Maintenance Manual

RT-flex58T-E

Supply Unit on Exhaust Side

2021-12

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Modification Service

Engine Documentation

RT-flex58T-E Supply Unit on Exhaust Side — Summary for Maintenance Manual

Page No.	Modification		Title	Subject	Page or Manual	
	Date	No.				
					new	exch.
	2014			**Issue 2014**	x	
				Date of publication 2014-02-20		
9403-5/A1 (37)	2014-04		Tool List	Tools: 94211, 94212 deleted		x
				Date of publication 2014-04-02		
0020-1/A1	2015-08		Table of Contents	New instruction for HP injection pipe with ICU Mk3.		x
0352-1/A1 (1)	2015-08	EAAD086016	Tightening Values	New tightening values for elastic studs of cylinder cover (new pre-tensioning jack)		x
2124-3/A1 (2)	2015-08	EAAD085111	Cylinder Liner - Redressing Lubricating Grooves and Scavenge Ports	Fig. A Illustration of cylinder liner replaced (Oil Grooves)		x
2708-2	2015-08	EAAD086016	tensioning of cyl. Cover studs	new pretensioning jack for cyl. Cover CF94215		x
2722-1 (1, 9, 10)	2015-08		Injection valve	New tool for removal and installation of nozzle tip		x
Group 8	2015-08		Table of Contents	New instruction for HP injection pipe with ICU Mk3.		x
8733-1/A1 (1, 3)	2015-08	EAAD085234	HP injection Pipe to Injection Valve	Tool numbers changed. Fig D changed. Procedure in para 3 changed		x
8733-1/A2	2015-08		HP injection Pipe to Injection Valve (for ICU Mk3)	New instruction for HP injection pipe with ICU Mk3.	x	
9403-3/A1 (1, 5)	2015-08	EAAD086016	Pre-Tesnioning jacks	New jack for Cyl. Cover studs		x
9403-5/A1 (30)	2015-08	EAAD085234	Tool List	Tool numbers 94871 and 94871A added, new cyl. Cover press CF94215, 94278A and 94278B added		x
				Date of publication 2016-02-18		
2751-2/A1	2018	WinGD Input	Exhaust Valve: Disassemble and Assemble	Pge: 7. Paragraph 3.4 - Procedure changed.		x
Group 5 ToC	2018-02	WinGD Input	Lubrication of Supply Unit during Maintenance	New Title added 5552-4/A1	x	
5552-4/A1	2018-02	WinGD Input	Lubrication of Supply Unit during Maintenance	New document	x	
9403-5/A1	2018-02	DAAD083068	Tools List	Page 37: 94844 Lubrication device added.		x
				Date of publication 2018-02		
9403−5/A1	2020-07	WinGD Input	Tools List	Page 24: 94569a Blank flanges removed Page 26: GF 94569, GF 94569A Blank flange removed Page 26: TN 94597, TN 94598 Blank flange added		x
				Date of publication 2020-07		

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	2021			**Issue 2021**	x	
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2708-1/A1	2021-12	WinGD Input	Cylinder Liner	Safety Warning Updated.		x
2708-3/A1	2021-12	WinGD Input	Cylinder Liner – Machining of Sealing Face for Injection Valve	Safety Warning Updated.		x
0011-1/A1	2021-12	WinGD Input	General Guidelines for Maintenance	Procedure Updated		x
WinGD Logo	2021-12	WinGD Input	WinGD Logo	WinGD Logo Updated as per new style guide		x

General Information Group 0

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Engine Cross Section and Longitudinal Section 0803–1/A1

For Particular Attention

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It has always to be treated as confidential.

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Before the operator intends to use the engine or before maintenance work is undertaken, the Operating Instructions or the Maintenance Manual respectively is to be read carefully.

To ensure the best efficiency, reliability and lifetime of the engine and its components, only original spare parts should be used.
It is to be ensured as well that all equipment and tools for maintenance are in good condition.

The extent of any supplies and services is determined exclusively by the relevant supply contract.

The data, instructions and graphical illustrations etc. in this manual are based on drawings made by **Wärtsilä Switzerland Ltd** and correspond to the actual standard at the time of printing (year of printing is indicated on title page).
Those specifications and recommendations of the classification societies which are essential for the design have been considered therein. It must be recognized that such data, instructions and graphical illustrations may be subject to changes due to further development, widened experience or any other reason.

This manual is primarily intended for use by the engine operating and maintenance personnel. It must be ensured that it will always be at the disposal of such personnel for the operation of the engines and/or for the required maintenance work.

This manual has been prepared on the assumption that operation and maintenance of the engines concerned will always be carried out by qualified personnel having the special knowledge, training and qualifications needed to handle in a workman-like manner diesel engines of the corresponding size, the associated auxiliary equipment, as well as fuel and other operating media.

Therefore, generally applicable rules, which may also concern such items as protection against danger, are specified in this manual in exceptional cases only. It must be made sure that the operating and maintenance personnel are familiar with the rules concerned.

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Preface

The instructions contained in this **"Maintenance Manual"** are intended to help to ensure that the maintenance which must be carried out at specific intervals is correctly carried out.

It is a precondition that the personnel charged with such important work possesses the necessary training and experience.

Information about the operation of the engine as well as descriptions of the function of the various systems are part of a separate book, the "Operating Manual" containing also under 0010–1 explanations of the layout and structure of the Operating and Maintenance Manuals as well as of the used symbols, signs and special characters.

More detailed instructions on the operation and maintenance of components from sub-suppliers can be gathered from the instruction leaflets of the respective manufacturers. Outside makes are, for example, such engine components, tools or devices which are not manufactured in accordance with production drawings from Wärtsilä Switzerland Ltd.

The "Maintenance Manual" is divided into the following main chapters:

- General guidelines for maintenance
- Clearance tables, tightening values of screwed connections, masses (weights), seal rings
- Maintenance schedule
- Design groups
- Tool lists

A few explanations to the above:

- The 'General Guidelines for Maintenance' contain, in addition to recommendations on precautionary measures to be taken, also suggestions for carrying out the work.
- The above mentioned tables inform about normal and maximum acceptable clearances, the tightening of important screwed connections, weights of individual engine components as well as the type and use of various sealing rings.
- The 'Maintenance Schedule' indicates nominal intervals in which various maintenance operations are to be carried out. Please note that the maintenance intervals are based on experience and are subject to operation of the engine under standard conditions.
- Detailed instructions are given in the 'Design Groups' on the procedure of maintenance work on certain engine parts.
- Tools and devices necessary to carry out maintenance are described in the 'Tool Lists', and are generally supplied with the engine.

All information contained in the text and illustrations of this manual are valid at the time of printing.
Modifications will be incorporated in the next edition!

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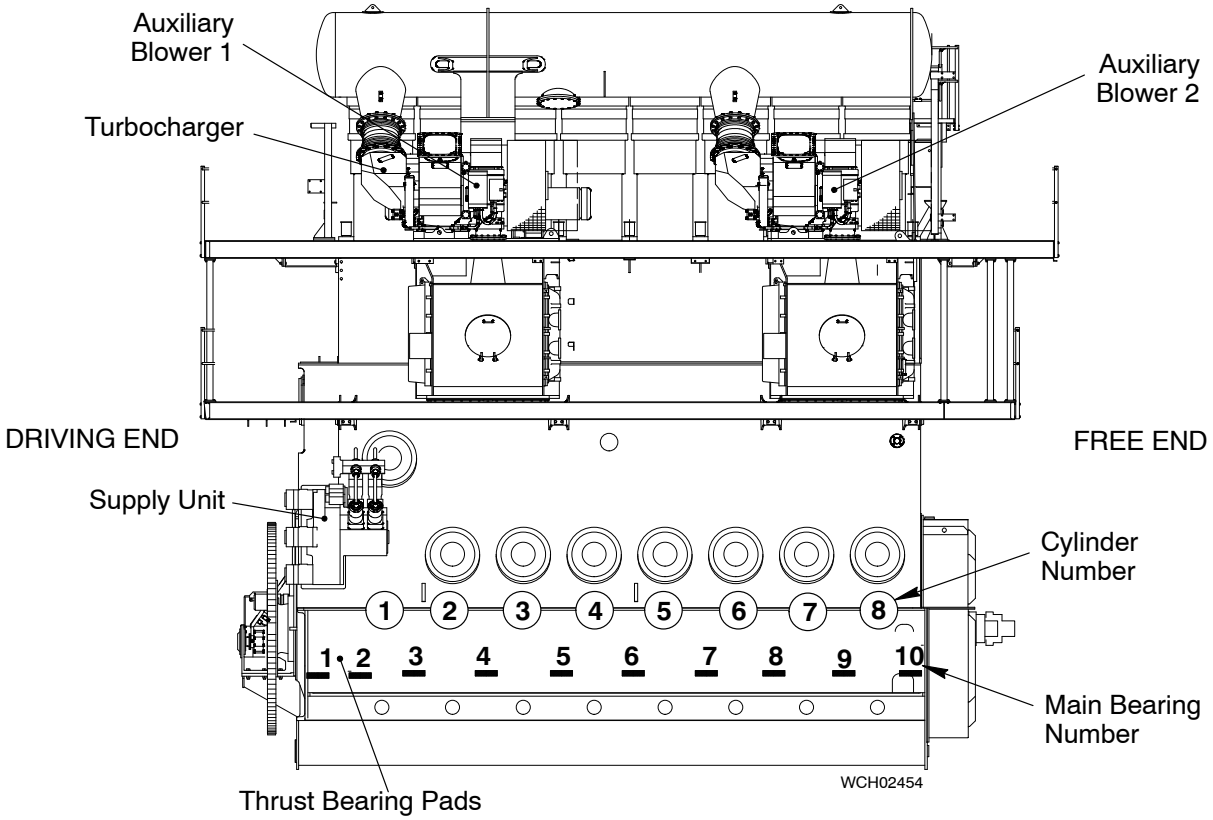
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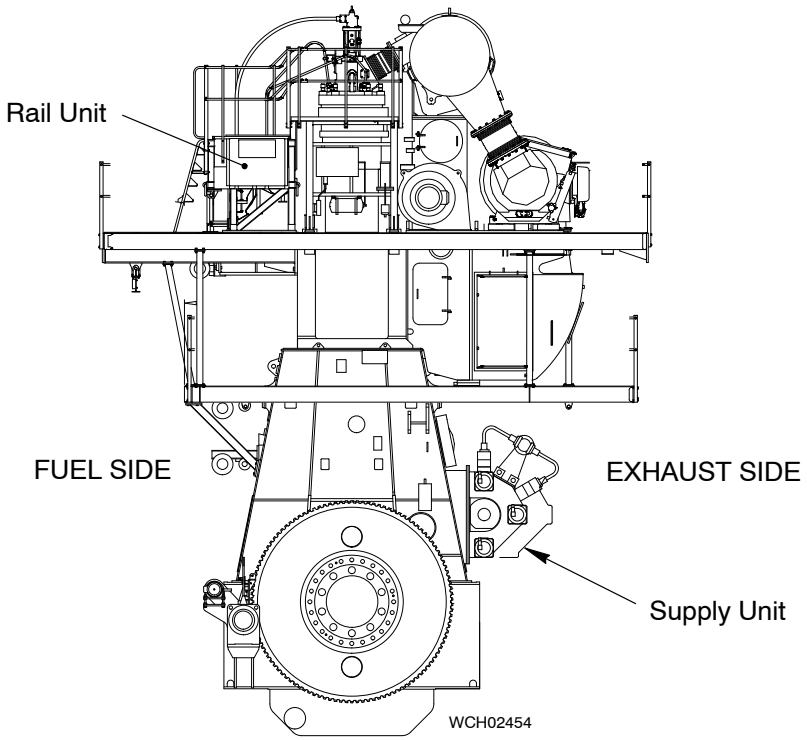
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General

Engine Numbers and Designations

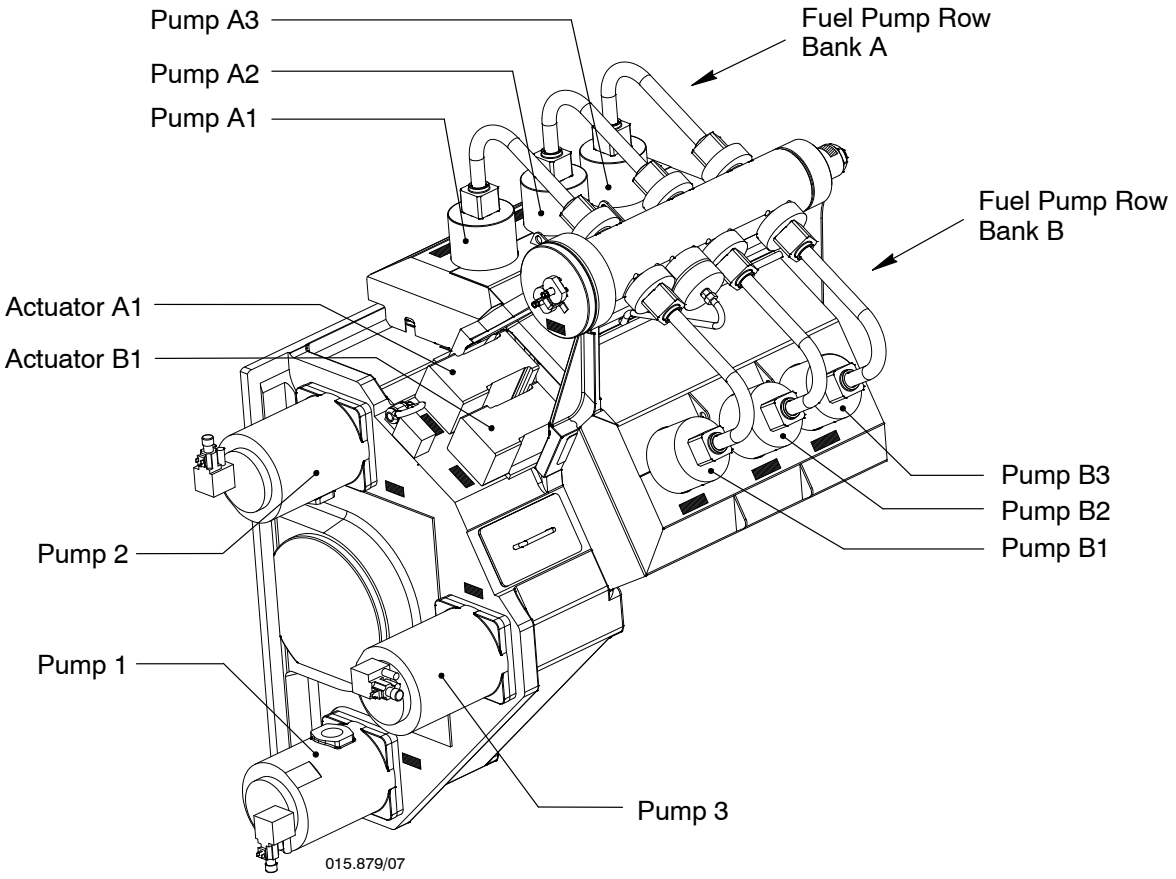
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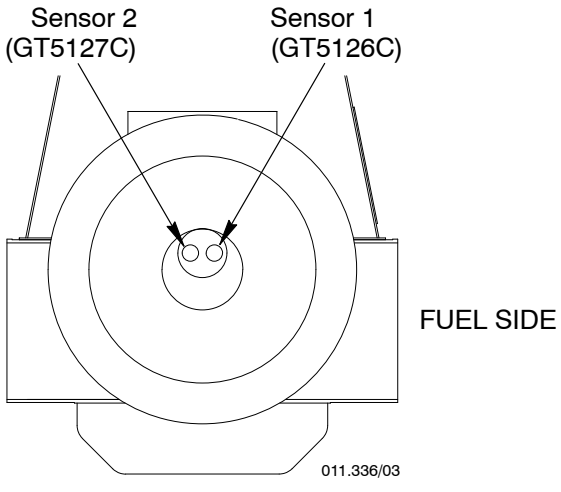


Engine Numbering and Designations

2. Flex parts



Crank Angle Sensors



FREE END

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Safety Precautions and Warnings

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1. General

The maintenance tasks necessary for the engine at regular intervals are given in the Maintenance Schedule 0380–1 of this manual and is a general guide. The maintenance intervals are related to the mode of operation, the power and the quality of the fuel used. For more data, refer to the Maintenance Schedule.

The maintenance intervals can change in relation to data collected during operation.

Note: The recommendations related to safety procedures and maintenance given below are mandatory. All other safety recommendations not given here must also be obeyed.

2. General Safety Precautions

The aim of this book is to give correct information about operation and maintenance of the engine. It is important to take the maximum safety in the engine room. All the engine room staff must follow these general safety precautions and safety guidelines given below as usual procedure :

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

- **Lighting**

Make sure that there is good permanent lighting available at applicable places in the engine room.

Make sure that the sufficient number of portable lamps available at different locations in the engine room.

Make sure that special lamp is available to insert through the scavenge ports.

- **Cleanliness**

Keep the engine and engine room as clean as possible. Also keep the area above and below floor plates clean. Keep the electronic control boxes on the rail unit clean and dry.

Make sure that no dust, grit, sand or chemical vapor can go into the engine room. This will help to prevent a fire in the engine room.

If there is a risk of grit and sand blow into the engine room when the ship is at port, ventilation must be stop, skylights and engine room door must be close.

Do not do weld or other work near the engine except if done in closed and protected environment, this will prevent spread of grit or swarf particles. Make sure that the turbocharger intake filters are covered.

Keep the external part of the engine clean and maintain the paintwork to find the

leakages easily.

- **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.

Clean the area around the relief valves free of oil, grease etc. This will prevent risk of fire cause by hot air or gas when the relief valves are open.

Do not weld or use naked lights in the engine room. Make sure that no explosive gases, vapour or liquids are available which can cause fire or explosion.

Be careful when using paint and solvents which has a low flash point. There is a risk of fire and explosion.

Be careful when the crankcase doors are open before the engine is at suitable temperature, weld or use of naked flames can cause risk of explosion and fire. Same is applicable to oil tanks and spaces below the floor at the time of inspection.

Make sure that the emergency exits are clearly marked and easy to access.

Do not use the porous insulating materials soaked in oil due to leakages. These materials are highly inflammable and must be replace with new materials.

- **Tools**

Make sure that hand tools are available on tool panels and easy to access when required. Keep the special tools near the work area in the engine room.

Make sure that all tools have protection from corrosion.

Keep all the tools and devices ready to use and make sure that no large objects are available on the floors and passages near engine area. Always keep the engine area clean.

- **Spare Parts**

Keep the large spare parts near the work area and must be easy to access for the engine room crane.

Make sure that the spare parts have protection from corrosion and mechanical damage.

Replace used spare parts as soon as possible.

Check and maintain the stock of spare parts at regular intervals and refill the stock if required.

- **Low temperature − Freezing**

To avoid freezing, drain all the cooling water from the engine, pumps, coolers and pipe systems.

Note: Make sure that engine is cool down before repair and maintenance work.

- **Check and Maintain**

Do a check of measuring equipment, filter element and lubricating oil condition.

- **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.

- **Alarms**

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.

All the alarms are important and most serious alarm are with slow−down and shut−down functions.

Make sure that all the engine crew members are trained and knows about the use and importance of the alarm system.

- **Sealing Materials**

Use hand gloves to remove the o−rings and other rubber or plastic based sealing materials. The sealing material from the area of abnormally high temperature can have caustic effect to personnel skin. To avoid this the hand gloves must be made up of neoprene or PVC. Discard the gloves after use.

- **Entering Crankcase or Cylinder**

Make sure that the turning gear is engage, even at the quay, the wake from the other ship may turn the propeller and then engine.

Make sure that starting air supply to the engine and the starting air distributor is shutoff.

If there is alert from the oil mist alarm, before you open the crankcase follow all the precautions.

- **Turning Gear and Slow turning**

Before you engage the turning gear, make sure that the starting air supply is shutoff and the indicator cocks are open.

When turning gear is engage, make sure that the indicator lamp “Turning gear in” is change to local. Make sure that turning gear is locked during the maintenance procedure.

When the engine is stop for more than 30 min, do the slow turning of the turning gear just before the engine start in order to prevent free rotation of the engine.

- **IMO and NOX components number**

Make sure that identification numbers are available to easily find the required drawings and certificate.

The schematic diagrams shows where to find the markings on the individual component types as below.

o Fx fuel valve nozzle or TC diffuser etc.

o Pictures that show the number.

o Technical files descriptions.

3. Safety notes

- **Danger**

This warning is used when an operation, procedure, or use may cause personal injury or loss of life.

- **Warning**

This warning is used when an operation, procedure, or use may cause a latently dangerous state of personal injury or loss of life.

- **Caution**

This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment and a injury.

- **Note**

This warning is used when an operation, procedure, or use may cause damage to or destruction of equipment.

4. General safety warnings and cautions

WARNING



Injury hazard: Engine parts can fall down and injury to personnel can occur. Make sure that no personnel is standing below the crane and the area is clear.

WARNING



Injury hazard: Do not open the cocks suddenly because it can discharge hot fluids and gases. Make sure to give a clear way for liquids, gases and flames to flow through it.

WARNING



Injury hazard: The disassembly of the engine parts can cause sudden release of springs and injury to personnel can occur. Always use the correct personal protective equipment.

WARNING



Injury hazard: The removal of fuel valves or other valves in the cylinder cover can cause the oil to fall on the piston crown. If the piston is hot this can cause explosion. Make sure that the engine is cool down before maintenance.

WARNING



Injury hazard: Do not touch the spray holes during the function test of the fuel valves. The sudden release of oil can cause injury to personal. Always use the correct personal protective equipment.

WARNING



Injury hazard: Make sure that the engine is stop and the current is switch–off from the main switch before maintenance work starts. The drain valve must be open and decrease the pressure to 0 bar during the maintenance procedure.

WARNING



Injury hazard: Before disassembly of the part from the system Check and release the pressure of the related system. injury to personnel can occur.

WARNING



Injury hazard: Do not repair the hydraulic servo oil or rail system, when pumps are in operation. Injury to personnel can occur.

WARNING



Injury hazard: Do not stand near the crankcase doors, engine room casing doors or relief valves when the alarm is active for oil mist, high lube oil temperature, no piston colling oil flow or scavenge box fire. Injury to personnel can occur.

CAUTION



Damage hazard: Always replace the damaged sealing materials with new sealing materials. Do not try to repair them.

CAUTION



Damage hazard: Do not weld or solder on any part of the fuel system and servo oil system. Damage to the system can occur.

5. Personal safety and protection equipment

Always use the below given personal protection equipment during repair and maintenance work on the engine.

- Safety helmet
- Ear protection.
- Cotton boiler suite.
- Safety shoes.
- Hand gloves.
- Safety goggles.
- Safety harness

6. General safety guidelines for Hot work

If you do hot 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 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 proceed any hot work in the engine room.

Set the engine room fire extinguisher to Manual mode.

Isolate the work area.

Make sure that emergency exists 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.

Use 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.

7. General safety lifting instructions

The engine crew members must obey the general safety lifting instructions before lifting the engine components:

- Always use the correct personal safety protective equipment.
- Plan the lifting sequence of engine components in all steps of the lifting procedure.
- Make sure that lifting attachments are tightened properly to the lifting component.
- Always use correct dedicated lifting points.
- Do not exceed the lowest safe working load (SWL) of the lifting equipment in the lifting chain.
- Keep away lifting equipment from sharp edges.
- Make sure that loads are attached correctly to the crank hook.
- When crane carrying a load, make sure that the space below the crane is clear.
- When crane carrying a load, do not stand below the crane.

General Guidelines for Lifting Tools

Wire Rope Slings, Span-sets, Eye Bolts, etc.

1. General

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 (see also Masses (Weights) 0360–1).

Remark: The admissible lifting (max. loading) capacity in kg corresponds to the **WLL** = **W**orking **L**oad **L**imit.

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

2. Attachment elements

2.1 Wire rope slings

The lifting capacity of the wire rope slings is listed under their tool number in Tools List 9403–5.

2.2 Span-sets

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

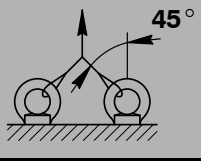
2.3 Eye bolts and eye nuts

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.

General Guidelines: Wire Rope Slings, Span-sets, Eye Bolts, etc.

Lifting capacity *(for information purposes only):*

Eye bolts & eye nuts, thread size	Lifting capacity [kg]	
	single-strand 	double-strand (45°)[1] 
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	11 500	8300

Remarks: The details listed in the table above are based on DIN 580 & 582:2003−08, requiring that the eye bolt or the eye nut:

- is completely turned in or screwed down;
- lies flat and fully on the seating surface;
- was checked for visible damages (e.g. corrosion, deformation) before using it.
- [1] **Full load is only permissible in the direction of the ring,** therefore the eye bolts or eye nuts must be brought to the right position, if necessary by using distance rings.

- 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.

2.4 RUD-eye bolts and RUD-swivel lugs

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

Manufacturer:

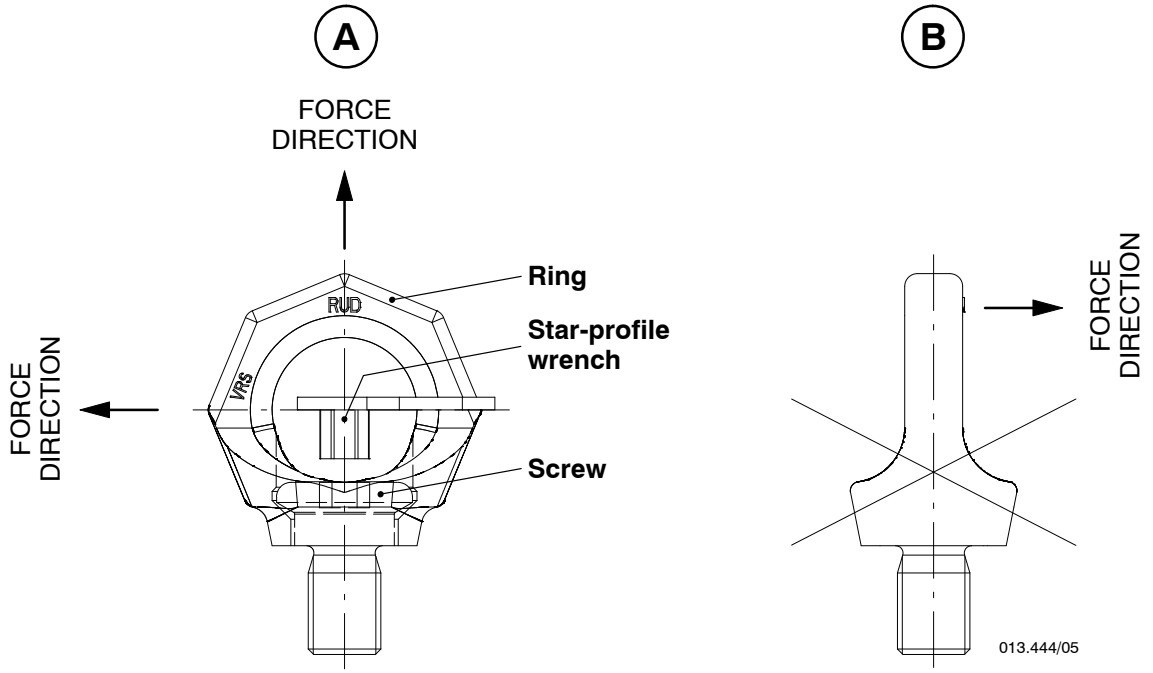
RUD Ketten
Rieger & Dietz GmbH u. Co
Friedensinsel
D−73432 Aalen
Germany
http://www.rud.com

General Guidelines: Wire Rope Slings, Span-sets, Eye Bolts, etc.

2.4.1 Remarks on the use of RUD-eye bolts

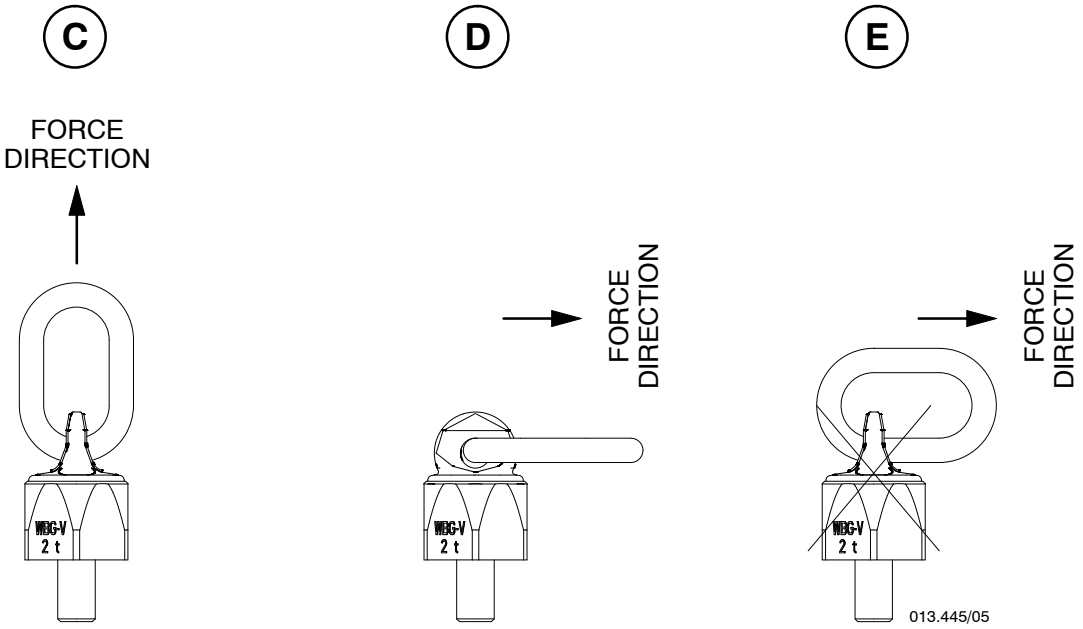
- they must be completely screwed down, lying fully on the seating surfaces.
- they are hand-screwed with their own star-profile wrenches (do not use any extension).

- In order that after tightening the ring of the RUD-eye bolt is freely rotatable, the star-profile wrench must be removed from the inner hexagon of the screw as shown in Fig. 'A'.
- 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!** (Fig. 'B')



2.4.2 Remarks on the use of RUD-swivel lugs

- they must be completely screwed down, lying fully on the seating surfaces.
- they are hand-screwed with an open end wrench.
- Prior to loading the RUD-swivel lug adjust it in force direction (Fig. 'C' and 'D').
- **Loading as shown in Fig. 'E' should be be avoided if possible!**



2.5 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.

Attention! **If tools are combined** (e.g. 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** (see details in Tools List 9403–5).

General Guidelines: Wire Rope Slings, Span-sets, Eye Bolts, etc.

3. Attaching and disconnecting

The following must be observed:

- ***Distribution of load:***
  - one strand carries the total of load weight
  - two strands carry each one half of the load weight
  - four strands carry each one quarter of the load weight if the load is distributed equally.
- ***Angle of strand:***
  - the flatter the strand angle, the more the strand is stressed
  - the more acute the strand angle is, the less the strand is stressed.

- Place a soft-wood board between rope and engine component, because the ropes tend to slide on smooth surfaces (e.g. tubes, shafts).
- Protect the ropes against damages by providing a wooden pallet or a rag. Sharp edges may even cut steel cables!
- If possible always tie down the load. (danger of fall)
- Wrapping the rope twice increases friction and adhesion in such a manner that even a smooth, oily shaft is sliding less.
- Hemp rope strands, wrapped around the hook, prevent sliding. Do not wrap steel cables, but cross them instead.



Danger of injuries! **For your own safety never stand beneath loads!**

Hold the ropes in the flat of your hands and keep your fingers stretched out. Never seize the load at the bottom, but always lead it laterally. Always put down the loads on a perfect ground, and use sufficiently sized bases.

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Clearance Table

Overview

– **General** 1/25
– **Crankshaft and Thrust Bearing** 2, 3/25
– **Crankshaft and Main Bearing** 4, 5/25
– **Crosshead Guide** 6, 7/25
– **Cylinder Liner** 8, 9/25
– **Piston Rod Gland** 10, 11/25
– **Exhaust Valve** 12, 13/25
– **Top and Bottom End Bearings to Connecting Rod** ... 14, 15/25
– **Piston Cooling and Crosshead Lubricating Link** 16, 17/25
– **Piston and Piston Rings** 18, 19/25
– **Driving Wheels for Supply Unit** 20, 21/25
– **Supply Unit** 22, 23/25
– **Fuel Pump** 24, 25/25

1. General

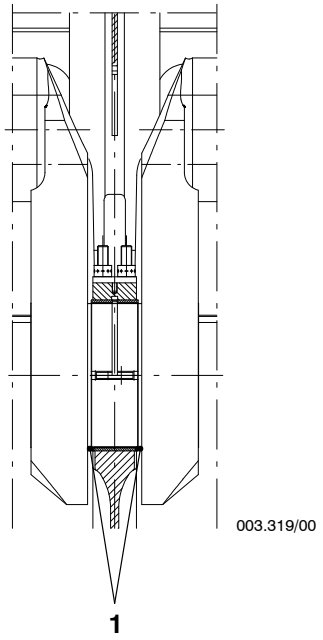
The clearances listed in the column 'Nominal dimension' of the following table correspond to design and manufacturing values or to the settings on the new engine.

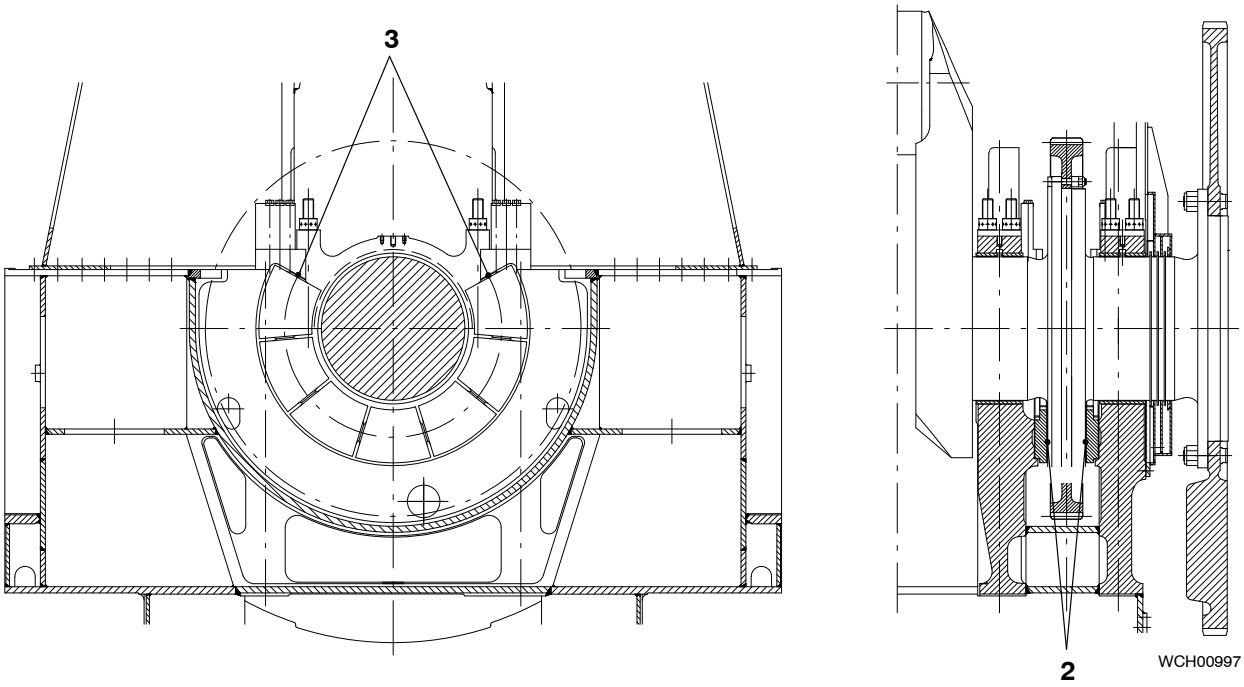
The values listed in the column 'Maximum clearance, dimension' are such values as may be reached after a lengthy operating period, which however may not be allowed to be exceeded or fall below. On components where the clearance is adjustable by modifying the thickness of shims, discs, spacers etc. the value given as 'Normal Clearance' should always be arrived at, or striven to attain. Where this is not possible, worn parts must be replaced by standard new ones or reconditioned by suitable material buildup.

If, during an overhaul, clearances are measured which have almost reached the permissible limit, it must be left to individual judgement to decide whether a component part should be replaced or remain fitted till the next overhaul. This depends for example on the duration of the next operation period until the next overhaul and what wear has to be expected based on experience gained.

Clearance Table

Crankshaft and Thrust Bearing





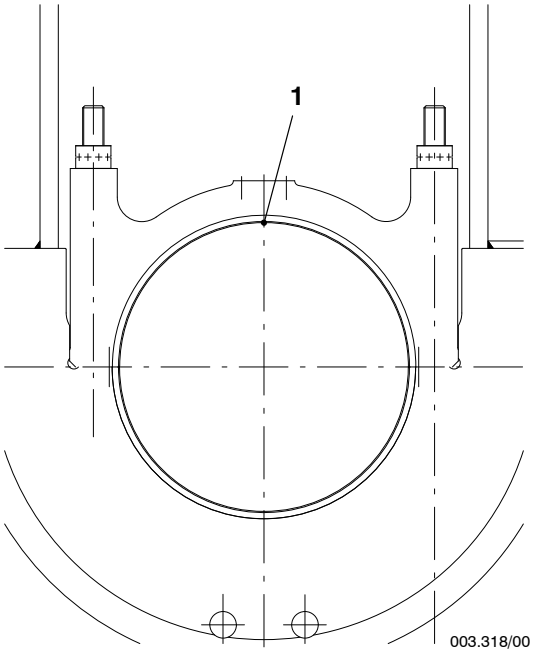
Clearance Table

Crankshaft and Thrust Bearing

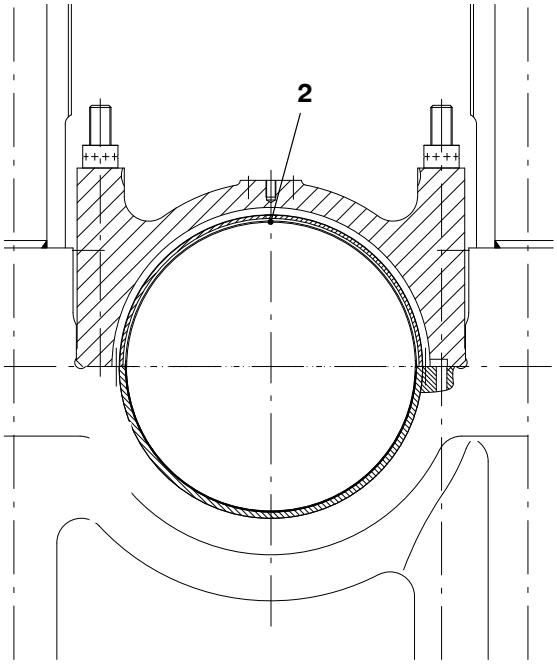
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
1132		**Main bearing**			
		Bearing shell	width	242	
	1	Lateral clearance	per side	12	
1203 1224		**Thrust bearing**			
		Thrust bearing pad	thickness	$66.5\ ^{-0.5}_{-0.6}$	
	2	Thrust bearing clearance	axial (total)	0.8–1.3	2.5
	3	Thrust bearing pad, lateral clearance	per side	3	

Clearance Table

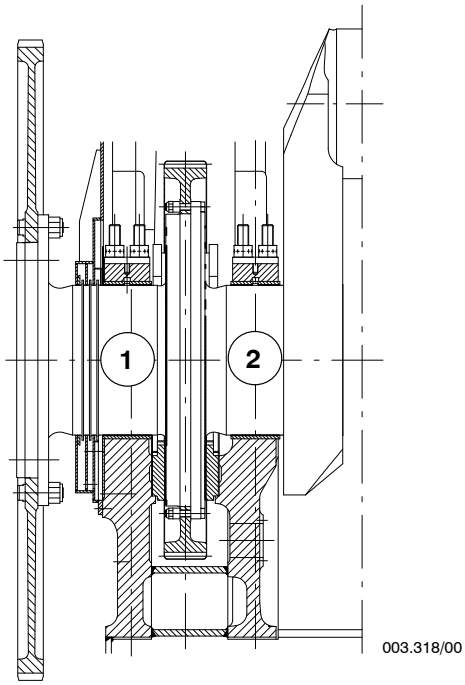
Crankshaft and Main Bearing



MAIN BEARING
No. 1



MAIN BEARING No. 2
AND FOLLOWING



Clearance Table

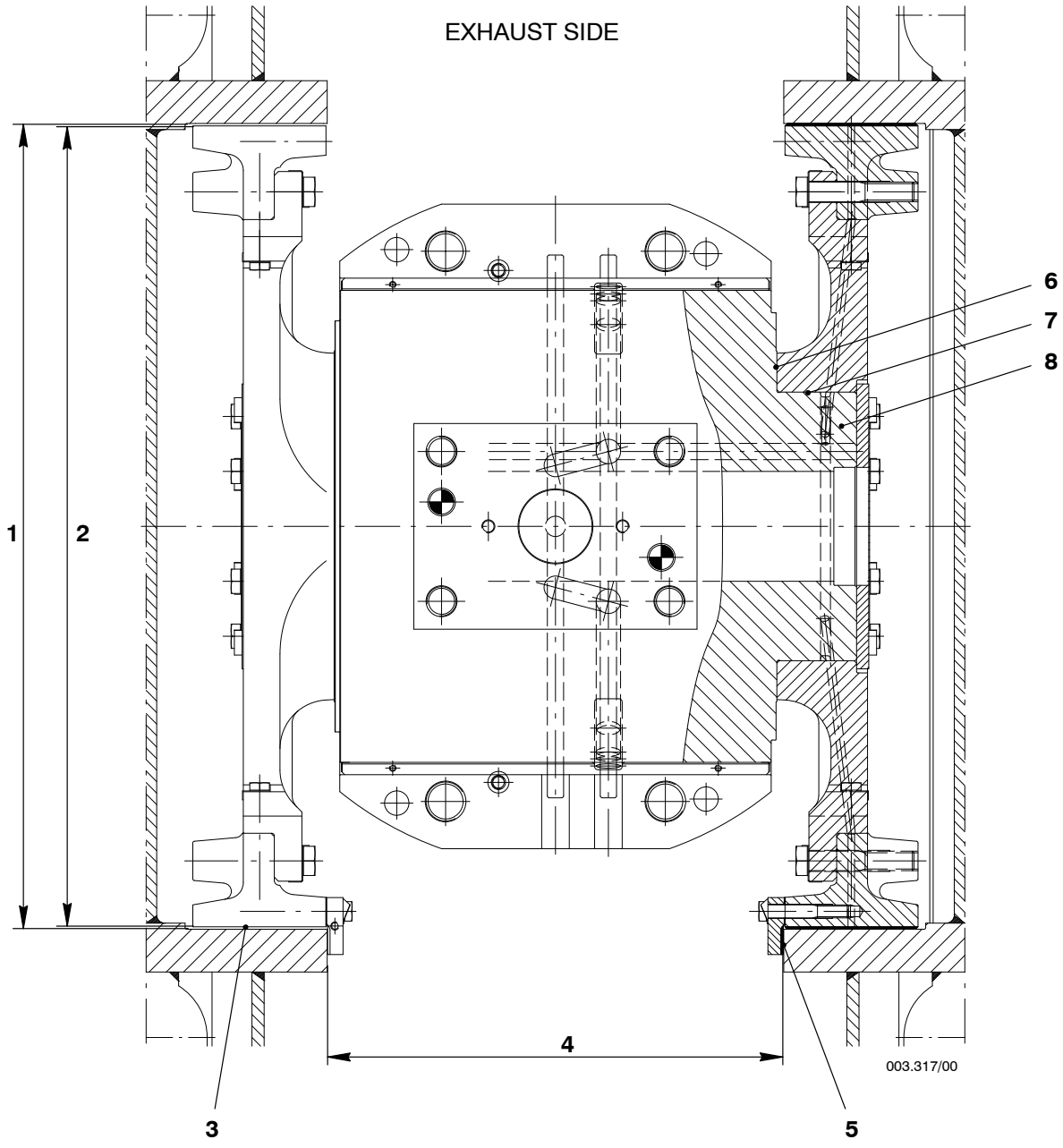
Crankshaft and Main Bearing

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
1132		**Main bearing No. 1**			
		Crankshaft	outer ∅	706 $^{0}_{-0.08}$	
		Main bearing	inner ∅	706	
	1	Bearing clearance	vertical	0.3–0.7	0.9
1132		**Main bearing No. 2 and following**			
		Crankshaft	outer ∅	706 $^{0}_{-0.08}$	
		Main bearing	inner ∅	706	
	2	Bearing clearance	vertical	0.2–0.6	0.8

All main bearing clearances are only valid with tie rods and main bearing studs tightened.

Clearance Table

Crosshead Guide



Clearance Table

Crosshead Guide

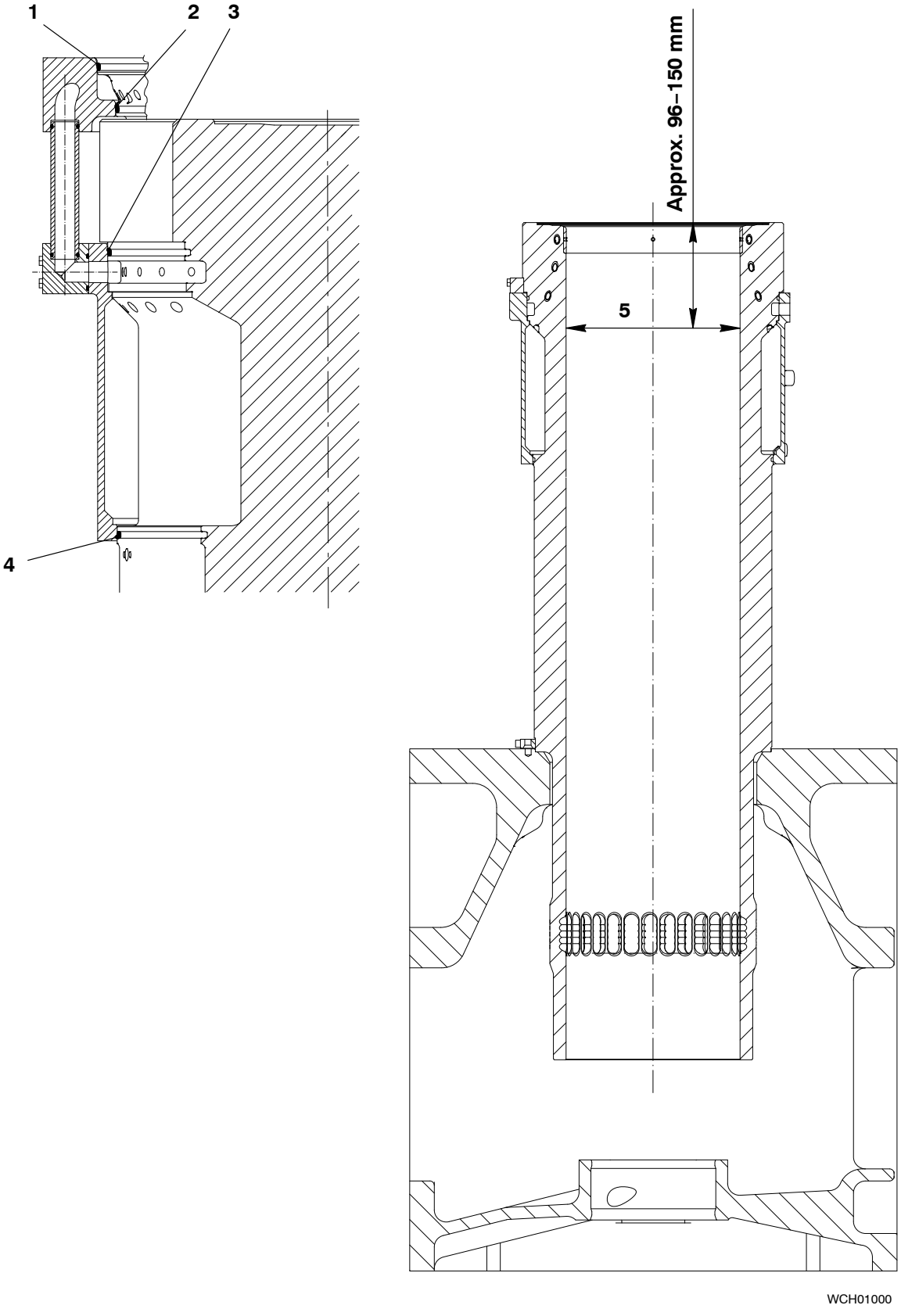
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
3326		**Crosshead guide**			
	1	Guide way (column)	transverse	990 $^{+\ 0.25}_{\ 0}$	
	2	Guide shoe	transverse	990 $^{-\ 0.20}_{-\ 0.31}$	
	3	Guide shoe clearance		0.20–0.90	1.1
	4	Guide rail	longitudinal	559.30–560.30	
	5	Guide rail, lateral clearance	total	0.60–1.80	2.2
	6	Guide shoe, lateral clearance	longitudinal	0.20–0.40	
	7	Guide shoe, bearing pin	outer ∅	330 $^{-\ 0.03}_{-\ 0.06}$	
		Guide shoe, bearing bore	inner ∅	330 $^{+\ 0.057}_{\ 0}$	
	8	Bearing clearance	radial	0.03–0.117	0.25

For measuring the clearances see instructions in group 3326–1.

Clearance 3 is **only valid with tie rods tightened**.

Clearance Table

Cylinder Liner



Clearance Table

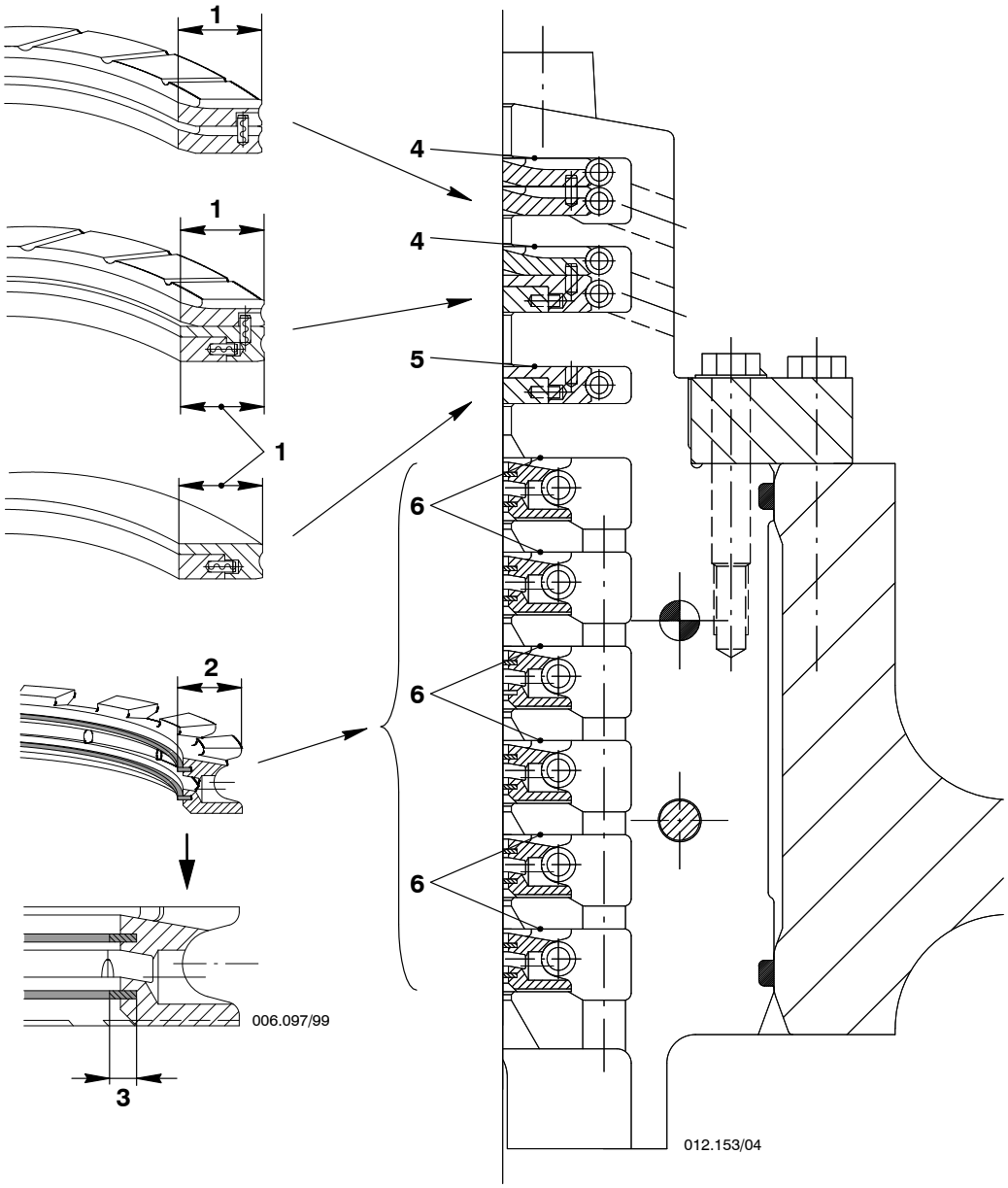
Cylinder Liner

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
2124		**Water guide jacket on cylinder cover**			
		Water guide jacket	Ø	$880^{+\ 0.60}_{+\ 0.40}$	
	1	Clearance	total	0.70–1.10	
		Water guide jacket	Ø	$810^{+\ 0.80}_{+\ 0.60}$	
	2	Clearance	total	0.90–1.30	
2124		**Water guide jacket on cylinder liner**			
		Water guide jacket	Ø	$840^{+\ 0.20}_{+\ 0}$	
	3	Clearance	total	0.20–0.60	
		Water guide jacket	Ø	$801^{+\ 0.60}_{+\ 0.40}$	
	4	Clearance	total	0.60–1.0	
2124		**Cylinder liner**			
	*5	Cylinder liner bore	radial	580	584

* Pay attention to measuring point!

Clearance Table

Piston Rod Gland



Clearance Table

Piston Rod Gland

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
2303		**Piston rod gland**			
	*1	Ring width	radial	31	min. 25
	*2	Ring width	radial	24	min. 22.20
	*3	Ring width	radial	5	min. 3.20
	4	Ring clearance	axial	0.05–0.16	0.50
	5	Ring clearance	axial	0.05–0.13	0.40
	6	Ring clearance	axial	0.10–0.17	0.40

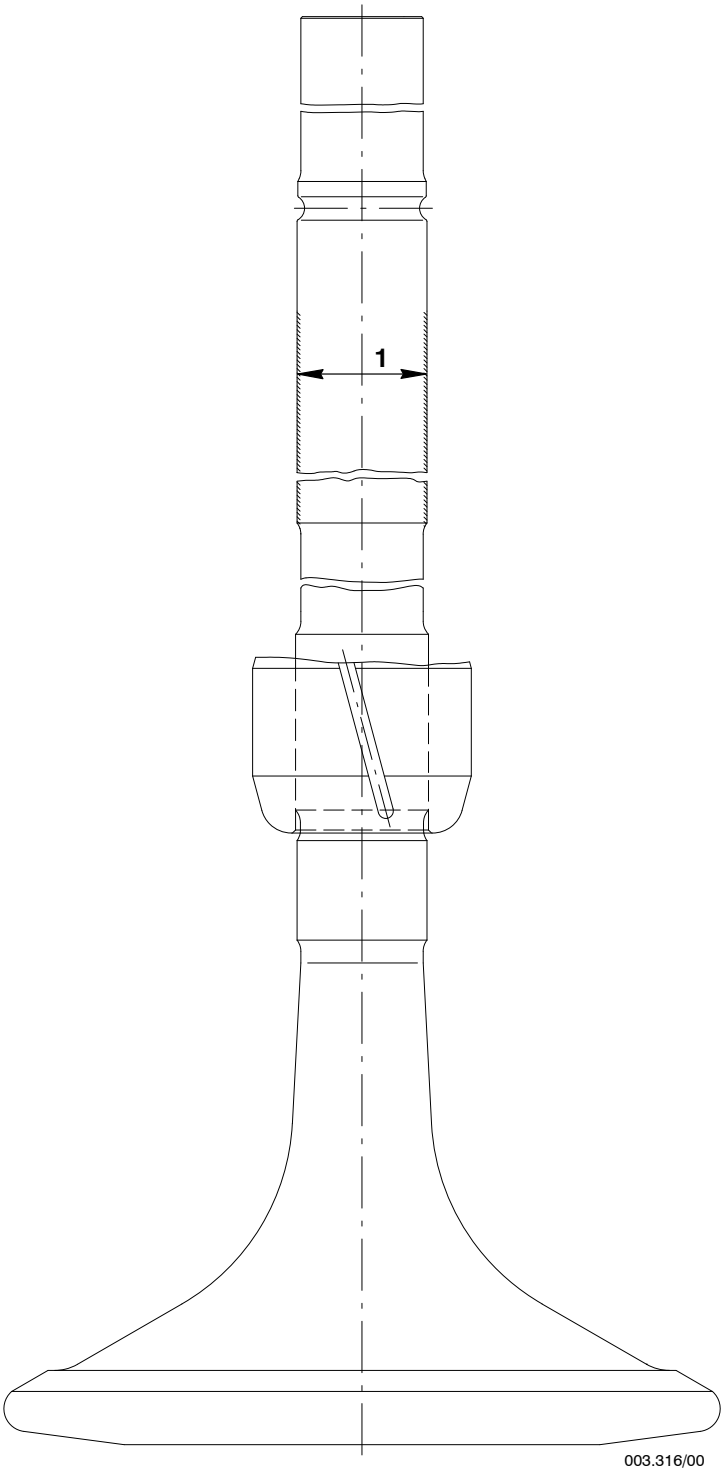
* **Ring wear**

The differential value between nominal dimension and max. wear is equal for all rings, i.e. also for undersize rings.

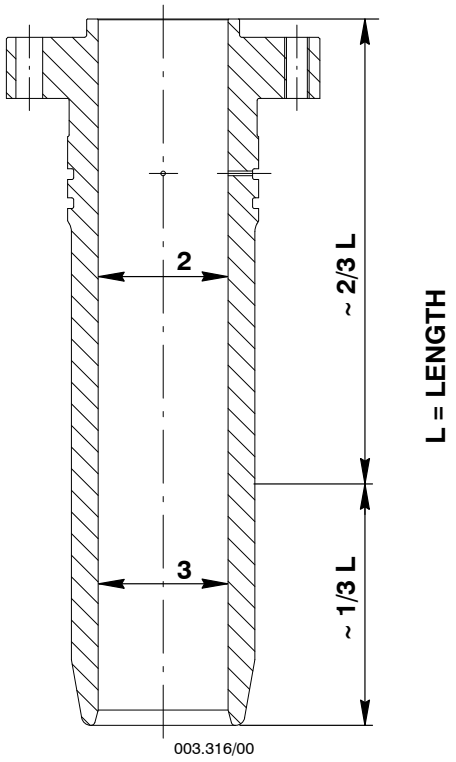
Clearance Table

Exhaust Valve

VALVE SPINDLE



GUIDE BUSH



Clearance Table

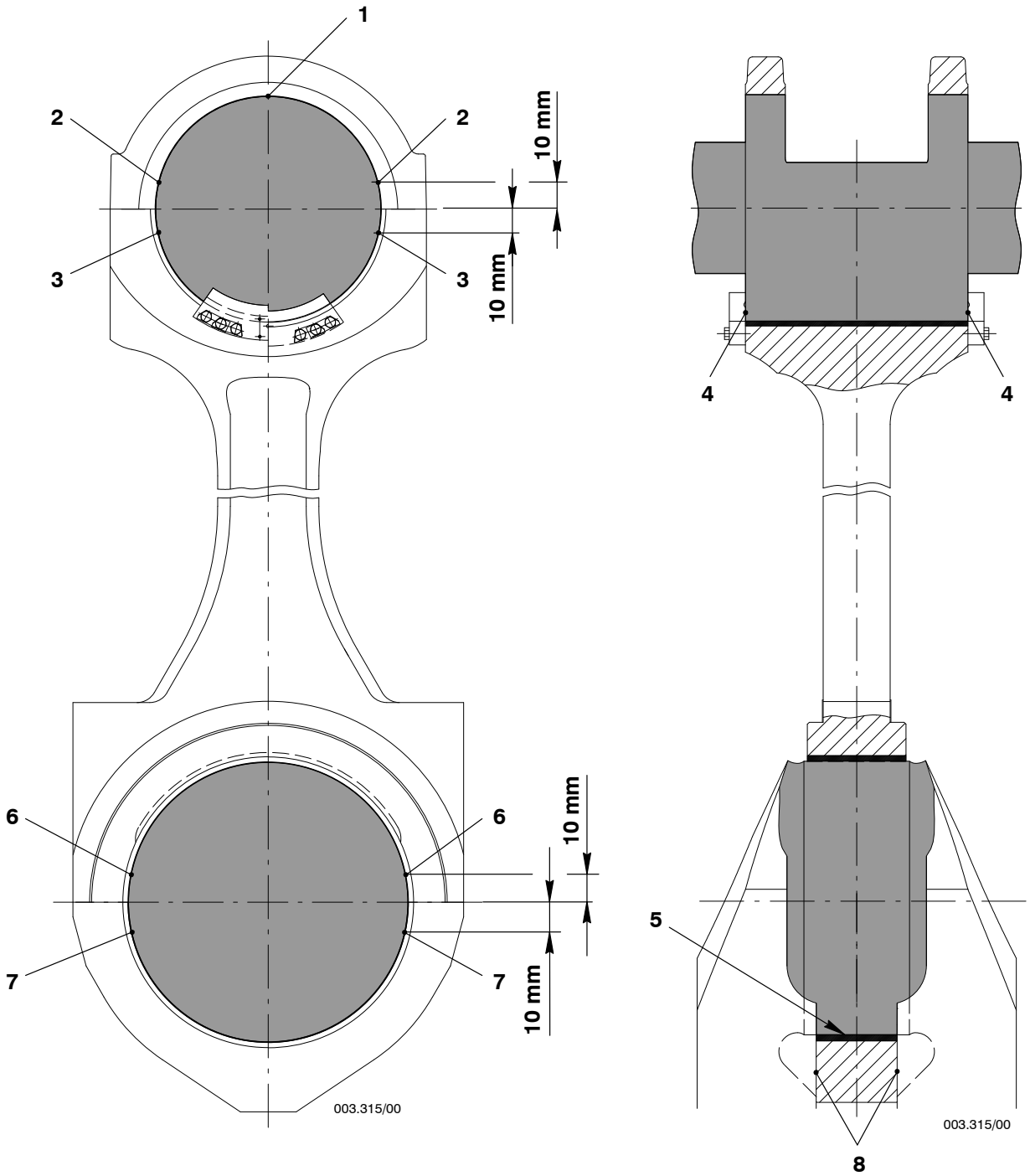
Exhaust Valve

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
2751		**Valve spindle**			
	1	Spindle	outer ∅	56 $^{-0.19}_{-0.23}$	55.4
2751		**Guide bush**			
	*2	Bore	inner ∅	56 $^{+0.03}_{0}$	56.3
	*3	Bore	inner ∅	56 $^{+0.03}_{0}$	57.0

* Pay attention to measuring point!

Clearance Table

Top and Bottom End Bearings to Connecting Rod



Clearance Table

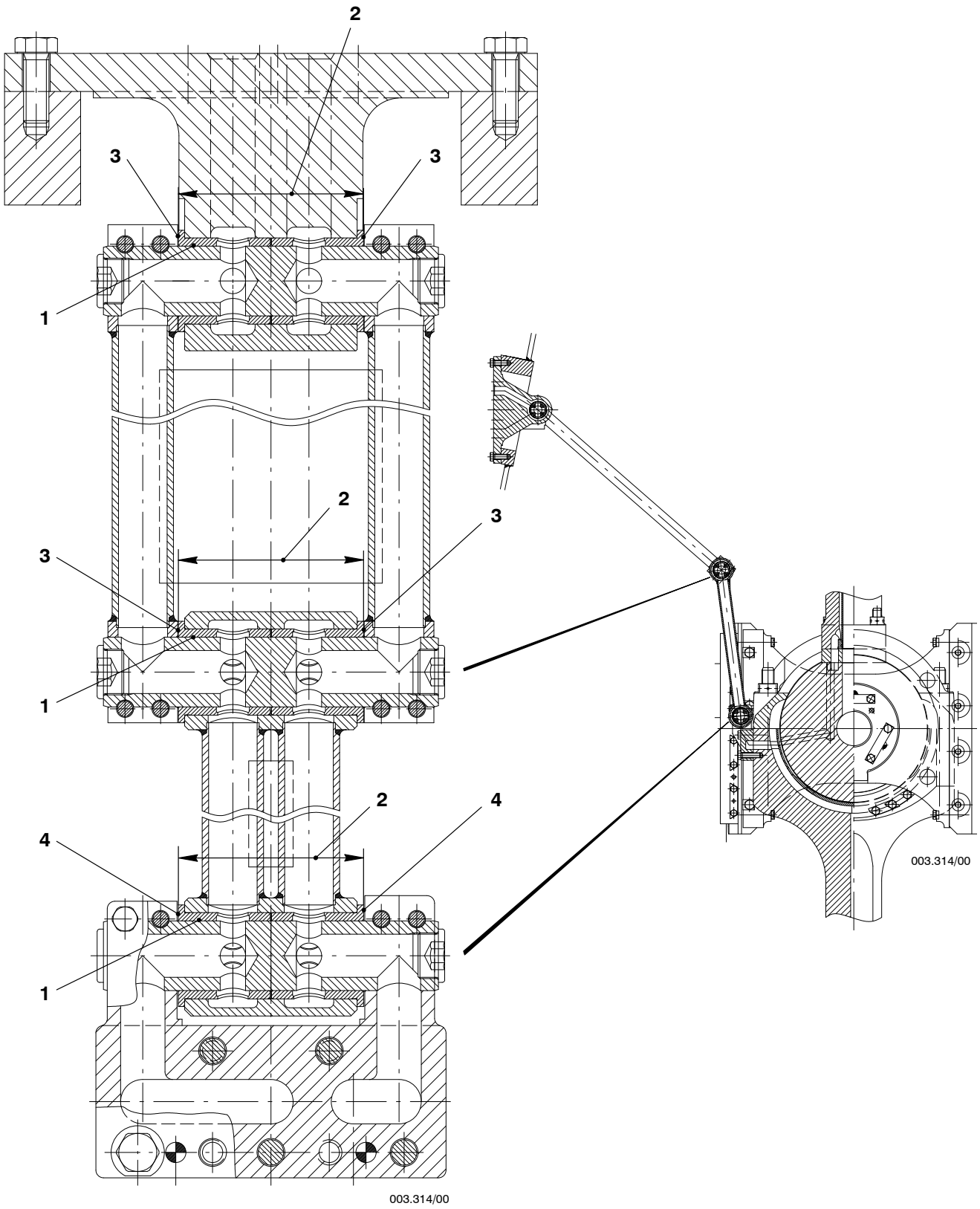
Top and Bottom End Bearings to Connecting Rod

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
3303 3326		**Top end bearing**			
		Crosshead pin	outer ∅	$580\ ^{0}_{-0.08}$	
		Bearing	inner ∅	580	
	1	Bearing clearance	vertical	0.31–0.55	0.75
	*2	Lateral clearance	total	0.41–0.57	
	*3	Lateral clearance	total	0.31–0.48	
	4	Axial clearance	per side	0.2–0.4	1.2
3303		**Bottom end bearing**			
		Crankshaft	outer ∅	$706\ ^{0}_{-0.08}$	
		Bearing	inner ∅	706	
	5	Bearing clearance	vertical	0.45–0.65	0.8
	*6	Lateral clearance	total	0.60–0.80	
	*7	Lateral clearance	total	0.60–0.80	
	8	Axial clearance	total	17	

* Pay attention to measuring point!

Clearance Table

Piston Cooling and Crosshead Lubricating Link



Clearance Table

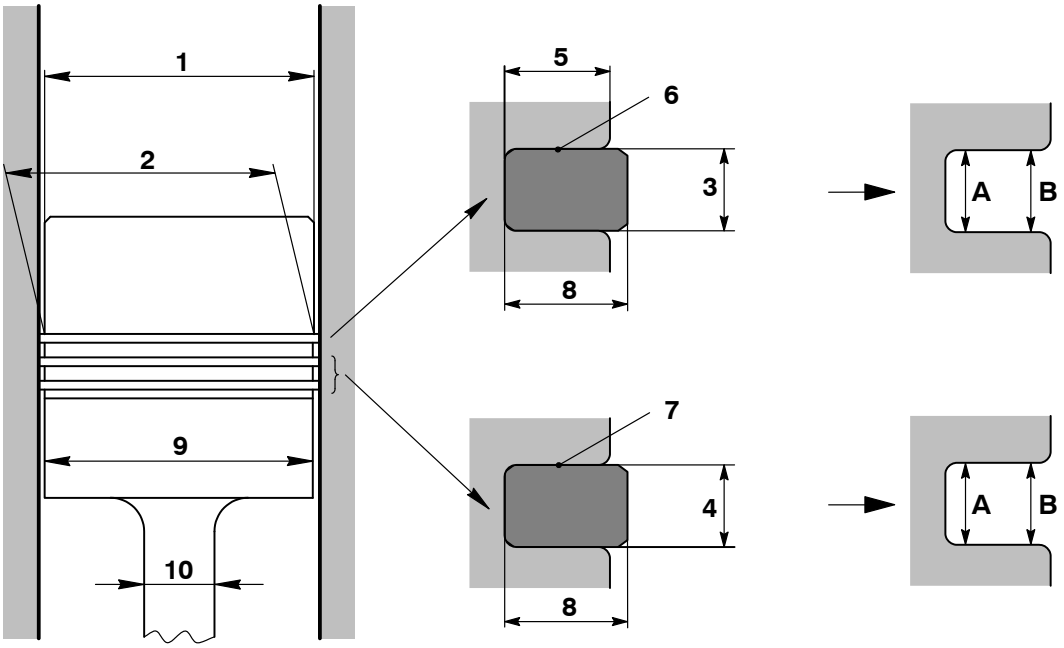
Piston Cooling and Crosshead Lubricating Link

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
3603		**Piston cooling and crosshead lubricating link**			
		Pin	outer ∅	55	
	1	Bearing clearance	radial	0.03–0.09	0.20
	2	Bearing	width	146	
	3	Lateral clearance	total	min. 1.0	
	4	Lateral clearance	total	2.0	

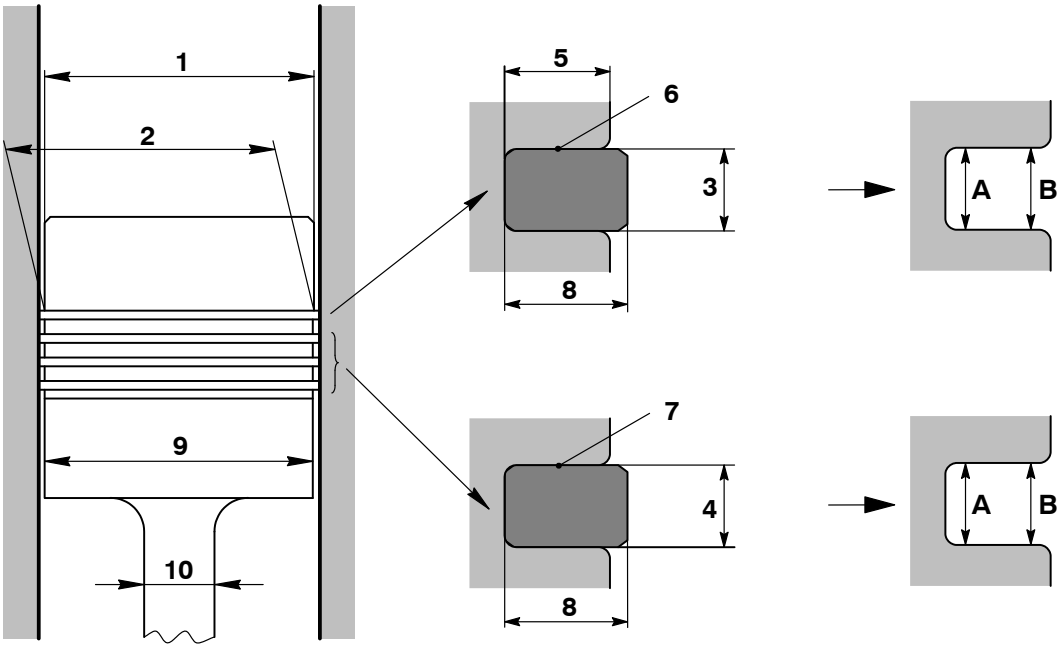
Clearance Table

Piston and Piston Rings

EXECUTION WITH THREE PISTON RINGS



EXECUTION WITH FOUR PISTON RINGS



Clearance Table

Piston and Piston Rings

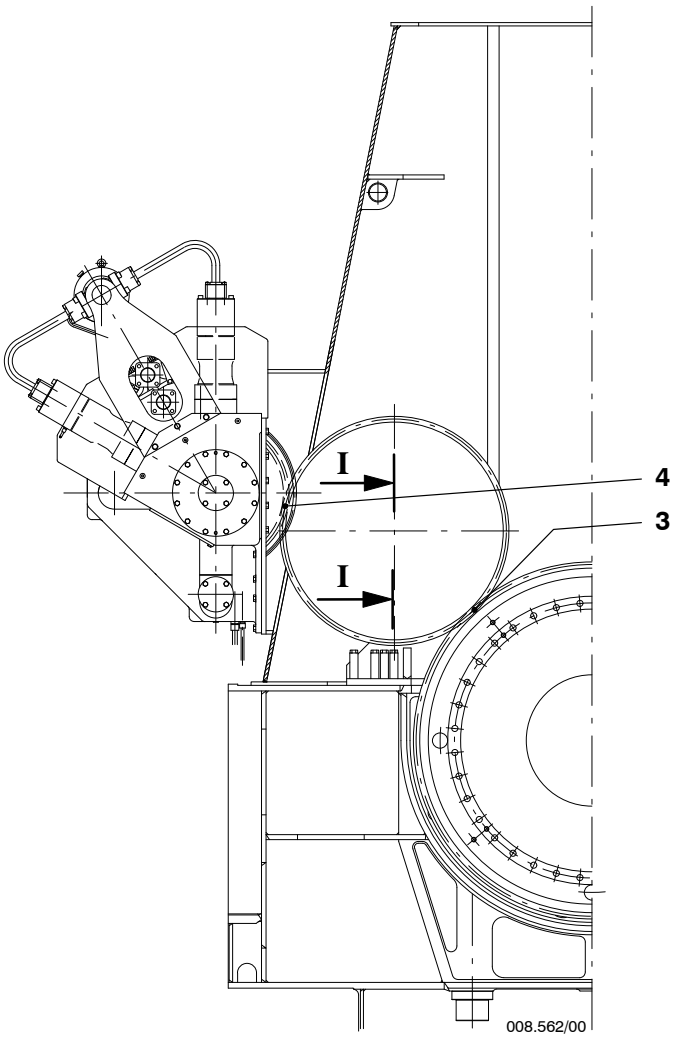
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]	
3403		**Piston crown**				
	1	Crown	outer ∅	$574.7\ ^{0}_{-0.2}$		
	2	Crown	outer ∅	$577.8\ ^{0}_{-0.2}$		
3403 3425		**Piston ring grooves**				
	3	Height of the uppermost groove	vertical	$16\ ^{+0.40}_{+0.35}$		
	4	Height of the two lower grooves	vertical	$16\ ^{+0.35}_{+0.30}$		
	5	Groove depth	radial	19.50		
3425		**Piston rings**				
		Ring height	vertical	$16\ ^{0}_{-0.03}$		
					Point A	**Point B**
	6	Ring clearance	vertical	0.35–0.43	0.60	0.75
	7	Ring clearance	vertical	0.30–0.38	0.55	0.70
	8	Ring width	radial	19 ± 0.25		
3403		**Piston skirt**				
	9	Skirt	outer ∅	$579.2\ ^{-0}_{-0.2}$	min. 578	
3403		**Piston rod**				
	10	Rod	outer ∅	$220\ ^{-0.050}_{-0.096}$	min. 219.3	

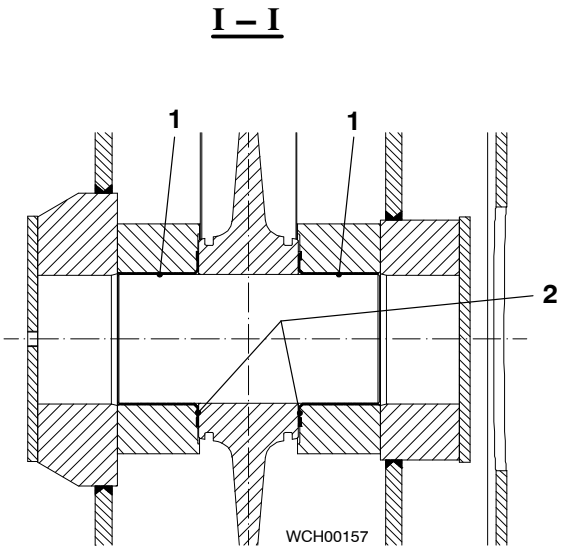
Used piston rings may be refitted if they will keep within their min. ring width until the next overhaul (for judging and reusing piston rings see also 3425–1).

For evaluating and reusing piston heads see 3425–1).

Clearance Table

Driving Wheels for Supply Unit





Clearance Table

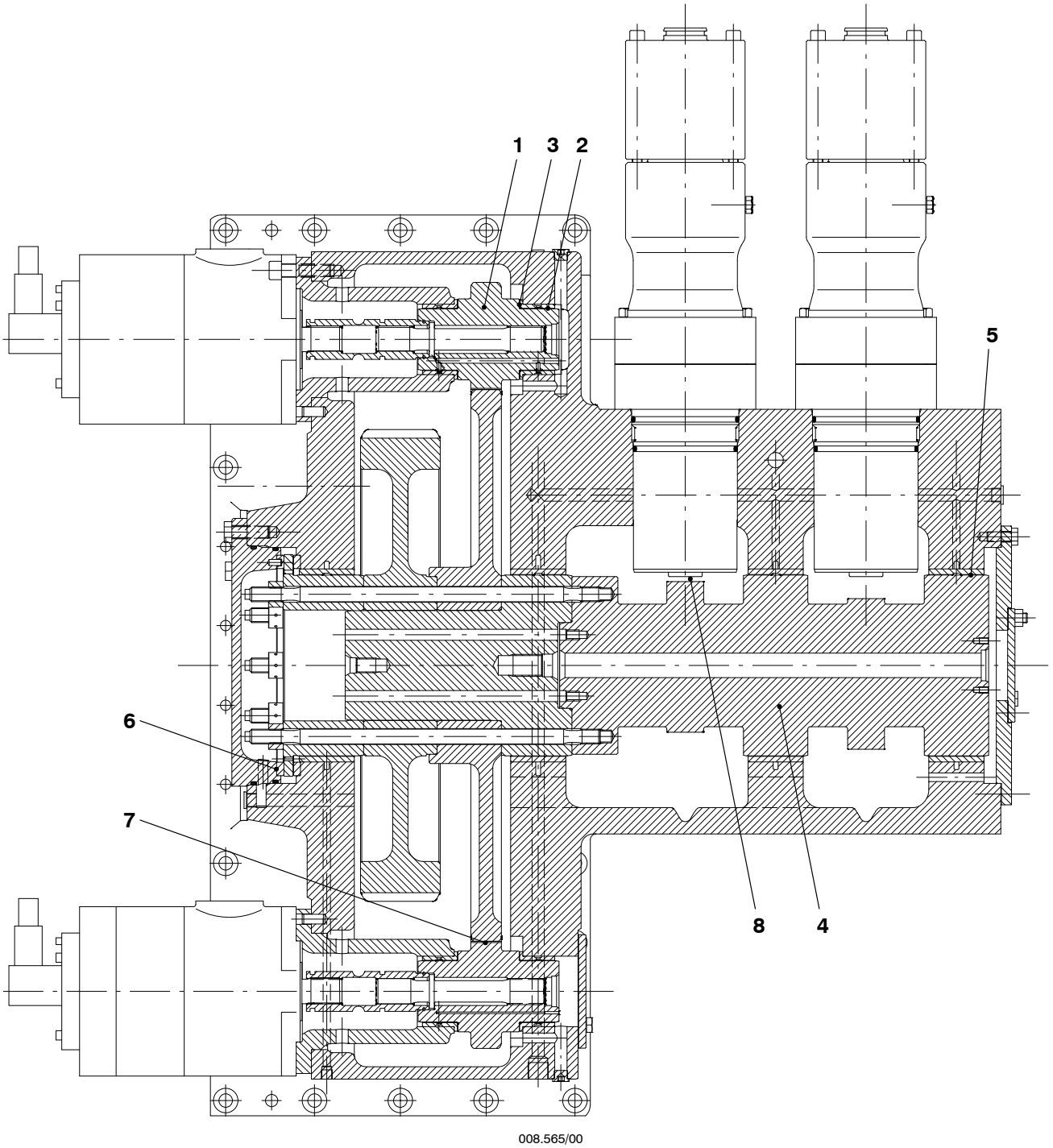
Driving Wheels for Supply Unit

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
4103		**Intermediate wheel**			
		Shaft	outer ∅	220	
	1	Bearing clearance	vertical	0.11–0.20	0.30
	2	Axial clearance	total	0.6–1.1	1.5
	3	Tooth backlash		0.38–0.54	
	4	Tooth backlash		0.28–0.40	

When measuring the tooth backlash pay attention to the tooth crowning of the tooth flanks in longitudinal direction.

Clearance Table

Supply Unit



Clearance Table

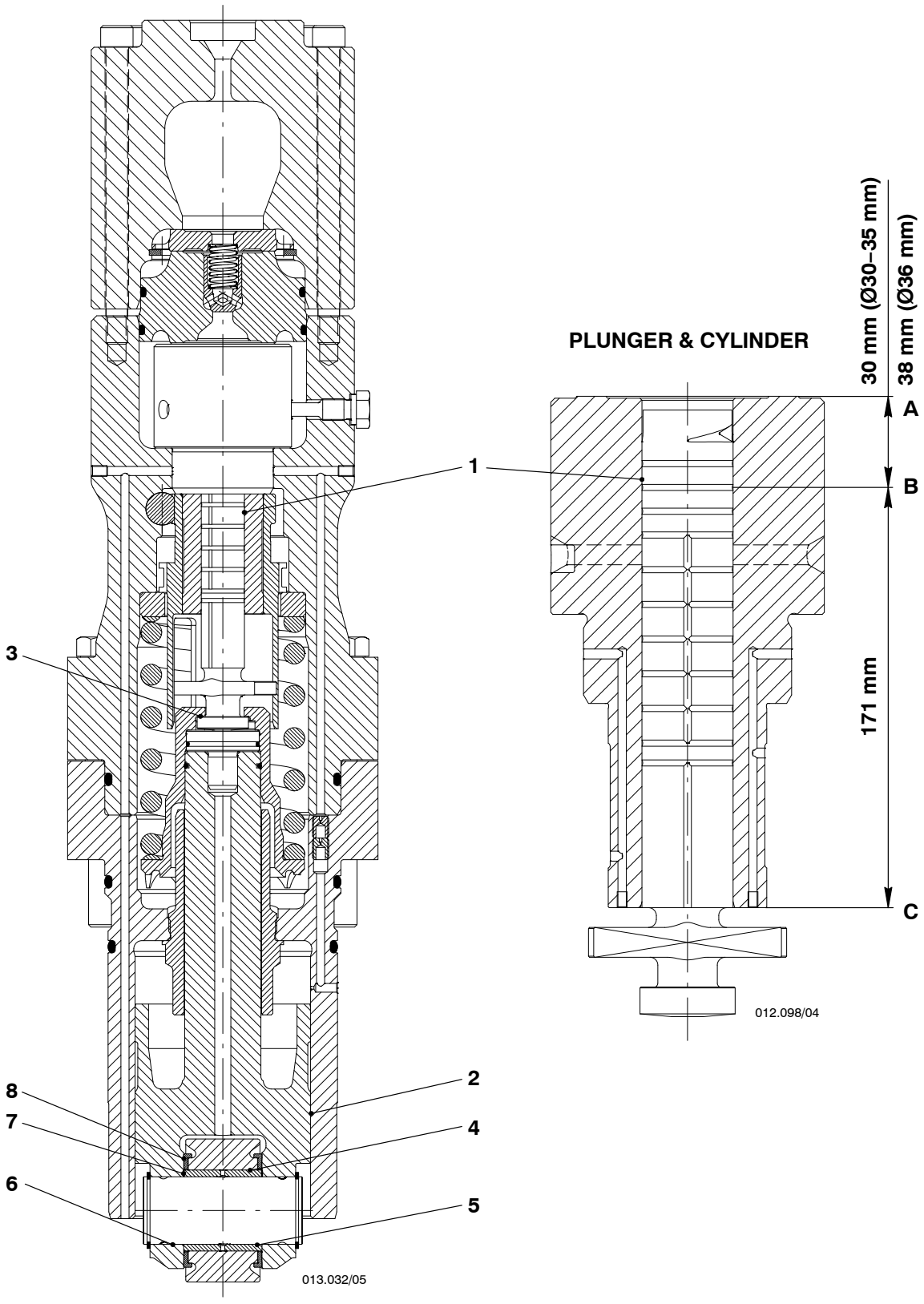
Supply Unit

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
5552		**Supply unit**			
	1	Pinion	outer ∅	100 $^{0}_{-0.022}$	
		Bearing (fitted)	inner ∅	100 $^{+0.118}_{+0.063}$	
	2	Bearing clearance	radial	0.063–0.14	
	3	Axial clearance	total	0.25–0.51	0.7
5552		**Camshaft unit**			
	4	Cam shaft	outer ∅	295 $^{0}_{-0.032}$	
		Bearing (fitted)	inner ∅	295 $^{+0.25}_{+0.18}$	
	5	Bearing clearance	radial	0.18–0.282	
	6	Axial clearance	total	0.25–0.5	0.7
	7	Tooth backlash		0.12–0.22	
	*8	Minimum clearance		2	

* Minimum clearance between cam and roller with fuel pump cut out.

Clearance Table

Fuel Pump



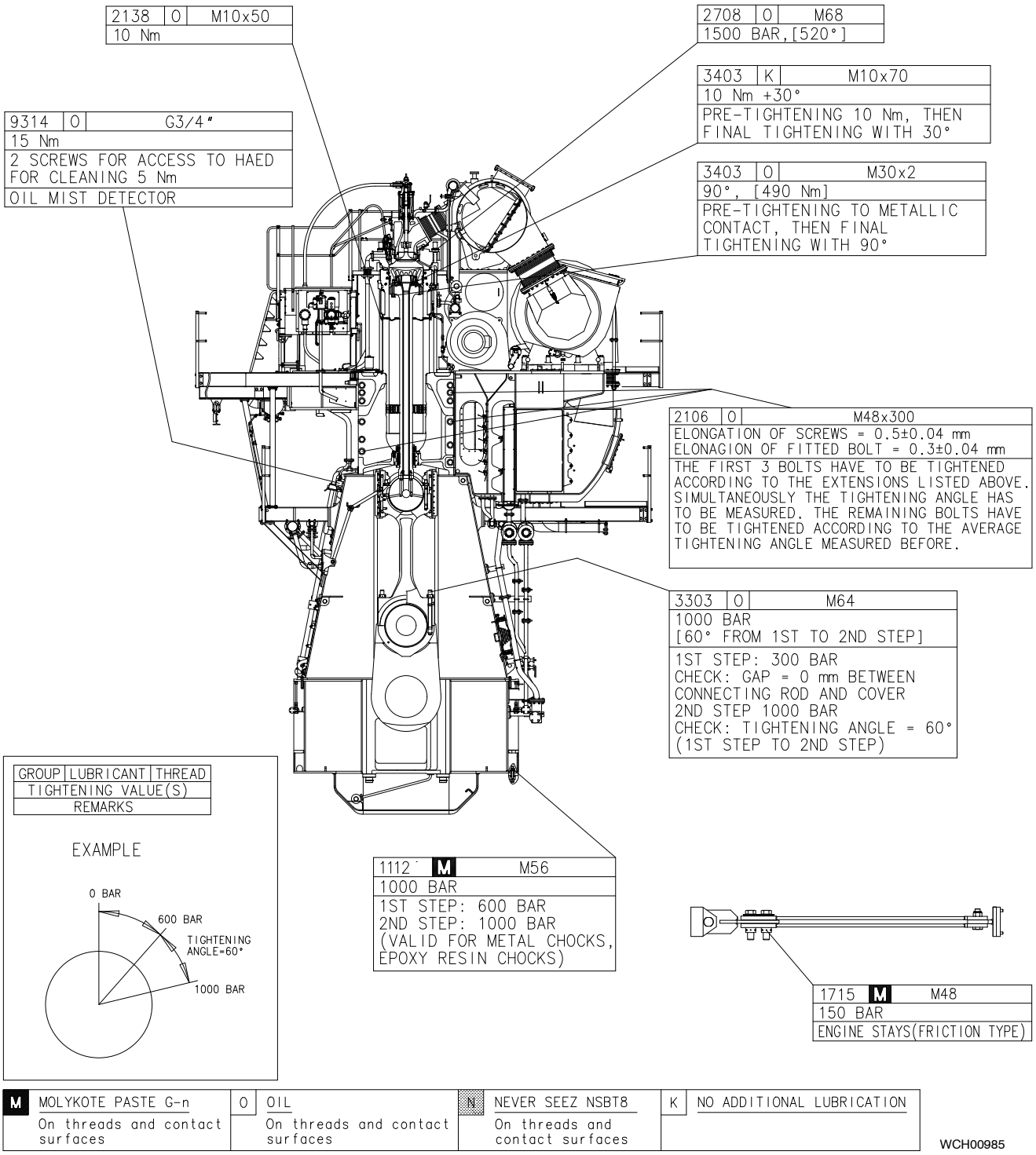
Clearance Table

Fuel Pump

Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
5556		**Fuel pump**			
	1	Clearance (plunger / cylinder) A–B	radial	0.028–0.030	0.037
		Clearance (plunger / cylinder) B–C	radial	0.018–0.020	0.027
		Guide piston	outer ∅	130	
		Lower housing	inner ∅	130	
	2	Clearance	radial	0.070–0.125	0.15
	3	Thrust piece / lower spring carrier	axial	0.02–0.06	0.08
5556		**Roller guide**			
		Bush	outer ∅	60	
		Roller	inner ∅	60	
	4	Clearance	radial	0.03–0.09	0.1
		Pin	outer ∅	50	
		Bush	inner ∅	50	
	5	Clearance	radial	0.025–0.080	0.1
		Pin	outer ∅	50	
		Guide piston (bore)	inner ∅	50	
	6	Clearance	radial	0.009–0.050	0.08
	7	Axial clearance of bush	total	0.2–0.4	0.5
	8	Total clearance between guide piston and roller with pressure discs	axial	0.24–0.54	0.7

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Tightening Values of Important Screwed Connections

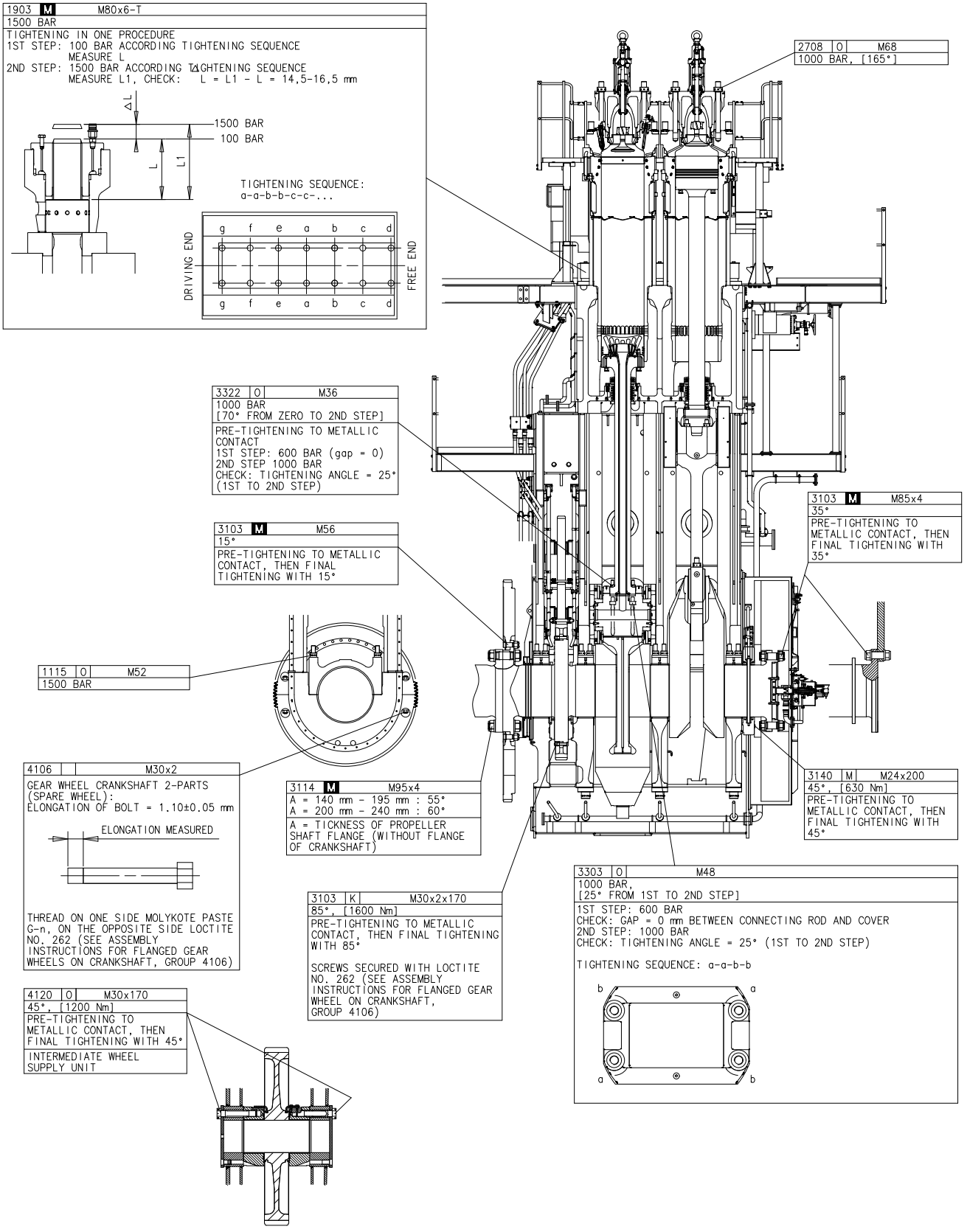


Remark: The screwed connections must be tightened in accordance with the values not in brackets. The values in brackets [...] are to be used for comparison only.

When using other hydraulic jacks, the required pressure in bar must be calculated in relation to the effective jack piston surface!
Conversion factor: 1 Nm = 0.102 mkp, 1 bar = kp/cm^2

- The relevant lubricant has to be applied to threads and seating surfaces, if no other instructions are mentioned.
- Bostik Findley Inc. (USA) is manufacturer of Never-Seez NSBT.

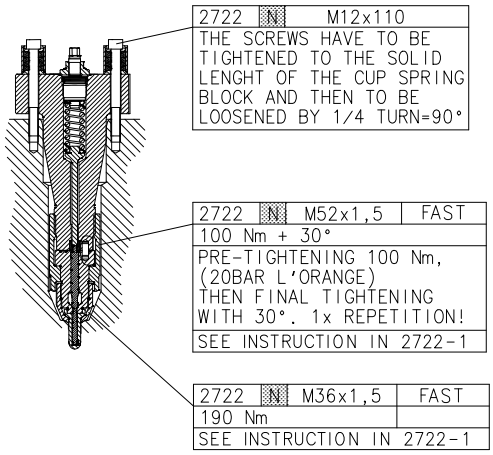
Tightening Values of Important Screwed Connections



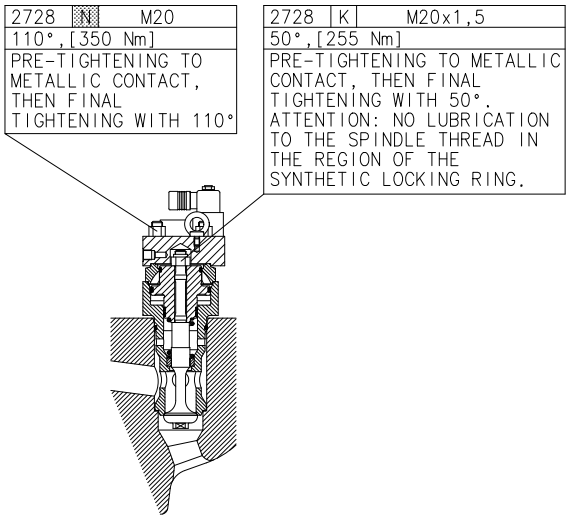
M	MOLYKOTE PASTE G-n On threads and contact surfaces	O	OIL On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces	K	NO ADDITIONAL LUBRICATION

Tightening Values of Important Screwed Connections

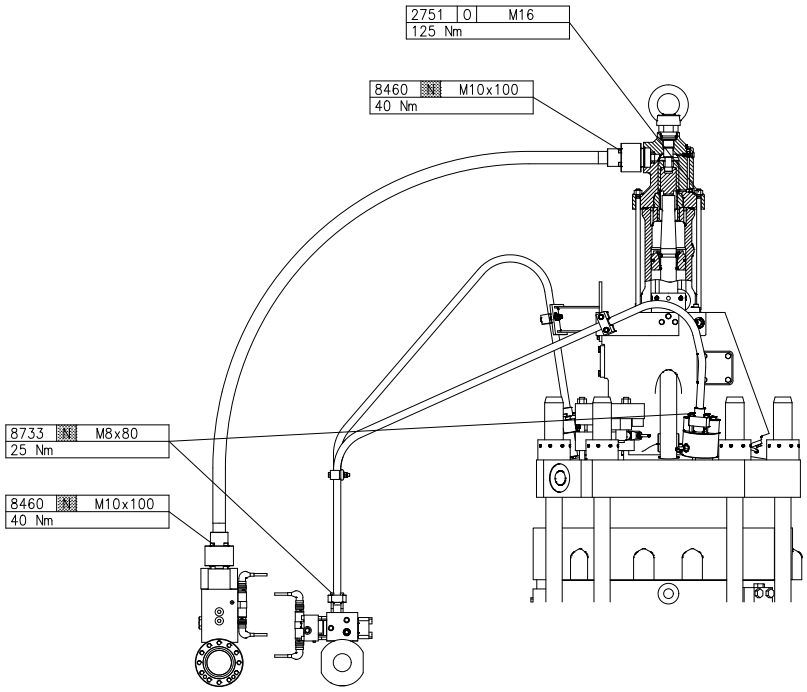
Injection Valve



Starting Air Valve



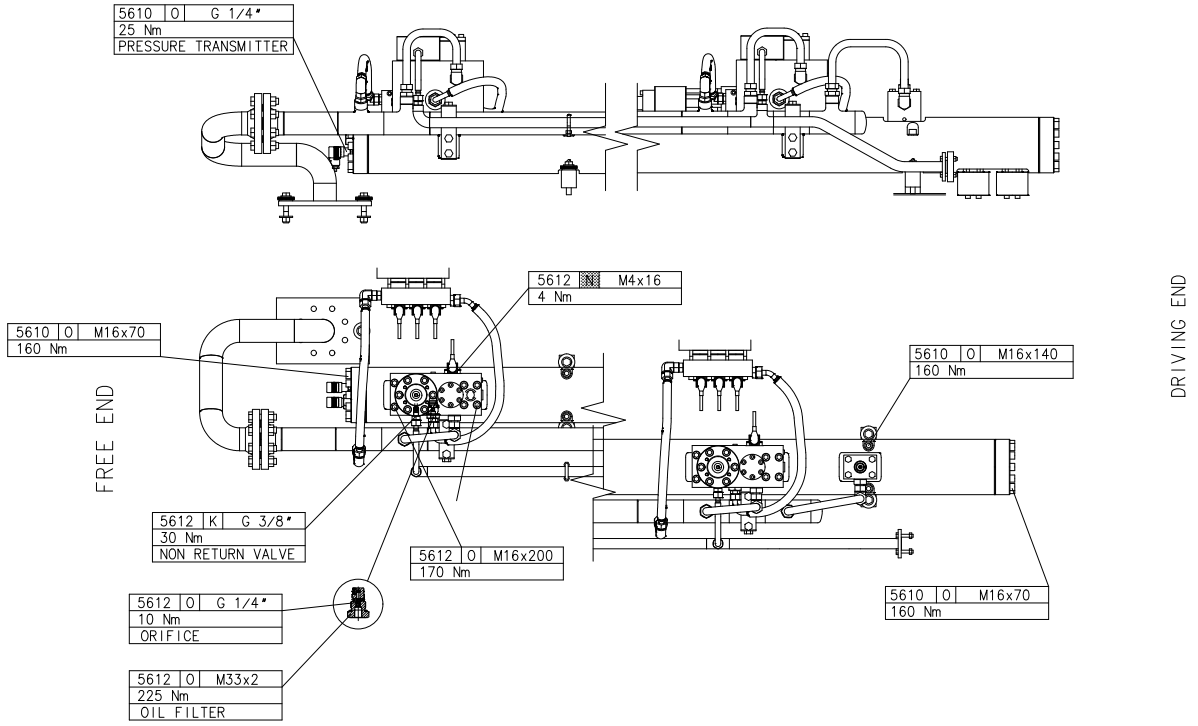
Exhaust Valve



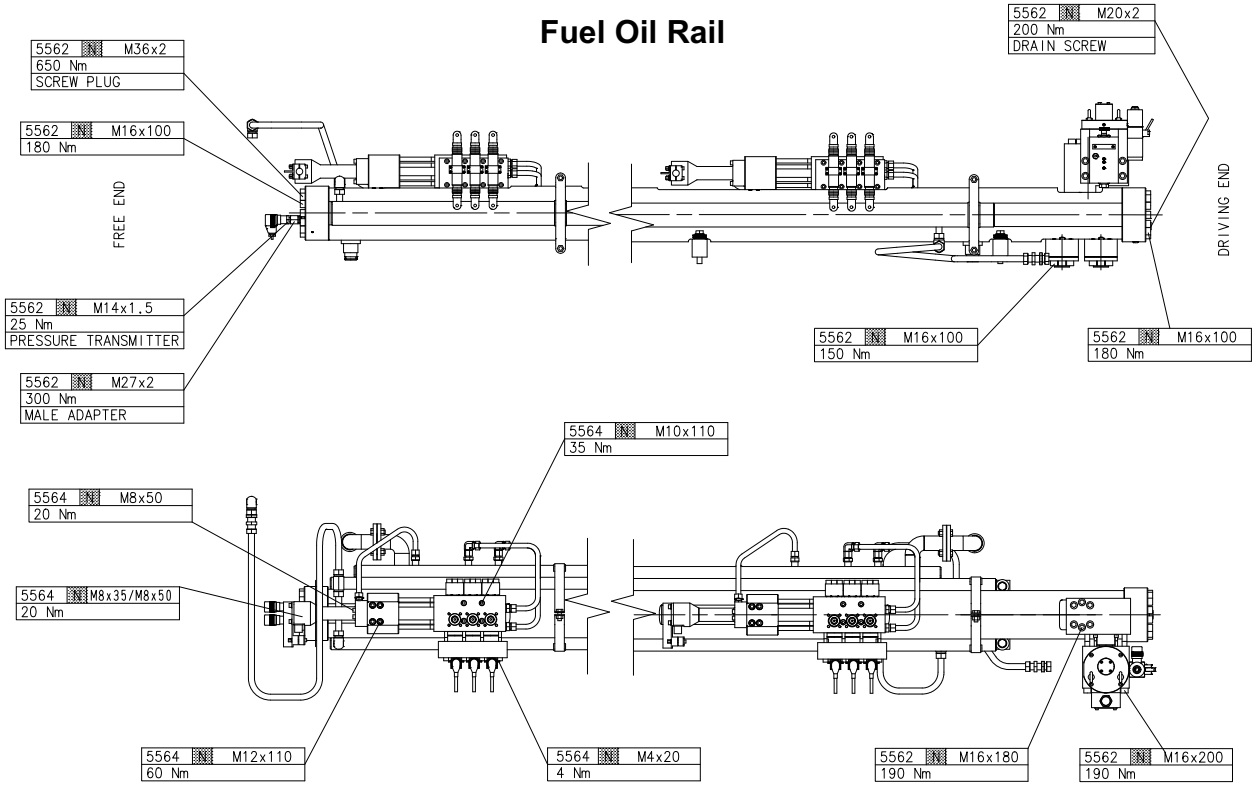
M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	N NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION

Tightening Values of Important Screwed Connections

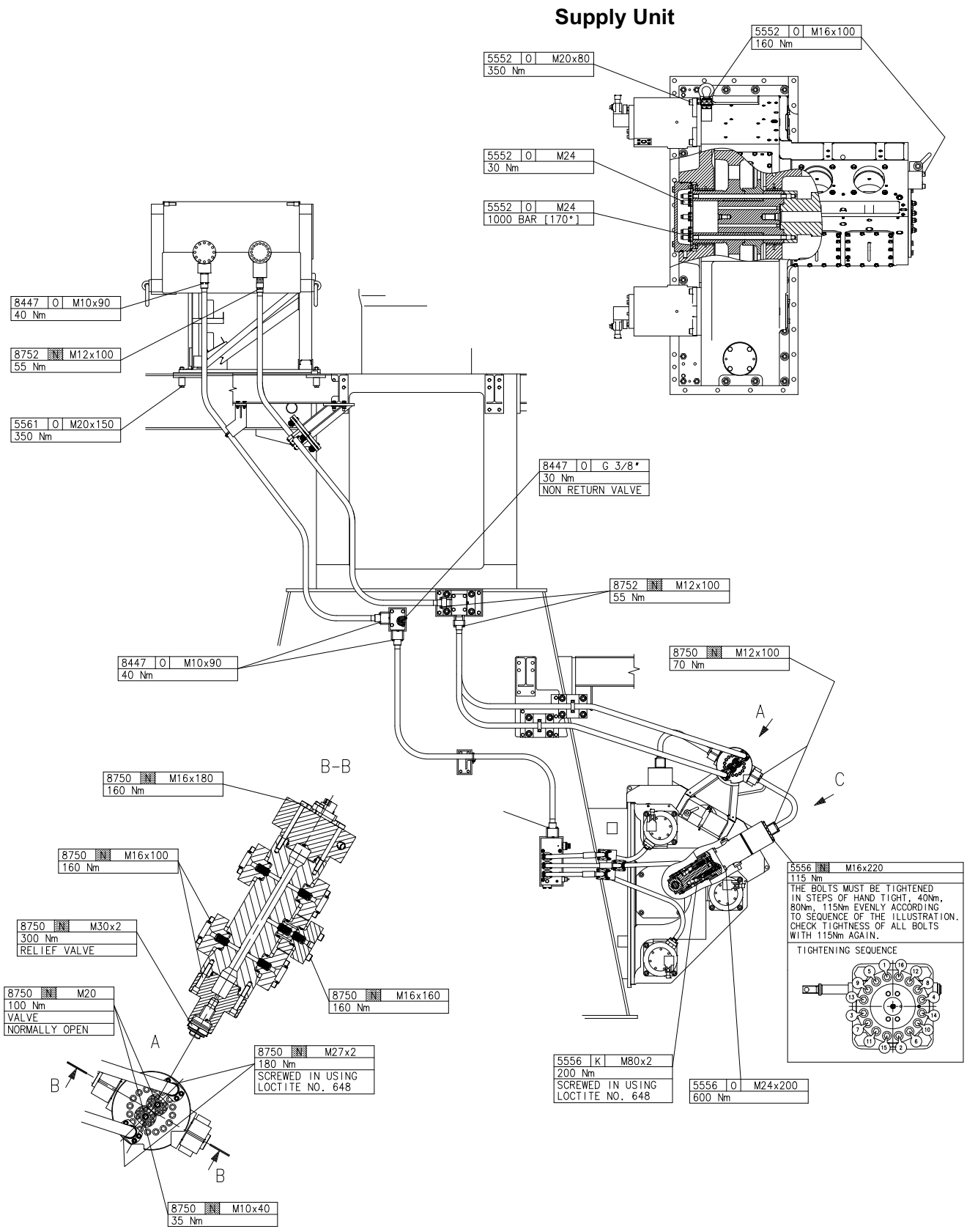
Servo Oil Rail



Fuel Oil Rail



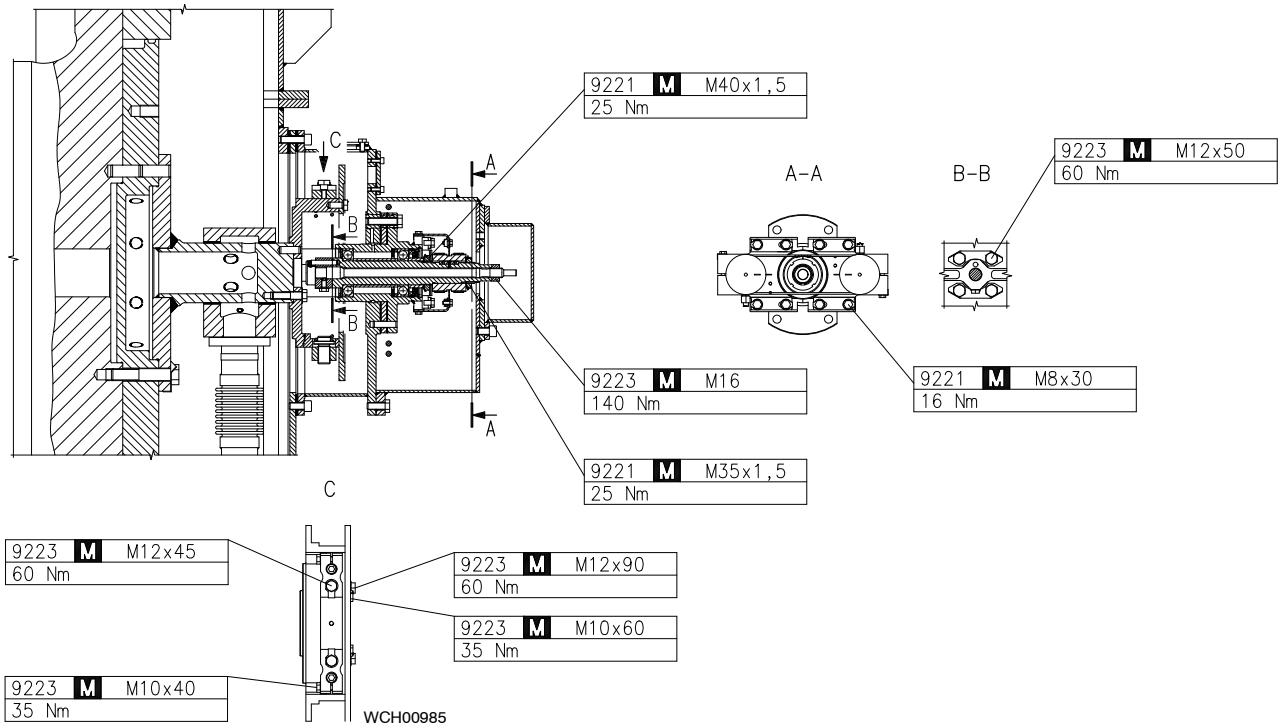
Tightening Values of Important Screwed Connections



M	MOLYKOTE PASTE G-n On threads and contact surfaces	O	OIL On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces	K	NO ADDITIONAL LUBRICATION

Tightening Values of Important Screwed Connections

Crank Angle Sensor Unit



M	MOLYKOTE PASTE G-n On threads and contact surfaces	O	OIL On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces	K	NO ADDITIONAL LUBRICATION

Tightening Values of Standard Screwed Connections

1. Tightening Torque for Standard Screws

We highly recommend tightening for all the metrical standard screws of grade 8.8 according to the table below. This applies to all threaded connections not mentioned on page 0352–1. The threads and base of the head has to be lubricated with lubricating oil SAE 30.

For the screws in high **temperature areas** (exhaust pipes, expansion pieces etc.), a heat resisting lubricant, for example NEVER SEEZ NSBT8, is strongly recommended,

In case if NEVER SEEZ NSBT8 is used the tightening torque must be reduced by 20% of the values given in the table.

These tightening torques do not apply to **turbo charger** installation. Refer to the documents of the turbocharger manufacturer for the correct tightening torques.

Standard thread	Fine thread	Tightening torque [Nm]
M8	M8 x 1	20
M10	M10 x 1.25	40
M12	M12 x 1.25	70
M14	M14 x 1.5	110
M16	M16 x 1.5	170
M18	M18 x 1.5	250
M20	M20 x 1.5	350
M22	M22 x 1.5	450
M24	M24 x 2	600
M27	M27 x 2	900
M30	M30 x 2	1200
M33	M33 x 2	1600
M36	M36 x 3	2100
M39	M39 x 3	2500
M42	M42 x 3	2900
M45	M45 x 3	3300
M48	M48 x 3	3700
M52	M52 x 3	4100
M56	M56 x 4	4600
M60	M60 x 4	5200

2. Elastic bolts

Elastic bolts must be tightened according to the values in the following diagram.

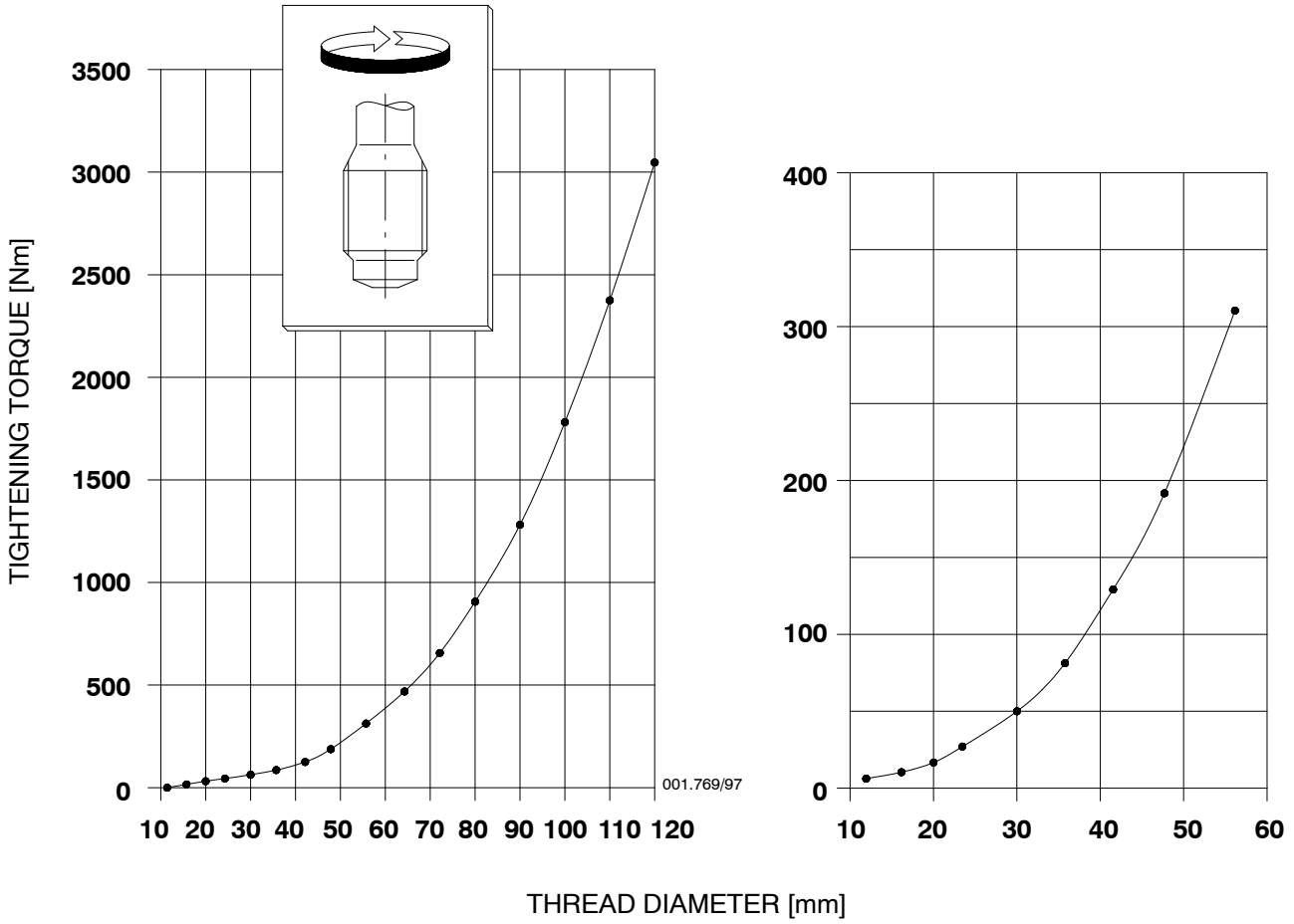
- Before fitting a elastic bolt clean its thread and corresponding tap hole. The sealing faces must be degreased (e.g. using white spirit) and subsequently primed.
- Screw in the elastic bolt without lubricant on the thread right to the bottom of the tap hole, and tighten. Always utilize a bolt driver or two nuts.



Tools like a pipe wrench etc. which would damage the bolt shank must never be used.

- For the protection of the elastic bolt in the cylinder block and cylinder cover, fill the annular space above the thread with a non-hardening jointing compound (see 2751–1).

TIGHTENING TORQUE FOR ELASTIC BOLTS



Masses (Weights)
Individual Components per Piece in kg

Group	Component	Execution	kg
1			
1115	Main bearing cover		250
1134	Main bearing shells (upper and lower)		74
1203	Holder for thrust bearing		36
1224	Thrust bearing pad		37
1717	Casing	free end	1200
1720	Oil baffle, upper part Oil baffle, lower part	driving end driving end	222 113
1903	Tie rod Tie rod nut Intermediate ring	complete	293 4.5 14
2			
2106	Elastic bolt in cylinder block		42
2124	Cylinder liner		3400
2130	Water guide jacket	upper lower	113 193
2303	Piston rod gland		129
2708	Elastic stud for valve cage Cylinder cover without accessories		20 1336
2722	Injection valve	complete	12
2728	Starting air valve	complete	30
2740	Indicator valve	complete	2
2751	Exhaust valve with spindle	complete	723
2754	Exhaust valve spindle		53
3			
3103	Balance weight		335–870
3122	Flywheel	Light middle weight heavy	2125–2924 4356–5155 7980–10838
3140	Axial damper cylinder	2-part	637
3303	Connecting rod Elastic stud with nut for bottom end bearing Elastic stud with nut for top end bearing	complete	1930 17 7

Individual Components per Piece in kg

Group	Component	Execution	kg
3306	Connecting rod		1340
3309	Lower bearing half for bottom end bearing with bearing shell and elastic stud	complete	259
3310	Lower bearing shell half for bottom end bearing		22
	Upper bearing shell half for bottom end bearing		30
3312	Upper bearing half for top end bearing		203
3315	Bearing shell for top end bearing		55
3326	Crosshead without guide shoes		1213
	Crosshead with guide shoes	complete	1807
	Middle part with guide shoes	complete	297
3403	Piston with piston rod	complete	1437
	Piston crown		350
	Piston skirt		62
	Piston rod		909
3603	Toggle lever to piston cooling and crosshead lubrication	complete	122
4			
4106	Gear wheel on crankshaft		663
	Gear wheel on crankshaft	2-part, complete	819
4120	Intermediate wheel for supply unit with bearing pins and bearings for	complete	975
	Bearing pair for intermediate wheel		186
4325	Shut-off valve for starting air		210
5			
5552	Supply unit with pumps, driving wheels and intermediate fuel accumulator	complete	4850
	Driving wheel		200
	Servo oil pump		150
	Driving pinion for servo oil pump		19
	Driving wheel for servo oil pump		152
	Gear wheel shaft		101
	Camshaft		250
5556	Fuel pump with plunger	complete	170

Individual Components per Piece in kg

Group	Component	Execution	kg
5564	Injection control unit	complete	55
5612	Exhaust valve control unit	complete	80
6			
6506	Exhaust gas turbocharger	A165 A170 A175	2000 3000 4900
6545	Auxiliary blower with electric motor Electric motor	complete	748 298
6606	Scavenge air cooler	SAC 2433 SAC 2451 SAC 2491	1803 1203 2003
6708	Water separator (stainless steel 3–lips)	A170, A175 A180	175 225
8			
8139	Expansion piece after exhaust valve	DN 300	58

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Maintenance Schedule

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
0			
	Lubricating oil	– Laboratory analysis	3000 Op. h (operating hours)
	Cooling water	– Check concentration of inhibitor (as per supplier's instructions)	
1			
1112–1	**Bedplate**	– Check pre-tension of foundation bolts, first time after 1500 Op. h	12 000 Op. h
	Crankcase	– Visual examination	1500–3000 Op. h
1132–2	**Main bearing**	– Remove bearing upper half for inspection	according to classification society
		– Remove bottom bearing shell for inspection	acc. to class. society
1203–1	**Thrust bearing**	– Check axial and radial clearances	6000–8000 Op. h
		– Check bottom drain for free passage	6000–8000 Op. h
1224–1		– Remove thrust bearing pads for inspection	acc. to class. society
1715–1	**Engine stays with friction shims**	– Check pre-tension of waisted studs, first time after sea trial	6000–8000 Op. h
1903–1	**Tie rod**	– Check pre-tension, if necessary re-tension first time after one year	24 000–30 000 Op. h
2			
2124–1	**Cylinder liner**	– Establish wear in bore (in fitted condition)	at every piston removal
2124–2		– Remove cylinder liner	as required
		– Replace O-rings	at every removal
		– Replace (soft iron) joint ring between cylinder liner and cylinder cover	at every piston removal
		– Water guide jacket, replace O-rings	at every piston removal
		– Check condition of antipolishing ring	at every piston removal
2124–3		– Grind off wear ridge in bore	at every piston removal
		– Refinish lubricating grooves	as required
		– Clean scavenge ports and refinish their edges	as required
2138–1	**Lubricating quill (pulse lubrication)**	– Check function and tightness	at every piston removal
		– Check function of non-return valves	at every liner removal

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
2303–1	**Piston rod gland**	– Clean rings, establish wear	at every piston removal
2708–1	**Cylinder cover**	– Check combustion space for damage	at every piston removal
2722–1	**Injection valve**	– Check externally for tightness	before starting engine after a longer standstill
		– Check spray pattern, opening pressure, tightness condition of nozzle tip, readjust opening pressure (life time of nozzle tip about 6000 Op. h)	3000 Op. h
2728–1	**Starting air valve**	– Check piping before the valve during operation, if piping is too hot, dismantle starting air valve	weekly
		– Remove and dismantle one starting air valve at random. From its condition determine time of overhaul for remaining valves	6000–8000 Op. h
		– Make sure that nut on solenoid is tight, if necessary tighten nut.	monthly
		– Solenoid valve, random functional check overhaul	6000 Op. h 18 000 Op. h
2751–1 to 2751–4	**Exhaust valve**	– General inspection of valve housing, valve spindle and valve seat (without dismantling of exhaust valve)	at every piston removal
		– Check condition and wear of valve spindle (if necessary regrind seat by machining)	24 000–36 000 Op. h
		– Check piston seal ring / air spring & rod seal ring / guide bush	24 000–36 000 Op. h
		– Check condition and wear of valve seat (if necessary regrind seat by machining)	24 000–36 000 Op. h
		– Random check of valve drive, outside and inside pistons, damper, thrust piece	18 000 Op. h
		– Random check of sc. conn. to measuring cone	18 000 Op. h
3			
3103–1	**Crankshaft**	– Measure crank deflection	according to classification society
		– Always in case of grounding of the ship as well as before and after every docking	
3130–1	**Torsional vibration damper**	– Take a silicon oil sample from viscous vibration damper (based on results of 1st sample, interval for taking further samples will be decided)	first time after 15 000 – 18 000 Op. h
3130–2		– Inspection interval and dismantling of GEISLINGER damper	acc. to instructions of damper manufacturer
3140–1	**Axial damper**	– Dismantling and inspection	36 000–48 000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
3206–1	**Turning gear**	– Inspection interval of turning gear	acc. to instructions of turn. gear manufacturer
		– Re-lubrication of tooth flanks of pinion & flywheel, depending on visual inspections, however every 2000 Op. h of diesel engine	
		– Check screwed connections, first time after one year (if necessary retighten)	12 000 Op. h
	Connecting rod bearings	– Check bearing clearances (see 0330–1)	6000–8000 Op. h
3303–2		– Inspect bottom end bearing (life time of shell 60 000–72 000 Op. h)	30 000–36 000 Op. h or acc. to class. society
3303–3		– Inspect top end bearing	30 000–36 000 Op. h or acc. to class. society
3326–1	**Guide shoe, Crosshead pin**	– Check clearances	6000–8000 Op. h
3326–2		– Remove crosshead	as required
3403–1	**Piston**	– Remove, clean and measure ring grooves (cylinder liner with antipolishing ring and chrome-ceramic piston rings)	18 000–36 000 Op. H (condition based)
		– Check tightness on piston in situ and with running oil pump, visual check through scavenge ports	after refitting
3403–3		– Dismantling and assembling (open cooling space & clean same, min. one piston every three years)	as required
3403–4		– Check condition of the piston top surface	at every piston removal
		– Visual check through scavenge ports to piston, piston rings and cylinder liner (rotate crankshaft with turning gear)	500–1000 Op. h
	Piston underside	– Check condition of space and clean it as required	1500–3000 Op. h
		– Check drains for free passage	1500–3000 Op. h
3425–1	**Piston rings**	– Measure thickness of chrome-ceramic layer	1500–2000 Op. H
		– Replace piston rings based on remaining coating thickness	18 000–30 000 Op. H (condition based)
4	**Start interlock**	– Check electric and pneumatic interlocks (see Operating Manual 4003–1)	quarterly
4103–1	**Driving wheels**	– Check condition of teeth	6000–8000 Op. h
		– Check running clearance and backlash of teeth	6000–8000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
	Starting air shut-off valve	– Vent	after each manoeuvring period
4325–1		– Dismantle, clean and check (particularly seat, springs and seal rings)	24 000–36 000 Op. h
		– Overhaul common start valve	18 000 Op. h
	Control air filter	– Drain filter	weekly
		– Clean filter	6000 Op. h
5			
5552–1	**Supply unit**	– Replace servo oil pump either with new one or a pump overhauled by a Wärtsilä workshop	24 000 Op. h
		– Check pinion and driving wheels to servo oil pump drive	3000 Op. h
		– Check bearing bushes to pinion	24 000 Op. h
5552–2		– Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h)	3000 Op. h
		– Camshaft, check bearing clearances at random	12 000 Op. h
		– Camshaft, check thrust bearing clearances	36 000 Op. h
5556–1	**Fuel pump**	– Replace O-rings in valve block	18 000 Op. h
		– Random visual check of plunger & cylinder, roller and roller guide	18 000 Op. h
5562–1	**Fuel pressure control valve (PCV)**	– Check shut-down function (see Operating Manual 4003–1)	3000 Op. h
		– Function check (see Operating Manual 5562–1)	6000 Op. h
		– General overhaul	only necessary when PCV fails
		– Replace oil filter	18 000 Op. h
5564–1	**Injection control unit**	– Overhaul unit or replace it (incl. rail valves) either with new one or a unit overhauled by a Wärtsilä workshop.	24 000–36 000 Op. h
		– Replace filter before pre-control valve (servo oil)	18 000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
5610	**Servo oil rail**	– Replace hoses	18 000–30 000 Op. h
5612–1	**Exhaust valve control unit**	– Random check of piston and slide rod	18 000 Op. h
		– Replace rail valve (pre-control valve)	30 000–36 000 Op. h
		– Replace filter	18 000 Op. h
5801–1	**Regulating linkage**	– Check for free movement, lubricate all movable parts	3000 Op. h
6			
6420–1	**Scavenge air receiver**	– Check and clean air flaps	4000–6000 Op. h
		– Clean receiver	4000–6000 Op. h
		– Check water drain pipings for free passage	1500–3000 Op. h
	Exhaust gas turbocharger	– Wash-cleaning of blower in service	(see Operating Manual)
		– Wash-cleaning or dry cleaning of turbine in service	(see Operating Manual)
	Air filter	– Check filter	half yearly
		– Cleaning of filter at a Δp increase of 50% compared to the shop test value at same engine load (see Operating Manual 6510–1)	as required
6545–1	**Auxiliary blower**	– Clean impeller and casing	24 000–36 000 Op. h
		– Replace ball-bearing	24 000–36 000 Op. h
6606–1	**Scavenge air cooler**	– Cleaning of scavenge air cooler (air side) in service at the beginning weekly, later at a Δp (pressure drop through SAC) increase of 50% compared to the shop test value at same engine load (see Operating Manual 6606–1)	as required
		– 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 Op. h
		– Check scavenge air cooler sealing	quarterly
		– Vent	daily
		– Remove scavenge air cooler for general overhaul	as required

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
6708−1	**Water separator**	− 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 Op. h
		− Check water separator elements (if necessary clean them)	1500−3000 Op. h
		− Remove water separator for general overhaul	as required
7 7218−1	**Lubricating pump and accumulator (Pulse lubrication)**	− General maintenance works	according to instructions of equipment manufacturer
		− Checking gas (nitrogen) pre-charge pressure: **CLU4−C** min. 30 bar / max. 35 bar directly after installation of a new accumulator −> then at least once in first week after start-up −> afterwards −>	every three months
8 8135−1	**Exhaust Waste Gate (LLT)**	− During a longer operation period at low engine load, manually open butterfly valve at least once per week (see Operating Manual 8135−1) − General inspection	according to instruction of valve manufacturer
	Servo oil automatic filter	− Follow manufacturer's instructions	
	Starting air piping	− Drain (de-water)	before and after every manoeuvering period
	Pressure gauges and pyrometers	− Compare and calibrate according to master instruments	6000−8000 Op.h
	Fuel and lubricating oil filters	− Clean or replace filter elements (depending on make, follow manufacturer's instructions)	as required
	Pipe holders	− Check fastenings periodically, if necessary retighten screws (first time after 100 Op.h, then half yearly)	as required
8447	**Collector block**	− Replace safety valve (servo oil)	36000 Op.h.
8447	**Servo oil system**	− Check spindle of shut−off valve for free movement	6000 Op.h.

Group	Component	Work to be carried out	Intervals
8447–1	**HP servo oil pipe**	– Regrind sealing faces	as required
8460–1	**Hydraulic pipe for exhaust valve drive**	– Regrind sealing faces	as required

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
8733−1	**HP pipe to injection valve (on cylinder cover)**	– Regrind sealing faces	as required
8744	**Supply unit fuel drain piping**	– Check regularly for free passage at least once a year	6000 Op.h
8750	**Intermediate fuel accumulator**	– Random check of non-return valves	18 000 Op.h
8750−1	**Relief valve** (fuel overpressure safety valve)	– Function check on test bench	18 000 Op.h
8752−1	**HP fuel pipe**	– Regrind sealing faces	as required
9			
9223−1	**Crank angle sensor unit**	– Check tension visually Check cracks and wear of tooted belt visually Visual lubricating oil check	3000 Op.h
		– Replace toothed belt	24 000 Op.h
		– Overhaul drive (ball bearing, sealing ring etc.) and check shaft eccentricity of CAS drive	48 000 Op.h
		– Check shaft eccentricity of CAS drive	at every CAS exchange
		– Replace crank angle sensor	48 000 Op.h (only if new soft belt is applied from beginning)
	Oil mist detector	– Follow manufacturer's instructions	half yearly
	WECS electronic components	– Replace FCM−20, ALM−20, ACM−20 modules (see Operating Manual 4002−4)	36 000 ... 50 000 Op. h
		– Check cabling and wiring. Replace damaged cables and wires	quarterly

Inspection and Overhaul Intervals (Guidelines)

The indicated maintenance intervals must be taken as **guidance** and may vary depending on the installation. The proper intervals are subject to the points mentioned below. Experience will show whether these intervals can be extended or must be shortened.

- Environmental and operating conditions
- Heavy fuel oil and lubricating oil qualities (see Operating Manual 0710–1 and 0750–1)
- Engine load
- Fuel, lubricating oil and cooling water care (see Operating Manual 0720–1 and 0760–1)
- Overhaul according to Maintenance Manual
- Genuine spare parts used
- Engine monitoring
- Engines according to specifications of Wärtsilä Switzerland Ltd.

On the engine sectional drawings 0803–1, those parts are marked with group numbers, as they are found in the Maintenance Manual.

Group numbers exist of the following engine components, although these parts are not marked on the sectional drawings:

Engine Control System WECS

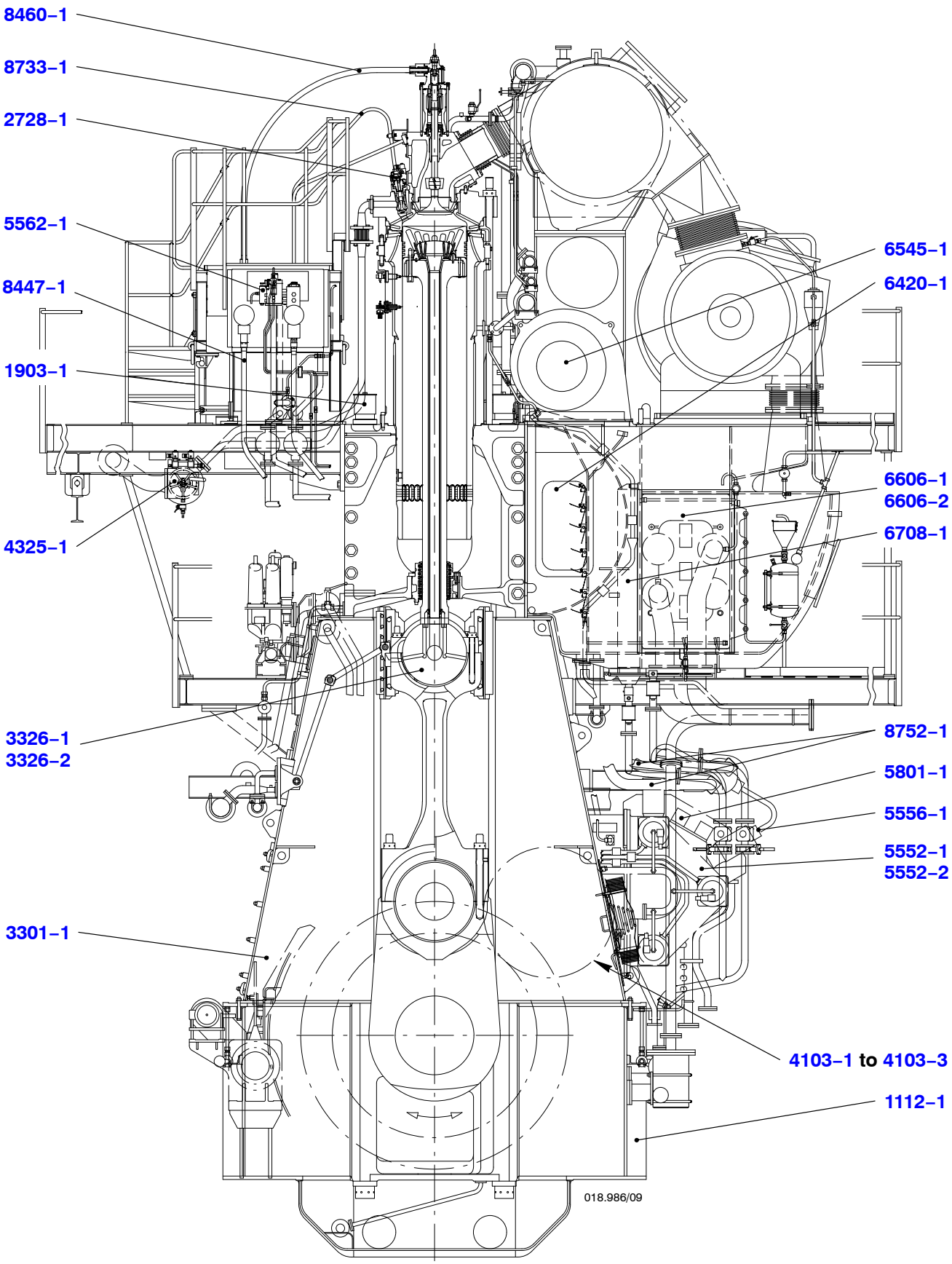
Control works in the WECS (**W**ärtsilä **E**ngine **C**ontrol **S**ystem) are described in the following groups of the Operating Manual:

- Regular checks and recommendations 4002–4
- Engine control 4003–1

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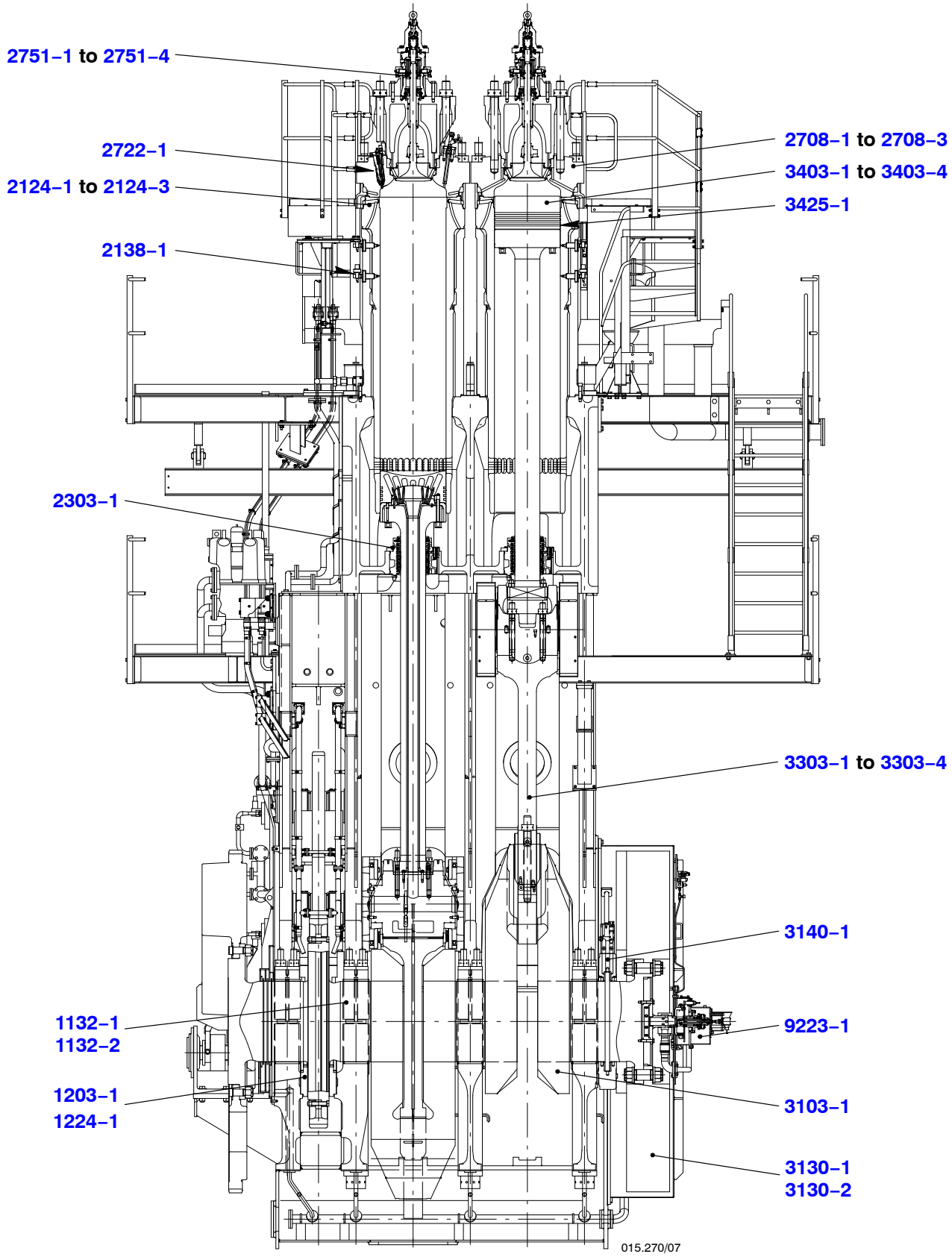
Engine Cross Section and Longitudinal Section

Cross Section:



Engine Cross Section and Longitudinal Section

Longitudinal Section:



Bedplate and Tie Rod Group 1

Bedplate and Thrust Bearing: Checking the Foundation Bolts 1112–1/A1

▽ **Main Bearing**

- Loosening and Tensioning of Elastic Studs 1132–1/A1
- Removal and Fitting of a Main Bearing 1132–2/A1

▽ **Thrust Bearing**

- Checking the Axial Clearance 1203–1/A1
- Removal and Fitting the Thrust Bearing Pads 1224–1/A1

Engine Stays with Friction Shims: Checking the Pre-tension 1715–1/A1

Hydraulic Engine Stays: Checking the Oil Pressure 1715–1/A2

Tie Rod: Checking the Pre-tension and Tensioning the Tie Rods with M80x6 Thread Diameter 1903–1/A2

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Bedplate and Thrust Bearing

Checking the Foundation Bolts

Tools:

1	Feeler gauge	94122
1	Pre-tensioning jack	94145
1	HP oil pump	94931
1	Hydr. distributor	94932
1	Hydr. distributor	94934A
1	Plug piece	94934E
1	HP hose	94935
1	HP hose	94935A

Key to Illustrations:

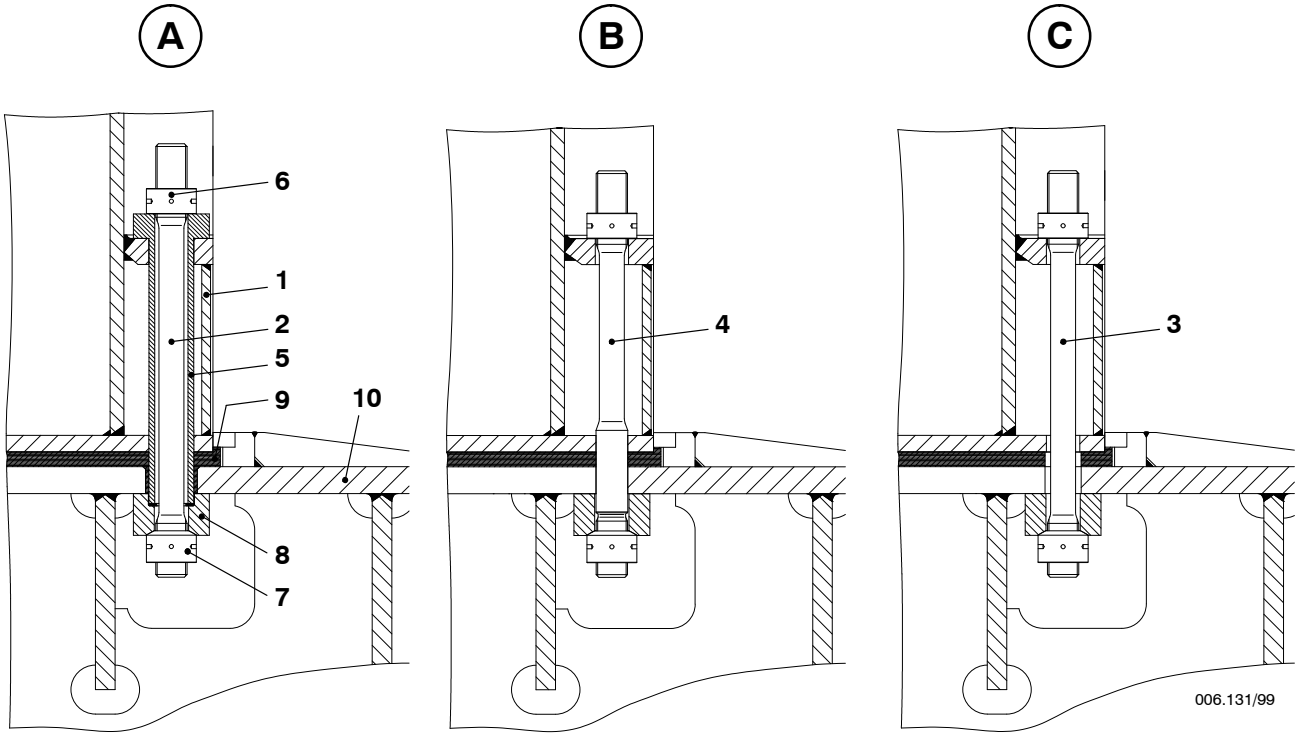
1	Bedplate	11	Control pin
2	Foundation bolt	12	Vent screw
3	Foundation bolt	13	Cylinder
4	Foundation fitted stud	14	Piston
5	Sleeve		
6	Nut		
7	Nut	EV	Relief valve
8	Conical socket	KO	Slot
9	Chock	RS	Round bar
10	Ship's foundation plate	SA	Gap

1. General

The pre-tension of the foundation bolts (holding down studs) must be checked at longer intervals e.g. during overhauls (see 0380–1).

In the area of the thrust bearing the foundation may be fastened with foundation bolts 2 and sleeves 5 (Fig. 'A') or with foundation fitted studs 4 (Fig. 'B').
The remaining area is fastened with foundation bolts 3, however without sleeves 5 (Fig. 'C').

Remark: Pay attention to the General Application Instructions 9403–4 for the hydraulic pre-tensioning jacks.



Checking the Foundation Bolts

2. Checking of the pre-tension

⇒ Clean the threads of the foundation bolts and the seating surfaces. Subsequently apply MOLYKOTE G paste to the threads.

⇒ Place pre-tensioning jack 94145 on the foundation bolt to be checked. Screw it completely down with vent screw 12 open until there is only little or no clearance at 'x'.

⇒ Connect pre-tensioning jack with HP oil pump 94931. Fit plug piece 94934E on one side of Hydr. distributor 94934A.

⇒ Close relief valve 'EV' and actuate the HP oil pump until oil flows bubble-free at the vent screw.

⇒ Close the vent screw. Tension the foundation bolt with **1000 bar** and keep pressure constant.

STOP

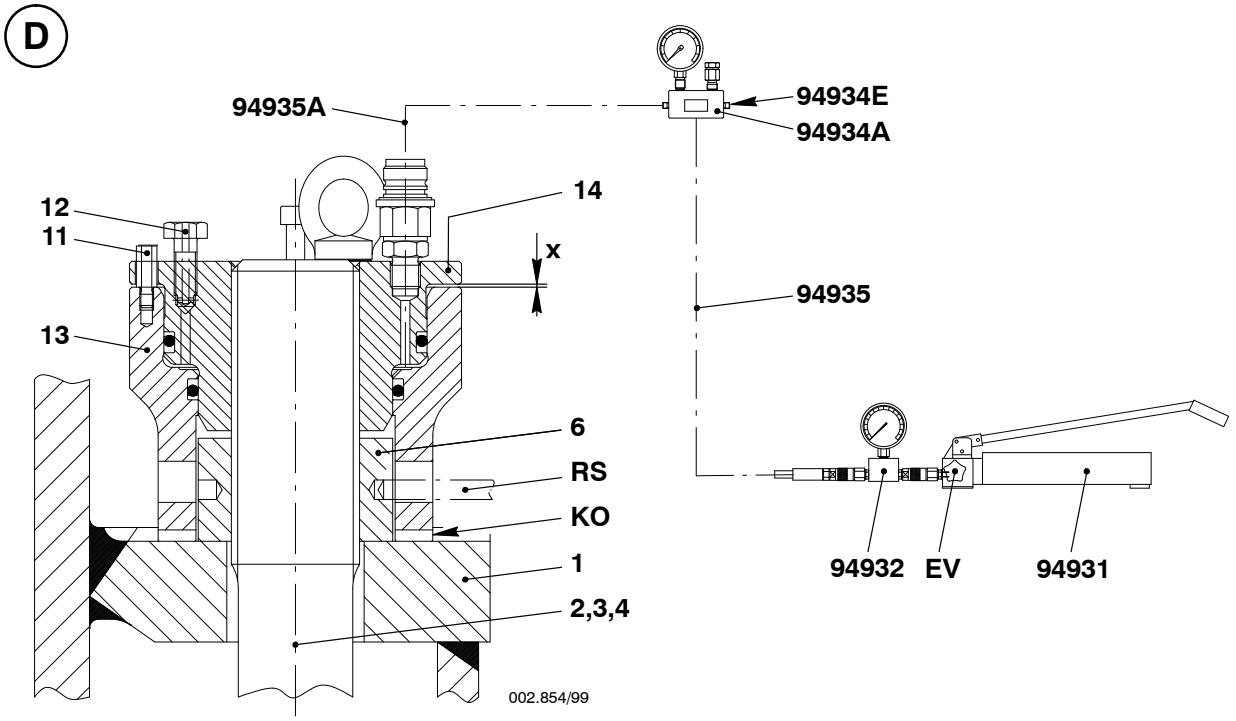
Control pin 11 must always protrude over the top edge of piston 14. When the control pin is flush with the top edge of the piston, the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

CHECK

Check with feeler gauge through slot 'KO' if there is any clearance between nut 6 and its seating.

⇒ If there is no clearance, this means that the tightening condition of the foundation bolt has remained unchanged since the last check. The pressure can be released to zero with relief valve 'EV' and the pre-tensioning jack removed. Should a clearance be found, nut 6 must be tightened down onto its seating with round bar 'RS' while the pressure is kept at **1000 bar** (check with feeler gauge). Subsequently lower the pressure to zero.

Remark: If the foundation bolts have completely loosened and have to be tensioned again, then all foundation bolts have to be pre-tensioned first with **600 bar (1st step)**. Subsequently all foundation bolts are to be tensioned with **1000 bar (2nd step)**.



Checking the Foundation Bolts

3. Loosening of the foundation bolts

⇒ First screw down pre-tensioning jack 94145 as for checking the pre-tension, then turn back by ½ turn (gap 'SA').

⇒ Connect the pre-tensioning jack with HP oil pump 94931. Fit plug piece 94934E on one side of Hydr. distributor 94934A.

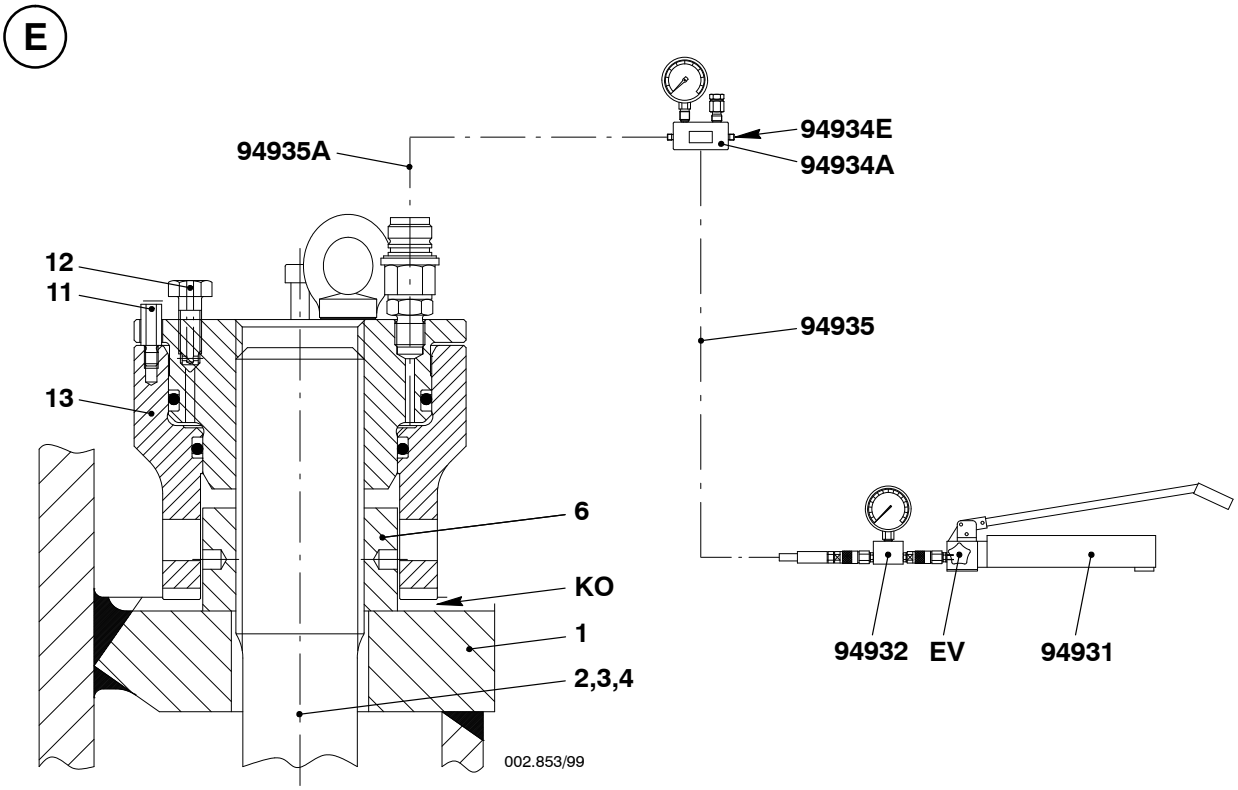
⇒ Close relief valve 'EV' and actuate HP oil pump until oil flows bubble-free at vent screw 12.

⇒ Close vent screw and pump until a pressure of **1020 bar** has been reached.

STOP

Control pin 11 must always protrude over the top edge of piston 14. When the control pin is flush with the top edge of the piston, the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

⇒ Turn back nut 6 by one turn, and release the pressure to zero.
Remove the pre-tensioning jack.



4. Tensioning of the foundation bolts

- Tensioning of the foundation bolts must be carried out in two steps. Tension all foundation bolts first with **600 bar** (1st step), then finish tension them with **1000 bar** (2nd step).
- Tensioning must be carried out as described above, in 'Checking of the pre-tension'.

STOP

Control pin 11 must always protrude over the top edge of piston 14. When the control pin is flush with the top edge of the piston, the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

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Main Bearing

Loosening and Tensioning of Elastic Studs

Tools:

2	Double pre-tensioning jacks	94114
1	Assembly tool	94114A
1	Feeler gauge	94122
1	Special feeler gauge	94123
1	Hydr. distributor	94932
1	Connection block	94934
3	HP hoses	94935
1	Hydraulic unit	94942

Key to Illustrations:

1	Elastic stud
2	Main bearing cover
3	Nut
4	Nut
5	Piston
6	Cylinder
7	Cover
8	Main bearing girder
9	Suspension hole
KO	Slot
RS	Round bar

1. General

The double pre-tensioning jacks 94114 must always be used for loosening and for tensioning of elastic studs 1 for the main bearing.

STOP ***Attention!*** Thereby device 94111 for removal and fitting of main bearing cover 2 must not be installed (see 1132–2).

Prior to screwing the nuts onto the elastic studs, threads and the nut seating surfaces must be clean. Apply oil to the threads. Pay attention to the free movement of the nuts.

Remark: Pay attention to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

2. Loosening the elastic studs

⇒ Hook assembly tool 94114A into suspension holes 9 of double pre-tensioning jacks 94114 and place the latter onto elastic studs 1 for the main bearing (Fig. 'C').

⇒ Connect both double pre-tensioning jacks by HP hoses 94935, connection block 94934 and hydraulic distributor 94932 with hydraulic unit 94942 (arrangement see Fig. 'C').

⇒ Screw on nuts 4 of the double pre-tensioning jacks until pistons 5 fully seat on cylinders 6 (Fig. 'B').

CHECK The pistons are fully down on the cylinders when distance 'L' is about 23 mm, measured from the top of the piston to the upper edge of cover 7.
Check the oil level in hydraulic unit 94942.

⇒ Subsequently loosen all nuts 4 by about ¾ to one turn.

⇒ Raise the pressure to **1500 bar** (max. 1600 bar) at the hydraulic unit.

⇒ Unscrew nuts 3 by one turn with round bar 'RS'.

⇒ Release pressure to zero at the hydraulic unit and then remove both double pre-tensioning jacks.

3. Tensioning the elastic studs

After fitting the main bearing cover as described in 1132–2, elastic studs 1 are to be tensioned as follows:

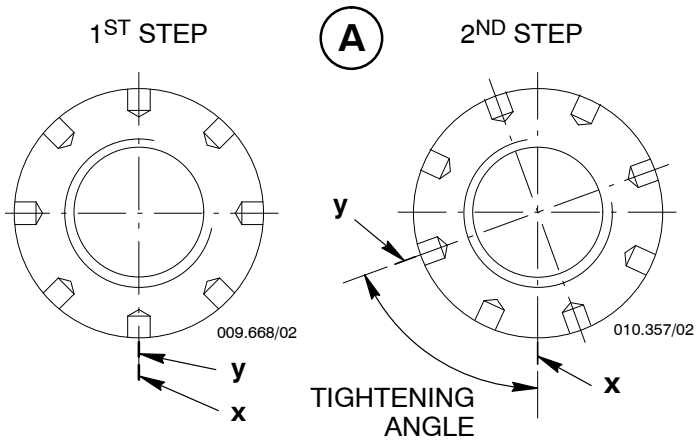
⇒ Place both double pre-tensioning jacks 94114 onto elastic studs 1 for the main bearing (Fig. 'C').

⇒ Connect both double pre-tensioning jacks by HP hoses 94935, connection block 94934 and hydraulic distributor 94932 with hydraulic unit 94942 (arrangement see Fig. 'C').

⇒ Screw on nuts 4 of the double pre-tensioning jacks till piston 5 fully seat on cylinders 6 (Fig. 'B').

CHECK

The pistons are fully down on the cylinders when distance 'L' is about 23 mm, measured from the top of the piston to the upper edge of cover 7.
Check the oil level in hydraulic unit 94942.



⇒ Actuate the hydraulic unit, adjust the pressure to **1500 bar** and keep it constant.

⇒ Mark the position of nuts 3 against bearing cover = **1st step** (Fig. 'A').

⇒ Tighten all nuts 3 with round bar 'RS' until firmly seated.

CHECK

Using feeler gauge 94122 inserted in slot 'KO', check if there is no clearance at hand between the nuts and the seating surfaces **(2nd step)**.
No clearance must also be at hand between main bearing girder 8 and main bearing cover 2 (Fig. 'C')!

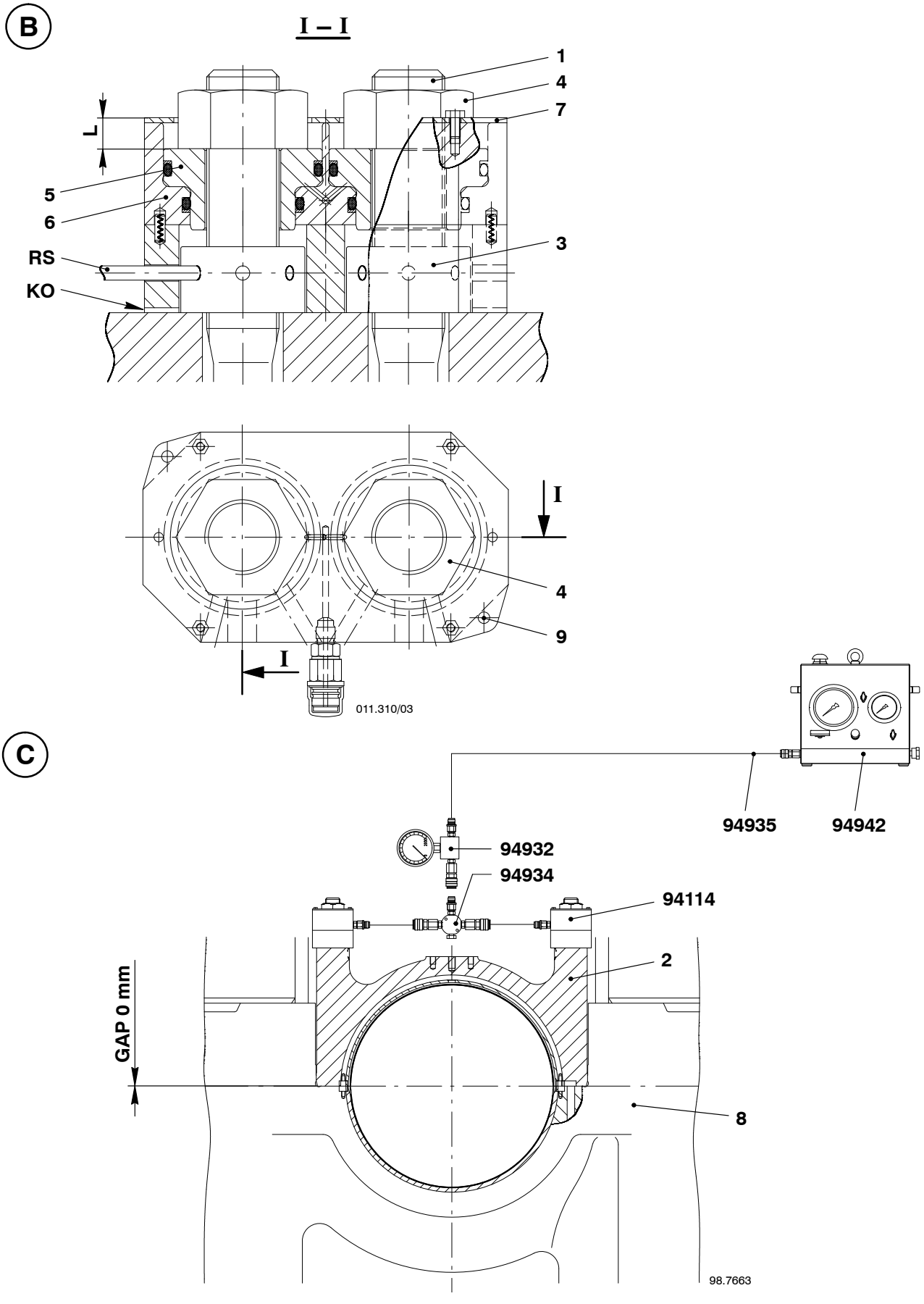
⇒ Release pressure to zero at the hydraulic unit and then remove both double pre-tensioning jacks.

CHECK

Check if **all the nuts** have been turned by about **the same value.**
Finally check the horizontal and vertical clearance by means of special feeler gauge 94123 (see Clearance Table 0330–1 'Crankshaft and main bearing').

Remark: All main bearing clearance values are valid only with tightened tie rods and elastic studs.

Main Bearing: Loosening and Tensioning of Elastic Studs



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Main Bearing

Removal and Fitting of a Main Bearing

Tools:

4	Manual ratchets WLL ≥ 800 kg	94016 (H1…H4)
1	Eye bolt	94045–M16 (RC)
1	Lifting device	94111
1	Guide	94115
1	Lifting tool	94116
1	Roller support	94117
1	Deviation pipe	GF 94117A
1	Turning-out device (girder width 210 mm)	94118
1	Turning-out device (girder width 230 mm)	94118A
1	Lifting yoke	94119
1	Eyelet	94120
1	Rope with shackle (500 mm)	94120B
1	Ropes with shackle (800 mm)	94120C
1	Rope with shackle (1350 mm)	94120E
1	Rope with shackle (1500 mm)	94120F
1	Rope with shackle (1600 mm)	94120G
1	Allen wrench	94128
1	Hexagon screwdriver	94129
1	Cleaning tool	94130
1	Support	94141
2	Ground plates	94141A
2	Working platforms	94142
1	HP oil pump	94931
1	Hydr. distributor	94932
1	Hydr. distributor	94934A
1	HP hose	94935
2	HP hoses	94935A
2	Hydraulic jacks	94936
1	Hydraulic ram	94950

Key to Illustrations:

1	Crankshaft
2	Main bearing cover*
3	Lower main bearing shell**
4	Elastic stud
5	Lifting screw
6	Bearing girder
7	Oil bore
8	Flywheel
9	Locating dowel pin
10	Upper main bearing shell**
11	Allen screw
12	Allen screw
13	Dial gauge with magnetic base
PR	Protection
WU	Wooden underlay
*	(hereafter called bearing cover,
**	bearing shell)

Overview

1. **General** 1/14
2. **Placing of device 94111** 2/14
3. **Removal of main bearing cover** 3/14
4. **Turning out and removal of lower main bearing shell** 6/14
5. **Inspecting main bearing shells** 12/14
6. **Fitting of lower main bearing shell** 12/14
7. **Fitting of main bearing cover** 14/14

1. General

The removing and fitting procedures for bearing covers 2 as well as for bearing shells 3 and 10 are the same for all main bearings with the exception of main bearing No. 1 at the driving end.

