

WIN GD

Winterthur Gas & Diesel

WÄRTSILÄ RT-flex58T-D

Maintenance Manual

“Marine”

Version 2

Supply Unit Aft End

Vessel:

Type:

Engine No.:

Document ID: DBAC351676

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RT-flex58T-D Version 2 Supply Unit Aft End				Summary for Maintenance Manual (MM)			
Page No.	Modification		Title	Subject	Page or Manual		
	Date	No.			new	exch.	
	2013			Issue 2013	x		
				Date of publication 2013-01-30			
0380-1/A1 (2)	2013-02	TB RT-143	Maintenance Schedule	2728-1: Monthly check of nut to solenoid added		x	
2728-1/A1			Starting Air Valve	Check concerning venting of starting air manifold and tightening of nut (18) to solenoid (17) added		x	
2124-1/A1			Cylinder Liner	Execution cylinder liner / supporting ring replaced with cylinder liner / water guide jacket		x	
2124-3/A1 (2)			Cylinder Liner			x	
2708-1/A1			Cylinder Cover	Cylinder liner with upper and lower water guide jacket adapted		x	
2722-1/A1 (6)			Injection Valve	Sec. 7: Remark added concerning replacing of a nozzle tip		x	
6420-1/A1			Scavenge Air Receiver	Arrangement of air flaps standardized to those in OM		x	
9403-4/A1 (2)			Hydr. Pre-tens. Jacks	1132-1: Comparison value in (°) deleted		x	
				Date of publication 2013-02-20			
0002-1/A1	2013-08		Table of Contents	3425-1/A1, A2: checking wear of ... ring grooves and new group 9223-1/A2 added		x	
Index 3, 9						x	
0008-1/A1 (2)		EAAD084591	Engine Numbering and Designations	Crank angle sensor unit at gear wheel added		x	
0011-1/A1 (1)			Safety Measures and Warnings	Attention concerning clean areas (no water or cleaning fluids) added		x	
0330-1/A1 (18, 19)			Clearance Table	Key No. 6 and 7: points A and B added		x	
0380-1/A1 (2)			Maintenance Schedule	3103-1: Interval changed "according to classification society"		x	
(3)				3403-1: Intervals changed to 18 000-36 000 operating hours 3403-4: Intervals changed to 500-1000 operating hours 3425-1: Work to be carried out and intervals changed		x	
2303-1/A1 (1, 7)		EAAD084619	Piston Rod Gland	Recess applied on clamping ring 94345b as shown in Fig. 'G'		x	
2722-1/A1 (1, 3, 4-6, 8)			Injection Valve	Sec. 11 added; system oil as test media mentioned; Sec. 3: keeping opening pressure changed from 10 to 30 seconds; Sec. 5 revised; Remark concerning IMO technical file and detail of nozzle type added		x	
3103-1/A1			Measuring Crank Deflection	1. General aspects; 2. Condition of measuring and 4. Crank deflection limits revised		x	
3425-1/A1			Piston Rings (Four Piston Rings)	Determination of wear rate of chrome-ceramic piston rings and measuring piston ring grooves introduced		x	
3425-1/A2			Piston Rings (Three Piston Rings)	Determination of wear rate of chrome-ceramic piston rings and measuring piston ring grooves introduced		x	
4103-3/A1 (5)			Replacing Gear Wheel on Crankshaft	Stud side (thread) to be applied with MOLYKOTE and LOCTITE 262 corrected		x	
5801-1/A2 (1)			Regulating Linkage	(with Woodward ProAct II Analog Actuator): 2nd sentence about configuration and setting procedure added		x	
8733-1/A1 (1, 2)		EAAD084136	HP Pipe to Injection Valve	Special spanner 94874 and detail concerned in Fig. 'B' added		x	
9223-1/A2		2013	EAAD084591	Crank Angle Sensor Unit	Assembly and replacement of proximity sensor (pickup) at <u>gear wheel</u> introduced	x	
9403-5/A1 (30, 33, 34)		2013-08		Tool List	Tools 94874, 94291A, 94356 (only figure modified) and 94357 added		x
				Date of publication 2013-08-23			
9403-5/A1 (3,4,10,21,26,27,28,29,35)		2014-01		Tool List	94012 changed to 94012C, GF94020 changed to 94020D, 94022 changed to 94022B,94142 changed to 94142-L and -R, 94345F changed to 94345F/94345G,94651 changed to 94651C, 94662 deleted, 94481 deleted,94870E,F,G changed to 94870K,94870A,B,C changed to 94870J		x

RT-flex58T-D Version 2 Supply Unit Aft End				Summary for Maintenance Manual (MM)		
Page No.	Modification		Title	Subject	Page or Manual	
	Date	No.			new	exch.
				Date of publication 2014-01-09		
9403-5/A1 (36)	2014-04		Tool List	Tools: 94211, 94212 deleted		x
				Date of publication 2014-04-02		
0352-1/A1 (1)	2015-08	EAAD086016	Tightening Values	New tightening values for elastic studs of cylinder cover (new pre-tensioning jack)		x
2708-2/A1	2015-08	EAAD086016	tensioning of cyl. Cover studs	new pretensioning jack for cyl. Cover GF94215A		x
9403-3/A1 (1, 5)	2015-08	EAAD086016	Pre-Tensioning 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 GF94215A		x
				Date of publication 2016-02-17		
2751-2/A1	2018	WinGD Input	Exhaust Valve: Disassemble and Assemble	Pge: 7. Paragraph 3.4 - Procedure changed.		x
5552-5/A1	2018-02	Wartsila Input	Lubrication of Supply Unit during Maintenance	Procedure changed		x
Group 5 ToC	2018	WinGD Input	ToC	Analog Actuator replaced with Digital Actuator		x
5801-1/A2	2018	WinGD Input	Regulating Linkage - Woodward ProAct II - Digital Actuator	Procedure changed. Analog actuator replace with digital actuator		x
9403-5/A1	2018-01	DAAD083068	Tools List	Page 36: 94844 Lubrication device added.		x
				Date of publication 2018-02		

0 General Information

1 Bedplate and Tie Rod

2 Cylinder Liner and Cylinder Cover

3 Crankshaft, Connecting Rod and Piston

4 Driving Wheels and Shut-off Valve for Starting Air

5 Supply Unit, Injection and Exhaust Valve Control

6 Scavenge Air Receiver and Auxiliary Blower

7 Cylinder Lubrication

8 Piping

9 Crank Angle Sensor Unit, Tools

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For Particular Attention	0000-1/A1
Preface	0001-1/A1
Table of Contents	0002-1/A1
Engine Numbering and Designations	0008-1/A1

▽ General Guidelines

- for Maintenance: Safety Measures and Warnings	0011-1/A1
- for Lifting Tools: Wire Rope Slings, Span-Sets, Eye Bolts etc.	0012-1/A1

▽ Clearance Table 0330-1/A1

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

▽ Tightening Values

- of Important Screwed Connections	0352-1/A1
- of Standard Screwed Connections	0352-2/A1

Masses (Weights): Individual Components per Piece in kg

Maintenance Schedule: Inspection and Overhaul Intervals (Guidelines)

Engine Cross Section and Longitudinal Section

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For Particular Attention

This manual is put at the disposal of the recipient solely for use in connection with the corresponding type of diesel engine.
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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.

This manual has been prepared to the best knowledge and ability of its authors. However, neither Wärtsilä Switzerland Ltd nor their employees assume any liability – under any legal aspect whatsoever, including possible negligence – in connection with this manual, its contents, or modifications to it or in connection with its use.

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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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Table of Contents

General Information	Group 0
For Particular Attention	0000-1/A1
Preface	0001-1/A1
Engine Numbering and Designations	0008-1/A1
▽ General Guidelines	
– for Maintenance: Safety Measures and Warnings	0011-1/A1
– for Lifting Tools: Wire Rope Slings, Span-Sets, Eye Bolts etc.	0012-1/A1
▽ Clearance Table	0330-1/A1
– General	Page 1
– Crankshaft and Thrust Bearing	2, 3
– Crankshaft and Main Bearing	4, 5
– Crosshead Guide	6, 7
– Cylinder Liner	8, 9
– Piston Rod Gland	10, 11
– Exhaust Valve	12, 13
– Top and Bottom End Bearings to Connecting Rod	14, 15
– Piston Cooling and Crosshead Lubricating Link	16, 17
– Piston and Piston Rings	18, 19
– Driving Wheels for Supply Unit	20, 21
– Supply Unit	22, 23
– Fuel Pump	24, 25
▽ Tightening Values	
– of Important Screwed Connections	0352-1/A1
– of Standard Screwed Connections	0352-2/A1
Masses (Weights): Individual Components per Piece in kg	0360-1/A1
Maintenance Schedule: Inspection and Overhaul Intervals (Guidelines)	0380-1/A1
Engine Cross Section and Longitudinal Section	0803-1/A1

Table of Contents

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
Tie Rod: Checking the Pre-tension and Tensioning the Tie Rods	1903-1/A2
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 with Pulse <u>Jet</u> Lubrication: Removal and Fitting	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 Elastic Studs	2708-2/A1
– Machining of Sealing Face for Injection Valve	2708-3/A1
Injection Valve: Checking, Dismantling, Assembling and Adjusting	2722-1/A1
Starting Air Valve: Removal, Fitting and Dismantling, Grinding-in and Assembling	2728-1/A1
Relief Valve for Cylinder Cover	2745-1/A1
▽ Exhaust Valve	
– Removal and Fitting of Exhaust Valve, Replacing of Elastic 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

Table of Contents

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 Tothing	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 Piston Ring Wear (Piston with four Piston Rings)	3425-1/A1
– Checking Piston Ring Wear (Piston with three Piston Rings)	3425-1/A2
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

Table of Contents

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
– Removing and Fitting the Gear Wheel on Camshaft	5552-3/A1
– Removal and Fitting	5552-4/A1
– Lubrication of Supply Unit During Maintenance Works	5552-5/A1
Fuel Pump: Dismantling and Assembling	5556-1/A1
Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling	5562-1/A1
Fuel Overpressure Safety Valve: Checking and Setting	5562-2/A1
Injection Control Unit: Removal and Fitting	5564-1/A1
Pressure Reducing Valve 8.11-1: Checking the Gas Pre-charge Pressure	5610-1/A1
Exhaust Valve Control Unit: Removal, Fitting, Dismantling and Assembling	5612-1/A1
▽ Regulating Linkage	
– Adjusting: with Heinzmann StG 10-01 Actuator	5801-1/A1
– Adjusting: with Woodward ProAct II – Analog Actuator	5801-1/A2
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
Cylinder Lubrication	Group 7
Lubrication Pump CLU4-C: Checking the Gas Pre-charge Pressure	7218-1/A2
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 Fuel Pipe: Removing, Fitting and Regrinding	8752-1/A1

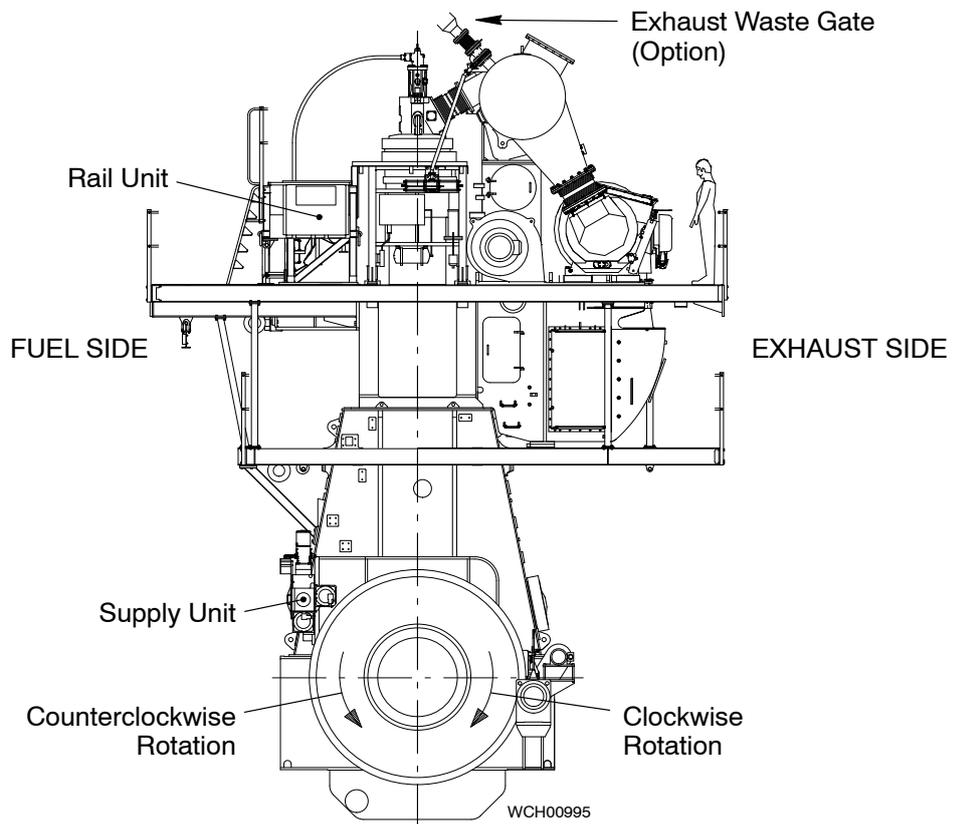
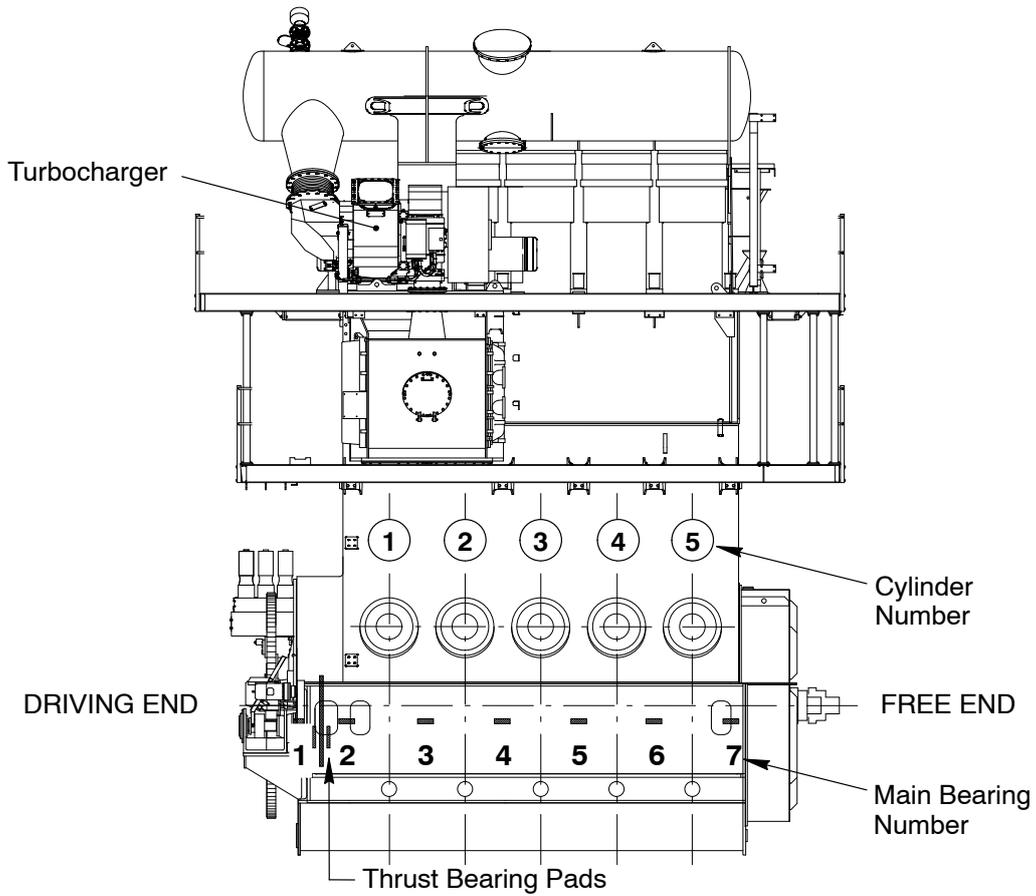
Table of Contents

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 – 32
– Recommended Special Tools	Pages 33 – 35
– Special Tools Obtainable on Loan	Pages 36 & 37

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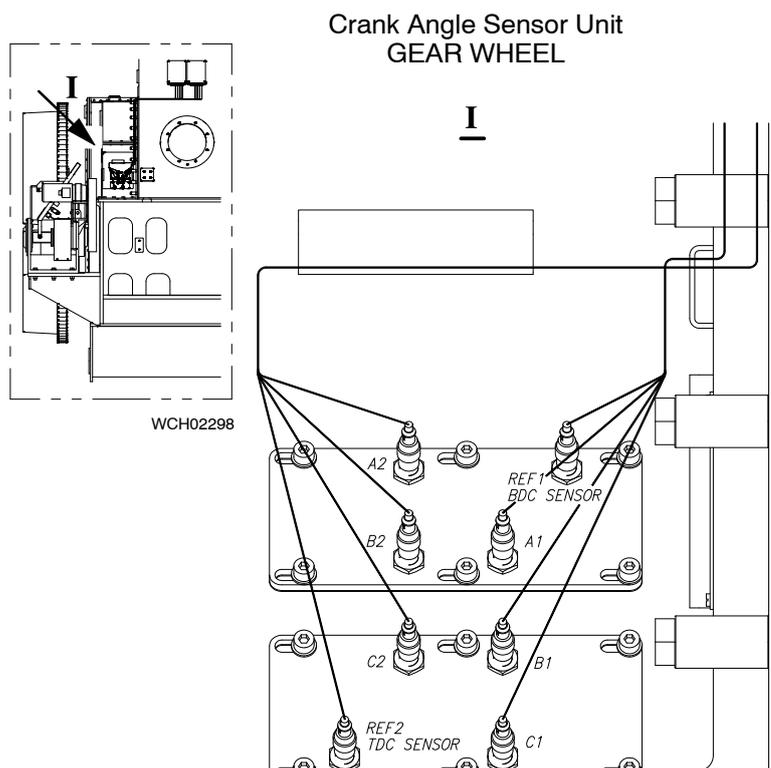
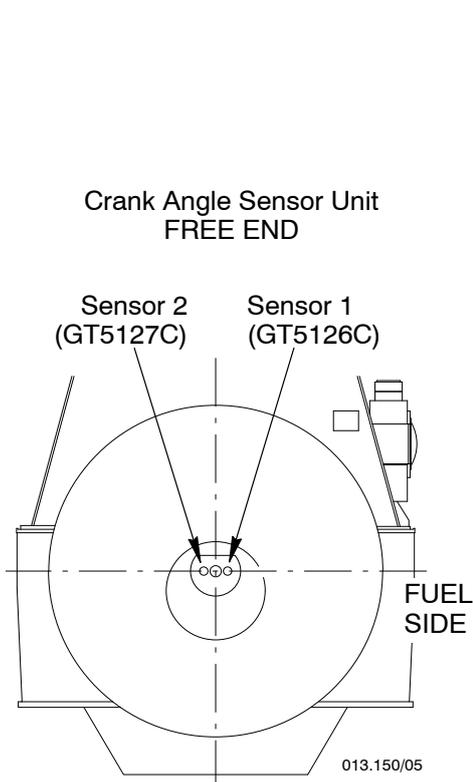
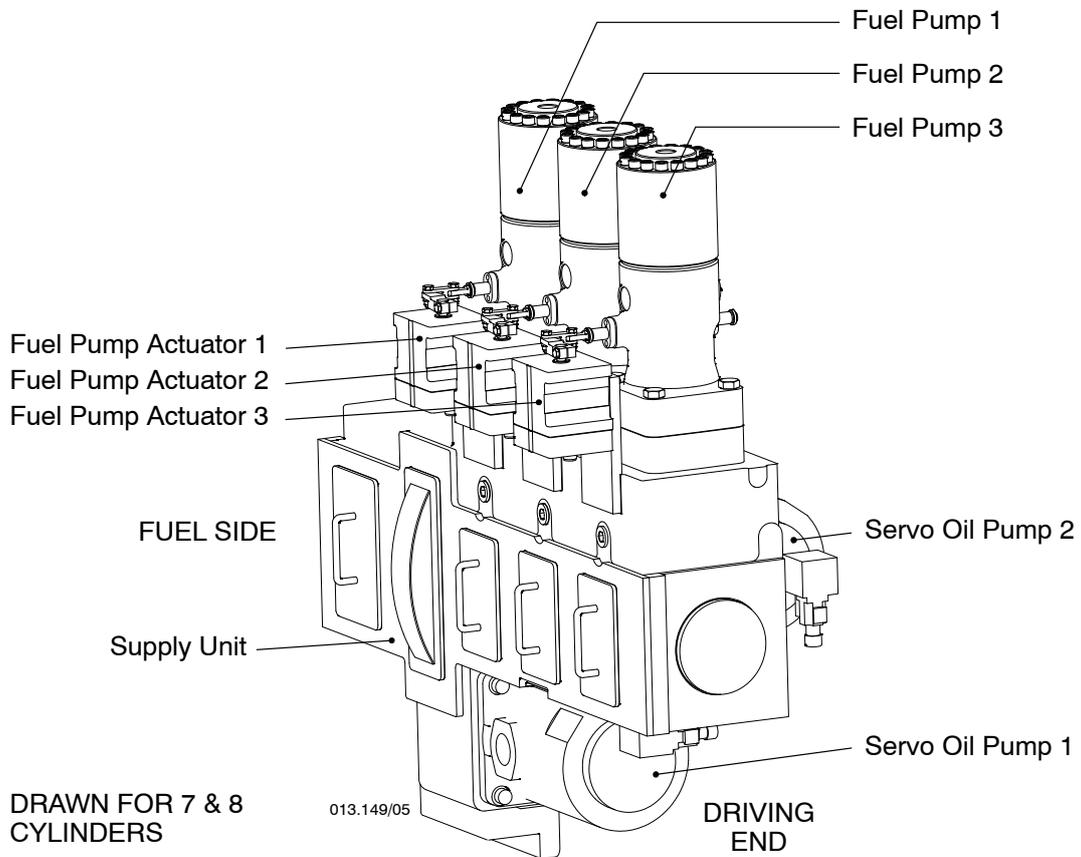
General

Engine Numbering and Designations



Engine Numbering and Designations

flex Parts:



General Guidelines for Maintenance

Safety Measures and Warnings

Overview

1.	General	1/4
2.	General safety precautions	1/4
3.	Precautionary measures before beginning of maintenance work	2/4
4.	Special safety measures	3/4
5.	Recommendations for performing work	3/4

1. General

The maintenance work which is required to be carried out on the engine at regular intervals is described in the Maintenance Schedule 0380-1 of this manual and is to be understood as a general guide. The maintenance intervals are dependent on the mode of operation, on the power as well as on the quality of the fuel used. Further details are set out in the maintenance schedule.

Experience will show whether the intervals may be extended or need to be shortened.

Strict compliance with the below mentioned recommendations regarding safety measures and maintenance work is mandatory; the recommendations are not exhaustive.

2. General safety precautions

- It is the operator's duty to assure that all personnel is familiar with all safety, health as well as environment protection rules released for operating and maintaining a diesel engine plant. In particular greatest attention has to be given to the functioning, handling and dangers of cranes and lifting devices.
- The safety officer has to make sure that all precautions have been taken in order to avoid dangerous situations.
- The operator has to nominate a person responsible for assigning work tasks to every person who is participating in maintenance work.
- Make sure that fluids or gases draining or escaping cannot cause accidents, fires or explosions during maintenance work. Keep the engine and the surroundings clean. Cleanliness increases the quality of the work and helps to prevent accidents.
Before beginning maintenance work on the diesel engine the corresponding systems which are influenced by the maintenance work must be relieved of pressure and/or drained if necessary. A protocol must be established evidencing these activities.
- Certain media, i.e. fuels etc., are highly inflammable, therefore all precautionary measures have to be taken that they do not come into in contact with fires, glowing or hot parts. Smoking in the engine room is strictly forbidden.
Special attention has to be paid to the rules of fire fighting.
Make absolutely sure that in case of fire alarm no fire extinguishing gases can be released into the engine room while people are still inside. Emergency escapes are to be marked and personnel is to be instructed of what to do in case of fire.
- Oils and other media can cause slippery surfaces. In order to avoid injury all surfaces which can be stepped on must be kept clean and dry.



Attention! Do not use water or any cleaning fluid to clean the WECS electronic components and control boxes on the engine as well as on the rail unit. Damage can occur if water goes into these electronic components or control boxes.

Safety Measures and Warnings

3. Precautionary measures before beginning of maintenance work

Before starting any maintenance work on the engine (particularly on the running gear), take the following precautionary measures:

- ⇒ Close the shut-off valves on the starting air bottles.
- ⇒ Close all the shut-off valves in the control air supply unit, and open the drain on the air bottle until it is depressurized.
- ⇒ Close by hand the (automatic) shut-off valve for starting air and open the vent and drain valve to the main starting air piping on the engine as well as the vent valves on the shut-off valve for starting air, and leave them in this position until maintenance work is completed.
- ⇒ Open all indicator cocks on the cylinder covers and leave them in this position until maintenance work is completed.
- ⇒ Engage turning gear (gear pinion must be in engaged position) and lock the lever (see also 3206-1 and 0750-1 in the Operating Manual).
- **Where the engine has been stopped due to overheated running gear or bearings, wait at least 20 minutes before opening the crankcase doors.**
- **The crankcase doors must always be locked with all the clamps whenever the engine is running**, even if this is only for a short time in order to make temperature checks (e.g. after changing bearings during an overhaul, etc.).
- In the case of a fire in the engine having been extinguished by means of CO₂, the spaces affected must be well ventilated before work can be carried out within them.



Attention! When performing electric welding near or on the engine, electromagnetic fields or peak voltage may occur, which may damage the electronic components of the WECS (**W**ärtsilä **E**ngine **C**ontrol **S**ystem).

Therefore, prior to performing electric welding in the vicinity of the mentioned components, the following precautions must be taken:

- Stop the engine if it is in operation.
- Power off the electronic system and wait one minute.
- If the welding point is within a radius of two metres from an electronic module and/or a sensor, disconnect the modules and/or sensors.
- Close the covers of all electric boxes and protect cables, sensors, etc. against sparking and heat.
- Shield the check and control units with a conductive material and connect them to earth.
- Run the welding cable from the welding apparatus directly to the welding point without any unnecessary loops; also, avoid leading the welding cable parallel to cables of the electronic control unit.

Safety Measures and Warnings

4. Special safety measures

- Prior to turning the crankshaft with the turning gear, make sure that no person is inside the engine and no loose parts, tools or devices can get jammed. Also bear in mind that the coupled propeller turns too (danger in surroundings).
- At all times when somebody is inside the engine casing another person must stand by in order that he can give the necessary aid if something unexpected happens to the person inside the engine. The person who is inside the engine casing must be equipped with all safety gears which are required to prevent suffocation within the limited space and atmospheric conditions. Moreover an antifall guard must be carried at dangerous places!
- The allowed load capacity of the engine room crane, the lifting tools, ropes and chains must be sufficient for the parts to be lifted (see 0360-1). Pay also attention to the weight distribution and attachment of the lifting tackle in order that the part which must be lifted cannot tip over or crash down!
- Sharp edges, mating faces etc. as well as ropes are to be protected by wooden pieces, leather or special edge guards which are placed between the part and the rope or chain.
- Always use gloves, a face shield and wear safety goggles when working with hydraulic tools.
- For your own safety keep away from under hanging loads, never undersling hanging parts with your fingers or hands and never embrace lifting ropes with your hands.
- Removed parts must be secured in the engine room.
- For reasons of safety, openings resulting from removed engine components must be closed!



Remark: For further instructions see also Safety Precautions and Warnings (General Information) 0210-1 in the Operating Manual.

5. Recommendations for performing work

- Pay attention to Utilization of Working Platform and Ladder 3301-1.
 - Carry out all work carefully, observing utmost cleanliness!
 - For maintenance work on the engine use the tools and devices intended for the particular job, which, as a rule, are supplied with the engine (see tool list at the end of this manual).
- ⇒ Tools and devices must be made ready prior to use, make sure they are in perfect condition.
- ⇒ Calibrate gauge tools before using and at periodical intervals.
- ⇒ Check hydraulic tools periodically for tightness and perfect functioning.
- ⇒ Protect running faces and sealing faces of removed parts by suitable means to prevent damages.

Safety Measures and Warnings

- ⇒ Close all openings which form when certain parts are removed e.g. pipes, oil holes etc. to prevent dirt from entering the engine. (This includes also the pipes which are removed).
- ⇒ Check all repaired, overhauled or replaced parts for perfect functioning before starting the engine.
- ⇒ Check all pipes which have been removed, for tightness after they are refitted.
- ⇒ Clearances of moving parts must be checked periodically. Should the maximum permissible values (see Clearance Table [0330-1](#)) have been reached or even exceeded, these parts must be replaced.
- ⇒ Arrange to replace all parts taken from spares stock. **When ordering new parts refer to the Code Book, mention code numbers and description.**
- When tightening studs, nuts or screws, take the utmost care not to damage their thread. They must be screwed in by hand until metal to metal contact is achieved. Always use the specified lubricants on the threads.
- Adhere to tightening values wherever they are indicated. Use the specified lubricant on the threads (see [0352-1](#) and [0352-2](#)).
- Locking devices of bolts, nuts, etc. must be fitted correctly and secured properly. Use locking plates and locking wires only once.
- For threads of screws and studs which are getting very hot, (i.e. exhaust pipe or turbocharger fastenings) apply a high temperature resistant lubricant before assembly, to prevent a heat seizure.
- Used rubber rings must always be replaced by new ones when an overhaul of any engine component takes place; they must conform in dimension and quality to the Wärtsilä specifications.
The fitting of piston seal rings and rod seal rings requires the greatest of care to prevent damage, over expansion or deformation. Before fitting the rings heat them first in boiling water.

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 = Working Load Limit**.

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

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

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

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.

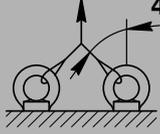
2.3 Eye bolts and eye nuts

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.

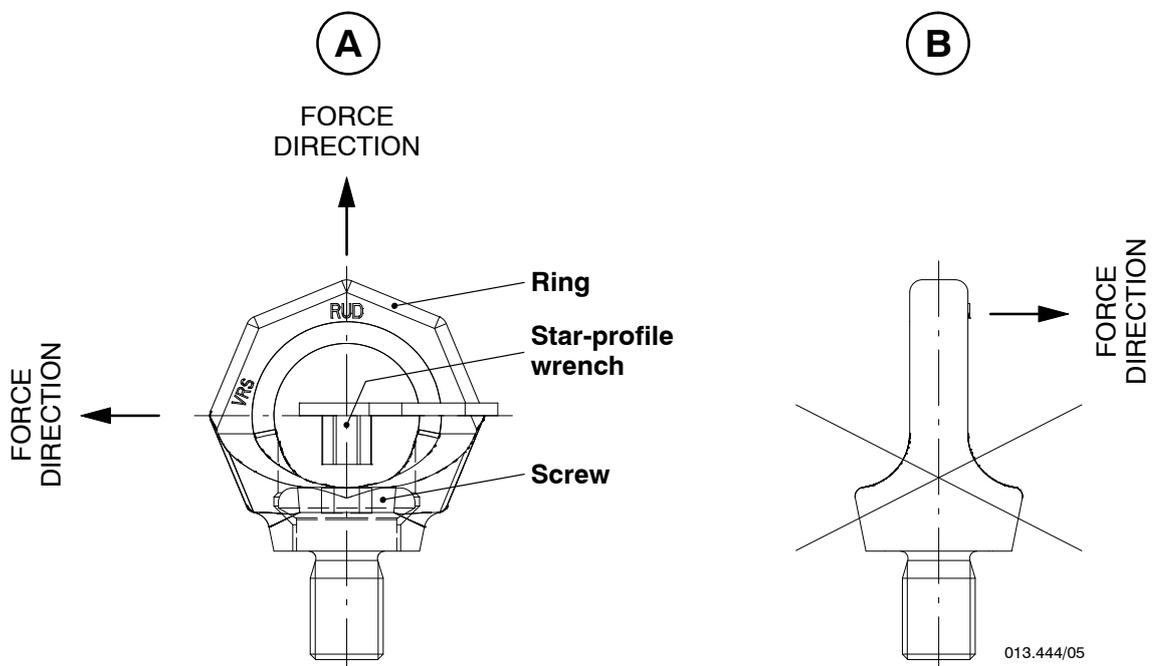
Manufacturer:

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

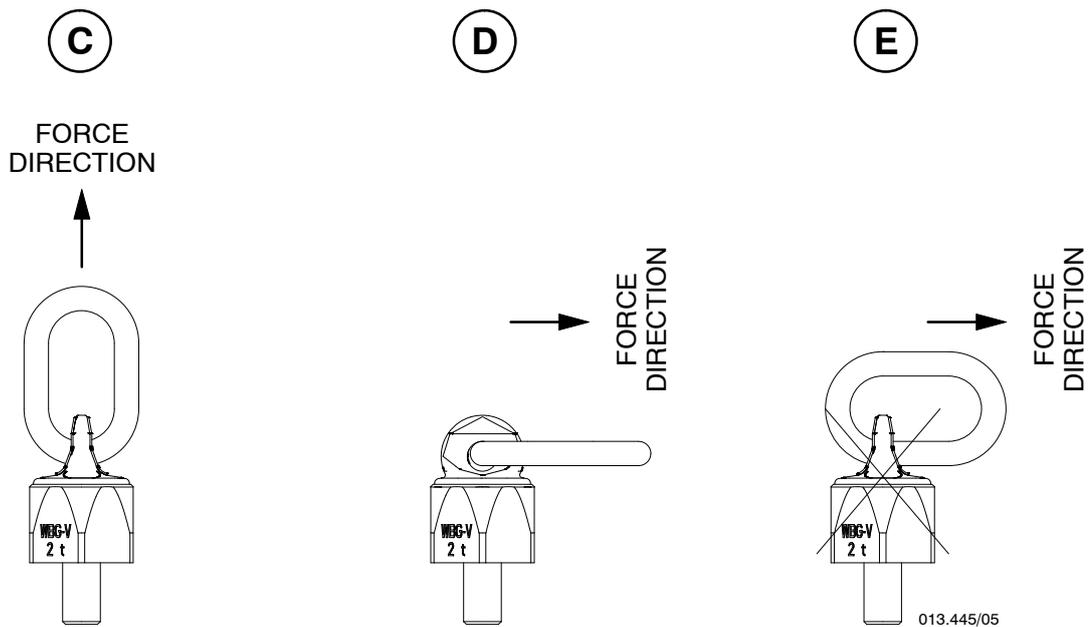
- they must be completely screwed down, lying fully on the seating surfaces.
- they are hand-screwed with their own star-profile wrenches (do not use any extension).
- In order that after tightening the ring of the RUD-eye bolt is freely rotatable, the star-profile wrench must be removed from the inner 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')



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

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 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

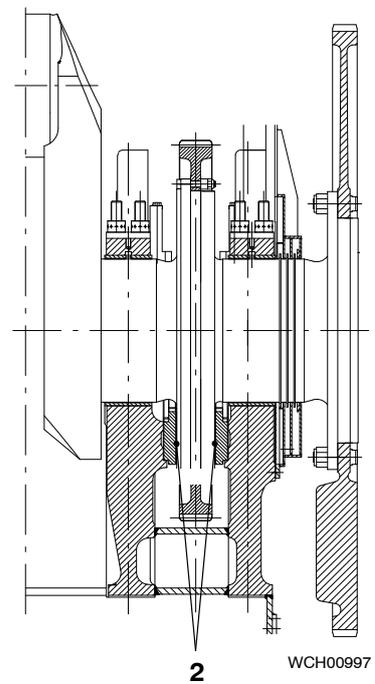
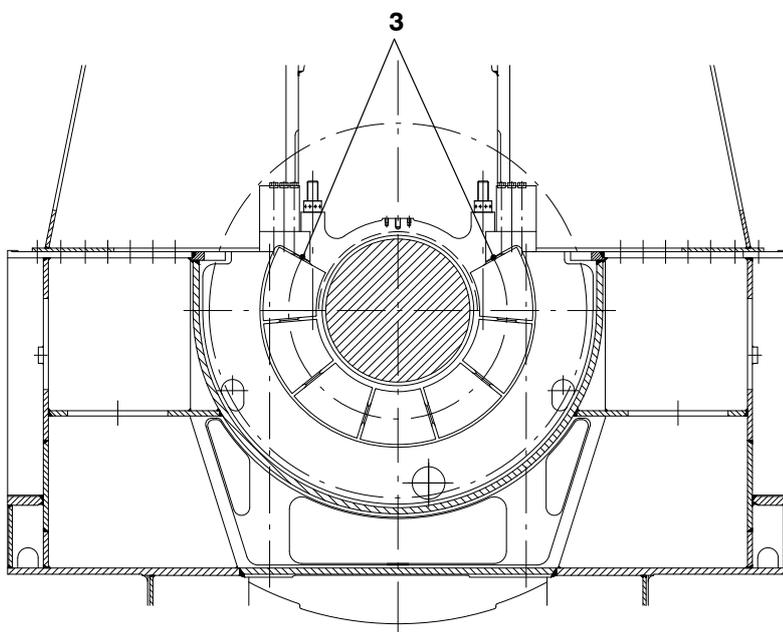
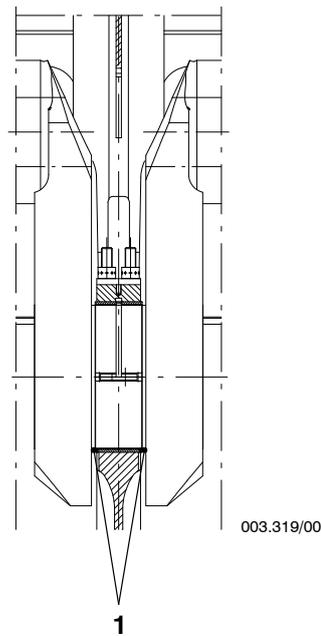
The clearances listed in the column 'Nominal dimension' of the following table correspond to design and manufacturing values or to the settings on the new engine.

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



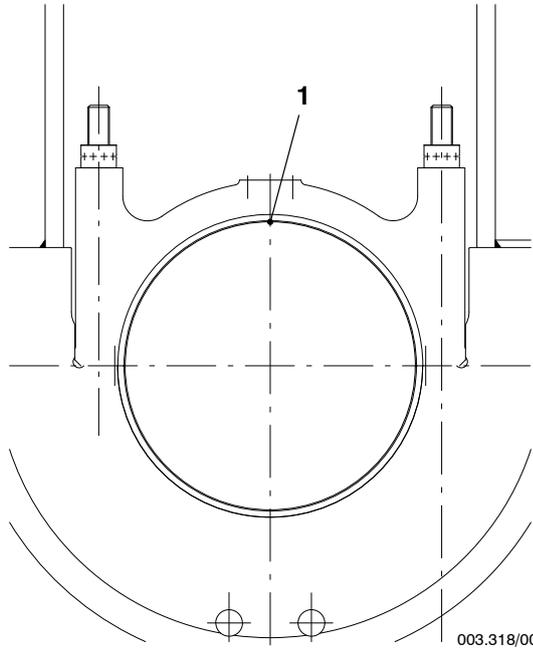
Clearance Table

Crankshaft and Thrust Bearing

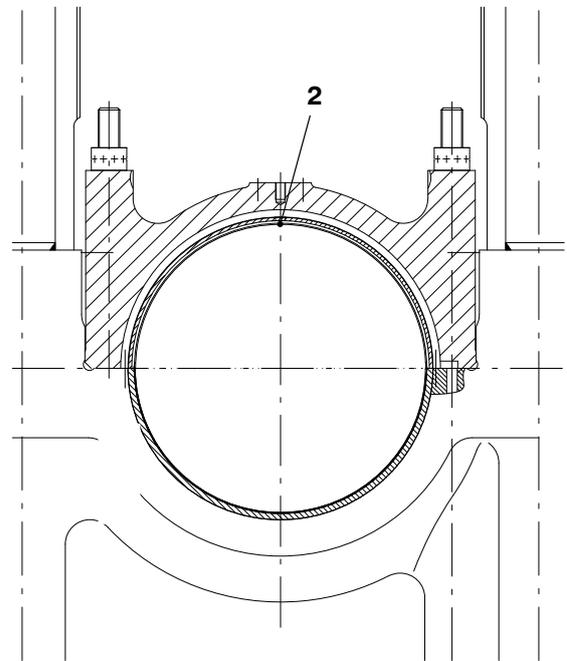
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
1132		Main bearing			
		Bearing shell	width	242	
	1	Lateral clearance	per side	12	
1203 1224		Thrust bearing			
		Thrust bearing pad	thickness	66.5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

Clearance Table

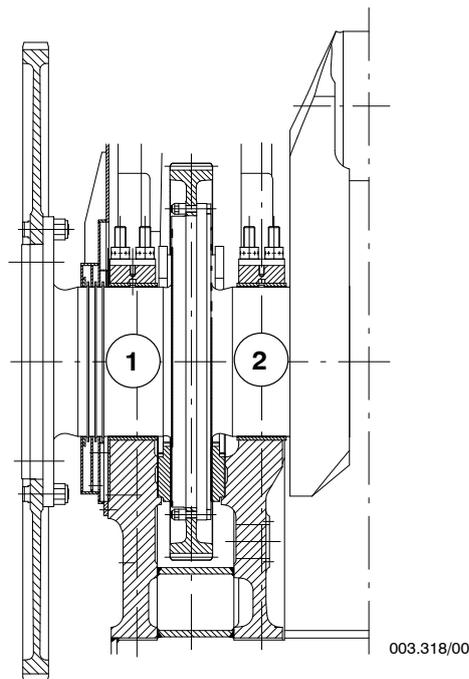
Crankshaft and Main Bearing



**MAIN BEARING
No. 1**



**MAIN BEARING No. 2
AND FOLLOWING**



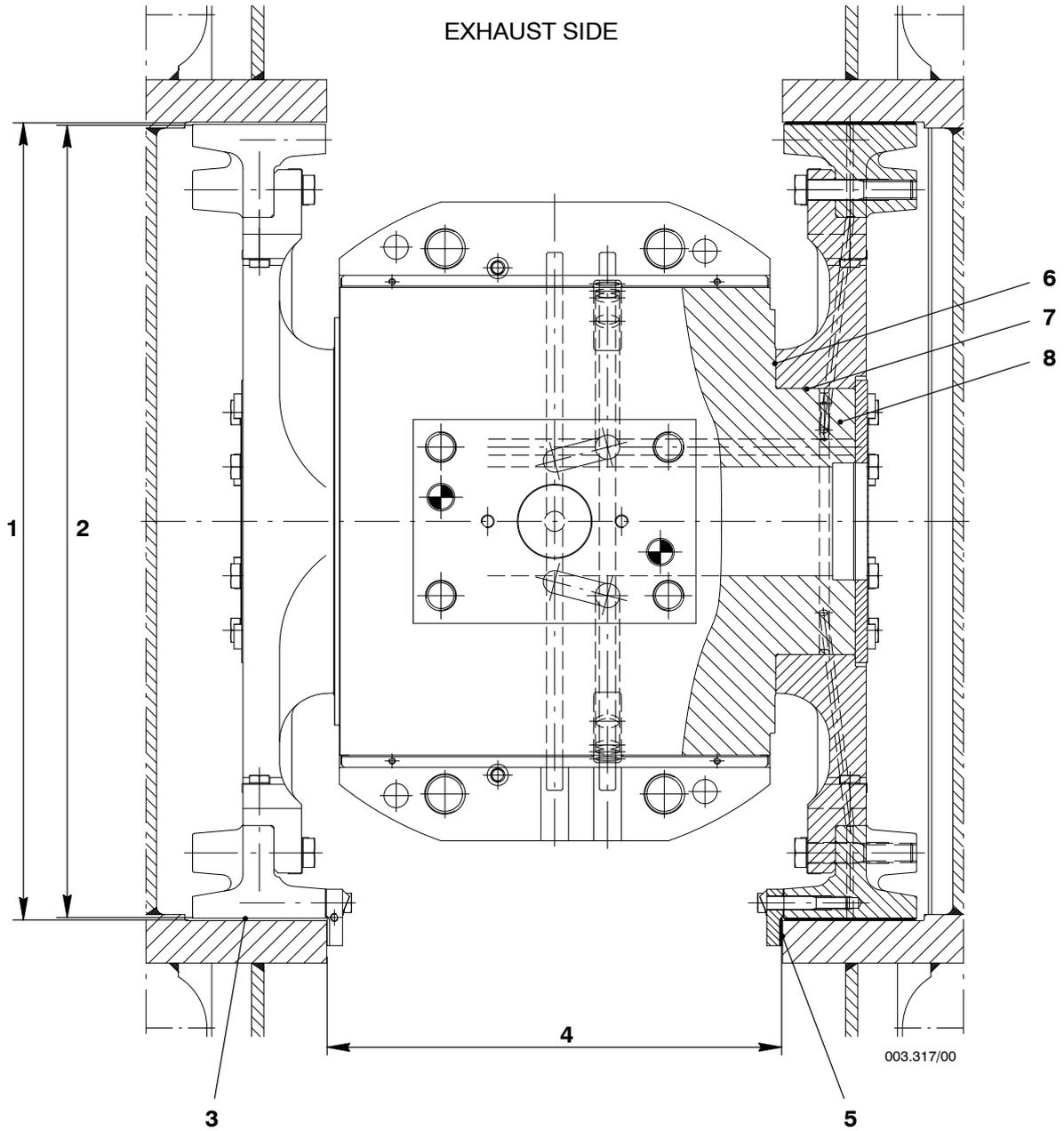
Clearance Table

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 \varnothing	706 $\begin{matrix} 0 \\ - 0.08 \end{matrix}$	
		Main bearing	inner \varnothing	706	
	1	Bearing clearance	vertical	0.3-0.7	0.9
1132		Main bearing No. 2 and following			
		Crankshaft	outer \varnothing	706 $\begin{matrix} 0 \\ - 0.08 \end{matrix}$	
		Main bearing	inner \varnothing	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

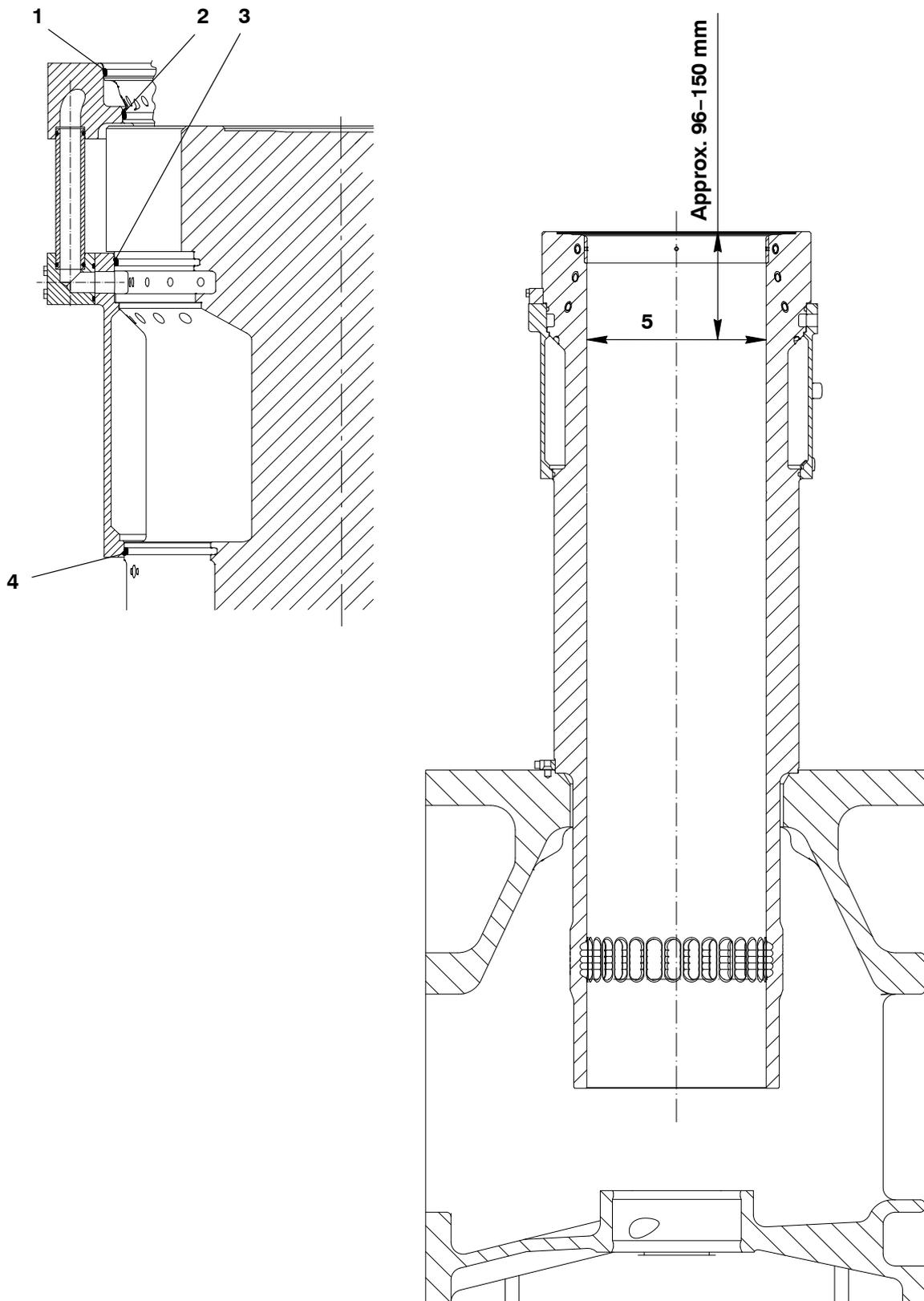
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
3326		Crosshead guide			
	1	Guide way (column)	transverse	990 $\begin{matrix} + 0.25 \\ 0 \end{matrix}$	
	2	Guide shoe	transverse	990 $\begin{matrix} - 0.20 \\ - 0.31 \end{matrix}$	
	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 \varnothing	330 $\begin{matrix} - 0.03 \\ - 0.06 \end{matrix}$	
		Guide shoe, bearing bore	inner \varnothing	330 $\begin{matrix} + 0.057 \\ 0 \end{matrix}$	
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



WCH01000

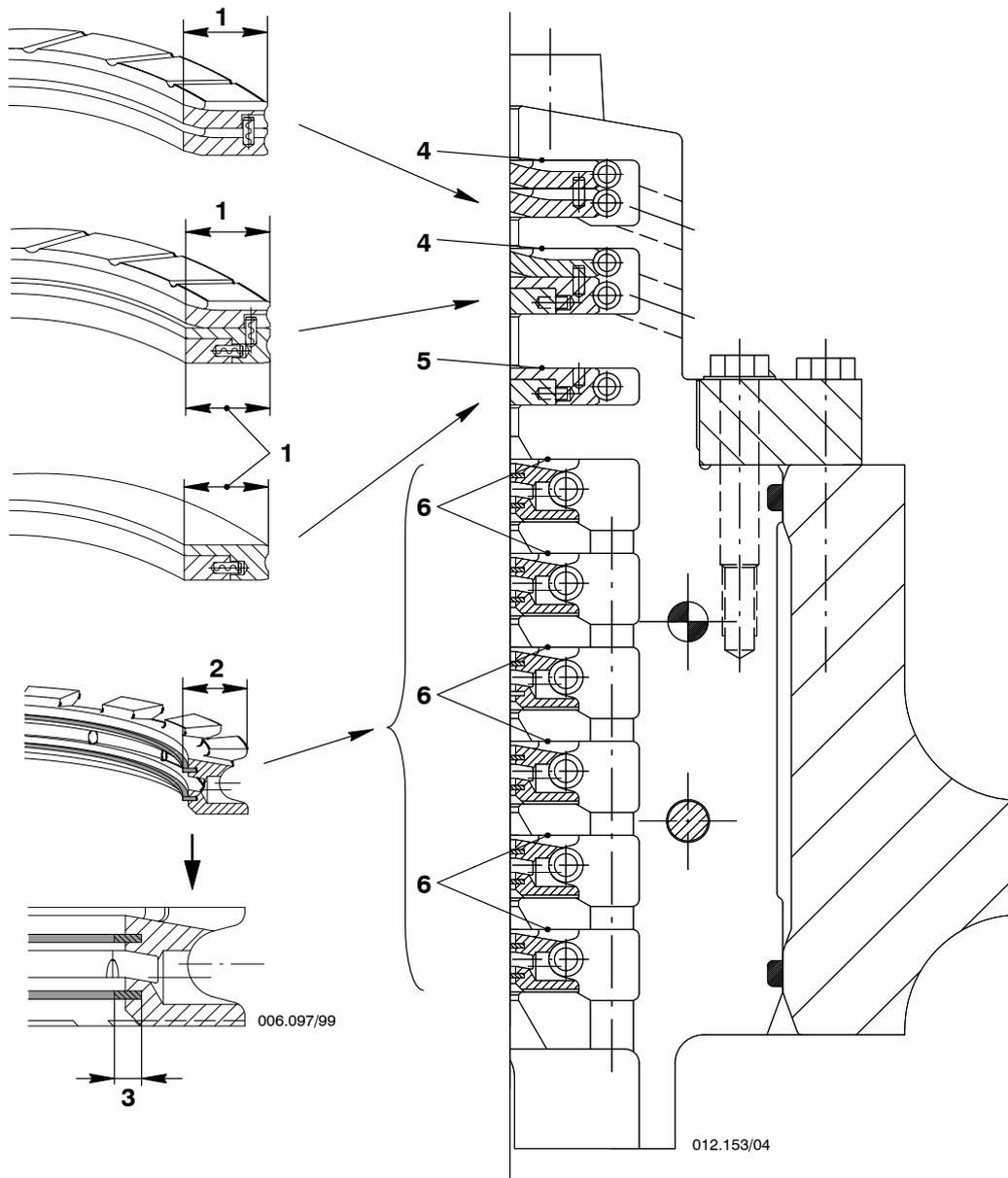
Clearance Table

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	∅	880 ^{+ 0.60} _{+ 0.40}	
	1	Clearance	total	0.70-1.10	
		Water guide jacket	∅	810 ^{+ 0.80} _{+ 0.60}	
	2	Clearance	total	0.90-1.30	
2124		Water guide jacket on cylinder liner			
		Water guide jacket	∅	840 ^{+ 0.20} _{+ 0}	
	3	Clearance	total	0.20-0.60	
		Water guide jacket	∅	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

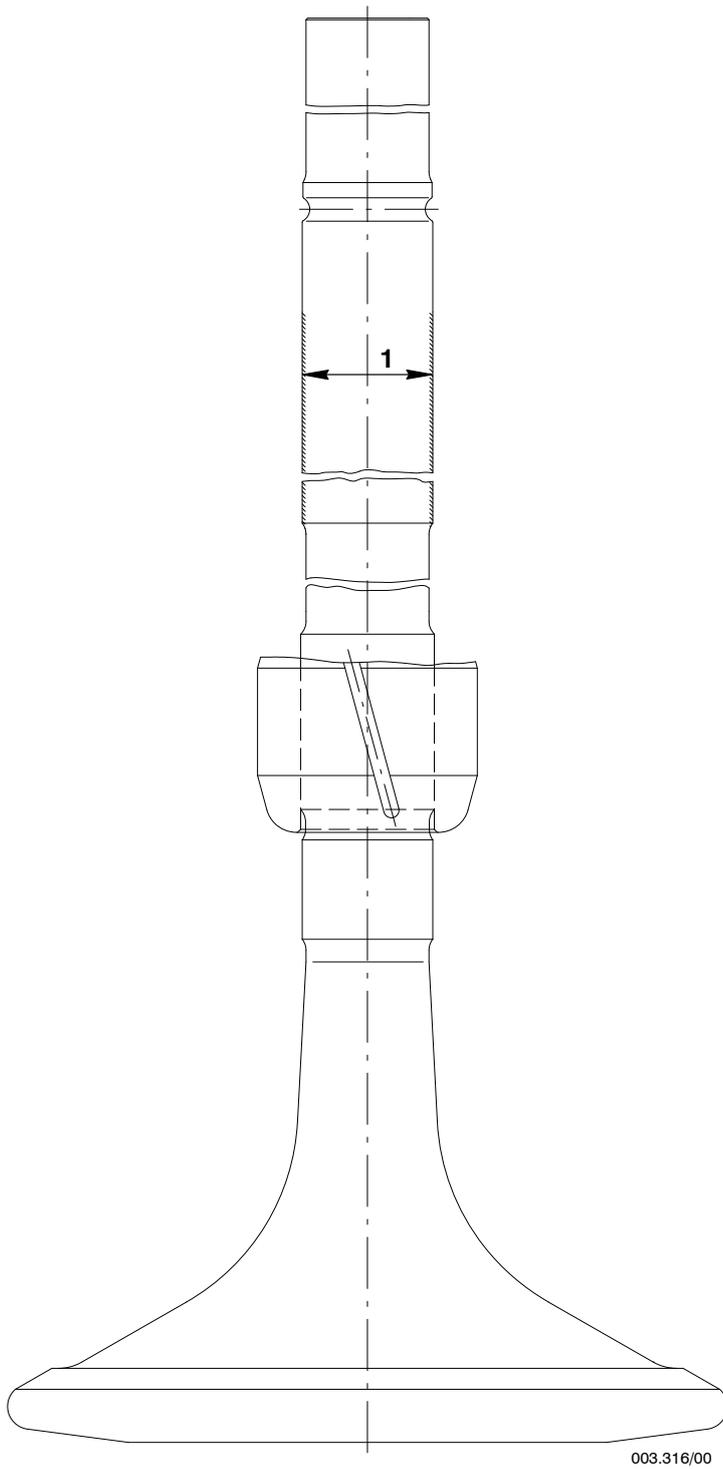
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
2303		Piston rod gland			
	*1	Ring width	radial	31	min. 25
	*2	Ring width	radial	24	min. 22.20
	*3	Ring width	radial	5	min. 3.20
	4	Ring clearance	axial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

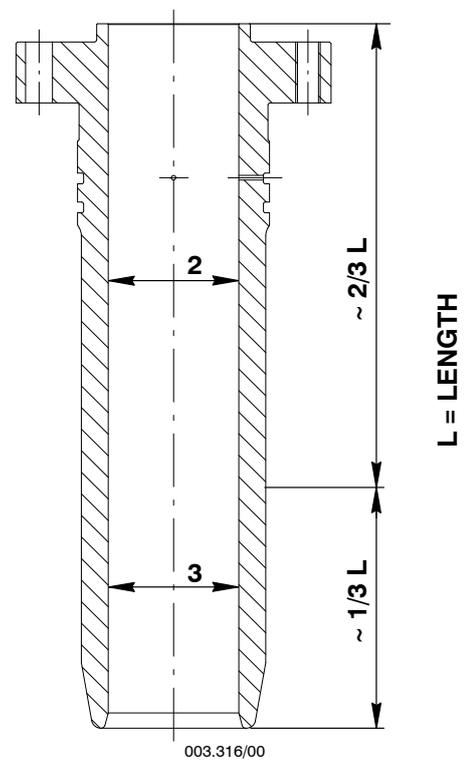
The differential value between nominal dimension and max. wear is equal for all rings, i.e. also for undersize rings.

Clearance Table
Exhaust Valve

VALVE SPINDLE



GUIDE BUSH



Clearance Table

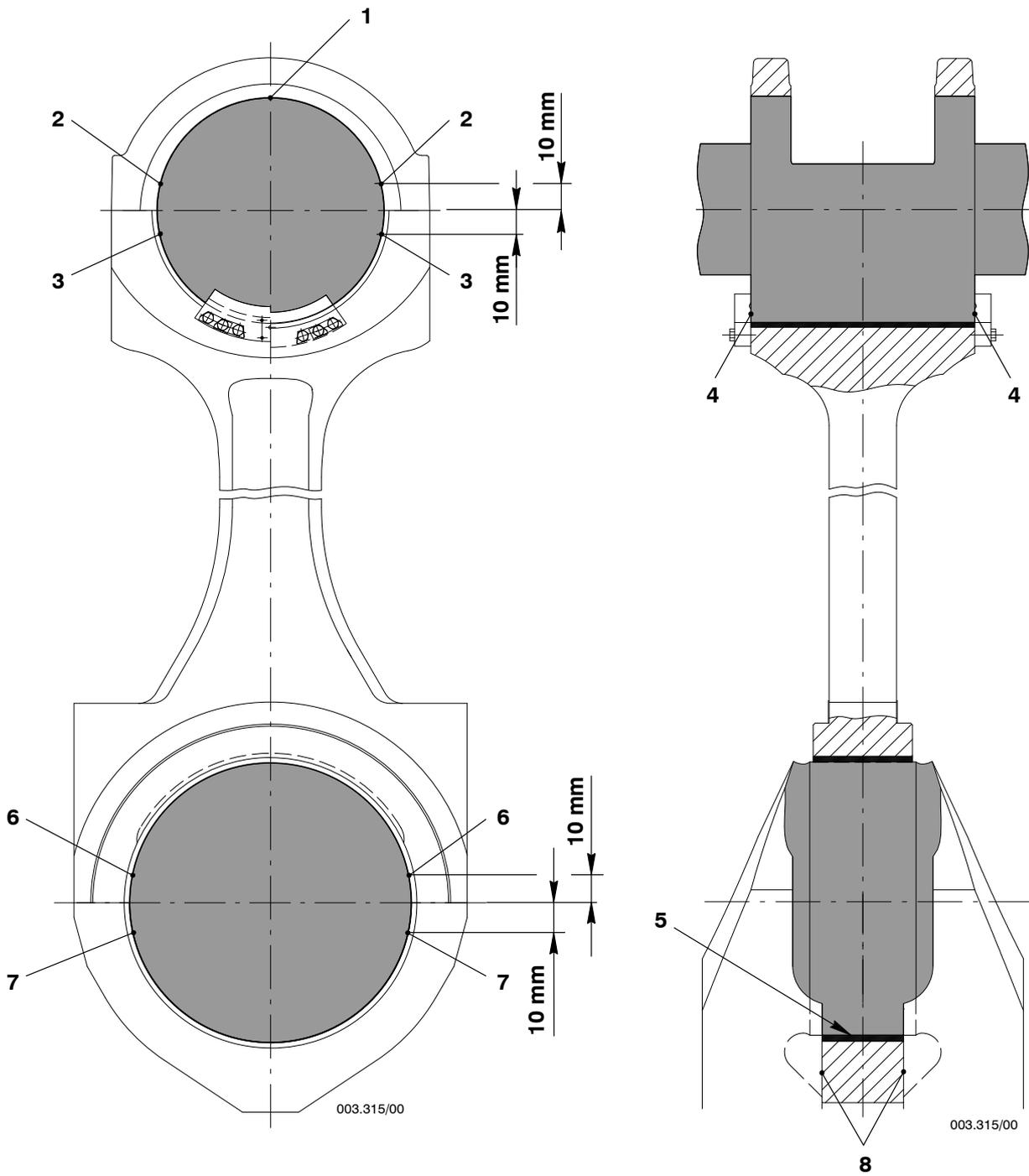
Exhaust Valve

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 \varnothing	56 $\begin{matrix} - 0.19 \\ - 0.23 \end{matrix}$	55.4
2751		Guide bush			
	*2	Bore	inner \varnothing	56 $\begin{matrix} + 0.03 \\ 0 \end{matrix}$	56.3
	*3	Bore	inner \varnothing	56 $\begin{matrix} + 0.03 \\ 0 \end{matrix}$	57.0

* Pay attention to measuring point!

Clearance Table

Top and Bottom End Bearings to Connecting Rod



Clearance Table

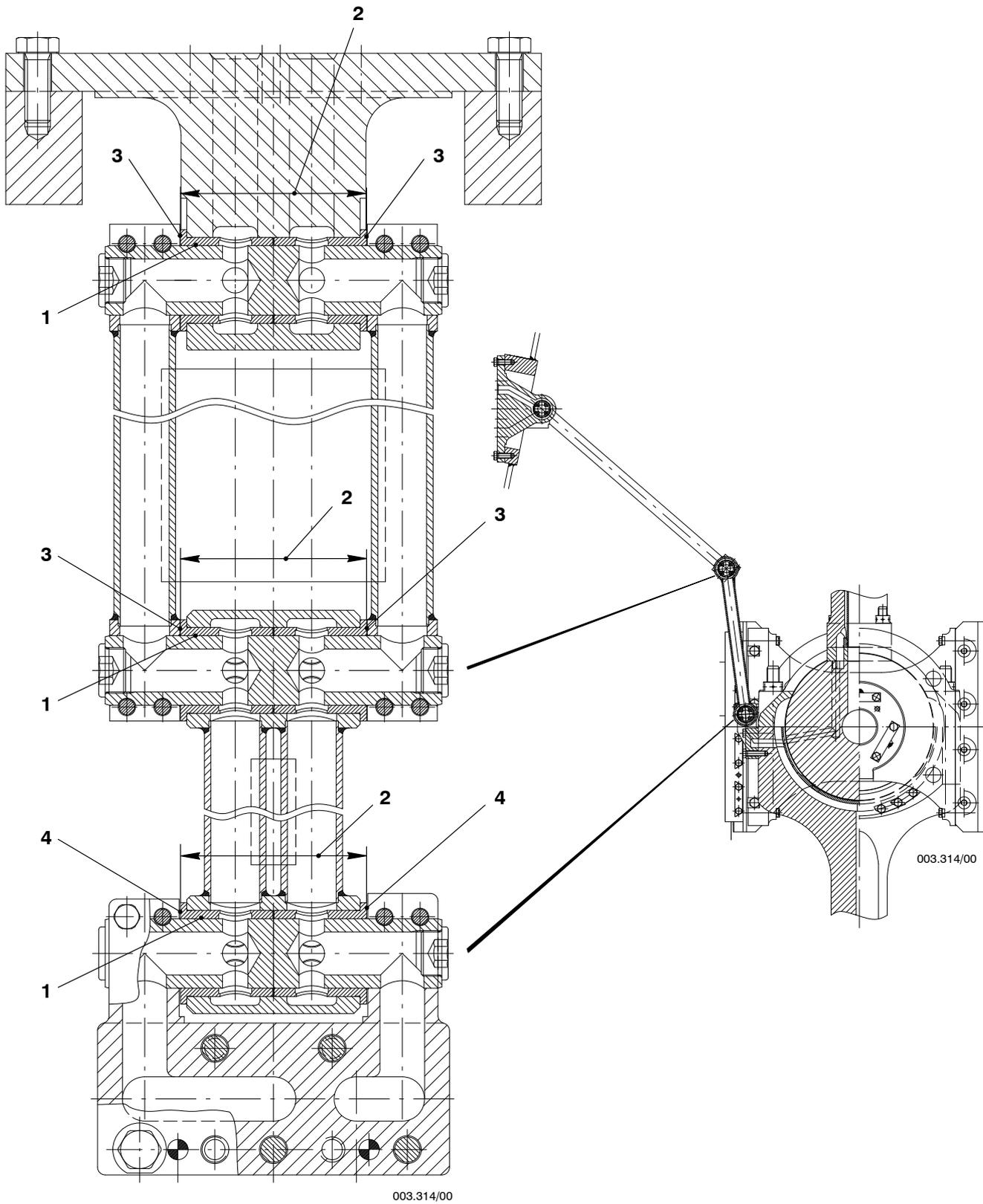
Top and Bottom End Bearings to Connecting Rod

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 \varnothing	580 $\begin{smallmatrix} 0 \\ - 0.08 \end{smallmatrix}$	
		Bearing	inner \varnothing	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 \varnothing	706 $\begin{smallmatrix} 0 \\ - 0.08 \end{smallmatrix}$	
		Bearing	inner \varnothing	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



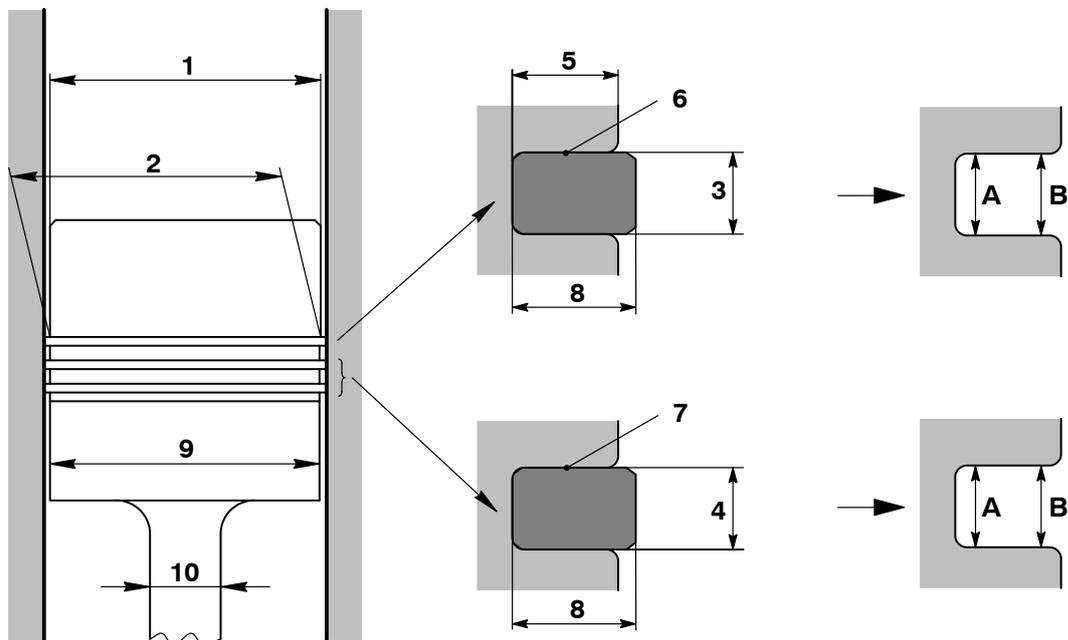
Clearance Table

Piston Cooling and Crosshead Lubricating Link

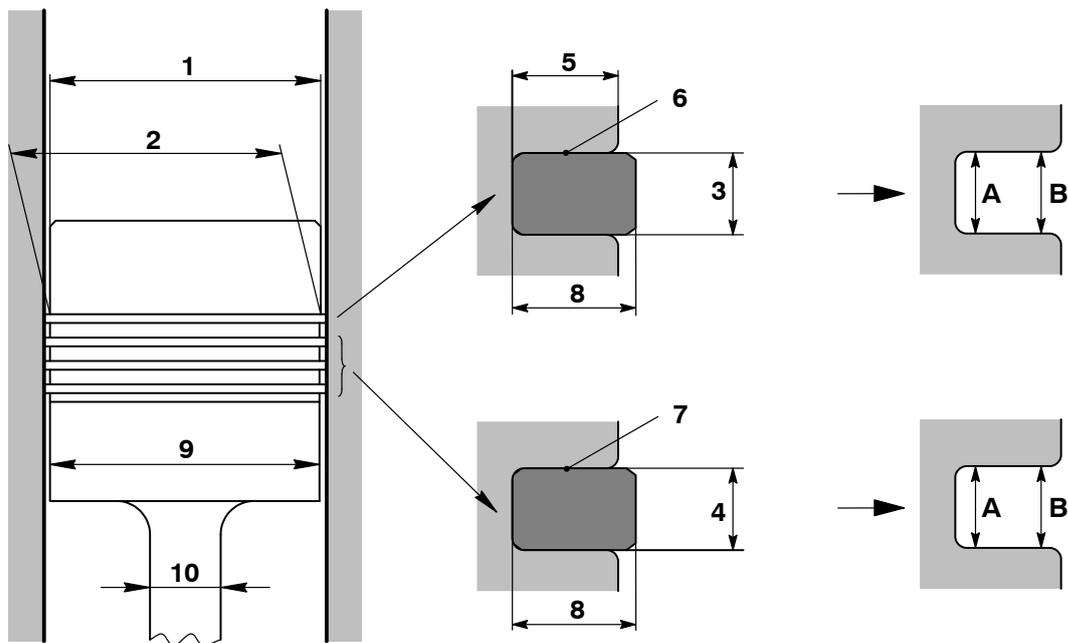
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]
3603		Piston cooling and crosshead lubricating link			
		Pin	outer \varnothing	55	
	1	Bearing clearance	radial	0.03-0.09	0.20
	2	Bearing	width	146	
	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

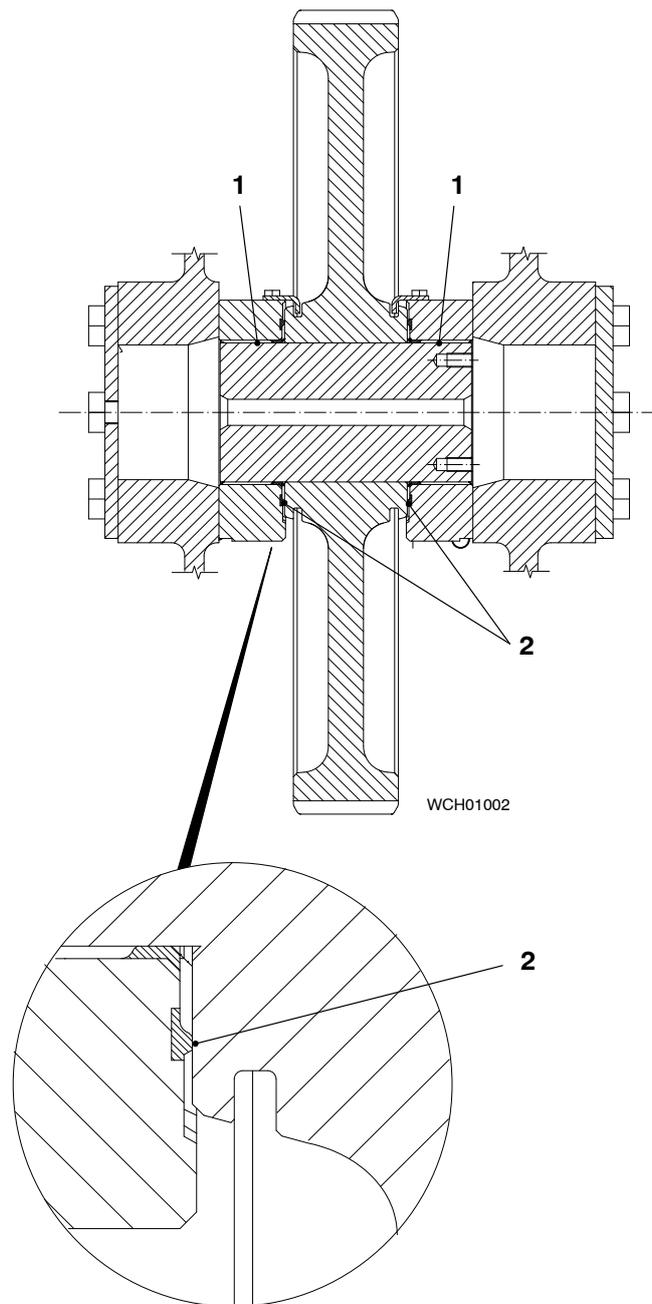
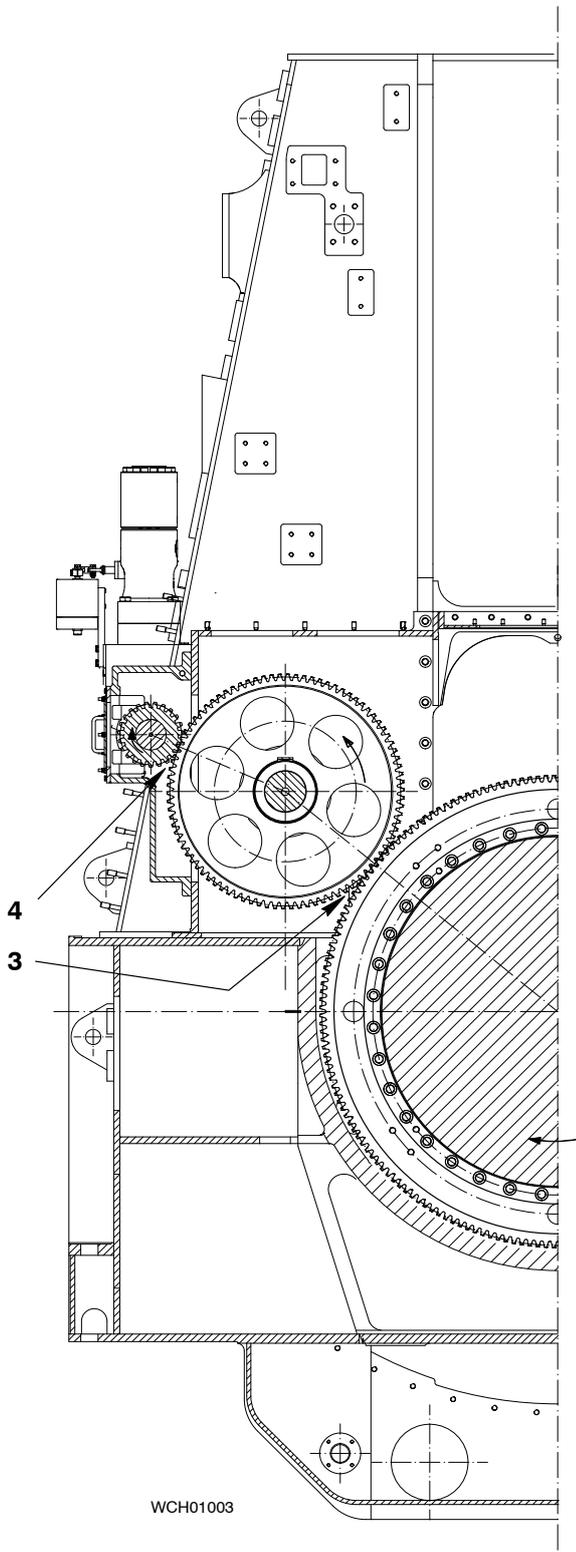
Group	Key No.	Description	Measuring direction (method of measuring)	Nominal dimension (normal, new) [mm]	Maximum clearance, dimension (due to wear) [mm]	
					Point A	Point B
3403		Piston crown				
	1	Crown	outer \varnothing	574.7 $^0_{-0.2}$		
	2	Crown	outer \varnothing	577.8 $^0_{-0.2}$		
3403 3425		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 \varnothing	579.2 $^0_{-0.2}$	min. 578	
3403		Piston rod				
	10	Rod	outer \varnothing	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

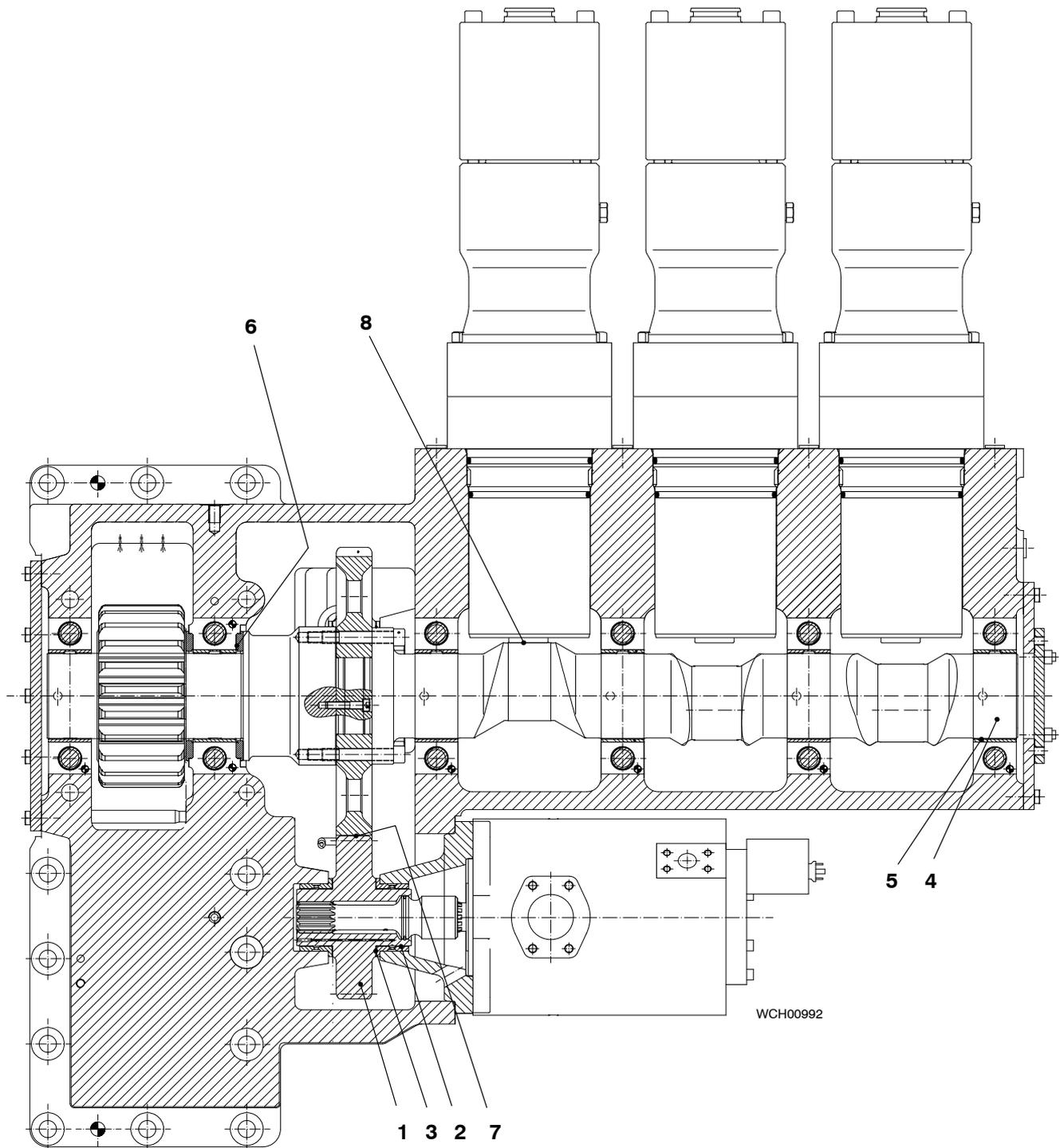
Driving Wheels for Supply Unit

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 \varnothing	160	
	1	Bearing clearance	vertical	0.08-0.15	0.25
	2	Axial clearance	total	0.6-1.1	1.5
	3	Tooth backlash		0.28-0.45	0.65
	4	Tooth backlash		0.20-0.34	0.55

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

Clearance Table

Supply Unit



Clearance Table

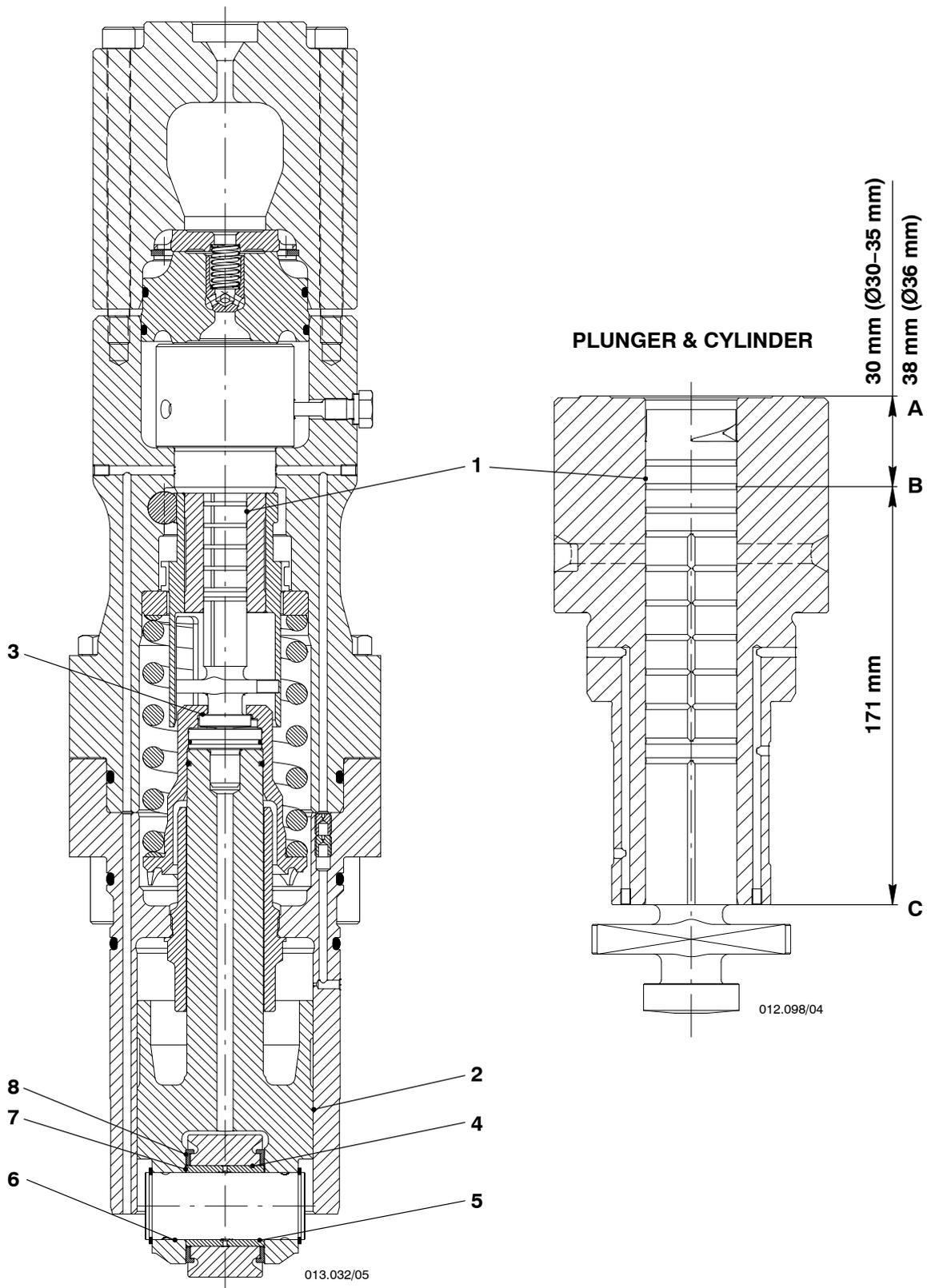
Supply Unit

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 \varnothing	80 $\begin{smallmatrix} 0 \\ - 0.019 \end{smallmatrix}$	
		Bearing (fitted)	inner \varnothing	80 $\begin{smallmatrix} + 0.10 \\ + 0.058 \end{smallmatrix}$	
	2	Bearing clearance	radial	0.058-0.119	
	3	Axial clearance	total	0.25-0.54	0.7
5552		Camshaft unit			
	4	Cam shaft	outer \varnothing	120 $\begin{smallmatrix} 0 \\ - 0.022 \end{smallmatrix}$	
	5	Bearing clearance	radial	0.10-0.19	
	6	Axial clearance	total	0.2-0.5	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
	2	Guide piston	outer Ø	130	
		Lower housing	inner Ø	130	
		Clearance	radial	0.070-0.125	0.15
	3	Thrust piece / lower spring carrier	axial	0.02-0.06	0.08
5556		Roller guide			
	4	Bush	outer Ø	60	
		Roller	inner Ø	60	
		Clearance	radial	0.03-0.09	0.1
	5	Pin	outer Ø	50	
		Bush	inner Ø	50	
		Clearance	radial	0.025-0.080	0.1
	6	Pin	outer Ø	50	
		Guide piston (bore)	inner Ø	50	
		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

2138	O	M10x50
10 Nm		

9314	O	G3/4"
15 Nm		
2 SCREWS FOR ACCESS TO HAED FOR CLEANING 5 Nm		
OIL MIST DETECTOR		

2106	O	M68
1500 BAR, [380°]		

3403	K	M10x70
10 Nm +30°		
PRE-TIGHTENING 10 Nm, THEN FINAL TIGHTENING WITH 30°		

3403	O	M30x2
90°, [490 Nm]		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 90°		

2106	O	M48x300
ELONGATION OF SCREWS = 0.5±0.04 mm		
ELONAGION OF FITTED BOLT = 0.3±0.04 mm		
THE FIRST 3 BOLTS HAVE TO BE TIGHTENED ACCORDING TO THE EXTENSIONS LISTED ABOVE. SIMULTANEOUSLY THE TIGHTENING ANGLE HAS TO BE MEASURED. THE REMAINING BOLTS HAVE TO BE TIGHTENED ACCORDING TO THE AVERAGE TIGHTENING ANGLE MEASURED BEFORE.		

3303	O	M64
1000 BAR		
[60° FROM 1ST TO 2ND STEP]		
1ST STEP: 300 BAR		
CHECK: GAP = 0 mm BETWEEN CONNECTING ROD AND COVER		
2ND STEP 1000 BAR		
CHECK: TIGHTENING ANGLE = 60° (1ST STEP TO 2ND STEP)		

GROUP	LUBRICANT	THREAD	TIGHTENING VALUE(S)	REMARKS
EXAMPLE				
			0 BAR	
			600 BAR	
			1000 BAR	TIGHTENING ANGLE=60°

1112	M	M56
1000 BAR		
1ST STEP: 600 BAR		
2ND STEP: 1000 BAR (VALID FOR METAL CHOCKS, EPOXY RESIN CHOCKS)		

1715	M	M56
150 BAR		
ENGINE STAYS(FRICTION TYPE)		

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
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WCH00985



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/cm²

- 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-8.

Tightening Values of Important Screwed Connections

DRIVING END

FREE END

g f e a b c d

g f e a b c d

TIE ROD ELONGATION

ΔL

L1

L

1903	M	M80x6-T
1500 BAR		
TENSIONING IN ONE PROCEDURE		
- 100 BAR : MEASURE L		
- 1500 BAR : MEASURE L1		
CHECK: $\Delta L = L1 - L = 14,5 - 16,5$ mm		
ACCORDING TO SEQUENCE a-a,b-b...		

3322	O	M36
1000 BAR		
[70° FROM ZERO TO 2ND STEP]		
PRE-TIGHTENING TO METALLIC CONTACT		
1ST STEP: 600 BAR (gap = 0)		
2ND STEP 1000 BAR		
CHECK: TIGHTENING ANGLE = 25° (1ST TO 2ND STEP)		

3103	M	M56
15°		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 15°		

3114	M	M95x4
A = 140 mm - 195 mm : 55°		
A = 200 mm - 240 mm : 60°		
A = THICKNESS OF PROPELLER SHAFT FLANGE (WITHOUT FLANGE OF CRANKSHAFT)		

4120	O	M30x170
45°, [1200 Nm]		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 45°		
INTERMEDIATE WHEEL SUPPLY UNIT		

2708	O	M68
1000 BAR, [165°]		

3103	M	M85x4
35°		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 35°		

3140	M	M24x200
45°, [630 Nm]		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 45°		

3103	K	M30x2x170
85°, [1600 Nm]		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 85°		
SCREWS SECURED WITH LOCTITE NO. 262 (SEE ASSEMBLY INSTRUCTIONS FOR FLANGED GEAR WHEEL ON CRANKSHAFT, GROUP 4106)		

3303	O	M48
1000 BAR, [25° FROM 1ST TO 2ND STEP]		
1ST STEP: 600 BAR		
CHECK: GAP = 0 mm BETWEEN CONNECTING ROD AND COVER		
2ND STEP: 1000 BAR		
CHECK: TIGHTENING ANGLE = 25° (1ST TO 2ND STEP)		
TIGHTENING SEQUENCE: a-a-b-b		

1115	O	M52
1500 BAR		

4106		M30x2
GEAR WHEEL CRANKSHAFT 2-PARTS (SPARE WHEEL):		
ELONGATION OF BOLT = 1.10±0.05 mm		
THREAD ON ONE SIDE MOLYKOTE PASTE G-n, ON THE OPPOSITE SIDE LOCTITE NO. 262 (SEE ASSEMBLY INSTRUCTIONS FOR FLANGED GEAR WHEELS ON CRANKSHAFT, GROUP 4106)		

M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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WCH00985

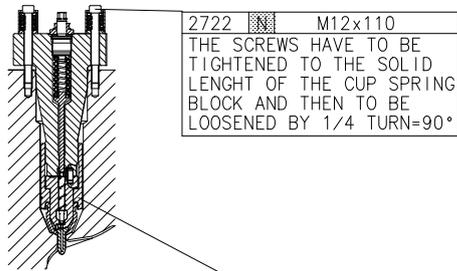
2013 / V2

2 / 7

Winterthur Gas & Diesel Ltd.

Tightening Values of Important Screwed Connections

Injection Valve



2722	M12x110
THE SCREWS HAVE TO BE TIGHTENED TO THE SOLID LENGTH OF THE CUP SPRING BLOCK AND THEN TO BE LOOSENED BY 1/4 TURN=90°	

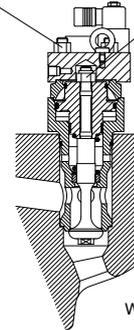
2722	M52x1,5
100 Nm + 30°	
PRE-TIGHTENING 100 Nm, (20BAR L ORANGE) THEN FINAL TIGHTENING WITH 30°.	
ACTION 1x REPETITION!	

WCH00985

Starting Air Valve

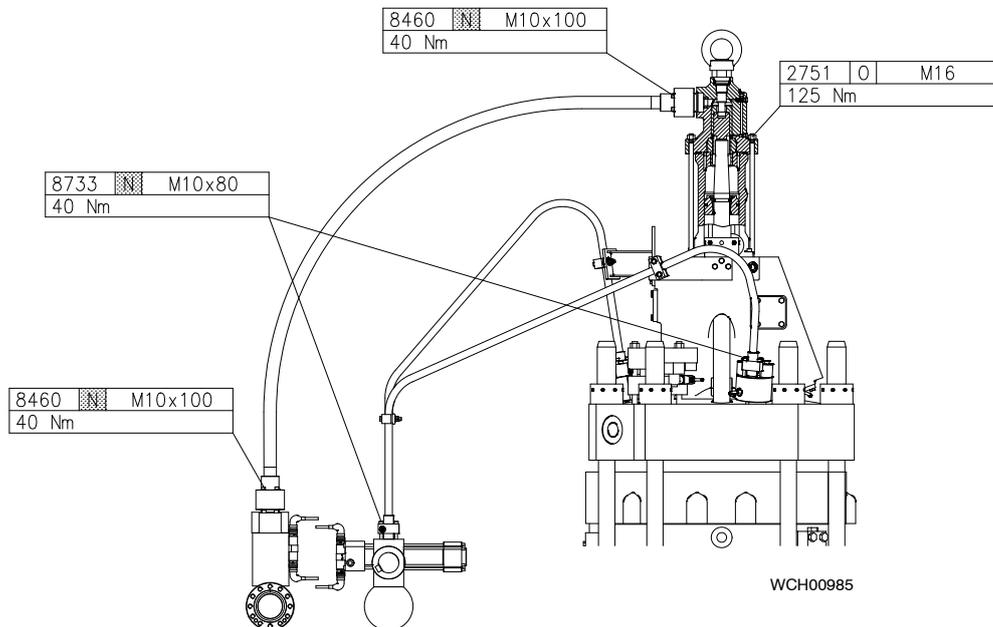
2728	M20
110°, [350 Nm]	
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 110°	

2728	K	M20x1,5
50°, [255 Nm]		
PRE-TIGHTENING TO METALLIC CONTACT, THEN FINAL TIGHTENING WITH 50°.		
ATTENTION: NO LUBRICATION TO THE SPINDLE THREAD IN THE REGION OF THE SYNTHETIC LOCKING RING.		



WCH00985

Exhaust Valve



8460	M10x100
40 Nm	

2751	O	M16
125 Nm		

8733	M10x80
40 Nm	

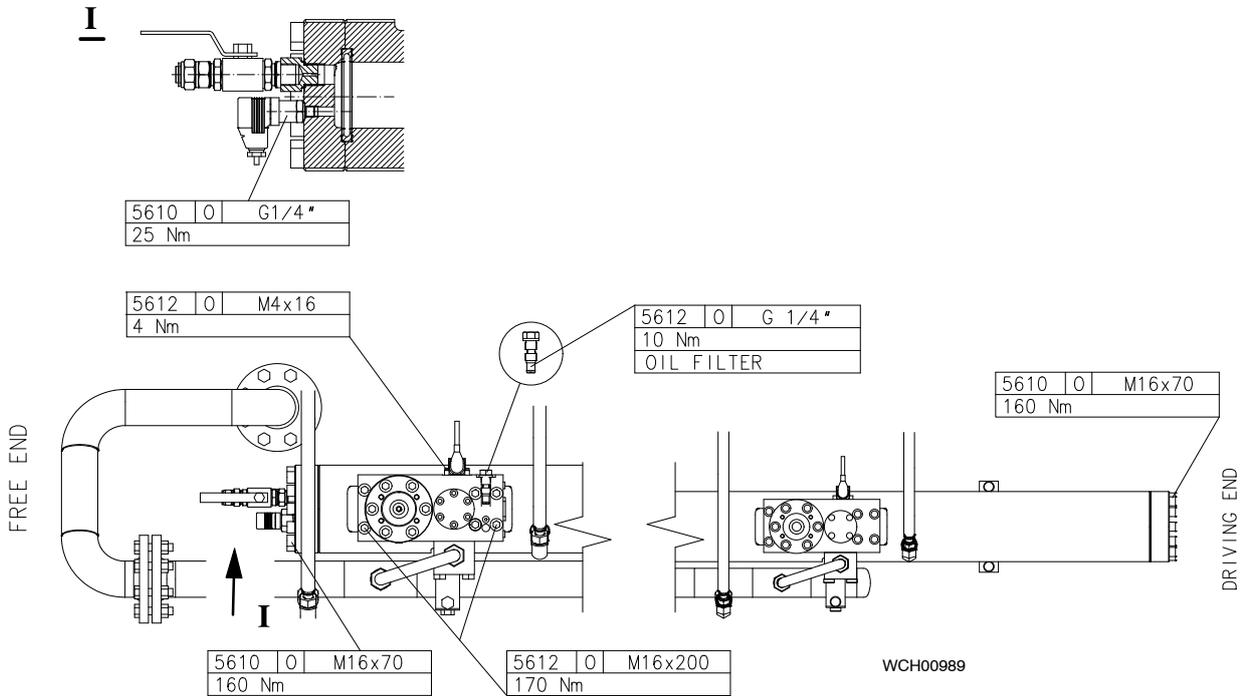
8460	M10x100
40 Nm	

WCH00985

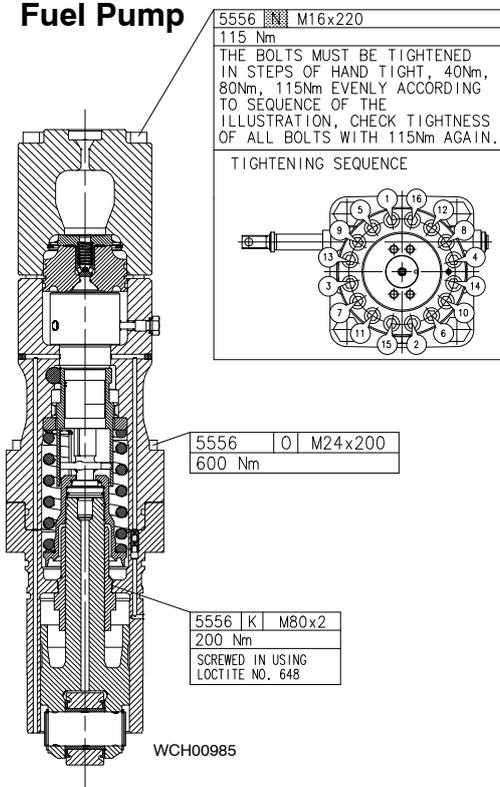
M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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Tightening Values of Important Screwed Connections

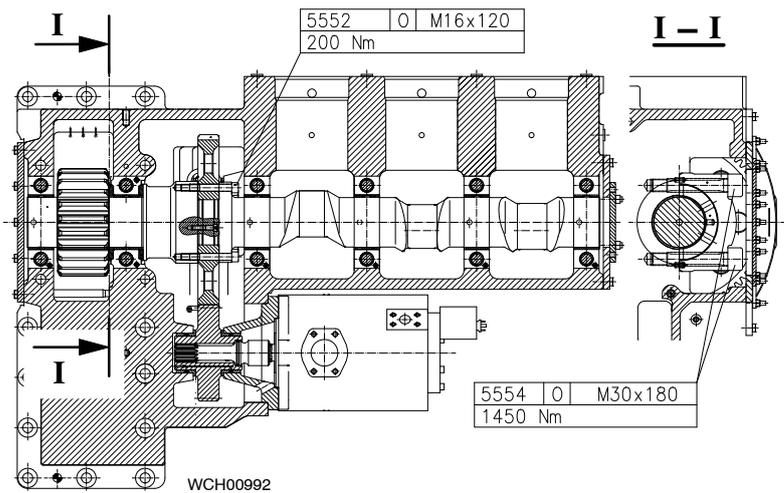
Servo Oil Rail



Fuel Pump



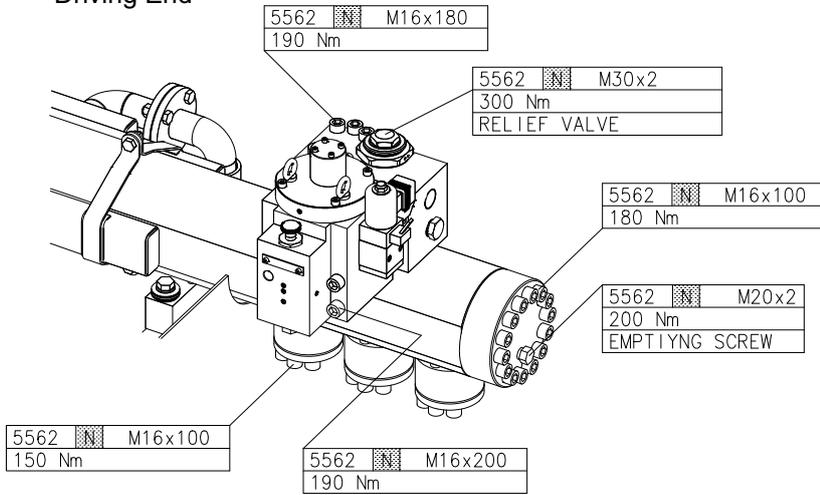
Supply Unit



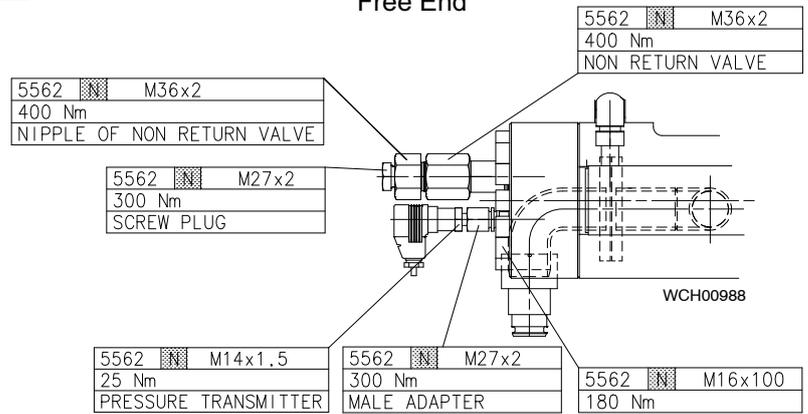
M MOLYKOTE PASTE G-n On threads and contact surfaces	0 OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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Tightening Values of Important Screwed Connections

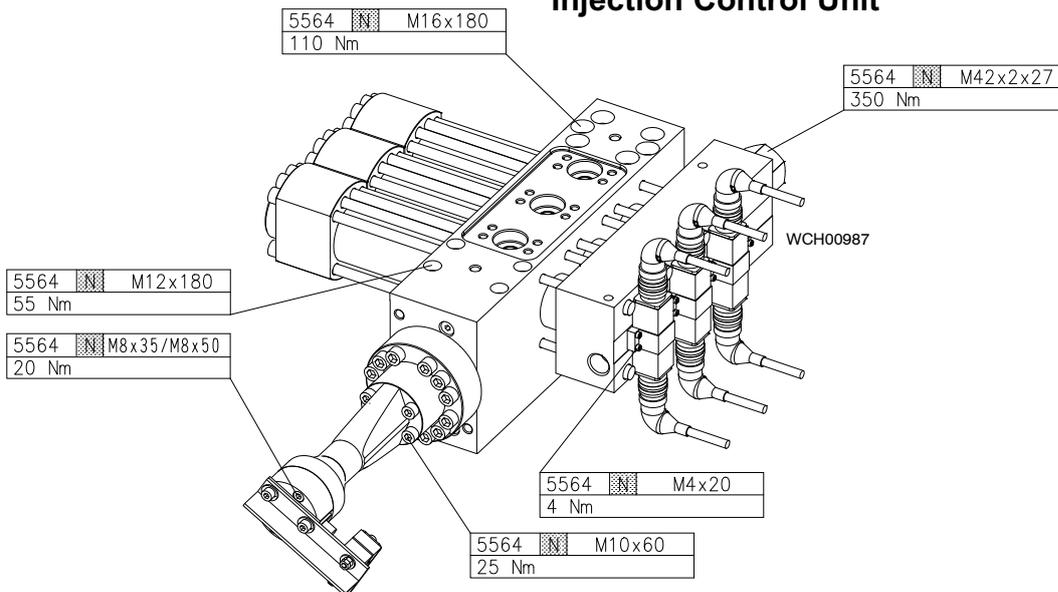
Fuel Rail
Driving End



Fuel Rail
Free End



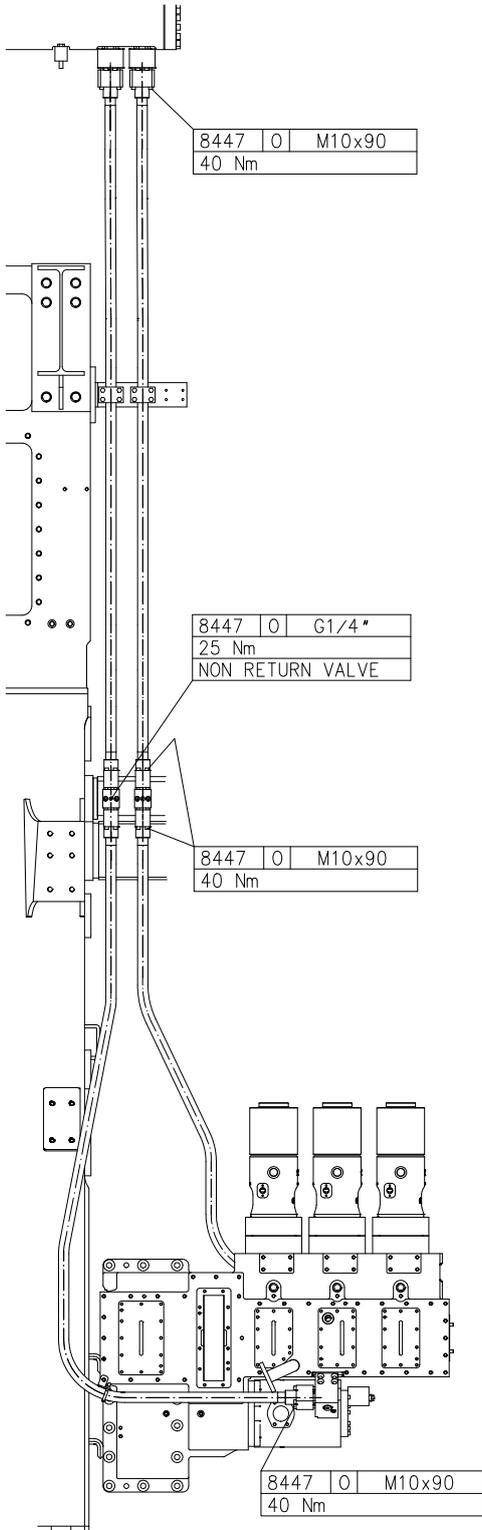
Injection Control Unit



M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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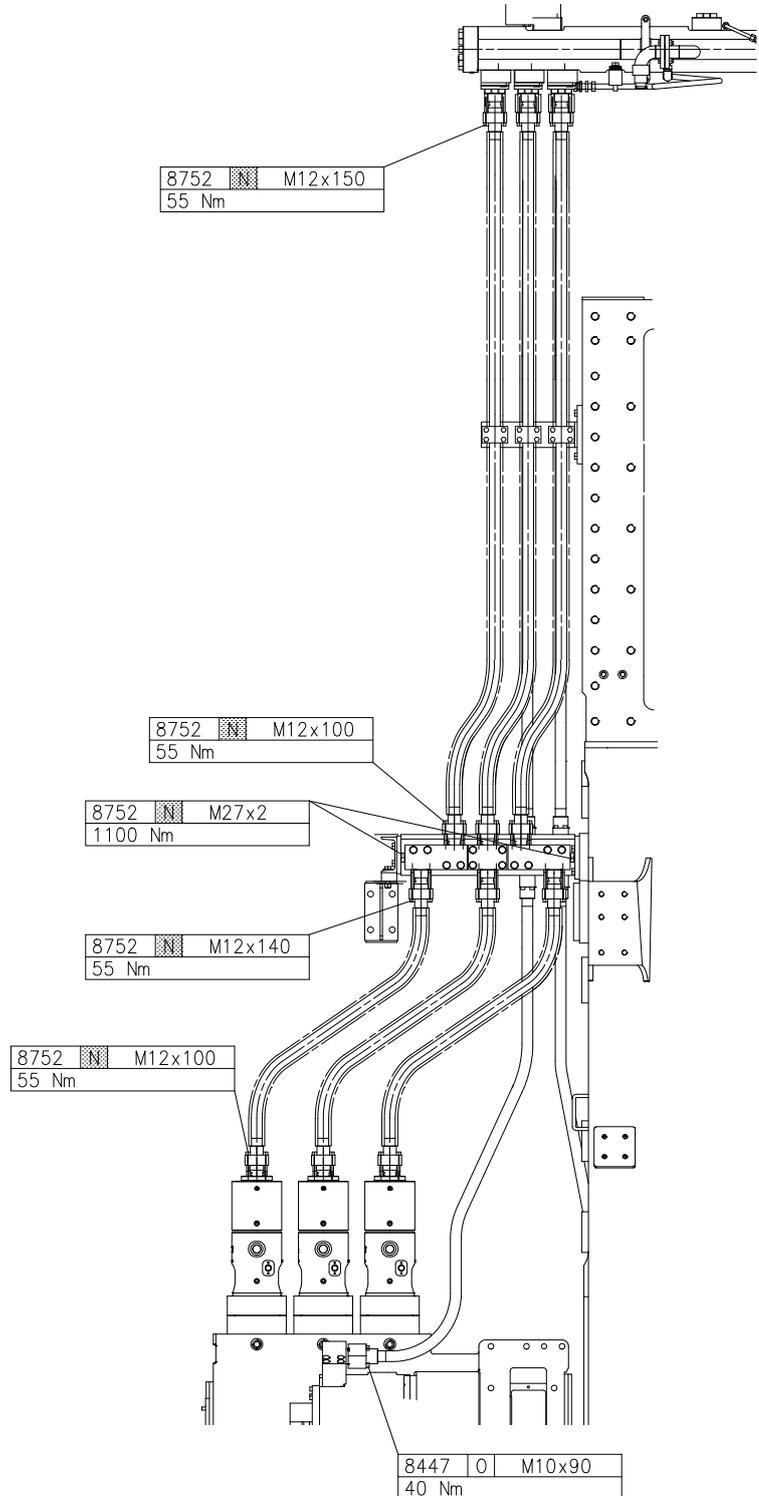
Tightening Values of Important Screwed Connections

High Pressure Servo Oil Pipe



WCH00990

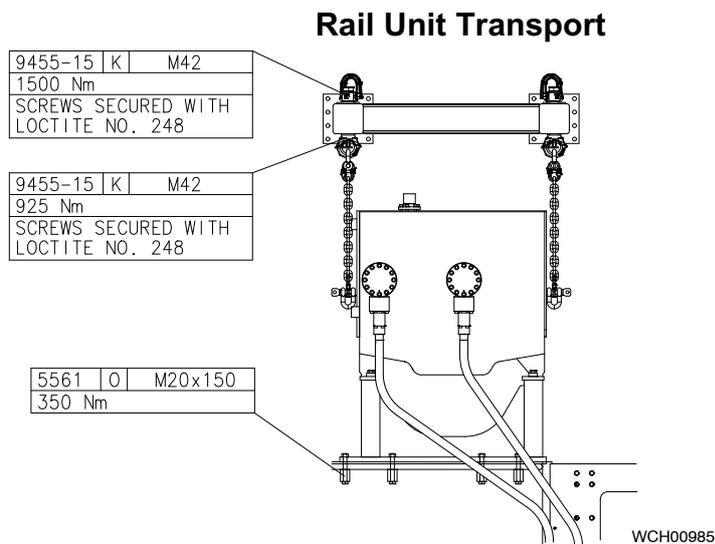
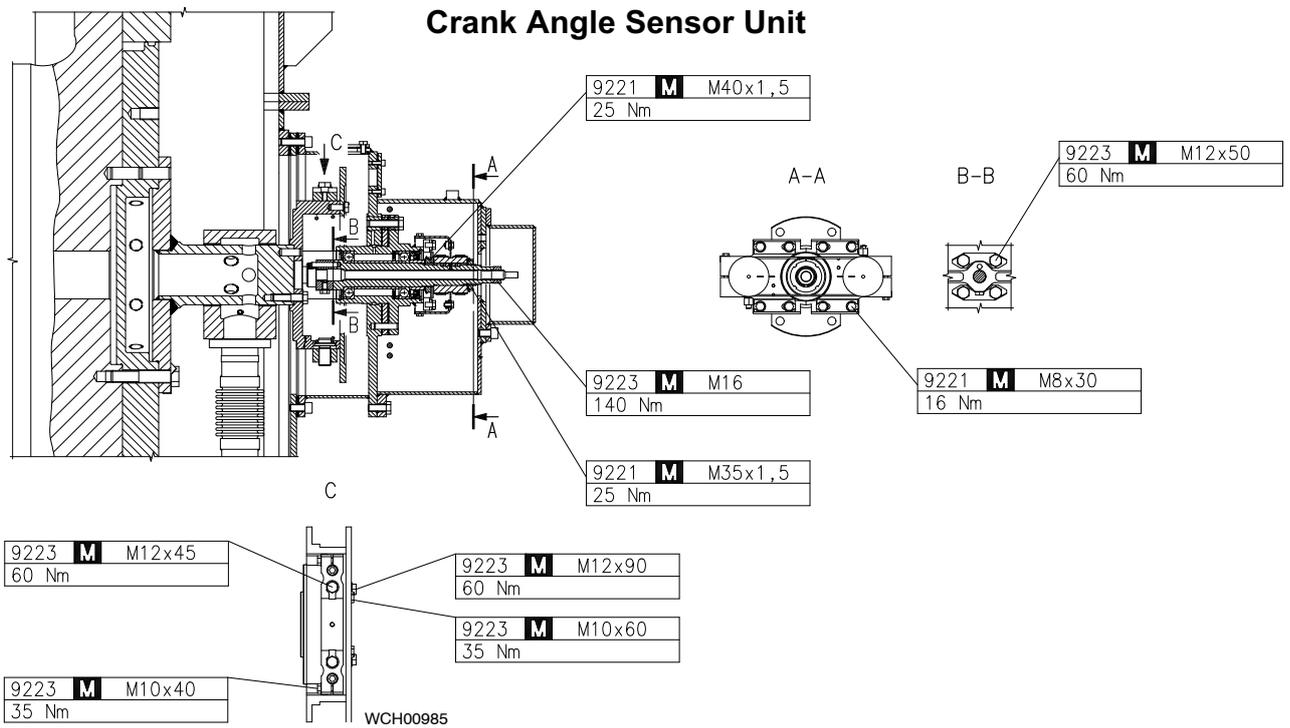
High Pressure Fuel Pipe



WCH00991

M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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Tightening Values of Important Screwed Connections



M MOLYKOTE PASTE G-n On threads and contact surfaces	O OIL On threads and contact surfaces	NEVER SEEZ NSBT8 On threads and contact surfaces	K NO ADDITIONAL LUBRICATION
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Tightening Values of Standard Screwed Connections

1. Standard screws

This table is valid for all screws that are not considered in [0352-1](#).

It is recommended to lubricate the threads for screws which come into contact with hot parts like exhaust pipings, expansion pieces, etc. with a heat-resisting lubricant, e.g. THREAD GARD or Never-Seez NSBT-8, etc.



Attention! These tightening instructions are valid only if:

- screws are made of the **8.8** material
- threads have been lubricated with **oil**

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

Tightening Values of Standard Screwed Connections

2. Elastic bolts

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

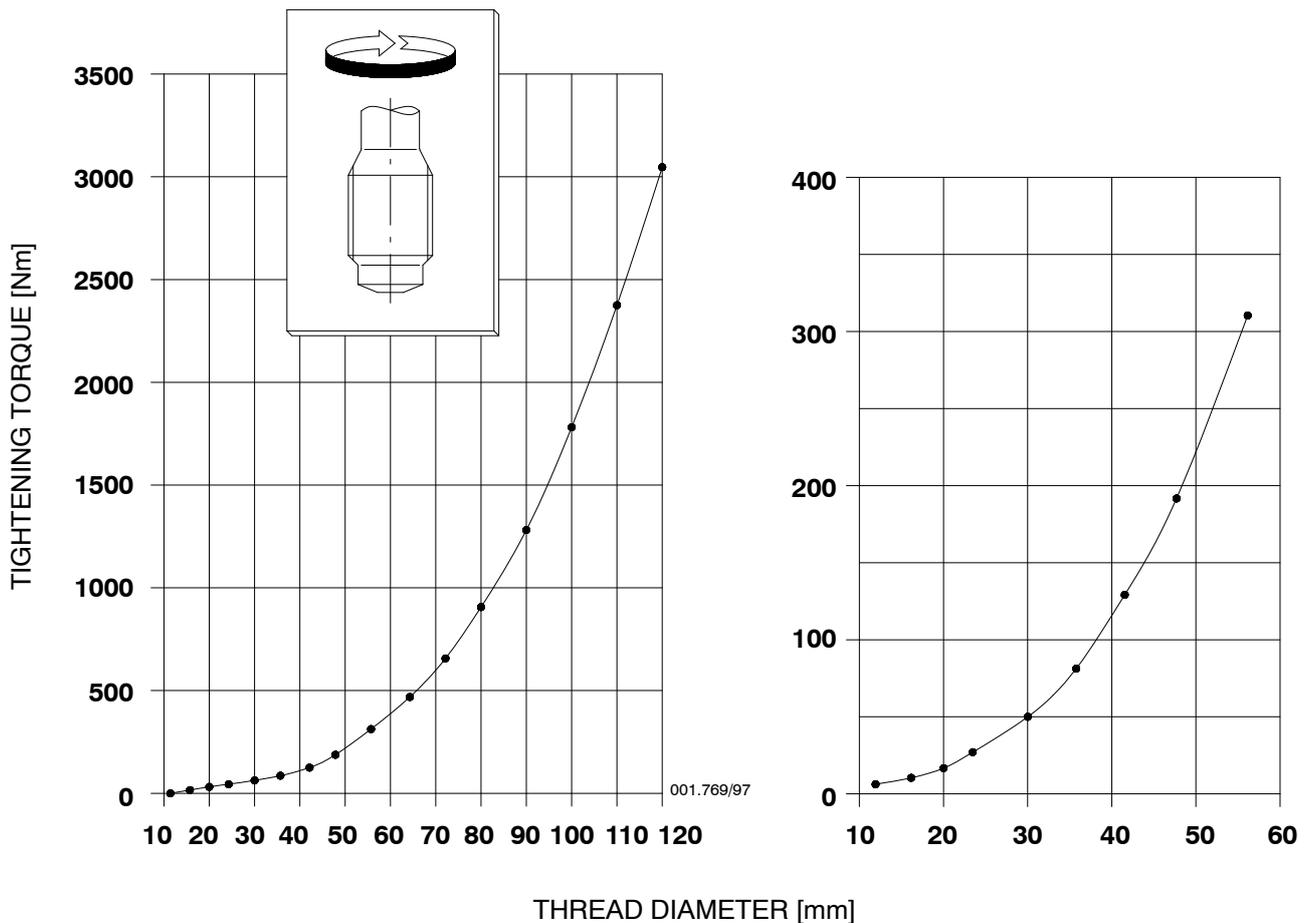
- Before fitting a elastic bolt clean its thread and corresponding tap hole. The sealing faces must be degreased (e.g. using white spirit) and subsequently primed.
- Screw in the elastic bolt without lubricant on the thread right to the bottom of the tap hole, and tighten. Always utilize a bolt driver 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		32
1224	Thrust bearing pad		37
1717	Casing	free end	1200
1720	Oil baffle, upper part	driving end	147
	Oil baffle, lower part	driving end	113
1903	Tie rod	complete	293
	Tie rod nut		4.5
	Intermediate ring		14
2			
2106	Elastic bolt in cylinder block		42
2124	Cylinder liner		3390
2130	Water guide jacket		330
2303	Piston rod gland		129
2708	Elastic stud for valve cage		20
	Cylinder cover without accessories		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	complete	1930
	Elastic stud with nut for bottom end bearing		17
	Elastic stud with nut for top end bearing		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 with bearing pins and bearings for supply unit	complete	339
	Bearing for intermediate wheel		50
4325	Shut-off valve for starting air		210
5			
5552	Supply unit with pumps	complete	2068
	Servo oil pump		150
	Gear wheel and shaft		81
	Camshaft		79
5556	Fuel pump with plunger	complete	170

Individual Components per Piece in kg

Group	Component	Execution	kg
5564	Injection control unit	complete	131
5612	Exhaust valve control unit	complete	73
6			
6506	Exhaust gas turbocharger	A165 A170 A175 A180 MET53MA/MB MET60MA/MB MET66MA/MB TPL73-B TPL77-B	2000 3000 4900 7000 3550/2000 4260/4500 6250/6500 2600 4070
6545	Auxiliary blower with electric motor Electric motor	complete	700-915 250-420
6606	Scavenge air cooler	SAC245 (Tier II) SAC243 (Tier II)	1203 1803
6708	Water separator (stainless steel 3-lips)	TPL73, MET53 TPL77, A170, A175, MET60/66 A180	200 175 225
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 – Remove bottom bearing shell for inspection	according to classification society 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 – Check function of non-return valves	at every piston removal 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 – Check spray pattern, opening pressure, tightness condition of nozzle tip, readjust opening pressure (life time of nozzle tip about 6000 Op. h)	before starting engine after a longer standstill 3000 Op. h
2728-1	Starting air valve	– Check piping before the valve during operation, if piping is too hot, dismantle starting air valve – Remove and dismantle one starting air valve at random. From its condition determine time of overhaul for remaining valves – Make sure that nut on solenoid is tight, if necessary tighten nut. – Solenoid valve, random functional check overhaul	weekly 6000-8000 Op. h monthly 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) – Check condition and wear of valve spindle (if necessary regrind seat by machining) – Check piston seal ring / air spring & rod seal ring / guide bush – Check condition and wear of valve seat (if necessary regrind seat by machining) – Random check of valve drive, outside and inside pistons, damper, thrust piece – Random check of sc. conn. to measuring cone	at every piston removal 24 000-36 000 Op. h 24 000-36 000 Op. h 24 000-36 000 Op. h 18 000 Op. h 18 000 Op. h
3 3103-1	Crankshaft	– Measure crank deflection – Always in case of grounding of the ship as well as before and after every docking	according to classification society
3130-1 3130-2	Torsional vibration damper	– Take a silicon oil sample from viscous vibration damper (based on results of 1 st sample, interval for taking further samples will be decided) – Inspection interval and dismantling of GEISLINGER damper	first time after 15 000 – 18 000 Op. h 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	<ul style="list-style-type: none"> - Inspection interval of turning gear - 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) 	acc. to instructions of turn. gear manufacturer 12 000 Op. h
3303-2	Connecting rod bearings	<ul style="list-style-type: none"> - Check bearing clearances (see 0330-1) 	6000-8000 Op. h
3303-3		<ul style="list-style-type: none"> - Inspect bottom end bearing (life time of shell 60 000-72 000 Op. h) - Inspect top end bearing 	30 000-36 000 Op. h or acc. to class. society 30 000-36 000 Op. h or acc. to class. society
3326-1	Guide shoe, Crosshead pin	<ul style="list-style-type: none"> - Check clearances 	6000-8000 Op. h
3326-2		<ul style="list-style-type: none"> - Remove crosshead 	as required
3403-1	Piston	<ul style="list-style-type: none"> - Remove, clean and measure ring grooves (cylinder liner with antipolishing ring and chrome-ceramic piston rings) 	18 000-36 000 Op. H (condition based)
3403-3		<ul style="list-style-type: none"> - Check tightness on piston in situ and with running oil pump, visual check through scavenge ports 	after refitting
3403-3		<ul style="list-style-type: none"> - Dismantling and assembling (open cooling space & clean same, min. one piston every three years) 	as required
3403-4		<ul style="list-style-type: none"> - Check condition of the piston top surface - Visual check through scavenge ports to piston, piston rings and cylinder liner (rotate crankshaft with turning gear) 	at every piston removal 500-1000 Op. h
	Piston underside	<ul style="list-style-type: none"> - Check condition of space and clean it as required 	1500-3000 Op. h
		<ul style="list-style-type: none"> - Check drains for free passage 	1500-3000 Op. h
3425-1	Piston rings	<ul style="list-style-type: none"> - Measure thickness of chrome-ceramic layer - Replace piston rings based on remaining coating thickness 	1500-2000 Op. H 18 000-30 000 Op. H (condition based)
4	Start interlock	<ul style="list-style-type: none"> - Check electric and pneumatic interlocks (see Operating Manual 4003-1) 	quarterly
4103-1	Driving wheels	<ul style="list-style-type: none"> - Check condition of teeth 	6000-8000 Op. h
		<ul style="list-style-type: none"> - Check running clearance and backlash of teeth 	6000-8000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
4325-1	Starting air shut-off valve	<ul style="list-style-type: none"> - Vent - Dismantle, clean and check (particularly seat, springs and seal rings) - Overhaul common start valve 	after each manoeuvring period 24 000-36 000 Op. h 18 000 Op. h
	Control air filter	<ul style="list-style-type: none"> - Drain filter - Clean filter 	weekly 6000 Op. h
5			
5552-1	Supply unit	<ul style="list-style-type: none"> - Replace servo oil pump either with new one or a pump overhauled by a Wärtsilä workshop - Check pinion and driving wheels to servo oil pump drive - Check bearing bushes to pinion - Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h) - Camshaft, check bearing clearances at random - Camshaft, check thrust bearing clearances 	24 000 Op. h 3000 Op. h 24 000 Op. h 3000 Op. h 12 000 Op. h 36 000 Op. h
5552-2			
5556-1	Fuel pump	<ul style="list-style-type: none"> - Replace O-rings in valve block - Random visual check of plunger & cylinder, roller and roller guide 	18 000 Op. h 18 000 Op. h
5562-1	Fuel pressure control valve (PCV)	<ul style="list-style-type: none"> - Check shut-down function (see Operating Manual 4003-1) - Function check (see Operating Manual 5562-1) - General overhaul - Replace oil filter 	3000 Op. h 6000 Op. h only necessary when PCV fails 18 000 Op. h
5562-2	Fuel overpressure safety valve	<ul style="list-style-type: none"> - Function check on test bench 	18 000 Op. h
5564-1	Injection control unit	<ul style="list-style-type: none"> - Replace unit (incl. rail valves) either with new one or a unit overhauled by a Wärtsilä workshop - Replace filter before pre-control valve (servo oil) 	24 000-36 000 Op. h 18 000 Op. h
5610	Servo oil rail	<ul style="list-style-type: none"> - Replace hoses 	18 000-30 000 Op. h
5610-1	Pressure reducing valve	<ul style="list-style-type: none"> - Checking gas (nitrogen) pre-charge pressure: the same criteria apply as specified for 7218-1 on page 6 	

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
5612-1	Exhaust valve control unit	<ul style="list-style-type: none"> - Random check of piston and slide rod - Replace rail valve (pre-control valve) - Replace filter 	18 000 Op. h 30 000-36 000 Op. h 18 000 Op. h
5801-1	Regulating linkage	<ul style="list-style-type: none"> - Check for free movement, lubricate all movable parts 	3000 Op. h
6 6420-1	Scavenge air receiver	<ul style="list-style-type: none"> - Check and clean air flaps - Clean receiver - Check water drain pipings for free passage 	4000-6000 Op. h 4000-6000 Op. h 1500-3000 Op. h
	Exhaust gas turbocharger	<ul style="list-style-type: none"> - Wash-cleaning of blower in service - Wash-cleaning or dry cleaning of turbine in service 	(see Operating Manual) (see Operating Manual)
	Air filter	<ul style="list-style-type: none"> - Check filter - Cleaning of filter at a Δp increase of 50% compared to the shop test value at same engine load (see Operating Manual 6510-1) 	half yearly as required
6545-1	Auxiliary blower	<ul style="list-style-type: none"> - Clean impeller and casing - Replace ball-bearing 	24 000-36 000 Op. h 24 000-36 000 Op. h
6606-1	Scavenge air cooler	<ul style="list-style-type: none"> - 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) - Check condensate collector through sight glass (see Operating Manual 8345-1) - Check condensate collector for free passage (see Operating Manual 8345-1) - Check scavenge air cooler sealing - Vent - Remove scavenge air cooler for general overhaul 	as required daily 1500-3000 Op. h quarterly daily as required

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals
6708-1	Water separator	<ul style="list-style-type: none"> - Check condensate collector through sight glass (see Operating Manual 8345-1) - Check condensate collector for free passage (see Operating Manual 8345-1) - Check water separator elements (if necessary clean them) - Remove water separator for general overhaul 	<p>daily</p> <p>1500-3000 Op. h</p> <p>1500-3000 Op. h</p> <p>as required</p>
7 7218-1	Lubricating pump and accumulator (Pulse lubrication)	<ul style="list-style-type: none"> - General maintenance works - 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 -> 	<p>according to instructions of equipment manufacturer</p> <p>every three months</p>
8 8135-1	Exhaust Waste Gate (LLT)	<ul style="list-style-type: none"> - 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 	<p>according to instruction of valve manufacturer</p>
	Servo oil automatic filter	<ul style="list-style-type: none"> - Follow manufacturer's instructions 	
	Starting air piping	<ul style="list-style-type: none"> - Drain (de-water) 	<p>before and after every manoeuvring period</p>
	Pressure gauges and pyrometers	<ul style="list-style-type: none"> - Compare and calibrate according to master instruments 	<p>6000-8000 Op.h</p>
	Fuel and lubricating oil filters	<ul style="list-style-type: none"> - Clean or replace filter elements (depending on make, follow manufacturer's instructions) 	<p>as required</p>
	Pipe holders	<ul style="list-style-type: none"> - Check fastenings periodically, if necessary retighten screws (first time after 100 Op.h, then half yearly) 	<p>as required</p>
8447-1	HP servo oil pipe	<ul style="list-style-type: none"> - Regrind sealing faces 	<p>as required</p>
8460-1	Hydraulic pipe for exhaust valve drive	<ul style="list-style-type: none"> - Regrind sealing faces 	<p>as required</p>

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
	Non-return valve	– Random check	18 000 Op.h
8744	Supply unit fuel drain piping	– Check regularly for free passage at least once a year	6000 Op.h
8752-1	HP fuel pipe	– Regrind sealing faces	as required
9 9223-1	Crank angle sensor unit	<ul style="list-style-type: none"> – Check tension visually – Check cracks and wear of toothed belt visually – Visual lubricating oil check – Replace toothed belt – Overhaul drive (ball bearing, sealing ring etc.) and check shaft eccentricity of CAS drive – Check shaft eccentricity of CAS drive – Replace crank angle sensor 	3000 Op.h 24 000 Op.h 48 000 Op.h at every CAS exchange 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	<ul style="list-style-type: none"> – Replace FCM-20, ALM-20, ACM-20 modules (see Operating Manual 4002-4) – Check cabling and wiring. Replace damaged cables and wires 	36 000 ... 50 000 Op. h 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:

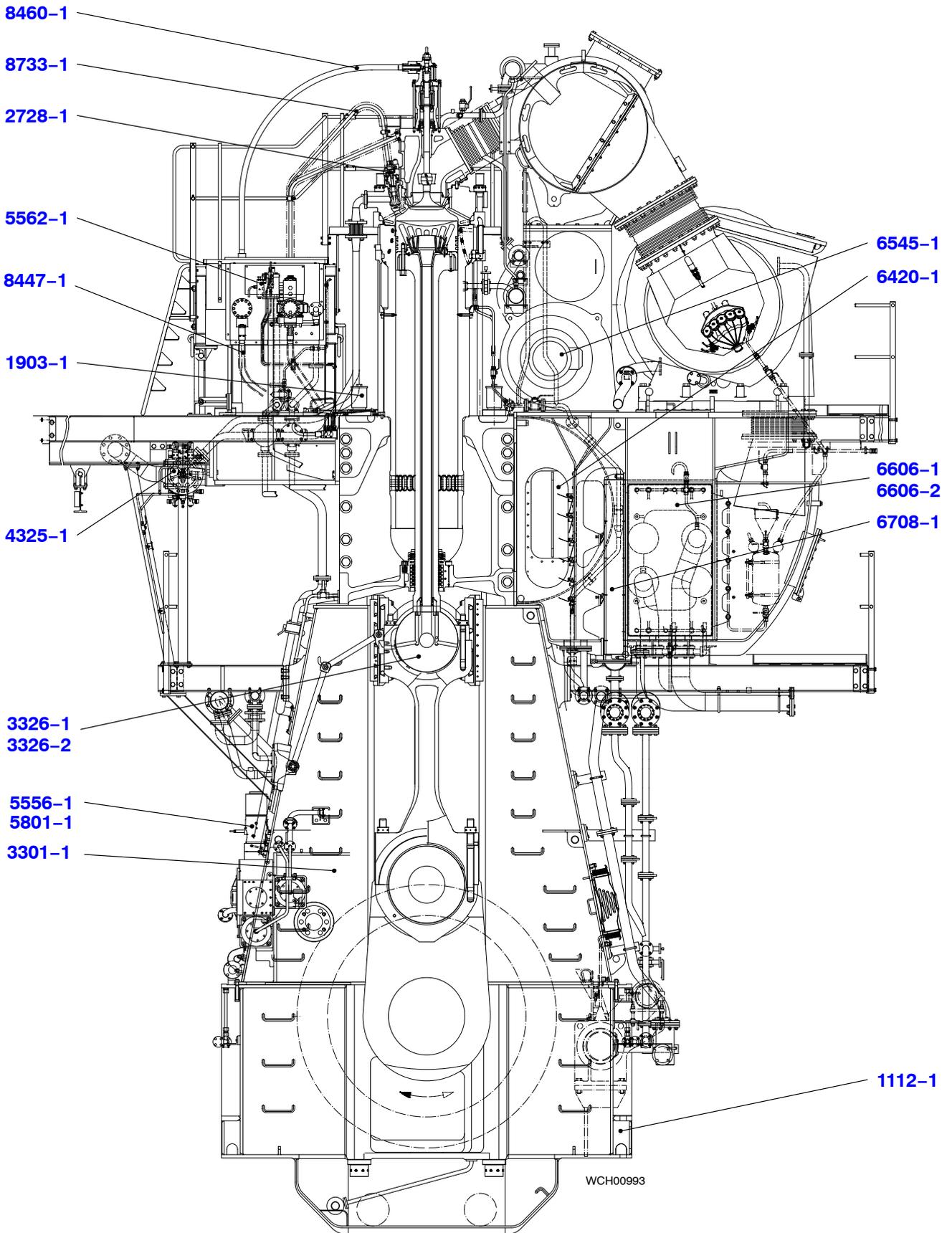
Engine Control System WECS

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

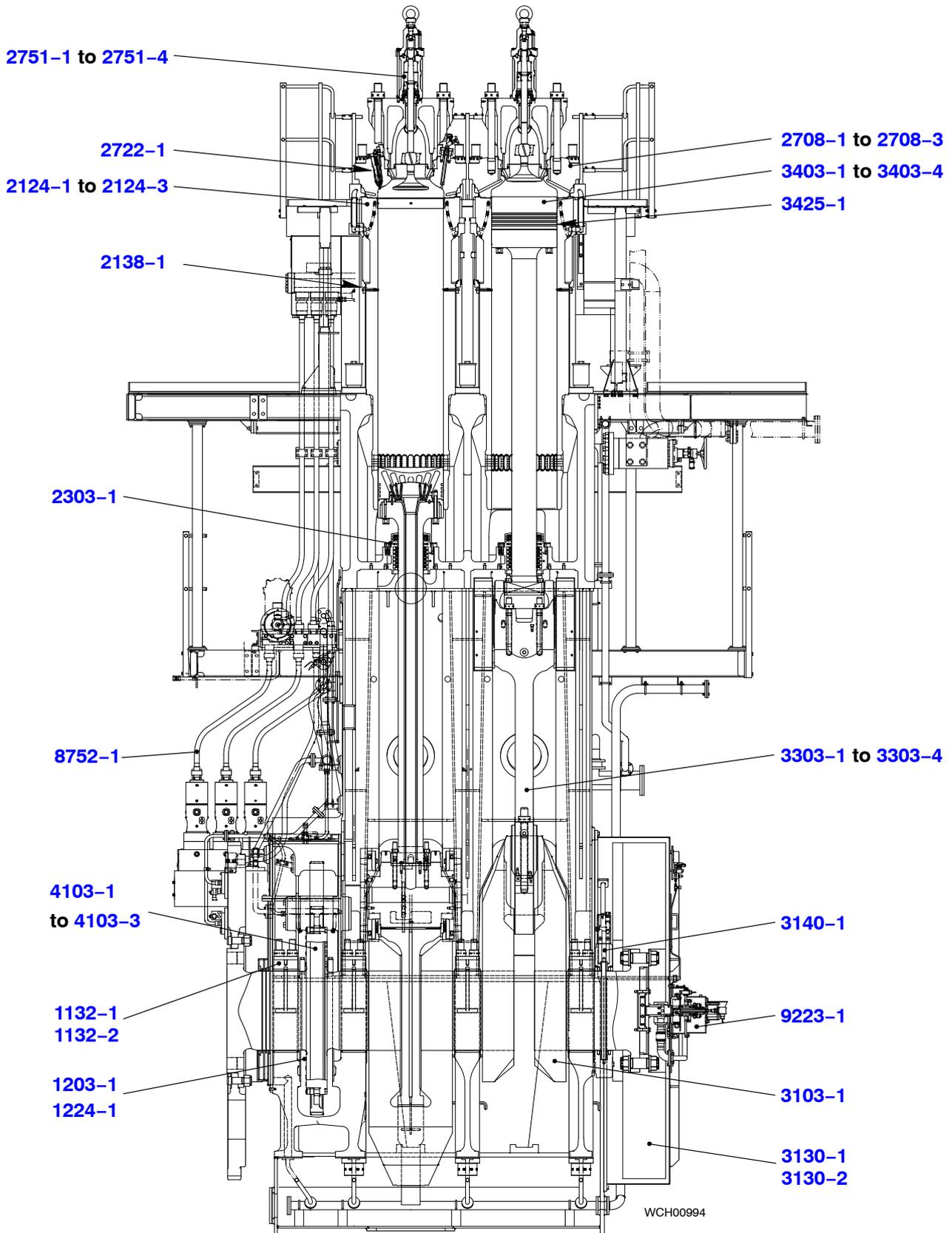
Engine Cross Section and Longitudinal Section

Cross Section:



Engine Cross Section and Longitudinal Section

Longitudinal Section:



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](#)

Tie Rod: Checking the Pre-tension and Tensioning the Tie Rods [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

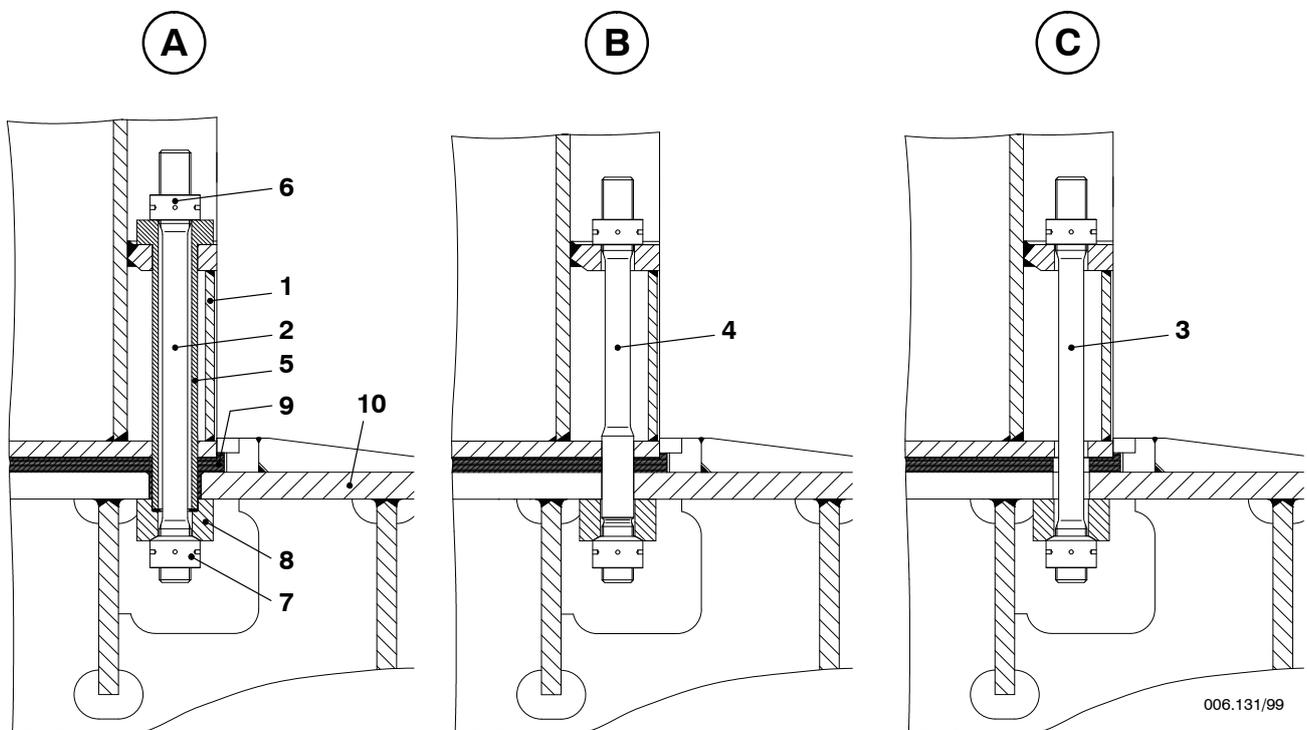
1. General

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.



