



WIN GD

X62

Maintenance Manual

“Marine”

Vessel:

Type:

Engine No.:

Document ID:

Winterthur Gas & Diesel Ltd.
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W-X62				Summary for Maintenance Manual		
Page No.	Modification		Title	Subject	Page or Manual	
	Date	No.			new	exch.
	2014			Maintenance Manual, Issue 2014	x	
				Date of publication 2014-06-02		
0380-1/A1 (2)	2014-08		Overhaul intervals	New overhaul times for injection valve.		x
2722-2/A1	2014-08	EAAD085272	Injection Valve	New tools and procedure for nozzle tip replacement.		x
2722-2/A1 (3)	2014-08	EAAD085264	Injection Valve	New pressures for Injection nozzle check.		x
8460-1/A1 (3)	2014-08	EAAD085307	Hydraulic Pipe	New pipe grinding tools 94841 (replaces 94834)		x
8733-1/A1 (3)	2014-08	EAAD085307	HP Fuel Pipe	New pipe grinding tools 94871		x
8752-1/A1	2014-08		HP fuel Pipe	New pipe grinding tools 94870		x
9403-5/A1 (15)	2014-08	EAAD085272	Tools	Tool 94289D replaced with Tool 94278A and 94278B		x
9403-5/A1 (29, 30)	2014-08	EAAD085307	Tools	New pipe grinding tools 94841 (replaces 94834), 94871 and 94870		x
9403-5/A1 (28)	2014-08		Tools	New Tool numbers for T/C Covers		x
				Date of publication 2014-09-18		
0020-1/A1	2015-06		Tabel of contents	Completed with new page numbers		x
0380-1/A1	2016-01		maintenance schedule	Update of maintenance schedule		
2124-1/A1	2015-06		Cylinder Liner bore measurement	New safety aspects		x
2722-1/A1	2015-06		Injection Valve	Corrections of preliminary works		
2722-2/A1	2015-06	EAAD085606	Injection Valve	Page 8, Step 8 - Torque angle data changed		x
2751-1/A1	2015-06		Exhaust Valve	Corrections of preliminary works		x
3303-2/A1 (1,3)	2015-03	EAAD085741	Bottom End Bearing	Update for engines with ELBA (New Support 94322A)		x
3303-3/A1 (1,3)	2015	EAAD085741	Top End Bearing	Update for engines with ELBA (New Support 94322A)		x
4325-1/A1	2015-04		Sarting Air Shut-off Valve	Data changed in pages 3, 5 and 6		x
Group 5	2015-12		Index (Groups)	Instructions added (5562-3/A1)		x
5562-3/A1	2015-06		Flow Limiting Valve	New maintenance work added	x	
Group 7	2015-12		Index (Groups)	Two instructions added (7762-1 and 7758-1)		x
7758-1/A1	2015		iELBA drive	New maintenance work added	x	
7762-1/A1	2015		iELBA proximity sensor	New maintenance work added	x	
8447-1/A1	2015-03	EAAD085307	Servo Oil Pipes	New pipe grinding tool number. Page 3 Updated		x
9403-3/A1	2014-10	EAAD085437	Hydraulic Pre-tensioning Jacks	New pretensioner for cylinder cover 94215A		x
9403-5/A1	2014-08	EAAD085741	Standard Tools	Tool 94322A added to page 37, new tools for iElba: 94701, 94702, 94703, 94704, 94705		x
				Date of publication 2016-02-22		
All pages	2017-10	Update WinGD	All documents	Engine brand changed from Wärtsilä to WinGD X62		x
3303-2/A1 (1,3)	2017-10	Update WinGD	Bottom End Bearing	corrections for support 94322		x
3303-3/A1 (1,3)	2017-10	Update WinGD	Top End Bearing	correction for Support 94322		x
7758-1/A1 (11)	2017-10	Update WinGD	Electric Balancer	small correction		x
				Date of publication 2017-10-27		

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General Information

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For Your Attention

1. General

This manual is for the operator and is for use only for the related type of diesel engine (the engine described in this manual). The data in this manual is confidential.

Make sure that you read carefully the Operation Manual before you operate the engine.

Make sure that you know the Inspection and Overhaul intervals in the Maintenance Manual before you operate the engine.

Make sure that you read the data in Group 0 in the Maintenance Manual before you do maintenance work on the engine.

2. Spare Parts

Use only original spare parts and components to make sure that the engine will continue to operate satisfactorily. All equipment and tools for maintenance and operation must be serviceable and in good condition.

The extent of all supplies and services is set exclusively to the related supply contract.

3. Data

The specifications and recommendations of the classification societies, which are essential for the design, are included in this manual.

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

4. Personnel

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

Data related to protection against danger and damage to equipment are specified in this manual as Warnings and Cautions.

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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:

- 1) General guidelines for maintenance
- 2) Clearance tables, tightening values of screwed connections, masses (weights)
- 3) Maintenance schedule
- 4) Design groups
- 5) Tool lists

A few explanations to the above:

- 1) The 'General Guidelines for Maintenance' contain, in addition to recommendations on precautionary measures to be taken, also suggestions for carrying out the work.
- 2) 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.
- 3) 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.
- 4) Detailed instructions are given in the 'Design Groups' on the procedure of maintenance work on certain engine parts.
- 5) Tools and devices necessary to carry out maintenance are described in the 'Tool Lists', and are generally supplied with the engine.

All information contained in the text and illustrations of this manual are valid at the time of printing.

Modifications will be incorporated in the next edition!

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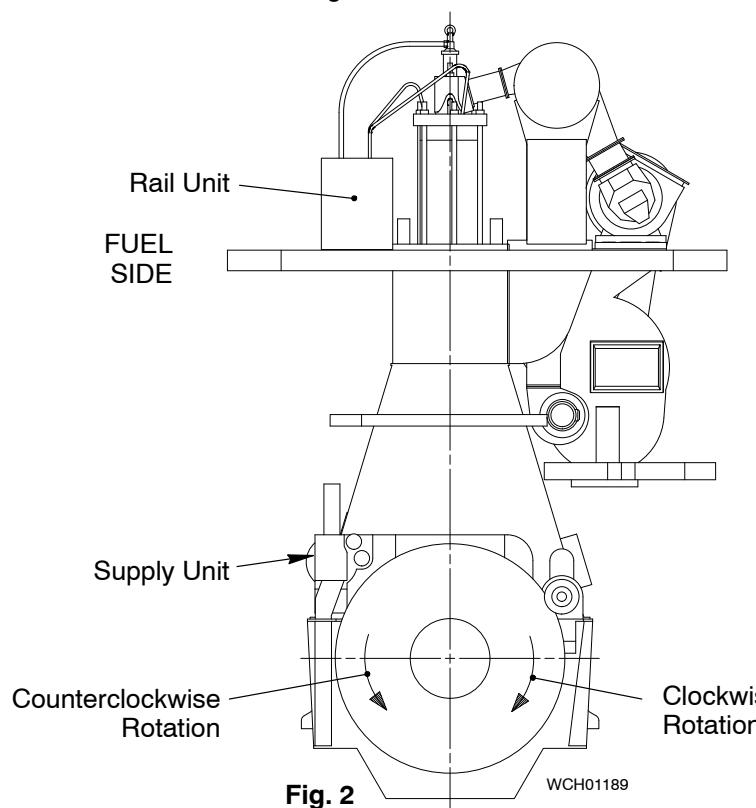
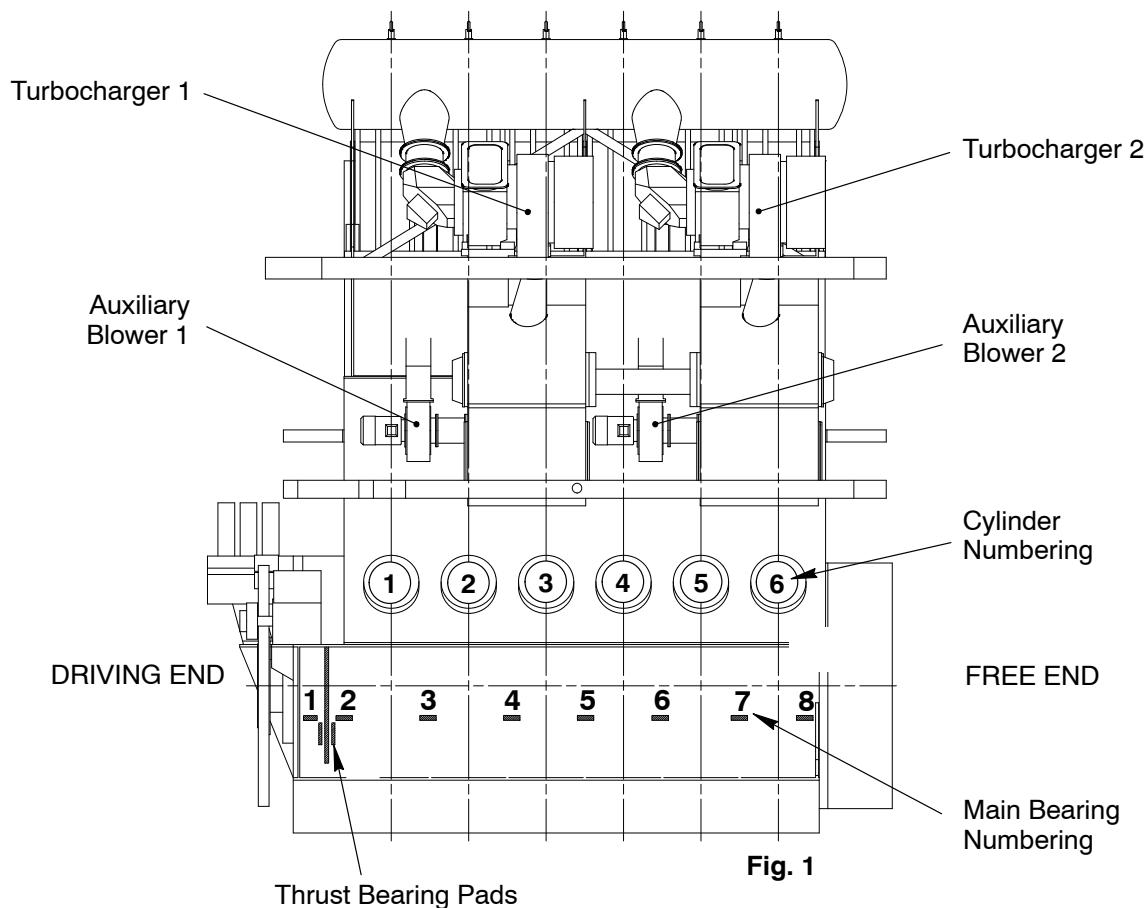
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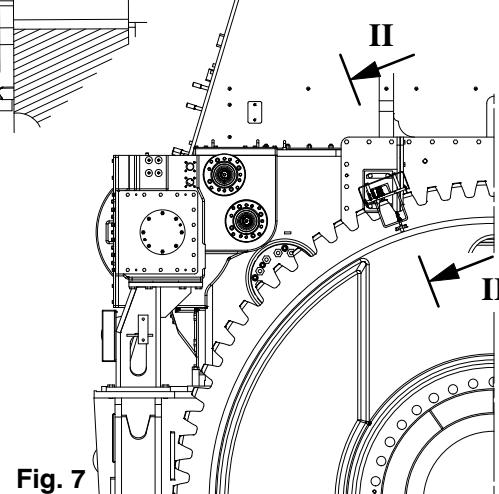
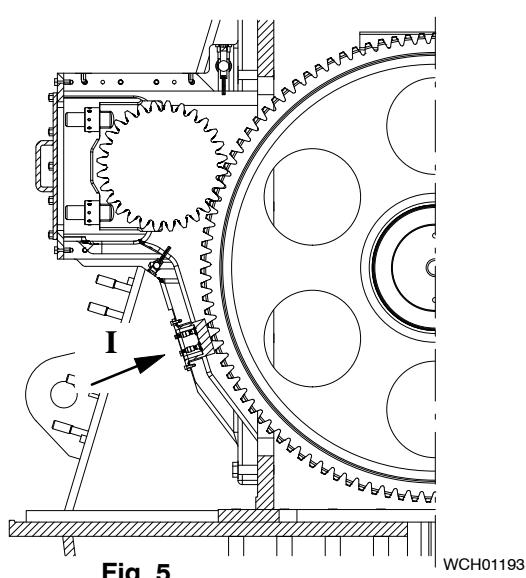
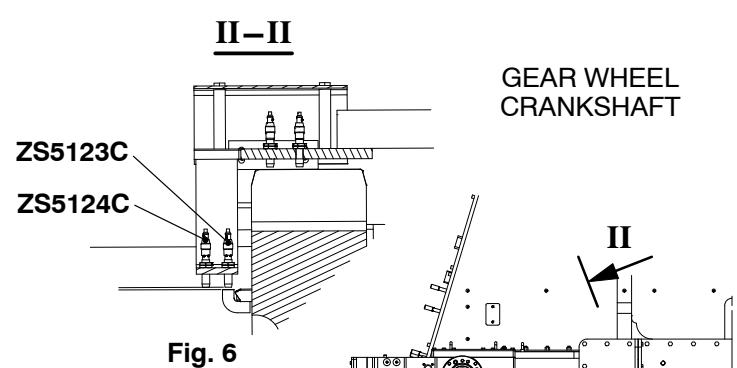
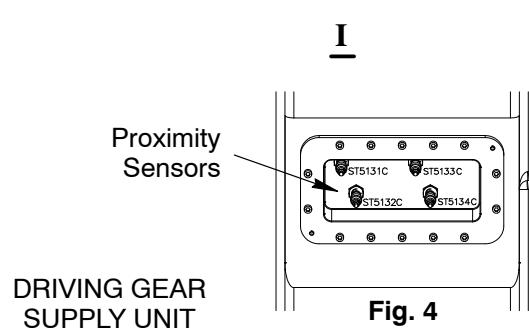
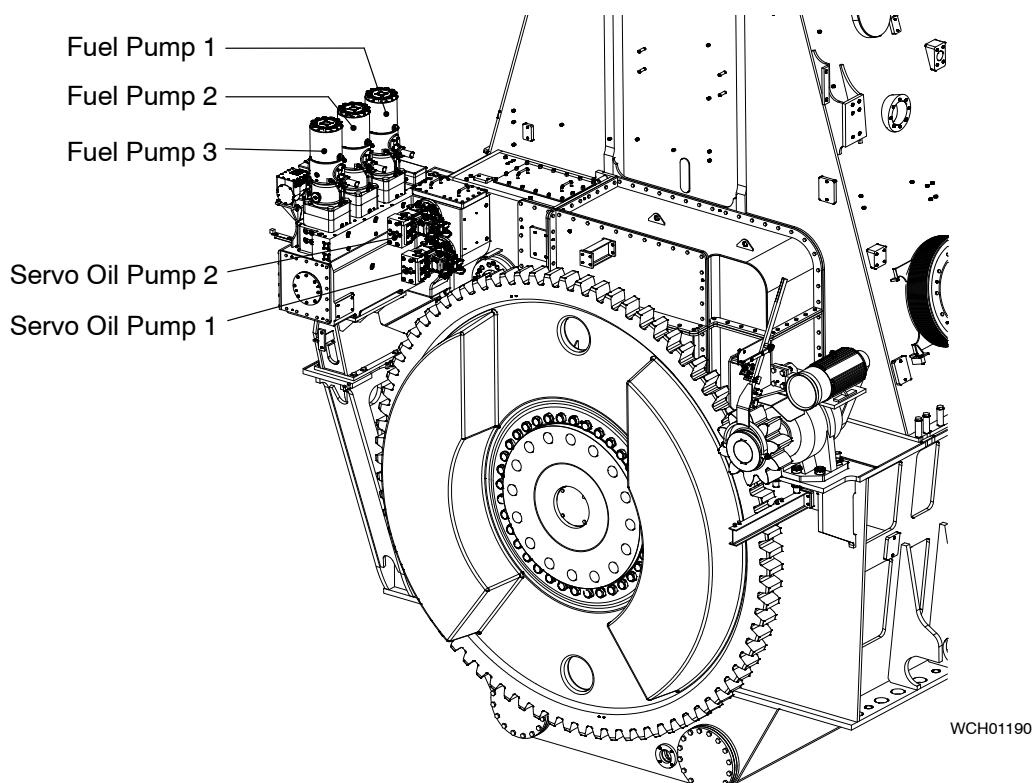
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Engine Numbering and Designations



DRAWN FOR TWO A175 TURBOCHARGERS

flex Parts:



General Guidelines for Maintenance

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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 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.

CAUTION



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.

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:

- 1) Close the shut-off valves on the starting air bottles.
- 2) Close all the shut-off valves in the control air supply unit, and open the drains on both air bottles until it is depressurized.
- 3) 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.
- 4) Open all indicator cocks on the cylinder covers and leave them in this position until maintenance work is completed.
- 5) 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.

CAUTION



When performing electric welding near or on the engine, electro-magnetic fields or peak voltage may occur, which may damage the electronic components of the Engine Control DENIS-UNIC.

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.

4. Special safety measures

- Prior to turning the crankshaft with the turning gear, make sure and take notice:
 - 1) that no person is inside the engine and no loose parts, tools or devices can get jammed.
 - 2) 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 [0012-1](#) and [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!

Note: 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 [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).
 - 1) Tools and devices must be made ready prior to use, make sure they are in perfect condition.
 - 2) Calibrate gauge tools before using and at periodical intervals.
 - 3) Check hydraulic tools periodically for tightness and perfect functioning.
 - 4) Protect running faces and sealing faces of removed parts by suitable means to prevent damages.

Safety Measures and Warnings

- 5) 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).
- 6) Check all repaired, overhauled or replaced parts for perfect functioning before starting the engine.
- 7) Check all pipes which have been removed, for tightness after they are refitted.
- 8) 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.
- 9) 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.

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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).

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

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

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

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

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 (round slings)

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.

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

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

- 1) is completely turned in or screwed down;
- 2) lies flat and fully on the seating surface;
- 3) was checked for visible damages (e.g. corrosion, deformation) before using it.
- 4) 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>

2.4.1 Remarks on the use of RUD-eye bolts

- 1) they must be completely screwed down, lying fully on the seating surfaces.
- 2) 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. '1'.
- 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. '2')

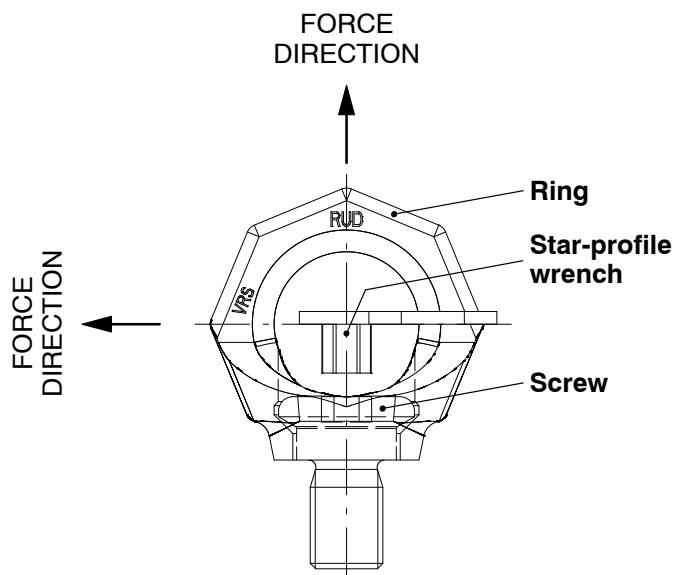


Fig. 1

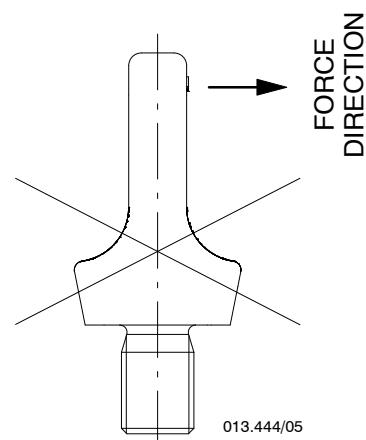


Fig. 2

2.4.2 Remarks on the use of RUD-swivel lugs

- 1) they must be completely screwed down, lying fully on the seating surfaces.
 - 2) they are hand-screwed with an open end wrench.
- Prior to loading the RUD-swivel lug adjust it in force direction (Fig. '3' and '4').
 - **Loading as shown in Fig. 'E' should be avoided if possible!**

FORCE
DIRECTION

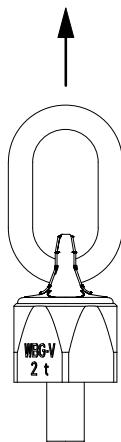


Fig. 3

FORCE
DIRECTION



Fig. 4

FORCE
DIRECTION

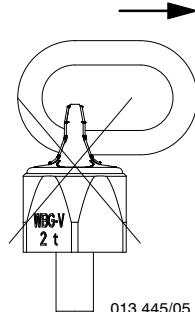


Fig. 5

013.445/05

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.

CAUTION



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).

3. Attaching and disconnecting

The following must be observed:

- **Distribution of load:**

- 1) one strand carries the total of load weight
- 2) two strands carry each one half of the load weight
- 3) four strands carry each one quarter of the load weight if the load is distributed equally.

- **Angle of strand:**

- 1) the flatter the strand angle, the more the strand is stressed
 - 2) 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.

WARNING

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

1. General	1
Crankshaft and Thrust Bearing	2
Crankshaft and Main Bearing	4
Crosshead Guide	6
Cylinder Liner	8
Piston Rod Gland	10
Exhaust Valve	12
Top and Bottom End Bearings to Connecting Rod	14
Piston Cooling and Crosshead Lubricating Link	16
Piston and Piston Rings	18
Driving Wheels for Supply Unit	20
Fuel and Servo Pump Units	22
Fuel Pump	24

1. General

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

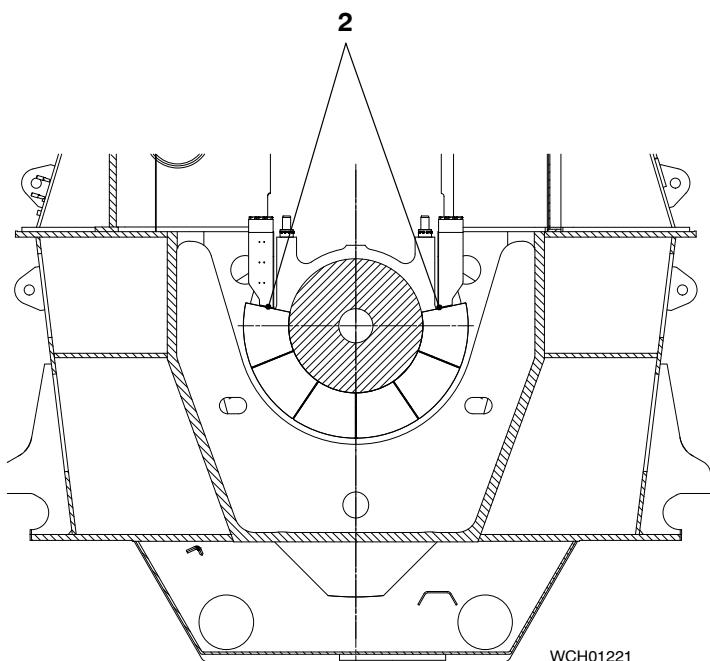
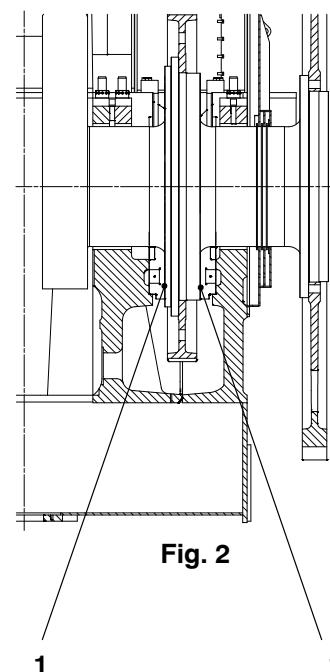
The values given in the columns Maximum Clearance, Dimension are the possible results after a long period of operation. The differences in the clearances must not be less than or more than those given.

On components where the clearance is adjustable (changed thickness of shims, discs, spacers etc) the values must be those given in Usual Clearance. Where this is not possible, you must replace worn parts with standard new parts, or reconditioned with applicable material buildup.

If, during an overhaul, clearances are measured that are almost at the permitted limit, personnel must make a decision to:

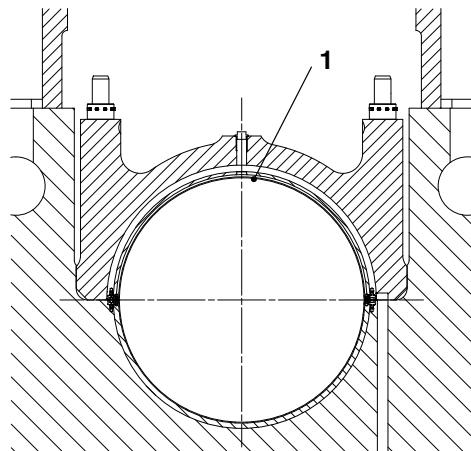
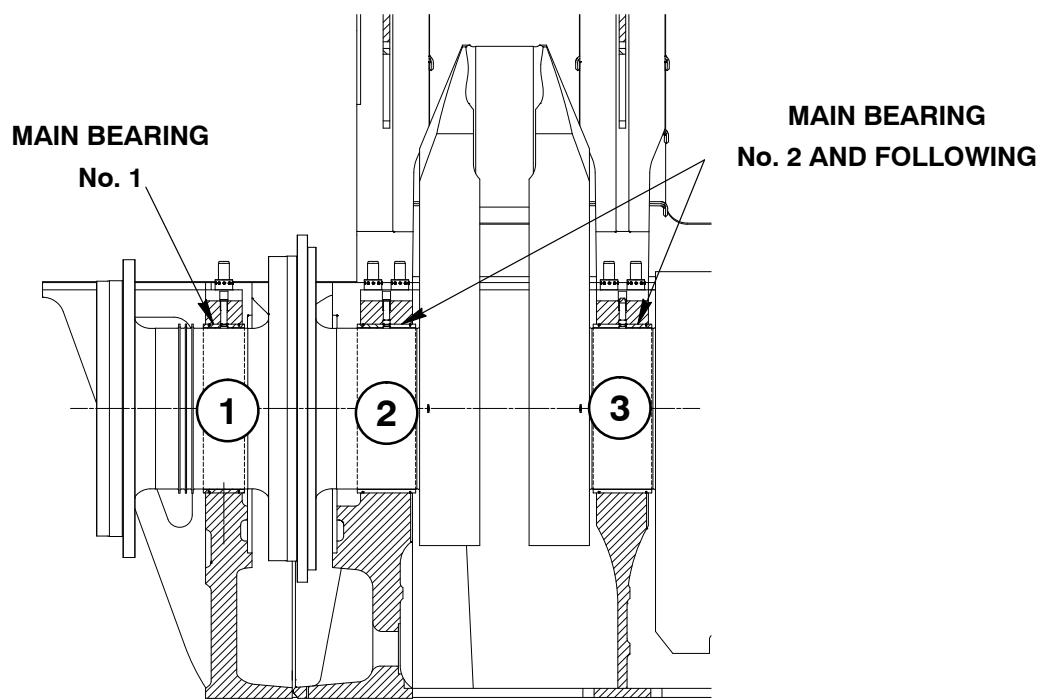
- Replace a component part, or
- Let the item stay installed until the next overhaul.

This is related, for example, on the length of the next operation period until the next overhaul and what wear has to be expected based on experience gained.

Clearance Table**Crankshaft and Thrust Bearing****Fig. 1****Fig. 2**

Clearance Table**Crankshaft and Thrust Bearing**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
1203 1224		Thrust bearing			
		Thrust bearing pad	thickness	100 ^{0.5} _{-0.6}	
	1	Thrust bearing clearance	axial (total)	0.4...0.65	1.0
	2	Clearance between thrust pad and bracket	Per side	3	

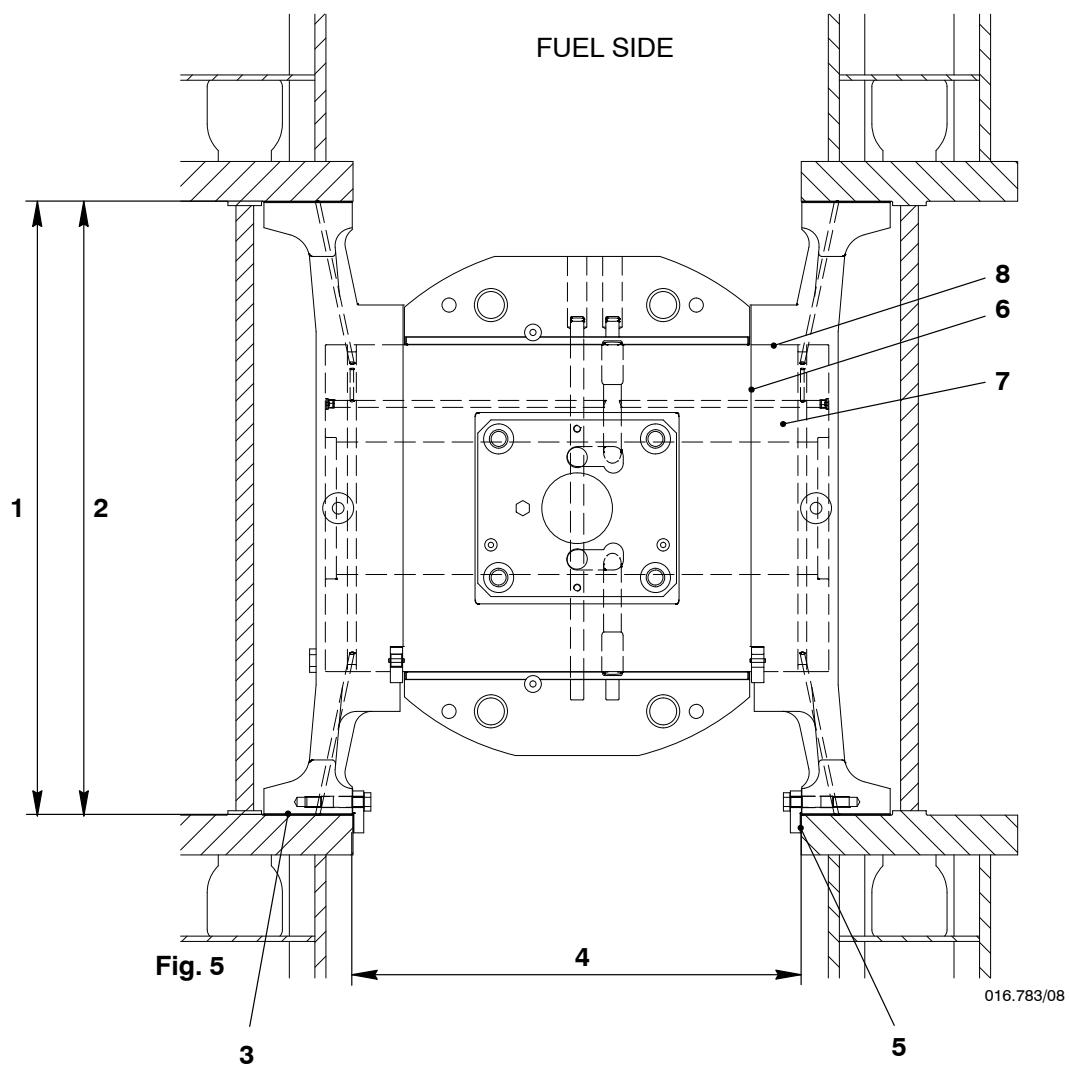
Clearance Table**Crankshaft and Main Bearing****Fig. 3****Fig. 4**

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Clearance Table**Crankshaft and Main Bearing**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
1132		Main bearing No. 1			
		Crankshaft	outer Ø	760 ⁰ _{- 0.08}	
		Main bearing	inner Ø	760	
	1	Bearing clearance	vertical	0.25–0.55	0.75
1132		Main bearing No. 2 and following			
		Crankshaft	outer Ø	760 ⁰ _{- 0.08}	
		Main bearing	inner Ø	760	
	2	Bearing clearance	vertical	0.25–0.55	0.75