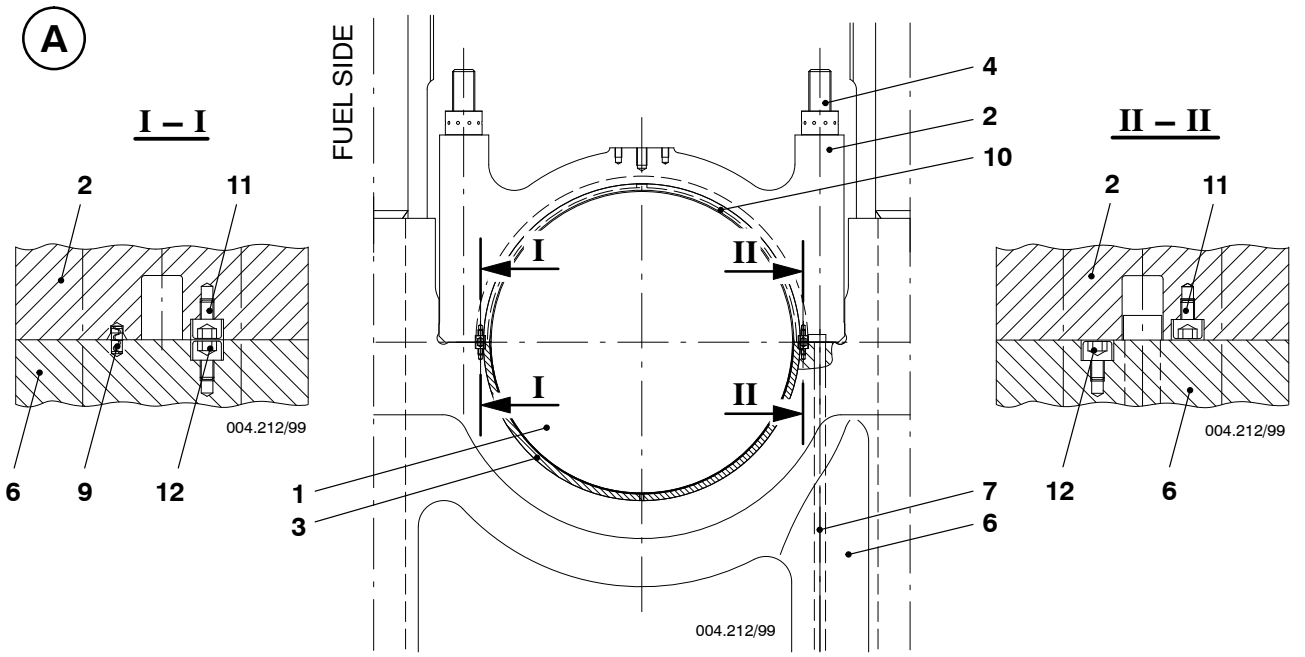
The loosening and tensioning of elastic studs 4 are described in 1132–1.

Always use working platform 94142 when working in the crankcase on the main bearings! See Utilization of the Working Platform 3301–1.



Attention! Never turn the crankshaft while the working platforms or any other tools are in position!

Removal and Fitting of a Main Bearing



2. Placing of device 94111

Attention! Device 94111 must only be fastened onto the bearing cover with elastic studs 4 loosened and their nuts removed!

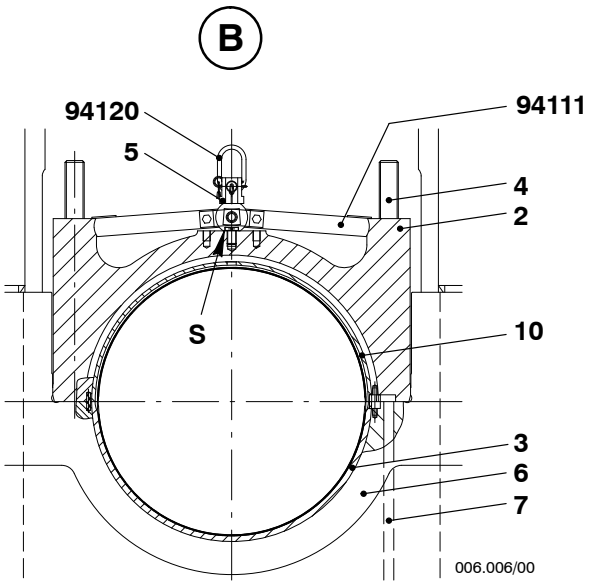
Device 94111 must always be used for removal and fitting of the bearing covers; and handled carefully and not be changed as its arm lengths correspond to a specified dimension.

Eyelet 94120 must be used for the removal and fitting of the bearing cover No. 1.

⇒ Fit device 94111 onto bearing cover 2 as shown below.

⇒ Screw down lifting screw 5 fully onto the bearing cover.

CHECK There must be no clearance 'S' between bearing cover and lifting screw.



Removal and Fitting of a Main Bearing

3. Removal of main bearing cover

3.1 Removal of bearing cover No. 1

⇒ Turn crank of Cyl. No.1 to exhaust side approx. 85° after T.D.C..

⇒ Remove upper part of oil baffle and upper casing at the driving end.

⇒ Protect slinger rings on the crankshaft.

⇒ Loosen nuts for elastic studs hydraulically (see 1132–1).

⇒ Place device 94111 with eyelet 94120 as described in section 2.

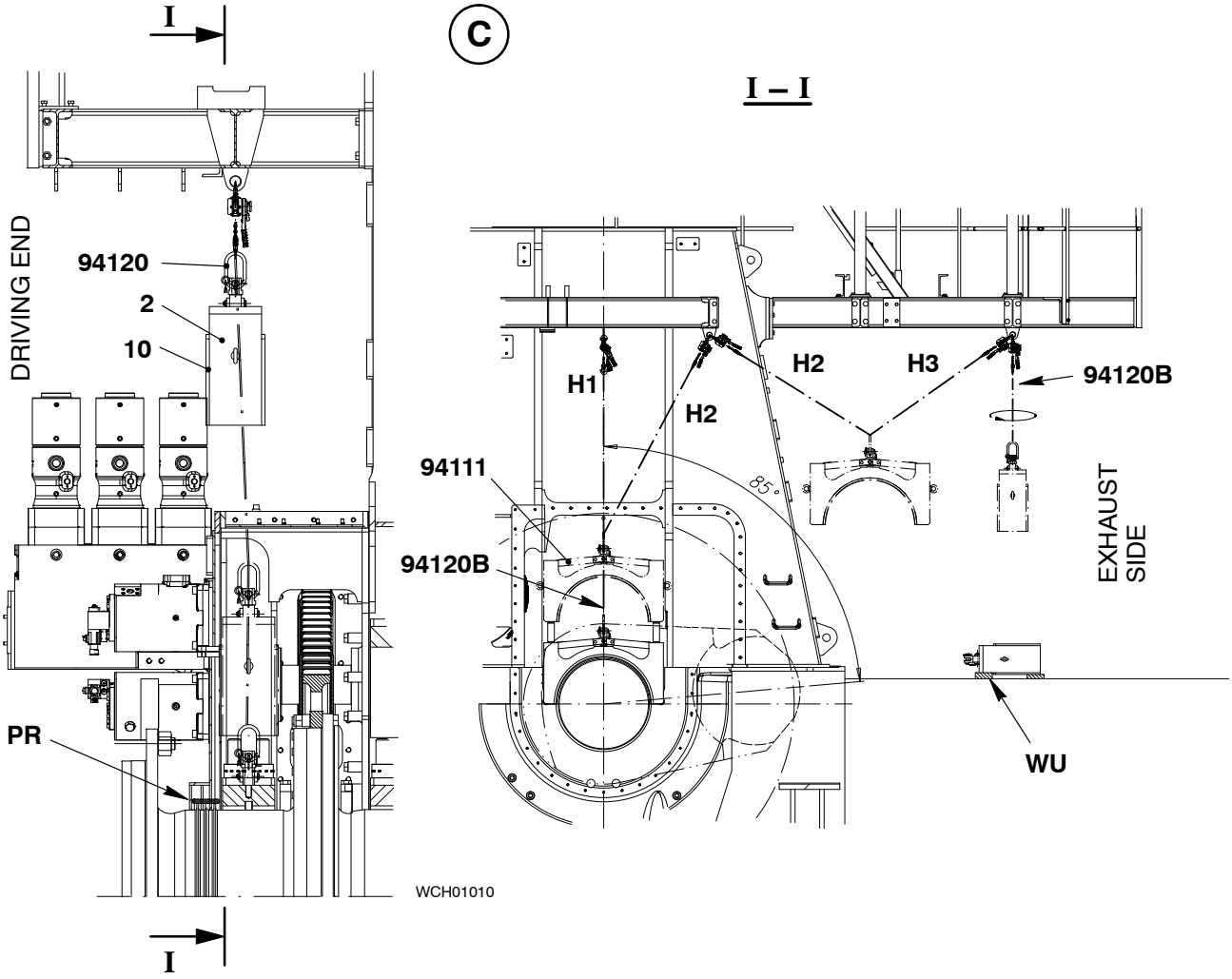
⇒ Lift bearing cover over the elastic bolts using rope 94120B and manual ratchet 'H1'.

Remark: Oil bore 7 in bearing girder 6 must be closed off immediately after lifting the bearing cover, to prevent any dirt from entering (Fig. 'A').

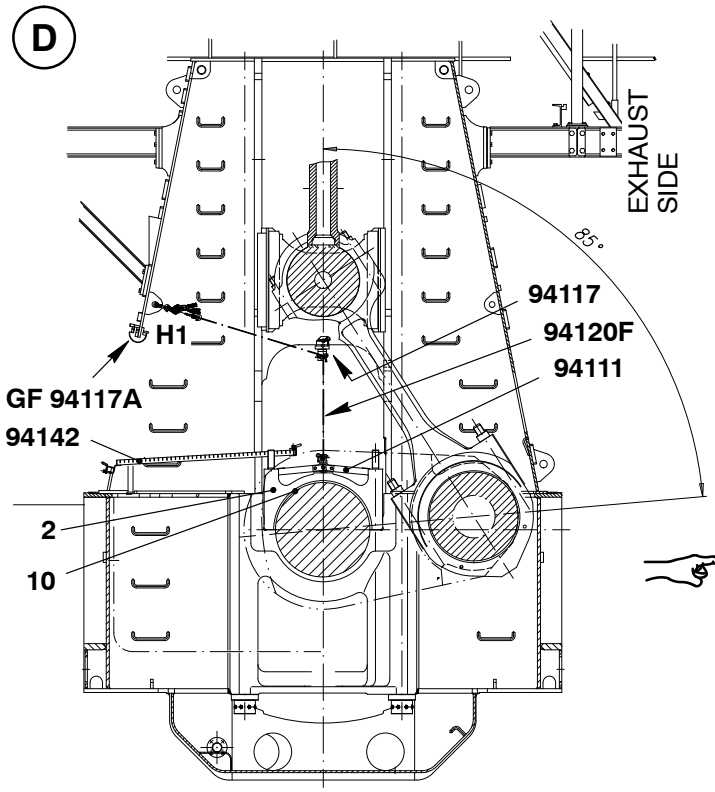
⇒ Remove the bearing cover from the column.

⇒ Connect ratchets 'H3' with rope 94120B and 'H2' and lift the bearing cover out of the flywheel area.

⇒ Carefully put the bearing cover in horizontal position on wooden underlay 'WU'. Make sure the protruding bearing shell 10 does not get damaged.



3.2 Removal of bearing cover No. 2 and following



⇒ Turn corresponding crank to exhaust side approx. 85° after T.D.C.

⇒ Install working platform 94142 (see 3301–1).

⇒ Remove nuts for elastic studs (see 1132–1).

⇒ Place lifting device 94111 (without eyelet 94120) as described in section 2.

⇒ Attach deviation pipe GF 94117A and install roller support 94117 on the column (Fig. 'D').

⇒ To protect upper bearing shell 10, provide protection at the side of adjacent crank webs.

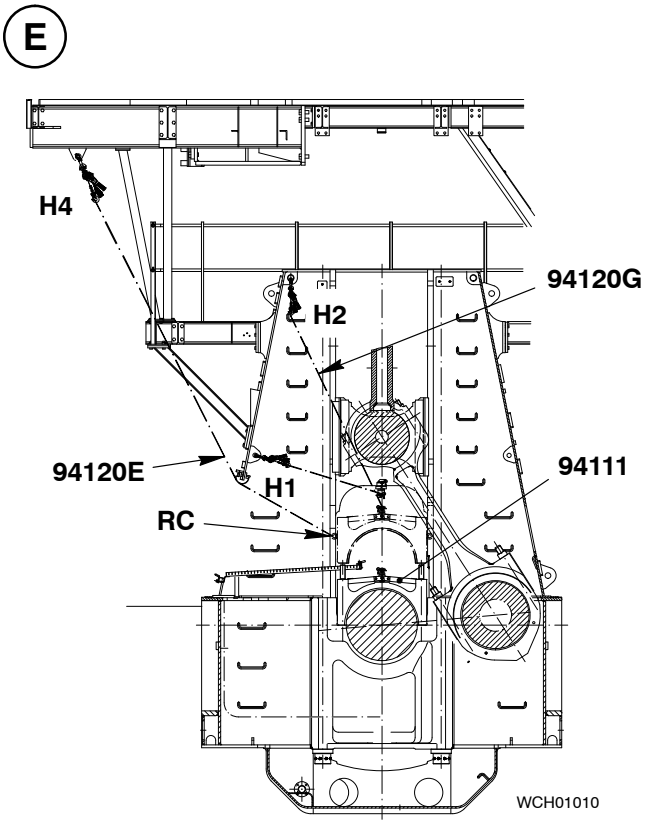
⇒ Attach manual ratchet 'H1'with rope 94120F to the column wall and lift the bearing cover 2 via roller support 94117 over the elastic studs.

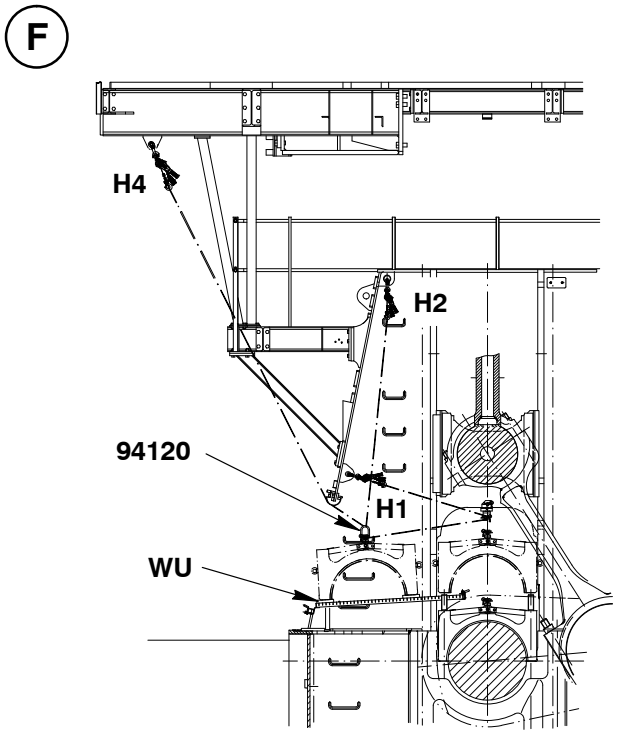
Remark! Oil bore 7 in bearing girder 6 must be closed off immediately after lifting the bearing cover, to prevent any dirt from entering (Fig. 'A').

⇒ Screw eye bolt 'RC' into the bearing cover and connect it with rope 94120E to manual ratchet 'H4' (Fig. 'E').

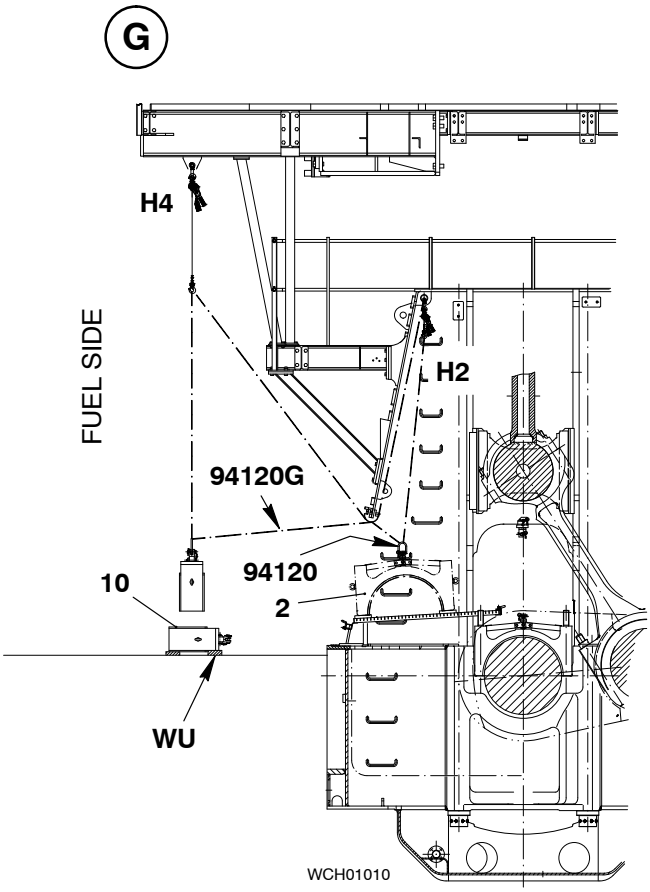
⇒ Attach manual ratchet 'H2' with rope 94120G to lifting device 94111.

⇒ Lift bearing cover by means of manual ratchets 'H1' and 'H2' over the crank web (Fig. 'E') and place it with manual ratchet 'H4' on working platform with a wooden underlay 'WU' (Fig. 'F').





Removal and Fitting of a Main Bearing



⇒ Remove manual ratchet ’H1’.

⇒ Install eyelet 94120 to lifting device 94111.

⇒ Lift bearing cover 2 out of crankcase by means of manual ratchet ’H2’ with rope 94120G and manual ratchet ’H4’.

⇒ Carefully put the bearing cover in horizontal position on wooden underlay ’WU’. Make sure the protruding bearing shell does not get damaged.

4. Turning out and removal of lower main bearing shell

Attention! **Never** remove two neighbouring bearing shells at the same time!

The removing procedure for a lower bearing shell 3 (Fig. 'A') is the same for all main bearings with the exception of main bearing No. 1 at the driving end.

- For the removal of bearing shells No. 1 and 2 the flywheel must additionally be pressed up with hydraulic ram 94950. To protect the flywheel toothing, put a copper or aluminium plate between the ram and the flywheel (Fig. 'K').

4.1 Placing of hydraulic jacks

⇒ Turn corresponding crank to exhaust side approx. 90° after T.D.C.

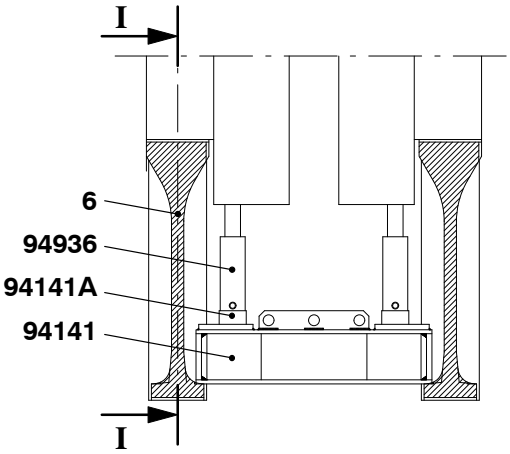
⇒ Put support 94141 on two bearing girders 6 parallel to the engine axis.

⇒ Place hydraulic jacks 94936 on support 94141.

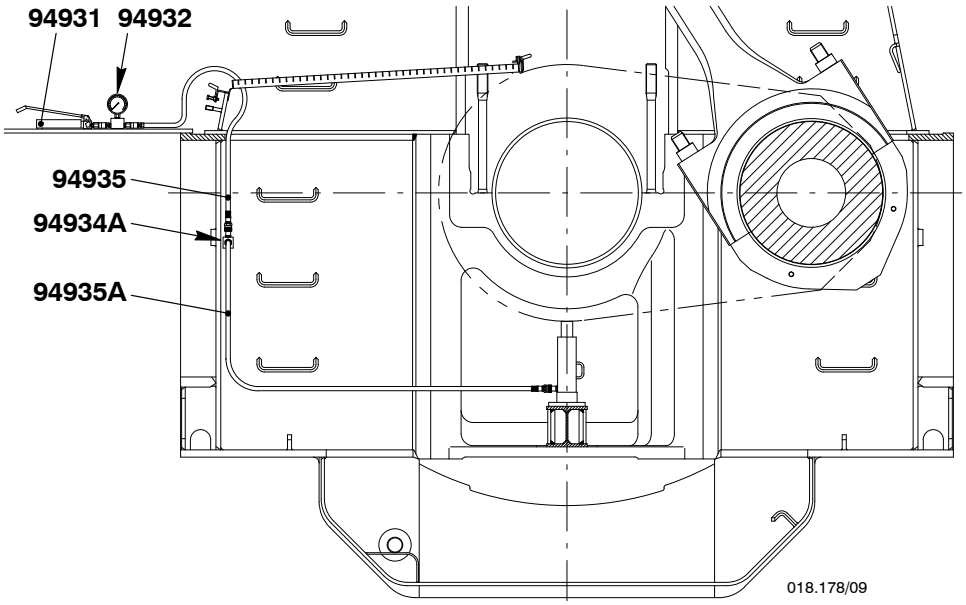
⇒ Connect the hydraulic jacks with HP hoses 94935 and 94935A, as well as hydr. distributor 94934A to HP oil pump 94931.

Remark: Depending on hydraulic jacks 94936, ground plates 94141A must be placed onto support 94141 in order to reach the height necessary to lift the crankshaft.

H



I – I



Removal and Fitting of a Main Bearing

4.2 Lifting the crankshaft

⇒ Measure and note lateral bearing clearances 'y_1' and 'y_2' between crankshaft journal 1 and lower bearing shell 3 at about 50 mm below the bearing division.

⇒ Install dial gauge with magnetic base 13 above the crankshaft near the bearing to be removed and set it to zero.

⇒ Actuate HP oil pump 94931 and lift the crankshaft by means of hydraulic jacks 94936 reaching value 'x' = 0.2 mm (check on dial gauge).

Attention! Lift the crankshaft max. to the point where the neighboring main bearings show no vertical clearance between upper bearing shells and crankshaft.

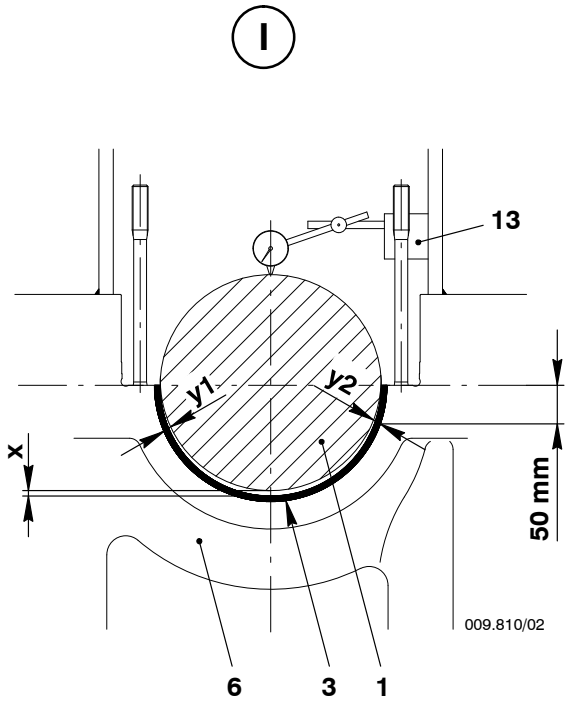
⇒ Keep pressure in the hydraulic jacks constant.

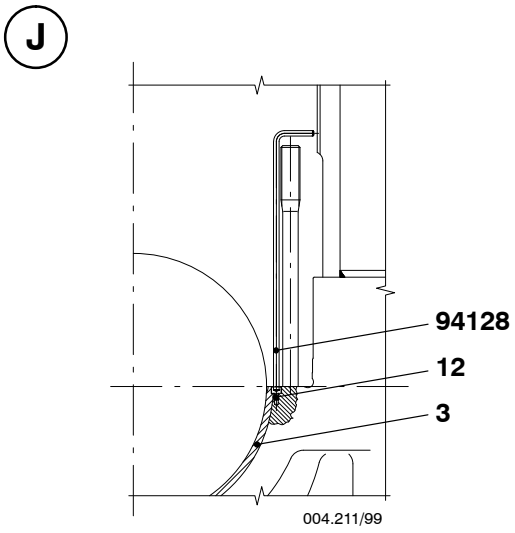
⇒ Measure again lateral bearing clearances 'y_1' and 'y_2', and compare the values with those from the 1st measurement as described above.

- If the lateral clearance has changed by more than 0.1 mm due to lifting of the crankshaft, the latter must be lowered again and the hydraulic jacks be newly placed in direction of the smaller clearance. Subsequently lift the crankshaft again.

4.3 Loosen the Allen screw

⇒ Loosen and remove both Allen screws 12 with Allen wrench 94128.





4.4 Turning out main bearing shell No. 1

- Crankshaft lifted up by approx. 0.2 mm (see paragraphs 5.1 and 5.2).

Remark: Turning-out device 94118 must only be fitted to bearing shell No. 1 instead of turning-out device 94118A, which is provided for all other bearing shells.

⇒ Fasten manual ratchet 'H1' with rope 94120B to gallery support.

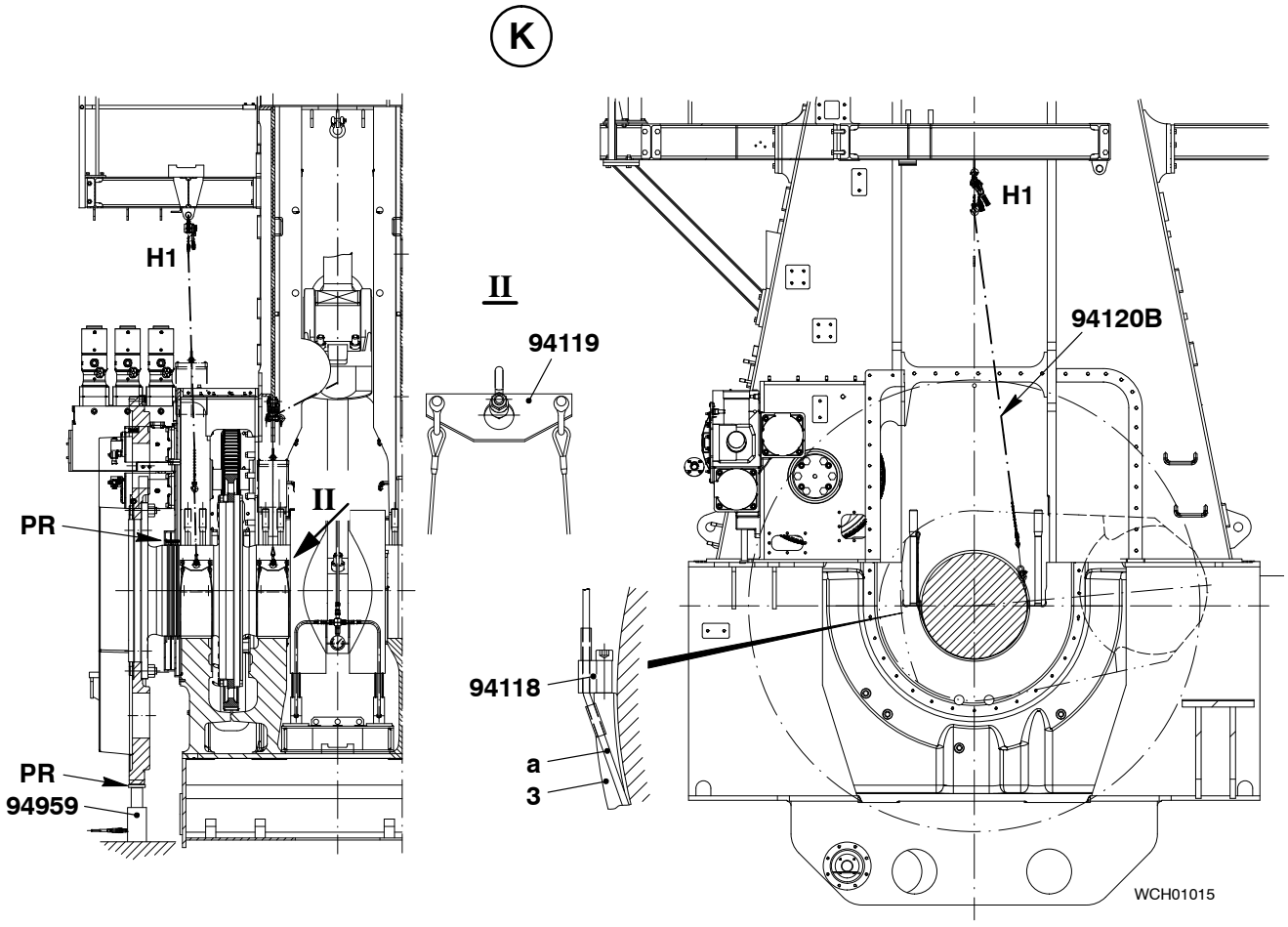
⇒ Fasten turning-out device 94118 to bearing shell 3 using screwdriver 94129, lead ropes 'a' along the lateral edges of the bearing shell 3 to the other side and connect them with lifting yoke 94119.

Remark: By means of a wire attached to the ropes they can be pulled below the bearing journal to the other side.

⇒ Slowly turn out bearing shell using manual ratchet 'H1' from the bearing girder until both ends of the bearing shell are free (no meshing), **check!**

⇒ Remove lifting yoke.

Remark: If a bearing shell jams during turning out, lifting yoke 94119 must be fastened to the two opposite wire ropes of turning-out device 94118. Subsequently draw the bearing shell back to the initial position until the bearing shell is freed.



Removal and Fitting of a Main Bearing

4.5 Removal of main bearing shell No. 1

⇒ Fasten lifting tool 94116 to lower bearing shell 3.

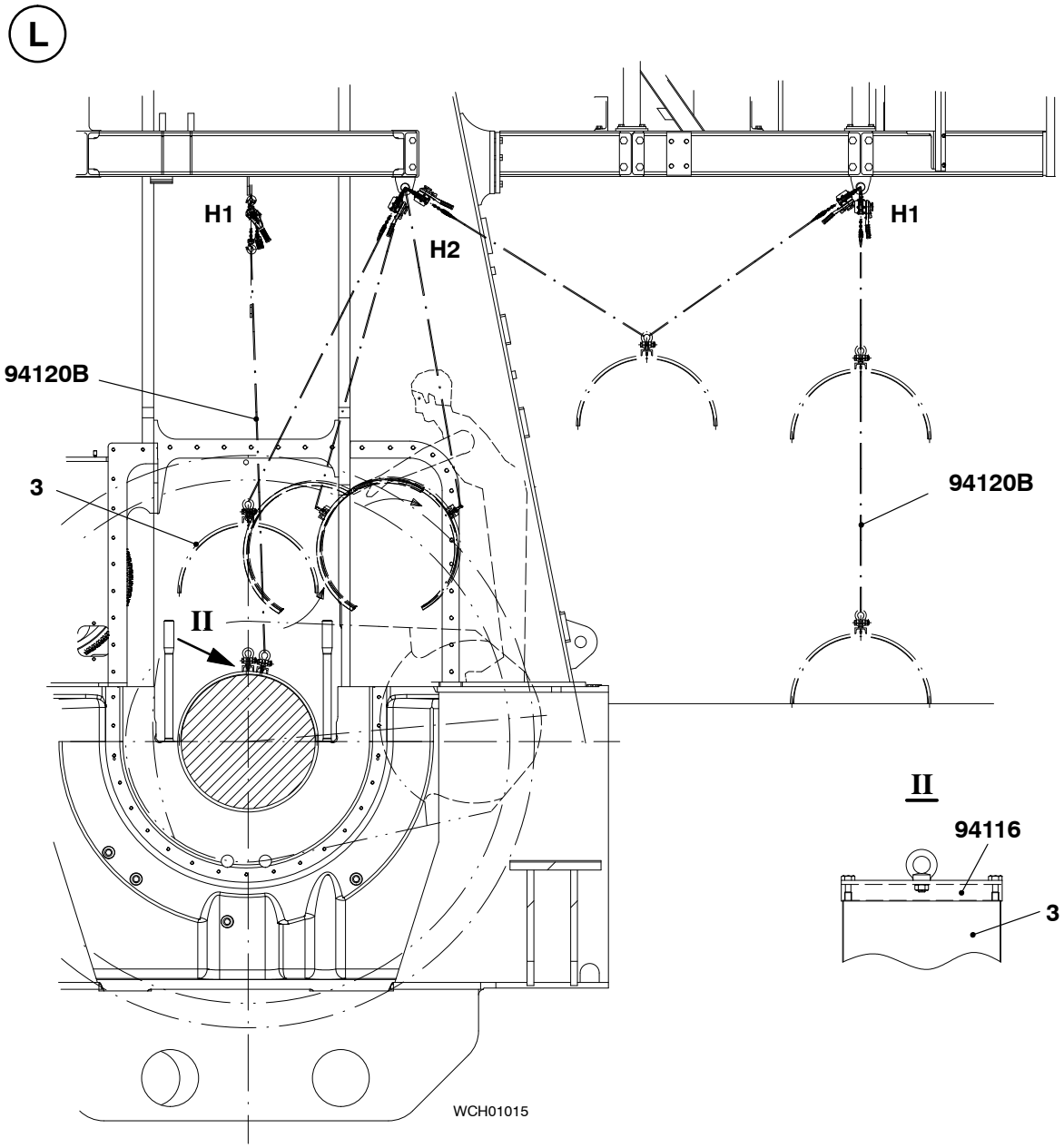
⇒ Connect rope 94120B to manual ratchet ’H1’ and lift bearing shell 3.

⇒ Attach manual ratchet ’H2’ and connect it to lifting device 94116.

⇒ Lift bearing shell 3 as high as possible and move it to exhaust side.

⇒ Disconnect manual ratchet ’H1’ with rope 94120B and reposition it to gallery support.

⇒ Move bearing shell using manual ratchets ’H2’ and ’H1’ out of column and place it carefully on platform.



4.6 Turning out the main bearing shells No. 2 and following

- Crankshaft lifted up by approx. 0.2 mm (see paragraphs 4.1 and 4.2).

⇒ Install roller support 94117 on the column.

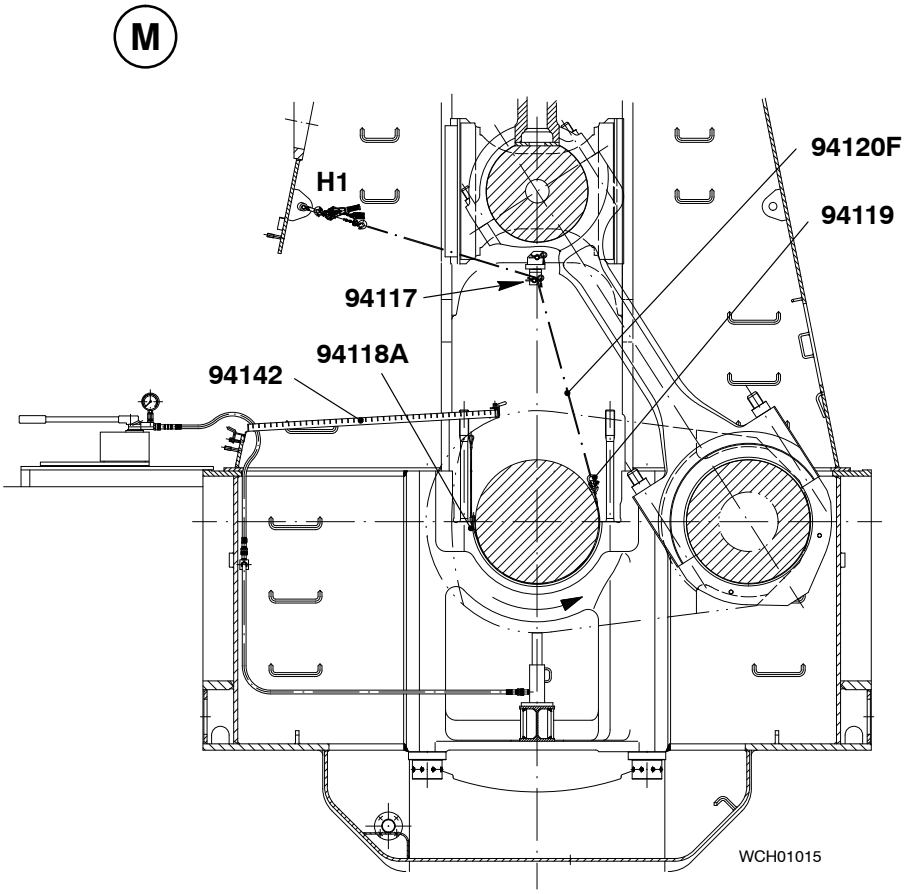
⇒ Attach manual ratchet 'H1' with rope 94120F to lifting yoke 94119 via roller support.

- Turning-out device 94118A and lifting yoke 94119 are mounted in the same way as described in paragraph 4.4.

⇒ With manual ratchet 'H1' pull bearing shell slowly out from the bearing girder until both ends of the bearing shell are free (no meshing), **check!**

⇒ Remove lifting yoke.

Remark: If a bearing shell jams during turning out, lifting yoke 94119 must be fastened to the two opposite wire ropes of turning-out device 94118A. Subsequently draw the bearing shell back to the initial position until the bearing shell is freed.



Removal and Fitting of a Main Bearing

4.7 Removal of main bearing shells No. 2 and following

⇒ Fasten lifting tool 94116 to lower bearing shell 3.

⇒ Attach rope 94120F to lifting tool 94116 and guide it over roller support 94117 to manual ratchet 'H1'.

⇒ Provide protection at the side of adjacent crank webs.

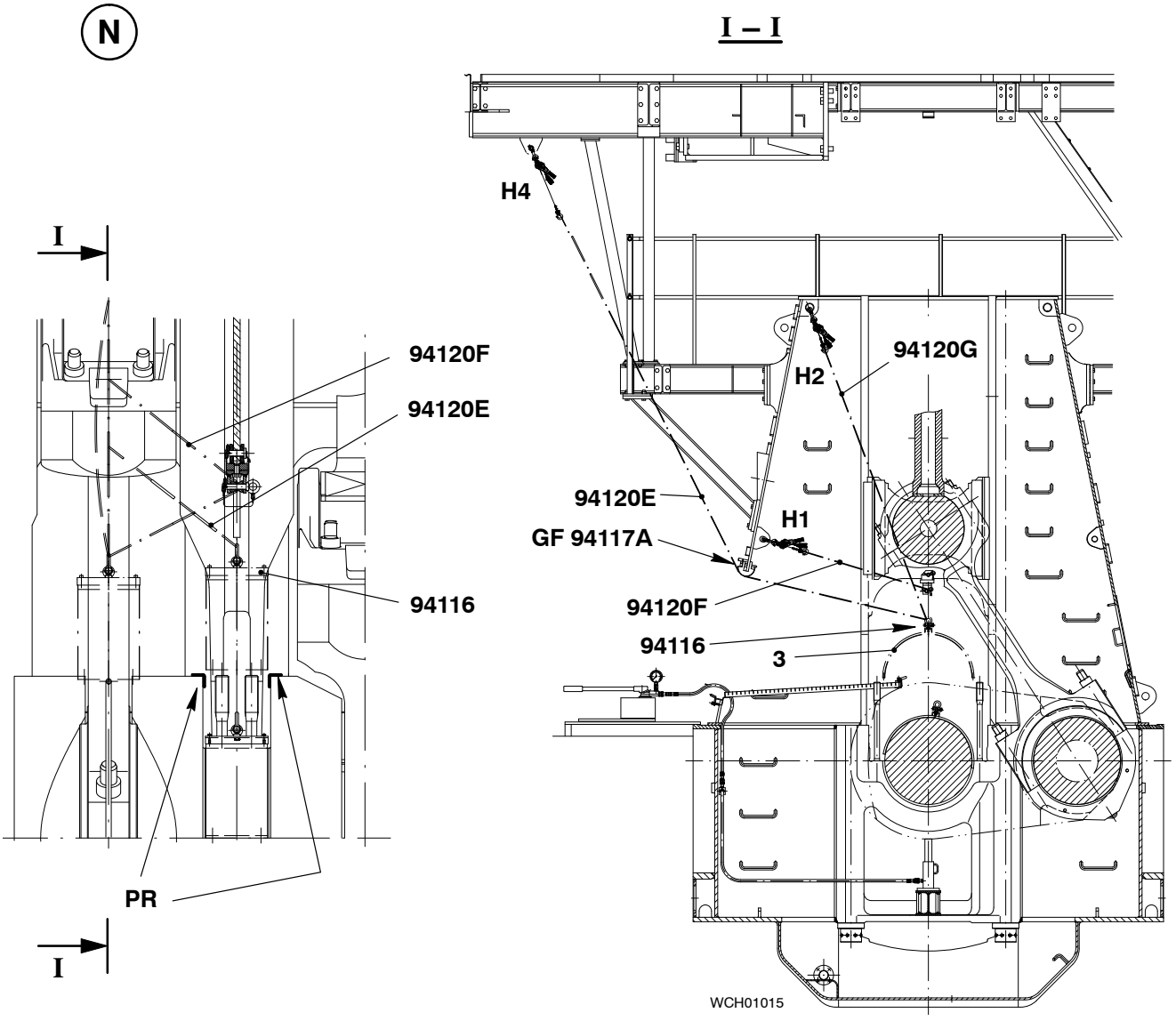
⇒ Lift bearing shell up to roller support 94117.

⇒ Connect rope 94120G to lifting tool 94116 and manual ratchet 'H2'.

⇒ Connect rope 94120E to lifting tool 94116 and manual ratchet 'H4'.

⇒ Take over bearing shell to manual ratchet 'H2' and manual ratchet 'H4' and disconnect manual ratchet 'H1' with rope 94120F.

⇒ Guide bearing shell out of column by means of manual ratchets 'H2' and 'H4' and place it carefully on platform.



5. Inspecting main bearing shells

⇒ Clean the bearing shells with a soft cloth.

⇒ Check the bearing shells for damages such as breakouts or cracks.

⇒ Slight scratches and running marks can be removed by scotch brite.

Attention! Do not scrape the bearing shell in the loaded area.

⇒ If the running marks are more uneven distributed than expected, the crank deflection must be measured.

⇒ If necessary, replace the bearing shells.

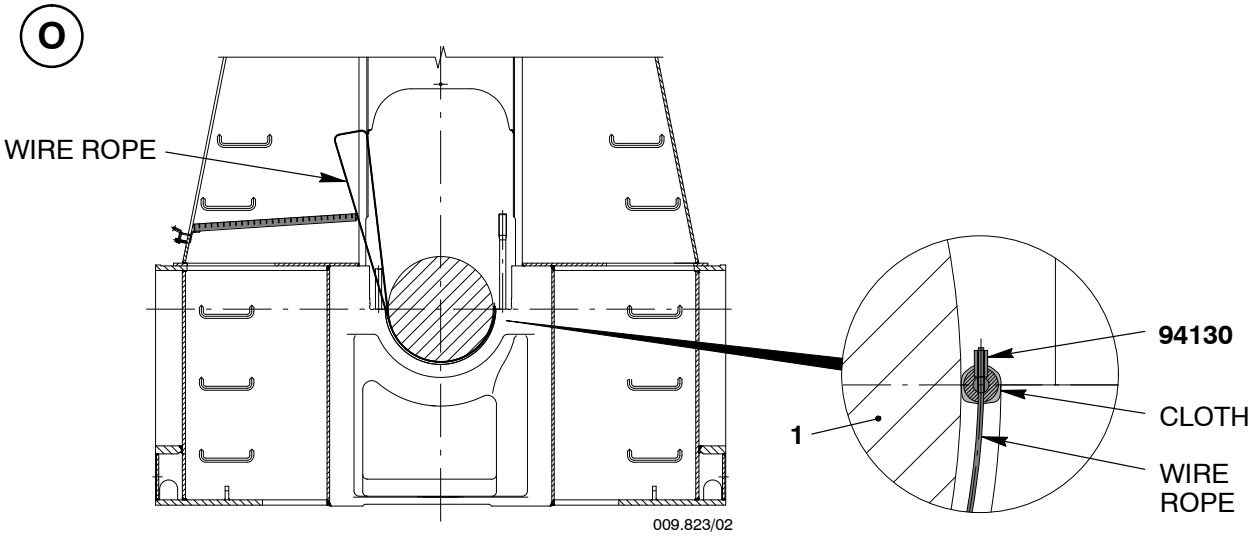
⇒ Inspect the surface of the bearing journal. Scratches must be polished.

6. Fitting of lower main bearing shell

Cleaning of bearing bore:

Use cleaning tool 94130 to clean the bearing bore.

For this purpose the round bar of the cleaning tool is to be wrapped in clean cloths, then stuck between the bearing bore and the bearing journal of crankshaft 1 and, by means of a wire rope, pulled under the bearing journal to the other side. Take care not to damage the running face of the bearing journal with the wire rope!



Conditions before fitting:

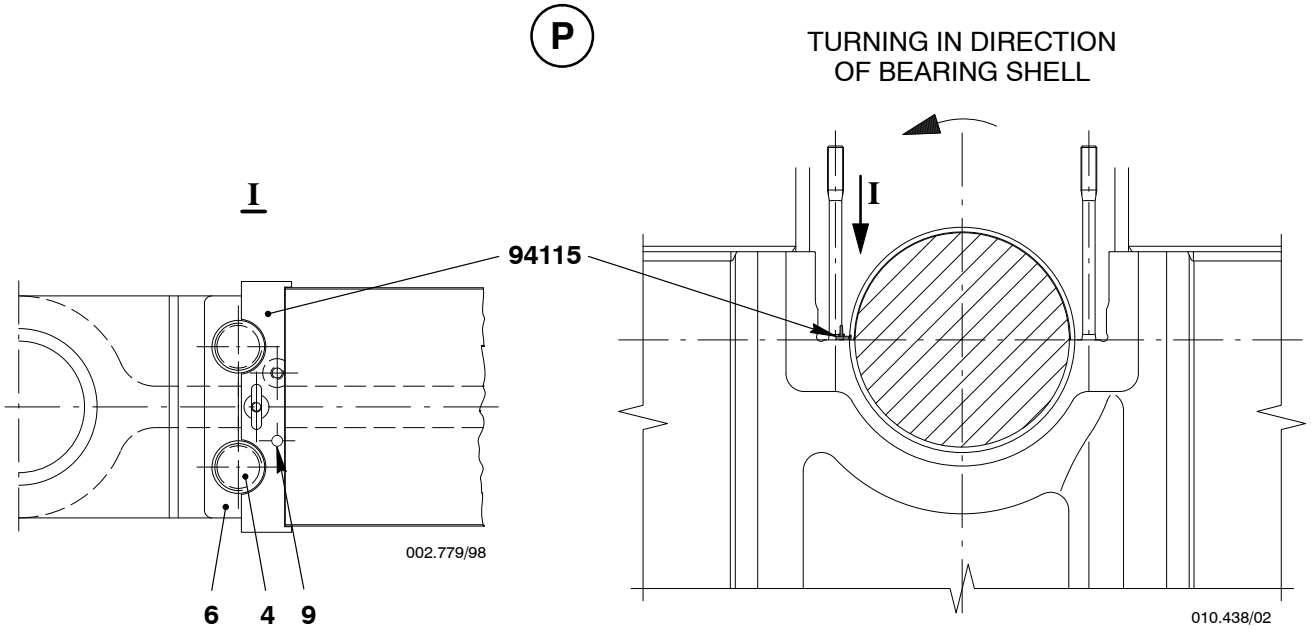
- Bearing shell in perfect condition, undamaged and thoroughly cleaned.
- Oil bore 7 in the bearing girder 6 must be clean and without particles of white metal.
- Thoroughly cleaned bore in bearing girder.
- Allen screw 12 (Fig. 'A') fully driven into bearing girder for fastening the lower bearing shell on exhaust side.
- Crankshaft lifted as described in section 4.

Removal and Fitting of a Main Bearing

6.1 Turning in the main bearing shell

- All bearing shells are marked on their faces with DRIVING END. Therefore , they must be fitted correspondingly.
- Used bearing shells must be fitted into the bearing girders in their original positions.

⇒ Place guide 94115 on bearing girder 6 between elastic studs 4 on fuel side. Thereby locating dowel pin 9 (see also Fig. 'A') must fit into the guide. The lower bearing shell is located in longitudinal direction by means of guide 94115.



⇒ Fasten turning-out device 94118 (94118A) to the front face of lower bearing shell 3. The two recesses in the turning-out device must point towards the bearing shell rear side.

⇒ Thoroughly clean and lavishly oil both main bearing sides.

⇒ The bearing shell may be lifted onto the crankshaft with fitted lifting tool 94116 analogously to the removal but in reverse sequence.

- Be careful that **turning-out device 94118 (9411A) is located on fuel side.**

⇒ Using lifting tool, slightly lift the lower bearing shell off the crankshaft, and push it about 10–20 mm between crankshaft 1 and bearing girder 6 on fuel side.

⇒ While holding the lower bearing shell in position by means of turning-out device 94118 (94118A), lifting tool 94116 can be removed.

⇒ Due to the dead weight, the lower bearing shell slides now slowly into main bearing girder 6 by about 90° whereby the turning-out device must be followed up correspondingly.

STOP ***Attention!*** In order to prevent the risk of jamming under no circumstances let the bearing shell slide uncontrolled into the bearing girder!

⇒ Lead both ropes of turning-out device 94118 (94118A) to the other side, and connect these with lifting yoke 94119 as described for the removal.

⇒ Using corresponding ropes (same arrangement as for the removal), turn the lower bearing shell completely into bearing girder until it seats at Allen screw 12 previously driven in on exhaust side.

⇒ Remove turning-out device 94118 (94118A) and guide 94115.

⇒ Fit and tighten Allen screw 12 (Fig. 'A') to arrest the lower bearing shell on fuel side.

⇒ Release the pressure at HP oil pump 94931 (Fig. 'H') and lower the crankshaft completely.

⇒ Remove immediately all the tools from the crankcase.

CHECK The bearing clearances and the crank deflection must be measured after a new lower bearing shell has been fitted and the bearing cover has been tightened (see 3103–1).

7. Fitting of main bearing covers

Fitting the bearing cover is carried out analogously to the removal but in the reverse sequence, whereby attention must be paid to the following:

- Upper bearing shell 10 (Fig. 'A') is placed in bearing cover 2, and fixed with two Allen screws 11. Pay attention to the cleanliness during fitting!
- The bearing cover must not be interchanged, and always be installed in the same bearing girder.
- Always use device 94111 for fitting a bearing cover, as described in section 2.
- Pay attention to locating dowel pin 9 on fuel side during fitting the bearing cover (Fig. 'A')!
- Remove all plugs from oil bore 7.
- Oil bore 7 in the bearing girder must be clean and without particles of white metal.
- Carefully clean all contact surfaces at bearing cover 2 and bearing girder 6.
- After fitting of bearing cover, elastic studs 4 are to be tensioned as described in 1132–1, and the clearances to be checked according to 0330–1 'Crankshaft and Main Bearing'.

CHECK After assembly, check if lubricating oil is supplied to the main bearing with the oil pump in operation!

Thrust Bearing

Checking the Axial Clearance

Tools:		
1	Inside micrometer	94101
1	Feeler gauge	94238
1	Dial gauge with magnetic base	

Key to Illustrations:

1	Coupling flange	7	Thrust bearing pads for ASTERN
2	Oil baffle, upper part	7a	Thrust bearing pads for AHEAD
3	Oil baffle, lower part	8	Cover
4, 4a	Holder		
5	Thrust flange		
6	Crankshaft		

1. Measuring method 1

The total displacement which results from pushing the crankshaft axially both ways until it contacts the thrust bearing pads AHEAD and ASTERN, is measured with a dial gauge. This is then checked against the figure marked on the sheet 'Check Dimensions' in the engine documents supplied (see also Clearance Table 0330–1 'Crankshaft and main bearing').
An increase compared with the nominal figure signifies wear of the thrust bearing pads.

2. Measuring method 2

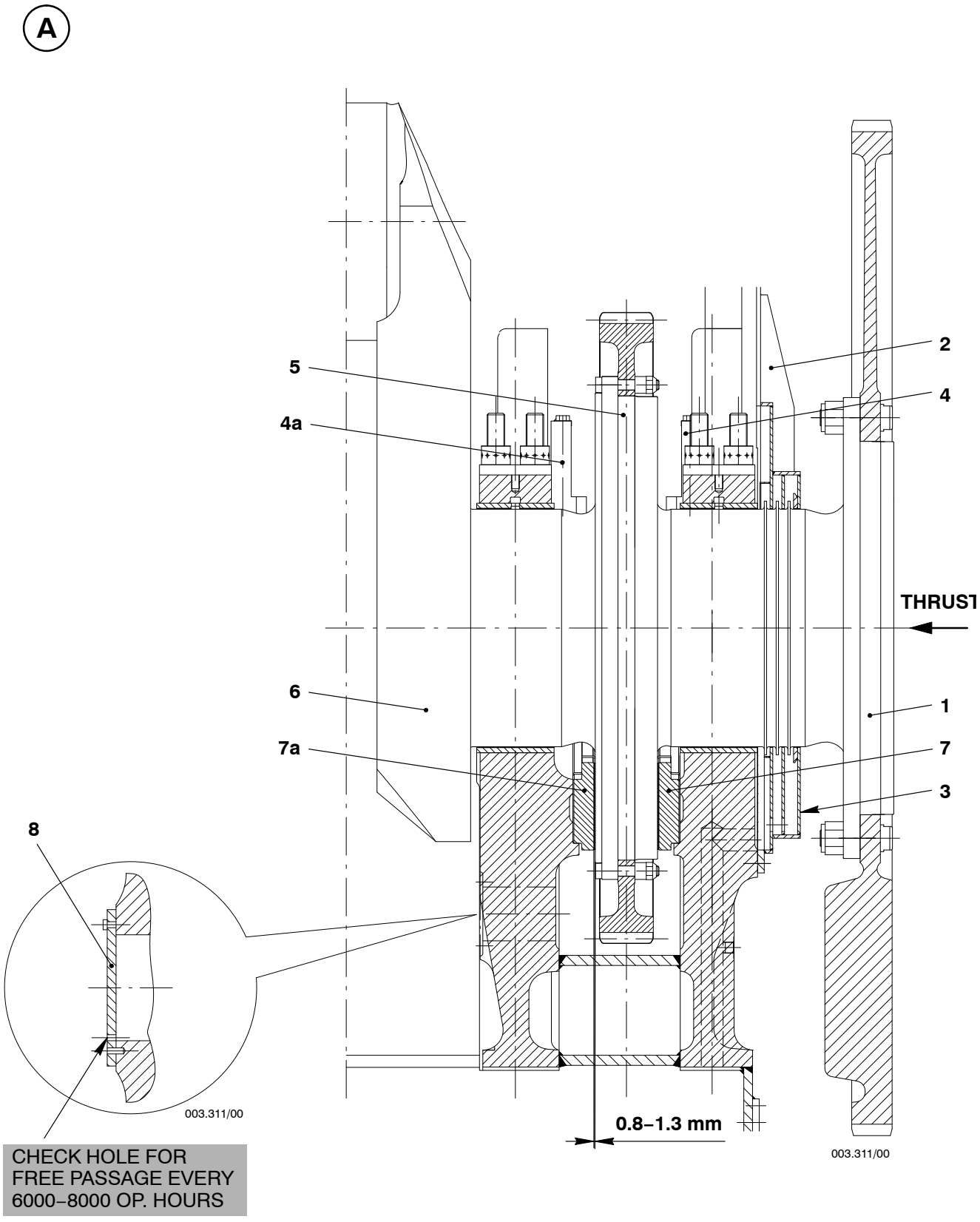
⇒ Displace the crankshaft axially until it rests on the engine side thrust bearing pads (AHEAD) and then fix it in this position.

⇒ Measure the distance between the coupling flange and the upper part of the oil baffle with inside micrometer 94101 at the position indicated (see Fig. 'B'). The amount by which distance 'X' is smaller than that given on the sheet 'Check Dimensions' corresponds to the wear of the engine side thrust bearing pads (AHEAD).

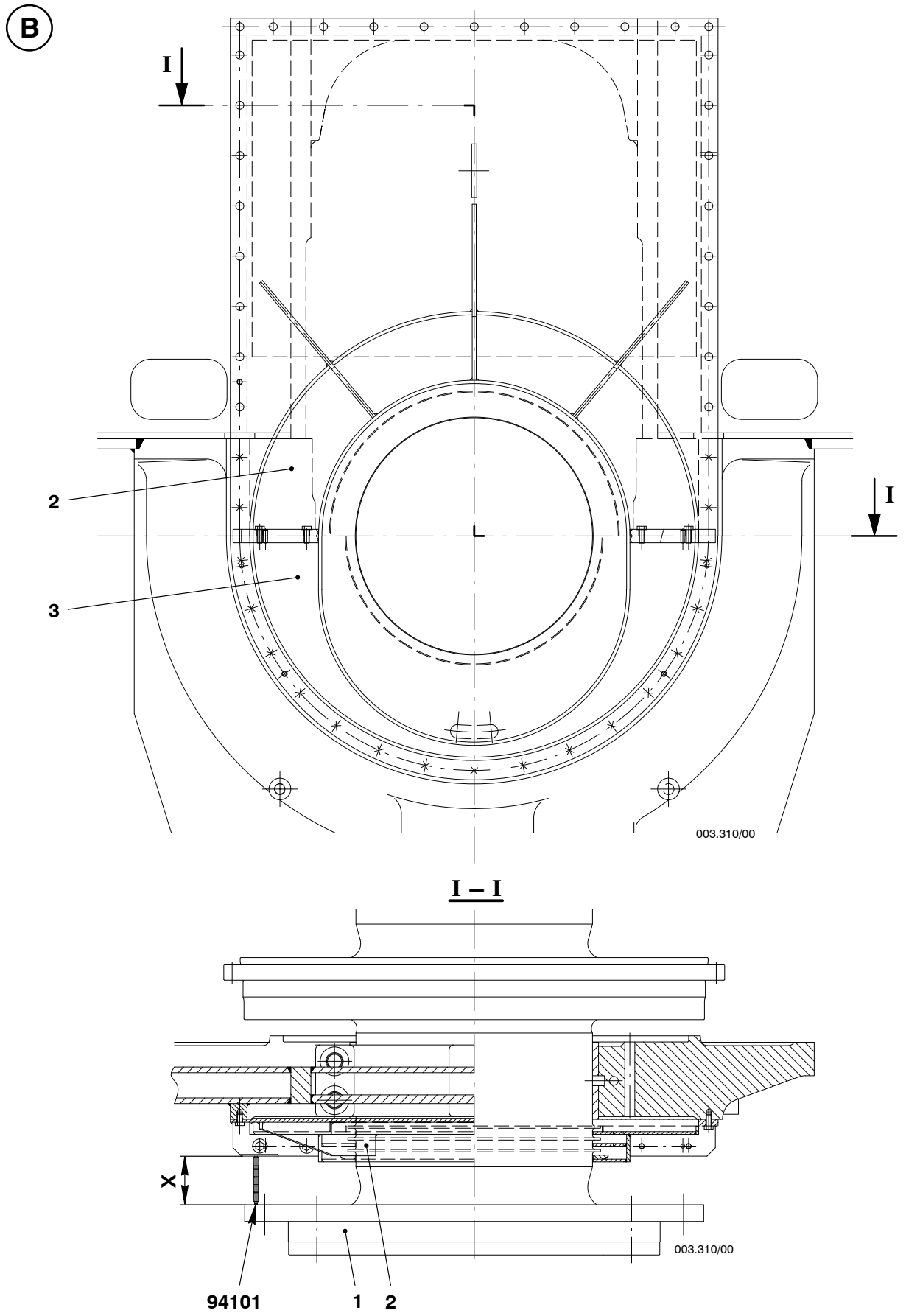
⇒ Displace the crankshaft axially until it rests on the thrust bearing pads for ASTERN. Determine the total axial clearance with the inside micrometer.

Remark: If during checking or repair work any objects should fall into the thrust bearing housing, they can be removed after dismantling cover 8. After major works have been carried out in the thrust bearing space dismantle cover 8 for a check-up on the thrust bearing housing. Remove any foreign matters through the opening.

Thrust Bearing: Checking the Axial Clearance



Thrust Bearing: Checking the Axial Clearance



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Thrust Bearing

Removal and Fitting the Thrust Bearing Pads

Tools:

1	Turning-out device for engines with 1-part gear wheel	94155
1	Turning-out device for engines with 2-part gear wheel	94155A
1	Eye bolt M16	

Key to Illustrations:

1	Thrust bearing flange
2, 2a	Thrust bearing pads
3	Gear wheel on thrust bearing flange
4	Holder
5	Screws with locking plates
6	Bearing cover
7	Oil baffle, upper part

1. Removal

⇒ Remove screws 5 to both holders 4 (Fig. 'A').

⇒ In addition, to ensure a better access for the removal of thrust bearing pads 2 (ASTERN operation), the upper part of oil baffle 7 (Fig. 'B') is also to be removed (see 1132–2).

⇒ Insert and laterally fasten turning-out device 94155 or 94155A as illustrated on Fig. 'B'.

⇒ The crankshaft is then to be turned with the turning gear until an eye bolt M16 can be screwed into a pad which can then be lifted up and removed one by one.

Remark: When only a few thrust bearing pads of a row are to be removed the crankshaft is located in its axial position by the remaining pads. When all thrust bearing pads must be removed then the crankshaft must be prevented from sliding axially. Therefore, insert a piece of hardwood of the same thickness in place of the thrust bearing pad.

2. Fitting

Make absolutely sure that all the thrust bearing pads are meticulously clean and smeared with fresh engine oil; the thrust bearing pads must all be replaced in their original position. Note the numbering of the individual pads! Also refer to the following pages for the arrangement of thrust bearing pads on engines with fixed pitch propellers (F.P.P.) and controllable pitch propellers (C.P.P.) respectively.

For fitting the thrust bearing pads tools 94155 or 94155A respectively can also be utilized. Note in this respect that the first pad, when pushed in, rests against the tool. The following thrust bearing pads can then be fitted one after the other while simultaneously turning the crankshaft. The thrust bearing pads should slide in without effort to their end position.

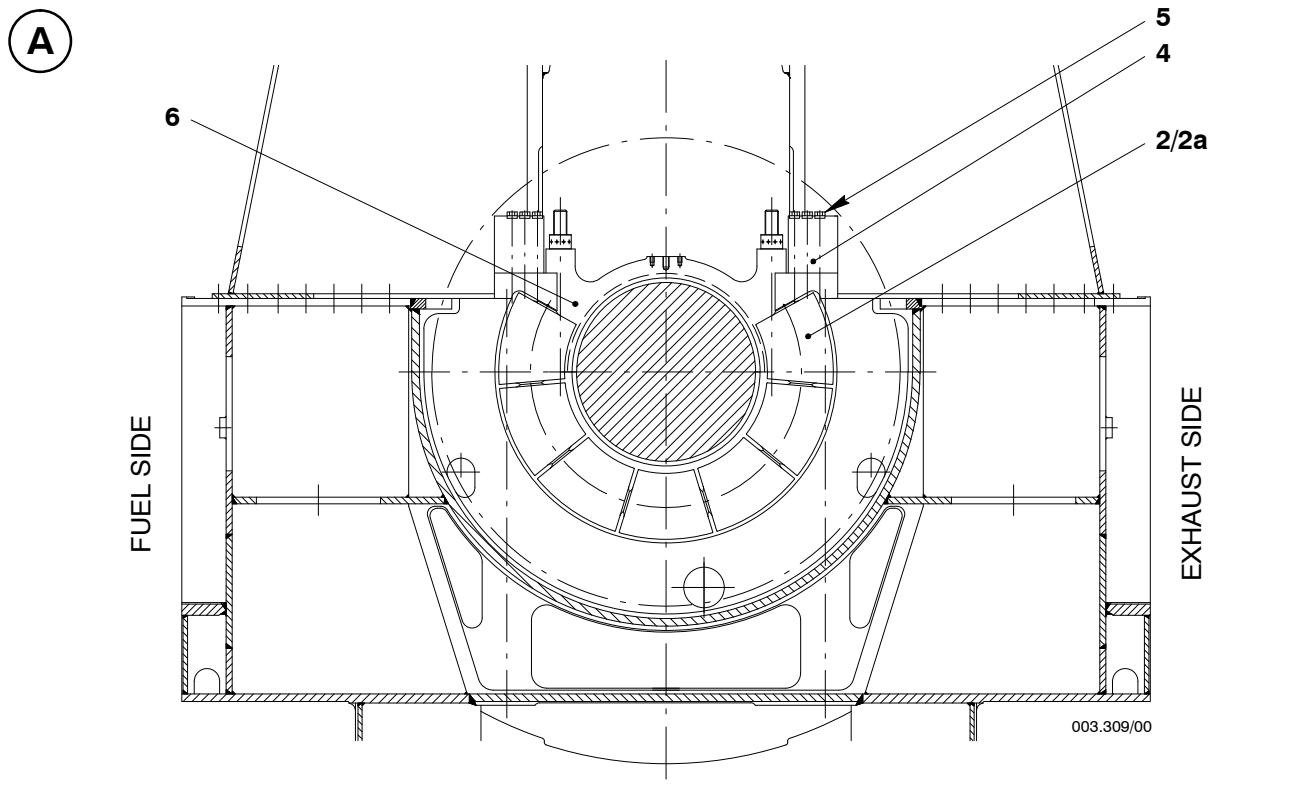
CHECK

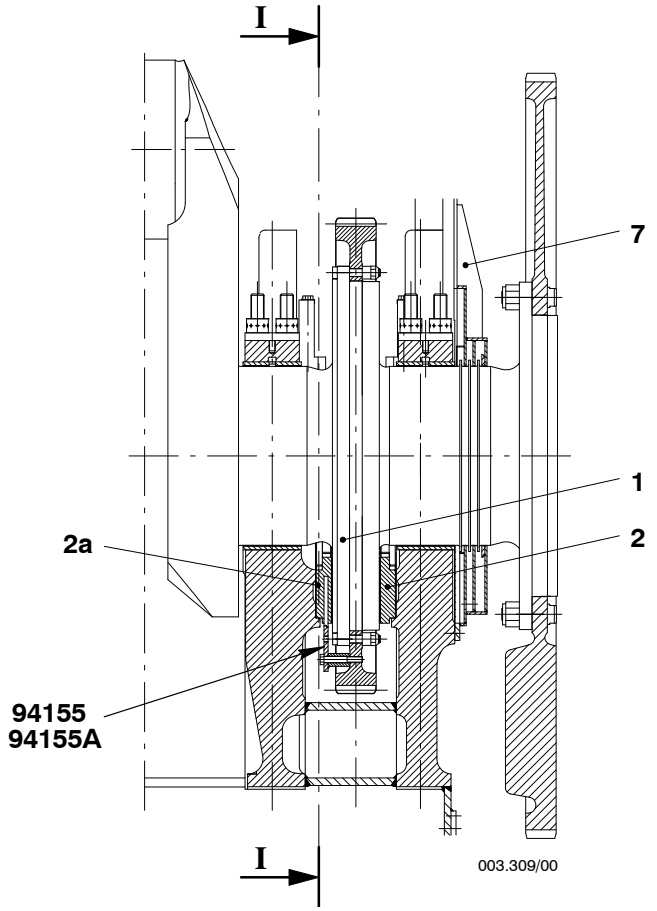
With all the thrust bearing pads in position the distances from the outermost pads on the fuel side and on the exhaust side to the upper edge of the bedplate must be equal. The holders 4 can now be refitted. Subsequently check the clearance between holder and thrust bearing pads 2 and 2a (see Clearance Table 0330–1 'Crankshaft and thrust bearing').

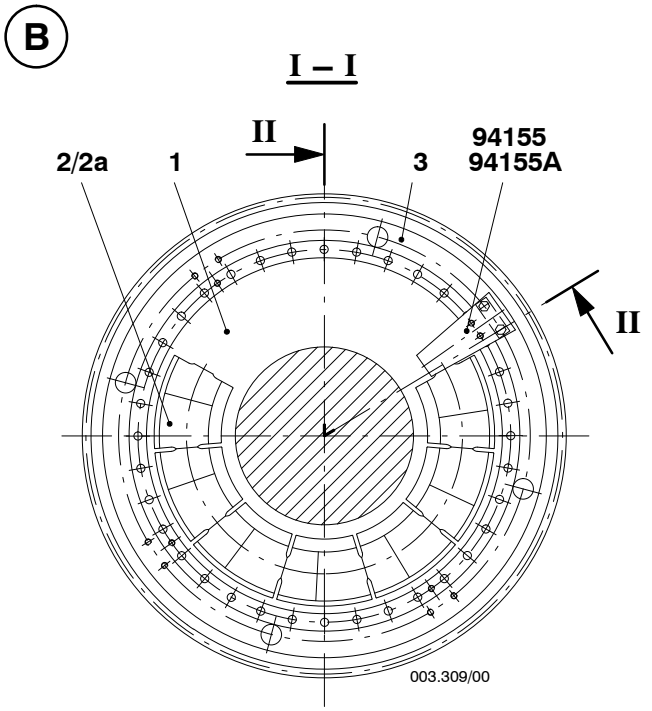
Attention! After fitting the thrust bearing pads immediately remove tool 94155 or 94155a respectively.

Remark: When fitting new or remetalled thrust bearing pads, care must be taken that their thickness (final dimension) corresponds exactly with the neighboring pads.
When replacing a complete row of new or remetalled thrust bearing pads the clearance must be adjusted to the original values (see Clearance Table 0330–1 'Crankshaft and thrust bearing' and 1203–1).

Removal and Fitting the Thrust Bearing Pads

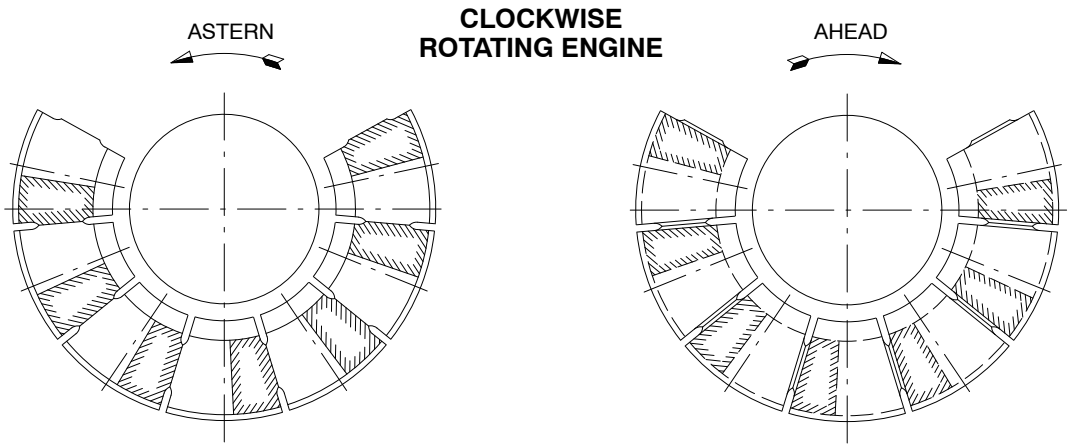


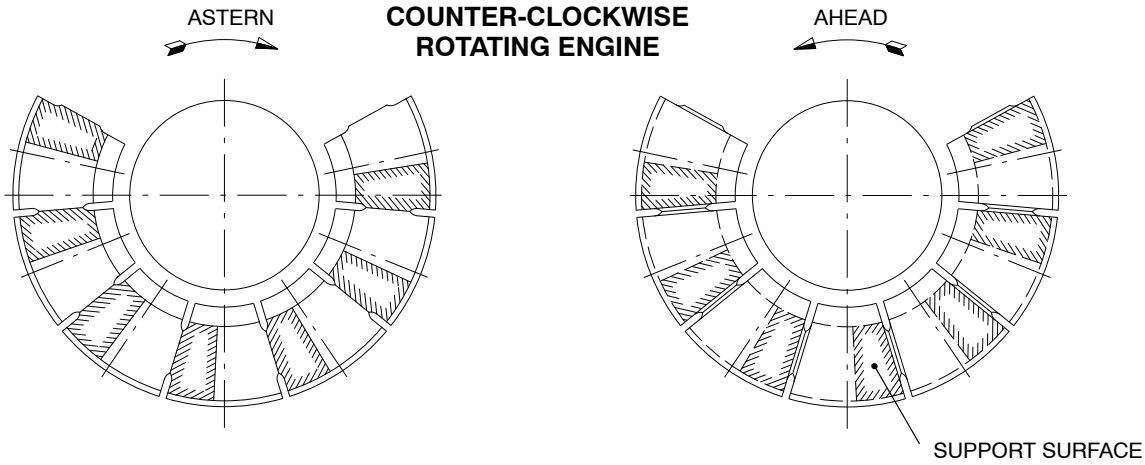


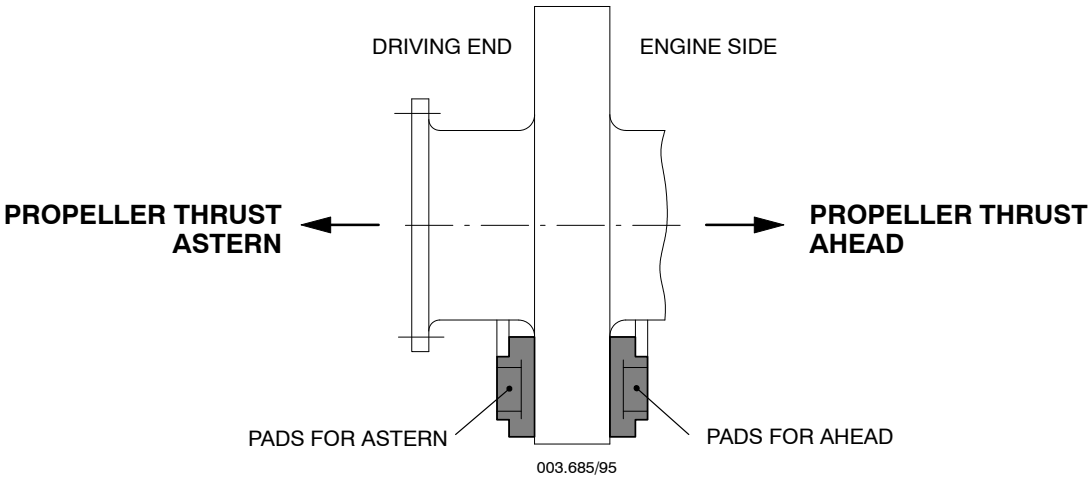


Removal and Fitting the Thrust Bearing Pads

ARRANGEMENT OF THRUST BEARING PADS FOR ENGINES WITH FIXED PITCH PROPELLER

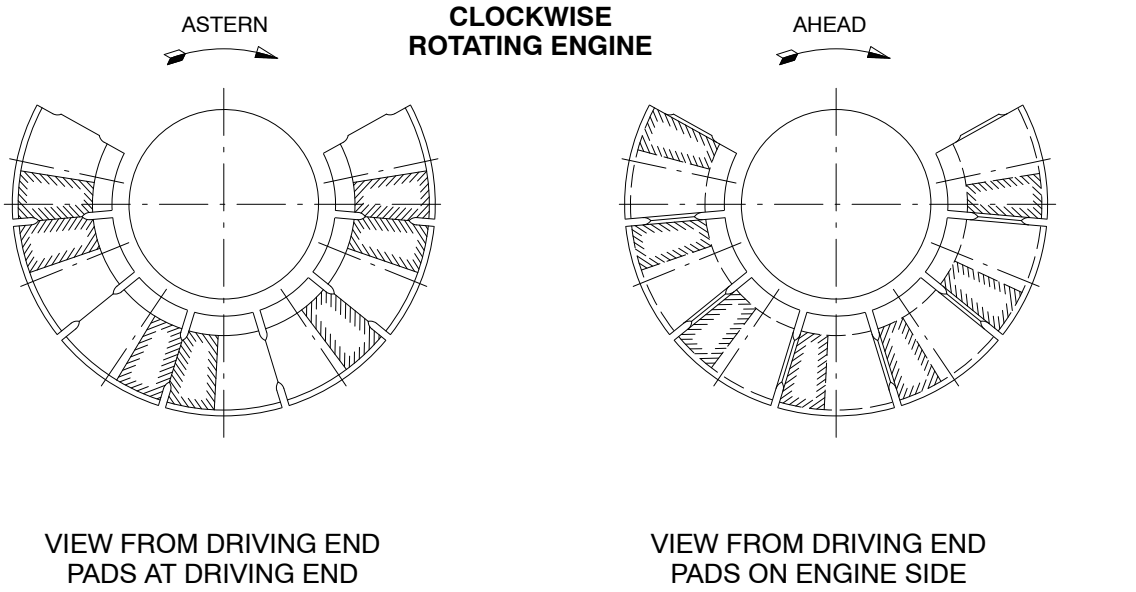


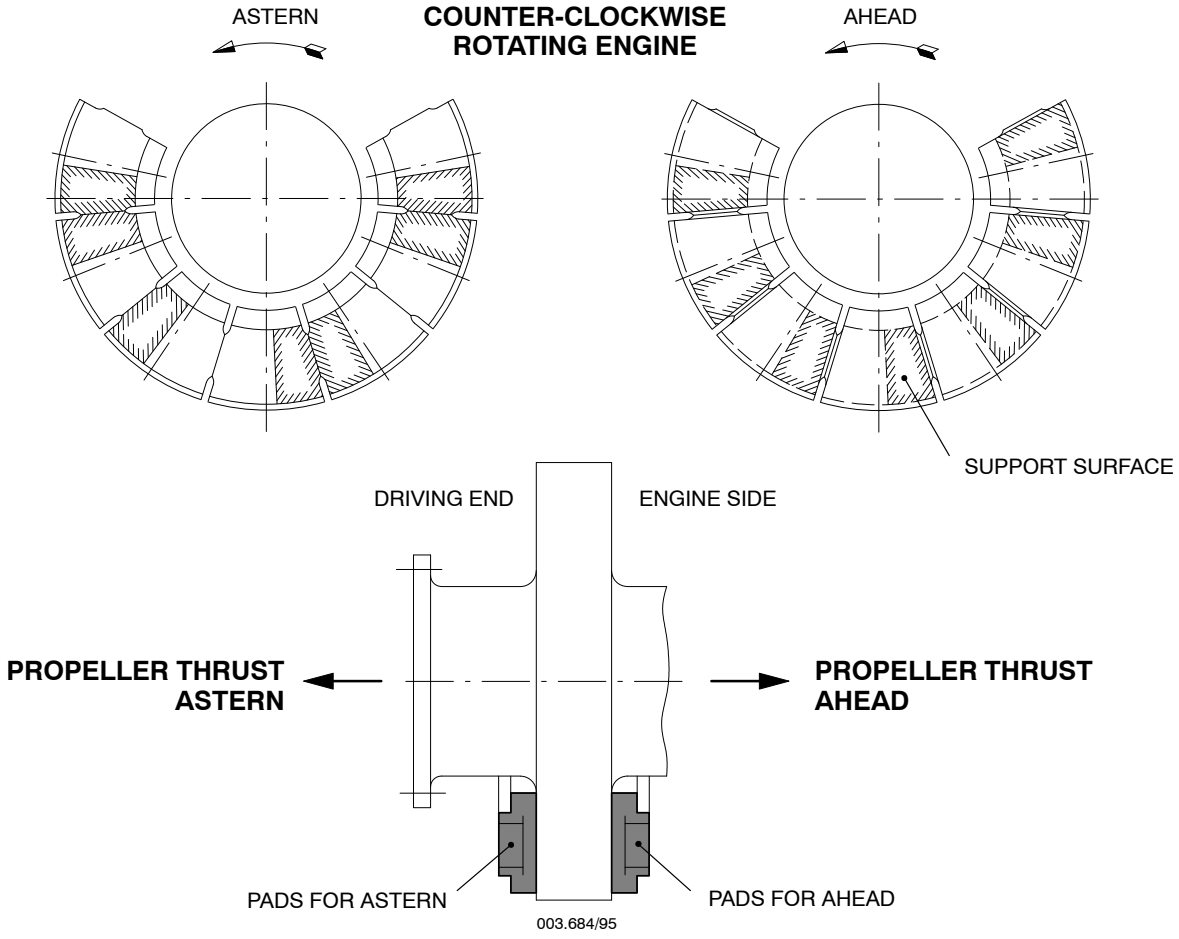




Removal and Fitting the Thrust Bearing Pads

ARRANGEMENT OF THRUST BEARING PADS FOR ENGINES WITH CONTROLLABLE PITCH PROPELLER





Engine Stays with Friction Shims

Checking the Pre-tension

Tools:

1	Rod	94005D
1	Feeler gauge	94122
1	Pre-tensioning jack	94145
1	HP oil pump	94931
1	Hydr. distributor	94932
1	Hydr. distributor	94934A
1	Plug piece	94934E
1	HP hose	94935
1	HP hose	94935A

Key to Illustrations:

1	Engine stays		
2	Friction shims		
3	Screw		
4	Nut		
5	Disc spring		
6	Piston		
7	Cylinder		
8	Vent screw	EV	Relief valve
9	Pin	KO	Slot

1. General

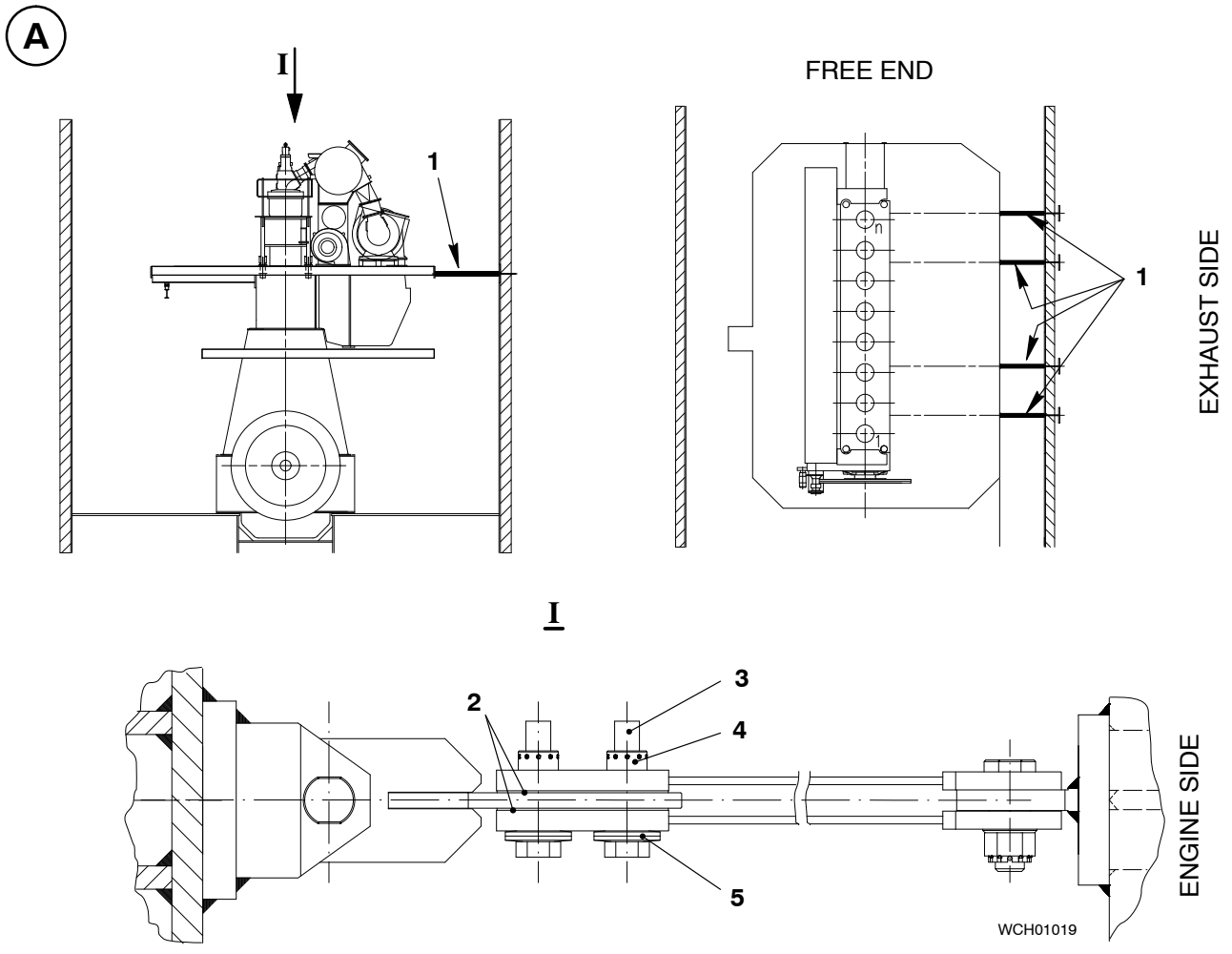
Two friction type stays 1 each are installed on the fuel side and at the free end of the engine (Fig. 'A').

CHECK

The pre-tension of screws 3 must be checked at specified intervals (see 0380–1).

Remark: Pay attention to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

For checking the pre-tension of the foundation bolts (1112–1), same jack 94145 is used and its nameplate engraved with 1000 bar. **Therefore, special care is required for the following procedure, i.e. particularly to the pre-tensioning value of 150 bar!**



2. Checking the pre-tension

⇒ Clean the thread of the screw and the seating surface. Subsequently apply MOLYKOTE to the thread.

⇒ Place pre-tensioning jack 94145 on the screw to be checked, and screw it completely down with vent screw 8 open until there is only little or no clearance at 'x' (Fig. 'B').

⇒ Connect pre-tensioning jack 94145 with HP oil pump 94931 as shown in Fig. 'B', whereby one side of hydr. distributor 94934A must be plugged with plug piece 94934E.

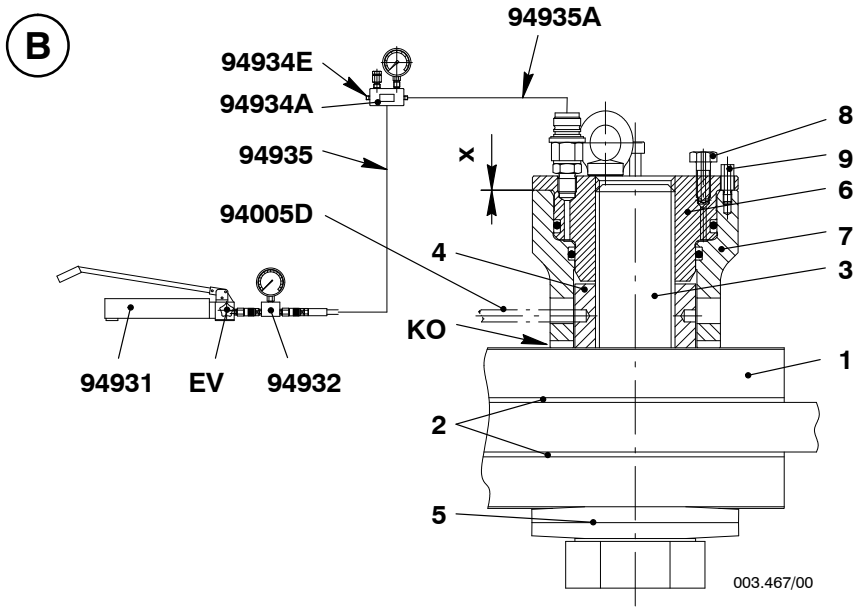
⇒ Close relief valve 'EV' at the HP oil pump, then actuate the HP oil pump until the oil comes out without bubbles from the opened vent screw 8.

⇒ Close vent screw 8, tension the screw with **150 bar** and keep the pressure constant.

CHECK

Check with feeler gauge through slot 'KO' if there is any clearance between nut 4 and its seating.

⇒ If there is no clearance, this means that the tensioning condition of the screw has remained unchanged since the last check. The pressure can be released to zero and the pre-tensioning jack removed.
Should a clearance be found, nut 4 must be tightened down onto its seating with rod 94005D while the pressure is kept at **150 bar** (check with feeler gauge). Subsequently lower the pressure to zero.



3. Loosening the screws

If the screws must be loosened, first screw on pre-tensioning jack 94145 completely, then loosen it by about ½ turn. Afterwards tension the screw with **170 bar**, and turn nut 4 back by one turn. Attention should be paid to ensure that pin 9 always protrudes slightly compared with piston 6 on the pre-tensioning jack!

Hydraulic Engine Stays

Checking the Oil Pressure

Key to Illustrations:

1 Hydraulic engine stays
2 Hydraulic cylinder
3 Bladder accumulator
4 Rod
5 Ball valve
6 Plug $^{3}/_{8}$ NPT
7 Pressure gauge

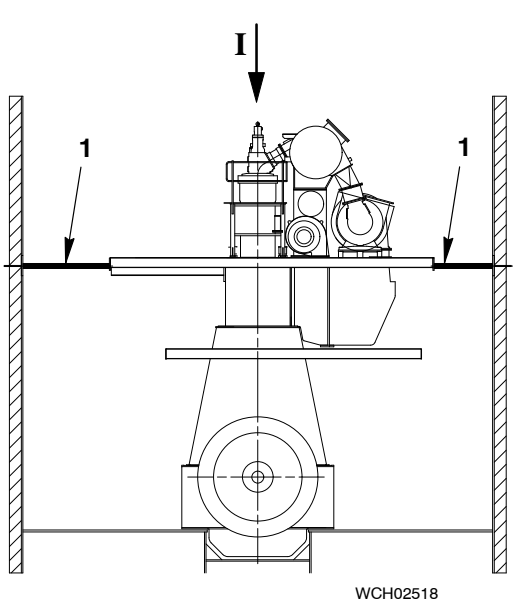
1. General

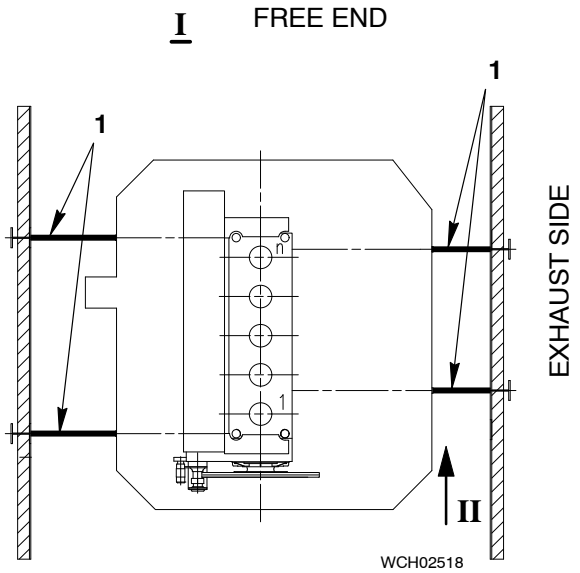
Two hydraulic type stays 1 are installed each on the exhaust side and fuel side of the engine.

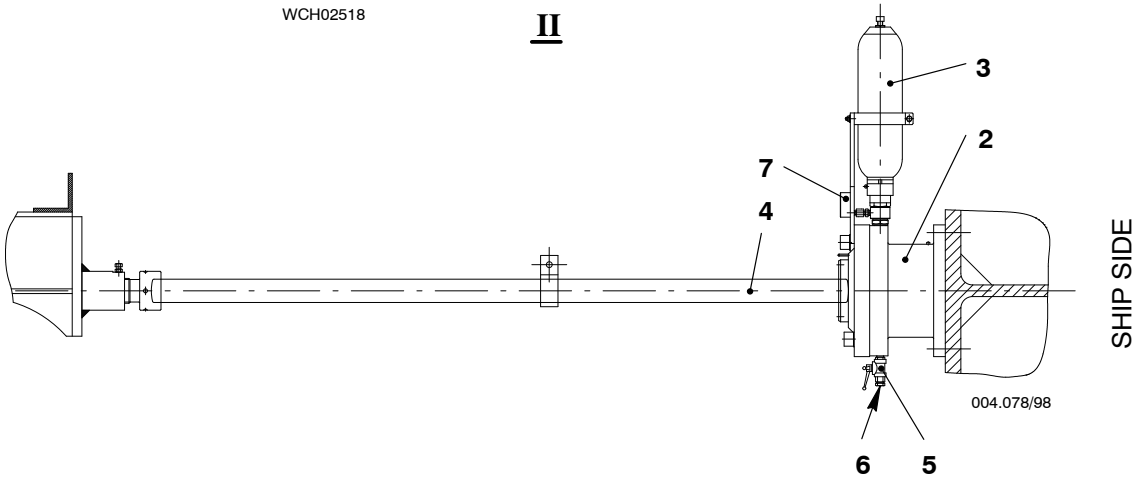
CHECK

The oil pressures on the pressure gauges of the hydraulic cylinders must be checked and compared with each other at regular intervals.

If one of the hydraulic cylinders shows a pressure below 30 bar, which could be caused by defective O-rings, leaking valves or screwed connections, the opposite hydraulic cylinder must also be released of its pressure till 30 bar.
The defective engine stays must be repaired at the first opportunity. Afterwards the oil pressure must be readjusted to the required value on all the engine stays, whereby the detailed instructions of the respective maker must be considered.







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Tie Rod

Checking the Pre-tension and Tensioning the Tie Rods with M80x6 Thread Diameter

Tools:

1	Rod	94005F
1	Feeler gauge	94122
2	Pre-tensioning jacks	GF 94180
1	Hydr. distributor	94934A
2	HP hoses	94935A
1	HP hose	94935
1	Hydraulic unit	94942

Key to Illustrations:

1	Cylinder block	12	Bearing girder
2	Intermediate ring	13	Lower backing ring
3	Upper tie rod nut	14	Lower tie rod nut
4	Cylinder	15	Bush
5	Piston	16	O-ring
6	Vent screw		
7	Tie rod (M80x6)		
8	Protection cover	AN	Drain slot
9	Screw M24x40	BN	Limiting groove
10	Clamp screw	KO	Slot
11	Column	SA	Gap

1. General

We recommend that about one year after commissioning the engine all the tie rods are checked for their correct pre-tensioning and if necessary to tension them to the specified value. Later it is sufficient to make random checks during major overhauls, or the pre-tension of all tie rods has to be checked within four years.

For such checks it is not required to loosen the elastic studs of the main bearings nor the clamp screws 10 (Fig. 'D').

Remark: Pay attention to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

2. Checking the pre-tension of tie rods

⇒ Remove protection cover 8 from all tie rods and clean the contact face of intermediate ring 2.

⇒ Place both pre-tensioning jacks GF 94180 onto two tie rods lying opposite each other. Screw them completely down with vent screws 6 open until there is only little or no clearance at 'x' (Fig. 'A').
If necessary, turn the pre-tensioning jack back a little so that the holes in the tie rod nuts are accessible.

⇒ Connect both pre-tensioning jacks with hydraulic unit 94942.

⇒ Actuate the hydraulic unit until bubble-free oil flows out through the vent screws. Close vent screws.

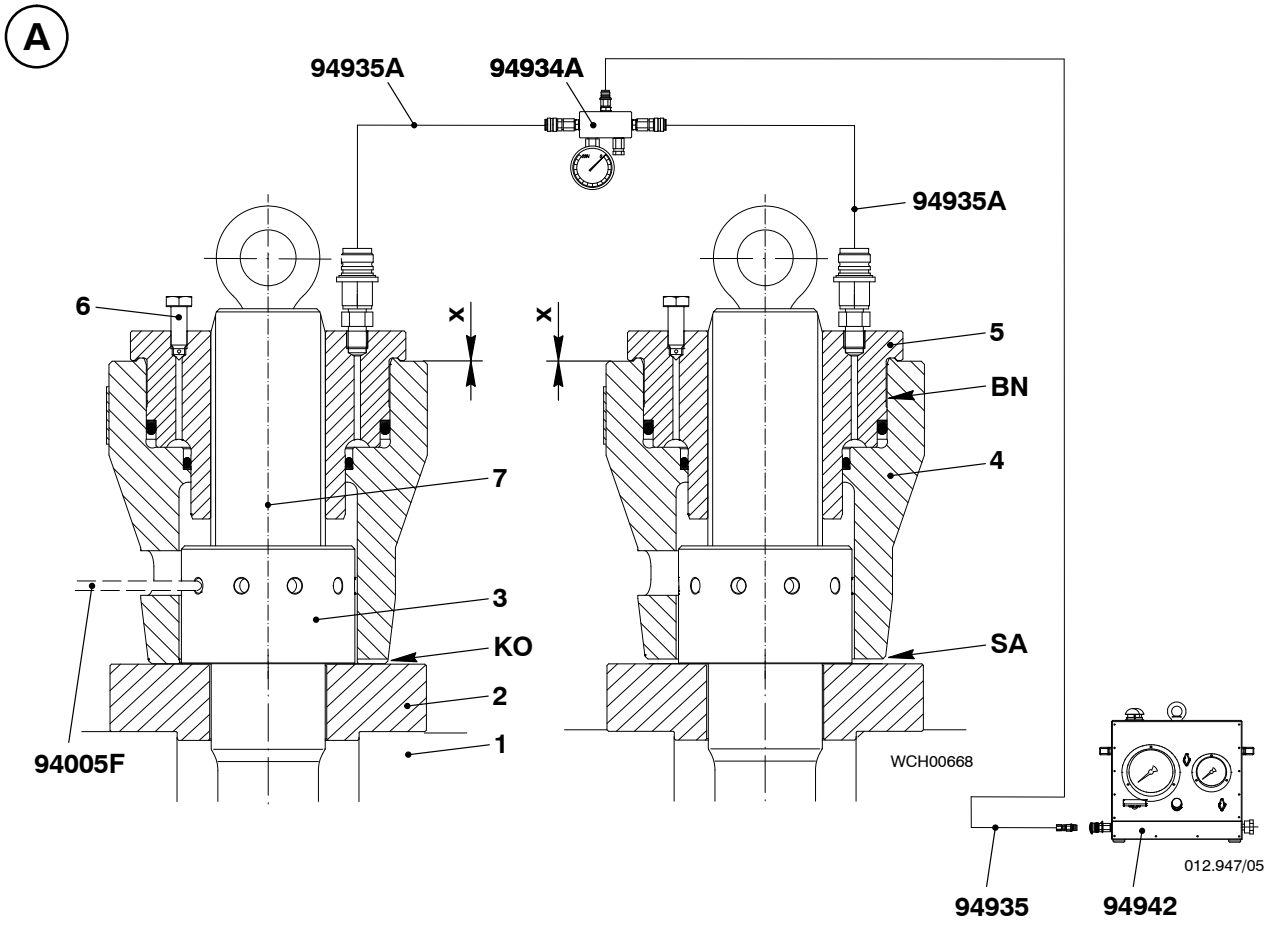
⇒ Operate hydraulic unit up to **1500 bar** and maintain this pressure.

STOP

Never move pistons 5 of the pre-tensioning jacks further up than to the red limiting grooves 'BN' (Fig. 'A').

PRE-TENSIONING JACK GF 94180
PLACED FOR TENSIONING

PRE-TENSIONING JACK GF 94180
PLACED FOR LOOSENING



CHECK

Using a feeler gauge inserted through slot 'KO', check whether tie rod nut 3 rests on intermediate ring 2 without any clearance.

⇒ If any clearance does exist, tighten the nut with rod 94005F until it rests firmly on the intermediate ring. Subsequently release the pressure to zero at the hydraulic unit. If no clearance exists, the pressure can immediately be released and the pre-tensioning jacks removed. Check all the tie rods in this manner and, wherever necessary, tighten the nut.

⇒ Protect the tie rod threads against corrosion by coating them with non-acidic grease after checking has been completed. Fit and fasten protection cover.

3. Loosening and tensioning the tie rods

Should tie rods have to be removed or fitted, the following points have to be observed:

⇒ Remove clamp screws 10 (Fig. 'D').

- If the tie rods have been newly tensioned, then the elastic studs of the main bearings also have to be checked for correct pretensioning (see 1132–1).
- Tensioning has to be carried out in one procedure.
- The sequence in which the tie rods are to be loosened or tensioned is shown in Fig. 'B', i.e. in pairs, first tie rods a/a, then b/b, etc.



Never move pistons 5 of the pre-tensioning jacks further up than to the red limiting grooves 'BN' (Fig. 'A').

3.1 Loosening

The procedure for loosening the tie rods is the same as the one described in section 2 'Checking the pre-tension', except that pre-tensioning jacks must be turned back by 3½ turns after being completely screwed down the pre-tensioning jacks (gap 'SA' in Fig. 'A'). At this starting point connect the jacks with hydraulic unit 94942 and operate it until a pressure of approx. **1530 bar** is reached.

⇒ Screw back nuts 3 by 3½ turns with rod 94005F.

⇒ Release pressure to zero and remove the pre-tensioning jacks.

3.2 Tensioning

Preliminary works:

- Clamp screws 10 must not be tightened up.
- Lower tie rod nut 14 is screwed on.

⇒ Clean the seating surface for intermediate ring 2 and upper tie nut 3 and smear them with MOLYKOTE G paste.

⇒ Smear the tie rod thread lavishly with MOLYKOTE G paste and screw on upper tie nut with the marking TOP upwards (check for easy threading).

⇒ Screw eye bolt into the tie rod and lift it carefully until the lower tie rod nut rests snugly against the bearing girder.



Risk of accident! Use a manual ratchet hooked onto the crane, with which the tie rod can be lifted manually until the lower nut is snug on its seating, as with the crane alone the landing of the nut cannot easily be felt and the rope might break.

⇒ In this position tighten the upper tie rod nut with rod 94005F until firmly seated on the intermediate ring, and separate the manual ratchet from the tie rod.

CHECK

There must now be no clearance between bearing girder and lower tie rod nut and the lower tie rod nut must be flush with the tie rod end (Fig. 'D').

⇒ Place pre-tensioning jacks GF 94180 onto tie rods **a**/**a**.

⇒ Screw pre-tensioning jacks completely down with vent screws 6 open until there is only little or no clearance at 'x' (Fig. 'A').
If necessary, turn the pre-tensioning jack back a little so that the holes in the tie rod nuts are accessible.

Tensioning in one procedure:

⇒ Connect pre-tensioning jacks with hydraulic unit 94942.

⇒ Actuate the hydraulic unit until bubble-free oil flows out through the vent screws. Close the vent screws.

⇒ Raise pressure to **100 bar**, keep it constant, and firmly tighten the two upper tie rod nuts 3 with rod 94005F.

⇒ Measure and record distance 'L' (the measurements can be taken directly on the mounted pre-tensioning jacks, i.e. from top edge of tie rod 7 to cylinder 4).

⇒ Subsequently tension tie rods with **1500 bar**, keep it constant and firmly tighten the two upper tie rod nuts 3 with rod 94005F.

STOP Never move pistons 5 of the pre-tensioning jacks further up than to the red limiting grooves 'BN'.

⇒ Measure again distance 'L' and record it as 'L_1'.

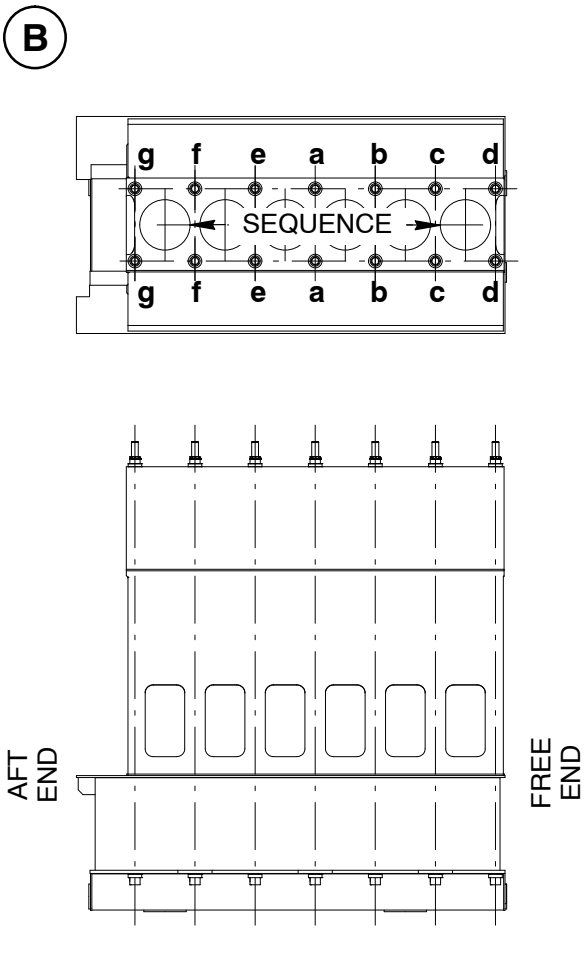
The tie rods are correctly tensioned with 1500 bar when the following reference value of a total elongation ΔL ('L_1'–'L') is measured:

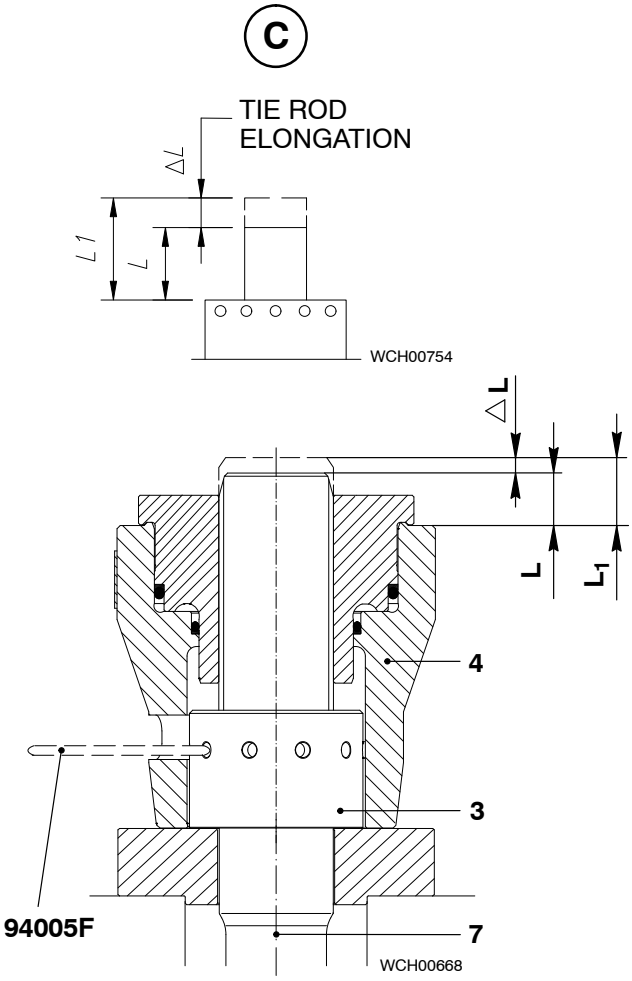
ΔL = 14.5 ... 16.5 mm

⇒ Release pressure to '0'.

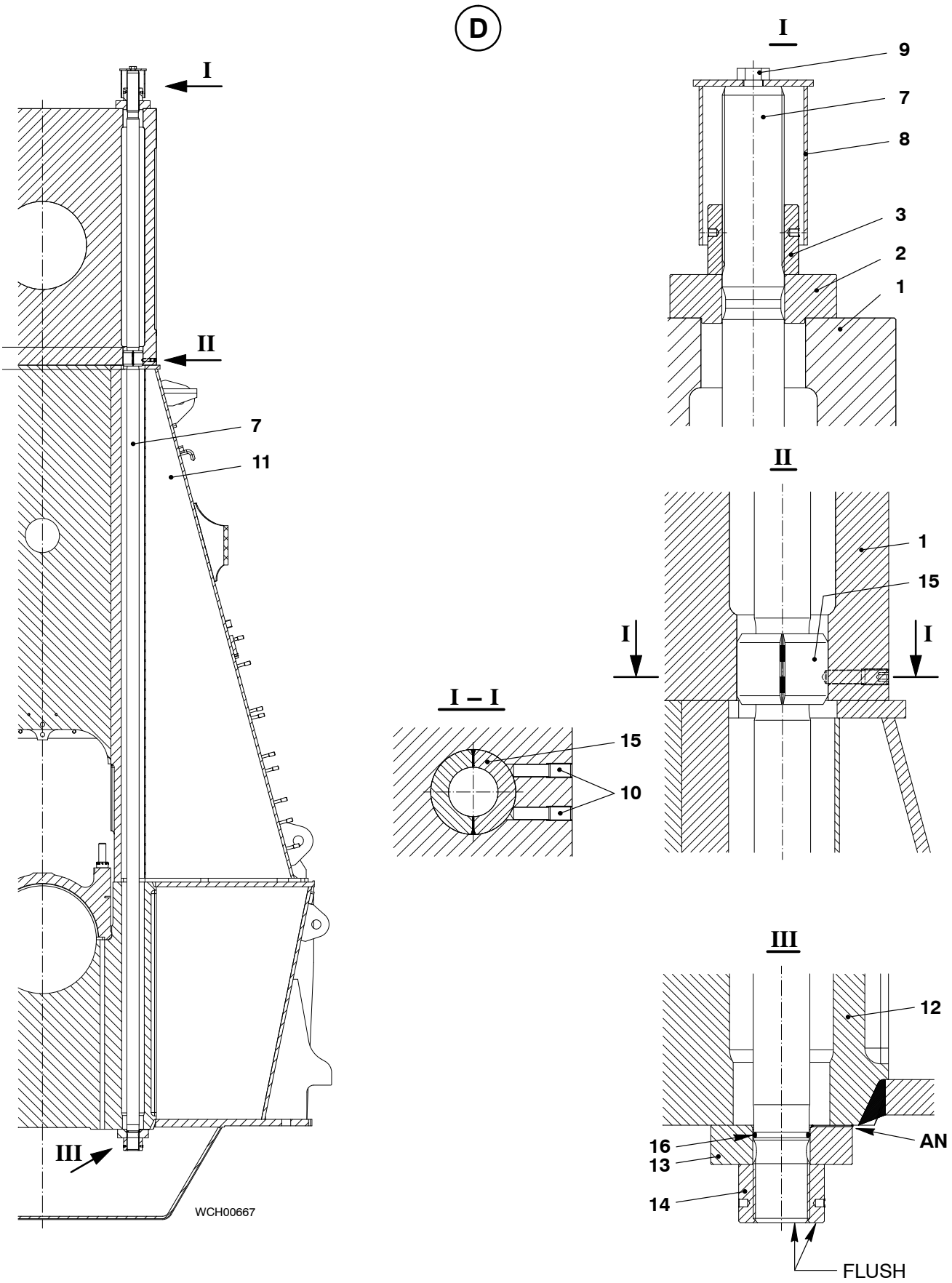
⇒ Proceed in the same way following the required sequence for all tie rods **b**/**b, c**/**c, d**/**d** ect.

⇒ After completing the tensioning, smear the protruding thread portions of all the tie rods lavishly with acid-free grease and fit protection covers 8.





Checking the Pre-tension and Tensioning the Tie Rods with M80x6 Thread Diameter



Cylinder Liner and Cylinder Cover Group 2

▽ **Cylinder Liner**

- Measuring Bore Wear 2124–1/A1
- Removal and Fitting 2124–2/A1
- Removing the Wear Ridge, Re-dressing Lubricating Grooves and Scavenge Ports 2124–3/A1

Lubricating Quill: Removal and Fitting with Pulse Feed Lubrication 2138–1/A2

Piston Rod Gland: Dismantling and Assembling, Measuring the Wear 2303–1/A1

▽ **Cylinder Cover**

- Removal and Fitting of Cylinder Cover and Water Guide Jacket 2708–1/A1
- Loosening and Tensioning of Cylinder Cover Waisted Studs 2708–2/A1
- Machining of Sealing Face for Injection Valve 2708–3/A1

Injection Valve: Checking, Dismantling, Assembling and Adjusting Injection Valve with FAST 2722–1/A2

Starting Air Valve: Removal, Fitting and Dismantling, Grinding-in and Assembling 2728–1/A1

Relief Valve for Cylinder Cover: Checking Blow-off Pressure 2745–1/A1

▽ **Exhaust Valve**

- Removal and Fitting of Exhaust Valve, Replacing of Waisted Studs 2751–1/A1
- Dismantling and Assembling 2751–2/A1
- Replacing and Grinding the Valve Seat 2751–3/A1
- Grinding the Seating Surface on the Valve Head 2751–4/A1

Cylinder Liner

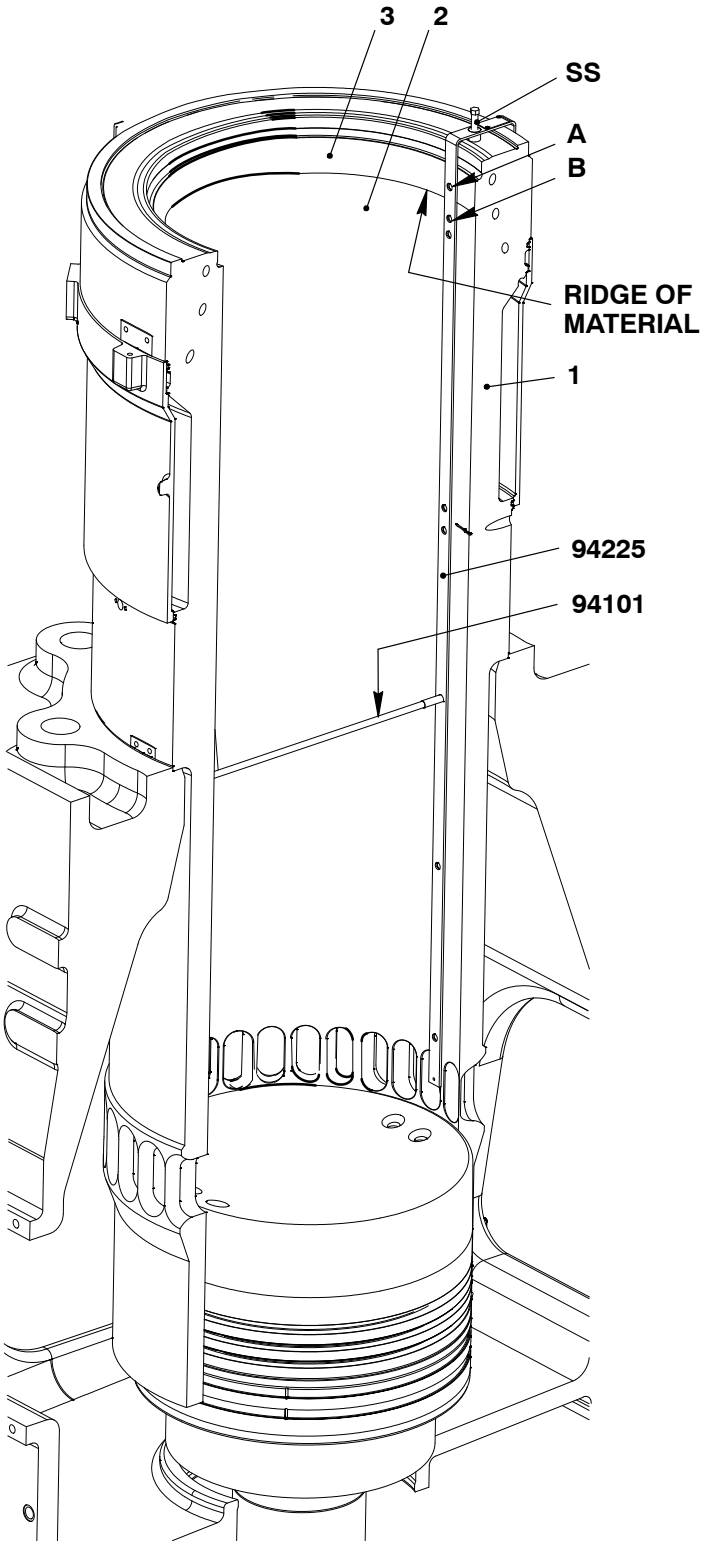
Measuring Bore Wear

Tools:

1	Inside micrometer	94101
1	Measuring gauge	94225

Key to Illustrations:

1	Cylinder liner
2	Running surface
3	Non-running surface
A / B	Measurement holes in gauge 94225
SS	Setting screw



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You measure the cylinder liner wear before you remove a piston.

⇒ Remove the cylinder cover, (see 2708–1).

⇒ Use the turning gear to move the piston to BDC.

⇒ Clean the non-running surface 3.

⇒ Remove the bottom part of the gauge (94225).

⇒ Put the gauge (94225) in position on the top face of the cylinder liner 1 in line with the longitudinal axis of the engine.

⇒ Make sure that the top measurement position A is above the ridge in the non-running surface of the cylinder liner 1.

⇒ Read the values from the last bore wear measurement. You compare these values with the new values.

⇒ Put the micrometer (94101) in the top hole A, to measure the distance. Record the value.

⇒ Put the micrometer in position in the subsequent hole B in the gauge (94225), then record the value.

⇒ Do the step above for the remaining holes below A and B.

⇒ Move the gauge 90° (in line with the transverse axis of the engine).

⇒ Do the steps above again to measure the bore wear in the positions F up to A.

⇒ Use the formula below to calculate the wear rate:

$$WR = \frac{(D1-D2) \times 1000}{T1}$$

WR = Wear rate [mm/1000 h]
T1 = Total running hours [h]
D1 = Max. Liner diameter in running surface (points B and below) [mm]
D2 = Liner diameter in non-running surface (point A) [mm]

⇒ For the maximum permitted inner diameter, refer to 0330–1 Clearance Table, Cylinder liner.

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Cylinder Liner

Removal and Fitting

Tools:

2	RUD-eye bolts	94040–M16
1	Device	GF 94201
	consisting of:	
1	Lifting tool	GF 94202
1	Chain	GF 94202L
1	Shackle	GF 94202M
2	Holders	GF 94206
2	Special screws M42	GF 94207
4	Suspension straps	94208
1	Assembly tool	94345E

Key to Illustrations:

1	Cylinder block	11	Insulation bandage
2	Cylinder liner	12	Plate
3	Water guide jacket	13	Tension spring
	(lower part)	14	Holder
4	Antipolishing ring	15	Screw
5	Water guide jacket	16	Screw
	(upper part)	17-19	O-rings
6	Transition tube		
7	Connection piece	AF	Seating surface
8	Screw	DF	Sealing surface
9	Centring pin	DP	Depository for GF 94207
10	Cylinder cover	WU	Wooden underlay

Overview

1. Preparatory works 1/7
2. Removal and fitting of cylinder liner 2/7
3. Removal and fitting of antipolishing ring 4/7
4. Removal and fitting of water guide jacket 5/7
5. Removal and fitting of insulation bandage 6/7
6. Laying down and raising cylinder liner 7/7

1. Preparatory works

⇒ Drain cylinder cooling water from the respective cylinder and remove cylinder cover (see 2708–1).

⇒ Remove piston together with piston rod gland (see 3403–1 and 2303–1).

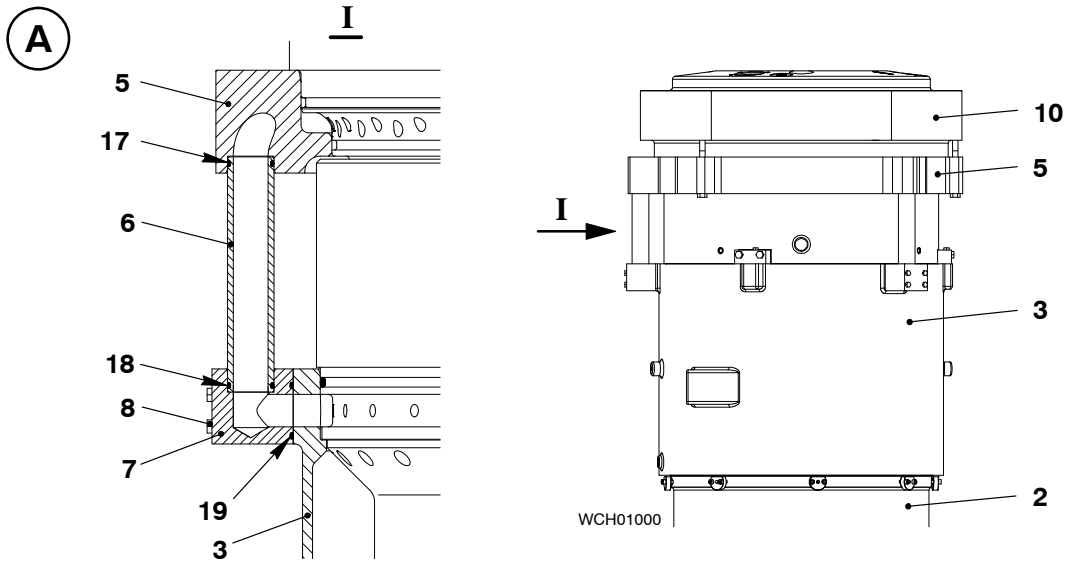
⇒ Separate all piping connections for cylinder oil from the lubricating quills. **All lubricating quills must be removed whenever a cylinder liner is being pulled out** (see 2138–1) **.**

Remark: Pay attention to:
– General Guidelines for Lifting Tools 0012–1.

2. Removal and fitting of cylinder liner

⇒ Loosen the screws 8 and remove them together with pipe connection 7 and the transition tubes 6 from the water guide jackets 3 and 5.

Remark: Transition tubes are pressed into connection pieces (press fit).

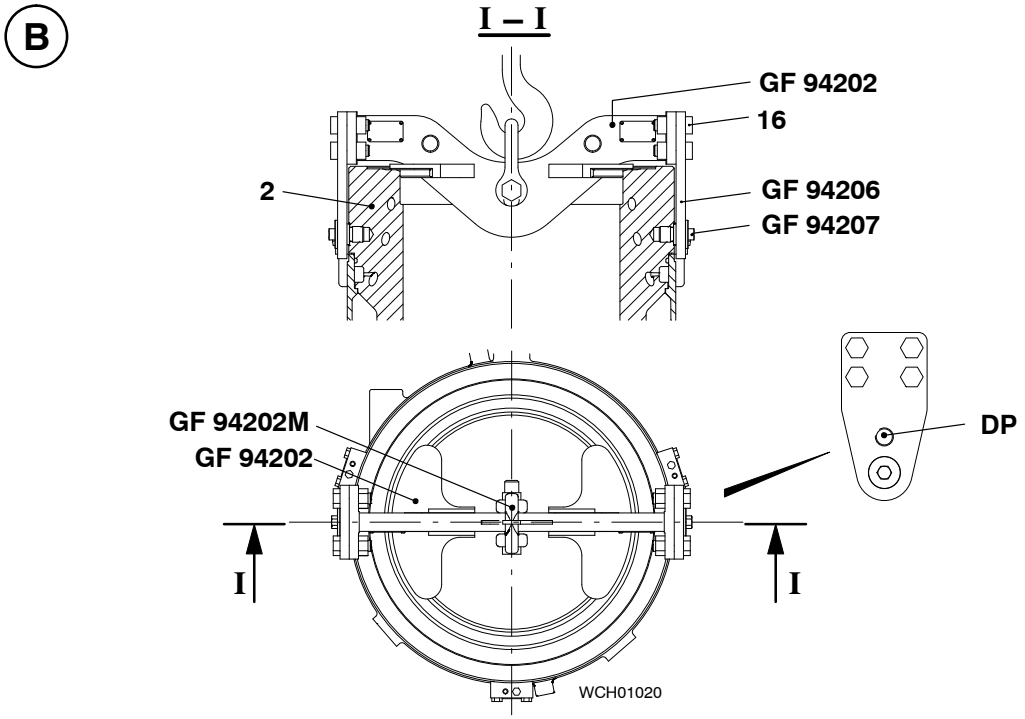


2.1 Placing device GF 94201

⇒ Place the device GF 94201 with its lifting tool GF 94202 and all parts diagonally onto cylinder liner 2 as shown below.

⇒ Apply copper paste to the threads of screws 16 and tighten them with **860 Nm**.

⇒ Apply copper paste to the threads of special screws GF 94207 and tighten them with **300 Nm**.



Cylinder Liner: Removal and Fitting

2.2 Removal

A cylinder liner can be removed by crane and lifting gear.

⇒ Lift the cylinder liner on shackle GF 94202M provided in the center of the device (Fig. 'B').

2.3 Fitting

⇒ Place the device GF 94201 diagonally onto the cylinder liner 2 in accordance with paragraph 2.1.

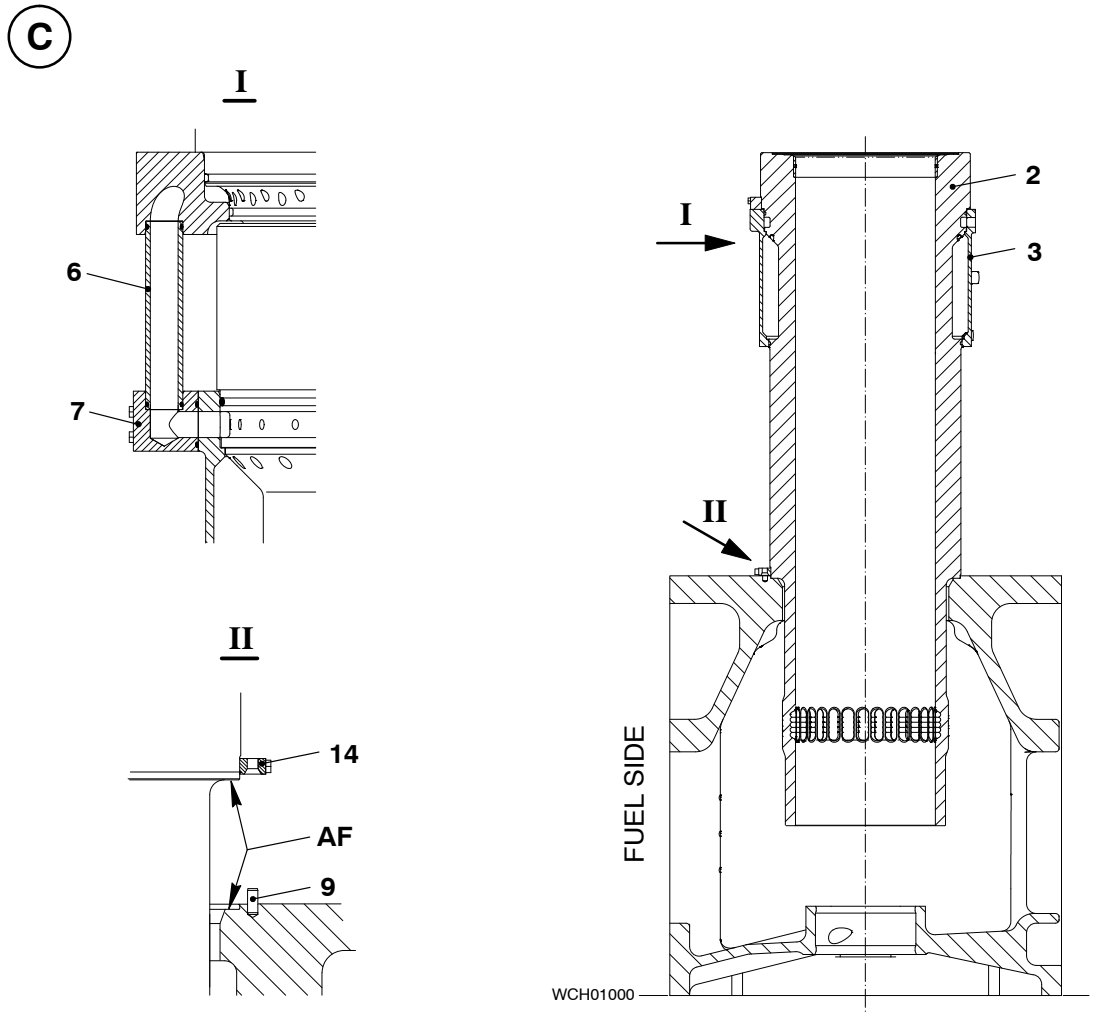
⇒ Clean the seating surfaces 'AF' on cylinder liner 2 and cylinder block 1. Apply a non-hardening sealing compound.

⇒ Turn the cylinder liner 2 and align the centring hole in holder 14 with the centring pin 9 of the cylinder block 1. Lower the cylinder liner.

⇒ Fit the connection pieces 7 with transition tubes 6 to water guide jacket.

⇒ Fit all lubricating quills and connect their piping.

CHECK Actuate the cylinder lubricating pump until oil emerges from all the lubricating grooves in the corresponding cylinder liner (see Operating Manual 2138–1 'Function check').



3. Removal and fitting of antipolishing ring

3.1 Removal

⇒ Fit four suspension straps 94208.

⇒ Turn the piston to T.D.C. whereby antipolishing ring 4 is pushed out of its seating and then it can be removed.

3.2 Fitting

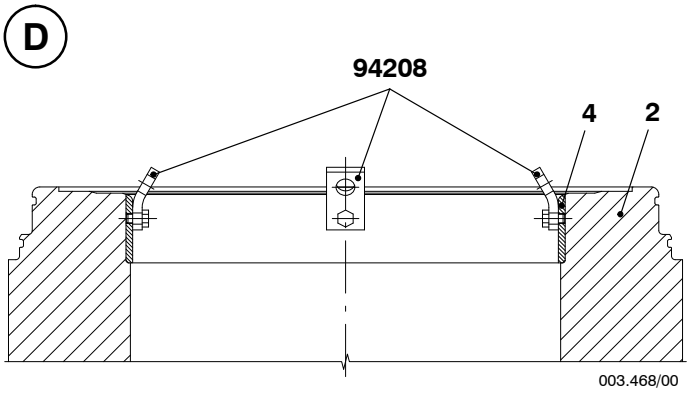
⇒ Clean the seating surfaces on the antipolishing ring and cylinder liner.

⇒ Fit four suspension straps 94208.

- Pay attention that one of the holes for fastening the suspension straps lies on fuel side.

⇒ Smear the antipolishing ring lightly with oil.

⇒ Fasten the ropes to the suspension straps and fit the antipolishing ring by means of the crane.



4. Removal and fitting of water guide jacket

4.1 Removal

⇒ Lift cylinder liner according to paragraph 2.

⇒ Fasten the RUD-eye bolts 94040–M16 to the water guide jacket 3 as shown below.

⇒ Remove holder 14.

⇒ Connect manual ratchets with the RUD-eye bolts.

⇒ Loosen three screws 15. If necessary use them to separate the water guide jacket from the cylinder liner.

⇒ Lay down water guide jacket on the bottom plates by means of manual ratchets.

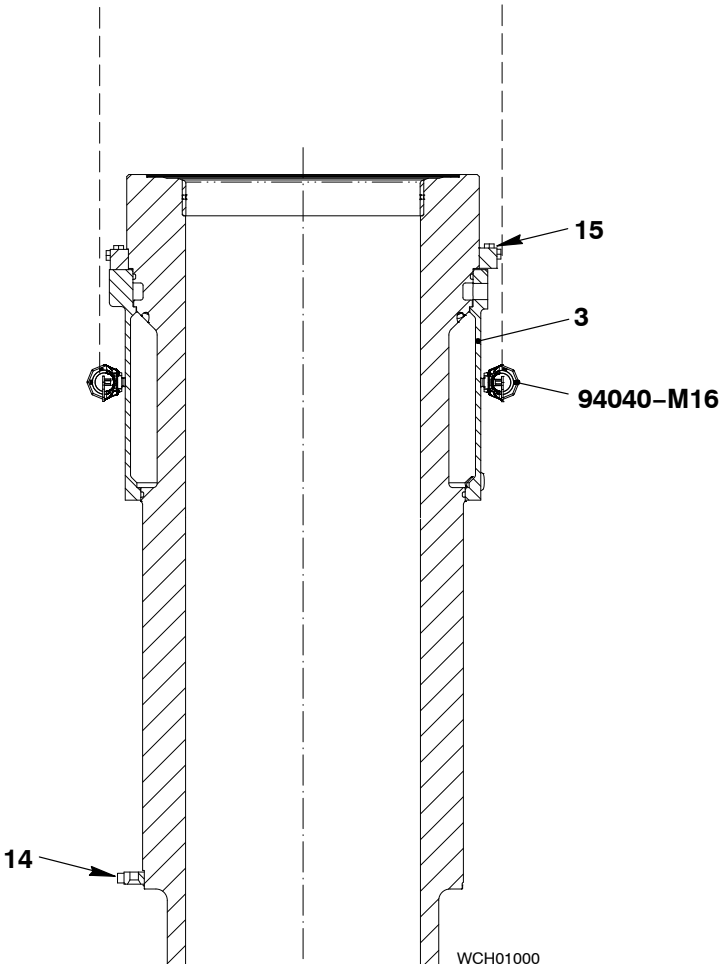
⇒ Lift cylinder liner and place it on the bottom plates.

4.2 Fitting

Fitting of the water guide jacket is carried out analogously to the removal but in reverse sequence.

⇒ Fit new O-rings and oil them slightly.

E



5. Removal and fitting of insulation bandage

5.1 Removal

⇒ Lift the cylinder liner in accordance with paragraph 2.

⇒ Remove the water guide jacket referring to paragraph 4.

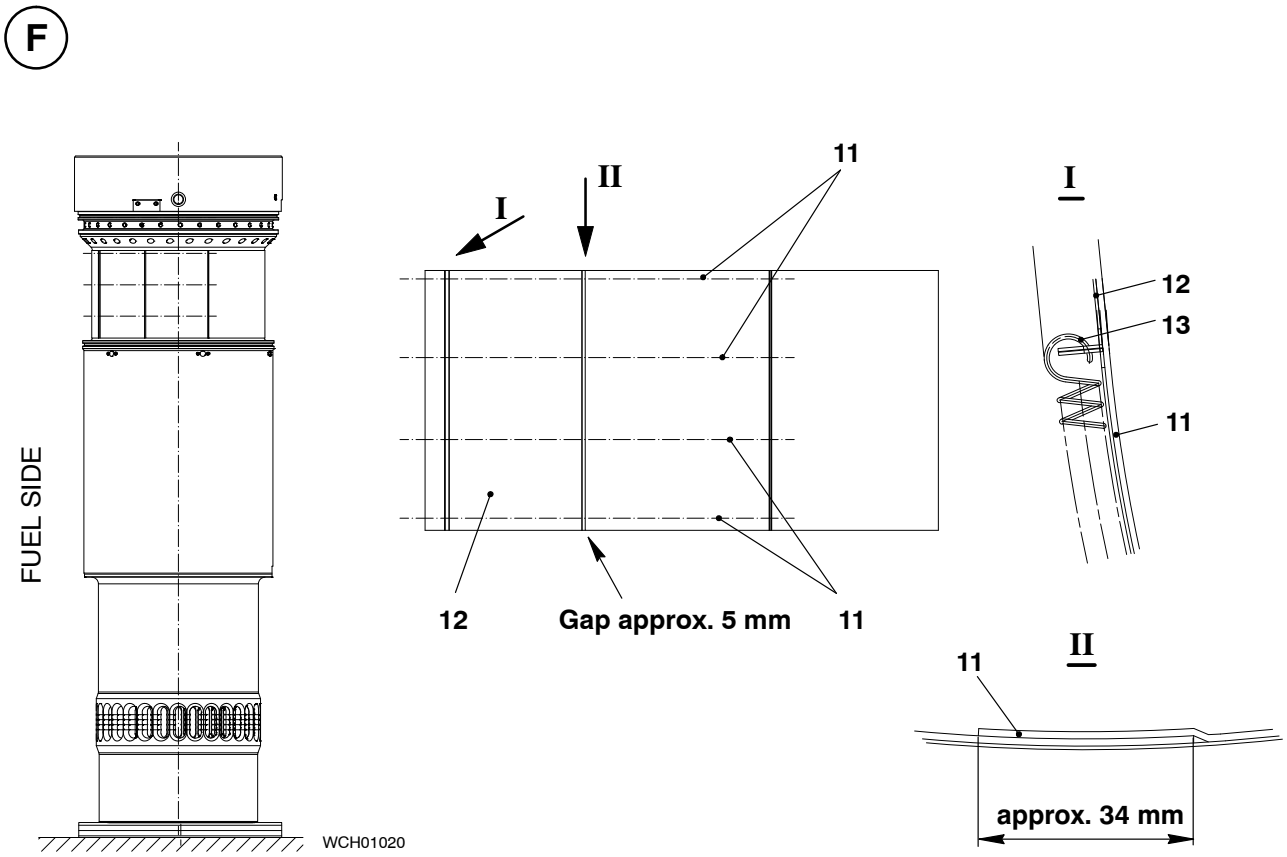
⇒ Loosen all tension springs 13 with assembly tool 94345E.

⇒ Remove the plate 12 for insulation bandage.

⇒ Remove the insulation bandage 11.

5.2 Fitting

Fitting of the insulation bandage is carried out analogously to the removal but in reverse sequence. Make sure the insulation bandage overlaps approximately 34 mm.



6. Laying down and raising cylinder liner

⇒ Place the device GF 94202 according to paragraph 2.1.

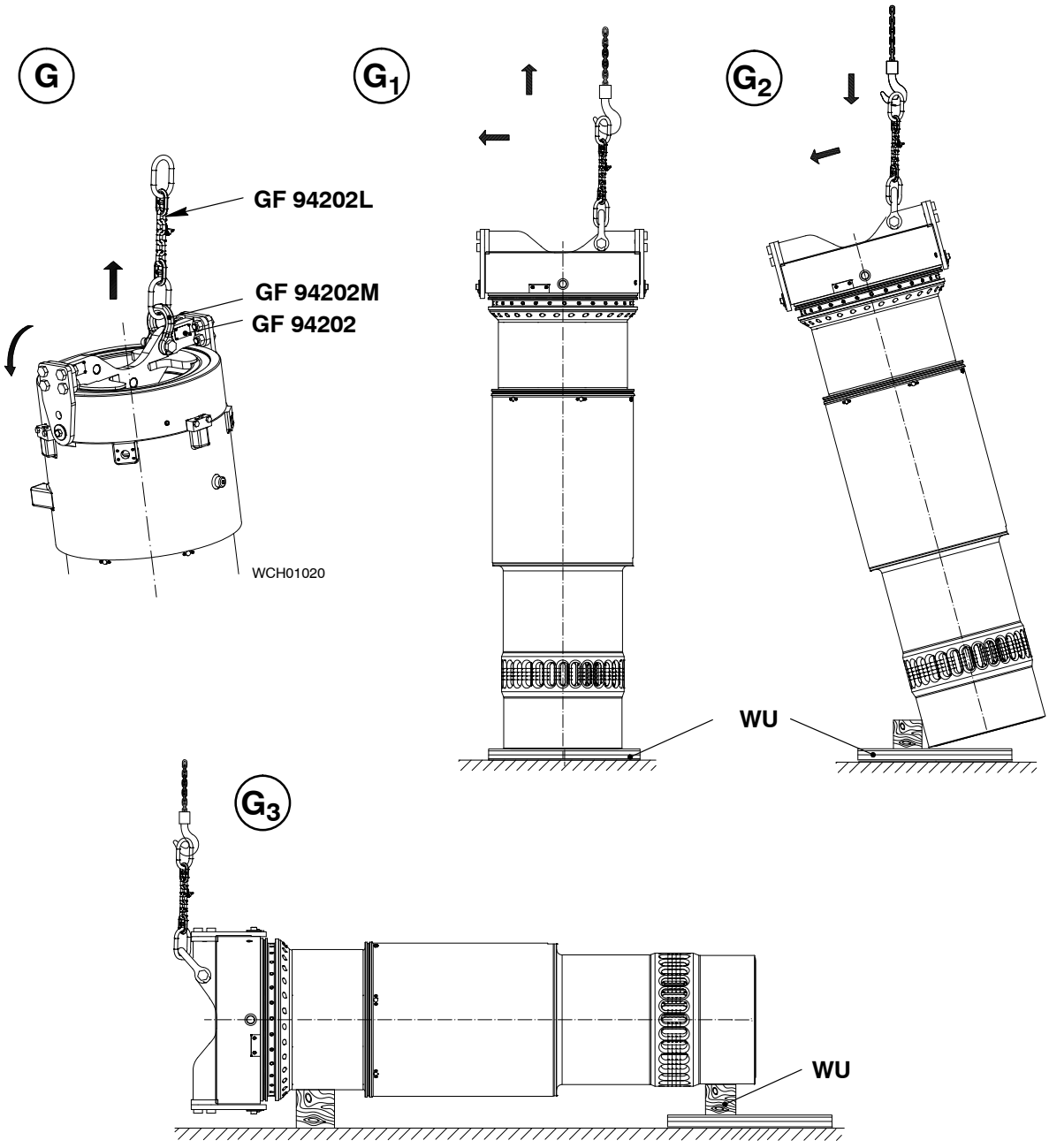
⇒ Change position of shackle GF 94202M as shown below.

⇒ Connect the chain GF 94202L (WLL 4000 kg) to the crane. Lay down the cylinder liner following the sequence drawn below and secure it against rolling away by means of wooden underlays and wedges.

- Raising the cylinder liner is carried out in reversed sequence.

Risk of accident! **Laying down and raising a cylinder liner must not be done in any other way than as shown in the figures!**

Never lay down the cylinder liner with fitted water guide jacket or insulation bandage!



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Cylinder Liner

Removing Wear Ridge, Re-dressing Lubricating Grooves and Scavenge Ports

Tools:

1	Wear ridge grinding device	94299

Key to Illustrations:

1	Roller support	9	Thread nozzle
2	Holder	10	Carbide milling cutter
3	Holder	11	Cylinder liner
4	Spacer roller	12	Top piston ring
5	Pipe (column)		
6	Grinder		
7	Air hose	SI	Scavenge port
8	Hose oiler	SN	Lubricating grooves

1. General

Due to wear in the cylinder liner a ridge is formed on top to where the piston rings do not reach. By that also the lubricating grooves in the cylinder liner lose their depth, and the corner radii of the scavenge port edges become smaller.

After every piston removal measure the bore of the cylinder liner (see 2124–1) and remedy any irregularities. For that the following points are of importance:

- Protect the space below the cylinder liner from falling particles.
- After completing the reconditioning, clean the bore of the cylinder liner thoroughly (particularly the lubricating grooves).
- Remove waste particles which may have passed into the scavenge space through the ports.
- Actuate the cylinder lubrication until oil flows from all the lubricating points, thereby flushing away any metal dust.

2. Removing wear ridge



When grinding away the wear ridge take greatest care not to damage the running surface. The machining of the wear ridge has to be carried out as shown in Fig. 'B'.

Therefore, always use wear ridge grinding device 94299 for carrying out this work.

3. Re-dressing the lubricating grooves

If the depth of the lubricating grooves has worn to less than 1.5 mm, re-dress them to their original depth and slightly round their edges with an oil stone.

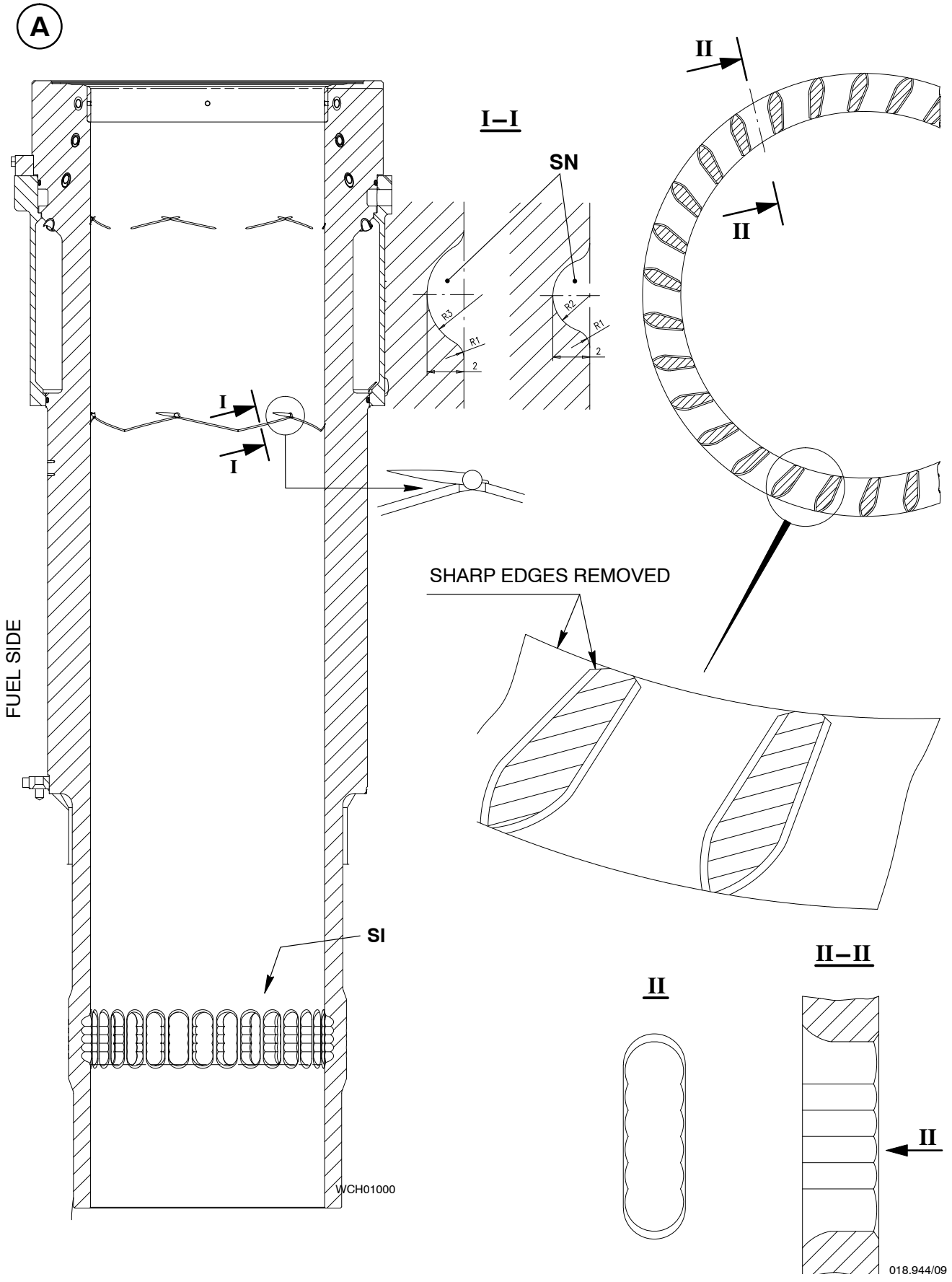


Remark: There are two possible lubricating groove-machining options according to section I–I in Fig. 'A'.

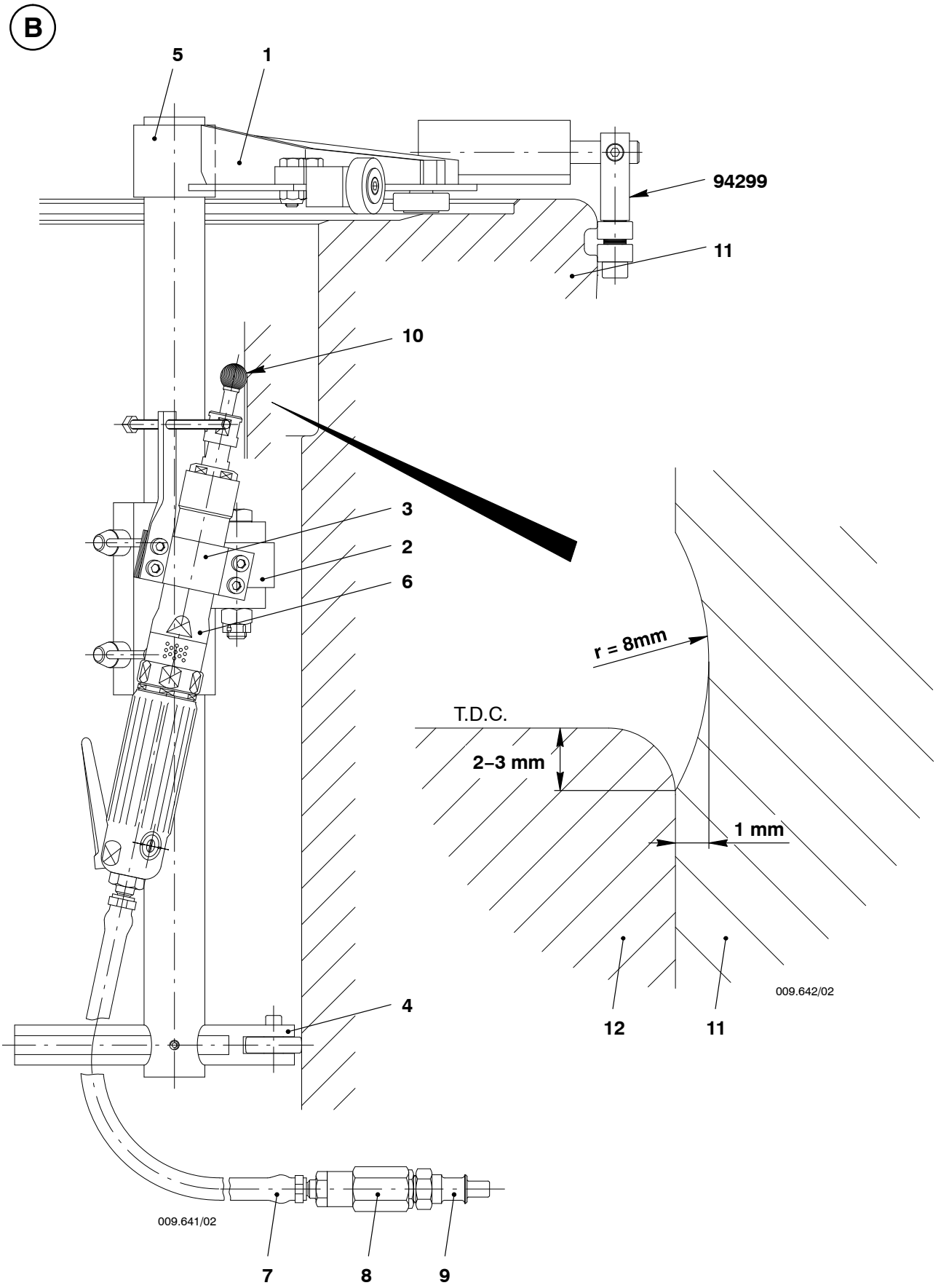
4. Re-dressing edges on scavenge ports

The shape of the scavenge ports shown in Fig. 'A' corresponds to new cylinder liners. When reconditioning (depending on the degree of wear or damage) aim at matching these shapes. Take care not to damage the running surface in the cylinder liner bore! Polish (round) the passages into the running surface with emery cloth.

Cylinder Liner: Re-dressing Lubricating Grooves and Scavenge Ports



Cylinder Liner: Removing Wear Ridge



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Lubricating Quill

Removal and Fitting — with Pulse Jet Lubrication

Tool:

1	Tool box with fittings for charging accumulator	94720C
1	HP oil pump	94931
1	Hydr. distributor (with pr. gauge 0...25 bar)	94934H
1	Connection nipple (G¼")	94934I
1	HP hose	94935

Key to Illustrations:

1	Cylinder liner	13	4/2-way solenoid valve
2	Lubricating pump	14	Sink plunger
3	Accumulator	15	Pin (tool)
4	Water guide jacket (lower part)	16	Shut-off valve servo oil
5	Lubricating quill (items 6 to 8)	17	Venting valve servo oil
6	Nozzle tip	18	Venting valve lube oil
7	Holder	19	Pipe bracket
8	Non-return valve	20	Stop valve
9	Screw		
10	Screw-in union		
11	Angle union		
12	Lubricating oil pipe	DF	Sealing surface

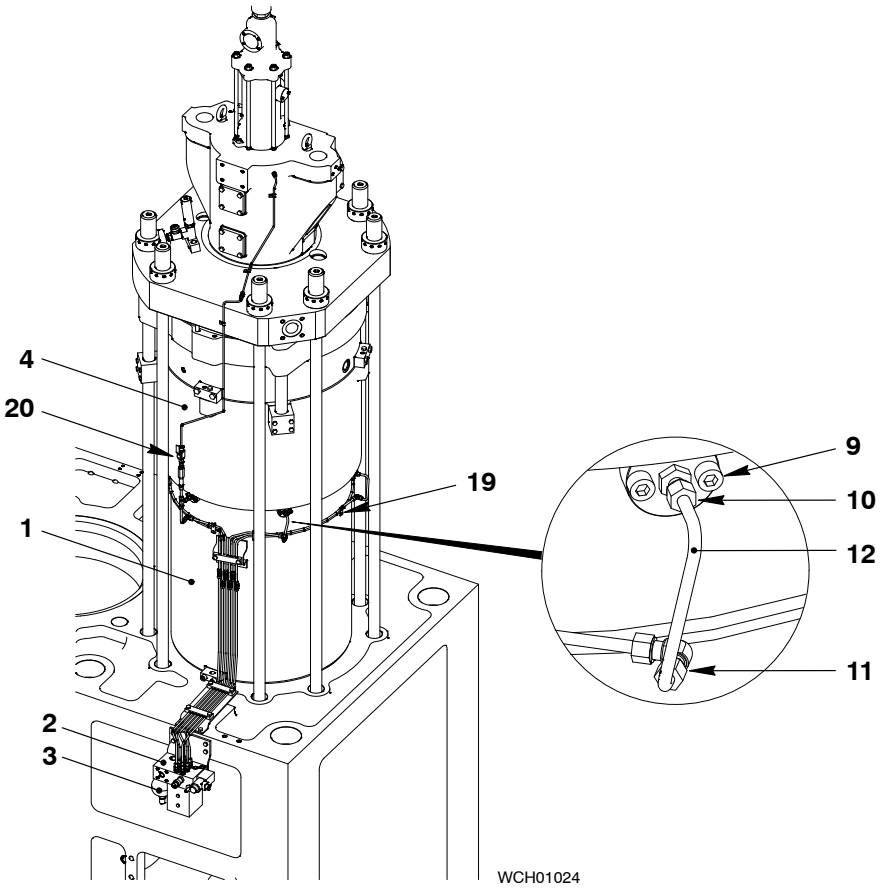
1. General

If the lubricating quill (items 6 to 8) must be removed with cylinder liner in situ, the cylinder cooling water must not be drained.

In order to remove a cylinder liner 1 however, it is recommended to remove first all lubricating quills, **whereby the cylinder cooling water must be drained on the relevant cylinder** (see 2708–1 'Removal of cylinder cover').

Remark: For the handling of stop valve 20 see detailed instructions in the Operating Manual 7218–1.

A



2. Removal and fitting of lubricating quill

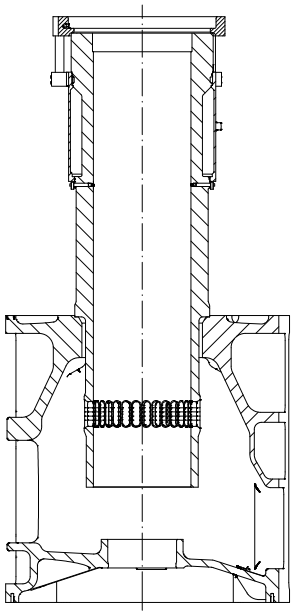
⇒ Loosen screws 9, nuts of screw-in union 10 and angle union 11 (Fig. 'A'). Disconnect lubricating oil pipe 12 and protect it against any damages and entering of dirt.

⇒ Remove lubricating quill.

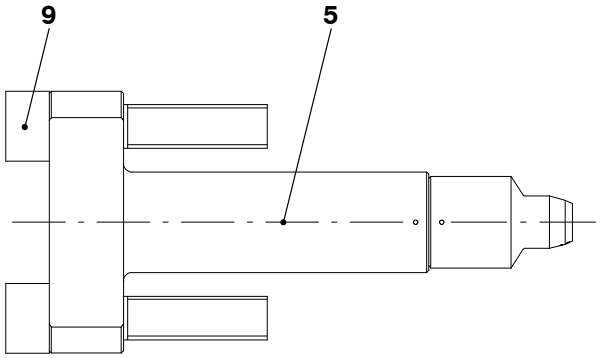
Remark: The assembly of nozzle tip / nozzle holder is based on the press fit design. **The lubricating quill must be replaced as a whole unit, i.e. nozzle tip 6 with non-return valve 8 inserted and holder 7.**

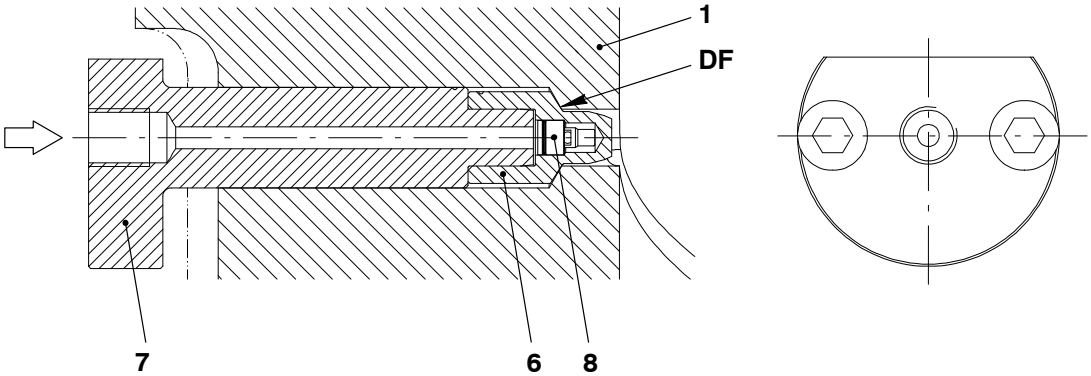
- When refitting the lubricating quill, the sealing surface 'DF' must be clean and undamaged, as it seals metallically. Moreover, the proper seat angles in the cylinder liner (120°) and on the nozzle tip (114°) differs slightly. Therefore, do not use any gasket between cylinder liner 1 and nozzle tip 6!
- Tighten the oiled screws 9 with a torque of max. **10 Nm**.

B



WCH00201





3. Checking a non-return valve

For judging the proper functioning of the non-return valve an opening pressure test **(opening pressure = 5 bar)** must be carried out.

During testing the lubricating quill should be kept in horizontal position and an oil with a viscosity of either SAE 50 at 40°C (approx. 200 cSt) or SAE 30 at 25°C (approx. 190 cSt) must be used.

3.1 Test procedure

- Instead of screw-in union, fit connection nipple 94934I into lubricating quill.

⇒ Connect lubricating quill 5 to oil pump 94931 as shown below.

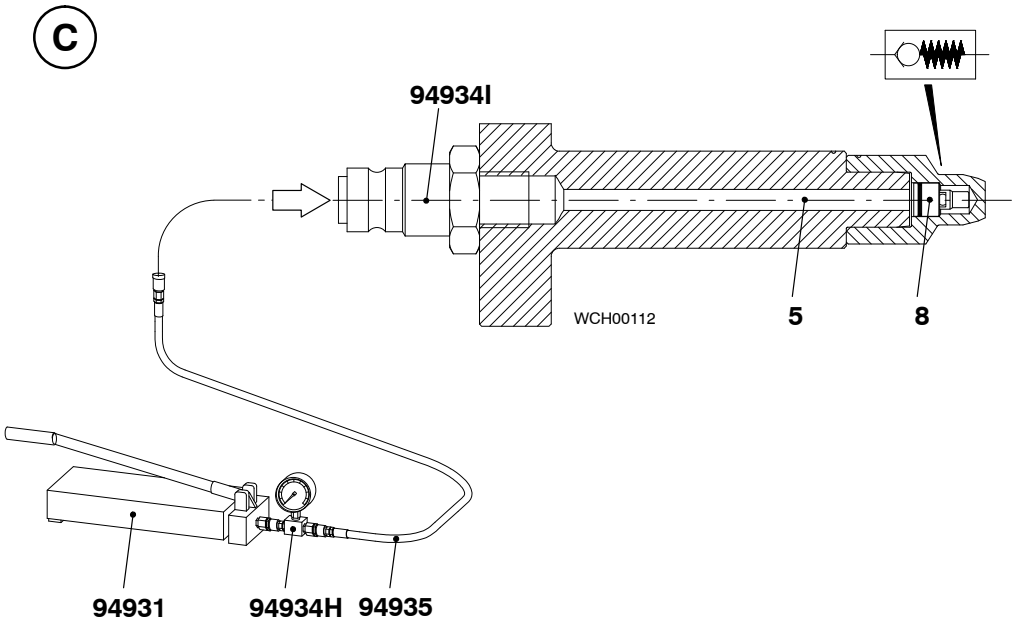
⇒ Vent the lubricating quill.

⇒ Apply a pressure of 2 bar and increase it in steps of 1 bar until the non-return valve opens.

⇒ Note down the opening pressure.

Remark: The opening (cracking) pressure should be at least 4.25 bar for correct functioning.

With an opening pressure below 4.25 bar the non-return do not function properly or it is damaged and must be replaced.



3. Venting of the cylinder lubricating system

A function control must be carried out after every assembly of the lubricating quills, tightening lubricating oil pipes 12 and pipe brackets 19. The lubricating oil pipes must be vented at screw-in union 10.

⇒ Select the respective cylinder number on context MANUAL LUBRICATION ON CYLINDER shown on the operator interface or manually operate 4/2-way solenoid valve 13.

⇒ Hold the position of the union with an open-end spanner while loosening the lower union nut by about 1 to 2 turns.

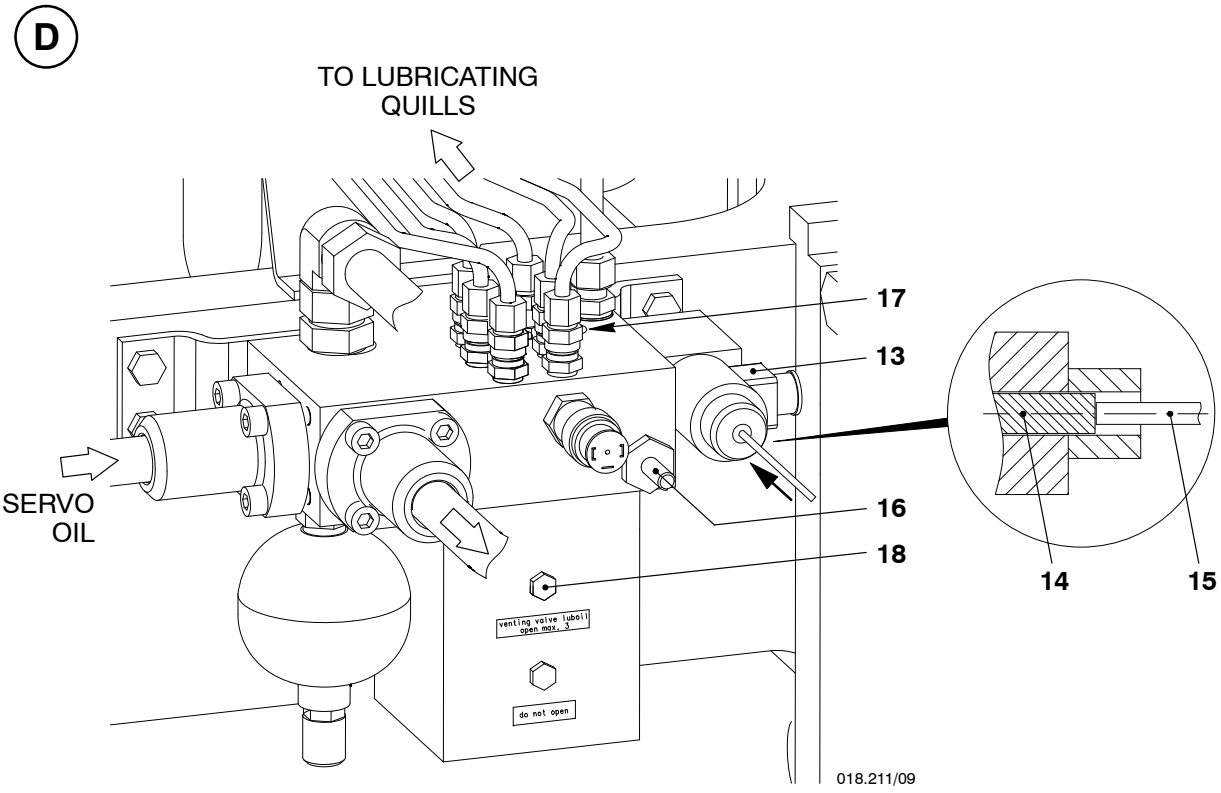
⇒ Push with pin 15 (diameter 3.5 mm) on top of sink plunger 14 of the 4/2-way solenoid valve. This must be repeated until the cylinder lubricating oil is flowing bubble-free out of the loosened connection.