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!

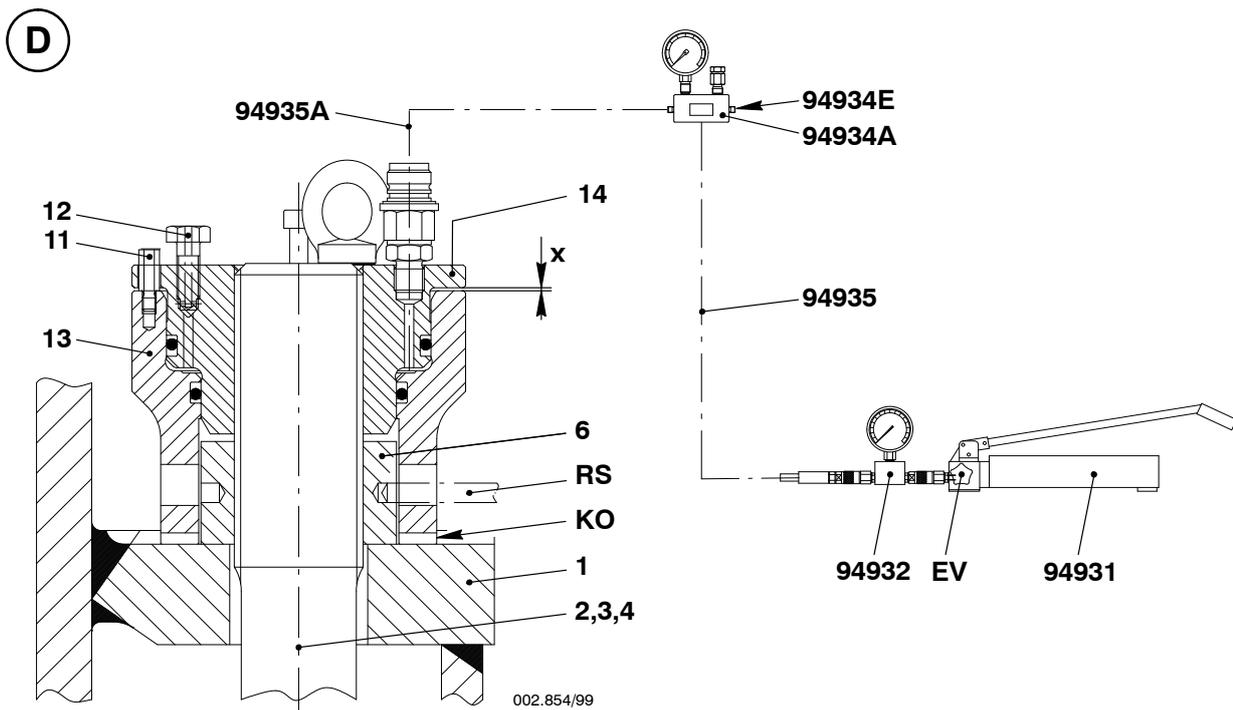


Check with feeler gauge through slot 'KO' if there is any clearance between nut 6 and its seating.

- ⇒ 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

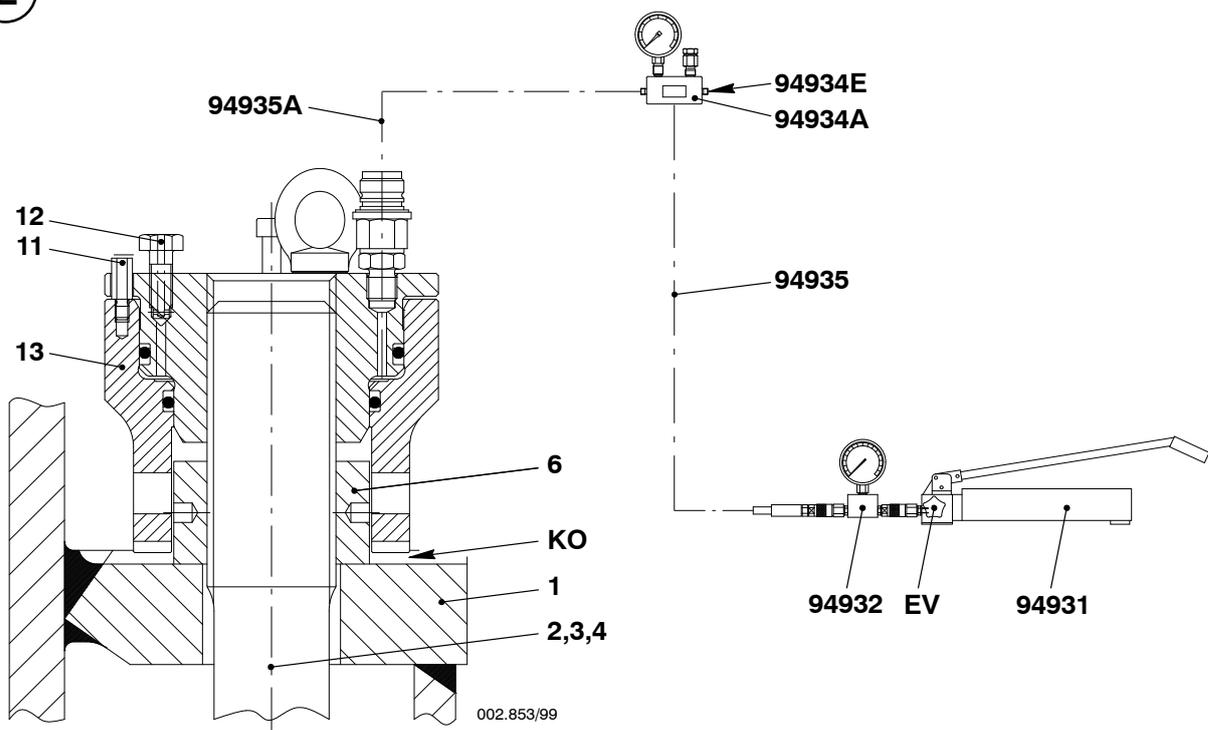
- ⇒ First screw down pre-tensioning jack 94145 as for checking the pre-tension, then turn back by $\frac{1}{2}$ turn (gap 'SA').
- ⇒ Connect the pre-tensioning jack with HP oil pump 94931. Fit plug piece 94934E on one side of Hydr. distributor 94934A.
- ⇒ Close relief valve 'EV' and actuate HP oil pump until oil flows bubble-free at vent screw 12.
- ⇒ Close vent screw and pump until a pressure of **1020 bar** has been reached.



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.

E

**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'.



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.



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.

Main Bearing: Loosening and Tensioning of Elastic Studs

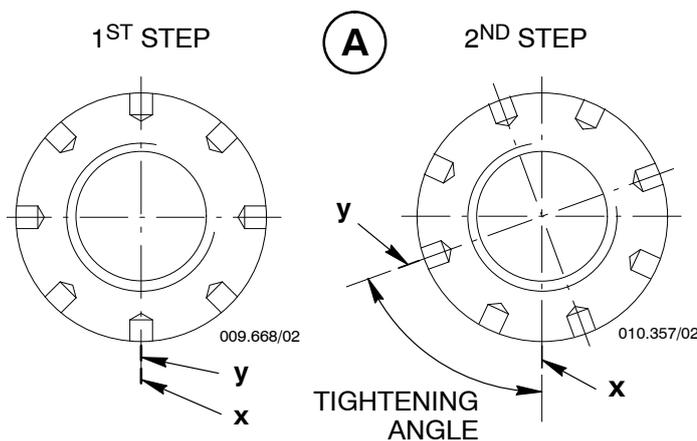
3. Tensioning the elastic studs

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**.

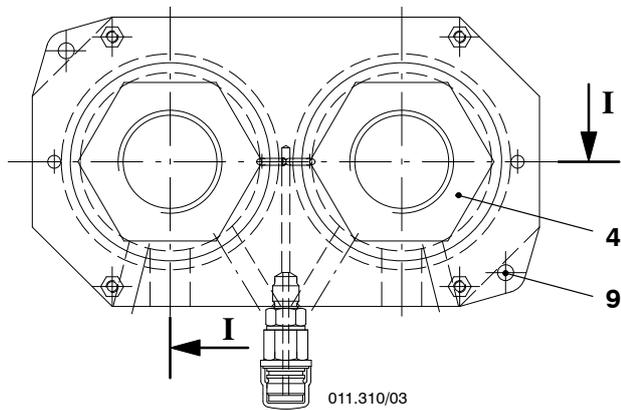
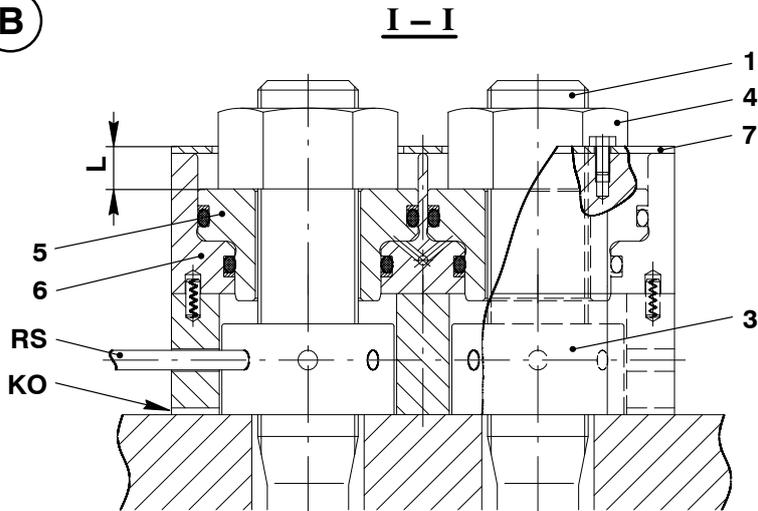
Finally check the horizontal and vertical clearance by means of special feeler gauge 94123 (see Clearance Table 0330-1 'Crankshaft and main bearing').



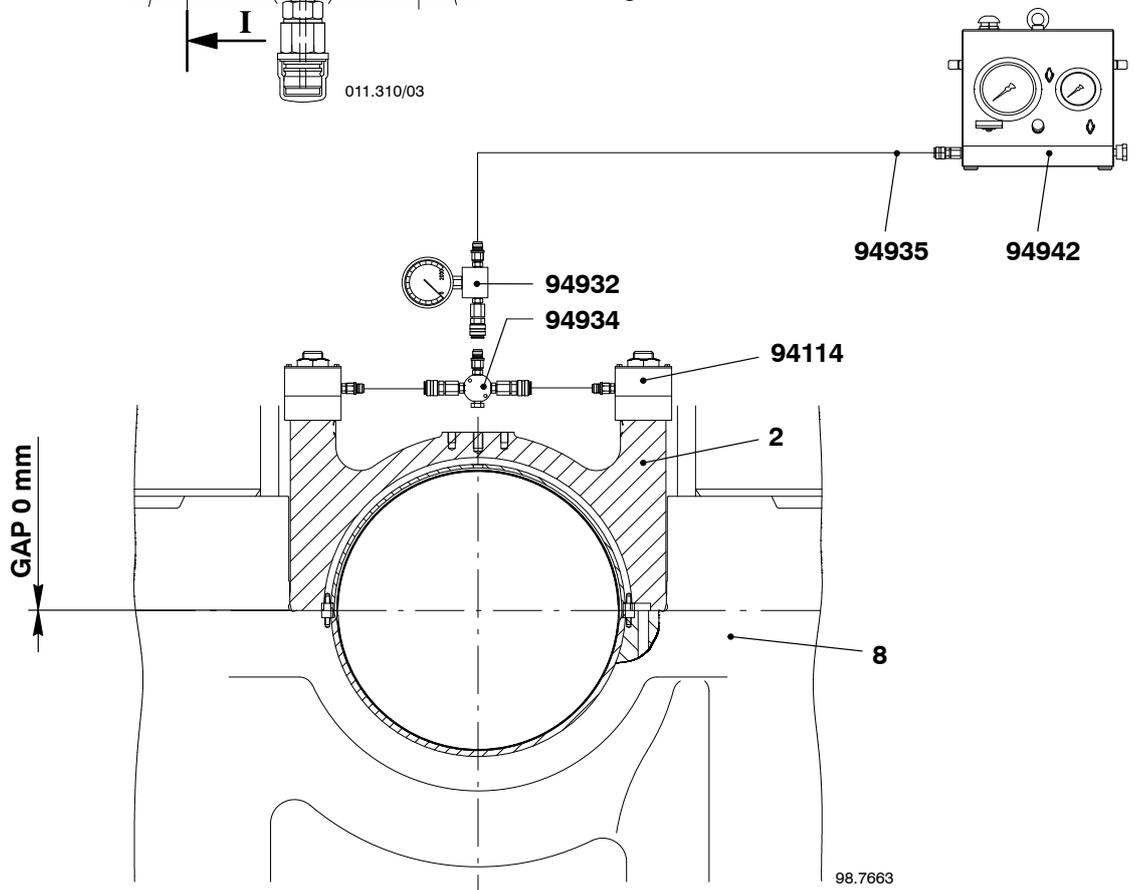
Remark: All main bearing clearance values are valid only with tightened tie rods and elastic studs.

Main Bearing: Loosening and Tensioning of Elastic Studs

B



C



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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.

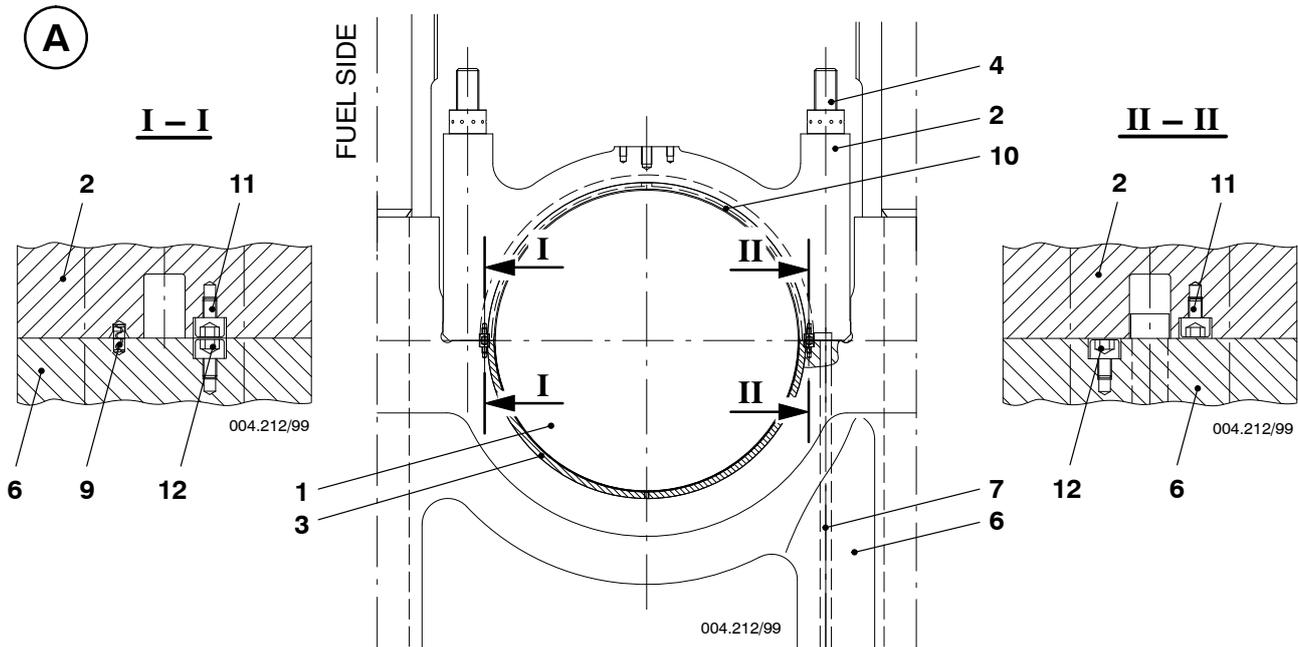
The loosening and tensioning of elastic studs 4 are described in [1132-1](#).

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.

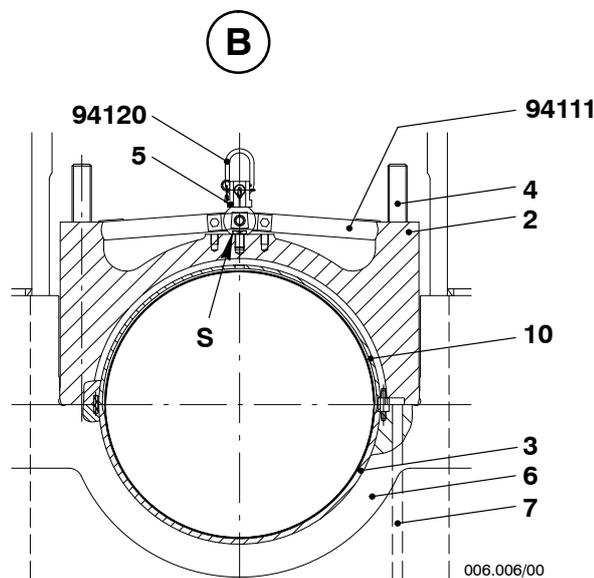
Eyelet 94120 must be used for the removal and fitting of the bearing cover No. 1.

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

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

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

CHECK



Removal and Fitting of a Main Bearing

3. Removal of main bearing cover

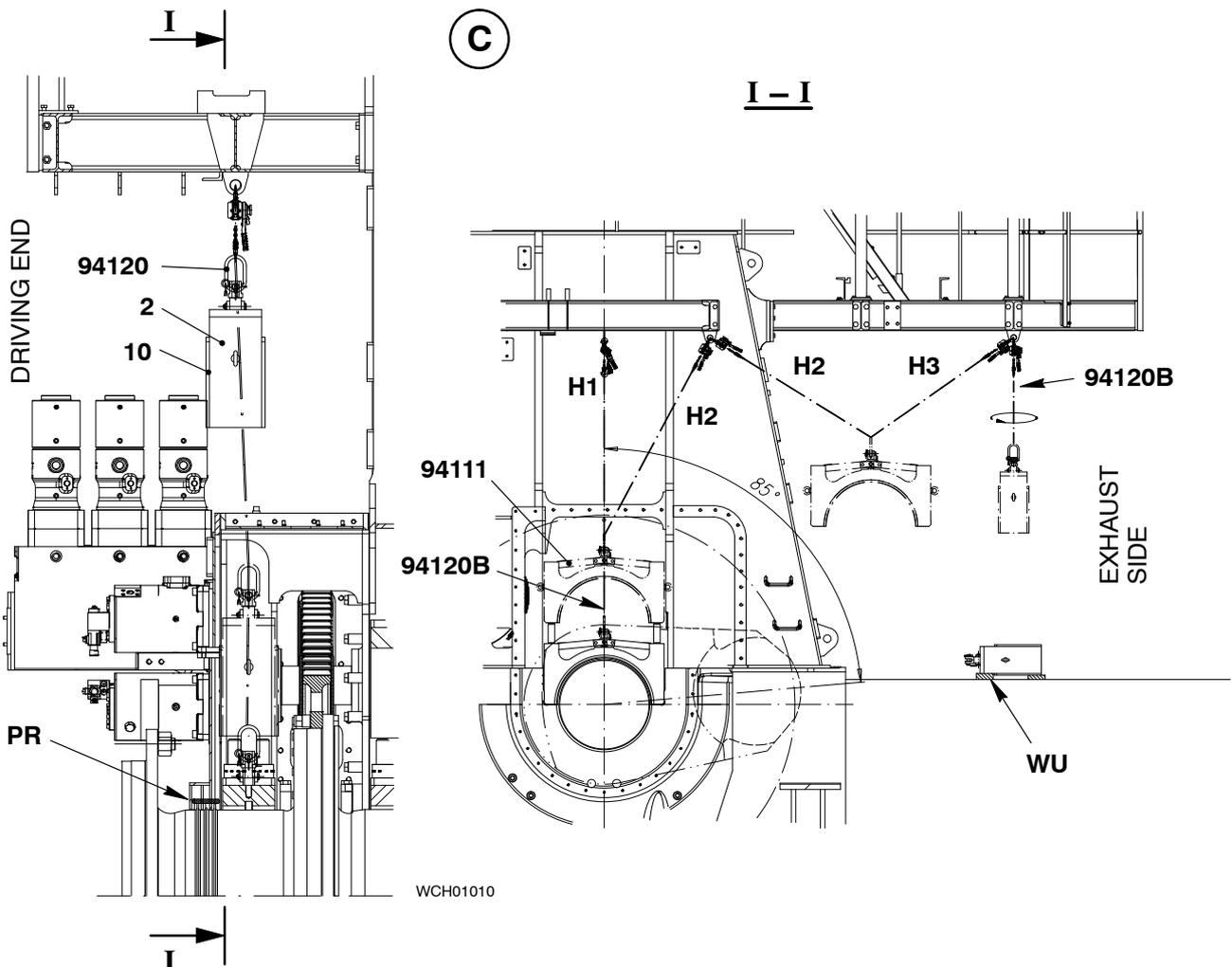
3.1 Removal of bearing cover No. 1

- ⇒ 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'.



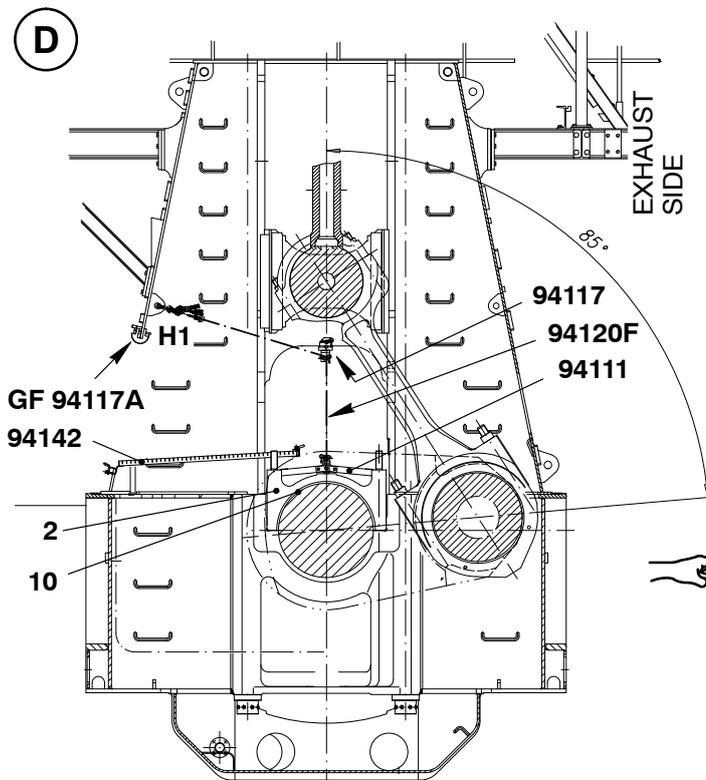
Remark: Oil bore 7 in bearing girder 6 must be closed off immediately after lifting the bearing cover, to prevent any dirt from entering (Fig. 'A').

- ⇒ 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.



Removal and Fitting of a Main Bearing

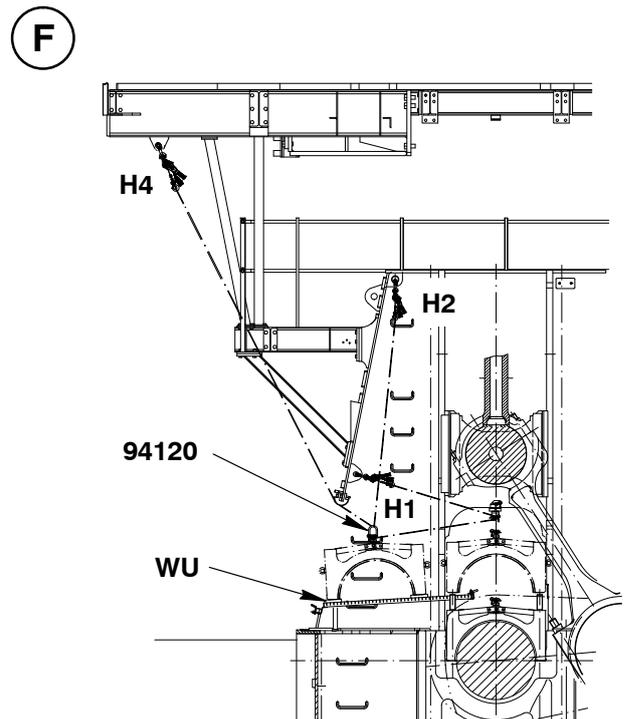
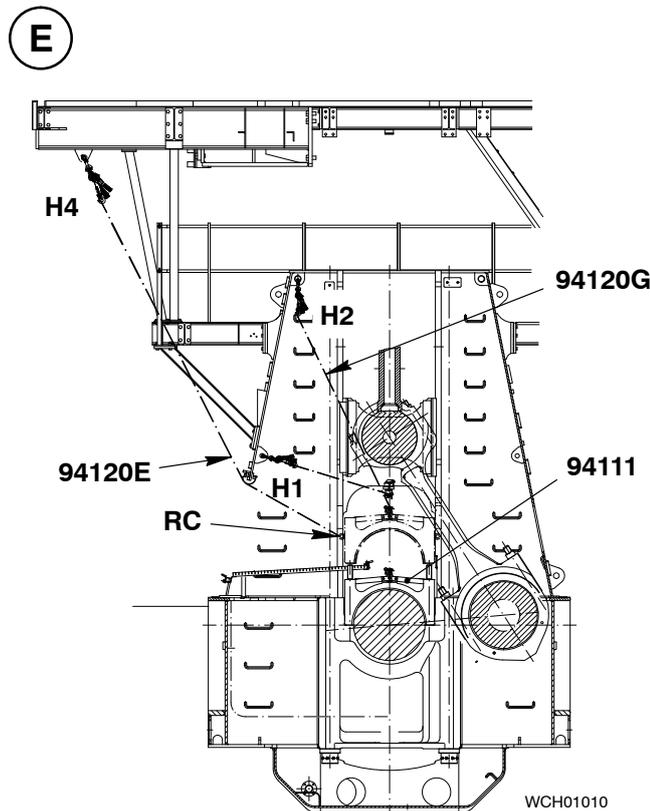
3.2 Removal of bearing cover No. 2 and following



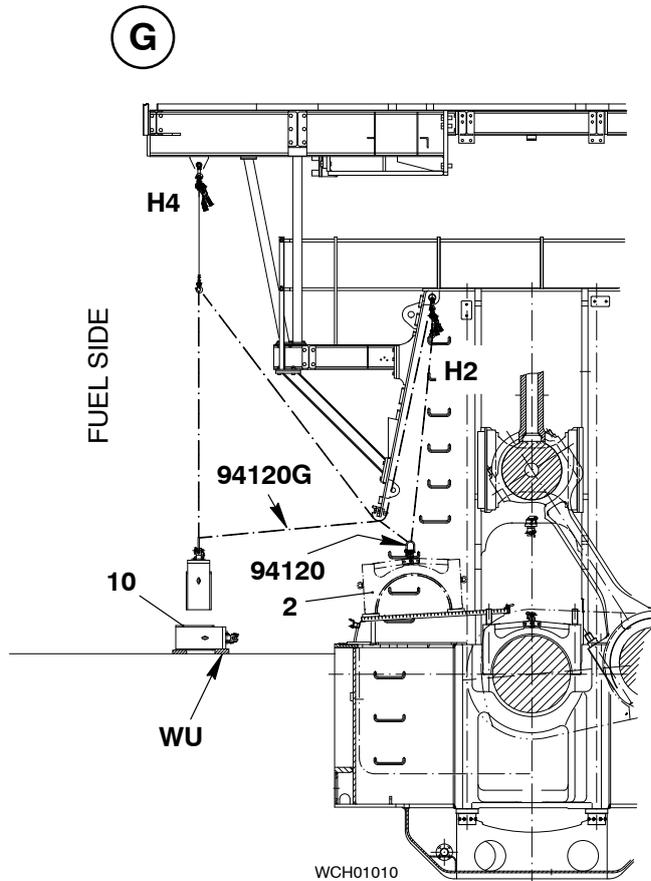
- ⇒ Turn corresponding crank to exhaust side approx. 85° after T.D.C.
- ⇒ Install working platform 94142 (see 3301-1).
- ⇒ Remove nuts for elastic studs (see 1132-1).
- ⇒ Place lifting device 94111 (without eyelet 94120) as described in section 2.
- ⇒ Attach deviation pipe GF 94117A and install roller 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.

Removal and Fitting of a Main Bearing

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').

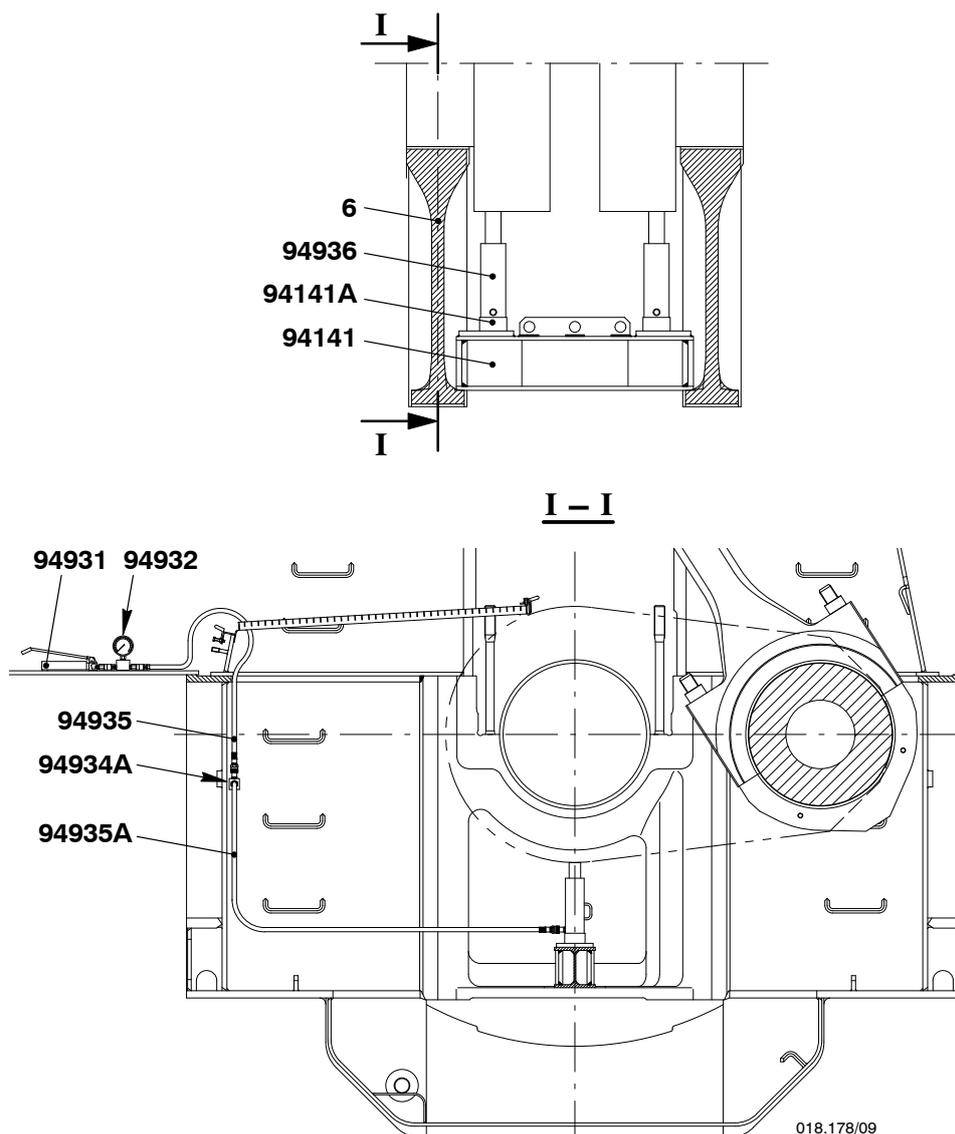
4.1 Placing of hydraulic jacks

- ⇒ 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)



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).

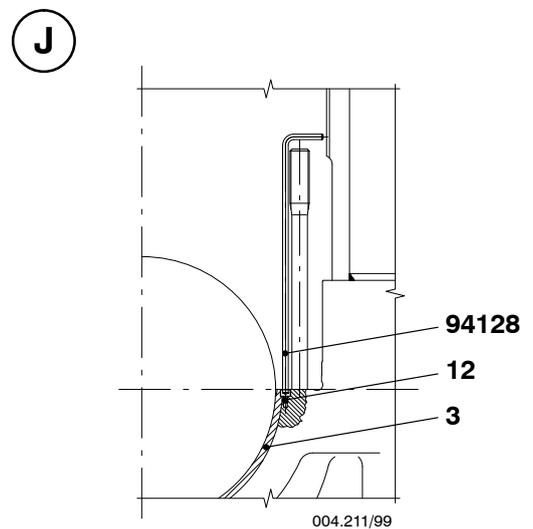
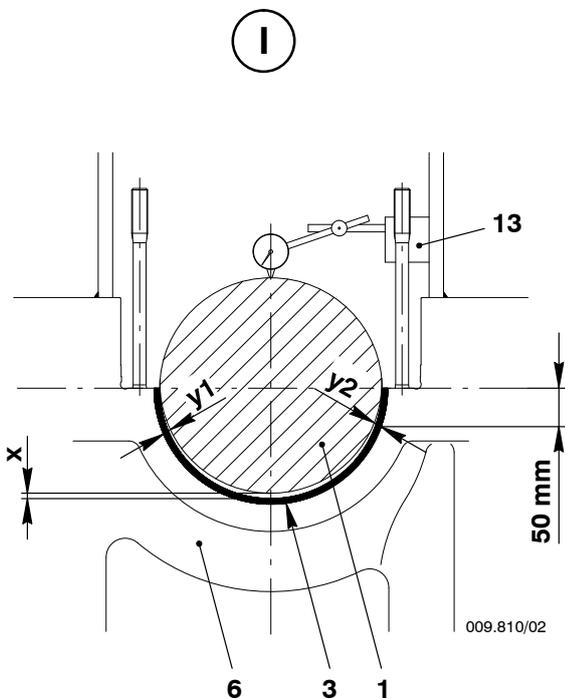


Attention! Lift the crankshaft max. to the point where the neighboring main bearings show no vertical clearance between upper bearing shells and crankshaft.

- ⇒ 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.



Removal and Fitting of a Main Bearing

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.



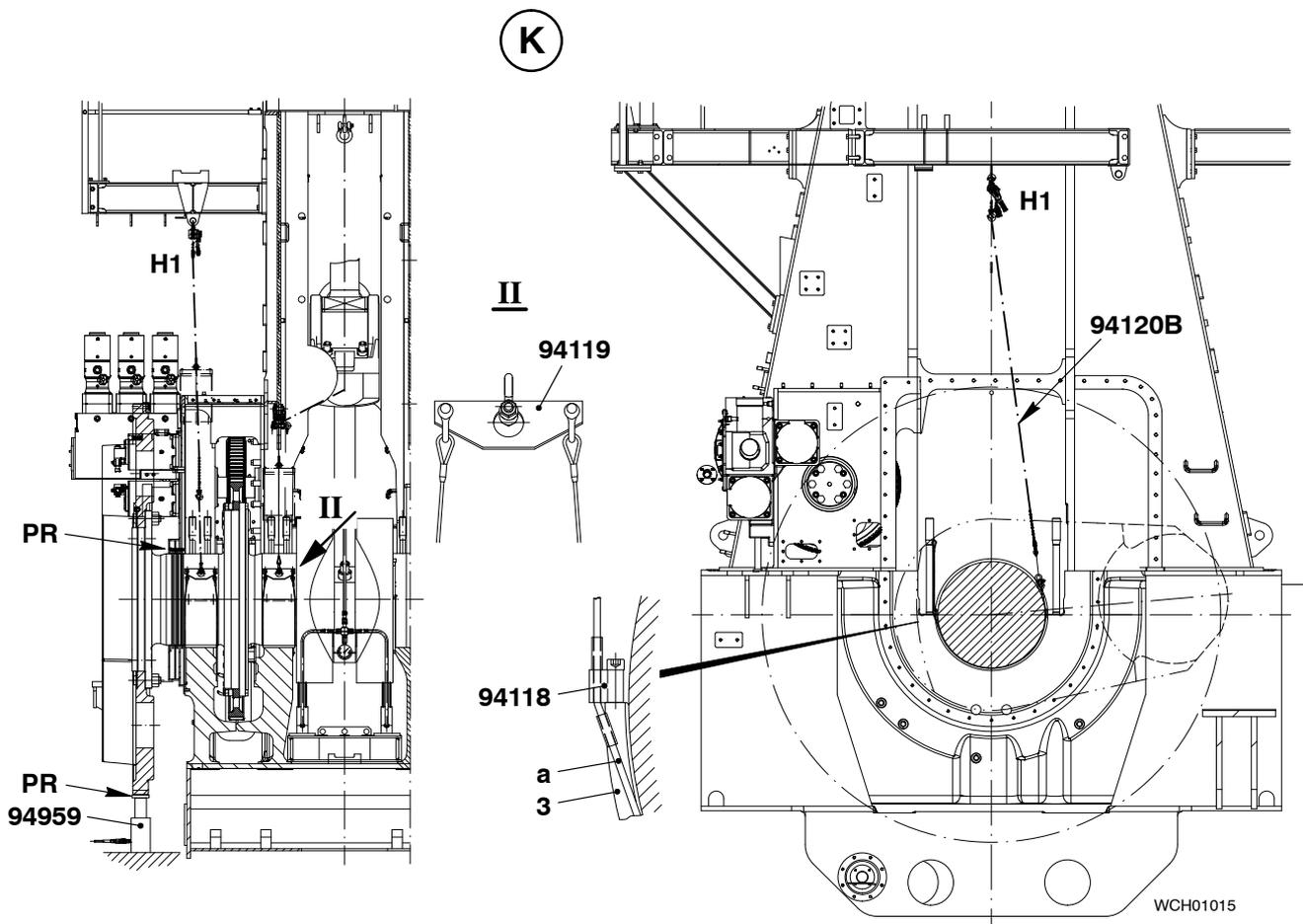
Remark: By means of a wire attached to the ropes they can be pulled below the bearing journal to the other side.

⇒ 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.

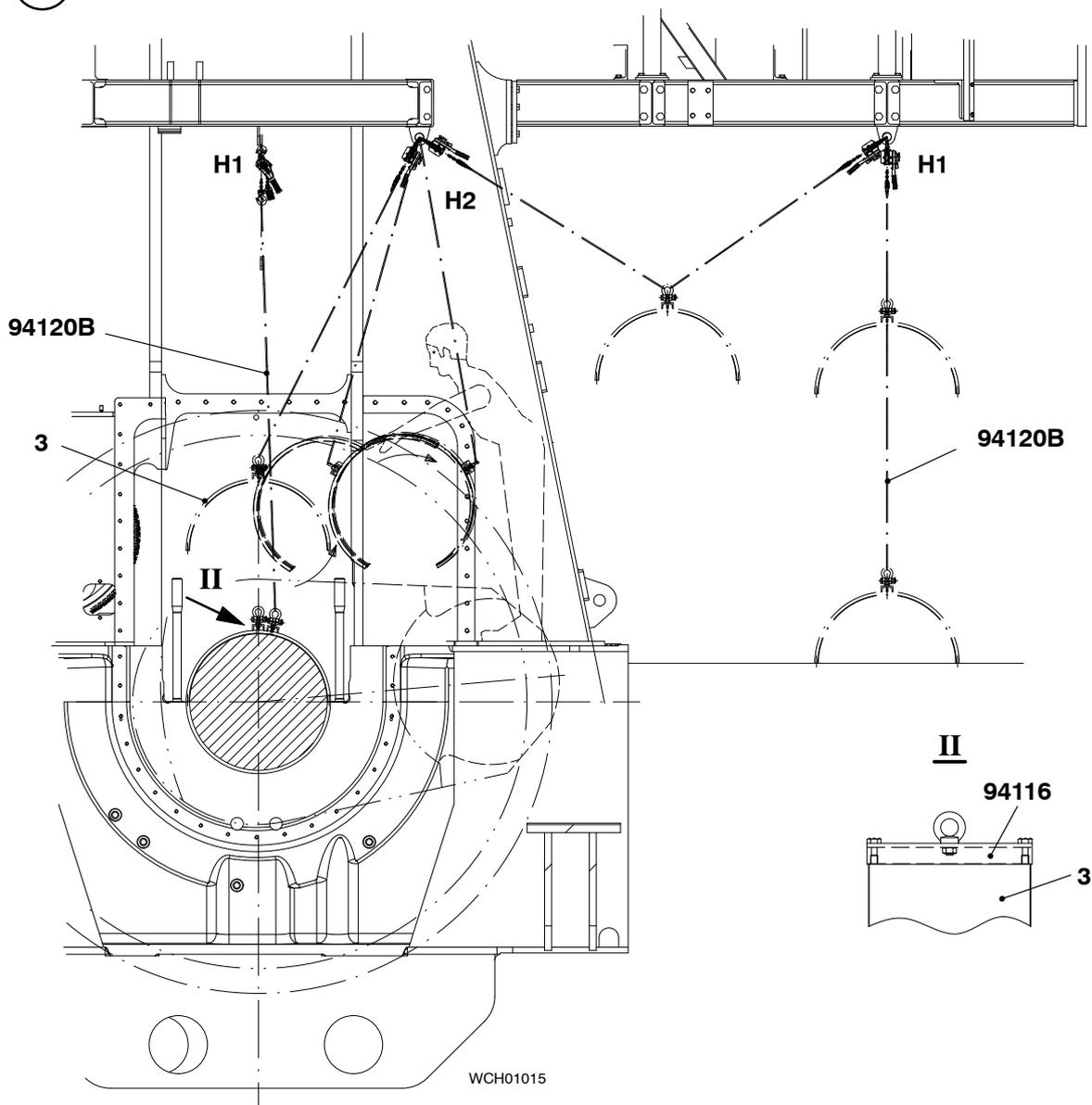


Removal and Fitting of a Main Bearing

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.

L



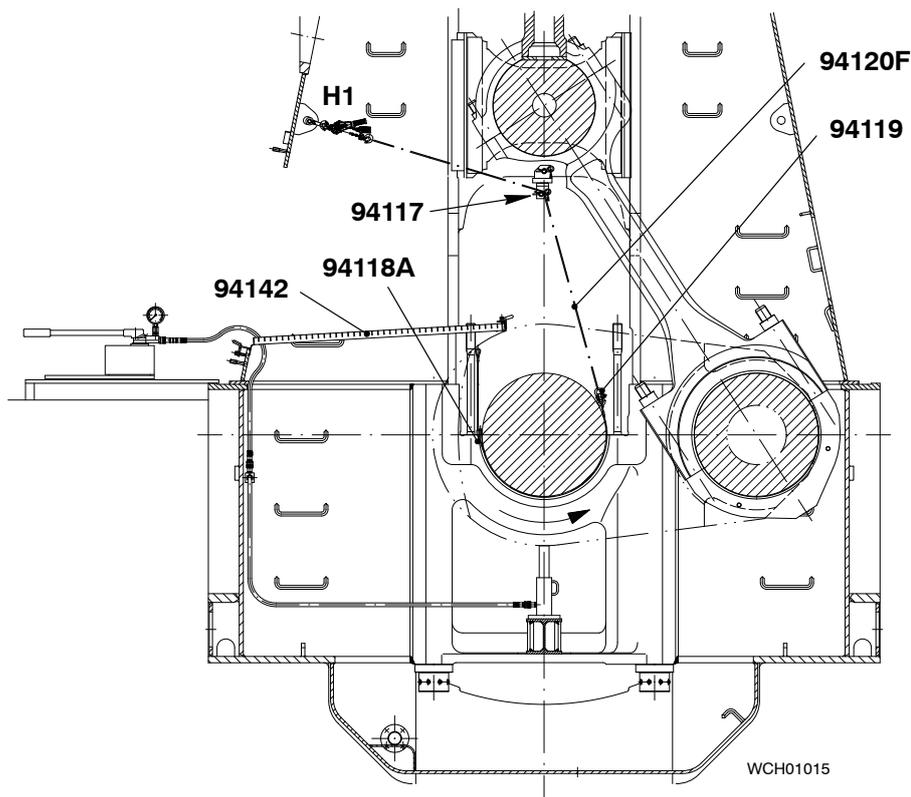
Removal and Fitting of a Main Bearing

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.



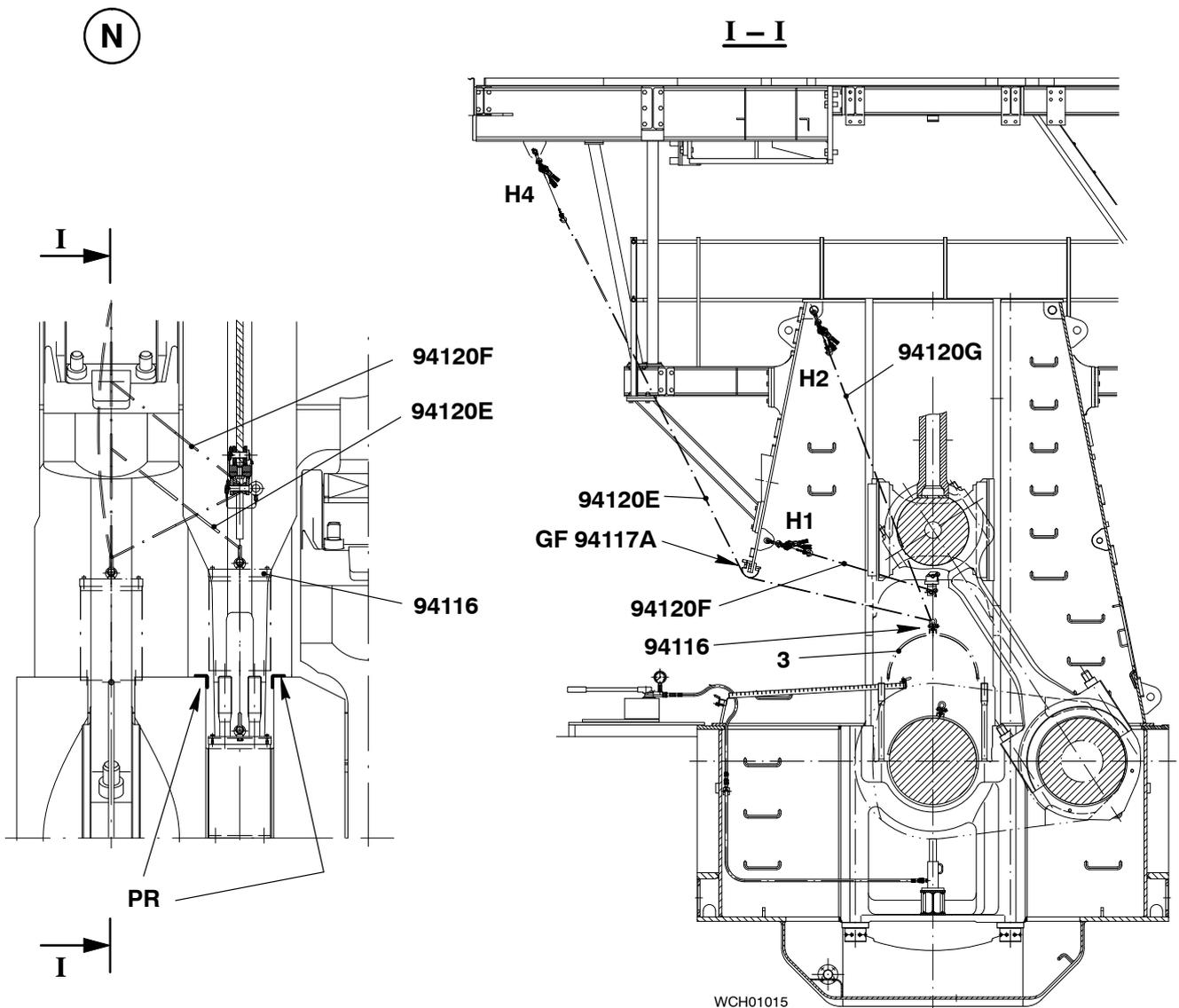
Remark: If a bearing shell jams during turning out, lifting yoke 94119 must be fastened to the two opposite wire ropes of turning-out device 94118A. Subsequently draw the bearing shell back to the initial position until the bearing shell is freed.



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.



Removal and Fitting of a Main Bearing

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.

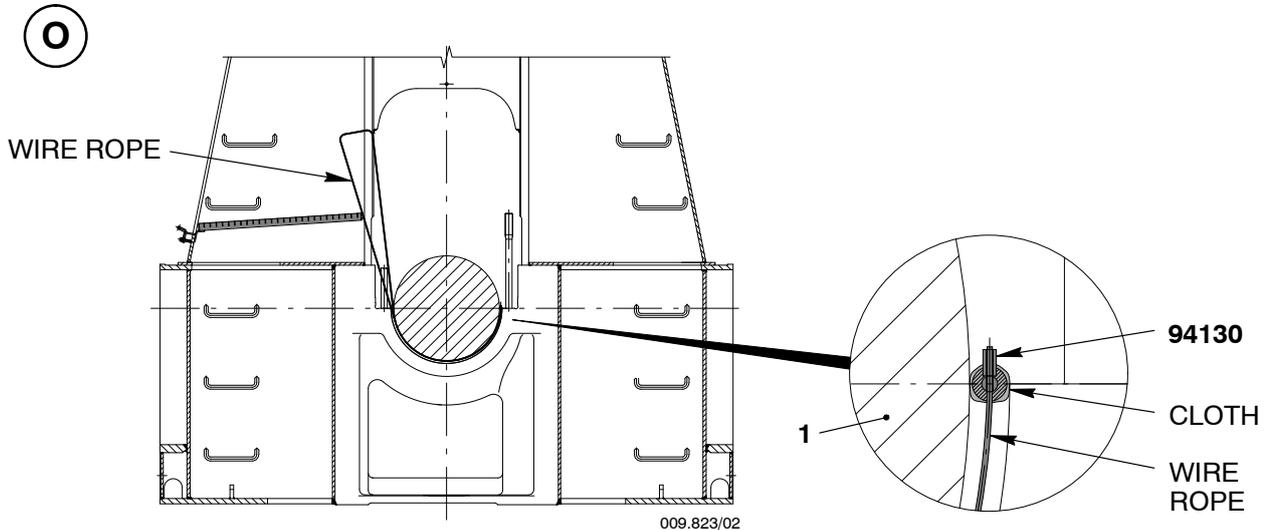
- ⇒ If the running marks are more uneven distributed than expected, the crank deflection must be measured.
- ⇒ If necessary, replace the bearing shells.
- ⇒ Inspect the surface of the bearing journal. Scratches must be polished.

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!



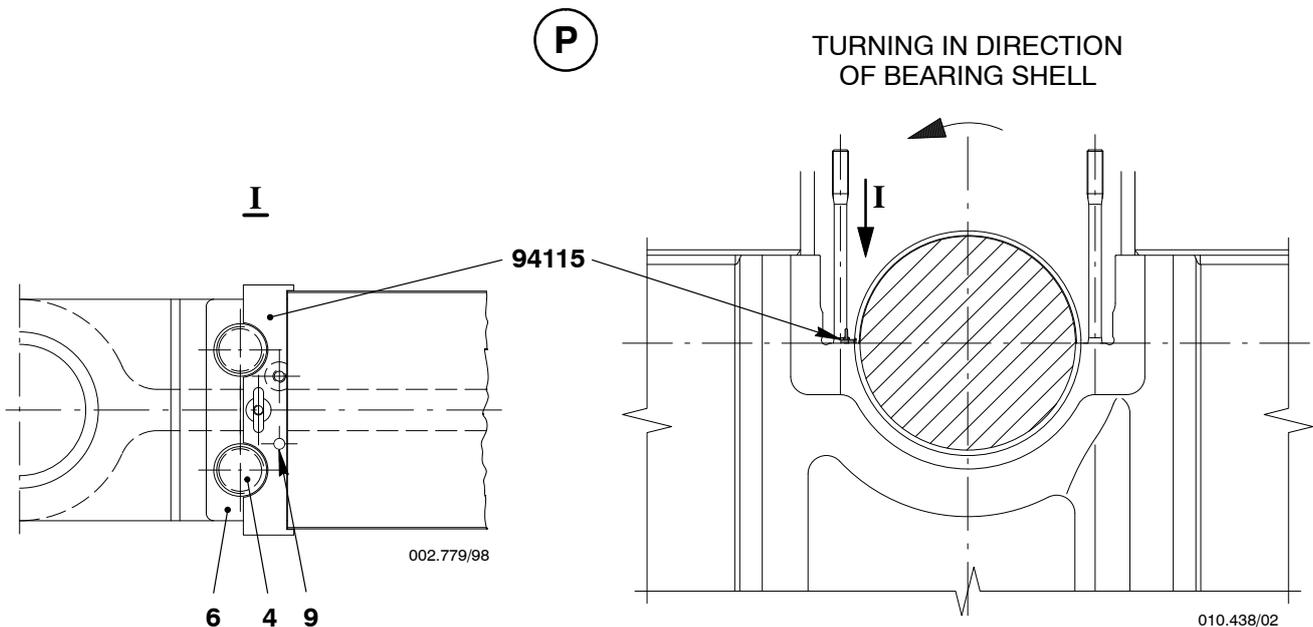
Conditions before fitting:

- 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.

Removal and Fitting of a Main Bearing

- ⇒ 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.



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').

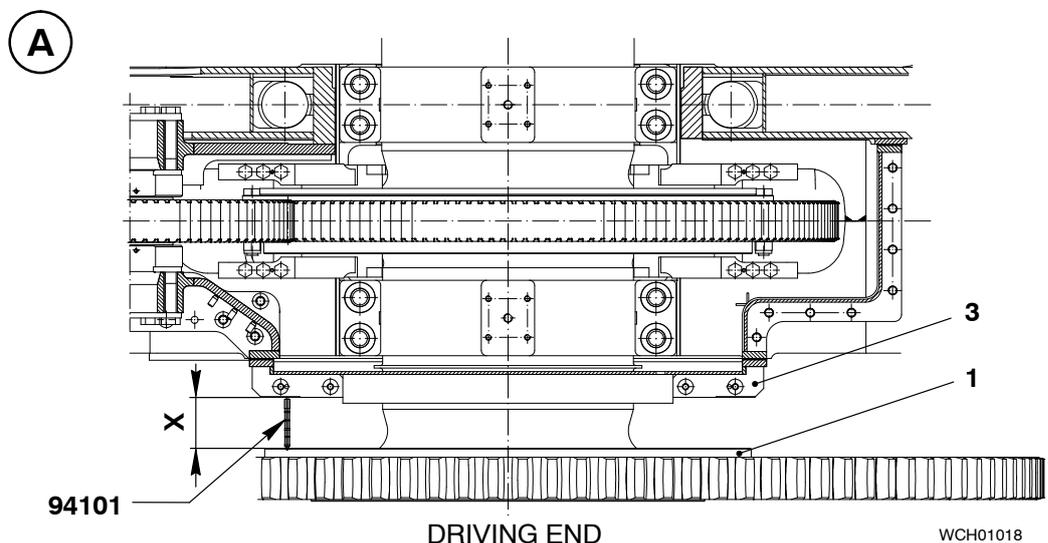
An increase compared with the nominal figure signifies wear of the thrust bearing pads.

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. 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.

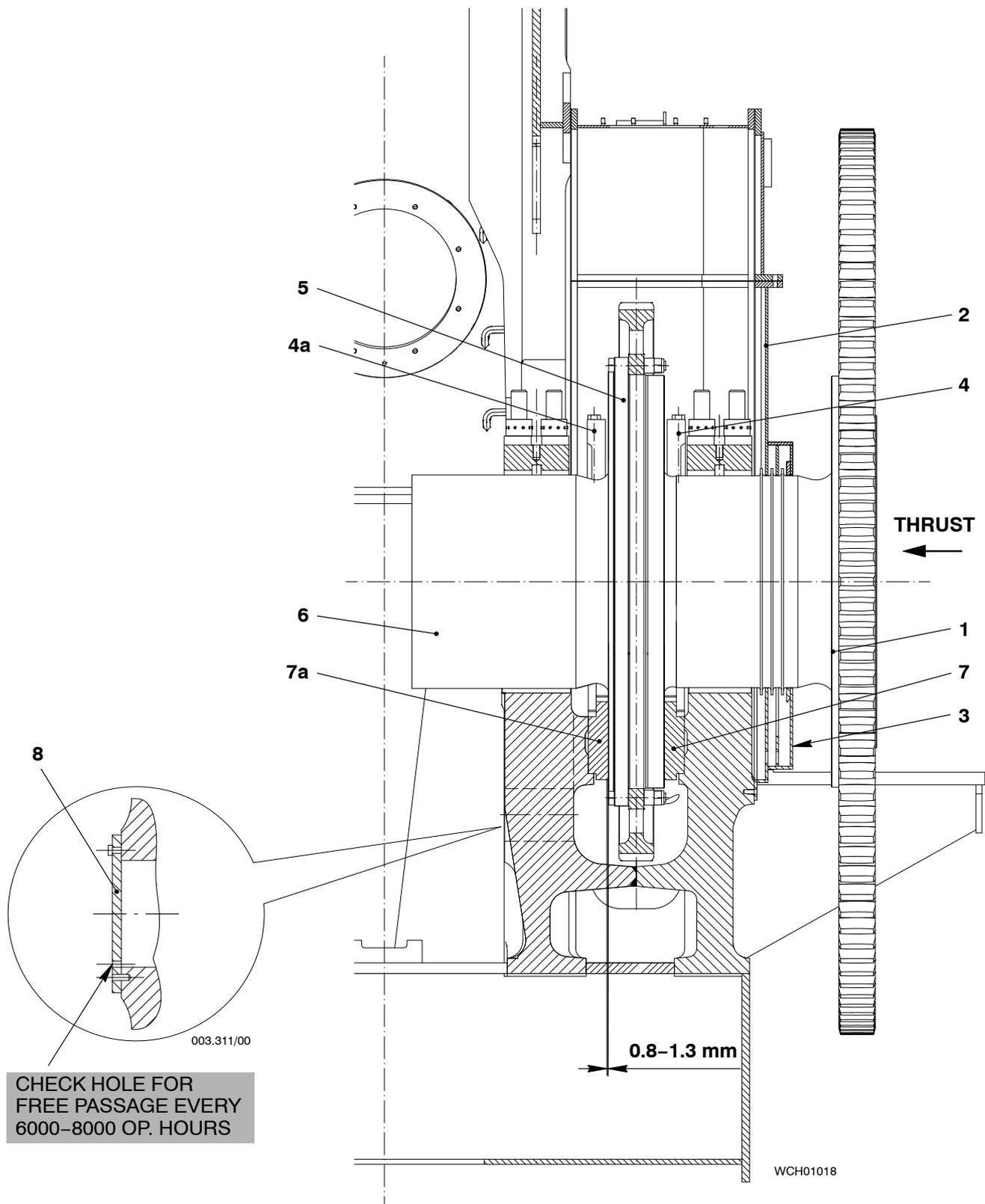


Remark: If during checking or repair work any objects should fall into the thrust bearing housing, they can be removed after dismantling cover 8. After major works have been carried out in the thrust bearing space dismantle cover 8 for a check-up on the thrust bearing housing. Remove any foreign matters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



Thrust Bearing: Checking the Axial Clearance

B



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

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').



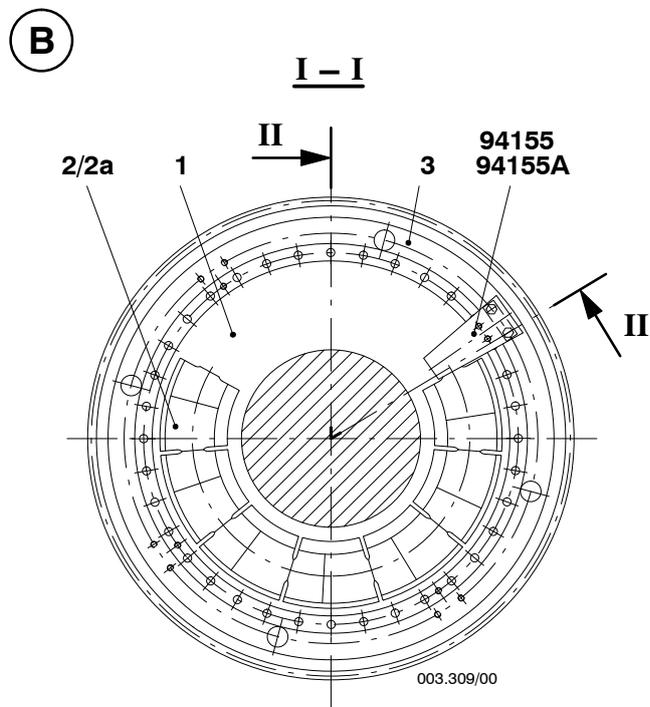
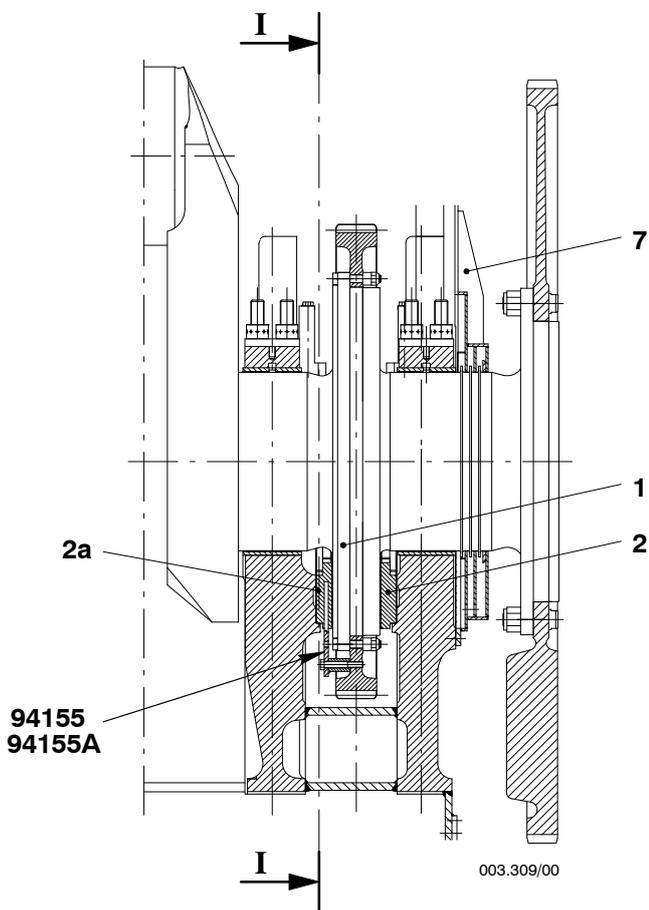
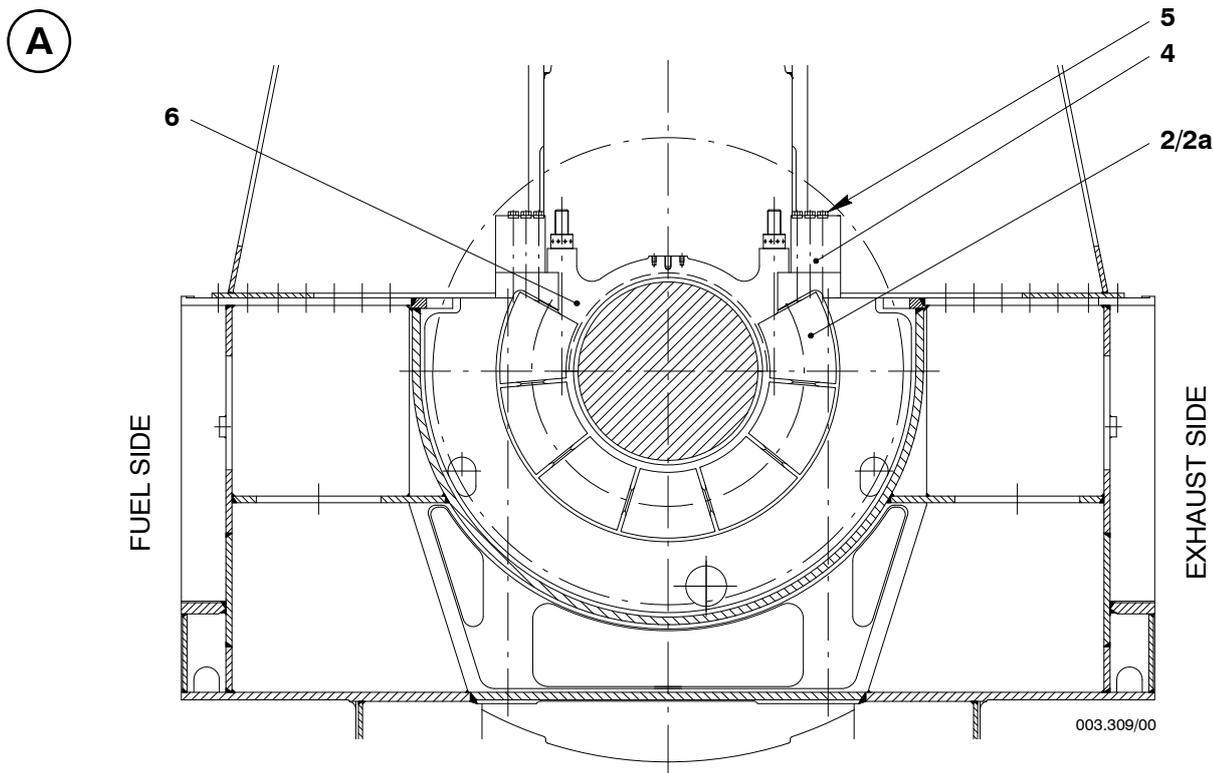
Attention! After fitting the thrust bearing pads immediately remove tool 94155 or 94155a respectively.



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



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').

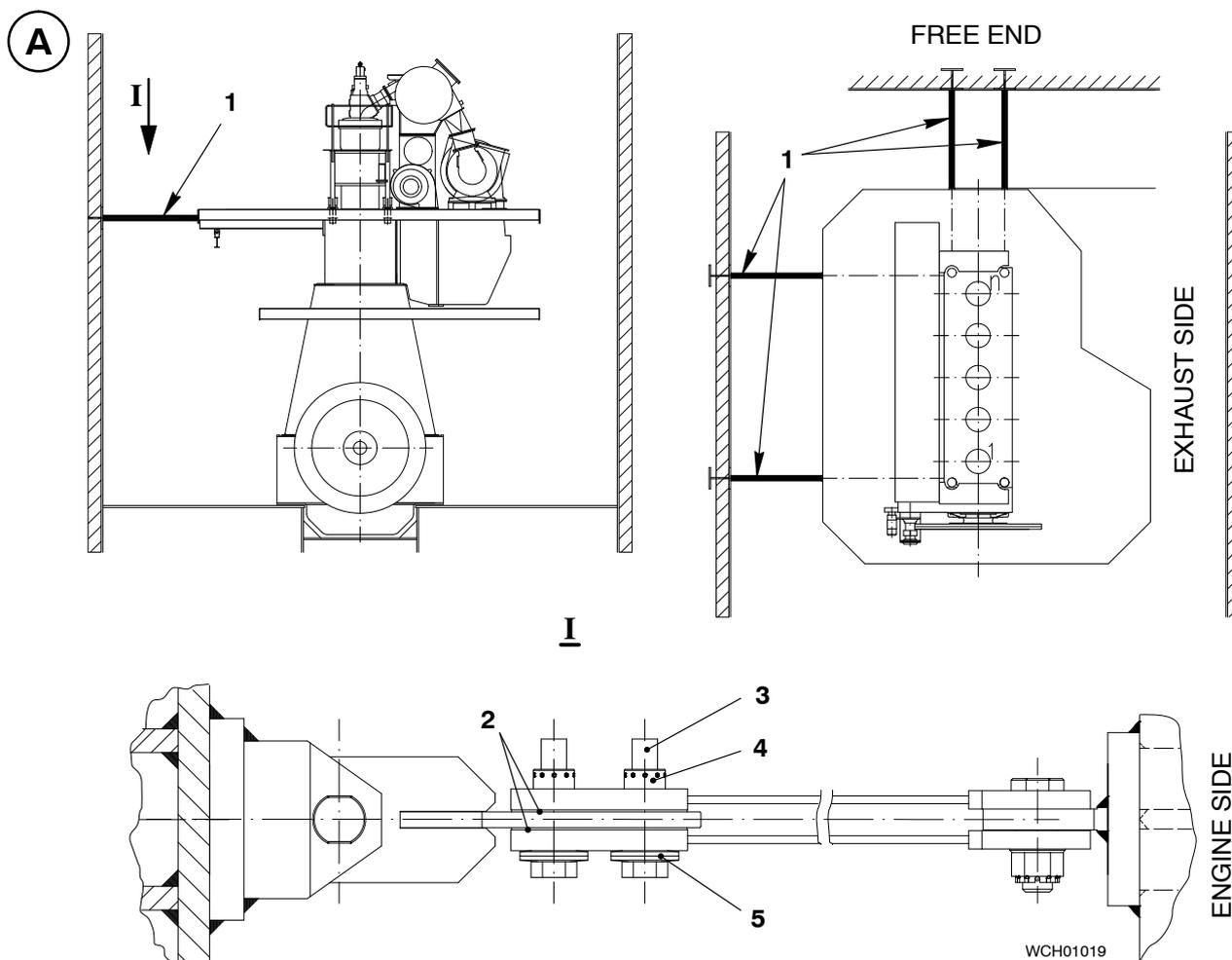
CHECK



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!**



WCH01019

Engine Stays with Friction Shims: Checking the Pre-tension

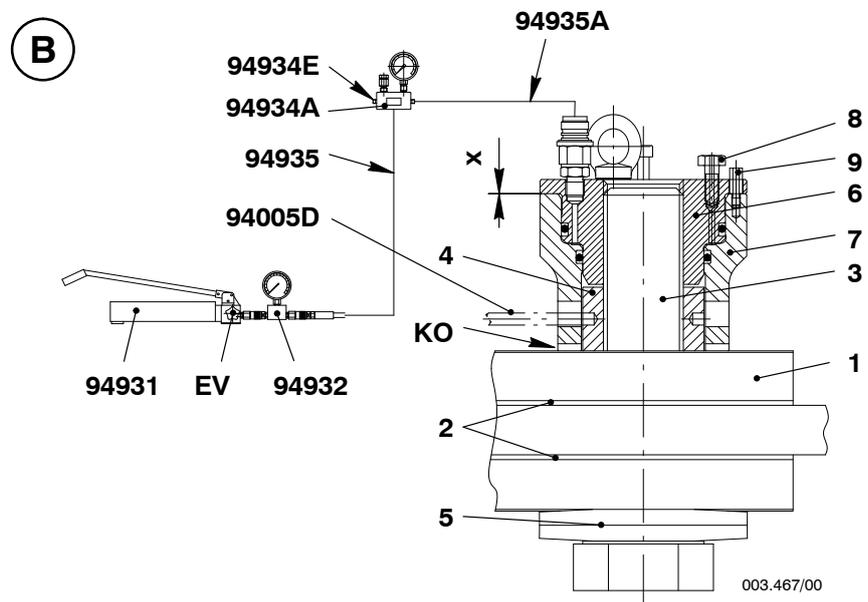
2. Checking the pre-tension

- ⇒ 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 $\frac{1}{2}$ 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!

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

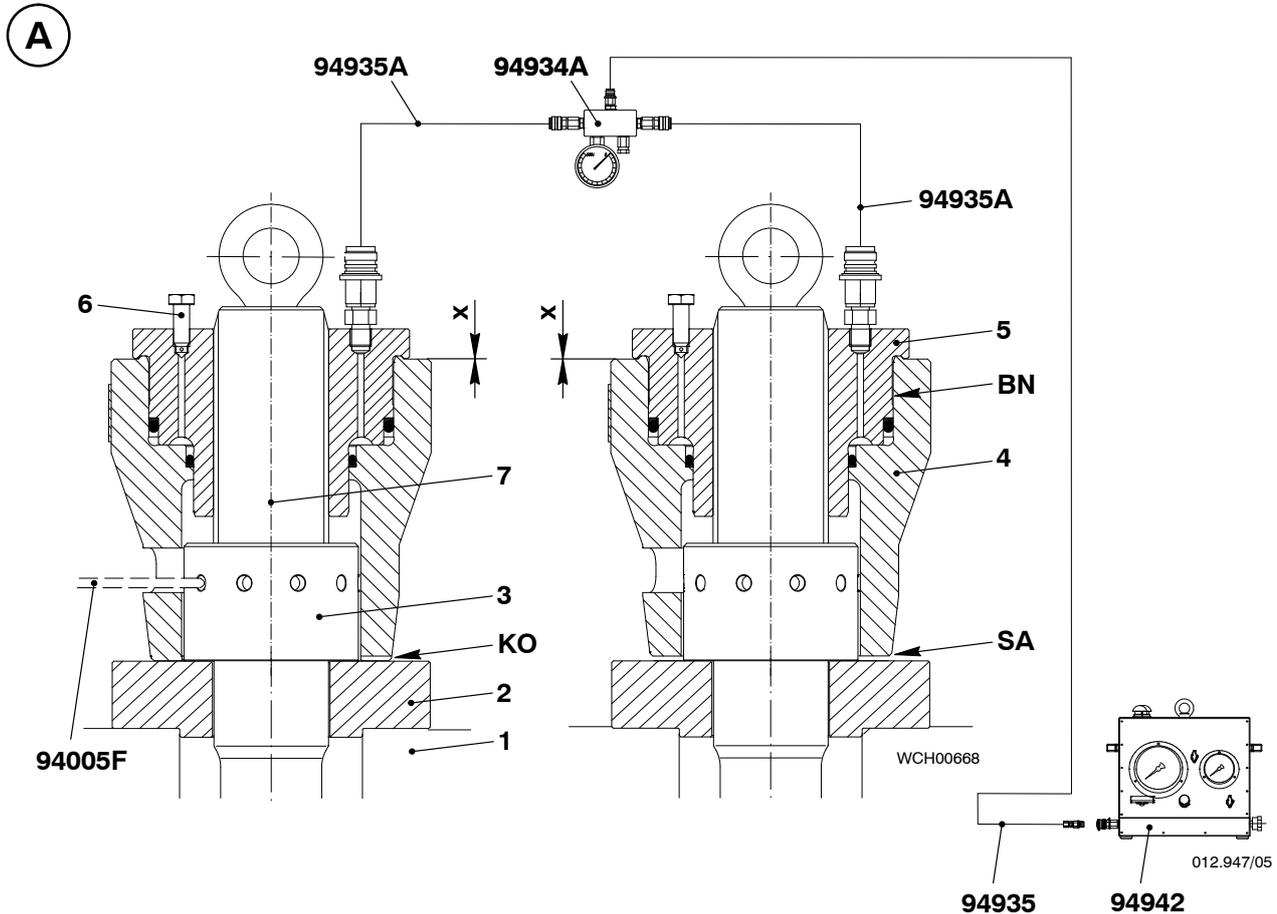
- ⇒ Remove protection cover 8 from all tie rods and clean the contact face of intermediate ring 2.
- ⇒ Place both pre-tensioning jacks GF 94180 onto two tie rods lying opposite each other. Screw them completely down with vent screws 6 open until there is only little or no clearance at 'x' (Fig. 'A').
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.



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

Checking the Pre-tension and Tensioning the Tie Rods

with M80x6 Thread Diameter

PRE-TENSIONING JACK GF 94180
PLACED FOR TENSIONINGPRE-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.

Checking the Pre-tension and Tensioning the Tie Rods

with M80x6 Thread Diameter

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.

Checking the Pre-tension and Tensioning the Tie Rods

with M80x6 Thread Diameter

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.



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

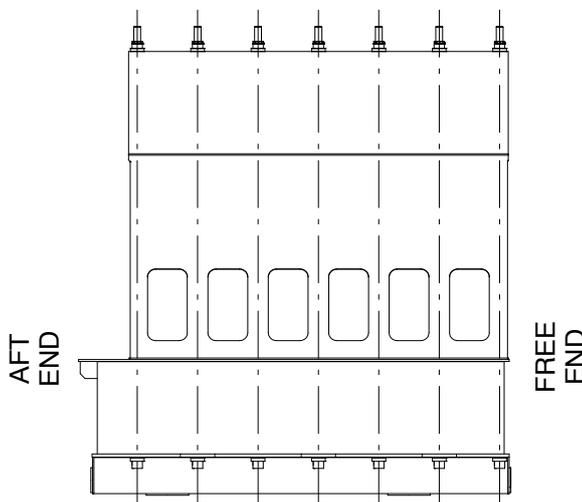
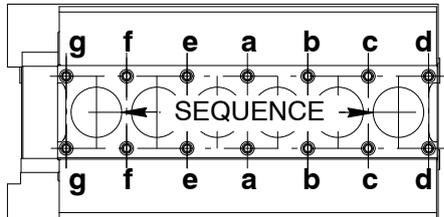
- ⇒ Measure again distance 'L' and record it as 'L₁'.

The tie rods are correctly tensioned with 1500 bar when the following reference value of a total elongation ΔL ('L₁'-'L') is measured:

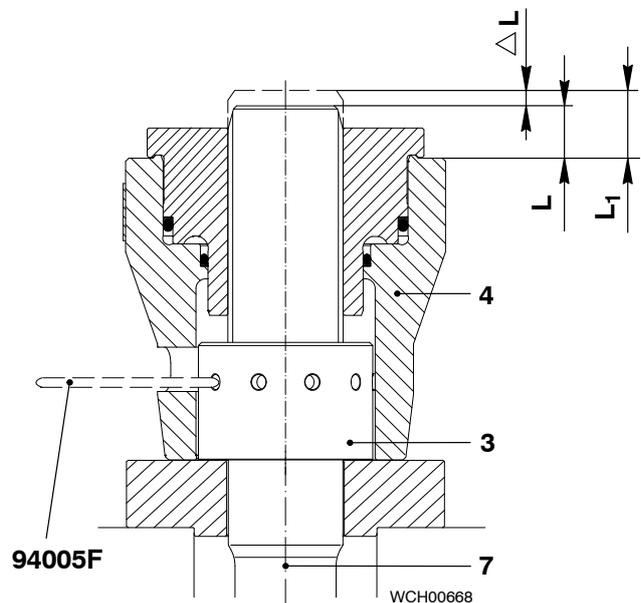
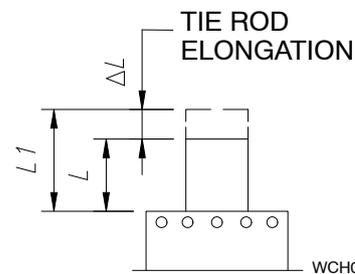
$$\Delta L = 14.5 \dots 16.5 \text{ mm}$$

- ⇒ 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.

B

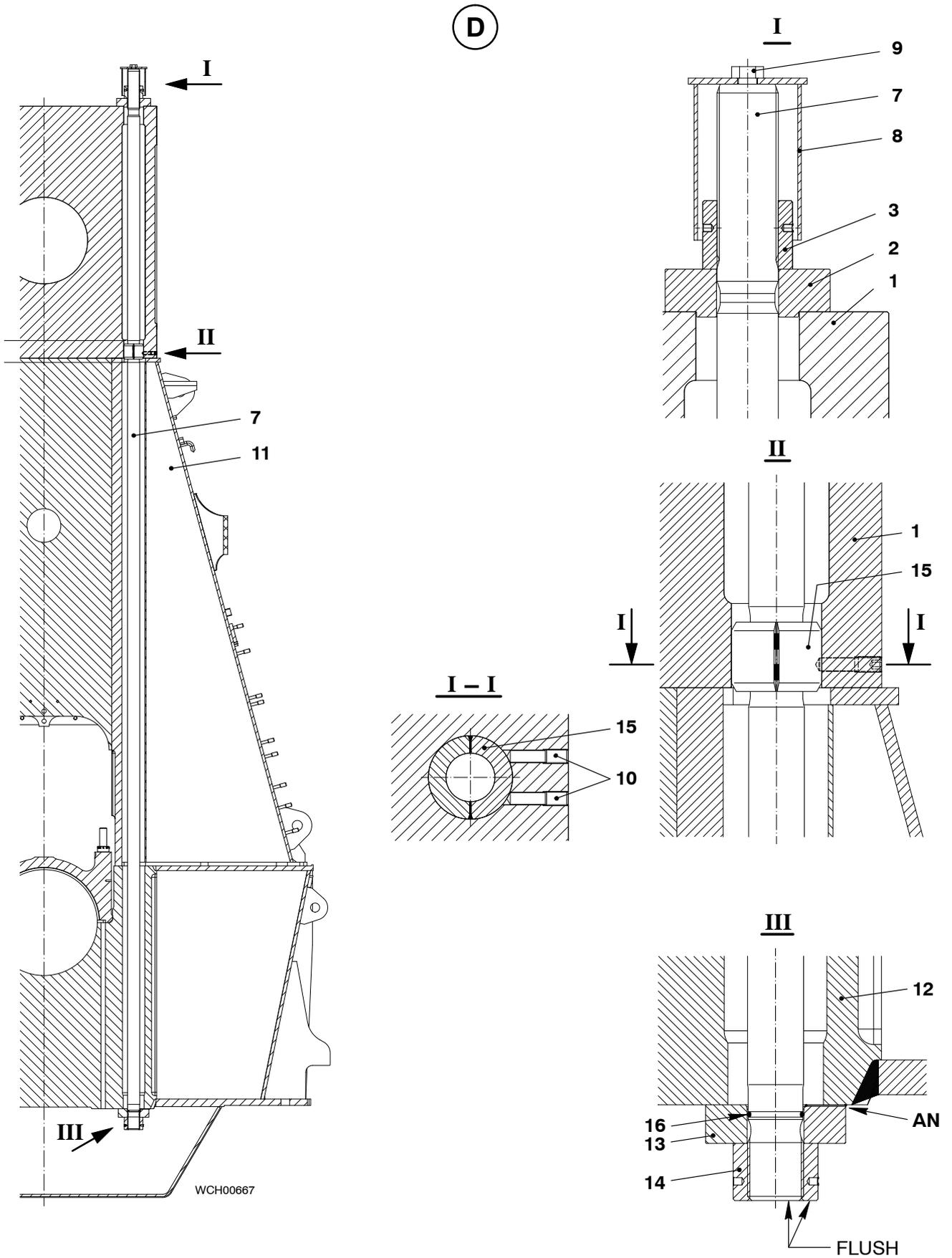


C



Checking the Pre-tension and Tensioning the Tie Rods

with M80x6 Thread Diameter



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▽ **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 with Pulse Jet Lubrication: Removal and Fitting 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 Elastic Studs 2708-2/A1
- Machining of Sealing Face for Injection Valve 2708-3/A1

- Injection Valve: Checking, Dismantling, Assembling and Adjusting 2722-1/A1
- Starting Air Valve: Removal, Fitting and Dismantling, Grinding-in and Assembling 2728-1/A1
- Relief Valve for Cylinder Cover 2745-1/A1

▽ **Exhaust Valve**

- Removal and Fitting of Exhaust Valve, Replacing of Elastic 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

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Cylinder Liner

Measuring Bore Wear

Tools:

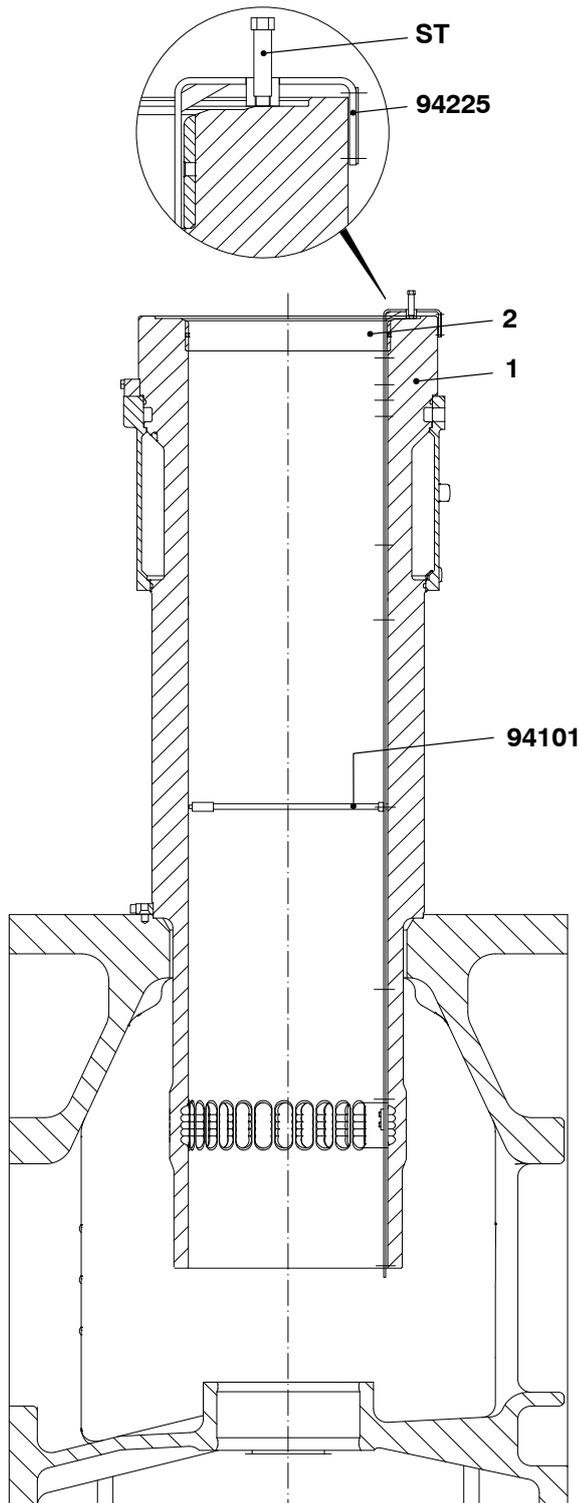
- 1 Inside micrometer 94101
- 1 Measuring gauge 94225

Key to Illustrations:

- 1 Cylinder liner
- 2 Antipolishing ring

ST Setting screw

SETTING SCREW 'ST' DRAWN FOR COMPRESSION SHIM THICKNESS = 0 mm.



CHECK

CHECK

- ⇒ The cylinder liner wear is to be determined after every piston removal with the cylinder liner in situ.
- ⇒ To permit comparisons with previous measures always carry out measuring in the same place and note down the values in a log.
- ⇒ Always use the properly adjusted measuring gauge 94225.

Check setting screw 'ST'. Its lower protruding length must correspond to the mean thickness of the built-in compression shims. This ensures that the topmost measuring point is located between the top ring wear ridge and the antipolishing ring.

The unrun position must be thoroughly cleaned from any deposits or lacquer before measurement.

- ⇒ Hook the measuring gauge over the top face of the cylinder liner.
- ⇒ The measurements have to be taken in longitudinal and transversal directions to the engine axis by putting the inside micrometer 94101 into the holes provided in the measuring gauge.

For maximum permissible inside diameter refer to Clearance Table 0330-1 'Cylinder liner'.

- ⇒ The ridge at the top of the cylinder bore has to be removed carefully without damaging the running surface for the piston rings (see 2124-3).
- ⇒ Remove the lower part of the measuring gauge 94225 for measuring the cylinder liner with piston in situ. Turn piston to B.D.C.

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

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](#)).



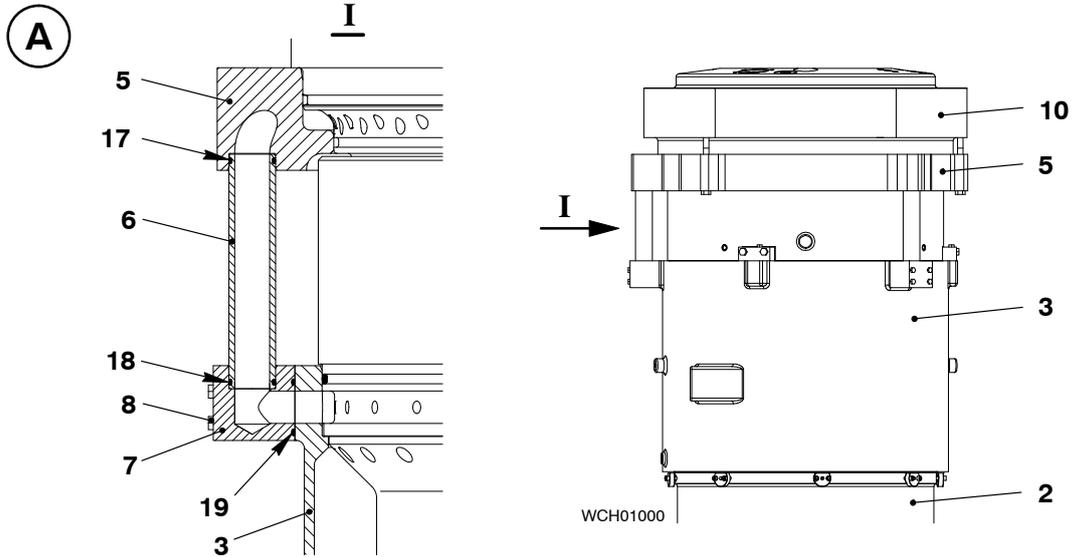
- Remark:** Pay attention to:
- General Guidelines for Lifting Tools [0012-1](#).

Cylinder Liner
Removal and Fitting

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).

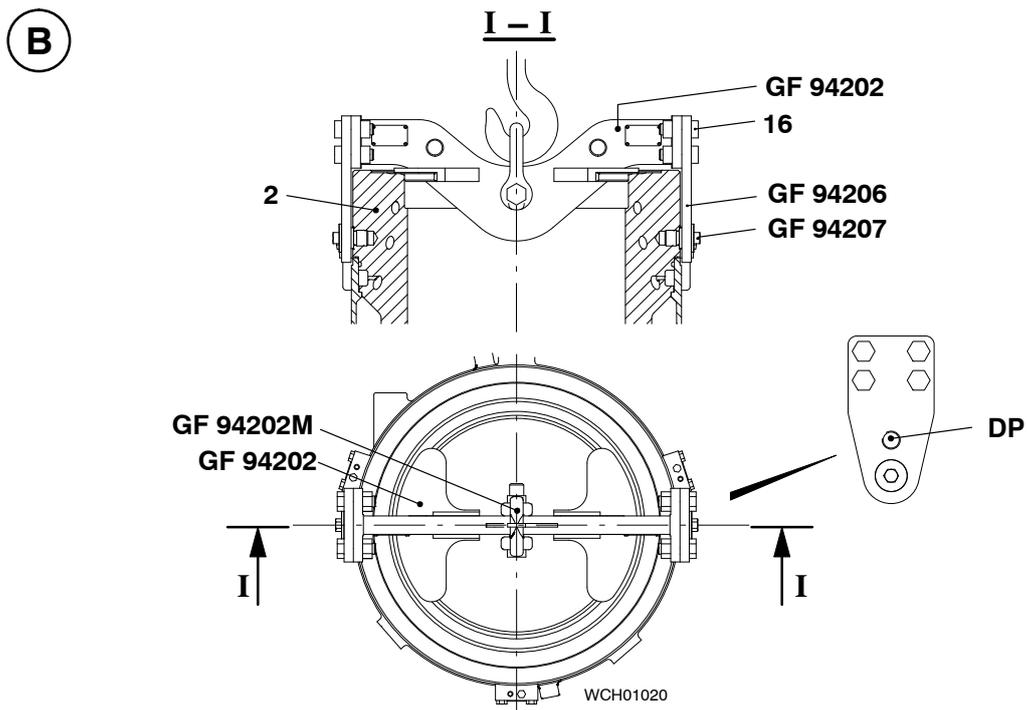


2.1 Placing device GF 94201

⇒ 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.

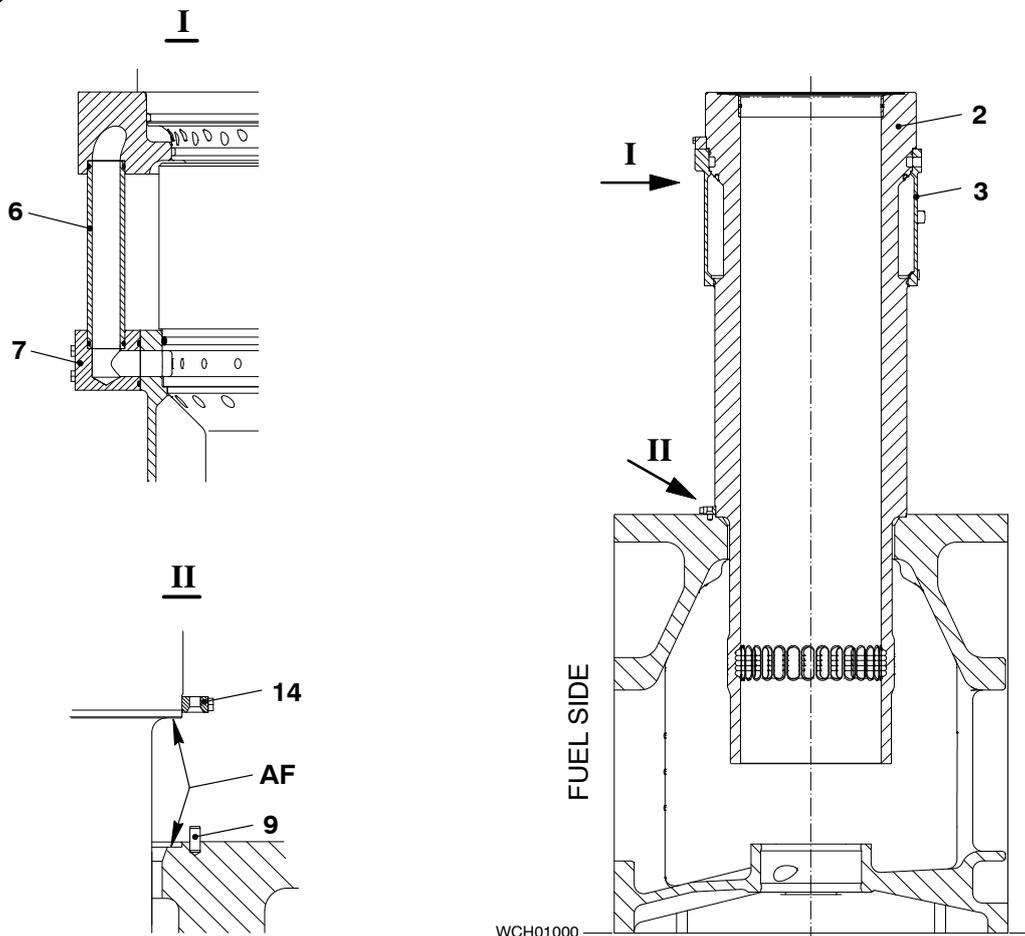
⇒ Fit the connection pieces 7 with transition tubes 6 to water guide jacket.

⇒ Fit all lubricating quills and connect their pipings.

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').

C



Cylinder Liner Removal and Fitting

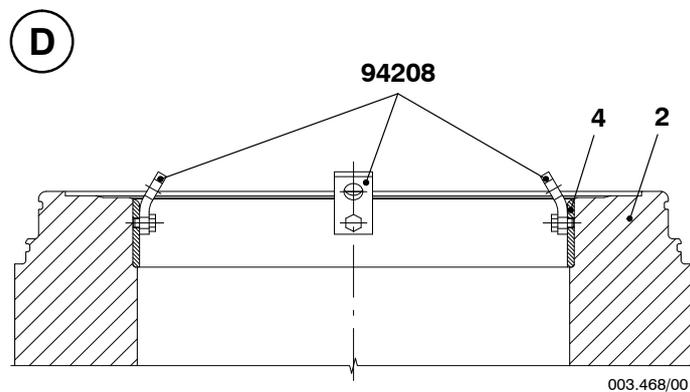
3. Removal and fitting of antipolishing ring

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.



Cylinder Liner

Removal and Fitting

4. Removal and fitting of water guide jacket

4.1 Removal

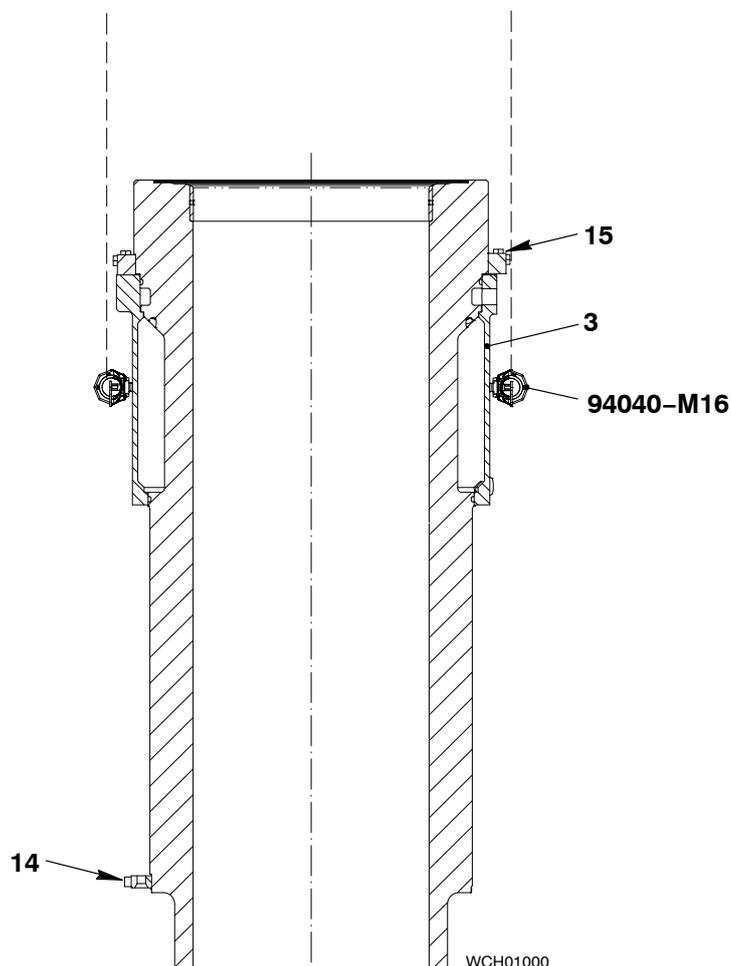
- ⇒ Lift cylinder liner according to paragraph 2.
- ⇒ Fasten the RUD-eye bolts 94040-M16 to the water guide jacket 3 as shown below.
- ⇒ Remove holder 14.
- ⇒ Connect manual ratchets with the RUD-eye bolts.
- ⇒ Loosen three screws 15. If necessary use them to separate the water guide jacket from the 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



Cylinder Liner: Removal and Fitting

5. Removal and fitting of insulation bandage

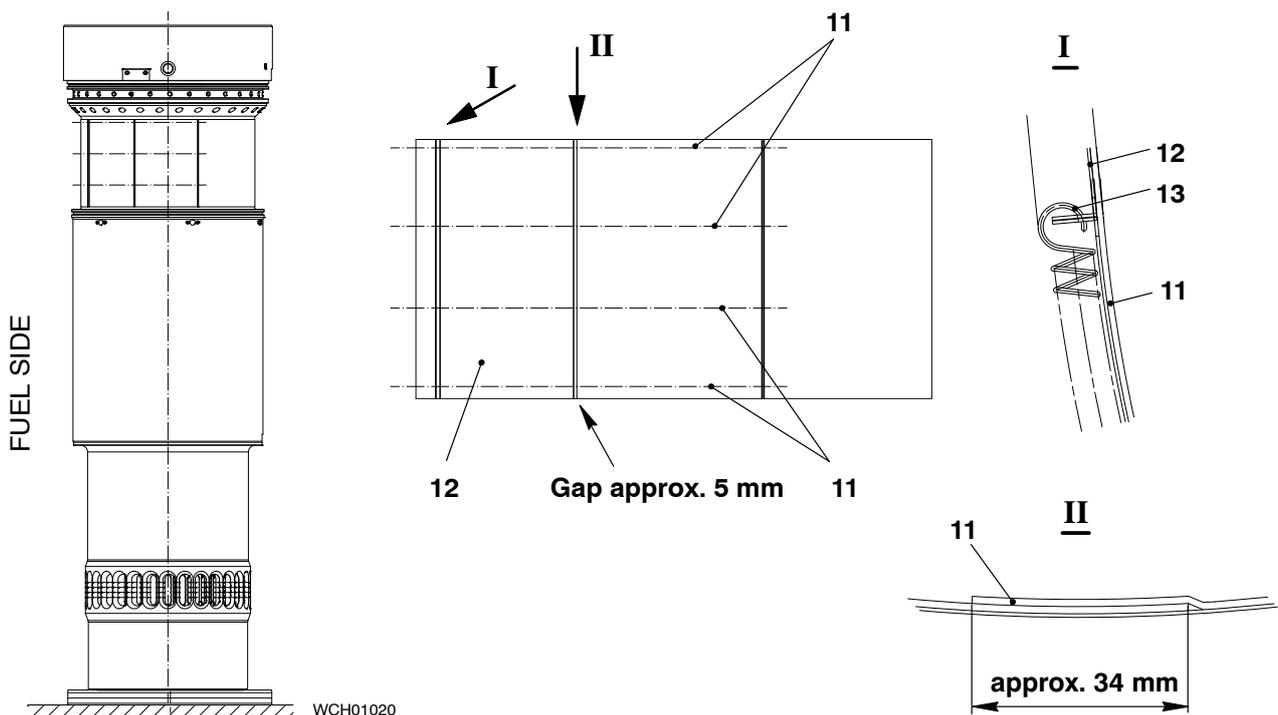
5.1 Removal

- ⇒ 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.

F



Cylinder Liner

Removal and Fitting

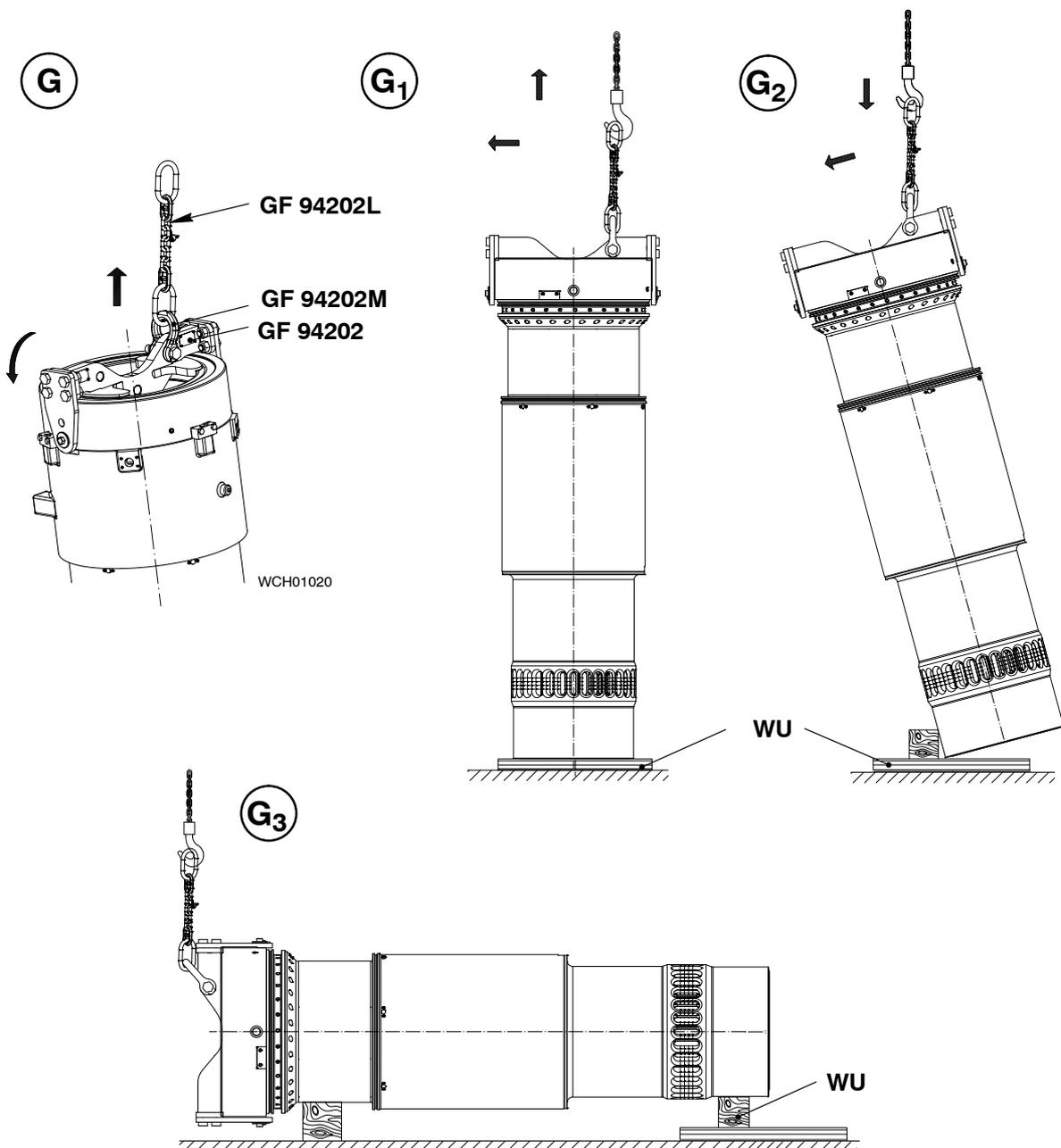
6. Laying down and raising cylinder liner

- ⇒ 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.

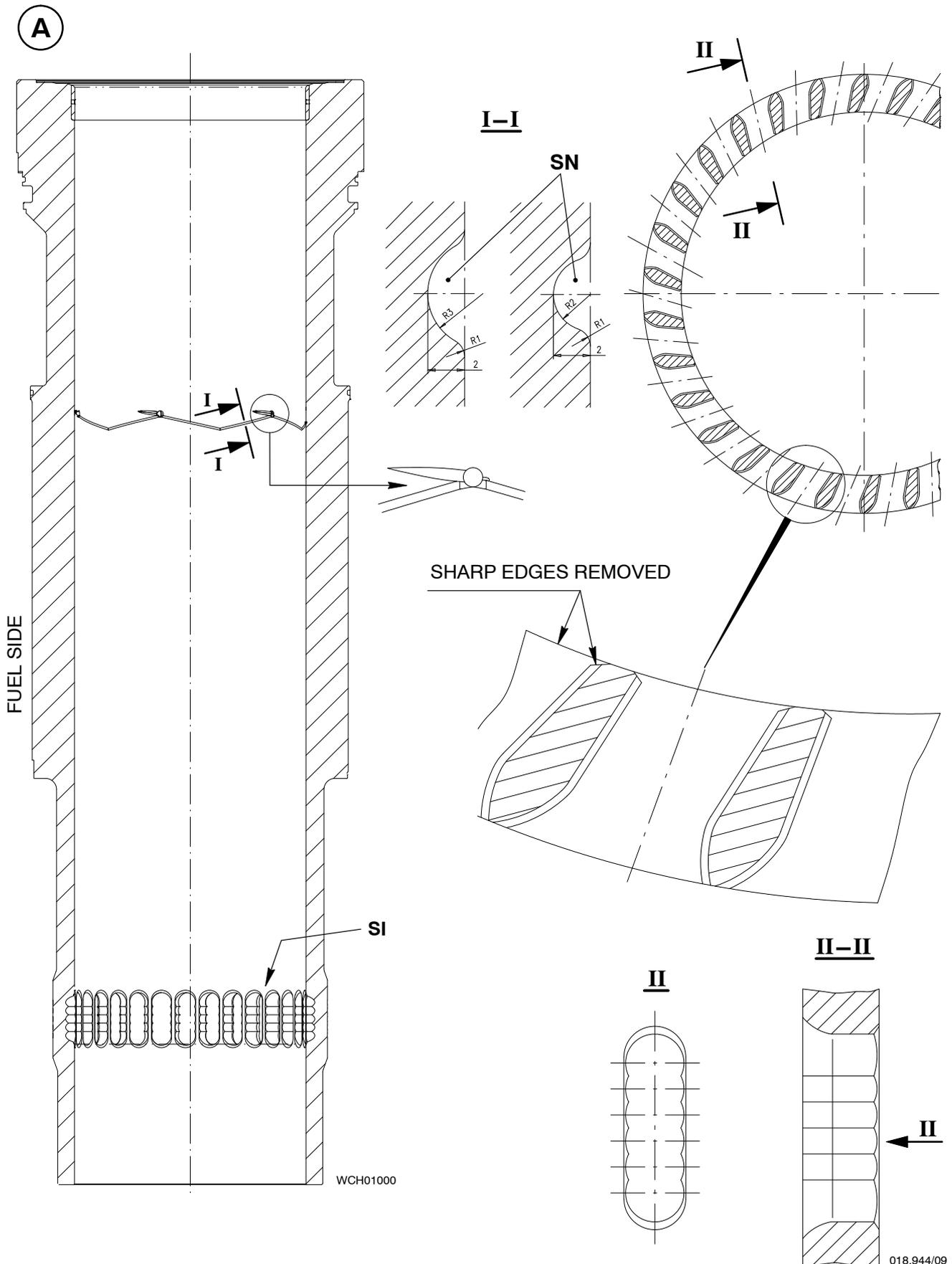


Remark: There are two possible lubricating groove-machining options according to section I–I in Fig. 'A'.

4. Re-dressing edges on scavenge ports

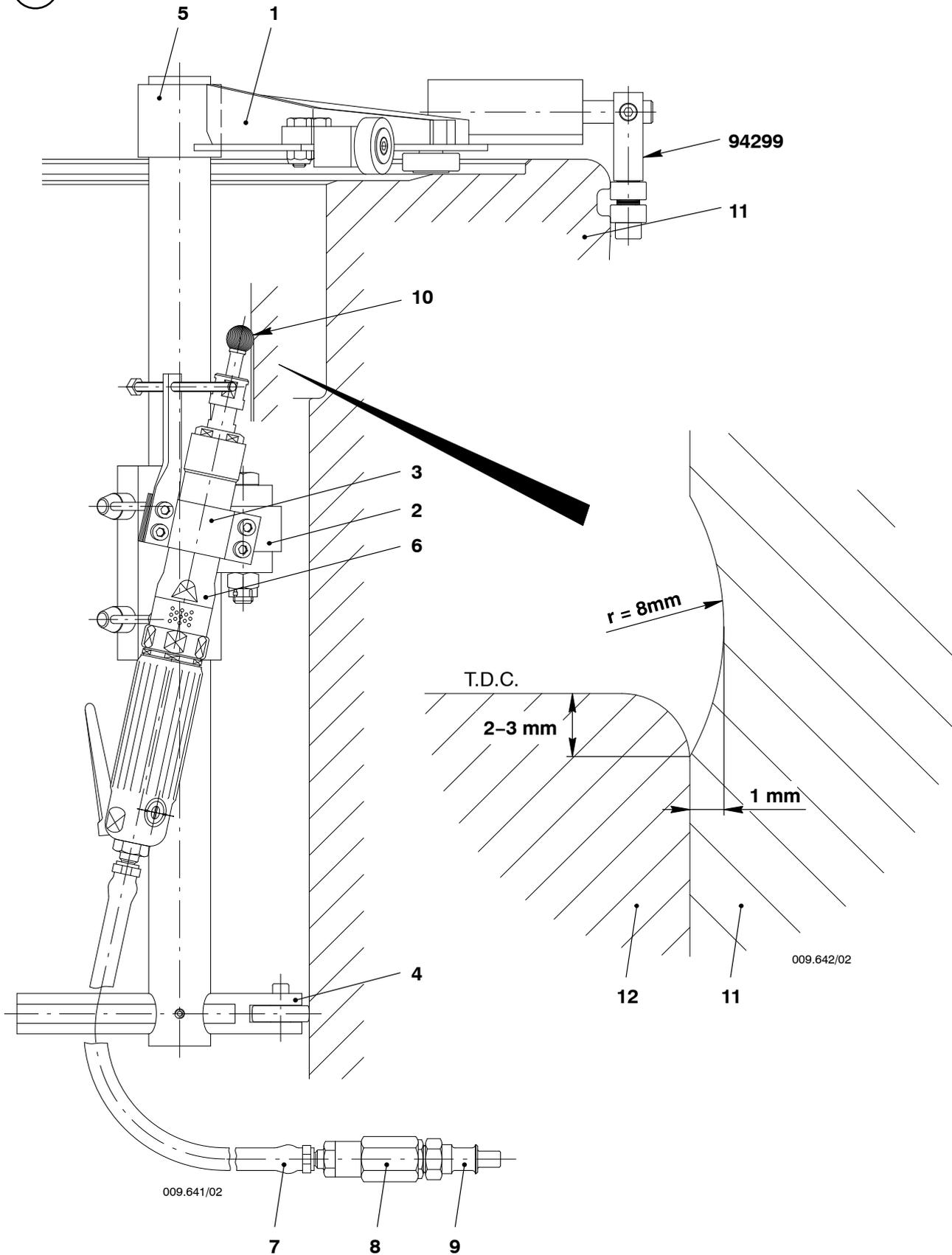
The shape of the scavenge ports shown in Fig. 'A' corresponds to new cylinder liners. When reconditioning (depending on the degree of wear or damage) aim at matching these shapes. Take care not to damage the running surface in the cylinder liner bore! Polish (round) the passages into the running surface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

Cylinder Liner: Re-dressing Lubricating Grooves and Scavenge Ports



Cylinder Liner: Removing Wear Ridge

B



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Lubricating Quill

Removal and Fitting

with Pulse Jet Lubrication

Tool:

- 1 Tool box 94720C
with fittings for charging accumulator
- 1 HP oil pump 94931
- 1 Hydr. distributor 94934H
(with pr. gauge 0...25 bar)
- 1 Connection nipple (G1/4") 94934I
- 1 HP hose 94935

Key to Illustrations:

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

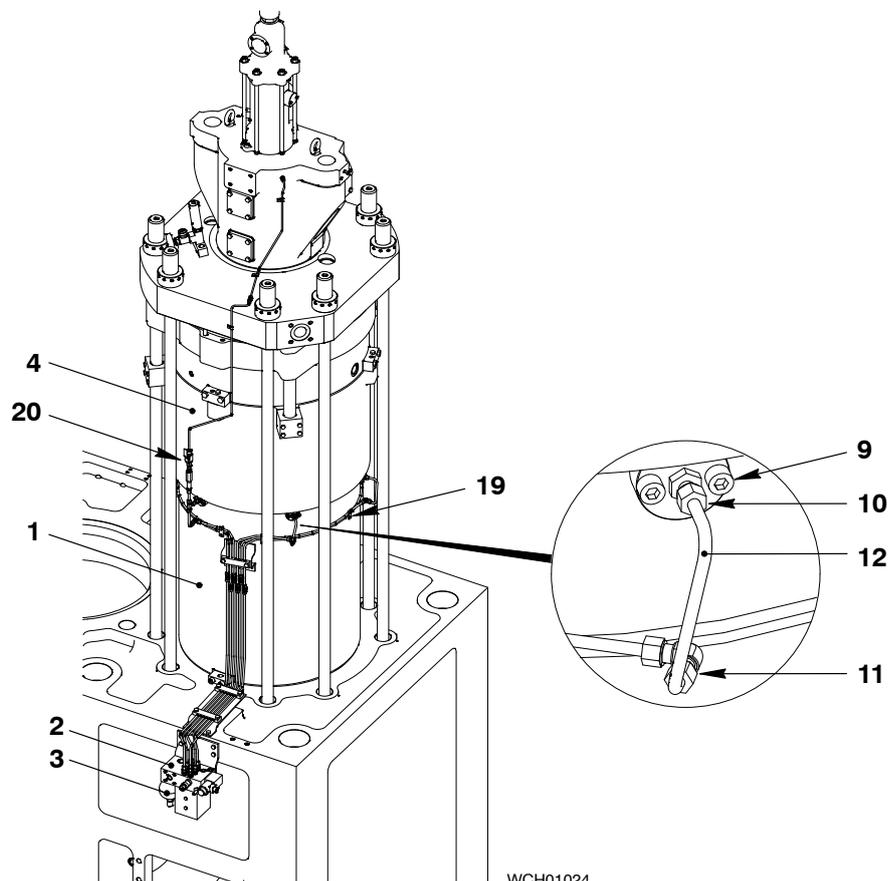
1. General

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.



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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.

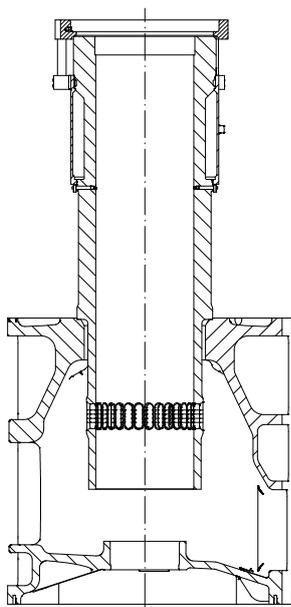
⇒ Remove lubricating quill.



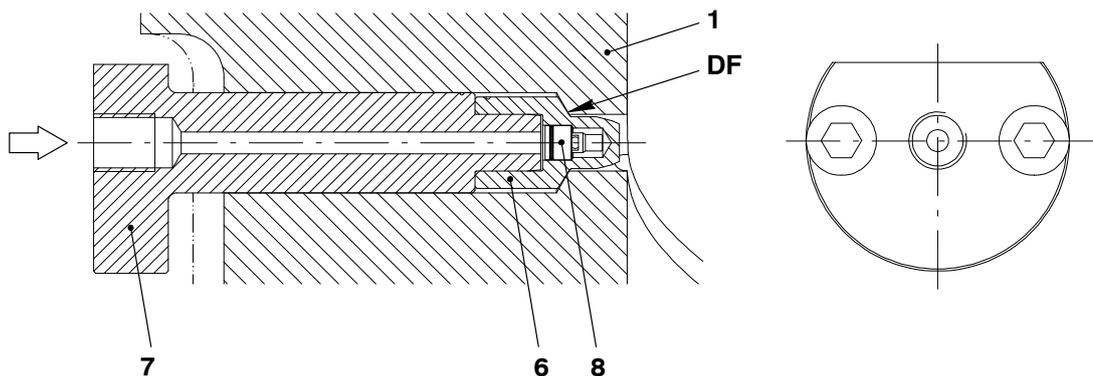
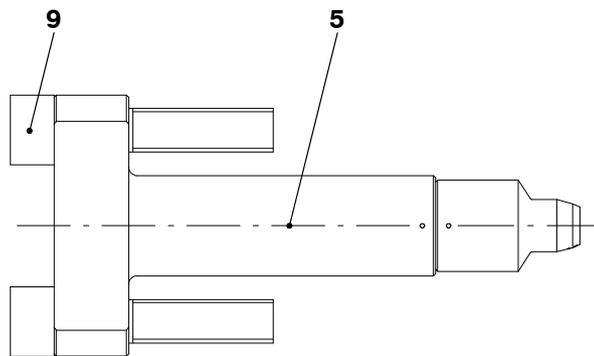
Remark: The assembly of nozzle tip / nozzle holder is based on the press fit design. **The lubricating quill must be replaced as a whole unit, i.e. nozzle tip 6 with non-return valve 8 inserted and holder 7.**

- When refitting the lubricating quill, the sealing surface 'DF' must be clean and undamaged, as it seals metalically. 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



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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.

