000	950	44.0	
Exxon/Esso	Cylessso TK1000	925	46.7	
Mobil	Extra Hecla super cylinder oil	680	39.0	0.905
Shell	Fiona oil 1500	1500	37.0	0.958
Shell	Valvata oil 1000	1000	45.4	0.924
Texaco	650T mineral oil	985	44.0	0.919

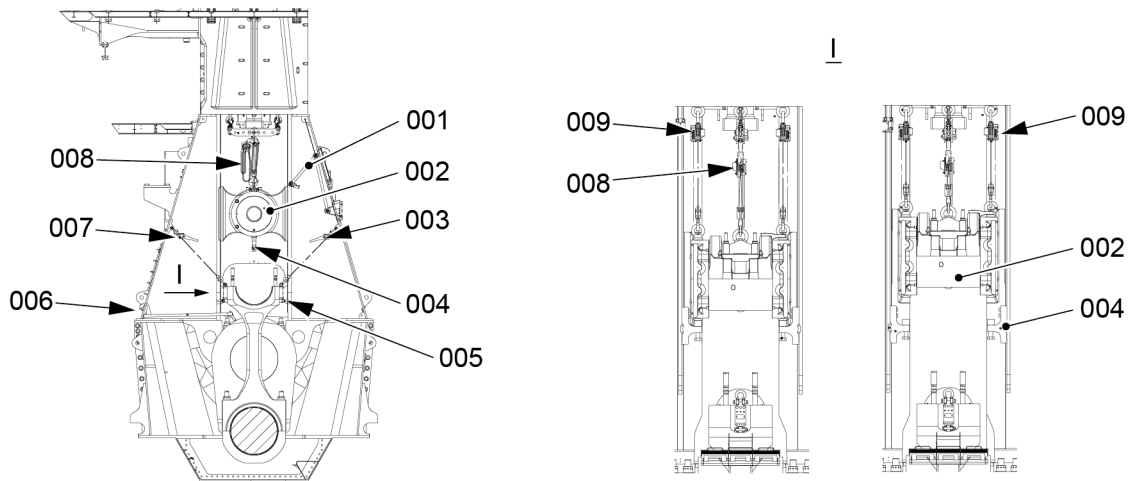
- 3 Clean the seating surface of the connecting rod and make sure that there is no damage.
- 4 Make sure that the surface of crosshead pin is in a satisfactory condition.
- 5 Install the brackets (008) on the bearing shell (004). Make sure that the lugs face in.
- 6 Attach the chain (010) to the brackets (008).
- 7 Attach the sling (006) to the gallery.
- 8 Make sure that the deviation pipe (001) is attached to the column.
- 9 Attach the spur-gear chain block (005) to the sling (006) and to the chain (010).
- 10 Operate the chain block (005) to lift the bearing shell (004).
- 11 Attach the lever chain hoist (007) to the chain (010).
- 12 Operate the chain block (005) and the lever chain hoist (007) to move the bearing shell (004) through the column door.
- 13 Operate the lever chain hoist (007) and the chain block (005) to lower the bearing shell (004) into position in the connecting rod (003).
- 14 Attach the bearing shell (004) to the connecting rod with the two screws (009).
- 15 Remove the lever chain hoist (007) and the chain block (005).
- 16 Remove the brackets (008).
- 17 Attach the lever chain hoist (002) to the lifting tool on the connecting rod (003).

**Fig 8-39** Top end bearing - move

00766

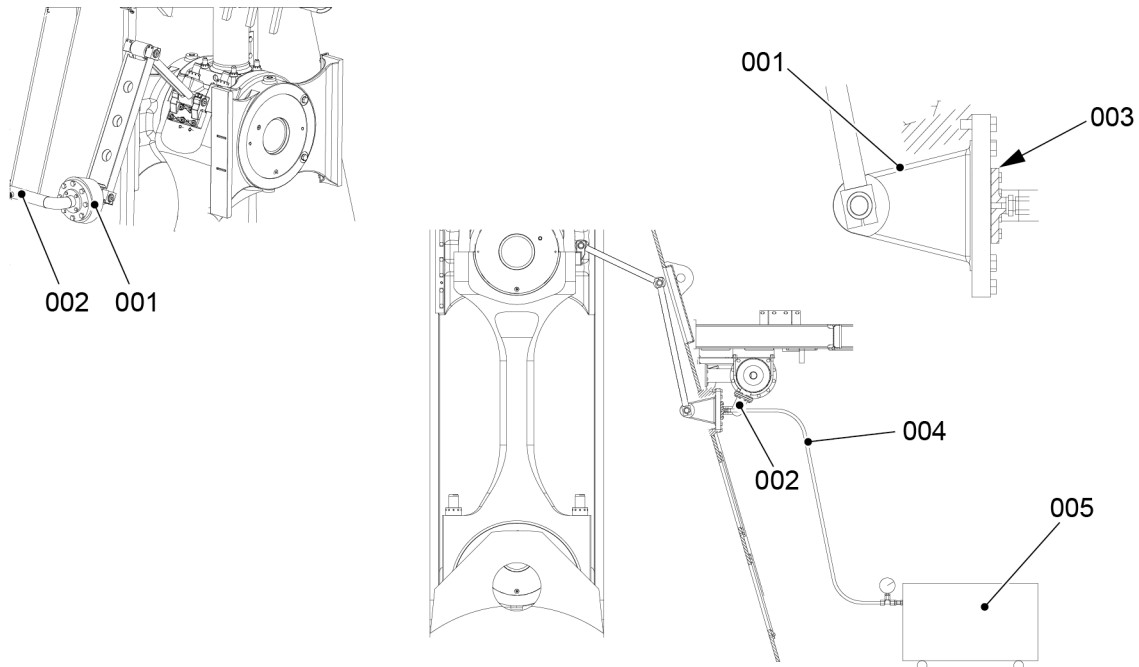
- 18** Operate the lever chain hoists (003 and 007, [Figure 8-40](#)) to move the connecting rod to the vertical position.
- 19** Make sure that the platform (006) is installed.
- 20** Operate the chain blocks (008, 009) to lift the crosshead (002) a small distance.
- 21** Remove the two supports (004).
- 22** Operate the chain blocks (008, 009) to lower the crosshead into position on the connecting rod.
- 23** Attach the toggle lever (001) to the connection piece on the crosshead (002).

Fig 8-40 Crosshead - lower



00801

- 24 Put the round nuts (002, Fig. 9) on the elastic studs (001).
- 25 Use a round bar to tighten equally the round nuts (002).
- 26 Measure the distances (X1, X2) between the edges of the bearing shells and the connecting rod (003).
- 27 For a new bearing shell the clearance must be  $X1+X2 = 0.45\pm 0.04$  mm.
- 28 Apply tension to the elastic studs (002), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 29 Attach the piston to the crosshead, refer to section [8.7.7 Piston - install](#).
- 30 Remove the oil inlet pipe (002, [Figure 8-41](#)).
- 31 Attach the flange (003) to the support (001).
- 32 Attach the hose (004) to the flange (003).
- 33 Fill the lubricating pump (005) with steam-engine cylinder oil (see [Table 8-5 - ISO VG 1000/1500 suppliers](#)).
- 34 Operate the lubricating pump (005) until oil flows from the sides of the bearing.  
**NOTE:** Do [Step 34](#) weekly if the engine does not operate for some weeks.
- 35 Before you operate the engine do [Step 35.1](#) to [Step 35.4](#):
  - 35.1 Make sure that the hose (004) has no pressure.
  - 35.2 Remove the hose (004) from the flange (003).
  - 35.3 Remove the flange (003).
  - 35.4 Install the oil inlet pipe (003) to the support (001).  
**NOTE:** The steam-engine cylinder oil can stay in the oil system.

**Fig 8-41 Bearing lubrication**

00802

**CLOSE UP**

- None



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## 8.5.9 Connecting rod - remove the top end bearing cover

### Periodicity

Description	
Working hours	70 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Platform			1
Deviation pipe			1
Holder			2
Eye bolt			2
Chain			1
Shackle			2
Spur-gearred chain block			2
Spur-gearred chain block			2
Shackle			1
Sling			1
Spur-gearred trolley			1

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

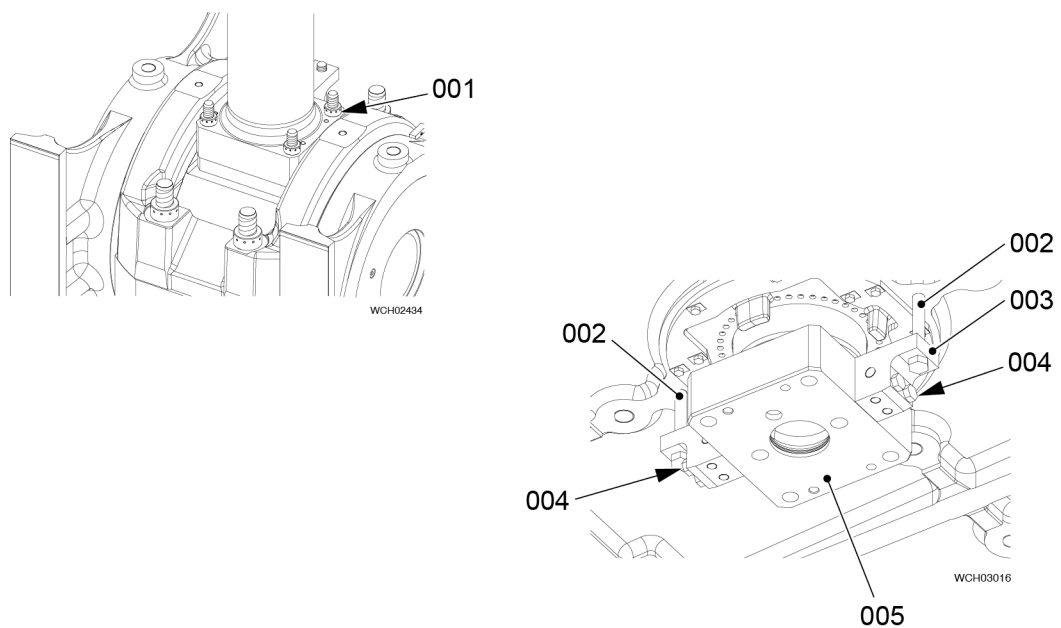
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Prepare the top end bearing of the connecting rod for removal.
  - 1.1 Operate the turning gear to turn the crank to BDC.
  - 1.2 Remove the round nuts (001, [Figure 8-42](#)), refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
  - 1.3 Operate the turning gear to turn the crank to TDC.
  - 1.4 Put oil on the threads of the four bolts (004).
  - 1.5 Attach the two holders (003) to the piston rod foot (005) with the four bolts (004).
  - 1.6 Torque the four bolts (004) to the correct value, refer to section [16.1 Tightening instructions](#).
  - 1.7 Tighten the two bolts (002).
  - 1.8 Operate the turning gear to move the crank to BDC.
  - 1.9 Lock the turning gear to prevent movement of the crankshaft.

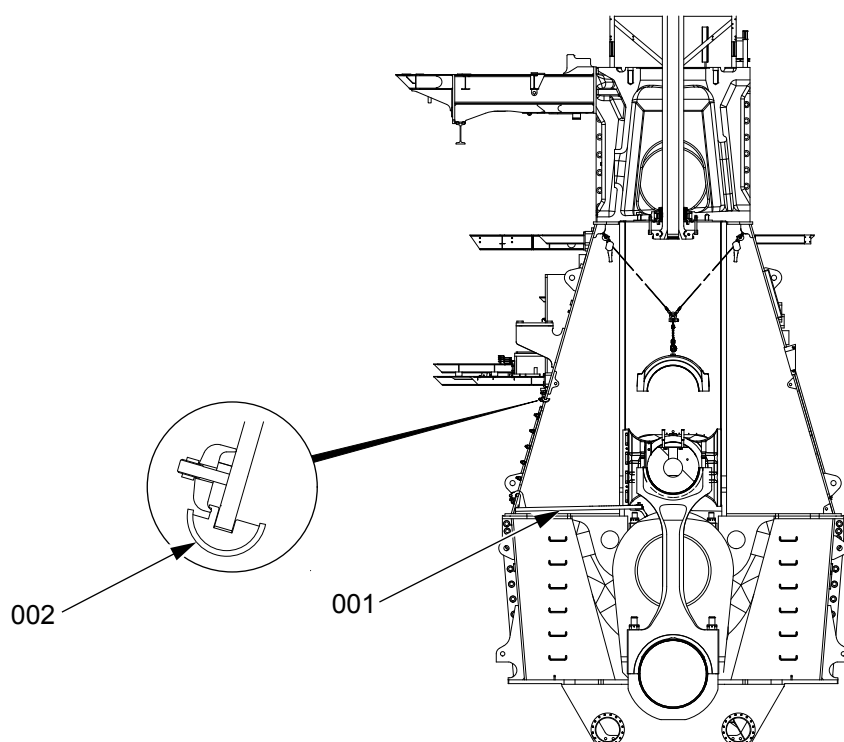
**Fig 8-42** Preparation



00694

- 1.10 Make sure that the platform (001, [Figure 8-43](#)) are installed.
- 1.11 Install the deviation pipe (002) to the column.

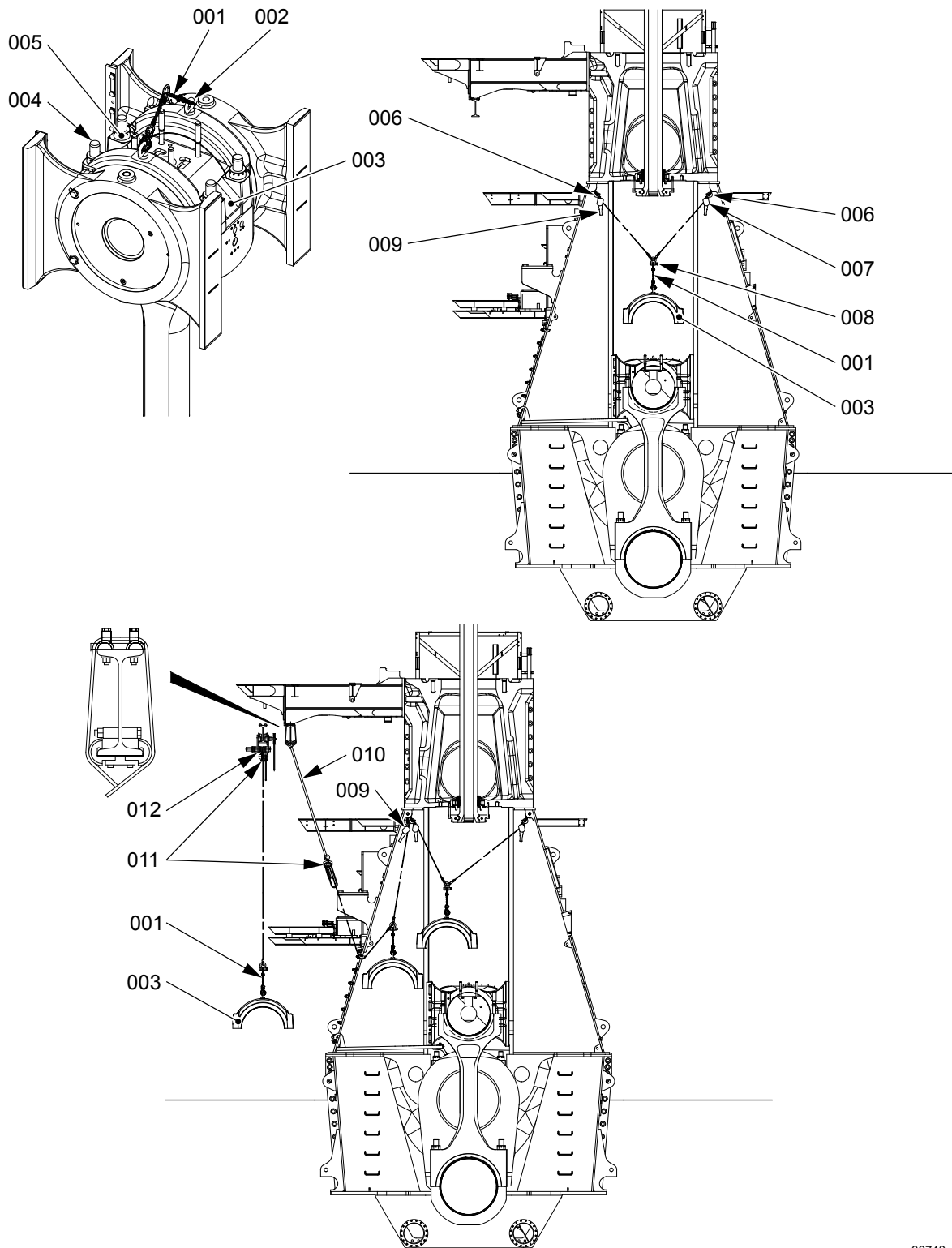
Fig 8-43 Equipment - install



00741

- 2 Remove the four round nuts (005, [Figure 8-42](#)) from the elastic bolts (004), refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 3 Attach the two eye bolts (002) to the bearing cover (003).
- 4 Attach the chain (001) to the two eye bolts (002).
- 5 Attach two shackles (006) to the strong-points on the frame.
- 6 Attach the two spur-gear chain blocks (007, 009) to the shackles (006).
- 7 Attach the shackle (008) to the chain (001) and the chain blocks (007, 009).
- 8 Make sure that the chain (001) is vertically aligned with the center of the bearing cover to prevent damage to the elastic bolts.
- 9 Operate the two chain blocks (007, 009) to carefully lift the bearing cover (003).
- 10 Attach the sling (010) to the beam.
- 11 Attach spur-gear chain block (011) to the sling (010).
- 12 Operate the chain blocks (007, 009) to move the bearing cover (003) to a position near the column door. Make sure that the chain (of the chain block (009)) is vertical.
- 13 Remove the chain block (007).
- 14 Attach the chain block (011) to the shackle (008).
- 15 Operate the chain blocks (009, 010) to move the bearing cover (003) through the opening in the column.
- 16 When the sling (010) and chain block (011) are vertical, remove the chain block (009).
- 17 Attach one more spur-gear chain block to the shackle (011) and to the engine room crane, or to the spur-gear trolley (012).
- 18 Operate the engine room crane or the trolley (012) to move the bearing cover (003) to an applicable area.
- 19 Lower the bearing cover (003) on to an applicable surface.

Fig 8-44 Top bearing cover - removal



00740

**CLOSE UP**

- None

## 8.5.10 Connecting rod - install the top end bearing cover

### Periodicity

Description	
Working hours	70 000

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Eye bolt			2
Chain			1
Shackles			2
Spur-gearred chain block			2
Spur-gearred chain blocks			2
Shackle			1
Sling			1
Spur-gearred trolley			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Bearing cover			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

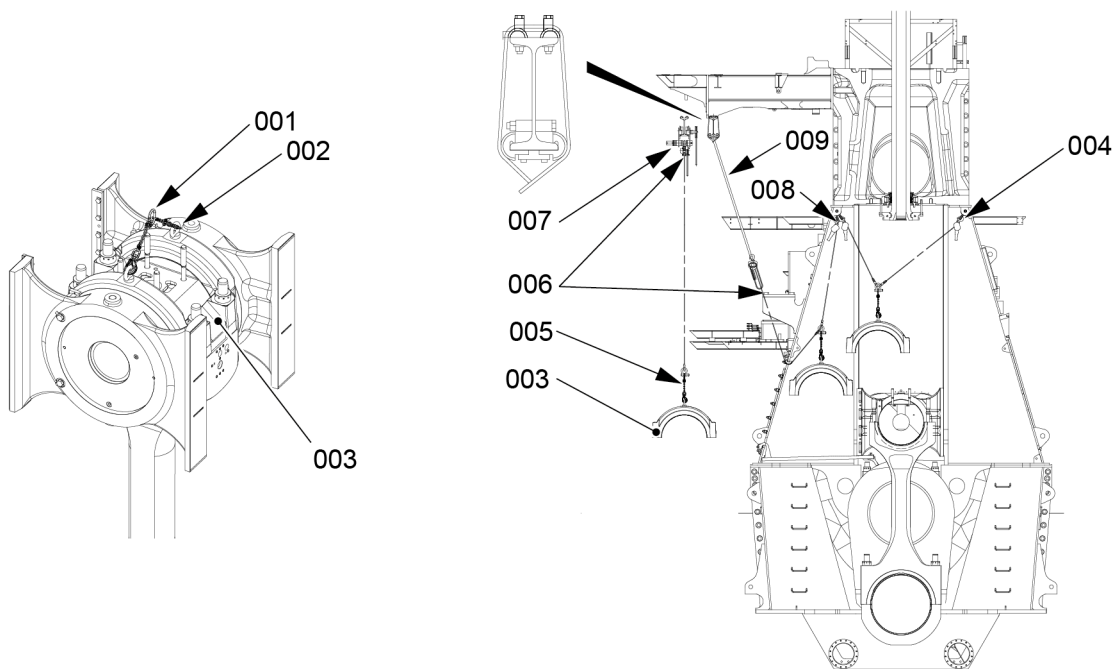
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Make sure that the bearing cover (003, [Figure 8-45](#)) has no damage.
- 2 Attach the two eye bolts (002) to the bearing cover (003).
- 3 Attach the shackle (001) to the chain (005).
- 4 Attach the chain (005) to the two eye bolts (002).
- 5 Attach the spur-gear chain blocks (006) (or the engine room crane) to the chain (005).
- 6 Operate the chain block (006) to lift the bearing cover (003).
- 7 Move the spur-gear trolley (007), or operate the engine room crane to move the bearing cover (003) to the applicable position.
- 8 Attach the other spur-gear chain blocks (008) to the shackle (001).
- 9 Operate the chain blocks (008, 006) to move the bearing cover (003) into the engine.
- 10 Remove the chain block (006).
- 11 Attach the chain block (004) to the shackle (001).
- 12 Remove the chain block (006).
- 13 Operate the chain blocks (004, 008) to align the bearing cover (003) directly above the crosshead.

**Fig 8-45 Top bearing cover - move**



00695

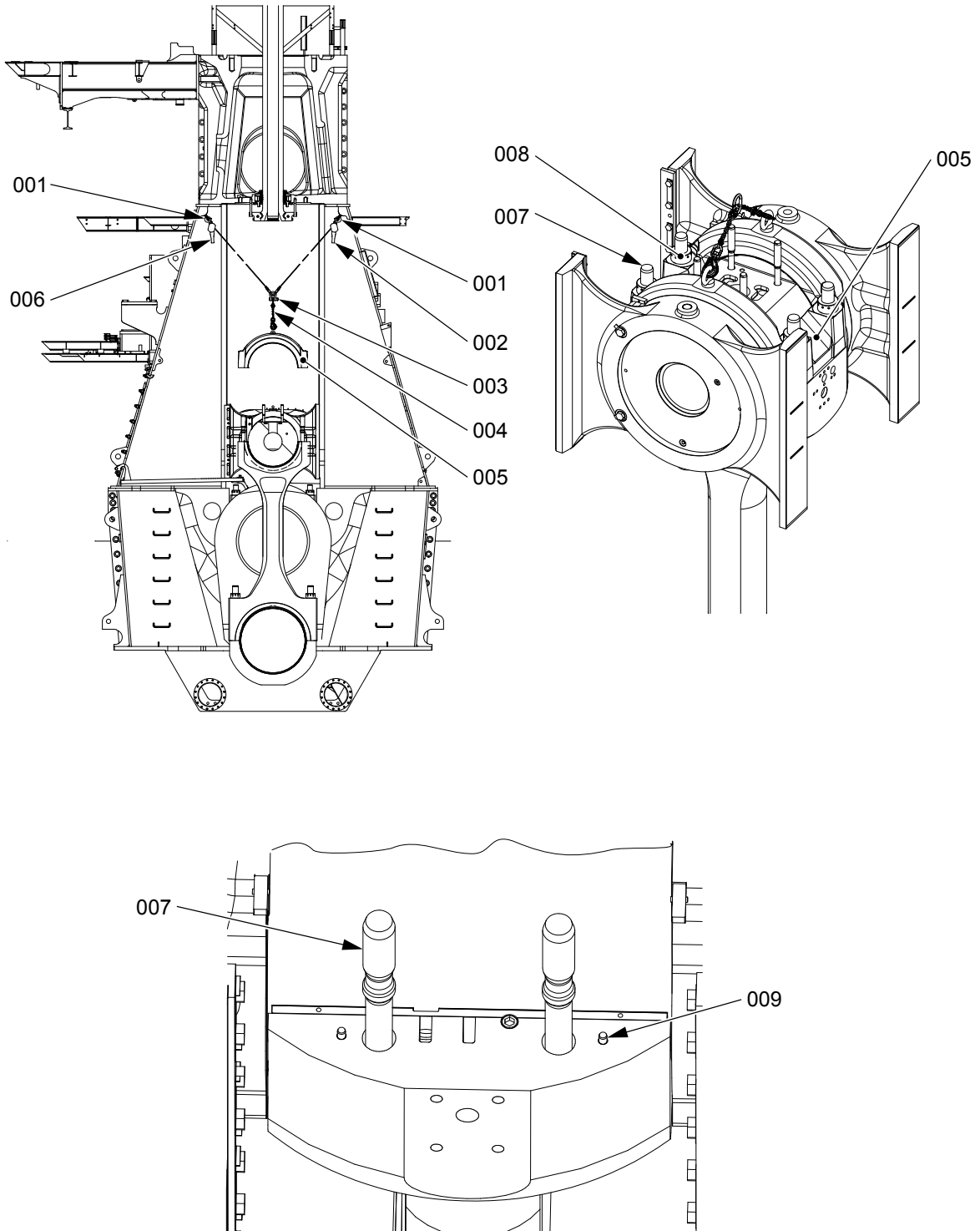
### CAUTION

**During this step, make sure that you do not cause damage to the elastic bolts.**

- 14 Operate carefully the chain blocks (002 and 006, [Figure 8-46](#)) to lower the bearing cover (005) on to the crosshead pin.

- 15 Make sure that the holes in the bearing cover (005) engage with the four dowel pins (009).
- 16 Remove the chain blocks (002, 006), chain (004), shackles (001, 003) and eye bolts.
- 17 Install the four round nuts (008) to the elastic bolts (007), refer to section [4.2 Tighten a round nut with a pre-tensioner](#).

Fig 8-46 Top bearing cover - install



00742

**CLOSE UP**

- None

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## 8.6 Crosshead

### 8.6.1 Crosshead - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Lifting tool			2
Spur-gearred chain block			1
Spur-gearred chain block			2
Spur-gearred chain block			1
Spur-gearred chain block			1
Lever chain hoist			2
Lifting tool			1
Eye bolt			6
Eye bolt			2
Shackle (WLL 8500 kg)			2
Shackle (WLL 13 500 kg)			2
Shackle (WLL 12 000 kg)			1
Sling			1
Spur-gearred trolley			1
Deviation pipe			1
Deviation pipe			1
Bracket			1
Deviation pipe			1
Chain			1
Support			1 or 2
Support			1
Platform			1

### Supplies

Description	QTY
Oil SAE 30	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are on the platform or near the flywheel.

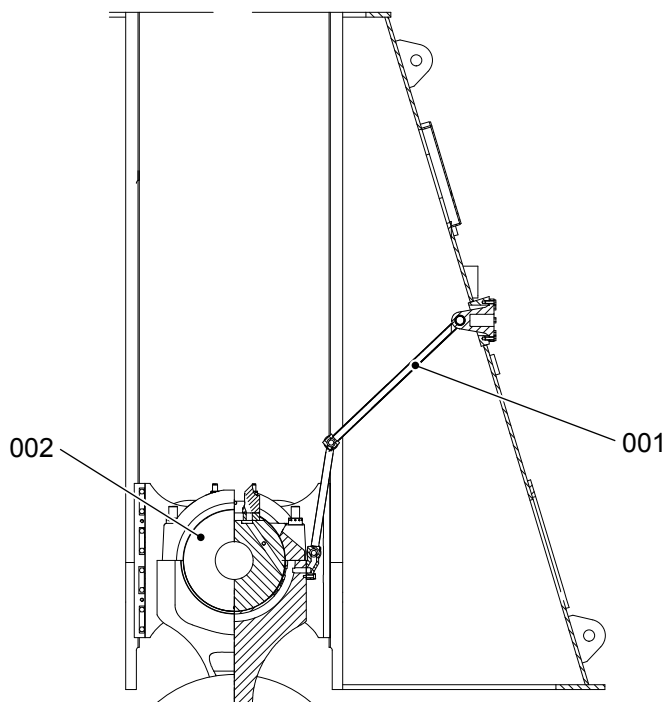
### PRELIMINARY OPERATIONS

- The piston must be removed, refer to section [8.7.3 Piston - remove](#)

## PROCEDURE

- 1 Prepare the crosshead before removal:
  - 1.1 Remove the toggle lever (001, [Figure 8-47](#)) from the crosshead pin (002). Let the toggle lever hang in the column.

**Fig 8-47 Toggle lever - remove**

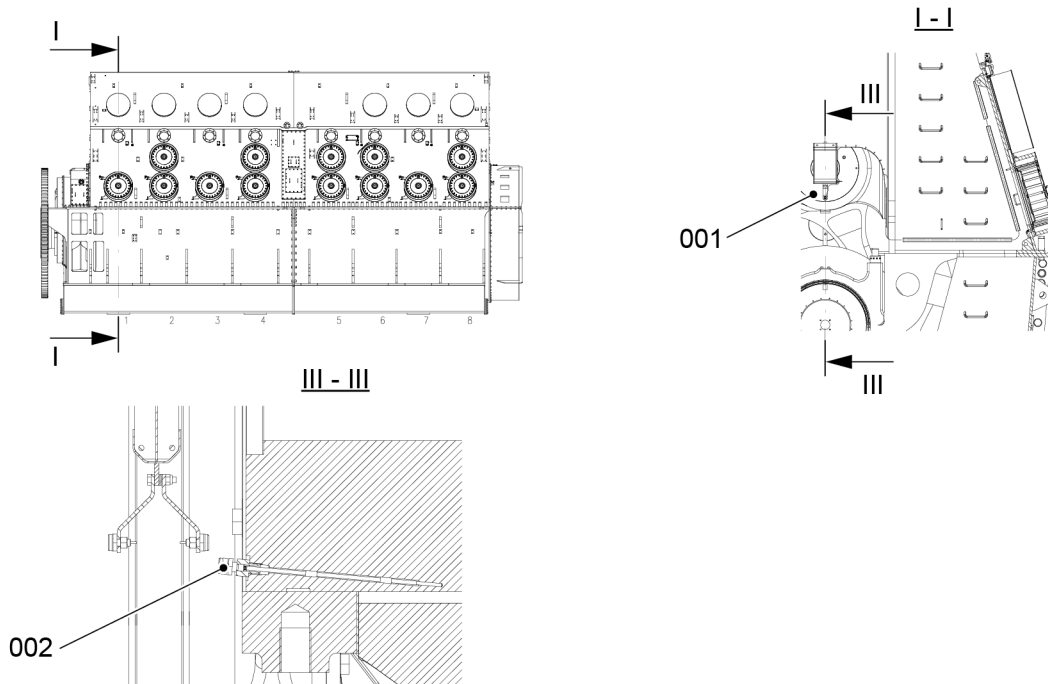


NOTE: THE CRANK SHAFT IS AT BDC

00757

- 1.2 Remove the round nuts from the elastic studs on the connecting rod, refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 1.3 Make sure that the platforms is installed.
- 1.4 Put protection on the oil inlets of the crosshead pin to prevent damage and contamination.
- 1.5 Disconnect the electrical connection from the temperature sensor (002, [Figure 8-50](#)).
- 1.6 Remove the temperature sensor (002).



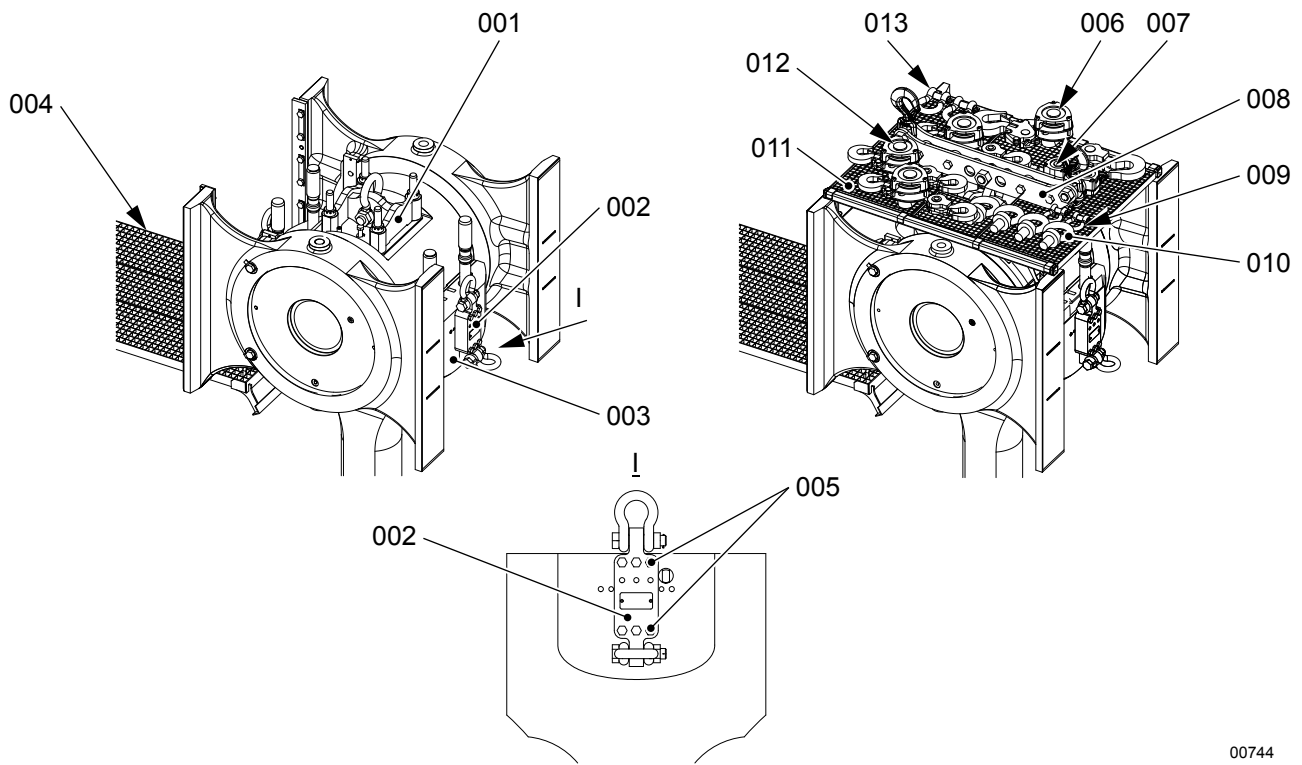
**Fig 8-48 Crosshead bearing - temperature sensor**

00518

- 2 Use an applicable tool to remove the compression shim.
- 3 Attach the engine room crane to the lifting tool (001, [Figure 8-49](#)).
- 4 Operate the engine room crane to lower the lifting tool (001) on to the crosshead pin.
- 5 Remove the engine room crane.
- 6 Attach the lifting tool (001) to the crosshead pin with the four round nuts.
- 7 Put oil on the threads and surfaces that will touch on the screws (005) on the lifting tools (002).
- 8 Attach a lifting tool (002) to each side of the connecting rod with the screws (005).
- 9 Torque the screws (005) to the correct value, refer to section [16.1 Tightening instructions](#).
- 10 Put the platform (011) on the crosshead pin.
- 11 Put the tools that follow on the platform (011):
  - Spur-gearred chain block (006)
  - Spur-gearred chain block (012)
  - Spur-gearred chain block (007)
  - Eye bolts (010)
  - Shackles (009)
  - Shackles (013)
  - Bracket (008).

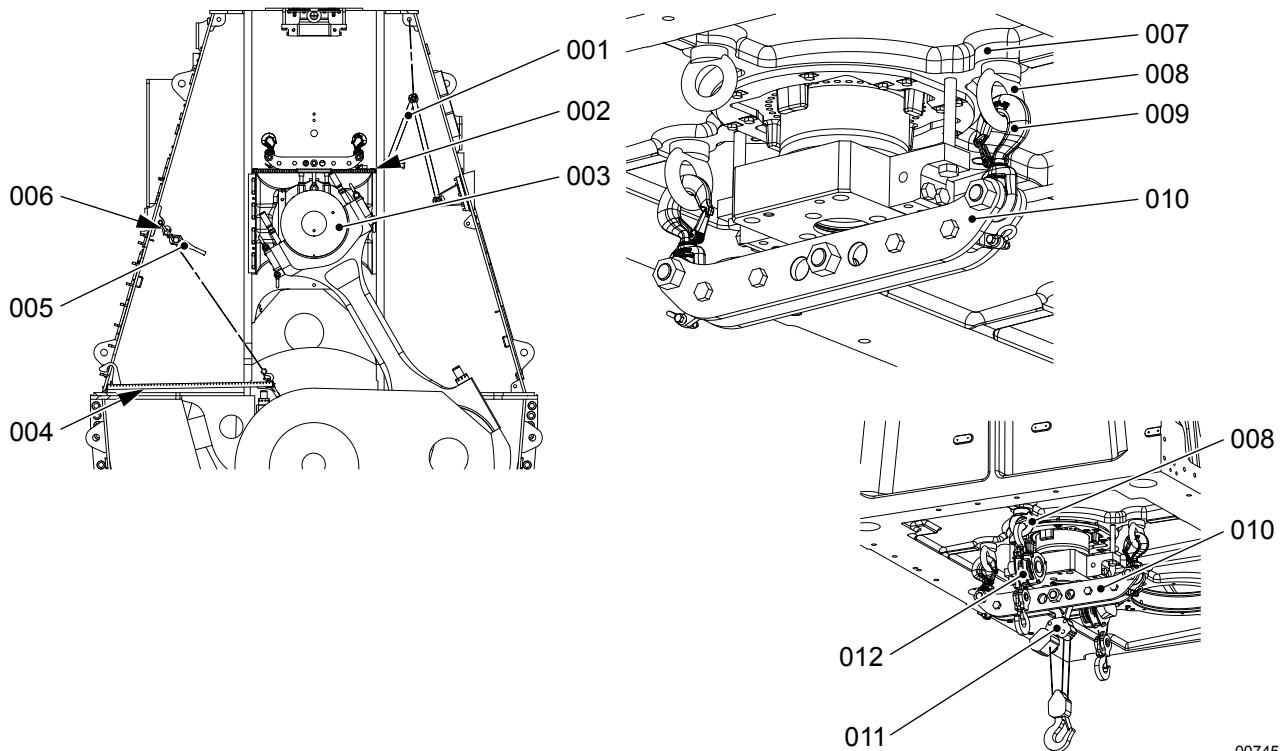
**NOTE:** Make sure that the tools do not fall into the machine room.

Fig 8-49 Tools - prepare



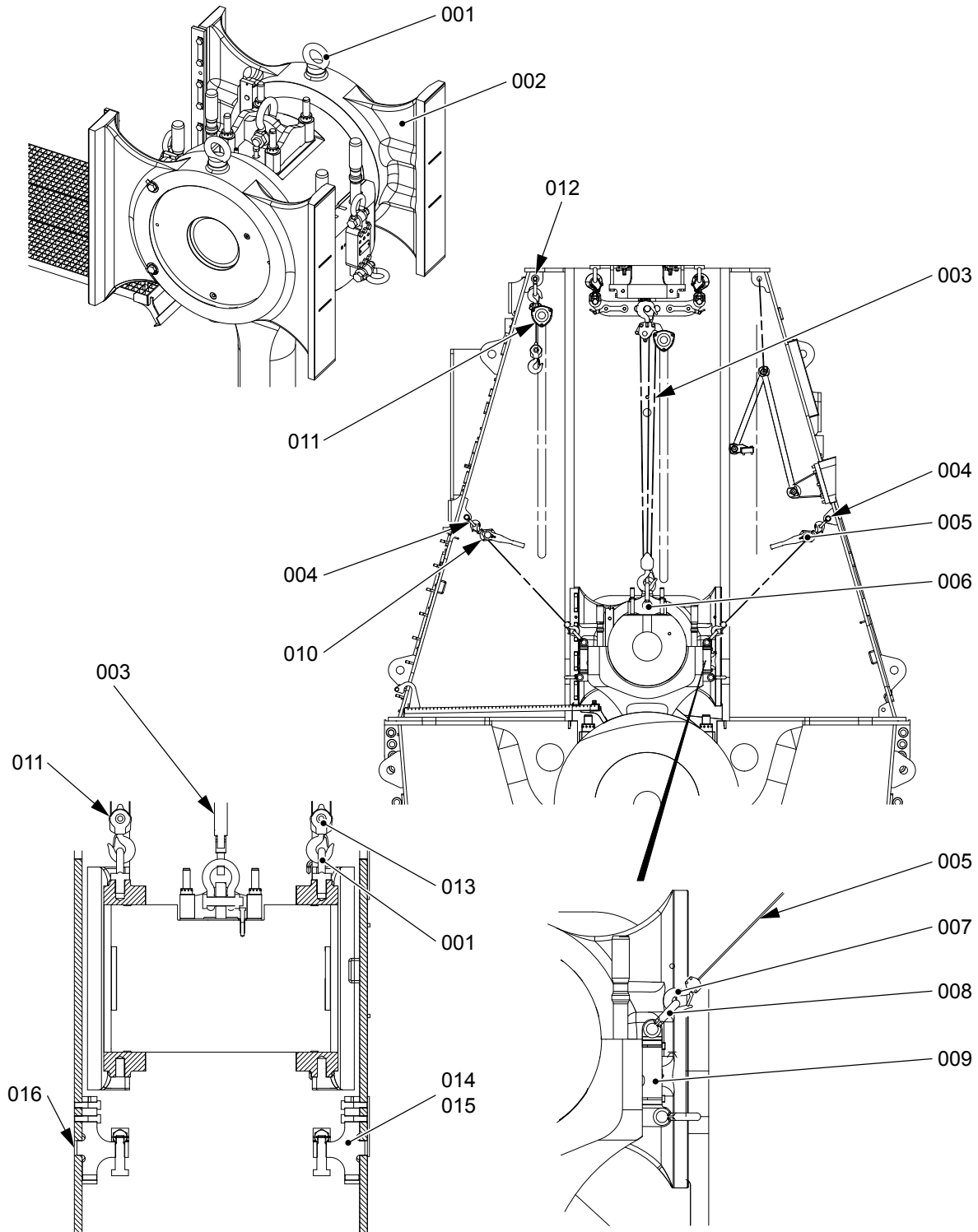
00744

- 12 Remove the toggle lever (001, [Figure 8-50](#)) from the crosshead pin. Let the toggle lever hang in the column.
- 13 Attach one of the two shackles (006) to the column.
- 14 Attach one of the two lever chain hoist (005) to the shackle (006) and to the platform (004).
- 15 Operate the chain hoist (005) to lift the platform (004).
- 16 Operate the turning gear to move the platform and tools up to a sufficient height.
- 17 Attach four of the eye bolts (008) to the cylinder block (007).
- 18 Attach two of the spur-gear chain block (012) to the eye bolts (008) and the shackles on the bracket (010).
- 19 Operate the chain blocks (012) to lift the bracket (010) to the bottom of the cylinder block (007).
- 20 Attach the bracket (010) to the eye bolts (008).
- 21 Remove the chain blocks (012) from the shackles on the bracket (010).
- 22 Attach the spur-gear chain block (011) to the bracket (010).

**Fig 8-50 Bracket - attach**

- 23 Attach the shackle (012, [Figure 8-51](#)) to the column on the fuel side.
- 24 Attach the chain block (011) to the shackle (012).
- 25 Operate the turning gear to move the crank of the applicable cylinder to BDC.
- 26 Remove the platform from the crosshead pin.
- 27 Attach the two eye bolts (001) to the guide shoes (002).
- 28 Attach the shackles (004) to the column as shown.
- 29 Attach the lever chain hoists (005, 010) to the shackles (004).
- 30 Attach the lever chain hoists (005, 010) to the two top shackles (008) on the lifting tools (009) on the connecting rod.
- 31 Attach the chain block (003) to the lifting tool (006).
- 32 Operate the lever chain hoists (005, 010) to put a light tension on their chains. Make sure that the primary load stays on the chain block (003).

Fig 8-51 Tools - attach

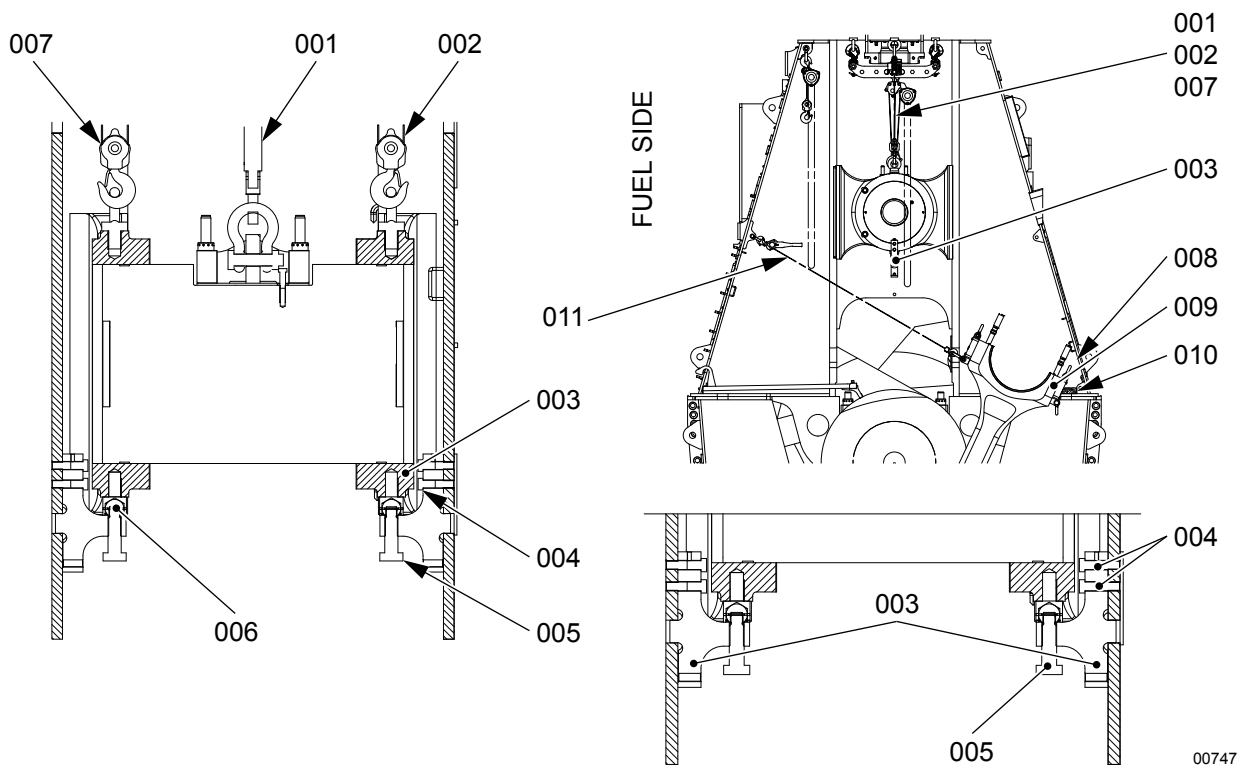


00746

- 33 Operate the chain block (001, [Figure 8-52](#)) to lift the crosshead pin to approximately 300 mm above the center of the pin holes in the column walls.
- 34 Attach the two chain blocks (002, 007) to the eye bolts on the guide shoes.

- 35 Put oil on the threads and surfaces that touch on the bolts (004) of each support (003).
- 36 Attach the two supports (003) to the columns with the bolts (004).
- 37 Torque the bolts (004) to the correct value, refer to section [16.1 Tightening instructions](#).
- 38 Operate the chain blocks (001, 002, 007) to lower the crosshead pin on to the supports (003). Make sure that the two cups (006) engage with the recesses in the crosshead.
- 39 Tighten the special screws (005).
- NOTE:** Make sure that the primary load stays on the chain of the spur-gearred chain block (001).
- 40 Put a wooden chock (010) in position as shown.
- 41 Operate the lever chain hoists (008, 011) to move the connecting rod (009) to the exhaust side. Continue until the connecting rod touches the wooden chock (010).
- 42 Remove the two lever chain hoists (008, 011).
- 43 Remove the supports (003) as follows:
- 43.1 Remove the special screw (005).
- 43.2 Loosen the bolts (005).
- 43.3 Remove the supports (003).
- 44 Operate the chain blocks (001, 002, 007) to lower the crosshead pin sufficiently to do the work.
- NOTE:** Make sure that the primary load stays on the chain block (001).

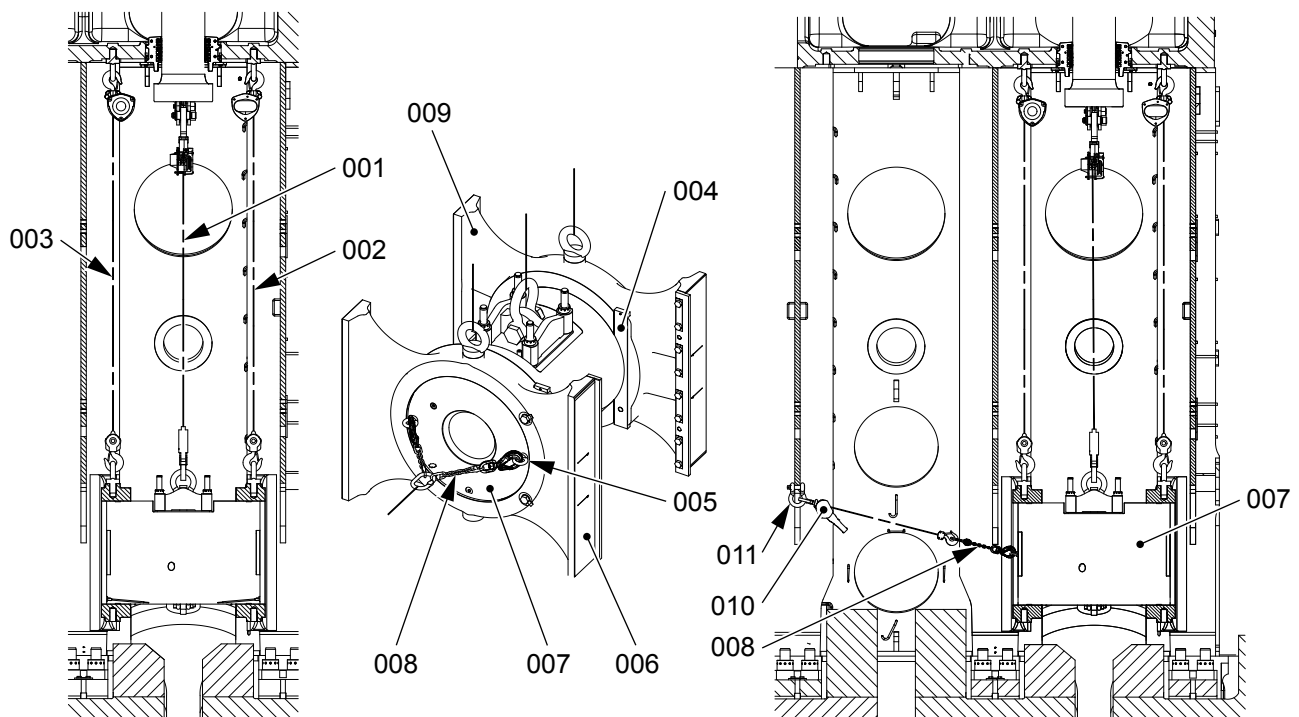
**Fig 8-52 Connecting rod - move**



- 45 Remove the two bolts, tab washers and holding plates (004, [Figure 8-53](#)) from the guide shoe (006 or 009).
- 46 When the crosshead pin (007) is in the second or next to last position, do as follows:
- 46.1 Attach the two eye bolts (005) to the crosshead pin (007).

- 46.2 Attach the chain (008) to the eye bolts (005).
- 46.3 Attach the shackle (011) to an applicable position on the column.
- 46.4 Attach the lever chain hoist (010) to the shackle (011) and the chain (008).
- 46.5 Operate the lever chain hoist (010) to apply tension to the chain.
- 46.6 Operate the lever chain hoist (010) to move the crosshead pin (007) away from the guide shoe (006 or 009).

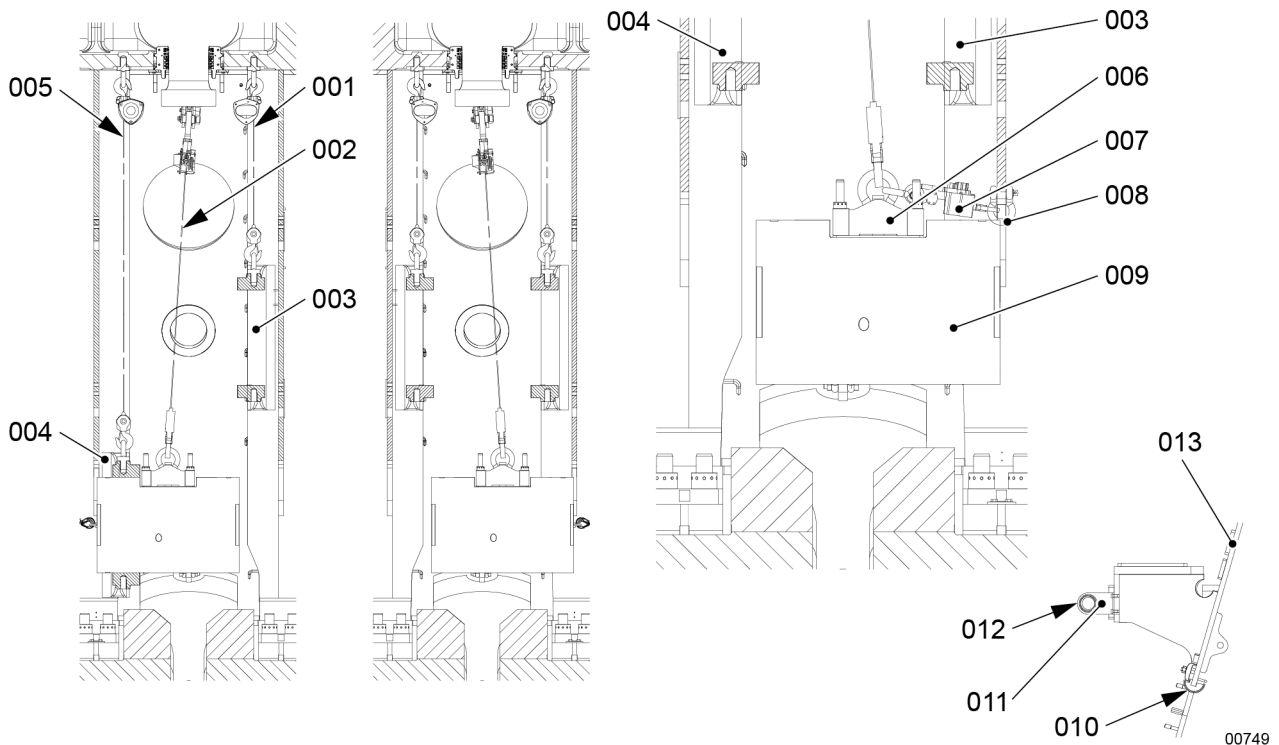
**Fig 8-53 Crosshead - move**



- 46.7 Operate the chain block (001, [Figure 8-54](#)) to lift the guide shoe (003).
  - 46.8 Remove the chain (008, [Figure 8-53](#)), eye bolts (005), shackle (011) and lever chain hoist (010).
  - 46.9 Attach the eye bolts (005) to the other end of the crosshead pin (007).
  - 46.10 Attach the shackle (011) to an applicable position on the column.
  - 46.11 Attach the lever chain hoist (010) to the shackle (011) and the chain (008).
  - 46.12 Do [Step 46.1](#) to [Step 46.8](#) for the other guide shoe.
- 47** When the crosshead pin is in the first or last cylinder position, do as follows:
- 47.1 Attach the eye bolt (008, [Figure 8-54](#)) to an applicable hole in the column.
  - 47.2 Attach the lever chain hoist (007) to the eye bolt (008) and the shackle on the lifting tool (006).
  - 47.3 Operate the lever chain hoist (007) to move the crosshead pin (009) from the guide shoe (004).
  - 47.4 Operate the chain block (005) to lift the guide shoe (004).
  - 47.5 Remove the lever chain hoist (007) and the eye bolt (008).
  - 47.6 Attach the eye bolt (008) to the other side of the column.
  - 47.7 Do [Step 47.2](#) to [Step 47.5](#) for the other guide shoe (003).

- 48 Remove the lever chain hoist (007) and the eye bolt (008).
- 49 Attach the deviation pipe (010) to the door frame (013).
- 50 Attach the deviation pipe (012) to the support (011) on the supply unit.

**Fig 8-54 Crosshead - remove**

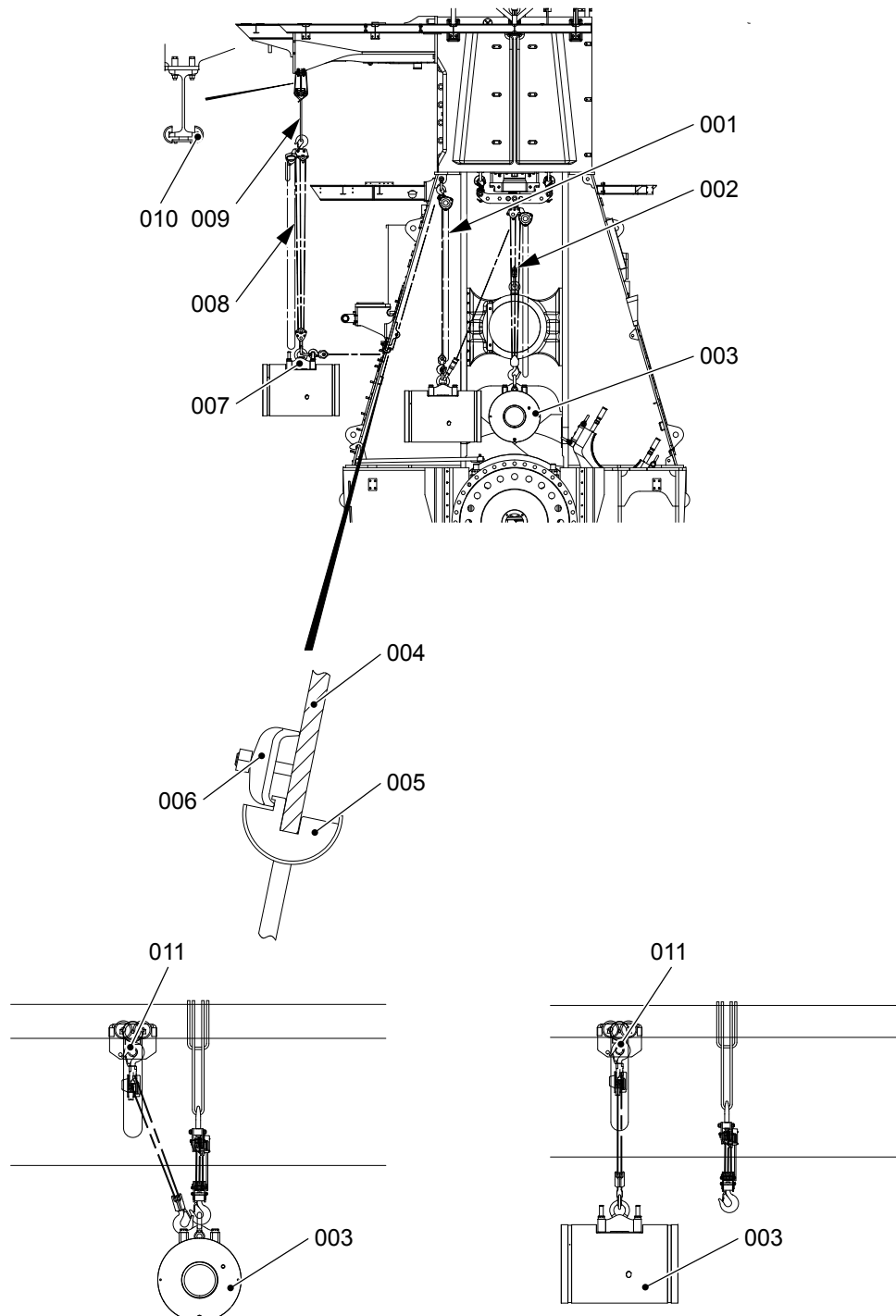


- 51 Attach the deviation pipe (010, [Figure 8-55](#)) to the support on the gallery.
- 52 Attach the sling (009) to the beam in the gallery.
- 53 Attach the spur-gear chain block (008) to the sling (009).
- 54 Turn the crosshead pin (003) 90°.
- 55 Attach the chain block (001) to the shackle on the lifting tool (007) on the crosshead pin (003).
- 56 Operate the chain blocks (001, 002) to move the crosshead pin (003) to the fuel side.  
**NOTE:** During this step, make sure that you keep tension on the chain block (002).
- 57 Attach the chain block (008) to the shackle on the lifting tool on the crosshead pin (003).
- 58 Apply tension to the chain of the chain block (008).
- 59 Remove the chain block (002).
- 60 Operate the chain blocks (008, 001) to move the crosshead pin (003) through the column door.
- 61 Lower the crosshead pin (003) on to the platform.
- 62 Remove the chain blocks (001) from the lifting tool (007).
- 63 If necessary, move the crosshead as follows:
  - 63.1 Attach the spur-gear trolley (011) to the gallery.
  - 63.2 Attach the sling (009) and the chain block (008) to the trolley (011).
  - 63.3 Attach the chain block (008) to the lifting tool (007).
  - 63.4 Operate the chain block (008) to lift the crosshead pin (003).

- 63.5** Move the trolley (011) and crosshead pin (003) to an applicable area.
- 63.6** Lower the crosshead pin on an applicable surface.
- 63.7** Remove the chain block (008) from the lifting tool (007) on the crosshead (003).



Fig 8-55 Crosshead - remove

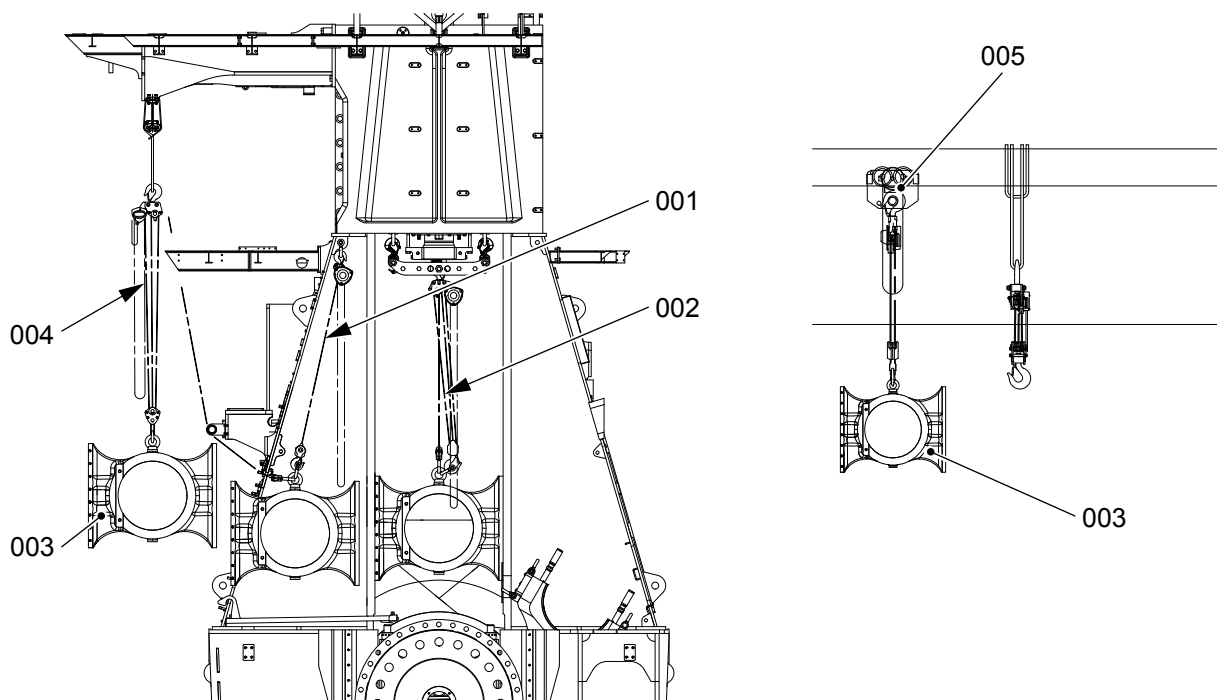


00750

- 64** Record the positions of the guide shoes (003, [Figure 8-56](#)). The shims of the guide shoes can have different dimensions (0.3 mm, 0.5 and 1 mm thickness). This will help you during the installation procedure.
- 65** Operate the chain blocks (002) to lower the guide shoes (003).

- 66 Attach the chain blocks (001, 004) to the eye bolt on one of the guide shoes.
- 67 Operate the chain blocks (001, 004) to put a light tension on the chains.
- 68 Remove the chain block (002).
- 69 Operate the chain blocks (001, 004) to move the guide shoe (003) through the door frame.
- 70 Lower the guide shoe (003) on to the platform.
- 71 Remove the chain block (004) from the eye bolt on the guide shoe (003).
- 72 Do [Step 64](#) to [Step 71](#) for the other guide shoe.
- 73 If necessary, move the guide shoe (00X) as follows:
  - 73.1 Attach the sling and the chain block (004) to the trolley (005).
  - 73.2 Attach the chain block (004) to the eye bolt on the guide shoe (003).
  - 73.3 Operate the chain block (004) to lift the guide shoe (003).
  - 73.4 Move the trolley (005) and guide shoe (003) to an applicable area.
  - 73.5 Lower the guide shoe (003) on an applicable surface.
  - 73.6 Remove the chain block (004) from the eye bolt on the guide shoe (003).

**Fig 8-56 Guide shoes - remove**



00751

### CLOSE UP

- None

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## 8.6.2 Crosshead - do a check of the clearances

### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Feeler gauge			1
Tool			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

Injury hazard. Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

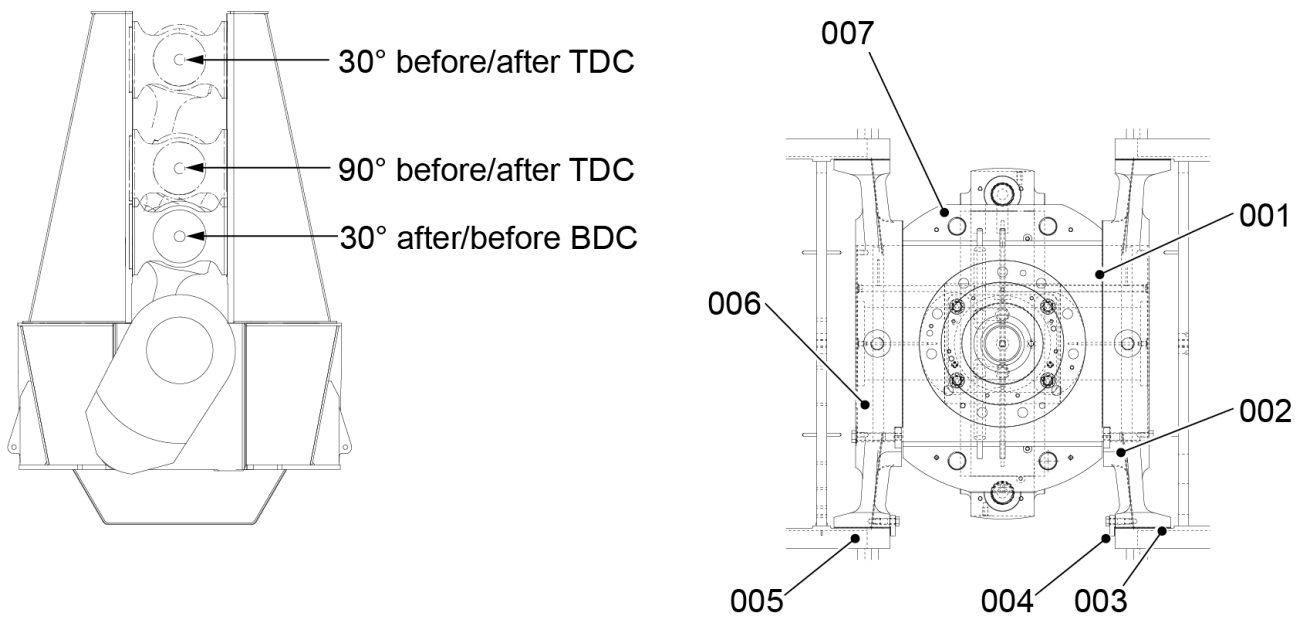
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

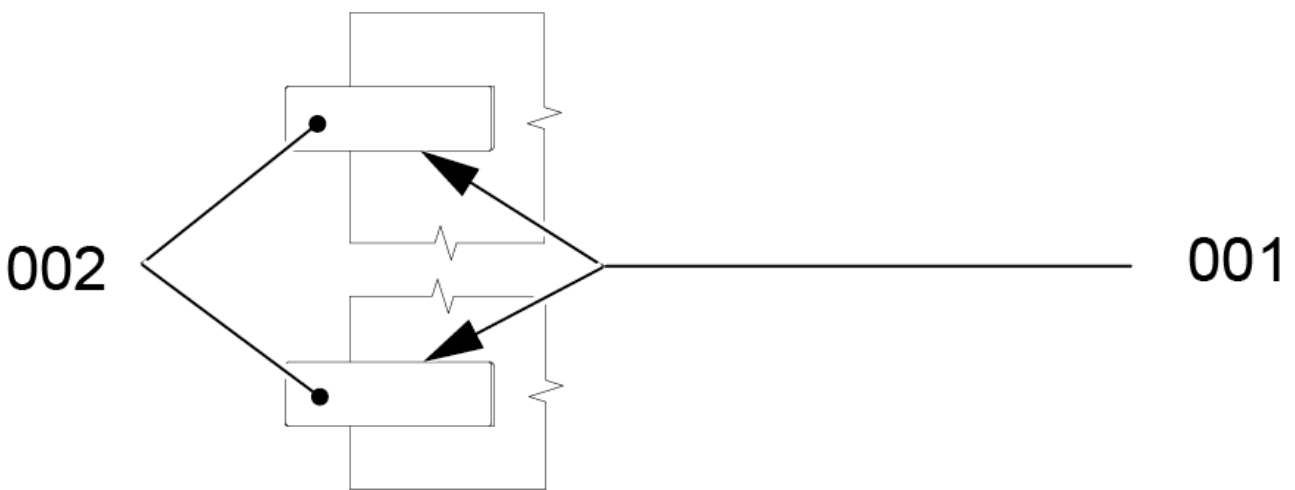
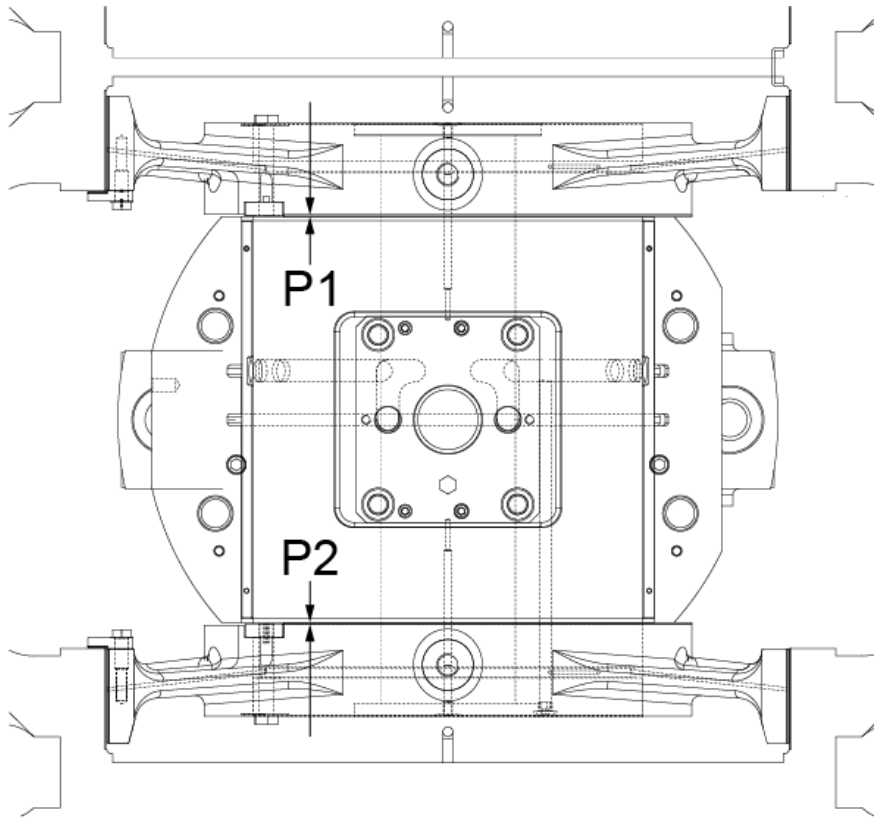
- 1 Measure the clearance (003, [Figure 8-57](#)) of the guide shoe and guide way at the first position as follows:
  - 1.1 Make sure that the related crank pin is in a position so that the guide shoes (006) touch the guide ways (004) on the fuel side (or the exhaust side).
  - 1.2 Operate the turning gear to move the crank to the first position.
  - 1.3 Measure the clearance (003) between the guide shoe (006) and the guide way (004), refer to section [3.3 Clearances - general](#).
- 2 Do [Step 1](#) again for the other positions.
- 3 Measure the full lateral clearance (001) between the top end bearing (007) and the guide shoes (006).
- 4 Measure the radial clearance (002) between the guide shoe (006) and the crosshead pin at all positions of the crosshead.

**Fig 8-57 Clearance checks**



- 5 Measure the clearance of the crosshead as follows:
  - 5.1 Make sure that the holding plates (002, [Figure 8-58](#)) of the guide shoes touch at the positions (001).
  - 5.2 Use the feeler gauge to measure the clearances (P1, P2).

**Fig 8-58 Dimensions check**



**CLOSE UP**

- None

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### 8.6.3 Crosshead - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Lifting tools			2
Spur-gearred chain block			1
Spur-gearred chain block			2
Spur-gearred chain block			1
Spur-gearred chain block			1
Lever chain hoist			2
Lifting tool			1
Eye bolt			6
Eye bolt			2
Shackle (WLL 8500 kg)			2
Shackles (WLL 13 500 kg)			2
Shackle (WLL 12 000 kg)			1
Sling			1
Spur-gearred trolley			1
Deviation pipe			1
Deviation pipe			1
Bracket			1
Deviation pipe			1
Chain			1
Support			1 or 2
Support			1
Platform			1

#### Supplies

Description	QTY
Bearing oil	A/R
Loctite 243	A/R



**Spare Parts**

Description	Part No.	CSN	QTY
Guide shoe			2
Crosshead pin			1

**SAFETY PRECAUTIONS****WARNING**

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are on the platform or near the flywheel.

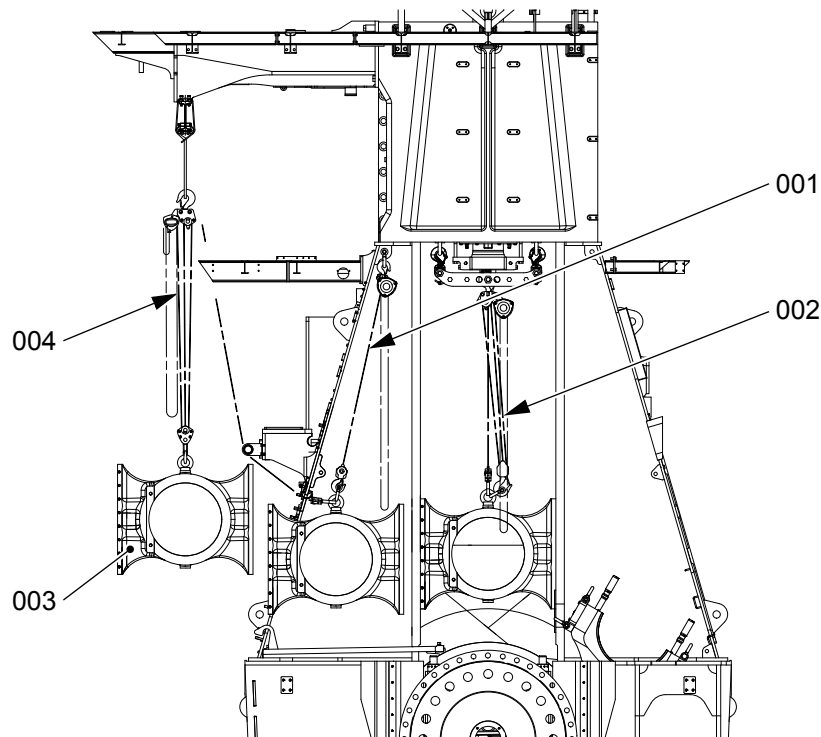
**PRELIMINARY OPERATIONS**

- None

## PROCEDURE

- 1 If necessary, attach the eye bolt to the guide shoe (003, [Figure 8-59](#)).  
**NOTE:** Make sure that you install the guide shoes in their original positions.
- 2 Attach the spur-gear chain block (004) and the spur-gear chain block (001) to the eye bolt on the guide shoe (00X).
- 3 Operate the chain blocks (004, 001) to move the guide shoe (003) through the column door frame.
- 4 Attach the spur-gear chain block (002) to the eye bolt on the guide shoe (003).
- 5 Remove the chain blocks (001, 004).
- 6 Operate the chain block (002) to lift the guide shoe (00X).
- 7 Do [Step 1](#) to [Step 6](#) for the other guide shoe.

**Fig 8-59 Guide shoe - move**

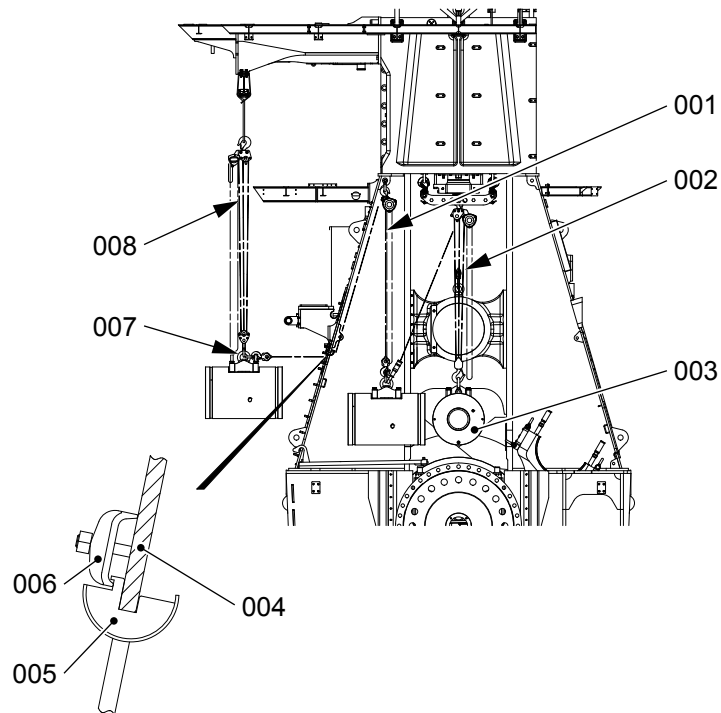


00753

- 8 Clean the (003, [Figure 8-60](#)) and all surfaces that touch.
- 9 Make sure that the surfaces of the crosshead pin (003) are clean and have no damage.
- 10 Apply to all surfaces that touch on the crosshead pin (003).
- 11 If necessary, attach the lifting tool (007) to the crosshead pin (003).
- 12 Attach the chain blocks (008, 001) to the eye bolt on the lifting tool (007).
- 13 Operate the chain blocks (008, 001) to lift the crosshead pin (003).
- 14 Operate the chain blocks (008, 001) to move the crosshead pin (003) through the column door frame.
- 15 Attach the chain block (002) to the lifting tool (007).
- 16 Apply tension to the chain block (002).
- 17 Remove carefully the chain blocks (008).

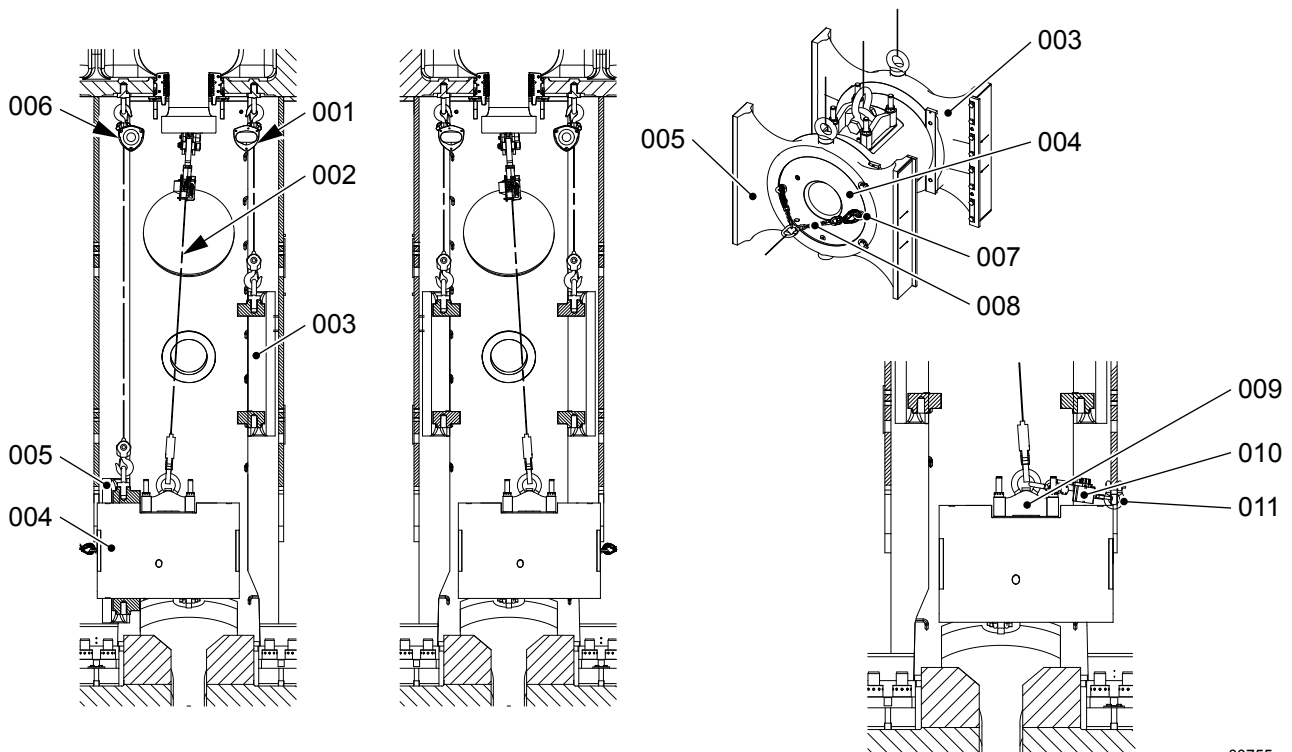
- 18 Turn the crosshead pin 90°.
- 19 Remove the deviation pipe (005).

**Fig 8-60 Crosshead - move**



00754

- 20 Operate the chain block (006, [Figure 8-61](#)) to lower the guide shoe (005). Align the guide shoe with the crosshead pin (004).
- 21 Attach the two eye bolt (007) to the crosshead pin (004).
- 22 Attach the chain (008) to the eye bolts (007).
- 23 Attach the eye bolt (011) to an applicable position on the column.
- 24 Attach the lever chain hoist (010) to the eye bolt 011) and the chain (008).
- 25 Operate the lever chain hoist (010) to pull the crosshead pin (004) into the guide shoe (005).
- 26 Remove the chain (008), the eye bolts (007, 011) and the lever chain hoist (010).
- 27 Do [Step 20](#) to [Step 26](#) for the other guide shoe (003).

**Fig 8-61 Guide shoes - install**

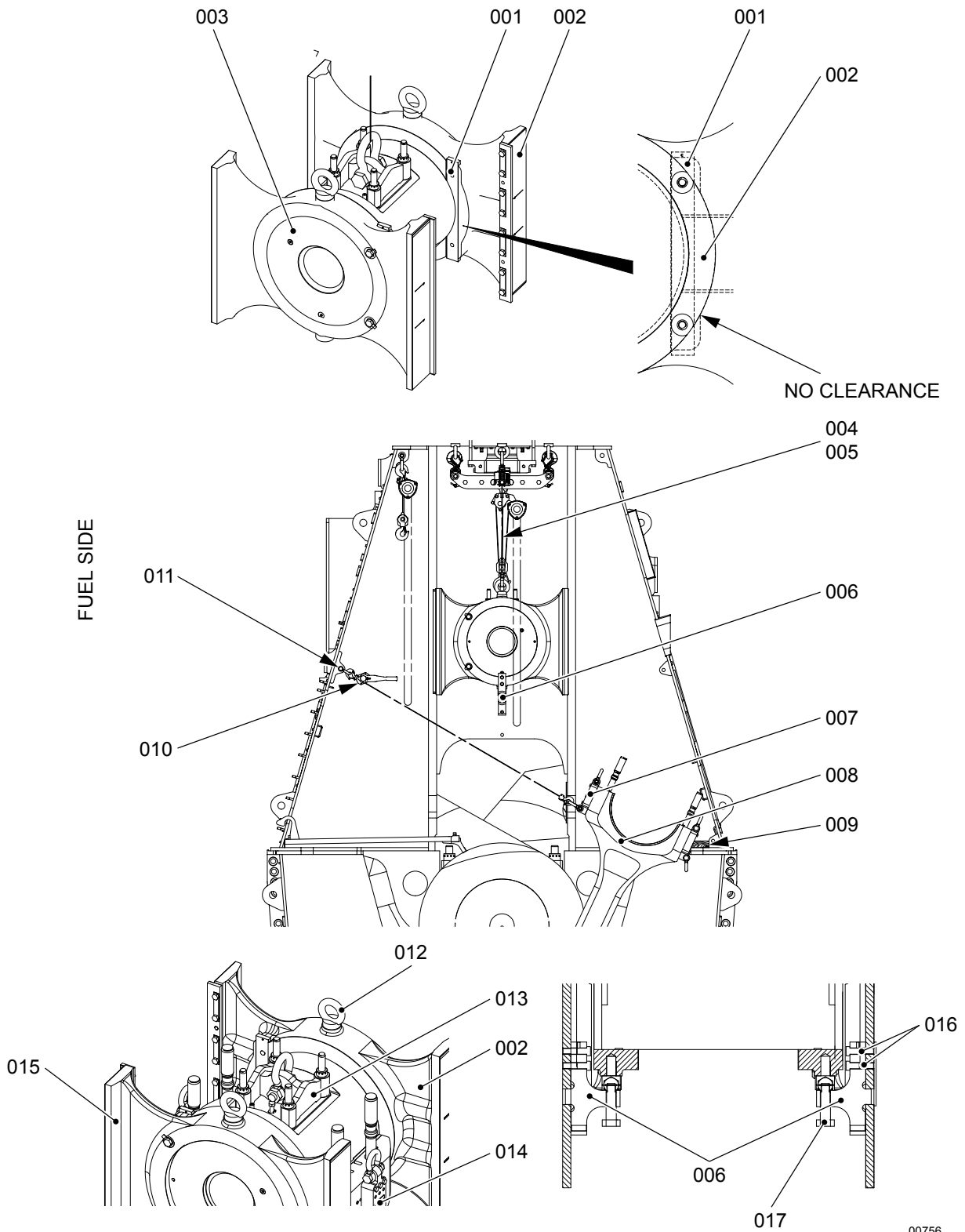
00755

- 28 Attach the two holding plates (001, [Figure 8-62](#)) to the guide shoe (002) with the tab washers and bolts.
- 29 Make sure that there is no clearance between the holding plates (001) and crosshead pin (003).
- 30 Operate the chain blocks (004, 005) to lift the crosshead approximately 300 mm above the center of the pin hole.
- 31 Use an applicable tool and sufficient personnel to attach the two supports (006) to the guide way.
- 32 Torque the four bolts (016) to the correct value, refer to section [16.1 Tightening instructions](#).
- 33 Tighten the two special screws (017).
- 34 Lower the crosshead pin (003) on to the supports (006)
- 35 Attach the lever chain hoist (010) to the shackle (011) on the column and to the shackle on the lifting tool (007) on the connecting rod (008).
- 36 Operate the lever chain hoist (010) to move the connecting rod (008) a small distance.
- 37 Remove the wooden block (009).
- 38 Attach the other lever chain hoist to the other shackle on the lifting tool (014).
- 39 Operate the lever chain hoists (011) to move the connecting rod (008) to the vertical position.
- 40 Operate the chain blocks (004, 005) to lift the crosshead pin (003) a small distance.
- 41 Loosen the two special screws (017).
- 42 Use an applicable tool and sufficient personnel to remove the two supports (006).
- 43 Operate the chain blocks (004, 005) to lower the crosshead pin (003) on to the connecting rod (008).

**NOTE:** During this step, make sure that the elastic bolts in the connecting rod align with the holes in the crosshead pin.

- 44** Remove the two lever chain hoists (011).
- 45** Use an applicable tool and sufficient personnel to remove the two lifting tools (007, 014) from the connecting rod (008).

Fig 8-62 Connecting rod - move

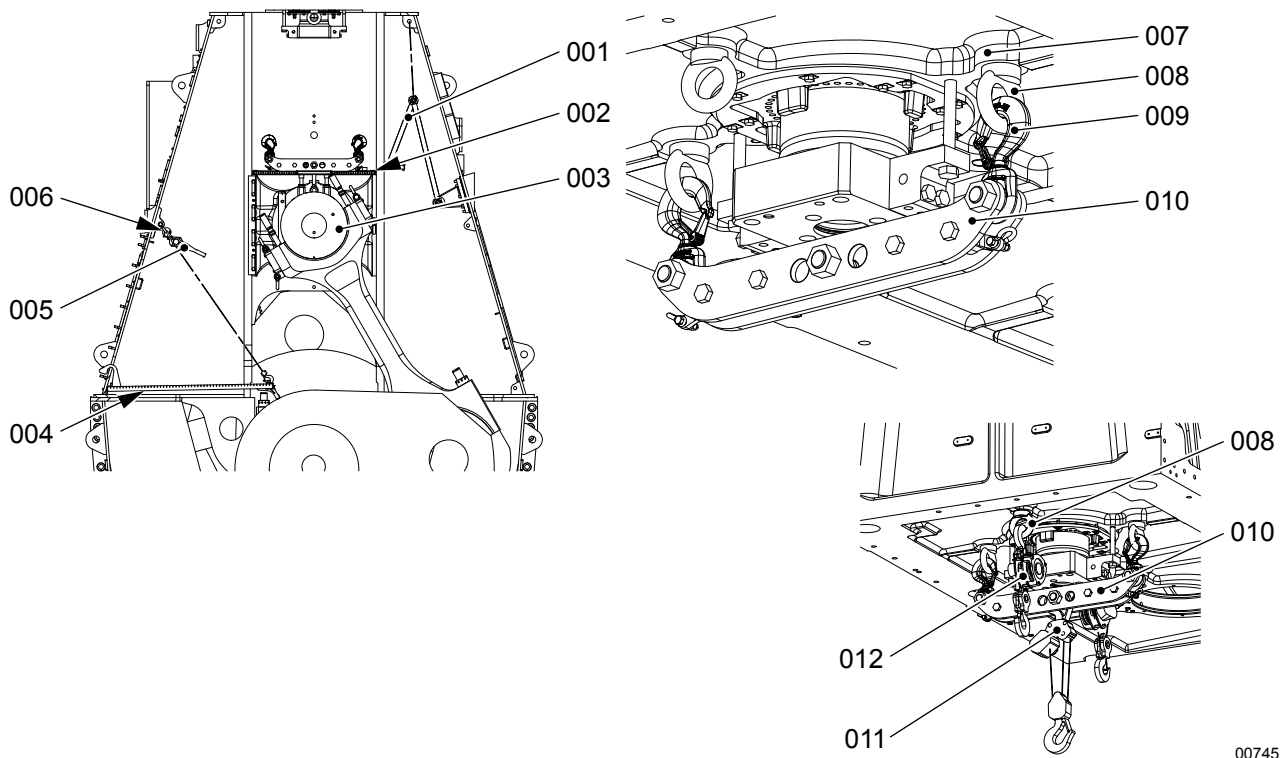


00756

- 46** Install the platform to top of the crosshead.
- 47** Attach the lever chain hoist (012, [Figure 8-63](#)) to the shackle (008) and the platform.

- 48 Operate the lever chain hoist (004) to lift the platform a small distance from the crankshaft.
- 49 Operate the turning gear to lift the platform sufficiently to remove the tools from the cylinder block.
- 50 Use the chain blocks (012) to remove the bracket (010).
- 51 Remove the chain blocks (012) and eye bolts (008).
- 52 Put the removed tools on the platform.
- 53 Operate the turning gear to lower the crank to BDC.
- 54 Remove the tools from the platform.
- 55 Remove the platform.
- 56 Remove all remaining eye bolts, chain blocks, lever chain hoists and shackles etc.
- 57 Remove the protection from the crosshead pin.

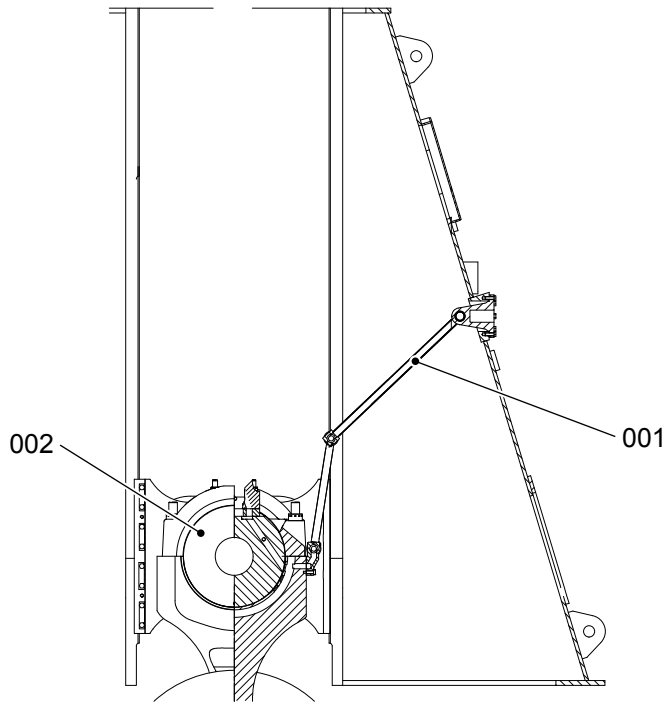
Fig 8-63 Tools - remove



### CAUTION

Damage will occur to an incorrectly connected toggle lever. Make sure that you connect the toggle lever correctly.

- 58 Attach the toggle lever (001, [Figure 8-64](#)) to the crosshead pin (002). Make sure that the toggle lever is in the correct position shown.
- 59 Do the clearance checks, refer to section [8.6.2 Crosshead - do a check of the clearances](#).

**Fig 8-64 Toggle lever - attach**

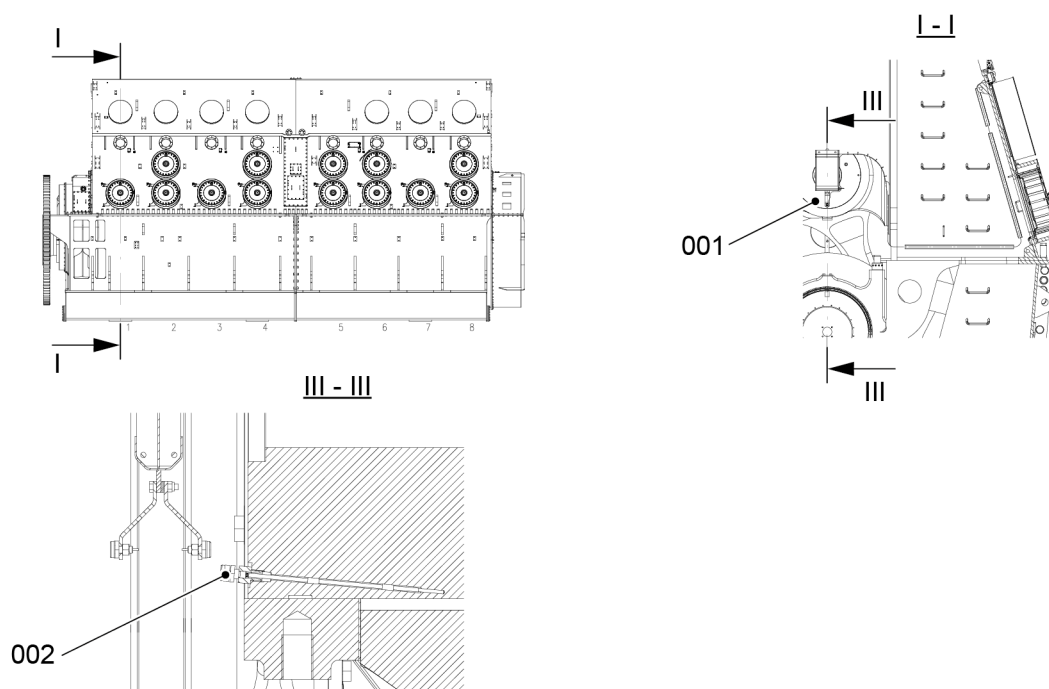
NOTE: THE CRANK SHAFT IS AT BDC

00757

- 60** Apply Loctite 243 to the thread of the temperature sensor (002, [Figure 8-65](#)).
- 61** Attach the temperature sensor (002) to the crosshead (001).
- 62** Connect the electrical connection to the temperature sensor (002).



Fig 8-65 Crosshead bearing - temperature sensor



00518

- 63 Install the round nuts to the elastic studs on the connecting rod, refer to section 4.2 [Tighten a round nut with a pre-tensioner](#).
- 64 Install the top bearing cover, refer to section [\[section not applicable for this engine\]](#).
- 65 Set to on the lubricating oil pump.
- 66 Make sure that the crosshead and the bottom end bearings of the connecting rod have sufficient lubrication.
- 67 Set to off the lubricating oil pump.

### CLOSE UP

- None

## 8.7 Piston

### 8.7.1 Piston (installed) - do checks of the surface and clearances

#### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	A/R

#### Support equipment

Description	Part No.	CSN	QTY
Template			1
Feeler gauge			1

#### Supplies

Description	QTY
Emery cloth	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

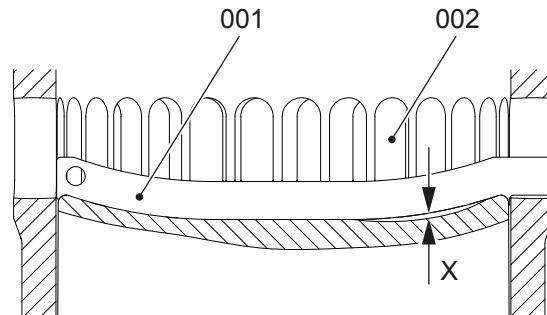
## PROCEDURE

- 1 Operate the turning gear to move the piston to BDC.
- 2 Look through the scavenge ports (002, [Figure 8-66](#)) for burn scars on the piston head.
- 3 Put the template (001) through the related scavenge port (002).
- 4 Use the feeler gauge to measure the depth X of the burn scars.  
**NOTE:** You can also use a depth gauge to measure the depth X of the burn scars.
- 5 Compare the measured depth X with the maximum depth X, refer to [Table 8-6 - Maximum depth X for burn scars](#).

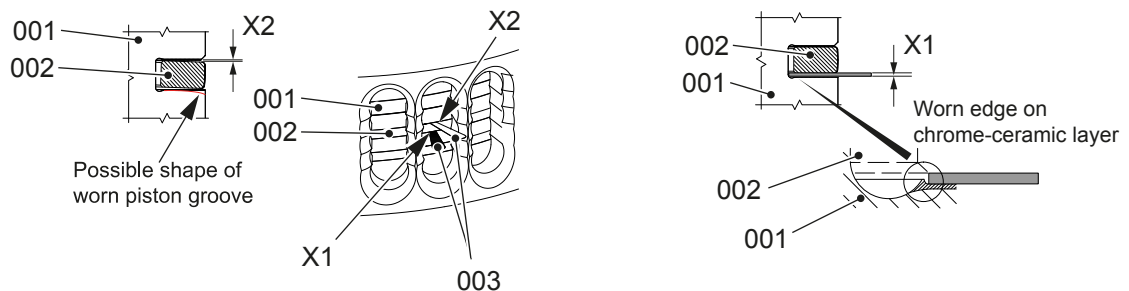
**Tab 8-6 Maximum depth X for burn scars**

Engine type	Maximum depth X [mm]
X35, X35-B	5.0
X40, X40-B X40DF	5.0
X52 X52DF	10.0
X62, X62-B X62DF	10.0
X72, X72-B X72DF	10.0
X82, X82-B X82DF	10.0
X92, X92-B X92DF	10.0

- 6 Remove the template (001).
- 7 If there are more burn scars, do [Step 3](#) to [Step 6](#) again through an other scavenge port.
- 8 If the burn scars are less than the maximum depth, do as follows:
  - 8.1 Use an applicable tool to grind the burn scars.
  - 8.2 Use an emery cloth to make sharp edges smooth.
- 9 If the burn scars are equal or more than the maximum depth, do as follows:
  - 9.1 Remove the piston, refer to section [8.7.3 Piston - remove](#).
  - 9.2 Disassemble the piston, refer to section [8.7.4 Piston - disassemble](#).
  - 9.3 Use surface welding to repair the piston head to its original thickness.
  - 9.4 Assemble the piston, refer to section [8.7.6 Piston - assemble](#).
  - 9.5 Install the piston, refer to section [8.7.7 Piston - install](#).

**Fig 8-66 Top surface - dimensions check**

- 10 Find the cause of the burn scars and repair the fault.
- 11 Operate the turning gear to move the piston (001, [Figure 8-67](#)) until you can see the piston rings (002) through the scavenge ports.

**Fig 8-67 Piston ring - clearance**

- 12 Measure the clearance of the first piston ring at an applicable position as follows:
  - 12.1 Measure the clearance X1 and X2 with the feeler gauge.
 

**NOTE:** If there is an edge of worn material on the chrome-ceramic layer or in the piston groove, you can not fully push the feeler gauge into the groove.

**NOTE:** Clearance X2 can be more than zero, if the piston ring is tilted or if there is contamination in the piston groove.
  - 12.2 Record the total clearance  $X = X1 + X2$ .
- 13 If possible do [Step 12](#) again on different positions of the first piston ring.
- 14 Do [Step 12](#) and [Step 13](#) again for the other piston rings.
- 15 Compare the recorded clearances with the maximum permitted values, refer to section [3.3 Clearances - general](#).
- 16 If the clearance is more than the permitted value, do as follows related to the defective item:
  - 16.1 Replace the defective piston rings.
  - 16.2 Repair the defective piston head.
 

**NOTE:** For the repair of piston heads, speak to the nearest WinGD Service Center.
- 17 Record the data that follow:
  - All dimensions

- Date of the overhaul
- Operation hours of the different components
- Operation hours of the engine.

**CLOSE UP**

- None

## 8.7.2 Piston - prepare before removal

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Distance holder			2
Piston suspension device			1
Plate			2

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or inside the engine.

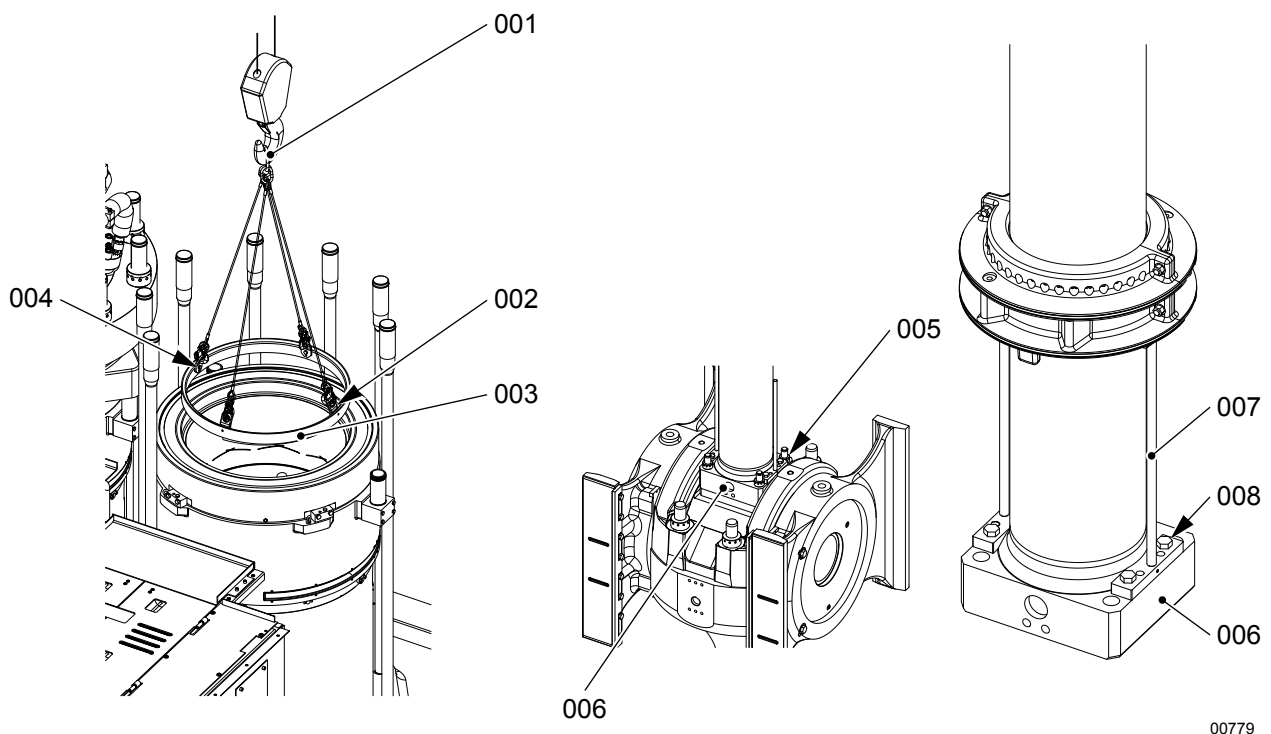
## PRELIMINARY OPERATIONS

- The cylinder cover must be removed, refer to section [7.5.1 Cylinder cover - remove](#)
- The engine temperature must be cool.

## PROCEDURE

- 1 Attach the four plates (002, [Figure 8-68](#)) to the antipolishing ring (003) with the four screws (004).
- 2 Connect the engine room crane to the lifting tool (001).
- 3 Attach the tool 94209 to the antipolishing ring (003).
- 4 Attach the lifting tool (001) to the tool 94209.
- 5 Remove the antipolishing ring (003).
- 6 Look at the area where the piston stroke ends. If there is a wear edge, refer to section [7.1.4 Cylinder liner - grind](#).
- 7 Operate the turning gear to move the crank to BDC.
- 8 Remove the round nuts (005) from the piston rod foot (006), refer to section [4.3 Loosen a round nut with a pre-tensioner](#).
- 9 Attach the two distance holders (007) to the piston rod foot (006) with the screws (008).
- 10 Remove the knee lever from the crosshead connection.
- 11 Attach the knee lever in a save position.

**Fig 8-68** Piston - Preparation

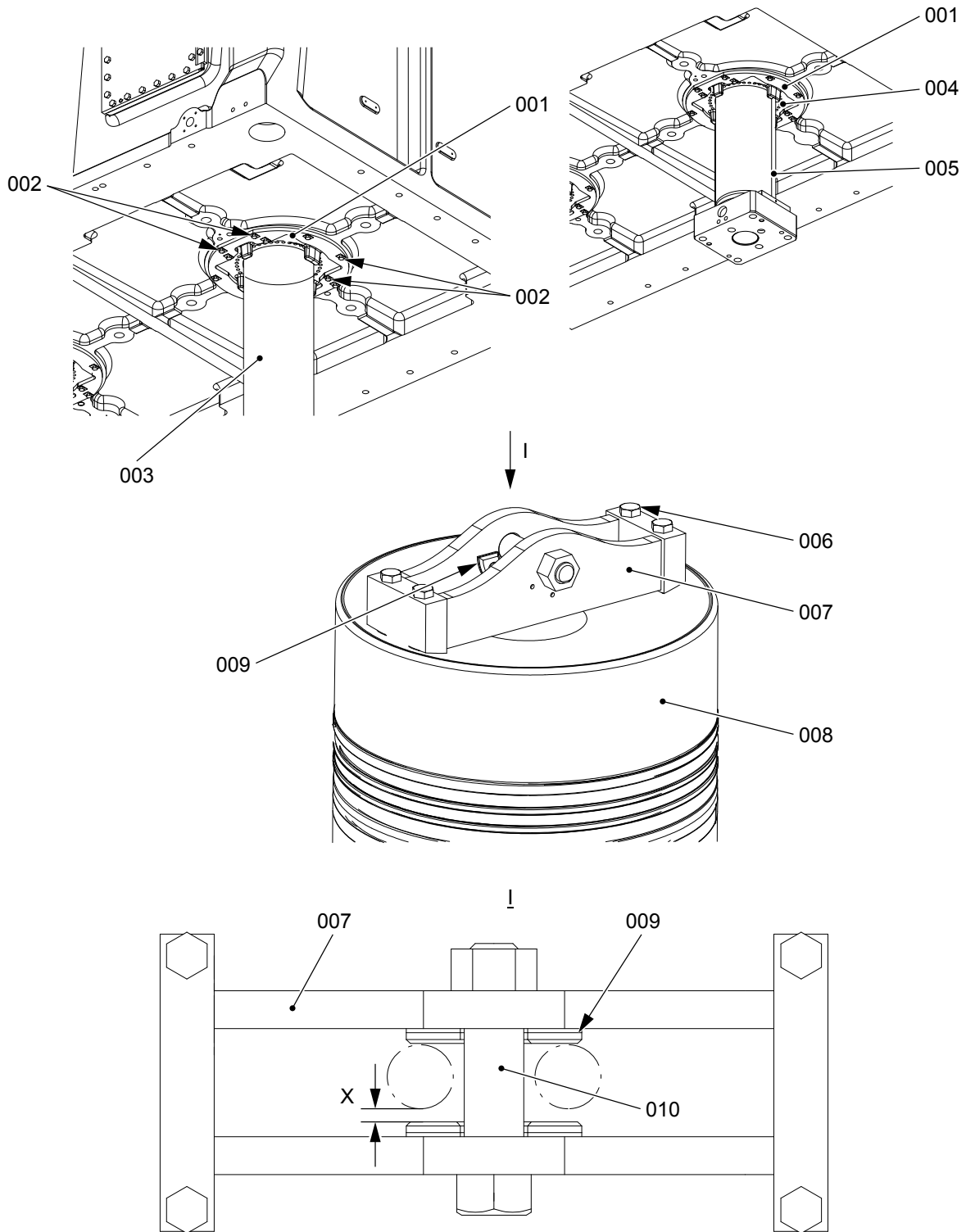


- 12 Remove the four bolts (002) from the gland box support (001, [Figure 8-69](#)).
- 13 Operate the turning gear to move the crosshead up until the distance pieces (005) touch the gland box.
- 14 Operate the turning gear to push out the gland box out of the cylinder jacket.
- 15 Continue to operate the turning gear to move the piston to TDC.
- 16 Clean the threads of the three holes and the top part of the piston crown.
- 17 Make sure that the lifting tool 94341 is clean.
- 18 Remove the six bolts and the three brackets.

- 19 Apply Molykote past G-n to the threads of the six bolts.
- 20 Use the engine room crane to put the lifting tool 94341 in position of the piston crown.
- 21 Attach the three brackets to the lifting tool with the six bolts. Make sure that the brackets fully engage in the holes in the piston crown.
- 22 Torque the four screws to the related value, refer to section [16.1 Tightening instructions](#).



Fig 8-69 Piston - Preparation before removal (example)



00780

**CLOSE UP**

- None

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### 8.7.3 Piston - remove

#### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Piston support			1
Cover			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

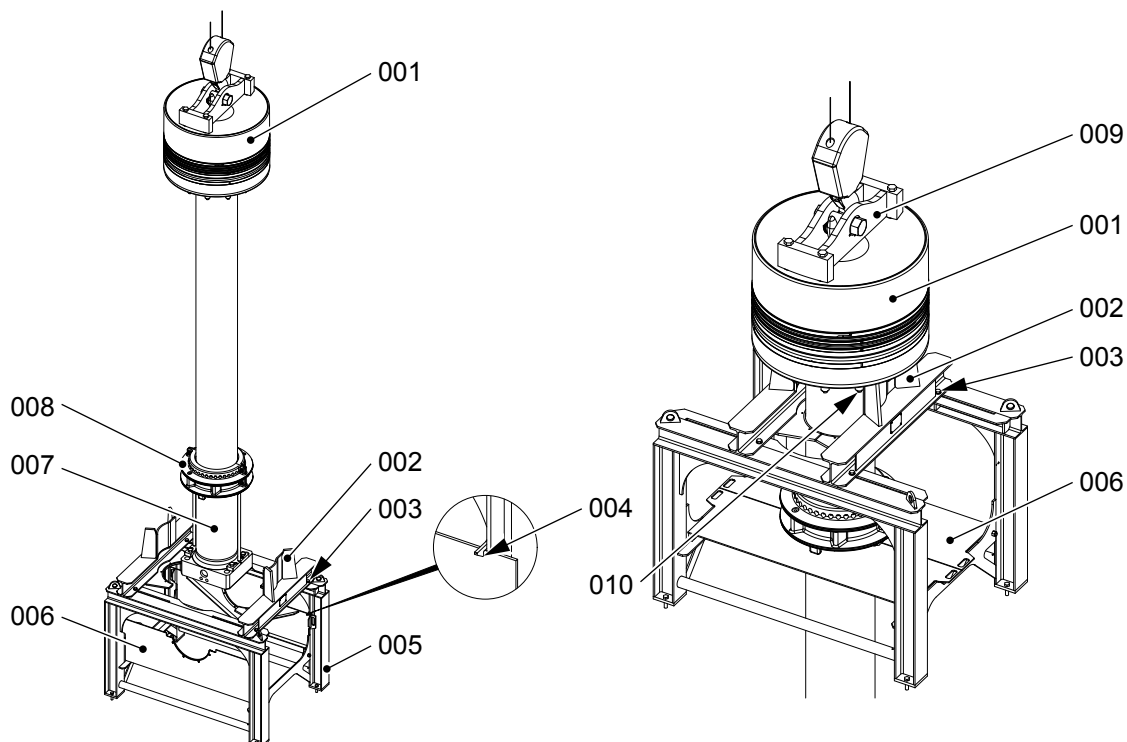
#### PRELIMINARY OPERATIONS

- The piston must be prepared for removal, refer to section [8.7.2 Piston - prepare before removal](#)

## PROCEDURE

- 1 Make sure that the piston support (005, [Figure 8-70](#)) in position on the top platform.
- 2 Attach the engine room crane to the lifting tool (009).
- 3 Carefully operate the engine room crane to lift the piston (001) from the cylinder liner.  
**NOTE:** During this step, make sure that the piston rod foot does not touch the gland box support.
- 4 Loosen the screws (003) of the device (005) and push the supports (002) fully out.
- 5 Open the two plates (006).
- 6 Lock the two plates (006) in position with the bars (004).
- 7 Lower the piston (001) and the gland box (008) until the piston rod foot is below the plates (006).
- 8 Close the plates (006).
- 9 Push in the supports (002).
- 10 Tighten the screws (003).
- 11 Lower the piston on to the supports (002). Make sure that the supports (002) are between the round nuts (010).
- 12 Remove the engine room crane from the suspension device (009).
- 13 Install the cover to the piston rod bore.
- 14 If necessary, disassemble the gland box, refer to section [7.4.1 Piston rod gland - remove](#).