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

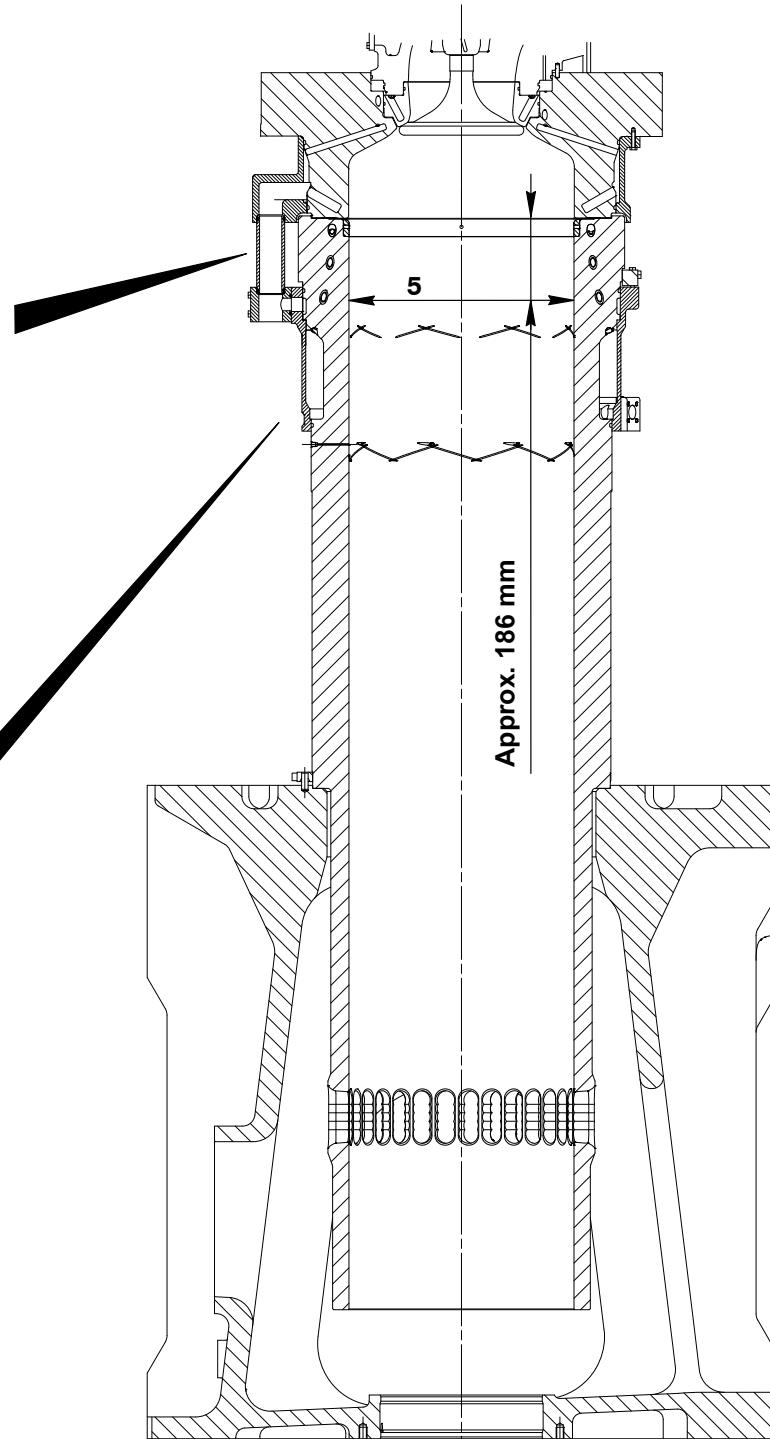
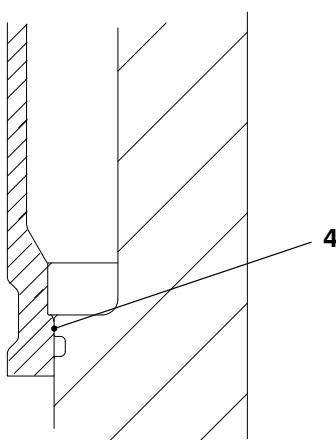
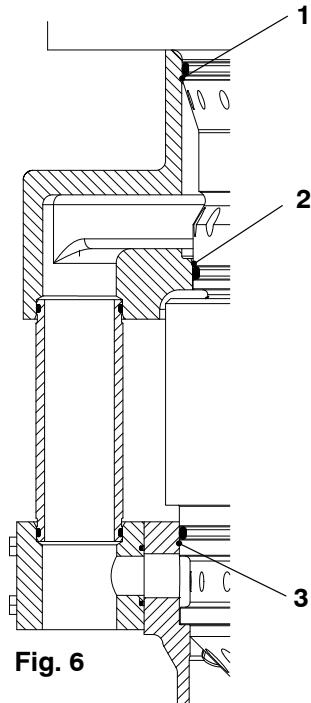
Clearance Table**Crosshead Guide**

Clearance Table**Crosshead Guide**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
3326		Crosshead guide			
	1	Guide bar (column)	transverse	1096 ${}^+ 0.25$ ${}_0$	
	2	Guide shoe	transverse	1096 ${}^- 0.20$ ${}^- 0.30$	
	*3	Guide way clearance		0.20–1.10	1.25
	4	Guide rail	longitudinal	707.52–708.28	
	5	Guide rail, lateral clearance	total	0.30–1.00	1.5
	6	Guide shoe, lateral clearance	total	0.20–0.60	0.9
	7	Guide shoe, bearing pin	outer Ø	580 0 ${}^- 0.08$	
		Guide shoe, bearing bore	inner Ø	580 ${}^+ 0.11$ ${}^+ 0.07$	
	8	Bearing clearance	radial	0.07–0.19	0.2

For measuring of clearances see instructions in **3326-1**.

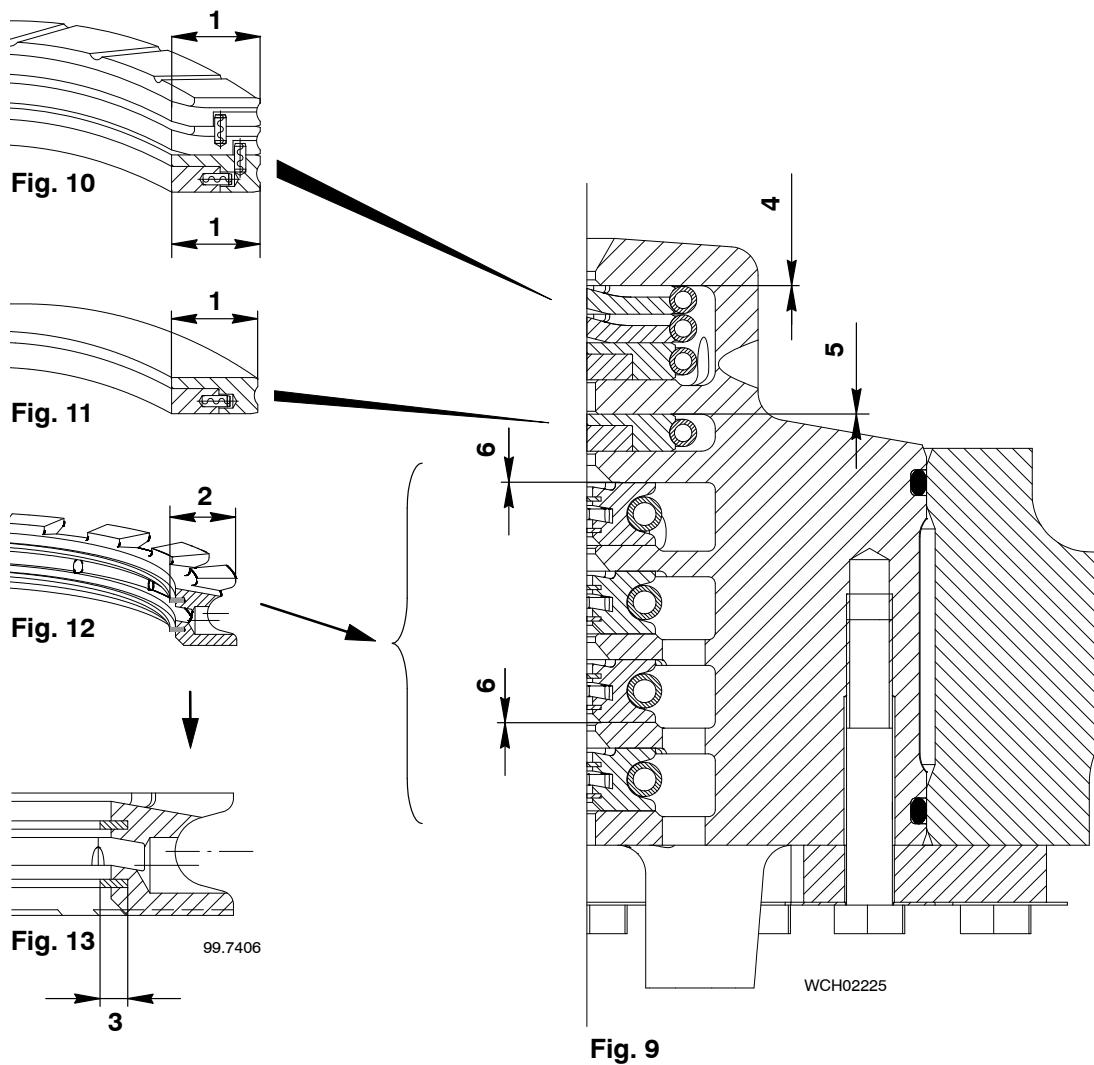
* Clearance 3 is **only valid with tie rods tightened**.

Clearance Table**Cylinder Liner**

Clearance Table**Cylinder Liner**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
2130		Water guide jacket on cylinder cover			
		Water guide jacket upper part	Ø	870 ^{+ 0.50} _{+ 0.30}	
	1	Clearance	total	0.40–0.70	
		Water guide jacket upper part	Ø	850 ^{+ 0.50} _{+ 0.30}	
	2	Clearance	total	1.30–1.60	
		Water guide jacket lower part	Ø	870 ^{+ 0.50} _{- 0.30}	
	3	Clearance	total	0.10–0.650	
		Water guide jacket lower part	Ø	856 ^{+ 0.70} _{+ 0.50}	
	4	Clearance	total	0.40–0.80	
2124		Cylinder liner			
	*5	Cylinder liner bore	radial	620	625.50

* Pay attention to measuring point!

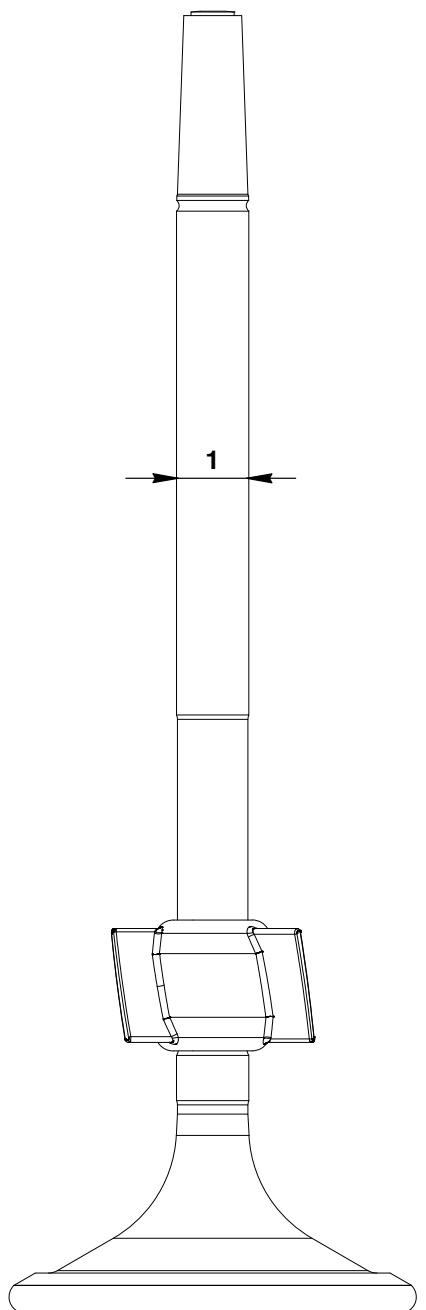
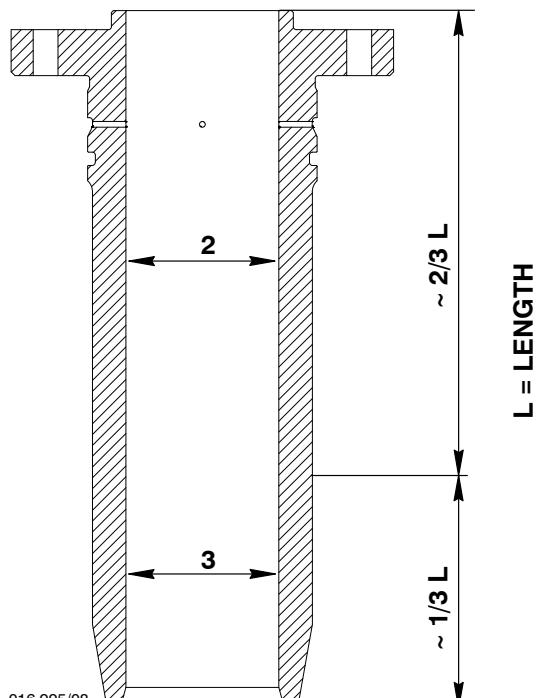
Clearance Table**Piston Rod Gland**

Clearance Table**Piston Rod Gland**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
2303		Piston rod gland			
	*1	Ring width	radial	31	min. 25
	*2	Ring width	radial	24	min. 20.20
	*3	Ring width	radial	5	min. 3.20
	4	Ring clearance	axial	0.05–0.19	0.30
	5	Ring clearance	axial	0.05–0.13	0.25
	6	Ring clearance	axial	0.10–0.17	0.20

*** Ring wear**

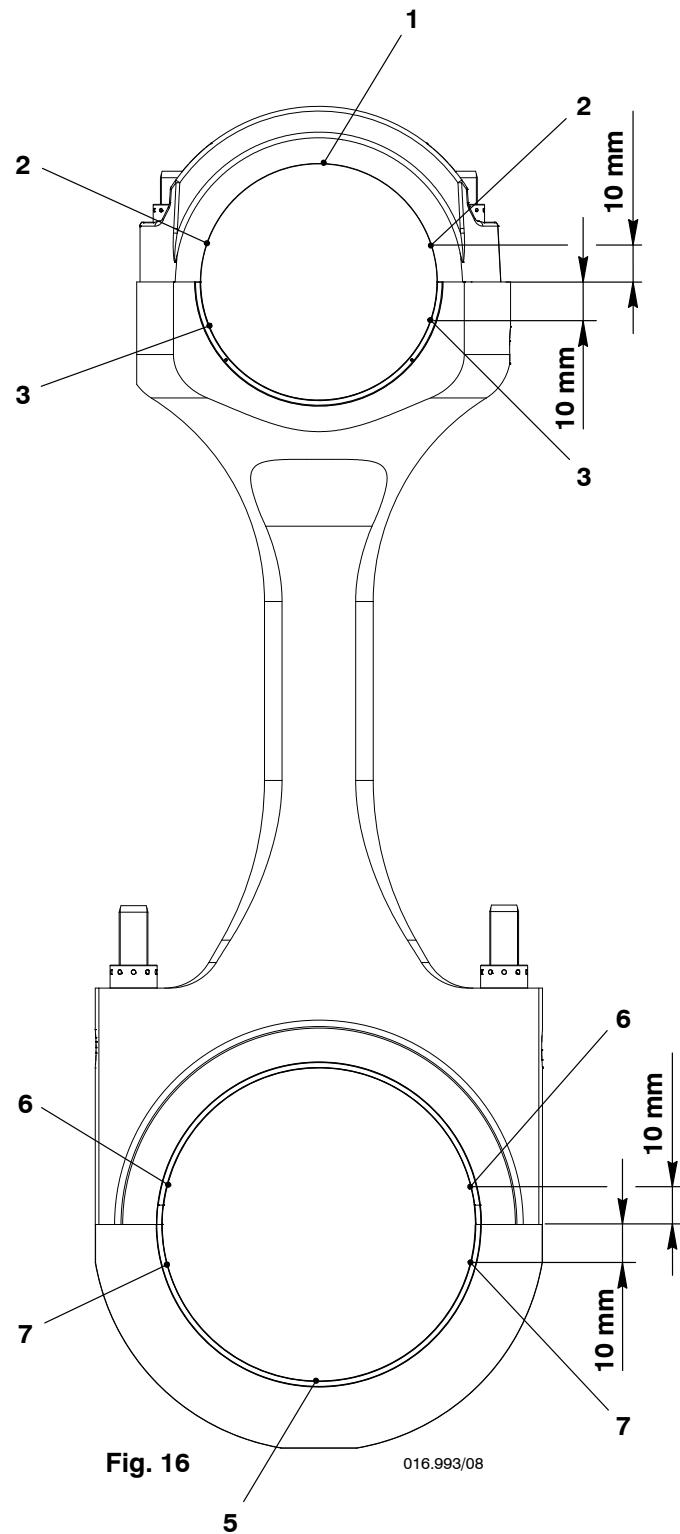
The differential value between nominal dimension and max. wear is equal for all rings, i.e. also for undersize rings.

Clearance Table**Exhaust Valve****VALVE SPINDLE****Fig. 14****GUIDE BUSH****Fig. 15**

Clearance Table**Exhaust Valve**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
2754		Valve spindle			
	1	Spindle	outer Ø	58 -0.21 -0.24	49.50
2751		Guide bush			
	*2	Bore	inner Ø	58 $+0.030$ 0.0	58.40
	*3	Bore	inner Ø	58 $+0.030$ 0.0	51.25

* Pay attention to measuring point!

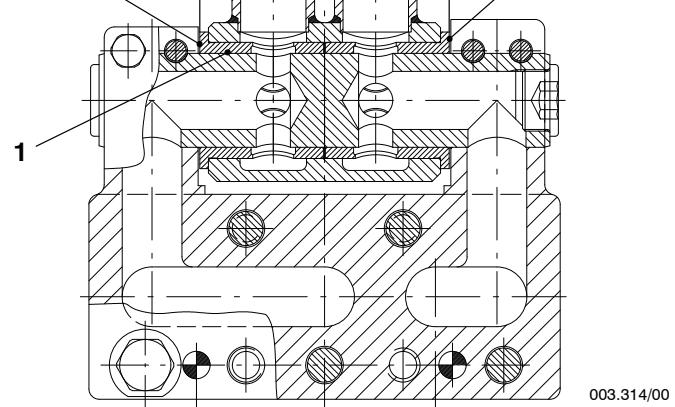
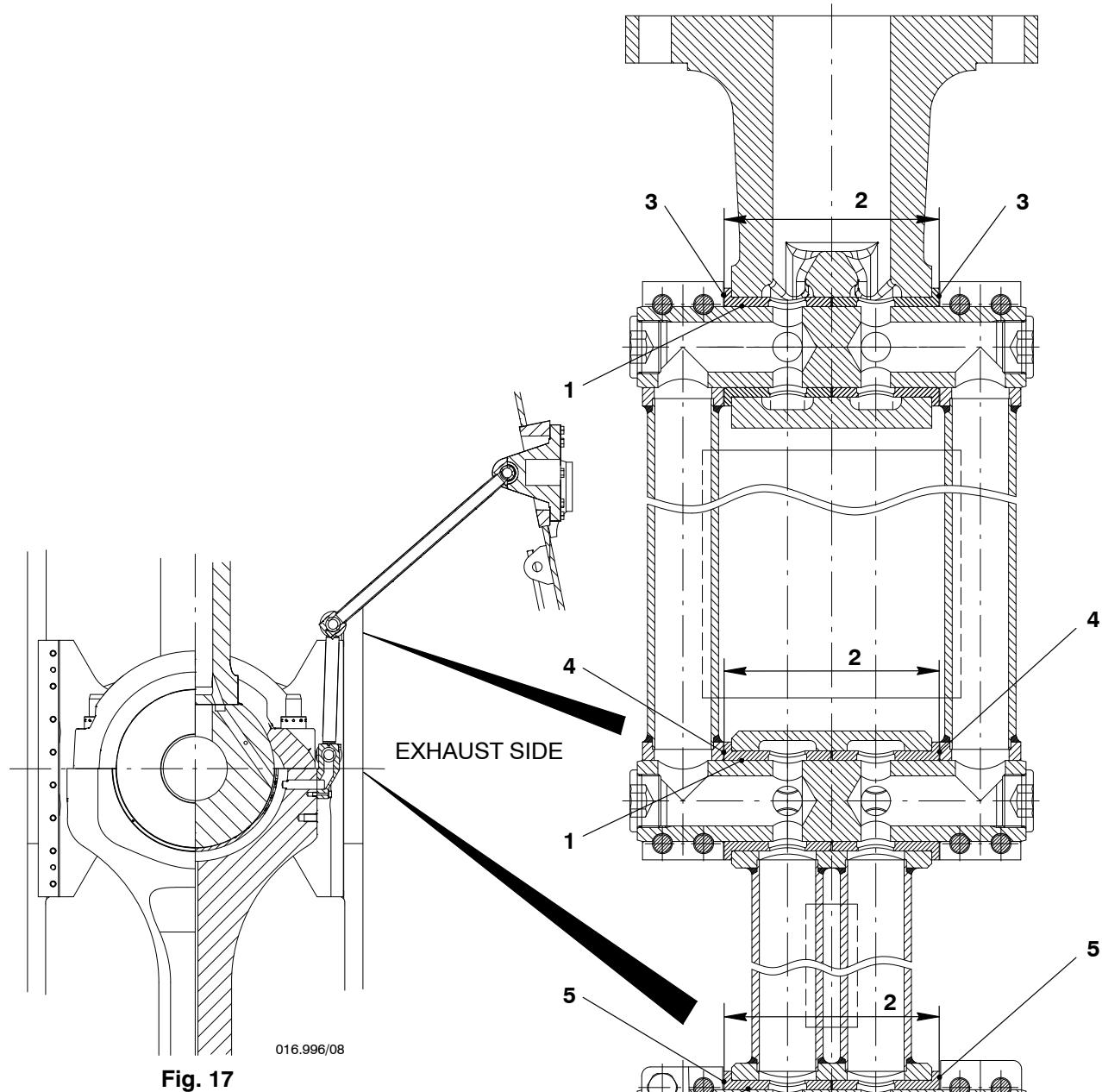
Clearance Table**Top and Bottom End Bearings to Connecting Rod****Fig. 16**

016.993/08

Clearance Table**Top and Bottom End Bearings to Connecting Rod**

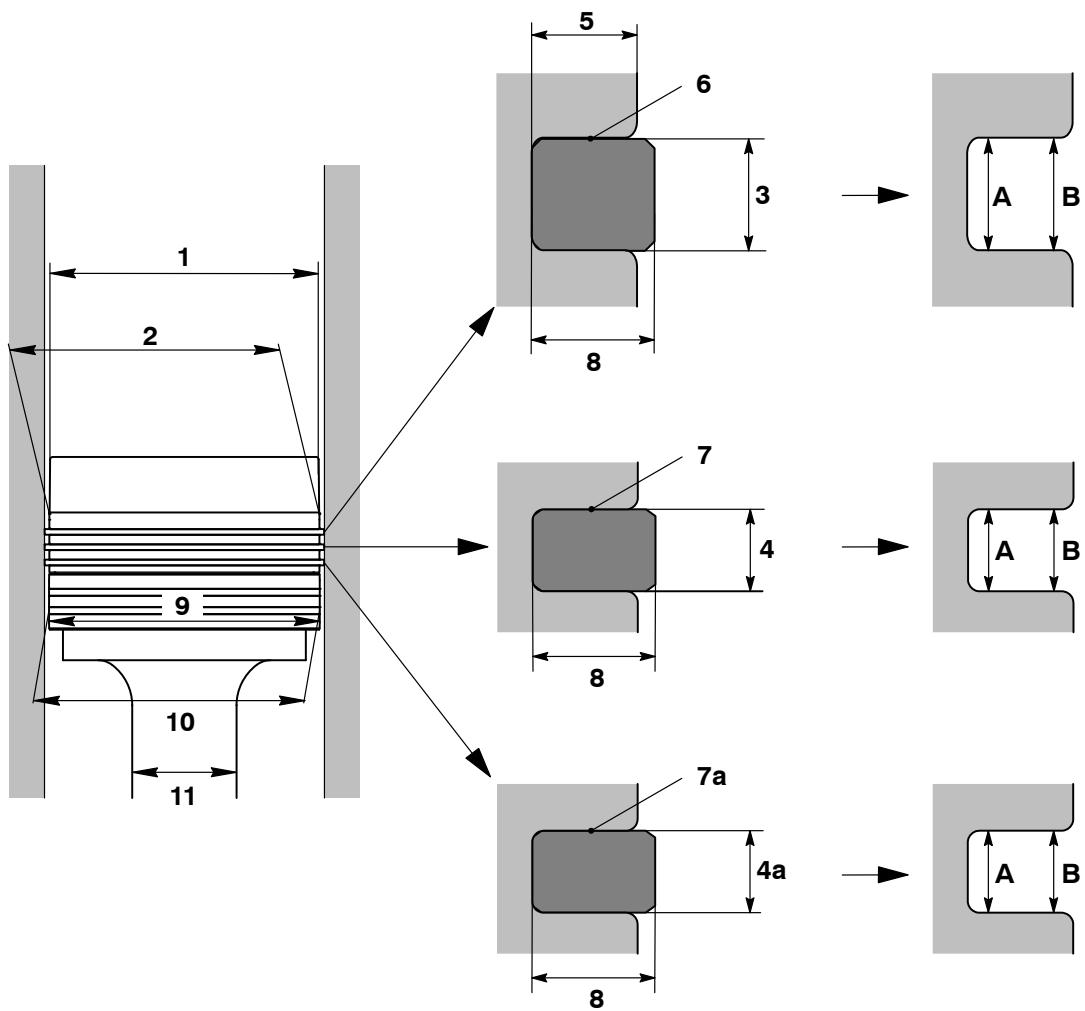
Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
3303 3326		Top end bearing			
		Crosshead pin	outer Ø	580 $^{+ 0.62}_{+ 0.56}$	
		Bearing	inner Ø	580	
	1	Bearing clearance	vertical	0.40–0.60	0.8
	*2	Lateral clearance	total	0.40–0.60	
	*3	Lateral clearance	total	0.30–0.50	
3303		Bottom end bearing			
		Crankshaft	outer Ø	760 $^{+ 0}_{- 0.08}$	
		Bearing	inner Ø	760	
	5	Bearing clearance	vertical	0.40–0.65	0.85
	*6	Lateral clearance	total	0.50–0.70	
	*7	Lateral clearance	total	0.50–0.70	

* Pay attention to measuring point!

Clearance Table**Piston Cooling and Crosshead Lubricating Link**

Clearance Table**Piston Cooling and Crosshead Lubricating Link**

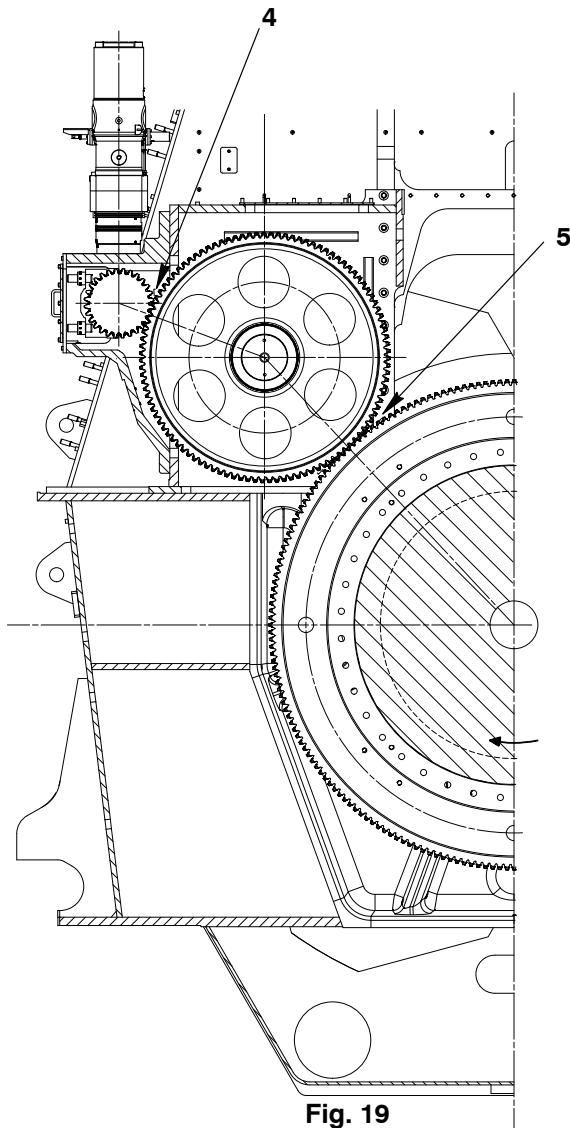
Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
3603		Piston cooling and crosshead lubricating link			
		Pin	outer Ø	55	
	1	Bearing clearance	radial	0.03–0.09	0.20
	2	Bearing	width	146	
	3	Lateral clearance	per side	min. 0.5	
	4	Lateral clearance	per side	min. 0.5	
	5	Lateral clearance	per side	min. 1.0	

Clearance Table**Piston and Piston Rings**

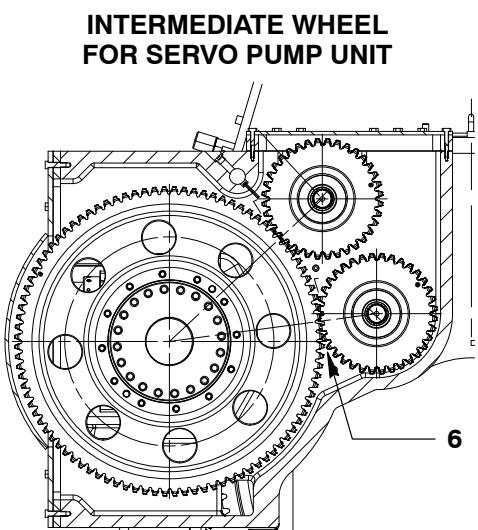
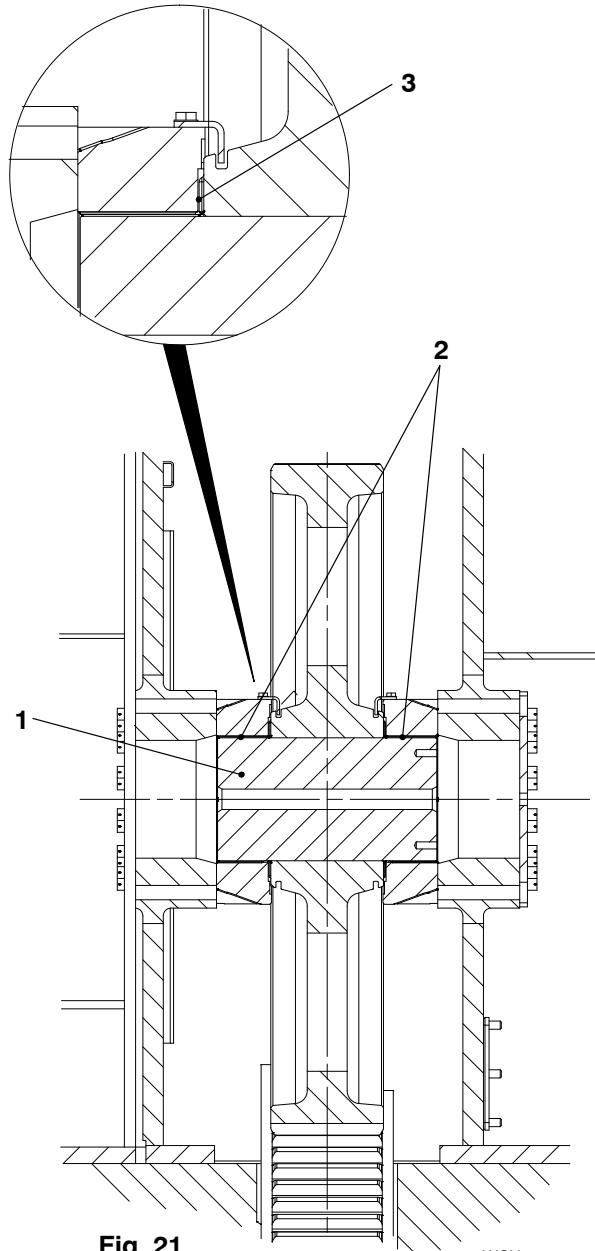
Clearance Table**Piston and Piston Rings**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
3406		Piston head			
	1	Head (tapered part)	outer Ø	615 ${}^0_{-0.2}$	
	2	Head	outer Ø	616 ${}^0_{-0.2}$	
3406		Piston ring grooves			
	3	Height of the uppermost groove	vertical	20 ${}^{+0.45}_{+0.40}$	
	4	Height of the middle groove	vertical	12 ${}^{+0.40}_{+0.35}$	
	4a	Height of the lowest groove	vertical	12 ${}^{+0.40}_{+0.35}$	
	5	Groove depth	radial	21 ${}^{+0.2}_{+0}$	
3425		Piston rings			
	3	Ring height	vertical	20 ${}^0_{-0.03}$	
	4	Ring height	vertical	12 ${}^0_{-0.03}$	
	4a	Ring height	vertical	12 ${}^0_{-0.03}$	
	6	Ring clearance	vertical	0.40–0.48	Point A
	7	Ring clearance	vertical	0.35–0.43	0.60
	7a	Ring clearance	vertical	0.35–0.43	0.75
	8	Ring width	radial	20 ± 0.25	Point B
3403		Piston skirt			
	9	Skirt	outer Ø	619.2 ${}^0_{-0.1}$	min. 618.1
	10	Rubbing ring	outer Ø	619.4 ${}^0_{-0.1}$	
3403		Piston rod			
	11	Rod	outer Ø	240 ${}^{-0.050}_{-0.096}$	min. 239.0

Used piston rings can be installed again if they are in their minimum ring width until the next overhaul (for more data about the piston rings see also [3425-1](#)).