Remark: As described above the lubricating module can also be operated with the operator interface of the control system. Further information and adjustments about the lubricating pumps are given in the Operating Manual 7218–1.

Venting valve 18 to lubricating pump 2 may be opened by max. three turns only.

⇒ Hold the position of the union with an open-end spanner while tightening the lower union.

- If all cylinder lubricating oil pipes are vented and afterwards properly tightened again, actuate the cylinder lubrication module until bubble-free cylinder oil emerges from all lubricating points in the respective cylinder liner. This visual inspection of the lubrication process is carried out through the scavenge ports at piston underside and the piston is therefore at T.D.C. position.



Piston Rod Gland

Dismantling and Assembling, Measuring the Wear

Tools:

1	Dismantling device (recommended special tool)	94344
2	Distance holders	94345
1	Clamping ring (2-part)	94345B
1	Gauge	94345C
2	Spring assembly tools	94345E
4	Distance pieces	94345F
1	Piston supporting device	94350

Key to Illustrations:

1	Housing (2-part)	11	Cylinder cover stud
2	Scraper ring	12	Screw
3	Sealing ring	12a	Fitted bolt
4	Sealing ring	13	Locking plate
5	Ring support	14	Screw
6	Scraper ring	15	Ring (2-part)
7	Locating pin	16	Cylinder block
7a	Locating pin	17	Piston rod
8	Tension spring	18	Hinged cover
9	Tension spring	19	O-ring
10	Screw	20	Screw

Overview

1. General 1/7
2. Removing, dismantling and assembling (variant 1) 2/7
2.1 Removing a gland 2/7
2.2 Dismantling a gland 2/7
2.3 Assembling a gland 4/7
3. Removing, dismantling and assembling (variant 2) 6/7

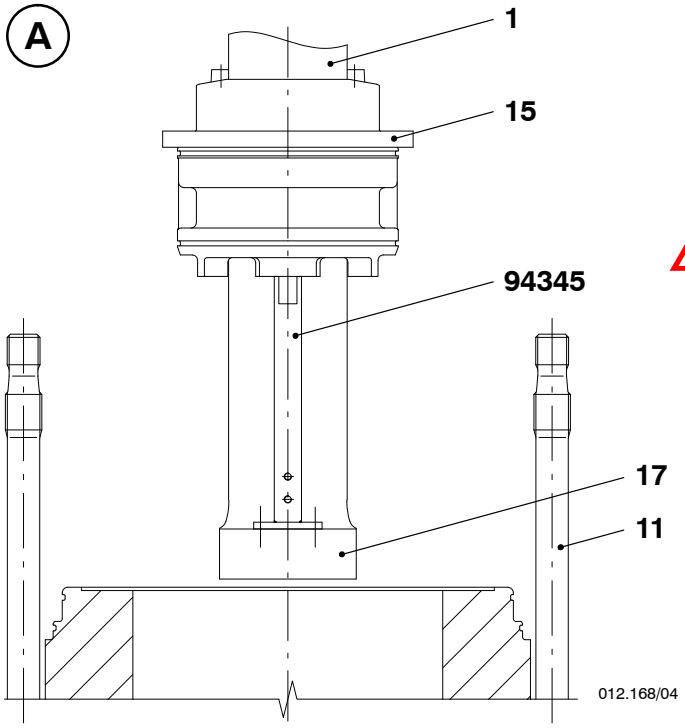
1. General

The removal of the piston rod gland (hereafter called gland) can be carried out in two different ways, i.e. removing the gland together with the piston (variant 1) or removing the gland downwards into the crankcase leaving the piston in situ and using dismantling device 94344 (variant 2).

On every piston overhaul, the gland must also be dismantled and inspected. Excessively worn or damaged parts are to be replaced.
It is important that the gland be in perfect condition when assembled. A possible earlier than planned inspection of the gland with a piston in situ can only be carried out under difficult conditions and with the help of dismantling device 94344.

Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

2. Removing, dismantling and assembling (variant 1)



2.1 Removing a gland

⇒ Both distance holders 94345 are to be screwed on the foot of piston rod 17 (Fig. 'A').

⇒ Unscrew the four outer screws 14 to 2-part ring 15 (Fig. 'B').

Attention! **For reasons of safety**, the ten inner screws 10 to 2-part ring 15 (Fig. 'B') are to be loosened and removed **after** dismantling the gland.

- Remove the piston including gland (see 3403–1 'Removal of a piston').

2.2 Dismantling a gland

⇒ Place the piston in piston supporting device 94350. For this 2-part housing 1 of the gland must rest on the two hinged covers 18 of the device.

⇒ Loosen screws 10 and remove 2-part ring 15 (Fig. 'B').

⇒ Loosen and remove screws 12 and fitted bolts 12a to 2-part housing 1.

⇒ Push both halves of the 2-part housing away from the piston rod.

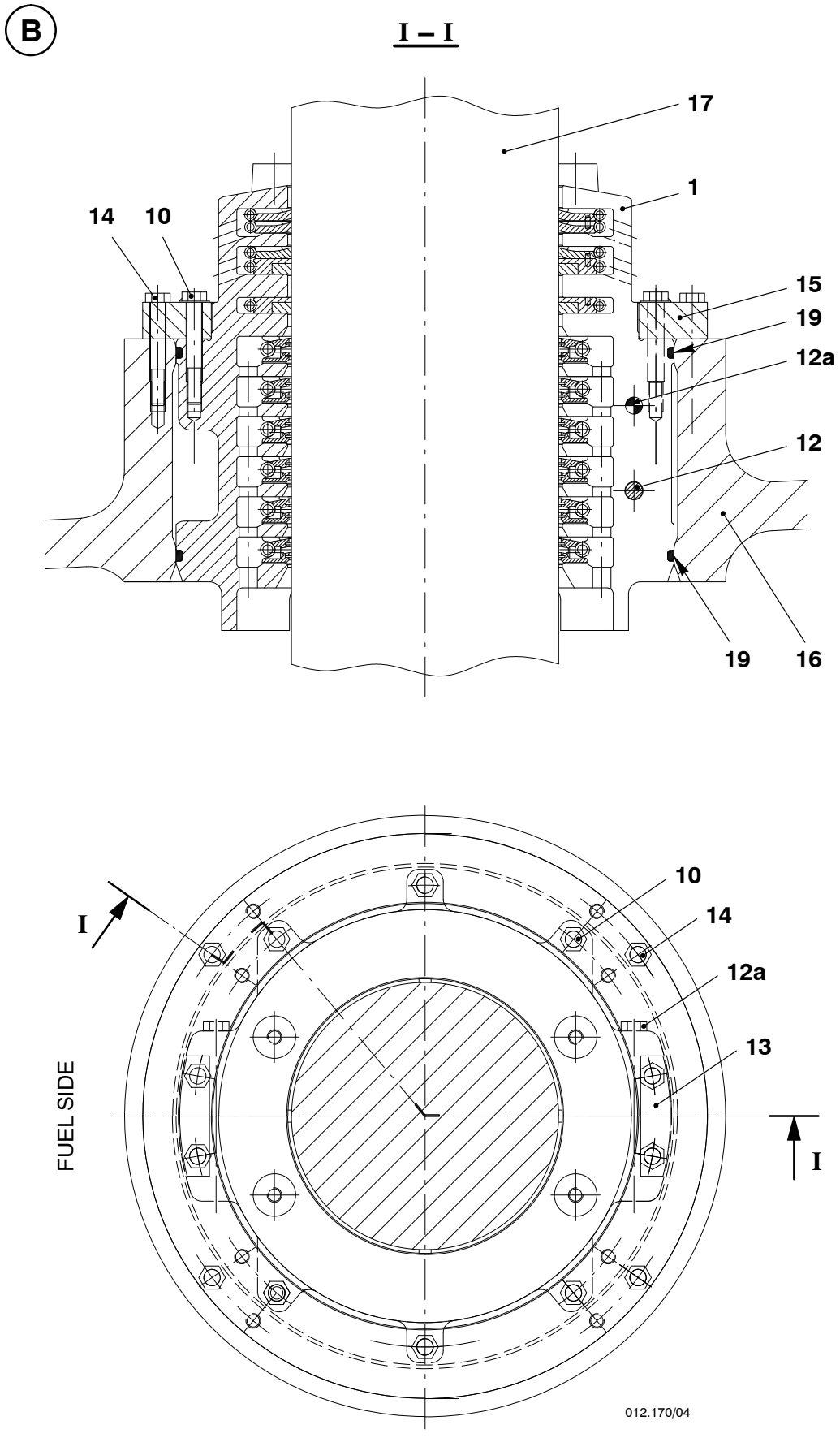
⇒ Remove all tension springs, scraper rings, sealing rings, and ring supports.

⇒ Determine the wear on the following parts (Fig. 'D') and compare it with the permissible values mentioned in clearance table 0330–1:

- Scraper rings 2 and 6
- Sealing rings 3 and 4

- Parts which are beyond the admissible tolerance must be replaced. If necessary remove scraper rings 6 from ring supports 5 and replace them with new ones.
- Defective tension springs 8, 9 and O-rings 19 have to be replaced with new ones.

Piston Rod Gland: Dismantling and Assembling, Measuring the Wear



2.3 Assembling a gland

⇒ Place the piston in piston supporting device 94350, its hinged covers 18 must be folded down.

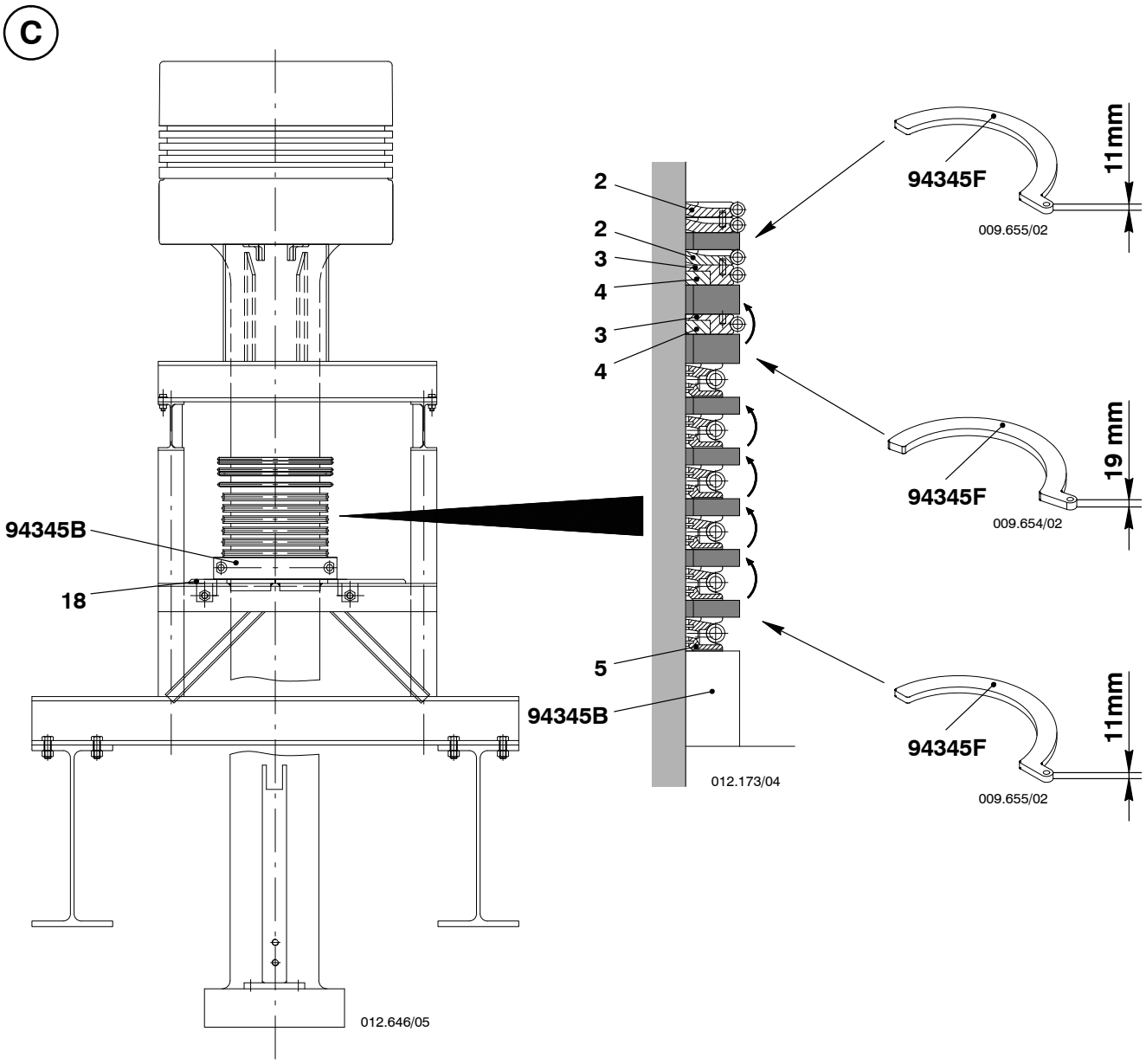
⇒ Attach clamping ring (2-part) 94345B – resting on hinged cover – to piston rod 17.

⇒ Place the three parts of a ring support 5 on the clamping ring with scraper ring 6 (Fig. 'D') fitted. Distribute the distances evenly.

⇒ Use assembly tool 94345E (see 9403–5) for fitting tension spring 9.

⇒ Place two distance pieces 94345F (11 mm) on ring support 5 and fit another ring support with scraper ring 6 and tension spring 9 as described above.

- The height of distance pieces 94345F corresponds to the respective web height of the ring grooves in 2-part housing 1.



Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

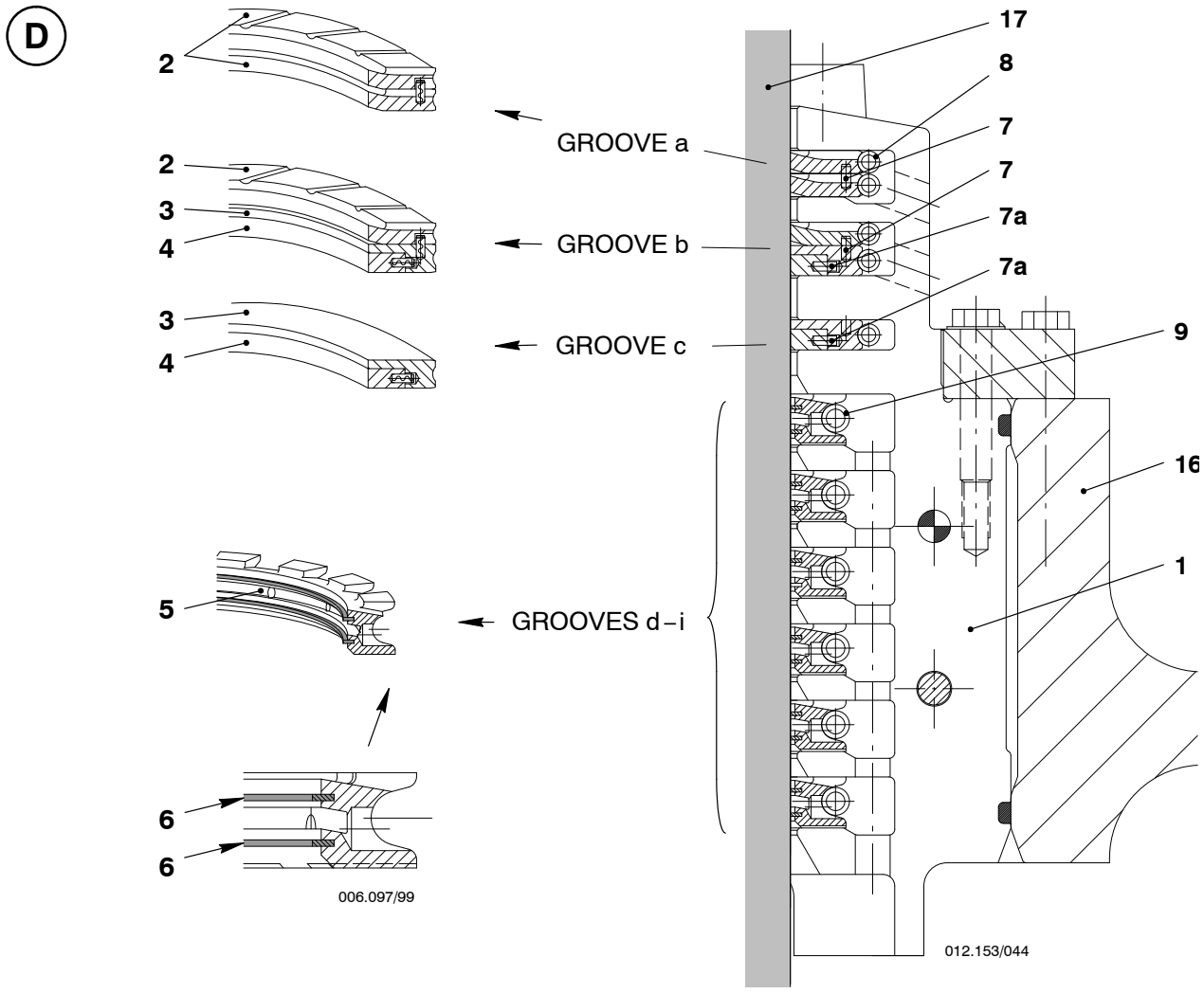
⇒ After assembly of the ring supports for grooves 'd' – 'i' (Fig. 'D'), place two distance pieces 94345F (19 mm) on the uppermost ring support 5 and fit sealing rings 3, 4 and tension spring 8 for groove 'c'.

- Take care that **one** segment is always provided with two horizontal locating pins 7a lying side by side on sealing ring 4. These locating pins must fit into the corresponding bores in sealing ring 3. Remove possibly existing vertical locating pins 7.
  The remaining three segments are provided only with one horizontal locating pin each.

⇒ Place distance pieces 94345F (19 mm) on the assembled sealing ring 3 and fit again sealing rings 3, 4 and scraper ring 2 with tension springs 8 for groove 'b'.

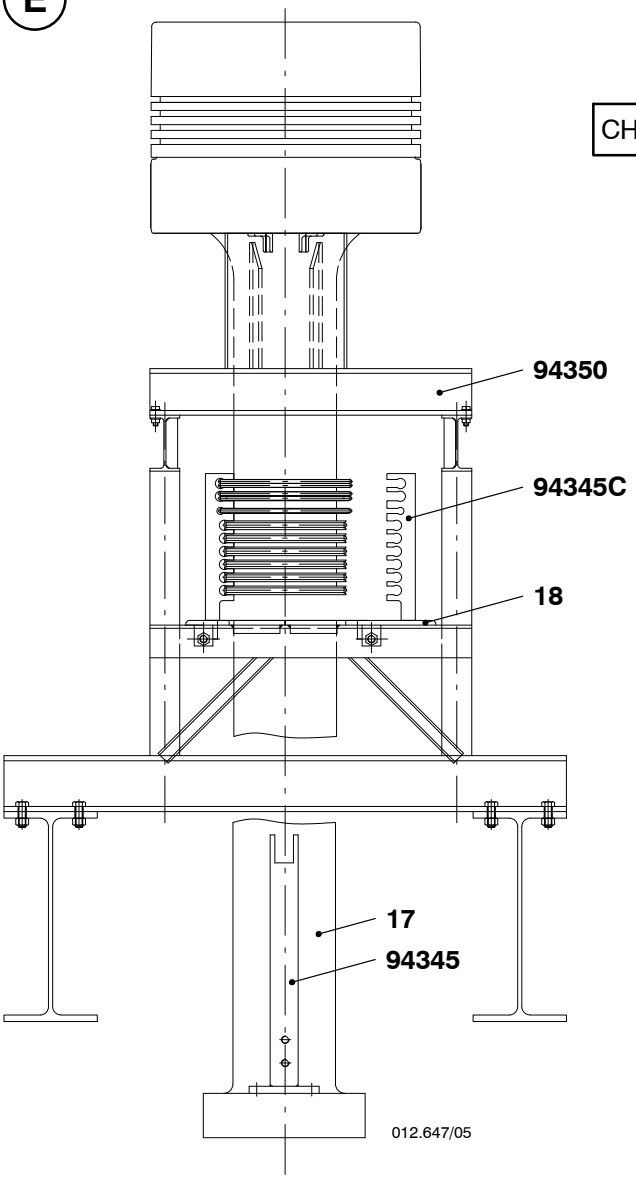
- Proceed in the same way as mentioned above for sealing rings 3 and 4, however, a vertical locating pin 7 in sealing ring 3 must fit into the respective recess in scraper ring 2.
  No vertical locating pin may be fitted in the scraper ring.

⇒ Place distance pieces 94345F (11 mm) on the assembled scraper ring 2 and fit the two uppermost scraper rings 2 with their tension springs 8 for groove 'a'.
No vertical locating pin may be fitted in the uppermost scraper ring.



Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

E



⇒ Remove all distance pieces 94345F and clamping ring 94345B.

CHECK Check proper position of all rings with gauge 94345C resting on hinged cover 18 (Fig. 'E').

⇒ Smear piston rod and all rings with bearing oil.

⇒ Push both housing halves 1 on hinged covers 18 over the ring pairs against the piston rod, then screw them together with screws 12 and fitted bolts 12a according Fig. 'B'.

⇒ Place O-rings 19.

⇒ Place 2-part ring 15 on the housing and screw it together by means of screws 10 and 14 (Fig. 'B'). Secure screws 10 with locking plates 13 on the housing division.

⇒ Just before the gland is fitted with the piston, apply lubricating oil to the respective bores in the cylinder block as well as to the gland housing in the region of the O-rings.

- When fitting the gland into the cylinder block distance holders 94345 must be mounted on the foot of the piston rod.
- For fitting the gland in the cylinder block see also 3403–1.

3. Removing, dismantling and assembling (variant 2)

For removing the gland with piston in situ using dismantling device 94344 (Fig. 'F') the following procedure should be observed:

⇒ Turn the piston to B.D.C.

⇒ Dismantling device 94344 (2-part) as shown in Fig. 'F' is to be set on the stud nuts of the crosshead/piston rod connection and both halves of the dismantling device are to be screwed together.

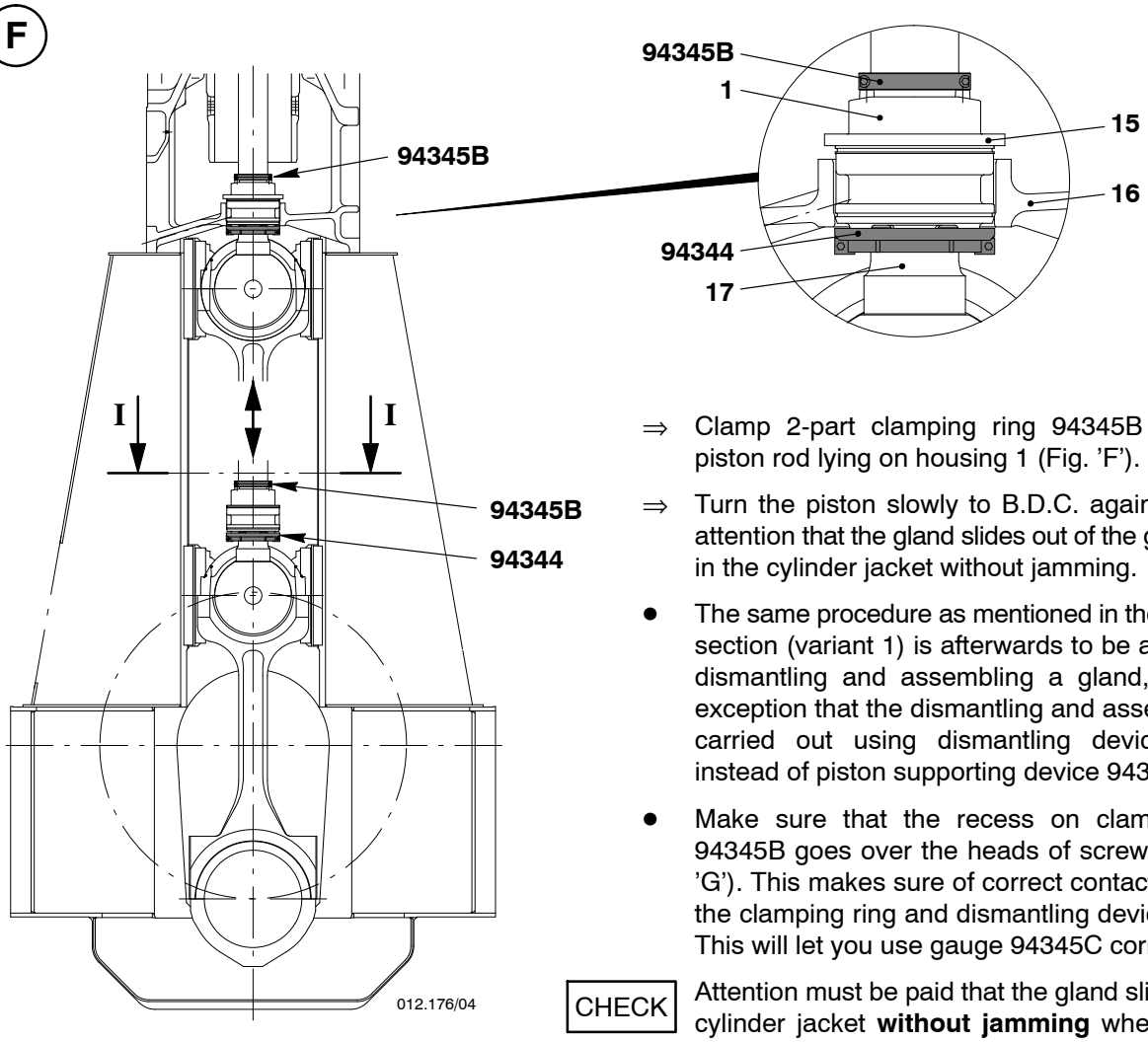
⇒ Loosen and remove the four outer screws 14 from 2-part ring 15 (Fig. 'B').

⇒ Turn the piston with the mounted dismantling device carefully to T.D.C. until 2-part ring 15 is pushed a little upwards (Fig. 'F').

⇒ Loosen and remove the ten inner screws 10 together with 2-part ring 15 (Fig. 'B').

Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

F



⇒ Clamp 2-part clamping ring 94345B onto the piston rod lying on housing 1 (Fig. 'F').

⇒ Turn the piston slowly to B.D.C. again and pay attention that the gland slides out of the gland bore in the cylinder jacket without jamming.

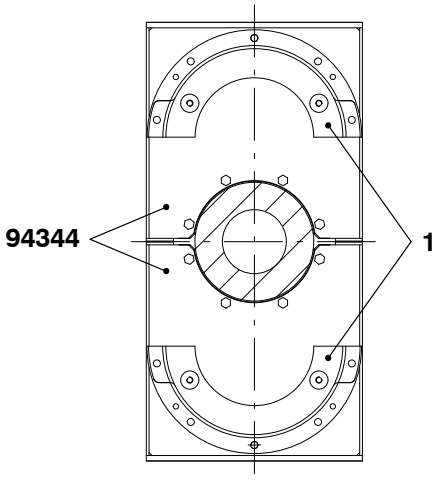
- The same procedure as mentioned in the previous section (variant 1) is afterwards to be applied for dismantling and assembling a gland, with the exception that the dismantling and assembling is carried out using dismantling device 94344 instead of piston supporting device 94350.
- Make sure that the recess on clamping ring 94345B goes over the heads of screws 20 (Fig. 'G'). This makes sure of correct contact between the clamping ring and dismantling device 94344. This will let you use gauge 94345C correctly.

CHECK Attention must be paid that the gland slides in the cylinder jacket **without jamming** when assembling it using dismantling device 94344 and the turning gear.

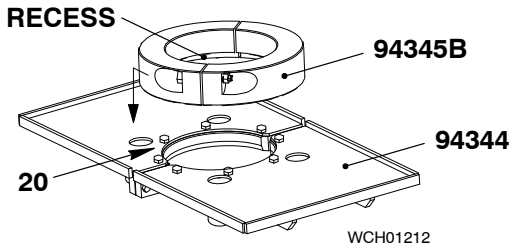
⇒ Turn the piston to T.D.C. Fit 2-part ring 15, fasten it with inner screws 10 and secure it with locking plates 13 on the housing division (Fig. 'B').

⇒ Turn the piston to B.D.C. and remove dismantling device 94344. Subsequently screw in and tighten outer screws 14.

I – I



G



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Cylinder Cover

Removal and Fitting of Cylinder Cover and Water Guide Jacket

Tools:

1	Suspension device	GF 94265

Key to Illustrations:

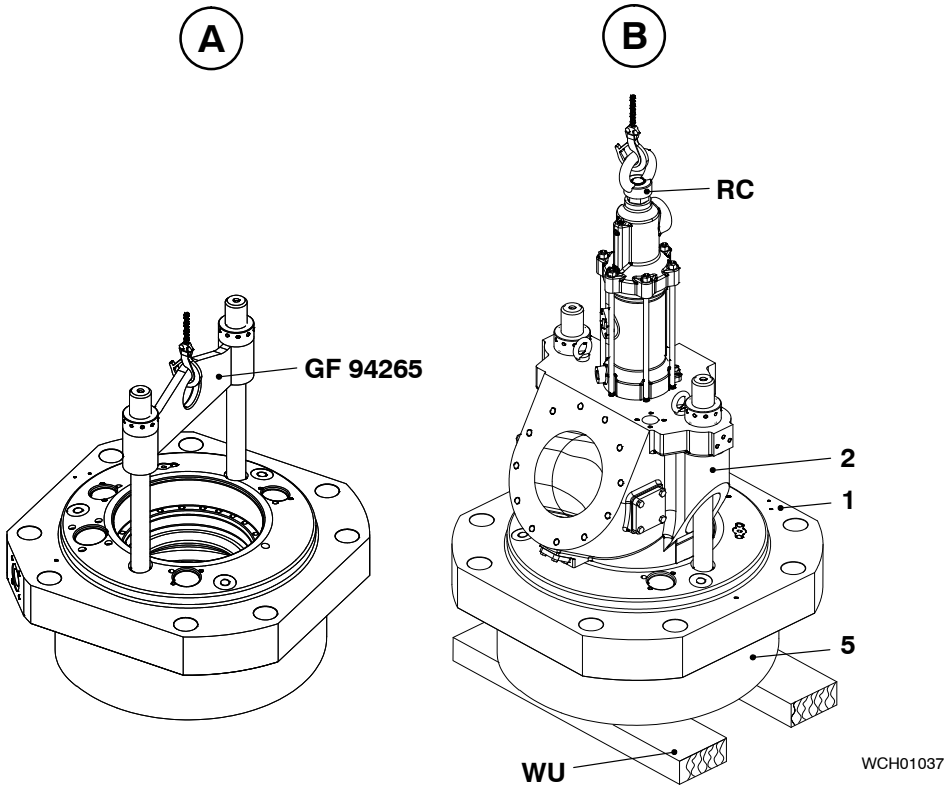
1	Cylinder cover	8	Pad
2	Exhaust valve cage	9	Pipe
3	Cylinder liner	10–12	O-rings
4	Joint ring		
5	Upper water guide jacket	RC	Eye bolt
6	Lower water guide jacket	TH	Threaded hole
7	Allen screw	WU	Wooden underlay

1. General

Risk of accident! The cylinder cover may be lifted or transported with tool GF 94265 and eye bolt 'RC' which is part of the exhaust valve as shown in Fig. 'A' and 'B'.

Risk of accident! 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.

Attention! **Wooden underlays 'WU' placed on the upper platform are provided for cylinder cover overhauling. However, they may be used at port only, and in no case this may serve as storage place during the voyage!** Moreover, always bear in mind, that the passage between engine and cylinder cover is limited (e.g. as possible escape route) on the platform.



Removal and Fitting of Cylinder Cover and Water Guide Jacket

2. Removal of cylinder cover

⇒ Drain cylinder cooling water (see Operating Manual 8017–1).

⇒ Disconnect all connections to the cylinder cover and to the exhaust valve as well as the expansion piece between exhaust valve and exhaust manifold.

- Expansion piece 2751–1.
- Hydraulic Pipe for Exhaust Valve Drive 8460–1.
- HP Pipe to Injection Valve 8733–1.

⇒ Loosen nuts of cylinder cover elastic studs (see 2708–2).

⇒ Lift complete cylinder cover 1 with the engine crane.

Risk of accident! Heavy parts can fall down. Do not stand under the hanging parts. Injury to personnel can occur.

Risk of accident! Heavy parts can crush body parts. Always use correct personal protective equipment.

⇒ Place cylinder cover 1 with exhaust valve cage 2 and water guide jacket 5 onto wooden underlays 'WU' (Fig. 'B').

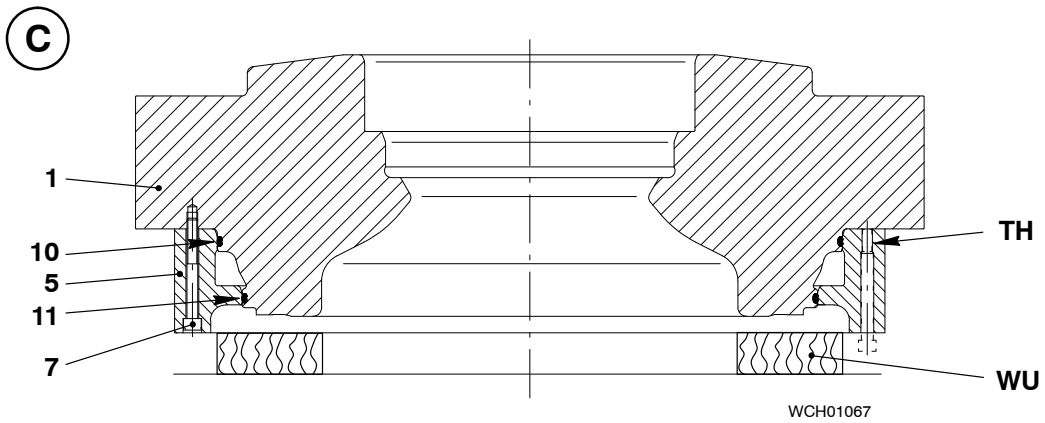
3. Removal of water guide jacket

⇒ Loosen all Allen screws 7.

⇒ Screw them into the three threaded holes 'TH' until they stop at the cylinder cover.

⇒ Lift the cylinder cover slightly with the crane approx. 10...20 mm. Continue to drive in the Allen screws. Repeat this action until the water guide jacket is withdrawn from the cylinder cover and lies on wooden underlays 'WU'.

Risk of accident! Never put your hands between the water guide jacket and the wooden underlays!



4. Fitting of water guide jacket and cylinder cover

Fitting the water guide jacket and cylinder cover are carried out analogously to the removal but in reverse sequence, whereby attention must be paid to the following:

Removal and Fitting of Cylinder Cover and Water Guide Jacket



Risk of accident! Heavy parts can fall down. Do not stand under the hanging parts. Injury to personnel can occur.



Risk of accident! Heavy parts can crush body parts. Always use correct personal protective equipment.

4.1 Water guide jacket

- Clean all the sealing faces and O-ring grooves.
- Fit new O-rings 10 and11 in cylinder cover 1 and oil them slightly.
- Unscrew Allen screws 7 from the threaded holes 'TH'.
- Align cylinder cover above upper water guide jacket 5 in such a way that tape holes and through holes in water guide jacket for the Allen screws are in line.
- Drive Allen screws into the through holes evenly until the water guide jacket contacts the cylinder cover. Tighten the Allen screws.

4.2 Cylinder cover

Before placing the cylinder cover in position the following points must be taken care of:

- The compression space must be absolutely free of foreign particles or dirt.
- The seating surfaces on cylinder cover and cylinder liner must be clean and undamaged.
- A new soft iron joint ring 4 of 2 mm thickness must be placed on the cylinder liner in such a way that it lies flat all over.
- Fit new O-rings 12 in pipes 9 and oil them slightly.
- Threads of cylinder cover elastic studs must be clean and smeared with oil.

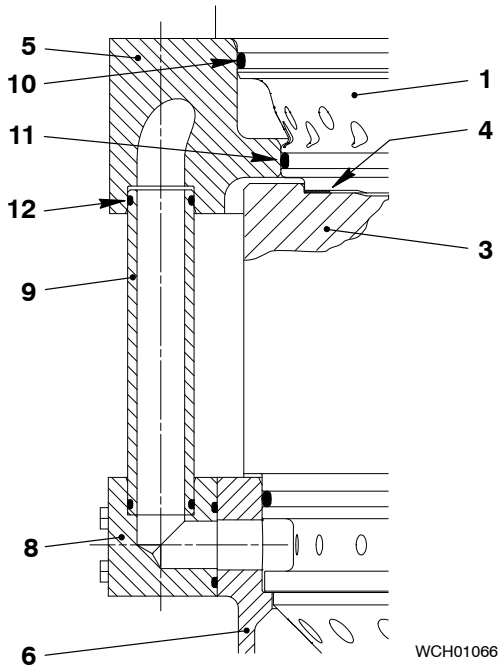
When these conditions are met, align the bores in the upper water guide jacket 5 with pipes 9 and lower the cylinder cover slowly over the elastic studs.

- Screw all the nuts by hand onto the cylinder cover studs, paying attention to easy turning.
- Tighten nuts of elastic studs (see 2708–2).
- Reconnect all connections to cylinder cover and to exhaust valve as well as expansion piece between exhaust valve and exhaust manifold.

CHECK

A leak test must be carried out after fitting of a cylinder cover with cooling water pump switched on and running at its normal operating pressure.

D



Cylinder Cover

Loosening and Tensioning of Cylinder Cover Elastic Studs

	Tools:	
1	Hydraulic tensioning device	CF 94215
	consisting of:	
	8 Pre-tensioning jacks	CF 94215
	7 HP hoses	CF 94215K
1	Connection block	94934
1	Hydr. distributor	94932
3	HP hoses 2600 bar	94935
1	Hydraulic unit	94942

Key to Illustrations:

1 Cylinder cover
2 Cylinder cover elastic studs
3 Nut

1. General

For removal and fitting of a cylinder cover and water guide jacket see 2708–1.

Should a cylinder cover elastic studs have to be replaced, please observe the indication in 2751–1.

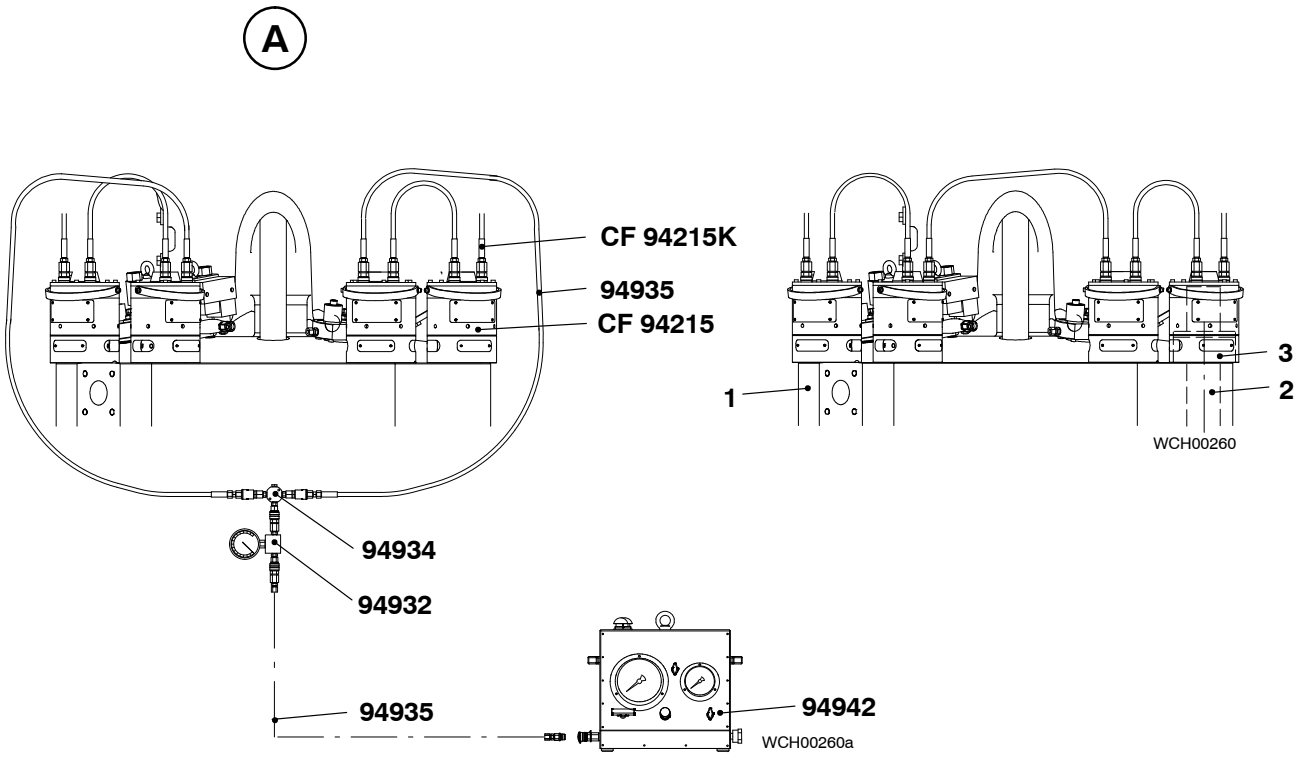
2. Loosening and tensioning of cylinder cover elastic studs

Please refer to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

- Tensioning of all eight studs 2 must be carried out in one step with **1500 bar**.

CHECK

Based on the markings applied, check by how much nuts 3 were turned after pre-tightening by means of round bar 'RS'. **Tightening angle** to be approx. **520**° for comparison.



Loosening and Tensioning of Cylinder Cover Elastic Bolts

Where it is found that a nut of the elastic stud can be turned considerably less than the others, it must be assumed that the respective studs has become insufficiently tensioned.

Possible causes:

- Sealing rings, i.e. back-up and O-rings defective.
- Piston of pre-tensioning jack jams.
- Junctions of HP hoses leaky.

- To remedy the cause, loosen all studs and then repeat the tensioning procedure according to 9403–4.

⇒ Release pressure to zero and remove all pre-tensioning jacks.

CHECK

Verify again that all nuts have been turned by an angle of approx. **520**°.

For loosening the elastic studs, screw back the round nuts by about **1 turn**.

Cylinder Cover

Machining of Sealing Face for Injection Valve

Tools:

1	Overhaul device	94270
1	Overhaul device	94270f
1	Ring spanner AF24	

Key to Illustrations:

1	Cylinder cover	5	Profile cutter
2	Cutter holder	6	Centring mandril
3	Guide flange	7	Set screw
4	Screws		

1. General

The seat sealing face in the cylinder cover must be clean and undamaged as the sealing is metallic.



If any blow-by of combustion gases have been noticed during engine operation, the spring packets with their screws of the injection valve are not, under any circumstances, to be tightened further as a counter measure.



Risk of accident! Heavy parts can fall down and crush body parts. Use the correct support tool to work on the lower side of the cylinder cover. Always use the correct personal protective equipment.

2. Machining of sealing face

Dirty or slightly damaged sealing faces can be re-conditioned on the spot by using overhauling device 94270 or 94270f for injection valve with **F**uel **A**ctuated **S**acless **T**echnology (FAST).

⇒ Carefully insert profile cutter 5 into the hole in cylinder cover 1.

⇒ Fasten guide flange 3 with screws 4.

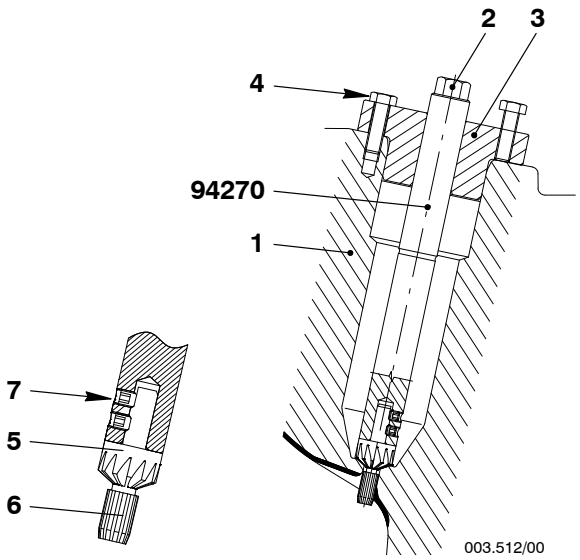
⇒ When the device is being used, the centring mandril on the profile cutter on the one hand and the guide flange on the other, give the device the necessary stability and direction.

⇒ Cutting is done by pressing down lightly with the hand on cutter holder 2 and turning the hexagon evenly with the other hand using a ring spanner.

⇒ Remove as little material as possible but sufficient to obtain a perfect seating area.

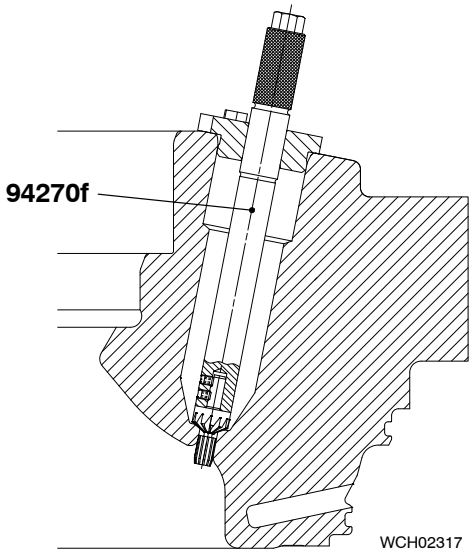
- Putting some sticky grease on the profiling cutter will prevent any foreign matter from entering the combustion chamber during overhaul.
- Two tapped holes in guide flange 3 are for the depository of screws 4.

A



B

VERSION INJECTION
VALVE WITH FAST



Tools:

1	Torque spanner	94011A
1	Slugging wrench	94269A–55
1	Hydraulic cylinder	94269B
1	Socket wrench insert	94269C–41
1	Socket wrench insert	94269C–55
1	Protection cap	94271
1	OBEL test bench	94272
1	Connecting piece	94272B
1	Valve holder	94273
1	HP hose	94275
1	Nozzle removal tool	94278A
1	Nozzle installation tool	94278B

Key to Illustrations:

1	Injection valve	14	Nozzle body
2	Allen screw	15	Clamping nut
3	Spring plate	16	Dowel pin
4	Cup spring packet	17	Dowel pin
5	Nozzle holder	18	Dowel pin
6	Collar nut	19	Spring cage
7	Spring tensioner	20	Receiver
8	Nozzle tip		
9	O-ring		
10	Tappet	LF	Leakage fuel
11	Coupling nut	SF	Sealing face
12	Compression spring	SS	Seating surface
13	Nozzle needle	WU	Wooden underlay

Overview

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2. Checking an injection valve 2/12
3. Judging an injection valve 3/12
4. Dismantling an injection valve 4/12
5. Assembling an injection valve 5/12
6. Adjusting the opening pressure 8/12
7. Replacing a nozzle tip 9/12
8. Arrangement of cup spring packet 11/12
9. Fitting an injection valve in cylinder cover 11/12
10. Protecting a nozzle tip 12/12
11. Storage and handling of injection valve 12/12

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 at 40 °C	mm^2/s	**ASTM D445**	2.6
Density at 15 °C	kg/m^3	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.

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! Moreover, the support must be removed from the valve holder when placing the injection valve with FAST (Fig. 'A').

⇒ Remove combustion residues and clean nozzle tip externally with a brass wire brush.

⇒ Place injection valve 1 with nozzle tip pointing downwards into valve holder 94273 and fasten it with Allen screws 2 and spring cages 19.

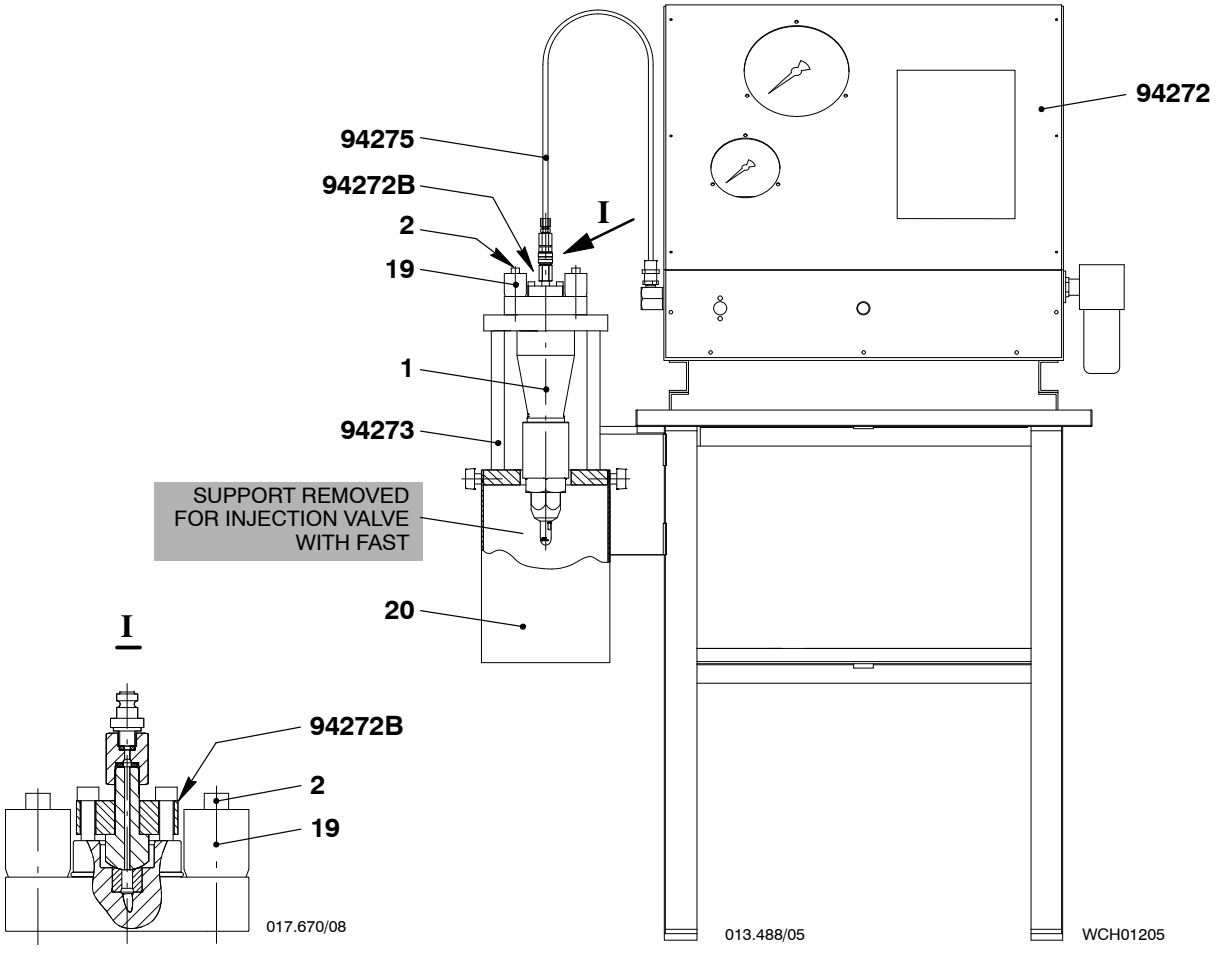
⇒ Tighten HP hose 94275 to connecting piece 94272B.

⇒ 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



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 **460 ±5 bar**.

  On **used** injection valves a pressure reduction of 30 bar may be acceptable. If a readjustment of the opening pressure be 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 8 must not be flushed out unduly.

⇒ Injection valves which do not spray efficiently must be dismantled as described in 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 holder 5 and nozzle body 14 (Fig. 'D') with poor sealing faces 'SF' must either be replaced or reconditioned by the manufacturer or an authorized company.

4. Dismantling an injection valve

⇒ Remove receiver 20.

⇒ Screw down injection valve 1 on valve holder 94273, as mentioned in section 2, however without connecting HP hose 94275.

⇒ Loosen collar nut 6 and unscrew spring tensioner 7 until the compression spring 12 is completely released (Fig. 'D').

⇒ Turn valve holder 94273 through 180° into vertical position.

⇒ 1ST step: Loosen clamping nut 15 (AF 41) by means of socket wrench insert 94269C–41 and torque spanner 94011A.

⇒ 2ND step: Loosen coupling nut 11 (AF 55) by means of slugging wrench 94269A–55 and hydraulic cylinder 94269B.

⇒ Unscrew the clamping nut and coupling nut.

⇒ Remove the nozzle body 14 with nozzle needle 13 and nozzle tip 8, tappet 10 and compression spring 12.

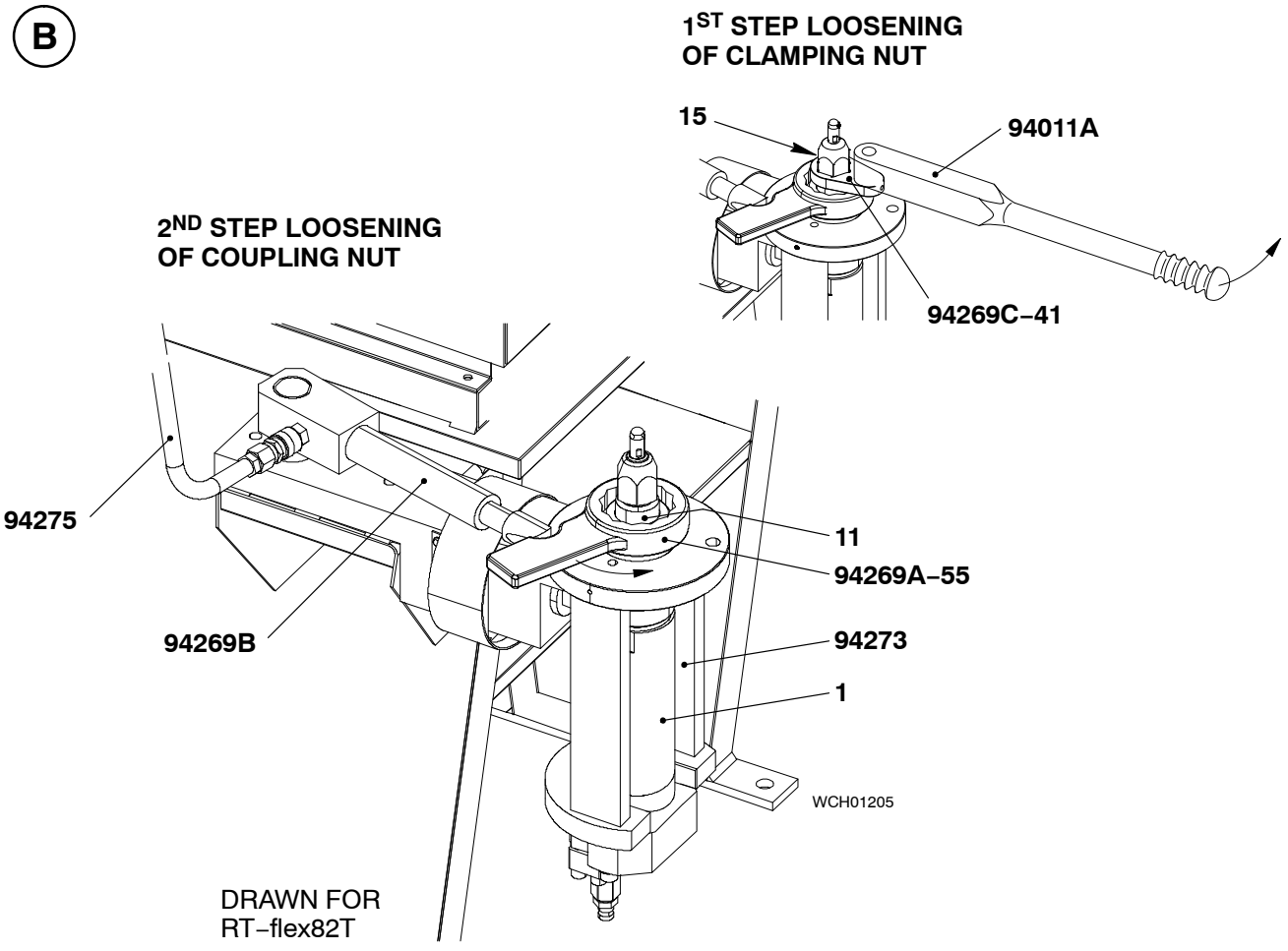
- If necessary, withdraw the nozzle tip in accordance with section 7.

CHECK

Examine all parts for their condition.

STOP

Never interchange nozzle needle 13 and nozzle body 14! Each nozzle needle belongs to its mated nozzle body into which it has been individually fitted with greatest precision.



5. Assembling an injection valve

5.1 Determining of the relevant tightening torque with displaced pivot point

Due to the displaced pivot point, make sure that the coupling nut 11 and clamping nut 15 is tightened only to the **reduced tightening torque** as explained below.

The set torque ST can be determined with the following data:

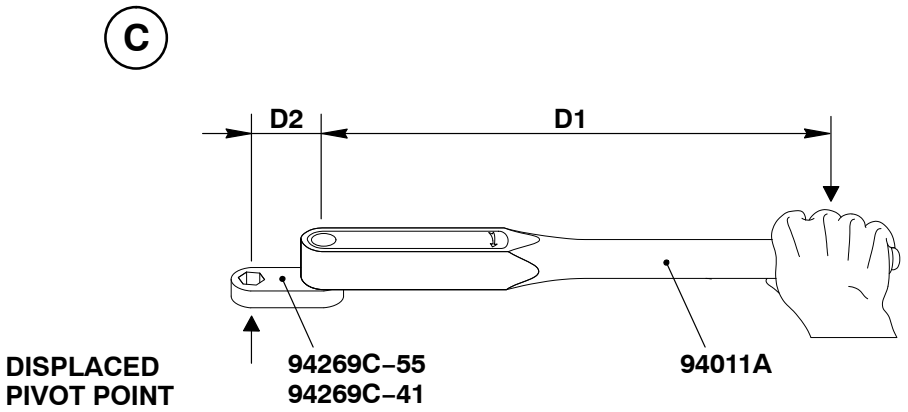
$$ST = \frac{TT \times D1}{D2 + D1}$$

	ST (Nm)	**TT** (Nm)	**D1** (mm)	**D2** (mm)
Coupling nut (11) AF55	**89**	100	530	65
Clamping nut (15) AF41	**172**	190	530	55

- ST = Set Torque to be set on the scale of torque spanner
- TT = Tightening torque specified for coupling nut and clamping nut
- D1 = Distance from middle of square drive to middle of handgrip
- D2 = Distance from middle of square drive to middle of coupling nut and clamping nut

Coupling nut (11) AF55 **100 x 530 : 65 + 530 = 89 Nm**

Clamping nut (15) AF41 **190 x 530 : 55 + 530 = 172 Nm**



5.2 Assembling

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 8, nozzle body 14 and nozzle holder 5 is given by dowel pins 16 and 17 (Fig. 'D').

⇒ 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.

⇒ If tappet 10, compression spring 12 and spring tensioner 7 with collar nut 6 are already fitted, the spring tensioner must be screwed by approx. one turn only, in order to prevent the compression spring from being under tension in any case, otherwise nozzle body 14 does not lie flat on nozzle holder 5 during assembly.

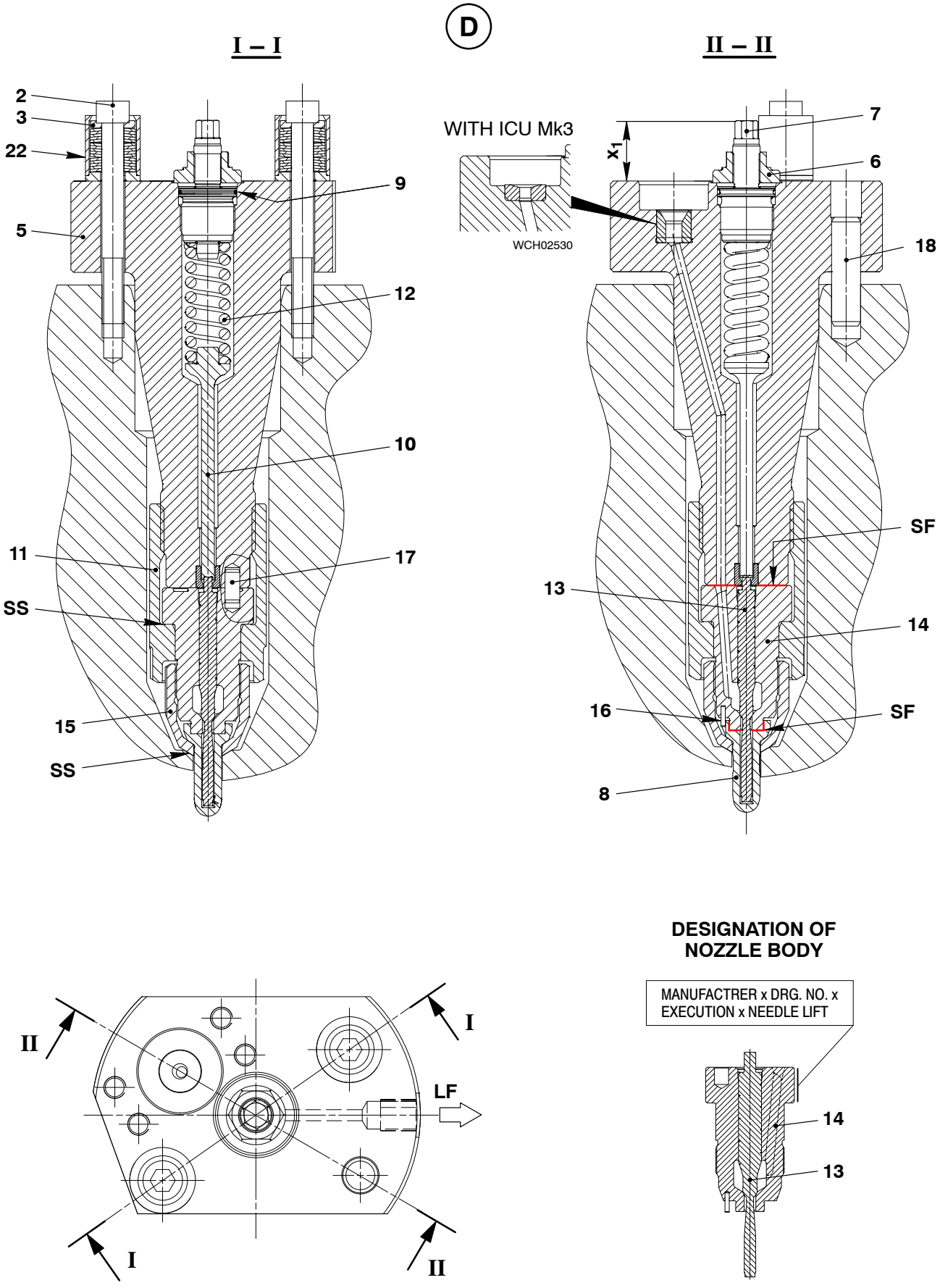
⇒ Apply a layer **of Never-Seez NSBT-8 to the thread and the seating surface 'SS'** of coupling nut 11.
First tighten the coupling nut to **89 Nm** (see paragraph 5.1) using socket wrench insert 94269C−55 and torque spanner 94011A. Starting from this position, tighten the coupling nut by a final angle of **30**° by means of test bench 94271 and hydraulic cylinder 94269B.

- Repeat the tightening procedure on the initial assembly.
- An angle of 30° corresponds to 16.8 mm on the circumference relating to a nut diameter of 64 mm.

⇒ Apply a layer of **Never-Seez NSBT-8 to the thread and the seating surface 'SS'** of clamping nut 15.

⇒ Tighten the clamping nut to **172 Nm** (see paragraph 5.1) using socket wrench insert 94269C−41 and torque spanner 94011A.

CHECK After assembling the injection valve must be checked and judged according to sections 2 and 3.


D
I – I
II – II
2
3
22
5
9
12
10
11
17
SS
15
SS
WITH ICU Mk3
WCH02530
x_1
7
6
18
SF
13
14
16
SF
8
II
I
LF
I
II
DESIGNATION OF NOZZLE BODY
MANUFACTRER x DRG. NO. x EXECUTION x NEEDLE LIFT
14
13

6. Adjusting the opening pressure

⇒ Install the injection valve in the test bench as described in section 2.

⇒ The opening pressure of the injection valve can be set by adjusting spring tensioner 7.

⇒ For readjusting the opening pressure, compression spring 12 must first be completely released by means of spring tensioner 7.

⇒ Then operate the valve test bench and tighten the spring tensioner simultaneously until the required opening pressure is reached.

⇒ Check the injection valve as described in section 2.

⇒ After adjusting the opening pressure, tighten collar nut 6.

Remark: **An opening pressure of 460 bar corresponds with the reference dimension 'x_1' = 33.30 mm .**

7. Nozzle tip – replace

Ensure that always specified nozzle tips are used in accordance with the IMO Technical File of the engine.

Remark: The injection valve with the new **F**uel **A**ctuated **S**acless **T**echnology is specified with the abbreviation FAST.

7.1 Removal

It is not recommended but possible to replace the nozzle tip with the needle installed. Remove only lock nut 7 according to paragraph 4 and proceed with disassembly tool 94278A.

⇒ Disassemble the injection valve, see paragraph 4.

⇒ Make sure that the needle 5 is removed from the nozzle body 4, see Fig. D.

⇒ Attach the nozzle body 4 with coupling nut 6 to the injection valve 1 on the injection test bench.

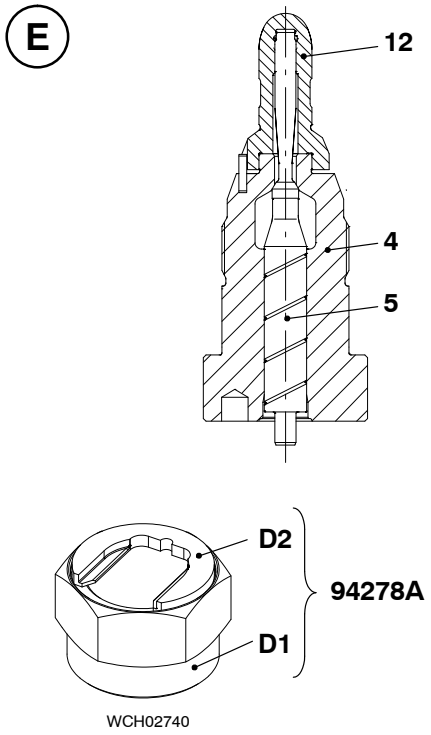
⇒ Screw the hex nut D1 (94278A) over the nozzle body 4.

⇒ Put the plate D2 in the clearance between the nozzle body 4 and the nozzle tip 12.

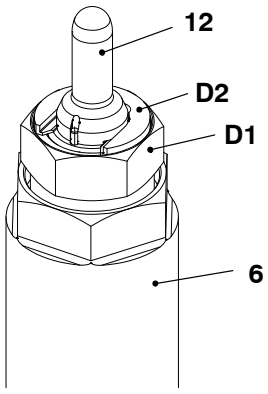
⇒ Turn the hex nut D1 upwards to withdraw the nozzle tip 12. Do it carefully if the needle is installed.

⇒ Remove the nozzle tip 12 from the nozzle body 4.

⇒ Remove the tool 94278A from the nozzle tip 12.

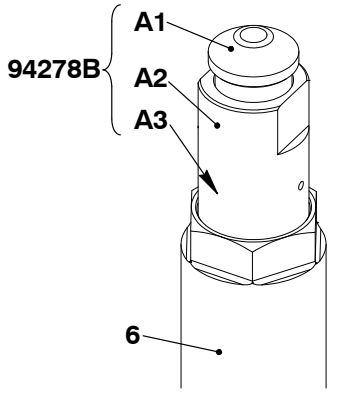


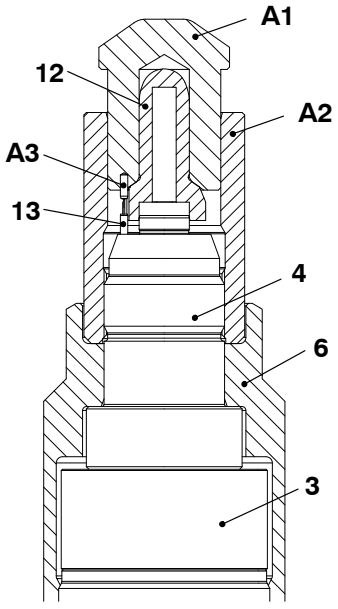
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F





WCH02908

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7.2 Installation

⇒ Make sure that the needle 5, is removed from the nozzle body 4, see Fig. E.

⇒ Attach the nozzle body 4 with coupling nut 6 to the injection valve 1 on the injection test bench.

⇒ Make sure the dowel pin 13 is installed.

⇒ Screw the guide bush A2 of tool 94278B onto the nozzle body 4.

⇒ Put the nozzle tip 12 into mounting cylinder A1 of tool 94278B and align the recess in the nozzle tip with the dowel pin A3.

⇒ Guide the mounting cylinder A1 with the inserted nozzle tip 12 into the guide bush A2.

⇒ Turn the mounting cylinder A1 until the recess of the nozzle tip aligns with the dowel pin 13.

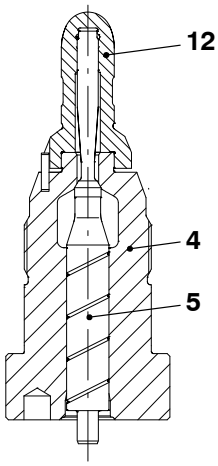
⇒ The mounting cylinder lowers a little bit and can not be turned anymore.

⇒ Use copper or rubber hammer to tap the mounting cylinder A1 fully down.

⇒ Screw the guide bush A2 out to remove the nozzle assembly tool 94278B.

⇒ Remove coupling nut 6 and nozzle body 4.

G



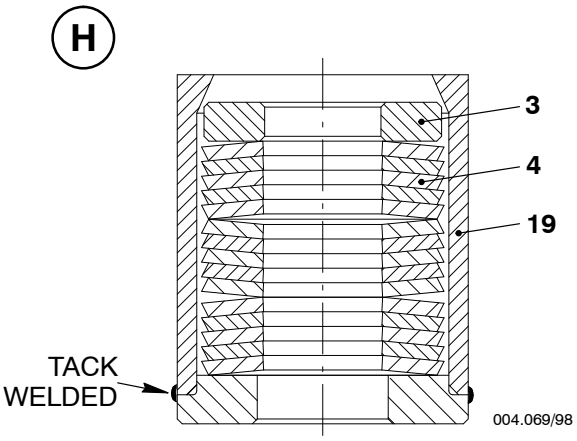
⇒ Use clean diesel oil, or clean kerosene to clean the needle 5.

⇒ Use a clean, low-pressure air supply to dry the needle 5.

⇒ Put the needle 5 into the nozzle body 4 / nozzle tip 12. Make sure that the the needle moves freely.

⇒ Assemble the injection valve, see paragraph 5.2.

8. Arrangement of cup spring packet



Cup spring packet 4 consists of three packs composed of five cup springs which are arranged and fitted in spring cage 19.

The spring cage forms a unit and therefore its bush and bottom are diagonally tack welded.

9. Fitting an injection valve in cylinder cover

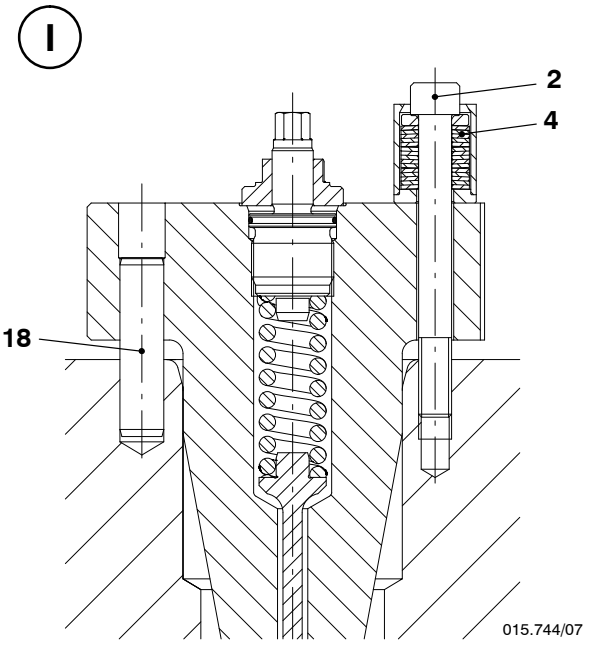
CHECK

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).

STOP

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 18 assures the correct position.



9.1 Screwing down the injection valve

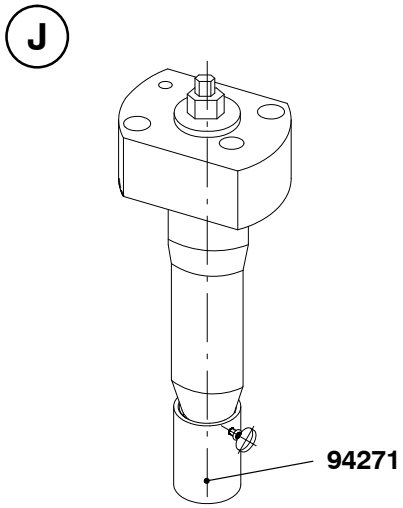
⇒ Apply Never-Seez NSBT-8 to the threads and the seating surfaces of Allen screws 2.

⇒ Press the injection valve onto its seat in the cylinder cover by equally tightening the Allen screws.

The correct pressure is reached when both spring packets 4 are completely compressed (solid block length), then loosen both Allen screws by 90°. The so called solid block length is reached when the Allen screws are tightened with a noticeable higher resistance.

10. Protecting a nozzle tip

Remark: To 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!

Starting Air Valve

Removal, Fitting and Dismantling, Grinding-in and Assembling

Tools:

2 Jacking screws

Key to Illustrations:

1	Nut	12	Joint ring
2	Cover	13	Control valve
3	Intermediate ring	14	Connecting pipe
4	Casing	15	O-ring
5	O-ring to casing	16	Piston ring
6	Cylinder cover	17	Solenoid
7	Self-locking nut	18	Nut with lock washer
8	Piston		
9	Valve spindle	CA	Control air pipe (from starting air pipe)
10	Allen screws		
11	Compression spring	RC	Eye bolt

1. General

Should functional difficulties occur with the starting air valves when starting, or should a starting air pipe near to the connection become noticeably hotter in operation than on the neighboring cylinders, then the starting air valve must be dismantled and reconditioned at the very next opportunity.

If no such difficulties occur it is recommended to dismantle yearly at random one starting air valve for a thorough check and to overhaul the other starting air valves in frequencies determined by such checking.

CHECK

Periodical venting of the starting air manifold under higher pressure must be provided as mentioned in the Operating Manual 0320–1. In addition, regular checks must be carried out to make sure, that nut 18 on solenoid 17 is tight (see also Maintenance Schedule 0380–1).

2. Removal from the cylinder cover

⇒ Loosen pipe for control air 'CA'.

⇒ Loosen and remove all four nuts 1.

⇒ Loosen and remove Allen screws 10. Screw jacking screws into the threaded holes in casing 4 and by tightening them jack the complete starting air valve from the bore in the cylinder cover 6.

⇒ Reinsert both Allen screws 10 for removing the complete valve.

⇒ Suspended by eye bolts 'RC' lift the valve off the cylinder cover.

- When the removal is carried out with the cylinder cover fitted on the engine, the vacated opening must be immediately covered by suitable means to prevent the possibility of foreign particles entering the combustion space.

3. Dismantling a starting air valve

- Lift cover 2 with mounted control valve 13 off casing 4. Take care that during lifting, the cover does not get jammed, whereby connecting pipe 14 risks being damaged.

⇒ Remove intermediate ring 3 from casing 4.

⇒ For further dismantling clamp the valve on the milled faces below the spindle head (spanner purchase) in a vice.

Starting Air Valve: Removal, Fitting and Dismantling, Grinding-in and Assembling

⇒ Loosen self-locking nut 7 with a socket spanner, and remove it.

⇒ Pull piston 8 and compression spring 11 from the casing.

⇒ Lift casing 4 up over valve spindle 9.

4. Grinding-in

- Slightly damaged seat faces may be ground in (lapped) manually.
- Badly worn seat faces must first be machined and then ground in (lapped) manually.

Remark: The valve spindle has an angle of 61°, however, the valve seat angle amounts to 60°.

5. Assembling

Assemble the valve in reverse sequence to the dismantling.

⇒ Clean all parts and smear them lightly with oil.

⇒ Apply MOLYKOTE paste G to the thread of spindle 9 and tighten self-locking nut 7 with **225 Nm** or by a tightening angle of 50°.

STOP The spindle thread in the region of the locking ring of self-locking nut 7 must **not** be lubricated.

⇒ Place new O-rings 5 and 15 in the groove in the valve casing and connecting pipe 14 respectively, and oil lightly.

CHECK After completing the assembly (without cover 2) check the easy movement of the spindle by moderately tapping the upper end of the spindle several times with a lead block in an axial direction; the spindle must jump every time back on the seat. If the valve seat have been ground/machined several times, check clearance 'x' (see figure) with a depth gauge from the upper edge of intermediate ring 3 onto piston 8.
Clearance 'x' must be minimum 1 mm.

⇒ Fit cover 2 and tighten it with Allen screws 10. Take care that transfer sleeve 14 does not interfere when assembling cover 2.

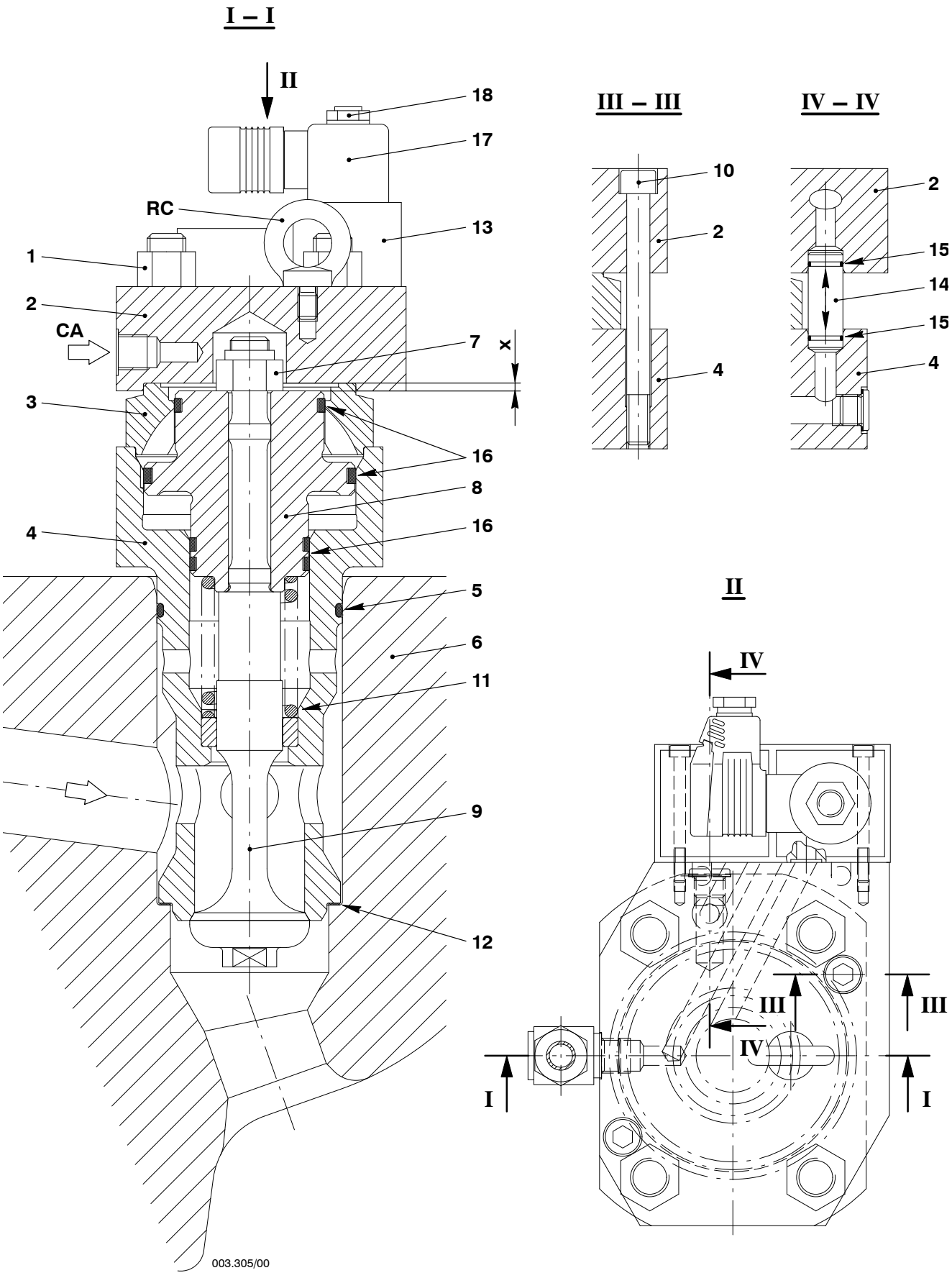
6. Fitting in the cylinder cover

⇒ Place a new joint ring 12 on the shoulder of the bore in the cylinder cover.

⇒ Smear bore in cylinder cover lightly with oil and fit the assembled starting air valve.

⇒ Apply Never-Seez NSBT-8 to the threads of nuts 1, fit and tighten them cross-wise through an angle of **110**°.

Starting Air Valve: Removal, Fitting and Dismantling, Grinding-in and Assembling



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Relief Valve for Cylinder Cover

Checking Blow-off Pressure

Tools:

1	OBEL test bench	94272
1	Valve holder	94272C
1	HP oil pump	94931
2	Hydr. distributors	94934A
1	HP hose	94935

Key to Illustrations:

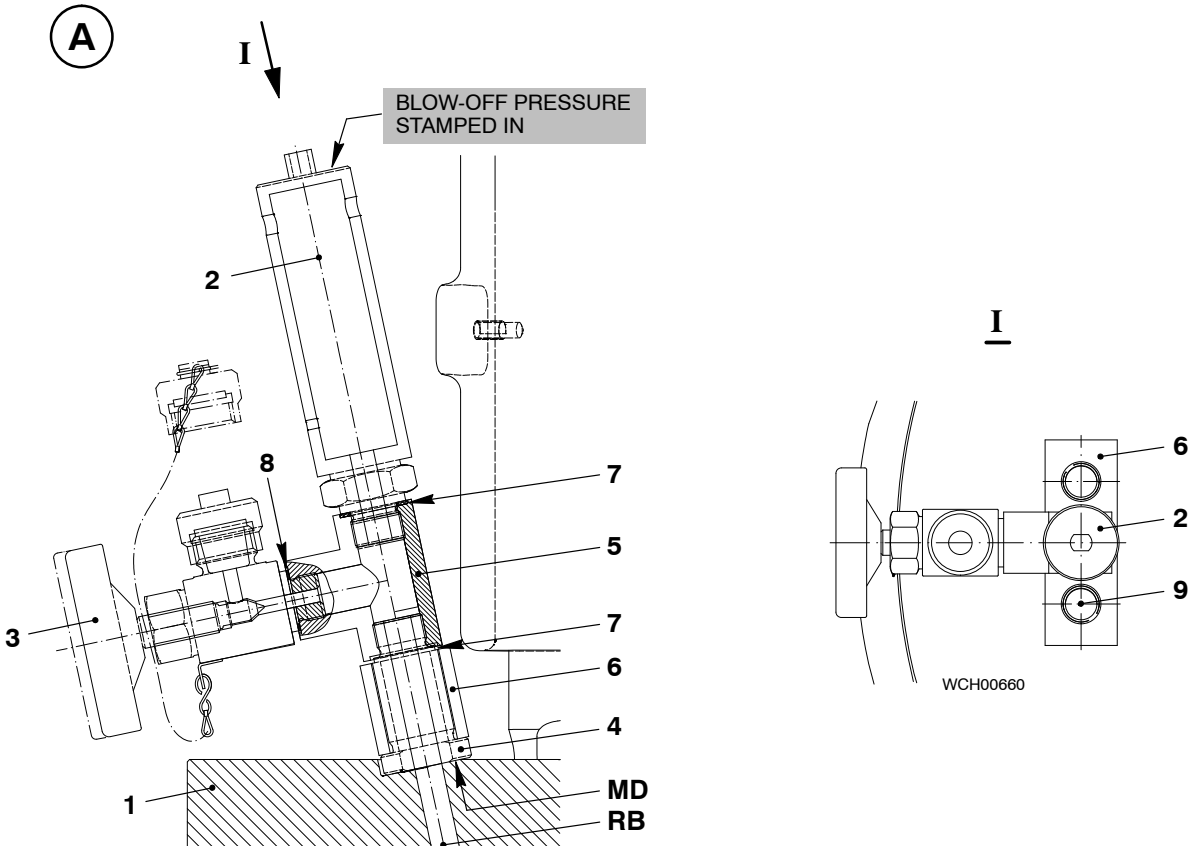
1	Cylinder cover	9	Allen screw M20x70
2	Relief valve	10	Receiver
3	Indicator valve		
4	Adapter piece		
5	Adapter piece	EV	Relief valve
6	Flange	MD	Metallic sealing
7	Gasket	RB	Relief bore from compression chamber
8	Gasket		

1. General

Each cylinder cover is provided with an indicator valve combined, depending on class requirements, with a relief valve, which is connected by relief bore 'RB' to the compression chamber. An inadmissible high pressure peak in the compression chamber opens the valve and the over-pressure is immediately reduced.

A relief valve which has blown off or valves leaking during engine operation must be replaced at the first opportunity (with engine stopped only).
A relief valve can not be repaired nor adjusted any more after having blown-off!

Relief valves require no maintenance, however they should be checked in general at every major engine overhaul. Basically leaking or damaged valves should be returned to the manufacturer for inspection and repair.



Relief Valve: Checking Blow-off Pressure

2. Checking blow-off pressure

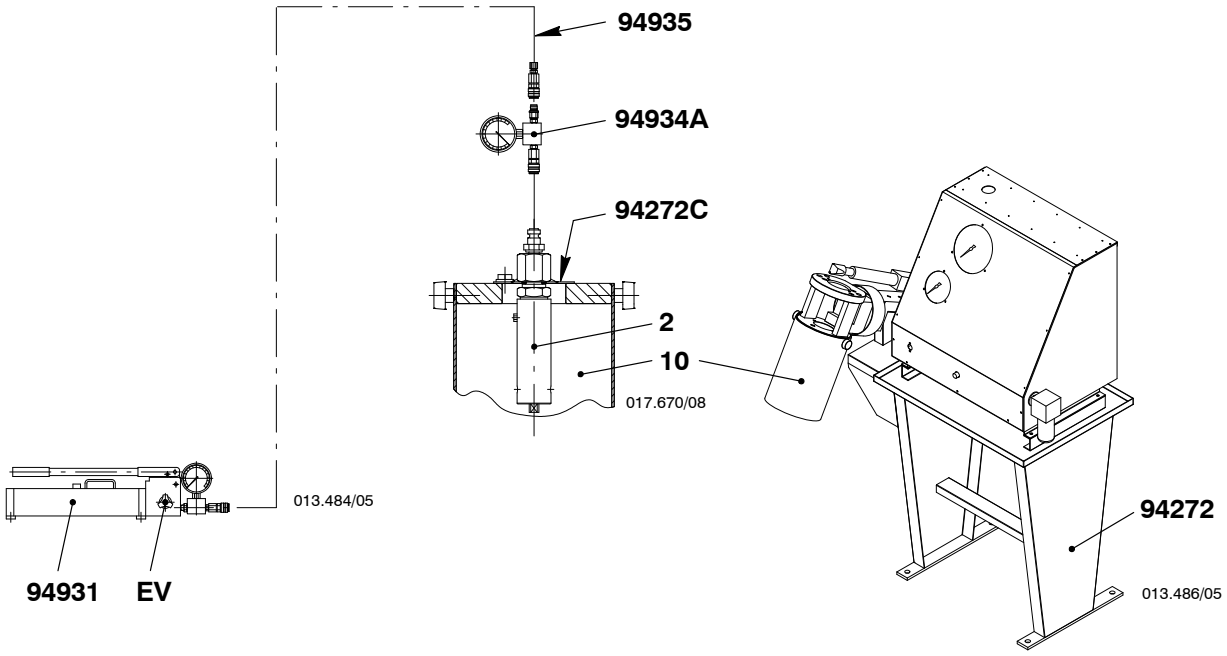
For checking relief valve 2 use test bench 94272 and test & calibration fluid (see specification in 2722–1) or a thin-bodied oil as test medium.

Remark: Pay attention to the manufacturer's detailed instructions and working specifications of the test bench.

If necessary, a relief valve must be replaced completely and set according to the following table:

Firing pressure [bar]	**Blow-off pressure** [bar]
156–160	225
166–169	235
174–175	245
176–180	250

B



3. Fitting the relief valve

⇒ Apply Never-Seez NSBT-8 to the thread of relief valve 2 and fit it with new gasket 7.

⇒ Always properly close indicator valve 3 so that no gas escapes and then screw on its cap.

Remark: If indicator valves leak for a long period the seats will become damaged. Early replacement of a leaking indicator valve will allow easy repair. All threads and internal parts must also be smeared with Never-Seez NSBT-8.

Exhaust Valve

Removal and Fitting of Exhaust Valve, Replacing of Elastic Studs

	Tools:	
1	Dismantling tool	94008A–M68
2	Pre-tensioning jacks	94252
1	Valve protector	94262
1	Wire rope sling	GF 94333D
2	Lifting lugs	94811
1	Hydr. distributor	94932
1	Hydr. distributor	94934A
1	HP hose	94935
2	HP hoses	94935A
1	Hydraulic unit	94942

Key to Illustrations:

1	Elastic stud	6	Expansion piece
2	Nut	7	Protection pipe
3	Valve cage		
4	Valve seat	RC	Eye bolt
5	Valve spindle	RS	Round bar

1. General

Prior to the removal of an exhaust valve, drain first the cylinder cooling water from the respective cylinder (see 2708–1), and close the air inlet to the air spring at the control air supply (see 0520–1 in the Operating Manual).

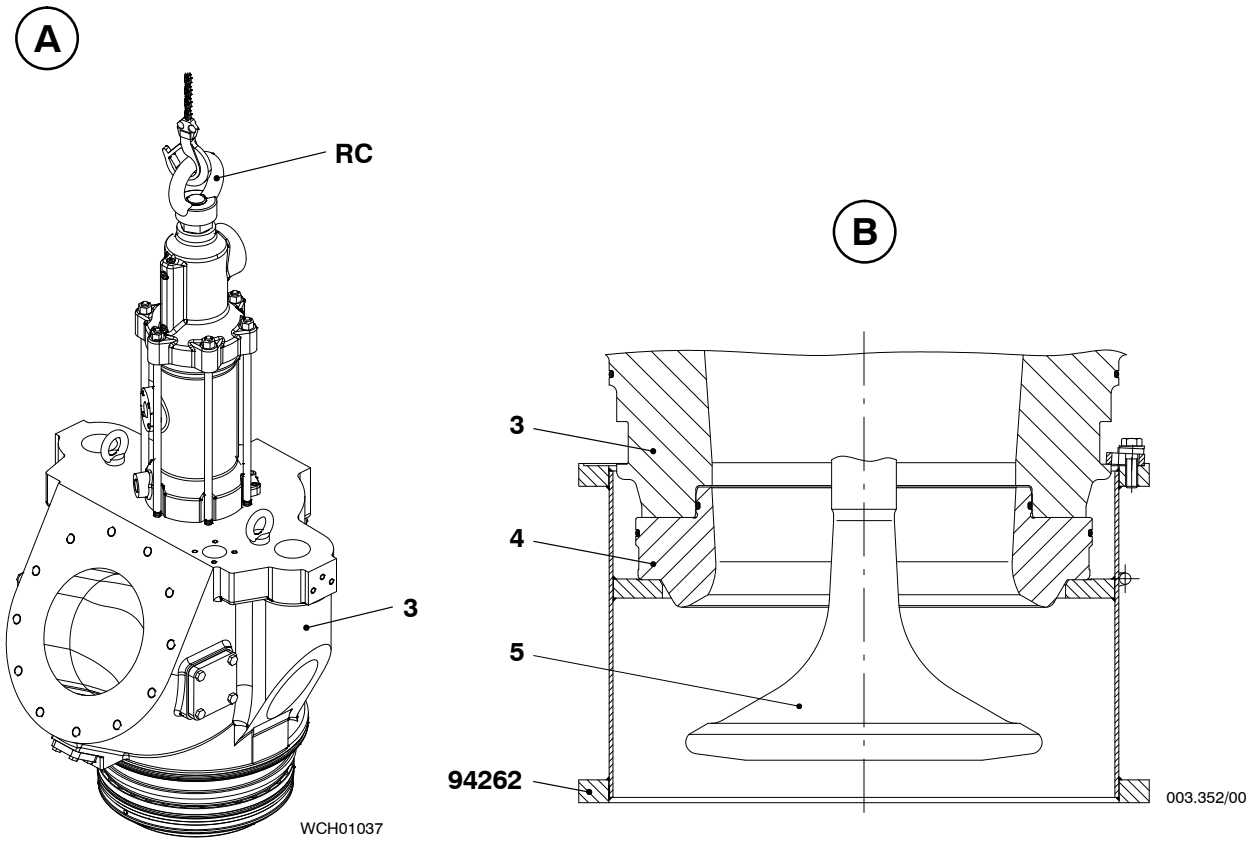
The exhaust valve can be removed from the cylinder cover or transported with the eye bolt 'RC'.

The valve cage must be suspended as shown in Fig. 'A'.

Remark: Pay attention to:

- General Guidelines for Lifting Tools 0012–1.
- General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

- If the exhaust valve is not to be dismantled at site immediately, mount the valve protector 94262.



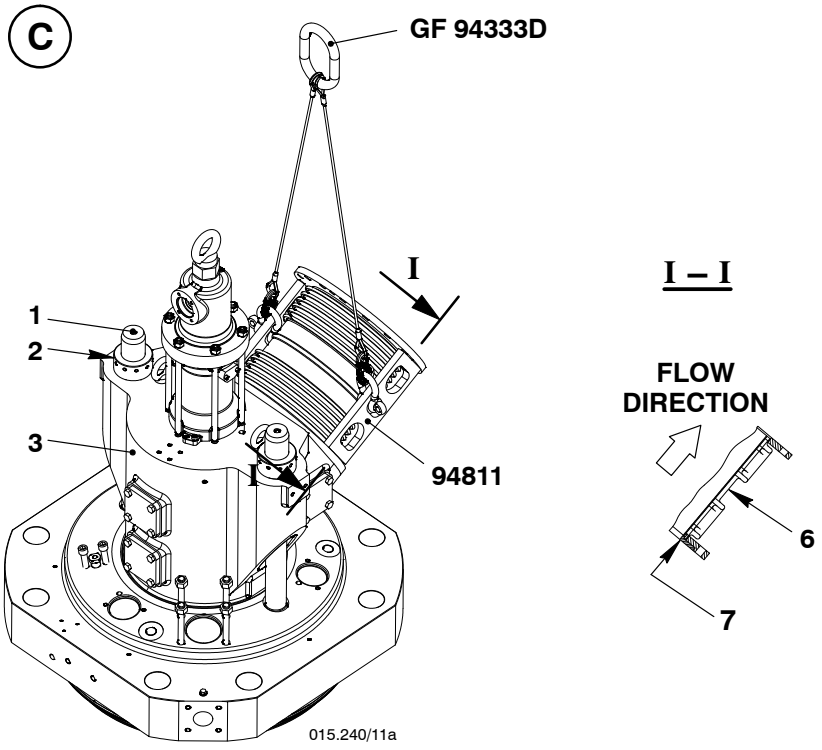
2. Removal

⇒ Remove all connected pipes.

⇒ Removal of hydraulic pipe see 8460−1.

2.1 Dismantling the expansion piece

⇒ Expansion piece 6 has to be removed with the aid of lifting lugs 94811 and the wire rope sling GF 94333D. Therefore, two screws of each suspension strap have to be screwed into the expansion piece flange. After removing the connecting screws from the expansion piece flanges the expansion piece can be taken out in the engine longitudinal direction.



Removal and Fitting of Exhaust Valve, Replacing of Elastic Studs

3. Fitting

- Before fitting the exhaust valve into the cylinder cover, the sealing surfaces must be checked for cleanliness and possible damage.
- Make sure that the soft iron gasket of 2 mm thickness lies flat in its recess in the cylinder cover.

⇒ Fit new O-rings on the valve cage and valve seat and oil these slightly.

⇒ Fit the complete exhaust valve suspended on the eye bolt 'RC', taking care not to damage the thread of the elastic studs.

- The correct position of the exhaust valve cage is determined by the cylindrical dowel pin set in the cylinder cover.

⇒ Lightly oil the threads of the elastic studs.

CHECK

Fit nuts 2 and tighten them firmly with round bar 'RS' until fully seated before mounting the pre-tensioning jacks (check seating with feeler gauge).

⇒ Mark position of the nuts 2 on a corner and their position on valve cage 3 with a felt-tip pen (for later checks).

⇒ Tighten elastic studs according to General Application Instructions 9403–4.

Remark: When fitting expansion piece 6 smear its flange surfaces and connecting screws lightly with a heat resisting lubricant. The expansion piece has to be fitted in such a way that protection pipe 7 of the expansion piece comes to lie in flow direction i.e. on the valve cage side as shown in Fig. 'C'.

4. Replacement of elastic studs

When fitting a new elastic stud (in the following text called stud for short) of the cylinder cover or exhaust valve cage, the instructions hereafter must be strictly observed.

Before fitting the stud, clean and degrease the joint surface respectively sealing face.

If recommended by the jointing compound manufacturer, apply an adhesive primer in order to improve the adhesion on the joint surface.

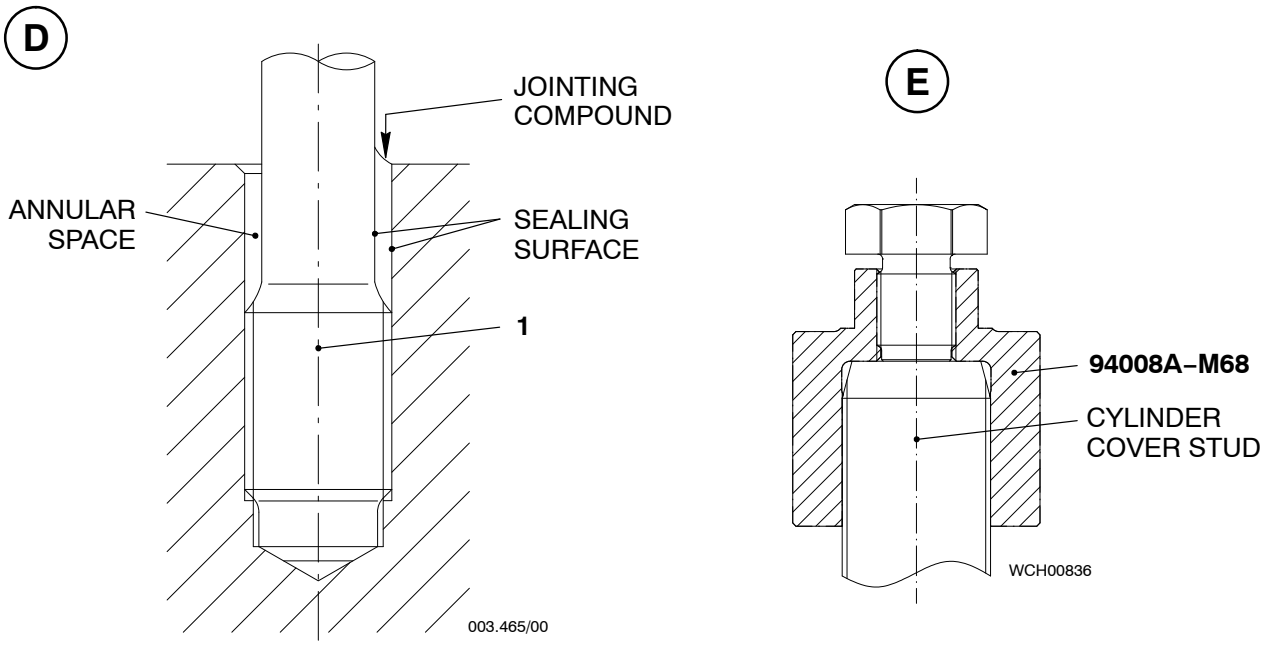
STOP **Do not apply adhesive primer and any lubricant to the thread!**

⇒ Screw in the stud right to the bottom and until it rests on its seating surface and tighten it according to instructions 0352–2 using always a stud driver or two counter locked nuts. Tool 94008A–M68 must be used for the cylinder cover stud.

STOP Tools like pipe wrenches or multigrip tongs, etc. which would cause damages to the shank of the stud must never be used!

⇒ Fill the annular space completely up to the rim with jointing compound.

4.1 Studs fitted in cylinder block and cylinder cover



4.2 Recommended jointing compound and adhesive primers

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 LTD Wylds Rd Bridgwater Somerset TA6 4DD Uk-Great Britain

Remark: Mixing and applying of the jointing compounds must be done according to the instruction of the respective manufacturer.

Products of other manufacturers are also allowed when fulfilling the below specification:

- Containing no acid, e.g. no acetic acid.
- Resistant to oil, marine diesel oil, heavy fuel oil and water at a permanent temperature of approximately 100 °C.
- Short age hardening time, i.e. at least 24 hours under ISO standard reference conditions.
- Well flowing to properly fill out the annular space, in order to avoid the creation of any hollow space.
- Good adhesion on adhesive-primed metallic surface.
- Easy to prepare and combine.
- None or only minimal surface shrinkage.
- The jointing compound must remain elastic, as a cylinder cover stud may be removed at any given time.

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Exhaust Valve

Dismantling and Assembling

Tools:

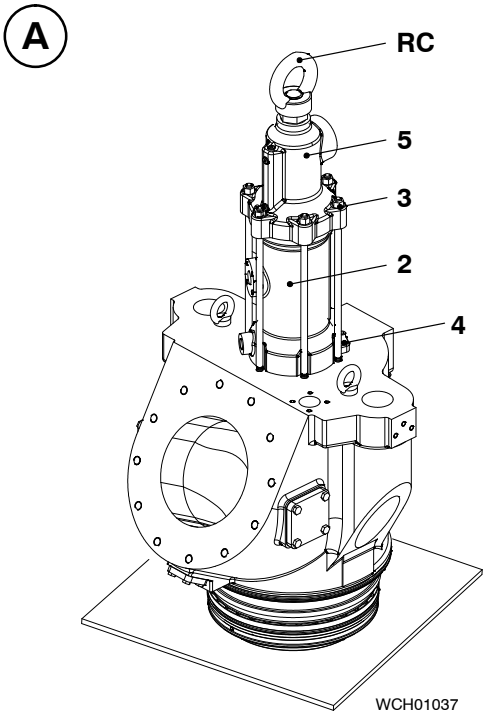
1	Depth gauge	94124
1	Pressure element	GF 94259
2	Jack screws	94263

Key to Illustrations:

1	Valve cage	21	Guide bush
2	Lower housing	22	Rod seal ring
3	Nut	23	Valve seat
4	Screw	24	Screw plug
5	Upper housing	25	Filter with orifice
6	Outside piston	26	Adapter
7	Inside piston	27	Non-return valve
8	Thrust piece	28	Spring dowel pin
9	Valve spindle	29	Valve stroke sensor
10	Measuring cone	30	Screw
11	Piston guide	31	Housing
12	Spring dowel pin	32	Damper
13	Screw with washer	33	Shim
14	Circlip	34–41	O-rings
15	Valve cotter		
16	Piston		
17	Piston seal ring		
18	Disc spring	BO	Bore
19	Distance ring	OB	Oil bore
20	Head screw	RC	Eye bolt

Overview

1. **General** 1/9
2 **Dismantling of exhaust valve** 3/9
3. **Assembling of exhaust valve** 5/9
4. **Blocking of exhaust valve** 9/9



1. General

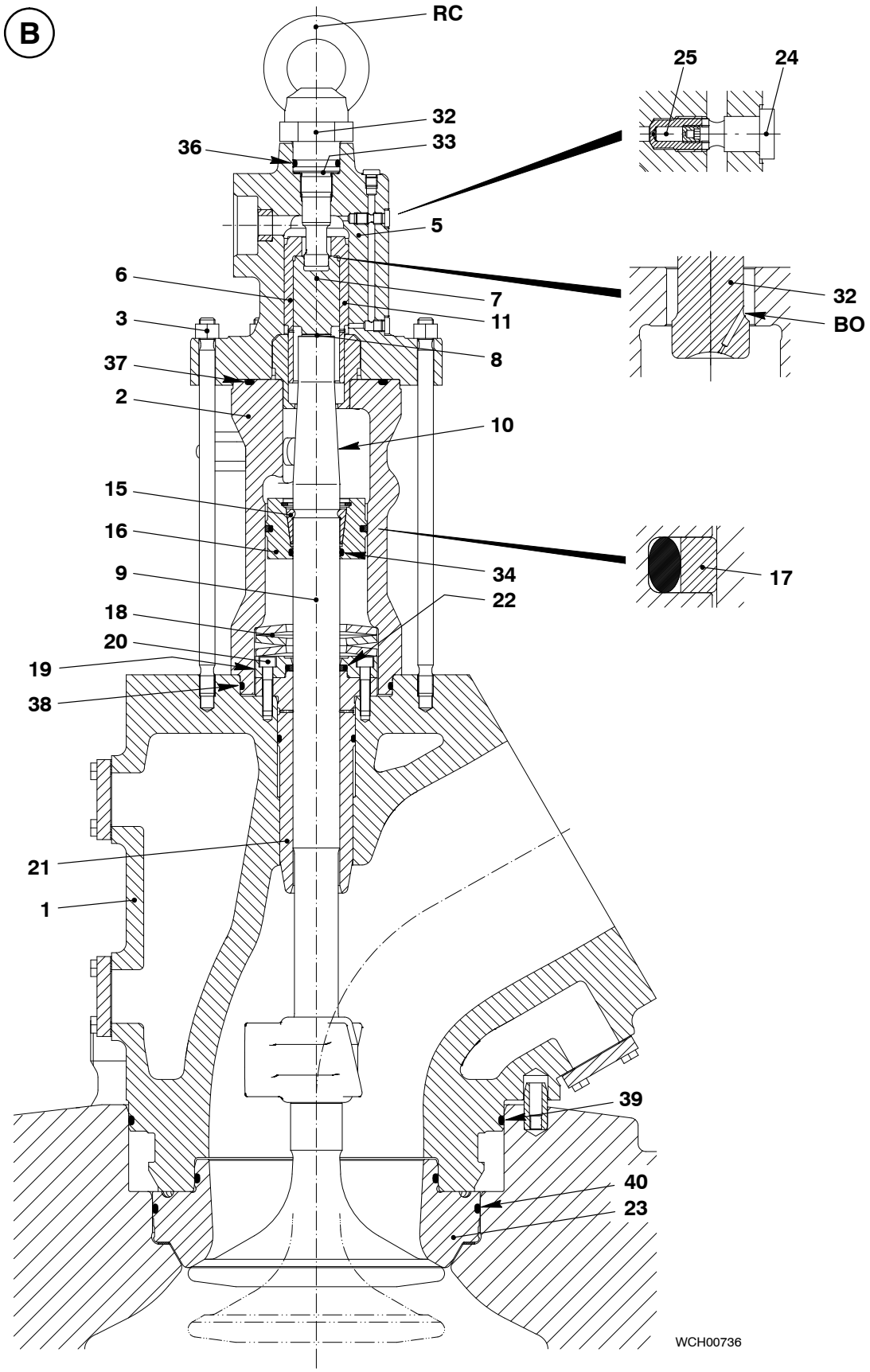
There are in minimum two complete exhaust valves on board, as recommended by the International Association of Classification Societies (IACS). Therefore, they must be used as a replacement in any case of difficulties appeared during operation.

Defective exhaust valves may, however, only be repaired or reconditioned by qualified personnel or a Wärtsilä Switzerland Ltd. authorized repair workshop.

For inspection and overhaul intervals see Maintenance Schedule 0380–1.

Remark: Pay attention to General Guidelines for Lifting Tools 0012–1.

Exhaust Valve: Dismantling and Assembling



Exhaust Valve: Dismantling and Assembling

2. Dismantling of exhaust valve

2.1 Dismantling of complete valve drive

Attention! During dismantling and assembling, the activity area has to be clean and as dust-free as possible (grinding dust etc.), and performing electric welding must absolutely be omitted near or on the engine.

⇒ Place the exhaust valve on wooden underlay 'HU' in vertical position.

⇒ Loosen and remove all nuts 3 (Fig. 'A').

⇒ Lift the upper valve drive and remove it using eye bolt 'RC'.

⇒ Loosen screws 30 and remove transmitter housing 31 and valve stroke sensor 29. See Fig. 'H'.

⇒ Loosen and remove all screws 4 (Fig. 'A').

⇒ Lift lower housing 2 and remove it.

2.2 Dismantling of valve spindle

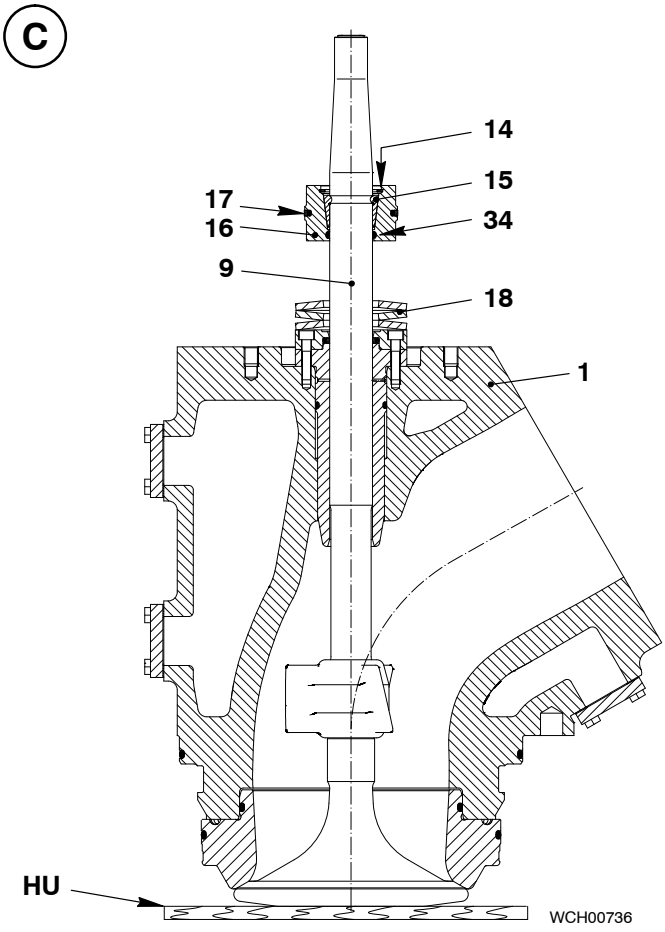
⇒ Remove circlip 14.

⇒ Push piston 16 away from valve cotters 15, then remove the latter.

⇒ Withdraw the piston from the valve spindle.

⇒ Remove disc spring 18.

⇒ Carefully lift valve cage 1 by means of the engine room crane. Ensure that the valve spindle always stands on the wooden underlay while the valve cage is sliding out.



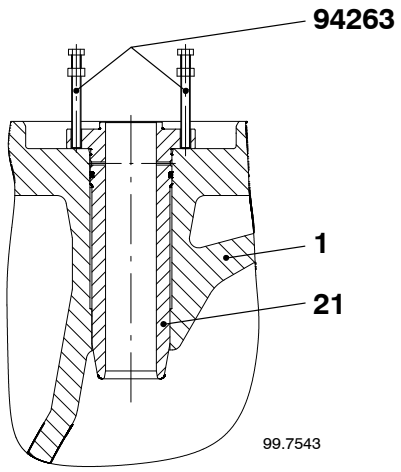
2.3 Removal of guide bush

⇒ Loosen head screws 20 and remove them together with distance ring 19 and rod seal ring 22 (Fig. 'B').

⇒ Withdraw guide bush 21 from valve cage 1 by means of jack screws 94263.

CHECK Check and measure the inner diameter of the guide bush according to Clearance Table 0330–1 'Exhaust Valve'.

D



2.4 Fitting of guide bush

⇒ Clean the bore in valve cage 1 concerned and guide bush 21.

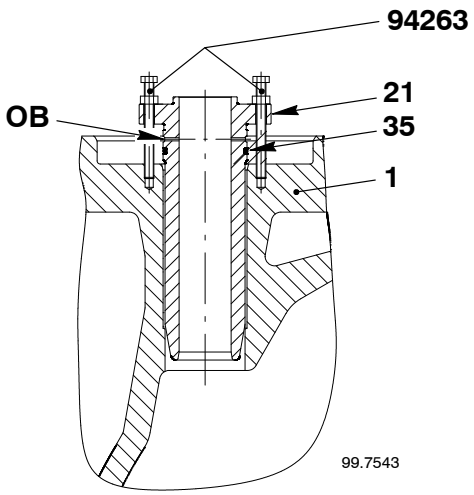
CHECK Check oil bores 'OB' in guide bush for free passage.

⇒ Replace O-ring 35.

⇒ Oil and fit the guide bush.

⇒ Fit distance ring 19 and hold it provisionally tight with head screws 20.

E



3. Assembling of exhaust valve

Assembling is carried out analogously to dismantling but in reverse sequence.

CHECK

Check the dimensions of valve spindle 9 with Clearance Table 0330–1 'Exhaust Valve'.

The condition of piston seal ring 17 (Fig. 'B') is to be examined on every occasion, at the latest, however, on the occasion of an overhaul of the exhaust valve according to the maintenance schedule. A damaged piston seal ring must be replaced in any case.

STOP

Heat new piston seal rings in boiling water before fitting them. When fitting proceed with care, to avoid their damage; **do not use any sharp edged utensils** for assistance.

⇒ Check all O-rings of the dismantled parts for damage and replace them if necessary.

Remark: If an exhaust valve is to be fitted with a new seat or spindle, the seats must be checked according to the instructions given in 2751–3.

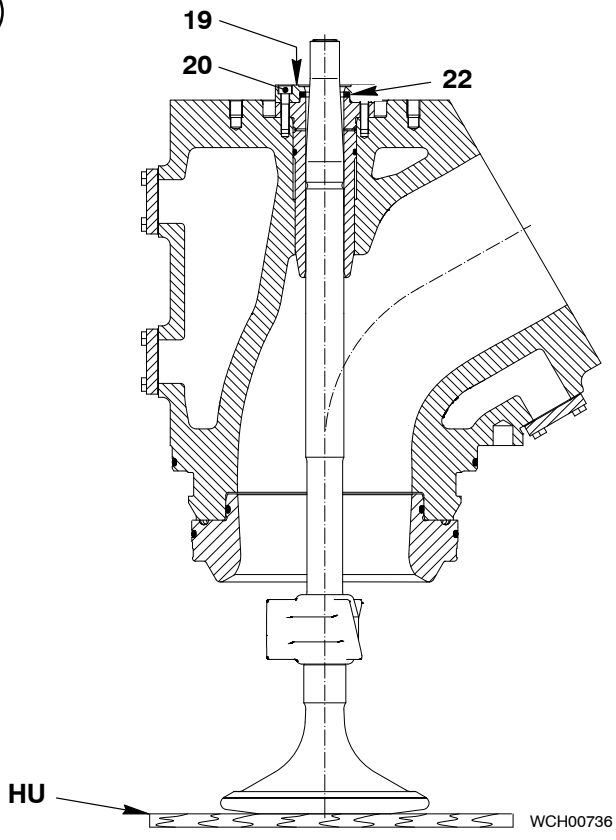
3.1 Fitting of valve spindle

⇒ Apply oil to the valve spindle and fit it.

⇒ Apply oil to a new rod seal ring 22, fit it with distance ring 19 and tighten the latter with head screws 20.

Remark: Always fit rod seal ring and distance ring only after fitting the valve spindle, otherwise the rod seal ring might be damaged.

F



3.2 Assembling of valve drive

⇒ Bring valve cage to vertical position and fit disc springs 18 as shown in Fig. 'C'.

⇒ Fit piston 16, valve cotters 15 and circlip 14.

⇒ Fit lower housing 2.

⇒ Fit and tighten screws 4 (Fig. 'A').

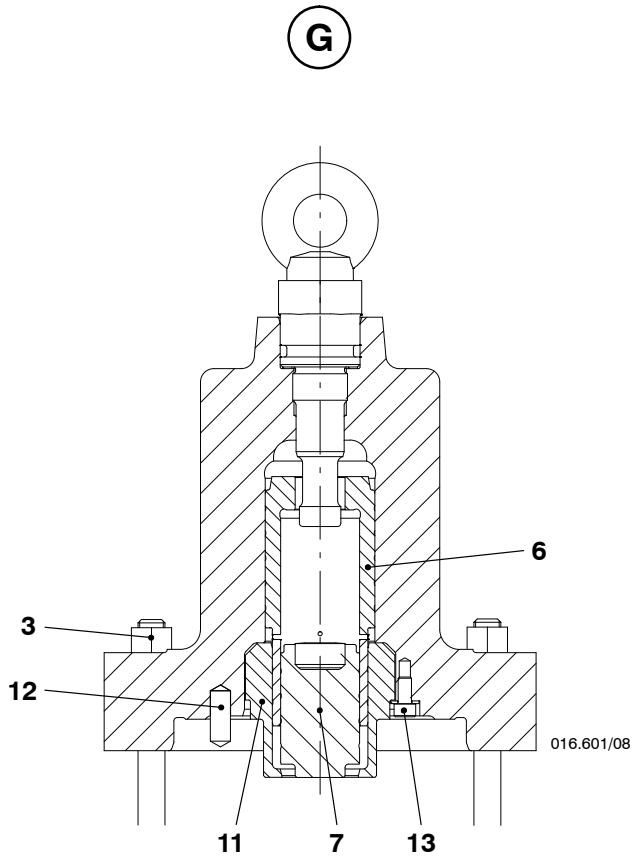
⇒ Fit upper part of valve drive paying attention to position of spring dowel pin 12 (Fig. 'G').

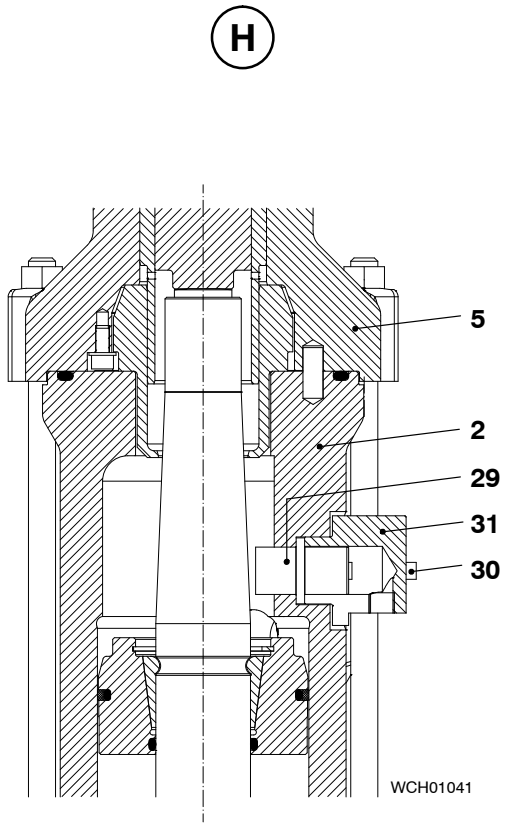
⇒ Oil nuts 3, fit and tighten them equally up to a torque of **125 Nm**.

3.3 Fitting of valve stroke sensor

⇒ Clean valve stroke sensor, bore and collar in lower housing as well as transmitter housing.

⇒ Push valve stroke sensor 29 together with transmitter housing 31 into the bore and fasten it using screws 30.





3.4 Damper Setting

You set the damper 32, Fig. I only after you replace a valve spindle or valve seat, or after one of the seating faces is ground.

⇒ Remove the damper 32.

⇒ Make sure that the bores BO in the damper 32 are clear.

⇒ Make sure that the exhaust valve is closed.

⇒ Use a feeler gauge to make sure there is no clearance between the valve plate and valve seat.

⇒ Use a depth gauge 94124 to measure the height H between the top and bottom of the bore in the top housing.

⇒ Make sure that the distance H is 122 ±0.5 mm.

Remark: For example, if the measured distance H is 121 mm, you must install one shim 33. Each shim has a thickness of 1.0 mm.

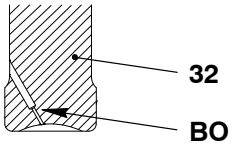
⇒ Install the correct quantity of shims 33 to get the correct distance H.

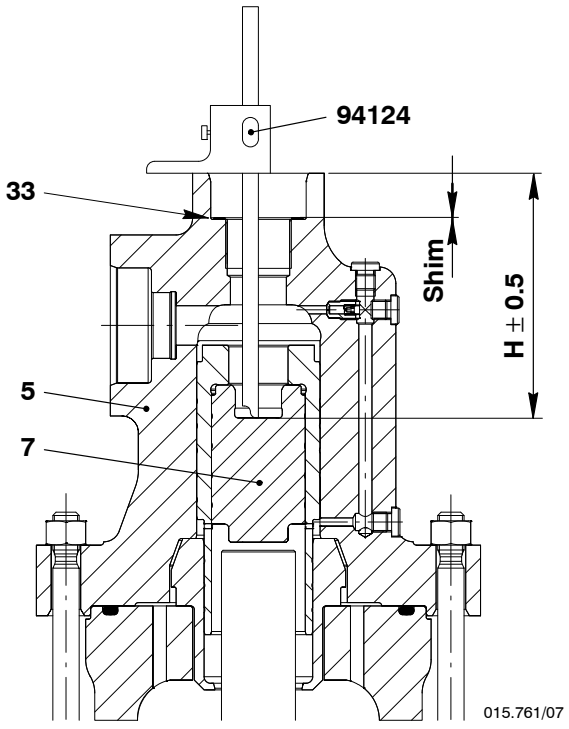
⇒ Instal the damper 32.

⇒ Apply Loctite 271 to the threads of the eye nut RC.

⇒ Install the eye nut RC.

I





3.6 Checking filter

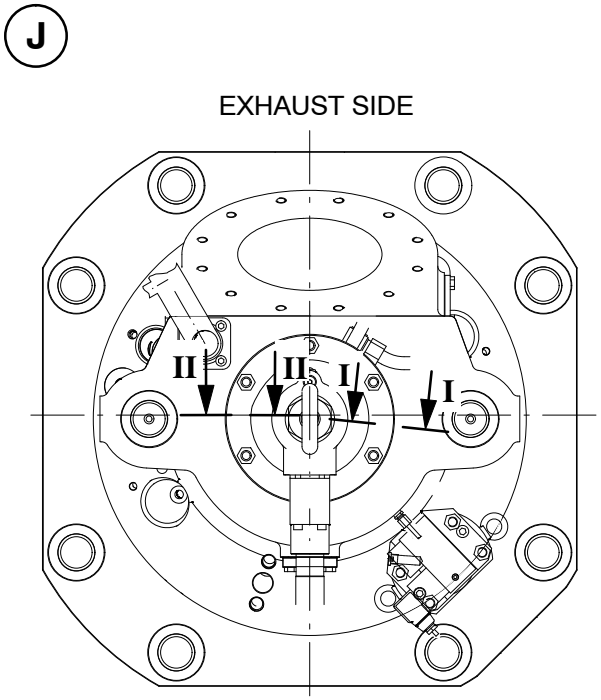
⇒ Remove screw plug 24 (detail in Fig. 'B'). Loosen filter 25 together with its orifice and check them for fouling.

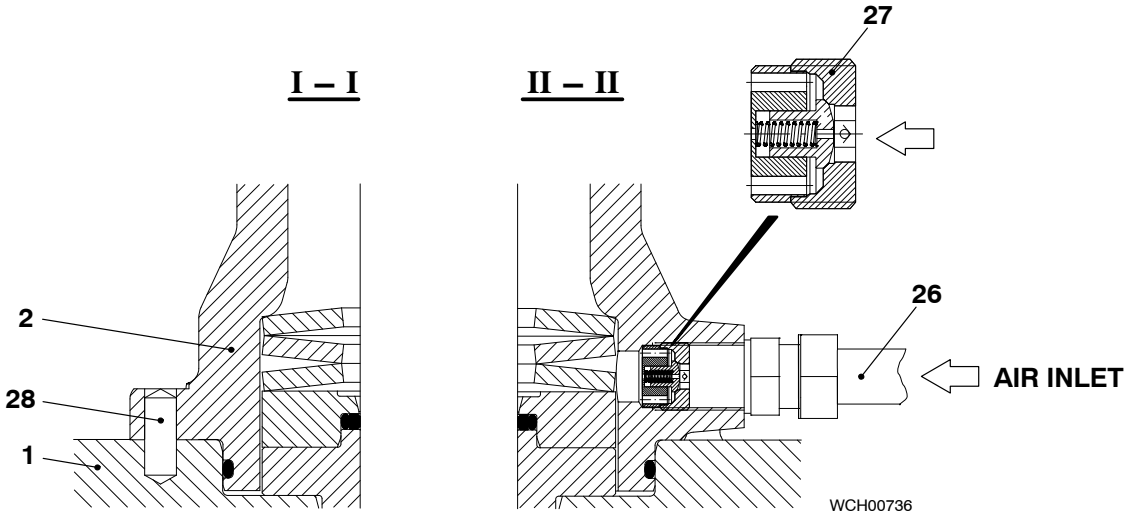
3.7 Checking non-return valve

⇒ Loosen and remove adapter 26.

⇒ Check non-return valve 27 for cleanliness on every overhaul.

Remark! When fitting the non-return valve pay attention to the air inlet side!

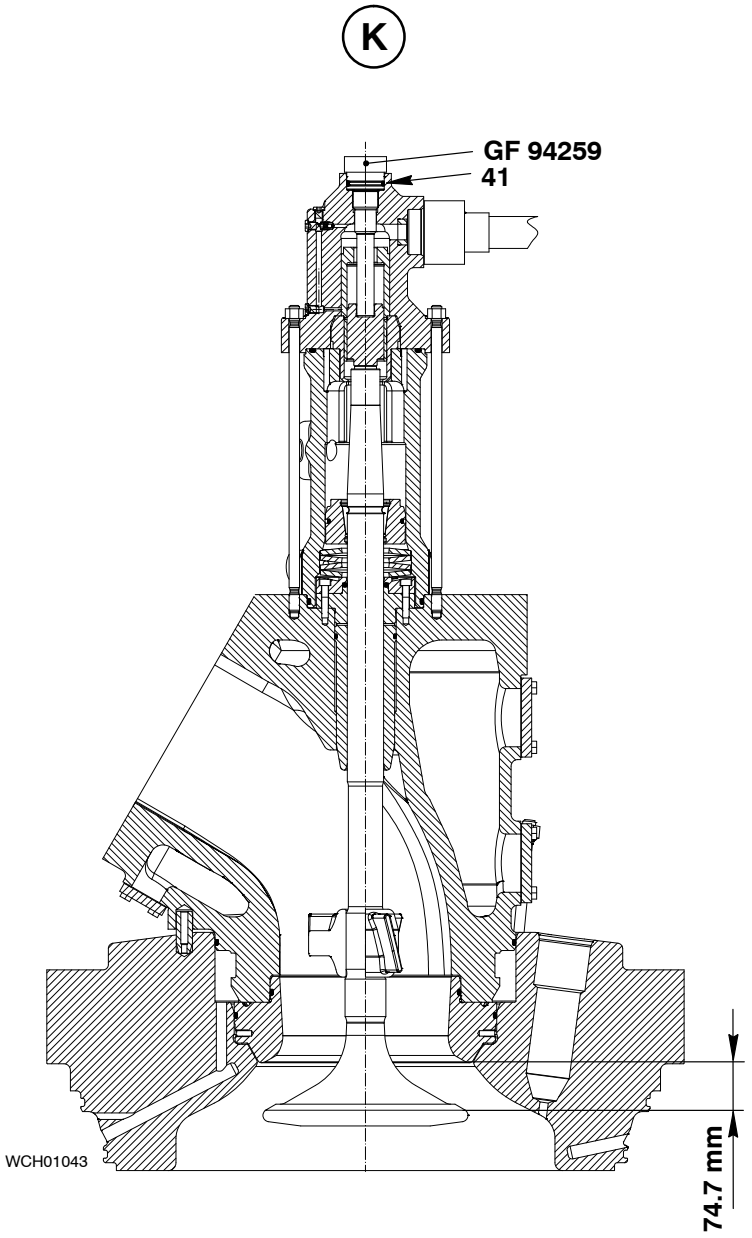




4. Blocking of exhaust valve

The engine operation must be interrupted temporarily for blocking an exhaust valve.

In case of an emergency, i.e. with water leakages into the combustion chamber damper 32 (Fig. 'B') can be removed and the exhaust valve blocked in open position by means of pressure element GF 94259. The latter must also be fitted if an exhaust valve is jammed in the open position (see 0520–1 in the Operating Manual).



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Exhaust Valve

Replacing and Grinding the Valve Seat

Tools:		
1	Feeler gauge	94122
1	Valve seat fitting and dismantling device	94261
1	Gauge	94279
1	Valve grinding device	94291

Key to Illustrations:			
1	Valve seat	AF	Seating face
2	Valve cage	HA	Hammer
3	O-ring	RC	Eye bolt

Overview

1. General 1/5
2. Removing the valve seat 1/5
3. Fitting the valve seat 2/5
4. Grinding the valve seat 3/5
5. Checking the valve seat 5/5

1. General

Valve seats of which the seat surfaces are badly damaged, or on which the wear limit has been reached through frequent grinding, must be replaced.

The most advantageous position for replacing the valve seat is to bring the valve cage in a vertical position as shown in Fig. 'A'.

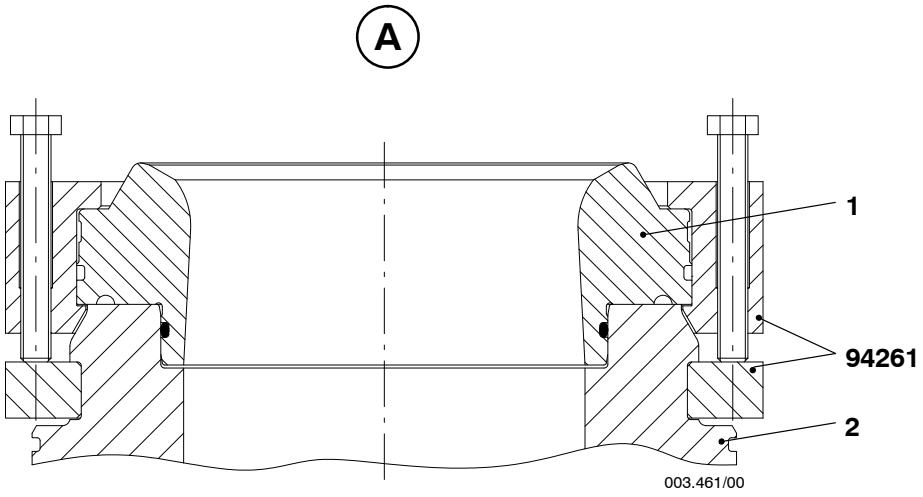
Remark: When the valve seat must be removed with the valve cage in the inverted upside down position, it must be suspended on the engine room crane slightly above a wooden underlay. Device 94261 can then be attached from below and the valve seat carefully withdrawn until it drops caused by its own weight (42 kg). Therefore, the valve seat must be properly secured with additional wooden underlays. The distance to the wooden underlay is to be kept as small as possible to avoid any accidents or damage.

2. Removing the valve seat

⇒ Fit both pairs of ring halves of the valve seat fitting and dismantling device 94261 into the groove on the circumference of valve cage 2 and valve seat 1 respectively.

⇒ With the aid of the three jack screws of the valve seat fitting and dismantling device, the valve seat can be pressed out of its seating in the valve cage.

- Should a valve seat be removed for any reason, it must be reground by means of valve grinding device 94291 before refitting.



3. Fitting the valve seat

⇒ Place valve cage vertically.

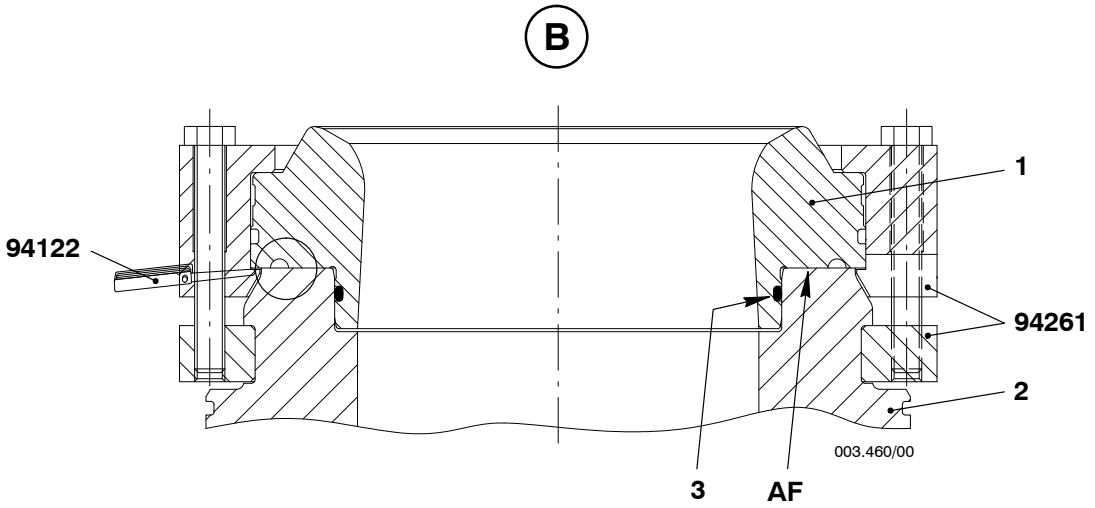
⇒ Clean bore as well as seating shoulder at 'AF' meticulously.

⇒ Smear the bore into which the valve seat has to fit with oil, or lubricants such as THREAD GARD, LOCTITE, ANTI-SEIZE COMPOUND etc.

⇒ Smear new O-ring 3 of original specification with the same lubricant.

⇒ Push valve seat as far as possible into the bore, then mount valve seat fitting and dismantling device 94261 and by equal tightening of the jack screws press the valve seat down until fully seated.

CHECK Through the control openings in the valve seat fitting and dismantling device check with feeler gauge 94122 all around the circumference that no clearance remains at 'AF'.



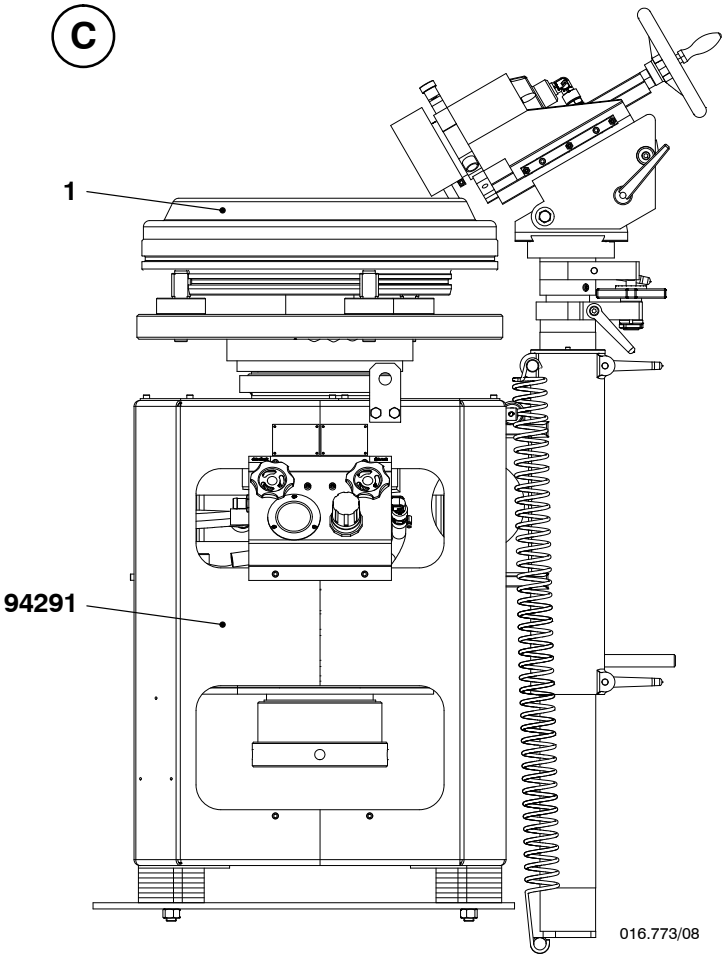
Exhaust Valve: Replacing and Grinding the Valve Seat

4. Grinding the valve seat

Grinding in valve seats using the valve spindle with grinding paste must be avoided as a matter of principle!

Therefore, always use the valve grinding device 94291 for grinding in the valve seats in the following cases:

- When new or reconditioned valve spindles are fitted.
- When the seat surface on the valve seat is badly damaged (impacts, corrosion scars).



Exhaust Valve: Replacing and Grinding the Valve Seat

Remark: Regarding the operation of the grinding machine refer to the operating instructions of the respective manufacturer.

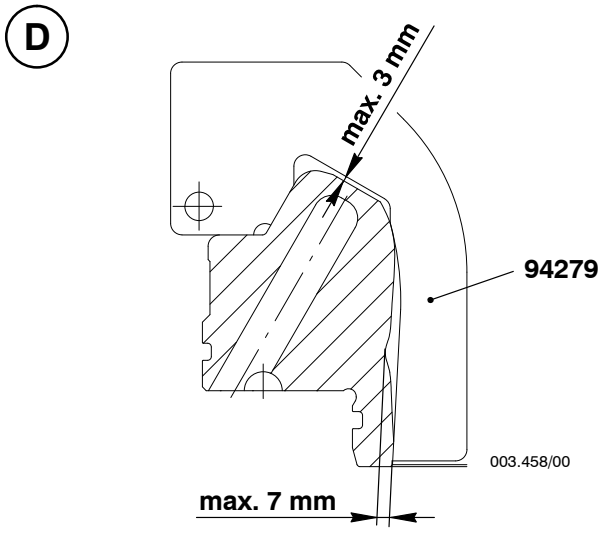
- The grinding must produce an even and smooth surface.

Valve seat angle = $30^{\circ}\ ^{+2'}_{0}$

CHECK

The grinding allowance on the valve seat is maximum 3 mm. The wear condition can be checked efficiently with gauge 94279 in combination with feeler gauge 94122. Possible burn scars at the inside of the valve seat must not exceed 7 mm. The depth of the burn scars can also be verified with the gauge 94279 as shown in Fig. 'D'.

- Valve seats which exceed the above mentioned values must be replaced.



Exhaust Valve: Replacing and Grinding the Valve Seat

5. Checking the valve seat

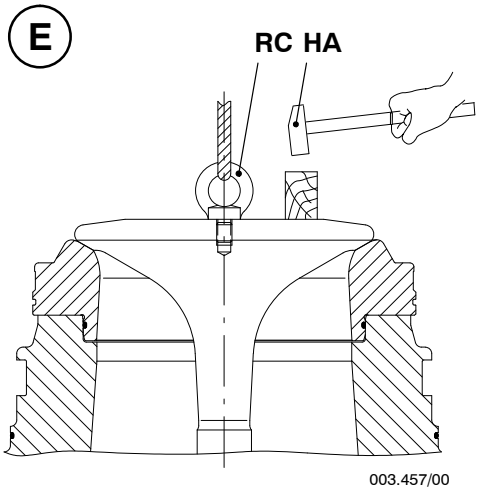
CHECK

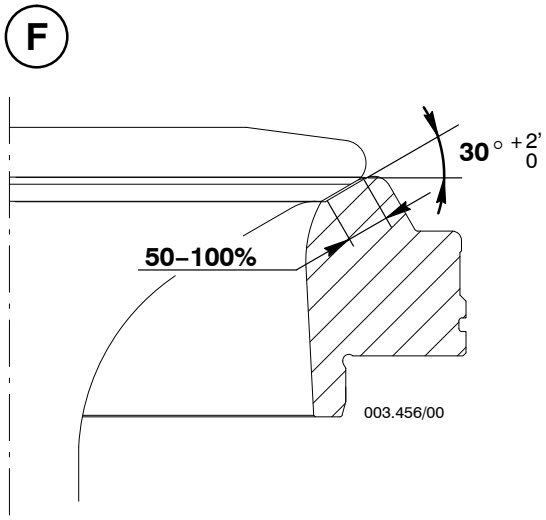
After grinding it is necessary to check whether the new or re-ground valve makes correct contact with the valve seat. For this the spindle head seat face is spread with a thin coating of blueing paste, then inserted vertically into the valve guide bush.

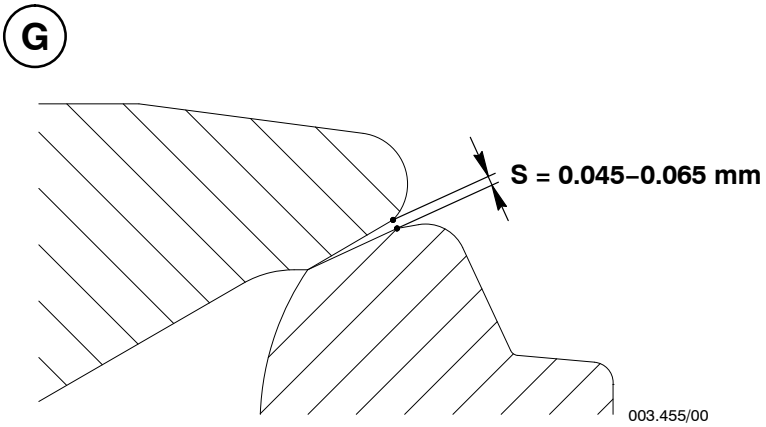
Remark: The angle difference is chosen such that in the hot operating condition the valves makes contact by 50% – 100% from the outer edge (Fig. 'F'). The blueing check should show that the cold valve makes contact only from inside around the whole circumference. The angle difference can be checked at gap 'S' on the outer edge with a feeler gauge (Fig. 'G').

⇒ The blueing on the valve seat must be checked by tapping the valve head three or four times with a hammer on a wooden block! (Fig. 'E').

STOP **Do not rotate the valve spindle on the valve seat face, as this risks seizure of the seating.**







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Exhaust Valve

Grinding the Seating Surface on the Valve Head

Tools:

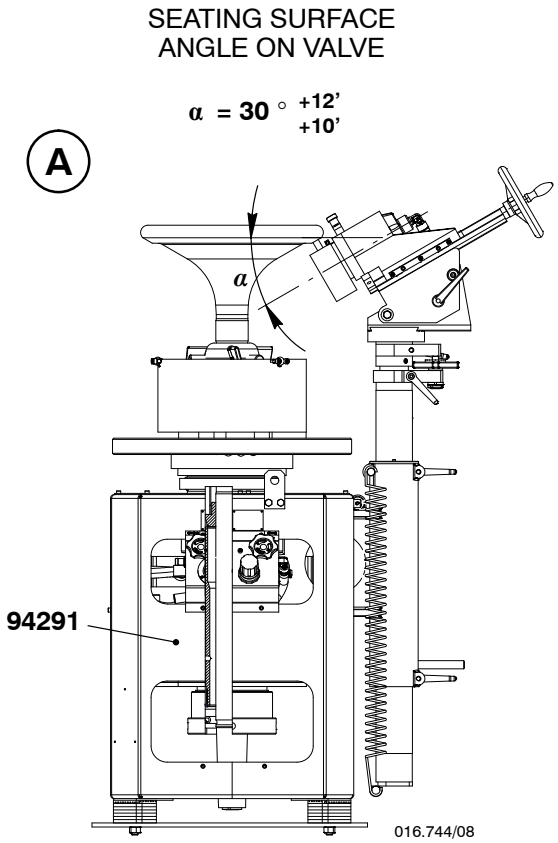
1	Feeler gauge	94122
1	Valve grinding device	94291
1	Gauge	94292

1. General

Grinding in a valve together with its valve seat with grinding paste is not permitted. Valves which have had the seating surfaces badly damaged by pitting or corrosion have to be reground by machine. It is strongly recommended that a suitable grinding device 94291 be made available.

Remark: A valve spindle with missing rotation wing may not be reground. The wing hub must be shrink-fitted on the valve shaft by heating it to 480 °C. Grinding may first begin after the whole unit has cooled down.
The devices from the makers 'HUNGER' and 'CHRIS - MARINE' are well proven for valve grinding and can also be ordered directly from Wärtsilä Switzerland Ltd., Winterthur.

2. Grinding the seating surface



- Only as little material as necessary should be ground off the valve seating surface to provide a clean and smooth finished surface.
  Only grind with cooling (wet).

- In order to avoid the appearance of chatter marks on the seating surface, the grinding machine should be placed in an area which is free of vibration from running machinery or engines, etc. If necessary the grinding machine should be stood on a rubber mat.

Remark: For the application of the grinding device refer to the operating instructions.

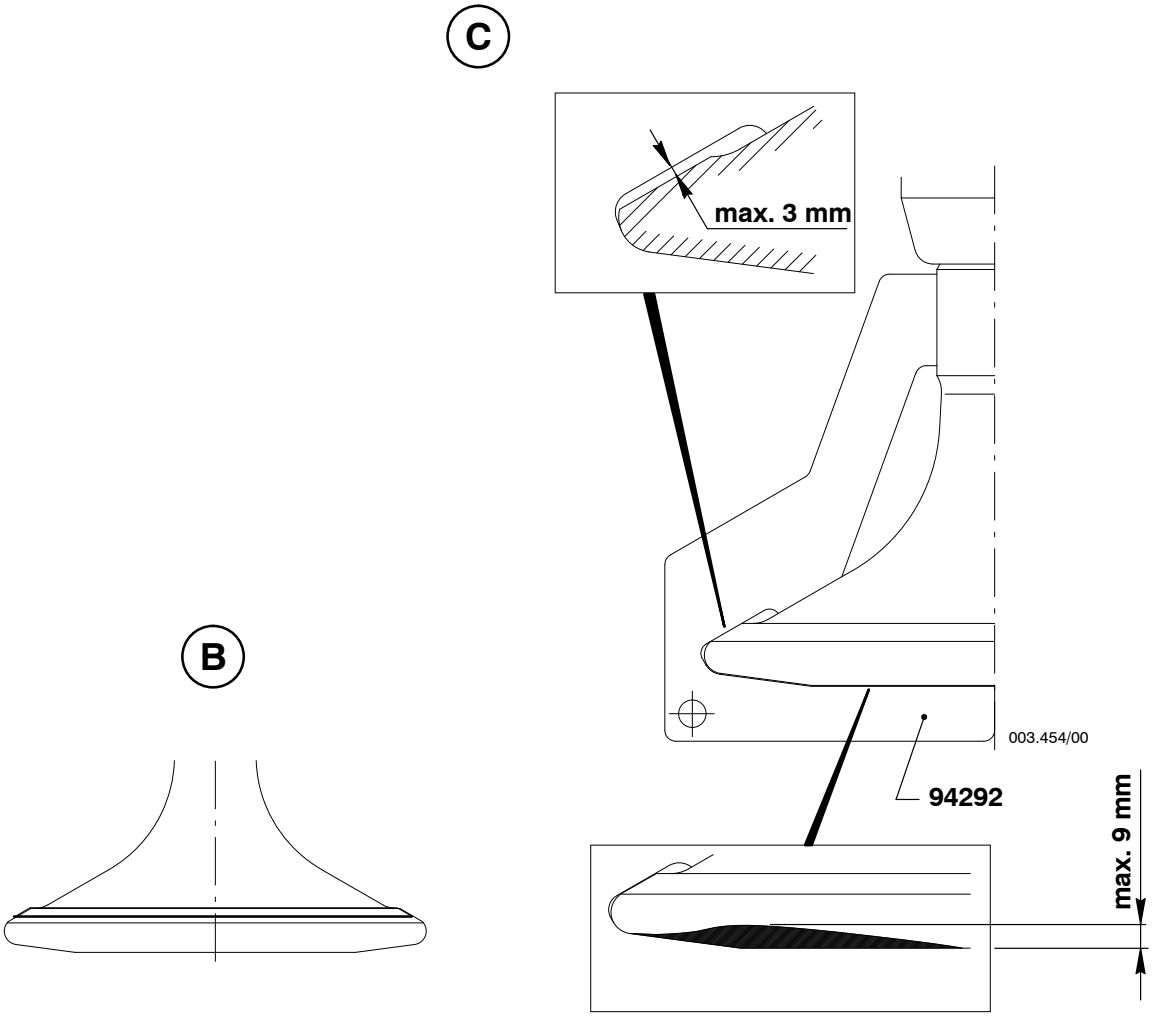
Exhaust Valve: Grinding the Seating Surface on the Valve Head

CHECK

The wear condition can be checked at any time with gauge 94292 and feeler gauge 94122.

- Where the precise angle required has been obtained during grinding, a check with marking blue with the valve on the reground valve seat in the valve cage will show only a line contact or a very narrow band (extent of contact) starting from the smaller diameter as shown in Fig. 'B'.
  See also remarks in 2751–3 regarding the valve behaviour at running temperature.
- A maximum of 3 mm may be ground off the valve seating surface. Valve plates, where the seat surface has been ground back by more than 3 mm can be reconditioned by build-up welding.
- On engines with arduous operating conditions, corrosion may form at the bottom of the valve plate, after a longer operating time. Exhaust valves can be reconditioned if the loss of material on the valve plate is less than or equal to 9 mm.
  Exhaust valves cannot be reconditioned anymore, when the loss of material is more than 9 mm, but can be kept in operation up to 16 mm loss of material.

Remark: Reconditioning of exhaust valves may, however, only be carried out by a Wärtsilä Switzerland Ltd authorized repair workshop.



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Crankshaft, Connecting Rod and Piston — Group 3

Crankshaft: Measuring Crank Deflection 3103–1/A1

▽ **Vibration Damper**

- Taking a Silicone Fluid Sample 3130–1/A1
- Inspection (GEISLINGER Vibration Damper) 3130–2/A1

Axial Damper: Dismantling and Assembling 3140–1/A1

Turning Gear: Checking the Toothing 3206–1/A1

Crankcase: Utilization of Working Platform 3301–1/A1

▽ **Connecting Rod**

- Loosening and Tensioning the Connecting Rod Studs 3303–1/A1
- Inspection, Removal and Fitting of Bottom End Bearing 3303–2/A1
- Inspection, Removal and Fitting of Top End Bearing 3303–3/A1
- Removal and Fitting 3303–4/A1
- Removal of Bearing Cover to Top End Bearing 3303–5/A1

▽ **Crosshead**

- Checking the Clearances and Fitting the Guide Shoes 3326–1/A1
- Removal and Fitting of a Crosshead Pin 3326–2/A1

▽ **Piston**

- Removal and Fitting 3403–1/A1
- Changing the Compression Shims 3403–2/A1
- Dismantling and Assembling 3403–3/A1
- Checking Piston Top Surface 3403–4/A1

▽ **Piston Rings**

- Checking Wear of Piston Rings and Ring Grooves with Four Piston Rings 3425–1/A1
- Checking Wear of Piston Rings and Ring Grooves with three Piston Rings 3425–1/A2

Crankshaft

Measuring Crank Deflection

Tool:			Key to Illustrations:	
1	Crankshaft checking equipment (dial gauge)	94305	1	Flywheel
			2	Pinion

1. General

Regular crankweb deflection measurements according to the intervals defined by the class rules are sufficient. Detailed alignment measurements might become necessary only in case of abnormalities, like

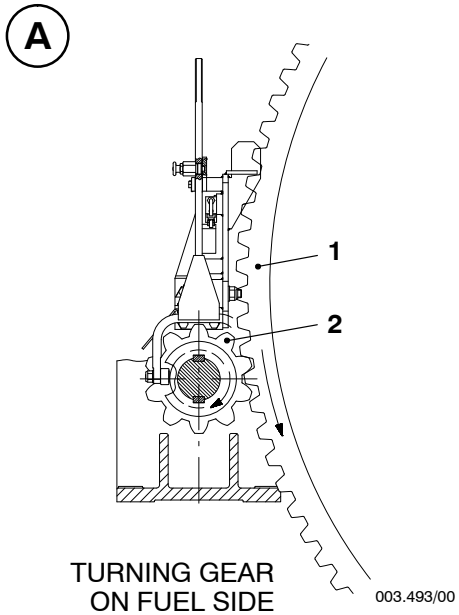
- significant change of crankweb deflection measurement results compared to the set of previous measurements.
- bearing temperature alarms or bearing damage.
- after replacing main bearing shells and again after approx. 100 service hours.
- in case the ship has touched ground.

In any such cases it is recommended to contact Wärtsilä for support.

The checking equipment 94305 is clamped between the crank webs into the provided center punch marks. When turning the crankshaft, the change in distance between the crank webs can be read from the dial gauge as it indicates any opening or closing up. The smaller the variation the better the alignment of the crankshaft. Thereby, however, the function of the checking equipment, i.e. the sign on dial gauge “+” (standard) or “–” must be taken into consideration.

2. Conditions for measuring

- Indicator valves must be open.
- The ship must be floating freely and lying in the water as horizontal as possible.
- The crankshaft must rest perfectly on all the main bearings.



2.1 Influences on measuring

- Engine cold or at service temperature.
- The difference in temperature between the lubricating oil sump tank and the seawater.
- Loaded condition of the ship (draught).
- Strong sunshine.

It is recommended to include these data in the records.

3. Measuring procedure

Despite the ordinary rotation direction of the engine, the crankshaft must **always** be turned in such a manner that flywheel 1 and pinion 2 of the turning gear are **rotating as indicated by the arrows.**

Measuring Crank Deflection

3.1 Setting the checking equipment

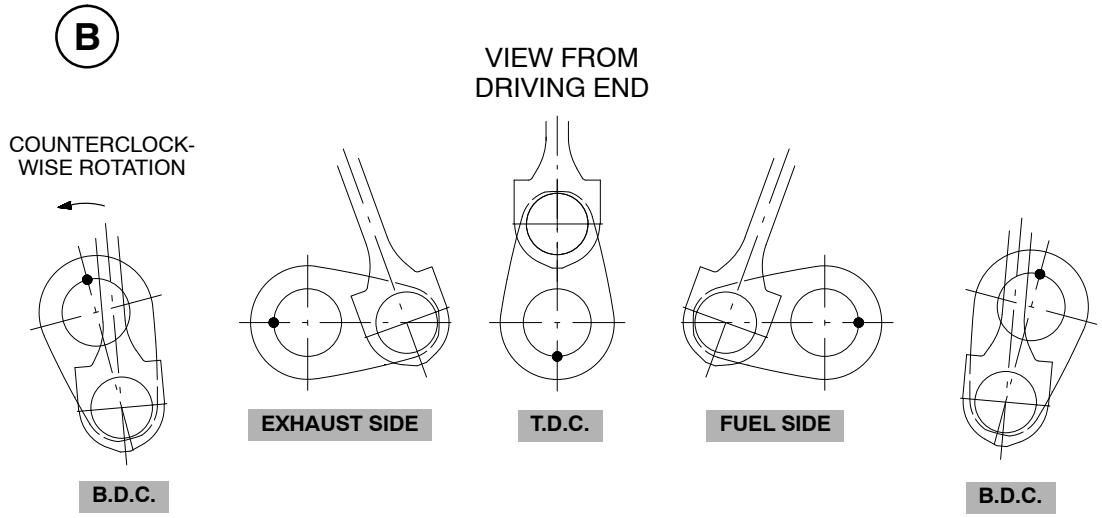
With the running gear in situ, the crank to be measured has to be turned correspondingly after B.D.C. The checking equipment can now be clamped next to the connecting rod into the provided center punch marks.

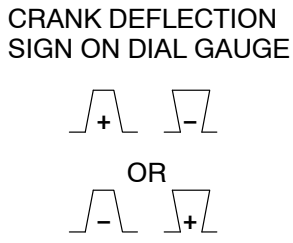
⇒ Pretension the dial gauge of checking equipment 94305 and turn the latter around its own axis for its proper settling.

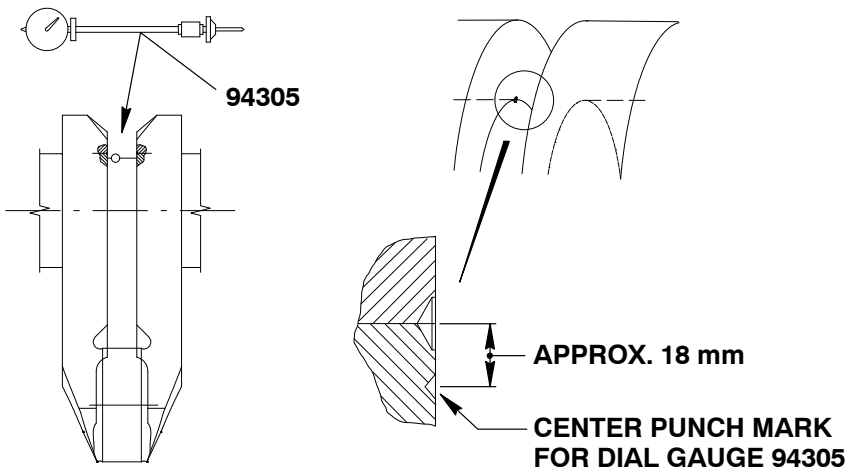
⇒ Dial gauge must not deviate more than 0.01 mm. Set subsequently dial gauge to zero.

⇒ Turn crankshaft by means of turning gear, reading the dial gauge in the shown **crank positions** at B.D.C. – EXHAUST SIDE – T.D.C. – FUEL SIDE – B.D.C and noting down the values.

- The last value at B.D.C. is for checking. With correctly carried out measuring procedure it should be again nearly zero. **If it deviates more than 0.04 mm from the first reading, then the measuring must be repeated.**

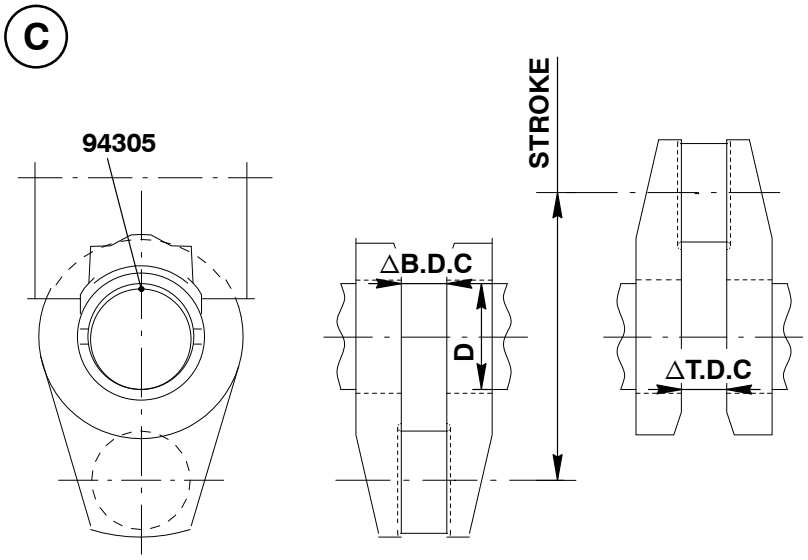






Measuring Crank Deflection

4. Judging the measuring



The difference between the indicated values shows the amount of crank deflection during one revolution (Fig. 'B').

Where values are measured which lie above the maximum permissible limits, the cause has to be found and the necessary remedial measures taken (defective main bearing, engine stay altered due to hull deformation, loose holding-down bolts, defective propeller shaft bearings or checking equipment 94305, etc.).

The limits are valid for any condition of ship service after ship delivery, i.e.:

- The ship's draught and trim are within the limits for normal operation.
- The engine is stopped and hot or cold.
- In case of measurements at cold engine condition, any tank heating which is arranged close or below the main engine as well as the pre-heater of the main lubricating oil separator have to be out of operation at least 8 hours prior to the measurement.

Normal ship service: Crankweb deflection limits [mm]				
Vertical				**Horizontal**
Cylinder No. 1 (Driving end)	**Cylinder No. 2 to penultimate cylinder**	**Last cylinder** (Free end)		**All cylinders**
		1)	**2)**	
0.58 –0.58	0.41 –0.41	0.41 –0.41	0.41 –0.58	0.19 –0.19

1) For engine without torsional vibration damper or front disc or free end PTO.

2) For engine with torsional vibration damper or front disc or free end PTO.

Contact Wärtsilä Switzerland, if the final measurements exceed the limits given in the above table.

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Vibration Damper

Taking a Silicone Fluid Sample

Key to Illustrations:

1	Casing trough	7	Crankshaft
2	Casing cover	8	Cap nut
3	Screw plug		
4	O-ring		
5	Sealing ring	KS	Secured by centre punch mark
6	Coupling bolt	PB	Sample container

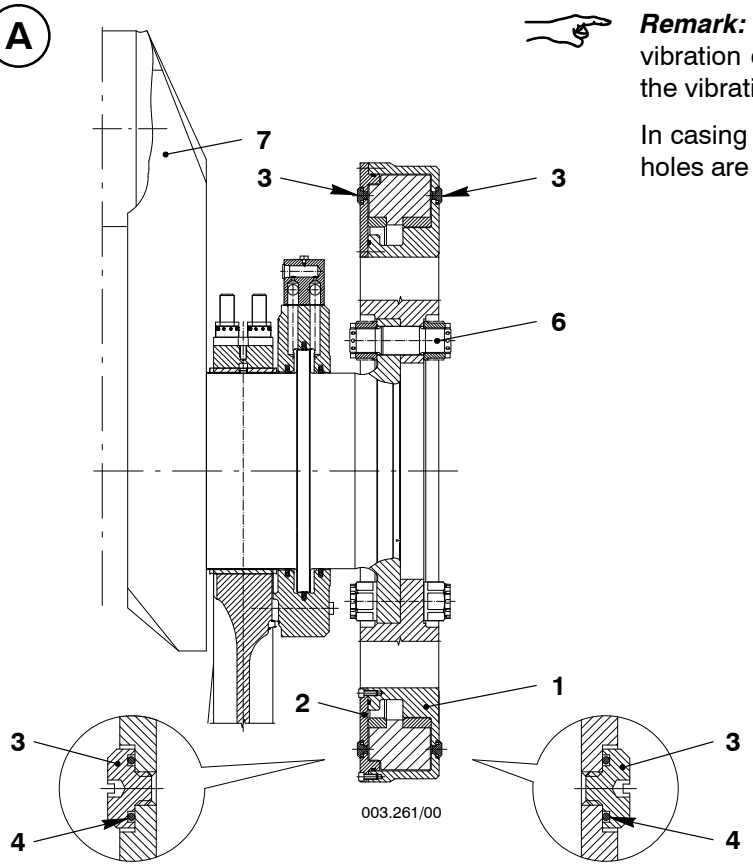
1. General

Viscous vibration dampers manufactured by Hasse & Wrede, Metaldyne International UK, STE Schwingungstechnik and Geislinger can be mounted at the free end of the crankshaft and in case of RTA engines as well at the free end of the camshaft.