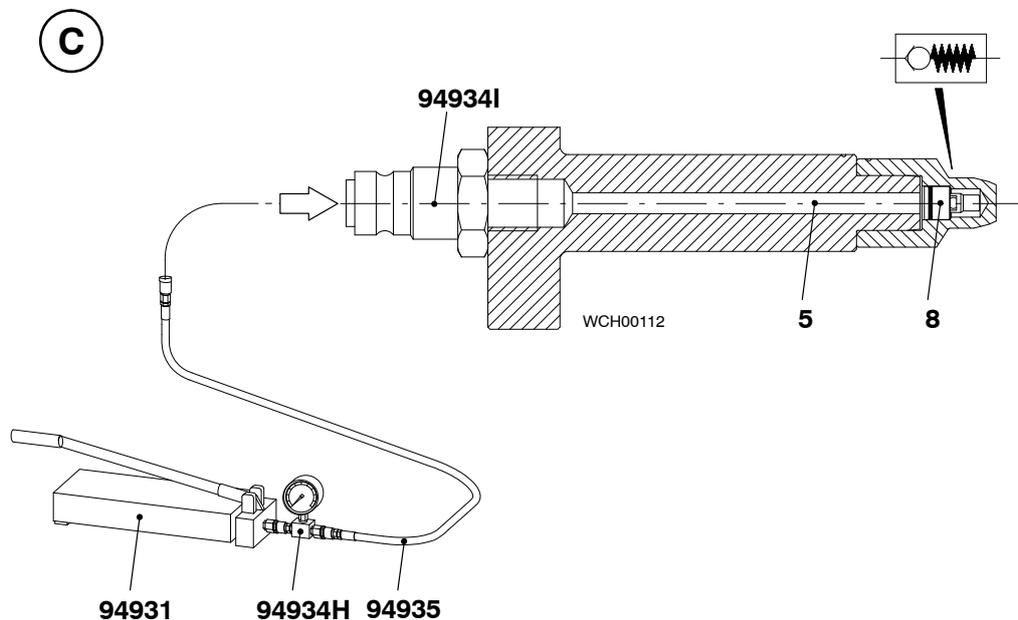
3.1 Test procedure

- 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.

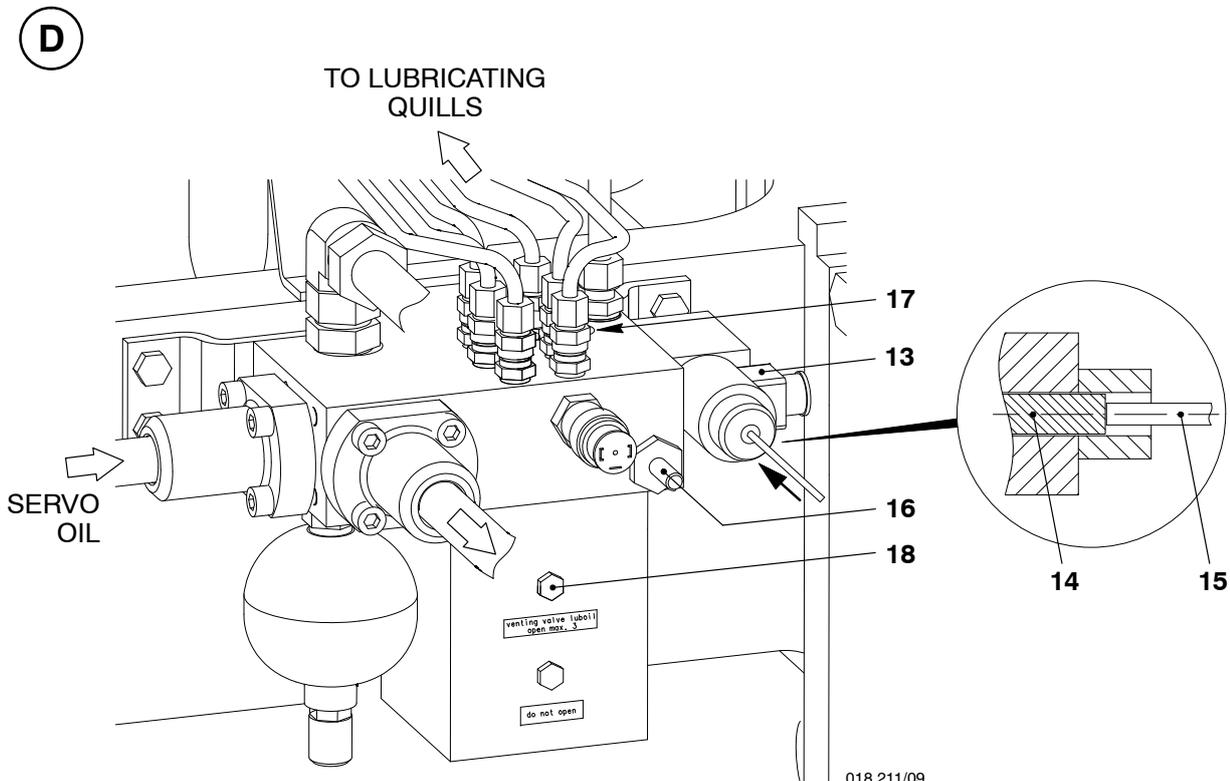
- ⇒ Select the respective cylinder number on context MANUAL LUBRICATION ON CYLINDER shown on the operator interface or manually operate 4/2-way solenoid valve 13.
- ⇒ Hold the position of the union with an open-end spanner while loosening the lower union nut by about 1 to 2 turns.
- ⇒ Push with pin 15 (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

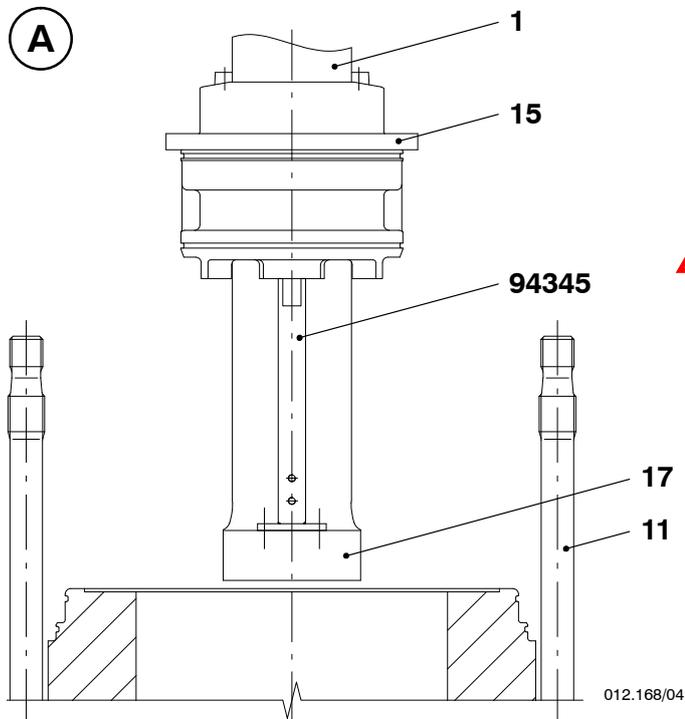
1. General

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').

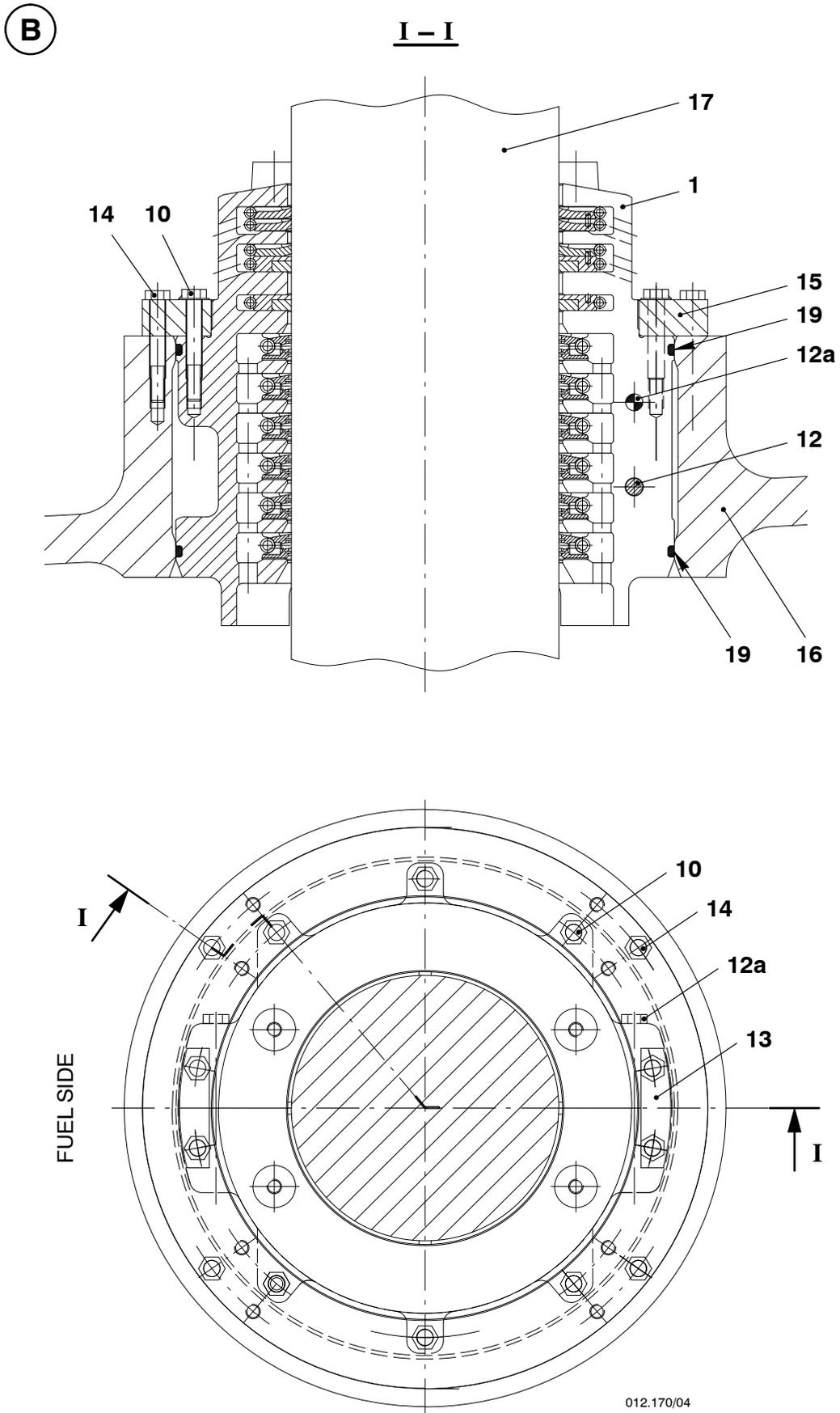
2.2 Dismantling a gland

- ⇒ 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.

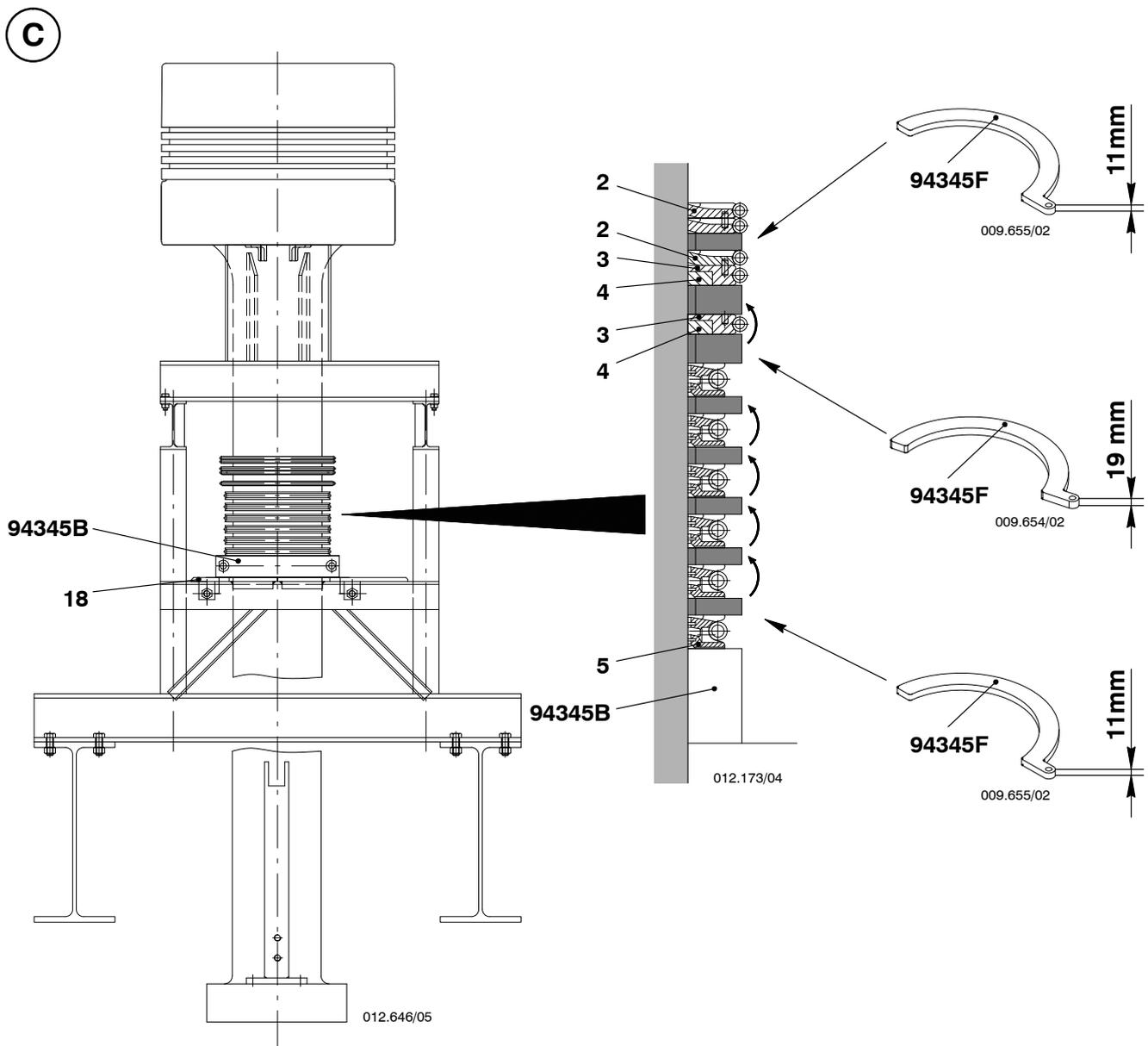
Piston Rod Gland: Dismantling and Assembling, Measuring the Wear



Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

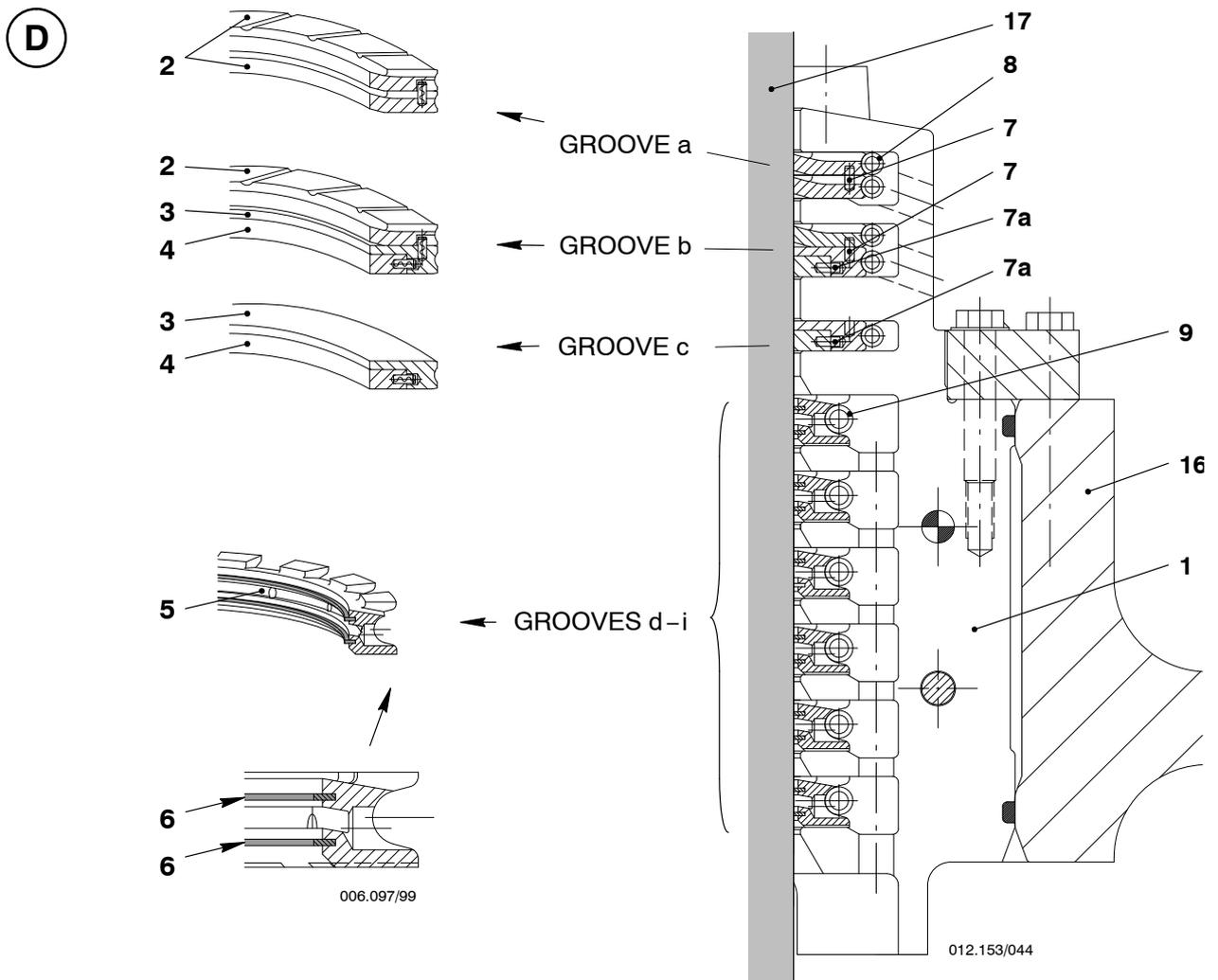
2.3 Assembling a gland

- ⇒ 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.

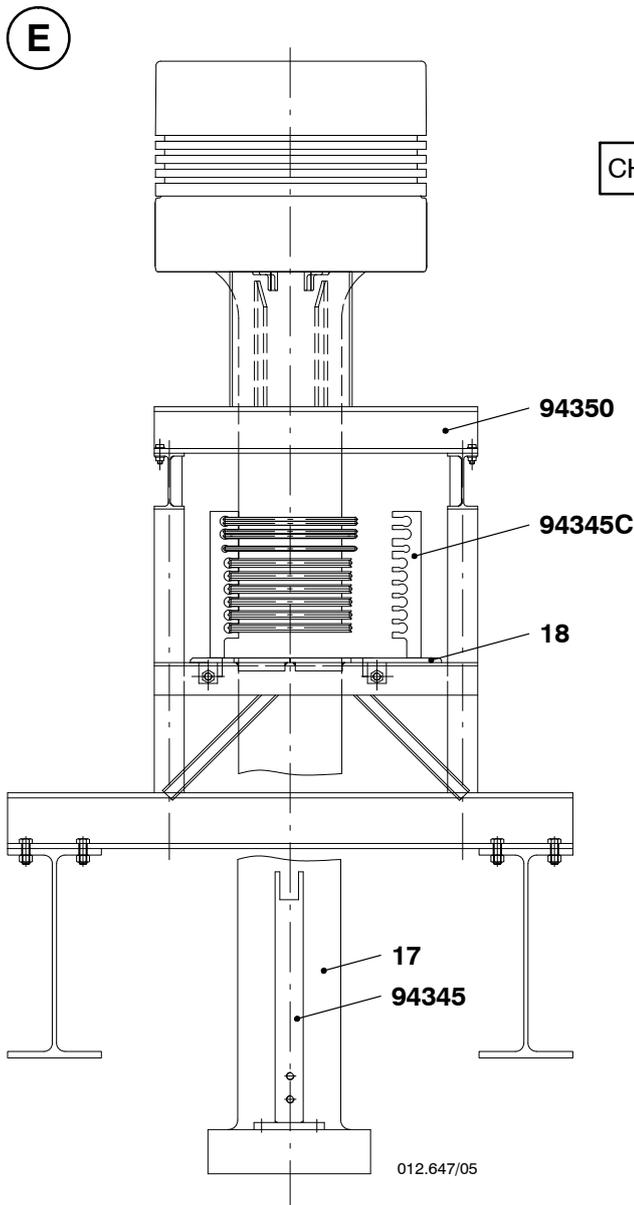


Piston Rod Gland: Dismantling and Assembling, Measuring the Wear

- ⇒ 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



⇒ 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.

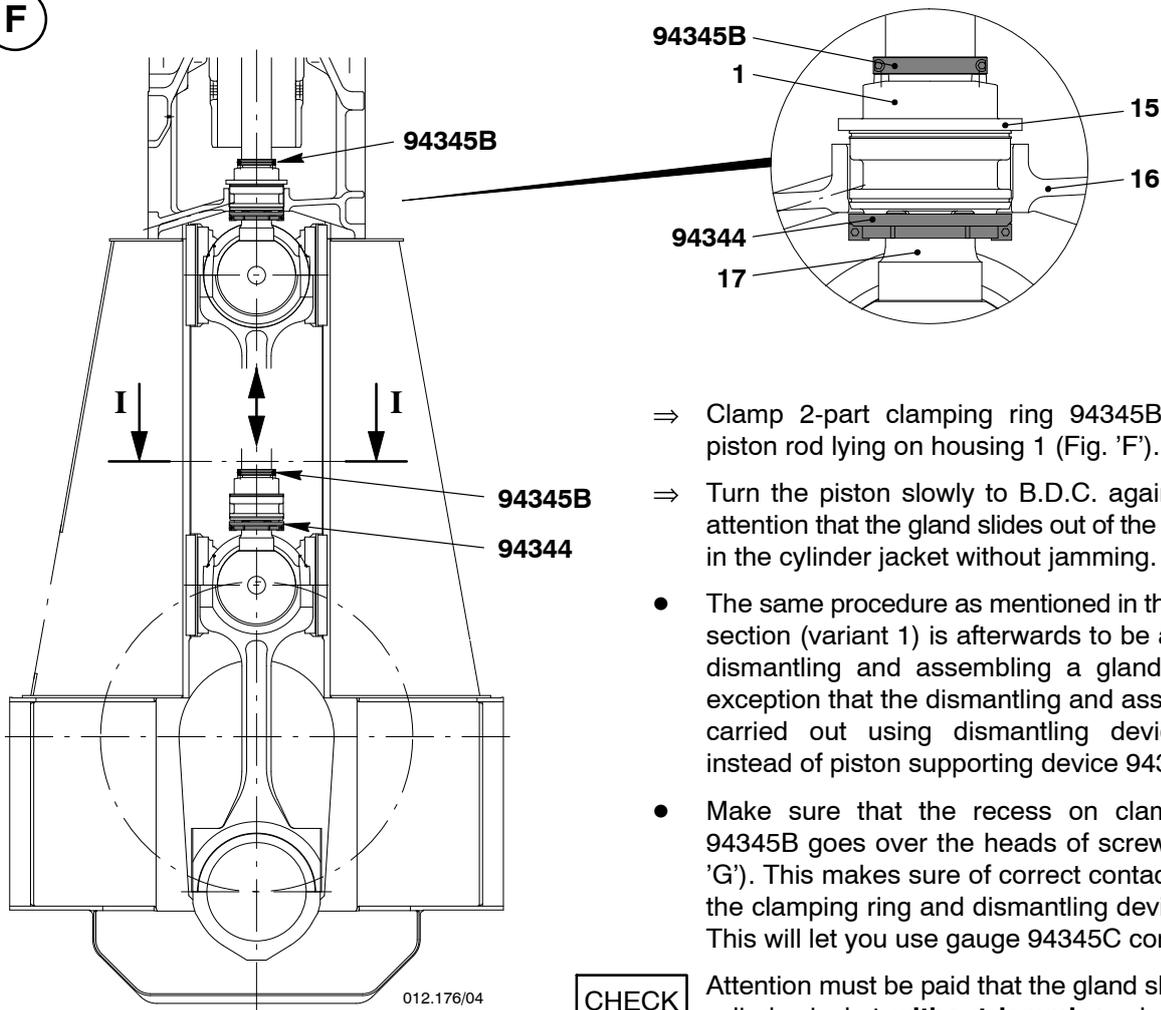
⇒ Loosen and remove the four outer screws 14 from 2-part ring 15 (Fig. 'B').

⇒ 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

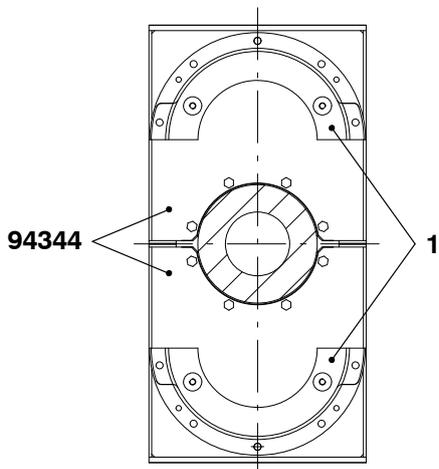


- ⇒ Clamp 2-part clamping ring 94345B onto the piston rod lying on housing 1 (Fig. 'F').
- ⇒ Turn the piston slowly to B.D.C. again and pay attention that the gland slides out of the gland bore in the cylinder jacket without jamming.
- The same procedure as mentioned in the previous section (variant 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.

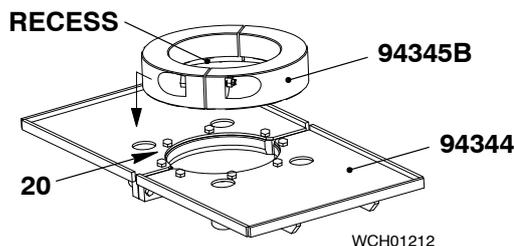
CHECK Attention must be paid that the gland slides in the cylinder jacket **without jamming** when assembling it using dismantling device 94344 and the turning gear.

- ⇒ 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:

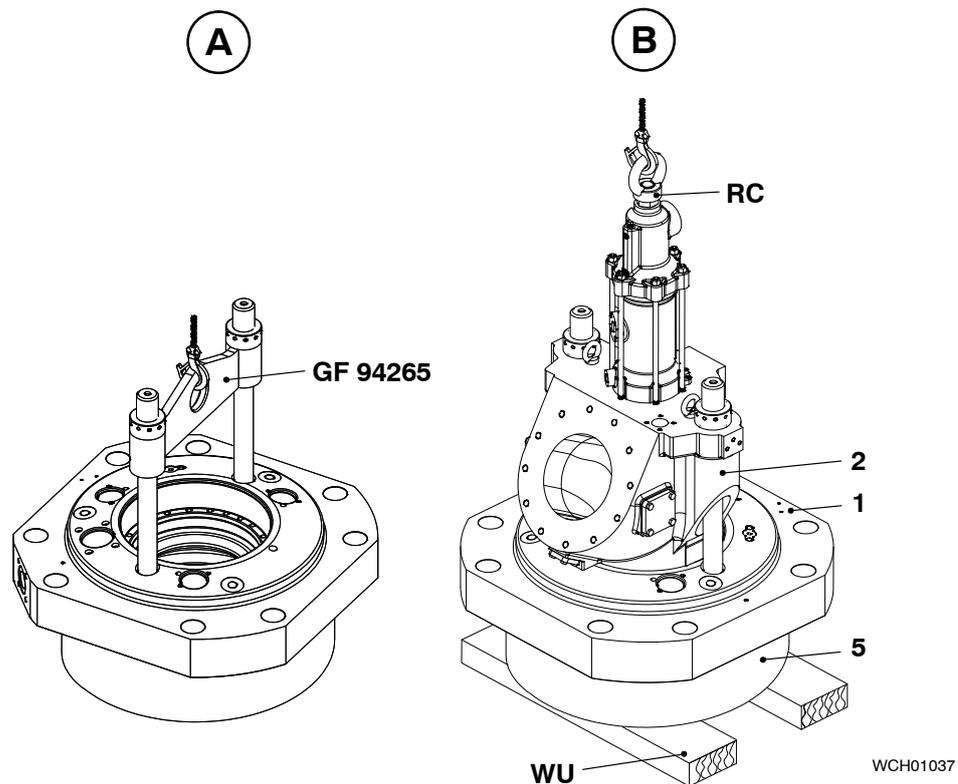
- | | |
|----------------------------|--------------------|
| 1 Cylinder cover | 8 Pad |
| 2 Exhaust valve cage | 9 Pipe |
| 3 Cylinder liner | 10-12 O-rings |
| 4 Joint ring | |
| 5 Upper water guide jacket | RC Eye bolt |
| 6 Lower water guide jacket | TH Threaded hole |
| 7 Allen screw | WU Wooden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

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

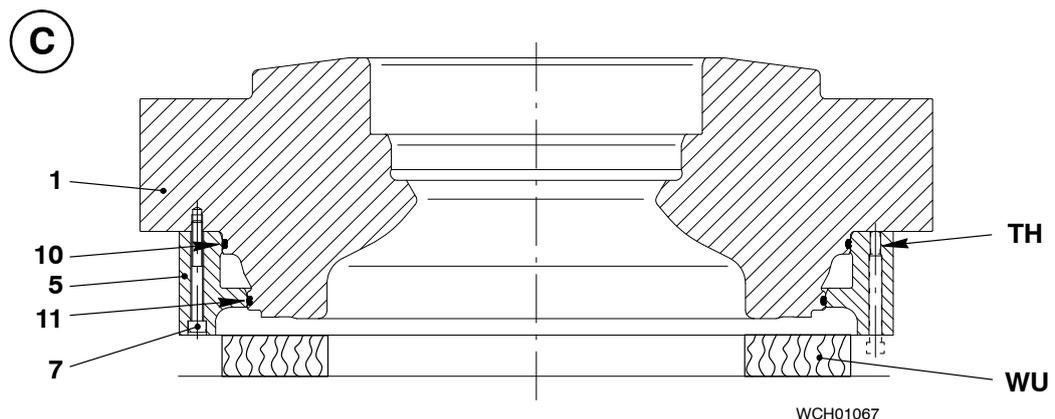
- ⇒ Drain cylinder cooling water (see Operating Manual 8017-1).
- ⇒ Disconnect all connections to the cylinder cover and to the exhaust valve as well as the expansion piece between exhaust valve and exhaust manifold.
 - Expansion piece 2751-1.
 - Hydraulic Pipe for Exhaust Valve Drive 8460-1.
 - HP Pipe to Injection Valve 8733-1.
- ⇒ Loosen nuts of cylinder cover elastic studs (see 2708-2).
- ⇒ Lift complete cylinder cover 1 with the engine crane.
- ⇒ 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

4.1 Water guide jacket

- Clean all the sealing faces and O-ring grooves.
- Fit new O-rings 10 and 11 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:

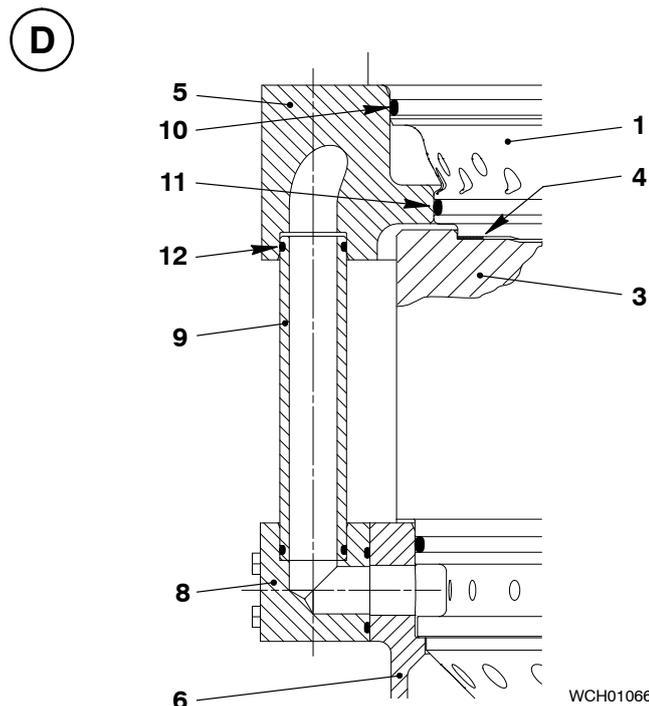
- The compression space must be absolutely free of foreign particles or dirt.
- The seating surfaces on cylinder cover and cylinder liner must be clean and undamaged.
- A new soft iron joint ring 4 of 2 mm thickness must be placed on the cylinder liner in such a way that it lies flat all over.
- Fit 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.



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Cylinder Cover

Loosening and Tensioning of Cylinder Cover Elastic Studs

Tools:

1	Hydraulic tensioning device	GF 94215
	consisting of:	
8	Pre-tensioning jacks	GF 94215
7	HP hoses	GF 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

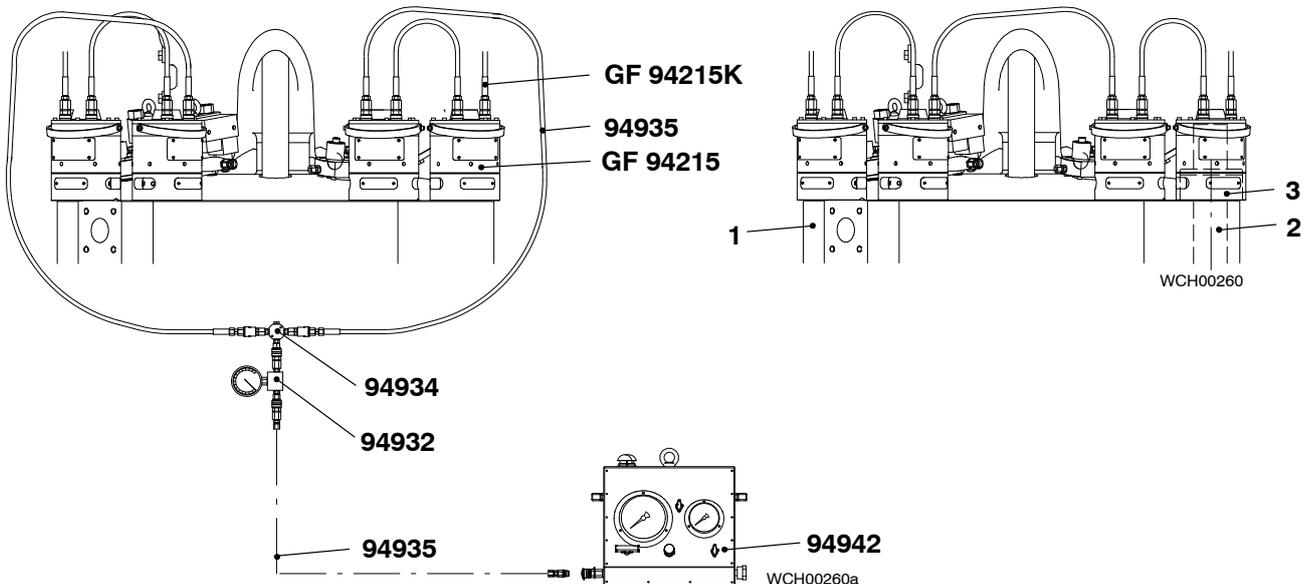
Please refer to General Application Instructions [9403-4](#) for hydraulic pre-tensioning jacks.

- Tensioning of all eight elastic 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. **380°** for comparison.

A



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 one time equally by an angle of approx. **380°**.

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 Overhauling device 94270

Key to Illustrations:

1 Cylinder cover	6 Centring mandril
2 Milling cutter holder	7 Screw
3 Guide flange	
4 Setscrews	
5 Profiling cutter	DP Depository for screw

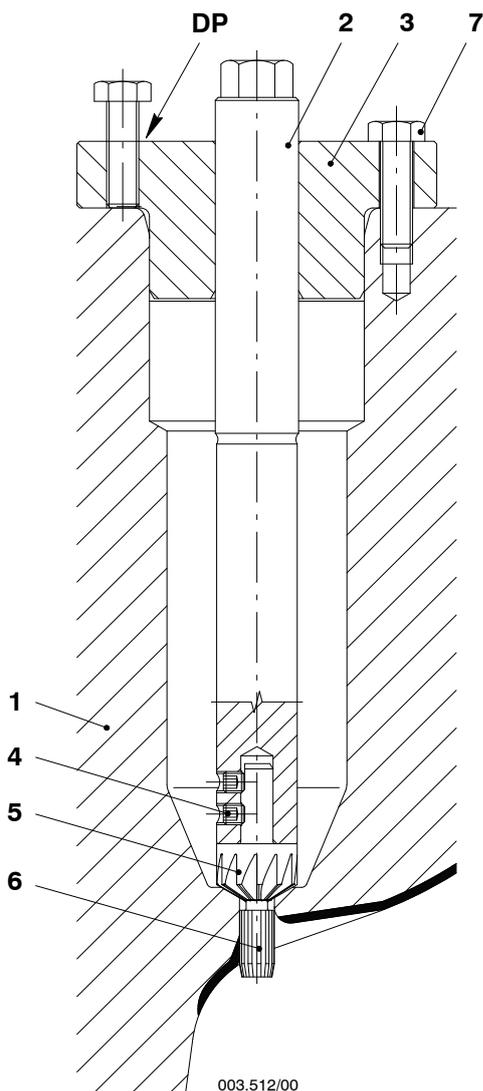
1. General

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



Should 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.

2. Machining of sealing face



Dirty or slightly damaged sealing faces can be re-conditioned on the spot by using the overhauling device 94270.

- ⇒ Carefully insert the profiling cutter, bolted to the milling cutter holder, into the hole in the cylinder cover.
- ⇒ Fasten guide flange 3 with screws 7. When the tool is being used, the centring mandril on the profiling cutter on the one hand and the guide flange on the other, give the tool the necessary stability and direction.
- ⇒ Cutting is done by pressing down lightly with the hand on the milling cutter holder at the same time as turning the hexagon evenly with the other hand using the ring spanner. Try to remove as little material as possible but sufficient, however, to obtain the desired standard for the seating area.
- Putting some sticky grease on the profiling cutter will prevent any foreign matter from entering the combustion chamber during overhaul.

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Injection Valve

Checking, Dismantling, Assembling and Adjusting

Tools:

- 1 Protection cap 94271
- 1 OBEL test bench 94272
- 1 Connecting piece 94272b

Key to Illustrations:

- | | |
|-----------------------|---------------------|
| 1 Injection valve | 14 Nozzle body |
| 2 Allen screw | 15 Retaining sleeve |
| 3 Spring plate | 16 Snap ring |
| 4 Cup spring packet | 17 Dowel pin |
| 5 Nozzle holder | 18 Dowel pin |
| 6 Collar nut | 19 Cylinder cover |
| 7 Spring tensioner | 20 Support |
| 8 Nozzle tip | 21 HP hose |
| 9 O-ring | 22 Receiver |
| 10 Tappet | 23 Dowel pin |
| 11 Retaining nut | 24 Spring cage |
| 12 Compression spring | |
| 13 Nozzle needle | LF Leakage fuel |

Overview

- | | |
|--|-----|
| 1. General | 1/8 |
| 2. Checking an injection valve | 2/8 |
| 3. Judging an injection valve | 3/8 |
| 4. Dismantling an injection valve | 4/8 |
| 5. Assembling an injection valve | 4/8 |
| 6. Adjusting the opening pressure | 6/8 |
| 7. Replacing a nozzle tip | 6/8 |
| 8. Arrangement of cup spring packet | 7/8 |
| 9. Fitting an injection valve in cylinder cover | 7/8 |
| 10. Protecting a nozzle tip | 8/8 |
| 11. Storage and handling of injection valve | 8/8 |

1. General

For checking, dismantling, assembling and adjusting the injection valve, test bench 94272 as well as test & calibration fluid has to be used (e.g. Shell Calibration Fluid S.9365) complying with the data according to the following table:

Physical characteristics for test & calibration fluid:

Kinematic Viscosity		ASTM D445	
at 40 °C	mm ² /s		2.6
Density at 15 °C	kg/m ³	ISO 12185	827
Pour Point	°C	ISO 3016	-27



Remark: Clean diesel oil (gas oil) can be used if no calibration fluid is available. The use however is not recommended, if the injection valve will be stored and not directly installed on the engine (corrosion reasons).

On some injection valves the leakage flow amount might be bigger than on others. In case of the test bench flow is not sufficient to open the nozzle needle, a clean additive-type crankcase (system) oil of the SAE 30 viscosity grade (for additional data see 0750-1 'System oil' in the Operating Manual) can be used for testing instead of the above mentioned fluids.

Injection Valve: Checking, Dismantling, Assembling and Adjusting

2. Checking an injection valve

Before commissioning the instructions and directions of the test bench manufacturer must be observed.

CHECK



From time to time check the pressure gauges of the test bench with a master pressure gauge and adjust them if necessary.

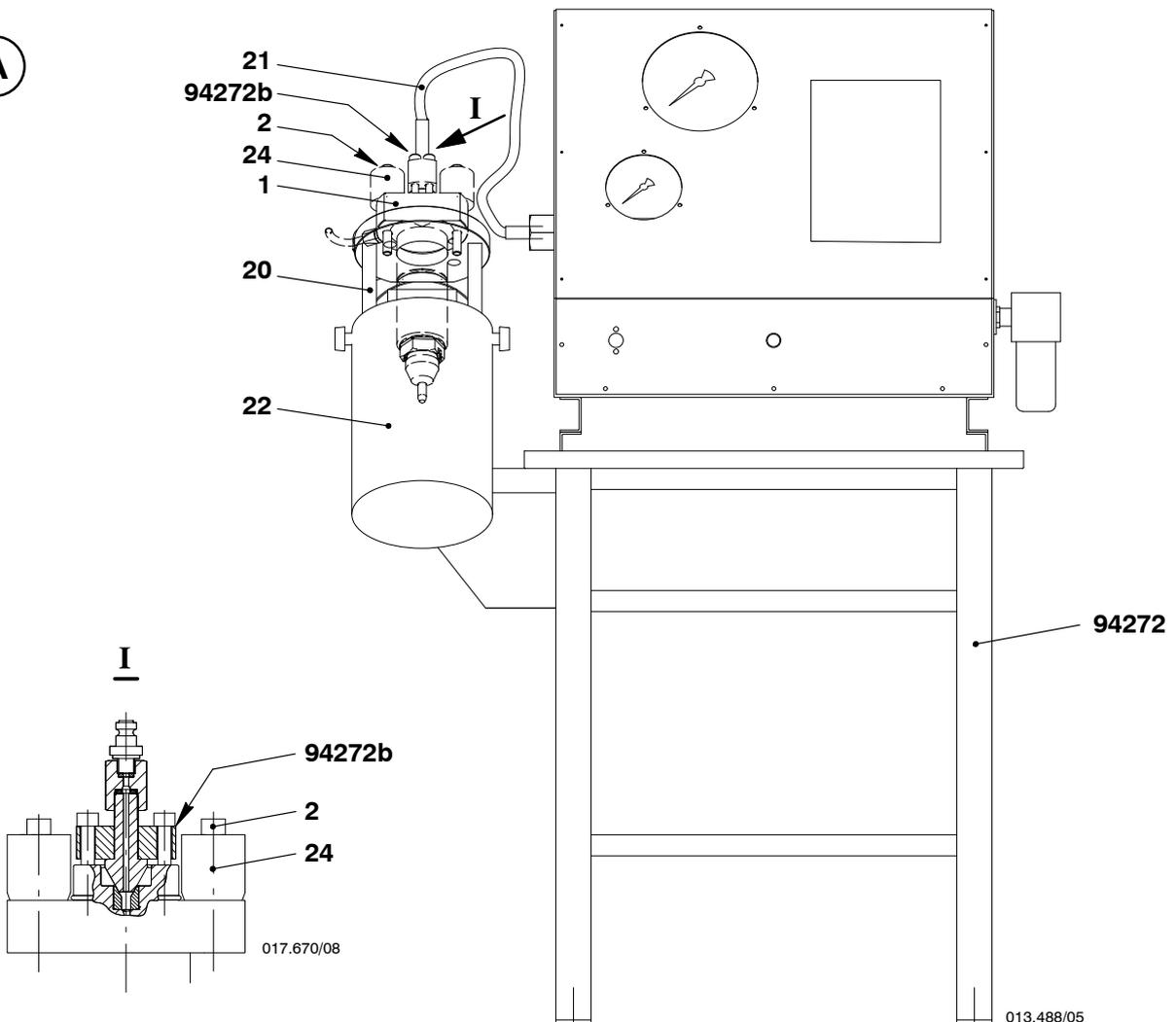
Remark: The work station must be clean; welding and grinding should not be done nearby!

- ⇒ Remove combustion residues and clean nozzle tip externally with a brass wire brush.
- ⇒ Place injection valve 1 with nozzle tip pointing downwards into support 20 of test bench 94272 and fasten it with two Allen screws 2 and spring cages 24.
- ⇒ Tighten high pressure hose 21 of the test bench with connecting piece 94272b.
- ⇒ Start the test bench following the proper manufacturer's instructions.
- ⇒ Bring the injection valve to spray with a few short pump jerks, and then observe at what pressure the injection valve opens, applying slow, equal pump jerks.



Danger of injuries! Never hold fingers or hands directly before the spray holes of the nozzle tip!

A



Injection Valve: Checking, Dismantling, Assembling and Adjusting

3. Judging an injection valve

For correct functioning and for a reuse of an injection valve observe the following points:

- Spray pattern: Fuel will spray mainly from the holes in the first level of the nozzle tip at the specified opening pressure. No fuel should drip from nozzle tip when injection is finished.
- For **new** injection valves the opening pressure is **375 ± 5 bar**.

On **used** injection valves a pressure reduction of 30 bar may be acceptable. Should 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. 'B') with poor sealing faces must either be replaced or reconditioned by the manufacturer or a special company.

Injection Valve: Checking, Dismantling, Assembling and Adjusting

4. Dismantling an injection valve

- ⇒ Remove receiver 22.
- ⇒ Screw down the injection valve on support 20 of test bench 94272, as mentioned, however without connecting HP hose 21 to the injection valve.
- ⇒ Loosen collar nut 6 and unscrew spring tensioner 7 until the compression spring 12 is completely released (Fig. 'B').
- ⇒ Turn valve holder through 180° into vertical position.
- ⇒ Place the special tool of the test bench onto retaining nut 11 and loosen it with the press of the test bench.
Note test bench manufacturer's application instruction!
- ⇒ Remove retaining nut 11, nozzle tip 8, retaining sleeve 15, nozzle body 14 and nozzle needle 13.

CHECK

Examine all parts for their condition.

Remark: If only a nozzle tip 8 has to be replaced, see section 7.

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

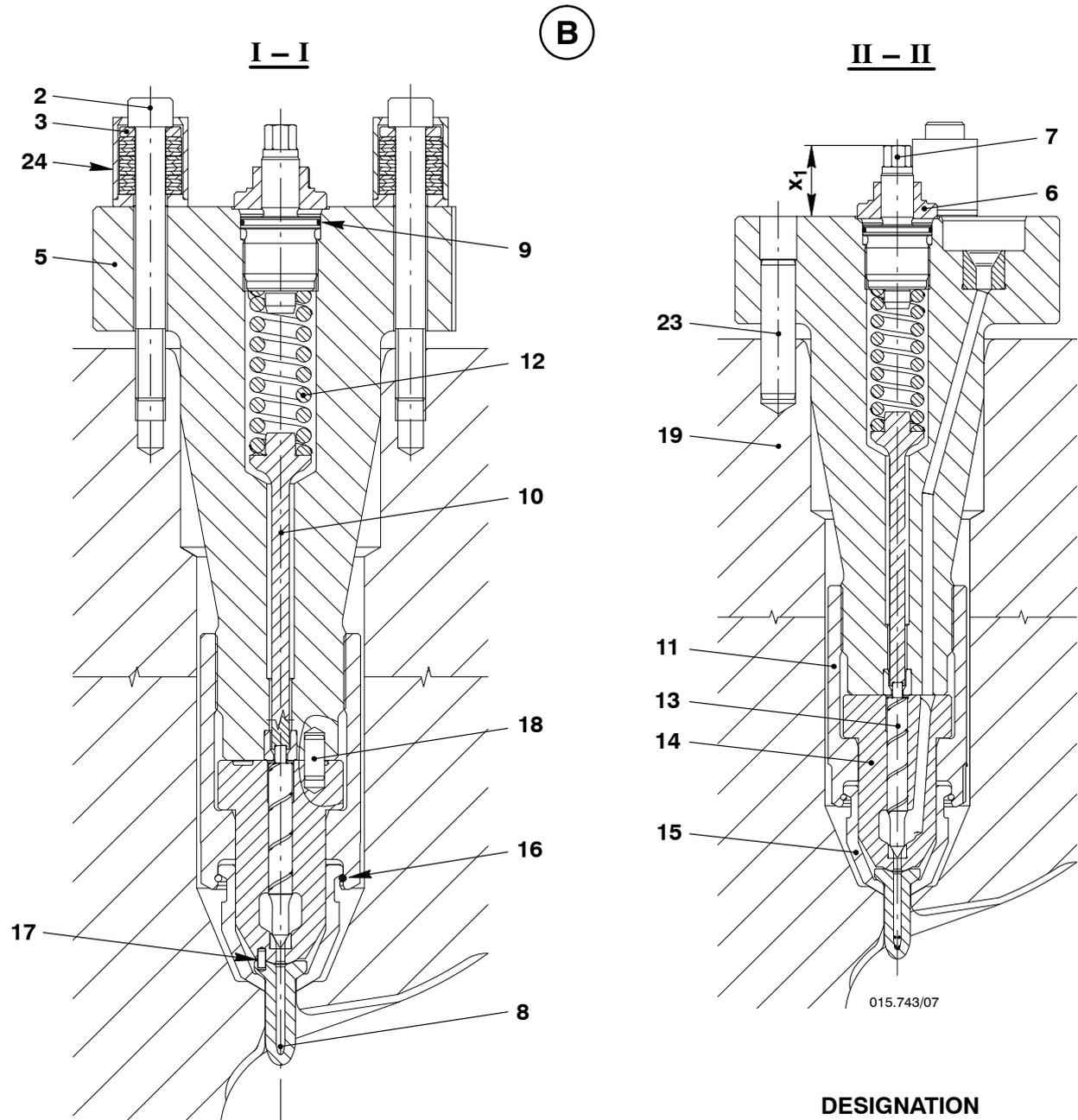
To assemble an injection valve, follow generally the reverse sequence of the dismantling process, but note also the following points:

- ⇒ To clean 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 17 and 18 (Fig. 'B').
- ⇒ Make sure that the sealing faces 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 of retaining nut 11.
- ⇒ First tighten retaining nut 11 to **100 Nm** using a torque wrench. Starting from this position, tighten the retaining nut by a further angle of **30°** by means of the hydraulic tightening (or loosening) device of the test bench.
- Repeat the tightening procedure on the initial assembly.
- An angle of 30° corresponds to 16.8 mm on the circumference relating to a nut diameter of 64 mm.

CHECK

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

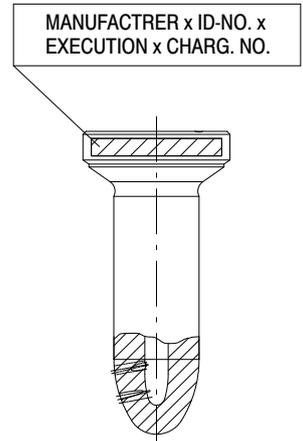
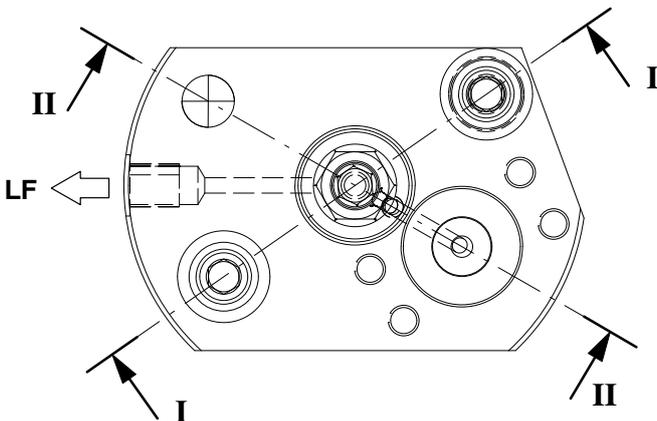
Injection Valve: Checking, Dismantling, Assembling and Adjusting



015.743/07

DESIGNATION OF NOZZLE TIP

MANUFACTURER x ID-NO. x EXECUTION x CHARG. NO.



Injection Valve: Checking, Dismantling, Assembling and Adjusting

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.

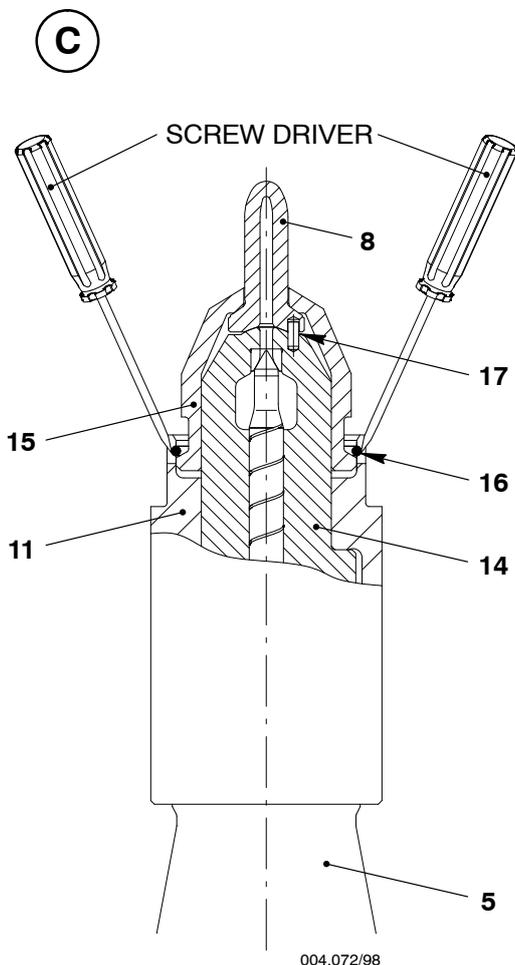


Remark: An opening pressure of 375 bar corresponds with reference dimension 'x₁' = 33.05 mm .

7. Replacing a nozzle tip

Ensure that always specified nozzle tips are used in accordance with the IMO technical file of the engine or the shoptest protocol.

If the nozzle tip 8 should be dismantled only, it is sufficient to remove the retaining sleeve 15.

**7.1 Removal**

- ⇒ Using two screw drivers inserted between both recesses in retaining nut 11, press snap ring 16 out of the groove in the retaining nut, whereby the retaining sleeve can be withdrawn.
- Watch that the snap ring does not jump off unexpectedly.
- ⇒ Remove nozzle tip.

7.2 Fitting

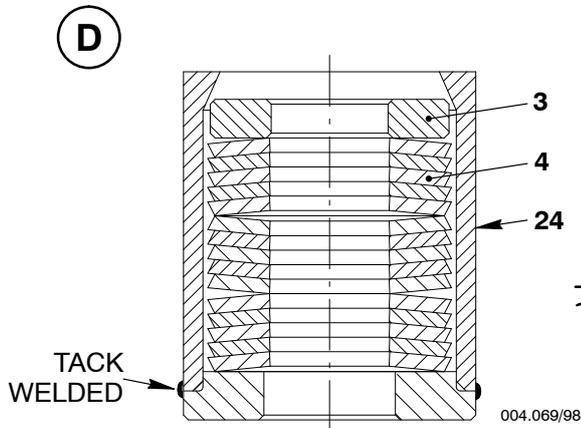
For fitting it is advantageous to clamp the injection valve on its flange into a vice (nozzle body 14 pointing upwards), and then proceed as follows:

- ⇒ Clean all parts with clean diesel oil or kerosine and blow them out with compressed air.
- ⇒ Place nozzle tip on the nozzle body whereby the position is assured by dowel pin 17.
- ⇒ Put retaining sleeve 15 over the nozzle tip, and press snap ring 16 into the groove of the retaining nut by means of the screw drivers.

After replacing a nozzle tip the injection valve must be checked and judged according to sections 2 and 3.

Injection Valve: Checking, Dismantling, Assembling and Adjusting

8. 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 24 as shown in Fig. 'D'.



Remark: 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

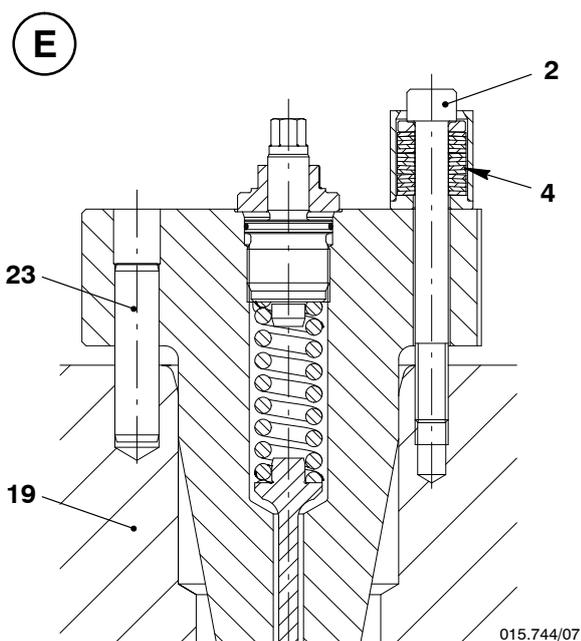
Clean the seating surface of the injection valve in the cylinder cover and check for damages.

If necessary recondition the seating surface using the special tool supplied with the tools set (see 2708-3).



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 23 assures the correct position.



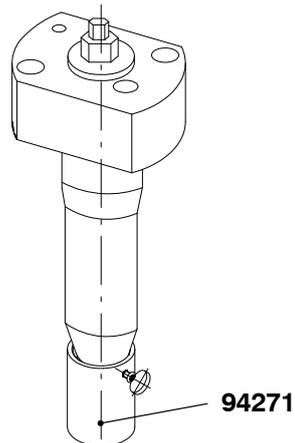
9.1 Screwing down the injection valve

- ⇒ Apply Never-Seez NSBT-8 to the threads and the seating surfaces of Allen screws 2.
- ⇒ Press the injection valve onto its seat in cylinder cover 19 by equally tightening 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.

Injection Valve: Checking, Dismantling, Assembling and Adjusting

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.

F**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	RC Eye bolt
11 Compression spring	

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° .



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.

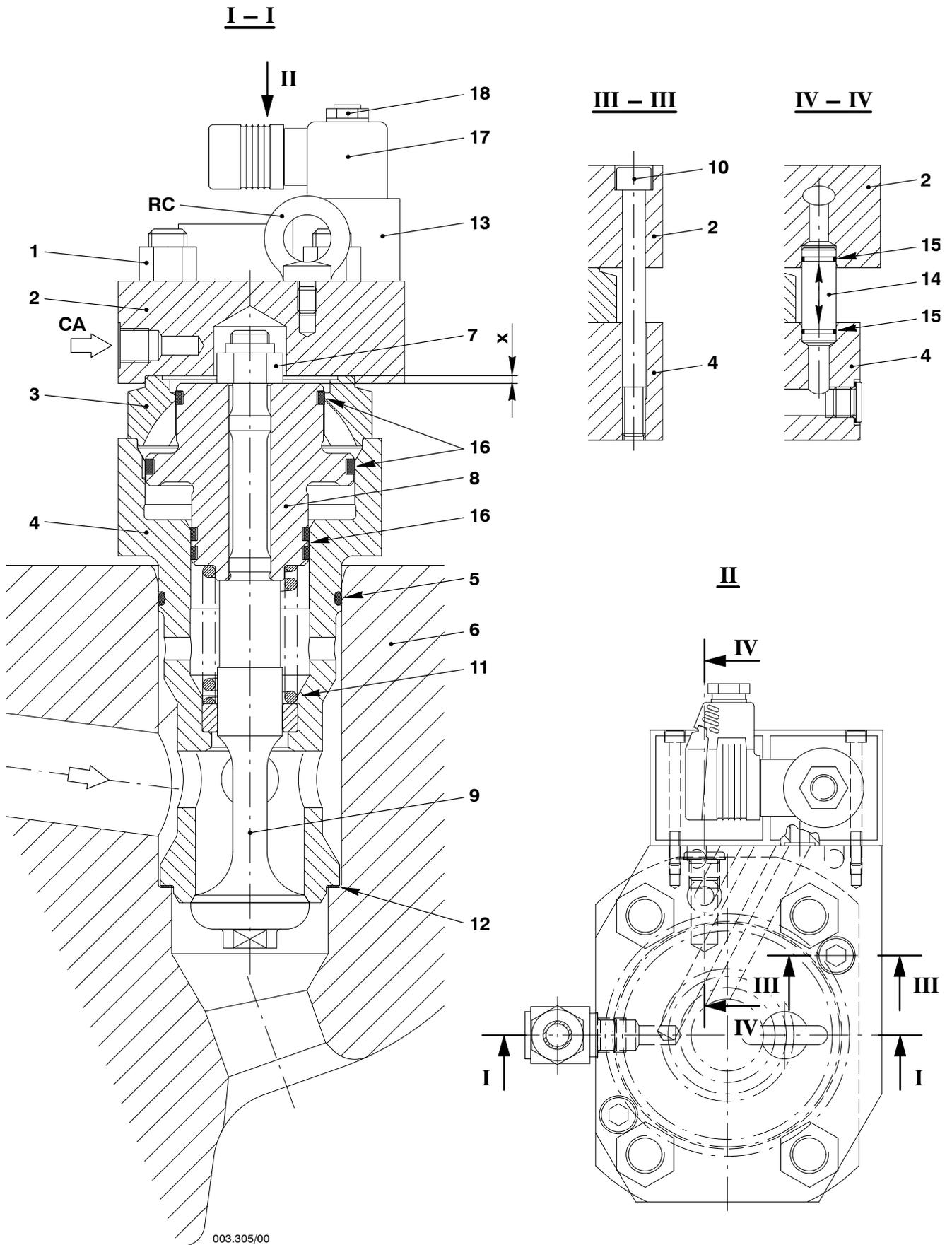
Clearance 'x' must be minimum 1 mm.

- ⇒ 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		

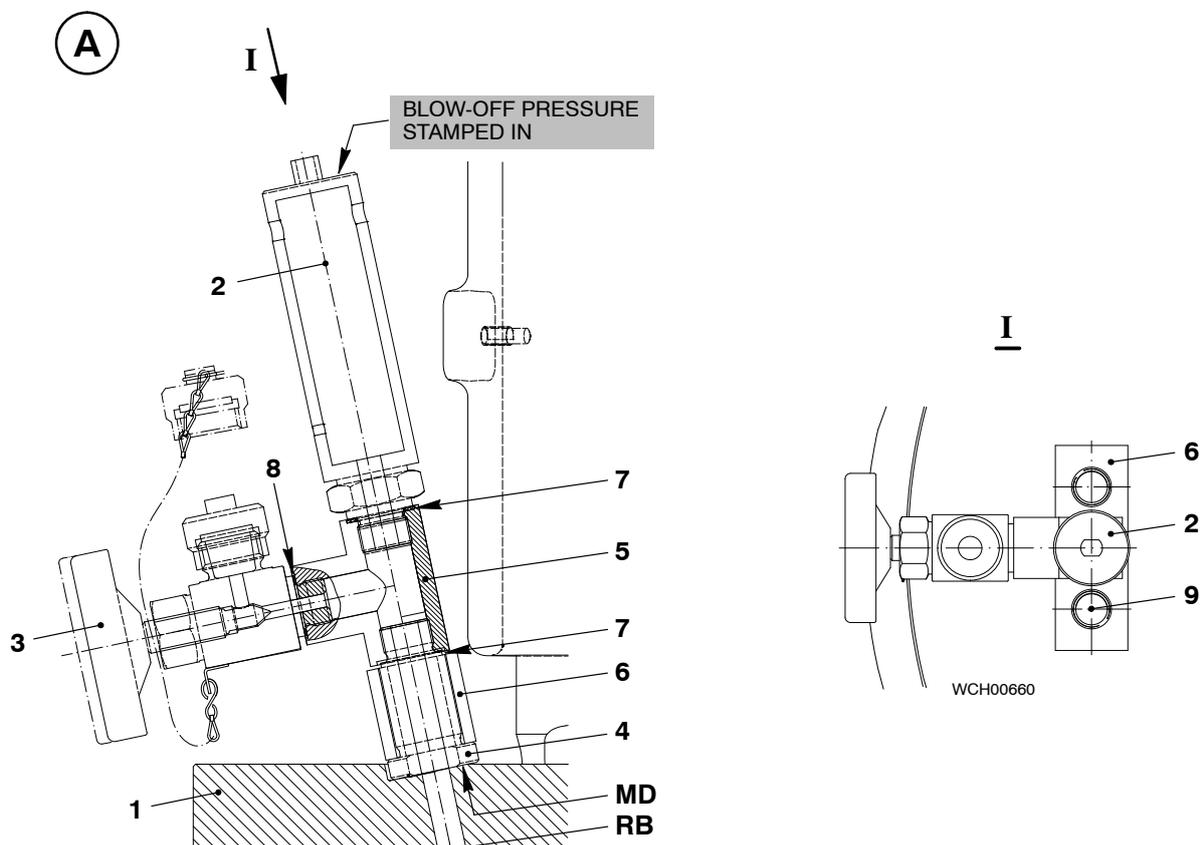
1. General

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.

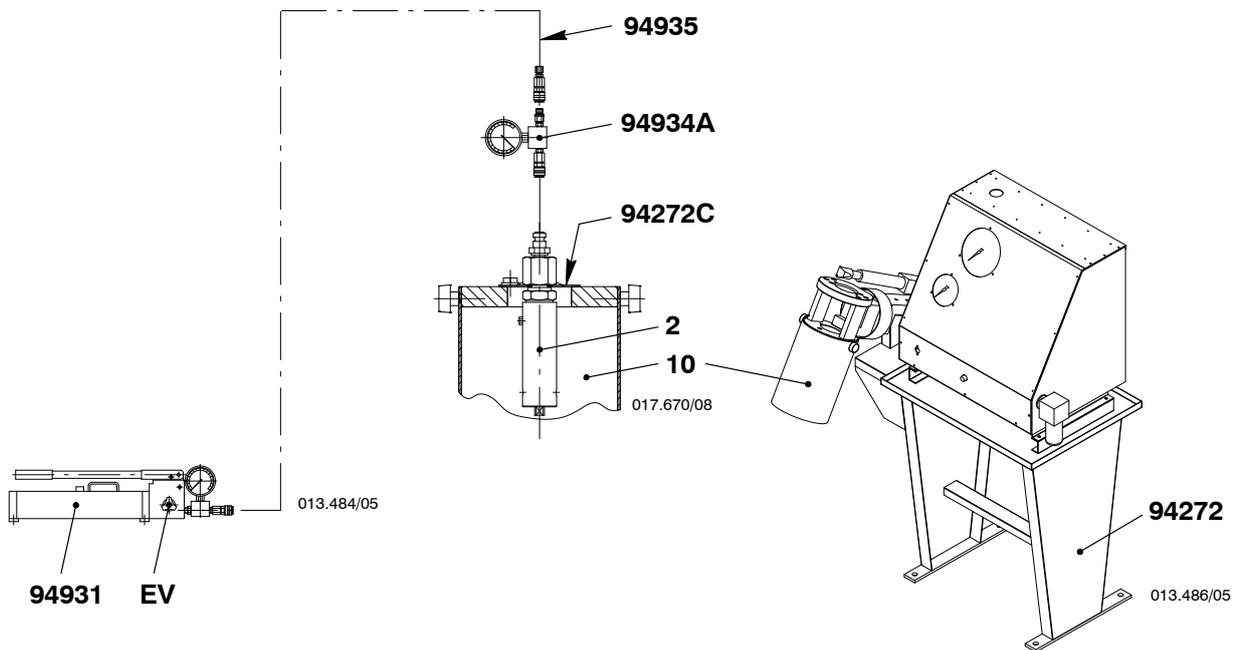


Remark: Pay attention to the manufacturer's detailed instructions and working specifications of the test bench.

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	RC	Eye bolt
4	Valve seat	RS	Round bar
5	Valve spindle		

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'.

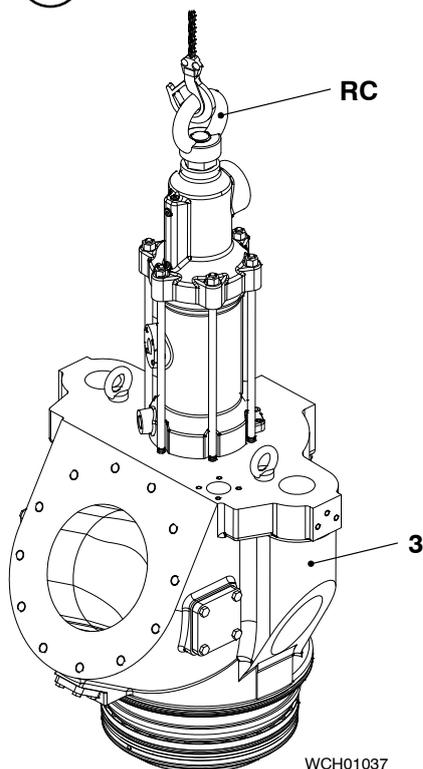
The valve cage must be suspended as shown in Fig. 'A'.



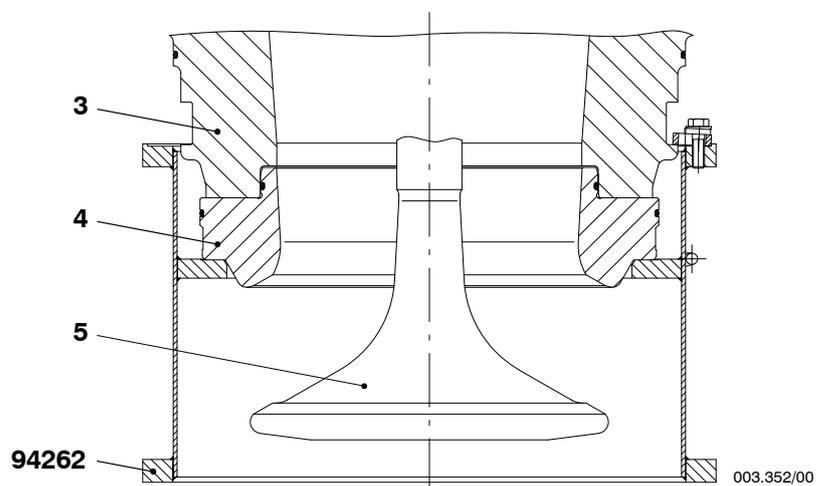
Remark: Pay attention to:

- 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.

A



B



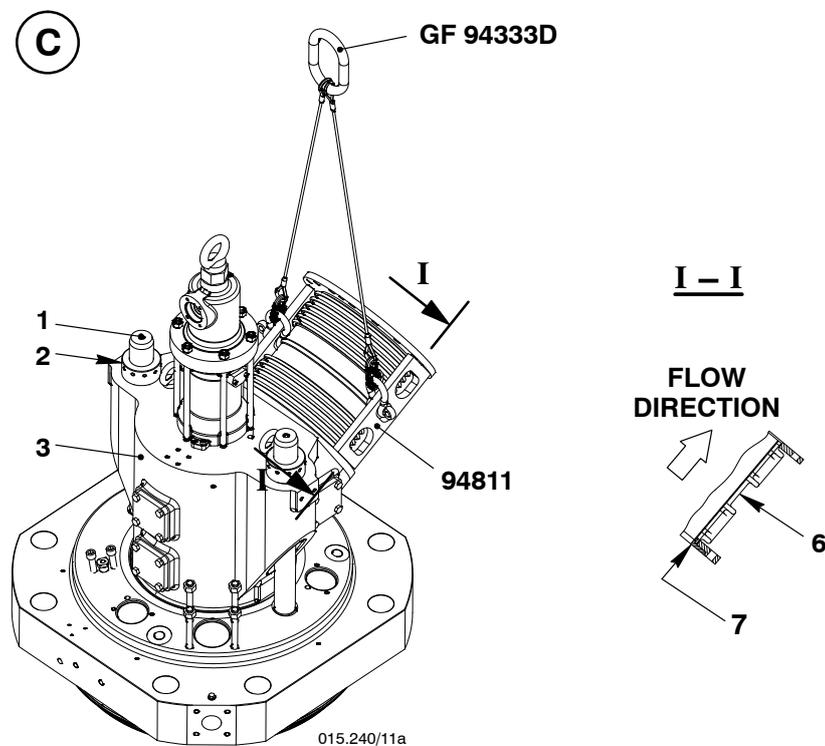
Removal and Fitting of Exhaust Valve, Replacing of Elastic Studs

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'.

Removal and Fitting of Exhaust Valve, Replacing of Elastic Studs

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.



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

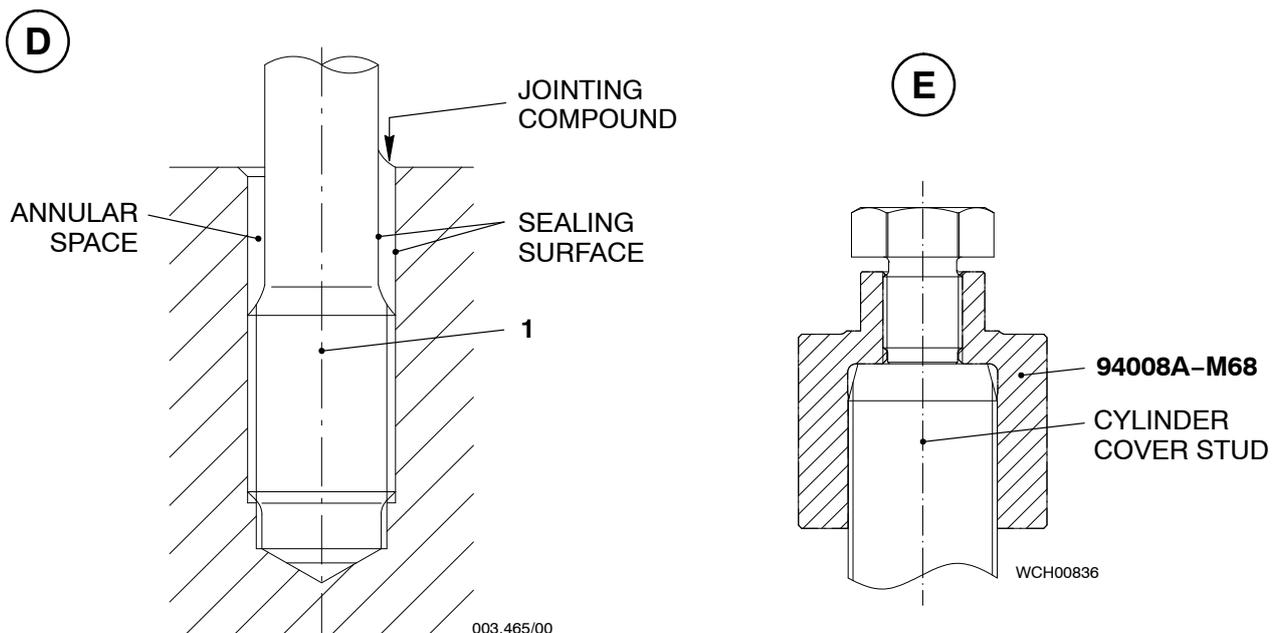
⇒ Screw in the stud right to the bottom and until it rests on its seating surface and tighten it according to instructions 0352-2 using always a stud driver or two counter locked nuts. Tool 94008A-M68 must be used for the cylinder cover stud.



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



Removal and Fitting of Exhaust Valve, Replacing of Elastic Studs

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 Wylde 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:

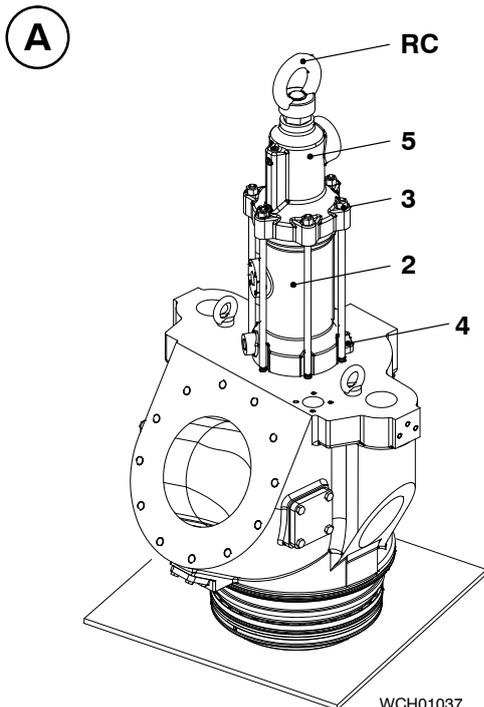
- 1 Depth gauge 94124
- 1 Pressure element GF 94259
- 2 Jack screws 94263

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.

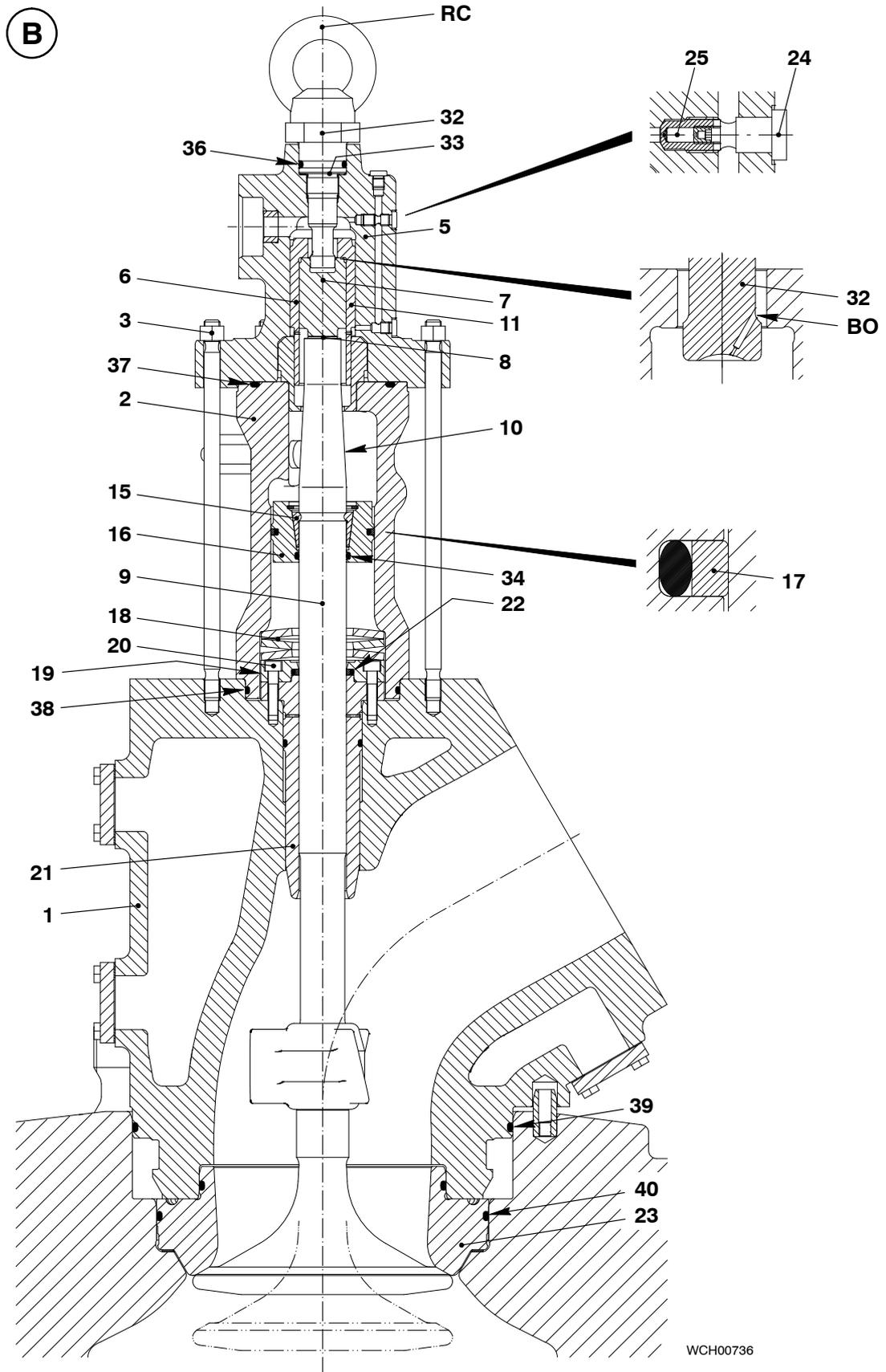
Defective exhaust valves may, however, only be repaired or reconditioned by qualified personnel or a Wärtsilä Switzerland Ltd. authorized repair workshop.

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**

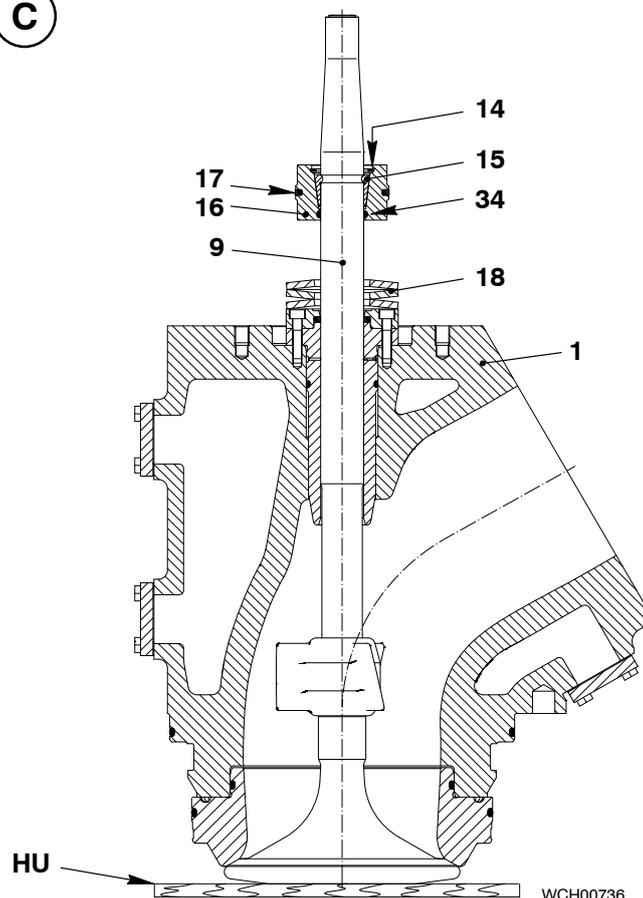
Attention! During dismantling and assembling, the activity area has to be clean and as dust-free as possible (grinding dust etc.), and performing electric welding must absolutely be omitted near or on the engine.

- ⇒ 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.

(C)



Exhaust Valve: Dismantling and Assembling

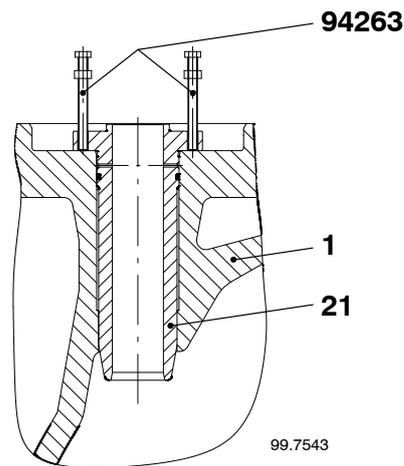
2.3 Removal of guide bush

- ⇒ 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

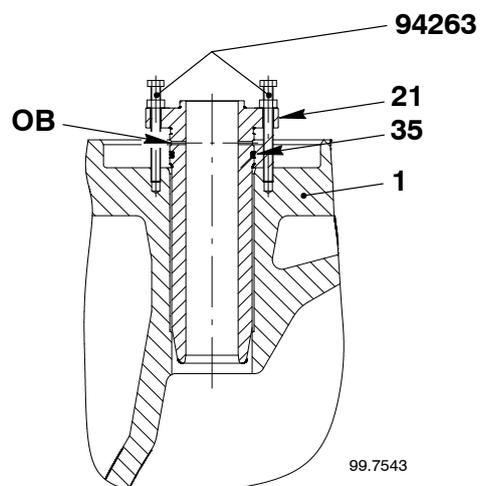
- ⇒ Clean the bore in valve cage 1 concerned and guide bush 21.

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



Exhaust Valve: Dismantling and Assembling

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.



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.

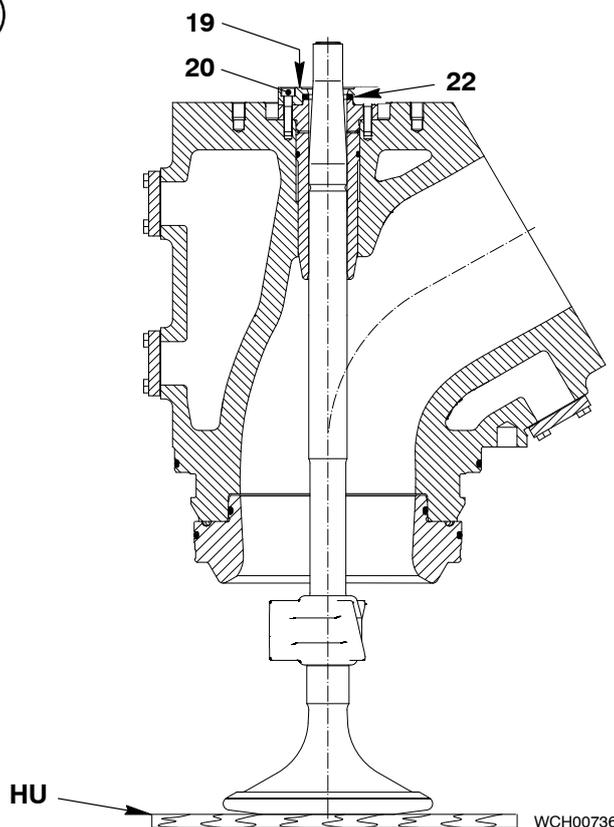
3.1 Fitting of valve spindle

⇒ 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

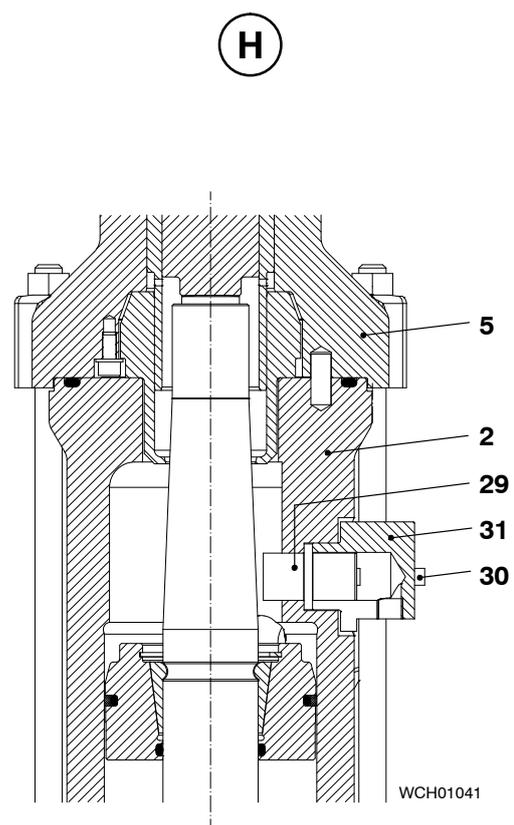
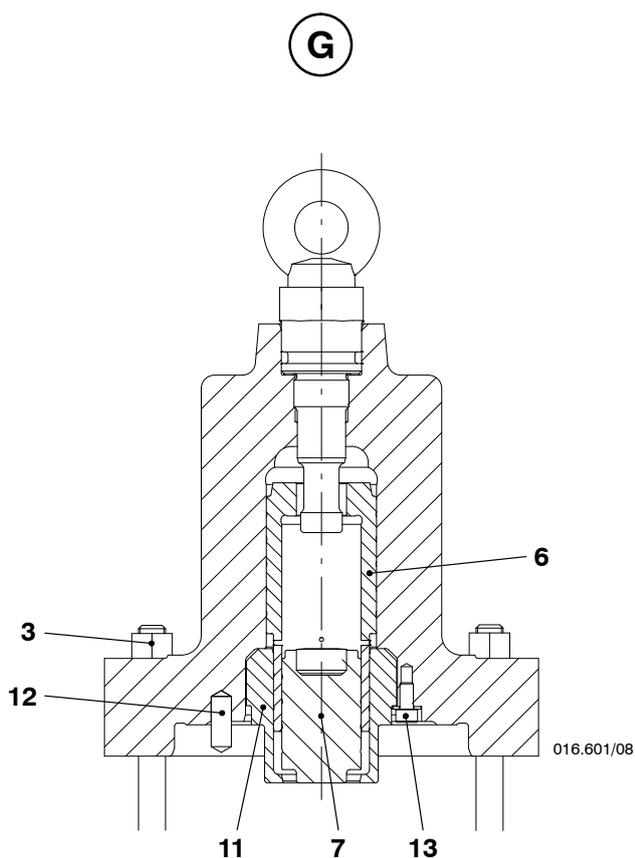
Exhaust Valve: Dismantling and Assembling

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.



Exhaust Valve: Dismantling and Assembling

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.

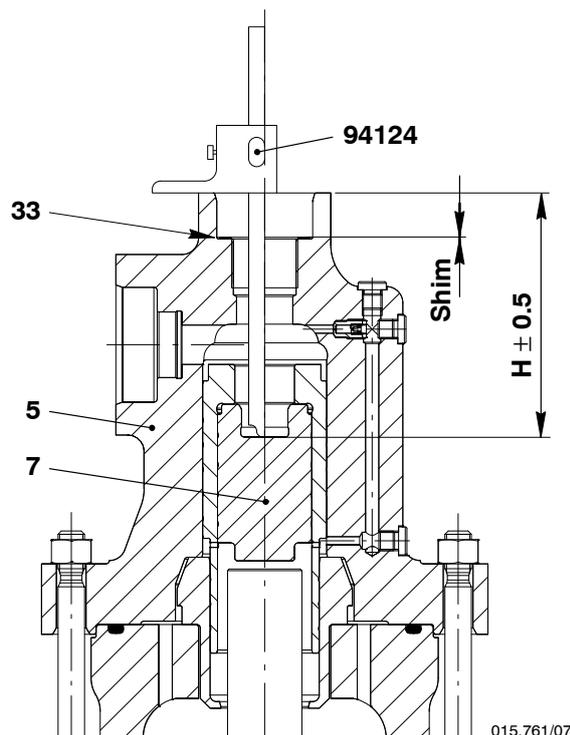
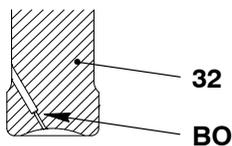
- ⇒ Remove the damper 32.
- ⇒ Make sure that the bores in the damper are clear.
- ⇒ Make sure that the exhaust valve is closed.
- ⇒ Use a feeler gauge to make sure there is no clearance between the valve plate and valve seat.
- ⇒ Use a depth gauge 94124 to measure the height H between the top and bottom 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



Exhaust Valve: Dismantling and Assembling

3.6 Checking filter

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

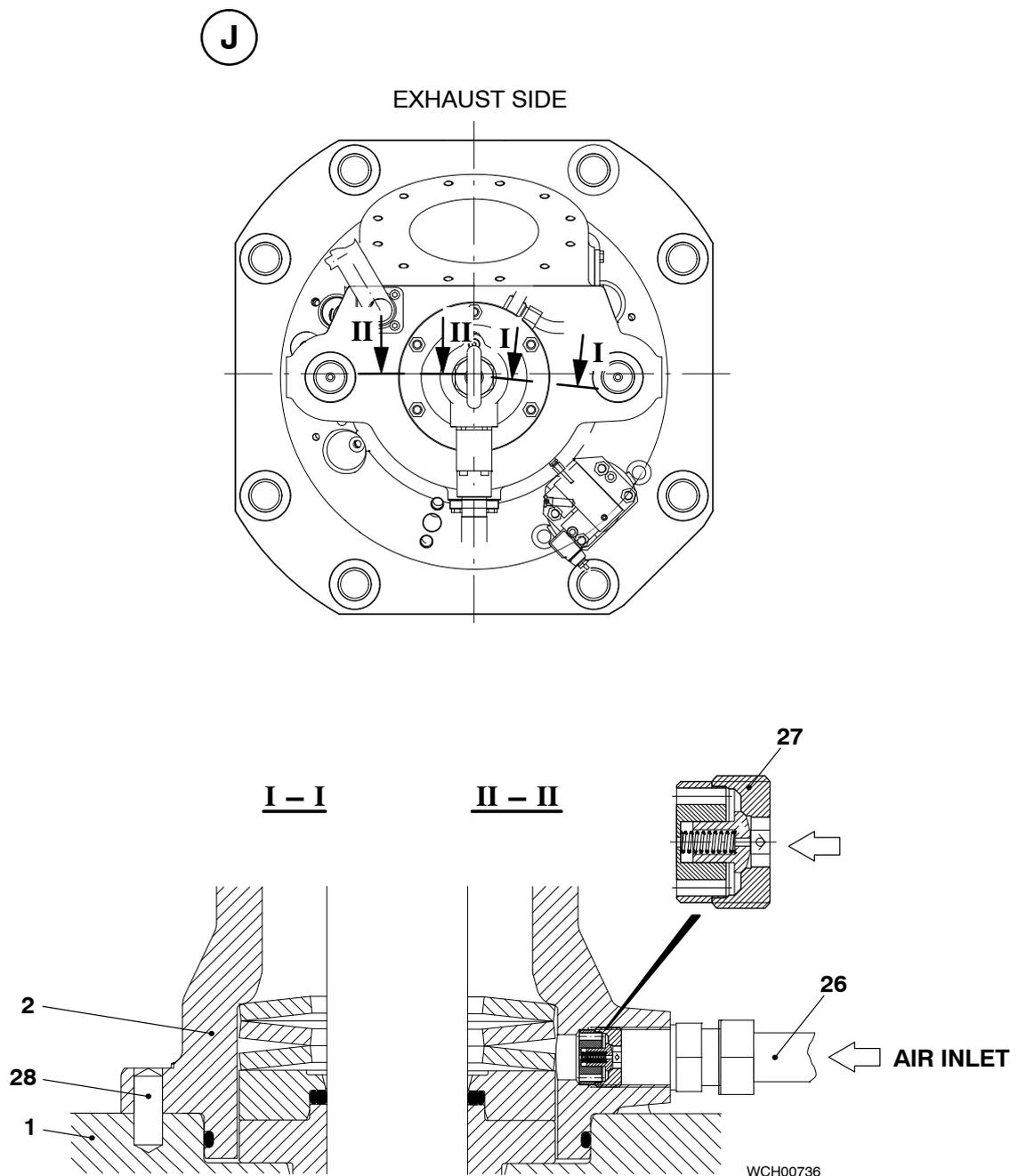
3.7 Checking non-return valve

⇒ 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!

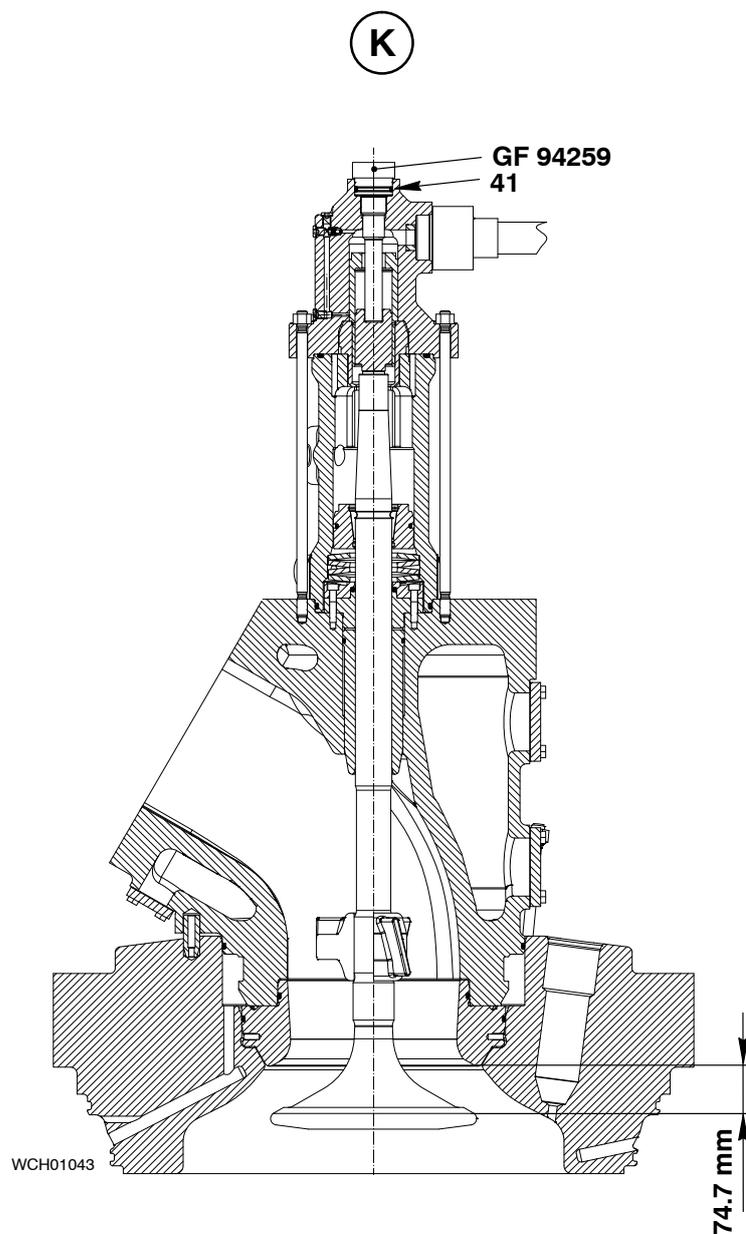


Exhaust Valve: Dismantling and Assembling

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.

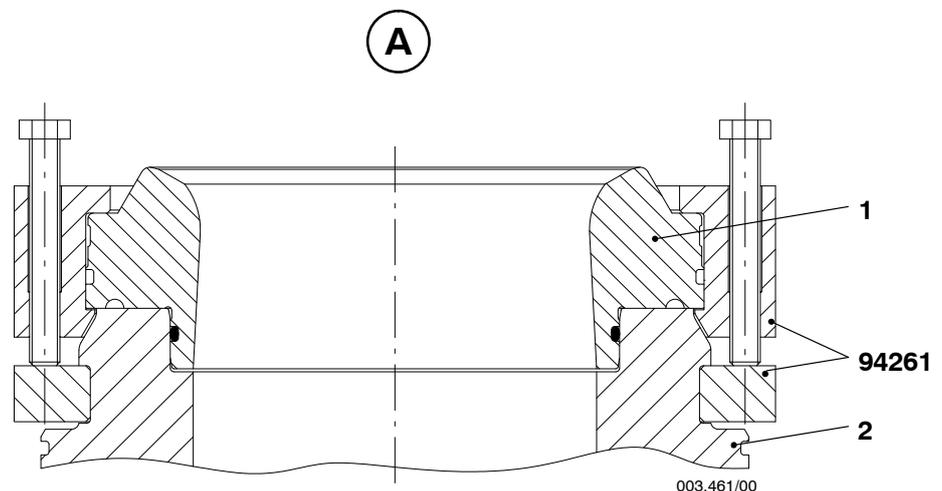
The most advantageous position for replacing the valve seat is to bring the valve cage in a vertical position as shown in Fig. 'A'.



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.



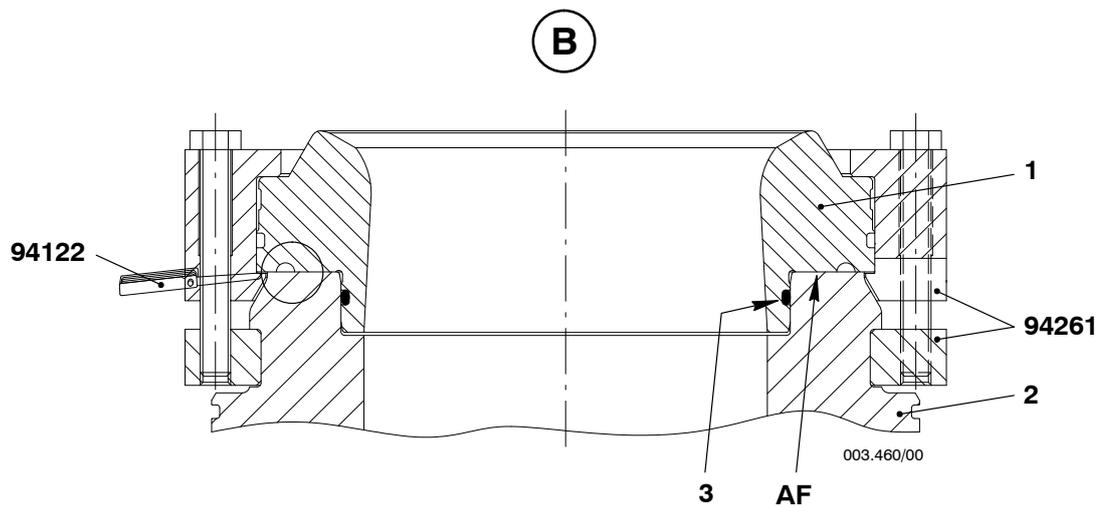
Exhaust Valve: Replacing and Grinding the Valve Seat

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'.



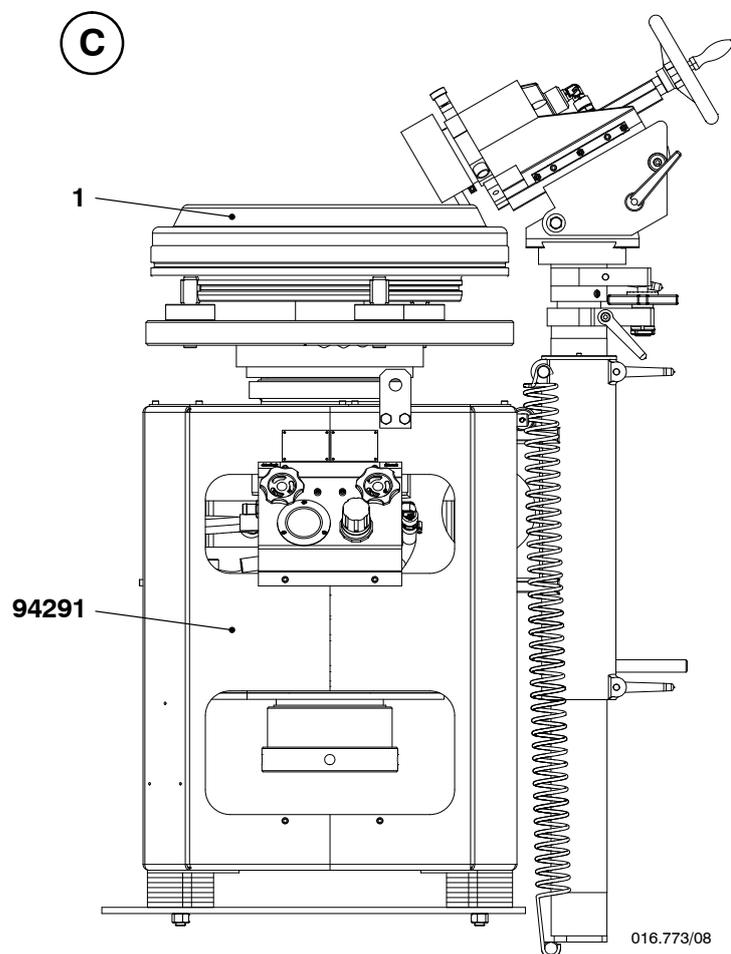
Exhaust Valve: Replacing and Grinding the Valve Seat

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.

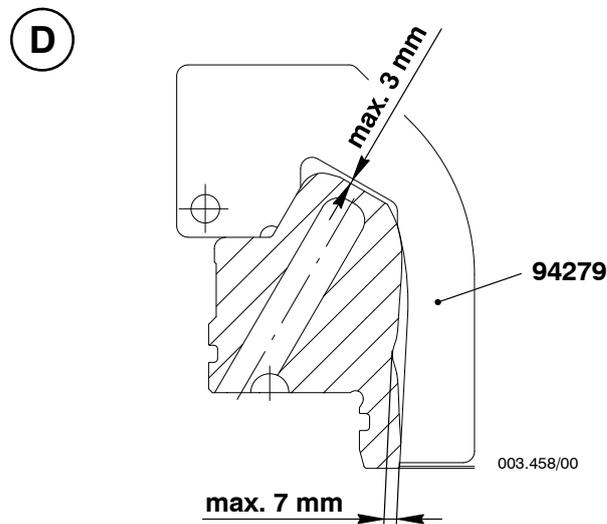
- The grinding must produce an even and smooth surface.

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

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.

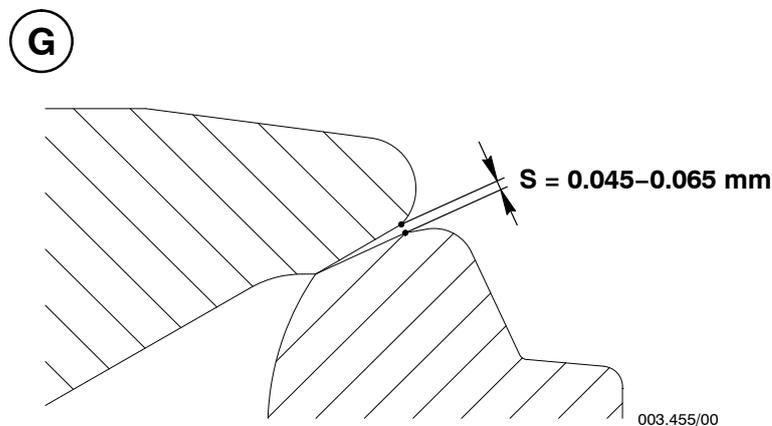
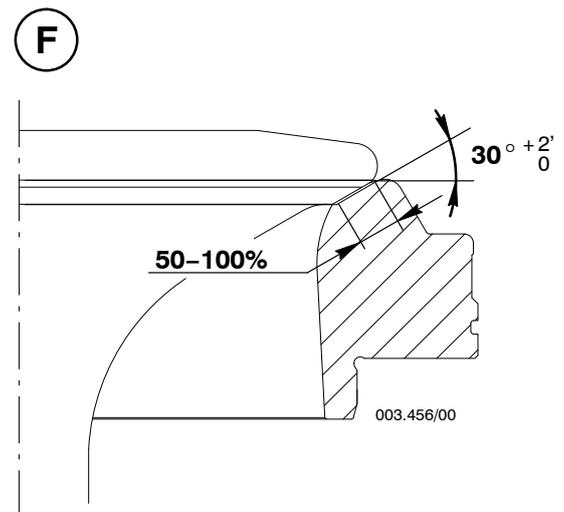
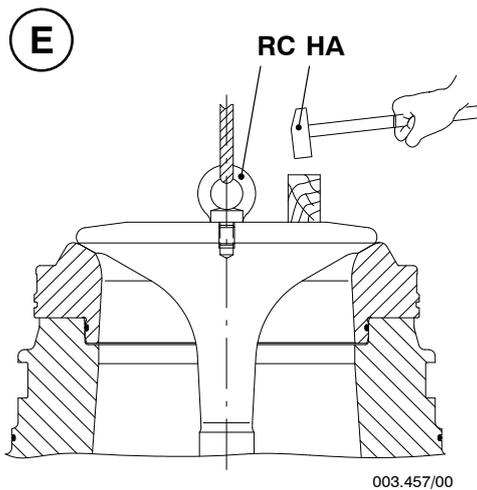


Remark: The angle difference is chosen such that in the hot operating condition the valves makes contact by 50% – 100% from the outer edge (Fig. 'F'). The blueing check should show that the cold valve makes contact only from inside around the whole circumference. The angle difference can be checked at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



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.

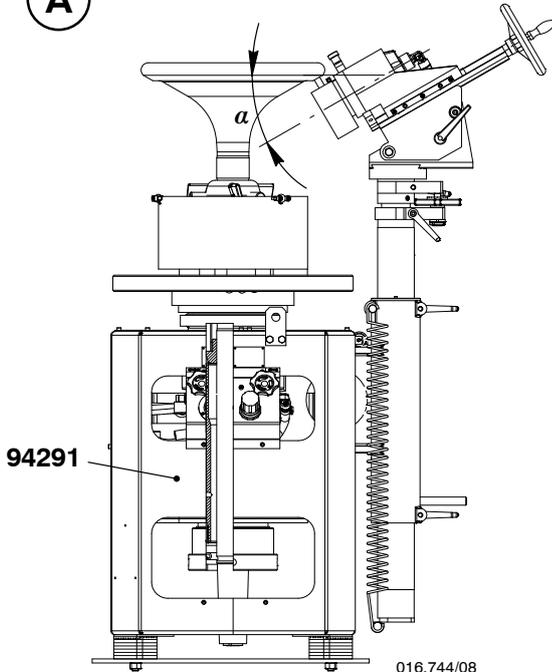
The devices from the makers 'HUNGER' and 'CHRIS - MARINE' are well proven for valve grinding and can also be ordered directly from Wärtsilä Switzerland Ltd., Winterthur.

2. Grinding the seating surface

SEATING SURFACE
ANGLE ON VALVE

$$\alpha = 30^{\circ} \begin{matrix} +12' \\ +10' \end{matrix}$$

A



- 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

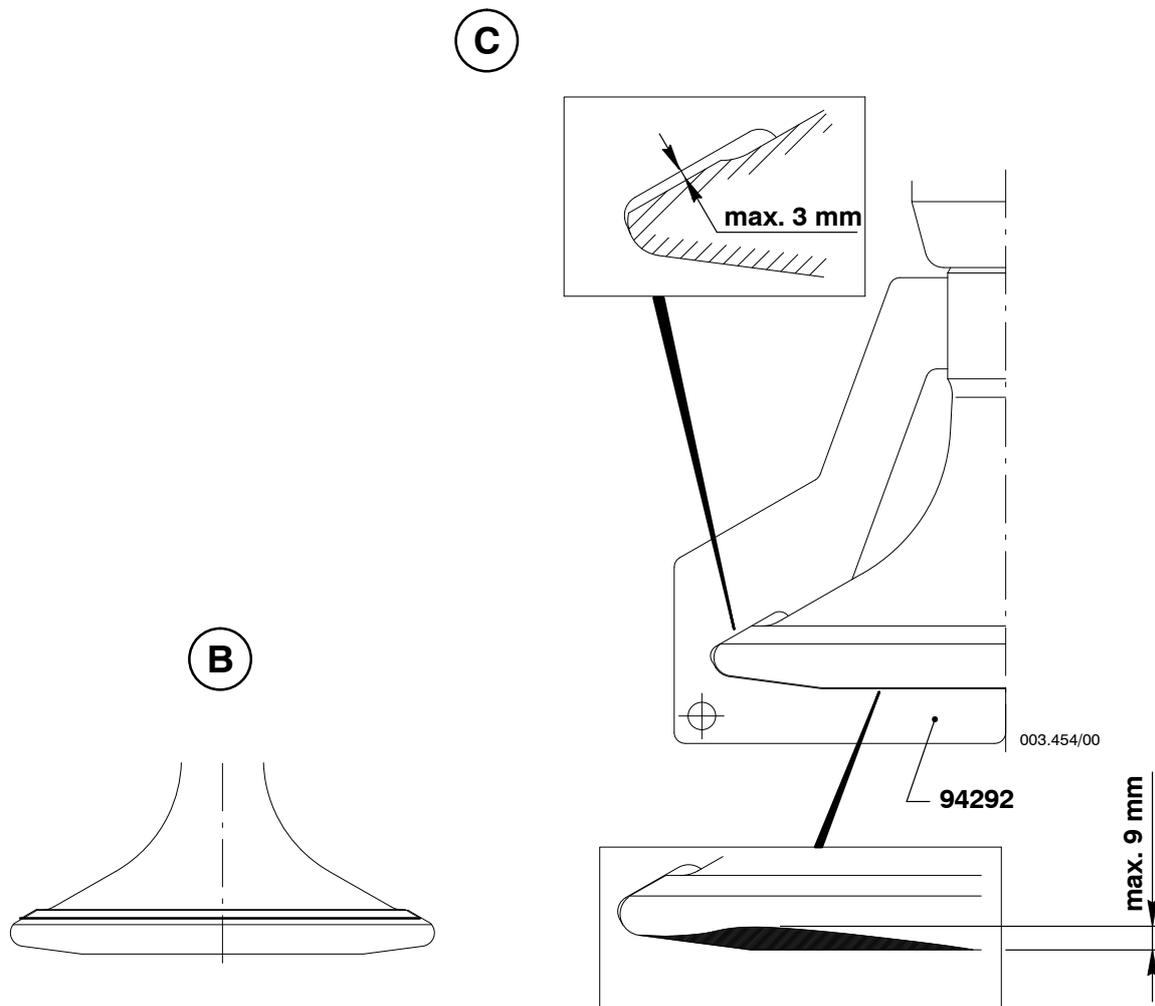
CHECK

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.



	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 Tothing	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 (Piston with four Piston Rings)	3425-1/A1
	– Checking Wear of Piston Rings and Ring Grooves (Piston with three Piston Rings)	3425-1/A2

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Crankshaft

Measuring Crank Deflection

Tool:

- 1 Crankshaft checking equipment 94305
(dial gauge)

Key to Illustrations:

- 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.

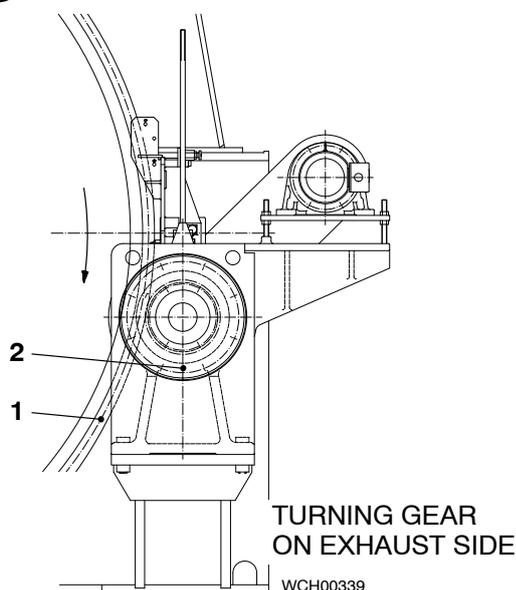
In any such cases it is recommended to contact Wärtsilä for support.

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.

A



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

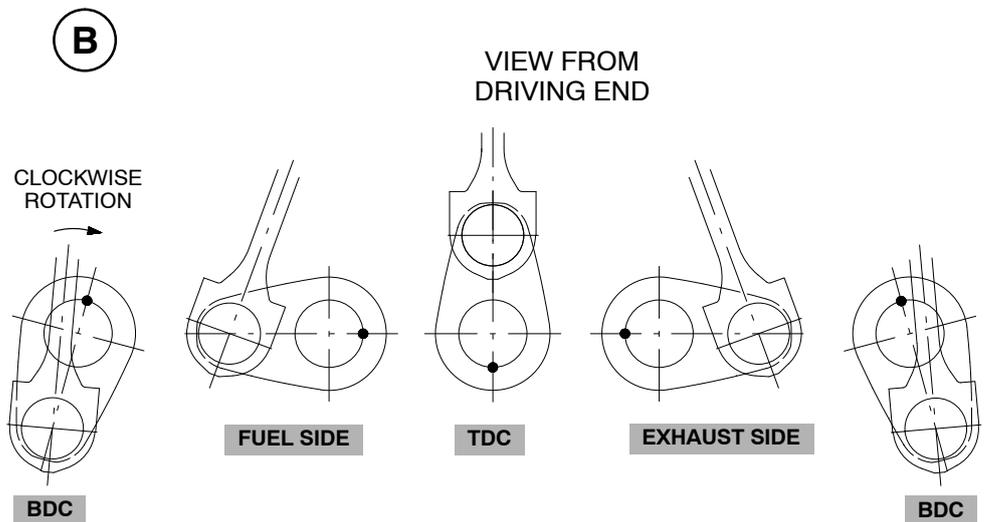
Despite the ordinary rotation direction of the engine, the crankshaft must **always** be turned in such a manner that flywheel 1 and pinion 2 of the turning gear are **rotating as indicated by the arrows**.

Measuring Crank Deflection

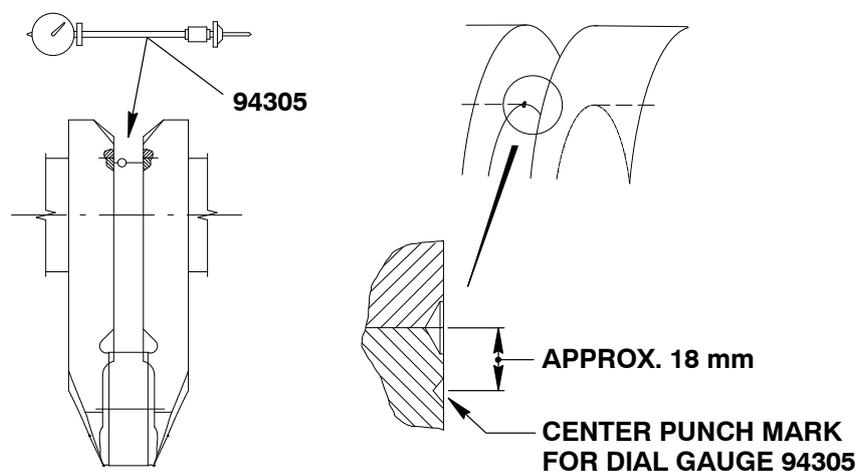
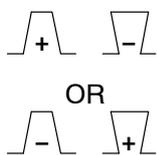
3.1 Setting the checking equipment

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. – FUEL SIDE – T.D.C. – EXHAUST 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.**

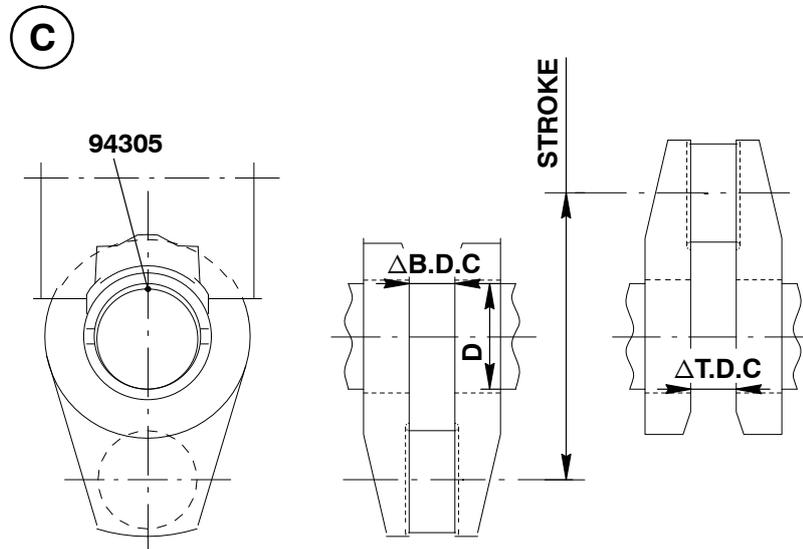


CRANK DEFLECTION SIGN ON DIAL GAUGE



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	0.41	0.41	0.41	0.19
-0.58	-0.41	-0.41	-0.58	-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 |

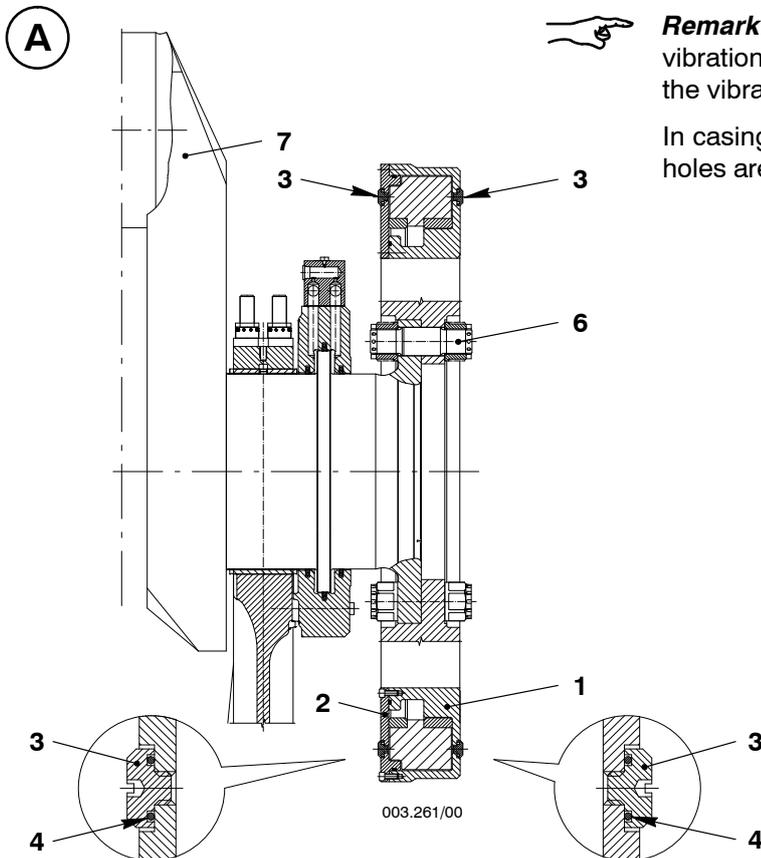
1. General

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.



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.

Taking a Silicone Fluid Sample

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.

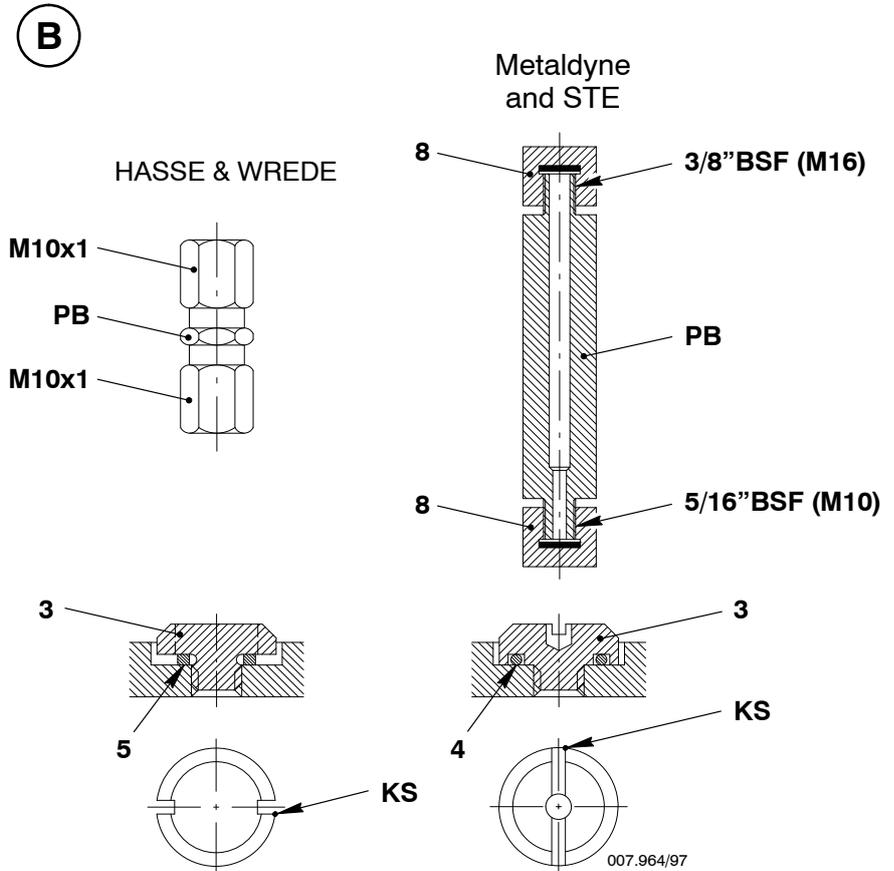


Remark: Two different threads are used for the sample bores of the 'Simpson International' and STE vibration dampers. Therefore, the ends of the sample container are provided with different threads.

- ⇒ 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	6	Coupling bolt
2	Vent nozzles	7	Torsiograph drive
3	Sealing rings	8	Vibration damper
4	Oil supply piping	9	Sealing ring
5	Crankshaft		

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.

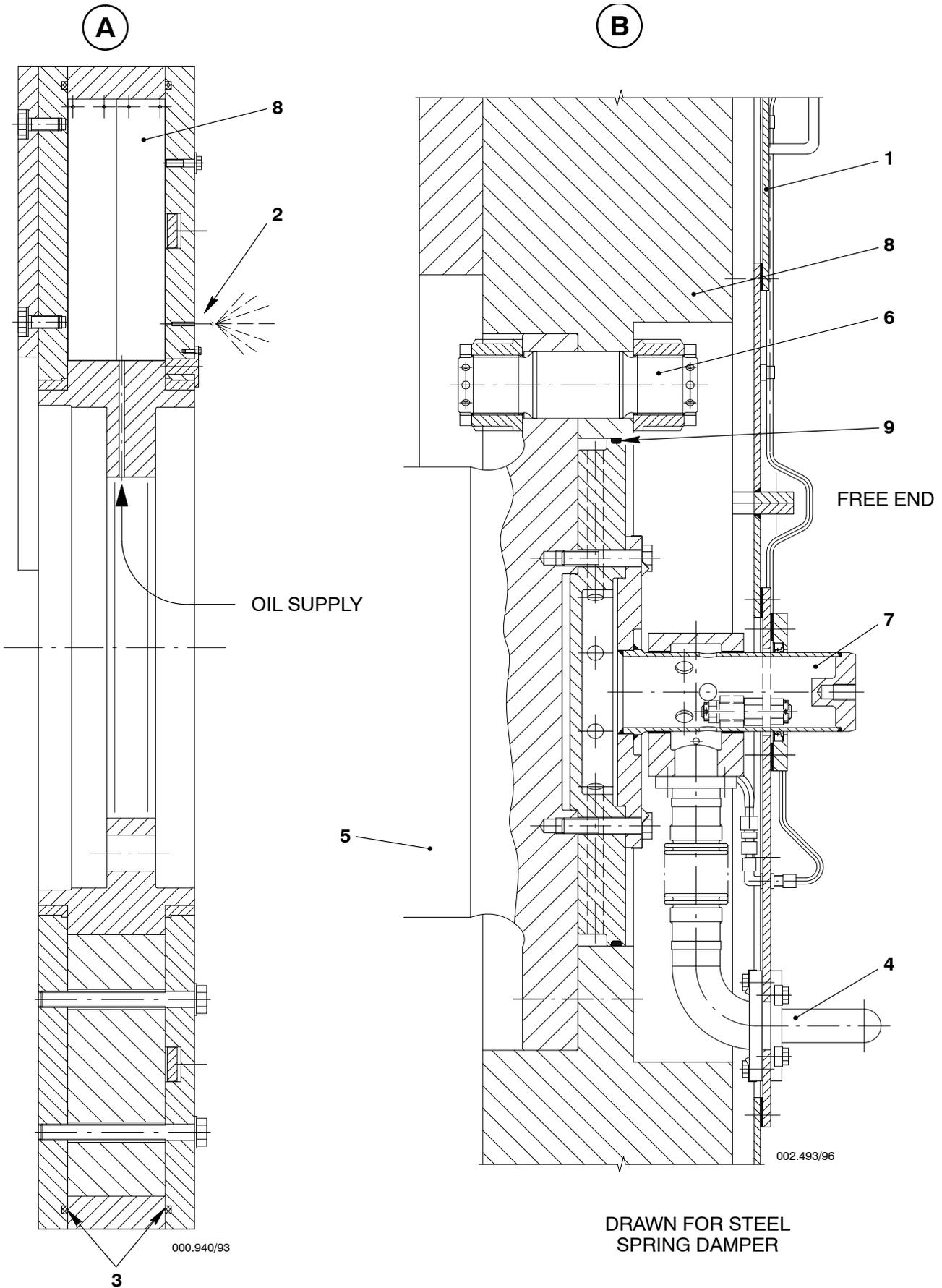


Remark: For the test run after the first commissioning, as well as the normal checking and servicing intervals, refer to the manual of the damper manufacturer.