Clearance Table**Driving Wheels for Supply Unit**

**INTERMEDIATE WHEEL
FOR SUPPLY UNIT**

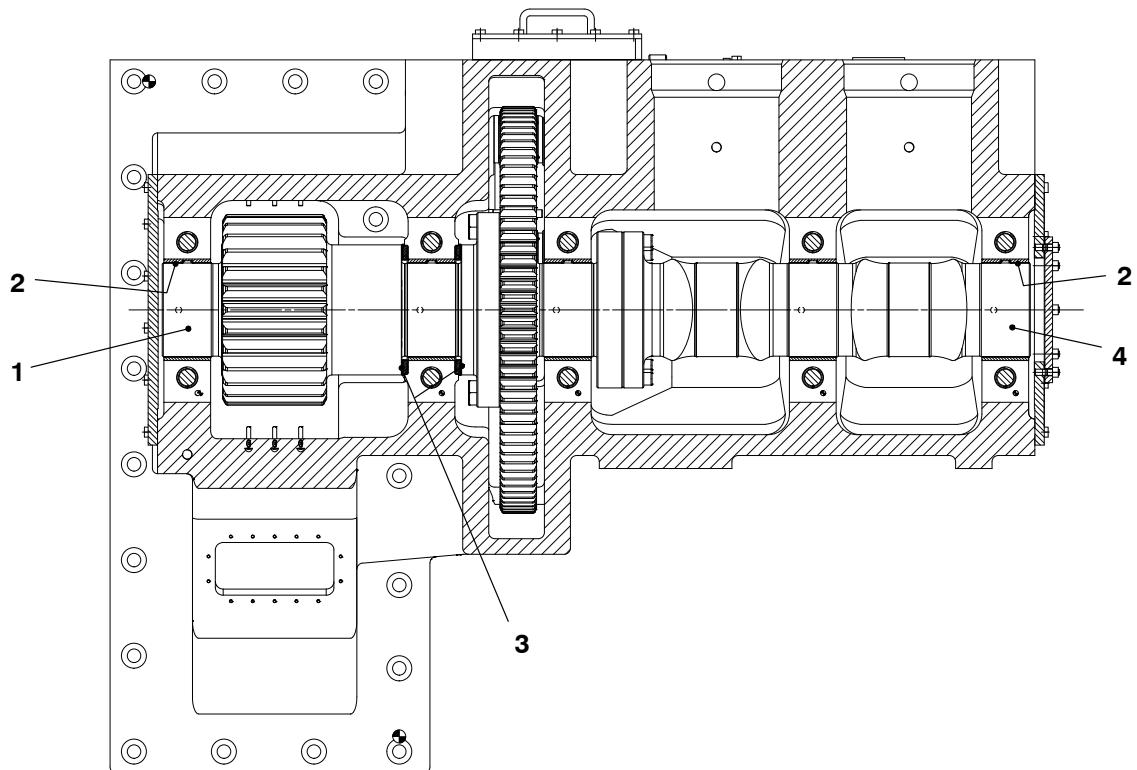
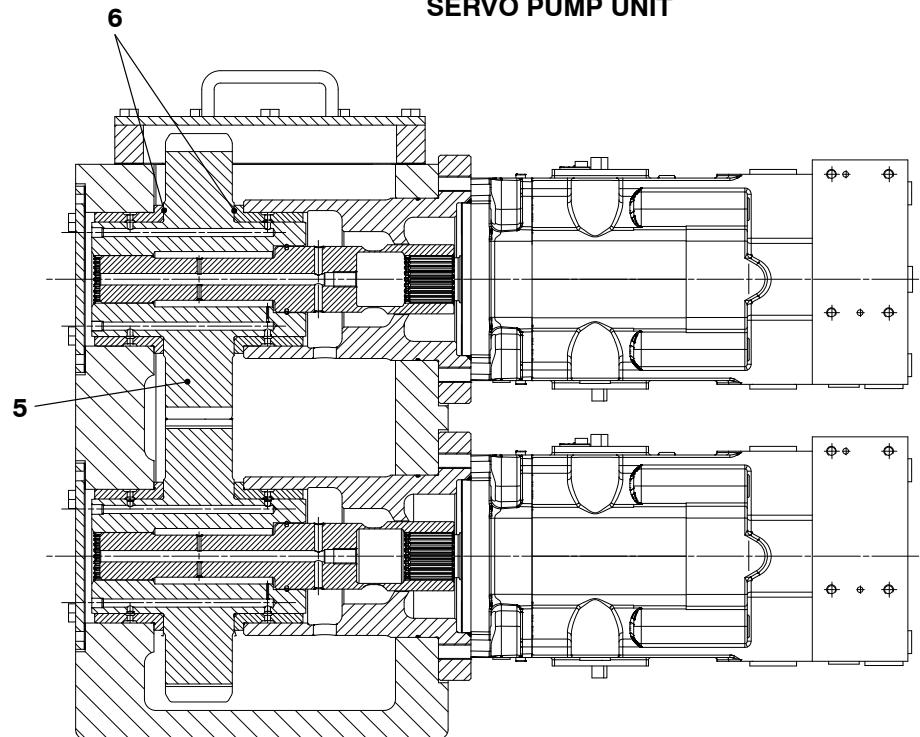


**INTERMEDIATE WHEEL
FOR SERVO PUMP UNIT**

Clearance Table**Driving Wheels for Supply Unit**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
4103		Intermediate wheel			
	1	Shaft	outer Ø	240	
	2	Bearing clearance	vertical	0.15–0.18	0.20
	3	Axial clearance	total	0.6–1.1	1.5
	4	Tooth backlash		0.24–0.39	0.41
	5	Tooth backlash		0.33–0.51	0.53
	6	Tooth backlash		0.16–0.30	0.34

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

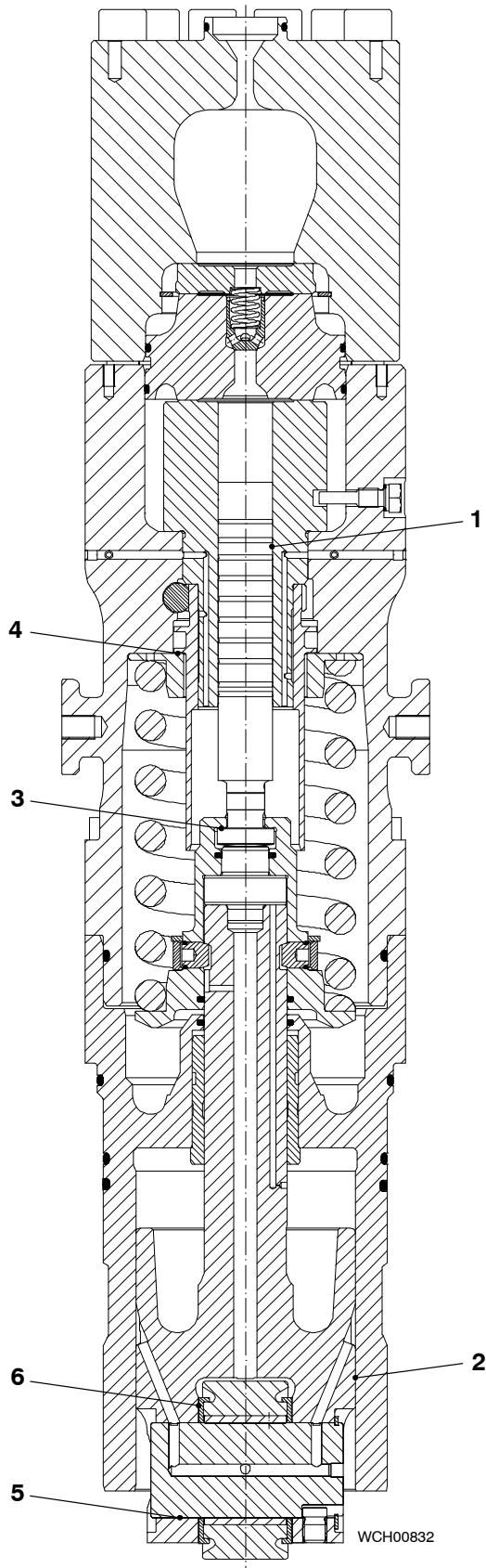
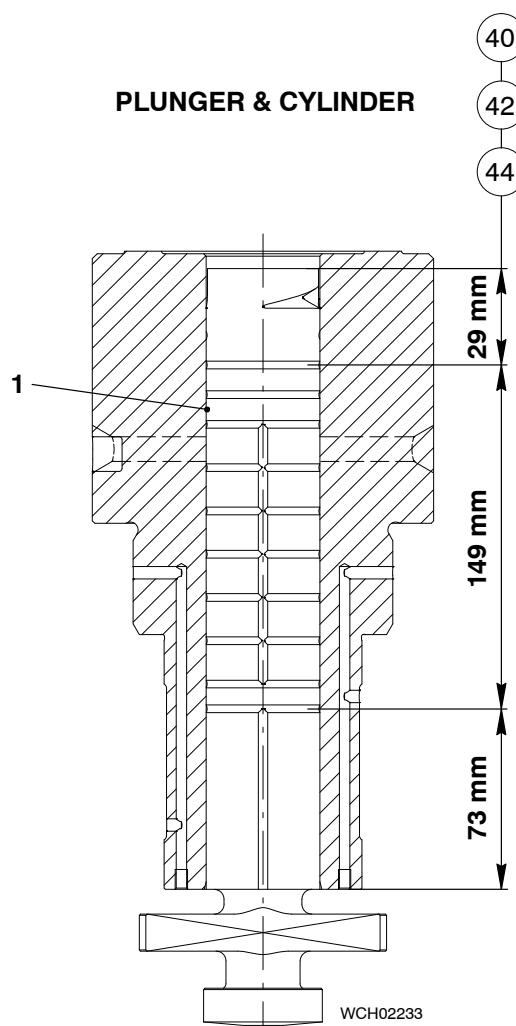
Clearance Table**Fuel and Servo Pump Units****FUEL PUMP UNIT****Fig. 22****SERVO PUMP UNIT**

WCH02232

Fig. 23

Clearance Table**Fuel and Servo Pump Units**

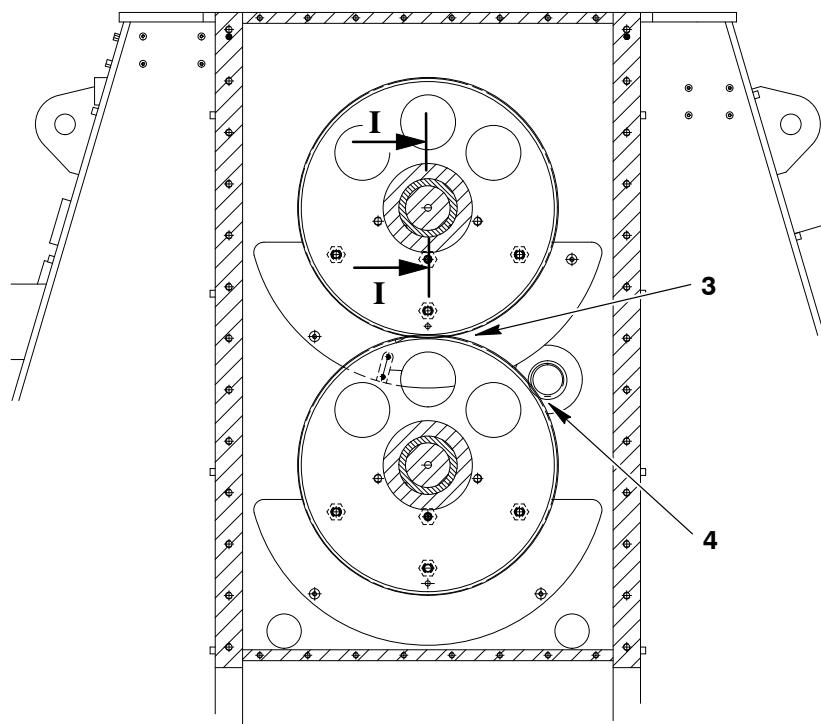
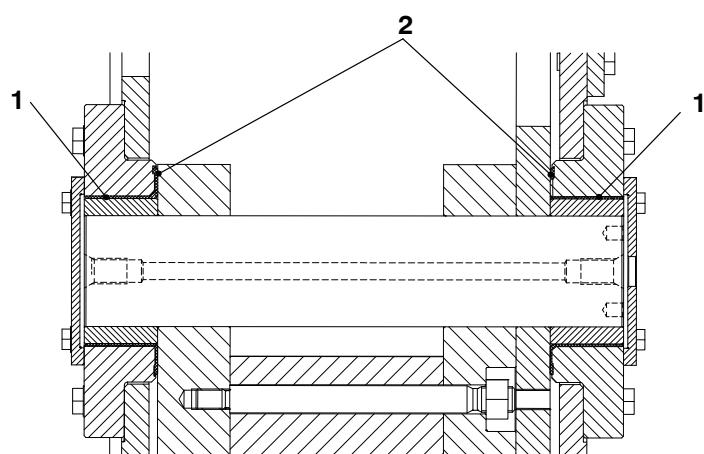
Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of wear) [mm]
5552		Fuel pump unit			
	1	Gear Wheel	outer Ø	180 ⁰ _{- 0.025}	0.33
	2	Bearing clearance	radial	0.153–0.237	
	3	Axial clearance	total	0.30–0.65	0.81
	4	Cam shaft	outer Ø	180 ⁰ _{- 0.025}	
5552		Servo pump unit			
	5	Pinion	outer Ø	120 ⁰ _{- 0.022}	0.85
	6	Axial clearance	total	0.30–0.65	

Clearance Table**Fuel Pump****Fig. 24****Fig. 25**

Clearance Table**Fuel Pump**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
5556		Fuel pump			
		Plunger (40, 42 and 44 mm)			
	1	Clearance (plunger / cylinder) A-B	radial	0.035–0.038	0.045
		Clearance (plunger / cylinder) B-C	radial	0.025–0.028	0.035
		Clearance (plunger / cylinder) D	radial	0.040–0.043	0.5
	2	Guide piston	outer Ø	185	
		Lower housing	inner Ø	185	
		Clearance	radial	0.22–0.68	0.8
	3	Piston / lower spring carrier	axial	0.12–0.24	0.3
	4	Regulating sleeve / upper spring carrier	axial	0.5–0.7	0.8
5556		Roller guide			
		Pin	outer Ø	80 ⁰ _{- 0.013}	
	5	Guide piston (bore)	inner Ø	80 ^{+ 0.04} _{+ 0.01}	
		Clearance	radial	0.010–0.053	0.08
		Total clearance between guide piston and roller with pressure discs	axial	0.26–0.54	0.7

* Plunger conically machined in range 'C'–'D'; i.e. clearance increases in diameter of 0.015 mm.

Clearance Table**Integrated Electric Balancer**I - I

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Fig. 26

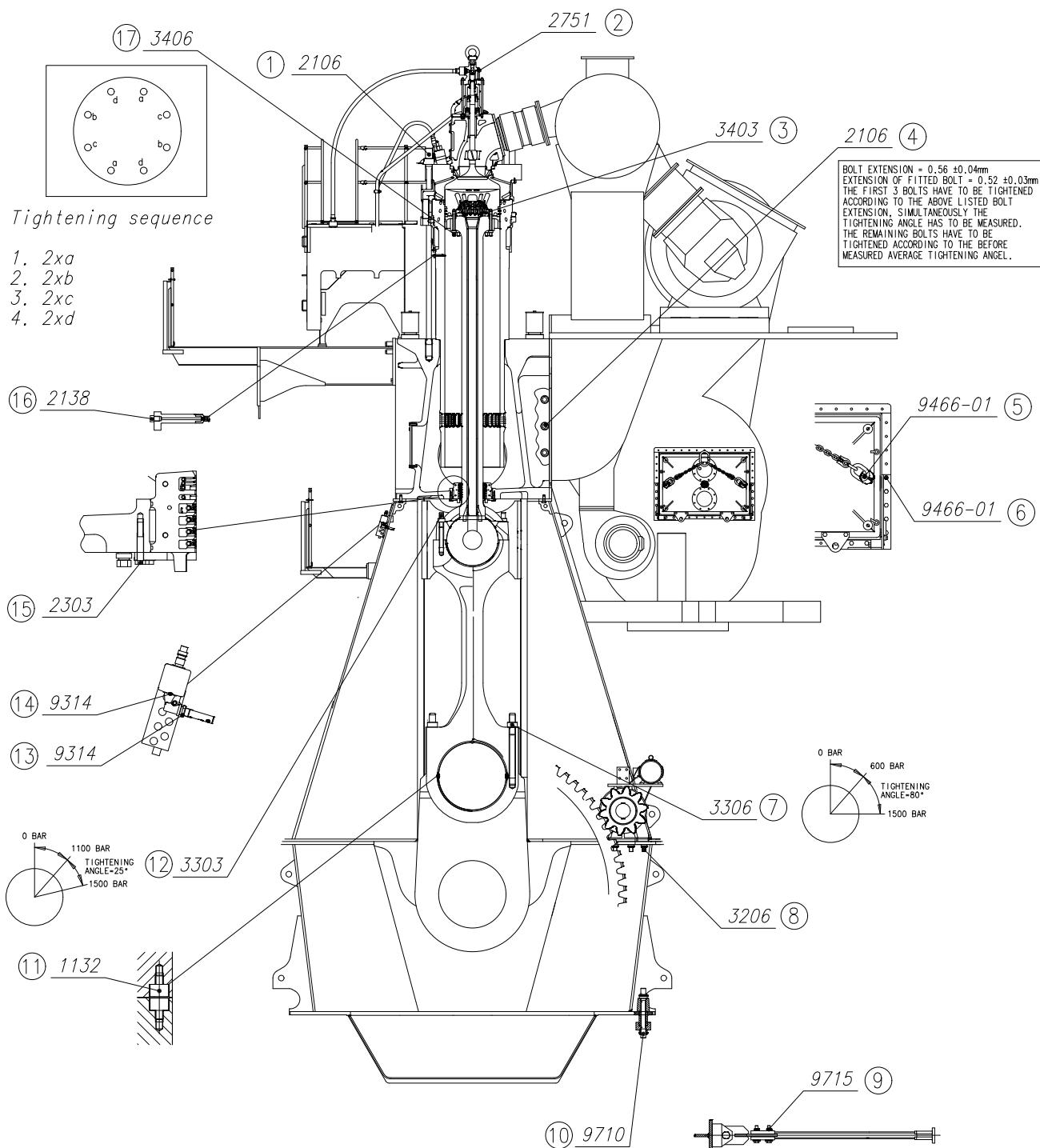
Clearance Table**Integrated Electric Balancer**

Group	Key No.	Description	Measuring Direction (method of measuring)	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of wear) [mm]
7758		Bearing			
	1	Bearing pin	outer Ø	170	
	1	Bearing clearance	radial	0.16–0.28	0.320
	2	Axial clearance	total	0.5–1.1	1.5
7758		Compensating shaft			
	3	Tooth backlash*		0.20–0.25	
	3	Deviation over width		0.02	
	4	Tooth backlash*		0.30–0.35	
	4	Deviation over width		0.02	

*When measuring the tooth backlash pay attention to the tooth crowning of the tooth flanks in longitudinal direction. Use lead wire of Pb99.9 fine and 1 mm diameter

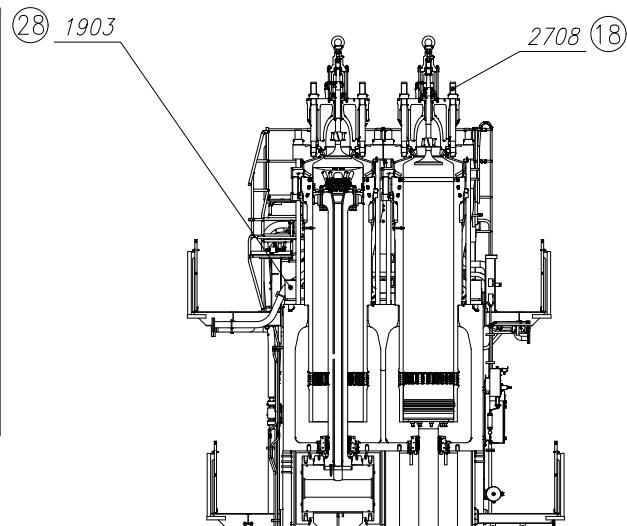
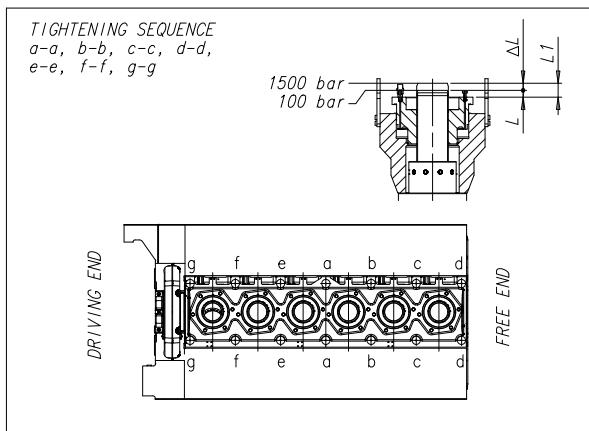
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Tightening Values of Important Screwed Connections

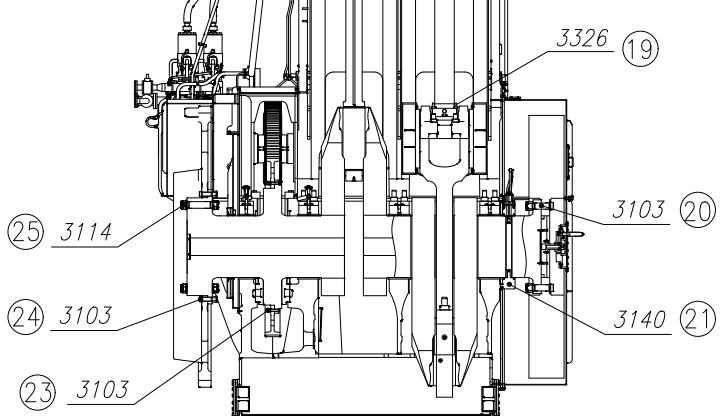
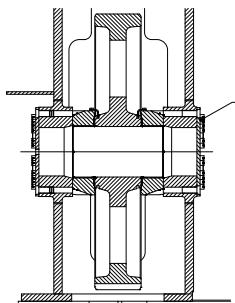


Tightening Values of Important Screwed Connections

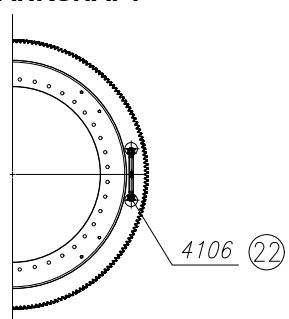
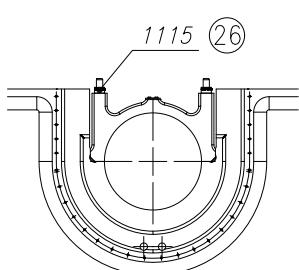
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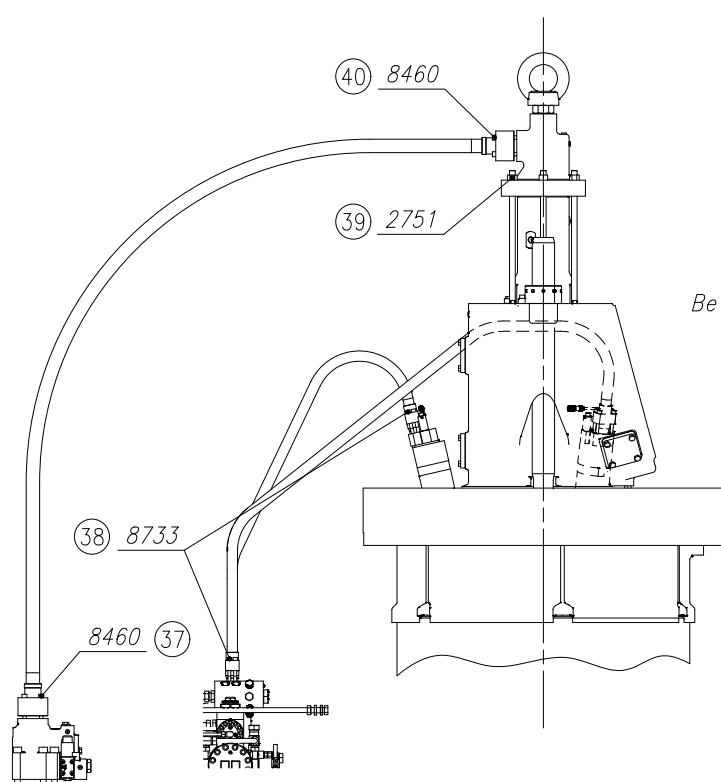
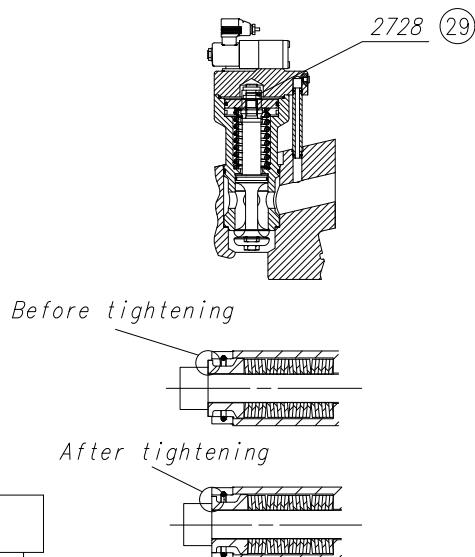
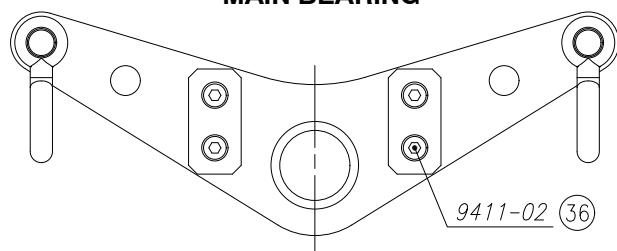
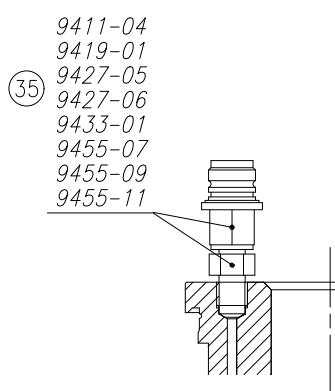
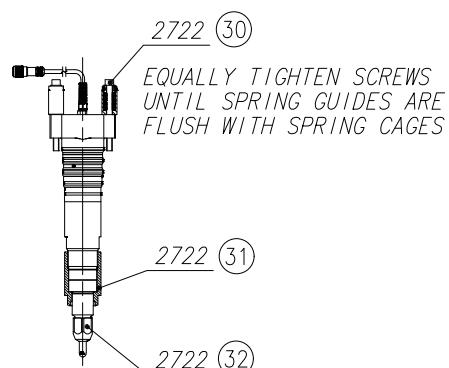
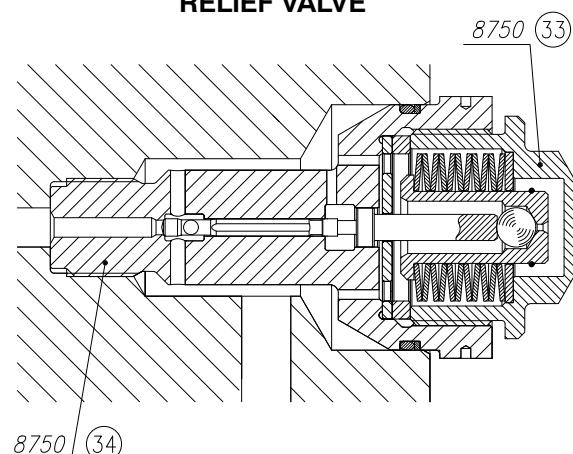
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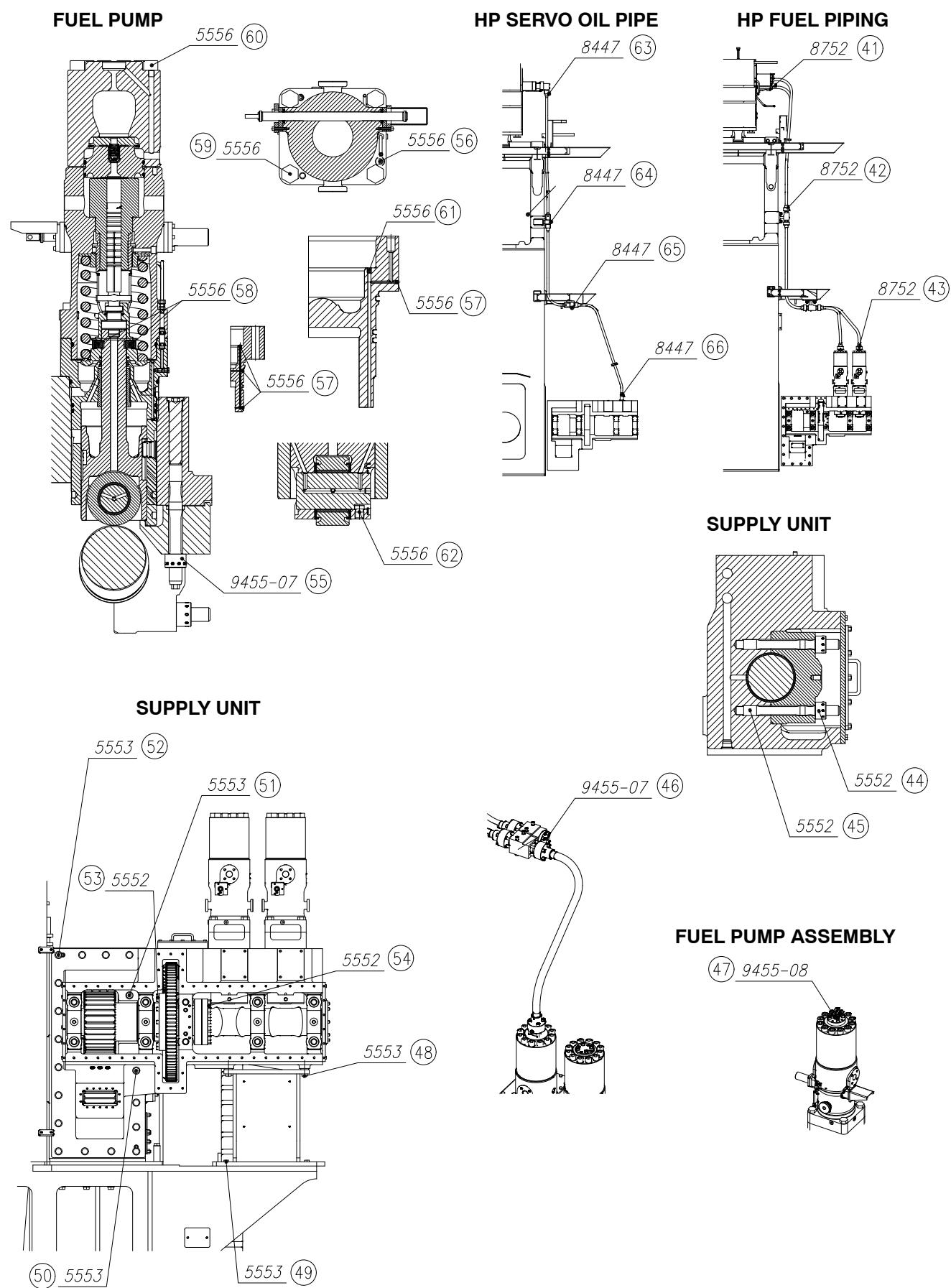
MAIN BEARING