**Fig 8-70** Piston - remove (example)



00778

**CLOSE UP**

- None

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## 8.7.4 Piston - disassemble

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Hydraulic unit			1
Pressure gauge			1
Distributing piece			1
Flexible hose			5
Jacking screws			3
Jacking screws			2
Jacking screws			3
Lifting tool			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

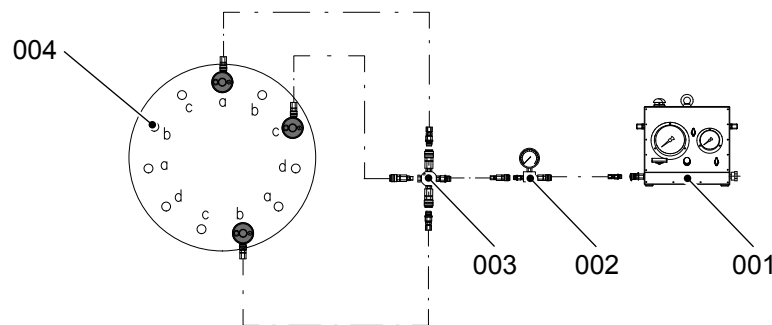
- The piston must be removed, refer to section [8.7.3 Piston - remove](#)



## PROCEDURE

- 1 Prepare the piston for disassembly.
  - 1.1 Attach the hydraulic unit (001, [Figure 8-71](#)), the pressure gauge (002), the distributing piece (003) and the flexible hoses as shown.
  - 1.2 Remove the 11 round nuts (004) in the sequence given, refer to section [4.3 Loosen a round nut with a pre-tensioner](#).

**Fig 8-71 Piston - Preparation before disassembly**

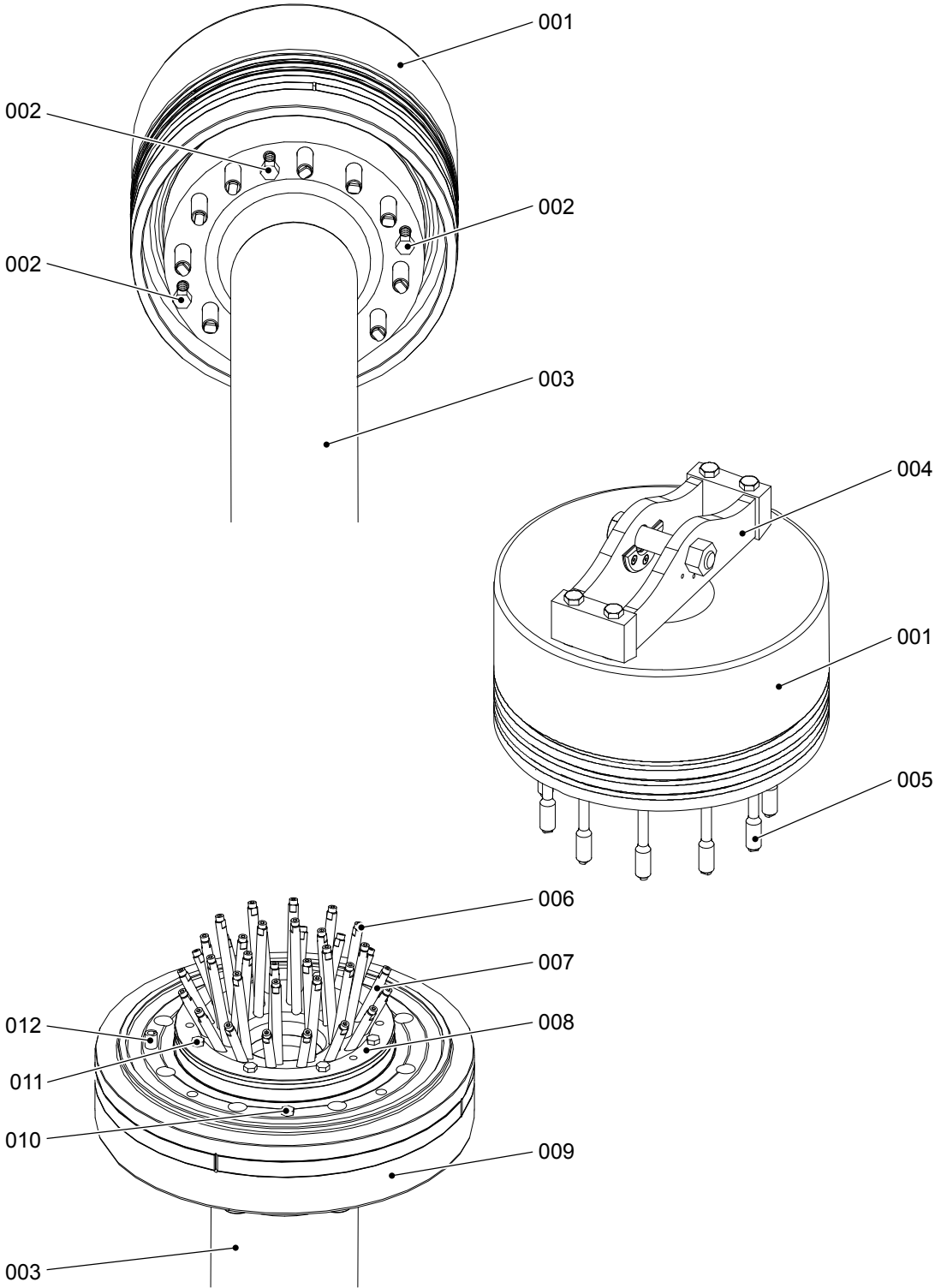


00782

- 2 Put the three jacking screws (002, [Figure 8-72](#)) fully into the three tap holes in the top of the piston rod (003). Make sure that the jacking screws (002) touch the piston head (001).
- 3 Tighten equally the three jacking screws (002) until there is a clearance between the piston head (001) and the piston rod (003).
- 4 Attach the lifting tool (004) to the piston head (001) with the four screws (006).
- 5 Torque the bolts to the correct value, refer to section [16.1 Tightening instructions](#).
- 6 Attach the engine room crane to the lifting tool (004).
- 7 Operate the engine room crane to lift the piston head (001).
- 8 Move the piston head (001) to an applicable area.
- 9 Remove the three jacking screws (002) from the piston rod (003).
- 10 Remove the piston skirt (010) from the piston rod (003) as follows:
  - 10.1 Remove the two screws (011).
  - 10.2 Use the jacking screws to separate the piston skirt (010) from the piston rod (003).
  - 10.3 Lift the piston skirt (010) from the piston rod (003).
 

**NOTE:** When you lift the piston skirt (010) make sure that the spring dowel pin (013) does not catch.
- 11 Remove the eight screws (012).
- 12 Use the two jacking screws to remove the spray plate (009) from the piston rod (003).
- 13 If necessary, remove the pipes (008) and nozzles (007).
- 14 Remove the lifting tool (004).
- 15 Do a check of the top surface of the piston head (001), refer to section [8.7.5 Piston \(removed\) - do checks of the surface and clearances](#).

Fig 8-72 Piston - disassemble (example)



00781

**CLOSE UP**

- None

## 8.7.5 Piston (removed) - do checks of the surface and clearances

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Template			1
Feeler gauge			1
Calliper gauge			1
Inside micrometer set			1

### Supplies

Description	QTY
Emery cloth	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

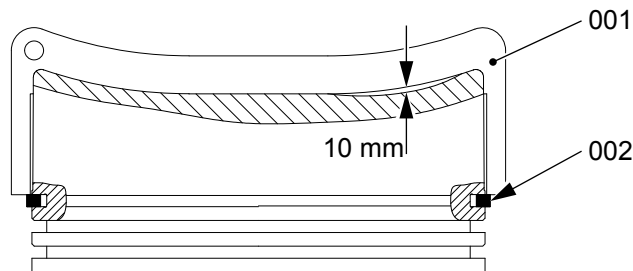
### PRELIMINARY OPERATIONS

- The piston must be removed, refer to section [8.7.3 Piston - remove](#)
- The piston rings must be removed, refer to section [8.8.1 Piston ring - remove](#)

## PROCEDURE

- 1 Put the template (001, [Figure 8-73](#)) in position on the top piston ring (002).
- 2 Turn the template (001) around the axis of the piston head.
- 3 Use the feeler gauge to measure the depth of the burn scar(s).  
**NOTE:** You can also use a depth gauge to measure the depth of the burn scar(s).
- 4 Remove the template (001).
- 5 If the burn scars are less than 10 mm, do as follows:
  - 5.1 Use an applicable tool to grind the burn scars.
  - 5.2 Use emery paper to make sharp edges smooth.
- 6 If the burn scars are 10 mm or more, do as follows:
  - 6.1 Disassemble the piston head, refer to section [8.7.4 Piston - disassemble](#).
  - 6.2 Use surface welding to get the piston head to its original thickness.
  - 6.3 Assemble the piston, refer to section [8.7.6 Piston - assemble](#).

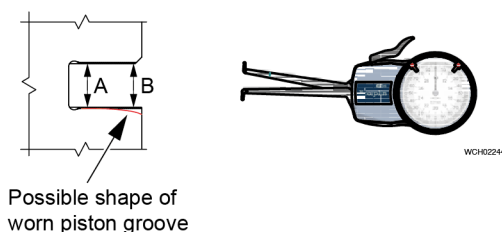
**Fig 8-73 Top surface - dimensions check**



00776

- 7 Find the cause of the burn scars and repair the fault.
- 8 Measure the thickness of the first piston ring at a minimum of four locations around the circumference of the first piston ring.
- 9 Measure the height at point A and point B at a minimum of four locations around the circumference of the related piston groove.  
**NOTE:** You can use the calliper gauge or the inside micrometer set. If you have none of these instruments, you can use a piece of a piston ring and a feeler gauge.

**Fig 8-74 Piston groove clearance - calliper gauge**



00097

- 10** Record the values.
- 11** Use the formula that follows to calculate the piston ring clearance:
- $C = GH - RT$  with the values that follow:
- C = clearance
  - GH = measured height of the piston ring groove (mm)
  - RT = nominal piston ring thickness (mm).
- 12** Do [Step 8](#) to [Step 11](#) again for the other piston rings and piston grooves.
- 13** Compare the calculated clearances with the maximum permitted values, refer to section [3.3 Clearances - general](#).
- 14** If a clearance is more than the permitted value, do [Step 14.1](#) or [Step 14.2](#) related to the defective item.
- 14.1** Replace the piston rings.
- 14.2** Repair the piston head.
- NOTE:** For the repair of piston heads, speak to the nearest WinGD Service Center.
- 15** Measure the diameter of the piston skirt.
- 16** Compare the measured value with the minimum permitted value, refer to section [3.3 Clearances - general](#).
- 17** If the piston skirt is too small, install a new piston skirt.
- 18** Record the data that follow:
- All dimensions
  - Date of the overhaul
  - Operation hours of the different components
  - Operation hours of the engine.

## CLOSE UP

- None

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## 8.7.6 Piston - assemble

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			1
Hydraulic unit			1
Pressure gauge			1
Distributing piece			1
Flexible hose			5

### Supplies

Description	QTY
Loctite No. 0270	A/R
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			2
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- None



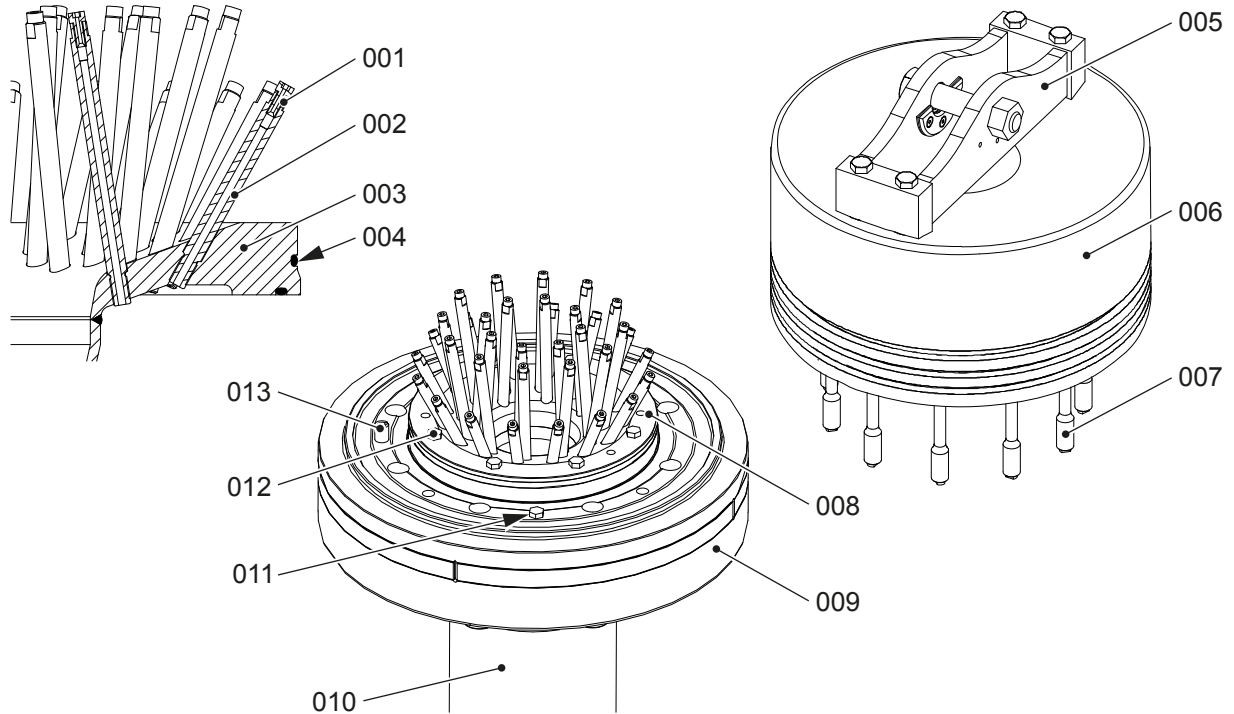
## PROCEDURE

- 1 If the pipes (002, [Figure 8-75](#)) were removed, install the pipes as follows:
  - 1.1 Apply Loctite to the bottom thread of the pipe (002).  
**NOTE:** Do not install pipes that have damage.
  - 1.2 Use an applicable tool to install the pipe (002) to the spray plate (003).
  - 1.3 Apply Loctite to the thread of the nozzle (001).
  - 1.4 Use an applicable tool to install the nozzle (001) to the pipe (002).
- 2 Put oil on the new O-rings (004).
- 3 Attach the two new O-rings (004) on the spray plate (003).
- 4 Install a new O-ring to the piston rod.
- 5 Attach the spray plate (003) to the piston rod (010) with the bolts (012).
- 6 Symmetrically torque the bolts (012) related to [Table 8-7 - Torque values](#).

**Tab 8-7 Torque values**

Engine type	1. step	2. step
X52 X52DF	15 Nm	40°
X62 / -B X62DF	20 Nm	45°
X72 / -B X72DF	20 Nm	45°

- 7 Attach the piston skirt (009) to the piston rod (010) with the screws (011).  
**NOTE:** During this step, make sure that the dowel pin (012) engages in the related hole in the piston skirt (009).
- 8 Attach the engine room crane to the lifting tool (005).
- 9 Operate the engine room crane to lower the piston head (006) on to the piston skirt (009). Make sure that the dowel pin (013) engages with the hole in the piston skirt.

**Fig 8-75** Piston - assemble (example)

- 10** Attach the hydraulic unit, the pressure gauge, the distributing piece and the flexible hoses.
- 11** Install the round nuts to the elastic studs in the sequence given, refer to section 4.2 [Tighten a round nut with a pre-tensioner.](#)

### CLOSE UP

- None

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## 8.7.7 Piston - install

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Installation tool			1
Lifting tool			1
Piston suspension device			1
Distance holder			2
Lifting plate			4

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Piston			1

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

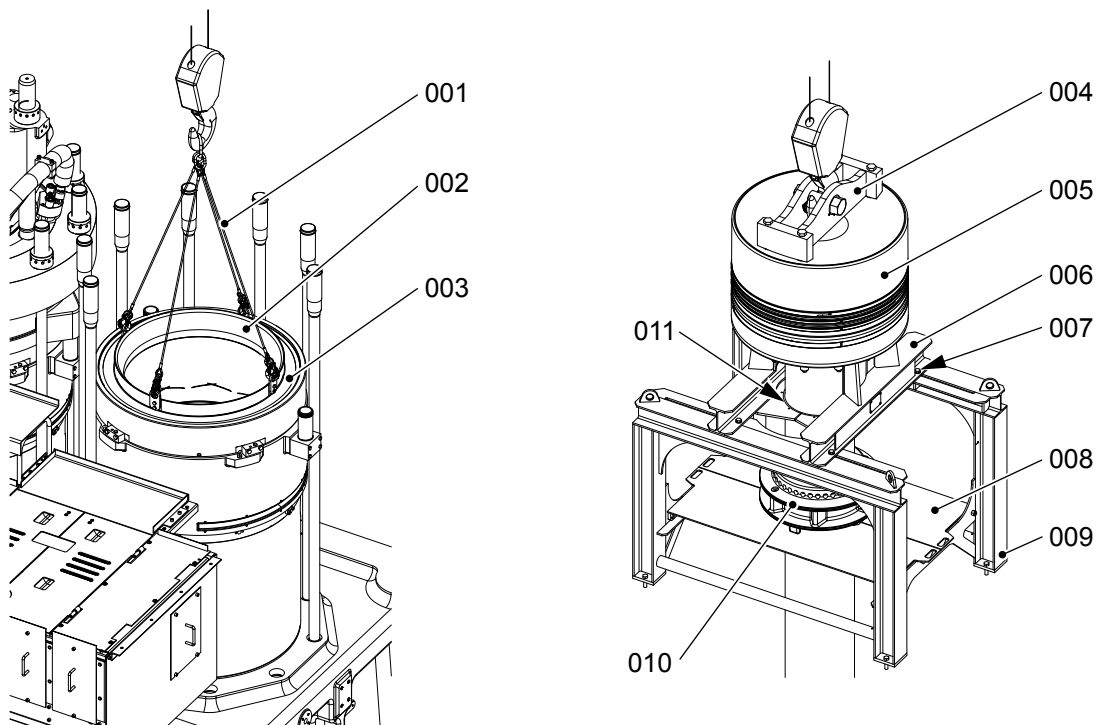
## PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Clean all parts of the piston, piston rings, gland box bore, cylinder liner, cylinder liner bore and the installation tool (002, [Figure 8-76](#)).
- 2 Apply oil to the piston, piston rings, gland box bore, cylinder liner and cylinder liner bore.
- 3 Remove the cover plate from the piston rod bore.
- 4 Attach the lifting tool (001) to the installation tool (002) and the engine room crane.
- 5 Operate the engine room crane to put the installation tool (002) on the cylinder liner (003).
- 6 Remove the engine room crane and the lifting tool (001).
- 7 Operate the turning gear to move the crank to TDC.
- 8 Put oil on the bore and on the O-rings of the piston rod gland.
- 9 Attach the piston suspension device (004) to the top of the piston (005).
- 10 Torque the bolts to the correct value, refer to section [16.1 Tightening instructions](#).
- 11 Attach the distance holders to the piston rod foot.
- 12 Make sure that the piston rod gland (010) is correctly installed on the piston rod.
- 13 Attach the engine room crane to the lifting tool (004).
- 14 Operate the engine room crane to lift the piston (005) a small distance.
- 15 Loosen the eight bolts (007).
- 16 Open fully the two supports (006).
- 17 Continue to lift the piston until the distance holders touch the gland box (010).
- 18 Open the plates (008).

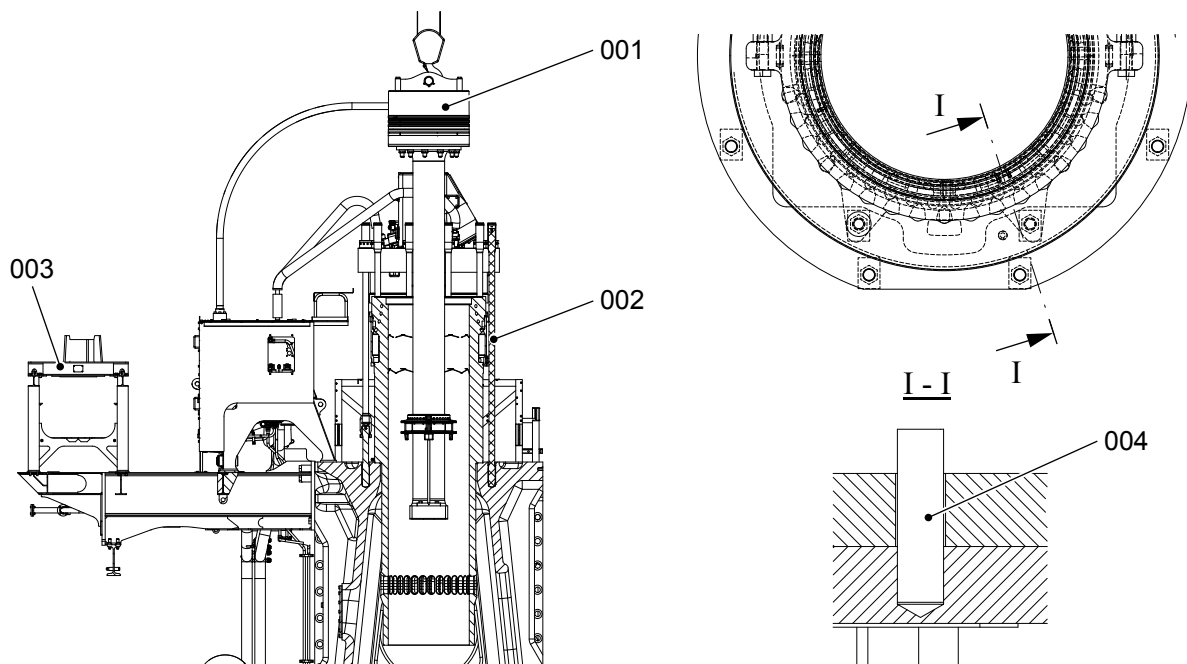
**Fig 8-76** Piston - move (example)



00784

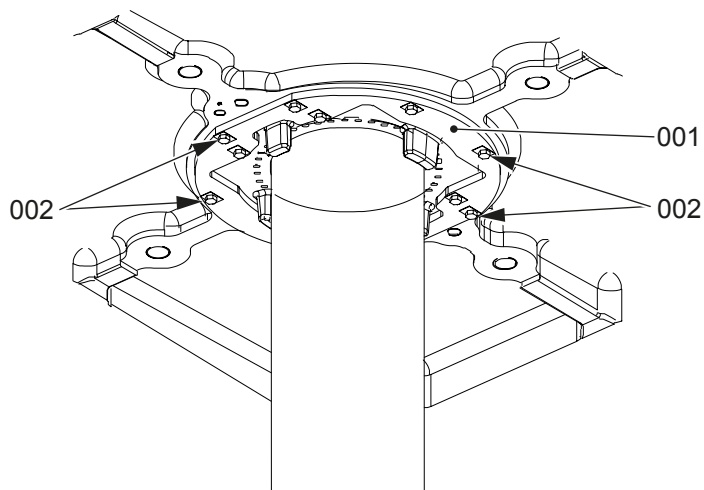
- 19 Operate the engine room crane to remove fully the piston from the piston support 003, [Figure 8-77](#)).
- 20 Carefully lower the piston (001) into the cylinder liner (002).
- 21 Operate the turning gear to turn the crank to BDC.
- 22 Make sure that the piston rod gland is in the correct position for the dowel pin (004) to align with the crosshead.

**Fig 8-77** Piston - install (example)



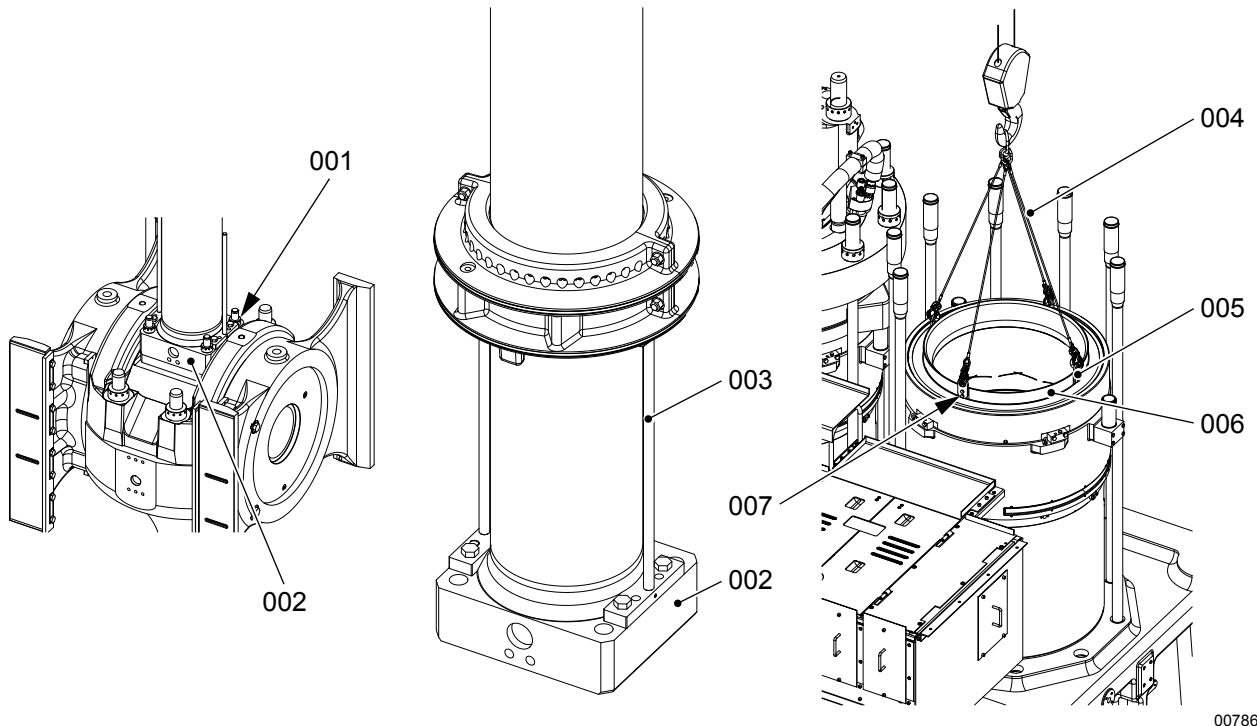
00785

- 23 Put oil on the four bolts (002, [Figure 8-78](#)).
- 24 Attach the piston rod gland (001) to the cylinder block with the four bolts (002) and new locking plates.
- 25 Torque the four bolts (002) to the correct value, refer to section [16.1 Tightening instructions](#).
- 26 Bend the locking plates to lock the bolts.

**Fig 8-78** Piston rod gland - attach (example)

00699

- 27 Remove the distance holders (003, [Figure 8-79](#)).
- 28 Attach the round nuts (001) to the elastic bolts, refer to section [4.2 Tighten a round nut with a pre-tensioner](#).
- 29 Use the engine room crane to remove the installation tool from the cylinder liner.
- 30 Make sure that the cylinder liner and the antipolishing ring (006) are clean and in a satisfactory condition.
- 31 Put oil on the surfaces of the antipolishing ring (006).
- 32 Attach the four lifting plates (005) to the antipolishing ring (006) with the four screws (007).
- 33 Attach the lifting tool (004) to the lifting plates (005) on the engine room crane.
- 34 Operate the engine room crane to put the antipolishing ring (006) into the cylinder liner.
- 35 Remove the lifting tool (004).

**Fig 8-79** Piston - attach (example)**CLOSE UP**

- None



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## 8.8 Piston ring

### 8.8.1 Piston ring - remove

#### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

#### Support equipment

Description	Part No.	CSN	QTY
Piston ring tool	94338		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

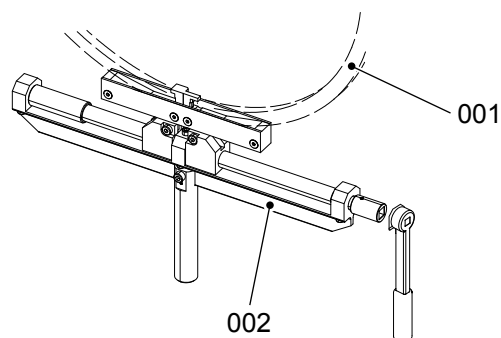
#### PRELIMINARY OPERATIONS

- The piston must be removed, refer to the related procedure.

## PROCEDURE

- 1 If the same piston rings (001, [Figure 8-80](#)) will be installed again, record their positions.

**Fig 8-80** Piston ring - remove (example)



00791

## CAUTION

**Damage Hazard: Do not open the piston rings too far. This causes damage to the piston rings.**

- 2 Use the Piston ring tool (002) to remove all the piston rings (001).
- 3 Clean the piston ring grooves.
- 4 Measure the piston ring grooves.
- 5 If the same piston rings (001) will be installed again, clean the piston rings (001).
- 6 Measure and record the thickness of the chrome-ceramic layer of each piston ring (001). This will help you monitor the rate of wear during operation.
- 7 If it is necessary to keep the piston rings in storage, do as follows:
  - 7.1 Keep the piston rings in their original packages.
  - 7.2 Put the piston rings in a clean, dry area.
  - 7.3 Make sure that the piston rings are in a horizontal position on a flat surface.

## CLOSE UP

- None

## 8.8.2 Piston ring - examine

### Periodicity

Description	
Working hours	1750
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Permascope MP0 (with instruments to measure chrome-ceramic layers)	94356		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

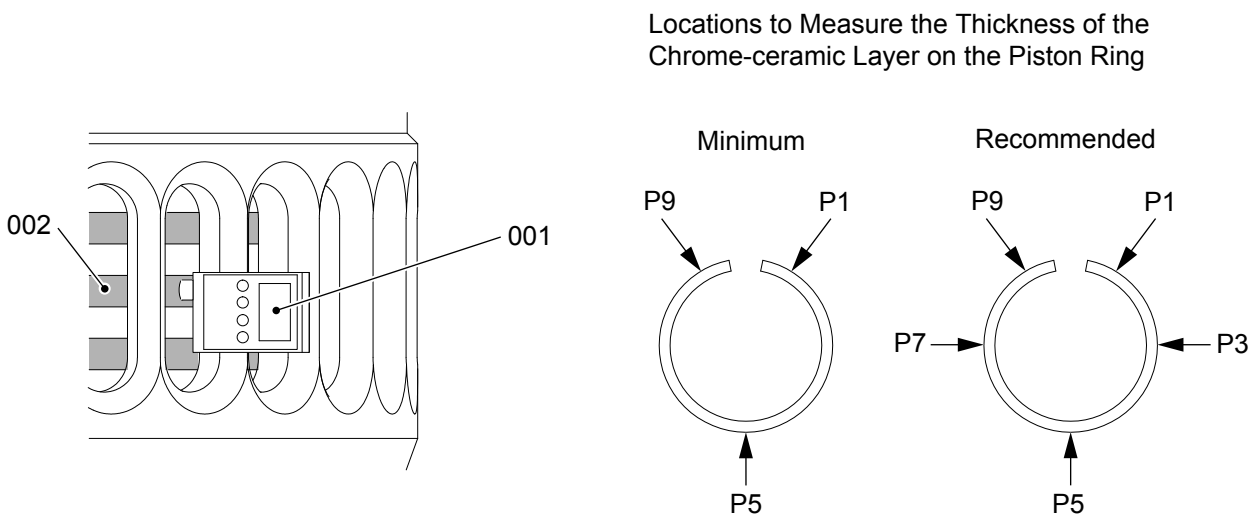
## PROCEDURE

### 1 Chrome ceramic layer - piston installed

Do [Step 1.1](#) to [Step 1.7](#) to measure the chrome ceramic layer:

- 1.1 Read the data in the supplier documentation for the [Permascope MP0 \(with instruments to measure chrome-ceramic layers\)](#) (001, [Figure 8-81](#)).
- 1.2 Calibrate the Permascope MP0. Use the calibration foils and the top flank of a spare top piston ring to get a correct setting.
- 1.3 Operate the turning gear to move the piston almost to BDC (so that you can see the piston rings).
- 1.4 Clean the surface of the piston ring (002) at the locations P1 to P9.
- 1.5 Put the sensor of the Permascope MP0 (001) against the middle of the piston ring (002).
- 1.6 Record the value on the digital display of the Permascope MP0 (001).
- 1.7 Compare the measured data with the limits given in [3.3 Clearances - general](#). If the recorded data is not in the limits given, you must do an overhaul of the piston head.

**Fig 8-81** Piston rings - measure



00787

### 2 Service life - calculate

Do [Step 2.1](#) to [Step 2.5](#) to calculate the service life of the piston rings:

- 2.1 Use the formula below in [Figure 8-82](#) to calculate the rate of wear of a piston ring.

**Fig 8-82** Equation wear rate

$$WR = \frac{(D1 - D2) \times 1000}{(T2 - T1)}$$

00094

Where:

- WR = wear rate (mm each 1000 hrs)
- D1 = first recorded thickness of the chrome ceramic layer (mm)
- D2 = second recorded thickness of the chrome ceramic layer (mm)
- T2 = hours (hrs)
- T1 = first recorded operation hours (hrs).

2.3 Refer to [Table 8-8 - Examples of wear rate](#) for examples of the results:

**Tab 8-8** Examples of wear rate

D1	D2	T1	T2	WR
0.382	0.367	0 (new)	1500	0.01
0.351	0.340	3500	5000	0.0073

2.4 Use the formula in [Figure 8-83](#) to calculate the remaining service life of the piston.

**Fig 8-83** Equation service time

$$ST = \frac{(D1 - D_{\min}) \times 1000}{WR}$$

00093

Where:

- ST = remaining service time (hrs)
- D2 = second recorded thickness of the chrome ceramic layer (mm)
- Dmin = Minimum thickness of the chrome-ceramic layer (mm) (see paragraph 2.4)
- WR = calculated rate of wear (mm each 1000 hrs).

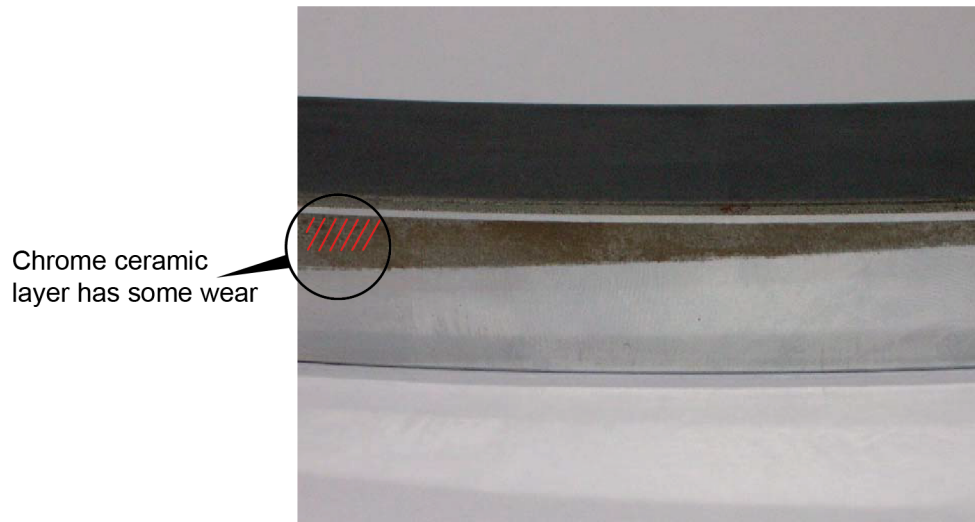
2.5 Refer to [Table 8-9 - Examples of remaining service life](#) for the examples of remaining service life:

**Tab 8-9** Examples of remaining service life

D1	D2	Dmin	T1	T2	WR	ST
0.382	0.367	0.05	0 (new)	1500	0.01	31 700
0.351	0.340	0.05	3500	5000	0.00733	39 545

- 3 If a piston ring that has some wear of the chrome-ceramic layer is found, do an overhaul of the unit as soon as possible. Refer to [Figure 8-84](#) for data about worn areas of the chrome ceramic layer.

**Fig 8-84 Chrome ceramic layer**



00092

- 4 If the thickness of the chrome-ceramic layer is less than the limits given below, replace the applicable piston ring:
  - Top piston ring, more than 0.05 mm
  - Bottom piston rings, more than 0.02 mm.

#### **CLOSE UP**

- None

### 8.8.3 Piston ring groove (piston installed) - do a check with a ring piece

#### Periodicity

Description	
Working hours	54000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
feeler gauge	94122		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

#### PRELIMINARY OPERATIONS

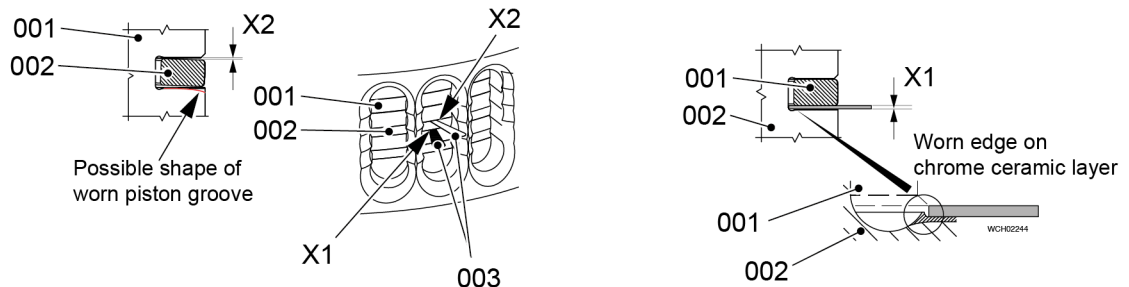
- The engine must be stopped and made safe for maintenance.



## PROCEDURE

- 1 Do [Step 2](#) to [Step 7](#) and record the results. These records are important for an analysis of the running gear and must include the data that follow:
  - All dimensions
  - The date of the overhaul
  - The operation hours of the different components
  - The operation hours of the engine.
- 2 Operate the turning gear to move the piston (002, Fig. 1) down until you can see the piston rings (002).

**Fig 8-85** Piston ring clearance



00096

- 3 Put the [feeler gauge](#) fully into the piston ring groove. Make sure that the feeler gauge touches the inner diameter of the groove.
- 4 Measure the clearance X1 at Point A.
 

**NOTE:** If there is an edge of worn material on the chrome-ceramic layer, you can push the feeler gauge only to that point.
- 5 Measure the clearance at X2.
- 6 Do [Step 4](#) and [Step 5](#) at between two and four different locations around the piston (001).
 

**NOTE:** The sum of each value from X1 and X2 gives the total piston ring clearance. The maximum clearance is at point A. The maximum dimensions for worn areas are given in [3.3 Clearances - general](#).
- 7 If the clearance at point A is more than the permitted value, do [Step 7.1](#) and [Step 7.2](#).
  - 7.1 Replace the piston rings.
  - 7.2 Repair the piston head.
 

**NOTE:** For the repair of piston heads, speak to the nearest WinGD Service Center.

## CLOSE UP

- None

## 8.8.4 Piston ring groove (piston removed) - do a check with a calliper gauge

### Periodicity

Description	
Working hours	54000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Calliper gauge	N/A		1
Inside micrometer set	94101		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

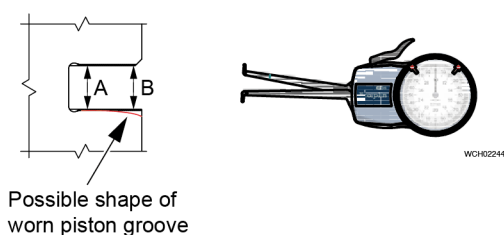
- The piston must be removed, refer to [\[section not applicable for this engine\]](#)

## PROCEDURE

- 1 **NOTE:** You can use the [Inside micrometer set](#), or the [Inside micrometer set](#) for this procedure.

Measure the height at point A and point B at a minimum of four locations around the circumference of the piston head.

**Fig 8-86** Piston groove clearance - calliper gauge



00097

- 2 Record the value from the calliper gauge or the inside micrometer set.  
**NOTE:** If the clearance at point A or point B is more than the permitted value, you must repair the piston head.
- 3 Refer to [3.3 Clearances - general](#) for the maximum dimensions for worn areas.

## CLOSE UP

- None

## 8.8.5 Piston ring groove (piston removed) - do a check

### Periodicity

Description	
Working hours	54000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
feeler gauge	94122		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

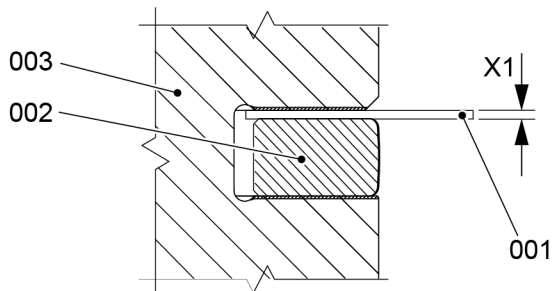
### PRELIMINARY OPERATIONS

- The piston must be removed, refer to [\[section not applicable for this engine\]](#)

## PROCEDURE

- 1 Measure the thickness of piston ring piece (002, [Figure 8-87](#)).

**Fig 8-87** Piston groove clearance - ring piece



00098

- 2 Put the piston ring piece (002) into the piston ring groove.
- 3 Use the [feeler gauge](#) (001) to measure the clearance X1 between the face of the piston ring piece (002) and the groove.  
**NOTE:** You must measure the groove height at a minimum of four locations around the circumference of the piston head (003).
- 4 Use the formula that follows to calculate the piston ring clearance:

$$C = GH - RT$$

Where:

- C = Clearance
  - GH = the measured height of the piston ring groove (mm)
  - RT = the nominal piston ring thickness (mm).
- 5 Refer to [3.3 Clearances - general](#) for the maximum dimensions for worn areas.  
**NOTE:** If the clearance at X1 is more than the permitted value, you must repair the piston head. For the repair of piston heads, speak to the nearest WinGD Service Center.  
Do not install a piston head that has clearances near the maximum value because the service life will be too short.

## CLOSE UP

- None

## 8.8.6 Piston ring - install

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
Piston ring tool			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Piston rings			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The piston must be removed.

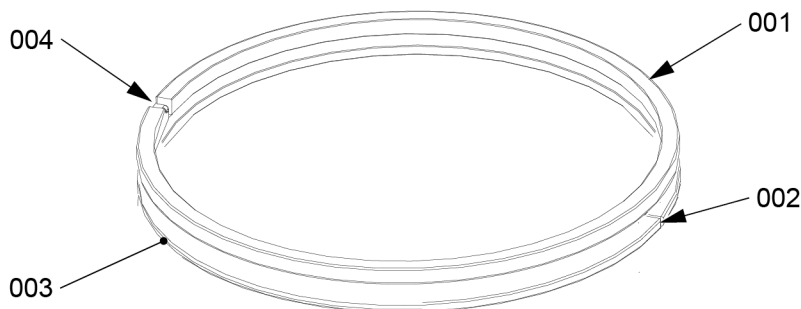
## PROCEDURE

### CAUTION

**Damage Hazard: Do not open the piston rings too far. This causes damage to the piston rings.**

- 1 Make sure that the mark TOP on the piston rings (001, 003, [Figure 8-88](#)) points up.  
**NOTE:** The piston can have two or more piston rings.  
Only install piston rings that are clean and are in a satisfactory condition.  
The piston rings are for a new and fully honed cylinder liner or a used cylinder liner in good condition.
- 2 Use the piston ring tool to install the applicable bottom piston ring (003) to the related groove of the piston head.
- 3 Use the piston ring tool to install the other applicable piston rings (001) to the piston head. Make sure that the ring clearance (004) is opposite the ring clearance (002) of the installed piston rings (003).
- 4 For the running-in procedure for new piston rings, refer to the Operation Manual.

**Fig 8-88** Piston rings - install (example)



00990

## CLOSE UP

- None

## 8.8.7 Piston ring - do the preservation

### Periodicity

#### Description

Unscheduled

Duration for performing preliminary requirements 0.0 man-hours

Duration for performing the procedure 0.0 man-hours

Duration for performing the requirements after job completion 0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- None



## PROCEDURE

- 1 Keep the piston rings in their original packages in a dry area. Make sure that the piston rings are in a horizontal position on a flat surface.
- 2 To prevent damage, be careful when you prepare the piston rings for installation and during movement.

## CLOSE UP

- None

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## 9 Group 4 - Supply unit drive and control components

<b>9.1</b>	<b>Driving wheels</b>	
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## 9.1 Driving wheels

### 9.1.1 Gear wheel crankshaft - examine the teeth

#### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard.** Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Operate the turning gear to turn the crankshaft while you do an inspection of all teeth.  
**NOTE:** On new engines during the running-in period, you must do a visual check of the gear wheels after approximately one and two operation hours. You must do the same checks on used engines that have new gear wheels installed.  
**NOTE:** To do checks of the clearances and tooth marks, you must tighten the tie rods and elastic studs of the main bearings.
- 2 Set to on the service pump.
- 3 Make sure that oil flows freely from all nozzles.
- 4 Set to off the service pump.
- 5 Make sure that all screws are correctly locked.
- 6 After the running-in period, do a check of the drive wheels each three months as given above. If faults show during this period, repair them.
- 7 If you hear unusual noises in the area of the gear train, you must find the cause. Replace defective drive wheels as soon as possible to prevent damage to adjacent drive wheels.

## CLOSE UP

- None

## 9.1.2 Gear wheel crankshaft - do a check of the teeth backlash

### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
Feeler gauge			1
Micrometer			1
Dial gauge			1

### Supplies

Description	QTY
Wire 1.5 mm	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

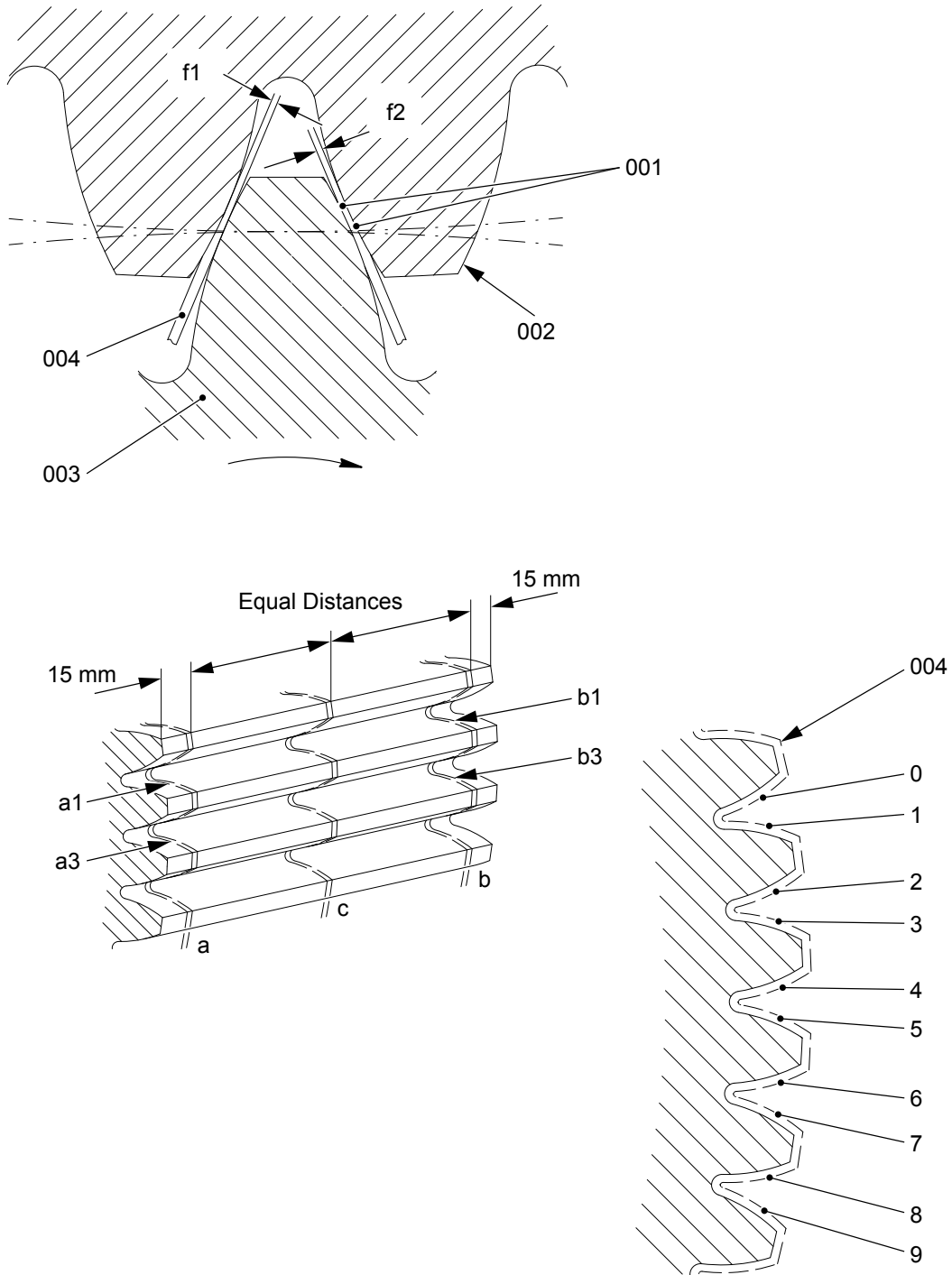
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Measure the gear tooth backlash with one of the procedures that follows:  
**NOTE:** For data about the gear tooth backlash values, refer to [3.3 Clearances - general](#).  
**NOTE:** There are three procedures to measure the backlash.
- 2 Measure the clearance between the tooth flanks (001, [Figure 9-1](#)) with a feeler gauge. Do this procedure at a minimum of four positions around the circumference of the gear wheel.
- 3 Measure the gear tooth backlash with a dial gauge as follows:
  - 3.1 Put the dial gauge in a position where you can read the backlash value when the gear wheel (003) moves.
  - 3.2 Make sure that the drive wheel (003) does not move.
  - 3.3 Operate the turning gear to carefully move the gear wheel (003) a sufficient distance.
  - 3.4 Measure the backlash when one tooth of the gear wheel (003) moves between the profiles of two gear wheel teeth.
- 4 Measure the gear tooth backlash with a wire as follows:  
**NOTE:** Use a new wire of 1.5 mm diameter (Pb 9.99 fine) for each measurement.  
**NOTE:** The wire (c) shows the full backlash (f). The wires (a) and (b) show the parallelity of the tooth profile.  
**NOTE:** The obliquity  $\Delta f$  is the difference between the values of the wires on the tooth flanks between for example  $a1 - b1$ .
  - 4.1 Attach three lengths of wire (approximately 200 mm) in the positions shown with Scotch tape.
  - 4.2 Put marks (0 to 9) on the tooth profiles as shown.
  - 4.3 Use the turning gear to turn the gear wheel (003) so that the wire (004) goes once through the teeth of the gear wheel and drive wheel (002).
  - 4.4 Remove the wire (004).
  - 4.5 Use the micrometer to measure the wire (004).
  - 4.6 Calculate as follows:
    - The full tooth backlash:  $f = f1 + f2$
    - The obliquity:  $\Delta f = a1 - b1$  or  $a3 - b3$ .  
**NOTE:** The permitted difference of the tooth profile parallelity is between 0.0% and 0.2% across the width of the tooth.

Fig 9-1 Driving wheel - gear tooth backlash



00795



**CLOSE UP**

- None

### 9.1.3 Driving wheel gear train - monitor the condition

#### Periodicity

Description	
Working hours	7000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.**

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 After commissioning, do a check of the performance of the gear train as follows:
  - 1.1 Apply a thin layer of oil resistant engineer's blue ink to three of the teeth on each of the gear wheels.
  - 1.2 Operate the turning gear to turn the engine.
  - 1.3 Do a check of the marks on the gear wheel teeth and driving wheel teeth. This makes sure that the teeth engage correctly and are parallel.

## CLOSE UP

- None

## 9.2 Shut-off valve for starting air

### 9.2.1 Shut-off valve for starting air - disassemble

#### Periodicity

Description	
Working hours	33 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

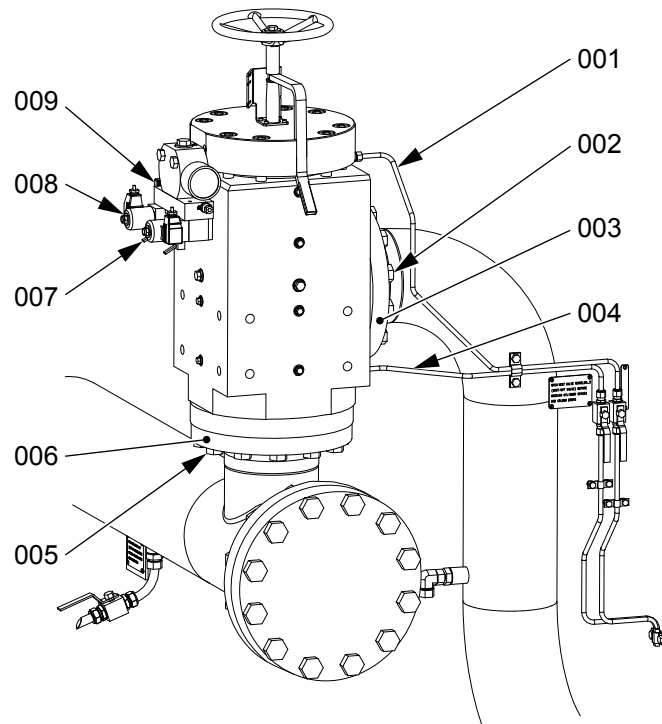
- 1 Prepare the shut-off valve for starting air for disassembly.
  - 1.1 Disconnect the electrical connections from the pressure transmitter (009, [Figure 9-2](#)) and the solenoid valves (007, 008).
  - 1.2 Disconnect the pipes (004, 001) from the shut-off valve for starting air.
  - 1.3 Remove the screws (005) from the flange (006).
  - 1.4 Remove the screws (002) from the flange (003).

### CAUTION

**Use applicable equipment and personnel to lift and move the shut-off valve for starting air.**

- 1.5 Remove the shut-off valve for starting air from the engine.
- 1.6 Make sure that the two gaskets on the flanges (003, 006) are serviceable. If the gaskets have damage, replace them.

**Fig 9-2 Shut-off valve for starting air - prepare for disassembly**

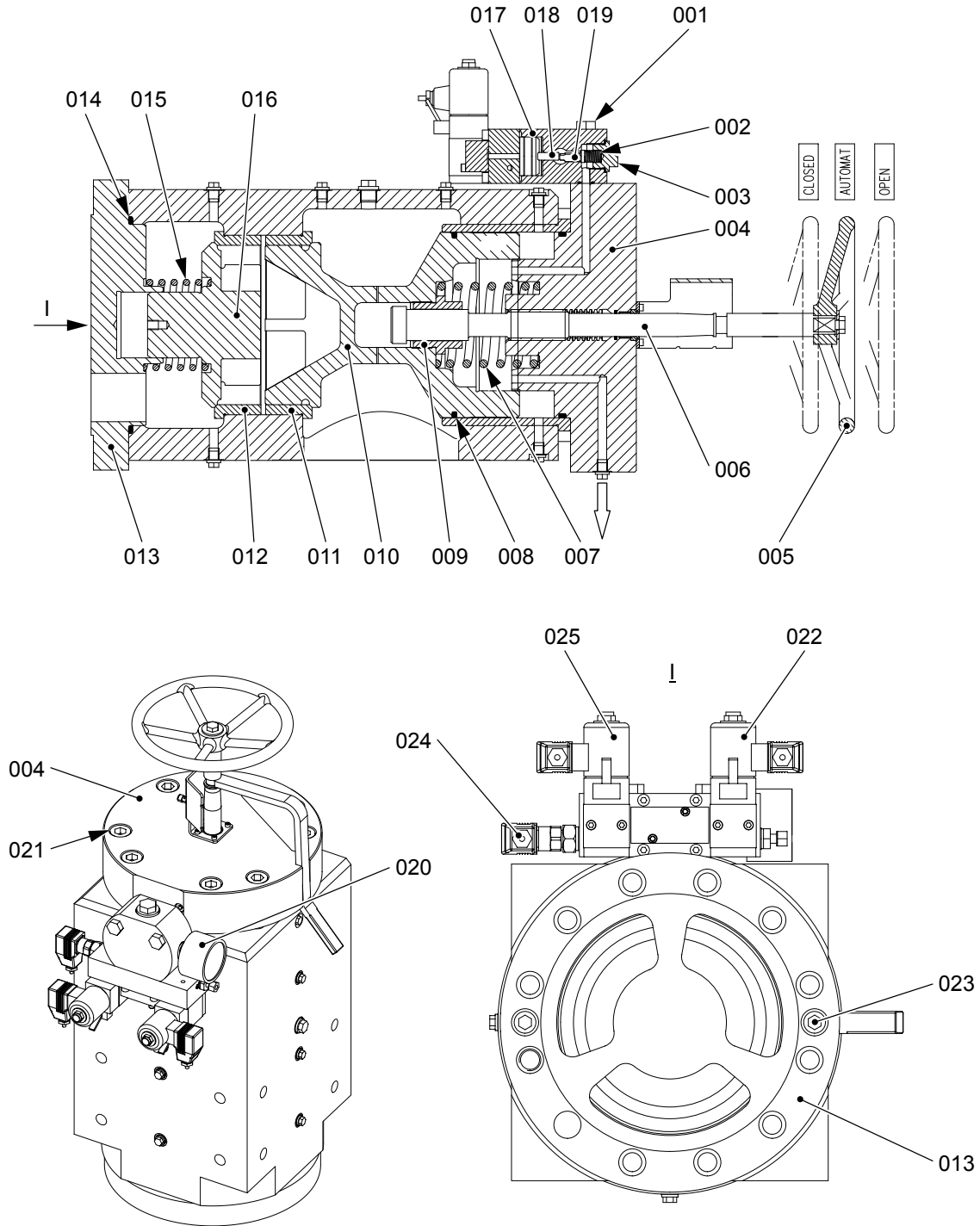


00801

- 2 Remove the screws (021, [Figure 9-3](#)) from the cover (004).
- 3 Turn the hand-wheel (005) fully in to move the spindle (006) out of cover (004).
- 4 Remove the hand-wheel (005), the cover (004) and the spring (007).
- 5 Use a swan neck spanner to remove the spindle nut (009).
- 6 Remove the spindle (006).
- 7 Remove the two screws (023) from the valve guide (013).
- 8 Remove the valve guide (013).

- 9** Remove the valve body (016) together with the spring (015).
- 10** Remove the two bolts (001) from the control valve (017).
- 11** Remove the control valve (019).
- 12** Remove the screw plug (003) together with the spring (002), valve (019) and piston (018) from the control valve (017).
- 13** Remove the silencer.
- 14** Clean the items that follow:
  - Valve (003)
  - Piston (018)
  - Spring (002)
  - Springs (007) and (015)
  - Valve body (016)
  - Valve guide (013)
  - Valve (010)
  - Spindle (006).
- 15** If you find corrosion on the springs (007, 022 and/or 002) you must replace them.
- 16** Do a check of all gaskets and O-rings that you removed for damage. If you find damage, replace the applicable gaskets and/or O-rings.
- 17** Do a check of the piston joint ring (008). If you find damage, replace the piston joint ring.
- 18** Do a check of the valve seats (011, 012). If necessary, grind the sealing surfaces.

Fig 9-3 Shut-off valve for starting air - disassemble



00800

**CLOSE UP**

- None



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## 9.2.2 Shut-off valve for starting air - assemble

### Periodicity

Description	
Working hours	33 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Molykote paste	A/R
Loctite 0243	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- None

## PROCEDURE

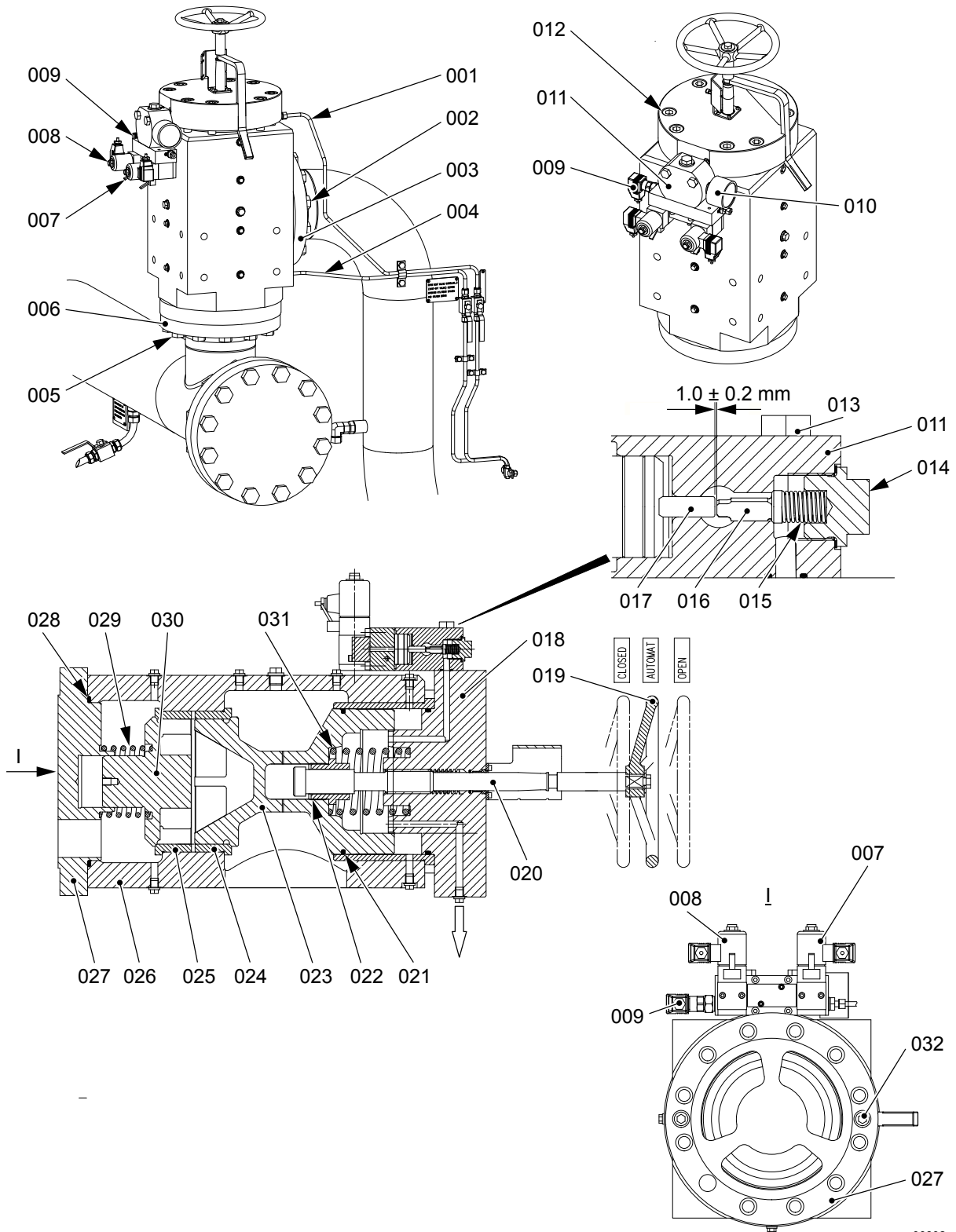
- 1 Make sure that all bores are clear.
- 2 Apply a thin layer of Molykote paste to the spring (029, [Figure 9-4](#)) and to the sliding surface of the valve guide (027) and the valve body (030).
- 3 Put the O-ring (028) and valve body (030) into the housing (026).
- 4 Put the spring (029) on to the valve guide (027).
- 5 Attach the valve guide (027) to the housing (026) with the two screws (032).
- 6 Torque the screws (032) to the value given in section [3.5 Torque values - standard screws](#).
- 7 Apply Molykote paste to the bore of the spindle nut (022).
- 8 Put the spindle nut (022) on to the spindle (020).
- 9 Apply Loctite 0243 to the threads of the spindle nut (022).
- 10 Put the spindle (020) and spindle nut (022) into valve (023).
- 11 Attach the valve (023) together with the spindle (020) and piston joint ring (021) to the housing (026).
- 12 Apply Molykote paste to the sealing surface of the cover (018) and to the thread of the spindle (020).
- 13 Put the spring (031) into the valve (023).
- 14 Attach the cover (018) and the O-ring to the spindle (020).
- 15 Attach the cover (018) to the housing (026) with the eight screws (012).
- 16 Torque the screws (012) to the value given in section [3.5 Torque values - standard screws](#).
- 17 Attach the hand-wheel (019).
- 18 Attach the control valve (011) to the cover (018) with the bolts (013).
- 19 Torque the bolts (013) to the value given in section [3.5 Torque values - standard screws](#).
- 20 Put the piston (017), valve (016), spring (015) and screw plug (014) in position in the control valve (011).
- 21 Look through the hole in the control valve (011) to make sure that the clearance between the valve (016) and the piston (017) is  $1.0 \pm 0.2$  mm.
- 22 Attach the silencer (010) to the control valve (011).

## WARNING

**Use applicable equipment to lift and move the shut-off valve.**

- 23 Put the assembled shut-off valve in position as shown.
- 24 Attach the flange (006) to the valve guide with the screws (005).
- 25 Attach the flange (003) to the shut-off valve with the screws (002).
- 26 Torque the screws (002) and (005) to the value given in section [3.5 Torque values - standard screws](#).
- 27 Attach the pipes (004) and (001) to the shut off valve.
- 28 Connect the electrical connections of the pressure transmitter (009) and the solenoid valves (007, 008).

Fig 9-4 Shut-off valve for starting air - assemble



00802

**CLOSE UP**

- None

### 9.2.3 Shut-off valve for starting air - do a test of the operation

#### Periodicity

Description	
Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

Injury Hazard: During this test, do not select START. Injury to personnel can occur.

##### WARNING

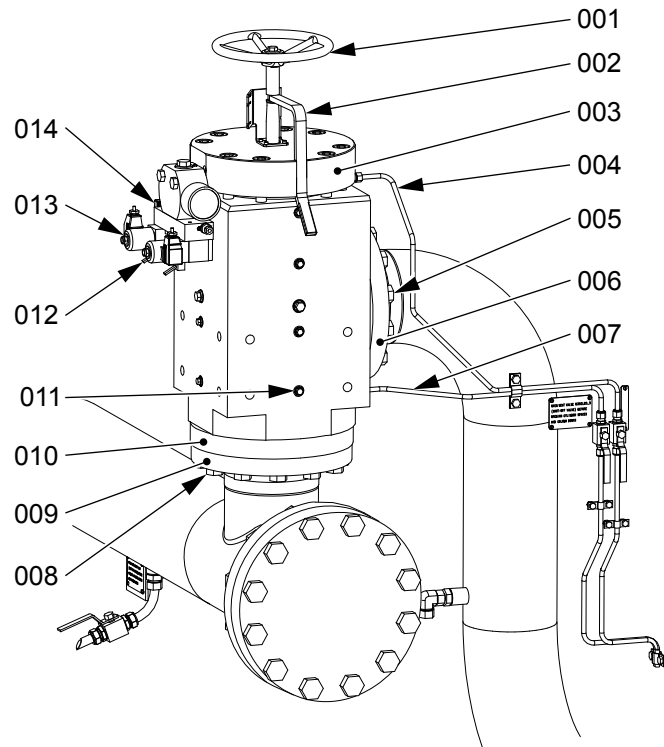
Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

#### PRELIMINARY OPERATIONS

- The engine must be fully assembled and ready to start.

## PROCEDURE

- 1 To set the shut-off valve for starting air (shut-off valve) to the initial test position, do [Step 1.1](#) to [Step 1.3](#):
  - 1.1 Make sure that the stop valves 930-V03 and 930-V04 are closed.
  - 1.2 Use the hand-wheel (001, [Figure 9-5](#)) to move the shut-off valve in the position CLOSED.
  - 1.3 Make sure that the turning gear is disengaged.
  
- 2 To do a test the shut-off valve, do [Step 2.1](#) to [Step 2.8](#):
  - 2.1 Close the drain valves 30-8605\_E0\_6/7 on the supply pipe.
  - 2.2 Slowly open the stop valves 930-V03 and 930-V04.
  - 2.3 **NOTE:** If air flows out, tighten the screw plug (011). The shut off valve is not airtight.  
  
Slowly loosen the screw plug (011). Make sure that no air flows out.
  - 2.4 Remove the screw plug (011).
  - 2.5 Slowly turn the hand-wheel (001) to move the shut-off valve to the position OPEN.
  - 2.6 Make sure that air flows from the bore of the screw plug (011). When air flows, the manual function of the shut-off valve operates correctly.
  - 2.7 Use the hand-wheel (001) to move the shut-off valve to the position AUTOMAT. Make sure that the lever (002) engages with the groove in the spindle.
  - 2.8 Make sure that no air flows from the bore of the screw plug (011). When no air flows, the automatic function of the shut-off valves operates correctly.
  
- 3 To set the starting air shut-off valve into automatic mode, do [Step 3.1](#) to [Step 3.5](#):
  - 3.1 Make sure that the shut-off valve is in the position AUTOMAT.
  - 3.2 **NOTE:** When you do the step below, air will flow through the pipe. This activates the control valve (012), which shows that the valve body and valve operate.  
  
Open the ball valve 35-8353\_E0\_2 to activate the control valve (012). The shutoff valve opens automatically.
  - 3.3 Make sure that air flows from the bore of the screw plug (011).
  - 3.4 Close the ball valve 35-8353\_E0\_2.
  - 3.5 Make sure that no air flows from the bore of the screw plug (011).
  
- 4 To complete the test procedure, do [Step 4.1](#) to [Step 4.3](#):
  - 4.1 Use the hand-wheel (001) to move the shut-off valve to the position CLOSED.
  - 4.2 Install the screw plug (011).
  - 4.3 Attach the pipes (004, 007) to the shut-off valve.

**Fig 9-5 Shut-off valve for starting air - operation test**

00799

**CLOSE UP**

- None



# 10 Group 5 - Supply unit, pumps and control valves

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## 10.1 Servo oil pump

### 10.1.1 Servo oil pump - do a check for wear and damage

#### Periodicity

Description	
Working hours	3000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the screws from the cover of the supply unit.
- 2 Remove the cover from the supply unit.
- 3 Do a check of the pinions and of the camshaft gear wheel for wear and damage.
- 4 Compare the value for clearance with the value given in section [3.3 Clearances - general](#).
- 5 If there is too much wear and / or damage, you must replace the pinions and the camshaft gear wheel.
- 6 Attach the cover to the supply unit casing with the screws.

## CLOSE UP

- None

## 10.1.2 Servo oil pump - remove

### Periodicity

Description	
Working hours	36000 (HAWE)
Working hours	66000 (Bosch)
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Shackles			2
Spur-gearred chain block			2
Lifting tool			1
Slings WLL 1000 kg			2
Deviation pipe			1
Sling WLL 2000 kg			1
Lever chain hoist			1
Shackle			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### CAUTION

Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

- The applicable HP servo oil pipes must be removed, refer to section [13.1.1 HP servo oil pipe - remove](#)

## PROCEDURE

- 1 Prepare the servo oil pumps for removal.
  - 1.1 Remove the applicable HP fuel pipes from the related fuel pumps.
  - 1.2 Disconnect the electrical connections.
  - 1.3 Remove all pipes from the servo oil pumps.
- 2 Remove the first servo oil pump.
  - 2.1 Put the sling around the servo oil pump two times.
  - 2.2 Attach the sling to the engine room crane.
  - 2.3 Operate the engine room crane and put sufficient tension on the sling to hold the weight of the servo oil pump.
  - 2.4 Remove the nuts and the washers.
  - 2.5 Remove the servo oil pump and the O-ring.
  - 2.6 Move the servo oil pump to an applicable area.
  - 2.7 Remove the sling from the servo oil pump.
- 3 Do [Step 2](#) again to remove the other servo oil pump(s).

## CLOSE UP

- None



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### 10.1.3 Servo oil pump - install

#### Periodicity

Description	
Working hours	36000 (HAWE)
Working hours	66000 (Bosch)
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Shackles			2
Spur-gearred chain block			2
Lifting tool			1
Slings WLL 1000 kg			2
Deviation pipe			1
Sling WLL 2000 kg			1
Lever chain hoist			1
Shackle			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### CAUTION

Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

- The applicable HP servo oil pipes must be removed, refer to section [13.1.1 HP servo oil pipe - remove](#)

## PROCEDURE

- 1 Install the first servo oil pump.
  - 1.1 Put a new O-ring in the pump support.
  - 1.2 Apply a small quantity of oil to the O-ring.
  - 1.3 Put the sling around the servo oil pump two times.
  - 1.4 Attach the sling to the engine room crane.
  - 1.5 Operate the engine room crane to put the servo oil pump in position.
  - 1.6 Attach the servo oil pump to the casing with the nuts and the washers.
  - 1.7 Remove the sling from the servo oil pump.
- 2 Do [Step 1](#) again to install the other servo oil pump(s).
- 3 Finish the installation of the servo oil pumps.
  - 3.1 Install all pipes to the servo oil pumps.
  - 3.2 Connect the electrical connections.
  - 3.3 Install the applicable HP fuel pipes from the related fuel pumps.

## CLOSE UP

- None

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## 10.2 Supply unit for pilot fuel

### 10.2.1 Supply unit for pilot fuel - remove the pump

#### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
HP oil pump			1
Pressure gauge			1
HP hose			1
Assembly tool			1

#### Supplies

Description	QTY
Molykote G-Rapid Plus	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

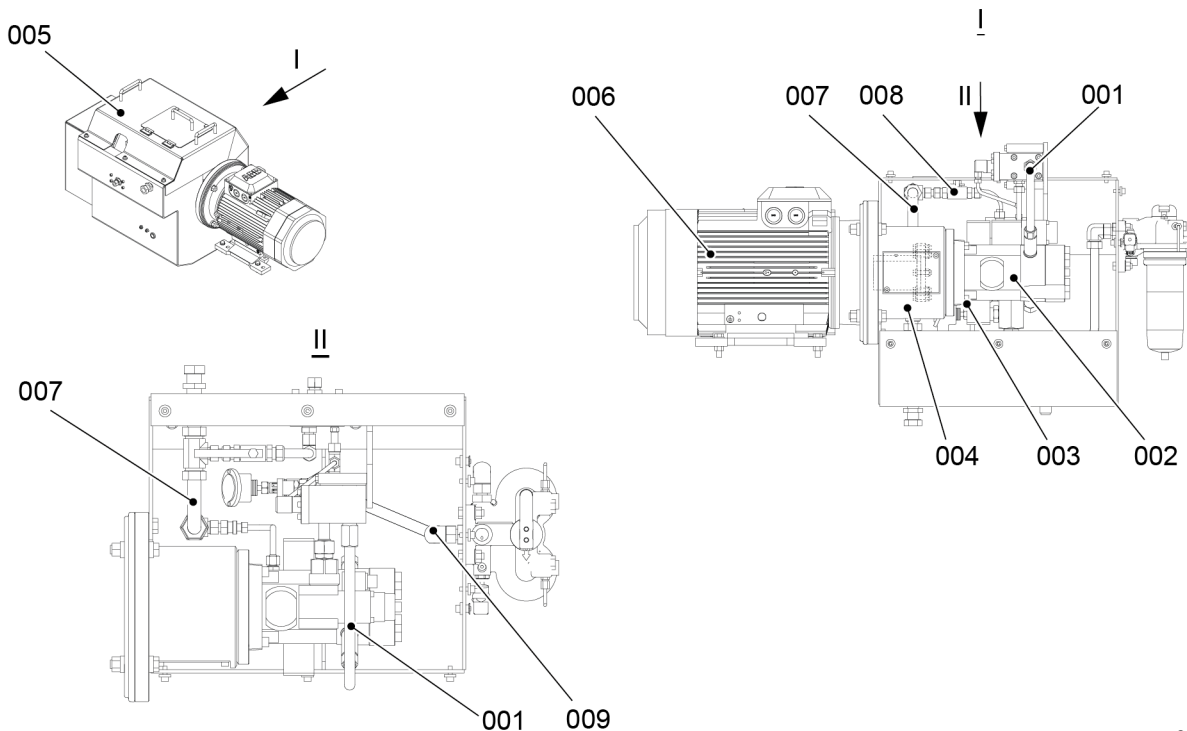
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 If necessary, remove the cover (005, [Figure 10-1](#)).
- 2 Make sure that the pilot fuel pump (002) has stopped.
- 3 Disconnect the electrical connection from the electric motor (006).
- 4 Close the stop valve (008).
- 5 Remove the pilot fuel pressure pipe (001).
- 6 Remove the pilot fuel return pipe (007).
- 7 Remove the fuel inlet pipe (009).
- 8 Hold the weight of the pilot fuel pump (004).
- 9 Remove the four Allen screws (003).
- 10 Remove the pilot fuel pump (002) from the electric motor (006).

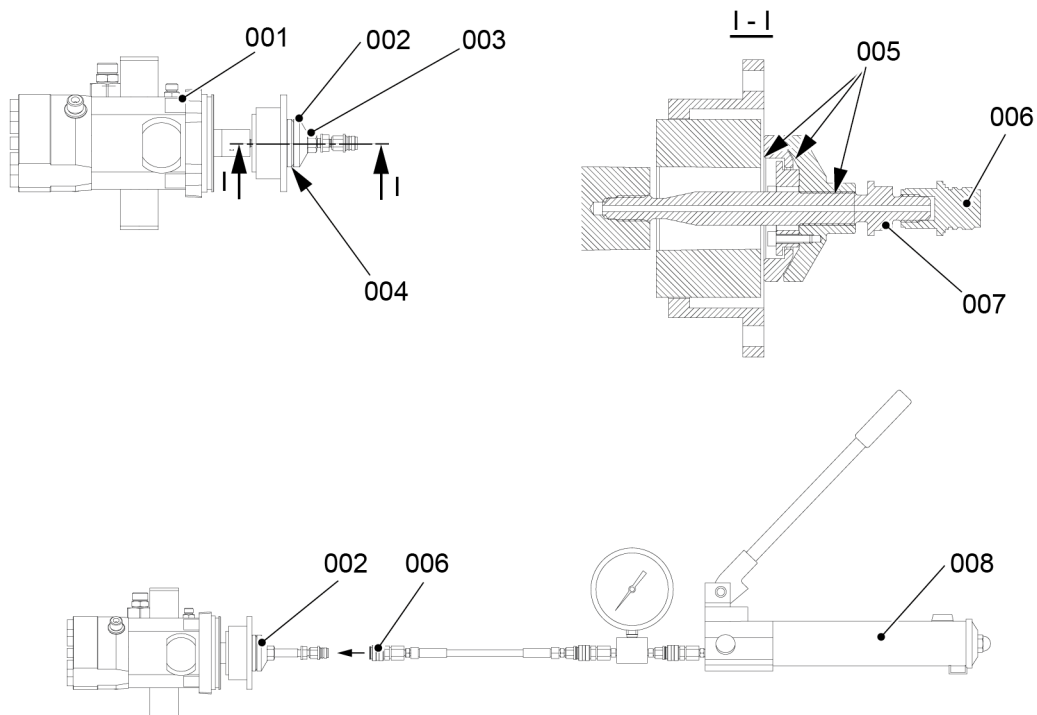
**Fig 10-1** Supply unit for pilot fuel



00903

- 11 On the assembly tool (002, [Figure 10-2](#)), turn fully back the special nut (003).
- 12 Apply Molykote G-Rapid Plus to the surfaces (005).
- 13 Attach the adapter piece (007) to the shaft of the pilot fuel pump (001).
- 14 Torque the adapter piece (007) to 45 Nm.
- 15 Turn the special nut (003) until it touches the spherical disc (004). Do not tighten the special nut.
- 16 Connect the HP oil pump (008) and the HP hose (006) to the assembly tool (002).
- 17 Operate the HP oil pump (008) to increase the pressure to between 1600 bar and 1800 bar. Make sure that the coupling-half floats on the oil film.
- 18 Operate the HP oil pump (008) to keep the pressure constant.

- 19 Turn back 5.0 mm the special nut (003). Make sure that the hydraulic force pushes the coupling-half against the spherical disc (004).
- 20 Make sure that the coupling-half is loose.
- 21 Release the pressure from the HP oil pump (008).
- 22 Remove the gear coupling.

**Fig 10-2 Supply unit for pilot fuel - tool**

00904

**CLOSE UP**

- None



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## 10.2.2 Supply unit for pilot fuel - lubricate the coupling

### Periodicity

Description	
Working hours	2250
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Grease for gear couplings	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

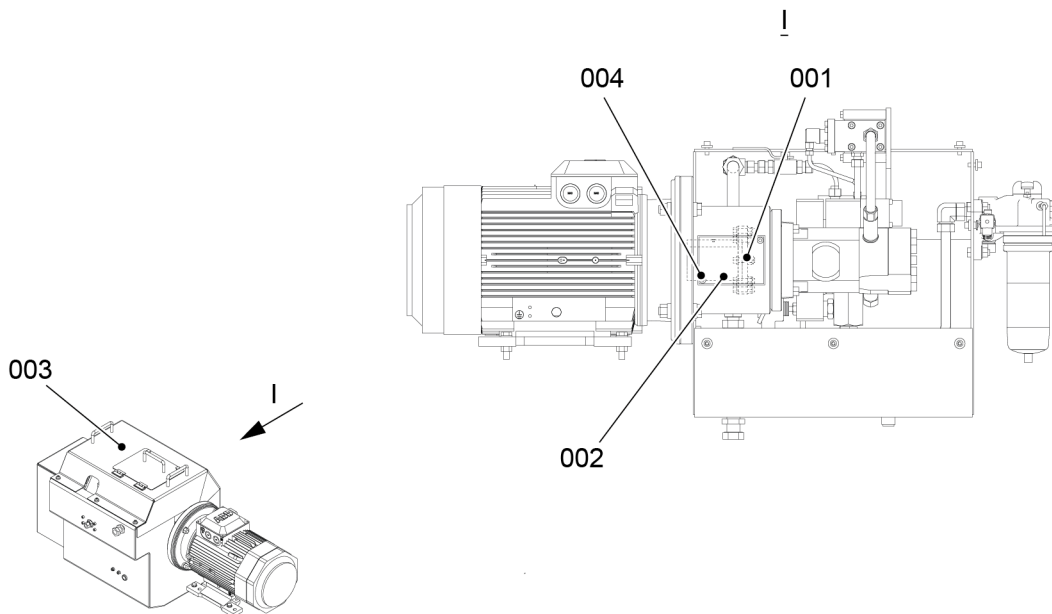
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the cover (003, [Figure 10-3](#)).
- 2 Remove the two Allen screws (004).
- 3 Remove the service cover (002).
- 4 Turn the flange (001) until you see the grease nipple.
- 5 Lubricate the coupling with an applicable grease for gear couplings.
- 6 Attach the service cover (002) with the two screws (004).
- 7 Attach the cover (003).

**Fig 10-3 Pilot fuel supply unit**



00902

## CLOSE UP

- None

### 10.2.3 Supply unit for pilot fuel - install the pump

#### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
HP oil pump			1
Pressure gauge			1
HP hose			1
Assembly tool			1

#### Supplies

Description	QTY
Molykote G-Rapid Plus	A/R
Never Seez NSBT8	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Pilot fuel pump			1

#### SAFETY PRECAUTIONS

- None

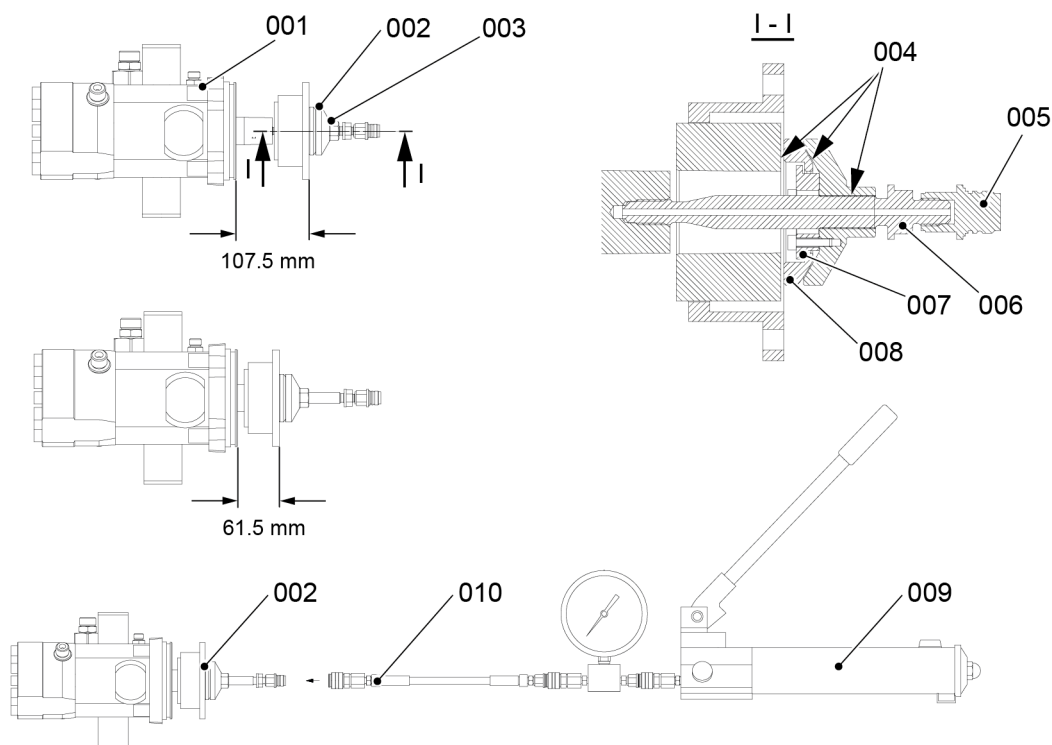
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Push as far as possible the special nut (003, [Figure 10-4](#)) on the shaft of the pilot fuel valve (001). Make sure that the coupling is at 90° to the shaft of the pilot fuel valve.
- 2 Measure the distance from the special nut (003) to the end face of the pump (001). Make sure that the distance is approximately 107.5 mm.
- 3 On the assembly tool (002) turn fully back the special nut (003).
- 4 Apply Molykote G-Rapid Plus to the surfaces (004).
- 5 Attach the adapter piece (006) to the shaft of the pilot fuel pump (001).
- 6 Torque the adapter piece (006) to 45 Nm.
- 7 Turn the special nut (003) until it touches the spherical disc (008).
- 8 Attach the HP hose (010) to the HP oil pump (009).
- 9 Attach the HP hose (010) to the closing valve (005).
- 10 Operate the HP oil pump (009) to get a pressure of between 1600 bar and 1800 bar.
- 11 Make sure that the coupling floats on the oil film.
- 12 Push the special nut (002) forward until the distance from the end face of the pilot fuel pump is 61.5 mm.
- 13 Release the pressure in the HP oil pump (009).
- 14 Remove the hose (010) from the closing valve (005).
- 15 Remove the assembly tool (002) from the pilot fuel pump (001).

**Fig 10-4 Pilot fuel supply unit - install**

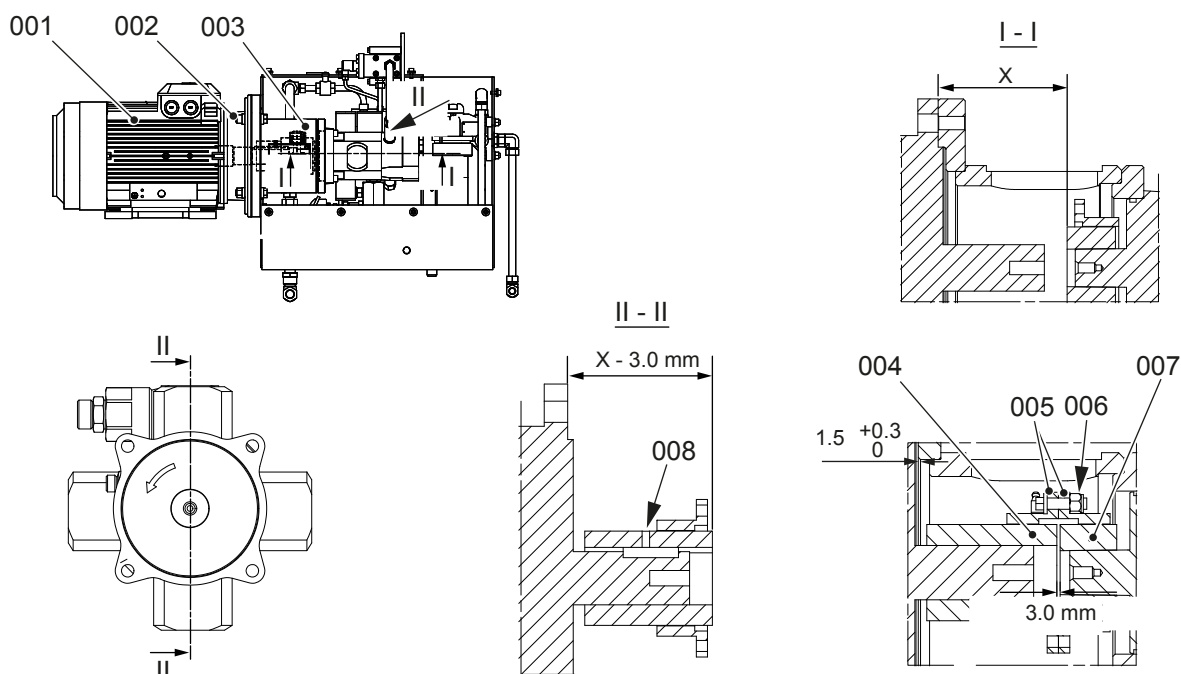


00616

- 16 Attach the pilot fuel pump (003, [Figure 10-5](#)) to the electric motor (001) temporarily with the four bolts and nuts (002).
- 17 Measure the distance X through the opening in the connection piece (003).
- 18 Remove the electric motor (001) from the connection piece (003).

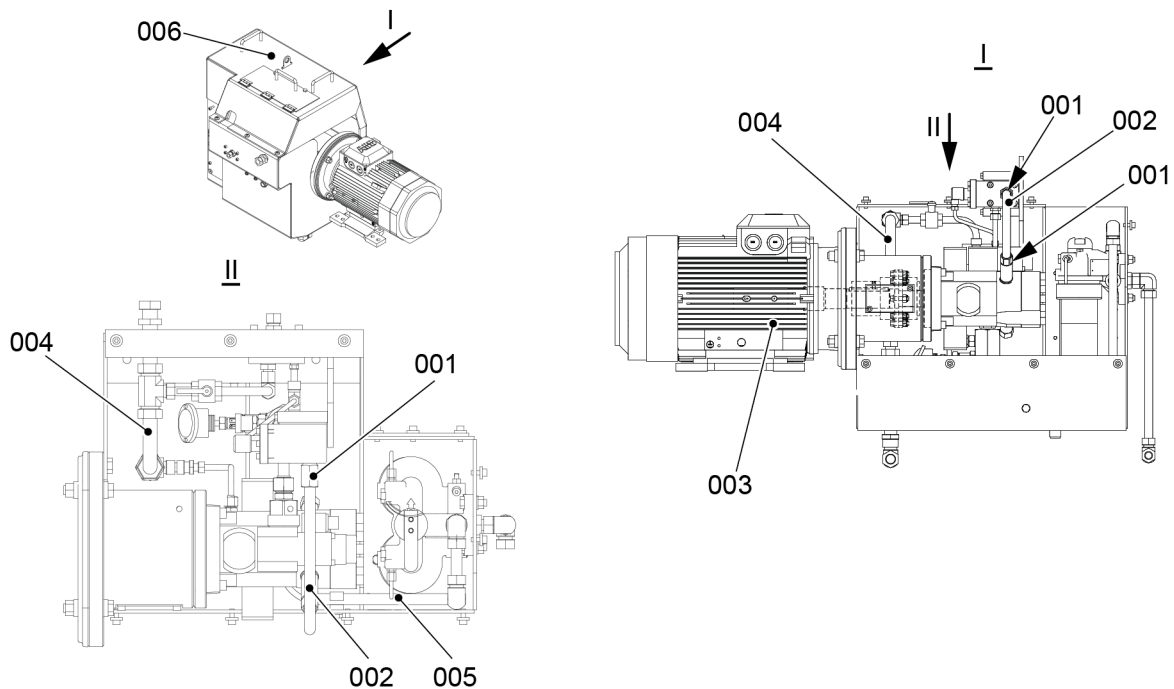
- 19 Push the flange on the motor shaft until you get a distance of  $X=3.0$  mm.
- 20 Lock the hubs with an M8 screw (008).
- 21 Fill the coupling with grease.
- 22 Attach the electric motor (001) to the connection piece (003) with the four bolts and nuts (002).
- 23 Make sure that the distance between the hubs (004, 007) is 3.0 mm.
- 24 Attach the sleeves together with the screws and nuts (006).
- 25 Torque the nuts (006) to 36 Nm.
- 26 Make sure that the sleeves (005) move freely a distance of  $1.5^{+1.5}_0$  mm.

**Fig 10-5 Pilot fuel supply unit - clearances**



- 27 Apply NeverSeez NSBT8 to the threads and surfaces that touch of the coupling nuts (001, [Figure 10-6](#)).
- 28 Attach the pilot fuel pressure pipe (002) to the position shown.
- 29 Torque the two coupling nuts (001) to 30 Nm.
- 30 Install the pilot fuel return pipe (004).
- 31 Install the fuel inlet pipe (005).
- 32 Connect the electrical connection to the electric motor (003).
- 33 Attach the cover (006) to the pilot fuel supply pump.

Fig 10-6 Pilot fuel supply unit - completion



00618

**CLOSE UP**

- None

## 10.3 Fuel pump

### 10.3.1 Fuel pump (X4) - prepare before removal

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.1 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Fuel pump rack	94592		1
Screws	94592D		2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Fire Hazard: Do not weld or grind materials in the area. Sparks can cause a fire to occur.**

#### WARNING

**Injury Hazard: Put on gloves and eye protection. Fuel can come out as a spray and cause injury.**

#### CAUTION

**Damage Hazard: Do not operate the engine with a fuel pump removed. This will decrease the supply of oil, i.e. there could be a decrease of lubrication to the other fuel pumps. Damage to equipment can occur.**

### PRELIMINARY OPERATIONS

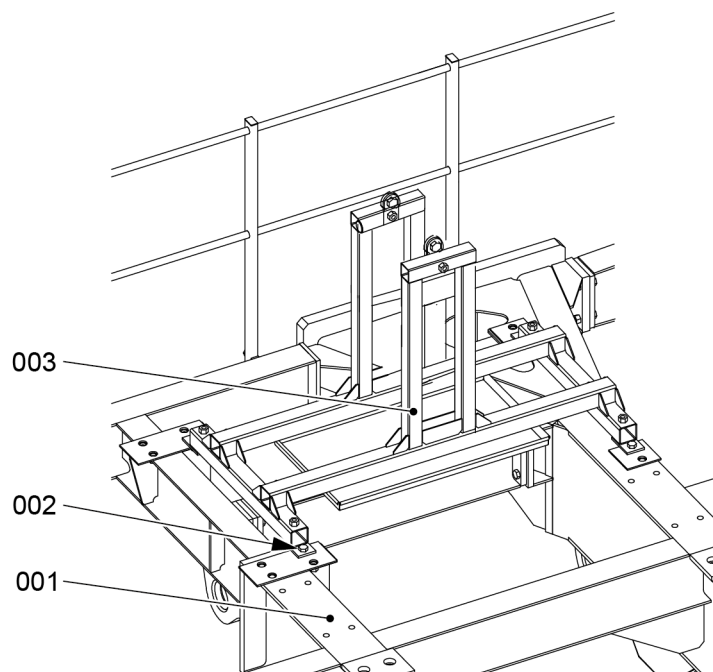
- None



## PROCEDURE

- 1 To prepare the fuel pump before removal, do the below steps:
  - 1.1 Stop the engine.  
**NOTE:** Read the data in [3.1 Lifting tools](#).
  - 1.2 Set to off the fuel supply pump.
  - 1.3 Set to off the main oil supply pump.
  - 1.4 Open the fuel return valve.
  - 1.5 Close the fuel inlet valve.
  - 1.6 Make sure that the pressure in the supply unit is released to zero bar.
  - 1.7 Set to off the power supply to the fuel pump actuators.
  - 1.8 Make sure that there is no pressure in the fuel system.
  - 1.9 Make sure that the temperature of the fuel has decreased to ambient.
  - 1.10 Clean the work area.
  - 1.11 Set to off the power supply to the actuators.
  - 1.12 Close the valves to the fuel pumps.
  - 1.13 Attach the pump rack (003, [Figure 10-7](#)) to the top primary platform (001) with the screws (002).

**Fig 10-7 Fuel Pump (X4) - Preparation before removal**



## CLOSE UP

- None

## 10.3.2 Fuel pump (X4) - remove

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Lifting tool	94552		1
Manual ratchet	94016-015		1
Fuel pump rack	94592		1
Screws	94592C		2
Limiters	94592B		2
Oil tray	94592A		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

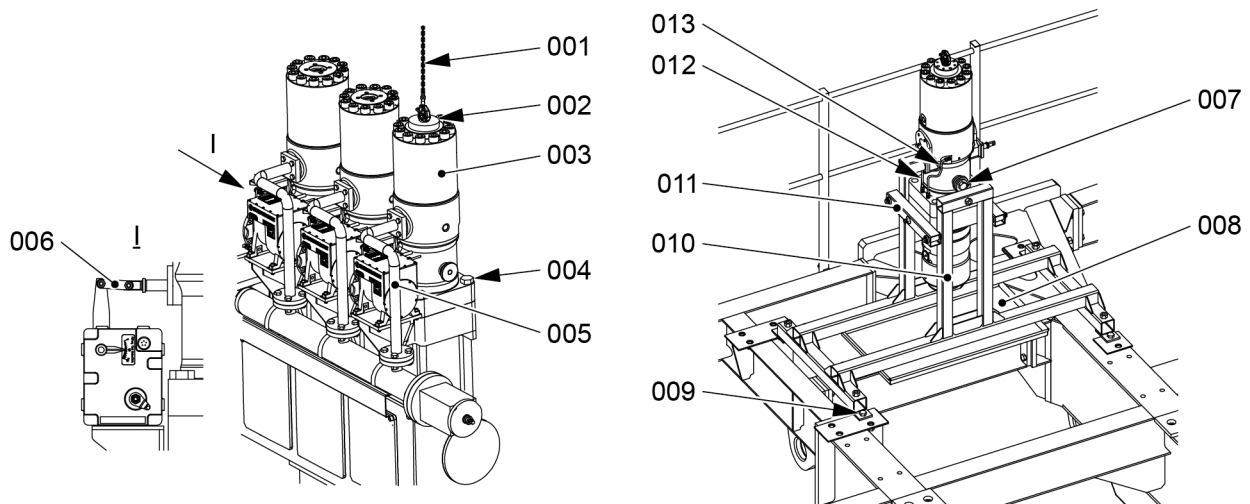
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 To remove the fuel pump, do the below steps:
  - 1.1 Turn the turning gear to get the applicable cam in the supply unit to BDC.
  - 1.2 Disconnect the applicable oil pipe (005, [Figure 10-8](#)).
  - 1.3 Attach the lifting tool (002) to the fuel pump (003).
  - 1.4 Disconnect the connecting element (006).
  - 1.5 Remove the four screws (004) from the fuel pump (003).
  - 1.6 Attach the manual ratchet (001) to the engine room crane.
  - 1.7 Attach the manual ratchet (001) to the lifting tool (002).
  - 1.8 Operate the manual ratchet (001) to lift the fuel pump (003) carefully.  
**NOTE:** Put the covers on the open ends of the oil pipe.
  - 1.9 Operate the manual ratchet (001) to lower the fuel pump (003) into the fuel pump rack (010).
  - 1.10 Attach the fuel pump (003) to the fuel pump rack (010) with two screws (007).
  - 1.11 Put the limiters (011) on the two sides of the fuel pump rack (010).
  - 1.12 Put the oil tray (008) below the fuel pump (003).
  - 1.13 Remove the manual ratchet (001).
  - 1.14 Remove the oil inlet pipe (012).
  - 1.15 Remove the oil drain pipe (013).

Fig 10-8 Fuel pump (X4) - Removal



**CLOSE UP**

- None

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### 10.3.3 Fuel pump (X4) - disassemble

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Screws	94592E		pc 2
Limiters	94592B		pc 2
Lifting tool	94552		pc 1
Oil tray	94592A		pc 1
Spindle press	94551		pc 1
Handle screw	94009-M10		pc 1
2-part clamping ring	94550		pc 1

#### Supplies

Description	QTY
Molykote G-Rapid Plus	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

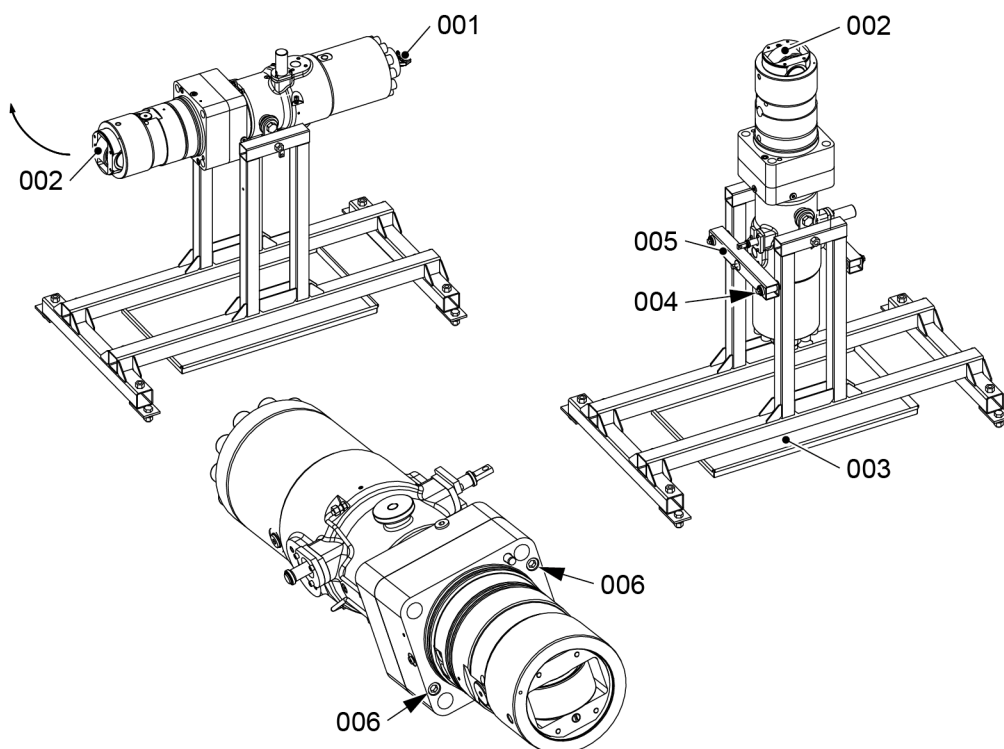
#### PRELIMINARY OPERATIONS

- The fuel pump must be removed, refer to section [10.3.2 Fuel pump \(X4\) - remove](#)

## PROCEDURE

- 1 To prepare the fuel pump before disassemble, do the below steps.
  - 1.1 Remove the two screws (004, [Figure 10-9](#)).
  - 1.2 Remove the two limiters (005).
  - 1.3 Turn the fuel pump until the roller (002) point up.
  - 1.4 Attach the two limiters (005) on each side of the fuel pump with the two screws (004).
  - 1.5 Remove the lifting tool (001).
  - 1.6 Let the fuel drain into the oil tray (003).
  - 1.7 Remove the two Allen screws (006).

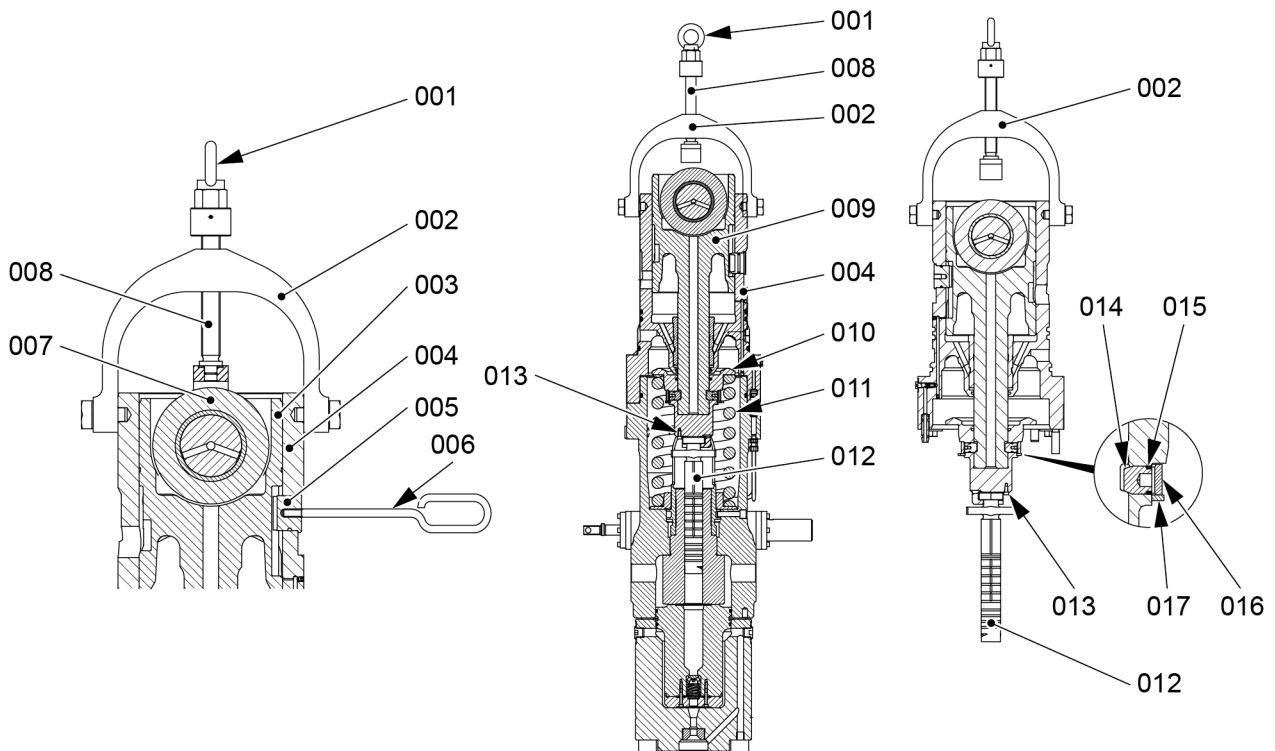
**Fig 10-9 Fuel pump (X4) - Preparation before disassemble**



- 1.8 Lubricate the spindle (008, [Figure 10-10](#)) with Molykote G-Rapid Plus.
- 1.9 Attach the spindle press (002) to the bottom housing (004).
- 1.10 Turn the eye bolt (001) in clockwise direction slowly to push the roller (007) into the bottom housing (004).
- 1.11 Remove the guide pin (005) with a handle screw (006).
- 1.12 Turn the eye bolt (001) in counterclockwise direction to move the spindle (008) up.
- 1.13 Lift the bottom housing (004), guide piston (009), the bottom spring carrier (010) and pump plunger (012) carefully.
- 1.14 Remove the compression spring (011).
- 1.15 Remove the screw (013).
- 1.16 Remove the pump plunger (012).
- 1.17 Remove the circlip (017) and push the retaining ring (016) down.

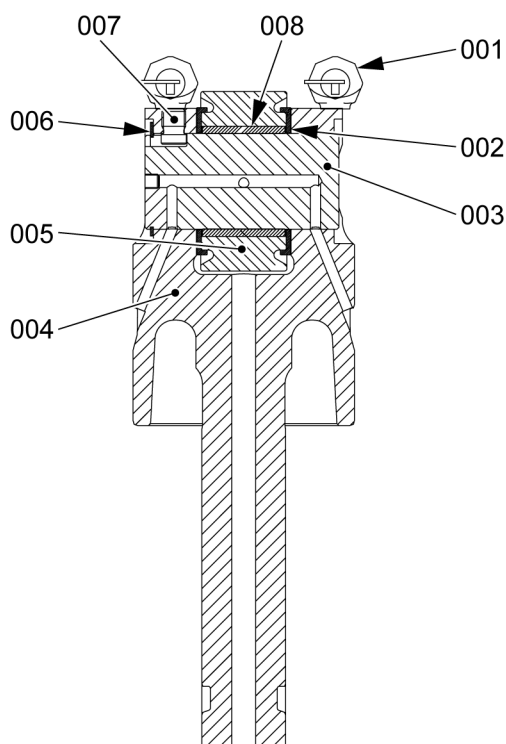
- 1.18 Remove the two connection spring pins (014).
- 1.19 Keep the bottom housing (004) and pump plunger (012) to the safe storage area.
- 1.20 Remove the spindle press (002).

**Fig 10-10 Fuel pump (X4) - Disassemble**

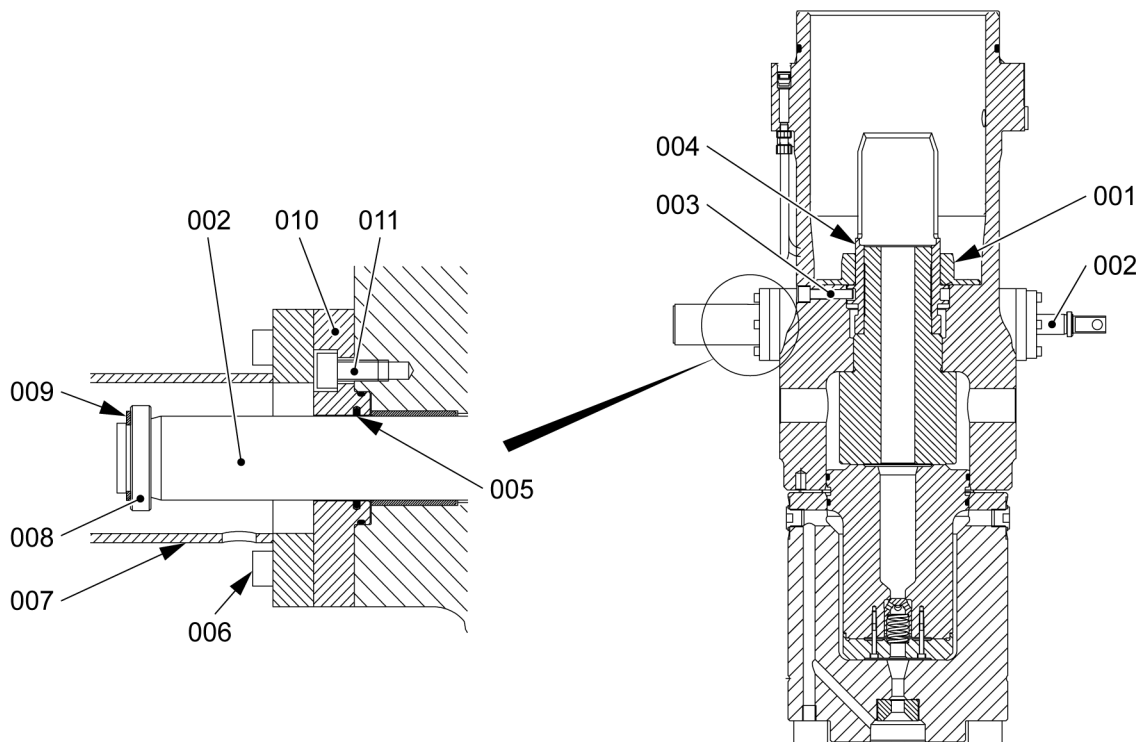


- 2 To remove the guide piston, do the below steps:
  - 2.1 Remove the guide piston (004, [Figure 10-11](#)).
  - 2.2 The two M10 eye bolts (001).
  - 2.3 Remove the circlip (006).
  - 2.4 Remove the pin (007).
  - 2.5 Push the roller pin (003) out then remove the roller (005), bush (008) and the two pressure discs (002).
  - 2.6 Keep the parts in a safe storage area.