The service life of a vibration damper is largely dependent on the speed range in which the engine is run. Wear of the inner parts as well as changes in the silicone oil properties can reduce the effectiveness of the damper. By periodic examination of the silicone oil the makers of the vibration damper can draw conclusions on its condition.
The silicone oil must be examined for the first time after about 15 000 – 18 000 operating hours. Future intervals for examinations depend on the result of these first findings.

Special sample containers 'PB' (Fig. 'B') can be obtained from the vibration damper makers.

A



Remark: Before taking a sample, or before working on a vibration damper, always follow first the instructions of the vibration damper manufacturer.

In casing trough 1 and casing cover 2, two oil sampling holes are carefully closed and sealed with screw plugs 3.

2. Preparation for taking a silicone fluid sample

⇒ Remove the casing of the vibration damper.

⇒ Turn the crankshaft in such a way that both screw plugs 3 of the vibration damper are positioned horizontally to each other, whenever possible. If in this position the screw plugs cannot be loosened , then the vertical position can also be chosen.

⇒ Before removing the screw plug, carefully clean the area around it.

- Leave the damper in the mentioned position for at least two hours.
  (If the oil sample is to be withdrawn from a removed vibration damper the same conditions apply as regards the positions and the waiting time).

⇒ Using a flat caulker, hammer back the squeezed material in the corresponding slot, which serves as locking means of the screw plug 3.

⇒ Loosen the screw plug, but do not unscrew it yet, it must still seal.

3. Taking the sample

CHECK

Prepare sample container 'PB', i.e. remove both cap nuts 8 and examine the bore which must be meticulously clean.

Remark: Two different threads are used for the sample bores of the 'Simpson International' and STE vibration dampers. Therefore, the ends of the sample container are provided with different threads.

⇒ Remove the previously loosened screw plug 3, and screw in sample container 'PB' instead.

⇒ After fully screwing in the sample container, screw it back by one turn to prevent it from touching the flywheel inside the vibration damper.

⇒ Wait until the silicon fluid appears at the open end of the sample container. Depending on the viscosity of the fluid, this may take some seconds only, or much longer.

⇒ As soon as the silicon fluid flows out of the sample container, close its open end with the respective cap nut.

⇒ Unscrew the sample container from the vibration damper housing (taking care not to let escape the fluid), then immediately set in screw plug 3 with a new O-ring 4 or sealing ring 5. (Avoid any leaking of silicon fluid.)

⇒ Screw the second cap nut on the sample container and tighten it moderately.

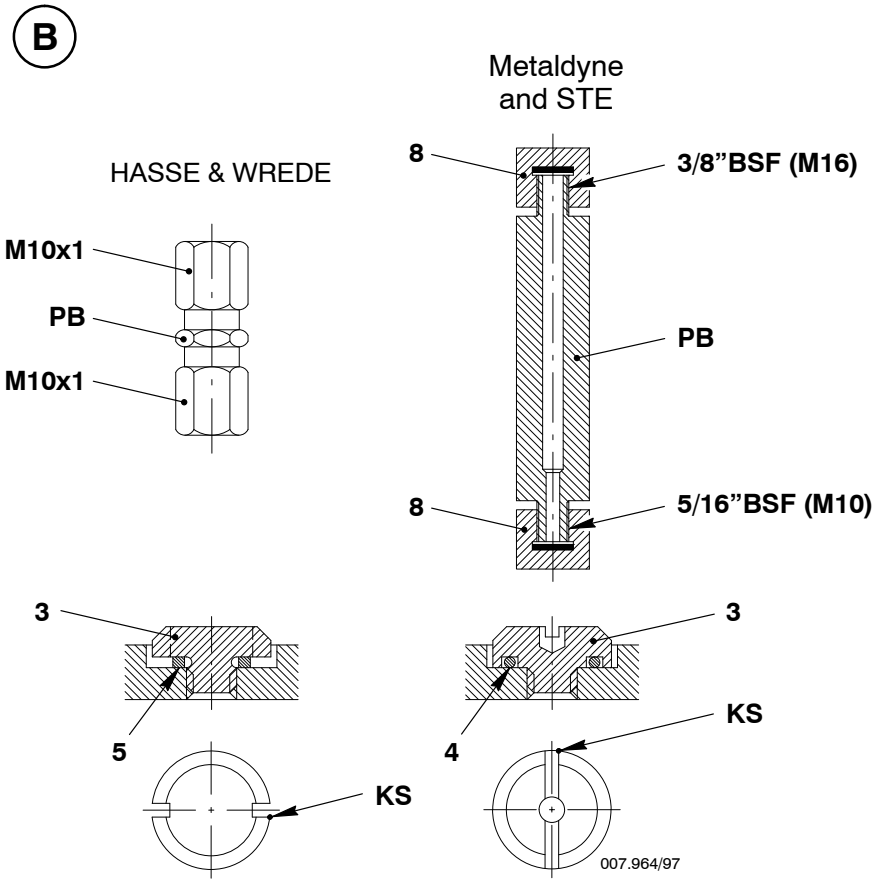
⇒ For the different vibration dampers tighten screw plugs 3 as follows:

- Metaldyne International with **25 Nm**
- Hasse & Wrede with **20 Nm**
- STE with **15 Nm** (M10) or **45 Nm** (M16)

⇒ Finally secure the screw plugs with centre punch mark 'KS' (Fig. 'B').

Taking a Silicone Fluid Sample

SAMPLE CONTAINERS



If a sample is not obtained by the method described, proceed as follows:

- Leave sample container in position.

⇒ Remove the opposite screw plug, connect a compressed air supply and apply about 3.5 bar pressure.

- Only dried and filtered air may be used (connections and air hose must be clean, free from any fouling).

⇒ As soon as fluid reaches open end of sample container shut off compressed air supply and then fit one of the two cap nuts 8 to the sampling container.

⇒ Disconnect compressed air supply. Remove sample container and fit the other cap nut 8**.**

⇒ Re-fit the corresponding screw plugs to all withdrawal openings.

⇒ Tighten and lock the screw plugs as already mentioned under ’Taking the sample’.

Remark: The special sample container permits drawing a specific quantity of silicone oil from the damper. The total number of samplings should be limited to 10.

Taking a Silicone Fluid Sample

The filled sample container has to be labelled and depending on the manufacturer sent to one of the following addresses for examination:

Hasse & Wrede
Georg-Knorr-Strasse 4
D-12681 Berlin
Germany
Tel: +49 30 93 92 3135
Fax: +49 30 70 09 0835

Remark: Samples taken on dampers manufactured by STE Schwingungstechnik have to be sent to Hasse & Wrede.

Metaldyne International UK Ltd
131 Parkinson Lane
GB-Halifax HX1 3RD
United Kingdom
Tel: +44 1422 357 234
Fax: +44 1422 354 432

Geislinger GmbH
Hallwanger Landesstrasse 3
A-5300 Hallwang / Salzburg
Austria
Tel: +43 662 66 999 0
Fax: +43 662 66 999 40

The label must contain the following information:

- Engine type
- Engine No.
- Number of operating hours of the vibration damper
- Ship name
- Shipyard and hull number
- Manufacturing serial number of damper (see manufacturing plate or stamped marks)
- Damper location (crankshaft or camshaft)

Vibration Damper

Inspection (GEISLINGER Vibration Damper)

Key to Illustrations:

1 Damper casing
2 Vent nozzles
3 Sealing rings
4 Oil supply piping
5 Crankshaft
6 Coupling bolt
7 Torsiograph drive
8 Vibration damper
9 Sealing ring

1. General

Depending on the design execution of an engine, a vibration damper of GEISLINGER make may be mounted at the free end of the crankshaft.

The service life of a vibration damper depends largely on the speed range in which the engine is operated. Water, in particular sea-water, in the lubricating oil leads to increased wear and loss of damping action.

2. Check

- The engine filters should regularly be checked for steel or bronze chippings. If such chippings are found also in the damper housing, the damper supplier is to be informed accordingly.



Until the reasons for such findings are not clarified and rectified, it is not allowed to put the damper back into service.

- Should the oil pressure drop below 1 bar, it may not be corrected by adjustment of the adjustable throttle in the supply piping. Instead, the cause of the pressure drop must be investigated (defective oil supply piping 4).



Attention! If the oil supply to the damper is interrupted, the engine must be stopped immediately, otherwise the damper may be seriously damaged. The oil supply has to be reestablished before restarting the engine.

- Should damage be noticed on the engine bearings which is due to water contamination of the lubricating oil, then the vibration damper must also be inspected for possible damage at the very earliest opportunity.
- To check the inner spring tips and groove flanks the inspection cover on the face of damper casing 1 (Fig. 'B') can be removed (with stopped engine). For wear limits refer to the manual of the damper manufacturer.
- Dismantling of a vibration damper should only take place if there is a reasonable suspicion that the damper is damaged or wear rates have exceeded their limits. In this case contact the damper manufacturer for further instructions.
- For tightening values of coupling bolts 6 see 0352–1.



Attention! Adjustments on the vibration damper may only be carried out by a specialist, with simultaneous torsional vibration measurements.
Prior to removing a vibration damper and balance weight mark their positions with reference to the crankshaft.

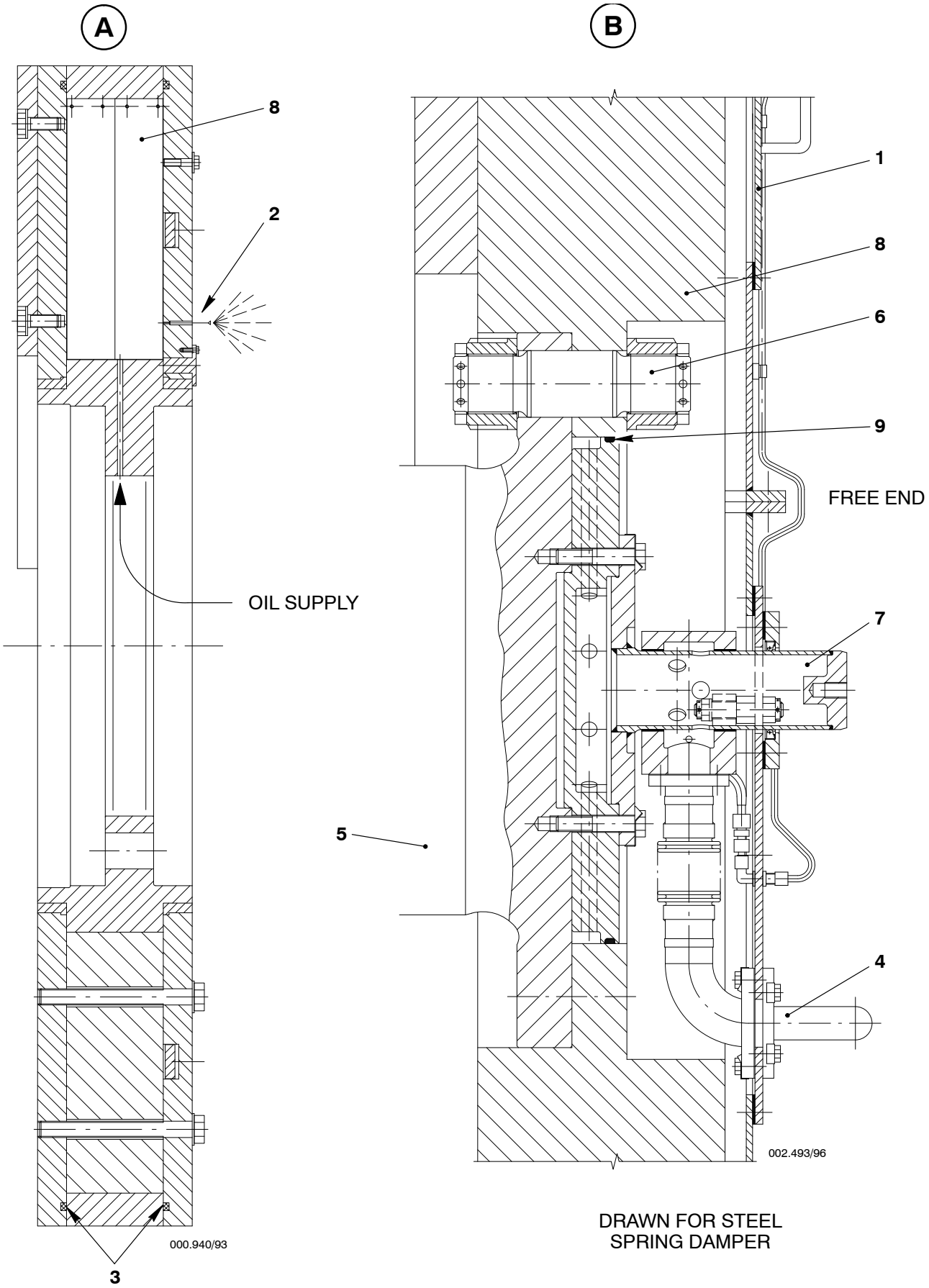


Remark: For the test run after the first commissioning, as well as the normal checking and servicing intervals, refer to the manual of the damper manufacturer.

Contact address for GEISLINGER vibration dampers:

Geislinger GmbH
A-5300 Hallwang / Salzburg
Austria

Inspection (GEISLINGER Vibration Damper)



DRAWN FOR STEEL SPRING DAMPER

Axial Damper

Dismantling and Assembling

Tools:

1	Manual ratchet (WLL 2500 kg)	94016E
2	RUD-eye bolts M16	94040-M16
1	Support	94320
1	Wire rope sling	GF 94333D

Key to Illustrations:

1	Upper part of cylinder	12	Orifice
2	Lower part of cylinder	13	Oil inlet pipe
3	Bolt M20x150	14	Main bearing cover
4	Bolt M24x200	15	Crankshaft
5	Bolt M20x480	16	Main bearing shell
6	2-part gasket	17	Oil drain pipe
7	2-part gasket	18	Upper casing
8	Tension spring	19	Screw M16x160
9	Tension spring	20	Piping for damper monitoring
10	Housing		
11	Taper pin		

1. Dismantling

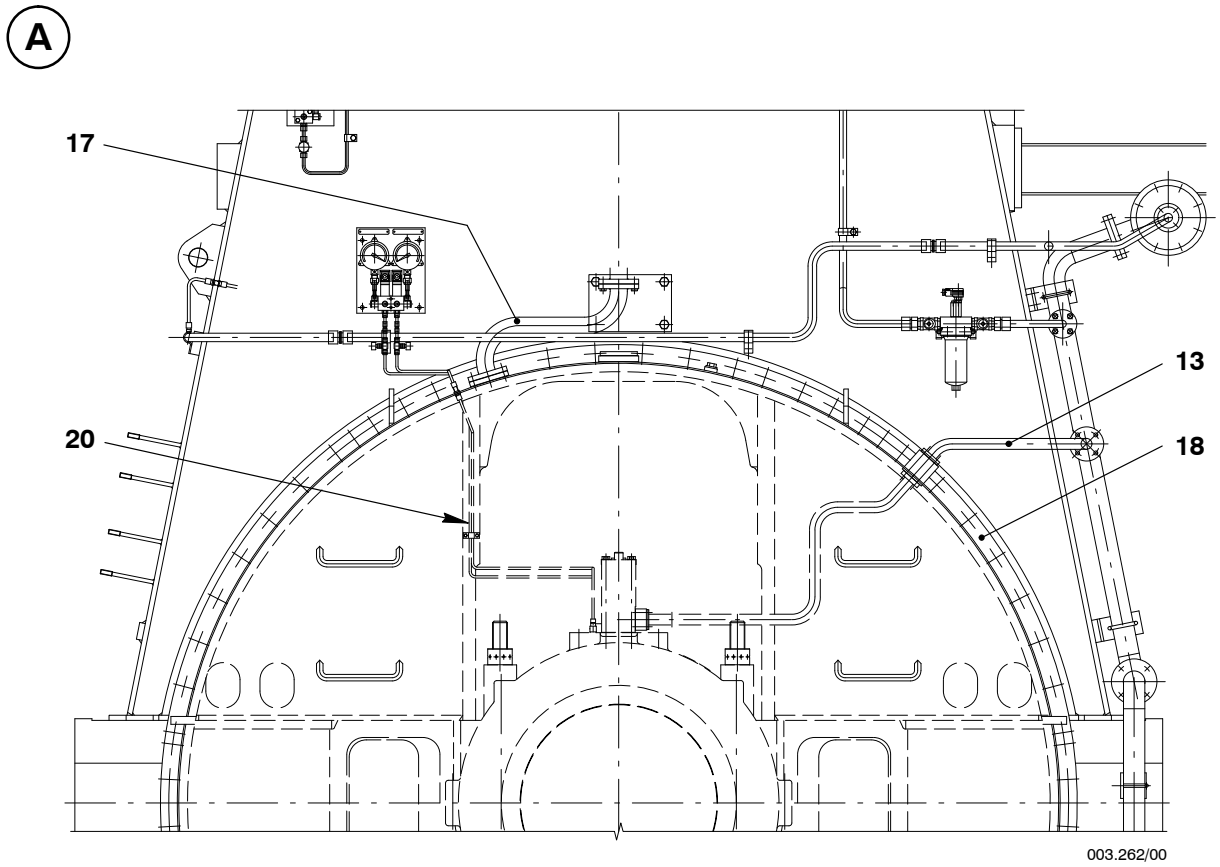
When the 2-part gaskets 6 or 7 has to be removed from an axial damper, proceed as follows:

⇒ Switch off the bearing oil pump.

⇒ Remove oil drain pipe 17.

⇒ Unscrew and remove oil inlet pipes 13 and the piping for damper monitoring 20 internally and externally from upper casing 18.

⇒ Remove upper casing 18.



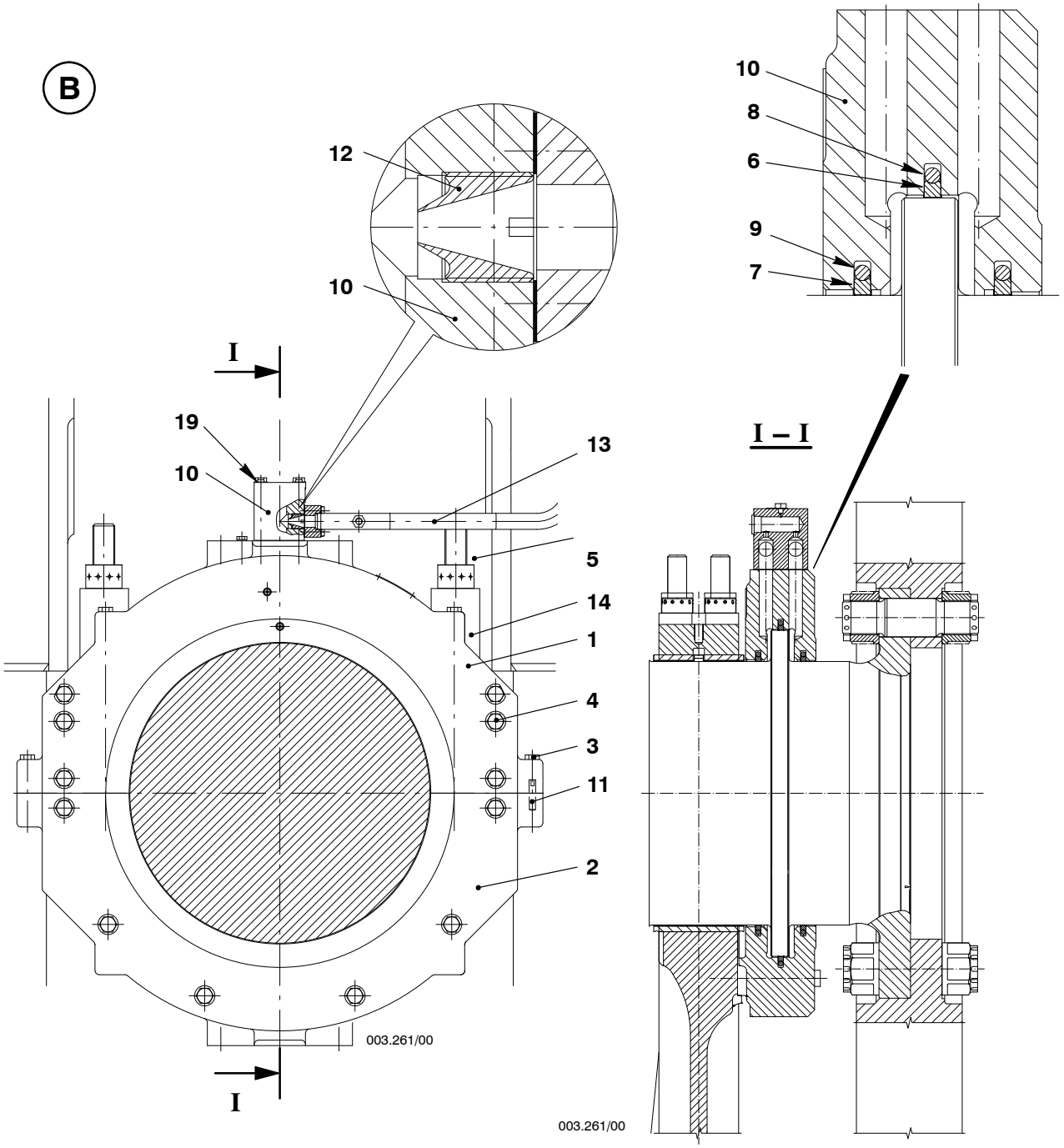
Axial Damper: Dismantling and Assembling

⇒ Loosen screws 19 and remove housing 10.

⇒ Pull out both taper pins 11 locating the upper and lower part of cylinder 1 and 2.

⇒ Remove all screws 5 and 3 (Fig. 'B').

⇒ Remove all screws 4 to the upper part of cylinder 1. On engines provided with vibration damper loosen the screws and pull them out as far as possible.



Axial Damper: Dismantling and Assembling

⇒ Fasten support 94320 to the face of the free end of the engine.

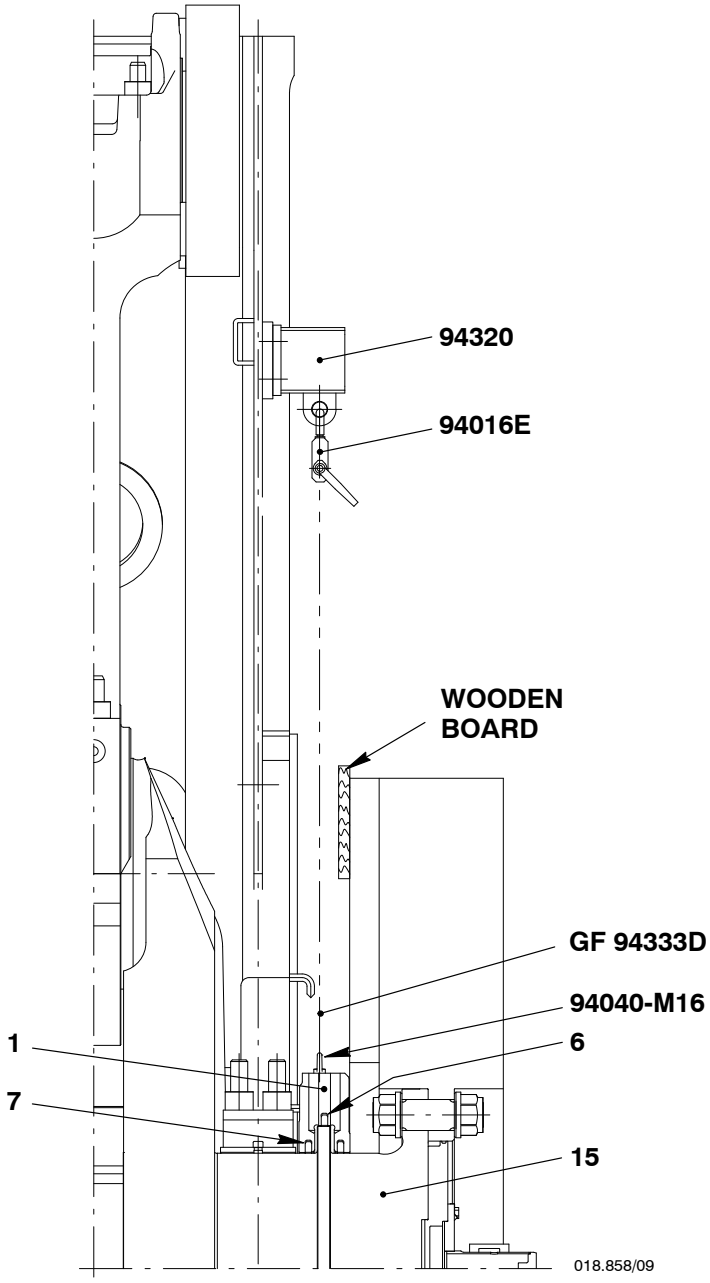
⇒ Screw two RUD-eye bolts 94040–M16 into the upper part of cylinder 1, then join these by means of wire rope sling GF 94333D to manual ratchet 94016E.

⇒ **For inspection of the 2-part gaskets** carefully lift the cylinder upper part as shown in figures below using the manual ratchet.

Attention! When lifting make sure that the cylinder upper part **slides out of 2-part gaskets 6 and 7 without jamming**, as otherwise the gaskets risk being damaged. Moreover provide a wooden board in order to protect the cylinder upper part and the vibration damper.

⇒ Turn 2-part gaskets 6 and 7 until their tension springs 8 and 9 can be unhooked. Remove tension springs and gaskets.

C



3. Assembling

Remark: The 2-part gaskets normally have no signs of wear, therefore no dimension due to wear is indicated. However, worn or damaged 2-part gaskets 6 and 7 due to contamination must be replaced.
See also 3146–1 'Monitoring system' in the Operating Manual.

- Immediately before fitting 2-part gaskets smear them with clean engine oil.
- Newly fitted 2-part gaskets must allow radial movement when fitted.
- The assembling of the axial damper is done analogously to dismantling but in reverse sequence. Pay the utmost attention when lowering upper part of cylinder 1 into place, to prevent 2-part gaskets 6 and 7 from being damaged.
- Before tightening screws 3 as well as 4 and 5 fit the taper pins for the upper part and lower part of the cylinder.
- New packings must be used for the assembly of the housing 10 and oil inlet pipe 13.

Remark: Apply MOLYKOTE Paste G-n to the thread and seating surface and tighten bolts 4 between axial damper and bedplate with a tightening angle of **45**° (or 630 Nm, see 0352–1).

Turning Gear

Checking the Toothing

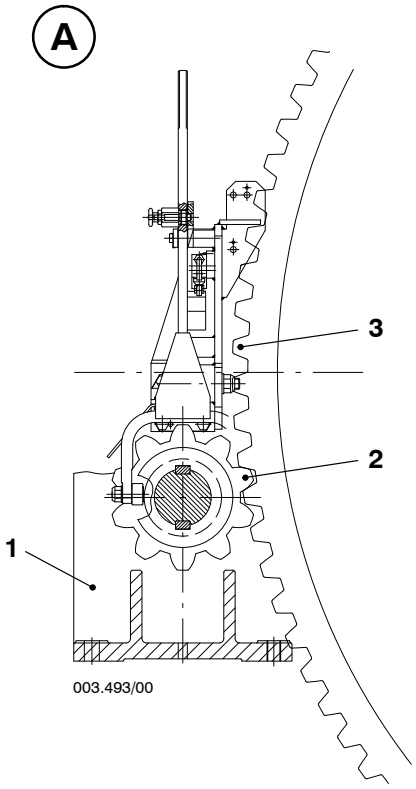
Key to Illustration:

1 Turning gear
2 Pinion
3 Toothing of flywheel

1. General

Before putting the turning gear into operation, the condition of the tooth flanks, i.e. the lubricant of pinion 2 and toothing of flywheel 3 must always be checked. See also 0750–1 in the Operating Manual.

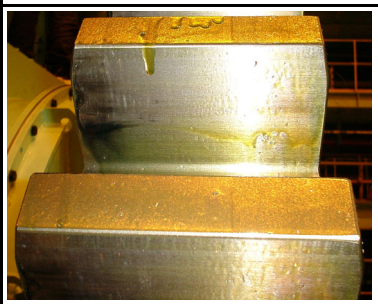
For maintenance of the turning gear the instructions recommended by the manufacturer must be followed.



2. Checking the toothing

2.1 Application instruction

The lubricant needs to be spread evenly in a **very thin layer** over the tooth flanks of pinion 2 and flywheel 3 in order to prevent it from being thrown off at full engine speed.

	Brand	Application picture	Remark
1	**LE 5182 PYROSHIELD**		Apply lubricant in a zig-zag line to provide a thin layer of lubricant over the entire gear tooth surface.
2	**Klüberfluid C–F 3 ULTRA**		In order to reach a very thin shiny layer of lubricant, it is recommended to warm up Klüberfluid to approx. 35 °C in a small tin which is put into warm water.

2.2 Re-lubrication intervals

According to visual inspection results, when hardly any lubricant is left any more on the highest loaded tooth flank areas, i.e. before the tooth flanks nearly run dry:
Approximately every 2000 operating hours of the diesel engine, or more frequently, as required.

2.3 Recommended suppliers

1 **Lubrication Engineers Inc.**
300 Bailey Avenue
Forth Worth TX
USA
http://www.lelubricants.com
Email: info@le-inc.com

2 **Klüber Lubrication München KG**
Geisenhausenerstrasse 7
81379 München
Germany
http://www.klueber.com
Email:info@klueber.com

Crankcase

Utilization of Working Platform

Tools:

2	Working platforms, consisting of 2 grids each	94142
2	Working supports	94143

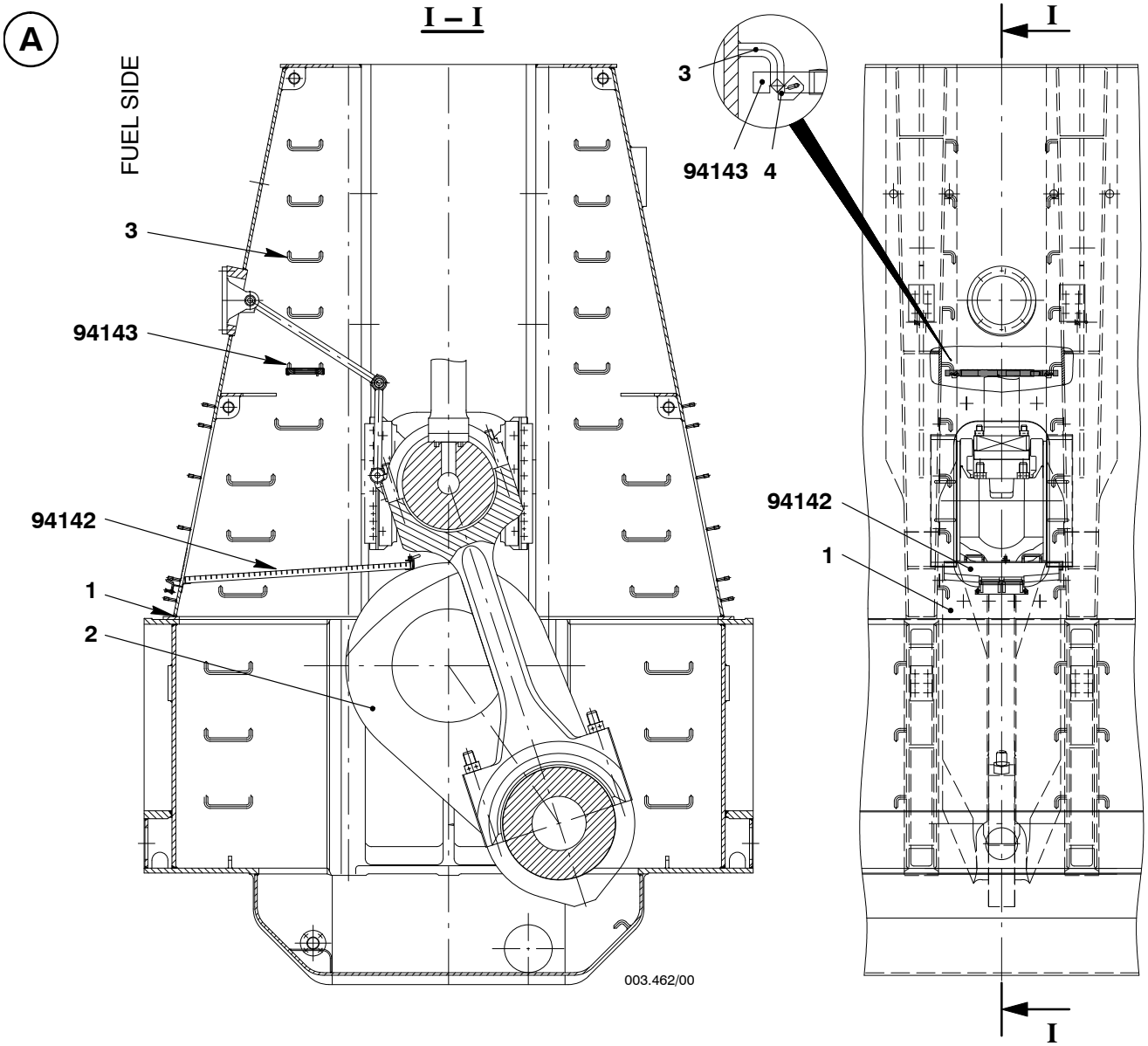
Key to Illustrations:

1 Engine longitudinal beam
2 Crank web
3 Step
4 Strap

To avoid accidents, the grids of working platform 94142 and working supports 94143 should be used for inspections or work in the crankcase. The grids must always be fitted in such a way that their U-profiles come to lie between engine longitudinal beam 1 and that the opposite end rests on crank web 2.

Working support 94143 can be fitted between the columns at the desired height, on steps 3. These are safeguarded against falling down by shoving straps 4 against the steps.

Attention! Never rotate the crankshaft while the grids or working supports are in position.



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Connecting Rod

Loosening and Tensioning the Connecting Rod Studs

	Tools:	
1	Feeler gauge	94122
2	Pre-tensioning jacks	94314
2	Pre-tensioning jacks	94315
1	Hydr. distributor	94934A
1	HP hose	94935
2	HP hoses	94935A
1	Hydraulic unit	94942

Key to Illustrations:

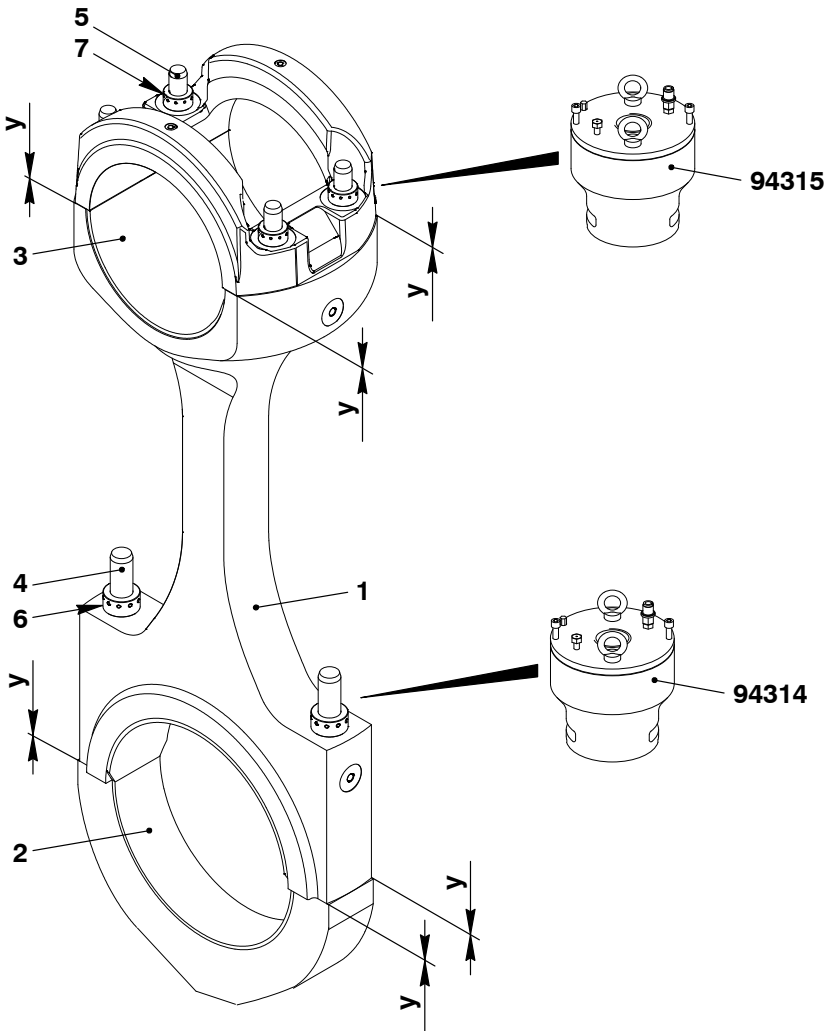
1	Connecting rod
2	Bottom end bearing
3	Top end bearing
4	Stud of bottom end bearing
5	Stud of top end bearing
6	Nut
7	Nut

1. General

Attention! Never turn the crankshaft (with the turning gear) as long as the pre-tensioning jacks are mounted on the connecting rod studs!

Please refer to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

A



DRAWN FOR
RT–flex68–D

2. Loosening and tensioning the connecting rod studs

2.1 Bottom end bearing

- Tighten the nuts with a round bar and equally distribute clearance 'y' between the bearing halves (bearing protrusion) as shown in Fig. A.
- Tensioning of the studs of bottom end bearing 4 must be carried out in two steps without exception, i.e. tension studs first with **300 bar (1st step)**, then finish tensioning with **1000 bar (2nd step)**.

CHECK

Based on the markings applied, check by how much the nuts were turned after pre-tightening (1st step) to the 2nd step. **Tightening angle** to be about **60**° for comparison.

2.2 Top end bearing

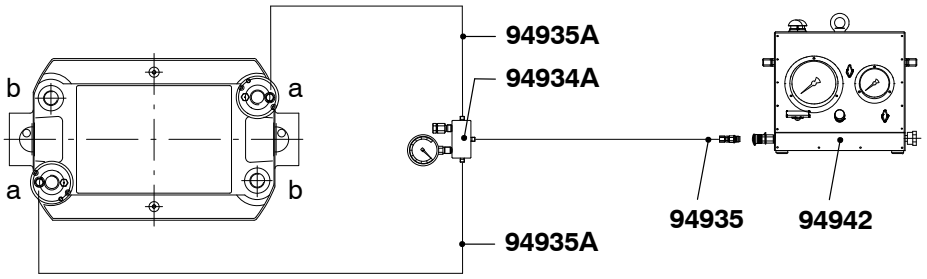
- Tighten the nuts with a round bar and equally distribute clearance 'y' between the bearing halves (bearing protrusion) as shown in Fig. A.
- Tensioning of the studs of top end bearing 5 must be carried out in two steps without exception, i.e. tension all elastic studs first with **600 bar (1st step)**, then finish tensioning with **1000 bar (2nd step)**.

CHECK

Based on the markings applied, check by how much the nuts were turned after pre-tightening (1st step) to the 2nd step. **Tightening angle** to be about **25**° for comparison.

- Moreover, **always** carry out loosening and tightening procedures **crosswise,** i.e. a/a and b/b **for each step**.

B ARRANGEMENT OF PRE-TENSIONING JACKS 94315



Connecting Rod

Inspection, Removal and Fitting of Bottom End Bearing

	Tools:	
2	Handle screws	94009-M8
3	Manual ratchets (WLL ≥ 800 kg)	94016, A, D (H1...H3)
2	RUD-eye bolts	94040-M30 (RC)
1	Deviation pipe	GF 94117A
2	Ropes	94120B
1	Rope	94120G
1	Working platform	94142
4	Retaining pins	94323
2	Shackles	94572C

	Key to Illustrations:		
1	Connecting rod stud		
2	Nut		
3	Crank		
4	Bearing cover		
5	Connecting rod		
6	Guide way		
7	Upper bearing shell		
8	Lower bearing shell		
9	Allen Screw		
10	Dowel pin	WU	Wooden underlay

1. Inspection and removal

- Loosen nuts 2 of connecting rod studs 1 according to 3303–1.

Attention! Never turn the crankshaft as long as the pre-tensioning jacks are mounted on the connecting rod studs!

Remark: Pay attention to:
- General Guidelines for Lifting Tools 0012–1.
- Utilization of Working Platform 3301–1.

1.1 Lowering of bearing cover

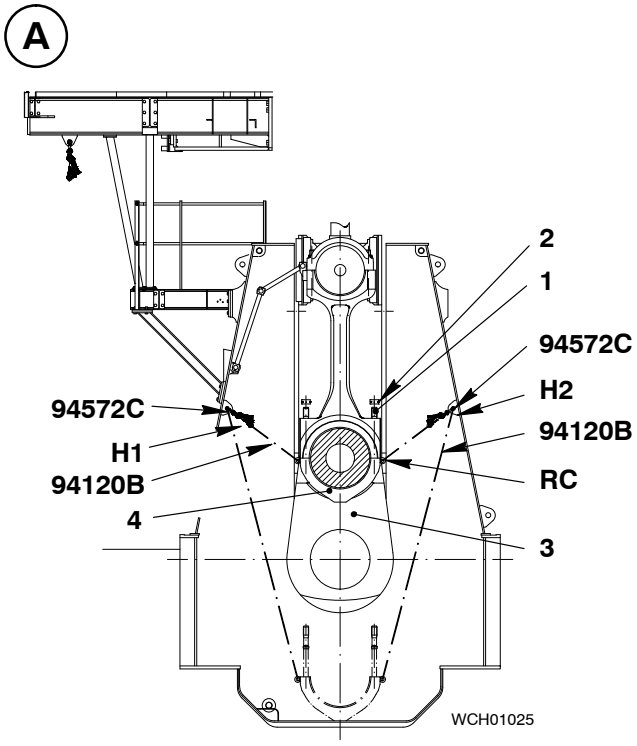
⇒ Turn crankshaft to T.D.C.

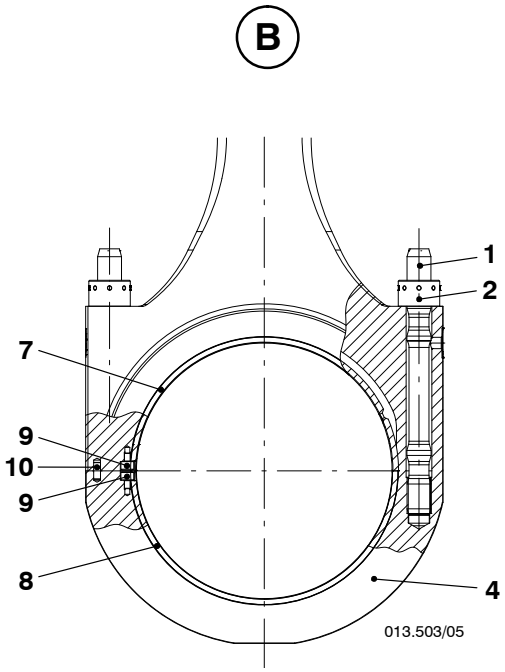
⇒ Fit RUD-eye bolt 'RC' on each side of bearing cover 4.

⇒ Attach manual ratchets 'H1' and 'H2' with shackles 94572C and ropes 94120B and connect them to RUD-eye bolts 'RC'.

⇒ Remove nuts 2.

⇒ Carefully lower the bearing cover. Make sure the threads of the connecting rod studs and the surface of the crankpin do not get damaged.





1.2 Inspection of bearing shell

- Lower bearing cover 4 (see paragraph 1.1).

⇒ Turn the crankshaft to T.D.C.

⇒ Insert four retaining pins 94323 into the bore of guide ways 6.

⇒ Carefully turn crank towards fuel side until the guide shoes come to rest on the retaining pins (if, however, not all retaining pins touch the guide shoes, turn them such that their eccentrics contact the guide shoes).

⇒ Secure the connecting rod with manual ratchet ’H1’.

⇒ Carefully turn down the crank to fuel side, following with the connecting rod bottom by pulling it with the lifting tackle ’H1’ just as far as to keep **always** a distance ’x’ between the connecting rod bearing and crank 3 (Fig. ’E’).

- The bearing shell surface can now be inspected.

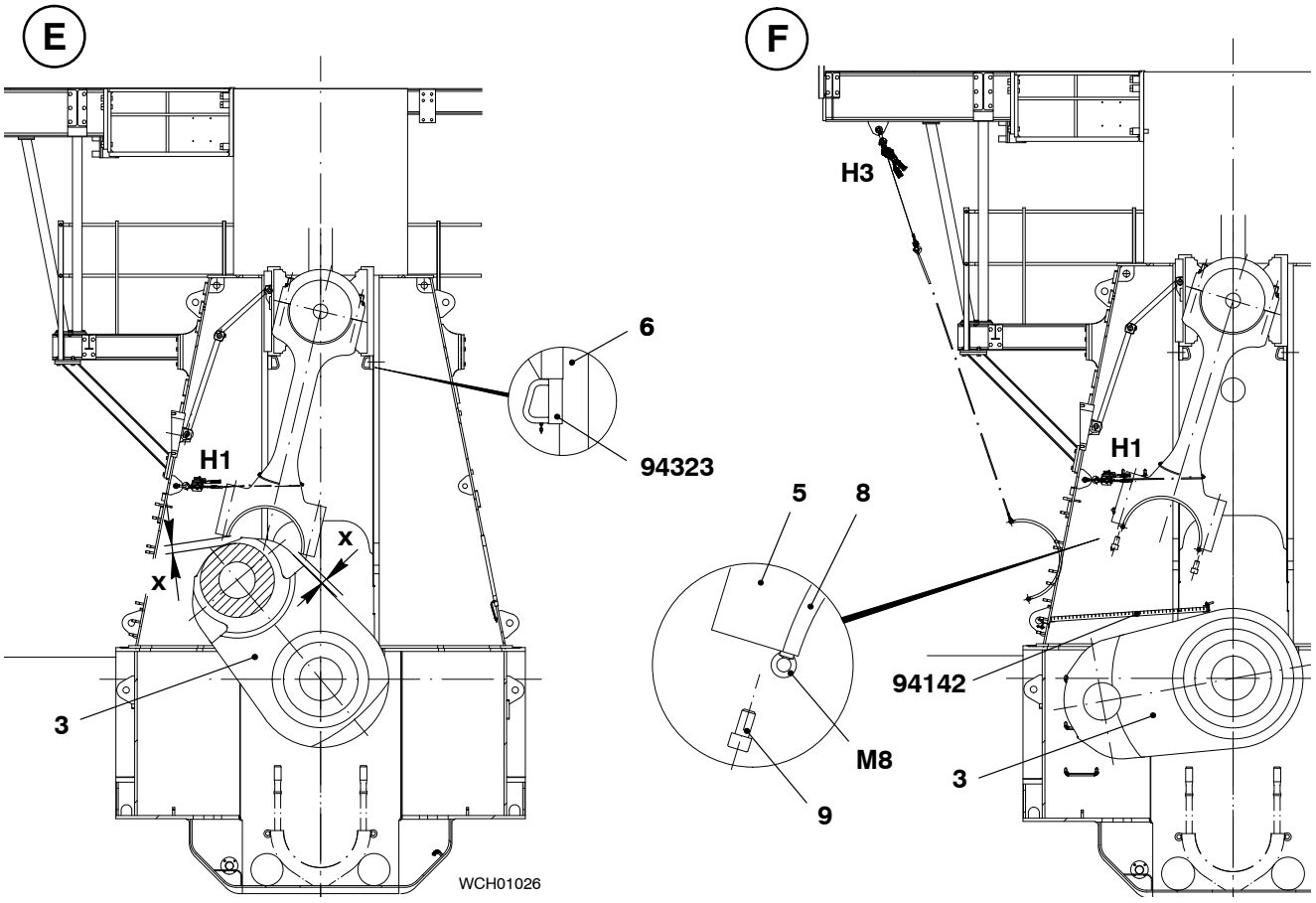
1.3 Removal of lower bearing shell

⇒ Turn crankshaft downwards (Fig. ’F’).

⇒ Install working platform 94142.

⇒ Remove Allen screws 9.

⇒ Remove bearing shell (29 kg) manually or with help of manual ratchet ’H3’ and two eye bolts M8.



1.4 Removal of bearing cover

Remark: Only with a lifting tool having at least 3.5 m hoisting capacity, instead of manual ratchet 'H1', the bearing cover can be removed directly from the crankcase bottom (Fig. 'A').

⇒ Fit a RUD-eye bolt 'RC' on each side of bearing cover 4.

⇒ Mount deviation pipe GF 94117A to the column door.

⇒ Attach manual ratchet 'H1' with shackle 94572C. Attach manual ratchet 'H2' with shackle 94572C and rope 94120B.

⇒ Remove nuts 2.

⇒ Carefully lower the bearing cover until the connecting rod studs 1 are out of the connecting rod.

⇒ Turn crankshaft about 30° in exhaust side direction.

⇒ Slacken manual ratchet 'H2' until the bearing cover is moved in position as shown in Fig. 'C'

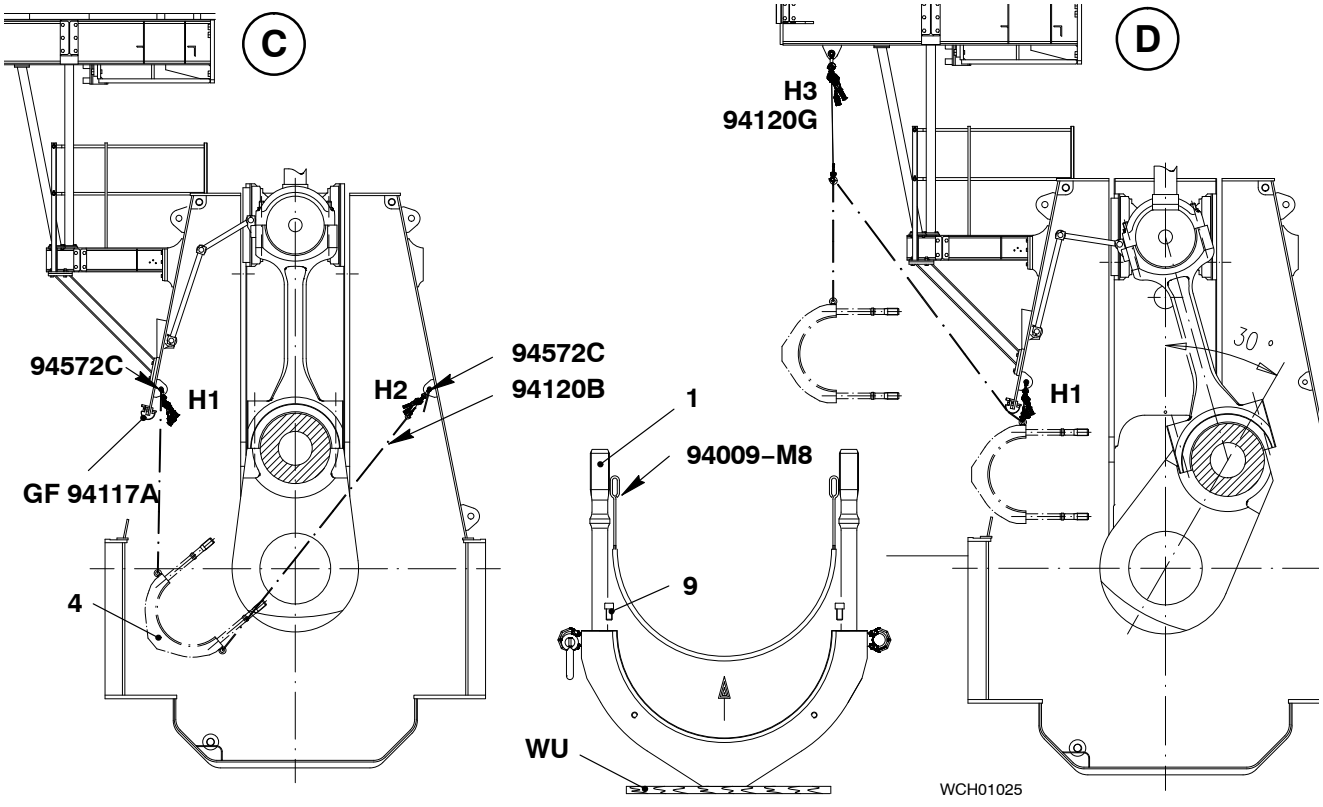
⇒ Lift bearing cover with manual ratchet 'H1' as high as possible. Disconnect manual ratchet 'H2'

⇒ Attach manual ratchet 'H3' with rope 94120G, move bearing cover out of column and place it on wooden underlay 'WU'.

1.5 Removal of lower bearing shell

⇒ Remove Allen screws 9.

⇒ Remove bearing shell by means of handle screws 94009-M8 which are screwed into the front faces of the bearing shell.



2. Fitting

Fitting of the bearing shells and bearing cover is carried out analogous to removal but in reverse sequence.

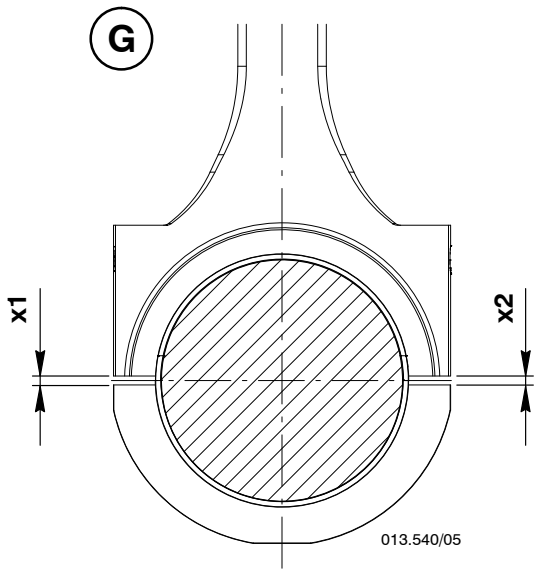
- The running surfaces have to be lavishly smeared with clean bearing oil.
- Tensioning of connecting rod studs must be carried out according to 3303–1.

Attention! After completing the work make sure all retaining pins 94323 are removed.

3. Fitting of a bearing shell

- The surface of the crankpin must be in perfect condition.
- The contact surfaces of the shell rear side and the bearing bore must be free from any damage.
- While fitting bearing shells prevent dirt or foreign particles from entering between the shell rear surface and its seating! Immediately before inserting the bearing shells wipe them with a slightly oily hand.
- The bearing shell should be placed in the connecting rod head such that it protrudes by the same distance at both ends of the separating face.

This protrusion is a must and under no circumstances may the separating face of the bearing shell be filed to reduce it!



Protrusion of new bottom end bearing shells:

$x_1 + x_2$ = approx. 0.96 – 1.12 mm
(total for both bearing shells)

Remark: Above measuring checks must be carried out when fitting new bearing shells. For this the bearing shells are placed in position the bearing cover fitted and the nuts tightened by hand with a round bar.

Prior to final assembly smear the running surfaces lavishly with clean bearing oil. If, however, the engine have to be frequently turned after the fitting of the bearing, or should a re-start of the engine not be immediately planned, then instead of bearing oil a mixture of $^2/_3$ steam-engine cylinder oil and $^1/_3$ normal bearing oil should be used. Special oils suited to this purpose are also available from reliable suppliers.

In order to further reduce the risk of dry running on newly fitted bearing shells, the latter can be post-lubricated by means of a lubricating pump (see 3303–3).

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing

	Tools:	
2	Handle screws	94009–M8
2	Manual ratchets (WLL≥800 kg)	94016, D (H1)
2	Manual ratchets (WLL 2500 kg)	94016E (H2)
2	RUD-eye bolts	94040–M16 (RC)
2	RUD-eye bolts	94040–M20 (RC1)
2	RUD-eye bolts	94040–M30 (RC2)
1	Working platform	94142
4	Retaining pins	94323
1	Stop plate	GF 94335
1	Connecting flange	94336
2	Shackles	94572C

	Key to Illustrations:		
1	Elastic stud	12	Guide segment
2	Nut	13	Threaded hole M30
3	Connecting rod	14	Cylinder block
4	Crosshead pin		
5	Toggle lever		
6	Bearing cover		
7	Bearing shell		
8	Allen screw		
9	Guide way		
10	Guide shoe	DL	Pressure pipe
11	Dowel pin	OP	Lubricating pump

1. Inspection of bearing shell

Risk of accident! Ensure that the crankshaft does not turn unintentionally during all the maintenance work.

Remark: Pay attention to:

- General Guidelines for Lifting Tools 0012–1.
- Utilization of Working Platform 3301–1.

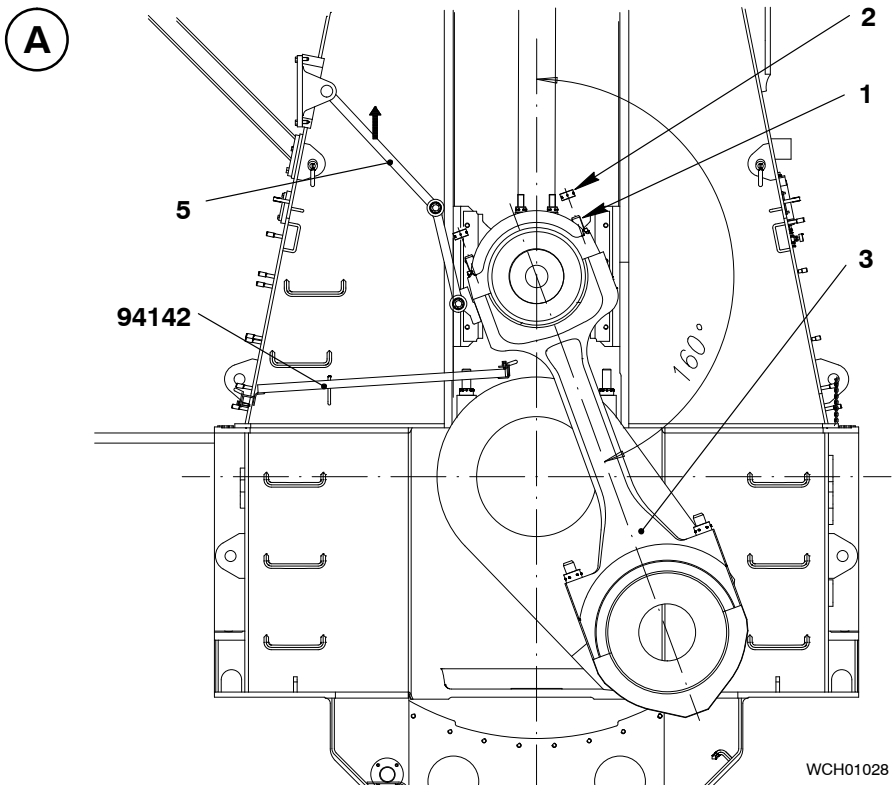
⇒ Turn crankshaft to 160° before T.D.C.

⇒ Install working platform 94142.

⇒ Disconnect toggle lever 5 from connecting rod 3 and tie it upwards to the colunm.

⇒ Loosen nuts 2 of elastic studs 1 according to 3303–1.

⇒ Remove working platform 94142.



Inspection, Removal and Fitting of Top End Bearing

⇒ Turn crankshaft to B.D.C..

⇒ Fit a RUD-eye bolt ’RC2’ on each side of the connecting rod head (threaded hole 13) and tighten it with **190 Nm**.

⇒ Fasten manual ratchets ’H1’ with shackles 94572C to the column and connect them with RUD-eye bolts ’RC2’. Secure the connecting rod.

⇒ Place stop plate GF 94335 as shown in view I and fasten it to bearing cover 6.

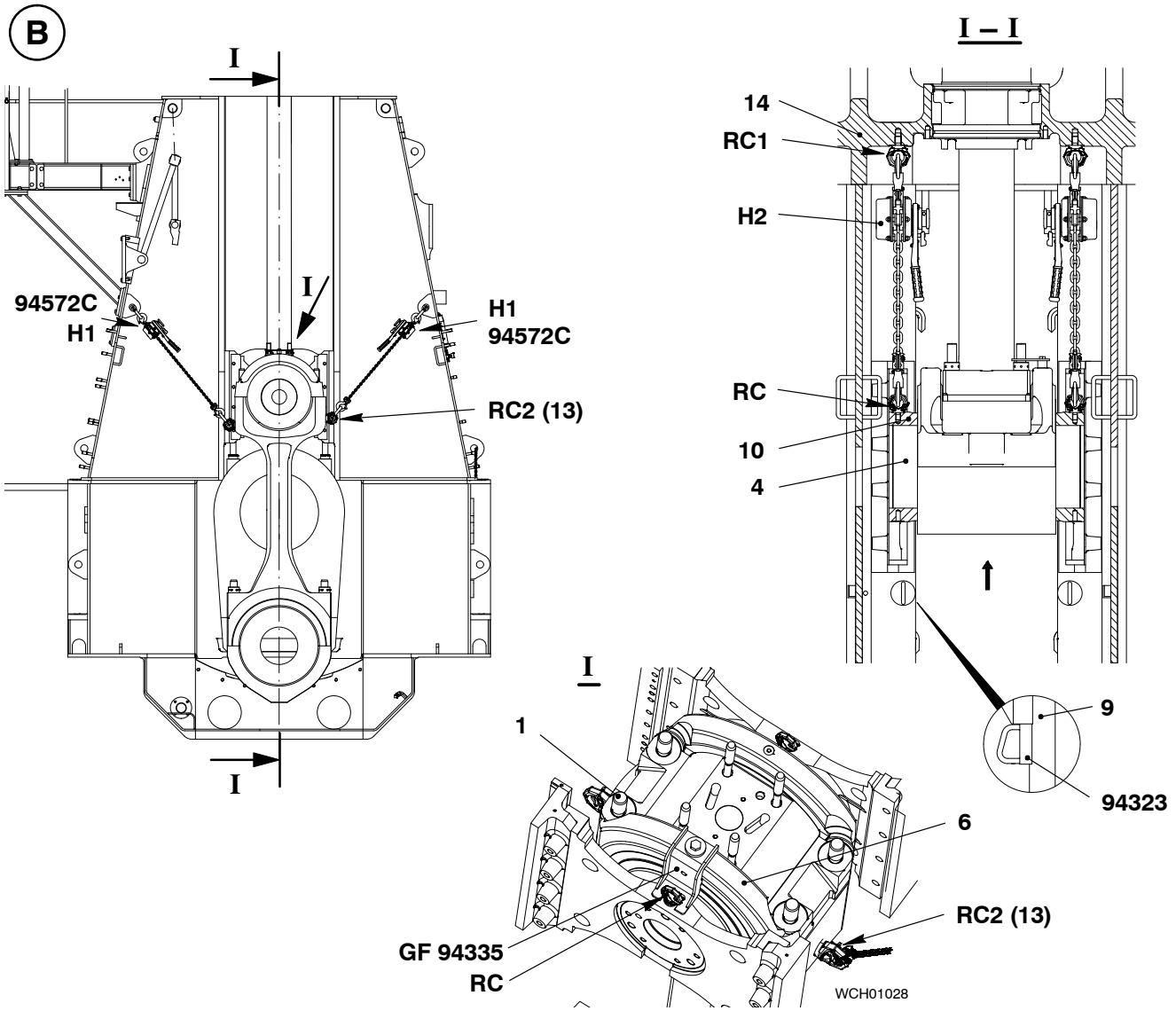
⇒ Fit RUD-eye bolts ’RC1’ into cylinder block 14 and tighten them with **115 Nm**.

⇒ Fit RUD-eye bolts ’RC’ into guide shoe 10 and tighten them with **60 Nm**.

⇒ Connect manual ratchets ’H2’ with RUD-eye bolts ’RC’. Lift crosshead pin 4 beyond the lower bores in guide ways 9. Make sure dowel pins 11 and elastic studs 1 slide out without jamming.

⇒ Insert four retaining pins 94323 into the guide ways.

⇒ Carefully relieve manual ratchets ’H2’ until guide shoes 10 come to rest on the retaining pins.
If, however, not all retaining pins touch the guide shoes, turn them such that their eccentrics contact the guide shoes.



Inspection, Removal and Fitting of Top End Bearing

2. Removal of bearing shell

⇒ Swing the connecting rod with manual ratchets 'H1' to fuel side, ensuring that it will not tilt back to exhaust side.

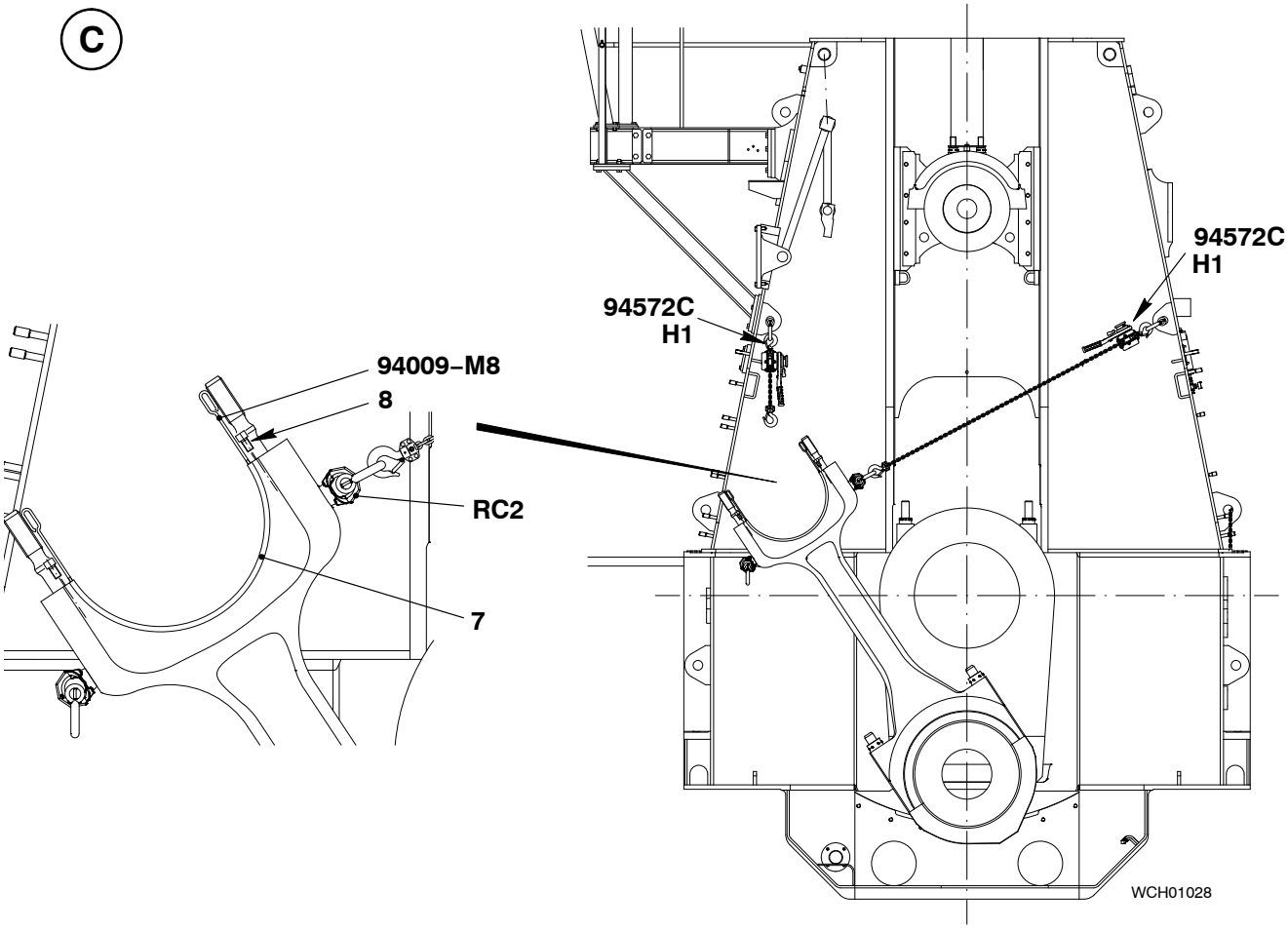
⇒ Remove manual ratchet 'H1' on fuel side and swing connecting rod to the position as shown in the figure below.

⇒ Remove Allen screw 8 for positioning bearing shell 7.

⇒ Remove bearing shell by means of handle screws 94009-M8 which are screwed into the front faces of the bearing shell.

⇒ Lift the bearing shell out of the connecting rod whereby the threads of the elastic studs must be covered with lugs in order not to damage the bearing shell.

⇒ Place bearing shell on a wooden underlay.



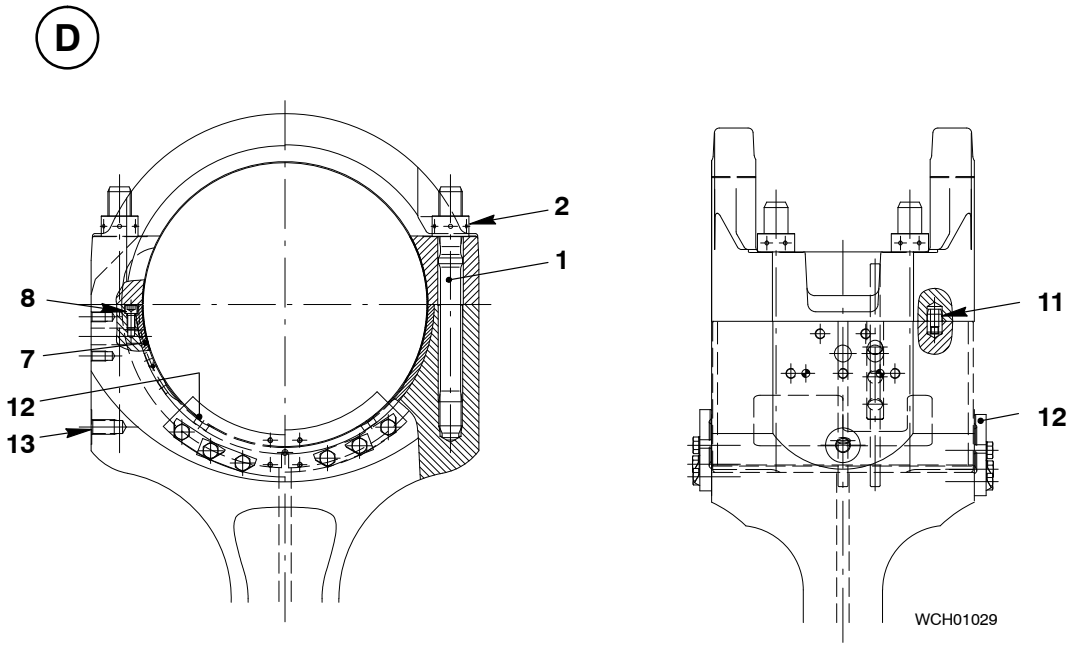
Inspection, Removal and Fitting of Top End Bearing

3. Fitting

Fitting of the bearing shell and bearing cover (see 3303–5) is carried out analogously but in reverse sequence to the removal.

- The running surfaces have to be lavishly smeared with clean bearing oil.
- Tensioning of the elastic studs must be carried out according to 3303–1.
- When fitting the bearing shell, as well as the crosshead pin, pay attention not to damage the two guide segments 12. The two white metal lined guide segments are fitted to the front sides of the upper connecting rod head.

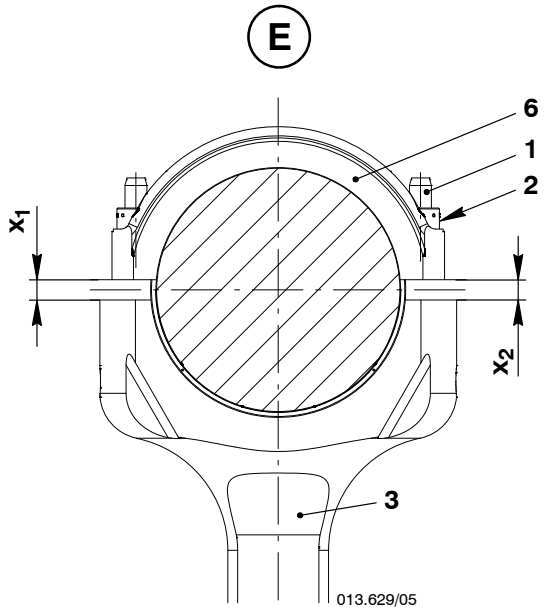
Attention! Always fit toggle lever 5 in such a way that its curvature stands upwards.
After completing the work all retaining pins 94323 must be removed without fail!



4. Fitting the bearing shell

- The surface of the crosshead pin must be in perfect condition.
- The contact surfaces of the shell rear side and the bearing bore must be free from any damage.
- While fitting bearing shell prevent dirt or foreign particles from entering between the shell rear surface and its seating! Immediately before inserting the bearing shells wipe them with a slightly oily hand.
- The bearing shell should be placed in the connecting rod head such that it protrudes by the same distance at both ends of the separating face.

STOP This protrusion is a must and under no circumstances must the separating face of the bearing shell be filed to reduce it!



4.1 Fitting a new top end bearing shell

⇒ Proceed as described in section 3, however protrusion $x_1 + x_2$ must be measured prior to tension elastic studs 1.

4.1.2 Measuring the protrusion

⇒ Hand-tighten nuts 2 with a round bar and measure the protrusion (of a new bearing shell):

$x_1 + x_2$ = approx. 0.36 – 0.44 mm

Remark: Above measuring checks must be carried out when fitting new bearing shell. For this the bearing cover is fitted and the nuts tightened by hand with a round bar.

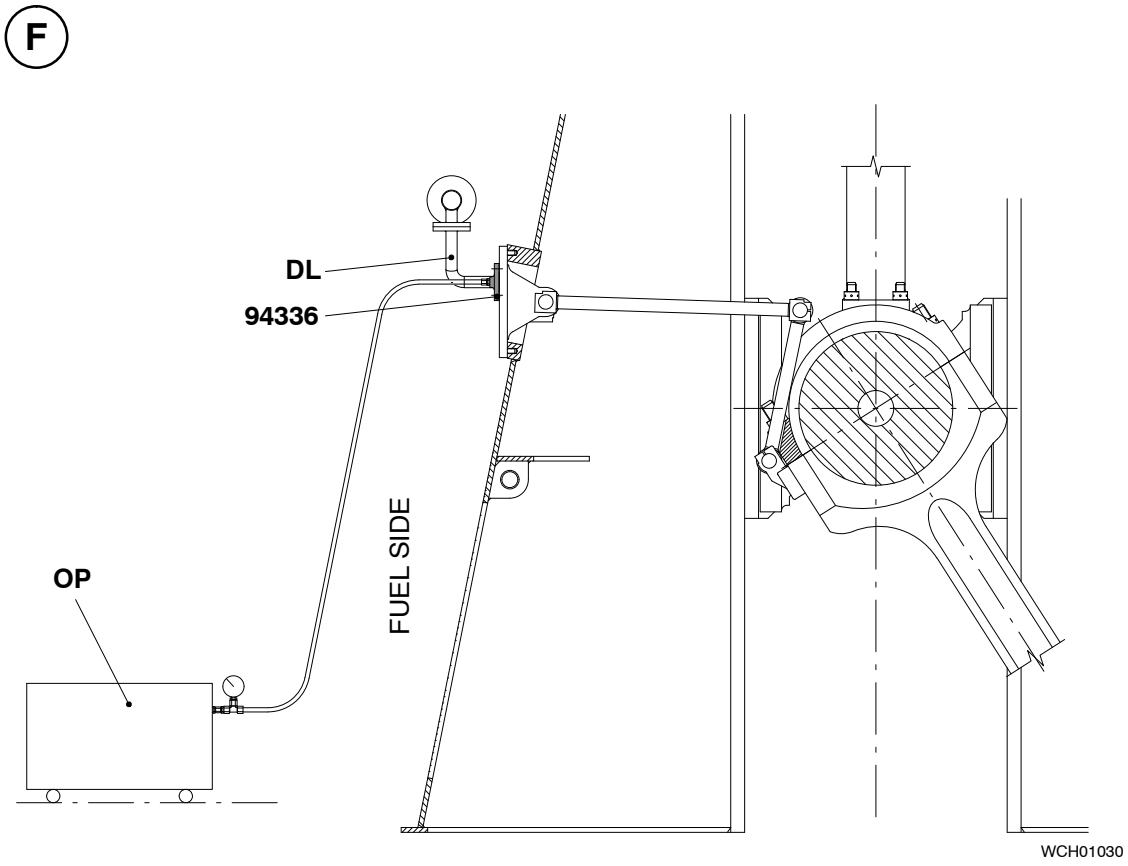
Prior to final assembly smear the running surfaces of the bearing shells and journal lavishly with clean bearing oil.

If, however, the engine must still often be turned or a restart is not immediately planned, then instead of bearing oil a mixture of $^2/_3$ steam-engine cylinder oil and $^1/_3$ normal bearing oil can be used. Special oils suitable for this purpose are also available on the market.

4.1 Post lubrication of connecting rod bearing

In order to further reduce the risk of dry running on newly fitted bearing shells, connecting flange 94336 can be fitted after removing the oil pressure pipe 'DL' to the crosshead bearing as shown in figure below. The connecting flange has to be connected via an oil pressure hose to a lubricating pump 'OP'.

The pump has to be filled with the mentioned oil mixture (steam-engine cylinder oil) or special oil. The lubricating pump has to be operated weekly, until oil is pouring out from the bearing side faces. Before the engine is put back into operation, the oil pressure pipe 'DL' must be refitted. The remainder of the above mentioned special oil or oil mixture may remain in the engine oil system.



Connecting Rod

Removal and Fitting

Tools:

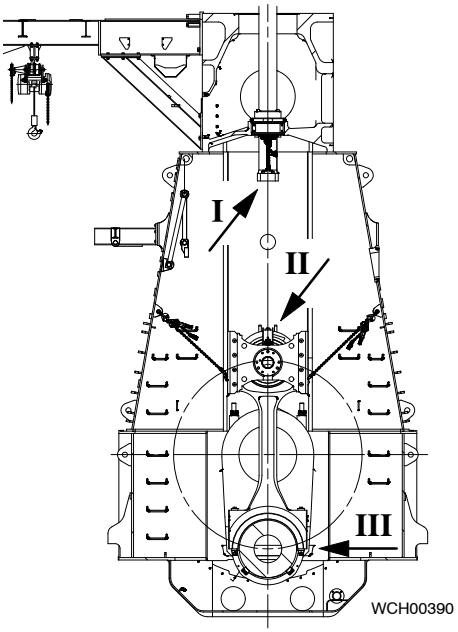
2	Manual ratchets (WLL 1600 kg)	94016A (H2)
2	Manual ratchets (WLL 2500 kg)	94016E (H1)
1	Spur-geared chain block (WLL 3000 kg)	94017A (H3)
6	RUD-eye bolts (RC1)	94040–M20
2	RUD-eye bolts (RC2)	94040–M30
1	Round sling (WLL 1000 kg)	94049A
2	Retaining pins	94323
2	Lifting tools	GF 94333A
2	Chains	GF 94333B
1	Holder	94334
1	Connecting element	94334A
1	Stop plate	GF 94335
1	Lifting tool	GF 94337
2	Shackles (WLL 4750 kg)	94572C
1	Shackle (WLL 2000 kg)	94572I

Key to Illustrations:

1	Crankpin
2	Connecting rod
3	Bottom end bearing
4	Piston rod
5	Toggle lever
6	Crosshead
7	Top end bearing cover
8	Guide shoe middle part
9	Guide way
10	Cylinder block

1. Initial Situation

A



SEE DETAILS OF VIEWS I, II AND III ON PAGE 2

- Toggle lever 5 detached from connecting rod 2, tilted upward and secured with a rope.

⇒ Turn crank of the respective cylinder to B.D.C.

⇒ Install working platform 94142.

⇒ Loosen nuts of elastic studs to piston rod foot fastening according to 3403–1.

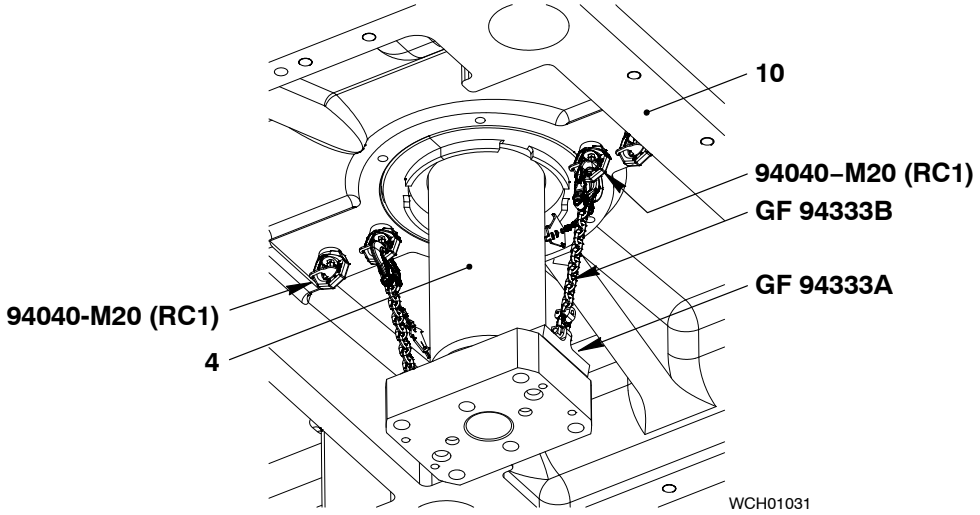
⇒ Screw four RUD-eye bolts 'RC1' into cylinder block10 with **115 Nm**. Mount lifting tools GF 94333A and tighten the oiled screws with **140 Nm** (View I).

⇒ Turn crankshaft firstly back until both chains GF 94333B can be attached to the mentioned tools and subsequently slowly downwards as shown in View I.

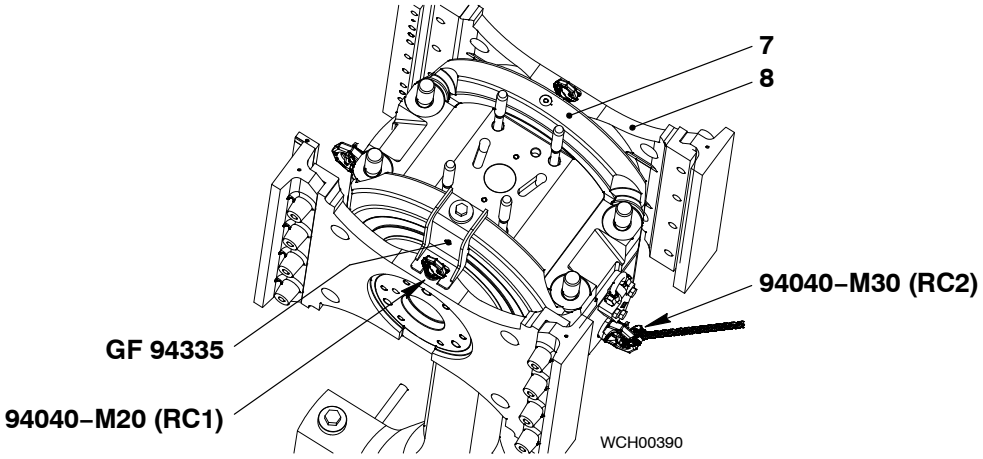
- Bottom end bearing cover removed (see 3303–2) and replaced with holder 94334. Lifting tool GF 94337 mounted to connecting rod (View III).
- Stop plate GF 94335 mounted to top end bearing cover 7 and guide shoe middle part 8. Bearing cover locked against tilting with a RUD-eye bolt 94040–M20 (View II).
- Crankpin concerned positioned in B.D.C..

Remark: Pay attention to:
- General Guidelines for Lifting Tools 0012–1.
- Utilization of Working Platform 3301–1.

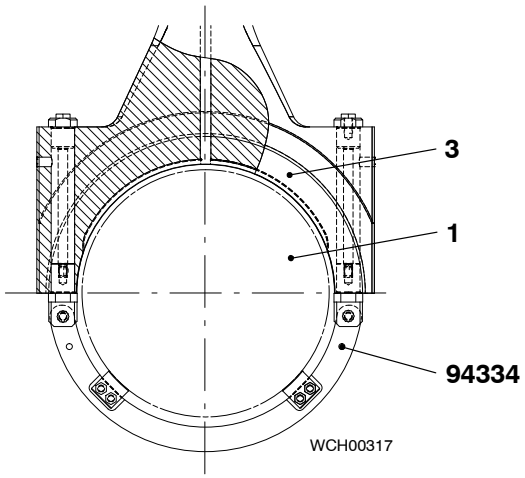
***VIEW I* –> Piston suspended to cylinder block:**



***VIEW II* –> Stop plate mounted and top end bearing cover locked against tilting:**



***VIEW III* –> Bottom end bearing cover replaced with holder:**



2. Removal

- Loosen and remove the nuts of the top end bearing according to 3303–1.

⇒ Connect manual ratchets 'H1' to RUD-eye bolts 'RC1' in cylinder block 10 and guide shoe middle part 8.

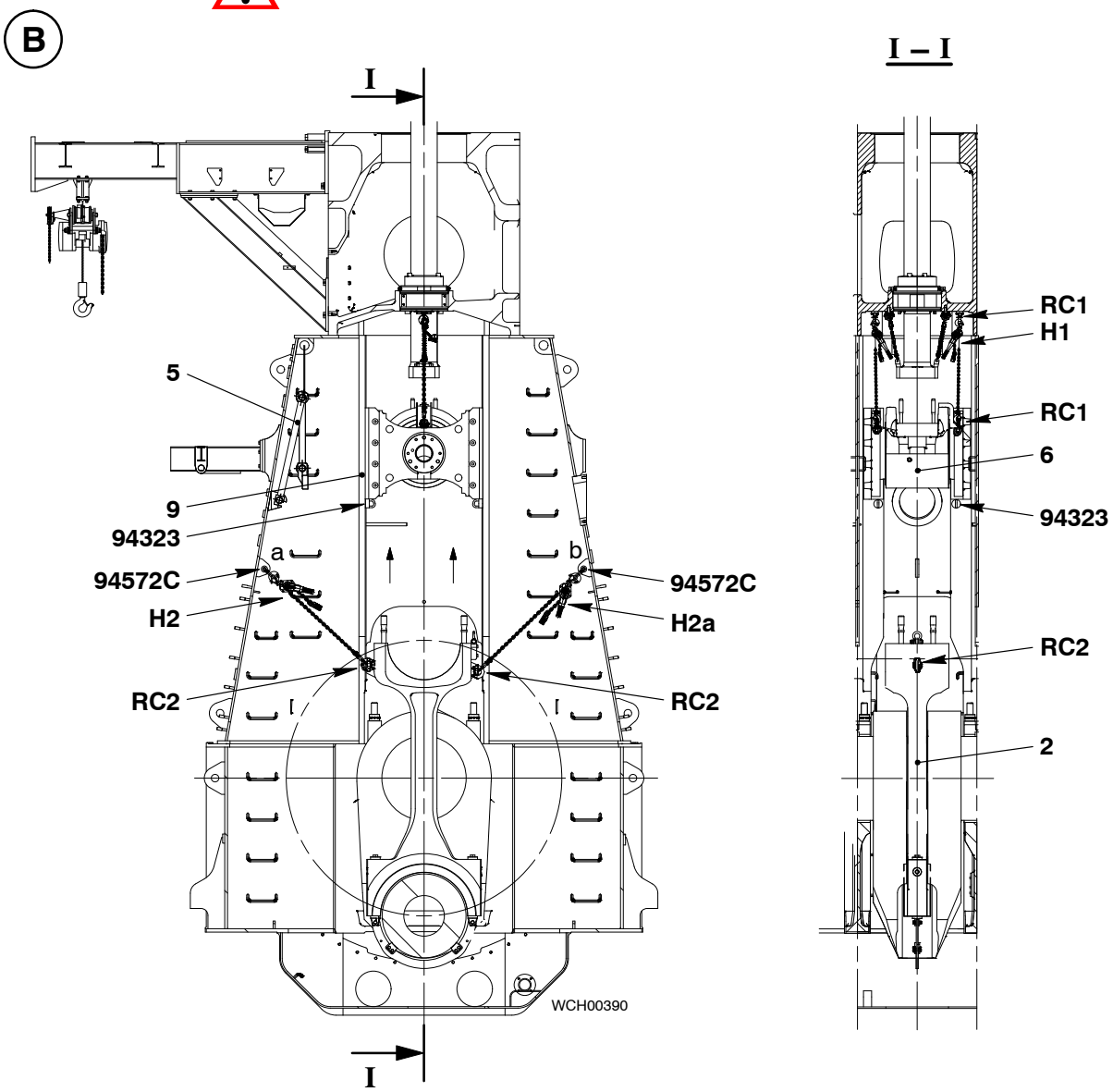
⇒ Tighten RUD-eye bolts 'RC2' to connecting rod 2 with **330 Nm**.

⇒ By means of shackles 94572C fasten manual ratchets 'H2' & 'H2a' between connecting rod and suspension centers 'a' and 'b' on the column and lock the connecting rod into position.

⇒ Using manual ratchets 'H1' hoist crosshead 6 until retaining pins 94323 can be inserted into guide ways 9.

⇒ Carefully lower the crosshead until the guide shoes come to rest on the retaining pins (if, however, not all retaining pins touch the guide shoes, turn them such that their eccentrics contact the guide shoes).

Risk of accident! For safety reasons do not remove manual ratchets 'H1'!



Removal and Fitting

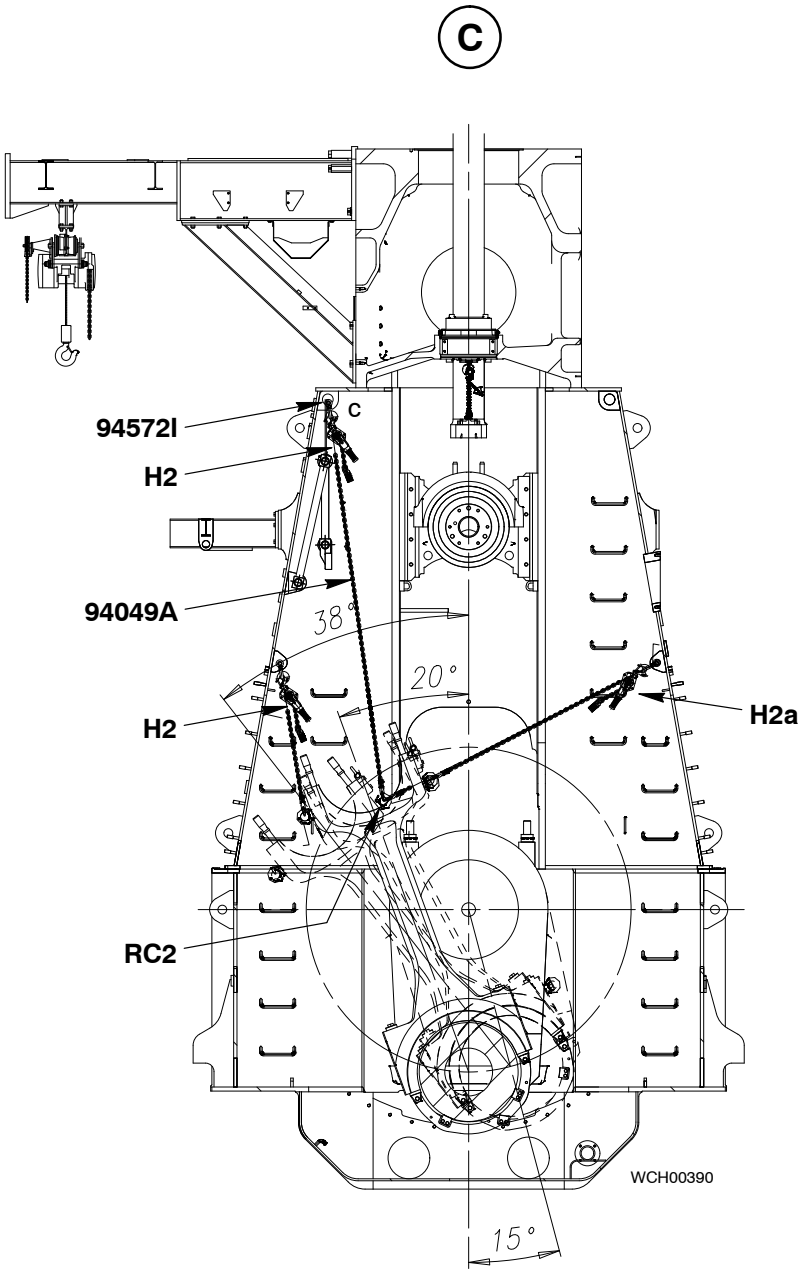
- Working platforms 94142 must be removed before tilting the connecting rod and turning the crankshaft.

⇒ Tilt the connecting rod about 20° towards fuel side by pulling manual ratchet 'H2' and slackening manual ratchet 'H2a'.

⇒ Detach manual ratchet 'H2' from RUD-eye bolt 'RC2' in connecting rod.

⇒ Turn crankshaft 15° in counter-clockwise direction.

⇒ Tilt the connecting rod towards fuel side by slackening manual ratchet 'H2a' until manual ratchet 'H2' with round sling 94049A can be mounted by means of shackles 94572I between suspension 'c' and RUD-eye bolts 'RC2'. Tighten manual ratchet 'H2' and remove manual ratchet 'H2a'.



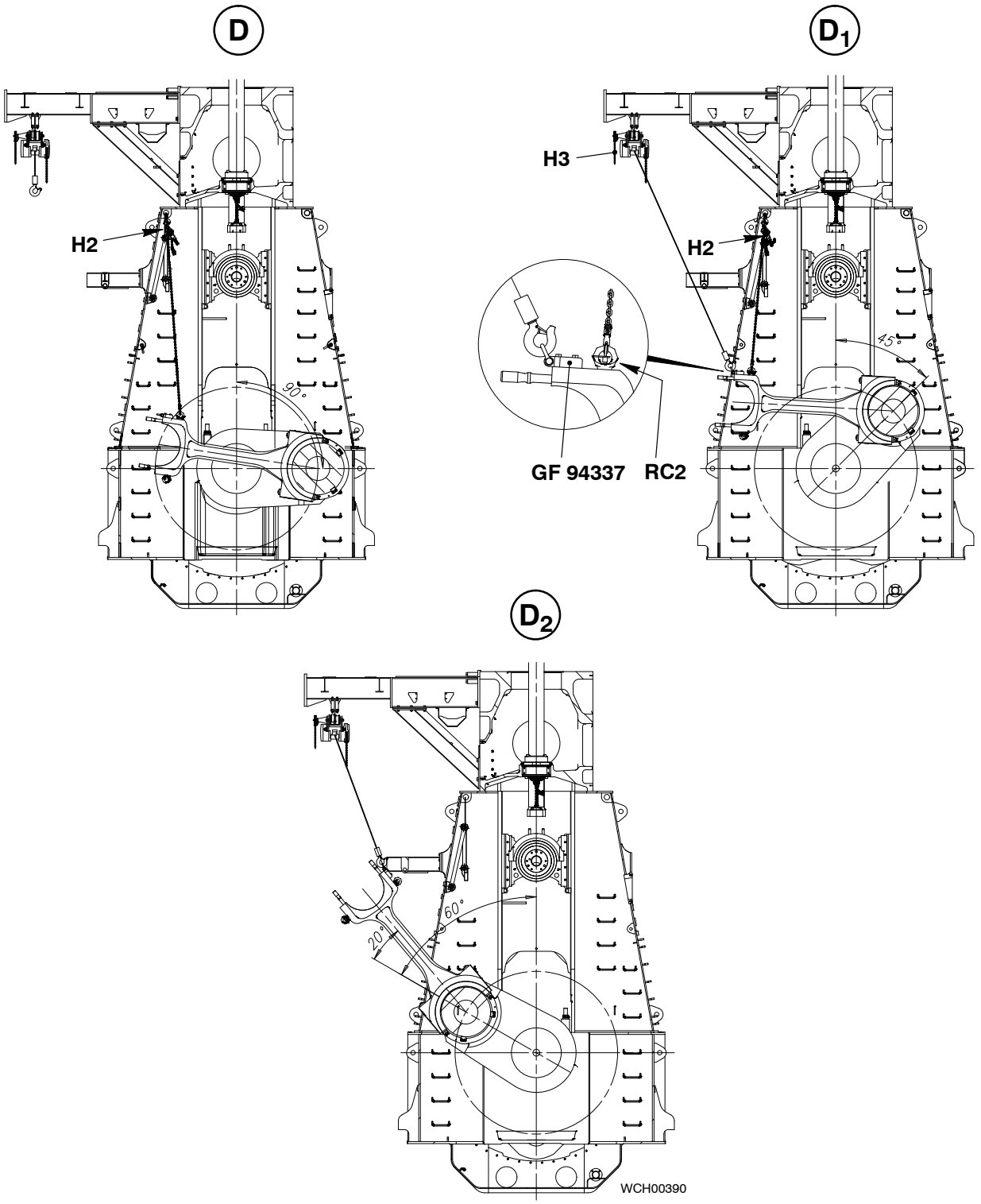
Removal and Fitting

⇒ Turn the crankshaft anticlockwise until the crankpin is 90° before T.D.C.

⇒ While constantly turning crankshaft anticlockwise until the crankpin is approx. 45° before T.D.C. tighten manual ratchet 'H2' until the connecting rod is protruding from the engine.

⇒ Hook spur-geared chain block 'H3' in lifting tool GF 94337 in order to take over the connecting rod, then detach manual ratchet 'H2'.

⇒ Continue turning carefully until the crankpin is approx. 60° after T.D.C., thus turning the connecting rod out of the engine.



Connecting Rod: Removal and Fitting

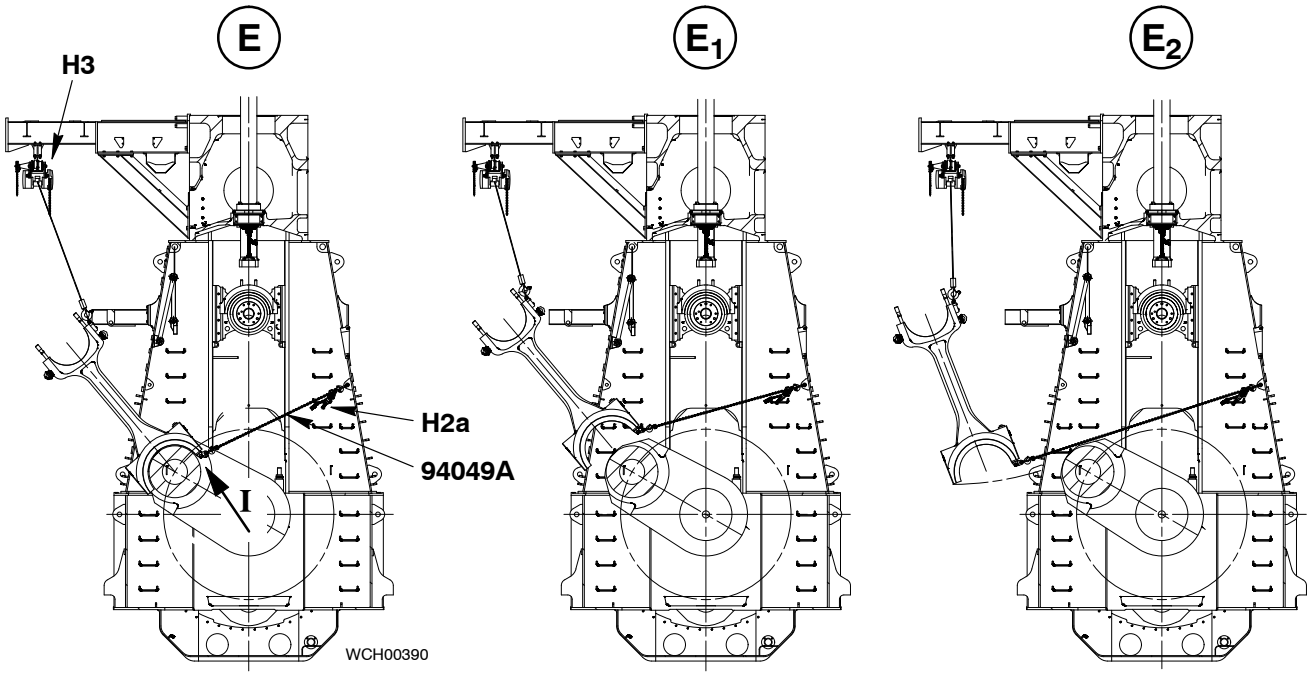
⇒ Partially dismount holder 94334 (fastening shaft and threaded rod M24x451) and mount connecting element 94334A to the remaining holder part as shown below.

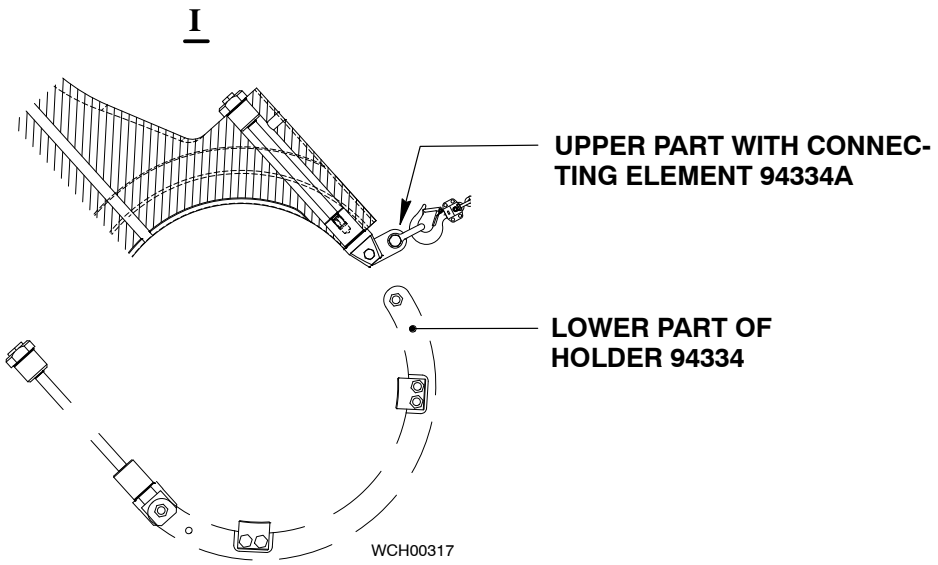
⇒ Attach manual ratchet 'H2a' with round sling 94049A to the shackle of the connecting element.

⇒ Slowly and carefully detach the connecting rod from the crankpin by means of spur-geared chain block 'H3' and manual ratchet 'H2a'.

⇒ Completely remove the connecting rod by loosening manual ratchet 'H2a'. If more space between the crankpin and connecting rod is required, gradually tighten spur-geared chain block 'H3'.

⇒ Dismantle manual ratchet 'H2a' before carrying the connecting rod with spur-geared chain block 'H3' along the engine.





Connecting Rod: Removal and Fitting

3. Fitting

Fitting the connecting rod is carried out analogously to the removal, but in reverse sequence, whereby attention must be paid to the instructions 3303–1 to 3303–3.

For the assembly bearings and bearing pins must be in perfect condition. They must be smeared lavishly with fresh bearing oil.

CHECK

Measure the clearances according to Clearance Table 0330–1 'Top and bottom end bearings to connecting rod'.

Attention! Always fit toggle lever in such a way that its curvature stands upwards. After completing the work retaining pins 94323 and all other tools must be removed immediately from the crankcase.

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Connecting Rod

Removal of Bearing Cover to Top End Bearing

Tools:

1	Manual ratchet (WLL 800 kg)	94016 (H3)
1	Manual ratchet (WLL 2500 kg)	94016E (H1)
2	Manual ratchets (WLL 250 kg)	94016G (H2)
2	Eye bolts	94045-M12 (RC)
2	Round slings (WLL 1000 kg)	94049
1	Round sling (WLL 1000 kg)	94049A
1	Deviation pipe	GF 94117A
1	Working platform	94142
2	Lifting tools	GF 94333A
2	Chains with hook and shackle	GF 94333B
1	Wire rope sling	GF 94333D
2	Shackles	94572I

Key to Illustrations:

1	Piston rod
2	Cylinder block
3	Elastic stud
4	Toggle lever
5	Bearing cover
6	Crosshead pin

1. Removal

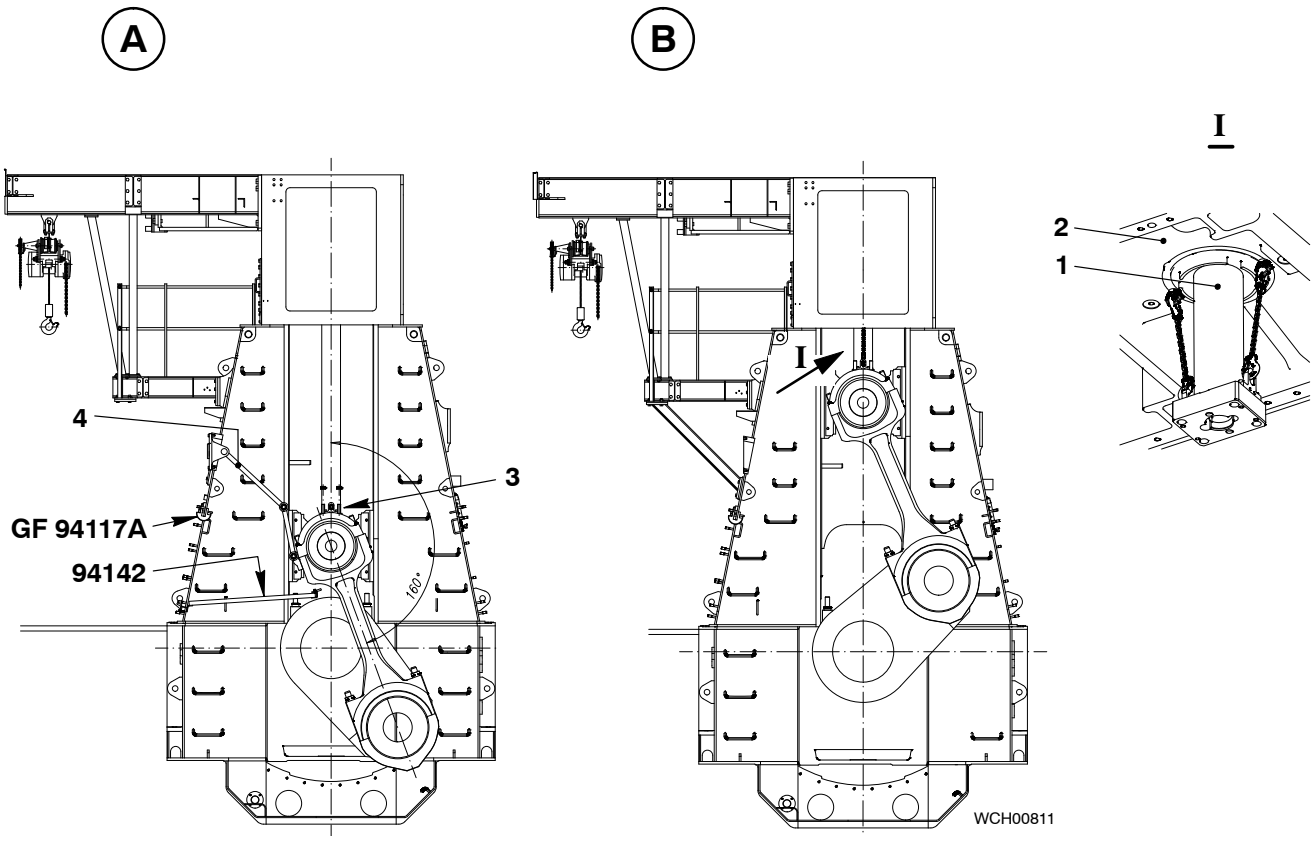
Remark: Pay attention to General Guidelines for Lifting Tools 0012–1.

⇒ Suspend piston rod 1 and turn crank of the cylinder concerned to B.D.C. as described for Changing the Compression Shims 3403–2 (see also view I).

⇒ Remove toggle lever 4.

⇒ Remove platform element.

⇒ Mount deviation pipe GF 94117A to the column door.



Removal of Bearing Cover to Top End Bearing

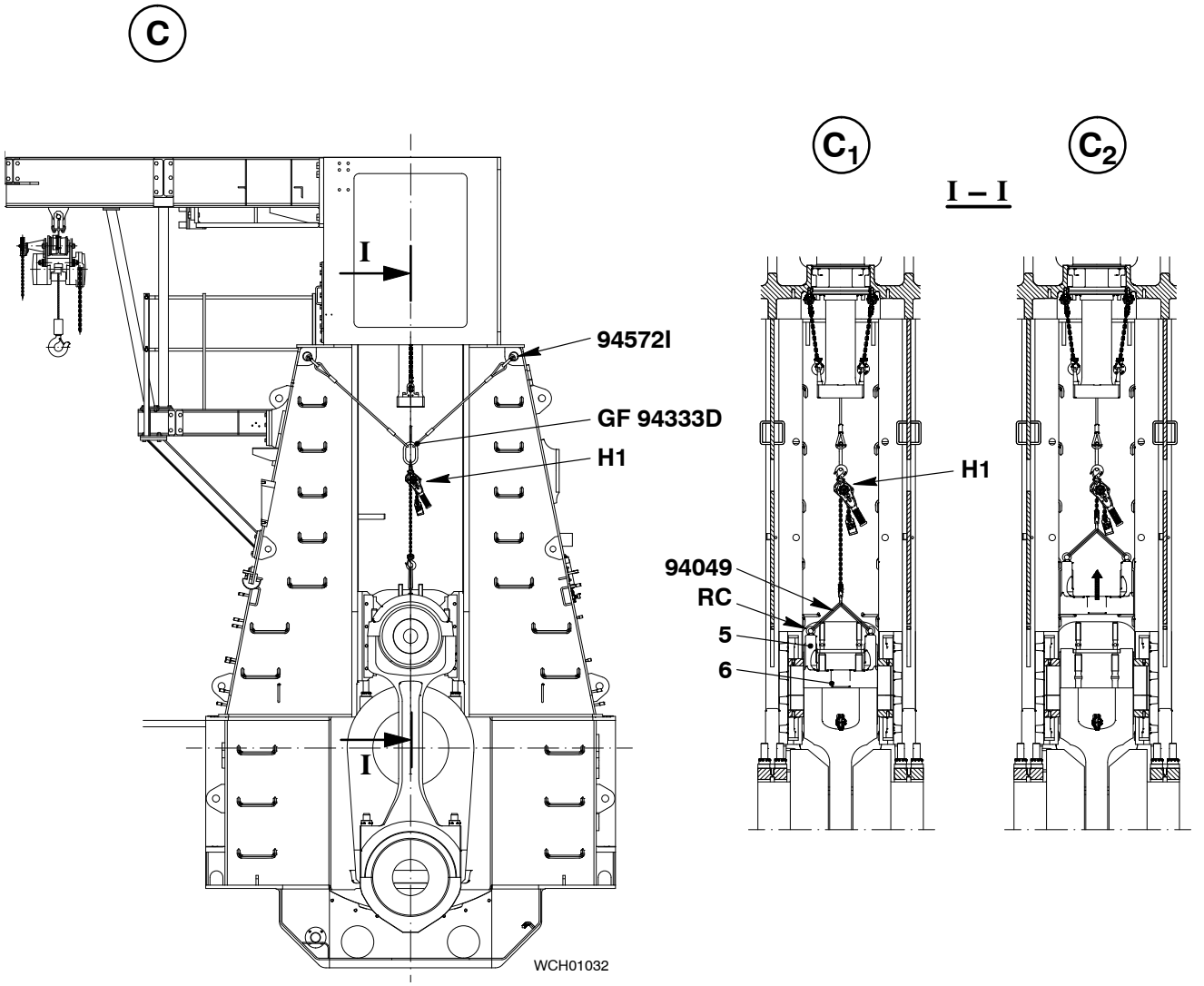
⇒ Fasten wire rope sling GF 94333D with shackles 94572I to the column and connect it with manual ratchet 'H1'.

⇒ Screw eye bolts 'RC' into bearing cover 5.

⇒ Fasten bearing cover by means of two round slings 94049 to manual ratchet 'H1'.

⇒ Lift the bearing cover.

⇒ Protect crosshead pin 6 against dirt and damage.



Removal of Bearing Cover to Top End Bearing

⇒ Fasten manual ratchet ’H2’ with round sling 94049A to the column.

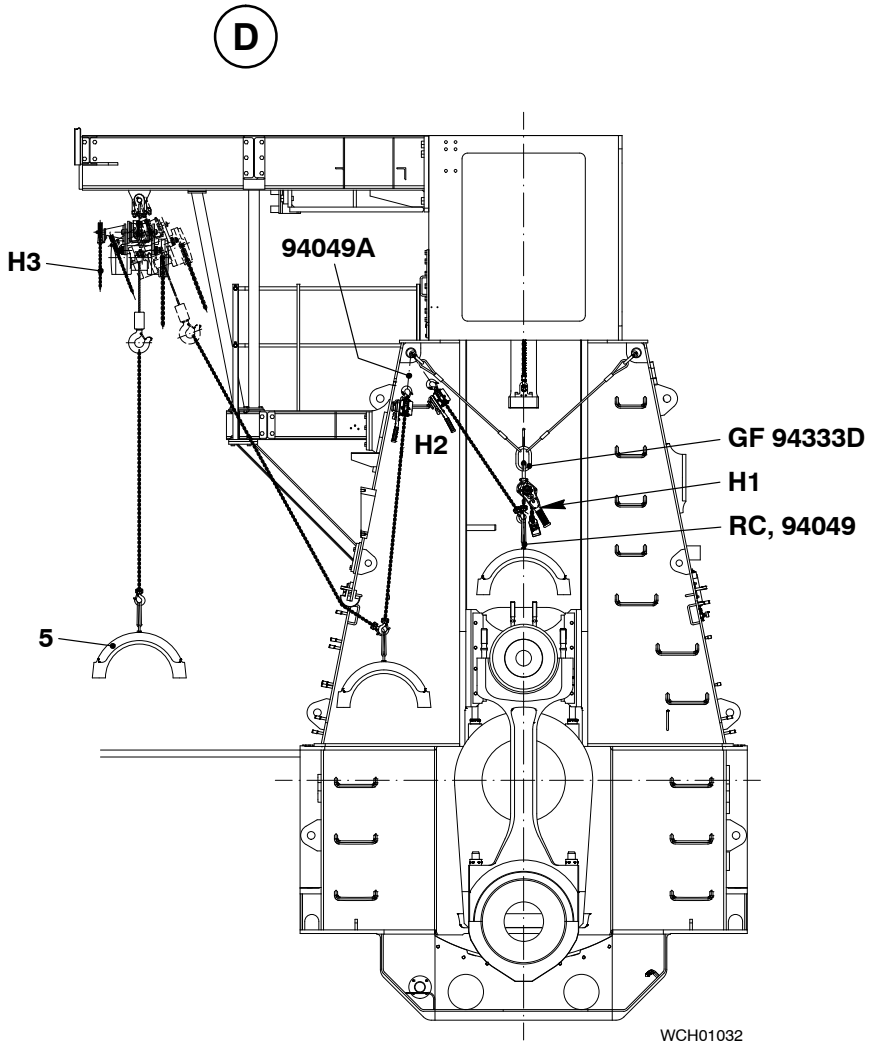
⇒ Remove bearing cover 5 from the crankcase using manual ratchets ’H2’ and ’H3’.

2. Fitting

Fitting of the bearing cover is carried out analogously to the removal but in reverse sequence.

- The running surfaces have to be lavishly smeared with clean bearing oil.
- Tensioning of the elastic studs must be carried out according to 3403–1.

Attention! Always fit toggle lever 4 in such a way that its curvature stands upwards.



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Crosshead

Checking the Clearances and Fitting the Guide Shoes

Tools:

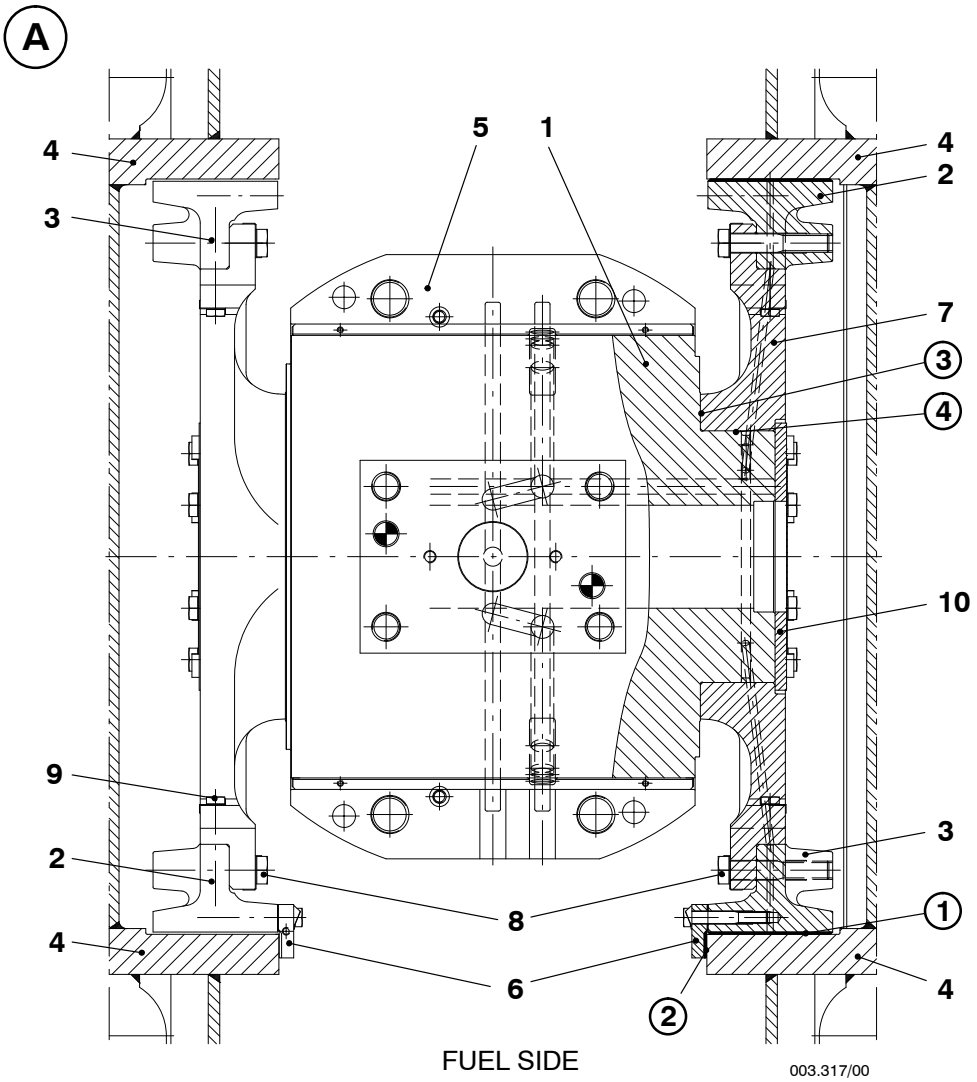
1	Feeler gauge	94238

Key to Illustrations:

1	Crosshead pin	6	Guide rail
2	Guide shoe	7	Middle part
3	Guide shoe	8	Screw
4	Guide way in engine column	9	Screw
5	Top end bearing	10	Retaining cover

1. General

On the occasion of an overhaul or when a crosshead has been removed, the opportunity should be taken to measure the various running clearances and to compare them with the values found in the Clearance Table 0330–1, so that possible wear may be discovered.



2. Checking the clearances

Clearance (1) ***Clearances between guide shoes and guide ways:***

The corresponding crankpin must stand in such a position that guide shoes 2 lie on guide ways 4 on fuel or exhaust side.

Clearance (1) is valid for the whole guide way length and is measured according to the positions as shown in Fig. 'B'.

Clearance (2) ***Lateral clearance of crosshead between the columns:***

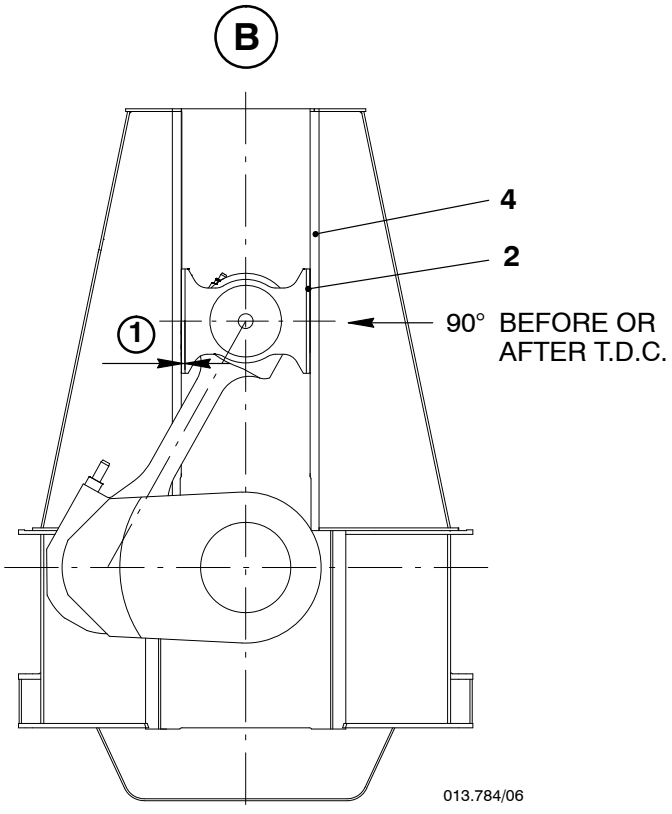
The clearance is measured in every position of the crosshead. The complete crosshead must be pressed axially to a side with suitable hardwood wedges or similar aids. The pressure must be exerted onto the guide shoe or the middle part 7 and **not** onto the crosshead pin 1.

Clearance (3) ***Lateral clearance between middle part and crosshead pin:***

Push the corresponding middle part to the stop of the retaining cover 10 in the above mentioned position of the crosshead.

Clearance (4) ***Radial clearance between crosshead pin and middle part:***

This clearance is very difficult to establish inside the engine. It is therefore best to measure and calculate this clearance on the removed crosshead. For this the pin diameter and the bore in the middle part have to be measured with micrometers.



Checking the Clearances and Fitting the Guide Shoes

3. Fitting the guide shoes



The lubricating oil bores in guide shoes 2 and 3 are different in design. Therefore, guide shoe 2 must **not** be replaced with guide shoe 3 and vice versa nor exchanged!

- Guide rails 6 are screwed on **fuel side only!**
- Attention must be paid when mounting a guide shoe onto middle part 7 so that the middle part bears the guide shoe with **no clearance** whatsoever.

⇒ For this purpose, screws 9 are first to be tightened slightly.

⇒ Then screws 8 are to be tightened slightly by hand and subsequently tightened and secured with **750 Nm** or to an angle of 60°.

⇒ Tighten and secure screws 9.

CHECK

Check with feeler gauge 94238 that there is **no clearance** between the surfaces of guide shoe and middle part 7.

Intentionally blank

Crosshead

Removal and Fitting of a Crosshead Pin

	Tools:		Key to Illustrations:	
1	Manual ratchet (WLL 800 kg)	94016 (H1)	1	Crank
2	Manual ratchets (WLL 1000 kg)	94016D (H2, H3)	2	Connecting rod
1	Manual ratchet (WLL 2500 kg)	94016E (H4)	3	Piston rod
1	Manual ratchet (WLL 250 kg)	94016G (H5)	4	Crosshead pin
1	Spur-geared chain block (WLL 3000 kg)	94017A (H6)	5, 5a	Guide shoe
4	RUD-eye bolts (RC1)	94040–M20	6, 6a	Guide shoe middle part
2	RUD-eye bolts (RC2)	94040–M30	7	Guide rail
1	Eye bolt (RC3)	94045–M10	8	Screw
1	Deviation pipe	GF 94117A	9, 9a	End cover
1	Working platform	94142	10	Guide way
2	Cover and lifting plate	94324		
2	Holders	94325		
1	Wire rope sling	GF 94333D		
3	Shackles (WLL 4750 kg)	94572C		
2	Shackles (WLL 2000 kg)	94572I	WU	Wooden underlay

1. General

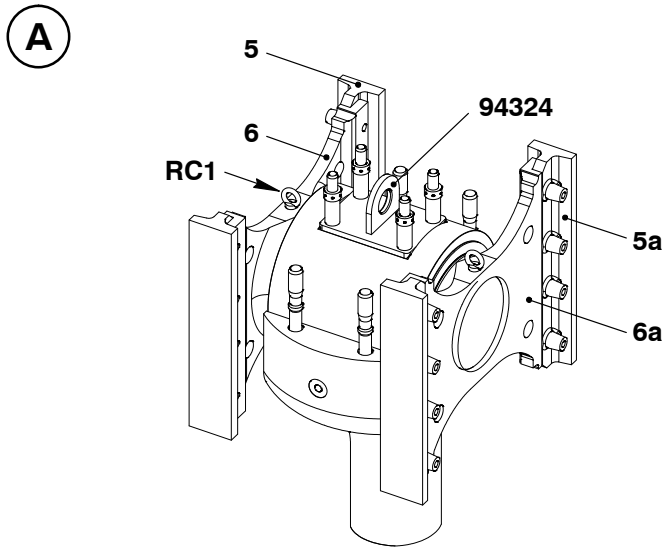
Risk of accident! Ensure that the crankshaft does not turn unintentionally during all the work.

Remark: Pay attention to:

- General Guidelines for Lifting Tools 0012–1.
- Utilization of Working Platform 3301–1.

2. Preparatory works

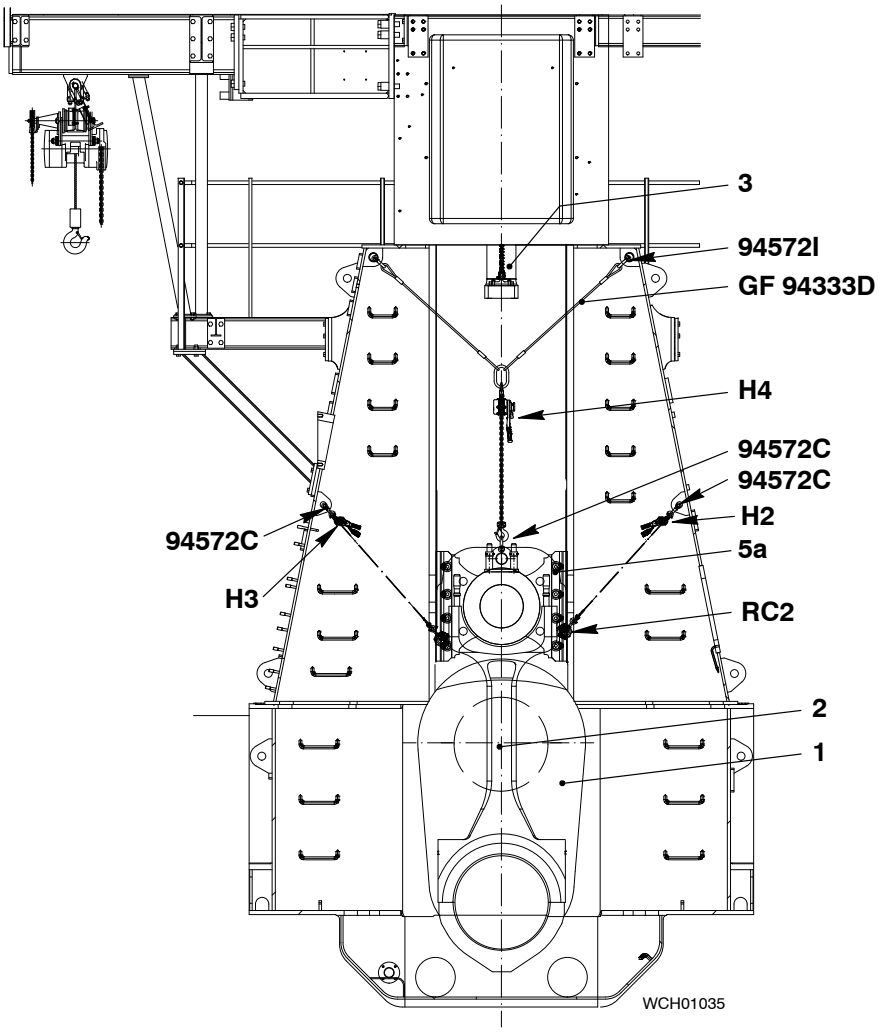
- Top end bearing cover removed (see 3303–5) and piston rod 3 suspended.
- Platform element removed.
- Relevant cylinder turned to B.D.C.
- Lifting plate 94324 mounted on crosshead pin.
- Two RUD-eye bolts 'RC1' tightened to middle parts 6, 6a with **115 Nm**.



Removal and Fitting of a Crosshead Pin

- Two RUD-eye bolts 'RC1' tightened to cylinder block with **115 Nm** (Fig. 'E').
- RUD-eye bolts 'RC2' tightened to either side of connecting rod 2 with **330 Nm**.
- Wire rope sling GF 94333D attached by means of shackles 94572I to the middle lifting lugs in the column.
- Manual ratchet 'H4' attached to the eyelet of wire rope sling GF 94333D and lifting plate 94324.

B



Removal and Fitting of a Crosshead Pin

3. Removal of crosshaed pin

⇒ Secure the connecting rod with manual ratchets ’H2’ and ’H3’ attached to RUD-eye bolts ’RC2’ (Fig. ’B’).

⇒ Lift off crosshead pin 4 using manual ratchet ’H4’.

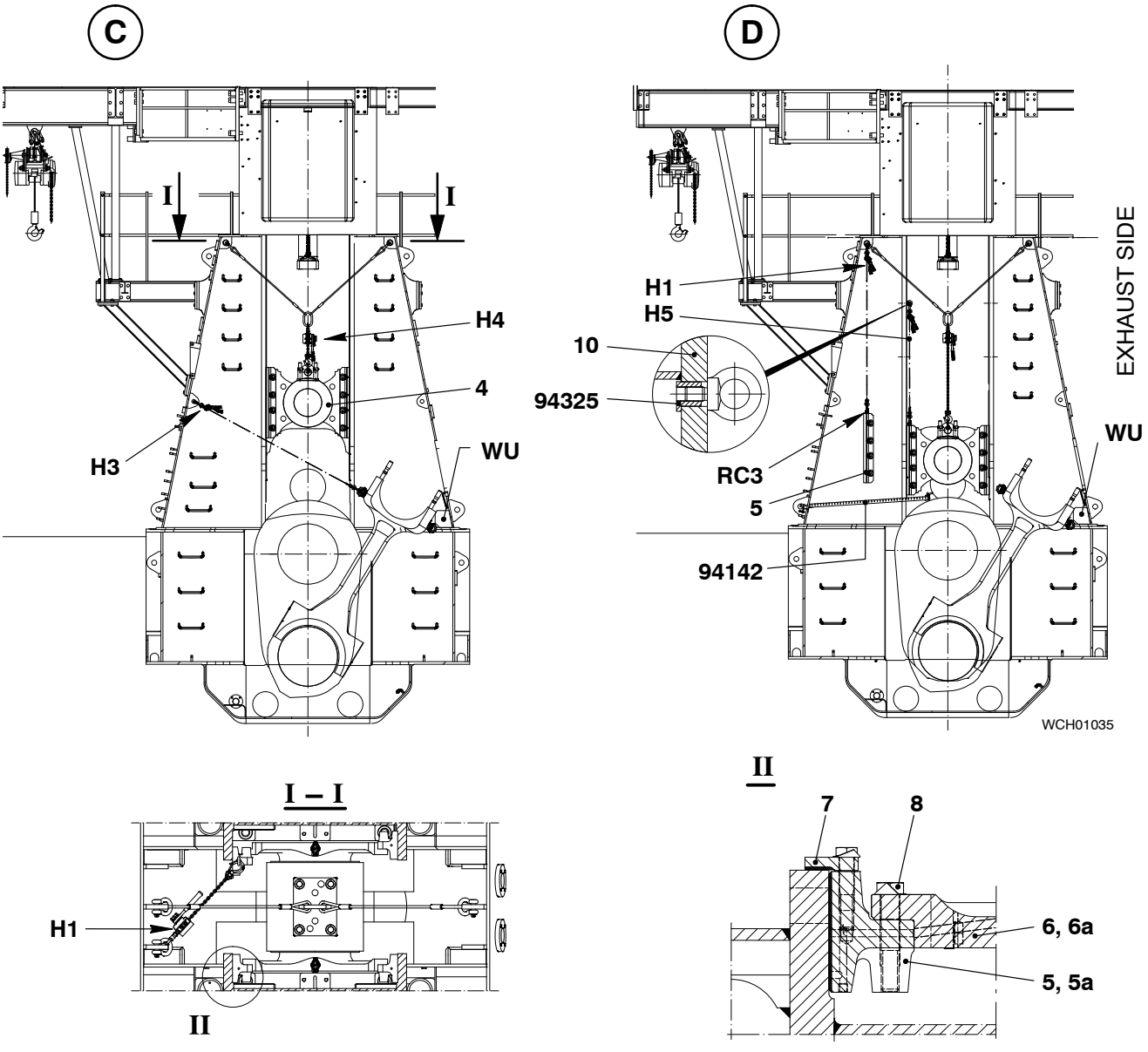
⇒ Carefully swing the connecting rod towards exhaust side by means of manual ratchets ’H2’ and ’H3’.

⇒ Remove manual ratchet ’H2’ and RUD-eye bolt ’RC2’ on exhaust side before the connecting rod reaches the column door and lower the upper part onto wooden underlay ’WU’.

⇒ Install working platform 94142.

⇒ Lower the crosshead as far as possible. Install holders 94325 in the bores of guide way 11 in the column located on fuel side.

⇒ Secure guide shoes 5, 5a with manual ratchet ’H5’ attached to holder 94325 and eye bolt ’RC3’. Loosen screws 8, detach guide shoes from middle part 6, 6a and remove them from the engine with manual ratchets ’H5’ and ’H1’.



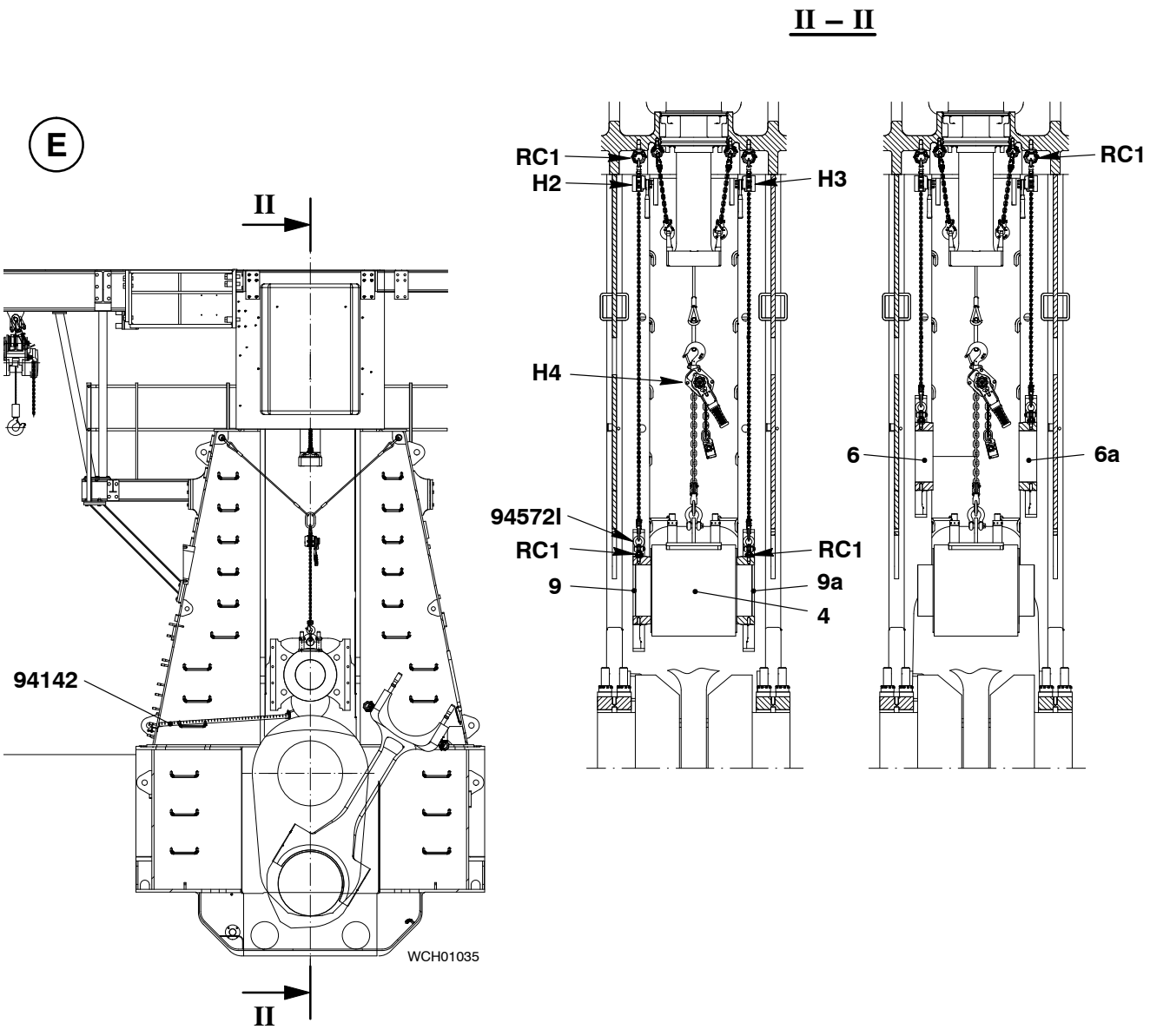
Removal and Fitting of a Crosshead Pin

⇒ Secure guide shoe middle parts 6, 6a with manual ratchets ’H2’ and ’H3’ connected to RUD-eye bolts RC1.

⇒ Remove end covers 9, 9a.

⇒ Retract guide shoe middle parts form crosshead pin 4 and lift them beyond the crosshead pin.

⇒ Remove working platform 94142.

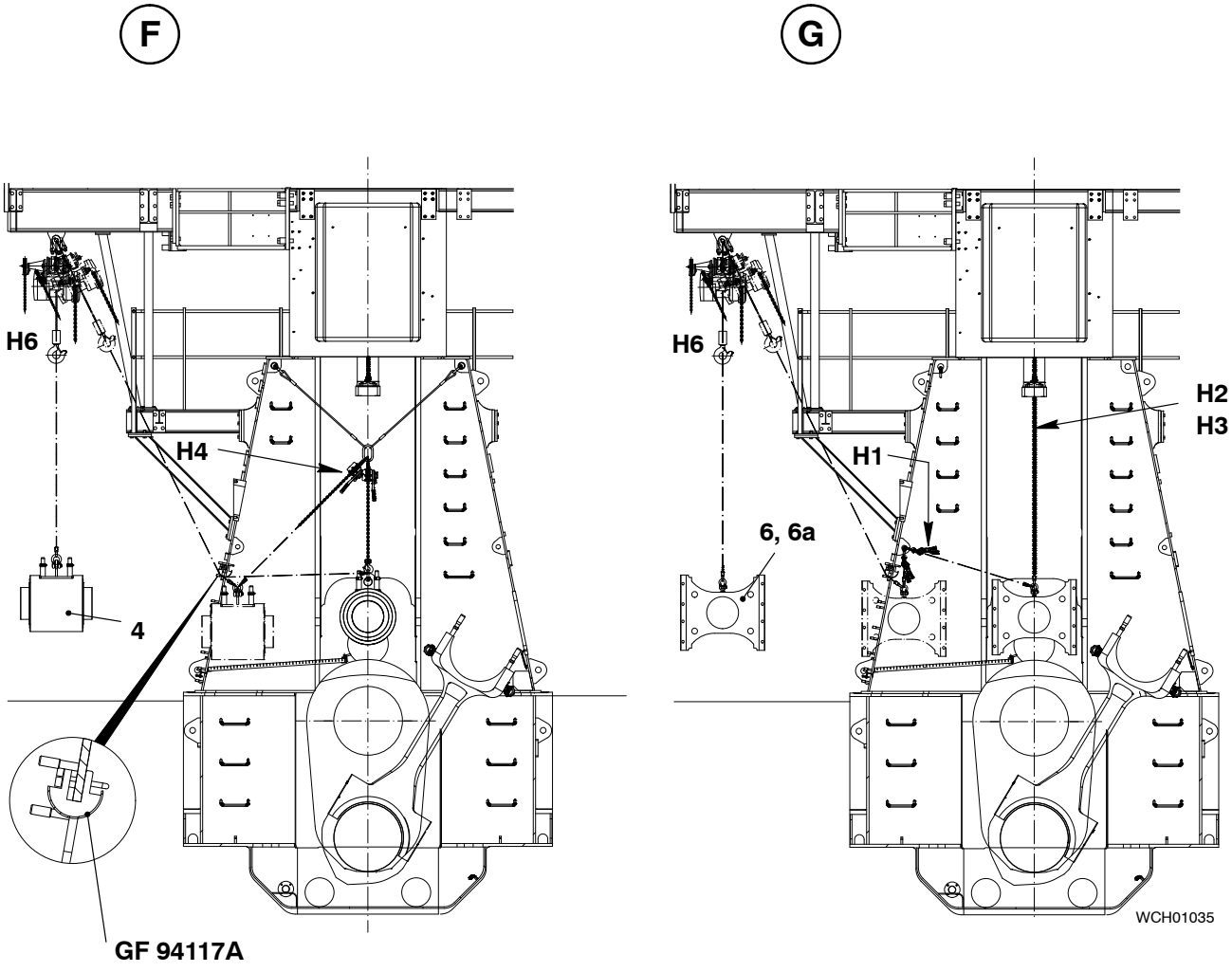


Removal and Fitting of a Crosshead Pin

⇒ Mount deviation pipe GF 94117A on the column.

⇒ Turn crosshead pin by 90° and remove it from column using manual ratchets ’H4’ and spur-geared chain block ’H6’.

⇒ Lower guide shoe middle parts 6, 6a and remove it from column using manual ratchets ’H1’, ’H2’ and ’H3’.



4. Fitting

Fitting procedure is analogous to the removal, but in reverse sequence.

- Fit only crosshead pins which have a perfect, undamaged running surface.
- For fitting the guide shoes see 3326–1.
- Before fitting the crosshead pin clean all guide and bearing surfaces carefully and smear them lavishly with bearing oil.



Risk of accident! Secure the connecting rod when lifting up in vertical direction with manual ratchet 'H2' (Fig. 'B') so that it can not tilt to fuel side.

Attention! Always fit the toggle lever to crosshead lubrication and piston cooling in such a way that its curvature stands upwards.

CHECK

After completing the work check that all tools and foreign bodies are removed from the crankcase, and that all the screwed fastenings are tightened to specification and locked accordingly.
Check crosshead clearances according to Clearance Table 0330–1 'Crosshead Guide'.
Check with lubricating oil pump running that crosshead and connecting rod bottom end bearings are lavishly supplied with oil.

Piston

Removal and Fitting

Tools:

1	Feeler gauge	94122
1	Piston ring tensioning device	94338 (94338A)
1	Suspension device	94341
1	Insertion funnel	GF 94342
2	Locking devices	GF 94343
2	Distance holders	94345
1	Cover plate	94345D
2	Pre-tensioning jacks	94340
1	Tap	94348
1	Piston supporting device	94350
1	HP oil pump	94931
1	Hydr. distributor	94932
1	Hydr. distributor	94934A
1	HP hose	94935
2	HP hoses	94935A

Key to Illustrations:

1	Piston crown	13	Securing screw
2	Piston skirt	14	Platform support
3	Piston rod	15	Support
4	Crosshead pin	16	Strap
5	Centring pin	17	Screwed connection
6	Elastic stud	18	Hinged cover
7	Cylinder liner		
8	Piston rod gland		
9	Elastic stud		
10	Nut	PL	Plate
11	Elastic screw	RS	Round bar
12	Locking element	SP	Stop plate

Overview

1. **General** 1/7
2. **Loosening and tensioning the elastic studs of piston rod foot fastening** 2/7
3. **Removal of piston** 3/7
4. **Fitting the piston** 6/7
5. **Leak test** 7/7

1. General

Remark: Pay attention to General Guidelines for Lifting Tools 0012–1.

- 2124–3 'Removing wear ridge' in cylinder liner at every piston removal.
- 2708–1 'Removal of cylinder cover' and draining cylinder cooling water.

Attention! The piston may not be transported with built-on piston rod gland (gland for short).

Attention! **The supporting device 94350 can be used for piston overhauling work at calm sea only, however, in no case this may serve as storage place during the voyage!**
Moreover, always bear in mind, that the passage between engine and supporting device is limited (e.g. as possible escape route) on the platform.

2. Loosening and tensioning the elastic studs of piston rod foot fastening

Please refer to General Application Instructions 9403–4 for hydraulic pre-tensioning jacks.

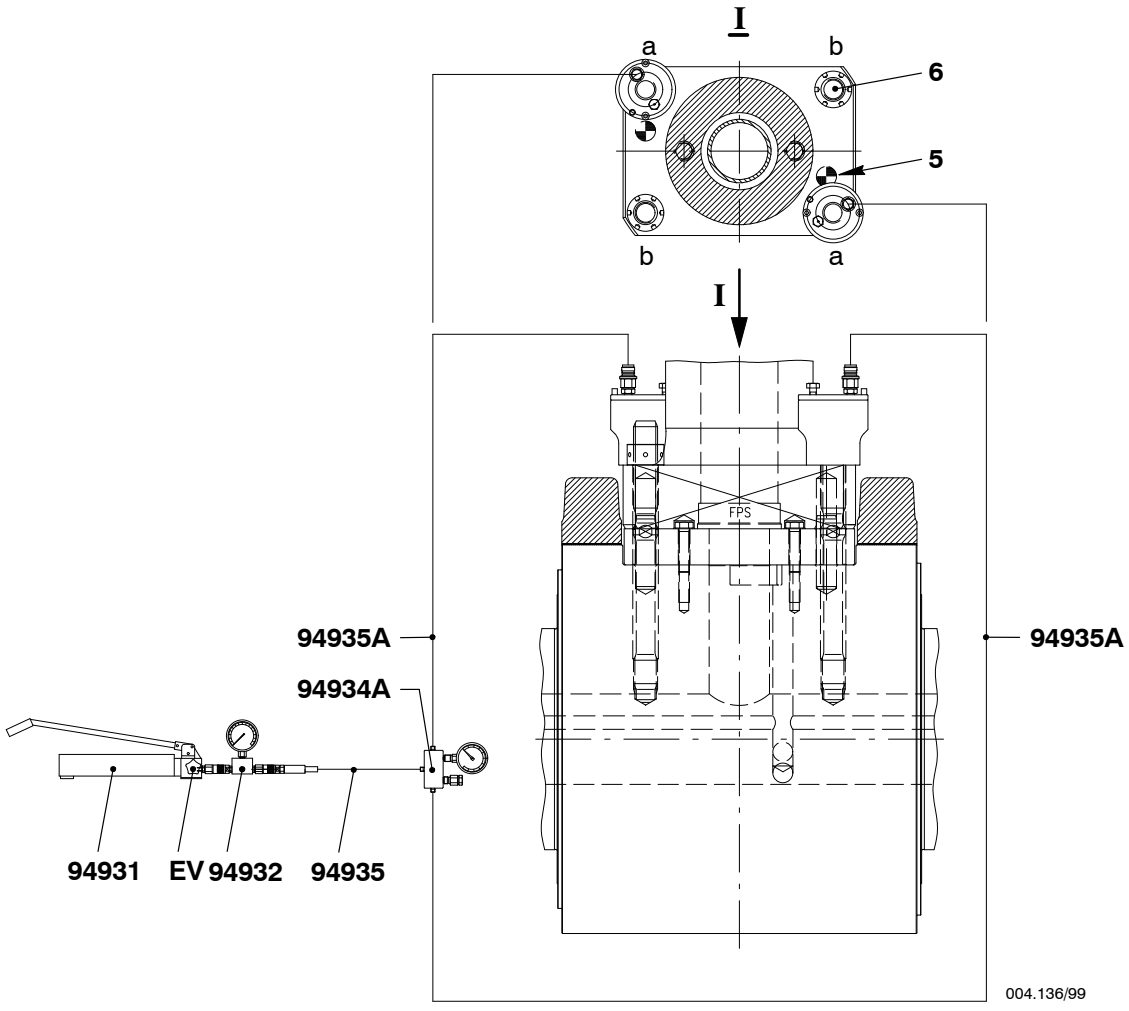
- Tensioning of elastic studs 6 must be carried out in two steps without exception, i.e. tension all elastic studs first with **600 bar (1st step)**, then finish tensioning with **1000 bar (2nd step)**.

CHECK

Based on the markings applied, check by how much the nuts were turned after pre-tightening (1st step) to the 2nd step. **Tightening angle** to be about **25°** for comparison.

- Moreover, **always** carry out loosening and tightening procedures **crosswise,** i.e. a/a and b/b **for each step**.

A ARRANGEMENT OF PRE-TENSIONING JACKS 94340



Piston: Removal and Fitting

3. Removal of piston

Remark: Loosen and remove all screws for the screwing piston rod gland / cylinder block (see 2303–1).
Remove the antipolishing ring from the collar of the cylinder liner (see 2124–2).
Fit locking devices GF 94343 in order to prevent the cylinder liner from being lifted when the piston is pulled out (for the relevant details see also Fig. 'G').

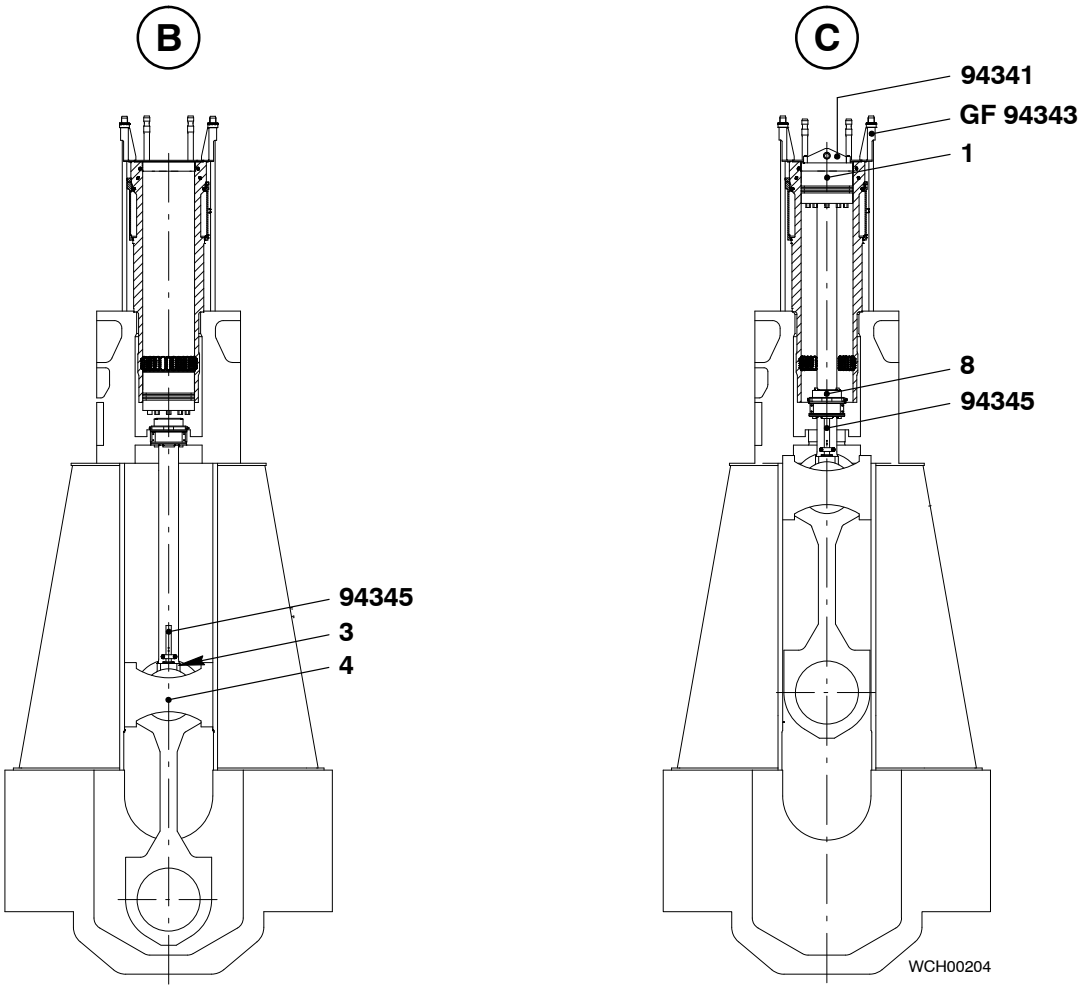
⇒ Screw fasten both distance holders 94345 to the piston rod foot (3).

⇒ Turn crank to T.D.C. whereby piston rod gland 8 is pushed out of its seating in the cylinder block by distance holders 94345.

⇒ Use tap 94348 to clean threaded holes of combustion residue in the piston crown 1.

⇒ Mount suspension device 94341 to piston crown.

- **Before** pulling the piston out, the crosshead pin and the top end bearing must be protected, so that entry of dirt into the top end bearing is absolutely prevented.



Piston: Removal and Fitting

⇒ Fasten piston supporting device 94350 to platform supports 14 at the upper platform.

⇒ Pull piston by crane out of cylinder liner.

⇒ Loosen screwed connection 17 and push supports 15 of piston supporting device 94350 completely outwards and turn up hinged covers 18.

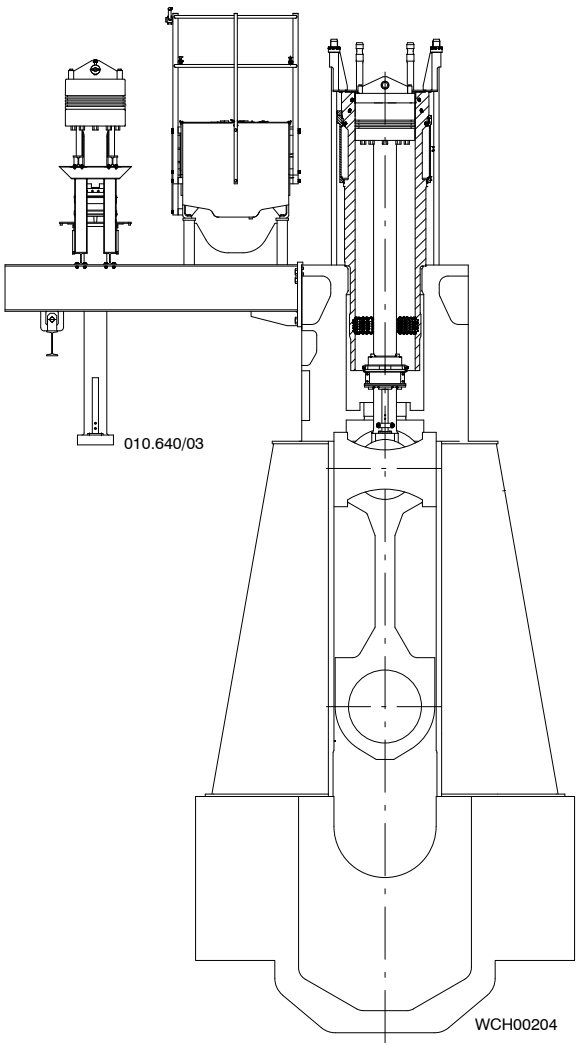
⇒ Lower piston on crane into the supporting device until the piston rod foot protrudes below the supporting device.

⇒ Turn the two hinged covers 18 down and lower the piston until piston rod gland 8 rests on the two hinged covers. Push supports 15 together and firmly tighten screwed connection 17.

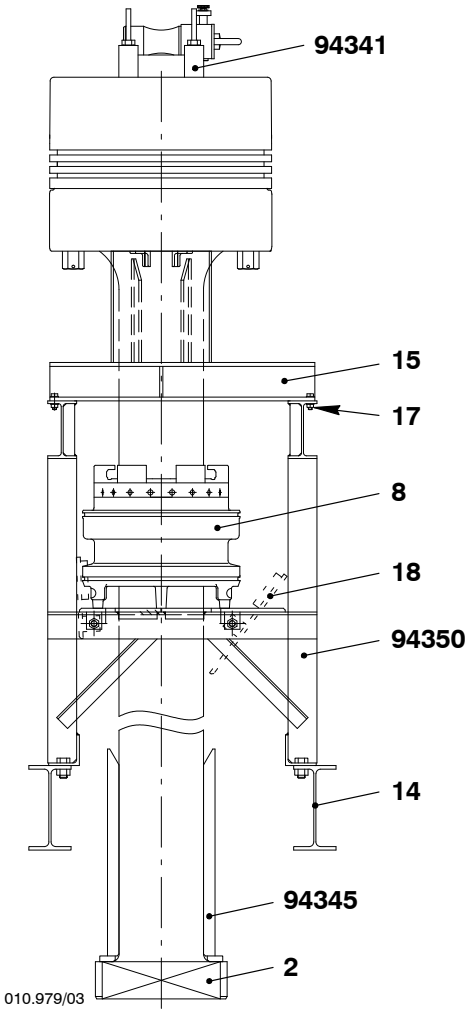
⇒ Lower the piston further until the piston rod head rests on support 15.

Attention! To prevent having a fall place cover plate 94345D over the gland bore in the cylinder block and fasten it provisionally with several screws.

D



E



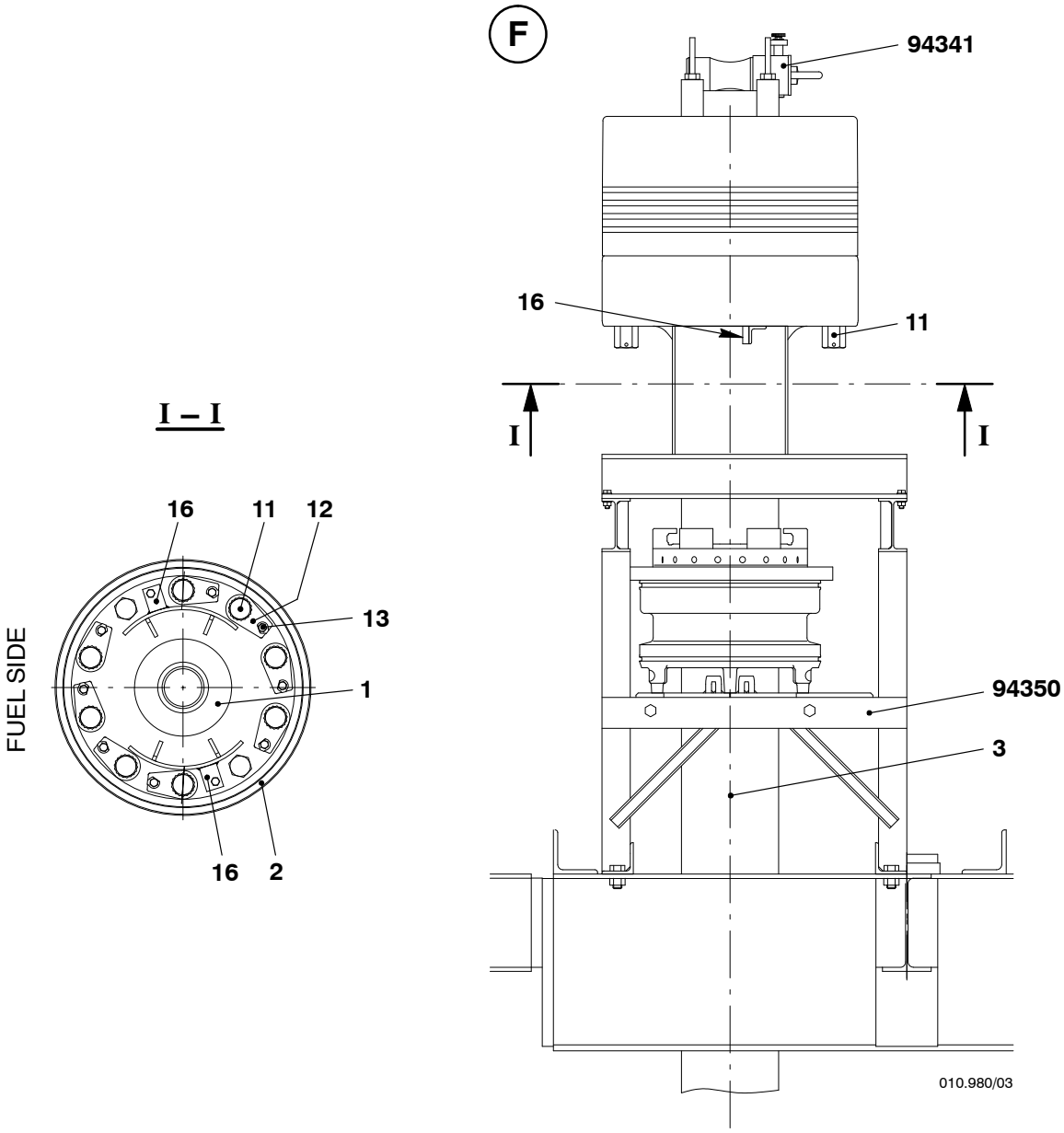
Piston: Removal and Fitting

When the piston has to be dismantled, it must be secured against turning when loosening elastic screws 11, whereby the procedure is as follows:

⇒ Lower the piston until access is obtained to securing screws 13.

⇒ In place of straps 16 which are fixed to the piston as shown in Fig. 'F', loosen and remove securing screws 13 together with their locking plates and locking elements 12.

⇒ Fully lower the piston and fit the straps by means of the securing screws.



4. Fitting the piston

Prior to fitting the piston, the following works must be carried out:

⇒ Remove piston rings with tensioning device 94338 (see 3425–1) and clean piston exterior thoroughly (do not use any tools that might damage the surface!).

CHECK

Establish the height of the piston ring grooves (see Clearance Table 0330–1 'Piston and piston rings').

⇒ Clean piston rings and measure them.

Remark: For refitting of used and new piston rings, follow strictly the instructions in 3425–1.

- **When refitting used piston rings be sure to fit them in the same positions and grooves as removed.**
- **Fit the piston rings in such a manner that their marking TOP is on top.**

CHECK

Check the piston top surface (see 3403–4).
Measure bore of cylinder liner (see 2124–1) and carry out any needed reconditioning to lubricating grooves and scavenge ports (see 2124–3).

⇒ Actuate the cylinder lubrication until oil flows from all the lubricating points.

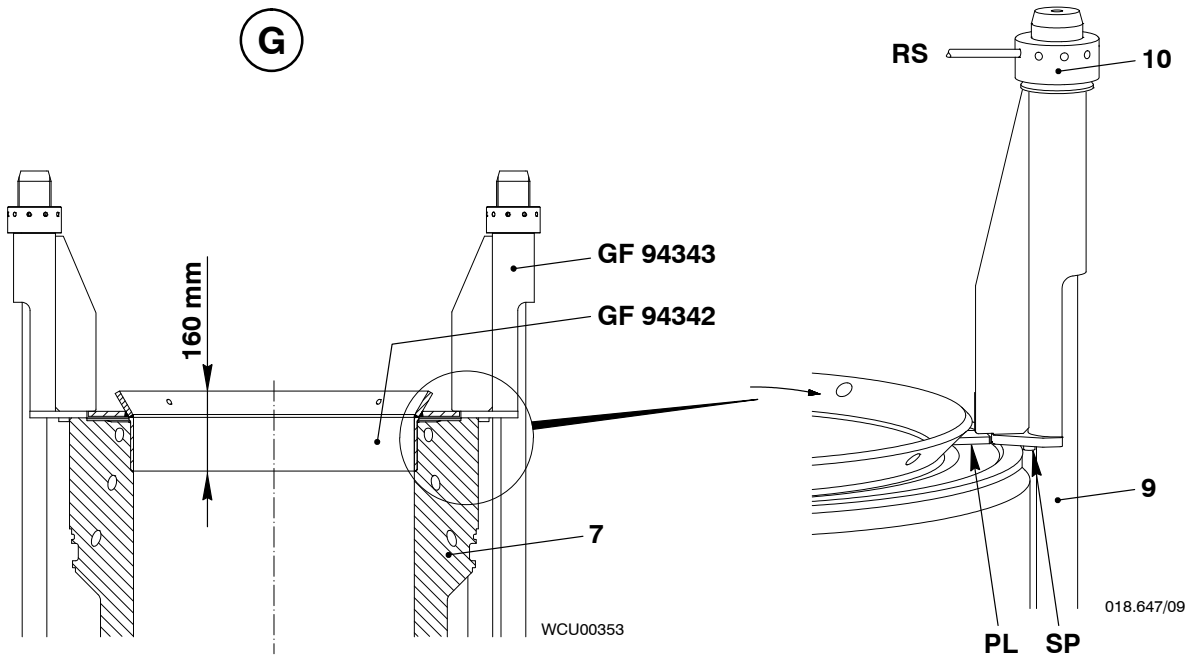
- Piston rod gland and both distance holders 94345 must be mounted on the piston rod foot (see 2303–1).
- Locking devices GF 94343 must be properly fitted; thereby stop plate 'SP' guides the device laterally on the cylinder liner when tightening the round nut with round bar 'RS'.