Contact address for GEISLINGER vibration dampers:

Geislinger GmbH
A-5300 Hallwang / Salzburg
Austria

Inspection (GEISLINGER Vibration Damper)



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

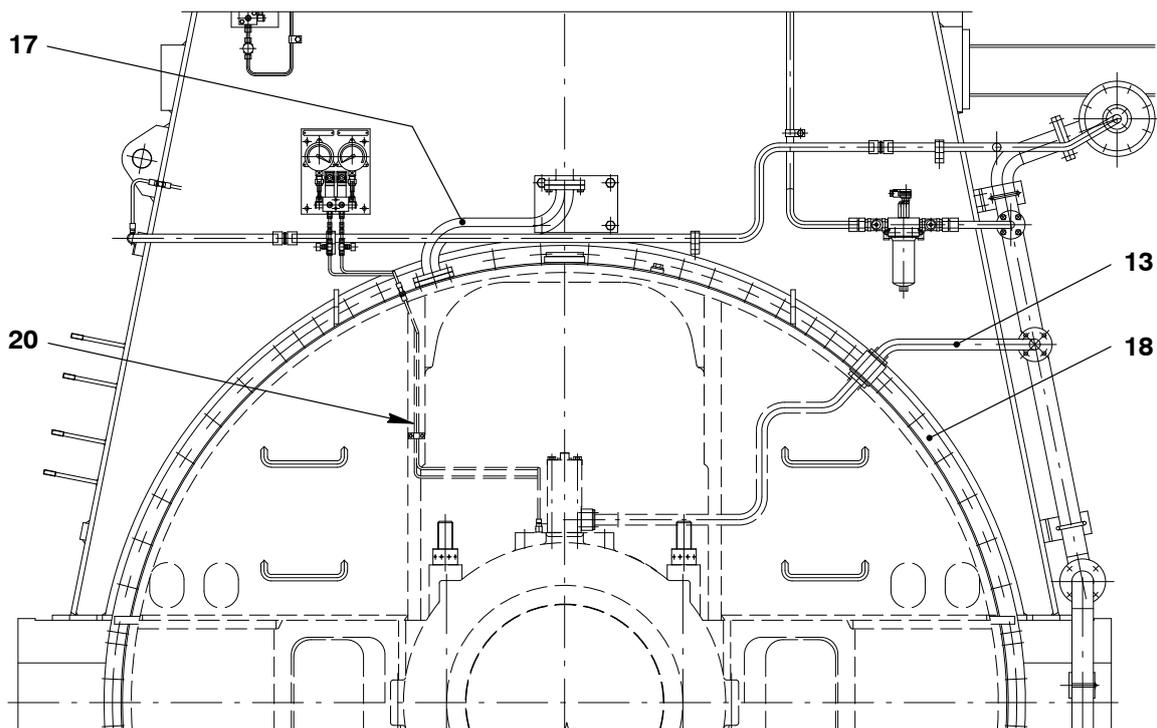
Key to Illustrations:

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:

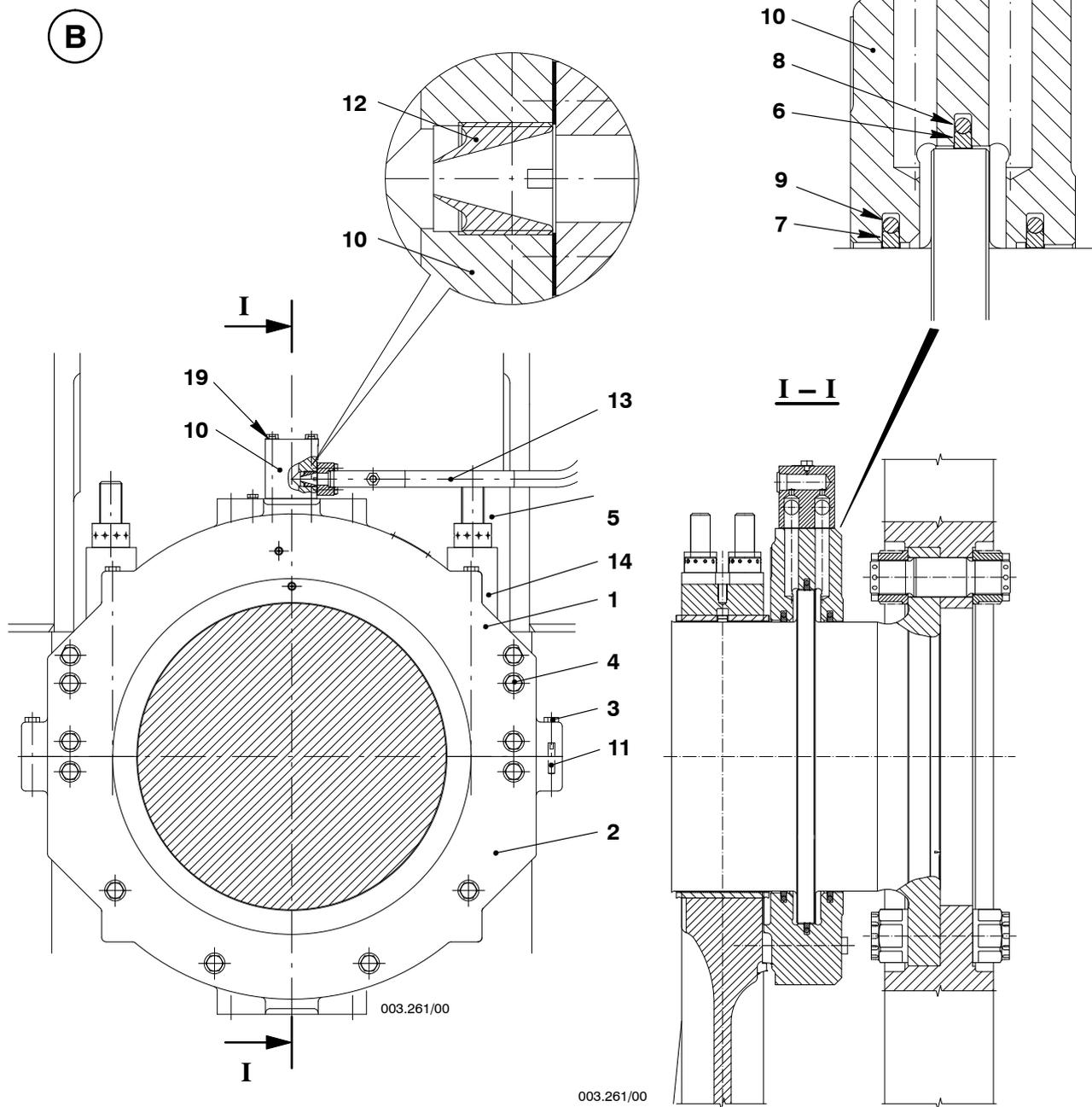
- ⇒ Switch off the bearing oil pump.
- ⇒ Remove oil drain pipe 17.
- ⇒ Unscrew and remove oil inlet pipes 13 and the piping for damper monitoring 20 internally and externally from upper casing 18.
- ⇒ Remove upper casing 18.

A

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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

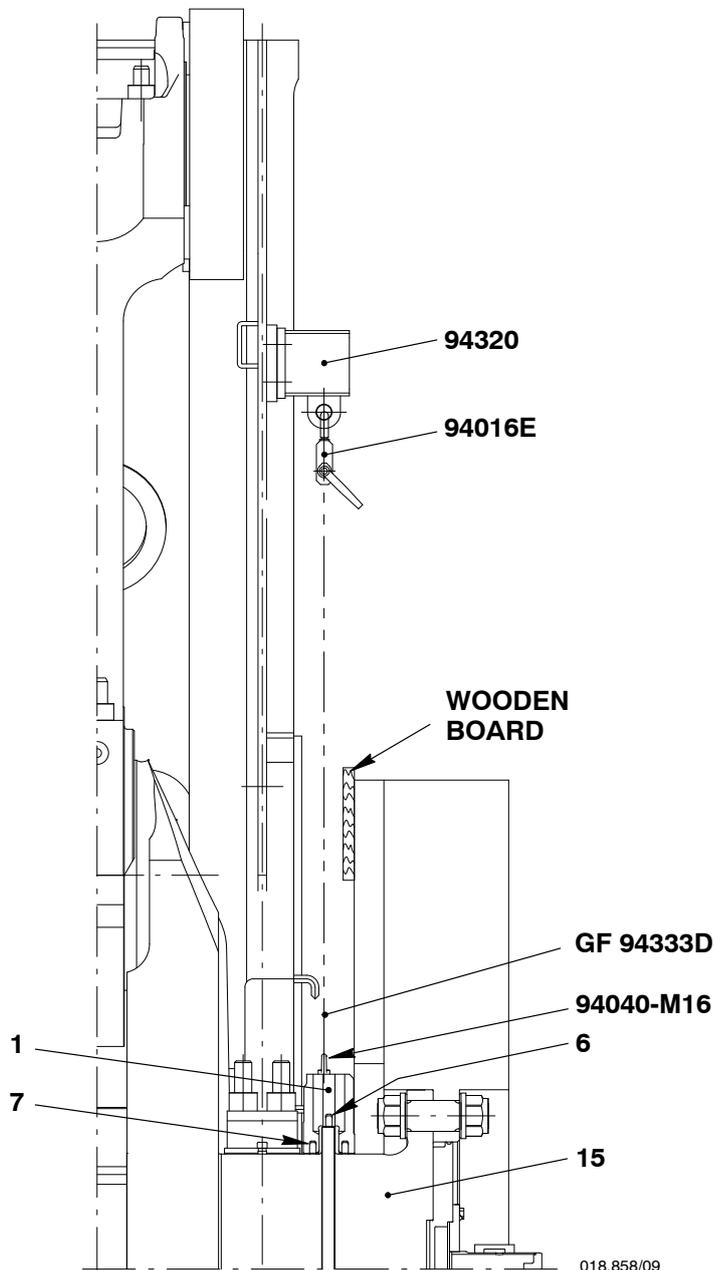
- ⇒ Fasten support 94320 to the face of the free end of the engine.
- ⇒ Screw two RUD-eye bolts 94040-M16 into the upper part of cylinder 1, then join these by means of wire rope sling GF 94333D to manual ratchet 94016E.
- ⇒ **For inspection of the 2-part gaskets** carefully lift the cylinder upper part 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)



Axial Damper: Dismantling and Assembling

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

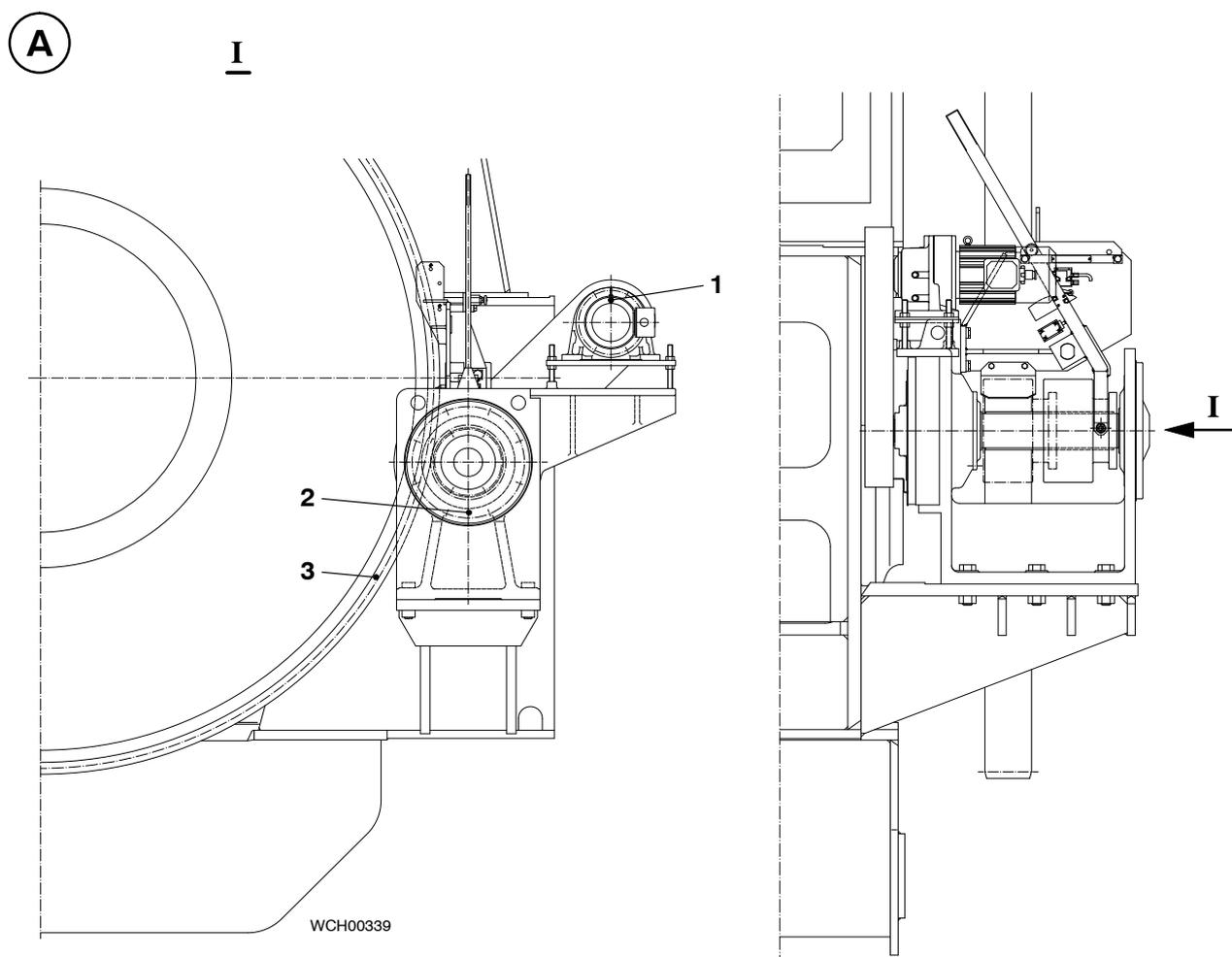
Key to Illustration:

- 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 tothing 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.

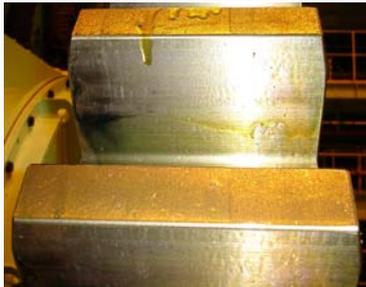


Turning Gear: Checking the Tothing

2. Checking the tothing

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.l Lubricants.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:

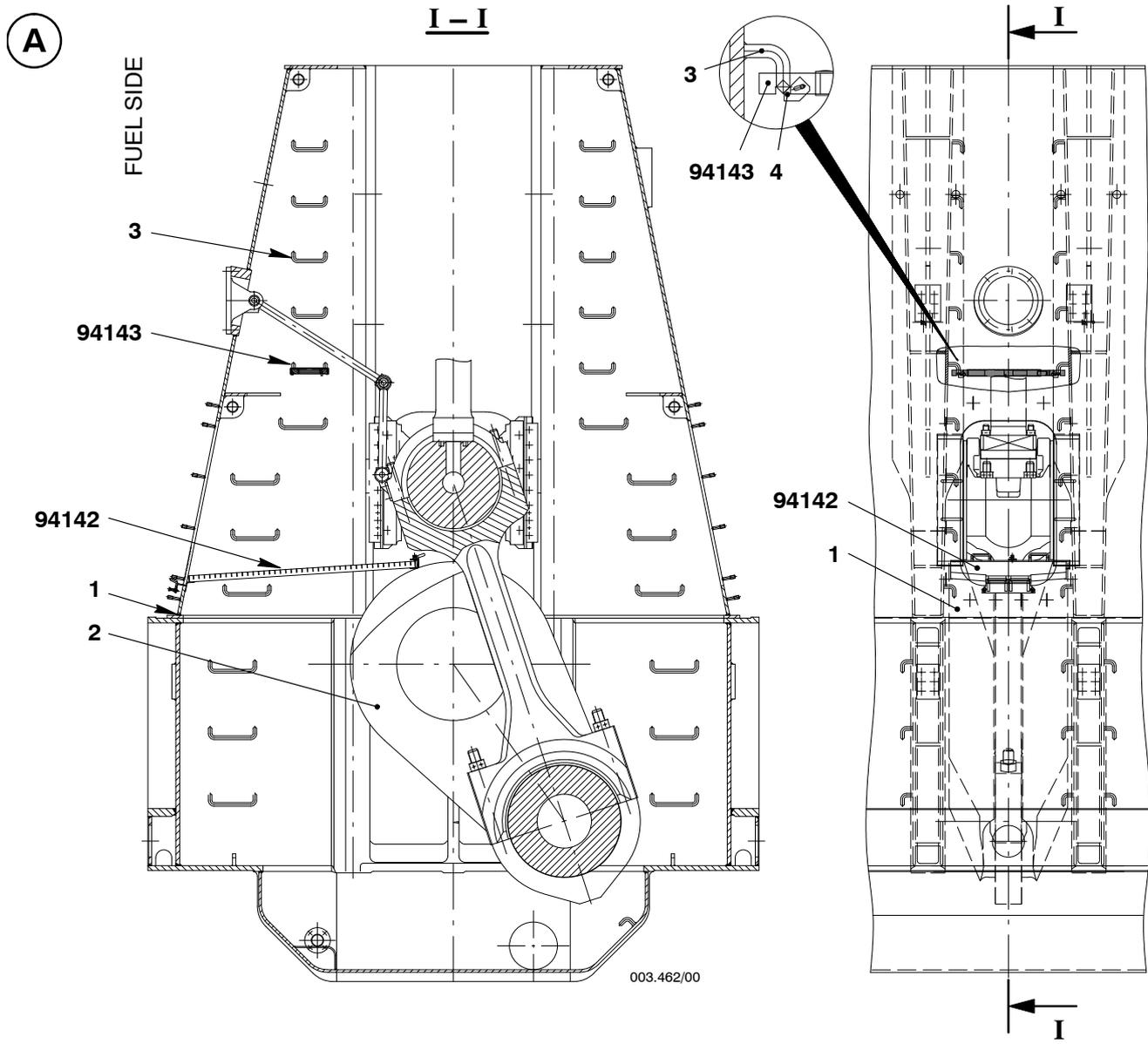
- | |
|----------------------------|
| 1 Engine longitudinal beam |
| 2 Crank web |
| 3 Step |
| 4 Strap |

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

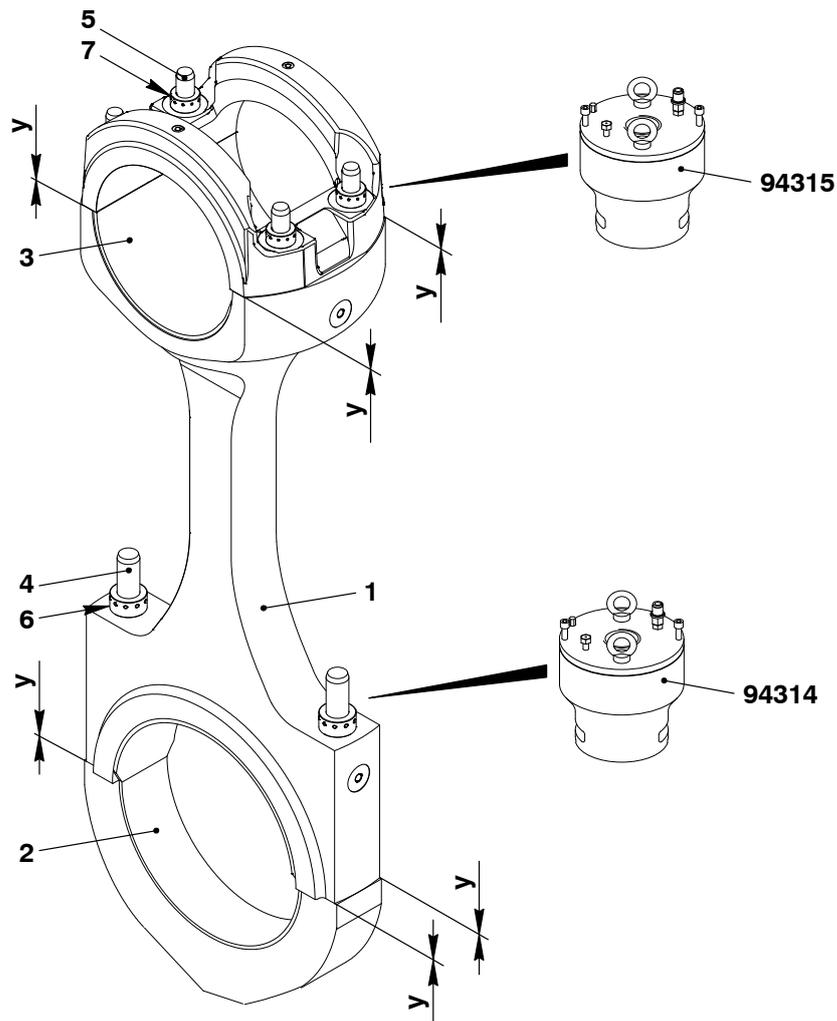
1. General



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

Loosening and Tensioning the Connecting Rod Studs

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)**.

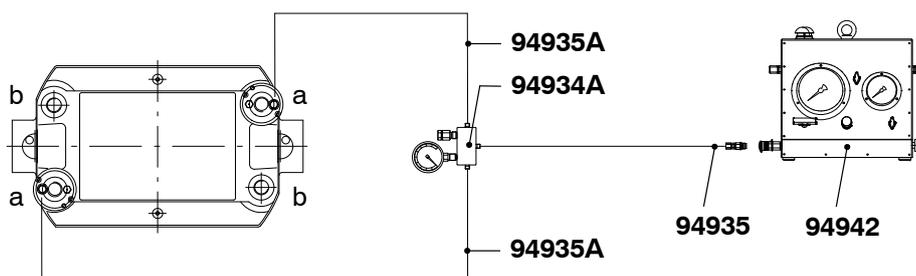
CHECK

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!

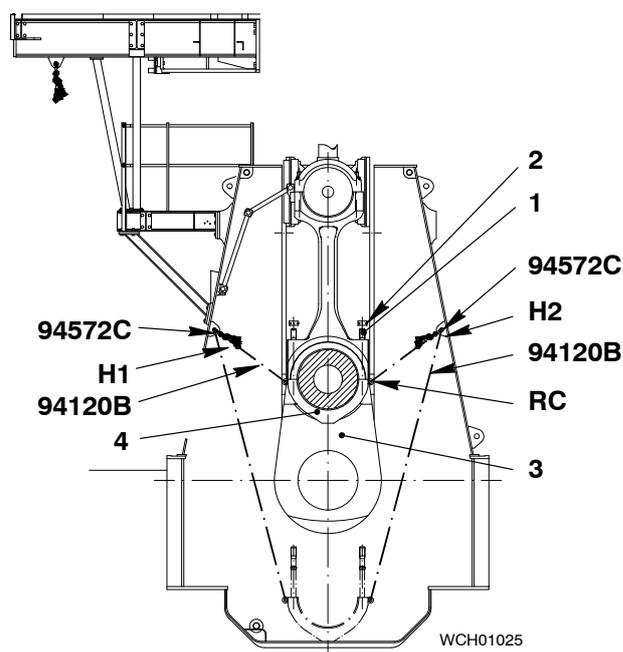
Remark: Pay attention to:

- General Guidelines for Lifting Tools 0012-1.
- Utilization of Working Platform 3301-1.

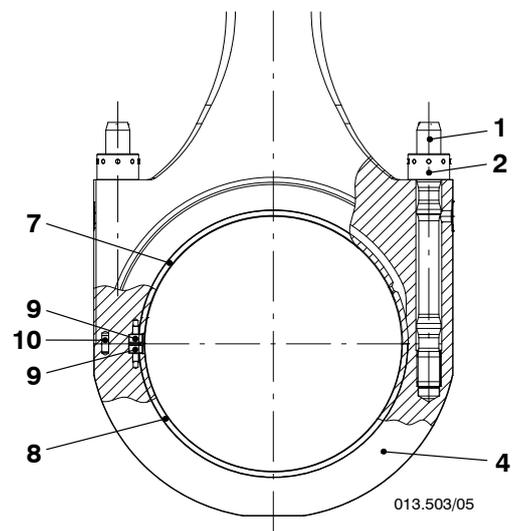
1.1 Lowering of bearing cover

- ⇒ 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.

A



B



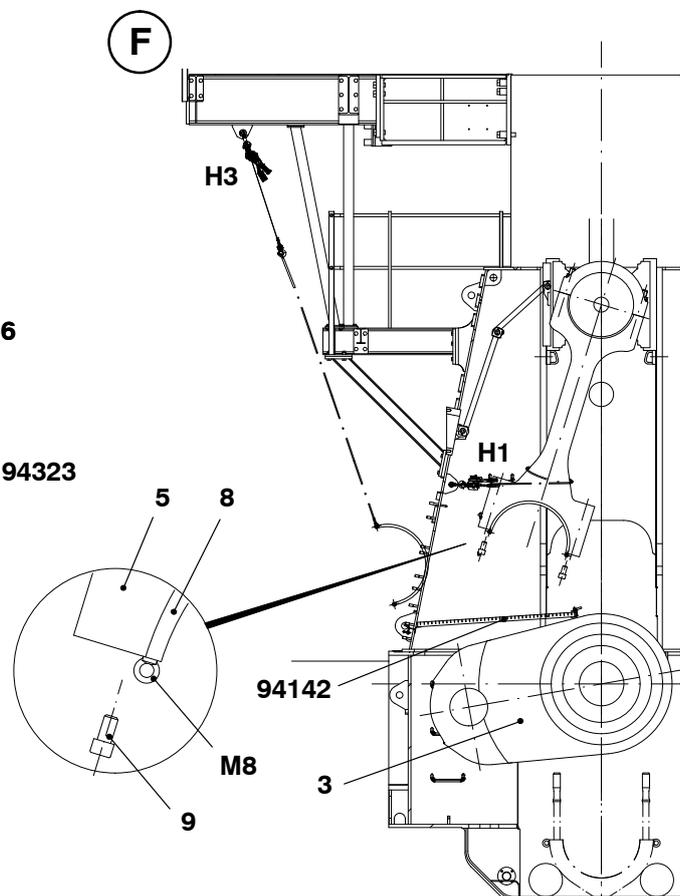
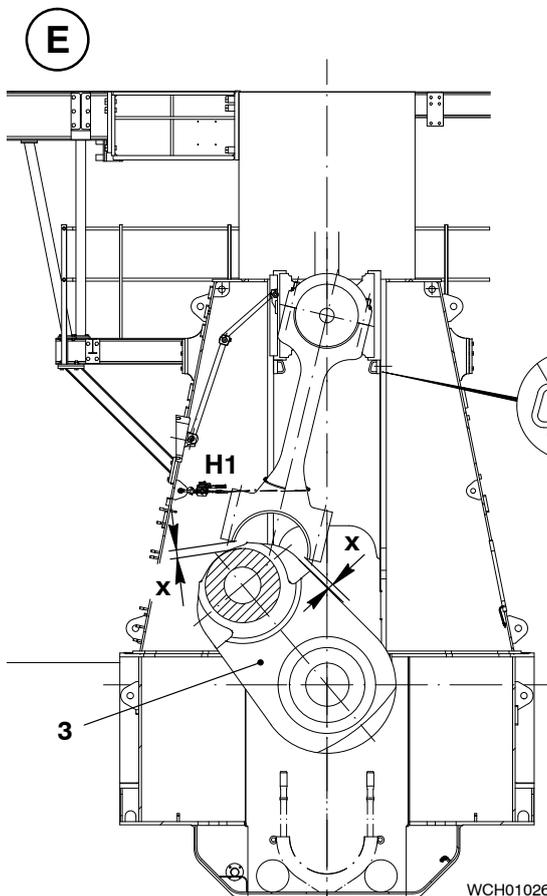
Inspection, Removal and Fitting of Bottom End Bearing

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.



Inspection, Removal and Fitting of Bottom End Bearing

1.4 Removal of bearing cover

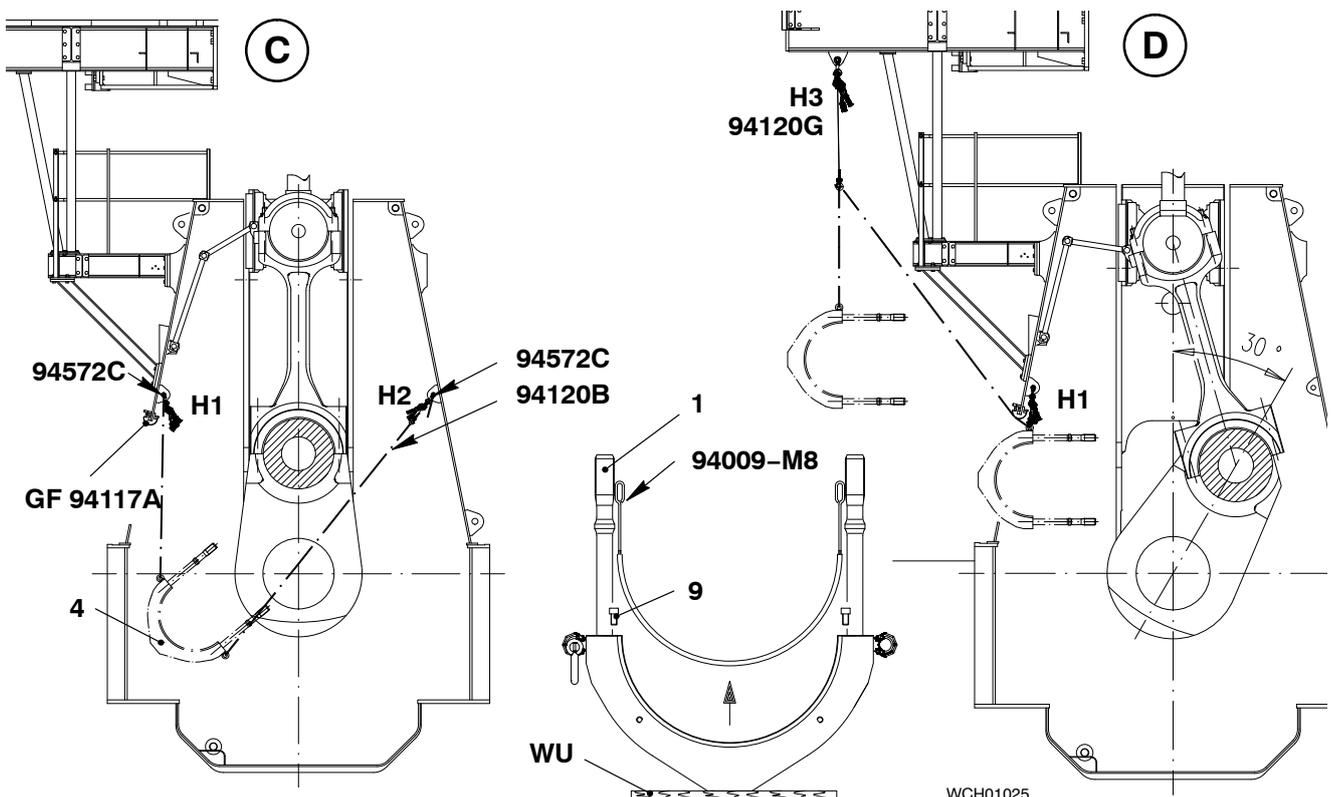


Remark: Only with a lifting tool having at least 3.5 m hoisting capacity, instead of manual ratchet 'H1', the bearing cover can be removed directly from the crankcase bottom (Fig. 'A').

- ⇒ 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.



Inspection, Removal and Fitting of Bottom End Bearing

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](#).



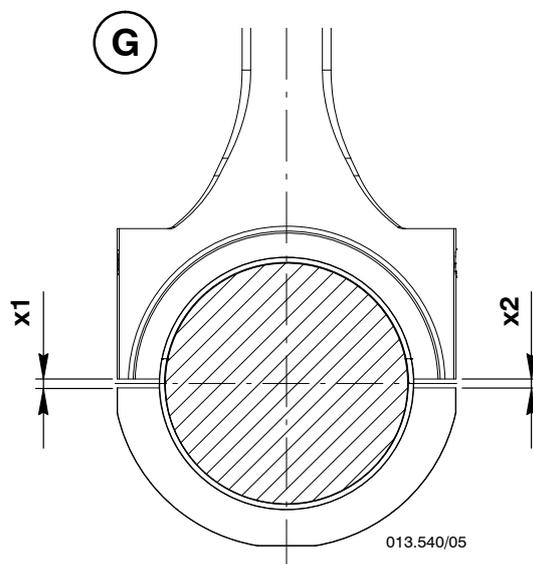
Attention! After completing the work make sure all retaining pins 94323 are removed.

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:

$x_1 + x_2 = \text{approx. } 0.96 - 1.12 \text{ mm}$
(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 $\frac{2}{3}$ steam-engine cylinder oil and $\frac{1}{3}$ 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	DL	Pressure pipe
10	Guide shoe	OP	Lubricating pump
11	Dowel pin		

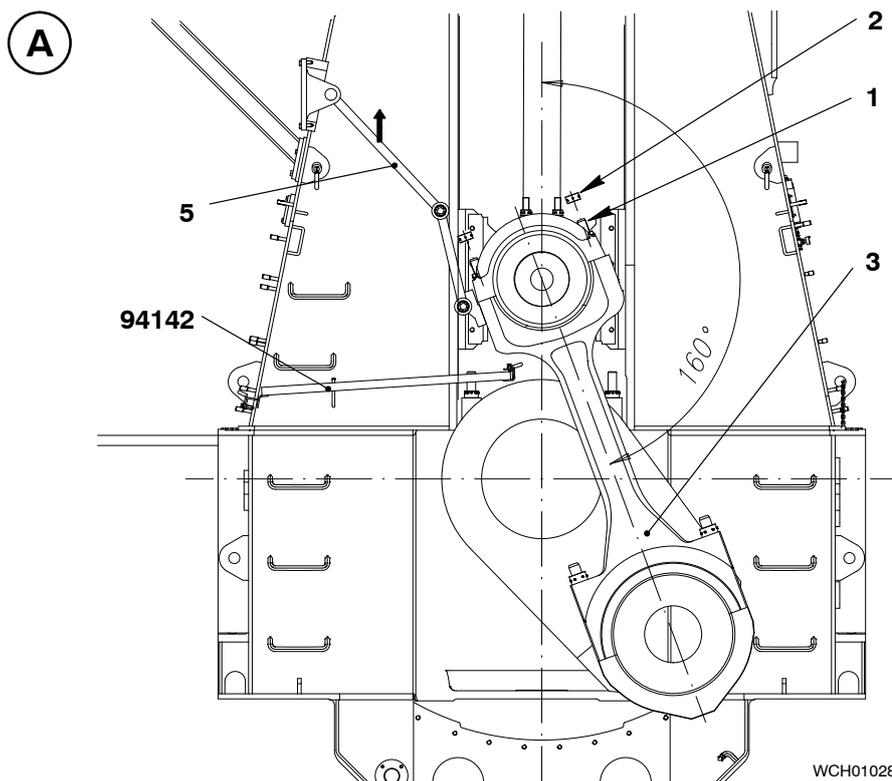
1. Inspection of bearing shell

Risk of accident! Ensure that the crankshaft does not turn unintentionally during all the maintenance work.



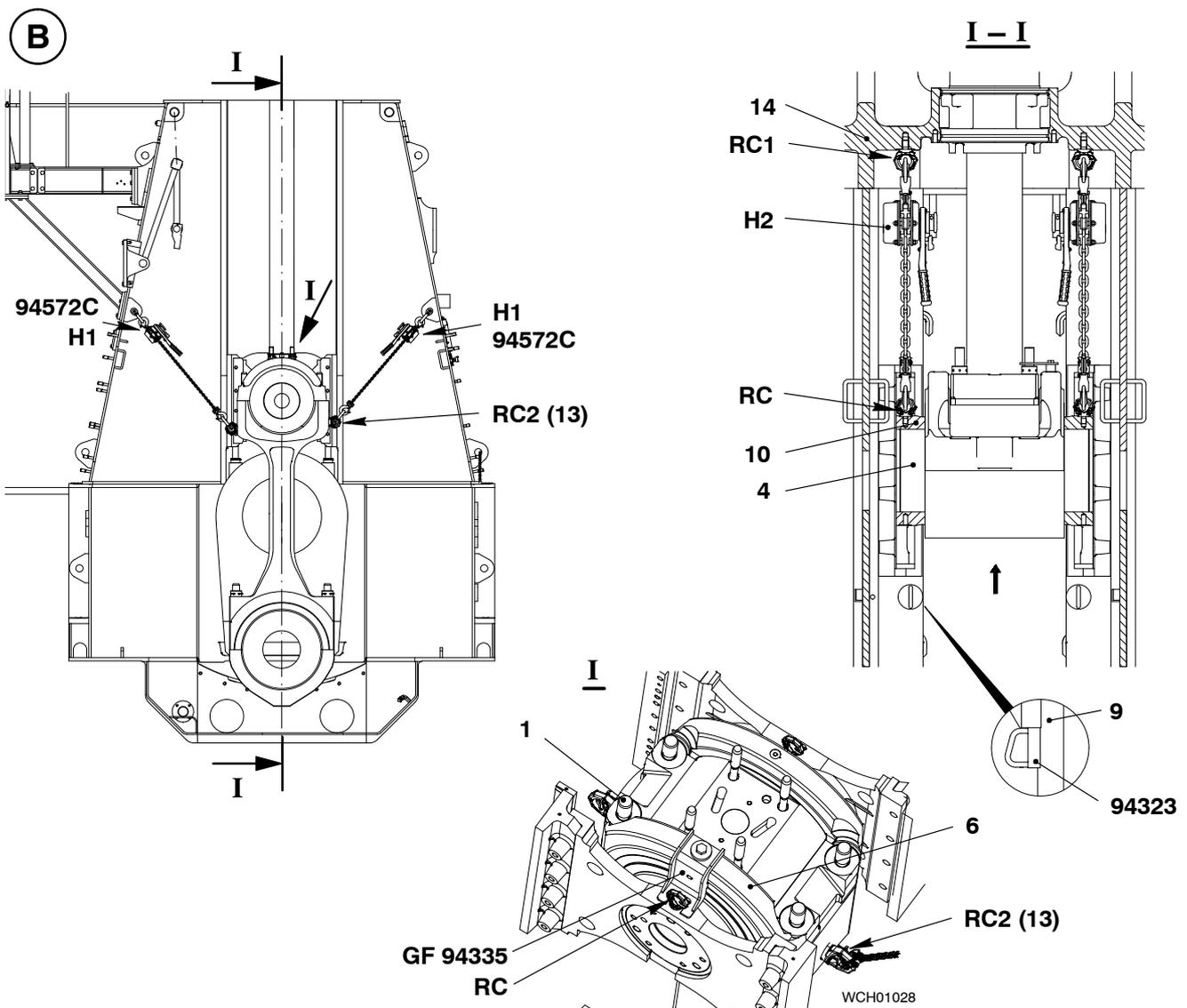
Remark: Pay attention to:

- 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 column.
- ⇒ Loosen nuts 2 of elastic studs 1 according to [3303-1](#).
- ⇒ Remove working platform 94142.



Inspection, Removal and Fitting of Top End Bearing

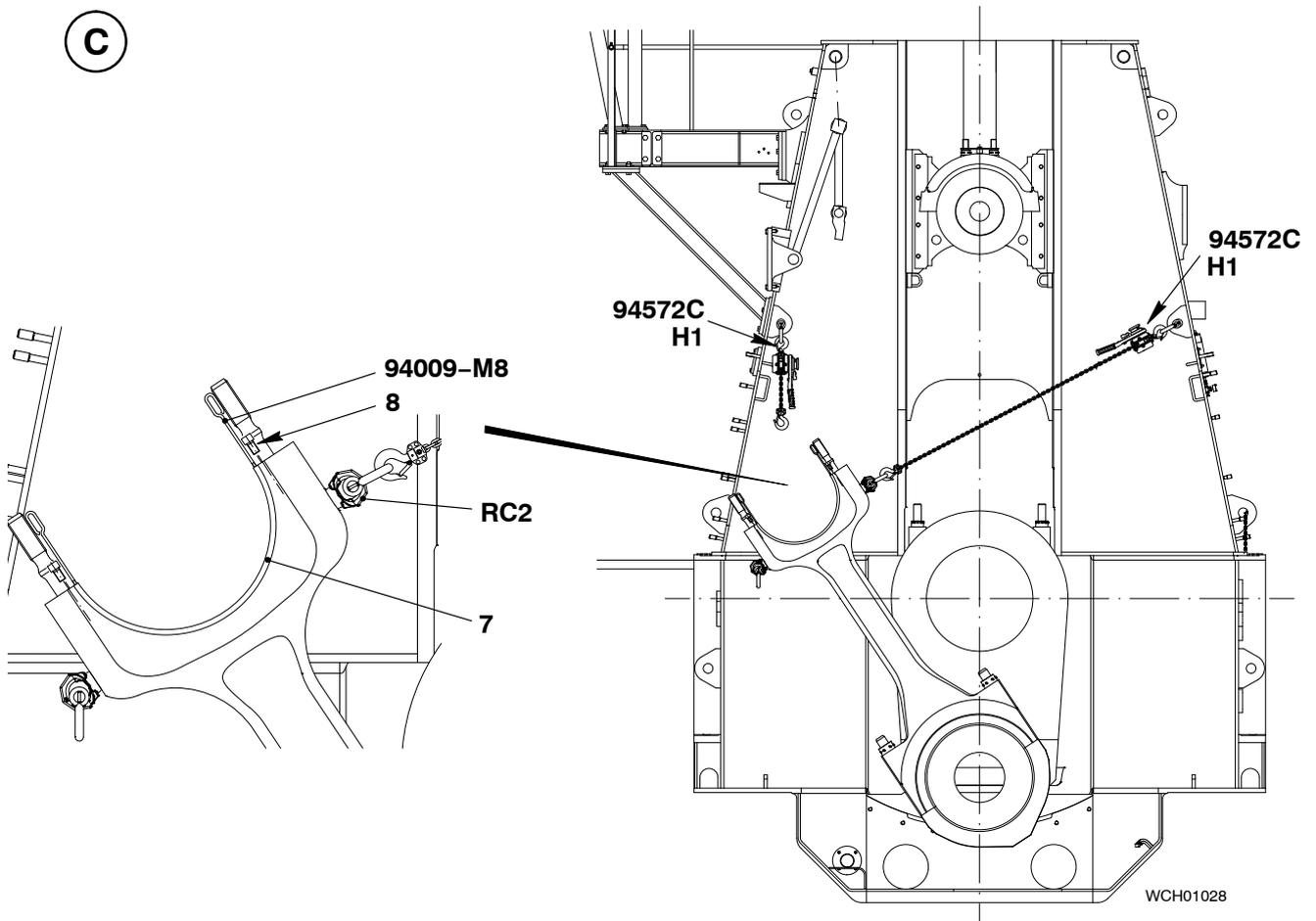
- ⇒ Turn crankshaft to B.D.C..
- ⇒ Fit a RUD-eye bolt 'RC2' on each side of the connecting rod head (threaded hole 13) and tighten it with **190 Nm**.
- ⇒ Fasten manual ratchets 'H1' with shackles 94572C to the column and connect them with RUD-eye bolts 'RC2'. Secure the connecting rod.
- ⇒ Place stop 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

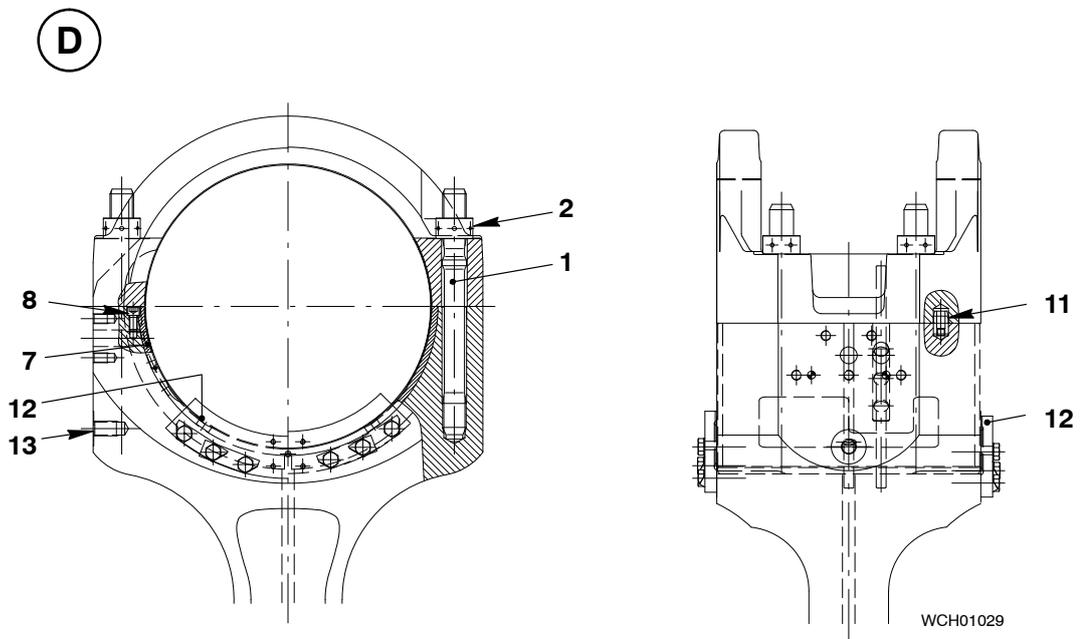
Fitting of the bearing shell and bearing cover (see 3303-5) is carried out analogously but in reverse sequence to the removal.

- 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!



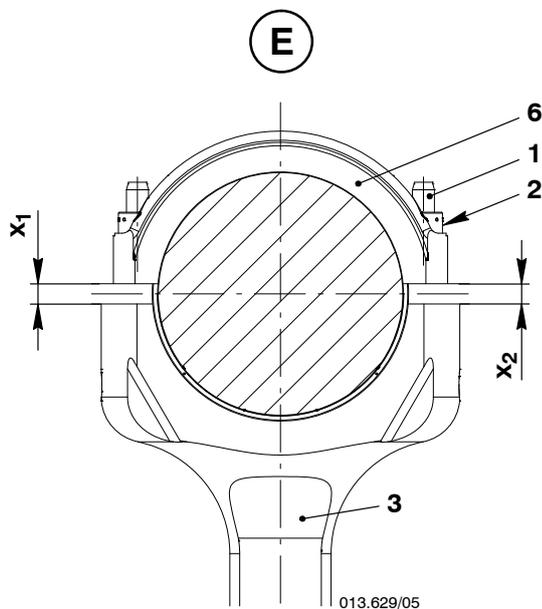
Inspection, Removal and Fitting of Top End Bearing

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.



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):

$$x_1 + x_2 = \text{approx. } 0.36 - 0.44 \text{ mm}$$



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.

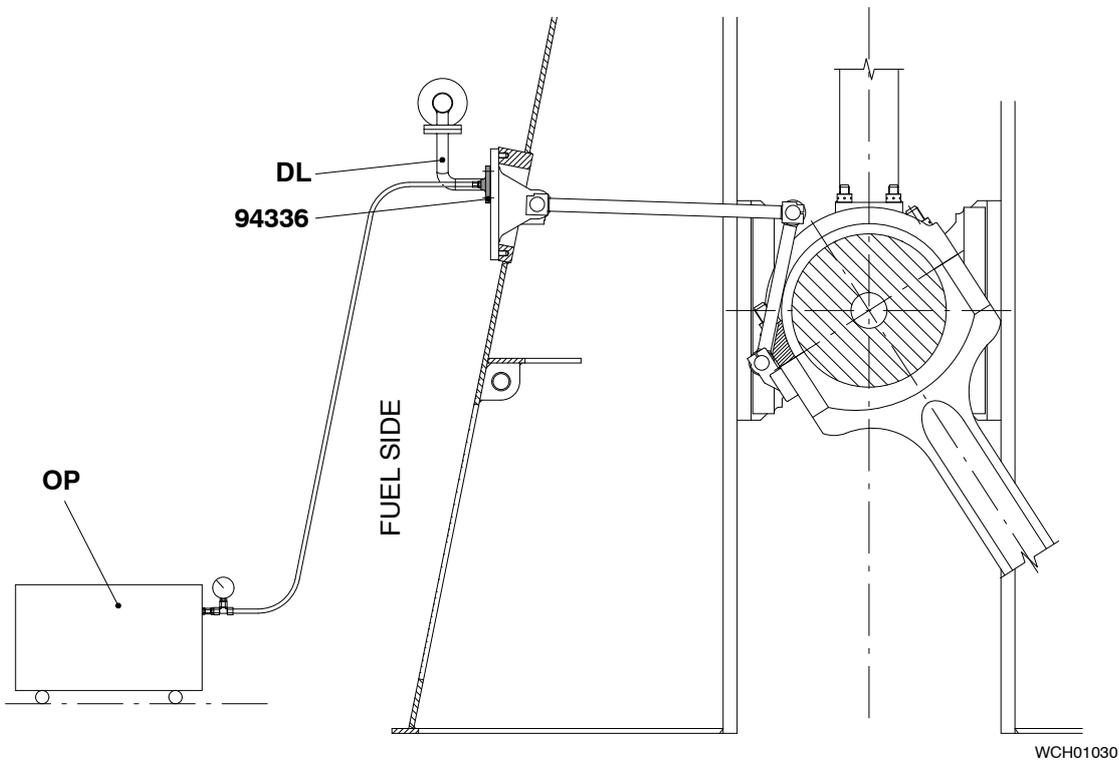
If, however, the engine must still often be turned or a restart is not immediately planned, then instead of bearing oil a mixture of $\frac{2}{3}$ steam-engine cylinder oil and $\frac{1}{3}$ normal bearing oil can be used. Special oils suitable for this purpose are also available on the market.

Inspection, Removal and Fitting of Top End Bearing

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.

F

Connecting Rod

Removal and Fitting

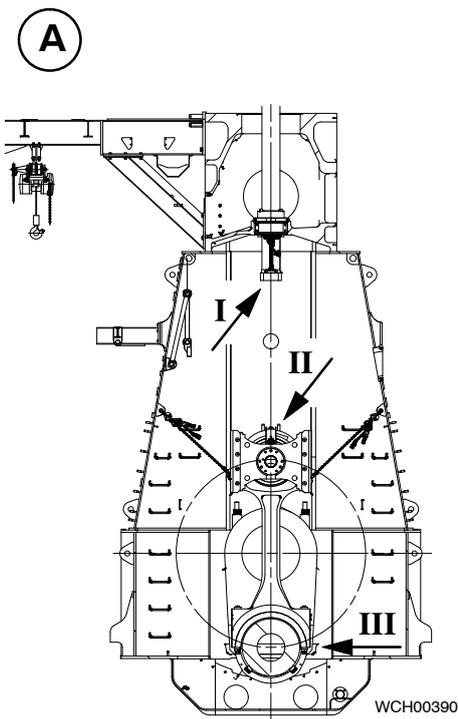
Tools:

2 Manual ratchets (WLL 1600 kg)	94016A (H2)
2 Manual ratchets (WLL 2500 kg)	94016E (H1)
1 Spur-gearred 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



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 block 10 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..

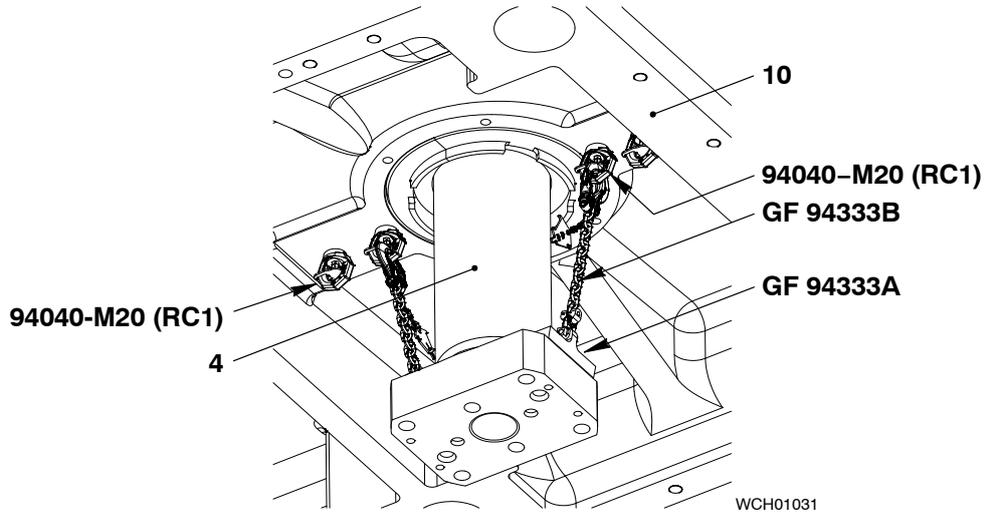


Remark: Pay attention to:

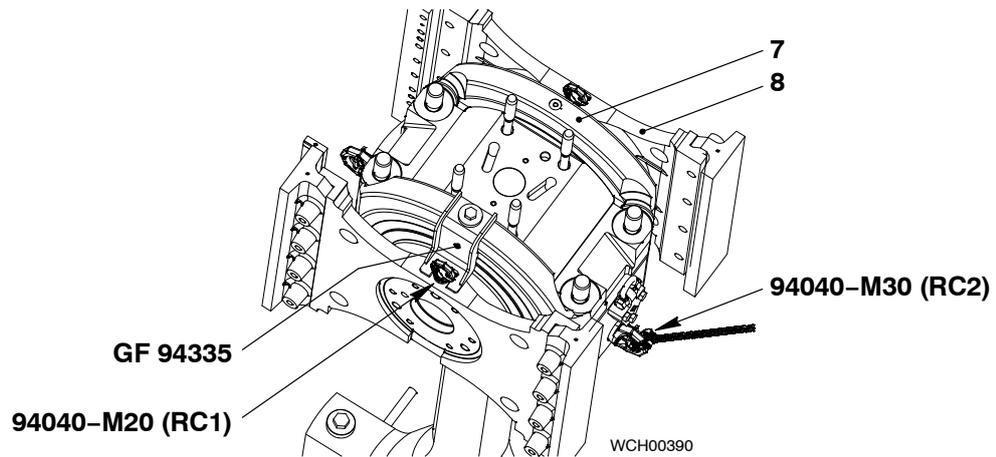
- General Guidelines for Lifting Tools 0012-1.
- Utilization of Working Platform 3301-1.

Removal and Fitting

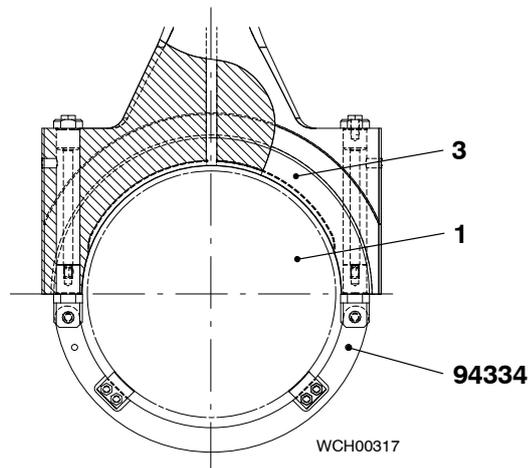
VIEW I -> Piston suspended to cylinder block:



VIEW II -> Stop plate mounted and top end bearing cover locked against tilting:



VIEW III -> Bottom end bearing cover replaced with holder:



Removal and Fitting

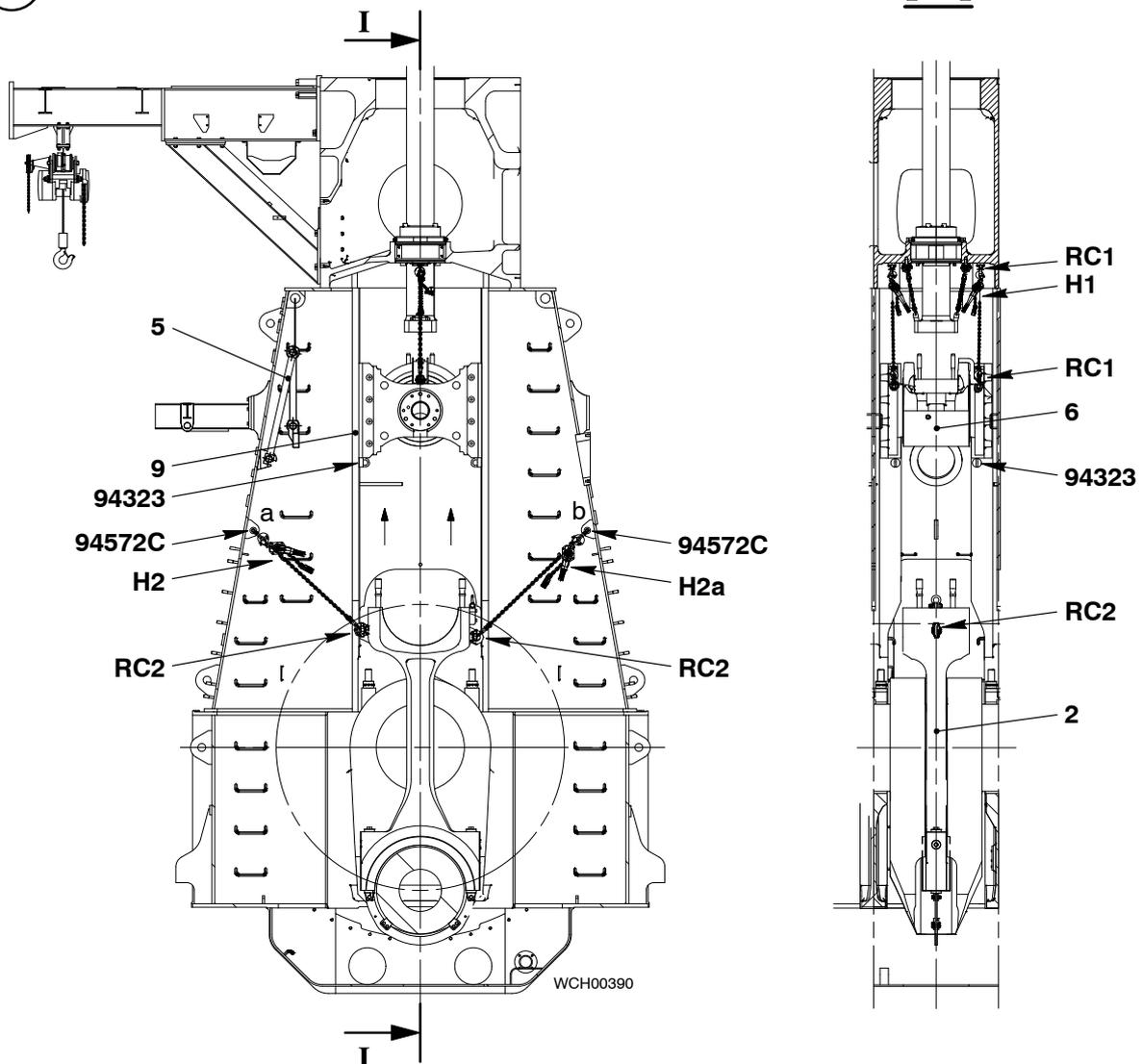
2. Removal

- 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).



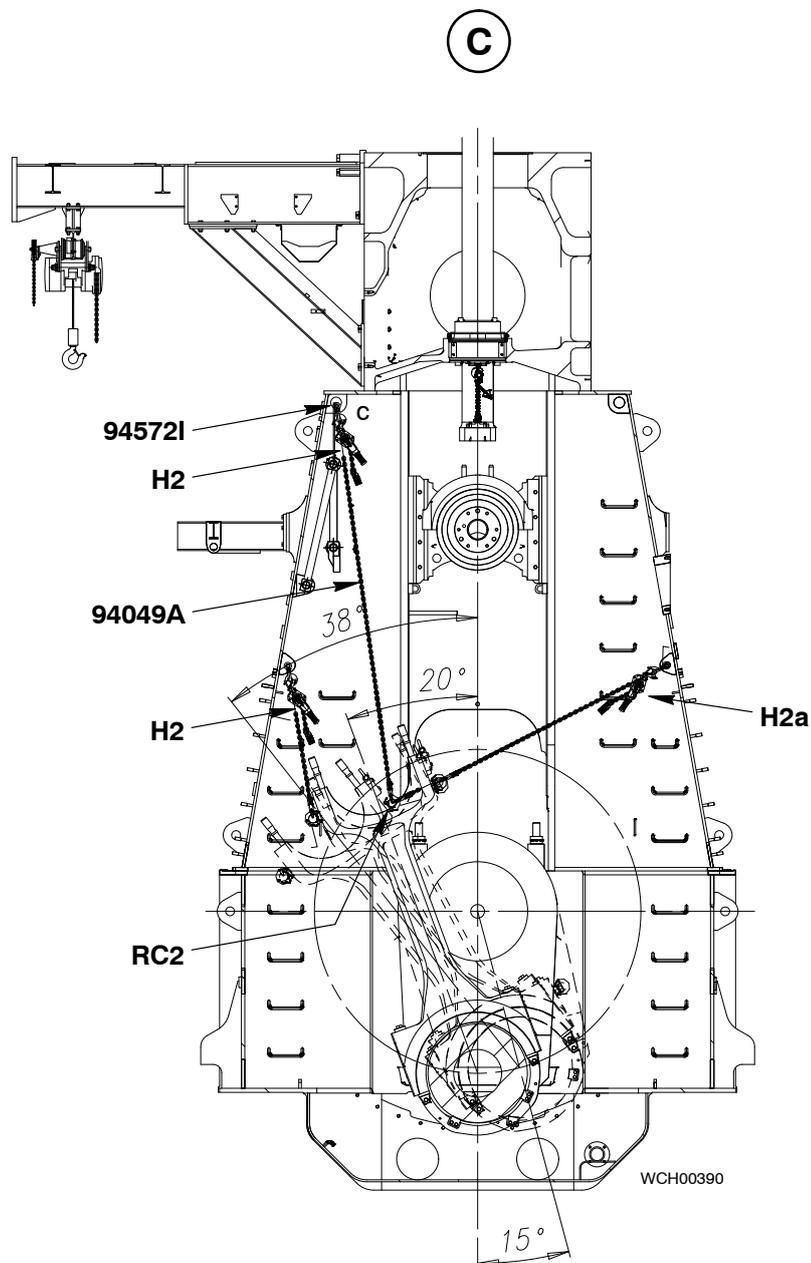
Risk of accident! For safety reasons do not remove manual ratchets 'H1'!

B



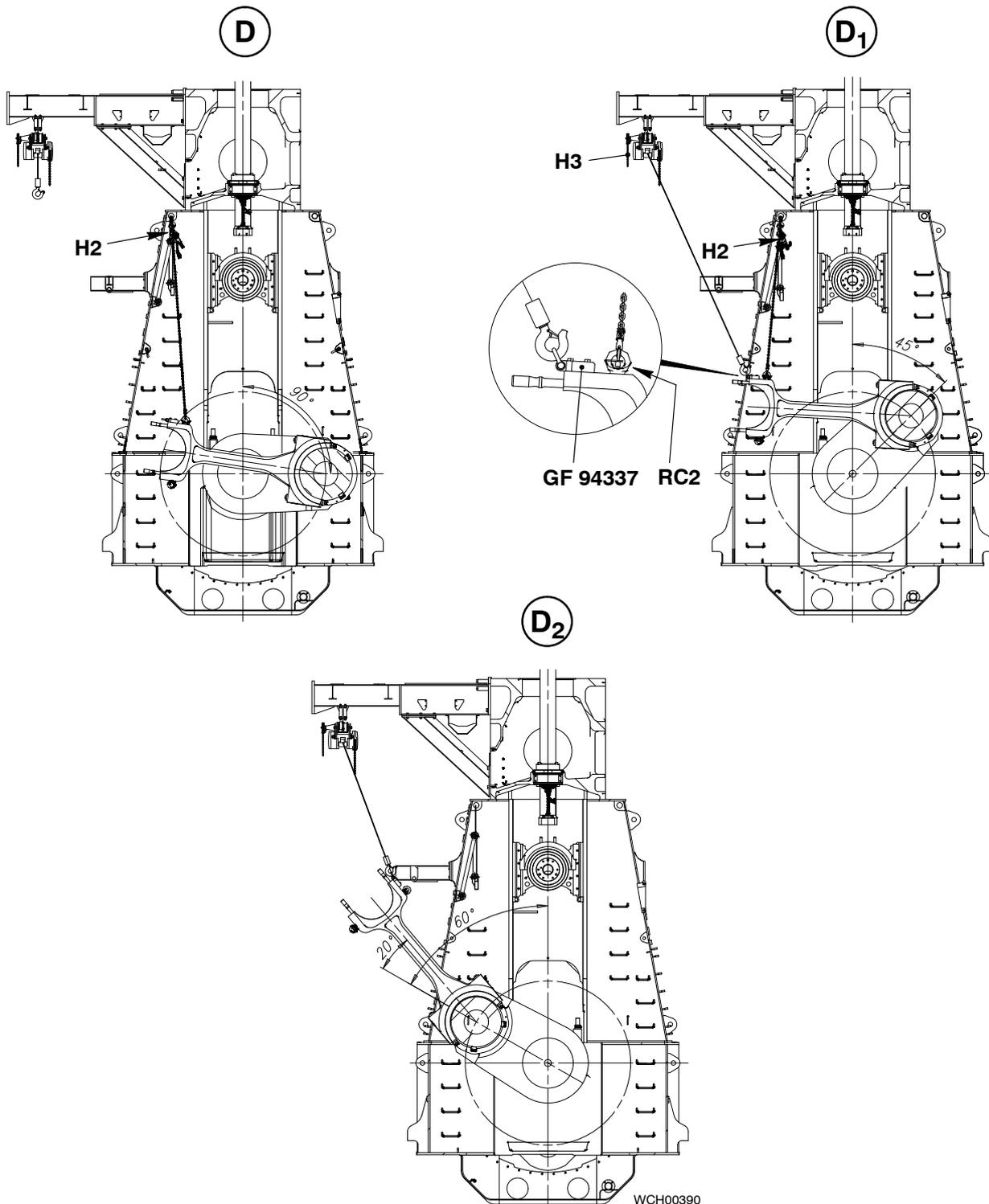
Removal and Fitting

- 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'.



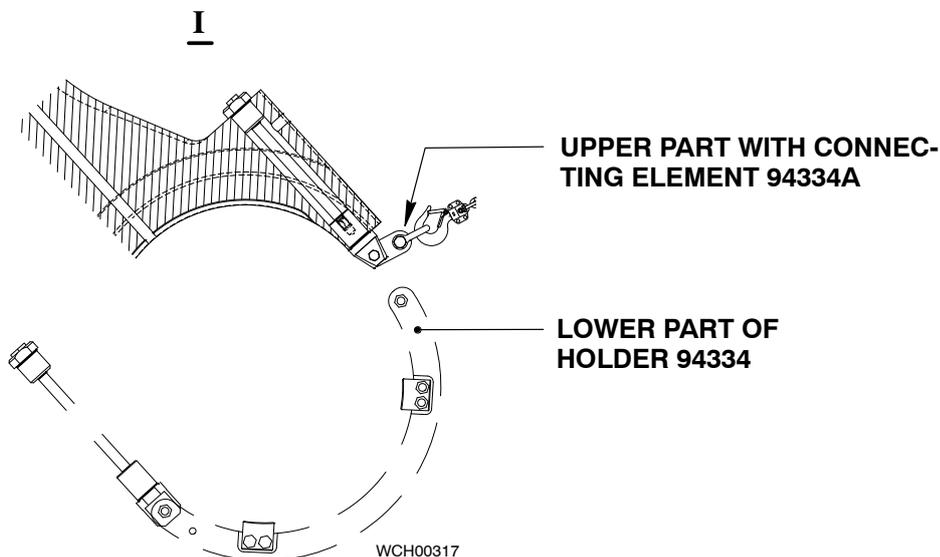
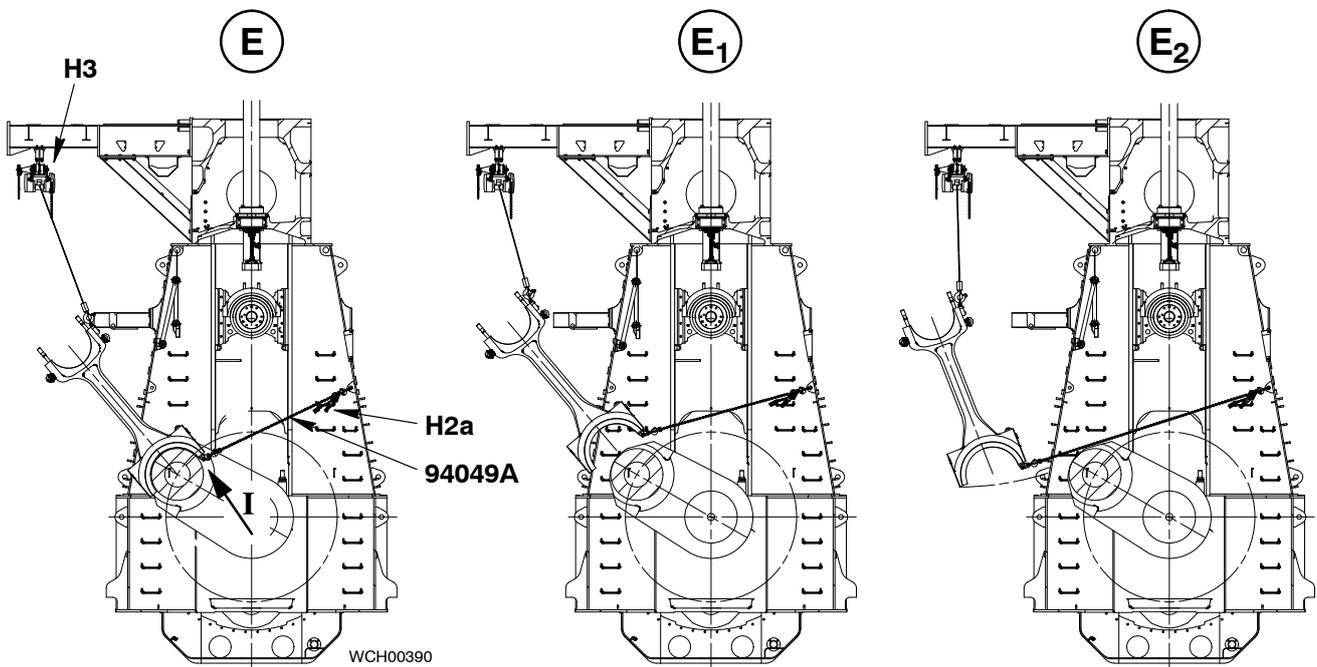
Removal and Fitting

- ⇒ 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:

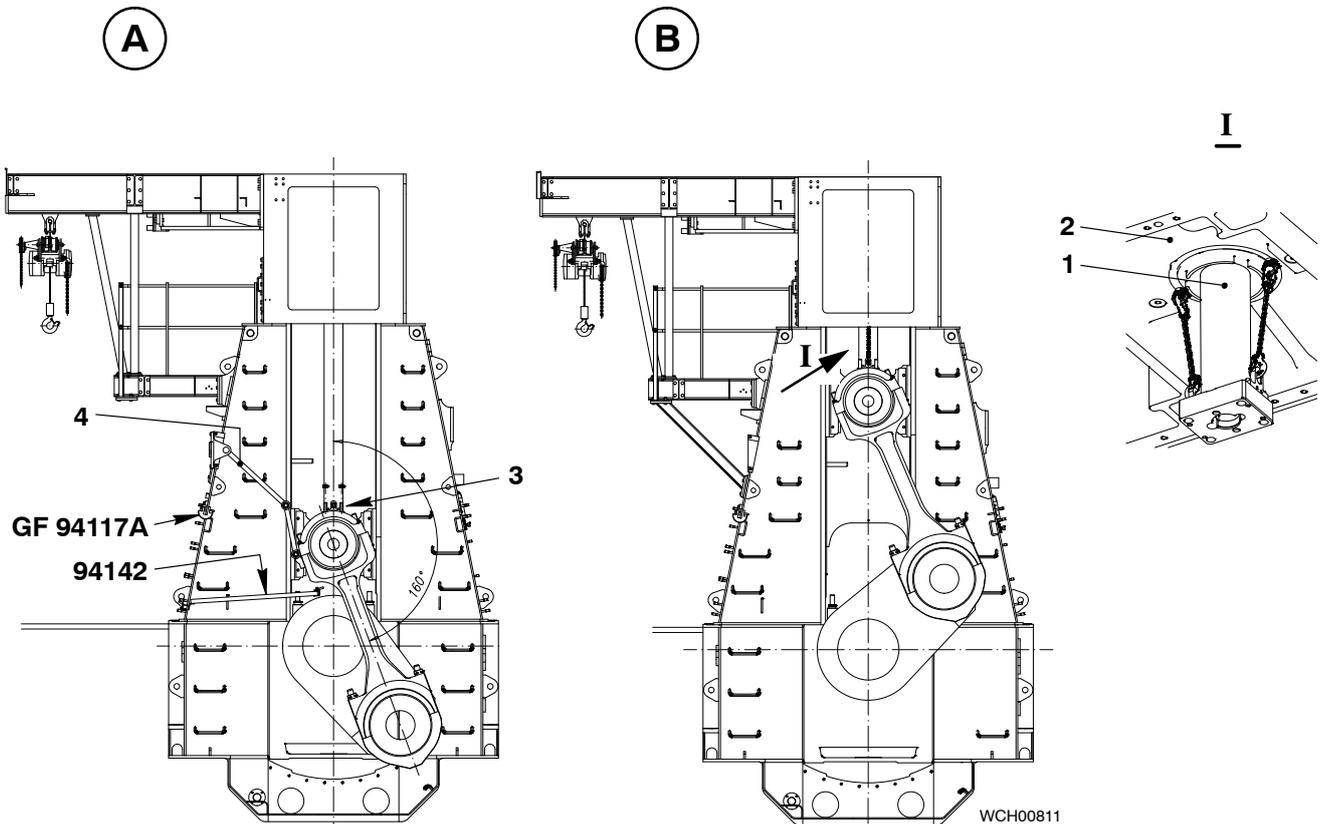
1	Piston rod
2	Cylinder block
3	Elastic stud
4	Toggle lever
5	Bearing cover
6	Crosshead pin

1. Removal



Remark: Pay attention to General Guidelines for Lifting Tools [0012-1](#).

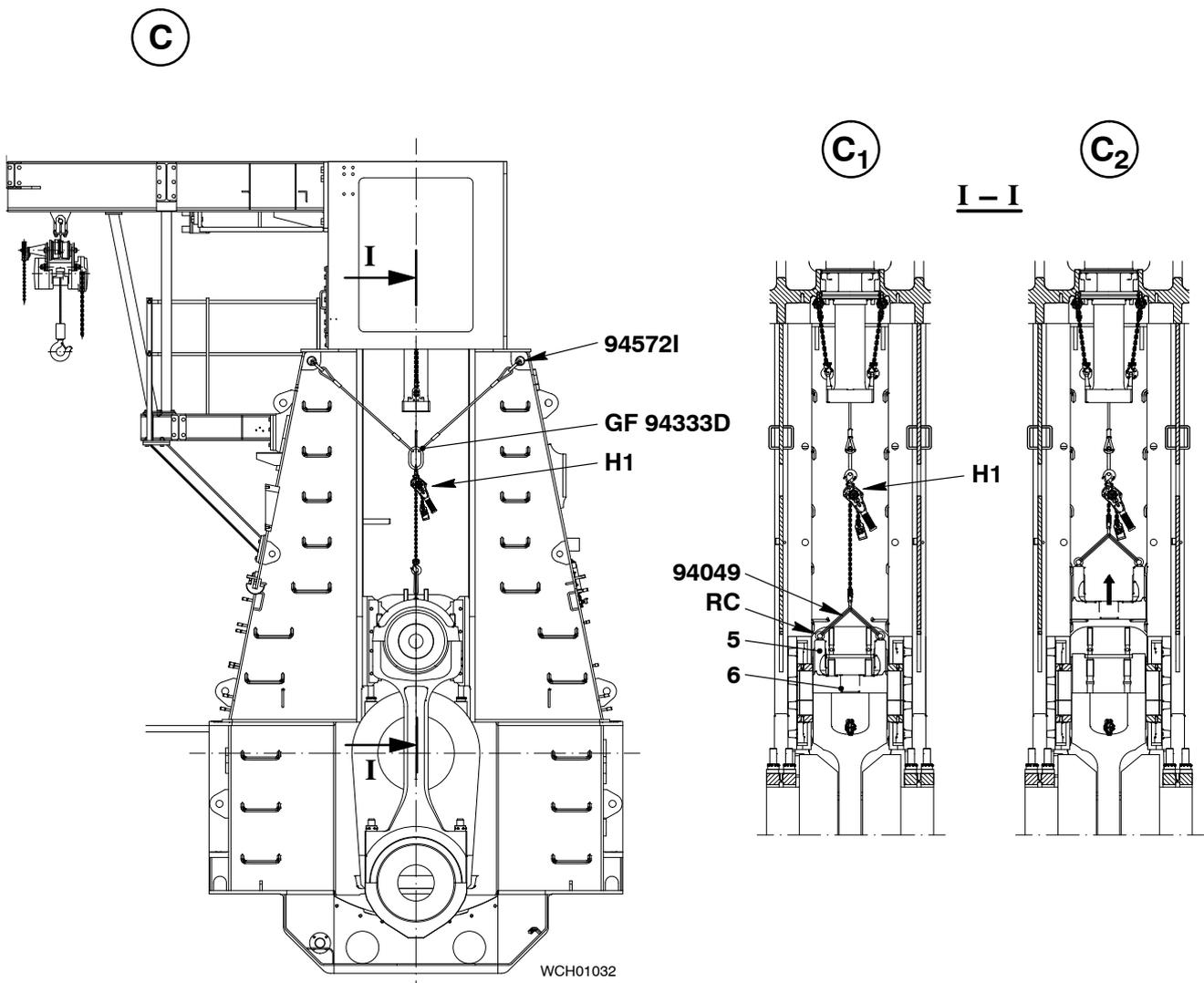
- ⇒ Suspend piston rod 1 and turn crank of the cylinder concerned to B.D.C. as described for Changing the Compression Shims [3403-2](#) (see also view I).
- ⇒ Remove toggle lever 4.
- ⇒ Remove platform element.
- ⇒ Mount deviation pipe GF 94117A to the column door.



WCH00811

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'.

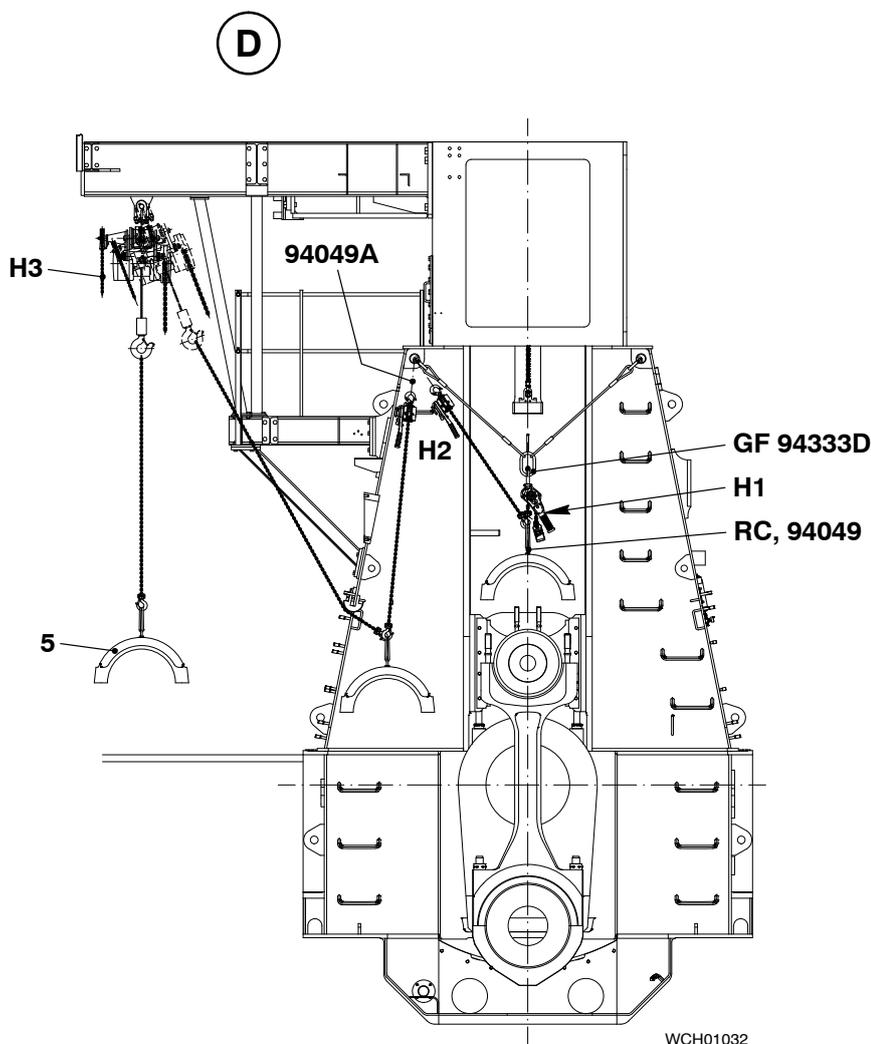
2. Fitting

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:

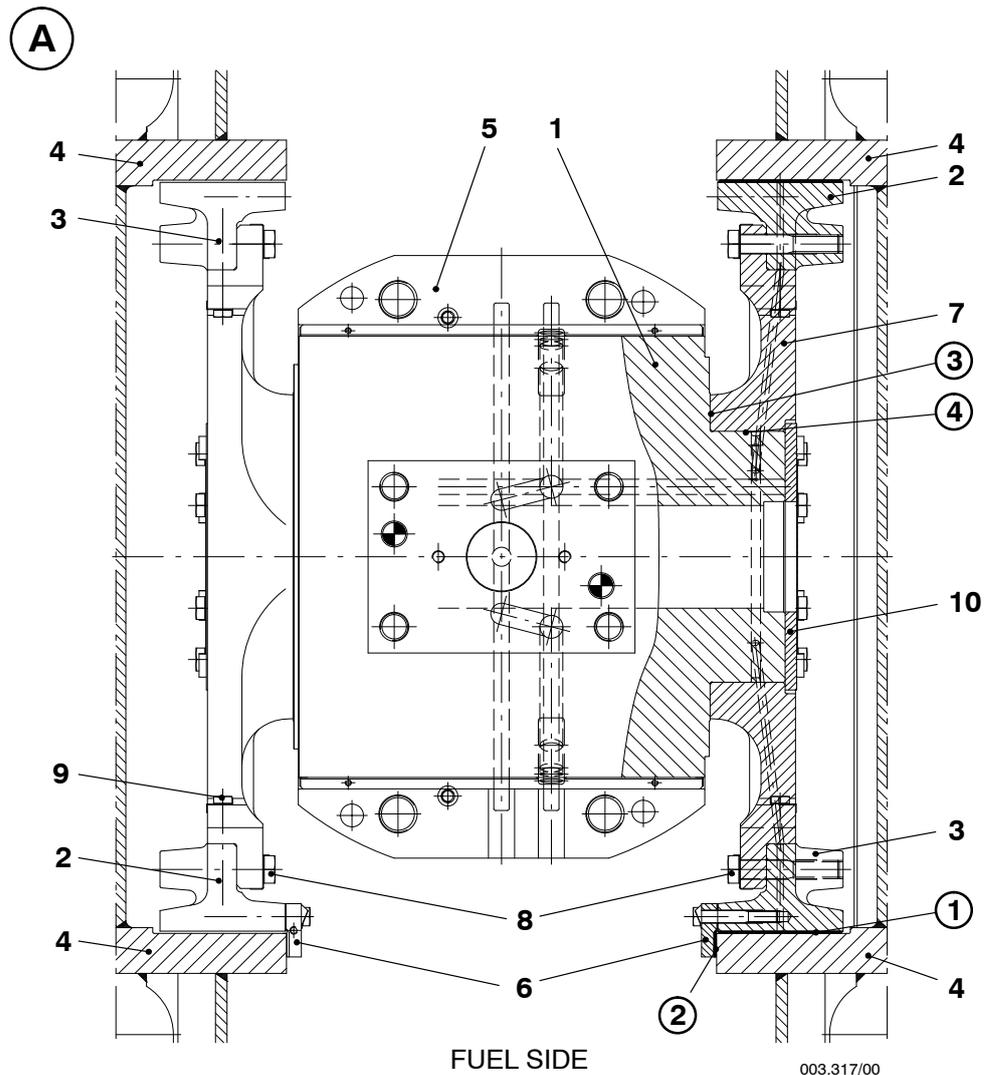
- 1 Feeler gauge 94238

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.



Checking the Clearances and Fitting the Guide Shoes

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

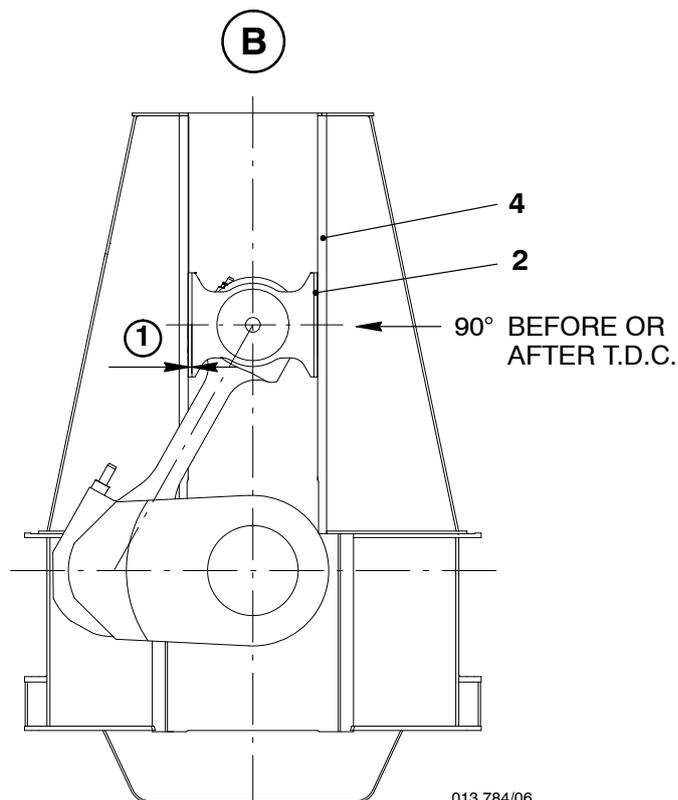
Lateral clearance between middle part and crosshead pin:

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:

1 Manual ratchet (WLL 800 kg)	94016 (H1)
2 Manual ratchets (WLL 1000 kg)	94016D (H2, H3)
1 Manual ratchet (WLL 2500 kg)	94016E (H4)
1 Manual ratchet (WLL 250 kg)	94016G (H5)
1 Spur-gearred chain block (WLL 3000 kg)	94017A (H6)
4 RUD-eye bolts (RC1)	94040-M20
2 RUD-eye bolts (RC2)	94040-M30
1 Eye bolt (RC3)	94045-M10
1 Deviation pipe	GF 94117A
1 Working platform	94142
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

Key to Illustrations:

1	Crank
2	Connecting rod
3	Piston rod
4	Crosshead pin
5, 5a	Guide shoe
6, 6a	Guide shoe middle part
7	Guide rail
8	Screw
9, 9a	End cover
10	Guide way

WU Wooden underlay

1. General



Risk of accident! Ensure that the crankshaft does not turn unintentionally during all the work.

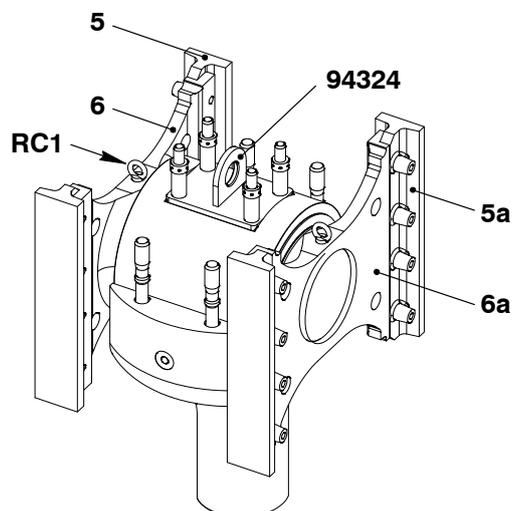
Remark: Pay attention to:

- General Guidelines for Lifting Tools [0012-1](#).
- Utilization of Working Platform [3301-1](#).

2. Preparatory works

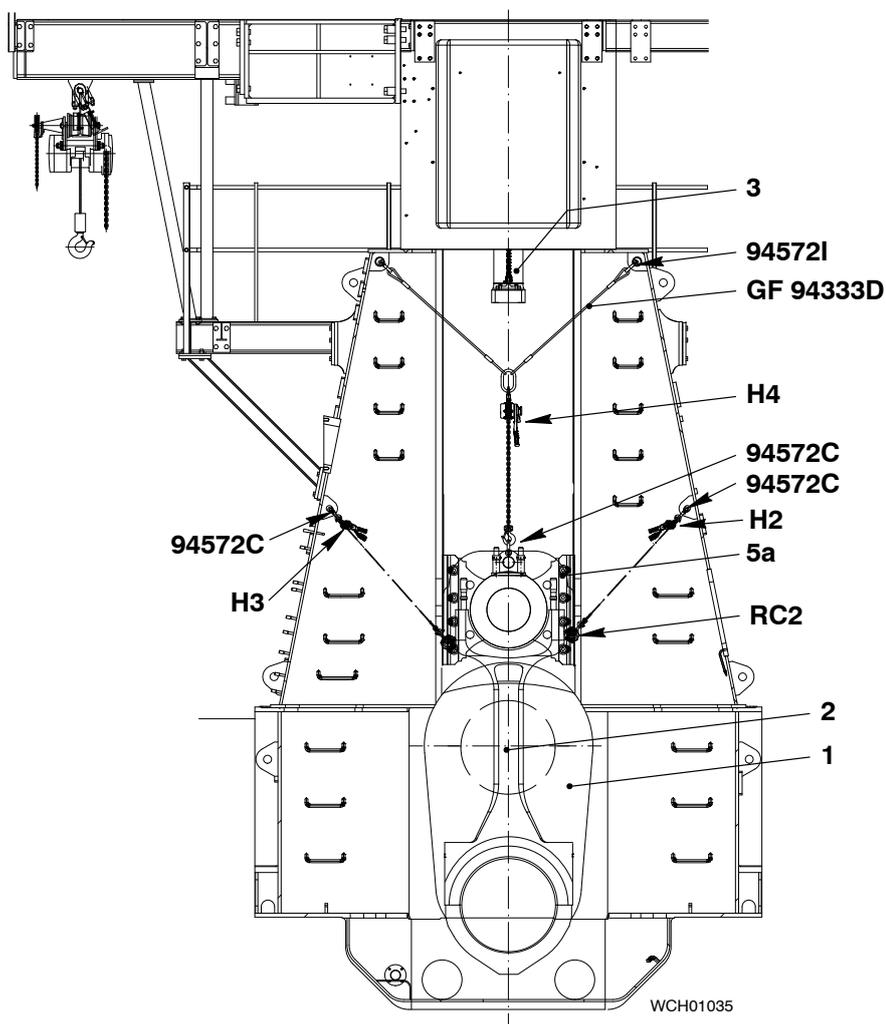
- Top end bearing cover removed (see [3303-5](#)) and piston rod 3 suspended.
- Platform element removed.
- Relevant cylinder turned to B.D.C.
- Lifting plate 94324 mounted on crosshead pin.
- Two RUD-eye bolts 'RC1' tightened to middle parts 6, 6a with **115 Nm**.

A



Removal and Fitting of a Crosshead Pin

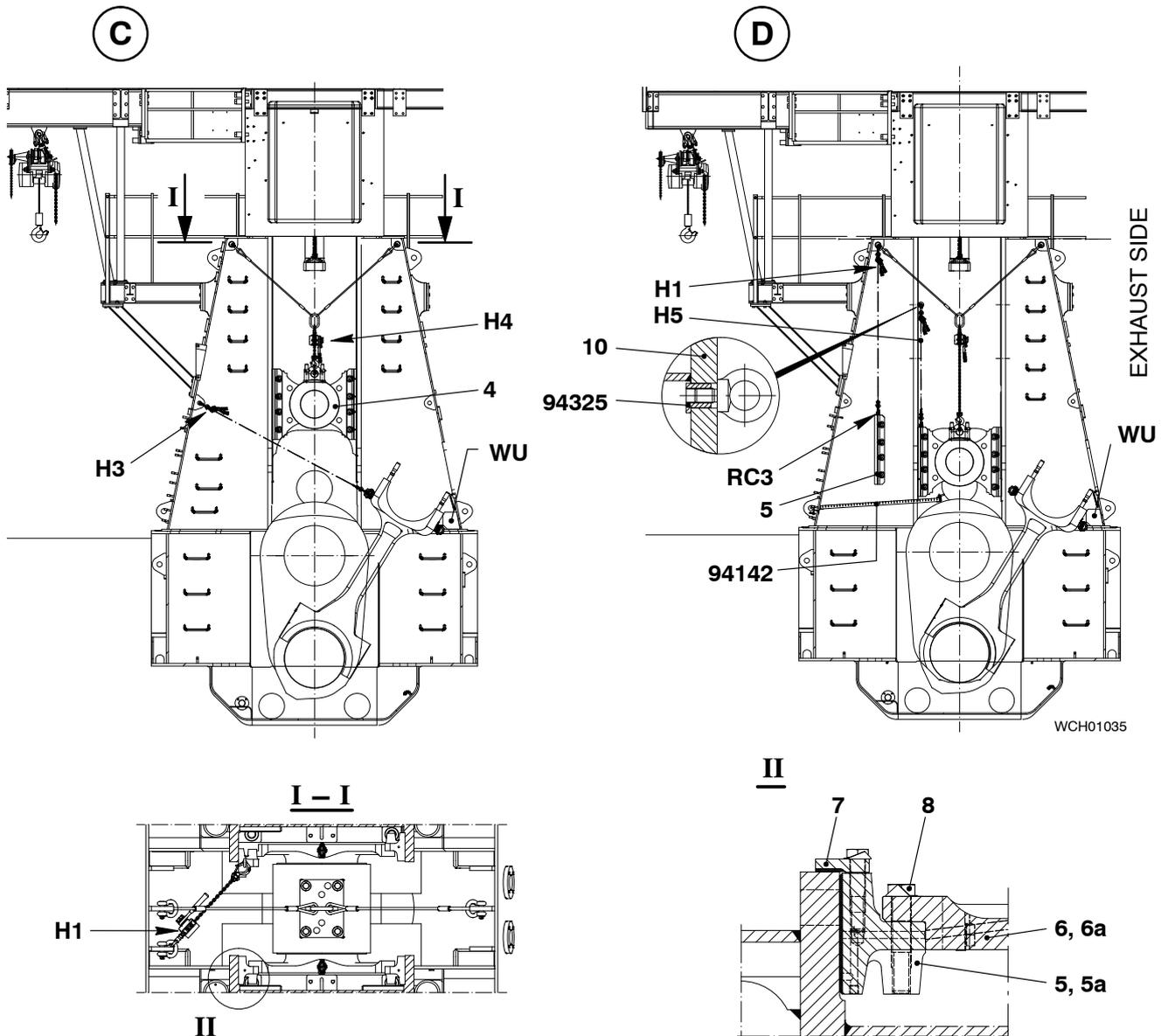
- Two RUD-eye bolts 'RC1' tightened to cylinder block with **115 Nm** (Fig. 'E').
- RUD-eye bolts 'RC2' tightened to either side of connecting rod 2 with **330 Nm**.
- Wire rope sling GF 94333D attached by means of shackles 94572I to the middle lifting lugs in the column.
- Manual ratchet 'H4' attached 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

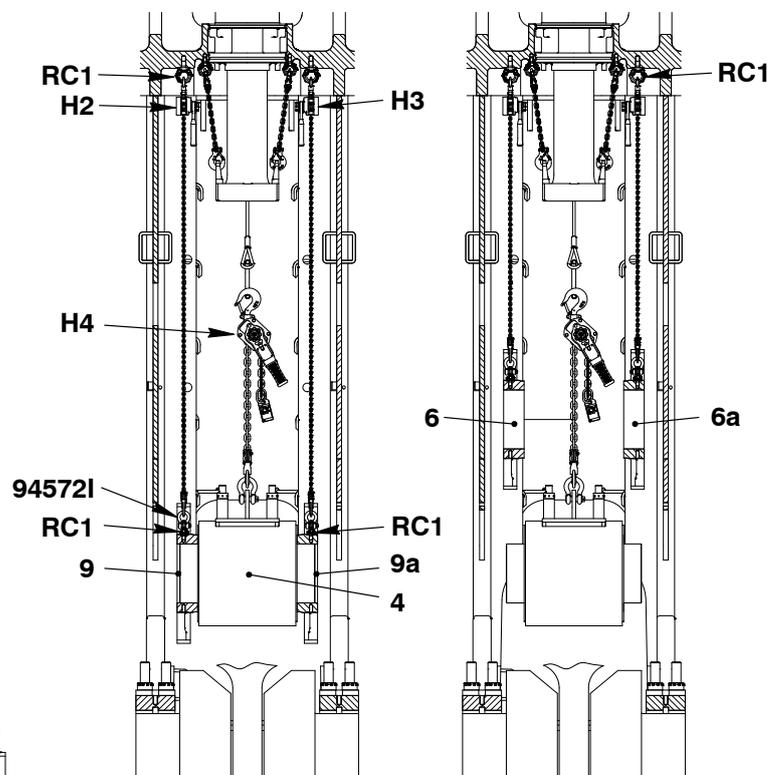
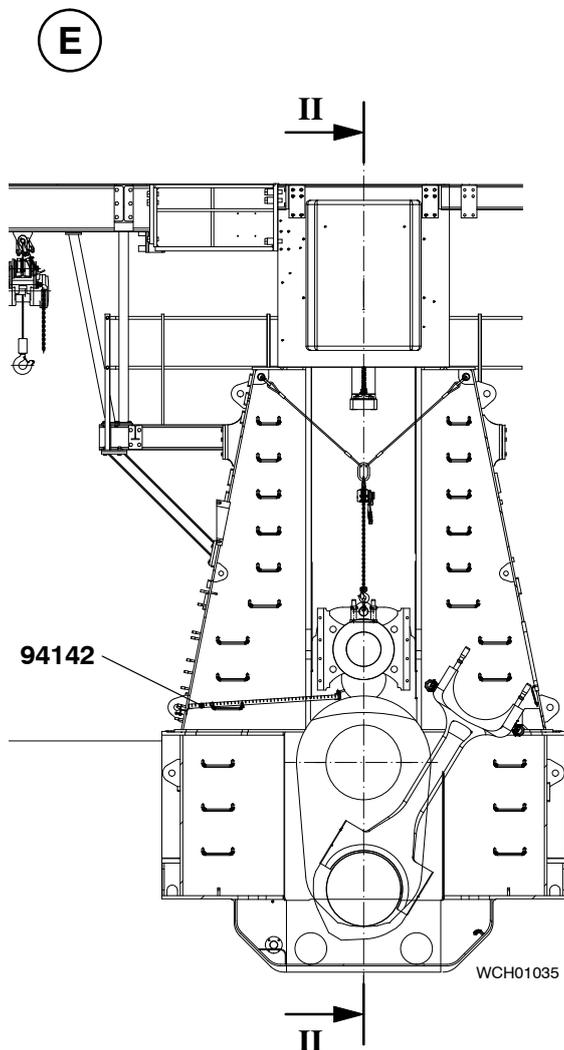
- ⇒ Secure the connecting rod with manual ratchets 'H2' and 'H3' attached to RUD-eye bolts 'RC2' (Fig. 'B').
- ⇒ Lift off crosshead pin 4 using manual ratchet 'H4'.
- ⇒ Carefully swing the connecting rod towards exhaust side by means of manual ratchets 'H2' and 'H3'.
- ⇒ Remove manual ratchet 'H2' and 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

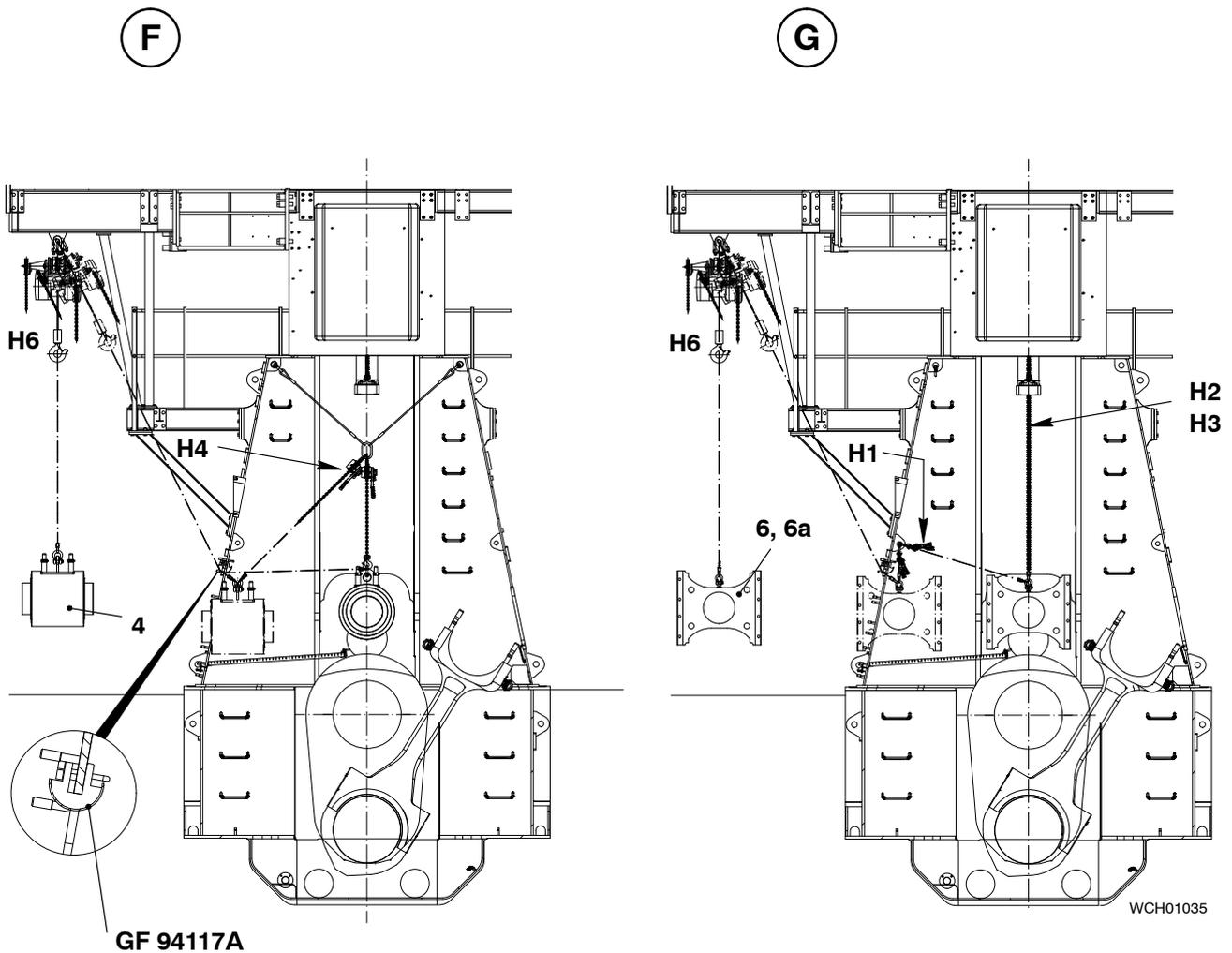
- ⇒ Secure guide shoe middle parts 6, 6a with manual ratchets 'H2' and 'H3' connected to RUD-eye bolts RC1.
- ⇒ Remove end covers 9, 9a.
- ⇒ Retract guide shoe middle parts from crosshead pin 4 and lift them beyond the crosshead pin.
- ⇒ Remove working platform 94142.

II - II



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-gear chain block 'H6'.
- ⇒ Lower guide shoe middle parts 6, 6a and remove it from column using manual ratchets 'H1', 'H2' and 'H3'.



Removal and Fitting of a Crosshead Pin

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.

Piston: Removal and Fitting

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.

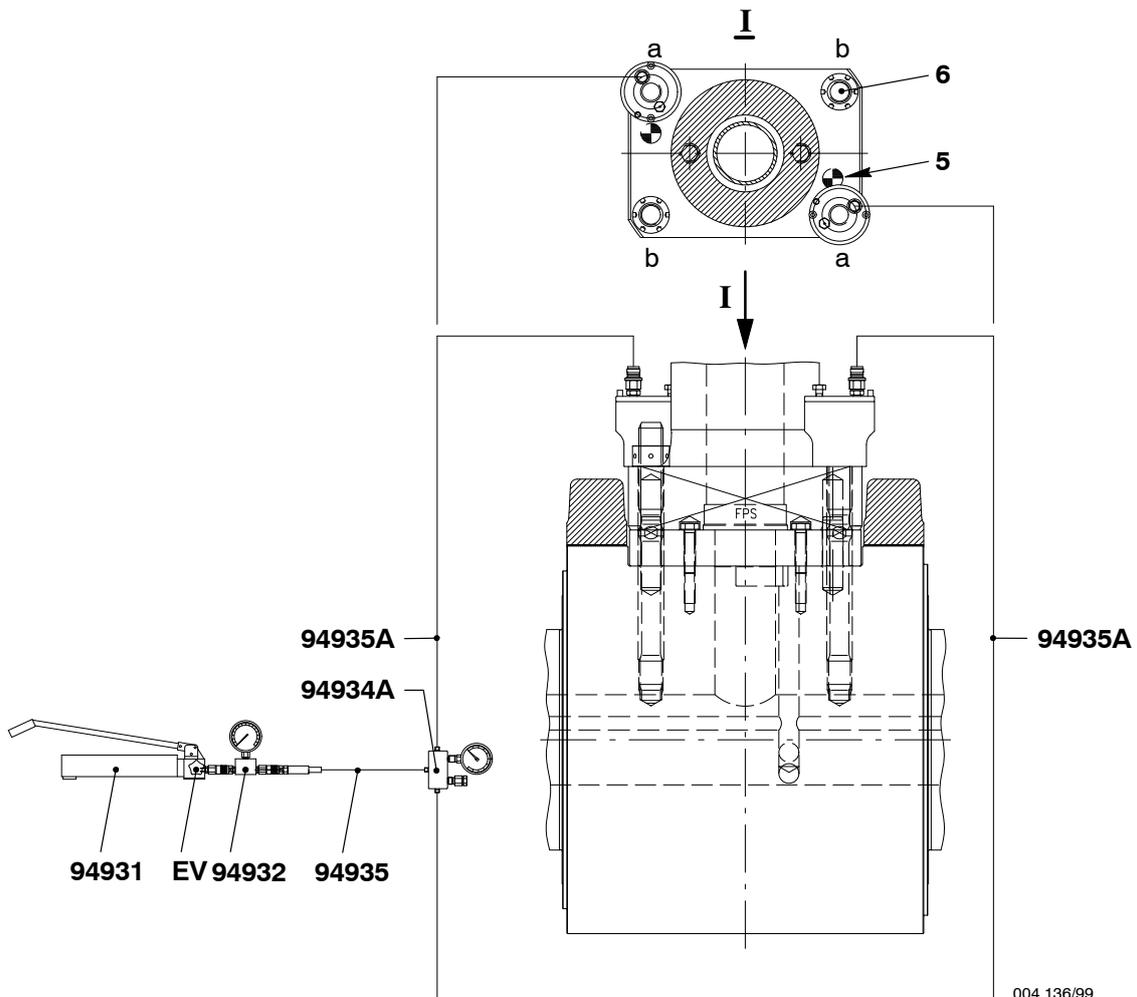
- Tensioning of elastic studs 6 must be carried out in two steps without exception, i.e. tension all elastic studs first with **600 bar (1st step)**, then finish tensioning with **1000 bar (2nd step)**.

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').

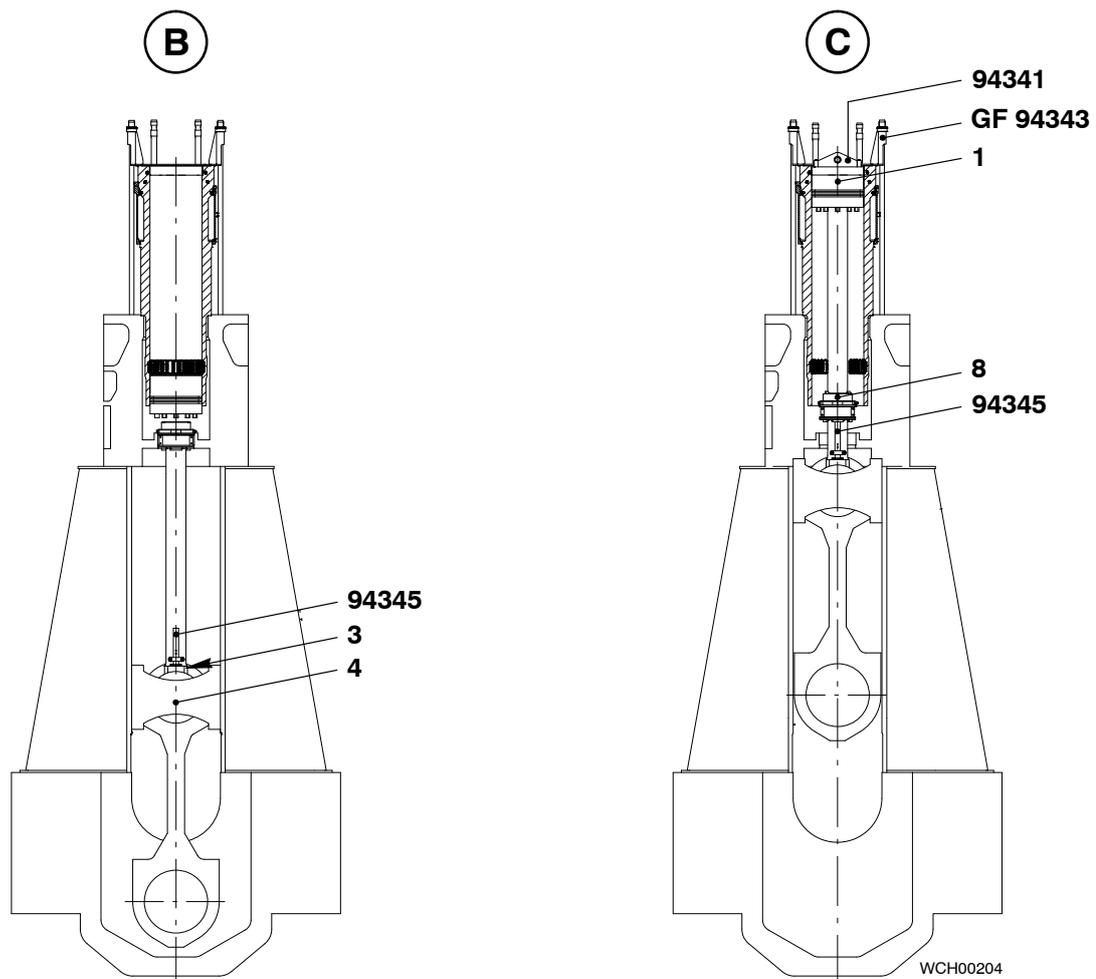
⇒ Screw fasten both distance holders 94345 to the piston rod foot (3).

⇒ 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.

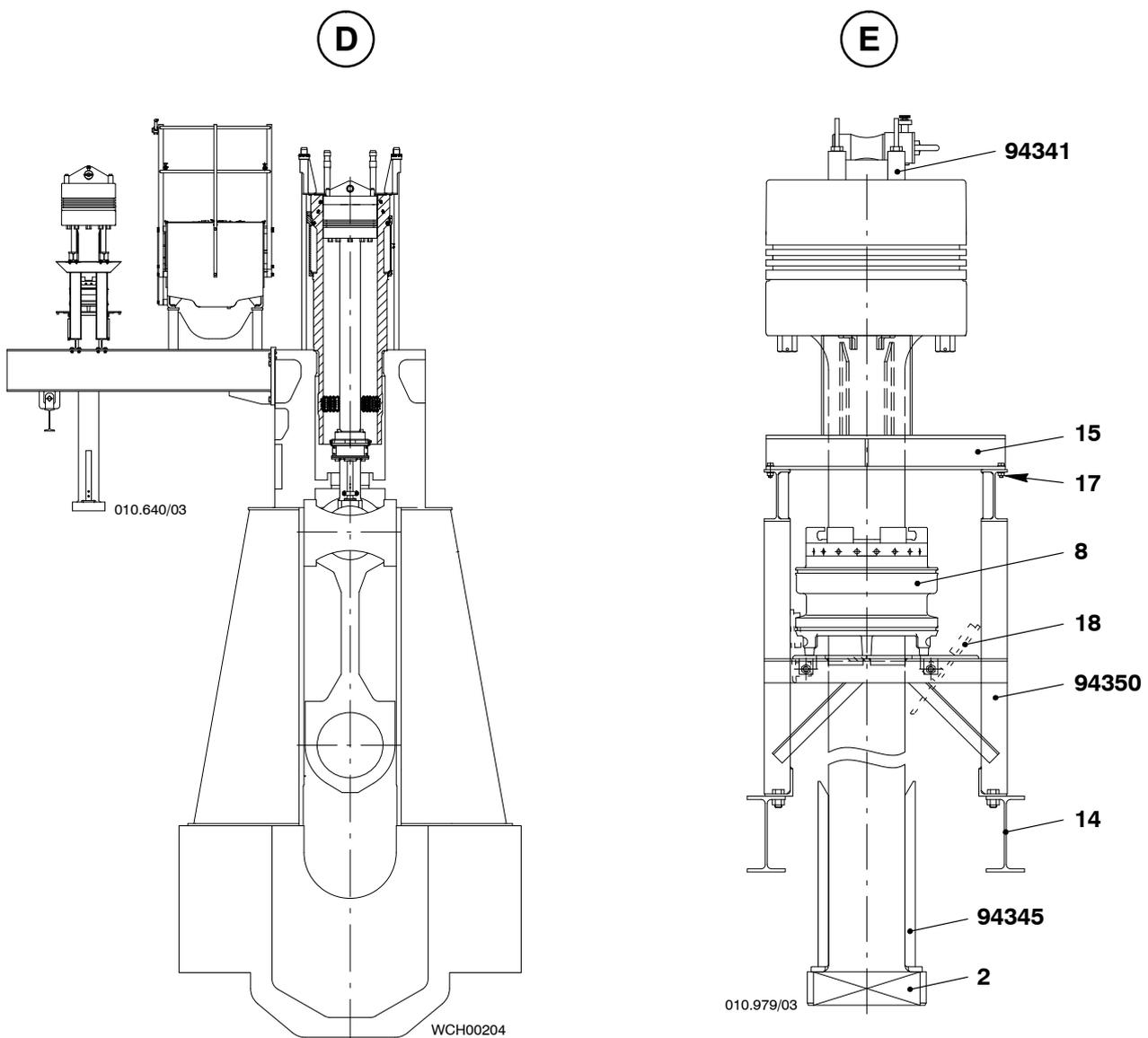


Piston: Removal and Fitting

- ⇒ 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.



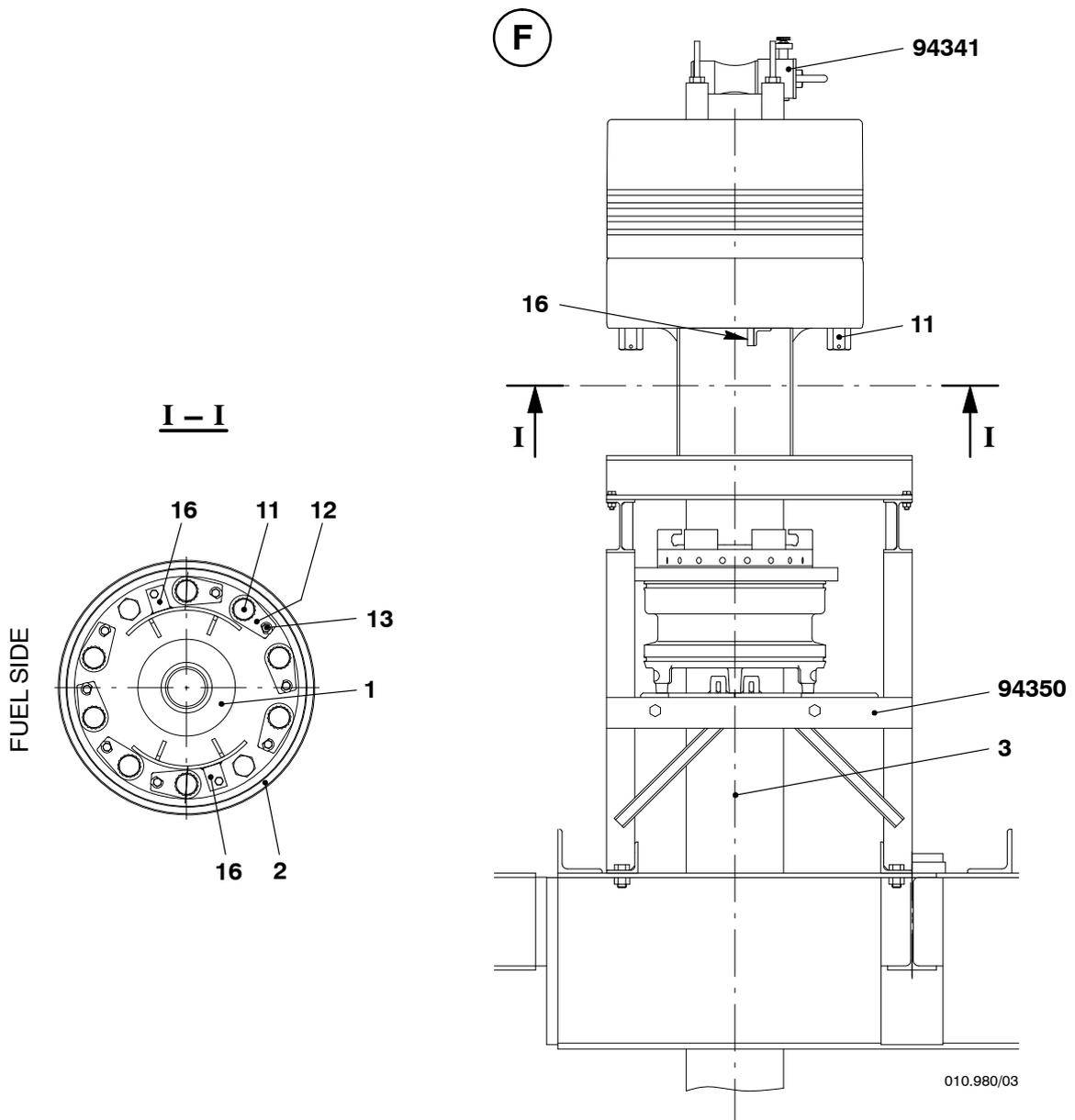
Attention! To prevent having a fall place cover plate 94345D over the gland bore in the cylinder block and fasten it provisionally with several screws.



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.



Piston: Removal and Fitting

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).

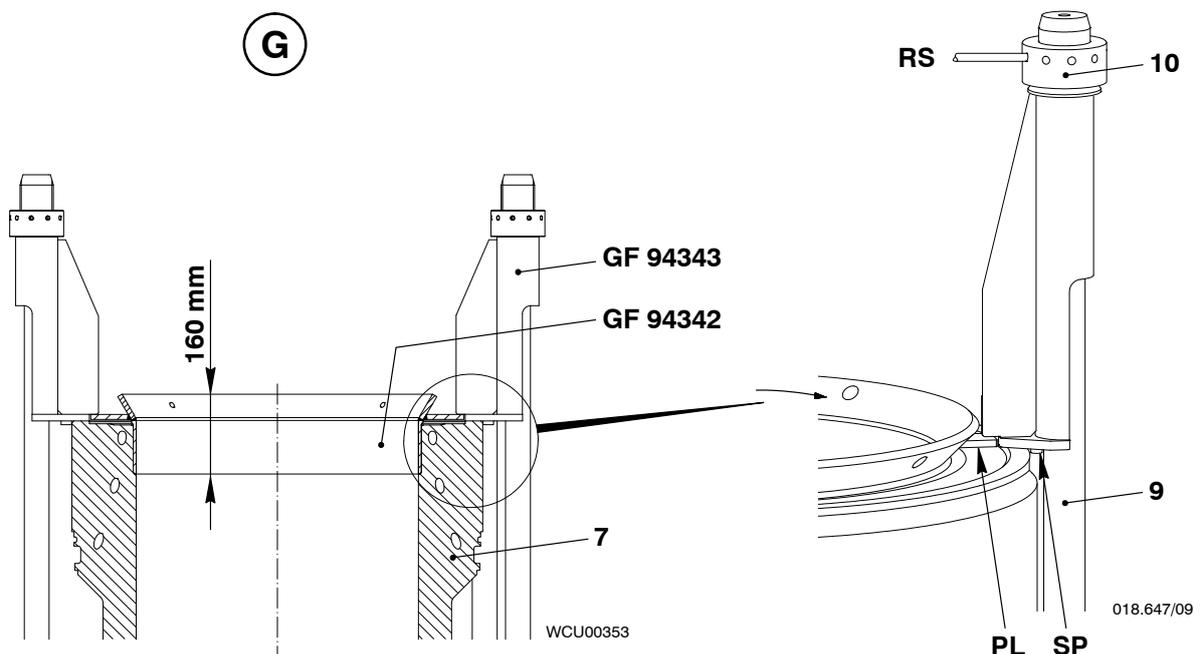
⇒ Actuate the cylinder lubrication until oil flows from all the lubricating points.

- 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'.

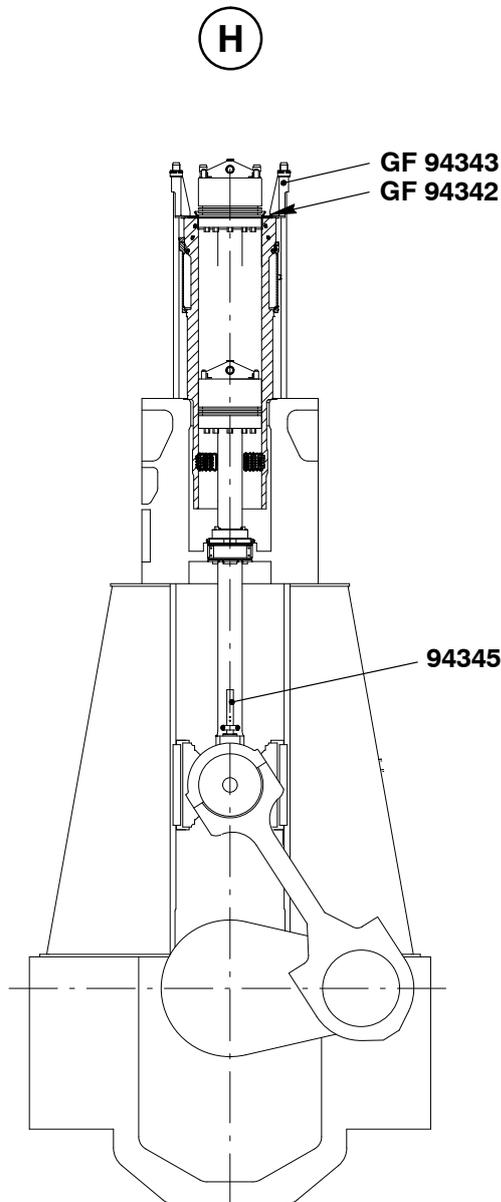
⇒ Place insertion funnel GF 94342 on cylinder liner 7. Turn it so that the two welded plates 'PL' of the insertion funnel are exactly located under the locking devices.

- 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

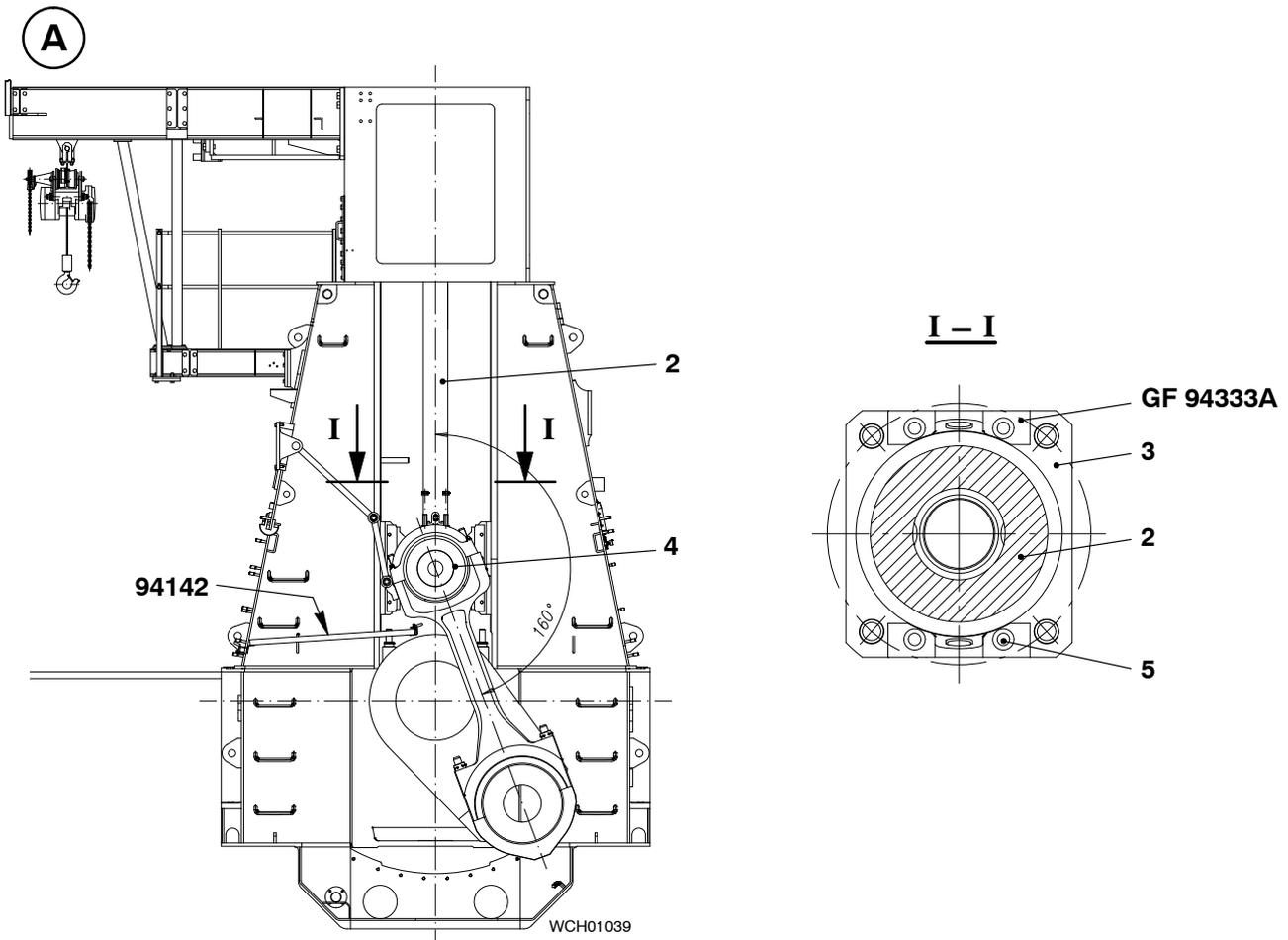
Tools:

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

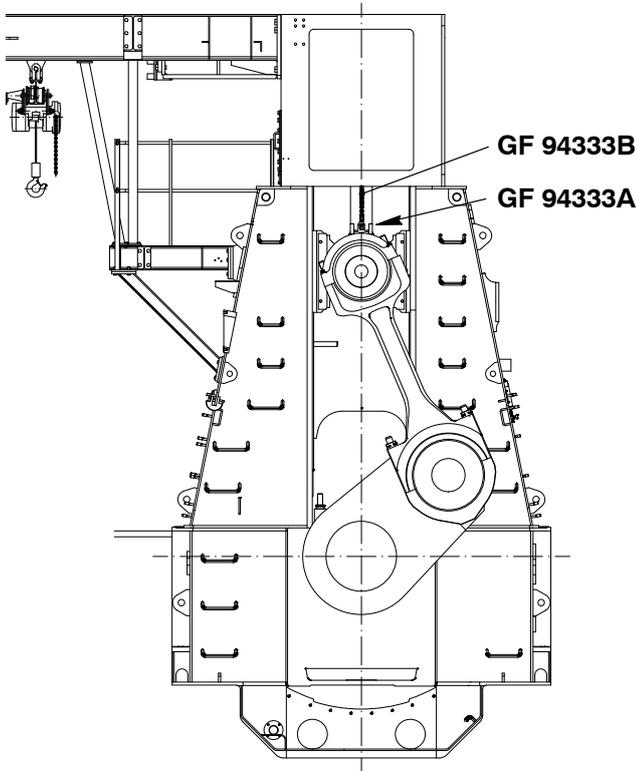
1. Fitting and removing compression shim

**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.



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.

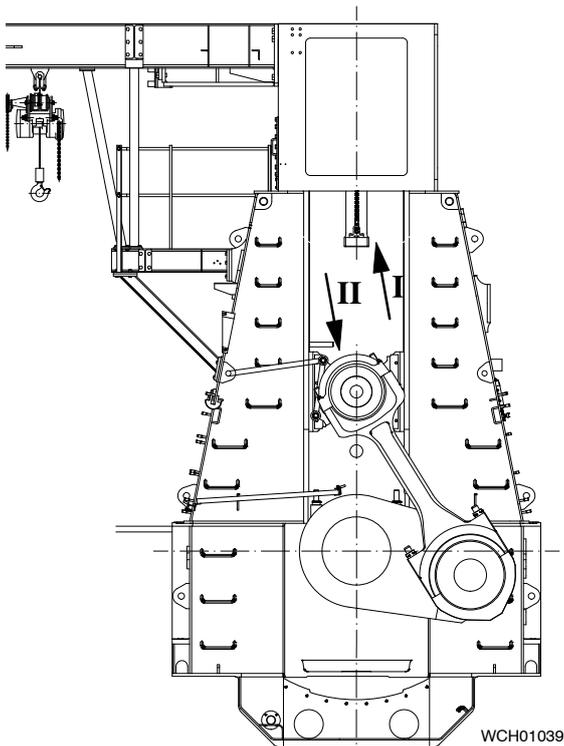
⇒ Remove the compression shim with the aid of two eye bolts.

For fitting the new compression shim proceed in reverse sequence to the removal.

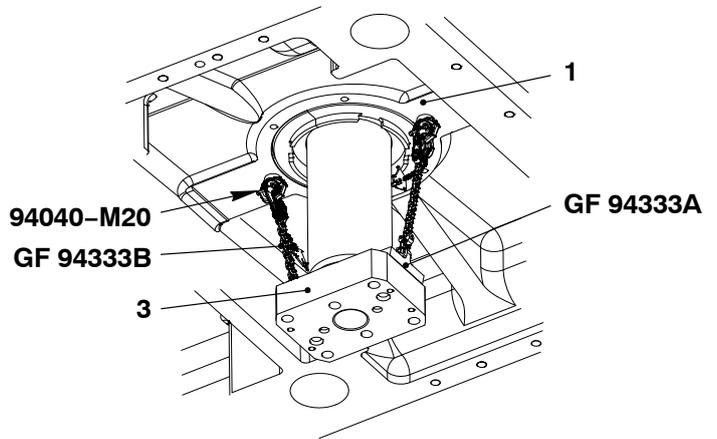


Remark: Please note the correlation between setting screw 'ST' on measuring gauge 94225 (see 2124-1) and the mean thickness of built-in compression shims.

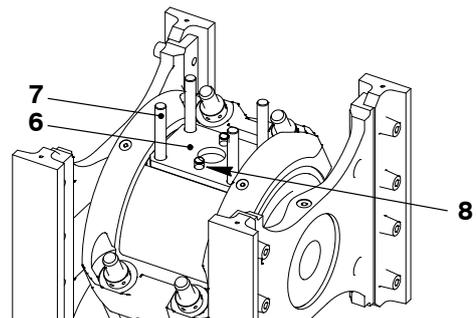
C



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.

Piston: Dismantling and Assembling

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).

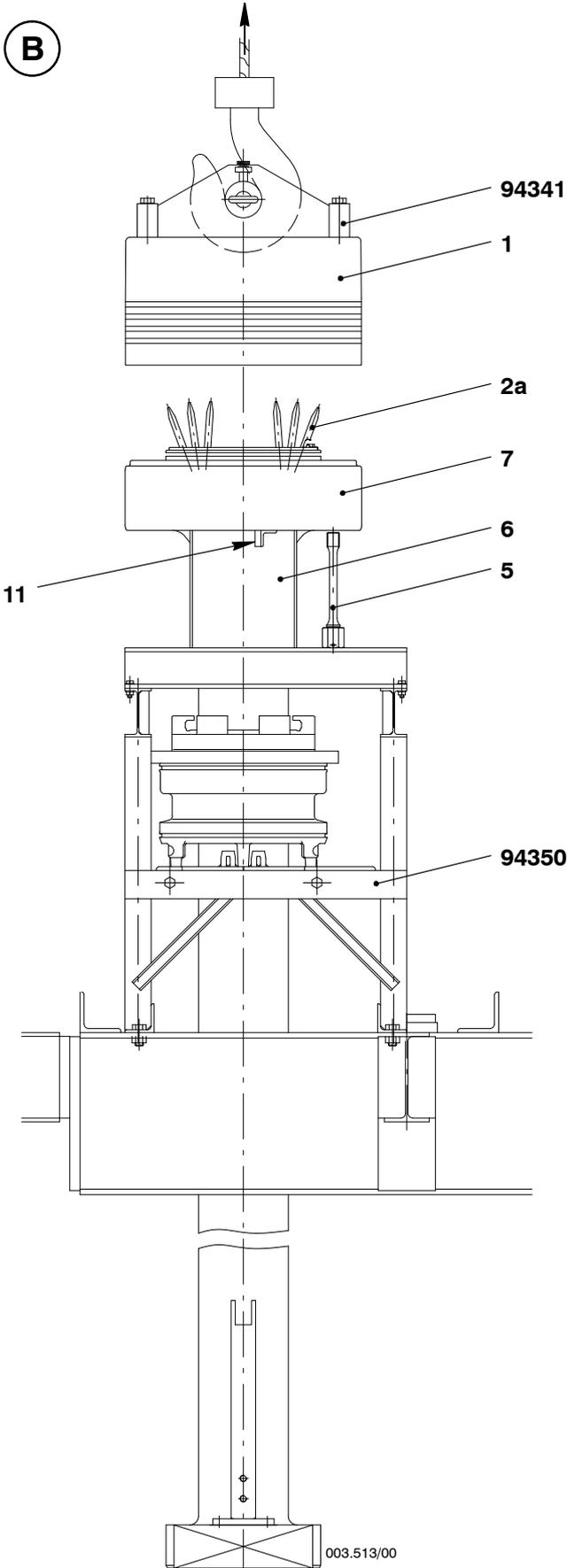
CHECK

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°).