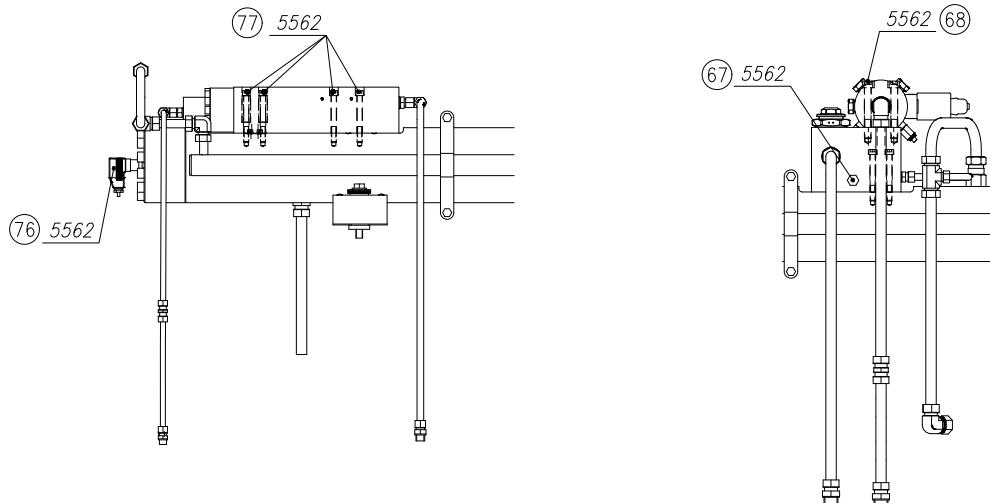
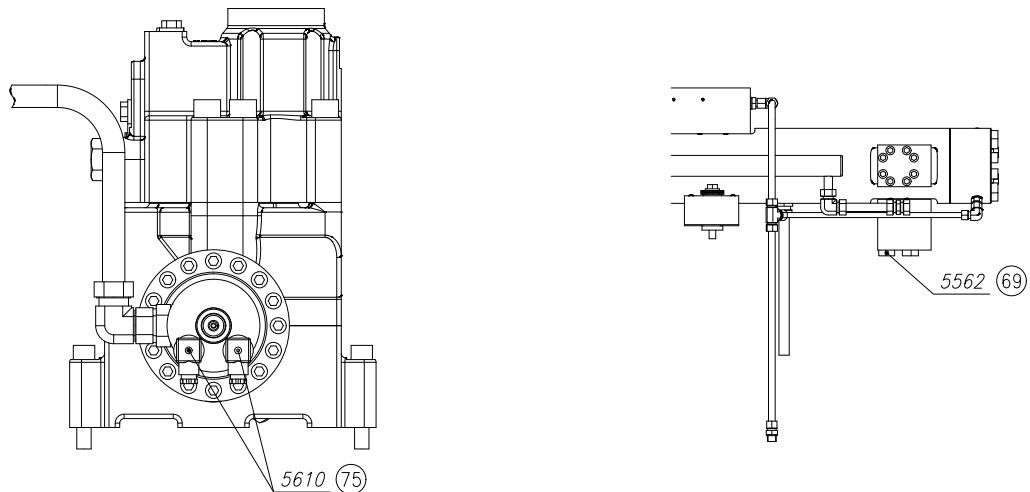
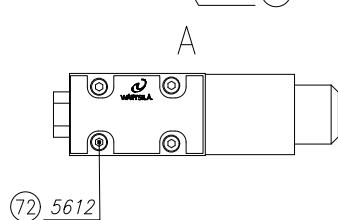
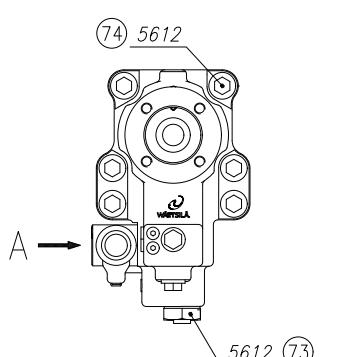
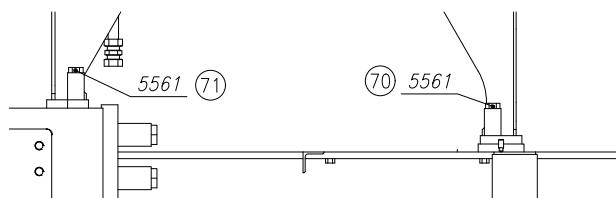
Tightening Values of Important Screwed Connections

HP PIPE INJECTION VALVE**STARTING AIR VALVE****MAIN BEARING****INJECTION VALVE****RELIEF VALVE**

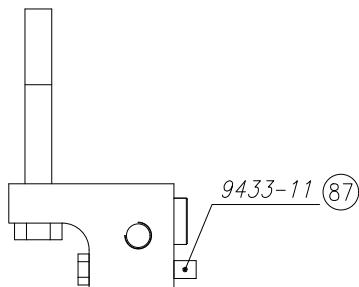
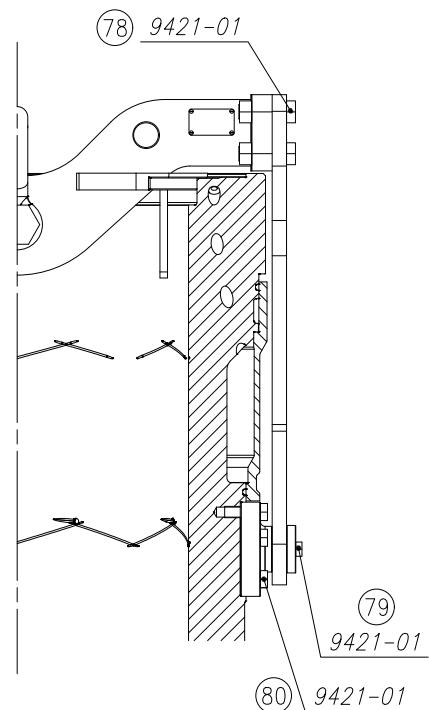
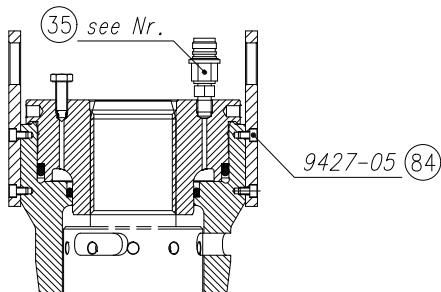
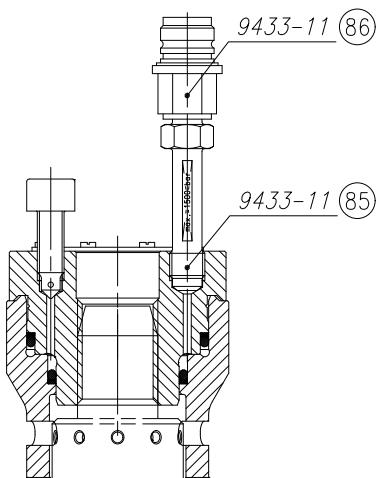
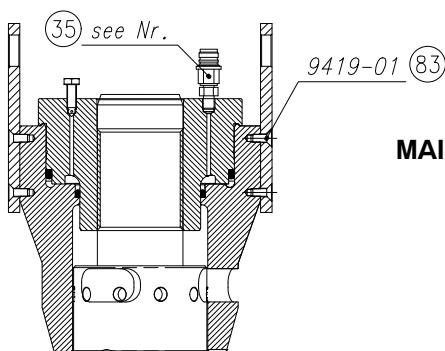
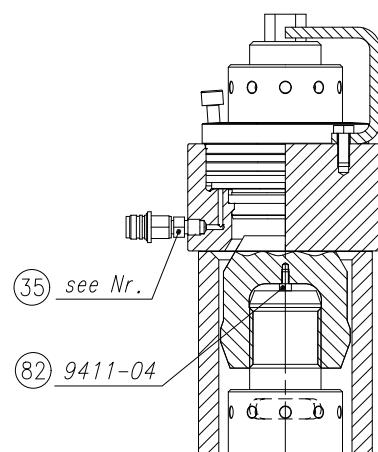
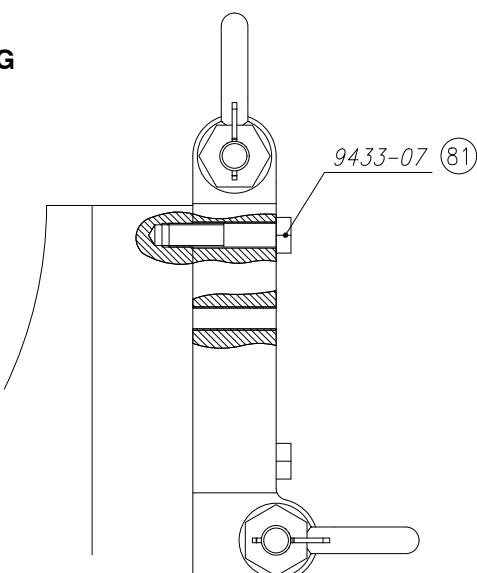
Tightening Values of Important Screwed Connections



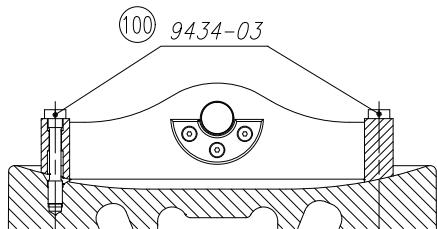
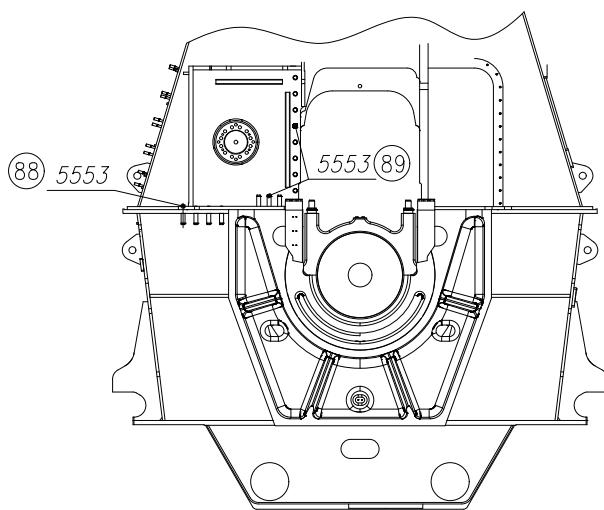
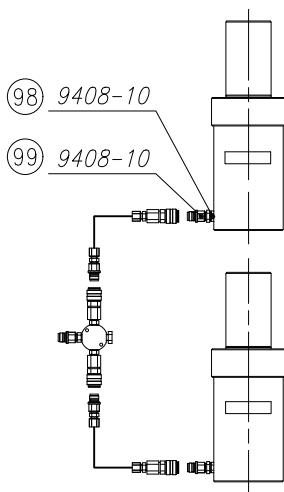
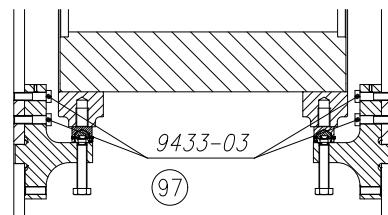
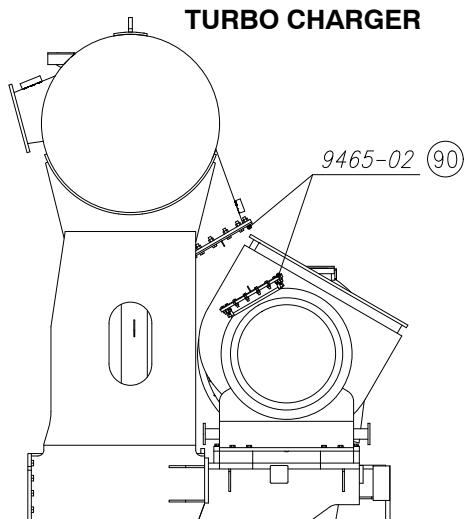
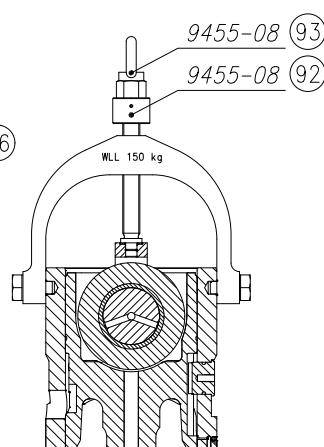
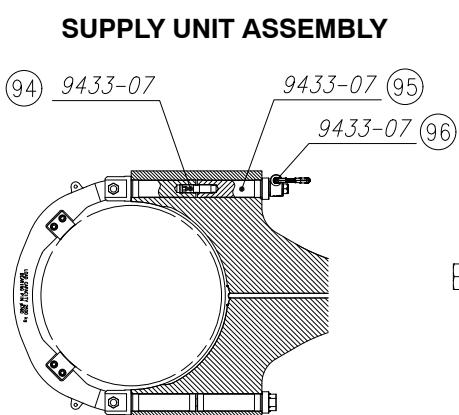
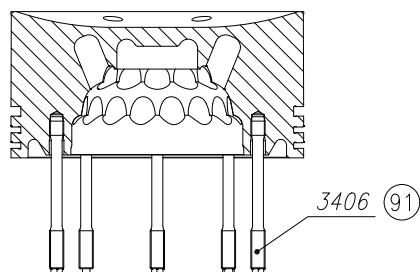
Tightening Values of Important Screwed Connections

FUEL RAIL**SERVO OIL RAIL****EXHAUST VALVE CONTROL UNIT****RAIL UNIT**

Tightening Values of Important Screwed Connections

CONNECTING ROD BEARING**CYLINDER LINER ASSEMBLY****VALVE CAGE / LOWER CONNECTING ROD PRE-TENSIONING****CONNEC. ROD BEARING PRE-TENSIONING****TIE ROD PRE-TENSIONING****MAIN BEARING PRE-TENSIONING****CONNECTING ROD ASSEMBLY**

Tightening Values of Important Screwed Connections

PISTON ASSEMBLY**SUPPLY UNIT ASSEMBLY PARTS****(GENERAL) JACKS AND PUMPS****CONNECTING ROD CROSSHEAD****TURBO CHARGER****FUEL PUMP ASSEMBLY****PISTON HEAD**

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [Nm]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [°]	Control angle from step 1 to step 2 [*]	Lubricant	Thread size	Comments
1	1500					(396)		O	M76x6	
2		20						O	M12x1.5	
3		(75)	20 Nm	45°				K	M12	
4					0.56 ±0.04			O	M48	See on page 1 position 4
5		225						O	M30	Or hand-tight with open-end spanner
6		136						O	M16	
7	1500		600 bar	1500 bar			80	O	M72	
8		(2000)				60		M	M48	See on page 1 position 8
9	170							K	M64	Hydraulic jack Group 9710
10	1500		1000 bar	1500 bar				K	M64	
11		10						K	M10	
12	1500		1100 bar	1500 bar			25	O	M48	
13		14–15						M	G ³ / ₄ "	
14		1.7–2.3						K	–	
15		150						O	M16	
16		10						O	M10	
17	1500					(85)		O	M30	See on page 1 position 17
18	1500					(200)		O	M72x6	
19	1500		1000 bar	1500 bar			20	O	M30	
20		(3900)				25		M	M56	
21		(900)				40		M	M30	
22					1.3 ±0.06			M	M39	
23		1600				(80)		K	M30x2	Secured with Loctite 262
24		3900				(25)		M	M56	
25		(14000)				50		M	M85	
26	1500							O	M52	
27		(1200)				60		M	M30	
28	1500				11.5 to 13.5			M	M90x6	
29		300						K	M24	
30								N	M12	See on page 3 position 30
31			100 Nm	40°				N	M65x1.5	

M	MOLYKOTE PASTE G–N On threads and contact surfaces	C	MOLYSLIP COPASLIP On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces
K	NO ADDITIONAL LUBRICATION	O	LUBRICATING OIL SAE 30 On threads and contact surfaces		

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [NM]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [°]	Control angle from step 1 to step 2 [°]	Lubricant	Thread size	Comments
32		190						N	M36x1.5	
32		600						N	M60	
33		300						N	M30	
34		45						O	G ¹ / ₄ "	
35		45						O	G ¹ / ₄ "	
36		1.6						K	M8	
37		40						O	M10	
38		60						N	M12	
39		150						O	M16	
40		40						O	M10	
41		80						N	M14	
42		80						N	M14	
43		80						N	M14	
44	1500							O	M39	
45		100						O	M39	
46		80						N	M14	
47		115						K	M20	Secured with Loctite 240
48		600						O	M24	
49		350						O	M20	
50		600						O	M24	
51		600						O	M24	
52		600						O	M24	
53		215						O	M16	
54		215						O	M16	
55	1500				84			K	M36	
56		140						N	M16	
57		3						K	M6	Stuck on with Loctite 0243
58		80						K	M22x1.5	
59		(1250)			64			O	M30	
60		480						N	M27	
61		7						K	M8	Stuck on with Loctite 0243
62		60						K	M20	

M	MOLYKOTE PASTE G-N On threads and contact surfaces	C	MOLYSLIP COPASLIP On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces
K	NO ADDITIONAL LUBRICATION	O	LUBRICATING OIL SAE 30 On threads and contact surfaces		

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [Nm]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [*]	Control angle from step 1 to step 2 [°]	Lubricant	Thread size	Comments
63	20					O	M10			
64	20					O	M10			
65	20					O	M10			
66	20					O	M10			
67	70					N	M20x2			
68	190					N	M16			
69	110					N	M14			
70	350					O	M20			
71	350					O	M20			
72	9					O	M5			
73	225					O	M33x2			
74	350					O	M20			
75	25					O	G1/4"			
76	25					N	M14x1.5			
77	70					N	M16			
78	min. 290					C	M30	Min. 290 Nm – max. 960 Nm		
79	205					C	M42			
80	140					C	M20			
81	175					O	M20			
82	7					K	M6	Secured with Loctite 2701		
83	16					O	M8			
84	7					O	M6			
85	45					O	G1/4"			
86	45					O	G1/4"			
87	80					O	M16			
88	600					O	M24			
89	600					O	M24			

M	MOLYKOTE PASTE G–N On threads and contact surfaces	C	MOLYSLIP COPASLIP On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces
K	NO ADDITIONAL LUBRICATION	O	LUBRICATING OIL SAE 30 On threads and contact surfaces		

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [Nm]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [°]	Control angle from step 1 to step 2 [*]	Lubricant	Thread size	Comments
90		60						O	M16	
91		25						O	M30	
92		10						K	M24	Secured with Loctite 2701
93		10						K	M16	Secured with Loctite 2701
94		140						K	M36	Screw glued in with Loctite 268
95		70						C	M36	
96		400						K	M27	Lifting Lug glued in with Loctite 268
97		240						O	M24	
98		45						K	G1/4"	Closing Valve sealed with Loctite 542
99		45						O	G1/4"	
100		60						O	M20	

M	MOLYKOTE PASTE G-N On threads and contact surfaces	C	MOLYSLIP COPASLIP On threads and contact surfaces	N	NEVER SEEZ NSBT8 On threads and contact surfaces
K	NO ADDITIONAL LUBRICATION	O	LUBRICATING OIL SAE 30 On threads and contact surfaces		

Designation: Short form:	LUBRICATION OIL SAE 30 0	Designation: Short form: K factor: Manufacturer:	MOLYSLIP COPASLIP C 0.16 Molyslip Atlantic Ltd A1 Danebrook Court Oxford Office Village Langford Lane, Kidlington Oxfordshire OX5 1LQ England
Designation: Short form: Coefficient of friction: (M12, 8.8 blackened)	MOLYKOTE PASTE G-N Plus M Thread: 0.12 Head: 0.06 Dow Corning Corporation Corporate Center PO Box 994 MIDLAND MI 48686-0994 United States	Designation: Short form: K factor: Manufacturer:	NEVER SEEZ NSBT8 N 0.13 Bostik, Inc, Bostik Americas Technology Center 11320 W. Watertown Plank Road Wauwatosa, WI 53226 414 United States

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Torque Values and Elastic Stud Replacement

Torque Values – Standard Screws and Elastic Studs

1. Torque Values – Standard Screws

We highly recommend the torque values given in the table below for all standard metric screws of grade 8.8. This applies to all threaded connections not shown on page [0352-1](#). The threads and base of the head must be lubricated with oil SAE 30.

For the screws in high temperature areas (exhaust pipes, expansion pieces etc), a heat resistant lubricant, e.g. NEVER SEEZ NSBT8, is recommended.

If NEVER SEEZ NSBT8 is used, the torque value must be decreased by 20% of the values given in the table.

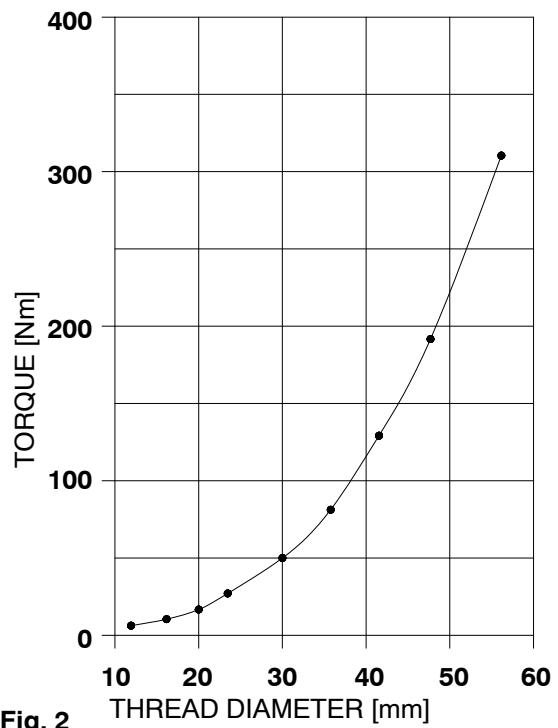
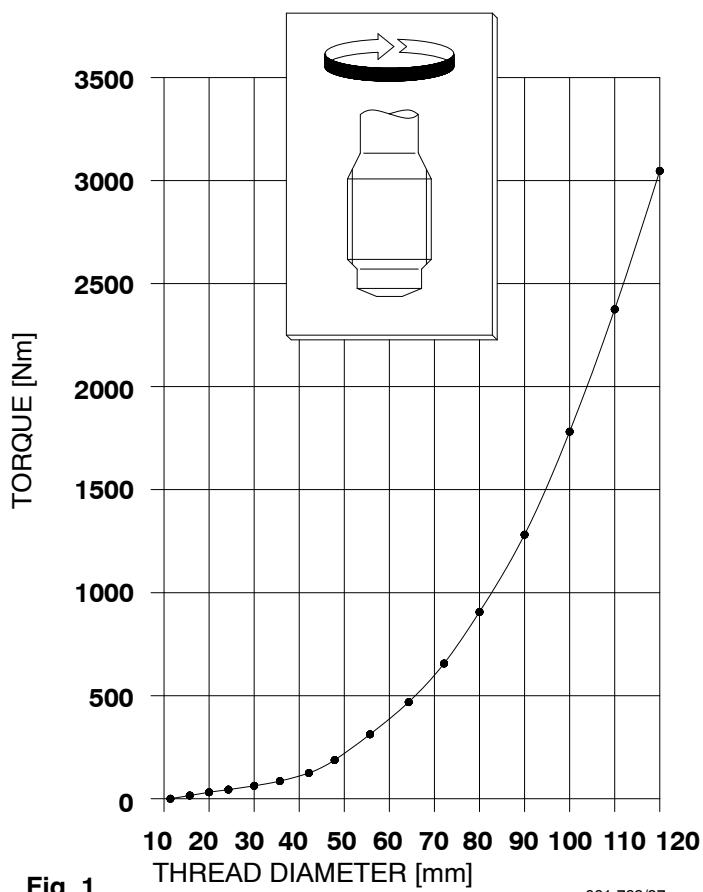
These torques values do not apply to turbocharger installations. Refer to the documents of the turbocharger manufacturer for the correct torque values.

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

2. Replacement of Elastic Studs

2.1 Procedure

- 1) Read the data in the manual of the jointing compound manufacturer.
- 2) Remove the unserviceable elastic stud.
- 3) Remove the grease and clean the sealing surfaces of the new elastic stud.
- 4) Remove the grease and other unwanted material from the tap hole and the area where the elastic stud will be installed.
- 5) Clean the tap hole and the area where the elastic stud will be installed.
- 6) If necessary, apply an adhesive primer to the shank of the elastic stud. Make sure that no adhesive primer goes on to the threads.
- 7) Use only a stud driver (or two nuts locked together) to fully install the stud into the tap hole.
- 8) Torque the elastic stud to the applicable value given in the table below:



Torque Values – Standard Screws and Elastic Studs

- 9) For the elastic studs installed in the valve cage, cylinder liner and cylinder jacket fill the area around the elastic stud with jointing compound (see Fig. 3).

(A)

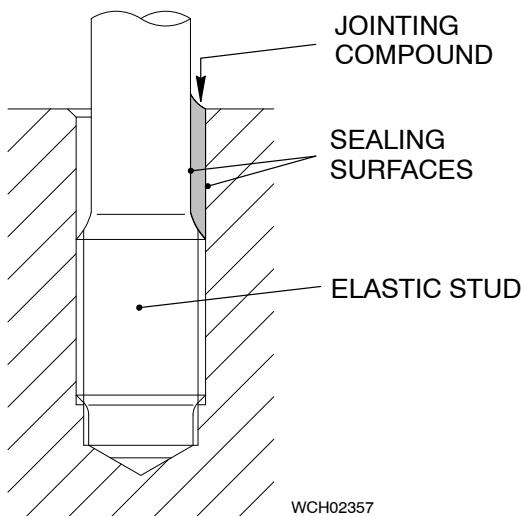


Fig. 3

WCH02357

2.2 Jointing compound

See the table below for the recommended manufacturers of jointing compounds and adhesive primers:

Jointing compound	Hardener	Adhesive primer	Manufacturer
Elastosil RT 622 A	RT 622 B	G 790	Wacker-Chemie GmbH Geschäftsbereich Silicone Hanns-Seidel-Platz 4 D-81737 München
Silcoset 105 RTV	Silcoset Curing Agent A	Silcoset Primer	AMBERSIL LTD Wylds Rd Bridgwater Somerset TA6 4DD Uk-Great Britain

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

Materials from other manufacturers are permitted, but must have the qualities given below:

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

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Masses (Weights)**Individual Components per Piece in kg**

Group	Component	Execution	kg
1			
1115	Main bearing cover (1st)		328 (252)
1134	Main bearing shell		43.0
1224	Thrust bearing pad		67.0
1717	Casing (lower part) Casing (upper part)	free end	1158 639
1719	Casing right Casing left	driving end	161 52
1720	Oil baffle, upper half Oil baffle, lower half		259 161
1903	Tie rod Tie rod nut Intermediate ring for tie rod nut		318 6.69 7.6
2			
2106	Elastic bolt in cylinder jacket		50.5
2124	Cylinder liner		3535
2130	Water guide jacket (upper part) Water guide jacket (lower part)		91.9 156
2303	Piston rod gland	complete	109
2708	Elastic bolt for valve cage Cylinder cover without accessories Cylinder cover with exhaust valve unit, all valves and upper water guide jacket	complete	26.8 1487 2283.9
2722	Injection valve	complete	19.9
2728	Starting valve	complete	34.0
2751	Exhaust valve housing with spindle	complete	677.5
2754	Exhaust valve spindle		65.5
3			
3122	Flywheel		3390-11003
3140	Axial damper cylinder	2-part	793
3206	Turning gear with planetary gear		1266
3306	Connecting rod With elastic stud and nut for bottom end bearing	complete	2443
3306	Bearing cover for bottom end bearing with elastic studs	complete	360

Individual Components per Piece in kg

Group	Component	Execution	kg
3310	Bearing shell for bottom end bearing		35.0
3312	Bearing cover for top end bearing		297
3315	Bearing shell for top end bearing		65.0
3326	Crosshead pin Crosshead with guide shoes Guide shoe	complete complete	1460 2214 349
3403	Piston with piston rod Piston crown Piston skirt Piston rod Spraying plate with oil pipe Piston rings	complete	1800.2 444 112 1160 72.4 11.8
3603	Toggle lever to piston cooling and crosshead lubrication	complete	100
4			
4106	Gear wheel on crankshaft	2-part, complete	1598
4325	Shut-off for starting air		246
5			114
5551	Servo oil pump		
5552	Supply unit with 3 fuel pumps and 2 oil pumps		5863
5556	Fuel pump	complete	420
5581	Camshaft with gear wheels	compl. (3 fuel p.)	745
5612	Exhaust valve control unit	complete	37.4
6			
6506	Turbocharger	MET 42MB MET 53MB MET 60MB MET 66MB MET 71MB MET 83MB ABB A265 ABB A270 ABB A275 ABB A280	1600 4100 4500 6500 800 12500 2700 3800 6300 8600
6545	Auxiliary blower with electric motor Electric motor	complete	946 450

Individual Components per Piece in kg

Group	Component	Execution	kg
6509	Expansion piece between exhaust manifolds and before turbocharger		50–70
6606	Scavenge air cooler	GEA A9	2740
6708	Water separator		202
7 7758	Electric balancer compensating shaft (gear wheel, counter weight and bearing pin) Electric motor		1326 180
8 8103	Expansion piece after exhaust valve	DN 500	80.0

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Maintenance Schedule**Inspection and Overhaul Intervals (Guidelines)**

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
0	Lubricating oil	<ul style="list-style-type: none"> - Laboratory analysis 	3000
	Main fuel and lubricating oil filters	<ul style="list-style-type: none"> - Check filter elements – in particular for white metal particles (clean or replace filter as necessary). Follow manufacturer's instructions 	3000
	Cooling water	<ul style="list-style-type: none"> - Calculate quality, concentration of inhibitor and pH value (follow instructions of inhibitor manufacturer) 	weekly
1			
1112-1	Bedplate	<ul style="list-style-type: none"> - Check pre-tension of foundation bolts, first check after 1500 Op. H 	12000
		<ul style="list-style-type: none"> - Check condition of rubber gasket in the vertical oil drain to sump tank (see SPC 9722), first time at the earliest opportunity after ship delivery. - Estimated lifetime: Bedplate foundation bolts 	30000 (replacement recommended) engine lifetime
	Crankcase	<ul style="list-style-type: none"> - Visual examination, 100 Op. h after overhaul works: search for white metal particles from bearings and for abnormalities in general. - Estimated lifetime: crankcase 	1500 – 3000 engine lifetime
1132-2	Main bearing	<ul style="list-style-type: none"> - Bearing shell inspection is only necessary if bearing clearance, crankshaft deflection, wire check oil analysis or crankcase inspection indicates excessive wear or damage - Bearing edge check by wire - Check bearing clearance see 0330-1 - Estimated lifetime: Main bearing shell 	at indications of excessive wear or damage 6000 6000 90000 (replacement if required)
1203-1	Thrust bearing	<ul style="list-style-type: none"> - Check axial and vertical clearances - Check bottom drain for free passage 	6000 – 8000 6000 – 8000
1224-1		<ul style="list-style-type: none"> - Thrust bearing pads inspection is only necessary if bearing clearance, oil analysis or crankcase inspection indicates excessive wear or damage - Estimated lifetime: Thrust bearing 	at indications of excessive wear or damage 90000 (replacement if required)