⇒ Place insertion funnel GF 94342 on cylinder liner 7. Turn it so that the two welded plates 'PL' of the insertion funnel are exactly located under the locking devices.

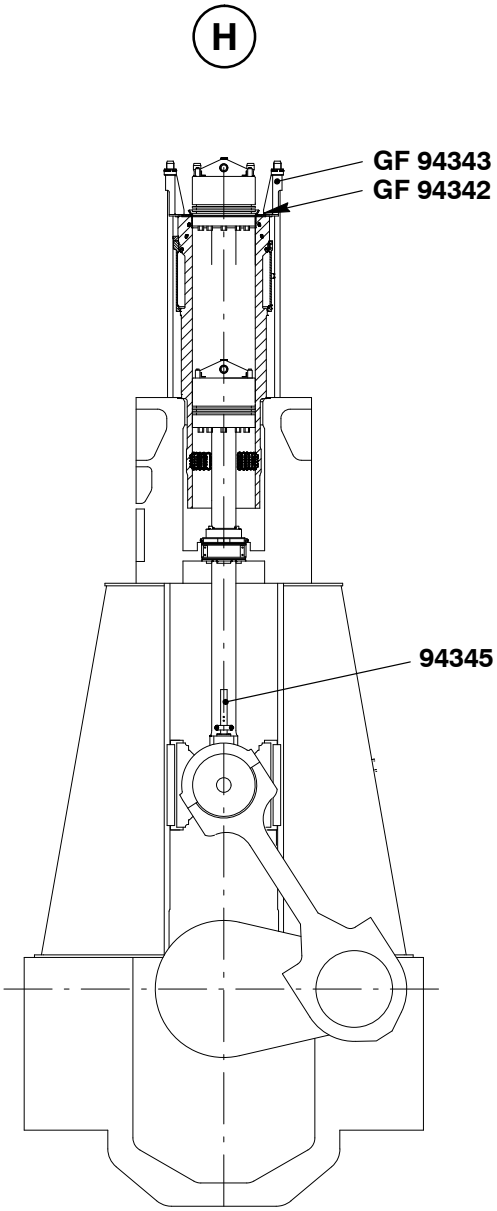
- Suspension device 94341 must be fastened to the top of the piston crown.

⇒ Smear piston rings, piston skirt, piston rod and running surface in cylinder liner lavishly with bearing oil.

4.1 Placing and fastening insertion funnel and cylinder liner



Piston: Removal and Fitting



4.2 Fitting

⇒ Turn crank of the cylinder concerned to T.D.C.

⇒ Slightly lift piston by crane. Loosen screwed connections 17 (Fig. 'E') and push both supports 15 outwards. Then lift the piston including piston rod gland 8 so far that the two hinged covers 18 can be turned up.

⇒ Bring the piston over the cylinder liner and then slowly lower it.

- When the piston is lowered into the cylinder liner until the lowest piston ring is at the upper level of insertion funnel GF 94342, arrange the piston rings so that their gaps alternate by 180° to each other (see 3425–1).

⇒ Slowly lower the piston further until its piston rod foot has arrived just above the crosshead pin. While one person directs the further lowering of the piston from the top, another directs the piston rod progress from the engine interior and how it must be turned to guide the piston rod foot without jamming into centring pins 5 (Fig. 'A') in the crosshead pin 4.

⇒ Slacken the crane rope a bit and remove the suspension device.

⇒ Turn piston to B.D.C. and direct the insertion of the piston rod gland into its seating bore in the cylinder block (see 2303–1).

⇒ Loosen and remove both distance holders from the piston foot.

⇒ Firmly tighten all screws fastening the piston rod gland housing.

⇒ Tension elastic studs 6 for the piston rod foot fastening as described in section 2.

⇒ Refit the antipolishing ring (see 2124–2).

5. Leak test

A leak test must be carried out after every fitting of a piston in the cylinder. For this, start the bearing lubrication pump and set the bearing lubricating pressure. Check through the scavenge space on the fuel side in the cylinder block (piston underside) whether cylinder liner running surface and piston rod remain dry.

Any increase in the dirty oil level in the scavenge air space may be caused by a faulty O-ring in the piston.

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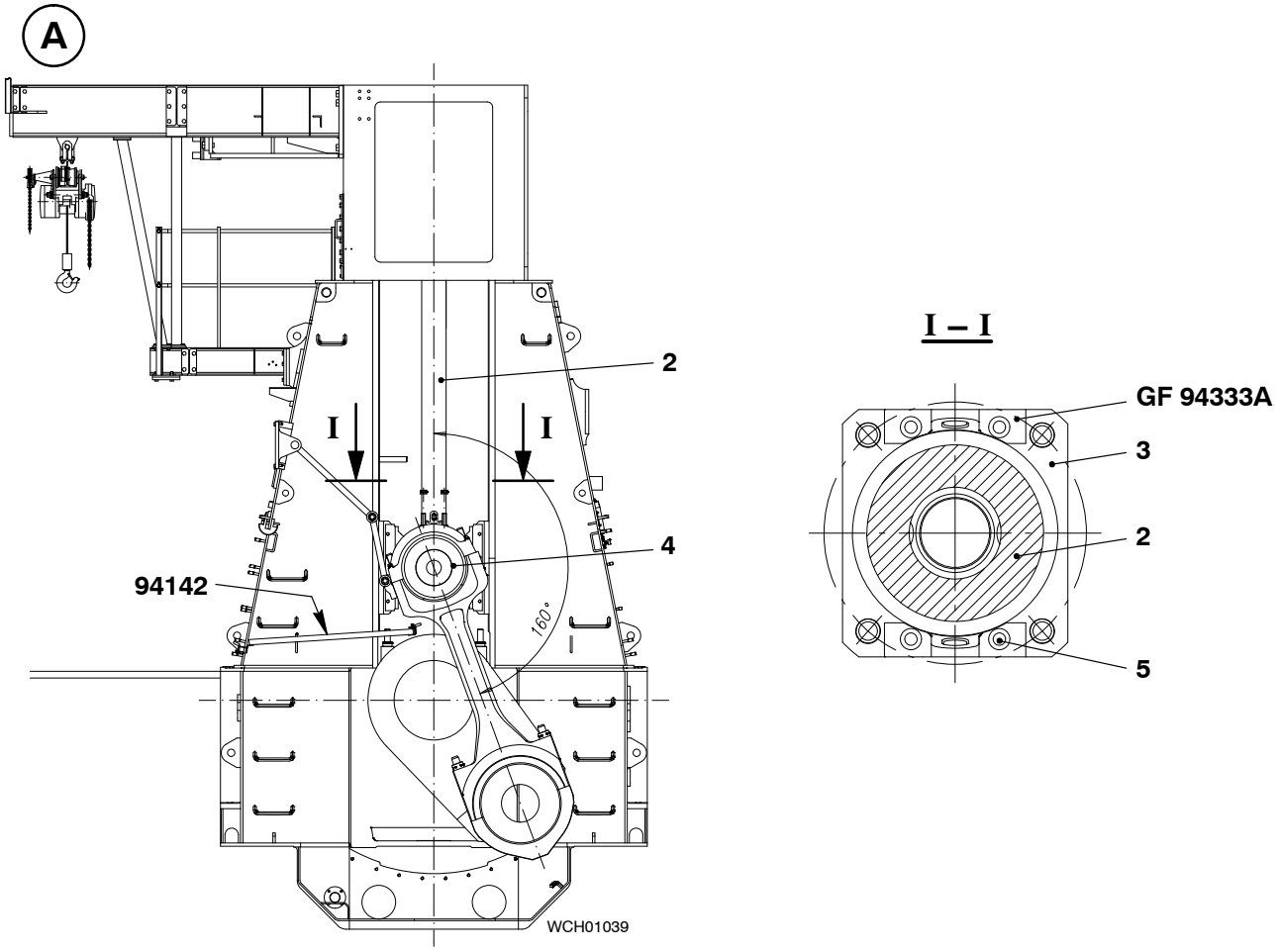
Piston

Changing the Compression Shims

Tools:		
2	RUD-eye bolts	94040–M20
1	Working platform	94142
2	Lifting bosses	GF 94333A
2	Suspension chains	GF 94333B

Key to Illustrations:			
1	Cylinder block	5	Allen screw
2	Piston rod	6	Compression shim
3	Piston rod foot	7	Elastic stud
4	Crosshead pin	8	Dowel pin

1. Fitting and removing compression shim



Remark: Pay attention to:

- General Guidelines for Lifting Tools 0012–1.
- Utilization of Working Platform 3301–1.

⇒ Turn crank of the cylinder concerned to Approx. 160° before B.D.C.

⇒ Install working platform 94142 according to the instruction in 3301–1.

⇒ Loosen the nuts of the elastic studs for the screwing of piston rod foot 3 and crosshead pin 4, as described in 3403–1.

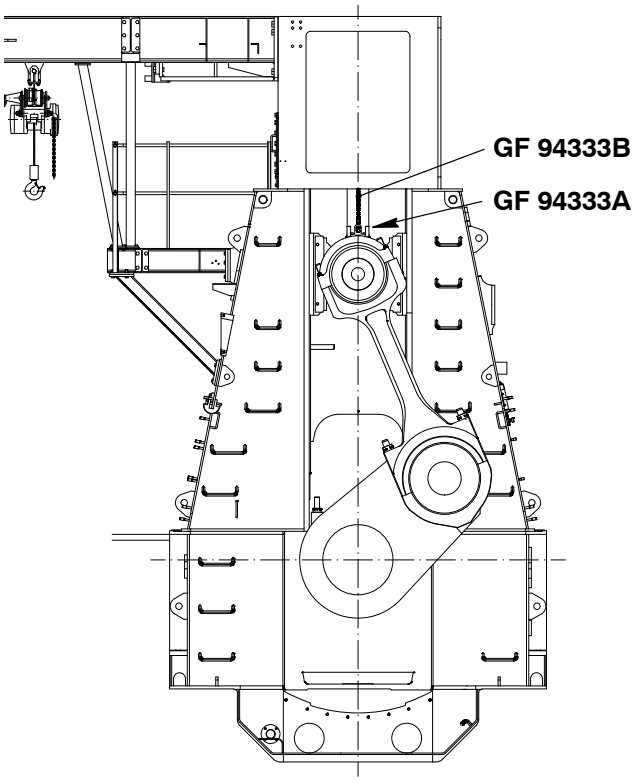
⇒ Fasten lifting bosses GF 94333A and tighten their oiled Allen screws 5 on the piston rod foot with **140 Nm**.

⇒ Screw two RUD-eye bolts 94040–M20 into cylinder block 1 and tighten them with **115 Nm**. Connect suspension chains GF 94333B (View I).

⇒ Remove the working platform.

Piston: Changing the Compression Shims

B



⇒ Turn crank upwards to exhaust side until suspension chains GF 94333B can be put into lifting bosses GF 94333A.

STOP **The crank may be turned max. 30° towards T.D.C.**

⇒ Carefully turn crank downwards until elastic studs 7 are cleared from piston rod foot 3. Take care that the two dowel pins 8 in cross-head pin 4 do not jam in the piston rod foot.

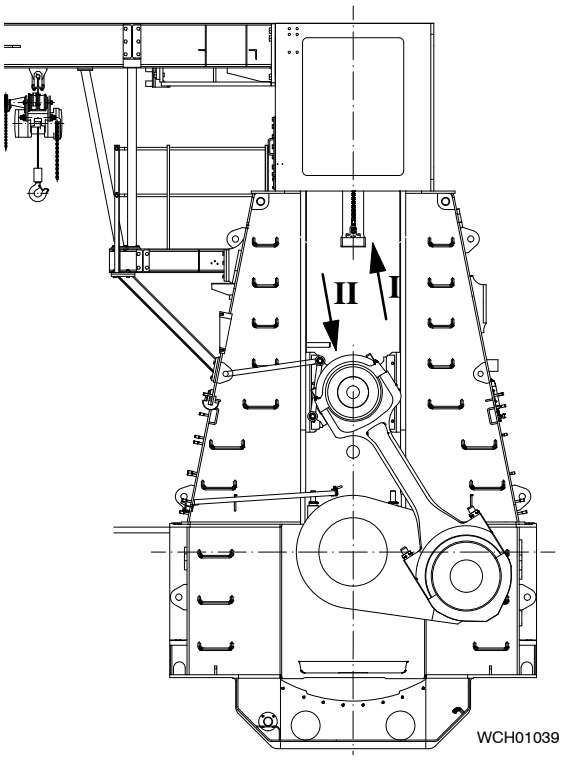
⇒ Loosen and remove the screws fastening compression shim 6.

⇒ Remove the compression shim with the aid of two eye bolts.

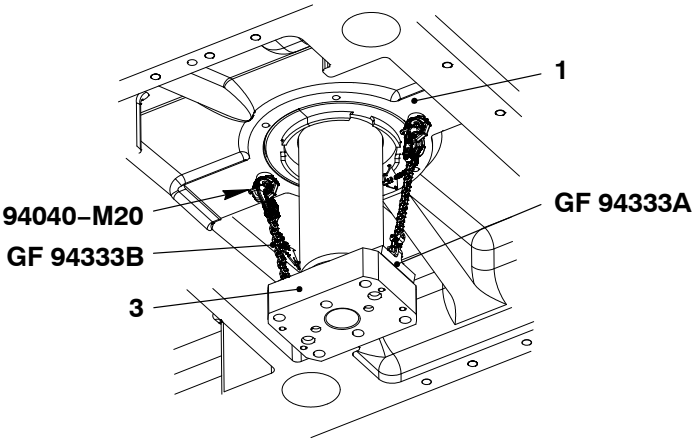
For fitting the new compression shim proceed in reverse sequence to the removal.

Remark: Please note the correlation between setting screw 'ST' on measuring gauge 94225 (see 2124–1) and the mean thickness of built-in compression shims.

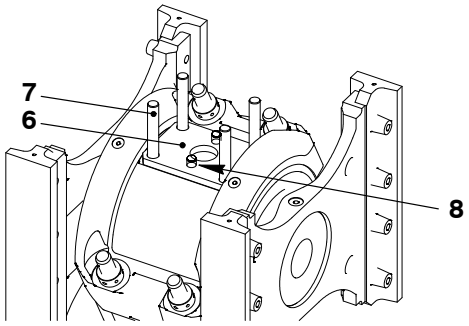
C



I



II



Piston

Dismantling and Assembling

Tools:		
1	Suspension device	94341
1	Piston supporting device	94350
2	Jacking screws	94363
2	Jacking screws	94364
1	Impact ring spanner AF46	
1	Torque wrench	

Key to Illustrations:			
1	Piston crown	8	Centering pin
2	Spraying plate with oil pipe	9	Screw
2a	Spraying nozzle	10	Locating pin
3	Locking element	11	Strap
4	Screw with locking plate	12	Screw
5	Elastic screw	13	O-ring
6	Piston rod	14	O-ring
7	Piston skirt	15	Locating pin

1. General

Should the dismantling of a piston become necessary (cleaning the cooling chamber, reconditioning the ring grooves etc.), then this can be carried out as described below. For this purpose the piston is to be placed in the piston supporting device 94350 according to 3403–1.

When fitting and removing elastic screws 5 the piston rod must be steadied against rotation with two straps 11 of supporting device and two locking screws 4.



Attention! When dismantling or assembling a piston take particular care that the spraying nozzles are not damaged.

2. Dismantling of a piston

⇒ Remove locking elements 3 with screw and locking plate 4 from all elastic screws 5 (Fig. 'A').

⇒ Loosen and remove all elastic screws 5.

⇒ Insert both jacking screws 94363 into the two opposite bores for locking screws 4 in the piston rod head (Fig. 'A'), and drive them in until they press against centering pin 8 (Fig. 'C'). Equally tighten the two jacking screws in small steps, until the piston crown is separated from the piston rod.

- When raising piston crown 1 take particular care not to damage spraying nozzles 2a.

⇒ Remove both jacking screws from piston rod head.

Following the removal of piston crown separate piston skirt 7 from piston rod 6 as described below:

⇒ Loosen and remove both screws 9 (Fig. 'A').

⇒ Using two jacking screws 94364 (see Fig. 'D') the piston skirt can be separated from the piston rod.

- While raising the piston skirt pay attention that locating pin 10 does not jam.

For the removal of spraying plate with oil pipe 2 (Fig. 'A') loosen and remove first screws 12 with locking plates. The spraying plate with oil pipe can then be pulled as a complete unit from piston rod 6.

- Attention! Do not damage the spraying nozzles.

3. Assembling of a piston

For assembling the piston the following points must be observed:

- Damaged spraying nozzles 2a may under no circumstances be reused. New ones must be fitted with liquid securing agent LOCTITE No. 0648.
- Whenever possible always use new O-rings, they must conform in dimensions and quality to our specifications.
- All cylindrical **guide portions** as well as **O-rings, screw head seatings** and **threads** of the elastic screws must be smeared with **oil** before fitting.

CHECK

Pre-tighten oiled screws 12 with **10 Nm** using a torque wrench, subsequently tighten to an angle of **30**° and finally secure them with locking plates. **No additional lubricant** must be applied to the threads of screws 12.

- Attention must be paid to locating pin 10 when assembling piston skirt 7 with piston rod 6.

⇒ Insert and tighten both screws 9.

- For the assembly of piston crown 1 to piston rod 6 make sure that two centering pins 8 (Fig. 'A'), serving also as guides, mate with the corresponding bores in piston skirt 7 and the piston rod.

⇒ Screw all oiled elastic screws 5 into the well cleaned threaded holes until fully seated; tighten these carefully crosswise in small steps with ring impact spanner.

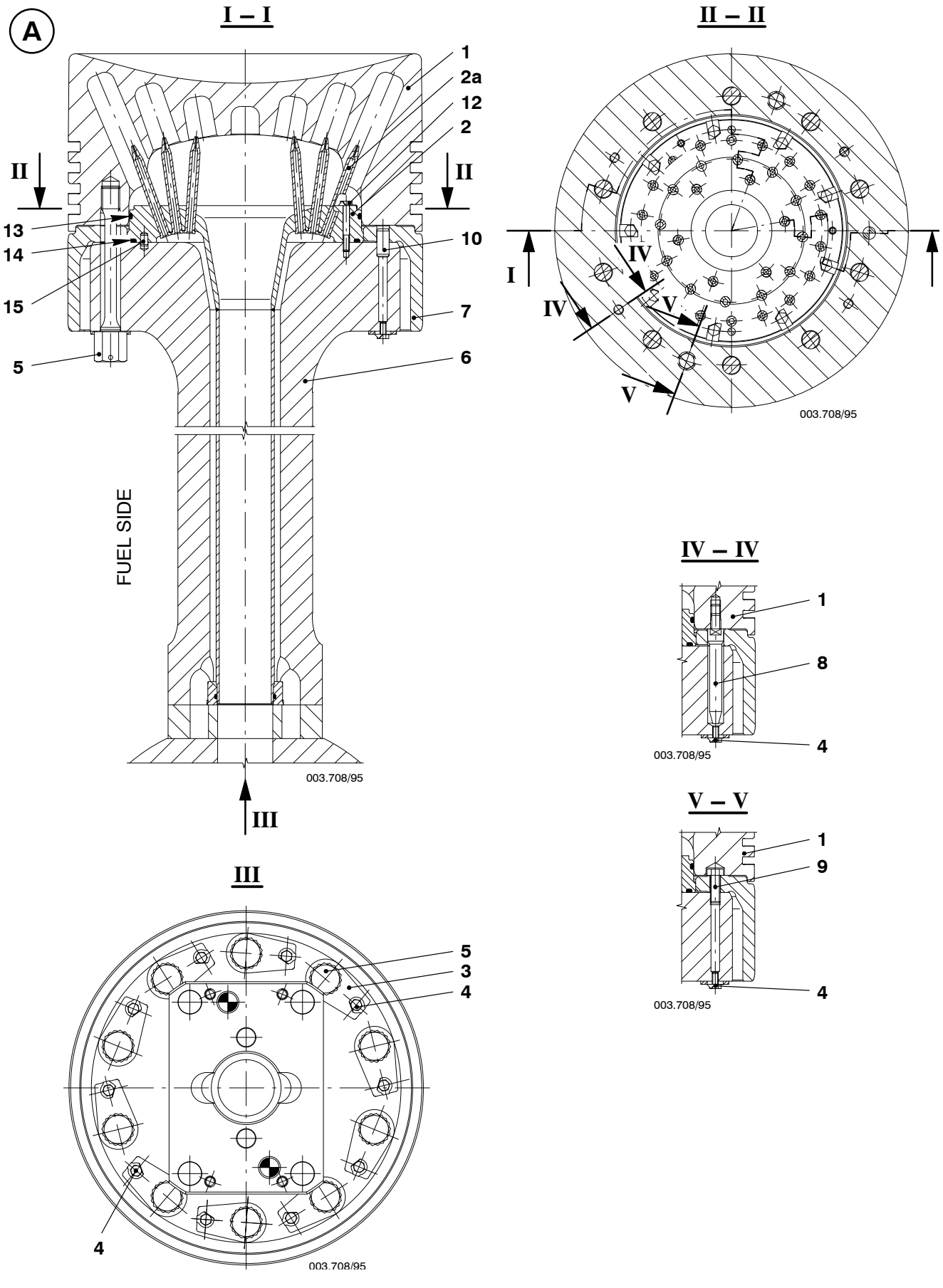
⇒ Mark position of screw heads against piston rod flange with felt marker (= initial position).

CHECK

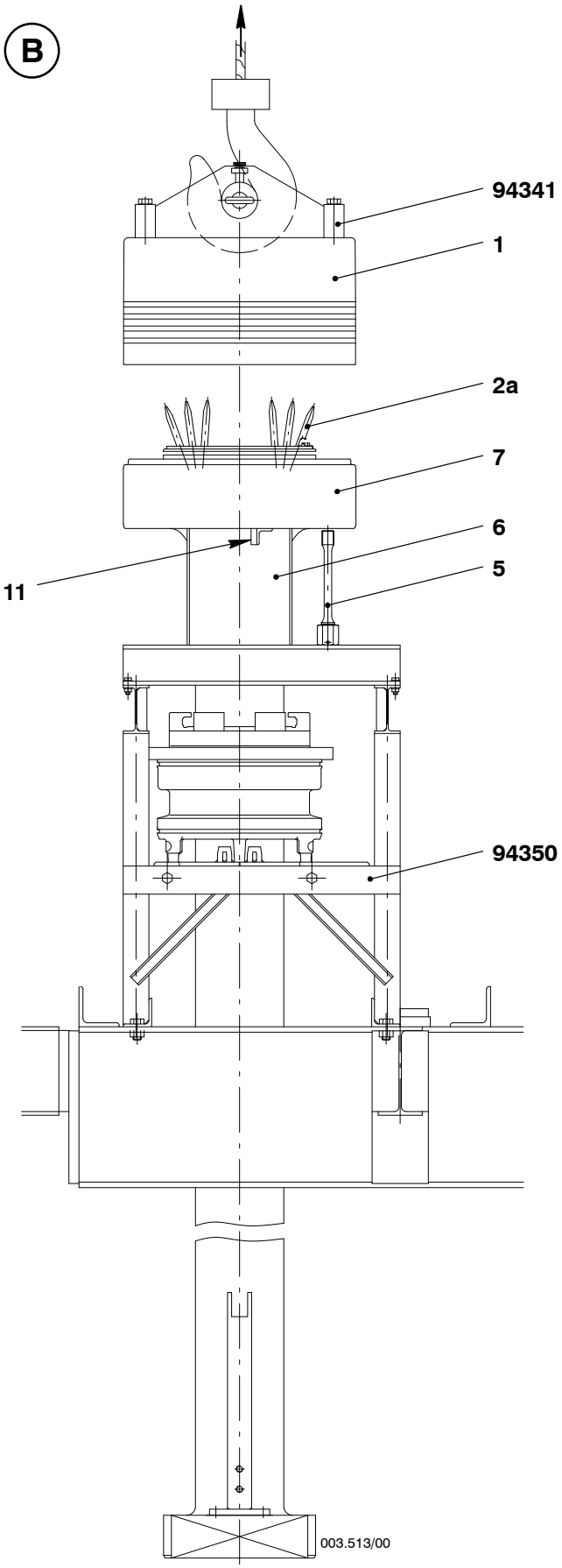
Using an impact ring spanner and a hammer, tighten the elastic screws crosswise in small steps until these have been turned by an angle of **90**° compared with the initial position (see 0352–1).

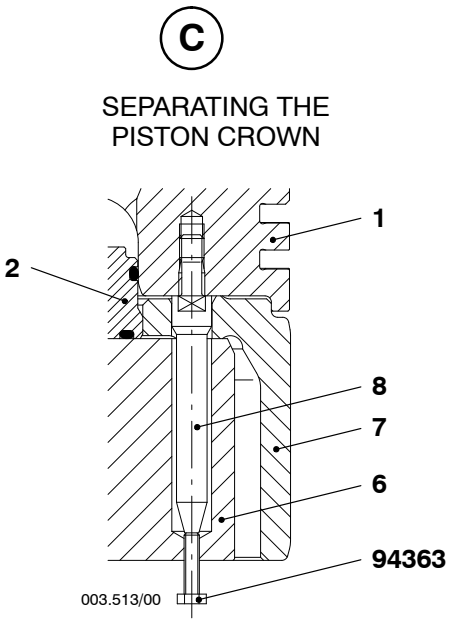
⇒ Lock all elastic screws 5 with their locking elements 3. For fitting a locking element a screw may under **no circumstances be turned back;** it must instead be tightened further (by max. 5°).

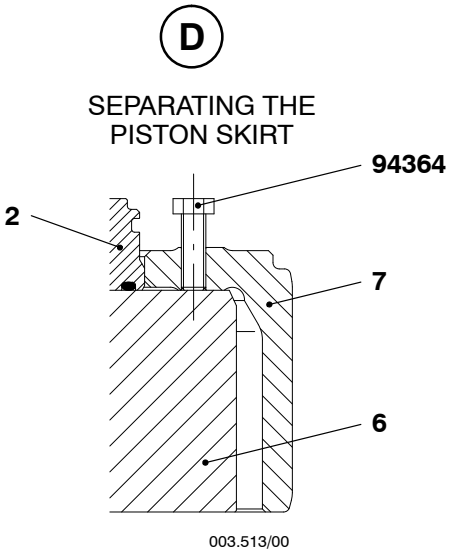
Piston: Dismantling and Assembling



Piston: Dismantling and Assembling







Piston

Checking Piston Top Surface

Tools:

1	Feeler gauge	94122
1	Template	94366
1	Template	94366A

CHECK

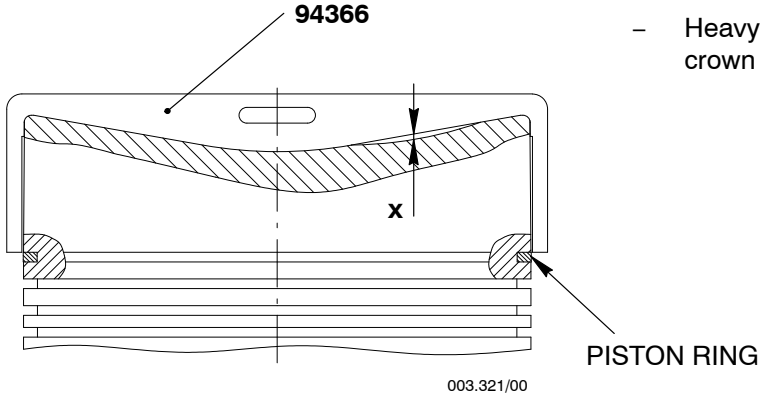
Every time a piston is pulled out, the piston top surface contour must be checked with template 94366 and with feeler gauge 94122. The template is placed on the topmost piston ring and rotated around the piston axis (see Fig. 'A').

- Where burn scars are only slight it is sufficient to grind them over and to smooth sharp-edged zones with emery cloth. Where, however, burn scars exceed x = 10 mm the original material thickness must be restored by surface welding. This entails the removal of the piston crown.

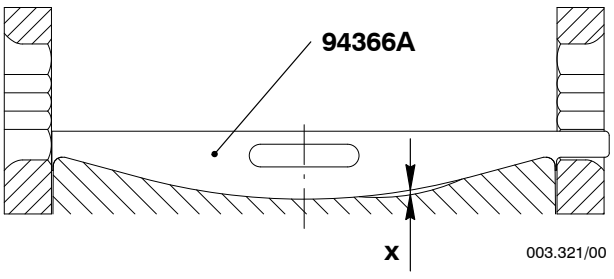
Before re-starting the engine, the reason for such heavy burns should be established. The causes must be remedied.
Causes of heavy burn scars may be:

- Poor combustion
- Worn nozzles
- Heavy local carbon deposits on top of the piston crown etc.

A



B



Template 94366A should be used if the shape of the crown top of a piston in situ has to be checked.
As shown in Fig. 'B', the template is to be pushed through one of the scavenge ports of the cylinder liner and placed on top of the piston crown.

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Piston Rings

Checking Wear of Piston Rings and Ring Grooves with Four Piston Rings

	Tools:	
1	Inside micrometer	94101
1	Feeler gauge	94122
1	Piston ring tensioning device	94338
1	Equipment case with instruments for measuring chrome layers	94356
1	Micrometer (0–30 mm)	
1	Calliper gauge	94357

Key to Illustration:

1 Piston ring
2 Cylinder liner
3 Piston head
4 Claw

Overview

1. General 1/7
2. Determine wear rate of piston rings 1/7
3. Measuring piston ring grooves 4/7
4. Removing piston rings 6/7
5. Fitting piston rings 7/7
6. Storage and handling of piston rings 7/7

1. General

For judging and evaluating the condition of cylinder liner, piston and piston rings the following guidelines serve for a condition-based Maintenance for piston and cylinder liner overhaul.

Wear rates strongly depend on operational factors, such as fuel in use, engine load profile, ambient conditions etc.

By visual inspections, critical conditions of cylinder liners and piston rings can be detected at an early stage. Further information to monitor the cylinder liner and piston ring conditions are given in the Operating Manual 0750–1 Lubricating Oils.

The information regarding measuring piston ring grooves helps to define if the wear on piston ring grooves is within the given limits or if the piston head must be reconditioned. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

2. Determine wear rate of piston rings

Measure the thickness of the chrome-ceramic coating of the piston rings as scheduled in 0380–1 to determine the wear rate and the remaining life time of the piston rings.

Remark: See suppliers operation manual for the usage of layer measurement tool 94356.

2.1 Measure coating thickness with piston in situ (through scavenge ports)

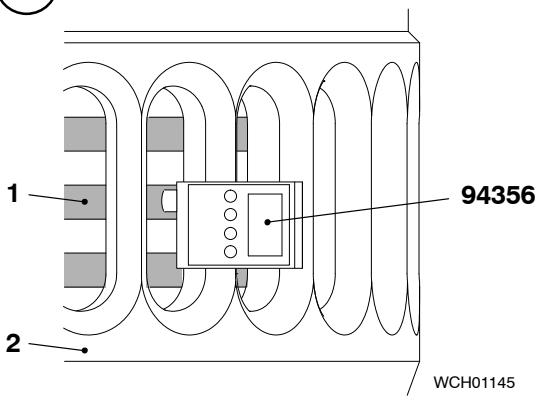
Before each measurement the layer measurement tool 94356 must be calibrated. Use the delivered calibration foils and the bare top flank of a spare top piston ring as base material for proper setting.

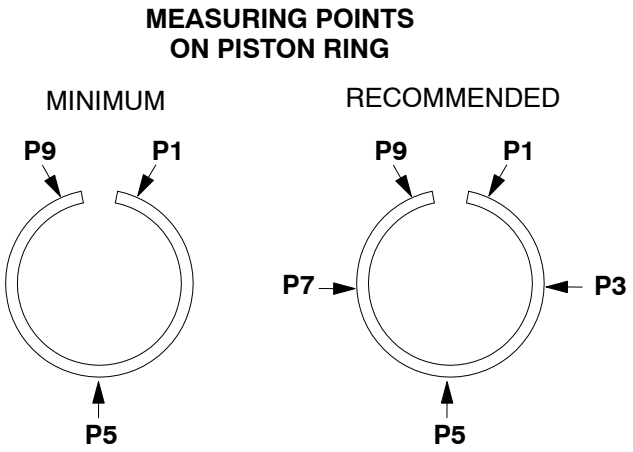
⇒ Clean piston ring running surface at reachable measuring points P1 to P9.

⇒ Press the sensor of the layer measurement tool against the piston ring surface at middle of ring height.

⇒ Measure the layer thickness and note the output value.

A





2.2 Wear rate

The chrome-ceramic coating is a lifetime coating. However, the actual wear depends on operating conditions. When during a piston underside inspection a piston ring with a partially worn chrome-ceramic coating is found, we recommend overhauling the unit at next opportunity (Fig. 'B').

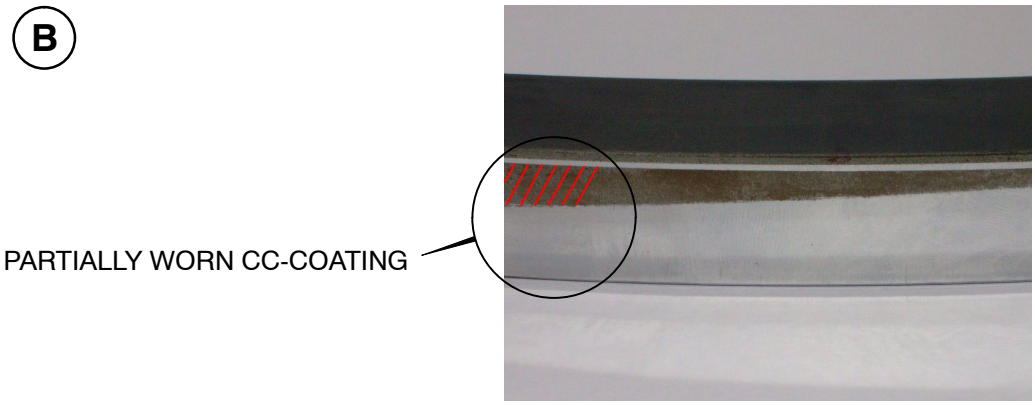
With regular done measuring you can determine the specific wear rate for each piston ring.

The piston rings can still be used, if the remaining chrome-ceramic coating is above the following limits:

- Uppermost piston ring 'a' **> 0.05 mm**
- Lower piston rings 'b' and 'c' **> 0.02 mm**

Below those minimal coating thicknesses, a piston ring replacement must be planned.

B



2.3 Lifetime calculation

Calculate the wear rate and the remaining lifetime of a piston ring.

Use the formula below to calculate the wear rate:

$$WR = \frac{(D1-D2) \times 1000}{T2-T1}$$

WR = Wear rate [mm/1000 h]

T2 = Actual running hours [h]

T1 = Running hours at previous measurement [h]

D2 = Actual coating thickness [mm]

D1 = Coating thickness at previous measurement [mm]

Example for wear rate calculation:

D1	D2	T1	T2	**WR**
0.382	0.367	0 (new)	1500	0.01
0.351	0.340	3500	5000	0.0073

Use the formula below to calculate the remaining piston ring lifetime according to the latest condition setting:

$$LT = \frac{(D2- Dmin) \times 1000}{WR}$$

LT = Remaining lifetime [h]

D2 = Actual coating thickness [mm]

Dmin = Minimal coating thickness [mm] (see chapter 2.2)

WR = Calculated wear rate [mm/1000 h]

Example for remaining lifetime calculation:

D1	D2	Dmin	T1	T2	WR	**LT**
0.382	0.367	0.05	0 (new)	1500	0.01	31700
0.351	0.340	0.05	3500	5000	0.007333	39545

3. Measuring piston ring grooves

CHECK

Check all dimensions and record them (see Clearance Table 0330–1 'Piston and piston rings'). These records are important for later evaluation of the running gear. They should encompass all dimensions, the date of overhaul and operating hours of the various components and of the engine itself.

3.1 Measurement with piston in situ (through scavenge ports)

The measurement of the piston ring clearance has to be carried out at two to four free positions around the complete circumference of the piston head. The number of measurement points depends on the accessibility.

Make sure that feeler gauge 94122 is pushed into the piston ring groove until it touches the inner diameter of the groove, i.e. at point A. If there is a wear step on the chromium layer, the feeler gauge can be pushed only to that point (C3).

Remark: Also consider the deposits in the piston ring groove and/or on the piston ring top face.

⇒ Move piston 3 down (C1) by means of the turning gear.

⇒ Make sure that the total clearance is measured:
First measure the clearance 'x1'at point A.

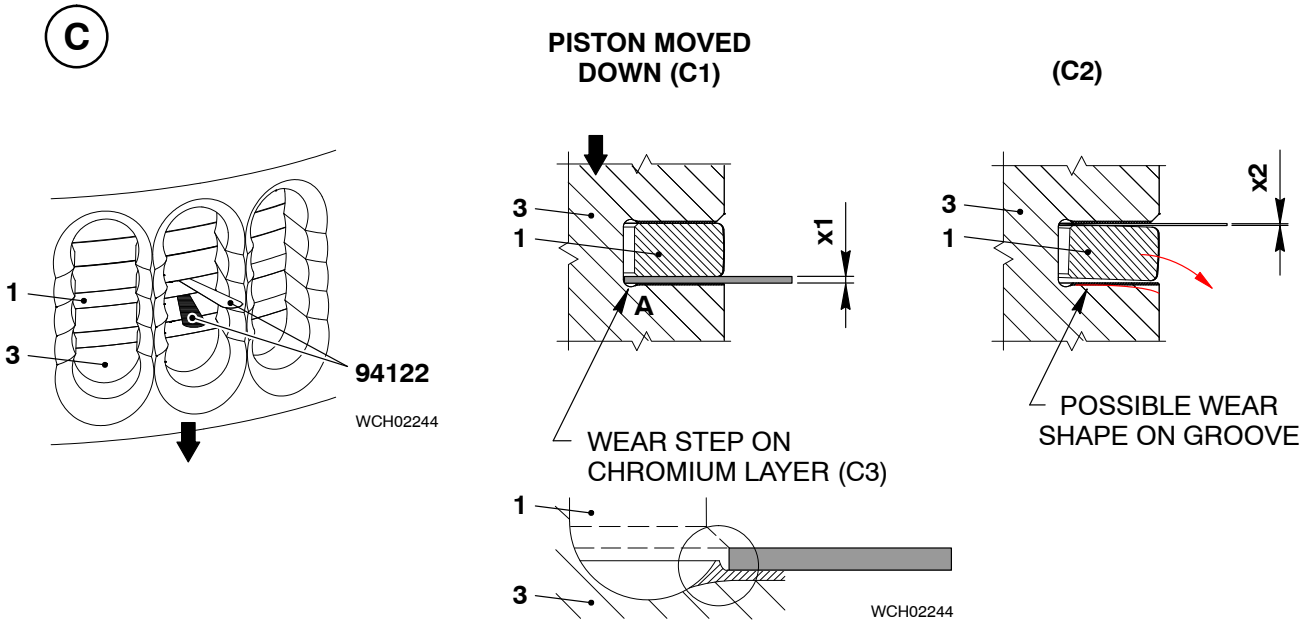
⇒ Afterwards repeat the measurement at the same circumferential position and measure the clearance 'x2'.
The sum of both values will give the total piston ring clearance.

Remark: The reason for this split measuring principle is that the piston rings might be in a tilted position and thus not fully pushed-up and tight to the upper face of the piston ring groove (C2).

The maximum clearance is at point A. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

STOP

If the clearance at point A exceeds the permitted value, the piston rings have to be replaced and the piston head has to be reconditioned.
For reconditioning of piston crowns please contact your nearest Wärtsilä Service Center.



3.2 Measurement with piston removed from cylinder liner

The measurement of the piston ring clearance has to be carried out on at least four positions around the complete circumference of the piston head.

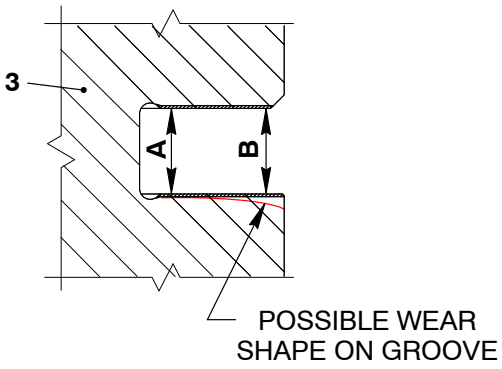
⇒ Remove the piston rings as described in section 4.

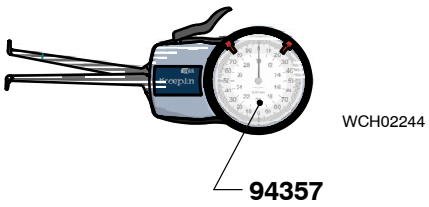
⇒ Clean the piston ring grooves.

Measuring method with calliper gauge:

⇒ Measure the groove height with calliper gauge 94357 at point A and B.

D





Measuring method with a piece of a piston ring:

⇒ Measure the thickness of piece of a piston ring (1).

⇒ Place piece of piston ring into the piston ring groove.

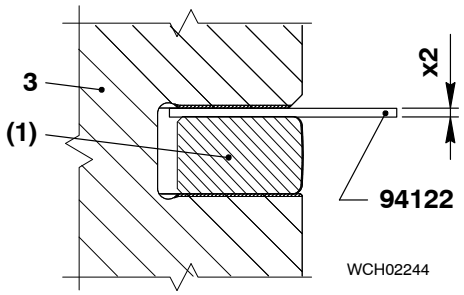
⇒ Measure gap 'x2' between the face of piston ring and groove with feeler gauge 94122.

⇒ Evaluate the piston ring clearance with the following data:

CL = GH – RT (mm)

- CL = CLearance
- GH = Measured piston ring Groove Height (mm)
- RT = Nominal piston Ring Thickness (mm)

E



STOP

If the clearance at point A and/or B exceeds the permitted value, the piston head has to be reconditioned. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

A piston head with clearances close to the maximum value may not be further used as the expected remaining lifetime is too short.

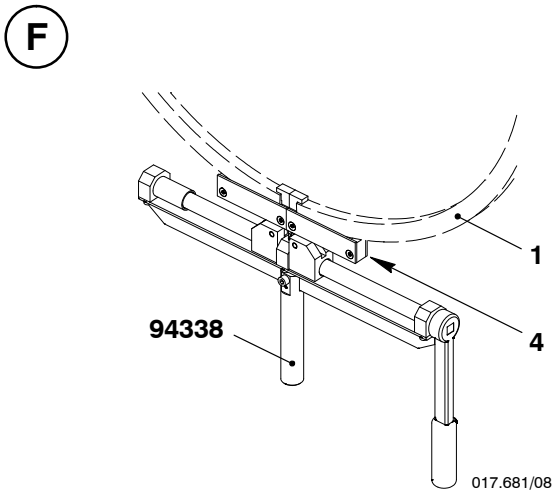
4. Removing piston rings

For removing piston rings 1, always use the corresponding tensioning device with its specially designed claws 4 preventing the coating from being chipped off at the ring ends.

To prevent deformation it is of the utmost importance not to open the rings more than absolutely necessary, i.e. allowing removal over the piston crown.

⇒ Thoroughly clean piston, piston rings and piston ring grooves.

- Take care not to damage the chromed surfaces.



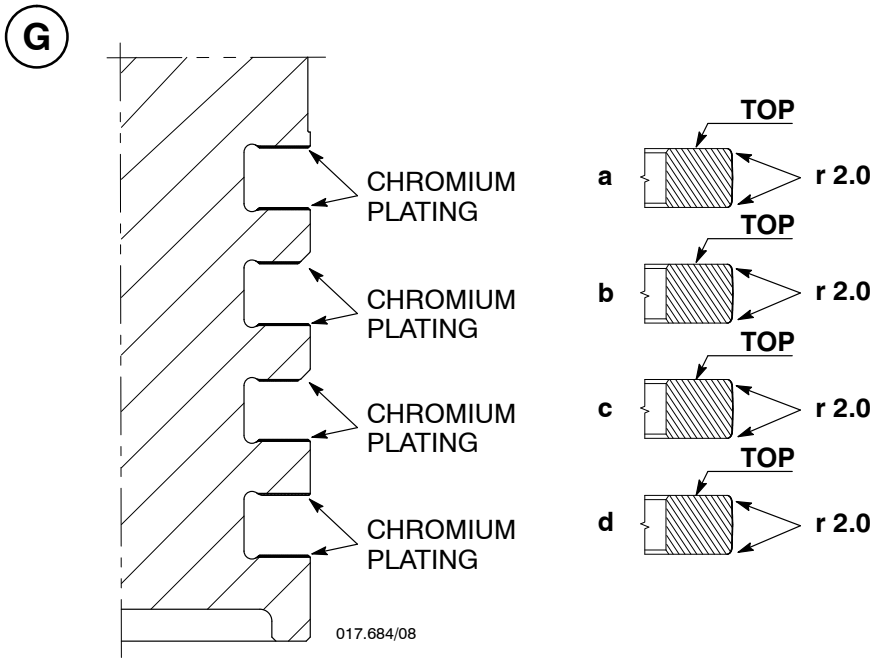
5. Fitting piston rings

- When reusing piston rings, only rings in perfect condition may be fitted, however in the same position and groove as removed.
- **Always fit piston ring with the marking TOP upwards**
  (when the piston is assembled the piston rings must be turned such that the ring gaps are staggered by 180°).
- The chromium plating thickness of a new CC coated piston ring should be measured and recorded to monitor the wear rate over time.

Remark: New piston rings have to be run-in according to the relevant indications in the Operating Manual 0410–1.

Standard piston ring arrangement:

Ring type	Coating / material	Application
Uppermost piston ring 'a' 1 x SCP1CC16_**S**traight **C**ut	chrome-ceramic coated	for new and fully honed cylinder liners as well as for used cylinder liners in good conditions
Piston rings 'b', 'c' and 'd' 3 x SCP2CC16_**S**traight **C**ut	chrome-ceramic coated	



6. Storage and handling of piston rings

Store the piston rings in a dry place but not in a place contaminated with exhaust gases or any other corrosive atmosphere. Lay the piston rings horizontally on a flat surface, keeping them in their original packing. Handle with care when preparing for use and avoid any hard contact against other objects.

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Piston Rings

Checking Wear of Piston Rings and Ring Grooves with Three Piston Rings

	Tools:	
1	Inside micrometer	94101
1	Feeler gauge	94122
1	Piston ring tensioning device	94338
2	Claws for gastight piston ring	94338A
1	Equipment case with instruments for measuring chrome layers	94356
1	Micrometer (0–30 mm)	
1	Calliper gauge	94357

Key to Illustration:

1 Piston ring
2 Cylinder liner
3 Piston head
4 Claw

Overview

1. General 1/7
2. Determine wear rate of piston rings 1/7
3. Measuring piston ring grooves 4/7
4. Removing piston rings 6/7
5. Fitting piston rings 7/7
6. Storage and handling of piston rings 7/7

1. General

For judging and evaluating the condition of cylinder liner, piston and piston rings the following guidelines serve for a condition-based Maintenance for piston and cylinder liner overhaul.

Wear rates strongly depend on operational factors, such as fuel in use, engine load profile, ambient conditions etc.

By visual inspections, critical conditions of cylinder liners and piston rings can be detected at an early stage. Further information to monitor the cylinder liner and piston ring conditions are given in the Operating Manual 0750–1 Lubricating Oils.

The information regarding measuring piston ring grooves helps to define if the wear on piston ring grooves is within the given limits or if the piston head must be reconditioned. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

2. Determine wear rate of piston rings

Measure the thickness of the chrome-ceramic coating of the piston rings as scheduled in 0380–1 to determine the wear rate and the remaining life time of the piston rings.

Remark: See suppliers operation manual for the usage of layer measurement tool 94356.

2.1 Measure coating thickness with piston in situ (through scavenge ports)

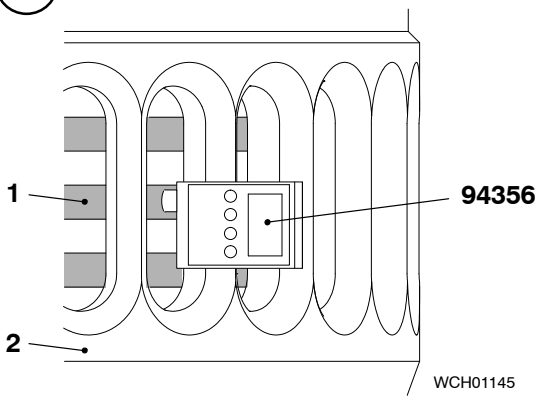
Before each measurement the layer measurement tool 94356 must be calibrated. Use the delivered calibration foils and the bare top flank of a spare top piston ring as base material for proper setting.

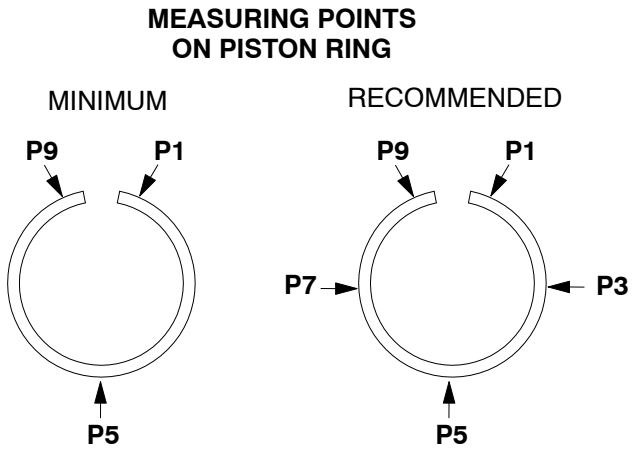
⇒ Clean piston ring running surface at reachable measuring points P1 to P9.

⇒ Press the sensor of the layer measurement tool against the piston ring surface at middle of ring height.

⇒ Measure the layer thickness and note the output value.

A





2.2 Wear rate

The chrome-ceramic coating is a lifetime coating. However, the actual wear depends on operating conditions. When during a piston underside inspection a piston ring with a partially worn chrome-ceramic coating is found, we recommend overhauling the unit at next opportunity (Fig. 'B').

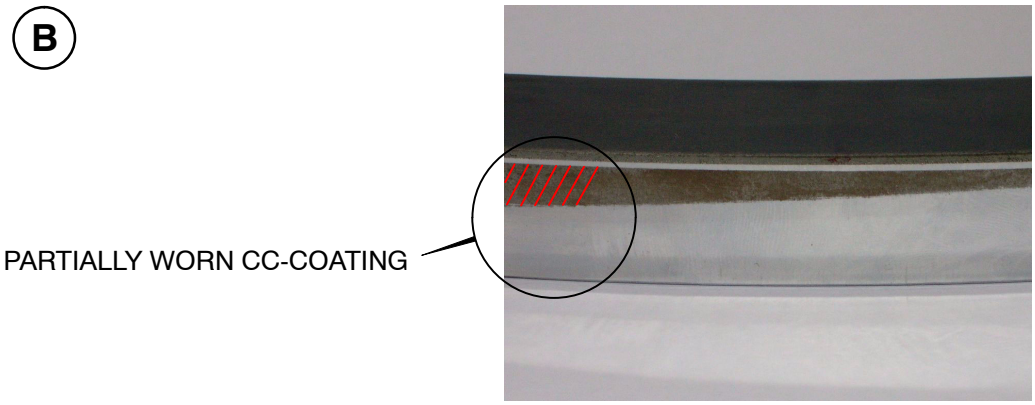
With regular done measuring you can determine the specific wear rate for each piston ring.

The piston rings can still be used, if the remaining chrome-ceramic coating is above the following limits:

- Uppermost piston ring 'a' **> 0.05 mm**
- Lower piston rings 'b' and 'c' **> 0.02 mm**

Below those minimal coating thicknesses, a piston ring replacement must be planned.

B



2.3 Lifetime calculation

Calculate the wear rate and the remaining lifetime of a piston ring.

Use the formula below to calculate the wear rate:

$$WR = \frac{(D1-D2) \times 1000}{T2-T1}$$

WR = Wear rate [mm/1000 h]

T2 = Actual running hours [h]

T1 = Running hours at previous measurement [h]

D2 = Actual coating thickness [mm]

D1 = Coating thickness at previous measurement [mm]

Example for wear rate calculation:

D1	D2	T1	T2	**WR**
0.382	0.367	0 (new)	1500	0.01
0.351	0.340	3500	5000	0.0073

Use the formula below to calculate the remaining piston ring lifetime according to the latest condition setting:

$$LT = \frac{(D2- Dmin) \times 1000}{WR}$$

LT = Remaining lifetime [h]

D2 = Actual coating thickness [mm]

Dmin = Minimal coating thickness [mm] (see chapter 2.2)

WR = Calculated wear rate [mm/1000 h]

Example for remaining lifetime calculation:

D1	D2	Dmin	T1	T2	WR	**LT**
0.382	0.367	0.05	0 (new)	1500	0.01	31700
0.351	0.340	0.05	3500	5000	0.007333	39545

3. Measuring piston ring grooves

CHECK

Check all dimensions and record them (see Clearance Table 0330–1 'Piston and piston rings'). These records are important for later evaluation of the running gear. They should encompass all dimensions, the date of overhaul and operating hours of the various components and of the engine itself.

3.1 Measurement with piston in situ (through scavenge ports)

The measurement of the piston ring clearance has to be carried out at two to four free positions around the complete circumference of the piston head. The number of measurement points depends on the accessibility.

Make sure that feeler gauge 94122 is pushed into the piston ring groove until it touches the inner diameter of the groove, i.e. at point A. If there is a wear step on the chromium layer, the feeler gauge can be pushed only to that point (C3).

Remark: Also consider the deposits in the piston ring groove and/or on the piston ring top face.

⇒ Move piston 3 down (C1) by means of the turning gear.

⇒ Make sure that the total clearance is measured:
First measure the clearance 'x1'at point A.

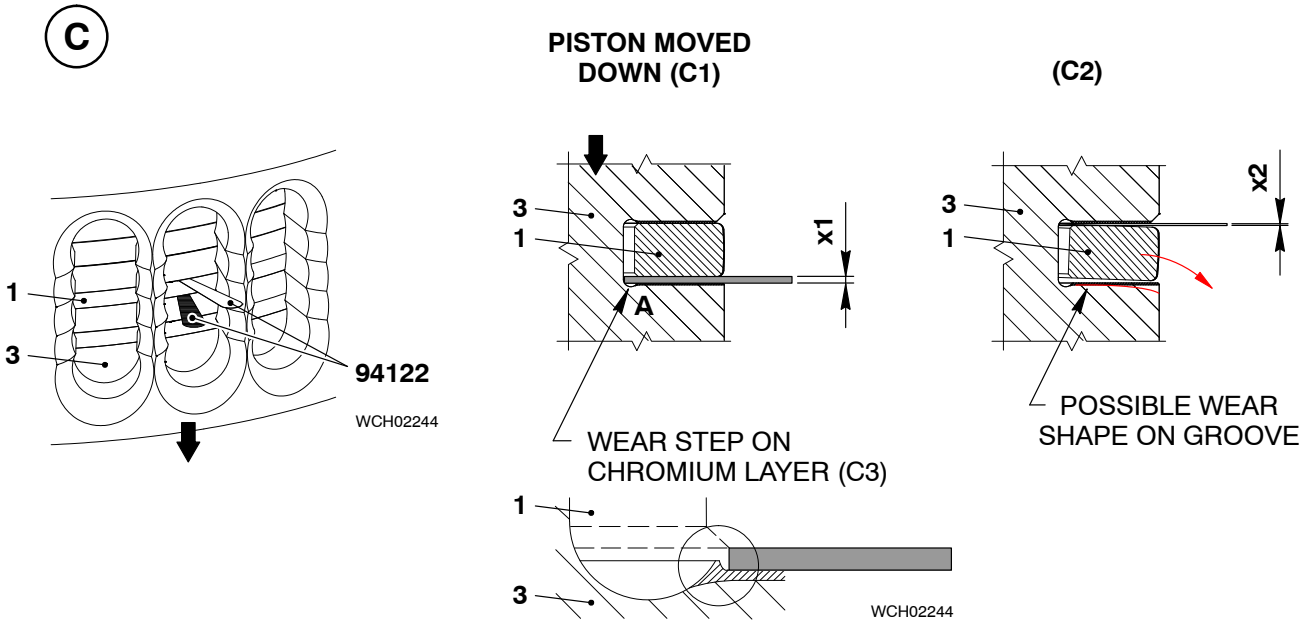
⇒ Afterwards repeat the measurement at the same circumferential position and measure the clearance 'x2'.
The sum of both values will give the total piston ring clearance.

Remark: The reason for this split measuring principle is that the piston rings might be in a tilted position and thus not fully pushed-up and tight to the upper face of the piston ring groove (C2).

The maximum clearance is at point A. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

STOP

If the clearance at point A exceeds the permitted value, the piston rings have to be replaced and the piston head has to be reconditioned.
For reconditioning of piston crowns please contact your nearest Wärtsilä Service Center.



3.2 Measurement with piston removed from cylinder liner

The measurement of the piston ring clearance has to be carried out on at least four positions around the complete circumference of the piston head.

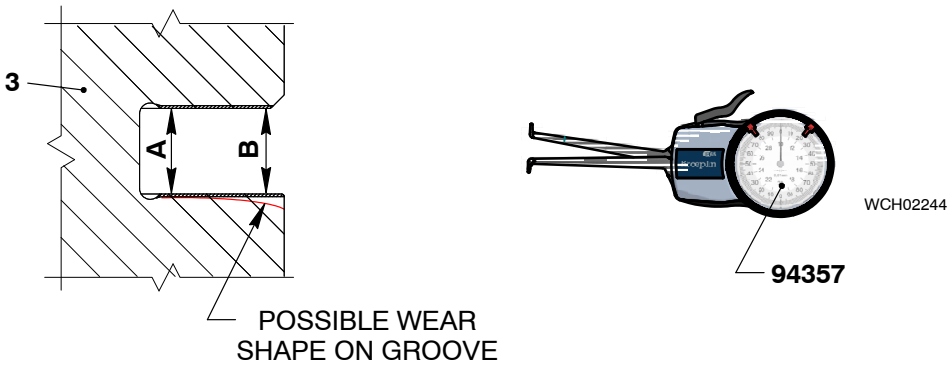
⇒ Remove the piston rings as described in section 4.

⇒ Clean the piston ring grooves.

Measuring method with calliper gauge:

⇒ Measure the groove height with calliper gauge 94357 at point A and B.

D



Measuring method with a piece of a piston ring:

⇒ Measure the thickness of piece of a piston ring (1).

⇒ Place piece of piston ring into the piston ring groove.

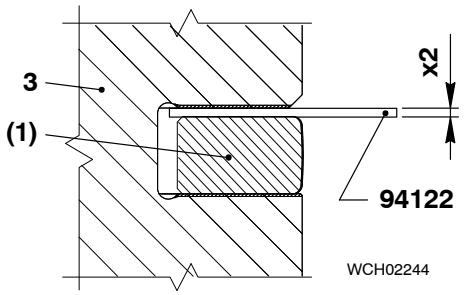
⇒ Measure gap 'x2' between the face of piston ring and groove with feeler gauge 94122.

⇒ Evaluate the piston ring clearance with the following data:

CL = GH – RT (mm)

- CL = CLearance
- GH = Measured piston ring Groove Height (mm)
- RT = Nominal piston Ring Thickness (mm)

E



STOP

If the clearance at point A and/or B exceeds the permitted value, the piston head has to be reconditioned. For the maximum wear data see Clearance Table 0330–1 'Piston and Piston Rings'.

A piston head with clearances close to the maximum value may not be further used as the expected remaining lifetime is too short.

4. Removing piston rings

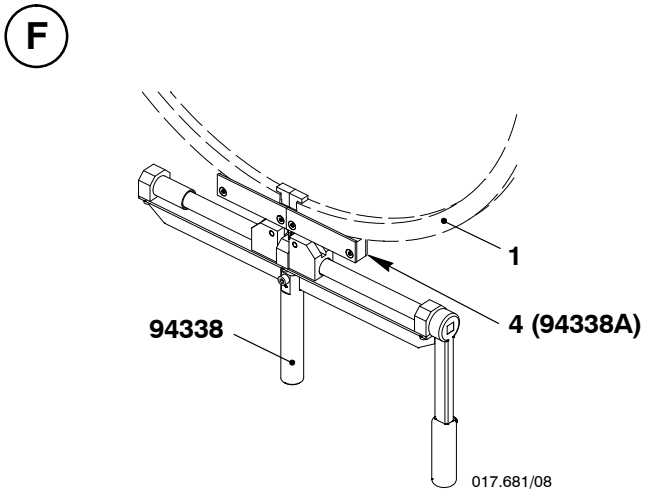
For removing piston rings 1, always use the corresponding tensioning device with its specially designed claws 4 preventing the coating from being chipped off at the ring ends:

Claws 94338A must be fitted onto piston ring tensioning device for the 1st gastight piston ring 'a' (see also Tool List 9403–5).

To prevent deformation it is of the utmost importance not to open the rings more than absolutely necessary, i.e. allowing removal over the piston crown.

⇒ Thoroughly clean piston, piston rings and piston ring grooves.

- Take care not to damage the chromed surfaces.



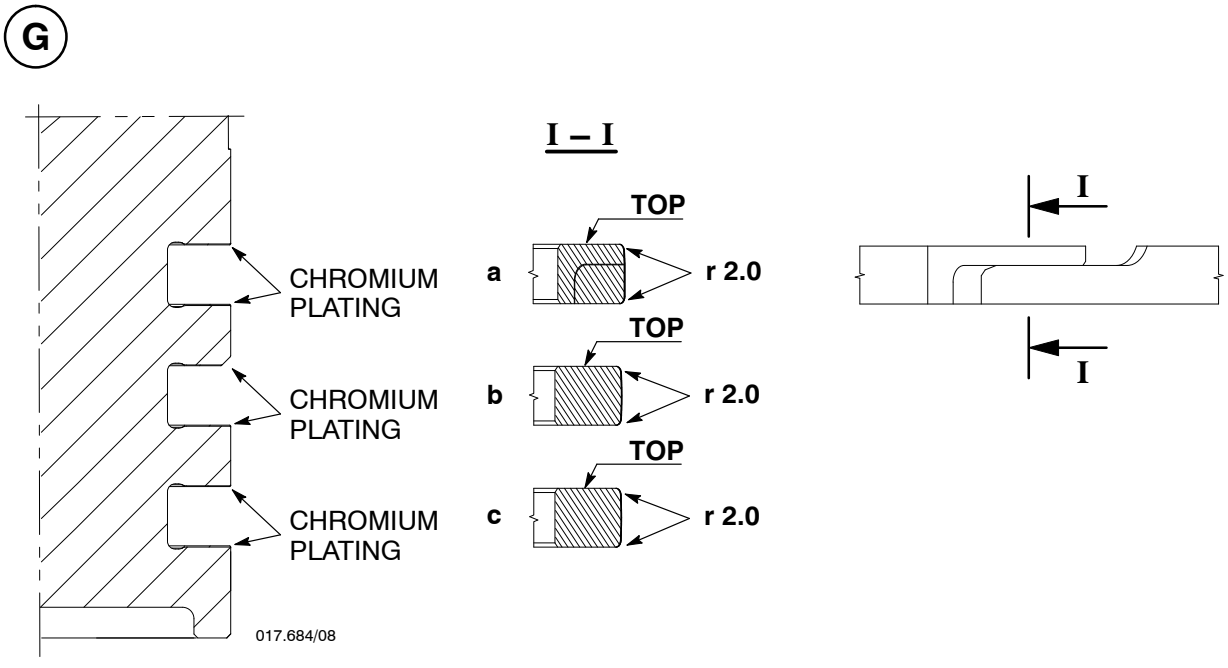
5. Fitting piston rings

- When reusing piston rings, only rings in perfect condition may be fitted, however in the same position and groove as removed.
- **Always fit piston ring with the marking TOP upwards**
  (when the piston is assembled the piston rings must be turned such that the ring gaps are staggered by 180°).
- The chromium plating thickness of a new CC coated piston ring should be measured and recorded to monitor the wear rate over time.

Remark: New piston rings have to be run-in according to the relevant indications in the Operating Manual 0410–1.

Standard piston ring arrangement:

Ring type	Coating / material	Application
Uppermost piston ring 'a' 1 x GTP1CC16_**G**as **T**ight	chrome-ceramic coated	for new and fully honed cylinder liners as well as for used cylinder liners in good conditions
Piston rings 'b' and 'c' 2 x SCP2CC16_**S**traight **C**ut	chrome-ceramic coated	



6. Storage and handling of piston rings

Store the piston rings in a dry place but not in a place contaminated with exhaust gases or any other corrosive atmosphere. Lay the piston rings horizontally on a flat surface, keeping them in their original packing. Handle with care when preparing for use and avoid any hard contact against other objects.

Driving Wheels and Shut-off Valve for Starting Air Group 4

▽ **Driving Wheels**

- Checking the Running and Backlash Clearances and Condition of Teeth .... 4103−1/A1
- Replacing the Gear Wheel on Crankshaft ..... 4103−3/A1

Shut-off Valve for Starting Air: Cleaning and Function Check ..... 4325−1/A1

Driving Wheels

Checking the Running and Backlash Clearances and Condition of Teeth

Tools:		
1	Feeler gauge	94122
1	Micrometer	
1	Dial gauge	
1	Lead wire Ø 1.5 mm	

Key to Illustrations:	
0–6	Tooth profile
a, b, c	Lead wires
TF	Driving flanks

1. General

Gear wheels of new engines have to be checked visually during the running-in period after about 1 –2 operating hours. The same applies to old engines which have been equipped with new gear wheels.

2. Check

⇒ Rotate crankshaft with the turning gear until all the teeth have been inspected.

⇒ Check with running lubricating oil pump, whether all the spray nozzles are delivering oil freely.

⇒ Check whether all the screws are correctly locked, and whether any irregularities can be detected.

⇒ After the running-in period check the gear wheels periodically every three months in the manner described above. Should in this time faults appear, then these can in certain cases be remedied by an experienced engineer.

- Should noises be heard in the region of the gear train, search for its cause. Replace defective gear wheels as soon as ever possible, to prevent damage to the mating gear wheels.
- When the gear wheels have run well for an initial running period of 6000–8000 hours the above-mentioned inspection may be carried out annually.
- For the checking of clearances and tooth impressions the tie rods and the elastic studs of the main bearings must be tightened.

3. Checking the gear tooth backlash

Information concerning the gear tooth backlash values can be found in the table of clearances (see 0330–1). The backlash can be determined in several ways. Depending on the possibilities, the following methods of measurement can be used:

3.1 With feeler gauge 94122

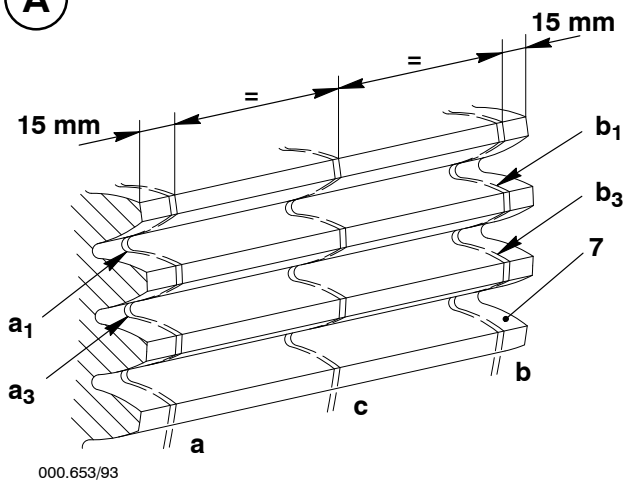
Measure the gap between the teeth flanks by using different thicknesses of feelers. Repeat the measurement at a minimum of four points on the circumference of the gear wheel.

3.2 With dial gauge

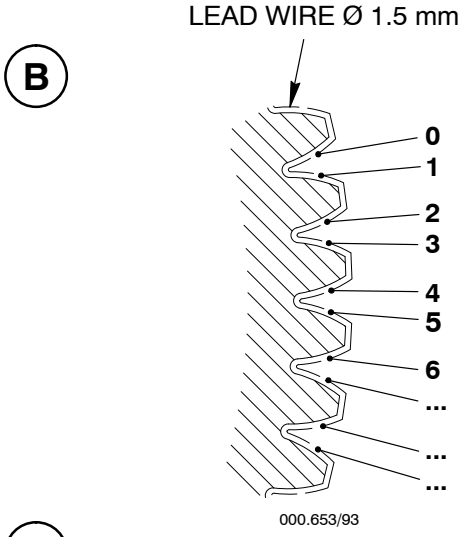
Mount the dial gauge in such a way that the turning movement can be read off in mm. The gear wheel is turned in such a way that the tooth profile of one tooth moves from one side to the other. When using this method of measuring care must be taken since the drive wheel must not be allowed to turn.

Checking the Running and Backlash Clearances and Condition of Teeth

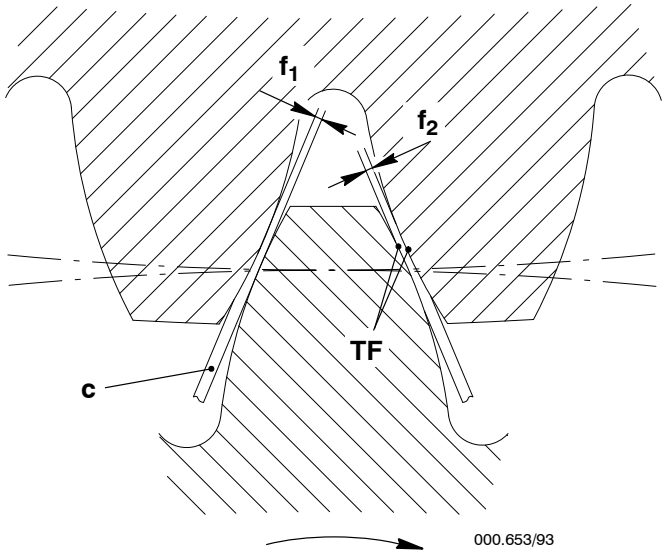
A



B



C



3.3 Measuring tooth backlash with lead wire

- Use a fresh piece of lead wire Pb 99.9 fine of **1.5 mm diameter** for each measurement.
- Always use lead wires of the same diameter and quality.

⇒ Place lead wire pieces a, b, c of about 200 mm length around the tooth profile and attach them with scotch tape (see Fig. 'A' and 'B').

⇒ Number the tooth profiles in accordance with Fig. 'B'.

⇒ Turn the lead wires only **once** through the teeth meshing.

- Lead wire 'c' (Fig. 'A') serves to verify total tooth backlash 'f' (Fig. 'C').
  With lead wires 'a' and 'b' (Fig. 'A') the tooth profile parallelity is checked.
- Total tooth backlash 'f' (Fig. 'C') composes of f_1 and f_2 (thickness of lead wire):
  $f = f_1 + f_2$.
- Obliquity 'Δf' is calculated from the difference in thickness of the squashed lead wires along **driving flanks TF** (Fig. 'A'):
  $\Delta f = a_1 - b_1$ or $a_3 - b_3$ etc.
- The admissible deviation of tooth profile parallelity amounts to max. $0.2^{o}/_{oo}$ across the width of the tooth.

4. Checking the running performance

To enable judging the running performance of the gear train after re-commissioning, three teeth each of the gear wheels are smeared with a thin coat of oil resisting marking blue (ink) equally spread. This check is necessary in order to verify the mating appearance of the teeth.
One brand of oil resisting marking blue is, for example, Dykem Layout Red Dx-296.

Driving Wheels

Replacing the Gear Wheel on the Crankshaft

Tools:

1	Ring slugging wrench	94002–46
1	Feeler gauge	94122

Key to Illustrations:

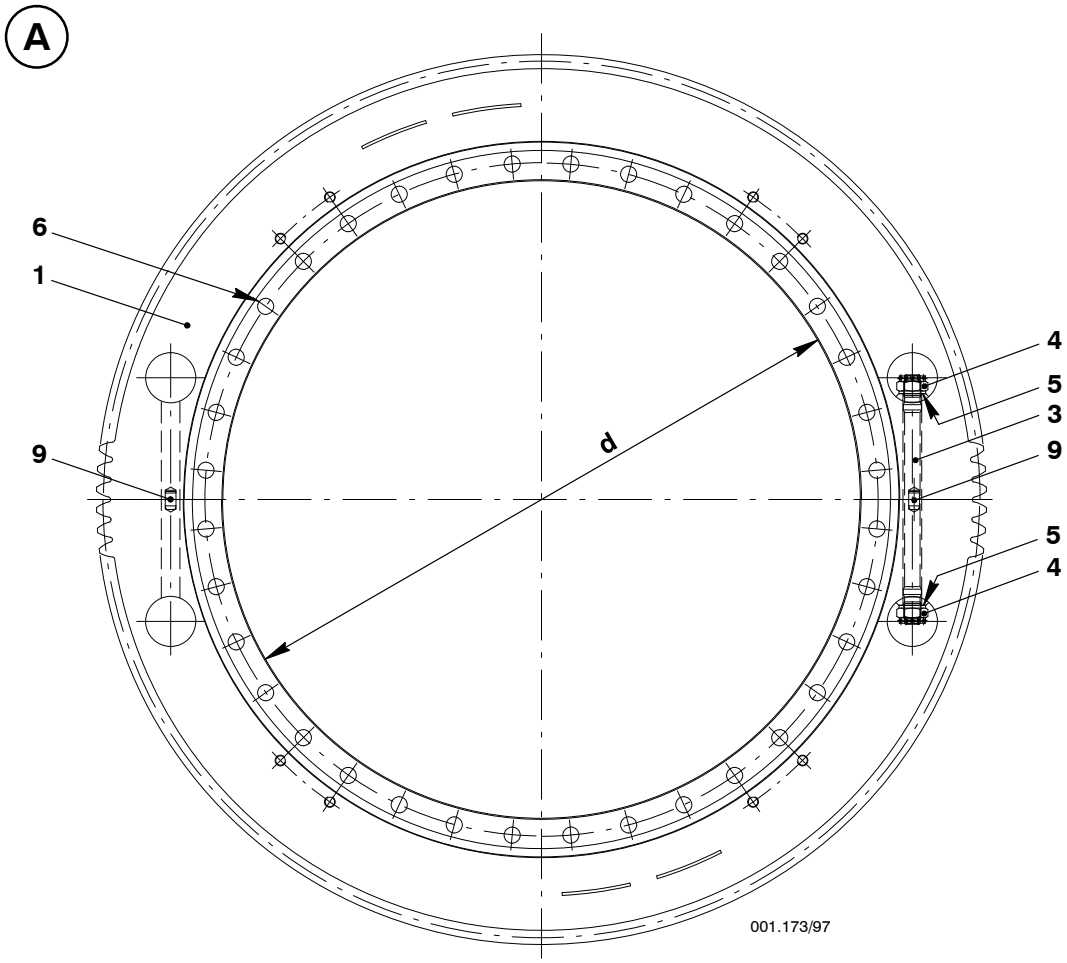
1	Gear wheel	6	Flange screw
2	Crankshaft flange	7	Distance sleeve
3	Elastic studs	8	Self-locking nut
4	Castle nut	9	Dowel pin
5	Base		

Overview

1. General 2/5

2. Preparing assembly of 2-part gear wheel 2/5

3. Assembly of 2-part gear wheel 3/5



Replacing the Gear Wheel on the Crankshaft

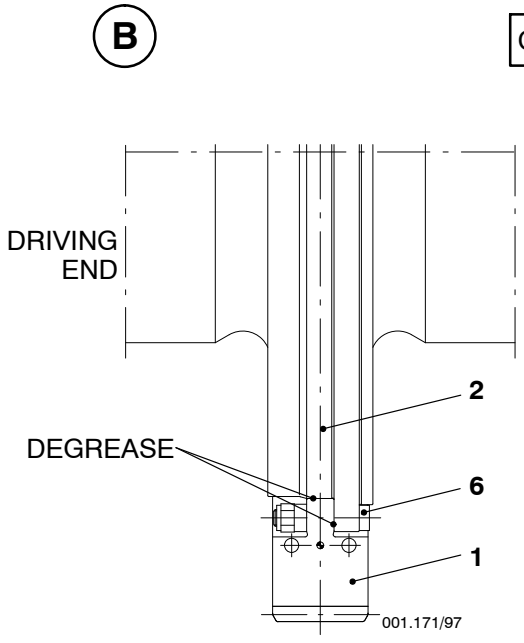
1. General

Usually, the gear wheel on the crankshaft (from now on referred to as gear wheel) is executed in one part and fitted as such on the crankshaft. If a damaged gear wheel in the engine is to be replaced, it must be separated into two halves for dismantling. **In order to avoid damages, especially to the crankshaft,** please obtain the necessary instructions and recommendations for executing such dismantling work from the engine supplier or from Wärtsilä Switzerland Ltd.

The spare gear wheel is executed in two parts and must be fitted as described below.

Remark: When ordering a 2-part spare wheel, please indicate the engine type, the engine No., as well as the engine supplier. This data is necessary because the centring diameter of the crankshaft is registered for mounting the gear wheel, and the center hole of the 2-part spare wheel is manufactured according to these dimensions.

2. Preparing the assembly of gear wheel



CHECK

The undersize of center hole ‘d’ (Fig. A) on 2-part gear wheel 1 with regard to the corresponding centring diameter of the crankshaft has to be checked **and** recorded beforehand. For measuring, the crankshaft, the gear wheel, and the measuring instrument must have the **same** temperature.
The undersize of the center hole with respect to the centring diameter must be 0.05 ... 0.13 mm.

- If the undersize is not within the mentioned tolerance, the gear wheel must not be assembled, but the center hole of the gear wheel has to be given an appropriate after-treatment (remachine / possibly bore and flame-spray, and machine to obtain the correct diameter).
- Check whether there is a mark on the crankshaft flange 2 for fitting the gear wheel. For the assembly, the gear wheel partition must coincide with this mark.
  The designation DRIVING END, which is located on the front of the gear wheel, must be on the side of the flywheel!

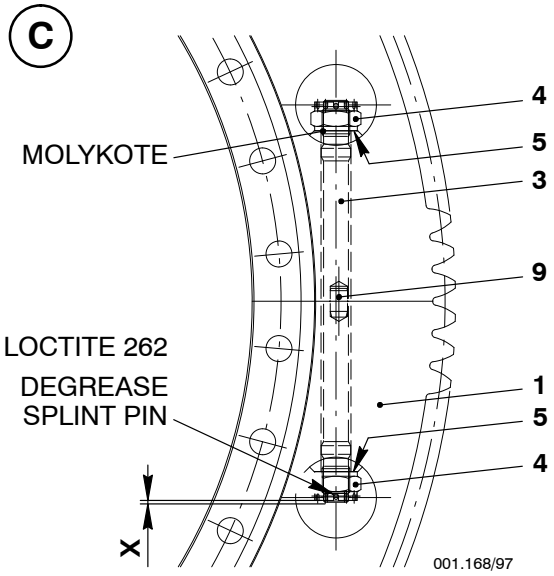
Replacing the Gear Wheel on the Crankshaft

- Before assembling, the centring diameter of the crankshaft flange as well as the centre hole of the gear wheel with the corresponding flange faces must be well cleaned **and degreased** (Fig. B). Do not use neither oil nor MOLYKOTE. All surfaces must be in faultless condition.

Remark: The assembly of the gear wheel must be carried out carefully, since relatively small faults could have a negative influence on the operating performance of all gear wheels of the drive.

3. Assembly of 2-part gear wheel

The connection consists of four elastic studss 3, each of them comprising two castle nuts 4 and bases 5.



⇒ Before assembling the gear wheel halves, fit two elastic studs crosswise into each half.

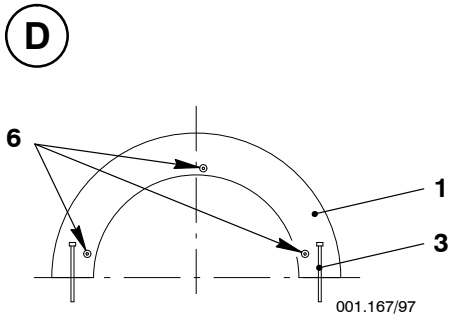
⇒ Fasten a base 5 and a castle nut 4 on **either side** of each elastic stud.
The projection 'X' of the elastic stud with respect to the castle nut must be 7 mm.

⇒ Before fitting the castle nut, degrease the thread and apply LOCTITE 262 to it.

⇒ In addition, secure the castle nut with a split pin to prevent it from slipping when tightening the elastic studs afterwards.

- Wait one or two days before tightening the elastic studs in order to ensure thorough curing of the LOCTITE.

Remark: The castle nut secured with LOCTITE and a split pin must be fitted in such a way that the elastic stud can be tensioned together with the castle nut opposite, as shown in Fig. I.



3.1 Work sequence

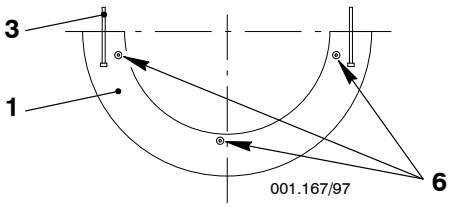
⇒ Turn the crankshaft so that the mark on the crankshaft flange is approximately horizontal with regard to the crankshaft centre line.

⇒ Put one gear wheel half with two pre-assembled elastic studs 3 on the centring diameter of the crankshaft flange in such a way that the joint face of the gear wheel coincides with the mark on the crankshaft flange. The designation DRIVING END located on the front of the gear wheel must be on the side of the flywheel.

⇒ Insert flange screws 6 each in the centre and at both ends of the gear wheel half 1 and tighten them temporarily.

Replacing the Gear Wheel on the Crankshaft

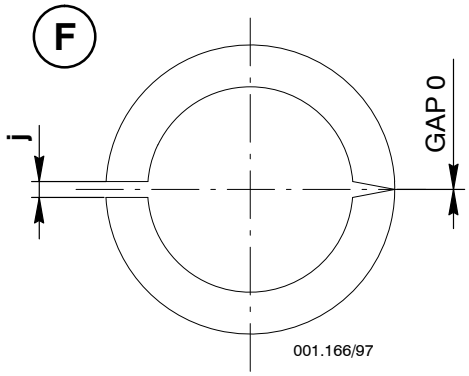
E



⇒ Turn the gear wheel half to the bottom (Fig. E) and place the second gear wheel half, which is also provided with two pre-assembled elastic studs 3, on the top (Fig. G).

- Check the correct diameter tolerance by measuring the size of the gap between both gear wheel halves. For that the gap must be closed on the opposite side (Fig. F).

F

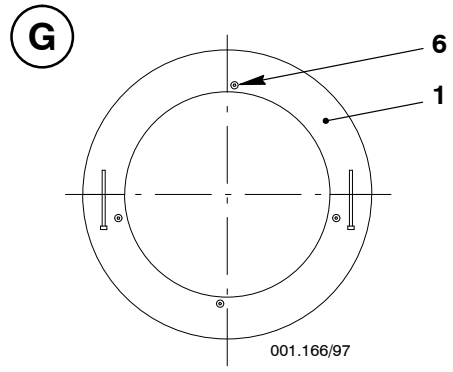


CHECK Gap 'j' must be 0.16 mm ... 0.41 mm. If the dimension is not within the mentioned tolerance, the gear wheel must not be assembled, but the center hole has to be given an appropriate re-machining (see Preparing the assembly of the gear wheel).

⇒ After measuring, align the gaps between the wheel halves and slightly tighten castle nuts 4 of elastic studs 3 (Fig. C).

⇒ Also insert a flange screw 6 in the centre of upper gear wheel half and tighten it temporarily (Fig. G).

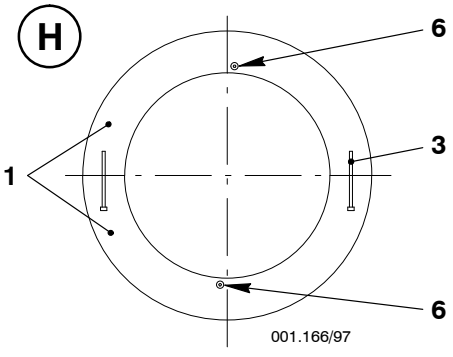
G



⇒ Remove flange screws 6 from each end of the lower gear wheel half so that there are now only two flange screws 6, each of them tightened temporarily in the centres of the upper and the lower gear wheel half (Fig. H).

CHECK There must be no clearance on the seating surfaces between the gear wheel and the crankshaft flange – **check!**

H



⇒ For fitting the four remaining castle nuts 4 belonging to elastic studs 3 (Fig. C), apply MOLYKOTE paste to the threads and the seating surfaces. Tighten only the castle nuts treated with MOLYKOTE paste. Use fork wrench 94412E (Fig. I) for holding up the castle nuts opposite which have already been fitted and secured with LOCTITE and a split pin.

⇒ Tighten the four castle nuts of elastic studs 3 crosswise by means of ring slugging wrench 94002–46, measuring and recording the length of the elastic studs **beforehand**.

Replacing the Gear Wheel on the Crankshaft

CHECK

The elastic studs are correctly pretensioned if an extension of △**L 1.10± 0.05 mm** is measured.
Check: There must be **no gap** in the gear wheel partition.

⇒ If the split pin for securing the castle nut cannot be fitted, turn the castle nut only so far as to allow the split pin to be fitted.

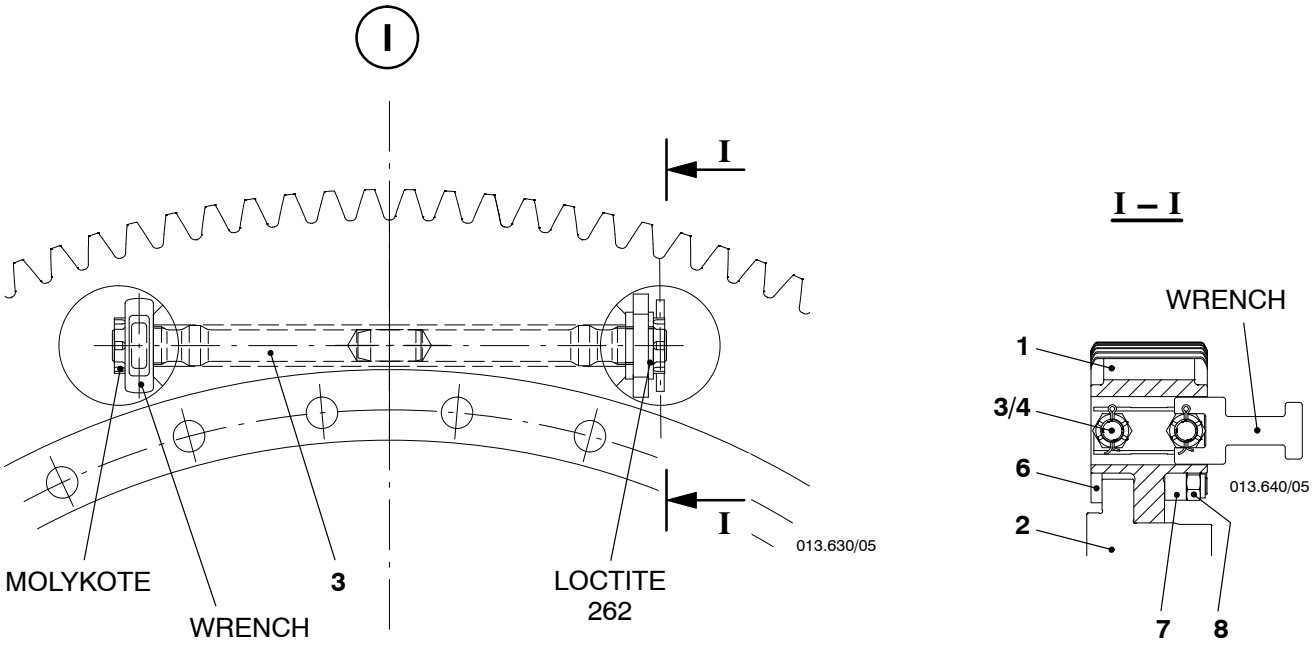
⇒ After the check mentioned above has been carried out, dismantle both flange screws 6 which have been temporarily fitted beforehand (Fig. H).

STOP

Degrease the threads of all flange screws 6 and their self-locking nuts 8 and then apply LOCTITE 262 to them; **do not use MOLYKOTE!**

⇒ Fit all flange screws 6 with distance sleeves 7 and self-locking nuts 8 (Fig. I). Afterwards, tighten them crosswise and evenly distributed over the circumference with an angle of twist of **85**° (1600 Nm).

Remark: After fitting 2-part gear wheel, the running and backlash clearances and performance of the teeth must be checked (see 4103–1).



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Shut-off Valve for Starting Air

Cleaning and Function Check

Key to Illustrations:

1	Valve seat	16	Handwheel
2	Cover	17	Locking lever
3	Spring	18	Common start valve
4	Valve	19	Stopper
5	Spindle		
6	Spindle guide		
7	Valve seat	BB	Balance bore
8	Valve guide	CA*	Control air
9	Spring	IP*	To instrument panel and pressure transmitter PT 4301C
10	Valve body		
11	Control valve	TV*	To (drain and) test valve 2.06
12	Piston seal ring	VV*	To venting valve 2.21
13	Piston		
14	Valve	*	See Control Diagram 4003–2 in the Operating Manual
15	Screw plug		

1. General

The shut-off valve must be dismantled, cleaned and inspected according to Maintenance Schedule 0380–1.

Remark: To avoid accumulation of water in the main starting air piping open for a short time water drain pipe on the main starting air piping after each starting operation.

Risk of accident! Before starting work on the shut-off valve for starting air it is essential to manually close the stop valves on the starting air receivers.
The turning gear must be engaged.
Venting valve 2.21 to connection 'VV' as well as venting valve 2.27 must be opened for venting and draining the main starting air piping on the engine (see Control Diagram 4003–2 in the Operating Manual).

2. Dismantling and assembly

2.1 Dismantling

⇒ If valve seat 1 is to be grind in, first loosen the screws to cover 2.

⇒ Withdraw spring 3 together with valve 4 and spindle 5 as an unit.

⇒ Unscrew spindle guide 6 and remove the valve from the spindle.

⇒ If valve seat 7 of the non-return valve is to be grind in, then the shut-off valve must be completely dismantled.

⇒ After dismantling valve guide 8, stopper 19 and spring 9 remove valve body 10 of the non-return valve.

- When the above mentioned items are being checked, control valve 11 has also to be dismantled and cleaned.

Shut-off Valve for Starting Air: Cleaning and Function Check

2.2 Assembly

⇒ Before reassembling all items replace corroded springs by new ones.

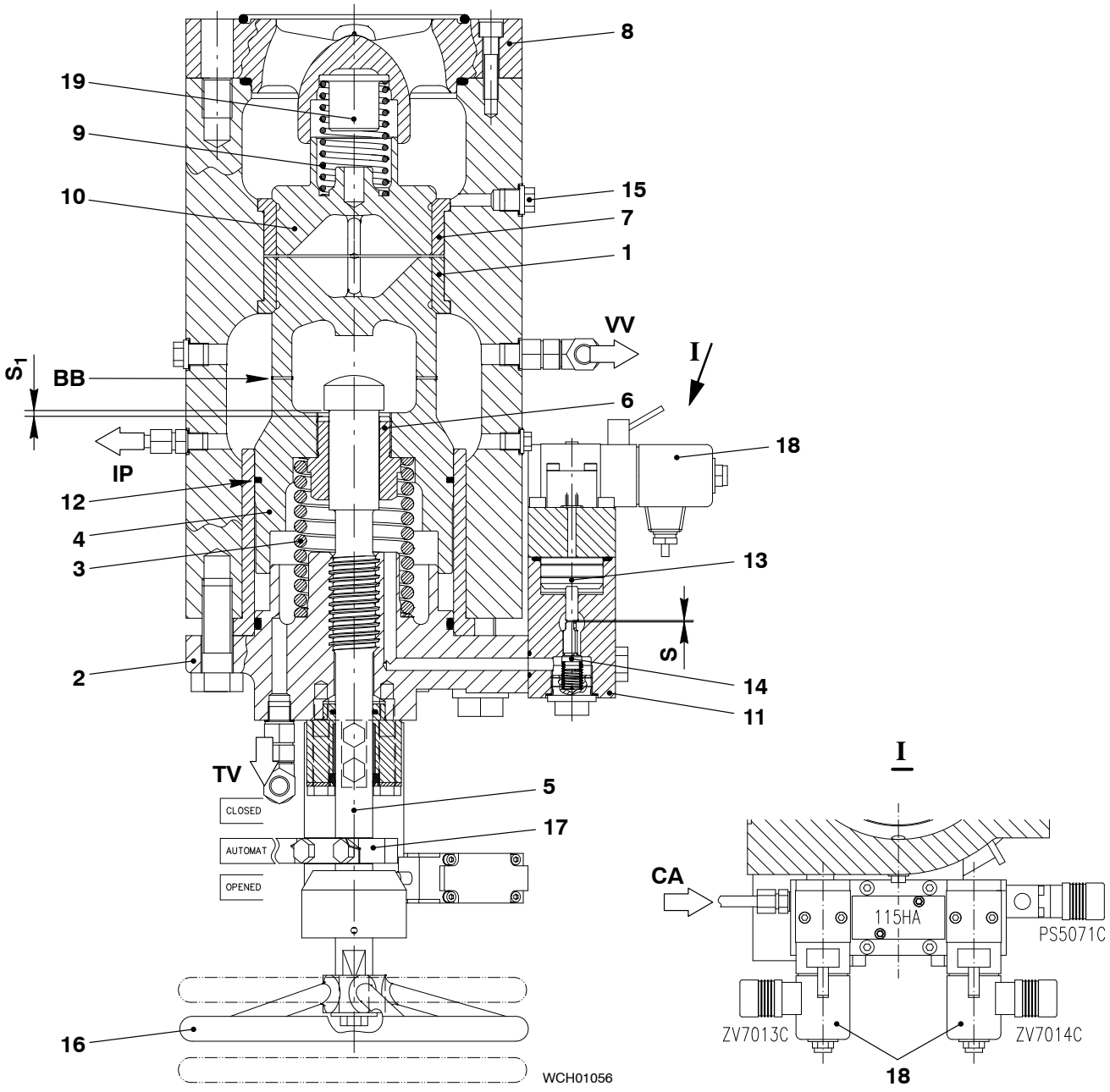
⇒ Replace damaged or much worn piston seal ring 12.

⇒ Check balance bores 'BB' for free passage.

⇒ Before reassembling spindle 5, the threads in valve 4 and spindle guide 6 are to be thoroughly degreased and then smeared with LOCTITE. Insert the spindle and fully tighten the spindle guide.

⇒ For the assembly smear all the parts lightly with MOLYKOTE paste.

CHECK Check to ascertain that clearance 'S' between piston 13 and valve 14 of control valve 11 amounts to approx. 1 mm.



Shut-off Valve for Starting Air: Cleaning and Function Check

3. Function check

After completing the assembly carry out a function check, for which the following precautions have to be taken:

3.1 Initial position

- The stop valves of the starting air receivers must still be closed.
- Screw plug 15 of the shut-off valve has to be removed.
- Shut-off valve for starting air is in position CLOSED (closed by hand).
- Venting valve 2.21 to connection 'VV' must be closed.
- **The engine has to be completely assembled, ready to start and the turning gear must be in the disengaged position.**
- The area of flywheel, propeller shaft and propeller must be free of persons or objects.
- During the functional check the reversing must remain in position STOP and **START may not be actuated** under any circumstances.

3.2 Tightness

⇒ Close venting valve 2.27.

⇒ Open the stop valve of a starting air receiver **slowly.**

CHECK

Check whether the automatic shut-off valve is airtight, i.e. verify that no air escapes from the bore of screw plug 15.

3.3 Manual opening

⇒ Open the shut-off valve **slowly** with the help of handwheel 16 until locking lever 17 is in the position OPENED (by hand). The discharging air at the bore for screw plug 15 indicates that valve 4 of the shut-off valve and valve body 10 of the non-return valve are open.



Risk of accident! Great care must be taken for this operation. To prevent accidents from compressed air suddenly escaping out of the bore for screw plug 15 a sufficient distance has to be kept.

3.4 Automatic closing

⇒ Turn handwheel 16 to position CLOSED until locking lever 17 engages in position AUTOMATIC.

- In this position the shut-off valve should, through the spring resistance, be automatically closed. No more air should come out at the bore for screw plug 15.
- In this position, the valve closes positively only if there is a clearance 'S_1' between spindle 5 and spindle guide 6 (in new condition min. 2 mm – max. 5 mm).

CHECK

By turning the spindle carefully to position OPENED, the contact with spindle guide 6 can be felt. The clearance 'S_1' can thus be determined externally and it shall be min. 2 mm corresponding to $^1/_3$ turn of the spindle.

- Should virtually no clearance exist after frequent reconditioning of valve seat and valve, these parts have to be replaced during the next overhaul.

3.5 Automatic opening

- Locking lever 17 is in position AUTOMATIC.
- By opening test valve 2.06, which is fitted in piping 'TV', the same effect is obtained as when actuating control valve 11.
- Upon opening test valve 2.06 the shut-off valve opens automatically. The air now escaping at the bore for screw plug 15 indicates that valve 4 of the shut-off valve and valve body 10 of the non-return valve have opened.



Risk of accident! Great care must be taken for this operation. To prevent accidents from compressed air suddenly escaping out of the bore for screw plug 15 a sufficient distance has to be kept from the shut-off valve.

- After shutting test valve 2.06 no air must escape from bore for screw plug 15.

⇒ After completing these checks fit and tighten screw plug 15, and close the shut-off valve with the handwheel 16 to position CLOSED (by hand).

Supply Unit, Injection and Exhaust Valve Control Group 5

▽ **Supply Unit**

- Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive 5552–1/A1
- Removal and Fitting of Camshaft and Bearing Shells 5552–2/A1
- Removal and Fitting 5552–3/A1
- Lubrication of Supply Unit During Maintenance 5552–4/A1

Fuel Pump: Dismantling and Assembling 5556–1/A1

Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling 5562–1/A1

Injection Control Unit: Removal and Fitting 5564–1/A1

Exhaust Valve Control Unit:
Removal, Fitting, Dismantling and Assembling 5612–1/A1

▽ **Regulating Linkage**

- Adjusting 5801–1/A1

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Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

Key to Illustrations:

1	Casing	12	Thread piece
2	Servo oil pump	13	Spray nozzle
3	Screw	14	Spring dowel pin
4	Screw	15	Housing
5	Pump support	16	Bearing bush
6	Carrier	17	Screw
7	Snap ring	18	Cover
8	Pinion		
9	Shaft	SB	Shearable overload protection
10	Gear wheel		(predetermined breaking point)
11	Plug	SC	Screw M10

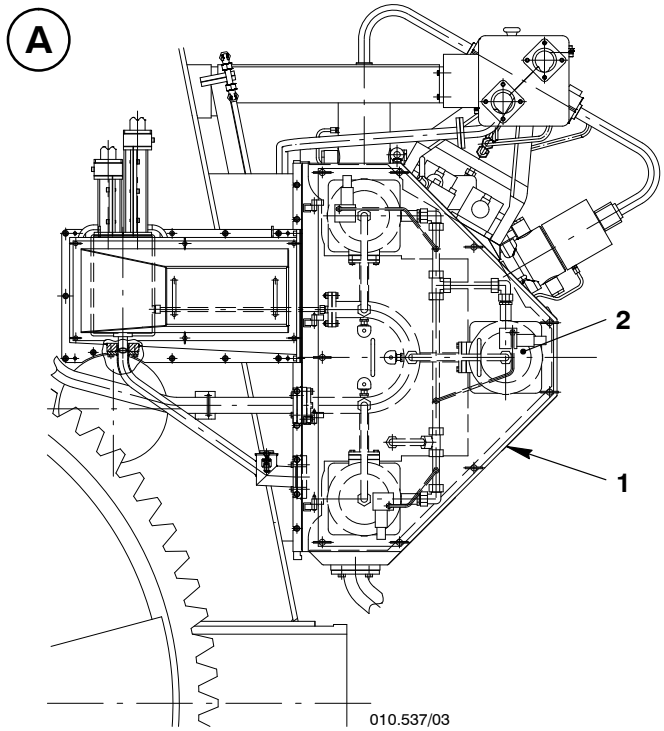
Overview

1. **General** 1/3
2. **Removal of servo oil pump** 1/3
3. **Spray nozzles** 3/3
4. **Fitting** 3/3

1. General

Concerning the maintenance of the servo oil pump observe the instructions from the manufacturer. The servo oil pump drive must be checked with the Maintenance Schedule 0380–1 'Supply Unit'.
In order to prevent damages in case of the blocking of a servo oil pump, carriers 6 are provided with shearable overload protection 'SB' (Fig. 'C').

2. Removal of servo oil pump



⇒ Stop the engine.

⇒ Remove the plug with the control cables from the servo oil pump.

⇒ Shut the shut–off valves before and after the automatic fine filter (see Operating Manual 5551–1).

⇒ Screw off all oil pipes from servo oil pump 2 and remove them if necessary.

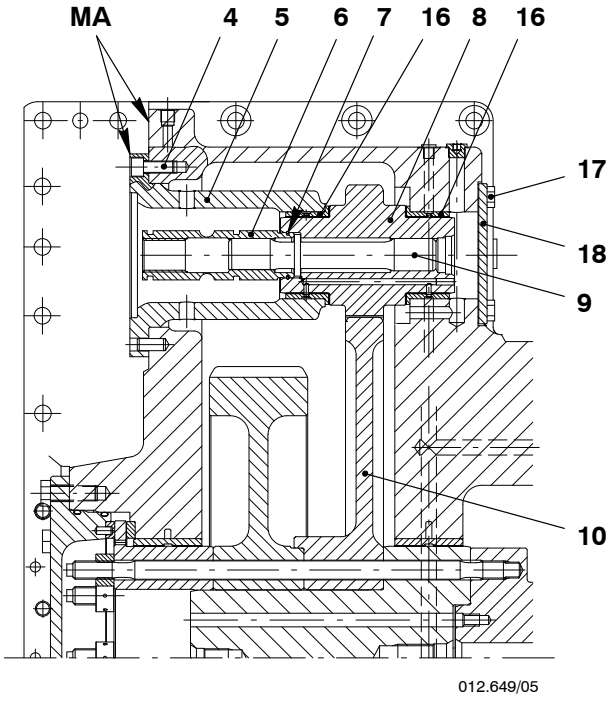
⇒ Loosen the pipe and flange connections to casing 1 of the housing.

⇒ Suspend the casing to eye bolts, unscrew and remove it.

⇒ Attach the servo oil pump (150 kg) to a lifting tackle, unscrew screws 3, and remove the servo oil pump in horizontal direction (Fig. 'D').

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

B



2.1 Removal of pinion

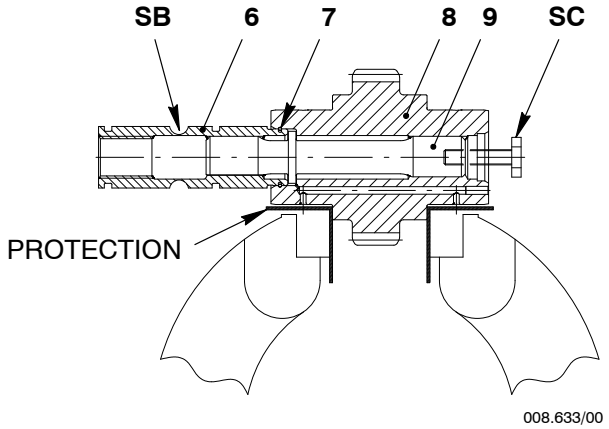
⇒ Remove screws 4 and screw in thread pieces M16 instead.

⇒ Screw two screws 4 into the flange of pump support 5 until the latter allows to be withdrawn from the housing.

Remark: To ensure that pinion 8 remains in place during withdrawing of pump support 5, a counterforce must be provided with carrier 6.

⇒ Remove carrier together with pinion.

C



2.2 Removal of shaft

⇒ Clamp pinion 8 and carrier 6 into a vice.

⇒ Turn a screw 'SC' into shaft 9, and treat the screw with hammer blows until carrier with snap ring 7 comes off the pinion.

⇒ Remove screw 'SC'.

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

3. Spray nozzles

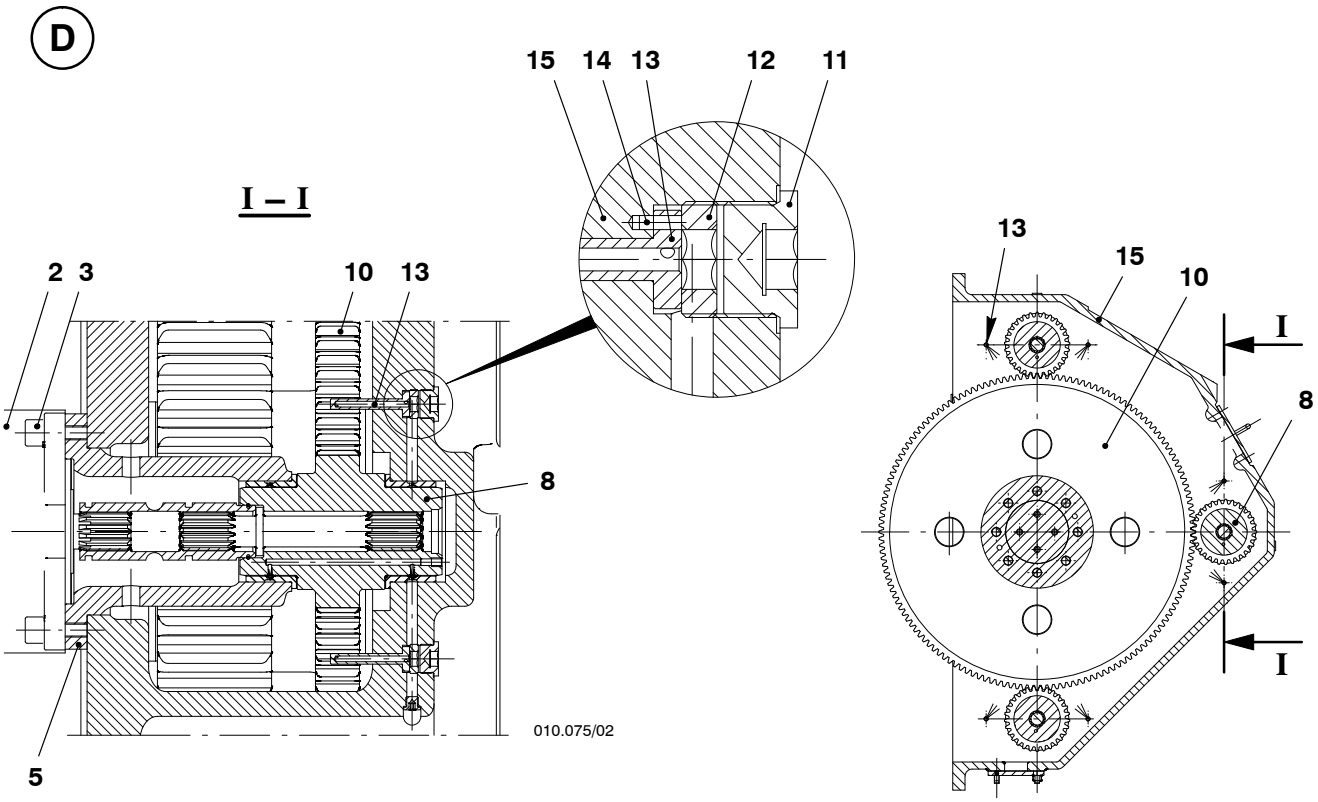
Two spray nozzles 13 are provided for each pinion; they are arranged in such a manner that oil is sprayed between pinion 8 and gear wheel 10.
All spray nozzles are identical. The fitting position is determined by spring dowel pin 14 of the spray nozzle and by the pinhole in housing 15.
The spray nozzles can be removed each time the engine and the lubricating pump are stopped.

3.1 Removal of spray nozzles

⇒ Remove plug 11.

⇒ Unscrew thread piece 12 (AF 17) and remove spray nozzle 13.

CHECK Check spray nozzle for free passage.



4. Fitting

Fitting is carried out analogously to the removal but in reverse sequence.

During fitting the clearances are to be determined with the Clearance Table 0330–1 'Supply Unit'.

Remark: Bores for bearing bushes 16 in housing 15 and pump support 5 are machined together and marked accordingly. Therefore, never interchange the pump supports and take special care of marks 'MA' (Fig. 'B') on assembly!

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Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

Tools:

1	Guide bar	94575
2	Screws M16	94576
2	Pre-tensioning jacks	94577
1	Supporting plate	94578a
1	Supporting angle	94578b
1	Supporting device	94579a
1	Centring ring	94579b
1	Threaded rod	94579c
1	Pressure gauge	94932a
1	Hydr. distributor	94934a
1	HP hose	94935
2	HP hoses	94935a
1	Hydraulic unit	94942
1	Hydraulic jack	94950

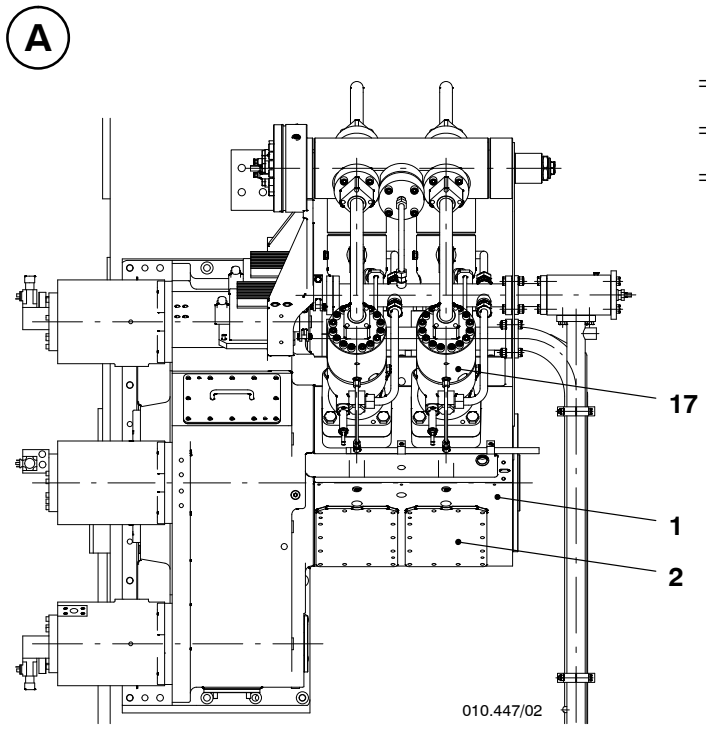
Key to Illustrations:

1	Supply unit	15	Camshaft
2	Cover	16	Bearing shell
3	Thrust bearing cover	17	Fuel pump
4	Screw	18	O-ring
5	Pin	19	Screw
6	Thrust bearing ring	20	Centring piece
7	Nut	21	Nut
8	Waisted bolt	22	Retaining plate
9	Cover		
10	Piston		
11	Vent screw	H_1, H_2	Lifting tackle
12	Pin	RC	Eye bolt M16
13	Gear wheel shaft	RS	Round bar
14	Parallel pin	SA	Gap

Overview

1. **Preparation** 1/12
2. **Removal of camshaft** 2/12
3. **Fitting of camshaft** 6/12
4. **Final assembly** 7/12
5. **Removal and fitting of bearing shells** 8/12

1. Preparation



⇒ Cut out the main lubricating pump.

⇒ Unscrew and remove the casings.

⇒ Remove fuel pumps 17 (see 5556–1).

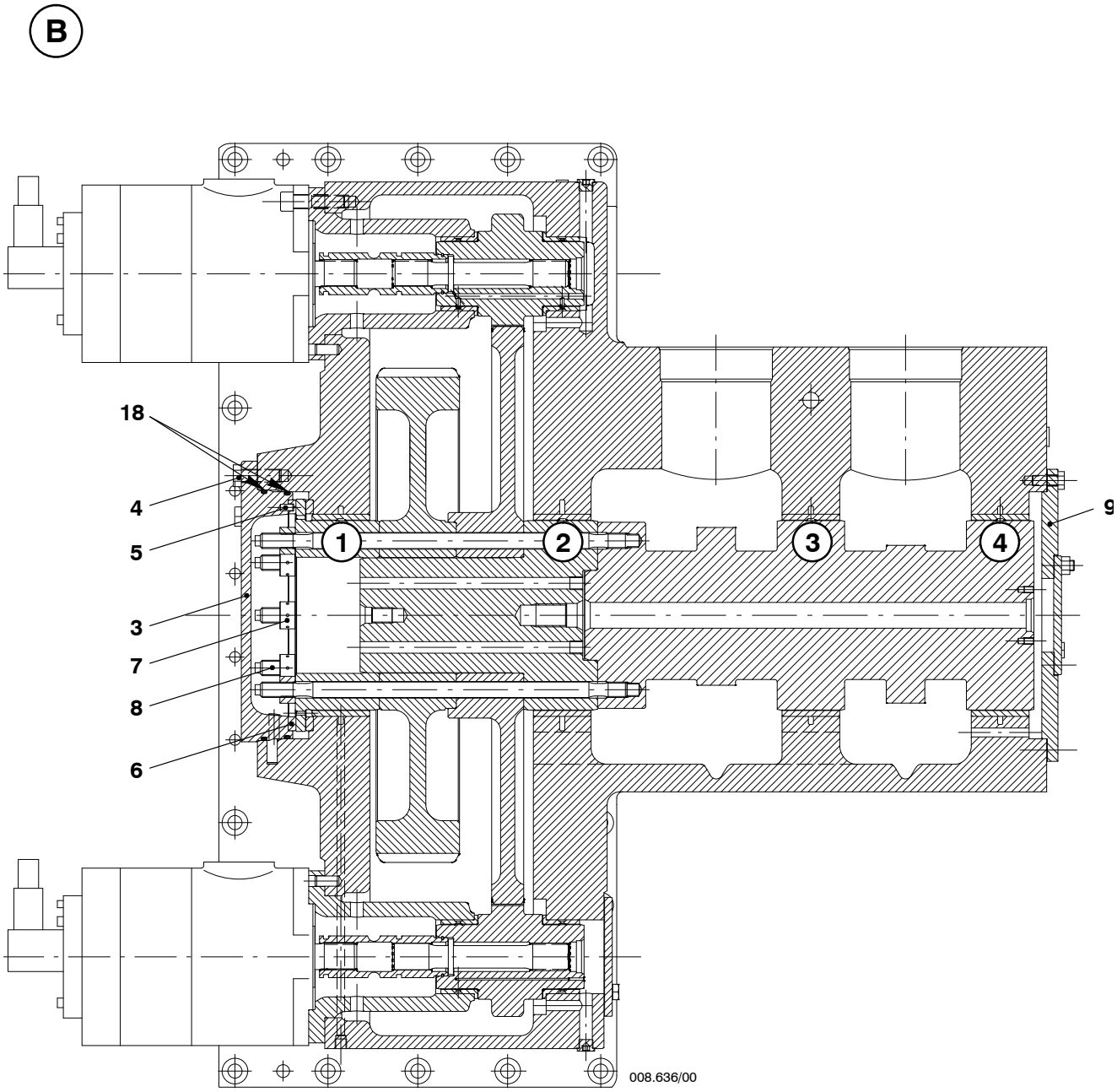
2. Removal of camshaft

⇒ Remove screws 4 for thrust bearing cover 3.

⇒ Separate the thrust bearing cover from the housing by screwing three screws 4 in the corresponding tapholes.

⇒ Remove thrust bearing cover and thrust bearing ring 6.

⇒ Screw off cover 9.



2.1 Loosening of waisted bolts

Remark: To slacken waisted bolts 8 pre-tensioning jacks 94577 must **always** be screwed on crosswise.

⇒ With vent screw 11 open, screw pre-tensioning jacks 94577 on waisted bolts 8 until there is little or no clearance at 'x'. Then unscrew the pre-tensioning jack by one turn (gap 'SA' in view I).

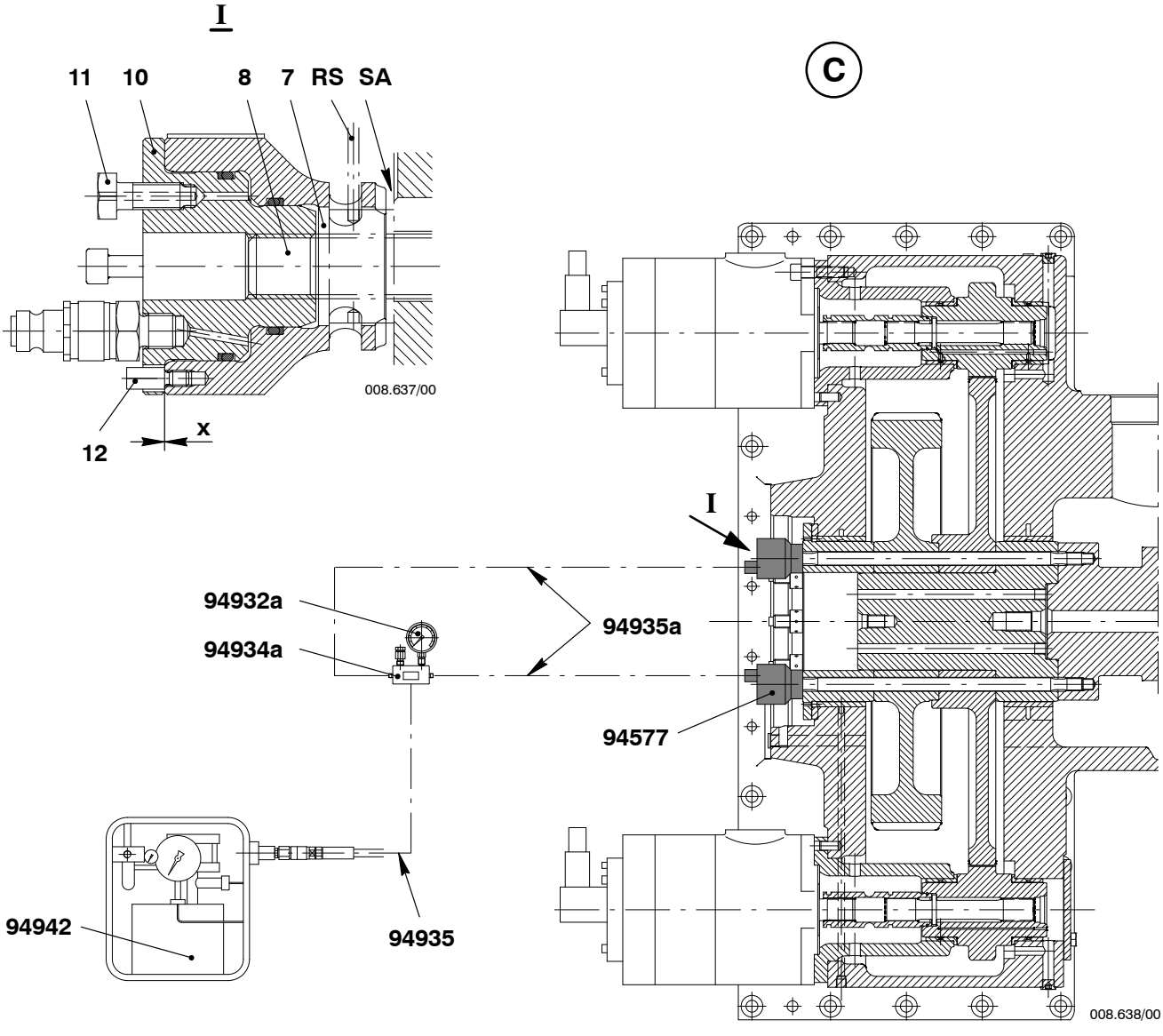
⇒ Connect the pre-tensioning jacks to hydraulic unit 94942 as shown in Fig. 'C'.

⇒ Start the hydraulic unit, and close the vent screws as soon as oil comes out bubble-free.

⇒ Keep the hydraulic unit running until both pressure gauges indicate **1020 bar**.

- Attention should be paid to ensure that pins 12 always protrude slightly compared with pistons 10 on the pre-tensioning jacks!

⇒ Turn back nuts 7 with round bar 'RS' by about five holes, let the pressure drop to zero, and remove the pre-tensioning jacks.



2.2 Loosening of camshaft

⇒ Screw off waisted bolts 8 (Fig. 'B') by their spot face and remove them.

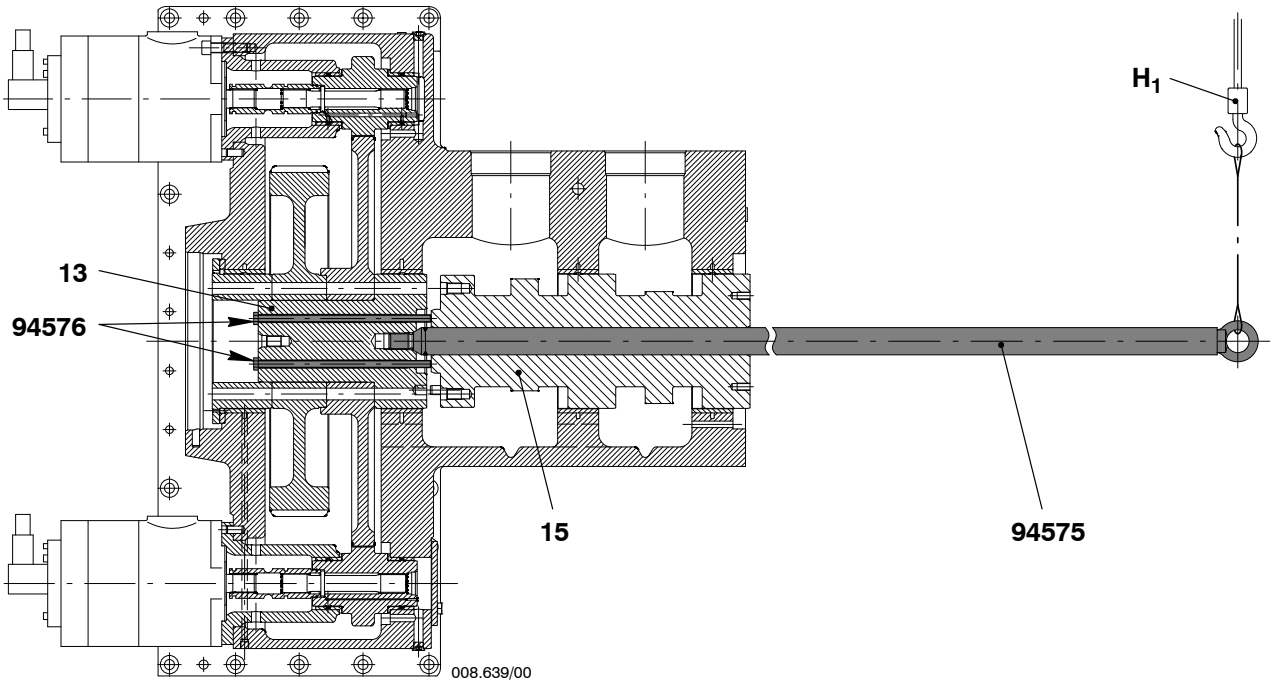
⇒ Clean guide bar 94575 and check thread M36 for ease of movement.

⇒ Screw guide bar in gear wheel shaft 13 until it stops.

⇒ Connect the guide bar to lifting tackle 'H_1'.

⇒ Screw two screws 94576 – until seated on their heads – in the corresponding bores of the gear wheel shaft (camshaft separated from gear wheel).

D



2.3 Withdrawing of camshaft

⇒ Lift camshaft 15 with lifting tackle 'H_1' just far enough to separate it from bearing shells 16.

⇒ Screw eye bolt 'RC' in the end of camshaft 15, then pull the latter carefully out of the housing with a rope.

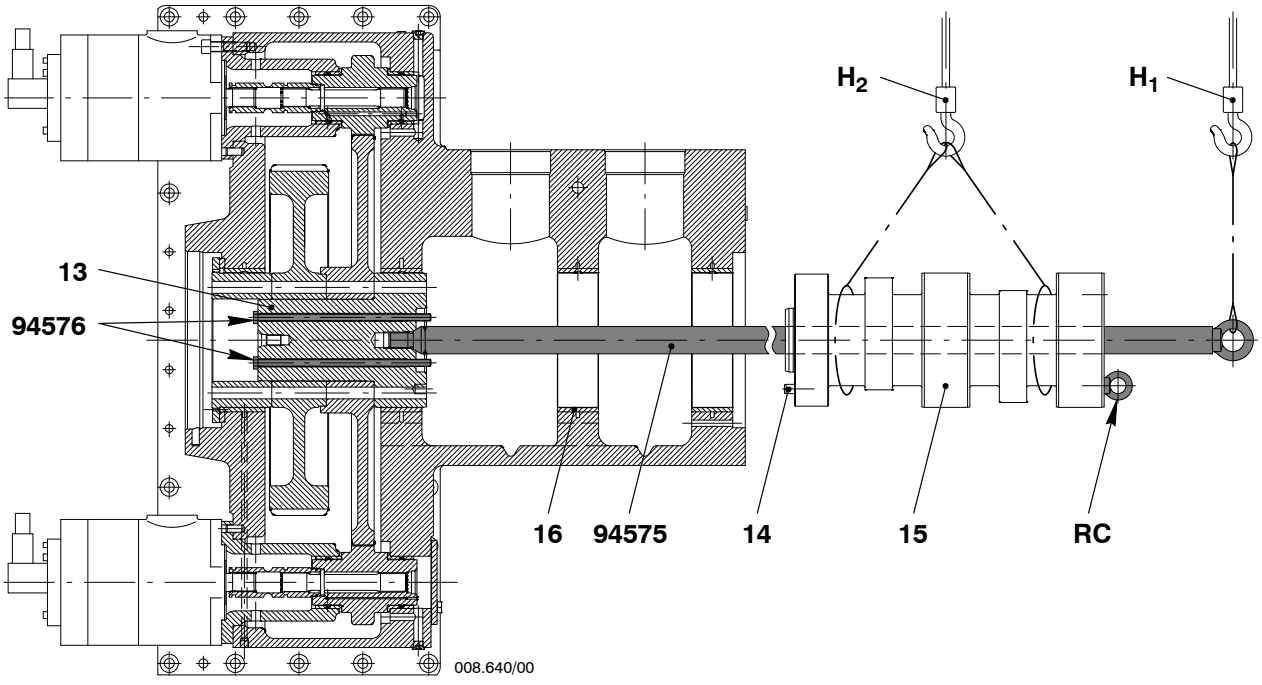
Remark: When pulling out the camshaft take care to leave the gear wheel shaft in situ!

⇒ Attach the camshaft to the lifting tackle 'H_2' as shown in Fig. 'E', then unscrew guide bar 94575.

⇒ Remove the camshaft.

⇒ Remove screws 94576.

E



3. Fitting of camshaft

⇒ Clean the camshaft, check it for damaged spots and, as shown in Fig. 'E', position it in front of the housing, aligning parallel pin 14 with the corresponding bore in gear wheel shaft 13.

⇒ Push the camshaft carefully into the gear wheel shaft.

⇒ Through the bores in the gear wheel shaft drive screws 94576 in the camshaft, until camshaft and gear wheel shaft are joined together.

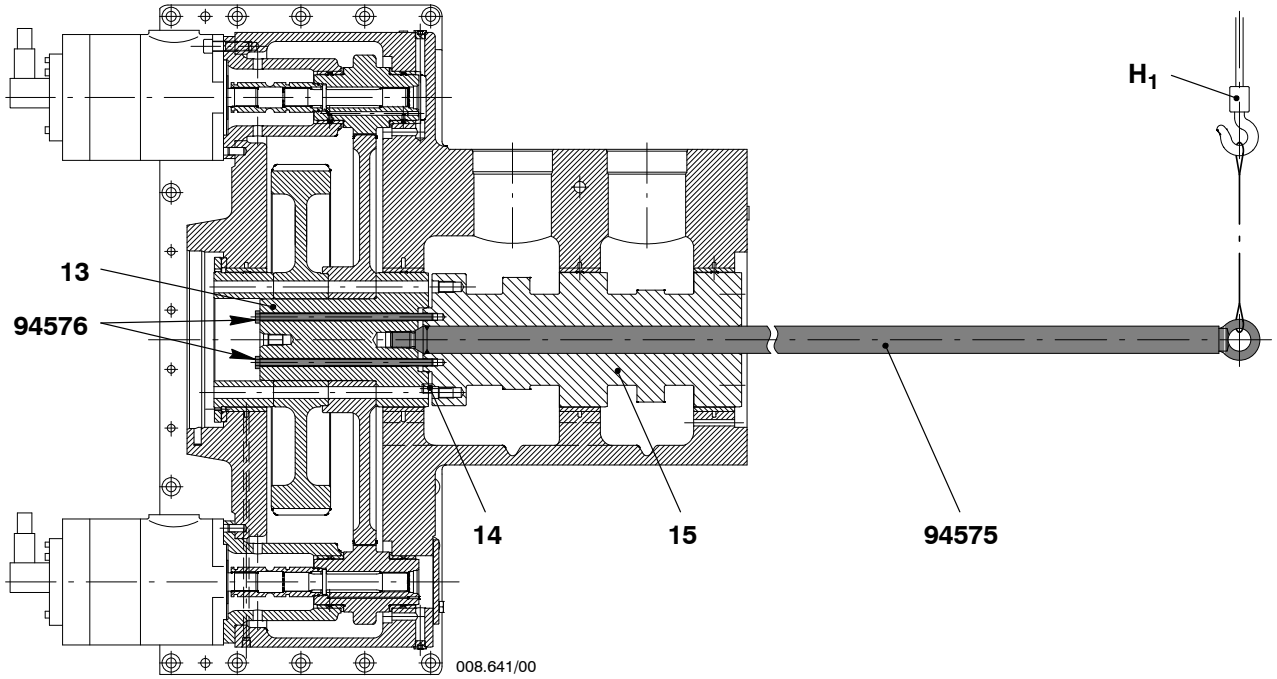
⇒ Remove guide bar 94575.

⇒ Screw waisted bolts 8 (Fig. 'B') – with their threads oiled – in the camshaft and tighten them.

⇒ Remove screws 94576.

⇒ Oil nut 7 (Fig. 'B'), screw it on the waisted bolts, and tighten it with round bar 'RS'.

F



3.1 Tensioning of waisted bolts

Remark: To tension waisted bolts 8 pre-tensioning jacks 94577 must **always** be screwed on crosswise.

⇒ As described in section 2.1 the pre-tensioning jacks are to be screwed on the waisted bolts and connected with hydraulic unit 94942 (Fig. 'C').

- **Do not** turn back the pre-tensioning jacks after screwing them on!

⇒ Start the hydraulic unit until a pressure of **1000 bar** is reached, then tighten nuts 7 with round bar 'RS'.

⇒ Remove the pre-tensioning jacks.

4. Final assembly

⇒ Oil and fit thrust bearing ring 6.

⇒ Fit and screw down thrust bearing cover 3, with O-rings 18 assembled and the oil drain opening turned to the bottom.

⇒ Determine the clearances according to clearance table 0330–1 'Supply Unit'.

⇒ Fit fuel pumps 17 (see 5556–1).

⇒ Start the main lubricating pump and check if the camshaft bearings are lubricated.

⇒ Fit covers 2 and 9 with their gaskets.

⇒ Fit the casings.

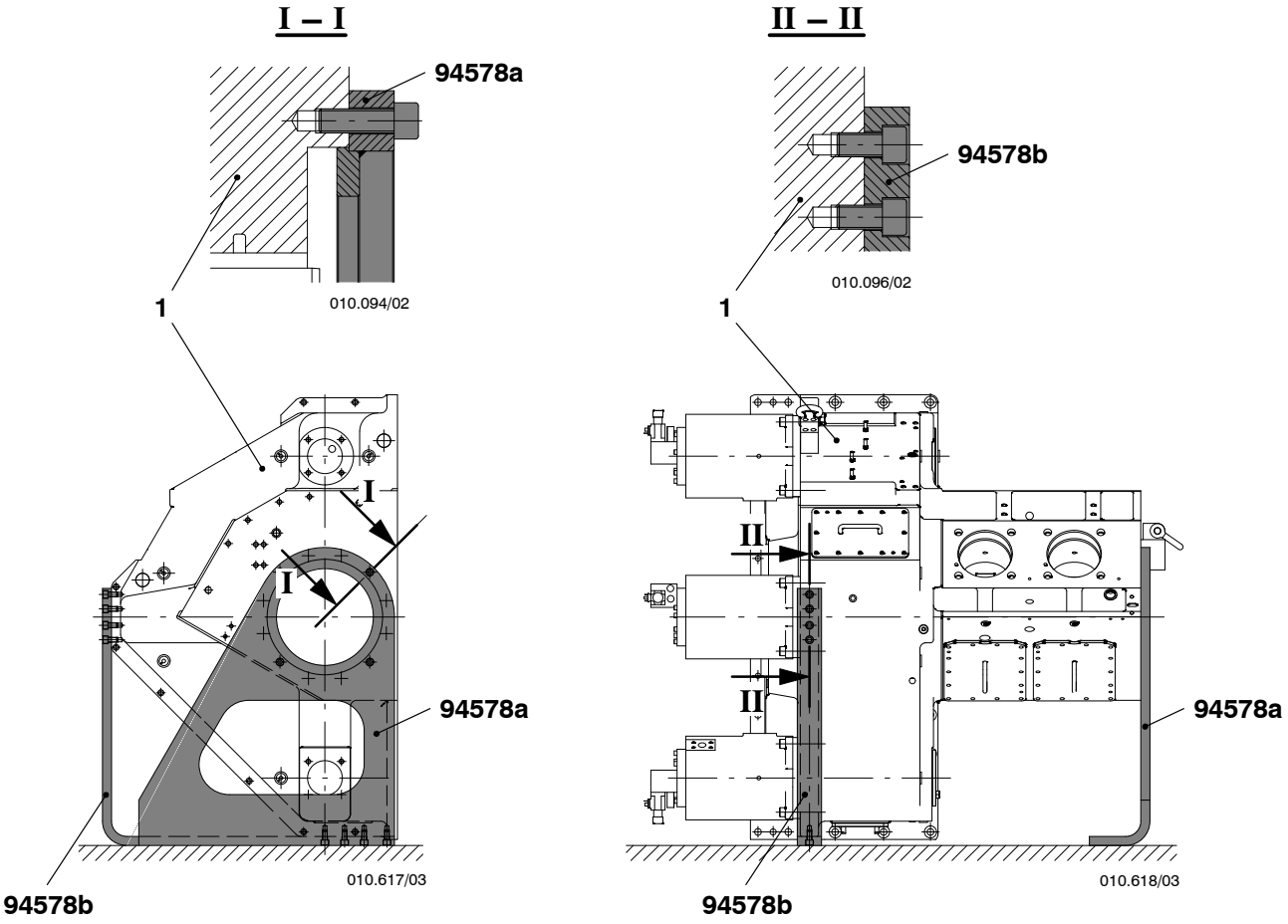
5. Removal and fitting of bearing shells

Bearing shells 16 to bearings No. (3) and (4) can be replaced only with camshaft 15 removed (Fig. 'B').
For that the supply unit 1 must not be removed from the engine.

If bearing shells to bearings No. (1) and (2) must be replaced however, in addition the supply unit must be removed from the engine and the driving wheels to the camshaft from the supply unit.

The removed supply unit can be placed in horizontal position by means of supporting plate 94578a fastened to the supply unit and supporting angle 94578b on front side (Fig. 'G').

G



Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

5.1 Removal of bearing shells to camshaft

- Pay attention to the removal direction of bearing shells and fitting position of the tools!
- The removal procedure is the same for all bearing shells, however, the tools are differently arranged depending on the bearing number (Fig. 'H').

⇒ Push centring ring 94579b into the bearing shell to be removed.

⇒ Push supporting device 94579a into the opposite bearing shell and fasten it with retaining plate 22 and two screws.

⇒ Fasten hydr. jack 94950 with screws 19 to the supporting device.

⇒ Bearing shells No. (3) and (4) : Screw threaded rod 94579c into the centring ring. Fit centring piece 20 and drive in the threaded rod until the centring piece rests on the piston of the hydr. jack.

- Bearing shells No. (1) and (2) : The piston of hydr. jack 94950 presses directly onto centring ring 94579b.

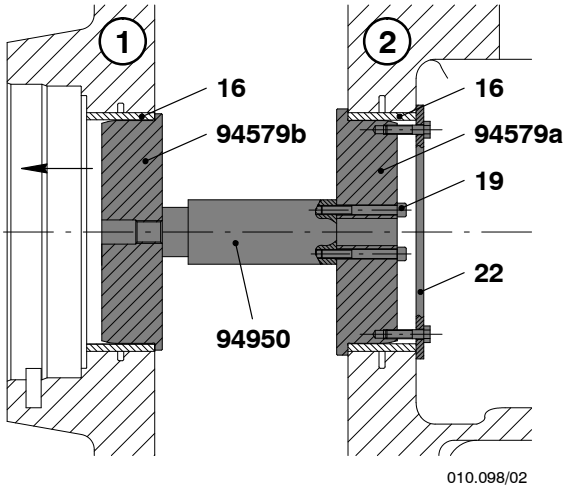
⇒ Connect hydr. jack to hydraulic unit 94942 as shown in Fig. 'C'.

⇒ Slowly actuate the hydraulic unit and press bearing shell 16 carefully out.

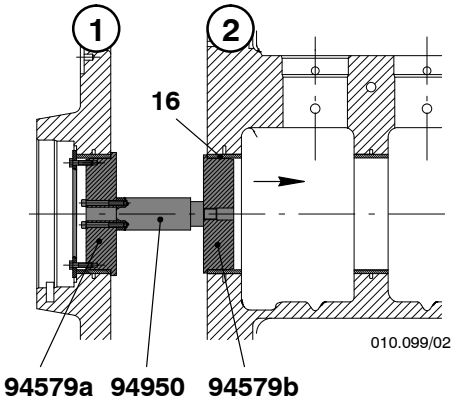
H

REMOVAL:

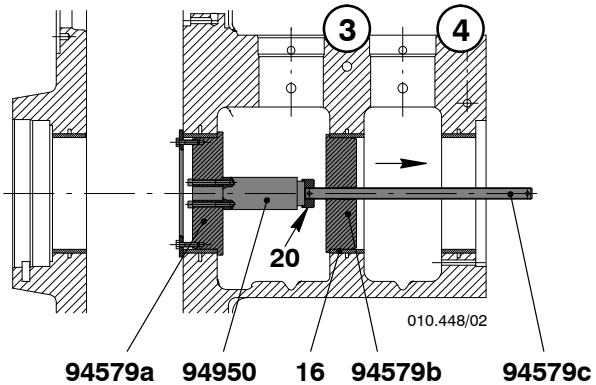
BEARING SHELL NO. (1)



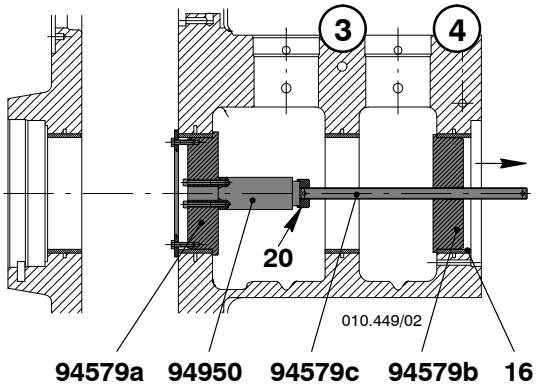
BEARING SHELL NO. (2)



BEARING SHELL NO. (3)



BEARING SHELL NO. (4)



5.1.1 Removal of bearing shells No. (3) and (4) with driving wheels in situ

Bearing shells 16 are withdrawn from the housing bore mechanically for lack of space instead of hydr. jack 94950 (Fig. 'I').

- Pay attention to the removal direction of bearing shells and fitting position of the tools!
- The removal procedure is the same for all bearing shells, however, the tools are differently arranged depending on the bearing number. Fitting of the tools is described for the removal of the bearing shell No. (3) and for No. (4) they must be installed accordingly.

⇒ Push centring ring 94579b into bearing shell No. (3).

⇒ Push retaining plate 22 onto threaded rod 94579c and screw threaded rod into the centring ring. Tighten screw 21.

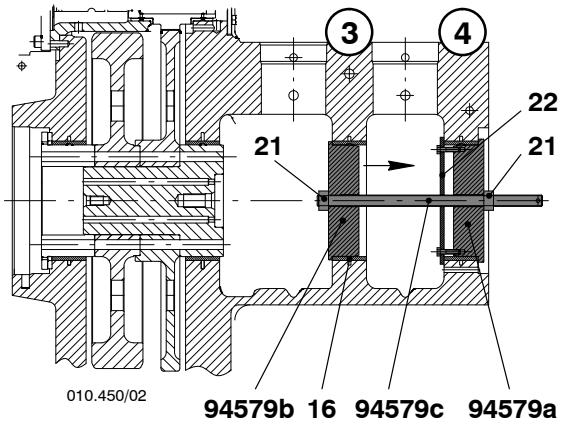
⇒ Push supporting device 94579a into the opposite bearing shell and fasten it with retaining plate 22 and two screws.

⇒ Screw nut 21 onto the threaded rod (on the side of the supporting device) and tighten it until the bearing shell is completely withdrawn from the housing bore.

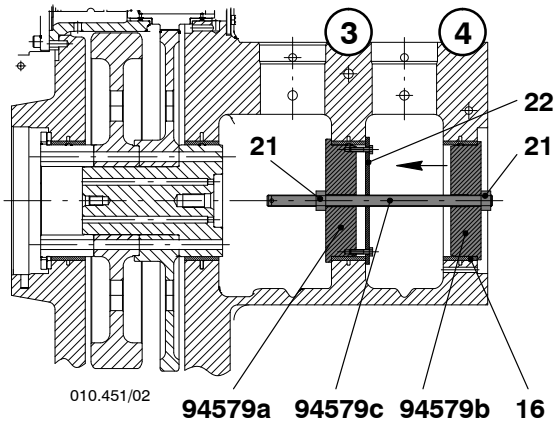
I

REMOVAL:

BEARING SHELL NO. (3)



BEARING SHELL NO. (4)



5.2 Fitting of bearing shells to camshaft

The bores in the housing as well as bearing shells 16 must be clean and in perfect condition. For the assembly smear bores and bearing shells lightly with oil.

- The markings of bearing shell on front side and on the housing must coincide.
- Pay attention to the removal direction of bearing shells and fitting position of the tools!
- The fitting procedure is the same for all bearing shells, however, the tools are differently arranged depending on the bearing number (Fig. 'K').
- The fitting procedure of the tools is the same as described for the removal, however, threaded rod 94579c and centring piece 20 are always used.

⇒ Together with centring ring 94579b push the bearing shell by hand into the housing bore as far as possible.

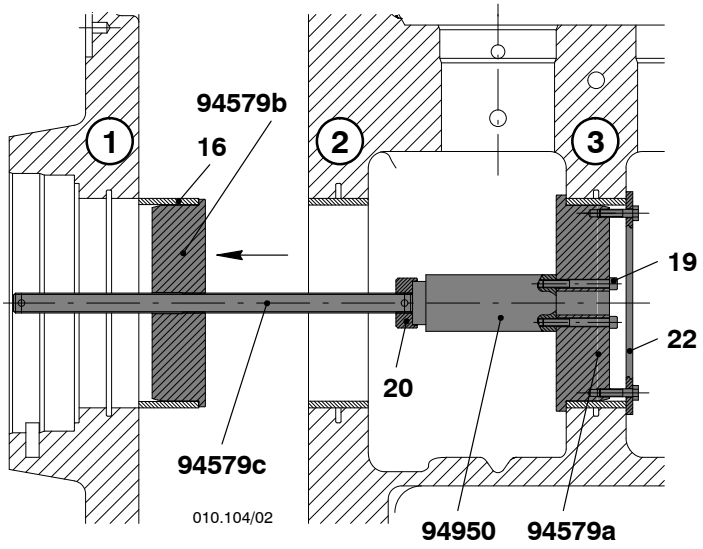
⇒ Connect hydr. jack to hydraulic unit 94942 as shown in Fig. 'C'.

⇒ Slowly actuate the hydraulic unit and press bearing shell carefully into the housing bore until the front face of the bearing shell is in line with the housing.

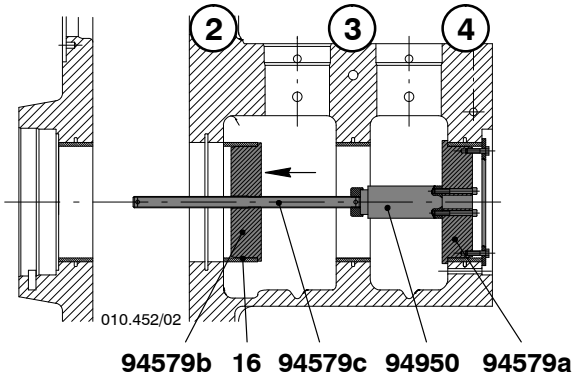
CHECK After assembly, check if lubricating oil is supplied to all bearings with the oil pump in operation!

K ***FITTING:***

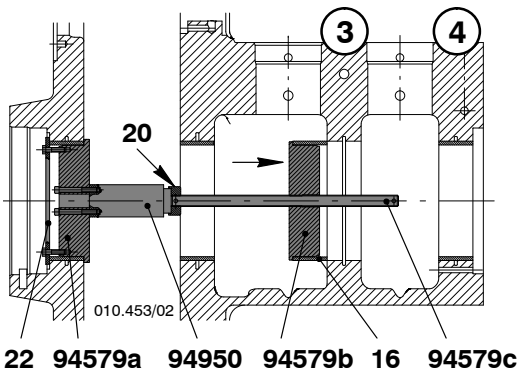
BEARING SHELL NO. 1



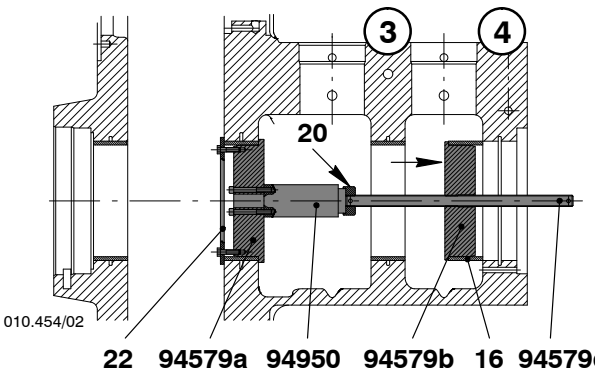
BEARING SHELL NO. 2



BEARING SHELL NO. 3



BEARING SHELL NO. 4



5.2.1 Fitting of bearing shells No. (3) and (4) with driving wheels in situ

The bores in the housing as well as bearing shells 16 must be clean and in perfect condition. For the assembly smear bores and bearing shells lightly with oil.

The bearing shells are drawn into the housing bore mechanically for lack of space instead of hydr. jack 94950 (Fig. 'L').

- The markings of the bearing shell on front side and on the housing must coincide.
- Pay attention to the fitting direction of the bearing shells and fitting position of the tools!
- The fitting procedure is the same for all bearing shells, however, the tools are differently arranged depending on the bearing number.
- The fitting procedure of the tools is the same as described for the removal.

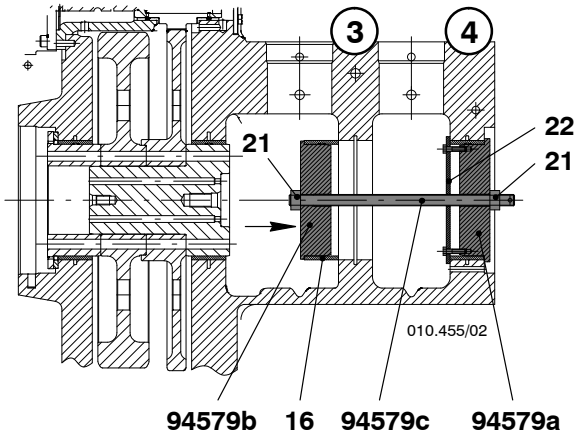
⇒ Together with centring ring 94579b push the bearing shell by hand into the housing bore as far as possible (Fig. 'L').

⇒ By tightening of nut 21 press bearing shell into the housing bore until the front face of the bearing shell is in line with the housing.

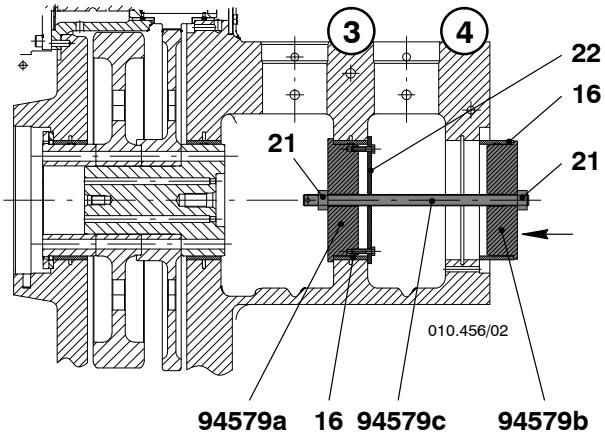
CHECK After assembly, check if lubricating oil is supplied to all bearings with the oil pump in operation!

L ***FITTING:***

BEARING SHELL NO. (3)



BEARING SHELL NO. (4)



Supply Unit

Removal and Fitting

	Tools:			Key to Illustrations:		
1	Lifting tool	94474	1	Fuel pump	8	Platform element
	consisting of:		2	Servo oil pump	9	Platform element
1	I-beaam	94474a	3	Intermediate fuel accumulator	10	Supply unit
1	Clamping piece	94474b	4	Spur-geared chain block		
1	Clamping piece	94474c	5	Stopper (pad)		
3	Clamping pieces	94474d	6, 6a	Supports		
1	Lifting tool	94474e	7, 7a	Supports	H_1...	Lifting tackles

Overview

1. **Preparations** 1/5
2. **Removal** 4/5
3. **Fitting** 5/5

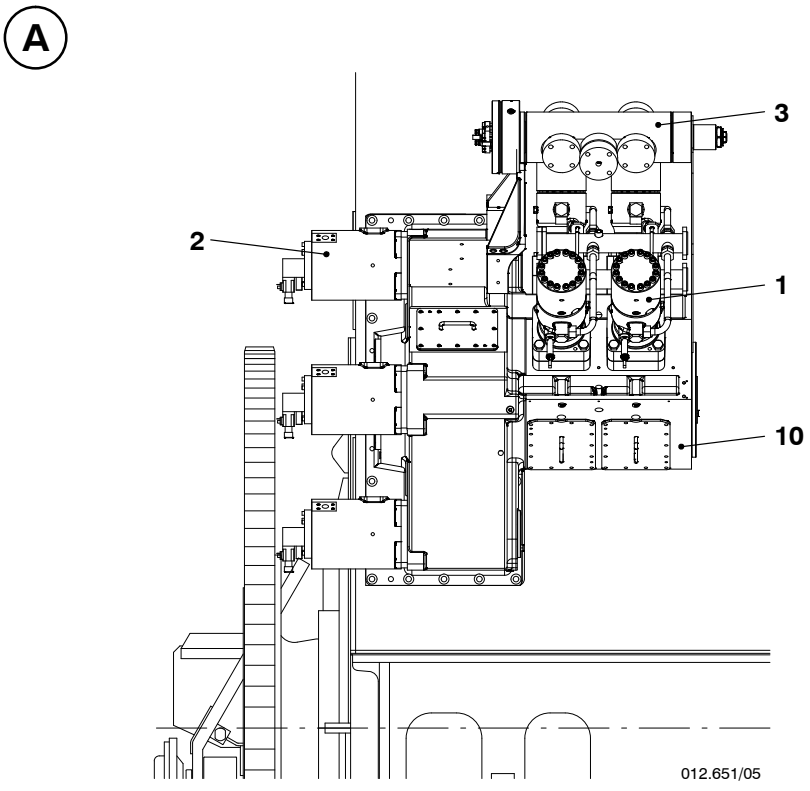
1. Preparations

- Removal of servo oil pump see 5552–1.
- Removal of fuel pump see 5556–1.

⇒ Disconnect cables, oil and fuel pipings from supply unit.

⇒ Remove intermediate fuel accumulator 3.

Attention! Removed parts, pipings and the supply unit must be well protected against dirt and damages!



Supply Unit: Removal and Fitting

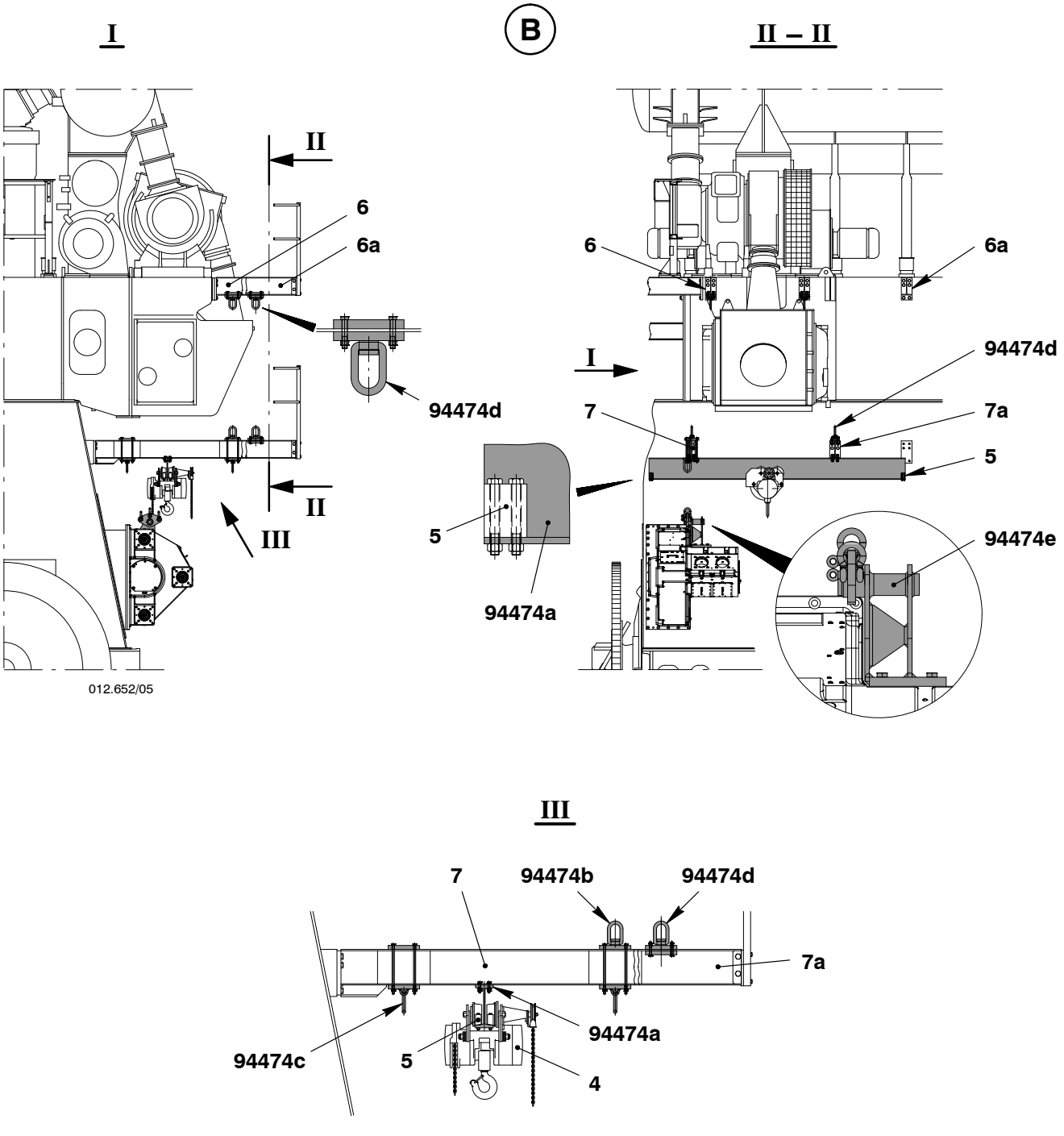
⇒ Clamp clamping pieces 94474d firmly to supports 6, 6a of the upper platform.

⇒ Clamp clamping pieces 94474b, 94474c firmly to support 7 and 94474d to support 7a of the lower platform.

⇒ Fasten I-beam 94474a to supports 7, 7a of the lower platform.

⇒ Loosen and refit a stopper 5 in order to push spur-geared chain block 4 onto the I-beam.

Risk of accident! Stoppers 5 must always be fastened to **both** ends of I-beam 94474a!



Supply Unit: Removal and Fitting

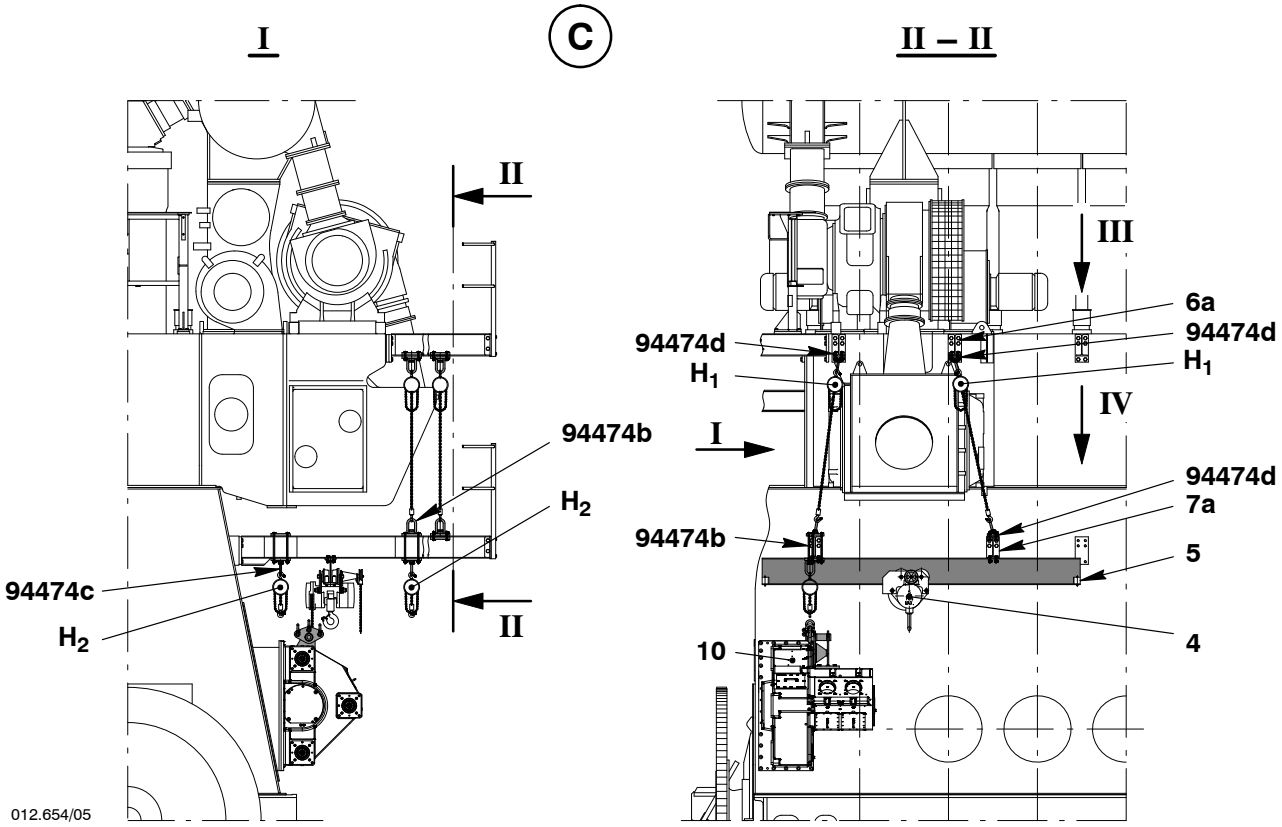
⇒ Remove pipings in the region of supply unit 10.

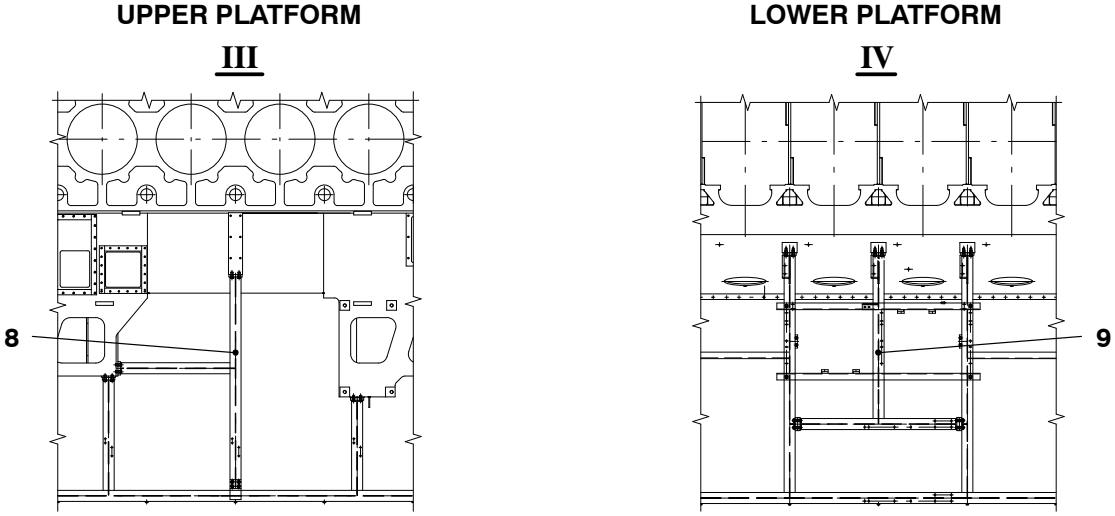
⇒ Remove bottom plates from platform element 8 of the upper platform and platform element 9 of the lower platform.

Risk of accident! Take measures to prevent having a fall, therefore immediately close the openings off after removing parts from the platforms!

⇒ Connect and tighten firmly lifting tackles H_1 (lifting capacity 3000 kg each) between clamping pieces 94474d to 94474b, and 94474d of support 6a to 94474d of support 7a.

⇒ Fasten lifting tackles H_2 (lifting capacity 5000 kg each) to clamping pieces 94474b and 94474c as shown in Fig. 'C'.