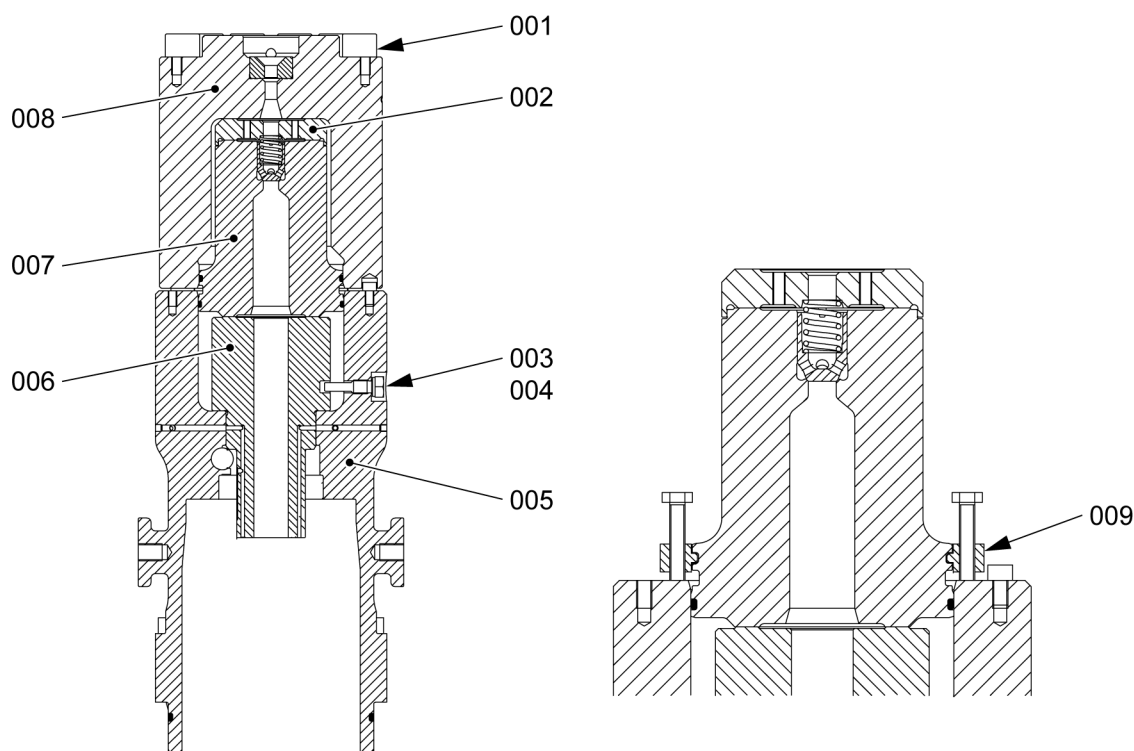


**Fig 10-11 Fuel pump (X4) - Guide piston removal**

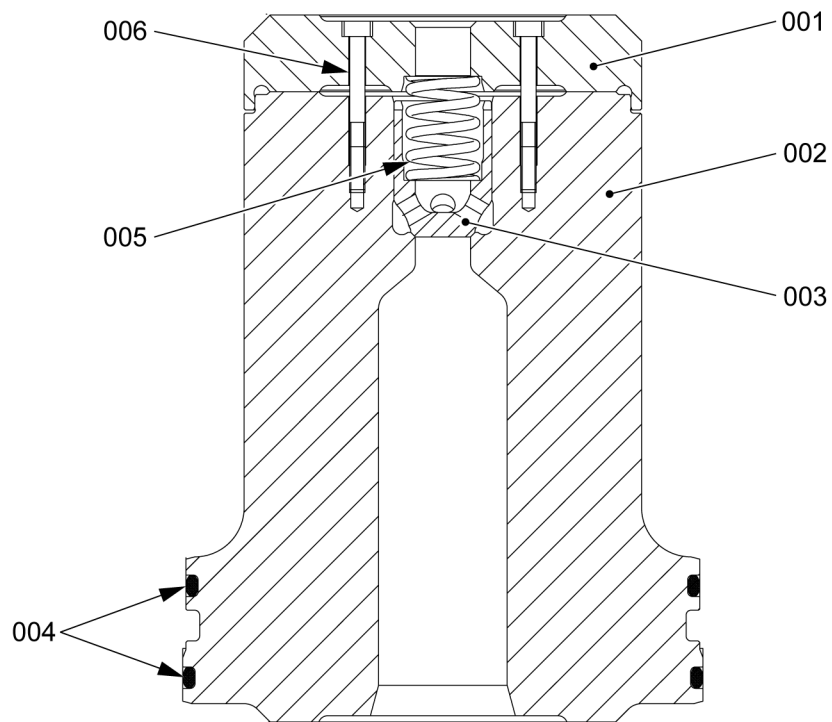
- 3** To remove the toothed rack, do the below steps:
- 3.1** Remove the top spring carrier (001, [Figure 10-12](#)) with two M8 bolts.
  - 3.2** Turn the regulating sleeve (004) until the guide pin (003) is in line with the cut-out.
  - 3.3** Remove the regulating sleeve (004).
  - 3.4** Remove the six screws (006).
  - 3.5** Remove the cover (007).
  - 3.6** Remove the two circlips (009).
  - 3.7** Remove the two rings (008).
  - 3.8** Remove the three screws (011).
  - 3.9** Remove the intermediate flange (010) and the rod joint ring (005).
  - 3.10** Remove the toothed rack (002).

**Fig 10-12 Fuel pump (X4) - Toothed rack removal**

- 4** To remove the pump cylinder do the below steps:
- 4.1** Turn the fuel pump until the pump cover (008, [Figure 10-13](#)) point up.
  - 4.2** Remove the twelve screws (001).
  - 4.3** Remove the pump cover (008) with applicable tool.
  - 4.4** Remove the valve block (007) with 2-part clamping ring (009).
  - 4.5** Remove the retaining screw (003) and fluted seal ring (004).
  - 4.6** Remove pump cylinder (006) from the upper housing (005) carefully.
  - 4.7** Keep the parts in a safe storage area.
- NOTE:** The pump cylinder (006) and pump plunger must stay together as a unit.

**Fig 10-13 Fuel pump (X4) - Pump cylinder removal**

- 5** To remove the non-return valve do the below procedure:
- 5.1** Remove the two screws (006, [Figure 10-14](#)).
  - 5.2** Remove the intermediate piece (001) and the compression spring (005).
  - 5.3** Remove the valve body (003) from the valve block (002).
  - 5.4** Remove the two O-rings (004).

**Fig 10-14 Fuel pump (X4) - Non-return valve removal****CLOSE UP**

- None

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### 10.3.4 Fuel pump (X4) - assemble

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Spindle press	94551		1
Handle	94009-M10		1
Mandrel	94597		1
Ring	94593A		1
Ring (2-part)	94593B		2
Guide Rod	94593C		2
Distance piece	94555		1
Limiters	94592B		2
Screws	94592C		2
Lifting tool	94552		1

#### Supplies

Description	QTY
NeverSeez NSBT	A/R
Loctite 243	A/R
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
O-ring			A/R
Seal ring			A/R

#### SAFETY PRECAUTIONS

- None

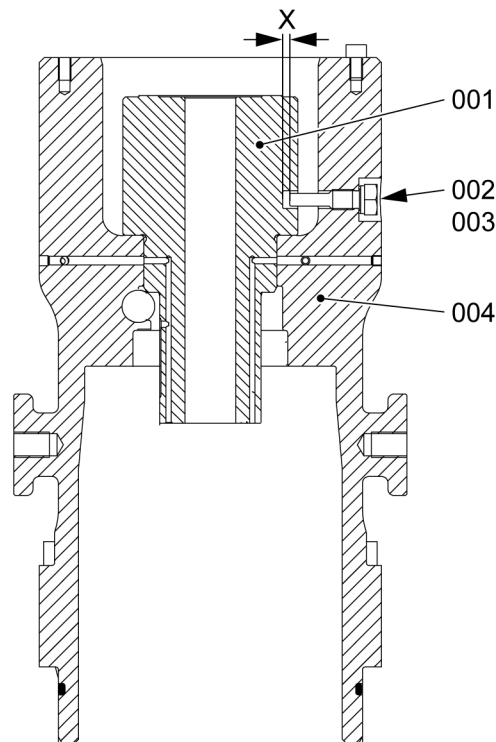
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 To prepare the fuel pump before assemble, do the below steps:
  - 1.1 Clean all parts of the fuel pump.
  - 1.2 Do a condition check for all parts. If necessary, replace damaged parts.
  - 1.3 Replace all the O-rings and rod seal rings.
  - 1.4 Use a low pressure air supply to clean the bores in the housing and in the pump cylinder (001).
  - 1.5 Make sure that the top housing (004, [Figure 10-15](#)) points up.
- 2 To assemble the pump cylinder do the below steps:
  - 2.1 Install the pump cylinder (001, [Figure 10-15](#)) in the top housing (004) carefully.
  - 2.2 Align the opening in the pump cylinder (001) with the screw (002) in the top housing (004).
  - 2.3 Install the fluted seal ring (004) and retaining screw (003).  
**NOTE:** Make sure that there is a clearance (X) between the end of the screw (002) and the opening in the pump cylinder (001).

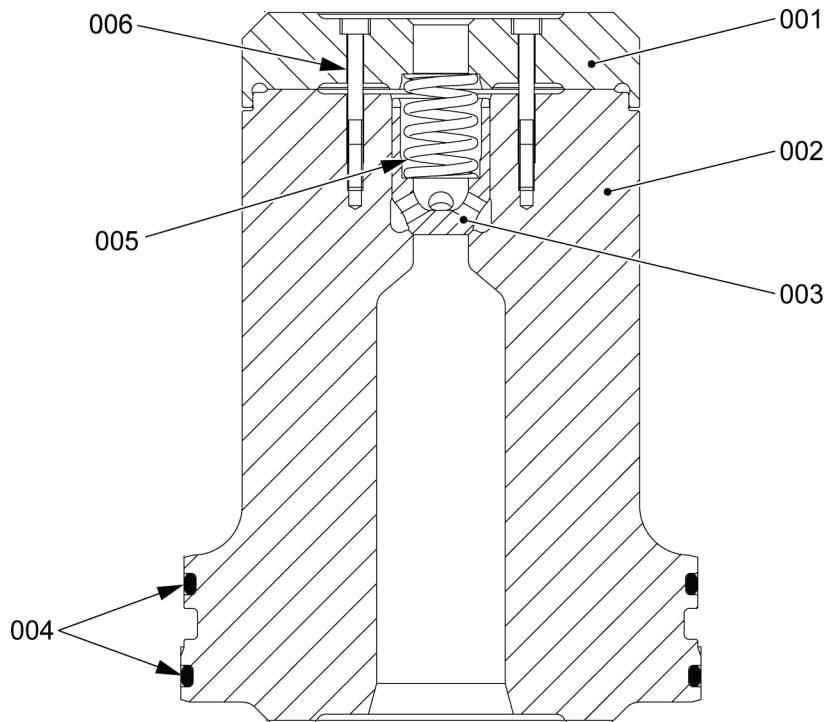
**Fig 10-15 Fuel pump (X4) - Pump cylinder assemble**



- 3 To assemble the Non-return valve, do the below steps:
  - 3.1 Do a condition check of sealing surfaces on the valve block (002, [Figure 10-16](#)).
  - 3.2 Lubricate the O-rings (004) with oil.
  - 3.3 Attach the O-rings (004) to the valve block (002).
  - 3.4 Install the compression spring (005) in its position on the valve body (003).
  - 3.5 Attach the intermediate disc (001) to the valve body (002) with the two bolt (006).

- 3.6 Torque the two bolts (006) to 4.0 Nm.

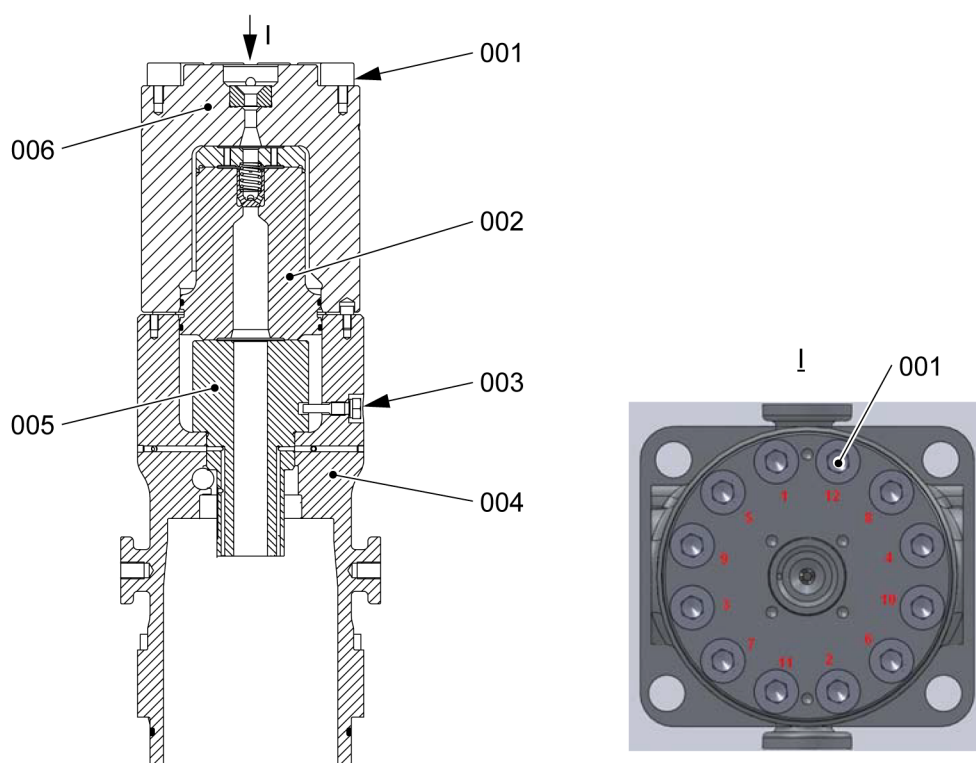
**Fig 10-16 Fuel pump (X4) - Non-return valve assemble**



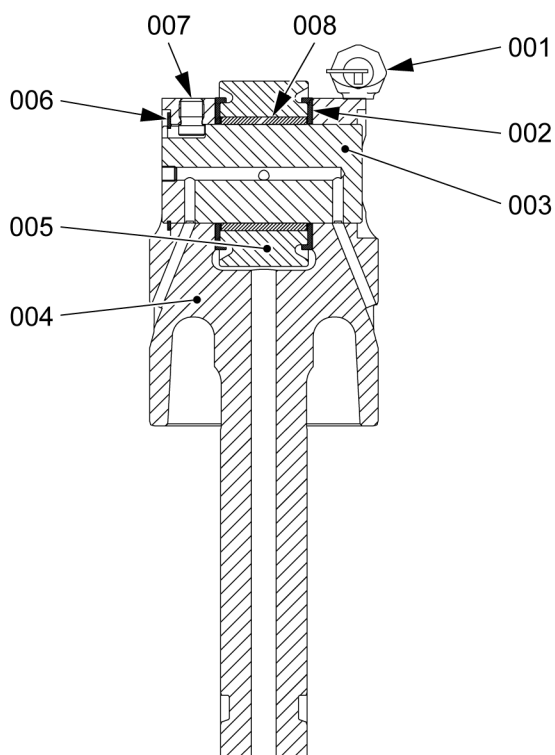
- 4 To assemble the pump cover do, the below steps:
- 4.1 Lubricate the bottom part of the non-return valve (002, [Figure 10-17](#)) with oil.
  - 4.2 Install the non-return valve (002) in the top housing (004) carefully.
  - 4.3 Install the pump cover (006).
  - 4.4 Apply Never-Seez NSBT to the threads and the bottom faces of the 12 bolts (001).
  - 4.5 Install the 12 bolts (001) in its position on the pump cover (006).
  - 4.6 Torque the 12 bolts (001) as below:
    - 4.6.1 Torque the 12 bolts in the sequence shown to 100 Nm.
    - 4.6.2 Torque the 12 bolts in the sequence shown to 300 Nm.
    - 4.6.3 Torque the 12 bolts in the sequence shown to 482 Nm.



Fig 10-17 Fuel pump (X4) - Pump cover assemble

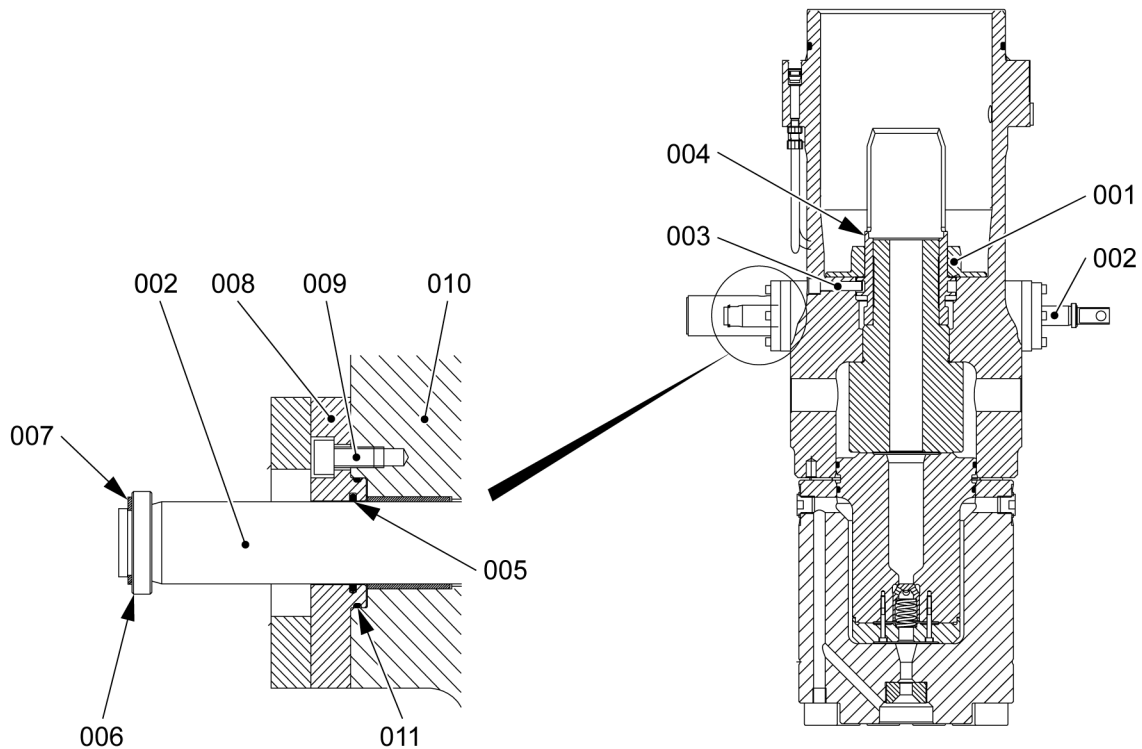


- 5** To assemble the guide piston, do the below steps:
- 5.1** Clean all parts of the guide piston (004, [Figure 10-18](#)).
  - 5.2** Lubricate all the parts of the guide piston (004) with oil.
  - 5.3** Install the locating pin (007) in its position on the guide piston (004).  
**NOTE:** Make sure that locating pin (007) is installed from the inner surface of the guide piston (004).
  - 5.4** Torque the locating pin (007) in counterclockwise direction to 60 Nm.
  - 5.5** Lubricate the flanks of the roller (005) with oil.
  - 5.6** Install the roller (005), bush (008) and the two pressure discs (002) in the guide piston (004).
  - 5.7** Hold the roller pin (003) in position and align the groove with locating pin (007).
  - 5.8** Attach the circlip (006) to hold the roller pin (003) in its position.

**Fig 10-18 Fuel pump (X4) - Guide piston assemble**

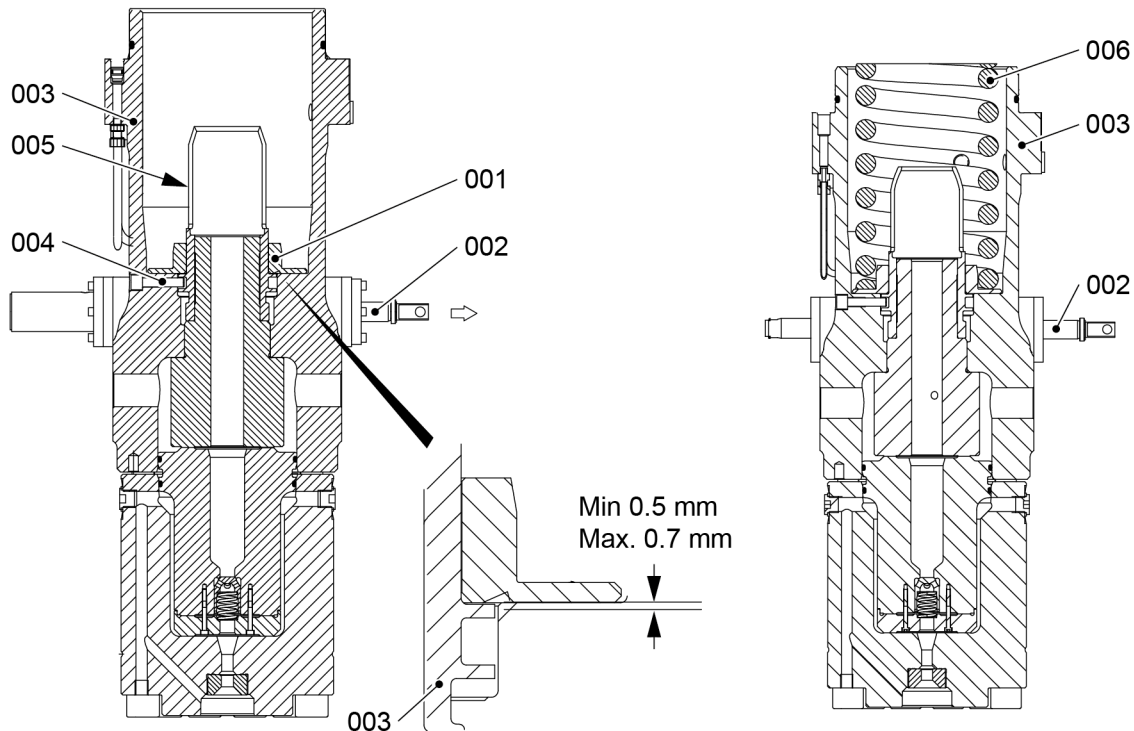
- 6** To assemble the top housing, do the below steps:
- 6.1** Turn the fuel pump into the position shown in [Figure 10-19](#).
  - 6.2** Install the toothed rack (002) in its position.  
**NOTE:** Make sure that the toothed rack (002) moves easily.
  - 6.3** Lubricate the rod seal ring (005).
  - 6.4** Install the rod seal ring (005) in the intermediate flange (008).
  - 6.5** Install the intermediate flange (008) and O-ring (001) in the top housing (010).
  - 6.6** Install the three screws (009).
  - 6.7** Attach the rings (006) and circlips (007).

Fig 10-19 Fuel pump (X4) - Top housing assemble



- 6.8** Move the toothed rack (002, [Figure 10-20](#)) fully out.
- 6.9** Install the regulating sleeve (005) in its position on the top housing (003).
- 6.10** Turn the regulating sleeve (005) until the guide pin (004) is in line with the cut-out.
- NOTE:** Move the toothed rack through the full range of movement.
- 6.11** Install the top spring carrier (001) in its position on the top housing (003).
- 6.12** Push the top spring carrier (001) to move the regulating sleeve (005) up and down.
- 6.13** Measure the axial clearance between the regulating sleeve (005) and the top spring carrier (001).
- NOTE:** Make sure that the axial clearance is between 0.5 mm to 0.7 mm.

Fig 10-20 Fuel pump (X4) - Top housing assemble



**6.14** Move the toothed rack (002) to the middle position.

**6.15** Install the compression spring (006) in its position on the top housing (003).

**7** To assemble the bottom housing, do the below steps:

**7.1** Attach the spindle press (001) to the bottom housing (011, [Figure 10-21](#)).

**7.2** Put a new O-ring on the guide pin (002).

**7.3** Install the guide piston (010) in the bottom housing (011).

**NOTE:** Make sure that the groove in the guide piston (010) aligns with the bore in the bottom housing (011).

**7.4** Install the guide pin (002) with the handle (003).

**7.5** Use a mandrel (012) to install the new seal (013) into the bottom spring carrier (009).

**7.6** Install the bottom spring carrier (009) in its position on the guide piston (010).

**7.7** Install the new O-rings (005) on the connection pins (004).

**7.8** Install the two connection pins (004).

**NOTE:** Make sure that two connection pins (004) aligns with the groove in the guide piston (010).

**7.9** Attach the retaining rings (006) to the two connection pins (004).

**7.10** Attach the circlips (007) to hold two connection pins (004) and retaining rings (006) in position.

**NOTE:** Lift the assembly into the position above the top housing.

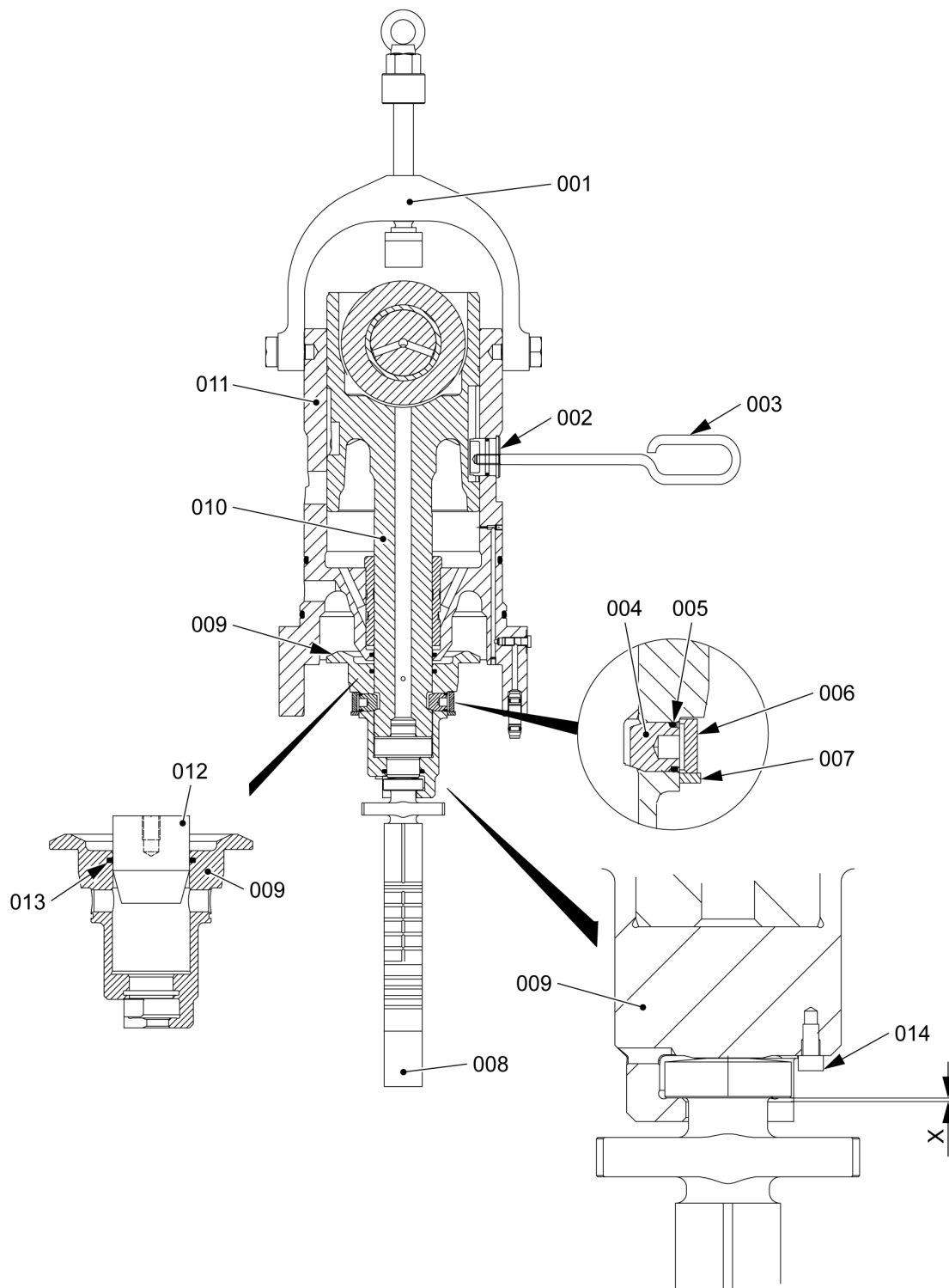
**7.11** Attach the pump plunger (008) to the bottom spring carrier (009).

**NOTE:** Make sure that there is a clearance (X) between 0.12 mm and 0.24 mm.

**7.12** Apply the Loctite 243 to the threads of the screw (014).

7.13 Torque the screw (014) to 9 Nm.

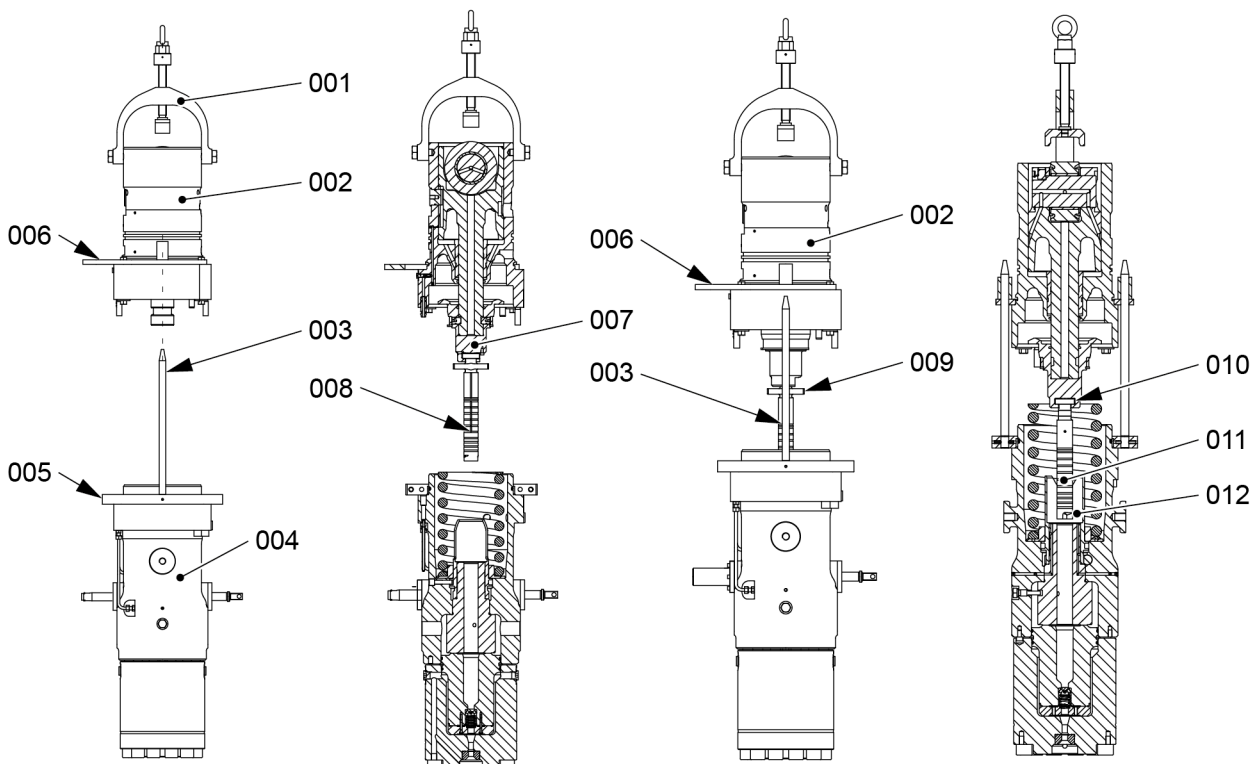
Fig 10-21 Fuel pump (X4) - Bottom housing assemble



8 To assemble the fuel pump, do the below steps:

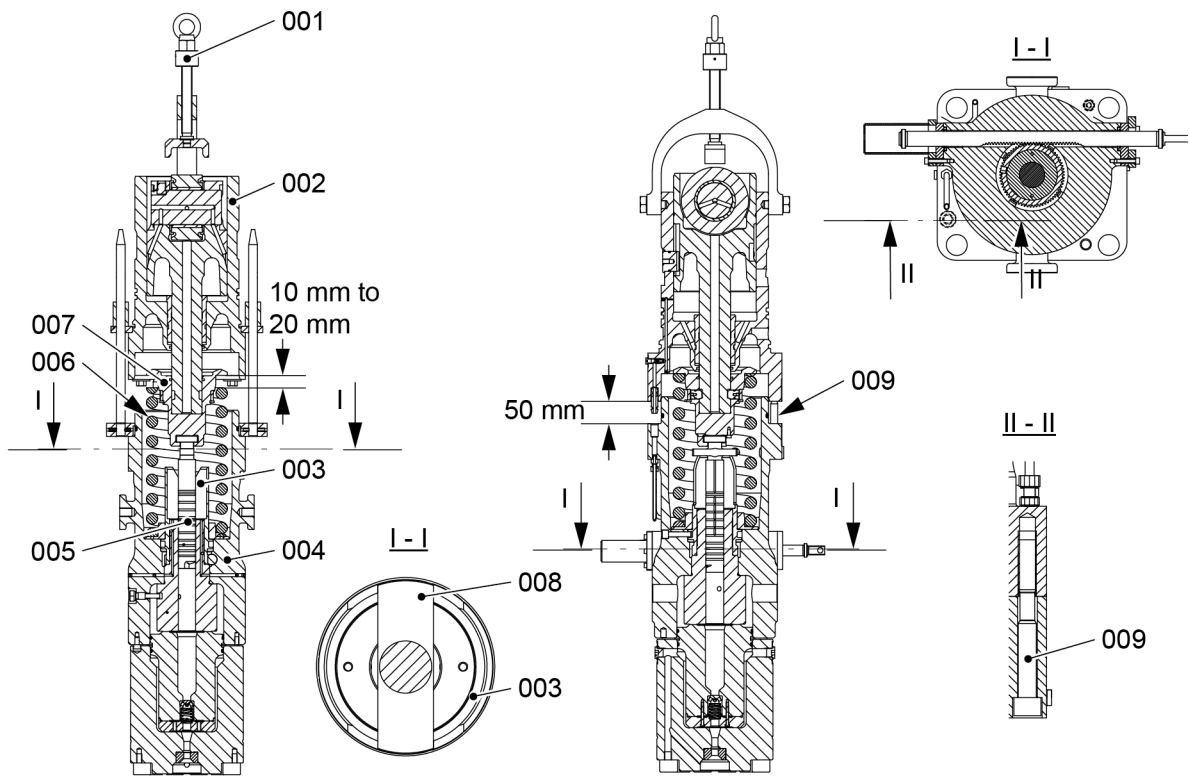
- 8.1 Attach the ring (006, [Figure 10-22](#)) to the bottom housing (002).
- 8.2 Attach the two-part ring (005) to the top housing (004).  
**NOTE:** Make sure that the guide rods (003) align with holes in the ring (006).
- 8.3 Attach the crane hook to the spindle press (001).
- 8.4 Carefully lower the bottom housing (002) to engage with the guide rods (003) and ring (006).
- 8.5 Continue to lower the bottom housing (002) until the pump plunger (011) is at a minimum distance from the regulating sleeve (012).

**Fig 10-22 Fuel pump (X4) - Assembly**



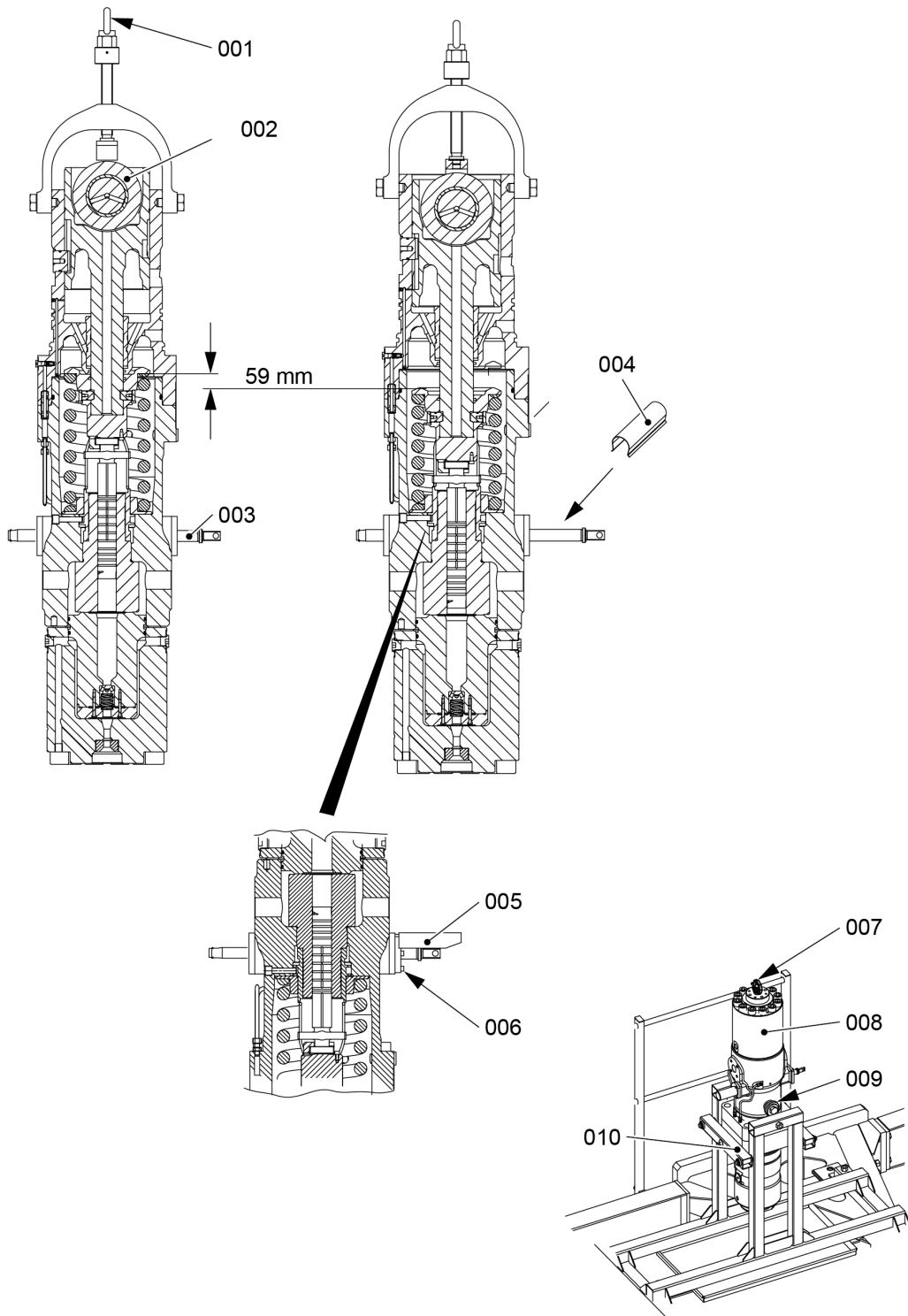
- 8.6 Lower the bottom housing (002, [Figure 10-23](#)) on the top housing (004) until the spring carrier (007) is approximately 10 mm to 20 mm above the spring (006).
- 8.7 Align the tabs (008) on the pump plunger (005) with the regulating sleeve (003).
- 8.8 Continue to lower the bottom housing (002) until the spring carrier (007) touches the spring (006).
- 8.9 Remove the crane hook from the spindle press (001).
- 8.10 Remove the ring (006, [Figure 10-22](#)) and the two-part ring (005).  
**NOTE:** Make sure that there is a clearance of 50 mm between the top housing (004, [Figure 10-23](#)) and bottom housing (002).
- 8.11 Install the two Allen screws (009).
- 8.12 Torque the two Allen screws (009) to 140 Nm manually.

Fig 10-23 Fuel pump (X4) - Assembly



- 8.13** Turn the eye bolt on the spindle press (001, [Figure 10-24](#)) to move the roller (002) down approximately 59 mm.  
**NOTE:** The distance of 59 mm is equal to a hub stroke of 55 mm.
- 8.14** Turn the eye bolt on the spindle press (001) back to the initial position.
- 8.15** Attach a spring balance to the toothed rack (003).
- 8.16** Use the spring balance to pull the toothed rack (003) fully out.  
**NOTE:** If the force to move the toothed rack is more than 30 Nm, disassemble the fuel pump and do a check of all important dimensions.
- 8.17** Install the distance piece (004).
- 8.18** Remove the spindle press (001).
- 8.19** Attach the cover (005) to the fuel pump with the six screws (006).
- 8.20** Torque the six screws (006) to 20 Nm.
- 8.21** Remove the limiters (009 and 010).
- 8.22** Turn the fuel pump (008) until the pump cover points up.
- 8.23** Attach the lifting tool (007) to the fuel pump (008).

Fig 10-24 Fuel pump (X4) - Assembly





**CLOSE UP**

- None

### 10.3.5 Fuel pump (X4) - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Manual ratchet	94016-015		1
Lifting tool	94552		1
Socket wrench insert	94598B		1
Extensions	94598A		2
Pneumatic impact wrench	94598		1

#### Supplies

Description	QTY
Molykote paste G	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Fuel pump			A/R
O-rings			A/R

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

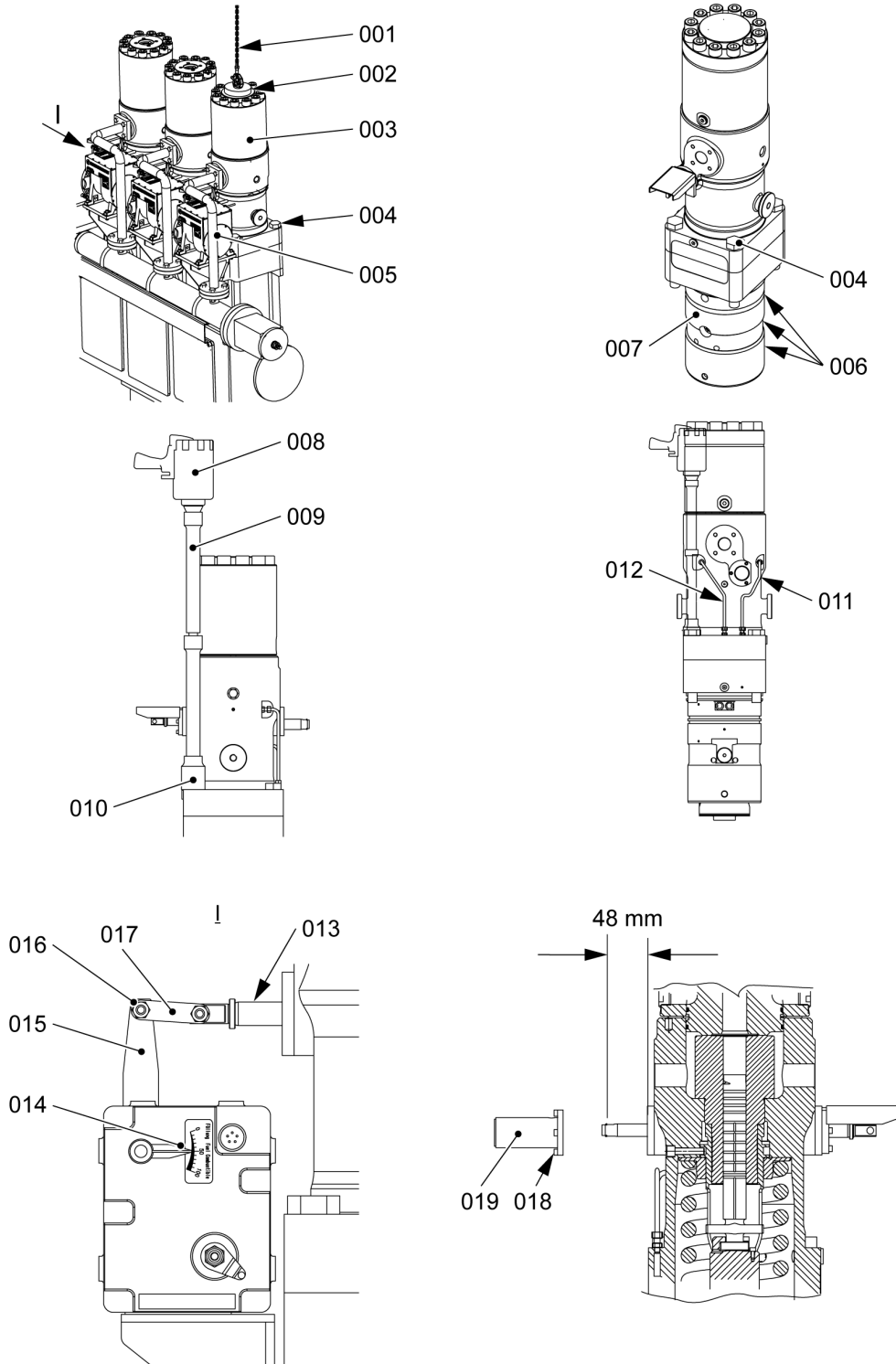
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 To install the fuel pump, do the below steps:
  - 1.1 Operate the turning gear to turn the camshaft until the applicable cam is at BDC.
  - 1.2 Do a condition check for all parts of the fuel pump.
  - 1.3 Make sure that the seating surfaces of the fuel pump are clean and have no damage.
  - 1.4 Put new O-rings (006, [Figure 10-25](#)) on the bottom housing (007).
  - 1.5 Put oil on the threads and seating surfaces of the four screws (004).
  - 1.6 Attach the manual ratchet (001) to the lifting tool (002) and the engine room crane.
  - 1.7 Lift the fuel pump.
  - 1.8 Put the fuel pump above the applicable position of the supply unit.
  - 1.9 Lower the fuel pump into position carefully.
  - 1.10 Torque the four screws (004) to 1250 Nm.  
**NOTE:** Use the socket wrench insert (010), the extensions (009) and pneumatic impact wrench (008).
  - 1.11 Install the applicable HP fuel pipe, refer to [\[section not applicable for this engine\]](#).
  - 1.12 Connect the oil drain pipe (011) and the oil inlet pipe (012).
  - 1.13 Make sure that the fuel return valve and fuel inlet valve are open, refer to the operation manual.
  - 1.14 Do a leakage check of the fuel pump.
  - 1.15 Make sure that connecting element (017) moves freely.
  - 1.16 Apply Molykote paste G to the connecting element (017).
  - 1.17 Connect the connecting element (017) to the actuator lever (015) with screw and self locking nut (016).
  - 1.18 Move the toothed rack (013) to the middle position as shown.  
**NOTE:** Make sure that there is 48 mm at each end of the toothed rack (013).
  - 1.19 Make sure that indicator (014) on the actuator shows 50% fuel.
  - 1.20 Attach the cover (019) to the fuel pump with six screws (018).
  - 1.21 Torque the six screws (018) to 20 Nm.

Fig 10-25 Fuel pump (X4) - Installation



**CLOSE UP**

- None

### 10.3.6 Fuel pump (X4) - function test

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

#### Support equipment

Description	Part No.	CSN	QTY
Heat gun			1
Small drill bit			1
Nylon brush			1

#### Supplies

Description	QTY
WD-40	A/R
Petroleum jelly	A/R
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

Injury hazard: Do not operate the engine, injury to personnel can occur.

##### WARNING

injury hazard: before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

#### PRELIMINARY OPERATIONS

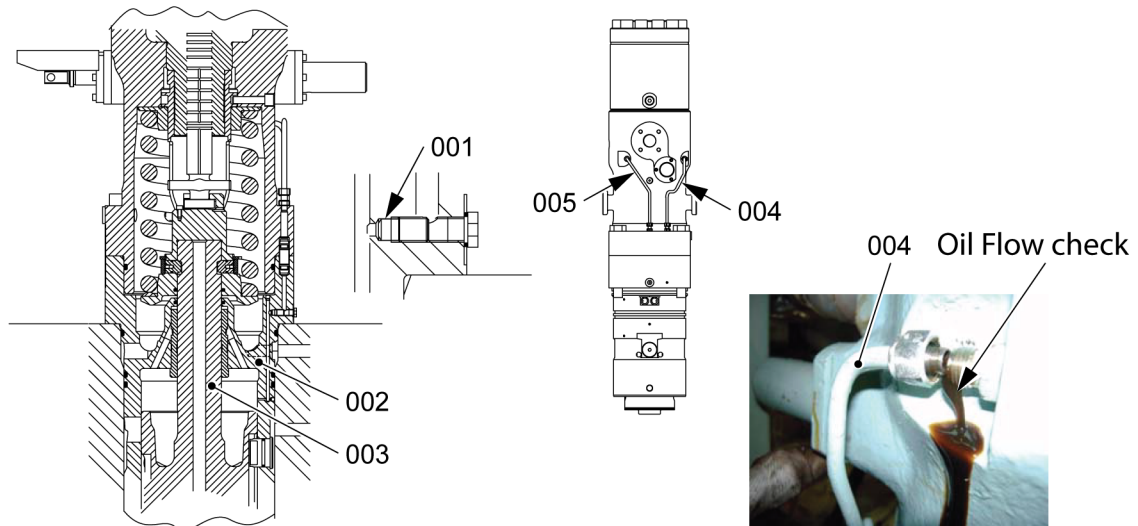
- The fuel pump must be installed, refer to section [10.3.5 Fuel pump \(X4\) - install](#)
- The engine must be stopped.

## PROCEDURE

- 1 To do a test operation of fuel pump, do the below steps:
  - 1.1 The engine must be stopped.
  - 1.2 Operate the turning gear to move the roller of the related fuel pump to its highest position (TDC).

**NOTE:** The oil flows through the throttle (001, [Figure 10-26](#)) to the bottom housing (002) and the guide piston (003).
  - 1.3 Remove the oil drain pipe (004) and oil inlet pipe (005) from the fuel pump.
  - 1.4 Set to ON the servo oil service pump.
  - 1.5 After one minute, make sure that you can see the oil flow as shown.
  - 1.6 If the oil does not flow as shown in [Figure 10-26](#), read the data in technical bulletin.
  - 1.7 Make sure that the oil flows in the oil inlet pipe (005).

**NOTE:** If the oil in the oil inlet pipe (005) does not flow freely, make sure that there are no unwanted particles in the oil supply system.
  - 1.8 If there is incorrect oil flow, or no flow through the drain bore do [Step 1.8.1](#) to [Step 1.8.4](#).
    - 1.8.1 If the oil cannot flow freely, flush the bores with WD-40.
    - 1.8.2 If there is no flow, use a heat gun to apply heat to the clogged drain bore.
    - 1.8.3 Use a small drill bit to open the bore.
    - 1.8.4 Remove the particles with a nylon brush.
  - 1.9 Install all the unions and plugs.
  - 1.10 Connect the oil drain pipe (004) to the fuel pump.

**Fig 10-26 Fuel pump (X4) - Oil flow check**

- 2 To keep the fuel pump in a storage area, do the below steps:
  - 2.1 Make sure that the storage area is clean and dry.
  - 2.2 Lubricate the fuel pump with oil to prevent contamination.
  - 2.3 Put the fuel pump in a vertical position.
  - 2.4 Apply a petroleum jelly in the oil inlet and oil drain bores of the fuel pump.
  - 2.5 Put the plastic stoppers on the open spaces.
  - 2.6 Put a cover on the fuel pump.

## CLOSE UP

- None



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### 10.3.7 Fuel pump (X4) seized pump plunger - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
Hydraulic ram	94595		1
Short push rod	94595B		1
Long push rod	94595C		1
Piston reset tool	94595D		1
Screws	94595E		2
HP oil pump	94931		1
Pressure gauge	94932		1
HP hose	94935		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### CAUTION

**Damage Hazard:** There is no support below the housing. the bottom housing can fall and cause damage when the screws are removed.

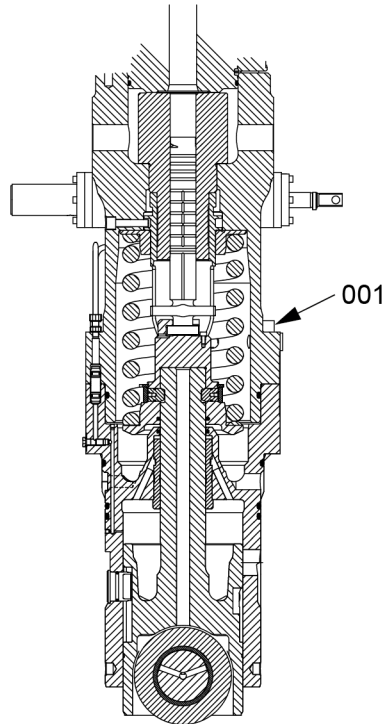
#### PRELIMINARY OPERATIONS

- The fuel must be removed, refer to section [10.3.2 Fuel pump \(X4\) - remove](#)

## PROCEDURE

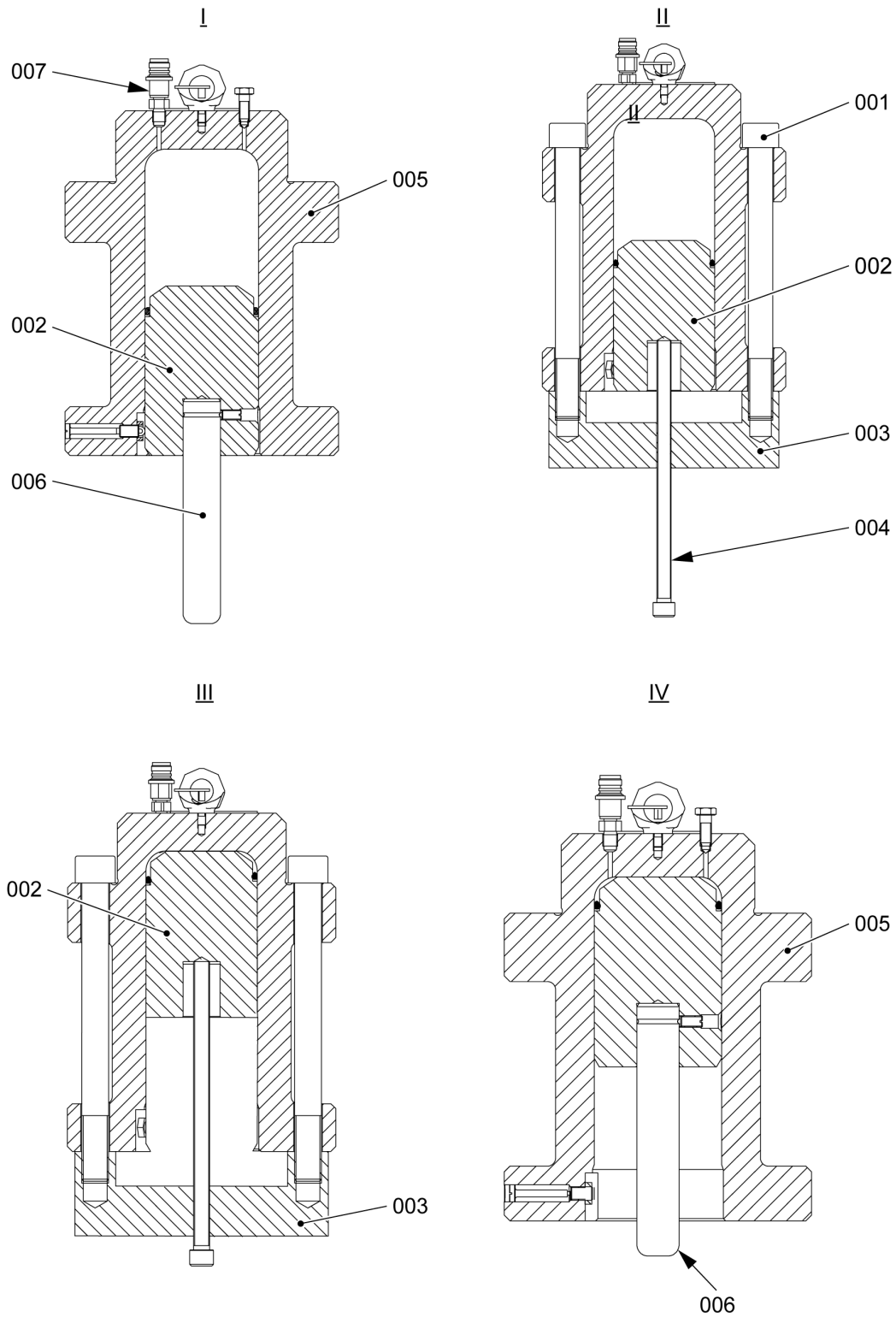
- 1 To prepare the seized pump plunger of fuel pump before removal, do the below step:
  - 1.1 Disassemble the fuel pump until the condition is as shown in [Figure 10-27](#).

**Fig 10-27 Fuel pump (X4) - Preparation**



- 2 To prepare the hydraulic ram, do the below steps:
  - 2.1 Open the vent screw (007, [Figure 10-28](#)) and push the piston (002) to the top of the cylinder of the hydraulic ram (005).
  - 2.2 If you cannot move the piston (002) manually, do a [Step 2.2.1](#) to [Step 2.2.3](#):
    - 2.2.1 Remove the short push rod (006) from the piston (002).
    - 2.2.2 Attach the piston reset tool (003) to the hydraulic ram (005) with the two screws (001).

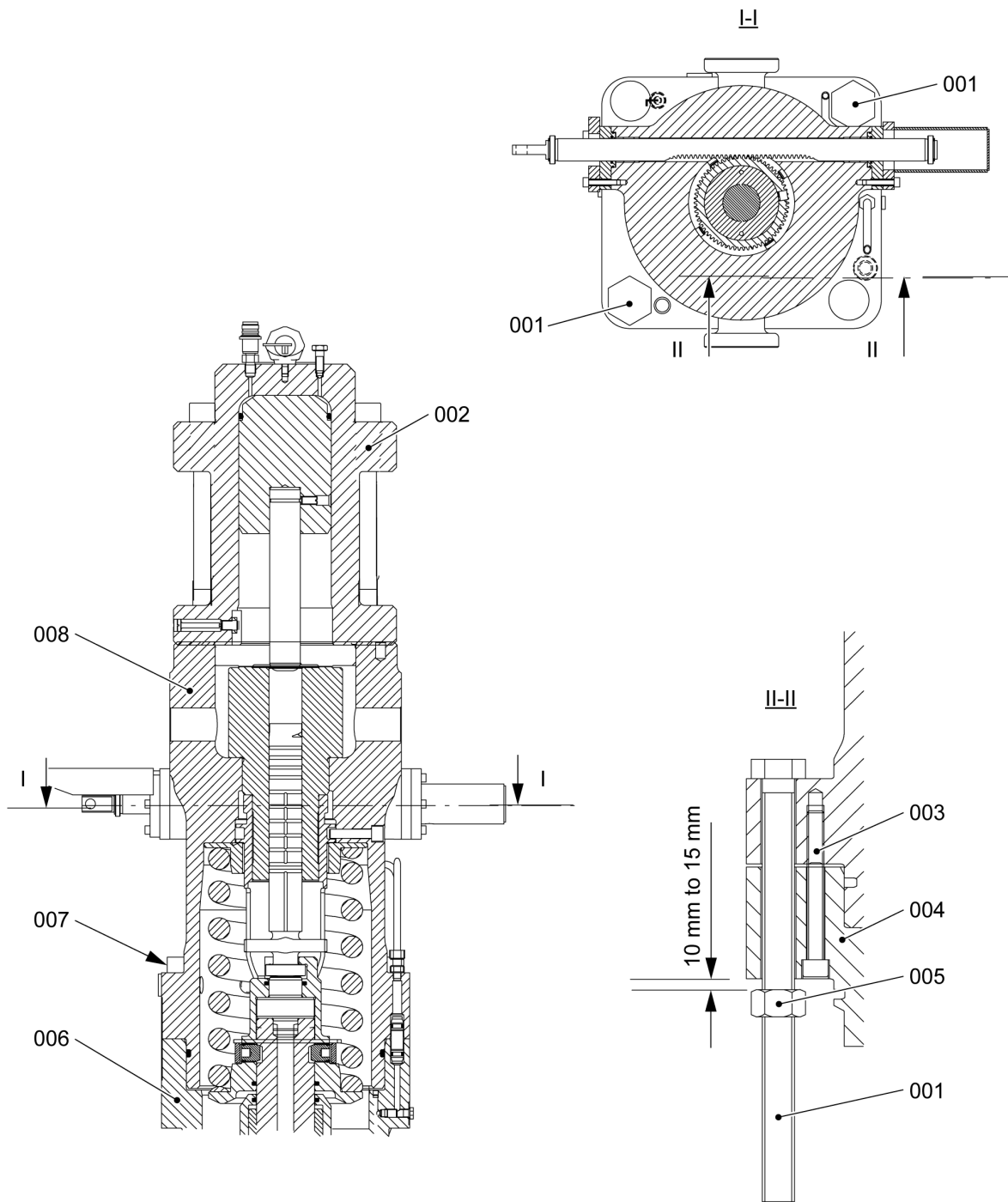
**NOTE:** The screws (001) are from the fuel pump cover.
    - 2.2.3 Use the spindle (004) to push the piston (002) to the of the cylinder.
  - 2.3 Remove the piston reset tool (003).
  - 2.4 Attach the short push rod (006) to the piston (002).

**Fig 10-28 Fuel pump (X4) - Hydraulic ram preparation**

- 3** To install the hydraulic ram, do the below steps:
- 3.1** Attach the hydraulic ram (002) to the fuel pump with the twelve screws (003).

- 3.2** Hold the bottom housing (006, [Figure 10-29](#)) in position and then remove the four bolts (007) from the top housing (008).
- 3.3** Install the two screws (001) through the bores of the flange in the top housing (008) and bottom housing (006).
- 3.4** Install the nuts (005) on the screws (001).
- 3.5** Adjust the nuts (005) to get a minimum clearance of between 10 mm to 15 mm.
- 3.6** Remove the two screws (003).

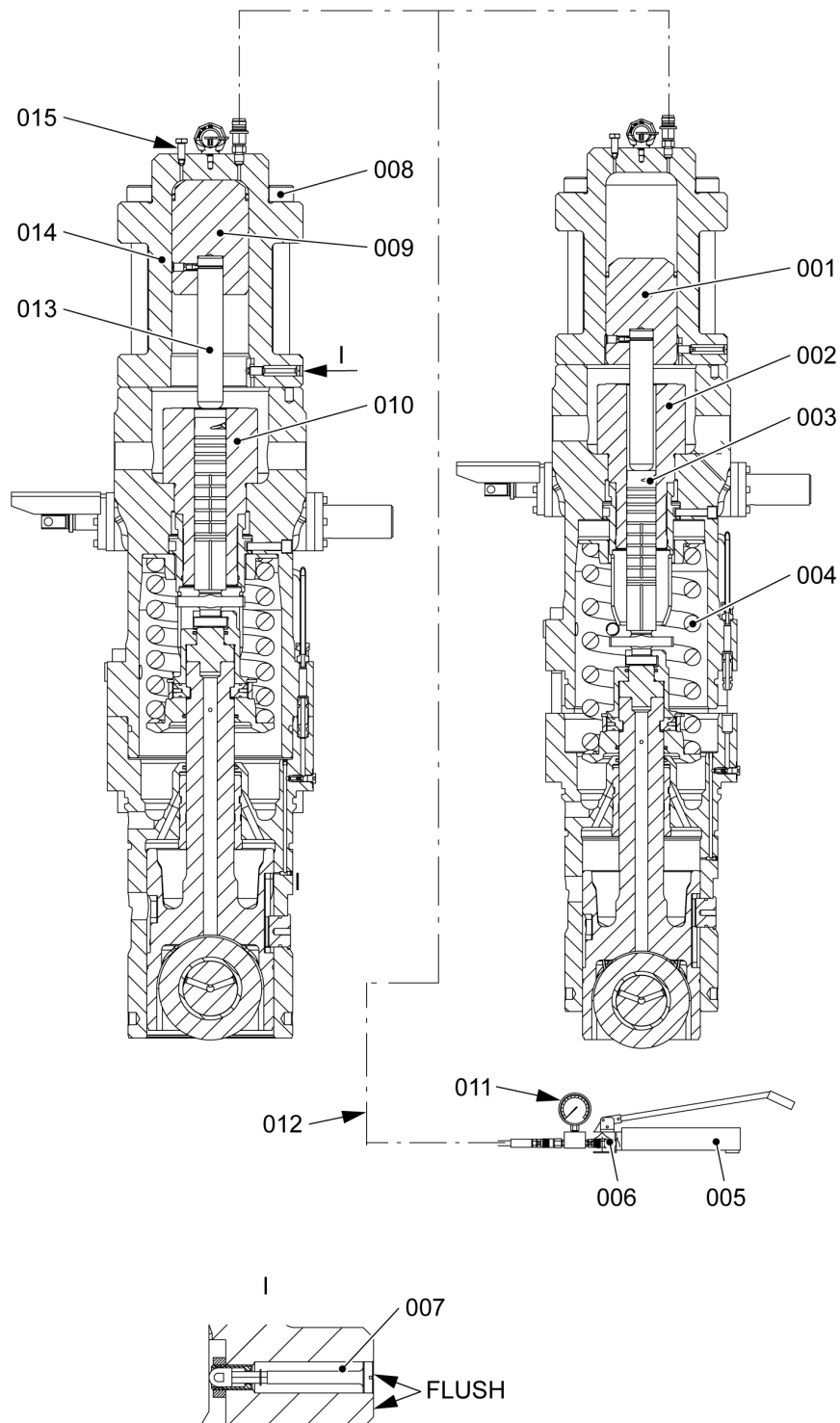
Fig 10-29 Fuel pump (X4) - Hydraulic ram installation



- 4** To remove pump plunger with short push rod, do the below steps:
- 4.1** Connect the hydraulic ram (014, [Figure 10-30](#)) to the HP oil pump (005).
  - 4.2** Close the relief valve (006).

- 4.3 Make sure that vent screw (015) is open.
- 4.4 Operate the HP oil pump until oil that no air flow from the vent screw (015).
- 4.5 Close the vent screw (015).
  - NOTE:** Before you do [Step 4.6](#), make sure that you keep a clearance between 10 mm and 15 mm between the nuts (005, [Figure 10-29](#)) and the bottom housing (006).
- 4.6 Slowly operate the HP oil pump (005, [Figure 10-30](#)) until the [Step 4.6.1](#) to [Step 4.6.2](#) is not completed.
  - 4.6.1 The compression spring (004) pushes the pump plunger (002) out of the cylinder (010), or
  - 4.6.2 The indicator (007) is flush with the housing. (This shows that the piston is at the end of its stroke.)
- 4.7 Open the relief valve (006) to release the pressure in the HP oil line.
- 4.8 Disconnect the HP oil pump (005) from the hydraulic ram (014).
- 4.9 Remove the plunger (003).
- 4.10 Remove the piston (009) to the initial position, refer to [Step 2](#).
- 4.11 Continue to disassemble fuel pump.
- 4.12 If you cannot remove the pump plunger (003), do the procedure given in [Step 5](#).

Fig 10-30 Fuel pump (X4) - Seized pump plunger removal with a short push rod

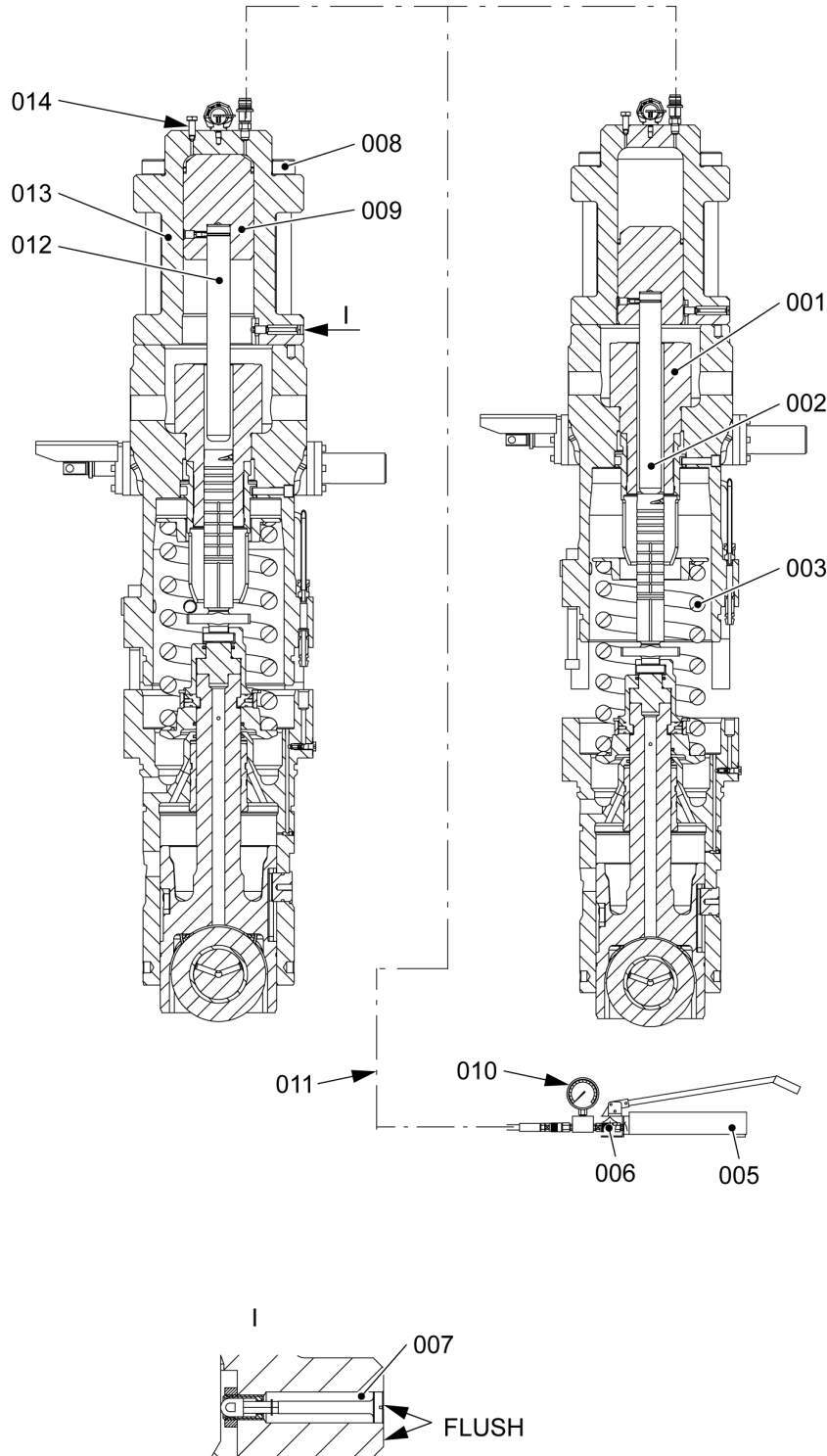


- 5** To remove the pump plunger with long push rod, do the below steps:
- 5.1** Put the long push rod (012) into the hydraulic ram (013).
  - 5.2** Install the hydraulic ram (013, [Figure 10-31](#)) to the fuel pump, refer to [Step 3](#).



- 5.3 Connect the hydraulic ram (013) to the HP oil pump.
- 5.4 Close the relief valve (006).
- 5.5 Open the vent screw (014).
- 5.6 Operate the HP oil pump until oil that has no air flows from the vent screw (014).
- 5.7 Close the vent screw (014).
  - NOTE:** Before you do [Step 5.8](#), make sure that you keep a clearance between 10 mm and 15 mm between the nuts (005, [Figure 10-29](#)) and the bottom housing (006).
- 5.8 Operate the HP oil pump (005, [Figure 10-31](#)) slowly until the below [Step 5.8.1](#) and [Step 5.8.2](#) are completed:
  - 5.8.1 The compression spring (003) pushes the plunger (007) out of the cylinder (001), or
  - 5.8.2 The indicator (007) is flush with the housing. (This shows that piston is at the end of its stroke.)
- 5.9 Remove the screws (008).
- 5.10 Remove the hydraulic ram (013).
- 5.11 Remove the pump plunger (002).
- 5.12 Continue to disassemble the fuel pump, refer to section [10.3.3 Fuel pump \(X4\) - disassemble](#)

Fig 10-31 Fuel pump (X4) - Seized pump plunger removal with a long push rod



**CLOSE UP**

- None

## 10.4 Fuel pump actuator

### 10.4.1 Fuel pump actuator - calibrate

#### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

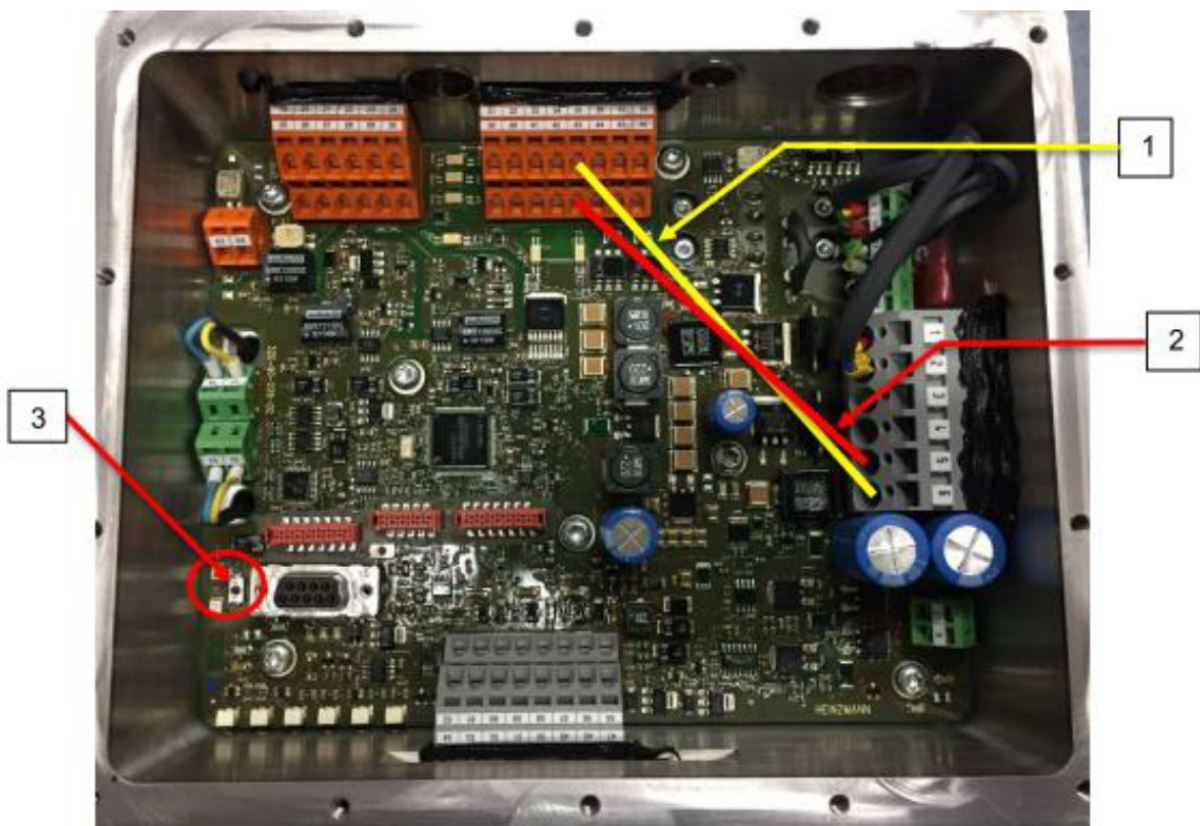
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Turn the power supply of E85 "off".
- 2 Remove the top cover from the actuator terminal box. Make sure that no particles or liquids enter the box.
- 3 Put a bridging wire between terminals 6 and 35. See number 1 in [Figure 10-32](#)
- 4 Put a bridging wire between terminals 5 and 43. See number 2 in [Figure 10-32](#)
- 5 Turn the power supply of E85 "on".
- 6 Push the switch. See number 3 in [Figure 10-32](#)  
**NOTE:** If the switch is pushed correctly, the actuator moves to the maximum and minimum position (self-adjustment).  
**NOTE:** The switch is very fragile. Make sure to use as little force as possible when pushing it.
- 7 Wait until the movement of the fuel pump actuator stops.
- 8 Turn the power supply of E85 "off".
- 9 Remove the two bridging wires. See numbers 1 and 2 in [Figure 10-32](#)
- 10 Re-attach the top cover of the actuator terminal box.
- 11 Turn the power supply of E85 "on".

Fig 10-32 Calibration illustration



**CLOSE UP**

- None

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## 10.4.2 Fuel pump actuator - adjust

### Periodicity

Description	
Working hours	24 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

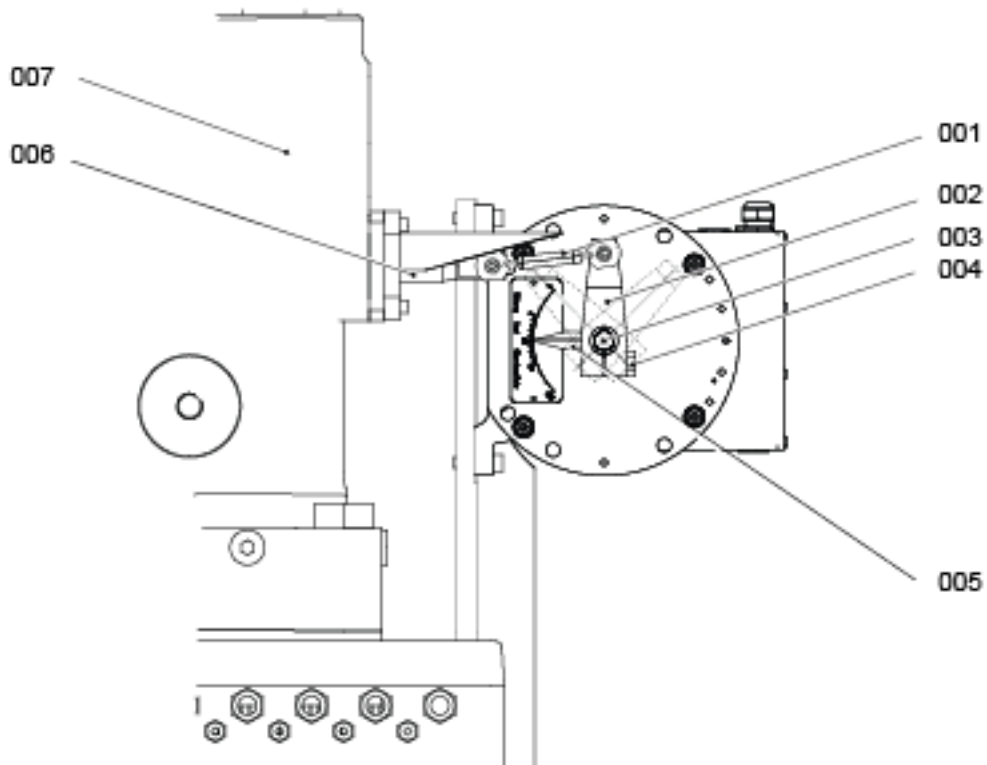
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

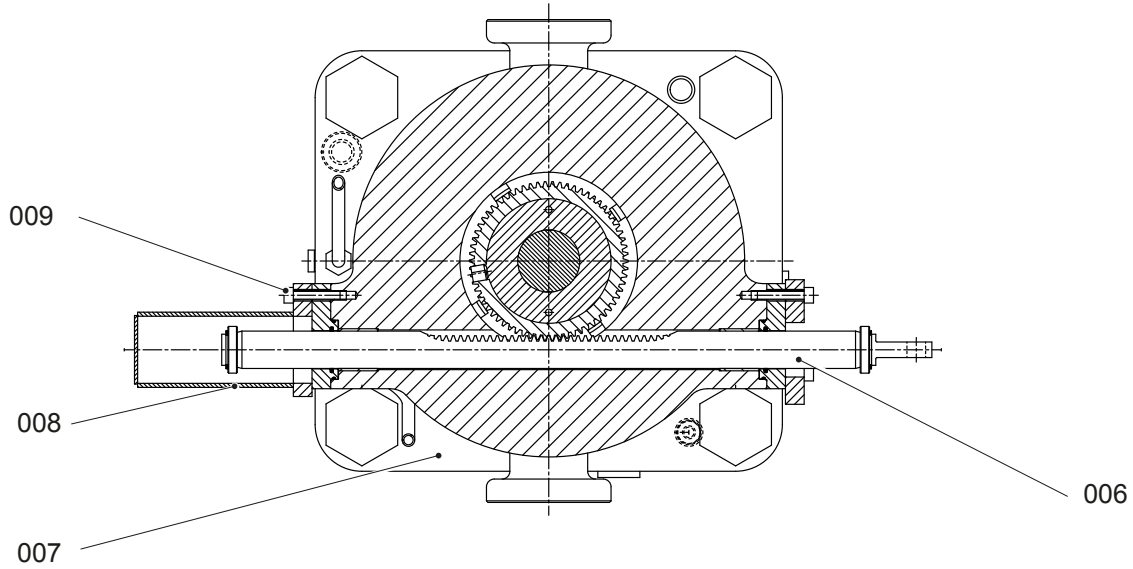


## PROCEDURE

- 1 Make sure that the power supply to the fuel pump actuator is set to OFF in E85.
- 2 Disconnect the connecting element (001, [Figure 10-33](#)) from the lever (002).
- 3 Put the lever (002) in position on the shaft (003).
- 4 Move the lever (002) to the start position as follows:
  - 4.1 Tighten the screw (004).
  - 4.2 Move the shaft (003) to move the indicator (005) to the 50% position.
  - 4.3 Loosen the screw (004).
- 5 Remove the screws (009, [Figure 10-34](#)) and the cover (008) on the fuel pump (007).
- 6 Move the toothed rack (006) to get a distance of 48 mm at each end.
- 7 Attach the lever (002) to the connecting element (001) with the related screw and with the self-locking nut.
- 8 Make sure that the toothed rack (006) stays in position and that the position of the indicator (005) shows 50%.
- 9 Tighten the screw (004).
- 10 Attach the cover (008) to the fuel pump (007) with the screws (009).

**Fig 10-33 Actuator - adjust**



**Fig 10-34 Actuator - adjust -2****CLOSE UP**

- None

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## 10.5 Fuel pressure control valve

### 10.5.1 Fuel rail - remove the pressure control valve

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard. Put on gloves and eye protection. Fuel can come out as a spray and cause injury.**

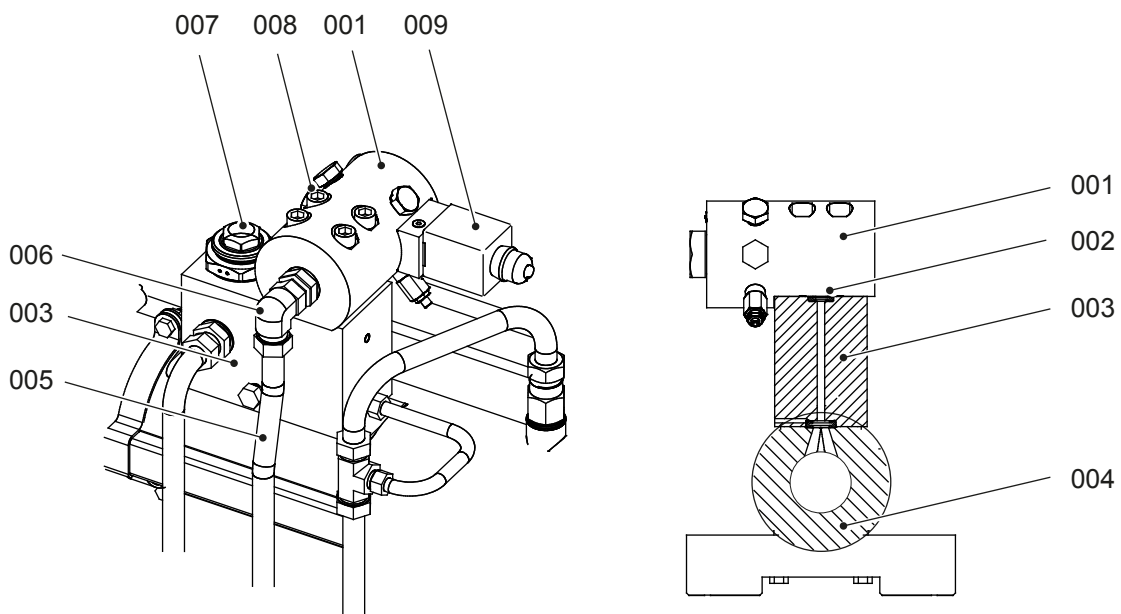
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Loosen the angle union (006, [Figure 10-35](#)).
- 2 Remove the fuel return pipe (005) from the pressure control valve (PCV) (001).
- 3 Disconnect the electrical connection from the solenoid valve (009).
- 4 Loosen the screws (008).
- 5 Remove the PCV (001) from the valve block (003).
- 6 Put the PCV (001) to a clean, dry area.
- 7 Put protection on the valve block (003) to prevent contamination.

**Fig 10-35 Pressure control valve - remove**



## CLOSE UP

- None

## 10.5.2 Fuel rail - do a check of the pressure control valve

### Periodicity

Description	
Working hours	6000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	1

### Support equipment

Description	Part No.	CSN	QTY
HP oil pump			1
Pressure gauge			1
HP hose			1
PCV test block with tube			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### CAUTION

Damage Hazard. Do not connect the solenoid valve. Damage to the PCV can occur.

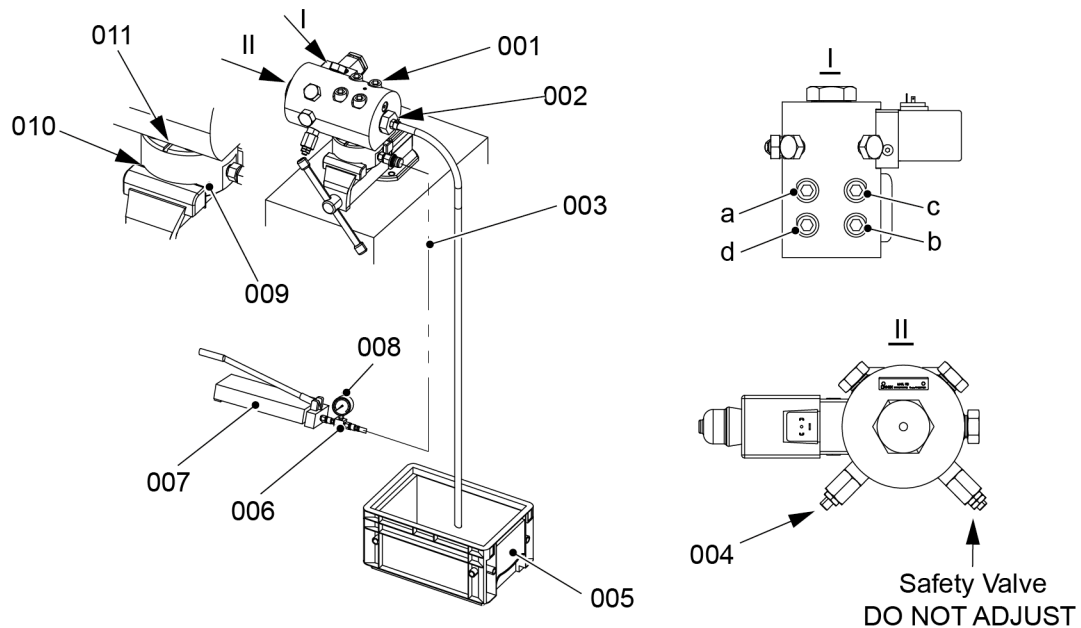
## PRELIMINARY OPERATIONS

- The engine must be stopped.
- The pressure control valve must be removed, refer to section [10.5.1 Fuel rail - remove the pressure control valve](#)

## PROCEDURE

- 1 Prepare the equipment as follows:
  - 1.1 Make sure that the work area is clean.
  - 1.2 Put protection (010, [Figure 10-36](#)) around the PCV test block (009).

**Fig 10-36 PCV - do a check**



00110

- 1.3 Put the test block (009) in a bench vice.
  - 1.4 Make sure that the sealing surfaces of the pressure control valve (PCV) and the test block (009) are clean and have no damage.
  - 1.5 Put the PCV in position on the test block (009).
  - 1.6 Put oil on the threads of the screws (001).
  - 1.7 Put the screws (001) in position in the PCV.
  - 1.8 Tighten the screws (001) in the sequence given in view I, refer to section [16.1 Tightening instructions](#).
  - 1.9 Attach the flexible tube (part of the test block 009) to the PCV outlet (002). Put the other end of the flexible tube into an applicable container (005).
  - 1.10 Connect the HP oil pump (007), the pressure gauge (008) and the HP hose (003) to the test block (009).
  - 1.11 Identify each of the two pressure control set screws.
  - 1.12 On the set-point adjustment valve (SAV) (004), loosen the locknut.
  - 1.13 Fully loosen the SAV (004) to minimum.
- 2 Adjust the PCV as follows:
    - 2.1 Operate the HP oil pump (007).
    - 2.2 Adjust the SAV (004) to get a value of 100 bar.

- 2.3** Do a check for leaks.  
**NOTE:** If oil flows into the groove (011), the PCV has a leak, or the O-ring in the test block (009) has damage.
- 2.4** Continue to adjust the SAV (004) and do checks for leaks at the same time.
- 2.5** Adjust the SAV (004) so that the PCV opens at 1050 bar.  
**NOTE:** Oil flows out through the flexible tube.
- 2.6** On the SAV (004), tighten the locknut.
- 2.7** On the HP oil pump (007), open the relief valve (006) to decrease the pressure to zero.

**3** Do a check of the set-point as follows:

- 3.1** On the HP oil pump (007), close the relief valve (006).
- 3.2** Operate the HP oil pump (007).
- 3.3** Make sure that the PCV opens at 1050 ±30 bar.
- 3.4** If the PCV opens at less than 1020 bar or more than 1080 bar, do the procedure in step [Step 2](#) again.

If the PCV does not open at less than 1300 bar or opens at less than 1020 bar (when the SAV (004) is fully closed), the PCV has a malfunction. You must find and repair the malfunction before you install the PCV.

- 3.5** On the HP oil pump (007), open the relief valve (006) to decrease the pressure to zero.
- 3.6** Disconnect the flexible tube from the PCV outlet (002).
- 3.7** Disconnect the HP hose (003) from the test block (009).
- 3.8** Remove the four screws (001) from the PCV.
- 3.9** Remove the PCV from the bench vice.

## CLOSE UP

- None



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### 10.5.3 Fuel rail - install the pressure control valve

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Never-Seez NSBT-8	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1
O-ring			1

#### SAFETY PRECAUTIONS

- None

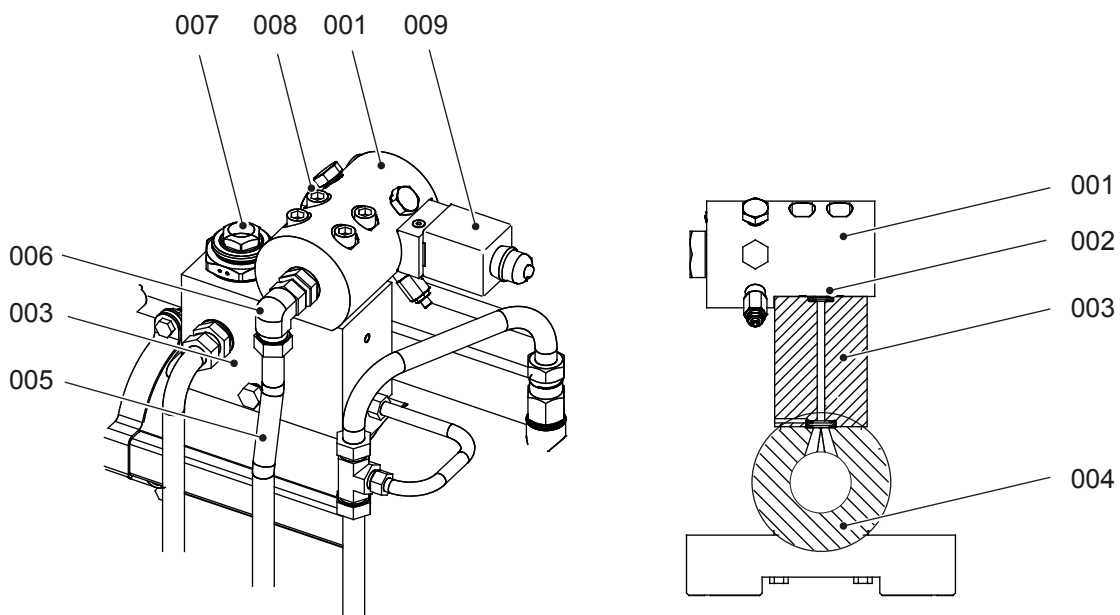
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Remove the protection from the valve block (003, [Figure 10-37](#)).
- 2 Do a check of the lip seal (002). If necessary replace the lip seal.
- 3 Make sure that the sealing surfaces of the PCV (001) and of the valve block (003) are clean and have no damage.
- 4 Put the PCV (001) in position of the valve block (003).
- 5 Apply Never-Seez NSBT-8 to the screw threads (008).
- 6 Put the screws (008) in position in the PCV (001).
- 7 Torque the screws (008), refer to section [16.1 Tightening instructions](#).
- 8 Tighten the angle union (006).
- 9 Connect the electrical connection to the solenoid valve (009).

**Fig 10-37 Pressure control valve - install**



## CLOSE UP

- None

## 10.6 Fuel overpressure safety valve

### 10.6.1 Fuel rail - remove the overpressure safety valve

#### Periodicity

Description	
Working hours	30 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Socket wrench AF41			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

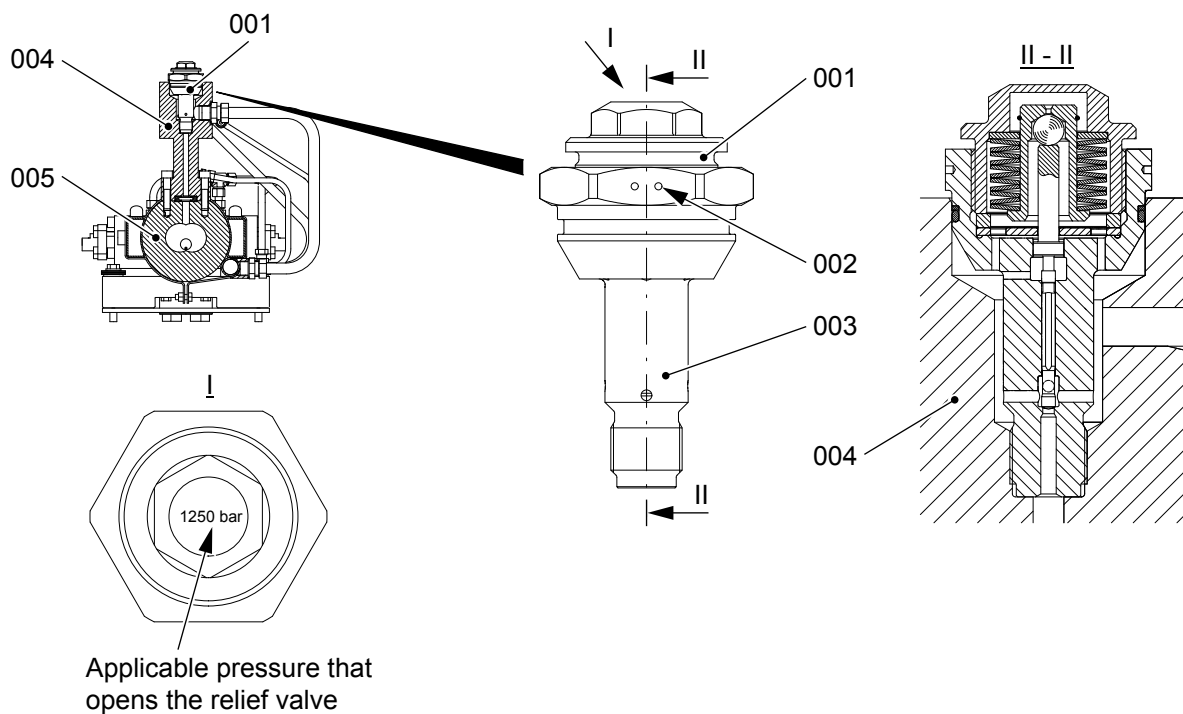
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- The fuel rail must have no pressure.

## PROCEDURE

- 1 Use the socket wrench to remove the relief valve (001, [Figure 10-38](#)) from the connecting piece (004) on the fuel rail (005).  
**NOTE:** The two bores (002) identify the relief valve (001) as a new item.
- 2 Make sure that there is no damage to the housing (003).

**Fig 10-38 Fuel overpressure safety valve**



00828

## CLOSE UP

- None

## 10.6.2 Fuel rail - do a check of the overpressure safety valve

### Periodicity

Description	
Working hours	30 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Injector test bench			1
Valve holder			1
HP oil pump			1
Pressure gauges			2
HP hoses			2

### Supplies

Description	QTY
Test fluid, ISO 4113	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

Health Hazard. Test fluid is harmful to your health.

## PRELIMINARY OPERATIONS

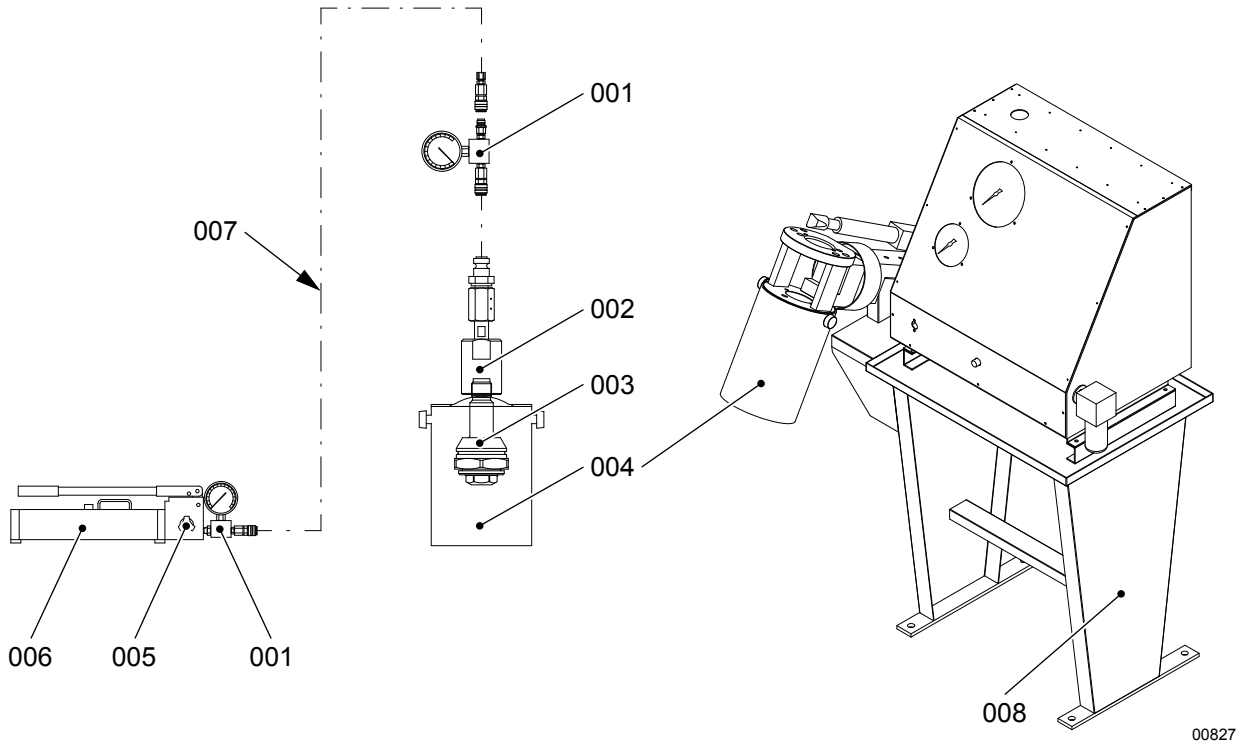
- The overpressure safety valve must be removed.
- Read the data in the instructions from the manufacturer about the specifications of the test bench.

## PROCEDURE

- 1 Prepare the overpressure safety valve.
  - 1.1 Attach the overpressure safety valve (003, [Figure 10-39](#)) to the valve holder.
  - 1.2 Tighten the overpressure safety valve (003).
  - 1.3 Attach the valve holder (002) to the test bench (008) or to the HP oil pump (006).
- 2 Do a check of the sealing pressure.
  - 2.1 Operate the test bench (008) or the HP oil pump (006) to increase the pressure to 1150 bar.
  - 2.2 Keep the pressure constant for one minute.
  - 2.3 Make sure that there are no leaks.
- 3 Do a check of the operation pressure.
  - 3.1 Operate the test bench (008) or the HP oil pump (006) to increase the pressure until the overpressure safety valve (003) opens.
  - 3.2 Make sure that the overpressure safety valve (003) opens at between 1200 bar and 1350 bar.
- 4 Complete the test.
  - 4.1 Operate the test bench (008) or open the valve (005) on the HP oil pump (006) to release the pressure.
  - 4.2 Remove the overpressure safety valve (003) from the valve holder (002).
- 5 Record the results in the Inspection Report.

**NOTE:** Unserviceable overpressure safety valves must be sent to the manufacturer, or a WinGD authorized repair workshop for inspection and repair.

Fig 10-39 Fuel overpressure safety valve - pressure check



**CLOSE UP**

- None



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### 10.6.3 Fuel rail - install the overpressure safety valve

#### Periodicity

Description	
Working hours	30 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Socket wrench AF41			1
Torque spanner			1

#### Supplies

Description	QTY
Never-Seez NSBT8	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Relief valve			1

#### SAFETY PRECAUTIONS

- None

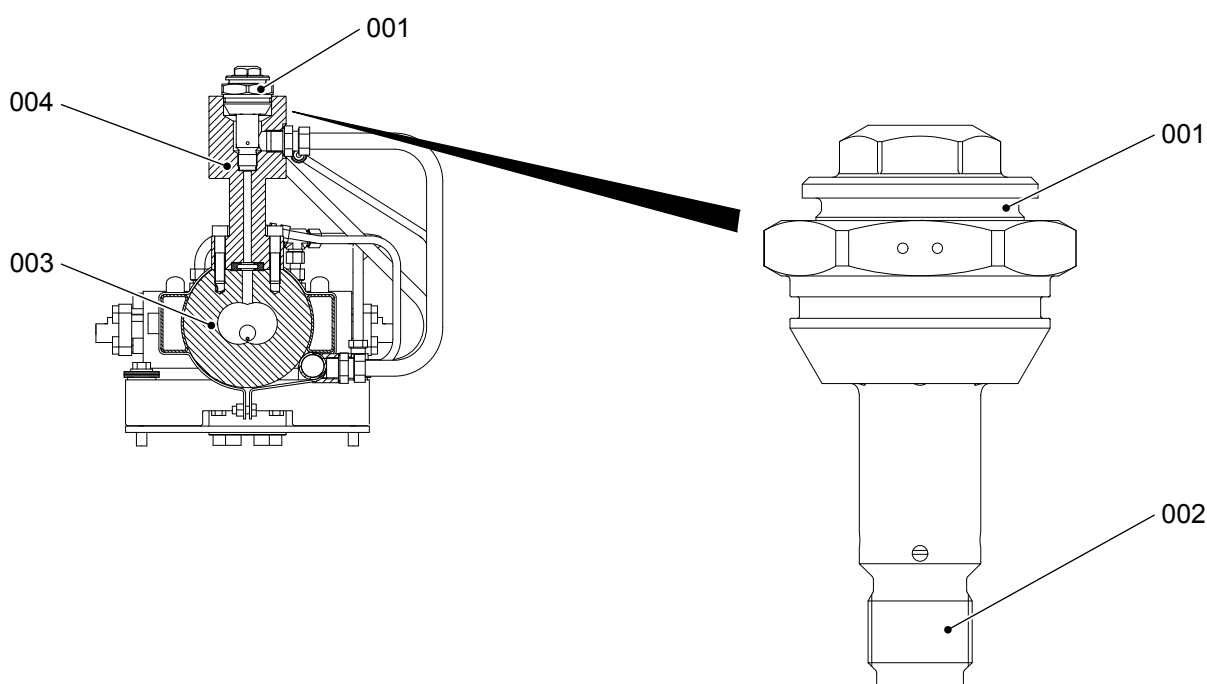
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Apply Never-Seez NSBT-8 to the thread of valve housing (002, [Figure 10-40](#)).
- 2 Put the relief valve (001) in the connecting piece (004) of the fuel rail (003).
- 3 Use the torque spanner and the socket wrench to torque the relief valve (001) to the correct value, refer to section [16.1 Tightening instructions](#).

**Fig 10-40 Fuel overpressure safety valve - installation**



00829

## CLOSE UP

- None

## 10.7 Injection control unit

### 10.7.1 Injection control unit - remove

#### Periodicity

Description	
Working hours	36000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
eye bolt	94045-M10		1
long hexagonal head driver	94022A-10L		1
chain	94327		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Fire Hazard: Do not weld or grind materials in the work area. Sparks can cause a fire.**

#### WARNING

**Injury Hazard: Put on gloves and safety goggles before you do work on hot components. Fuel and oil can come out as a spray and cause injury.**

#### WARNING

**Injury Hazard: Do not operate the turning gear. Fuel can come out of the opening in the fuel rail.**

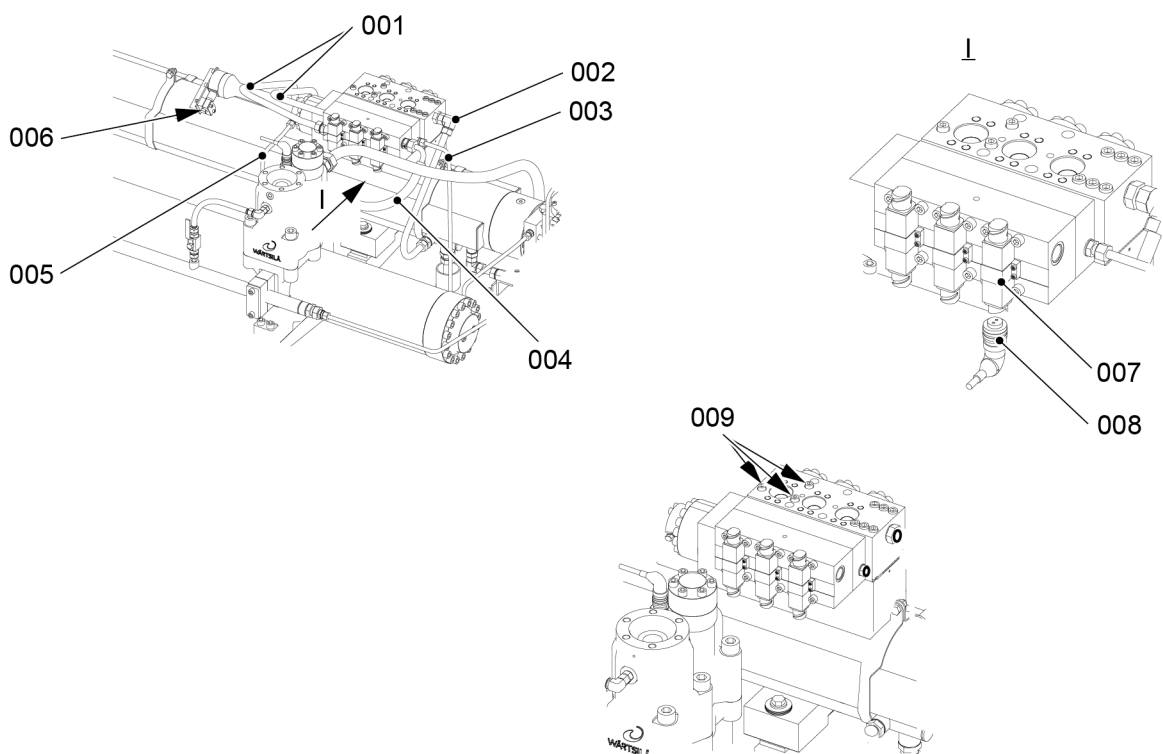
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.
- The fuel rail must have no pressure.
- The fuel injection system must have no pressure.
- The HP fuel pipes must be removed, refer to [13.3.1 HP fuel pipe \(fuel rail to injection valve\) - remove](#)

## PROCEDURE

- 1 Remove the pipes (001, 002, 003 and 004, 005, [Figure 10-41](#)) from the ICU.
- 2 Apply protection to the pipes (001, 002, 003, 004 and 005).
- 3 Apply protection to the openings on the injection control unit (ICU).
- 4 Disconnect the electrical connection from the fuel quantity sensor (006).
- 5 Disconnect the electrical connections (008) from the rail valves (007).
- 6 Use the [long hexagonal head driver](#) to remove the three Allen screws (009).

**Fig 10-41 Injection control unit - remove**



00831

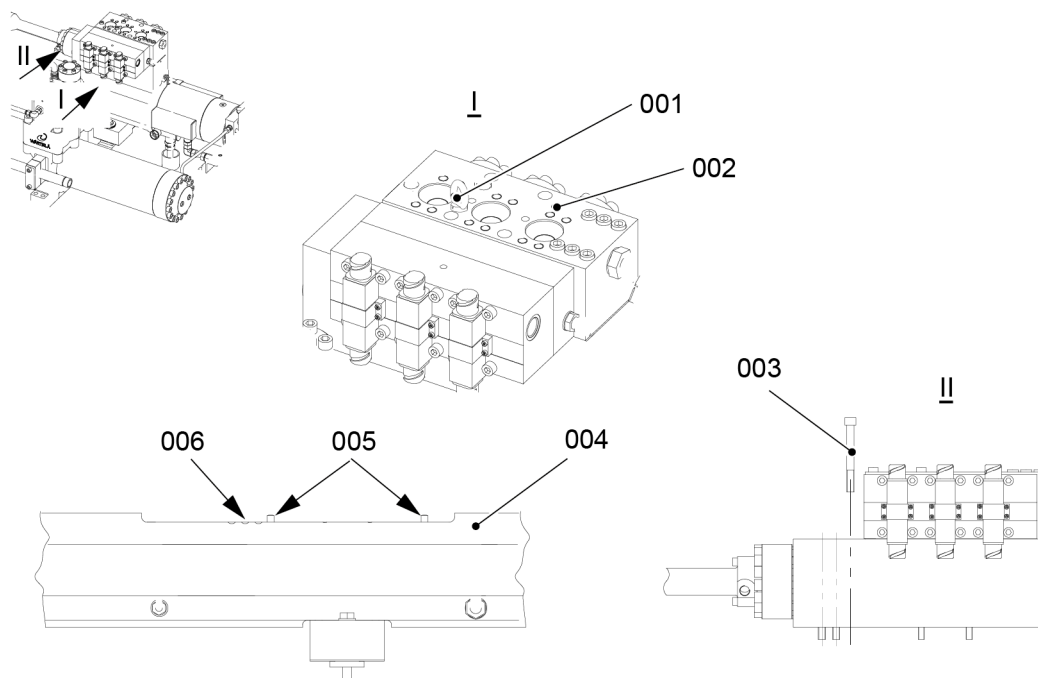
- 7 Use a long hexagonal head driver to remove the six Allen screws (003, [Figure 10-42](#)) from the ICU (002).
- 8 Attach the [eye bolt](#) (001) to the ICU (002).
- 9 Attach the [chain](#) to the eye bolt (001).

### CAUTION

**Injury Hazard: The weight of the ICU is 127 kg. Use the correct equipment for removal. This will prevent injury to personnel.**

- 10 Attach the engine room crane to the chain.
- 11 Operate the engine room crane to remove the ICU (002).
- 12 Lower the ICU (002) on to an applicable clean surface.
- 13 Remove the chain from the eye bolt (001).
- 14 Clean the area around the opening (006) in the fuel rail (004).
- 15 Apply protection to the opening (006) in the fuel rail (004).

- 16 Make sure that the dowel pins (005) stay in the fuel rail (004).
- 17 Apply protection to the bottom of the ICU (002).

**Fig 10-42 ICU - move**

00837

**CLOSE UP**

- If necessary, do the preservation procedure, refer to [10.7.3 Injection control unit - do the preservation](#)
- Install the ICU, refer to [10.7.2 Injection control unit - install](#)

## 10.7.2 Injection control unit - install

### Periodicity

Description	
Working hours	36000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
eye bolt	94045-M10		1
long hexagonal head driver	94022A-10L		1
chain	94327		1

### Supplies

Description	QTY
Never Seez NSBT8	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Injection control unit			1

## SAFETY PRECAUTIONS

### WARNING

**Fire Hazard: Do not weld or grind materials in the work area. Sparks can cause a fire.**

### WARNING

**Injury Hazard: Put on gloves and safety goggles before you do work on hot components. Fuel and oil can come out as a spray and cause injury.**

### WARNING

**Injury Hazard: Do not operate the turning gear. Fuel can come out of the opening in the fuel rail.**

## PRELIMINARY OPERATIONS

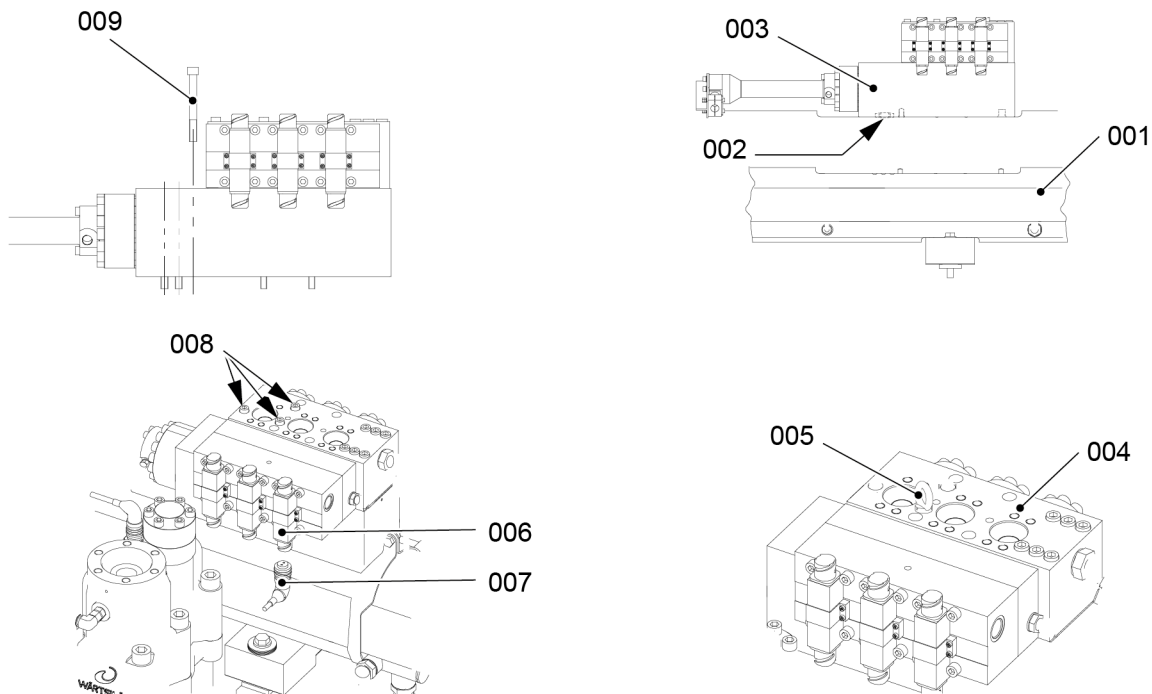
- None



## PROCEDURE

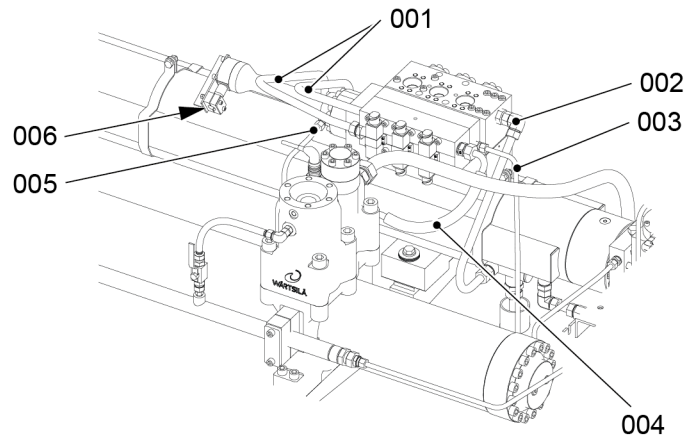
- 1 Attach the [eye bolt](#) (005, [Figure 10-43](#)) to the [Injection control unit](#) (003).
  - 2 Attach the [chain](#) to the engine room crane and the eye bolt (005).
  - 3 Make sure that the [lip seal](#) (002) is in position in the bottom of the ICU (003).
  - 4 Remove the protection from the inlet port on the fuel rail (001).
  - 5 Operate the engine room crane to get the ICU (003) into position above the inlet port in the fuel rail (001).
  - 6 **NOTE:** When you do this step, make sure that the dowel pins in the fuel rail (001) engage with the holes in the ICU (003).
- Lower the ICU (003) on to the fuel rail (001).
- 7 Remove the chain.
  - 8 Remove the eye bolt (005).
  - 9 Apply [Never Seez NSBT8](#) to the threads of the six Allen screws (009).
  - 10 Put the six Allen screws (009) in position.
  - 11 Torque symmetrically the six Allen screws (009) to 55 Nm.
  - 12 Put the three Allen screws (008) in position.
  - 13 Torque symmetrically the three Allen screws (008) to 30 Nm.
  - 14 Connect the electrical connections (007) to the rail valves (006).