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
1715-1	Engine stays	<ul style="list-style-type: none"> - Friction type: Check pre-tension of screws and remove corrosion marks from friction elements, first time after sea trial - Hydraulic type: Check oil pressure at the gauge 	6000 – 8000 monthly
1903-1	Tie rod	<ul style="list-style-type: none"> - Check pre-tension, if necessary re-tension, first time after one year of ship delivery - Estimated lifetime: Tie rod 	24000 – 30000 engine lifetime
2			
2124-1	Cylinder liner	<ul style="list-style-type: none"> - Measure liner wear (in installed condition) 	at each piston removal
2124-2		<ul style="list-style-type: none"> - Remove cylinder liner 	as necessary
		<ul style="list-style-type: none"> - Replace O-rings - Replace (soft iron) joint ring between cylinder liner and cylinder cover - Replace O-rings of Water guide jacket and transition tubes - Check condition of antipolishing ring 	at each liner removal at each piston removal at each liner removal at each piston removal
2124-3		<ul style="list-style-type: none"> - Grind off wear ridge in bore - Refinish lubricating grooves - Clean scavenge ports and refinish their edges - Estimated lifetime: Cylinder liner 	at each piston removal as necessary as necessary Up to 90000
2138-1	Lubricating quill (pulse lubrication)	<ul style="list-style-type: none"> - Check function and tightness - Check function of non-return valves 	at each piston removal at each piston removal
2303-1	Piston rod gland	<ul style="list-style-type: none"> - Clean rings, establish wear - Estimated lifetime: Piston rod gland 	at each piston removal 36000 (refers to rings)

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
2708-1	Cylinder cover	<ul style="list-style-type: none"> - Check combustion space for damage and wear - Estimated lifetime: Cylinder cover 	at each piston removal engine lifetime (remanufacturing as required)
2722-1	Injection valve (main fuel injector)	<ul style="list-style-type: none"> - Check externally for tightness - Function check (nozzle tip inspection, opening pressure). - Exchange nozzle tip (FAST type) - Replace O-rings - Replace injection valve complete - Estimated lifetime: Injection valve complete - Estimated lifetime: Nozzle spare parts set (e.g. coupling nut & nozzle body with needle) 	before starting the engine after longer standstill 8000 8000 8000 24000 24000 8000
2728-1	Starting air valve	<ul style="list-style-type: none"> - Check pipes upstream of the valve during operation, if pipes are too hot, disassemble starting valve - Remove and disassemble one starting valve, from the condition, calculate the time of overhaul for remaining valves - Make sure that the nut on the solenoid is tight, if necessary tighten the nut. - Solenoid valve; random functional check - Solenoid valve; Overhaul - Estimated lifetime: Starting valve 	weekly 12000 monthly 6000 18000 engine lifetime
2745-1	Relief valve to cylinder cover	<ul style="list-style-type: none"> - Check blow-off pressure 	as necessary
2751-1 to	Exhaust valve	<ul style="list-style-type: none"> - General inspection of valve housing, valve spindle and valve seat (without disassembly of the exhaust valve) 	at each piston removal
2751-4		<ul style="list-style-type: none"> - Check condition and wear of valve spindle (if necessary grind the seat) - Valve Drive: Check piston seal ring / air spring & rod seal ring / guide bush - Check condition and wear of valve seat - Random check of valve drive, outer and inner pistons, damper, thrust piece 	36000 (initial inspection 18000) 36000 (initial inspection 18000) 36000 (initial inspection 18000) 18000

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
2751-4		<ul style="list-style-type: none"> - Estimated lifetime: Exhaust valve spindle - Exhaust valve seat 	108000 (remanufacturing as required) 72000 (remanufacturing as required)
<u>3</u>			
3103-1	Crankshaft	<ul style="list-style-type: none"> - Measure crank deflection, always after the ship grounded and after each docking 	6000
3130-1	Torsional vibration damper	<ul style="list-style-type: none"> - Get a silicon oil sample from viscous vibration damper (based on results of 1st sample, interval for taking further samples will be decided by damper manufacturer) 	first time after 15000– 18000
3130-2		<ul style="list-style-type: none"> - Inspection interval and dismantling of vibration damper 	acc. to instructions of damper manufacturer
3140-1	Axial damper	<ul style="list-style-type: none"> - Disassembly and inspection 	36000 – 48000
3206-1	Turning gear	<ul style="list-style-type: none"> - Inspection interval of turning gear - Lubrication of tooth flanks of pinion and flywheel, related to visual inspections, however latest each 2000 Op. h of main engine - Check screwed connections, first time after one year 	in accordance with the instructions of the turning gear manufacturer 2000 12000
	Connecting rod bearings	<ul style="list-style-type: none"> - Check bearing clearances (see 0330-1) - Bearing edge check by wire 	6000 – 8000 6000 – 8000
3303-2		<ul style="list-style-type: none"> - Bottom end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage. 	at indications of excessive wear or damage
3303-3		<ul style="list-style-type: none"> - Top end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage. - Estimated lifetime: Connecting rod bottom end bearings - Estimated lifetime: Connecting rod top end bearings 	at indications of excessive wear or damage 90000 replacement if required 90000 replacement if required

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
3326-1	Guide shoe, crosshead pin	<ul style="list-style-type: none"> - Check clearances 	6000 – 8000
3403-1	Piston	<ul style="list-style-type: none"> - Remove and clean 	18000 – 36000 (condition based)
3403-3		<ul style="list-style-type: none"> - Check tightness on piston in installed position and with running oil pump, visual check through scavenge ports - Disassembly and assembly (open cooling space and clean same, min. one piston each three years) 	after installation as necessary
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 - Measure ring grooves, inspect the chromium plating and rechrome as necessary - Estimated lifetime: Piston head ring grooves - Piston head surface, full remanufacturing 	at each piston removal 500 – 1000 18000 – 36000 (condition based) 18000 – 36000 72000
	Piston underside	<ul style="list-style-type: none"> - Check condition of space and clean as necessary - Make sure that the drains and orifices are not blocked 	1500 – 3000 1500 – 3000
3425-1	Piston rings	<ul style="list-style-type: none"> - Measure thickness of chrome-ceramic layer 	1500 – 2000
		<ul style="list-style-type: none"> - Replace piston rings based on remaining coating thickness - Estimated lifetime: Piston rings 	18000 – 36000 (condition based) 18000 – 36000
4			
4103-1	Start interlock	<ul style="list-style-type: none"> - Check electric and pneumatic interlocks (see Operating Manual 4003-1) 	quarterly
	Driving wheels	<ul style="list-style-type: none"> - Check condition of teeth - Check running clearance and backlash of teeth - Estimated lifetime: driving wheels 	6000 – 8000 6000 – 8000 engine lifetime
	Starting air shut-off valve	<ul style="list-style-type: none"> - Release pressure / vent starting air inlet (manifold) pipe 	after each manoeuvring period

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
4325-1		<ul style="list-style-type: none"> - Disassemble, clean and check (Important parts are: seat, springs and sealing rings) - Do an overhaul of the common start valve (SPC: Control Valve Complete, Group 4325-2) - Estimated lifetime: Starting air shut-off valve 	30000 – 36000 18000 engine lifetime
	Control air filter	<ul style="list-style-type: none"> - Drain the filter - Clean the filter 	weekly 6000
<u>5</u>			
5551-1	Servo oil pump	<ul style="list-style-type: none"> - Replace servo oil pump either with new one or a pump overhauled by a Wärtsilä workshop 	36000
5552-1	Servo oil pump drive	<ul style="list-style-type: none"> - Check pinion and driving wheels to servo oil pump drive - Check bearing bushes to pinion - Check filter below the plug in the compensator for particles - Estimated lifetime: supply unit pinion bearing bushes 	3000 24000 2000 90000
5552-2	Fuel oil pump drive	<ul style="list-style-type: none"> - Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h) - Camshaft, check bearing clearances at random position - Camshaft, check thrust bearing clearances - Estimated lifetime: supply unit camshaft bearings 	3000 12000 36000 90000
5556-1	Fuel pump	<ul style="list-style-type: none"> - Random flow check of lubricating oil - Reconditioning of fuel pump - Estimated lifetime: Fuel Pump 	6000 18000 18000
5562-1	Fuel pressure control valve (PCV)	<ul style="list-style-type: none"> - Check shut-down function (see Operation Manual 4003-1) - Function check (see Operation Manual 5562-1) - General overhaul - Estimated lifetime: Fuel pressure control valve (PCV) 	3000 6000 only necessary if PCV fails engine lifetime

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
5562-2	Fuel overpressure safety valve / Relief Valve	<ul style="list-style-type: none"> - Function check on test bench 	24000 – 36000
5564-1	Flow limiting Valve (FLV)	<ul style="list-style-type: none"> - Inspect and clean piston rod and piston running surface - Overhaul unit or replace it with a new item or a Wärtsilä serviced item - Estimated Lifetime: Flow limiting valve 	12000 24000 24000
	Servo oil rail	<ul style="list-style-type: none"> - Replace hoses (at least each 5 years) 	30000
5612-1	Exhaust valve control unit	<ul style="list-style-type: none"> - Random check of piston and slide rod - Check servo oil filter - Replace 4/2 solenoid valve - Estimated lifetime: Exhaust valve control unit 	36000 18000 24000 – 36000 engine lifetime
5583-1 (or 5556-1)	Fuel pump Actuator	<ul style="list-style-type: none"> - Check for free movement of Regulating linkage, lubricate movable parts 	3000
<u>6</u>	Scavenge air receiver	<ul style="list-style-type: none"> - Check and clean air flaps - Clean the receiver - Make sure water drain pipes and orifices are not blocked 	4000 – 6000 4000 – 6000 1500 – 3000
	Turbocharger	<ul style="list-style-type: none"> - Wash–cleaning of blower in service - Wash–cleaning or dry cleaning of turbine in service 	acc. to manufacturer acc. to manufacturer
	Air filter	<ul style="list-style-type: none"> - Check filter - Cleaning of filter at a np increase of 50% compared to the shop test value at same engine load (see Operating Manual 6510-1) 	half yearly as necessary
6545-1	Auxiliary blower	<ul style="list-style-type: none"> - Clean impeller and casing - Replace ball bearing 	24000 – 36000 24000 – 36000

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
6606-1	Scavenging air cooler	<ul style="list-style-type: none"> - Cleaning of scavenging air cooler (air side) in service at the beginning weekly, later if np (pressure decrease through SAC) increases 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 scavenging air cooler sealing - Bleed - Remove scavenging air cooler for general overhaul 	as necessary daily 1500 – 3000 quarterly daily as necessary
6708-1	Water separator scavenging air	<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 	daily 1500 – 3000 1500 – 3000 as necessary
7	Lubricating pump	<ul style="list-style-type: none"> - Replace the lubricating pump with new item, or a pump overhauled by a Wärtsilä workshop. 	as necessary
7218-1	Filter replacement	<ul style="list-style-type: none"> - Replace filter element before the cylinder lubricating system 	as necessary
		<ul style="list-style-type: none"> - Estimated lifetime: Cylinder lubricating pump 	30000
7758-1	Electric Balancer iElba	<ul style="list-style-type: none"> - Check bearing clearance, see 0330-1 	6000
8	Exhaust Waste Gate (LLT)	<ul style="list-style-type: none"> - General Inspection. During a longer operation period at low engine load, manually open the butterfly valve (refer to Operation Manual 8135-1) 	in accordance with instructions of valve manufacturer
	Servo oil service pump (engine mounted)	<ul style="list-style-type: none"> - Check rate of flow and max. pressure 	acc. to manufacturer
	Starting air pipes on and before the engine	<ul style="list-style-type: none"> - Drain (remove water) 	before and after each manoeuvring period

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be carried out	Intervals & Lifetime [operating hours]
8135-1	Pressure gauges and pyrometers	<ul style="list-style-type: none"> - Compare and calibrate according to master instruments 	6000 – 8000
	Pipe holders	<ul style="list-style-type: none"> - Check fastenings at intervals if necessary, tighten the screws (first time after 100 Op.h.) 	half yearly
8447-1	Servo oil pipes	<ul style="list-style-type: none"> - Grind sealing faces 	as necessary
	Non-return valve	<ul style="list-style-type: none"> - Random check 	18000
8460-1	Hydraulic pipe for exhaust valve drive	<ul style="list-style-type: none"> - Grind sealing faces 	as necessary
8733-1	HP pipe to injection valve (on cylinder cover)	<ul style="list-style-type: none"> - Grind sealing faces 	as necessary
8744-1	Supply unit fuel drain pipes	<ul style="list-style-type: none"> - Make sure that the pipes are not blocked 	6000
8752-1	HP fuel pipe	<ul style="list-style-type: none"> - Grind sealing faces 	as necessary
9			
9223-1	Crank angle sensor (CAS) unit	<ul style="list-style-type: none"> - Replace the proximity sensor 	as necessary
9308-1	Cylinder cover – Relief valve	<ul style="list-style-type: none"> - Do a check of the blow-off pressure - replace Relief valve 	<p>as necessary (if installed) when blown off</p>
	Oil mist detector	<ul style="list-style-type: none"> - Follow manufacturer's instructions 	half yearly
	UNIC Control System	<ul style="list-style-type: none"> - Replace the modules: CCM-20, MCM-11 and LDU-20, see operation manual 4002-1. - Do a visual check of the cables 	<p>48000 – 50000 quarterly</p>

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.

- 1) Environmental and operating conditions
- 2) Heavy fuel oil and lubricating oil qualities (see Operating Manual 0710-1 and 0750-1)
- 3) Engine load
- 4) Fuel, lubricating oil and cooling water care (see Operating Manual 0720-1 and 0760-1)
- 5) Overhaul according to Maintenance Manual
- 6) Genuine spare parts used
- 7) Engine monitoring
- 8) 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.

Engine Cross Section and Longitudinal Section

1. Cross section

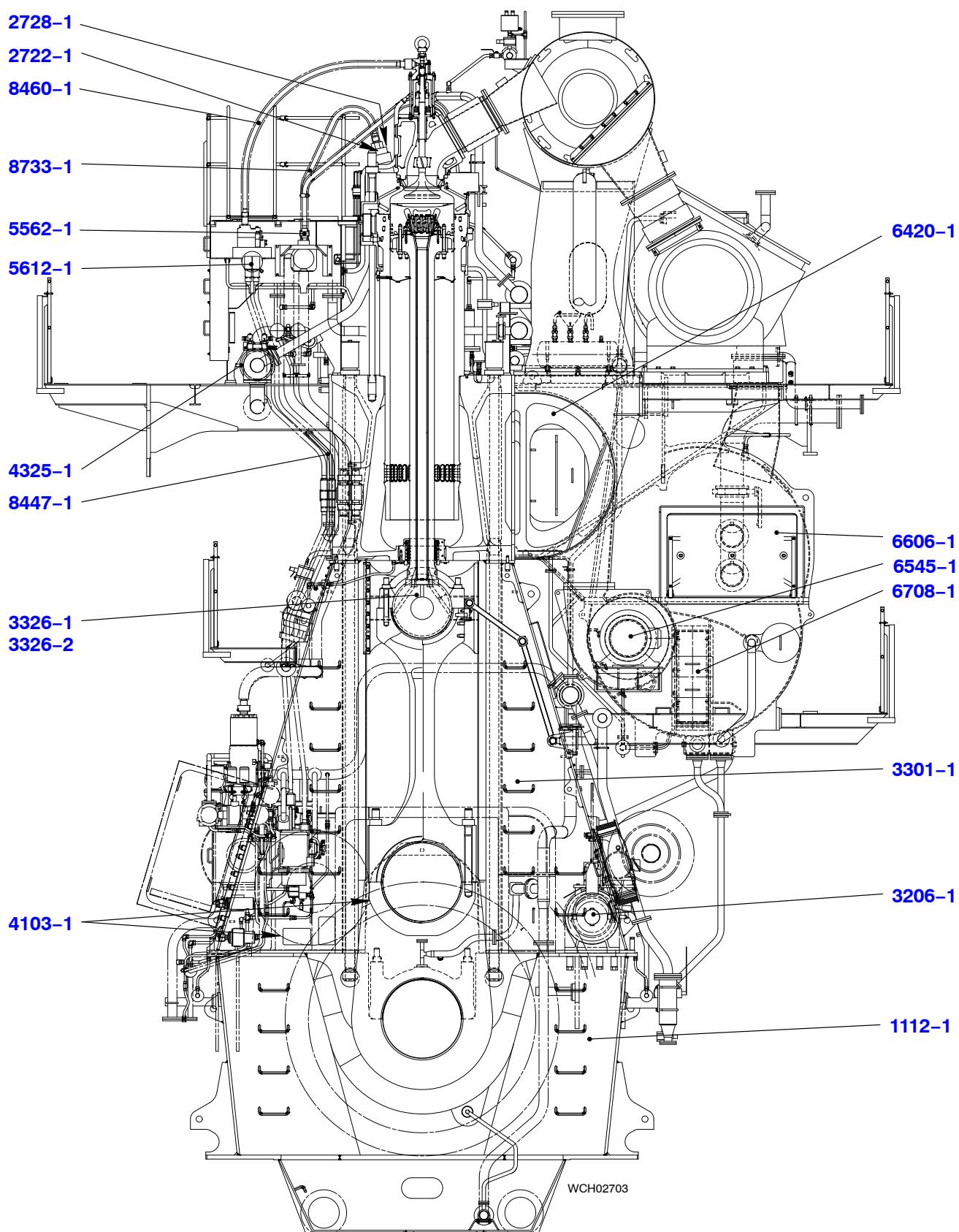


Fig. 1: Cross Section

Engine Cross Section and Longitudinal Section

2. Longitudinal section

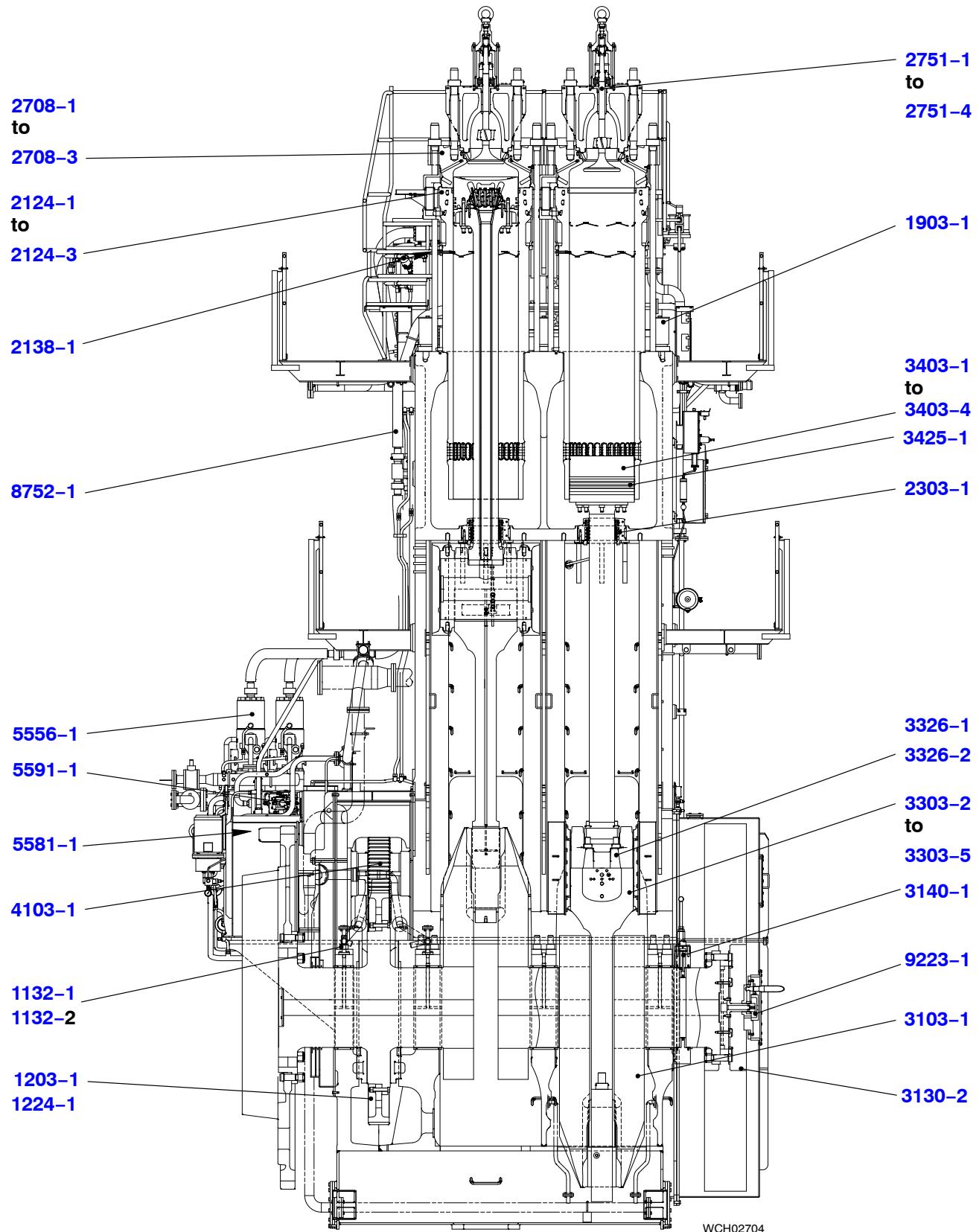


Fig. 2: Longitudinal Section

Bedplate and Tie Rod

Group 1

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

Main Bearing

Loosening and Tensioning of Elastic Studs 1132-1/A1

Removal and Fitting of a Main Bearing 1132-2/A1

Thrust Bearing

Checking the Axial Clearance 1203-1/A1

Removal and Fitting the Thrust Bearing Pads 1224-1/A1

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

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

Tie Rod: Checking the Pre-tension and Replacing the Tie Rods 1903-1/A1

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Bedplate and Thrust Bearing**Foundation Bolts – Check****Tools:**

1 Feeler gauge	94122	2 Hydr. distributors	94934A
1 Pre-tensioning jack	94145	1 HP hose	94935
1 HP oil pump	94931		

1. General

The pre-tension of the foundation bolts (holding down studs) must be checked at longer intervals e.g. during overhauls, refer to [0380-1](#).

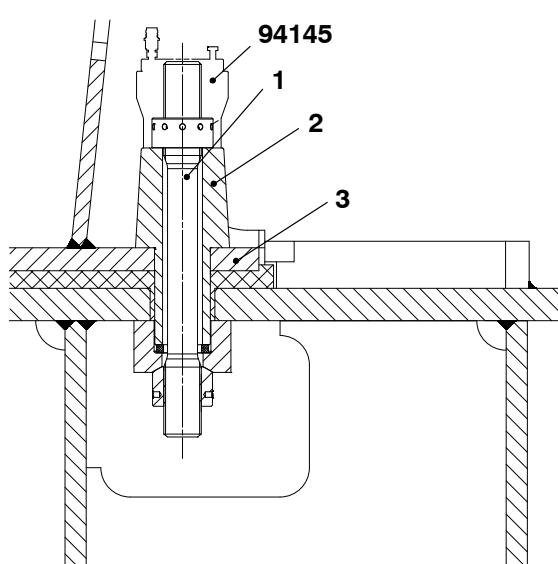
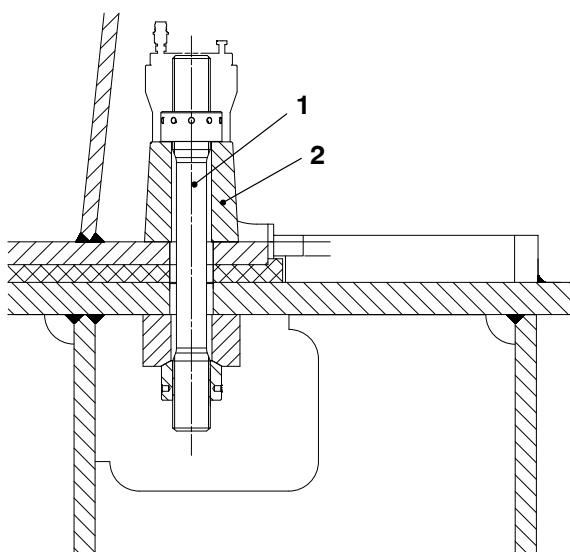
In the area of the thrust bearing, bedplate (3, [Fig.1](#)) and the foundation must be fastened with foundation bolts (1) and the long bushes (2).

The remaining area is fastened with foundation bolts (1, [Fig.2](#)) and the short bush (2).

1.1 Loosening or tensioning the foundation bolts

The tensioning of all foundation bolts starts at the driving end, continues alternately from one side to the other side and finishes at free end of the engine.

- 1) For loosening and tensioning the foundation bolts (1), use the pre-tensioning jack (94145, [Fig.1](#)).
- 2) Connect the pre-tensioning jacks (94145) to the hydraulic pump (94931, [Fig.3](#)), refer to [9403-3](#).
- 3) Do the procedure for loosening and tensioning 'Variant 1' as in [9403-4](#).
- 4) Do the tensioning in two steps: for both metal chocks or epoxy resin chocks, i.e. first apply tension to all foundation bolts to **1000 bar (1st step)**, then finish to **1500 bar (2nd step)**.

**Fig. 1:****Fig. 2:**

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2. Checking the pre-tension

- 1) Clean the threads of the foundation bolts (2, Fig.3) and the seating surfaces.
- 2) Attach the pre-tensioning jack (94145, Fig.1) to the foundation bolt (2, Fig.3).
- 3) Screw the foundation bolt (2) completely down with the opened vent screw (5), until there is only little or no clearance at 'x'.
- 4) Connect the pre-tensioning jack (94145) to the HP oil pump (94931), refer to 9403-3.
- 5) Set the relief valve (EV) to off and actuate the HP oil pump (94931) until the oil flows bubble-free at the vent screw (5).
- 6) Close the vent screw (5) and torque the foundation bolt (2) to 1500 bar and keep the pressure constant.
- 7) Do not move the piston (1) fo the pre-tesnioning jack (94145) further up than to the red limiting groove (BN).
- 8) Use the feeler gauge (94122) and put it through the slot (KO). Check if the is any clearance between the nut (4) and the bush (3).
- 9) If there is a clearance between the nut (4) and the bush (3), keep the pressure of 1500 bar and use the round bar (RS) to tighten it completely down.
- 10) Subsequently lower the pressure to zero and remove the pre-tensioning jack (94145).

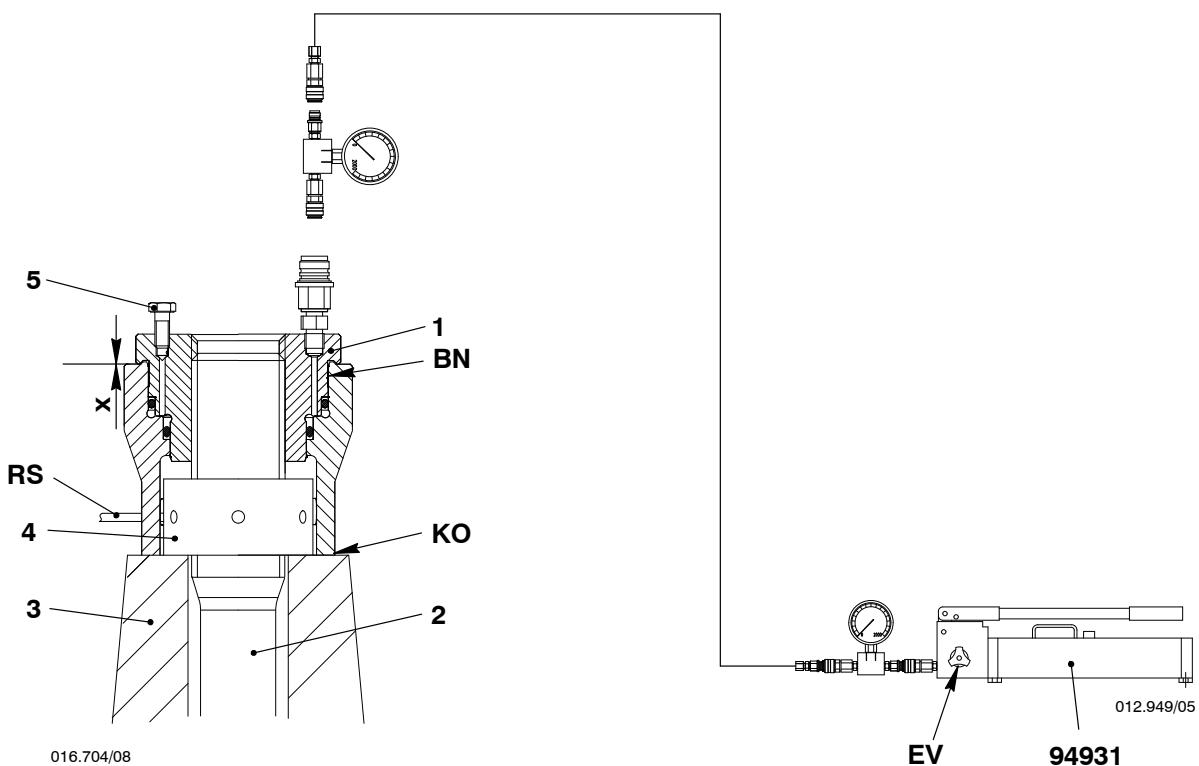


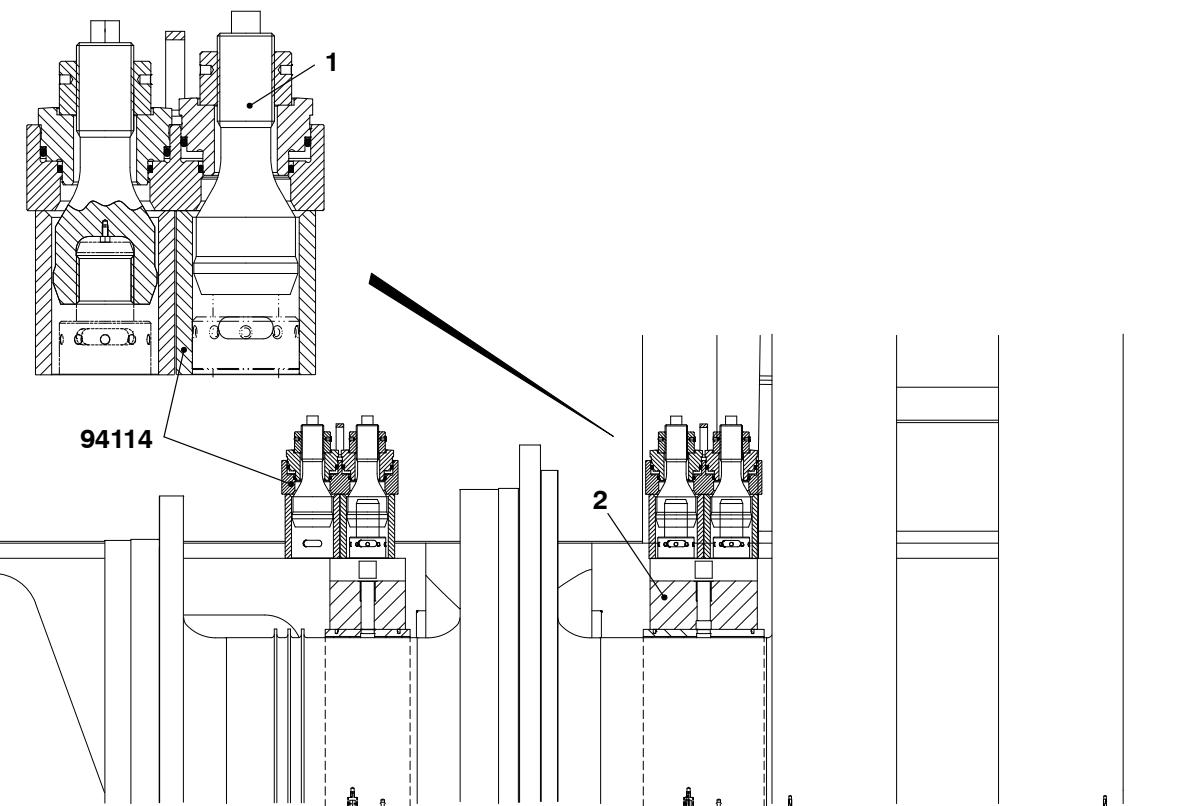
Fig. 3:

Main Bearing**Elastic Studs – Loosen and Apply Tension****Tools:**

2 Double pre-tensioning jacks	94114	4 Coupling elements	94934G
1 Feeler gauge	94122	3 HP hose	94935
1 Pressure gauge	94934A	1 Hydraulic unit	94942
1 Distributing piece	94934C		

- 1) Always use the hydraulic double pre-tensioning jacks (94114, [Fig.1](#)) for loosening and tensioning the main bearing elastic studs (1), as well as for the 1st main bearing cover (2) with only two elastic studs (1).
 - 2) Connect only the jack which is in use to the hydraulic unit.
 - 3) Do the general preparation for hydraulic jacks (94114) , refer to [9403-4](#), paragraph 1.
 - 4) Make sure that the threads of the elastic studs (1) are oiled.
 - 5) To loosen, do the procedure in [9403-4](#), paragraph 2.2 and 2.3.
 - 6) To apply tension, do the procedure in [9403-4](#), paragraph 3, 3.2 and 3.3.
- Tightening value for pre-tensioning jacks (94114) is 1500 bar in one step.
- 7) Use the feeler gauge (94122) to do the check of the horizontal and vertical clearance of the main bearing, refer to [0330-1](#), group 1132, Crankshaft and Main Bearing.