2. Removal

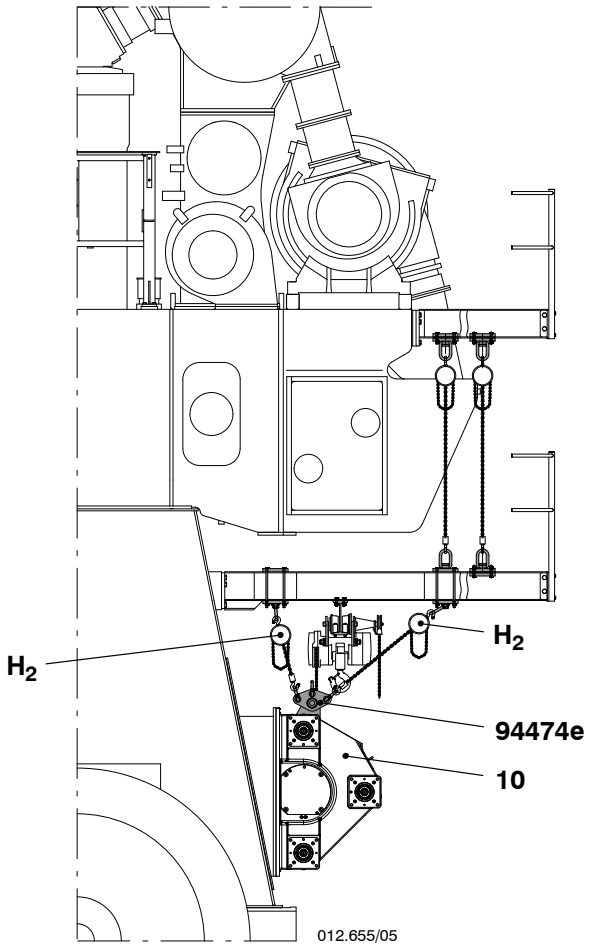
⇒ Connect lifting tackles H_2 to shackles of lifting tool 94474e as shown in Fig. 'D' and tighten them firmly.

⇒ Unscrew supply unit 10 from the column.

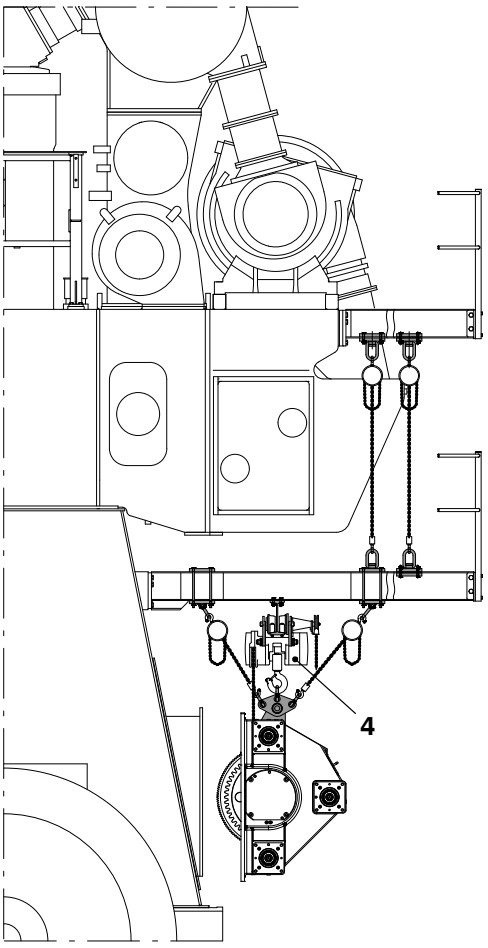
⇒ Move supply unit below of spur-geared chain block 4 by means of lifting tackles H_2 and then connect it with the middle shackles of the lifting tool as shown in Fig. 'E'.

⇒ Tighten spur-geared chain block and remove lifting tackles H_2.

D



E

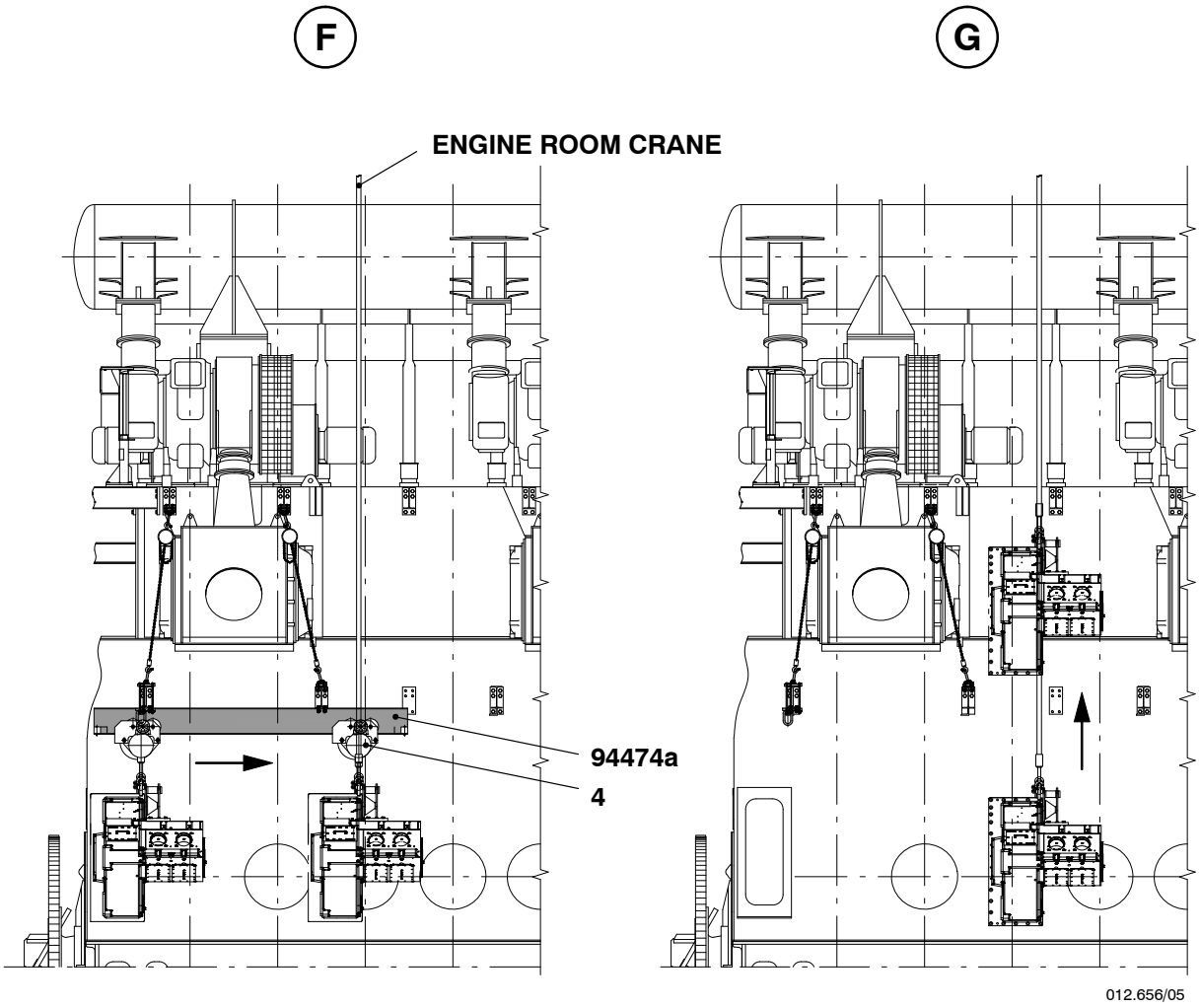


Supply Unit: Removal and Fitting

⇒ By means of spur-geared chain block 4, move the supply unit in such a position that lifting tool 94474e can be attached to the engine room crane as shown in Fig. 'F'.

⇒ Remove spur-geared chain block and I-beam 94474a.

⇒ Move the supply unit out of the engine room (Fig. 'G').



3. Fitting

Fitting of the supply unit is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

- The parts to be fitted must be in perfect condition, i.e. free from any damage.
- Pay attention to instructions in 5552–1, 5556–1 and 5801–1.

CHECK After the fitting, tooth backlash and clearances (see Clearance Table 0330–1 'Driving Wheels for Supply Unit') have to be checked.

Intentionally blank

Supply Unit

Lubrication of Supply Unit During Maintenance

Tools:

1	Lubrication tool	94844
1	Reduction nipple	
1	Adapter	
1	Adapter	

1. General

The engine has a manual lubrication system. This system prevents damage to the bearings and bushes of the supply unit (5, Fig. A) during dry–running of the engine.

Clean system oil is used for the lubrication.

2. Procedure

⇒ Clean the surface of the supply unit casing.

⇒ Remove the blind flange from the lubricating tool (94884).

⇒ Attach a flange with a G1/2” thread to the lubricating tool (94884).

⇒ Remove the applicable pipe from the supply unit (5).

⇒ Make sure that the ball valve (10) is closed.

⇒ Attach the adapter (1) to the flange (8) on the lubricating tool (94844).

⇒ Attach the flexible hose (2) to the adaptor (1) with the hose clip (7).

⇒ Attach the reduction nipple (4) to the supply unit (5).

⇒ Attach the adapter (3) to the reduction nipple (4).

⇒ Attach the lubricating tool (94844) to an applicable position approximately 2.0m above the supply unit as shown.

⇒ Attach the flexible hose (2) to the adaptor (3) with the hose clip (6).

⇒ Remove the inspection covers from the supply unit (5).

⇒ Fill the lubricating tool (94844) with system oil.

⇒ Open the ball valve (10).

⇒ Make sure that the system oil flows on to the bearings and camshaft (9).

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

Remark: If the turning gear operates for long periods, keep the system full to make sure that the bearings and camshaft (9) have sufficient lubrication.

⇒ Make sure that the bearings and camshaft (9) have sufficient lubrication.

⇒ Install the inspection covers to the supply unit (5) that you removed before.

⇒ Close the ball valve (10).

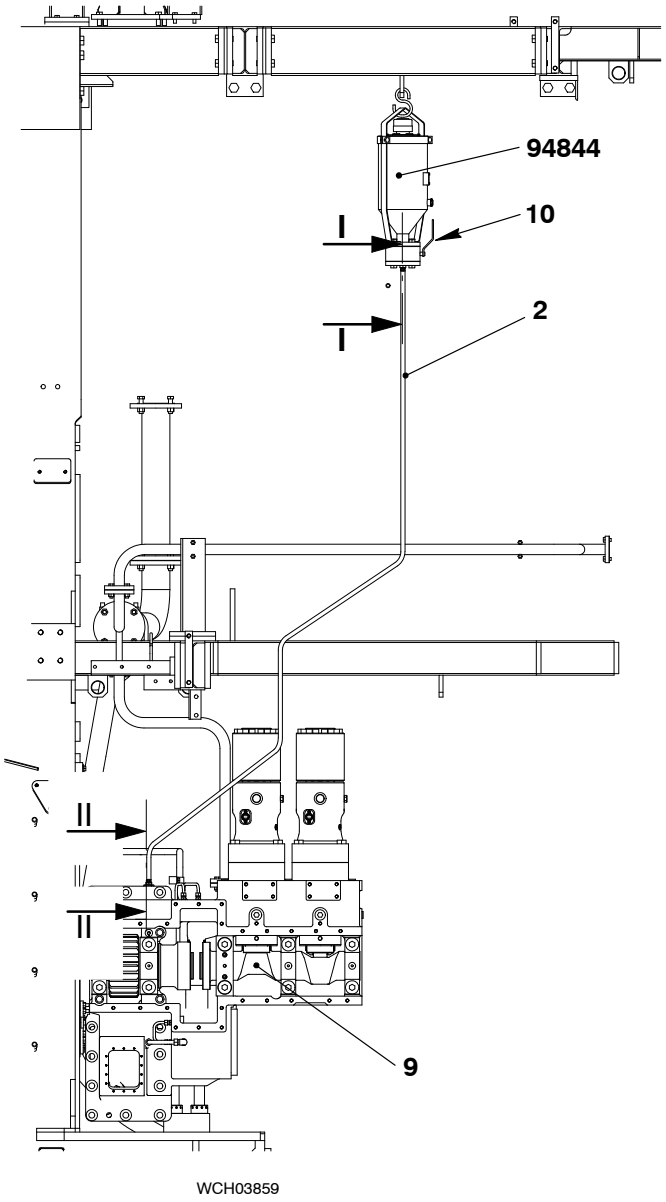
⇒ Remove the lubricating tool (94844), flexible hose (2) and adaptors (1, 3).

⇒ Remove the reduction nipple (4).

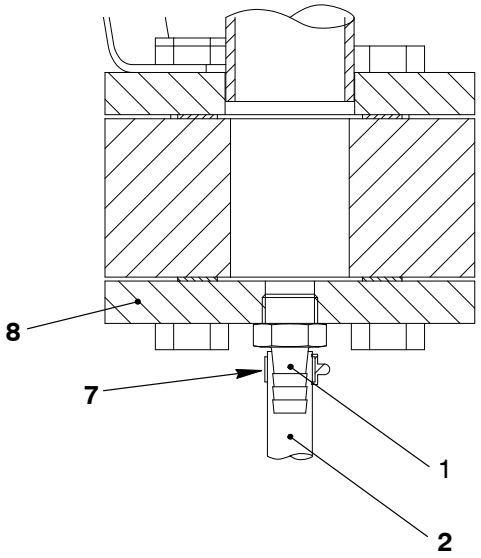
⇒ Install the pipe that you removed before to the supply unit (5).

⇒ Clamp clamping pieces 94474d firmly to supports 6, 6a of the upper platform.

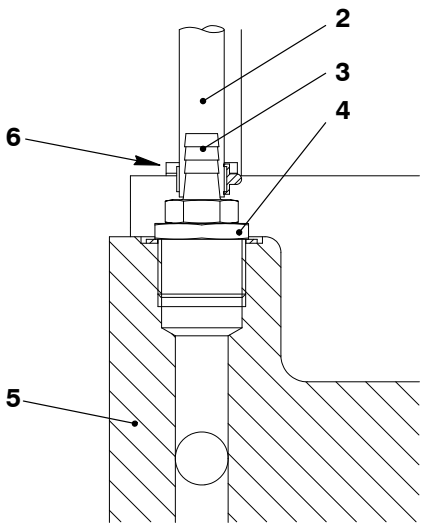
A



I – I



II – II



Fuel Pump

Dismantling and Assembling

Tool:

1	2-part clamping ring	94550
1	Fitting & dismantling device	94551
1	Cover	94552
1	Lifting support	94553
1	Spacer	94555
1	Checking gauge	94556

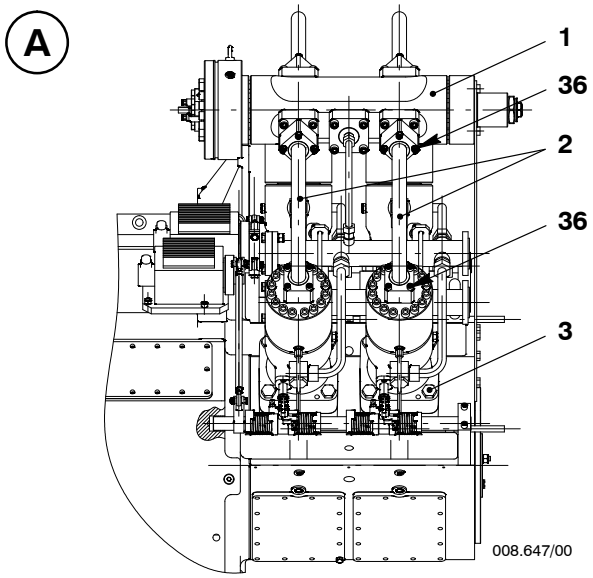
Key to Illustrations:

1	Intermediate fuel accumulator	24	Flange
2	Fuel pipe	25	Regulating (toothed) rack
3	Screw	26	Circlip
4	Pump cover	27	Stop ring
5	Upper housing	28	Screw
6	Lower housing	29	Valve block
7	Guide piston	30	Valve body
8	Roller	31	Compression spring
9	Guide pin	32	Holding screw (Cu-ring)
10	Pin	33	Pump cylinder
11	Circlip	34	Intermediate disc
12	Pressure disc	35	Circlip
13	Bush	36	Screw
14	Snap ring	37	O-ring
15	Pin	38	O-ring
16	Allen screw	39	O-ring
17	Lower spring carrier	40	Rod seal ring
18	Pump plunger	41	Bush
19	Compression spring		
20	Guide pin	DS	Pressure piece
21	Regulating sleeve	GS	Handle screw M6
22	Upper spring carrier	HZ	Lifting tackle
23	Screw	RC	Eye bolt M6

Overview

1. General 1/11
2. Removal of a fuel pump 2/11
3. Dismantling of a fuel pump 4/11
4. Assembling of a fuel pump 8/11
5. Preserving 11/11
6. Fitting of a fuel pump 11/11

1. General



The fuel pumps must be removed only with the engine at standstill and the fuel supply pump cut out.

Non-return valves are fitted between the intermediate fuel accumulator 1 and the fuel pipes 2. They allow removing the fuel pipes without draining the intermediate fuel accumulator. However, the shut-off valves to the fuel inlet and outlet pipes must be shut (Operating Manual 0720–1).

Dismantle and assemble the fuel pumps in a clean room which should be as dust-free as possible (grinding dust, etc).

2. Removal of a fuel pump

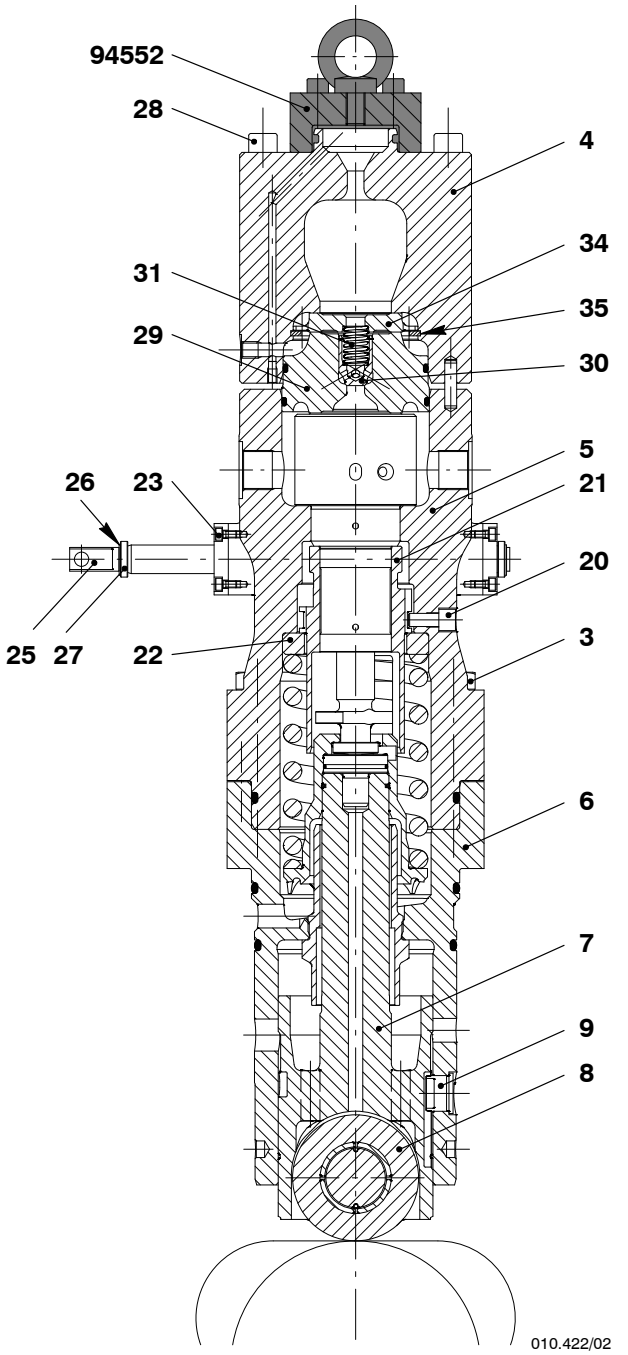
⇒ Turn the engine until roller 8 is seated on the cam base circle.

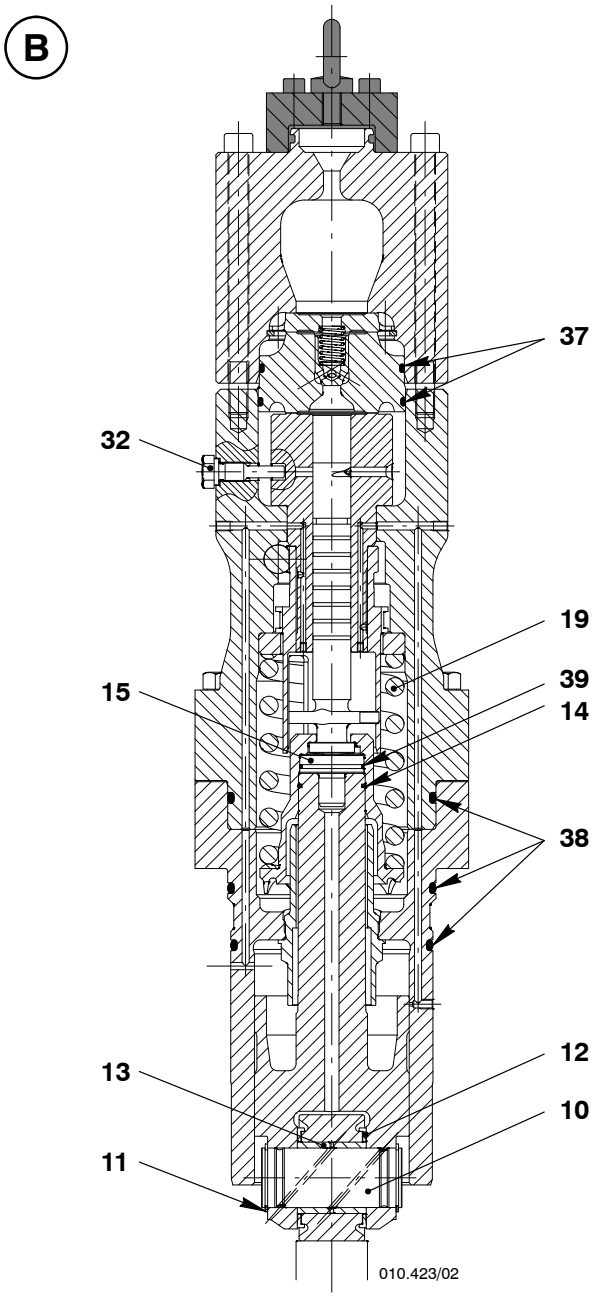
⇒ Remove the casing as far as necessary, and screw off the pipings fastened to the fuel pump.

⇒ Remove all screws 3 (Fig. 'A').

⇒ Using a jacking screw M12, lift the fuel pump until the locating pin is no longer meshing.

⇒ Fit cover 94552 onto pump cover 4.





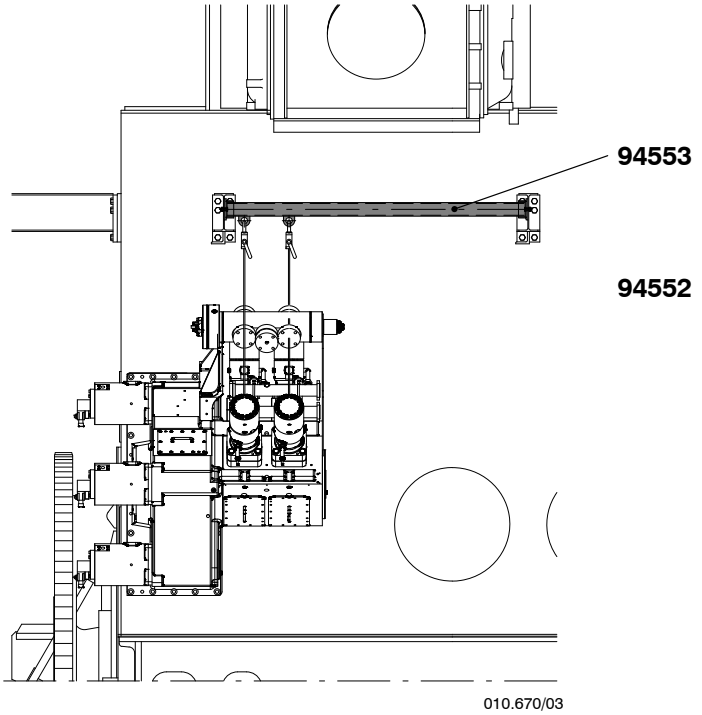
Fuel Pump: Dismantling and Assembling

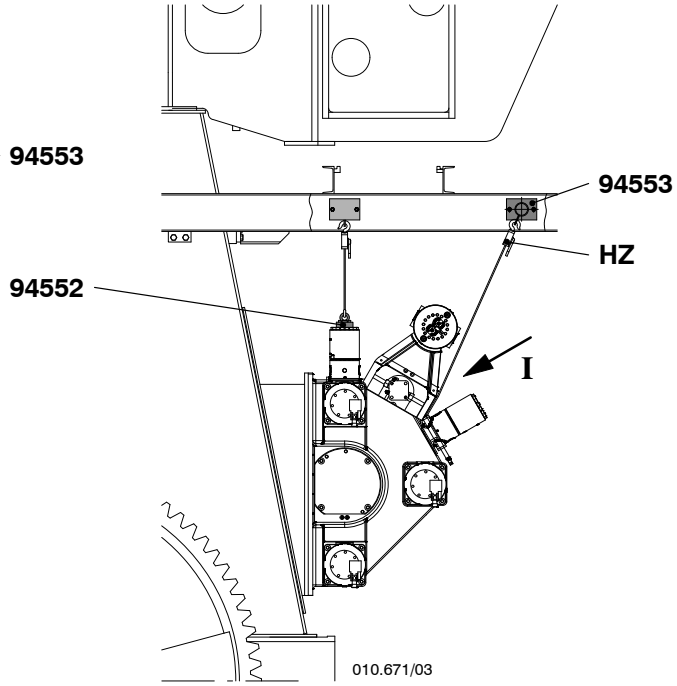
⇒ Fasten lifting support 94553 with screws M16 x 35 and nuts between the supports above the fuel pump to be removed.

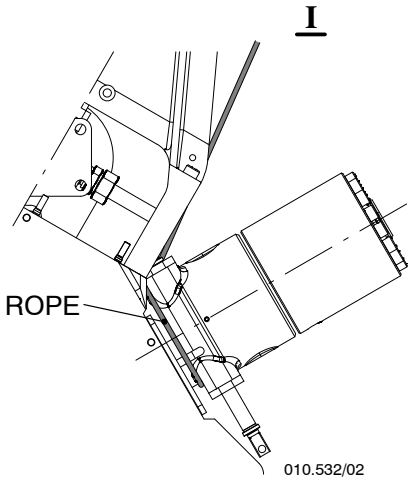
⇒ Hook lifting tackle 'HZ' to lifting support.

- The inner fuel pump ist pulled up at cover 94552. The outer one is slung around the center with a rope and pulled up as shown in Fig. 'C'.

C

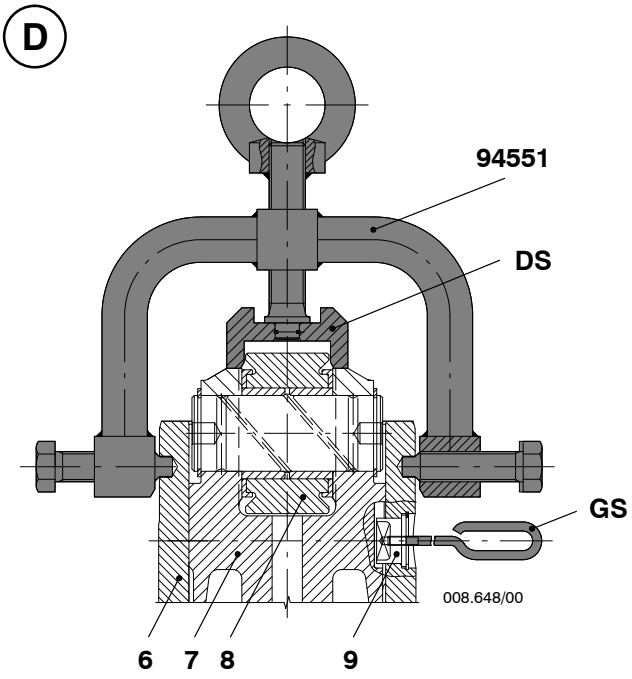






3. Dismantling of a fuel pump

D



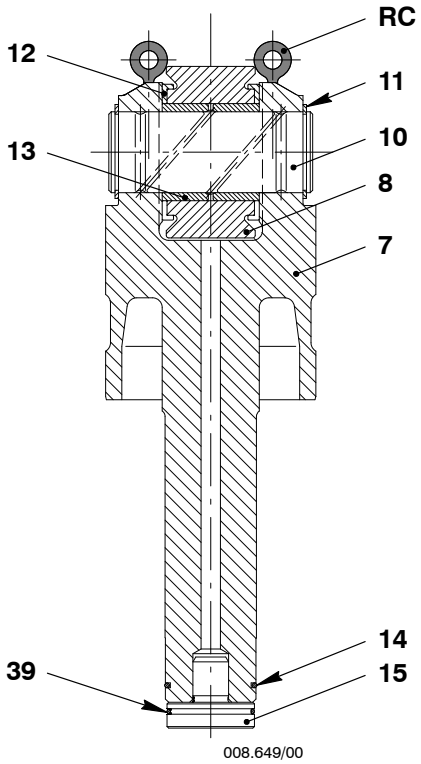
3.1 Removal of guide pin

⇒ With the head of the pump turned towards the bottom, fasten the fuel pump onto a work bench.

⇒ Mount fitting & dismantling device 94551 according to Fig. 'D', and press guide piston 7 inwards by turning the spindle of the device until guide pin 9 allows to be withdrawn by means of a handle screw.

⇒ Remove the fitting & dismantling device.

E



3.2 Removal of guide piston

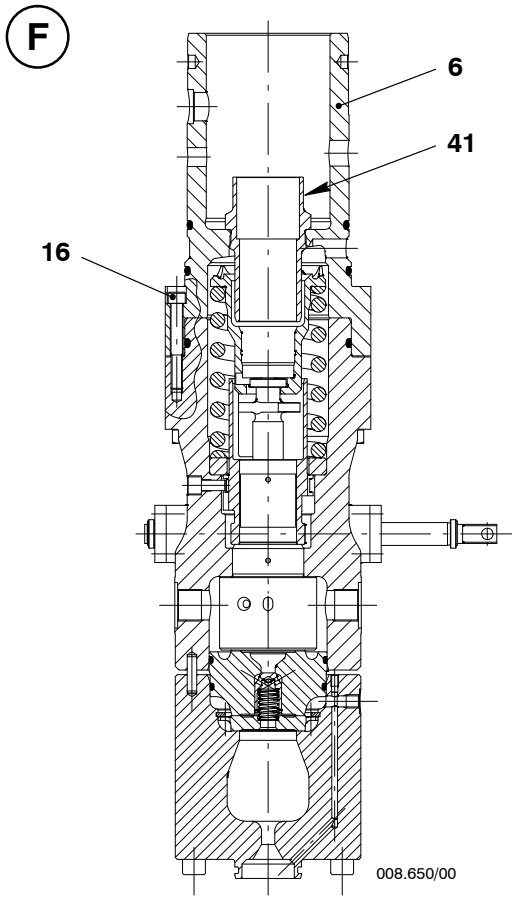
⇒ Screw two eye bolts 'RC' into guide piston 7, and withdraw the latter from the housing.

3.3 Removal of roller

⇒ Remove circlip 11.

⇒ Press out pin 10, and remove roller 8 together with pressure discs 12 and bush 13.

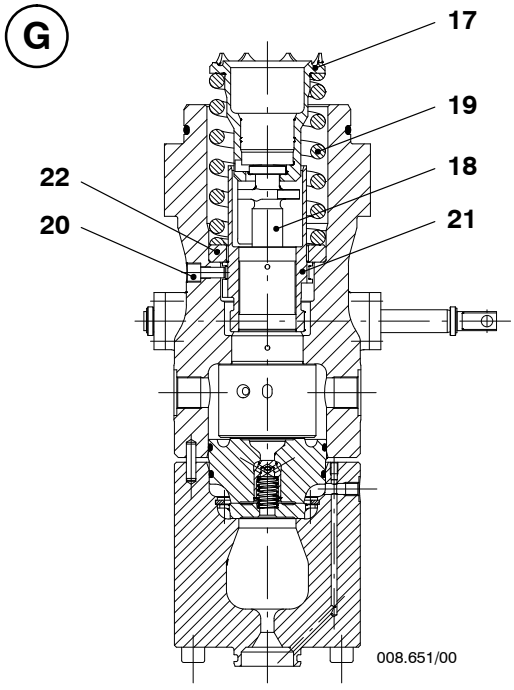
Fuel Pump: Dismantling and Assembling



⇒ Remove Allen screws 16.

⇒ Separate lower housing 6 from upper housing.

Remark: If bush 41 has to be replaced, the new one must be secured with LOCTITE No. 648 and tightened with a torque of **200 Nm**.

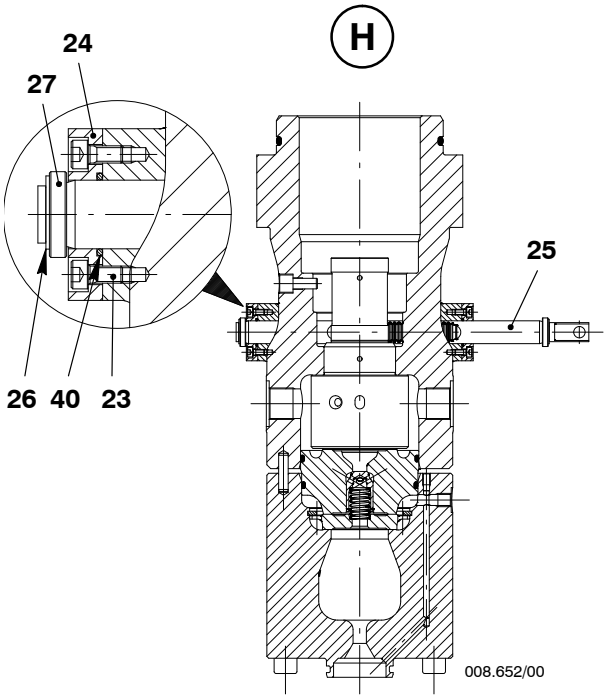


⇒ Dismantle lower spring carrier 17 together with pump plunger 18.
Store the pump plunger in a manner not to damage it.

⇒ Remove compression spring 19.

⇒ Remove regulating sleeve 21 together with upper spring carrier 22.

Fuel Pump: Dismantling and Assembling

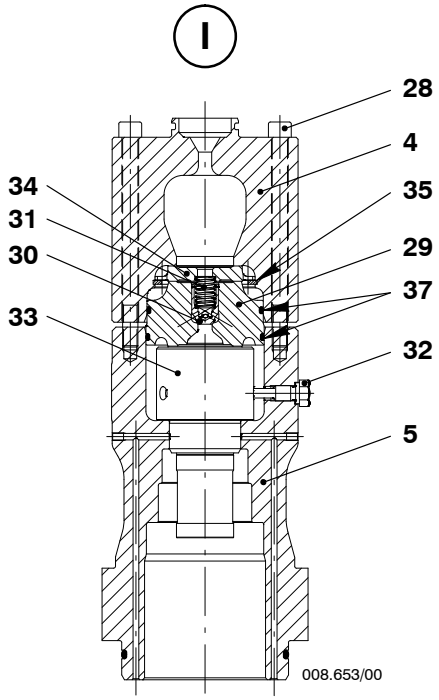


3.4 Removal of regulating rack

⇒ Unscrew all screws 23.

⇒ Remove circlip 26 and stop ring 27.

⇒ Remove flange 24, and push out regulating rack 25.



3.5 Removal of pump cylinder

⇒ With pump cover 4 turned upwards, clamp the fuel pump into the work bench.

⇒ Unscrew screws 28.

⇒ Remove pump cover 4 with valve block 29, valve body 30, and compression spring 31.

⇒ Remove holding screw 32 and pump cylinder 33.

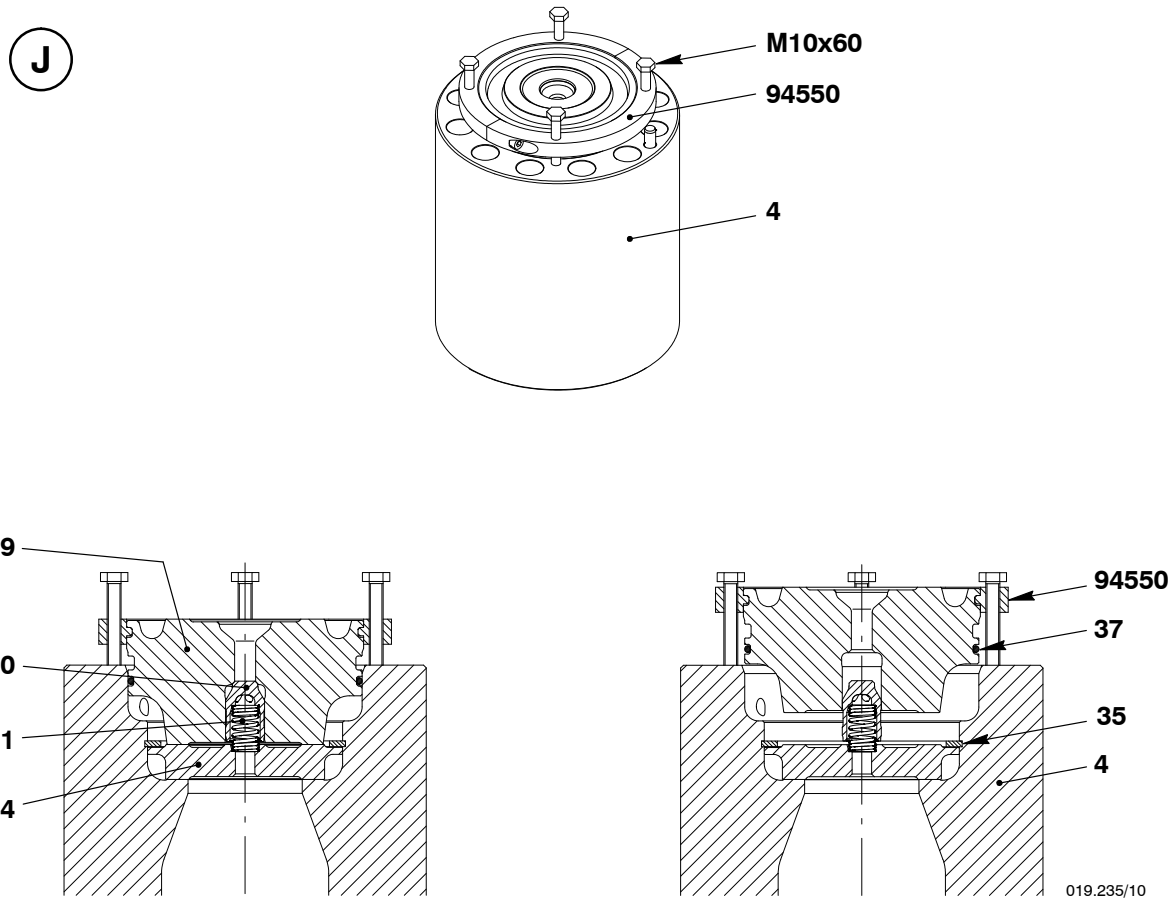
Remark: Pump cylinder 33 and pump plunger 18 are a single unit and must not be interchanged.
Therefore they are not delivered separately.

3.6 Removal of non-return valve

⇒ By means of 2-part clamping ring 94550 and the four screws M10x60 valve block 29 can be withdrawn from pump cover 4.

⇒ Remove circlip 35 with a snap ring tong.

Remark: The non-return valve must be replaced as a unit only, i.e. valve block 29, valve body 30, compression spring 31 and intermediate disc 34.



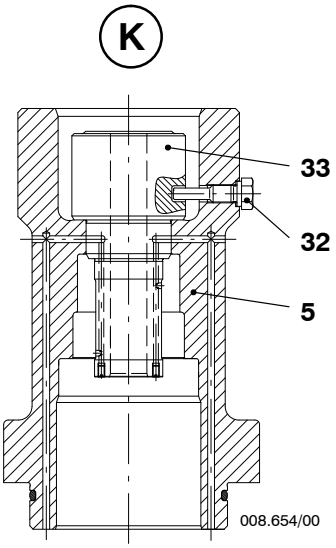
4. Assembling of a fuel pump

4.1 Preparation

⇒ Clean all parts and check their condition.
Damaged parts must be replaced.

⇒ Check the lubricating oil bores in the housings and in pump cylinder 33 for free passage using compressed air.

⇒ Replace all O-rings and rod seal rings.



4.2 Fitting of pump cylinder

⇒ Fasten upper housing 5 in vertical position onto a work bench.

⇒ Carefully fit pump cylinder 33, aligning the groove in the pump cylinder precisely with the bore provided for holding screw 32 in the upper housing.

⇒ Screw in and tighten the holding screw together with the Cu-ring.

Remark: There must be a clearance between holding screw 32 and the groove base!

4.3 Fitting of pump cover

Remark: Thoroughly check the joint faces for cleanness when fitting the valve block and the pump cover (Fig. 'I').

⇒ Fit valve block 29 with the mounted and lubricated O-rings 37 in upper housing 5. Then fit valve body 30 and compression spring 31 in the valve block.

⇒ Fit intermediate disc 34 with circlip 35 in the pump cover.

⇒ Fit pump cover 4.

⇒ Apply Never-Seez NSBT-8 to the threads and head seating surfaces of screws 28, fit and tighten them crosswise in equal steps with a total value of **115 Nm**.

4.4 Fitting of regulating rack

⇒ With the pump cover turned towards the bottom, fasten the upper housing onto a work bench.

⇒ Fit regulating rack 25 according to Fig. 'H'.

CHECK

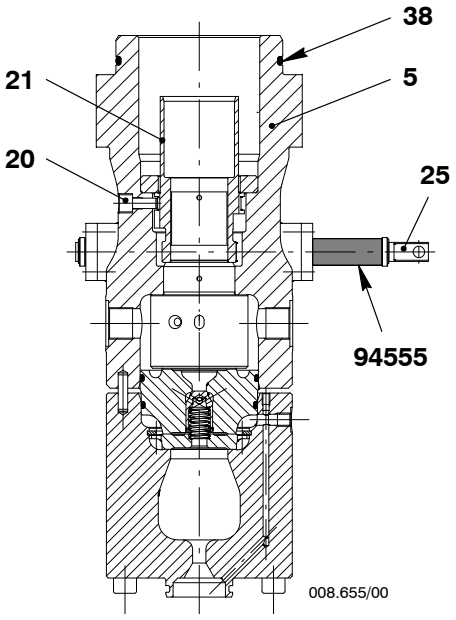
Check regulating rack 25 for easy movement.

⇒ Place rod seal ring 40 in both flanges 24.

⇒ Push both flanges onto the regulating rack and screw them up with the upper housing.

⇒ Fit stop rings 27 and circlips 26.

L



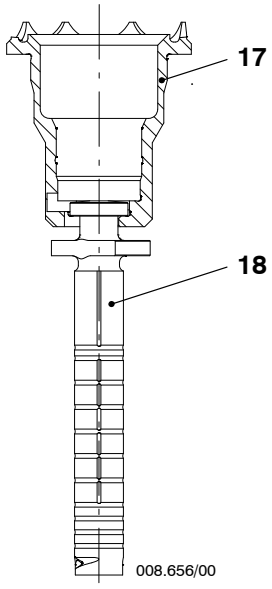
4.5 Fitting of regulating sleeve

⇒ Bring regulating rack 25 to the position shown in Fig. 'L' and place spacer 94555.

⇒ Fit regulating sleeve 21 in the upper housing (Fig. 'L'), the toothed rim turned to the bottom and the groove of 12 mm width being flush with guide pin 20.

4.6 Fitting of pump plunger and lower housing

M



⇒ Fit upper spring carrier 22 and compression spring 19 (Fig. 'G').

⇒ Nest pump plunger 18 in lower spring carrier 17 (Fig. 'M').

⇒ Lubricate the pump plunger with **clean** diesel oil and insert it in pump cylinder 33, taking care that both drivers at the pump plunger mesh in the lead of regulating sleeve 21 (Fig. 'G').

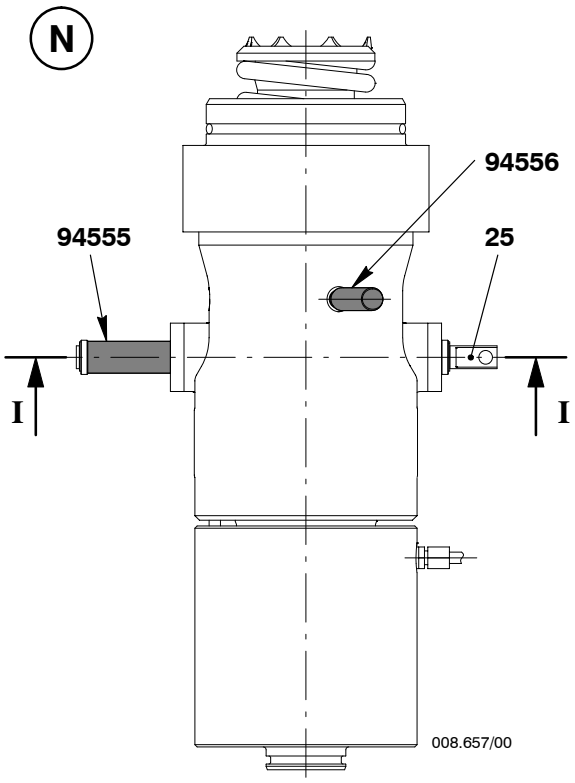
⇒ Place O-ring 38 in upper housing 5 and lubricate it (Fig. 'L').

⇒ Tension the lower and the upper housing together by means of two Allen screws 16. Thereby spring 19 is compressed (Fig. 'F').

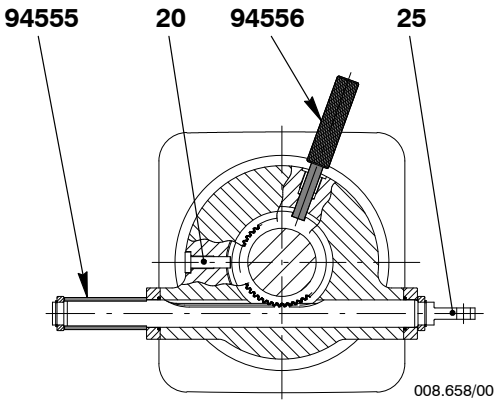
CHECK

After screwing up both housings with each other, check regulating rack 25 for easy movement.

Fuel Pump: Dismantling and Assembling



I – I



4.7 Checking of plunger position

⇒ Bring regulating rack 25 to the position shown in Fig. 'N' and place spacer 94555.

⇒ Remove screw plug from the checking bore and insert checking gauge 94556 in its place till the stop.

⇒ Remove spacer 94555 again and check whether the regulating rack is blocked.
With blocked regulating rack the plunger is correctly fitted.

⇒ After checking remove checking gauge, refit and tighten screw plug with Cu-joint.

4.8 Final assembly

⇒ Assemble guide piston 7, provided that parts have been removed (Fig. 'E').

CHECK

Check the axial clearances according to the Clearance Table 0330–1 'Fuel Pump'.

⇒ Lubricate O-ring 39 and push snap ring 14 with grease into the concentric position (Fig. 'E').

⇒ Lubricate the pump plunger.

⇒ Attach the guide piston to a lifting tackle by means of two eye bolts 'RC' (Fig. 'E'), and insert it carefully in the housing, taking care that the guide groove in the guide piston comes to rest opposite the bore provided for guide pin 9 (Fig. 'D').

⇒ Remove eye bolts 'RC', mount the fitting & dismantling device 94551, and press guide piston 7 downwards until guide pin 9 allows to be fitted. In case the guide pin touches the side of the guide groove, it can be brought into the right direction by turning pressure piece 'DS' (Fig. 'D').

⇒ Release the fitting & dismantling device and remove it.

CHECK

Check regulating rack 25 for easy movement.

⇒ Place O-rings 38 in the grooves at lower housing 6 (Fig. 'B').

5. Preserving

If a pump has to be stored over a long period of time, the spaces carrying fuel oil must be filled with vaseline oil and plugged with plastic stoppers.

Furthermore, lubricate the pump and protect it against humidity and soiling by wrapping it suitably.

The pumps must be stored in upright position.

6. Fitting of a fuel pump

⇒ Turn the engine until the cam belonging to the fuel pump concerned is on the base circle (Fig. 'B').

CHECK

Check whether the seating surfaces as well as the guide parts of engine housing and pump are in a faultless condition.

⇒ Lubricate the guide parts and fit the fuel pump, taking care of the locating pin and the regulating shaft (do **not** use any jointing agent).

⇒ Screw in screws 3 with lubricated threads and head seating surfaces, and tighten them crosswise in equal steps with a total value of **600 Nm** (Fig. 'A').

⇒ Check the setting of the regulating linkage (5801–1).

⇒ Fit all pipings. Apply Never-Seez NSBT-8 to the threads and head seating surfaces of screws 36 (Fig. 'A'), fit and tighten them crosswise in equal steps with a total value of **70 Nm**.

⇒ When putting the pump into operation, watch for possible leakages or abnormal temperature rise. Fit the casing when everything is in order.

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Fuel Pressure Control Valve

Removal, Fitting, Dismantling and Assembling

Key to Illustrations:

1	Fuel pressure control valve	15	Fuel rail
2	Piston	16	Intermediate piece
3	Valve tip	17	Screw M16x200
4	Valve seat	18	Locating pin
5	Oil pressure regulating valve	19	Intermediate ring
6	Compression spring	20	Connection piece
7	Compression spring	21	Solenoid valve
8	Knurled screw	22	Allen screw M6x55
9	Adjusting disc	23	Stay
10	Housing	24...26	O-rings
11	Cover		
12	Cover		
13	Filter	BA, BE	Fuel outlet, inlet
14	Union	OE	Oil inlet pipe

1. General

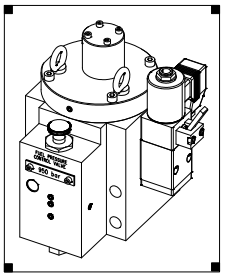
To avoid any risk of failures related to the fuel pressure control valve (PCV), Wärtsilä recommends only performing the below mentioned maintenance. PCV maintenance onboard is limited to:

- Replacement of the complete PCV
- Replacement of the 3/2-way solenoid valve
- Replacement or cleaning of the control oil inlet filter

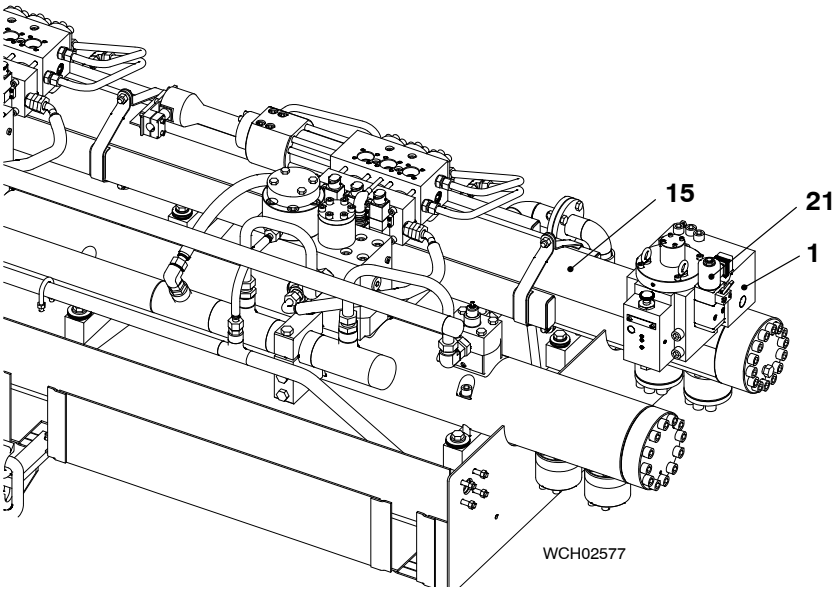
Remark: In case the PCV was replaced on a previous occasion, Wärtsilä offers a new or remanufactured PCV which will be equipped and set according to the latest technical specification with the correct pressure adjustment.

For detailed maintenance intervals of the PCV refer to the Maintenance Schedule 0380–1.

The engine has to be stopped when working on a PCV and the instructions 0515–1 in the Operating Manual must be strictly followed.



A



Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling

2. Removal of fuel pressure control valve

⇒ Remove all pipings from fuel pressure control valve 1.

⇒ Connect the PCV (45 kg) to the crane by means of a manual ratchet.

⇒ Loosen screws 17 and move the PCV in arrow direction, taking care that intermediate ring 19 and connection piece 20 do not fall down.

3. Fitting the fuel pressure control valve

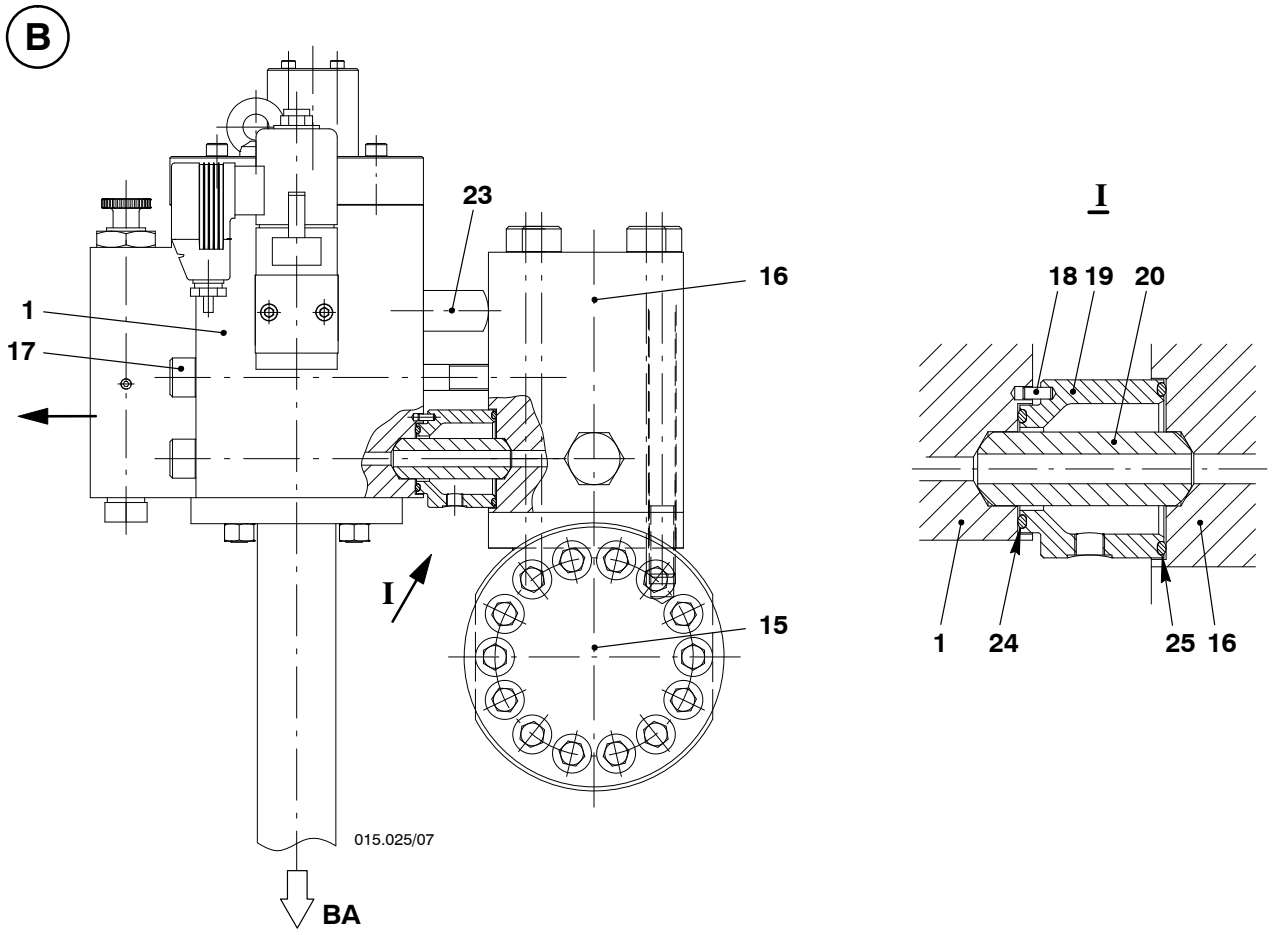
⇒ Bring the PCV in fitting position at the fuel rail by means of a manual ratchet.

⇒ Apply Never-Seez NSBT-8 to the screw threads 17.

⇒ Place new O-rings 24 and 25 into the grooves of intermediate ring 19.

⇒ Fit the intermediate ring over locating pin 18 and insert connection piece 20.

⇒ Fasten the PCV to intermediate piece 16 with screws 17 and tighten them crosswise with a torque of **190 Nm**.



Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling

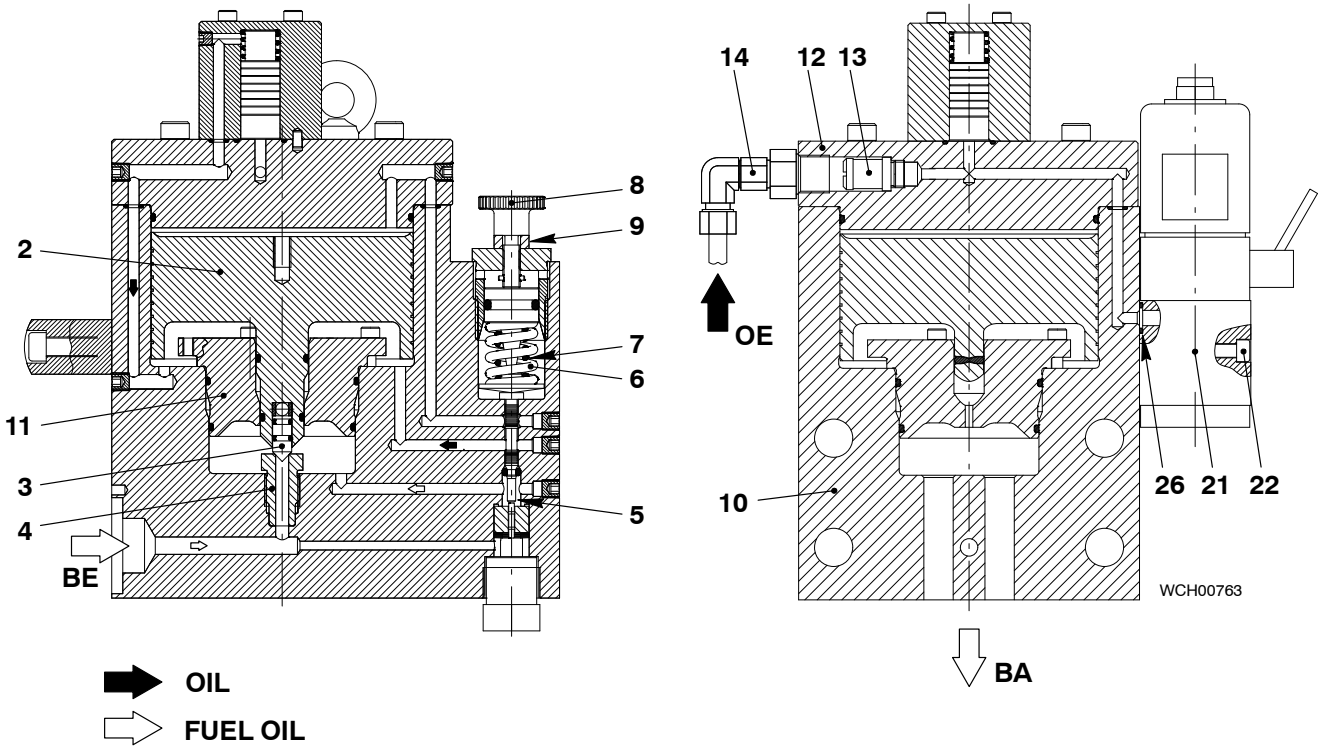
4. Cleaning the filter

⇒ Remove oil inlet pipe 'OE' and union 14.

⇒ Loosen filter 13 and clean it. If necessary replace it.

⇒ Oil the filter, screw it into cover 12 and apply a torque of **10 Nm**.

C



5. Storage on board

The spare parts must be carefully protected against corrosion.

- The PCV has to be free from any dirt, oil and grease.
- Apply coating liquids (e.g. Tectil 506, ISOTEC 337 or similar) on the surfaces to be preserved.
- All blind holes and tapped holes must be plugged.

Especially consignments transported overseas must be well protected against adverse climatic conditions (intense cold, rain, high humidity, etc.) and kept in a closed box.

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Injection Control Unit

Removal and Fitting

Tools:

2	Eye-bolts	94045-M8
1	Transport plate	94585A
1	Blind flange	94585B
2	Withdrawing tools	94589

Key to Illustrations:

1	Injection control unit	10	Fuel rail
2	Hose	11	Lip seal
3	Pipe	12	Exhaust valve control unit
4	Pipe	13	Cable plug to ICU
5	Pipe	14	Dowel pins
6	Bolt M12x110	15	Bolt M12x60
7	Bolt M10x110		
8	Hose		
9	Screw M8x30		

1. General

With the introduction of the Mark III Injection Control Unit it is possible to do the maintenance on board. On request at Wärtsilä Switzerland you can get several ouverhaul kits for the ICU including the work instruction:

– Repair kit for fuel valve assembly

– repair kit for pre–control device

– Repair kit for measuring device

Maintenance works on the injection control unit must be done only by qualified personel having the special knowledge of the Mark III ICU. Otherwise send the unit to a Wärtsilä service station and have it ouverhauled there.

Remark: No maintenance work is provided for pre-control valve (rail valves). If necessary it must be replaced.

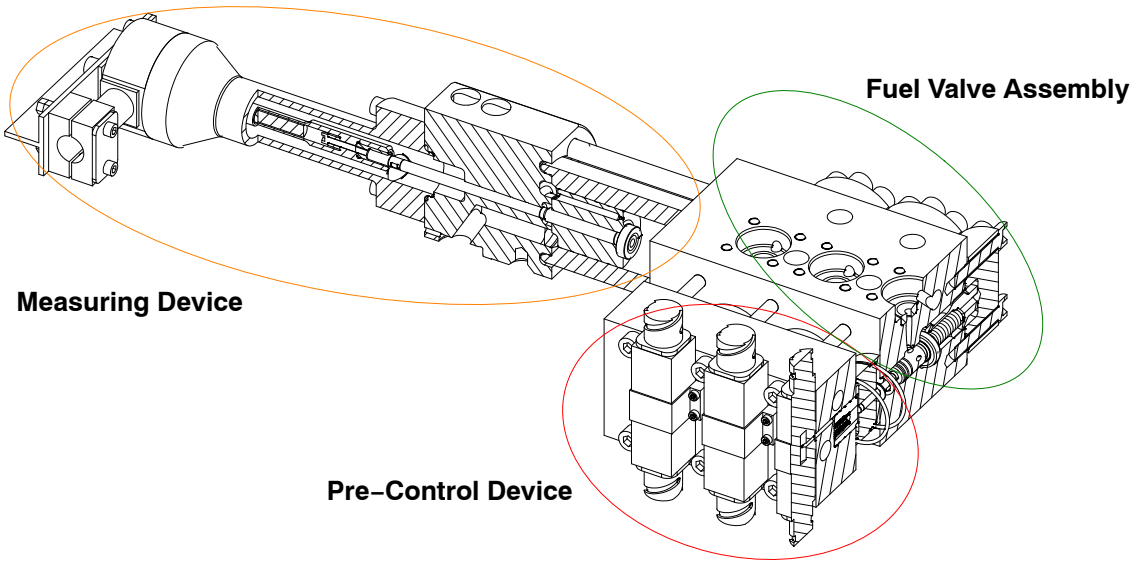


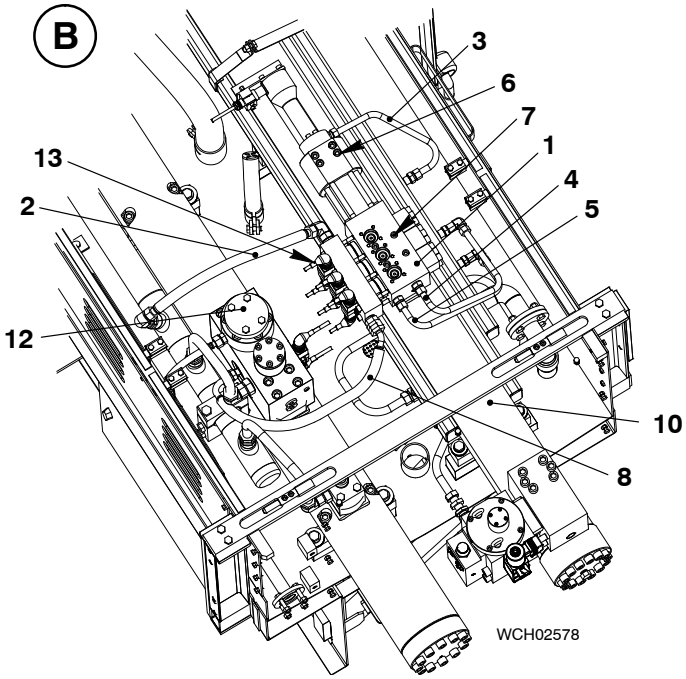
Fig. A: Injection Control Unit

2. Removal

⇒ Before you remove the injection control unit (ICU) follow the instructions 0510–1 in the Operating Manual.

Attention! Injury hazard. Use gloves and eye protection. Hot fuel can come out as a spray and cause injury.

Attention! Fire hazard. Do not weld or grind materials in the area.



⇒ Clean the work area you see in Fig. B.

⇒ Remove HP fuel pipe, refer to 8733–1.

⇒ Remove the hoses 2 and 8 (Fig. B).

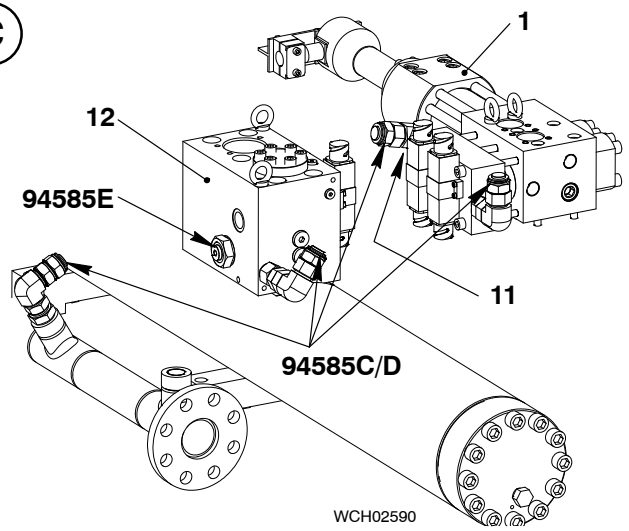
⇒ Disconnect pipes 3, 4 and 5 from Injection control unit 1.

⇒ Remove four bolts 7 and four bolts 6.

⇒ Remove cable plugs 13 from pre-control valves.

Injection Control Unit: Removal and Fitting

C

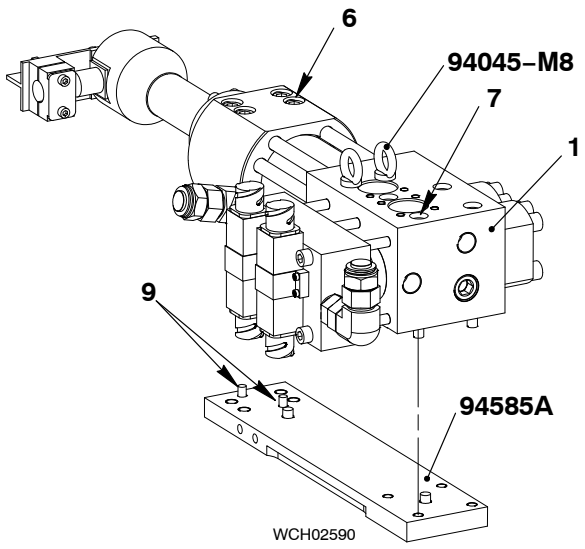


⇒ Close the unions with screw plugs 94585C/D.

⇒ Close the opening on the exhaust valve control unit 12 with capping end 94585E.

⇒ Remove the lip seal 11 on the underside of the ICU with one of the withdrawing tools 94589.

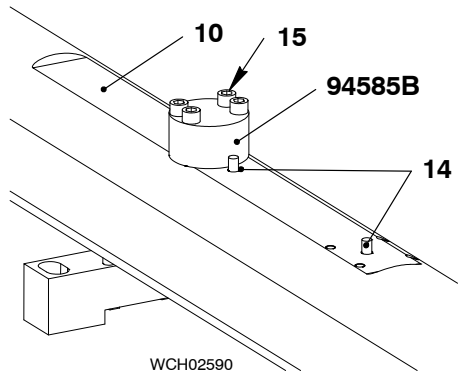
D



⇒ Install two eye-bolts 94045-M8 as shown in Fig. D.

⇒ Lift the injection control unit 1 and mount it on the transport plate 94585A with two hex head screws 9. Make sure the dowel pins fit correctly.

E

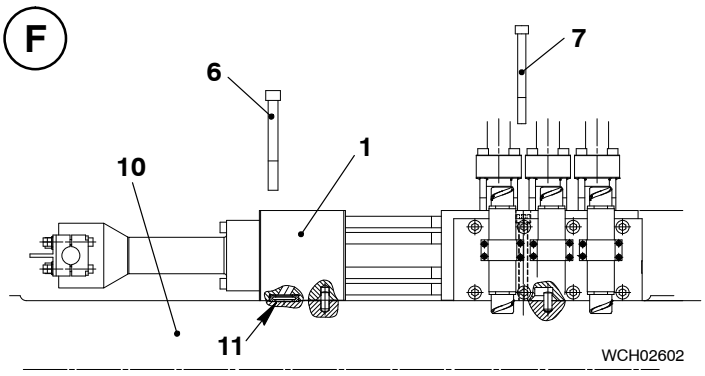


⇒ Clean the area on the fuel rail 10 around the injection port (Fig. E).

⇒ Install the blind flange 94585B over the injection port and tighten the four oiled bolts 15 equally with **70 Nm**.

⇒ Make sure the dowel pins 14 stay in the fuel rail.

3. Fitting



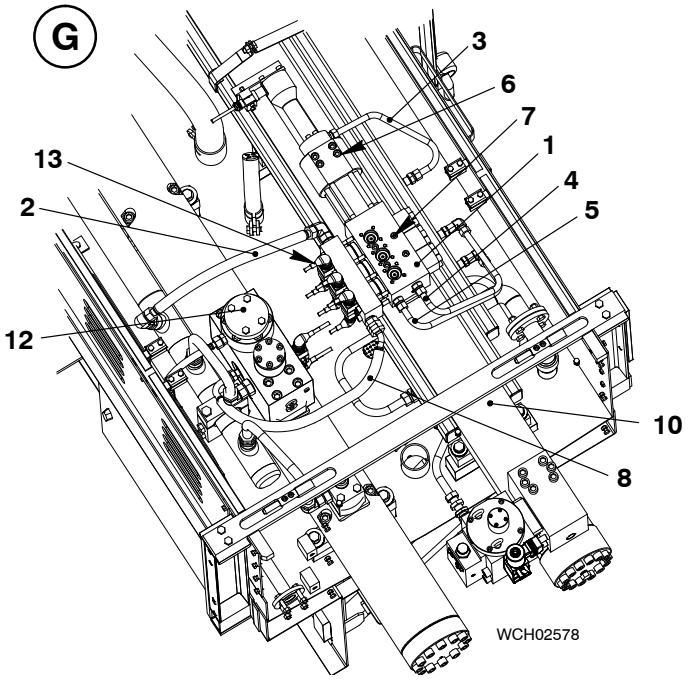
⇒ Make sure the working area is clean.

⇒ Remove transport plate 94585A (see Fig. D)

⇒ Carefully insert the lip seal 11 on the underside of the injection control unit 1.

⇒ Place the injection control unit according to the dowel pins in the fuel rail 1.

⇒ Insert four bolts 6 and four bolts 7.



⇒ Apply Never Seez NSBT8 to the threads and contact surfaces of the four bolts 6 and tighten them with **60 Nm**.

⇒ Apply Never Seez NSBT8 to the threads and contact surfaces of the four bolts 7 and tighten them with **35 Nm**.

⇒ Remove all plugs from unions and from injection control unit (see also Fig. C).

⇒ Connect pipes 3, 4 and 5 to Injection control unit 1 and fuel rail 10.

⇒ Install the hoses 2 to return pipe and 8 to exhaust control unit 12.

⇒ Install HP fuel pipe, refer to 8733–1.

⇒ Connect cable plugs 13 to pre-control valves.

⇒ For restarting the injection see instructions 0510–1 in the Operating Manual.

- After replacing the injection control unit, operate the engine for a minimum of 1.5 hours with marine diesel oil (MDO). For more data see Operation Manual 0270–1.

Exhaust Valve Control Unit

Removal, Fitting, Dismantling and Assembling

Tools:

2	Eye–bolts M10	94045–M10

Key to Illustrations:

1	Valve control block
2	Pipe
3	Rail valve (pre-control valve)
4	Screw
5	Screw
6	Servo oil rail
7	Dowel pin
8	Connecting block
9	Screw
10	Cover
11	Piston
12	Screw
13	Cover
14	Compression spring
15	Slide rod
16	Screw plug
17	Screw
18	Plug
19	Throttle
20	Filter holder
21	Filter
22–28	O-ring

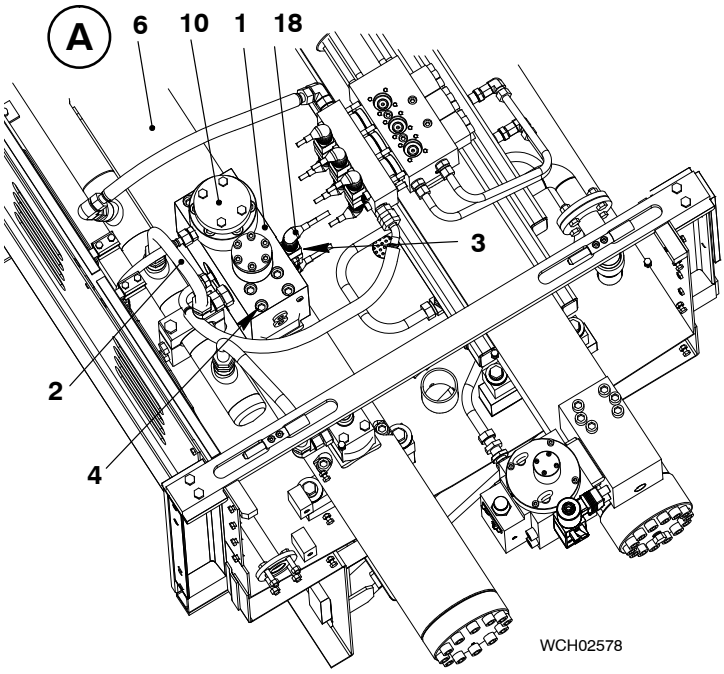
1. General

Stop the engine when working on the exhaust valve control unit.

Attention! HP Servo oil pipes must be pressureless. Follow the instruction in 0520–1 of the Operating Manual.
The respective work station must be clean; welding and grinding should not be done nearby!

2. Removal

⇒ For dismantling the exhaust valve control unit, first remove the hydraulic pipes from the exhaust valve control unit (see 8460–1).



⇒ Remove pipes 2.

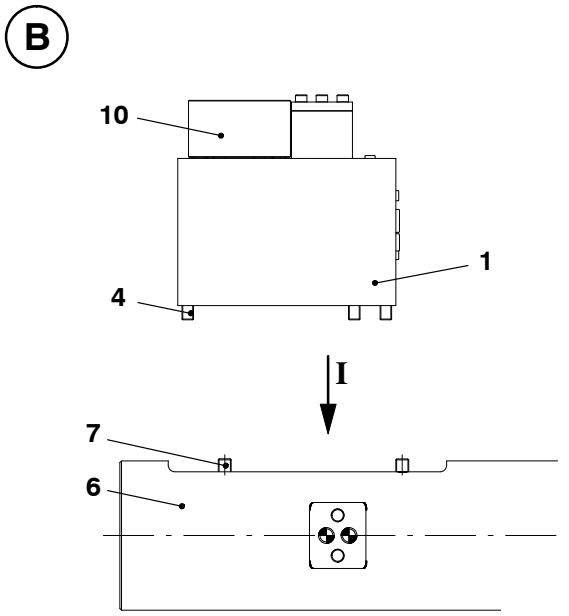
⇒ Disconnect plugs 18 from rail valve 3.

⇒ Loosen six screws 4.

⇒ Carefully lift the complete exhaust valve control unit (74 kg) with two eye-bolts M10 screwed into the cover 10.

⇒ Immediately cover opening in servo oil rail 6 and pipes to prevent dirt from entering.

Exhaust Valve Control Unit: Removal, Fitting, Dismantling and Assembling



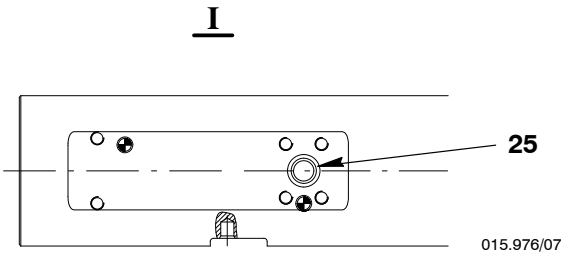
3. Fitting

⇒ Place new O-ring 25 into the groove of servo oil rail 6.

⇒ Lower the complete exhaust valve control unit onto the servo oil rail.

⇒ Apply oil to screws 4 and tighten them with a torque of **170 Nm**.

⇒ Install pipes. For fitting the hydraulic pipe to the exhaust valve control unit see 8460–1.



Exhaust Valve Control Unit: Removal, Fitting, Dismantling and Assembling

4. Dismantling of exhaust valve control unit

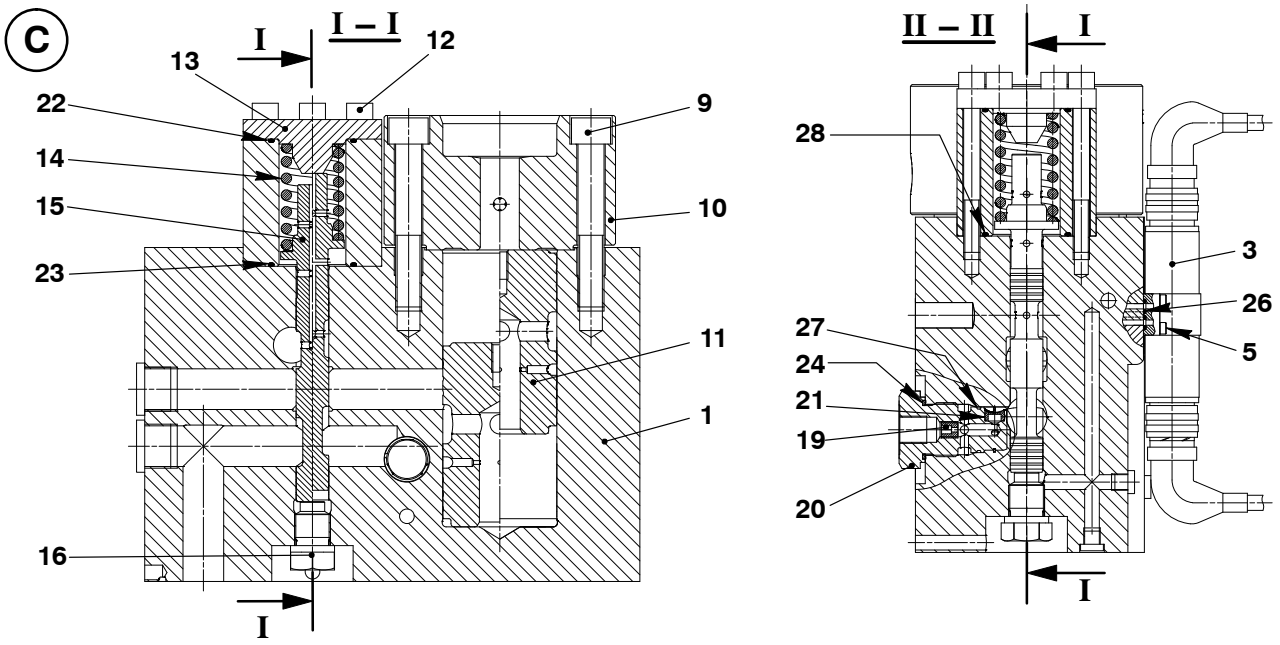
⇒ Loosen screws 9 and remove cover 10.

⇒ Withdraw piston 11 using a jacking screw M10.

⇒ Loosen screws 12 and remove cover 13.

⇒ Remove compression spring 14 and slide rod 15.

- In order to remove and clean filters 21, remove filter holder 20.
- Apply Loctite 222 to thread of throttle 19 and screw it into filter holder 20 with **10 Nm**.



5. Assembling of exhaust valve control unit

⇒ All O-rings must be replaced by new ones.

⇒ The threads of all screws, piston 11 and slide rod 15 (Fig. 'C') must be oiled prior to their fitting.

⇒ Equally tighten screws 9 with a torque of **170 Nm** and screws 12 with **40 Nm**.

⇒ Fit rail valve 3 with screws 5 and tighten them with a torque of **2.5 Nm**.

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Regulating Linkage

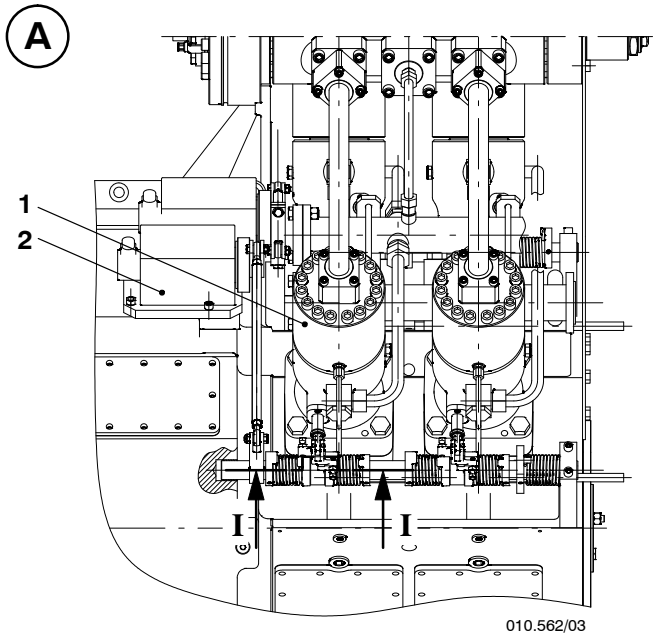
Adjusting

Key to Illustrations:

1	Fuel pump	8	DU bush
2	Actuator	9	Regulating (toothed) rack
3	Forked lever	10	Stop ring
4	Torsion spring	11	Flange
5	Pin	12	Lever
6	Adjusting screw	13a, b	Connecting rod
7	Limit lever		

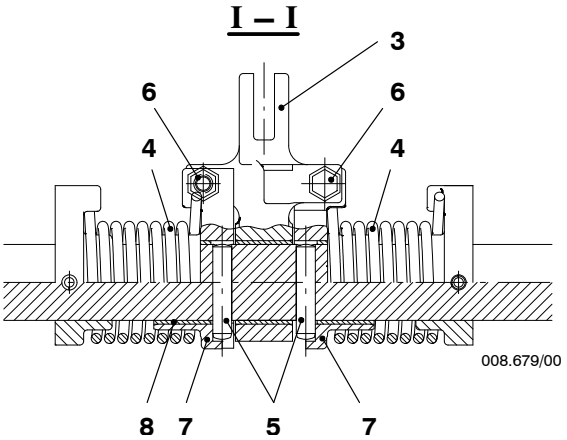
1. General

After overhauling the linkage or the fuel pumps, as well as after fitting a new fuel pump or a new actuator, the setting of the linkage must be checked and, if necessary, adjusted.



Attention! The power to the actuators 2 must be interrupted first, before they are disconnected from the regulating linkage (see 9362–1 in the Operating Manual).

2. Adjusting of regulating linkage



2.1 Setting of forked levers

⇒ Screw in adjusting screws 6 of all the forked levers just as far as they contact limit levers 7 without any clearance, and until there is no clearance between pins 5 and the limit levers.

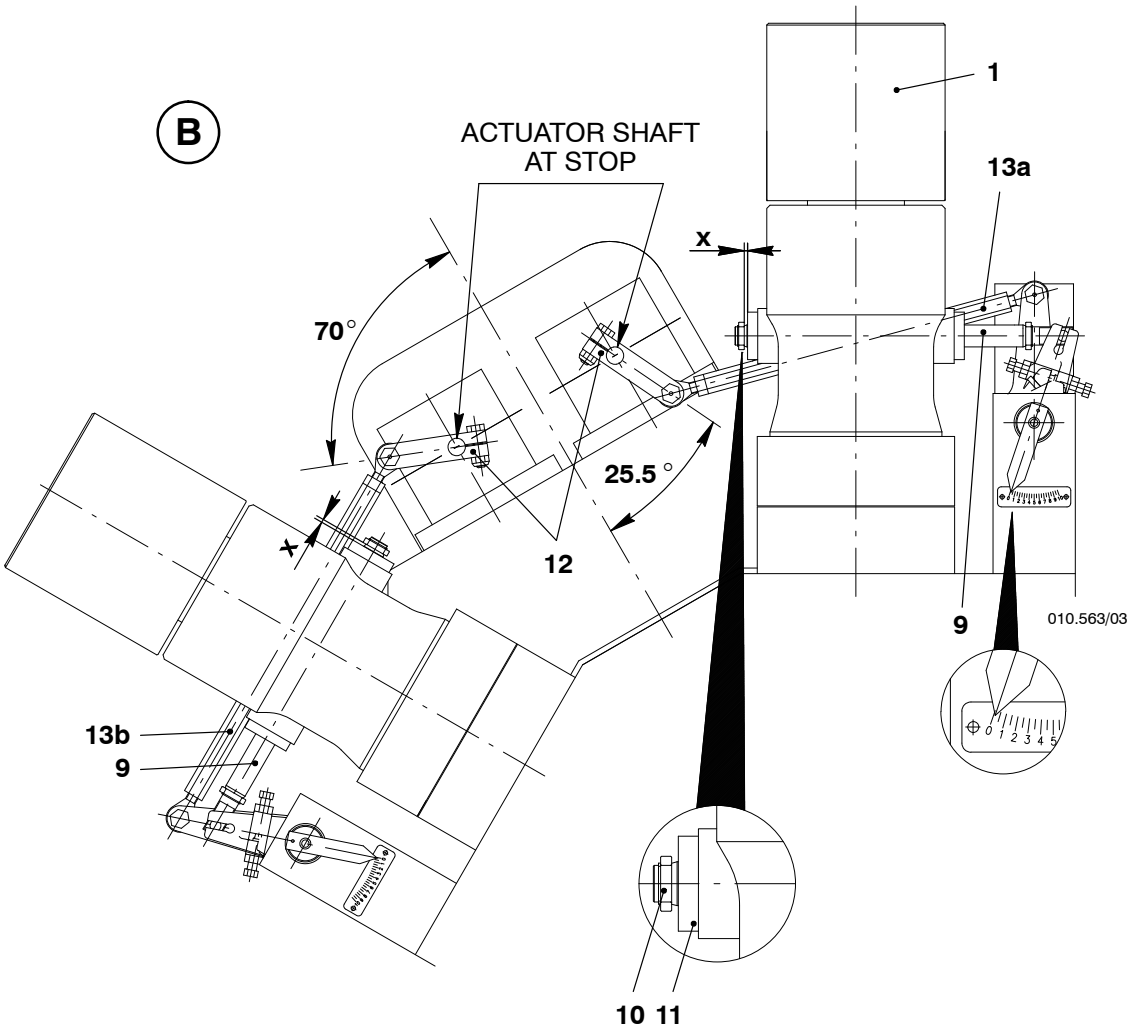
Regulating Linkage: Adjusting

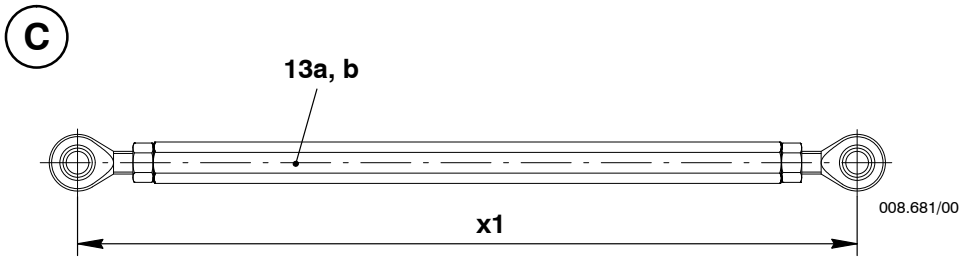
⇒ Set toothed racks 9 of actuator-side fuel pumps to dimension x = approx. 0.3 mm between stop ring 10 and flange 11.

⇒ Rotate the actuator shafts in counter-clockwise direction until they stop (position ’0’), then fit levers 12 as shown in Fig. ’B’.

⇒ Fit connecting rods 13a and 13b.

- Hole pitch ’x1’ of the connecting rods is 414 mm for 13a and 460 mm for 13b (Fig. ’C’).





Regulating Linkage: Adjusting

⇒ Set toothed racks 9 of actuator-side fuel pumps to dimension x2 = 36.6 mm (central position), the angle between levers 12 and connecting rods 13a and 13b being 90°.

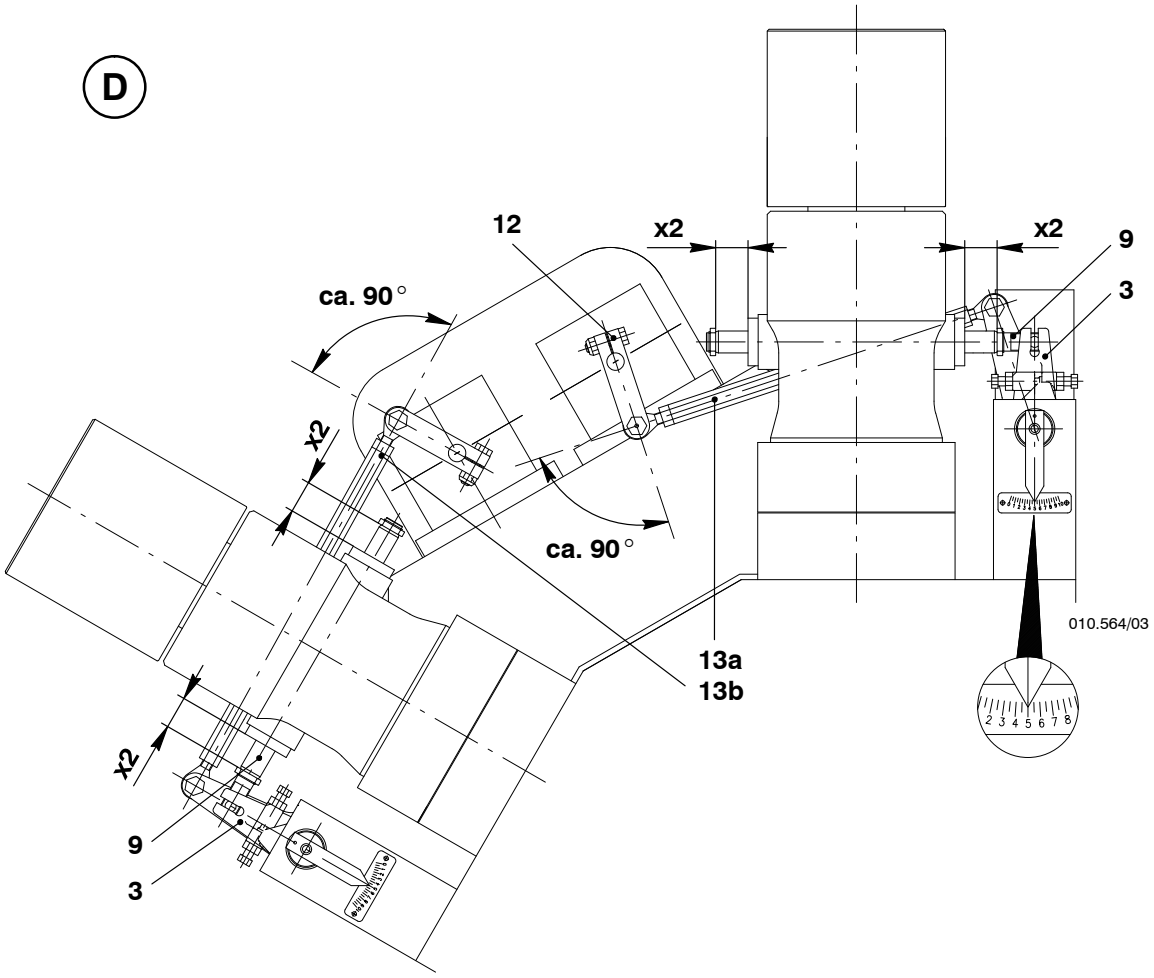
⇒ Set the toothed racks of the remaining fuel pumps to dimension x2 = 36.6 mm by means of the forked lever related to the corresponding fuel pump.
The permissible difference between the individual fuel pumps is ± 0.1 mm.

- The forked levers are adjusted by means of adjusting screws 6 (Fig. 'A', section I–I). Always screw in one adjusting screw while unscrewing the other by the same amount.

CHECK

Rotate the actuator shafts from stop to stop while checking the fuel linkage for ease of movement.
In both stop positions of the actuators all fuel pumps must show the dimension x = approx. 0.3 mm on the corresponding side of the toothed rack (Fig. 'B').

⇒ Secure adjusting screws 6 by a locking nut.



Scavenge Air Receiver and Auxiliary Blower Group 6

Scavenge Air Receiver: Checking the Air Flaps
and Cleaning the Scavenge Air Receiver 6420–1/A1

Auxiliary Blower: Maintenance 6545–1/A1

▽ **Scavenge Air Cooler**

– Cleaning (Water Side) on Engine at Standstill 6606–1/A1
– Removal and Fitting of Tube Stack 6606–2/A1

▽ **Water Separator**

– Maintenance of Water Separator (1-part Water Separator) 6708–1/A1
– Maintenance of Water Separator (2-part Water Separator) 6708–1/A2

Scavenge Air Receiver

Checking the Air Flaps and Cleaning the Scavenge Air Receiver

Key to Illustrations:

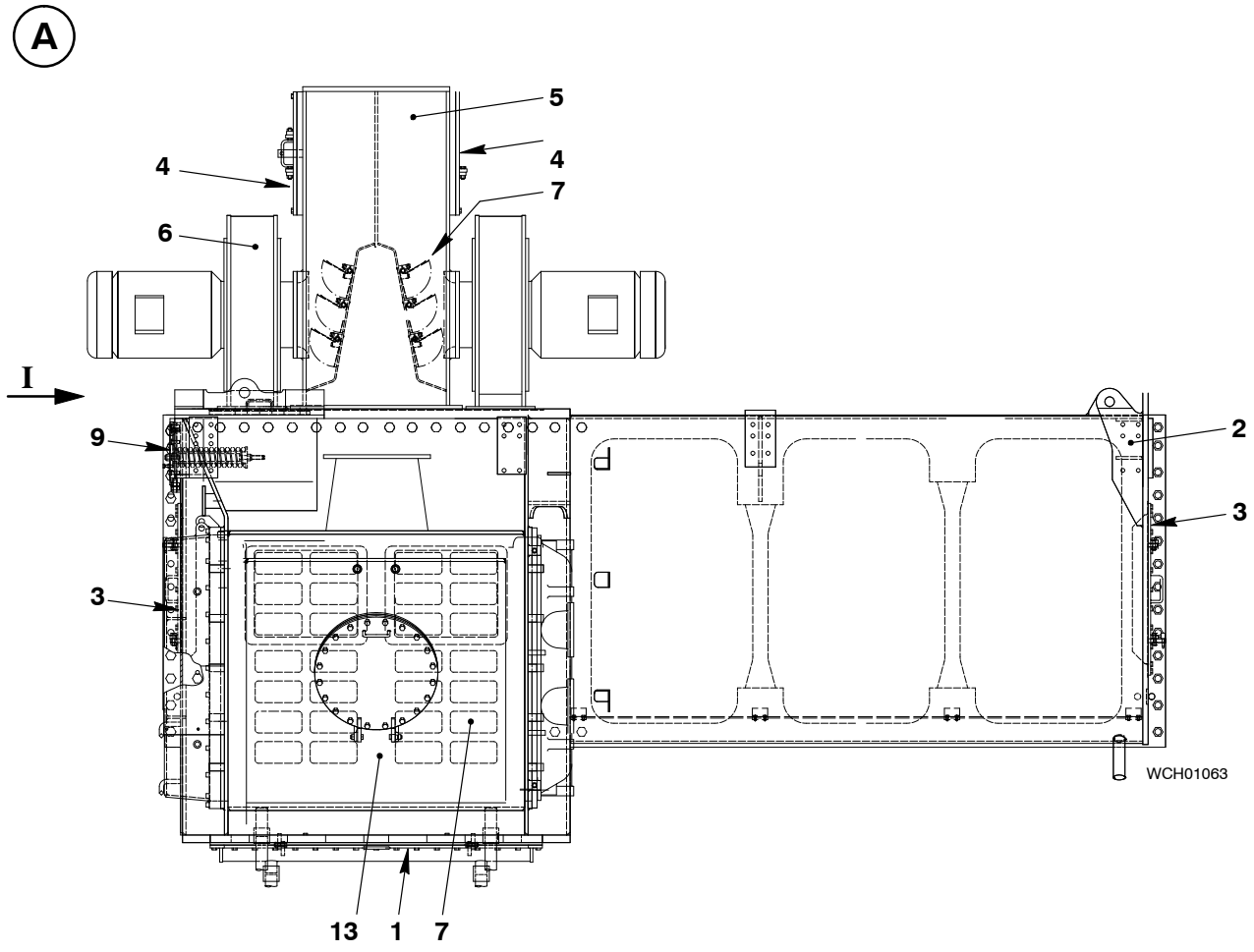
1	Hinged cover	8	Stop plate
2	Scavenge air receiver	9	Relief valve
3	Door	10	Water drainage piping
4	Inspection cover	11	Screw
5	Fixed support (suction space)	12	Distance ring
6	Auxiliary blower	13	Inspection cover
7	Air flap	14	Cover

1. Inspection of air flaps

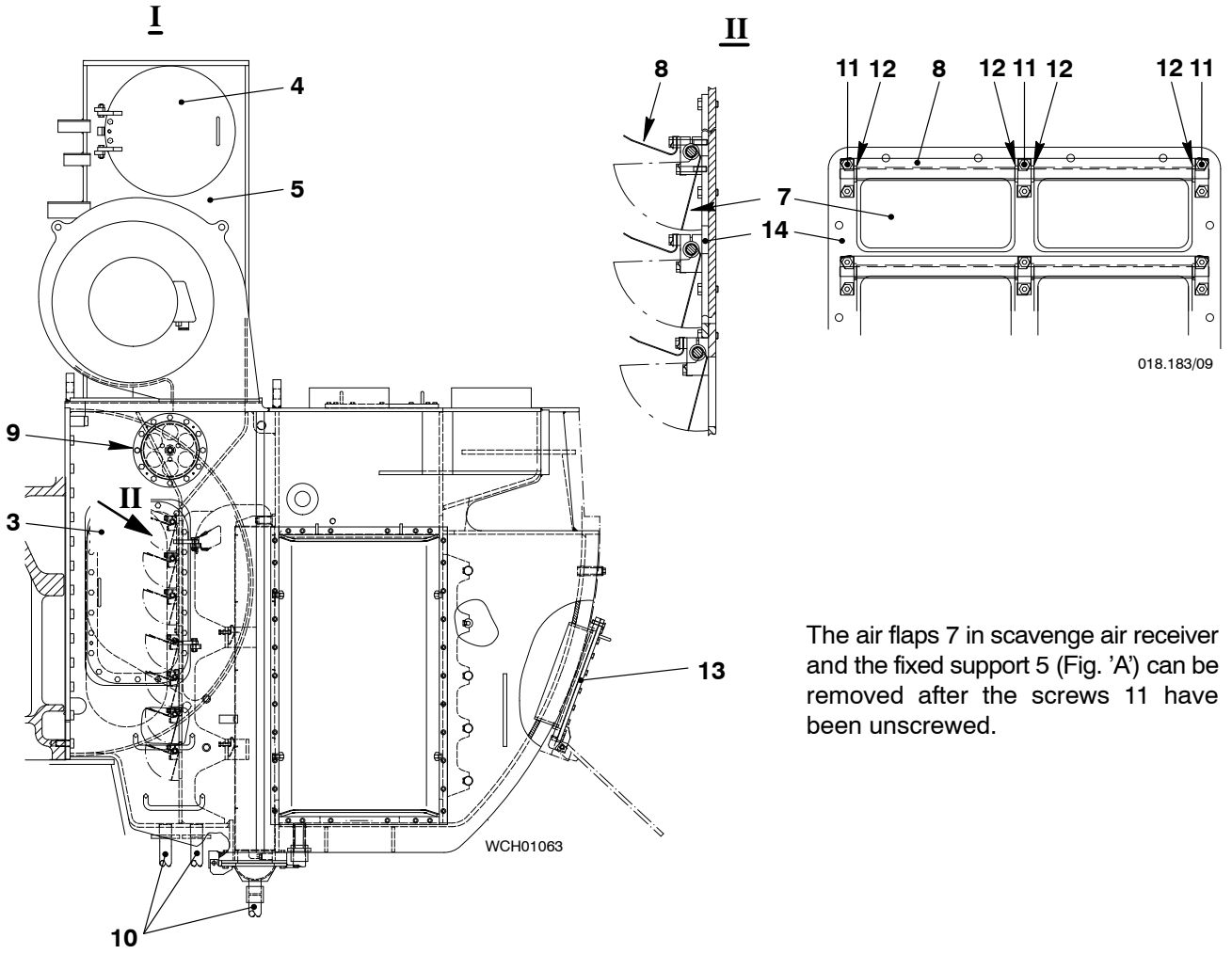
Air flaps 7 arranged in the scavenge air receiver and in fixed support 5 must be checked for damage, movability as well as fouling, in the course of the periodic cleaning of the scavenge air receiver (see 0380–1).

The air flaps in the receiver are reached through openings on the front sides of the scavenge air receiver, by loosening doors 3 and folding them back laterally.

To check the air flaps for auxiliary blowers 6, both inspection covers 4 at fixed support 5 are to be opened.



Checking the Air Flaps and Cleaning the Scavenge Air Receiver



The air flaps 7 in scavenge air receiver and the fixed support 5 (Fig. 'A') can be removed after the screws 11 have been unscrewed.

2. Cleaning the scavenge air receiver

Scavenge air receiver 2 should be checked for cleanliness at regular intervals (see 0380–1), however, always after a piston overhaul or after regular maintenance in the piston underside.

In particular check whether water drain piping 10 from the scavenge air receiver is not clogged, so that a permanent drainage is assured during operation.

CHECK

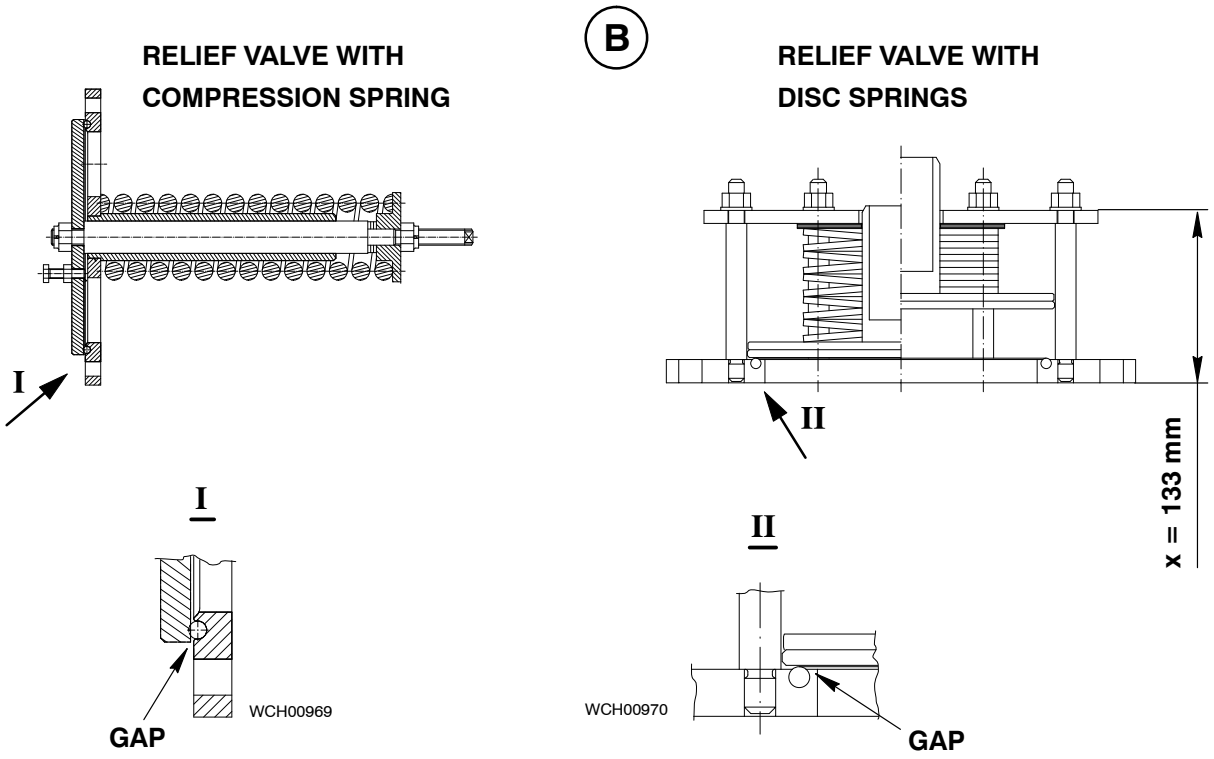
During a major overhaul check O-ring and spring preload of relief valve 9 as follows:

- Gap between metal must be visible (O-ring intact).
- Preload distance x must correspond to the value in Fig. 'B'.

If any defect or heavy rust is visible, replace the relief valve.

Remark: Do not open the relief valve with disc springs! In case of any damages or malfunctions please contact the manufacturer or Wärtsilä Switzerland Ltd.

Checking the Air Flaps and Cleaning the Scavenge Air Receiver



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Auxiliary Blower

Maintenance

	Tools:	
1	Spur-geared chain block (WLL 1000 kg)	94650
1	Dismantling device	94651
	consisting of:	
1	Trolley	94651C
2	Centring studs	94652

	Key to Illustrations:		
1	Electric motor	6	Fixed support
2	Motor plate	7	Screw
3	Spiral casing	8, 8a	Screw
4	Impeller	9	Longitudinal I-beam
5	Receiver	10	Exhaust manifold

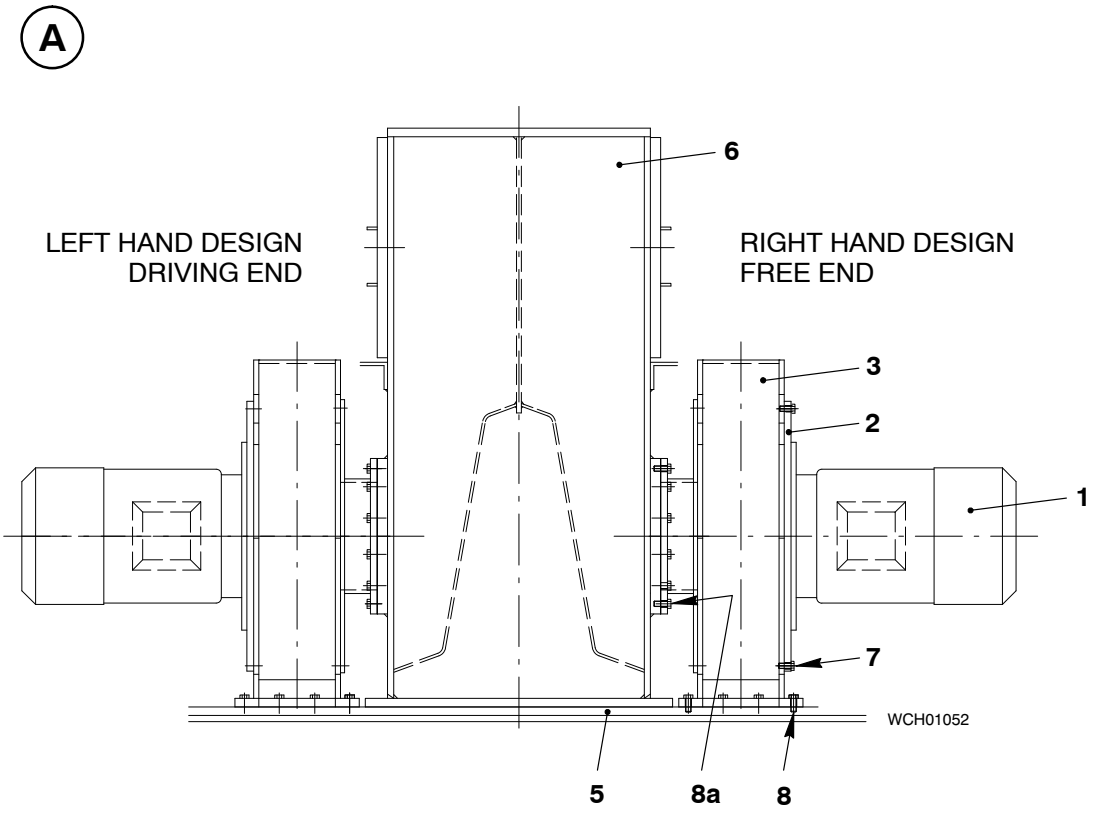
Overview

1. General 1/3
2. Removal 2/3
3. Dismantling 3/3
4. Fitting 3/3

1. General

The auxiliary blowers are fastened with screws 8, 8a to fixed support 6 and machined receiver surfaces 5 without any shims.

Auxiliary blowers which are out of service for a longer period should be started up for a short time twice a month. Where this is not feasible, the impeller should be turned by hand by several turns. This is necessary to protect the bearings from corrosion damage.



Auxiliary Blower: Maintenance

2. Removal

Remark: Pay attention to General Guidelines for Lifting Tools 0012–1.

⇒ Install trolley 94651C and spur-geared chain block 94650 (WLL 1000 kg) on the longitudinal I-beam 9.

⇒ Attach electric motor 1 to spur-geared chain block with corresponding ropes.

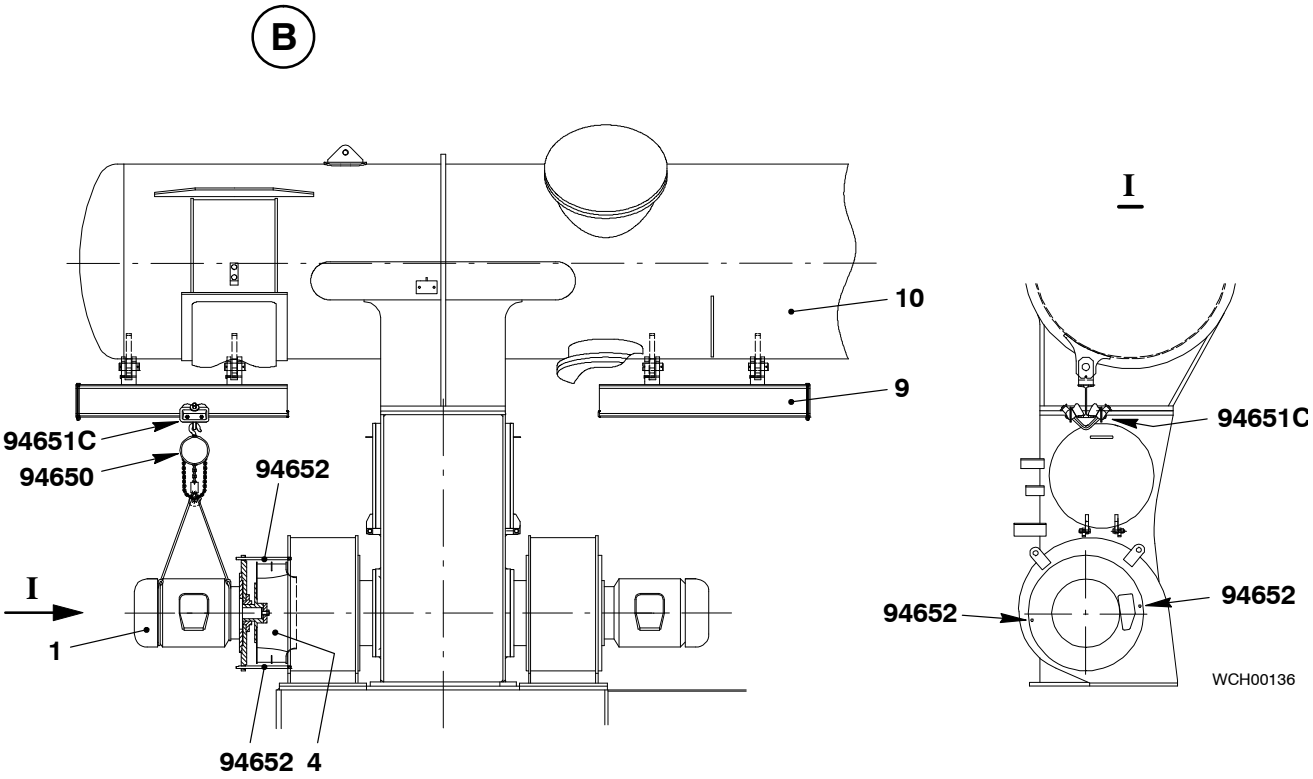
⇒ Unscrew two screws 7 (Fig. 'A') facing each other, then screw in two centring studs 94652 instead.

⇒ Unscrew the remaining screws of motor plate 2.

⇒ Separate the motor plate from the spiral casing with two jacking screws if necessary.

⇒ Extract electric motor with plate and impeller 4 from spiral casing in horizontal direction.

Attention! When removing take care not to damage the impeller.



Auxiliary Blower: Maintenance

3. Dismantling

For dismantling works and maintenance of the auxiliary blower, please comply with the instructions of the manufacturer.

The impeller is statically and dynamically balanced, and therefore must in no way suffer damage. The impeller must be rebalanced in case of any damaged or replaced parts turning together with the motor shaft.

4. Fitting

⇒ Fit both centring studs 94652.

⇒ With the aid of trolley 94651C and spur-geared chain block 94650 fit electric motor 1 including impeller 4 into spiral casing 3 and firmly tighten screws 7 crosswise.

⇒ Remove centring stud and replace it by screws.

⇒ Connect electric motor to mains and check direction of rotation.

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Scavenge Air Cooler

Cleaning (Water Side) on Engine at Standstill

Tools:

Tube brushes

Key to Illustrations:

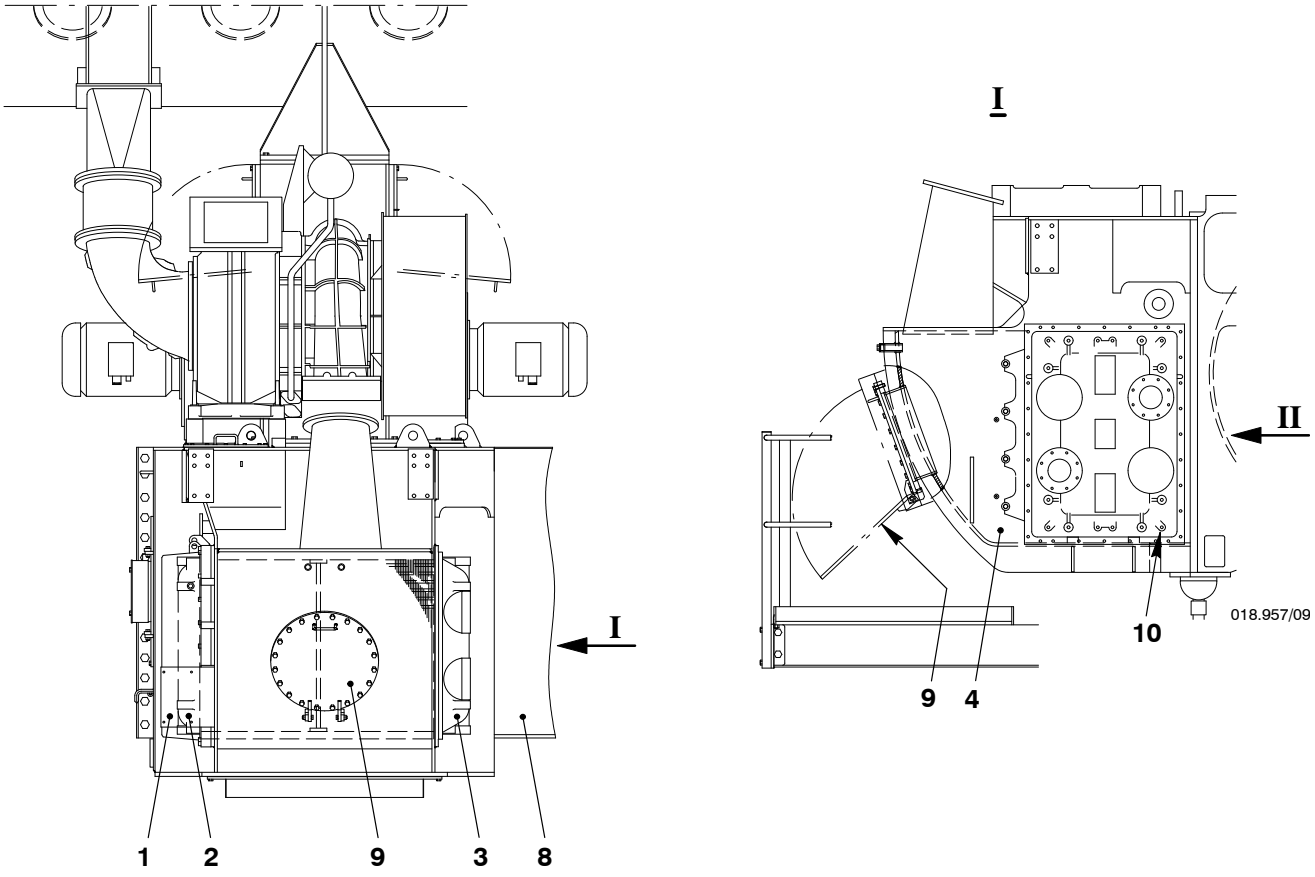
1 Cover
2 Return chamber
3 Connection chamber
4 Air duct before cooler
5 Cooling tubes
6 Cooling fins
7 Tube plate
8 Scavenge air receiver
9 Hinged cover
10 Drain

1. General

Depending on the cleanliness of the utilized cooling water a cleaning of the cooler tubes is required after a shorter or longer operating period. The necessity to clean becomes evident by measuring the temperature difference between cooling water inlet and outlet, and comparing this with the values recorded in the acceptance trials.

When using clean, neutral cooling water, cooling tube cleaning will be only rarely necessary.

A



Scavenge Air Cooler: Cleaning (Water Side) on Engine at Standstill

2. Cleaning methods

The cooling tubes can be cleaned by mechanical, by hydraulic or by chemical means.

2.1 Mechanical cleaning in fitted condition

⇒ First unscrew and remove the cover 1 (Fig. 'A').

⇒ Remove return chamber 2 and connection chamber 3 of the scavenge air receiver.

⇒ Remove the dirt accumulated in the tubes by means of special tube brushes and then flush away with water.

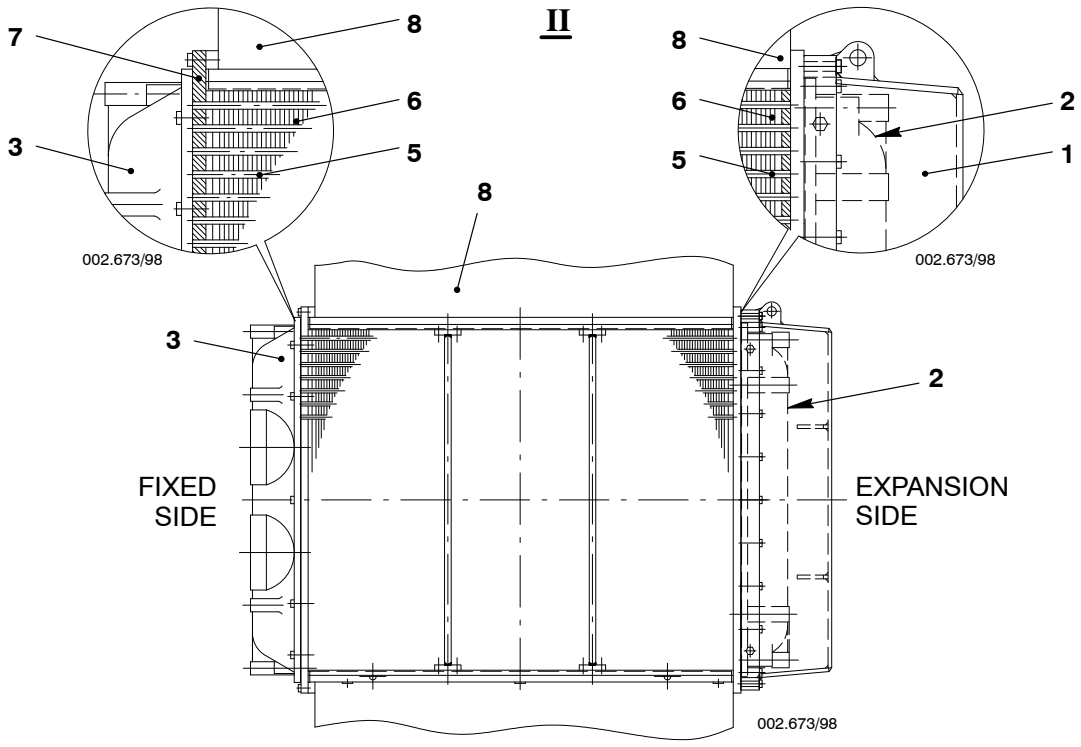
2.2 Hydraulic cleaning in fitted condition

Firmly adhering sediment which is not dislocated by the brush can be removed with high pressure water jets. Spray devices with special nozzles are used, which can be ordered from the cooler manufacturers.

2.3 Cleaning by chemical solvents in removed condition (removal see 6606–2)

Should the above-mentioned methods not be successful then chemical means must be utilized. By this the tube stack is immersed in a chemical cleansing bath, then flushed through with a strong water jet. During the cleansing process the effectiveness can be increased by circulating the chemical through the tubes, whereby the immersion time can be reduced.
For this type of cleaning the instructions of the cleaning agent makers must be strictly followed.

When choosing the cleaning agent we recommend using only products of renowned firms of this line such as: DREW, VECOM, GAMLEN, HENKEL, etc.



Scavenge Air Cooler: Cleaning (Water Side) on Engine at Standstill

3. Locating and sealing of leaking cooler tubes in service

Due to corrosion or mechanical damage tube leakages may occur. This causes cooling water to enter the air duct before cooler 4 and the scavenge air receiver 8.

If it is not possible to wait with the localization or sealing of leaky cooling tubes, this can be carried out during operation.

Proceed as follows:

⇒ Reduce engine power, until the air temperature before scavenge air cooler reaches about 65 to 70 °C, then shut off the water valves before and after the defective cooler and drain the cooler at connection 10.

⇒ Remove connection chamber 3 and brush soapy water over the pipe openings of cooling tubes 5. Leaking tubes will be revealed by soap bubbles.

⇒ Defective tubes are sealed up by hammering in slightly tapered plugs of hardwood, copper etc.

⇒ Stop the engine.

⇒ Remove cover 1 and return chamber 2.

⇒ Seal the same cooling tubes as on the opposite side.

⇒ Complete the scavenge air cooler again, thereby seal the return chamber and connection chamber as well as the cover with liquid sealing agent.



Danger of accident! Cover 1 (pressurized) must not be removed due to hot scavenge air while the engine is running!

4. Transportation of cooler tubestacks

Always utilize specially provided transport straps 'TR' (see 6606–2) which can be swung sideways. Where only holes are provided, use suitable shackles for transportation.

It is recommended to cover the finned surfaces, protecting the cooling fins and preventing the entrance of foreign particles during transportation and storage.

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Scavenge Air Cooler

Removal and Fitting of Tube Stack

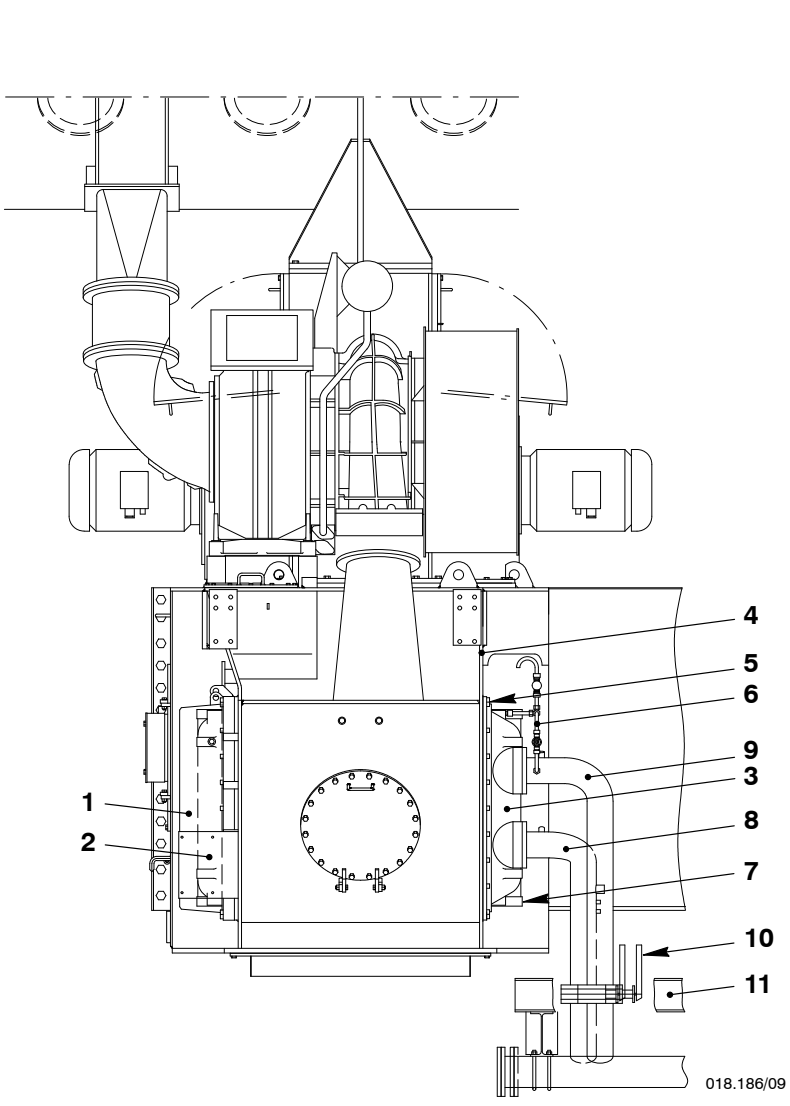
	Tools:	
1	Manual ratchet	94016 (H1)
1	Device complete consisting of:	94661
1	Roller plate	94662(A)
1	Dismantling and assembling device	94663A(B)
1	Pulley support	94664
1	Pin	94665
1	Roller	94665A

Key to Illustrations:

1	Cover	13, 13a	Screw
2	Return chamber	14	Packing strip
3	Connection chamber	15	Double spring clip
4	Scavenge air receiver	16	Support
5	Screw		
6	Vent		
7	Drain		
8	Cooling water inlet	AH	Stop lever
9	Cooling water outlet	DF	Sealing surface
10	Butterfly valve	ST	Setscrews
11	Rail	TR	Transport straps
12	Tube stack	ZS	Pull rope

1. General

The scavenge air cooler must be drained by means of drain 7 before removing a tube stack.

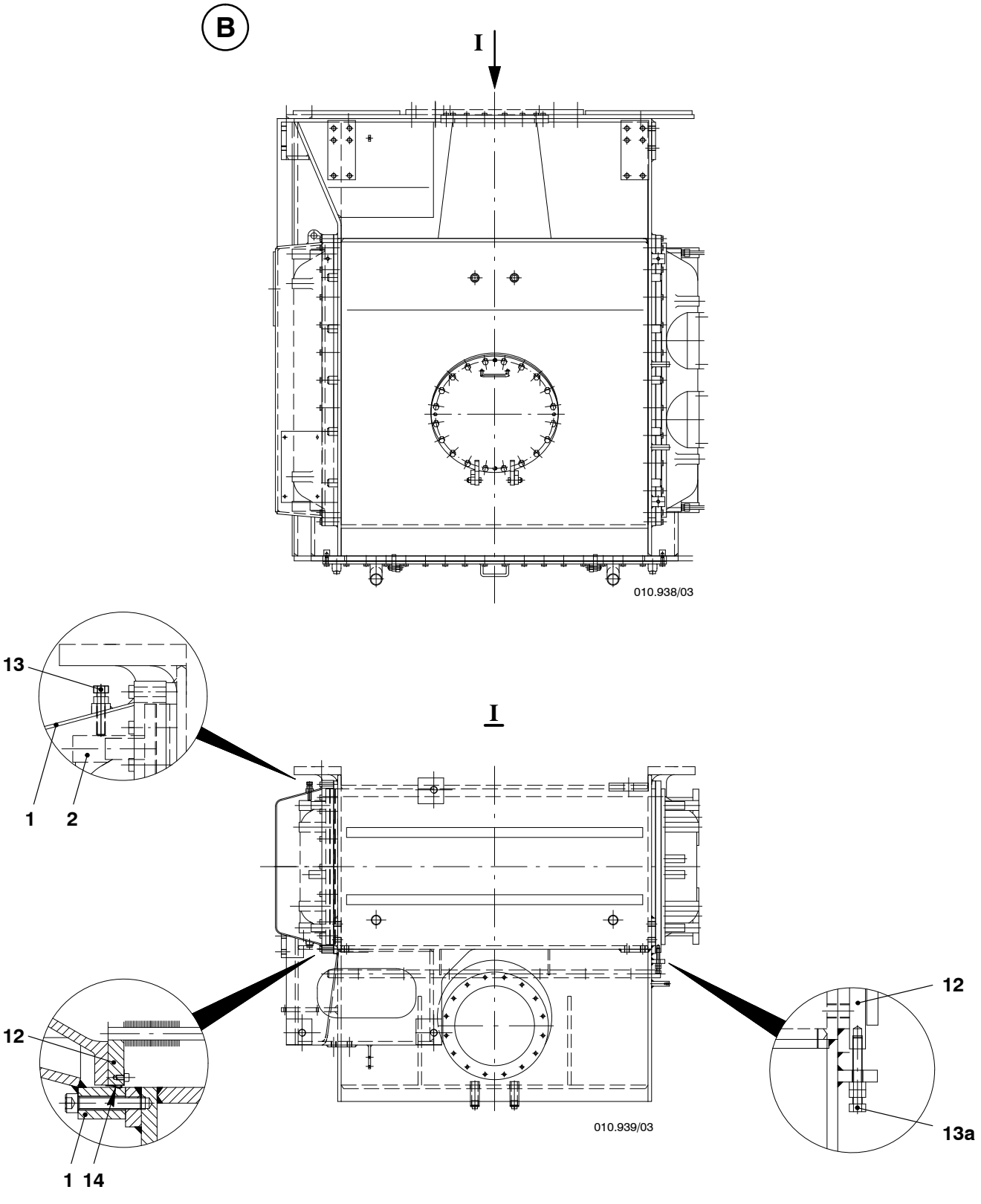


Scavenge Air Cooler: Removal and Fitting of Tube Stack

2. Removal

⇒ Loosen screws 13 in cover 1.

⇒ Remove screws 13a from tube stack 12.



Scavenge Air Cooler: Removal and Fitting of Tube Stack

⇒ Mount pin 94665 and roller 94665A on the corresponding support as shown in Fig. ’C’. Lock pin with its double spring clip 15.

⇒ Fasten manual ratchet ’H1’ to the upper support 16 and connect it to cover 1 via roller 94665A.

⇒ Loosen screws to cover 1, lower it to bottom plate and and push it to the side.

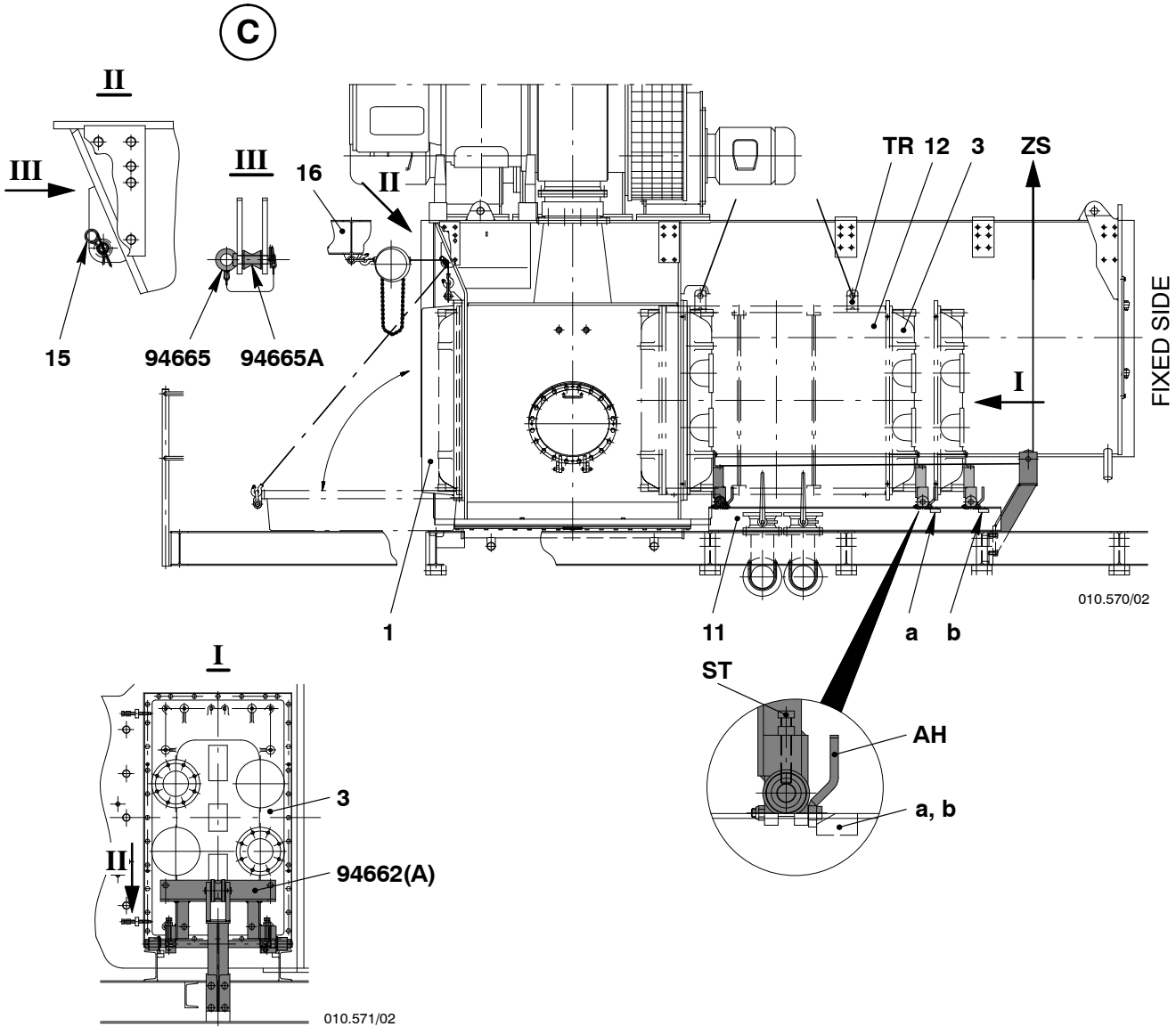
⇒ Remove vent pipe 6 and drain pipe 7.

⇒ Remove cooling water inlet pipe 8 and cooling water outlet pipe 9 between connection chamber 3 and butterfly valve 10.

⇒ Loosen screws 5 of the screw connection to tube stack 12 for scavenge air receiver 4 (Fig. ’A’).

⇒ Fix roller plate 94662(A) at connection chamber 3. Press the rollers a little against rails 11 by means of setscrews ’ST’ (Fig. ’C’).

⇒ Loosen the tube stack from the scavenge air receiver with the aid of jack screws. As soon as the tube stack is free, lift it a little by tightening setscrews ’ST’.



Scavenge Air Cooler: Removal and Fitting of Tube Stack

⇒ Fasten pulley support 94664 to the platform support which is near connection chamber 3 (designated also as fixed side). Attach pull rope 'ZS' of pulling tackle on roller plate and pull the tube stack out until arrester stop (see Fig. 'C').

⇒ Cover the cooling fins of the tube stack.

⇒ Connect the four transport straps 'TR' (see Fig. 'C') of the tube stack with wire ropes and attach them to the engine room crane. Tighten wire ropes.

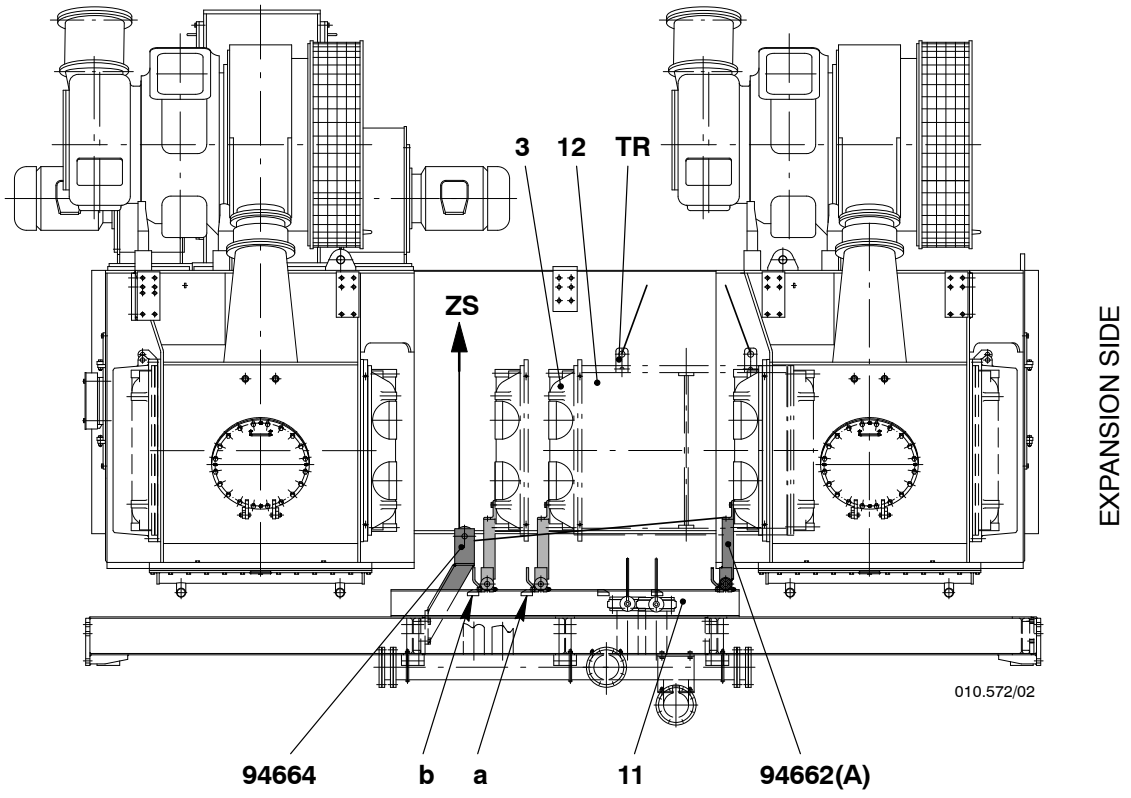
⇒ Raise stop lever 'AH' (see Fig. 'C') of roller plate and pull tube stack out of the scavenge air receiver until stop 'b'. Draw with the engine room crane at the same time, thereby the wire ropes should always be tensioned!

⇒ Lift tune stack and remove roller plate.

⇒ Move the tube stack with the engine room crane out of the engine room.

- The same procedures apply to the removal of a tube stack for engines provided with two scavenge air coolers (Fig. 'D') as described above, however, the inlet and outlet pipes must also be removed from both scavenge air coolers.

D



Scavenge Air Cooler: Removal and Fitting of Tube Stack

3. Fitting

⇒ Mount pulley support 94664 on the platform support nearest to the fixed side (Fig. 'E').

⇒ With the help of the engine room crane, lower tube stack to the fitting height and fasten roller plate 94662(A) and assembling device 94663A(B).

⇒ Apply non-hardening sealing compound to sealing surface 'DF'.

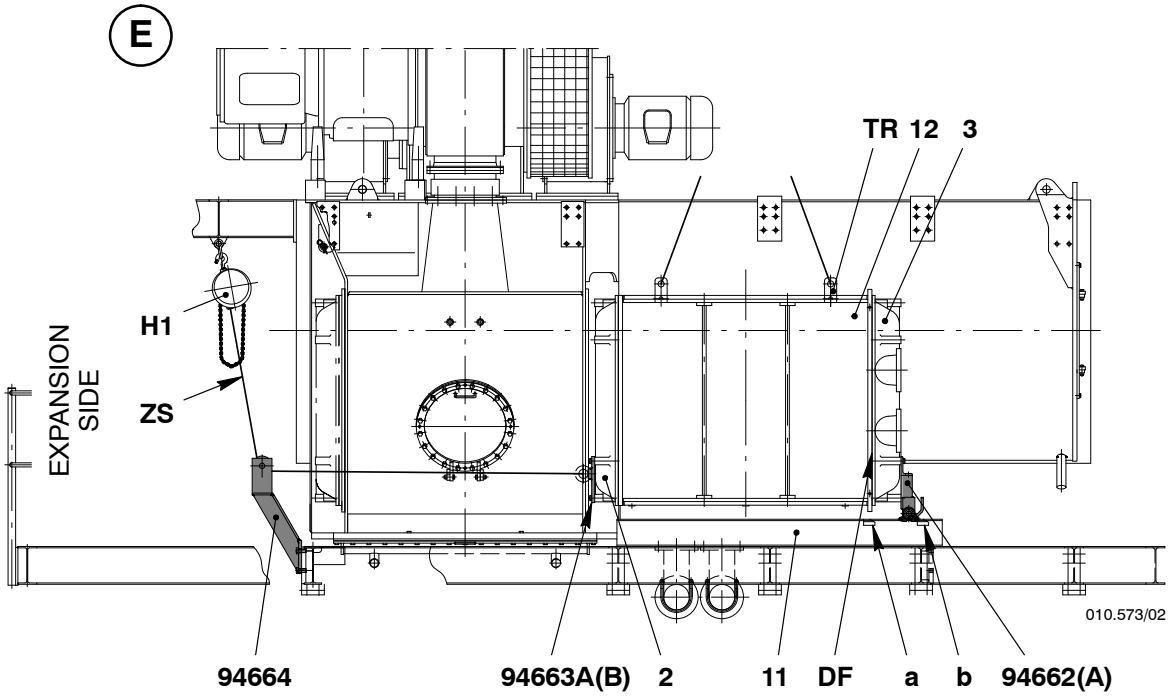
⇒ Place tube stack with fixed roller plate onto the rails 11.

⇒ With the engine room crane and pulling rope 'ZS', pull tube stack into the cooler casing until arrester stop 'a' (Fig. 'E').

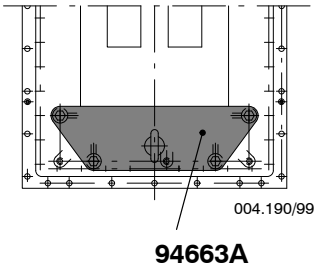
⇒ Remove wire ropes to transport straps 'TR'.

⇒ Raise stop lever 'AH' (Fig. 'C') of the roller plate and pull tube stack completely into the casing. Take care that the cooler element is slightly raised from cooler casing bottom by setscrews 'ST' (Fig. 'C').

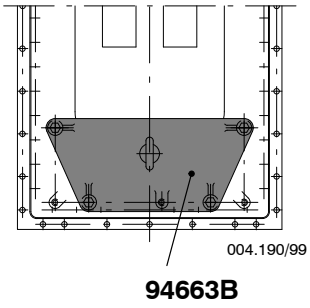
- The fitting of a tube stack for engines provided with one or two scavenge air coolers is carried out in the same way, however, the tools must be arranged as shown in Fig. 'F'.



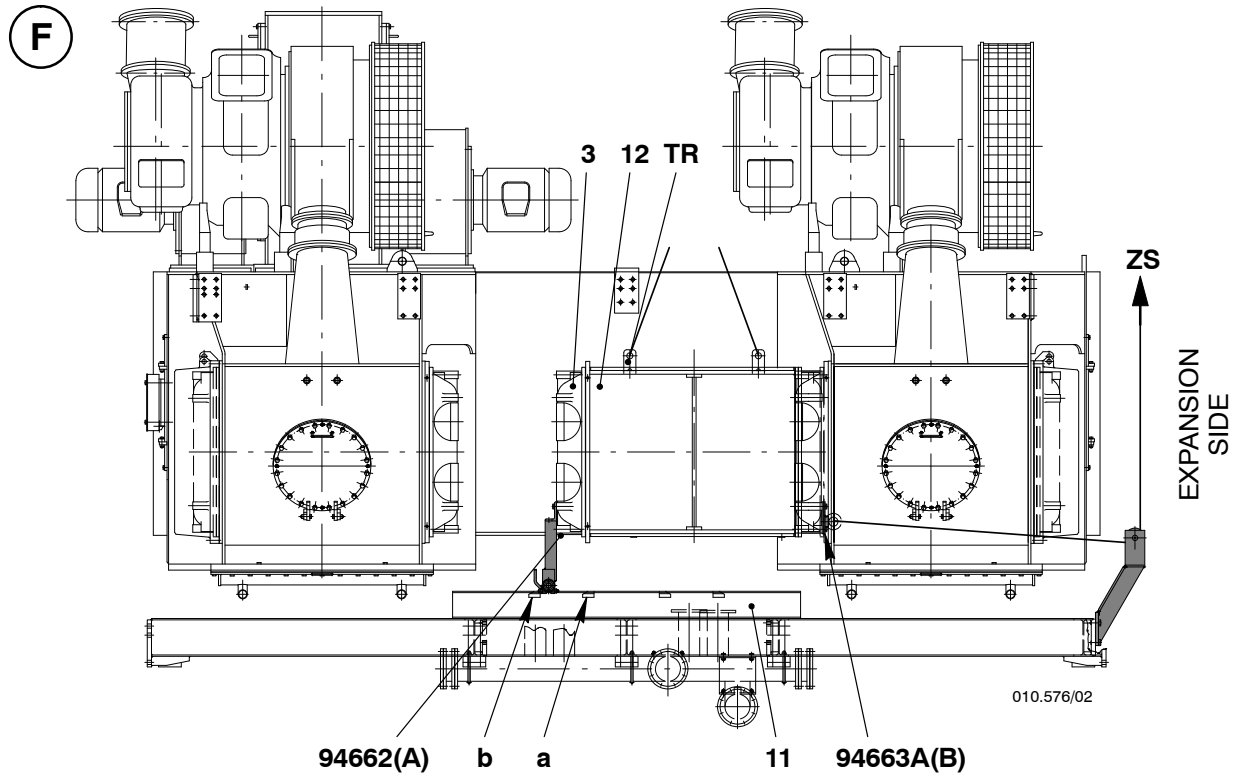
COOLER GEA 120/30/24/6



COOLER GEA 150/38/24/6



Scavenge Air Cooler: Removal and Fitting of Tube Stack



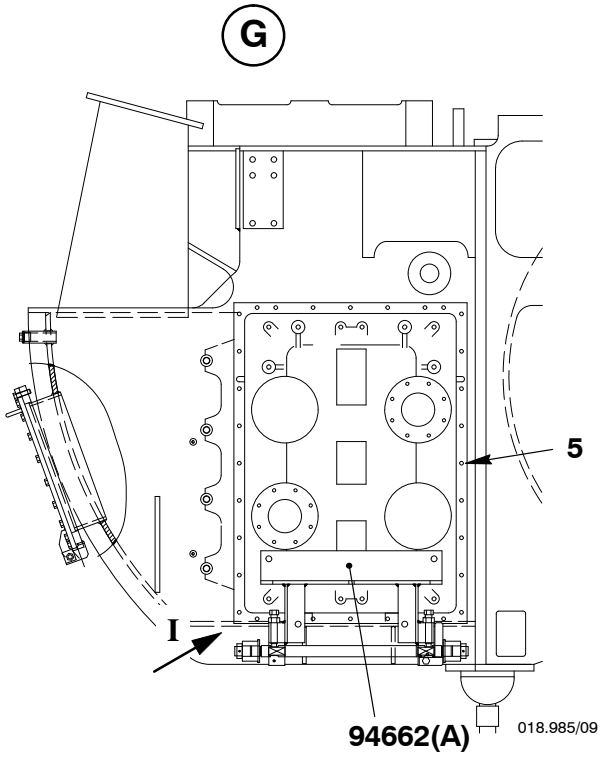
3.1 Final assembly

⇒ Screw in as much as possible of screws 5.

⇒ Push / pull tube stack 12 towards the air side by means of screws 13, 13a.

⇒ Remove pulley plate 94662(A).

⇒ Screw in remaining screws 5. Subsequently tighten all screws.



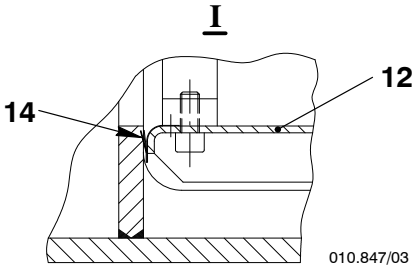
⇒ Remove assembling device & pulley support.

⇒ Connect piping, close drains 7, open vents 6 and butterfly valves 10.

⇒ Start cooling water pump and check tube stack for possible leaks.

⇒ Fit cover 1 and seal it with non-hardening sealing compound.

Remark: The connection of cooling water outlet 9 is arranged in such a way that it is always near to the scavenge air inlet into the receiver.



Water Separator

Maintenance of Water Separator 1-part Water Separator

Tools:

2	Manual ratchets (WLL 800 kg)	94016 (H1)

Key to Illustrations:

1	Receiver	10	Tension washer
2	Air flaps	11	Door
3	Water separator	12	Coupling
4	Cover on WS	13	Water drain
5	Seal	14	Cover
6	Screw	15	Screw
7	Plate		
8	Screw		
9	Spring pack	AF	Seating face

1. General

The water separator should be inspected after completing the first operating year. The cleaning interval for future servicing should be established on the basis of the degree of contamination found. If the air suction filter of the exhaust gas turbocharger is well maintained, the degree of contamination of the water separators should not be considerable.

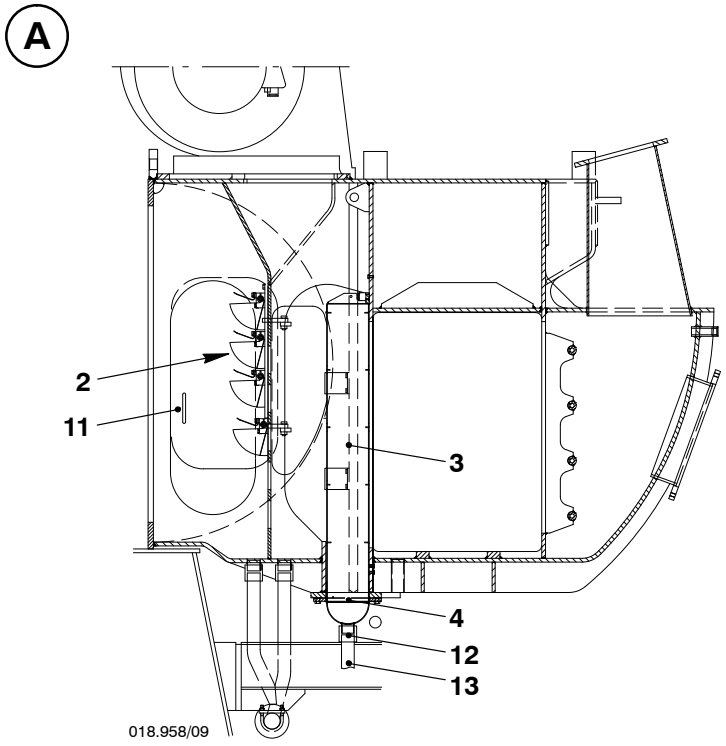
2. Inspection

⇒ Open door 11 on one side of the scavenge air receiver.

⇒ Enter the scavenge air receiver, tilting up air flaps 2, and check water separator 3 for damage and fouling.

⇒ Separate couplings 12 from water drains 13.

CHECK Check the water drains for free passage.



3. Removal

⇒ Fasten manual ratchets 'H1' to the corresponding lugs in the receiver, connect and tighten them with the water separator.

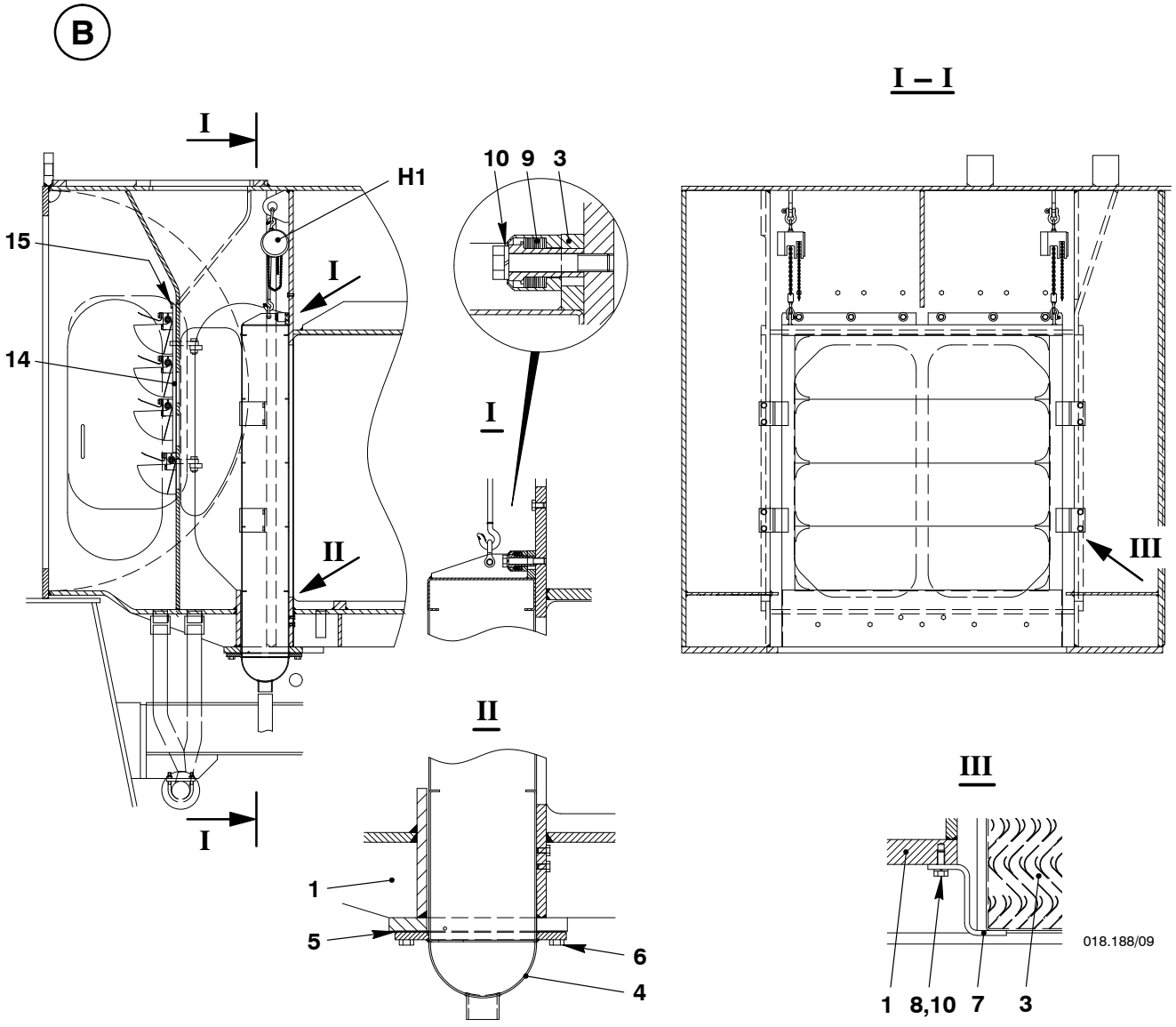
⇒ Remove screws 15 and put both covers 14 with their air flaps 2 fitted (approx. 47 kg each) on the bottom of receiver 1.

⇒ Loosen screws 8 and remove them together with plates 7.

⇒ Loosen and remove spring packs 9.

⇒ Loosen screws 6 on cover 4 to the water separator.

⇒ Carefully lower the water separator.



4. Cleaning

The water separator should be cleaned with the same media as used for cleaning the scavenge air cooler in operation.

- Do not use any sharp tools for cleaning.

5. Fitting

- Before fitting the water separator, its location in the scavenge air receiver must be thoroughly cleaned and the water drains checked for free flow. Furthermore seal 5 must be in perfect condition.

⇒ Apply a high-temperature (approx. 300 °C) silicone sealing compound e.g. COLTOGUN to all seating faces 'AF', thus avoiding an air bypass between frame and wall.

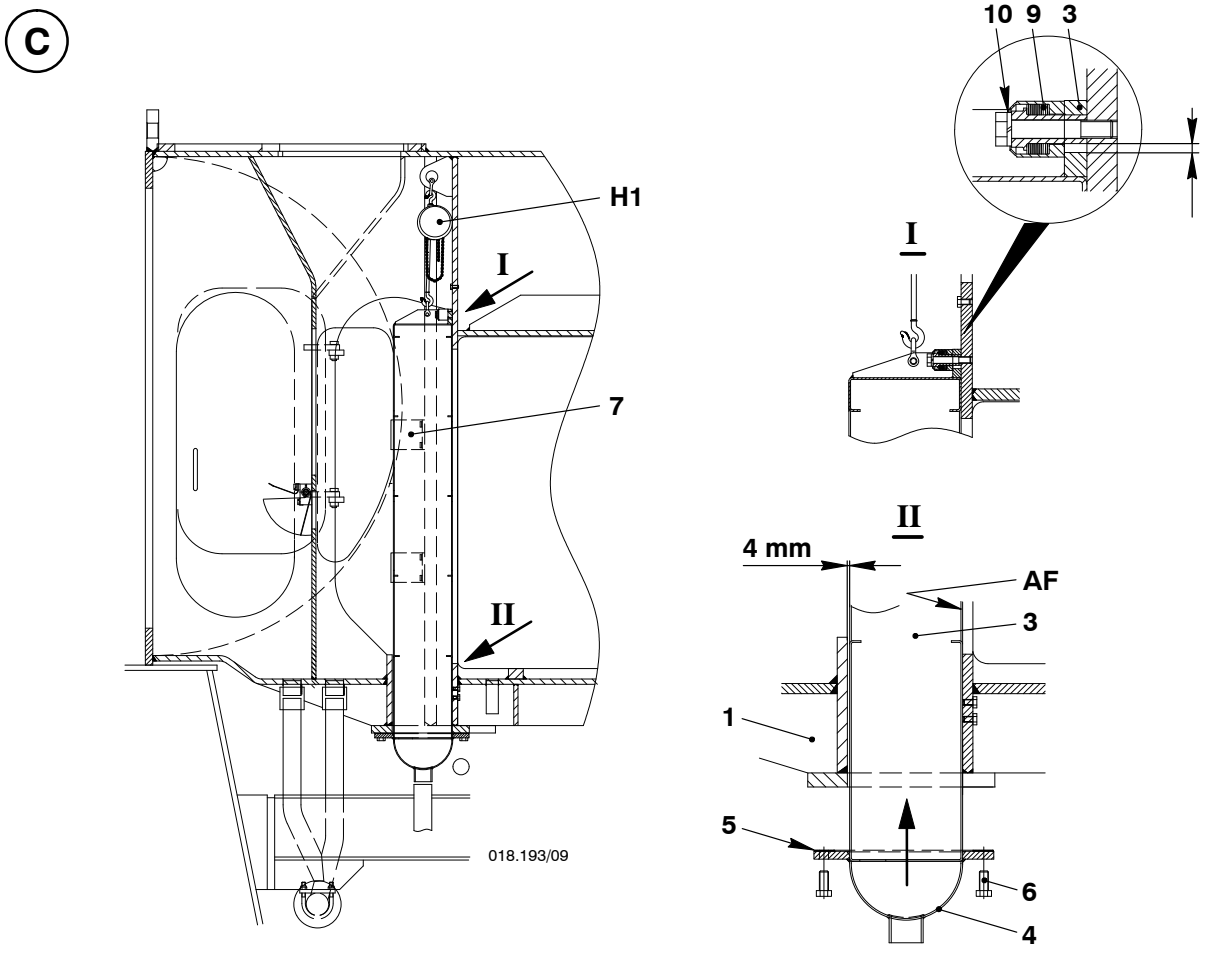
⇒ Carefully lift water separator 3 by means of manual ratchets 'H1' until cover 4 rests on the receiver. Insert screws 6.

⇒ Fit spring packs 9 with tension washer 10, paying attention to clearance 'x_1' on bottom side, and place plates 7 by means of screws 8 with tension washer 10. However do not tighten yet neither the spring packs nor the screws.

⇒ Fasten cover 4 by means of screws 6.

⇒ Carefully loosen manual ratchets 'H1' and tighten all spring packs and screws 8.

⇒ Install cover 14 with air flaps 2. Close door 11 and reconnect couplings 12.



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Water Separator

Maintenance of Water Separator 2-part Water Separator

Tools:

2	Manual ratchets (WLL 800 kg)	94016 (H1)

Key to Illustrations:

1	Receiver	12	Screw
2	Air flaps	13	Sleeve
3	Water separator	14	Pressure spring
4	Hinged cover	15	Disc
5	Screw	16	Door
6	Intermediate flange	17	Coupling
7	Screw	18	Water drain
8	Spring washer	19	Supporting plate
9	Tension sleeve		
10	Screw		
11	Cover	AF	Seating face

1. General

The water separator should be inspected after completing the first operating year. The cleaning interval for future servicing should be established on the basis of the degree of contamination found. If the air suction filter of the exhaust gas turbocharger is well maintained, the degree of contamination of the water separators should not be considerable.

2. Inspection

⇒ Open door 16 on one side of the scavenge air receiver.

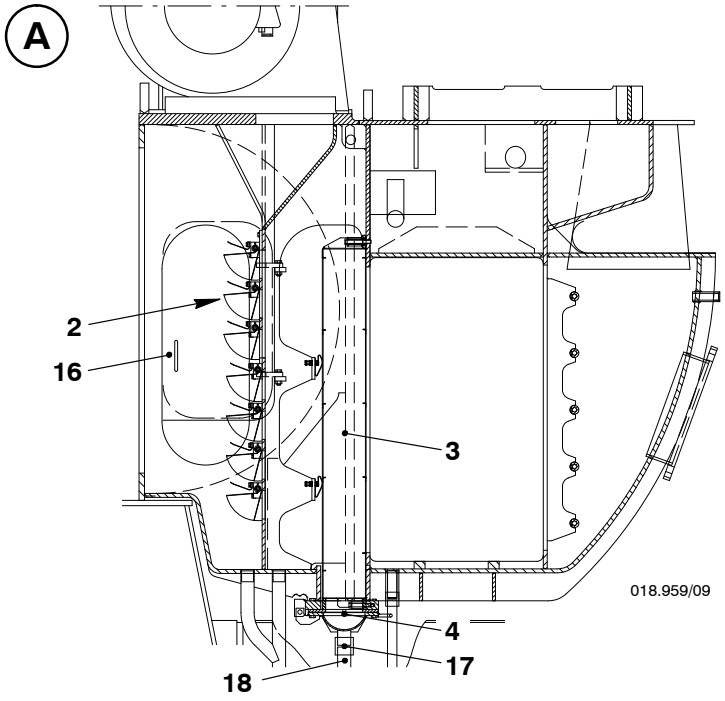
⇒ Enter the scavenge air receiver, tilting up air flaps 2, and check water separator 3 for damage and fouling.