**Fig 10-43 Injection control unit - install**



00843

- 15 Remove the protection from the pipes and openings and the ICU.
- 16 Install the pipes (001, 002, 003, 004 and 005, [Figure 10-44](#)) to the ICU.
- 17 Connect the electrical connection to the fuel quantity sensor (006).

**Fig 10-44** ICU - connect pipes

00844

## CLOSE UP

- Install the HP fuel pipes, refer to [13.3.3 HP fuel pipe \(fuel rail to injection valve\) - install](#)
- Cut in the injection, refer to the Operation Manual.
- Operate the engine for a minimum of 1.5 hours with marine diesel oil. For more data, refer to the Operation Manual.

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### 10.7.3 Injection control unit - do the preservation

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
vacuum cleaner	N/A		1

#### Supplies

Description	QTY
plastic bag	1

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Use a [vacuum cleaner](#) to remove dirt from all openings.
- 2 Clean the ICU.
- 3 Lubricate correctly the ICU.
- 4 Put the ICU in a [plastic bag](#).
- 5 Remove as much air as possible from the plastic bag.
- 6 Seal the plastic bag.

## CLOSE UP

- None

## 10.8 Supply unit

### 10.8.1 Supply unit camshaft and bearing shell - prepare before removal

#### Periodicity

Description	
Working hours	90000

#### Support equipment

Description	Part No.	CSN	QTY
roller lifting tool	94569B		6

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

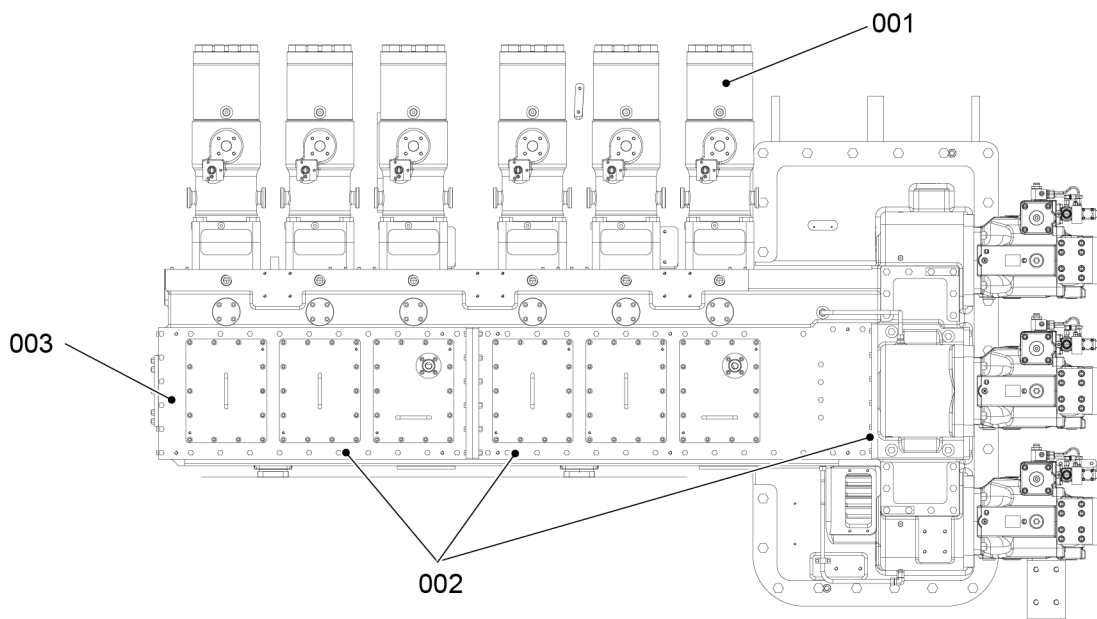
- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 **NOTE:** These procedures are applicable to a supply unit that has an independent lubrication system.

Remove the covers (002, [Figure 10-45](#)) from the casing (003).

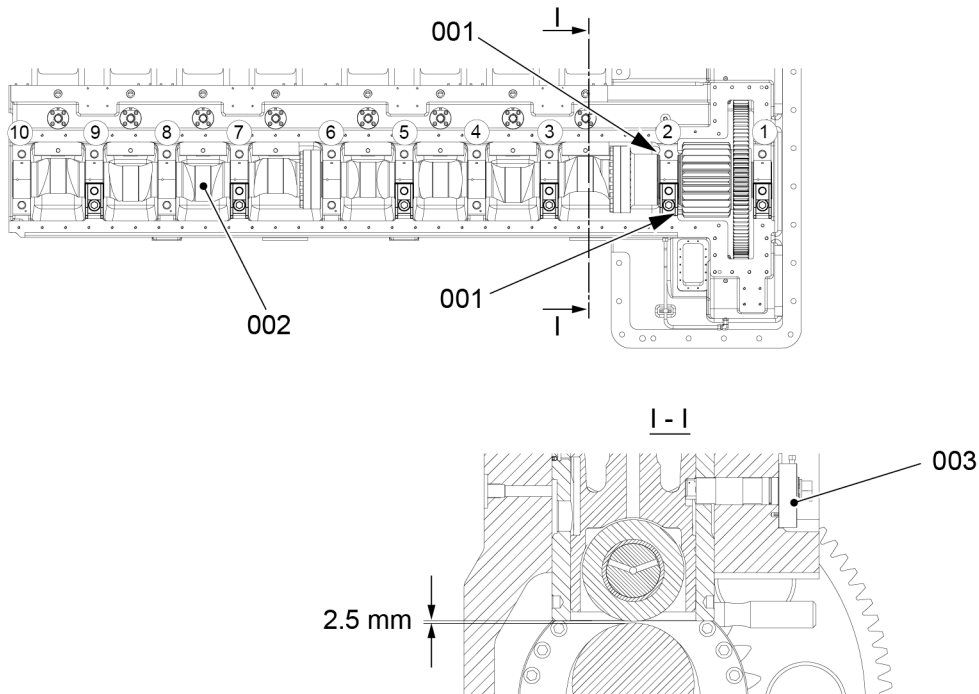
**Fig 10-45** Covers



00912

- 2 There are two methods for this procedure:
- Remove the fuel pumps, refer to [\[section not applicable for this engine\]](#), or
  - Lift the rollers, refer to [Step 3](#) and [Step 4](#).
- 3 Make sure that the bearing covers at positions No. 3 to No. 10 ([Figure 10-46](#)) and the casing (00X), have marks to identify them as a set.
- NOTE:** The bearing at position No. 2 has the two thrust bearing ring halves (002).
- 4 Install the [roller lifting tool](#)(003) to lift the rollers and guide pistons of the fuel pumps.

Fig 10-46 Rollers - lift

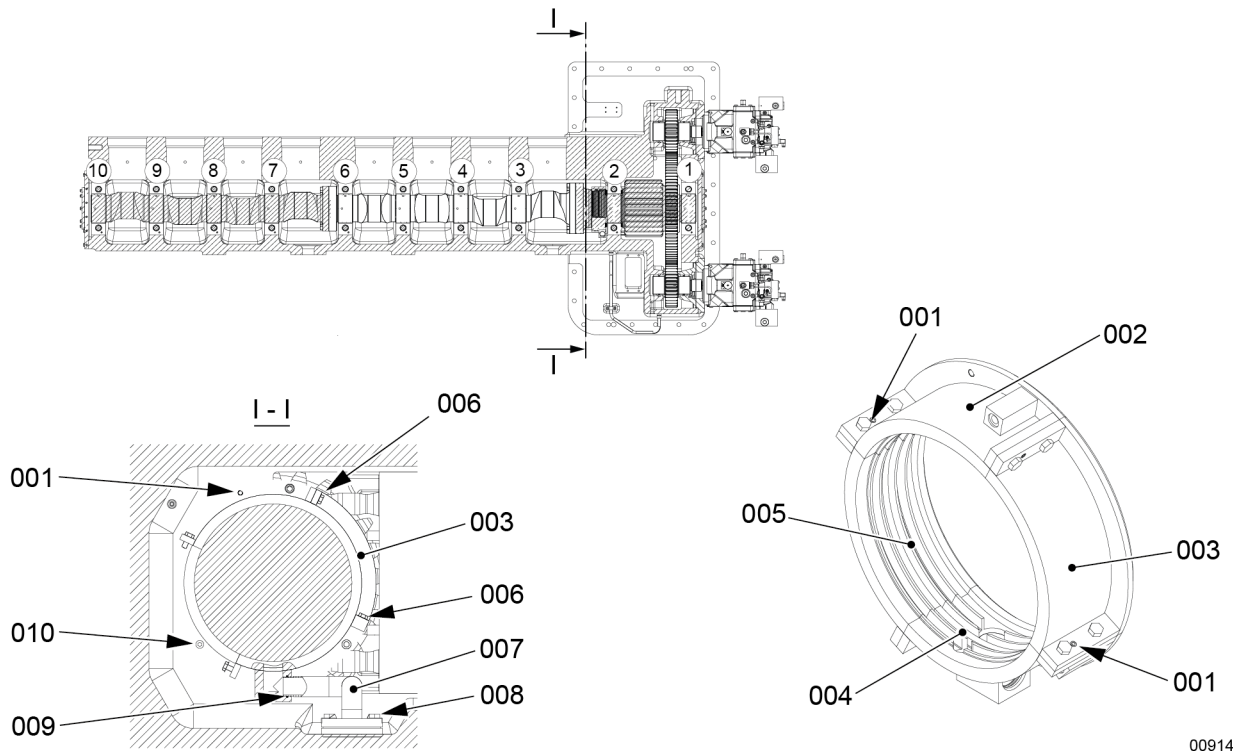


00913

- 5 NOTE:** The oil baffle has four parts.
- Remove the four bolts (008, [Figure 10-47](#)) and locking tabs.
- 6** Remove the pipe (007) from the oil baffle.
- 7** Remove and discard the O-ring (009).
- 8** Remove the three Allen screws (010).
- 9** Put two M8 screws into the holes (001).
- 10** Tighten the two M8 screws to loosen the oil baffle.
- 11** Remove the two M8 screws.
- 12** From the segment (003), remove the four screws (006) and the locking tabs.
- 13** Remove the segment (003).
- 14** Turn the remaining segments counterclockwise until you can get access to the segment (004).
- 15** Do [Step 9](#) to [Step 13](#) to remove the to remove the other segments (004, 005, 002).



Fig 10-47 Oil baffle



**CLOSE UP**

- Remove the camshaft and bearing shells, refer to [10.8.2 Supply unit camshaft and bearing shell - remove](#)

## 10.8.2 Supply unit camshaft and bearing shell - remove

### Periodicity

Description	
Working hours	90000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
pre-tensioning jacks	94557		2
support	94566		2
support	94566A		1
assembly template	94567		1
screw-jack	94567B		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.
- You must first do the procedure given in [10.8.1 Supply unit camshaft and bearing shell - prepare before removal](#)

## PROCEDURE

### 1 Bearing shells - removal

Loosen the two Allen screws. (002, [Figure 10-48](#)).

2 Remove the filling piece (003) from bearing cover No. 2.

3 Attach the two [pre-tensioning jacks](#) (004) to the elastic bolts at bearing cover No. 2.

4 Remove the two round nuts (001), refer to [4.3 Loosen a round nut with a pre-tensioner](#).

5 Do [Step 3](#) and [Step 4](#) to remove the round nuts from the bearing covers No. 3 to No. #.

6 Remove the bearing covers No. 2 to No. #.

7 Put the [screw-jack](#) (008) in position under the cam.

8 Turn the screw-jack (008) to lift the camshaft between 0.05 mm and 0.15 mm.

9 Put the [assembly template](#) (007) in position on the top bearing shell (006) of bearing No.5.

10 Use the assembly template (007) to turn the top and bottom bearing shells (005, 006) 90°.

11 **NOTE:** If you cannot turn the bearing shells, adjust the screw-jack (008).

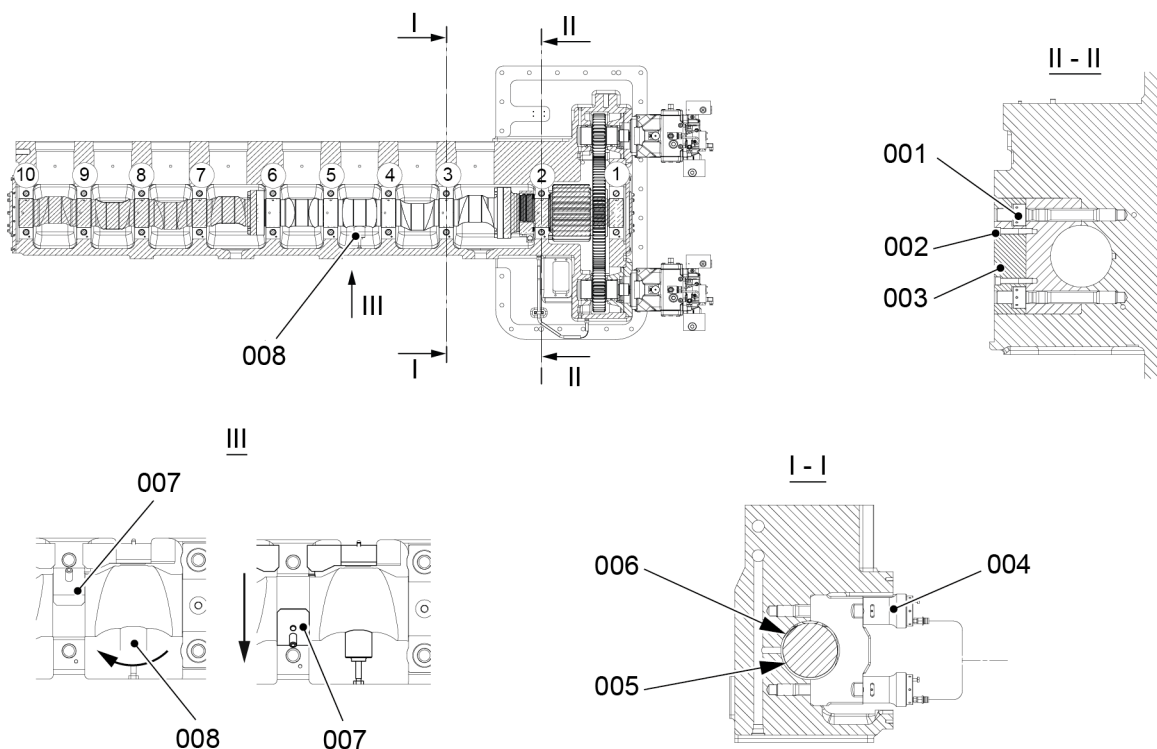
12 Hold the top bearing shell (006), then remove the assembly template (007).

13 Put marks on the top bearing shells to identify their positions. This will help you when you install the bearing shells.

14 Remove the top bearing shell (006).

15 Do [Step 7](#) to [Step 14](#) remove the remaining top bearing shells at bearings No. 3 to No. 5.

**Fig 10-48 Bearing shells - remove**

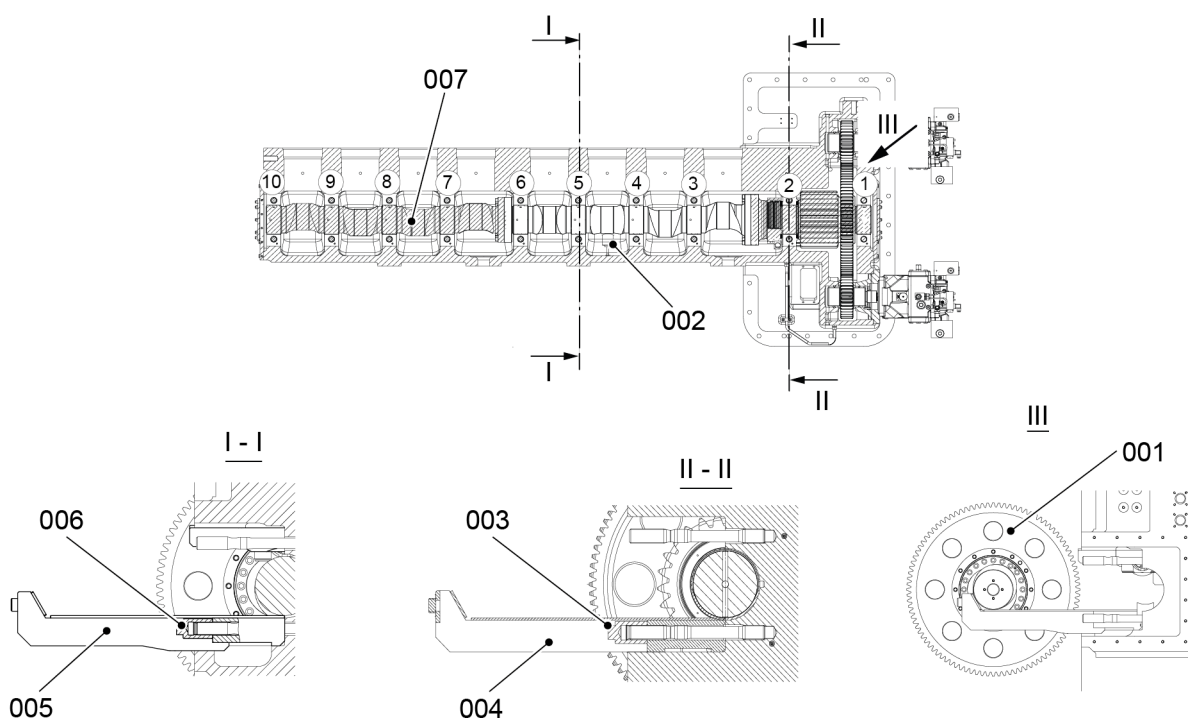


00915

### 16 Camshaft - removal

- Put the two support (004 and 005, [Figure 10-49](#)) in position at No. 2 and No. 5 bearings.
- 17 On the two supports (004, 005), tighten the nuts (003, 006).
  - 18 **NOTE:** Make sure that the camshaft stays in position before you remove the last bearing cover.
- Remove the remaining bearing covers and top bearing shells at positions No.2 and No.#, refer to [Step 3](#) to [Step 14](#).
- 19 Remove the screw-jack (002).
  - 20 Carefully move the camshaft (007) and the gear wheel (001) on to the two supports (004, 005).
  - 21 Make sure that the camshaft (007) and gear wheel (001) do not move.
  - 22 Make a mark on the remaining bottom bearing shells to identify their positions. This will help you when you install the bearing shells.
  - 23 Remove the remaining bearing shells.

**Fig 10-49 Camshaft - remove**



### CLOSE UP

- Install the camshaft and bearing shells, refer to [10.8.3 Supply unit camshaft and bearing shell - install](#)

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### 10.8.3 Supply unit camshaft and bearing shell - install

#### Periodicity

Description	
Working hours	90000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

#### Support equipment

Description	Part No.	CSN	QTY
pre-tensioning jacks	94557		2
support	94566		2
support	94566A		1
assembly template	94567		1
assembly template	94567A		1
screw-jack	94567B		1

#### Supplies

Description	QTY
oil	A/R
Loctite 5399	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
top bearing shell half			A/R
bottom bearing shell half			A/R
camshaft			1
O-ring			1

#### SAFETY PRECAUTIONS

- None

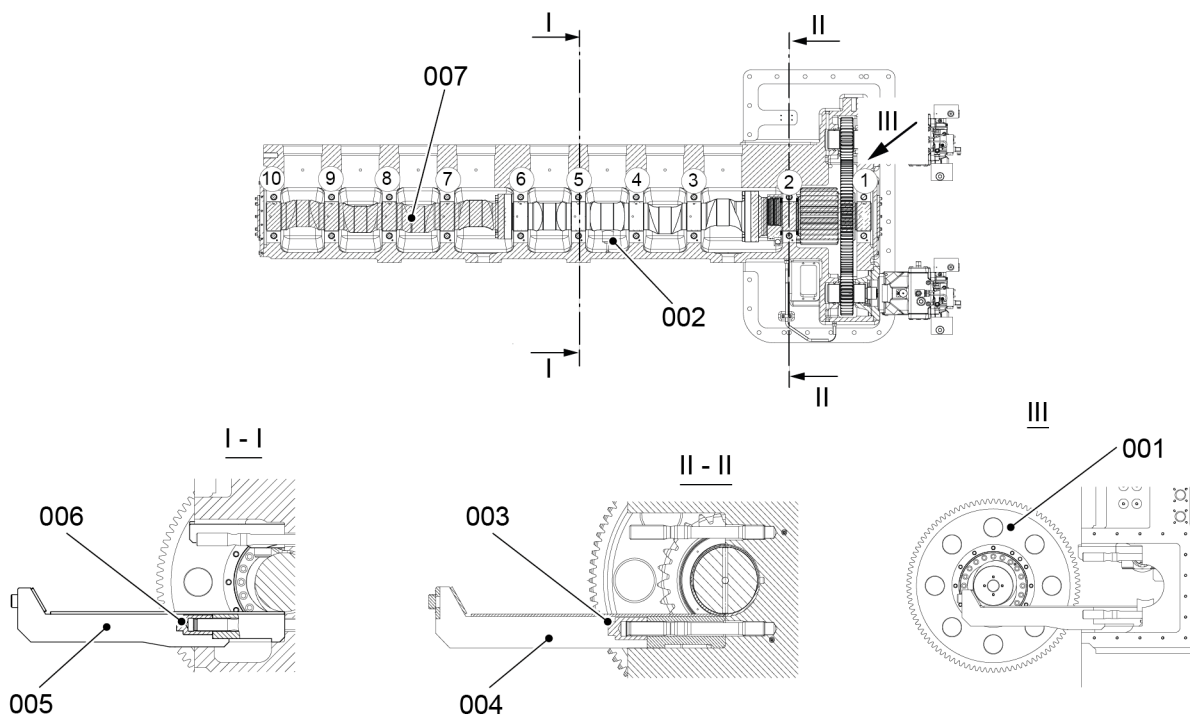
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 Make sure that all items are clean and do not have damage.
- 2 Apply oil to the **top bearing shell half**, the **bottom bearing shell half** and the **camshaft**.
- 3 Put all bottom bearing shells into the casing in their correct positions. Refer to the marks you made before.
- 4 Put the camshaft (007, [Figure 10-50](#)) and gear wheel (001) in position on the two **support** (004, 005).
- 5 Carefully move the camshaft (007) and the gear wheel (001) into the casing. Make sure that the bearing shells stay in position and do not fall.
- 6 Make sure that the camshaft does not move.
- 7 Put the screw-jack (002) in position.
- 8 Turn the screw-jack (002) to lift the camshaft between 0.05 mm and 0.15 mm.

**Fig 10-50 Camshaft**

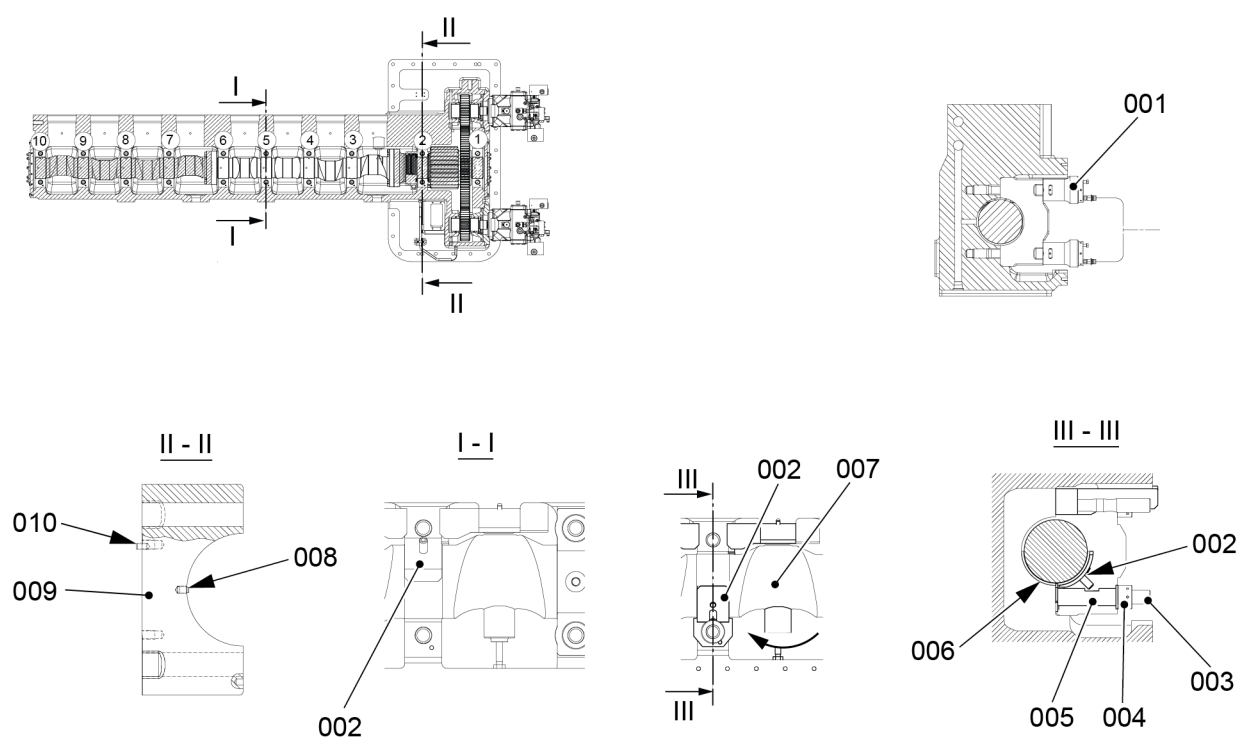


00916

- 9 Attach the **assembly template** (005, [Figure 10-51](#)) on the bottom elastic bolt (003) with the round nut (003).
- 10 Tighten with your hand the round nut (003).
- 11 Put the top bearing shell (006) in position on the camshaft (007).
- 12 Put the assembly template (002) in position on the bottom half of the top bearing shell (006). Use the assembly template to help you get the bearing shell in the center.
- 13 Use the assembly template (002) to move the bearing shell (006) 90° up.
- 14 Make sure that the semicircular slots of the top and bottom bearing shells are in a horizontal position.
- 15 Remove the assembly templates (002, 005).
- 16 Remove the holders (004 and 005, [Figure 10-50](#)).

- 17 Make sure that the pin (008, [Figure 10-51](#)) is in the bearing cover (009).
- 18 Attach the bearing cover (009).
- 19 Put the round nuts (004) on the elastic bolts (003). Tighten the round nuts with your hand.
- 20 Do step [Step 1](#) to [Step 19](#) for the remaining bearing shells.
- 21 Put the bearing cover (009) that has the dowel pin (010) on to position No. 3.
- 22 Install the [pre-tensioning jacks](#) (001) to the elastic bolts (003).
- 23 Tighten the round nuts (004) to the value specified in [4.2 Tighten a round nut with a pre-tensioner](#).

**Fig 10-51 Camshaft - install**



- 24 Oil baffle - installation

**NOTE:** Make sure that the all screws (006 and 008, [Figure 10-52](#)) have locking tabs.

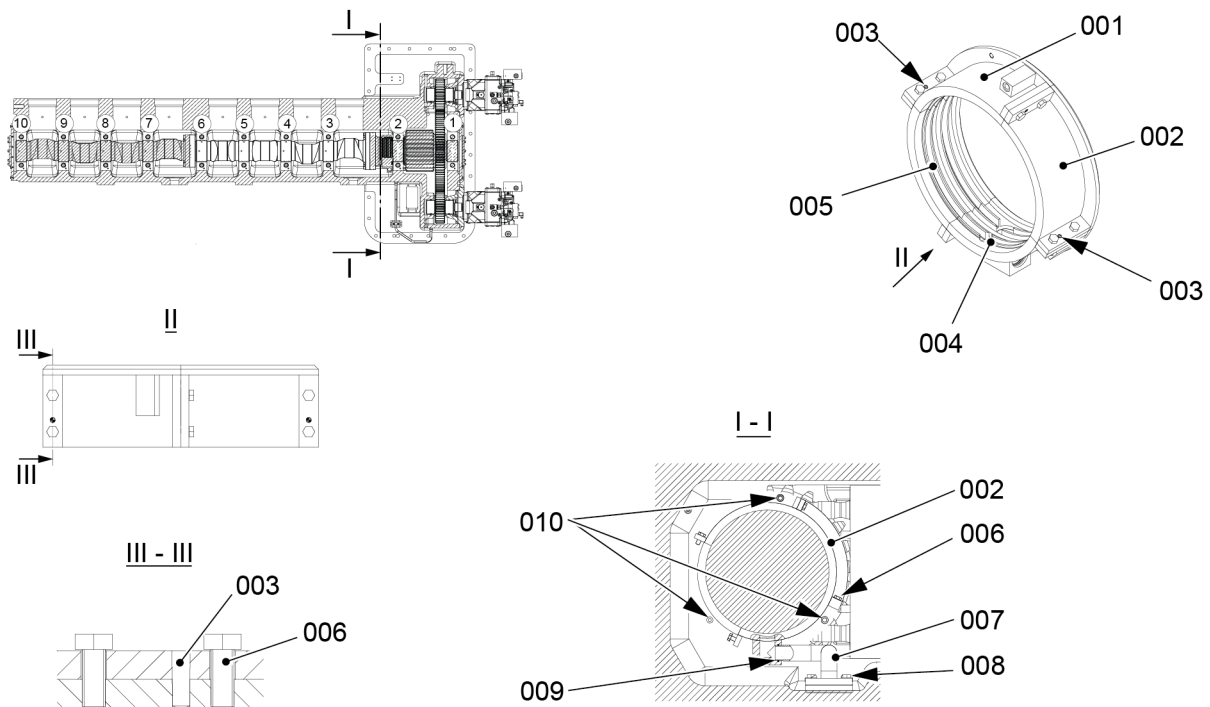
Clean the four segments and the interfaces of the oil baffle.

- 25 Apply the [Loctite 5399](#) (or an approved alternative) to the segments and interfaces of the oil baffle.
- 26 Put the segment (002) in position on the camshaft.
- 27 Turn the segment (002) clockwise approximately 90°.
- 28 Put the segment (004) in position on the camshaft.
- 29 Attach the segments (002, 004) together with the taper pin (003) and the two screws (006).
- 30 Turn the segments (002, 004) clockwise approximately 90°.
- 31 Put the segment (005) in position on the camshaft.
- 32 Attach the segments (005, 004) together with the taper pin (003) and the two screws (006).



- 33 Turn the segments (005, 004, 002) clockwise approximately 90°.
- 34 Put the segment (001) in position on the camshaft.
- 35 Attach the segment (001) to the segments (002, 005) with the taper pin (003) and the four screws (006).
- 36 Torque the eight screws (003) to 20 Nm.
- 37 Lock the eight screws (003) with their locking tabs.
- 38 Attach the assembled oil baffle to the supply unit casing with the three Allen screws (010).
- 39 Torque the three Allen screws (010) to 20 Nm.
- 40 Apply oil to the new O-ring (009).
- 41 Put the new O-ring (009) in the position shown.
- 42 Attach the pipe (007) to the flange and the oil baffle with the four screws (008).
- 43 Torque the four screws (008) to 20 Nm.
- 44 Lock the four screws (008) with the locking tabs.

Fig 10-52 Oil baffle - install



00921

### CLOSE UP

- None

## 10.8.4 Supply unit bearing bush - remove

### Periodicity

Description	
Working hours	90 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
eye bolt M20	94045-M20		1
eye bolt M16	94045-M16		1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### CAUTION

The weight of the pinion and shaft is 55 kg. Make sure that you use the correct equipment and sufficient personnel to lift and move the pinion and shaft. This will prevent injury to personnel.

## PRELIMINARY OPERATIONS

- The applicable servo oil pump must be removed.

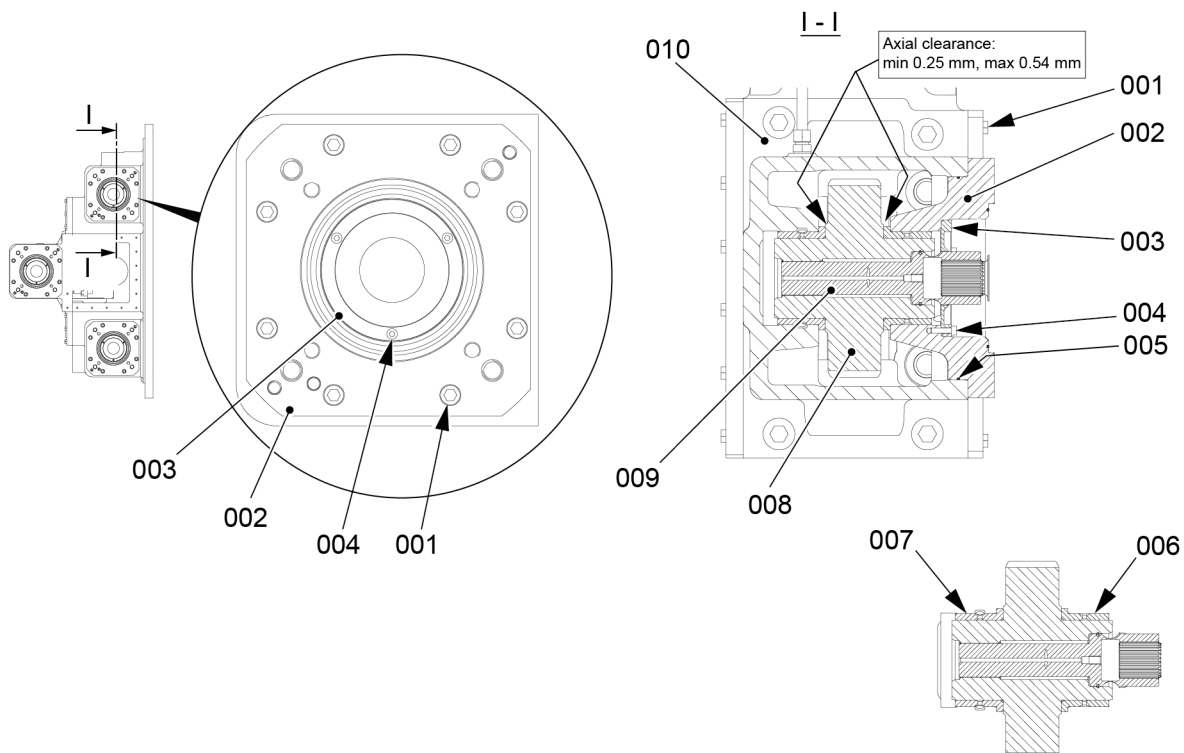
## PROCEDURE

- 1 **NOTE:** The bearing bushes (006 and 007, [Figure 10-53](#)) in the housing (010) and the pump support (002) are matched items and thus, are not interchangeable.

Do a check of the pinion (008) and shaft (009) for axial clearance and damage, refer to [3.3 Clearances - general](#) (Servo Pump Unit). If the dimensions are not in the limits given, do step [Step 1.1](#) to [Step 1.8](#).

- 1.1 Remove the three M8 screws (004).
- 1.2 Remove the disc (003).
- 1.3 Remove the eight M16 screws (001).
- 1.4 Use the [eye bolt M20](#) and an applicable lifting tool to remove the pump support (002).
- 1.5 Use the [eye bolt M16](#) to remove the shaft (009).
- 1.6 Carefully remove the pinion (008) from the casing (010).
- 1.7 Remove and discard the O-ring (005).
- 1.8 Examine the bearing bushes (006, 007) for damage. Replace damaged or worn parts.

**Fig 10-53 Bearing bushes**



00932

## CLOSE UP

- Install the bearing bushes, refer to [10.8.5 Supply unit bearing bush - install](#)

## 10.8.5 Supply unit bearing bush - install

### Periodicity

Description	
Working hours	90 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1
bearing bushes			2
pinion			1
shaft			1

### SAFETY PRECAUTIONS

#### CAUTION

The weight of the pinion and shaft is 55 kg. Make sure that you use the correct equipment and sufficient personnel to lift and move the pinion and shaft. This will prevent injury to personnel.

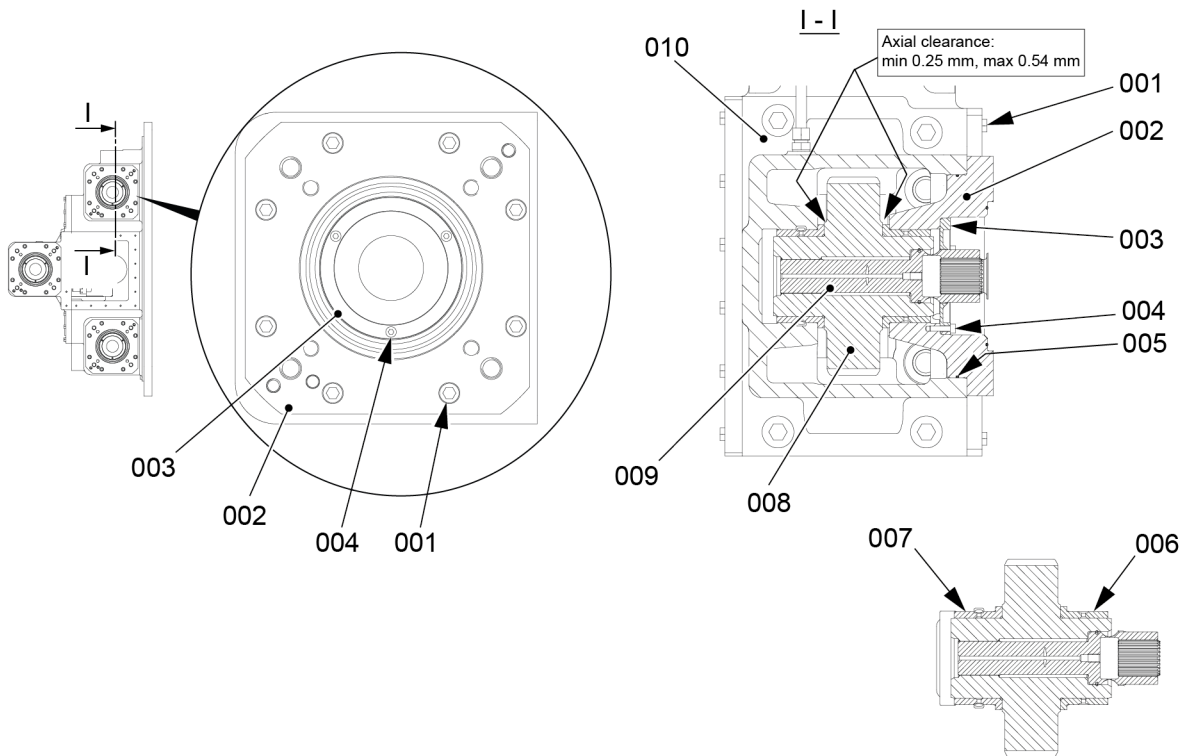
### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Put oil on the new bearing bushes (006 and 007, Figure 10-54).
- 2 Put a small quantity of oil on the O-ring (005).
- 3 Put the O-ring (005) on the pump support (002).
- 4 Carefully put the pinion (008) and shaft (009) in position in the casing (010).
- 5 Attach the pump support (002) to the casing (010) with the eight M16 screws (001).
- 6 Torque the eight M16 screws (001) to the value given in 3.5 Torque values - standard screws.
- 7 Install the disc (003) with three M8 screws (004).

Fig 10-54 Bearing bushes



00932

## CLOSE UP

- None

## 10.8.6 Supply unit camshaft and bearing shell - do the follow-on work

### Periodicity

Description	
Working hours	90000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Intermediate	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
sealing compound	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

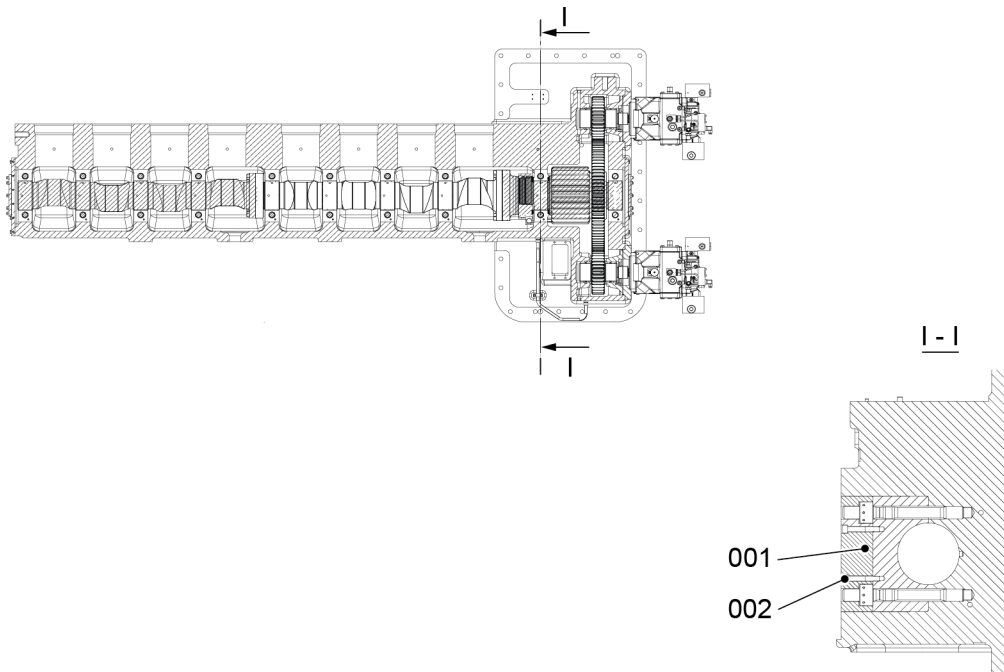
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 Measure the axial clearances and compare the results with those given in [3.3 Clearances - general](#).
- 2 If the axial clearances are not in the specified range, loosen the round nuts on one of the bearing covers, refer to [10.8.2 Supply unit camshaft and bearing shell - remove](#).
- 3 Tighten the round nuts on the bearing cover again, refer to [10.8.3 Supply unit camshaft and bearing shell - install](#).
- 4 Attach the filling piece (001, [Figure 10-55](#)) to the bearing cover with the two Allen screws (002).

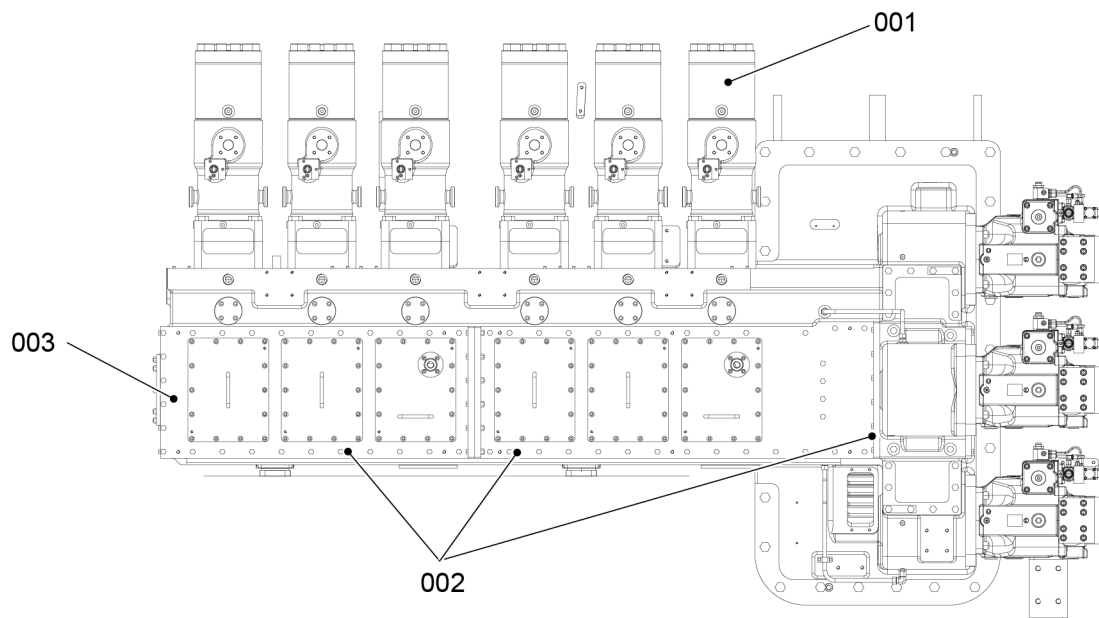
**Fig 10-55 Filling piece**



00928

- 5 If the fuel pumps (001, [Figure 10-56](#)) were not removed, do [Step 5.1](#). If the fuel pumps were removed, do [Step 5.2](#).
  - 5.1 Remove the roller lifting tools.
  - 5.2 Install the fuel pumps, refer to [\[section not applicable for this engine\]](#).
- 6 Apply [sealing compound](#) to the sealing surfaces of the covers (002).
- 7 Attach the covers (002) to the casing (003).
- 8 Set to on the oil pump.
- 9 Operate the turning gear to turn the engine.
- 10 Make sure that lubricating oil flows to all lubricating points and bearings.

Fig 10-56 Covers



00912

**CLOSE UP**

- None



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## 10.9 Exhaust valve control unit

### 10.9.1 Exhaust valve control unit (VCU) - remove

#### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

Do not operate welding or grinding equipment. Sparks can cause a fire.

#### CAUTION

The servo oil pipes must have no pressure. Injury to personnel can occur.

#### CAUTION

Use applicable lifting equipment to lift and move the VCU.

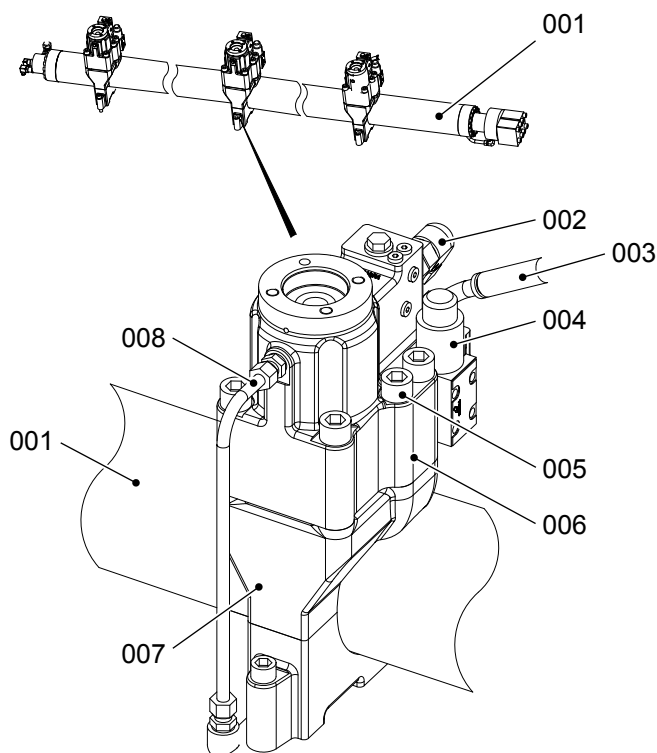
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)
- The applicable hydraulic pipe must be removed, refer to section [13.2.1 Hydraulic pipe exhaust valve - remove](#)

## PROCEDURE

- 1 If the valve control unit (VCU) to be removed is adjacent to the driving end of the servo oil rail, remove the HP hose (003, [Figure 10-57](#)) from the VCU (006).
- 2 Disconnect the electrical connection from the 4/2-way solenoid valve (004).
- 3 Remove and discard the 4/2-way solenoid valve (004).
- 4 Remove the return pipe (002) from the VCU (006).
- 5 Remove the supply pipe (008) from the VCU (006).
- 6 Remove the six screws (005) from the VCU (006).
- 7 Carefully remove the VCU (006).
- 8 Put protection over the bore in the holder (007) and the servo oil rail (001).
- 9 Install blanks to the ports on the VCU (006).

**Fig 10-57 Exhaust valve control unit - remove**



00400

## CLOSE UP

- None

## 10.9.2 Exhaust valve control unit (VCU) - disassemble

### Periodicity

Description	
Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

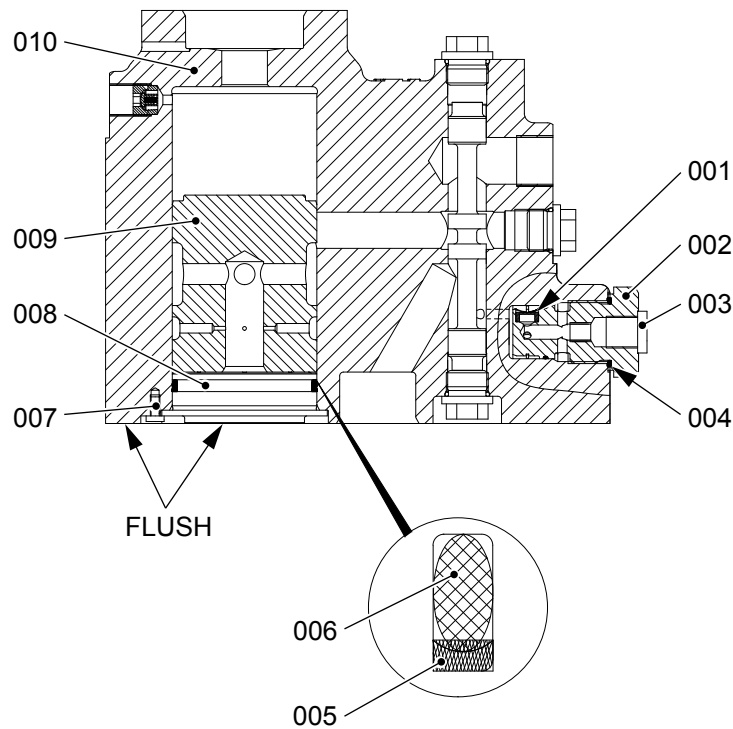
### PRELIMINARY OPERATIONS

- The exhaust valve control unit must be removed, refer to [10.9.1 Exhaust valve control unit \(VCU\) - remove](#)

## PROCEDURE

- 1 Remove the pan head screw (007, [Figure 10-58](#)).

**Fig 10-58 Exhaust valve control unit - disassemble/assemble**



00401

- 2 Remove the plug (008).
- 3 Remove and discard the O-ring (006) and the back-up ring (005).
- 4 Make sure that the piston (009) moves freely.
- 5 Remove the filter holder (002) and the screw plug (003) from the valve control block (010).
- 6 Make sure that the oil filter (001) is clean and has no damage. If necessary, remove and discard the oil filter.
- 7 Make sure that the seal (004) has no damage. If necessary, remove and discard the seal.

## CLOSE UP

- None

### 10.9.3 Exhaust valve control unit (VCU) - assemble

#### Periodicity

Description	
Working hours	18 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1
O-ring			1
O-ring			1
Back-up ring			1
Seal			1

#### SAFETY PRECAUTIONS

- None

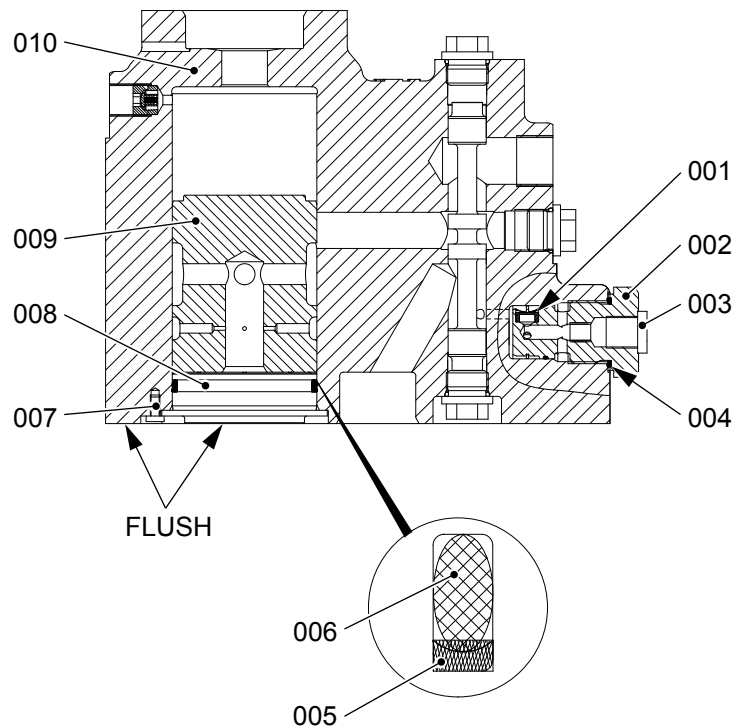
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Put a new oil filter (001, [Figure 10-59](#)) in the filter holder (002).
- 2 If necessary, put a new seal (004) on the filter holder (002).
- 3 Apply oil to the thread of the filter holder (002).
- 4 Put the filter holder (002) and the screw plug (003) into the control block (010).
- 5 Torque the filter holder (002) to the correct value, refer to section [16.1 Tightening instructions](#).
- 6 Put a new O-ring (006) and back-up ring (005) on the plug (008).

**Fig 10-59 Exhaust valve control unit - disassemble/assemble**



00401

- 7 Push the plug (008) into the valve control block (010).
- 8 Install the pan head screw (007).
- 9 Make sure that the plug (008) is flush with the bottom of the control block (010).

## CLOSE UP

- None

## 10.9.4 Exhaust valve control unit (VCU) - install

### Periodicity

Description	
Working hours	36 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
Oil	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Exhaust valve control unit			1
Piston joint ring			1

## SAFETY PRECAUTIONS

### CAUTION

**Injury Hazard.** Use applicable lifting equipment to lift and move the exhaust valve control unit.

## PRELIMINARY OPERATIONS

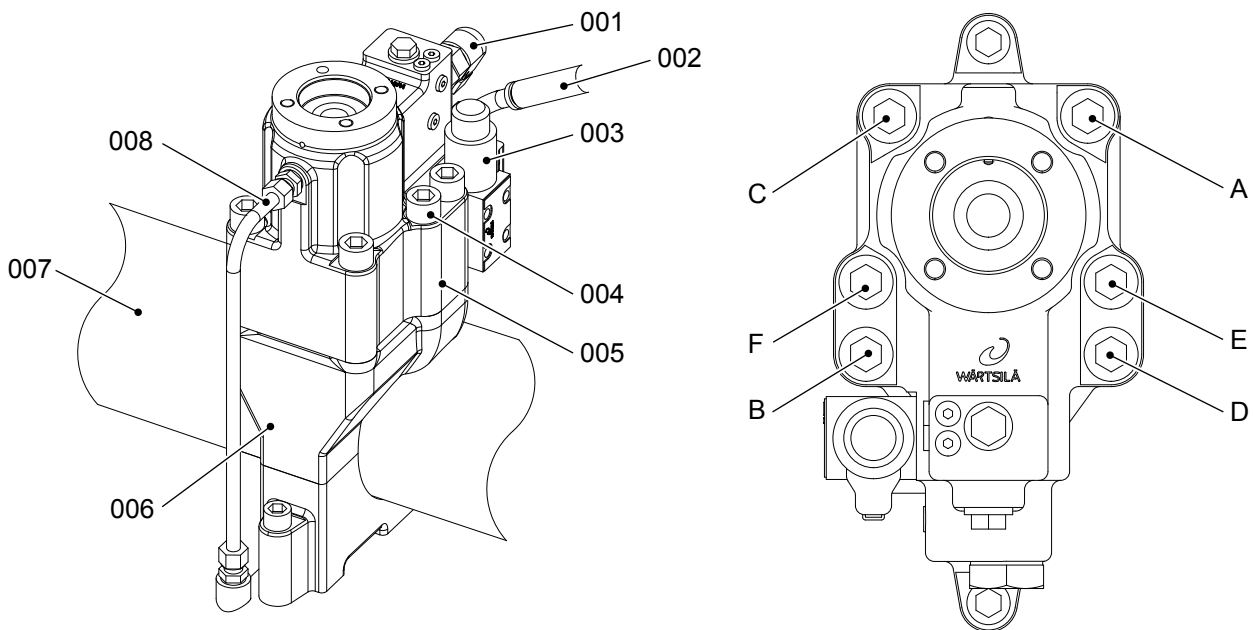
- The exhaust valve control unit must be assembled, refer to [10.9.3 Exhaust valve control unit \(VCU\) - assemble](#)



## PROCEDURE

- 1 If the exhaust valve control unit (VCU) is a new item, carefully remove it from its package.
- 2 Use oil to clean the VCU (005, [Figure 10-60](#)).
- 3 Remove the blanks from the ports in the VCU (005).

**Fig 10-60 Exhaust valve control unit - install**

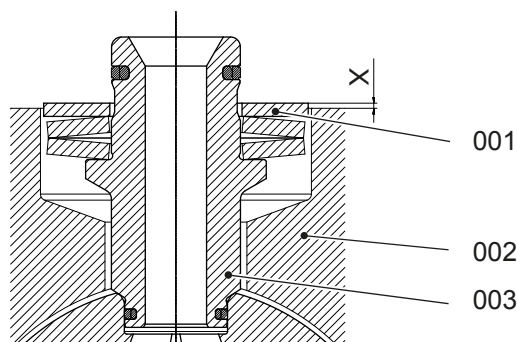


00402

- 4 Clean the seating surfaces of the VCU (005) and the holder (006).
- 5 Make sure that the mating surfaces of the holder (006) and the VCU (005) have no damage (for example no dents or no raised areas).

- 6 Make sure that the distance X (Figure 10-61) between the washer (001) and the holder (002) is in the correct range, refer to Table 10-1 - Distance X for VCU.

**Fig 10-61 Connection piece of VCU**



**Tab 10-1 Distance X for VCU**

Engine type	Distance X [mm]
X52 X52DF	2.5 +0.5
X62, X62-B X62DF	2.5 +0.5
X72, X72-B X72DF	2.5 +0.5
X82-B X82DF-1.0	2.5 +0.5
X92, X92-B X92DF	4.2 +0.5

- 7 If the distance X is not in the correct range, for example if the sealing surface of the connection piece (003) has changed, machine the washer (001) to get the correct distance X.
- 8 Carefully put the VCU (005, Figure 10-60) in position on the holder (006).
- 9 Apply oil to the threads of the screws (004).
- 10 Tighten with your hand the crews (004).
- 11 In the sequence given, torque the screws (004) to the correct value, refer to section 16.1 Tightening instructions.
- 12 Install the supply pipe (008) to the VCU (005).
- 13 Install the return pipe (001) to the VCU (005).
- 14 If the VCU (005) installed at the driving end of the servo oil rail (007), also install the HP hose (002) to the VCU (005).
- 15 Carefully attach the 4/2-way solenoid valve (003) to the VCU (005).
- 16 Torque the screws of the 4/2-way solenoid valve (003) to the correct value, refer to section 16.1 Tightening instructions.
- 17 Connect the electrical connection to the 4/2-solenoid valve (003).

**CLOSE UP**

- None

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# 11 Group 6 - Scavenge air components

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## 11.1 Scavenge air receiver

### 11.1.1 Scavenge air receiver - examine

#### Periodicity

Description	
Working hours	5000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

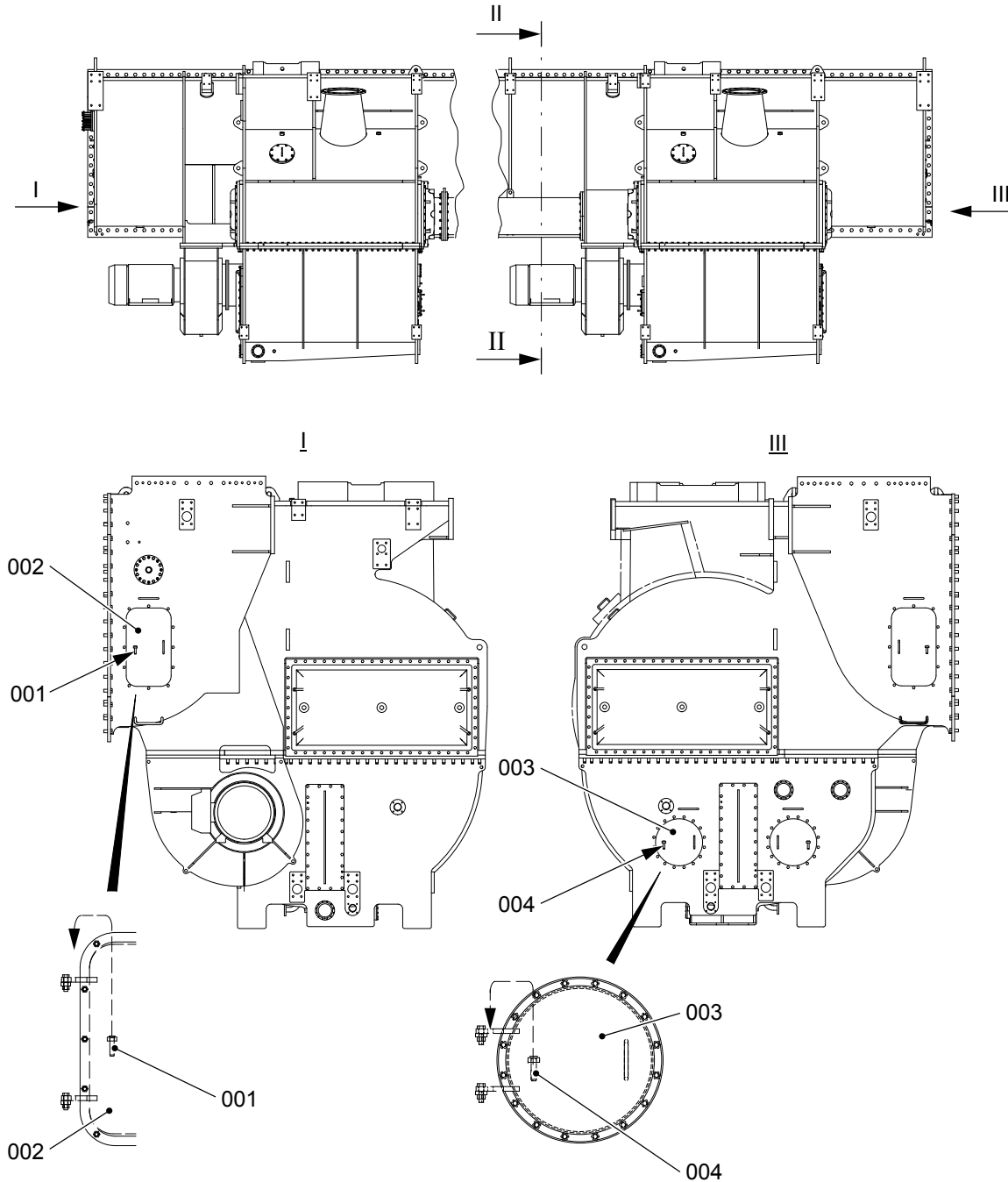
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

**PROCEDURE**

- 1 Open the covers (002 and 003, [Figure 11-1](#)).
- 2 Lock the covers (002, 003) in position with the pins (001, (004).
- 3 Clean the scavenge air receiver.

Fig 11-1 Scavenge air receiver - visual examination



00859

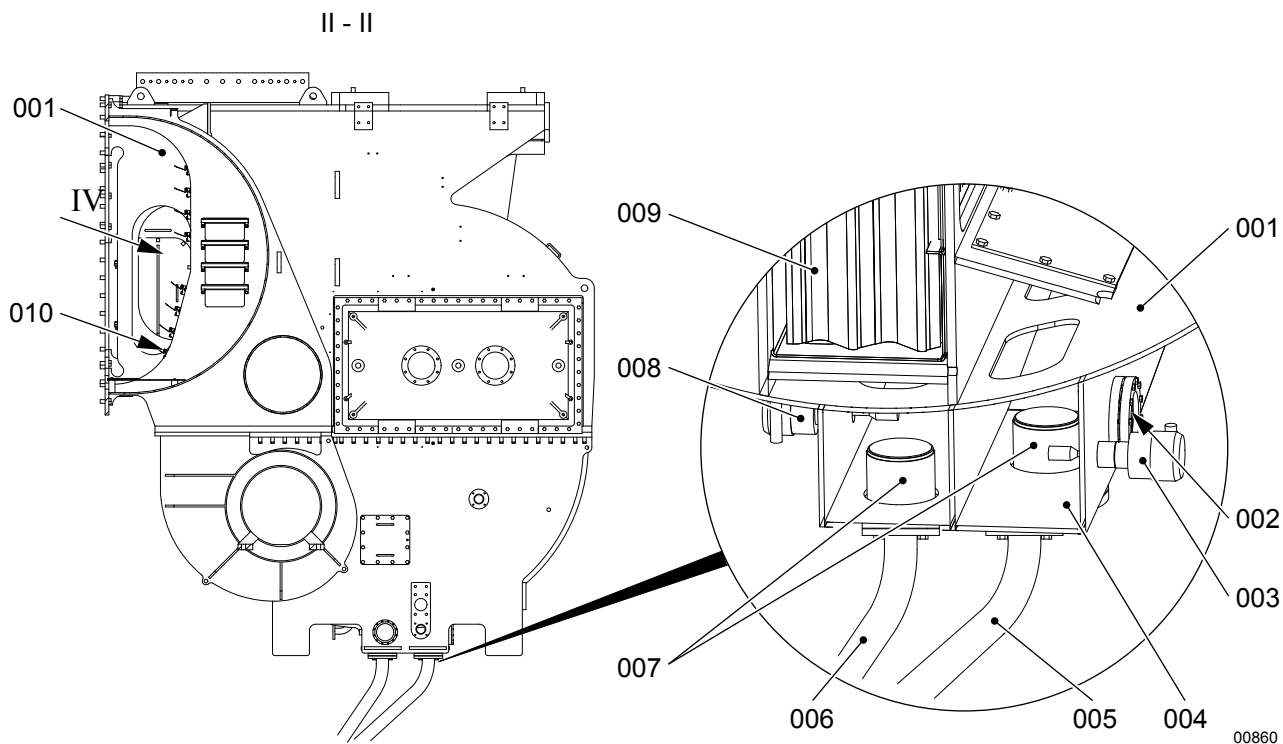
- 4 If necessary clean the filters (007) and the drain pipes (005, 006).
- 5 Make sure that the flaps (010) have no dirt or damage, and have free movement. If necessary, clean the flaps.



**NOTE:** If necessary, replace the flaps, refer to the related procedures.

- 6 Remove the pins (001 and 004, [Figure 11-1](#)) from the locked position.
- 7 Close the covers (002, 003).
- 8 Put the pins (001, 004) in their stowage positions.

**Fig 11-2 Level switches and filters**



### CLOSE UP

- None

## 11.1.2 Scavenge air receiver - do a check of the relief valve

### Periodicity

Description	
Unscheduled	During each engine overhaul
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

## SAFETY PRECAUTIONS

### WARNING

**Injury Hazard. If the disc springs are compressed, do not disassemble the relief valve. Parts can eject at high speed and cause injury.**

**NOTE:** If there is damage or a malfunction, speak to the manufacturer of the relief valve, or to WinGD.

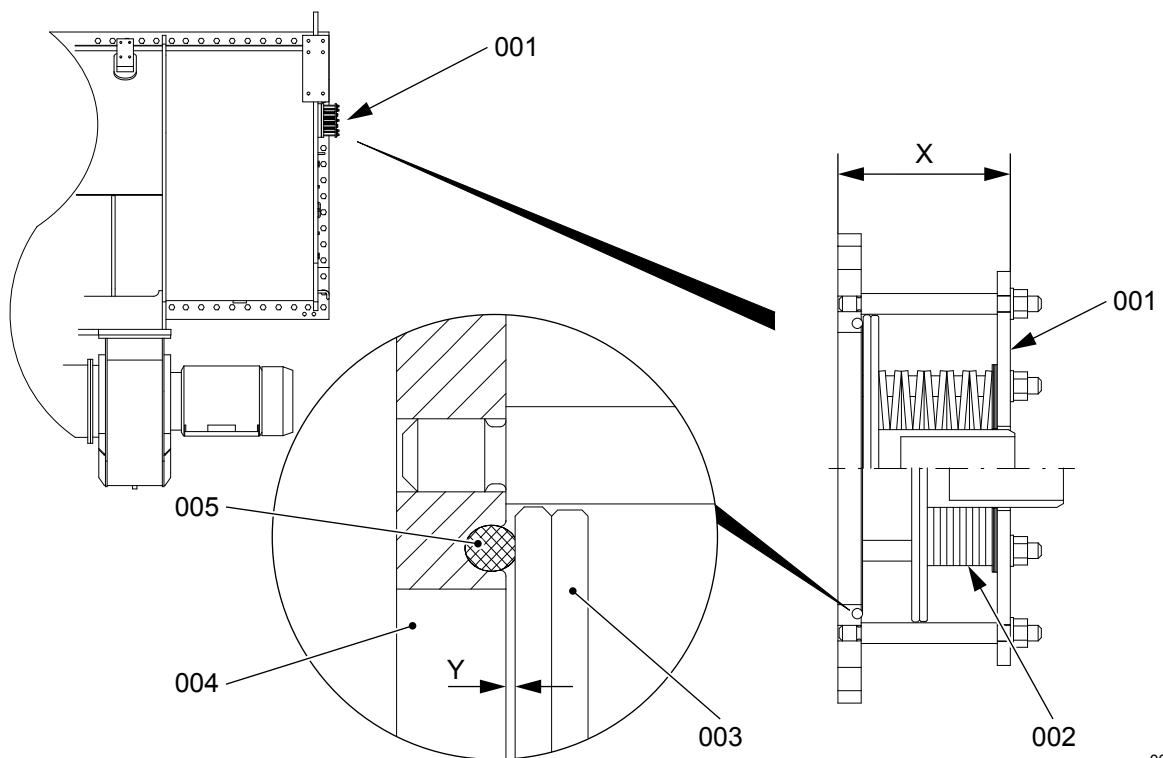
## PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Do a visual check for damage and corrosion. If necessary, replace the relief valve (001, [Figure 11-3](#)).
- 2 Make sure that there is a clearance (Y) between the flange (004) and the seal plate (003), thus the O-ring (005) is serviceable.
- 3 Make sure that the distance X is 133 mm, thus the pressure of the disc springs (002) is sufficient.

**Fig 11-3 Relief valve**



00863

## CLOSE UP

- None

### 11.1.3 Scavenge air receiver - remove the flaps

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

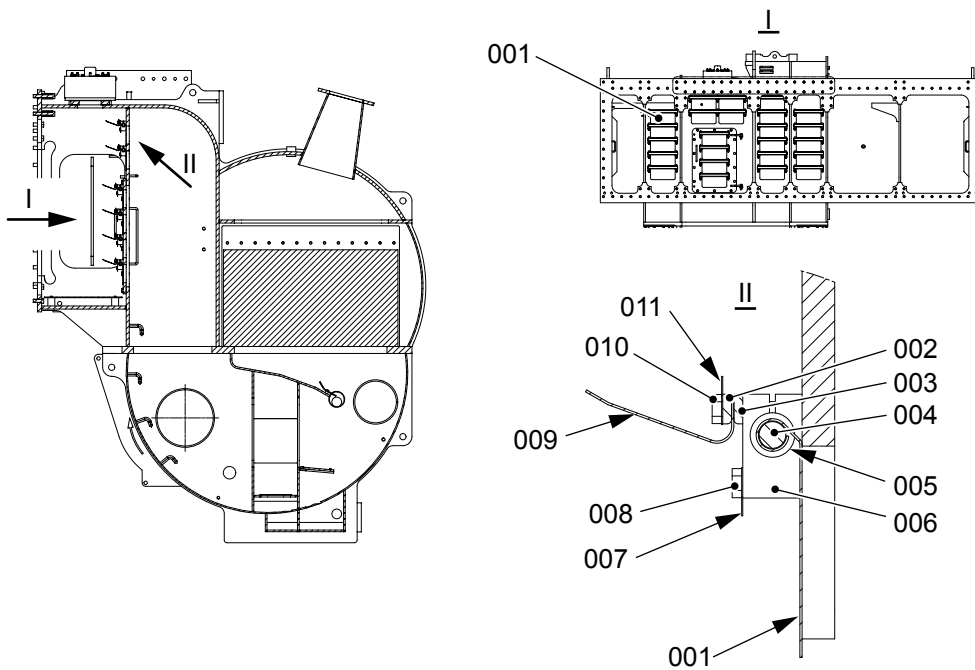
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Remove the screws (010, [Figure 11-4](#)) and the tab washers (011).
- 2 Remove the two flat bars (002, 003) and the stop plate (009).
- 3 Remove the screw (008) and the tab washer (007).
- 4 Remove the guide (006), distance ring (005), shaft (004), and the flap (001).

**Fig 11-4 Flaps - remove**



00536

## CLOSE UP

- None

## 11.1.4 Scavenge air receiver - install the flaps

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	2.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Flap			A/R

### SAFETY PRECAUTIONS

- None

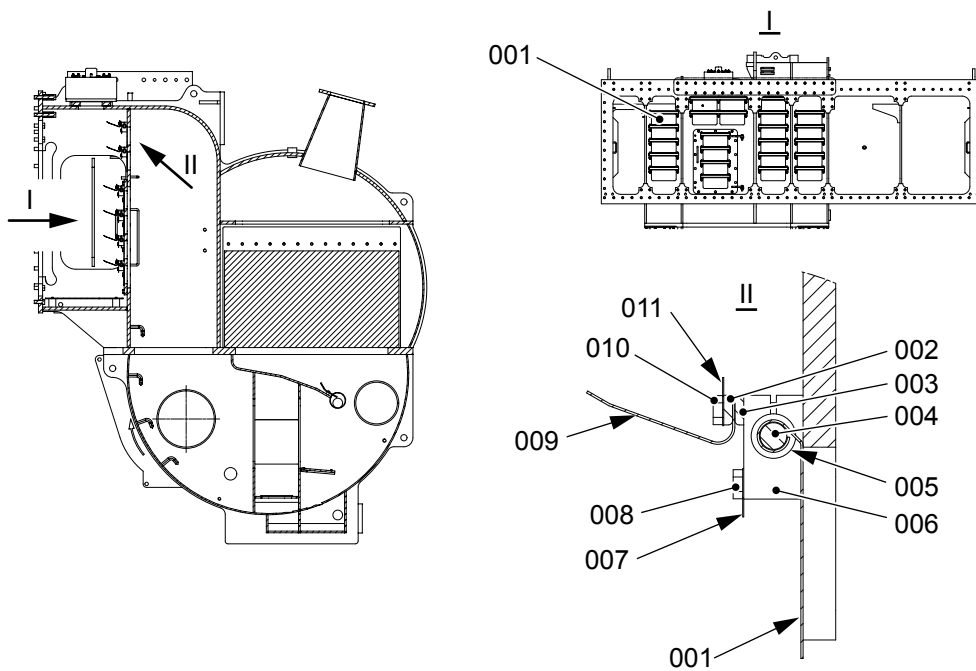
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Put the guide (006), distance ring (005), shaft (004), and the flap (001) in position ([Figure 11-5](#)).
- 2 Put the flat bar (003), stop plate (009), flat bar (002) new tab washers (011), and screws (010) in position. Do not tighten the screws at this step.
- 3 Put the screws (008) and new tab washers (007) in position. Do not tighten the screws at this step.
- 4 Make sure that the shaft (004) and the flap (001) move freely.
- 5 Tighten the screws (008, 010).
- 6 Bend the tab washers (007, 011) to lock the screws (008, 010).

**Fig 11-5 Flaps - install**



00536

## CLOSE UP

- None

## 11.2 Auxiliary blower

### 11.2.1 Auxiliary blower - remove

#### Periodicity

Description	
Working hours	30 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			2
Spur-gearred chain block			3
Shackle			2
Shackle			1
Shackle			3
Slings			2
Trolley			1
Lifting tool			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

Use only applicable equipment to lift and move the electric motor.

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



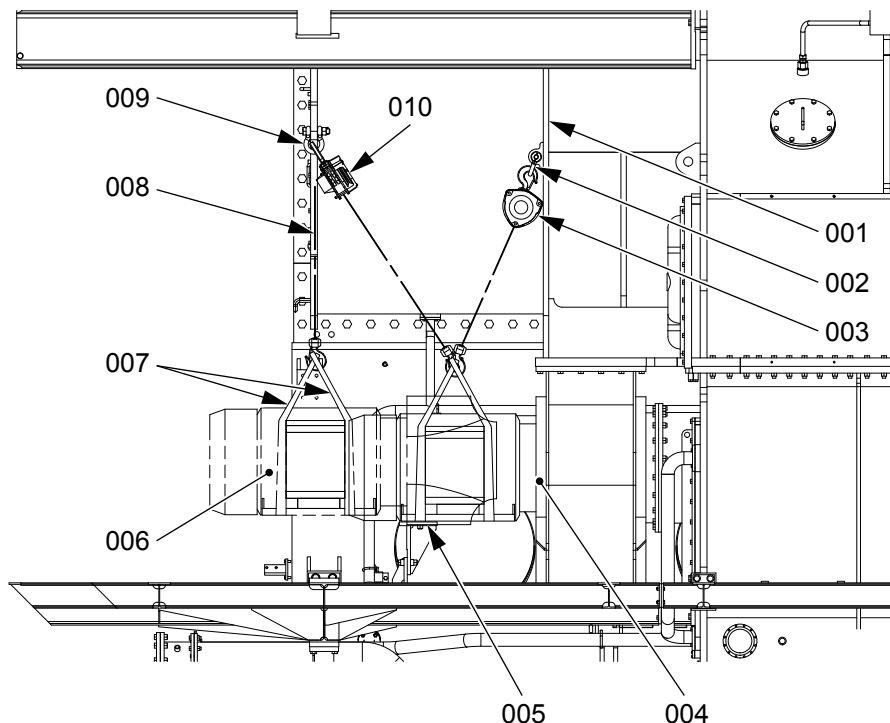
## PROCEDURE

### 1 Driving end

Do [Step 1.1](#) to [Step 1.26](#) for the electric motor at the driving end:

- 1.1 Disconnect the electrical connection from the electric motor.
- 1.2 Attach the shackle (WLL 8500 kg) (009, [Figure 11-6](#)) to the strut (008).
- 1.3 Attach the spur-gear chain-block (010) to the shackle (009).
- 1.4 Attach the shackle (WLL 6500 kg) (002) to the strut (001).
- 1.5 Attach the spur-gear chain-block (003) to the shackle (002).
- 1.6 Attach the two slings (WLL 2000 kg) (007) to the electric motor (006) and the chain blocks (003, 010).
- 1.7 Operate the chain blocks (003, 010) to hold the weight of the electric motor (006).
- 1.8 Remove the four nuts, bolts and eight washers (005) from the support.
- 1.9 Remove the bolts from the flange (004).
- 1.10 Operate the chain blocks (003, 010) to remove the electric motor (006) from the casing as shown.
- 1.11 Remove the chain block (003).

**Fig 11-6 Electric motor (driving end) - move**

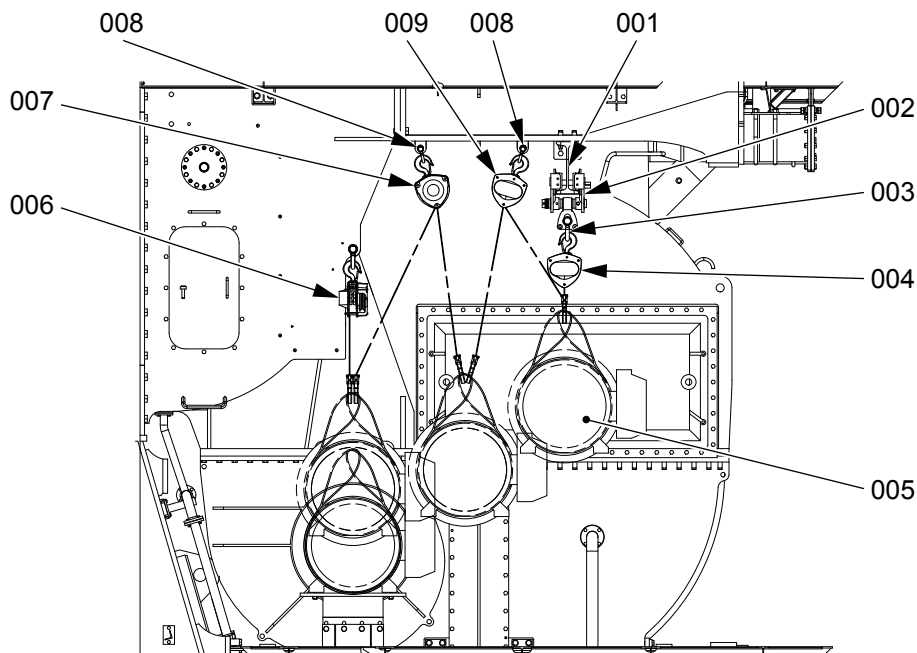


00865

- 1.12 Attach the two shackle (WLL 3250 kg) (008, [Figure 11-7](#)) to the lugs in the gallery.
- 1.13 Attach the spur-gear chain-block (007) to the shackle (008) and the slings.
- 1.14 Attach the spur-gear chain-block (009) to the shackle (008).
- 1.15 Attach the shackle (WLL 8500 kg) (002) to the beam (001).

- 1.16 Attach the (003) to the trolley (002).
- 1.17 Attach the spur-gear chain-block (004) to the shackle (003) and the slings.
- 1.18 Operate the chain block (007) to hold the weight of the electric motor (005).
- 1.19 Operate the chain blocks (007, 009, 004) to move the electric motor (005) to the position shown.
- 1.20 Make sure that the chain block (004) holds the weight of the auxiliary motor (005).
- 1.21 Remove the chain blocks (007, 009).
- 1.22 Move the trolley (004) and auxiliary motor (005) to the driving end.
- 1.23 Attach the engine room crane to the slings.
- 1.24 Operate the engine room crane to hold the weight of the auxiliary motor (005).
- 1.25 Remove the chain block (004) from the auxiliary motor (005).
- 1.26 Operate the engine room crane to lower the auxiliary motor (005) on to an applicable surface.

**Fig 11-7 Electric motor (driving end) - remove**



00866

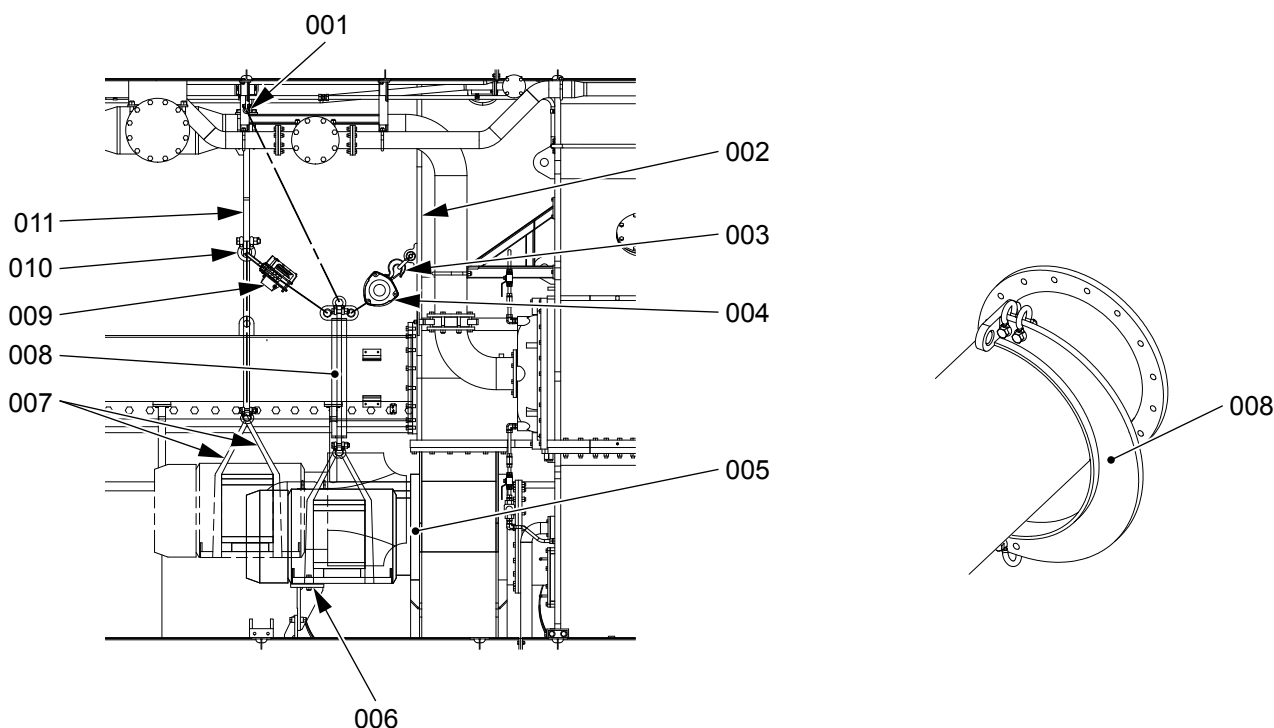
## 2 Free end

Do [Step 2.1](#) to [Step 2.25](#) for the electric motor at the free end:

- 2.1 Attach the shackle (WLL 8500 kg) (010, [Figure 11-8](#)) to the strut (011).
- 2.2 Attach the spur-gear chain block (009) to the shackle (010).
- 2.3 Attach the shackle (WLL 6500 kg) (003) to the strut (002).
- 2.4 Attach the spur-gear chain block (004) to the shackle (003).
- 2.5 Attach the chain blocks (004, 009) to the lifting tool (008).
- 2.6 Attach the two slings (007) to the electric motor and the lifting tool (008).

- 2.7 Operate the chain blocks (004, 009) to hold the weight of the electric motor.
- 2.8 Remove the four nuts, bolts and eight washers (006) from the support.
- 2.9 Remove the screws from the flange (006).
- 2.10 Operate the chain blocks (004, 009) to remove the electric motor from the casing as shown.
- 2.11 Operate the chain block (004) to release the tension until the auxiliary motor is below the chain block (009).
- 2.12 Remove the chain block (004).
- 2.13 Attach the shackle (001) to the lug in the gallery as shown.

**Fig 11-8 Electric motor (free end) - move**

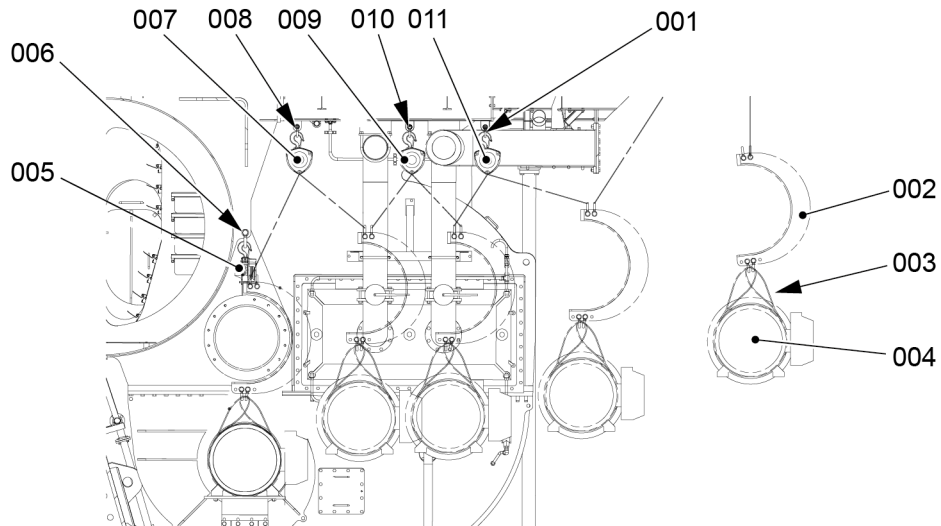


00867

- 2.14 Attach the spur-gear chain block (007, [Figure 11-9](#)) to the shackle (008) and the shackle on the lifting tool (002).
- 2.15 Attach the shackle (010) to the lug in the gallery.
- 2.16 Attach the spur-gear chain block (009) to the shackle (010) and the lifting tool (002).
- 2.17 Operate the chain blocks (007, 009) until the electric motor (004) is below the chain block (007).
- 2.18 Remove the chain block (005).
- 2.19 Attach the shackle (001) to the gallery.
- 2.20 Attach the chain block (011) to the shackle (001).
- 2.21 Operate the chain blocks (009, 011) to move the electric motor (004).
- 2.22 Attach the engine room crane to the shackle on the lifting tool (002).
- 2.23 Operate the engine room crane to hold the weight of the electric motor (004).
- 2.24 Remove the chain blocks (009, 011) from the lifting tool (002).

- 2.25 Operate the engine room crane to move the electric motor (004) to an applicable surface.

Fig 11-9 Auxiliary blower - remove



00939

### CLOSE UP

- None

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## 11.2.2 Auxiliary blower - install

### Periodicity

Description	
Working hours	30 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Spur-gearred chain block			2
Spur-gearred chain block			3
Shackle (WLL 8500 kg)			2
Shackle (WLL 6500 kg)			1
Shackle (WLL 3250 kg)			3
Slings (WLL 2000 kg)			2
Trolley			1
Lifting tool			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Electric motor			1
Electric motor			1

### SAFETY PRECAUTIONS

#### WARNING

Injury Hazard. Use only applicable equipment to lift and move the electric motor.

### PRELIMINARY OPERATIONS

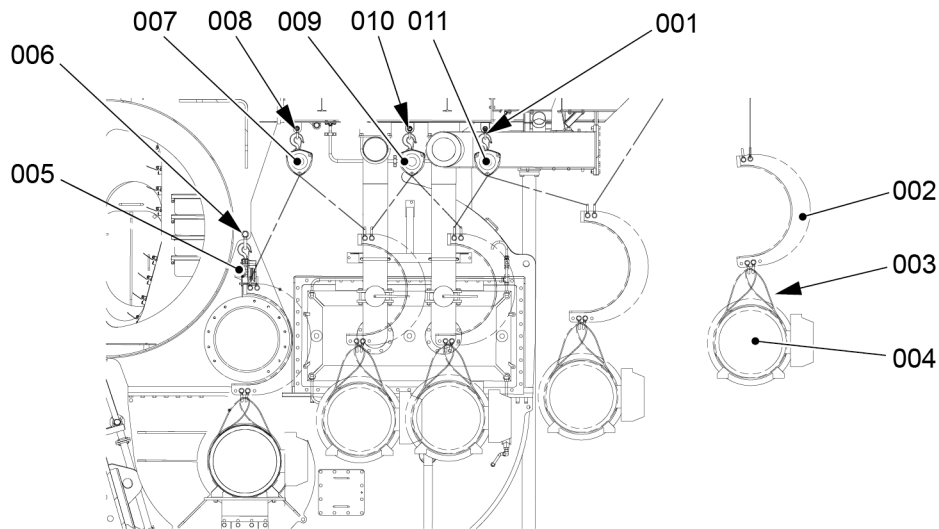
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

### 1 Electric motor - free end

Do [Step 1.1](#) to [Step 1.28](#) to install the applicable electric motor at the free end:

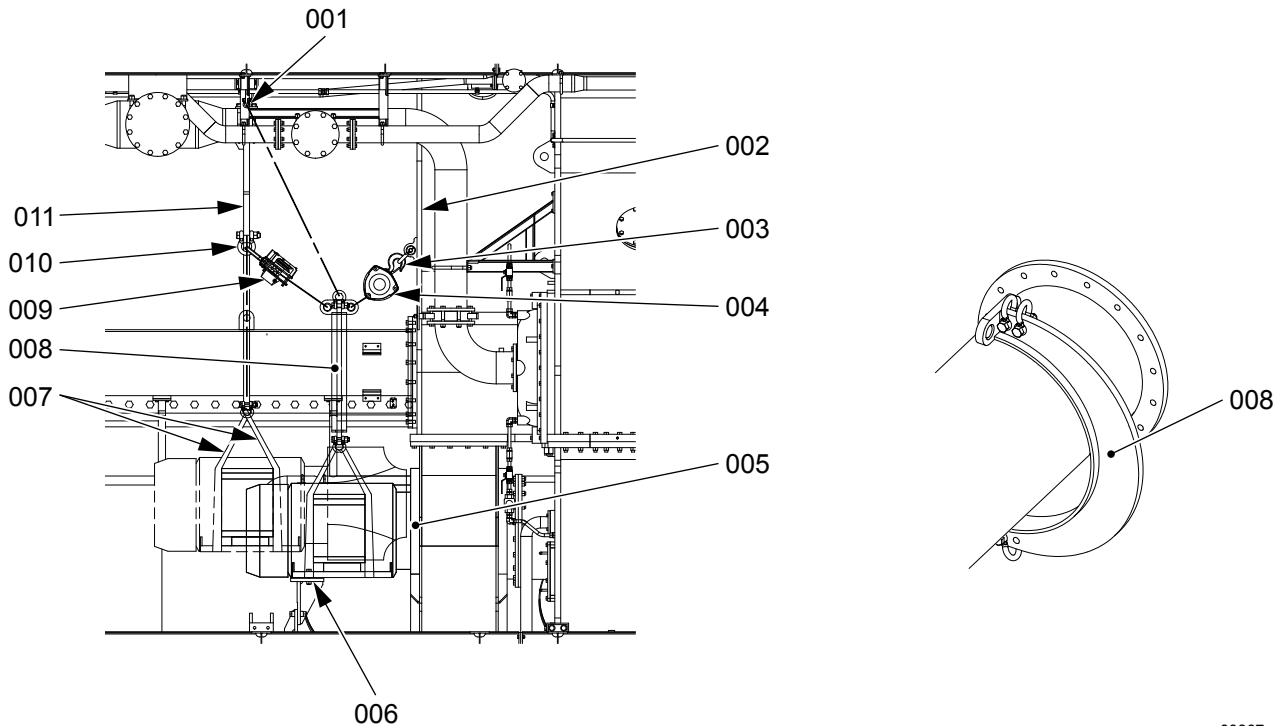
- 1.1 Attach the two slings (003, [Figure 11-10](#)) to the electric motor (004) and the shackle on the lifting tool (002).
- 1.2 Attach the engine room crane to the lifting tool (002).
- 1.3 Operate the engine room crane to lift and move the electric motor (004) into position.
- 1.4 Attach the spur-gear chain block (011) to the shackle (001) and the shackle on the lifting tool (002).
- 1.5 Attach the spur-gear chain block (009) to the shackle (010).
- 1.6 Operate the chain block (011) and the engine room crane until the electric motor (004) is below the chain block (009).
- 1.7 Attach the chain block (009) to the shackle on the lifting tool (002).
- 1.8 Operate the chain block (009) to hold the weight of the electric motor (004)
- 1.9 Remove the engine room crane from the lifting tool (002).
- 1.10 Attach the spur-gear chain block (007) to the shackle (008).
- 1.11 Operate the chain blocks (009, 011) until the electric motor (004) is below the chain block (007).
- 1.12 Attach the chain block (007) to the shackle on the lifting tool (002).
- 1.13 Operate the chain block (007) to hold the weight of the electric motor (004).
- 1.14 Carefully remove the chain block (011).
- 1.15 Attach the spur-gear chain block (005) to the shackle (006).
- 1.16 Operate the chain blocks (007, 009) to move the electric motor (004) into position below the chain block (005).
- 1.17 Attach the chain block (005) to the shackle on the lifting tool (002).
- 1.18 Operate the chain block (005) to hold the weight of the electric motor (004).
- 1.19 Carefully remove the chain blocks (007, 009).

**Fig 11-10 Auxiliary blower - move**

00939

- 1.20** Make sure that the shackle (003, [Figure 11-11](#)) is attached to the strut (002).
- 1.21** Attach the spur-gear chain block (004) to the shackle (003) and the lifting tool (009).
- 1.22** Operate the chain blocks (004, 009) to hold the weight of the electric motor.
- 1.23** Remove the chain block (001).
- 1.24** Operate the chain blocks (004, 009) to move the electric motor into the casing.
- 1.25** Attach the electric motor to the flange (005) with the screws.
- 1.26** Attach the electric motor to the support (006) with the eight applicable bolts.
- 1.27** Torque the applicable eight bolts.
- 1.28** Connect the electrical connection to the electric motor.



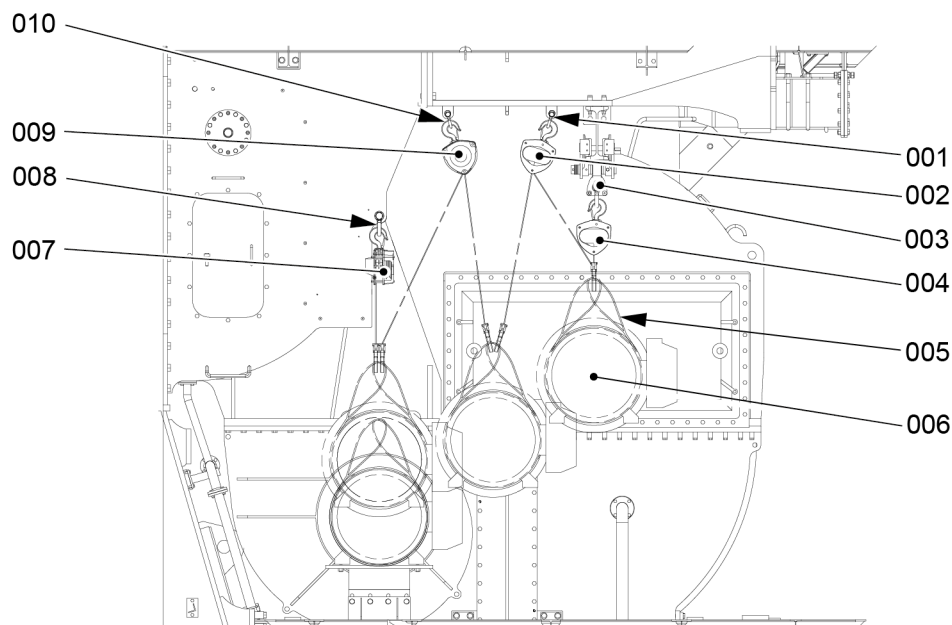
**Fig 11-11 Electric motor (free end) - install**

00867

**2 Electric motor - driving end**

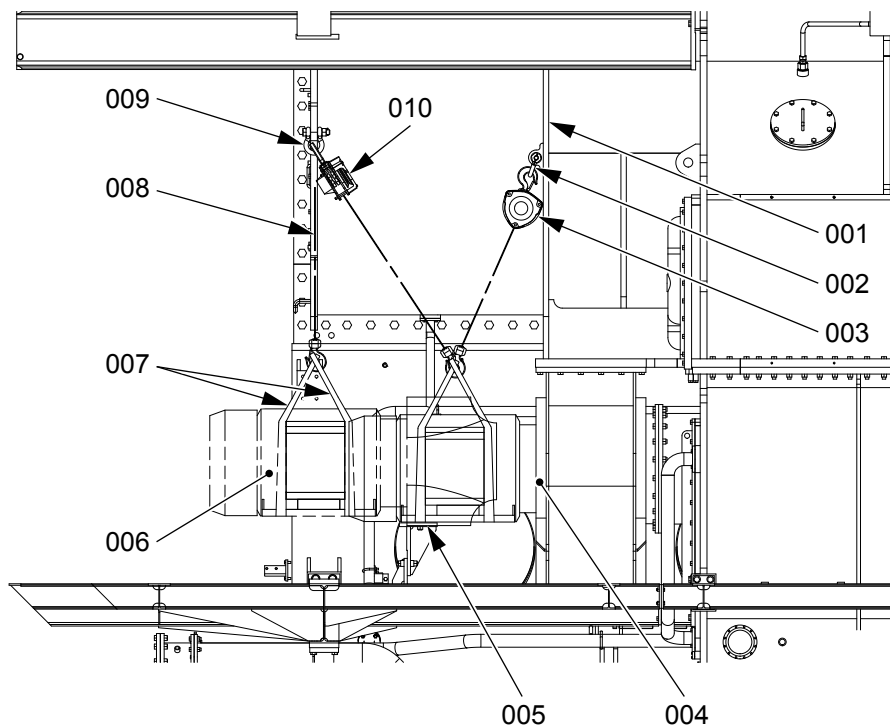
Do [Step 2.1](#) to [Step 2.22](#) for the electric motor (006, [Figure 11-12](#)) at the driving end:

- 2.1** Attach the two slings (005) to the electric motor (006).
- 2.2** Attach the spur-gear chain block (004) to the trolley (003) and the two slings (005).
- 2.3** Attach the shackle (001) to the lug.
- 2.4** Attach the spur-gear chain block (002) to the shackle (001).
- 2.5** Attach the shackle (008) to the strut as shown.
- 2.6** Attach the spur-gear chain block (007) to the shackle (008).
- 2.7** Attach the shackle (010) to the lug.
- 2.8** Attach the spur-gear chain block (009) to the shackle (010).
- 2.9** Operate the chain block (004) to lift the electric motor (006).
- 2.10** Move carefully the trolley (003) and electric motor (006) into position.
- 2.11** Attach the chain blocks (002, 009) to the two slings (005).
- 2.12** Operate the chain blocks (002, 004, 009) to move the electric motor (006) to the middle position.
- 2.13** Carefully remove the chain block (004).
- 2.14** Attach the chain block (007) to the two slings (005).
- 2.15** Operate the chain block (007) to hold the weight of the electric motor (006).
- 2.16** Carefully remove the chain blocks (002, 009) from the two slings (005).

**Fig 11-12 Auxiliary blower (driving end) move**

00938

- 2.17** Attach the shackle (002, [Figure 11-13](#)) to the strut (001).
- 2.18** Attach the spur-gear chain block (003) to the shackle (002) and the two slings (007).
- 2.19** Operate the chain blocks (002, 010) to move the electric motor (006) into the casing.
- 2.20** Attach the electric motor (006) to the flange (004) with the bolts.
- 2.21** Attach the electric motor (006) to the support (005) with the bolts.
- 2.22** Connect the electrical connection to the electric motor (006).

**Fig 11-13 Electric motor (driving end) - install**

00865

- 3 On the control panel set to ON the auxiliary blower, refer to the Operation Manual.
- 4 Make sure that the electric motor operates in the correct direction.

### CLOSE UP

- None

## **11.3 Scavenge air cooler**

### **11.3.1 Scavenge air cooler - Appendix**

For maintenance information about the scavenge air cooler, refer to [18.1 Appendix](#)

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## 11.4 Water separator

### 11.4.1 Water separator - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

#### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			3
Disassembly tool			1
Lever chain hoist			1
Shackle			2
Spur-gear chain block	9		2
Holder			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

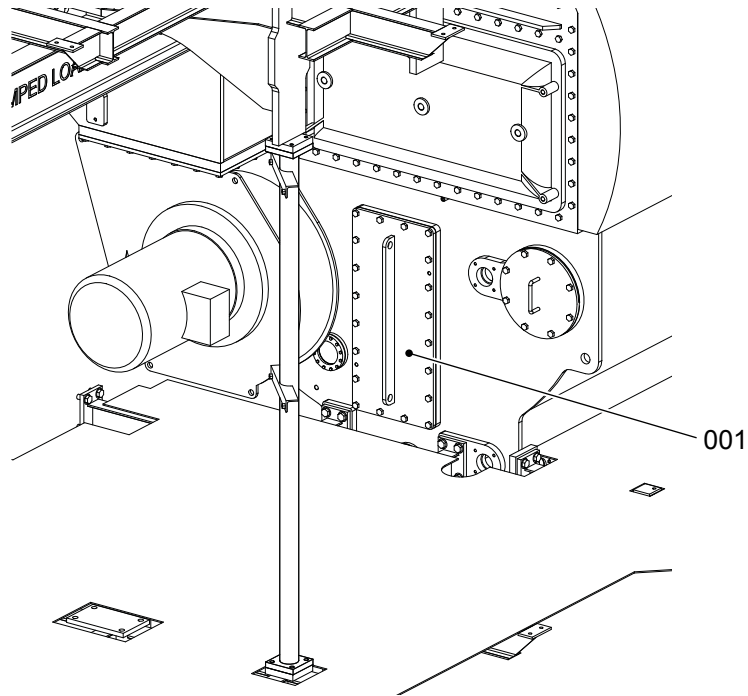
- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

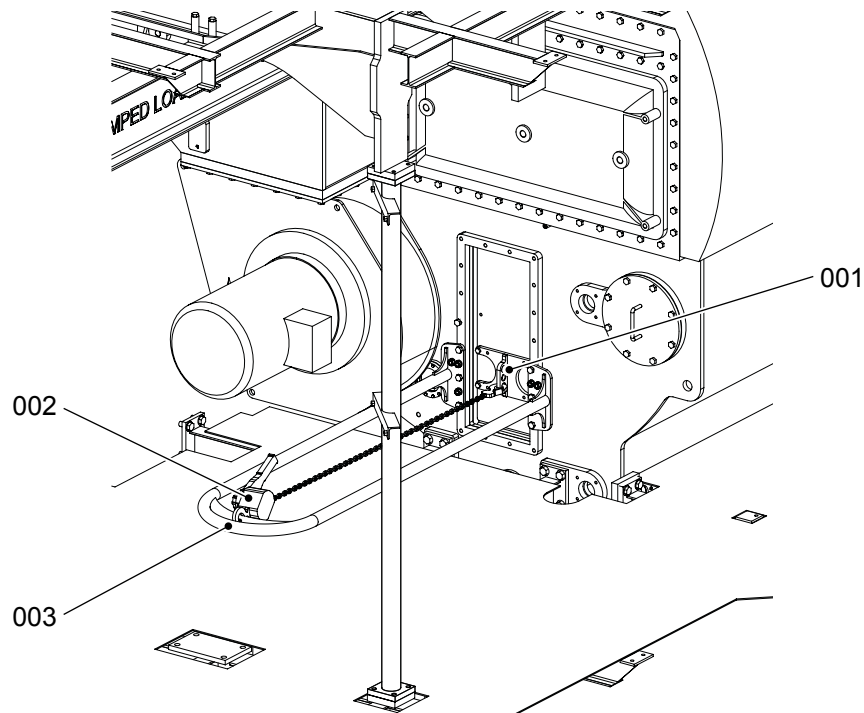
Fig 11-14 Water separator - view 1



00445

- 1 Remove the front cover (001, [Figure 11-14](#)) from the housing of the water separator.

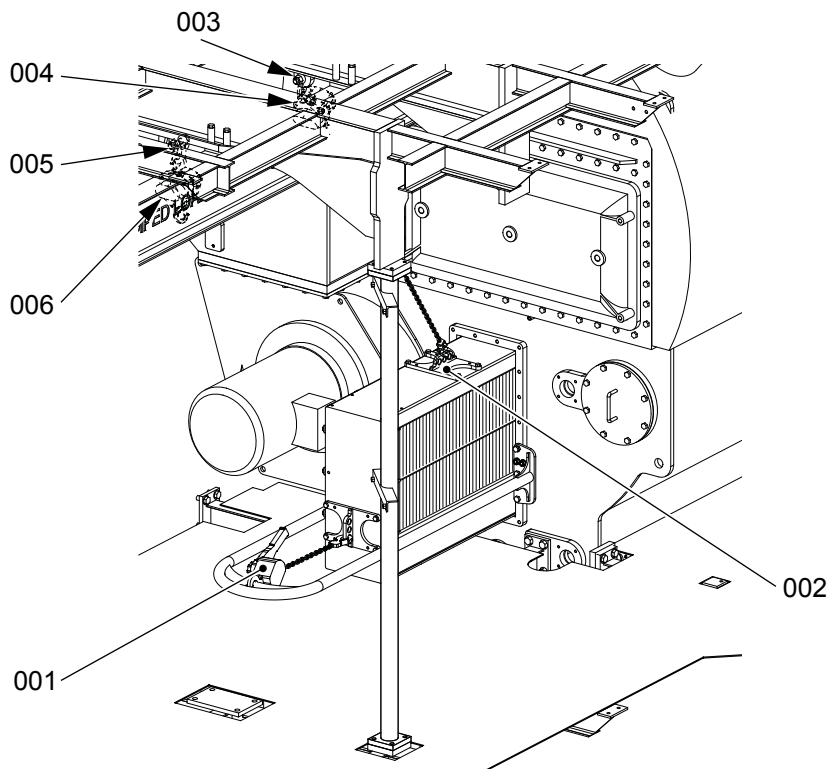
Fig 11-15 Water separator - view 2



00446

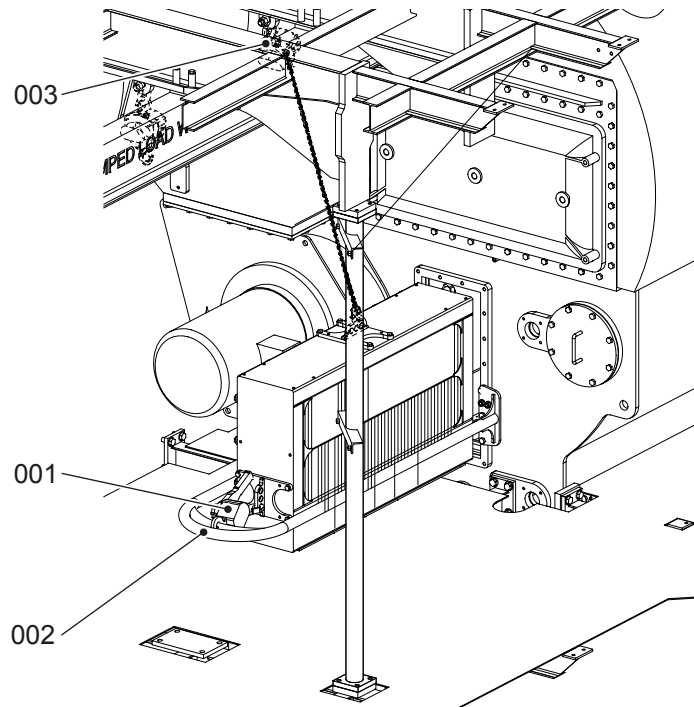
- 2 Install the lifting tool (001, [Figure 11-15](#)) to the front of the water separator.
- 3 Install the disassembly tool (003) to the housing of the receiver.  
**NOTE:** Depending on the specific engine, the sight glass beside the blower can interfere with the above step. In this case, add a 20mm distance plate between the tool and the underslung frame.
- 4 Attach the lever chain hoist (002) between the lifting tool (001) and the disassembly tool (003).



**Fig 11-16 Water separator - view 3**

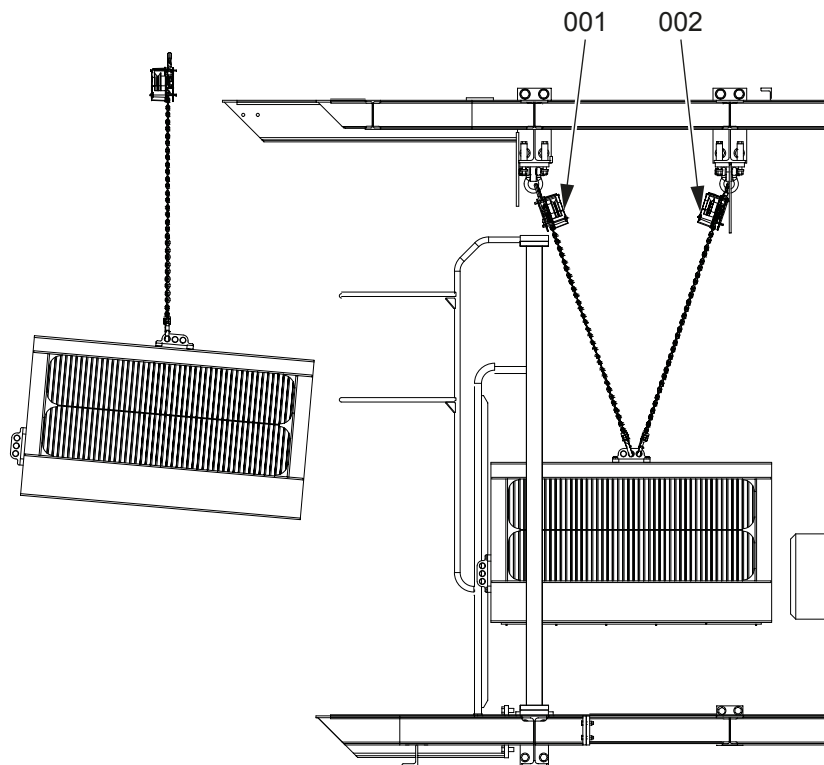
00447

- 5 Operate the lever chain hoist (001, [Figure 11-16](#)) until you can see the bores in the middle of the top side of the water separator.
- 6 Install the lifting tool (002).
- 7 Attach the shackles (004 and 005) and the spur-gear chain blocks (003 and 006) to the lugs of the platform at the exhaust side.
- 8 Put the spur-gear chain block (003) into the last hole of the lifting tool (002).
- 9 Operate the spur-gear chain block (003) to get sufficient tension to hold the water separator.

**Fig 11-17 Water separator - view 4**

00448

- 10** Continue to move out the water separator with the lever chain hoist (001) and the spur-gear chain block (003) until the water separator is fully out of the casing.
- 11** Remove the lever chain hoist (001) and the disassembly tool (002).

**Fig 11-18 Water separator - view 5**

00449

- 12 Put the spur-gear chain block (001, [Figure 11-18](#)) into the middle hole of the lifting tool.
- 13 Move the water separator until it hangs vertical to the spur-gear chain block (001).
  - 13.1 Loosen or tighten the spur-gear chain block (001).
  - 13.2 Loosen or tighten the spur-gear chain block (002).
- 14 Use the engine room crane to move the water separator to an applicable area.