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

**Fig. 1**

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Main Bearing**Main Bearing – Removal and Installation****Tools:**

1	Manual ratchet	94016-006	1	Dismantling device (narrow bearing shell)	94118A
2	Spur/geared chain blocks	94017-005	1	Dismantling device	94118B
4	Schackles	94018B	1	Lifting plate	94119
4	Schackles	94018C	1	Feeler gauge	94123
1	Chain (symmetric)	94019A	1	Bracket	94141A
1	Chain (asymmetric)	94019B	1	Working platform	94143
1	Eye bolt	94045-M36	1	HP oil pump	94931
1	Thrust device	94110	1	Connection block	94934
1	Lifting tool (wide bearing shell)	94116A	2	Pressure gauges	94934A
1	Lifting tool (narrow bearing shell)	94116B	1	Adapter piece	94934F
1	Lifting lug	94116C	3	HP hoses	94935
1	Roller support	94117	2	Hydraulic jacks	94936
1	Deviation pipe	94117B			

1.	Preparation	1
2.	Main Bearing Covers No. 2 – No. 8 – Removal	2
2.1	Tool – Installation	2
2.2	Main Bearing Cover – Removal	4
3.	Main Bearing Cover No. 1 – Removal	5
4.	Main Bearing Shell – Removal	6
4.1	Hydraulic Jacks – Installation	6
4.2	Crankshaft – Lifting	6
4.3	Main Bearing Shell No. 1 – Removal	7
4.4	Main Bearing Shells No. 2 to No. 8 – Removal	19
5.	Main Bearing Shells – Inspection	12
6.	Main Bearing Shell, Main Bearing Cover – Installation	12
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6.2	Cover – Installation	13
6.3	Main Bearing – Lubrication	13

1. Preparation**Note: Pay attention to:**

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

WARNING

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

WARNING

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

- 3) Use the turning gear to turn the crank to the exhaust side approx. 90° after T.D.C.
- 4) Set the main oil supply pumps to off and close the oil lubrication to the main bearing.

Main Bearing – Removal and Installation

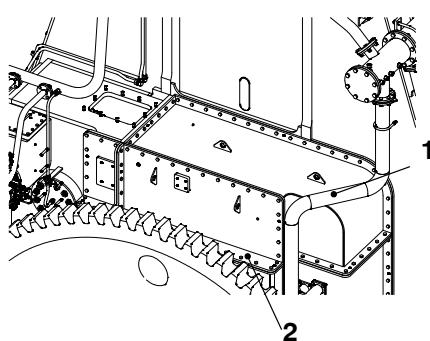


Fig. 1

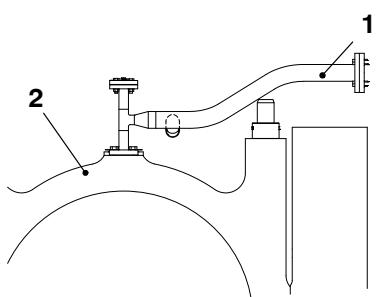


Fig. 2

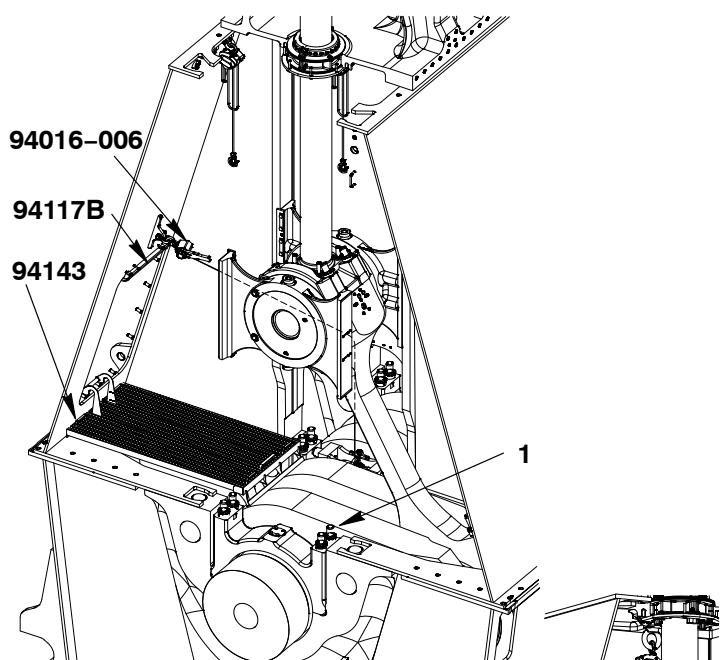


Fig. 3

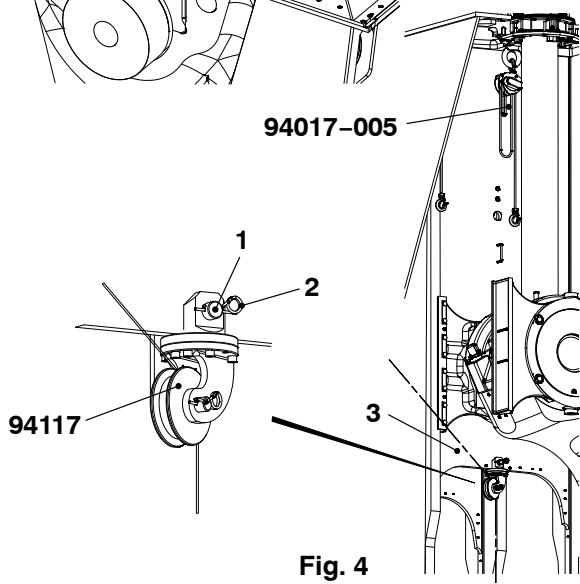


Fig. 4

2. Main Bearing Covers No. 2 to No. 8 – Removal

2.1 Tools – Installation

- 1) Remove the covers (1, Fig.1) and (2).
- 2) Remove the oil pipe (1, Fig.2) to the main bearing cover (2).
- 3) Attach the working platform (94143, Fig.3) .
- 4) Use the feeler gauge (94123) and do a check of the bearing clearance, refer to 0330-1.
- 5) Loosen the elastic studs (1) and remove their nuts, refer to 1132-1.
- 6) Install the spur-gearred chain blocks (94017-005, Fig.4) and the manual ratchet (94016-006, Fig.3).
- 7) Attach the roller support (94117, Fig.4) to the column (3) and put the a double spring clip (2) to secure the pin (1).
- 8) Attach the deviation pipe (94117B, Fig.3) to the column.

Removal and Fitting of a Main Bearing

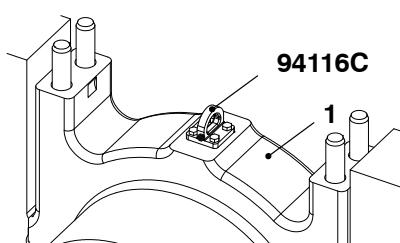


Fig. 5

- 9) Install the lifting lug (94116C, Fig. 5) on the main bearing cover (1).

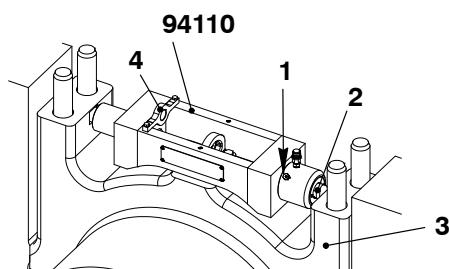
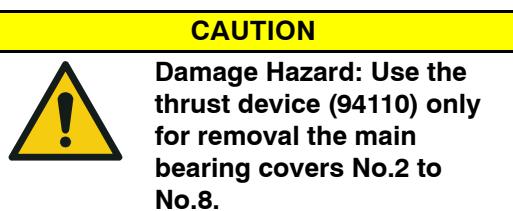


Fig. 6

- 10) Make sure that the thrust device (94110, Fig. 6) is clean.



- 11) Use the lifting plate (4) only for transport and installation of the thrust device (94110). If it is not in use, attach it as shown in Fig.6.
- 12) Apply cooper paste to the thread and the surface of the screw (1, Fig.7).
- 13) Open the vent screw (1, Fig.6) and make sure that the piston (2) is fully engaged.
- 14) Put the thrust device (94110) in position on the main bearing cover (3), as shown in Fig. 6.

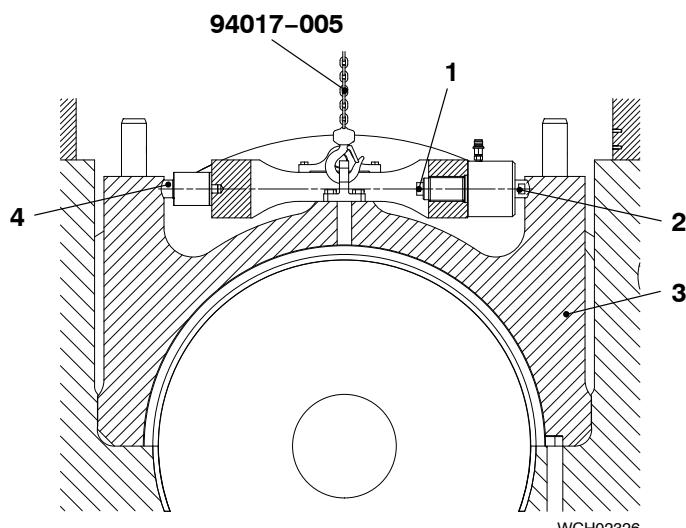


Fig. 7

- 15) Make sure that the tappet (4, Fig.7) and the piston (2) are in the cutout of the main bearing cover (3).
- 16) Connect the thrust device (94110) to the HP oil pump (94931), refer to 9403-2.
- 17) Operate the HP oil pump and close the vent screw (1, Fig.6) when the oil flows out bubble free.
- 18) Increase the pressure slowly to 1500 bar.
- 19) Tighten the screw (1, Fig.7) manually.
- 20) Release the pressure to zero and disconnect the HP hose.

Main Bearing – Removal and Installation

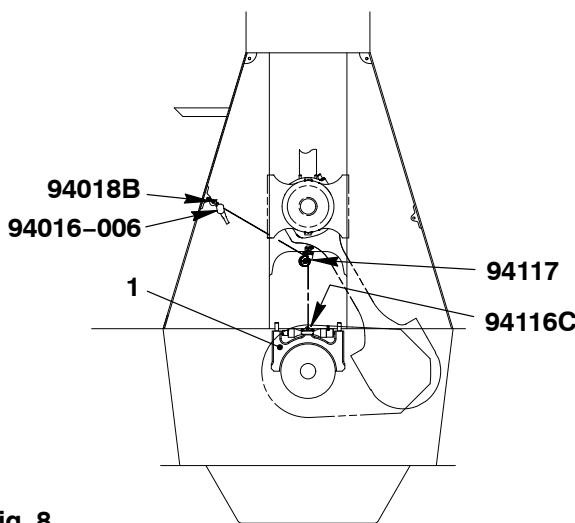


Fig. 8

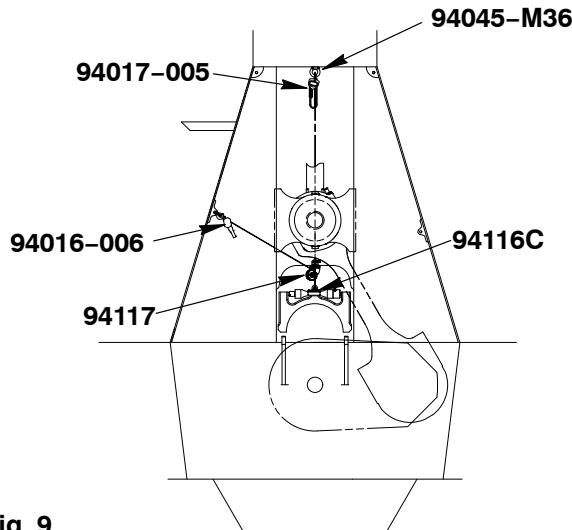


Fig. 9

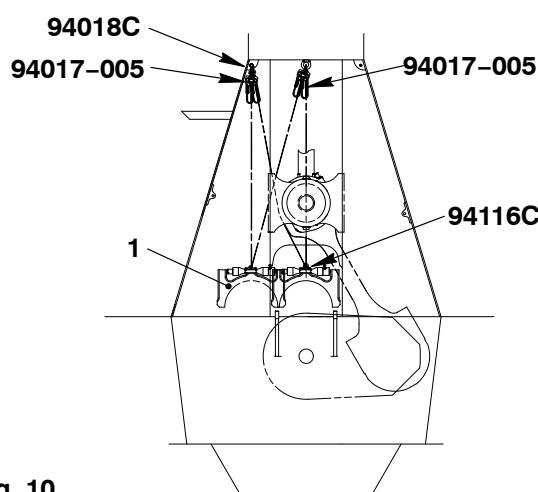
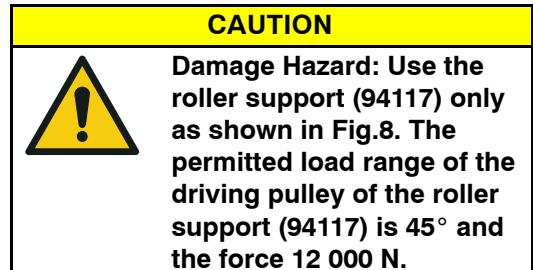


Fig. 10

2.2 Main Bearing Cover – Removal

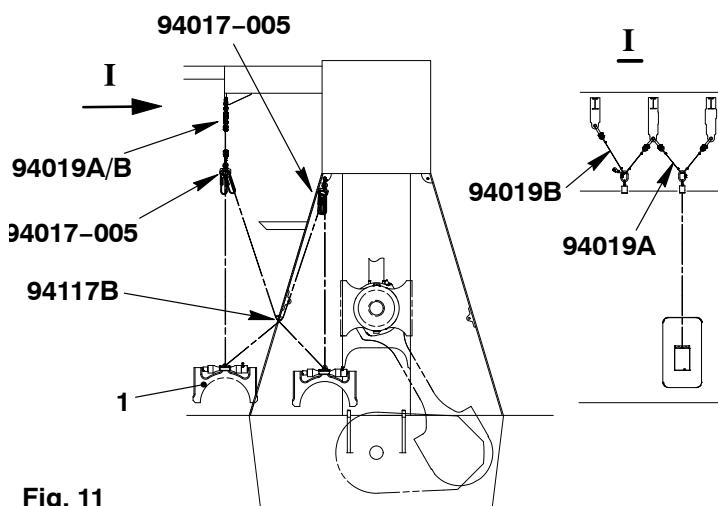
- 1) Attach the chain of the manual ratchet (94016-006, Fig.8), through the roller support (94117) to the lifting lug (94116C) as shown in Fig.7.



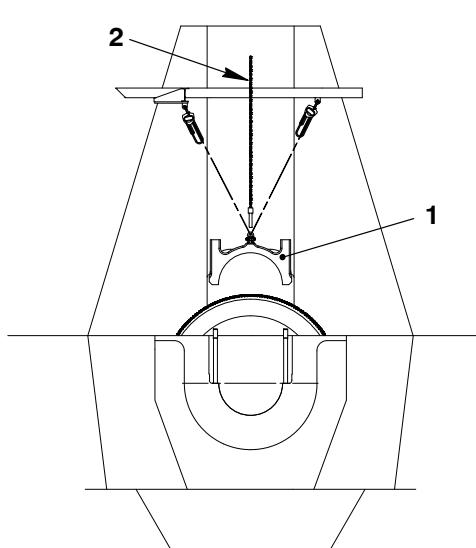
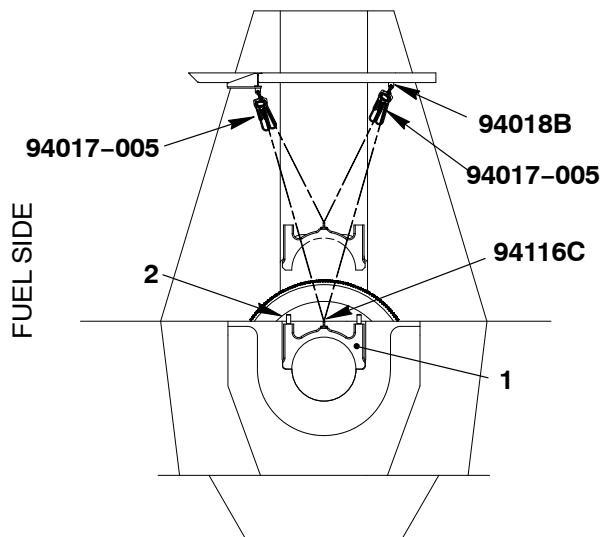
- 2) Use the manual ratchet (94016-006, Fig.8) to lift the main bearing cover (1).
- 3) Attach the spur-gear chain block (94017-005) to the lifting eye bolt (94045-M36).
- 4) Use the spur-gear chain block (94117-005) to attach it to the lifting lug (94116C).
- 5) Remove the roller support (94117) and the manual ratchet (94016-006).
- 6) Attach the second spur-gear chain block (94017-005, Fig.10) to the shackle (94018B) on the column.

- 7) Attach the second spur-gear chain block (94017-005) to the lifting lug (94116C).
- 8) Move the main bearing cover (1, Fig.10) in a fuel side direction, until the main bearing cover (1) hangs vertically on the spur-gear chain block (94017-005), as shown in Fig.10.

Main Bearing – Removal and Installation



- 9) Remove the first spur-gear chain block (94017-005).
- 10) Attach the chains (94019A) and (94019B) to the shackles (94018B).
- 11) Attach the spur-gear chain block (94017-005) first to the chain (94019B), and after to the chain (94019A) and continue to move the main bearing cover (1) until it is on the fuel side.
- 12) Put the main bearing cover (1) on a wooden underlay.
- 13) Connect the thrust device (94110) to the Hp oil pump (94931) and release the pressure to zero, refer to [9403-2](#).
- 14) Remove the thrust device (94110) from the main bearing cover (1).



3. Main Bearing Cover No.1 – Removal

- 1) Remove the upper part of the main casing.
- 2) Loosen the elastic studs (2, [Fig.12](#)) and remove the nuts, refer to [1132-1](#).
- 3) Remove the oil pipe (1, [Fig.2](#)) from the main bearing cover (1)
- 4) Do a check of a bearing clearance, refer to [0330-1](#).
- 5) Use an applicable tool to attach the lifting lug (94116C, [Fig.12](#)) to the main bearing cover (1).
- 6) Install the two spur-gear chain blocks (94017-05) to the shackles (94018B).
- 7) Attach the two spur-gear chain blocks to the lifting lug (94116C).
- 8) Lift the main bearing cover (1).
- 9) Use the machine crane (2, [Fig.13](#)) to remove the main bearing cover (1).

Main Bearing – Removal and Installation

4. Main Bearing Shell – Removal

CAUTION



Damage Hazard: Never remove the two main bearing shells situated next to each other at the same time.

4.1 Hydraulic Jacks – Installation

WARNING



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

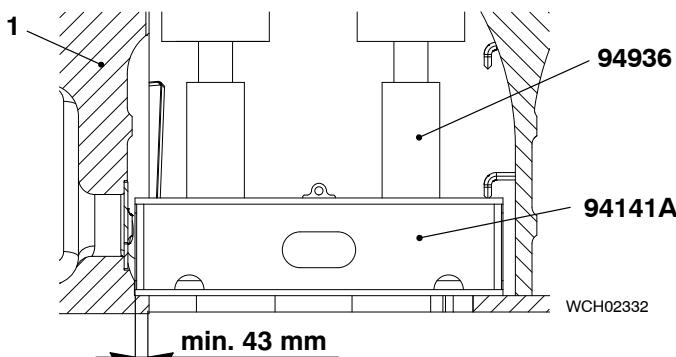


Fig. 14

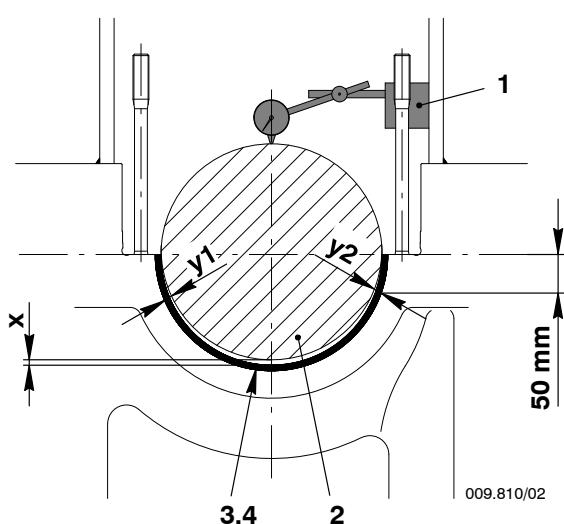


Fig. 15

- 1) Turn the crank to the exhaust side approximately 90° after T.D.C.
- 2) Put the bracket (94141A, Fig.14) on the two main bearing girders (1) parallel to the engine axis.
- 3) Make sure that the bracket is min 43 mm to the trust bearing side.
- 4) Put the hydraulic jacks (94936) on the bracket (94141A) and connect the hydraulic jacks (94936) to the HP oil pump (94931), refer to 9403-2.

4.2 Crankshaft – Lifting

- 1) Measure and record the lateral clearances y_1 and y_2 between the crankshaft (2, Fig.15) and the lower main bearing shell (3,4) at approximately 50 mm below the bearing division.
- 2) Install the dial gauge with magnetic base (1) above the crankshaft (2) as shown in Fig. 15 and set it to zero.
- 3) Install the jacks (94936).
- 4) Start the HP oil pump (94931).
- 5) Use the hydraulic jacks (94936) to lift the crankshaft (2) to $x=0.3$ mm.
- 6) Check the value x on the dial gauge.

CAUTION



Lift the crankshaft max. to the point where the next main bearings shows no vertical clearance between cover and crankshaft.

- 7) Keep the pressure constant.
- 8) Measure the lateral bearing clearances y_1 and y_2 and compare the value with the value from the first measurement, step 1).

Main Bearing – Removal and Installation

- If the value of the lateral bearing clearance changed more than 0.1 mm, lower the crankshaft again and do the steps:
- 9) Install the hydraulic jacks (94936) in position where the lateral bearing clearance is smaller.
- 10) Start the HP oil pump (94931).
- 11) Lift the crankshaft (1) to the value $x = 0.3$ mm.

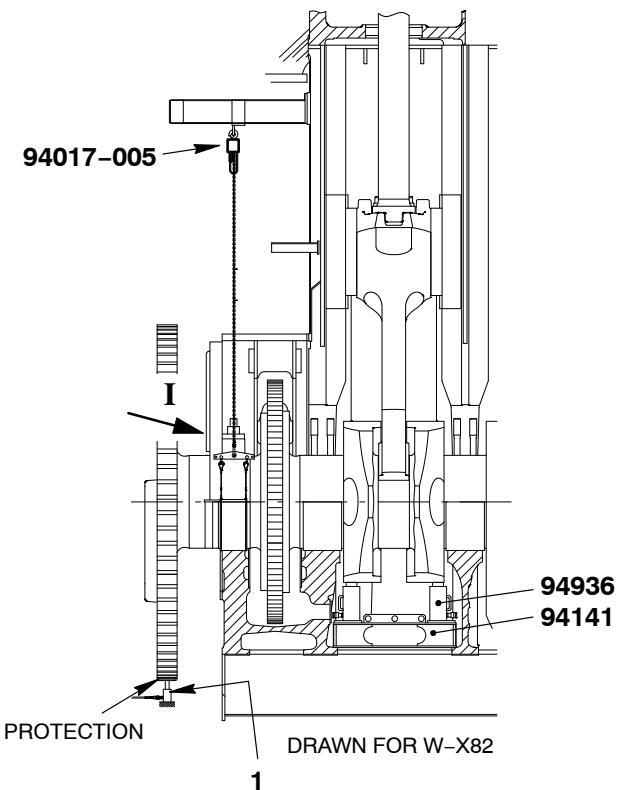


Fig. 16

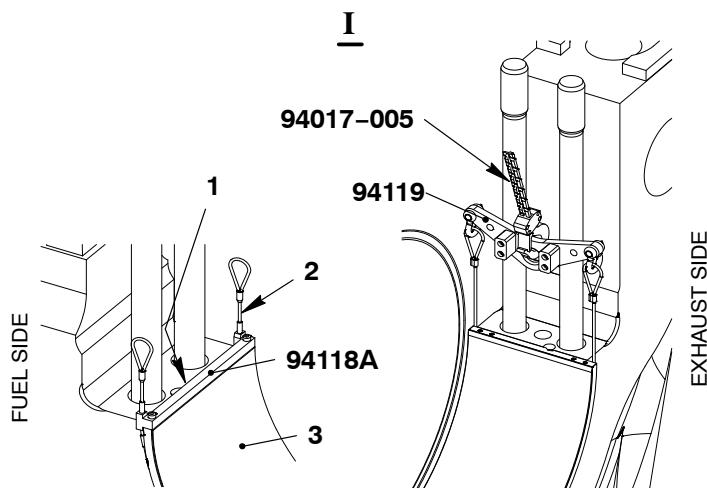
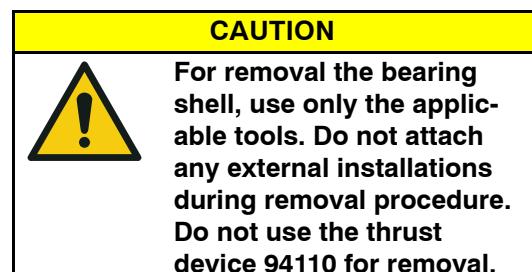


Fig. 17

Fig. 18

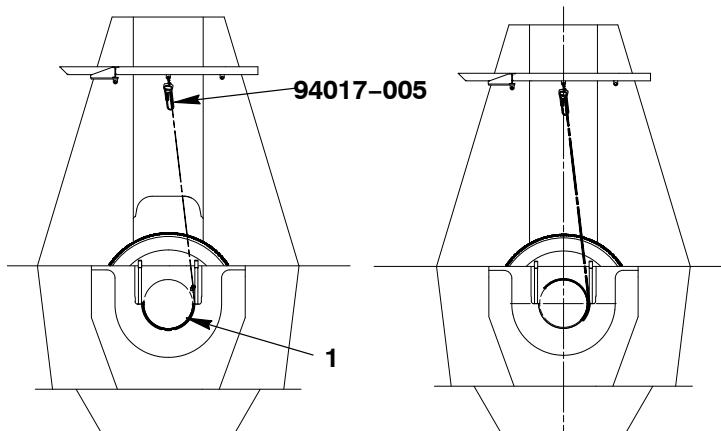
4.3 Bearing Shell No.1 (narrow) – Removal

- The bearing cover and the top main bearing shell are removed.
- The crank is to the exhaust side at T.D.C.



- 1) Make sure that the crankshaft is lifted by 0.3 mm, refer to paragraph 3.1 and 3.2.
- 2) Attach the spur-gear chain block (94017-005) to the eye bolt on the platform.
- 3) Remove the Allen screws (1, Fig.17) from the bearing girder, see also Fig. 32.
- 4) Attach the shackle of the spur-gear chain block (94017-005) to the lifting plate (94119, Fig.18).
- 5) Make sure that the shackle of the spur-gear chain block (94017-005, Fig.18) is correctly attached to the middle hole of the lifting plate (94119).
- 6) Attach the dismantling tool (94118A, Fig.17) to the bottom main bearing shell (3).
- 7) Put the ropes (2) along the lateral edges of the main bearing shell (3) to the other side and attach them to the lifting plate (94119) as shown in Fig. 18.

Main Bearing Removal and Installation



- 8) Use the spur-gear chain block (94017-005, [Fig.19](#)) to turn the bearing shell (1) as shown in [Fig.19](#) and [Fig.20](#).
- If the bearing shell (1) is jammed during removal procedure, the lifting plate (94119, [Fig.18](#)) must be attached to the other side of the dismantling tool (94118A, [Fig.17](#)). The bearing shell has to be moved back to its initial condition and the removal procedure repeated.

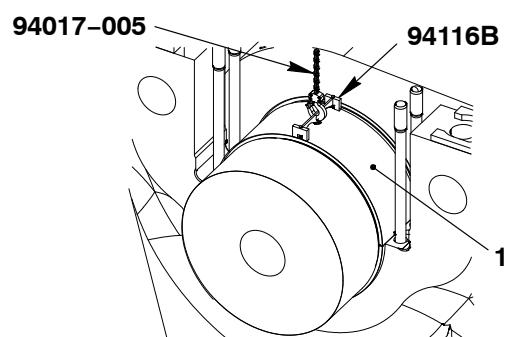


Fig. 21

- 9) Pull the bearing shell (1, [Fig.21](#)) out as shown in [Fig.22](#).
- 10) Remove the dismantling device (94118A, [Fig.17](#)).
- 11) Install the lifting tool (94116B, [Fig.21](#)) on the bearing shell (1).
- 12) Remove the spur-gear chain block (94017-005) from the lifting plate (94119) and attach it to the lifting tool (94116B).
- 13) Remove the lifting plate (94119).

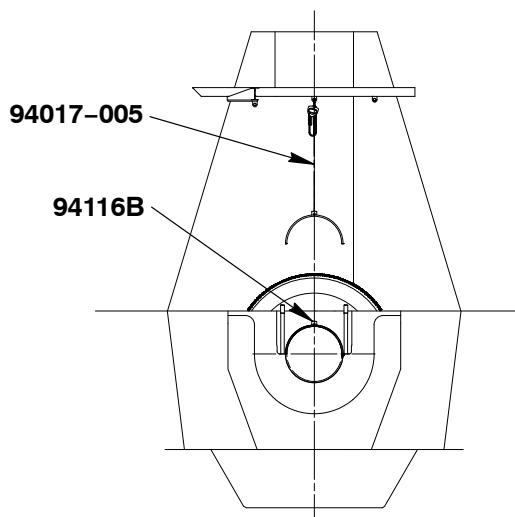


Fig. 22

- 14) Lift the bearing shell with the spur-gear chain blocks (94017-005) and take it over with the machine room crane.

Main Bearing – Removal and Installation

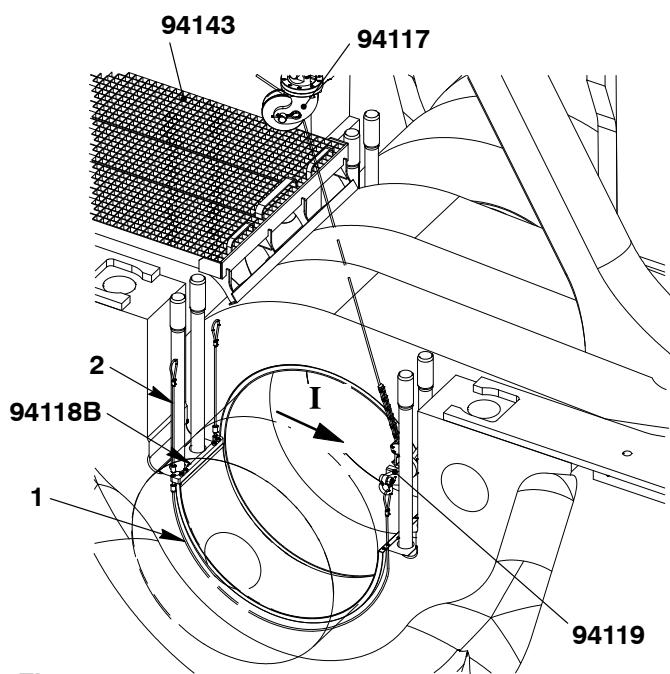


Fig. 23

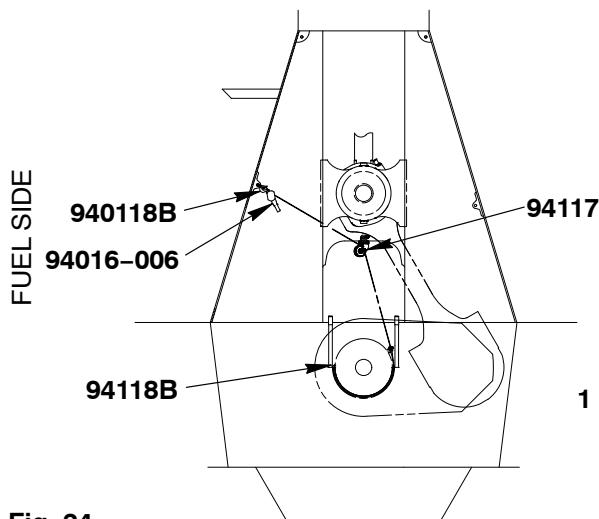


Fig. 24

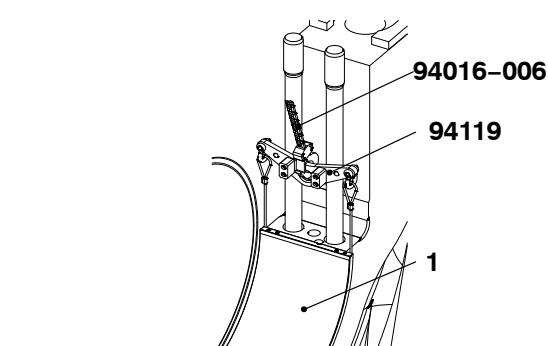


Fig. 25

4.4 Bearing Shell No. 2 to No. 8 – Removal

- The bearing cover and the top main bearing shell are removed.
- The crank is to the exhaust side at T.D.C.