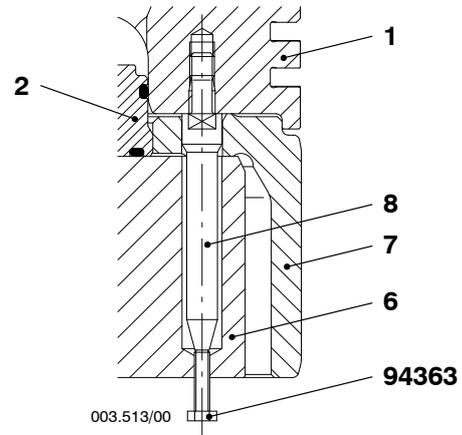
Piston: Dismantling and Assembling

B



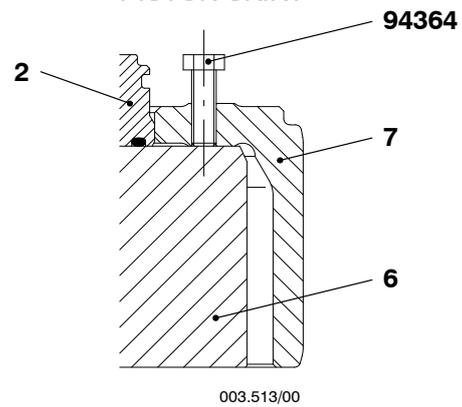
C

SEPARATING THE PISTON CROWN



D

SEPARATING THE PISTON SKIRT



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').

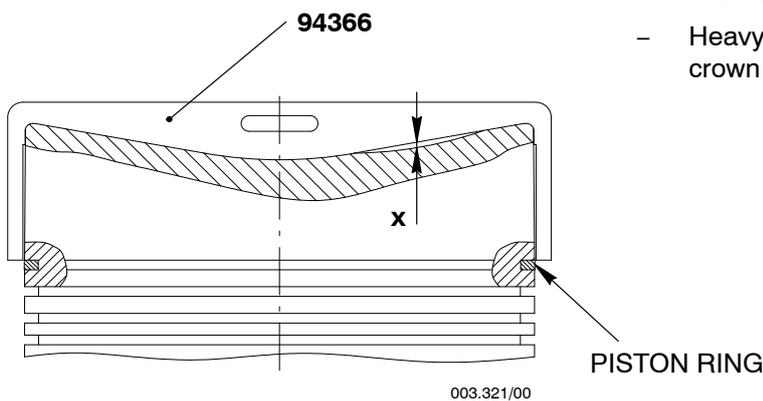
- Where burn scars are only slight it is sufficient to grind them over and to smooth sharp-edged zones with emery cloth. Where, however, burn scars exceed $x = 10$ mm the original material thickness must be restored by surface welding. This entails the removal of the piston crown.

Before re-starting the engine, the reason for such heavy burns should be established. The causes must be remedied.

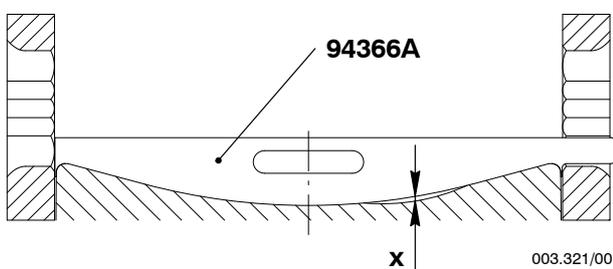
Causes of heavy burn scars may be:

- 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.

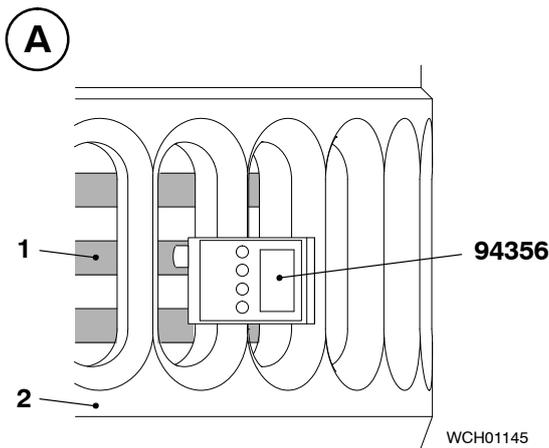
Checking Wear of Piston Rings and Ring Grooves

with Four Piston Rings

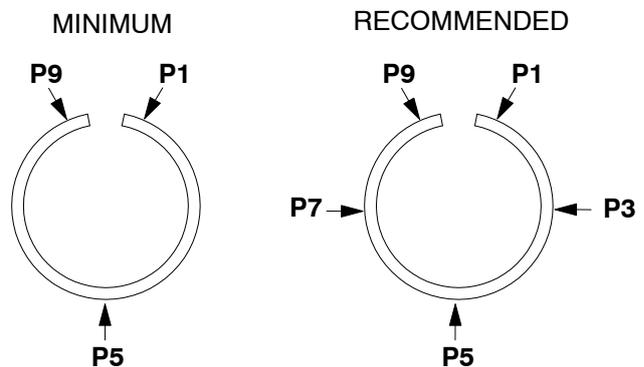
2.1 Measure coating thickness with piston in situ (through scavenge ports)

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.



MEASURING POINTS ON PISTON RING



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

PARTIALLY WORN CC-COATING



Checking Wear of Piston Rings and Ring Grooves

with Four Piston Rings

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).

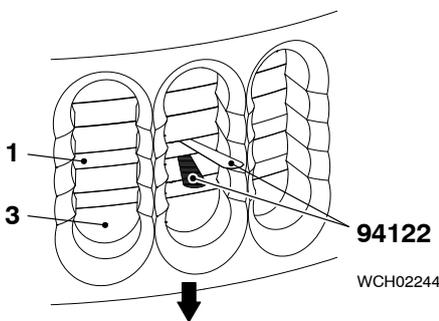
The maximum clearance is at point A. For the maximum wear data see Clearance Table 0330-1 'Piston and Piston Rings'.



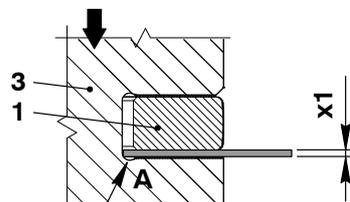
If the clearance at point A exceeds the permitted value, the piston rings have to be replaced and the piston head has to be reconditioned.

For reconditioning of piston crowns please contact your nearest Wärtsilä Service Center.

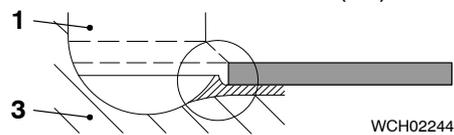
C



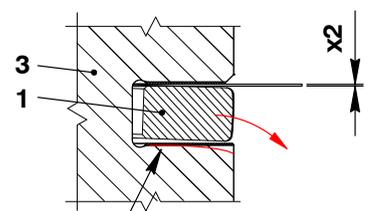
PISTON MOVED DOWN (C1)



WEAR STEP ON CHROMIUM LAYER (C3)



(C2)



POSSIBLE WEAR SHAPE ON GROOVE

Checking Wear of Piston Rings and Ring Grooves

with Four Piston Rings

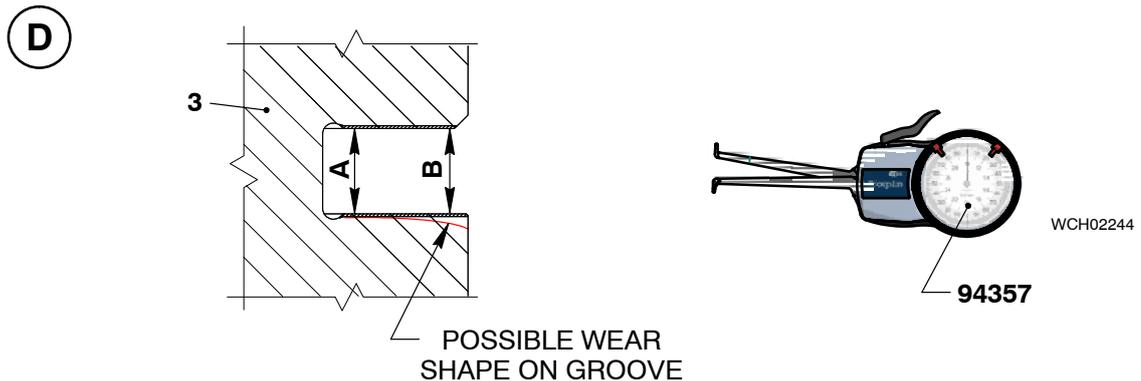
3.2 Measurement with piston removed from cylinder liner

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:

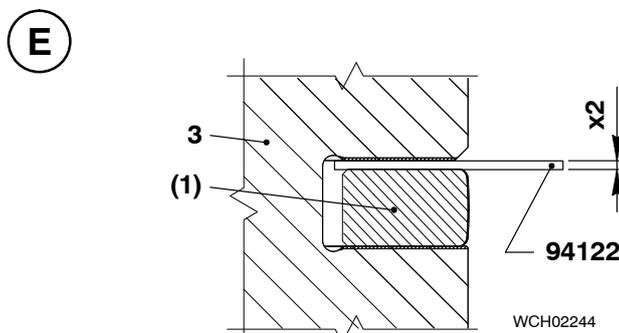
- ⇒ Measure the groove height with calliper gauge 94357 at point A and B.

**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:

$$CL = GH - RT \text{ (mm)}$$

- CL = Clearance
- GH = Measured piston ring Groove Height (mm)
- RT = Nominal piston Ring Thickness (mm)



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

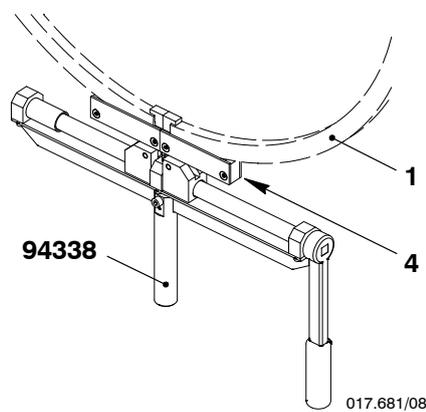
For removing piston rings 1, always use the corresponding tensioning device with its specially designed claws 4 preventing the coating from being chipped off at the ring ends.

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.

F



5. Fitting piston rings

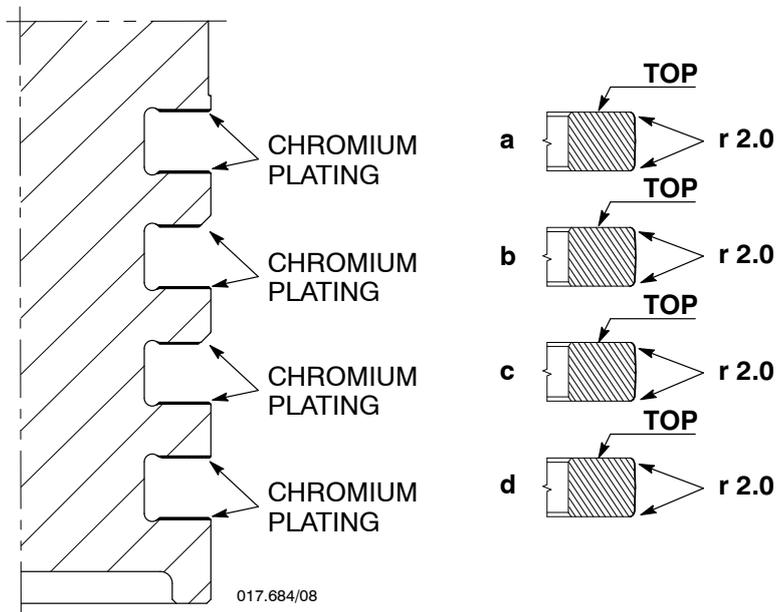
- When reusing piston rings, only rings in perfect condition may be fitted, however in the same position and groove as removed.
- **Always fit piston ring with the marking TOP upwards**
(when the piston is assembled the piston rings must be turned such that the ring gaps are staggered by 180°).
- The 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_Straight Cut	chrome-ceramic coated	for new and fully honed cylinder liners
Piston rings 'b', 'c' and 'd' 3 x SCP2CC16_Straight Cut	chrome-ceramic coated	as well as for used cylinder liners in good conditions



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.

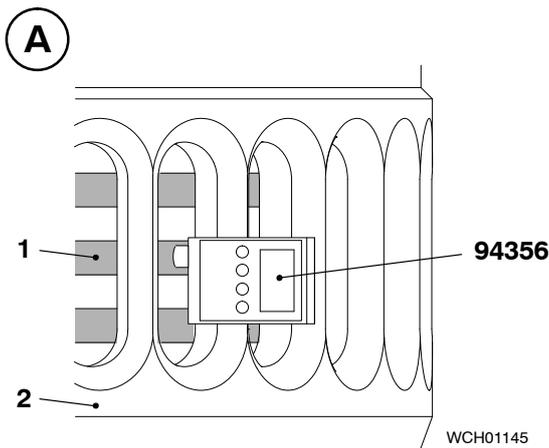
Checking Wear of Piston Rings and Ring Grooves

with Three Piston Rings

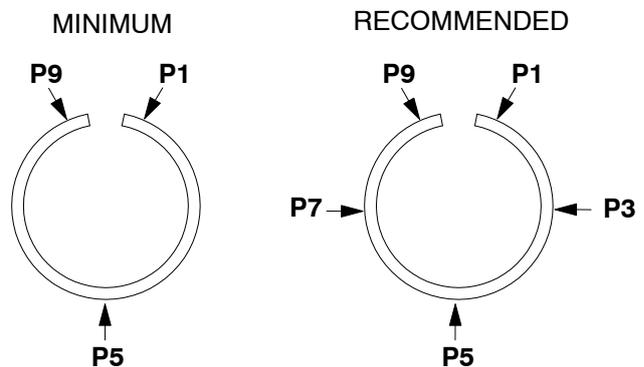
2.1 Measure coating thickness with piston in situ (through scavenge ports)

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.



MEASURING POINTS ON PISTON RING



2.2 Wear rate

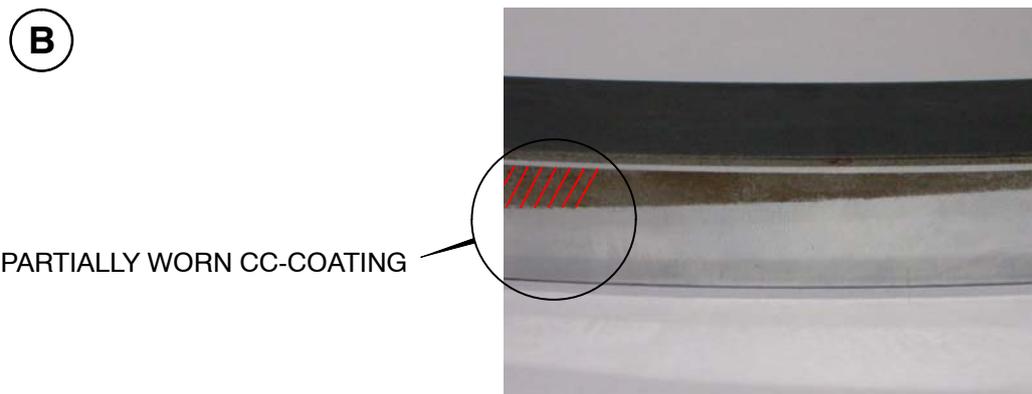
The chrome-ceramic coating is a lifetime coating. However, the actual wear depends on operating conditions. When during a piston underside inspection a piston ring with a partially worn chrome-ceramic coating is found, we recommend overhauling the unit at next opportunity (Fig. 'B').

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.



Checking Wear of Piston Rings and Ring Grooves

with Three Piston Rings

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).

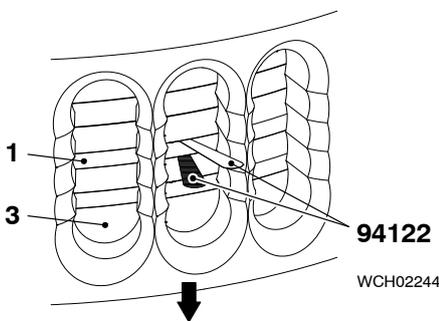
The maximum clearance is at point A. For the maximum wear data see Clearance Table 0330-1 'Piston and Piston Rings'.



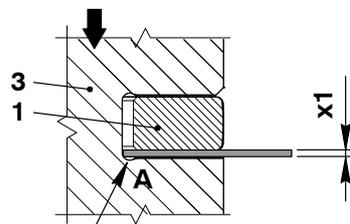
If the clearance at point A exceeds the permitted value, the piston rings have to be replaced and the piston head has to be reconditioned.

For reconditioning of piston crowns please contact your nearest Wärtsilä Service Center.

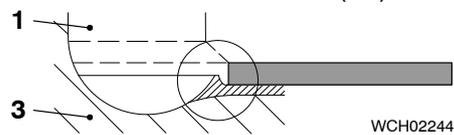
C



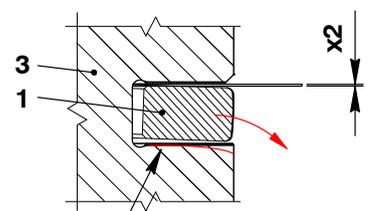
PISTON MOVED DOWN (C1)



WEAR STEP ON CHROMIUM LAYER (C3)



(C2)



POSSIBLE WEAR SHAPE ON GROOVE

Checking Wear of Piston Rings and Ring Grooves

with Three Piston Rings

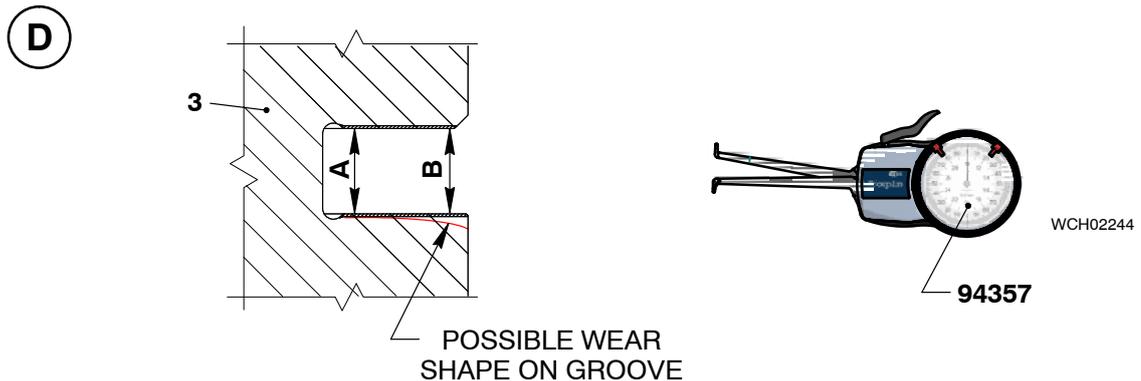
3.2 Measurement with piston removed from cylinder liner

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:

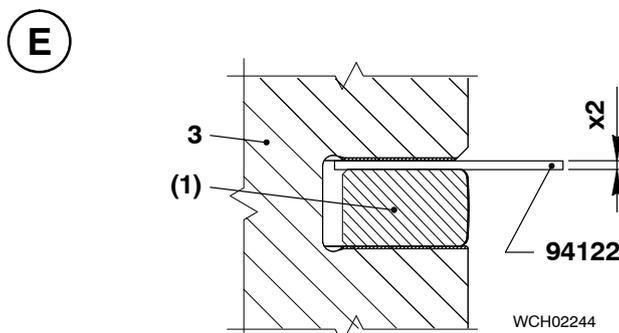
- ⇒ Measure the groove height with calliper gauge 94357 at point A and B.

**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:

$$CL = GH - RT \text{ (mm)}$$

- CL = Clearance
- GH = Measured piston ring Groove Height (mm)
- RT = Nominal piston Ring Thickness (mm)



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:

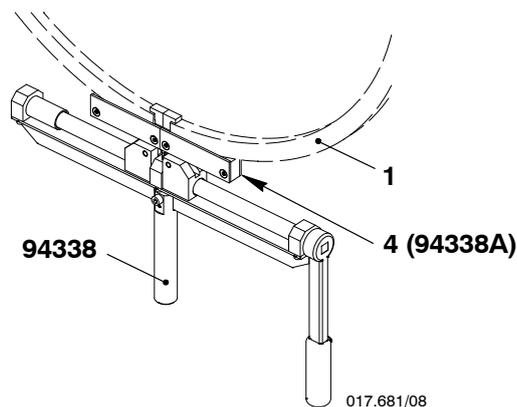
Claws 94338A must be fitted onto piston ring tensioning device for the 1st gastight piston ring 'a' (see also Tool List [9403-5](#)).

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.

F



5. Fitting piston rings

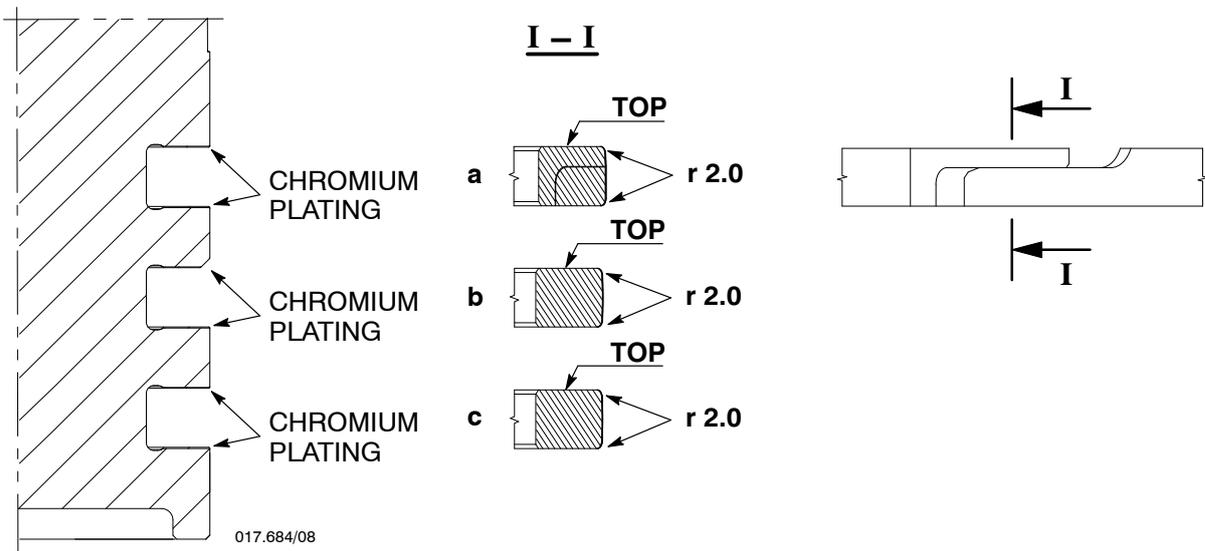
- When reusing piston rings, only rings in perfect condition may be fitted, however in the same position and groove as removed.
- **Always fit piston ring with the marking TOP upwards**
(when the piston is assembled the piston rings must be turned such that the ring gaps are staggered by 180°).
- The 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_Gas Tight	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_Straight Cut	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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▽ 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](#)

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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:

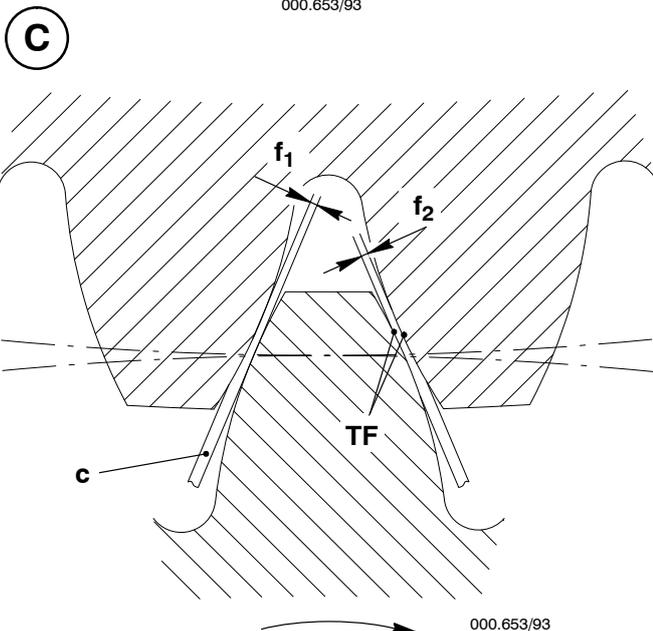
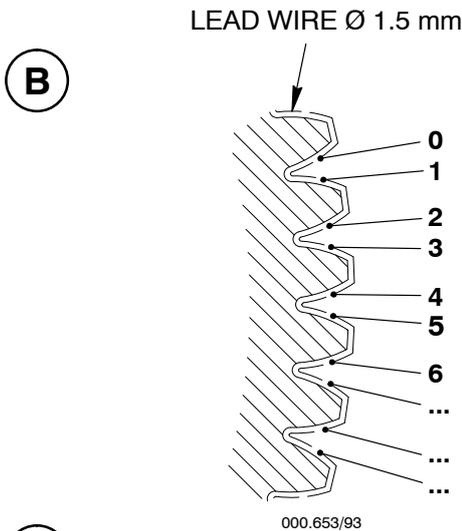
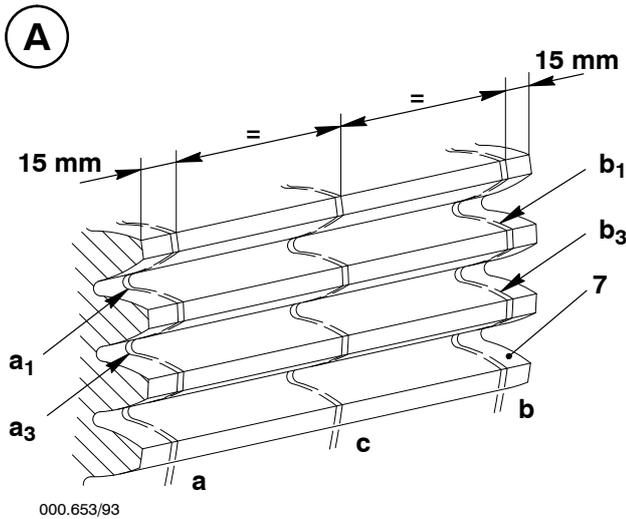
3.1 With feeler gauge 94122

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



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‰ 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:

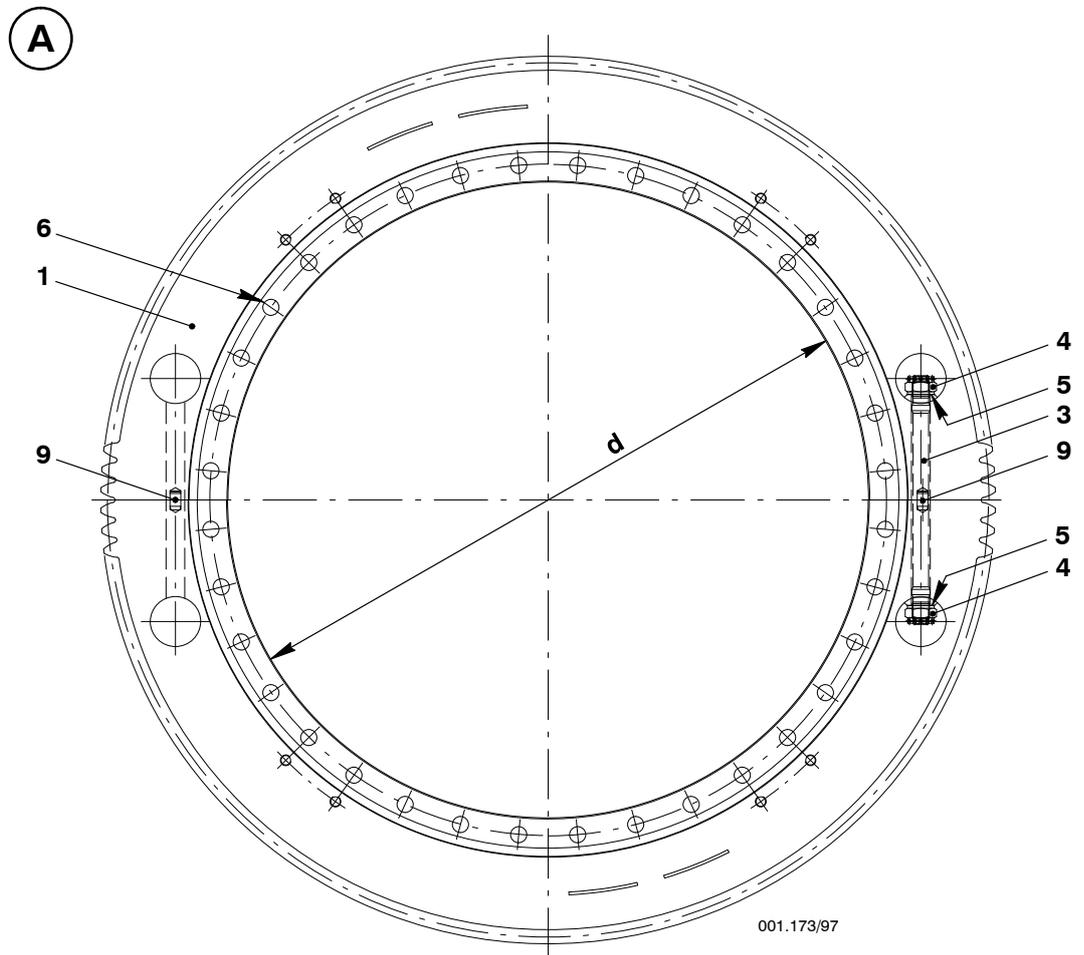
- 1 Ring slugging wrench 94002-46
- 1 Feeler gauge 94122
- 1 Fork wrench 94412E

Key to Illustrations:

- 1 Gear wheel
- 2 Crankshaft flange
- 3 Elastic studs
- 4 Castle nut
- 5 Base
- 6 Flange screw
- 7 Distance sleeve
- 8 Self-locking nut
- 9 Dowel pin

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.

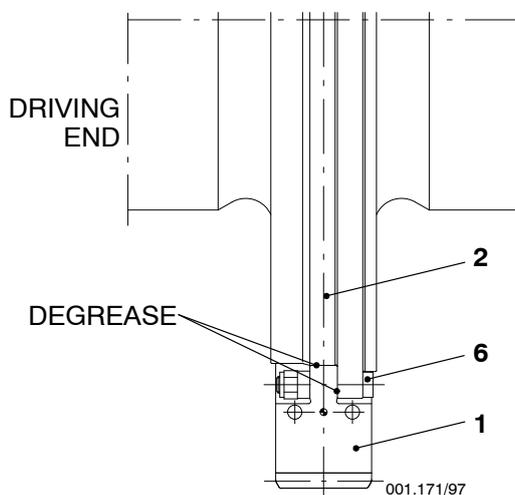


Remark: When ordering a 2-part spare wheel, please indicate the engine type, the engine No., as well as the engine supplier. This data is necessary because the centring diameter of the crankshaft is registered for mounting the gear wheel, and the center hole of the 2-part spare wheel is manufactured according to these dimensions.

2. Preparing the assembly of gear wheel

B

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

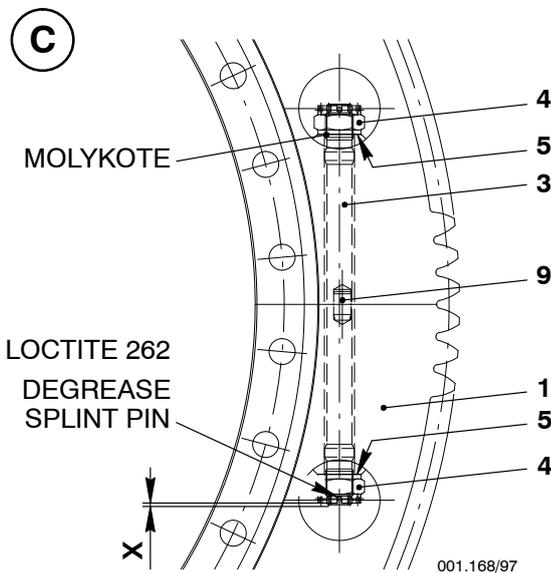
- Before assembling, the centring diameter of the crankshaft flange as well as the centre hole of the gear wheel with the corresponding flange faces must be well cleaned **and degreased** (Fig. B). Do not use neither oil nor MOLYKOTE. All surfaces must be in faultless condition.



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

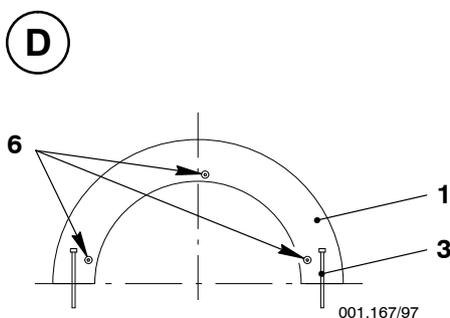
The connection consists of four elastic studs 3, each of them comprising two castle nuts 4 and bases 5.



- ⇒ 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.



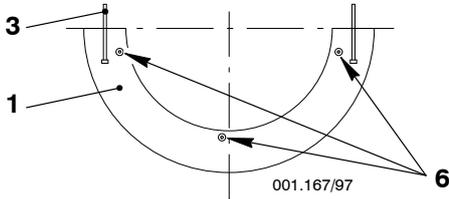
Remark: The castle nut secured with LOCTITE and a split pin must be fitted in such a way that the elastic stud can be tensioned together with the castle nut opposite, as shown in Fig. I.



3.1 Work sequence

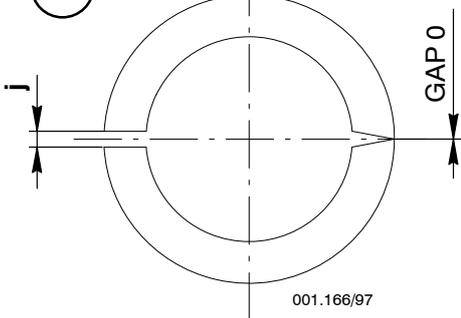
- ⇒ Turn the crankshaft so that the mark on the crankshaft flange is approximately horizontal with regard to the crankshaft centre line.
- ⇒ Put one gear wheel half with two pre-assembled elastic studs 3 on the centring diameter of the crankshaft flange in such a way that the joint face of the gear wheel 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).

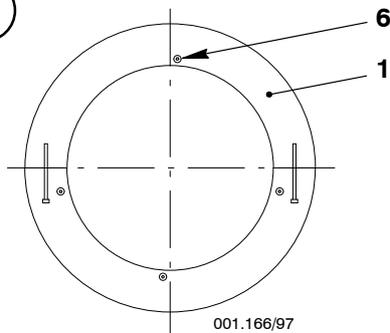
F**CHECK**

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).

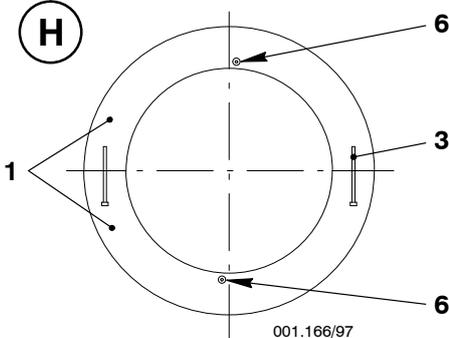
⇒ Remove flange screws 6 from each end of the lower gear wheel half so that there are now only two flange screws 6, each of them tightened temporarily in the centres of the upper and the lower gear wheel half (Fig. H).

G**CHECK**

There must be no clearance on the seating surfaces between the gear wheel and the crankshaft flange – **check!**

⇒ 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 cross-wise by means of ring slugging wrench 94002-46, measuring and recording the length of the elastic studs **beforehand**.

H

Replacing the Gear Wheel on the Crankshaft

CHECK

The elastic studs are correctly pretensioned if an extension of $\Delta L 1.10 \pm 0.05 \text{ mm}$ 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).

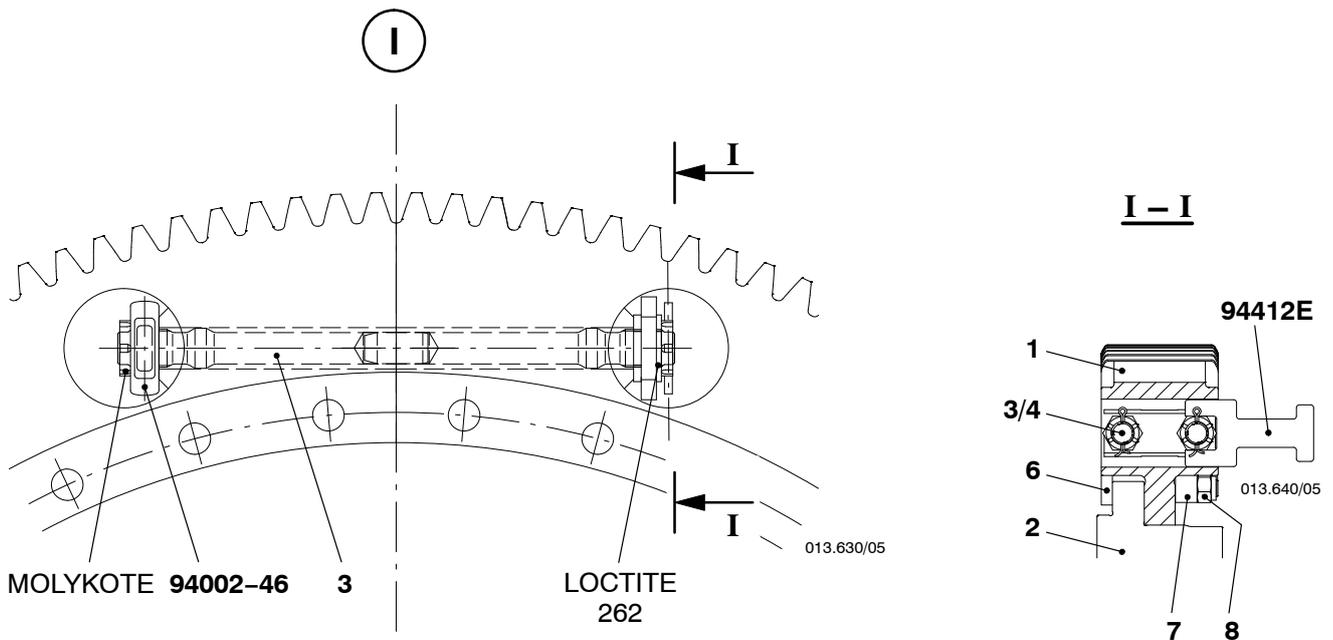


Degrease the threads of all flange screws 6 and their self-locking nuts 8 and then apply LOCTITE 262 to them; **do not use MOLYKOTE!**

- ⇒ 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	TV*	To (drain and) test valve 2.06
11	Control valve	VV*	To venting valve 2.21
12	Piston seal ring		
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.

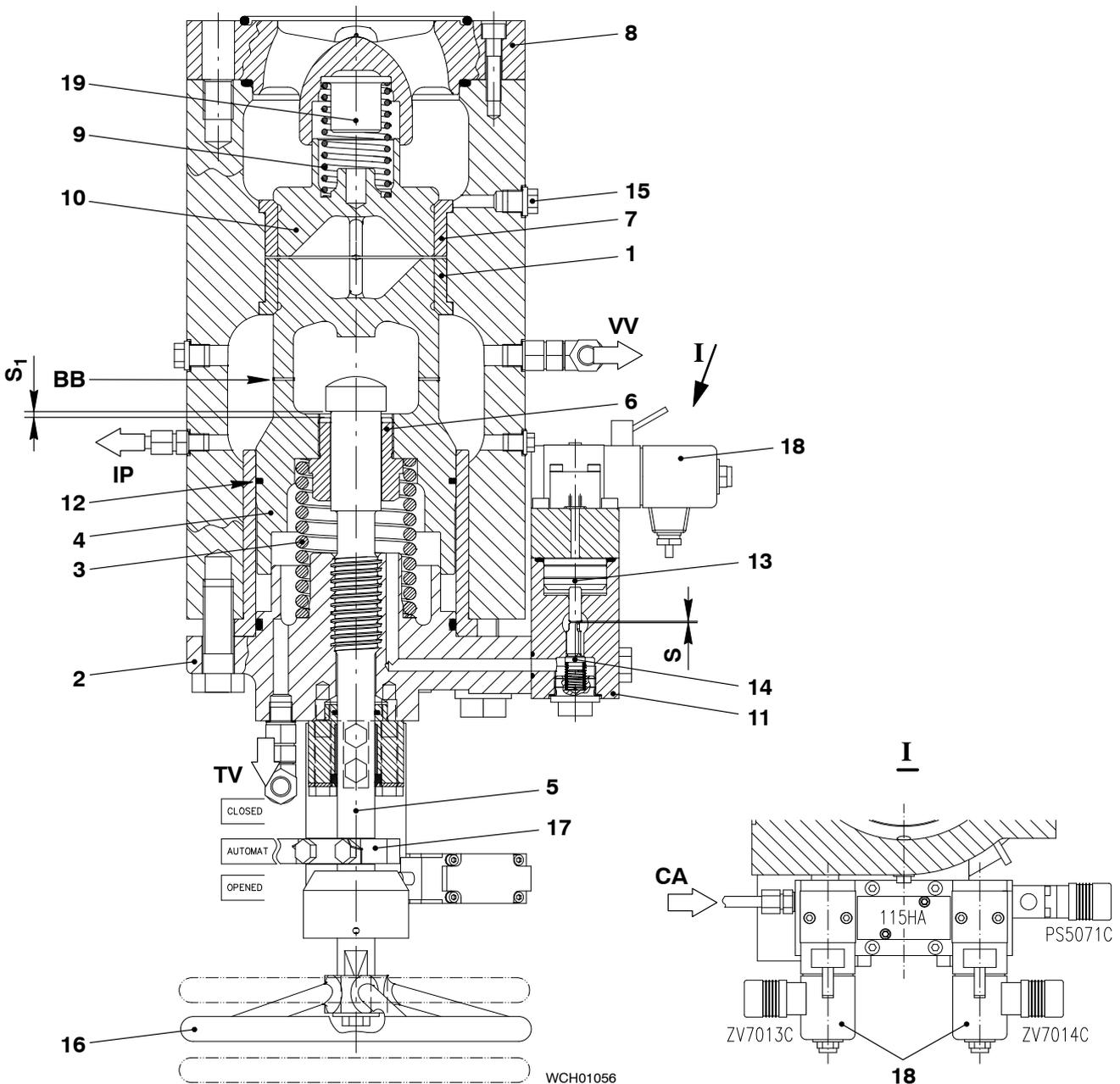
Shut-off Valve for Starting Air: Cleaning and Function Check

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 'S₁' between spindle 5 and spindle guide 6 (in new condition min. 2 mm – max. 5 mm).

Shut-off Valve for Starting Air: Cleaning and Function Check

CHECK

By turning the spindle carefully to position OPENED, the contact with spindle guide 6 can be felt. The clearance 'S₁' 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

- 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
- Removing and Fitting the Gear Wheel on Camshaft 5552-3/A1
- Removal and Fitting 5552-4/A1
- Lubrication of Supply Unit During Maintenance Works 5552-5/A1

- Fuel Pump: Dismantling and Assembling 5556-1/A1
- Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling 5562-1/A1
- Fuel Overpressure Safety Valve: Checking and Setting 5562-2/A1
- Injection Control Unit: Removal and Fitting 5564-1/A1
- Pressure Reducing Valve 8.11-1: Checking the Gas Pre-charge Pressure 5610-1/A1
- Exhaust Valve Control Unit:
Removal, Fitting, Dismantling and Assembling 5612-1/A1

▽ Regulating Linkage

- Adjusting: with Heinzmann StG 10-01 Actuator 5801-1/A1
- Adjusting: with Woodward ProAct II – Digital Actuator 5801-1/A2

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Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

Key to Illustrations:

1 Servo oil pump	12 Gear wheel
2 Screw	13 Spray nozzle
3 Screw	14 Cover
4 Pump support	15 Screw
5 Shaft	16 Screw
6 Pinion	17 Parallel pin
7 Housing	18 O-ring
8 Snap ring	
9 Bearing bush	MA Mark
10 Copper rod	SB Shearable overload protection (predetermined breaking point)
11 Spray nozzle	

Overview

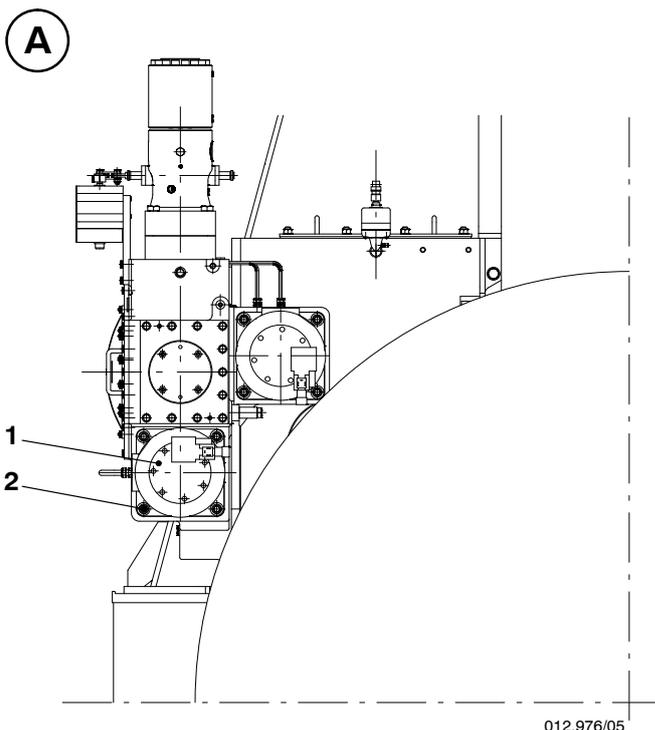
1. General	1/3
2. Removal of servo oil pump	1/3
3. Spray nozzles	3/3
4. Fitting	3/3

1. General

Concerning the maintenance of the servo oil pump observe the instructions from the manufacturer. The servo oil pump drive must be checked in accordance with the Maintenance Schedule 0380-1 'Supply Unit'.

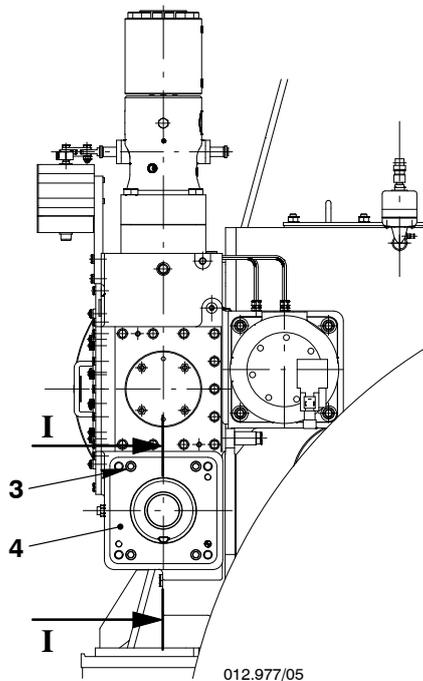
In order to prevent damages in case of the blocking of a servo oil pump, shafts 5 are provided with shearable overload protection 'SB' (Fig. 'C').

2. Removal of servo oil pump

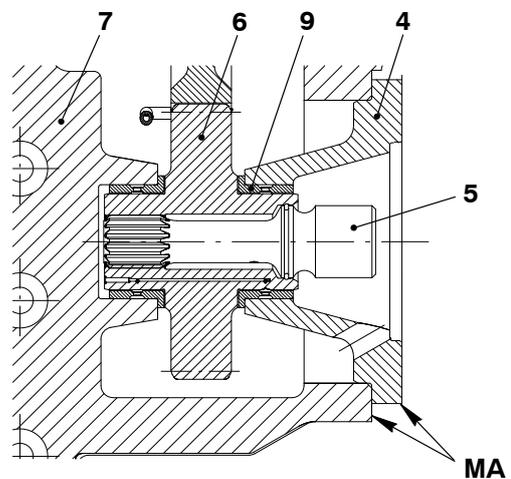
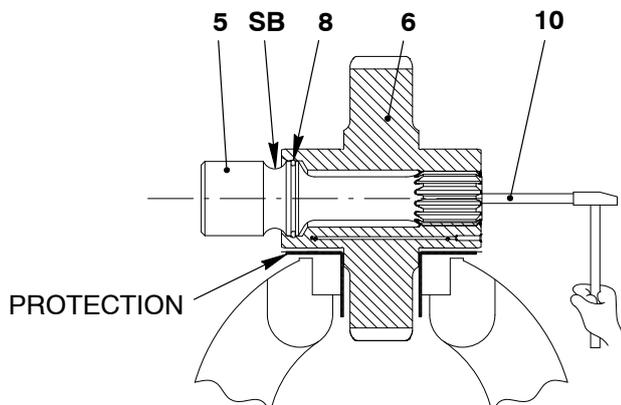


- ⇒ Stop the engine.
- ⇒ Shut the stop valve after automatic filter (see 5551-1 in the Operating Manual).
- ⇒ Remove electrical connections from servo oil pump 1 to be removed.
- ⇒ Remove the corresponding pipings.
- ⇒ Loosen screws 2 and remove the servo oil pump in horizontal direction.

Supply Unit: Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

B**2.1 Removal of pinion**

- ⇒ Loosen screws 3 and remove pump support 4.
- ⇒ Withdraw shaft 5 together with pinion 6 from housing 7.

I - I**C****2.2 Removal of shaft**

- ⇒ Clamp pinion 6 and shaft 5 into a vice.
- ⇒ Using a hammer and copper rod 10 strike onto the shaft until the latter with snap ring 8 comes off the pinion.

Supply Unit: Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

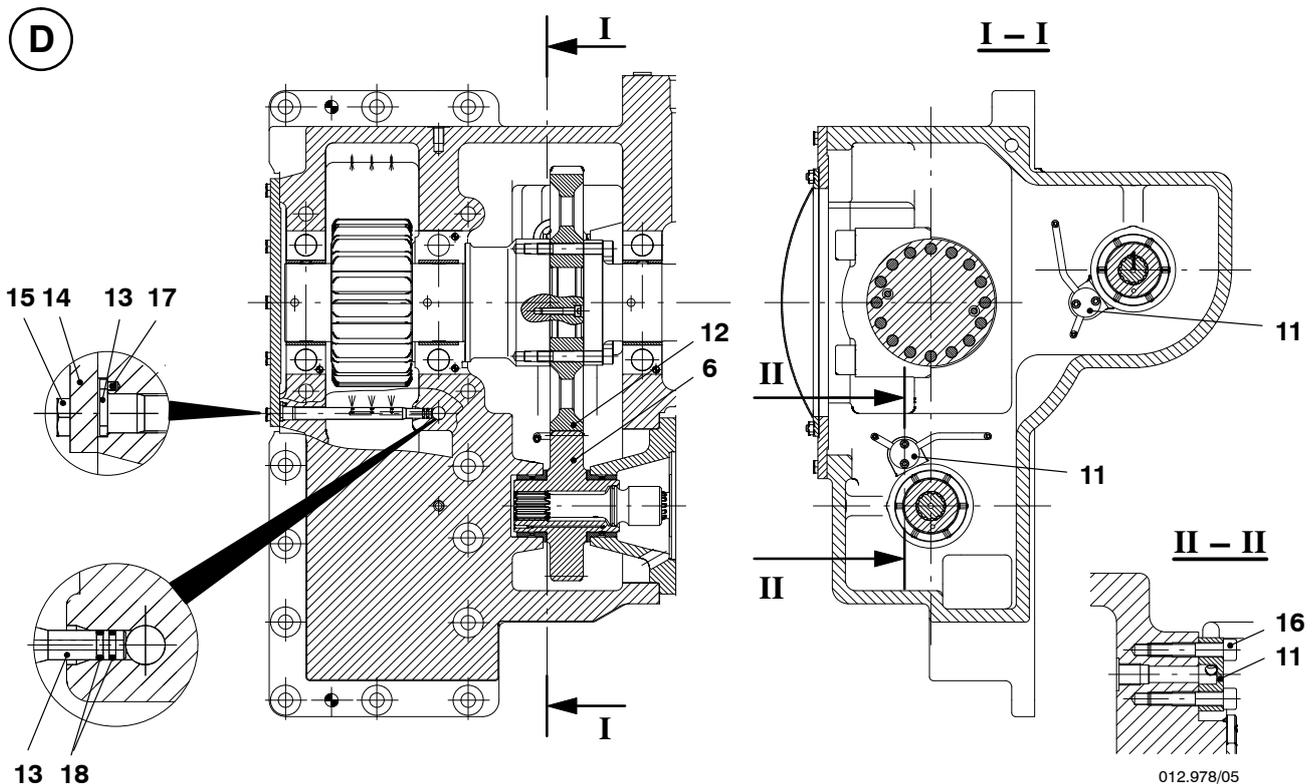
3. Spray nozzles

A spray nozzle 11 is provided for each pinion in order to spray oil between pinion 6 and gear wheel 12.

Clogged spray nozzles must be dismantled for cleaning.

3.1 Removal of spray nozzles

- Spray nozzle 11 can only be removed after removal of the corresponding servo oil pump 1 and pinion 6 as described before in section 2.
- Spray nozzle 13 can be removed easily after removal of cover 14. However, the engine and the lubricating oil pump must be stopped.



4. Fitting

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

- Screws 16 for fastening spray nozzles 11 (view II-II) must be secured with LOCTITE No. 243.
- O-rings 18 must be replaced. Parallel pin 17 ensures correct fitting of spray nozzle 13.



Remark: Bores for bearing bushes 9 in housing 7 and pump support 4 are machined together and marked accordingly. Therefore, never interchange the pump supports and take special care of marks 'MA' on assembly!

CHECK

During fitting the clearances are to be determined in accordance with Clearance Table 0330-1 'Supply Unit'.

Switch on the lubricating oil pump and check the oil flow in the bearings and spray nozzles.

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Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

Tools:

Devices (roller lifting tools)	94430
(depending on number of cylinders)	
1 Support	94566
1 Support	94566A
1 Centring device	94566B
1 Limiter	94566C
1 Assembly template	94567

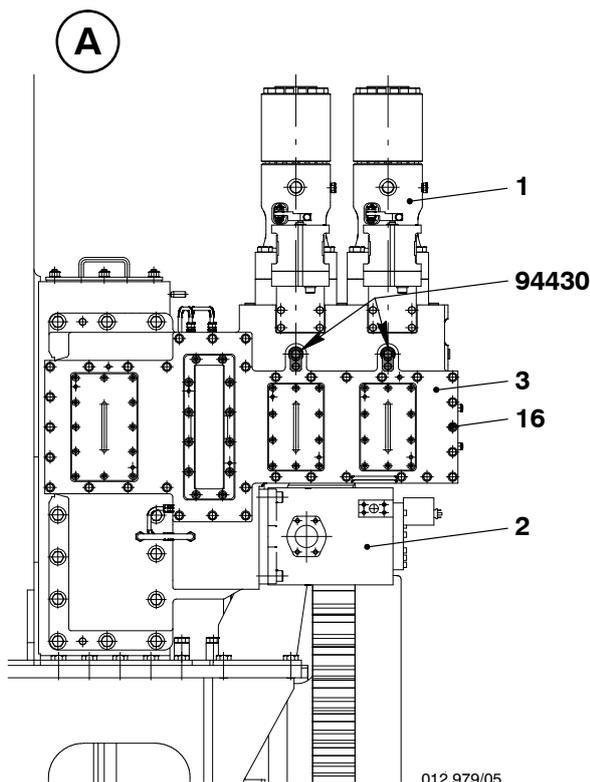
Key to Illustrations:

1 Fuel pump	15 Screw
2 Servo oil pump	16 Screw
3 Cover	17 Dowel pin
4 Cover	18 Lower bearing shell
5 Cover	19 Upper bearing shell
6 Spray nozzle	20 Torque amplifier
7 Elastic screw	21 Screw driver bit
8 Thrust bearing cover	22 Torque wrench ¾"
9 Bearing cover	23 Short backing rod
10 Housing	24 Long backing rod
11 Thrust bearing ring half	
12 Camshaft	
13 Screw	HK Wooden wedge
14 Cover	HU Wooden underlay

Overview

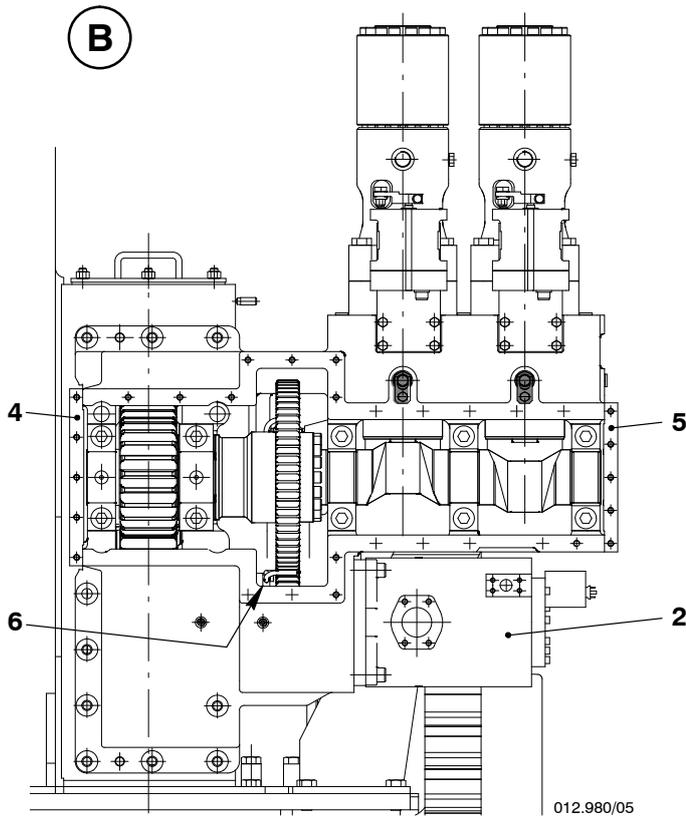
1. Preparation	1/11
2. Numbering of bearings	2/11
3. Removal of bearing shells	3/11
4. Removal of camshaft	4/11
5. Fitting of bearings and camshaft	6/11
6. Application of torque amplifier	8/11

1. Preparation



- ⇒ Stop the engine and main lubricating pump.
- ⇒ Loosen screws 16 and remove cover 3.
- Cut out of fuel pumps 1 by means of devices 94430 (see 5556-2 in the Operating Manual).

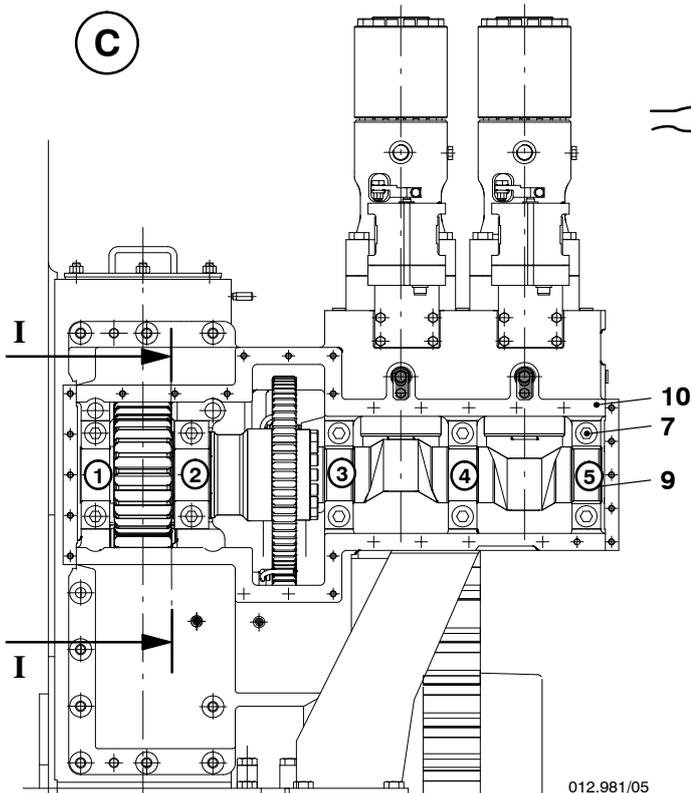
Supply Unit: Removal and Fitting of Camshaft and Bearing Shells



- ⇒ Remove covers 4 and 5.
- ⇒ Remove servo oil pump 2 and spray nozzle 6 (see 5552-1).

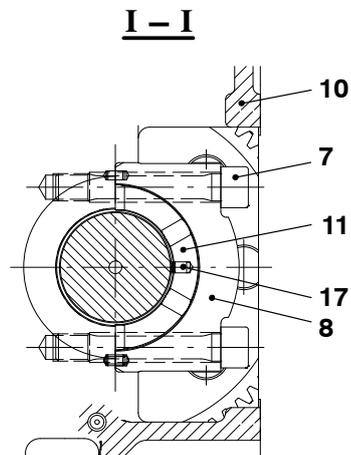
012.980/05

2. Numbering of bearings



Bearing No. ② is designed as thrust bearing, the other ones as normal bearing.

Remark: All bearing covers 8 and 9 are machined together with housing 10, therefore never interchange them! They must be marked accordingly before their removal.



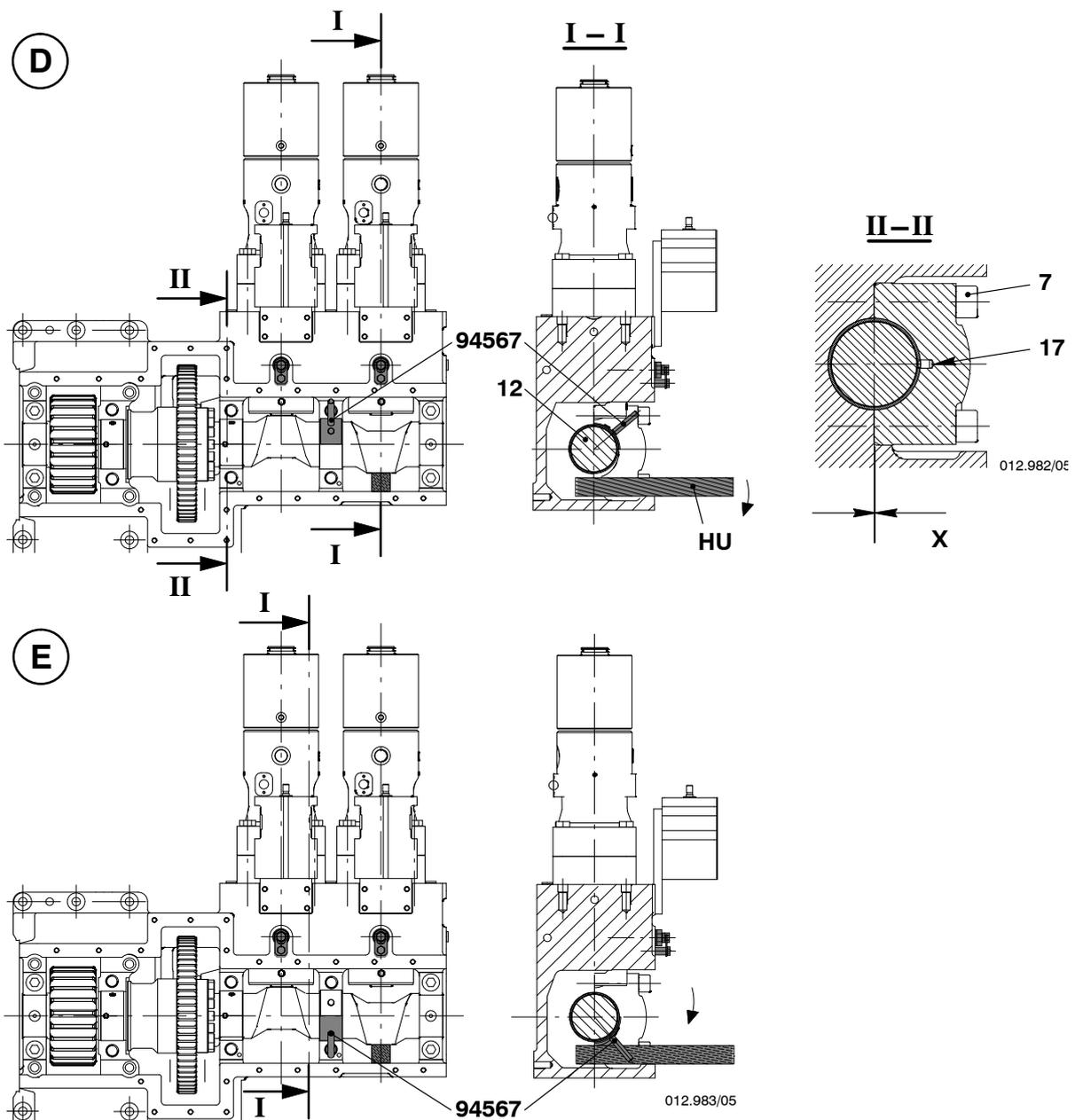
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Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

3. Removal of bearing shells

- ⇒ Loosen elastic screws 7 to bearings No. (2) (3) (4) and remove the bearing covers (Fig. 'C').
- ⇒ Place assembly template 94567 on an upper bearing shell (Fig. 'D').
- ⇒ Press camshaft 12 accordingly by means of wooden underlay 'HU' so that the upper bearing shell can be turned downwards with the assembly template at the same time (Fig. 'E').
- ⇒ Remove the assembly template, the relevant bearing shell and then all other ones.

 **Remark:** Mark bearing shells after removal!

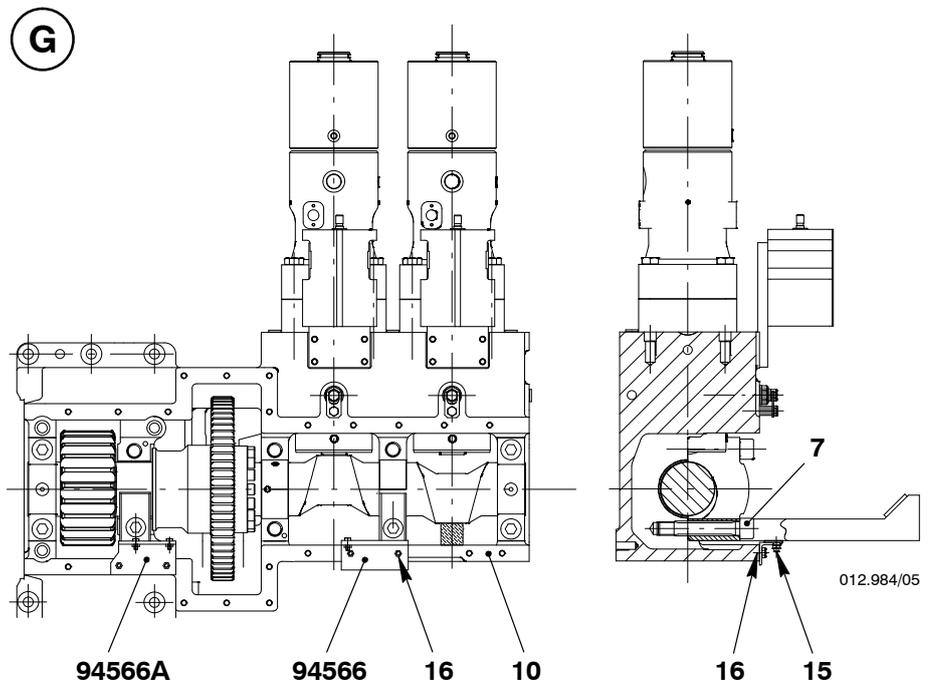
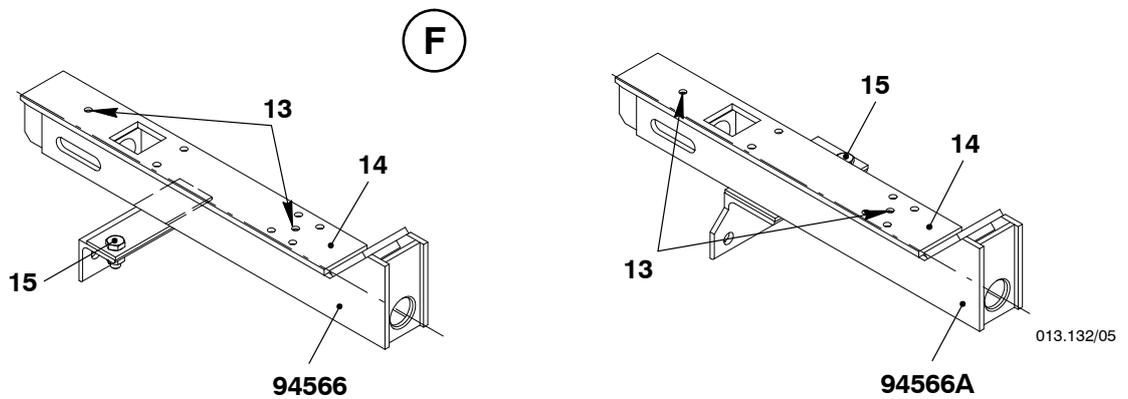


Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

4. Removal of camshaft

4.1 Removal of supports

- ⇒ Loosen screws 13 and remove covers 14 from supports 94566 and 94566A.
- ⇒ Loosen screws 15 a bit.
- ⇒ Fasten supports 94566 and 94566A to housing 10 as follows, using:
 - elastic screws 7 belonging to the bearing cover as shown in Fig. 'G' and
 - screws 16 (to cover 3 in Fig. 'A') and then tighten screws 15.

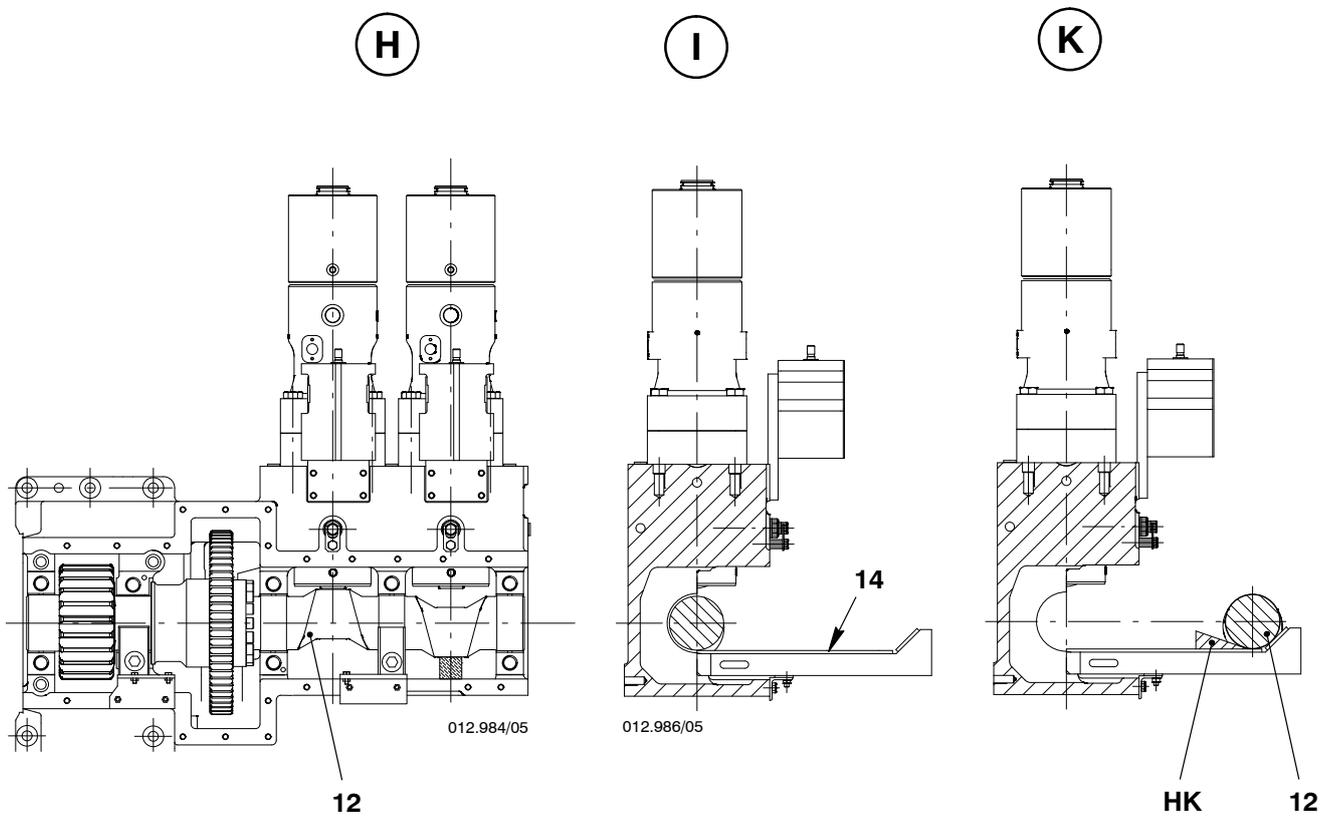


Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

- ⇒ Refit covers 14 to the supports with screws 13.
- ⇒ Remove the remaining bearing covers and bearing shells as described in section 3.
- ⇒ Roll out the camshaft (with the gear wheels) onto the supports and secure it at the stop with wooden wedges 'HK' for safety reason as shown in Fig. 'K'.
- ⇒ Remove all bearing shells.



Remark: Mark bearing shells after removal!



Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

5. Fitting of bearings and camshaft

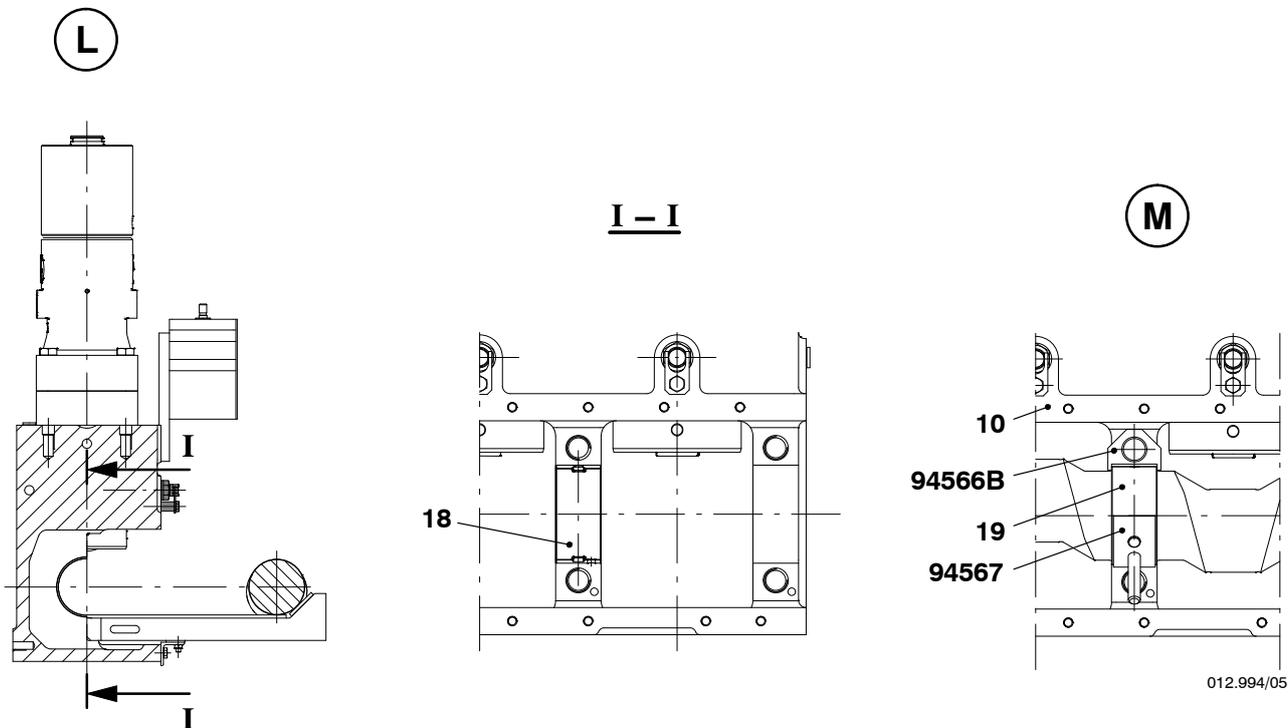
The fitting of bearings and camshaft is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

The camshaft can be installed in every position, however:

- all parts to be fitted must be clean and undamaged!
- for the assembly apply oil to bearing shells, thrust bearing ring halves and camshaft.
- take care of the designations of reused bearing shells.
- fit bearing shells, so that their bores provided for dowel pins 17 in the bearing covers point to the same side (Fig. 'C' and 'D').
- in order to align the bearing shell, centring device 94566B provided for this purpose is inserted into the corresponding tap hole of the elastic screw as shown in Fig. 'M'.
- take care of bearing cover numbering and meshing of dowel pin 17 (Fig. 'D').
- apply oil to the threads and seating surfaces of elastic screws 7 and tighten these equally with a torque of **1450 Nm** (for the application of torque amplifier 20 see section 6).

CHECK

After tightening the elastic screws there must be no clearance at 'x' (Fig. 'D', section II-II)!



Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

5.1 Final assembly

CHECK

Determine radial and axial clearances, see Clearance Table [0330-1](#) 'Supply Unit'.

- ⇒ Apply sealing compound to sealing surfaces of covers 3, 4, 5 and fit the latter.
- ⇒ Fit servo oil pump 2 (see [5552-1](#)).
- ⇒ Install all pipings.
- ⇒ Cut in the fuel pumps and remove tools 94430 (see 5556-2 in the Operating Manual).

CHECK

After assembly, turn the engine by means of turning gear and check if lubricating oil is supplied to all lubricating points and bearings with the oil pump in operation!

Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

6. Application of torque amplifier

Torque amplifier 20 must be used for tightening the elastic screws 7 to bearing covers 9.

The following figures 'N' to 'X' are drawn for 7 & 8 Cyl. engines, however, there are also shown all applications for 5 & 6 Cyl. engines.

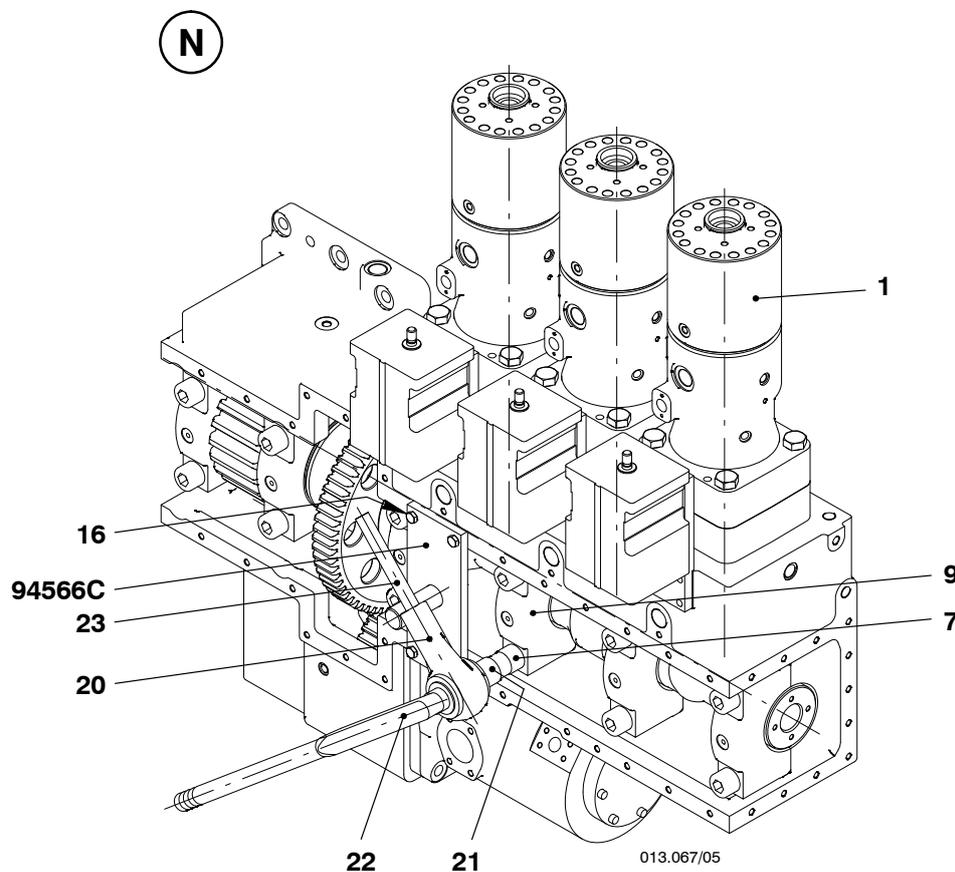
6.1 Procedure

- ⇒ Fasten limiter 94566C with screws 16 (of cover 3) to housing 10 below the 1st fuel pump.
- ⇒ Fit torque amplifier 20 with backing rod 23 or 24, together with screw driver bit 21 onto elastic screw 7 to be tightened.



Remark: Place the torque amplifier in such a manner that the corresponding backing rod 23 or 24 lies on limiter 94666c.

- ⇒ Taking the transmission ratio of torque amplifier 20 into consideration, the torque wrench 22 is to be adjusted as follows:
The required tightening value of elastic screws 7 is **1450 Nm**, therefore the **torque wrench must be adjusted to 290 Nm according to transmission factor 1:5**.
- ⇒ Place the torque wrench onto the amplifier.



Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

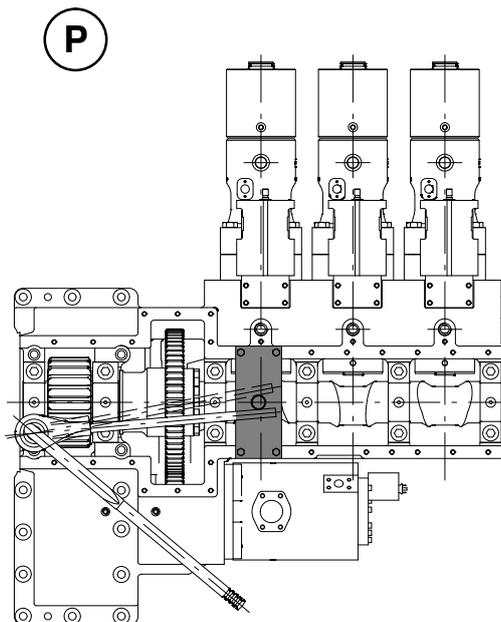
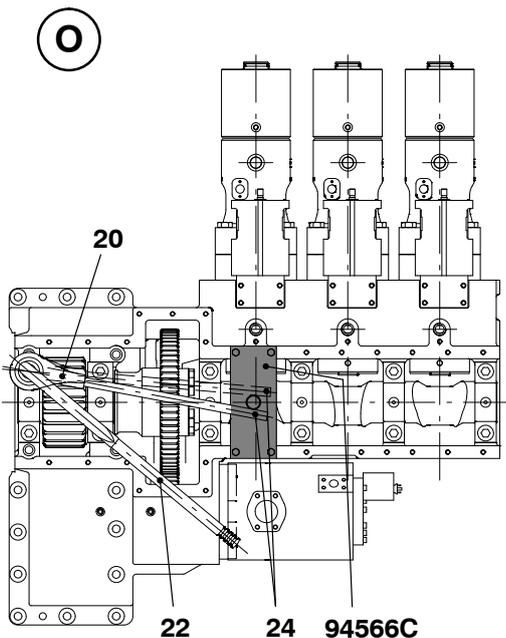
6.2 Torque amplifier applications

The following figures show the torque amplifier application for every single elastic screw 7.

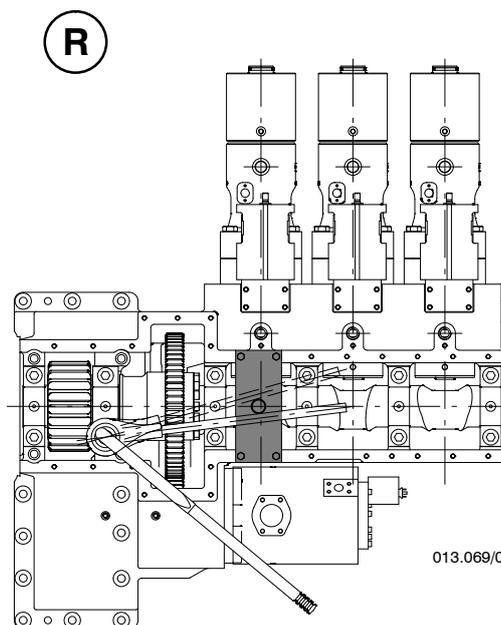
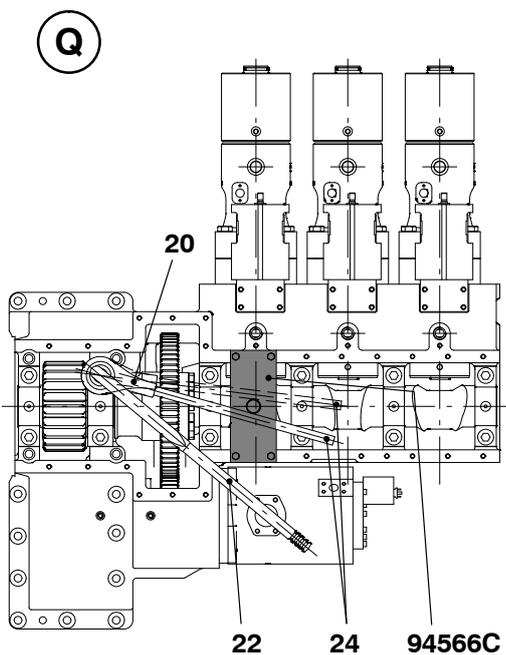
Backing rod 23 or 24 is drawn in the required position:

- with continuous lines for *tightening* and
- with broken lines for *loosening* procedure.

BEARING COVER NO. ①



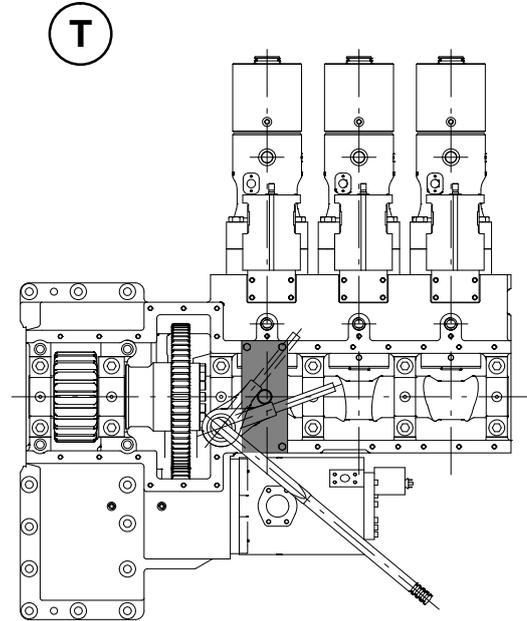
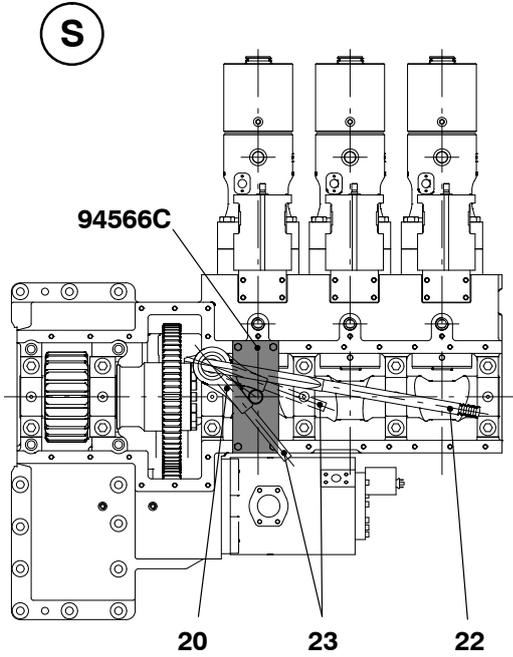
BEARING COVER NO. ②



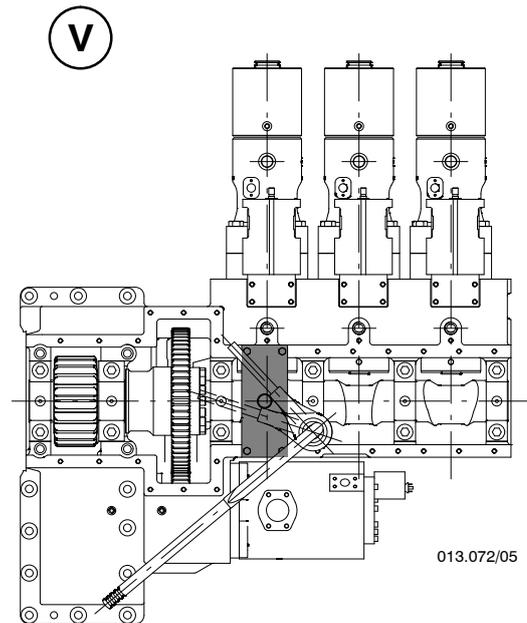
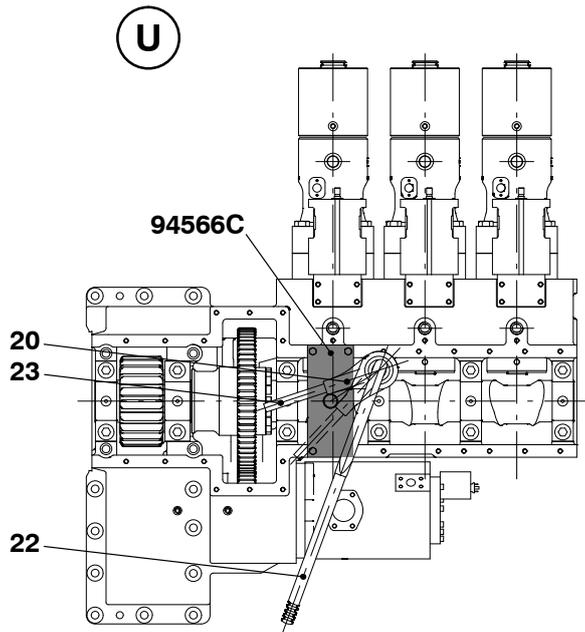
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Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

BEARING COVER NO. ③



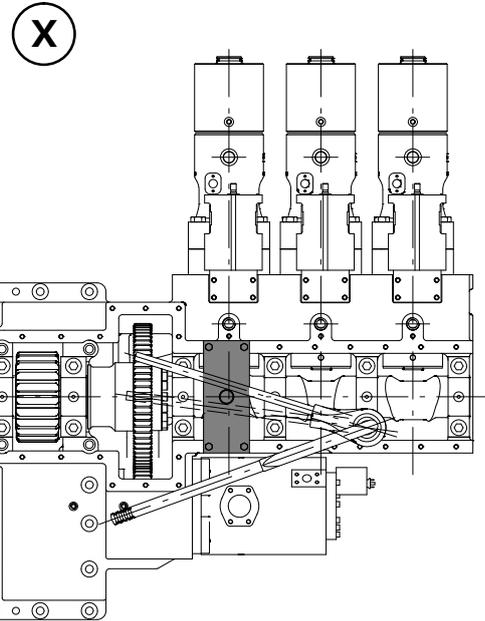
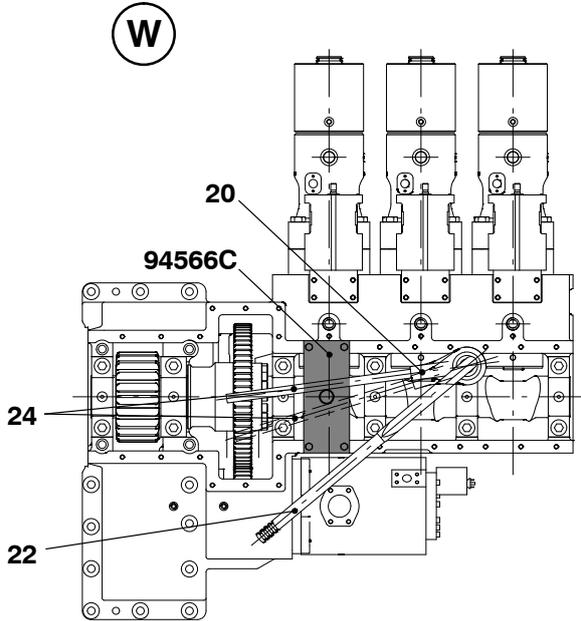
BEARING COVER NO. ④



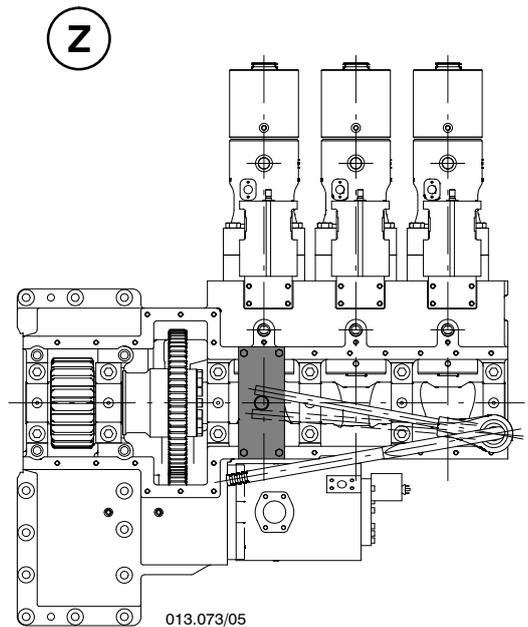
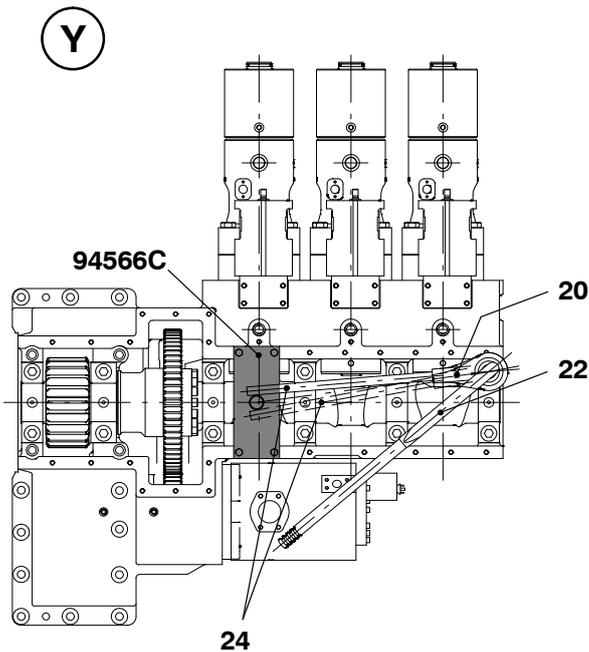
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Supply Unit: Removal and Fitting of Camshaft and Bearing Shells

BEARING COVER NO. ⑤



BEARING COVER NO. ⑥



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Supply Unit

Removing and Fitting the Gear Wheel on Camshaft

Key to Illustration:

1	Camshaft	4	Gear wheel
2	Gear wheel	5	Head screw
3	Shaft	6	Head screw

1. Removing

The camshaft must be removed from the supply unit for removing and fitting the gear wheel 2 (see 5552-2).

It is recommended to put camshaft 1 and shaft 3 on suitable wooden underlays to be able to work appropriately.

- ⇒ Loosen head screws 5 and withdraw camshaft 1 from gear wheel 2 using two jacking screws M10.
- ⇒ Loosen head screws 6 and withdraw gear wheel 2 from shaft 3 using two jacking screws M10.

2. Fitting

All parts must be clean and in perfect condition.

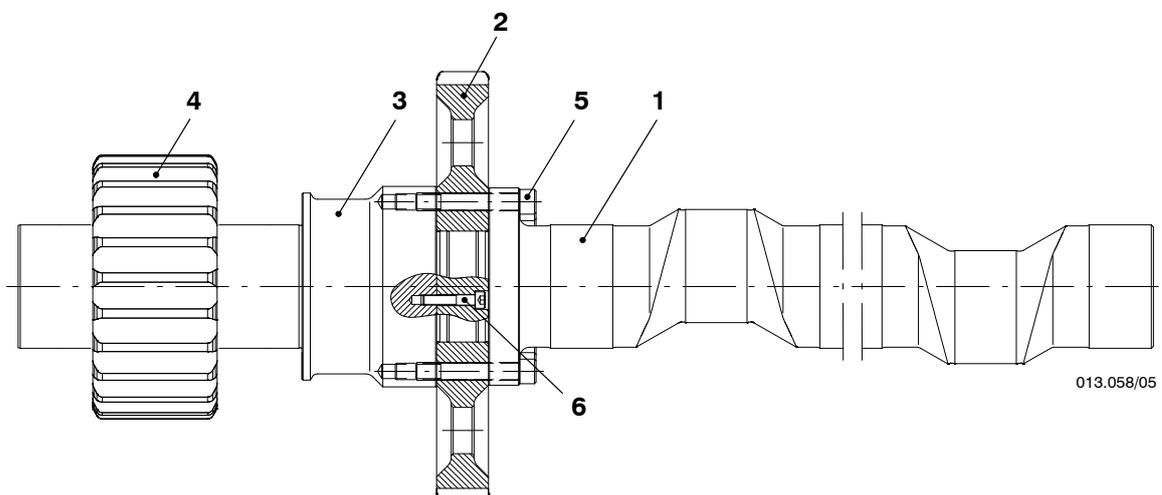
- ⇒ Oil the mating surfaces of gear wheel 2 and shaft 3.
- ⇒ Push gear wheel 2 carefully onto shaft 3 and fasten it with head screws 6.
- ⇒ Oil the mating surfaces of camshaft 1 and gear wheel 2.
- ⇒ Oil the threads and seating surfaces of head screws 5.
- ⇒ Join carefully camshaft with gear wheel 2 and fasten it with head screws 5.
- ⇒ Tighten the head screws crosswise and equally up to a torque of **200 Nm**.

CHECK



No clearance must be at hand between gear wheel 2 and shaft 3.

Remark: After a replacement of gear wheel 4 and shaft 3, the running and backlash clearances and performance of the teeth must be checked (see 4103-1).



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Supply Unit

Removal and Fitting

Tools:

2 RUD-eye bolts	94040-M16
1 Lifting tool (for transporting SU_5, 6 Cyl.)	94557
1 Lifting tool (for transporting SU_7, 8 Cyl.)	94557A
2 Roller lifting tools	94430

Key to Illustrations:

1 Supply unit	8 Head screw
2 Fuel pump	9 Housing
3 Cover	10 Spray nozzle
4 Dowel pin	11 Screw with distance sleeve
5 Screw	12 Holder
6 Screw	
7 Screw	MR Manual ratchet

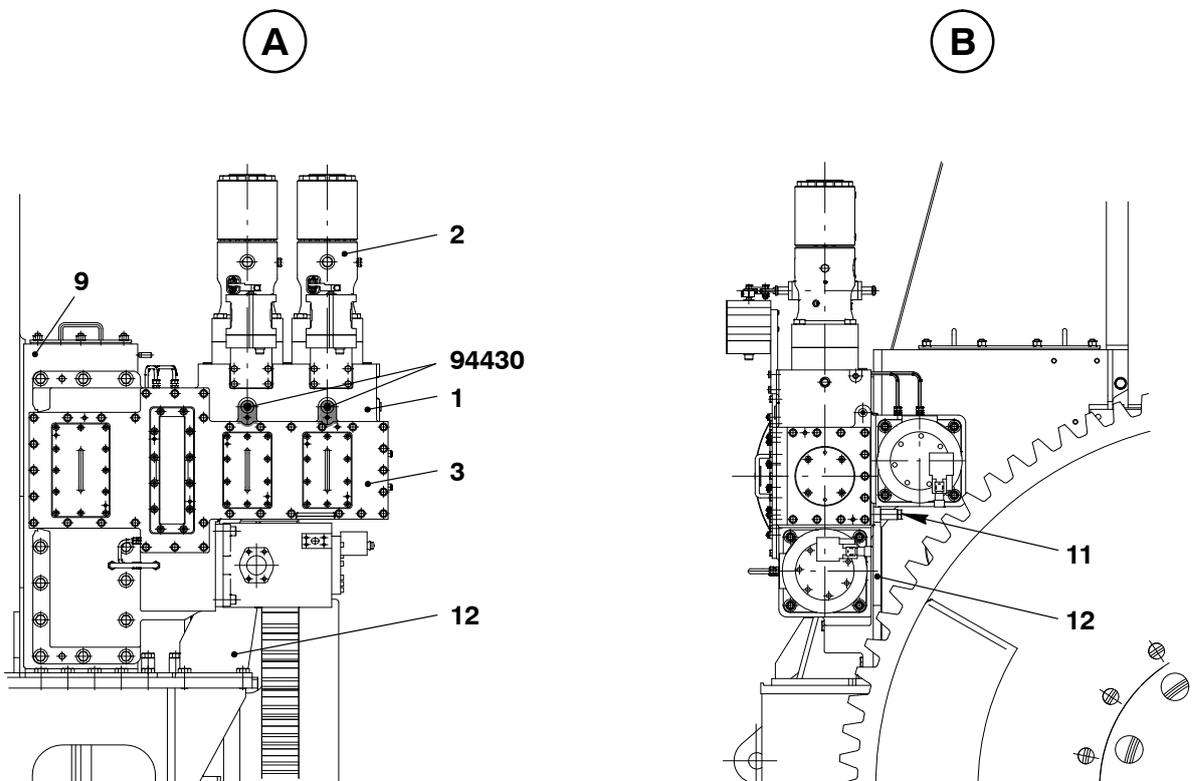
1. Removal

- Cut out of fuel pump 3 by means of device 94430 (see 5556-2 in the Operating Manual).



Remark: Pay attention to General Guidelines for Lifting Tools [0012-1](#).

- ⇒ Remove all pipings and electric connections if necessary.
- ⇒ Remove cover 3.
- ⇒ Withdraw dowel pins 4.

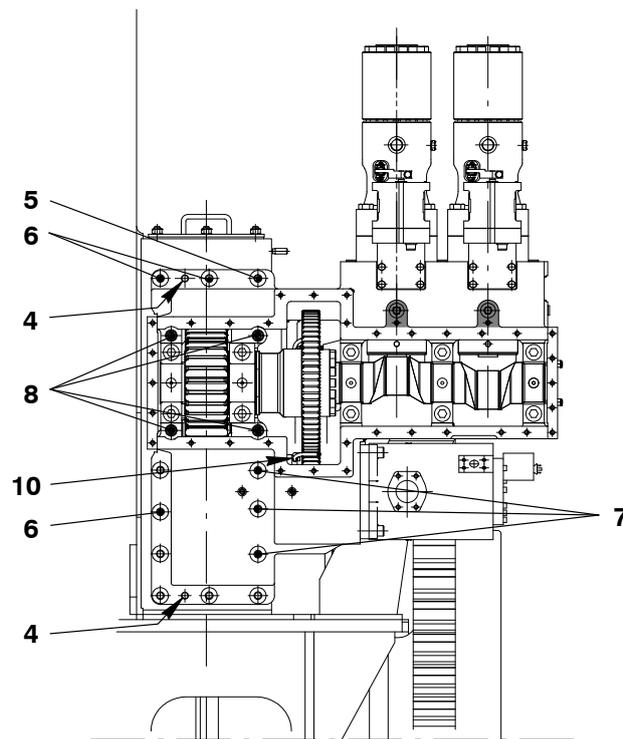


013.042/05

Removal and Fitting of Supply Unit

- ⇒ Screw two RUD-eye bolts 94040-M16 into housing of supply unit 1 as shown in Fig. 'D'.
- ⇒ Suspend lifting tool 94557 on manual ratchets 'MR' (WLL 2000 kg each) and connect these with RUD-eye bolts.
- ⇒ Tauten manual ratchets 'MR'.
- ⇒ Loosen screws 11 and remove them together with the distance sleeves.
- ⇒ Loosen screws 5, 6, 7 and cap screws 8.
- ⇒ Bring the supply unit in horizontal position with manual ratchets 'MR'.
- ⇒ Carefully move supply unit away.

(C)



013.042/05

Removal and Fitting of Supply Unit

2. Fitting

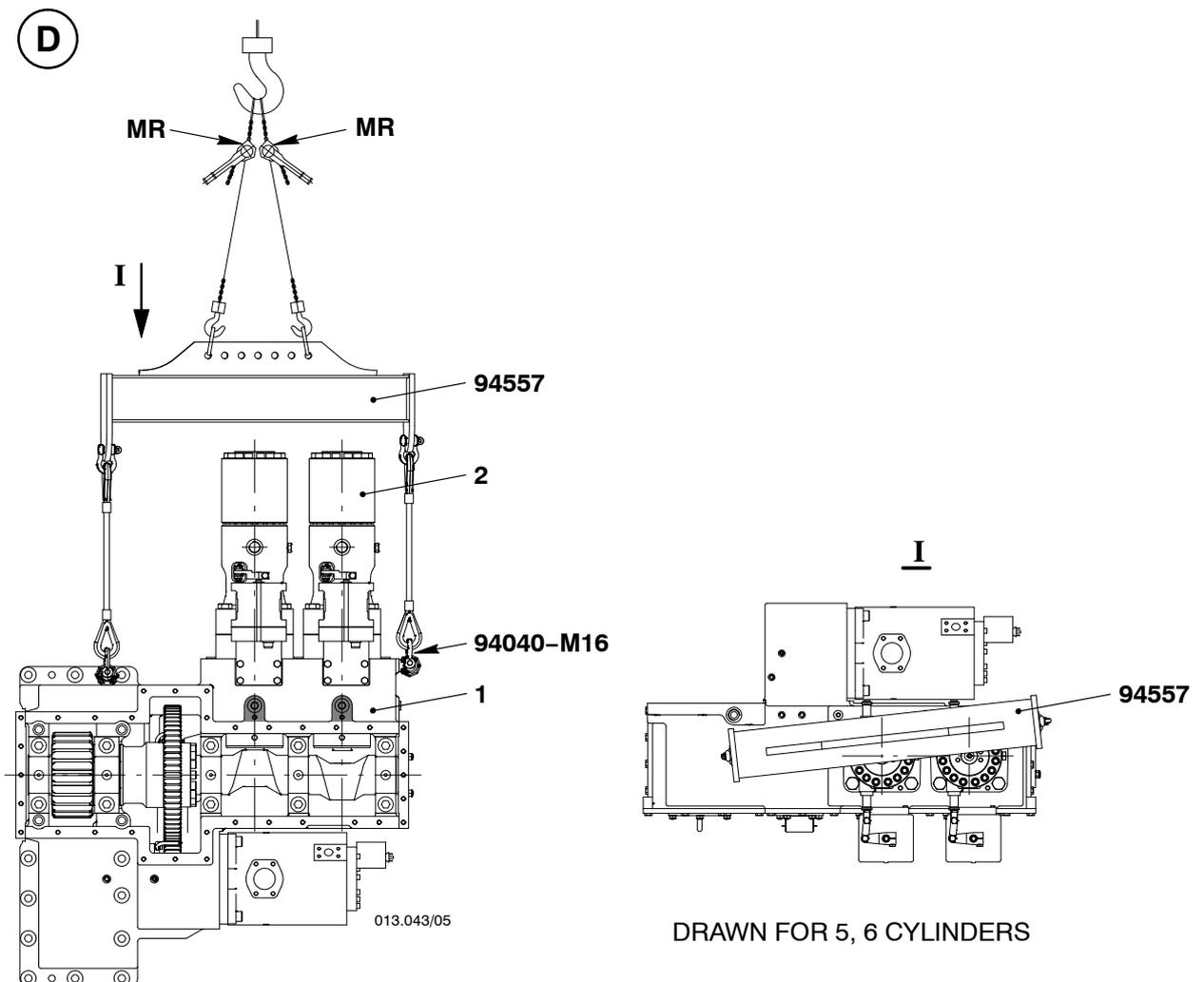
- ⇒ Connect supply unit 1 with the engine crane as described for the removal.
- ⇒ Apply a non-hardening sealing compound to the cleaned sealing surfaces of housing 9.
- ⇒ Move supply unit 1 carefully to the housing (Fig. 'A').
- ⇒ Fit screws 5, 6, 7 and cap screws 8 (Fig. 'B'), paying attention that the supply unit rests on the housing, however can still be freely moved.
- ⇒ Insert dowel pins 4 (Fig. 'C') and tighten screws 5, 6, 7.

CHECK Check and compare the backlash with **0330-1** 'Driving wheels for Supply Unit'.

- ⇒ Remove all tools.
- ⇒ Install all pipings.

CHECK Start lubricating oil pump and check oil flow to the bearings and spray nozzles 10 (Fig. 'C').

- ⇒ Apply a non-hardening sealing compound to the cleaned sealing surfaces of cover 3 and then fit the latter.



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Supply Unit

Lubrication of Supply Unit During Maintenance

Tools

- 1 Lubricating 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 2.0 m 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.



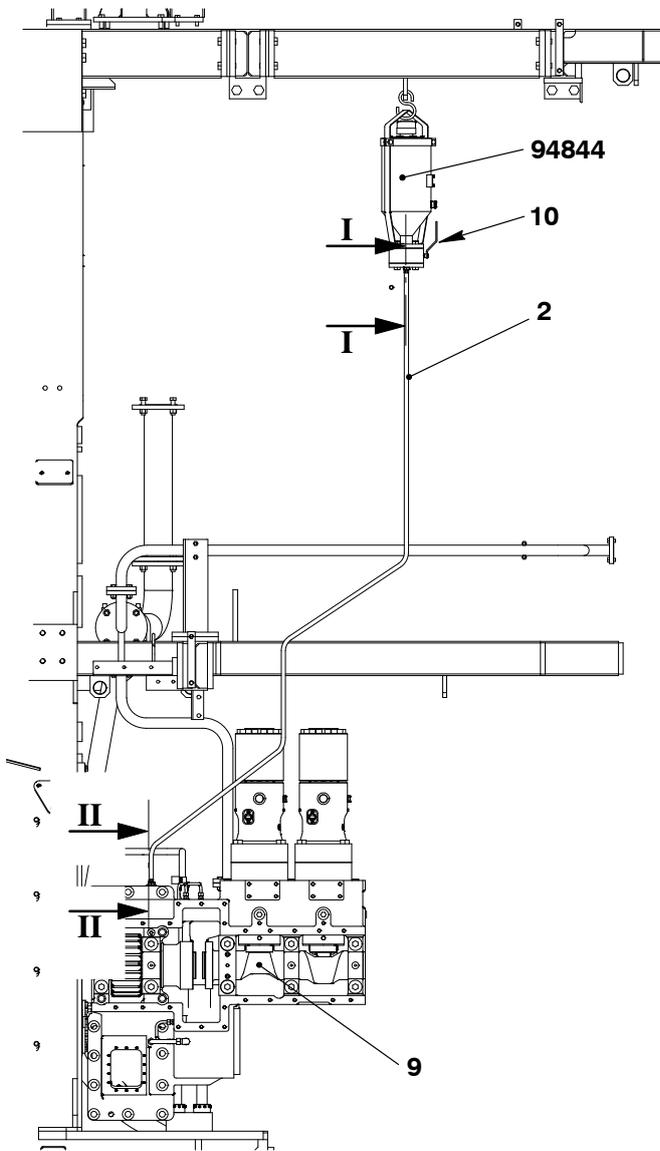
Remark: If the turning gear operates for long periods, keep the system full to make sure that the bearings and camshaft (9) have sufficient lubrication.

- ⇒ 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).

Supply Unit

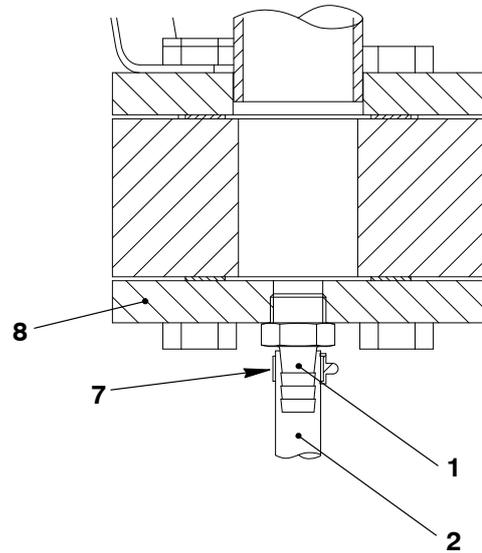
Lubrication of Supply Unit During Maintenance

A

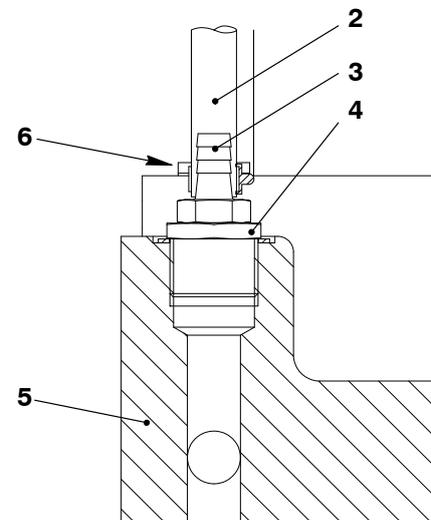


WCH03859

I - I



II - II



Fuel Pump

Dismantling and Assembling

Tool:

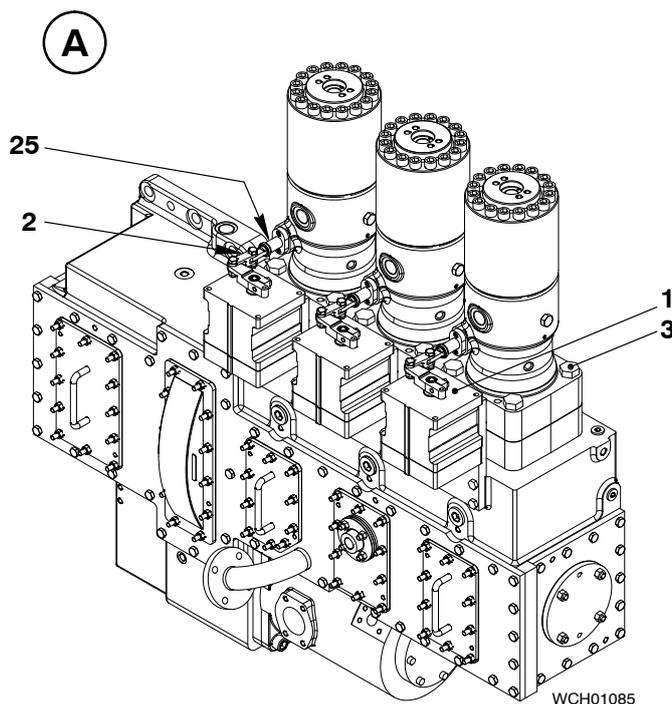
1	Handle screw	94009-M6
1	2-part clamping ring	94550
1	Fitting & dismantling device	94551
1	Cover	94552
1	Spacer	94555
1	Checking gauge	94556

Key to Illustrations:

1	Actuator	23	Screw
2	Connecting element	24	Flange
3	Screw	25	Regulating (toothed) rack
4	Pump cover	26	Circlip
5	Upper housing	27	Stop ring
6	Lower housing	28	Allen screw M16x220
7	Guide piston	29	Valve block
8	Roller	30	Valve body
9	Guide pin	31	Compression spring
10	Pin	32	Holding screw (Cu-ring)
11	Circlip	33	Pump cylinder
12	Pressure disc	34	Intermediate disc
13	Bush	35	Circlip
14	Snap ring	36	Screw
15	Pin	37	Bush
16	Allen screw	38	Rod seal ring
17	Lower spring carrier	39-41	O-rings
18	Pump plunger		
19	Compression spring		
20	Guide pin		
21	Regulating sleeve	DS	Pressure piece
22	Upper spring carrier	RC	Eye bolt M6

Overview

1.	Preparation	1/10
2.	Removal of a fuel pump	2/10
3.	Dismantling of a fuel pump	3/10
4.	Assembling of a fuel pump	7/10
5.	Fitting of a fuel pump	10/10
6.	Preserving	10/10



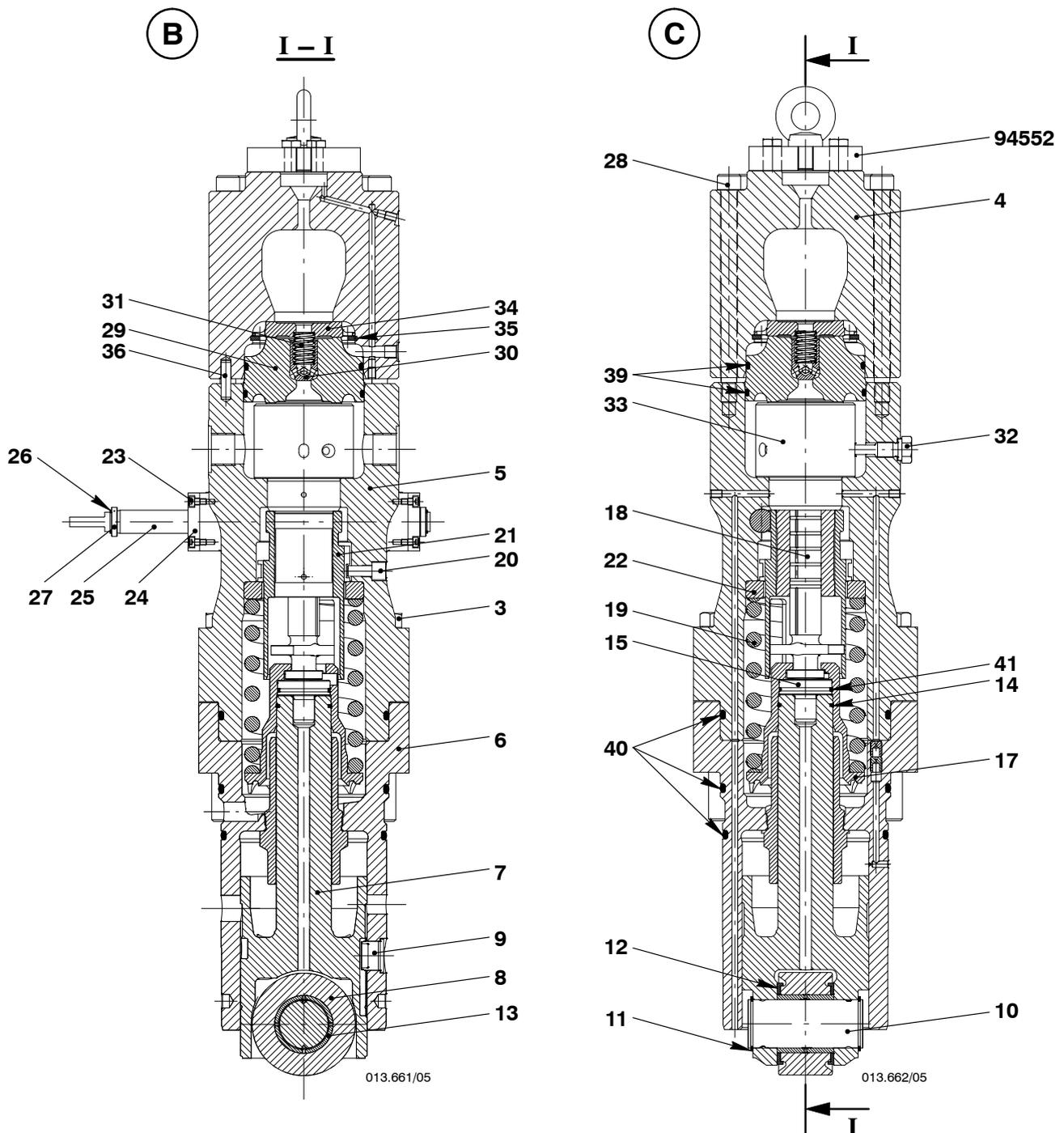
1. Preparation

- ⇒ Stop the engine and switch off the fuel supply pump.
- ⇒ Close shut-off valves to the fuel inlet and outlet pipes, as well as the pressure retaining valve. (see 0720-1 in the Operating Manual).
- ⇒ Remove the fuel inlet and outlet pipes.
- ⇒ Remove the fuel pressure piping (see 8752-1).
- ⇒ Remove connecting element 2 between regulating rack 25 of fuel pump and actuator 1.

Fuel Pump: Dismantling and Assembling

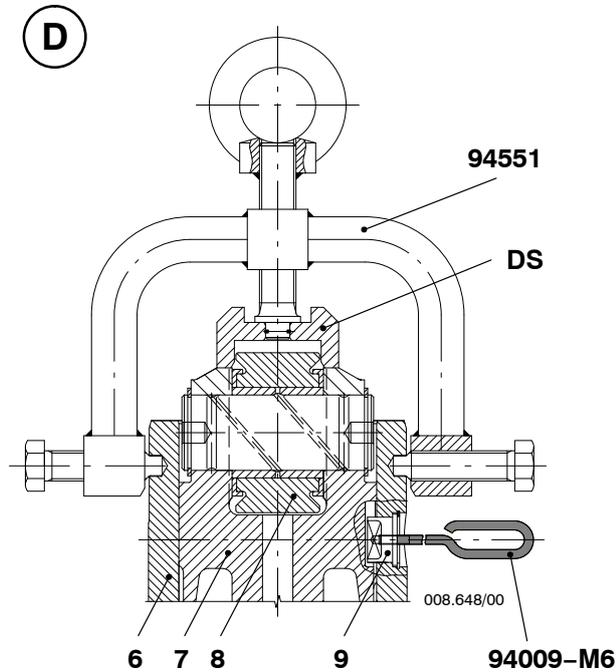
2. Removal of a fuel pump

- ⇒ Turn the engine until roller 8 is seated on the cam base circle (Fig. 'A').
- ⇒ Remove all screws 3.
- ⇒ 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

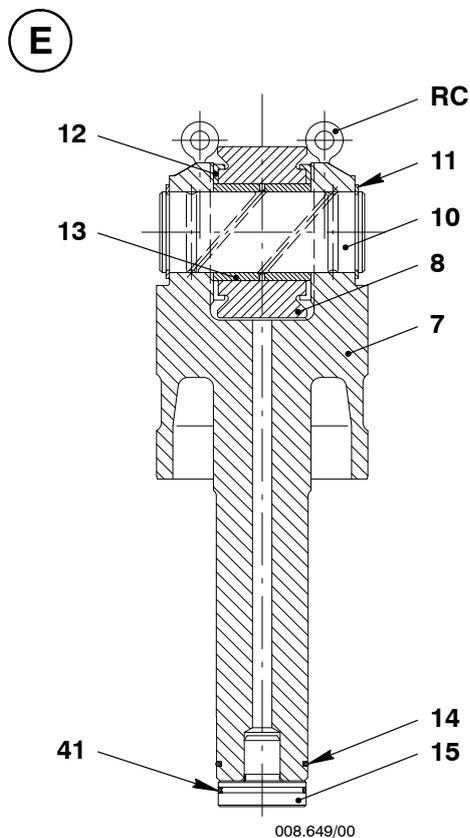
3. Dismantling of a fuel pump



Dismantle and assemble the fuel pumps in a clean room which should be as dust-free as possible (grinding dust, etc).

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 handle screw 94009-M6.
- ⇒ Remove the fitting & dismantling device.



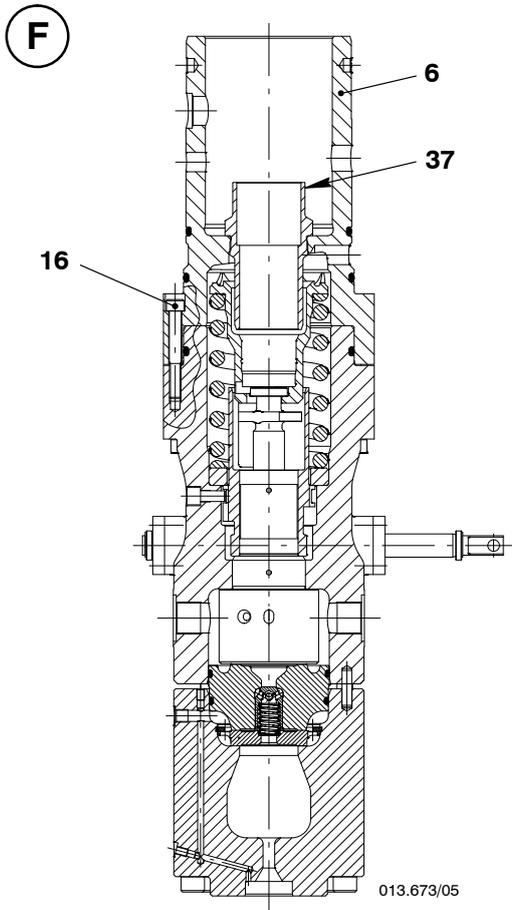
3.2 Removal of guide piston

- ⇒ 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

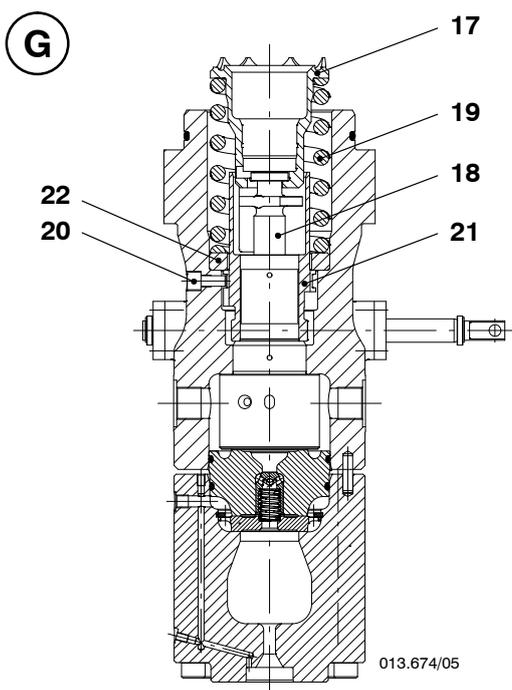


⇒ Remove Allen screws 16.

⇒ Separate lower housing 6 from upper housing.



Remark: If bush 37 has to be replaced, the new one must be secured with LOCTITE No. 648 and tightened with a torque of **200 Nm**.

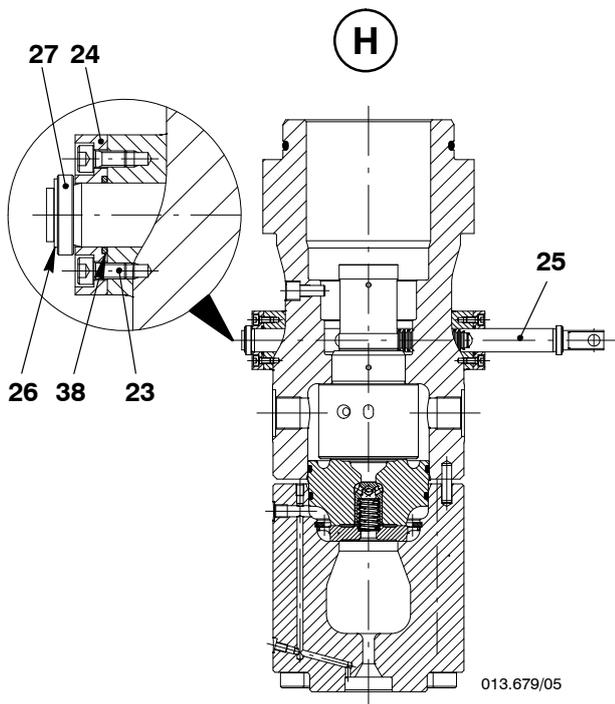


⇒ Dismantle lower spring carrier 17 together with pump plunger 18.
Store the pump plunger in a manner not to damage it.

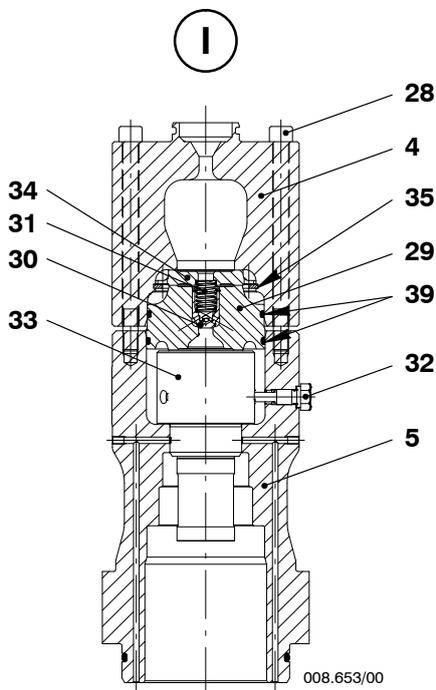
⇒ Remove compression spring 19.

⇒ 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 together with rod seal ring 38, 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 Allen screws 28.
- ⇒ Remove pump cover 4, valve block 29, valve body 30, and compression spring 31. For removing intermediate disc 34 remove circlip 35.
- ⇒ 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.

Fuel Pump: Dismantling and Assembling

3.6 Removal of non-return valve

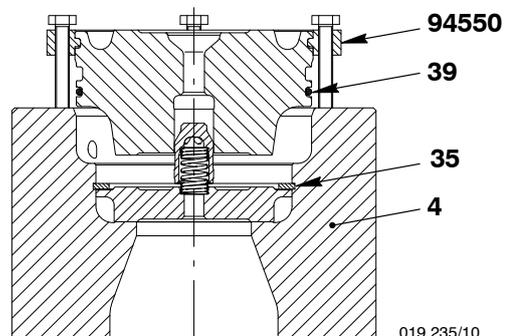
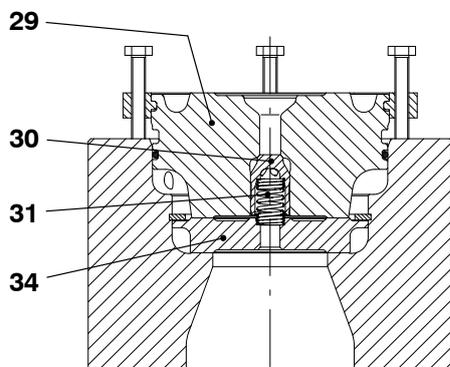
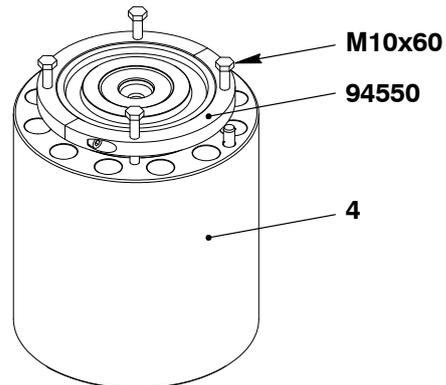
⇒ By means of 2-part clamping ring 94550 and the four screws M10x60 valve block 29 can be withdrawn from pump cover 4.