### CLOSE UP

- None

## 11.4.2 Water separator - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	1

### Support equipment

Description	Part No.	CSN	QTY
Lifting tool			3
Disassembly tool			1
Lever chain hoist			1
Shackle			2
Spur-gearred chain block			2
Holder			1

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

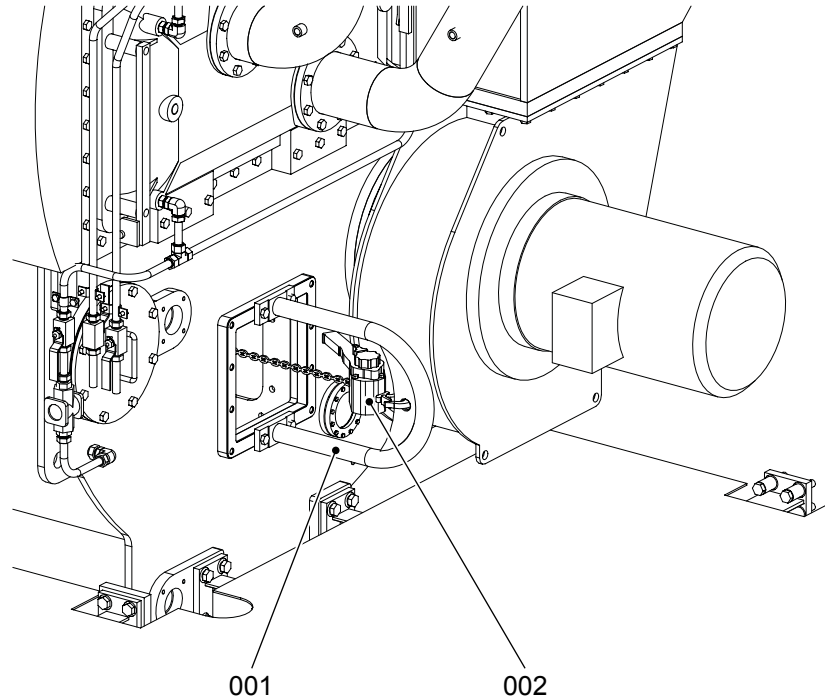
- None

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

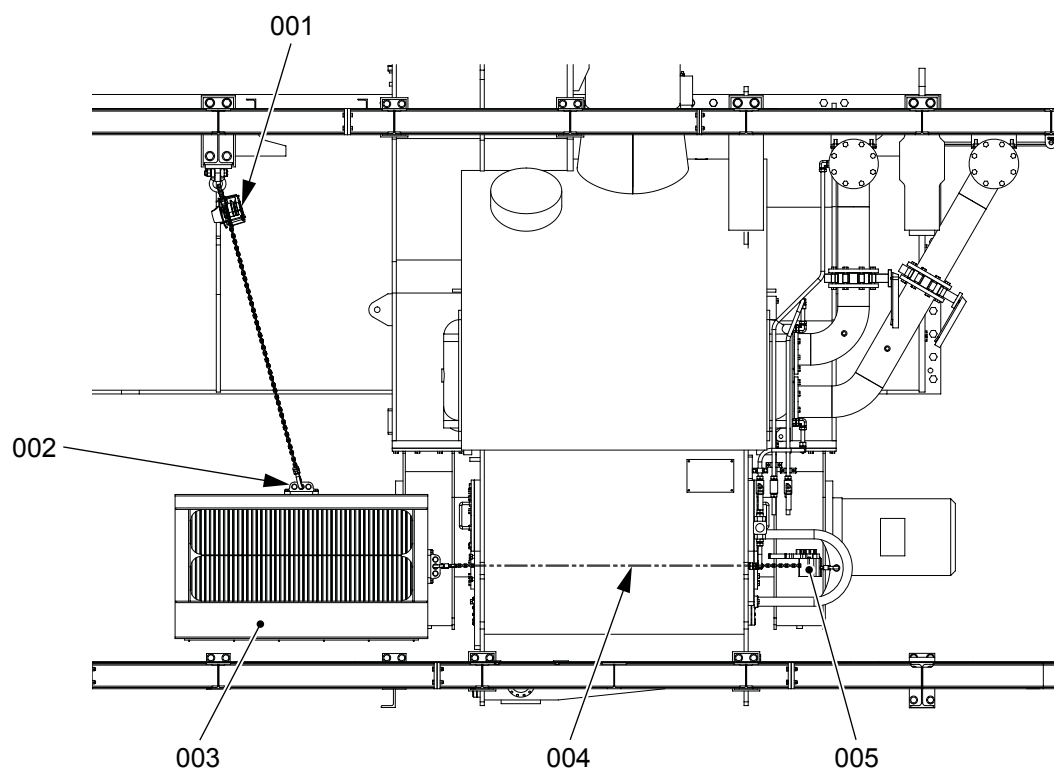
## PROCEDURE

**Fig 11-19 Water separator - view 6**



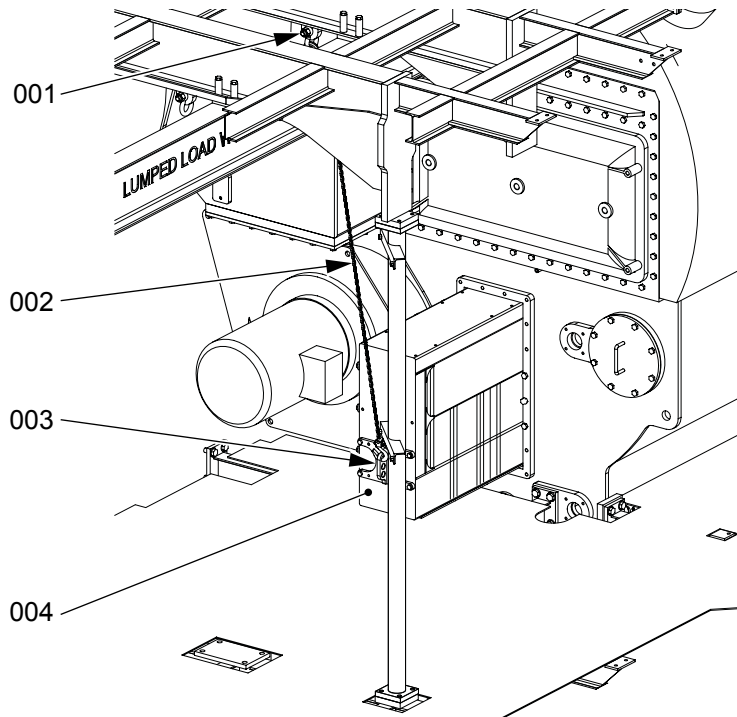
00500

- 1 Remove the rear cover from the housing of the water separator.
- 2 Install the holder (001, [Figure 11-19](#)) to the housing.
- 3 Put the lever chain hoist (002) into the holder (001).

**Fig 11-20 Water separator - view 7**

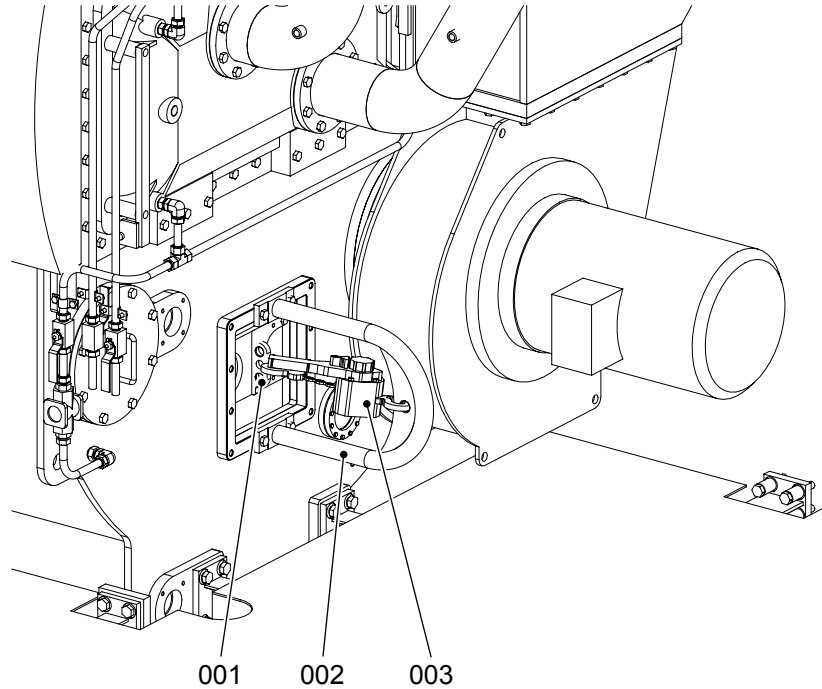
00501

- 4 Put the water separator (003, [Figure 11-20](#)) with the spur-gear chain block (001) in front of the opening.
- 5 Make sure that the water separator (003) is in the correct position.
- 6 Put the chain (004) into the lifting tool on the rear side of the water separator (003).
- 7 Operate the lever chain hoist (005) until the lifting tool (002) is near the opening.

**Fig 11-21 Water separator - view 8**

00452

- 8** Remove the lifting tool (003, [Figure 11-21](#)) from the top of the water separator (004) and attach it to the front of the water separator (004).
- 9** Operate the spur-gear chain block (001) to lift the water separator slightly.
- 10** Operate the lever chain hoist (005, [Figure 11-20](#)) until the water separator (004, [Figure 11-21](#)) is at the correct position.
- 11** Remove the lifting tool (003).

**Fig 11-22 Water separator - view 9**

- 12 Remove the lever chain hoist (003, [Figure 11-22](#)), the lifting tool (001) and the holder (002).
- 13 Remove all chain blocks and tools.
- 14 Attach the covers to the water separator.

### CLOSE UP

- None



## 12 Group 7 - Cylinder lubrication

### 12.1 Cylinder lubrication system

12.1.1	Cylinder lubrication system - do a functional test. ....	730
12.1.2	Cylinder lubrication system - bleed. ....	732
12.1.3	Cylinder lubricating pump - remove. ....	736
12.1.4	Cylinder lubricating pump (MK-E) - do a service. ....	740
12.1.5	Cylinder lubricating pump - install. ....	744

## 12.1 Cylinder lubrication system

### 12.1.1 Cylinder lubrication system - do a functional test

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel.

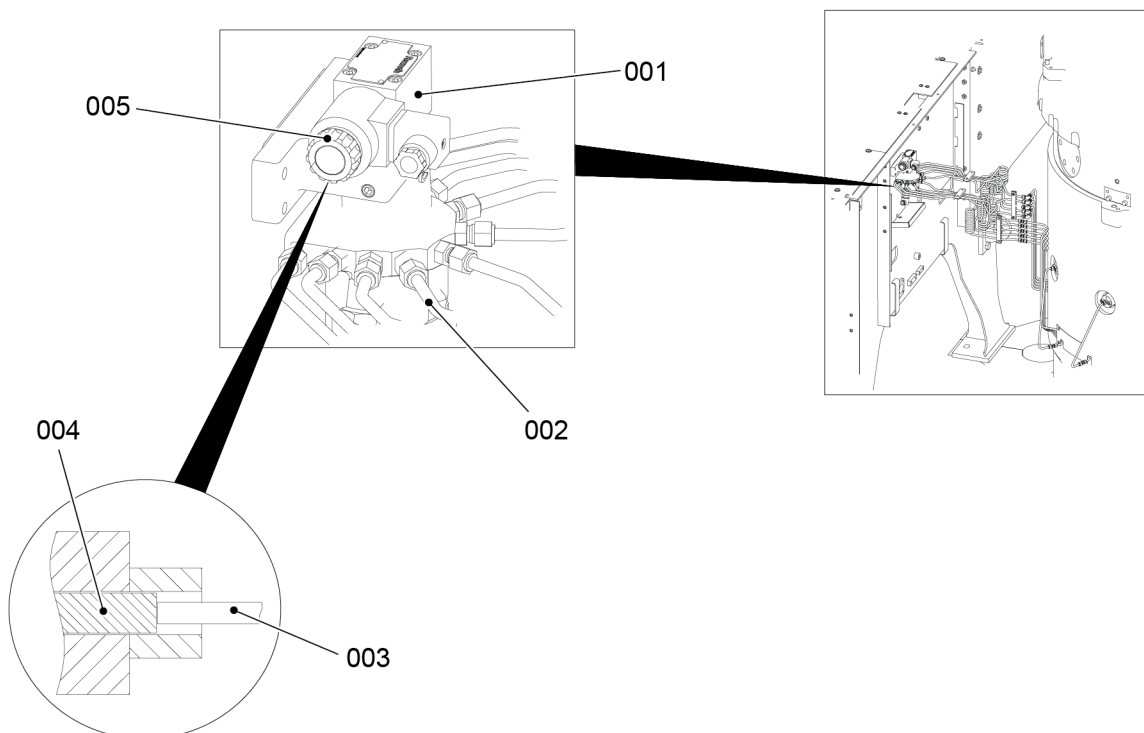
#### PRELIMINARY OPERATIONS

- The engine must be stopped.

## PROCEDURE

- 1 Make sure that the turning gear is engaged.
- 2 Operate the turning gear to get the piston of the first cylinder to the TDC position.
- 3 On the local control panel, get the cylinder lubrication page.
- 4 Select the applicable cylinder number.
- 5 If necessary, change the number of lube pulses (in the range 0 to 200).
- 6 Manually release a lube pulse, for example use an applicable tool (003, [Figure 12-1](#)) to push in the plunger (004) of the 4/2-way valve (005).
- 7 Look through the scavenge ports in the cylinder liner while the lubricating system operates.
- 8 Make sure that the lubricating oil flows correctly on to the cylinder liner wall.
- 9 Make sure that the oil that flows has no air. If necessary, bleed the cylinder lubricating pump (001) and the oil pipes (002), refer to section [12.1.2 Cylinder lubrication system - bleed](#).
- 10 Set to OFF the cylinder lubricating system for the applicable cylinder.
- 11 Do [Step 2](#) to [Step 10](#) again for the other cylinders.

**Fig 12-1** Cylinder lubrication system (example) - do a functional test



00974

## CLOSE UP

- None

## 12.1.2 Cylinder lubrication system - bleed

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

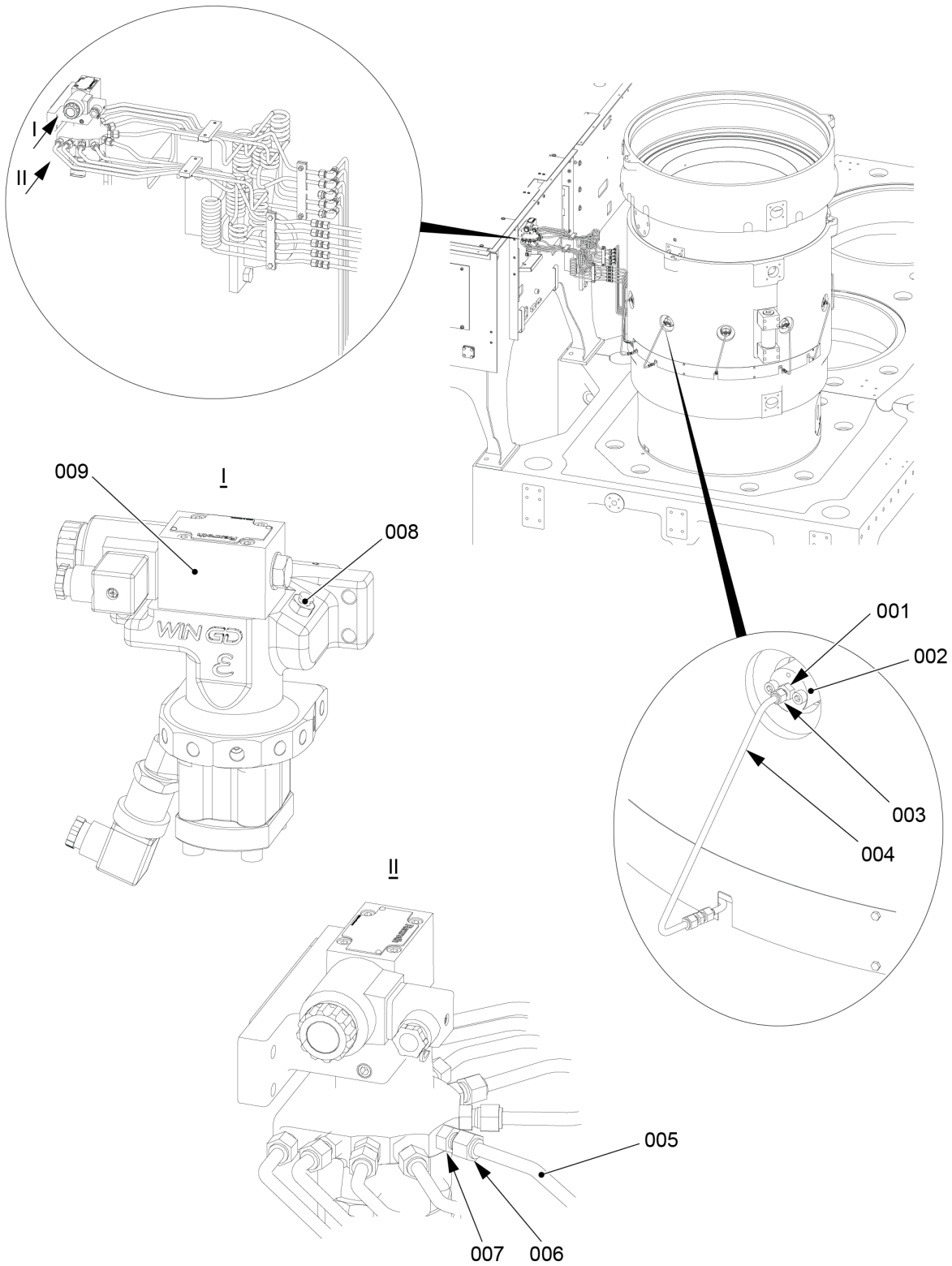
### PRELIMINARY OPERATIONS

- The engine must be stopped

## PROCEDURE

- 1 Bleed the cylinder lubricating pump as follows:
  - NOTE:** When you bleed the cylinder lubricating system, always start at the first cylinder at the free end. The hydrostatic pressure in the cylinder lubricating system helps you bleed the cylinder lubricating pump (009, [Figure 12-2](#)).
  - 1.1 Clean the external surface of the cylinder lubricating pump (009).
  - 1.2 Examine the cylinder lubricating pump (009) for damage and leaks.
  - 1.3 On the lubricating pump (009) push the button (008). Keep the button pushed until oil that flows has no air.
  - 1.4 Release the button (008).
  - 1.5 If necessary, bleed the oil pipes, refer to [Step 2](#).
- 2 Bleed the oil pipes as follows:
  - 2.1 On the local control panel, get the LUB display (refer to the Operation Manual for more data).
  - 2.2 Select the applicable cylinder number.
  - 2.3 If necessary, change the number of lube pulses (in the range 0 to 200).
  - 2.4 On the pipe (004), use an open-ended wrench to hold the screw-in union (001) in position.
  - 2.5 Loosen the nut (003) a maximum of two turns.
  - 2.6 Keep the nut (003) in the open position until oil that flows has no air.
  - 2.7 Tighten the nut (003).
  - 2.8 Clean the external surface of the lubricating quill (002).
- 3 If necessary, do [Step 3.1](#) to [Step 3.4](#):
  - 3.1 On the pipe (005), use an open ended wrench to hold the screw-in union (007).
  - 3.2 Loosen the nut (006) a maximum of two turns.
  - 3.3 Keep the nut (006) in the open position until oil that flows has no air.
  - 3.4 Tighten the nut (006).
  - 3.5 If necessary, do [Step 3.1](#) to [Step 3.5](#) for the adjacent pipes.

Fig 12-2 Cylinder lubrication system - bleed



00973

**CLOSE UP**

- None

### 12.1.3 Cylinder lubricating pump - remove

#### Periodicity

Description	
Working hours	45 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

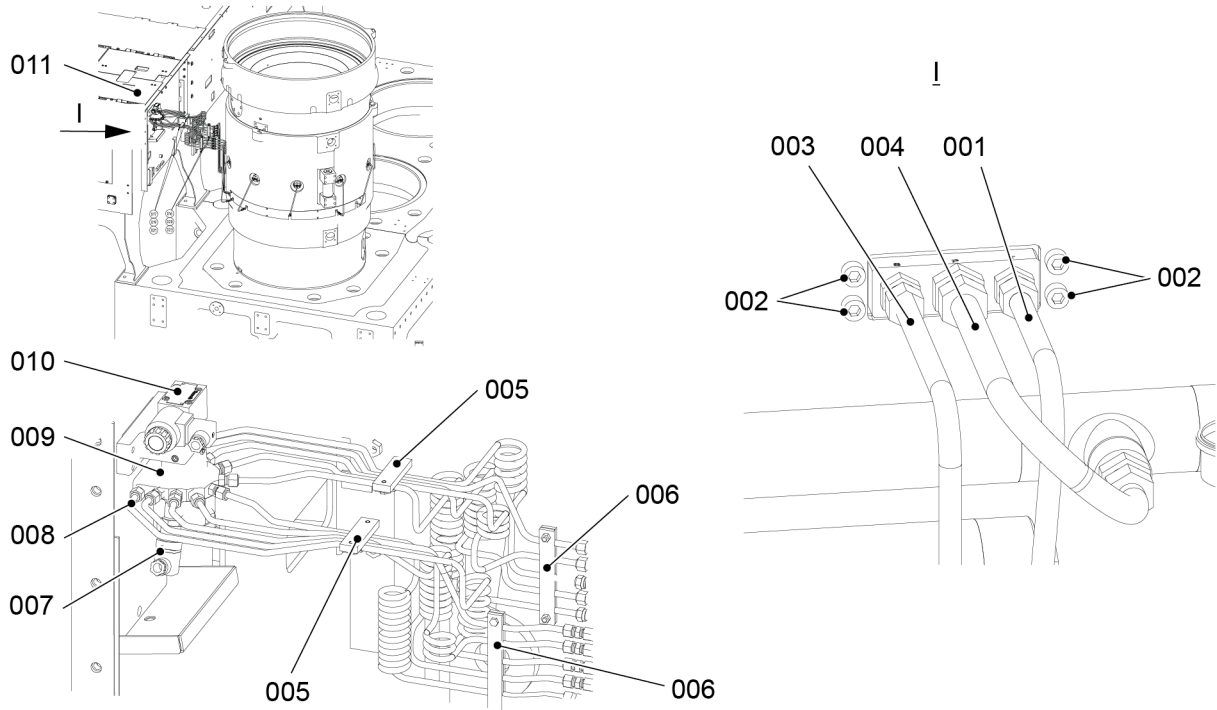
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Remove the cover (011, [Figure 12-3](#)) from the rail unit for access.  
**NOTE:** The figure is for MK-E pump. For MK-1 pump the pump and the pipes are partly different.
- 2 Put a drip tray under the pipes (001, 003, 004).
- 3 Put marks on the pipes (001, 003, 004) to identify them.
- 4 Remove the pipes (001, 003, 004).
- 5 Remove the pipe brackets (005).
- 6 If necessary, remove the pipe brackets (006).
- 7 Disconnect the electrical connection from the 4/2-way valve (010).
- 8 Disconnect the electrical connection from the pressure transmitter (007).
- 9 Put a drip tray under the pipes (008).  
**NOTE:** The number of pipes is related to the engine.
- 10 Remove the pipes (008).
- 11 Hold the weight of the cylinder lubricating pump (009).
- 12 Remove the screws (002).
- 13 Remove the cylinder lubricating pump (009).
- 14 To replace the 4/2-way valve (010), do as follows:  
**NOTE:** You also can do this step if the cylinder lubricating pump is installed.
  - 14.1 Remove the related screws of the 4/2-way valve (010).
  - 14.2 Remove the 4/2-way valve (010).
  - 14.3 Put the new 4/2-way valve (010) in position.
  - 14.4 Make sure that the O-rings are in position.
  - 14.5 Torque the screws of the 4/2-way valve (010) with 9 Nm.

Fig 12-3 Cylinder lubricating pump (MK-E, example) - remove



00979

**CLOSE UP**

- None

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## 12.1.4 Cylinder lubricating pump (MK-E) - do a service

### Periodicity

Description	
Working hours	45 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Torque wrench			1

### Supplies

Description	QTY
Mineral oil SAE 50	A/R
Loctite thread sealant No. 542	A/R
GP grease	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			A/R
Piston joint ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The cylinder lubricating pump (MK-E) must be removed.

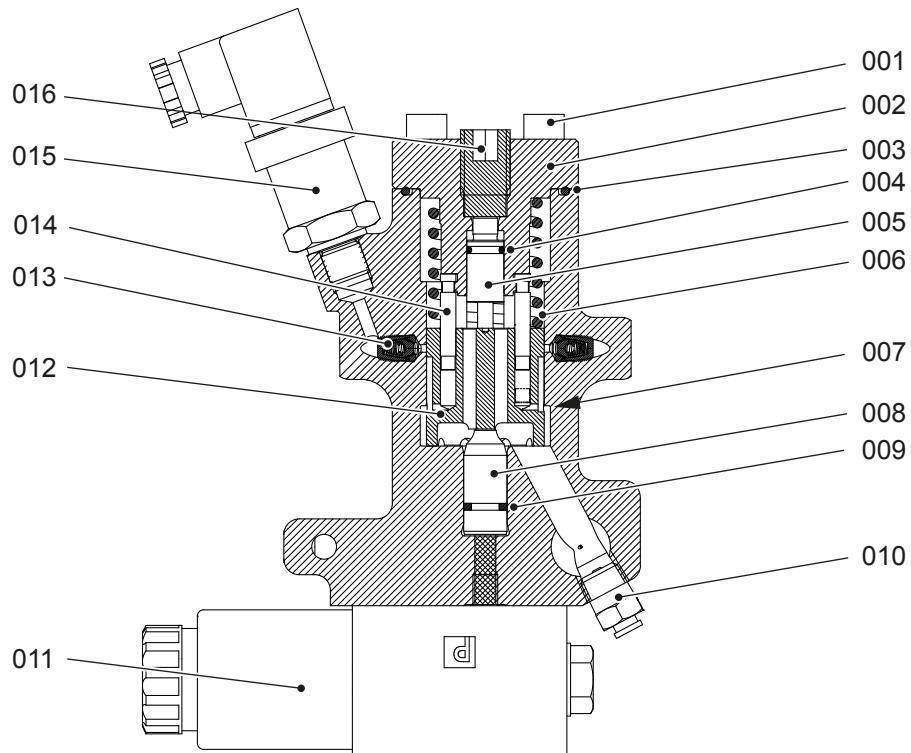
## PROCEDURE

- 1 Disassemble the cylinder lubricating pump as follows:
  - 1.1 Remove the solenoid valve (011).
  - 1.2 Put the cylinder lubricating pump with the air vent screw (010) point down into a vice with soft jaws.
  - 1.3 Remove the set screw (016, [Figure 12-4](#)).
  - 1.4 Remove the screws (001).
 

**NOTE:** The base (002) is under a small spring tension.
  - 1.5 Remove the base (002), the pin (005), the plungers (014) and the spring (006) together. This helps to keep the plungers (014) in position with the base (002).
  - 1.6 Remove the main piston (012) with the help of the four holes in the center of the main piston (012).
 

**NOTE:** Do not use the holes for the plungers (014) for this step.
  - 1.7 Push out the slide rod (008) with an applicable tool.
  - 1.8 Remove the O-rings (003, 004) and the piston joint ring (009).
  - 1.9 Remove the pressure transmitter (015).
  - 1.10 Remove the screw plugs and the check valves (013) from all pump outlets with a hexagon key.
  - 1.11 If there was air leakage during operation - remove the air vent screw (010).

Fig 12-4 Cylinder lubricating pump (MK-E)



- 2 Examine the cylinder lubricating pump as follows:
  - 2.1 Do a check of the tightness of the non return valves (013) as follows:
    - 2.1.1 Blow air through the non return valves (013) with your mouth.
    - 2.1.2 If from the two sides air comes out, clean the valve seat.
  - 2.2 Do a check of the surface of the main bore for scores or other damage.
  - 2.3 Do a check of the control edge (007) of the pump for scores or other damage.
  - 2.4 Do a check of the plungers (014) for scores or other damage.
  - 2.5 If there are scores or other damage, repair or replace the related part.
  - 2.6 Do a check of the main piston (012) for free movement.
  - 2.7 If there is no free movement, clean or replace the main piston (012).
- 3 Assemble the cylinder lubricating pump as follows:
  - 3.1 If the air vent screw (010) is removed, apply Loctite No. 542 to the air vent screw (010).
  - 3.2 If the air vent screw (010) is removed, install the air vent screw (010). Make sure that the exhaust hole points in the correct direction.

**NOTE:** In the operation position of the cylinder lubricating pump the hole must point down.

**NOTE:** Do not tighten the air vent screw (010) too much.
  - 3.3 Install the pressure transmitter (015) and torque it to 25 Nm.
  - 3.4 Apply a thin layer of oil to the piston joint ring (009).
  - 3.5 Install the piston joint ring (009) to the slide rod (008).
  - 3.6 Install the slide rod (008) into the housing in the correct direction.
  - 3.7 Apply a thin layer of oil to the main piston (012).
  - 3.8 Install the main piston (012) into the housing in the correct direction.
  - 3.9 Apply a thin layer of oil to the O-rings (003, 004).
  - 3.10 Attach the O-ring (003) to the groove of the housing.
  - 3.11 Attach the O-ring (004) to the groove of the pin (005).
  - 3.12 Apply a thin layer of oil to the plungers (014).
  - 3.13 Apply a thin layer of grease to the pin (005).
  - 3.14 Assemble the base (002) with the pin (005), the plungers (014), and the spring (006).
  - 3.15 Install these parts in the main bore and torque the screws (001) to 24 Nm.
  - 3.16 Install the non return valves (013) into the related holes and torque them to 8 Nm.
  - 3.17 Install the screw plugs.
  - 3.18 Install the set screw (016) and torque it to 80 Nm.
  - 3.19 Remove the cylinder lubricating pump from the vice.
  - 3.20 Install the solenoid valve (011) and torque the screws to 9 Nm.
- 4 Do a function test of the cylinder lubricating system, refer to section [12.1.1 Cylinder lubrication system - do a functional test](#).

## CLOSE UP

- None

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## 12.1.5 Cylinder lubricating pump - install

### Periodicity

Description	
Working hours	45 000
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
Cylinder lubricating pump			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

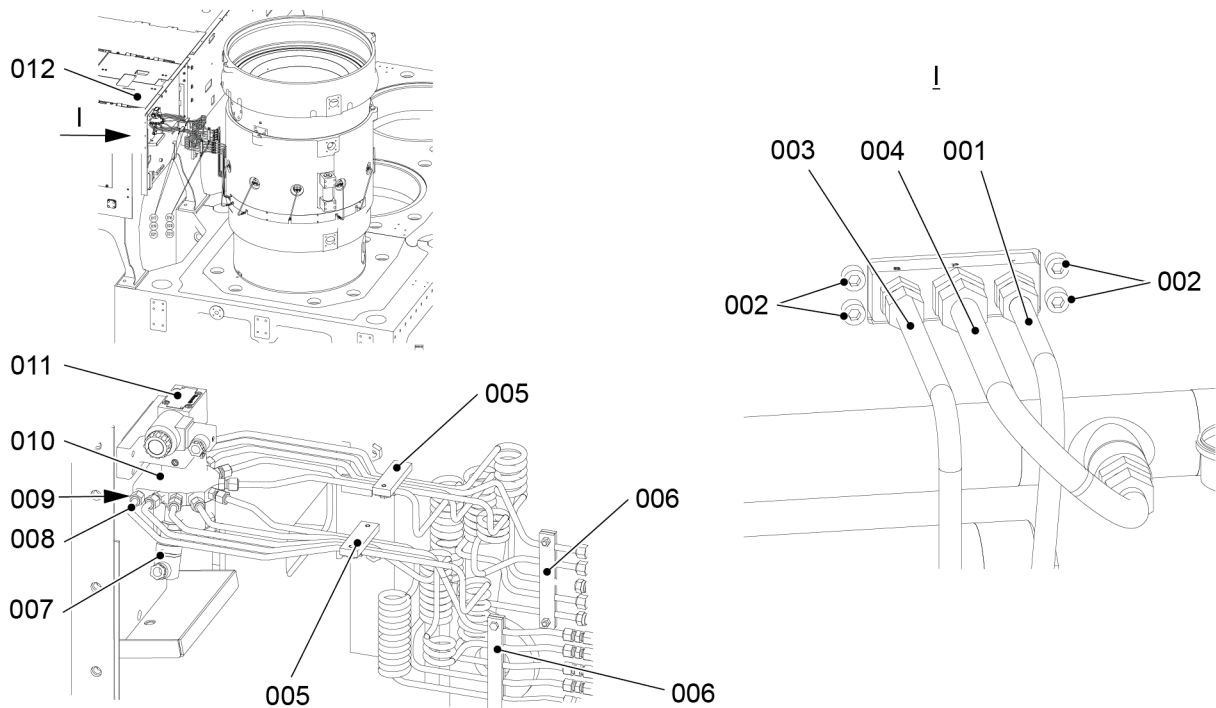
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1 Attach the cylinder lubricating pump (009, [Figure 12-5](#)) to the rail unit with the screws (002).  
**NOTE:** The figure is for MK-E pump. For MK-1 pump the pump and the pipes are partly different.
- 2 Tighten symmetrically the screws (002).
- 3 Attach the pipes (008) to the cylinder lubrication pump (009).  
**NOTE:** The number of pipes is related to the engine.
- 4 Tighten the nuts (009) of the pipes (008).
- 5 Connect the electrical connection to the 4/2-way valve (011).
- 6 Connect the electrical connection to the pressure transmitter (007).
- 7 Attach the pipes (001, 003 and 004) to the cylinder lubricating pump, refer to your notes made in the removal procedure.
- 8 Attach the pipe brackets (005) to the positions shown.
- 9 If necessary, attach the pipe brackets (006) to the positions shown.
- 10 Install the cover (012) to the rail unit.

Fig 12-5 Cylinder lubricating pump (MK-E, example) - install



00980

## CLOSE UP

- None

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## 13 Group 8 - Pipes

### 13.1 HP servo oil pipe

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## 13.1 HP servo oil pipe

### 13.1.1 HP servo oil pipe - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

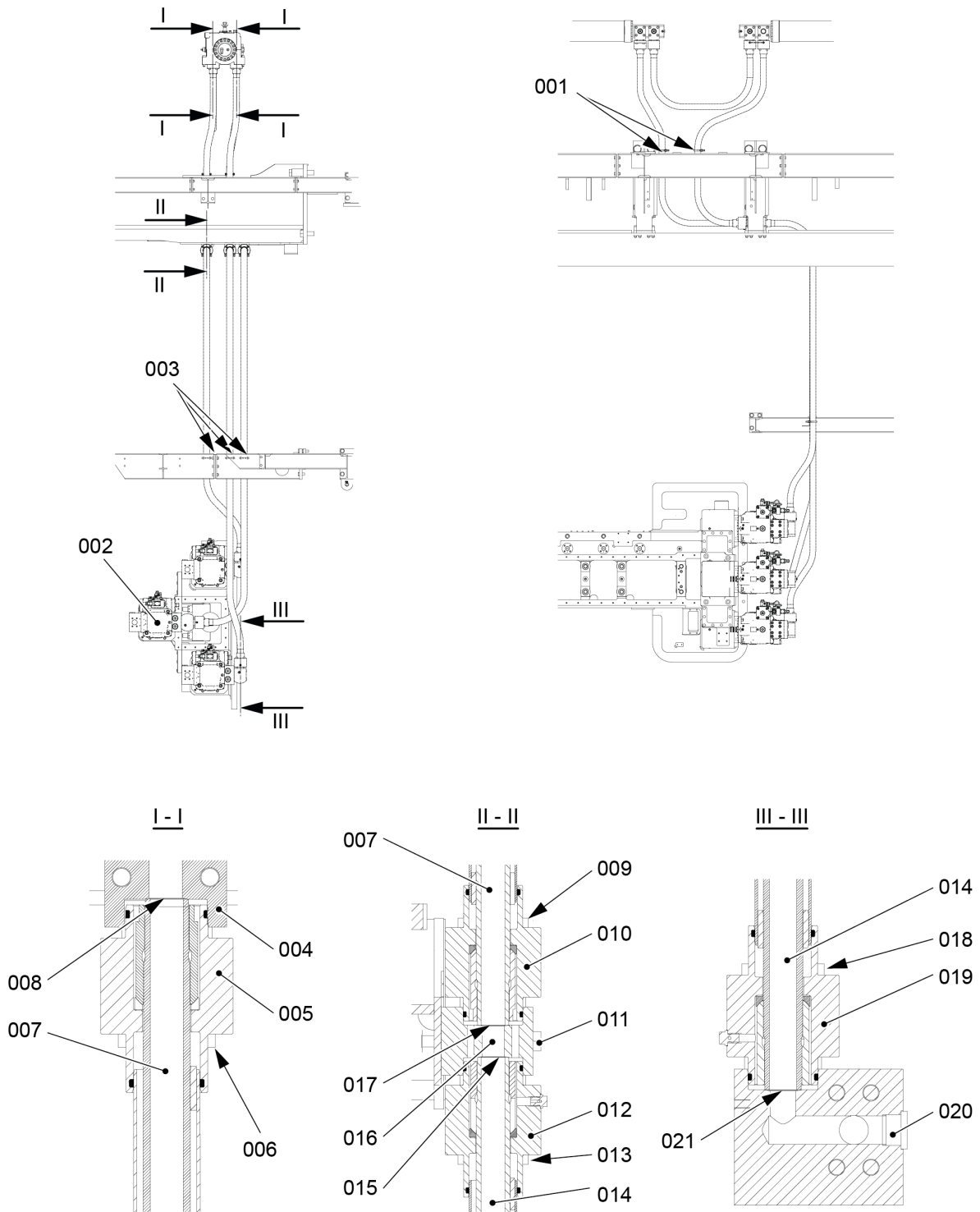
- 1 Put an oil tray under the applicable servo oil pump (002, [Figure 13-1](#)).
- 2 Remove the stirrup bolts (001, 003) from the applicable HP servo oil pipe.
- 3 Loosen the screw plug (022) to drain the applicable HP servo oil pipes (007, 018, 019).
- 4 On the flange (004), loosen the four screws (006).
- 5 Push down the flange (005) to get air into the HP servo oil pipe (007).  
**NOTE:** After approximately one minute, the oil will drain from the servo oil pipes.

## CAUTION

**Damage Hazard. Make sure that you do not damage the sealing faces or the HP servo oil pipes.**

- 6 Remove the four screws (018) from the flange (019).
- 7 Move the flange (019) up.
- 8 Remove the four screws (013) from the flange (012).
- 9 Remove the two screws and nuts (011) from the intermediate piece (016).
- 10 Carefully remove the HP servo oil pipe (014).
- 11 Apply protection to the sealing faces (015, 017) to prevent damage.
- 12 Remove the four screws (009) from the flange (010).
- 13 Move the flange (010) away from the intermediate piece (016).
- 14 Remove the intermediate piece (016).
- 15 Remove the four screws (006) from the flange (005).
- 16 Move the flange (005) down.
- 17 Carefully remove the HP servo oil pipe (007).
- 18 Apply protection to the sealing faces (008) to prevent damage.

Fig 13-1 Servo oil pipes - remove



00954

**CLOSE UP**

- None

## 13.1.2 HP servo oil pipe - grind the sealing face

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Support equipment

Description	Part No.	CSN	QTY
Grinding tool	94841		1

### Supplies

Description	QTY
Compound grade No. 200	A/R
Compound grade No. 500	A/R

### Spare Parts

Description	Part No.	CSN	QTY
O-ring			1

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The servo oil pipe must be removed, refer to section [13.1.1 HP servo oil pipe - remove](#)



## PROCEDURE

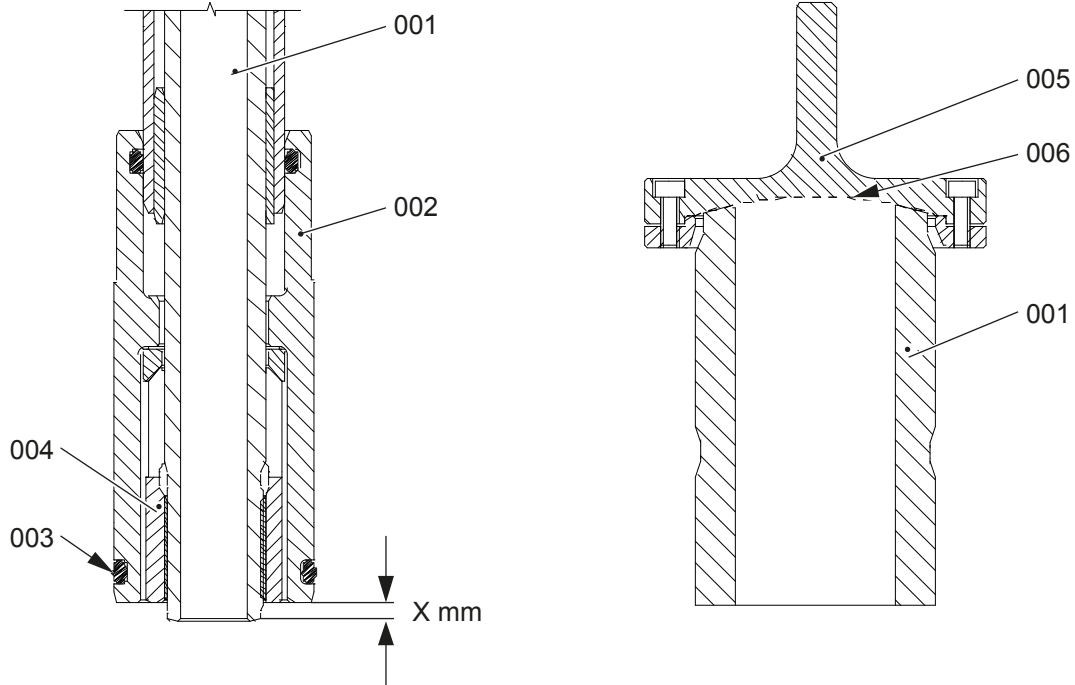
- 1 Remove and discard the O-ring (003, [Figure 13-2](#)).
- 2 Loosen the claw (004).
- 3 Put an applicable piece of material (for example a cloth) into the opening of the HP servo oil pipe (001).
- 4 Grind the sealing surface (006) of the HP servo oil pipe (001):
  - 4.1 Use the grinding tool (005) and compound grade No. 200 to grind the sealing surface of the HP servo oil pipe (001).
  - 4.2 Use the grinding tool (005) and compound grade No. 500 to get a smooth finish on the sealing surface (006) of the HP servo oil pipe (001).
- 5 Clean the HP servo oil pipe (001).
- 6 Attach a new O-ring (003) to the flange (002).
- 7 Remove the cloth from the opening in the HP servo oil pipe (001).
- 8 Remove the cloth from the opening in the HP servo oil pipe (001).
- 9 Make sure that the claw (004) is correctly attached to the HP servo oil pipe (001).
- 10 Make sure that the distance X between the end of the HP servo oil pipe (001) and the claw (004) is related to [Table 13-1 - Distance X for HP servo oil pipe](#).
 

**NOTE:** You can adjust the claw with an open-ended wrench.

**Tab 13-1 Distance X for HP servo oil pipe**

Engine type	Distance X [mm]
X35, X35-B	5.0
X40, X40-B X40DF	5.0
X52 X52DF	xxx
X62, X62-B X62DF	5.5
X72, X72-B X72DF	5.5
X82, X82-B X82DF	6.0
X92, X92-B X92DF	6.0

**Fig 13-2 HP servo oil pipe - grind and adjust**



00960

**CLOSE UP**

- None

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### 13.1.3 HP servo oil pipe - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
Servo oil pipe			A/R

#### SAFETY PRECAUTIONS

- None

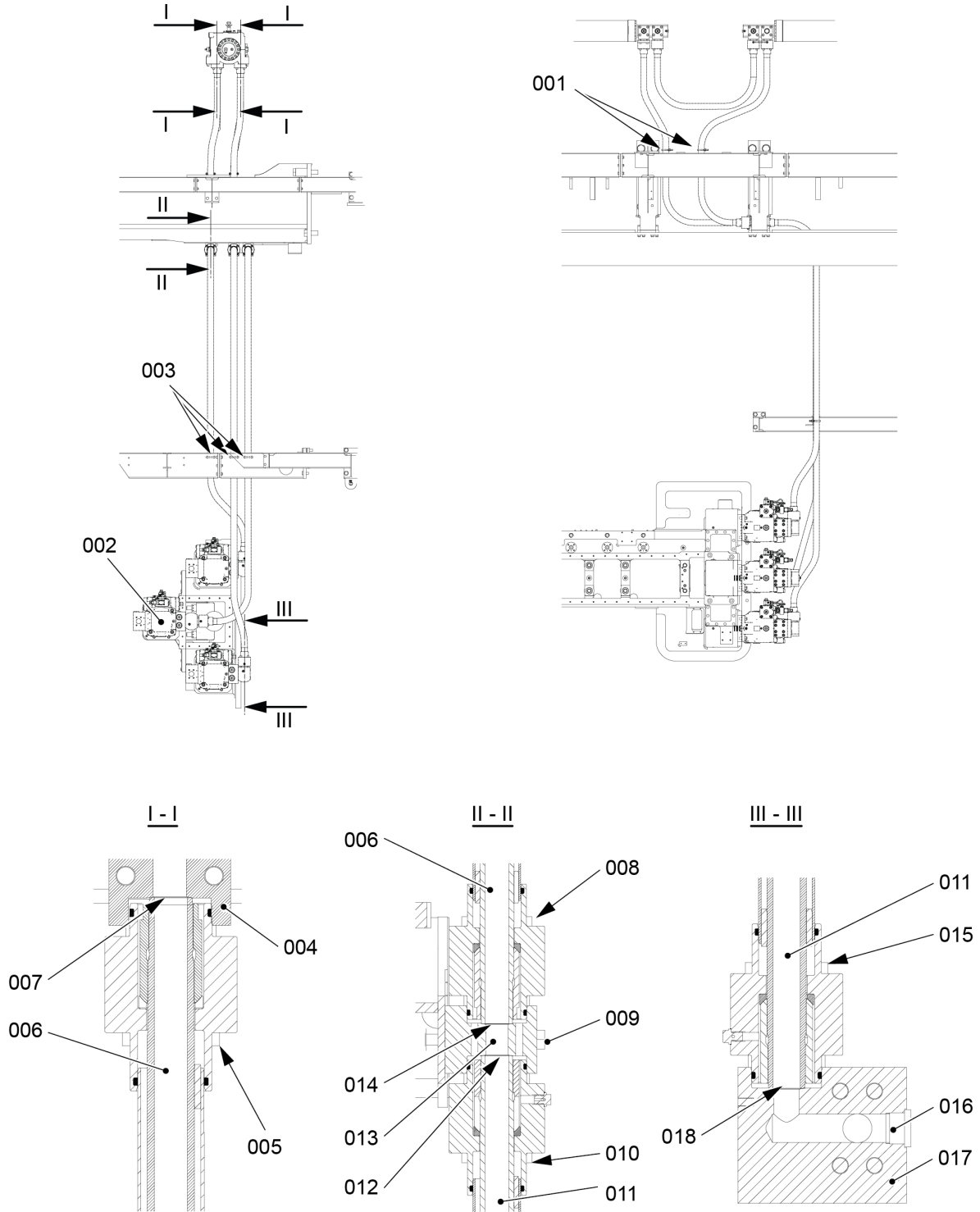
#### PRELIMINARY OPERATIONS

- None

## PROCEDURE

- 1 Remove all of the protection from the sealing faces (007, 013 and 018, [Figure 13-3](#)) of the servo oil pipes and the servo oil pump.
- 2 Apply oil to the threads of all the Allen screws (005, 008, 010, 015) and the bolts (009).
- 3 Carefully put the servo oil pipe (011) in position in the valve housing (017) and the intermediate piece (013).
- 4 Torque symmetrically the four Allen screws (015) to the correct value, refer to section [16.1 Tightening instructions](#).
- 5 Torque symmetrically the four Allen screws (010) to the correct value, refer to section [16.1 Tightening instructions](#).
- 6 Attach the intermediate piece (013) to the plate with the two bolts (009) and nuts. Do not tighten the bolts and nuts during this step.
- 7 Carefully put the servo oil pipe (006) in position in the intermediate piece (013) and the valve housing (004).
- 8 Torque symmetrically the four Allen screws (008) to the correct value, refer to section [16.1 Tightening instructions](#).
- 9 Torque symmetrically the four Allen screws (005) to the correct value, refer to section [16.1 Tightening instructions](#).
- 10 Tighten the bolts (009) on the intermediate piece (013).
- 11 Tighten the screw plug (016).
- 12 Attach the applicable servo oil pipes to the platform with the stirrup bolts (001, 003).

Fig 13-3 Servo oil pipes - install



00955

**CLOSE UP**

- None

## 13.2 Hydraulic pipe exhaust valve

### 13.2.1 Hydraulic pipe exhaust valve - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

Always put on gloves and safety goggles when you do work on hot components. When drain screws and plugs are opened, servo oil can come out as a spray and cause injury.

#### CAUTION

Injury Hazard: Use approved equipment or sufficient personnel to lift and move the hydraulic pipe.

#### CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the hydraulic pipes.

### PRELIMINARY OPERATIONS

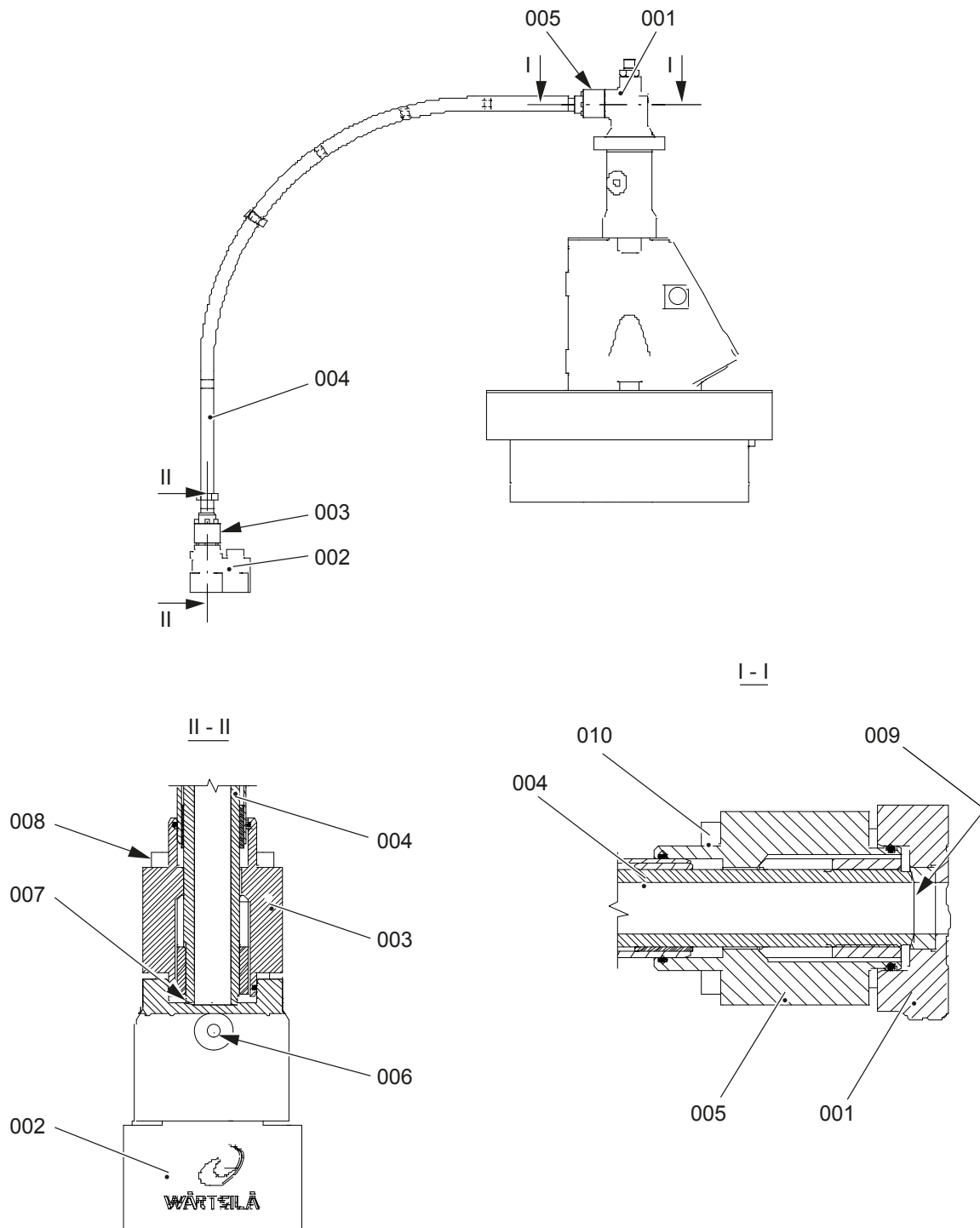
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



**PROCEDURE**

- 1** Put an oil tray under the applicable hydraulic pipe (004, [Figure 13-4](#)).
- 2** Loosen the screws (008) on the flange (003) to drain the applicable hydraulic pipe (004) through the check bore (006) in the housing of the exhaust valve control unit (VCU) (002).
- 3** Remove the six screws (010) from the flange (005).
- 4** Carefully move the flange (005) away from the top housing (001).
- 5** Remove the six screws (008) from the flange (003).
- 6** Carefully move the flange (003) away from the VCU (002).
- 7** Carefully remove the hydraulic pipe (004).
- 8** Apply protection to the sealing faces (007, 009) to prevent damage and contamination.

Fig 13-4 Hydraulic pipe (exhaust valve) - remove



00956

**CLOSE UP**

- None

## 13.2.2 Hydraulic pipe exhaust valve - grind the sealing face

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Grinding tool			1
Template			1
Hand drill			1

### Supplies

Description	QTY
Emery cloth	A/R
Molyslip Copaslip paste	A/R

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

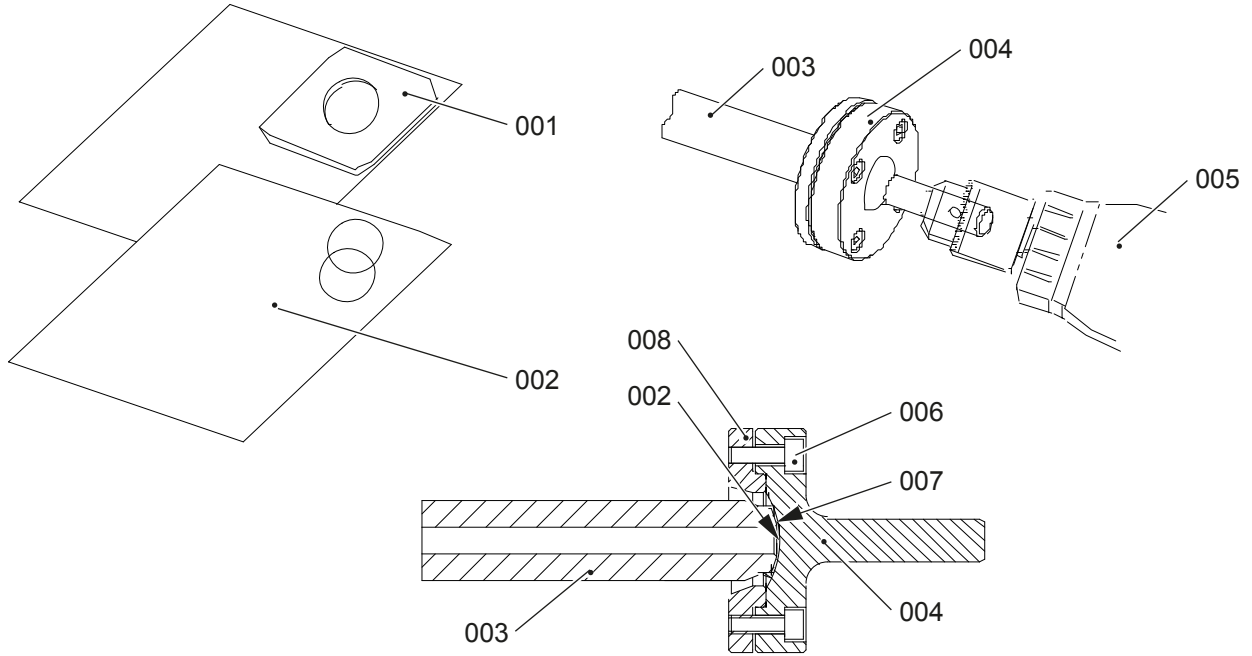
### PRELIMINARY OPERATIONS

- The hydraulic pipe must be removed, refer to section [13.2.1 Hydraulic pipe exhaust valve - remove](#)

## PROCEDURE

- 1 Put the template (001, [Figure 13-5](#)) on the back of the emery cloth (002).
- 2 Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
- 3 Use a pencil or a ball pen to make the inner shape.
- 4 Cut out accurately the shape.
- 5 Remove the four screws (006) and the grinding tool (94841).
- 6 Apply Moly slip Copaslip paste to the threads and faces of the four screws (006).
- 7 Remove the cover (008).
- 8 Put the emery cloth shape into the grinding tool (004).
- 9 Put the grinding tool (004), emery cloth and the cover (008) in position on the hydraulic pipe (003).
- 10 Torque symmetrically the four screws (006) to 2.0 Nm.
- 11 Put the hydraulic pipe (003) in a vice, as vertically as possible.
- 12 Adjust the speed of the hand drill to between 200 rpm and 500 rpm.
- 13 Align the hand drill and the grinding tool (004) accurately with the hydraulic pipe (003) as shown.
- 14 Apply a light pressure and start grinding.
- 15 Regularly remove the unwanted material from the grinding tool (004).
- 16 Make sure that the circular marks around the sealing face of the pipe are concentric.
- 17 Change the emery cloth for a smoother grade, then do [Step 1](#) to [Step 16](#) again until you get a smooth finish.
- 18 Replace the emery cloth with a polishing cloth as a last step to polish the hydraulic pipe (003).
- 19 Clean the hydraulic pipe (003).

**Fig 13-5 Hydraulic pipe (exhaust valve) - grind sealing face**



00957

**CLOSE UP**

- None

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### 13.2.3 Hydraulic pipe exhaust valve - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
O-rings			2
O-rings			2
Hydraulic pipe			1

#### SAFETY PRECAUTIONS

##### CAUTION

**Injury Hazard:** Use approved equipment or sufficient personnel to lift and move the hydraulic pipe.

##### CAUTION

**Damage Hazard:** Make sure that you do not cause damage the sealing faces or the hydraulic pipes.

#### PRELIMINARY OPERATIONS

- The hydraulic pipe exhaust valve must be removed, refer to section [13.2.1 Hydraulic pipe exhaust valve - remove](#)



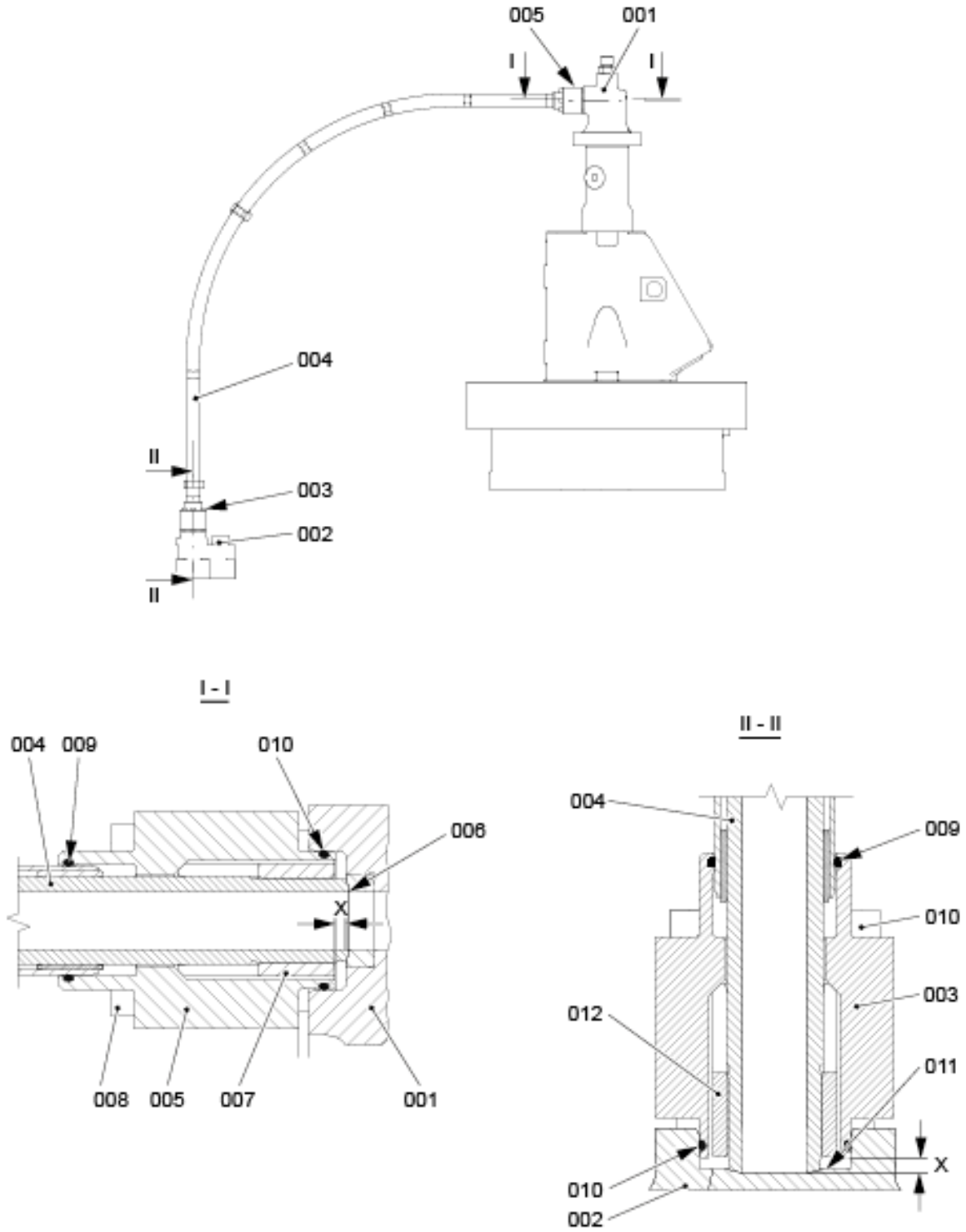
## PROCEDURE

- 1 Remove all the protection from the sealing faces in the top housing (001, [Figure 13-6](#)) and the exhaust valve control unit (VCU) (002).
- 2 Put oil on the new O-rings (009) and O-rings (010).
- 3 Attach the O-rings to the hydraulic pipe (004).
- 4 Make sure that the claws (007, 012) are correctly attached to the hydraulic pipe (004).  
**NOTE:** You can adjust the claws with an open-ended wrench.
- 5 Make sure that the distance X between the ends of the hydraulic pipe (004) and the claws (007, 012) refers to [Table 13-2 - Distance X for hydraulic pipe exhaust valve](#).
- 6 Apply oil to the threads of all the screws (008, 010).
- 7 Carefully put the hydraulic pipe (004) in position in the top housing (001) and the VCU (002).
- 8 Torque symmetrically the screws (008) to the correct value, refer to section [16.1 Tightening instructions](#).
- 9 Torque symmetrically the screws (010) to the correct value, refer to section [16.1 Tightening instructions](#).

**Tab 13-2 Distance X for hydraulic pipe exhaust valve**

Engine type	Distance X [mm]
X35, X35-B	5.0
X40, X40-B X40DF	5.0
X52 X52DF	5.5
X62, X62-B X62DF	5.5
X72, X72-B X72DF	5.5
X82, X82-B X82DF	6.0
X92, X92-B X92DF	9.5

Fig 13-6 Hydraulic pipe (exhaust valve) - install



00958

**CLOSE UP**

- None

## 13.3 HP fuel pipe

### 13.3.1 HP fuel pipe (fuel rail to injection valve) - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### CAUTION

**Damage Hazard:** Make sure that you do not damage the sealing faces or the HP injection pipes.

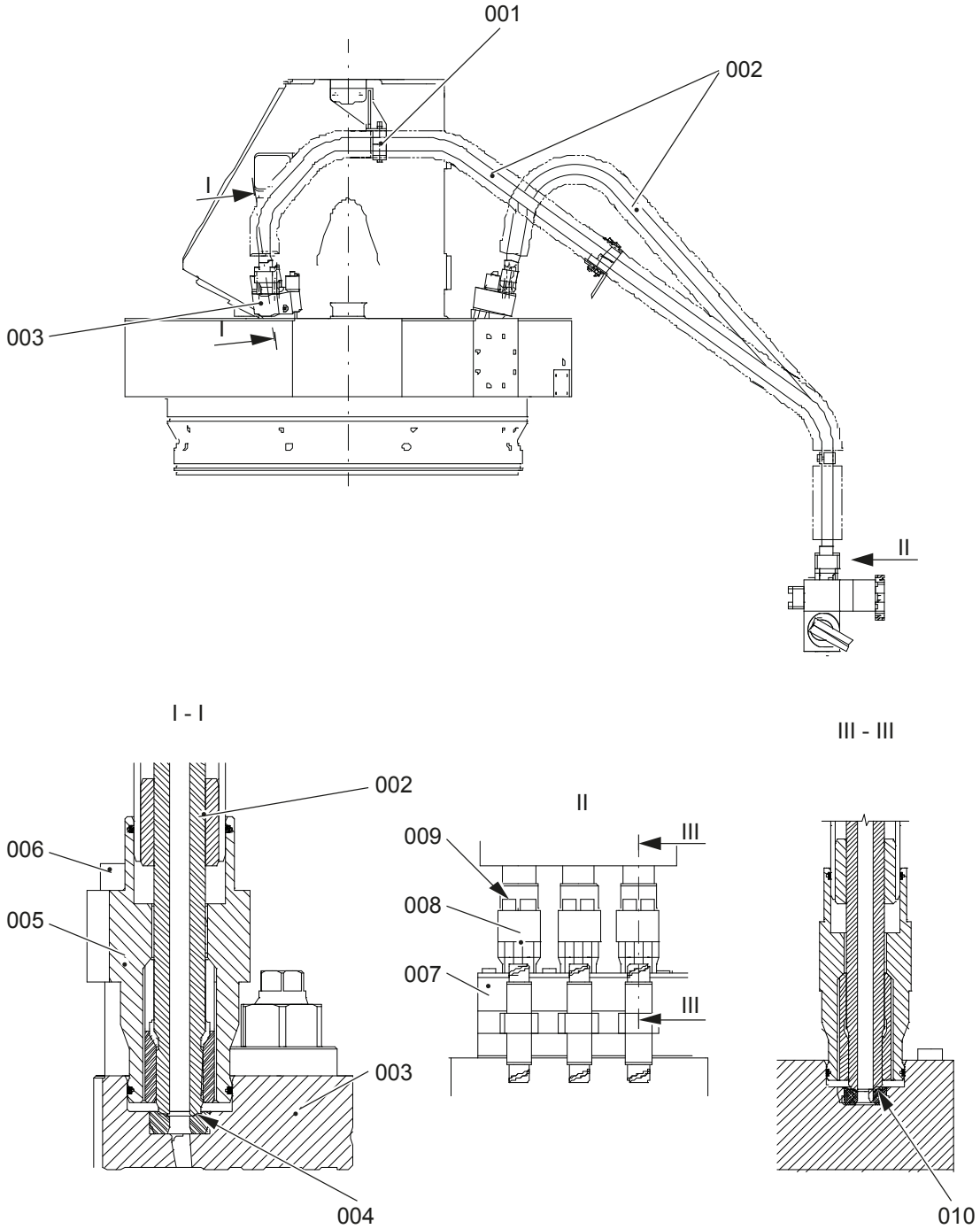
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.
- The electrical trace heating must be set to off.

## PROCEDURE

- 1 Do [Step 1.1](#) to [Step 1.4](#) to release the pressure in the fuel rail:
  - 1.1 In the plant, set to off the fuel booster pump.
  - 1.2 Close the shut-off valves to the fuel inlet and return pipes.
  - 1.3 Open the drain valve 10.5562\_E0\_14 to release the pressure in the fuel rail.
  - 1.4 On the local control panel, make sure that the pressure shows zero.
- 2 If necessary, remove the insulation from the applicable HP injection pipe (002, [Figure 13-7](#)).
- 3 Remove the applicable pipe bracket (001).
- 4 On the injection valve (003) remove the four screws (006) from the flange (005).
- 5 On the flange (008), remove the four screws (009).
- 6 Carefully remove the applicable HP injection pipe (002) from the injection valve (003) and the injection control unit (ICU) (007).
- 7 Apply protection to the sealing faces (004, 010) and the open ends of the HP injection pipe (002).

Fig 13-7 HP fuel pipe (fuel rail to injection valve) - remove



00959

**CLOSE UP**

- None

### 13.3.2 HP fuel pipe (fuel rail to injection valve) - grind the sealing face

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
grinding tool	94871		1
template	94871A		1
electric hand drill	N/A		1

#### Supplies

Description	QTY
emery cloth	A/R
Molyslip copaslip paste	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

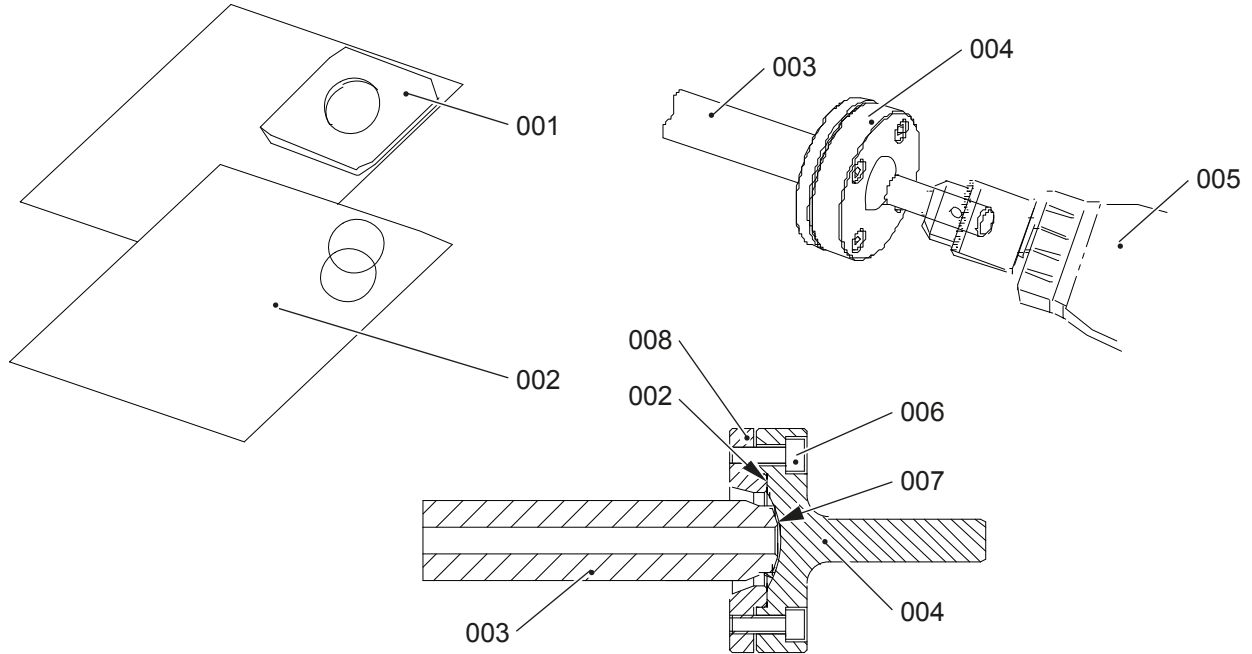
#### PRELIMINARY OPERATIONS

- The HP fuel pipe must be removed, refer to [13.3.1 HP fuel pipe \(fuel rail to injection valve\) - remove](#)



## PROCEDURE

- 1 Put the [template](#) (001, [Figure 13-8](#)) on the back of emery cloth.
- 2 Use the applicable grade of the [emery cloth](#) related to the quantity of metal you want to remove.
- 3 Use a pencil or a ball pen to make the inner shape.
- 4 Cut out accurately the shape.
- 5 Remove the four screws (006) and the [grinding tool](#) (004).
- 6 Apply [Molyslip copaslip paste](#) to the threads and faces of the four screws (006).
- 7 Remove the cover (008).
- 8 Put the emery cloth you cut out into the grinding tool (004).
- 9 Put the grinding tool (004), emery cloth and the cover (008) in position on the HP injection pipe (003).
- 10 Torque symmetrically the four screws (006) to 2.0 Nm.
- 11 Put the HP injection pipe (003) in a vice, as vertically as possible.
- 12 Adjust the speed of the [electric hand drill](#) between 200 and 500 rpm.
- 13 Align the hand drill and the grinding tool (004) accurately with the HP injection pipe (003) as shown.
- 14 Use light pressure and start grinding.
- 15 Regularly remove unwanted material from the grinding tool (004).
- 16 Make sure that the circular marks around the sealing face of the pipe are concentric.
- 17 Change the emery cloth for a smoother grade, then do [Step 1](#) to [Step 16](#) again until you get a smooth finish.
- 18 Replace the emery cloth with a polishing cloth as a last step to polish the HP injection pipe (003).
- 19 Clean the HP injection pipe (003).

**Fig 13-8 HP fuel pipe (fuel rail to injection valve) - grind**

00961

**CLOSE UP**

- Install the HP fuel pipe, refer to [13.3.3 HP fuel pipe \(fuel rail to injection valve\) - install](#)

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### 13.3.3 HP fuel pipe (fuel rail to injection valve) - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
Never-Seez NSBT	A/R
oil	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
HP fuel pipe			1
HP fuel pipe			1
HP fuel pipe			1
O-ring			2

#### SAFETY PRECAUTIONS

- None

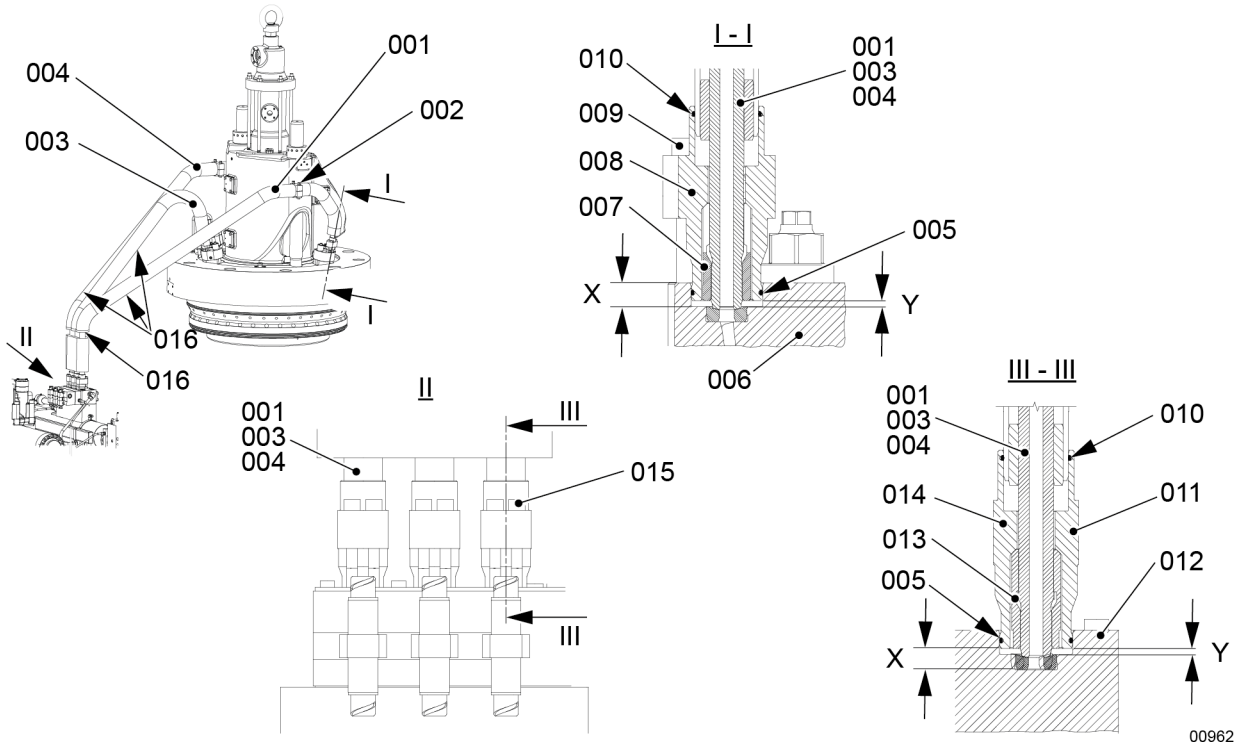
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 Put oil on the new [O-ring](#) (005 and 010, [Figure 13-9](#)).
  - 2 **NOTE:** The HP fuel pipes are as follows:
    - [HP fuel pipe](#) (001)
    - [HP fuel pipe](#) (003)
    - [HP fuel pipe](#) (004).
- Attach the O-rings (005, 010) to the applicable HP fuel pipe (001, 003, 004).
- 3 Make sure that the claws (007, 013) are correctly attached to the applicable HP injection pipe.  
**NOTE:** You can adjust the claws with an open-ended wrench.
  - 4 Remove the protection from the sealing faces in the injection valve (006) and the ICU (012).
  - 5 Make sure that there is distance of  $Y = 6.0$  mm between the ends of the applicable HP injection pipe and the claws (007, 013).
  - 6 Apply [Never-Seez NSBT](#) to threads of the screws (009, 015).
  - 7 Carefully put the HP injection pipe in position in the injection valve (006) and the ICU (012).
  - 8 Torque symmetrically the four Allen screws (009) to 48 Nm.
  - 9 Make sure that there is a distance of  $X = 12$  mm between the flange (008) and the injection valve (006).
  - 10 Torque symmetrically the four Allen screws (015) to 48 Nm.
  - 11 Make sure that there is a distance of  $X = 12$  mm between the flange (014) and the ICU (012).
  - 12 Attach the pipe clamps (002, 016).
  - 13 If necessary, attach the insulation to the applicable HP fuel pipe 001, 003, 004.

Fig 13-9 HP fuel pipe (fuel rail to injection valve) - install



**CLOSE UP**

- None

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### 13.3.4 HP fuel pipe (fuel pump to fuel rail) - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### WARNING

**Injury Hazard. Always put on gloves and safety goggles when you do work on hot components. When screws and plugs are opened, steam or fuel can come out and cause injury.**

#### CAUTION

**Damage Hazard: Make sure that you do not damage the sealing faces or the HP fuel pipes. Do not apply lateral force to the HP fuel pipes and the flanges.**

#### CAUTION

**Injury Hazard. The HP fuel pipes are heavy. Use only approved lifting equipment or sufficient personnel to lift and move the HP fuel pipes.**

### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.
- The fuel supply pump must be set to off.



- The trace heating must be set to off.

## PROCEDURE

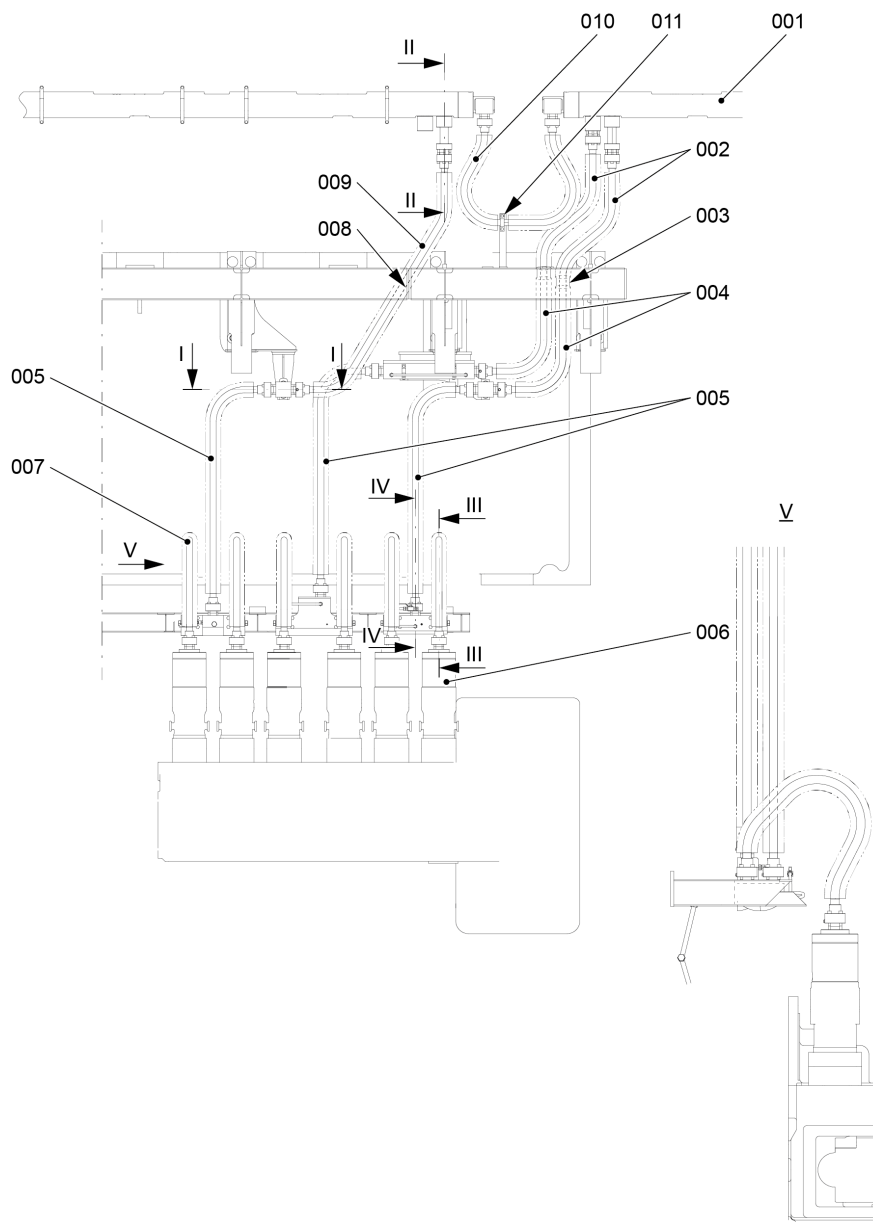
- NOTE:** The procedures to remove the HP fuel pipes (002, 004, 005, 007, 009 and 010, [Figure 13-10](#)) are almost the same. The procedure that follows applies to the HP fuel pipes (005, 007, 009).

**NOTE:** The views I-I, II-II, III-III, IV and V in [Figure 13-10](#) are shown in [Figure 13-11](#) and [Figure 13-12](#).

If necessary, disconnect the trace heating pipes.

- Remove the applicable pipe brackets (003, 008).
- Put an oil tray under the applicable fuel pump.

**Fig 13-10 HP fuel pipe fuel pump to fuel rail - prepare**



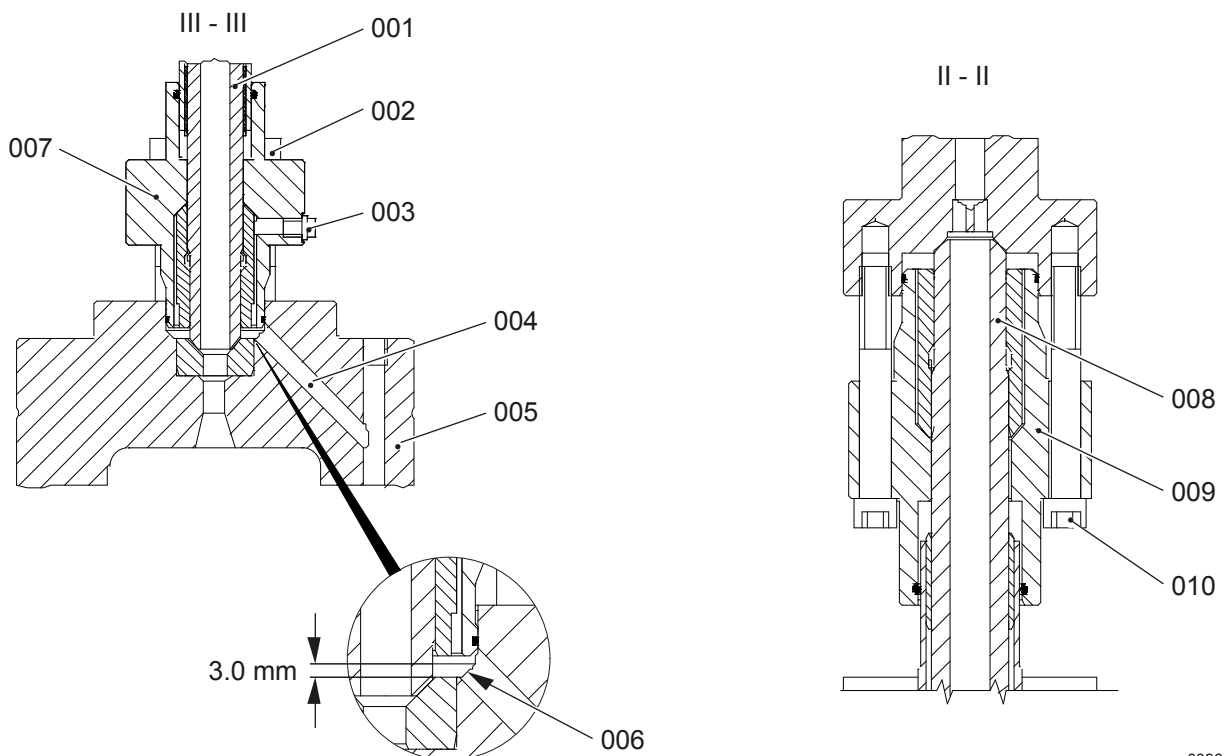
00963

**Legend**

001	Fuel rail	007	HP fuel pipe (qty 6)
002	HP fuel pipes (qty 2)	008	Pipe bracket
003	Pipe brackets	009	HP fuel pipe (qty 1)
004	HP fuel pipes (qty 2)	010	HP fuel pipe (qty 2)
005	HP fuel pipes (qty 3)	011	Pipe bracket
006	Fuel pumps		

- 4 Loosen the four screws (002, [Figure 13-11](#)) on the flange (007) a maximum of three turns.
- 5 Move the HP fuel pipe (001) up. Make sure that there is a distance of approximately 3.0 mm between the fuel pump cover (005) and the sealing face (006) of the HP fuel pipe.
 

**NOTE:** The fuel will drain through the drain bore (004) into the fuel leakage pipe.
- 6 Loosen the four screws (010) on the flange (009) a maximum of three turns.
- 7 Move the flange (009) down and make sure that air goes into the HP fuel pipe (008).
- 8 Open the screw plug (003). If there is no fuel, the HP fuel pipe (001) is fully drained.
- 9 Tighten the screw plug (003).

**Fig 13-11 HP fuel pipe (fuel pump to fuel rail) - prepare**

00964

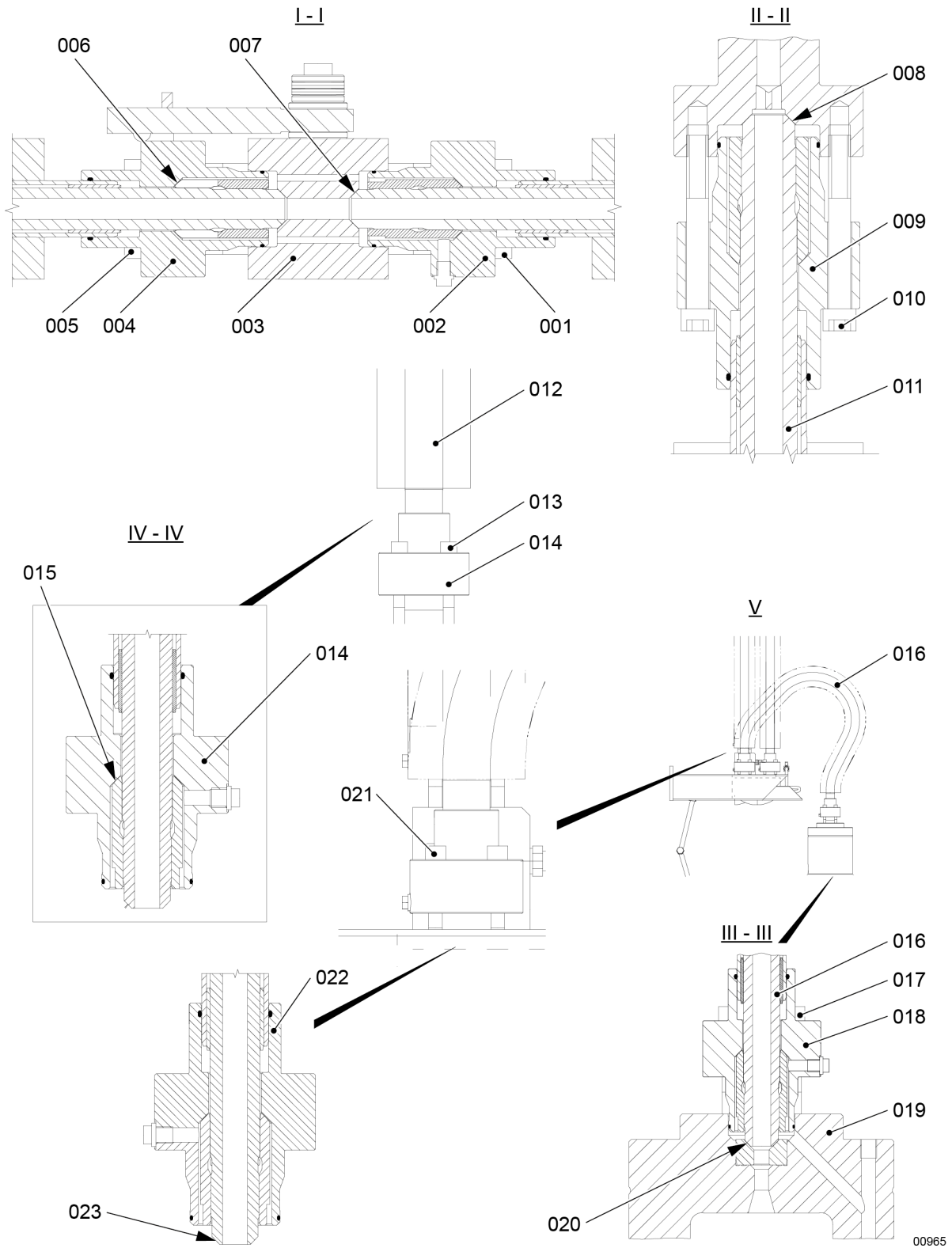
**CAUTION**

**Damage Hazard.** Make sure that you do not cause damage to the sealing faces or the HP fuel pipes.

- 10 Remove the four screws (005, [Figure 13-12](#)) from the flange (004).
- 11 Carefully move the flange (004) away from the connecting block (003).

- 12 Remove the four screws (010) from the flange (009).
- 13 Carefully move the flange (009) up.
- 14 Carefully remove the HP fuel pipe (011).
- 15 Remove the four screws (001) from the flange (002).
- 16 Carefully move the flange (002) away from the connecting block (003).
- 17 Remove the four screws (013) from the flange (014).
- 18 Carefully move the flange (014) up.
- 19 Carefully remove the HP fuel pipe (012).
- 20 Apply protection to the sealing faces (015) to prevent damage and contamination.
- 21 Remove the four screws (017) from the flange (018).
- 22 Carefully move the flange (018) up.
- 23 Remove the four screws (021) from the flange (022).
- 24 Carefully remove the HP fuel pipe (016).
- 25 Do a check of the sealing faces of all the HP fuel pipes that you removed. If you find damage, you must grind the HP fuel pipes, refer to [13.3.5 HP fuel pipe \(fuel pump to fuel rail\) - grind the sealing face](#).
- 26 Apply protection to the sealing faces to prevent damage and contamination.

Fig 13-12 HP fuel pipe (fuel pump to fuel rail) - remove



00965

**CLOSE UP**

- Install the HP fuel pipe, refer to [13.3.6 HP fuel pipe \(fuel pump to fuel rail\) - install](#)

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### 13.3.5 HP fuel pipe (fuel pump to fuel rail) - grind the sealing face

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
grinding tool	94870F		1
template	94870H		1
sleeve	94870E		1
locknut	94870G		1
electric drill	N/A		1

#### Supplies

Description	QTY
emery cloth (30 to 80 CAMI)	A/R
emery cloth (100 to 600 CAMI)	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

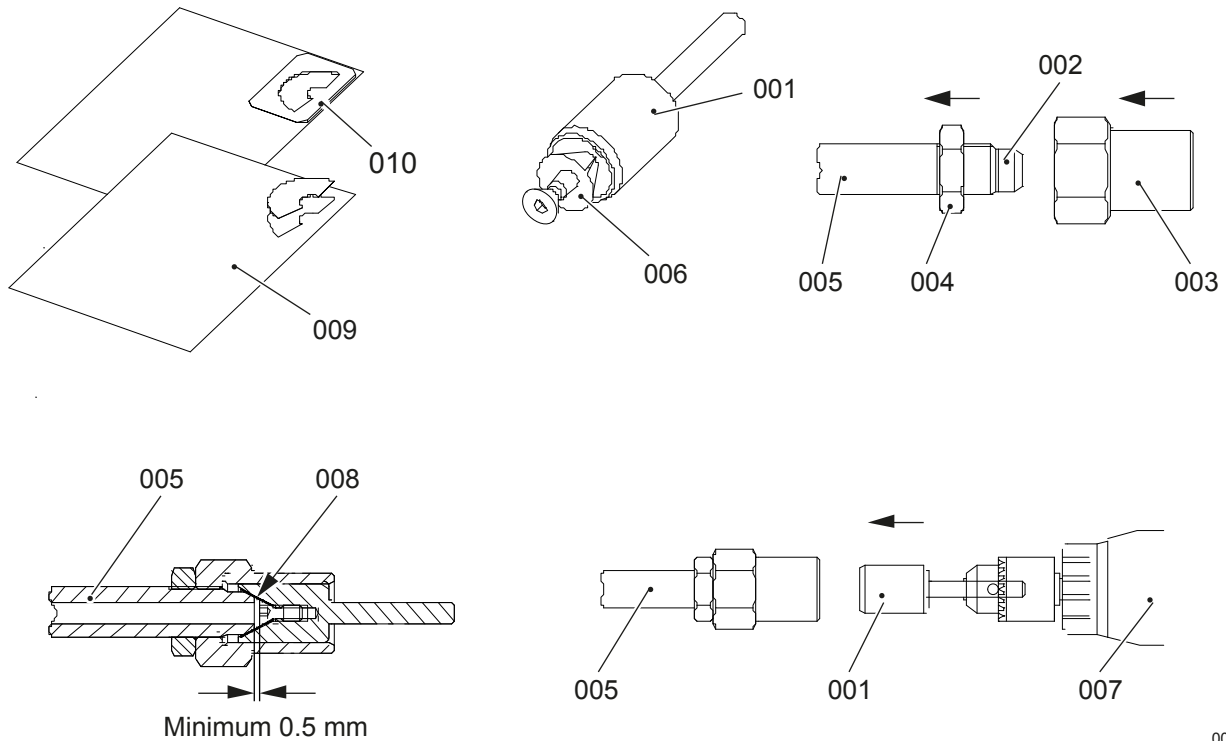
#### PRELIMINARY OPERATIONS

- The applicable HP fuel pipe must be removed, refer to [13.3.4 HP fuel pipe \(fuel pump to fuel rail\) - remove](#)



## PROCEDURE

- 1 Put the [template](#) (009, [Figure 13-13](#)) on the back of the [emery cloth \(30 to 80 CAMI\)](#) (008).
- 2 Use a pencil or a ball pen to make the inner shape.
- 3 Cut out accurately the shape.
- 4 Make the shape into a cone. Make sure that the graded surface (006) is the inner side.
- 5 Attach the shape to the cone of the [grinding tool](#) (001) with the countersunk screw.
- 6 Put the HP fuel pipe (005) in a vice.
- 7 Remove the claw from the HP fuel pipe (005).
- 8 Attach the [locknut](#) (004) to the threads on the end of the HP fuel pipe (005). Turn the locknut until it is fully attached to the HP fuel pipe.
- 9 Attach the [sleeve](#) (003) to the HP fuel pipe (005). Make sure that the sleeve touches the locknut (004).
- 10 Attach the grinding tool (001) to the [electric drill](#)(007).
- 11 Put the grinding tool (001) into the sleeve (003). Make sure that emery cloth touches the HP fuel pipe (005).
- 12 Adjust the speed of the electric drill (007) to a maximum of 1500 rpm.
- 13 Operate the electric drill (007) for between 3 seconds to 5 seconds.
- 14 Remove the grinding tool (001) from the sleeve (003).
- 15 Use a low-pressure air supply to remove unwanted material from the HP fuel pipe (005).
- 16 Do a quality check of the sealing surface. If necessary use new emery cloth of the same grade and do the grinding procedure again.
- 17 Replace the emery cloth with the smoother grade ([emery cloth \(100 to 600 CAMI\)](#)), then do [Step 1](#) to [Step 16](#) again until you get a smooth finish.
- 18 Replace the emery cloth with a polishing cloth as a last step to polish the HP fuel pipe.  
**NOTE:** If you find large notches, you must make the HP fuel pipe (005) shorter.
- 19 Make sure that there is a minimum distance of 0.5 mm between the countersunk screw and the sealing face (007) on the HP fuel pipe (005).
- 20 Remove the sleeve (003) and the locknut (004).
- 21 Attach the claw to the HP fuel pipe (005).

**Fig 13-13 HP fuel pipe (fuel pump to fuel rail) - sealing face - Grind**

00966

**CLOSE UP**

- Install the applicable HP fuel pipe, refer to [13.3.6 HP fuel pipe \(fuel pump to fuel rail\) - install](#)

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### 13.3.6 HP fuel pipe (fuel pump to fuel rail) - install

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
oil	A/R
Never-Seez NSBT	A/R

#### Spare Parts

Description	Part No.	CSN	QTY
O-ring			A/R
O-ring			A/R
HP fuel pipe			1
HP fuel pipe			1
HP fuel pipe			1
HP fuel pipe			1
HP fuel pipe			1

#### SAFETY PRECAUTIONS

##### CAUTION

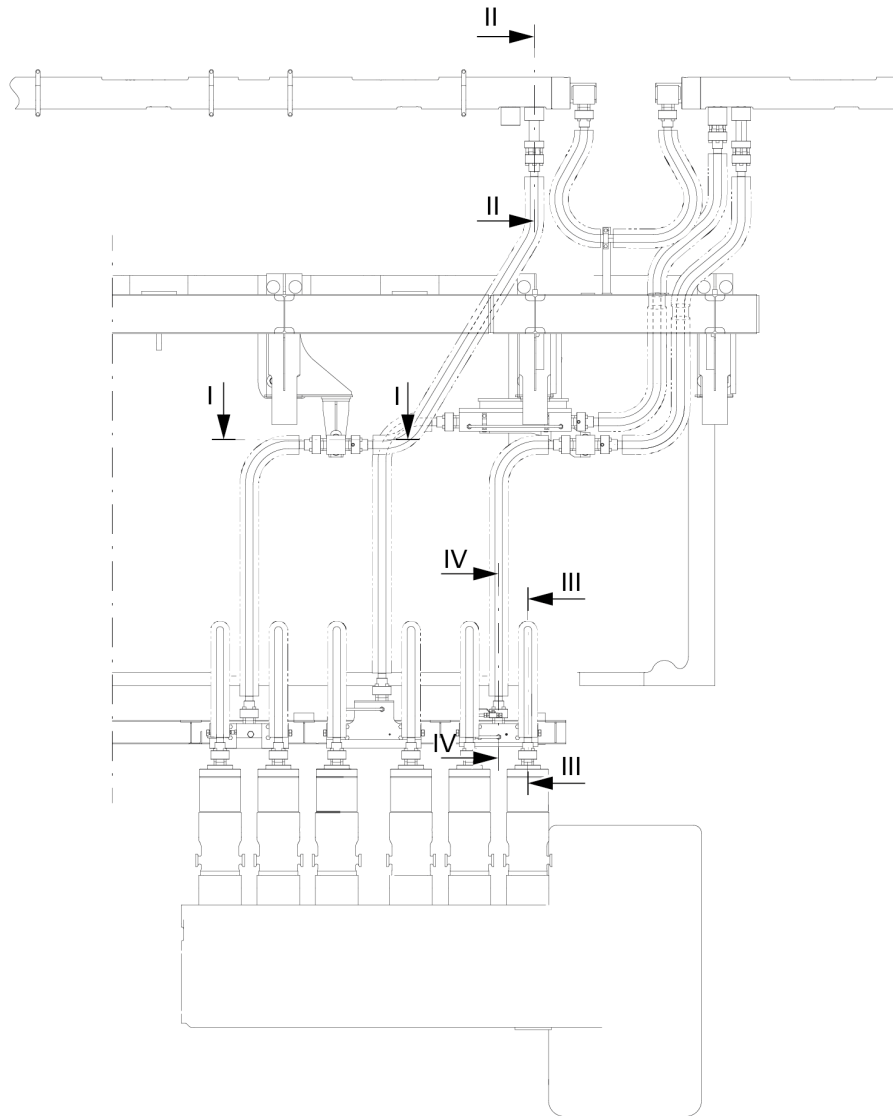
**Injury Hazard.** The HP fuel pipes are heavy. Use only approved lifting equipment to lift and move the HP fuel pipes.

#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

## PROCEDURE

- 1 The views I-I, II-II, III-III and IV-IV in [Figure 13-14](#), are shown in [Figure 13-15](#)

**Fig 13-14 HP fuel pipe (fuel pump to fuel rail) - views**

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- 2 Put oil on the new O-ring (005, [Figure 13-15](#)) and O-ring (002).
- 3 Remove all of the protection from the sealing faces (011, 020).
- 4 Make sure that the claw (024) is correctly attached to the HP fuel pipe (026).

**NOTE:** You can adjust the claw with an open-ended wrench.

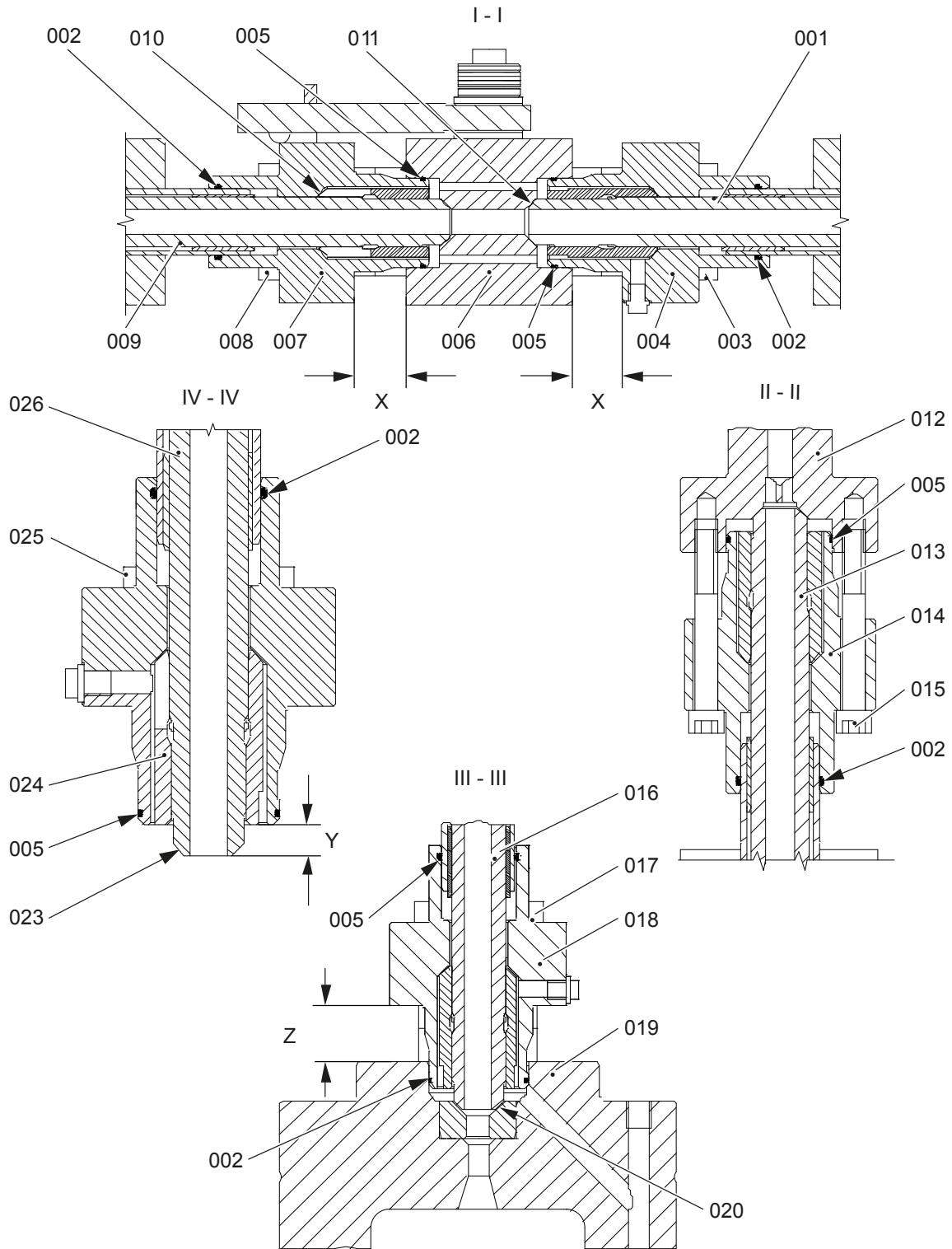
- 5 Make sure that there is a distance of  $Y = 14.0$  mm between the end of the HP fuel pipe (026) and the claw (024).
- 6 Attach the O-rings (002, 005) to the all positions shown.
- 7 Apply [Never-Seez NSBT](#) to the threads of all the screws (003, 008, 015, 017 and 025).

### CAUTION

**Damage Hazard. Make sure that you do not cause damage to the sealing faces (SF) or the HP fuel pipe. Do not apply lateral force to the HP fuel pipe and the flanges.**

- 8 Carefully put the HP fuel pipe (016) in the connecting block (006) and the fuel pump cover (7).
- 9 Torque the four screws (008) and the four screws (017) as follows:
  - 9.1 Torque symmetrically the four screws (008) and the four screws (017) to 30 Nm.
  - 9.2 Make sure that the flanges (007, 018) are not tilted and in the correct position.
  - 9.3 Torque symmetrically the four screws (008) and the four screws (017) to 55 Nm.
  - 9.4 Torque symmetrically the four screws (008) and the four screws (017) to 80 Nm.
- 10 Make sure that there is a distance of  $X = 36.5$  mm between the flange (006) and the connecting block (007).
- 11 Make sure that there is a distance of  $Z = 36.5$  mm between the flange (018) and the fuel pump cover (019).
- 12 Carefully put the HP fuel pipe (013) in position in the housing (012) and the connecting block (006).
- 13 Torque the four screws (003) and the four screws (015) as follows:
  - 13.1 Torque symmetrically the four screws (003) and the four screws (015) to 30 Nm.
  - 13.2 Make sure that the flanges (014, 004) are not tilted and in the correct position.
  - 13.3 Torque symmetrically the four screws (003) and the four screws (015) to 55 Nm.
  - 13.4 Torque symmetrically the four screws (003) and the four screws (015) to 80 Nm.
- 14 Make sure that there is a distance of  $X = 36.5$  mm between the flange (004) and the connecting block (006).
- 15 Make sure that there is a distance of  $Z = 36.5$  mm between the flange (018) and the fuel pump cover (019).
- 16 Attach the applicable pipe brackets.

Fig 13-15 HP fuel pipe (fuel pump to fuel rail) - install



00967



**CLOSE UP**

- None

## 13.4 HP pilot fuel pipe

### 13.4.1 HP pilot fuel pipe - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Oil tray	N/A		1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

#### CAUTION

**Damage Hazard:** Make sure that you do not cause damage to the sealing faces or the pilot fuel pipes. Do not apply lateral force to the HP pilot fuel pipes and the flanges.

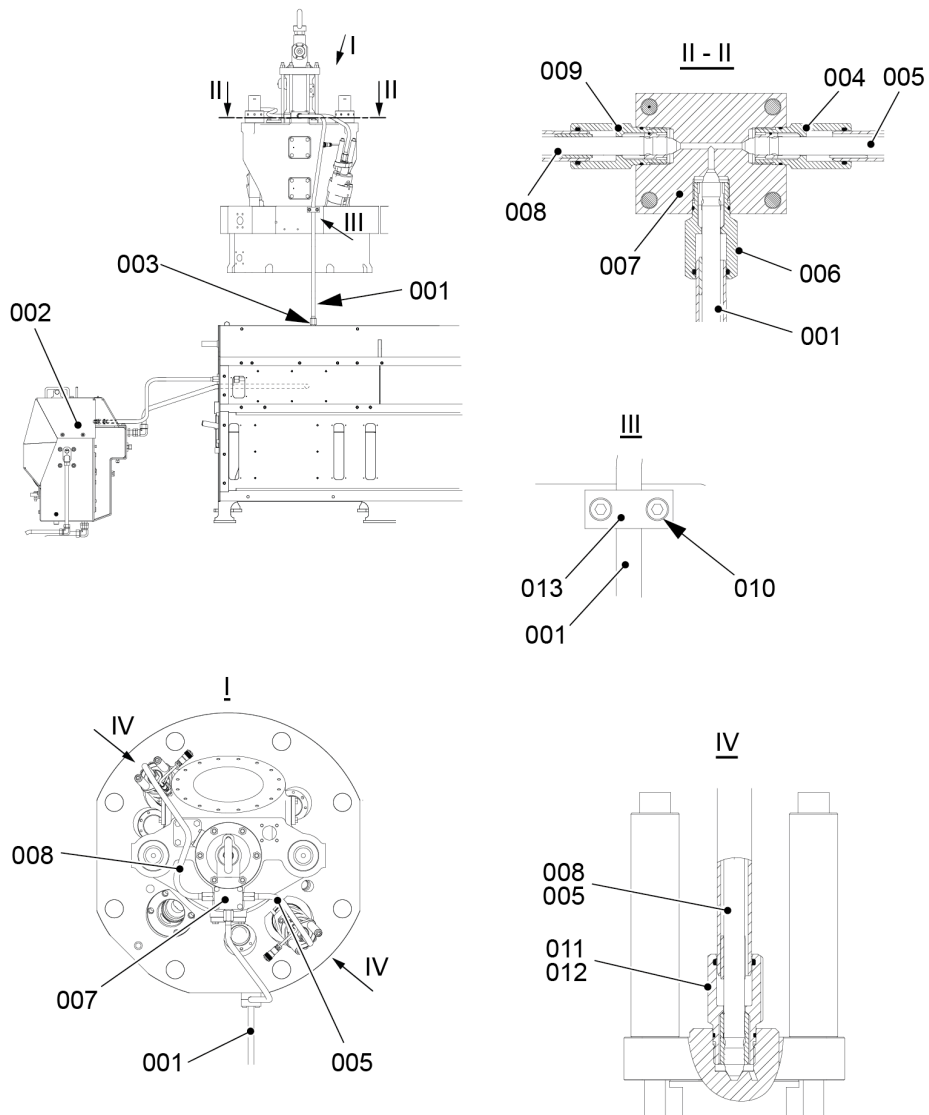
### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)

## PROCEDURE

- 1 Make sure that the pilot fuel supply unit (002, [Figure 13-16](#)) is set to OFF.
- 2 Make sure that the pressure in the pilot fuel supply unit is zero.
- 3 Remove the pilot fuel pipe (005 or 008).
  - 3.1 Put the oil tray under the pilot fuel pipe (005 or 008).
  - 3.2 On the pilot fuel pipe (005 or 008), loosen the coupling nut (011 or 012).
  - 3.3 On the distributor block (007), loosen the coupling nut (004 or 009).
  - 3.4 Carefully remove the pilot fuel pipe (005 or 008).
  - 3.5 Put protection on all openings.
  - 3.6 Attach protection to the sealing faces of the pilot fuel pipe (005 or 008).
  - 3.7 Put the pilot fuel pipe (005 or 008) in a clean, dry area.
- 4 Remove the pilot fuel pipe (001).
  - 4.1 Put an oil tray under the pilot fuel pipe (001).
  - 4.2 Remove the Allen screws (010) and the pipe clamp (013).
  - 4.3 On the distributor block (007), loosen the coupling nuts (003, 006). Make sure that the fuel drains into the oil tray.
  - 4.4 Carefully remove the pilot fuel pipe (001).
  - 4.5 Put protection on all openings.
  - 4.6 Attach protection to the sealing faces of the pilot fuel pipe (001).

Fig 13-16 Pilot fuel pipe - remove



00621

**CLOSE UP**

- None

## 13.4.2 HP pilot fuel pipe - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
Torque wrench			1

### Supplies

Description	QTY
Oil	A/R
Never Seez NSBT8	A/R

### Spare Parts

Description	Part No.	CSN	QTY
Pilot fuel pipe			1
Pilot fuel pipe			1
Pilot fuel pipe			1
O-ring type FKM			A/R
O-ring type FKM			A/R

### SAFETY PRECAUTIONS

#### CAUTION

**Damage Hazard:** Make sure that you do not cause damage to the sealing faces or the pilot fuel pipes. Do not apply lateral force to the pilot fuel pipes and the flanges.

### PRELIMINARY OPERATIONS

- None

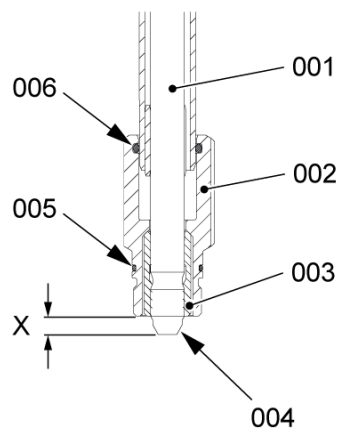
## PROCEDURE

- 1 Remove all protection from all openings and sealing faces.
- 2 Make sure that all sealing faces (004) have no damage.
- 3 Put a new O-ring (005) and a new O-ring (006) on each end the applicable pilot fuel pipe (001).
- 4 Make sure that the coupling nuts (002) are correctly attached.
- 5 Apply oil to all applicable coupling nuts (002, [Figure 13-17](#)).
- 6 Make sure that the distance X between the ends of the pilot fuel pipes (001) and the claws (003) refers to [Table 13-3 - Distance X for pilot fuel pipe](#).