CAUTION



For removal the bearing shell, use only the applicable tools. Do not attach any external installations during removal procedure.

- Attach the working support (94143, [Fig.23](#)).
- Install an applicable tools and do the procedure for lifting the crankshaft described in paragraphs 3.1 and 3.2.
- Make sure that the crankshaft is lifted up to approximately 0.3 mm.
- The two Allen screws from of the top bearing shell have to be removed.
- Attach the manual ratchet (94016-006, [Fig.24](#)) to the shackle (940118B) as shown in [Fig.24](#).
- Attach the dismantling tool (94118B) to the bottom main bearing shell (1), see [Fig. 23](#).
- Put the ropes (2, [Fig.23](#)) along the lateral edges of the main bearing shell (1) to the other side and attach them to the lifting plate (94119) as shown in [Fig.25](#).
- Attach the roller support (94117, [Fig.24](#)) to the column and secure it with its dowel pin.
- Attach the chain of the manual ratchet (94016-006) through the roller support (94117) to the lifting plate (94119) as shown in [Fig. 25](#).
- Make sure the the chain of the manual ratchet (94016-006) is in the middle of the lifting plate (94119).

Main Bearing Removal and Installation

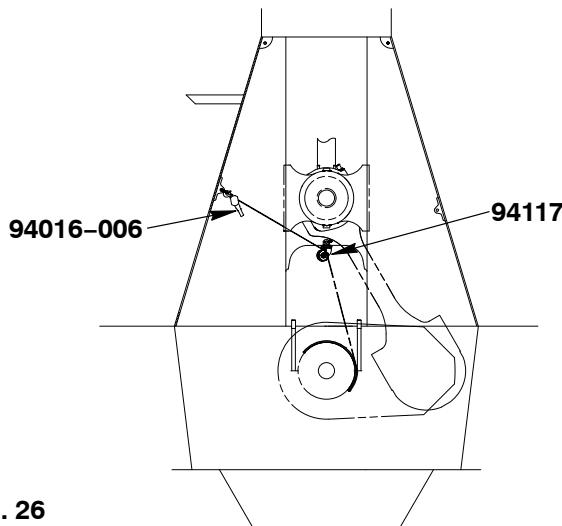


Fig. 26

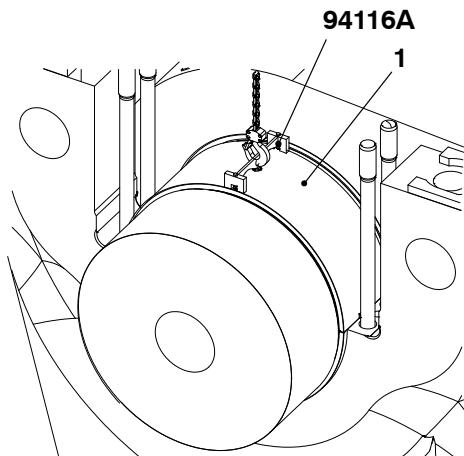


Fig. 27

- 10) Use the manual ratchet (94016-006, Fig.26) to pull the bottom bearing shell out until the hook of the chain is at the roller support (94117).

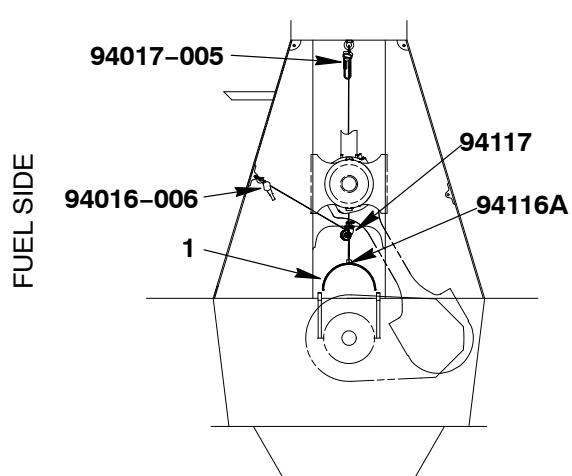


Fig. 28

- 11) Install the lifting tool (94116A) to the bearing shell (1, Fig.27).
- 12) Attach the chain of the (94016-006) to the middle of the lifting tool (94116A).
- 13) Remove the dismantling tool (94118B) and the lifting plate (94119).

- 14) Use the manual ratchet (94016-006, Fig.28) and the lifting tool (94116A) to lift the bearing shell (1).
- 15) Attach the spur-gear chain block (94017-005) to the lifting tool (94116A).
- 16) Remove the roller support (94117) and the manual ratchet (94016-006).

Main Bearing – Removal and Installation

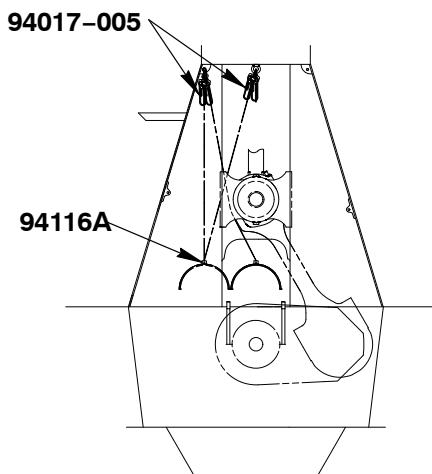


Fig. 29

17) Install the second spur-gearred chain block (94017-005, Fig.29) and attach it to the lifting tool (94116A).

18) Use the spur -geared chain block (94017-005) to move the bearing shell to the fuel side until it hangs vertically.

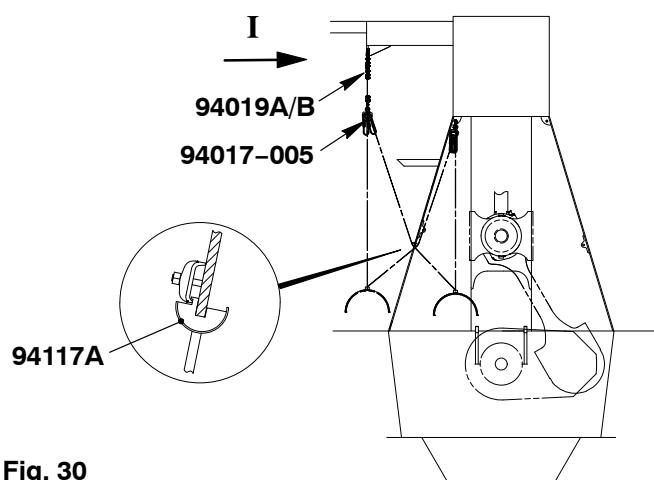


Fig. 30

19) Install the deviation pipe (94117A, Fig.30) to the column.

20) Attach the chains (94019A/B) to the gallery as shown in Fig. 30 and Fig. 31.

21) Attach the chains (94019B, Fig.31) to the spur-gearred chain block (94017-005) to move the bearing shell to the fuel side like shown in Fig. 31.

22) Put the bearing shell on wooden underlay on the bottom plate.

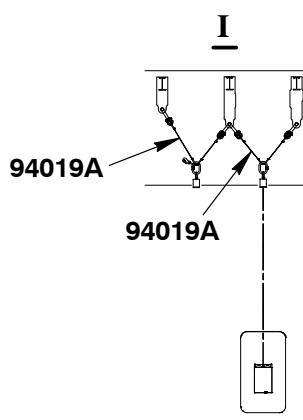


Fig. 31

Main Bearing – Removal and Installation

5. Main Bearing Shell – Inspection

- 1) Use the soft cloth to clean the bearing shell.
- 2) Do a check the bearing shell for damages such as breakouts or cracks.
- 3) Use the scotch brite to remove the slight scratches and running marks.

CAUTION



Do not scrape the bearing shell in the loaded area.

- 4) If the running marks are asymmetrical (axial or radial) contact Wärtsilä Service.
- 5) Replace the bearing shells if necessary.
- 6) Do an inspection of the surface of the bearing pin and polish the scratches.

6. Main Bearing Shell, Main Bearing Cover – Installation

Cover and bearing shell are marked on their faces with DRIVING END. They must be installed into the bearing girder in their original positions.

Before installation, the tools, crankshaft pin, girder bore for bearing shell, bearing shells and every part must be clean and in perfect condition.

The installation of the bearing shell and cover is done analogously to the removal but in the reverse sequence. Note the important working steps listed below.

CAUTION



Use only the applicable tools for installation the two different main bearing shells and main bearing covers, i.e the narrow- and the wide main bearing shell and cover.

6.1 Bearing Shell – Installation

- 1) Apply a very thin layer of MOLYKOTE paste G to the rear side of the bottom bearing shell, before every installation and turning.
- 2) For installation the bearing shell, make sure that:
 - The crankshaft pin and the running surface of the bearing shell are clean and fully lubricated with the clean engine oil.
 - Use the dismantling device (94118A) and the lifting tool (94116B) for the narrow bearing shell No. 1.
 - Use the dismantling tool (94118B), the lifting tool (94116A), the manual ratchet (94016-006) and the roller support (94117) to the bearing shells No.2 to No.8.
 - The tool (94118A/B) is installed on the fuel side.
- 3) Install the dismantling device (94118A/B) to the front face of the bottom bearing shell.
- 4) Attach the lifting tool (94116A/B) to the bearing shell.
- 5) Put the ropes of the dismantling device (94118A/B) below the crankshaft pin and connect it to the lifting plate (94119).
- 6) Use an applicable tool, attach it to the lifting tool (94116A/B) and lower the bearing shell into the crankshaft.

CAUTION



Be careful not to move the bearing shell into the bearing girder. It can cause a blockage of the bearing shell.

- To prevent the bearing shell movement into the bearing girder, hold the bearing shell and guide it slowly into the bearing girder (on fuel side) at the rope ends.
- 7) Carefully put the Allen screws and tighten it.
- 8) Release the pressure at HP oil pump (94931) and lower the crankshaft completely.

Main Bearing – Removal and Installation

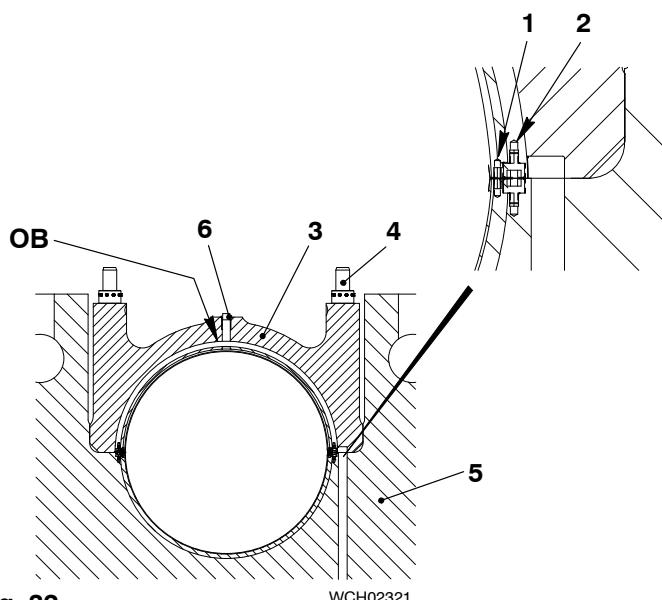


Fig. 32

6.2 Main Bearing Cover – Installation

- The top bearing shell is attached to the cover with two Allen screws (2, Fig. 32). Make sure the working area during the installation is clean.
 - Always use the device (94110) for installation the covers No.2 to No.8 as described in paragraph 2.
 - The spring dowel pins (1) help to get the bearing cover (3) in position during the installation.
- Remove all plugs from oil bore (OB).
 - Clean all contact surfaces on cover (3) and the bearing girder (5).
 - After installation of the cover is completed, apply tension to the elastic studs (4), refer to 1132-1.

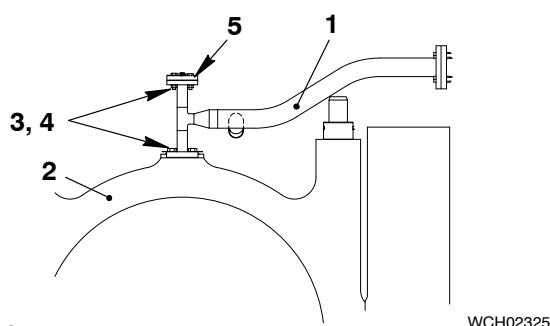


Fig. 33

- Clean the pipes (1, Fig. 33).
- Install the pipes (1) and their gaskets.
- Tighten the screws (3) and lock them with the new tab washers (4).
- Remove all tools from the engine and below the flywheel.
- Measure the bearing clearance and compare the value measured in paragraph 2.3 and with the value given in the Clearance Table 0330-1.
- If the clearance is in the limits given in, the bearing can be installed again.
- After every installation of a new bearing shell, measure the crank deflection, refer to 3103-1.
- Do a check of an oil supply to the main bearing.

7. Main Bearing – Post Lubrication

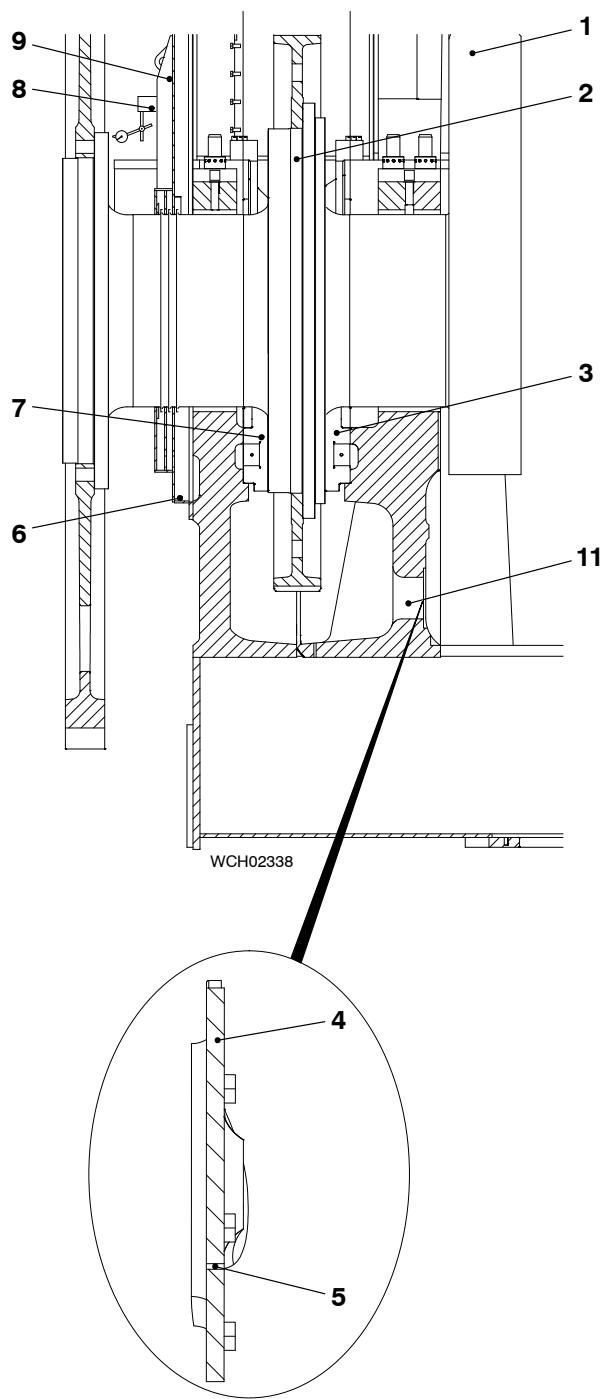
For overhaul the bearing shells, the additional lubricant can be added, to prevent damage of the surface the bearing shells. Refer to the chapter Lubricating Oils in Operation Manual 0750-1.

- To fill the bearing shell with the oil, remove the blank flange (5, Fig. 33) and the screw plug (6, Fig. 32) on the main bearing cover (3).

Intentionally blank

Thrust Bearing**Checking the Axial Clearance****Tools:**

1 Inside micrometer 94101

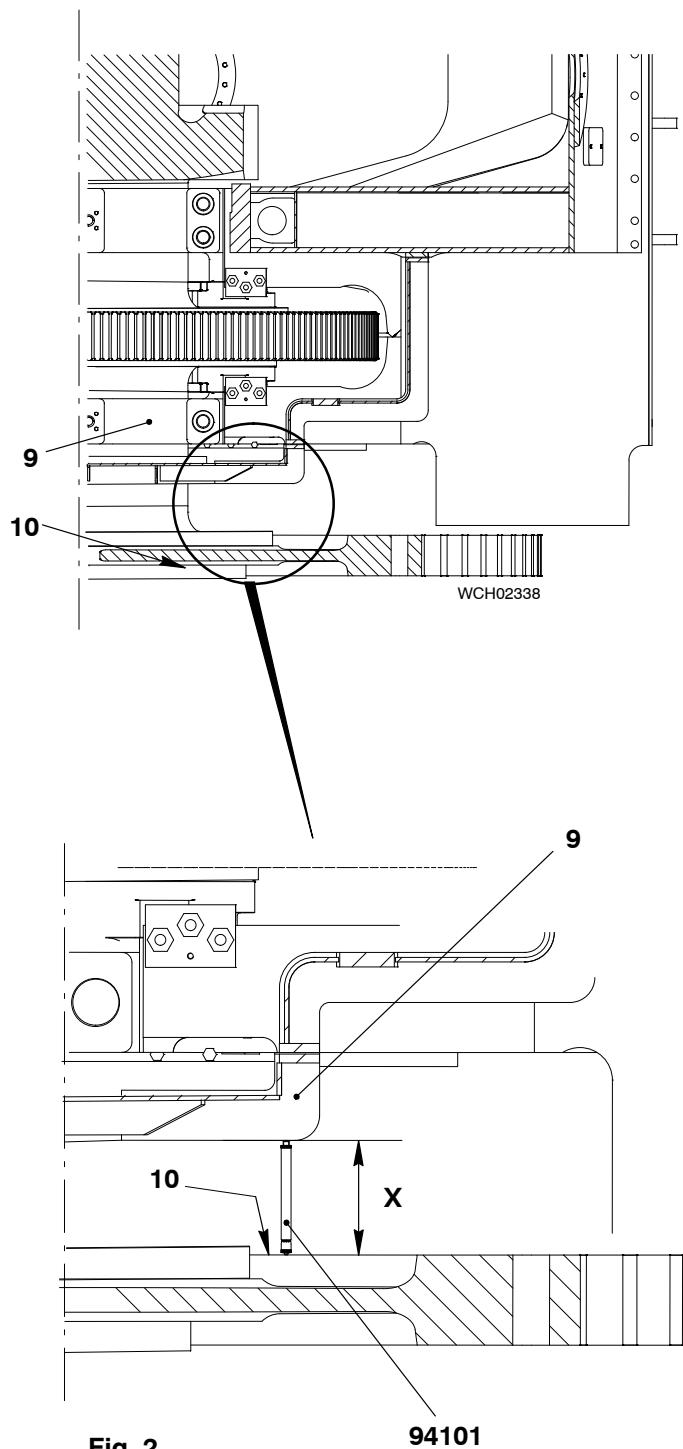
**Fig. 1****1. Procedure One**

- 1) Start the engine in the direction AHEAD to move the crankshaft fully forward.
- 2) Stop the engine.
- 3) Put the dial gauge (8) in position on the oil baffle (top part) (9, Fig. 1) and record the value.
- 4) Remove the dial gauge (8).
- 5) Start the engine in the direction REVERSE to move the crankshaft fully rearward.
- 6) Stop the engine.
- 7) Put the dial gauge (8) in position on the oil baffle (top part) (9) and record the value.
- 8) Remove the dial gauge (8).
- 9) Compare the values with those given in the engine documents on the Check Dimensions page (see also the [0330-1 Clearance Table, Crankshaft and Thrust Bearing](#)).

If the measured values are more than the nominal values given, the thrust pads are worn.

- 10) After maintenance on the area of the thrust bearing, do as follows:
- 11) Remove the cover (4).
- 12) Do a check of the thrust bearing housing.
- 13) If necessary, remove particles from the area (11).
- 14) Install the cover (4).
- 15) Each 6000 to 8000 operation hours, make sure that the opening (5) is clear.

Checking the Axial Clearance

B**Fig. 2****2. Procedure Two**

- 1) Start the engine in the direction AHEAD to move the crankshaft fully forward. The crankshaft must touch the thrust pads (3, Fig. 1).
- 2) Stop the engine.
- 3) Make sure that the crankshaft does not move.
- 4) Use the micrometer 94101 to measure the distance between the crankshaft flange (10) and the oil baffle (top part) (9, see Fig. 2).
- 5) Record the value.
- 6) Remove the micrometer 94101.
- 7) Compare the value with those given in the engine documents on the Check Dimensions page (see also the 0330-1 Clearance Table, Crankshaft and Thrust Bearing).

The difference between the distance X and the value given in the engine documents is related to the wear of the thrust pads (3, Fig. 1).

- 8) Start the engine in the direction ASTERN to move the crankshaft fully forward. The crankshaft must touch the thrust pads (7, Fig. 1).
- 9) Stop the engine.
- 10) Make sure that the crankshaft does not move.
- 11) Use the micrometer 94101 to measure the distance between the crankshaft flange (10) and the oil baffle (top part) (9, see Fig. 2).
- 12) Record the value.
- 13) Remove the micrometer 94101.
- 14) Compare the value with those given in the engine documents on the Check Dimensions page (see also the 0330-1 Clearance Table, Crankshaft and Thrust Bearing).

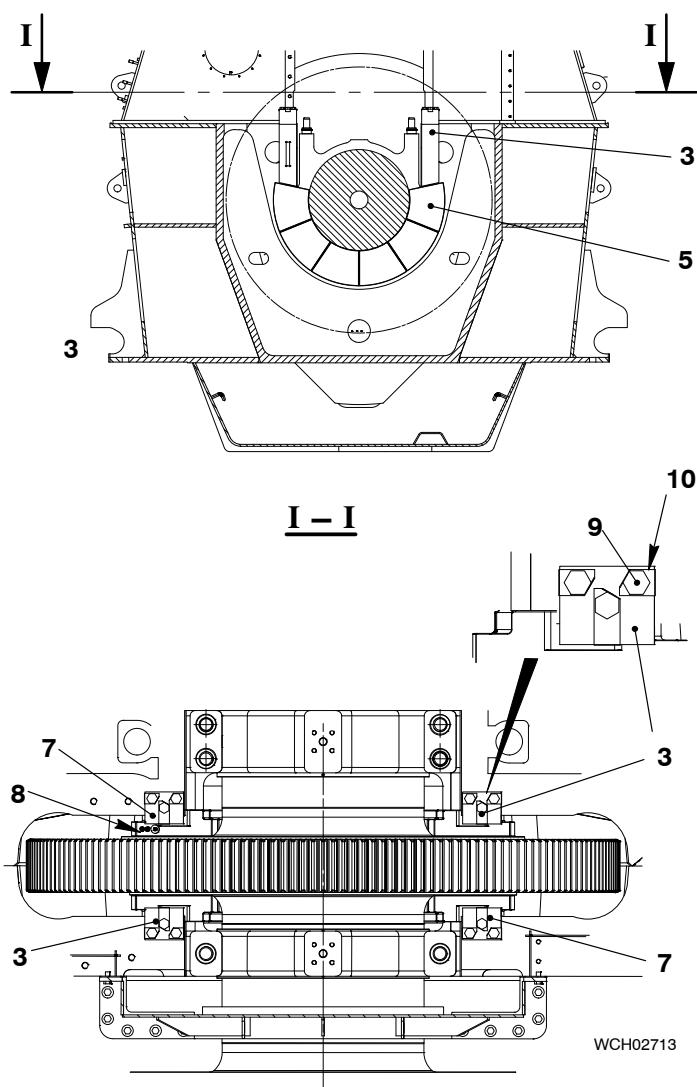
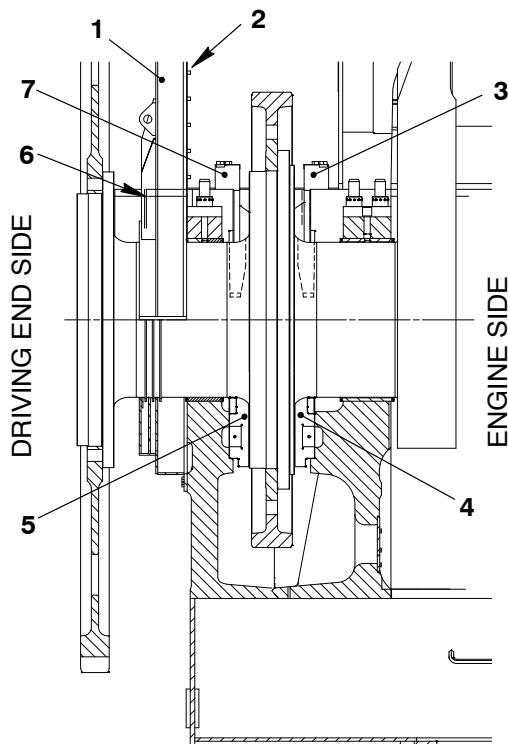
The difference between the distance X and the value given in the engine documents is related to the wear of the thrust pads (7, Fig. 1).

Thrust Bearing**Removal and Fitting the Thrust Bearing Pads****Tools:**

1 Manual ratchet	94016-006 (H3)	1 Carrier	94155
2 Spur-gear chain block	94017-005 (H1, H2)	1 Link	94321
2 Eye bolt	94045-M12		

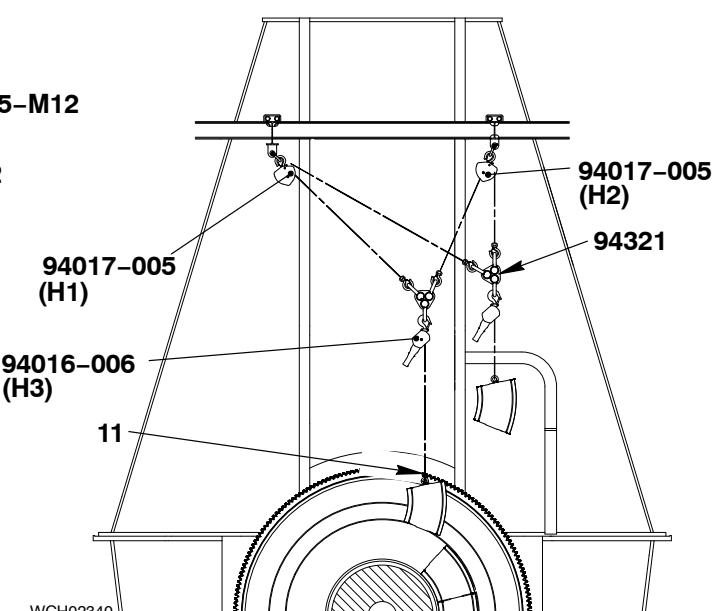
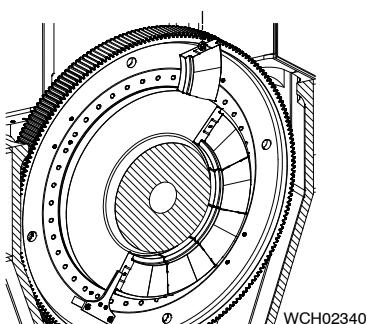
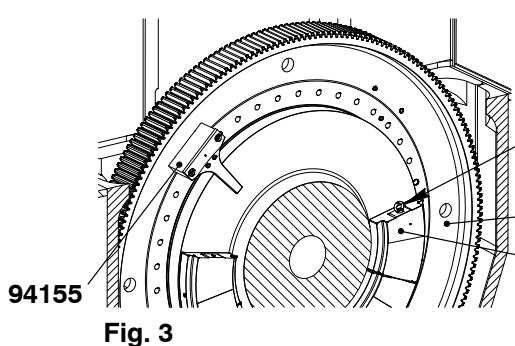
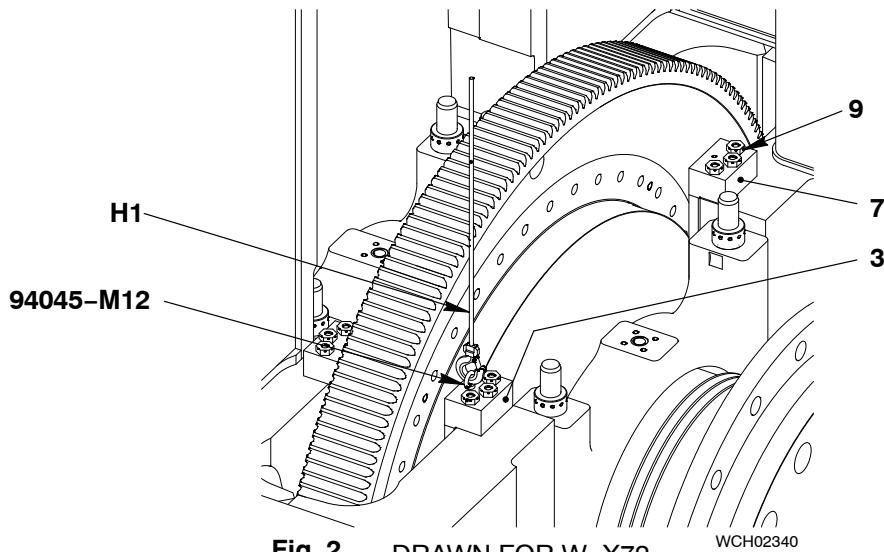
1. Removal

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Remove the cover 2 from the casing (1), see [Fig. 1](#).
- 3) Record the positions of the thrust bearing pads.



Removal and Fitting the Thrust Bearing Pads

- 4) Remove the bolts (9, Fig. 1) from the arbor supports (3, 7) of the applicable thrust bearing pads.
- 5) Attach the eye bolt 94045-M12 to the arbor support (3, or 7).
- 6) Attach the chain blocks H1 and H2 to the gallery (16, see Fig. 3).
- 7) Remove the applicable arbor supports (3, 7).



- 8) Connect hooks of chain blocks H1 and H2 with the link 94321.
- 9) Install the carrier 94155 on the gear wheel (12) as shown.
- 10) On the engine side: Start with the thrust pad which has temperature sensors (8, Fig. 1) in it – and remove those before lifting the pad.

Removal and Fitting the Thrust Bearing Pads

- 11) Use the turning gear to turn the crankshaft in the applicable direction.

While the gear wheel (12) turns, the carrier 94155 moves the thrust bearing pads. The first thrust bearing pad will come out.

- 12) Attach the eye bolt 94045-M12 to the thrust bearing pad (5, [Fig. 3](#)).
- 13) Attach manual ratchet H3 to lifting plate and to the eye bolt 94045-M12.
- 14) Lift the thrust pad with manual ratchet H3 and move it to exhaust side.
- 15) Lower the thrust bearing pad on to a stable area.
- 16) Do the procedure above for the remaining thrust bearing pads that you must remove.

If some of the thrust bearing pads are removed, the remaining thrust bearing pads will keep the crankshaft in position.

If all thrust bearing pads from the same side are removed, e.g. all the astern pads, the crankshaft can move.

- 17) To prevent crankshaft movement, do as follows:
- 18) Get a piece of hardwood that has the same dimensions as a thrust bearing pad.
- 19) Put the hardwood in the position of the removed thrust bearing pads.

2. Install

- 1) Make sure that the thrust bearing pads are clean.
- 2) Apply clean engine oil to the thrust bearing pads.

Note: You must install thrust bearing pads that you removed before in the same positions. Use your recorded notes and see Fig. E for the correct positions.