⇒ 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.

J

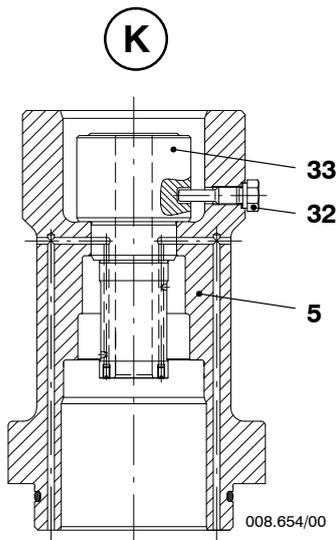


Fuel Pump: Dismantling and Assembling

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.



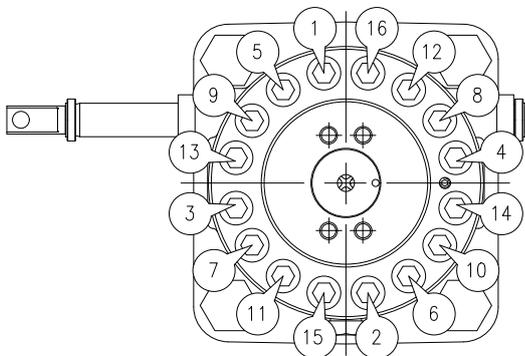
4.2 Fitting the pump cylinder

- ⇒ 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!

TIGHTENING SEQUENCE



4.3 Fitting the pump cover



Remark: Thoroughly check the joint faces for cleanness when fitting the valve block and the pump cover (Fig. 'l').

- ⇒ Fit valve block 29 with the mounted and lubricated O-rings 39 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 of the Allen screws 28. Tighten them: 1ST step **HAND TIGHT**, 2ND step **40 Nm**, 3RD step **80 Nm** and 4TH step with **115 Nm** providing the required sequence for every step.

Fuel Pump: Dismantling and Assembling

4.4 Fitting the 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'.

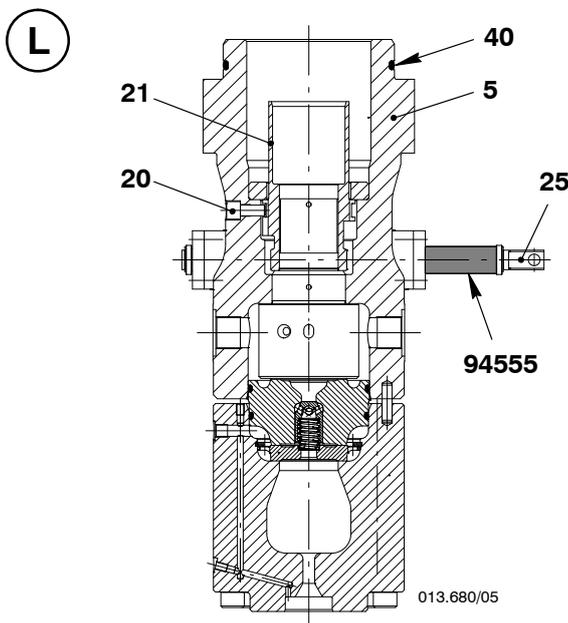
CHECK

Check regulating rack 25 for easy movement.

⇒ Place rod seal ring 38 in both flanges 24.

⇒ Push both flanges onto the regulating rack and screw them up with the upper housing.

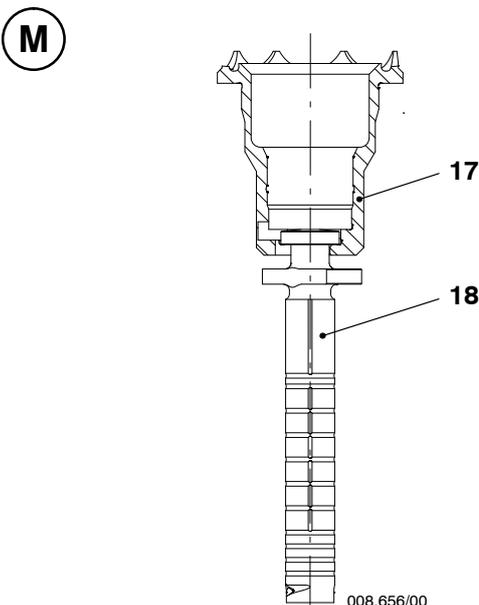
⇒ Fit stop rings 27 and circlips 26.



4.5 Fitting the regulating sleeve

⇒ Bring regulating rack 25 to position shown in Fig. 'L' and place spacer 94555.

⇒ Fit regulating sleeve 21 in the upper housing, the toothed rim turned to the bottom and the groove of 12 mm width being flush with guide pin 20.



4.6 Fitting the pump plunger and lower housing

⇒ Fit upper spring carrier 22 and compression spring 19 (Fig. 'G').

⇒ Nest pump plunger 18 in lower spring carrier 17.

⇒ 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').

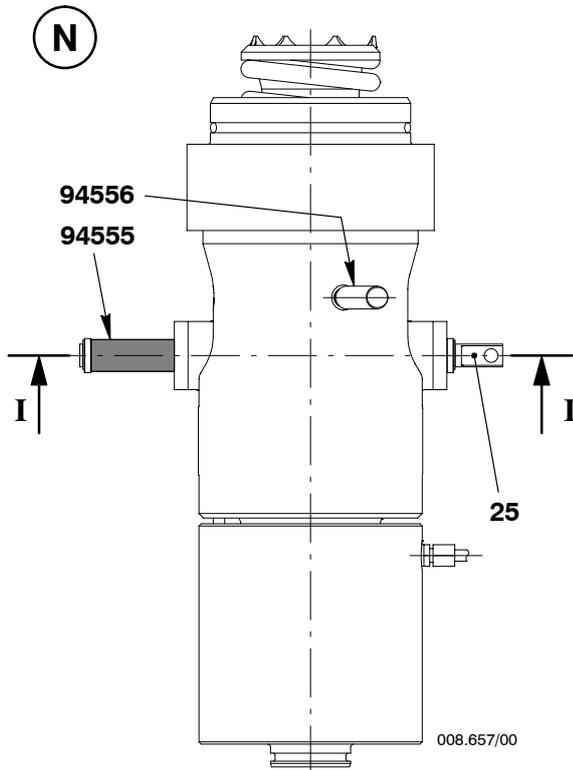
⇒ Place O-ring 40 in upper housing 5 and lubricate it (Fig. 'L').

⇒ Tension the lower and the upper housing together by means of two Allen screws 16. Thereby spring 19 is compressed (Fig. 'F').

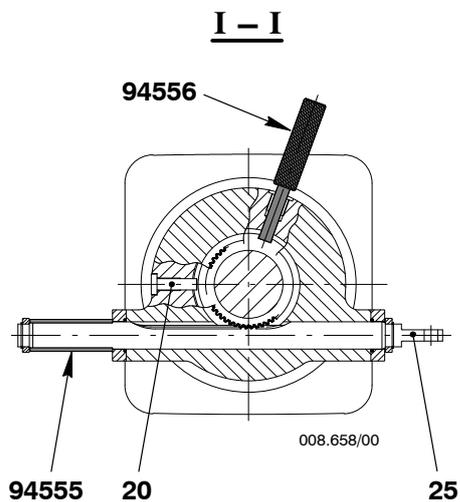
CHECK

After screwing up both housings with each other, check regulating rack 25 for easy movement.

Fuel Pump: Dismantling and Assembling

**4.7 Checking the 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 until 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.



Fuel Pump: Dismantling and Assembling

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 41 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 40 in the grooves at lower housing 6 (Fig. 'B').

5. Fitting of a fuel pump

⇒ Turn the engine until the cam belonging to the fuel pump concerned is on the base circle.

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. For fitting the fuel pressure piping see [8752-1](#).

⇒ When putting the pump into operation, watch for possible leakages or abnormal temperature rise. Fit the casing when everything is in order.

6. 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, oil the fuel pump and protect it against humidity and soiling by wrapping it suitably.

Always store the fuel pumps in upright position.

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	Fuel overpressure safety valve (relief valve)
10	Housing	24...26	O-rings
11	Cover	BA, BE	Fuel outlet, inlet
12	Cover	OE	Oil inlet pipe
13	Filter		
14	Union		

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:

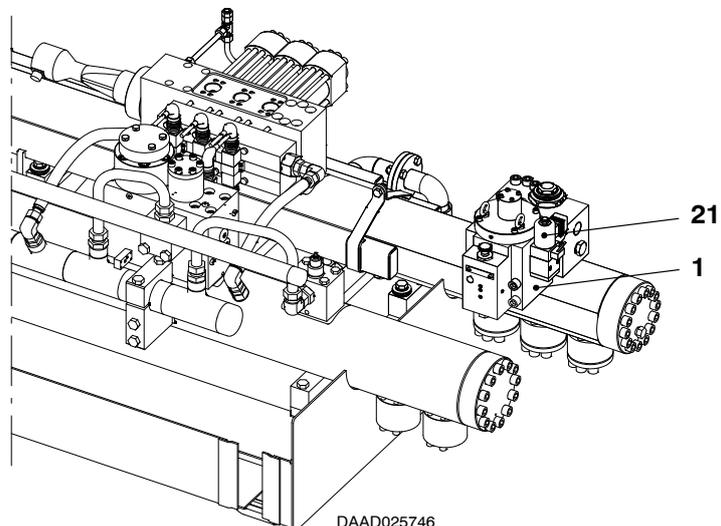
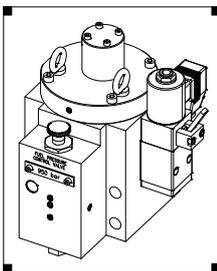
- Replacement of the complete PCV
- Replacement of the 3/2-way solenoid valve
- Replacement or cleaning of the control oil inlet filter



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.



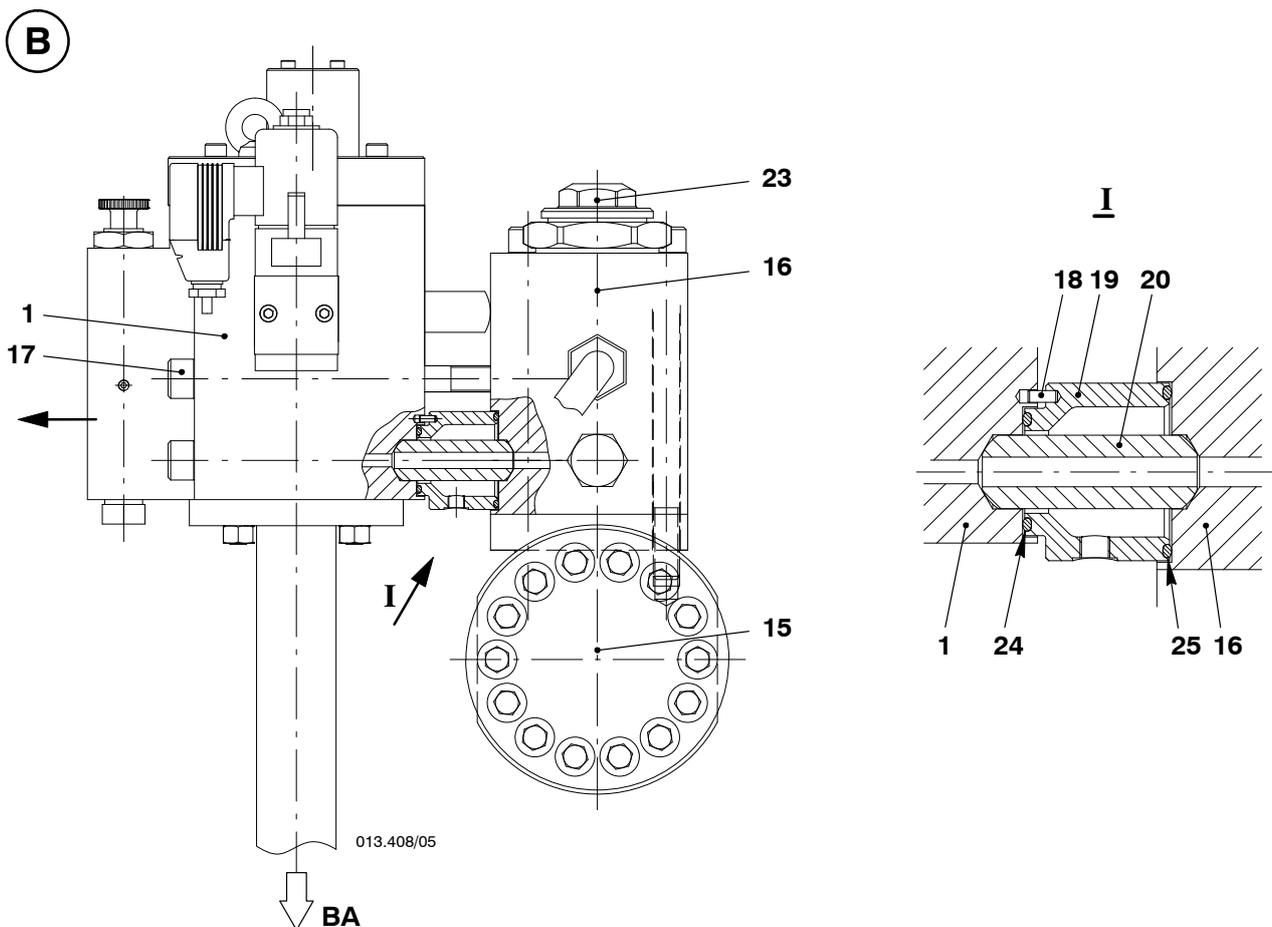
Fuel Pressure Control Valve: Removal, Fitting, Dismantling and Assembling

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

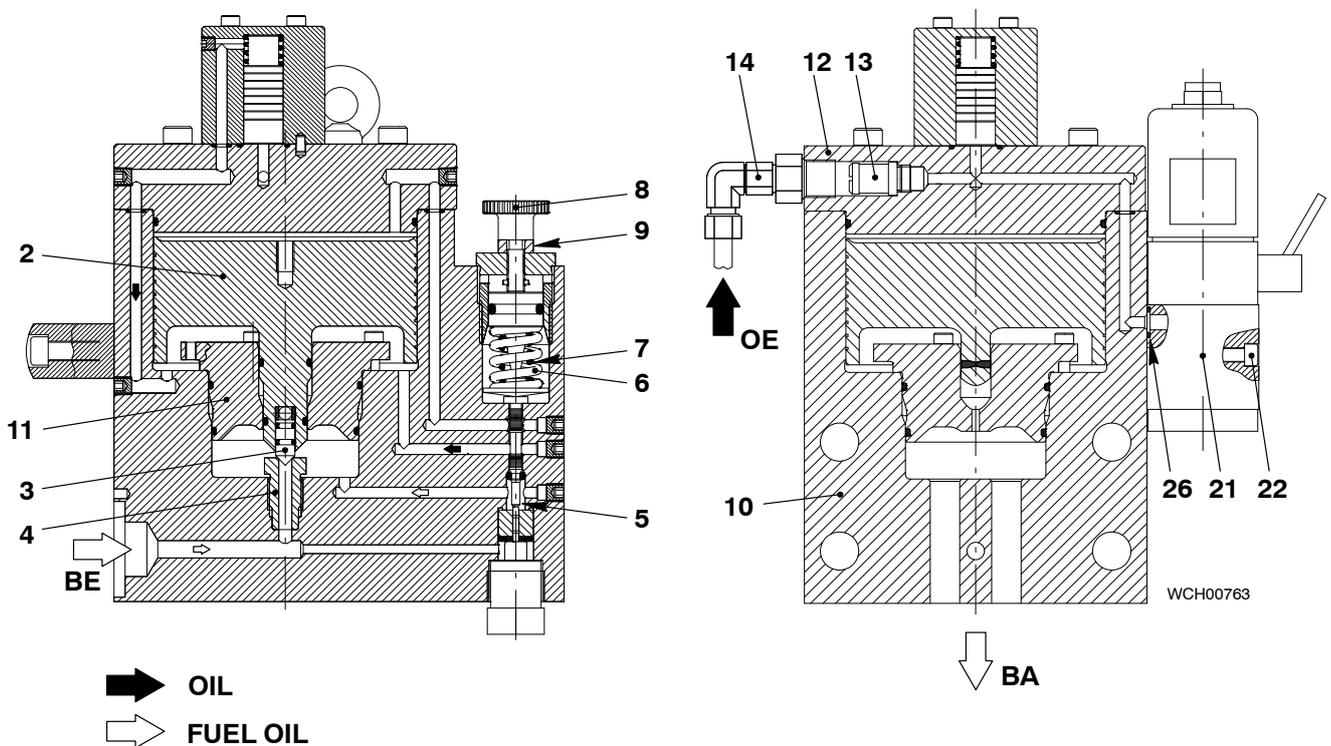
- ⇒ Bring the PCV in fitting position at the fuel rail by means of a manual ratchet.
- ⇒ Apply Never-Seez NSBT-8 to the screw threads 17.
- ⇒ Place new O-rings 24 and 25 into the grooves of intermediate ring 19.
- ⇒ Fit the intermediate ring over locating pin 18 and insert connection piece 20.
- ⇒ Fasten 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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Fuel Overpressure Safety Valve

Checking and Setting

Tools:

1	OBEL test bench	94272
1	Valve holder	94272A
1	HP oil pump	94931
2	Hydr. distributors	94932
2	HP hoses	94935

Key to Illustrations:

1	Valve housing	11	Fuel overpressure safety valve 3.52
2	Valve needle	12	Receiver
3	Ball	13	Back-up ring
4	Spring carrier	14	O-ring
5	Disc spring (11 pieces)		
6	Stop ring		
7	Distance ring		
8	Seating washer	AB	Drain bore
9	Snap ring	EV	Relief valve
10	Screw plug	MK	Marking Ø3 mm

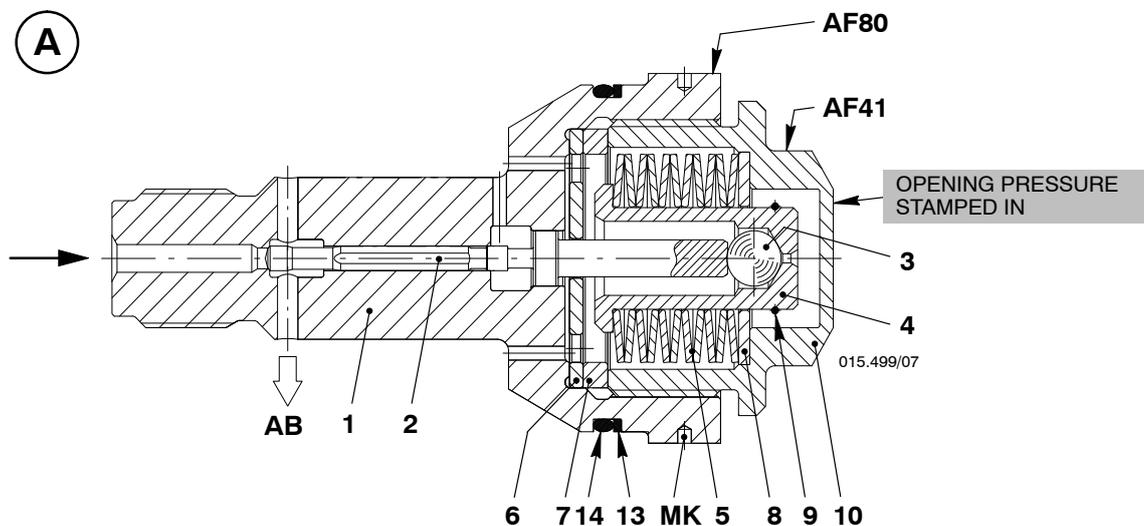
1. General

A relief valve normally requires no maintenance, however the opening pressure and the tightness should be checked according to Maintenance Schedule 0380-1. Leaky or faulty valves have to be returned to the manufacturer or to a Wärtsilä Switzerland Ltd. authorized repair workshop for inspection and repair.

The opening pressure of the relief valve must be approved by IACS (International Association of Classification Societies) and recorded on the Inspection Report.



Remark: To identify the new fuel overpressure safety valve (relief valve) 11, two bores 'MK' on one face have been provided as a marking.



2. Checking

In order to properly loosen the relief valve from the fuel accumulator, a spanner AF80 must be used and placed on housing 1!

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:

2.1 Physical characteristics for test & calibration fluid

Kinematic Viscosity		ASTM D445	
at 40 °C	mm ² /s		2.6
Density at 15 °C	kg/m ³	ISO 12185	827
Pour Point	°C	ISO 3016	-27

Fuel Overpressure Safety Valve: Checking and Setting



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

- ⇒ Fit relief valve 11 into the valve holder and tighten it.
- ⇒ Connect valve holder 94272A to HP oil pump 94931 (or hydraulic unit 94942).
- ⇒ Close relief valve 'EV'.

2.2 Checking the sealing pressure

- ⇒ Increase the pressure by means of HP oil pump to **1150 bar** and keep pressure constant during one minute.
- No leakage is allowed!

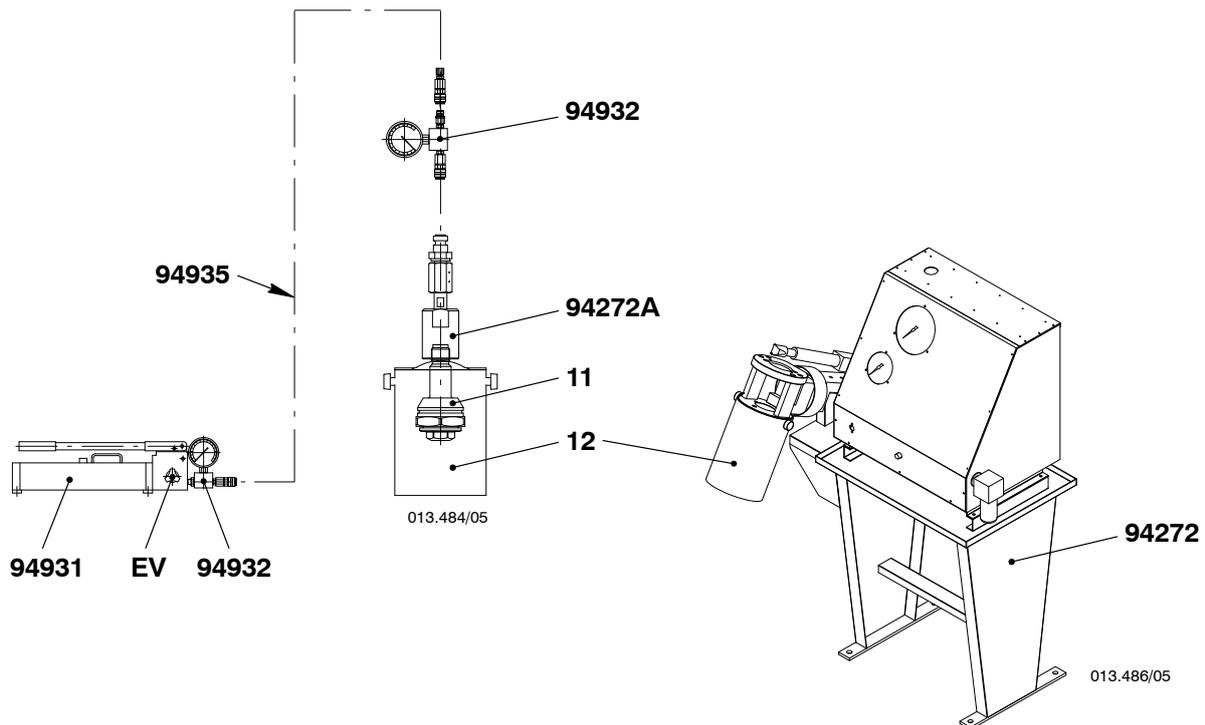
2.3 Checking the opening pressure

- ⇒ Increase the pressure by means of HP oil pump and observe at what value the relief valve opens.

Correct opening pressure = **1250 bar** \pm $\begin{matrix} +100 \\ -50 \end{matrix}$

- Confirm the opening pressure two times again.

B



3. Fitting the relief valve

- ⇒ Apply Never-Seez NSBT-8 to the thread of valve housing 1.
- ⇒ Screw the relief valve into the intermediate piece of fuel pressure control valve 3.06 and tighten it with a torque of **300 Nm** by means of a spanner with AF41.

Injection Control Unit Removal and Fitting

Tools:

1	Lifting plate	94584
2	Withdrawing tools	94589

Key to Illustrations:

1	Piping	10	Position sensor
2	Hose line	11	Nipple
3	Hose line	12	Nipple
4	Fuel rail	13	Dowel pin
5	Injection control unit	14	Connecting nipple
6, 6a	Screw	15	Filter holder
7	Pre-control valve	16	Oil filter
8	Screw	17	Circlip
9	Lip seal	18	O-ring

1. General

When working on an injection control unit the engine has to be stopped and the fuel booster and bearing oil pumps switched off.

If it is necessary to replace an injection control unit, the engine must operate for a minimum of 1.5 hours with marine diesel oil (MDO). For more data see Operation Manual 0270-1.



Attention! Fuel rail 4 must be pressureless! The corresponding drain (screws) valves must be opened as described in 0510-1 of the Operating Manual. **Follow the detailed instructions without fail!**

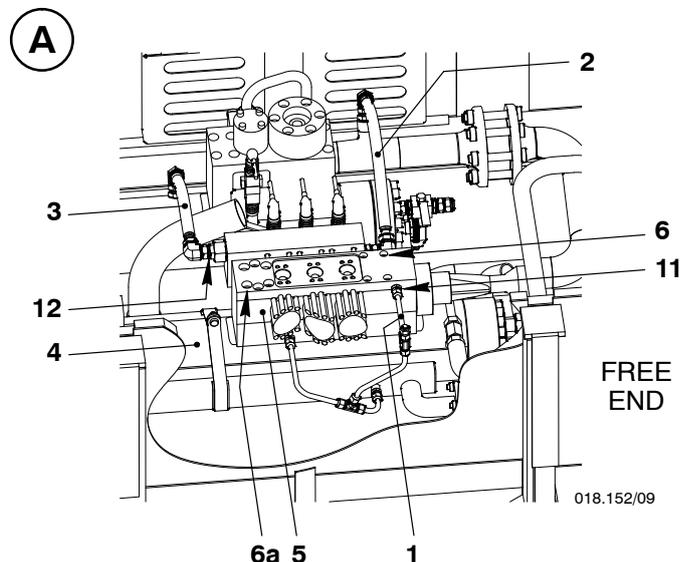
Maintenance works on the injection control unit may be carried out only by the manufacturer as a matter of principle. However, if troubles have been detected on the injection control unit during operation, it must be replaced by a revised unit, following the instruction below.



Remark: No maintenance work is provided for pre-control valve (rail valves) 7. If necessary it must be replaced as a whole unit!

2. Removal

- ⇒ Remove HP pipes to injection valves according to 8733-1.
- ⇒ Loosen piping 1, hose lines 2, 3 on injection control unit 5 and unscrew nipples 11 and 12 (the nipples are screwed into the spare injection control unit).
- ⇒ Remove screws 6 and 6a.



Injection Control Unit: Removal and Fitting

- ⇒ Fasten lifting plate 94584 onto injection control unit 5.
- ⇒ Remove cable plugs from pre-control valves 7 and position sensor 10.
- ⇒ Loosen screws 8 and remove them together with pre-control valves.
- ⇒ Lift up the injection control unit.



Remark: Immediately cover the appearing opening in fuel rail 4 to prevent dirt from entering in any circumstance!

- ⇒ Lip seal 9 (Fig. 'C') can be removed (if necessary) with one of withdrawing tools 94589.

2.1 Cleaning the filter

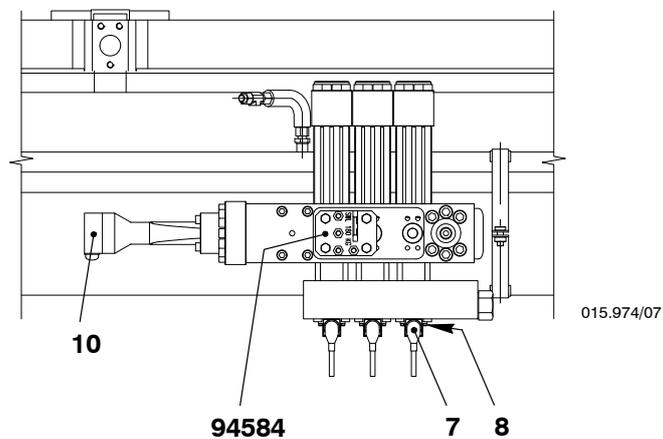
- ⇒ Loosen connecting nipple 14, remove filter holder 15 and clean oil filter 16.



Remark: Maintain the flow direction when refitting or replacing the oil filter. Moreover, the three oil filters must be secured by means of circlip 17.

- ⇒ Apply oil to the filter holder and tighten it with a torque of **120 Nm**.
- ⇒ Apply Never-Seez NSBT-8 to the threads of connecting nipple and tighten it with a torque of **350 Nm**.

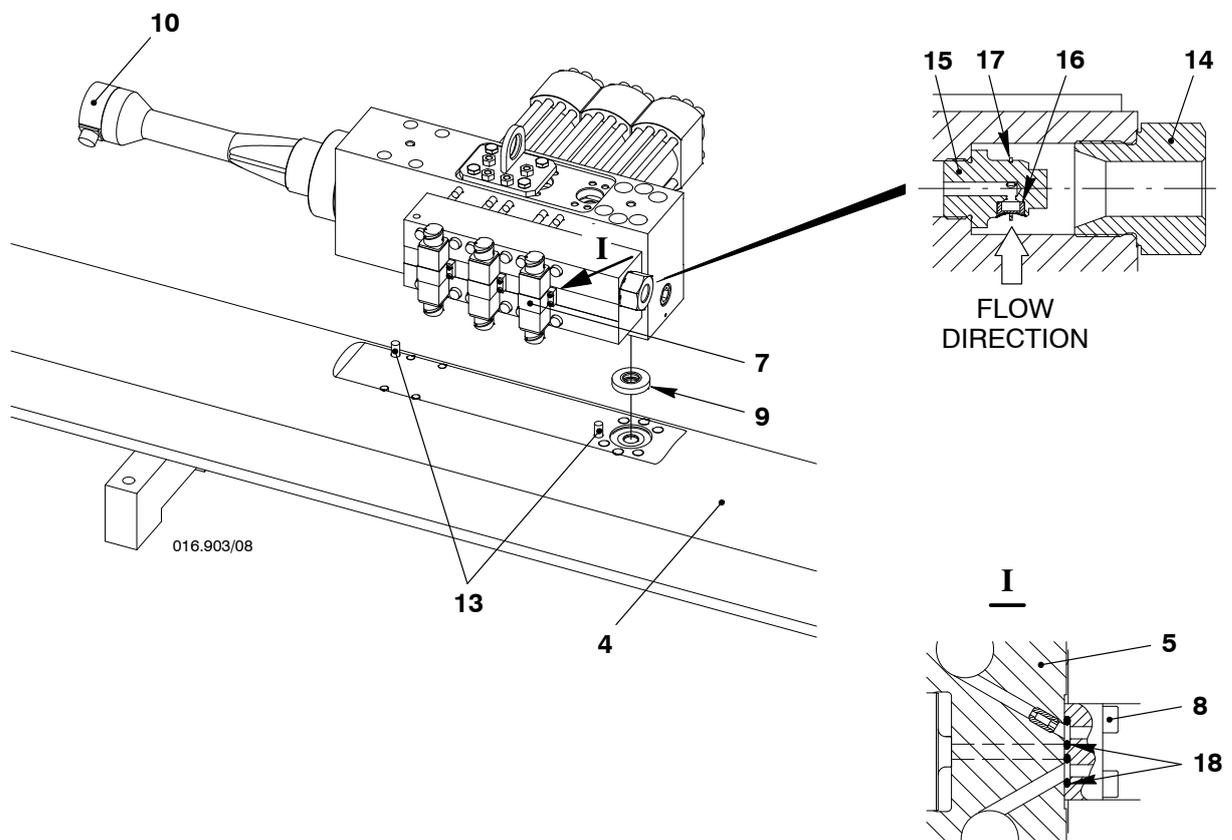
B



Injection Control Unit: Removal and Fitting

3. Fitting

- ⇒ Insert lip seal 9.
- ⇒ Lower injection control unit 5 carefully onto the fuel rail and remove the lifting plate.
- ⇒ Apply Never-Seez NSBT-8 to the threads of screws 6 and 6a (Fig. 'A').
- ⇒ First tighten screws 6a crosswise with a torque of **110 Nm** and subsequently screws 6 with a torque of **55 Nm**.
- ⇒ Replace O-rings 18, if necessary.
- ⇒ Apply Never-Seez NSBT-8 to screws 8 and fasten pre-control valve 7 to injection control unit 5 with them.
- ⇒ Tighten screws 8 with a torque of **2.5 Nm**.
- ⇒ Install hose lines and pipings.
- For fitting the HP pipes to injection valves see [8733-1](#).
- For restarting the injection see instructions 0510-1 in the Operating Manual.

C

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Pressure Reducing Valve 8.11-1

Checking the Gas Pre-charge Pressure

Tool:

- 1 Case 94720C consisting of: measurement set complete for checking / refilling of hydraulic accumulator

Key to Illustrations:

- | | |
|---------------------------------------|---------------------------|
| 1 Hydraulic accumulator | 9 Pressure reducing valve |
| 2 Protection cap | 10 Pressure transmitter |
| 3 Pressure reducing valve | 11 Cable socket |
| 4, 4a Hose (1m, 4 m) | 12 Pressure gauge |
| 5 Control unit with valves A, B and C | 13 Screw plug |
| 7 Pressure gauge 0-60 bar | 14 Stop valve |
| 8 Valve block | 15 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.**

The same measurement set 94720C must always be used to refill the accumulator as provided for checking the gas pre-charge pressure on the lubricating pump's hydraulic actuators (see also 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 valve block must be visible on pressure gauge 12 (PI2041L) of pressure reducing valve 8.11-1.

1.1 Preparation

- Stop servo oil supply.
- Close stop valve 14 between rail unit and pressure reducing valve (Fig. 'C').
- Drain servo oil system by means of screw plug 13.
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 not ok:

- ⇒ Refill the accumulator.

Pressure Reducing Valve: Checking the Gas Pre-charge Pressure

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 % N₂ by volume.

2.1 Refilling procedure

- ⇒ Fit pressure reducing valve 3 to nitrogen bottle 15 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 (C), and accumulator with short hose 4 to the left side (A) 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 14 between rail unit and pressure reducing valve valve 8.11-1 (Fig. 'C').
- ⇒ Close screw plug 13.

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).

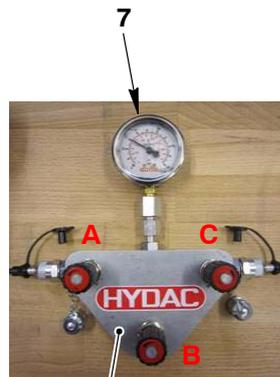
Pressure Reducing Valve: Checking the Gas Pre-charge Pressure

Case with measurement set 94720C for CLU4-C and PRV 8.11-1:

A



Case 94720C



4, 4a

3

5

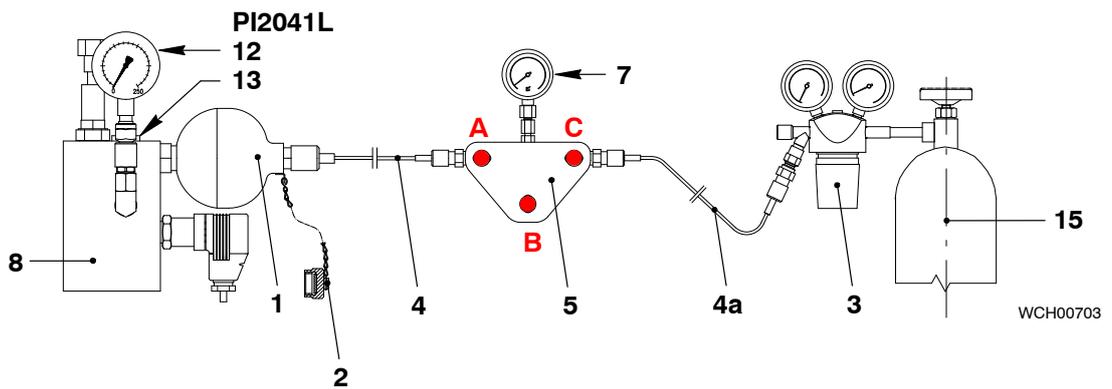
1

2

4

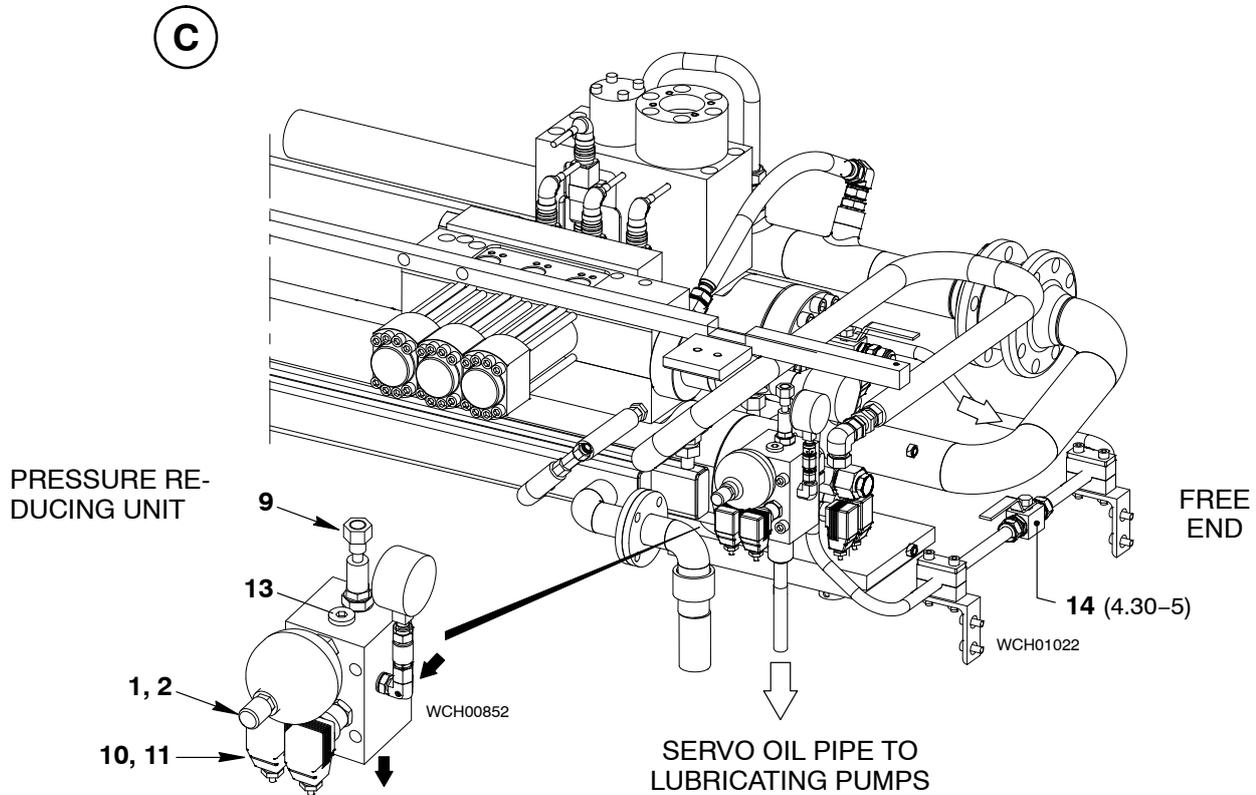
Arrangement of equipment:

B

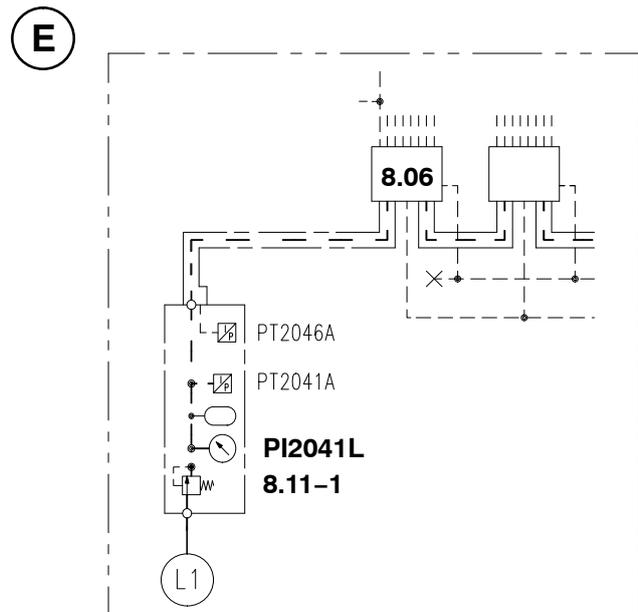
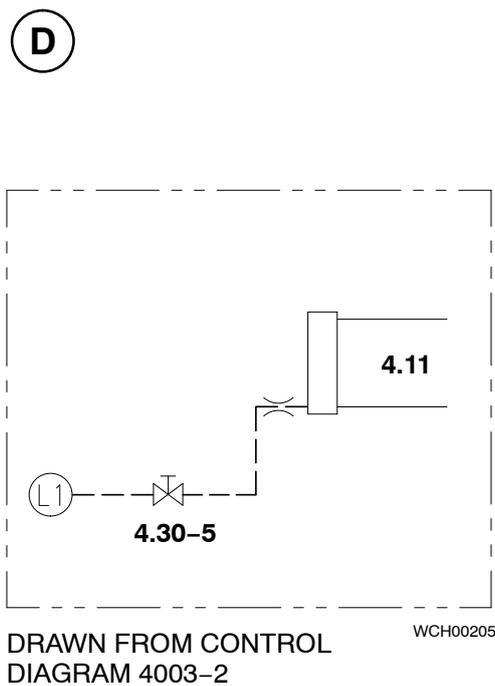


Pressure Reducing Valve: Checking the Gas Pre-charge Pressure

Pressure reducing valve 8.11-1:



Details of servo oil rail 4.11 -> pressure reducing valve 8.11-1 -> lubricating pump 8.06:



Exhaust Valve Control Unit

Removal, Fitting, Dismantling and Assembling

Key to Illustrations:

1	Valve control block	15	Slide rod
2	Pipe	16	Screw plug
3	Rail valve (pre-control valve)	17	Screw
4	Screw	18	Screw plug
5	Screw	19	Filter
6	Servo oil rail	20	Screw plug
7	Dowel pin	21	Filter
8	Connecting block	22	Throttle
9	Screw	23	Screw
10	Cover	24	Plug
11	Piston	25	O-ring
12	Screw	26	O-ring
13	Cover	27	O-ring
14	Compression spring	28	O-ring

1. General

When working on the exhaust valve control unit in principle the engine has to be stopped.



Attention! HP Servo oil pipes must be pressureless. Follow the instruction in 0520-1 of the Operating Manual without fail!

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.

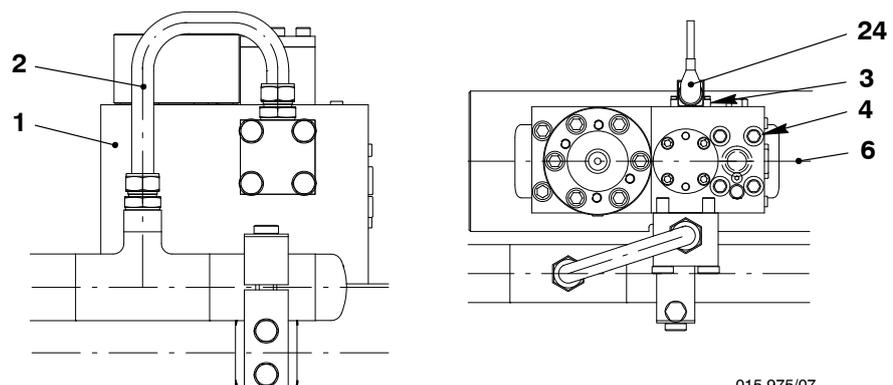
⇒ Disconnect plugs 24 from rail valve 3.

⇒ Loosen screws 4.

⇒ Carefully lift the complete exhaust valve control unit.

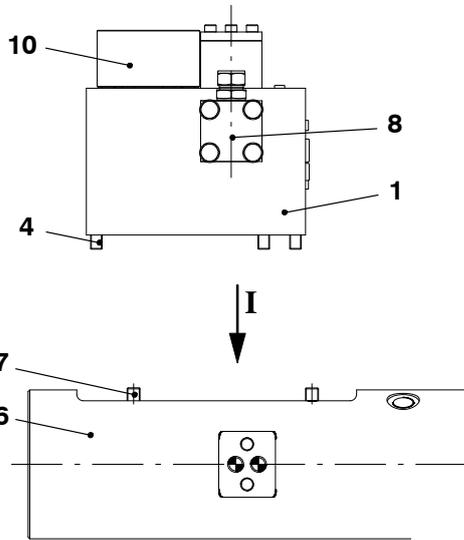


Remark: Immediately cover the appearing opening in servo oil rail 6 and pipes to prevent dirt from entering in any circumstance!

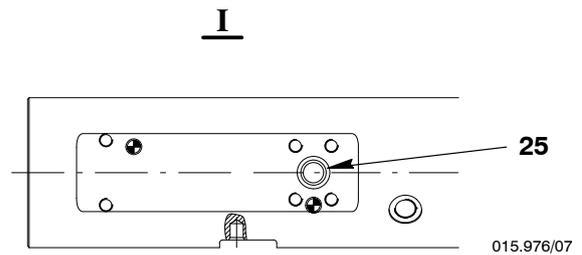


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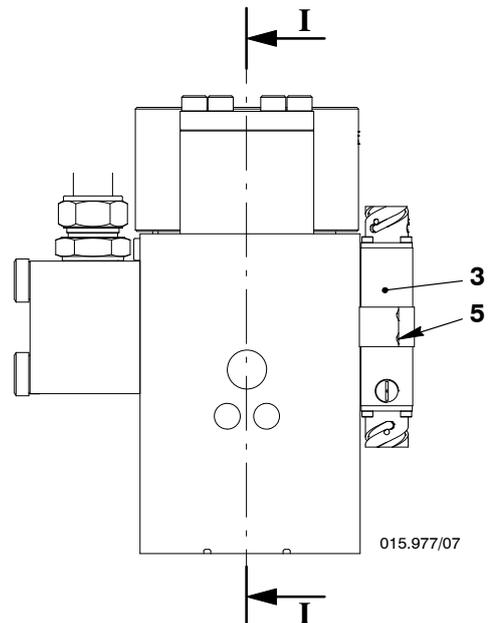
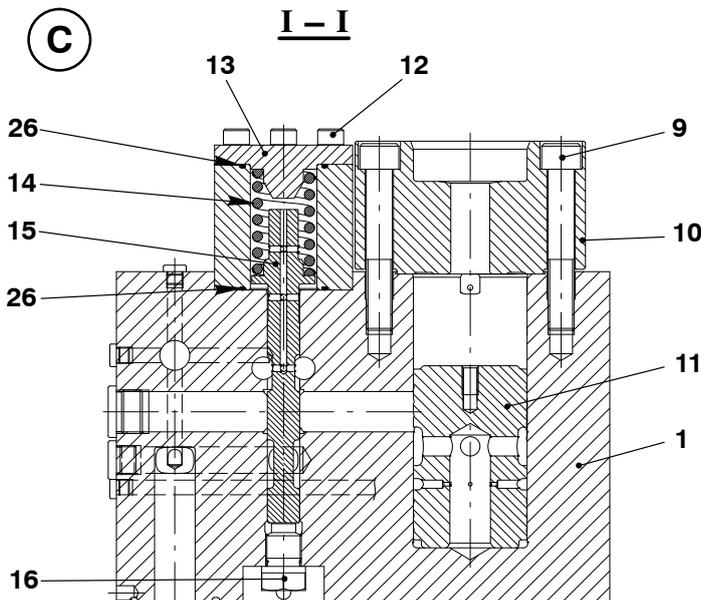
Exhaust Valve Control Unit: Removal, Fitting, Dismantling and Assembling

B**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](#).

**4. Dismantling of exhaust valve control unit**

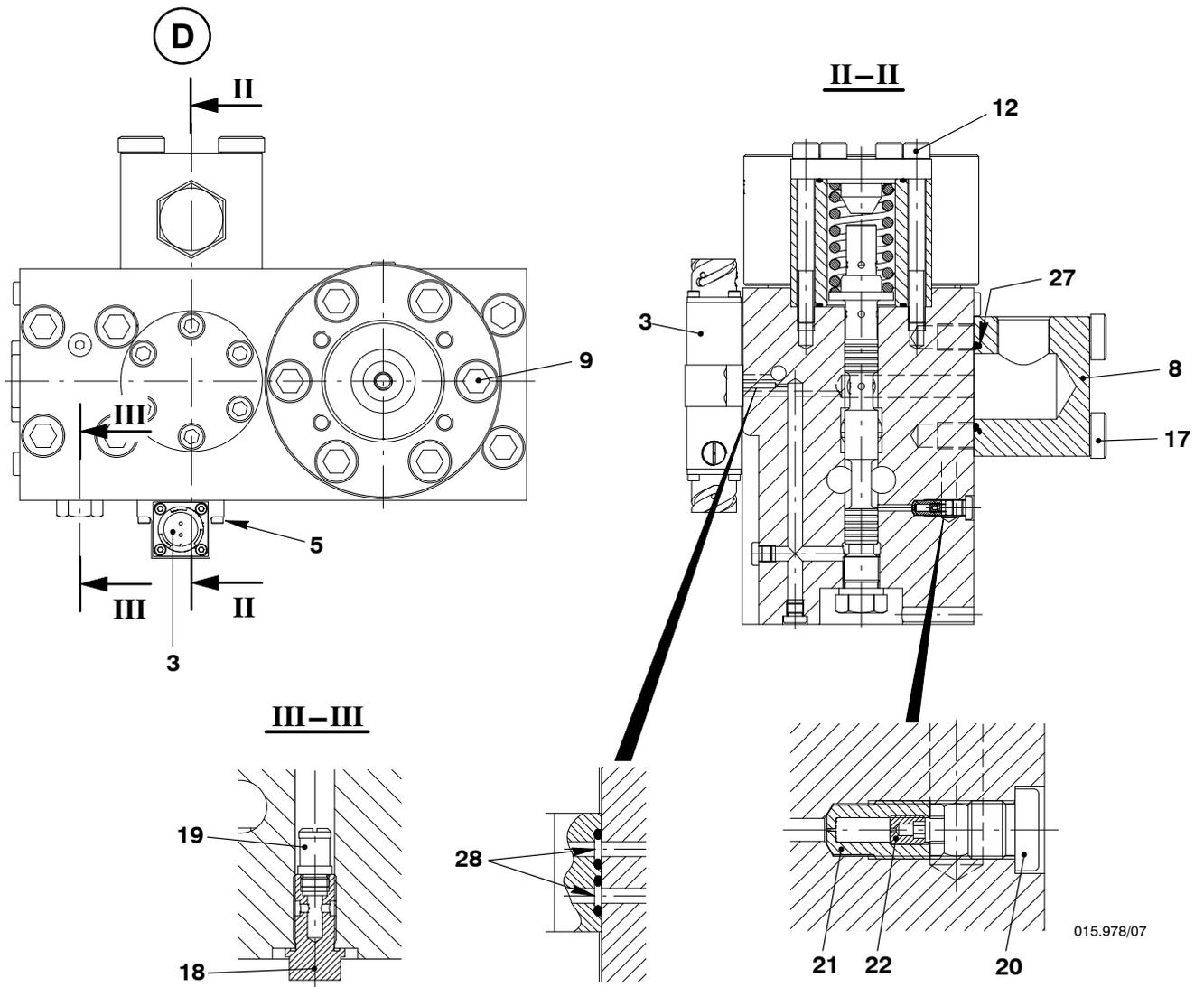
- ⇒ Loosen screws 9 and remove cover 10.
- ⇒ Withdraw piston 11 using a jacking screw M10.
- ⇒ Loosen screws 12 and remove cover 13.
- ⇒ Remove compression spring 14 and slide rod 15.
- In order to remove and clean filters 19 and 21, the relevant screw plugs 18 and 20 must be loosened.
- Throttle 22 is oiled, screwed into filter 21 and tightened with **3 Nm**.
- Filter 19 (thread oiled) is screwed into screw plug 18 and tightened with a torque of **10 Nm**.

C

Exhaust Valve Control Unit: Removal, Fitting, Dismantling and Assembling

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 of **70 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

with Heinzmann StG 10-01 Actuator

Tools:

- | | | |
|---|-----------------|--------|
| 1 | Adjusting scale | 94575 |
| 1 | Adjusting pin | 94575A |

Key to Illustrations:

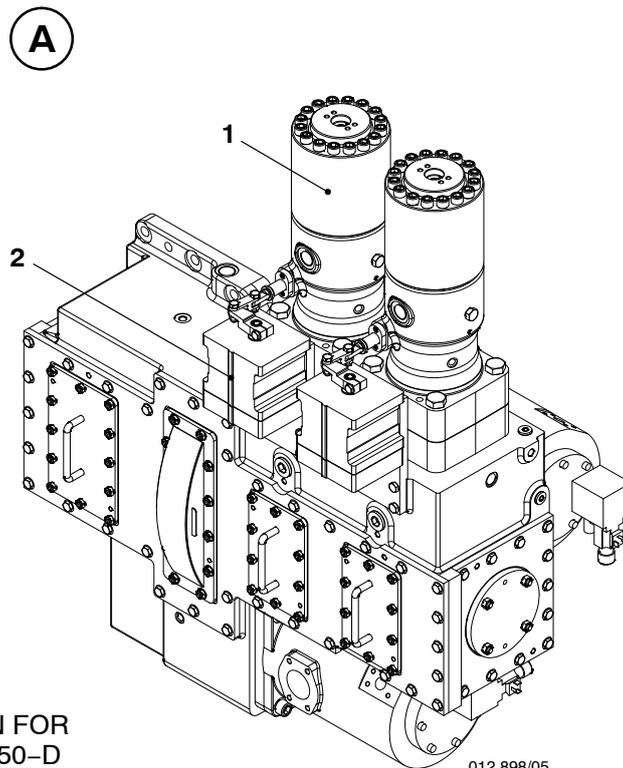
- | | | | |
|---|-----------------|----|--------------------|
| 1 | Fuel pump | 8 | Connecting element |
| 2 | Actuator | 9 | Toothed rack |
| 3 | Centring flange | 10 | Set screw |
| 4 | Actuator shaft | 11 | Spot-face |
| 5 | Lever | | |
| 6 | Sleeve | | |
| 7 | Screw | | |
- MA Mark

1. General

After overhauling the linkage or the fuel pumps, as well as after fitting a new fuel pump or a new actuator, the adjustment of the linkage must be checked and, if necessary, adjusted.



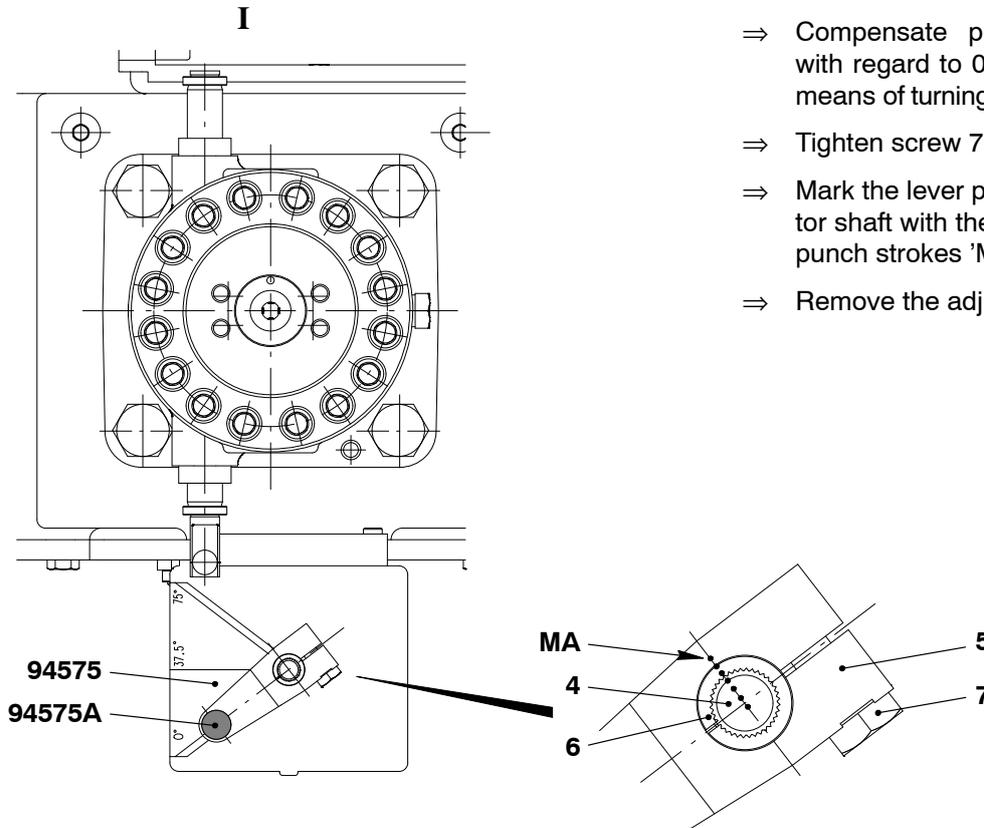
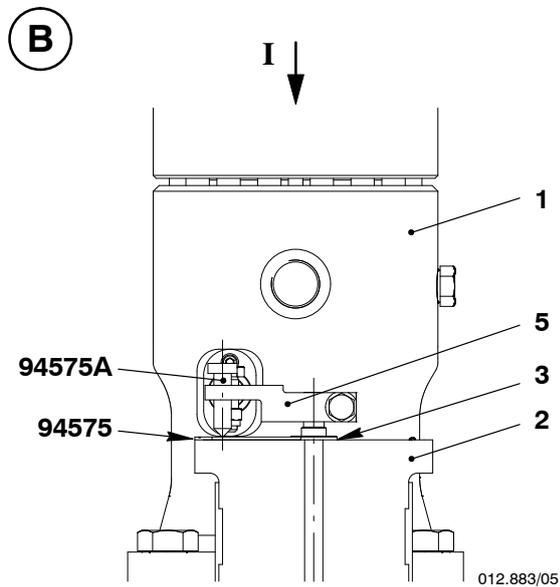
Attention! The power to the actuators 2 must be interrupted first, before they are disconnected from the regulating linkage (see 9362-1 in the Operating Manual).



DRAWN FOR
RT-flex50-D

012.898/05

2. Adjusting of regulating linkage



- ⇒ Place adjusting scale 94575 on actuator 2 as shown in Fig. 'B'. Push the tool against centring flange 3 aligning it parallel with the outer actuator edge simultaneously. Maintain this position during the following adjusting works.
- ⇒ Rotate actuator shaft 4 in counter-clockwise direction until the internal stop of the actuator (minimum stop).
- ⇒ Put lever 5 with inserted sleeve 6 and adjusting pin 94575A on actuator shaft 4 so that the pinpoint points at 0°-line as exactly as possible.
- ⇒ Slightly tighten screw 7.
- ⇒ Rotate lever 5 to 75°-mark (maximum stop) so that also in this position the pinpoint points at 75°-line as exactly as possible.
- ⇒ Compensate possible differences with regard to 0°- and 75°-lines by means of turning lever 5 on sleeve 6.
- ⇒ Tighten screw 7.
- ⇒ Mark the lever position to the actuator shaft with the aid of slight center punch strokes 'MA'.
- ⇒ Remove the adjusting tools.

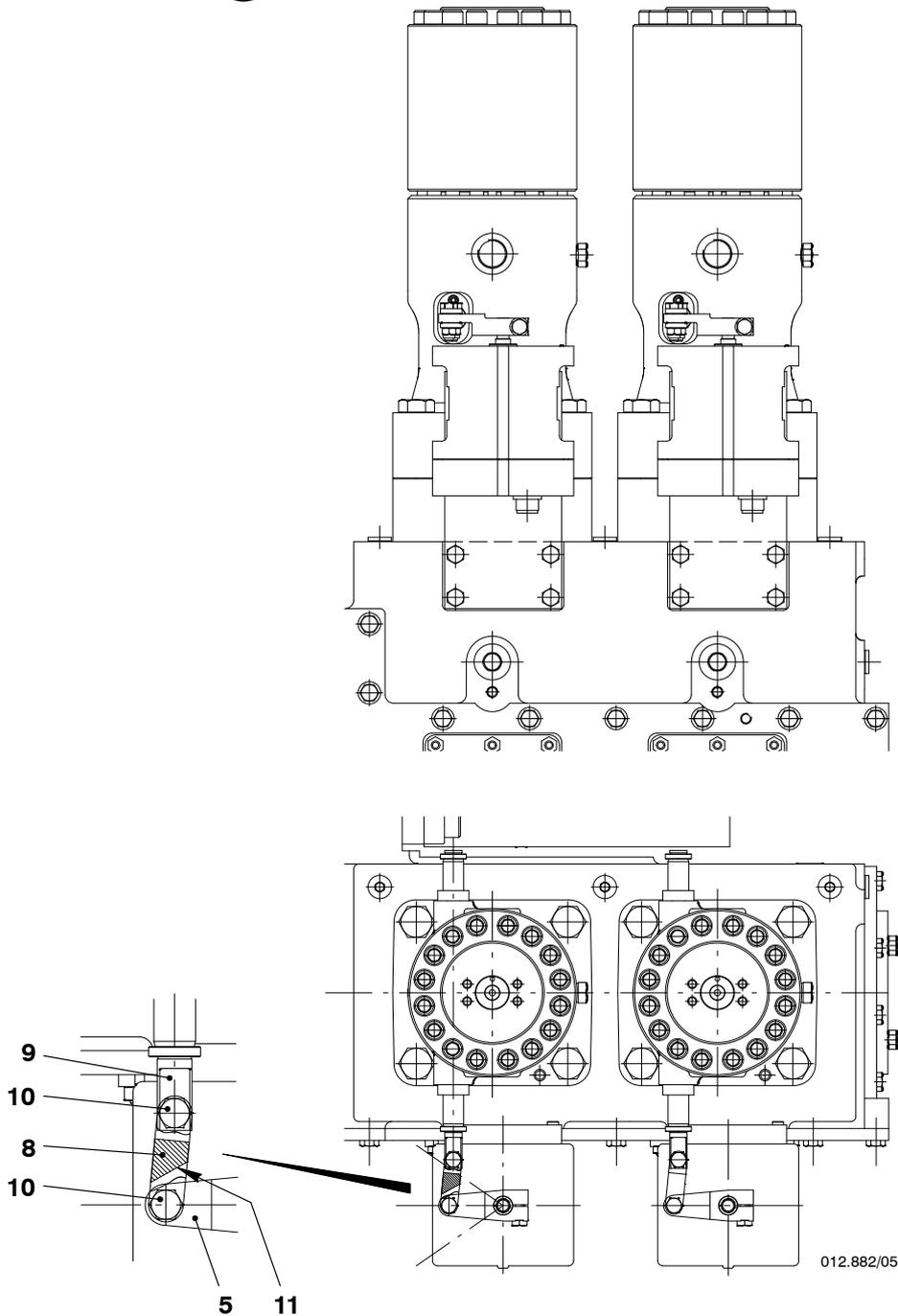
3. Fitting of connecting element

⇒ Join connecting element 8 with lever 5 and toothed rack 9 of fuel pump 1 using set screws 10.



Remark: The connecting element must be fitted in such a way that its spot-face 11 points to lever 5.

C



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Regulating Linkage

Adjusting

with Woodward ProAct II – Digital Actuator

Tools:

2 Spacers GF 94555A

Key to Illustrations:

1 Fuel pump

2 Actuator

3 Shaft

4 Lever

5 Clamping sleeve

6 Screw

7 Connecting element

8 Toothed rack

9 Set screw

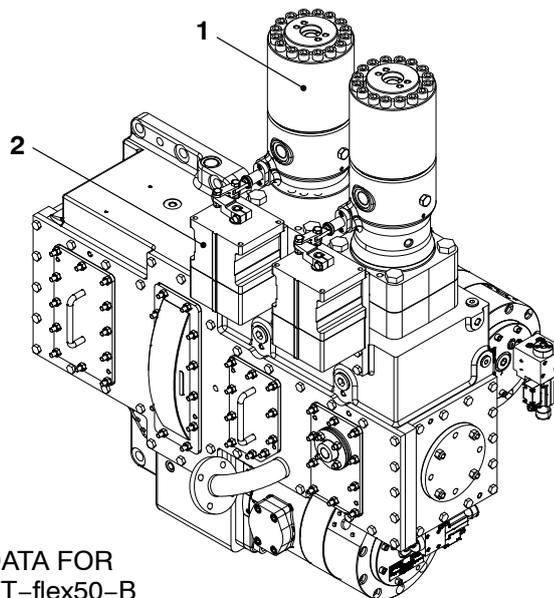
10 Self-locking nut

11 Mark

1. General

⇒ Make sure that the connecting element (1, Fig. A) is lubricated with Molykote paste G.

⇒ Make sure that the connecting element (1) can move freely.

ADATA FOR
RT-flex50-B

WCH03870

2. Actuator – Align

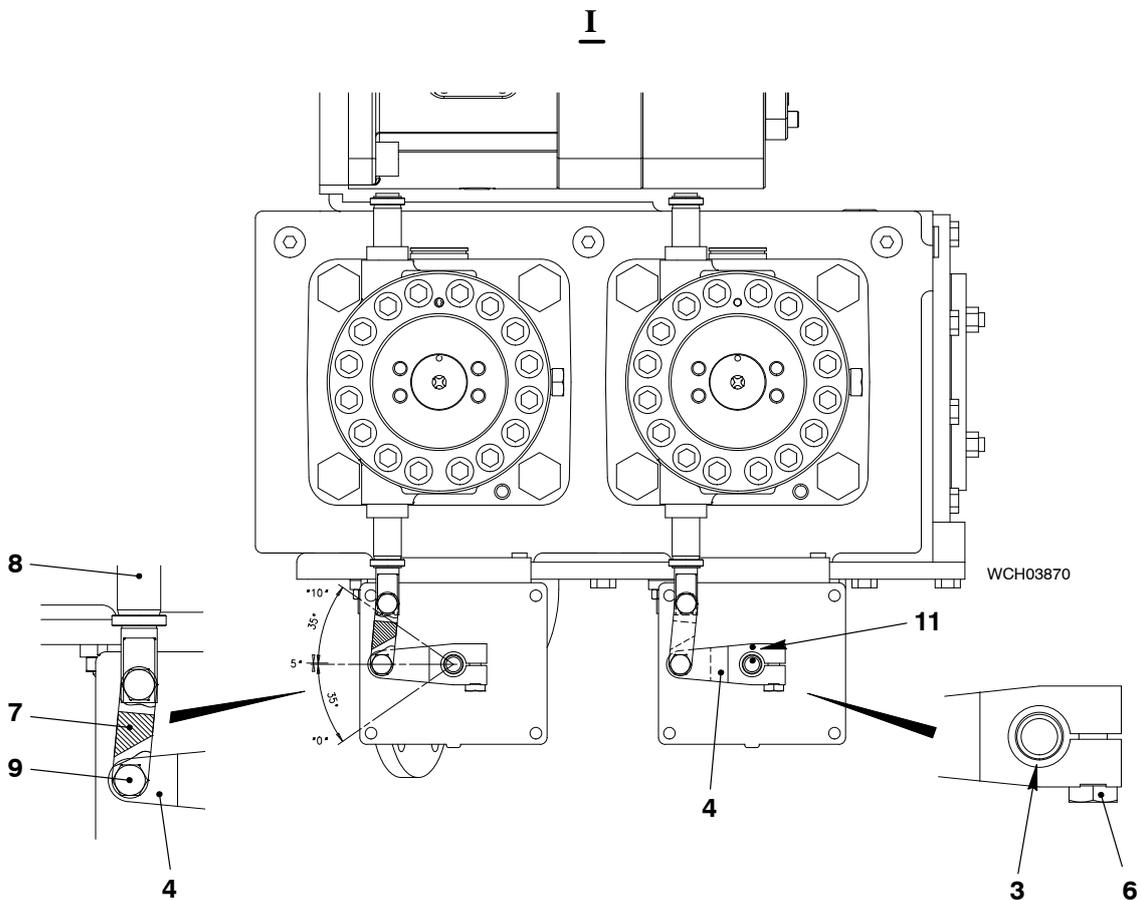
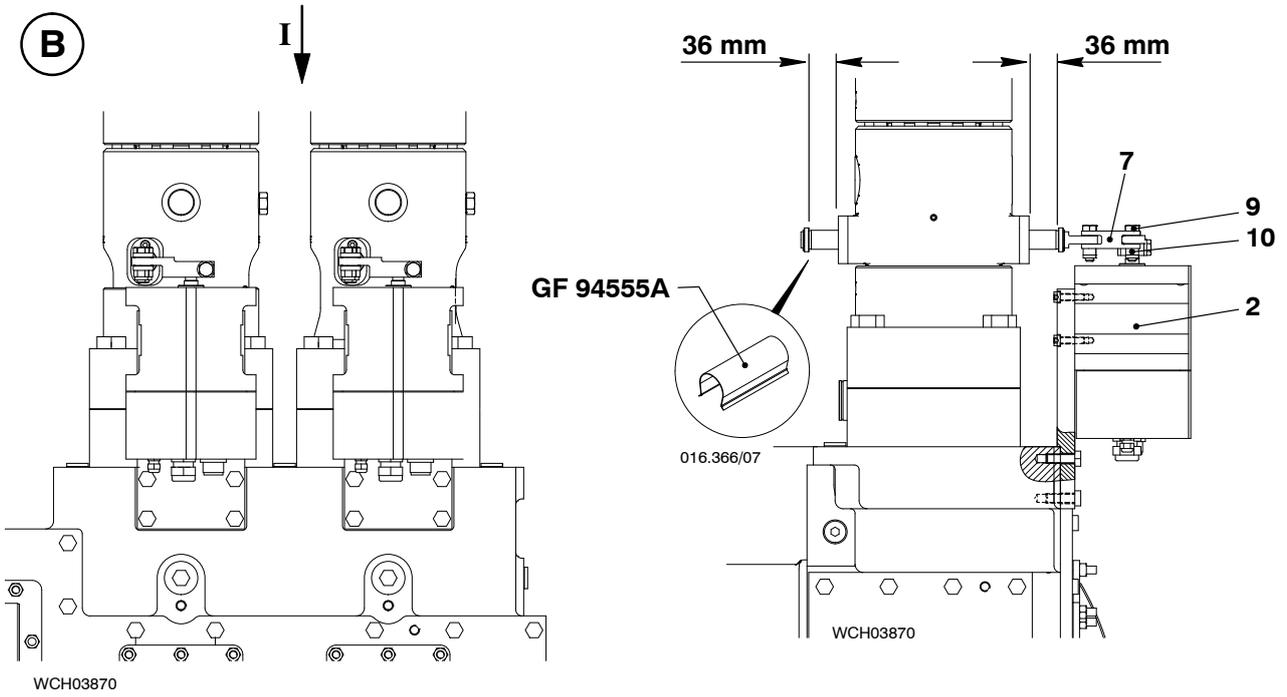
- ⇒ Refer to the manufacturer's instructions for the configuration and settings of the actuator.
- ⇒ Make sure that the actuator is electrically disconnected.
- ⇒ Make sure that the connecting element (1, Fig. B) is disconnected from the lever (4).
- ⇒ Use the spacers (94555A) to get a distance of 36 mm on each side of the toothed rack.
- ⇒ Put the lever (4) in position on the shaft (3). Make sure that the center-line of the lever aligns with the 50% fuel indication on the actuator.
- ⇒ Use a center punch to make the marks (11) on the shaft (3) and the lever (4) to record their positions.
- ⇒ Attach the lever (4) to the connecting element (7) with the screw (9) and self-locking nut (10).
- ⇒ Tighten the screw (6) on the shaft (3).



Remark: For data about emergency operation with defective fuel actuators, refer to the Operation Manual 0515-1.

Regulating Linkage: Adjusting

with Woodward ProAct II – Digital Actuator



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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

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Scavenge Air Receiver

Checking the Air Flaps and Cleaning the Scavenge Air Receiver

Key to Illustrations:

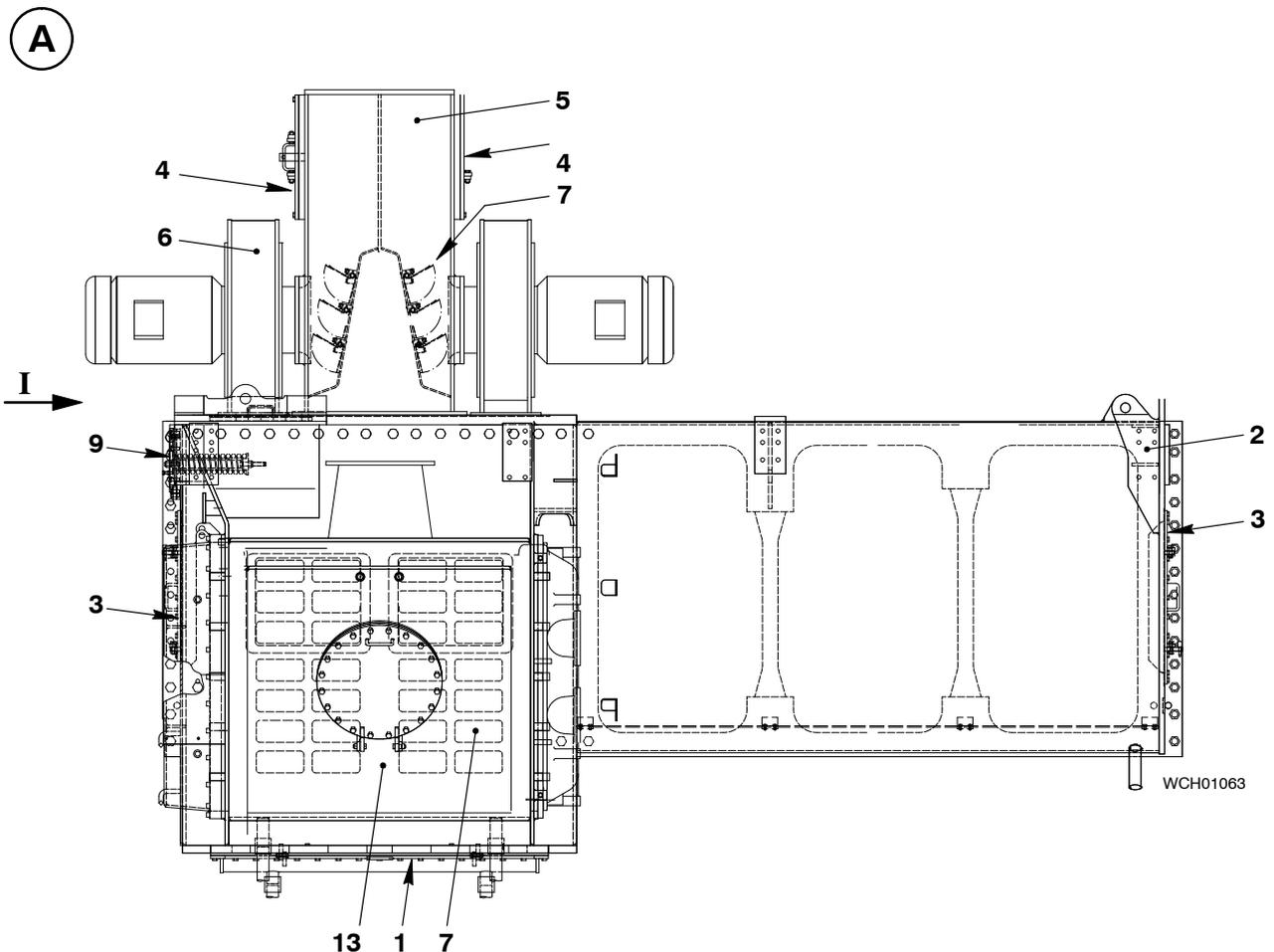
1 Hinged cover	8 Stop plate
2 Scavenge air receiver	9 Relief valve
3 Door	10 Water drainage piping
4 Inspection cover	11 Screw
5 Fixed support (suction space)	12 Distance ring
6 Auxiliary blower	13 Inspection cover
7 Air flap	14 Cover

1. Inspection of air flaps

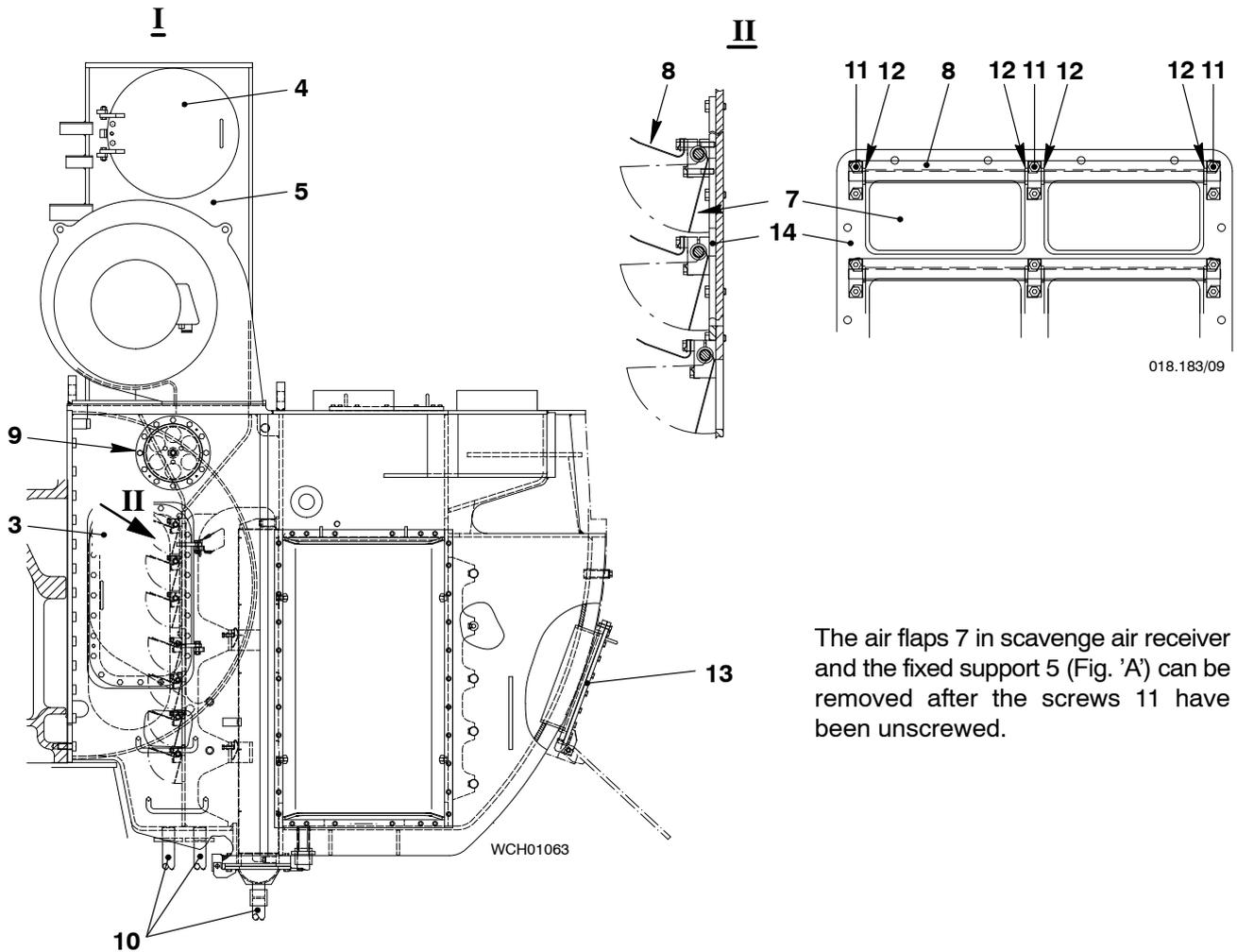
Air flaps 7 arranged in the scavenge air receiver and in fixed support 5 must be checked for damage, movability as well as fouling, in the course of the periodic cleaning of the scavenge air receiver (see [0380-1](#)).

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:

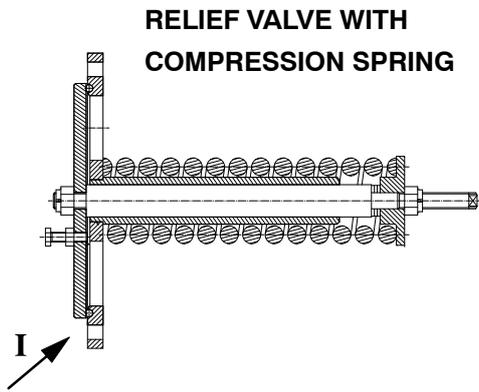
- Gap between metal must be visible (O-ring intact).
- Preload distance x must correspond to the value in Fig. 'B'.

If any defect or heavy rust is visible, replace the relief valve.

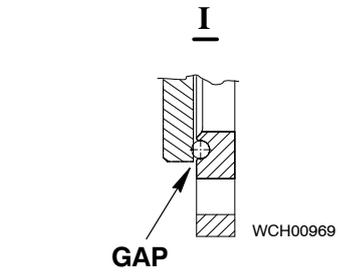


Remark: Do not open the relief valve with disc springs! In case of any damages or malfunctions please contact the manufacturer or Wärtsilä Switzerland Ltd.

Checking the Air Flaps and Cleaning the Scavenge Air Receiver



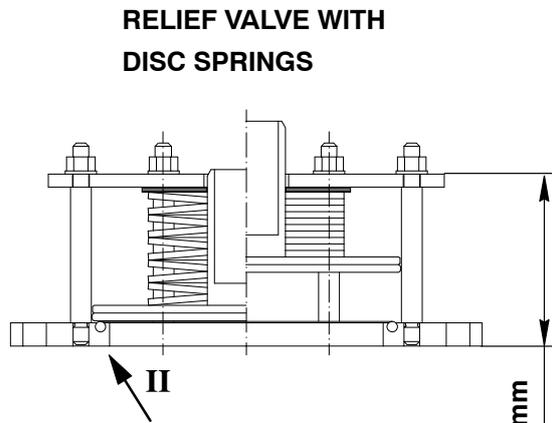
RELIEF VALVE WITH
COMPRESSION SPRING



GAP

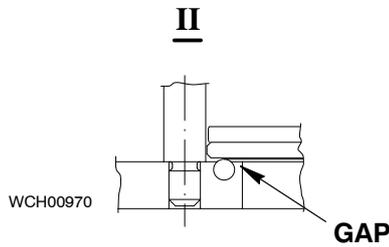
WCH00969

B



RELIEF VALVE WITH
DISC SPRINGS

x = 133 mm



WCH00970

GAP

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Auxiliary Blower

Maintenance

Tools:

1	Spur-gearred chain block (WLL 1000 kg)	94650
1	Dismantling device consisting of:	94651
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

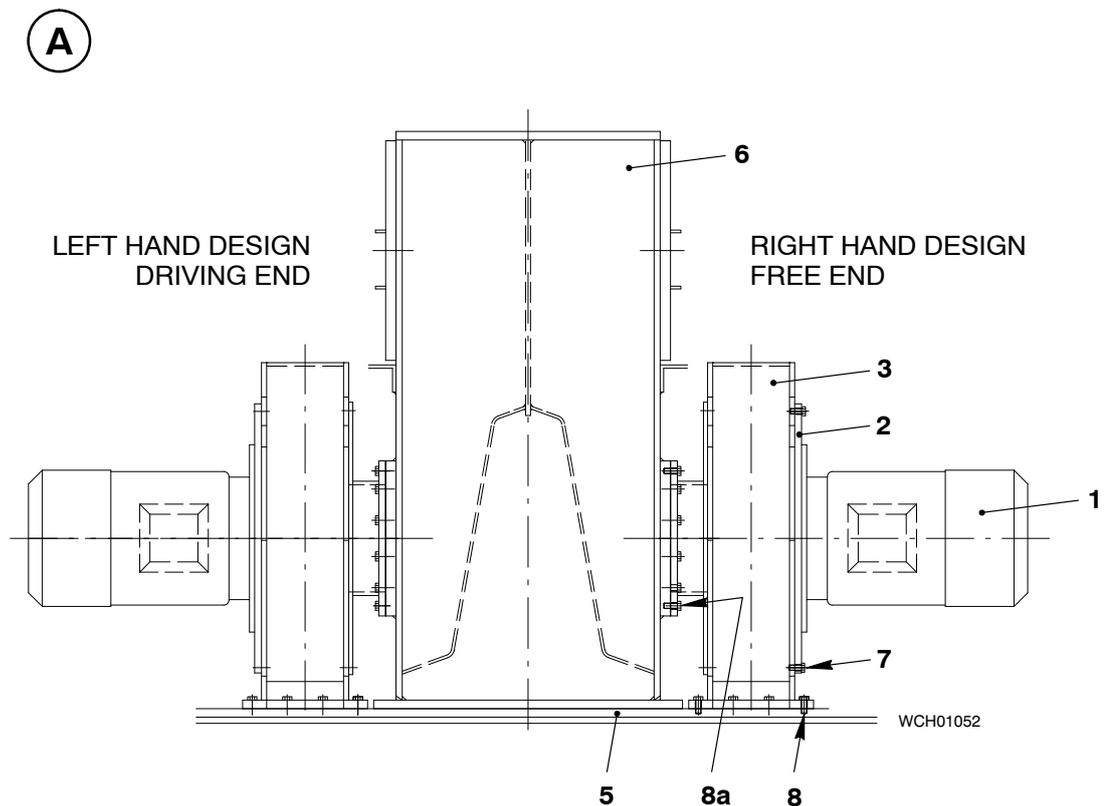
Overview

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



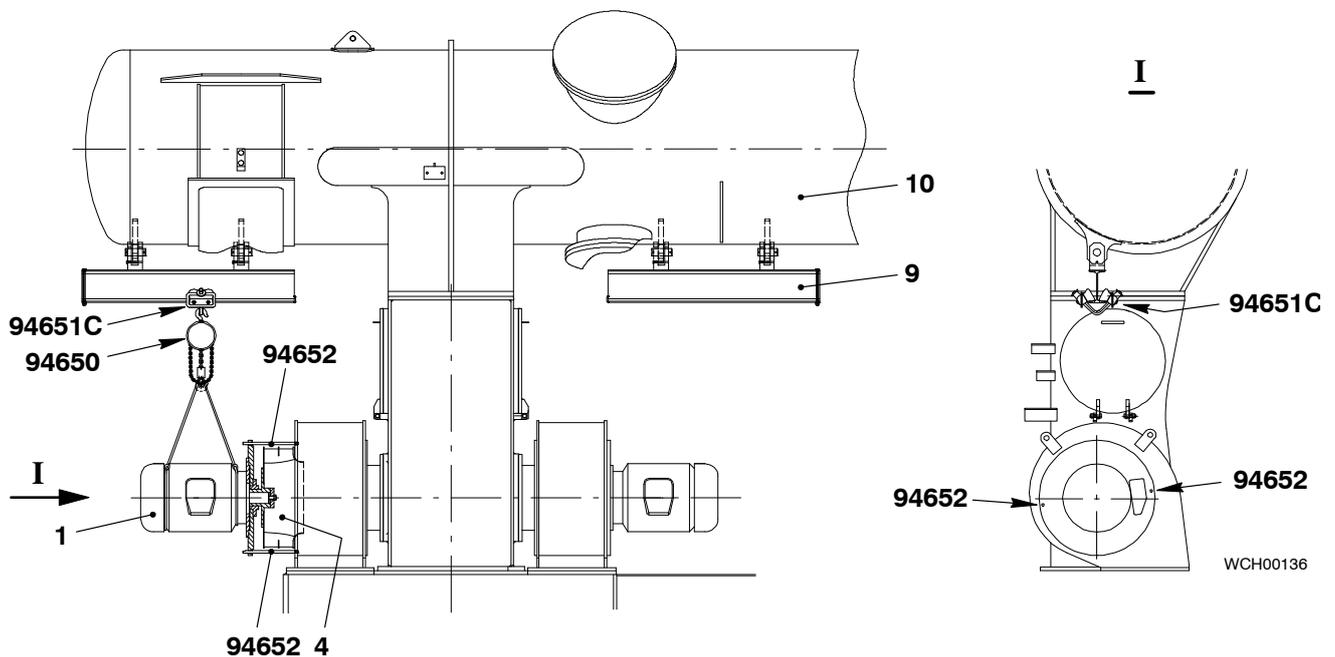
Remark: Pay attention to General Guidelines for Lifting Tools 0012-1.

- ⇒ Install trolley 94651C and spur-gear chain block 94650 (WLL 1000 kg) on the longitudinal I-beam 9.
- ⇒ Attach electric motor 1 to spur-gear 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.

B



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-gear 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

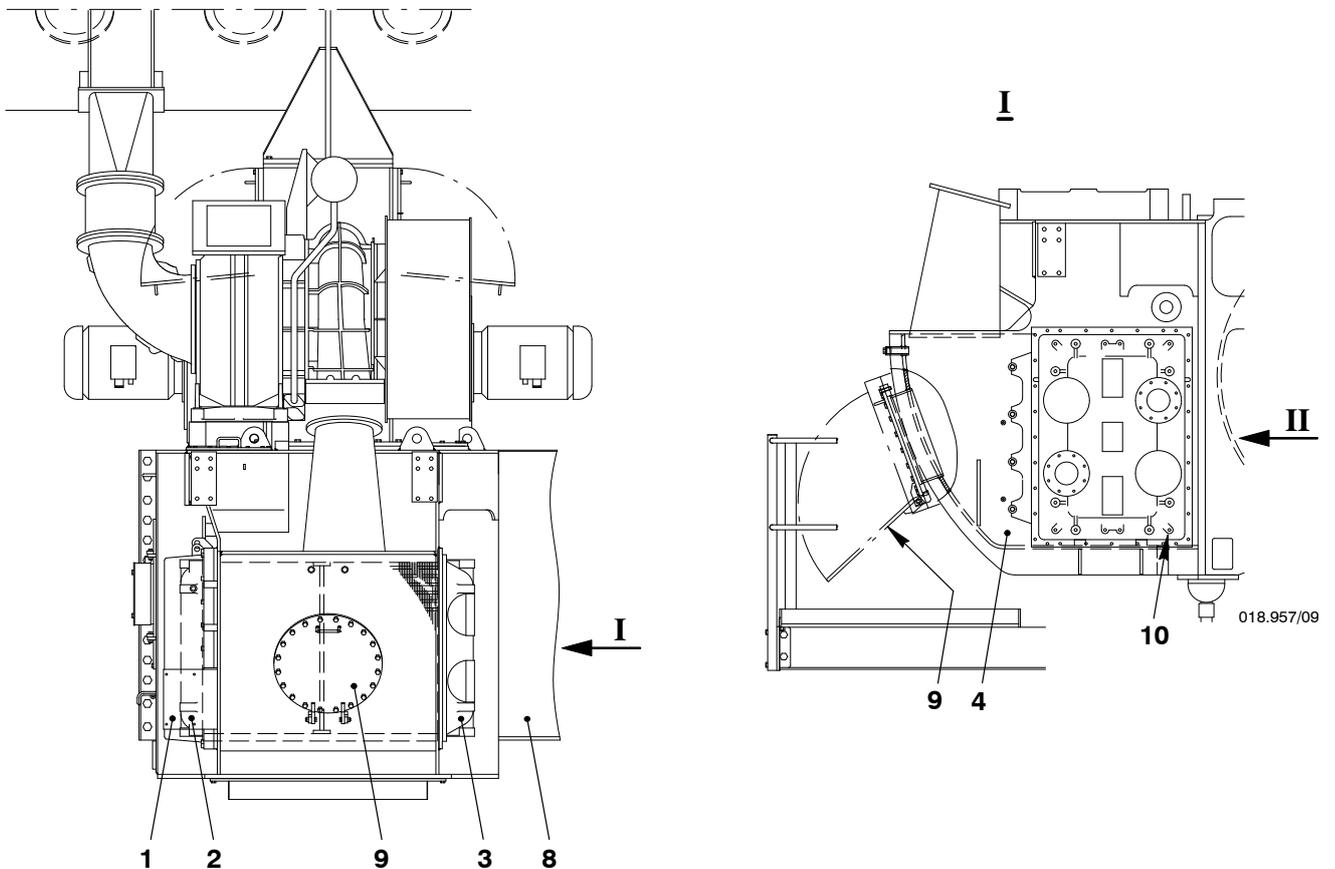
Key to Illustrations:

- | | |
|--------------------------|-------------------------|
| 1 Cover | 6 Cooling fins |
| 2 Return chamber | 7 Tube plate |
| 3 Connection chamber | 8 Scavenge air receiver |
| 4 Air duct before cooler | 9 Hinged cover |
| 5 Cooling tubes | 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.



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

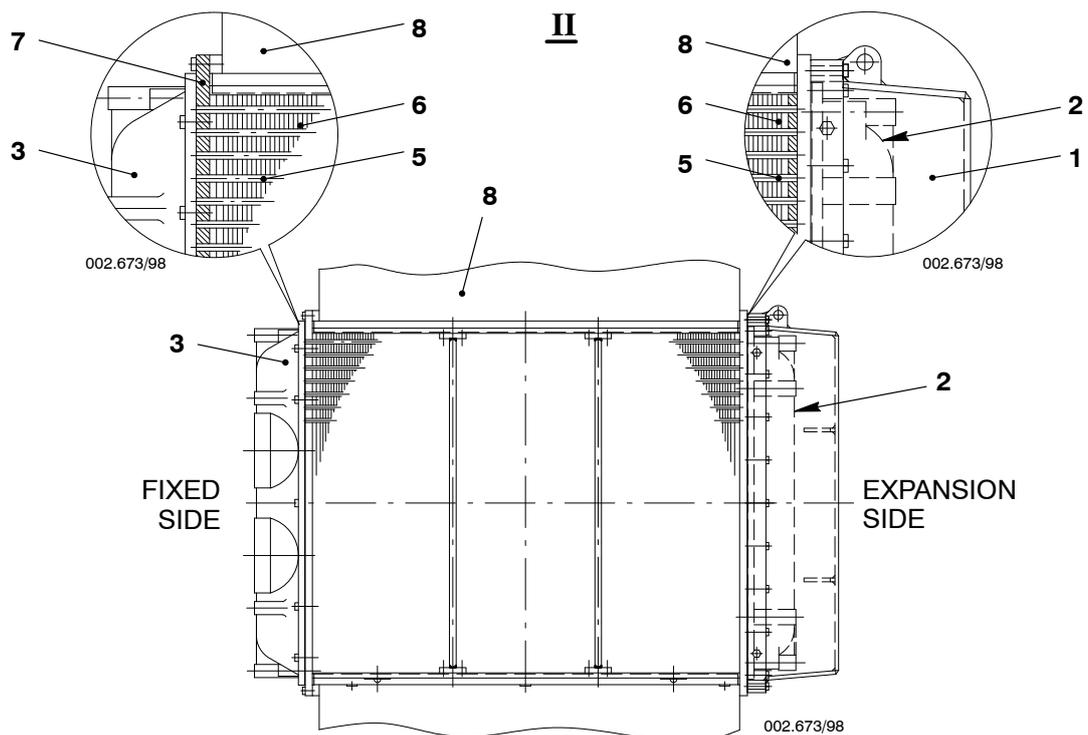
Firmly adhering sediment which is not dislocated by the brush can be removed with high pressure water jets. Spray devices with special nozzles are used, which can be ordered from the cooler manufacturers.

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

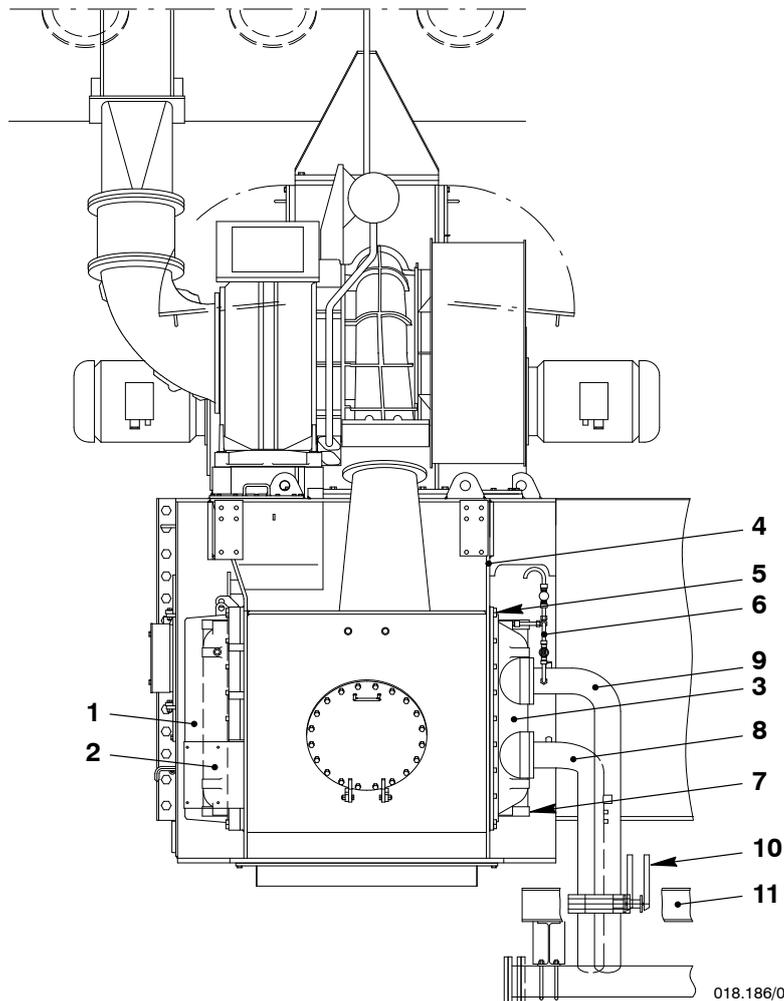
Key to Illustrations:

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.

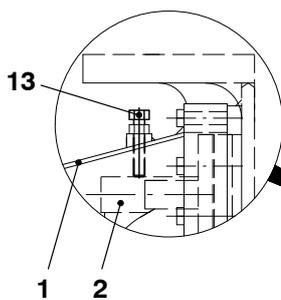
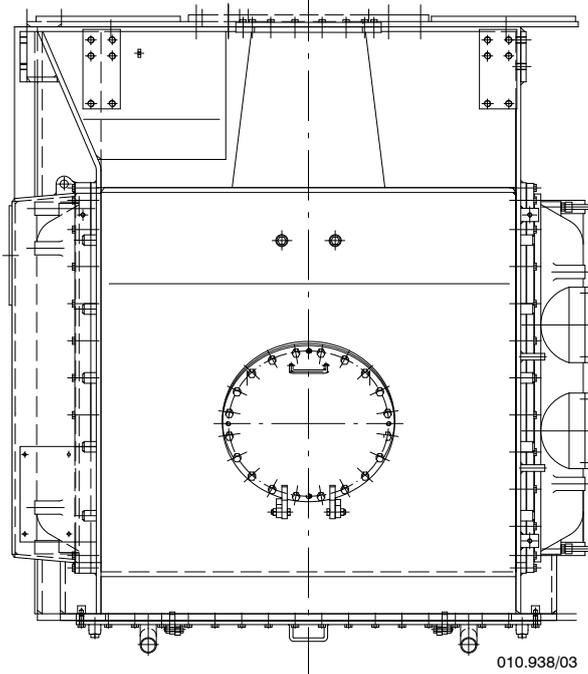
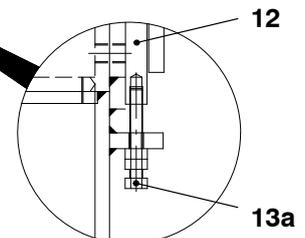
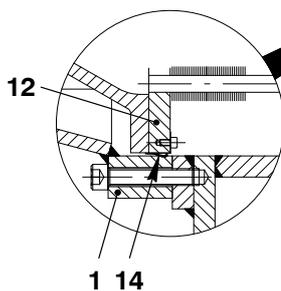
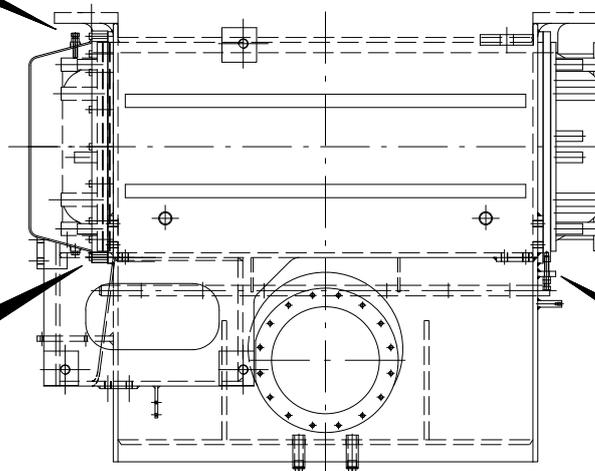
A



Scavenge Air Cooler: Removal and Fitting of Tube Stack

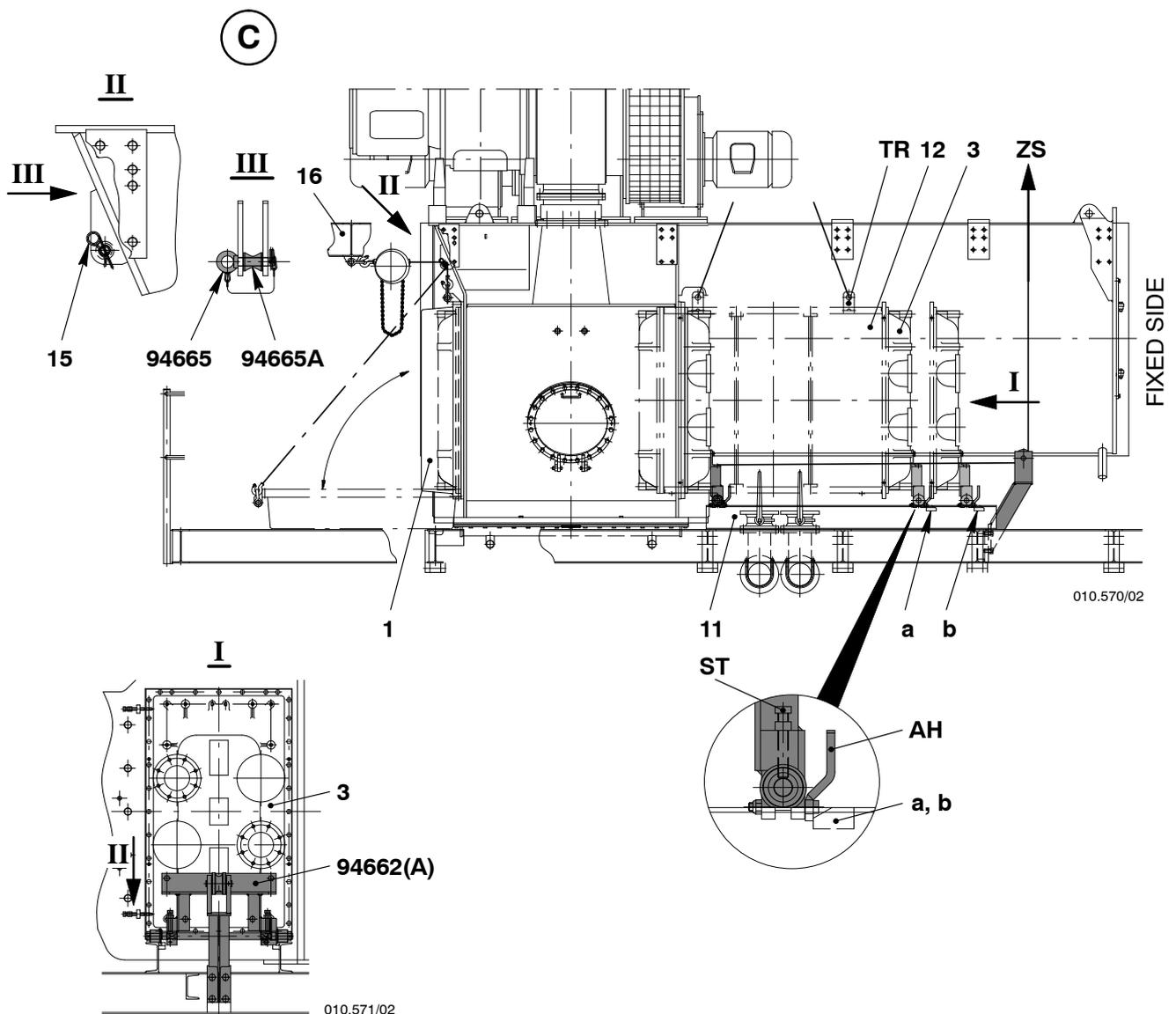
2. Removal

- ⇒ Loosen screws 13 in cover 1.
- ⇒ Remove screws 13a from tube stack 12.

B**I****I**

Scavenge Air Cooler: Removal and Fitting of Tube Stack

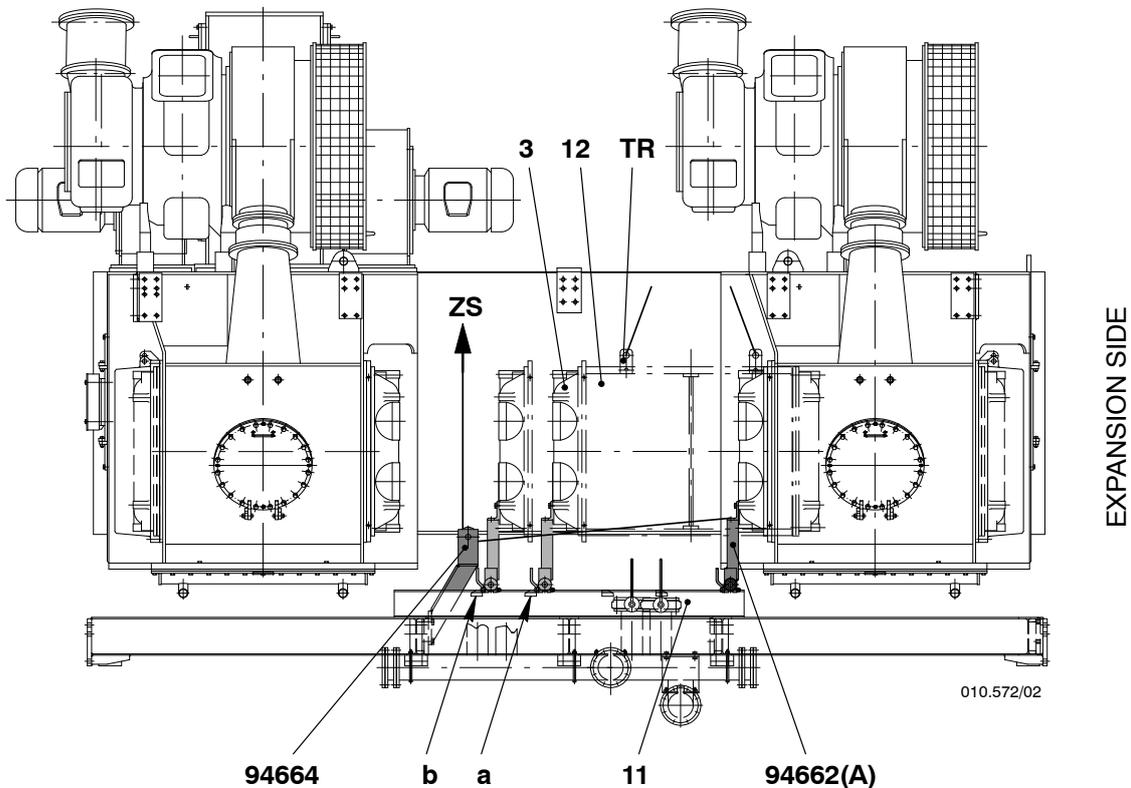
- ⇒ Mount pin 94665 and roller 94665A on the corresponding support as shown in Fig. 'C'. Lock pin with its double spring clip 15.
- ⇒ Fasten manual ratchet 'H1' to the upper support 16 and connect it to cover 1 via roller 94665A.
- ⇒ Loosen screws to cover 1, lower it to bottom plate and and push it 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 tube 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.

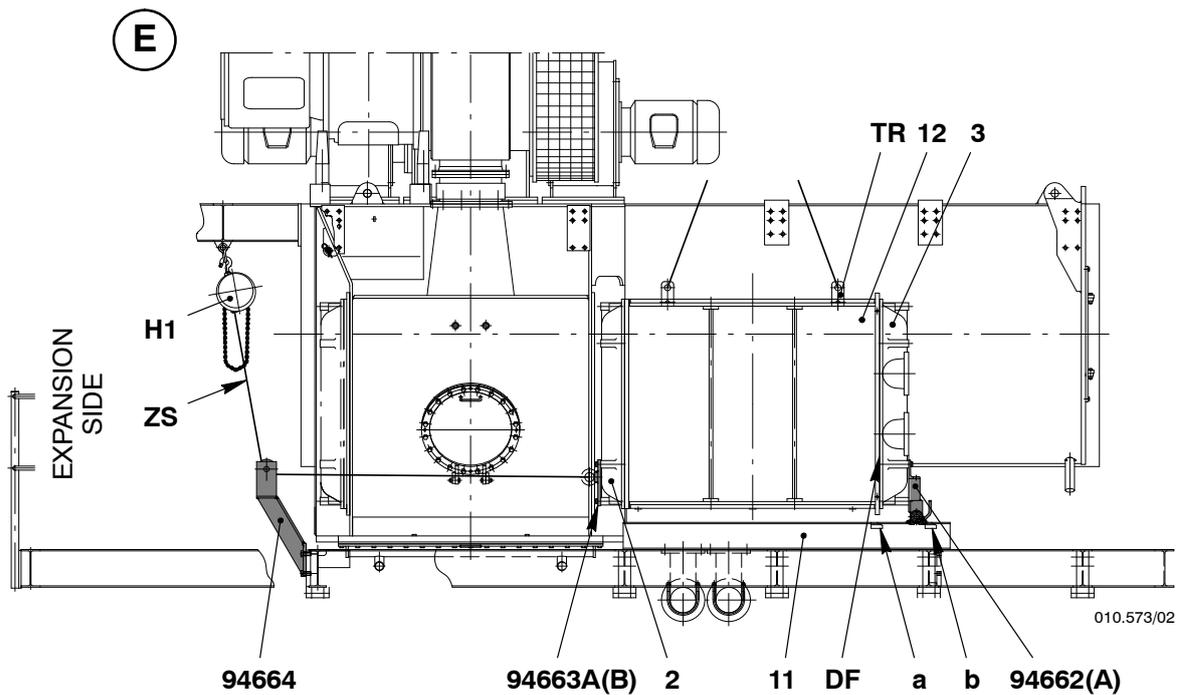
D



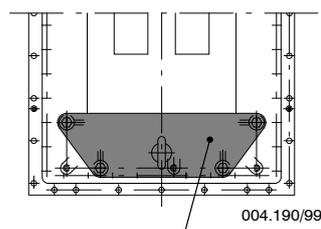
Scavenge Air Cooler: Removal and Fitting of Tube Stack

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'.

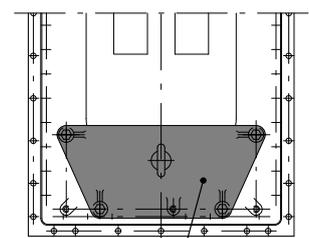


COOLER GEA
120/30/24/6



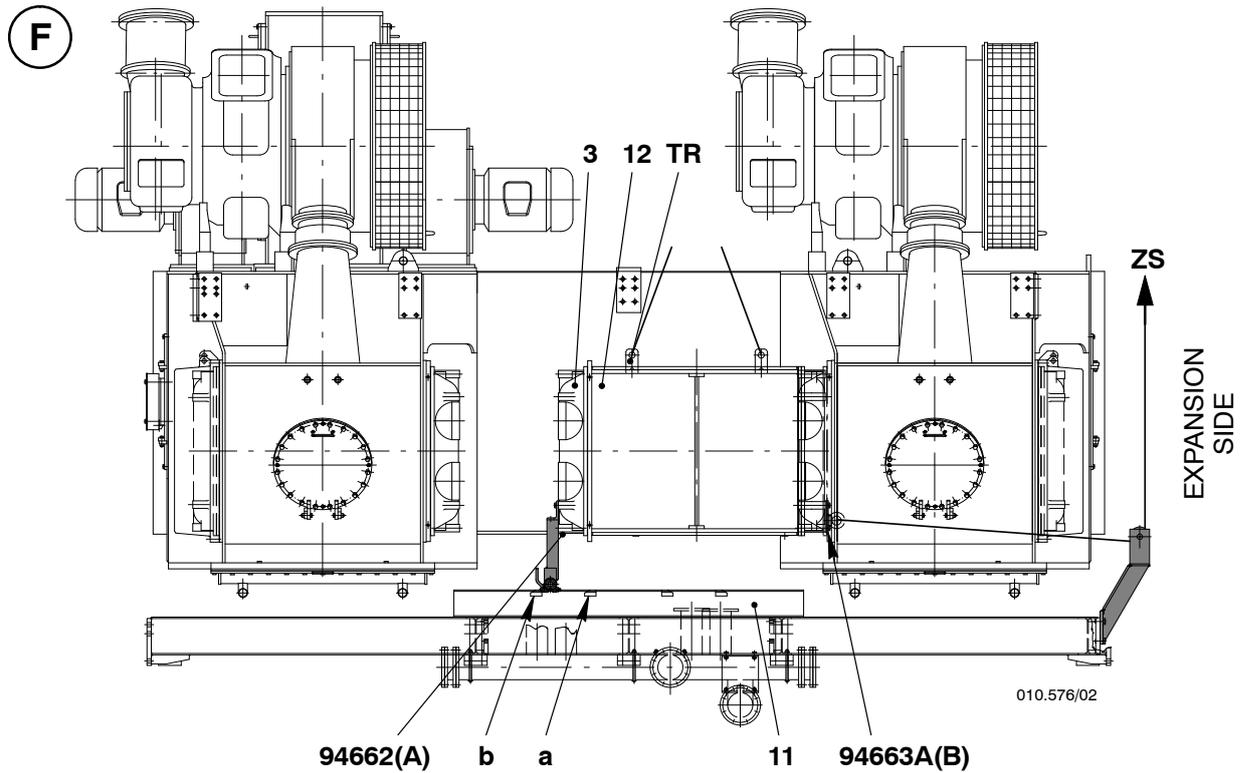
94663A

COOLER GEA
150/38/24/6



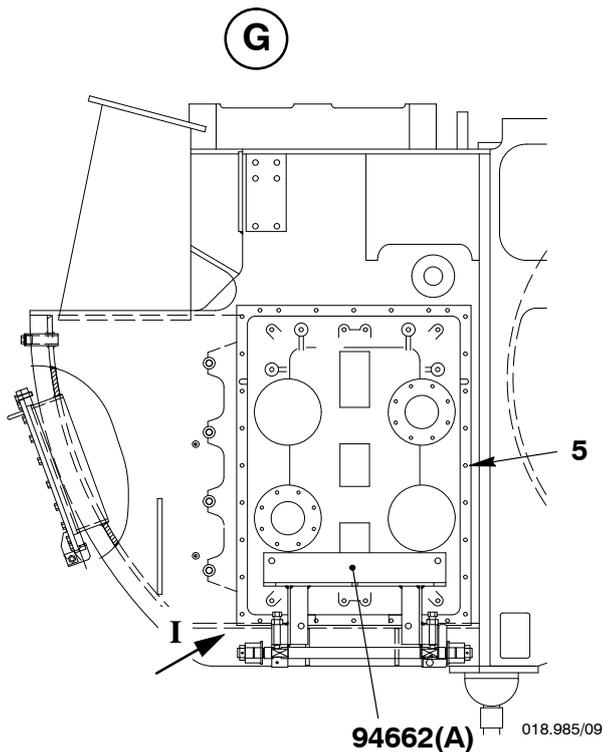
94663B

Scavenge Air Cooler: Removal and Fitting of Tube Stack



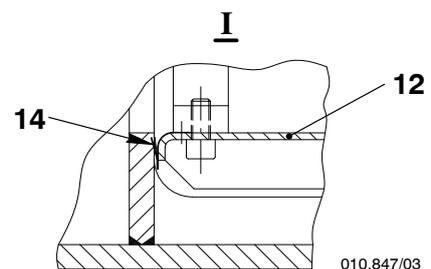
3.1 Final assembly

- ⇒ 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

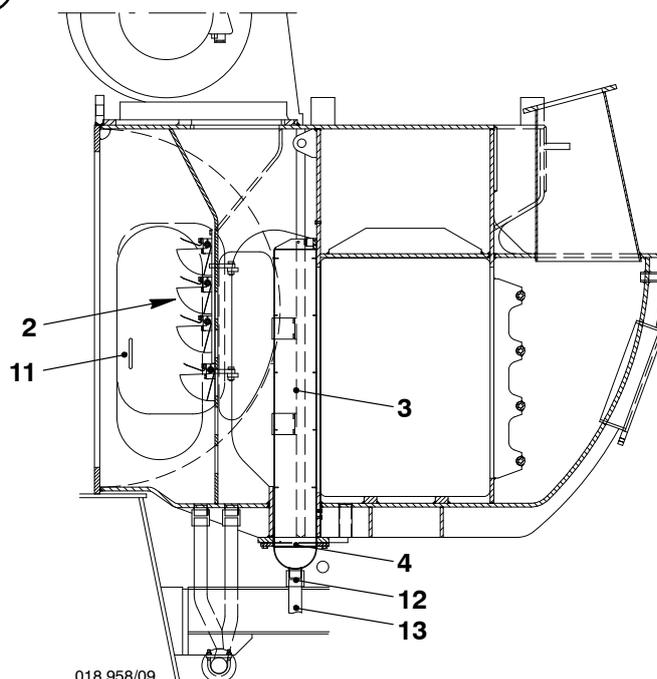
The water separator should be inspected after completing the first operating year. The cleaning interval for future servicing should be established on the basis of the degree of contamination found. If the air suction filter of the exhaust gas turbocharger is well maintained, the degree of contamination 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.

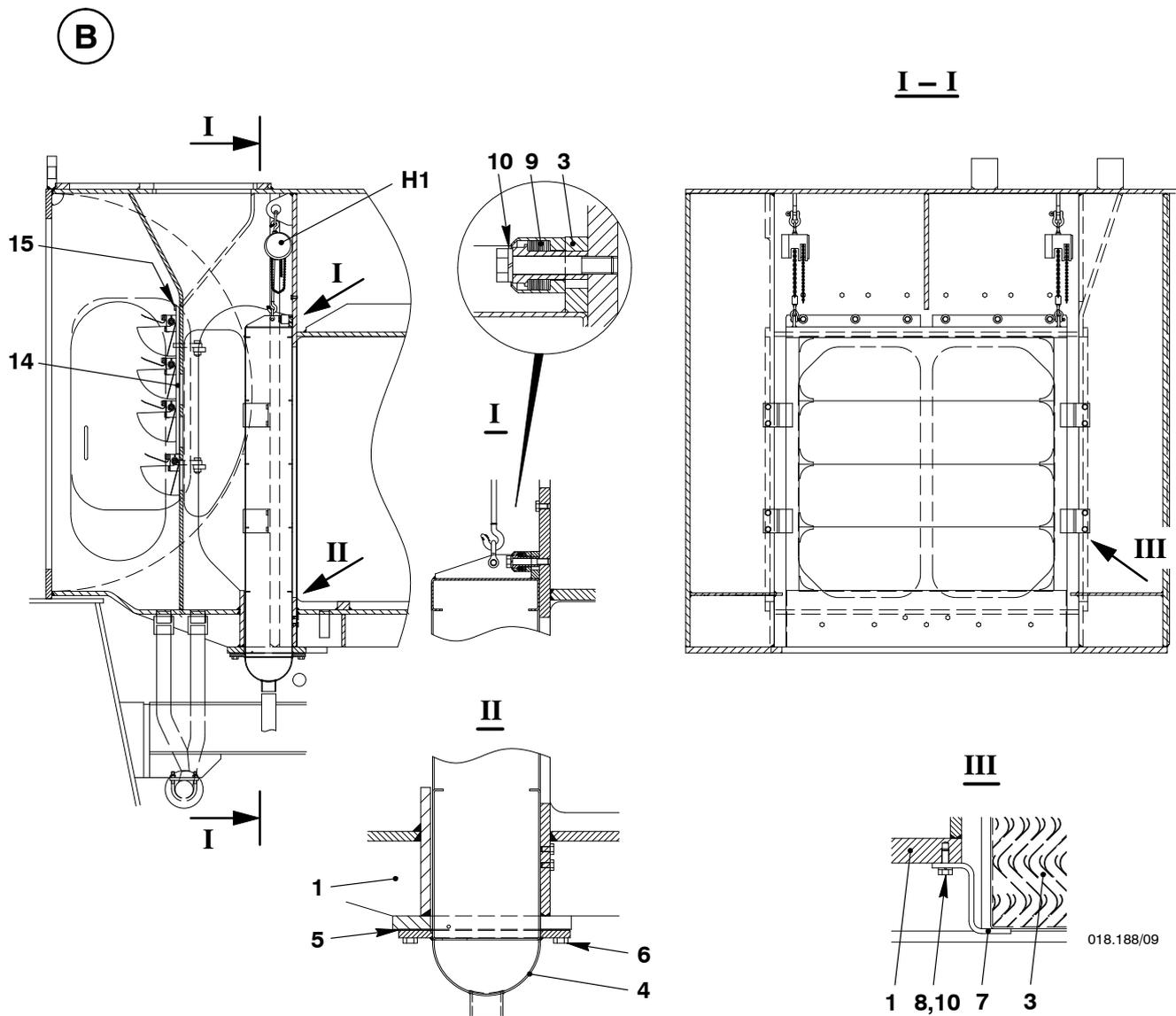
CHECK

Check the water drains for free passage.

A

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

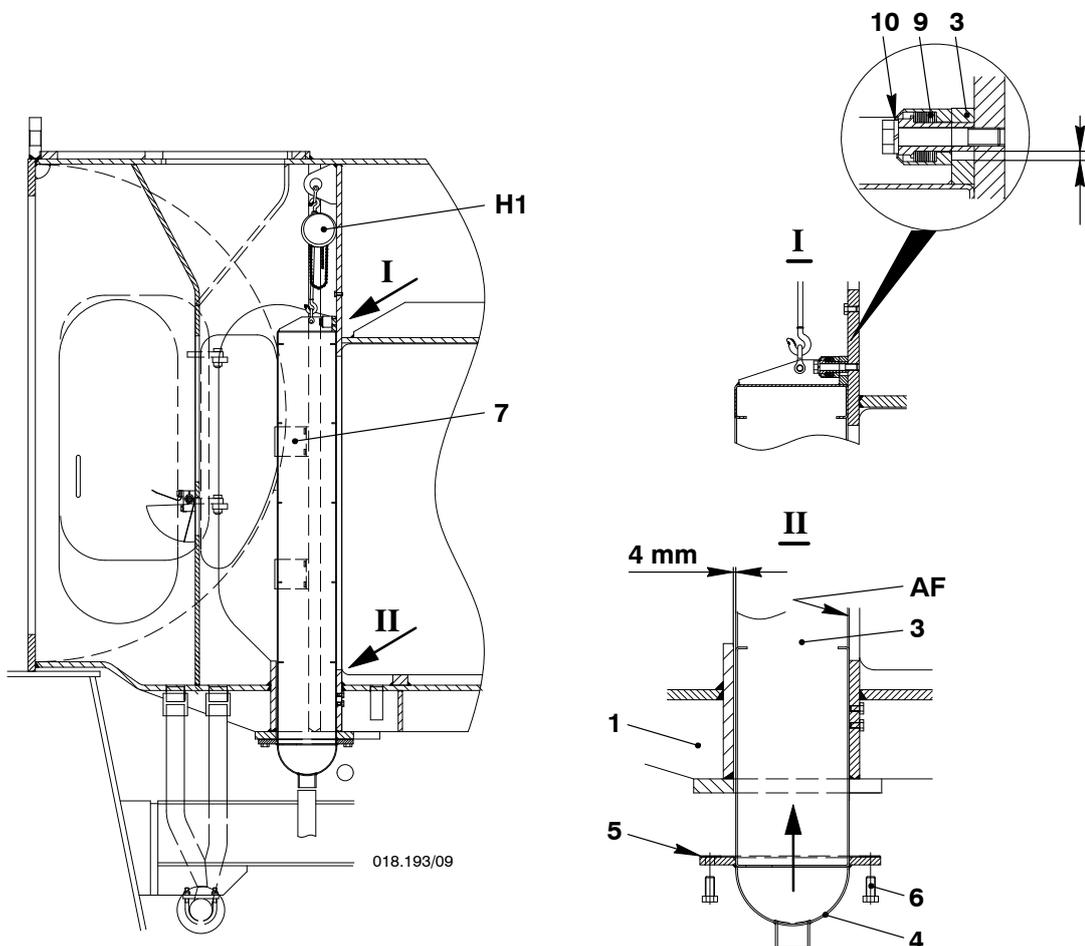
The water separator should be cleaned with the same media as used for cleaning the scavenge air cooler in operation.

- 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 'x₁' 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.

C



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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

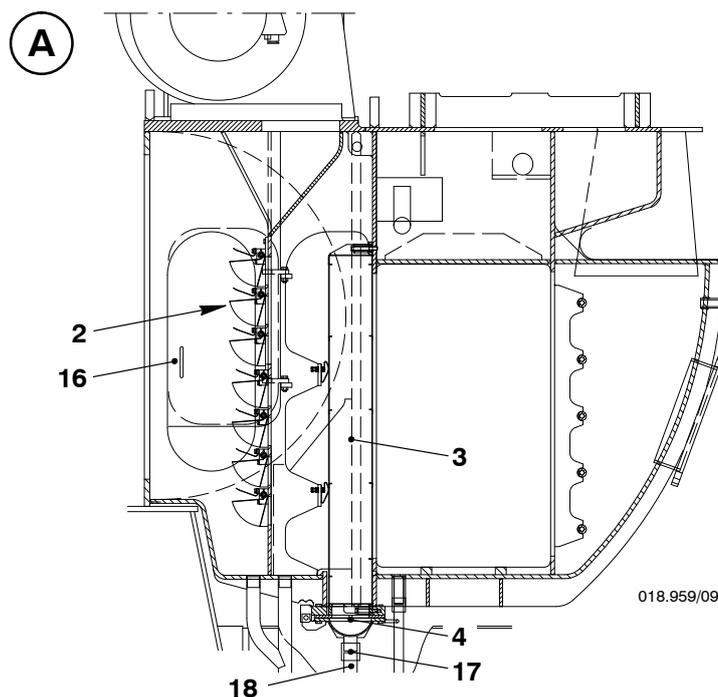
The water separator should be inspected after completing the first operating year. The cleaning interval for future servicing should be established on the basis of the degree of contamination found. If the air suction filter of the exhaust gas turbocharger is well maintained, the degree of contamination 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



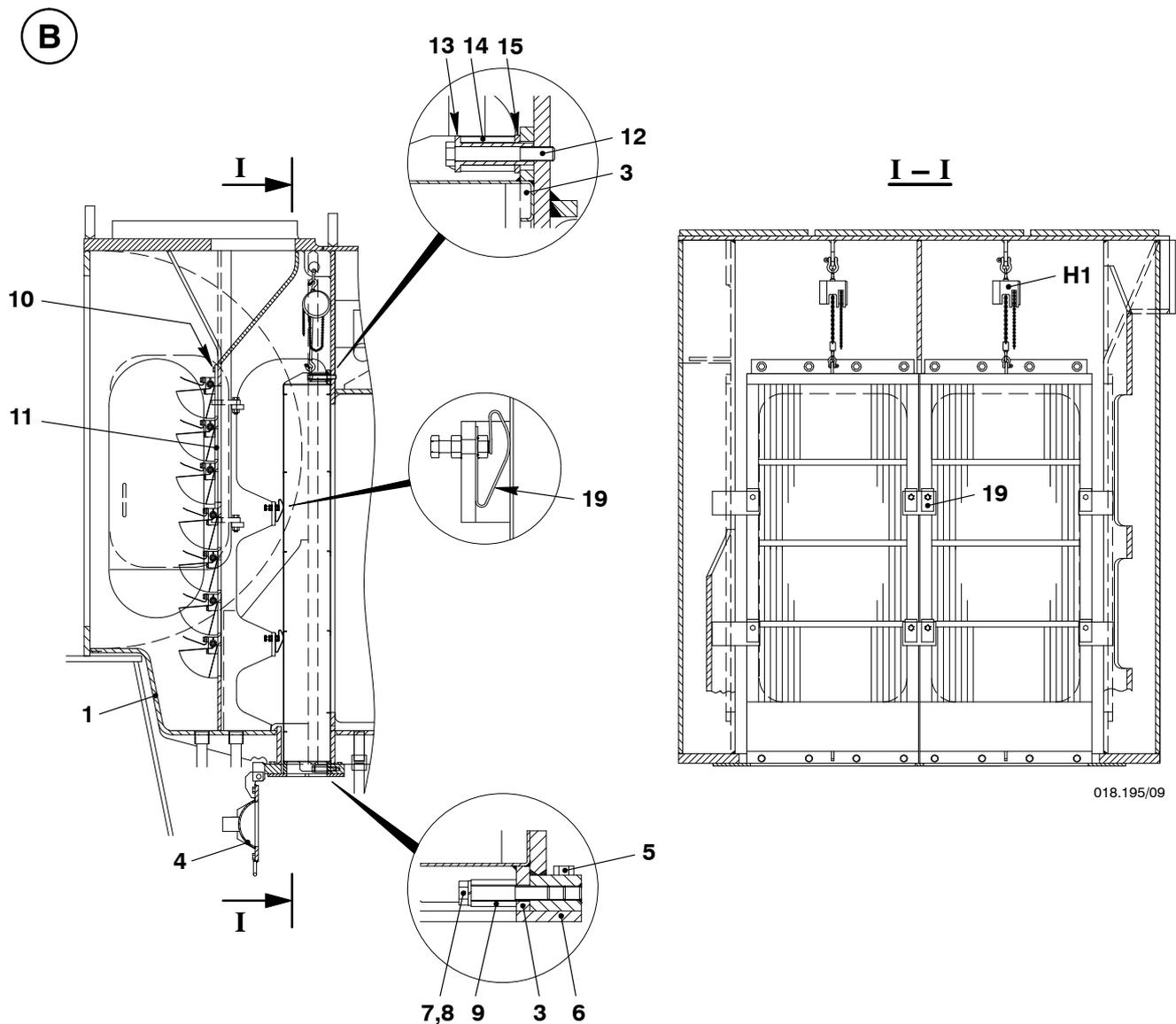
Remark: If the water separators must be dismantled above the supply unit, the half close to the free end must be removed first!