**Tab 13-3 Distance X for pilot fuel pipe**

Engine type	Distance X [mm]
X52DF	6.5
X62DF	6.5
X72DF	6.5
X82DF	7.5
X92DF	6.5

**Fig 13-17 Pilot fuel pipe - prepare**



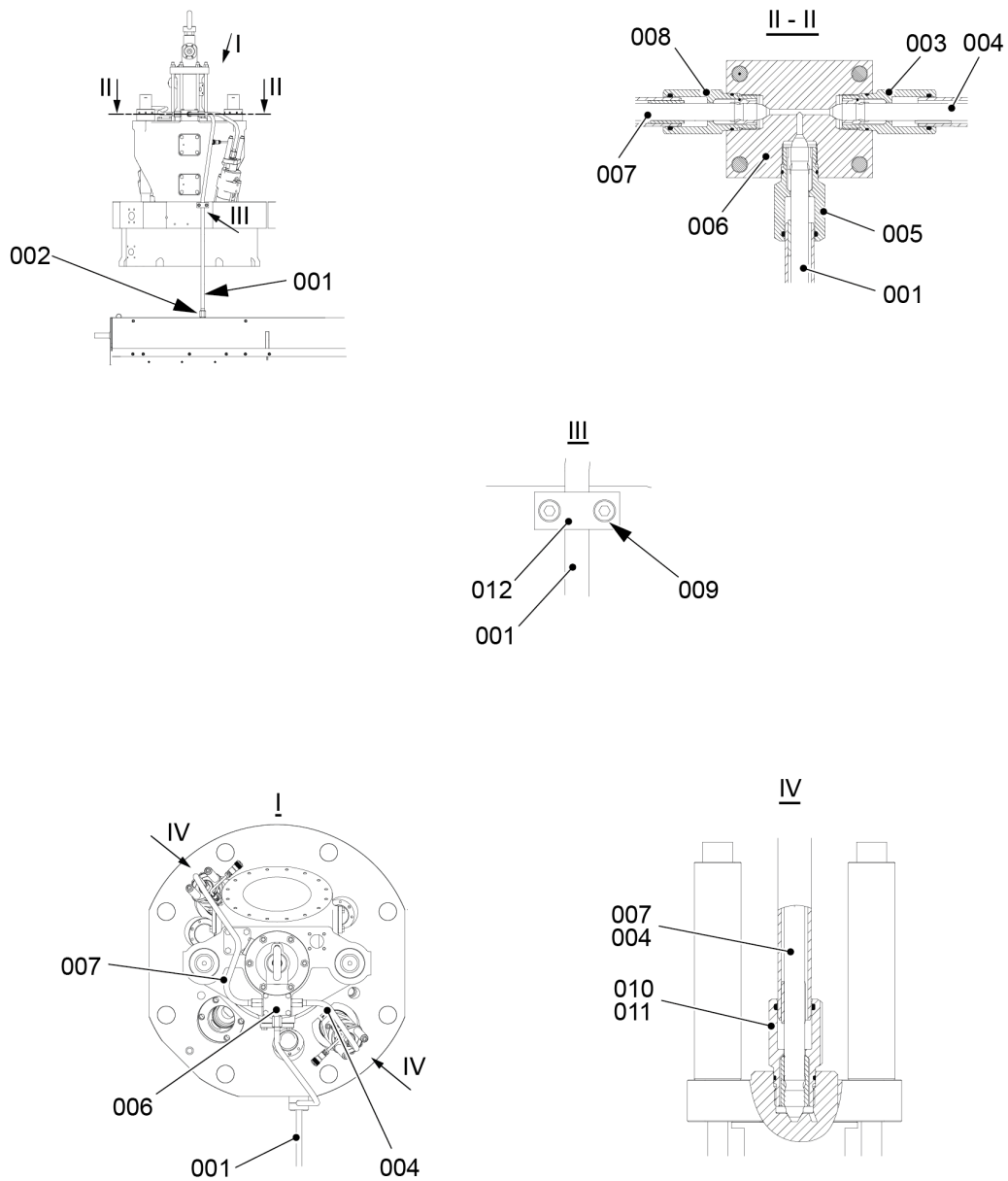
00622

- 7 Install the pilot fuel pipe (004 or 007).
  - 7.1 Attach the pilot fuel pipe (004 or 007, [Figure 13-18](#)) to the distributor block (006) and the pilot injection valve.

- 7.2** Apply Never Seez NSBT8 to surfaces that touch.
  - 7.3** Use the torque wrench to torque the coupling nuts (003 or 008) and (010 or 011) to the correct value, refer to section [16.1 Tightening instructions](#).
- 8** Install the pilot fuel pipe (001).
  - 8.1** Attach the pilot fuel pipe (001) to the distributor block (006) and the connection on the rail unit.
  - 8.2** Apply Never Seez NSBT8 to surfaces that touch.
  - 8.3** Use the torque wrench to torque the coupling nuts (005, 002) to the correct value, refer to section [16.1 Tightening instructions](#).
  - 8.4** Attach the pilot fuel pipe (001) to the cylinder cover with the pipe clamp (012) and the screws (009).
  - 8.5** Torque the screws (009).



Fig 13-18 Pilot fuel pipe - install



00623

**CLOSE UP**

- None

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## 13.5 Gas pressure regulation

### 13.5.1 Integrated gas pressure regulation - do a check

#### Periodicity

Description	
Working hours	200
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	1.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
Torque wrench			1

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

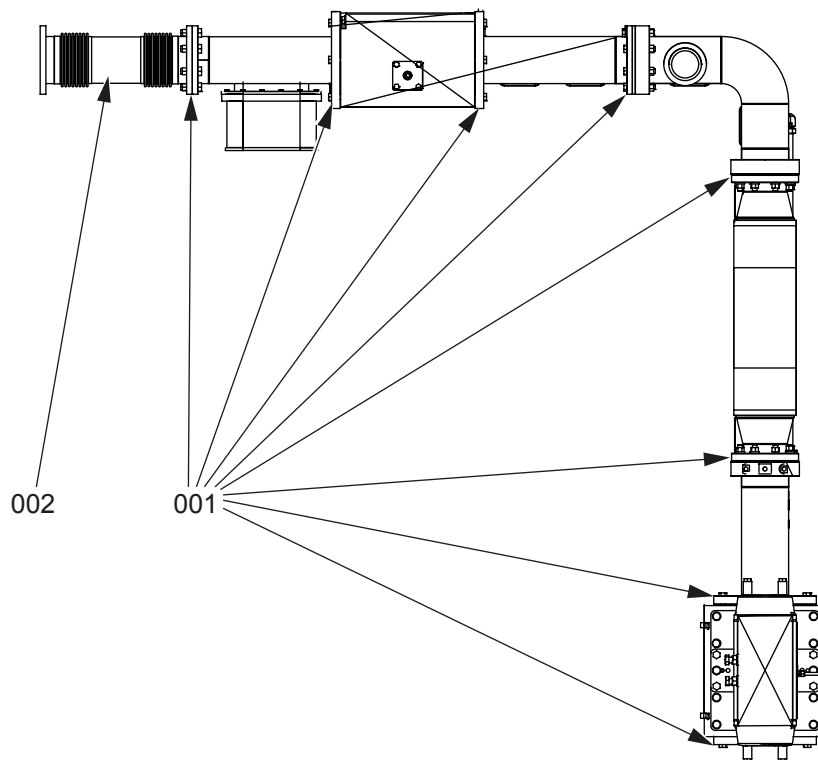
#### PRELIMINARY OPERATIONS

- The engine must be stopped.
- The gas pipes must be ventilated, refer to the Operation Manual.

## PROCEDURE

- 1 Do a check of the screws of all screwed connections (001, [Figure 13-19](#)) of the flanges.
  - 1.1 If the screws have a mark - use the mark to see if the connection is correct.
  - 1.2 If the screws have no mark - use a torque meter to see if the connection is correct, refer to tightening instructions.
- 2 If necessary tighten the screws to the correct value.
- 3 Apply a new mark to the related screw connections.
- 4 Do a visual check of the components that follow:
  - Compensator (002)
  - Wiring connections
  - Welded connections of the double wall pipes.
- 5 If necessary, repair or replace the related component or connection.

Fig 13-19 iGPR - do a check



## CLOSE UP

- None

## 13.5.2 Integrated gas pressure regulation - maintain

### Periodicity

Description	
Working hours	5000
Duration for performing preliminary requirements	1.0 man-hours
Duration for performing the procedure	5.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
None			

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

- The gas pipes must be ventilated, refer to the Operation Manual.

## PROCEDURE

- 1 Do an inspection of the surface of the ball valves. If necessary repair ball valves that have scratches.
- 2 Do an inspection of the gas filter. If necessary (for example unwanted material on the filter, or pressure drop is too high) clean the filter element or install a new filter element.
- 3 Do an inspection of the pressure regulating valve. If necessary (for example if the gas pressure during operation is not stable) repair the pressure regulating valve.

## CLOSE UP

- None

### 13.5.3 Integrated gas pressure regulation - fill with nitrogen

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	3.0 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	2

#### Support equipment

Description	Part No.	CSN	QTY
Pressure reducing valve			1
Hose (3 m)			2
O-Ring			2

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

- None

#### PRELIMINARY OPERATIONS

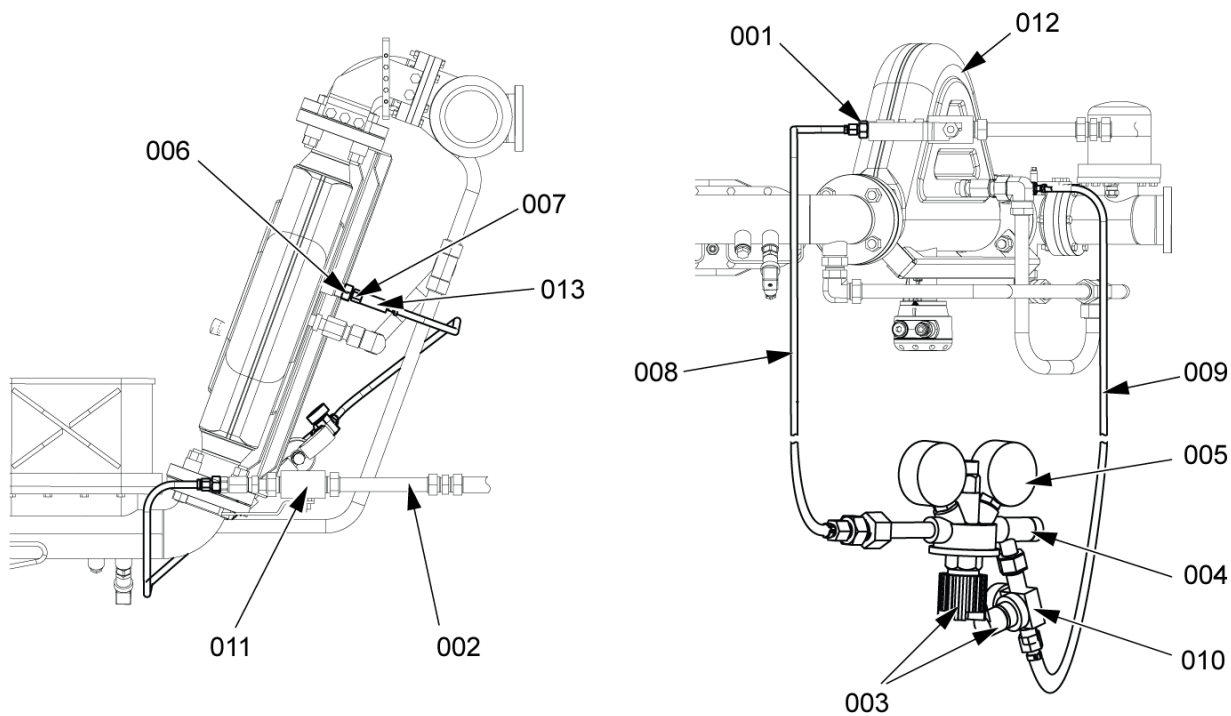
- The engine must be stopped and made safe for maintenance, refer to section [4.1 Do maintenance work - general procedure](#)



## PROCEDURE

- 1** The coriolis mass flowmeter has an intermediate space which is filled with nitrogen and monitored for pressure. If the nitrogen pressure drops, refill it.
  - 1.1** Screw the connecting piece (001, [Figure 13-20](#)) onto the nitrogen line (002). For sealing insert an O-ring into the groove.
  - 1.2** Turn the pressure adjustment screws (003) all the way back so that no gas can be released.
  - 1.3** Fully open the shut-off valve (004) on the pressure reducing valve (005).
  - 1.4** Dismantle the pressure sensor that is screwed into the sensor holder (006).
  - 1.5** Screw the connector (007) with the hose coupling half into the sensor seat. For sealing insert an O-ring into the groove.
  - 1.6** Connect the hose line (008) to the pressure reducing valve (005).
  - 1.7** Connect the hose line (009) to the precision pressure regulator (010).
  - 1.8** Slowly open the nitrogen line shut-off valve (011).
  - 1.9** Briefly flush the hose lines (008) and (009) with nitrogen to displace the air in the line. To do this, turn the pressure adjustment screws (003) slightly clockwise until nitrogen flows out of the end of the hose. Then turn the pressure adjustment screws (003) back (depressurise) and close the shut-off valve (004).
  - 1.10** Immediately connect the flushed hose line (009) to the Coriolis Mass Flowmeter (012).
  - 1.11** The Coriolis Mass Flowmeter (012) must now be filled with nitrogen to the prescribed pressure (9 bar). To do this open the shut-off valve (004) and adjust the pressure reducing valve (005) to a max. 10 bar. The pre-scribed filling pressure must be set on the precision pressure regulator (010).
  - 1.12** Close the shut-off valve (004) and nitrogen line shut-off valve (011).
  - 1.13** Disconnect the hose line (009) by uncoupling the quick coupling (013).
  - 1.14** Screw the connector (007) out of the sensor holder (006).
  - 1.15** Screw the pressure sensor into the sensor holder (006).
  - 1.16** Dismantle the hose lines (009).
  - 1.17** Open the shut-off valve (004) again.
  - 1.18** Release the pressure in the pressure reducing valve (005) and in the precision pressure regulator (010) completely.
  - 1.19** Turn the pressure adjustment screws (003) all the way back again (depressurised).
- 2** Stow away all nitrogen filling components properly.

Fig 13-20 iGPR - fill with nitrogen



**CLOSE UP**

- None

## 14 Group 9 - Monitoring instruments

### 14.1 Crank angle sensor unit

- 14.1.1 Crank angle sensor unit (flywheel) - proximity sensor - remove. . . . . 820
- 14.1.2 Crank angle sensor unit (flywheel) - proximity sensor - install. . . . . 824
- 14.1.3 Crank angle sensor unit (supply unit) - proximity sensor - remove. . . . . 828
- 14.1.4 Crank angle sensor unit (supply unit) - proximity sensor - install. . . . . 832

## 14.1 Crank angle sensor unit

### 14.1.1 Crank angle sensor unit (flywheel) - proximity sensor - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

Before you operate the turning gear, make sure that no personnel are near the flywheel or in the engine.

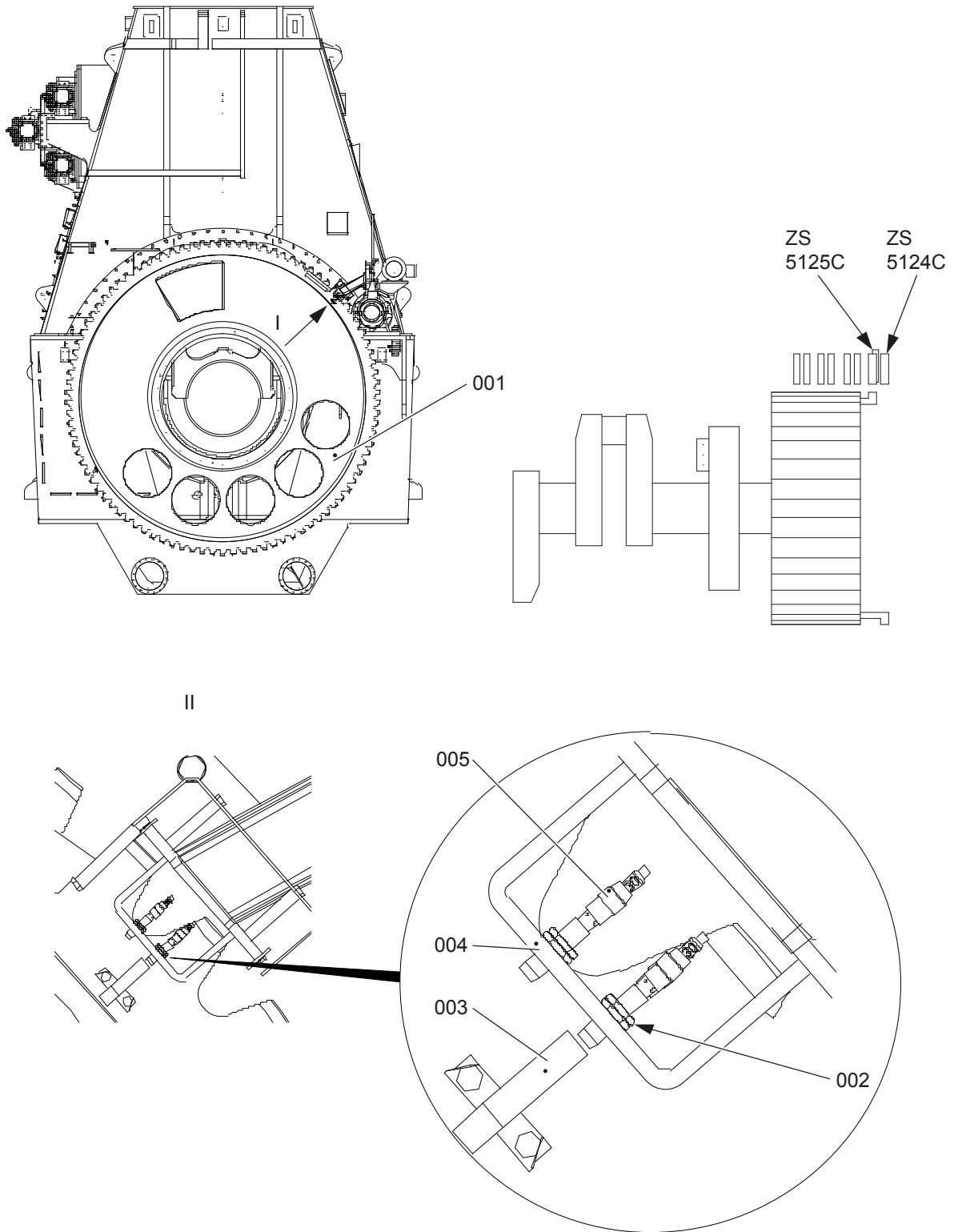
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

**PROCEDURE**

- 1 Operate the turning gear to get the crank angle mark (003, [Figure 14-1](#)) of the flywheel (001) opposite the applicable proximity sensor (005).
- 2 Put a mark on the applicable cable to identify its position.
- 3 Disconnect the applicable electrical connection from the proximity sensor (005).
- 4 Loosen the locknut (002).
- 5 Remove the proximity sensor (005) from the holder (004).

Fig 14-1 Proximity sensor (flywheel) - remove



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**CLOSE UP**

- Install the applicable proximity sensor, refer to [14.1.2 Crank angle sensor unit \(flywheel\) - proximity sensor - install](#)

## 14.1.2 Crank angle sensor unit (flywheel) - proximity sensor - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
proximity sensor			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

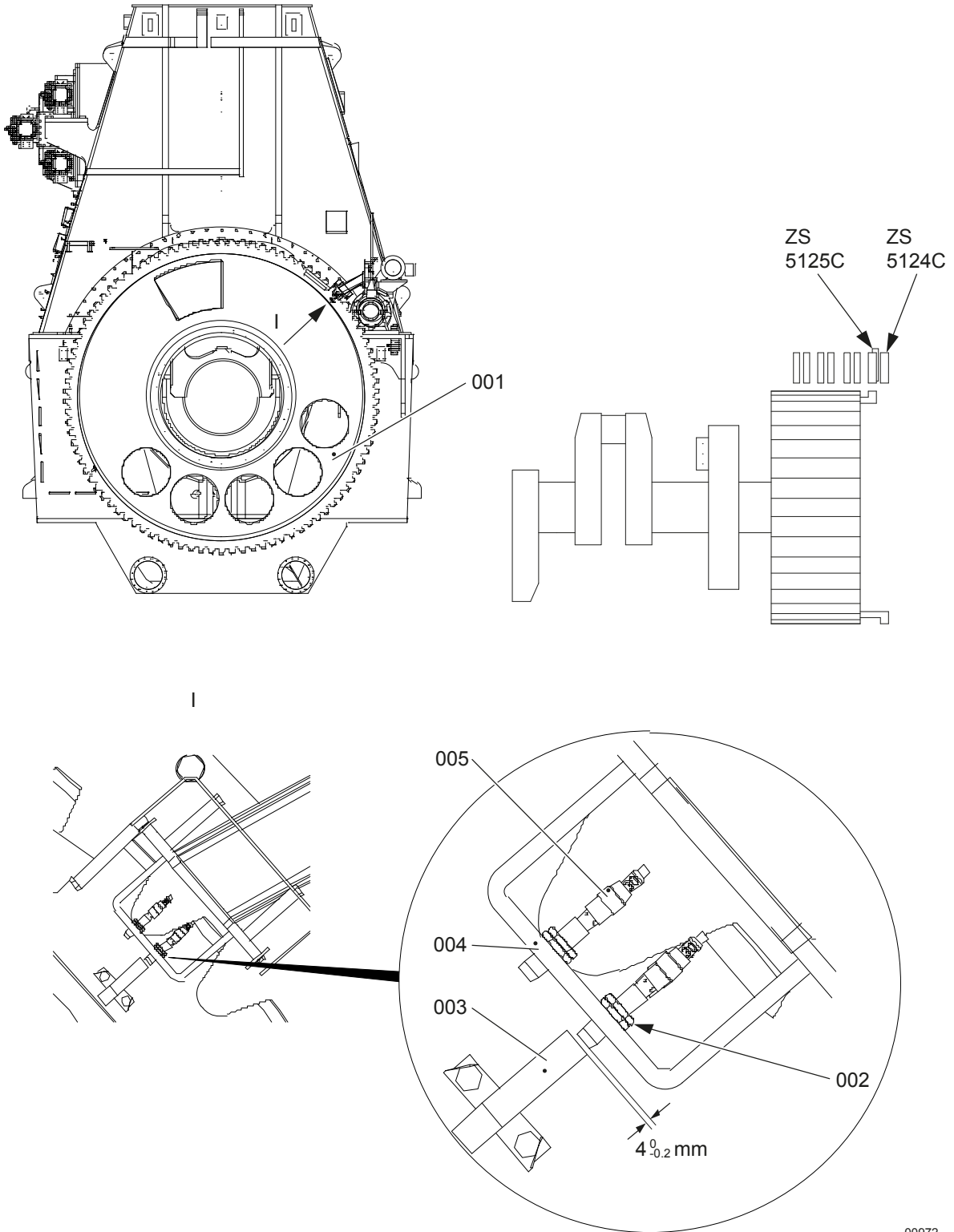
- The engine must be stopped and made safe for maintenance.



## PROCEDURE

- 1 Attach the [proximity sensor](#) (005 [Figure 14-2](#)) to the holder (004).
- 2 Make sure that the proximity sensor (005) touches the crank angle mark (003).
- 3 Loosen the proximity sensor three full turns ( $3 \times 360^\circ$ ) to get a clearance of  $4^{+0}_{-0.2}$  mm between the crank angle mark (003) and the bottom face of the proximity sensor (005).
- 4 Carefully tighten the locknut (002) with your fingers.
- 5 Connect the electrical connection to the proximity sensor (005). Refer to the mark made before to identify the correct cable.

Fig 14-2 Proximity sensor (flywheel) - install



00972

**CLOSE UP**

- None

### 14.1.3 Crank angle sensor unit (supply unit) - proximity sensor - remove

#### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

#### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

#### Support equipment

Description	Part No.	CSN	QTY
None			

#### Supplies

Description	QTY
None	

#### Spare Parts

Description	Part No.	CSN	QTY
None			

#### SAFETY PRECAUTIONS

##### WARNING

**Injury Hazard:** Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

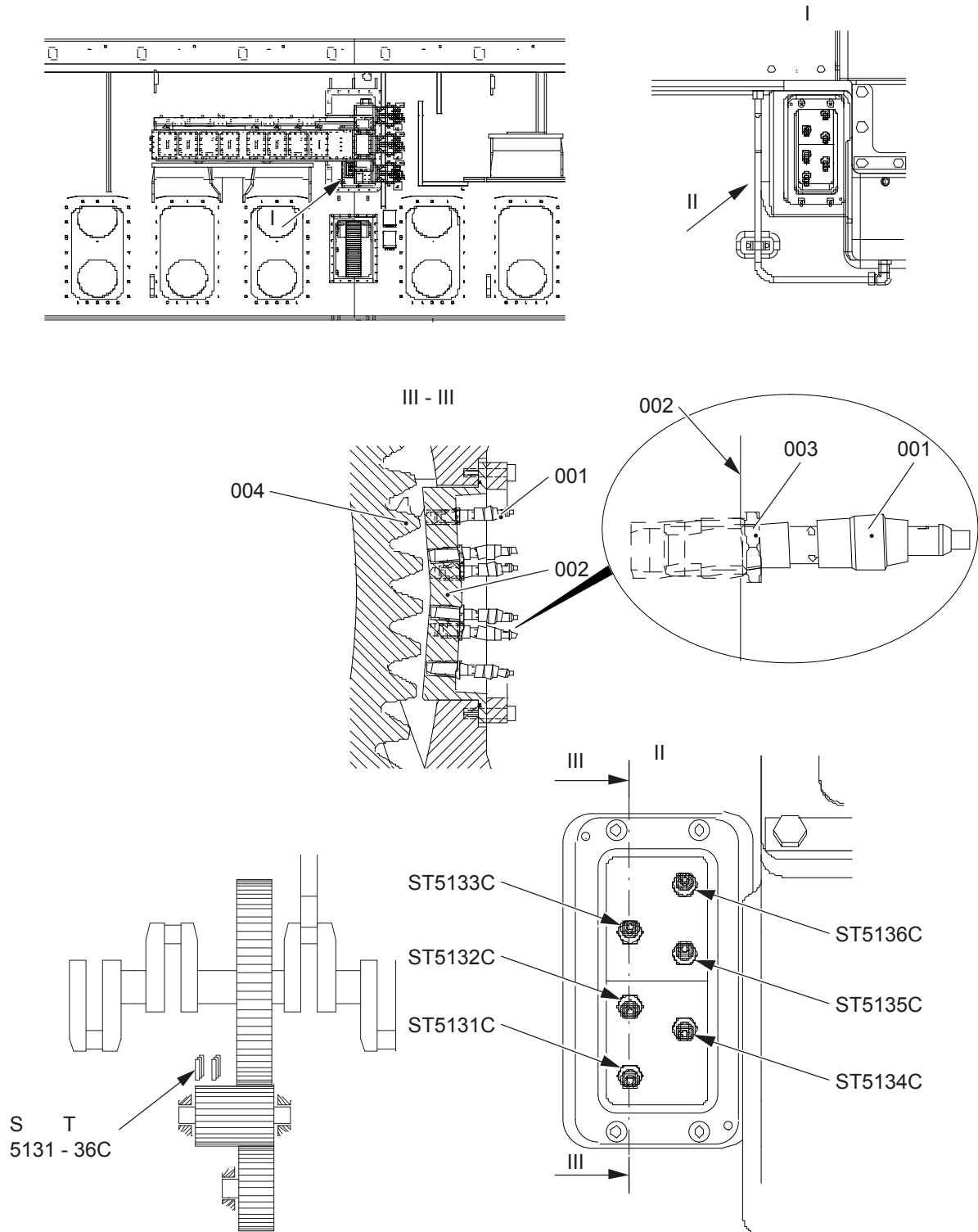
#### PRELIMINARY OPERATIONS

- The engine must be stopped and made safe for maintenance.

**PROCEDURE**

- 1 Operate the turning gear to get a tooth (004, [Figure 14-3](#)) of the intermediate wheel opposite the applicable proximity sensor (001).
- 2 If necessary, put a mark on the applicable cable to identify its position.
- 3 Disconnect the applicable electrical connection from the applicable proximity sensor (001).
- 4 Loosen the locknut (003).
- 5 Remove the proximity sensor (001) from the holder (002).

Fig 14-3 Proximity sensor - remove



00969

**CLOSE UP**

- Install the applicable proximity sensor, refer to [14.1.4 Crank angle sensor unit \(supply unit\) - proximity sensor - install](#)

## 14.1.4 Crank angle sensor unit (supply unit) - proximity sensor - install

### Periodicity

Description	
Unscheduled	
Duration for performing preliminary requirements	0.0 man-hours
Duration for performing the procedure	0.5 man-hours
Duration for performing the requirements after job completion	0.0 man-hours

### Personnel

Description	Specialization	QTY
Engine crew	Basic	AR

### Support equipment

Description	Part No.	CSN	QTY
None			

### Supplies

Description	QTY
None	

### Spare Parts

Description	Part No.	CSN	QTY
proximity sensor			A/R

### SAFETY PRECAUTIONS

- None

### PRELIMINARY OPERATIONS

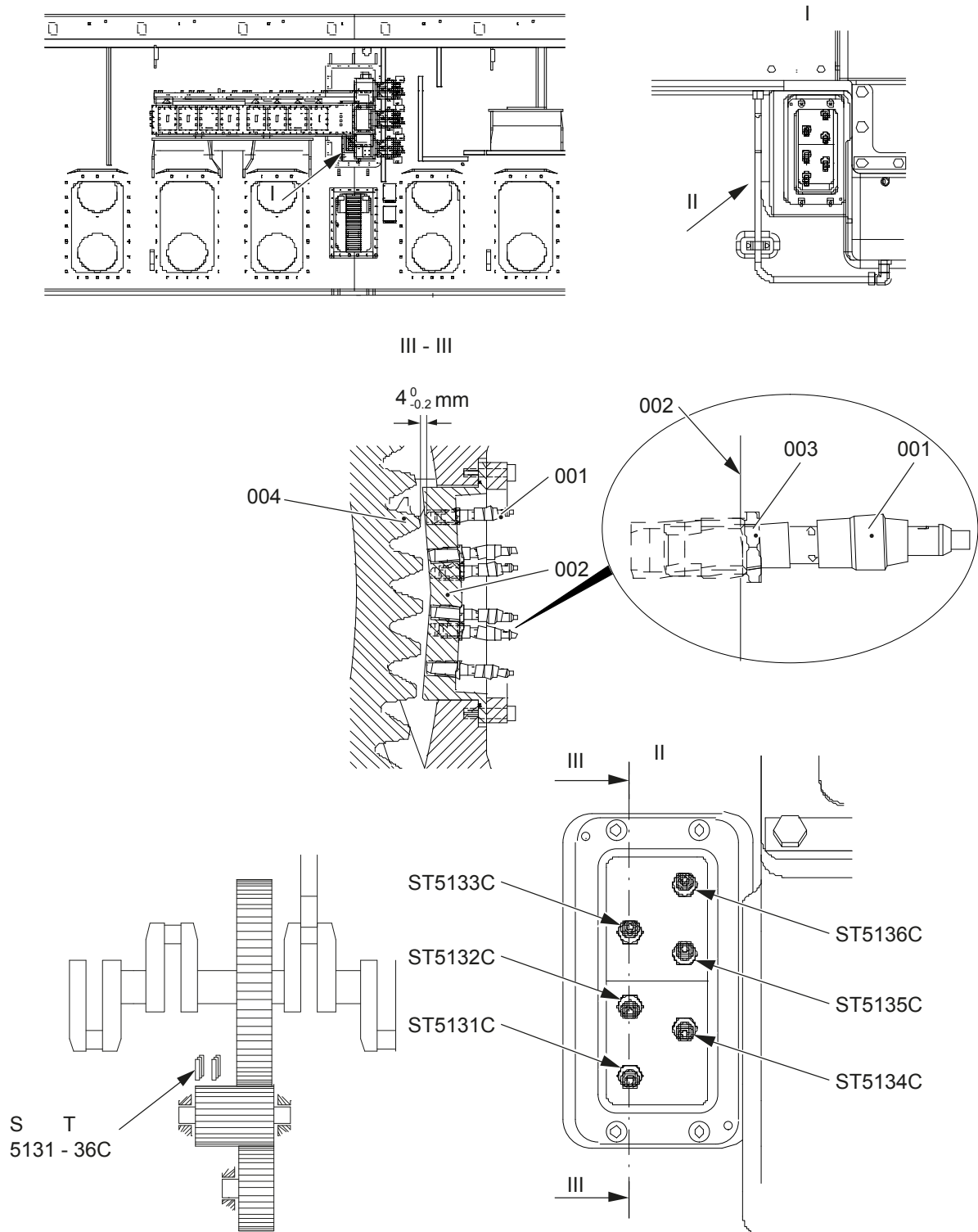
- The engine must be stopped and made safe for maintenance.



## PROCEDURE

- 1 Attach the [proximity sensor](#) (001, [Figure 14-4](#)) to the holder (002).
- 2 Turn the proximity sensor (001) fully down until the tip of the proximity sensor touches the bottom of the holder (002).  
**NOTE:** During installation/commissioning the clearance between the flywheel tooth (001) and the holder (002) is set to  $4^0_{-0.2}$ mm.
- 3 Loosen the proximity sensor (001) a half turn to get a clearance of  $4^0_{-0.2}$ mm between the flywheel tooth (004) and the bottom face of the proximity sensor.
- 4 Carefully tighten the locknut (003) with your fingers.
- 5 Connect the electrical connection to the proximity sensor (001). Refer to the mark made before to identify the correct cable.

Fig 14-4 Proximity sensor - install



00970

**CLOSE UP**

- None

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# 15 Tools

15.1	General for tools.....	838
15.2	Standard tools.....	840
15.3	Recommended tools.....	880

## 15.1 General for tools

For the maintenance of the engine it is necessary to have the correct tools. WinGD has specified a number of tools in the three groups that follow:

- **Standard tools**

Standard tools are general available tools (for example wrenches or pliers) or are specially made for the engine. WinGD supplies all standard tools together with the engine.

- **Recommended tools**

Recommended tools are specially made for the engine. They help to do the related maintenance work easier. WinGD supplies these tools only if you tell WinGD to do so.

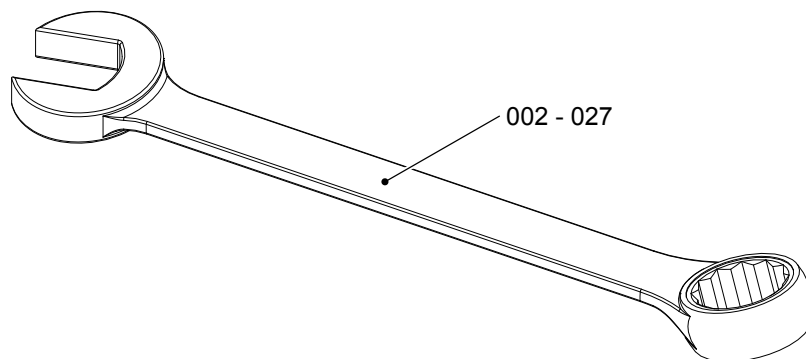
- **Loaned tools**

Loaned tools are specially made for the engine for special maintenance work. WinGD supplies these tools only temporary on a loan basis if you tell WinGD to do so.

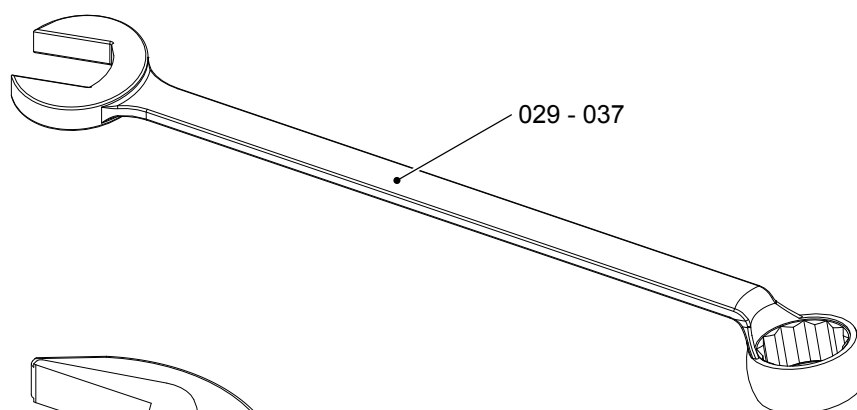
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## 15.2 Standard tools

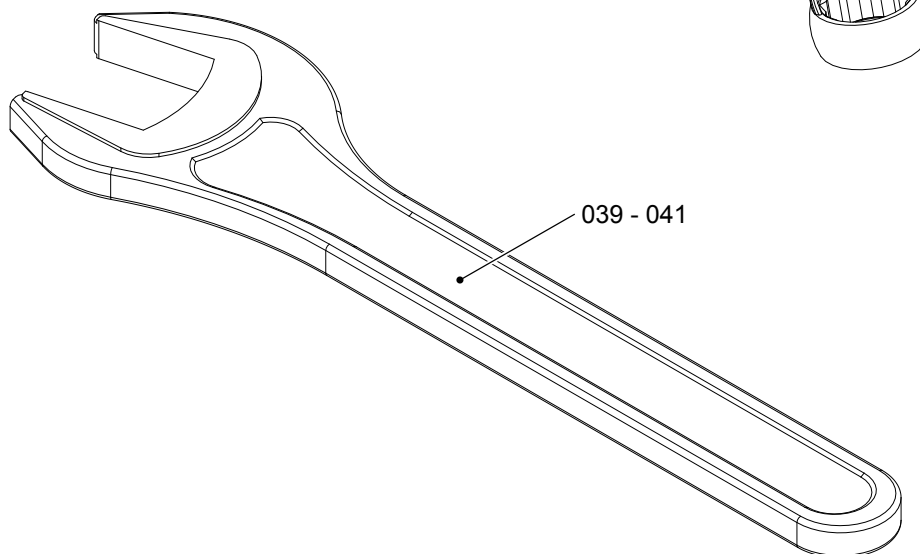
001



028

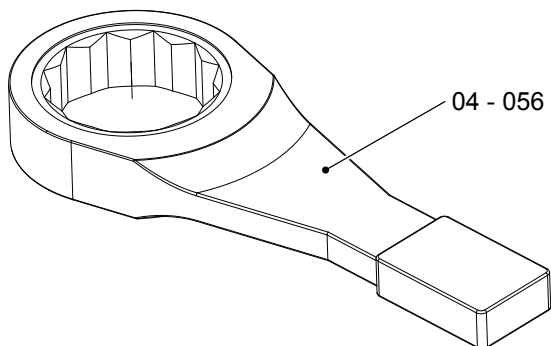


038

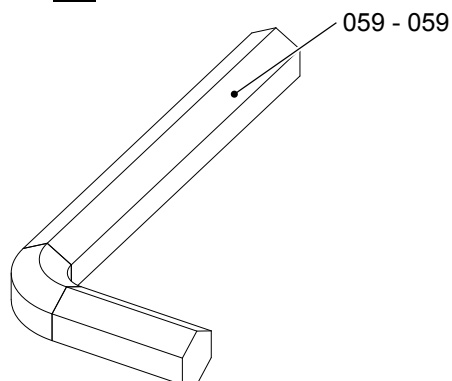




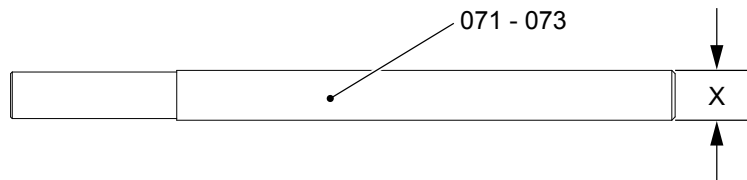
042



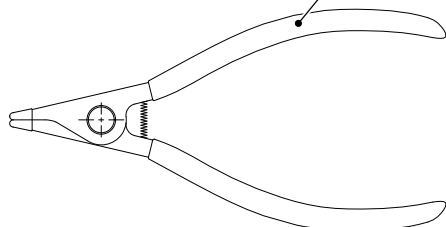
058



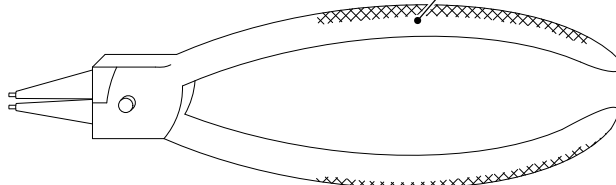
070



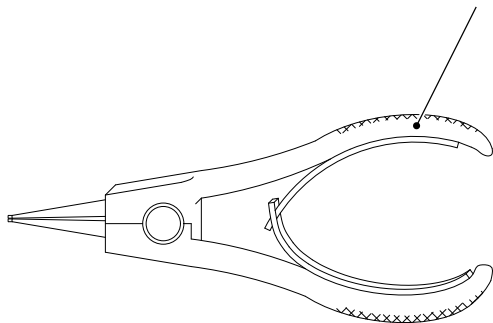
075



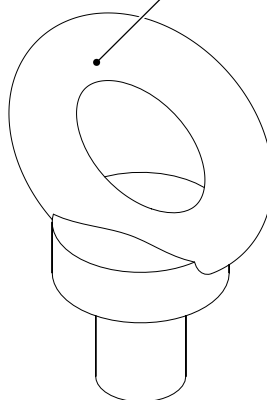
076 - 079



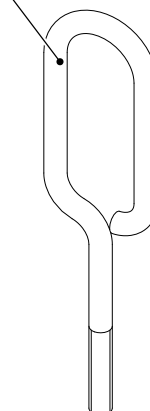
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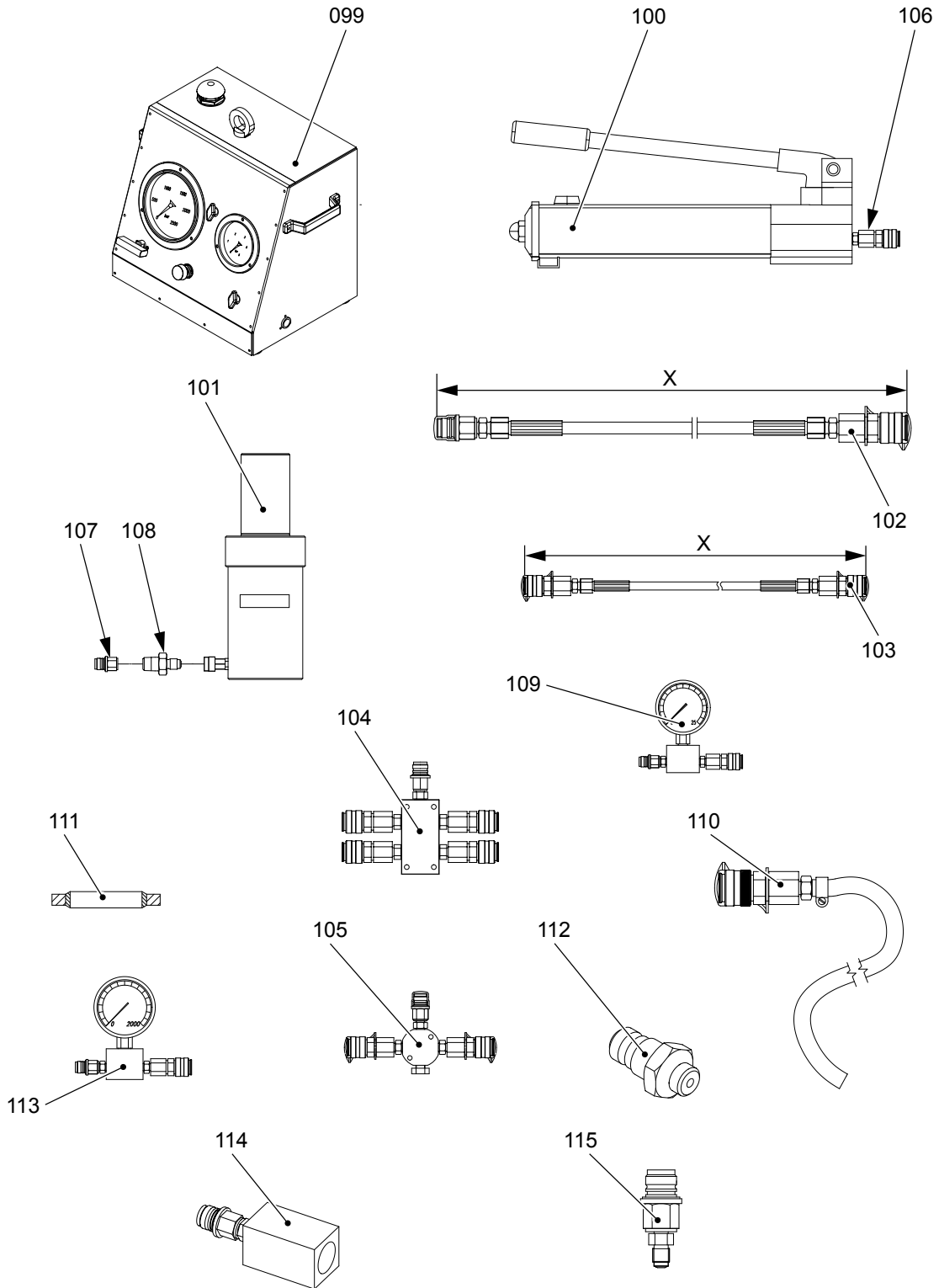


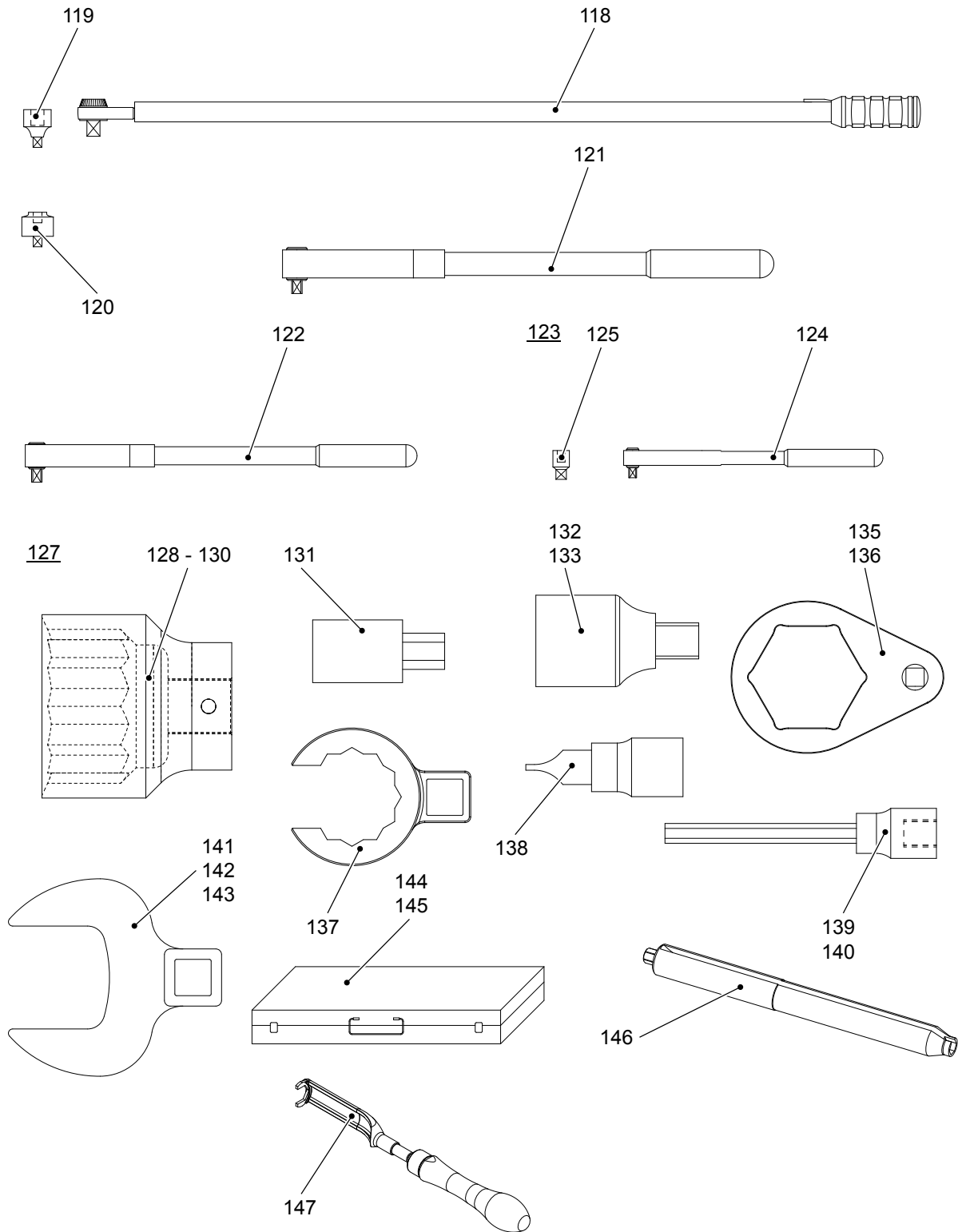
086 - 092

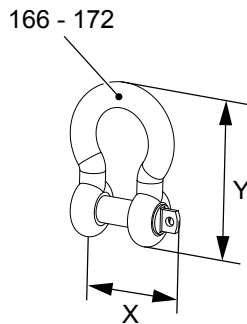
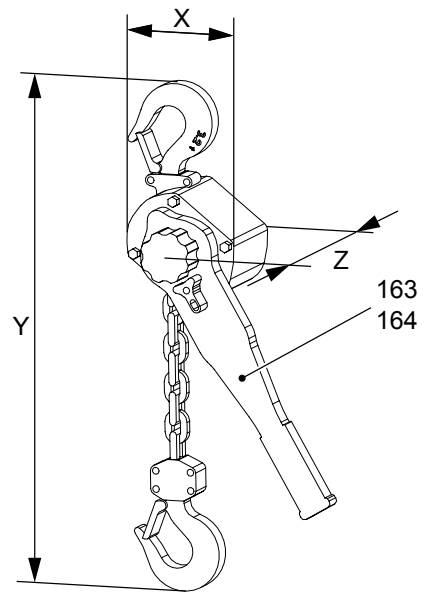
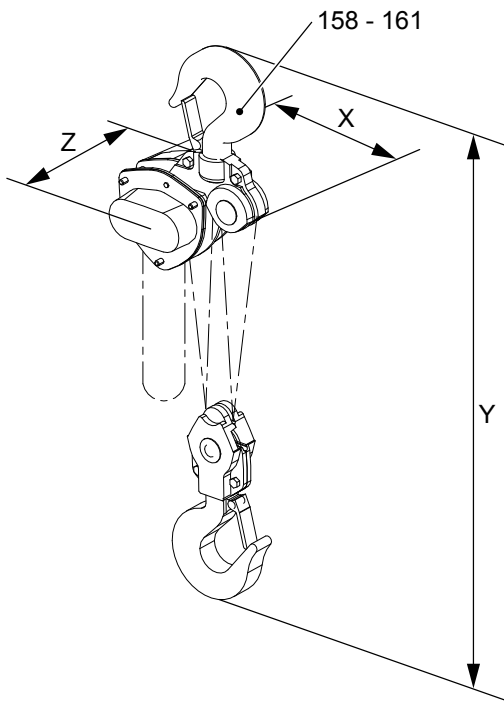
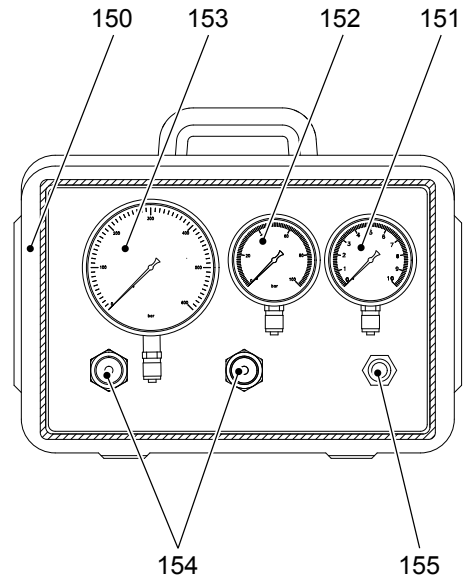
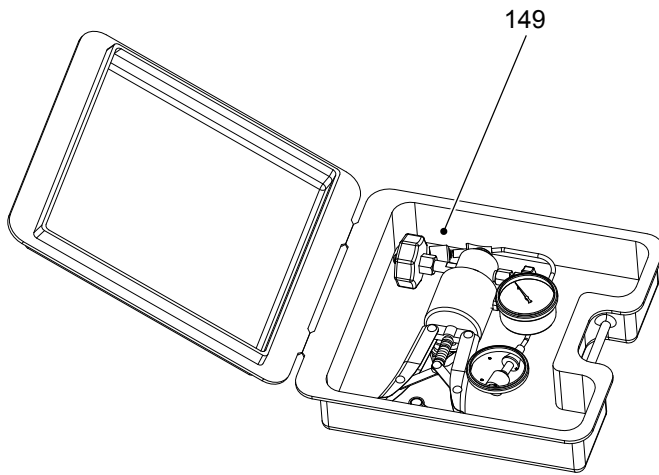


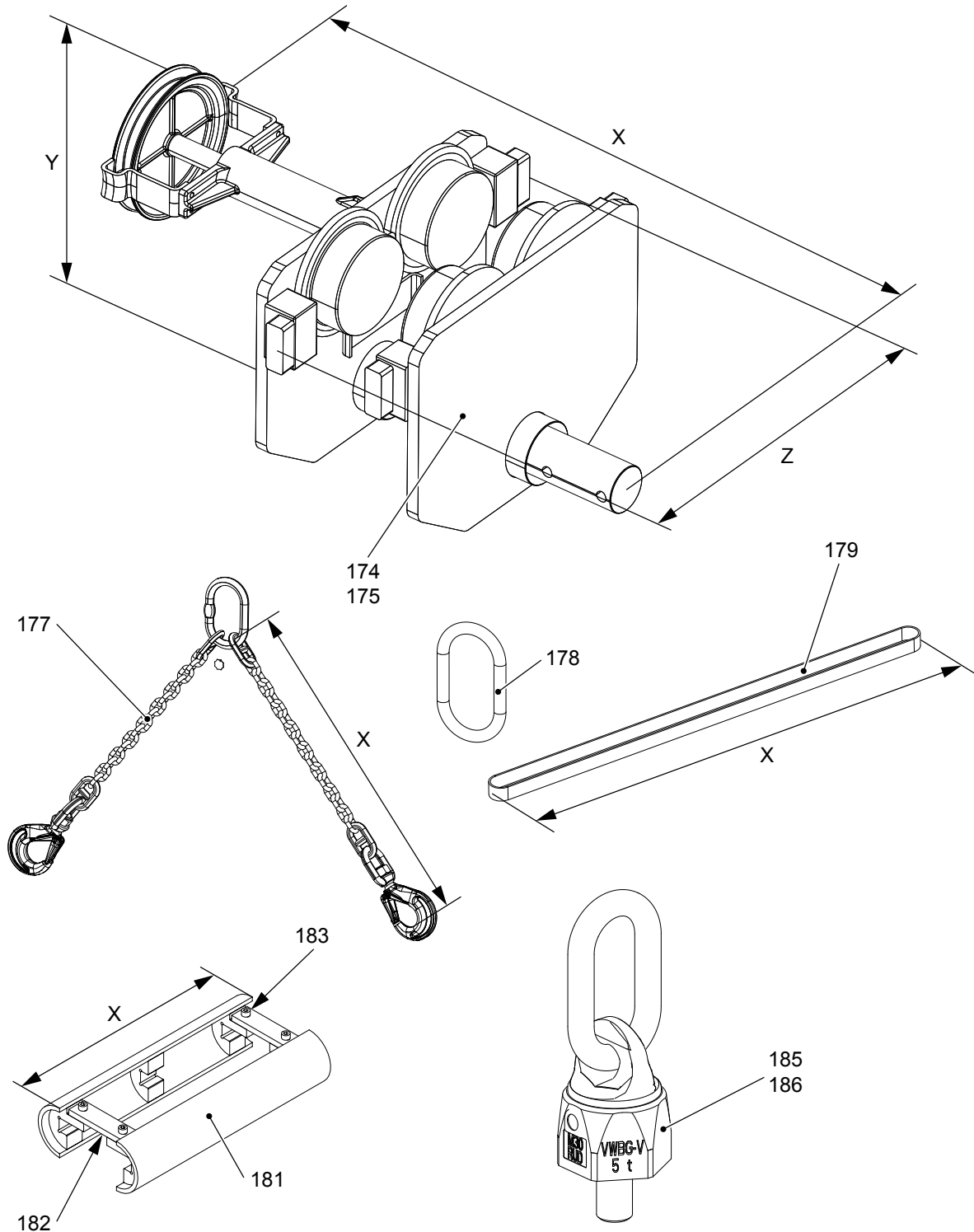
093 094 - 096

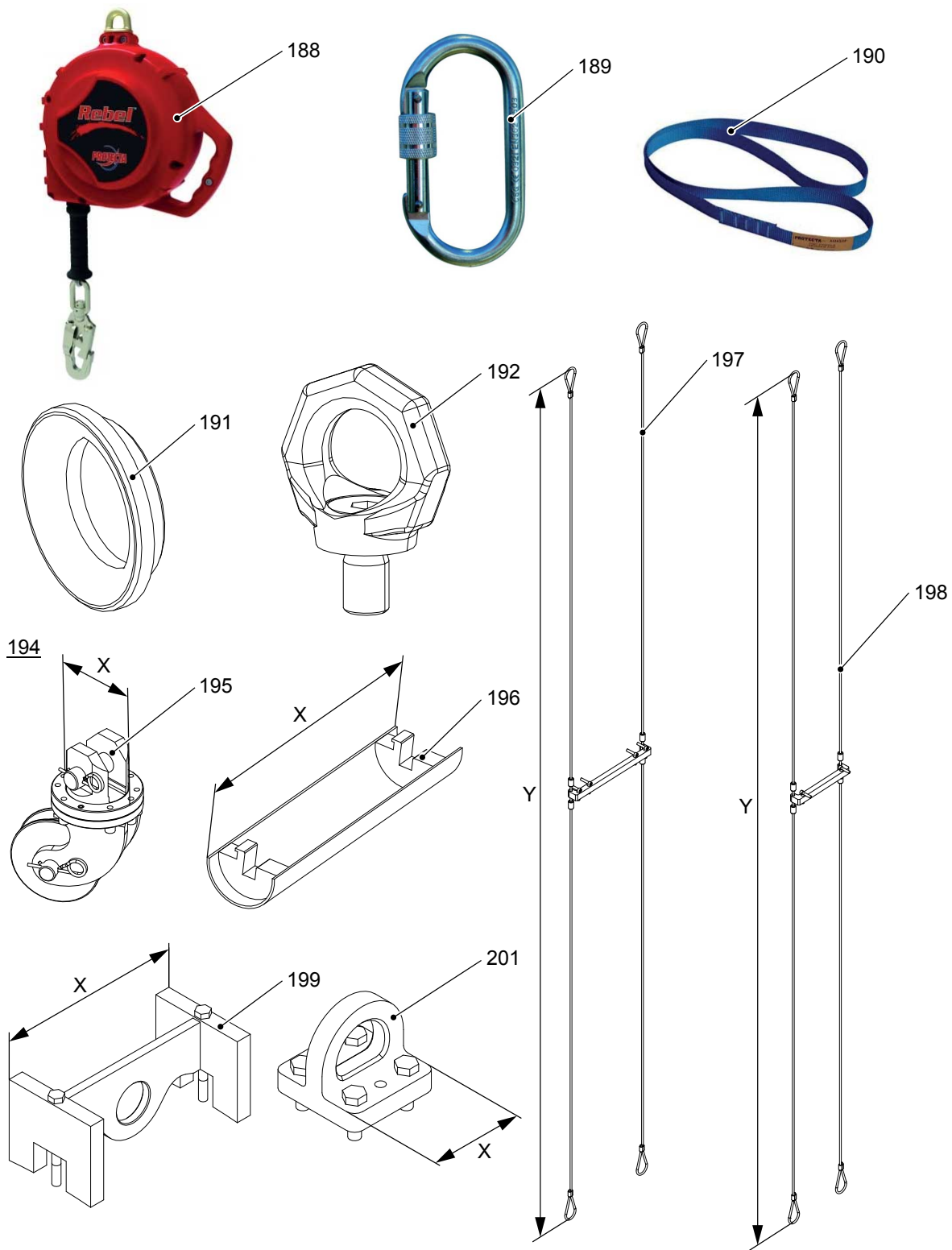


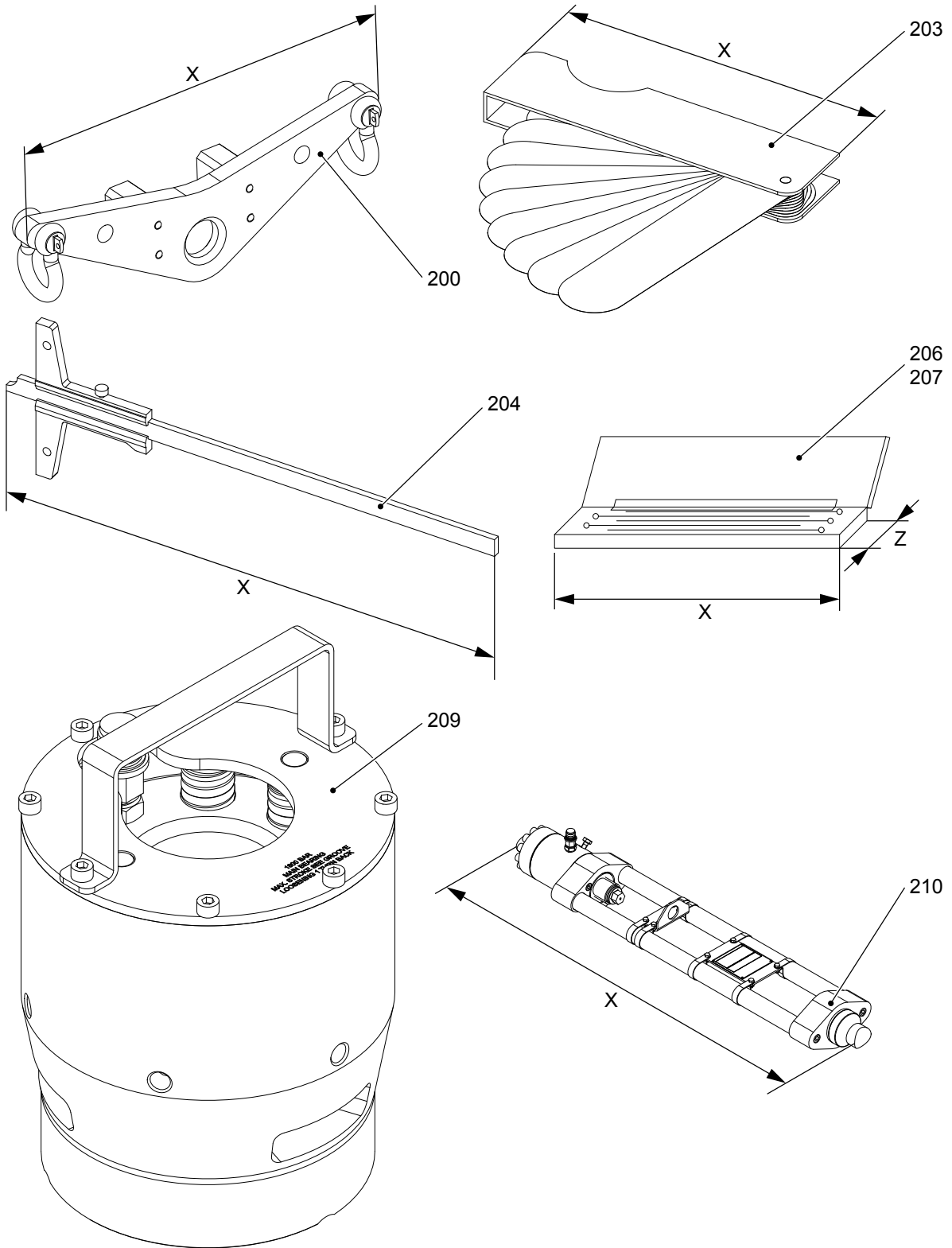


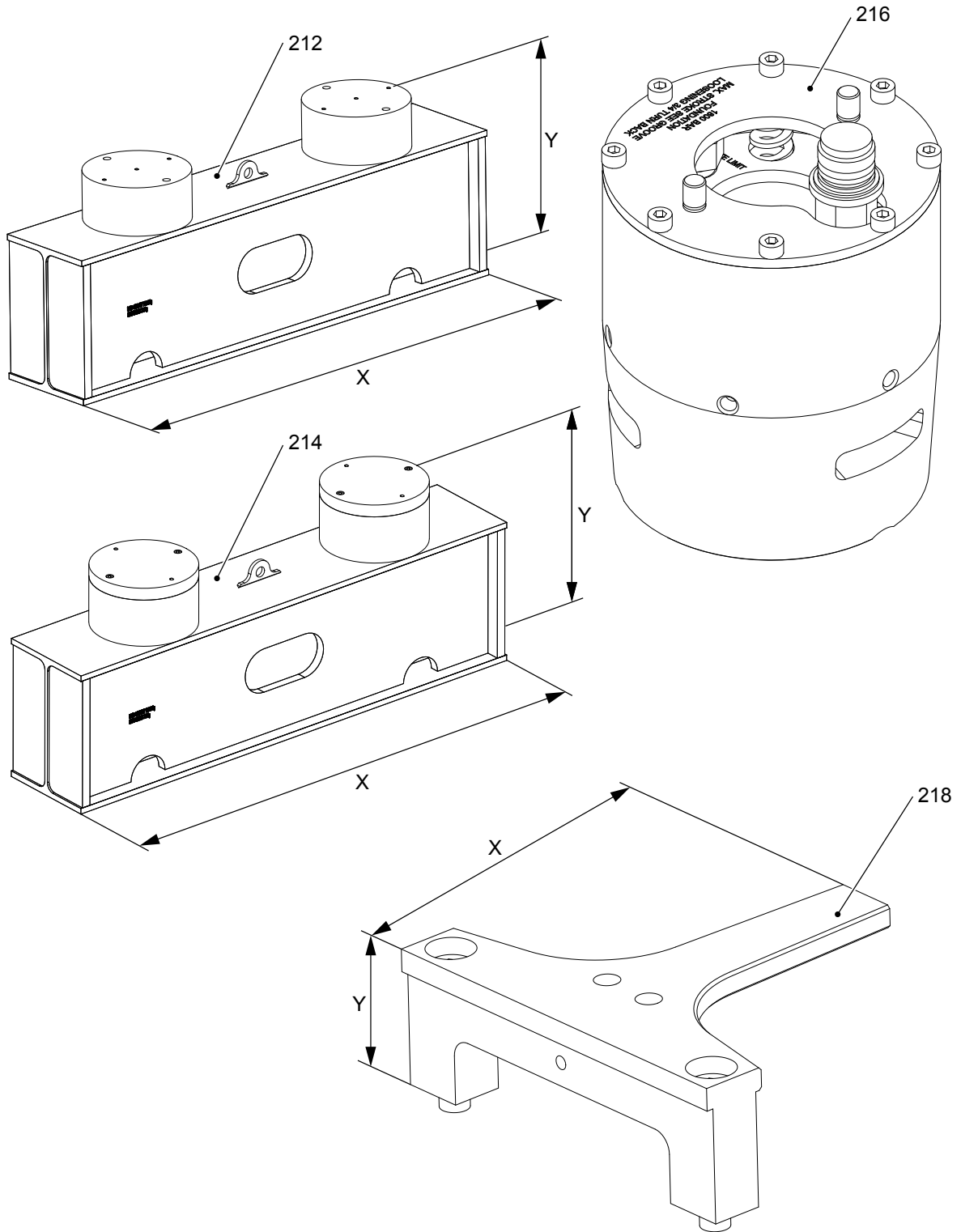




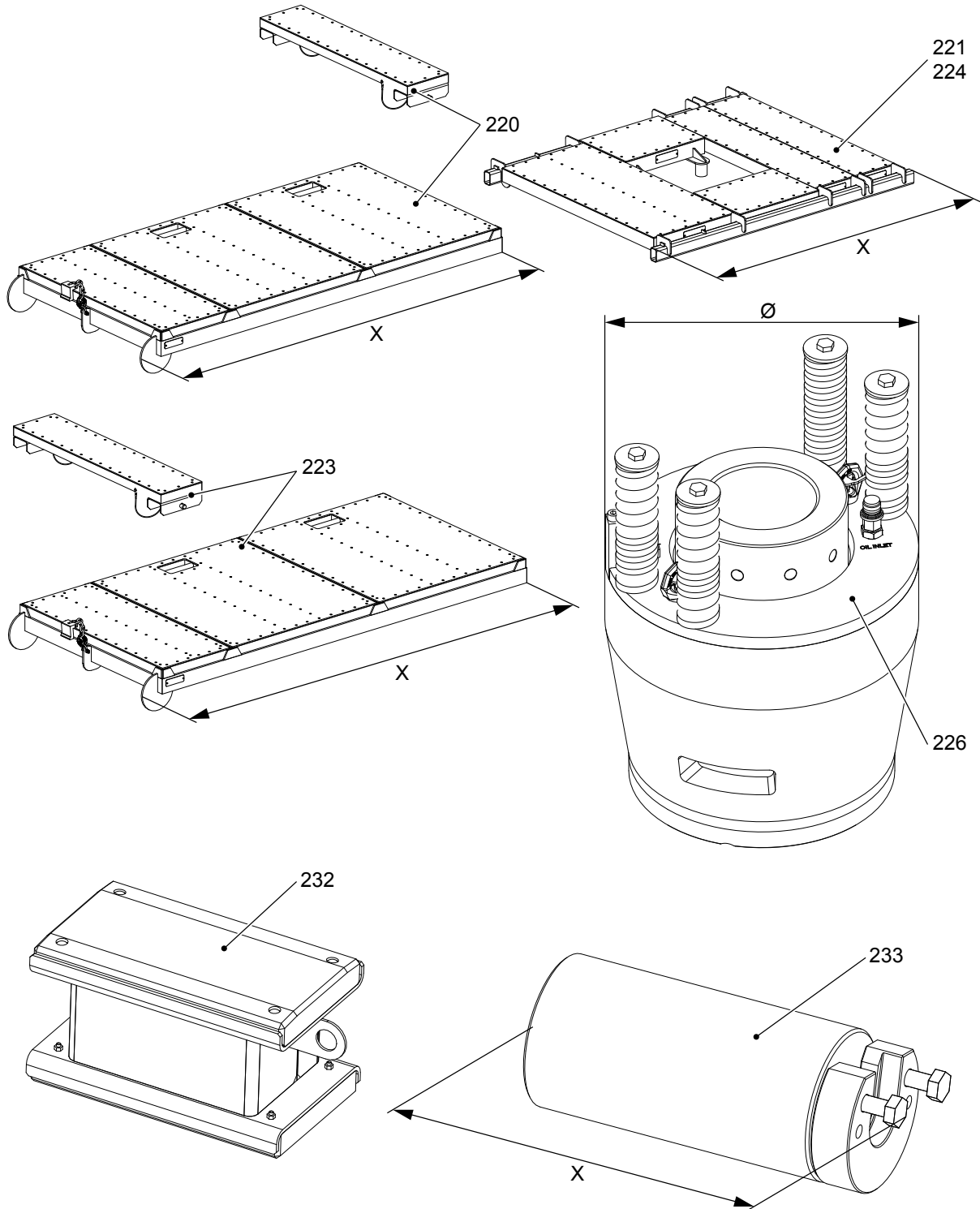


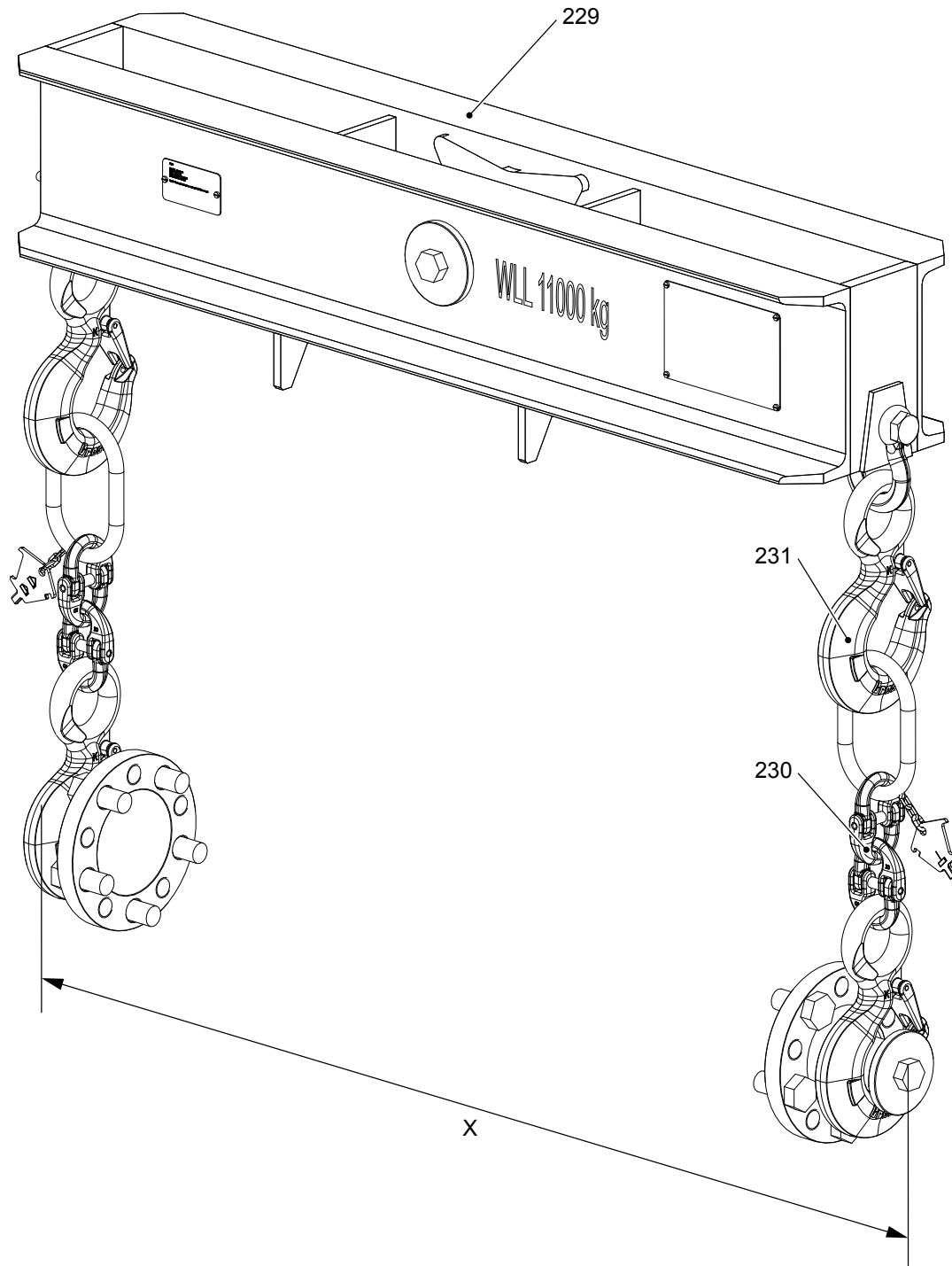


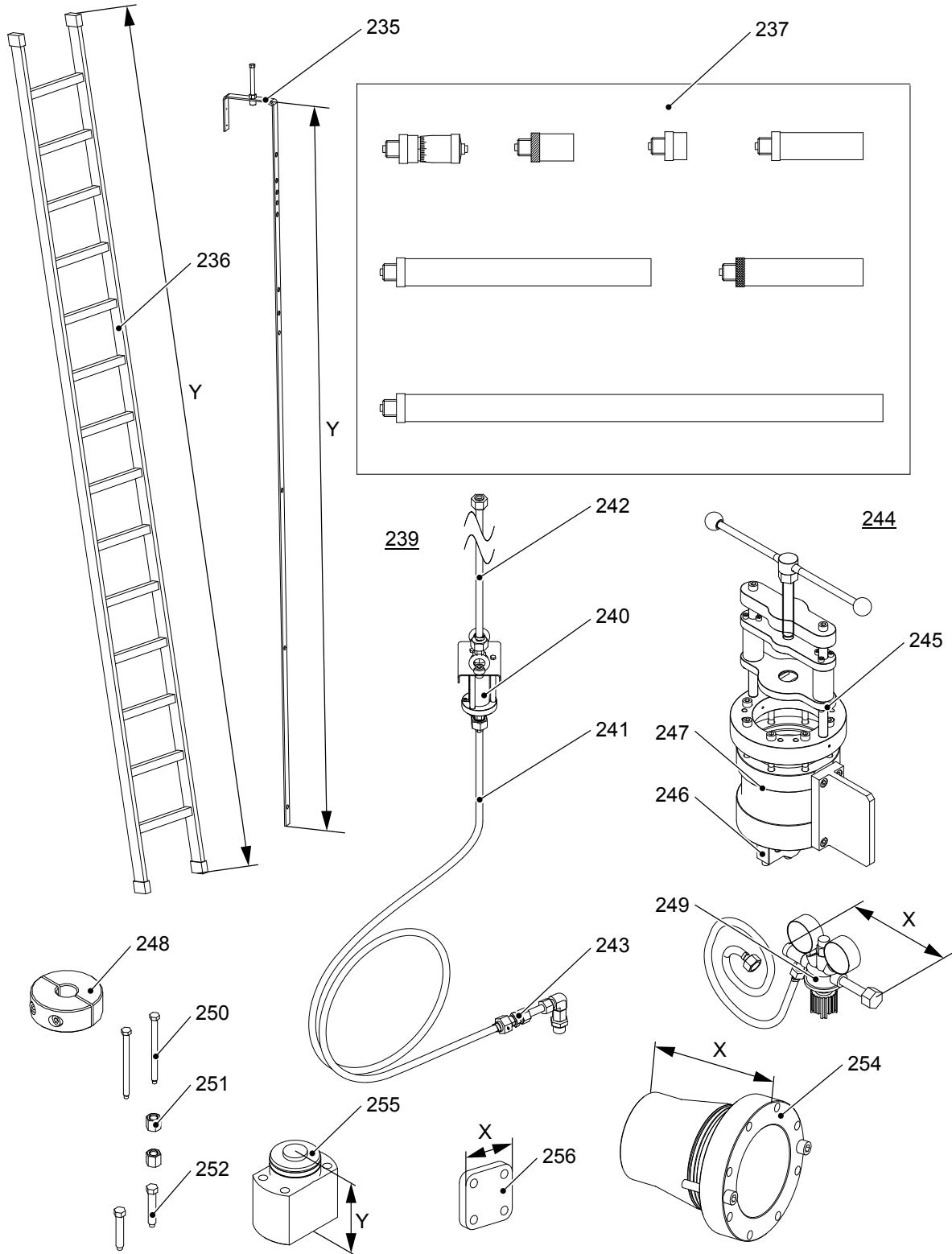


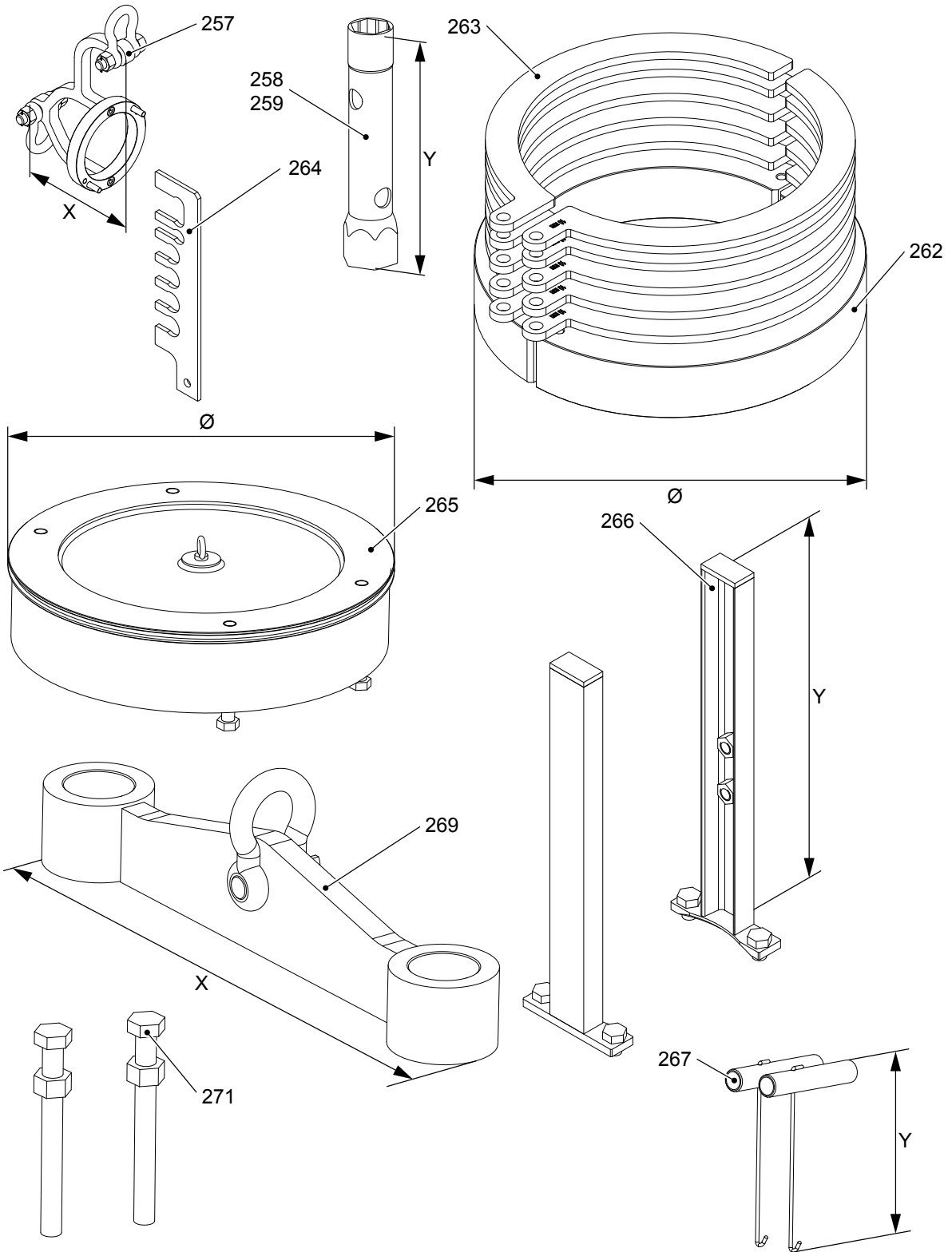


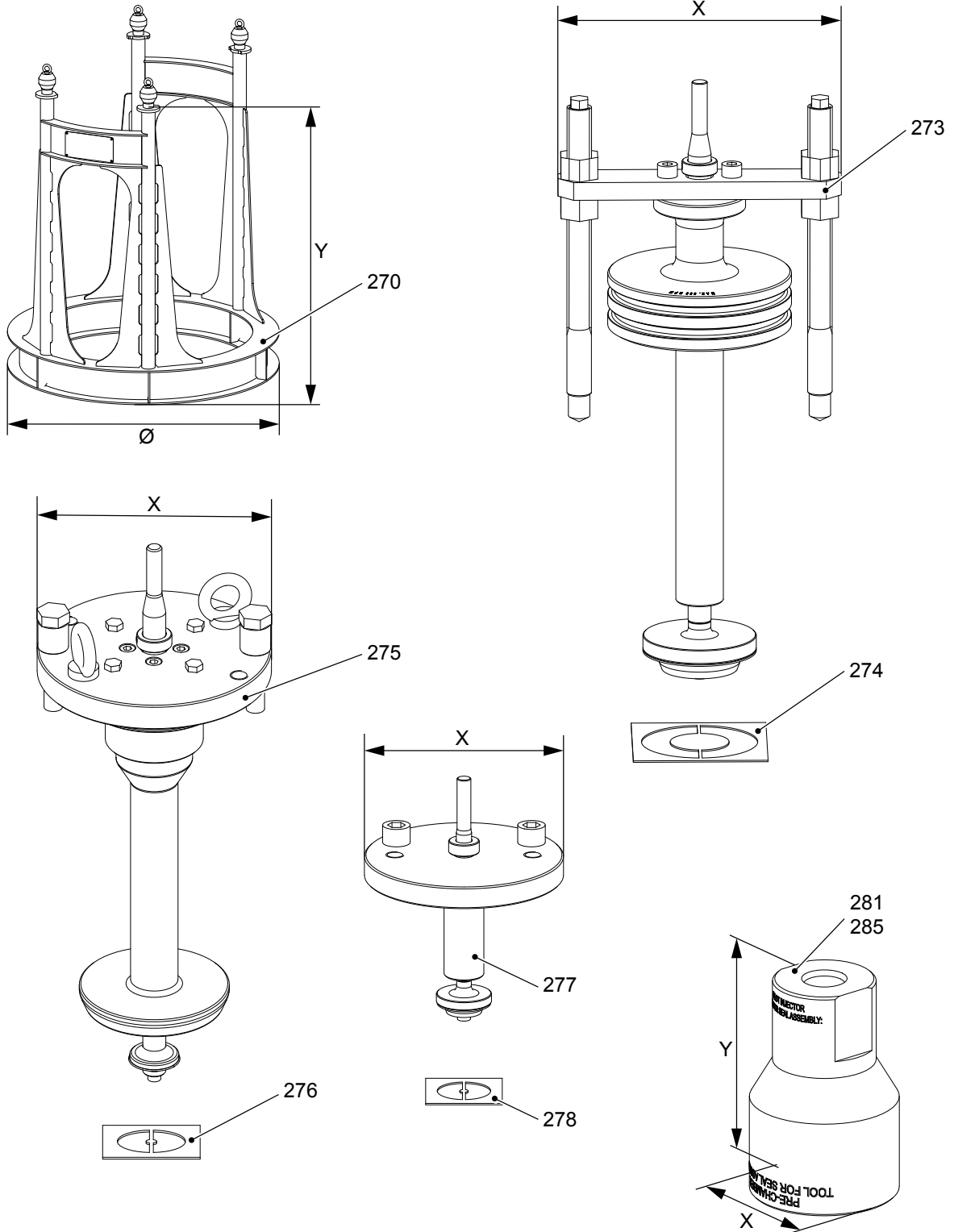


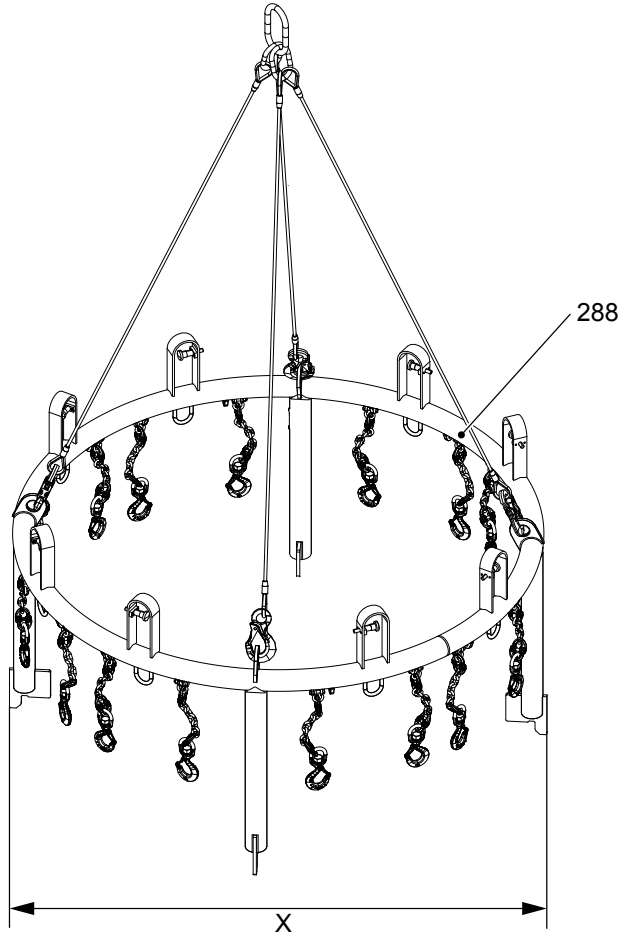
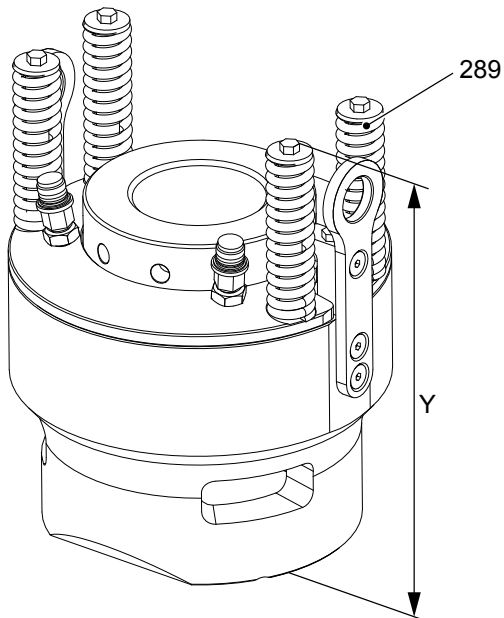
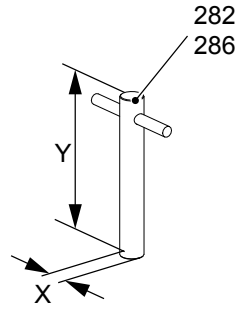
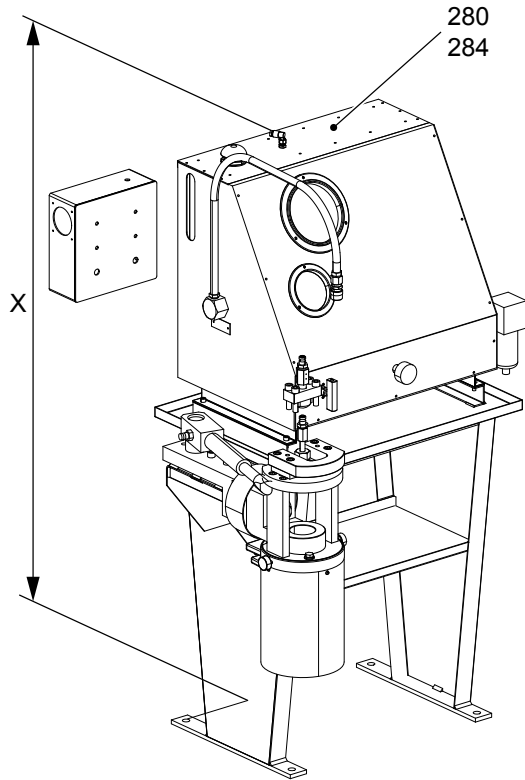