⇒ Separate couplings 17 from water drains 18.

⇒ Unscrew hinged cover 4 (52 kg) and tilt it down by means of a manual ratchet.

CHECK

Check the water drains for free passage.



3. Removal

Remark: If the water separators must be dismantled above the supply unit, the half close to the free end must be removed first!

⇒ Open hinged cover 4 and door 16 (Fig. 'A').

⇒ Remove screws 4 and intermediate flange 5.

Risk of accident! Before removing screws 5, it must be ensured that intermediate flange 6 (26 kg) cannot fall down!

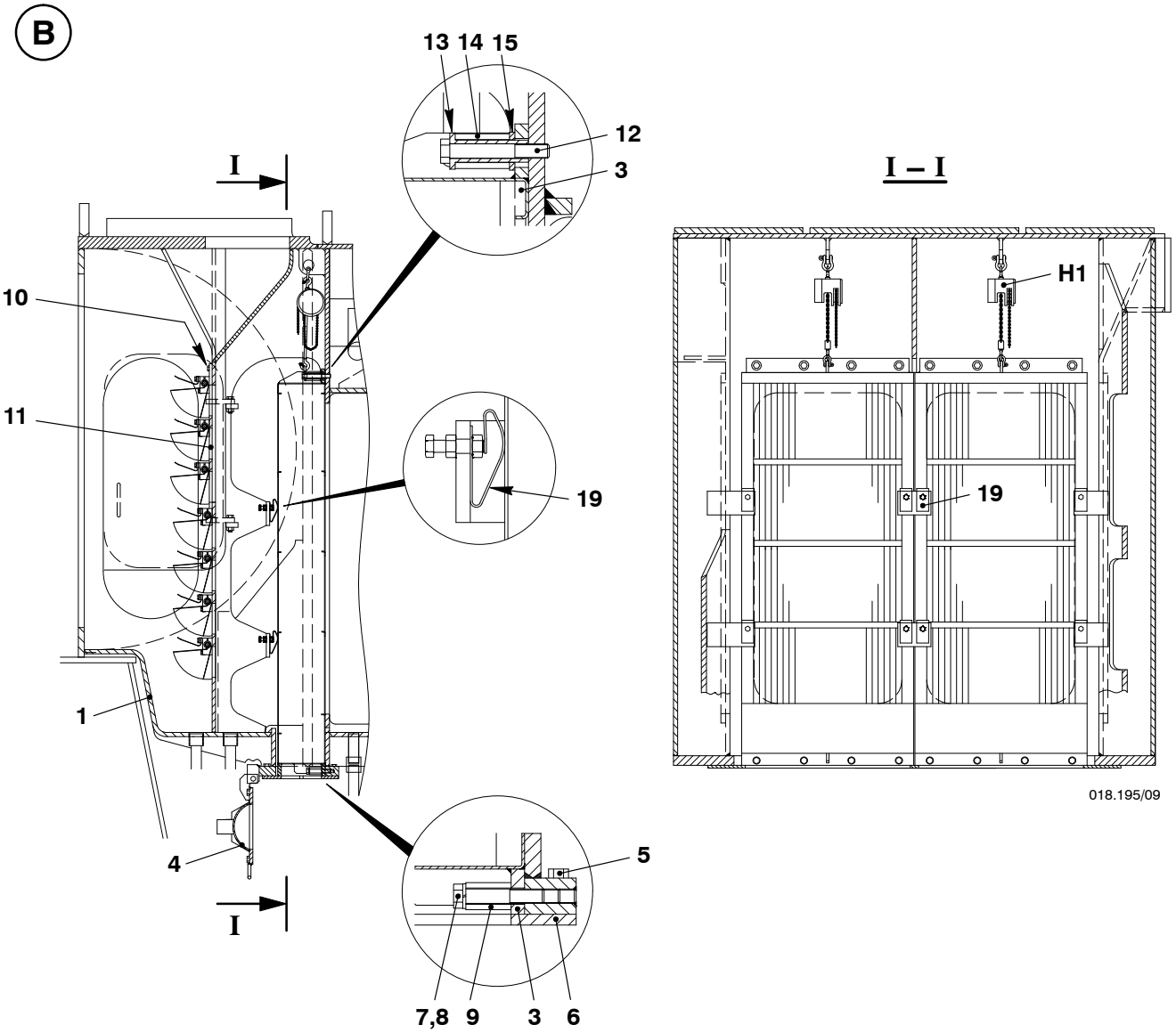
⇒ Remove screws 7 together with spring washer 8 and tension sleeves 9.

⇒ Remove screws 10 and put both covers 11 with their air flaps fitted (approx. 47 kg each) on the bottom of receiver 1.

⇒ Fasten manual ratchets 'H1', connect and tighten it with the water separator.

⇒ Remove screws 12 together with sleeves 13, pressure springs 14 and discs 15.

⇒ Lower water separator.



4. Cleaning

The water separator should be cleaned with the same media as used for cleaning the scavenge air cooler in operation.

- Do not use any sharp tools for cleaning.

5. Fitting

- Before fitting the water separator, its location in the scavenge air receiver must be thoroughly cleaned and the water drains checked for free flow.

⇒ Apply a high-temperature (approx. 300 °C) silicone jointing compound e.g. COLTOGUN to all seating faces 'AF', thus avoiding an air bypass between frame and wall.

⇒ Lift water separator 3 by means of manual ratchets 'H1' and fit (loose) screws 12 together with sleeves 13, pressure springs 14 and discs 15.

⇒ Pull water separator up until it rests on sleeves 13 (paying attention to clearance 'x_1' on bottom side), i.e. that it not protrudes anymore (distance 'x') compared with receiver 1.

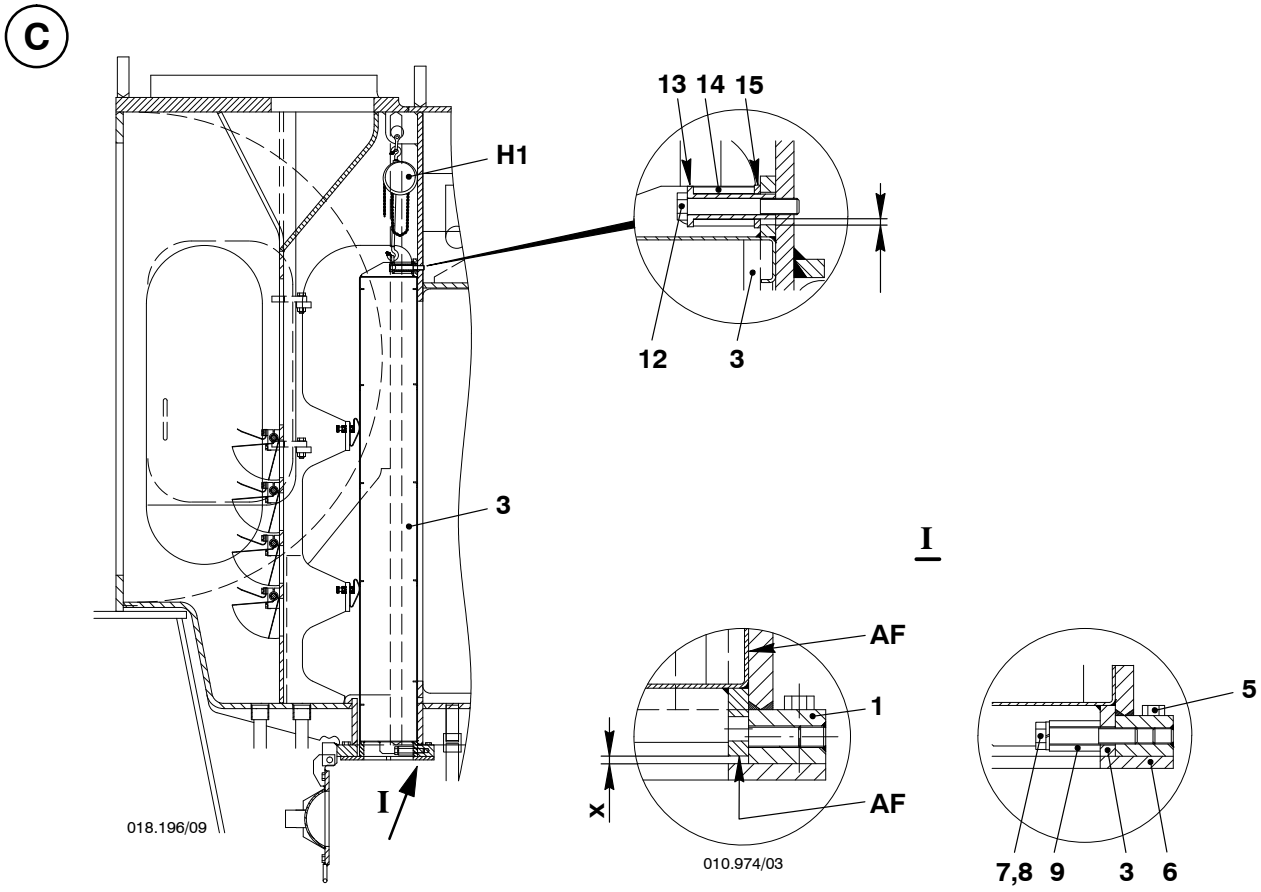
⇒ Fasten intermediate flange 6 with screws 5 and carefully lower water separator onto the intermediate flange.

⇒ Tighten screws 12.

⇒ Fit and tighten screws 7 together with spring washer 8 and tension sleeves 9.

⇒ Remove manual ratchets 'H1'.

⇒ Fit cover 11. Close door 16 and hinged cover 4, and reconnect couplings 17.



Lubrication Pump CLU4−C: Checking the Gas Pre-charge Pressure . . . . . 7218−1/A2

Lubricating Pump CLU4–C

Checking the Gas Pre-charge Pressure

Tool:

1	Case (for CLU4–C) consisting of: measurement set complete for checking / refilling of hydraulic accumulator	94720C	

Key to Illustrations:

1	Hydraulic accumulator	8	Lubricating pump (CLU4–C)
2	Protection cap	9	4/2-way solenoid valve
3	Pressure reducing valve	10	Shut-off valve servo oil
4, 4a	Hose (1m, 4 m)	11	Venting valve servo oil
5	Control unit with valves A, B and C	12	Venting valve lube oil
		13	Screw plug
7	Pressure gauge 0–60 bar	14	Nitrogen bottle

1. Checking the gas pre-charge pressure

Once filled with gas, the hydraulic accumulator is largely maintenance-free, however in order to ensure a trouble-free service, maintenance works must be carried out according to the manufacturer's detailed operating instructions of the Cylinder Lubricating System. **Checks and maintenance are only to be carried out, when the engine is at standstill**. Furthermore see also Operating Manual 7218–1.

CHECK

Check the filling pressure at least once in the first week after start-up of the accumulator. If no loss of gas is observed, recheck after three months. If there is still no change in pressure, an annual check might be sufficient, however, it is recommended to continue carrying out checks every three months.

Attention! Ensure that servo oil supply is shut off before starting accumulator pressure checking and charging. Also no residual oil pressure in the servo oil supply line must be visible on pressure gauge PI2041L of pressure reducing valve 8.11–1.

1.1 Preparation

- Stop servo oil supply.
- Close stop valve 4.30–5 on servo oil rail 4.11 (Fig. 'D').
- Drain servo oil system on screw plug 13 of pressure reducing valve 8.11–1 (Fig. 'E').
  Screw plug 13 must remain open during entire checking / refilling procedure.
- Remove protection cap 2 from accumulator 1.

1.2 Checking procedure

⇒ Close the three valves A, B and C on control unit 5.

⇒ Connect accumulator 1 to control unit 5 using short hose 4.

⇒ Open valve A and read pressure from gauge 7.
Required gas pressure: **min. 30 bar** / **max. 35 bar**.

If gas pre-charge pressure is ok:

⇒ Close valve A and drain remaining pressure in control unit by opening valve B.

⇒ Disconnect short hose from accumulator.

⇒ Refit protection cap.

Remark: During every check a small amount of gas may be lost to the atmosphere. Therefore, make sure a gas bottle is available before a pressure check is made in order to refill possible loss.

If gas pre-charge pressure is <u>not</u> ok:

⇒ Refill the accumulator.

2. Refilling the accumulator

Measurement set 94720C must always be used to refill the accumulator.

The hydraulic accumulator may only be filled with super-clean, class 4.0 nitrogen, 99.99 % N_2 by volume.

2.1 Refilling procedure

⇒ Fit pressure reducing valve 3 to nitrogen bottle 14 and adjust the pressure to **approx. 40 bar**.

⇒ Close the three valves A, B and C on control unit 5.

⇒ Connect pressure reducing valve with long hose 4a to the right side, and accumulator with short hose 4 to the left side of control unit.

⇒ Open valve A and read pressure from gauge 7.

⇒ Slowly open valve C and refill accumulator to the required pressure of **35 bar**.

⇒ Close valves A and C and drain remaining pressure in control unit by opening valve B.

⇒ Disconnect hoses 4, 4a and refit all protection caps.

2.2 After checking or refilling procedure

⇒ Reopen stop valve 4.30−5 on servo oil rail 4.11.

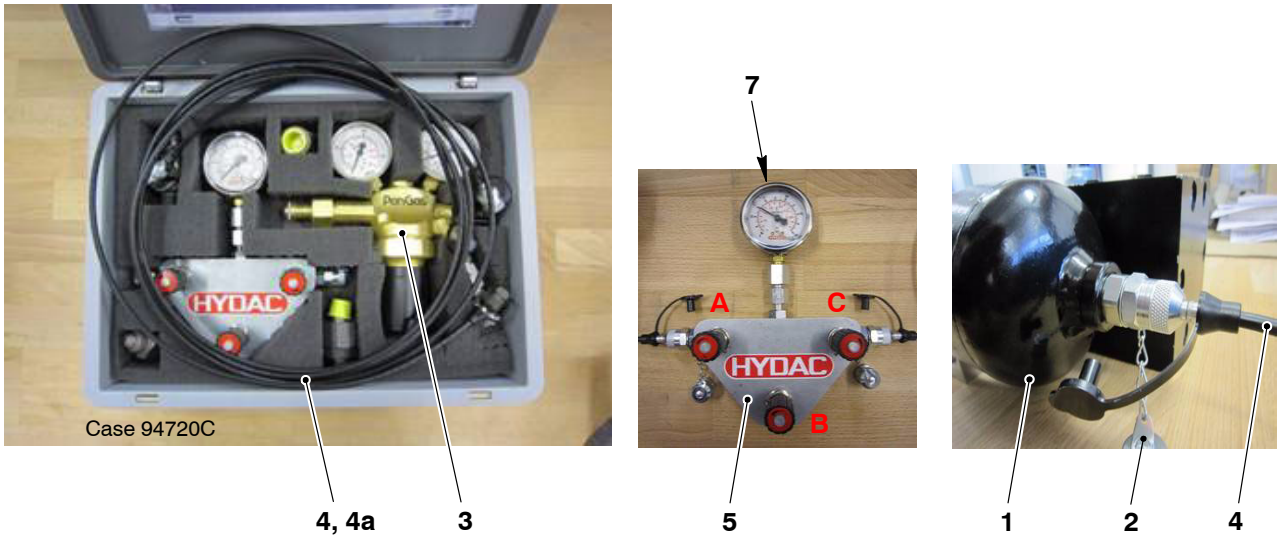
⇒ Close screw plug 13 on pressure reducing valve 8.11−1.

After pressure checking and refilling the accumulator, ensure to run the servo oil supply and vent air from the system before putting the pulse lubricating system into operation (see Operating Manual 7218−1).

Lubricating Pump CLU4–C: Checking the Gas Pre-charge Pressure

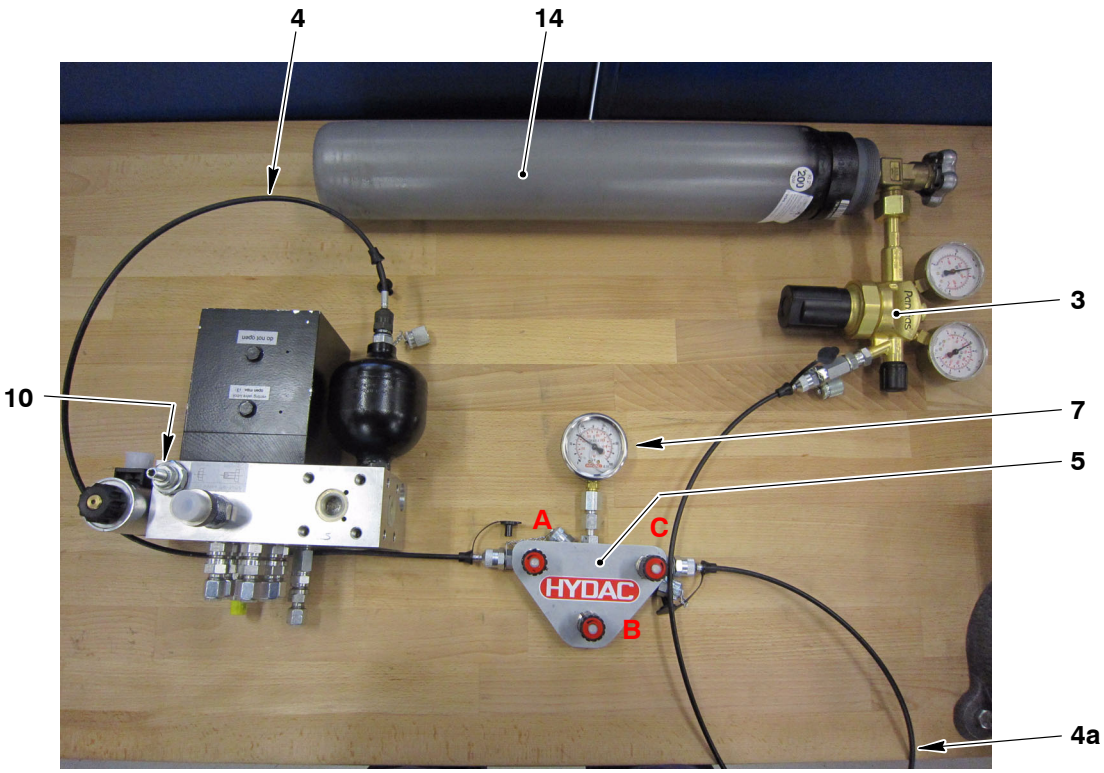
Case with measurement set 94720C for CLU4–C:

A



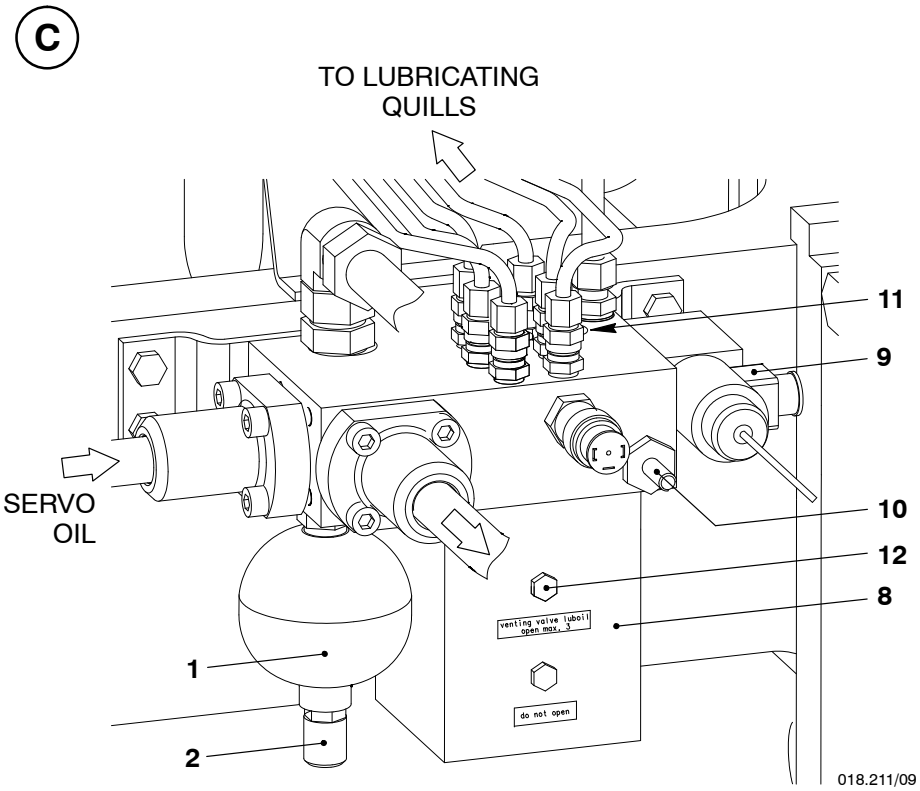
Arrangement of equipment:

B

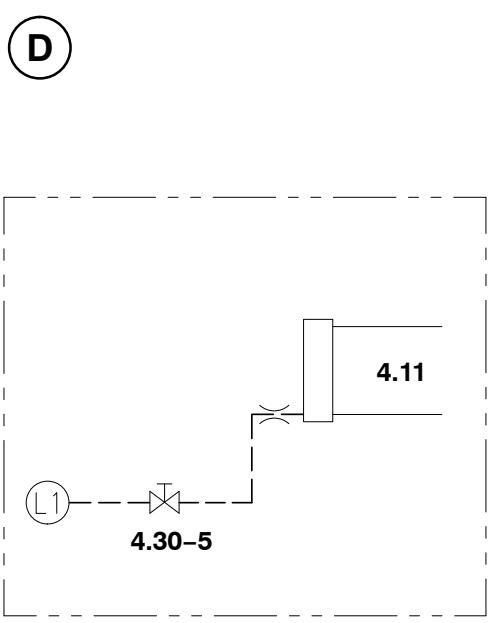


Lubricating Pump CLU4–C: Checking the Gas Pre-charge Pressure

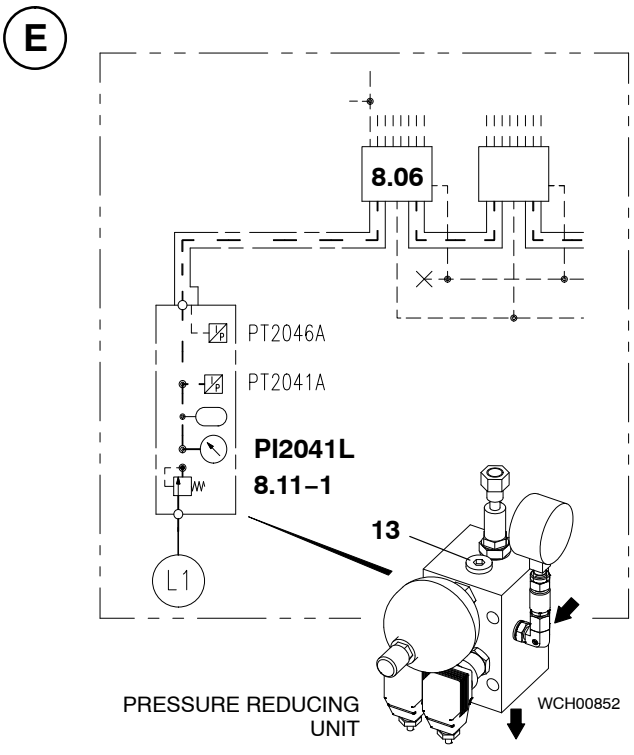
Lubricating pump (CLU4–C):



Details of servo oil rail 4.11 –> lubricating pump 8.06:



DRAWN FROM CONTROL DIAGRAM 4003–2



PRESSURE REDUCING UNIT

Piping Group 8

Exhaust Waste Gate (Low-Load Tuning) . . . . . 8135−1/A1
HP Servo Oil Pipe: Removing, Fitting and Regrinding . . . . . 8447−1/A1
Hydraulic Pipe for Exhaust Valve Drive: Removing, Fitting and Regrinding . . . . . 8460−1/A1
HP Pipe to Injection Valve: Removing, Fitting and Regrinding . . . . . 8733−1/A1
HP Pipe to Injection Valve (for ICU Mk3): Removing, Fitting and Regrinding . . . . 8733−1/A2
HP Fuel Pipe: Removing, Fitting and Regrinding . . . . . 8752−1/A1

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Exhaust Waste Gate (Low-Load Tuning)

1. General

The Low-Load Tuning provides the lowest possible **B**rake **S**pecific **E**xhaust gas **F**low (BSFC) in the operating range of 40 to 70% engine load.

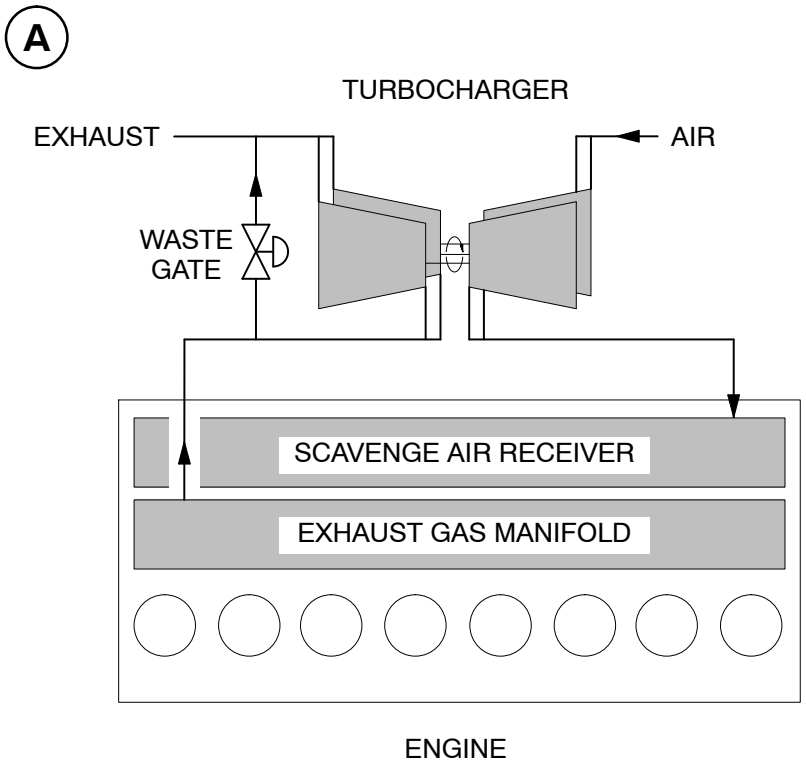
With Low-Load Tuning, engines can be operated continuously and reliably at any load in the range of 30 to 100%.

The Low-Load Tuning concept is based on the combination of a specifically designed turbocharging system setup and appropriately adjusted engine parameters related to fuel injection and exhaust valve control.

The reduced part-load BSFC in Low-Load Tuning is achieved by optimizing the turbocharger match for part-load operation. This is done by increasing the combustion pressure at less than 75% load through an increased scavenge air pressure and a higher air flow (waste gate closed), and by blowing off part of the exhaust gas flow (waste gate open) at engine loads above 85%.

Low-Load Tuning requires the fitting of an exhaust gas waste gate, i.e. a pneumatically operated valve on the exhaust gas manifold before the turbocharger turbine. Exhaust gas blown off through the waste gate is by-passed to the main exhaust uptake. The waste gate is opened at engine loads above 85% to protect the turbocharger and the engine from overload.

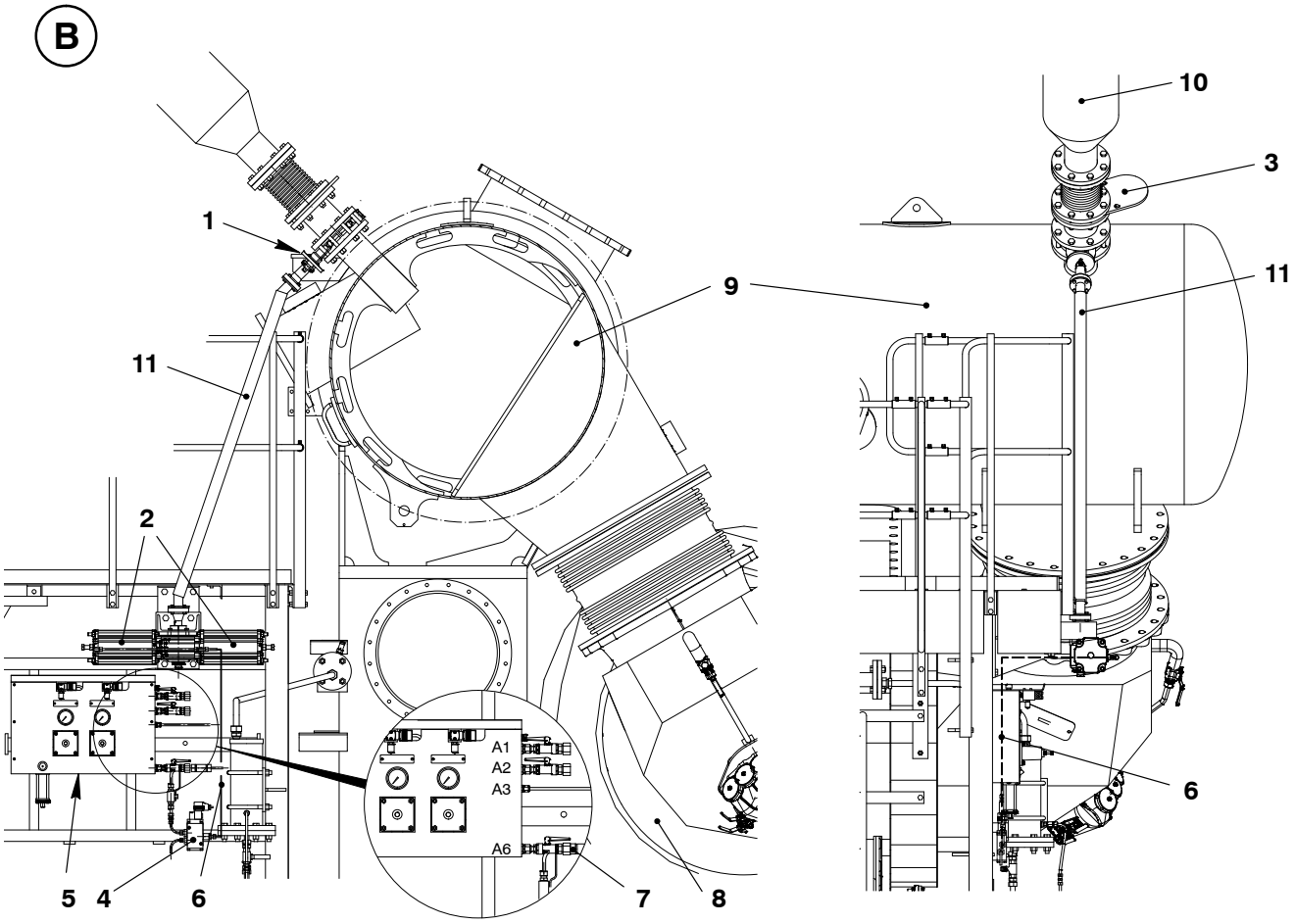
Schematic functional principle of Low-Load Tuning:



Exhaust Waste Gate (Low-Load Tuning)

2. Maintenance

- Butterfly valve 1 does not require special maintenance. For a general inspection however, the instructions of the valve manufacturer must be followed.
- To carry out a function check see 8135–1 in the Operating Manual and Maintenance Schedule 0380–1.
- The control actuator is single acting and normally closed by spring force. The control actuator opens by a pneumatic pressure of 5.5 bar.



Key to Illustrations:

1 Butterfly valve
2 Control actuator
3 Orifice
4 Solenoid valve
5 Control air supply
6 Control air pipe
7 Air spring air pipe
8 Exhaust gas turbocharger
9 Exhaust manifold
10 Exhaust by-pass line
11 Cardan rod

Servo Oil Piping

Removing, Fitting and Regrinding

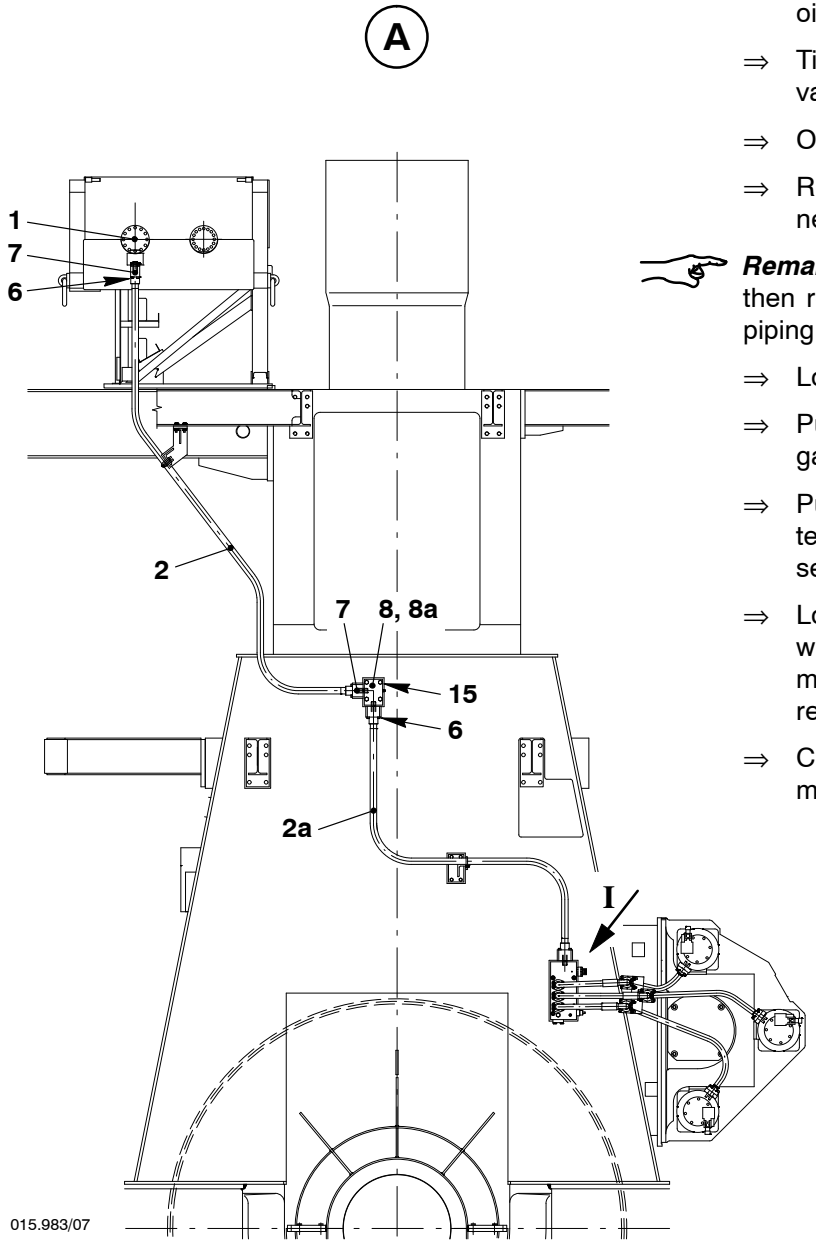
Tools:

1	Regrinding device	94834

Key to Illustrations:

1	Servo oil rail	10	Valve housing
2, 2a	Servo oil piping	11	Claw
3	Shut-off valve	12	Back-up ring
4	Drain screw	13	O-ring
5	Collector block	14	O-ring
6, 6a	Screws	15	Screws
7, 7a	Flange		
8, 8a	Intermediate piece		
9	Non-return valve	DF	Sealing face

1. Removal



⇒ Close shut-off valve 3 for the relevant servo oil piping.

⇒ Tighten the spindle of the closed shut-off valve with **100 Nm**.

⇒ Open drain screw 4 in collector block 5.

⇒ Remove the casing and pipe clamp where necessary.

Remark: **First** remove an upper servo oil piping 2; then remove the corresponding lower servo oil piping 2a:

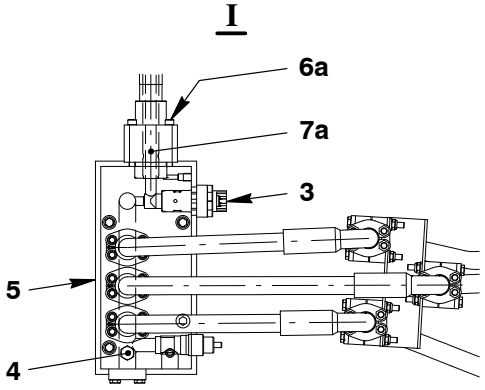
⇒ Loosen and remove screws 6 to flanges 7.

⇒ Push flanges back until they are no longer engaged.

⇒ Pull off and remove servo oil piping 2 from intermediate piece 8; do NOT damage the sealing faces DF!

⇒ Loosen screws 15 and remove them together with the intermediate piece 8. Loosen and remove screws 6a and flanges 7a, pull off and remove servo oil piping 2a.

⇒ Close off all connections and pipeends immediately and protect sealing faces.

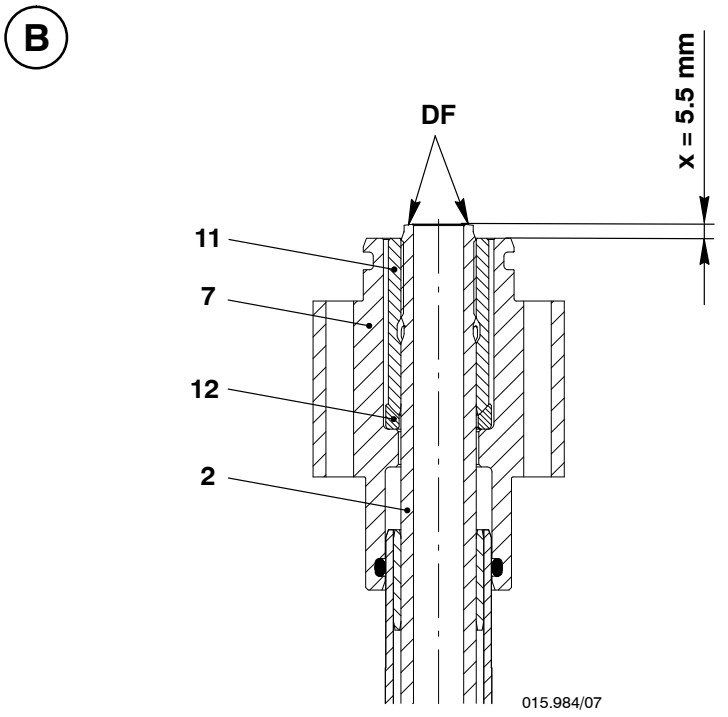


2. Fitting

2.1 Checking the claws position

⇒ Prior to fitting the servo oil piping, check if the claws are screwed on properly according to Fig, 'B', i.e. the servo oil piping must protrude by 'x' = 5.5 mm compared to the claw.

- Adjust distance 'x' by turning the claw by means of an open-end wrench.

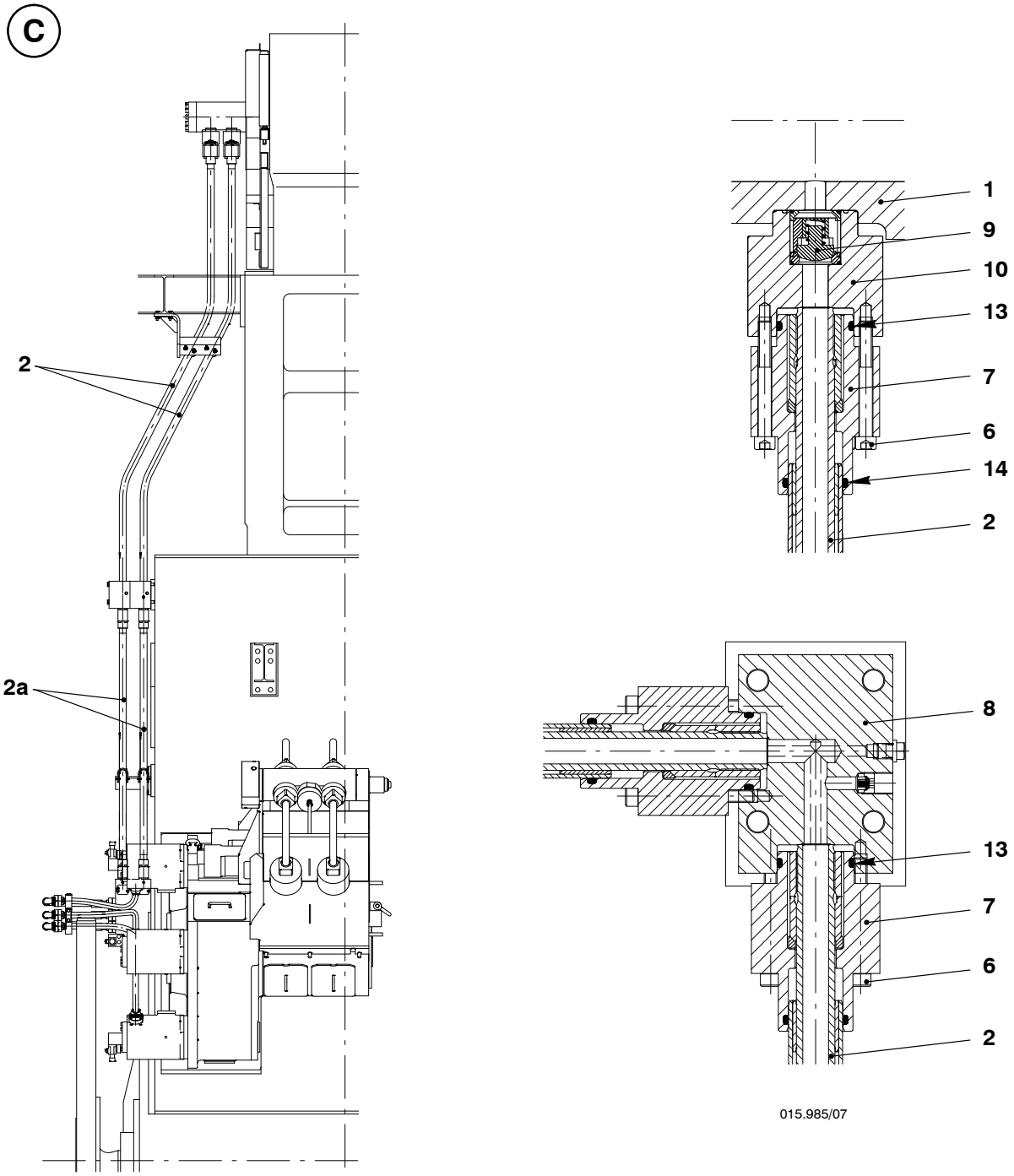


Servo Oil Piping: Removing, Fitting and Regrinding

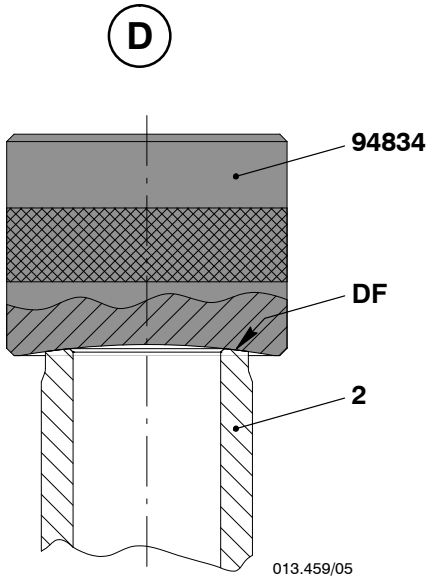
2.3 Fitting the servo oil pipings

Refit the servo oil pipings in reverse order as described above. Especially note:

- Oil the threads of screws 6 and tighten them crosswise with a torque of **40 Nm**.
- Close drain screw 4 and tighten with a torque of **130 Nm**.
- After refitting, open shut−off valves 3 and tighten their spindles with **100 Nm**.



3. Regrinding the sealing faces 'DF'



⇒ Loosen claw 11 (Fig. 'B').

⇒ To prevent grinding compound from entering the servo oil piping, plug its opening with a piece of cloth.

⇒ Use tool 94834 for regrinding the sealing face 'DF' (see Fig. 'D'): First rough-grind the sealing face with grinding compound No. 200, then fine−grind with grinding compound No. 500.

⇒ After grinding thoroughly clean the servo oil piping.

Hydraulic Pipe for Exhaust Valve Drive

Removing, Fitting and Regrinding

Tools:

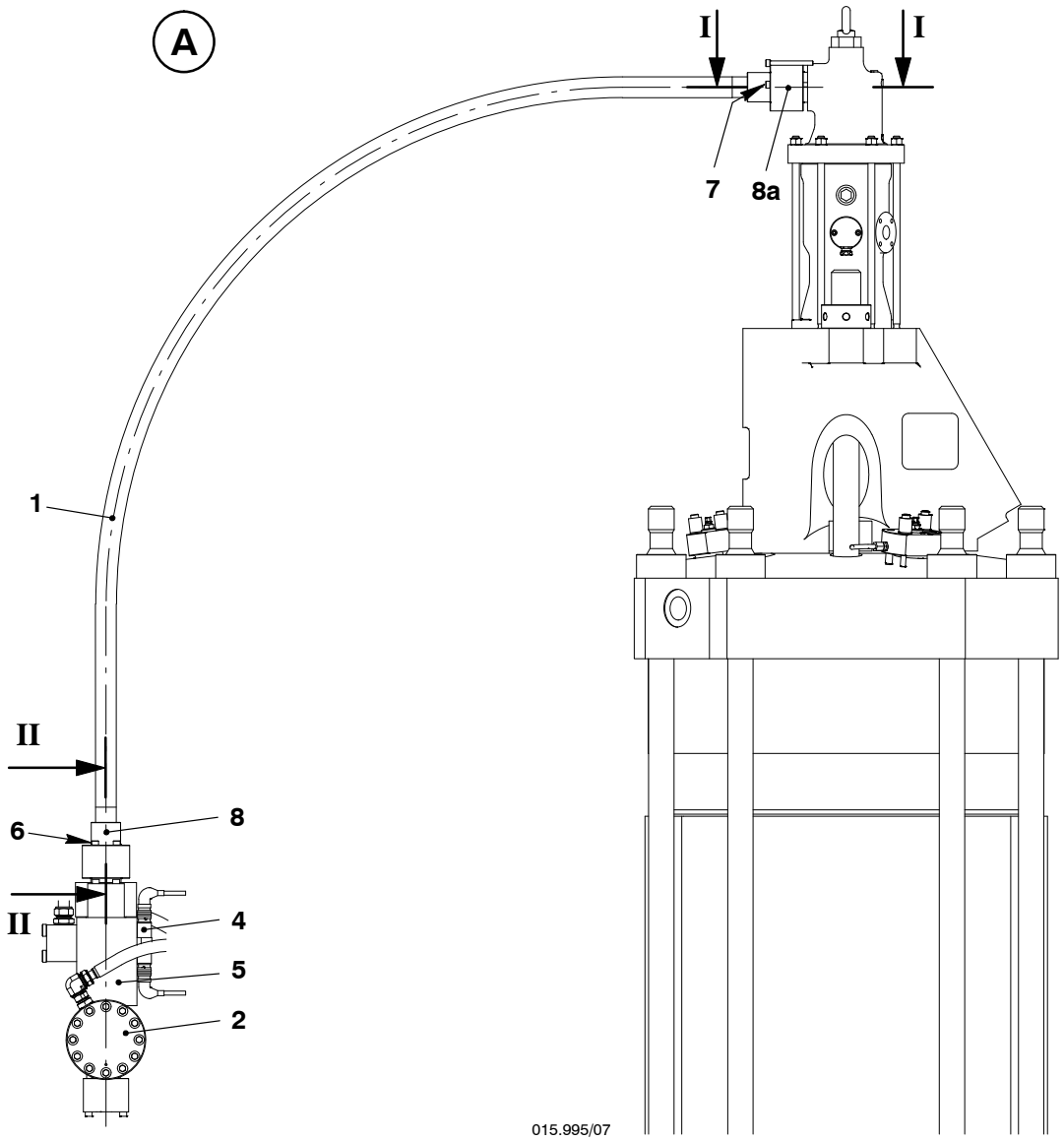
1	Regrinding device	94834

Key to Illustrations:

1	Hydraulic pipe	9	Claw
2	Servo oil rail	10	Thrust ring
3	Screw plug	11	O-ring
4	Pre-control valve	12	O-ring
5	Exhaust valve control unit	13	Stop valve
6	Screw		
7	Screw	DF	Sealing face
8, 8a	Flange	LB	Leak oil bore

1. Removal

Stop the motor before beginning any work on the hydraulic pipe. Strictly follow the instructions 0520–1 'Exchange of defective exhaust valve control unit or hydraulic pipe as set out in the Operating Manual.



Hydraulic Pipe: Removing, Fitting and Regrinding

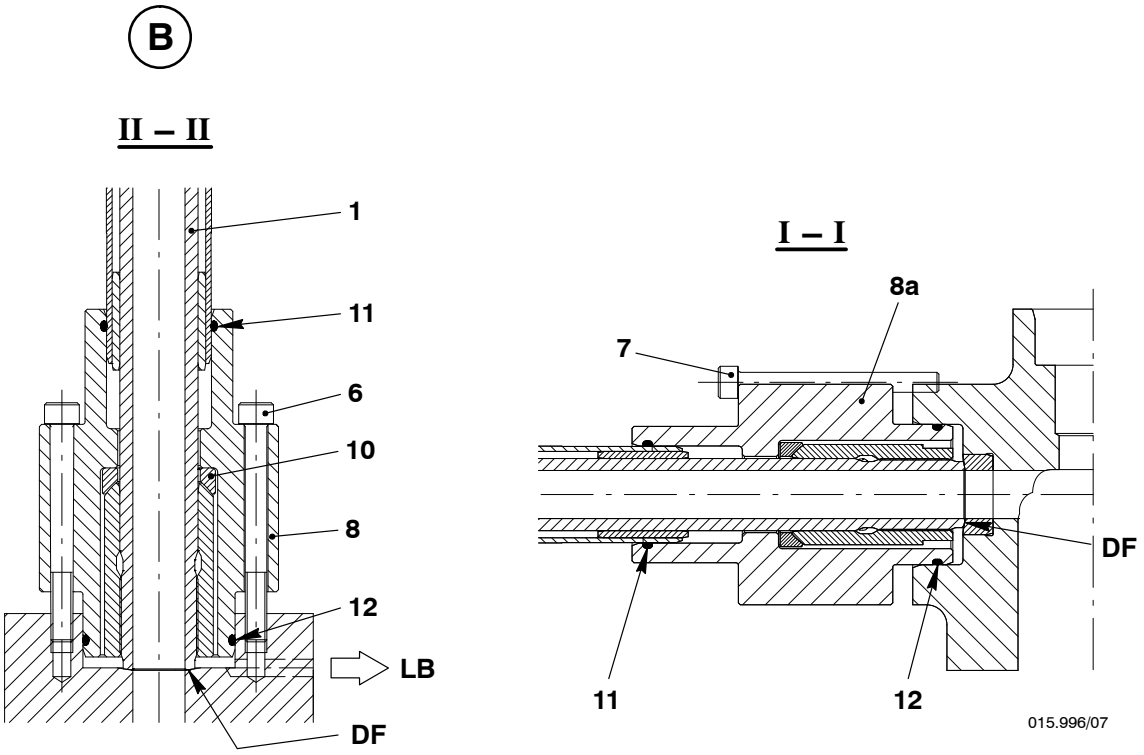
⇒ Loosen screws 6 by several turns.

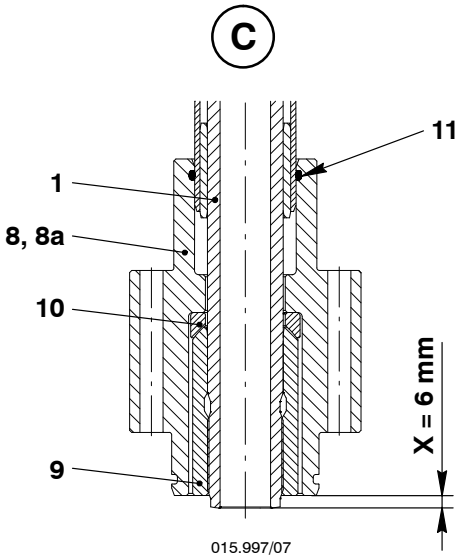
⇒ Undo screws 7 and push flange 8a back until it is no more engaged.

⇒ Push hydraulic pipe 1 back in axial direction and turn it to the side.

⇒ Connect the hydraulic pipe to the crane, undo screws 6 and remove the hydraulic pipe.

- Do **not** damage the sealing faces 'DF' when removing the hydraulic pipe!
- Close off all openings after removing the connections.





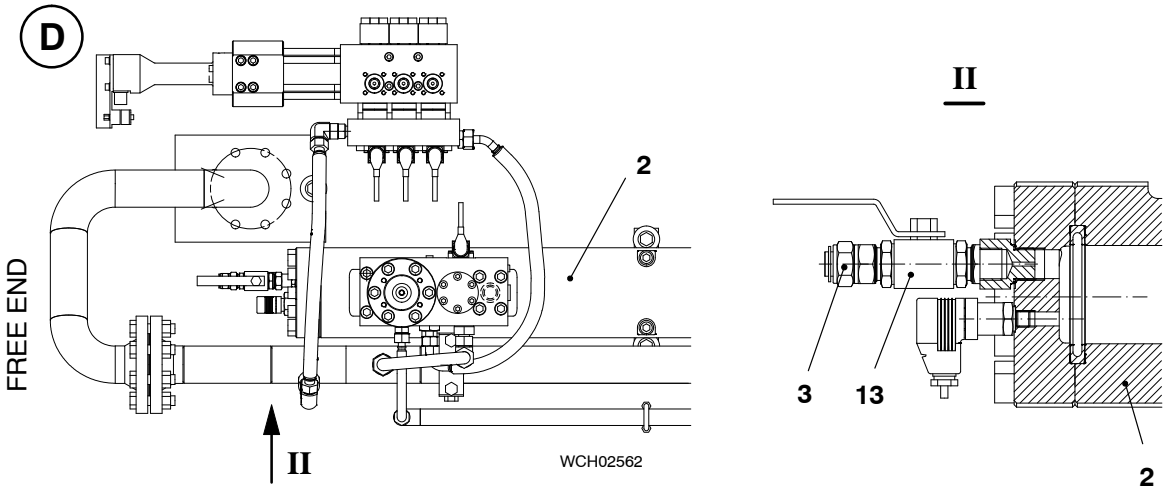
1.1 Checking claw position

⇒ Prior to fitting the hydraulic pipe, check if the claws 9 are screwed on properly according to Fig, 'C', i.e. the hydraulic pipe must protrude by 'x' = 6 mm compared to the claw.

- Adjust distance 'x' by turning the claw by means of an open-end wrench.

Hydraulic Pipe: Removing, Fitting and Regrinding

2. Fitting

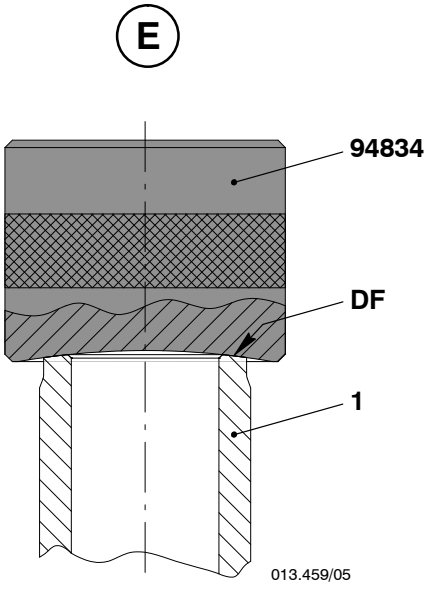


CHECK

Check prior to assembly if the inside of the hydraulic pipe and sealing faces 'DF' of pipe ends are clean and undamaged and if O-rings 12 are in perfect condition.

- Be sure to **fit objects together axially**, i.e. do **not** move objects to be connected laterally, in order to avoid any damaging of sealing faces 'DF'.
- After fitting, close stop valve 13, securely fasten screw plug 3 and follow instructions 0520–1 in the Operating Manual.
- Apply Never-Seez NSBT-8 to the threads of screws 6, 7 and tighten them crosswise with a torque of **40 Nm**.

3. Regrinding the sealing faces 'DF'



⇒ Loosen claw 9 (Fig. 'C').

⇒ To prevent grinding compound from entering the servo oil pipe, plug its opening with a piece of cloth.

⇒ Use device 94834 for regrinding sealing face 'DF'.

⇒ First rough-grind the sealing face with grinding compound No. 200, then finish-grind it with grinding compound No. 500.

⇒ After grinding thoroughly clean the HP servo oil pipe.

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HP Pipe to Injection Valve

Removing, Fitting and Regrinding of Sealing Faces

Tools:		
1	Regrinding device	94871
2	Template	94871A

Key to Illustrations:

1	Cylinder cover		8	Pipe bracket
2	Injection valve		9	O-ring
3	Injection control unit		10	O-ring
4	HP pipe			
5	Claw			
6	Flange			
7	Bolt M8x80		SF	Sealing face

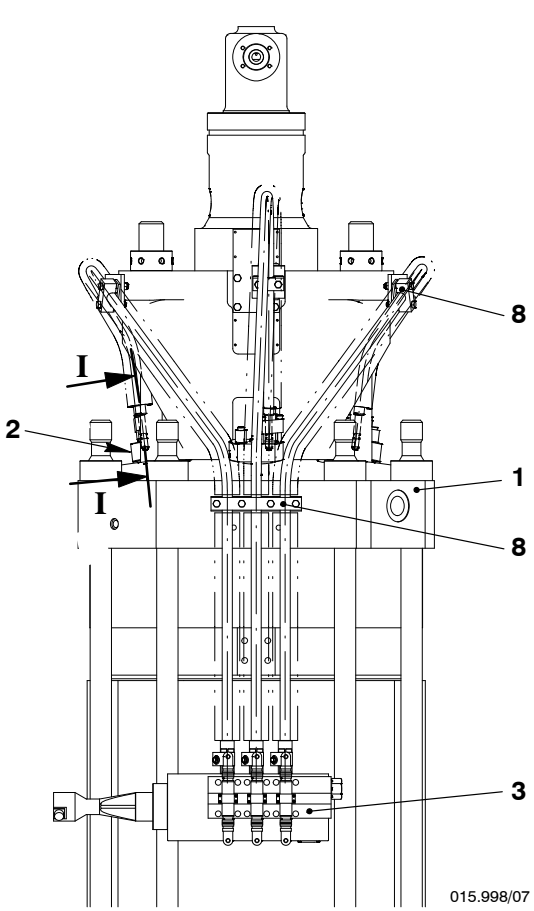
1. Removal

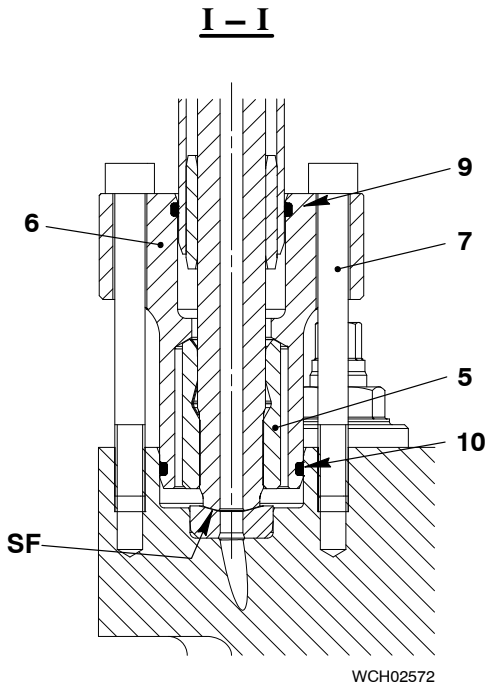
When working on a HP pipe 4 the engine has to be stopped, and it is essential that instructions 0510–1 in the Operating Manual be strictly followed.

⇒ Remove all pipe brackets 8.

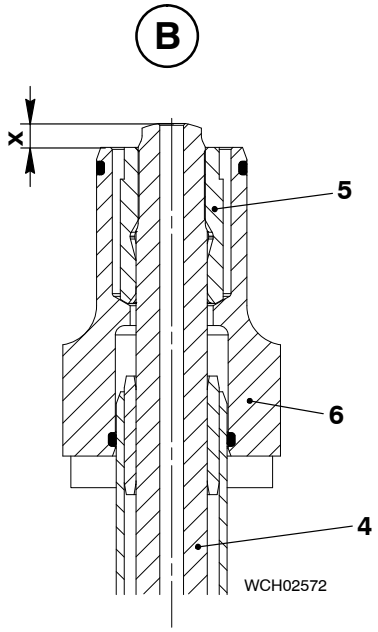
⇒ Remove bolt 7 from flange 6 on injection valve 2 and injection control unit 3 (Fig. 'A' and 'C').

- Pay attention not to damage sealing faces 'DF' when removing HP pipes 4.
- All connections must be closed off immediately and sealing faces 'SF' must be protected after removing HP pipes.





HP Pipe to Injection Valve: Removing, Fitting and Regrinding of Sealing Faces



2. Fitting

Fitting procedure is analogous to the removal but in reverse sequence.

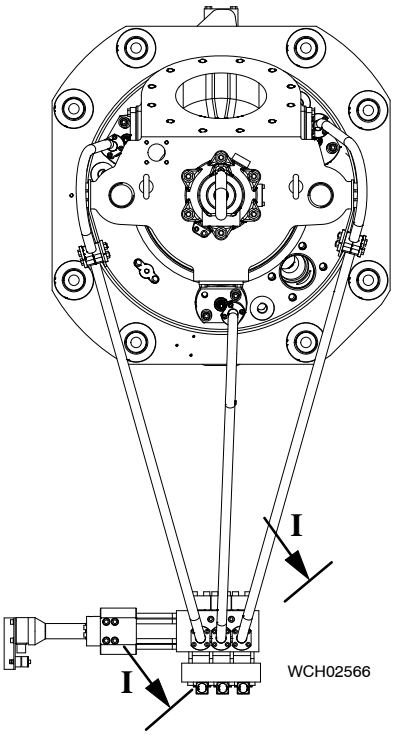
CHECK

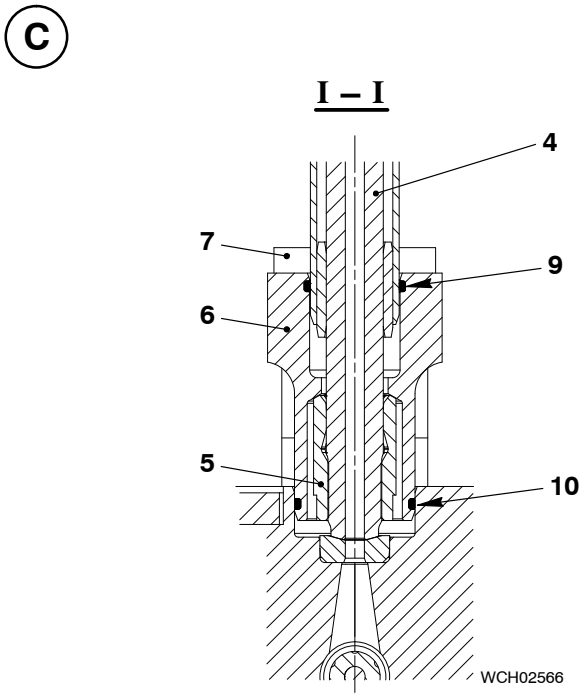
Before fitting HP fuel pipe 4 check whether its claws 5 are screwed on properly, i.e. the HP fuel pipe must protrude by 'x' = 6 mm compared to the claw as shown in Fig. 'B'.

Measurement 'x' can be adjusted by turning the claw using an open end spanner.

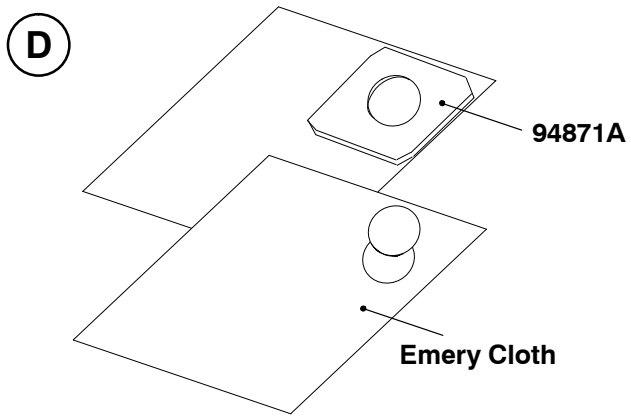
⇒ Fit HP fuel pipe.

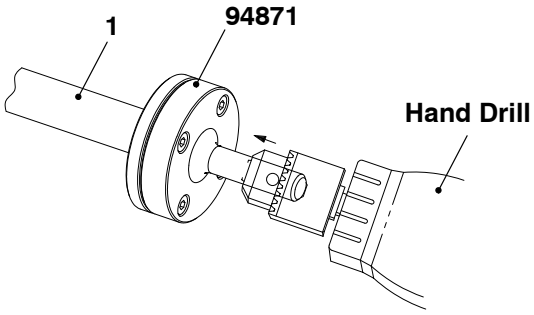
⇒ Apply Never-Seez NSBT-8 to threads of bolts 7 and tighten them crosswise with a torque of **25 Nm** , see Fig. C.

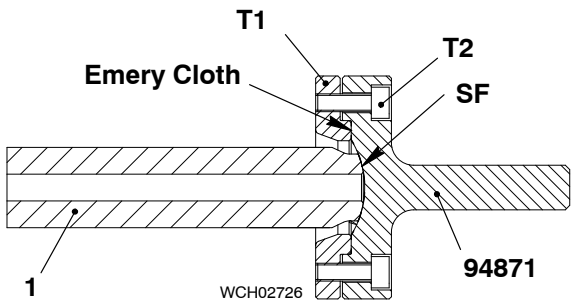




HP Fuel Pipe: Removing, Fitting and Regrinding of Sealing Faces







3. Sealing faces – grind

To get a clean and smooth finish on the HP injection pipe do the procedure that follows:

⇒ Put the template (94871A, Fig. C) on the back of emery cloth.

⇒ Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.

⇒ Use a pencil or a ball pen to make the the inner shape.

⇒ Cut out accurately the shape.

⇒ Remove the four screws (T2) and the grinding tool (94871).

⇒ Apply Molyslip Copaslip paste to the threads and faces of the four screws (T2).

⇒ Remove the cover (T1).

⇒ Put the emery cloth you cut out into the grinding tool (94841).

⇒ Put the grinding tool (94841), emery cloth and the cover (T1) in position on the HP injection pipe (1).

⇒ Torque symmetrically the four screws (T2) to 2 Nm.

⇒ Put the HP injection pipe (1) in a vice, as vertically as possible.

⇒ Adjust the speed of the hand drill between 200 rpm and 500 rpm.

⇒ Align the hand drill and the grinding tool (94841) accurately with the HP injection pipe (1) as shown.

⇒ Use light pressure and start grinding.

⇒ Regularly remove unwanted material from the grinding tool (94871).

⇒ Make sure that the circular marks around the sealing face of the pipe are concentric.

⇒ Make sure that the circular marks around the sealing face of the pipe are concentric.

⇒ Change the emery cloth for a smoother grade, then do the procedure above again until you get a smooth finish.

⇒ Replace the emery cloth with a polishing cloth as a last step to polish the HP injection pipe.

⇒ Clean the HP injection pipe (1).

⇒ If necessary, do the procedure above for the other HP injection pipes.

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HP Fuel Pipe to Injection Valve (for ICU Mk3)

Removal, Grinding and Installation

	Tools:	
1	Regrinding device	94871
1		94871A
1	Special spanner	94874
1	Torque wrench	

	Key to Illustrations:		
1	Cylinder cover	9	Screw
2	Injection valve	10	Pipe bracket
3	Injection control unit	11–14	O-ring
4	HP injection pipe	15	Flange
5	Claw		
6	Thrust ring	SF	Sealing face
7	Flange	EC	Emery cloth
8	Screw	HD	Hand drill

1. Preparation

⇒ Stop the engine.

⇒ Do the the instruction in Operation Manual, 0510–1, to release the pressure in the fuel rail.

⇒ Make sure that there is no pressure in the fuel rail.

⇒ Set to off the electrical trace heating and remove the insulation from HP injection pipe.

2. Removal

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces or the HP injection pipes.

⇒ On the applicable HP injection pipe 4, disconnect the electrical connection on the injection valve 2.

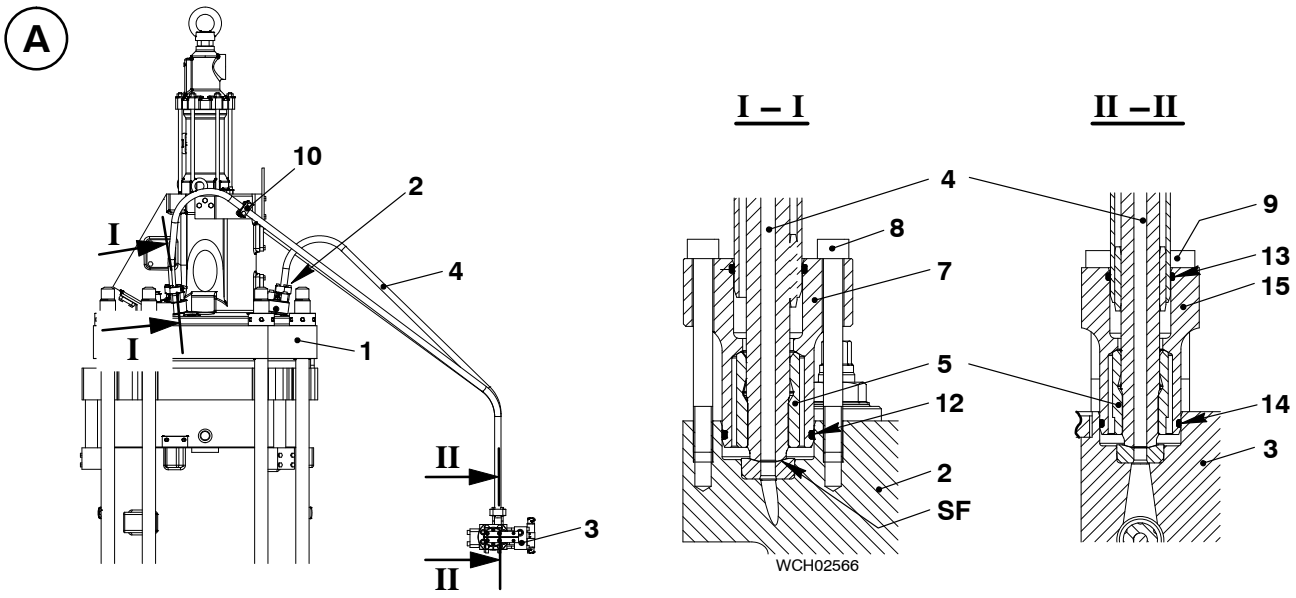
⇒ Remove the applicable pipe brackets 10.

⇒ On the injection valve 2, remove the four screws 8 from the flange 7.

⇒ On the flange 15, remove the four screws 9.

⇒ Carefully remove the applicable HP injection pipe 4 from the injection valve 2 and the injection control unit 3.

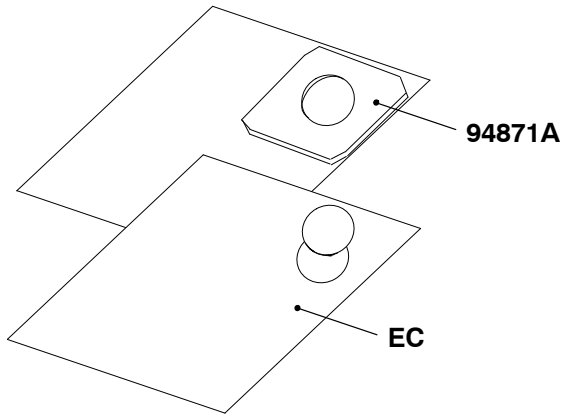
⇒ Apply protection to the sealing faces 'SF' and the open ends of the HP injection pipe 4.



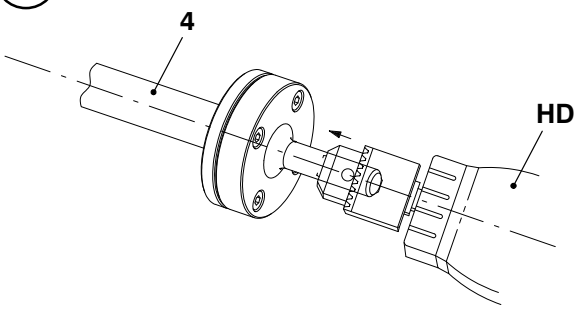
HP Pipe to Injection Valve: Removal, Grinding and Installation

3. Sealing Faces – Grind

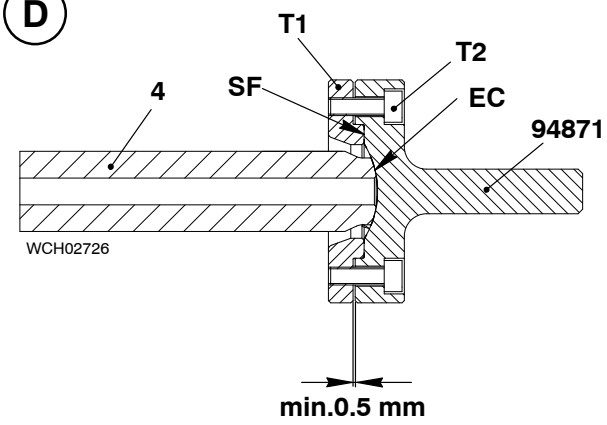
B



C



D



To get a clean and smooth finish on the pipe procedure as follows:

⇒ Do a check of the O-rings 11–14, Fig.' E'. If the O-rings are unserviceable, discard them.

⇒ Put the stencil 94871A on the back of emery cloth 'EC'.

⇒ Use a pointed pencil or a ball pen to sign the inner contour.

- Use the grade of the emery cloth according to amount of metal you want to grind.

⇒ Cut out accurately the singed contour.

⇒ Shape the cut emery cloth to cone. Make sure that the grained surface of the emery cloth shows to in.

⇒ Loosen and remove the four screws T2, Fig.'D'.

⇒ Apply Molyslip Copaslip paste to the threads and contact surface of the four crews T2.

⇒ Put the emery cloth 'EC' between the regrinding device 94871 and the flange T1.

Note: Make sure that the grained surface of the emery cloth shows to the flange T1.

⇒ Push the emery cloth 'EC' in the spherical shape of the regrinding device 94871.

⇒ Torque symmetrically the four screws T2 to 2 Nm.

⇒ Install the HP injection pipe 4 in a vice, as vertically as possible.

⇒ Adjust the speed of the hand drill between 200 and 500 rpm.

⇒ Put the hand drill with the regrinding device 94871 exactly in line on the HP injection pipe as shown in Fig. 'C' and start grinding with a slight pressure.

⇒ Check if the grinding circles are concentric around the bore of the pipe and remove the grinding swarf from the tool.

⇒ Do the grinding steps few times. For each step use a finer emery cloth 'EC'. For the last grinding step, use a polishing cloth.

⇒ Remove the regrinding device 94871 from the HP injection pipe 4.

⇒ Clean the HP injection pipe 4.

⇒ If necessary, put the new O-rings 11–14, see Fig. 'E'.

⇒ Check the quality of the sealing face 'SF' and if necessary use the new emery cloth 'EC' to repeat the grinding procedure.

Note: If there are a big notches, the pipe has to be shortened.

⇒ If necessary, do steps above for the other HP injection pipes.

HP Pipe to Injection Valve: Removal, Grinding and Installation

4. Installation

⇒ Use the special spanner 94874 to install the pipe claw 5.

⇒ Make sure that the claws 5 are correctly attached to HP injection pipe, i.e. that the claw 5 are adjusted to the end of the thread on the pipe.

⇒ Make sure that there is a distance of X = 6 ± 1 mm between the claw 5 and the HP injection pipe 4.

⇒ If necessary, use an open-ended wrench to adjust the claw 5.

⇒ Remove all of the protection from the sealing faces 'SF' in the injection valve 2 and the injection control unit 3.

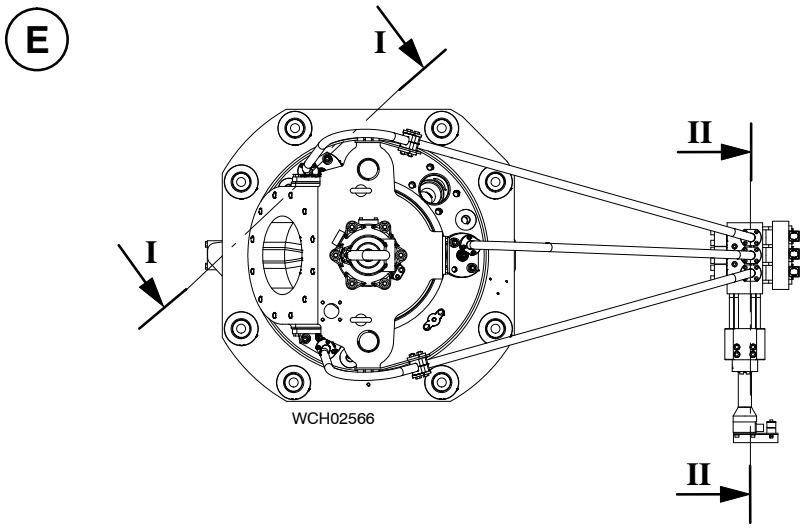
⇒ Apply Never-Seez NSBT-8 to threads of screws 8 and 9.

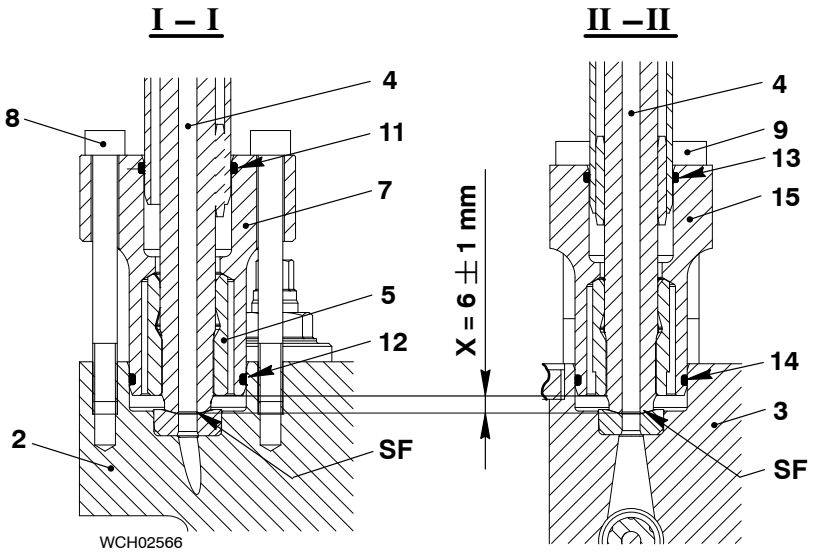
⇒ Carefully put the HP injection pipe 4 in position in the injection valve 2 and the injection control unit 3.

⇒ Torque symmetrically the four screws 8 to **25 Nm**.

⇒ Torque symmetrically the four screws 9 to **25 Nm**.

⇒ Install the applicable pipe bracket 10.





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Intermediate Fuel Accumulator

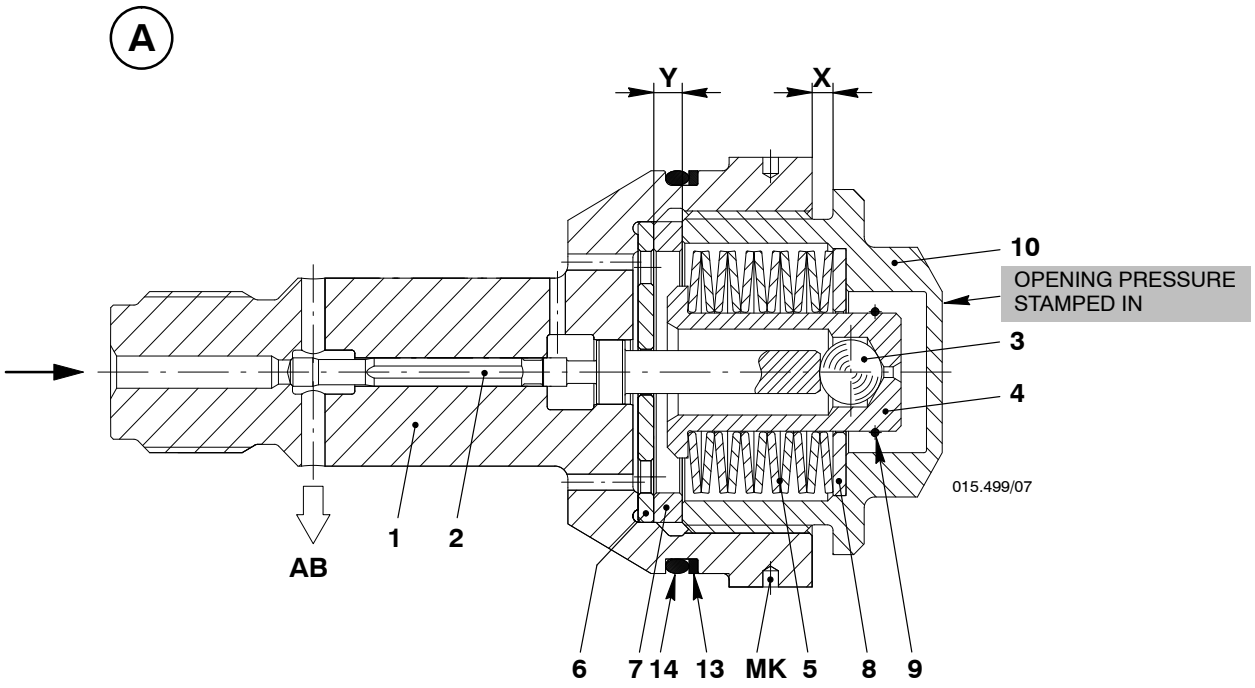
Checking and Setting of Relief Valve

Tools:

1	OBEL test bench	94272
1	Valve holder	94272a
1	HP oil pump	94931
1	HP hose	94935

Key to Illustrations:

1	Valve housing	11	Fuel overpressure safety valve 3.52
2	Valve needle		
3	Ball	12	Receiver
4	Spring carrier	13	Back-up ring
5	Disc spring (11 pieces)	14	O-ring
6	Stop ring		
7	Distance ring		
8	Seating washer	AB	Drain bore
9	Snap ring	EV	Relief valve
10	Screw plug	MK	Marking ∅3 mm



1. General

CHECK

Before dismantling a relief valve for overhaul (grinding in of the valve needle), distance 'X' must be measured and recorded as 'X'. For this purpose, distance ring 7 must be pressed against stop ring 6 by screw plug 10.

⇒ After grinding valve needle 2 into the seat of valve housing 1, thoroughly clean all parts, lightly oil valve needle 2 and apply MOLYKOTE paste G to parts 3, 4, 5 and 8.

- During assembly, care must be taken that disc springs 5 are correctly fitted.

⇒ **Not yet** fit distance ring 7.

⇒ Tighten screw plug till distance 'X' is approx. the same as before dismantling.

⇒ For testing and setting the relief valve use test bench 94272.

Remark: To identify the new fuel overpressure safety valve (relief valve) 11 two bores ∅ 3 mm 'MK' have been provided as a marking.

Intermediate Fuel Accumulator: Checking and Setting of Relief Valve

2. Setting the opening pressure

⇒ Fit fuel relief valve 11 (without joint) into the valve holder and tighten it.

⇒ Connect valve holder 94272a to HP oil pump 94931.

⇒ Close relief valve 'EV'.

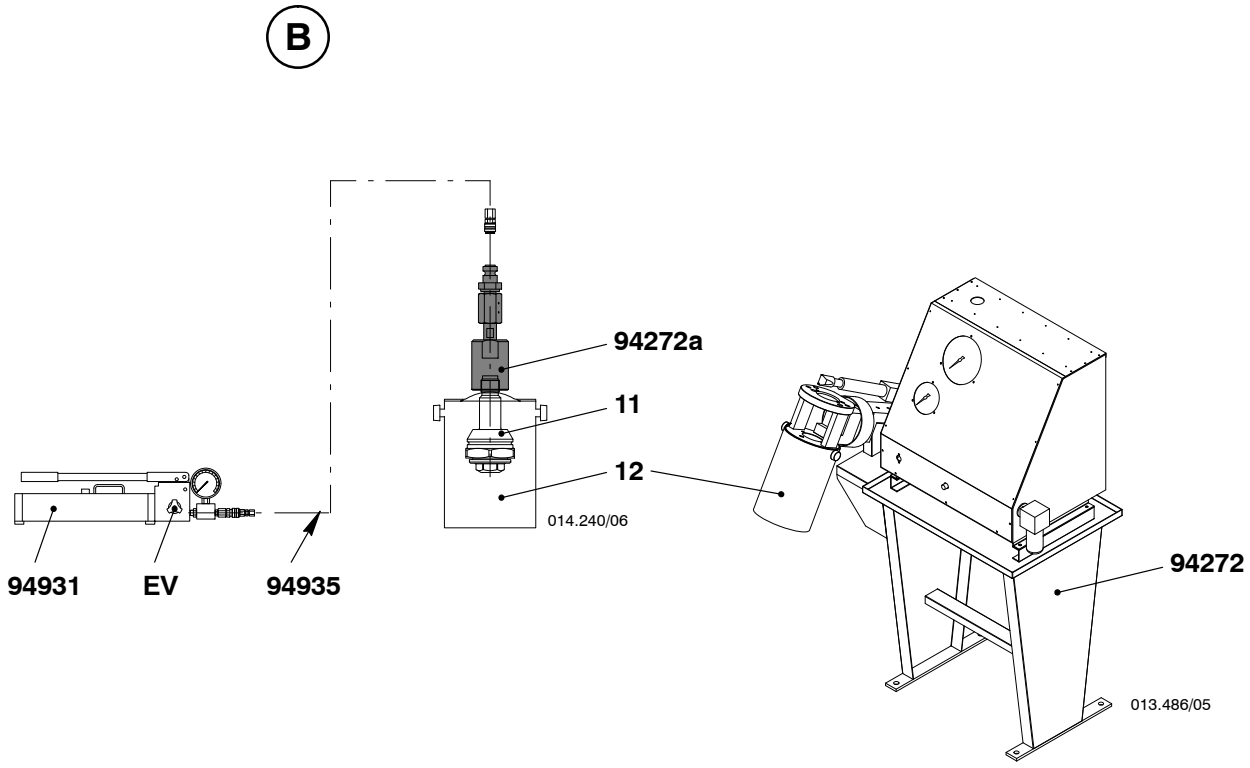
⇒ Increase the pressure by means of HP oil pump and observe at what value the fuel relief valve opens. Correct opening pressure = **1250 bar.**

⇒ Set required pressure by adjusting screw plug 10. Measure distance 'X' and note it as 'X_1' (Fig. 'A').

⇒ Reduce height 'Y' of distance ring 7 by the difference between distances 'X_1' and 'X'.

⇒ Reassemble relief valve **with** the distance ring and tighten screw plug until it is fully down on the distance ring.

CHECK Recheck the opening pressure on the completely assembled fuel relief valve.



3. Fitting the relief valve

⇒ Apply Never-Seez NSBT-8 to the thread of valve housing 1.

⇒ Screw the relief valve into the intermediate fuel accumulator and tighten it with a torque of **300 Nm**.

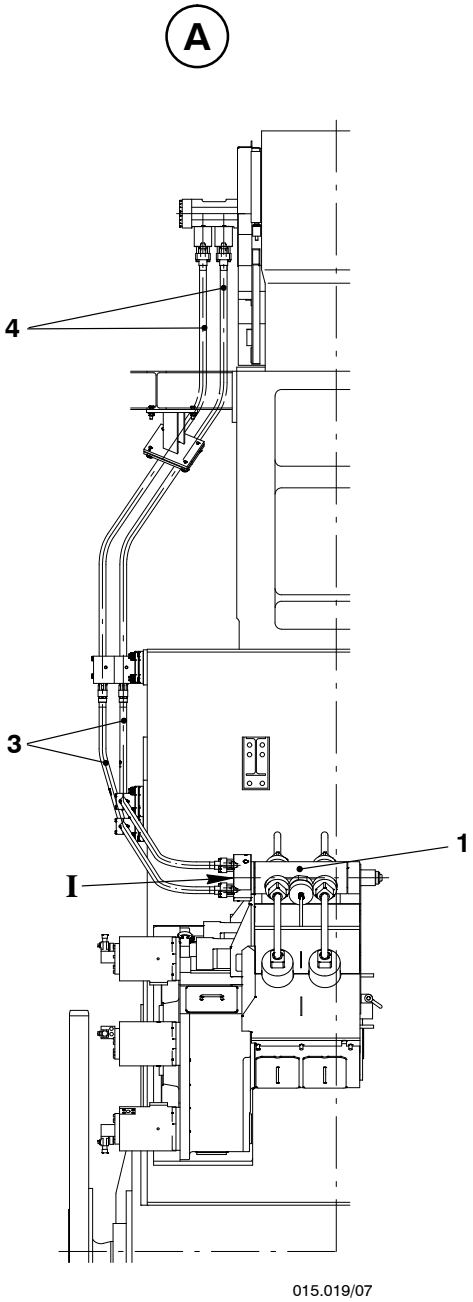
Fuel Pressure Piping

Removing, Fitting and Regrinding

	Tools:	
1	Regrinding device	94870
	consisting of:	
1	Screw-on sleeve	94870e
1	Grinding tool	94870f
1	Lock nut	94870g
1	Template	94870h
1	Torque wrench	

	Key to Illustrations:			
1	Intermediate fuel accumulator	9	Claw
2	Stop valve	10	Thrust ring
3	Fuel pressure piping	11	O-ring
4	Fuel pressure piping		
5, 5a	Screw		
6, 6a	Flange	DF	Sealing face
7	Screw	EC	Emery cloth
8	Intermediate piece	HD	Hand drill

1. Removal



015.019/07

1.1 Preparation to removal

Risk of injury! Always use gloves when working on hot components and wear safety goggles!

⇒ Stop the engine and switch off the fuel supply pump.

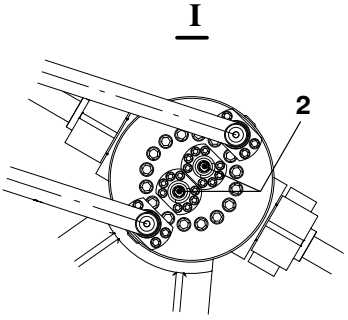
⇒ Close steam supply to heating pipes on plant side.

⇒ Undo union joints of corresponding heating pipes.

⇒ Remove the casing and pipe brackets where necessary.

⇒ Close stop valves 2 for corresponding fuel pressure pipings.

Remark: The spindles of the closed stop valves must be tightened with **100 Nm**.



1.2 Removal of fuel pressure pipings 3 and 4

- If a fuel pressure piping 4 must be removed, first dismantle the corresponding fuel pressure piping 3.
- Pay attention not to damage sealing faces 'DF' when removing fuel pressure pipings.
- All connections must be closed off immediately and the sealing faces must be protected after removing the fuel pressure pipings.

1.2.1 Removal of fuel pressure piping 3

⇒ Undo screws 5 and push flanges 6 back till they do not mesh any more.

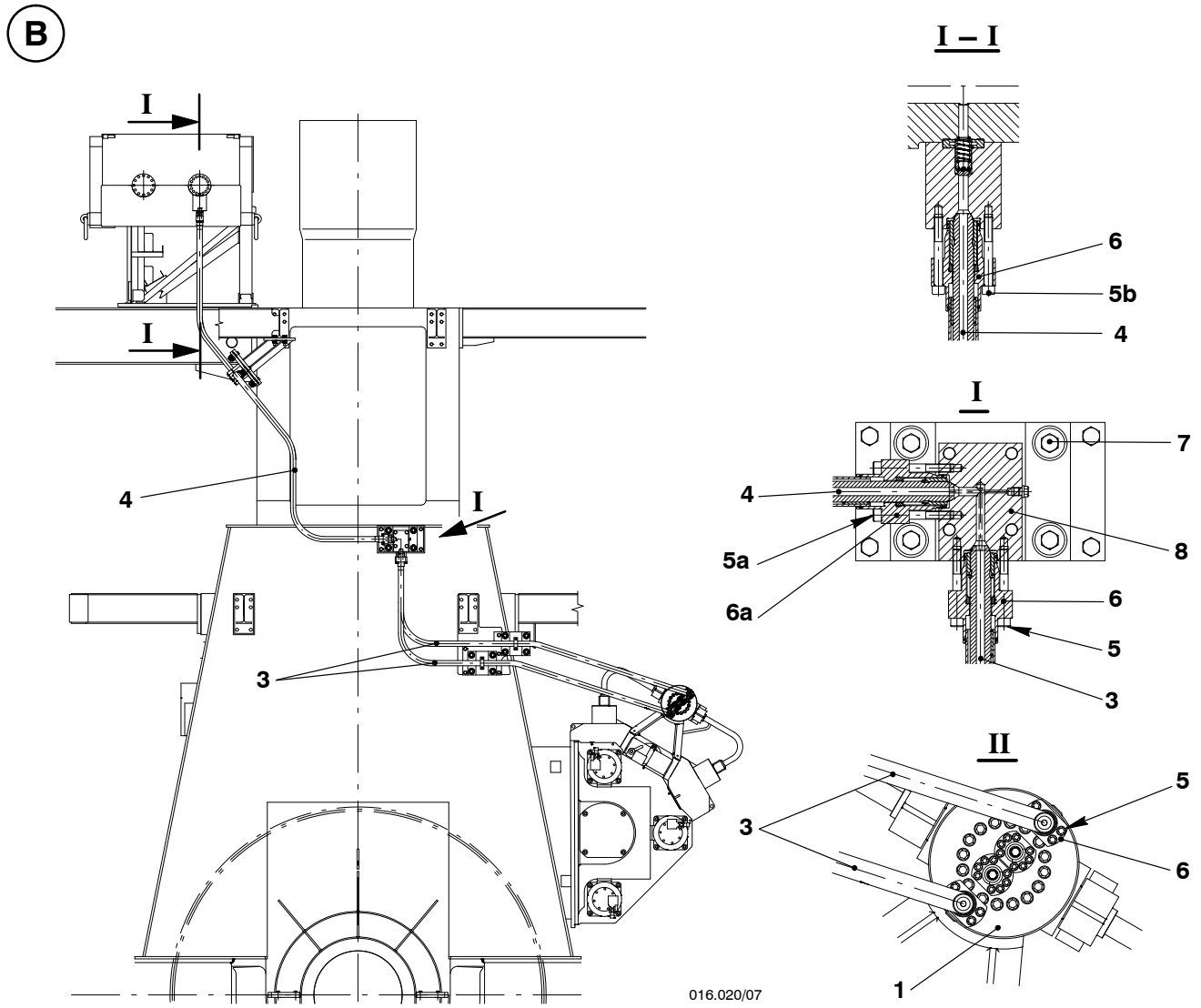
⇒ Pull fuel pressure piping 3 away and remove it from intermediate fuel accumulator 1.

1.2.2 Removal of fuel pressure piping 4

⇒ Undo screws 5a and push flange 6a back.

⇒ Undo screws 7 and remove them together with intermediate piece 8.

⇒ Undo screws 5b and remove fuel pressure piping 4.



Fuel Pressure Piping: Removing, Fitting and Regrinding

2. Fitting

Fitting procedure is analogous to the removal but in reverse sequence.

CHECK

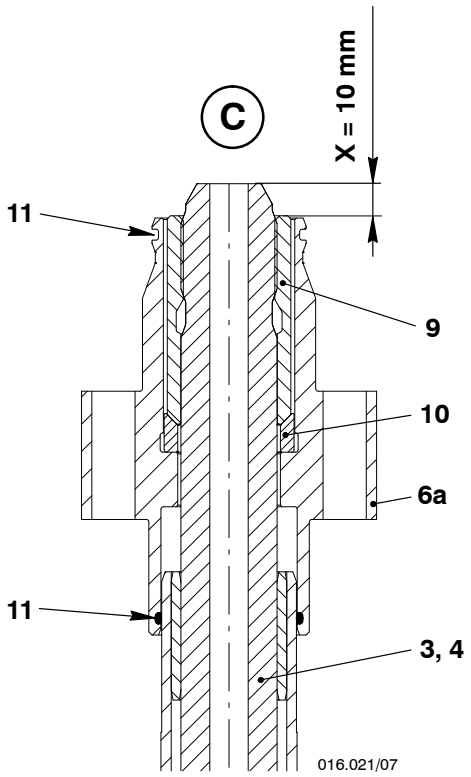
Before fitting fuel pressure piping 3, 4 check whether their claws 9 are screwed on properly, i.e. fuel pressure pipe must protrude by 'x' = 10 mm compared to the claw.

Measurement 'x' can be adjusted by turning the claw using an open end spanner.

⇒ Apply Never-Seez NSBT-8 to threads and head surfaces of screws 5, 5a and tighten them crosswise with a torque of **55 Nm**.

⇒ Close all drain screws.

⇒ After refitting the fuel pressure piping open stop valves 2 and tighten their spindles with **100 Nm**.

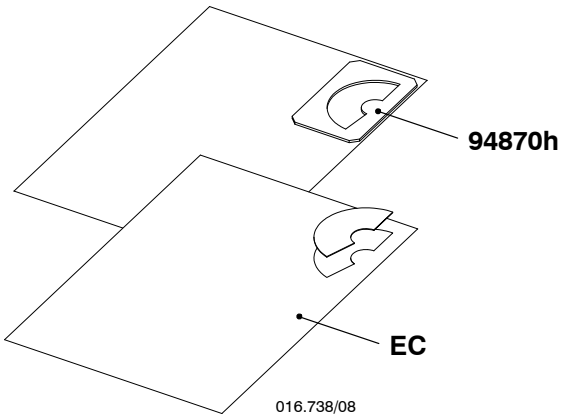


3. Regrinding of sealing faces 'DF'

3.1 With regrinding device 94870

In order to achieve a clean and smooth sealing face the following regrinding process is recommended. For deep notches > 0.1 mm choose emery cloth of medium to coarse grade. Once the deep notches have been ground off, use a fine or ultra fine emery cloth.

D

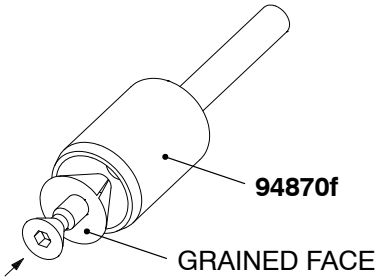


⇒ Place template 94870h on the back of emery cloth 'EC' .

⇒ Trace inner contour using a pointed pencil or a ball pen.

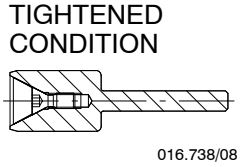
⇒ Cut out precisely the traced contour.

E



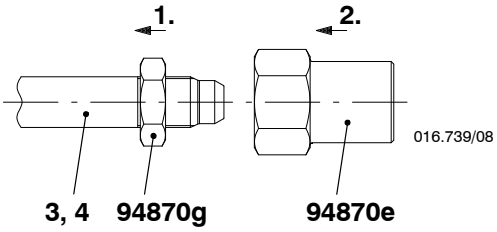
⇒ Shape the cut cloth in a manner to obtain a cone with the grained face being turned inward.

⇒ Place the emery cloth in the cone of the grinding tool 94870f and fix it by means of its countersunk screw.



Fuel Pressure Piping: Removing, Fitting and Regrinding

F



⇒ Remove claw 9 (Fig. 'C').

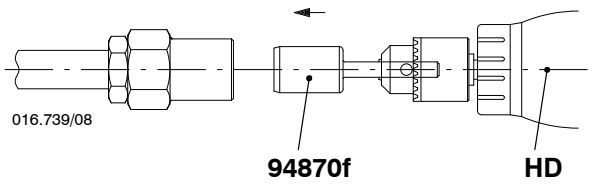
⇒ Fix fuel pressure piping 3, 4 e.g. in a vice.

⇒ Screw on counter nut 94870g until it reaches the thread end of the fuel pressure piping.

⇒ Turn screw-on sleeve 94870e up to the counter nut.

⇒ Lock the screw-on sleeve with the counter nut.

G

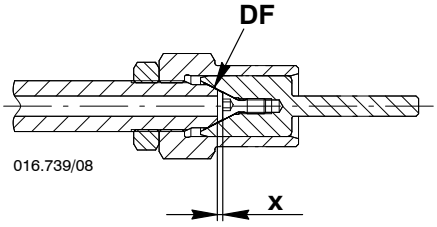


⇒ Clamp grinding tool 94870f in hand drill 'HD'.

⇒ Slide grinding tool into the screw-on sleeve until it slightly touches the fuel pressure piping.

⇒ Let the grinding tool rotate with a max. speed of 1500 rpm and grind for 3 to 5 seconds.

H



⇒ Withdraw the grinding tool from the screw-on sleeve and blow out both parts with pressurized air.

⇒ Verify the surface quality of sealing face 'DF' and if necessary repeat the regrinding process using a fresh emery cloth 'EC'.

Remark: In case of big notches the tube has to be shortened in order to restitute a clearance of 'x' = min. 0.5 mm between the countersunk screw and the end face.

⇒ Remove counter nut and screw-on sleeve.

⇒ After grinding thoroughly clean the fuel pressure piping.

Crank Angle Sensor Unit, Tools — Group 9

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting . . . . . 9223−1/A1
Tools: Explanation . . . . . 9403−1/A1
Hydraulic Jacks and Pumps: Arrangement and Application . . . . . 9403−2/A1

▽ **Hydraulic Pre-tensioning Jacks**
- Storing, Servicing and Maintenance . . . . . 9403−3/A1
- General Application Instructions . . . . . 9403−4/A1

▽ **Tool List** . . . . . 9403−5/A1
- Standard Tools . . . . . Pages 1 – 33
- Recommended Special Tools . . . . . Pages 34 – 36
- Special Tools Obtainable on Loan . . . . . Pages 37 & 38

Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

Tools:

1	Feeler gauge	94122
1	Hook spanner	94924
1	Hook spanner	94925

Key to Illustrations:

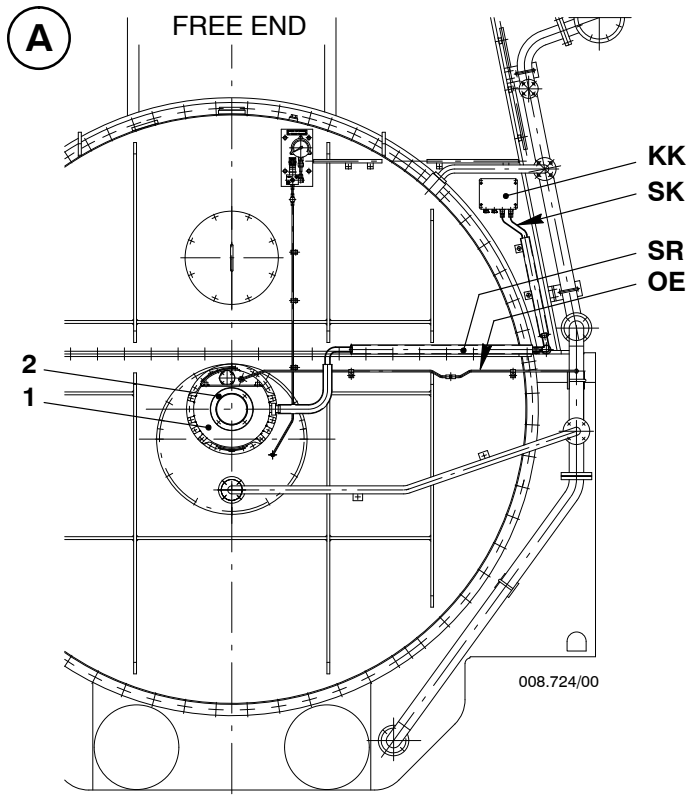
1	Protection hood	37	Disc
2	Covering cap	38	Key
3	Screw	39	Packing ring
4	Nut	40	Locating pin
5	Shaft	41	Inspection cover
6	Crank angle sensor (CAS)	42	Compression spring
7	Holder	43	Lever
8	Screw	44	Screw with locking plate
9	Toothed belt	45	Throttle
10	Protection plate	46	Housing
11	Screw with locking plate	47	Screw
12	Angle holder	48	Screw
13	Outer shaft encoder	48a	Locking plate
13a	Inner shaft encoder	49	Connecting unit
14	Bearing housing	50	Locating pin
15(a)	Screw	51	Coupling disc
16	Washer	52	Spring tensioner
17	Locking plate	53	Screw with locking plate
18	Gear wheel	54	Adjusting screw
19	Gear wheel	55	Clamp screw w. tab washer
20	Elastic screw	56	Distance piece
21	Screw with locking plate	57	Screw with locking plate
22	Packing ring	58	Locating pin
23	Adjusting disc	59	Spring balance
24	Locking plate	60	O-ring
25	Shaft nut		
26	Locking plate		
27	Shaft nut	GL	Tap hole
28	Circlip	KD	Cable clamp
29	Retaining ring	KK	Terminal box
30	Sealing ring	MB	Magnetic base with dial gauge
31	Distance ring	MK	Mark
32(a)	Ball bearing	OE	Oil inlet
33	Distance ring	SU	Collar
34	Distance sleeve	SH	Protective sleeve
35	Disc spring	SK	Sensor cable
36	Circlip	SR	Protective pipe

Overview

1. **Removal of shaft encoder** 2/22
2. **Shaft encoder** 3/22
3. **Fitting the shaft encoder and the toothed belt** 3/22
4. **Removal of crank angle sensor drive** 8/22
5. **Dismantling the crank angle sensor drive** 9/22
6. **Assembling the crank angle sensor drive** 11/22
7. **Fitting the crank angle sensor drive** 14/22
8. **Removal and fitting of compression spring** 15/22
9. **Checks** 18/22
10. **Replacement of toothed belt or CAS drive** 22/22

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

1. Removal of shaft encoder



1.1 Preparation

⇒ Pull out plug of sensor cable 'SK' at terminal box 'KK' (Fig. 'A').

⇒ Unscrew protection hood 1 and remove it together with covering cap 2.

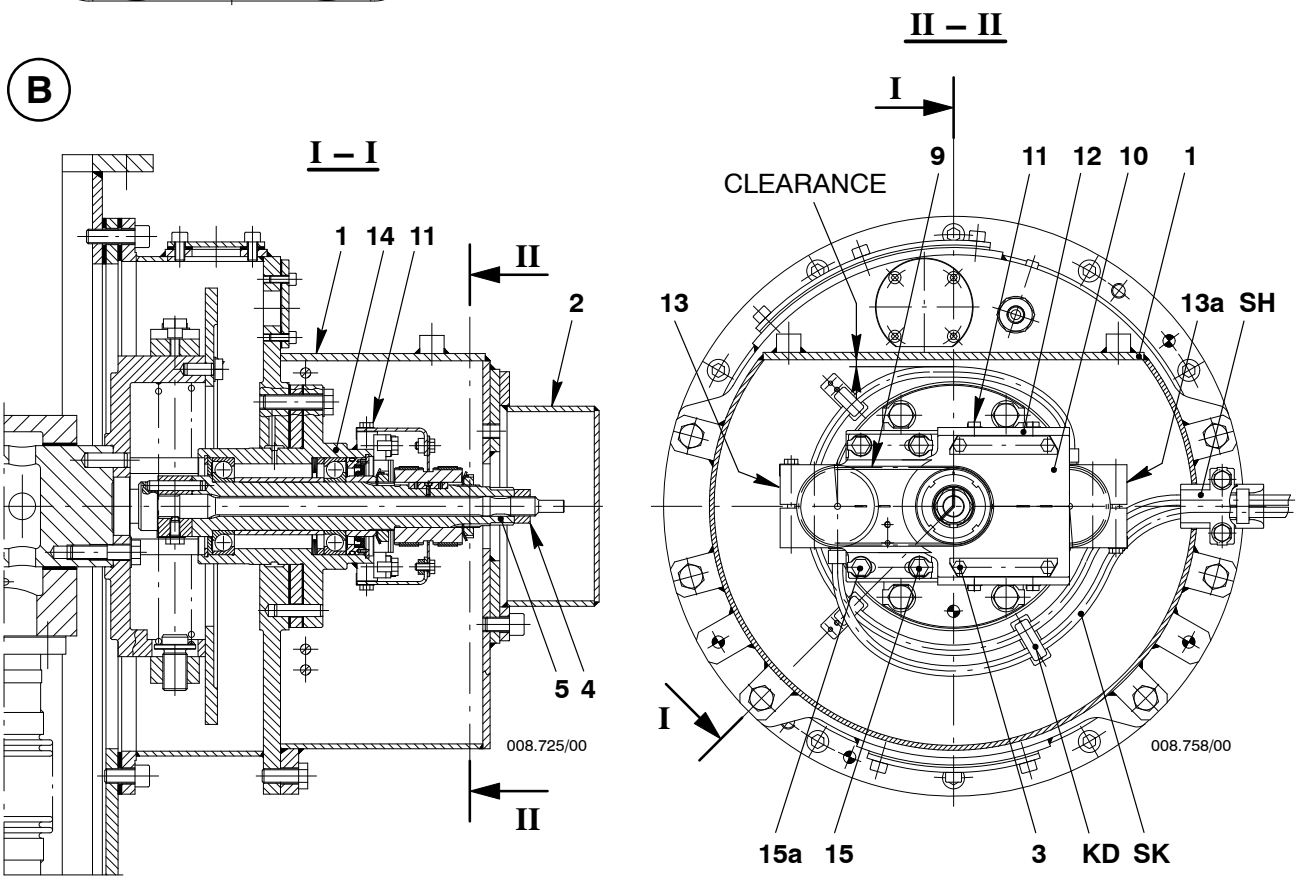
⇒ Unscrew cable clamps 'KD' as well as protective sleeve 'SH' and withdraw sensor cable from protective pipes 'SR'.

1.2 Outer shaft encoder

⇒ Loosen screws 3 and remove them together with protection plates 10.

⇒ Loosen screws 11 and remove them together with angle holder 12.

⇒ Loosen screws 15, 15a and remove outer shaft encoder 13 together with toothed belt 9.

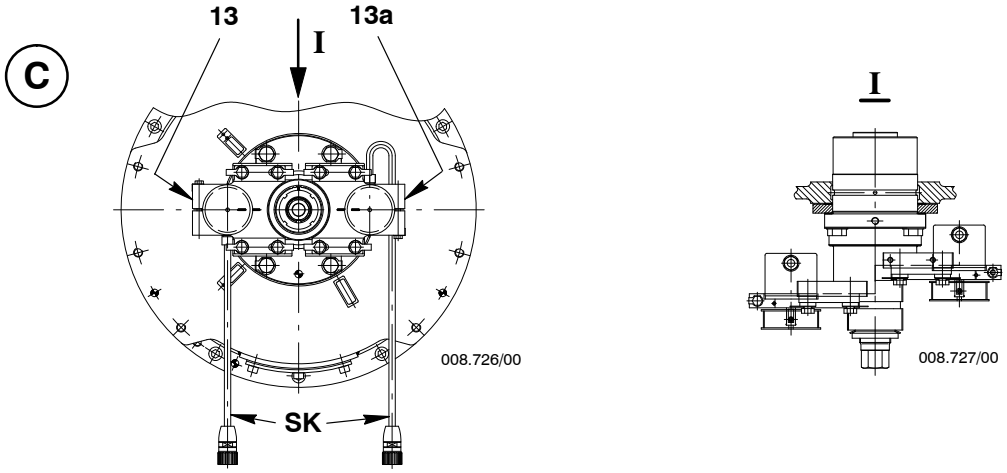


Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

1.3 Inner shaft encoder

Removing the inner shaft encoder 13a is only possible after the toothed belt of the outer shaft encoder 13 has been removed according to paragraph 1.2.

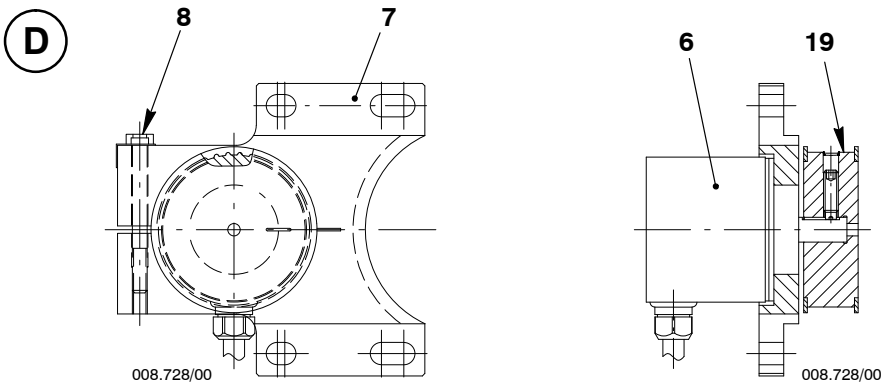
Removal of the inner shaft encoder 13a is carried out analogously to the outer one.



2. Shaft encoder

Shaft encoders are only supplied complete. The crank angle sensor 6 is fastened to the holder 7 and set by the manufacturer.

Attention! **Never** loosen screw 8!



3. Fitting the shaft encoder

3.1 Inner shaft encoder

⇒ Turn crankshaft to T.D.C. of Cyl. No.1.

⇒ Mount shaft encoder 13a (Fig. 'D' and 'F') on the guide plate of bearing housing 14 with screws 15, washers 16 and locking plates 17. Do not tighten screws 15. Apply MOLYKOTE paste G to the threads and head seatings.

CHECK

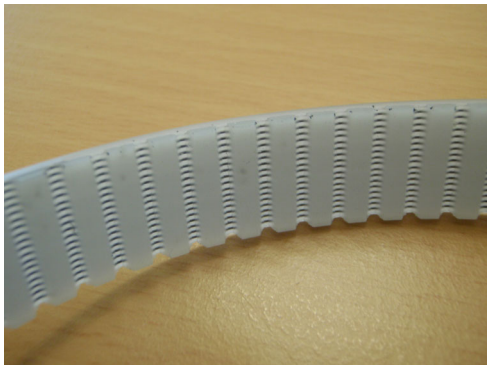
Slide shaft encoder along the guide plate to check that the shaft encoder is moving freely.

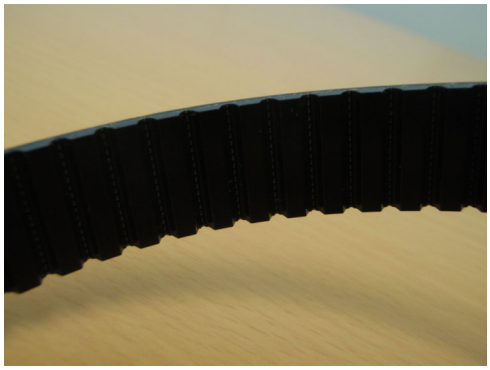
⇒ Push shaft encoder inwards.

3.2 Fitting the toothed belt

Only the new belt version (black colour) must be installed.

E





⇒ Connect gear wheels 19 and 18 with toothed belt 9, paying attention to their marks 'MK' which must coincide according to Fig. 'G' (zero position).

⇒ Push shaft encoder outwards until the toothed belt is lightly tensioned and meshing properly with the gear wheels. Lightly tighten screws 15. Recheck marks 'MK'.

⇒ Fit screws 15a, washers 16 and locking plates 17. Apply MOLYKOTE paste G to the threads and head seatings.

⇒ Align toothed belt exactly in running direction.

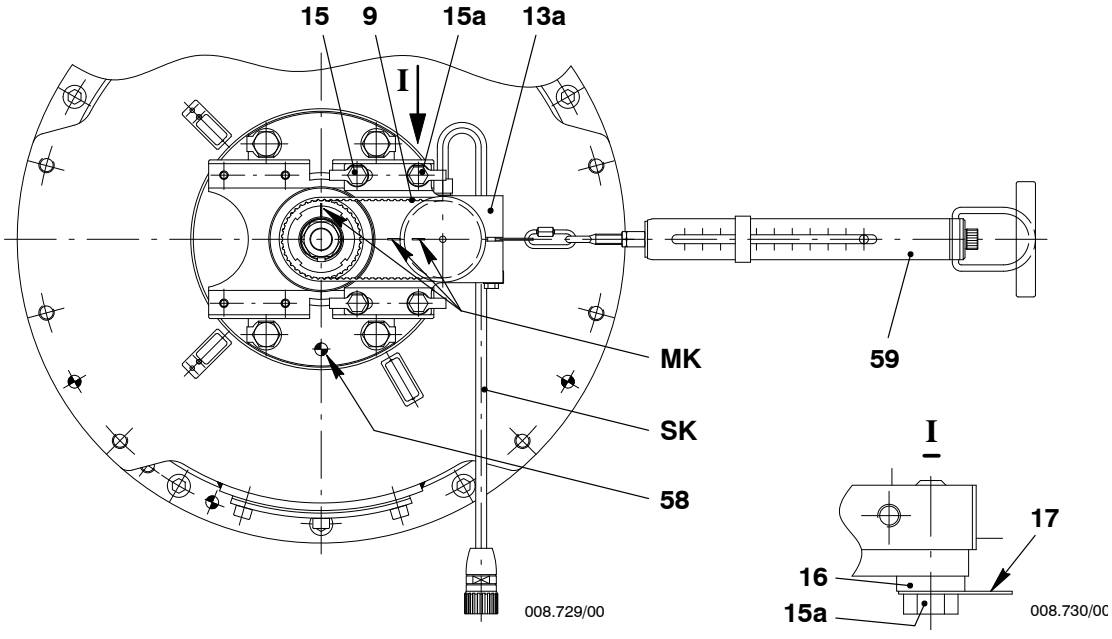
⇒ Attach spring balance 59 to the shaft encoder and slightly preload it according to Fig. 'F'.

⇒ Loosen all screws 15 and 15a, paying attention that the shaft encoder can still move freely.

⇒ Tension toothed belt with **30 N** indicated on spring balance, and fixate shaft encoder with screws 15 and 15a.

Remark: Pull the spring balance exactly in tensioning direction, keeping the friction between the holder guide and screw surfaces as small as possible.

F



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

⇒ In order to align toothed belt 9 on its running track, turn the crankshaft one to two revolutions with the turning gear.

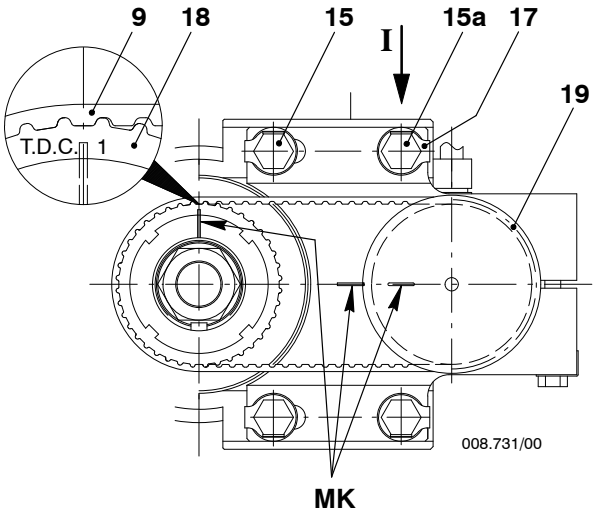
⇒ Recheck belt tension according to Fig. 'G' and 'H' as well as marks 'MK'. Repeat tensioning procedure if belt slackened after crankshaft has been turned or if marks 'MK' are not matching.

⇒ Adjust and bend the long lugs of locking plates 17 according to Fig. 'G'.

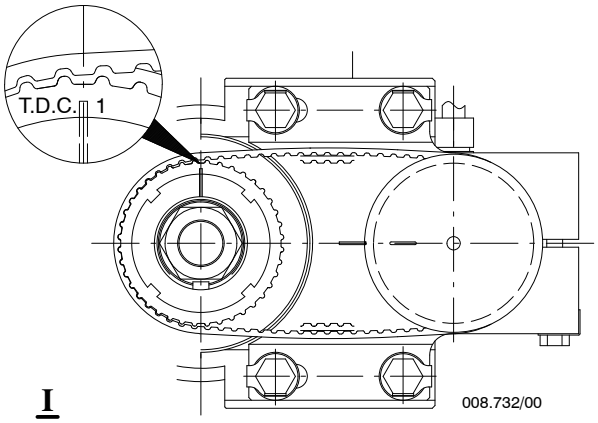
⇒ Tighten all screws 15 and 15a with a torque of **16 Nm** and lock them.

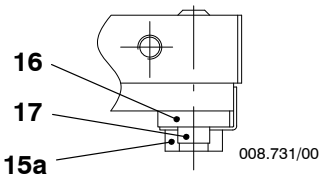
Attention! Always use new locking plates, bending them **once** only!

G **TOOTHED BELT TENSIONED**

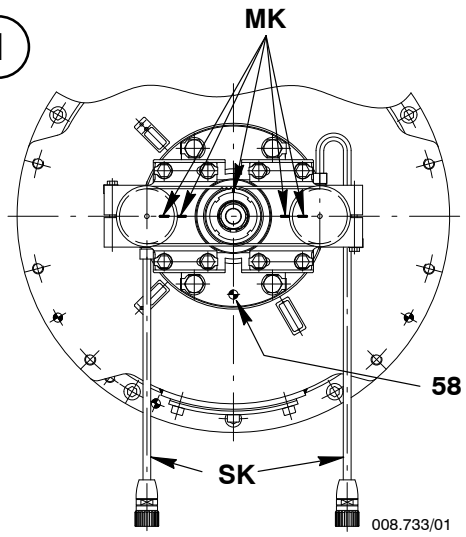


H **TOOTHED BELT LOOSE**





I



3.3 Outer shaft encoder

Fitting the outer shaft encoder 13 is carried out analogously to the inner one.

Attention! When fitting shaft encoders, toothed belts or crank angle sensor drive (section 7) always pay attention to the following points:

- Crankshaft at T.D.C. of Cyl. No.1.
- Bore for locating pin 58 of the crank angle sensor drive pointing downwards as shown in Fig. 'I'.
- Mark 'MK' (T.D.C. 1) of gear wheel 18 pointing upwards as shown in Fig. 'G' and all other marks aligned according to Fig. 'I'.

3.4 Final works

⇒ Fit angle holder 12 using screws 11 with their locking plates. Subsequently install protection plates 10 in such a way that they contact each other at the centre without overlapping and touching any moveable parts, using screws 3 with their locking plates.

⇒ Tighten and lock screws 3 and 11.

⇒ After assembling fit carefully the sensor cables 'SK'. Pay attention to the clearance which must exist between sensor cables and housing (Fig. 'B', section II).
Fit protection hood 1 together with covering cap 2.

3.5 Toothed belt change

If there should be changed only one toothed belt, proceed as follows:

⇒ Remove protection plate 10 and angle holder 12 (Fig. 'B').

⇒ Remove screws 15a with locking plates and washers.

⇒ Remove screws 15, replace locking plates and loosely refit the screws.

⇒ Push shaft encoder inwards and replace toothed belt.

- For fitting pay attention to paragraphs 3.1 to 3.4.

3.6 Rechecking of toothed belt tension

In accordance with Maintenance Schedule 0380–1 'Crank angle sensor unit' the toothed belt tension must be visually rechecked as shown in Fig. 'G' and 'H', and by lightly tapping on the toothed belt with a finger.

If necessary or in case of doubt the toothed belt must be retensioned as described in paragraph 3.2!



Attention! After every loosening of a shaft encoder the toothed belt tension must be rechecked after about five operating hours!

3.7 Adjustment of crank angle offset in WECS

After the mechanical work on the CAS and CAS drive, the crank angle offsets must be adjusted.

⇒ Turn the engine with the turning gear until the flywheel marks show T.D.C. of Cyl. No.1 = 0.0°.

⇒ Marks 'MK' must be aligned as indicated in Fig. 'J'.

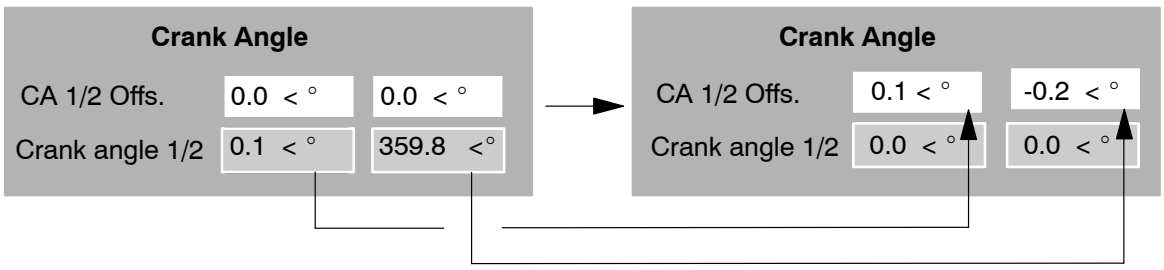
⇒ T.D.C. of the Cyl. No.1 can be cross checked from the crankcase. But safety measures must be taken accordingly before opening of the crankcase, see 'Warning labels' located near the crankcase doors on the engine.

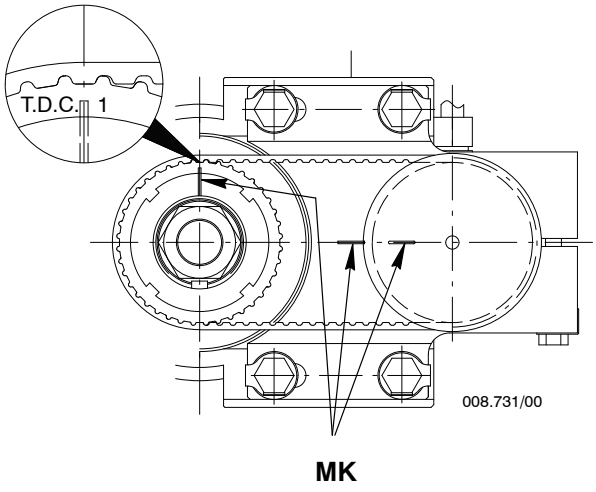
⇒ Start the 'flexView' programme and go to the ADJUST card.

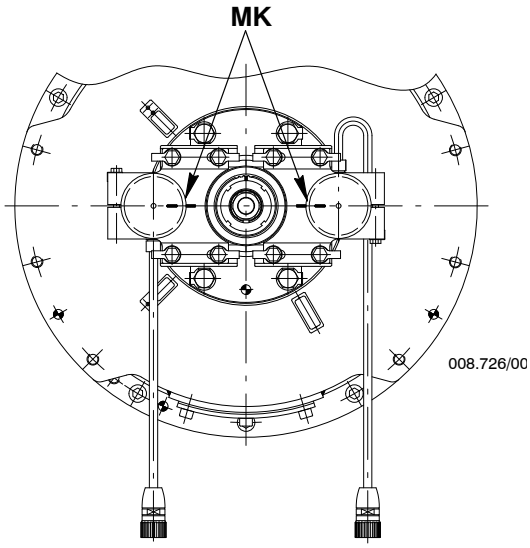
⇒ With the flywheel position as described above, read the crank angle values displayed in the fields 'Crank angle 1/2'. If they are different from 0.0° CA, enter the displayed values as offset in the fields 'CA 1/2 Offs'.

Remark! For negative deviations, e.g. 359.8 <°, use negative values – 0.2 <°.

J







4. Removal of crank angle sensor drive

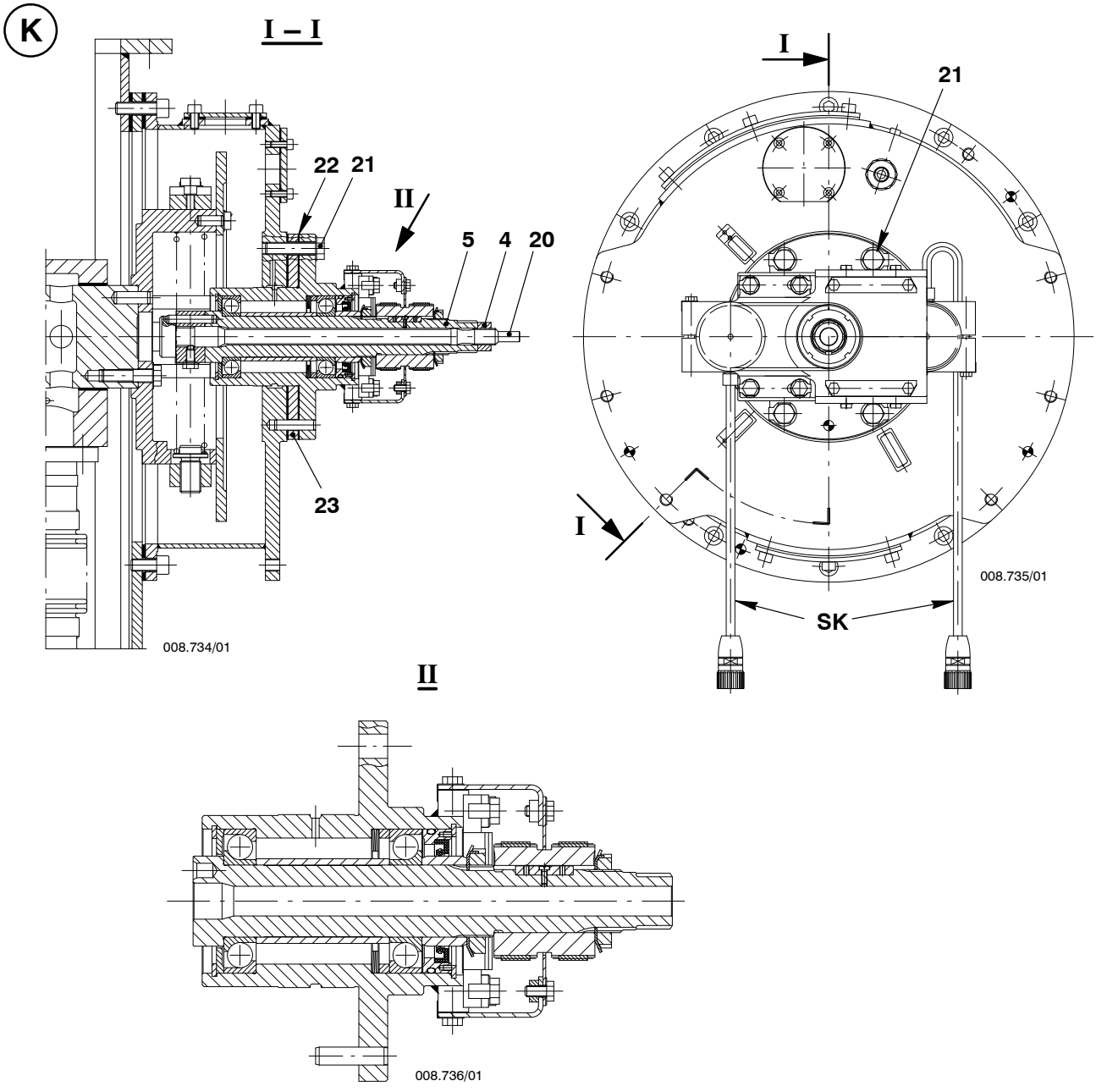
⇒ Preparation according to paragraph 1.1.

⇒ Loosen and remove nuts 4.

Attention! When loosening nut 4 **hold up** shaft 5 by means of an open end spanner AF27!

⇒ Remove screws 21 and withdraw the crank angle sensor from the elastic screw 20 (view II).

Remark: Do not unscrew adjusting disc 23.



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

5. Dismantling the crank angle sensor drive

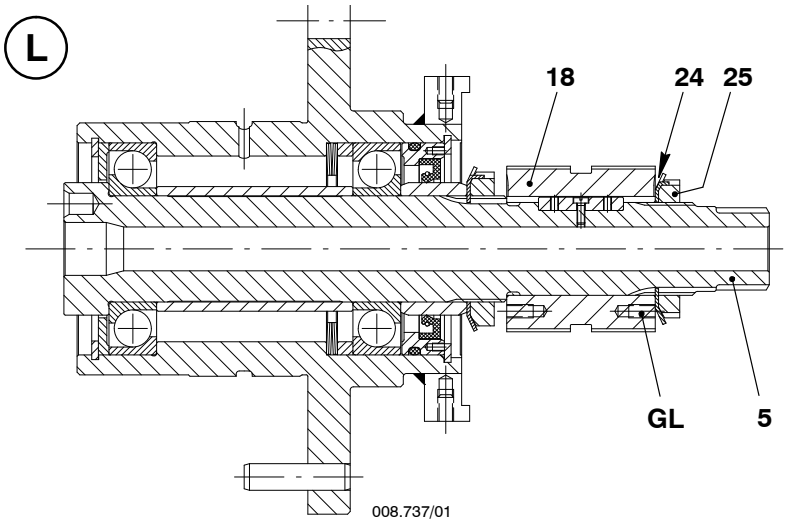
Recommendation: To ensure a high availability and quality standard we recommend that a complete crank angle sensor drive according to Fig. 'K', view II (including shaft encoder Fig. 'D') always be kept in stock. Maintenance works as described in sections 5 and 6 may be carried out only by qualified manufacturers as a matter of principle.

⇒ Remove shaft encoder according to paragraphs 1.2 and 1.3.

⇒ Unbend locking plate 24, loosen and remove shaft nut 25 using hook spanner 94924.

⇒ Withdraw gear wheel 18 from the shaft 5.

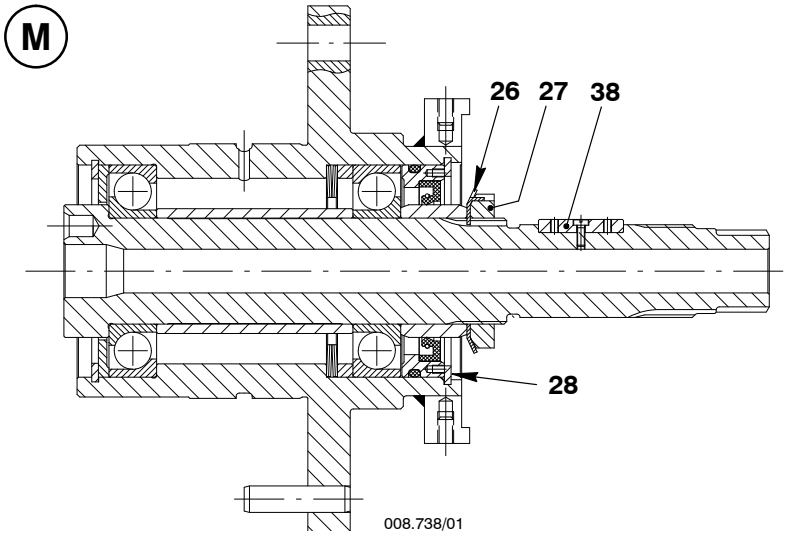
Remark: If withdrawing by hand is not possible, the gear wheel must be removed by means of the two tap holes 'GL' and suitable tools, however, without striking and damaging the toothing.



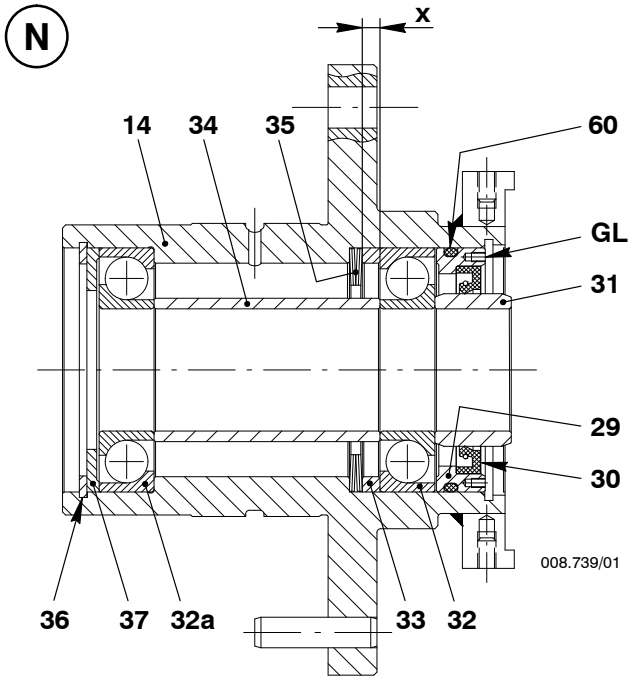
⇒ Remove circlip 28 using a snap ring tong.

⇒ Unbend locking plate 26, loosen and remove shaft nut 27 using hook spanner 94925.

⇒ Remove shaft 5, however, key 38 remains in situ.



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting



Parts to be removed in the following sequence:

- Retaining ring 29 (using tap holes 'GL') together with sealing ring 30 and O-ring 60.
- Distance ring 31.
- Ball bearing 32, distance ring 33, distance sleeve 34 and disc springs 35.
- Circlip 36.
- Disc 37 together with ball bearing 32a.

6. Assembling the crank angle sensor drive

⇒ Clean all parts and check their conditions prior to assembling.

⇒ Replace sealing ring 30, ball bearings 32, 32a and O-ring 60 (Fig. 'N').

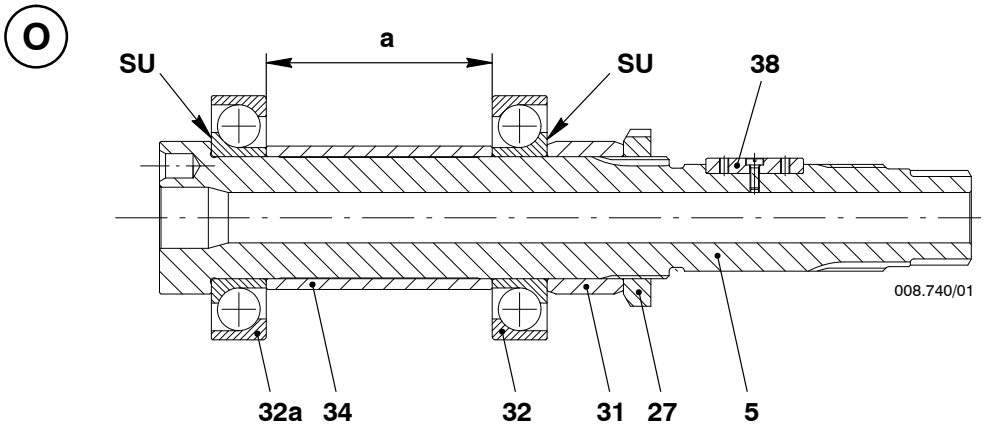
6.1 Determining of thickness 'x' of distance ring 33 (Fig. 'N')

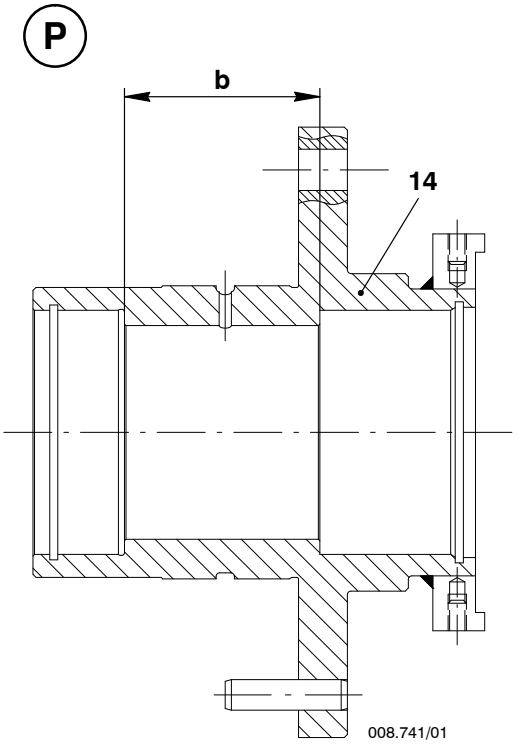
⇒ Push ball bearing 32a, distance sleeve 34, ball bearing 32 and distance ring 31 onto the shaft 5 according to Fig. 'O'.

Attention! Big collar 'SU' on inner ring of the ball bearings **must point outwards**!

⇒ Screw shaft nut 27 onto shaft 5 and lightly tighten it by means of hook spanner 94925.

⇒ Measure and note down distance 'a'.



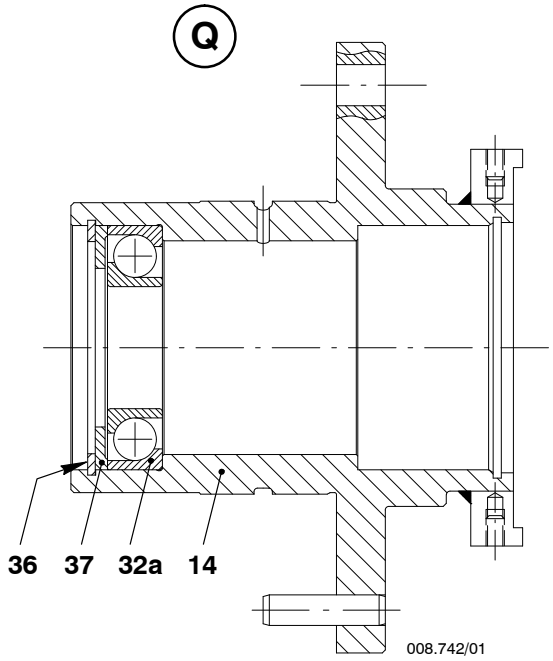


⇒ Measure and note down distance 'b' in housing 14.

According to the following formula determine thickness 'x' for distance ring 33 to be fitted:

x = a – b – 4.2 mm

Tolerance 'x' amounts to ± 0.2 mm.



6.2 Sub-assembly of bearing housing

⇒ Remove the parts which are fitted on shaft 5 as shown in Fig. 'O'.

⇒ Oil ball bearing 32a and insert it into housing 14. Pay attention to the fitting position in paragraph 6.1!

⇒ Place disc 37 with its smaller seating surface pointing to the ball bearing and fit circlip 36.

6.3 Completing of the bearing housing

⇒ Oil all parts.

⇒ Fit shaft 5.

⇒ Push distance sleeve 34 onto the shaft.

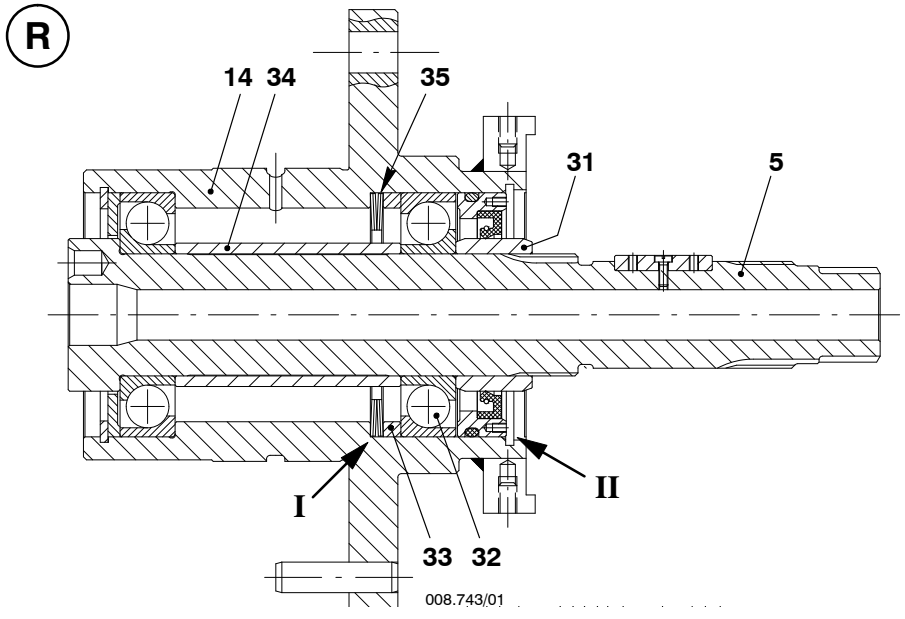
⇒ Fit disc springs 35 according to view I.

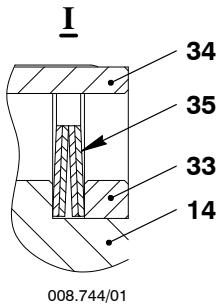
⇒ Fit distance ring 33 with thickness 'x' determined under paragraph 6.1.

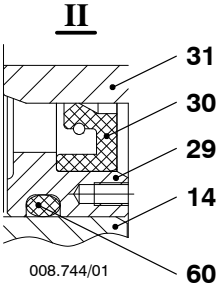
⇒ Oil ball bearing 32 and insert it into housing 14. Pay attention to the fitting position in paragraph 6.1!

⇒ Fit retaining ring 29 with new sealing ring 30 and O-ring 60 according to view II.

⇒ Fit distance ring 31.







6.4 Tightening the shaft nut

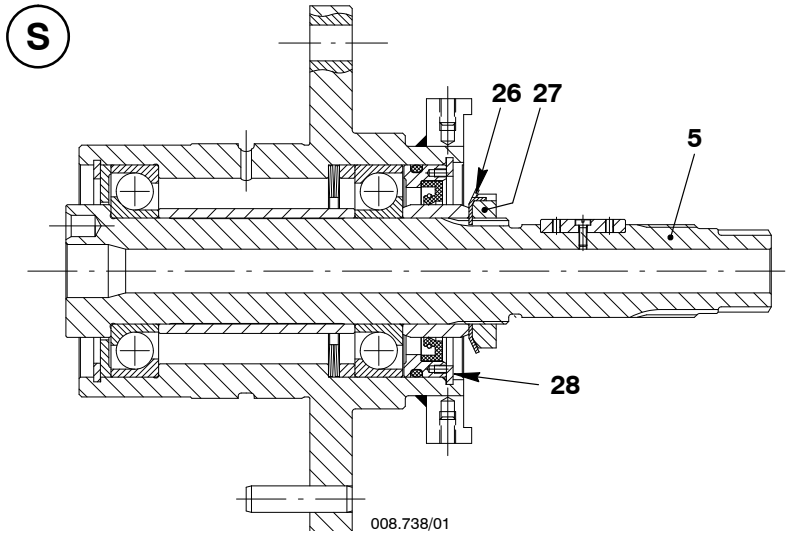
⇒ Apply MOLYKOTE paste G to the thread and seating surface of shaft nut 27.

⇒ Fit locking plate 26 and screw down shaft nut.

⇒ Put torque wrench with socket spanner AF27 on the hexagon of shaft 5 and tighten the shaft nut with **25 Nm** using hook spanner 94925.

⇒ Lock shaft nut with locking plate.

⇒ Fit circlip 28.



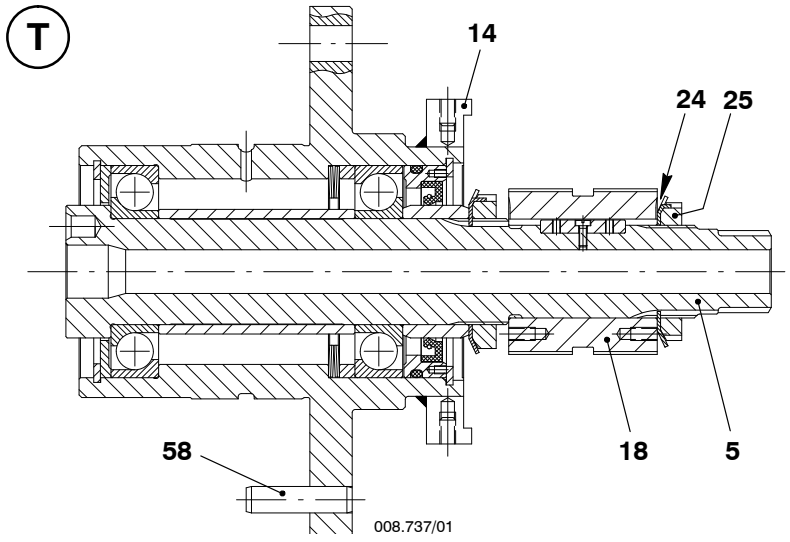
6.5 Fitting gear wheel 18

⇒ Oil bore and push gear wheel 18 onto shaft 5 until the stop.

⇒ Apply MOLYKOTE paste G to the thread and seating surface of shaft nut 25.

⇒ Fit locking plate 24 and screw down shaft nut 25.

⇒ Put torque wrench with socket spanner AF27 on the hexagon of shaft 5 and tighten the shaft nut with **25 Nm** using hook spanner 94924.



6.6 Fitting the shaft encoder

For the purpose of improved accessibility the shaft encoders 13 and 13a may be fitted onto the bearing housing 14 (Fig. 'T') outside the engine. For that proceed as described under paragraphs 3.1 and 3.2 with the difference that shaft 5 must be turned several times by hand in order to adapt it to its running track.
When fitting the toothed belt pay attention to the important points in paragraph 3.3!

7. Fitting the crank angle sensor drive

⇒ Push crank angle sensor drive with packing ring 22 a little onto elastic screw 20 and turn shaft 5 in such a way that locating pin 40 and the corresponding bore in the shaft are in line.

⇒ Push crank angle sensor drive further until the locating pin fits into the corresponding bore in shaft 5.

⇒ Fasten screws 21 with their locking plates.

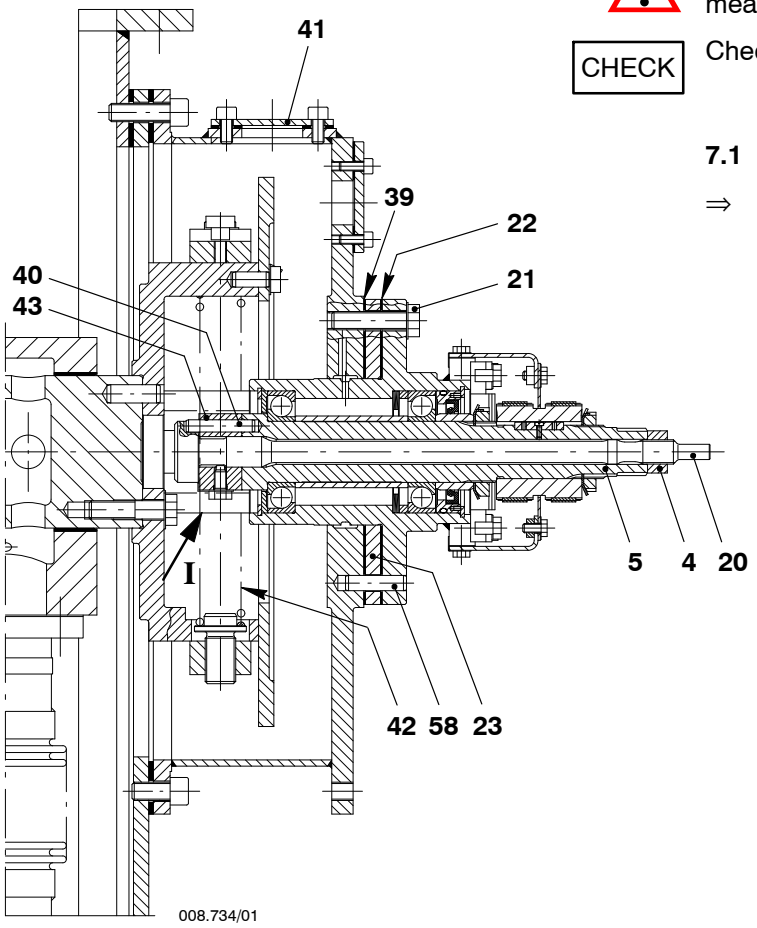
CHECK Turn crankshaft to an appropriate position.
Remove inspection cover 41 and check through the opening the fitting positions of:

– Compression springs 42, lever 43 and connection according to view I.

⇒ Apply MOLYKOTE paste G to the thread and seating surface of nut 4.

⇒ Screw nut onto elastic screw 20 and tighten it with a torque of **140 Nm**.

U

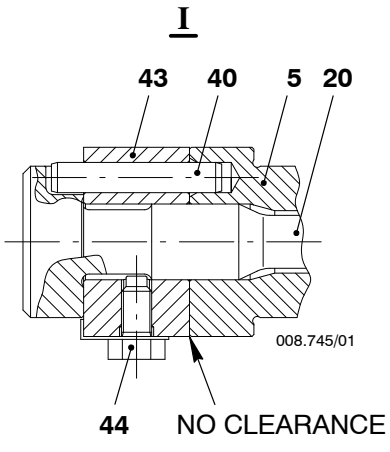


Attention! When tightening nut 4 **hold up** shaft 5 by means of an open end spanner!

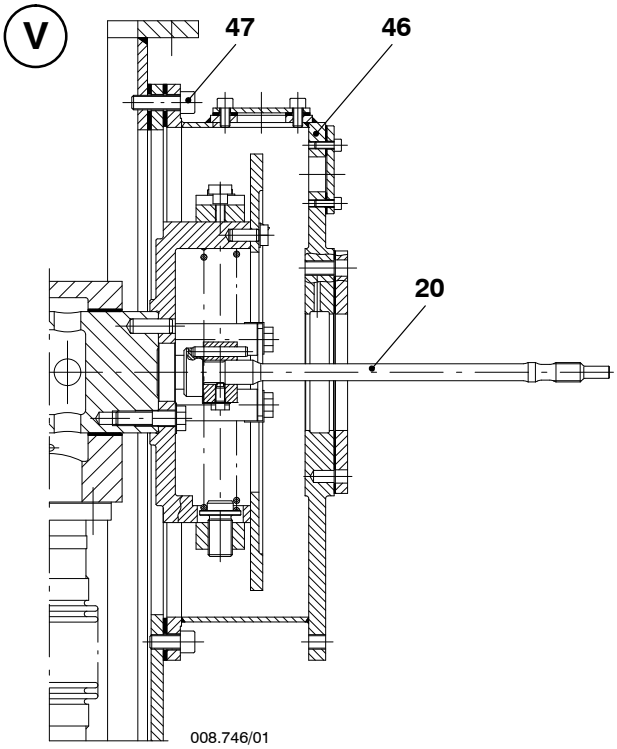
CHECK Check adjustments according to paragraph 3.3.

7.1 Final works

⇒ Carry out final works according to paragraphs 3.4 and 9.1.



8. Removal and fitting of compression spring

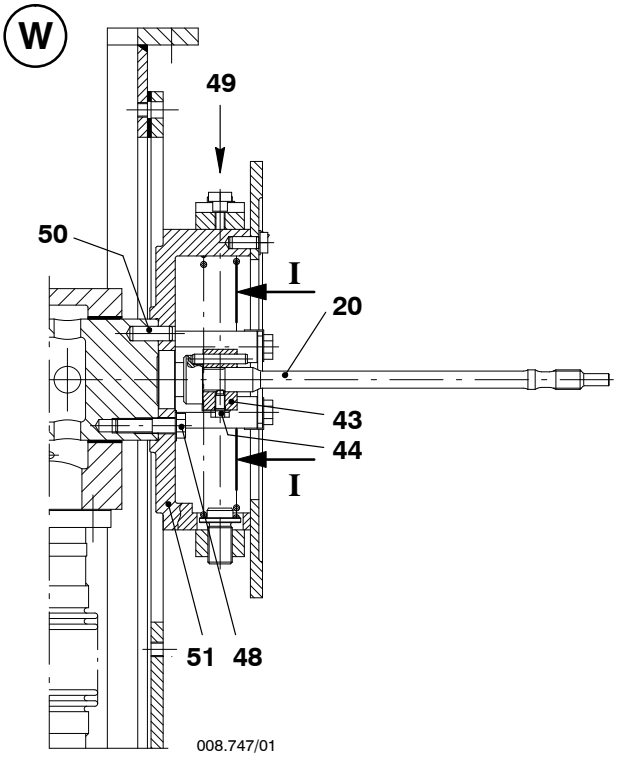


8.1 Preparation

⇒ Remove oil inlet 'OE' (Fig. 'A').

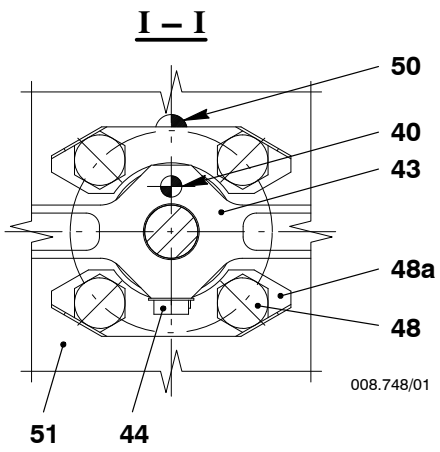
⇒ Dismantle crank angle sensor drive according to section 4.

⇒ Remove screws 47 and housing 46.

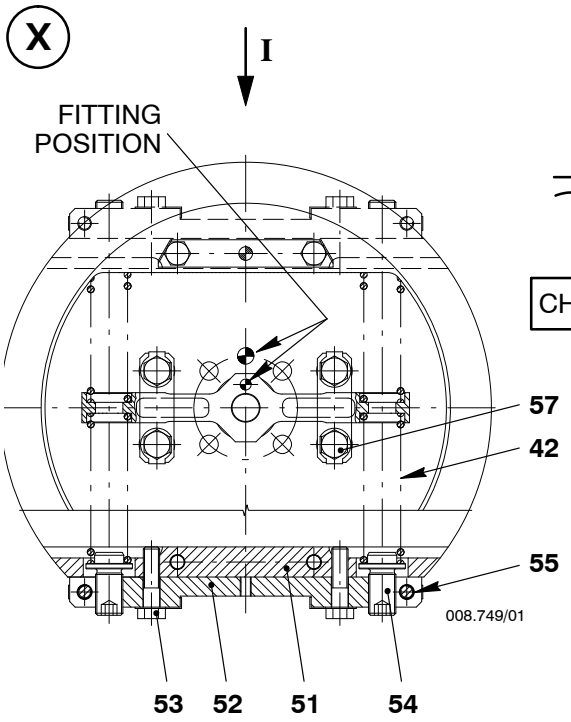


⇒ Remove screws 48 and connecting unit 49.

⇒ Remove screws 44 and withdraw elastic screw 20 from the lever 43.



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting



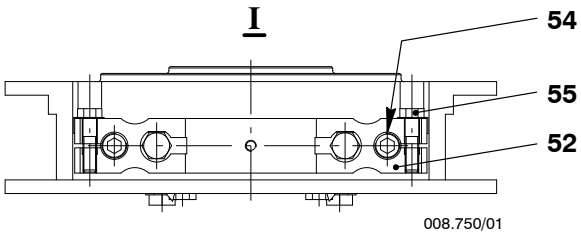
8.2 Removing the compression spring

⇒ Loosen screws 53 and remove them together with spring tensioner 52.

⇒ Remove and check compression springs.

Remark: When replacing only one compression spring 42, it is recommend to remove also the second spring tensioner for carrying out further adjustments.

CHECK Check spring seating surface for wear.



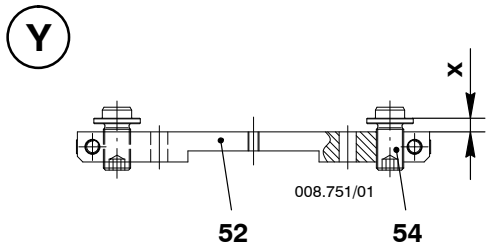
8.3 Fitting of the lever

⇒ When fitting lever 43 pay attention to its fitting position (Fig. 'X').

⇒ Replace locking plates to screws 57.

⇒ Apply MOLYKOTE paste G to threads and seating surfaces of screws 57.

⇒ Tighten screws 57 with a torque of **60 Nm** and lock them.



8.4 Fitting the compression spring

⇒ Loosen clamp screws 55 of spring tensioner 52 (Fig. 'X'). Replace locking plates. Apply MOLYKOTE paste G to threads and seating surfaces of screws 55 and refit them.

⇒ Oil and adjust all adjusting screws 54 to 'x' = 10 ± 0.10 mm (Fig. 'Y').

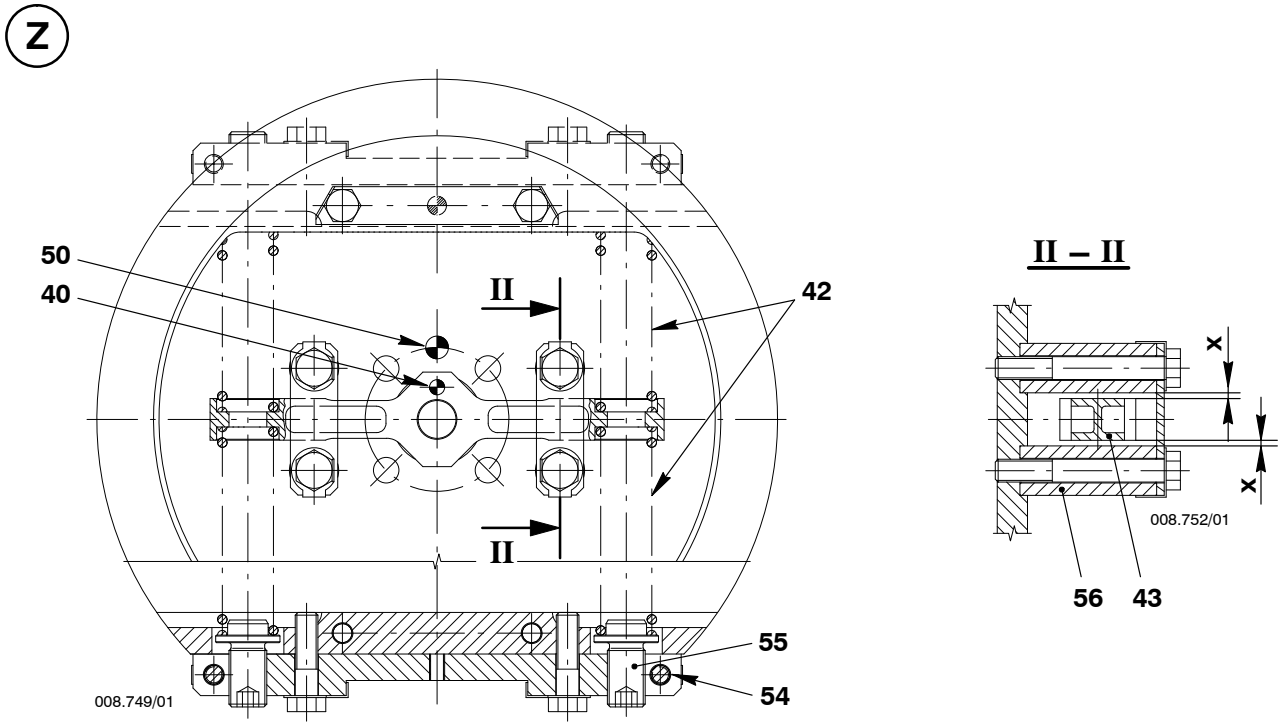
⇒ Insert compression springs 42, fit spring tensioner with screws 53 and new locking plates, applying MOLYKOTE paste G to threads and seating surfaces.

⇒ Tighten screws 53 with a torque of **60 Nm** and lock them.

8.5 Adjusting the compression spring

⇒ By means of synchronously adjusting screws 54 (i.e. if one of the adjusting screws is screwed-in by e.g. ½ turn, the opposite one must be screwed-out by ½ turn) move the relevant compression spring pair 42 until lever 43 shows the same distance 'x' between the stops on both sides (centering lever).
For measuring use feeler gauge 94122.

⇒ Tighten all clamp screws 55 with a torque of **35 Nm** and lock them.



8.6 Fitting the connecting unit (Fig. 'W')

⇒ Fit elastic screw 20 and screw 44 with new locking plates. Tighten and lock the latter (Fig. 'U' view I).

Remark: Screw 44 must **not** press against elastic screw 20!

⇒ Fit connecting unit 49 and screws 48 together with new locking plates 48a, applying MOLYKOTE paste G to threads and seating surfaces.

⇒ Tighten screws 48 with a torque of **60 Nm** and lock them.

CHECK Locating pin 40 and locating pin 50 must point upwards on Cyl. No.1 at T.D.C. according to Fig. 'W' and 'Z'!

8.7 Final fitting the crank angle sensor unit

⇒ Fit housing 46 with joint and fasten with screws 47 (Fig. 'V').

⇒ Fitting of the crank angle sensor drive according to section 7.

⇒ Carry out final works according to paragraphs 3.4 and 9.1.

9. Checks

The periodical checks **must** be carried out according to Maintenance Schedule 0380–1 'Crank angle sensor unit'.