- ⇒ 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

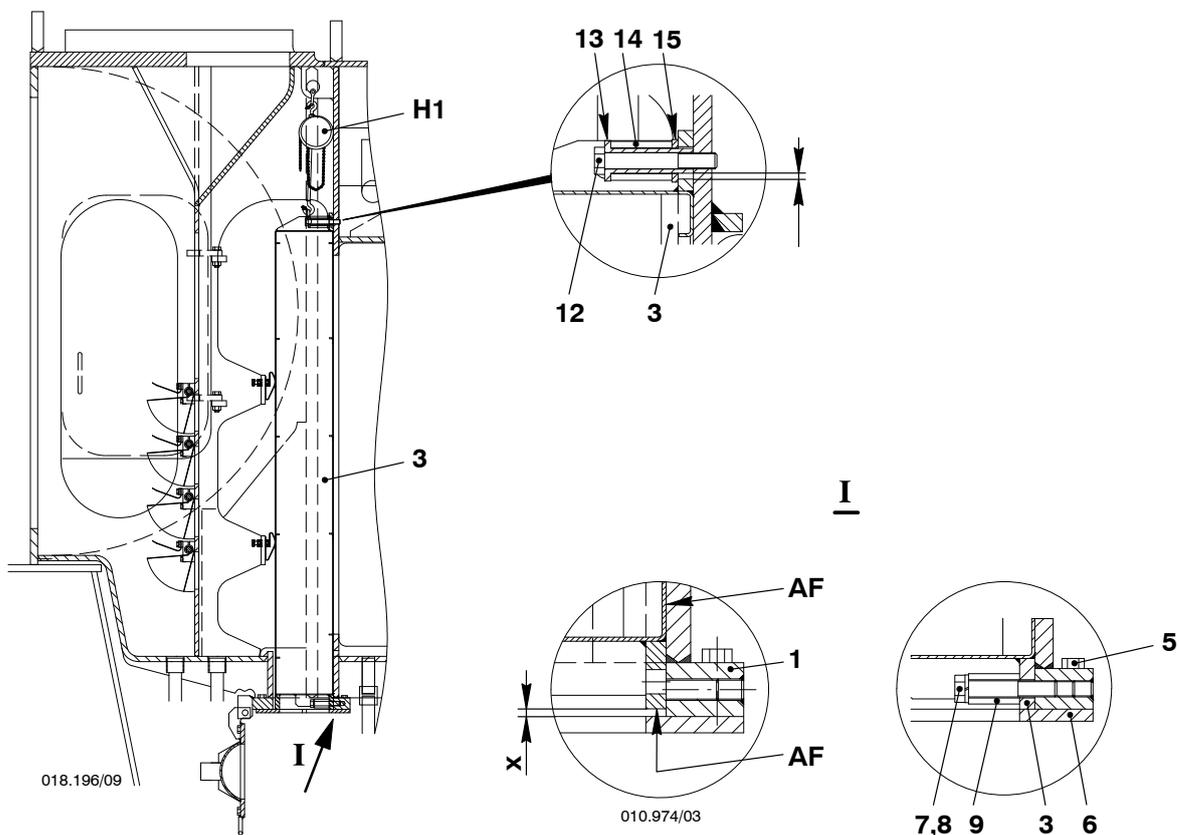
The water separator should be cleaned with the same media as used for cleaning the scavenge air cooler in operation.

- 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 'x₁' 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.

C



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Lubrication Pump CLU4-C: Checking the Gas Pre-charge Pressure [7218-1/A2](#)

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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
7 Pressure gauge 0-60 bar	13 Screw plug
	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 not ok:

- ⇒ Refill the accumulator.

Lubricating Pump CLU4-C: Checking the Gas Pre-charge Pressure

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 % N₂ 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

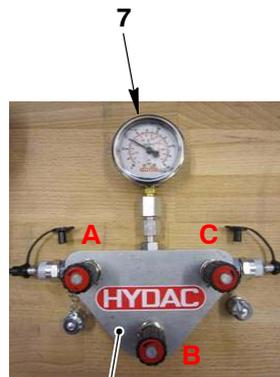
- ⇒ Reopen stop valve 4.30-5 on servo oil rail 4.11.
- ⇒ Close screw plug 13 on pressure reducing valve 8.11-1.

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



4, 4a

3

5

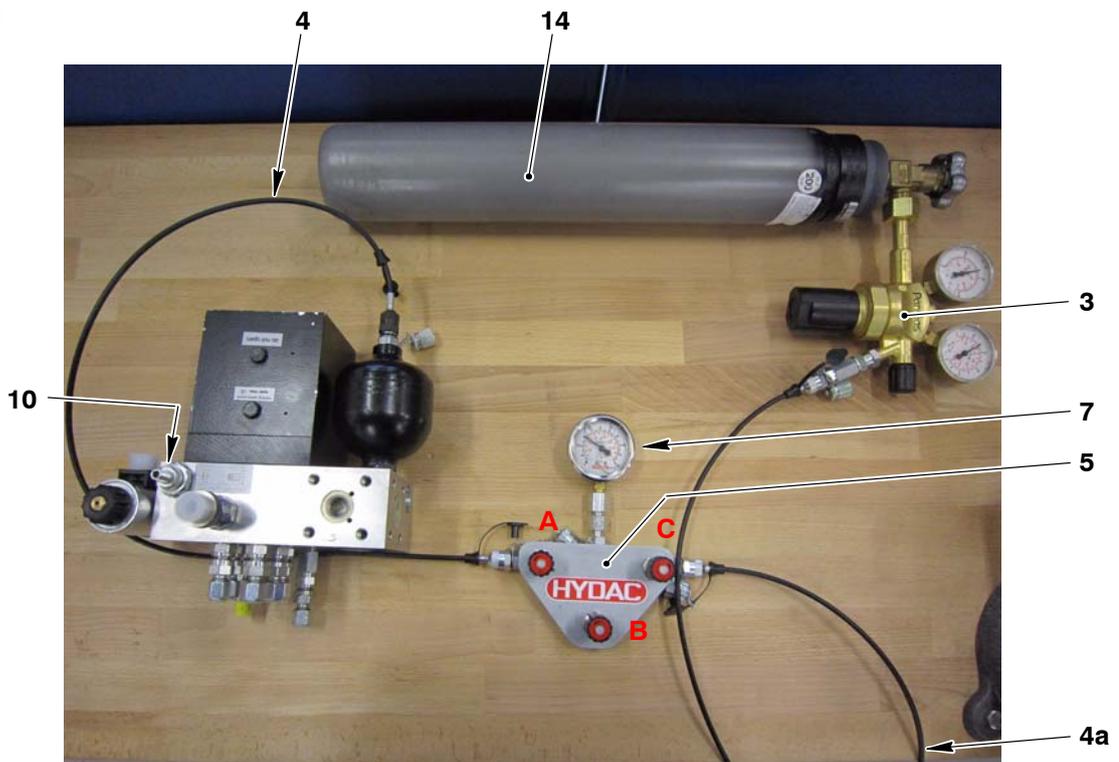
1

2

4

Arrangement of equipment:

B



4

14

10

3

7

5

A

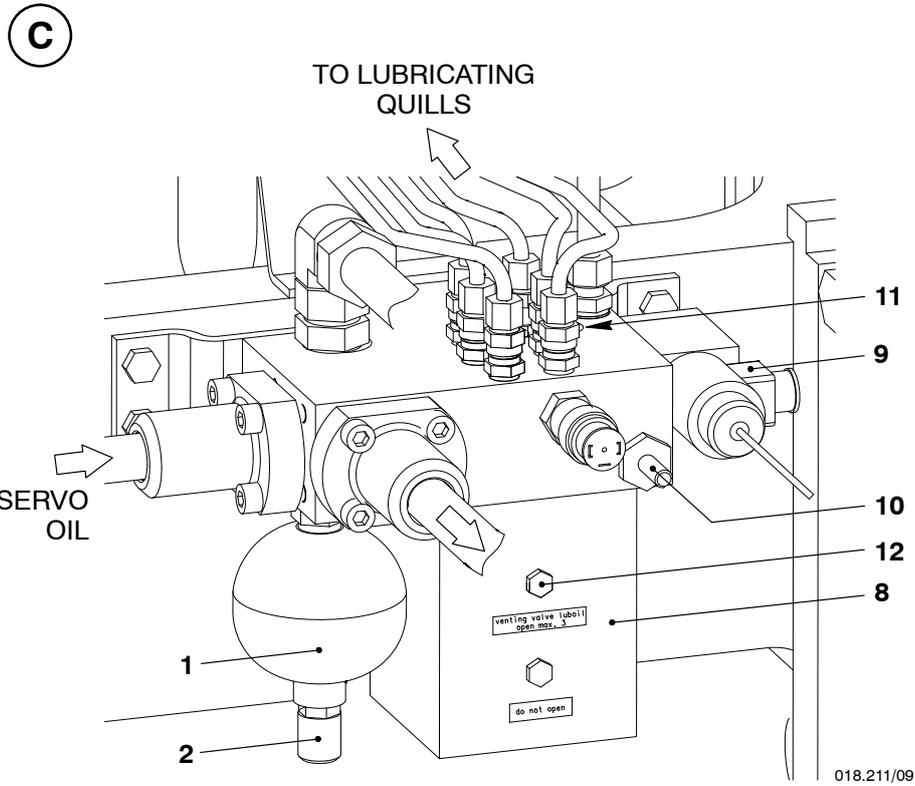
B

C

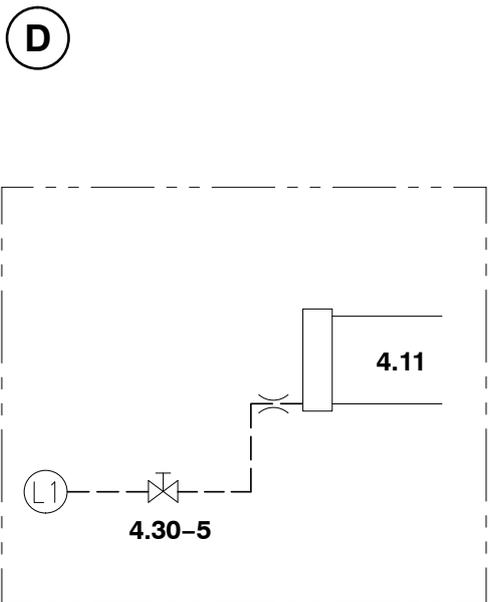
4a

Lubricating Pump CLU4-C: Checking the Gas Pre-charge Pressure

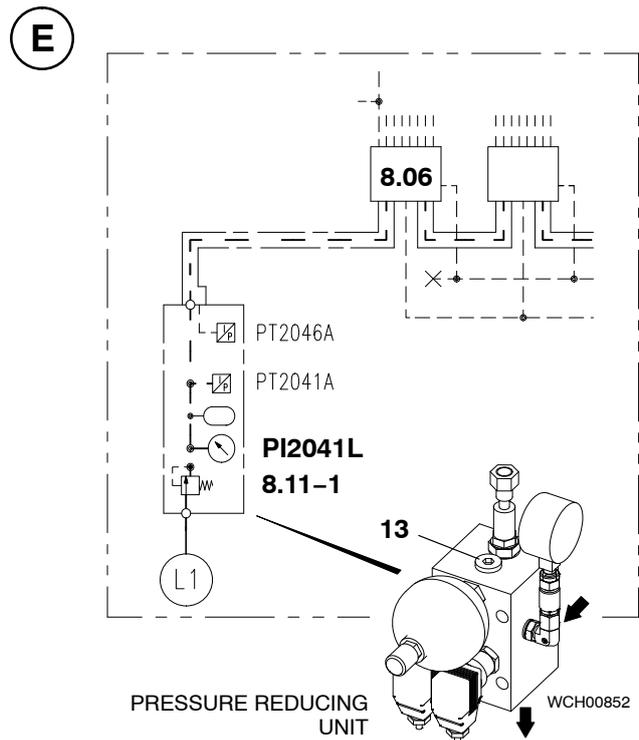
Lubricating pump (CLU4-C):



Details of servo oil rail 4.11 -> lubricating pump 8.06:



DRAWN FROM CONTROL DIAGRAM 4003-2



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 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 **Brake Specific Exhaust gas Flow (BSFC)** in the operating range of 40 to 70% engine load.

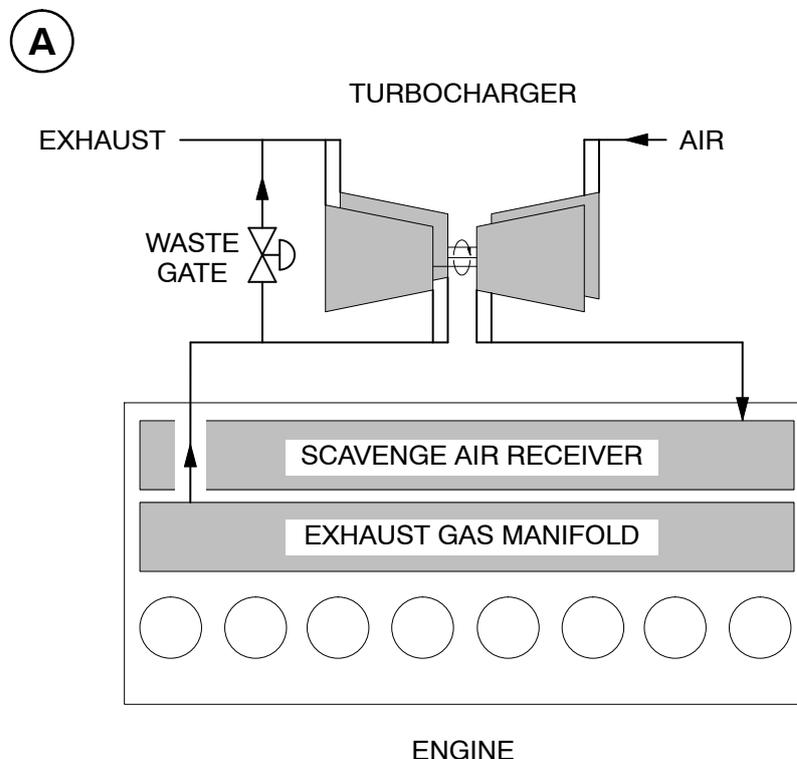
With Low-Load Tuning, engines can be operated continuously and reliably at any load in the range of 30 to 100%.

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.

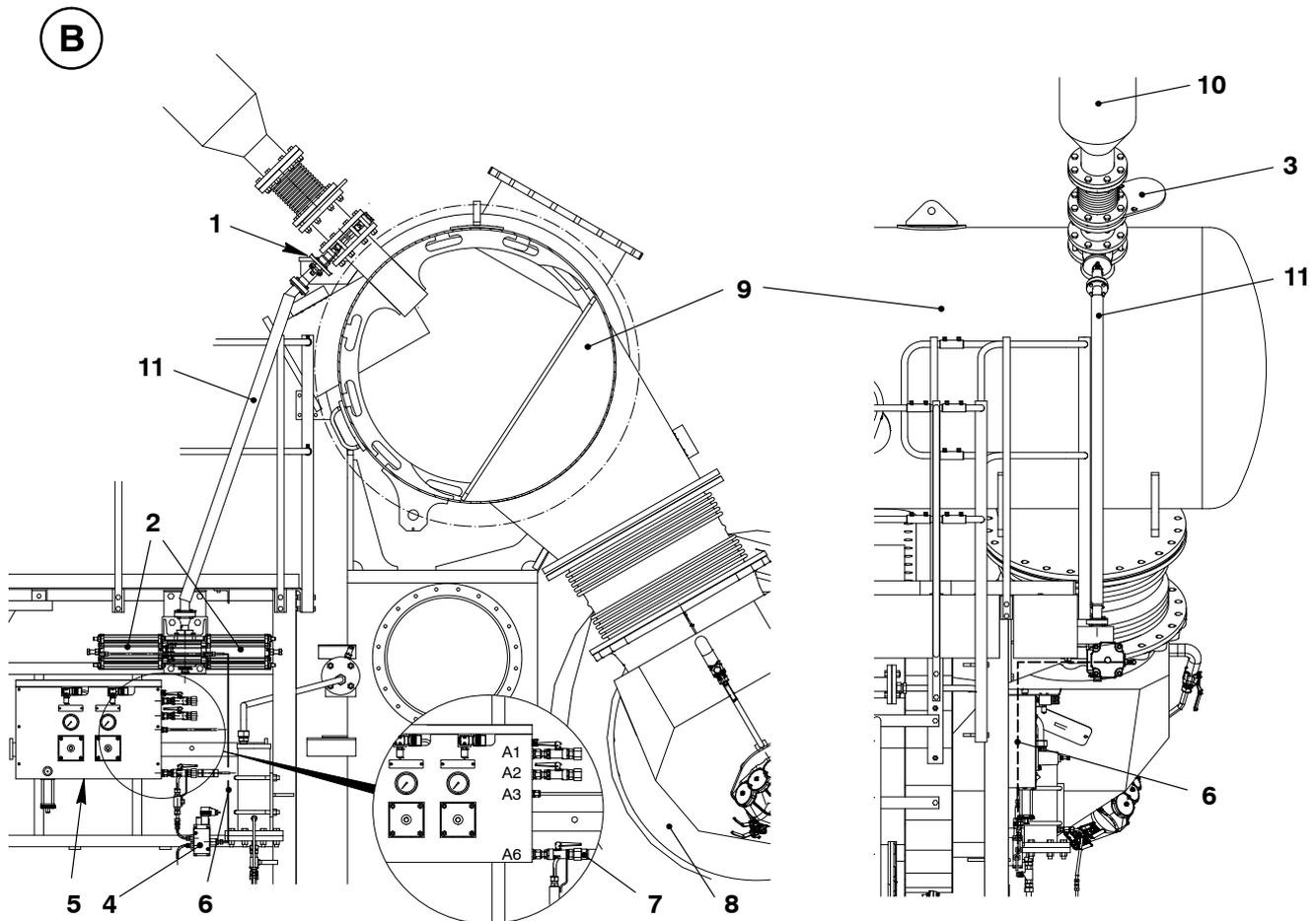
Schematic functional principle of Low-Load Tuning:



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 | 7 Air spring air pipe |
| 2 Control actuator | 8 Exhaust gas turbocharger |
| 3 Orifice | 9 Exhaust manifold |
| 4 Solenoid valve | 10 Exhaust by-pass line |
| 5 Control air supply | 11 Cardan rod |
| 6 Control air pipe | |

HP Servo Oil Pipe

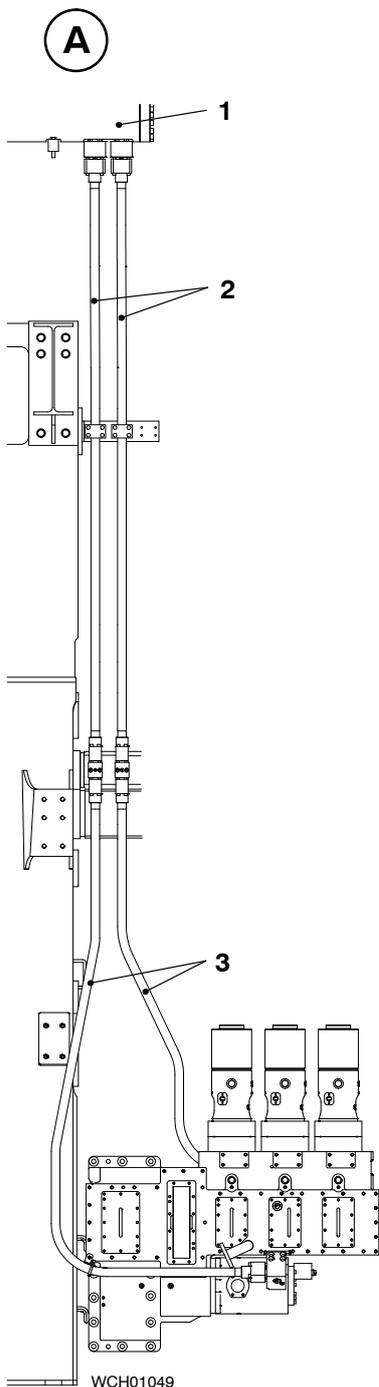
Removing, Fitting and Regrinding

Tools:

1 Regrinding device 94834

Key to Illustrations:

1	Servo oil rail	10	Thrust ring
2	HP servo oil pipe	11	Non-return valve
3	HP servo oil pipe	12	Valve housing
4,4a,4b	Screw	13	Connecting block
5,5a	Flange	14	Screw plug
6	Screw	15,16	O-ring
7	Intermediate piece		
8	Non-return valve	DF	Sealing face
9	Claw	OE	Oil inlet

**1. General**

The engine must be stopped and then the HP servo oil pipe can be drained via leakage oil pipes (or screw plug 14), however also a tray should be placed under the connecting blocks. See Fig. 'B'.

In order to separate HP servo oil pipe from its sealing faces 'DF', proceed as follows:

- ⇒ Loosen screws 4b and push flange 5a back at valve housing 12.
- ⇒ Loosen screws 4 and push flange 5 back at connecting block 13.

Non-return valves 11 prevents servo oil rail from discharging.

2. Removal

- Depending on the HP servo oil pipe to be removed, the pipes from servo oil service pump 4.88 to oil inlet 'OE' (Fig. 'B') must also be removed.
- To remove servo oil piping 2, the relevant servo oil piping 3 must be removed first.
- Pay attention not to damage sealing faces 'DF'.
- All connections must be closed off immediately and the sealing faces must be protected against any damages.

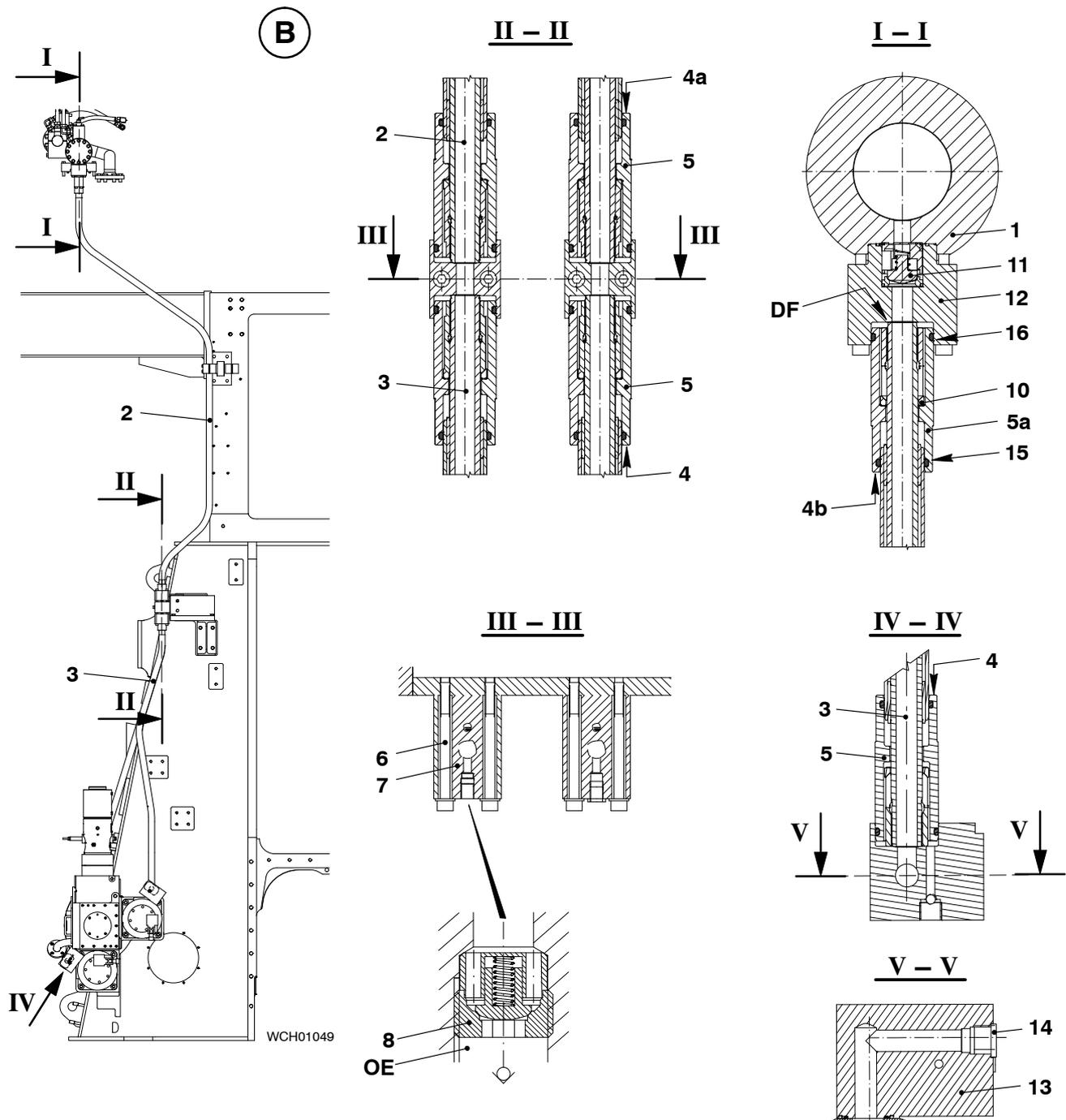
HP Servo Oil Pipe: Removing, Fitting and Regrinding

2.1 Removal of HP servo oil pipe 3

- ⇒ Loosen screws 4.
- ⇒ Push flanges 5 back until they are no more engaged, so that HP servo oil pipe 3 can be removed.

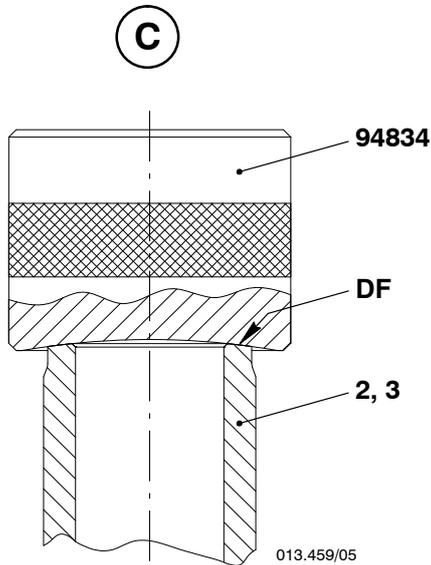
2.2 Removal of HP servo oil pipe 2

- ⇒ Loosen screws 4a and push flanges 5 back.
- ⇒ Loosen screws 6 and remove them together with intermediate piece 7.
- ⇒ Loosen screws 4b and remove HP servo oil pipe 2.



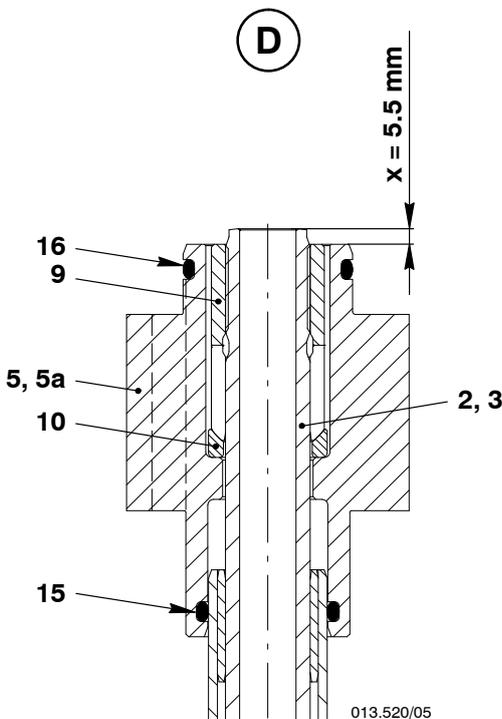
HP Servo Oil Pipe: Removing, Fitting and Regrinding

3. Regrinding the sealing faces 'DF'



- ⇒ Loosen claw 9 (Fig. 'D').
- ⇒ To prevent grinding compound from entering the HP servo oil pipe, plug its opening with a piece of cloth.
- ⇒ Use tool 94834 for regrinding the sealing face 'DF': First rough-grind the sealing face with grinding compound No. 200, then fine-grind with grinding compound No. 500.
- ⇒ After grinding thoroughly clean the HP servo oil pipes.

4. Adjusting the claws



- CHECK** Before fitting the HP servo oil pipes check whether its claws 9 are screwed on properly, i.e. the HP servo oil pipe must protrude by 'x' = 5.5 mm compared to the claw.
- Measure 'x' can be adjusted by turning the claw using an open-end wrench.

HP Servo Oil Pipe: Removing, Fitting and Regrinding

5. Fitting

Fitting is carried out analogously to the removal but in reverse sequence.



Remark: Take care that screws 6 of intermediate pieces 7 are tightened after all HP servo oil pipes have been tightened!

- Apply oil to the threads of screws 4, 4a, 4b and tighten them crosswise with a torque of **40 Nm**.
- If the non-return valves (Fig. 'B') have been removed maintain their flow direction and observe the following when refitting them:
 - Tighten non-return valve 8 with a torque of **25 Nm**.
 - Replace the O-rings on non-return valve 11.



Remark: For further information about the HP servo oil system, see 8016-1 in the Operating Manual.

Hydraulic Pipe for Exhaust Valve Drive

Removing, Fitting and Regrinding

Tools:

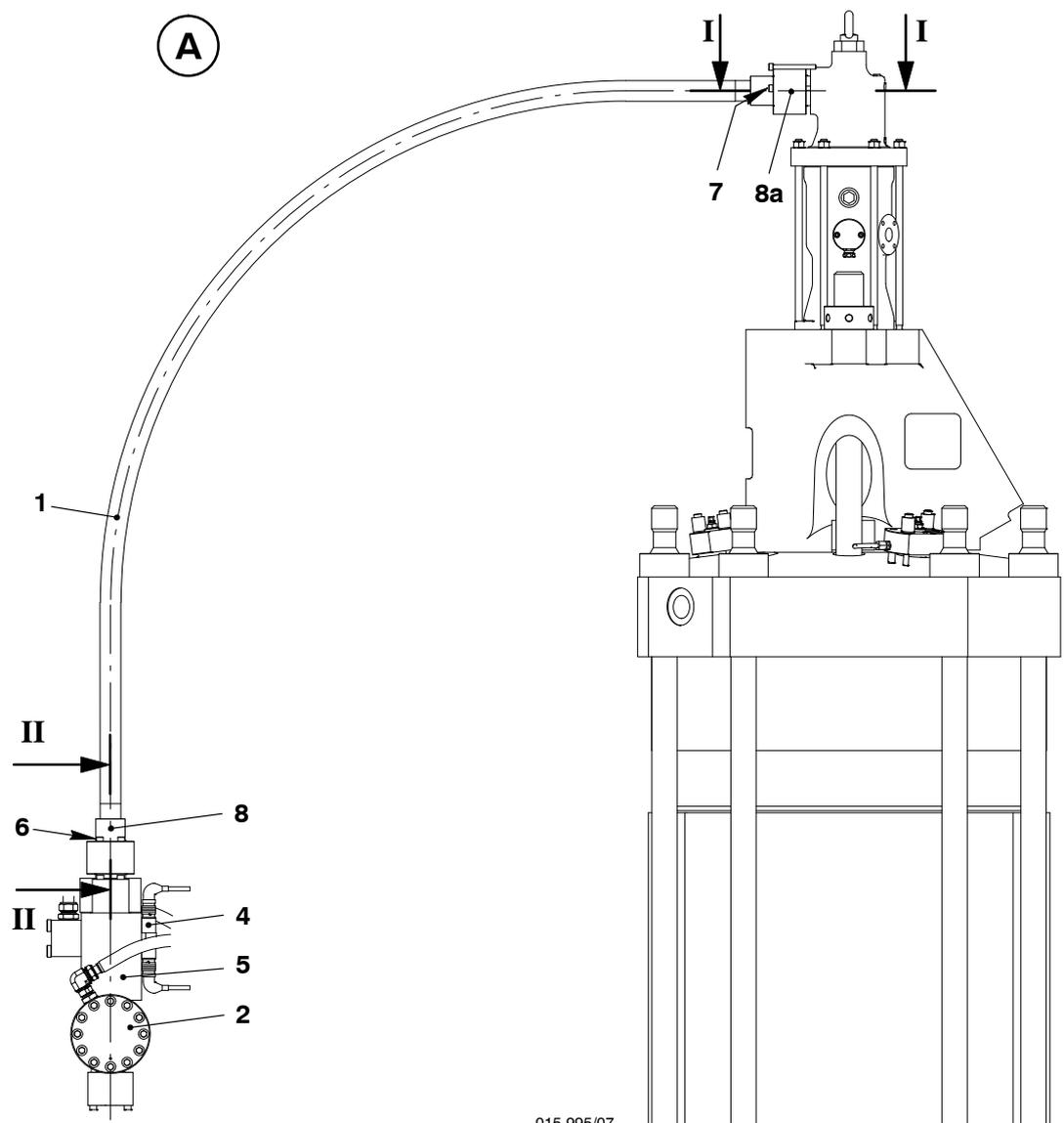
- 1 Regrinding device 94834

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

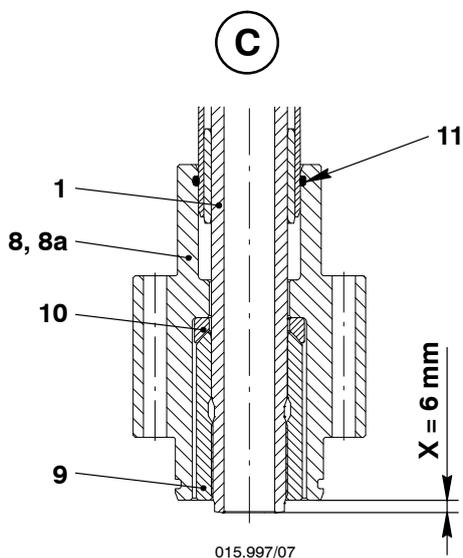
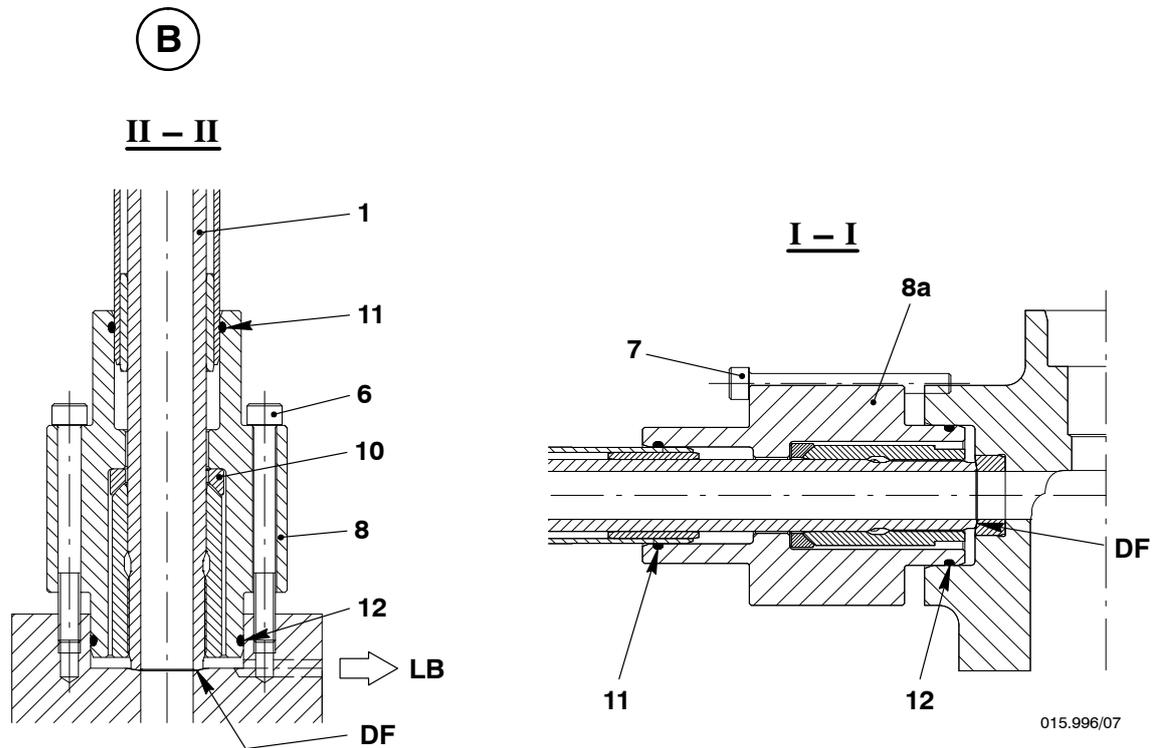
Stop the motor before beginning any work on the hydraulic pipe. Strictly follow the instructions 0520-1 'Exchange of defective exhaust valve control unit or hydraulic pipe as set out in the Operating Manual.



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Hydraulic Pipe: Removing, Fitting and Regrinding

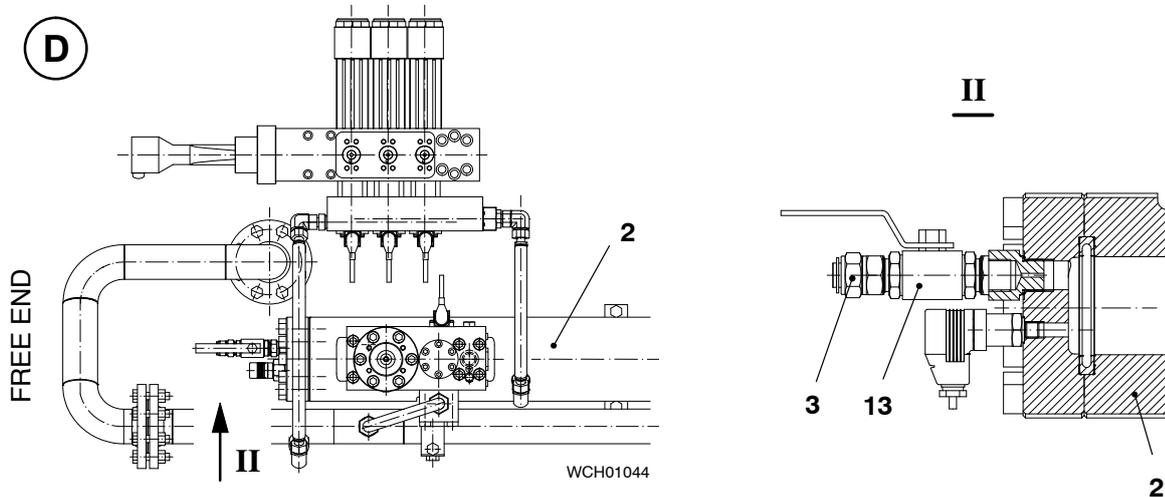
- ⇒ Loosen screws 6 by several turns.
- ⇒ Undo screws 7 and push flange 8a back until it is no more engaged.
- ⇒ Push hydraulic pipe 1 back in axial direction and turn it to the side.
- ⇒ Connect the hydraulic pipe to the crane, undo screws 6 and remove the hydraulic pipe.
- Do **not** damage the sealing faces 'DF' when removing the hydraulic pipe!
- Close off all openings after removing the connections.

**5.1 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

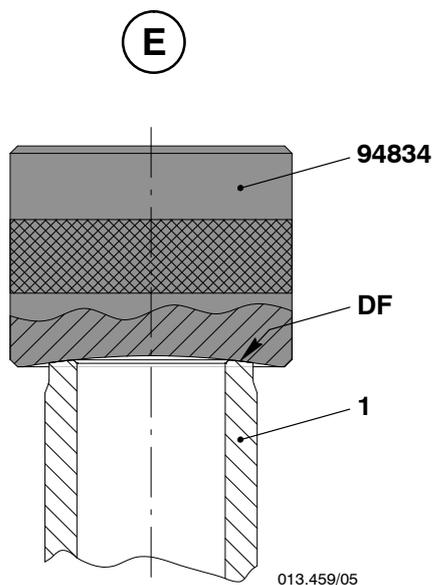


CHECK

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	94870
	consisting of:	
1	Screw-on sleeve	94870A
1	Grinding tool	94870B
1	Lock nut	94870C
1	Template	94870D
1	Special spanner	94874
1	Torque wrench	

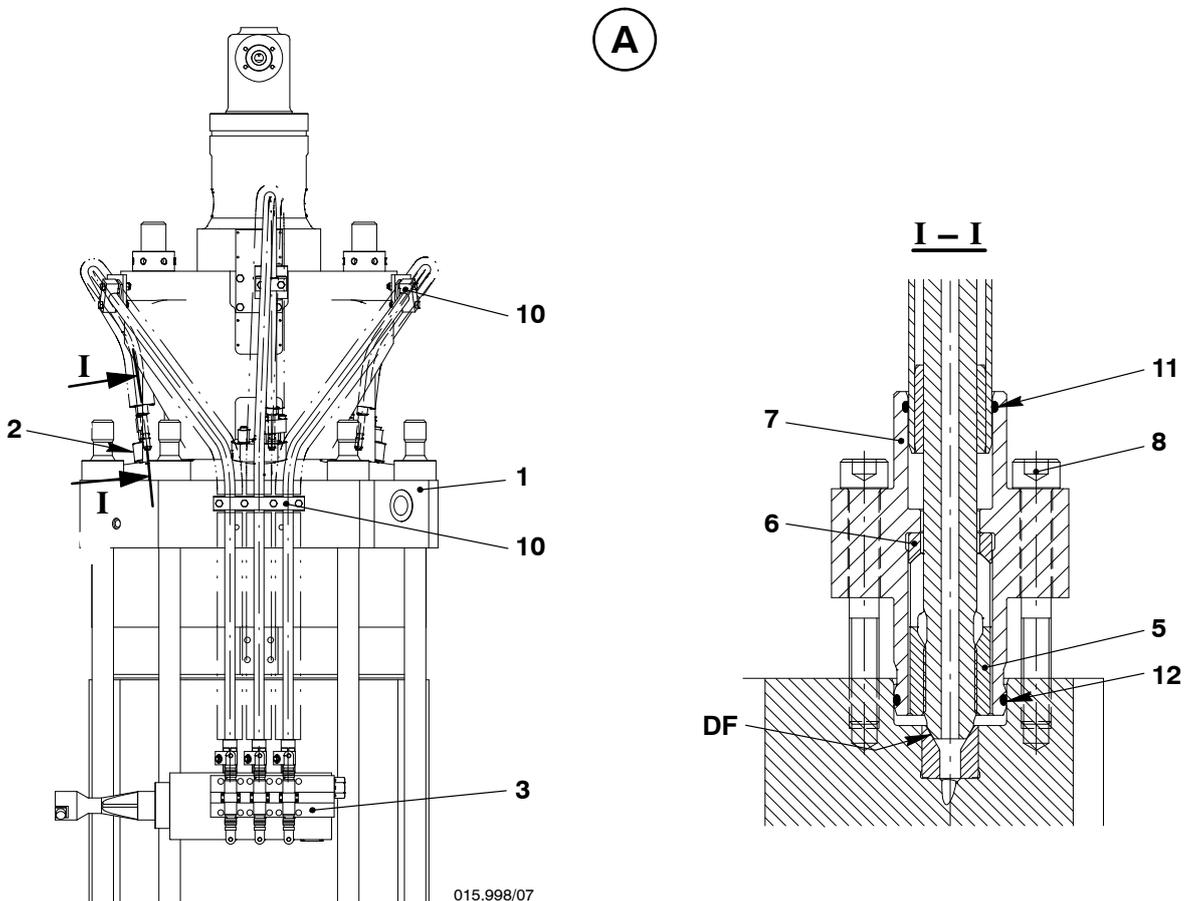
Key to Illustrations:

1	Cylinder cover	10	Pipe bracket
2	Injection valve	11	O-ring
3	Injection control unit	12	O-ring
4	HP pipe		
5	Claw		
6	Thrust ring		
7	Flange	DF	Sealing face
8	Head screw	EC	Emery cloth
9	Drain screw	HD	Hand drill

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 10.
- ⇒ Remove head screws 8 from flange 7 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 'DF' 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

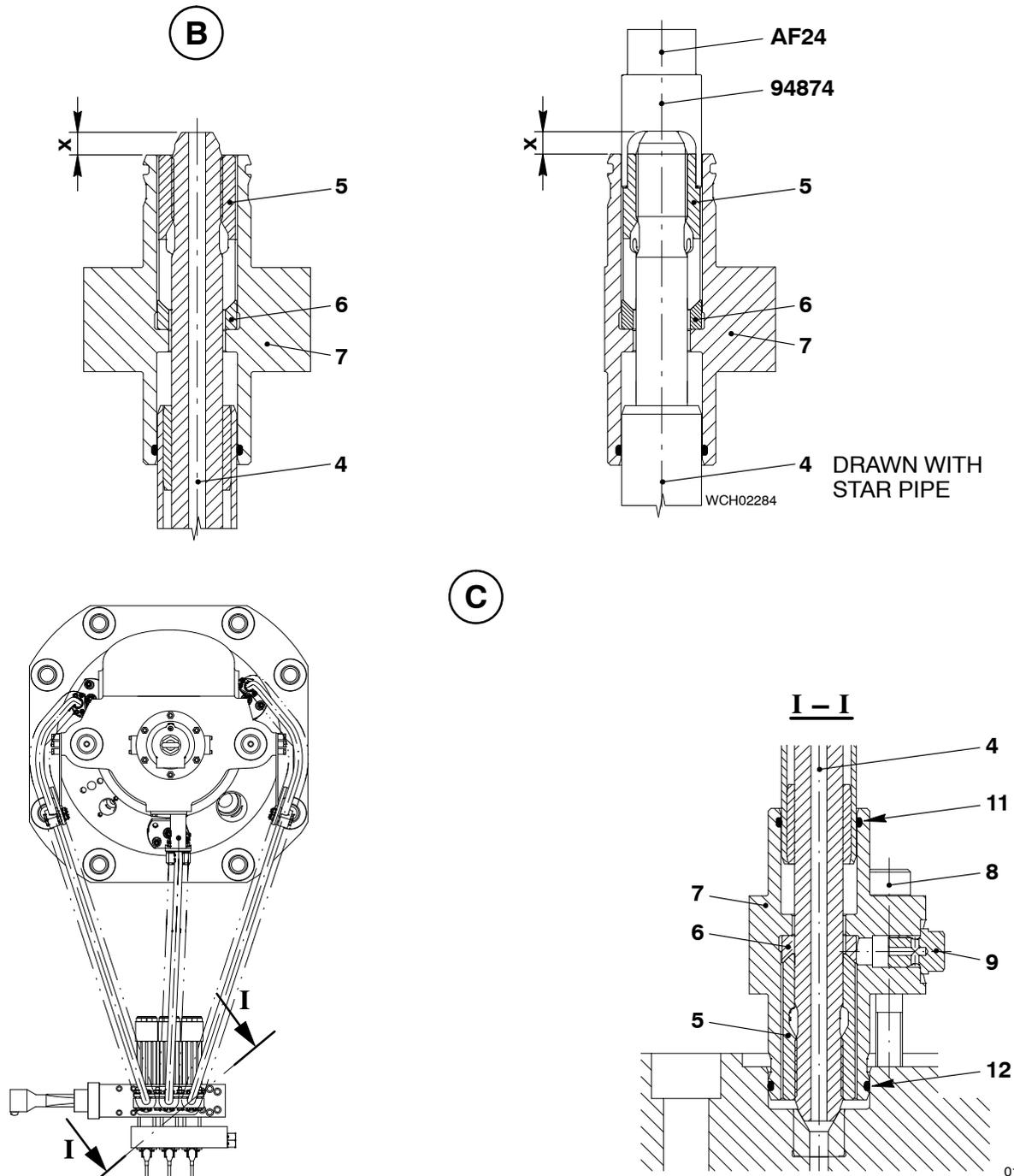
Before fitting HP pipe 4 check whether its claws 5 are screwed on properly, i.e. the HP pipe must protrude by 'x' = 8 mm compared to the claw.

Measurement 'x' can be adjusted by turning the claw using special spanner 94874.

⇒ Fit HP pipe.

⇒ Apply Never-Seez NSBT-8 to threads of screws 8 and tighten them crosswise with a torque of **40 Nm**.

⇒ Tighten drain screws 9.

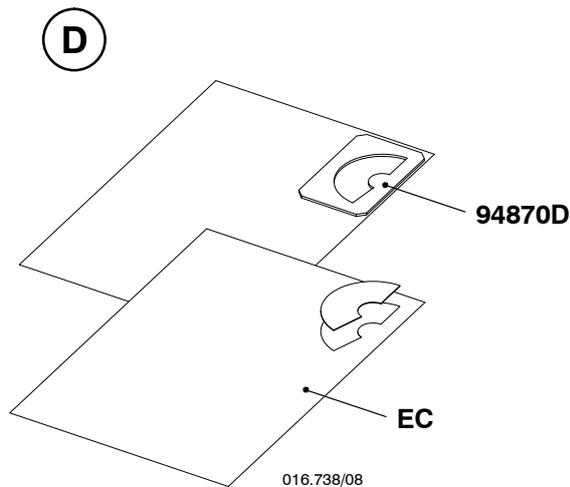


HP Pipe to Injection Valve: Removing, Fitting and Regrinding of Sealing Faces

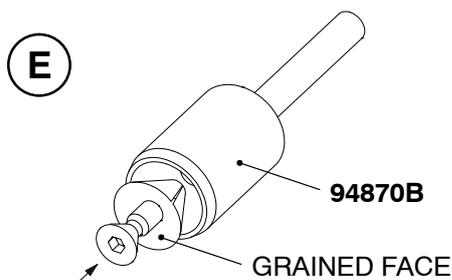
3. Regrinding of sealing faces 'DF'

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.

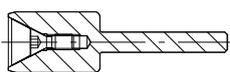


- ⇒ Place template 94870D on the back of emery cloth 'EC'.
- ⇒ Trace inner contour using a pointed pencil or a ball pen.
- ⇒ Cut out precisely the traced contour.



- ⇒ 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 94870B and fix it by means of its countersunk screw.

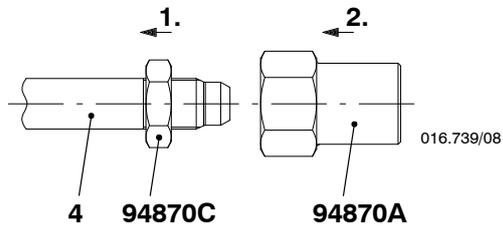
TIGHTENED
CONDITION



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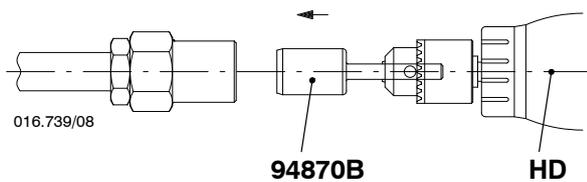
HP Pipe to Injection Valve: Removing, Fitting and Regrinding of Sealing Faces

F



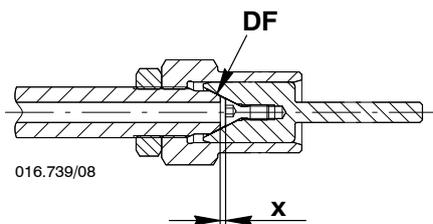
- ⇒ Remove claw 5 (Fig. 'B').
- ⇒ Fix HP pipe 4 e.g. in a vice.
- ⇒ Screw on counter nut 94870C until it reaches the thread end of the HP pipe.
- ⇒ Turn screw-on sleeve 94870A up to the counter nut.
- ⇒ Lock the screw-on sleeve with the counter nut.

G



- ⇒ Clamp grinding tool 94870B in hand drill 'HD'.
- ⇒ Slide grinding tool into the screw-on sleeve until it slightly touches the HP pipe.
- ⇒ 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 reconstitute 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 HP pipe.

HP Fuel Pipe

Removing, Fitting and Regrinding

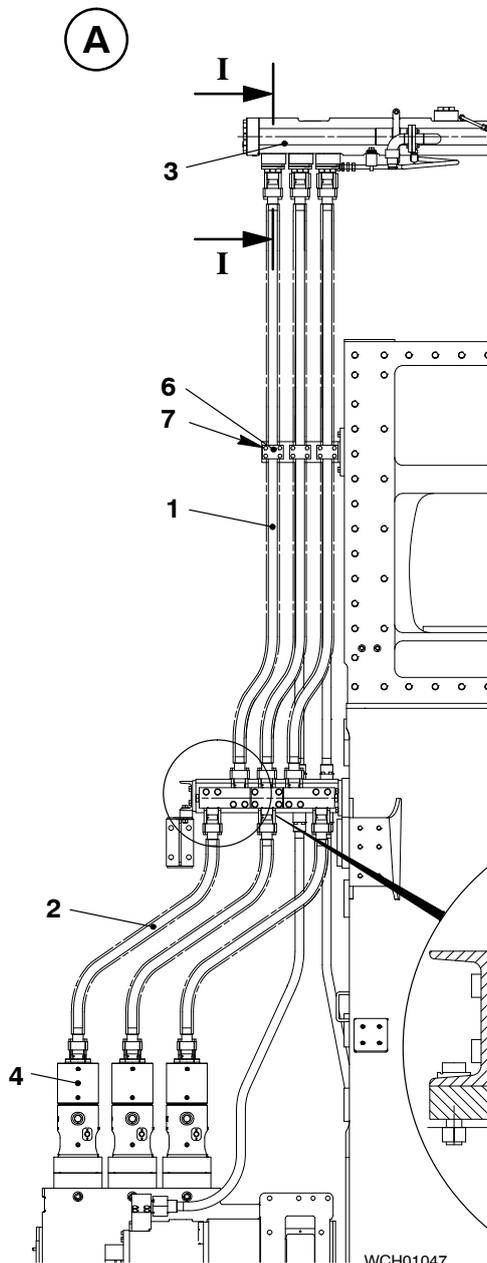
Tools:

- 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 | Upper HP fuel pipe | 13 | Screw |
| 2 | Lower HP fuel pipe | 14, 14a | Flange |
| 3 | Fuel rail | 15, 15a | Screw |
| 4 | Fuel pump cover | 16 | Non-return valve |
| 5 | Intermediate piece | 17 | Leakage fuel pipe |
| 6 | Mounting clamps | 18 | Claw |
| 7 | Screw | 19, 20 | O-ring |
| 8 | Screw | 21 | Thrust ring |
| 9 | Flange | DF | Sealing face |
| 10, 10a | Intermediate ring | EC | Emery cloth |
| 11 | Valve housing | HD | Hand drill |
| 12 | Flange | LB | Leakage fuel bore |



1. General

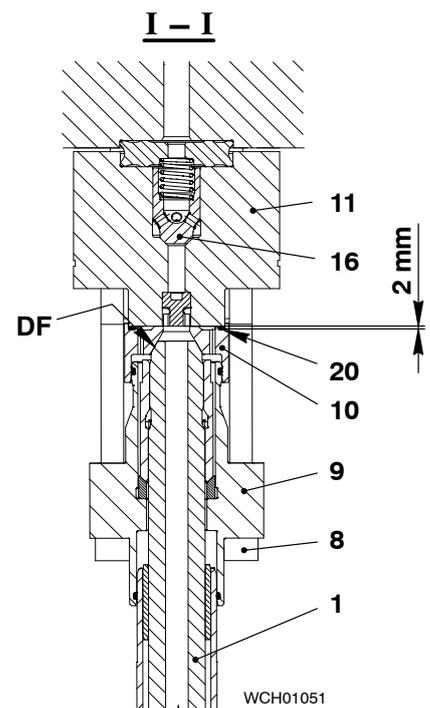
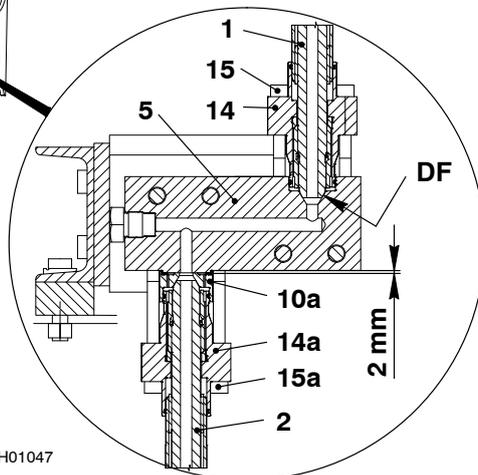
The engine must be stopped and the fuel supply pur switched off. After approx. 10 minutes the pressure is reduc in the HP fuel pipe and the fuel can be drained as follows:

- ⇒ Loosen screws 8, push back flange 9 and intermedie ri 10 (section I-I) in order to vent the pipe for draining.
- ⇒ Loosen screws 13, push back flange 12 and separate lower HP fuel pipe 2 from its sealing faces. Fuel oil drai via bores 'LB' and leakage fuel pipe 17 (section II-II).

Non-return valves 16 prevents the fuel rail from discharging



Risk of accident! Make sure that the steam supply is clos before loosening the screwed connections to the heating pipe



HP Fuel Pipe: Removing, Fitting and Regrinding

2. Removal



Remark: Always start removing a HP fuel pipe by disengaging its upper end.

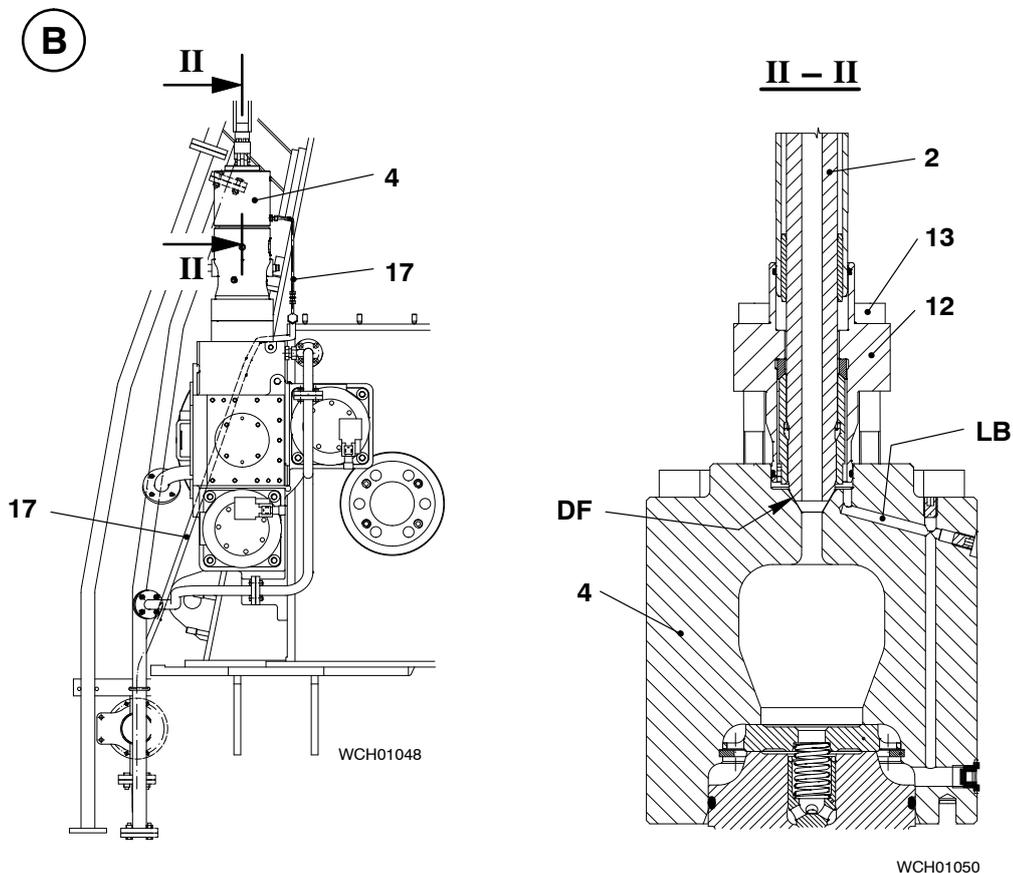
- Pay attention not to damage sealing faces 'DF'.
- All connections must be closed off immediately and the sealing faces must be protected after removing the HP fuel pipe.

2.1 Removal of upper HP fuel pipe 1

- ⇒ Loosen relevant screws 7 and mounting clamps 6 (Fig. 'A') from their holder.
- ⇒ Remove screws 8 and 15 and push flange 9 down and flange 14 up as much as possible (Fig 'A').
- ⇒ Press intermediate ring 10 together with upper HP fuel pipe 1 down by approx. 2mm and push the latter sideways. Remove the pipe together with intermediate ring 10.

2.2 Removal of lower HP fuel pipe 2

- ⇒ Remove screws 13 and 15a and push flange 14a down and flange 12 up as much as possible (Fig 'A' and 'B').
- ⇒ Press intermediate ring 10a together with lower HP fuel pipe 2 down by approx. 2 mm and push the latter sideways. Remove the pipe together with intermediate ring 10a.



HP Fuel Pipe: Removing, Fitting and Regrinding

3. Fitting

Fitting procedure is analogous to the removal but in reverse sequence. The fuel pressure pipings must be installed as stress-free as possible achieving a proper sealing function.

CHECK

Before fitting HP fuel pipes 1, 2 check whether their claws 18 are screwed on properly, i.e. HP fuel 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.

- ⇒ Replace O-rings 19 and 20 by new ones if necessary.
- ⇒ Apply Never-Seez NSBT-8 to threads and head surfaces of screws 8, 13, 15, 15a.
- ⇒ Place HP fuel pipe and slightly tighten screws 15 (13) on flange 14 (12).
- ⇒ Fit intermediate ring 10 (10a) onto upper flange 9 (14a) of HP fuel pipe 1 (2).
- ⇒ Carefully align bended pipe. If necessary, correct the alignment by rotating the pipes around their vertical axis.



Remark: During alignment, take care not to damage sealing faces 'DF'. These should be parallel to each other.

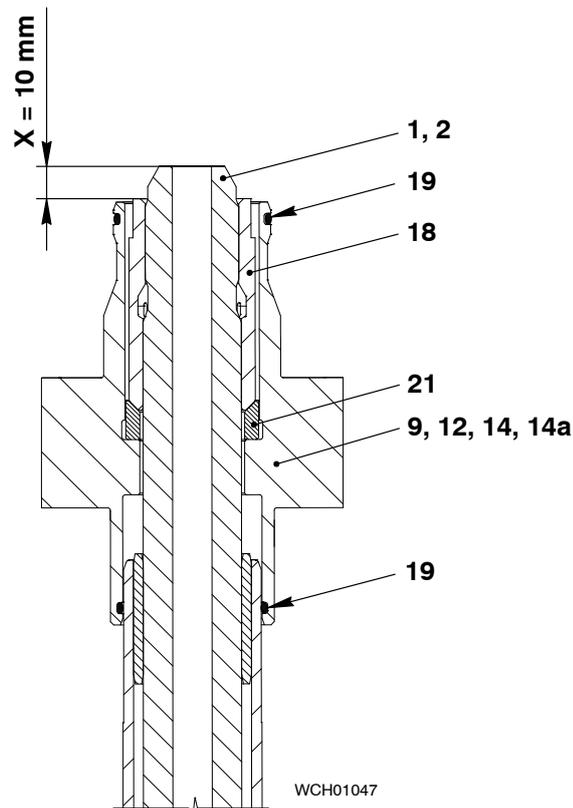
- ⇒ Tighten screws 8, 13, 15, 15a crosswise with a torque of **55 Nm**.

CHECK

Check the parallelism of all flanges 9, 12, 14, 14a by means of a feeler gauge.

- Fasten clamps 6 as stress-free as possible and equally tighten their screws 7. Retighten the clamps according to [0380-1](#) (see: Holder).

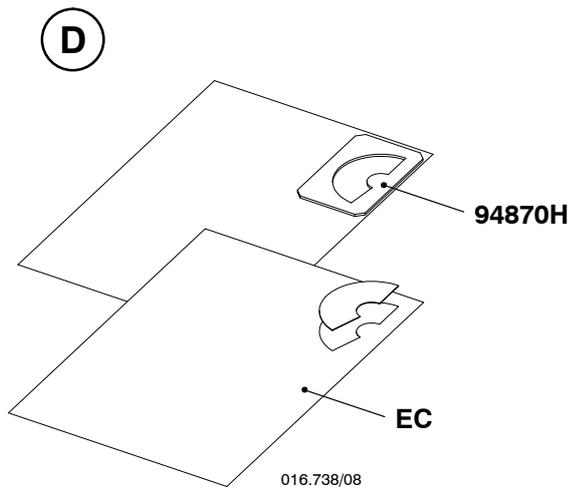
(C)



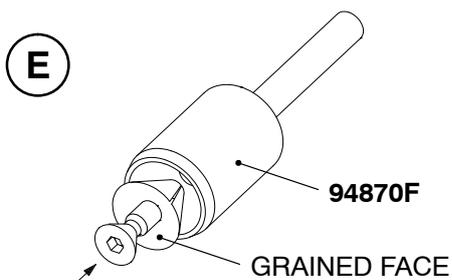
HP Fuel Pipe: Removing, Fitting and Regrinding

4. Regrinding of sealing faces 'DF'**4.1 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.

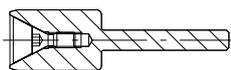


- ⇒ Place template 94870H on the back of emery cloth 'EC' .
- ⇒ Trace inner contour using a pointed pencil or a ball pen.
- ⇒ Cut out precisely the traced contour.



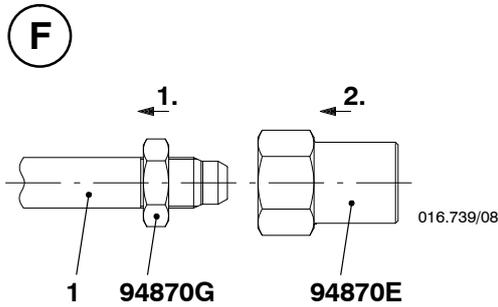
- ⇒ Shape the cut cloth in a manner to obtain a cone with the grained face being turned inward.
- ⇒ Place the emery cloth in the cone of the grinding tool 94870F and fix it by means of its countersunk screw.

TIGHTENED
CONDITION

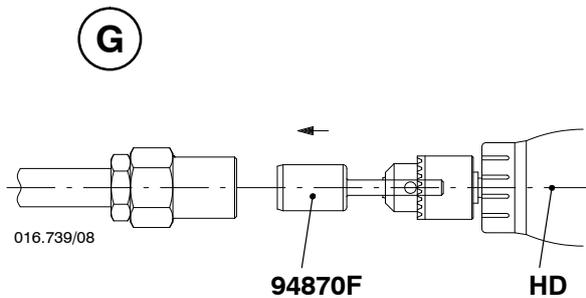


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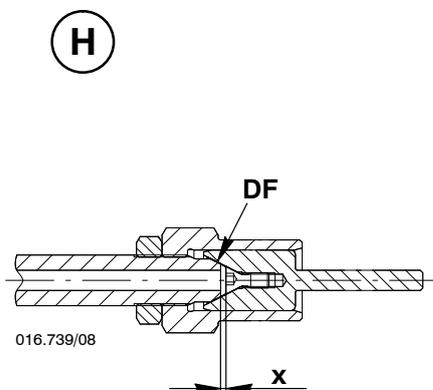
HP Fuel Pipe: Removing, Fitting and Regrinding



- ⇒ Remove claw 18 (Fig. 'B').
- ⇒ Fix HP fuel pipe 1 and 2, e.g. in a vice.
- ⇒ Screw on counter nut 94870G until it reaches the thread end of the HP fuel pipe.
- ⇒ Turn screw-on sleeve 94870E up to the counter nut.
- ⇒ Lock the screw-on sleeve with the counter nut.



- ⇒ Clamp grinding tool 94870F in hand drill 'HD'.
- ⇒ Slide grinding tool into the screw-on sleeve until it slightly touches the HP fuel pipe.
- ⇒ Let the grinding tool rotate with a max. speed of 1500 rpm and grind for 3 to 5 seconds.



- ⇒ 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 reconstitute 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 HP fuel pipe.

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▽	Crank Angle Sensor Unit	
	- Dismantling, Assembling and Adjusting (at Free End)	9223-1/A1
	- Assembly and Replacement of Proximity Sensor (at Gear Wheel)	9223-1/A2
	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 – 32
	- Recommended Special Tools	Pages 33 – 35
	- Special Tools Obtainable on Loan	Pages 36 & 37

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Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

Tools:

- 1 Feeler gauge 94122
- 1 Hook spanner 94924
- 1 Hook spanner 94925

Key to Illustrations:

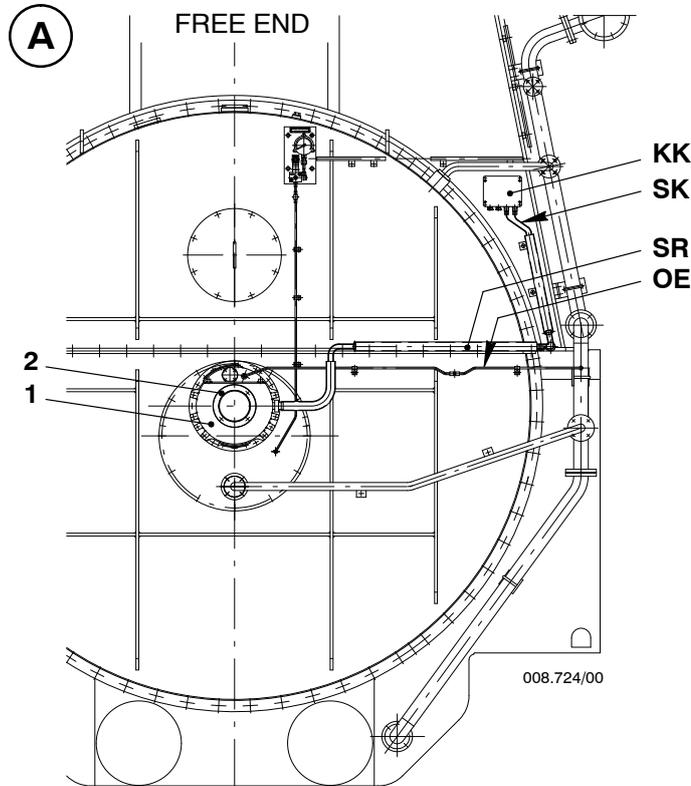
- | | |
|-----------------------------|----------------------------------|
| 1 Protection hood | 37 Disc |
| 2 Covering cap | 38 Key |
| 3 Screw | 39 Packing ring |
| 4 Nut | 40 Locating pin |
| 5 Shaft | 41 Inspection cover |
| 6 Crank angle sensor (CAS) | 42 Compression spring |
| 7 Holder | 43 Lever |
| 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

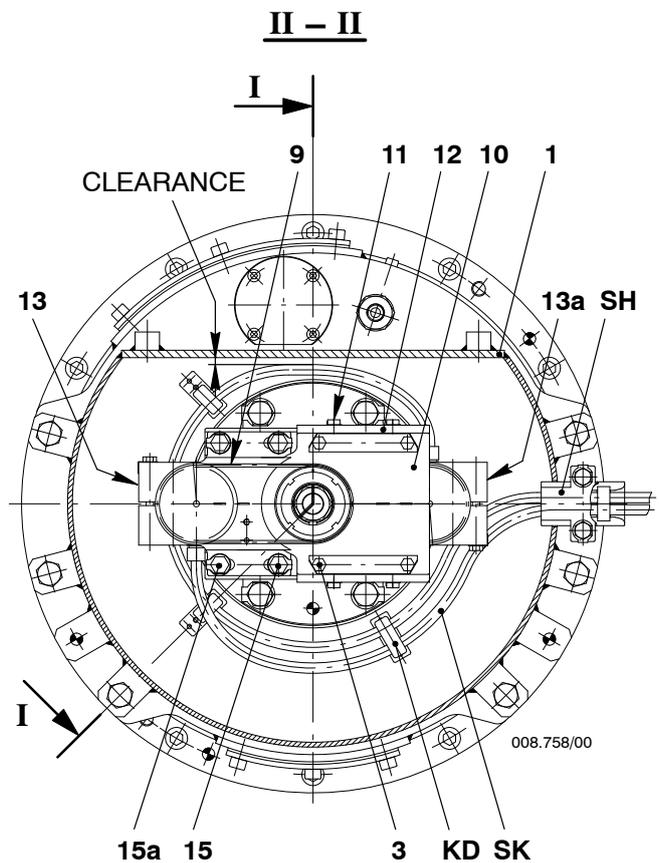
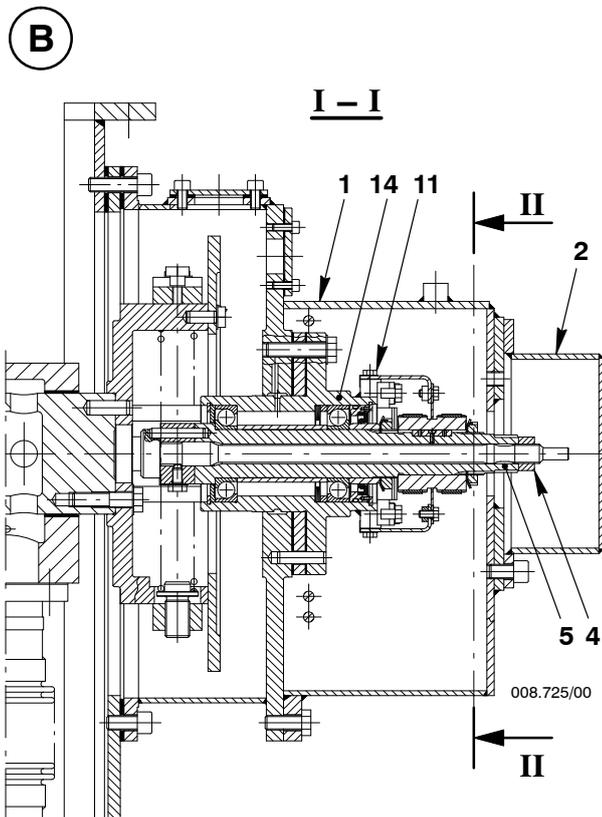


1.1 Preparation

- ⇒ 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.

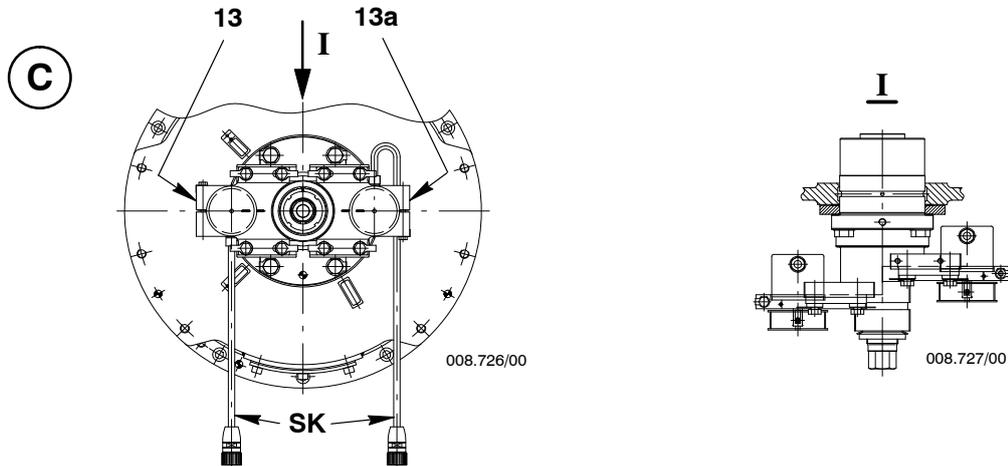


Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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.

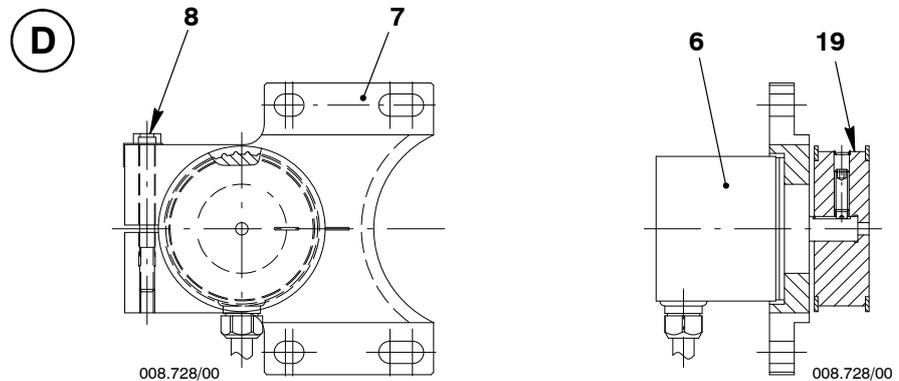
Removal of the inner shaft encoder 13a is carried out analogously to the outer one.

**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.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

3.2 Fitting the toothed belt

Only the new belt version (black colour) must be installed.

E

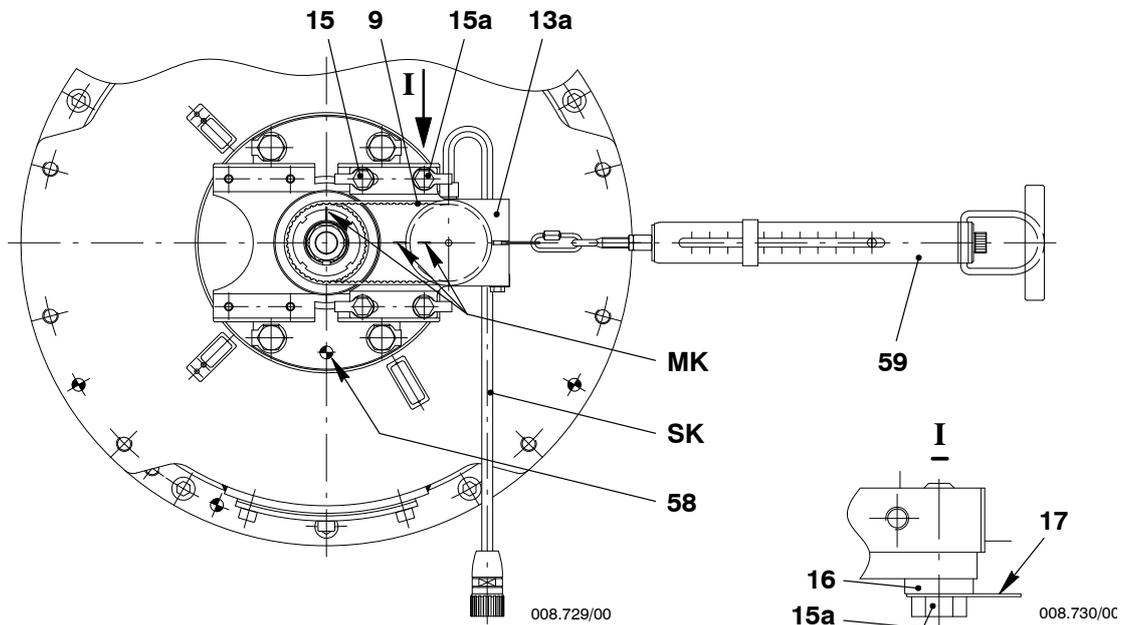


- ⇒ Connect gear wheels 19 and 18 with toothed belt 9, paying attention to their marks 'MK' which must coincide according to Fig. 'G' (zero position).
- ⇒ Push shaft encoder outwards until the toothed belt is lightly tensioned and meshing properly with the gear wheels. Lightly tighten screws 15. Recheck 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

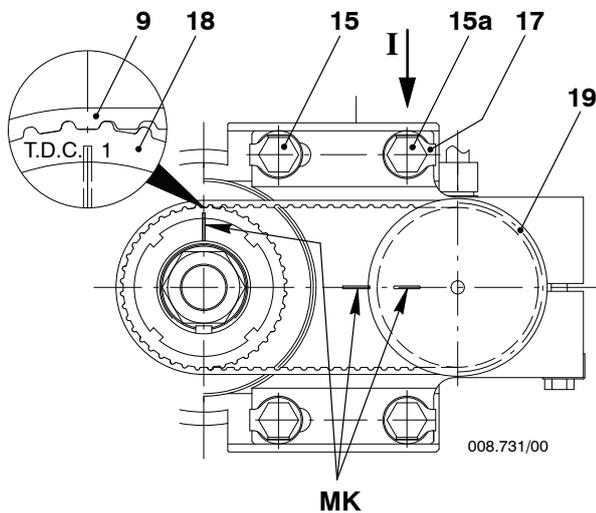
- ⇒ In order to align toothed belt 9 on its running track, turn the crankshaft one to two revolutions with the turning gear.
- ⇒ Recheck belt tension according to Fig. 'G' and 'H' as well as marks 'MK'. Repeat tensioning procedure if belt slackened after crankshaft has been turned or if marks 'MK' are 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!

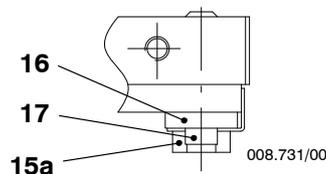
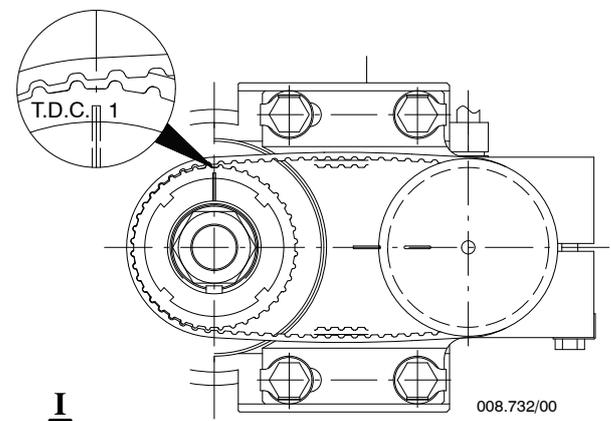
G

TOOTHED BELT TENSIONED

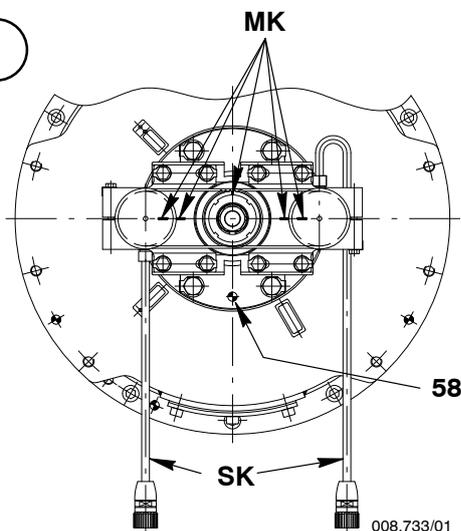


H

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'.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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!

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

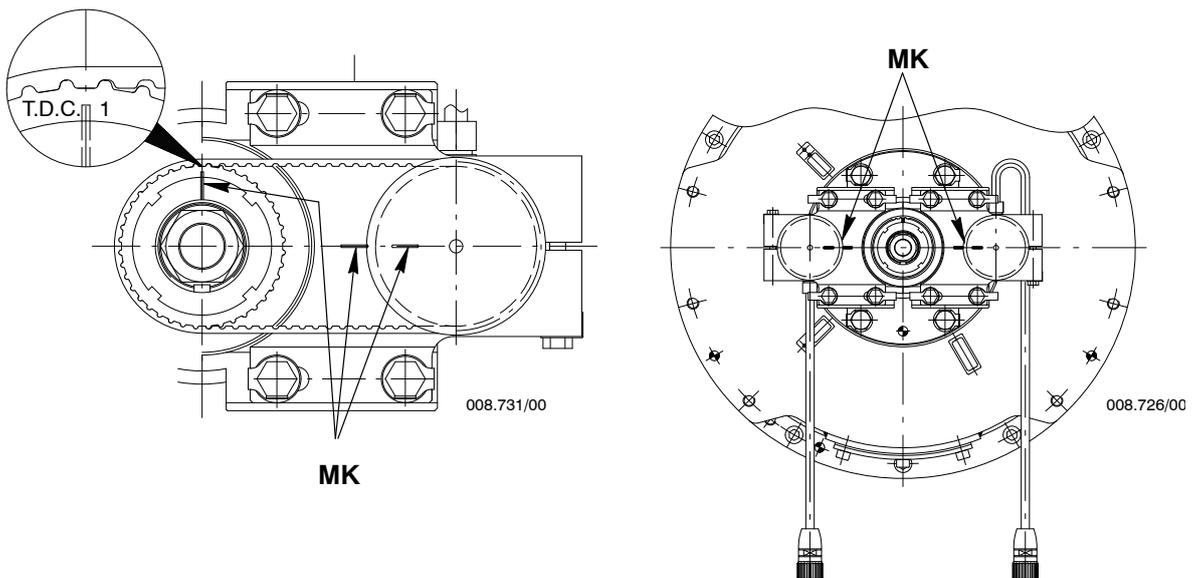
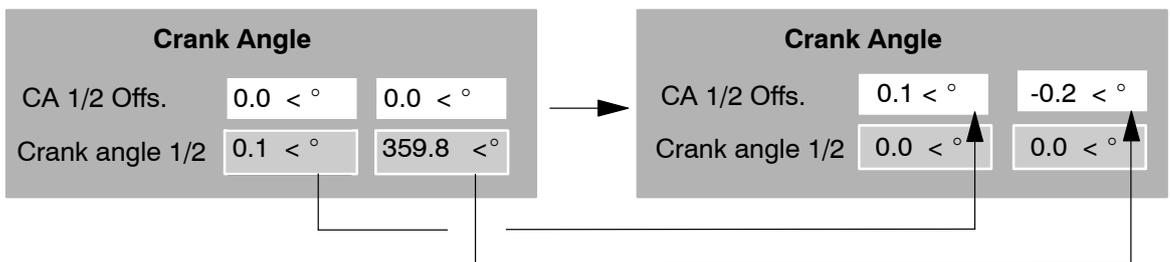
3.7 Adjustment of crank angle offset in WECS

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 $^{\circ}$, use negative values - 0.2 $^{\circ}$.

J



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

4. Removal of crank angle sensor drive

⇒ Preparation according to paragraph 1.1.

⇒ Loosen and remove nuts 4.

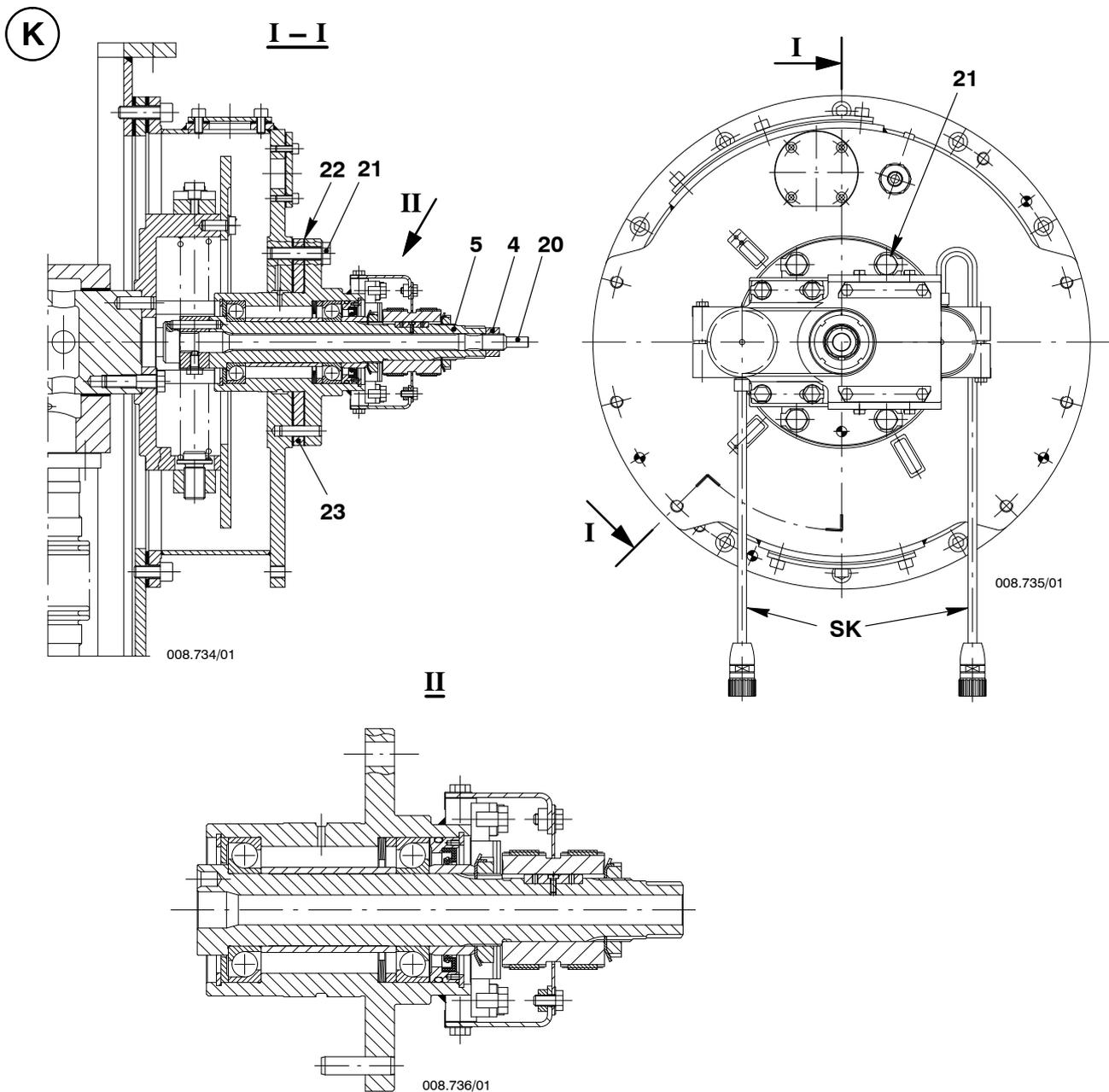


Attention! When loosening nut 4 **hold up** shaft 5 by means of an open end spanner AF27!

⇒ 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

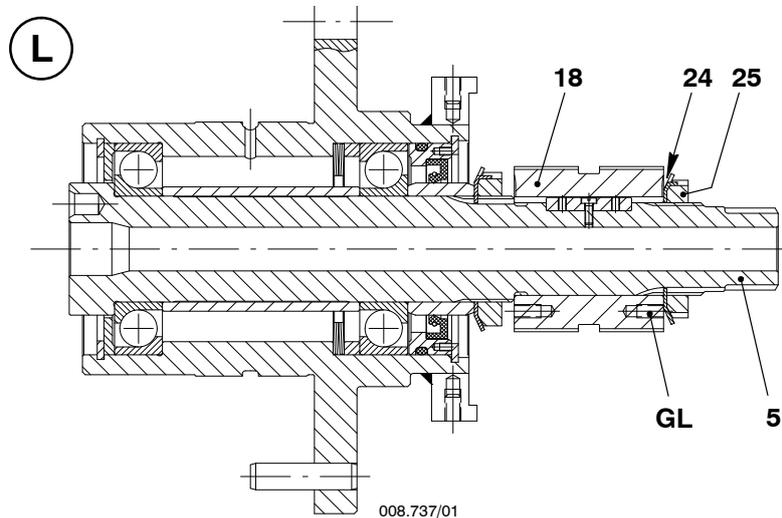
5. Dismantling the crank angle sensor drive

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.

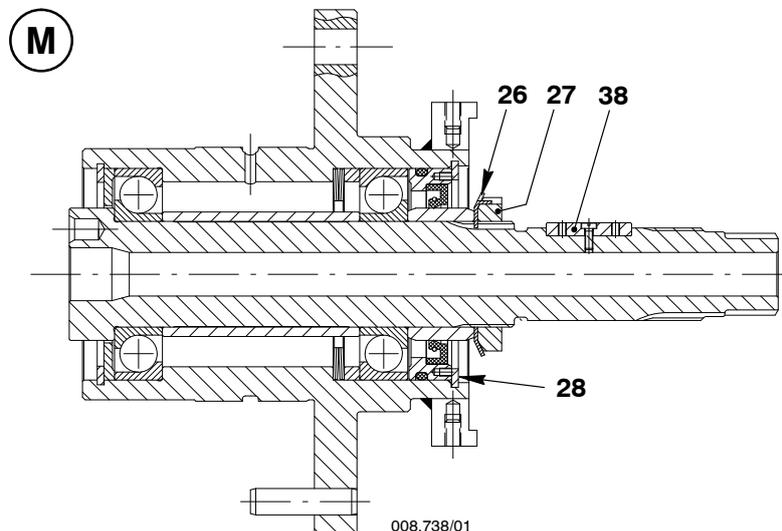
- ⇒ Remove shaft encoder according to paragraphs 1.2 and 1.3.
- ⇒ Unbend locking plate 24, loosen and remove shaft nut 25 using hook spanner 94924.
- ⇒ Withdraw gear wheel 18 from the shaft 5.



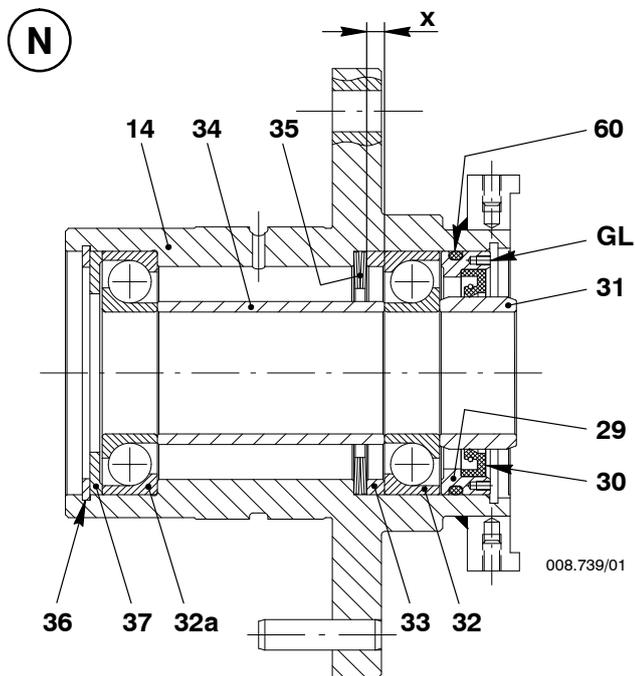
Remark: If withdrawing by hand is not possible, the gear wheel must be removed by means of the two tap holes 'GL' and suitable tools, however, without striking and damaging the toothing.



- ⇒ 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.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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').

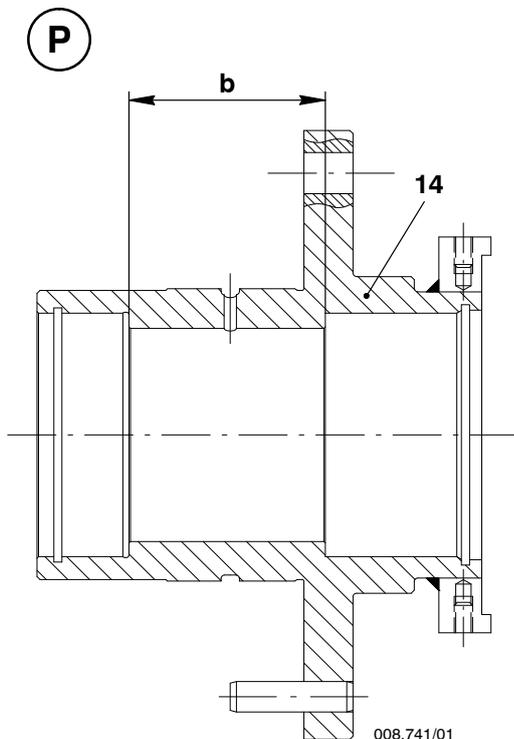
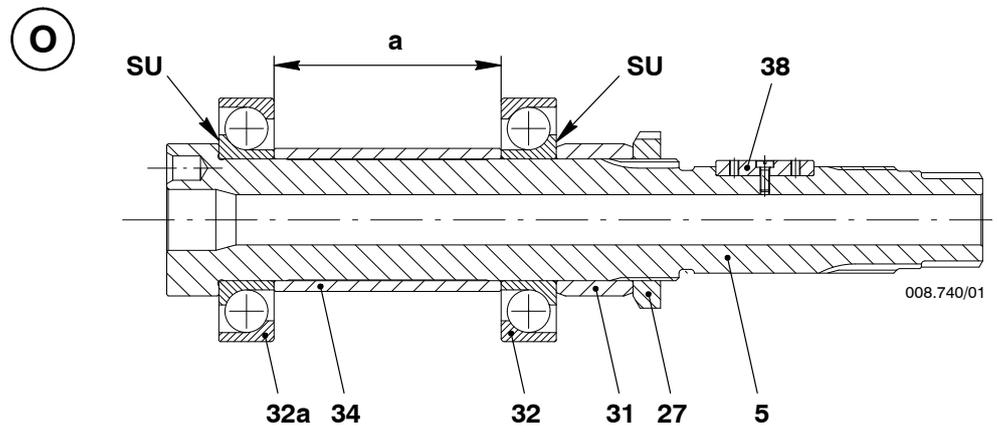
6.1 Determining of thickness 'x' of distance ring 33 (Fig. 'N')

- ⇒ 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'.

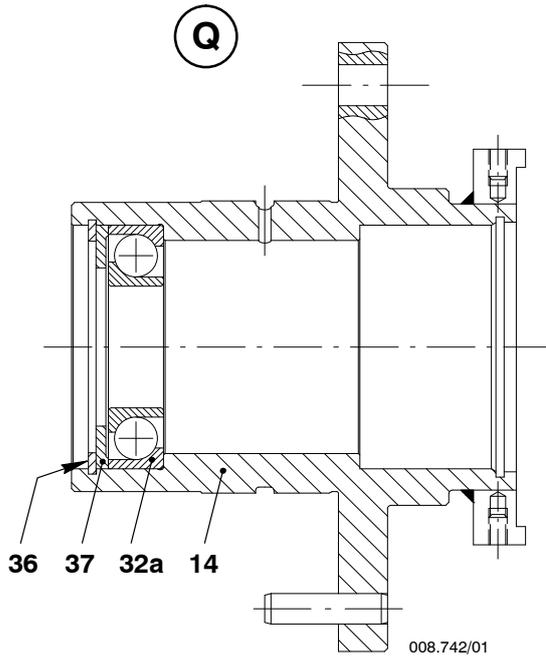


- ⇒ Measure and note down distance 'b' in housing 14.
- According to the following formula determine thickness 'x' for distance ring 33 to be fitted:

$$x = a - b - 4.2 \text{ mm}$$

Tolerance 'x' amounts to $\pm 0.2 \text{ mm}$.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

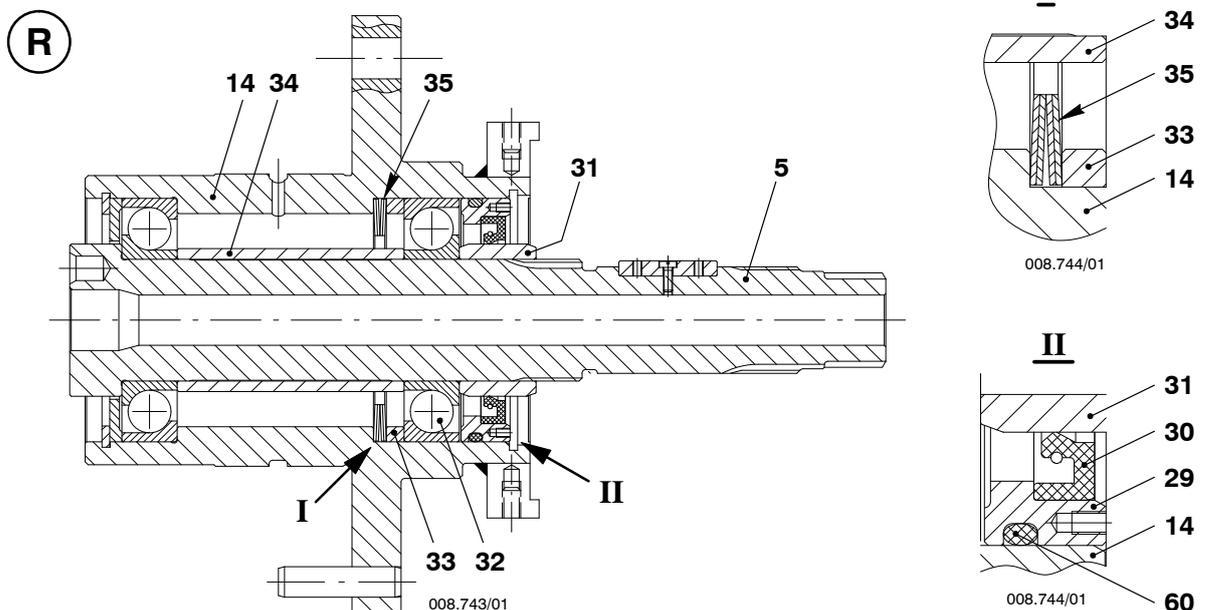


6.2 Sub-assembly of bearing housing

- ⇒ 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

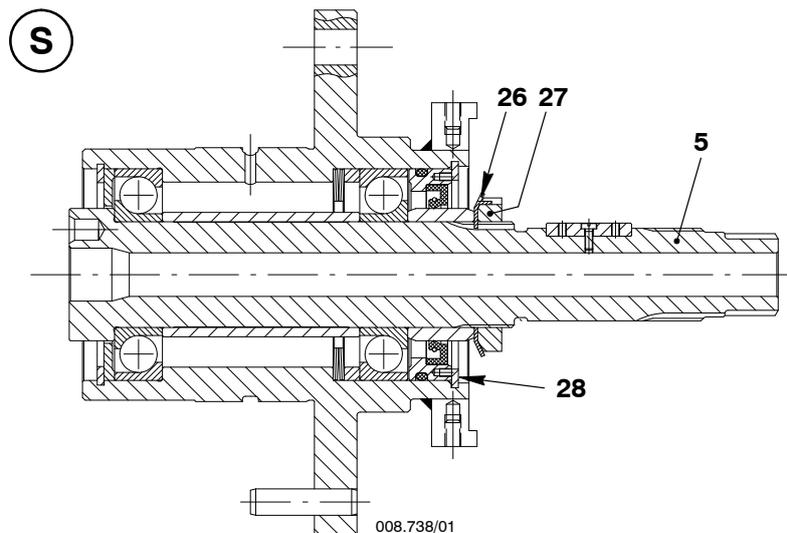
- ⇒ Oil all parts.
- ⇒ Fit shaft 5.
- ⇒ Push distance sleeve 34 onto the shaft.
- ⇒ Fit disc springs 35 according to view I.
- ⇒ Fit distance ring 33 with thickness 'x' determined under paragraph 6.1.
- ⇒ Oil ball bearing 32 and insert it into housing 14. Pay attention to the fitting position in paragraph 6.1!
- ⇒ Fit retaining ring 29 with new sealing ring 30 and O-ring 60 according to view II.
- ⇒ Fit distance ring 31.



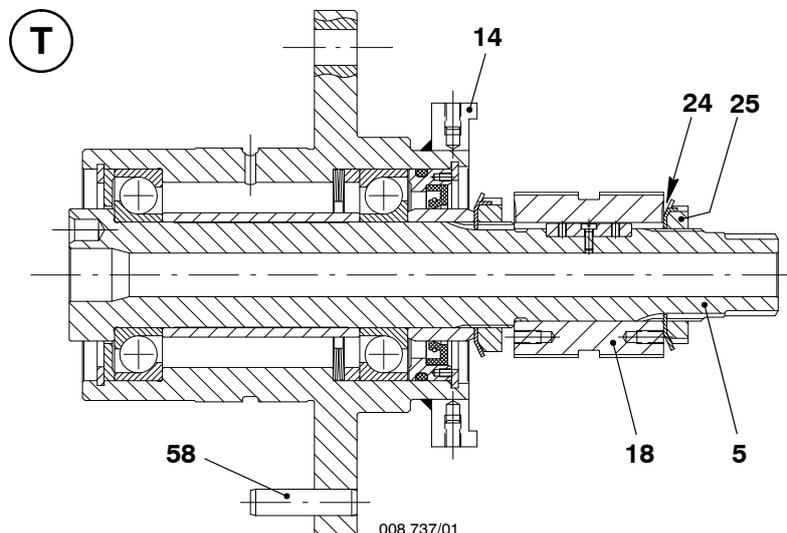
Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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.



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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

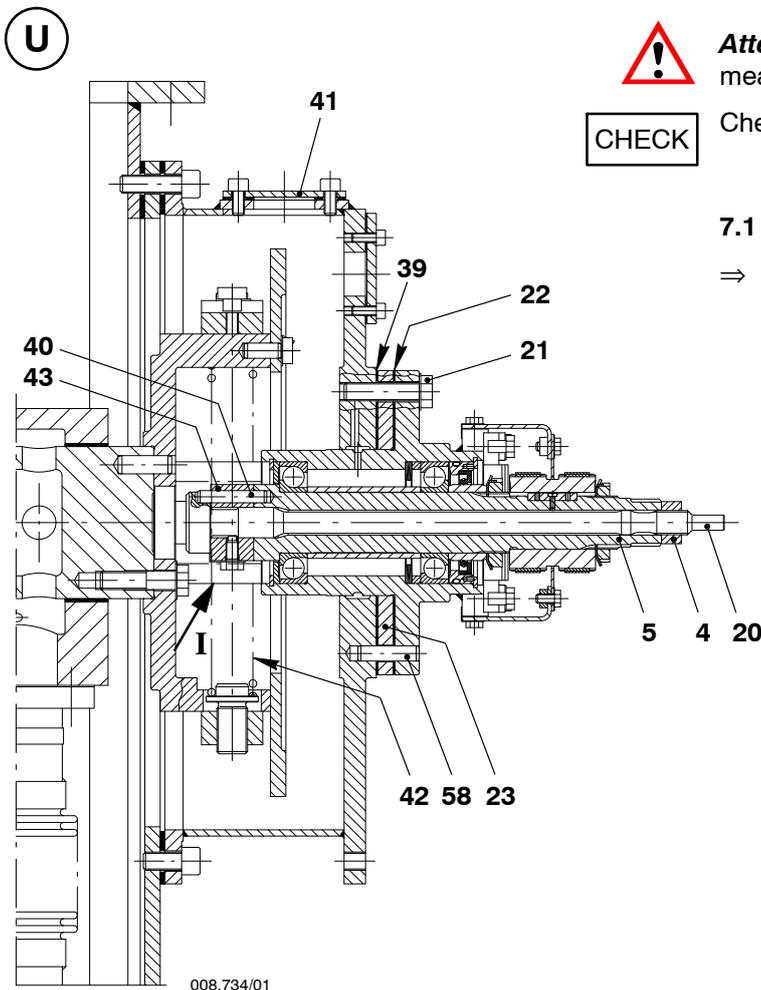
Turn crankshaft to an appropriate position.

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**.



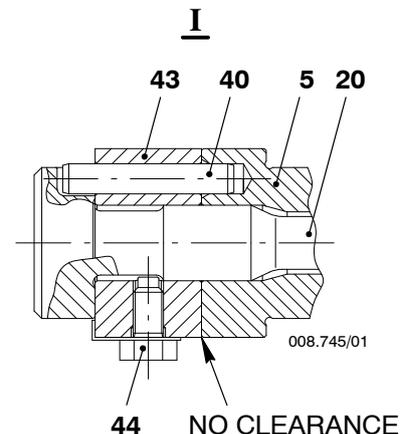
Attention! When tightening nut 4 hold up shaft 5 by means of an open end spanner!

CHECK

Check adjustments according to paragraph 3.3.

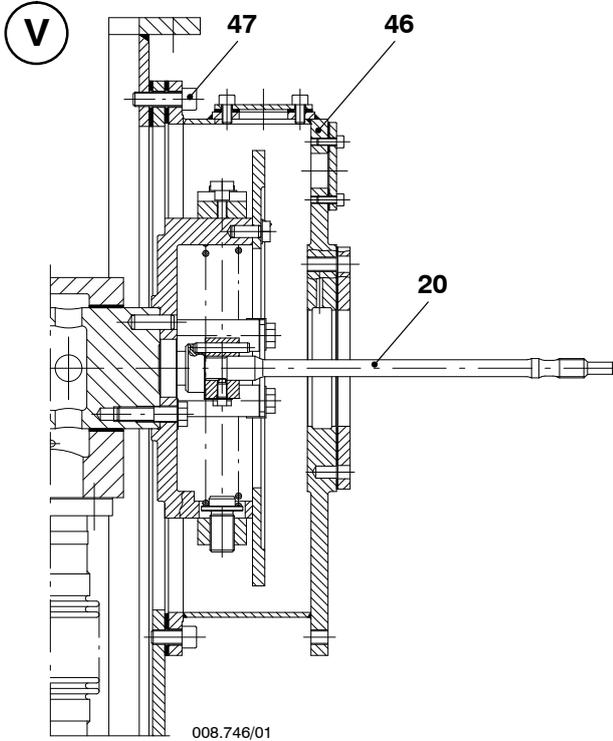
7.1 Final works

- ⇒ Carry out final works according to paragraphs 3.4 and 9.1.



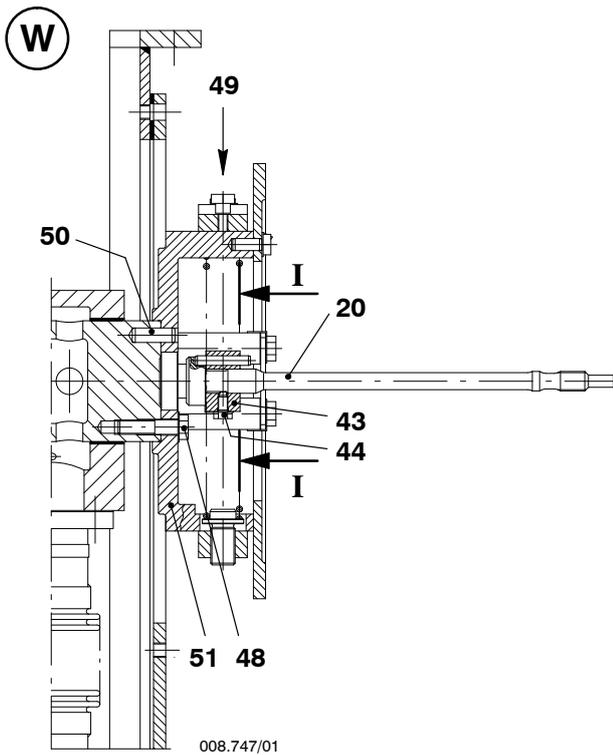
Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

8. Removal and fitting of compression spring

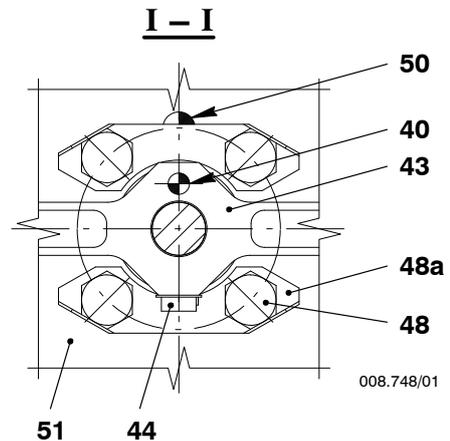


8.1 Preparation

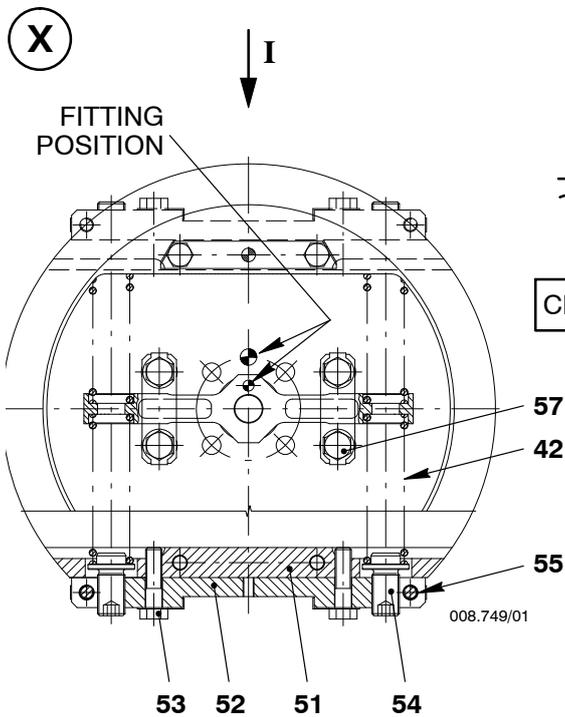
- ⇒ Remove oil inlet 'OE' (Fig. 'A').
- ⇒ Dismantle crank angle sensor drive according to section 4.
- ⇒ Remove screws 47 and housing 46.



- ⇒ 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**

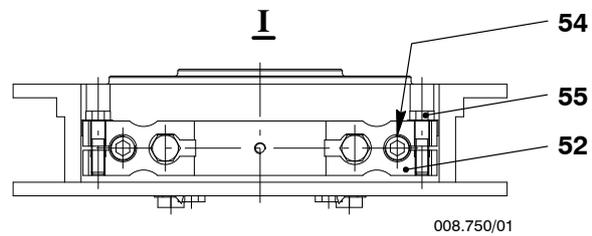
- ⇒ Loosen screws 53 and remove them together with spring tensioner 52.
- ⇒ Remove and check compression springs.



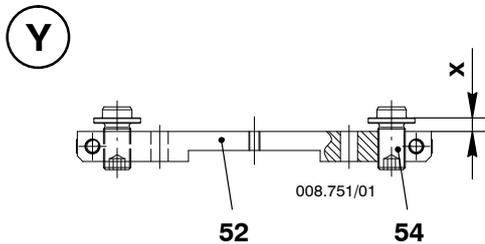
Remark: When replacing only one compression spring 42, it is recommended to remove also the second spring tensioner for carrying out further adjustments.

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**

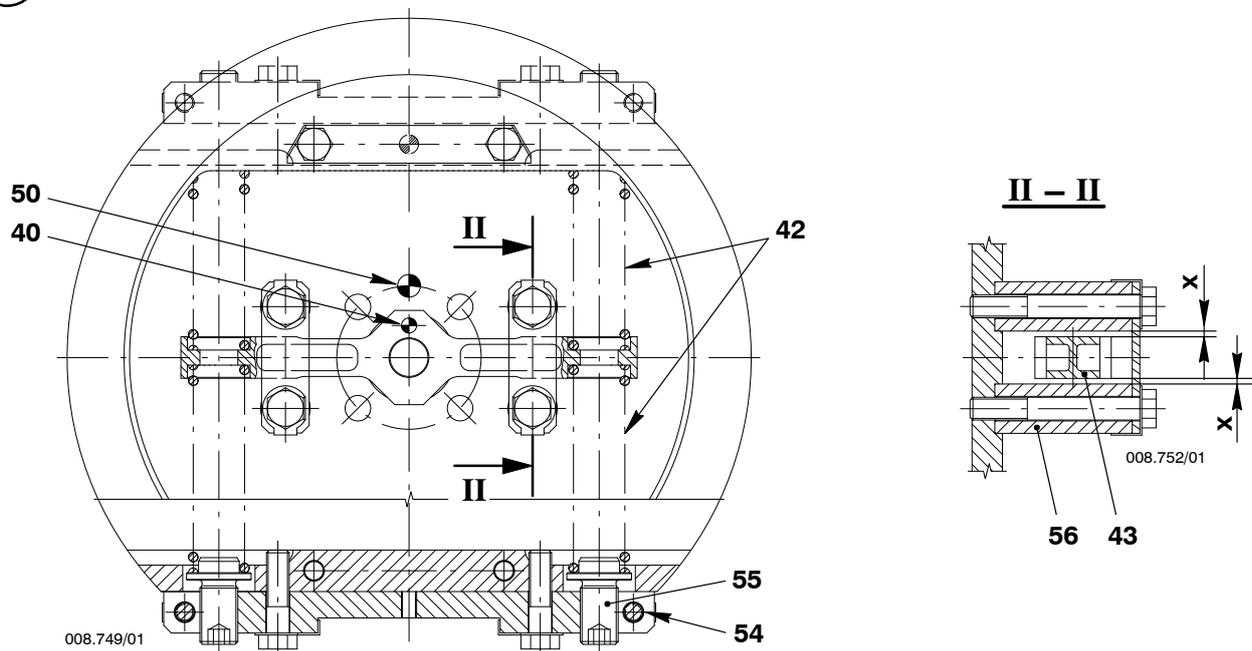
- ⇒ Loosen clamp screws 55 of spring tensioner 52 (Fig. 'X'). Replace locking plates. Apply MOLYKOTE paste G to threads and seating surfaces of screws 55 and refit them.
- ⇒ Oil and adjust all adjusting screws 54 to 'x' = 10 ± 0.10 mm (Fig. 'Y').
- ⇒ Insert compression springs 42, fit spring tensioner 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.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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. $\frac{1}{2}$ turn, the opposite one must be screwed-out by $\frac{1}{2}$ 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.

Z



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'!

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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

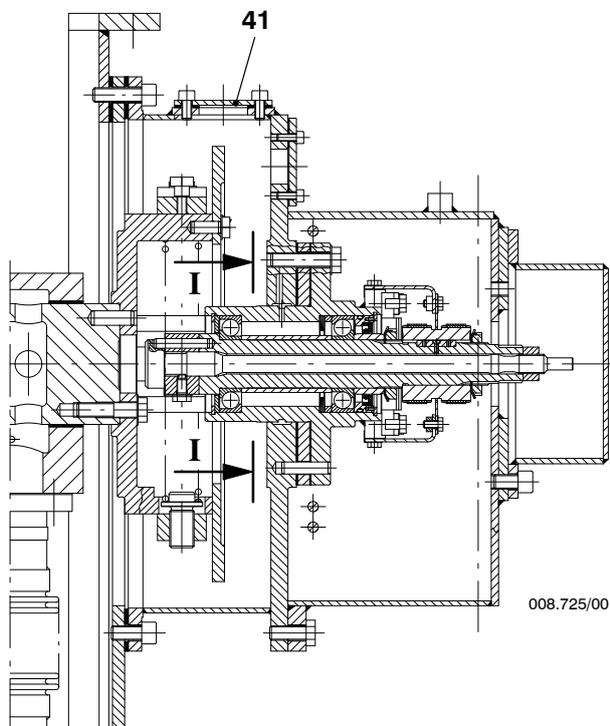
The periodical checks **must** be carried out according to Maintenance Schedule 0380-1 'Crank angle sensor unit'.

9.1 Lubricating oil flow in the crank angle sensor drive

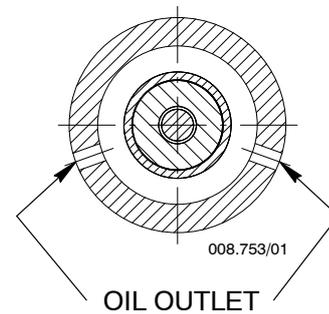
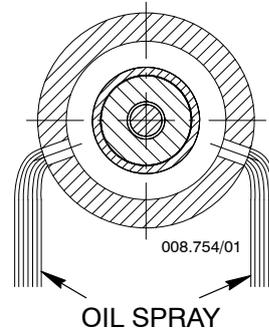
- ⇒ Start main lubricating oil pump and adjust bearing oil pressure.
- ⇒ Remove inspection cover 41.

With correct oil flow at operating temperature an oil spray results according to Fig. 'B₁'. However, the oil outlets should be filled up.

- ⇒ Refit inspection cover 41.

A₁

I - I

B₁

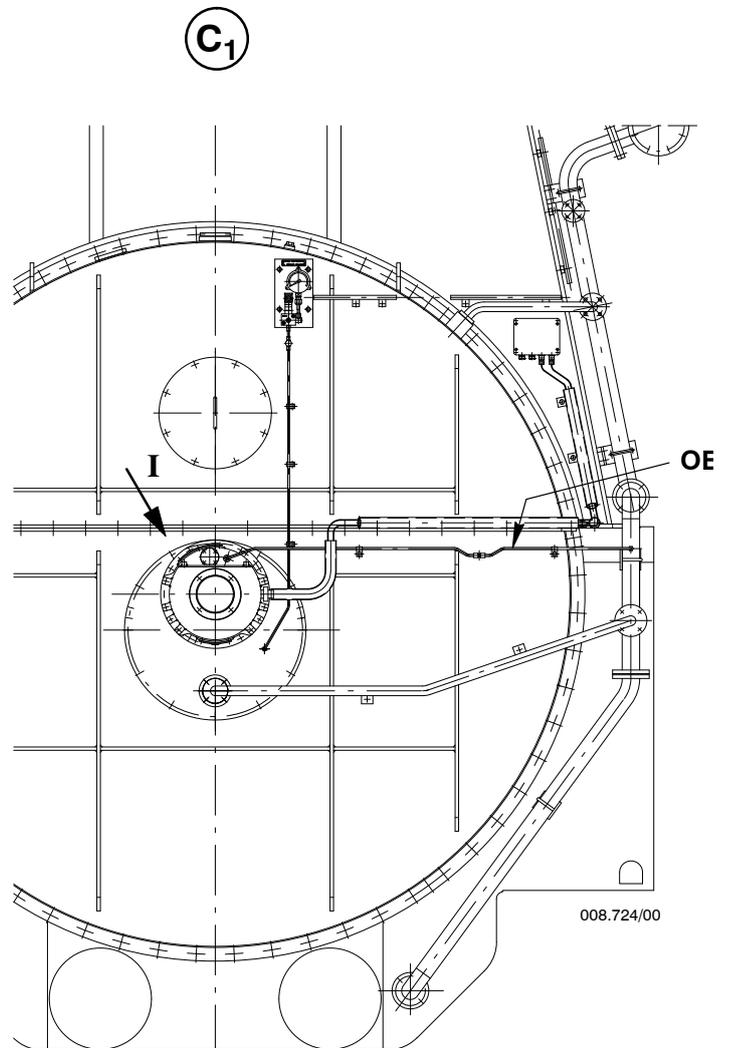
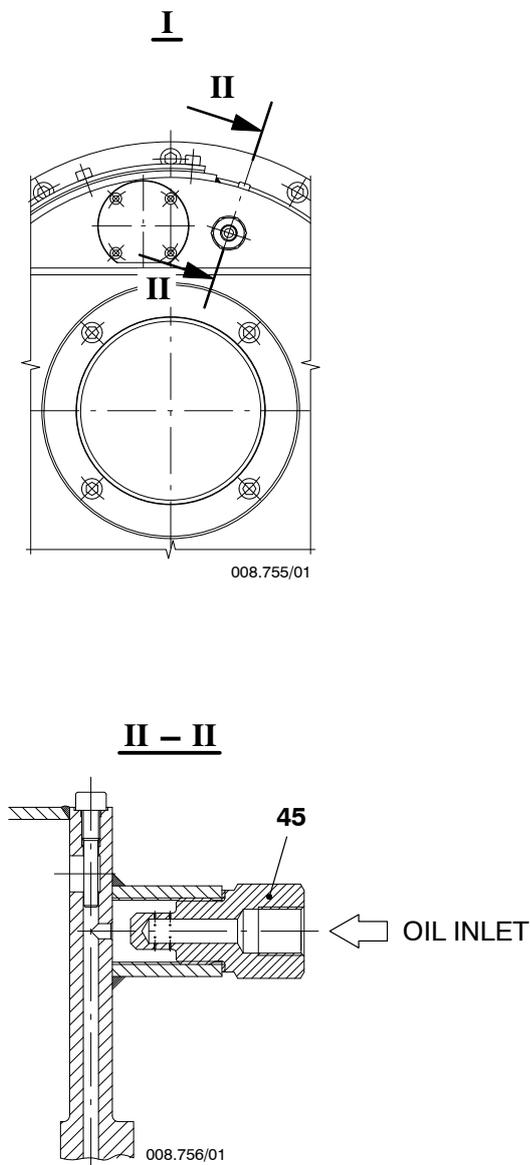
Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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.



Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

9.3 Checking the shaft eccentricity

The following checks and the replacement of CAS parts can only be carried out if the engine is at standstill.

Check the shaft eccentricity in case of CAS exchange.

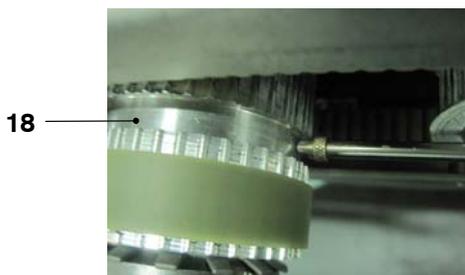
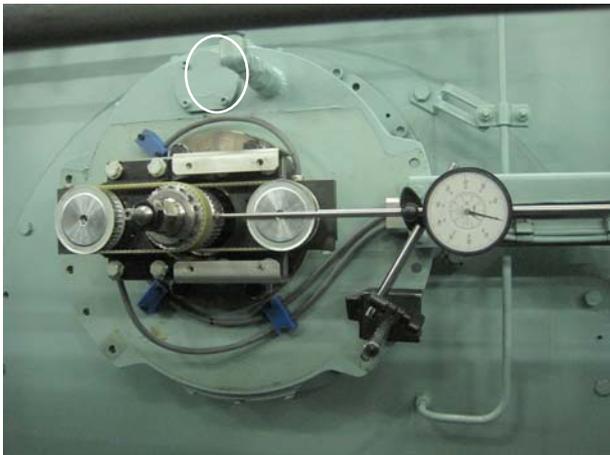
It is essential to perform the eccentricity check according to the Maintenance Schedule 0380-1.

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.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

9.5 Checking the clearance between shaft and internal bearing of the CAS

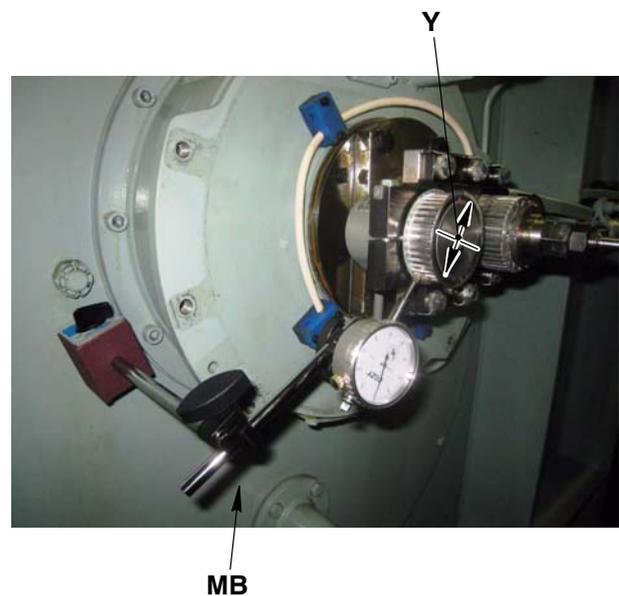
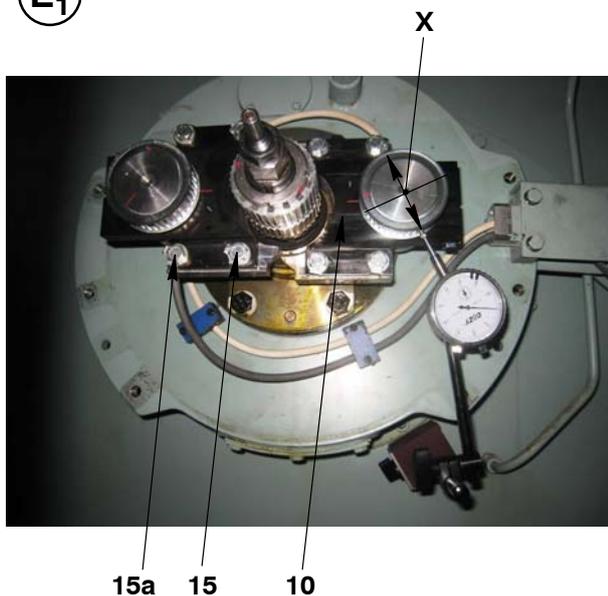
In case the CAS is over five years in service or has more than 48 000 operating hours, it is recommended to check the condition of the CAS before a new belt version is installed. The CAS condition is checked by measuring the clearance between the shaft and internal CAS bearing.

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**.

E₁

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 has to be performed, which means checking for possible cracks and worn-out areas.



Attention! Worn-out toothed belts must be replaced immediately.

Crank Angle Sensor Unit: Dismantling, Assembling and Adjusting

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.

Crank Angle Sensor Unit

Assembly and Replacement of Proximity Sensor (Pickup)

at Gear Wheel

Key to Illustrations:

- | | |
|----------------------------|-----------------------------------|
| 1 Proximity sensor | 4 Terminal boxes E.96.1 / E96.2 |
| 2 Crank angle mark (1 / 2) | 5 Plug with cable |
| 3 Gear wheel on crankshaft | 6 Bolt with locking plate and nut |

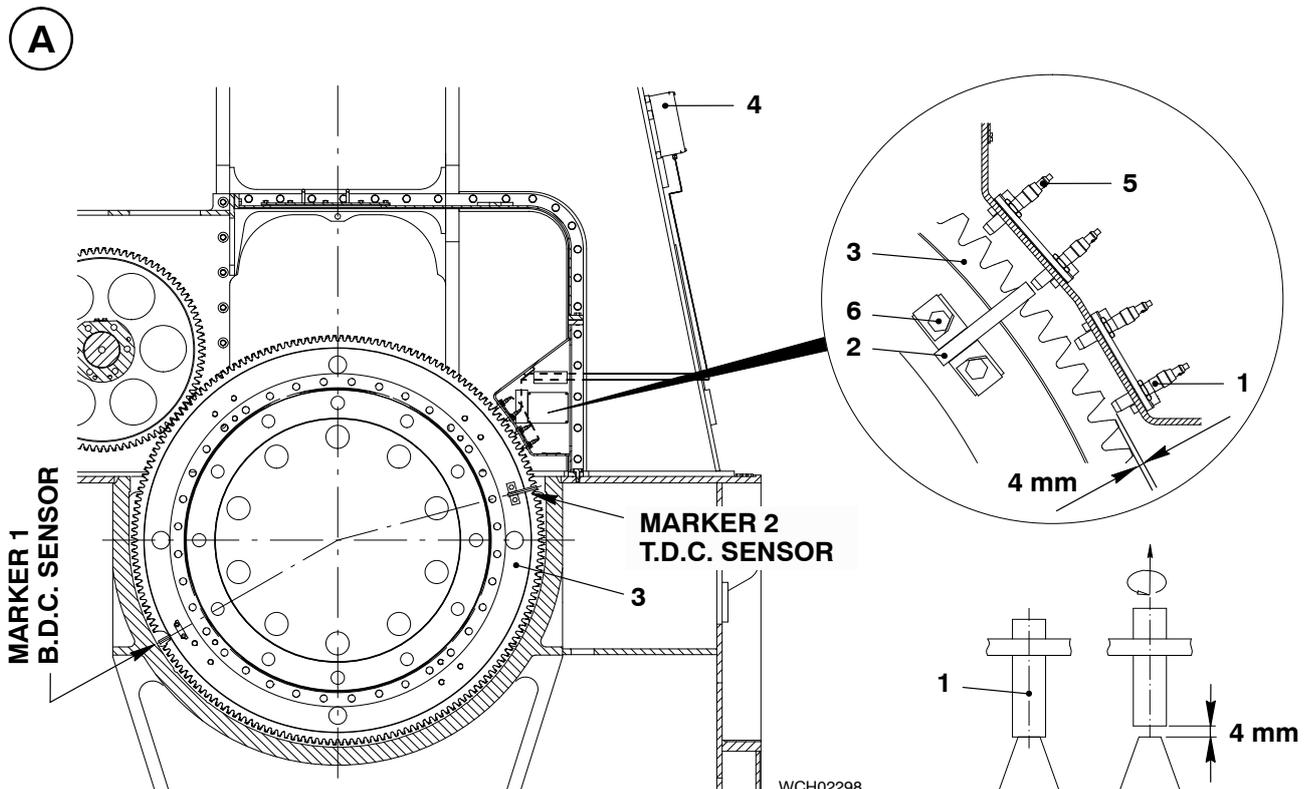
1. General

For the function of the Crank Angle Sensor Unit pay attention to General Application Instructions [9223-1](#) and for Regular Checks and Recommendation for replacing ACM-20 modules 4002-4 in the Operating Manual.