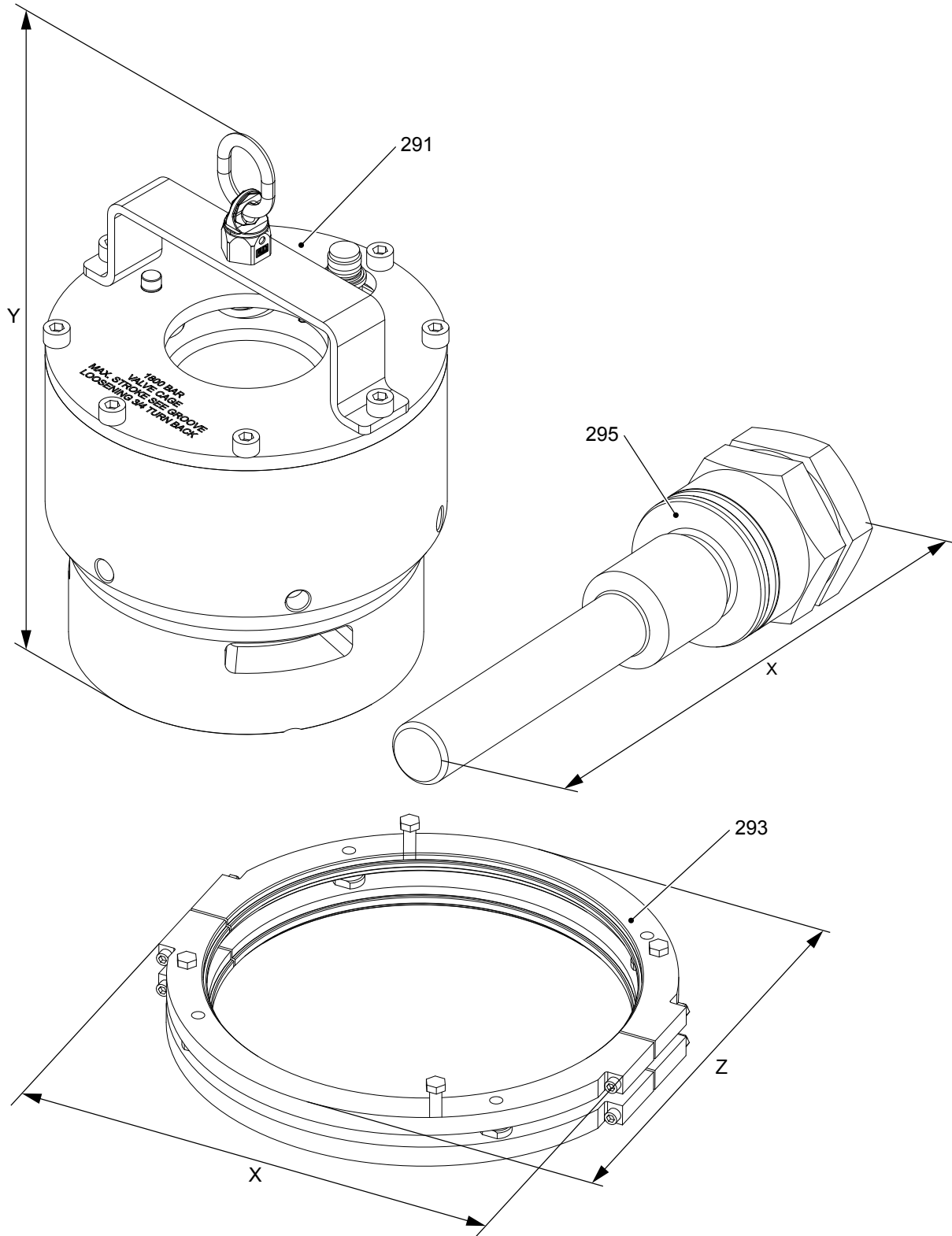


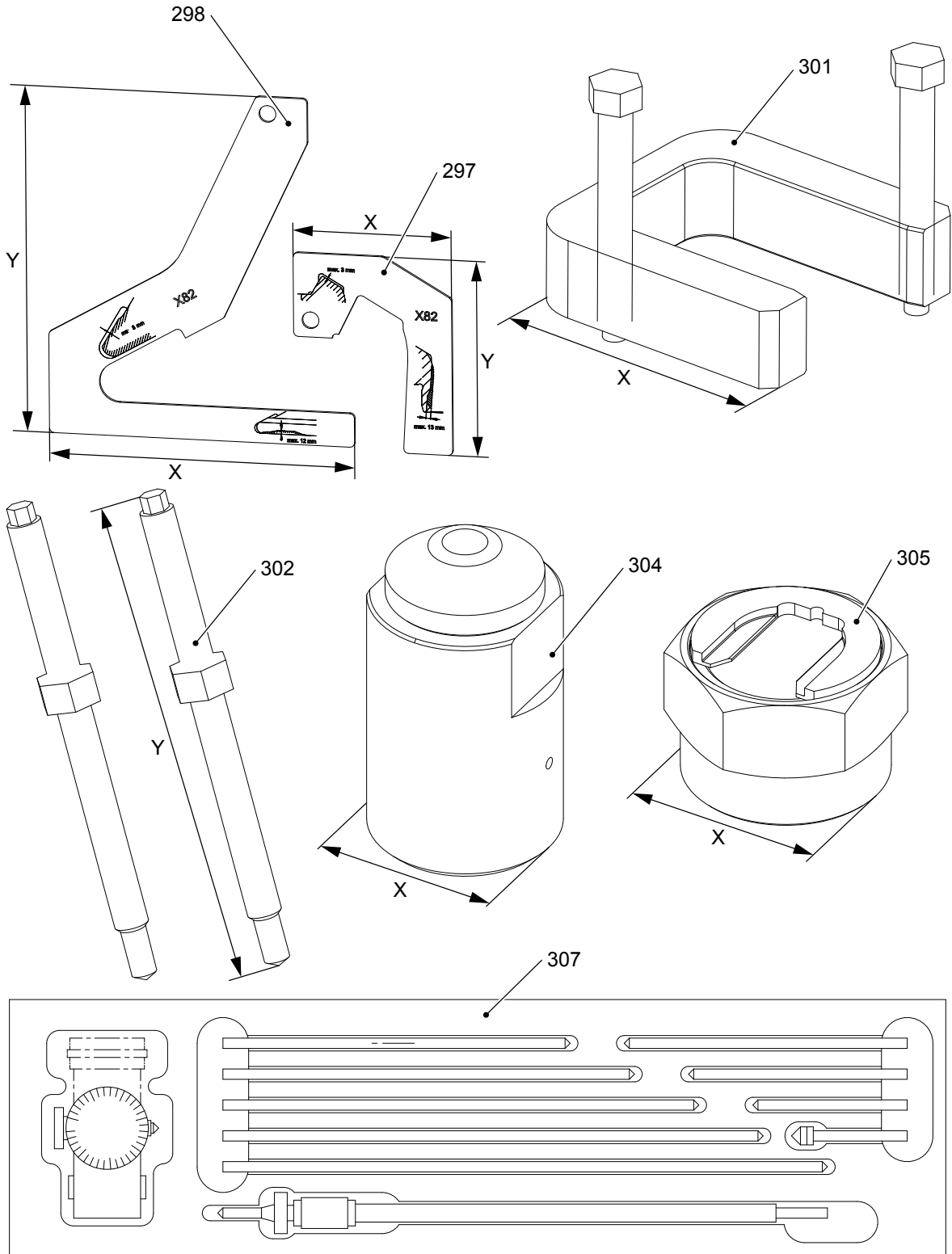




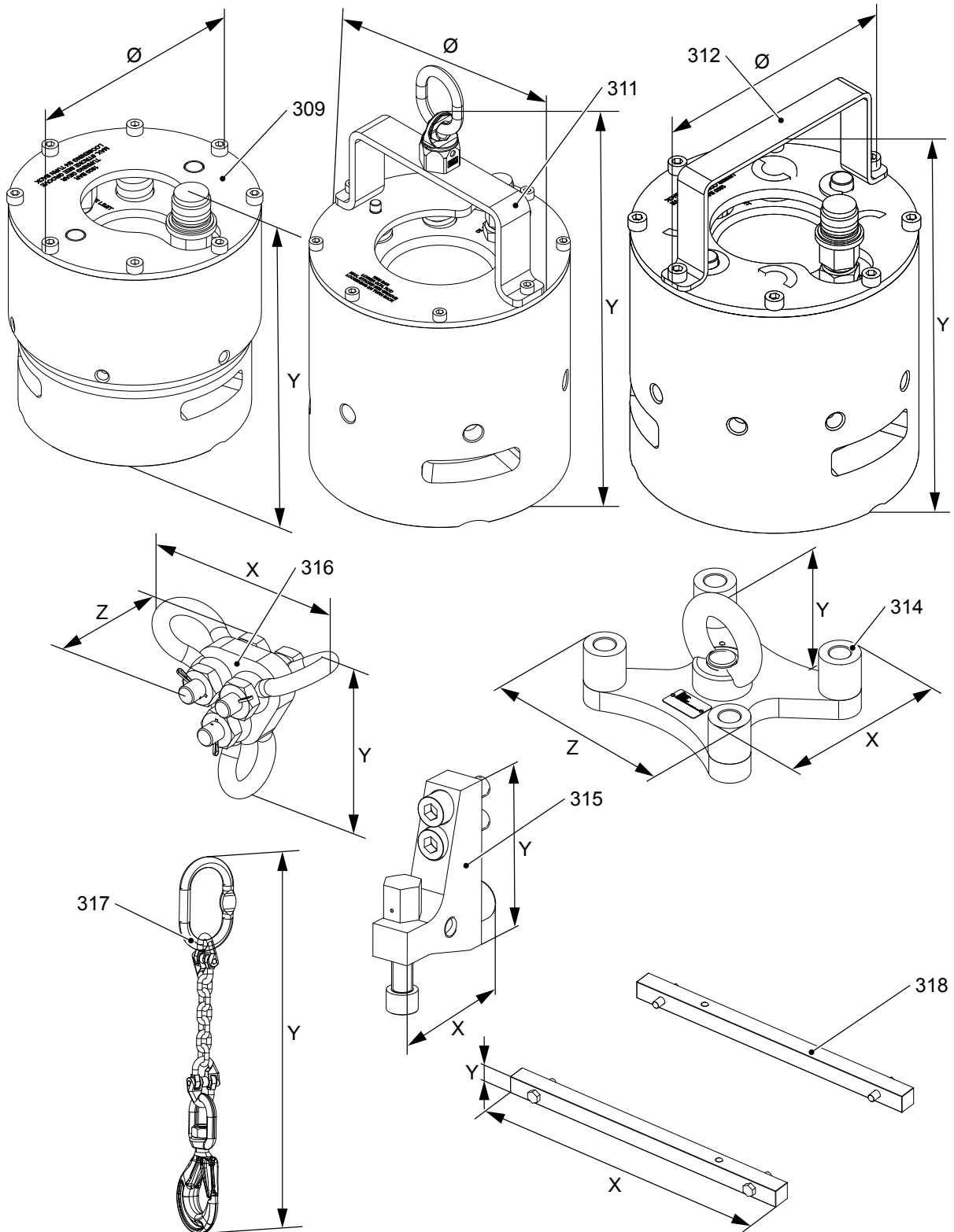


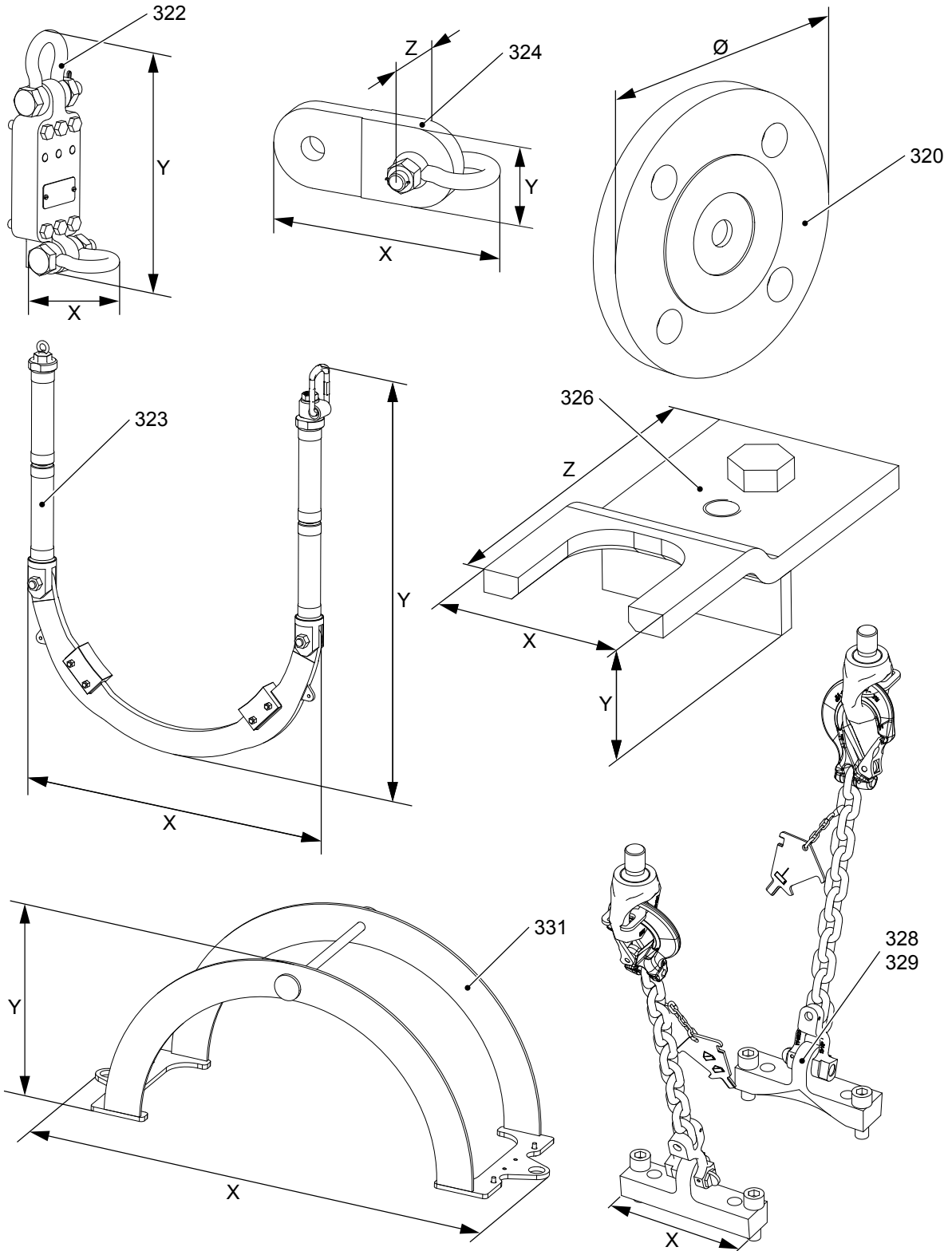


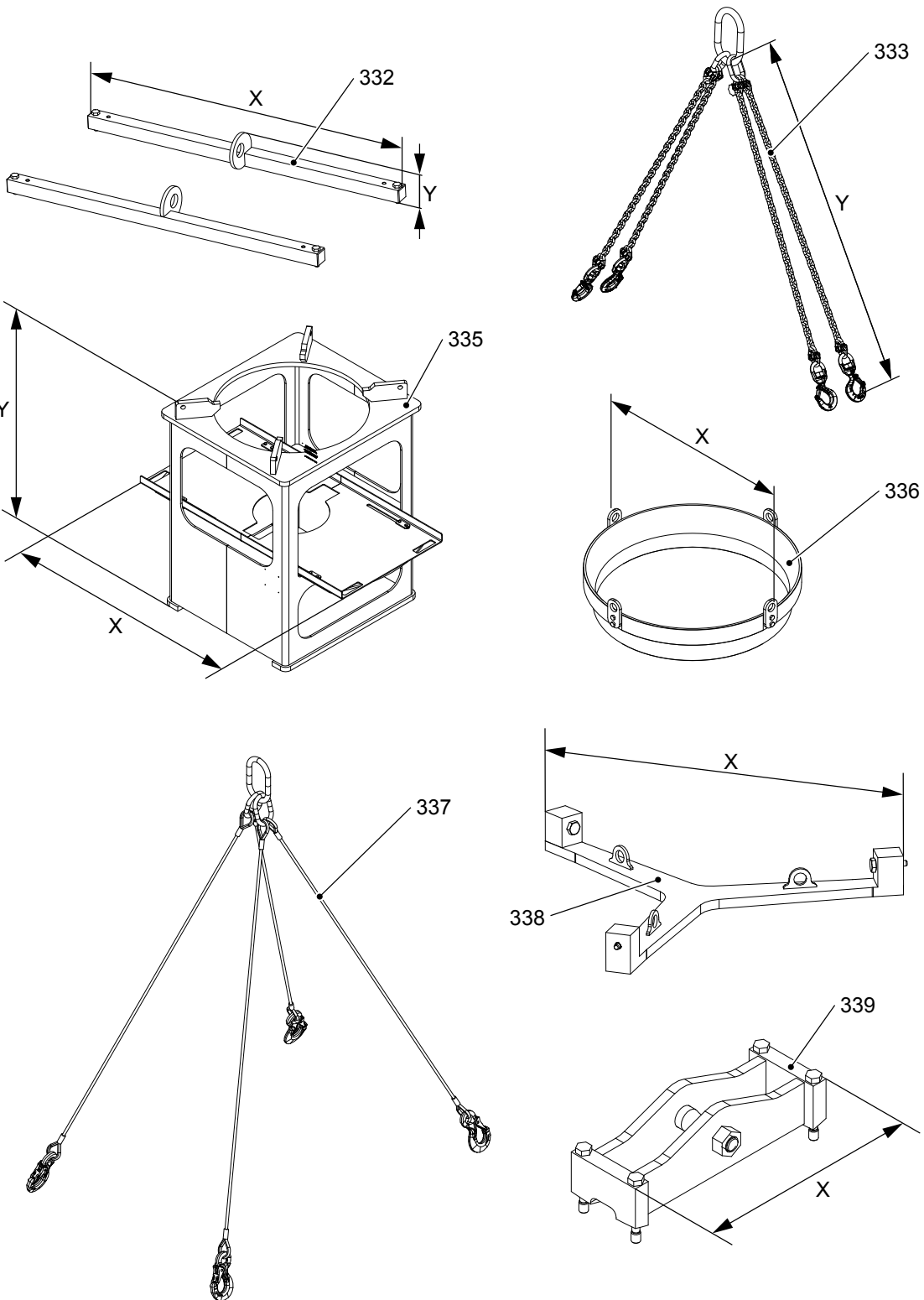


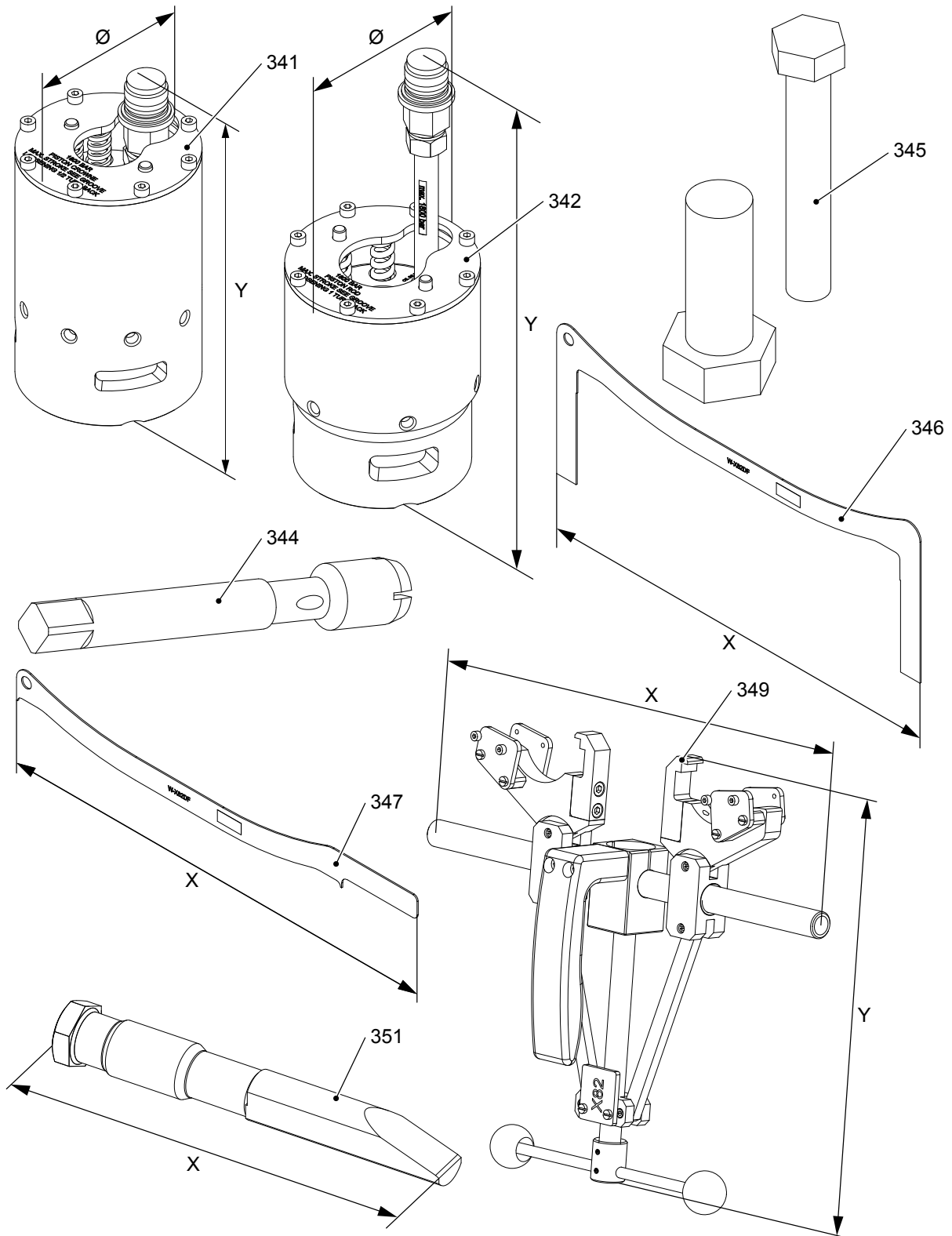


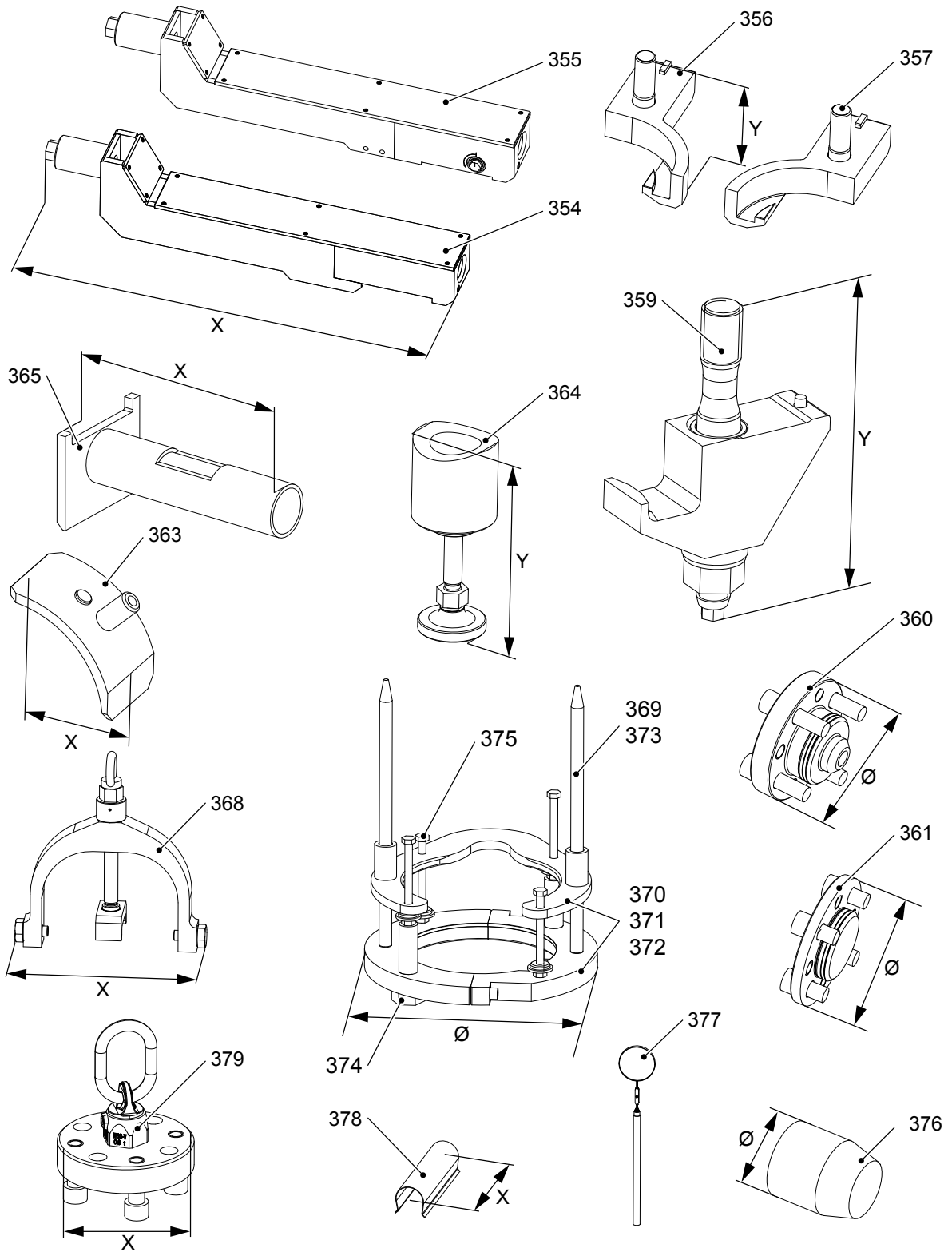


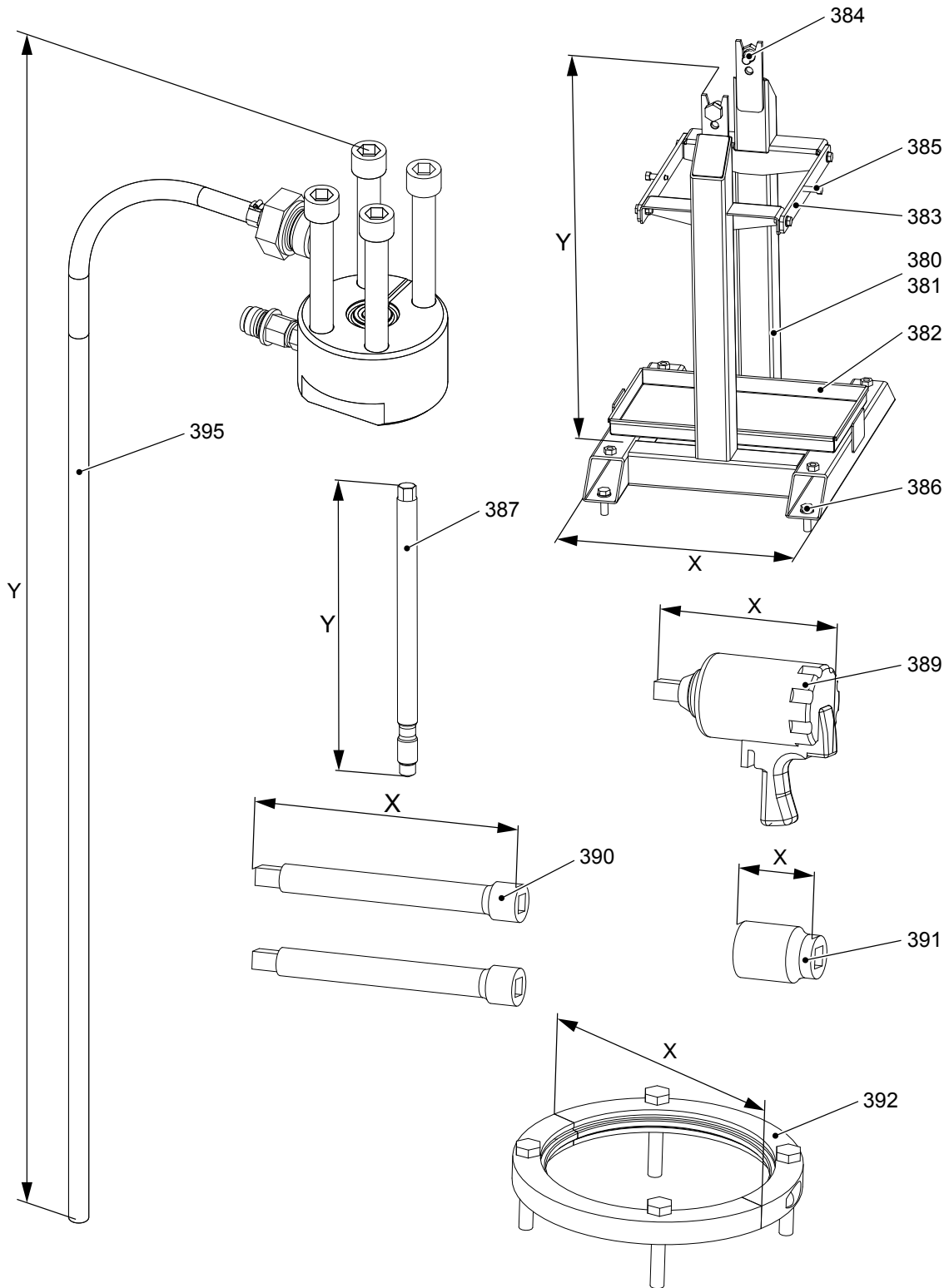


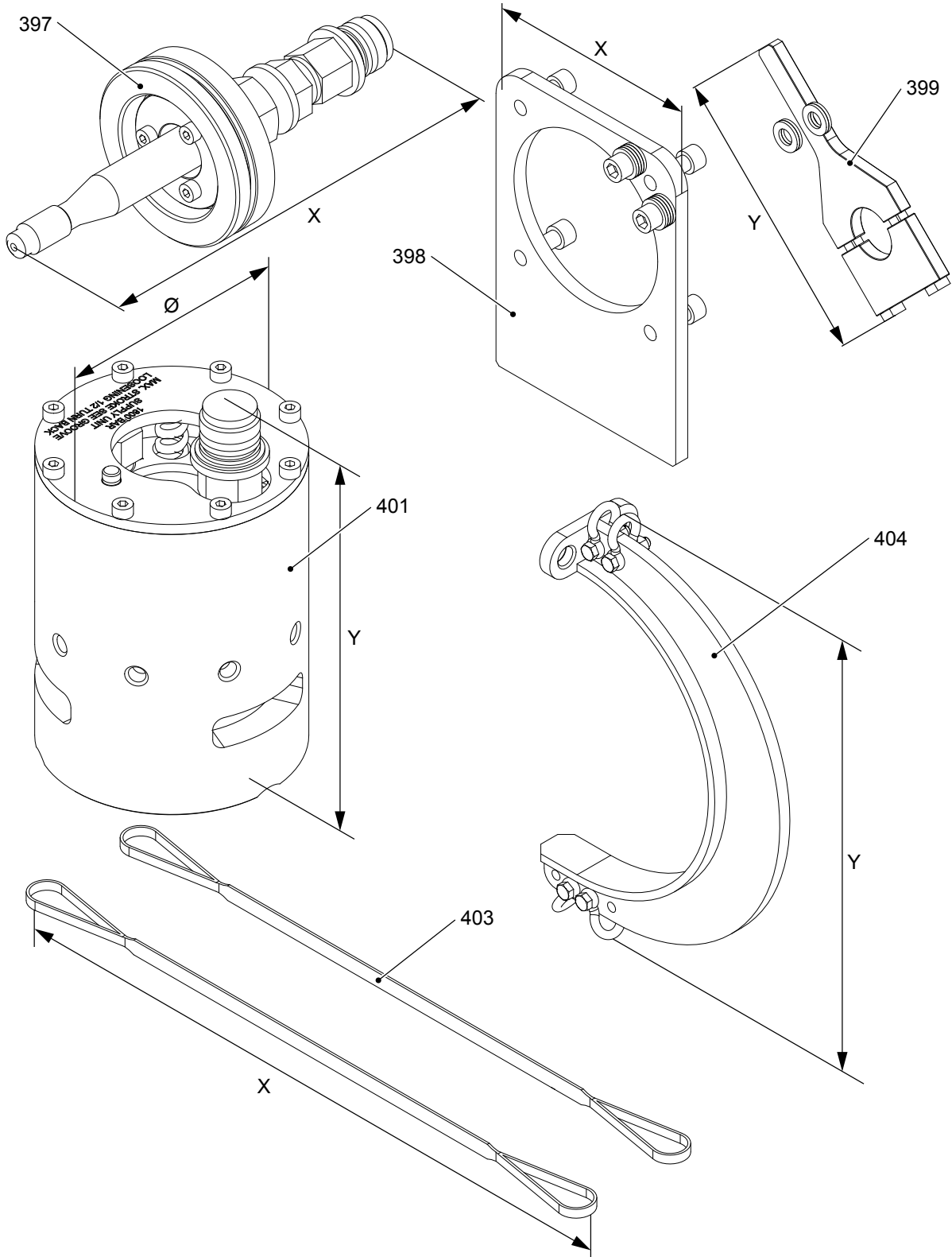


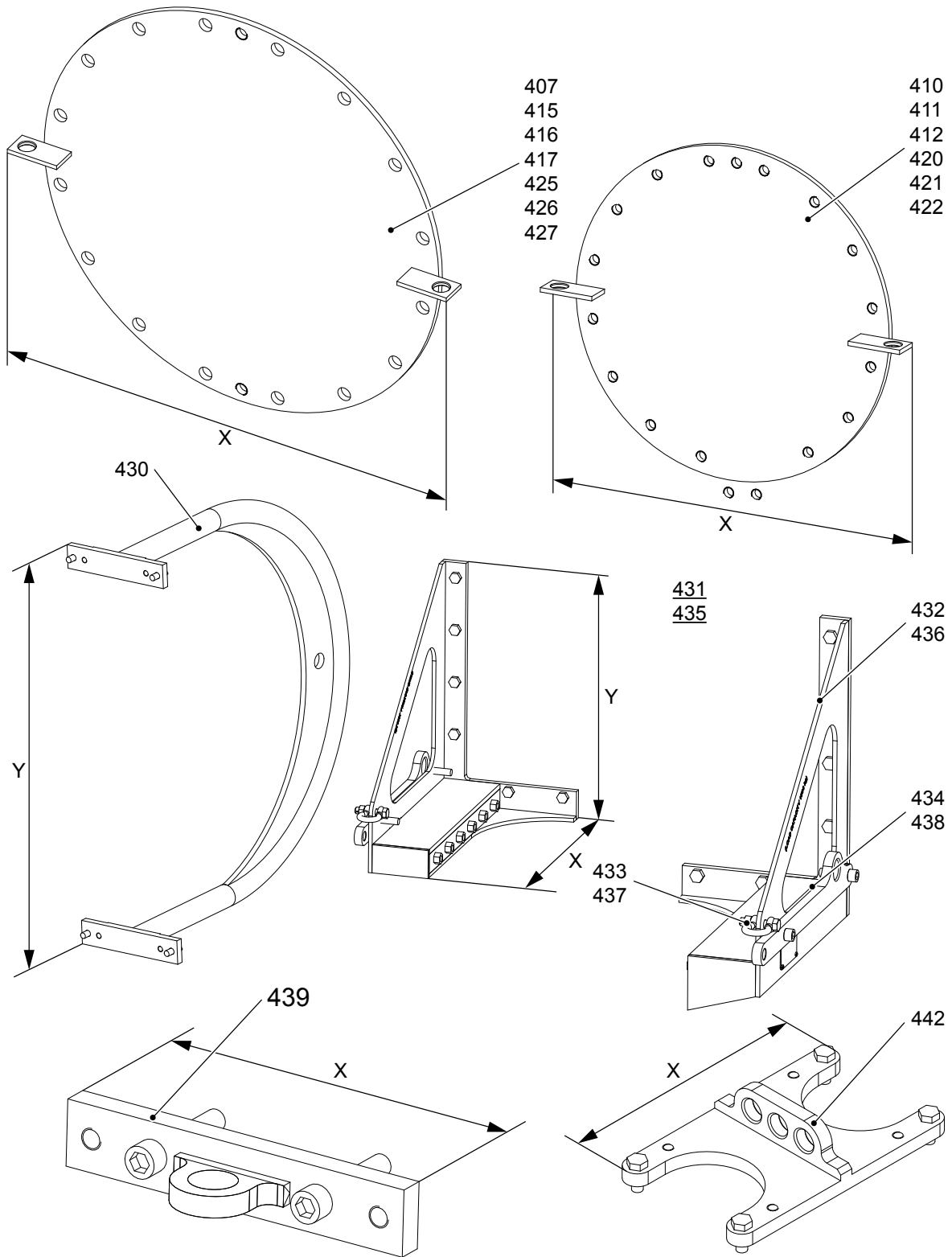




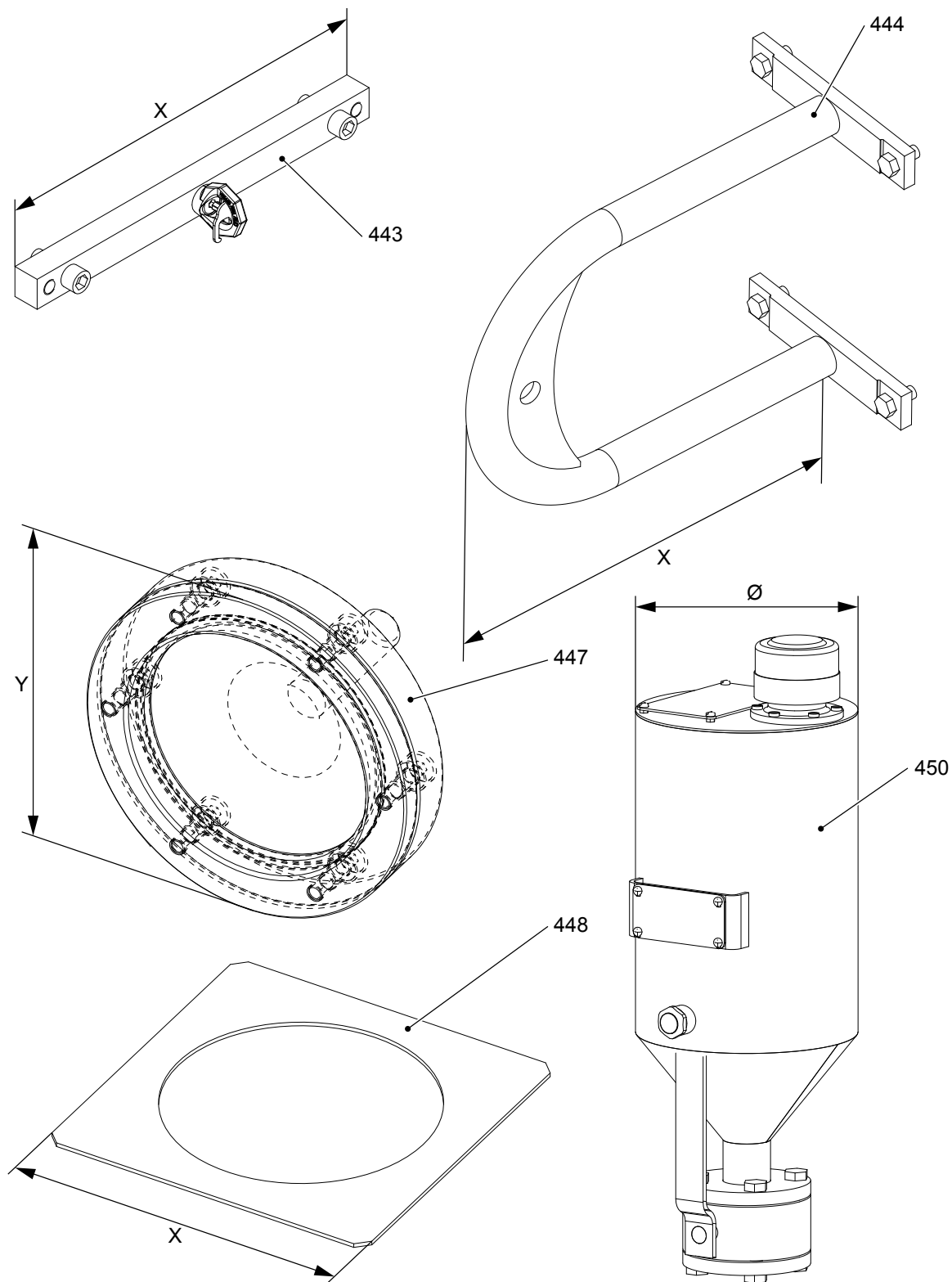


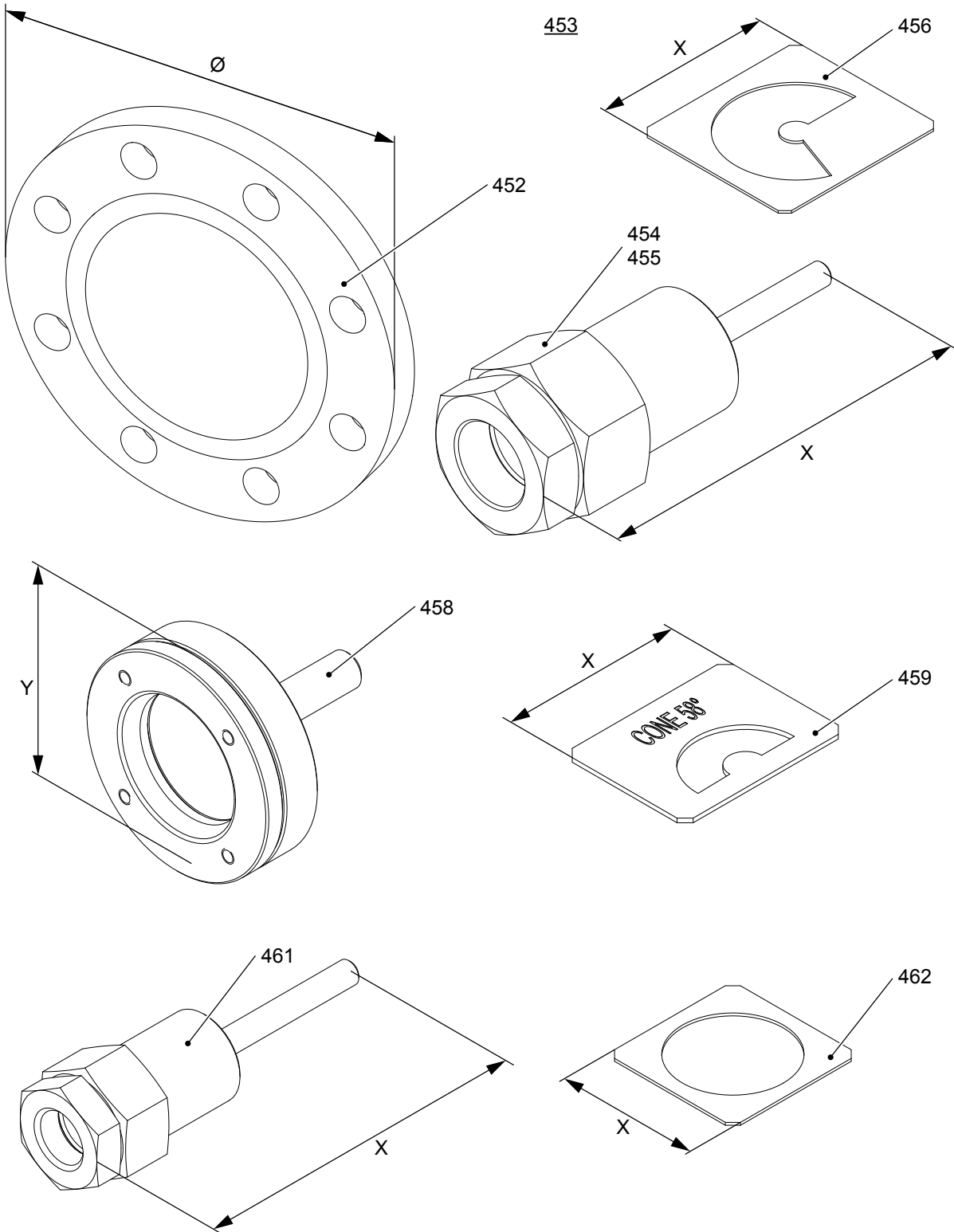


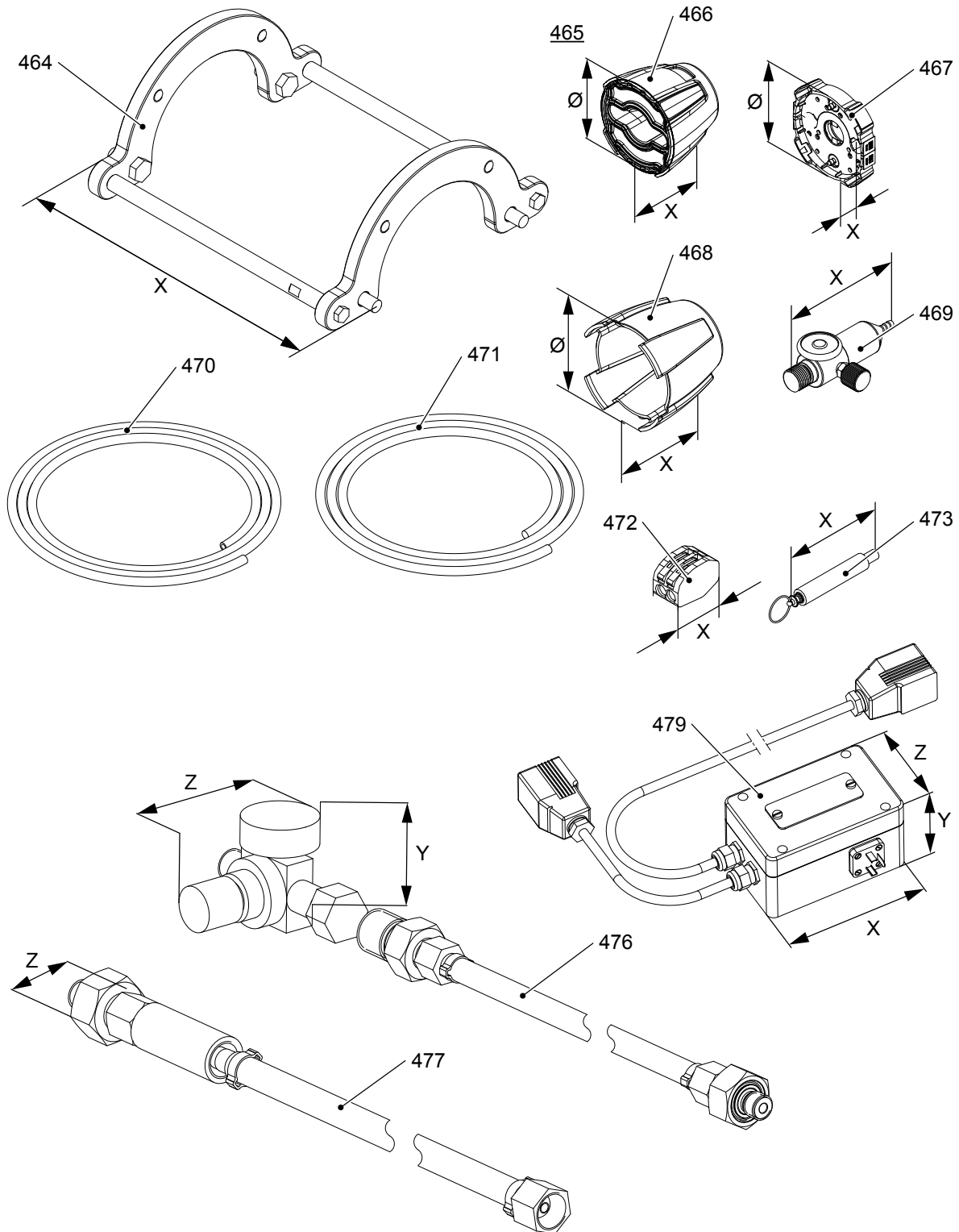












Pos.	Ind.	Part No.	Quantity	Description	Remark
nil	1	-		<b>Tool general combination wrench</b>	-
001	2	TN 94402	1 Piece	Combination wrench	-
002	3	94000-6	1 Piece	Combination wrench	SW6
003	3	94000-7	1 Piece	Combination wrench	SW7
004	3	94000-8	1 Piece	Combination wrench	SW8
005	3	94000-9	1 Piece	Combination wrench	SW9
006	3	94000-10	1 Piece	Combination wrench	SW10
007	3	94000-11	1 Piece	Combination wrench	SW11
008	3	94000-12	1 Piece	Combination wrench	SW12
009	3	94000-13	1 Piece	Combination wrench	SW13
010	3	94000-14	1 Piece	Combination wrench	SW14
011	3	94000-15	1 Piece	Combination wrench	SW15
012	3	94000-16	1 Piece	Combination wrench	SW16
013	3	94000-17	1 Piece	Combination wrench	SW17
014	3	94000-18	1 Piece	Combination wrench	SW18
015	3	94000-19	1 Piece	Combination wrench	SW19
016	3	94000-20	1 Piece	Combination wrench	SW20
017	3	94000-21	1 Piece	Combination wrench	SW21
018	3	94000-22	1 Piece	Combination wrench	SW22
019	3	94000-23	1 Piece	Combination wrench	SW23
020	3	94000-24	1 Piece	Combination wrench	SW24
021	3	94000-25	1 Piece	Combination wrench	SW25
022	3	94000-26	1 Piece	Combination wrench	SW26
023	3	94000-27	1 Piece	Combination wrench	SW27
024	3	94000-28	1 Piece	Combination wrench	SW28
025	3	94000-29	1 Piece	Combination wrench	SW29
026	3	94000-30	1 Piece	Combination wrench	SW30
027	3	94000-32	1 Piece	Combination wrench	SW32
028	2	TN 94403	1 Piece	Combination wrench	-
029	3	94000-34	1 Piece	Combination wrench	SW34
030	3	94000-36	1 Piece	Combination wrench	SW36
031	3	94000-38	1 Piece	Combination wrench	SW38
032	3	94000-41	1 Piece	Combination wrench	SW41
033	3	94000-46	1 Piece	Combination wrench	SW46
034	3	94000-50	1 Piece	Combination wrench	SW50
035	3	94000-55	1 Piece	Combination wrench	SW55
036	3	94000-60	1 Piece	Combination wrench	SW60
037	3	94000-65	1 Piece	Combination wrench	SW65
038	2	TN 94276	1 Piece	Combination wrench	-
039	3	94001-70	1 Piece	Wrench open end	-
040	3	94001-85	1 Piece	Wrench open end	-
041	3	94001-110	1 Piece	Wrench open end	-
042	1	<b>TN 94393</b>		<b>Tool gen. ring slugging wrench</b>	-
043	2	TN 94404	1 Piece	Tool gen. ring slugging wrench	-
044	3	94002-27	1 Piece	Slugging wrench/ ring	AF27
045	3	94002-30	1 Piece	Slugging wrench/ ring	AF30
046	3	94002-32	1 Piece	Slugging wrench/ ring	AF32
047	3	94002-36	1 Piece	Slugging wrench/ ring	AF36

Pos.	Ind.	Part No.	Quantity	Description	Remark
048	3	94002-41	1 Piece	Slugging wrench/ ring	AF41
049	3	94002-46	1 Piece	Slugging wrench/ ring	AF46
050	3	94002-50	1 Piece	Slugging wrench/ ring	AF50
051	3	94002-55	1 Piece	Slugging wrench/ ring	AF55
052	3	94002-60	1 Piece	Slugging wrench/ ring	AF60
053	3	94002-65	1 Piece	Slugging wrench/ ring	AF65
054	3	94002-70	1 Piece	Slugging wrench/ ring	AF70
055	3	94002-85	1 Piece	Slugging wrench/ ring	AF85
056	3	TN 94405	1 Piece	Slugging wrench/ ring	AF110
nil	1	-		<b>Tool general allen key</b>	-
058	2	94003	1 Piece	Special hexagon socket screw key	
059	3	94003-2	1 Piece	Special hexagon socket screw key	AF2
060	3	94003-2.5	1 Piece	Special hexagon socket screw key	AF2,5
061	3	94003-3	1 Piece	Special hexagon socket screw key	AF3
062	3	94003-4	1 Piece	Special hexagon socket screw key	AF4
063	3	94003-5	1 Piece	Special hexagon socket screw key	AF5
064	3	94003-6	1 Piece	Special hexagon socket screw key	AF6
065	3	94003-8	1 Piece	Special hexagon socket screw key	AF8
066	3	94003-10	1 Piece	Special hexagon socket screw key	AF10
067	3	94003-12	1 Piece	Special hexagon socket screw key	AF12
068	3	94003-14	1 Piece	Special hexagon socket screw key	AF14
069	3	94003-17	1 Piece	Special hexagon socket screw key	AF17
070	1	<b>94005</b>		<b>Tool general rods</b>	-
071	2	94005-08	1 Piece	Rod	X=200, Ø = 8
072	2	94005-10	1 Piece	Rod	X=200, Ø=10
073	2	94005-15	1 Piece	Rod	X=200, Ø=15
nil	1	-		<b>Tool general pliers</b>	-
075	2	94007-A41	1 Piece	Tool general pliers	1 piece - Type A41
076	2	94007-C8	1 Piece	Tool general pliers	1 Piece - Type C8
077	2	94007-C19	1 Piece	Tool general pliers	1 Piece - Type C19
078	2	94007-C40	1 Piece	Tool general pliers	1 Piece - Type C40
079	2	94007-C85	1 Piece	Tool general pliers	1 Piece - Type C85
080	2	94007-A10	1 Piece	Tool general pliers	1 Piece a Type A10
081	2	94007-A19	1 Piece	Tool general pliers	1 Piece a Type A19
082	2	94007-A40	1 Piece	Tool general pliers	1 Piece a Type A40
083	2	94007-A85	1 Piece	Tool general pliers	1 Piece - Type A85
nil	1	-		<b>Tool general lifting eyebolts</b>	-
nil	2	-	1 Piece	Lifting eye bolt	Complete set
086	3	94045-M10	6 Pieces	Lifting eye bolt	M10
087	3	94045-M12	4 Pieces	Lifting eye bolt	M12
088	3	94045-M16	5 Pieces	Lifting eye bolt	M16
089	3	94045-M20	4 Pieces	Lifting eye bolt	M20
090	3	94045-M24	4 Pieces	Lifting eye bolt	M24
091	3	94045-M30	4 Pieces	Lifting eye bolt	M30
092	3	94045-M48	4 Pieces	Lifting eye bolt	M48
093	2	94009	1 Piece	Handle screw	-
094	3	94009-M6	1 Piece	Handle screw	M6 x 100
095	3	94009-M8	1 Piece	Handle screw	M8 x 100

Pos.	Ind.	Part No.	Quantity	Description	Remark
096	3	94009-M10	1 Piece	Handle screw	M10 x 100
nil	1	=		<b>Tool general jacks/pumps</b>	-
nil	2	-	1 Piece	Hydraulic rams and pumps	-
099	3	94942	1 Piece	Hydraulic unit	Maximum pressure 2000 bar
100	3	94931	1 Piece	High-pressure piston pump	Maximum permitted pressure 2000 bar
101	3	94936	2 Pieces	Hydraulic ram	Maximum pressure 700 bar
102	3	94935	5 Pieces	Flexible hose	with closing valves and coupling sockets X = 2133 mm Operation pressure maximum 2000 bar
103	3	94935A	7 Pieces	Flexible hose	with coupling socket and adapter piece X = 1212 mm Operation pressure maximum 2000 bar
104	3	94934C	1 Piece	Distributing piece	-
105	3	94934	1 Piece	Distributing piece	-
106	3	94934F	1 Piece	Adapter piece	To high-pressure piston pump
107	3	94934K	2 Pieces	Closing valve	To hydraulic ram Maximum pressure 2000 bar
108	3	94934L	2 Pieces	Adapter	To hydraulic ram
109	3	94934A	2 Pieces	Pressure gauge	0 bar to 2000 bar
110	3	94935C	1 Piece	Oil pipe drain	For set-up of pre-tensioning jacks Length = 2000 mm
111	3	94934J	1 Piece	Tredo joint	For lubricating quill opening pressure test
112	3	94934I	1 Piece	Connection nipple	For lubricating quill opening pressure test
113	3	94934H	1 Piece	Pressure gauge	For lubricating quill opening pressure test 0 bar to 25 bar
114	3	94934K	1 Piece	Adapter piece	For the relief valve test
115	3	TN 94277	1 Piece	Adapter piece	-
nil	1	=		<b>Tool general torque wrenches</b>	-
nil	2	-	1 Piece	Torque spanner	-
118	3	94012	1 Piece	Torque spanner	3/4" 1228.5 mm; Torque range = 150 Nm to 750 Nm
119	3	94012A	1 Piece	Adapter piece	3/4" to 1/2"
120	3	94012B	1 Piece	Shell type ratchet	1/2" - 1/2"
121	2	94011A	1 Piece	Torque spanner	1/2" 597 mm; Torque range = 50 Nm to 225 Nm
122	2	94011	1 Piece	Torque spanner	1/2" 476 mm; Torque range = 12 Nm to 68 Nm
123	2	94010	1 Piece	Torque spanner	-
124	3	94010	1 Piece	Torque spanner	3/8" 315 mm; Torque range = 2.5 Nm to 12 Nm
125	3	94010A	1 Piece	Adapter piece	3/8" to 1/2"
nil	1	=		<b>Tool general spanners</b>	-
127	2	TN 94278	1 Piece	Accessory parts	Accessory parts
128	3	94022B-36	1 Piece	Socket wrench insert	3/4" AF36
129	3	94022B-41	1 Piece	Socket wrench insert	3/4" AF41
130	3	94022B-46	1 Piece	Socket wrench insert	3/4" AF46
131	3	94022B-19	1 Piece	Socket wrench insert	AF19
132	3	94022G	1 Piece	Reducer	1/2" - 3/8"

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## Standard tools

Pos.	Ind.	Part No.	Quantity	Description	Remark
133	3	TN 94279	1 Piece	Reducer	-
nil	3	-	1 Piece	Socket wrench insert	-
135	4	94022D-55	1 Piece	Socket wrench insert	AF55
136	4	94022D-70	1 Piece	Socket wrench insert	AF70
137	3	TN 94159	1 Piece	Crowfoot wrench	SW30
138	3	94022D-55	1 Piece	Socket wrench insert	AF55
139	3	94022A-8L	1 Piece	Hex head drivers	AF8 L = 190 mm
140	3	94022D-06	1 Piece	Socket wrench insert	AF06
141	3	94022C-22	1 Piece	Crowfoot wrench	AF22
142	3	94022C-24	1 Piece	Crowfoot wrench	AF24
143	3	94022C-35	1 Piece	Crowfoot wrench	AF35
144	2	94025	1 Piece	Socket wrench set	AF10-24, 26, 27, 28, 30,32, 33, 34, 36
145	2	94026	1 Piece	Hex head drivers	AF5-10, 12, 14, 17
146	2	94022H	1 Piece	Dismantling and assembling tool	AF19
147	2	TN 94334	1 Piece	Assembly tool	AF13
nil	1	-		<b>Tool general pres. measurement</b>	-
149	2	94051	1 Piece	Tool for pressure measurement	Contains: pressure generator 700 bar. HP hose; G 1/4" male connector; 1/4" NPT male connector
150	2	94050	1 Piece	Tool for pressure measurement	-
151	3	94050B	1 Piece	Pressure gauge	0-10 bar
152	3	9450G	1 Piece	Pressure gauge	0-100 bar
153	3	TN 94003	1 Piece	Pressure gauge	0-600 bar
154	3	94050H	2 Pieces	Stop valve	2 pieces
155	3	94050C	1 Piece	Adapter	1 piece
nil	1	-		<b>Tool general chain block</b>	-
nil	2	-	1 Piece	Spur-gear chain block	-
158	3	TN 94405	2 Pieces	Spur-gear chain block	M3 CB 010, X = 373 mm, Y = 896 mm, Z = 192 mm
159	3	94017-2.5-6-5	3 Pieces	Spur-gear chain block	M3 CB 025, X = 373 mm, Y = 896 mm, Z = 192 mm
160	3	94017-5-6-5	2 Pieces	Spur-gear chain block	M3 CB 050, X = 373 mm, Y = 896 mm, Z = 192 mm
161	3	94017-7.5-6-5	2 Pieces	Spur-gear chain block	M3 CB 075, X=373, Y=896, Z=192
nil	2	-	1 Piece	Lever chain hoist	-
163	3	94016-0.8-5.5	2 Pieces	Lever chain hoist	L5 LB 008, X = 159 mm, Y = 457mm, Z = 190mm
164	3	94016-015	2 Pieces	Lever chain hoist	L5 LB 032, X=159, Y=457, Z=190
nil	2	-	1 Piece	Shackle	-
166	3	94018A	4 Pieces	Shackle	WLL 2000 kg, X = 161 mm, Y = 233 mm
167	3	94018B	4 Pieces	Shackle	WLL 3250 kg, X = 161 mm, Y = 233 mm
168	3	94018C	4 Pieces	Shackle	WLL 4750 kg, X = 161 mm, Y = 233 mm
169	3	94018D	4 Pieces	Shackle	WLL 6500 kg, X = 161 mm, Y = 233 mm
170	3	94018E	4 Pieces	Shackle	WLL 8500 kg, X = 161 mm, Y = 233 mm

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Pos.	Ind.	Part No.	Quantity	Description	Remark
171	3	94019N	2 Pieces	Shackle	WLL 12000 kg, X = 161 mm, Y = 233 mm
172	3	94019P	4 Pieces	Shackle	WLL 13000 kg, X = 161 mm, Y = 233 mm
nil	2	-	1 Piece	Trolley	-
174	3	TN 94406	3 Pieces	Trolley	TSP020C, X = 794 mm, Y = 409 mm, Z = 542mm
175	3	94015-008	2 Pieces	Trolley	TSG075, X = 794 mm, Y = 409 mm, Z = 542mm
nil	2	-	1 Piece	Chain	-
177	3	94019A	1 Piece	Chain	Symmetric; 1089 mm
178	2	TN 94407	1 Piece	Ring	WLL (A, B, C): 23,200, 100, 6500kg
179	2	94039-057	1 Piece	Round sling	X = 8000 mm
nil	2	-	1 Piece	Deviation pipe	-
181	3	94117B	2 Pieces	Deviation pipe	for removal and installation of: main bearing, cover, shell etc.; X = 400 mm
182	3	TN 94407	2 Pieces	Plate	-
183	3	TN 94408	4 Pieces	Hexagon socket head cap screw	-
nil	1	-		<b>Tool special lifting points</b>	-
185	2	94048	1 Piece	Swivel lug	-
186	3	94048-M30	6 Pieces	Swivel lug	M30
nil	1	-		<b>Personal safety equipment</b>	-
188	2	TN 94100	1 Piece	Self-retracting lifeline	-
189	2	TN 94096	1 Piece	Carbine hook	-
190	2	TN 94280	2 Pieces	Round sling	-
191	2	TN 94281	1 Piece	Protection	-
192	2	TN 94282	1 Piece	Eye bolt	-
nil	1	-		<b>Tool main bearing assembly (JIS)</b>	-
194	2	TN 94283	1 Piece	Remov./ fitting of bearing cover	-
195	3	94117	1 Piece	Roller support	for removal and installation of main bearing cover; X = 160 mm; (WLL 1200 kg)
196	3	94117A	1 Piece	Deviation pipe	for removal and installation of: main bearing, cover, shell etc.; X = 600 mm
197	3	TN 94283	1 Piece	Dismantling tool	Y = 3360 mm
198	3	TN 94284	1 Piece	Dismantling tool	Y = 3360 mm
199	3	TN 94285	1 Piece	Lifting tool	X = 196 mm, WLL 110Kg
200	3	TN 94286	1 Piece	Lifting plate	X = 384 mm
201	3	TN 94287	1 Piece	Lifting lug	X = 100 mm
nil	1	-		<b>Tool main bearing measuring (ISO)</b>	-
203	2	94122	1 Piece	Feeler gauge	13 blades from 0.05 mm to 1.0 mm; X = 100 mm
204	2	94126	1 Piece	Depth gauge with case	X = 310 mm; measuring range: 0 mm to 200 mm
nil	2	-	1 Piece	Bearing feeler gauge	-
206	3	94123	1 Piece	Bearing feeler gauge	X = 620 mm; Z = 170 mm; with case
207	3	94123B	1 Piece	Bearing feeler gauge	X = 620 mm; Z = 130 mm; with case
nil	1	-		<b>Tool main bearing pre-tensioning</b>	-
209	2	TN 94409	4 Pieces	Pre-tensioner	Max working pressure 1800 bar
210	2	TN 94410	1 Piece	Thrust device	X = 1035 mm



Pos.	Ind.	Part No.	Quantity	Description	Remark
nil	1	-		<b>Tool main bearing shell assembly (CrankshaftDesign: CS.07.1.01,CS.07.1.04,CS.07.1.03,CS.07.1.02)</b>	-
212	2	TN 94411	1 Piece	Bracket	X = 1250 mm, Y = 467 mm, FCV1+2
nil	1	-		<b>Tool main bearing shell assembly (CrankshaftDesign: CS.07.1.05,CS.07.1.06 )</b>	-
214	2	TN 94412	1 Piece	Bracket	X = 1250 mm, Y = 467 mm, FCV1+4
nil	1	-		<b>Tool foundation pre-tensioning</b>	-
216	2	TN 94413	1 Piece	Pre-tensioner	Max working pressure 1800 bar
nil	1	-		<b>Tool thrust bearing assembly</b>	-
218	2	TN 94414	1 Piece	Carrier	X = 400 mm, Y = 146 mm
nil	1	-		<b>Tool column working support (CrankshaftDesign: CS.07.1.03,CS.07.1.01,CS.07.1.02,CS.07.1.04)</b>	-
220	2	TN 94415	1 Piece	Platform	X = 1980 mm
221	2	TBD	1 Piece	Platform	X = 1430 mm
nil	1	-		<b>Tool column working support (CrankshaftDesign: CS.07.1.03,CS.07.1.01,CS.07.1.02,CS.07.1.04)</b>	-
223	2	TN 94416	1 Piece	Platform	X = 2110 mm
224	2	TBD	1 Piece	Platform	X = 1430 mm
nil	1	-		<b>Tool tie rod pre-tensioning</b>	-
226	2	TN 94417	2 Pieces	Pre-tensioner	Ø = 354 mm, Max working pressure 1800 bar
nil	1	-		<b>Tool cylinder liner assembly</b>	-
nil	2	-	1 Piece	Lifting tool	-
229	3	TN 94418	1 Piece	Lifting tool	X = 1503 mm, WLL 11000 kg
230	3	TN 94419	2 Pieces	Chain	-
231	3	TN 94111	2 Pieces	Shackle	-
232	3	TN 94420	1 Piece	Pad	-
233	2	TN 94421	1 Piece	Dismantling tool	X = 143 mm
nil	1	-		<b>Tool cylinder liner measuring</b>	-
235	2	TN 94422	1 Piece	Measuring device	Y = 3100 mm
236	2	TN 94423	1 Piece	Ladder	Y = 3800 mm
237	2	94101	1 Piece	Inside micrometer	Set complete (7 pieces); Measuring range = 50 mm to 1010 mm
nil	1	-		<b>Tool gas admission valve</b>	-
239	2	TN 94059	1 Piece	Measuring tool	-
240	3	TN 94230	1 Piece	Measuring tool	-
241	3	TN 94264	1 Piece	Hose	-
242	3	TN 94265	1 Piece	Hose	-
243	3	TN 94266	1 Piece	Pipe	-
244	2	TN 94424	1 Piece	Dismantling and assembling tool	X = 306.5 mm
245	3	TN 94425	1 Piece	Dismantling and assembling tool	-
246	3	94214D	1 Piece	Dismantling and assembling tool	-
247	3	TN 94426	1 Piece	Bush	-
248	3	94214A	1 Piece	Handle	-

Pos.	Ind.	Part No.	Quantity	Description	Remark
249	3	94214B	1 Piece	Pressure reducing valve	X = 220 mm
250	3	94214L	2 Pieces	Screw	-
251	3	94214M	2 Pieces	Hexagon nut	M10
252	3	TN 94427	2 Pieces	Hexagon head screw with dog point	-
nil	2	-	1 Piece	Plug	-
254	3	TN 94428	1 Piece	Plug	X = 167 mm
255	3	TN 94062	1 Piece	Hydraulic pipe gas valve	Y = 100 mm
256	3	TN 94429	1 Piece	Blind flange square	X = 70 mm
257	2	TN 94430	1 Piece	Lifting tool	X = 238 mm
258	2	TN 94222	1 Piece	Socket wrench insert	-
259	3	TN 94223	1 Piece	Socket wrench insert	Y = 220 mm
nil	1	-	-	<b>Tool gland box assembly</b>	-
nil	2	-	1 Piece	Tool gland box assembly	Ø = 424 mm
262	3	TN 94431	2 Pieces	Clamping ring	Ø = 424 mm
263	3	TN 94432	10 Pieces	Distance piece	Ø = 424 mm
264	3	TN 94433	1 Piece	Template	-
265	2	TN 94434	1 Piece	Covering	Ø = 594 mm
266	2	TN 94435	1 Piece	Distance	Y = 735 mm
267	2	TN 94290	2 Pieces	Assembly tool	Y = 150 mm
nil	1	-	-	<b>Tool cyl. cover/exh. valve assy.</b>	-
269	2	TN 94436	1 Piece	Removal of cylinder cover	X = 970 mm
270	2	TN 94437	1 Piece	Support	Ø = 1547 mm, Y = 1750 mm
271	2	TN 94438	1 Piece	Assy and dismantling device	M12
nil	1	-	-	<b>Tool injection valve grinding</b>	-
273	2	TN 94064	1 Piece	Regrinding device	X = 185 mm
274	3	TN 94439	1 Piece	Stencil	-
275	2	TN 94440	1 Piece	Regrinding device	X = 153 mm
276	3	TN 94441	1 Piece	Stencil	-
277	2	TN 94065	1 Piece	Regrinding device	X = 130 mm
278	3	TN 94442	1 Piece	Stencil	-
nil	1	-	-	<b>Tool injector test bench (FuelInjectorValve (obsolete): FAST)</b>	<b>Fuel Injector Valve (obsolete): FAST</b>
nil	2	-	1 Piece	Tool injector test bench	Y = 1496 mm
281	2	TN 94067	1 Piece	Assembly tool	Ø = 130 mm; Y = 196.5 mm
282	2	TN 94068	1 Piece	Assembly tool	X = Ø 17 mm, Y = 120 mm
nil	1	-	-	<b>Tool injector test bench (FuelInjectorValve (obsolete): NON-FAST)</b>	<b>Fuel Injector Valve (obsolete): NON-FAST</b>
nil	2	-	1 Piece	Tool injector test bench	Y = 1496 mm
285	2	TN 94067	1 Piece	Assembly tool	Ø = 130 mm; Y = 196.5 mm
286	2	TN 94068	1 Piece	Assembly tool	X = Ø 17 mm, Y = 120 mm
nil	1	-	-	<b>Tool cyl. cover pre-tensioning</b>	-
288	2	TN 94443	1 Piece	Lifting tool	X = 1508 mm
289	2	TN 94444	8 Pieces	Pre-tensioner	Y = 342 mm, Max working pressure 1800 bar
nil	1	-	-	<b>Tool valve cage pre-tensioning</b>	-
291	2	TN 94445	2 Pieces	Pre-tensioner	Y = 362 mm, Max working pressure 1800 bar
nil	1	-	-	<b>Tool valve seat assembly</b>	-

Pos.	Ind.	Part No.	Quantity	Description	Remark
293	2	TN 94446	1 Piece	Dismantling and assembling tool	X = 680 mm, Z = 670 mm
nil	1	-		<b>Tool exhaust valve failure</b>	-
295	2	TN 94447	1 Piece	Pressure element	X = 270 mm
nil	1	-		<b>Tool exhaust valve grinding</b>	-
297	2	TN 94448	1 Piece	Template	Y = 175 mm, X = 140 mm
298	2	TN 94449	1 Piece	Template	Y = 310 mm, X = 270
nil	1	-		<b>Tool injection valve assembly</b>	-
nil	2	-	1 Piece	Tool injection valve assembly	-
301	3	TN 94450	1 Piece	Supporting plate	X = 110 mm
302	3	TN 94071	2 Pieces	Stud bolt	Y = 173 mm; M12
nil	1	-		<b>Tool injection nozzle assembly (FuelinjectorValve (obsolete): FAST)</b>	-
304	2	94278B	1 Piece	Assembly tool	X = Ø 64 mm
305	2	94278A	1 Piece	Disassembling tool	X = Ø 60 mm
nil	1	-		<b>Tool crankshaft measuring</b>	-
307	2	94305	1 Piece	Crankshaft checking equipment	For measuring crank deflection (in wooden box); X = 364 mm
nil	1	-		<b>Tool turning gear pre-tensioning</b>	-
309	2	TN 94451	1 Piece	Pre-tensioner	Y=151, X = Ø 130 mm
nil	1	-		<b>Tool connec. rod pre-tensioning</b>	-
311	2	TN 94452	2 Pieces	Pre-tensioner	X = Ø 190 mm, Y = 301 mm
312	2	TN 94453	2 Pieces	Pre-tensioner	X = Ø 154 mm, Y = 209 mm
nil	1	-		<b>Tool connecting rod assembly</b>	-
314	2	TN 94454	1 Piece	Cover and lifting plate	X = 400 mm, Y = 298, Z = 441 mm
315	2	TN 94455	2 Pieces	Support	X = 300, Y = 510 mm
316	2	94231	1 Piece	Link	X = 341, Y = 299 mm, Z = 184
317	2	94235	1 Piece	Chain	Y = 562 mm
318	2	TN 94456	1 Piece	Fixing device	X = 850 mm, Y = 50
nil	1	-		<b>Tool crosshead bearing lubr.</b>	-
320	2	94336	1 Piece	Re-lubrication	Ø = 150 mm
nil	1	-		<b>Tool connecting rod assembly</b>	-
322	2	TN 94346	2 Pieces	Lifting tool	X = 251 mm, Y = 551 mm
323	2	TN 94347	1 Piece	Tool connecting rod assembly	X = 1345 mm, Y = 1678 mm
324	2	TN 94348	1 Piece	Tool connecting rod assembly	X = 288 mm, Y = 119 mm, Z = 103 mm
nil	1	-		<b>Tool connec. rod bear. inspect.</b>	-
326	2	TN 94457	1 Piece	Stop plate	X = 130, Y = 76 mm, Z = 185 mm
nil	1	-		<b>Tool connec. rod bearing assy</b>	-
328	2	94333	1 Piece	Lifting tool	WLL 4000 kg
329	3	94333A	2 Pieces	Lifting tool	X = 265 mm, with screws M24x70
nil	1	-		<b>Tool bear. shell crank pin assy</b>	-
331	2	TN 94458	1 Piece	Fitting and dismantling device	X = 1276 mm, Y = 532 mm
332	2	TN 94459	1 Piece	Bracket	X = 872 mm, Y = 92 mm
333	2	TN 94460	1 Piece	Chain	Y = 1004 mm
nil	1	-		<b>Tool piston assembly</b>	-
335	2	TN 94461	1 Piece	Piston support/dismant.gland box	X = 1200 mm, Y = 1074 mm
336	2	TN 94462	1 Piece	Dismantling and assembling tool	X = 741 mm
337	2	TN 94029	1 Piece	Wire rope sling with hook	-
338	2	TN 94463	1 Piece	Dismantling tool	X = 732 mm

Pos.	Ind.	Part No.	Quantity	Description	Remark
339	2	TN 94464	1 Piece	Lifting tool	X = 669 mm
nil	1	-		<b>Tool piston-/rod/crosshd.pretens</b>	-
341	2	TN 94465	3 Pieces	Pre-tensioner	Ø = 86 mm, Y = 153 mm
342	2	TN 94466	2 Pieces	Pre-tensioner	Ø = 90 mm, Y = 210 mm
nil	1	-		<b>Tool piston measuring</b>	-
344	2	94348	1 Piece	Tab	-
345	2	TN 94467	1 Piece	Jacking screw	M24
346	2	TN 94468	1 Piece	Template	X = 916 mm
347	2	TN 94469	1 Piece	Template	X = 1009.7 mm
nil	1	-		<b>Tool piston ring assembly</b>	-
349	2	TN 94470	1 Piece	Piston ring fitting tool	X = 400 mm, Y = 324 mm
nil	1	-		<b>Tool intermediate wheel assembly</b>	-
351	2	94410	1 Piece	Adjusting gear	X = 227 mm
nil	1	-		<b>Tool supply unit assembly</b>	-
nil	2	-	1 Piece	Tool camshaft assembly	-
354	3	94566	1 Piece	Supporting device	X = 835 mm
355	3	TN 94471	1 Piece	Supporting device	X = 835 mm
356	3	94566B	3 Pieces	Holder	Y = 172 mm
357	3	94566C	1 Piece	Holder	Y = 172 mm
nil	2	-	3 Pieces	Roller lifting tool	-
359	3	TN 94472	1 Piece	Elastic bolt	Y = 300 mm
360	3	94569	1 Piece	Flange	X = Ø 116 mm
361	3	94569A	1 Piece	Flange	X = Ø 120 mm
nil	2	-	1 Piece	Tool camshaft assembly	-
363	3	94567	1 Piece	Assembly template	Y = 184.5 mm
364	3	94567A	1 Piece	Jacking screw	X = 209 mm
365	3	TN 94473	1 Piece	Plate	X = 102 mm
nil	1	-		<b>Tool fuel pump assembly</b>	-
nil	2	-	1 Piece	Pre-tensioning device	-
368	3	94551	1 Piece	Pre-tensioning device	X = 334 mm
369	3	94593	1 Piece	Tool fuel pump assembly	X = Ø 370 mm
370	4	94593A	1 Piece	Ring	-
371	5	TN 94261	1 Piece	Ring	-
372	5	94593C	1 Piece	Ring	-
373	4	94593C	2 Pieces	Guide rod	M30x110
374	4	94593E	2 Pieces	Hexagon head bolt	M12x130 with special nuts
375	4	94593D	4 Pieces	Hexagon head bolt	X = Ø 70 mm
376	3	94597	1 Piece	Mandrel	X = Ø 70 mm 9 to 12 cyl. 8 pieces
377	3	94592M	1 Piece	Tool	Mirror
378	2	94555	4 Pieces	Distance piece	X = 95 mm 9 to 12 cyl. 8 pieces
379	2	94552	1 Piece	Lifting tool	X = Ø 120 mm
380	2	TN 94474	1 Piece	Fitting and dismantling device	Y = 935 mm, X = 550 mm
381	3	TN 94475	1 Piece	Support	-
382	3	TN 94476	1 Piece	Oil trough	-
383	3	TN 94477	2 Pieces	Plate	-
384	3	94592C	2 Pieces	Screw	-
385	3	TN 94478	2 Pieces	Hexagon head screw with dog point	-
386	3	94592D	4 Pieces	Hexagon head screw	-

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Pos.	Ind.	Part No.	Quantity	Description	Remark
387	2	94553	2 Pieces	Rod	X = 470 mm
nil	2	-	1 Piece	Pneumatic impact wrench	-
389	3	94598	1 Piece	Pneumatic impact wrench	X = 271 mm
390	3	94598A	2 Pieces	Extension	X = 400 mm
391	3	94598B	1 Piece	Socket wrench insert	X = 100 mm
392	2	94550	1 Piece	Tool fuel pump assembly	X = Ø 210 mm Two part clamping ring
nil	1	-		<b>Tool rail unit maintenance</b>	-
nil	2	-	1 Piece	Instructions	-
395	3	TN 94479	1 Piece	Adjusting device	Y = 954 mm
nil	1	-		<b>Tool supply unit maintenance</b>	-
397	2	TN 94075	1 Piece	Assembly tool	X = 181 mm
398	3	TN 94164	1 Piece	Flange	X = 180 mm
399	3	TN 94165	1 Piece	Holder	Y = 211 mm
nil	1	-		<b>Tool supply unit pre-tensioning</b>	-
401	2	TN 94480	2 Pieces	Pre-tensioner	X = Ø 90 mm, Y = 146.5 mm
nil	1	-		<b>Tool auxiliary blower assembly</b>	-
403	2	TN 94481	1 Piece	Round sling	X = 2000 mm
404	2	94651	1 Piece	Lifting tool	Y = 1094 mm
nil	1	-		<b>Tool tc failure ABB A275</b>	-
406	2	TN 94239	1 Piece	Arrangement of covers	-
407	3	TN 94240	1 Piece	Cover	X = 800 mm, 16 holes, Cover to exhaust manifold outlet & TC inlet
nil	1	-		<b>Tool tc failure ABB A175</b>	-
nil	2	-	1 Piece	Arrangement of covers	-
410	3	TN 94234	2 Pieces	Cover	X = 820 mm, Cover to exhaust manifold and TC inlet
411	3	TN 94482	2 Pieces	Cover	X = 607 mm, Cover to TC outlet
412	3	94653B-A175	1 Piece	Cover	X = 630 mm, Cover to scavenge air receiver inlet
nil	1	-		<b>Tool tc failure ABB A275</b>	-
nil	2	-	1 Piece	Arrangement of covers	-
415	3	TN 94198	2 Pieces	Cover	X = 820 mm, Cover to exhaust manifold and TC inlet
416	3	TN 94240	2 Pieces	Cover	X = 607 mm, Cover to TC outlet
417	3	TN 94200	1 Piece	Cover	X = 630 mm, Cover to scavenge air receiver inlet
nil	1	-		<b>Tool tc failure ABB A175</b>	-
nil	2	-	1 Piece	Arrangement of covers	-
420	3	94653C-A175	4 Pieces	Cover	X = 697 mm, Cover to scavenge air receiver inlet
421	3	TN 94482	3 Pieces	Cover	X = 697 mm, Cover to scavenge air receiver inlet
422	3	94653B-A175	2 Pieces	Cover	X = 697 mm, Cover to scavenge air receiver inlet
nil	1	-		<b>Tool tc failure ABB A275</b>	-
424	2	TN 94034	1 Piece	Arrangement of covers	-
425	3	TN 94198	4 Pieces	Cover	X = 820 mm, Cover to exhaust manifold and TC inlet
426	3	TN 94240	3 Pieces	Cover	X = 607 mm, Cover to TC outlet

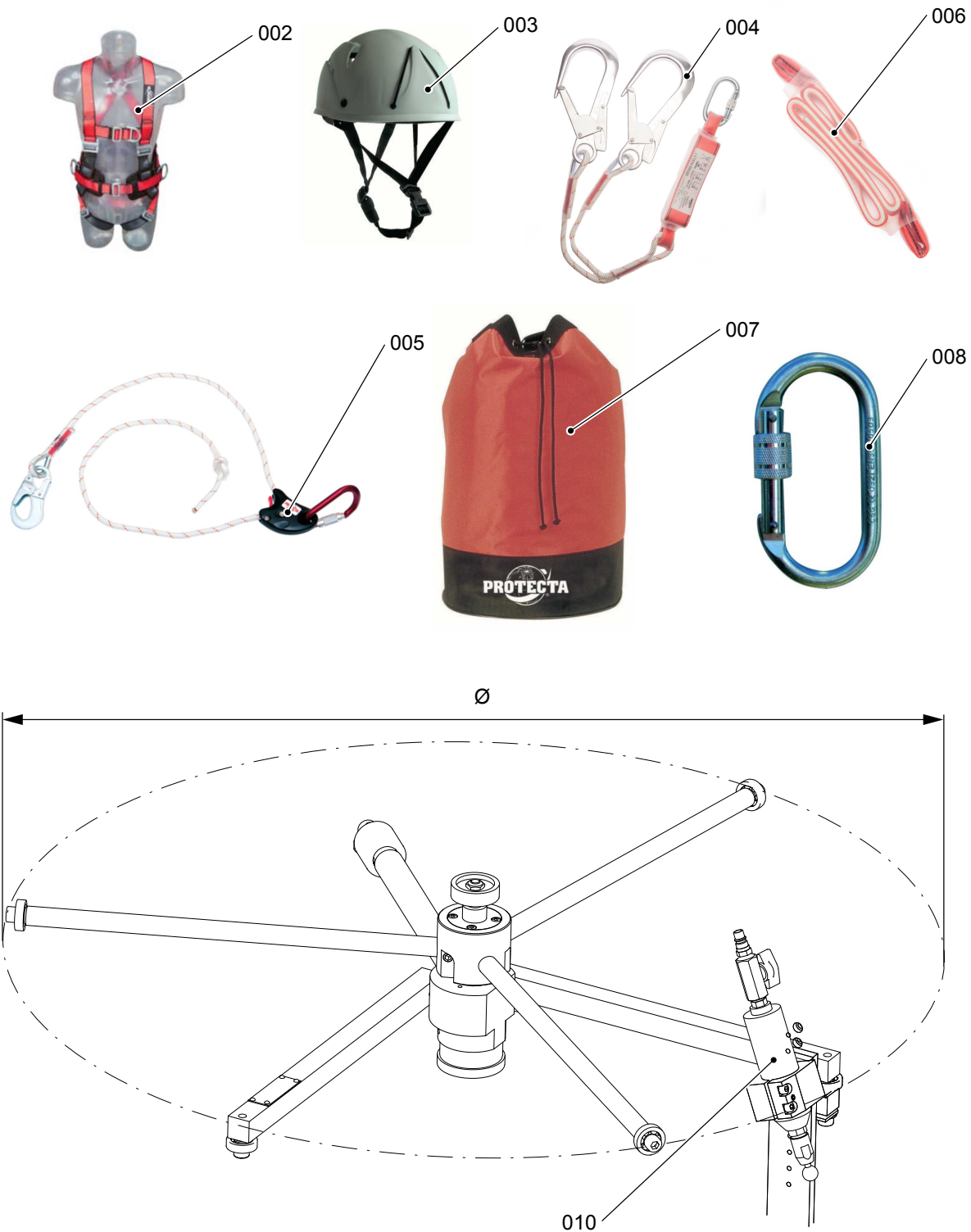
Pos.	Ind.	Part No.	Quantity	Description	Remark
427	3	TN 94200	2 Pieces	Cover	X = 630 mm, Cover to scavenge air receiver inlet
nil	1	-		<b>Tool sac assembly</b>	-
nil	2	-	1 Piece	Tool sac assembly	-
430	3	TN 94483	1 Piece	Tool sac assembly	Y = 1140 mm
431	3	TN 94484	1 Piece	Tool sac assembly	-
432	4	TN 94485	1 Piece	Support	Y = 640 mm, X = 575 mm
433	4	TN 94486	1 Piece	Chain	X = 2396 mm
434	4	TN 94487	1 Piece	Plate	-
435	3	TN 94488	1 Piece	Tool sac assembly	-
436	4	TN 94489	1 Piece	Support	Y = 640 mm, X = 575 mm
437	4	TN 94486	1 Piece	Chain	X = 2396 mm
438	4	TN 94487	1 Piece	Plate	-
439	3	TN 94492	2 Pieces	Dismantling tool	X = 276 mm
nil	1	-		<b>Tool water separator assembly</b>	-
nil	2	-	1 Piece	Tool water separator assembly	-
442	3	TN 94490	3 Pieces	Lifting tool	X = 300 mm
443	3	TN 94491	1 Piece	Dismantling tool	X = 448 mm
444	3	TN 94493	1 Piece	Assembly tool	X = 548 mm
nil	1	-		<b>Tool servo oil pipe grinding</b>	-
446	2	94841	1 Piece	Regrinding device	Y = 85 mm R100.5
447	3	TN 94494	1 Piece	Grinding device	-
448	3	94841A	1 Piece	Stencil	X = 85 mm
nil	1	-		<b>Tool supply unit lubrication</b>	-
450	2	TN 94495	1 Piece	Tool supply unit lubrication	X = Ø 200 mm
nil	1	-		<b>Tool air pipes failure</b>	-
452	2	TN 94496	1 Piece	Blind flange	X = Ø 280 mm
nil	1	-		<b>Tool fuel pipe grinding</b>	-
454	2	94870	1 Piece	Regrinding device	-
455	3	TN 94497	1 Piece	Regrinding device	-
456	3	94870H	1 Piece	Stencil	-
nil	2	-	1 Piece	Regrinding device	-
458	3	TN 94359	1 Piece	Grinding device	-
459	3	TN 94360	1 Piece	Stencil	-
nil	2	-	1 Piece	Regrinding device	-
461	3	TN 94361	1 Piece	Grinding device	-
462	3	TN 94247	1 Piece	Stencil	-
nil	1	-		<b>Tool gas pipe assembly</b>	-
464	2	TN 94498	1 Piece	Dismantling and assembling tool	X = 303 mm
465	2	TN 94081	1 Piece	Gas detector	-
466	3	TN 94365	1 Piece	Splash guard	Ø = 85 mm, X = 76 mm
467	3	TN 94366	1 Piece	Indicator	Ø = 86 mm, X = 19 mm
468	3	TN 94367	1 Piece	Adapter	Ø = 102.6 mm, X = 93.5 mm
469	3	TN 94368	1 Piece	Regulating valve	X = 94 mm
470	3	TN 94369	1 Piece	Cable	Length = 2.0 m
471	3	TN 94370	1 Piece	Hose	Length = 1.5 m
472	3	TN 94371	5 Pieces	2 conductor terminal block	ports = 2 ; X = 20.5 mm
473	3	TN 94372	1 Piece	Magnet	X = 67 mm

Maintenance Manual

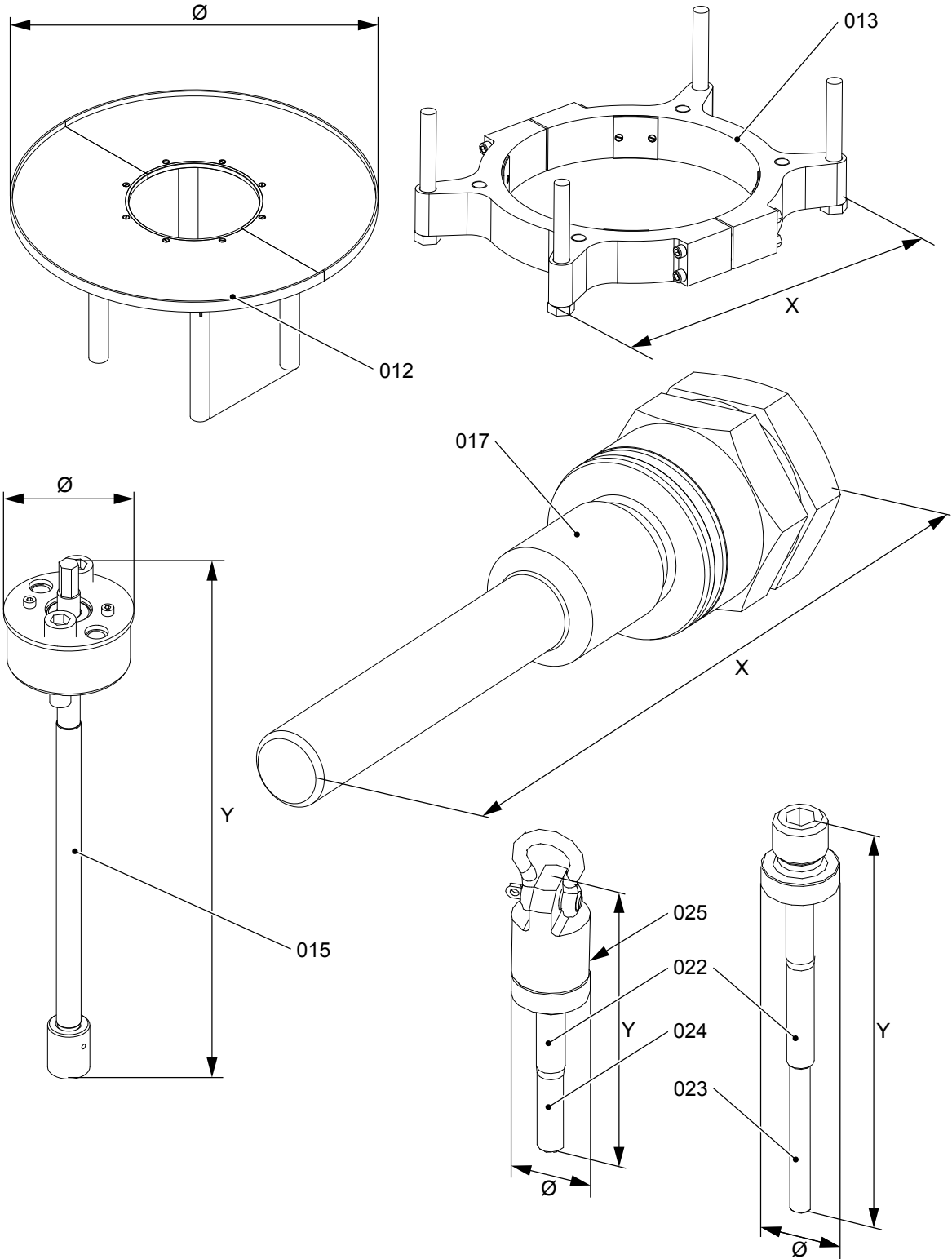
Standard tools

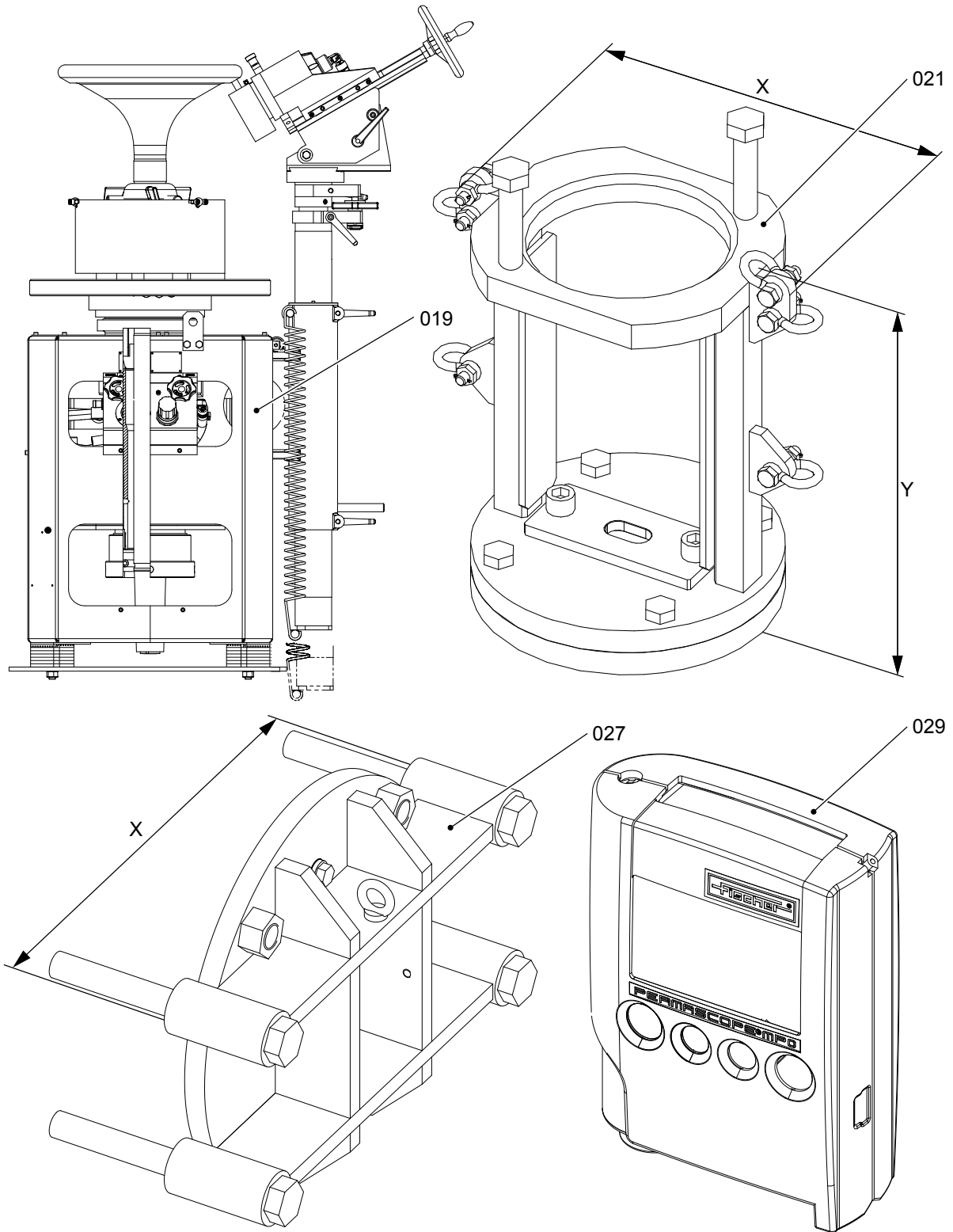
Pos.	Ind.	Part No.	Quantity	Description	Remark
nil	1	-		<b>Tool for igpr (GasPressureRegulation: IGPR)</b>	-
nil	2	-	1 Piece	Gas pressure regulation	-
476	3	TN 94276	1 Piece	Hose	Y = 55 mm, Z = 75 mm
477	3	TN 94279	1 Piece	Hose	Z = 31.2 mm
nil	1	-		<b>Tool emergency cyl. lubrication</b>	-
479	2	94929	1 Piece	Connecting cable with plug	X = 130 mm , Y = 72 mm, Z = 82 mm

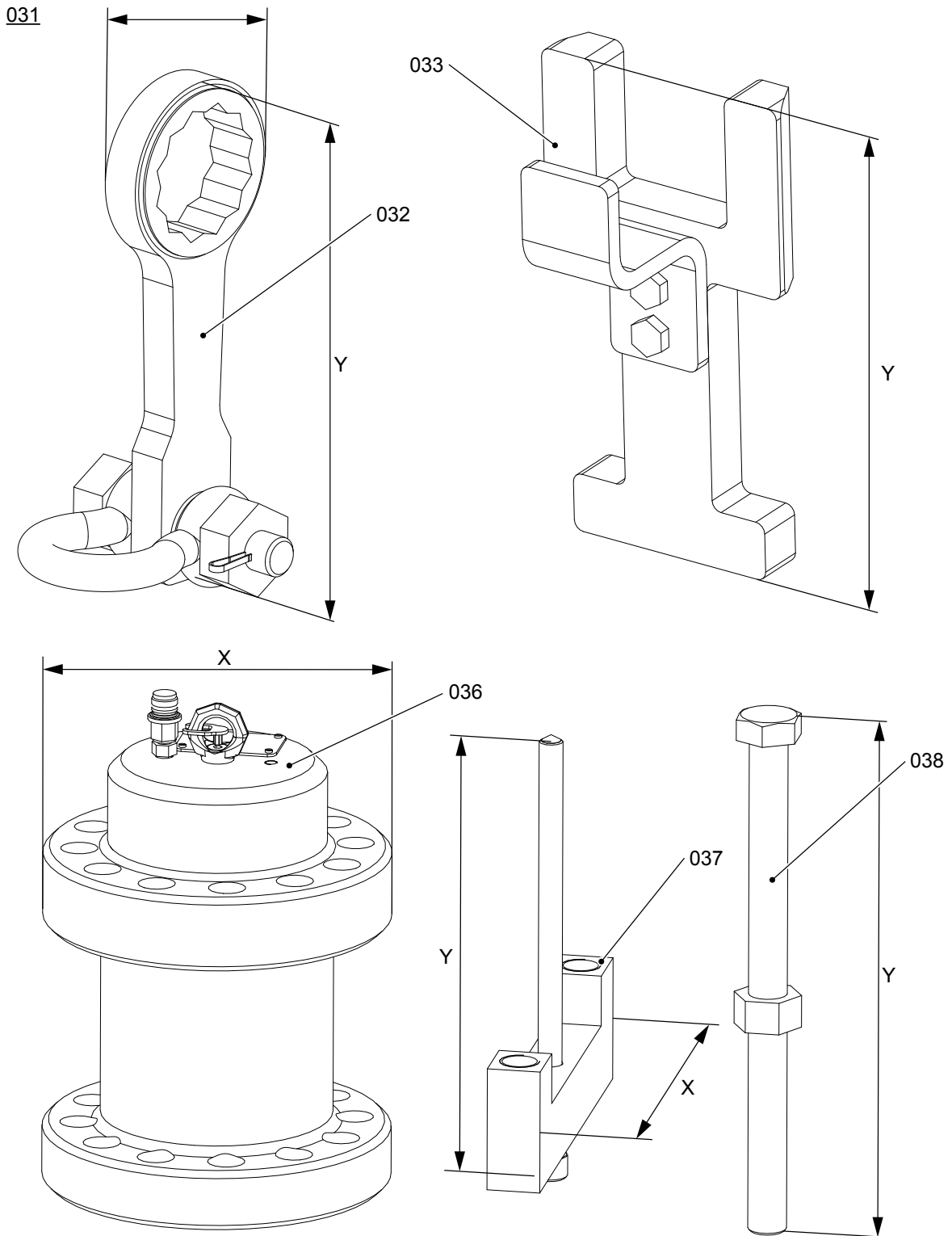
### 15.3 Recommended tools

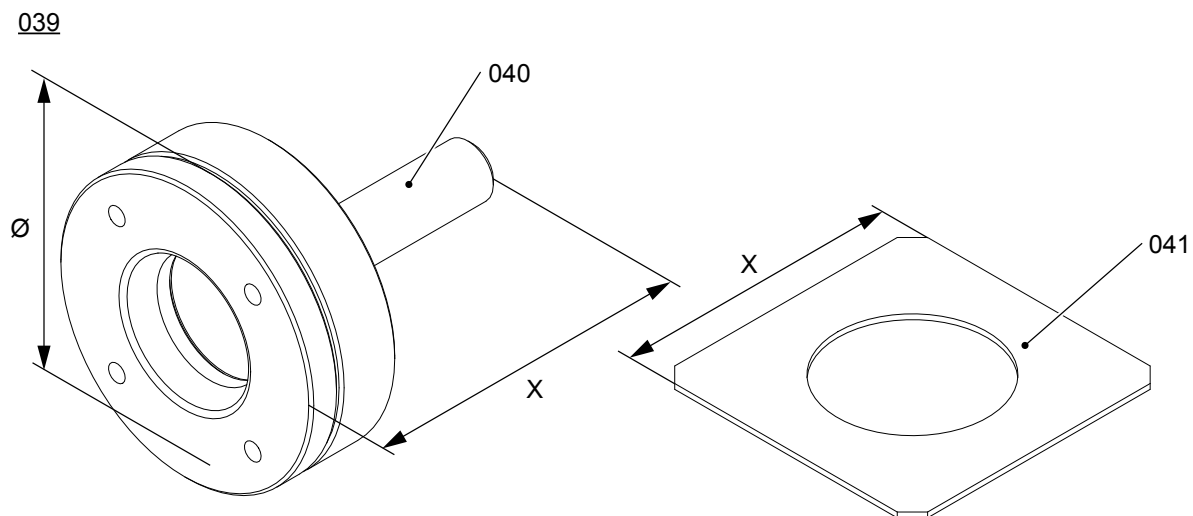












Pos.	Ind.	Part No.	Quantity	Description	Remark
nil	1	-		<b>Personal safety equipment</b>	-
nil	2	-	2 Pieces	Safety equipment	-
002	3	TN 94090	1 Piece	Safety harness	-
003	3	TN 94091	1 Piece	Helmet	-
004	3	TN 94092	1 Piece	Safety rope	-
005	3	TN 94093	1 Piece	Safety rope	-
006	3	TN 94094	1 Piece	Energy absorber	-
007	3	TN 94095	1 Piece	Bag	-
008	3	TN 94096	3 Pieces	Carbine hook	-
nil	1	-		<b>Tool cylinder liner grinding</b>	-
010	2	TN 94305	1 Piece	Wear ridge grinding device	Ø = 973 mm
011	1			<b>Tool gland box assembly platform</b>	-
012	2	TN 94324	1 Piece	Tool gland box assembly platform	Ø = 910 mm
013	2	TN 94325	1 Piece	Lifting tool	X = 487.5 mm
nil	1	-		<b>Tool cyl. cover/exh. valve assy.</b>	-
015	2	TN 94498	1 Piece	Lapping tool	Y = 365 mm, Ø = 74 mm
nil	1	-		<b>Tool exhaust valve failure</b>	-
017	2	TN 94338	1 Piece	Pressure element	X = 270 mm
nil	1	-		<b>Tool exhaust valve grinding</b>	-
019	2	94291	1 Piece	Grinding tool for valve spindle	for valve spindle and valve seat with Grinding discs (C-M No. 11373-01-01)
nil	1	-		<b>Tool starting air valve</b>	-
021	2	942719A	1 Piece	Assembly tool	X = 318 mm; Y = 364 mm
022	2	TN 94021	1 Piece	Lifting tool	Ø = 34 mm
023	3	TN 94053	2 Pieces	Screw	Y = 203 mm
024	3	TN 94054	2 Pieces	Screw	Y = 140 mm
025	3	TN 94055	2 Pieces	Cap	Ø = 34 mm
nil	1	-		<b>Tool piston pressure testing</b>	-
027	2	94349	1 Piece	Press-off device	X = 440 mm, Mass approximately 35 kg
nil	1	-		<b>Tool piston ring measuring</b>	-
029	2	94356	1 Piece	Measuring instruments	with instruments To measure thickness of chromeceramic-layer on piston rings
nil	1	-		<b>Tool gear wheel crankshaft assy.</b>	-
031	2	TN 94050	1 Piece	Tightening device	-
032	3	TN 94051	1 Piece	Tightening device	Y = 317.5 mm, Ø = 115mm
033	3	TN 94052	1 Piece	Fork wrench	Y = 250 mm
nil	1	-		<b>Tool fuel pump assembly</b>	-
nil	2	-	1 Piece	Hydraulic ram	-
036	3	TN 94047	1 Piece	Hydraulic ram	for removal of a fuel pump that cannot move Plunger (with 12-hole pump cover); X = Ø 270 mm
037	3	TN 94048	1 Piece	Piston reset device	X = 255 mm; Y = 173 mm
038	3	TN 94049	2 Pieces	Screw	Y = 419 mm
039	1			<b>Tool fuel pipe grinding</b>	-
040	2	TN 94077	1 Piece	Regrinding device	X = 57 mm, Ø = 50 mm
041	3	TN 94131	1 Piece	Stencil	X = 50 mm

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# 16 Tightening instructions

16.1	Tightening instructions.....	888
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## 16.1 Tightening instructions

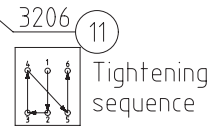
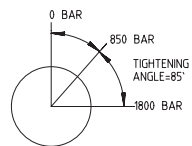
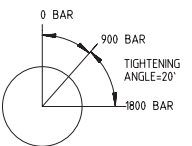
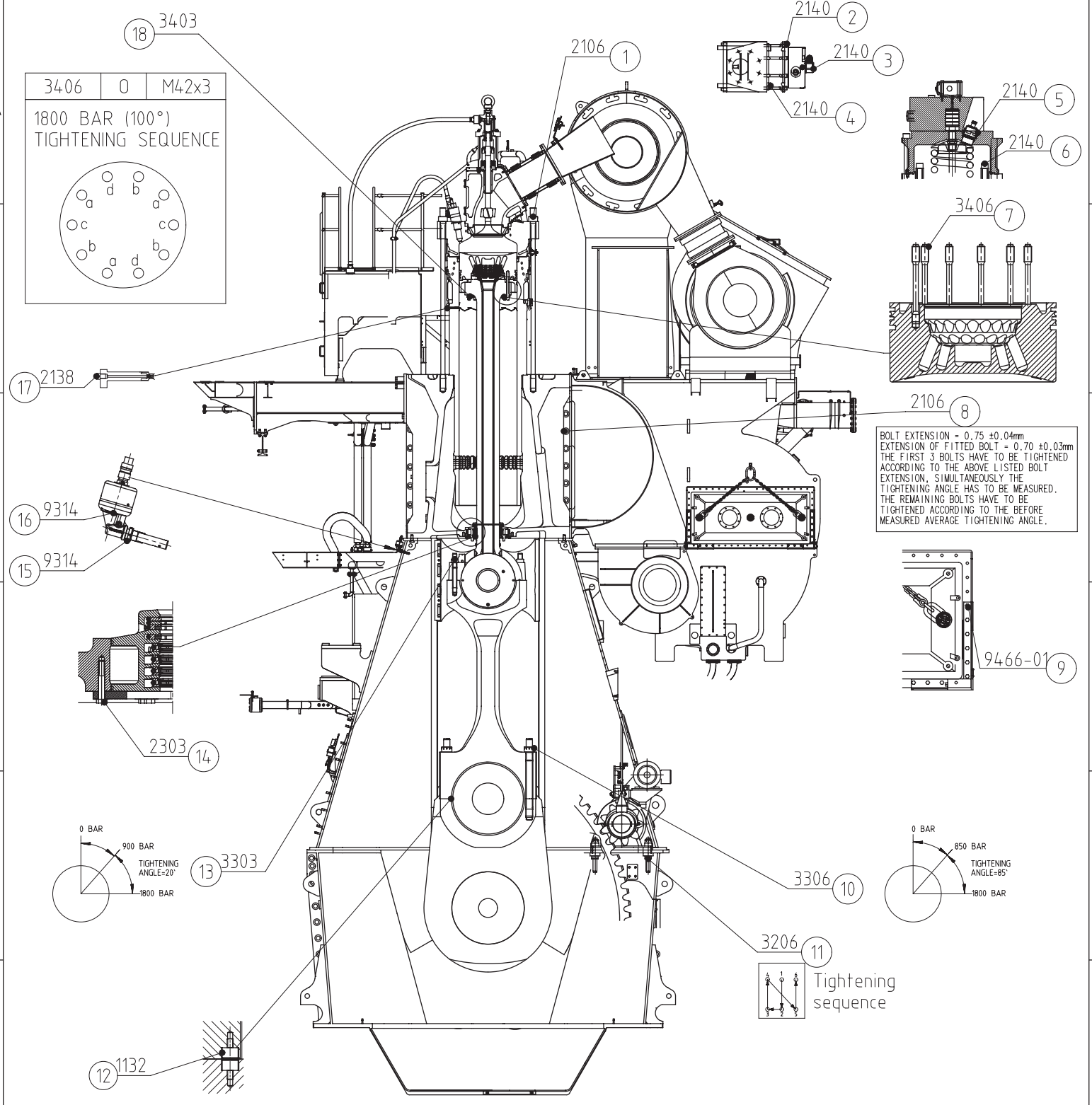
On the pages that follow you find the document “Tightening instructions” for important connections of the engine.

Use the number of the design group to find the related connection.



3406	0	M42x3
1800 BAR (100°)		
TIGHTENING SEQUENCE		

BOLT EXTENSION =  $0.75 \pm 0.04\text{mm}$   
 EXTENSION OF FITTED BOLT =  $0.70 \pm 0.03\text{mm}$   
 THE FIRST 3 BOLTS HAVE TO BE TIGHTENED ACCORDING TO THE ABOVE LISTED BOLT EXTENSION, SIMULTANEOUSLY THE TIGHTENING ANGLE HAS TO BE MEASURED. THE REMAINING BOLTS HAVE TO BE TIGHTENED ACCORDING TO THE BEFORE MEASURED AVERAGE TIGHTENING ANGLE.

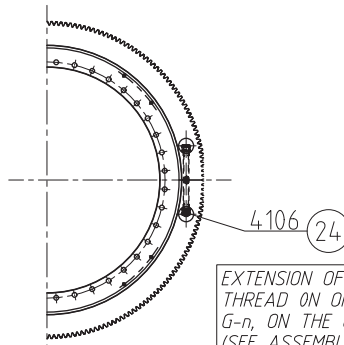
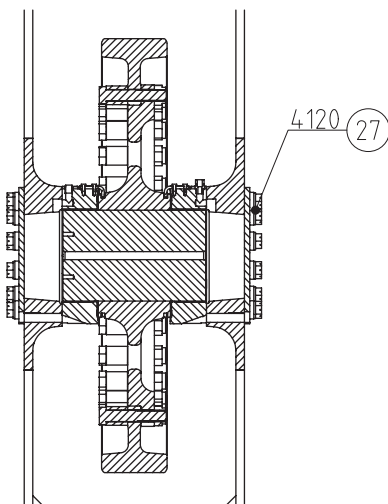
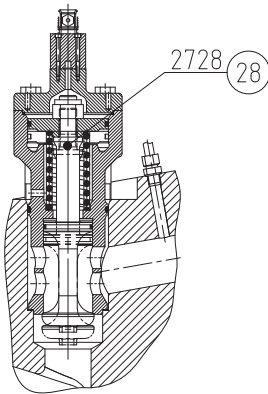
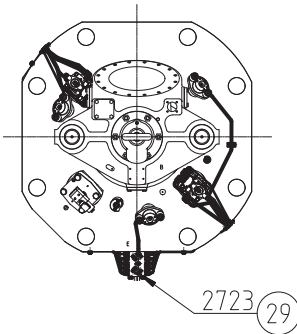
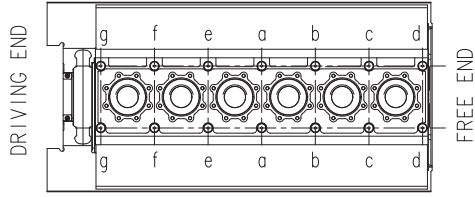
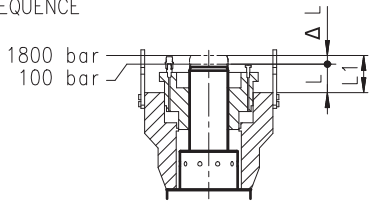


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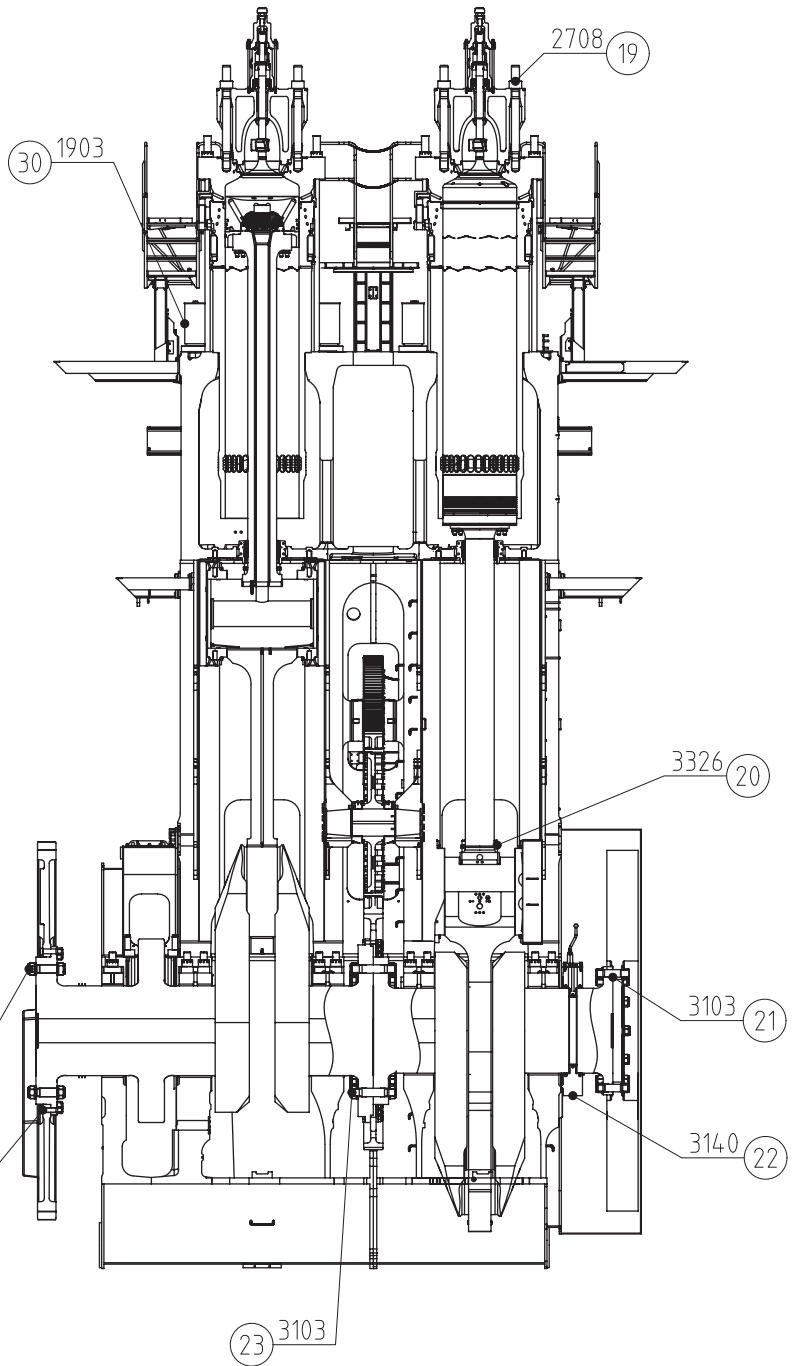
# Tightening Instructions

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TIGHTENING IN ONE PROCEDURE  
 - 100 BAR : MEASURE L  
 - 1800 BAR : MEASURE L1  
 CHECK:  $\Delta L = L1 - L = 16,5 - 18,5 \text{ mm}$   
 ACCORDING TO TIGHTENING SEQUENCE  
 a-a, b-b...



EXTENSION OF BOLT = 1.7510.05mm  
 THREAD ON ONE SIDE MOLYKOTE PASTE  
 G-n, ON THE OPPOSITE SIDE LOCTITE 262  
 (SEE ASSEMBLY INSTRUCTION FOR  
 SPARE WHEEL POS.011)

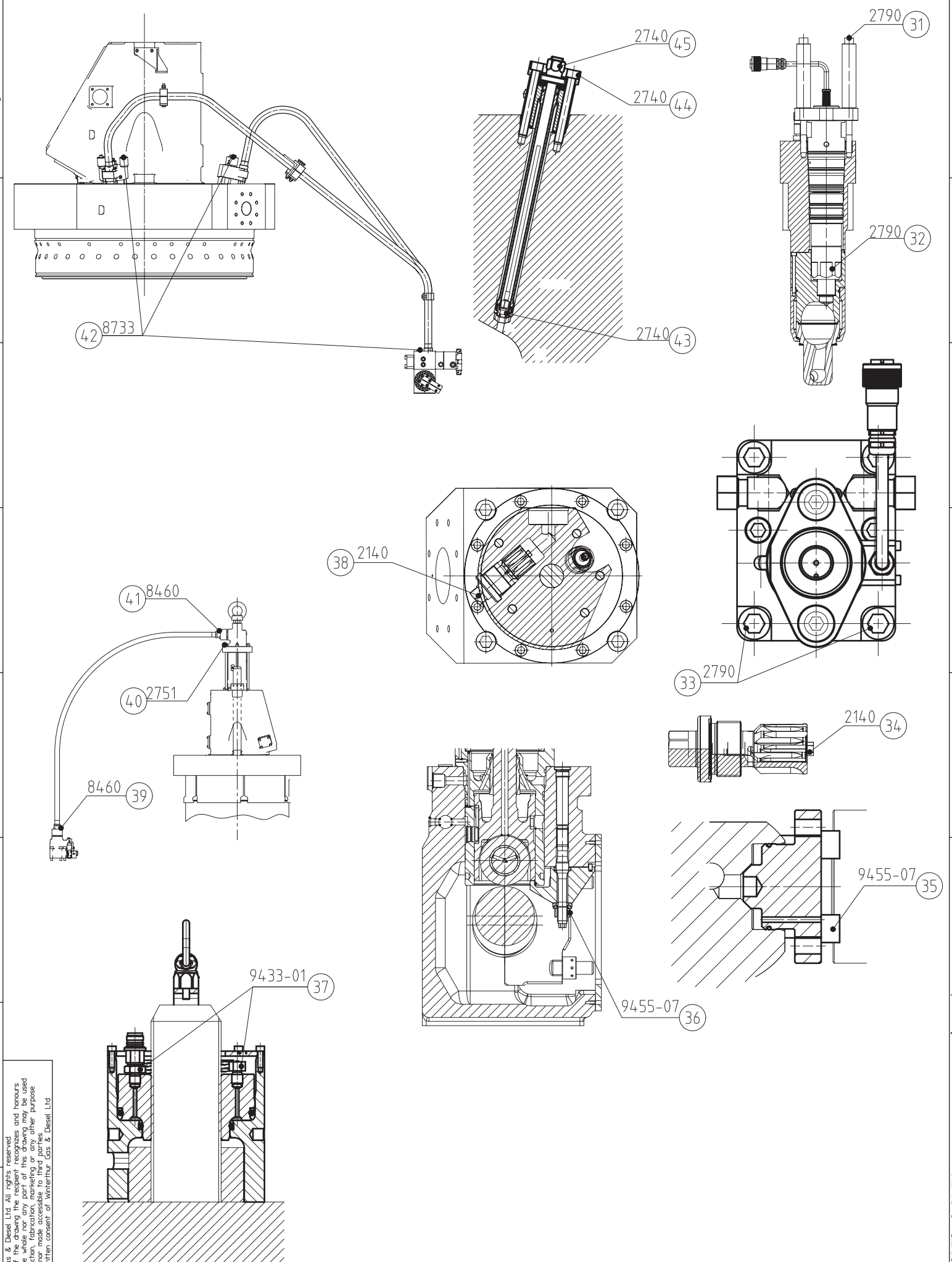


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### Tightening Instructions

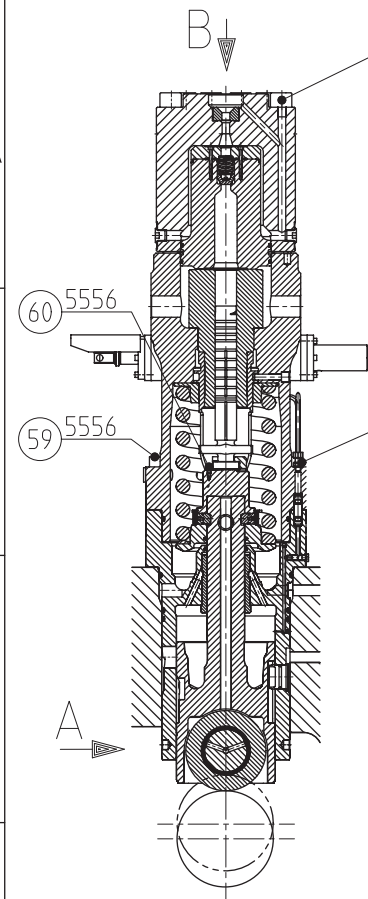
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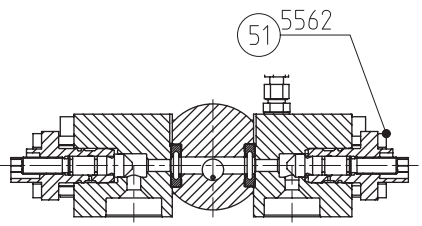
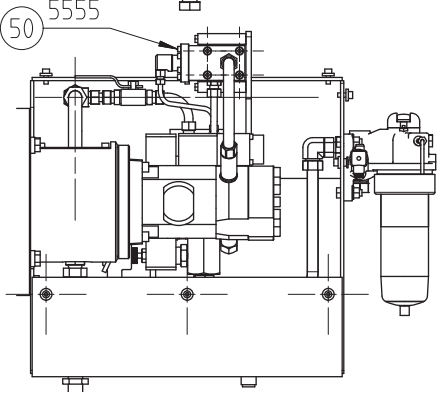
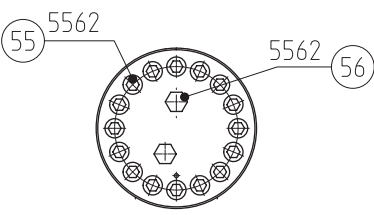
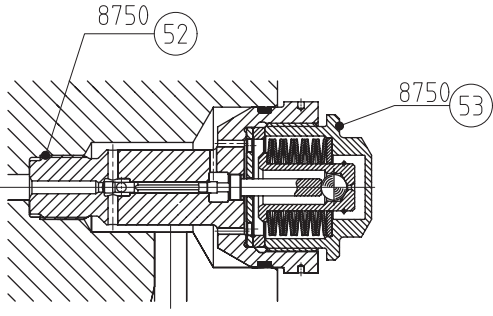
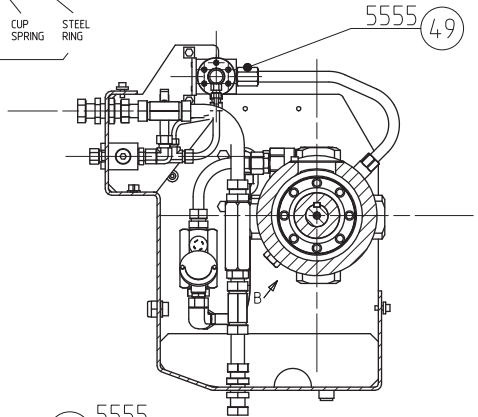
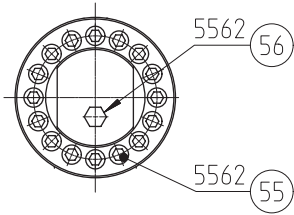
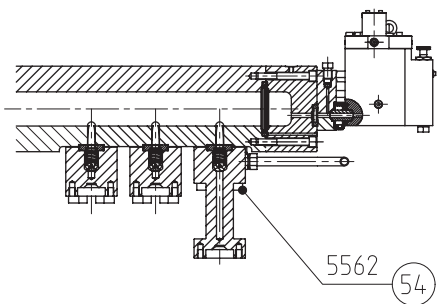
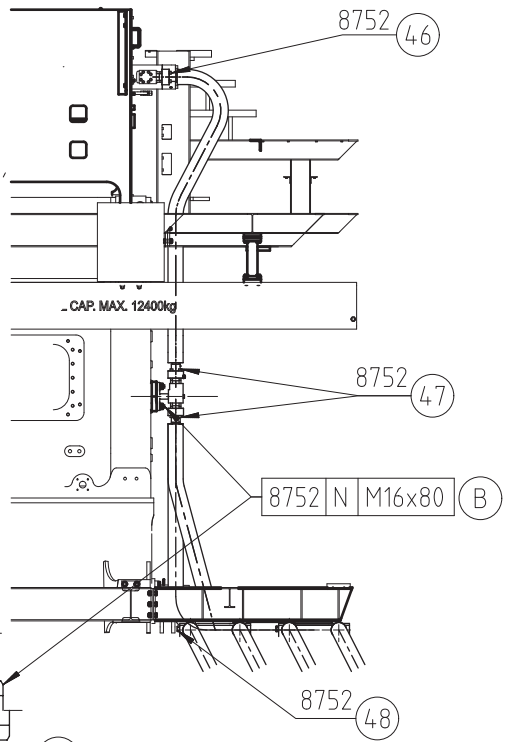
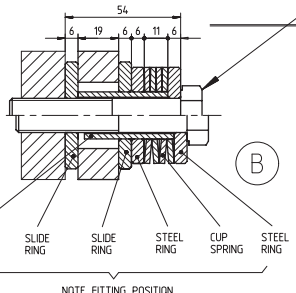
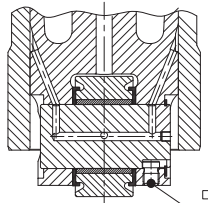
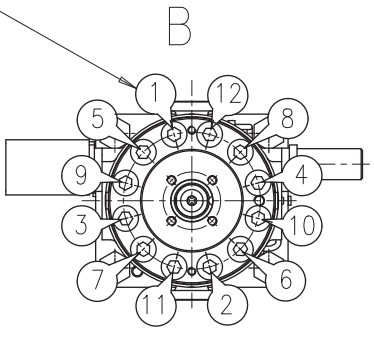


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### Tightening Instructions



The 12 HEXAGON SOCKET HEAD SCREWS' (M27x300) must be tightened in three steps; 100,300 and finally 480 Nm evenly according to tightening sequence using torque wrench with 19 mm align key socket. When this operation is complete, check the tightening torque of 480 Nm on all 12 HEXAGON SOCKET HEAD SCREWS' (M27x300) again!