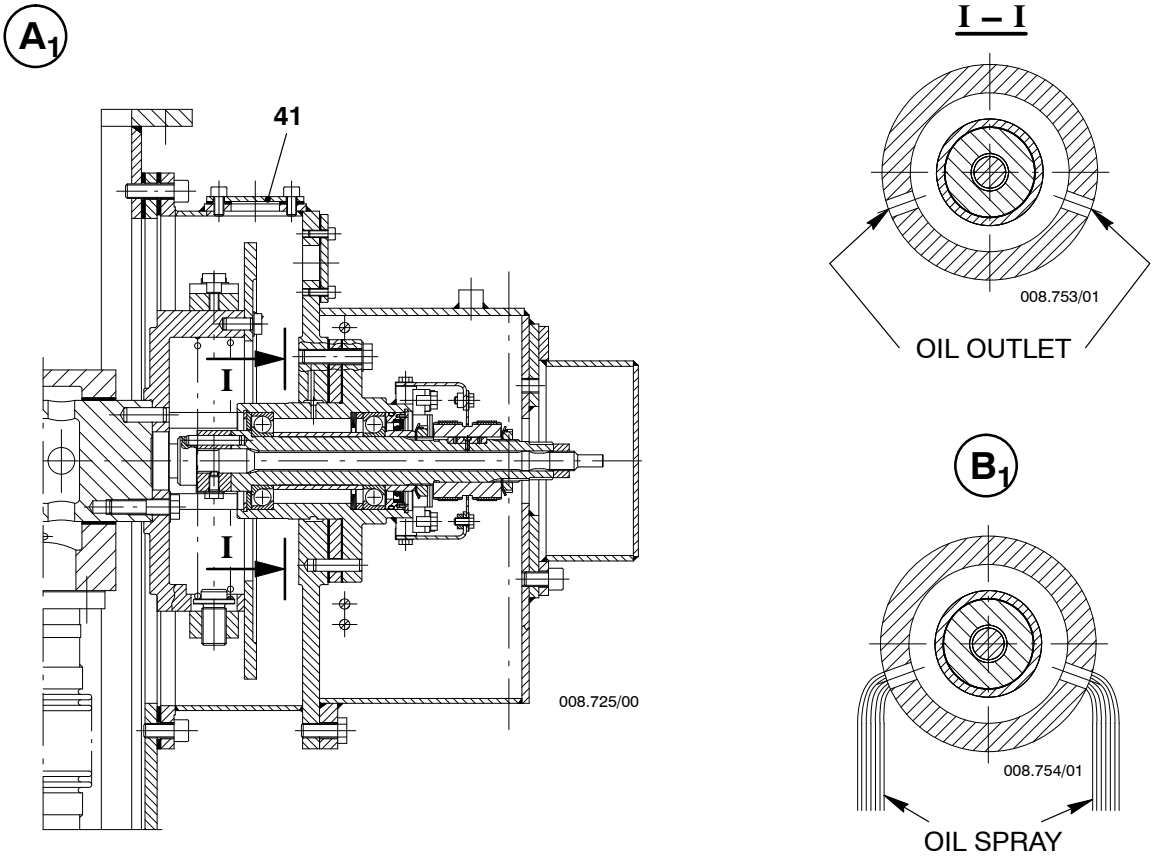
9.1 Lubricating oil flow in the crank angle sensor drive

⇒ Start main lubricating oil pump and adjust bearing oil pressure.

⇒ Remove inspection cover 41.

With correct oil flow at operating temperature an oil spray results according to Fig. 'B_1'. However, the oil outlets should be filled up.

⇒ Refit inspection cover 41.



9.2 Checking the throttle

Before reaching the crank angle sensor unit, the oil flows first through throttle 45, which reduces the oil quantity and also keeps back larger oil particles.

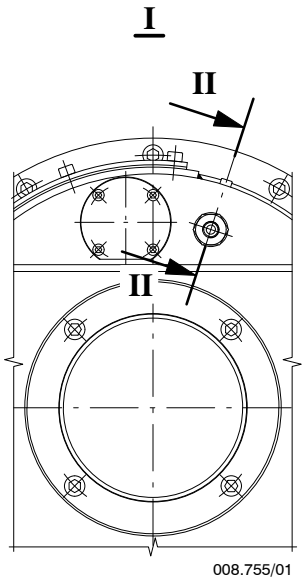
Checking the throttle is carried out as follows:

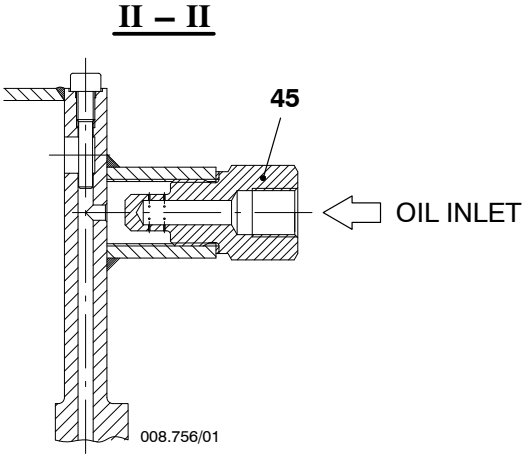
⇒ Stop main lubricating pump.

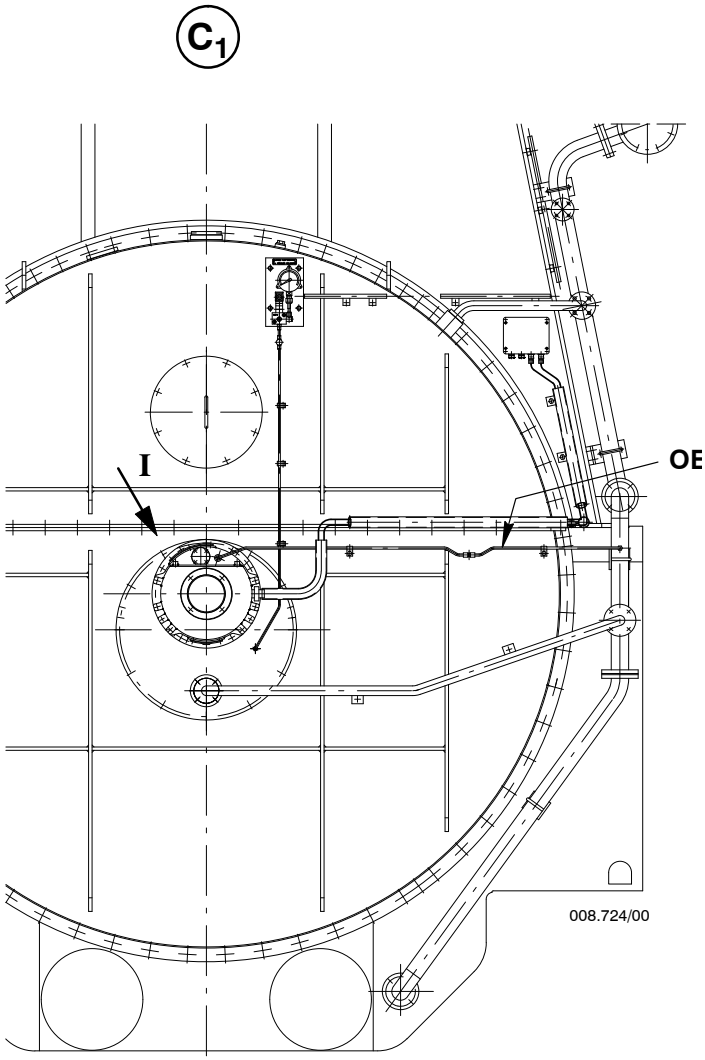
⇒ Remove oil inlet 'OE' from the throttle.

⇒ Unscrew throttle and check its oil spray holes for free passage. Clean if necessary.

⇒ Reinstall all parts.







9.3 Checking the shaft eccentricity

The following chekcs and the replacement of CAS parts can only be carried out if the engine is at standstill.

Ckeck the shaft eccentricity in case of CAS exchange.

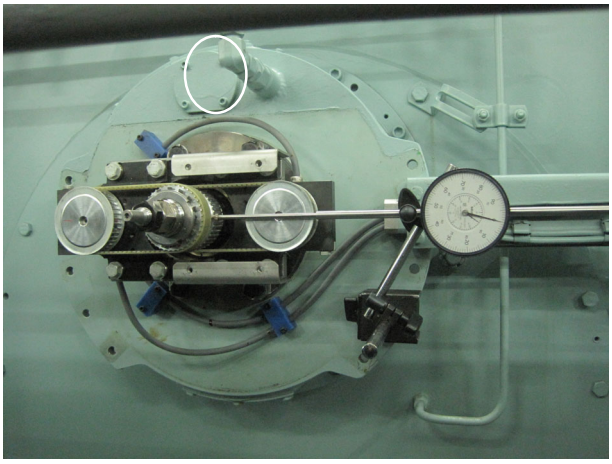
It is essential to perform the eccentricity check according to the Maintenance Schedule 0380-1.

9.4 Eccentricity check

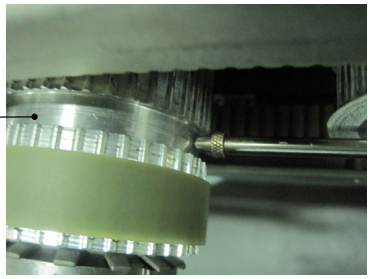
⇒ Remove the protection hood 1 of the CAS drive (see Fig.'B').

⇒ Install the magnetic base with dial gauge 'MB'.

D1







Remark! The measuring point must be horizontally adjacent of the gear wheel 18.

⇒ Read the deviation on the dial gauge while turning the crankshaft with the turning gear.

The average shaft eccentricity under normal working and assembly condition must be less than **0.15 mm**.

In case the measured value is out of the stated average eccentricity value, it is recommended to replace the CAS with a new one (see sections 5 and 7). A CAS drive is available as a standard spare part.

9.5 Checking the clearance between shaft and internal bearing of the CAS

In case the CAS is over five years in service or has more than 48 000 operating hours, it is recommended to check the condition of the CAS before a new belt version is installed. The CAS condition is checked by measuring the clearance between the shaft and internal CAS bearing.

***Procedure for measuring the clearance**:*

⇒ Remove the protection hood 1 of the CAS drive (see Fig.'B').

⇒ Remove the protection plate 10.

⇒ After loosening the screws 15a and 15, remove first the toothed belt of the outer CAS and then the toothed belt of the inner CAS.

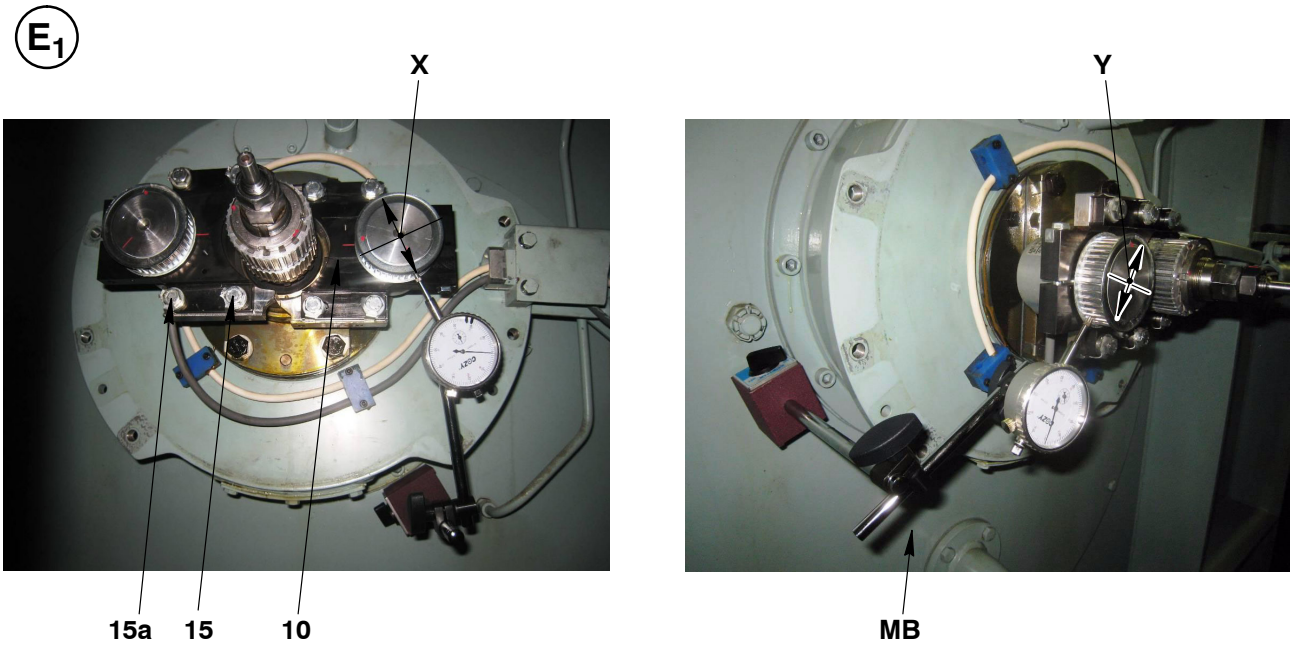
⇒ After removing the toothed belt, tighten the screws 15a and 15 again.

⇒ Install the magnetic base with dial gauge 'MB' as shown below.

⇒ Push the gear wheel of the CAS to the left and right direction.

The measurements 'X' and 'Y' have to be done in fixed condition of the outer and inner CAS but without the toothed belts.

⇒ Read the deviation on the dial gauge while pushing the gear wheel of the CAS. The average CAS clearance under normal working and in assembly condition must be less than **0.05 mm.**



9.6 Checking the toothed belt condition

The toothed belt has to be checked every 3000 operating hours for its pre-tension. In addition a visual inspection of the belt ha to be performed, which means checking for possible cracks and worn-out areas.

Attention! Worn-out toothed belts must be replaced immediately.

10. Replacement of toothed belt or CAS drive

10.1 Replacement of the toothed belt

The new toothed belt version must be used (Fig. 'E'), which can be ordered separately as single part according to the Spare Parts Code Book.

Do not use the old toothed belt anymore.

10.2 Reasons for CAS drive replacement

There are two reasons which require a CAS drive overhaul:

- High shaft eccentricity: To verify the eccentricity, see the paragraph 9.3.
- Maintenance schedule: Work to be carried out at 48 000 operating hours.

Before carrying out the replacement of a CAS drive which is available as a standard spare part, a new CAS drive must be ordered unless a repair kit is available on board.

The spare parts order number is to be found in the Spare Parts Code Book, Group 9, Chapter 9601–1, within item 'Crank Angle Sensor Unit' and named 'Shaft encoder drive, complete' or 'Shaft encoder, complete (box)'.

Remark! According to IACS regulations, at least one Shaft Encoder Package box containing the spring balance is part of the standard spare parts supply per ship.

Tools

Explanation

1. General

The tools required for erection and maintenance of the engine are divided into **three groups** as per the following 'Tool List':

- Standard tools
- Recommended special tools
- Special tools available on loan

When ordering additional tools or replacements, the tool No. as well as the tool description including engine type must be indicated (see 9403–5).

Detailed instructions on the arrangement and application, storing, servicing and maintenance of the hydraulic pre-tensioning jacks are given in 9403–2 to 9403–4.

When oil must be added to the hydraulic pumps, the specification regarding oil quality issued by the pump manufacturers must be followed. Utilize generally an engine lub. oil having viscosities SAE 30 to SAE 40.

A cylinder lubricating oil also can be used in exceptional cases.

A separate set of tools is issued for certain components from sub-suppliers, which should also be stored separately from the engine tools.

2. Standard tools

... are tools and devices required for normal maintenance work on the engine. In this respect take into consideration that, depending on the design execution of the engine, certain tools and devices which are mentioned in the above sheets are not required for specific maintenance work, and are therefore not part of the engine tools supply.

3. Recommended special tools

... are tools and devices, which allow certain maintenance work to be done with more ease, and in a shorter time, than with the standard tools.
These tools can be ordered separately either with the engine or at a later date.

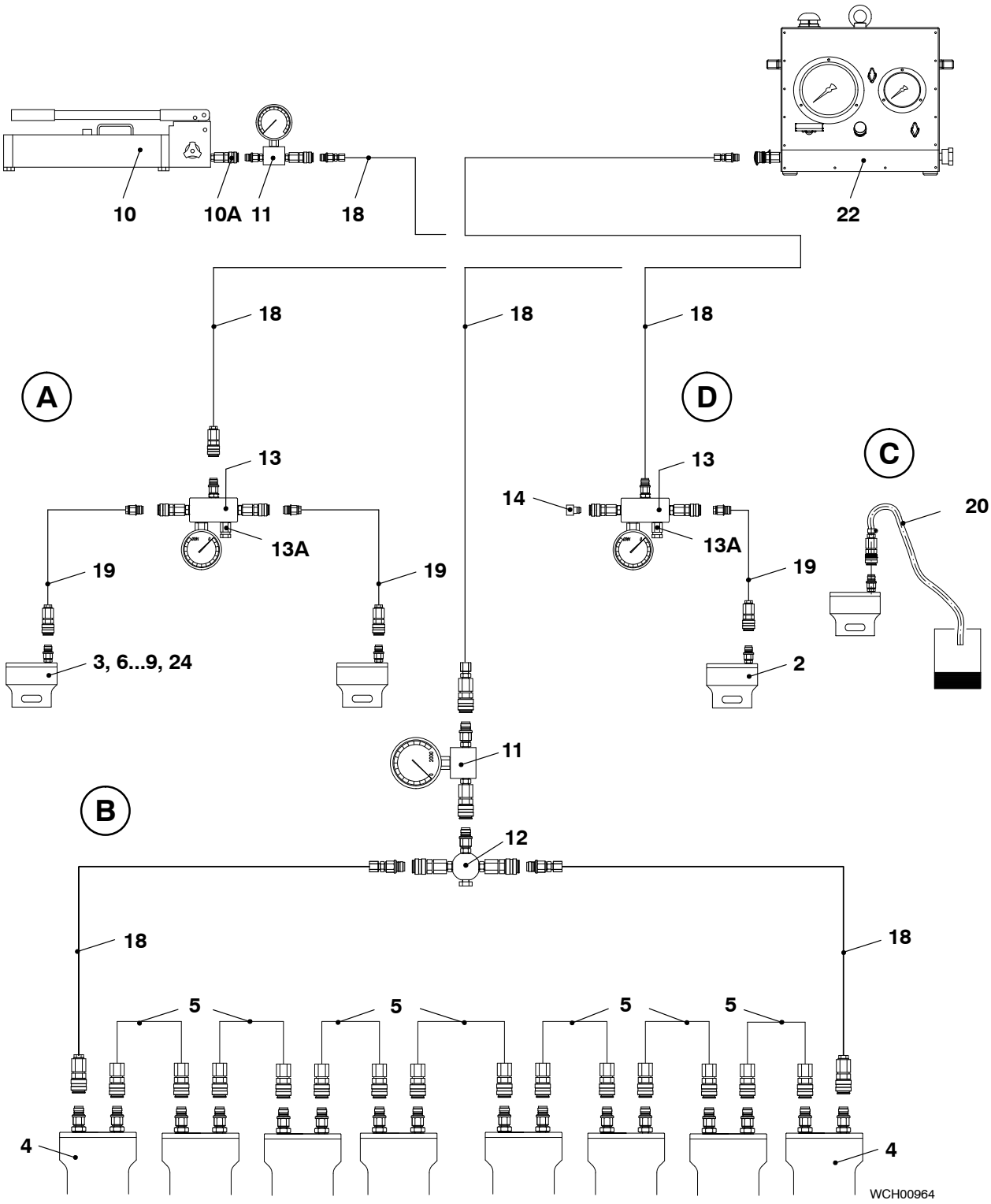
4. Special tools available on loan

... are such tools and devices which are loaned for transportation and for erection of the engine. They are to be returned to the engine manufacturer after completion of engine erection.

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Hydraulic Jacks and Pumps

Arrangement and Application



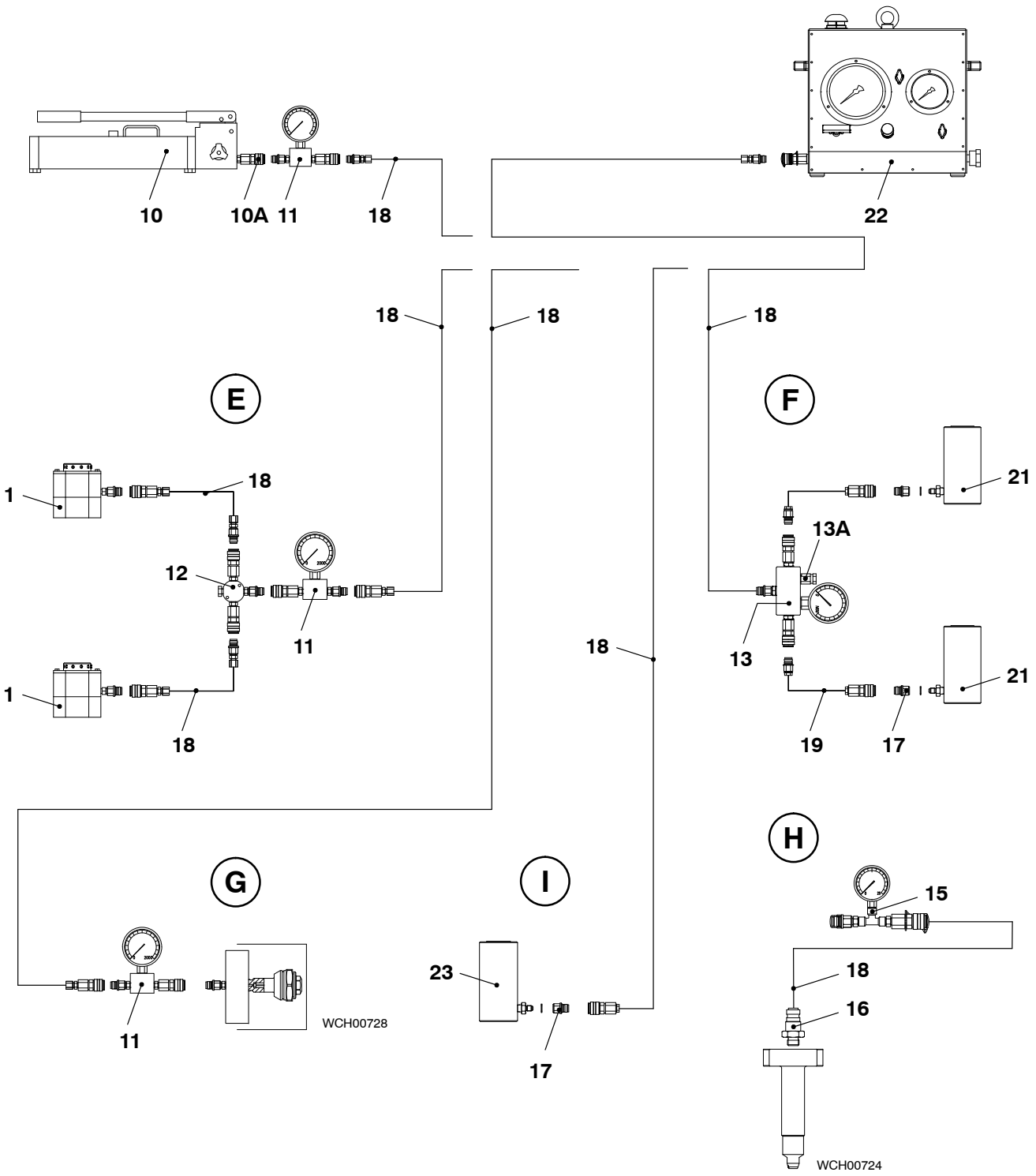
A = Tensioning / loosening of tie rods, elastic studs to exhaust valve cage, top and bottom end bearings to connecting rod, piston rod foot, supply unit

B = Tensioning / loosening of elastic studs to cylinder cover

C = Set-up of pre-tensioning jacks 4 (collecting squeezing oil)

D = Tensioning / loosening of foundation bolts and engine stays

Hydraulic Jacks and Pumps: Arrangement and Application



E = Tensioning / loosening of elastic studs to main bearing

F = Removal and fitting of main bearing shell

G = Checking and setting of fuel overpressure safety valve

H = Checking of non-return valve in lubricating quill for pulse lubrication

I = Removal and fitting of main bearing shell

Hydraulic Jacks and Pumps: Arrangement and Application

		Tool
1	Double pre-tensioning jacks (main bearing)	94114
2	Pre-tensioning jack (foundation bolts & engine stays)	94145
3	Pre-tensioning jacks (tie rods)	GF 94180
4	Pre-tensioning jack (cylinder cover)	GF 94215
5	Hose	GF 94215K
6	Pre-tensioning jack (exhaust valve cage)	94252
7	Pre-tensioning jack (bottom end bearing)	94314
8	Pre-tensioning jack (top end bearing)	94315
9	Pre-tensioning jack (piston rod foot)	94340
10	HP oil pump (2800 bar)	94931
10A	Adapter piece	94934F
11	Hydr. distributor	94932
12	Connection block	94934
13	Hydr. distributor	94934A
13A	Relief valve	94934K
14	Plug piece	94934E
15	Hydr. distributor (with pressure gauge 0...25 bar)	94934H
16	Connection nipple	94934I
17	Closing valve with Tredo joint	94934J
18	High pressure hose (2600 bar)	94935
19	High pressure hose (1500 bar)	94935A
20	Hose	94935C
21	Hydr. jack 230 kN (23 t)	94936
22	Hydraulic unit (2500 bar)	94942
22	Hydraulic unit (2500 bar)	94942
24	Pre-tensioning jack (supply unit)	94577

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1. General

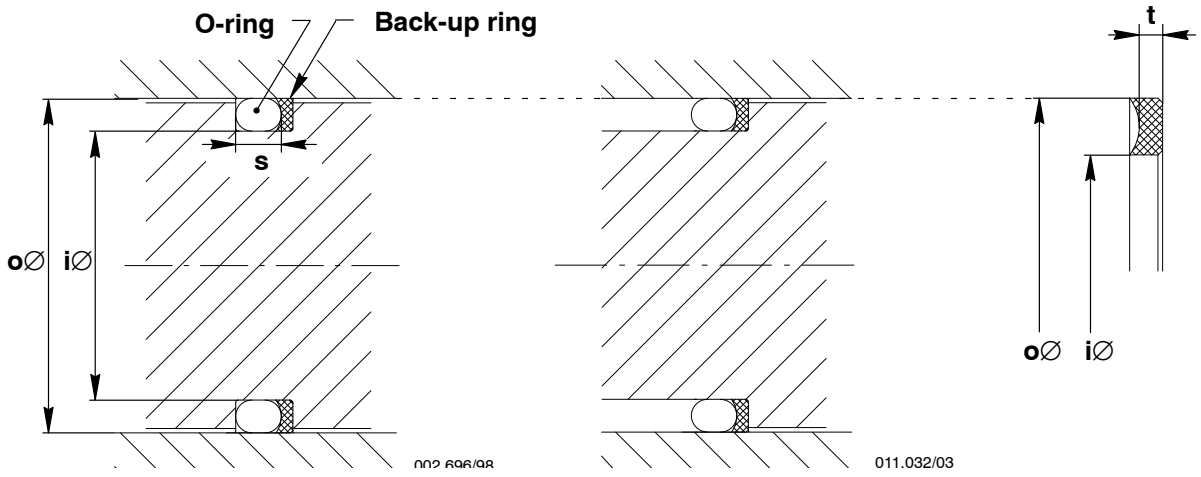
The hydraulic pre-tensioning jacks as engine tool kit are to be stored in their tool boxes when not in use. Grease them after use and close the connections with dust plugs. We recommend for each jack to keep a sealing–kit (KJ–) in stock.

Always pay attention to the correct position when fitting new back-up and O-rings as shown on the following pages.

When inserting new back-up and O-rings proceed with care to avoid their damage; do not use any sharp edged utensils for assistance!
Heat uncut back-up rings in boiling water before fitting them.

1.1 Dimensions of back-up and O-rings

Tool No.	Place of application of pre-tensioning jack	Part	Back-up ring uncut (*cut)	O-ring
			Dimension [mm]	
			o∅ x i∅ x t	i∅ x s
94114	Elastic bolts to main bearing	piston cylinder	109 x 99.6 x 1.7 * 79.9 x 70.5 x 1.7 *	97.79 x 5.33 69.22 x 5.33
94145	Foundation bolt and engine stay	piston cylinder	117 x 107.6 x 1.7 94.4 x 85 x 1.7	104.14 x 5.33 85.09 x 5.33
GF 94180	Tie rod	piston cylinder	183 x 170.8 x 2.5 127.4 x 118 x 1.7	164.47 x 6.99 116.84 x 5.33
CF 94215	Elastic bolt to cylinder cover	piston cylinder	140.5 x 128.3 x 2.5 99.4 x 90 x 1.7	126.37 x 6.99 91.44 x 5.33
94252	Elastic bolt to exhaust valve cage	piston cylinder	185 x 172.8 x 2.5 107.4 x 98 x 1.7	170.82 x 6.99 97.79 x 5.33
94314	Elastic bolt to bottom end bearing	piston cylinder	150 x 137.8 x 2.5 109.4 x100 x 1.7	135.89 x 6.33 100.97 x 5.33
94315	Elastic bolt to top end bearing	piston cylinder	115 x 105.6 x 1.7 84.4 x 75 x 1.7	104.14 x 5.33 75.57 x 5.33
94340	Elastic bolt to piston rod foot	piston cylinder	85 x 75.6 x 1.7 64.4 x 55 x 1.7	75.57 x 5.33 56.52 x 5.33
94577	Elastic bolt to supply unit	piston cylinder	70 x 64.6 x 1.4 50.4 x 45 x 1.4	63.09 x 3.53 44.04 x 3.53

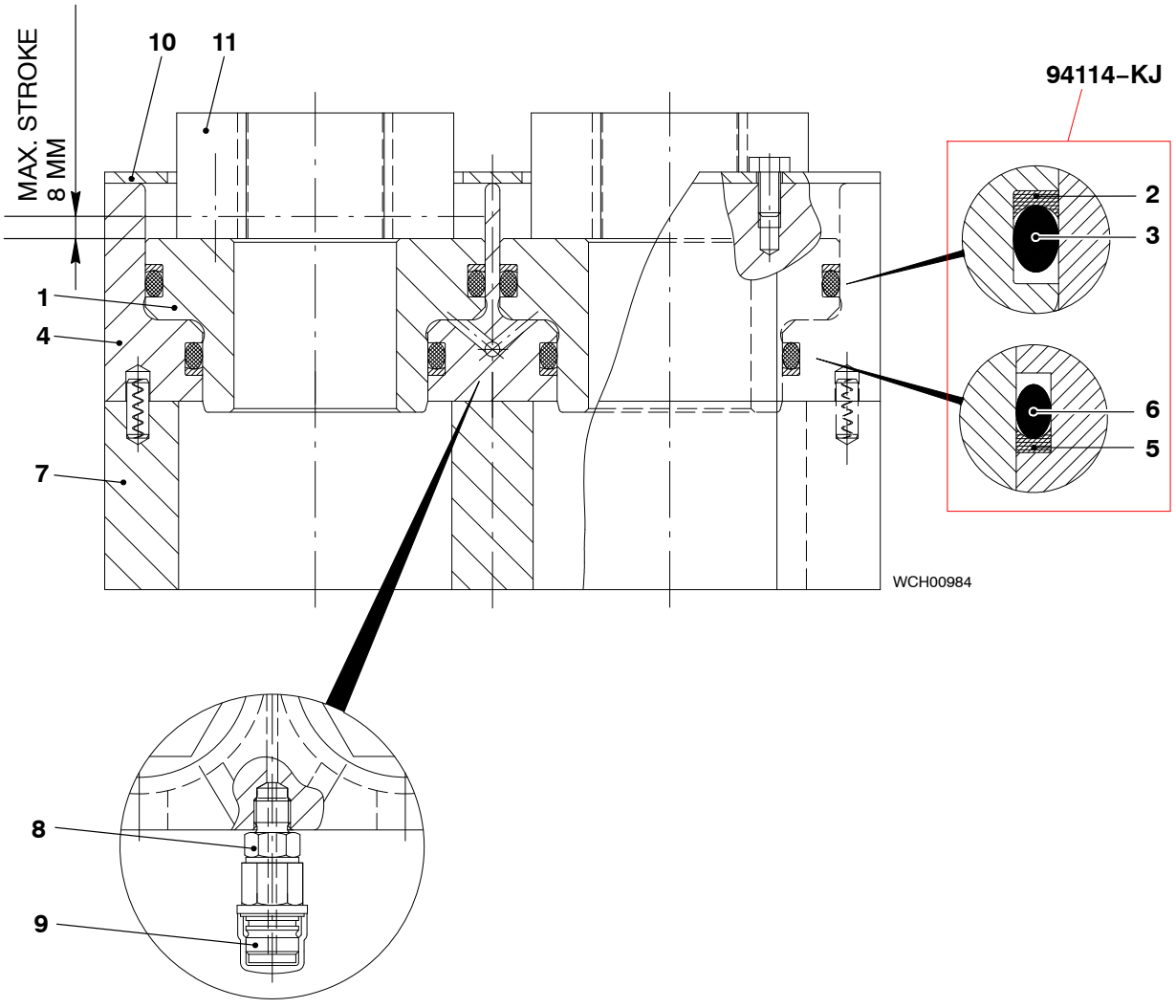


2. Overview of pre-tensioning jacks

Tool 94114 Double pre-tensioning jack for elastic bolts to main bearing

1 Piston
2 Back-up ring } Sealing ring
3 O-ring }
4 Double cylinder
5 Back-up ring } Sealing ring
6 O-ring }
7 Distance sleeve
8 Adapter piece
9 Closing valve
10 Cover
11 Round nut

94114–KJ **K**it with back-up and O-rings
for double pre-tensioning **J**ack

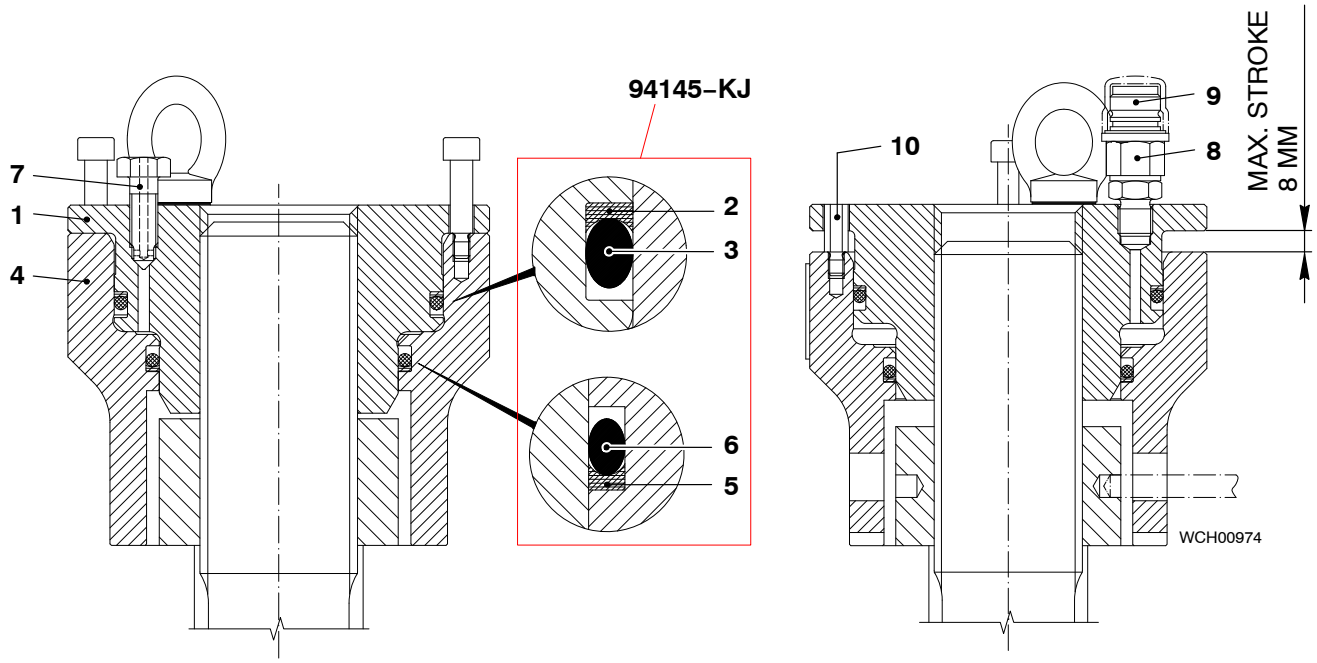


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94145 Pre-tensioning jack for foundation bolt and engine stay

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Vent screw
8 Adapter piece
9 Closing valve
10 Control pin

94145–KJ **K**it with back-up and O-rings for pre-tensioning **J**ack

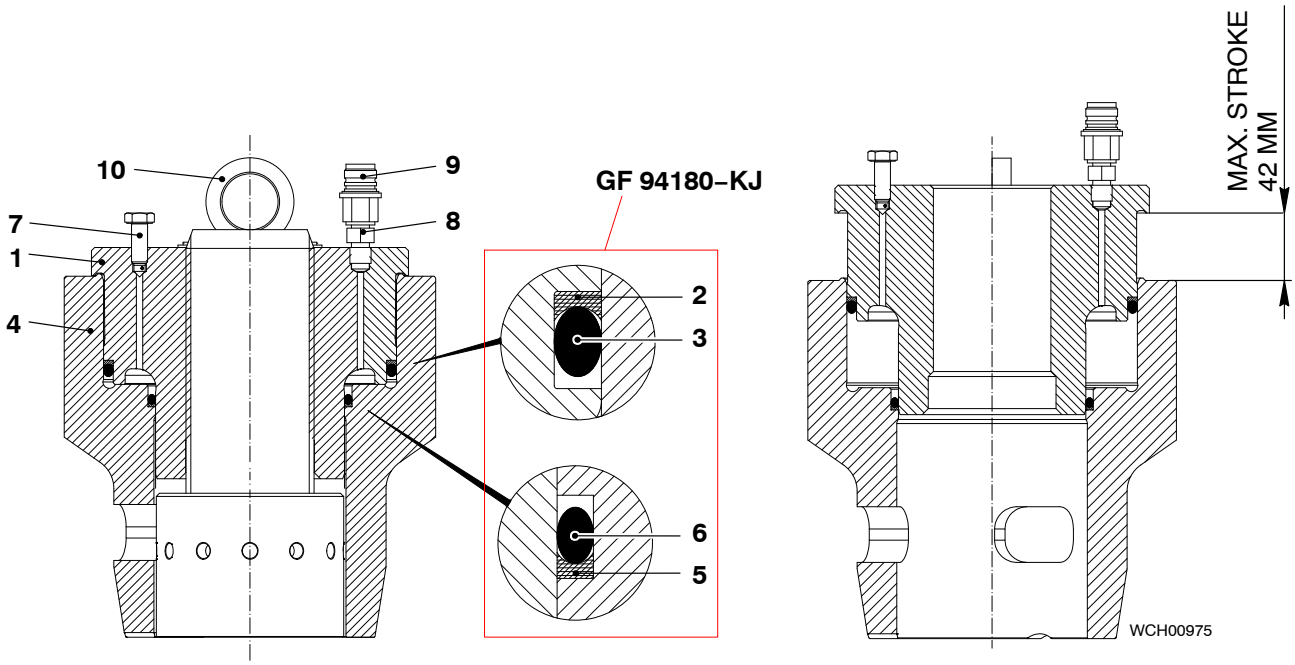


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool GF 94180 Pre-tensioning jack for tie rod

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Vent screw
8 Adapter piece
9 Closing valve
10 Eyelet

GF 94180–KJ **K**it with back-up and O-rings for pre-tensioning **J**ack

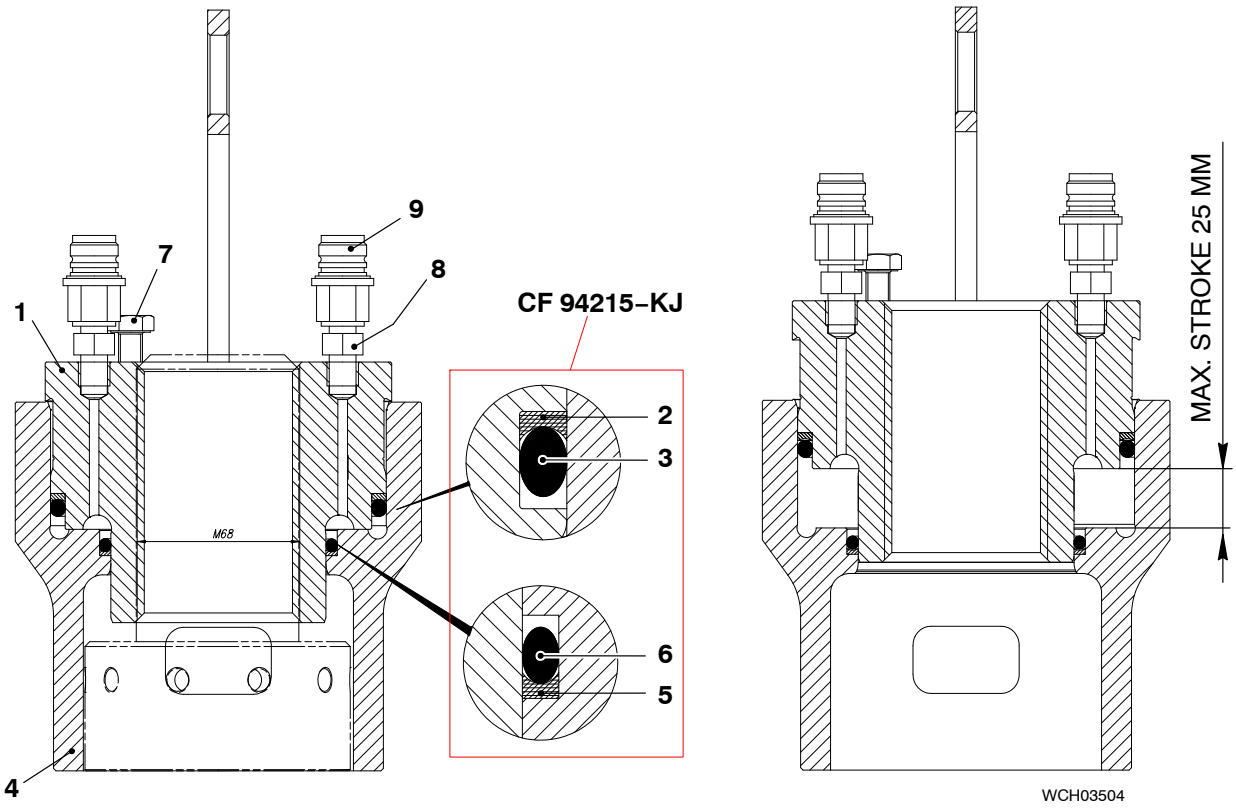


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool CF 94215 Pre-tensioning jack for elastic bolt to cylinder cover

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Vent screw
8 Adapter piece
9 Closing valve
10 Eyelet

CF 94215–KJ **K**it with back-up and O-rings for pre-tensioning **J**ack

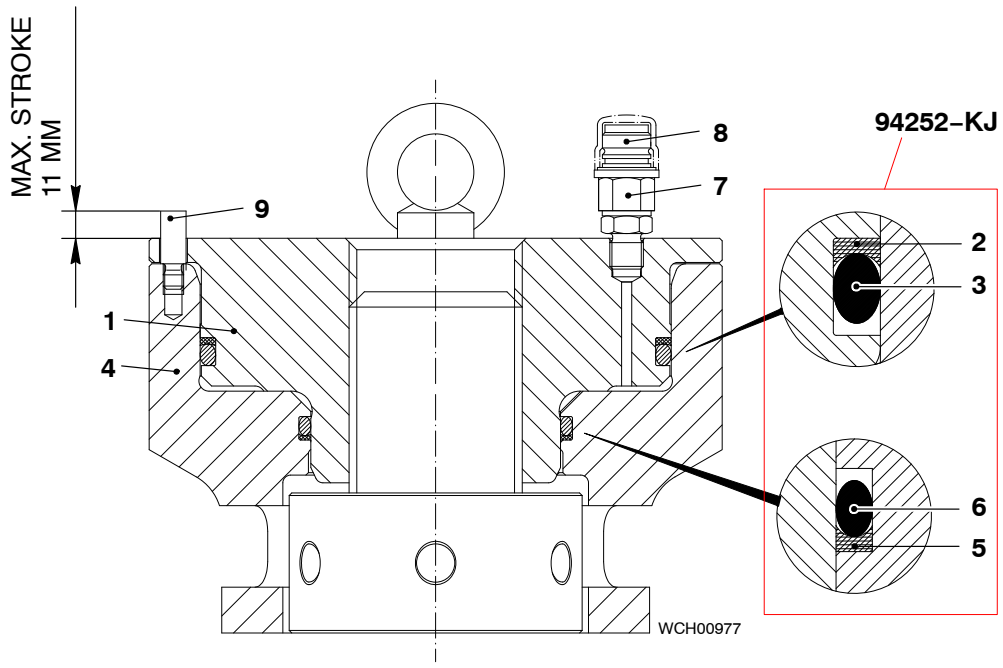


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94252 Pre-tensioning jack for elastic bolt to exhaust valve cage

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Adapter piece
8 Closing valve
9 Control pin

94252–KJ **K**it with back-up and O-rings for pre-tensioning **J**ack

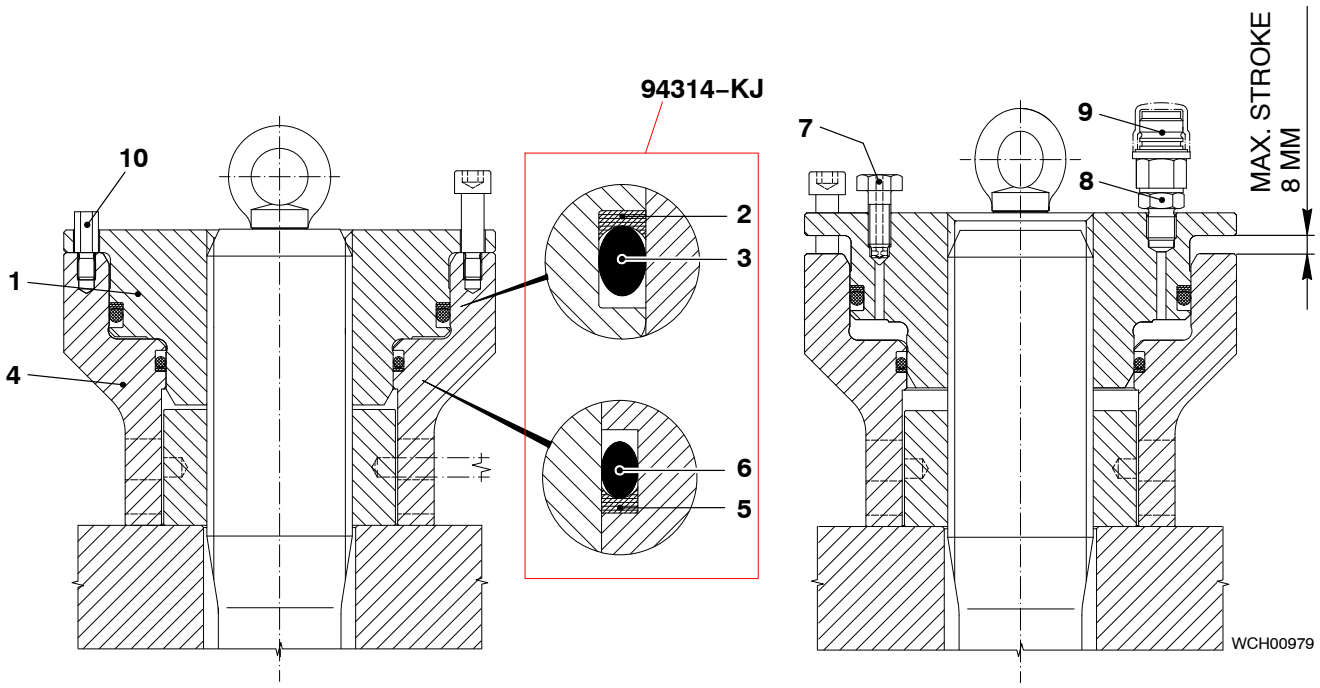


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94314 Pre-tensioning jack for elastic bolt to bottom end bearing

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Vent screw
8 Adapter piece
9 Closing valve
10 Control pin

94314–KJ **K**it with back-up and O-rings
for pre-tensioning **J**ack

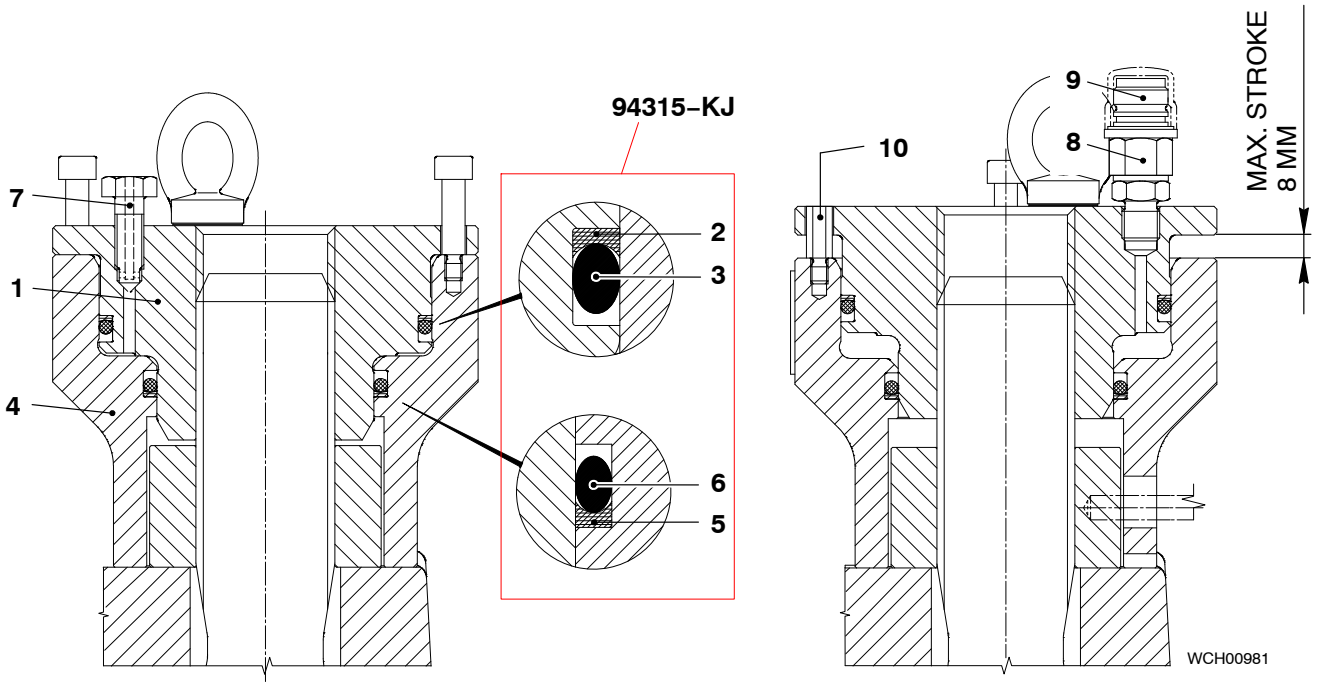


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94315 Pre-tensioning jack for elastic bolt to top end bearing

1	Piston		7	Vent screw
2	Back-up ring	} Sealing ring	8	Adapter piece
3	O-ring		9	Closing valve
4	Cylinder		10	Control pin
5	Back-up ring	} Sealing ring		
6	O-ring			

94315–KJ **K**it with back-up and O-rings
for pre-tensioning **J**ack

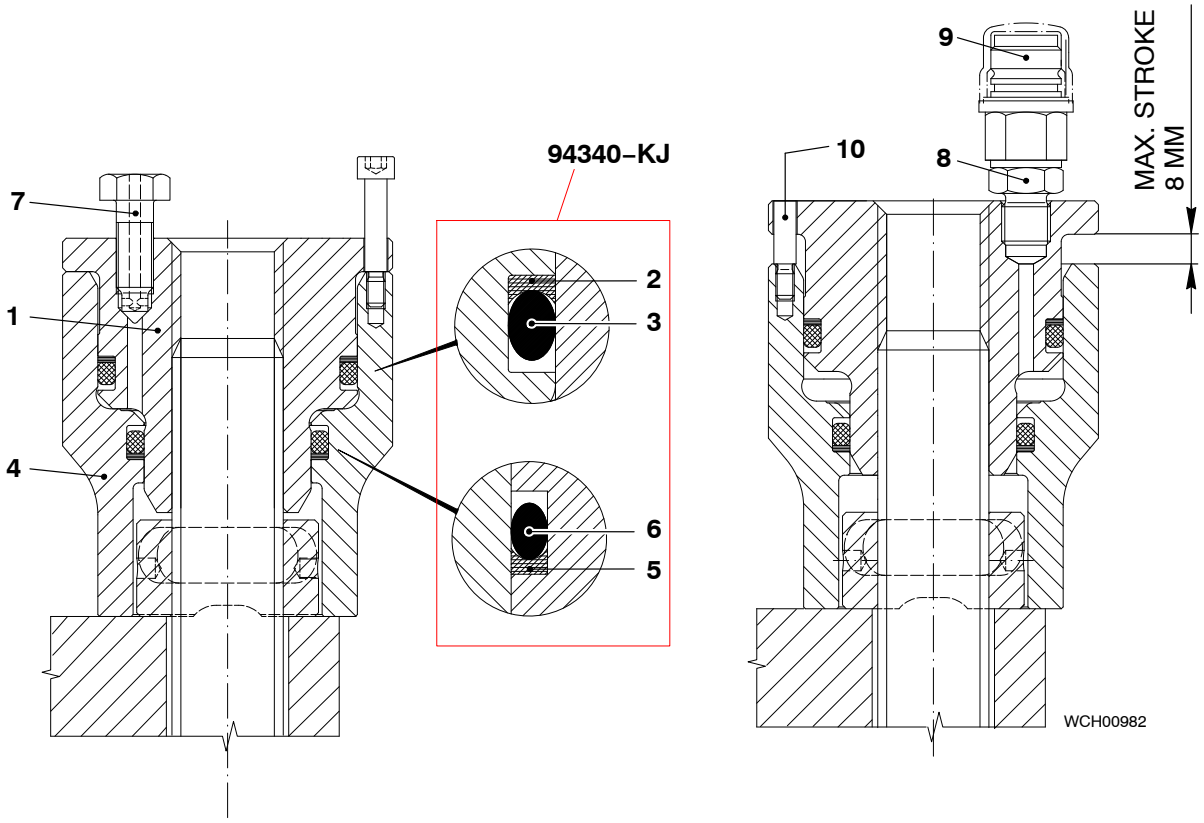


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94340 Pre-tensioning jack for elastic bolt to piston rod foot

1	Piston			7	Vent screw
2	Back-up ring	}	Sealing ring	8	Adapter piece
3	O-ring			9	Closing valve
4	Cylinder			10	Control pin
5	Back-up ring	}	Sealing ring		
6	O-ring				

94340–KJ **K**it with back-up and O-rings
for pre-tensioning **J**ack

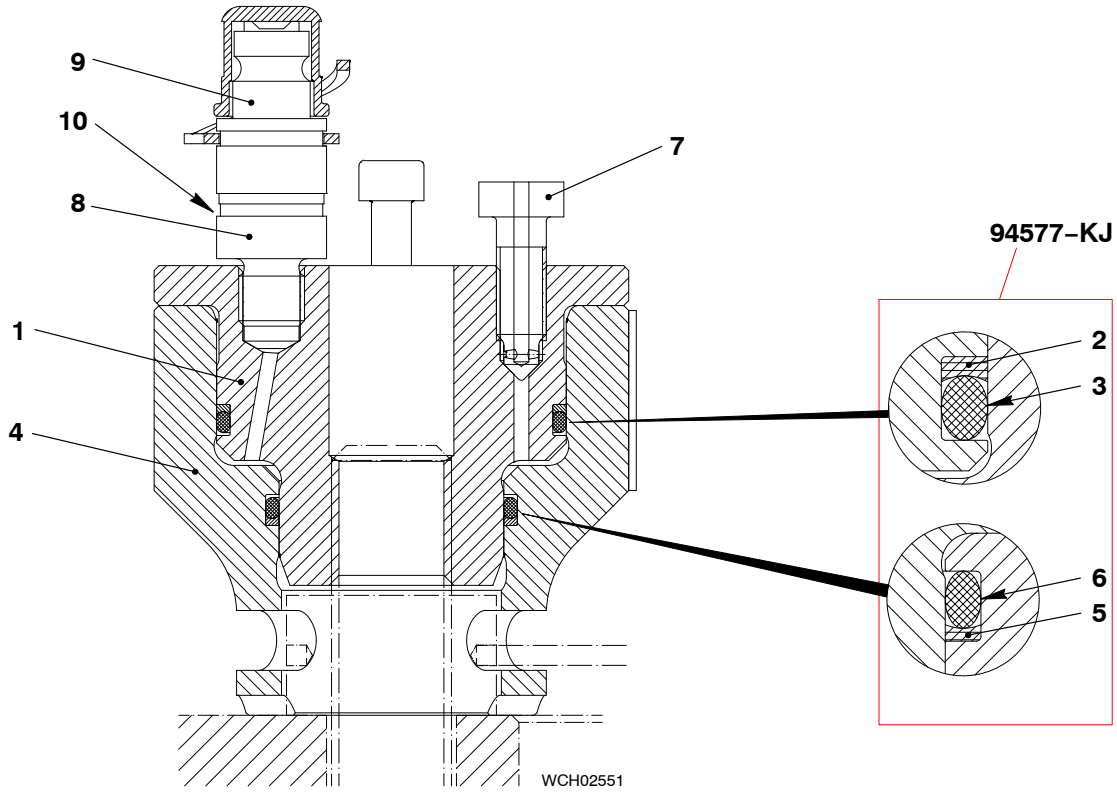


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94577 Pre-tensioning jack for elastic bolt to supply unit

1 Piston
2 Back-up ring } Sealing ring
3 O-ring
4 Cylinder
5 Back-up ring } Sealing ring
6 O-ring
7 Vent screw
8 Adapter
9 Closing valve
10 Control pin

94577–KJ **K**it with back-up and O-rings for pre-tensioning **J**ack



Hydraulic Pre-tensioning Jacks

General Application Instructions

	Tools:		Key to Illustrations:	
a)	**Hydr. pre-tensioning jacks for**		1	Cylinder
	Main bearing	94114	2	Piston
			3	High pressure connection
b)	**Hydr. pre-tensioning jacks for**		4	Vent screw
	Tie rod	GF 94180	5	Elastic bolt
	Cylinder cover	GF 94215	6	Nut
c)	**Hydr. pre-tensioning jacks for**			
	Foundation bolt and engine stay	94145	BN	Limiting groove
	Exhaust valve cage	94252	CP	Control pin
	Connecting rod, bottom end bearing	94314	KO	Slot
	Connecting rod, top end bearing	94315	RS	Round bar
	Piston rod foot	94340	SA	Gap
	Supply Unit	94577		

1. General

For screwed connections different designs and sizes of elastic bolts (bolts) are used with threads extending over the nuts. There are three variants of hydraulic pre-tensioning jacks (jacks), however with the same functionality:

a) See relevant descriptions in 1132–1

b) Jack with limiting groove (Fig. 'A')

c) Jack with control pin (Fig. 'B')

For each thread of the bolts suitable jacks are supplied. Since the bolts are pre-tensioned with them, the nuts are threaded-on only manually until seated.

Prior to the mounting of the jacks, their threads as well as the threads of the bolts must be carefully cleaned. Moreover the threads must be undamaged and freely working. Concerning utilization of lubricant for screwing on the nuts the instructions in 0352–1 must be followed.

However, proper sequences or procedures specified for tensioning or loosening are mentioned in the relevant group.

The arrangement and application of the jacks together with the necessary hydraulic components are presented in 9403–2.

The high pressure (HP) hoses must be tightened firmly, so that the integrated non-return valves are released.



Risk of accident! Always use gloves, a face shield and wear safety goggles when working with hydraulic tools.

CHECK

Check oil level in the HP oil pump or hydraulic unit. When oil must be added the specification issued by the pump manufacturers must be followed. Utilize generally an engine lub. oil having viscosities SAE 30 to SAE 40. A cylinder lubricating oil can also be used in exceptional cases.

For operation and maintenance of the HP oil pump or hydraulic unit we refer to the manufacturer's documentation.

The overview and remarks on storing, servicing and maintenance of the jacks as well as dimensions of back-up and O-rings are presented in 9403–3.

For fitting or replacing of elastic bolts, see 0352–2 or 2751–1.

Hydraulic Pre-tensioning Jacks: General Application Instructions

Overview of hydr. pre-tensioning jacks:

Group	Jack	Tightening value [bar]	Comparison [°∡, mm]	Reset of jack [turns]
1112–1	94145	(1st step 600) 1000	–	½
1132–1	94114	1500	–	¾
1715–1	94145	150	–	½
1903–1	GF 94180	(1st step 100) 1500	from 100 to 1500 bar 14.5...16.5 mm	3½
2708–2	GF 94215	1500	380°	1
2751–1	94252	1000	165°	¾
3303–1	94314	(1st step 300) 1000	1st to 2nd step 60°	½
	94315	(1st step 600) 1000	1st to 2nd step 25°	½
3401–1	94340	(1st step 600) 1000	1st to 2nd step 25°	½
5552–2	94577	1000	170°	1

2. Working procedure for loosening

2.1. Loosening procedure –> jack with limiting groove

⇒ Thread the jack with opened vent screw 4 onto the extending thread end of bolt 5 to be loosened until it is landed on the part and piston 2 on cylinder 1 if possible without clearance at 'x'.

⇒ **Reset, i.e. turn the jack correspondingly back** (see table).

- The clearance 'SA' thus obtained between jack and landing surface of the part or piston and cylinder is essential. It enables the loosening of the nut until total relaxation of the bolt in one single working sequence.

⇒ Shut relief valve ('EV') at the HP oil pump.

⇒ Connect the jack to the HP oil pump or hydraulic unit and actuate the latter. Close vent screw 4 as soon as oil flows out bubble-free.

⇒ Slowly raise the pressure approx. 20...30 bar beyond the nominal pressure (see table). The nut is now slack, loosen it correspondingly with round bar 'RS', while keeping the pressure constant.

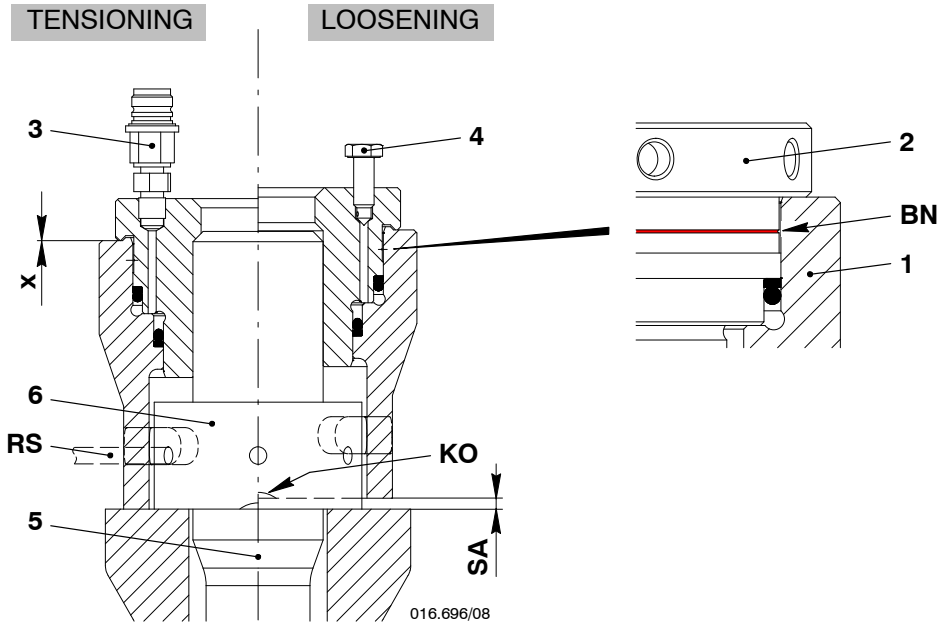
STOP Never move piston 2 of the pre-tensioning jack further up than to the red limiting groove 'BN'.

⇒ Release the pressure at HP oil pump or hydraulic unit to zero and remove the jack.

A

PRE-TENSIONING JACK SCREWED ON FOR

TENSIONING LOOSENING



2.2. Loosening procedure –> jack with control pin

⇒ Thread the jack with opened vent screw 4 onto the extending thread end of bolt 5 to be loosened until it is landed on the part and piston 2 on cylinder 1 if possible without clearance at 'x'.

⇒ **Reset, i.e. turn the jack (or the nut of 94215A) correspondingly back** (see table).

- The clearance 'SA' thus obtained between jack and landing surface of the part or piston and cylinder is essential. It enables the loosening of the nut until total relaxation of the bolt in one single working sequence.

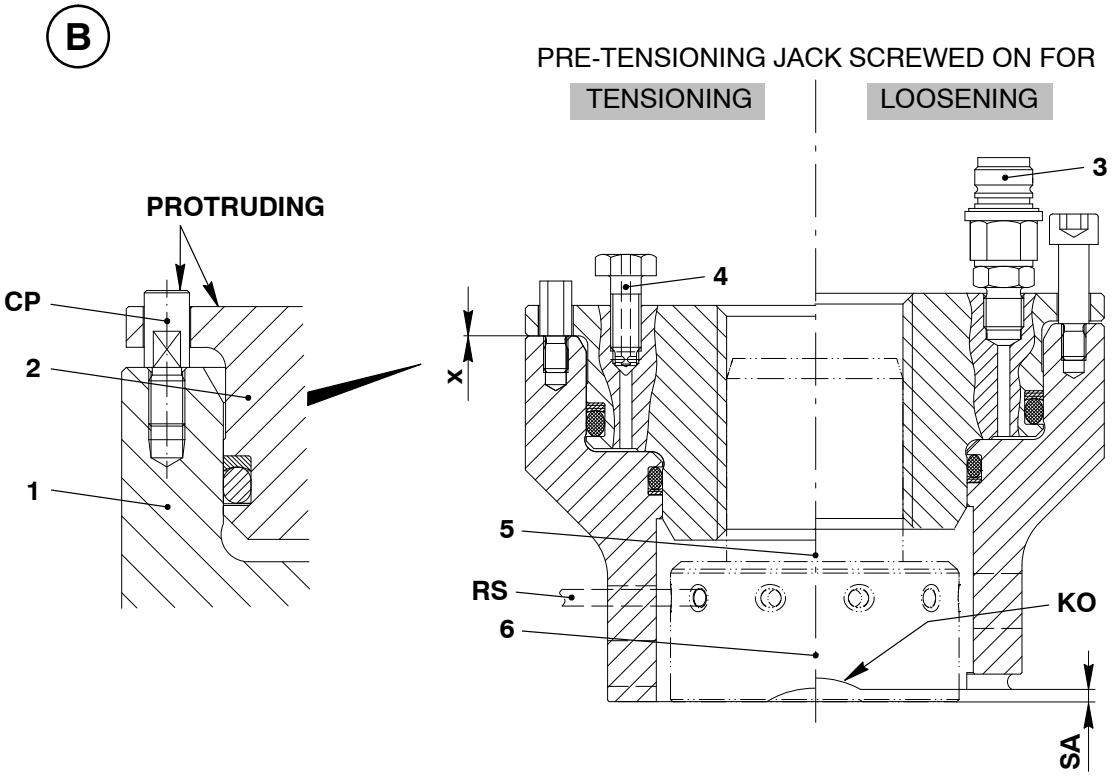
⇒ Shut relief valve ('EV') at the HP oil pump.

⇒ Connect the jack to the HP oil pump or hydraulic unit and actuate the latter. Close vent screw 4 as soon as oil flows out bubble-free.

⇒ Slowly raise the pressure approx. 20...30 bar beyond the nominal pressure (see table). The nut is now slack, loosen it correspondingly with round bar 'RS', while keeping the pressure constant.

STOP Control pin 'CP' must always protrude over the top edge of piston 2. When the pin is flush with the top edge of the piston the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

⇒ Release the pressure at HP oil pump or hydraulic unit to zero and remove the jack.



3. Working procedure for tensioning

3.1 Tensioning procedure –> jack with limiting groove

⇒ Firmly tighten nut 6 with round bar 'RS'.

CHECK

Check with a feeler gauge through slot 'KO' whether actually no clearance remains between nut and seating.

⇒ Use a felt pen to mark the position of the nut against its landing (Fig. 'C'); the mark is later a reference for judging the correct tensioning.

⇒ Thread the jack with opened vent screw 4 onto the extending thread end of bolt 5 to be loosened until it is landed on the part and piston 2 on cylinder 1 if possible without clearance at 'x'.

⇒ **The jack must not be reset, i.e. turned back for tensioning.**

- It may be necessary to turn the jack back a little to gain easy access through the slot in the cylinder lower part for manipulating round bar 'RS' to tighten the nut.

⇒ Shut relief valve ('EV') at the HP oil pump.

⇒ Connect the jack to the HP oil pump or hydraulic unit and actuate the latter. Close vent screw 4 as soon as oil flows out bubble-free.

⇒ Slowly raise the pressure to the nominal value and keep it constant (see table). Use round bar 'RS' to tighten the nut onto its landing until firmly seated.

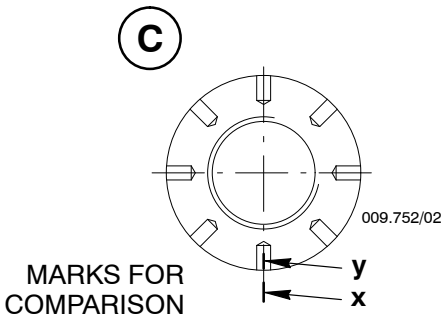
STOP

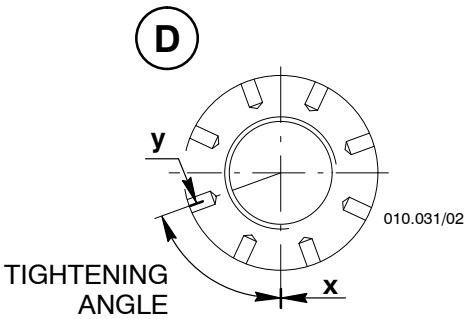
Never move piston 2 of the pre-tensioning jack further up than to the red limiting groove 'BN' (Fig. 'A').

CHECK

Check with a feeler gauge through slot 'KO' whether actually no clearance remains between nut and seating.
Check with the referenced mark, whether the nut of a screwed connection has been turned by the same value (Fig. 'D') as mentioned in the table (comparison value). If big differences are noted their causes have to be investigated and the tensioning procedure must be repeated.

⇒ Release the pressure at HP oil pump or hydraulic unit to zero and remove the jack.





3.2 Tensioning procedure –> jack with control pin

⇒ Firmly tighten nut 6 with round bar 'RS'.

CHECK

Check with a feeler gauge through slot 'KO' whether actually no clearance remains between nut and seating.

⇒ Use a felt pen to mark the position of the nut against its landing (Fig. 'C'); the mark is later a reference for judging the correct tensioning.

⇒ Thread the jack with opened vent screw 4 onto the extending thread end of bolt 5 to be loosened until it is landed on the part and piston 2 on cylinder 1 if possible without clearance at 'x'.

⇒ **The jack (or the round nut of 94215A) must not be reset, i.e. turned back for tensioning.**

- It may be necessary to turn the jack back a little to gain easy access through the slot in the cylinder lower part for manipulating round bar 'RS' to tighten the nut.

⇒ Shut relief valve ('EV') at the HP oil pump.

⇒ Connect the jack to the HP oil pump or hydraulic unit and actuate the latter. Close vent screw 4 as soon as oil flows out bubble-free.

⇒ Slowly raise the pressure to the nominal value and keep it constant (see table). Use round bar 'RS' to tighten the nut onto its landing until firmly seated.

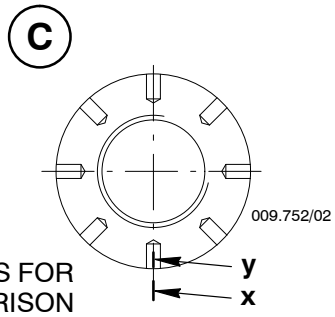
STOP

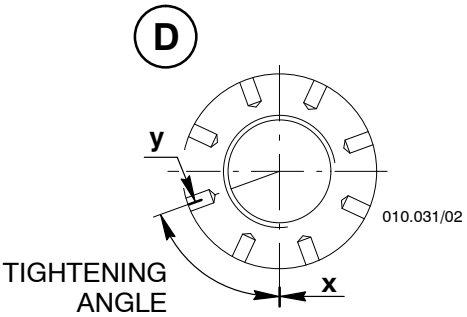
Control pin 'CP' must always protrude over the top edge of piston 2 (Fig. 'B'). When the pin is flush with the top edge of the piston the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

CHECK

Check with a feeler gauge through slot 'KO' whether actually no clearance remains between nut and seating.
Check with the referenced mark, whether the nut of a screwed connection has been turned by the same value (Fig. 'D') as mentioned in the table (comparison value). If big differences are noted their causes have to be investigated and the tensioning procedure must be repeated.

⇒ Release the pressure at HP oil pump or hydraulic unit to zero and remove the jack.

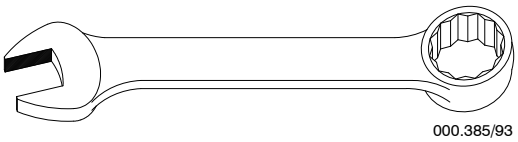




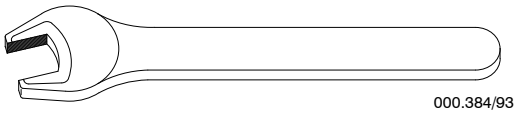
Tool List

Standard Tools

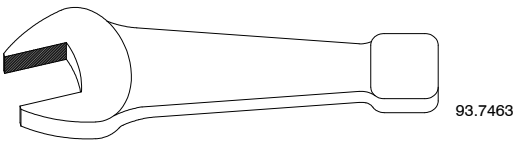
94000	**Combination wrenches**
94000–36	2 Pieces AF36
94000–41	2 Pieces AF41
94000–46	2 Pieces AF46
94000–50	2 Pieces AF50
94000–55	2 Pieces AF55
94000–60	2 Pieces AF60



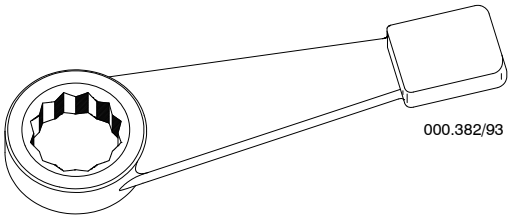
94001	**Open end wrenches**
94001–65	1 Piece AF65
94001–70	1 Piece AF70
94001–75	1 Piece AF75
94001–80	1 Piece AF80
94001–85	1 Piece AF85
94001–110	1 Piece AF110



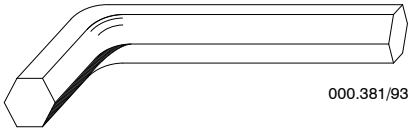
	Slugging open end wrench
94001A–110	1 Piece AF110



94002	**Ring slugging wrenches**
94002–27	1 Piece AF27
94002–30	1 Piece AF30
94002–32	1 Piece AF32
94002–36	1 Piece AF36
94002–41	1 Piece AF41
94002–46	1 Piece AF46
94002–50	1 Piece AF50
94002–55	1 Piece AF55
94002–60	1 Piece AF60
94002–65	1 Piece AF65
94002–70	1 Piece AF70
94002–75	1 Piece AF75
94002–85	1 Piece AF85
94002–95	1 Piece AF95
94002–110	1 Piece AF110
94002–135	1 Piece AF135



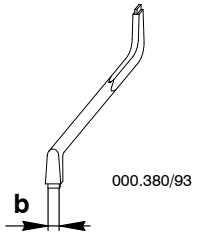
94003	**Allen keys**
94003–5	1 Piece AF5
94003–6	1 Piece AF6
94003–8	1 Piece AF8
94003–10	1 Piece AF10
94003–12	1 Piece AF12
94003–14	1 Piece AF14
94003–17	1 Piece AF17
94003–19	1 Piece AF19
94003–22	1 Piece AF22
94003–24	1 Piece AF24
94003–27	1 Piece AF27



Standard Tools

94004 **Angle screwdrivers**

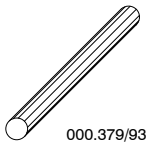
94004–10	1 Piece ..... b	=	10 mm
94004–12	1 Piece ..... b	=	12 mm
94004–25	1 Piece ..... b	=	25 mm



94005 **Rod**

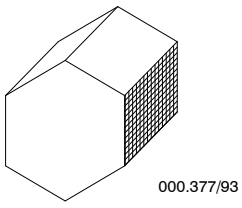
for pre-tensioning jacks

94005D	3 Pieces	Ø 7 mm
94005E	3 Pieces	Ø 7.5 mm
94005F	3 Pieces	Ø 9 mm
94005G	3 Pieces	Ø 15 mm



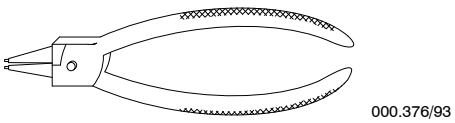
94006 **Socket head keys**

94006–11	1 Piece	AF11
94006–12	1 Piece	AF12
94006–14	1 Piece	AF14
94006–17	1 Piece	AF17
94006–19	1 Piece	AF19
94006–22	1 Piece	AF22
94006–27	1 Piece	AF27

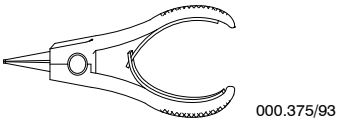


94007 **Tongs**

94007–C8	1 Piece	Type C 8
94007–C19	1 Piece	Type C 19
94007–C40	1 Piece	Type C 40



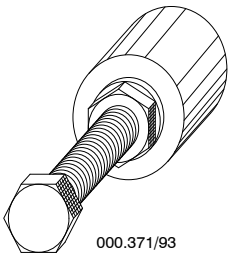
94007–A10	1 Piece	Type A 10
94007–A19	1 Piece	Type A 19
94007–A40	1 Piece	Type A 40

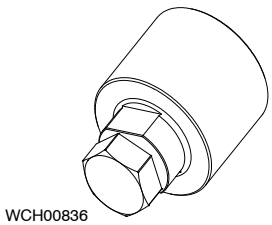


94008 **Withdrawing gears**

for taper & cylindrical dowels and pins

94008–M4	1 Piece	M4
94008–M5	1 Piece	M5
94008–M6	1 Piece	M6
94008–M8	1 Piece	M8
94008–M10	1 Piece	M10
94008–M12	1 Piece	M12
94008–M20	1 Piece	M20
94008A–M68	1 Piece	M68





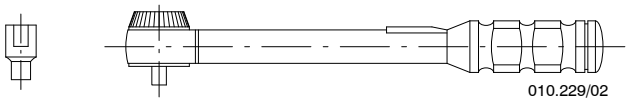
Standard Tools

94009 **Handle screws**

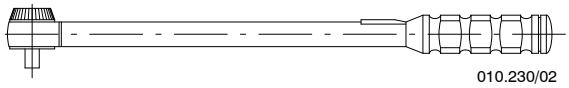
94009–M4 2 Piece M4x150
94009–M5 2 Piece M5x150
94009–M6 2 Piece M6x150
94009–M8 2 Piece M8x150
94009–M10 2 Piece M10x150



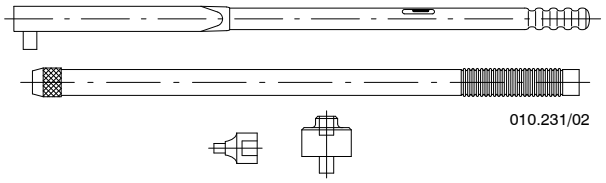
94010 1 **Torque spanner 3/8”**
(Range of adjustment 2–25 Nm)
94010A Adapter piece 3/8”–1/2”



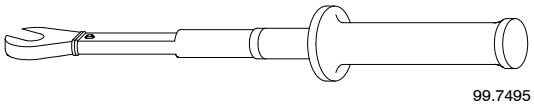
94011 1 **Torque spanner 1/2”**
(Range of adjustment 20–200 Nm)



94012 1 **Torque spanner**
Consisting of:
94012A adapter piece 3/4”–1/2”,
94012B shell type ratchet 3/4”–3/4”
94012C **Torque spanner 3/4”**
(Range of adjustment 140–760 Nm)
with extension tube and tool box



94014 1 **Torque spanner**
(Range of adjustment 140–620 Nm)
with open end spanner inserts:
94014–27 AF27
94014–41 AF41
94014–46 AF46
94014–50 AF50
94014–55 AF55



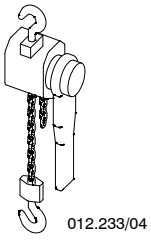
94016 2 **Manual ratchets**
(WLL 800 kg)

94016A 2 **Manual ratchets**
(WLL 1600 kg)

94016D 2 **Manual ratchets**
(WLL 1000 kg)

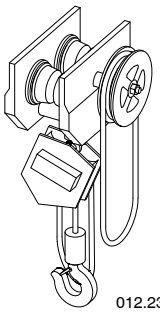
94016E 2 **Manual ratchets**
(WLL 2500 kg)

94016G 2 **Manual ratchets**
(WLL 250 kg)

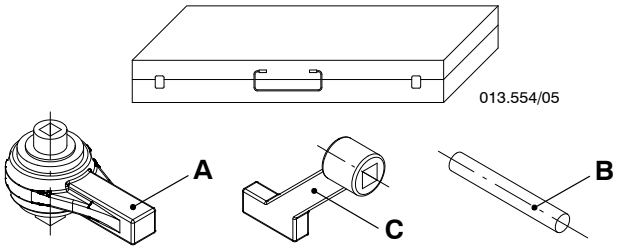


Standard Tools

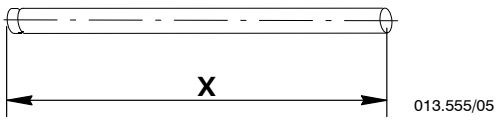
94017A – **Spur-geared chain block**
platform **with** crane rail
(WLL 3000 kg)



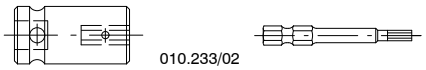
GF 94020 1 **Tool box**
consisting of:
GF 94020A 1 Power amplifier
(with transmission factor 1:5)
GF 94020B 1 Short backing rod
GF 94020C 1 Angle
GF 94020D 1 Case



GF 94021 1 **Large backing rod**
to power amplifier
X = 540 mm

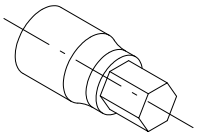


94022 1 **Adapter piece**
consisting of:
94022A 1 **Socket wrench insert**
AF3
94022B 1 **Adapter piece $^{3}/_{8}$"–¼"**

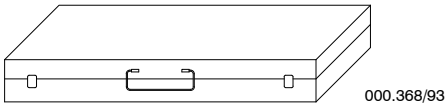


GF 94023 1 **Hex head driver 1"**
AF 22

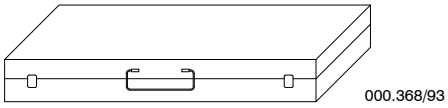
GF 94024 1 **Hex head driver ½"**
AF 19



94025 1 **Tool box with socket wrench set ½"**

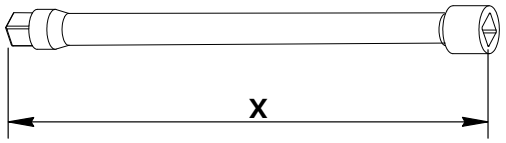


94026 1 **Tool box with hex. head drivers ½"**

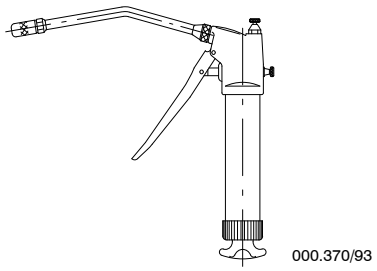


Standard Tools

GF 94027 **4** **Extensions**
for intermediate wheel assembly
X = 250 mm

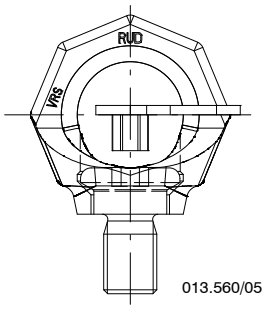


94032 **1** **High pressure grease gun**
for lubricating grease nipples on fuel pump regulating linkage



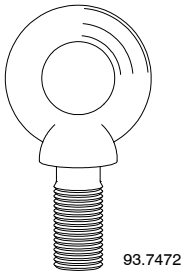
94040 **RUD-eye bolts**

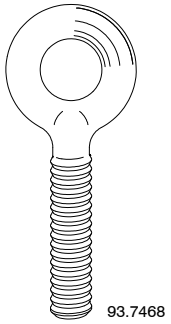
94040–M16	2 Pieces	.... M16
94040–M20	6 Pieces	.... M20
94040–M30	2 Pieces	.... M30



94045 **Eye bolts**

94045–M8	2 Pieces	.... M8
94045–M10	8 Pieces	.... M10
94045–M12	8 Pieces	.... M12
94045–M16	8 Pieces	.... M16
94045–M20	8 Pieces	.... M20
94045–M24	8 Pieces	.... M24
94045–M30	8 Pieces	.... M30
94045–M36	8 Pieces	.... M36
94045–M42	8 Pieces	.... M42
94045–M48	4 Pieces	.... M48



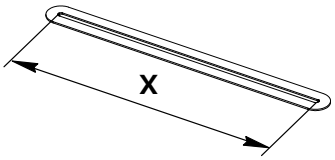


Eye screw

94045A–M16	6 Pieces	.... M16x145

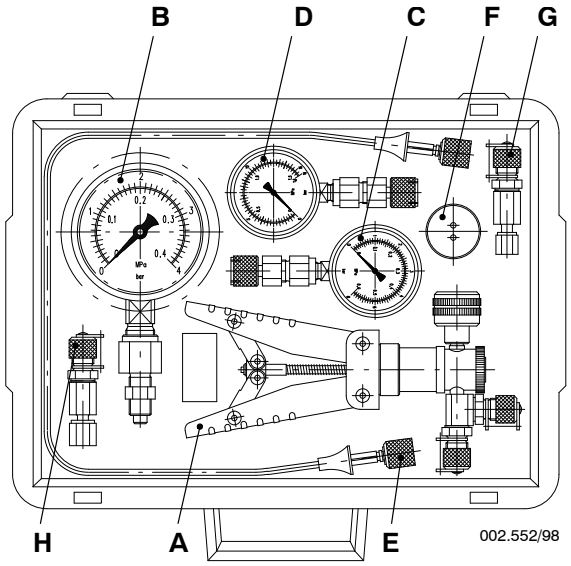
94049 **Round sling**

94049	2 Pieces 0.5 m	.... (WLL 1000 kg)
94049A	2 Pieces 1 m	..... (WLL 1000 kg)



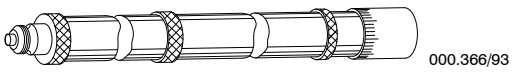
Standard Tools

94050	1	**Tool for pressure measurement** for pneumatic elements
94050A	1	Compressed air pump
94050B	1	Pressure gauge 0–4 bar
94050C	1	Pressure gauge 0–6 bar
94050D	1	Pressure gauge 0–16 bar
94050E	2	HP hoses
94050F	1	Adjusting tool
94050G	1	Measuring connection M12x1
94050H	1	Measuring connection M14x1

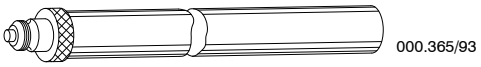


Standard Tools

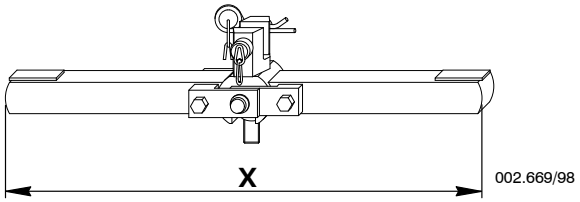
94101 **1** **Inside micrometer**
with case
(Measuring range 50–1010 mm)



94101A **1** **Extension**
Length of 480 mm

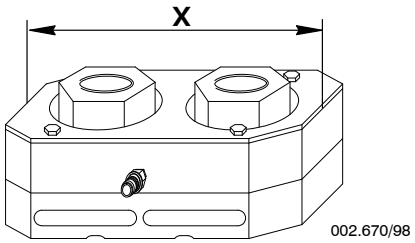


94111 **1** **Lifting device**
for removal and fitting of
main bearing cover
X = 733.4 mm

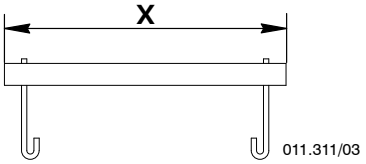


94114 **2** **Double pre-tensioning jacks**
for elastic studs to main bearing,
including a metal box
X = 254 mm

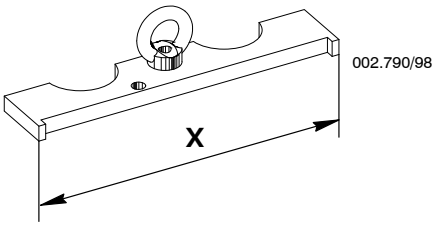
94114–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack



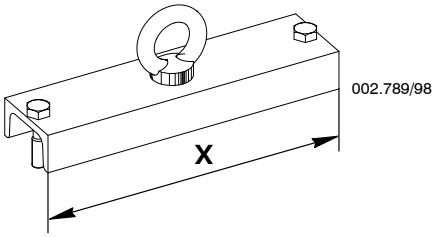
94114A **1** **Assembly tool**
for transporting double pre-tensioning
jacks 94114
X = 320 mm



94115 **1** **Guide**
for removal main bearing shell
X = 252 mm

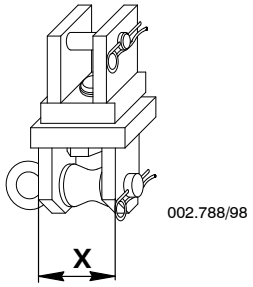


94116 **1** **Lifting tool**
for removal main bearing
X = 246 mm

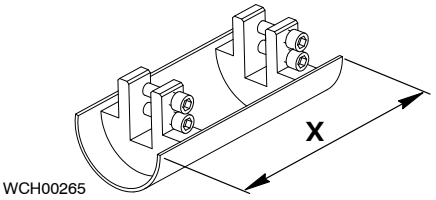


Standard Tools

94117 1 **Roller support**
for removal and fitting of main bearing
X = 74 mm

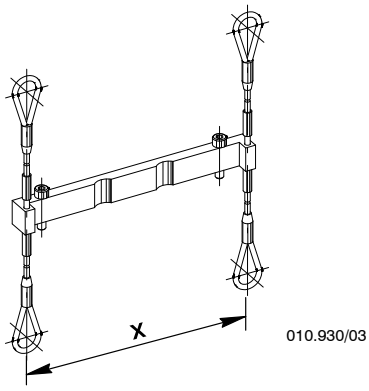


GF 94117A 1 **Deviation pipe**
for removal and fitting of:
– main bearing cover, shell
– crosshead pin
X = 300 mm

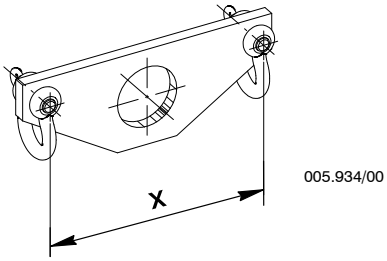


94118 1 **Turning-out device**
for removal and fitting of
main bearing shell
X = 232 mm (for girder width 210 mm)

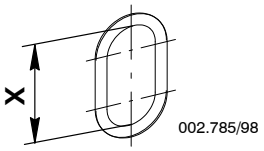
94118A 1 **Turning-out device**
for removal and fitting of
main bearing shell
X = 252 mm (for girder width 230 mm)



94119 1 **Lifting yoke**
for removal and fitting of
main bearing shell
X = 210 mm

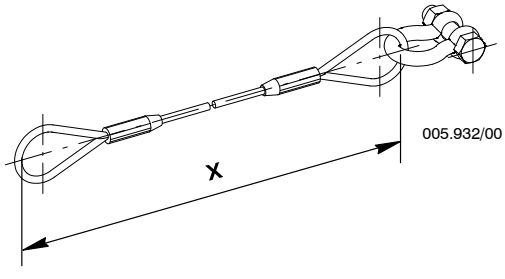


94120 1 **Eyelet** (WLL 1500 kg)
for removal and fitting of
main bearing cover
X = 127 mm



Ropes with shackle (WLL 500 kg)
for removal and fitting of
main bearing cover and shell

94120B 1 Piece . . . . . x = 500 mm
94120C 1 Piece . . . . . x = 800 mm
94120E 1 Piece . . . . . x = 1350 mm
94120F 1 Piece . . . . . x = 1500 mm
94120G 1 Piece . . . . . x = 1600 mm

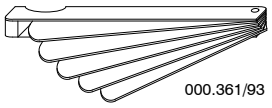


Rope (without shackle)

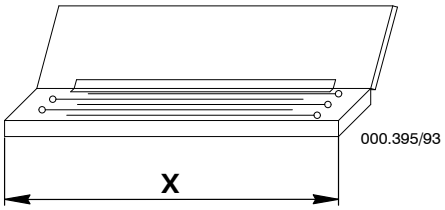
94120I 1 Piece . . . . . x = 1300 mm

Standard Tools

94122 1 Feeler gauge



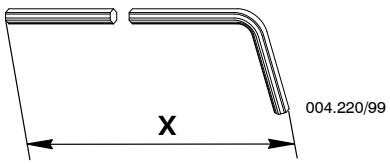
94123 1 Special feeler gauge
for main bearing
X = 625 mm



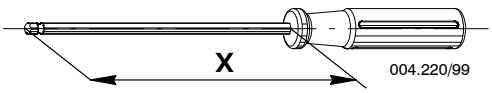
94124 1 Depth gauge
measuring range 250 mm



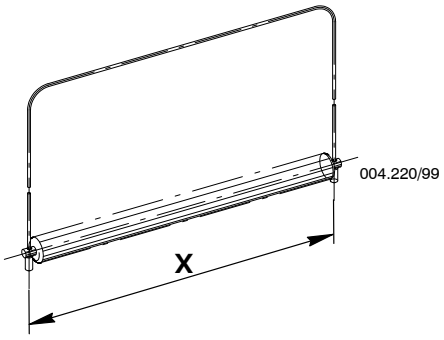
94128 1 Allen wrench
for Allen screw to main bearing
X = 680 mm



94129 1 Hexagon screwdriver
for screws to turning-out device 94118
X = 160 mm



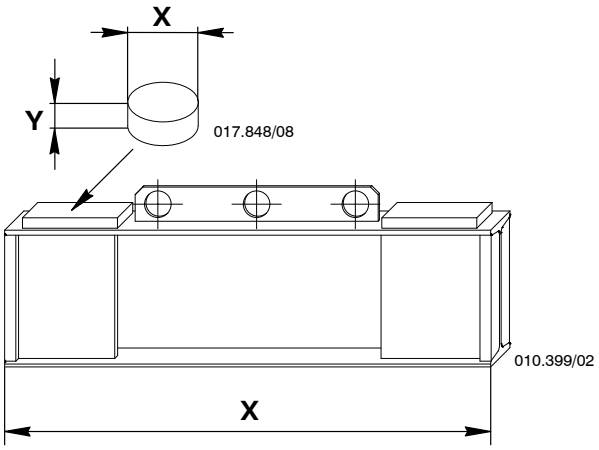
94130 1 Cleaning tool
for cleaning main bearing bore
X = 238 mm



Standard Tools

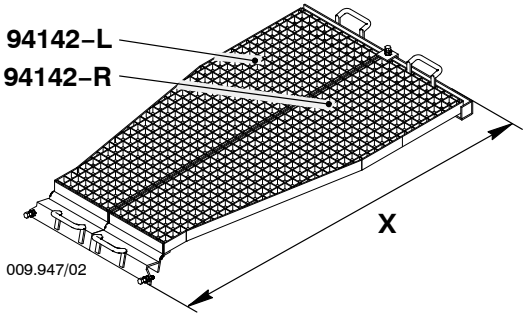
94141 **1** **Support**
for removal and fitting
of main bearing shells
X = 870 mm

94141A **2** **Ground plates**
X = ∅ 100 mm
Y = 50 mm

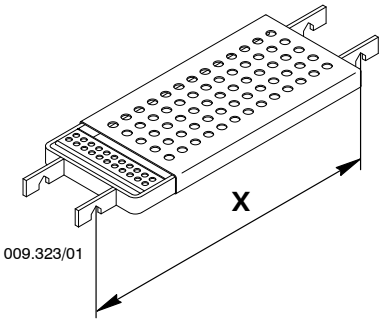


Working platform
X = 1532 mm

94142–L **1** Grid left side
94142–R **1** Grid right side

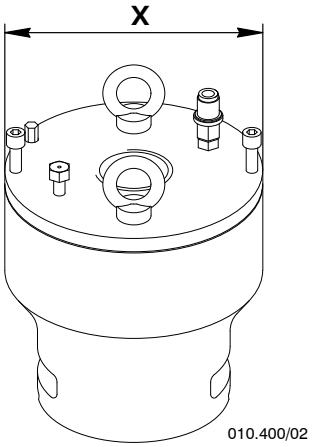


94143 **2** **Working supports**
X = 570–680 mm



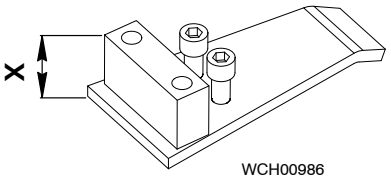
94145 **1** **Pre-tensioning jack**
for foundation bolts and engine stays,
including a metal box
X = 150 mm

94145–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack

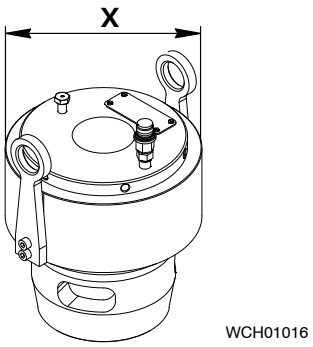


Standard Tools

GF 94155 **1** **Turning-out device**
with screws
for turning out thrust bearing pads
for 1-part gear wheel
X = 92 mm



GF 94180 **2** **Pre-tensioning jacks**
for tie rods,
including a metal box
X = ∅ 246 mm



GF 94180–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack

GF 94201 **1** **Device**
for fitting and transporting a cylinder liner, consisting of:

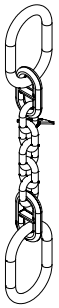
GF 94202 **1** **Lifting tool**
X = 1040 mm
(WLL 4000 kg)

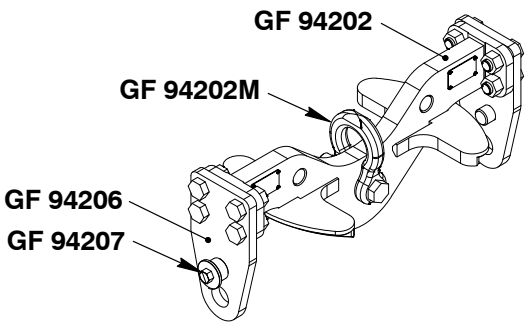
GF 94202L **1** **Chain**
(WLL 4000 kg)

GF 94202M **1** **Shackle**
(WLL 13500 kg)

GF 94206 **2** **Holders**
with 8 screws M30x84 and nuts

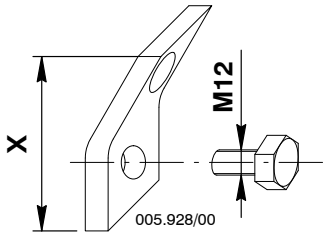
GF 94207 **2** **Special screws M42**





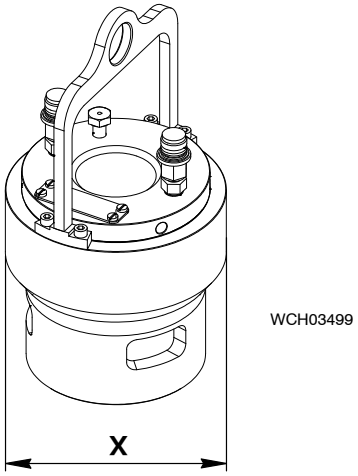
Standard Tools

94208 **4** **Suspension straps**
for removal and fitting of antipolishing ring
X = 88 mm

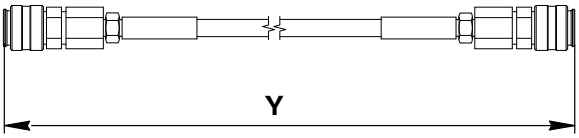


CF 94215 **8** **Pre-tensioning jacks (Mk 2)**
for cylinder cover
including a metal box
X = 170 mm

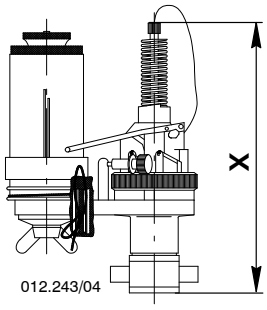
CF 94215K **7** **High pressure hoses**
Y = 1328 mm



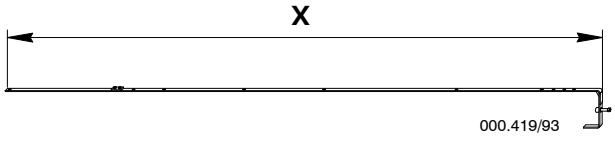
CF 94215–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack



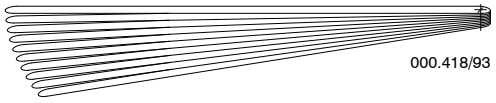
94219 **1** **Cylinder pressure measuring tool (indicator),**
including a wooden box
X = 165 mm



94225 **1** **Measuring gauge**
for measuring cylinder liner bore
(accessory for it:
inside micrometer tool 94101)
X = 2820 mm



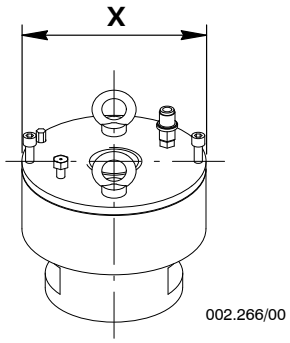
94238 **1** **Feeler gauge**
(10-part)
for checking bearing clearances
Leaf length = 600 mm



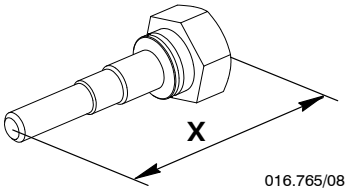
Standard Tools

94252 **2** **Pre-tensioning jacks**
for exhaust valve cage
including a metal box
X = 225 mm

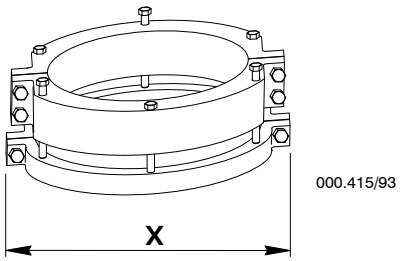
94252–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack



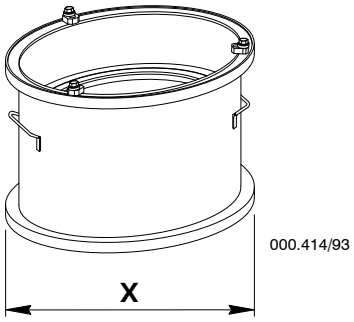
GF 94259 **1** **Pressure element**
for exhaust valve
with an O-ring
X = 247.7 mm



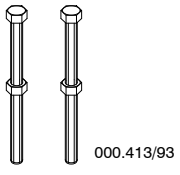
94261 **1** **Valve seat fitting and extracting device**
X = 555 mm



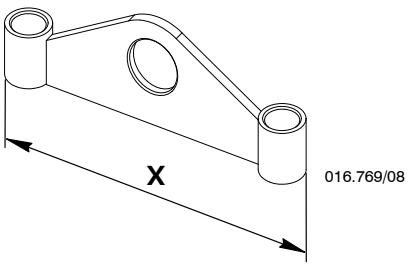
94262 **1** **Valve protector**
(only to be applied for transporting a complete exhaust valve)
X = 500 mm



94263 **2** **Jack screws with nuts**
to guide bush for exhaust valve
M10x120

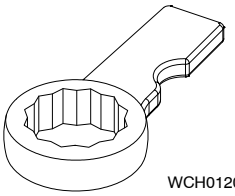


GF 94265 **1** **Suspension device**
for cylinder cover
X = 690 mm

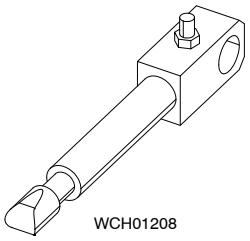


Standard Tools

94269A–55 **1** **Slugging wrench**
for loosening and tightening of coupling nut to injection valve with FAST

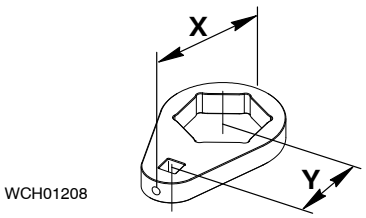

WCH01208

94269B **1** **Hydraulic cylinder**
for loosening and tightening of coupling nut to injection valve with FAST


WCH01208

94269C–41 **1** **Socket wrench insert**
for loosening and tightening of clamping nut
to injection valve with FAST
X = 106 mm
Y = 55 mm

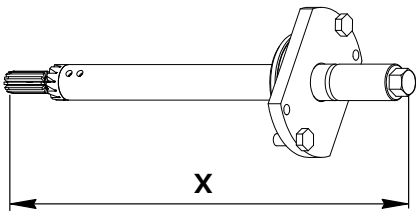
94269C–55 **1** **Socket wrench insert**
for pre-tightening of coupling nut
to injection valve with FAST
X = 126.5 mm
Y = 65 mm



WCH01208

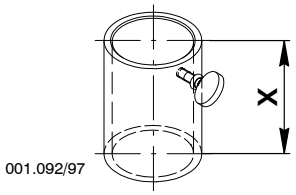
94270F **1** **Device** (FAST)
for overhauling injection valve seat in cylinder cover
X = 405 mm

94270AF **1** **Profile cutter** (FAST)



WCH01170

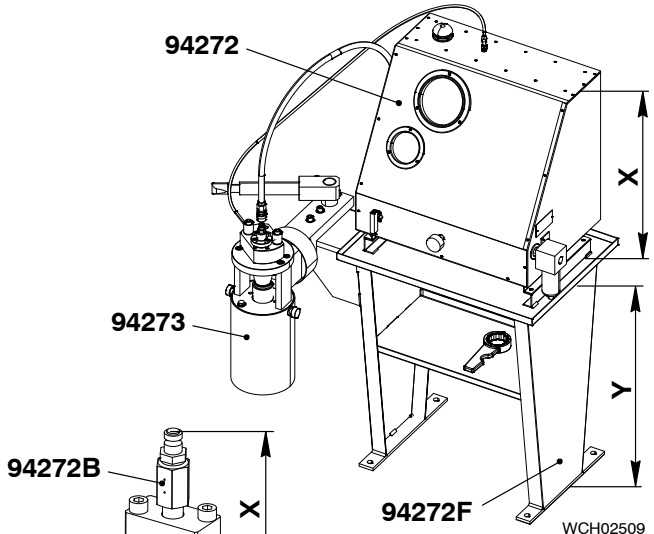
94271 **Protection cap**
for injection valve
(1 piece each nozzle)
X = 85 mm



001.092/97

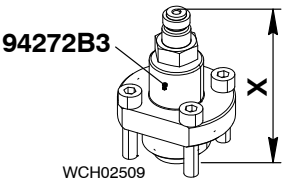
Standard Tools

94272 1 **OBEL injector test bench**
for setting and testing of:
– injection valve
– relief valve (cylinder cover)
– relief valve (PCV)
X = 606 mm
X = 149 mm

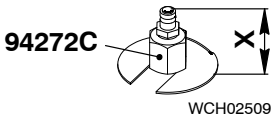


94272B 1 **Connecting piece**
for adjusting the injection valve
X = 124 mm

94272B3 1 **Connecting piece Mk3 ICU**
for adjusting the injection valve
X = 90 mm



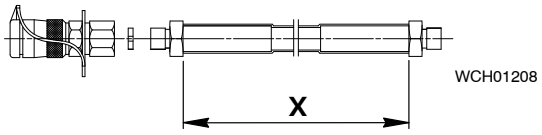
94272C 1 **Safety valve holder**
for checking and adjusting
Safety valve to cylinder cover
X = 68 mm



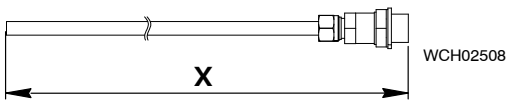
94272F 1 **Support device**
for injector test bench
Y = 852 mm

94273 1 **Valve holder**
to injector test bench
for fastening FAST injection valve

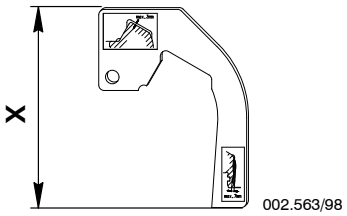
94275 1 **HP hose**
To connectinjection valve and hydraulic cylinder 94269B with injector test bench
X = 1000 mm, Max. 1800 bar



94275A 1 **Hose**
Leak oil hose for injector test bench
X = 1500 mm

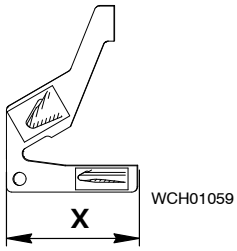


94279 1 **Gauge**
for checking wear and burn scar on exhaust valve seat
X = 184 mm

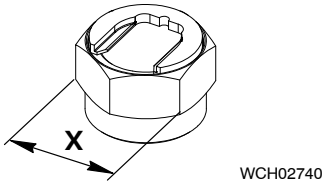


Standard Tools

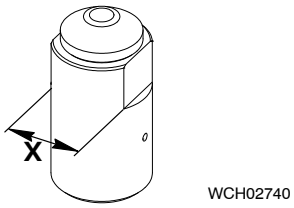
94292 **1** **Gauge**
for checking wear on disc of exhaust valve spindle
X = 180 mm



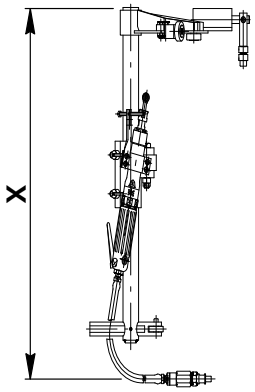
94278A **1** **Nozzle disassembly tool**
for injection nozzle disassembly
X = AF 60 mm



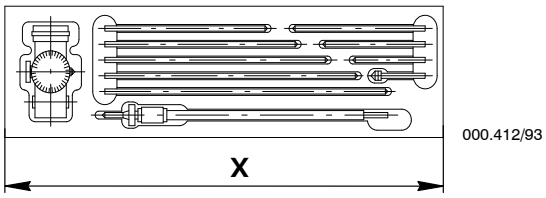
94278B **1** **Nozzle assembly tool**
for injection nozzle assembly
X = AF 55 mm



94299 **1** **Grinding device**
for removing a built-up wear ridge at top of cylinder liner running surface
X = approx. 600 mm



94305 **1** **Crankshaft checking equipment**
for measuring crank deflection (in wooden box)
X = 364 mm

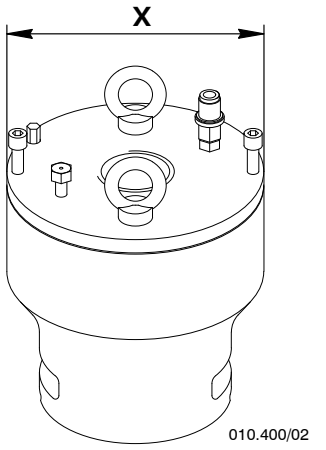


94314 **2** **Pre-tensioning jacks**
for connecting rod studs to bottom end bearing, including a metal box
X = 190 mm

94314–KJ **1** **K**it with back-up and O-rings for pre-tensioning **J**ack

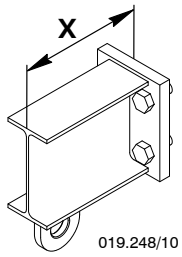
94315 **2** **Pre-tensioning jacks**
for connecting rod studs to top end bearing, including a metal box
X = 147 mm

94315–KJ **1** **K**it with back-up and O-rings for pre-tensioning **J**ack

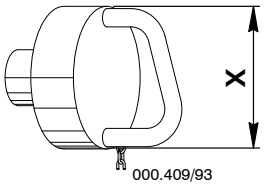


Standard Tools

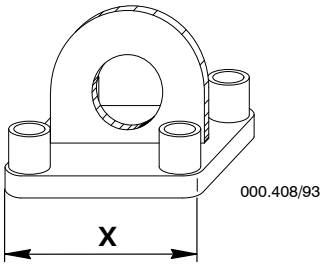
94320 **1** **Support**
for dismantling and assembling of axial damper
with 4 screws M24 x 55
X = 220 mm



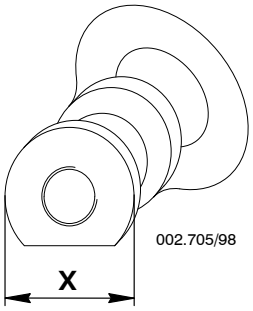
94323 **4** **Retaining pins**
to prop up crosshead guide shoes when removing or fitting a connecting rod or a crosshead
X = 85 mm



94324 **1** **Cover and lifting plate**
to crosshead
X = 255 mm

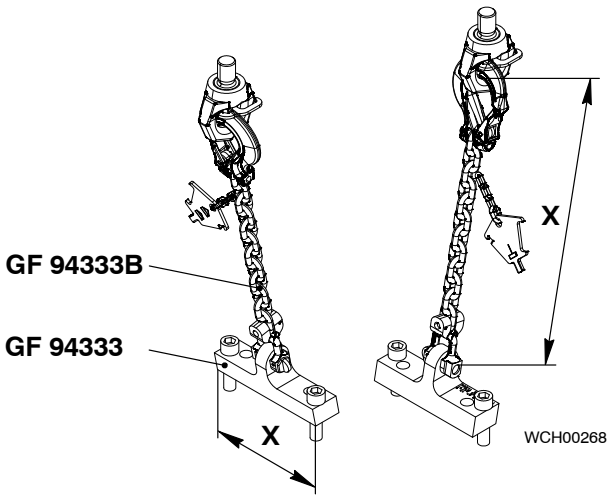


94325 **2** **Holders**
for removal of a crosshead guide shoe
X = 70 mm



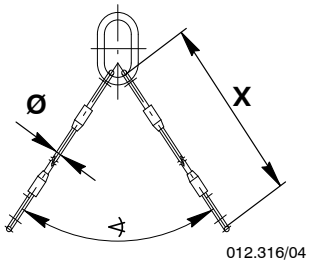
GF 94333 **1** **Lifting tool**
for inspection and removal of top end bearing
(WLL 1700 kg)

GF 94333B **2** **Chains with hook and shackle**
X = 422 mm
(WLL 2500)

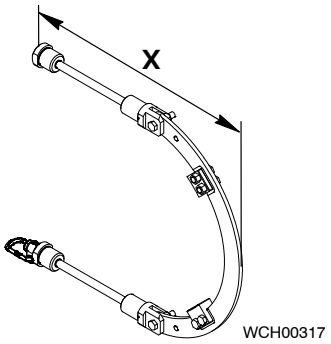


Standard Tools

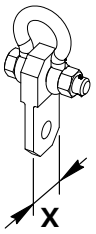
GF 94333D **1** **Wire rope sling**
for removal and fitting
of a crosshead pin,
and an expansion piece
X = 1238 mm
(WLL 1500 kg at ∡ 45...60°)



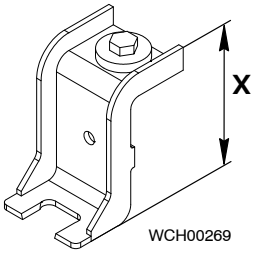
94334 **1** **Holder**
for removal and fitting of connecting rod
including: 2 Fastening shafts
2 Threaded rods
1 Lifting lug
X = 1010 mm



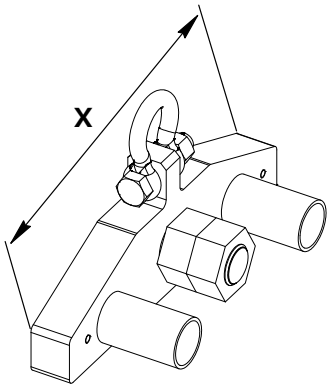
94334A **1** **Connecting element with shackle**
X = 70 mm



GF 94335 **1** **Stop plate**
with screw M12x40
for inspection to top end bearing
X = 215 mm

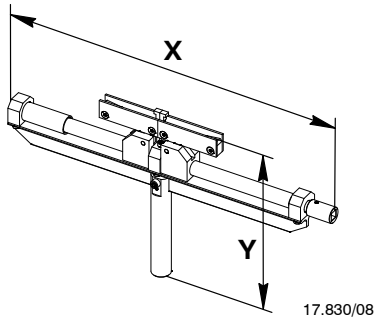


GF 94337 **1** **Lifting tool**
for the connecting rod
X = 450 mm
(WLL 1900 kg)



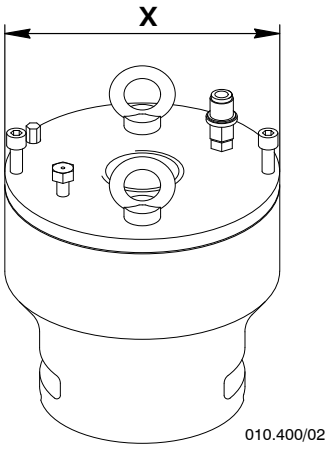
Standard Tools

94338 **1** **Piston ring expander**
X = 549.5 mm
Y = 285.5 mm

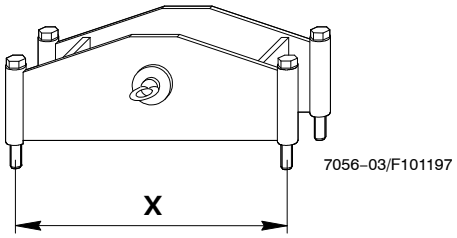


94340 **2** **Pre-tensioning jacks**
for piston rod screw connection,
including a metal box
X = 110 mm

94340–KJ **1** **K**it with back-up and O-rings
for pre-tensioning **J**ack

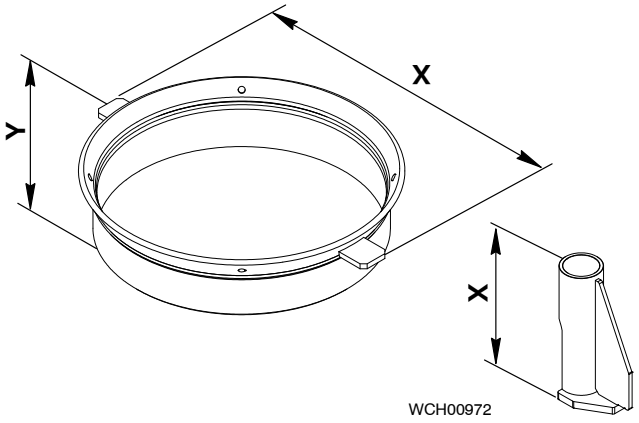


94341 **1** **Piston suspension device**
X = 469.8 mm



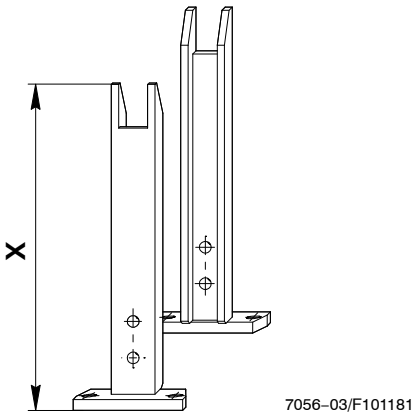
GF 94342 **1** **Insertion funnel**
for fitting the piston
X = 761.1 mm
Y = 160 mm
Mass approx. 22 kg

GF 94343 **2** **Locking devices**
for fastening insertion funnel or
cylinder liner during removing a piston
X = 312 mm

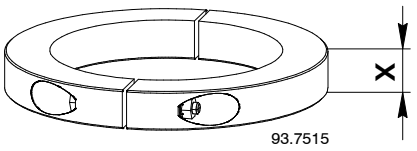


Standard Tools

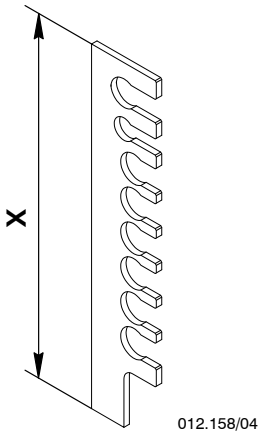
94345 2 Distance holders
for removal and fitting of piston rod gland and piston
X = 554 mm



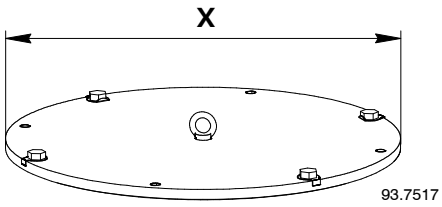
94345B 1 Clamping ring
X = 55 mm



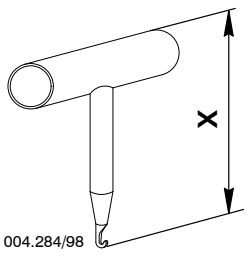
94345C 1 Gauge
for fitting scraper rings
X = 366 mm



94345D 1 Cover plate
for covering bore of piston rod gland in cylinder jacket (when piston and gland are removed)
X = 475 mm



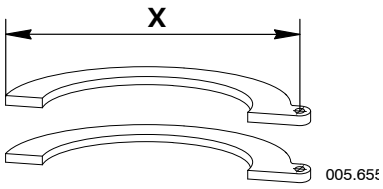
94345E 2 Assembly tools
for tensioning springs to piston rod gland
X = 160 mm



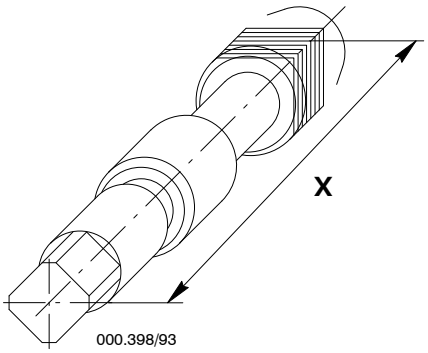
Standard Tools

94345F 2 Distance pieces
for fitting rings to upper gland group
2 pieces each 19 mm
X = 305 mm

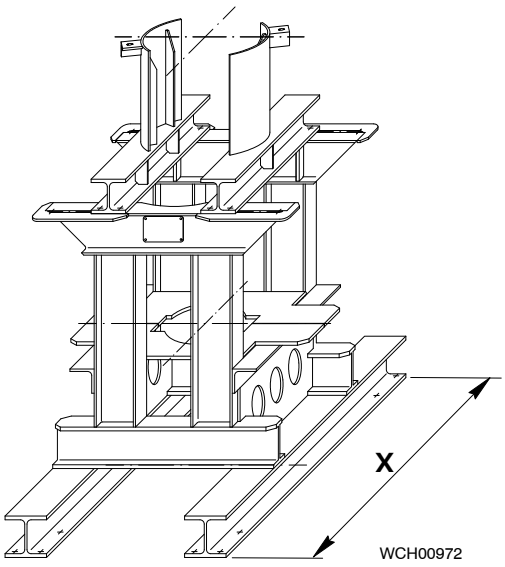
94345G 2 Distance pieces
for fitting rings to upper gland group
2 pieces each 11 mm
X = 305 mm



94348 1 Tap M20
for cleaning carbon deposits in
threaded holes of piston crown
X = 140 mm

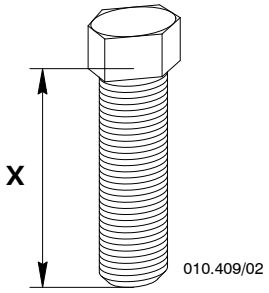


94350 1 Device
for supporting piston and removal of
the piston rod gland
X = 1206 mm



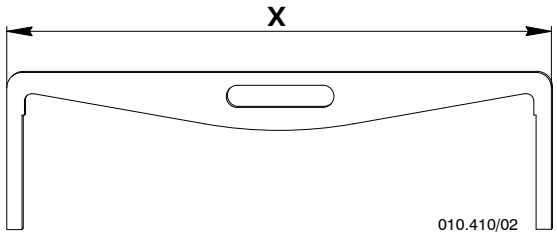
94363 2 Jacking screws M10
for separating piston crown from piston
skirt
X = 40 mm

94364 2 Jacking screws M16
for separating piston skirt from piston
rod
X = 50 mm

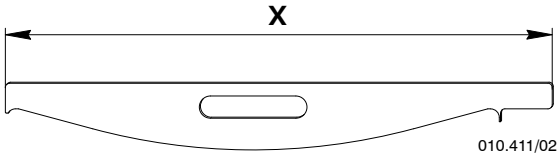


Standard Tools

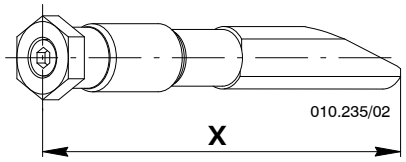
94366 **1** **Template**
for shape of top of piston crown
X = 634 mm



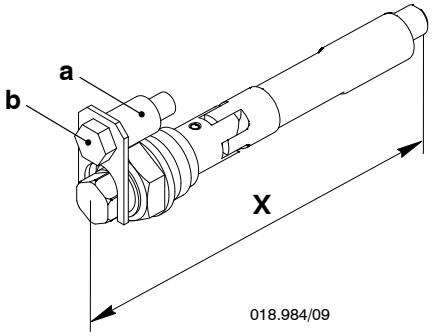
94366A **1** **Template**
for shape of top of piston crown
(for use with piston in situ)
X = 640 mm



94410–8C **6** **Adjusting devices**
for alignment of intermediate wheel
(with re-design column)
X = 212 mm



94430–8C **4** **Devices**
for cutting out & cutting in of fuel pump
including:
a 4 claws
b 4 screws M12x45
X = 224.5 mm



94474 **1** **Lifting tool**
for removal and fitting of supply unit
including:

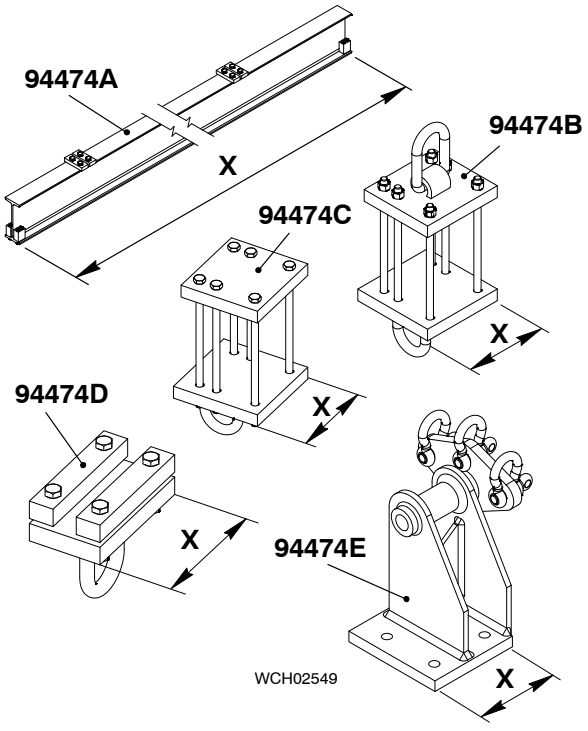
94474A **1** **I-beam**
X = 3600 mm

94474B **1** **Clamping piece**
X = 220 mm

94474C **1** **Clamping piece**
X = 220 mm

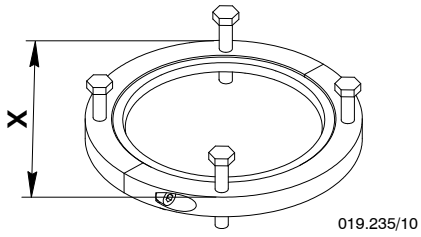
94474D **3** **Clamping pieces**
X = 220 mm

94474E **1** **Lifting tool**
X = 270 mm

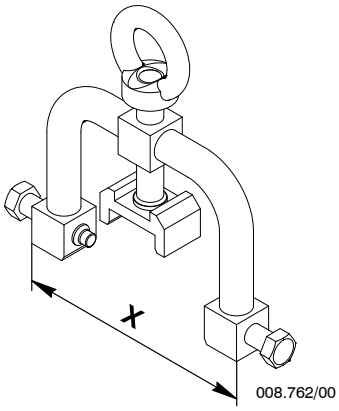


Standard Tools

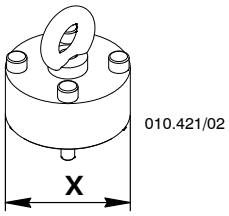
94550 **1** **2-part clamping ring**
for removal of non-return valve to fuel pump with 4 screws M10x60
X = 164 mm



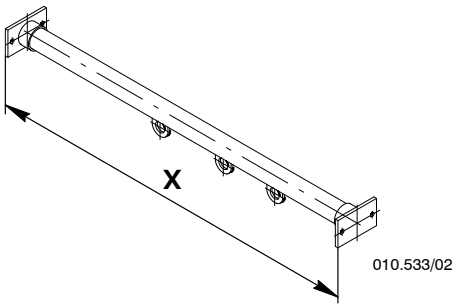
94551 **1** **Fitting and dismantling device**
for removal and fitting of guide pin to fuel pump
X = 255 mm



94552–8C **1** **Cover**
with Allen screws M12
for removal and fitting of fuel pump
X = 110 mm

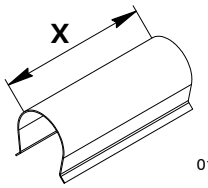


94553 **1** **Lifting support**
with 4 screws M16x35 and nuts
for removal and fitting of fuel pump
X = 2006 mm

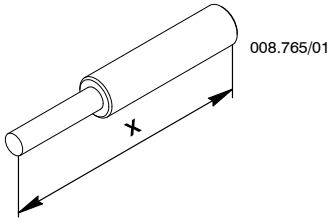


Standard Tools

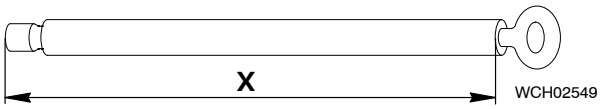
94555 **1** **Spacer**
for cutting out of individual fuel pumps
X = 72 mm



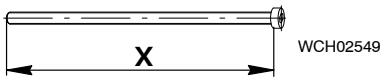
94556 **1** **Checking device**
for plunger position
X = 130 mm



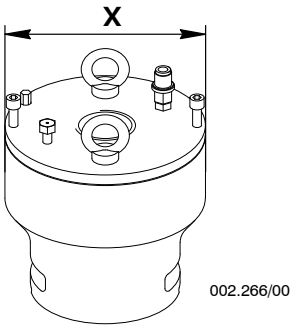
94575 **1** **Guide bar**
for removal and fitting of camshaft of supply unit
X = 2000 mm



94576 **2** **Screws M16**
for removal and fitting of camshaft of supply unit
X = 380 mm



94577 **2** **Pre-tensioning jacks**
for waisted bolt of supply unit
X = 95 mm



Standard Tools

94578 **1** **Supporting device**
consisting of:

94578A **1** **Supporting plate**
with 4 screws M16x50
X = 845 mm

94578B **1** **Supporting angle**
with 8 screws M16x30
depending on design
X = 915 mm

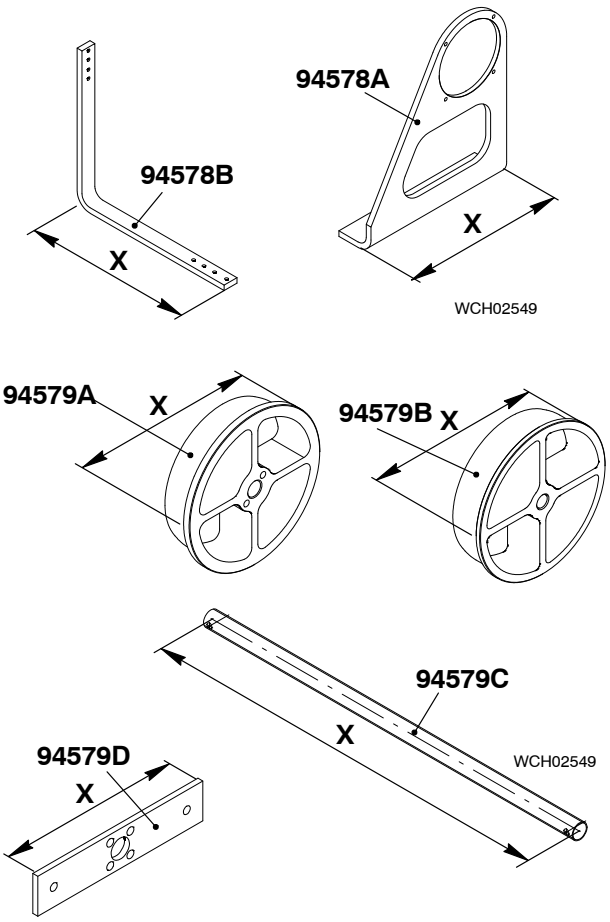
94579 **1** **Removal and fitting tool**
for camshaft bearing shells
including:

94579A **1** **Supporting device**
X = 325 mm

94579B **Centring ring**
X = 325 mm

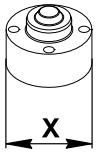
94579C **Threaded rod M30**
X = 750 mm

94579D **Holding plate**
X = 335 mm

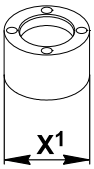


Standard Tools

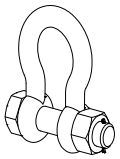
TN 94597 **1** **Blank flange**
Lubrication device
to intermediate fuel accumulator with
4 Screws M12x90
X = 112 mm



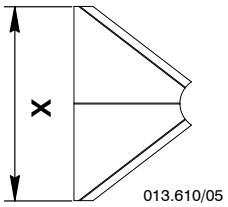
TN 94598 **1** **Blank flange**
to fuel pump with
4 Screws M12x90
X^1 = 110 mm



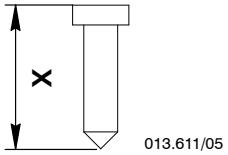
94572C **3** **Shackles**
(WLL 4750 kg)
94572E **3** **Shackles**
(WLL 3250 kg)
94572F **3** **Shackles**
(WLL 6500 kg)
94572I **3** **Shackles**
(WLL 2000 kg)



GF 94575 **1** **Adjusting scale**
(for Heinzmann StG 10-01 Actuator)
for regulating linkage
X = 120 mm
including:

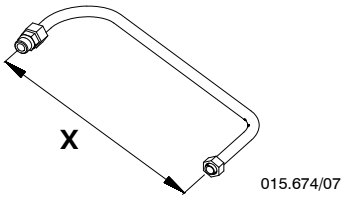


GF 94575A **1** **Adjusting pin**
(for Heinzmann StG 10-01 Actuator)
X = 51 mm

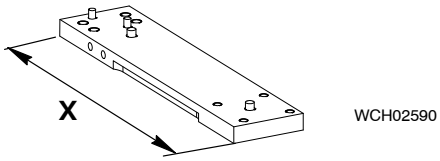


Standard Tools

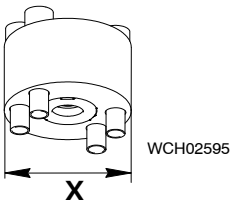
94583 1 Pipe
for pressure built-up in fuel rail during commissioning
X = 431 mm



94585A 1 Transport plate
for transport of injection control unit, including 2 screws M8x30
X = 400 mm



94585B 1 Blind flange
To seal the injection port in fuel rail, including 4 screws M12x60
X = 80 mm



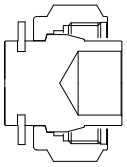
94585C 2 Screw plug G ½“
To close the servo oil unions

DIN 908

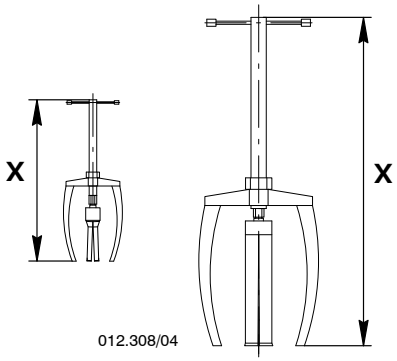
94585D 2 Screw plug G 3/8“
To close the servo oil unions

DIN 908

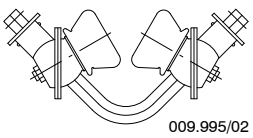
94585E 8 Capping end
To close the opening in exhaust valve control unit



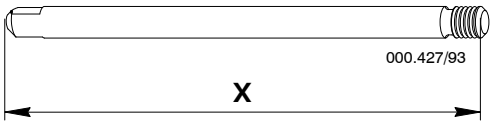
94589 2 Withdrawing tools
for removing lip seal from injection control unit
X = 310 mm & 638 mm



94651C 1 Trolley
(WLL 1000 kg)



94652 **2** **Centring studs M16**
for removal and fitting of electric motor
on auxiliary blower
X = 340 mm

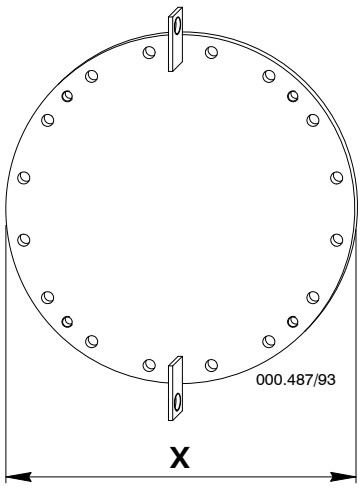


Standard Tools

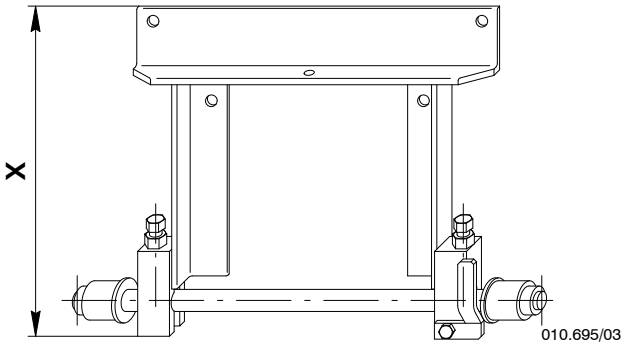
In case of a turbocharger breakdown

94653 2 Covers
to gas inlet housing and gas connection
X = 510 mm (TPL 73–B)
X = 600 mm (TPL 77–B)
X = 665 mm (MET 66S)
X =600 mm (MET 60MA/MB)
X =675 mm (ABB A170)
X = 810 mm (ABB A175)
X = 870 mm (ABB A180)

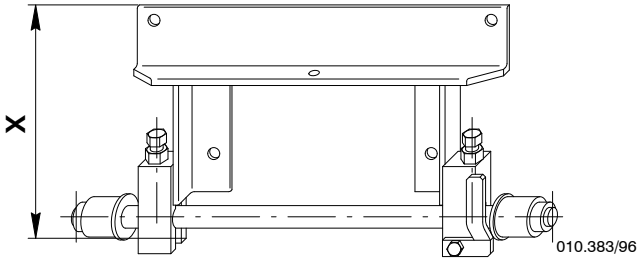
1 Cover
to air connection at diffuser
X = 470 mm (TPL 73–B)
X = 555 mm (TPL 77–B)
X = 460 mm (MET 53MA/MB)
X = 520 mm (MET 66S)
X = 520 mm (MET 60MA/MB)
X = 545 mm (ABB A170)
X = 625 mm (ABB A175)
X = 690 mm (ABB A180)



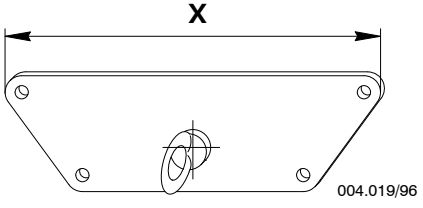
94661 1 Pulley plate
for cooler type:
GEA 120/30/24/6
X = 605 mm



94662 1 Pulley plate
for cooler type:
GEA 150/38/24/6
X = 430 mm

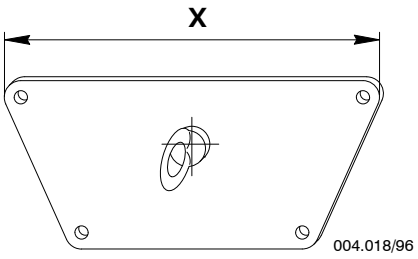


94663A 1 Dismantling and assembling device
for cooler type:
GEA 120/30/24/6
X = 680 mm

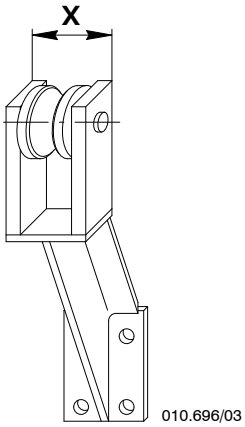


Standard Tools

94663B **1** **Plate**
for cooler type:
GEA 150/38/24/6
X = 680 mm

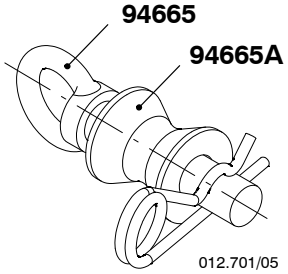


94664 **1** **Pulley support**
for dismantling and assembling the scavenge air cooler
X = 140 mm

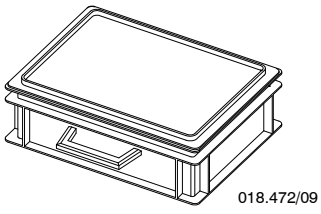


94665 **1** **Pin**
with double spring clip
for removal and fitting of tube stack
including:

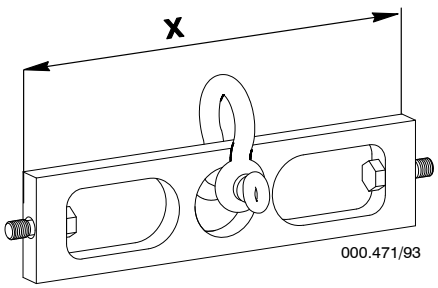
94665A **1** **Roller**



94720C **1** **Tool pulse accumulator**
(for CLU4–C)
consisting of:
measurement set complete
for checking / refilling of
hydraulic accumulator

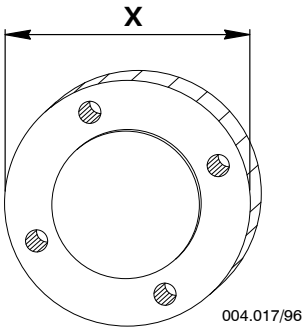


94811 **2** **Lifting lugs**
with 2 shackles
for removal and fitting expansion piece
to exhaust valve cage
X = 358 mm

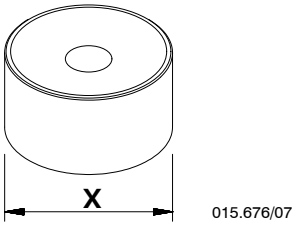


Standard Tools

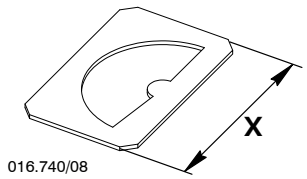
94831 **1** **Blank flange**
for blanking off starting air pipe during emergency operation
X = 200 mm



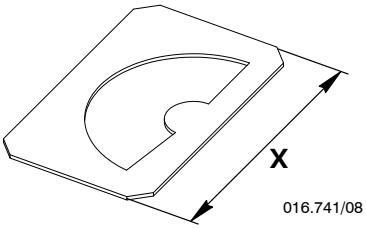
94834 **1** **Regrinding device**
to hydraulic pipes
for radius of 100 mm
X = 38 mm



94870D **1** **Stencil**
X = 48 mm

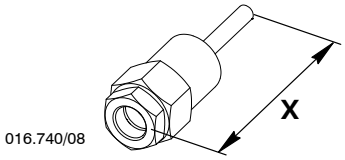


94870H **1** **Stencil**
X = 75 mm

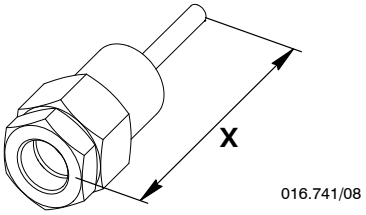


94870J–L **1** **Regrinding device left hand thread**

94870J–R **1** **Regrinding device**



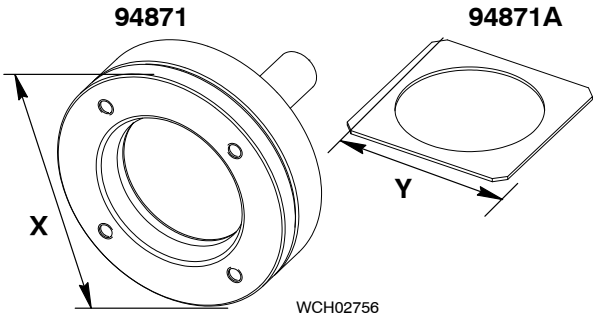
94870K **1** **Regrinding device**



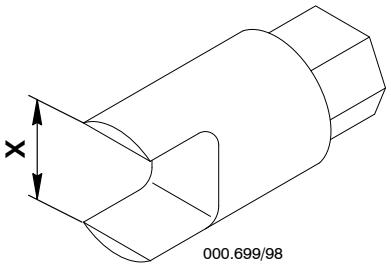
Standard Tools

94871 1 **Grinding tool**
for HP injection pipe
X = ∅ 50 mm, R30.5

94871 A 1 **Stencil**
Y = 50 mm

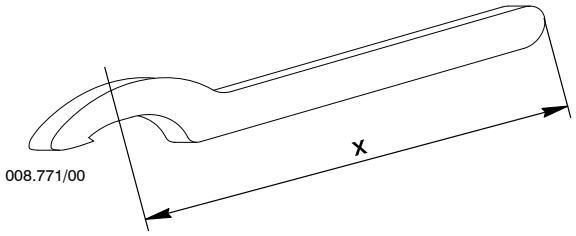


94874 1 **Special spanner**
for fitting claws
on HP pipe to injection valve
X = 24 mm

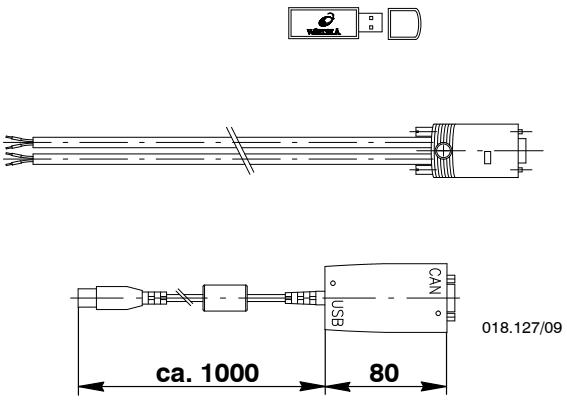


94924 1 **Hook spanner**
for crank angle sensor
X = 205 mm

94925 1 **Hook spanner**
for crank angle sensor
X = 242 mm



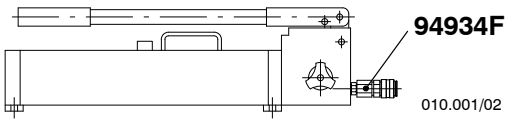
94930 1 **SW-download package**
to WECS–9520 for flexView operator
consisting of:
1 USB–memory stick
1 CAN cable (ca. 10 m)
1 UBS to CAN adapter
1 Connection diagram
1 Requirements



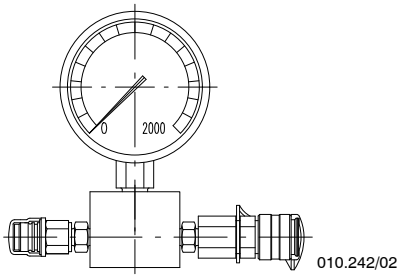
Standard Tools

Hydraulic parts and pump

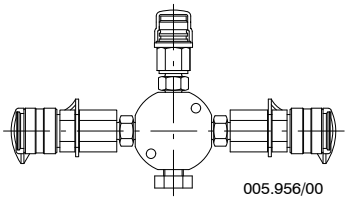
94931 1 HP oil pump
working pressure max. 2800 bar
94934F 1 Adapter piece



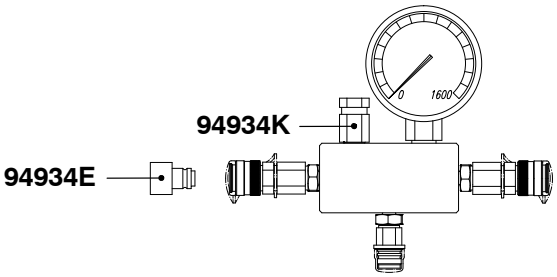
94932 2 Hydr. distributor with pressure gauge



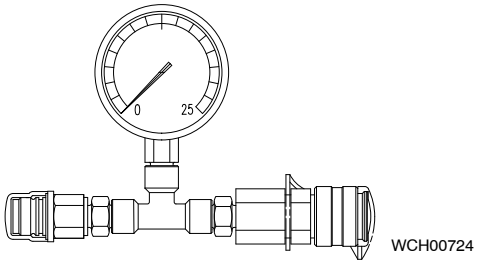
94934 1 Connection block



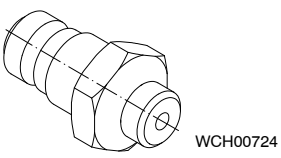
94934A 1 Hydr. distributor with pressure gauge
94934K 1 Relief valve
94934E 1 Plug piece



94934H 1 Hydr. distributor with pressure gauge 0...25 bar

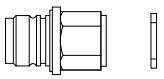


94934I 1 Connection nipple (G¼")

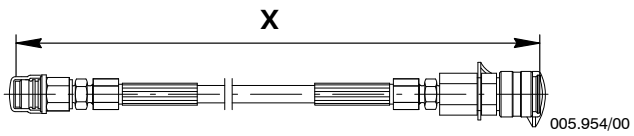


Standard Tools

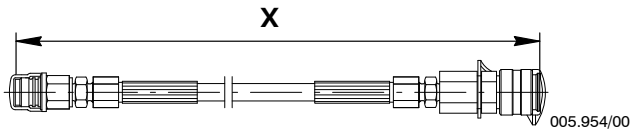
94934J 3 Closing valve with Tredo joint



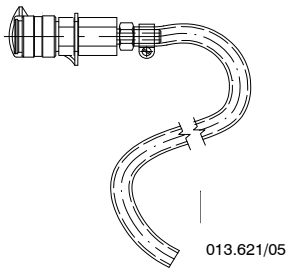
94935 3 HP hoses 2600 bar
with closing valves and coupling sockets
X = 2130 mm



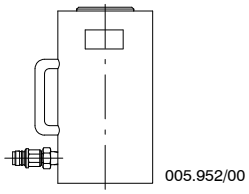
94935A 2 HP hoses 1500 bar
with closing valves and coupling sockets
X = 1880 mm



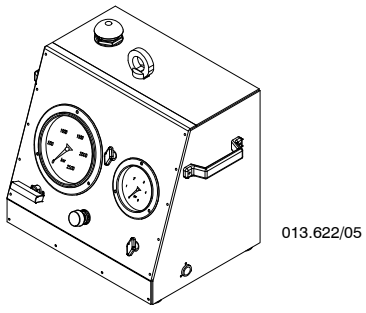
94935C 1 Hose
for set-up of pre-tensioning jacks
Length = 2000 mm



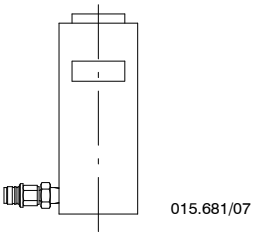
94936 2 Hydraulic jacks 230 kN (23 t)



94942 1 Hydraulic unit
working pressure max. 2500 bar

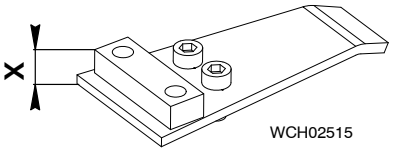


94950 1 Hydraulic jack 230 kN (23 t)



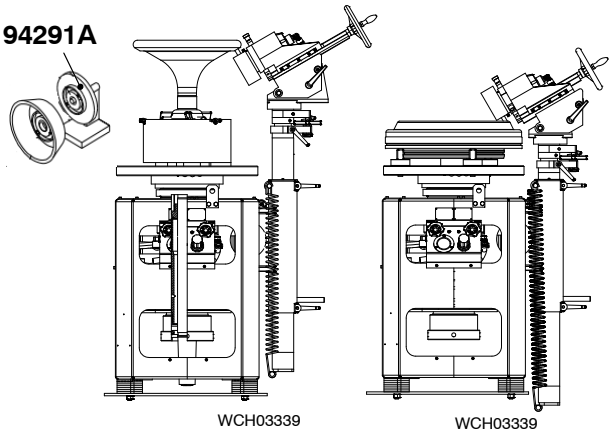
Recommended Special Tools

GF 94155A **1** **Turning-out device**
with screws
for turning out thrust bearing pads
For 2-part gear wheel
X = 57.5 mm

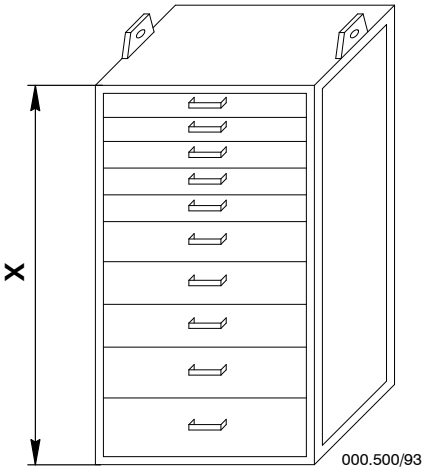


94291 **1** **Valve grinding device complete**
for valve spindle and valve seat

94291A **2** **Grinding discs**
(C-M No. 11373-01-01)

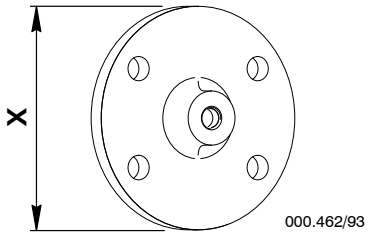


94300 **1** **Tool cupboard**
X = 1120 mm

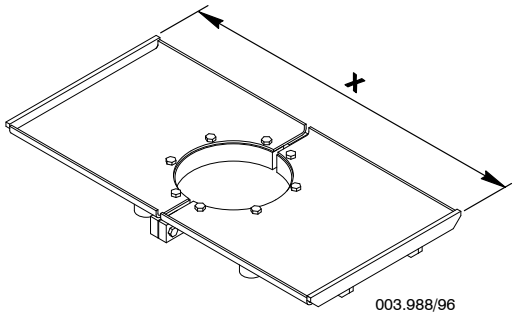


Recommended Special Tools

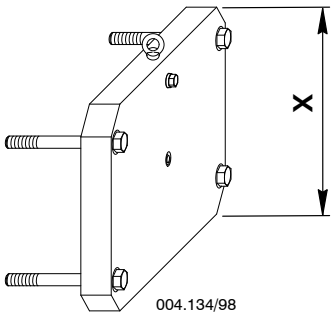
94336 **1** **Connecting flange**
for pre-lubrication of crosshead
and bottom end bearing
X = 140 mm



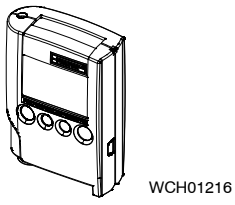
94344 **1** **Dismantling device**
for removal of piston rod
gland downwards
X = 812 mm



94349 **1** **Pressure testing device**
for piston
X = 252 mm



94356 **1** **Equipment case**
with instruments
for measuring thickness of chrome-
ceramic-layer on piston rings

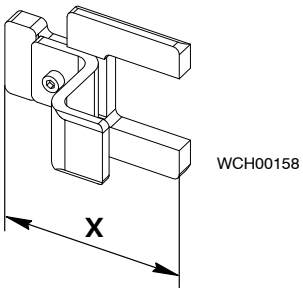


94357 **1** **Calliper gauge**
for measuring piston ring grooves

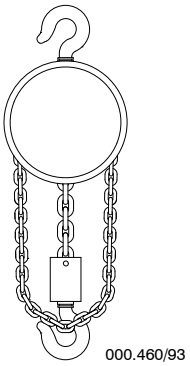


Recommended Special Tools

94412E 1 Fork wrench
for 2-part gear wheel on crankshaft,
AF55
X = 140 mm

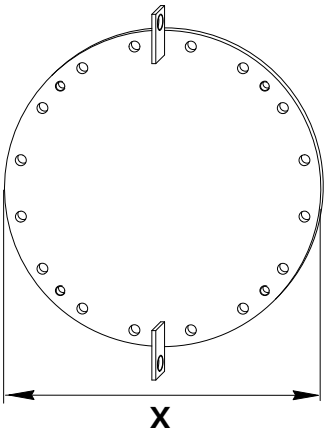


94650 1 Spur-geared chain block
for removing and fitting
electric motor to auxiliary blower
(WLL 1000 kg)



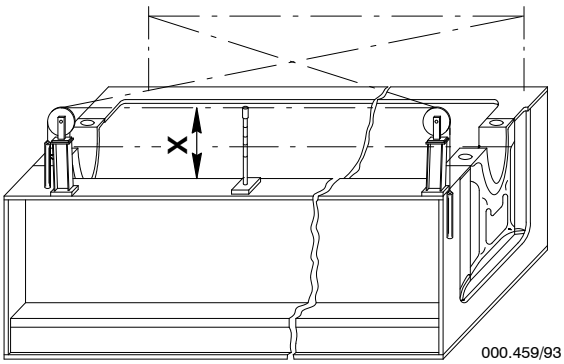
94655 1 Cover
to air inlet casing with suction pipe
in case of a turbocharger breakdown

X = 480 mm (TPL 73–B type)
X = 555 mm (TPL 77–B type)
X = 520 mm (MET 66S type)
X = 520 mm (MET60MA/MB)
X = 505 mm (ABB A170)
X = 595 mm (ABB A175)
X = 690 mm (ABB A180)

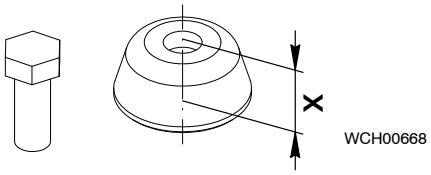


Special Tools Obtainable on Loan

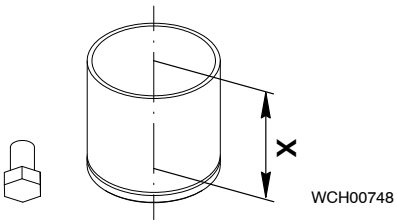
94105 **1** **Measuring apparatus**
for leveling bedplate
consisting of:
4 Supports
4 Weights with wire
1 Measuring underlay
X = 1335 mm



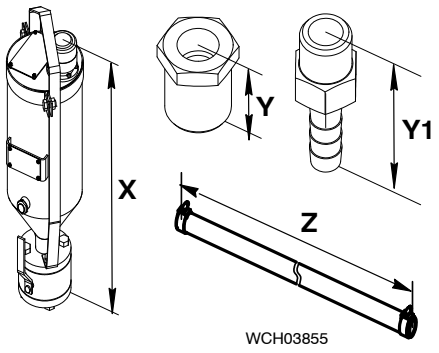
GF 94174 **1** **Thread protector**
to upper threads of tie rod
with screw M24x55
X = 38 mm



GF 94177 **1** **Thread protector**
to lower thread of tie rod
with screw M20x30
X = 104 mm



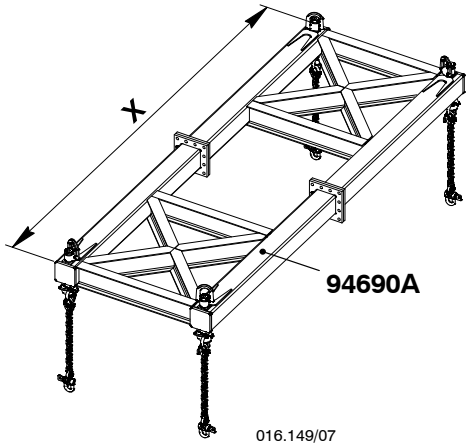
94844 **1** **Lubrication device**
for supply unit lubrication during
Maintenance
X = 600 mm
Adaptors:
Y = 28 mm
Y1 = 45 mm
Flexible hose:
Z = 3500 mm



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94691 1 Transport tool
for 5 or 6 Cyl. rail unit modules
(max. lifting capacity 14 000 kg)
X = 4164 mm
consisting of:

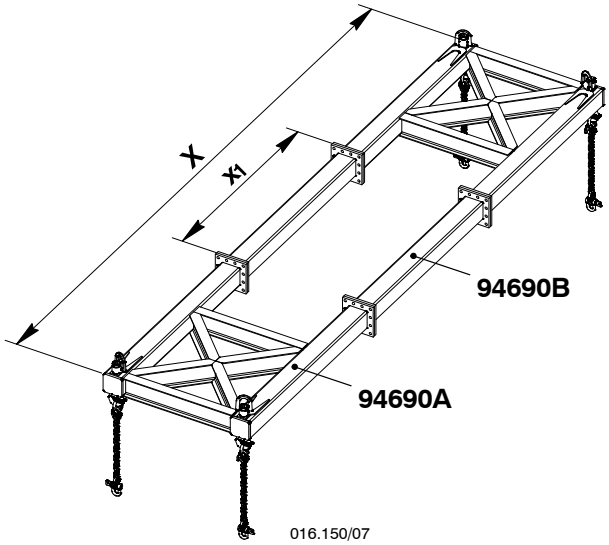
94690A 2 Lifting elements
incl. 24 screws M24x80 and nuts



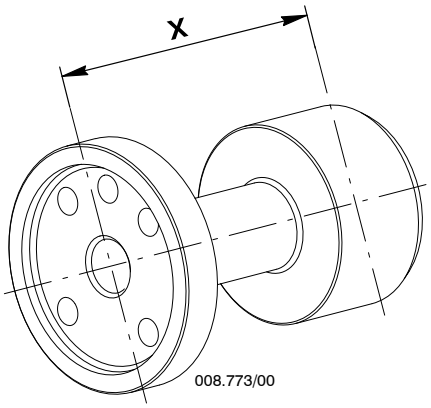
94692 1 Transport tool
for 7 Cyl. rail unit modules
(max. lifting capacity 14 000 kg)
X = 6176 mm
consisting of:

94690A 2 Lifting elements

94690B 1 Bracket
incl. 48 screws M24x80 and nuts
X_1 = 2012 mm



94922 1 Alignment tool
for crank angle sensor
X = 172 mm



Winterthur Gas & Diesel in brief

Winterthur Gas & Diesel Ltd. (WinGD) is a leading developer of two-stroke low-speed gas and diesel engines used for propulsion power in merchant shipping. WinGD's target is to set the industry standard for reliability, efficiency and environmental friendliness. WinGD provides designs, licences and technical support to manufacturers, shipbuilders and ship operators worldwide. The engines are manufactured under licence in four shipbuilding countries. WinGD has its headquarters in Winterthur, Switzerland, where its activities were founded in 1898.

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