For Inspection and Overhaul Intervals refer to Maintenance Schedule [0380-1](#).

2. Assembly and Replacement of Pickup

- ⇒ Disconnect the plug with cable 5 from the affected sensor 1 and screw the sensor out.
- ⇒ Screw in the new sensor until the sensor touches the tooth or head as shown below. Do not use any force.
- ⇒ Screw the sensor out four turns ($4 \times 360^\circ = 4 \text{ mm}$) in anticlockwise direction.
- ⇒ Secure the sensor with nut and connect the plug with cable.
- ⇒ Turn clockwise the engine by turning gear. The pickup signal sequence on the ACM-20 module has to be in the correct order: 'A', 'B', 'C'. When passing the reference flag the LED 'REF' lights up.



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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

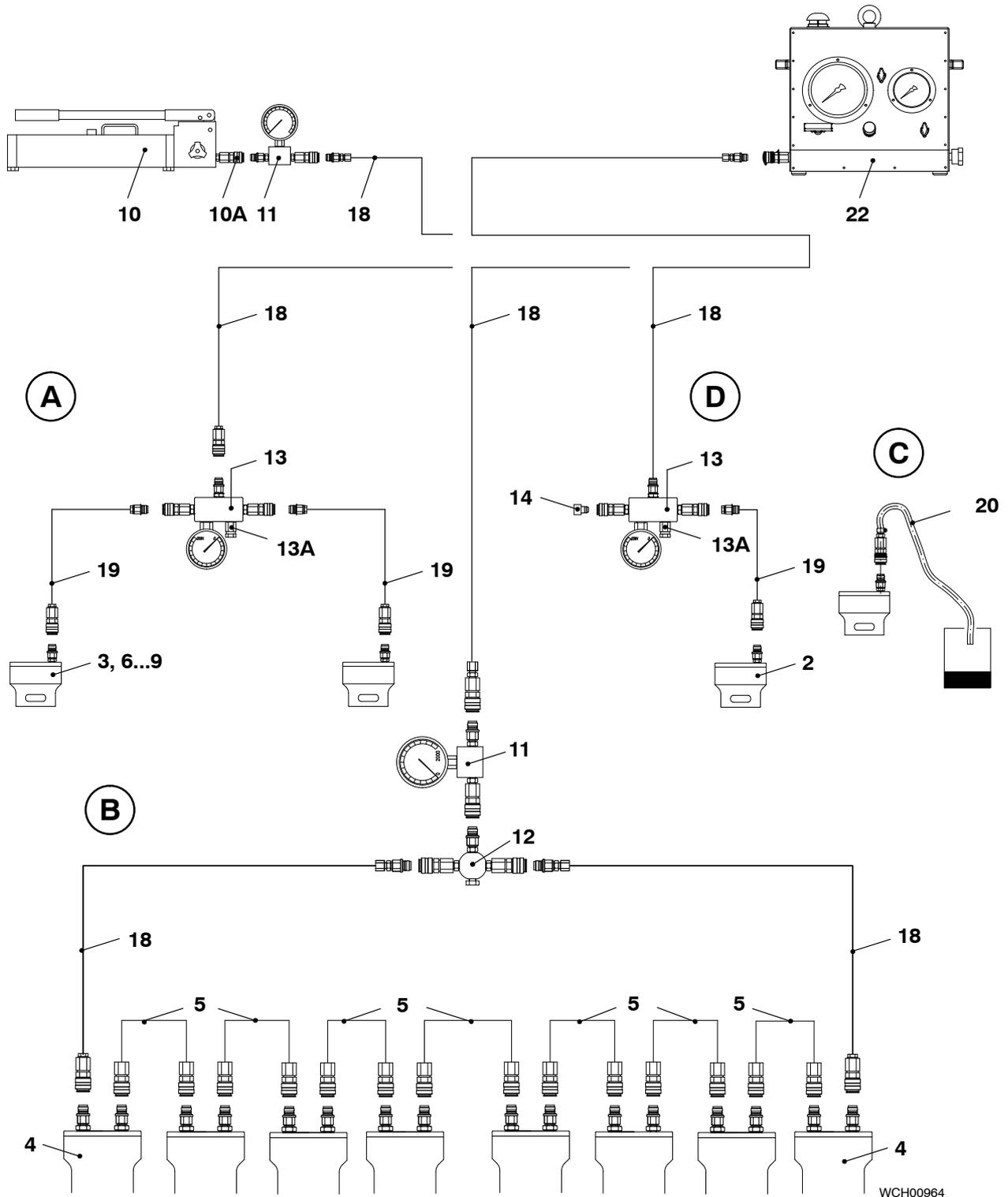
... are tools and devices, which allow certain maintenance work to be done with more ease, and in a shorter time, than with the standard tools. These tools can be ordered separately either with the engine or at a later date.

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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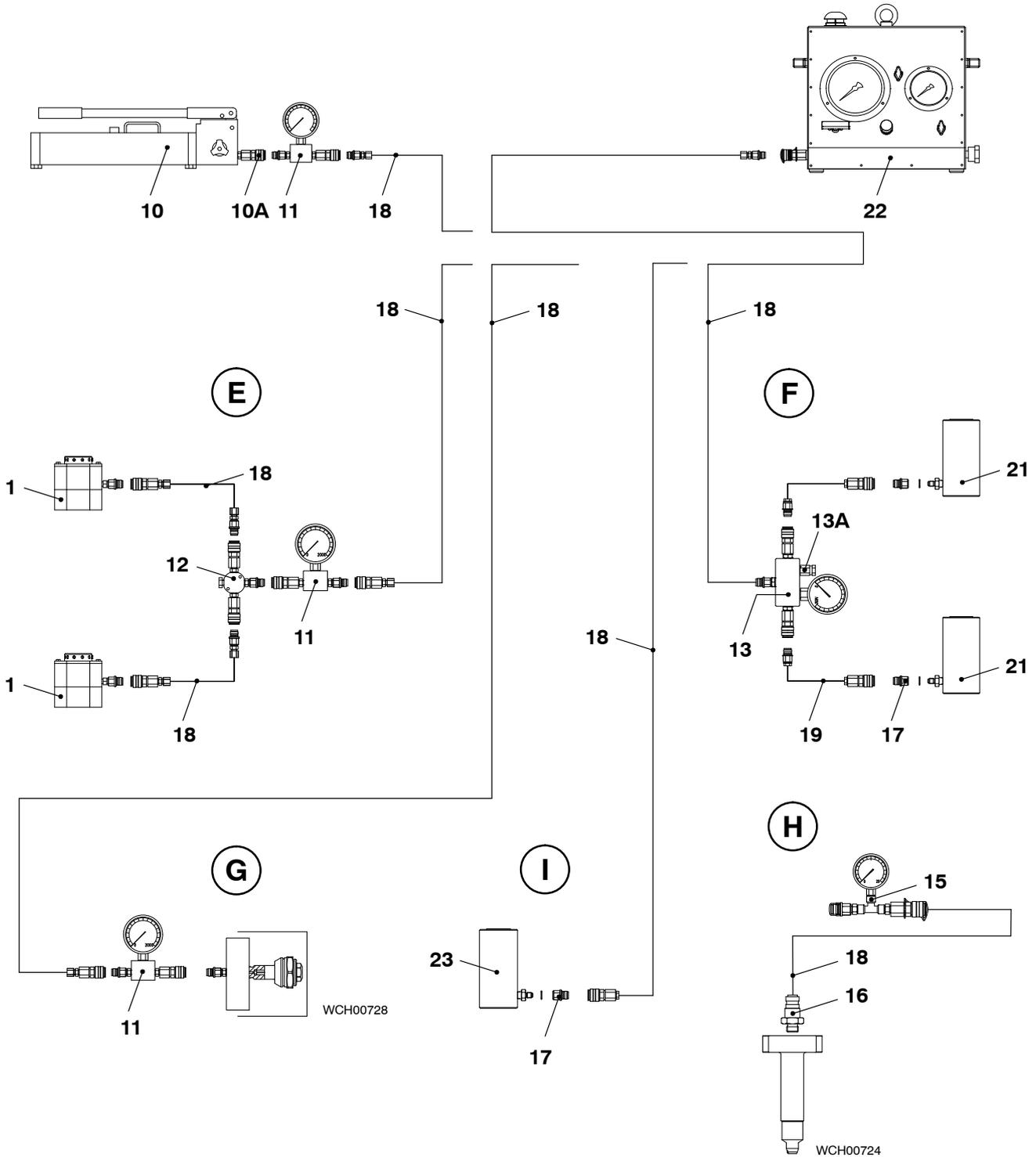
Hydraulic Jacks and Pumps
Arrangement and Application



WCH00964

- A = Tensioning / loosening of tie rods, elastic studs to exhaust valve cage, top and bottom end bearings to connecting rod, piston rod foot
- 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
23 Hydr. ram 230 kN (23 t)	94950

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Hydraulic Pre-tensioning Jacks
Storing, Servicing and Maintenance

1. General

The hydraulic pre-tensioning jacks forming part of the engine tool kit are to be stored in their tool boxes when not in use, in a clean place, where they are protected from damage (after greasing them and closing the connections with dust plugs). We recommend to always keep in stock a sufficient number of new back-up and O-rings of the specified quality and dimensions.

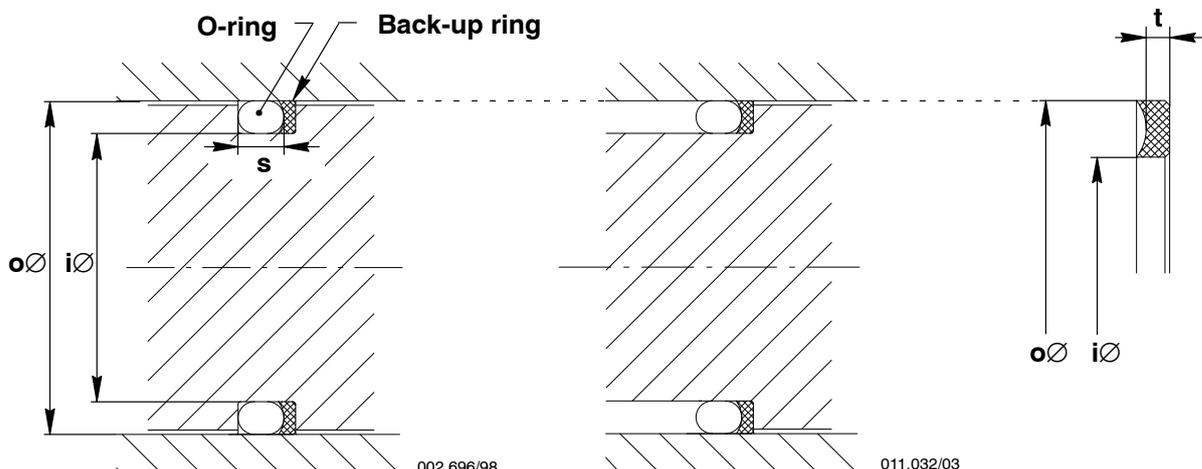
Always pay attention to the correct position when fitting new back-up and O-rings as shown on the following pages.



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]	
			$o\varnothing \times i\varnothing \times t$	$i\varnothing \times s$
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
GF 94215	Elastic bolt to cylinder cover	piston cylinder	129 x 119.6 x 1.7 98.4 x 89 x 1.7	116.84 x 5.33 88.27 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 x 100 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



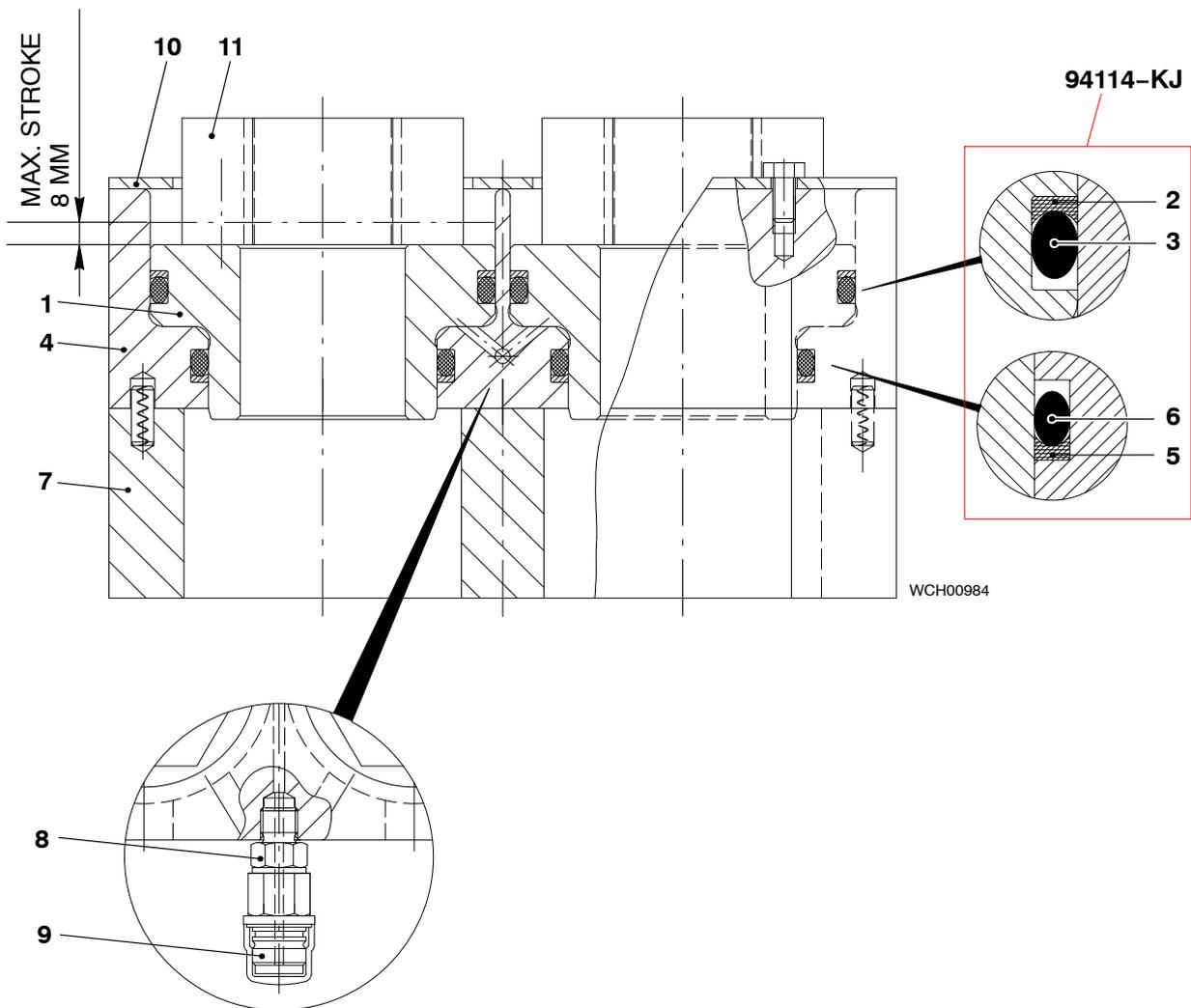
Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

2. Overview of pre-tensioning jacks

Tool 94114 Double pre-tensioning jack for elastic bolts to main bearing

- | | | | | |
|---|-----------------|----------------|----|-----------------|
| 1 | Piston | | 7 | Distance sleeve |
| 2 | Back-up ring | } Sealing ring | 8 | Adapter piece |
| 3 | O-ring | | 9 | Closing valve |
| 4 | Double cylinder | | 10 | Cover |
| 5 | Back-up ring | } Sealing ring | 11 | Round nut |
| 6 | O-ring | | | |

94114-KJ Kit with back-up and O-rings for double pre-tensioning Jack

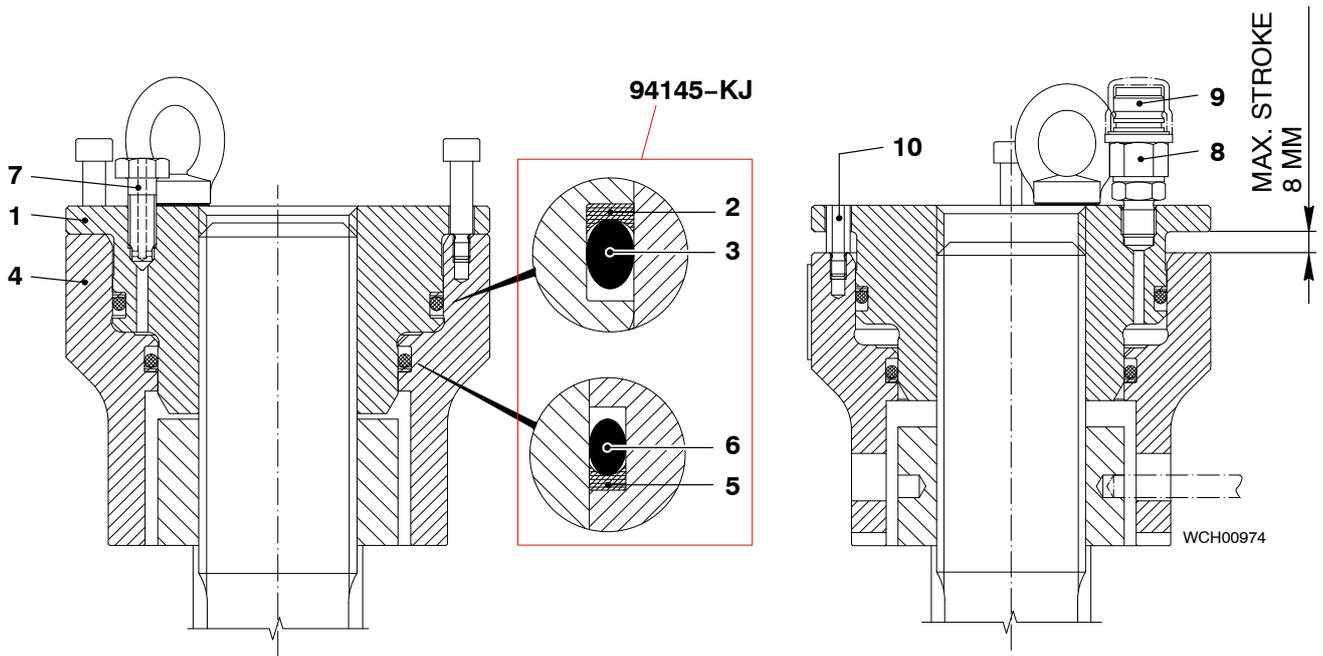


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94145 Pre-tensioning jack for foundation bolt and engine stay

- | | | |
|----------------|----------------|-----------------|
| 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 | | |

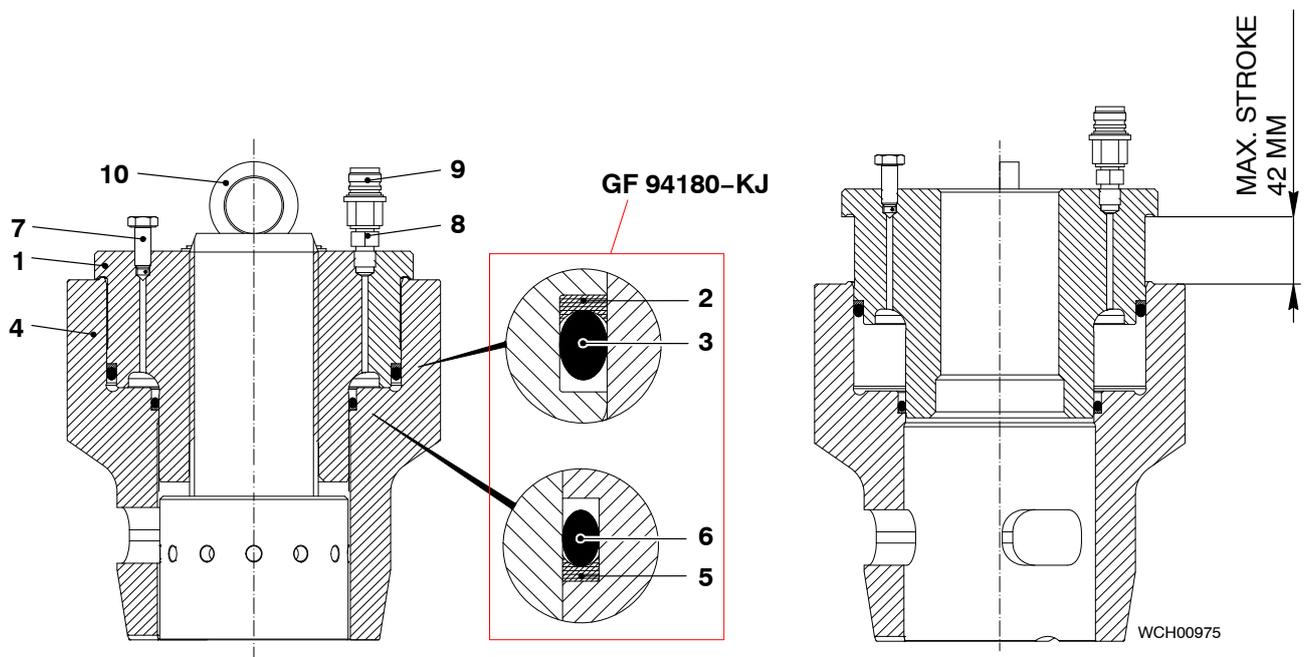
94145-KJ Kit with back-up and O-rings for pre-tensioning Jack



Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool GF 94180 Pre-tensioning jack for tie rod

- | | | | | |
|---|--------------|----------------|----|---------------|
| 1 | Piston | | 7 | Vent screw |
| 2 | Back-up ring | } Sealing ring | 8 | Adapter piece |
| 3 | O-ring | | 9 | Closing valve |
| 4 | Cylinder | | 10 | Eyelet |
| 5 | Back-up ring | } Sealing ring | | |
| 6 | O-ring | | | |

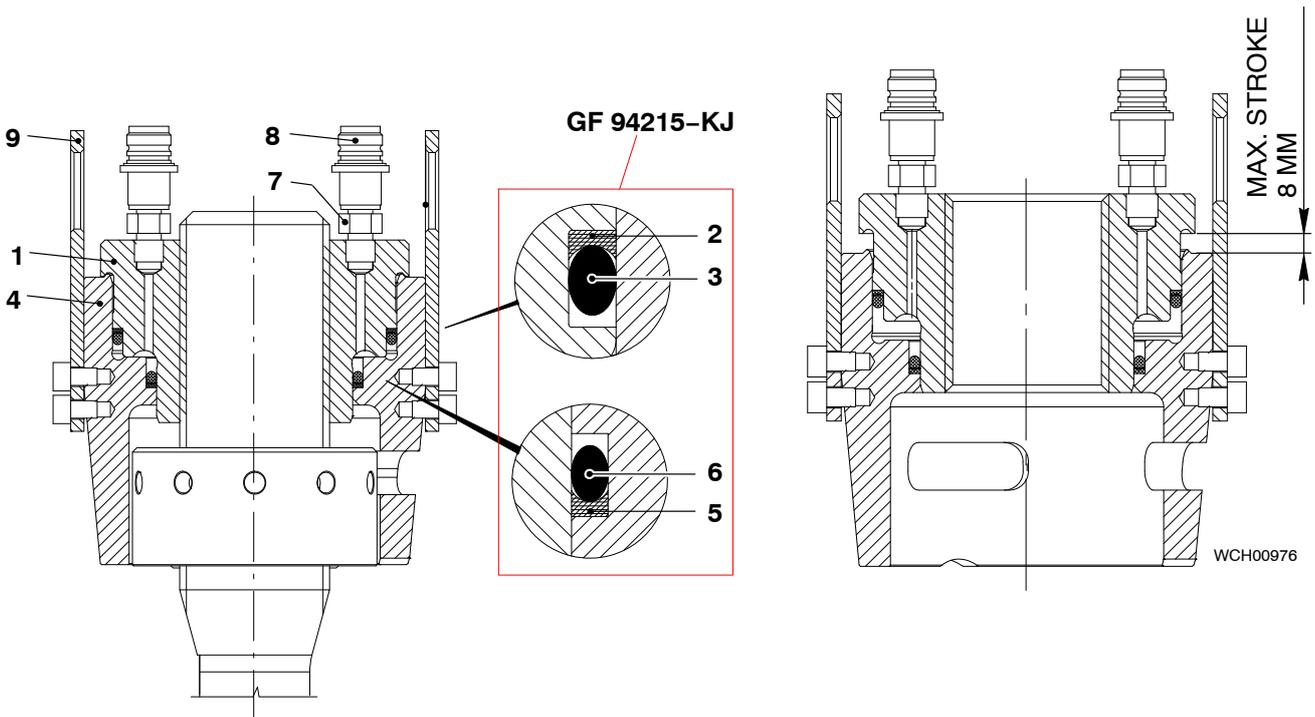
GF 94180-KJ Kit with back-up and O-rings for pre-tensioning Jack

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool GF 94215 Pre-tensioning jack for elastic bolt to cylinder cover

- | | | | | |
|---|--------------|----------------|---|---------------|
| 1 | Piston | | 7 | Adapter piece |
| 2 | Back-up ring | } Sealing ring | 8 | Closing valve |
| 3 | O-ring | | 9 | Eyelet |
| 4 | Cylinder | | | |
| 5 | Back-up ring | } Sealing ring | | |
| 6 | O-ring | | | |

GF 94215-KJ Kit with back-up and O-rings for pre-tensioning Jack

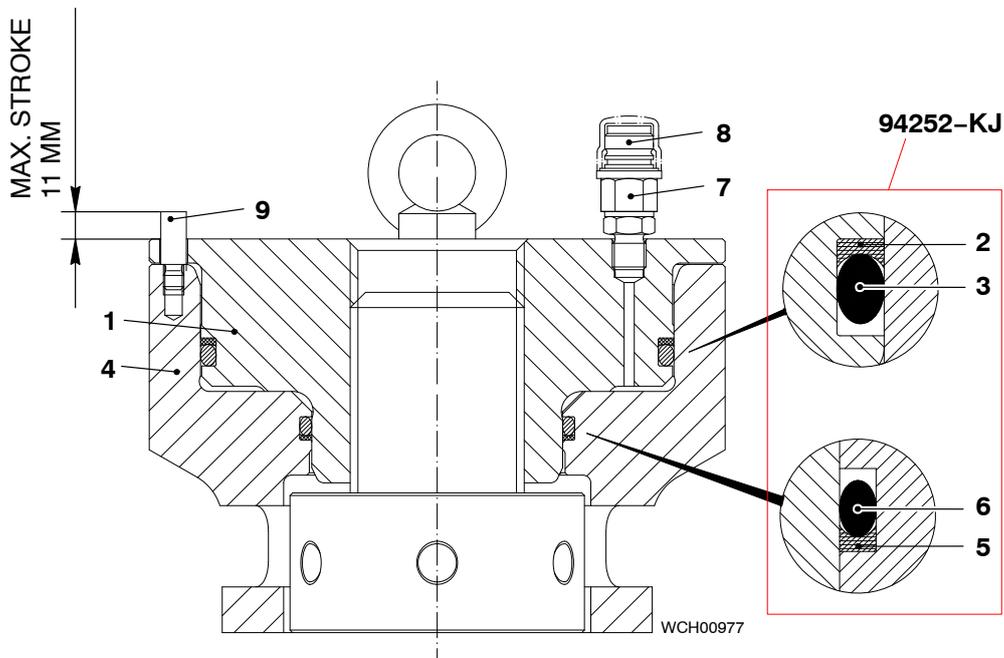


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94252 Pre-tensioning jack for elastic bolt to exhaust valve cage

- | | | | | |
|---|--------------|----------------|---|---------------|
| 1 | Piston | | 7 | Adapter piece |
| 2 | Back-up ring | } Sealing ring | 8 | Closing valve |
| 3 | O-ring | | 9 | Control pin |
| 4 | Cylinder | | | |
| 5 | Back-up ring | } Sealing ring | | |
| 6 | O-ring | | | |

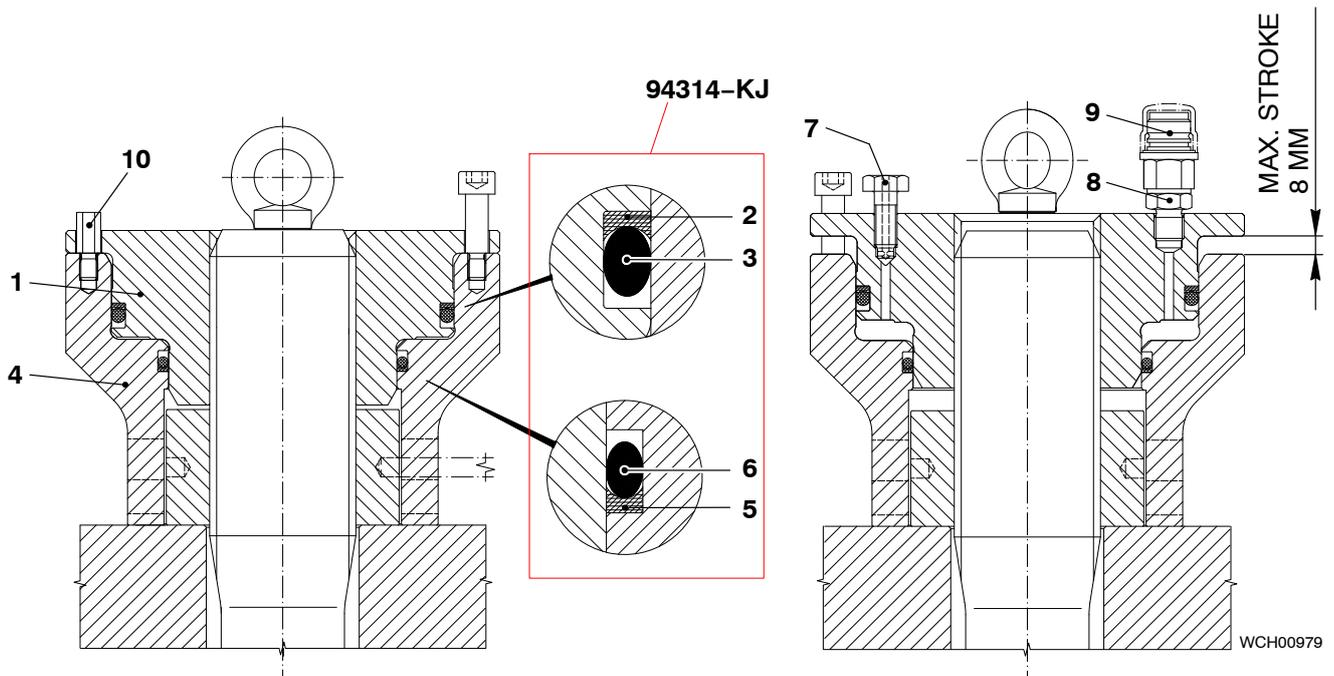
94252-KJ Kit with back-up and O-rings for pre-tensioning Jack



Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94314 Pre-tensioning jack for elastic bolt to bottom 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 | | | |

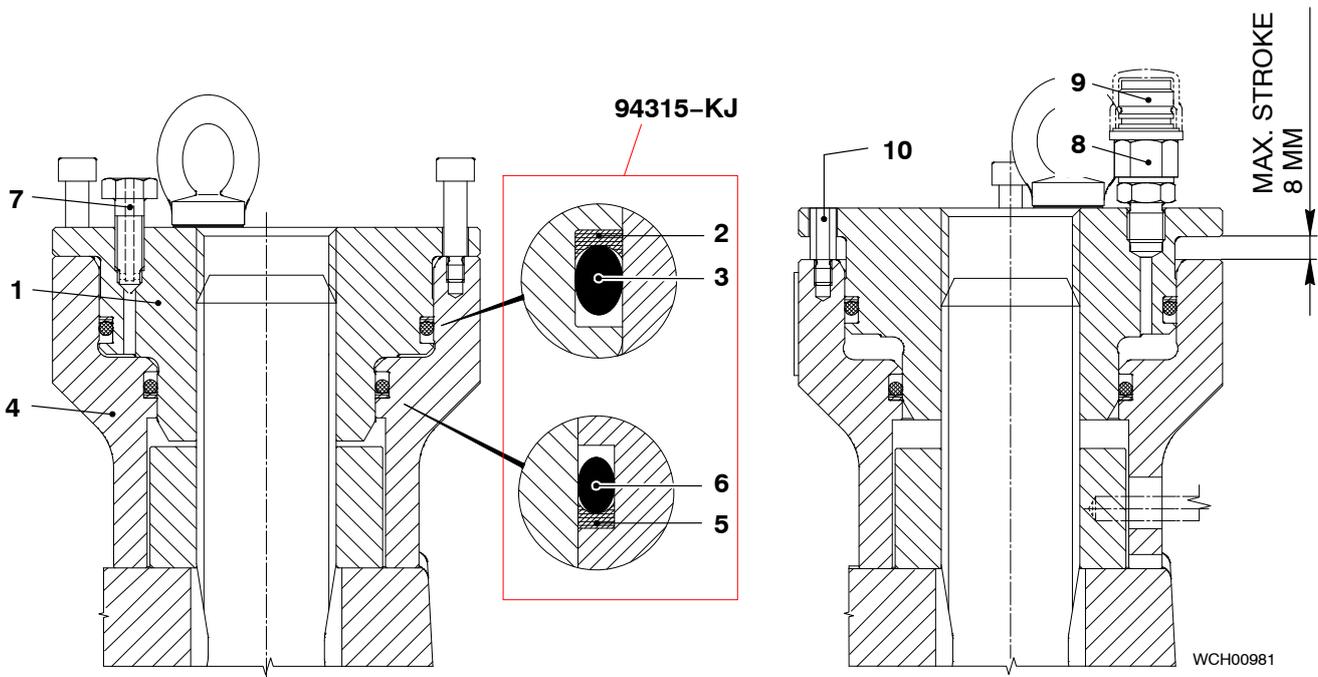
94314-KJ Kit with back-up and O-rings for pre-tensioning Jack

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 | | |

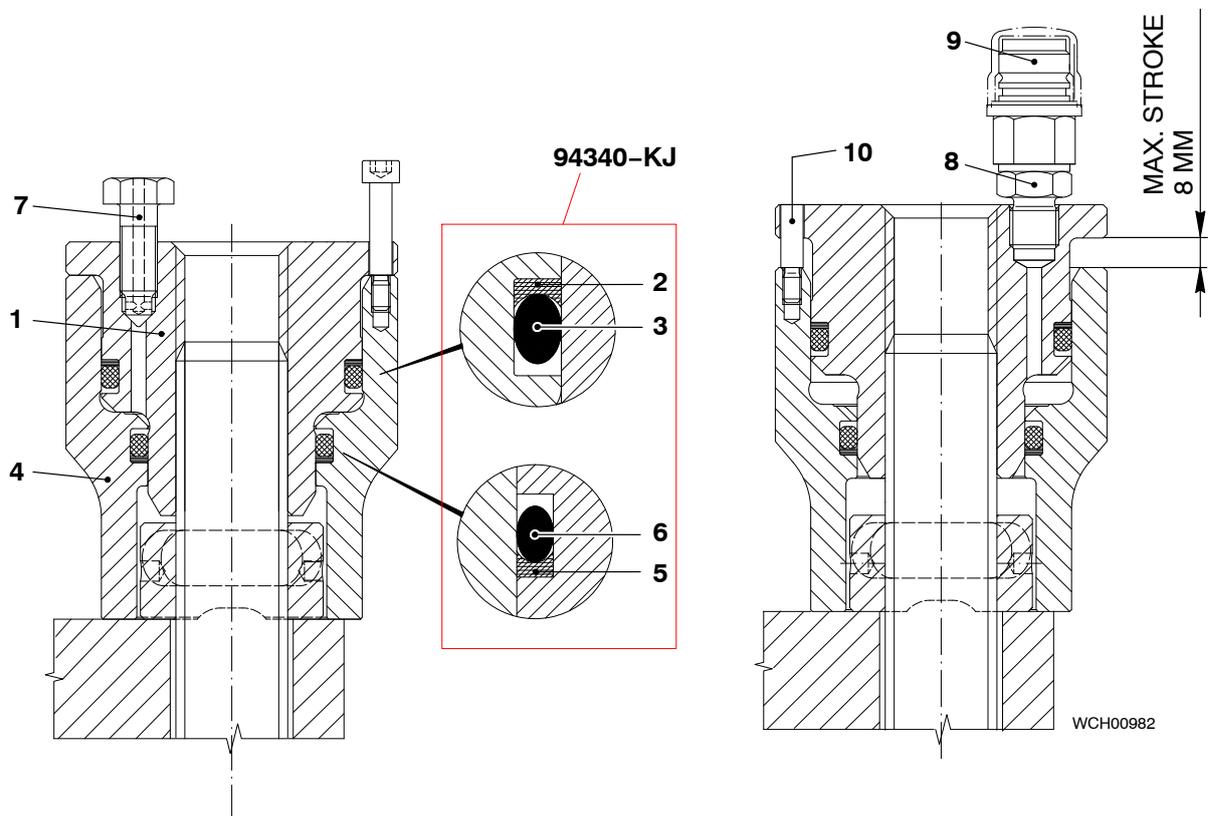
94315-KJ Kit with back-up and O-rings for pre-tensioning Jack



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 Kit with back-up and O-rings for pre-tensioning Jack

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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		BN Limiting groove
Foundation bolt and engine stay	94145	CP Control pin
Exhaust valve cage	94252	KO Slot
Connecting rod, bottom end bearing	94314	RS Round bar
Connecting rod, top end bearing	94315	SA Gap
Piston rod foot	94340	

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.



CHECK

Risk of accident! Always use gloves, a face shield and wear safety goggles when working with hydraulic tools.

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 [° \pm , mm]	Reset of jack [turns]
1112-1	94145	(1 st step 600) 1000	-	1/2
1132-1	94114	1500	-	3/4
1715-1	94145	150	-	1/2
1903-1	GF 94180	(1 st step 100) 1500	from 100 to 1500 bar 14.5...16.5 mm	3 1/2
2708-2	GF 94215	1500	380°	1
2751-1	94252	1000	165°	3/4
3303-1	94314	(1 st step 300) 1000	1 st to 2 nd step 60°	1/2
	94315	(1 st step 600) 1000	1 st to 2 nd step 25°	1/2
3401-1	94340	(1 st step 600) 1000	1 st to 2 nd step 25°	1/2

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.

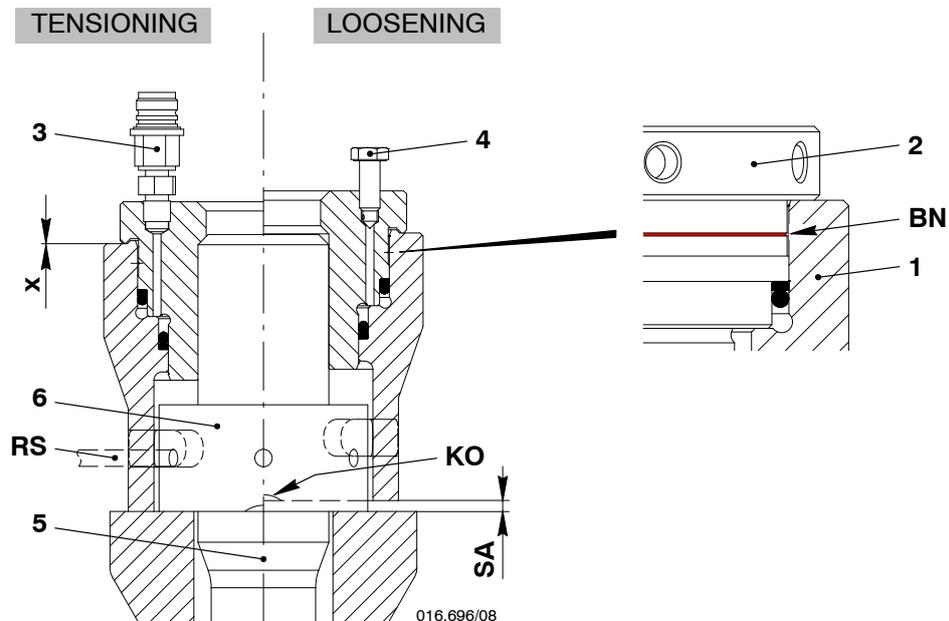


Never move piston 2 of the pre-tensioning jack further up than to the red limiting groove 'BN'.

- ⇒ Release the pressure at HP oil pump or hydraulic unit to zero and remove the jack.

A

PRE-TENSIONING JACK SCREWED ON FOR



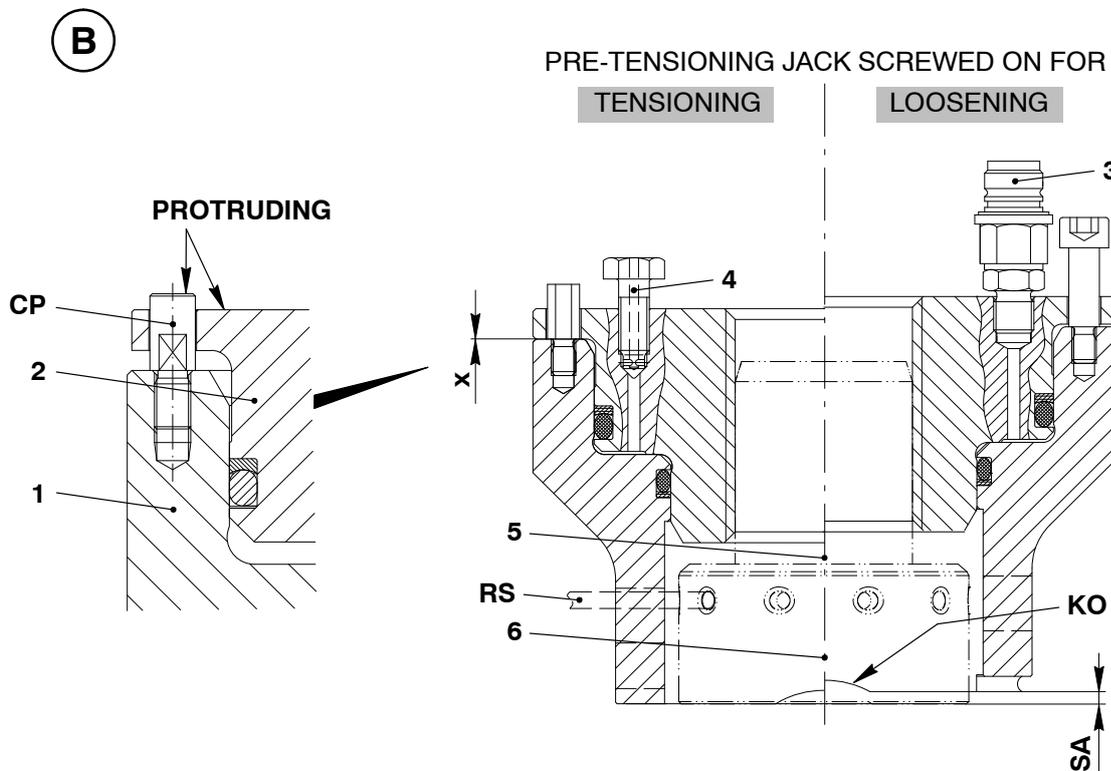
2.2. Loosening procedure -> jack with control pin

- ⇒ 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.



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.



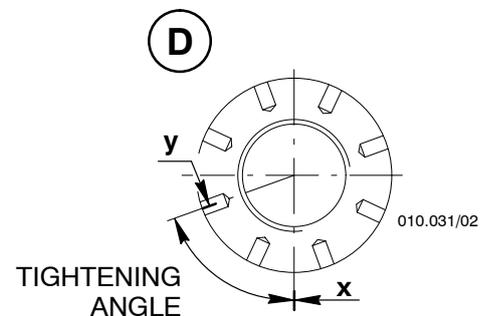
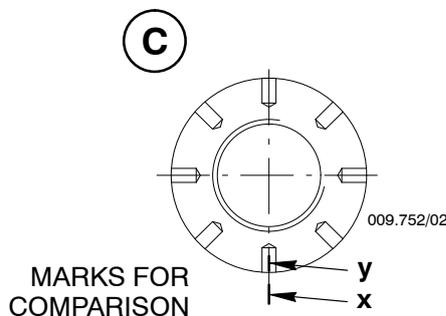
Never move piston 2 of the pre-tensioning jack further up than to the red limiting groove 'BN' (Fig. 'A').

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.



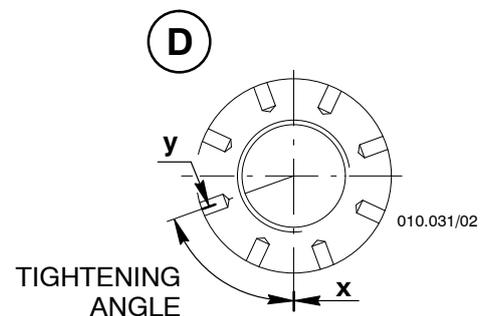
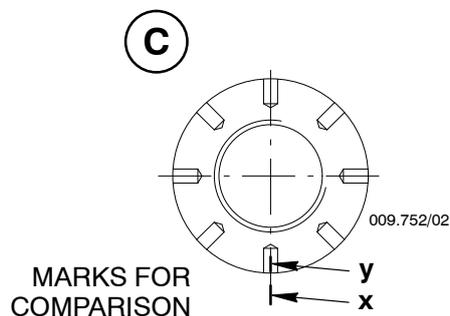
Control pin 'CP' must always protrude over the top edge of piston 2 (Fig. 'B'). When the pin is flush with the top edge of the piston the maximum stroke of the piston is reached. Therefore do not continue to operate the pre-tensioning jack!

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.

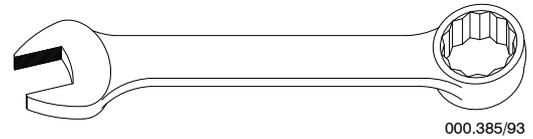


Tool List

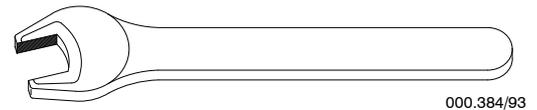
Standard Tools

94000**Combination wrenches**

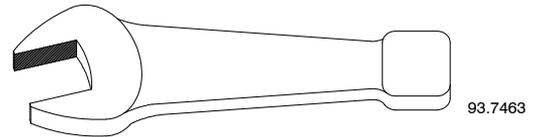
94000-36	2 Pieces AF36
94000-41	2 Pieces AF41
94000-46	2 Pieces AF46
94000-50	2 Pieces AF50
94000-55	2 Pieces AF55
94000-60	2 Pieces AF60

**94001****Open end wrenches**

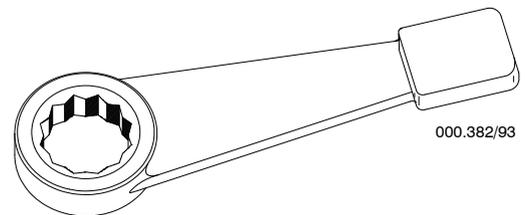
94001-65	1 Piece AF65
94001-70	1 Piece AF70
94001-75	1 Piece AF75
94001-80	1 Piece AF80
94001-85	1 Piece AF85
94001-110	1 Piece AF110

**Slugging open end wrench**

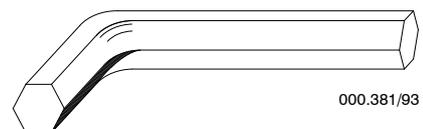
94001A-110	1 Piece AF110
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**94002****Ring slugging wrenches**

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**

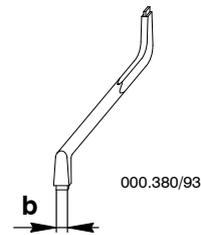
94003-5	1 Piece AF5
94003-6	1 Piece AF6
94003-8	1 Piece AF8
94003-10	1 Piece AF10
94003-12	1 Piece AF12
94003-14	1 Piece AF14
94003-17	1 Piece AF17
94003-19	1 Piece AF19
94003-22	1 Piece AF22
94003-24	1 Piece AF24
94003-27	1 Piece AF27



Standard Tools

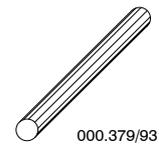
94004**Angle screwdrivers**

94004-10	1 Piece b = 10 mm
94004-12	1 Piece b = 12 mm
94004-25	1 Piece b = 25 mm

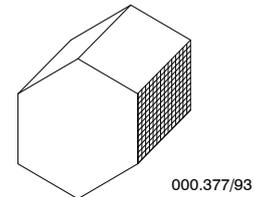
**94005****Rod**

for pre-tensioning jacks

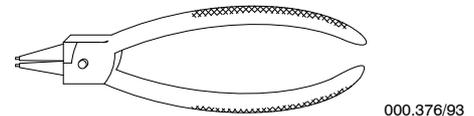
94005D	3 Pieces Ø 7 mm
94005E	3 Pieces Ø 7.5 mm
94005F	3 Pieces Ø 9 mm
94005G	3 Pieces Ø 15 mm

**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**

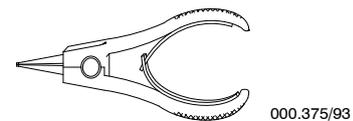
1 Piece Type A 10

94007-A19

1 Piece Type A 19

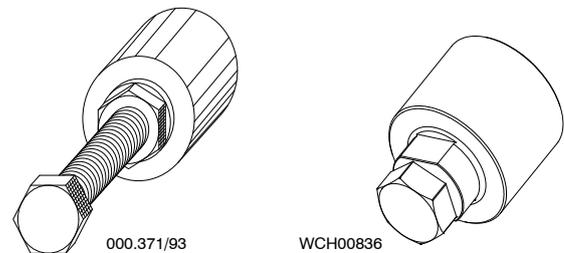
94007-A40

1 Piece Type A 40

**94008****Withdrawing gears**

for taper & cylindrical dowels and pins

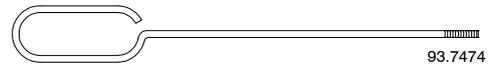
94008-M4	1 Piece M4
94008-M5	1 Piece M5
94008-M6	1 Piece M6
94008-M8	1 Piece M8
94008-M10	1 Piece M10
94008-M12	1 Piece M12
94008-M20	1 Piece M20
94008A-M68	1 Piece M68



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



93.7474

94010

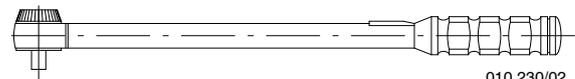
- 1 Torque spanner $\frac{3}{8}$ "**
(Range of adjustment 2–25 Nm)
94010A Adapter piece $\frac{3}{8}$ "– $\frac{1}{2}$ "



010.229/02

94011

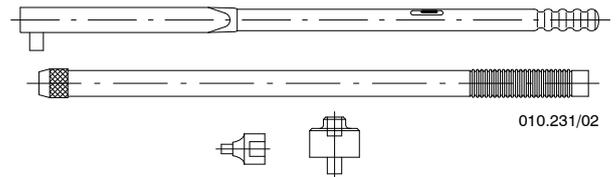
- 1 Torque spanner $\frac{1}{2}$ "**
(Range of adjustment 20–200 Nm)



010.230/02

94012

- 1 Torque spanner**
Consisting of:
adapter piece $\frac{3}{4}$ "– $\frac{1}{2}$ ",
shell type ratchet $\frac{3}{4}$ "– $\frac{3}{4}$ "
94012A
94012B
94012C **Torque spanner $\frac{3}{4}$ "**
(Range of adjustment 140–760 Nm)
with extension tube and tool box

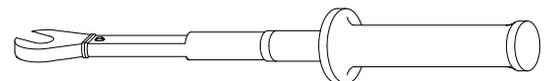


010.231/02

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



99.7495

94016

- 2 Manual ratchets**
(WLL 800 kg)

94016A

- 2 Manual ratchets**
(WLL 1600 kg)

94016D

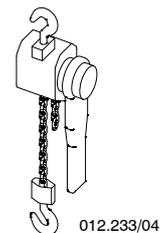
- 2 Manual ratchets**
(WLL 1000 kg)

94016E

- 2 Manual ratchets**
(WLL 2500 kg)

94016G

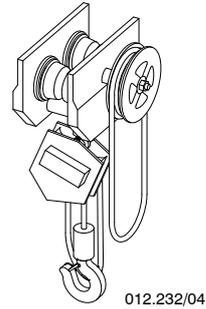
- 2 Manual ratchets**
(WLL 250 kg)



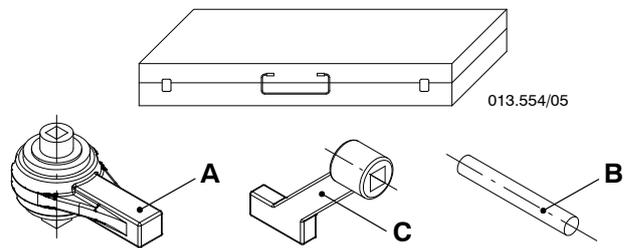
012.233/04

Standard Tools

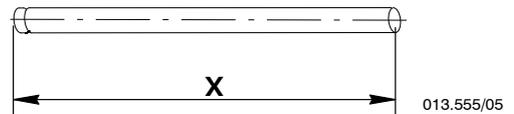
- 94017A - Spur-gearred chain block platform with crane rail (WLL 3000 kg)



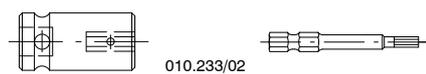
- GF 94020** 1 **Tool box** consisting of:
 - GF 94020A 1 Power amplifier (with transmission factor 1:5)
 - GF 94020B 1 Short backing rod
 - GF 94020C 1 Angle
 - GF 94020D 1 Case



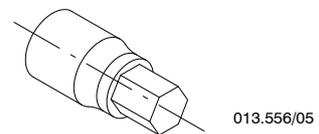
- GF 94021 1 **Large backing rod** to power amplifier X = 540 mm



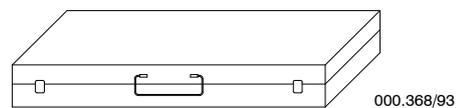
- 94022 1 **Adapter piece** consisting of:
 - 94022A 1 **Socket wrench insert** AF3
 - 94022B 1 **Adapter piece** 3/8" - 1/4"



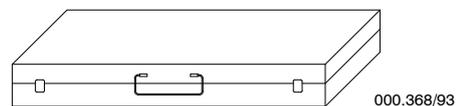
- GF 94023 1 **Hex head driver** 1" AF 22
- GF 94024 1 **Hex head driver** 1/2" AF 19



- 94025** 1 **Tool box with socket wrench set** 1/2"



- 94026** 1 **Tool box with hex. head drivers** 1/2"

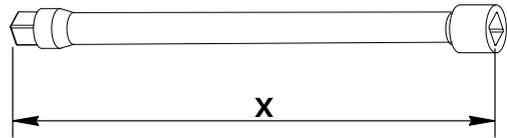


Standard Tools

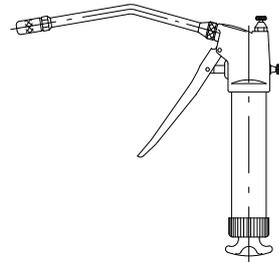
GF 94027**4 Extensions**

for intermediate wheel assembly

X = 250 mm

**94032****1 High pressure grease gun**

for lubricating grease nipples on fuel pump regulating linkage



000.370/93

94040**RUD-eye bolts****94040-M16**

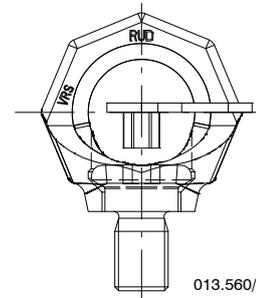
2 Pieces M16

94040-M20

6 Pieces M20

94040-M30

2 Pieces M30



013.560/05

94045**Eye bolts****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

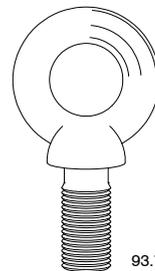
8 Pieces M36

94045-M42

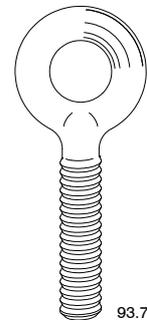
8 Pieces M42

94045-M48

4 Pieces M48



93.7472



93.7468

Eye screw**94045A-M16**

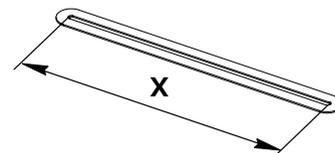
6 Pieces M16x145

94049**Round sling****94049**

2 Pieces 0.5 m (WLL 1000 kg)

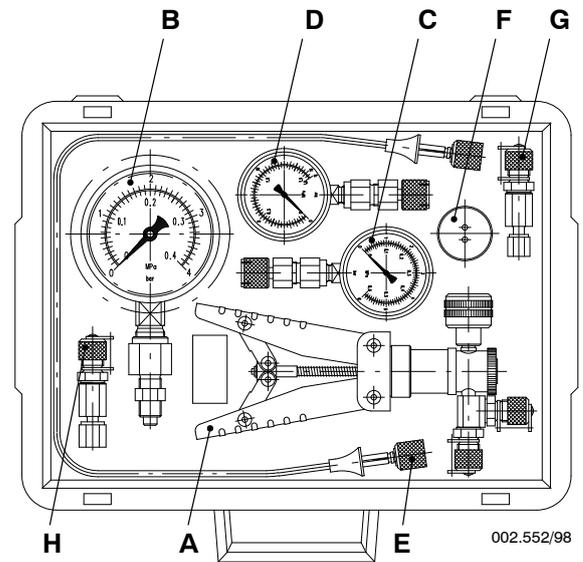
94049A

2 Pieces 1 m (WLL 1000 kg)



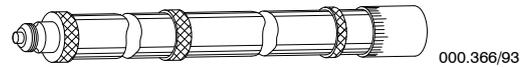
Standard Tools

- 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

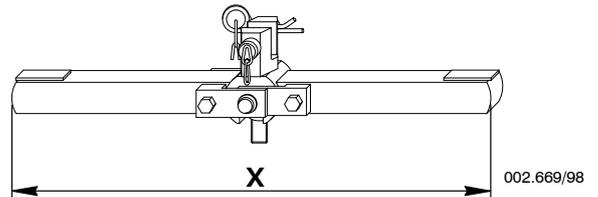
- 94101** **1 Inside micrometer**
with case
(Measuring range 50–1010 mm)



- 94101A** **1 Extension**
Length of 480 mm

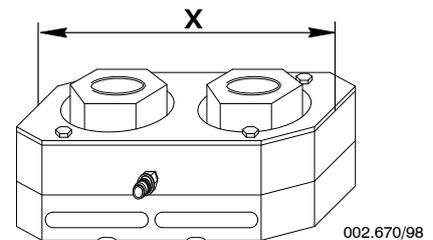


- 94111** **1 Lifting device**
for removal and fitting of
main bearing cover
X = 733.4 mm

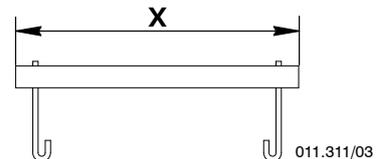


- 94114** **2 Double pre-tensioning jacks**
for elastic studs to main bearing,
including a metal box
X = 254 mm

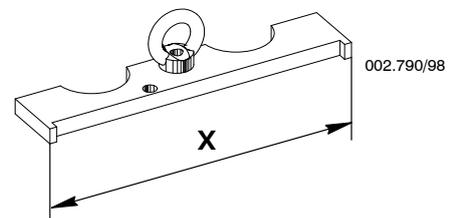
- 94114-KJ** **1 Kit with back-up and O-rings**
for pre-tensioning Jack



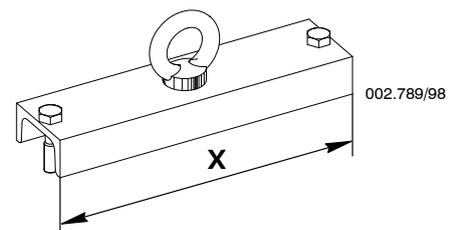
- 94114A** **1 Assembly tool**
for transporting double pre-tensioning
jacks 94114
X = 320 mm



- 94115** **1 Guide**
for removal main bearing shell
X = 252 mm

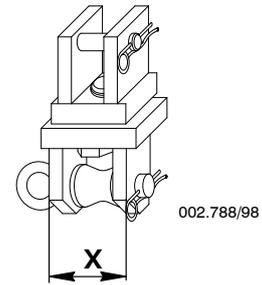


- 94116** **1 Lifting tool**
for removal main bearing
X = 246 mm

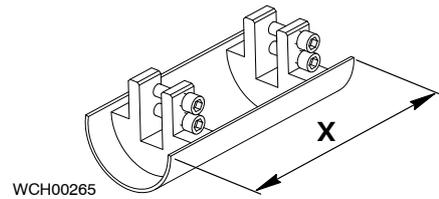


Standard Tools

- 94117** **1 Roller support**
 for removal and fitting of main bearing
 X = 74 mm

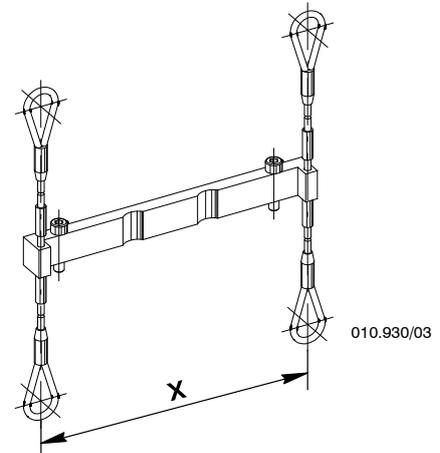


- GF 94117A** **1 Deviation pipe**
 for removal and fitting of:
 - main bearing cover, shell
 - crosshead pin
 X = 300 mm

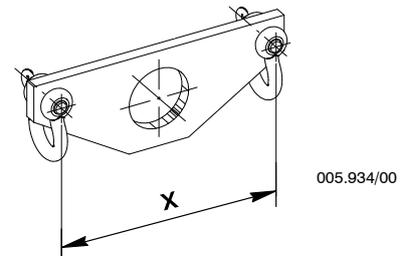


- 94118** **1 Turning-out device**
 for removal and fitting of
 main bearing shell
 X = 232 mm (for girder width 210 mm)

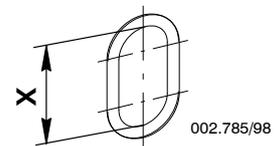
- 94118A** **1 Turning-out device**
 for removal and fitting of
 main bearing shell
 X = 252 mm (for girder width 230 mm)



- 94119** **1 Lifting yoke**
 for removal and fitting of
 main bearing shell
 X = 210 mm

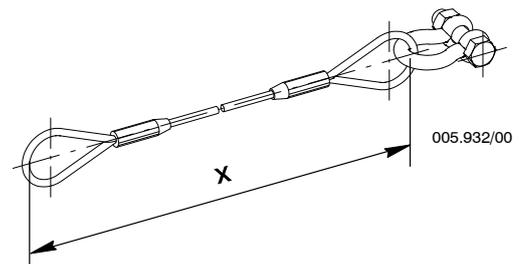


- 94120** **1 Eyelet (WLL 1500 kg)**
 for removal and fitting of
 main bearing cover
 X = 127 mm

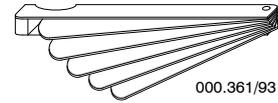


Ropes with shackle (WLL 500 kg)
 for removal and fitting of
 main bearing cover and shell

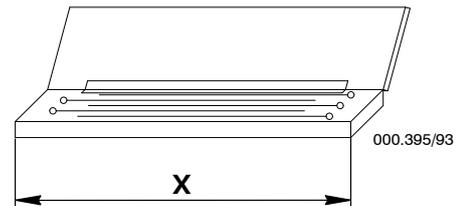
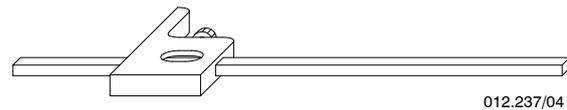
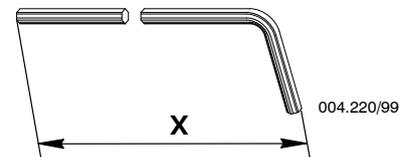
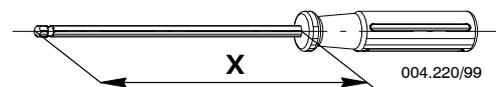
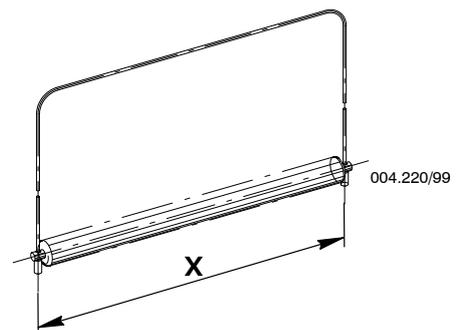
- 94120B** 1 Piece x = 500 mm
94120C 1 Piece x = 800 mm
94120E 1 Piece x = 1350 mm
94120F 1 Piece x = 1500 mm
94120G 1 Piece x = 1600 mm



Standard Tools

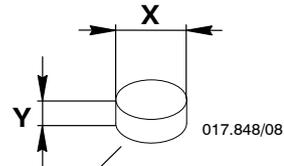
94122 1 Feeler gauge**94123 1 Special feeler gauge**

for main bearing
X = 625 mm

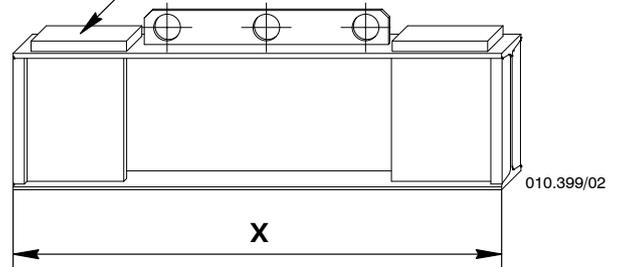
**94124 1 Depth gauge**
measuring range 250 mm**94128 1 Allen wrench**
for Allen screw to main bearing
X = 680 mm**94129 1 Hexagon screwdriver**
for screws to turning-out device 94118
X = 160 mm**94130 1 Cleaning tool**
for cleaning main bearing bore
X = 238 mm

Standard Tools

- 94141** **1 Support**
for removal and fitting
of main bearing shells
X = 870 mm



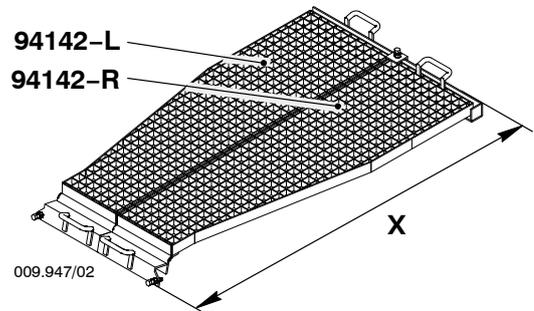
- 94141A** **2 Ground plates**
X = Ø 100 mm
Y = 50 mm



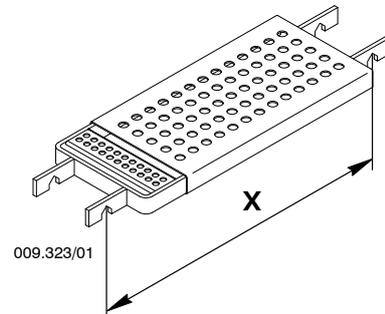
Working platform

X = 1532 mm

- 94142-L** **1 Grid left side**
- 94142-R** **1 Grid right side**

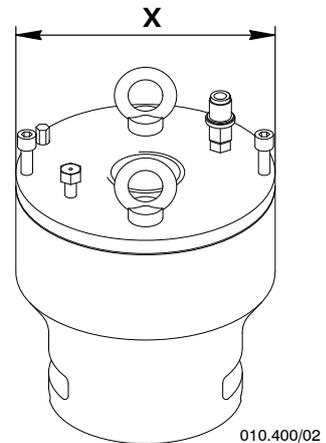


- 94143** **2 Working supports**
X = 570-680 mm



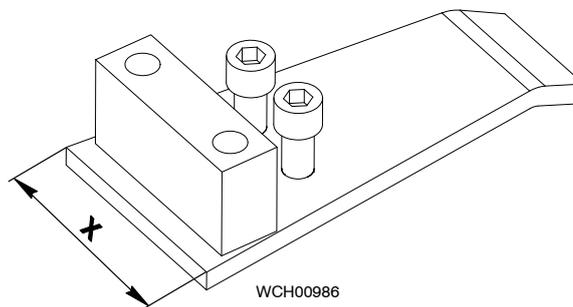
- 94145** **1 Pre-tensioning jack**
for foundation bolts and engine stays,
including a metal box
X = 150 mm

- 94145-KJ** **1 Kit with back-up and O-rings**
for pre-tensioning Jack

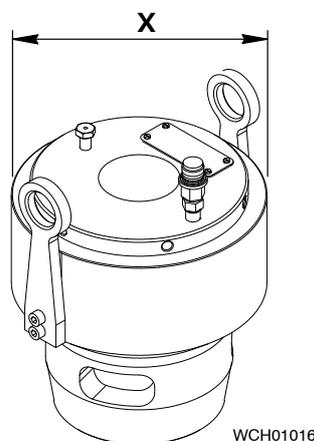


Standard Tools

- GF 94155** **1 Turning-out device**
 with screws
 for turning out thrust bearing pads
 (with 1-part gear wheel)
 X = 178 mm



- GF 94180** **2 Pre-tensioning jacks**
 for tie rods,
 including a metal box
 X = Ø 246 mm



- GF 94180-KJ** **1 Kit with back-up and O-rings**
 for pre-tensioning Jack

- GF 94201** **1 Device**
 for fitting and transporting a cylinder
 liner, consisting of:

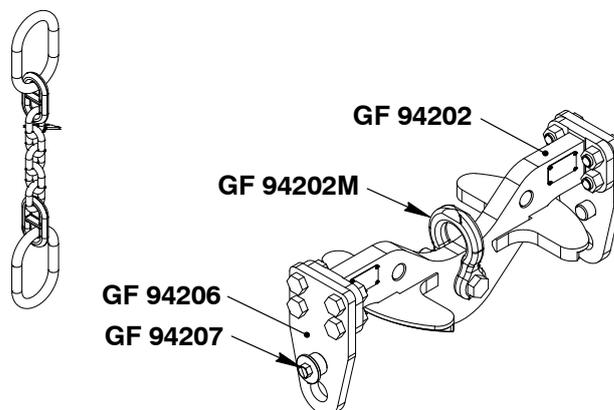
- GF 94202** **1 Lifting tool**
 X = 1040 mm
 (WLL 4000 kg)

- GF 94202L** **1 Chain**
 (WLL 4000 kg)

- GF 94202M** **1 Shackle**
 (WLL 13500 kg)

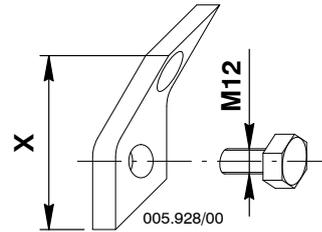
- GF 94206** **2 Holders**
 with 8 screws M30x84 and nuts

- GF 94207** **2 Special screws M42**

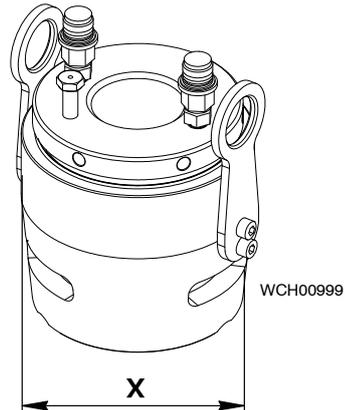


Standard Tools

- 94208** **4 Suspension straps**
 for removal and fitting of
 antipolishing ring
 X = 88 mm

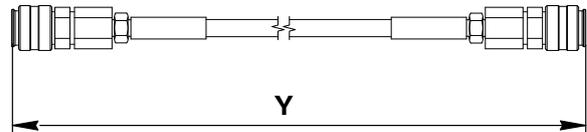


- GF 94215** **8 Pre-tensioning jacks**
 for cylinder cover
 including a metal box
 X = 167 mm

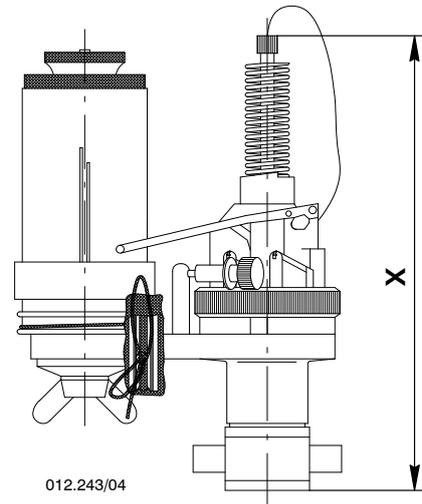


- GF 94215K** **7 High pressure hoses**
 Y = 1328 mm

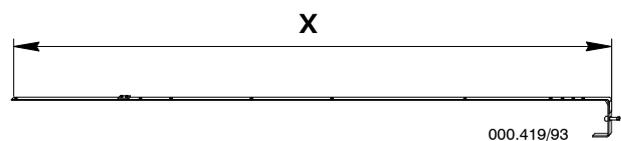
- GF 94215-KJ** **1 Kit with back-up and O-rings**
 for pre-tensioning Jack



- 94219** **1 Cylinder pressure measuring tool (indicator),**
 including a wooden box
 X = 165 mm

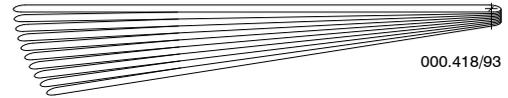


- 94225** **1 Measuring gauge**
 for measuring cylinder liner bore
 (accessory for it:
 inside micrometer tool 94101)
 X = 2820 mm



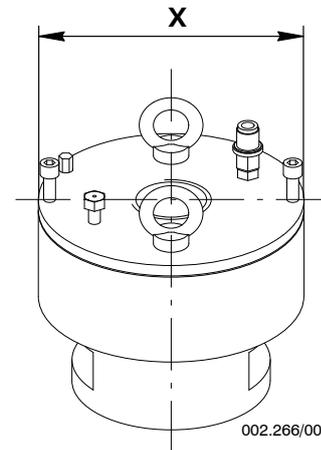
Standard Tools

- 94238** **1 Feeler gauge**
 (10-part)
 for checking bearing clearances
 Leaf length = 600 mm

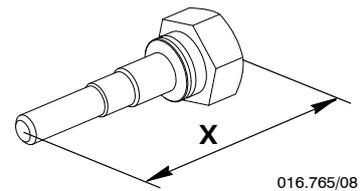


- 94252** **2 Pre-tensioning jacks**
 for exhaust valve cage
 including a metal box
 X = 225 mm

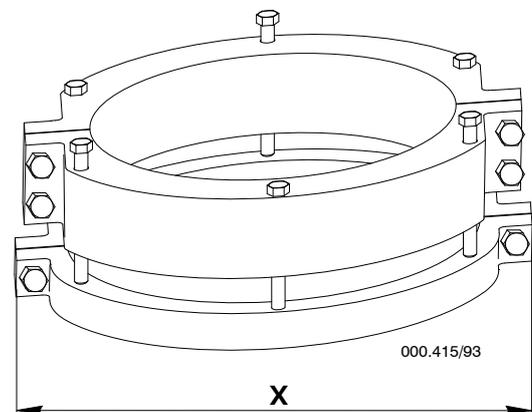
- 94252-KJ** **1 Kit with back-up and O-rings**
 for pre-tensioning Jack



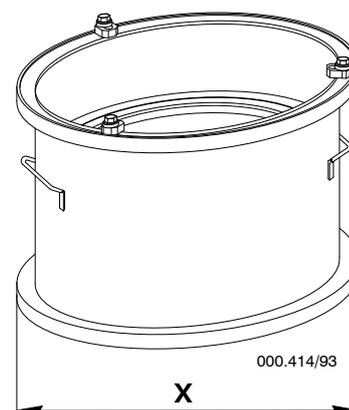
- GF 94259** **1 Pressure element**
 for exhaust valve
 with an O-ring
 X = 247.7 mm



- 94261** **1 Valve seat fitting and extracting device**
 X = 555 mm

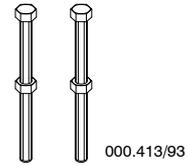


- 94262** **1 Valve protector**
 (only to be applied for transporting a
 complete exhaust valve)
 X = 500 mm



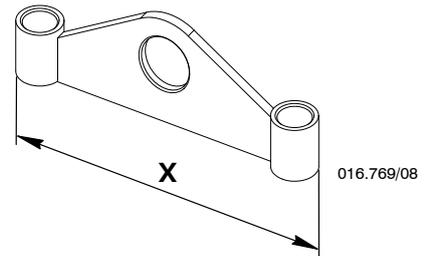
Standard Tools

- 94263** **2 Jack screws with nuts**
to guide bush for exhaust valve
M10x120



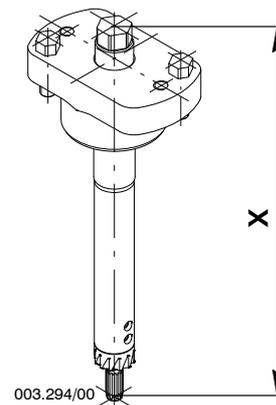
000.413/93

- GF 94265** **1 Suspension device**
for cylinder cover
X = 690 mm



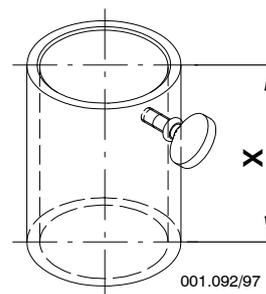
016.769/08

- 94270** **1 Device**
for overhauling injection valve seat in
cylinder cover
X = 344 mm



003.294/00

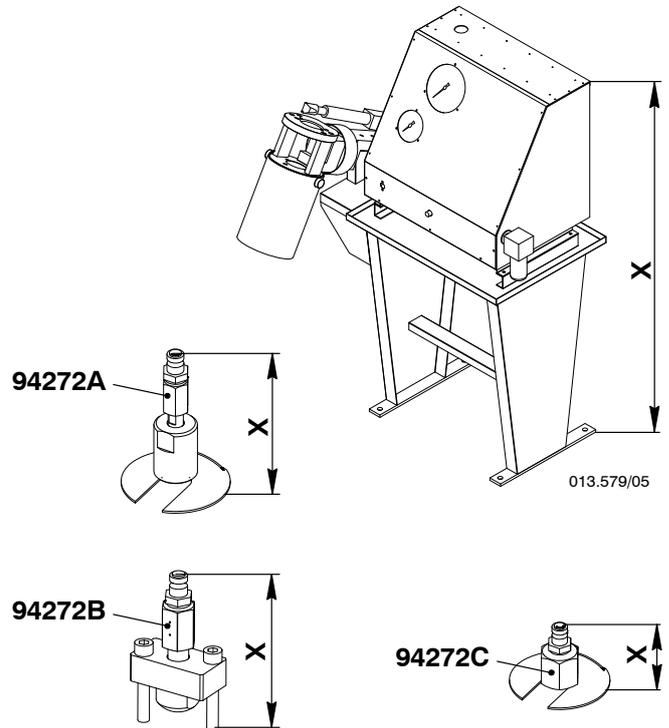
- 94271** **Protection cap**
for injection valve
(1 piece each nozzle)
X = 85 mm



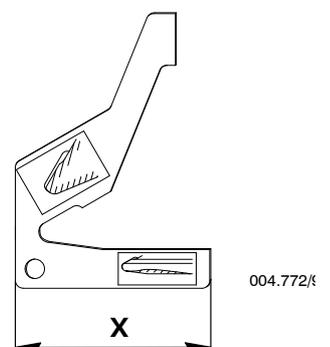
001.092/97

Standard Tools

- 94272** **1 OBEL test bench**
for setting and testing of:
– injection valve
– relief valve (cylinder cover)
– relief valve (PCV)
X = 1458 mm
including:
- 94272A** **1 Valve holder**
for checking and adjusting relief
valve
X = 149 mm
- 94272B** **1 Connecting piece**
for adjusting the injection valve
X = 124 mm
- 94272C** **1 Valve holder**
for checking and adjusting
relief valve to cylinder cover
X = 68 mm
- 94279** **1 Gauge**
for checking wear and burn scar on
exhaust valve seat
X = 184 mm

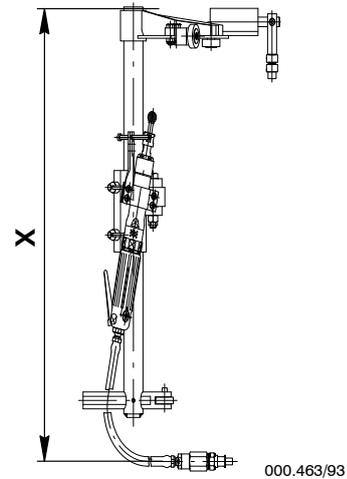


- 94292** **1 Gauge**
for checking wear on disc of
exhaust valve spindle
X = 180 mm

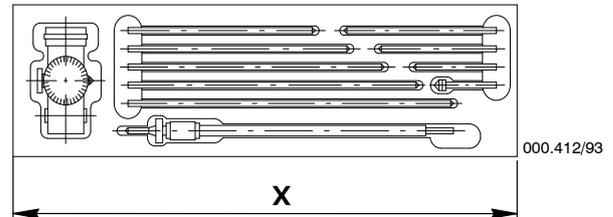


Standard Tools

- 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

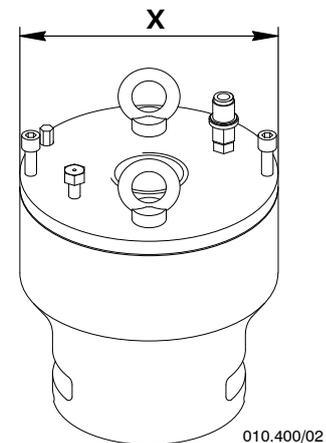


- 94314** **2 Pre-tensioning jacks**
for connecting rod studs to
bottom end bearing,
including a metal box
X = 190 mm

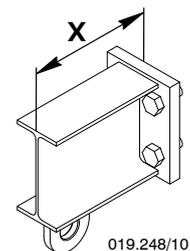
- 94314-KJ** **1 Kit with back-up and O-rings**
for pre-tensioning Jack

- 94315** **2 Pre-tensioning jacks**
for connecting rod studs to
top end bearing,
including a metal box
X = 147 mm

- 94315-KJ** **1 Kit with back-up and O-rings**
for pre-tensioning Jack

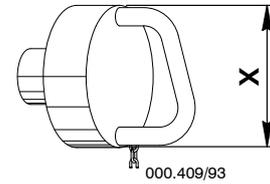


- 94320** **1 Support**
for dismantling and assembling of axial
damper
with 4 screws M24 x 55
X = 220 mm

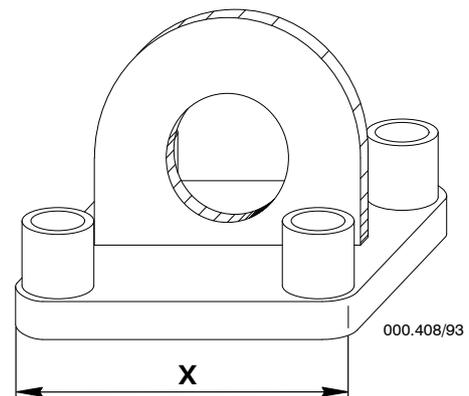


Standard Tools

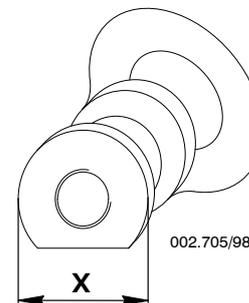
- 94323** **4 Retaining pins**
to prop up crosshead guide shoes
when removing or fitting a connecting
rod or a crosshead
X = 85 mm



- 94324** **1 Cover and lifting plate**
to crosshead
X = 255 mm

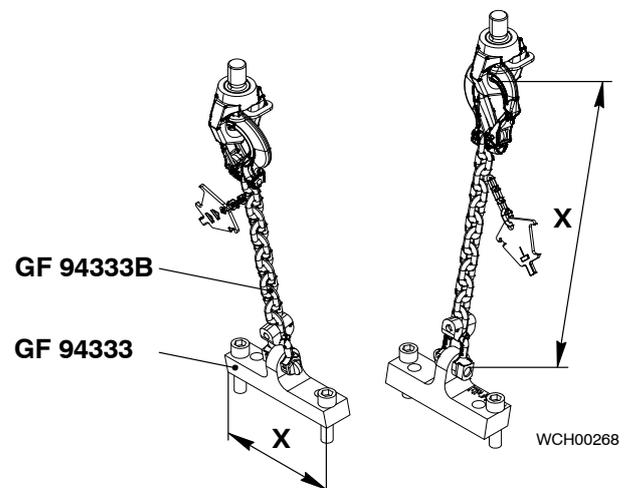


- 94325** **2 Holders**
for removal of a crosshead guide shoe
X = 70 mm



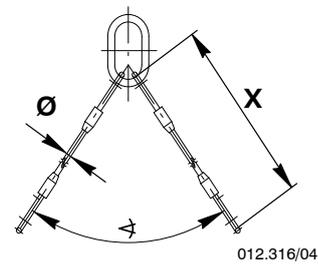
- GF 94333** **1 Lifting tool**
for inspection and removal
of top end bearing
(WLL 1700 kg)

- GF 94333B** **2 Chains**
X = 422 mm
(WLL 2500)

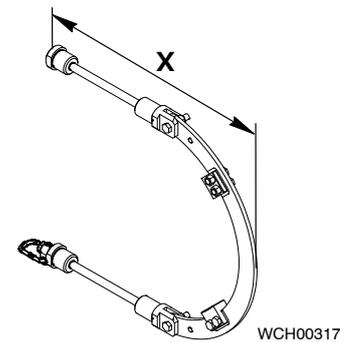


Standard Tools

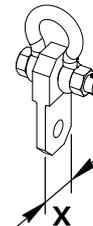
- GF 94333D 1 Wire rope sling**
for removal and fitting
of a crosshead pin,
and an expansion piece
X = 1238 mm
(WLL 1500 kg at \angle 45...60°)



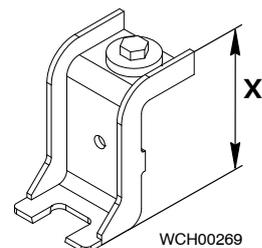
- 94334 1 Holder**
for removal and fitting of connecting rod
including: 2 Fastening shafts
2 Threaded rods
1 Lifting lug
X = 1010 mm



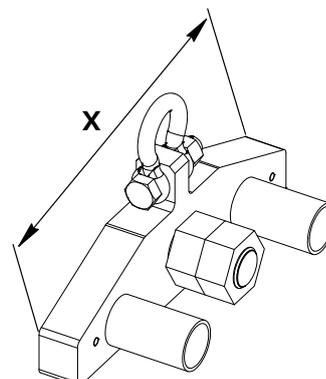
- 94334A 1 Connecting element with shackle**
X = 70 mm



- 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)

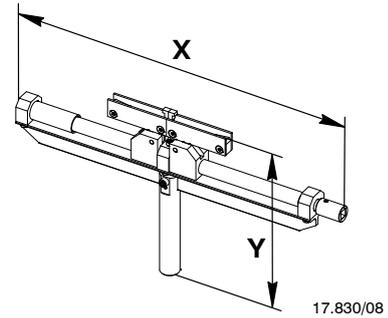


Standard Tools

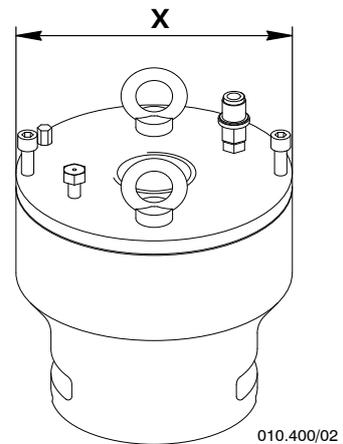
94338 1 Piston ring expander

X = 549.5 mm

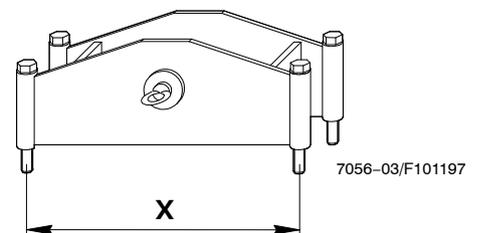
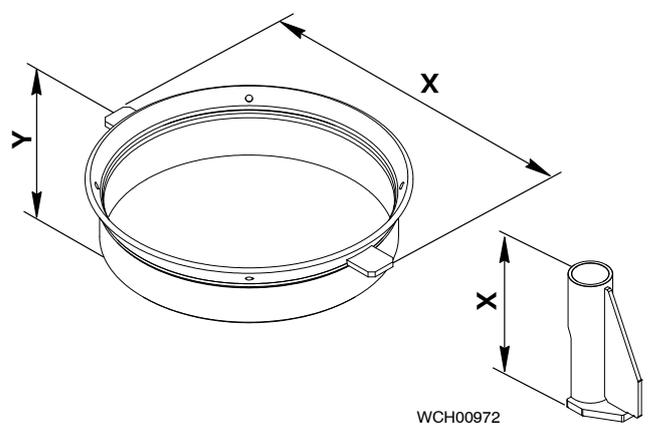
Y = 285.5 mm

**94340 2 Pre-tensioning jacks**
for piston rod screw connection,
including a metal box

X = 110 mm

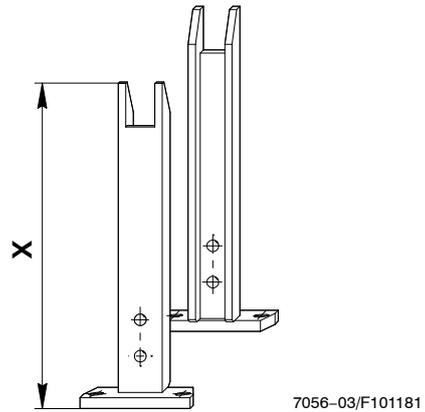
94340-KJ 1 Kit with back-up and O-rings
for pre-tensioning Jack**94341 1 Piston suspension device**

X = 469.8 mm

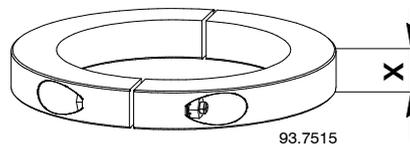
**GF 94342 1 Insertion funnel**
for fitting the piston
X = 761.1 mm
Y = 160 mm
Mass approx. 22 kg**GF 94343 2 Locking devices**
for fastening insertion funnel or
cylinder liner during removing a piston
X = 312 mm

Standard Tools

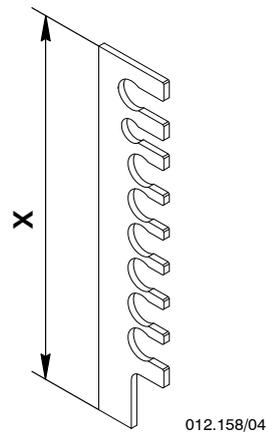
- 94345 2 Distance holders**
 for removal and fitting of piston rod gland and piston
 X = 554 mm



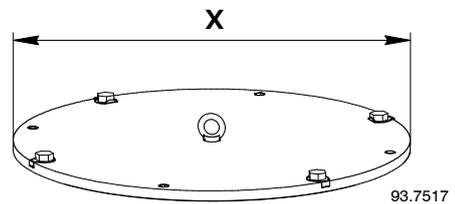
- 94345B 1 Clamping ring**
 X = 55 mm



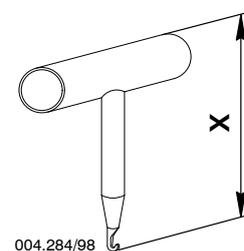
- 94345C 1 Gauge**
 for fitting scraper rings
 X = 366 mm



- 94345D 1 Cover plate**
 for covering bore of piston rod gland in cylinder jacket (when piston and gland are removed)
 X = 475 mm

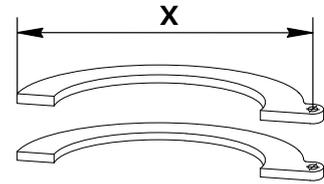


- 94345E 2 Assembly tools**
 for tensioning springs to piston rod gland
 X = 160 mm



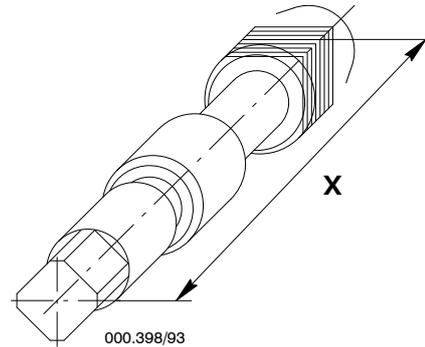
Standard Tools

- 94345F 2 Distance pieces**
for fitting rings to upper gland group
2 pieces each 19 mm
X = 305 mm

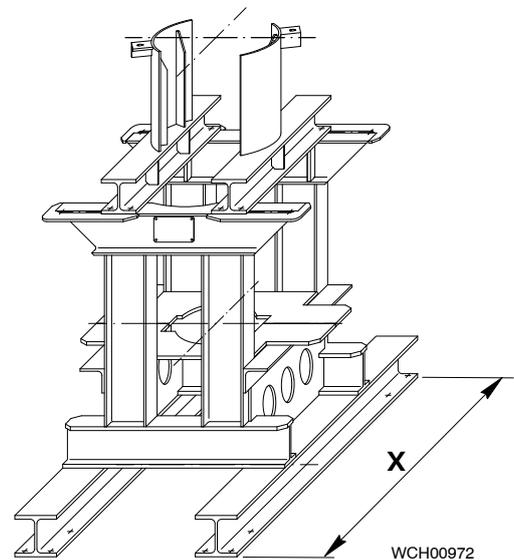


- 94345G 2 Distance pieces**
for fitting rings to upper gland group
2 pieces each 11 mm
X = 305 mm

- 94348 1 Tap M20**
for cleaning carbon deposits in
threaded holes of piston crown
X = 140 mm

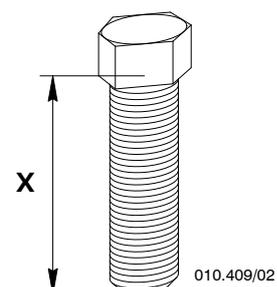


- 94350 1 Device**
for supporting piston and removal of
the piston rod gland
X = 1206 mm



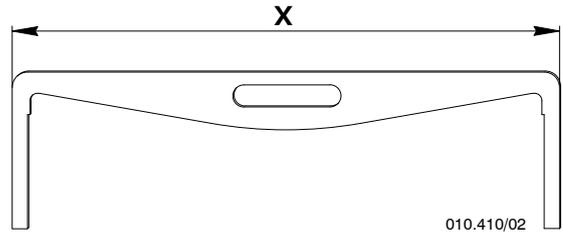
- 94363 2 Jacking screws M10**
for separating piston crown from piston
skirt
X = 40 mm

- 94364 2 Jacking screws M16**
for separating piston skirt from piston
rod
X = 50 mm

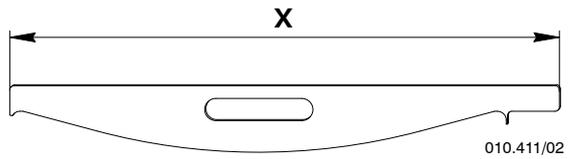


Standard Tools

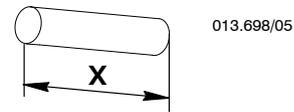
94366 **1 Template**
 for shape of top of piston crown
 X = 634 mm



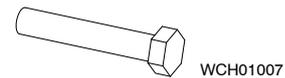
94366A **1 Template**
 for shape of top of piston crown
 (for use with piston in situ)
 X = 640 mm



GF 94410B **2 Pins**
 for intermediate wheel assembly
 X = 170 mm

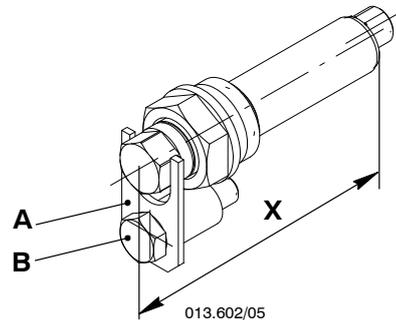


GF 94410C **1 Head bolt M30x150**
 for intermediate wheel assembly

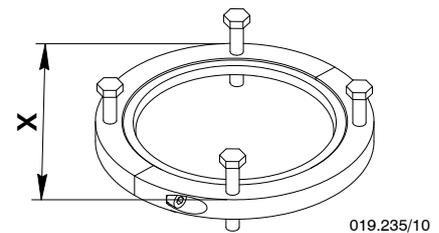


GF 94410D **1 Head bolt M30x170**
 for intermediate wheel assembly

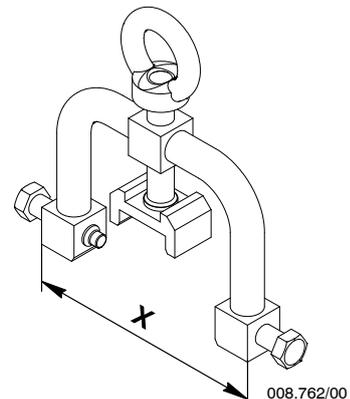
94430 **2 Roller lifting tools**
 for cutting out and cutting in of fuel
 pump
 including:
A 1 claw
B 1 screw M12x45
 X = 136 mm



94550 **1 2-part clamping ring**
 for removal of non-return valve to fuel
 pump with 4 screws M10x60
 X = 164 mm

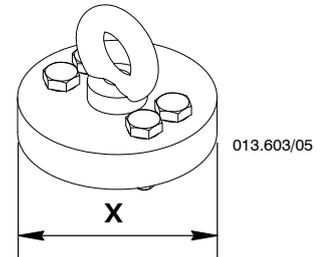


94551 **1 Fitting and dismantling device**
 for removal and fitting of guide pin to
 fuel pump
 X = 255 mm

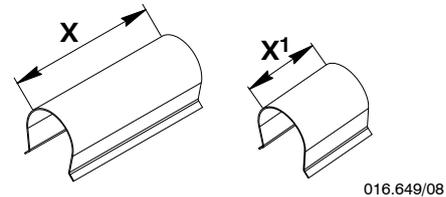


Standard Tools

- 94552** **1 Cover**
with Allen screws M12
for removal and fitting of fuel pump
X = 116 mm

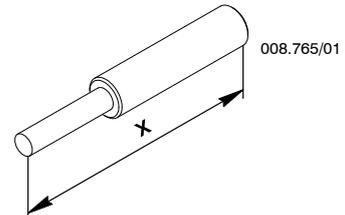


- 94555** **1 Spacer**
for cutting out of individual fuel pumps
X = 72 mm



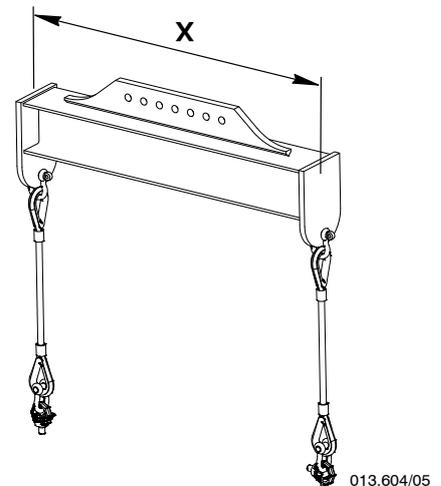
- GF 94555A** **2 Spacers**
for cutting out of individual fuel pumps
X₁ = 36 mm

- 94556** **1 Checking device**
for plunger position
X = 130 mm



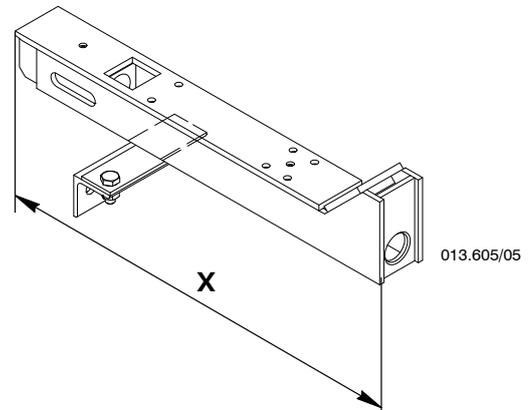
- GF 94557** **1 Lifting tool**
for transporting a complete supply unit
X = 922 mm
(WLL 2250 kg)

- GF 94557A** **1 Lifting tool**
for transporting a complete supply unit
X = 1182 mm
(WLL 2250 kg)

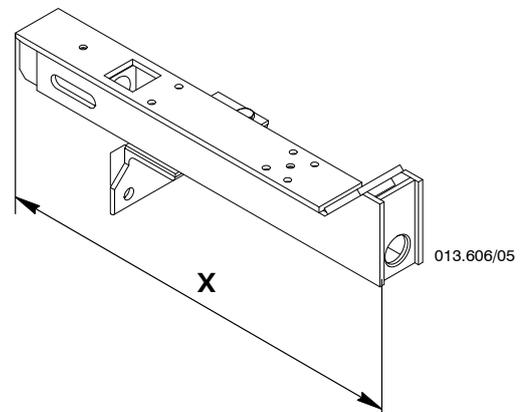


Standard Tools

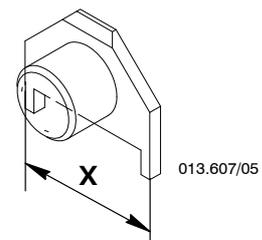
- 94566** **1 Support**
for removal and fitting of camshaft
X = 510 mm



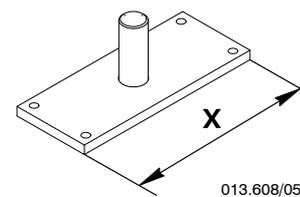
- 94566A** **1 Support**
for removal and fitting of camshaft
X = 510 mm



- 94566B** **1 Centring device**
for aligning bearing shells
X = 70 mm

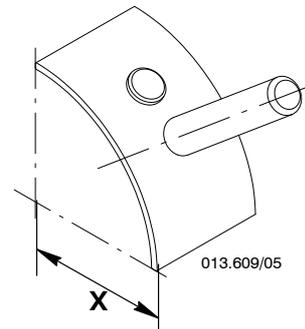


- 94566C** **1 Limiter**
for tightening or loosening bearing
covers to supply unit
X = 320 mm

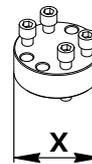


Standard Tools

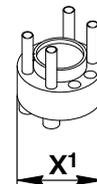
- 94567** **1 Assembly template**
 for removal and fitting of bearing shells
 to supply unit
 X = 68 mm



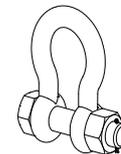
- GF 94569** **1 Blank flange**
 to fuel pump with
 4 Screws M12x50 and
 1 O-ring 42.52x2.62 mm
 X = 93 mm



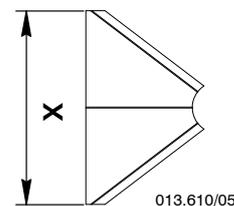
- GF 94569A** **1 Blank flange**
 to valve housing at fuel rail with
 4 Screws M12x80
 X₁ = 92 mm



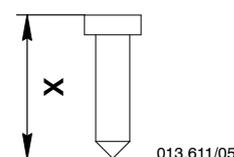
- 94572C** **3 Shackles**
 (WLL 4750 kg)
94572E **3 Shackles**
 (WLL 3250 kg)
94572F **3 Shackles**
 (WLL 6500 kg)
94572I **3 Shackles**
 (WLL 2000 kg)



- GF 94575** **1 Adjusting scale**
 (for Heinzmann StG 10-01 Actuator)
 for regulating linkage
 X = 120 mm
 including:



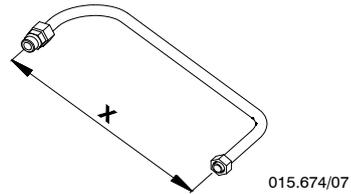
- GF 94575A** **1 Adjusting pin**
 (for Heinzmann StG 10-01 Actuator)
 X = 51 mm



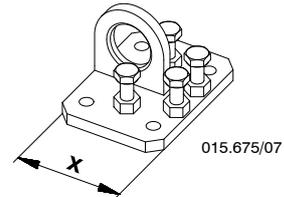
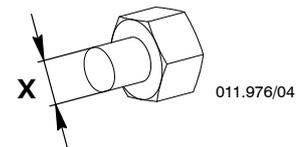
Standard Tools

94583 1 Pipe

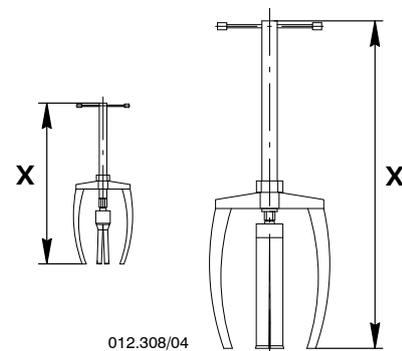
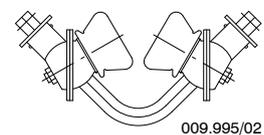
for pressure built-up in fuel rail
during commissioning
X = 431 mm

**94584 1 Lifting plate**

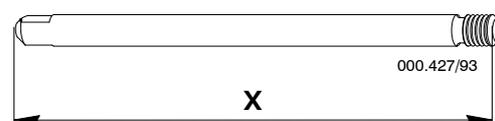
for removal and fitting of injection
control unit,
including 4 screws M10x25
X = 88 mm
(max. lifting capacity 180 kg)

**94587 8 Conical plugs** (4 pieces per Cyl.)
for servo and fuel oil returns in rail unit
X = 20 mm**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)

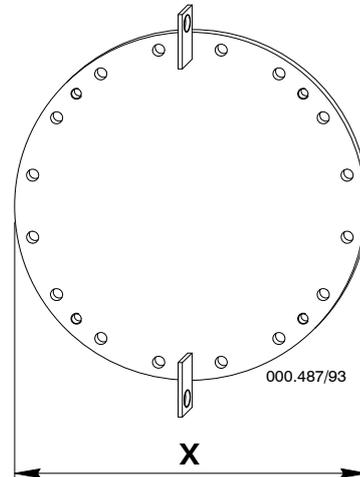
X = 520 mm (MET 66S)

X = 520 mm (MET 60MA/MB)

X = 545 mm (ABB A170)

X = 625 mm (ABB A175)

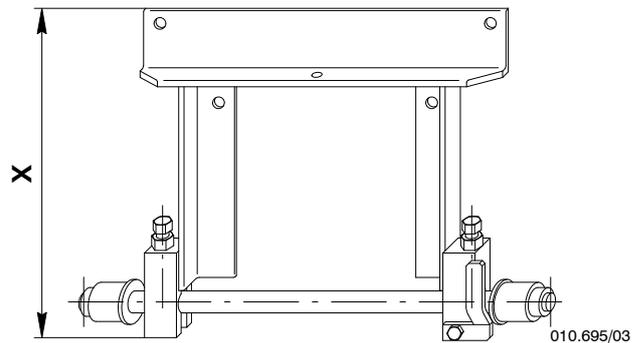
X = 690 mm (ABB A180)

**94661 1 Pulley plate**

for cooler type:

GEA 120/30/24/6

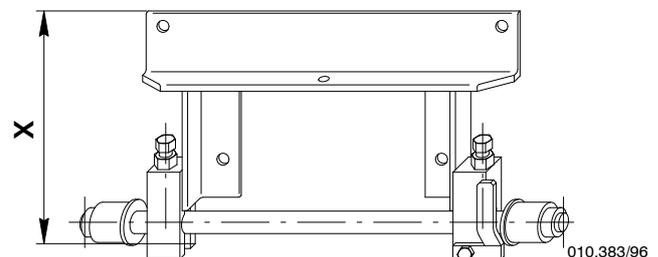
X = 605 mm

**94662 1 Pulley plate**

for cooler type:

GEA 150/38/24/6

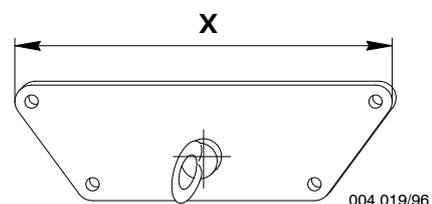
X = 430 mm

**94663A 1 Plate**

for cooler type:

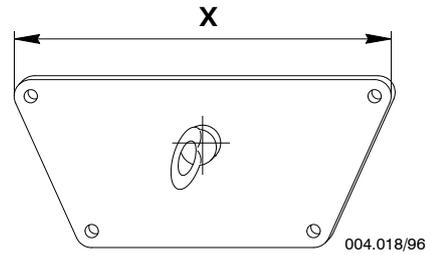
GEA 120/30/24/6

X = 680 mm

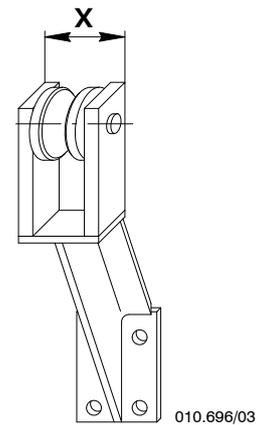


Standard Tools

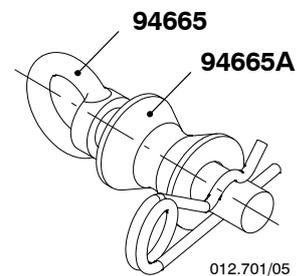
- 94663B** **1 Plate**
for cooler type:
GEA 150/38/24/6
X = 680 mm



- 94664** **1 Pulley support**
for dismantling and assembling the
scavenge air cooler
X = 140 mm

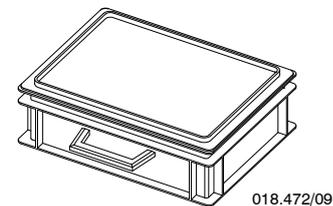


- 94665** **1 Pin**
with double spring clip
for removal and fitting of tube stack
including:

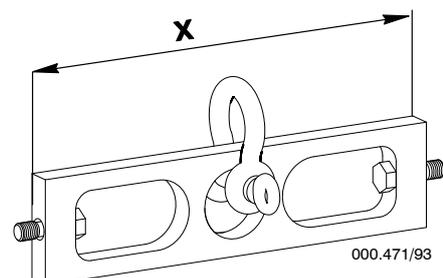


- 94665A** **1 Roller**

- 94720C** **1 Tool pulse accumulator**
(for CLU4-C)
consisting of:
measurement set complete
for checking / refilling of
hydraulic accumulator

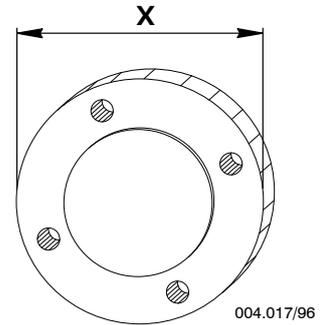


- 94811** **2 Lifting lugs**
with 2 shackles
for removal and fitting expansion piece
to exhaust valve cage
X = 358 mm

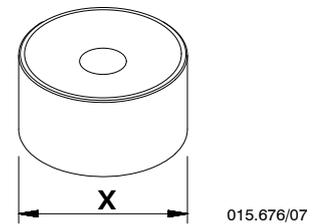


Standard Tools

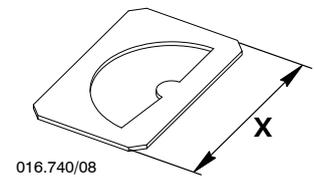
- 94831** **1 Blank flange**
 for blanking off starting air pipe during
 emergency operation
 X = 200 mm



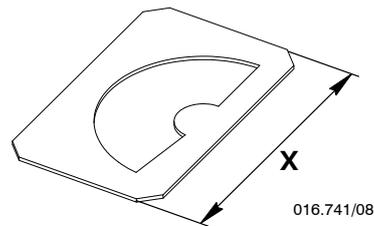
- 94834** **1 Regrinding device**
 to hydraulic pipes
 for radius of 100 mm
 X = 38 mm



- 94870D** **1 Stencil**
 X = 48 mm

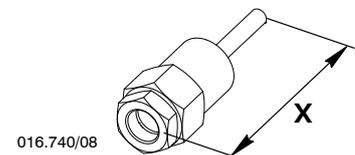


- 94870H** **1 Stencil**
 X = 75 mm

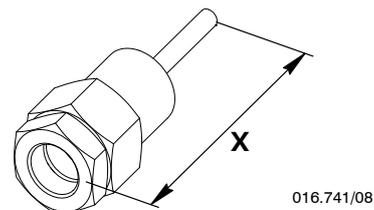


- 94870J-L** **1 Regridig device left hand thread**

- 94870J-R** **1 Regridig device**

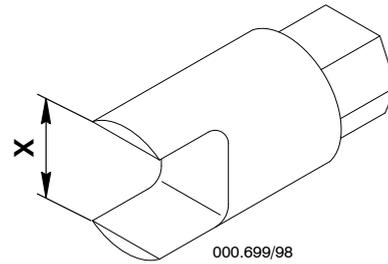


- 94870K** **1 Regridig device**

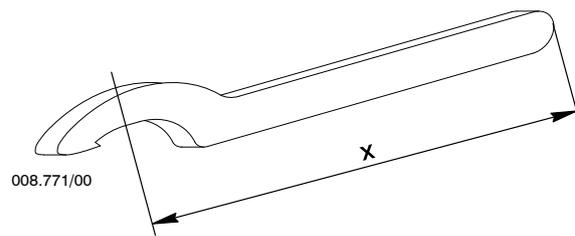


Standard Tools

- 94874 1 Special spanner**
for fitting claws
on HP pipe to injection valve
X = 24 mm

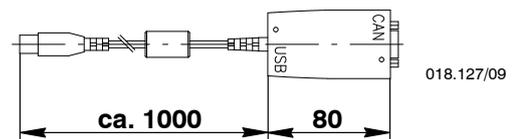
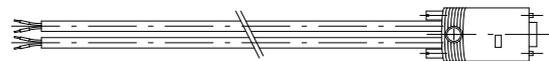


- 94924 1 Hook spanner**
for crank angle sensor
X = 205 mm



- 94925 1 Hook spanner**
for crank angle sensor
X = 242 mm

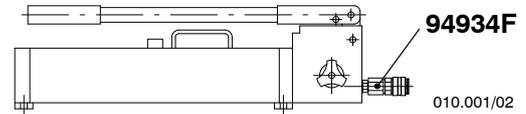
- 94930 1 SW-download package**
to WECS-9520 for flexView operator
consisting of:
1 USB-memory stick
1 CAN cable (ca. 10 m)
1 UBS to CAN adapter
1 Connection diagram
1 Requirements



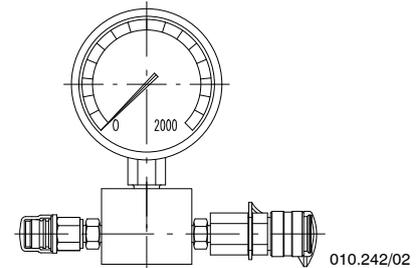
Standard Tools

Hydraulic parts and pump

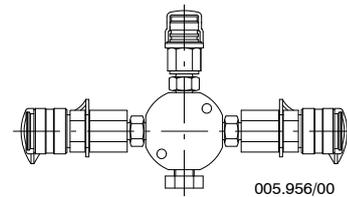
- 94931 1 HP oil pump
working pressure max. 2800 bar
- 94934F 1 Adapter piece



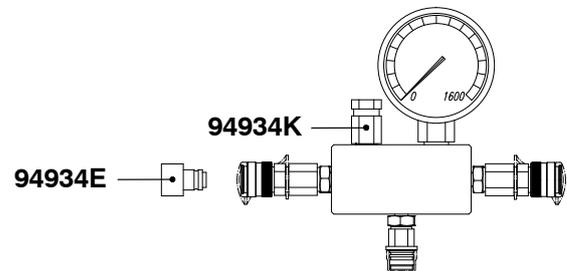
- 94932 2 Hydr. distributor
with pressure gauge



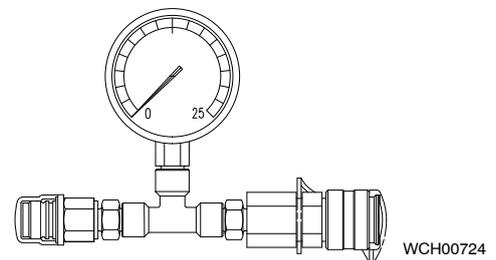
- 94934 1 Connection block



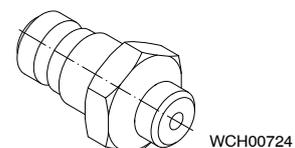
- 94934A 1 Hydr. distributor
with pressure gauge
- 94934K 1 Relief valve
- 94934E 1 Plug piece



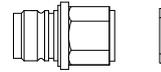
- 94934H 1 Hydr. distributor
with pressure gauge 0...25 bar



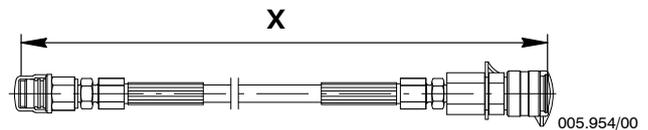
- 94934I 1 Connection nipple (G $\frac{1}{4}$ "



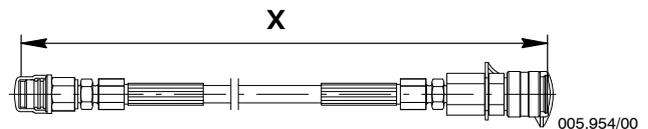
Standard Tools

94934J 3 Closing valve with Tredo joint

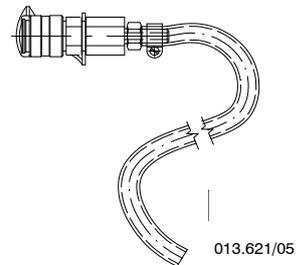
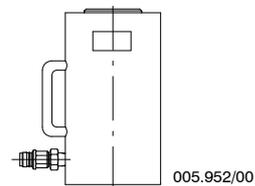
94935 3 HP hoses 2600 bar
with closing valves and coupling sockets
X = 2130 mm



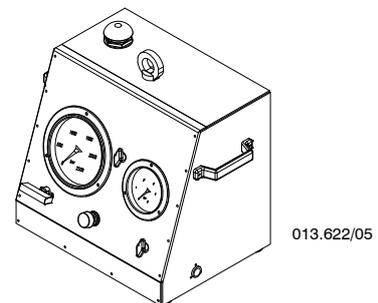
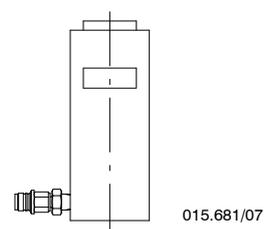
94935A 2 HP hoses 1500 bar
with closing valves and coupling sockets
X = 1880 mm



94935C 1 Hose
for set-up of pre-tensioning jacks
Length = 2000 mm

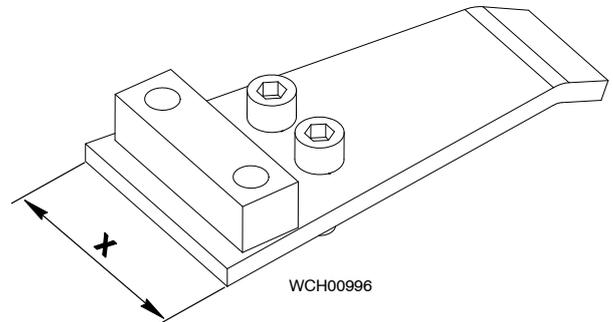
**94936 2 Hydraulic jacks 230 kN (23 t)**

94942 1 Hydraulic unit
working pressure max. 2500 bar

**94950 1 Hydraulic jack 230 kN (23 t)**

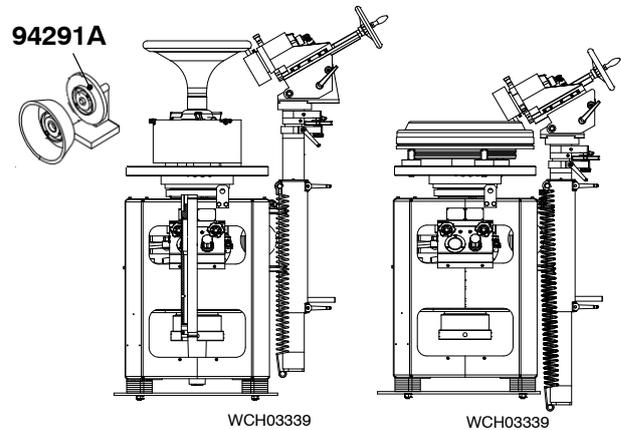
Recommended Special Tools

- GF 94155A 1 Turning-out device**
with screws
for turning out thrust bearing pads
(with 2-part gear wheel)
X = 178 mm

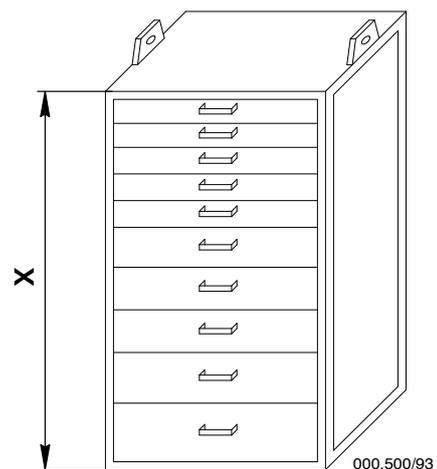


- 94291 1 Valve grinding device complete**
for valve spindle and valve seat

- 94291A 2 Grinding discs**
(C-M No. 11373-01-01)

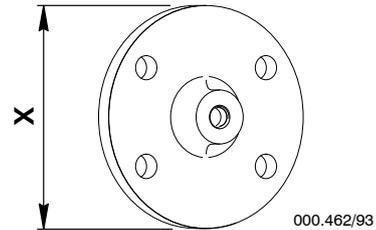


- 94300 1 Tool cupboard**
X = 1120 mm

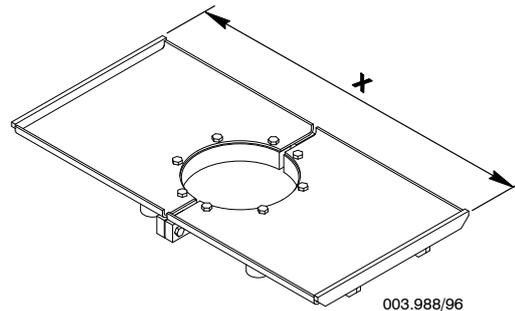


Recommended Special Tools

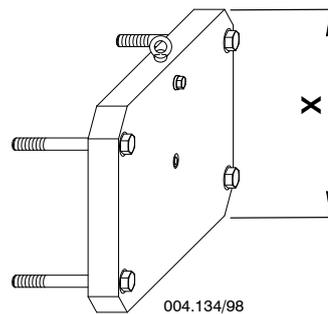
- 94336 1 Connecting flange**
for pre-lubrication of crosshead
and bottom end bearing
X = 140 mm



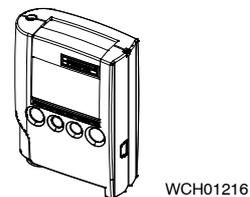
- 94344 1 Dismantling device**
for removal of piston rod
gland downwards
X = 812 mm



- 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

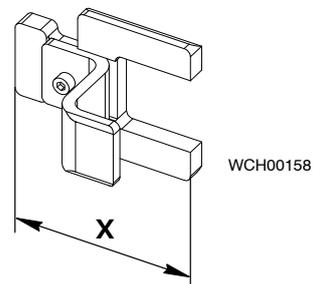


- 94357 1 Calliper gauge**
for measuring piston ring grooves

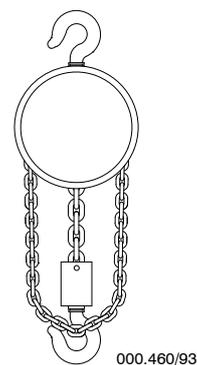


Recommended Special Tools

- 94412E 1 Fork wrench**
for 2-part gear wheel on crankshaft,
AF55
X = 140 mm

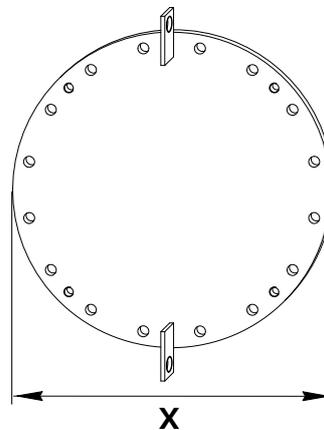


- 94650 1 Spur-geared chain block**
for removing and fitting
electric motor to auxiliary blower
(WLL 1000 kg)



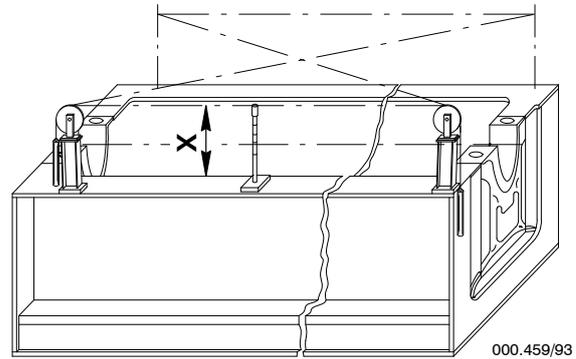
- 94655 1 Cover**
to air inlet casing with suction pipe
in case of a turbocharger breakdown

- 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)



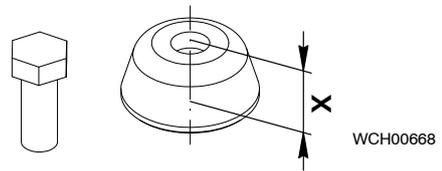
Special Tools Obtainable on Loan

- 94105 1 Measuring apparatus**
 for leveling bedplate
 consisting of:
 4 Supports
 4 Weights with wire
 1 Measuring underlay
 X = 1335 mm



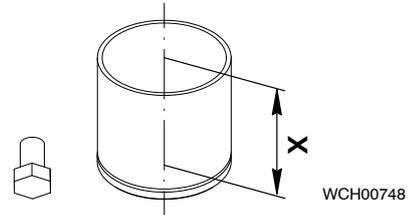
000.459/93

- GF 94174 1 Thread protector**
 to upper threads of tie rod
 with screw M24x55
 X = 38 mm



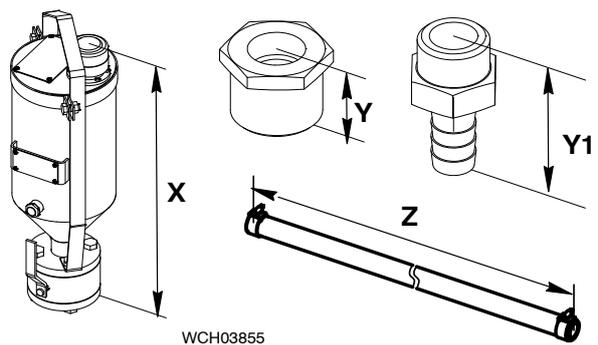
WCH00668

- GF 94177 1 Thread protector**
 to lower thread of tie rod
 with screw M20x30
 X = 104 mm



WCH00748

- 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

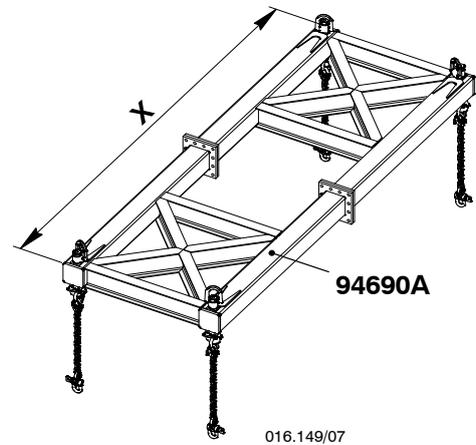


WCH03855

Special Tools Obtainable on Loan

- 94691 1 Transport tool**
for 5 or 6 Cyl. rail unit modules
(max. lifting capacity 14 000 kg)
X = 4164 mm
consisting of:

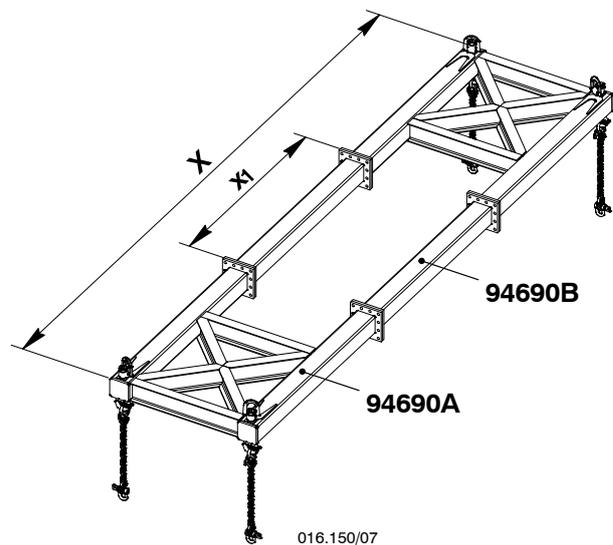
- 94690A 2 Lifting elements**
incl. 24 screws M24x80 and nuts



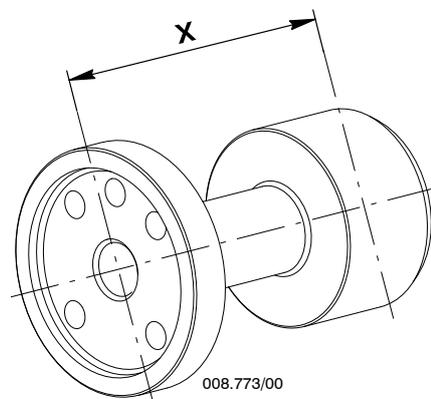
- 94692 1 Transport tool**
for 7 Cyl. rail unit modules
(max. lifting capacity 14 000 kg)
X = 6176 mm
consisting of:

- 94690A 2 Lifting elements**

- 94690B 1 Bracket**
incl. 48 screws M24x80 and nuts
X₁ = 2012 mm



- 94922 1 Alignment tool**
for crank angle sensor (FREE END)
X = 172 mm



Intentionally blank