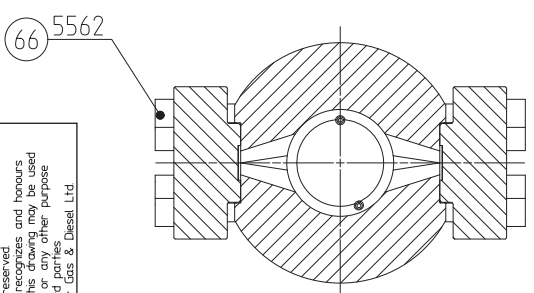
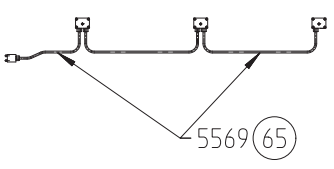
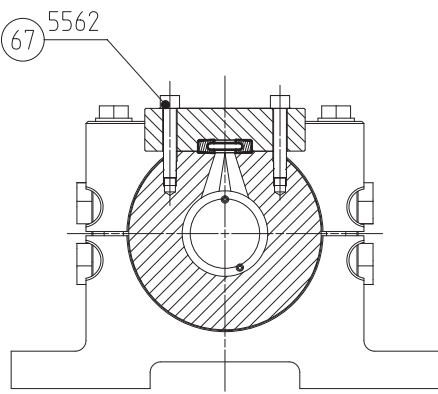
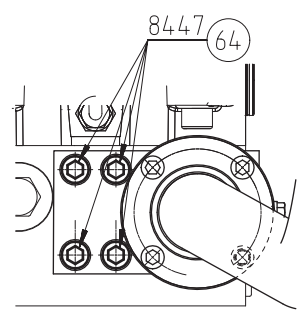
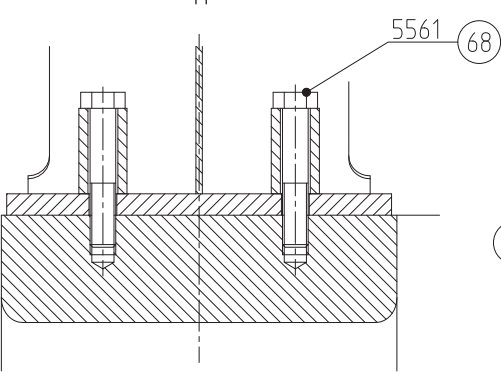
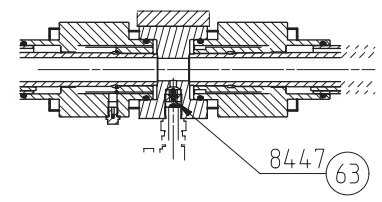
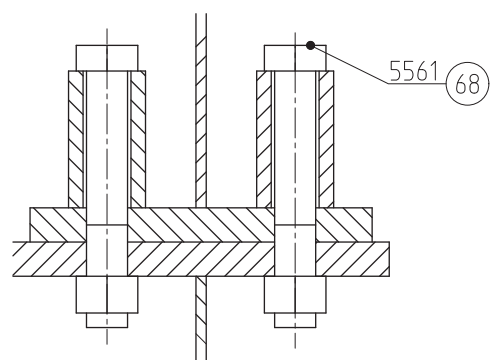
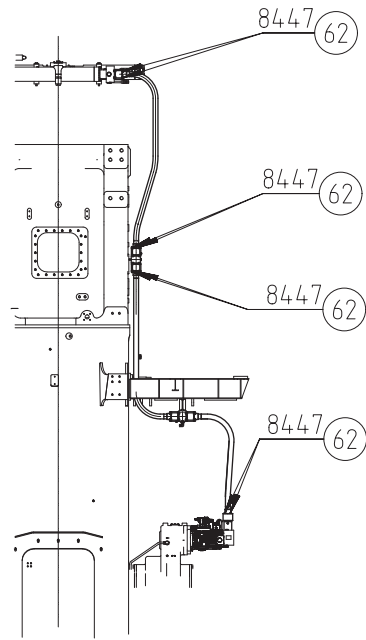
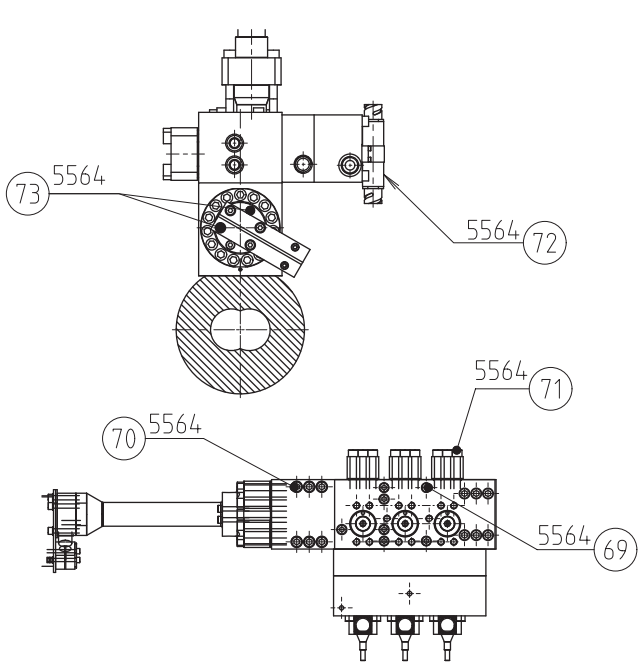


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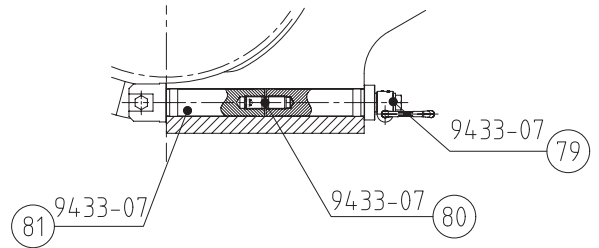
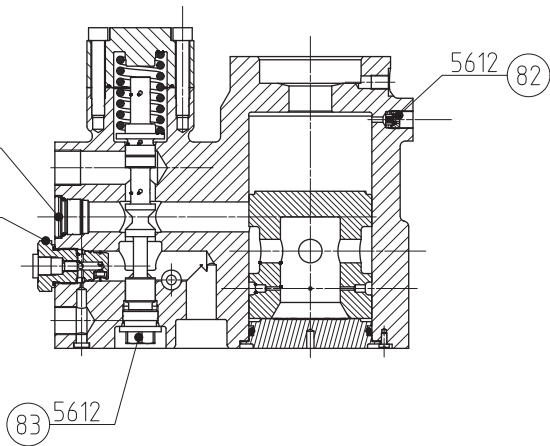
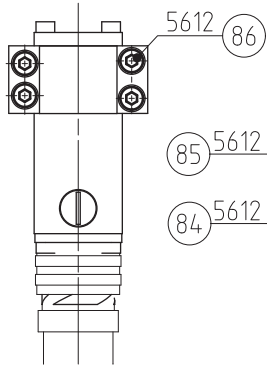
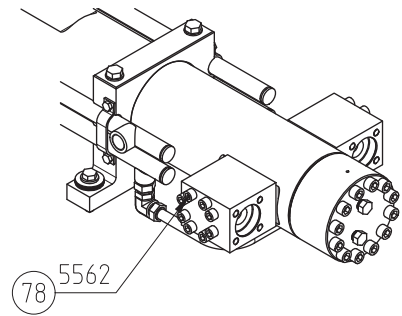
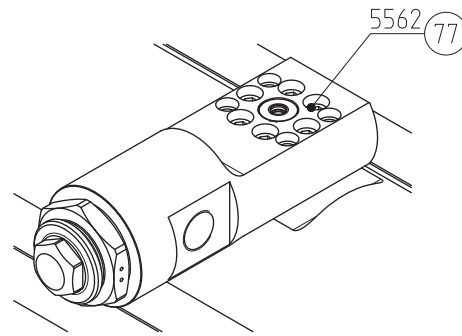
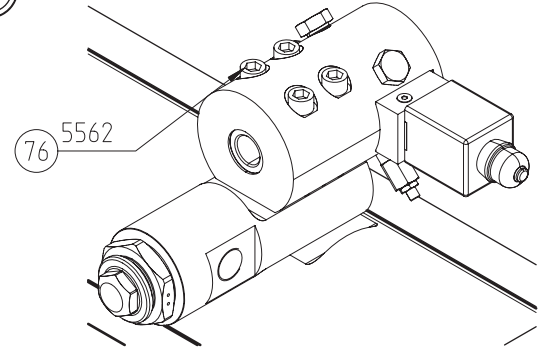
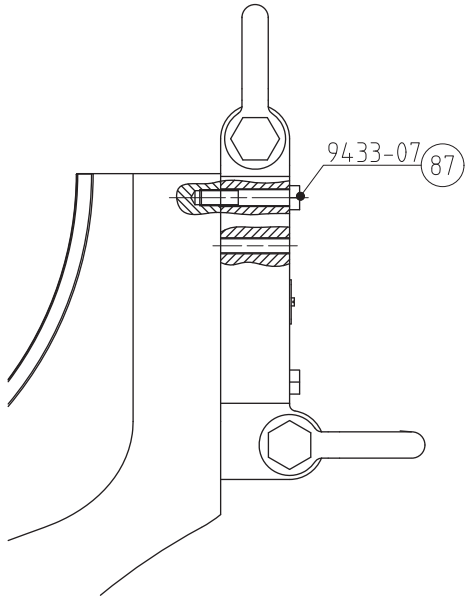
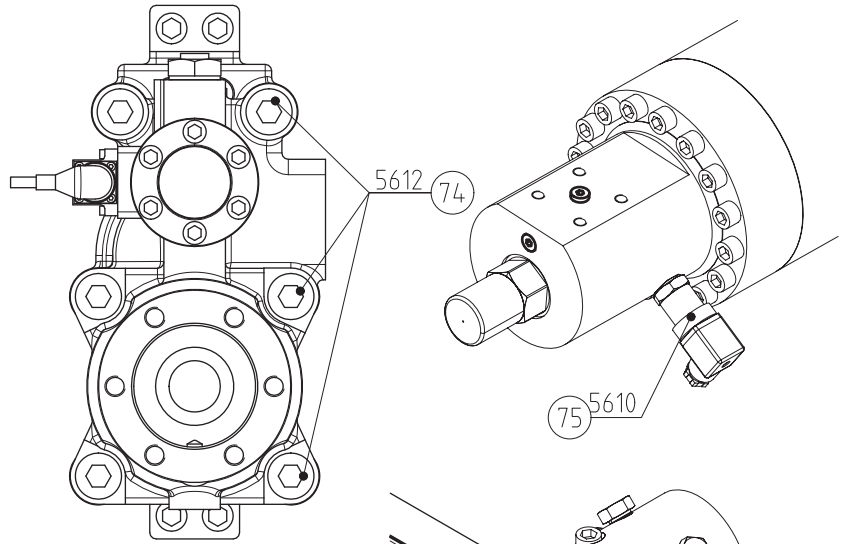
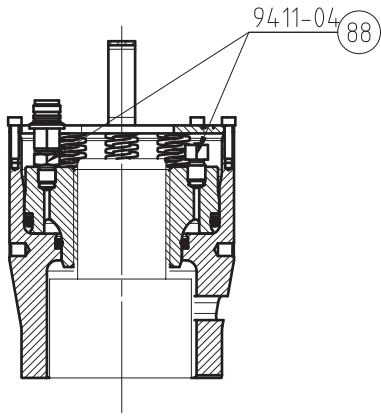
### Tightening Instructions

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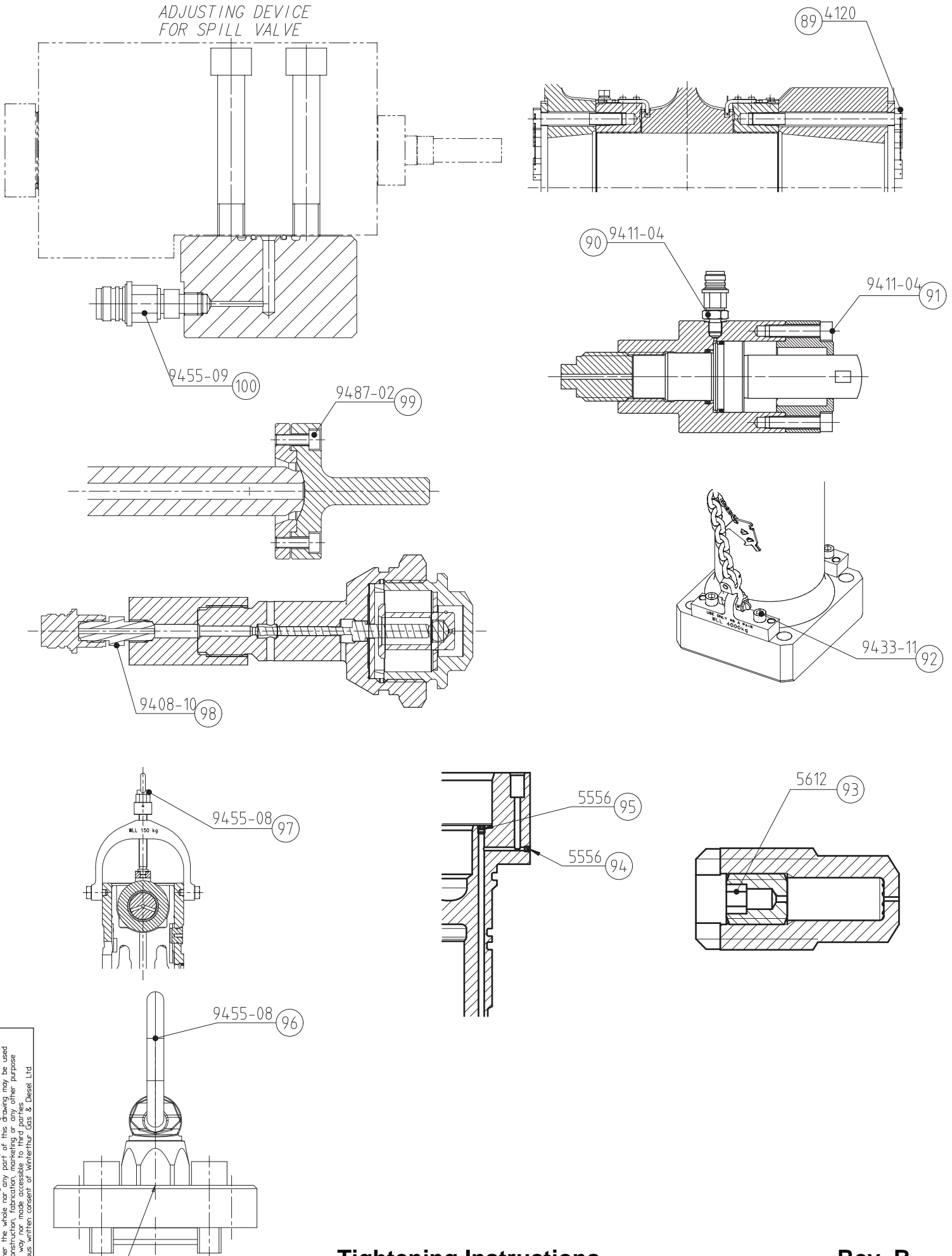
**Tightening Instructions**



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### Tightening Instructions

ADJUSTING DEVICE  
FOR SPILL VALVE



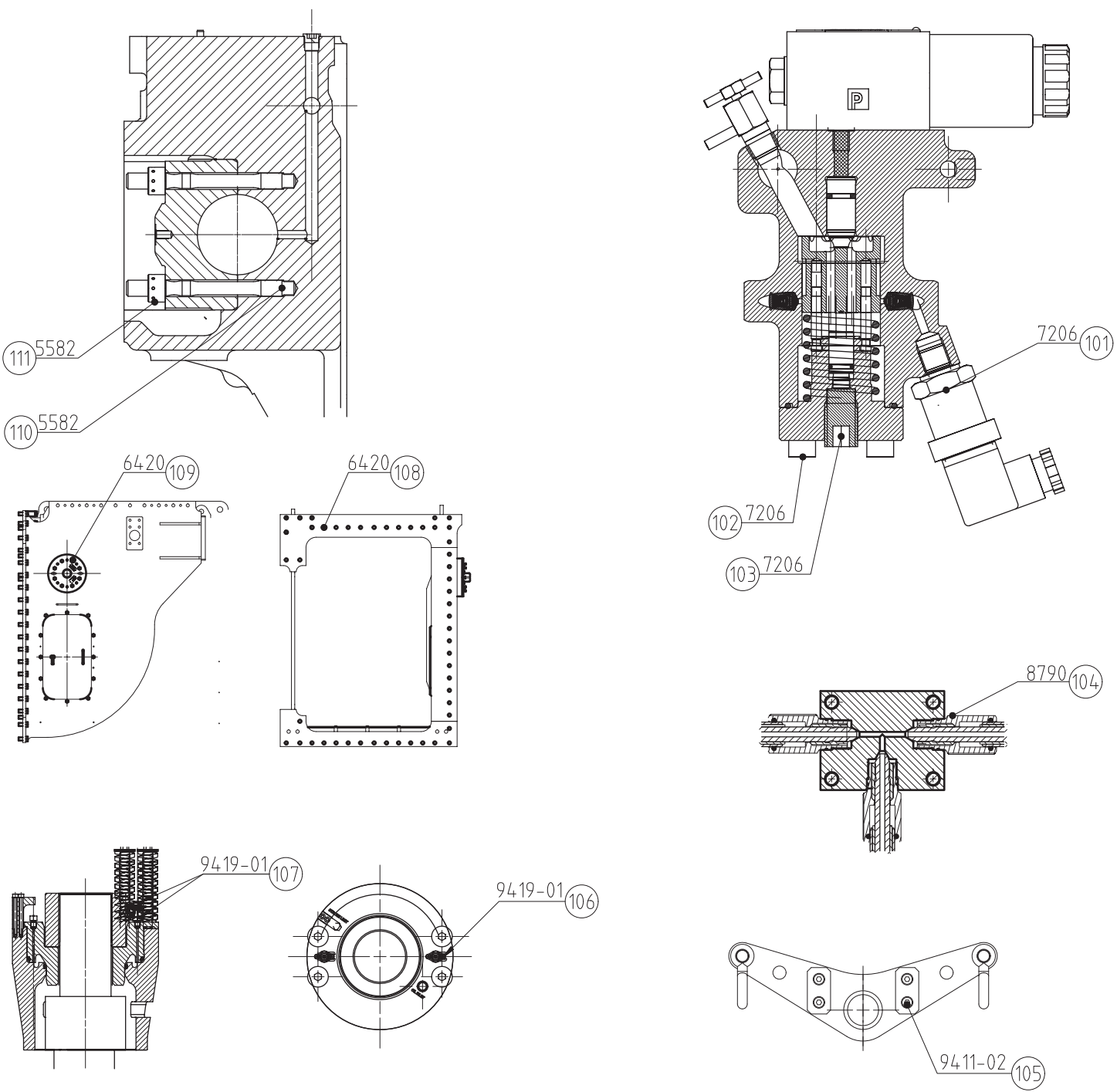
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**Tightening Instructions**

**Rev. B**  
**Page 7 / 14**

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### Tightening Instructions

**Rev. B**  
**Page 8 / 14**



	1	2	3	4	5	6					
A	Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) (Nm)	Step 1	Step 2	Delta L (mm)	Tightening angle or control angle (in brackets)(°)	Control angle from step 1 to step 2 [°]	Lubricants	Thread size	Comments
	1	1800					673		O	M100	
	2		40						S	M10	
	3		4						O	M4	
	4		300						S	M20	
	5		40						S	M30	
	6		50						S	M10	
B	7			130 Nm					O	M42	
	8					0.70+/-0.03			O	M56	see on page 1 position 8
	9		136						O	M16	
	10	1800		850 bar	1800 bar		85		O	M85	
	11	1800		750 bar					O	M52	see on page 1 position 11
	12		40						K	M16	
	13	1800		1200 bar	1800 bar		20		O	M68	
	14		170						O	M16	
	15		14-15						M	G3/4"	
	16		1.7-2.3						K	-	
	17		10						O	M10	
	18				1800 bar		100		O	M42	(A)
	19	1500					260		D	M95	
	20	1800		1200 bar	1800 bar		65		O	M36	
	21		(15000)				36		M	M85	
	22		(15000)				55		M	M36	
	23		(4300)				70		K	M42	
D	24					1.75 +/-0.05			M	M48	
	25		(4000)				21		M	M56	
	26		(22000)				85		M	M85	
	27		1200				65		M	M30	For Crankshaft parts : 2
	28		600						K	M30	
	29		40						N	G1/4	
	30	1800		1000 bar	1800 bar				M	M130	
	31		45	10 Nm	45 Nm				N	M12	
E	32		800+30						M	56x1.5	
	33		80						N	M16	
	34		20						O	M20	
	35		80						N	M14	
	36		980						O	M30	
	37		45						O	G 1/4"	
	38		300						O	M42	
	39		60						O	M12	
	40		435						O	M24	
F	41		60						O	M12	
	42		48						N	M10	
	43		50						N	M22	
	44		50						N	M12	
	45		80						N	M39	
	46		80						N	M14	
	47		80						N	M14	
	48		500						N	M36	

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## Tightening Instructions

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	1	2	3	4	5	6					
A	Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) (Nm)	Step 1	Step 2	Delta L (mm)	Tightening angle or control angle (in brackets) [°]	Control angle from step 1 to step 2 [°]	Lubricants	Thread size	Comments
	49		30						N	M24	
	50		15						N	M6	
	51		190						N	M16	
	52		300						N	M30	
	53		600						N	M60	
	54		150						N	M16	
	55		190						N	M16	
	56		200						N	M20	
	57		60						K	M20	
	58		140						N	M16	
	59		(1250)				64		O	M30	
	60		9						K	M6	
	61		480	100 Nm	300 Nm				N	M27	Tightening Sequence see P.4
	62		60						O	M12	
	63		40						O	G1/2"	
	64		90						O	M14	
	65		150						O	M34x1.5	
	66		110						N	M14	
	67		70						N	M12	
	68		350						O	M24	
	69		30						N	M10	
	70		55						N	M12	
	71		60						N	M12	
	72		6						N	M5	
	73		20						N	M8	
	74		490						O	M24	
	75		25						O	G1/4"	
	76		190						N	M16	
	77		190						N	M12	
	78		100						N	M14	
	79		700						K	M42	
	80		100						K	M42	
	81		70						C	M42	
	82		25						O	G3/8"	
	83		310						O	M28	
	84		225						O	M33	
	85		310						O	M33	
	86		6						O	M5	
	87		150						O	M20	
	88		45						O	G1/4"	
	89		1200				65		M	M30	
	90		45						O	G1/4"	
	91		74						O	M12	
	92		340						O	M24	
	93		3						O	-	
	94		3						K	M6	
	95		7						K	M8	
	96		10						K	M12	
	97		10						K	M16	

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## Tightening Instructions

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	1	2	3	4	5	6					
A	Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) (Nm)	Step 1	Step 2	Delta L (mm)	Tightening angle or control angle (in brackets)(°)	Control angle from step 1 to step 2 [°]	Lubricants	Thread size	Comments
	98		45						O	G1/4"	
	99		2						C	M4	
	100		45						O	G1/4"	
	101		25						O	G1/4"	
	102		24						O	M8	
B	103		80						-	M16	
	104		30						N	M24	
	105		1.6						K	M8	
	106		10						K	M8	
	107		45						O	G1/4"	
	108		980						O	M30	
	109		110						O	M16	
C	110		100						O	M39	
	111	1500 bar							O	M39	

D

E

F

G

H

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## Lubricants

**O** LUBRICATION OIL SAE 30  
On threads and contact surfaces

**C** MOLYSLIP COPASLIP  
On threads and contact surfaces

**M** MOLYKOTE PASTE G-n  
On threads and contact surfaces

**N** Never Seez RegularGrade  
On threads and contact surfaces

**K** NO ADDITIONAL  
LUBRICATION

**S** NEVER SEEZ HIGH  
TEMPERATUR STAINLESS  
On threads and contact surfaces

Designation:	LUBRICATION OIL SAE 30
Short form:	O
Designation:	MOLYSLIP COPASLIP
Short form:	C
K factor:	0.16
Manufacturer:	Molyslip Atlantic Ltd A1 Danebrook Court Oxford Office Village Langford Lane, Kidlington Oxfordshire OX5 1LQ ENGLAND
Designation:	MOLYKOTE PASTE G-n Plus
Short form:	M
Coefficient of friction:	Thread: 0.12
(M12, 8.8 blackened)	Head: 0.06
Manufacturer:	Dow Corning Corporation Corporate Center PO Box 994 Midland MI 48686-0994 UNITED STATES
Designation:	NEVER SEEZ Regular Grade
Short form:	N
K factor:	0.13
Manufacturer:	Bostik, Inc. Bostik Americas Technology Center 11320 W Watertown Plank Road Wauwatosa, WI 53226 414 UNITED STATES

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## Tightening torque for standard screws

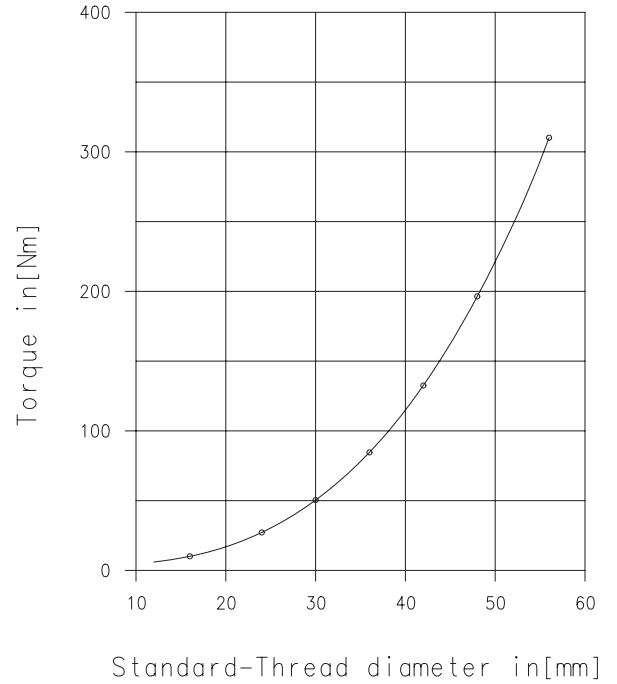
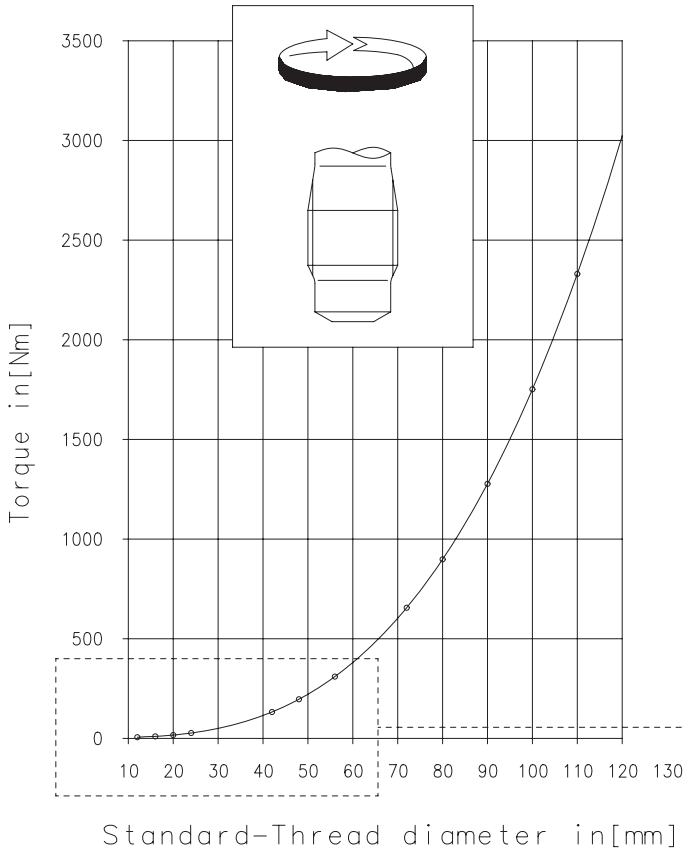
We recommend tightening all the metrical standard screws of grade 8.8 according to table beside. This applies to all threaded connections not mentioned on pages 1 to 8 of this instruction. Threads and bearing surfaces of screw heads have to be lubricated with lubricating oil SAE 30.

In case another lubricant is used instead of SAE 30 oil the tightening torque must be reduced according table below:

Lubricant	Required torque reduction
MOLYSLIP COPASLIP	8 % ( 0 to 15 %)
NEVER SEEZ Regular Grade	24 % (17 to 30 %)
MOLYKOTE PASTE G-n Plus	27 % (20 to 33 %)

Standard thread grade 8.8	Fine thread grade 8.8	Thread Tightening torque Nm
M3	M3x0.35	0.9
M4	M4x0.5	2.1
M5	M5x0.5	4.2
M6	M6x0.75	7.2
M8	M8x1	18
M10	M10x1.25	35
M12	M12x1.25	60
M14	M14x1.5	94
M16	M16x1.5	145
M18	M18x1.5	200
M20	M20x1.5	280
M22	M22x1.5	380
M24	M24x2	490
M27	M27x2	720
M30	M30x2	980
M33	M33x2	1300
M36	M36x3	1700
M39	M39x3	2200
M42	M42x3	2700
M45	M45x3	3400
M48	M48x3	4100
M52	M52x3	5300
M56	M56x4	6600
M60	M60x4	8100

## Assembly torque for elastic studs



Before fitting a elastic stud clean and degrease the stud thread and the tap hole.  
Screw in the stud right to the bottom of the tap hole and tighten.

**Attention** Always utilize a stud driver or two lacking nuts. Tools like a pipe wrench etc. which would damage the stud shank must never be used.

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# 17 Maintenance overview

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## 17.1 Maintenance overview

On the pages that follow you find the document "Maintenance Intervals / Lifetime" for the related components of the engine.



Component	Work to be carried out	Intervals & Lifetime [operating hours]
<b>System oil</b>	Laboratory analysis	3000
<b>Main fuel and lubricating oil filters</b>	Check filter elements - in particular for white metal particles (clean or replace filter as necessary). Follow manufacturer's instructions	3000
<b>Cooling water</b>	Calculate quality, concentration of inhibitor and pH value (follow instructions of inhibitor manufacturer)	weekly
<b>Bedplate (Group 11xx)</b>	Check pre-tension of foundation bolts, first check after 1500 Op. H	12000
	Check condition of rubber gasket in the vertical oil drain to sump tank (see SPC 9722), first time at the earliest opportunity after ship delivery.	30000 (replacement recommended)
	Estimated lifetime: bedplate foundation bolts	engine lifetime
<b>Crankcase</b>	Visual examination, 100 Op. h after overhaul works: search for white metal particles from bearings and for abnormalities in general.	1500 - 3000
<b>Main bearing (Group 12xx)</b>	Bearing shell inspection is only necessary if bearing clearance, crankshaft deflection, wire check, oil analysis or crankcase inspection indicates excessive wear or damage	at indications of excessive wear or damage
	Bearing edge check by wire	6000
	Check bearing clearance see 0330-1	6000
	Estimated lifetime: main bearing shell	>100000
<b>Thrust bearing (Group 12xx)</b>	Check axial and vertical clearances	6000 - 8000
	Check bottom drain for free passage	6000 - 8000
	Thrust bearing pads inspection is only necessary if bearing clearance, oil analysis or crankcase inspection indicates excessive wear or damage	at indications of excessive wear or damage
	Estimated lifetime: thrust bearing	engine lifetime (replacement if required)
<b>Engine stays (Group 97xx)</b>	Hydraulic type: check oil pressure at the gauge	monthly
<b>Tie rod (Group 19xx)</b>	Check pre-tension, if necessary re-tension, first time after one year of ship delivery	24000 - 30000
	Estimated lifetime: tie rod	engine lifetime
<b>Cylinder liner (Group 21xx)</b>	Measure liner wear (in installed condition)	at every piston removal
	Remove cylinder liner	as necessary
	Replace o-rings	at every liner removal
	Replace (soft iron) joint ring between cylinder liner and cylinder cover	at every piston removal
	Replace o-rings of water guide jacket and transition tubes	at every liner removal
	Check condition of antipolishing ring	at every piston removal
	Grind off wear ridge in bore	at every piston removal
	Refinish lubricating grooves	as necessary
	Clean scavenge ports and refinish their edges	as necessary
Estimated lifetime: cylinder liner	90 000 and above (condition based on wear measurement)	
<b>Lubricating quill (pulse lubrication, group 21xx)</b>	Check function and tightness	at every piston removal
	Check function of non-return valves	at every piston removal
<b>Gas admission valve (GAV, group 21xx)</b>	Perform pressure check of gas manifolds for each engine side individually. Tightness of the GAVs, the vent valve and the shut-off valve can be confirmed by this check	6000
	Overhaul/replace compression spring including valve seat lapping	18000 - 21000
	Visual check of compensator gas inlet pipe	6000
	Estimated lifetime: Rail valve	36000
	Estimated lifetime: Housing and servo drive	engine lifetime

Component	Work to be carried out	Intervals & Lifetime [operating hours]
<b>Piston rod gland (Group 23xx)</b>	Clean rings, establish wear	at every piston removal
	Estimated lifetime: piston rod gland	36000 (refers to rings)
<b>Cylinder cover (Group 27xx)</b>	Do a check for cracks and dirty seat sealing faces of the injection valve. Make sure that the seat sealing faces have no damage.	at every cylinder cover removal
	Estimated lifetime: cylinder cover	engine lifetime (remanufacturing as required)
<b>Injection valve (main fuel injector, group 27xx)</b>	Check externally for tightness	after engine stop, before a longer standstill
	Function check (nozzle tip inspection, opening pressure).	4000-6000
	Make sure that the opening pressure is correct	1000 after injector parts are replaced
	Exchange nozzle tip (FAST type)	8000-12000
	Replace nozzle body & needle + retaining nut (FAST)	8000-12000
<b>Starting air valve (Group 27xx)</b>	Check pipes upstream of the valve during operation, if pipes are too hot, disassemble starting valve	weekly
	Remove and disassemble one starting valve, from the condition, calculate the time of overhaul for remaining valves	12000
	Make sure that the nut on the solenoid is tight, if necessary tighten the nut.	monthly
	Solenoid valve; random functional check	6000
	Solenoid valve; overhaul on board	18000
	Estimated lifetime: starting valve	engine lifetime
<b>Relief valve to cylinder cover</b>	Check blow-off pressure	as necessary
<b>Exhaust valve (Group 27xx)</b>	General inspection of valve housing, valve spindle and valve seat (without disassembly of the exhaust valve)	at every piston removal
	Check condition and wear of valve spindle (if necessary grind the seat)	36000 (initial inspection 18000)
	Valve drive: check piston seal ring / air spring & rod seal ring / guide bush	36000 (initial inspection 18000)
	Check condition and wear of valve seat	36000 (initial inspection 18000)
	Random check of valve drive, outer and inner pistons, damper, thrust piece	18000
	Estimated lifetime: exhaust valve spindle (Nimonic)	108000 (remanufacturing as required)
	Exhaust valve seat	72000 (remanufacturing as required)
<b>Pilot injection valve (Group 27xx)</b>	Check externally for tightness	after engine stop, before a longer standstill
	Replace nozzle spare parts set & perform function check	12000
	Replace O-rings and sealing ring	everytime when the pilot injector is removed from the holder
	Replace pilot injection valve complete	24000
	Replace pre-chamber	18000
<b>Crankshaft (Group 31xx)</b>	Measure crank deflection, always after the ship grounded and after each docking	6000
<b>Torsional vibration damper (Group 31xx)</b>	Get a silicon oil sample from viscous vibration damper (based on results of 1 <sup>st</sup> sample, interval for taking further samples will be decided by damper manufacturer)	first time after 15000- 18000
	Inspection interval and dismantling of vibration damper	in accordance with instructions of the damper manufacturer

Component	Work to be carried out	Intervals & Lifetime [operating hours]
<b>Axial damper (Group 31xx)</b>	Disassembly and inspection	36000 - 48000
<b>Turning gear (Group 32xx)</b>	Inspection interval of turning gear	in accordance with the instructions of the turning gear manufacturer
	Lubrication of tooth flanks of pinion and flywheel, related to visual inspections, however latest each 2000 Op. h of main engine	2000
	Check screwed connections, first time after one year	12000
<b>Connecting rod bearings (Group 33xx)</b>	Check bearing clearances (see 0330-1)	6000
	Bearing edge check by wire	6000
	Bottom end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage
	Top end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage
	Random inspection of connecting rod top end bearing and bottom end bearing	70000
	Estimated lifetime: connecting rod bottom end bearings	90000 (replacement if required)
	Estimated lifetime: connecting rod top end bearings	90000 (replacement if required)
<b>Guide shoe, crosshead pin (Group 33xx)</b>	Check clearances	6000 - 8000
<b>Piston (Group 34xx)</b>	Remove and clean	36000 (condition based)
	Check tightness on piston in installed position and with running oil pump, visual check through scavenge ports	after installation
	Disassembly and assembly (open cooling space and clean same, min. one piston each three years)	as necessary
	Check condition of the piston top surface	at every piston removal
	Visual check through scavenge ports to piston, piston rings and cylinder liner	500 - 1000
	Measure ring grooves, inspect the chromium plating and rechrome as necessary	36000 - 72000 (condition based)
	Estimated lifetime: piston head ring grooves	36000 - 72000 (condition based)
	Piston head surface, full remanufacturing	72 000
<b>Piston underside</b>	Check condition of space and clean as necessary	1500 - 3000
	Make sure that the drains and orifices are not blocked	1500 - 3000
<b>Piston rings (Group 34xx)</b>	Measure thickness of chrome-ceramic layer	1500 - 2000
	Replace piston rings based on remaining coating thickness	36000 (condition based)
	Estimated lifetime: piston rings	36000 (condition based)
<b>Start interlock</b>	Check electric and pneumatic interlocks (see operating manual 4003-1)	quarterly
<b>Driving wheels (Group 41xx)</b>	Check condition of teeth	6000 - 8000
	Check running clearance and backlash of teeth	6000 - 8000
	Estimated lifetime: driving wheels	engine lifetime
<b>Starting air shut-off valve (Group 43xx)</b>	Release pressure / vent starting air inlet (manifold) pipe	after every manoeuvring period
	Disassemble, clean and check (Important parts are: seat, springs and sealing rings)	30000 - 36000
	Do an overhaul of the common start valve (SPC: control valve complete, group 4325-2)	18000
	Estimated lifetime: starting air shut-off valve	engine lifetime
<b>Control air filter</b>	Drain the filter	weekly

Component	Work to be carried out	Intervals & Lifetime [operating hours]
	Clean the filter	6000
<b>Servo oil pump (Group 55xx)</b>	Replace servo oil pump with new one	36000 (HAWE) or 66000 (BOSCH)
<b>Servo oil pump drive</b>	Check pinion and driving wheels to servo oil pump drive	3000
	Estimated lifetime: supply unit pinion bearing bushes	90000 (replacement if required)
<b>Fuel oil pump drive</b>	Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h)	3000
	Check pinion and driving wheels to fuel oil pump drive	3000
	Camshaft, check bearing clearances at random position	12000
	Camshaft, check thrust bearing clearances	36000
	Estimated lifetime: supply unit camshaft bearings	90000 (replacement if required)
<b>Pilot fuel supply unit (Group 87xx)</b>	Lubricate the flexible coupling of the pilot fuel pump	1500 - 3000 (regardless of the operating mode)
	Replace the pilot fuel pump	24000 (regardless of the operating mode)
	Replace the pilot fuel oil filter cartridges. the cartridges must be replaced earlier if the pressure difference indicator shows high pressure increase	1000 (regardless of the operating mode)
	Clean the wire gauze and filter housing.	1000
	Estimated lifetime: pilot fuel pump	24000
<b>Fuel pump (Group 55xx)</b>	Random flow check of lubricating oil	6000
	Do a check of the fuel oil leakage from the fuel pump cover (the O-ring in the non-return valve can become weak)	weekly
	Remanufacture fuel pump or overhaul on board	18000-22000
<b>Fuel pressure control valve (PCV, group 55xx)</b>	Check shut-down function (see operation Manual 4003-1)	3000
	Removal and pressure check	6000
	General overhaul	only necessary if PCV fails
	Estimated lifetime: fuel pressure control valve (PCV)	engine lifetime
<b>Fuel overpressure safety valve / relief valve (Group 55xx)</b>	Function check on test bench	24000 - 36000
<b>Injection control unit (ICU, group 55xx)</b>	Use flexView to do a check on the on-time of the rail valves. Replace if the on-time is more than 2.6 ms	monthly
	Replace ICU with a new item, or a Wartsila serviced item (incl. rail valves)	36000
<b>Servo oil rail (Group 56xx)</b>	Replace hoses (at least every 5 years)	30000
<b>Exhaust valve control unit (Group 56xx)</b>	Use flexView to do a check on the on-time of the rail valves. Replace if the on-time is more than 2.6 ms	monthly
	Random check of piston and slide rod	36000
	Replace rail valve	36000
	Check VCU last chance filter	18000
	Estimated lifetime: exhaust valve control unit	engine lifetime
<b>Fuel pump actuator (Group 55xx)</b>	Check for free movement of regulating linkage, lubricate movable parts	3000
	Replace fuel pump actuator (WEA-40) with a new item or a remanufactured fuel pump actuator from maker	24000 (replacement if required)
	Replace fuel pump actuator (PRO ACT IV-DIGITAL PLUS) with a new item	50000 (replacement if required)
<b>Scavenge air receiver (Group 64xx)</b>	Check and clean air flaps	4000 - 6000
	Clean the receiver	4000 - 6000
	Make sure water drain pipes and orifices are not blocked	1500 - 3000
<b>Turbocharger (Group 65xx)</b>	Wash-cleaning of blower in service	acc. to manufacturer

Component	Work to be carried out	Intervals & Lifetime [operating hours]
	Wash-cleaning or dry cleaning of turbine in service	acc. to manufacturer
<b>Air filter (Group 65xx)</b>	Check filter	half yearly
	Cleaning of filter at a $\Delta p$ increase of 50% compared to the shop test value at same engine load (see operating manual 6510-1)	as necessary
<b>Auxiliary blower (Group 65xx)</b>	Clean impeller and casing	24000 - 36000
	Replace ball bearing	24000 - 36000
<b>Scavenge air cooler (Group 66xx)</b>	Cleaning of scavenge air cooler (air side) in service at the beginning weekly, later if $\Delta p$ (pressure decrease through SAC) increases compared to the shop test value at same engine load (see Operating Manual 6606-1)	as necessary
	Check condensate collector through sight glass (see Operating Manual 8345-1)	daily
	Check condensate collector for free passage (see Operating Manual 8345-1)	1500 - 3000
	Check scavenge air cooler sealing	quarterly
	Bleed	daily
	Remove scavenge air cooler for general overhaul	as necessary
<b>Water separator scavenge air (Group 67xx)</b>	Check condensate collector through sight glass (see Operating Manual 8345-1)	daily
	Check condensate collector for free passage (see Operating Manual 8345-1)	1500 - 3000
	Check water separator elements (if necessary clean them)	1500 - 3000
	Remove water separator for general overhaul	as necessary
<b>Cylinder lubricating pump (Group 72xx)</b>	Remanufacture cylinder lubricating pump or overhaul on board	45000
<b>Cylinder lube oil filter</b>	Replace filter element before the cylinder lubricating system	as necessary
<b>Exhaust Waste Gate (LLT, group 81xx)</b>	General Inspection. During a longer operation period at low engine load, manually open the butterfly valve (refer to Operation Manual 8135-1)	in accordance with instructions of valve manufacturer
<b>Servo oil service pump (engine mounted)</b>	Check rate of flow at max. pressure	30000
<b>Starting air pipes on and before the engine</b>	Drain (remove water)	before and after every manoeuvring period
<b>Pressure gauges and pyrometers</b>	Compare and calibrate according to master instruments	6000 - 8000
<b>Pipe holders (Group 8xxx)</b>	Check fastenings at intervals if necessary, tighten the screws (first time after 100 Op.h.)	as necessary
<b>Servo oil pipes (Group 84xx)</b>	Grind sealing faces	as necessary
<b>Non-return valve (fuel inlet at fuel rail)</b>	Random check	18000
<b>Hydraulic pipe for exhaust valve drive (Group 8460)</b>	Grind sealing faces	as necessary
<b>HP pipe to injection valve (on cylinder cover, group 87xx)</b>	Grind sealing faces	as necessary
<b>Supply unit fuel drain pipes (Group 87xx)</b>	Make sure that the pipes are not blocked	6000
<b>HP fuel pipe (Group 87xx)</b>	Grind sealing faces	as necessary
<b>Gas distributor pipe (Group 89xx)</b>	Shut off and vent valves: Check tightness of ball valves and of shaft sealing	6000
	Visual check of compensators	6000
	Estimated lifetime	engine lifetime
<b>Crank angle sensor (on gear wheel)</b>	Replace the proximity sensor	as necessary
<b>Cylinder cover - relief valve</b>	Replace relief valve	when blown off
<b>Oil mist detector (Group 93xx)</b>	Follow manufacturer's instructions	half yearly
<b>WiCE Control System</b>	Replace Cylinder Control Unit (CCU), Main Control Unit (MCU) and Gateway Unit (GTU) (refer to the Operation Manual, Group 4)	66000

Component	Work to be carried out	Intervals & Lifetime [operating hours]
	Replace exhaust valve stroke sensor and TDC sensors if defective	66000 (replacement if required)
<b>WiCE Control System</b>	Do a visual check of the cables; replace damages cables and wires	quarterly

**Notes to Maintenance Intervals & Lifetime;**

- 1) All data provided on the pages above are for information purposes only, explicitly non-binding and subject to change without further notice. Detail maintenance schedule is included in Maintenance Manuals for specific engine type.
- 2) Intervals for inspection or overhauls and estimated lifetimes are estimates only. They are based on past experience and valid for engines fully according to currently applicable Winterthur Gas & Diesel Ltd and Wärsilä Services Switzerland Ltd specifications. They are given for information purposes only and do not constitute any guarantee or warranty whatsoever as the actual service life can vary considerably due to numerous conditions and influences such as but not limited to:
  - Environmental and operating conditions;
  - Heavy fuel and lubricating oil qualities;
  - Engine load factor;
  - Fuel, lubricating oil and cooling water treatment;
  - Overhaul according to engine manuals;
  - Only genuine spare parts used;
  - Careful and continuous engine monitoring.
- 3) "Estimated lifetime" refers to the life expectancy in hours under normal operating conditions before the component is removed for replacement or remanufacturing.

# 18 Appendix

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## 18.1 Appendix

On the pages that follow you find additional information which may be referenced in other parts of this document.



## Injection Valve

### Checking, Dismantling, Assembling and Adjusting

#### Tools:

1	Protection cap	94271
1	OBEL test bench	94272
1	Connecting piece	94272b

#### Key to Illustrations:

1	Injection valve	17	Fixing piece
2	Nozzle holder	18	Snap ring
3	Intermediate piece	19	Allen screw
4	Nozzle body	20	Spring cage
5	Nozzle needle	21	Circlip
6	Retaining nut	22	Spring guide
7	Retaining sleeve	23	Cup spring (spring packet)
8	Snap ring	24	Shim ring
9	Shim ring	25	Shim
10	Compression spring (unloaded length = 84 mm)	26	Support
11	Tappet	27	HP hose
12	Nozzle tip	28	Receiver
13	Dowel pin		
14	Dowel pin	LF	Leakage fuel
15	Dowel pin	SF	Sealing face
16	Dowel pin	SS	Seating surface

#### Overview

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11.	<b>Storage and handling of injection valve</b> .....	9/9

## 1. General

For checking, dismantling, assembling and adjusting the injection valve, test bench 94272 as well as test & calibration fluid has to be used (e.g. Shell Calibration Fluid S.9365) complying with the data according to the following table:

#### **Physical characteristics for test & calibration fluid:**

Kinematic Viscosity		ASTM D445	
at 40 °C	mm <sup>2</sup> /s		2.6
Density at 15 °C	kg/m <sup>3</sup>	ISO 12185	827
Pour Point	°C	ISO 3016	-27

Clean diesel oil (gas oil) can be used if no calibration fluid is available. The use however is not recommended, if the injection valve will be stored and not directly installed on the engine (corrosion reasons).

On some injection valves the leakage flow amount might be bigger than on others. In case of the test bench flow is not sufficient to open the nozzle needle, a clean additive-type crankcase (system) oil of the SAE 30 viscosity grade (for additional data see 0750-1 'System oil' in the Operating Manual) can be used for testing instead of the above mentioned fluids.

## Injection Valve: Checking, Dismantling, Assembling and Adjusting

## 2. Checking an injection valve

Before commissioning the instructions and directions of the test bench manufacturer must be observed.

CHECK



From time to time check the pressure gauges of the test bench with a master pressure gauge and adjust them if necessary.

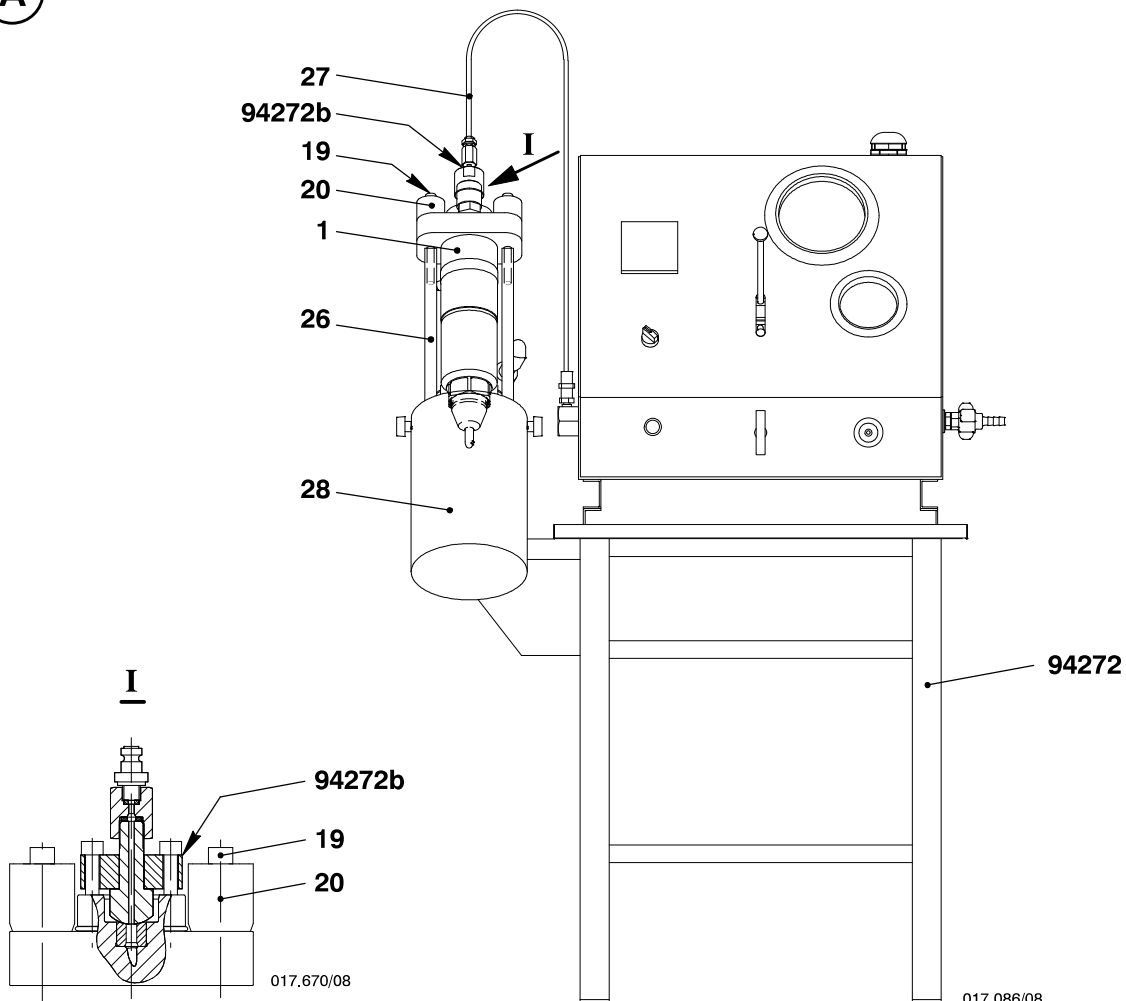
**Remark:** The work station must be clean; welding and grinding should not be done nearby!

- ⇒ Remove combustion residues and clean nozzle tip externally with a brass wire brush.
- ⇒ Place injection valve 1 with nozzle tip pointing downwards into support 26 of test bench 94272 and fasten it with two Allen screws 19 and spring cages 20.
- ⇒ Tighten high pressure hose 27 of the test bench with connecting piece 94272b.
- ⇒ Start the test bench following the proper manufacturer's instructions.
- ⇒ Bring the injection valve to spray with a few short pump jerks, and then observe at what pressure the injection valve opens, applying slow, equal pump jerks.



**Danger of injuries! Never** hold fingers or hands directly before the spray holes of the nozzle tip!

A



## Injection Valve: Checking, Dismantling, Assembling and Adjusting

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### 3. Judging an injection valve

For correct functioning and for a reuse of an injection valve observe the following points:

- Spray pattern: Fuel will spray mainly from the holes in the first level of the nozzle tip at the specified opening pressure. No fuel should drip from nozzle tip when injection is finished.
- For **new** injection valves the opening pressure is **375 ± 10 bar**.

On **used** injection valves a pressure reduction of 30 bar may be acceptable. If a readjustment of the opening pressure is necessary, see section 'Adjusting the opening pressure'.

- In order to test tightness between the nozzle needle and needle seat, keep the pressure in the test bench constant at approx. 20 bar below the opening pressure. During a time period of 30 seconds no 'dripping' should occur at the nozzle tip.
- The spray holes of nozzle tip 12 must not be flushed out unduly.

⇒ Injection valves which do not spray efficiently must be dismantled as described under section 4. Often, a thorough cleaning suffices to make them fully functional.



**Remark:** Nozzle tips with flushed out spray holes must be replaced by new ones. Nozzle holders 2, intermediate pieces 3 and nozzle bodies 4 (Fig. 'B') with poor sealing faces must either be replaced or reconditioned by the manufacturer or an authorized company.

## Injection Valve: Checking, Dismantling, Assembling and Adjusting

**4. Dismantling an injection valve**

- ⇒ Remove receiver 28.
- ⇒ Screw down the injection valve on support 26 of test bench 94272, as mentioned, however without connecting HP hose 27.
- ⇒ Turn the valve holder through 180° into vertical position.
- ⇒ Place the special tool of the test bench onto retaining nut 6 and loosen it with the press of the test bench.  
Note test bench manufacturer's application instruction!
- ⇒ Remove retaining nut 6, nozzle tip 12, retaining sleeve 7, nozzle body 4, nozzle needle 5, intermediate piece 3, tappet 11, compression spring 10 and shim rings 9.

**CHECK**

Examine all parts for their condition.

**Remark:** If only a nozzle tip has to be replaced, see section 7.

**Never interchange nozzle needle 5 and nozzle body 4 !** Each nozzle needle belongs to its mated nozzle body into which it has been individually fitted with greatest precision.

**5. Assembling an injection valve**

Note the following points when assembling the injection valve:

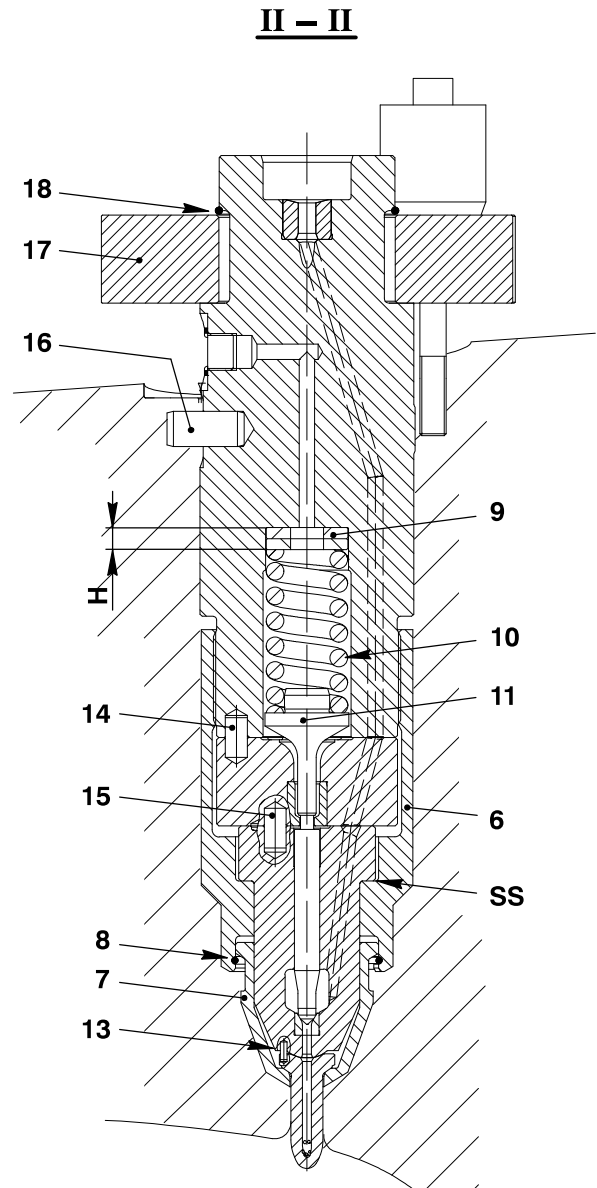
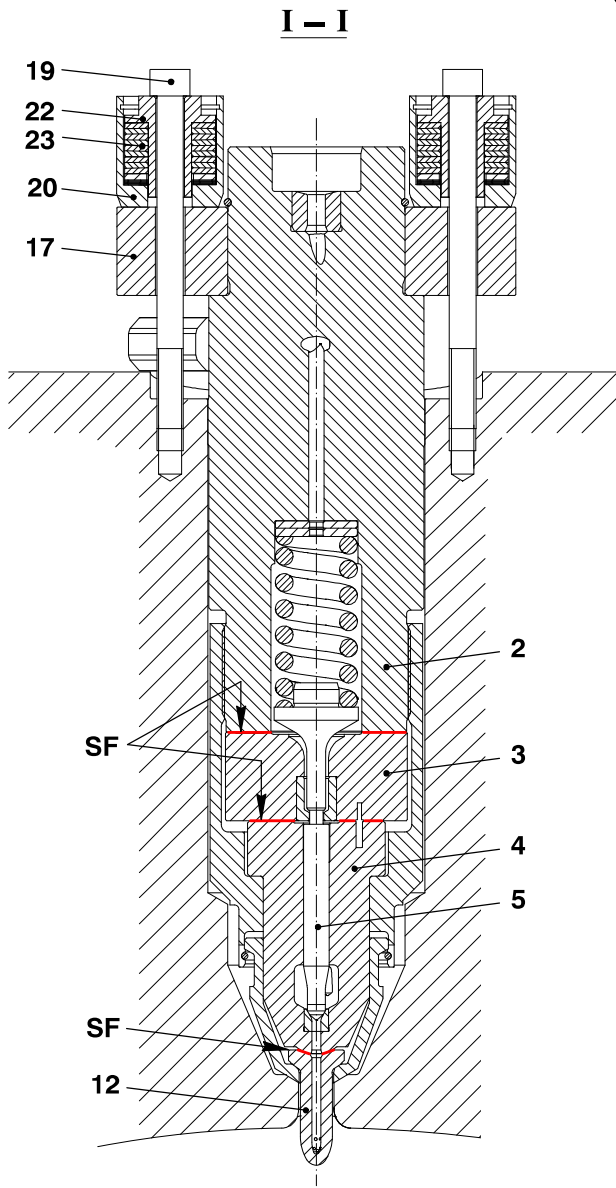
- ⇒ Clean the injection valve parts. Use only clean diesel oil (gas oil) or fresh kerosene, and dry compressed air.
- ⇒ The fitting position of nozzle tip 12, nozzle body 4 and intermediate piece 3 is given by dowel pins 13, 14 and 15 (Fig. 'B').
- ⇒ Make sure that the red marked **sealing faces 'SF'** are in perfect condition and that **no lubricant** is applied.
- ⇒ Fit the nozzle tip in accordance with section 7.
- ⇒ Install shim rings 9, compression spring 10, tappet 11, intermediate piece 3, nozzle body 4 with nozzle needle 5 and nozzle tip 12.
- ⇒ Apply a layer of **Never-Seez to the thread and the seating surface 'SS'** of retaining nut 6.
- ⇒ Carefully tighten the coupling nut manually with an open end wrench (AF 70) until all the relevant parts are tight on the nozzle holder 2.  
First tighten retaining nut to **100 Nm** using a torque wrench. Starting from this position, tighten the retaining nut by a further angle of **30°** by means of the hydraulic tightening (or loosening) device of the test bench.
- Repeat the tightening procedure on the initial assembly.
- An angle of 30° corresponds to 25.1 mm on the circumference relating to a nut diameter of 96 mm.

**CHECK**

After assembling the injection valve must be checked and judged according to sections 2 and 3.

Injection Valve: Checking, Dismantling, Assembling and Adjusting

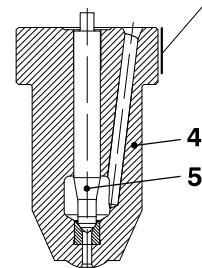
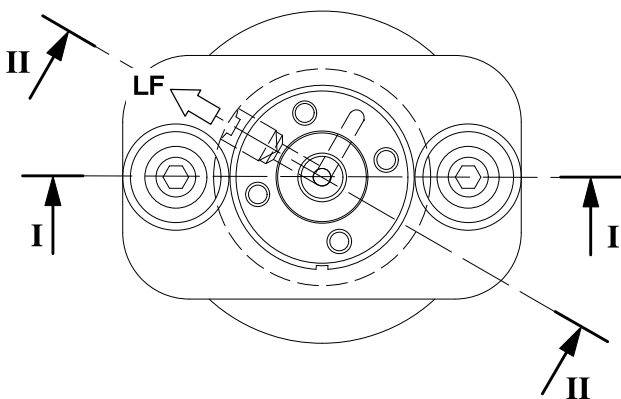
(B)



WCH00831

DESIGNATION OF NOZZLE BODY

DRAWING. NO. x EXECUTION CODE NO. x NEEDLE LIFT



## Injection Valve: Checking, Dismantling, Assembling and Adjusting

**6. Adjusting the opening pressure**

- ⇒ Dismantle injection valve (section 4).
- ⇒ Fit two shim rings 9 provisionally, which are supplied with the injection valve, with a total thickness of 7 mm.
- ⇒ Assemble injection valve (section 5).
- ⇒ Check injection valve (section 2) and note the opening pressure as 'p<sub>1</sub>'.
- ⇒ Determine thickness 'H' of shim rings 9 to be fitted.

**6.1 Determining of total shim thickness 'H'**

The total shim thickness 'H' can be determined with the following formula:

$$H = 7 + \frac{p_0 - p_1}{C}$$

**Example:**

- p<sub>0</sub> = 375 bar ± 10 bar      specified opening pressure
- p<sub>1</sub> = 352 bar                      measured opening pressure
- C = 53.6 (bar / mm)              ratio pressure / spring deflection

$$375 - 352 : 53.6 = 0.4 \text{ mm}$$

$$H = 7 + 0.4 = 7.4 \text{ mm} \rightarrow \text{corresponds to total shim thickness 'H'}$$

In this example there are shim rings with a total thickness of 7.4 mm to be fitted, i.e. shim rings of 3.3 mm and 4.1 mm.



**Remark:** Ensuring the determined total thickness, the pre-machined shim rings (set of 3.3 mm, 3.5 mm, 3.7 mm, 3.9 mm and 4.1 mm) must be used which are supplied with every injection valve.

**CHECK**

After the proper shim rings have been fitted, the injection valve must be rechecked confirming the specified **opening pressure of 375 bar ± 10 bar**.

## Injection Valve: Checking, Dismantling, Assembling and Adjusting

**7. Replacing a nozzle tip**

Ensure that always specified nozzle tips are used in accordance with the IMO Technical File of the engine.

If nozzle tip 12 should be dismantled only, it is sufficient to remove only retaining sleeve 7.

**7.1 Removal**

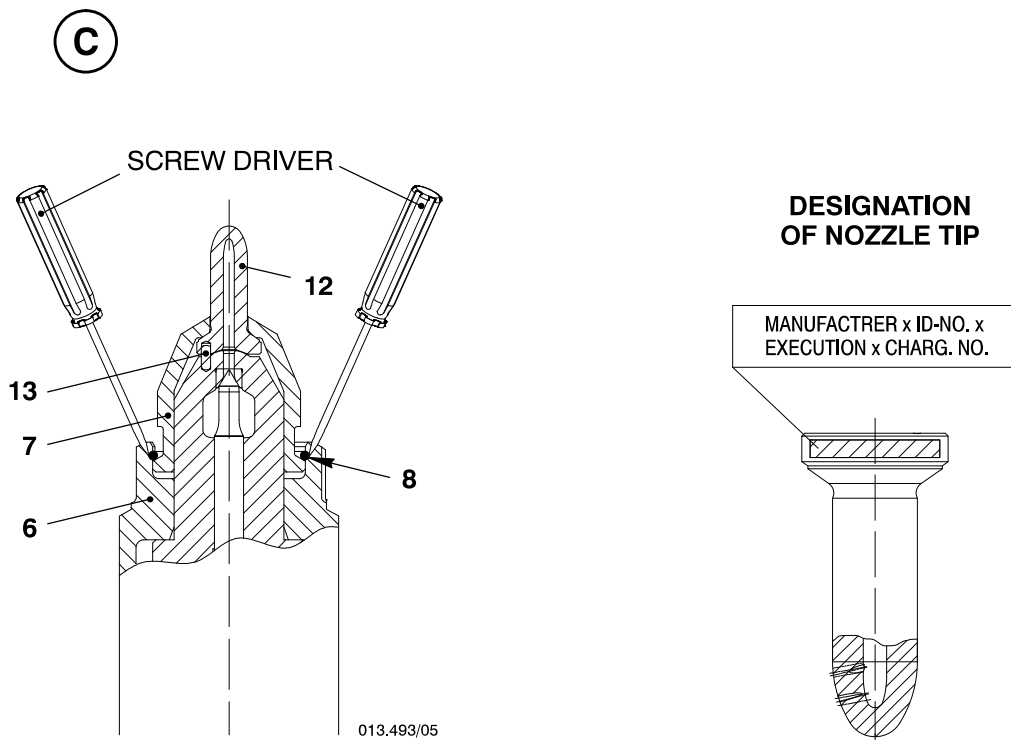
- ⇒ Using two screw drivers inserted between both recesses in retaining nut 6, press snap ring 8 out of the groove in the retaining nut, whereby the retaining sleeve can be withdrawn.
- Watch that the snap ring does not jump off unexpectedly.
- ⇒ Remove nozzle tip.

**7.2 Fitting**

For fitting it is advantageous to clamp the injection valve on its flange into a vice (nozzle body 4 pointing upwards), and then proceed as follows:

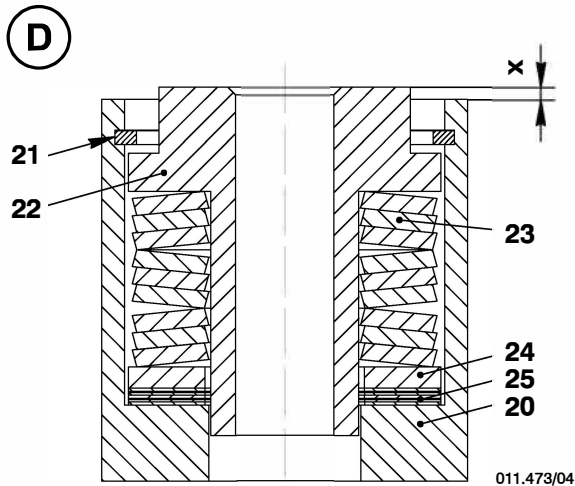
- ⇒ Clean all parts with clean diesel oil or kerosine and blow them out with compressed air.
- ⇒ Place nozzle tip on the nozzle body whereby the position is assured by dowel pin 13.
- ⇒ Put retaining sleeve 7 over the nozzle tip, and press snap ring 8 into the groove of the retaining nut by means of the screw drivers.

After replacing a nozzle tip the injection valve must be checked and judged according to sections 2 and 3.



## Injection Valve: Checking, Dismantling, Assembling and Adjusting

## 8. Assembling a spring cage



- Cup springs 23 are fitted in spring cage 20.
- The spring packet consists of three packs composed of three cup springs which are arranged as shown in Fig. 'D'.

In order to maintain an equal contact force when screwing down the injection valve, **distance 'x'** must be adjusted to  $1.6 \pm 0.1 \text{ mm}$  with shims 25.

## 9. Fitting an injection valve in cylinder cover

**CHECK**

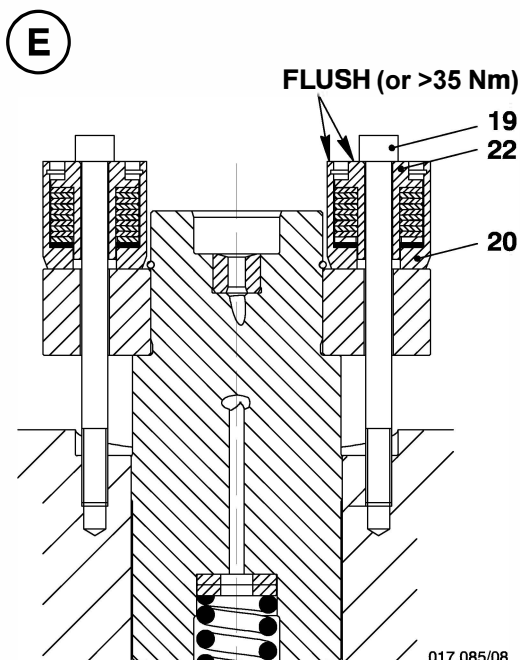
Clean the seating surface of the injection valve in the cylinder cover and check for damages.

If necessary recondition the seating surface using the special tool supplied with the tools set (see 2708-3).



The sealing must be metal-to-metal, i.e. **no joint** must be put in between.

⇒ Place the injection valve carefully in the cylinder cover. Dowel pin 16 (Fig. 'B') assures the correct position.



## 9.1 Screwing down the injection valve

- ⇒ Apply Never-Seez to the threads and the seating surfaces of Allen screws 19.
- ⇒ Fit and equally tighten Allen screws until spring guides 22 are flush with spring cages 20.

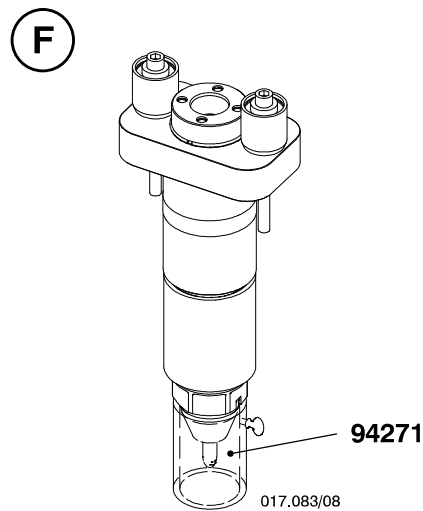


## Injection Valve: Checking, Dismantling, Assembling and Adjusting

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### 10. Protecting a nozzle tip

Protect the nozzle tip integrated in the injection valve against damage. Always fit protection cap 94271 for transport, storage, etc.



### 11. Storage and handling of injection valve

Store an injection valve in a dry place but not in a place contaminated with exhaust gases or any other corrosive atmosphere. Keep the injection valve in its original packing. Handle with care when preparing for use and avoid any hard contact against other objects.



**Attention!** Do not open vacuum packed injection valve before the installation on the engine.

For cleaning use white spirit, e.g. Shellsol TD, Shellsol T or Solvent FP68. Always wear gloves and safety goggles with closed side frame!

## Gas Admission Valve (GAV) Removal Disassembly and Installation

### Tools:

1 Eye bolt	94045-M10	1 Pressure reducing valve	94214B
1 Dismantling tool	94214	1 Assembly tool	94023A
1 Handle	94214A	2 M10 Screws	

<b>1. General</b>	<b>1</b>
<b>2. Preparation</b>	<b>1</b>
<b>3. Removal</b>	<b>2</b>
<b>4. Disassemble</b>	<b>2</b>
<b>5. Pressure Test</b>	<b>4</b>
<b>6. Valve Seat – Lap</b>	<b>4</b>
<b>7. Assemble</b>	<b>5</b>
<b>8. Installation</b>	<b>7</b>

## 1. General

- 1) Read the data in the:
  - Operation Manual
  
- 2) For the inspection intervals, refer to the Maintenance Schedule

## 2. Preparation

- 1) Stop the engine. Refer to the Operation Manual
- 2) Set to off the main bearing oil pumps (use the service pump for tests).
- 3) Make sure that the pressure in the servo oil supply pipes is zero.
- 4) Make sure that the pressure in the gas pipe, high pressure pipe and lubricating oil pipe is zero.
- 5) Make sure that the drain from the gas control valve is open.

### WARNING



**Danger: Some gas can leak during the removal of the GAV. Do not use equipment that can cause a spark. Make sure that all equipment that can cause a spark is not in the work area. This will prevent an explosion, or a fire.**

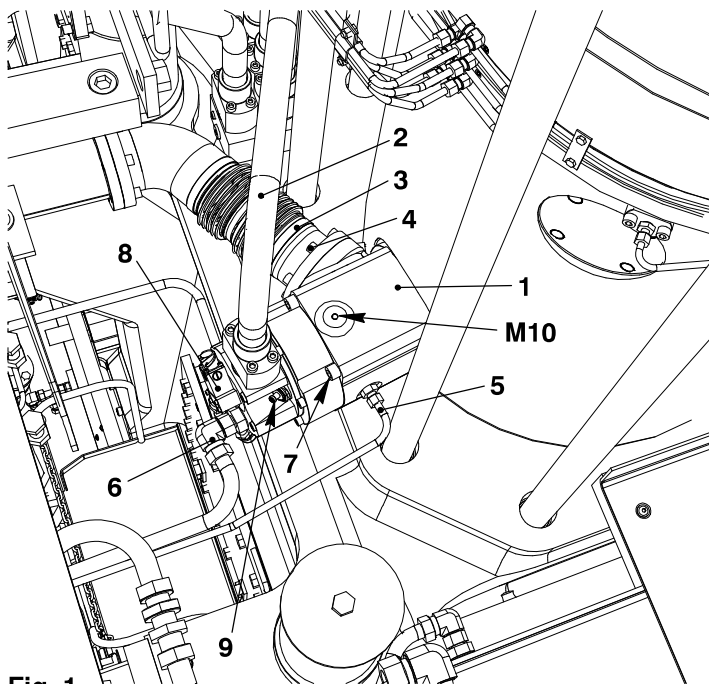


Fig. 1

WCH03350

### 3. Removal

- 1) Put an oil tray below the GAV (1).
- 1) Remove the oil pipe (2). Do not damage sealing surface.
- 2) Remove the return pipe (6) and lubrication pipe (5) from the GAV (1).
- 3) Put protection on the pipe openings.
- 4) Disconnect the electrical connections from the rail valve (8) and the valve stroke sensor (9).

**Note: Use the tool 94023A to remove the plug from the valve stroke sensor (see Fig. 11).**

- 5) Install an eye bolt 94045-M10 (M10) on top of the GAV.
- 6) Install a suitable lifting tool (GAV=70 kg) and attach the hook to the eye bolt.
- 7) Remove the four bolts (7).
- 8) Remove the six screws (4, Fig. 1) and push the gas distributor pipe (3) back small distance.
- 9) Move carefully the GAV to a clean working area.
- 10) Attach protection to the opening of the gas distributor pipe (3).

### 4. Disassemble

- 1) Remove four bolts (2, Fig 2).
- 2) Carefully remove the cover (1) together with the rail valve (3).

**Note: Remove carefully the cover (1). There is a piston attached to the cover.**

- 3) Remove the coupling nut (5) on the valve stroke sensor (4).
- 4) Remove the valve stroke sensor (4) with its distance sleeve.
- 5) Remove symmetrically the six bolts (6).
- 6) Carefully remove cover (7).

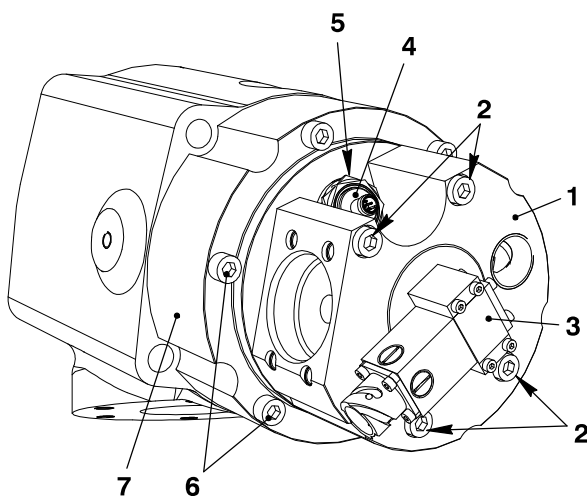


Fig. 2

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## Gas Admission Valve: Removal, Disassembly and Installation

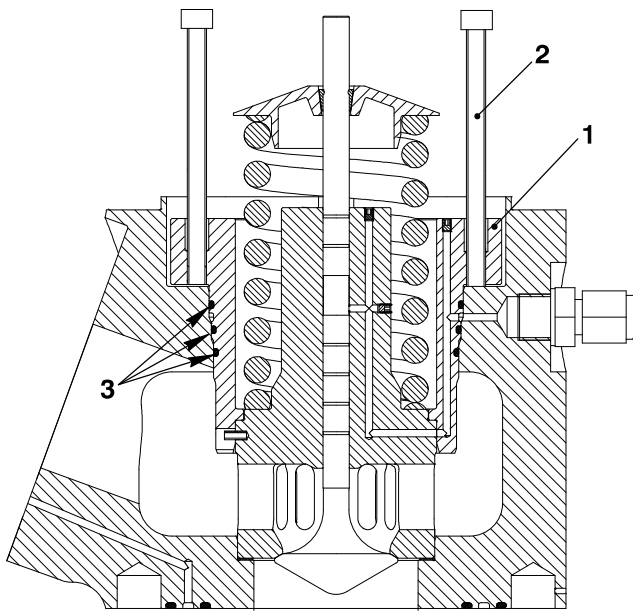


Fig. 3

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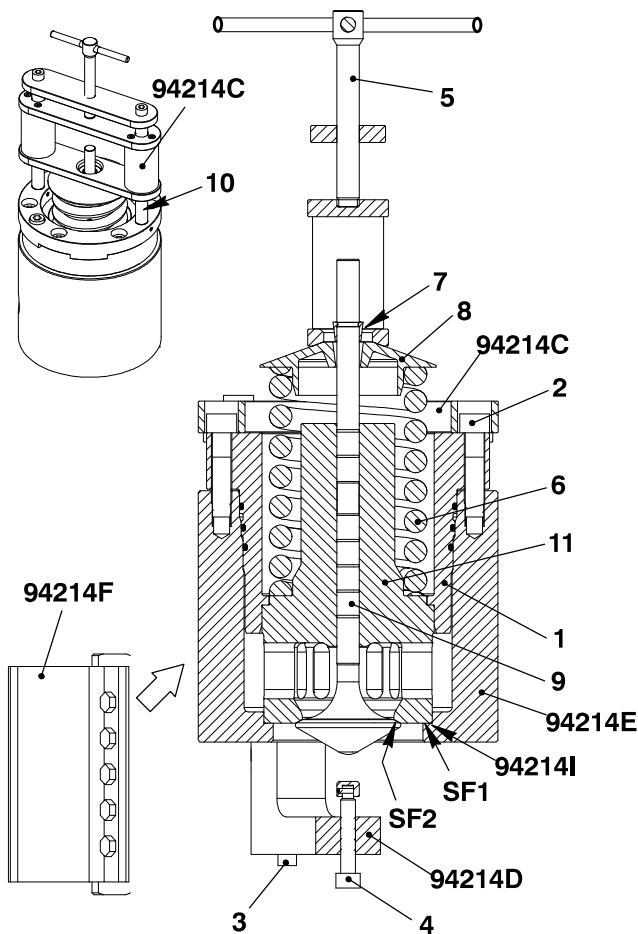


Fig. 4

WCH03362

- 7) To remove the valve assembly (1), use two long M10 screws (2) and turn them equally into the two opposite M10 threads.
- 8) Remove the valve assembly (1).
- 9) Replace the three O-rings (3) and apply oil to them before installation.
- 10) Attach the steel plate 94214F to the bush 94214E with the five screws (Fig. 4).
- 11) Put the steel plate 94214F and the bush 94214E attached to it horizontally into a vice.
- 12) Make sure that the sealing faces SF1 are clean.
- 13) Install the soft metal gasket 94214I between sealing faces SF1.
- 14) Put the valve assembly (1) into the bush 94214E.
- 15) Apply Molykote G-Rapid plus to the rods of spring press 94214C.
- 16) Attach the spring press 94214C and the valve assembly (1) with the six M10x45 screws (2) to the bush 94214E.
- 17) Torque the screws (2) to 40 Nm.
- 18) Install the bracket 94214D with two M6x75 screws (3) on the other side of the bush 94214E.
- 19) Turn the special screw (4) fully in.
- 20) Turn the spindle (5) in to compress the spring (6). This will push the valve cotter (7) out of the spring carrier (8).
- 21) Remove the valve cotter (7).
- 22) Turn the spindle (5) out to release the tension in the spring (6).
- 23) Remove the bracket 94214D.
- 24) Remove the valve spindle (9), clean the valve spindle and do a check it for damage, specially the sealing surface SF2.
- 25) Carefully put the valve spindle (9) into the valve guide (11) and move the spindle in and out. The friction must be the same during the stroke, e.g. the valve spindle must not slip, or stay in position. The weight of valve spindle must move it down.

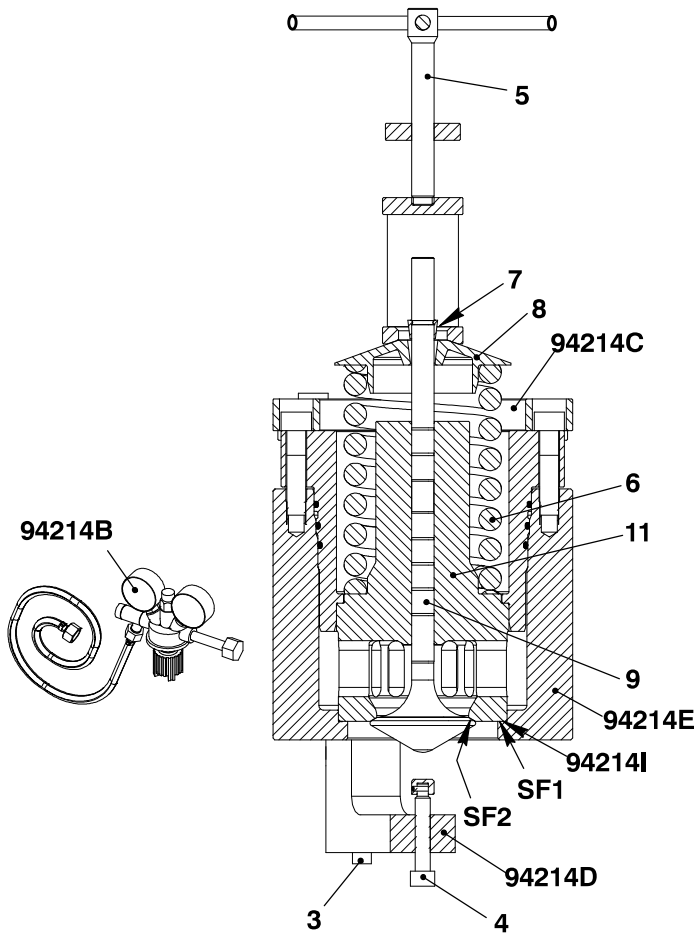


Fig. 5

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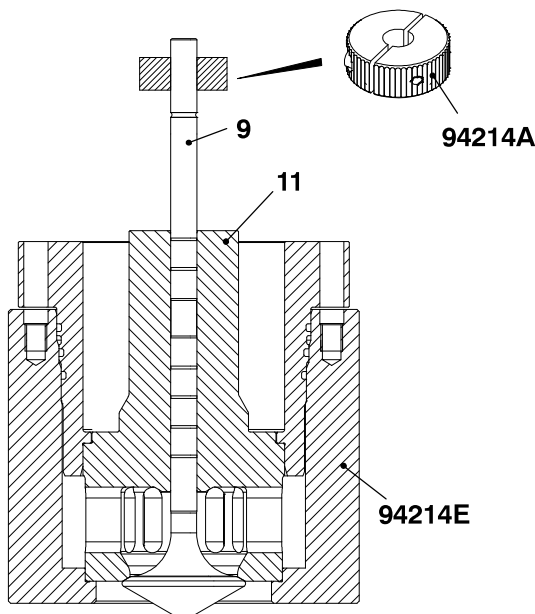


Fig. 6

WCH03362

## 5. Pressure Test

- 1) Apply lube oil to the valve spindle (9).
- 2) Put the valve spindle (9) into the valve guide (11).
- 3) Install the bracket 94241D to the bush 94214E with the two M6x75 screws (3).
- 4) Turn the special screw (4) fully in.
- 5) Turn the spindle (5) in to compress the spring (6).
- 6) Install the valve cotter (7) on the valve spindle (9).
- 7) Turn the spindle (9) back to release the tension in the spring (6). Make sure that the valve cotter (7) is fully in the spring carrier (8).
- 8) Attach the pressure reducing valve 94241B to the bush 94214E.
- 9) Attach a pressurized nitrogen supply to the pressure reducing valve 94241B.
- 10) Set the pressure reducing valve to 10 bar.
- 11) Apply a thin layer of WD40 (or an approved alternative) as a spray to the area of the valve seat SF2.
- 12) The test is satisfactory if:
  - a) Up to five bubbles each second come from the valve seat.
  - b) No bubbles come from the soft metal seal.
- 13) If the test results are different than those given, do the procedure given in paragraph 6.

## 6. Valve Seat – Lap

- 1) Remove the spring (6, Fig. 4), refer to paragraph 4.
- 2) Attach the handle 94214A to the valve spindle as shown in Fig. 6.
- 3) Apply lube oil to the valve spindle (9).
- 4) Put the valve spindle (9) into the valve guide (11).
- 5) Use oil based lapping paste with a grain size of 0.5 to 4.0 microns and lap the valve seat.
- 6) Do the pressure test again. If the leakage is unsatisfactory, replace valve spindle and the valve guide.

## Gas Admission Valve: Removal, Disassembly and Installation

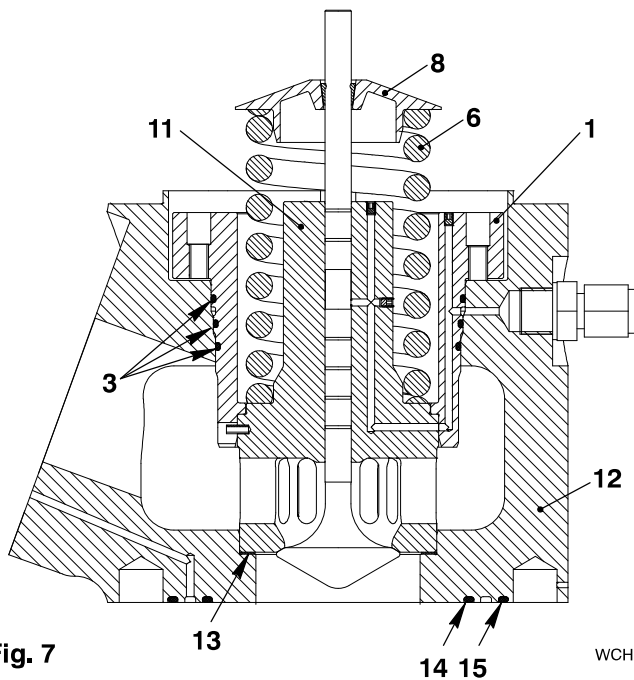


Fig. 7

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## 7. Assemble

- 1) Clean all parts and bores.
- 2) Make sure the O-rings (3) are in a satisfactory condition.
- 3) Apply oil to the O-rings (3).
- 4) Replace the gasket (13).
- 5) Put the valve assembly: bush (1), valve guide (11), spring (6), spring carrier (8), valve spindle (9) into the housing (12).
- 6) Replace the O-rings (14) and (15).

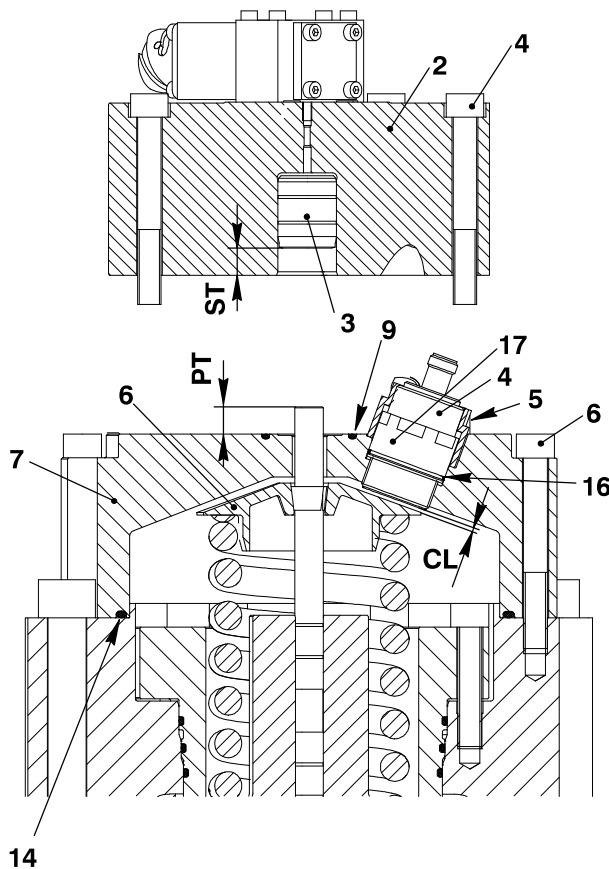


Fig. 8

WCH03361

- 7) Replace the O-ring (14, Fig. 8).
  - 8) Apply Never Seez NSBT to the six bolts M10x80 (6).
  - 9) Install the cover (7) the the cover (12) with the six bolts M10x80 (6).
  - 10) Torque the six bolts (6) to 40 Nm.
  - 11) Measure the distance PT of the valve spindle to the cover (7).
  - 12) Clean the piston hole in the cover (2).
  - 13) Apply lube oil to the piston (3).
  - 14) Put the piston (3) fully into the hole.
  - 15) Measure the piston stroke ST.
  - 16) Calculate the valve clearance  $ST - PT$ :
- Note: The valve clearance  $ST - PT$  must be 0.20 to 1.37 mm. If the valve clearance is too low, the valve cannot close completely.**
- 17) Replace the O-ring (9).

## Gas Admission Valve: Removal, Disassembly and Installation

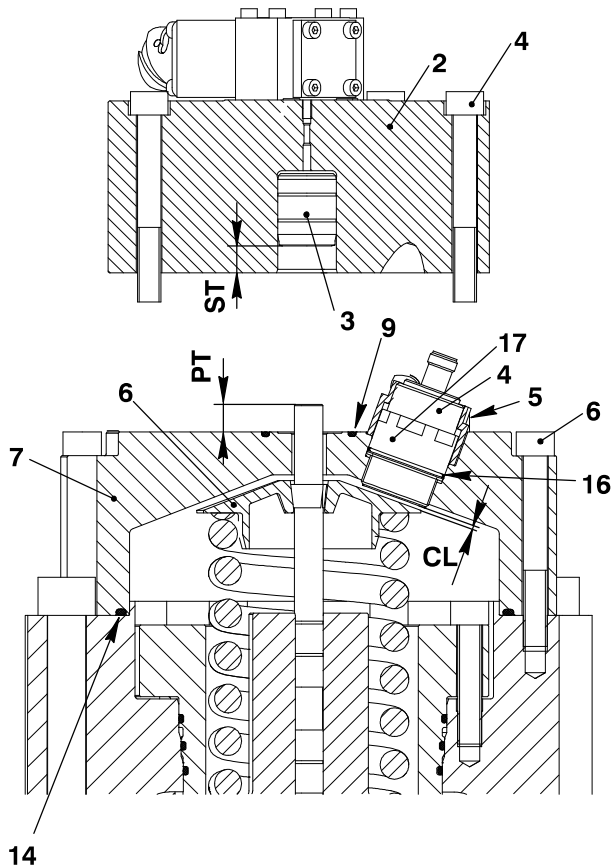


Fig. 9

WCH03361

- 18) Replace the O-ring (16) on the distance sleeve (17) (the distance sleeve is bonded on).
- 19) Put the valve stroke sensor (4) into the cover (7). Turn the valve stroke sensor clockwise until it touches the spring carrier (6).
- 20) Move the valve stroke sensor (4) counterclockwise one turn. This gives the clearance where  $CL = 1.5\text{ mm}$ .
- 21) Apply Never Seez NSBT to the thread of coupling nut (5).
- 22) Hold the sensor (4) and torque the coupling nut to 90 Nm.
- 23) Clean the surfaces of the cover (7) and the cover (2).
- 24) Apply Never Seez to the threads of the four bolts (2).
- 25) Attach the cover (2) with the four bolts (4).
- 26) Torque the four bolts (4) to 40 Nm.

## Gas Admission Valve: Removal, Disassembly and Installation

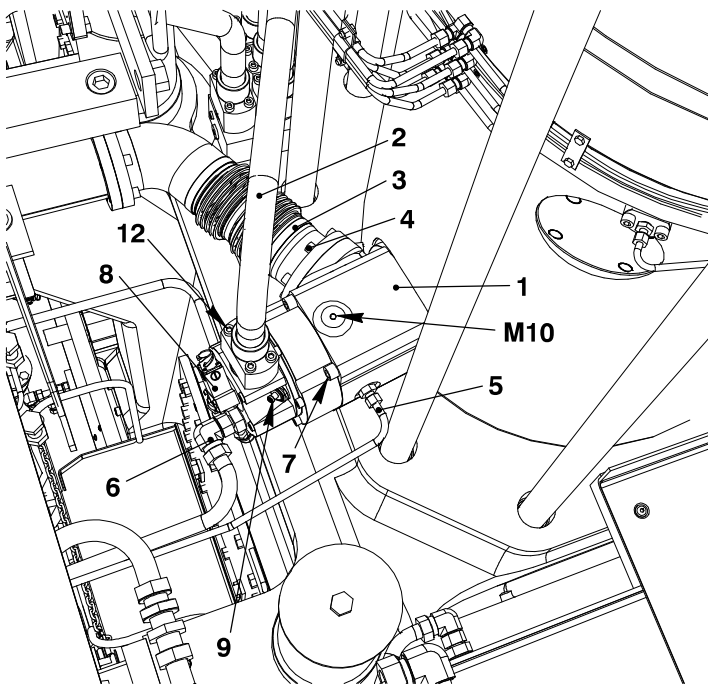
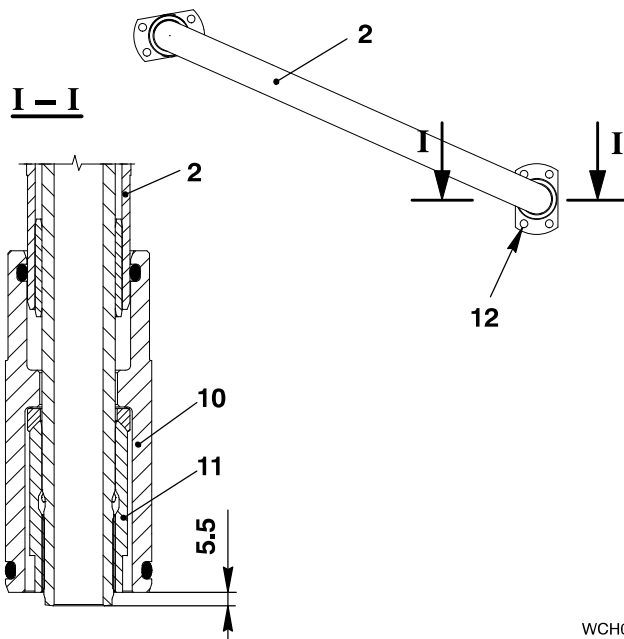


Fig. 10

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## 8. Installation

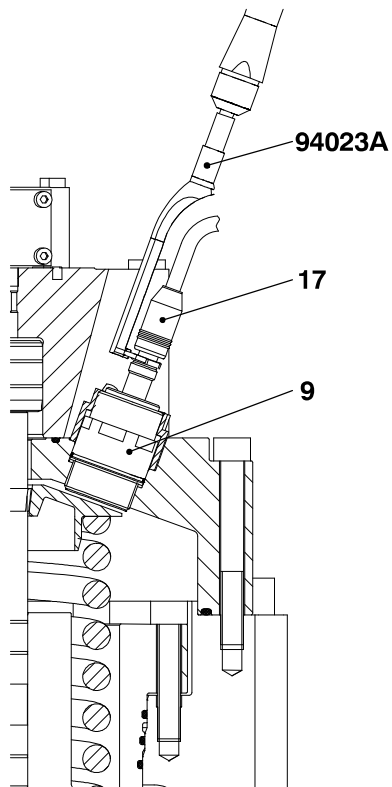
- 1) Attach an M10 eye bolt (M10) to the housing of the GAV (1).
- 2) Lift and move the GAV (1) to the applicable position at the cylinder liner.
- 3) Make sure all surfaces are clean.
- 4) Apply Never Seez NSBT to the four bolts (7).
- 5) Attach the the GAV (1) to the cylinder liner with the four bolts (7).
- 6) Torque equally the four bolts (7) to 170Nm.
- 7) Remove the flange of the gas distributor pipe (3).
- 8) Replace the O-rings in the flange of gas distributor pipe (3).
- 9) Attach the gas distributor pipe (3) to the GAV (1) with the six screws (4).
- 10) Tighten the six screws (4) equally.
- 11) Attach the return pipe (6) and the lubrication pipe (5) to the GAV (1).
- 12) Connect the electrical connection to the rail valve (8).
- 13) Make sure that the sealing face of the oil pipe (2) has no damage. If there is damage, grind the sealing faces (refer to 8460-1).
- 14) Adjust the claw (11) with an open end wrench until there is a distance of 5.5mm between the claw and the end of the pipe (2) .
- 15) Apply oil to the eight screws (12).
- 16) Carefully install the oil pipe (2).
- 17) Torque the eight screws (12) equally to 40Nm.



Gas Admission Valve: Removal, Disassembly and Installation

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- 19) Use the assembly tool 94023A (Fig. 11) to attach the electrical connection (17) to the valve stroke sensor (9).
- 20) Do a check for leaks immediately.

**Fig. 11**

WCH03362

**SCAVENGE AIR COOLER – ASSEMBLY/DISASSEMBLY**

**Tools:**

TOOL NO	GROUP	DESCRIPTION	COMMENT
T1	9408-16	TROLLEY	LOAD CAPACITY 2000 kg
T2	9408-16	TROLLEY	LOAD CAPACITY 2000 kg
T3	9408-18	RUD SWIVEL LUG	LOAD CAPACITY 5000 kg
T4	9408-16	SHACKLE	LOAD CAPACITY 2000 kg
T5	9408-16	LEVER CHAIN HOIST	LOAD CAPACITY 3200 kg / LOAD CHAIN STROKE 5.5 m
T6	9466-01	TOOL SAC ASSEMBLY	LOAD CAPACITY 1500 kg
T7	9466-01	TOOL SAC ASSEMBLY	LOAD CAPACITY 1500 kg
T8	9466-01	DISMANTLING TOOL	LOAD CAPACITY 6000 kg
T9	9408-16	ROUND SLING	PERMISSIBLE LOAD 4000 kg / LENGTH 2.5 m
T10	9408-16	SPUR GEARED CHAIN BLOCK	LOAD CAPACITY 2500 kg / LOAD CHAIN STROKE 6 m / HANDCHAIN STROKE 5 m
T11	9408-16	SPUR GEARED CHAIN BLOCK	LOAD CAPACITY 2500 kg / LOAD CHAIN STROKE 6 m / HANDCHAIN STROKE 5 m
T12	9408-16	SHACKLE	LOAD CAPACITY 8500 kg
T13	9408-16	TROLLEY	LOAD CAPACITY 2000 kg
T14	9408-16	SPUR GEARED CHAIN BLOCK	LOAD CAPACITY 5000 kg / LOAD CHAIN STROKE 6 m / HANDCHAIN STROKE 5 m
T15	9408-16	SPUR GEARED CHAIN BLOCK	LOAD CAPACITY 5000 kg / LOAD CHAIN STROKE 6 m / HANDCHAIN STROKE 5 m
T16	9466-01	TOOL SAC ASSEMBLY	-

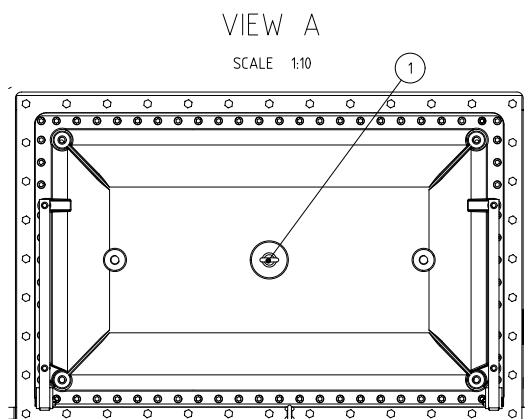
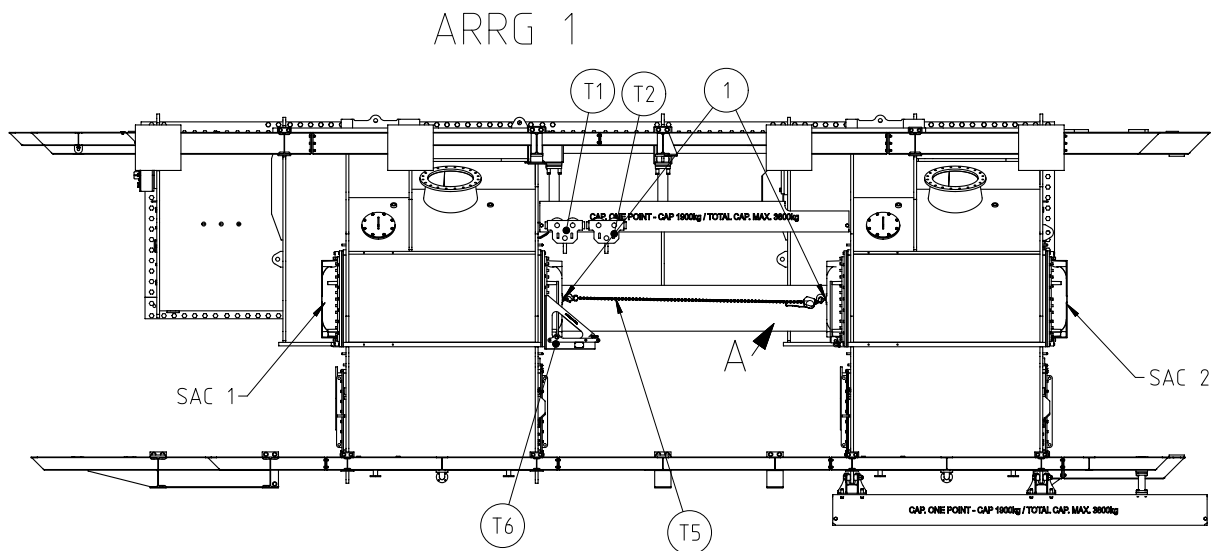
**ATTENTION:**

COOLER SHOULD NEVER BE LIFTED FROM THE CENTER SWIVELLING LUG WITHOUT SECURING SIDES AGAINST ROTATION. IF LIFTING IS DONE ONLY FROM CENTER LUG THERE IS A RISK THAT THE COOLER STARTS ROTATING.

## DISASSEMBLING

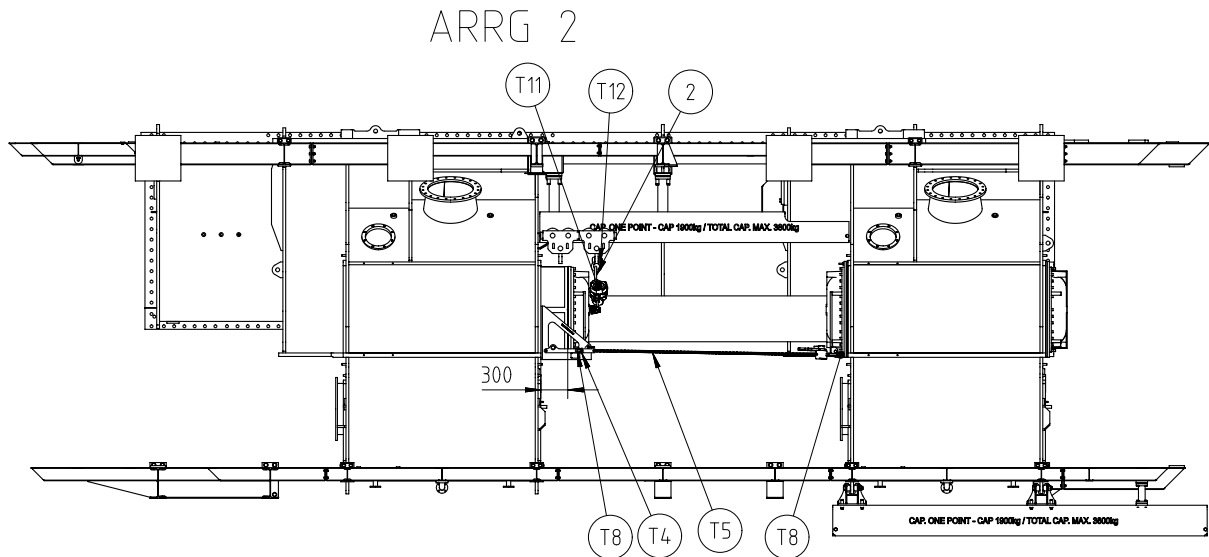
### ARRG 1

1. Attach the tool SAC assembly (T6) and (T7) to the left and right of the receiver frame
2. Remove screws and dismantle adjoining pipework from the cooler.
3. Attach the two trolleys with chain blocks (T1)+(T2) to the crane rail.
4. Fit the rod swivel lug (T3) to the front of the SAC.
5. Dismount flange screws.
6. Eyebolt (1) into cooler and opposite one, lever chain hoist.
7. Hook the lever chain hoist (T5) into the eye bolts of SAC 1 and SAC 2.
8. Withdraw SAC 1 by about 300 mm.



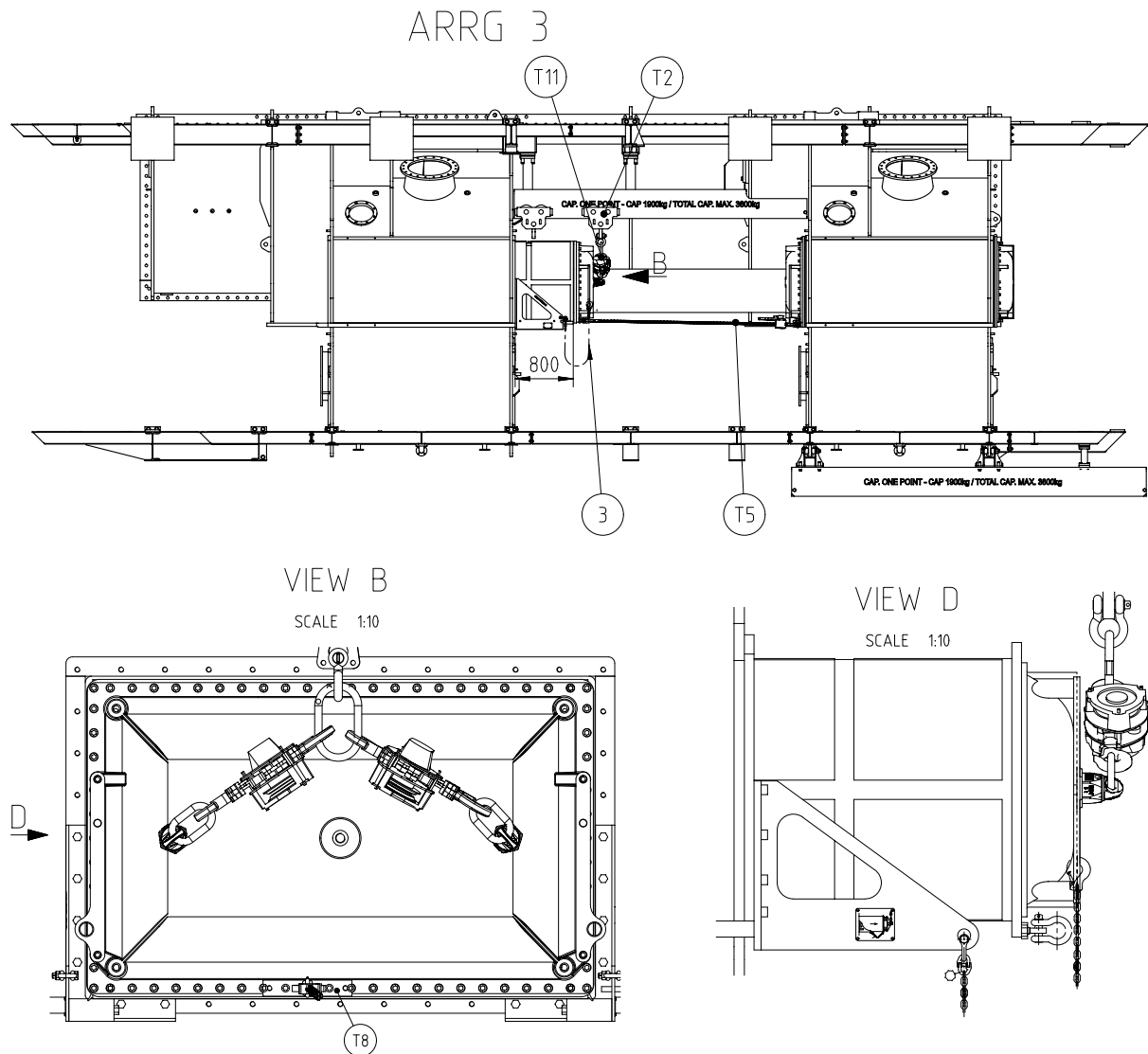
## ARRG 2

9. Attach the dismantling tool (T8) in the bottom center of the air cooler
10. Attach the shackle (T12) to the trolley (T2) and ring (2) to the shackle.
11. Attach the spur geared chain hoist (T11) to the ring (2)
12. Attach the shackle (T4) with dismantling tool (T8) in the cooler to be dismantled.
13. Hook the lever chain hoist (T5) to the shackle (T4) of the opposite cooler with shackle.
14. Remove the eye bolt (1)
15. Withdraw the SAC 1 by about 800 mm.



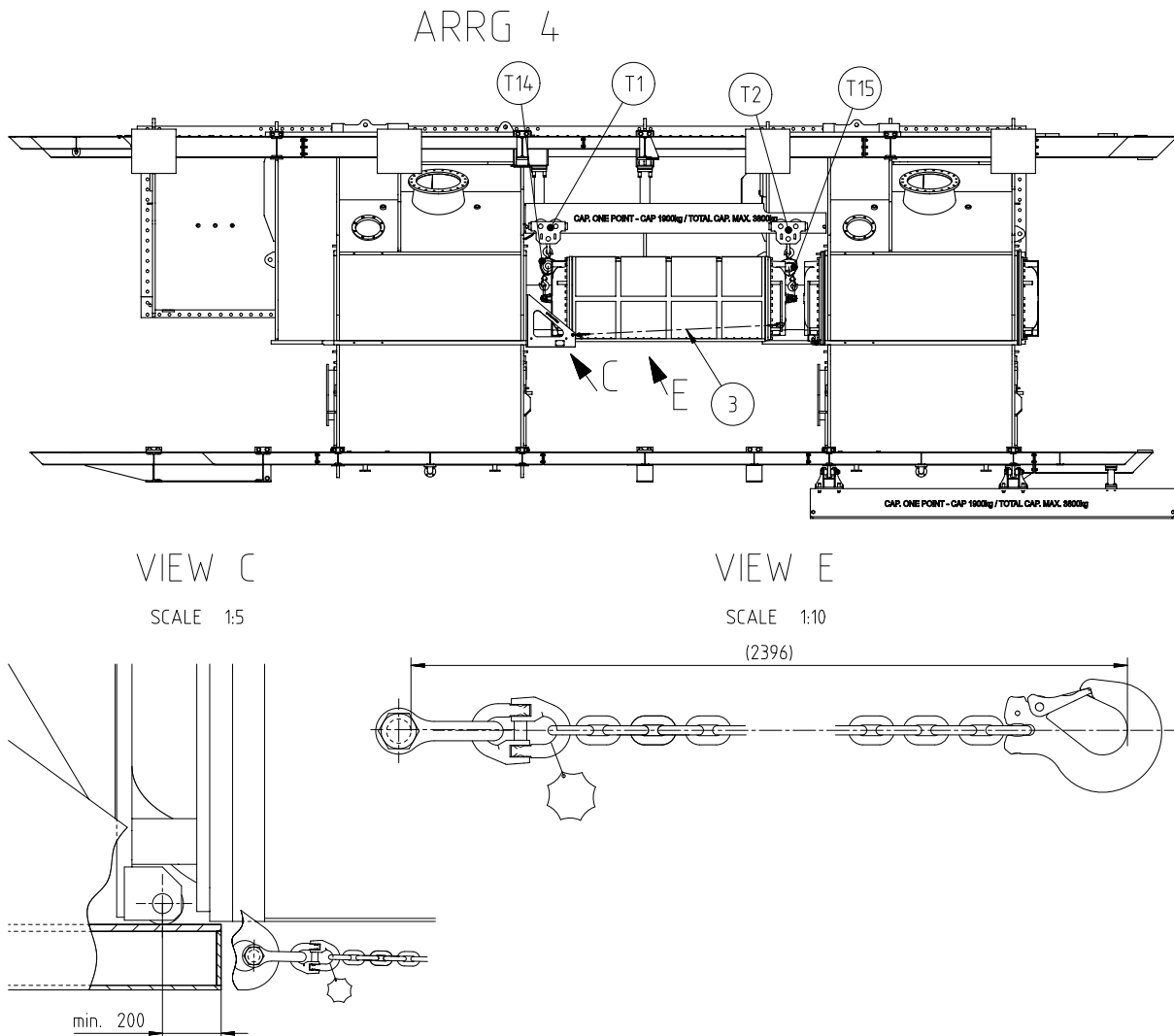
### ARRG 3

16. Mount the plate for the safety chain to the front of the SAC.
17. Hook the safety chain (3) to tool SAC assembly (T6) to the air cooler flange of SAC.
18. Using lever chain hoist (T5) now carefully withdraw the SAC up to max. 200 mm before the guide end of the support.



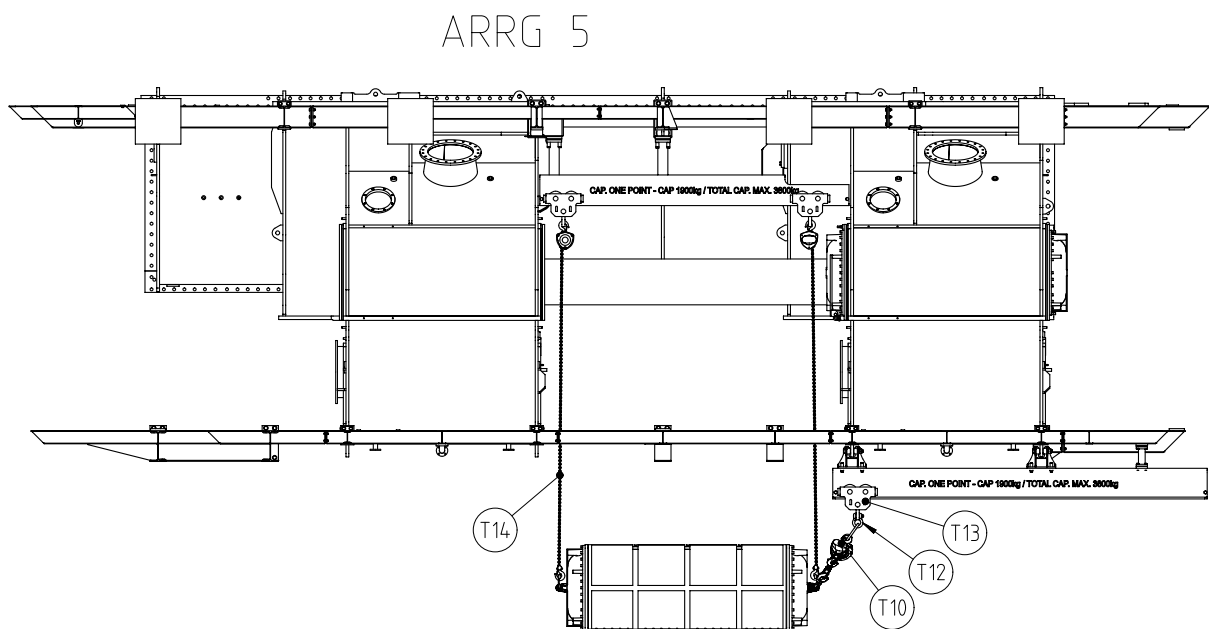
#### ARRG 4

19. Attach the spur geared chain hoist (T14) to the SAC with trolley (T1).
20. Attach the spur geared chain hoist (T15) to the SAC with trolley (T2).
21. Need to attention here the cooler hanging will be changing from 3 points to 2 points cooler must be stabilized while downing.
22. Remove the dismantling tool (T8), spur geared chain, lever chain hoist and necessary supports in order to lower the SAC.
23. Remove the safety chain (3) and tool SAC assembly (T6) left and right of the receiver.
24. Lower the SAC through the opening in the walk area.



## ARRG 5

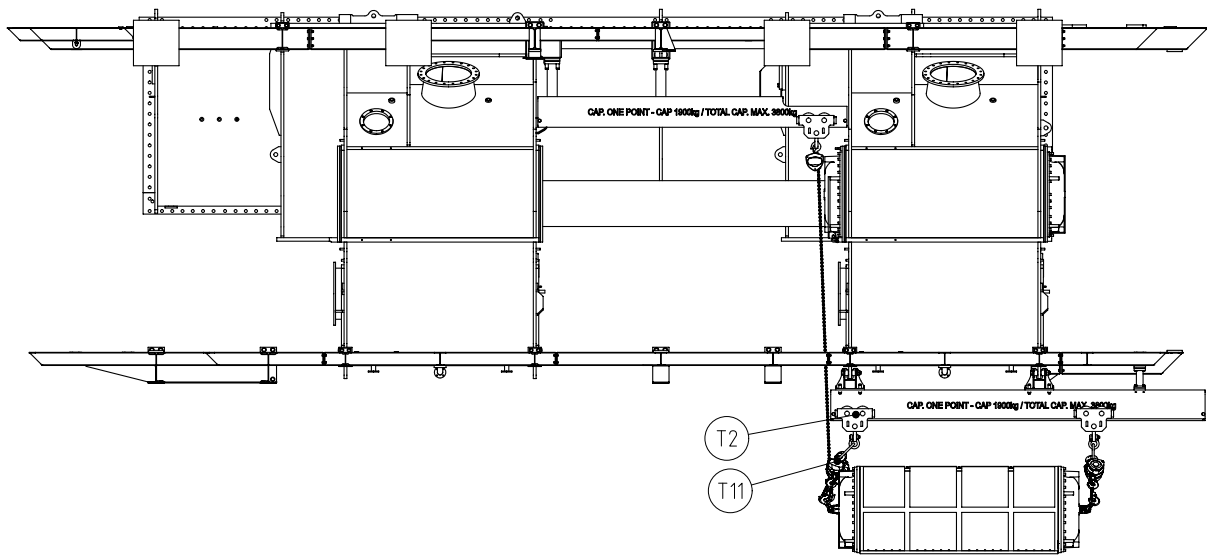
25. Using spur geared chain blocks (T14) + (T15) move SAC beyond the opening to lower it and put it down.
26. Attach the trolley (T13) to lower crane rail.
27. Attach the shackle (T12) and ring (2) to the trolley (T13)
28. Attach the spur geared chain hoist (T10) to the ring (2) and SAC both rud swivel lug.
29. Carry SAC away slowly by trolley and chain bock.
30. Remove the trolley (T2) and spur geared chain bock (T15) from SAC.



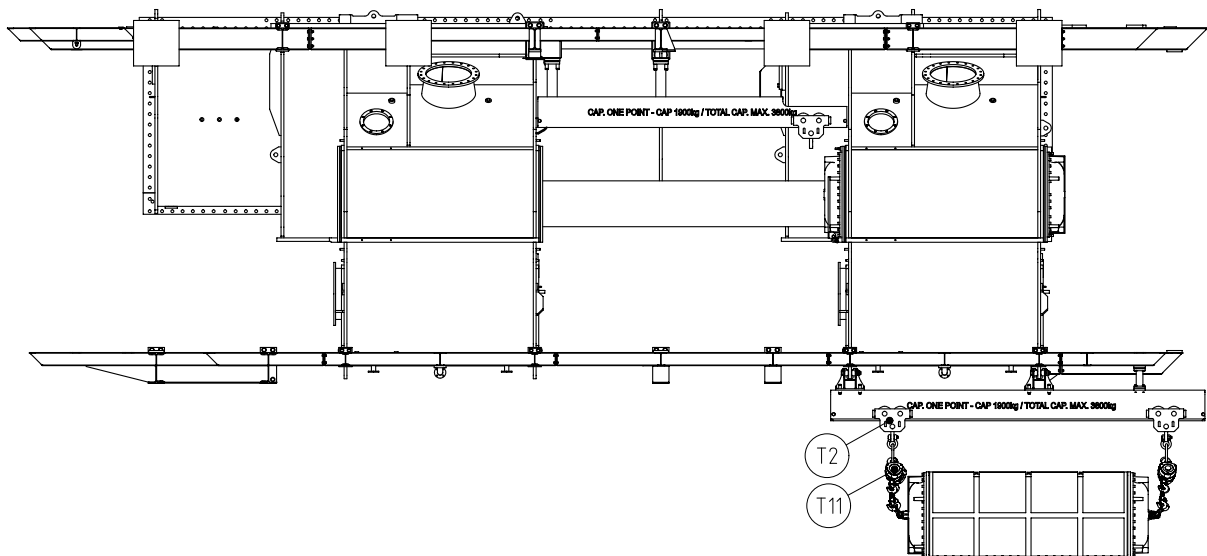
**ARRG 6-9**

31. Attach the trolley (T2) to lower crane rail.
32. Attach the shackle (T12) and ring (2) to the trolley (T2)
33. Attach the spur geared chain block (T11) to the ring (2) and to the rud swivel lug.
34. Carry SAC away by using trolleys and spur geared chain block.

ARRG 6

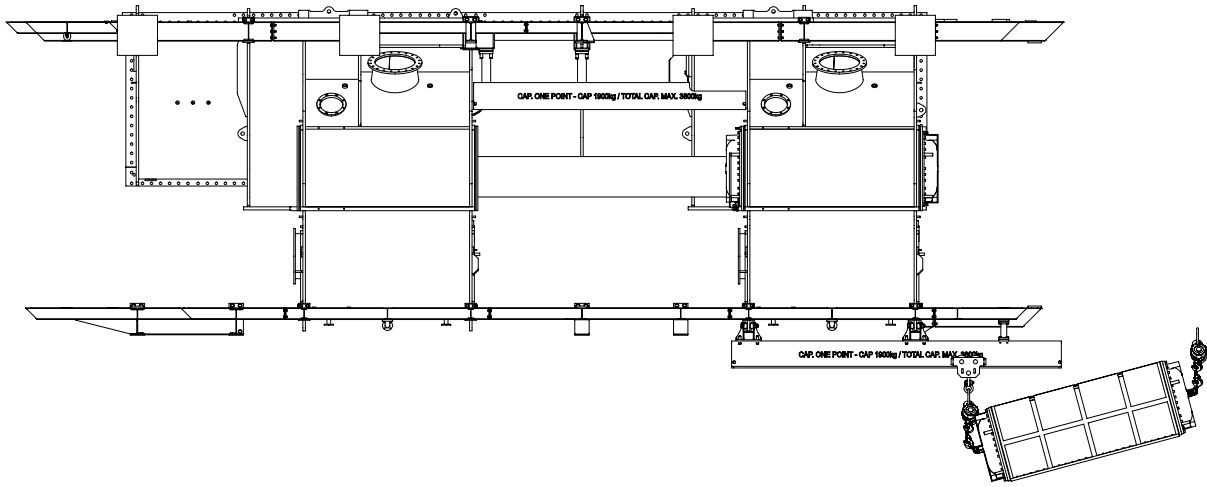


ARRG 7

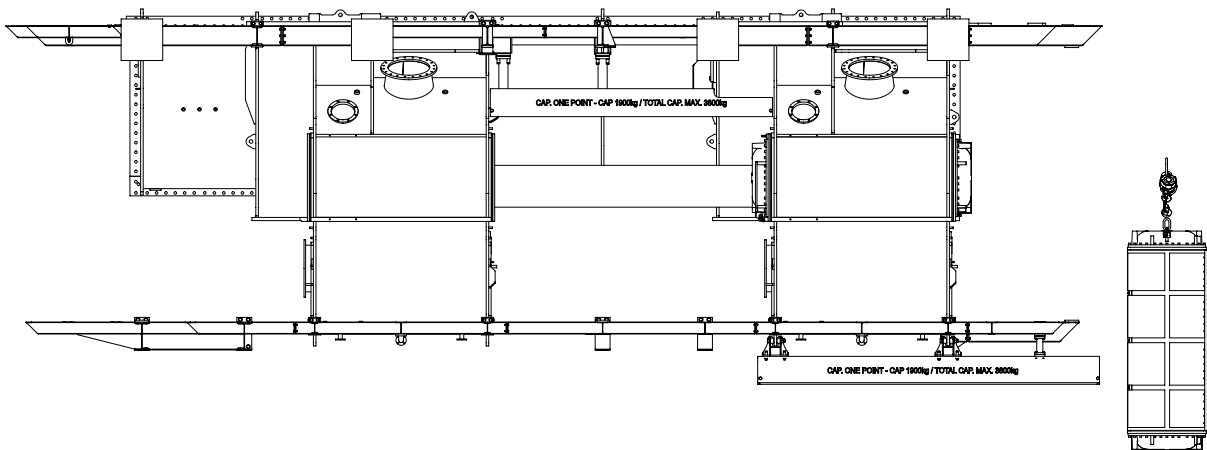




ARRG 8



ARRG 9



Note: Dismantling of SAC (2) is carried out in the same way to SAC (1), but in the opposite direction.

## ASSEMBLING

### ARRG 10

35. Lift the SAC using spur geared chain hoist (T14) and (T15) with trolley (T1) and (T2).
36. Mount the plate for the safety chain to the front of the SAC
37. Attach the tool SAC assembly (T6) and (T7) to the left and right of the receiver frame
38. Hook the safety chain (3) to tool SAC assembly (T6) to the air cooler flange of SAC
39. Attach the tool SAC assembly (T16) to the receiver frame
40. Hook the lever chain hoist (T5) to the tool SAC assembly (T16) and to the SAC. Pull the SAC inside the receiver frame.