- 3) Attach the eye bolt to the thrust bearing pad 5 (see [Fig. 3](#)).
- 4) Use the manual ratchet H3 to lift the thrust bearing pad.
- 5) Put the first thrust bearing pad in position. Make sure that the thrust pad touches the carrier (94155).
- 6) Use the turning gear to turn the crankshaft in the applicable direction.
- 7) Put the subsequent thrust bearing pad in position.
- 8) Do the steps above for each thrust bearing pad.
- 9) Install the temperature sensors (8, [Fig. 1](#)) on the engine side.
- 10) When all thrust bearing pads are in position the top, outer thrust bearing pads must be at equal height.
- 11) Remove the carrier (94155).
- 12) Install the arbor supports (3, 7) as follows:
- 13) Attach the eye bolt 94045-M12 to the applicable arbor support.
- 14) Lift then lower the arbor support (3) into position.

Removal and Fitting the Thrust Bearing Pads

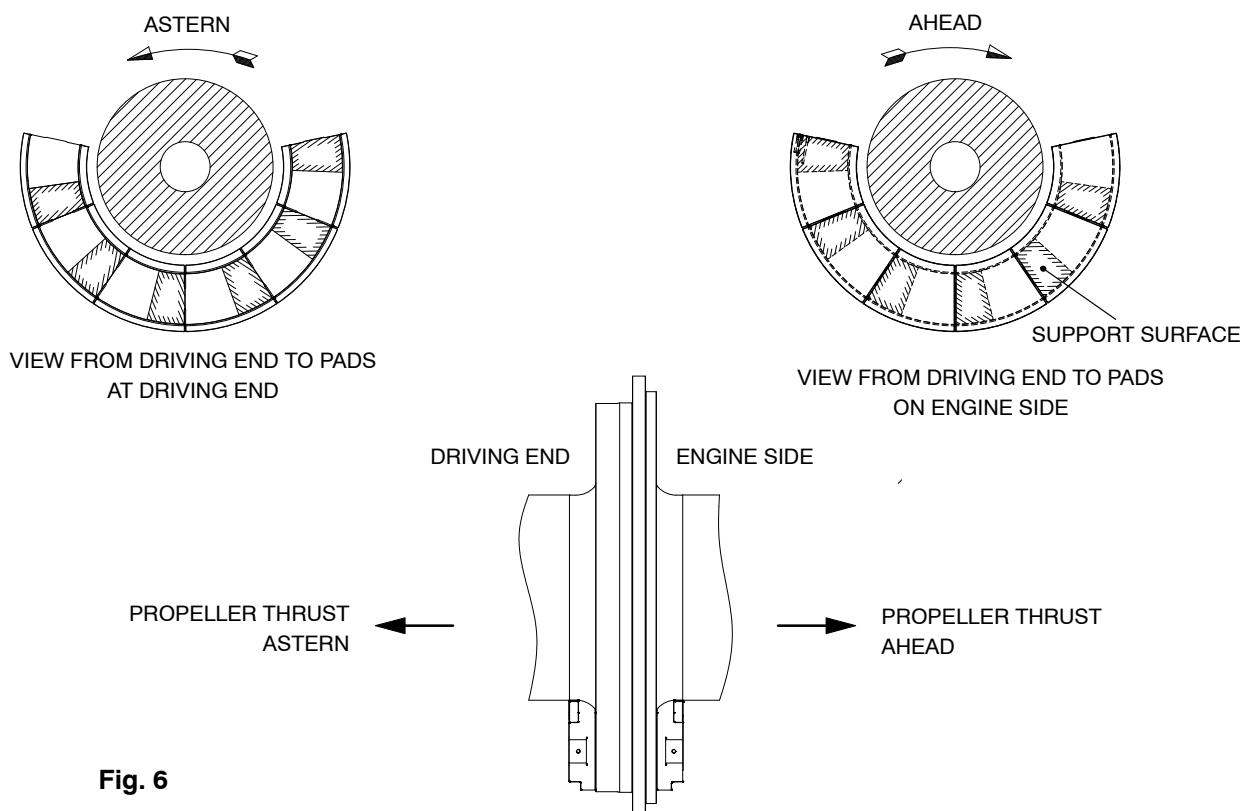
- 15) Remove the eye bolt.
- 16) Install the three bolts 9 with new locking plates (10, [Fig. 1](#)) to the arbor support (3, 7).
- 17) Install temperature sensor (8, see [Fig. 1](#)).
- 18) Do a check of the clearances between the arbor supports and the thrust bearing pads (see [0330-1 Clearance Table, Crankshaft and thrust bearing](#)).

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

When you replace a full set of thrust bearing pads (or a full set of thrust bearing pads that have new metal), you must adjust the clearances to the original values (see [0330-1 Clearance Table, Crankshaft and thrust bearing](#) and [1203-1 Checking the Axial Clearance](#))

CONFIGURATION OF THRUST BEARING PADS WITH FIXED PITCH PROPELLER

CLOCKWISE ROTATING ENGINE



Engine Stays with Friction Shims

Checking the Pre-tension

Tools:

1 Feeler gauge	94122	2 Pressure gauge	94934A
1 Pre-tensioning jack	94145	1 HP hose	94935
1 HP oil pump	94931		

1. General

Depending on ship design, there are four engine stays (1, Fig. 1) with friction shims either on exhaust or on fuel side and two engine stays on driving end and free end.

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

For checking the pre-tension of the engine stays, same jack 94145 is used as for foundation bolts. The nameplate is engraved with 1500 bar. The pre-tensioning value for engine stays is 170 bar only!

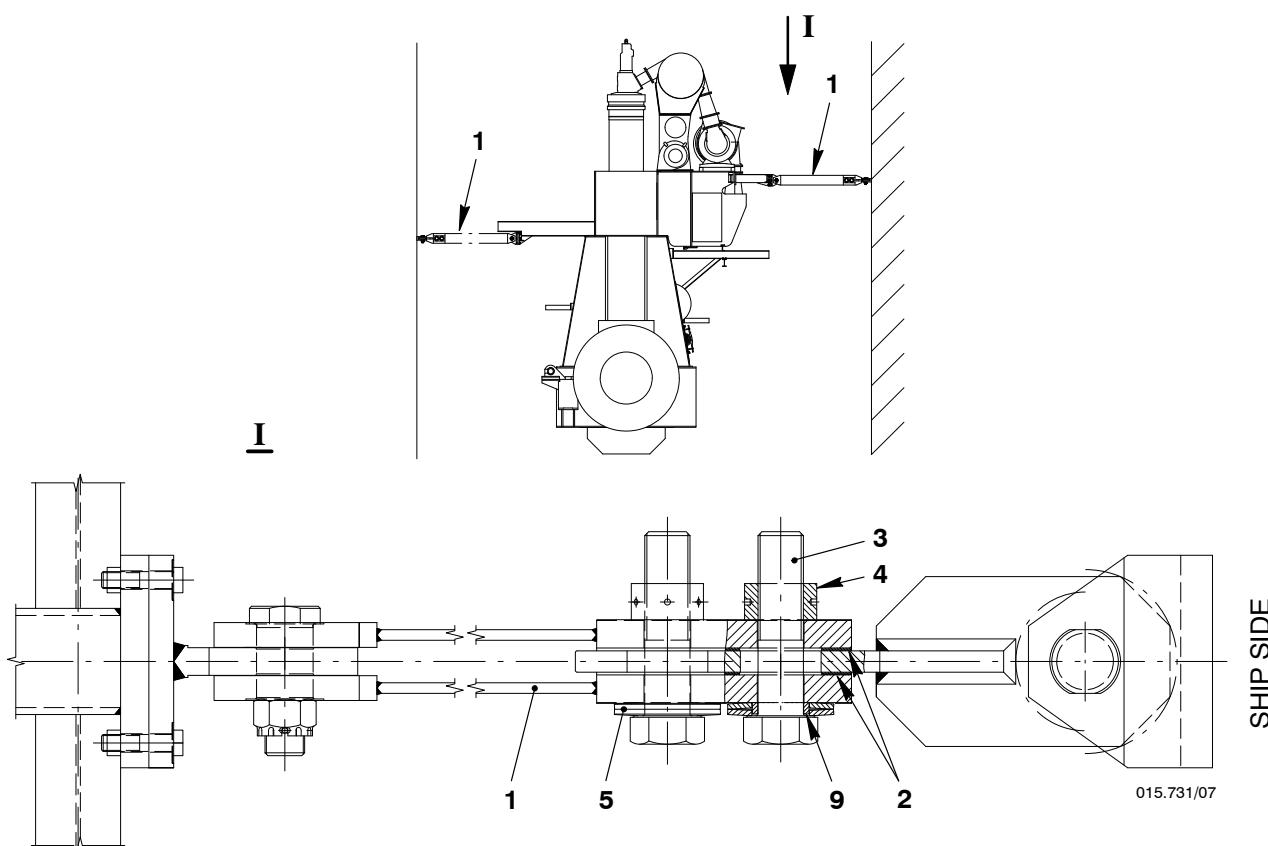


Fig. 1

Engine Stays with Friction Shims: Checking the Pre-tension

2. Checking the pre-tension

- 1) Clean the threads of the screws (3, Fig. 1) and the seating surfaces. Subsequently apply MOLYKOTE G paste to the threads.

- 2) Pre-tension the screw (3) to **170 bar** according to [9403-4](#).

Check with feeler gauge 94122 through slot 'KO' if there is any clearance between nut 4 and its seating.

- 3) 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 round bar 'RB' (check with feeler gauge).

- Loosening of the screws (3) is also given in [9403-4](#).

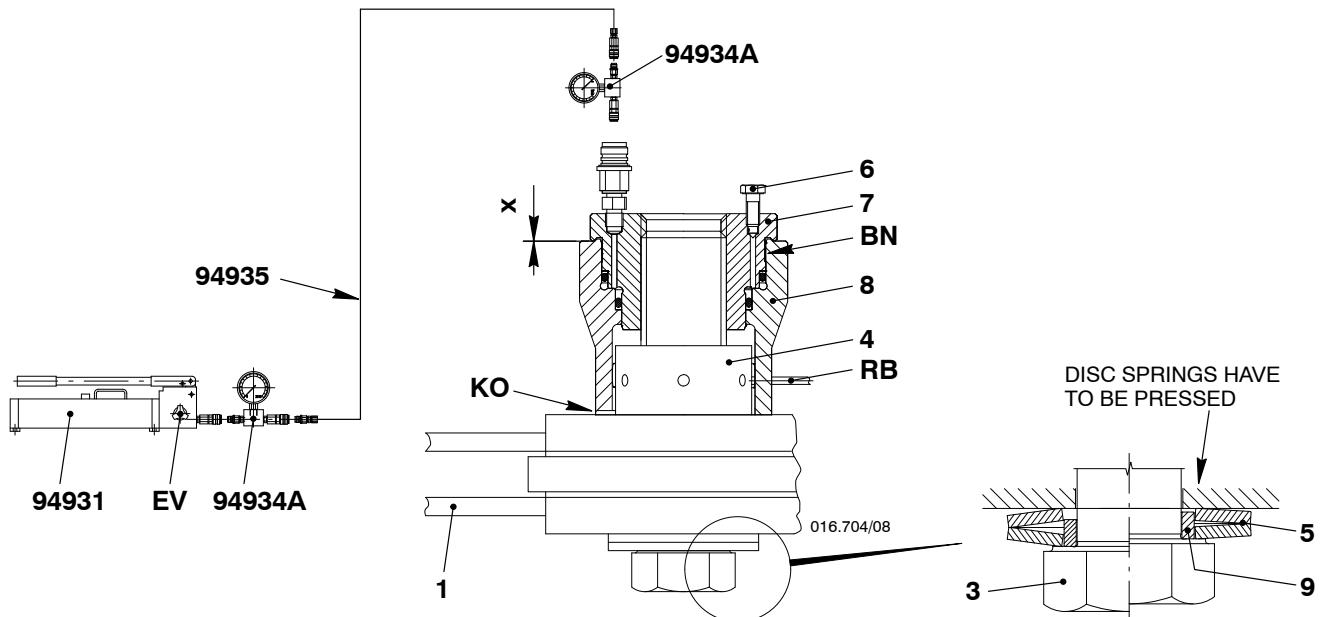


Fig. 2

Hydraulic Engine Stays

Checking the Oil Pressure

1. General

Two hydraulic engine stays (1) are installed on the exhaust side and two on fuel side of the engine.

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

If one of the hydraulic cylinders shows a pressure below 30 bar, which could be caused by defective O-rings, leaking valves, screwed connections or a defective bladder accumulator, the one cylinder on the opposite must also be released of its pressure down to 30 bar.

The defective engine stays must be repaired at the first opportunity. Afterwards the oil pressure must be readjusted to the required value on all the engine stays, whereby the detailed instructions of the respective maker must be considered.

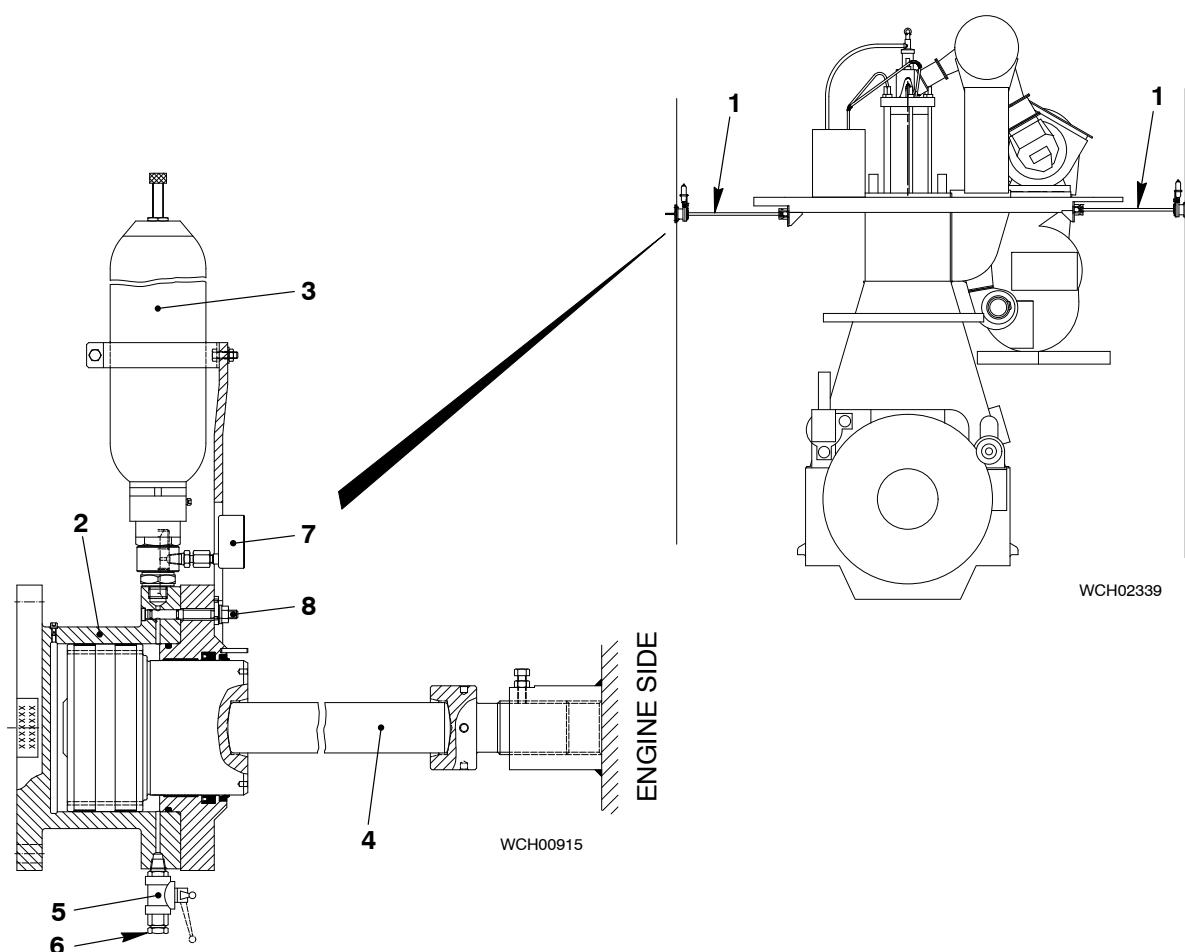


Fig. 1

Fig. 1 Hydraulic Engine Stays

- | | | | |
|---|------------------------|---|--------------------------|
| 1 | Hydraulic engine stays | 5 | Ball valve |
| 2 | Hydraulic cylinder | 6 | Plug $\frac{3}{8}$ " NPT |
| 3 | Bladder accumulator | 7 | Pressure gauge |
| 4 | Rod | 8 | Damping control valve |

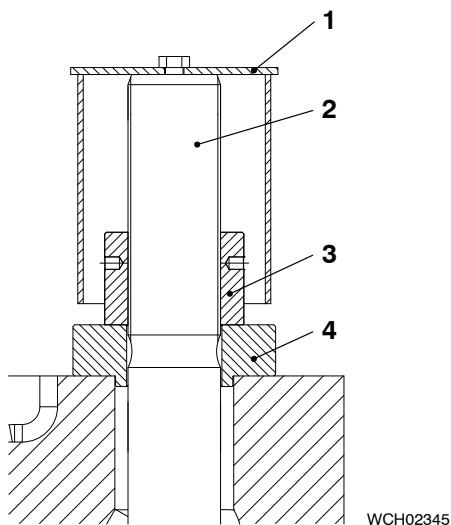
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Tie Rod**Checking the Pre-tension and Tie Rods Replacement****Tools:**

1 Feeler gauge	94122	1 Pressure gauge	94934A
2 Pre-tensioning jacks	94180	3 HP hoses	94935
1 Connection block	94934	1 Hydraulic unit	94942

1. General

We recommend to check the pre-tensioning of all the tie rods one year after commissioning. If necessary, tension them to the specified value. After that follow the maintenance schedule [0380-1](#).

2. Checking the pre-tension of tie rods**Fig. 1**

- 1) Remove protection cover (1, [Fig.1](#)) from all tie rods (2) and clean the contact face of intermediate ring (4).
- 2) Attach the two pre-tensioning jacks (94180, [Fig.3](#)) on the two tie rods (2, [Fig.1](#)), which are opposite to each other.
- 3) Apply tension to the tie rods (2) with 1500 bar, refer to [9403-4](#).
- 4) Tighten the round nut (3) if possible.
- 5) If the tie rod nut (3) is blocked or seized, put a brass or copper bar into a hole in the tie rod nut through the slotted aperture of the jack and first loosen, then tighten the nut with several heavy hammer blows. Make sure that the edge of the hole is not seriously deformed.
- 6) After the check of the tensioning is completed, apply a layer of the non-acidic grease to the tie rod (2) threads to protect it against corrosion.
- 7) Install the protection cover (1).

Checking the Pre-tension and Replacing the Tie Rods

3. Tie Rods – Replacement

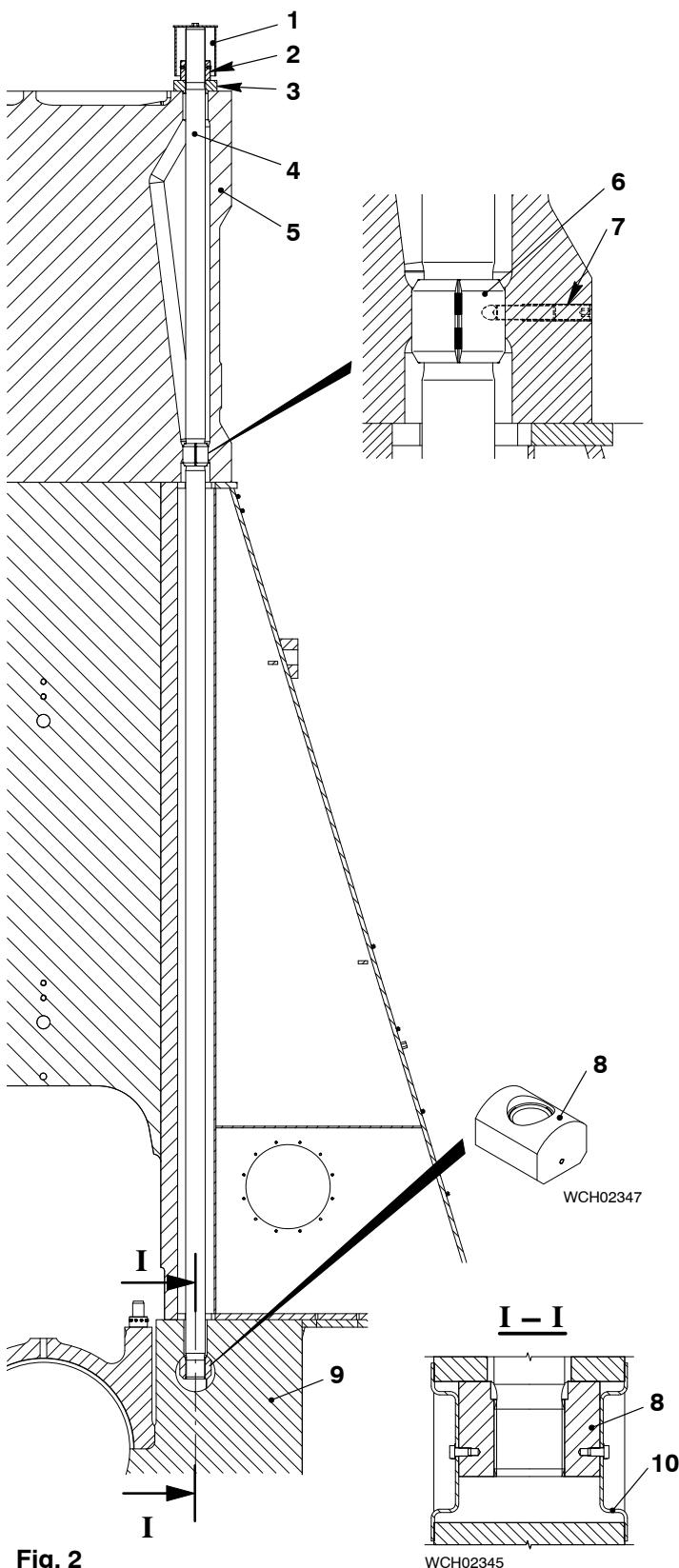


Fig. 2

3.1 Loosening

- 1) Remove the protection cover (1, Fig.2) from the tie rods (4) and clean the surface of the intermediate ring (3).
- 2) Attach the two pre-tensioning jacks (94180, Fig.3) on the two tie rods (4, Fig.2), opposite to each other.
- 3) Loosen the tie rods, refer to 9403-4.

3.2 Removal

- 1) Remove the set screws (7, Fig.2).
- 2) Unscrew the tie rod (4) with the two round nuts (2) countered against each other.
- 3) Use an applicable eye bolt and attach it to the head of the tie rod (4).

CAUTION

Injury Hazard: The weight of the tie rod is 318 kg. Use the correct equipment for removal.

- 4) Use the crane and attach the crane hook to the eye bolt.
- 5) Lift the tie rod (4) and take it out of the cylinder jacket (5).

3.3 Install

- 1) Remove the holders (10, Fig.2) on each side.
- 2) Make sure the nut (8) is correctly attached.
- 3) Add MOLYKOTE G paste to the lower thread of the tie rod (4).
- 4) Attach an applicable eye bolt to the head of the tie rod (4).
- 5) Use the crane and attach the crane hook to the eye bolt.
- 6) Install the bush (6) to the tie rod.
- 7) Lower the tie rod (4) and screw it into the nut (8) until their bottom ends are flushed.
- 8) Clean the upper surfaces of the cylinder block (9).
- 9) Install the intermediate ring (3).
- 10) Add MOLYKOTE G paste to the upper thread of the tie rod (4) and to the upper surface of intermediate ring (3).
- 11) Screw the round nut (2) on the tie rod (4).
- 12) Lift the tie rod (4) and screw down the round nut (2) completely.
- 13) Check if the nut (8) is fully up and install the holders (10) on each side (only one on first tie rod).
- 14) Tension the tie rods (1), refer to paragraph 3.4.

Checking the Pre-tension and Replacing the Tie Rods

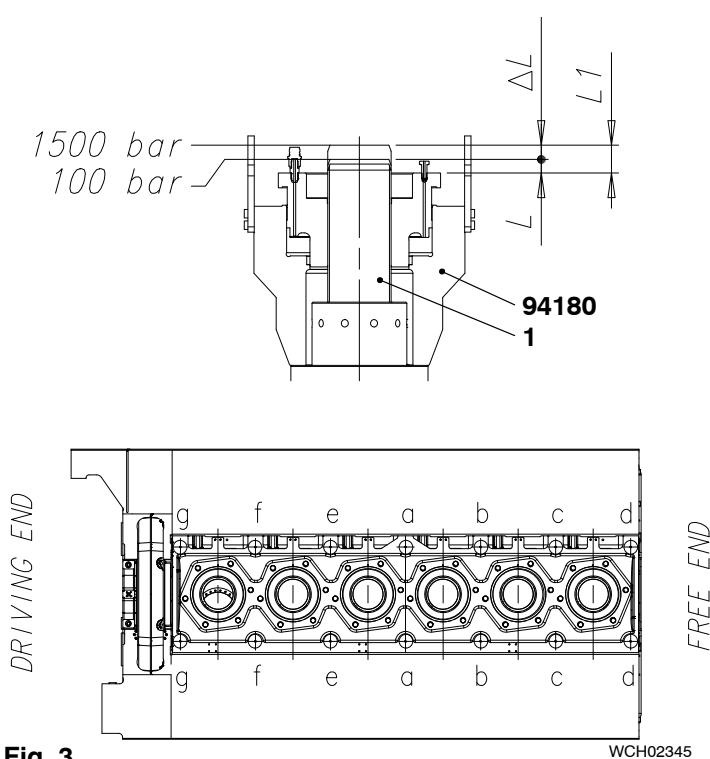


Fig. 3

3.4 Tensioning

- 1) Put the two pre-tensioning jacks (94180, [Fig.3](#)) on the to two tie rods (1) which are opposite to each other.
 - Start from the middle of the engine outwards.
 - 2) Record the elongation of the tie rods (1) from 100 bar to nominal 1500 bar.
 - 3) Tension the tie rods, refer to [9403-4](#).
 - The elongation of the correct tensioned tie rod (1) must be:
- $\Delta L = 11.5 \dots 13.5 \text{ mm}$
- 4) Screw in and tighten the set screws (7, [Fig.2](#))
 - 5) Apply a layer of the non-acidic grease to the rod threads to protect the tie rod (1, [Fig.3](#)) against corrosion.
 - 6) Put the protection cover (1, [Fig.2](#)) on all tie rods.

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Cylinder Liner and Cylinder Cover

Group 2

Cylinder Liner

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

Lubricating Quill: Removal and Installation 2138-1/A2

Piston Rod Gland: Replace, Assembling, Wear Measurement 2303-1/A1

Cylinder Cover

Removal and Fitting of Cylinder Cover and Upper Water Guide Jacket	2708-1/A1
Machining of Sealing Face for Injection Valve	2708-3/A1

Injection Valve: Replacement 2722-1/A1

Injection Valve: Disassemble, Checks, Assemble (Injection Valve with FAST) 2722-2/A1

Starting Air Valve: Removal, Disassemble, Grinding, Assemble, Installation 2728-1/A1

Relief Valve on Cylinder Cover: Blow-off Pressure Check 2745-1/A1

Exhaust Valve

Exhaust Valve – Removal and Installation	2751-1/A1
Disassemble and Assemble	2751-2/A1
Valve Seat – Replace / Grind	2751-3/A1
Grinding the Seating Surface on the Valve Head	2751-4/A1

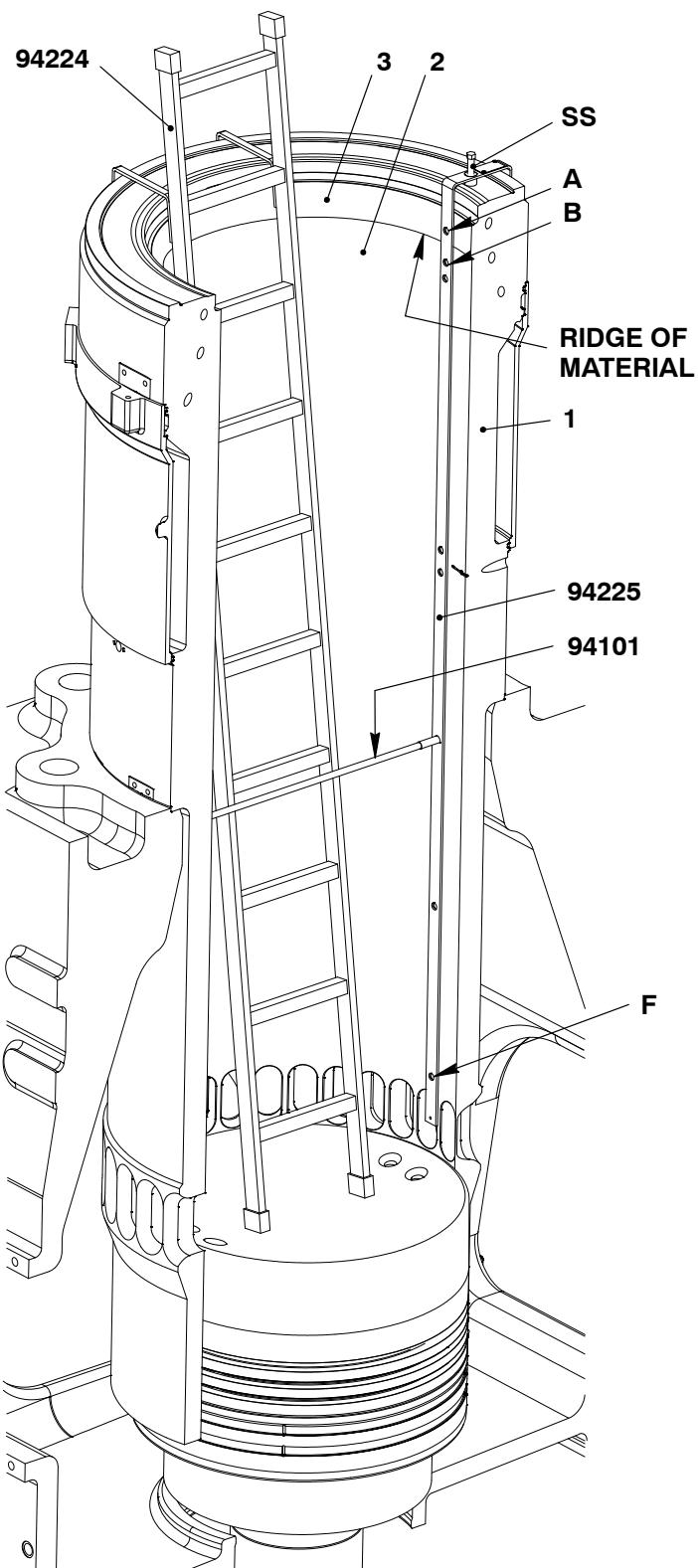
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Cylinder Liner

Measure the Bore

Tools:

1 Inside micrometer	94101
1 Ladder	94224
1 Gauge	94225

**Fig. 1**

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Measure the cylinder liner before you remove a piston.

- 1) Remove the cylinder cover, (refer to 2708-1).

WARNING


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

WARNING


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

CAUTION


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

Note: Do not go into the combustion chamber without removing the cylinder cover.

- 2) Operate the turning gear to move the piston to BDC.
- 3) Put on a harness that is attached to a safety person. If necessary, the safety person can pull you out of the cylinder liner if there is an emergency.
- 4) Lock the lever of the cooling water valve in the closed position. This makes sure that no cooling water can go into the cylinder liner.
- 5) Clean the area (3) above the running surface (2).
- 6) Remove the bottom part of the gauge (94225).

Measure the Bore

- 7) Put the gauge (94225) in position on the top face of the cylinder liner (1) in line with the longitudinal axis of the engine.
- 8) Make sure that the top hole (A) is above the ridge in the non-running surface of the cylinder liner (1, [Fig. 1](#)).
- 9) Read the values from when the bore was measured before. You compare these values with the new values.
- 10) Put the micrometer (94101) in the top hole (A) to measure the distance. Record the value.
- 11) Put the micrometer in position in the subsequent hole (B) in the gauge (94225), then record the value.
- 12) Do the step above for the remaining holes below (A and B).
- 13) Move the gauge 90° (in line with the transverse axis of the engine).
- 14) Do the steps above again to measure the bore in the positions (F up to A).
- 15) Use the formula below to calculate the rate:

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

Where:

WR = Wear rate (mm/1000 hours)

T1 = Total running hours (h)

D1 = Maximum liner diameter of running surface (point B and below) (mm)

D2 = Liner diameter of non-running surface (point A) (mm)

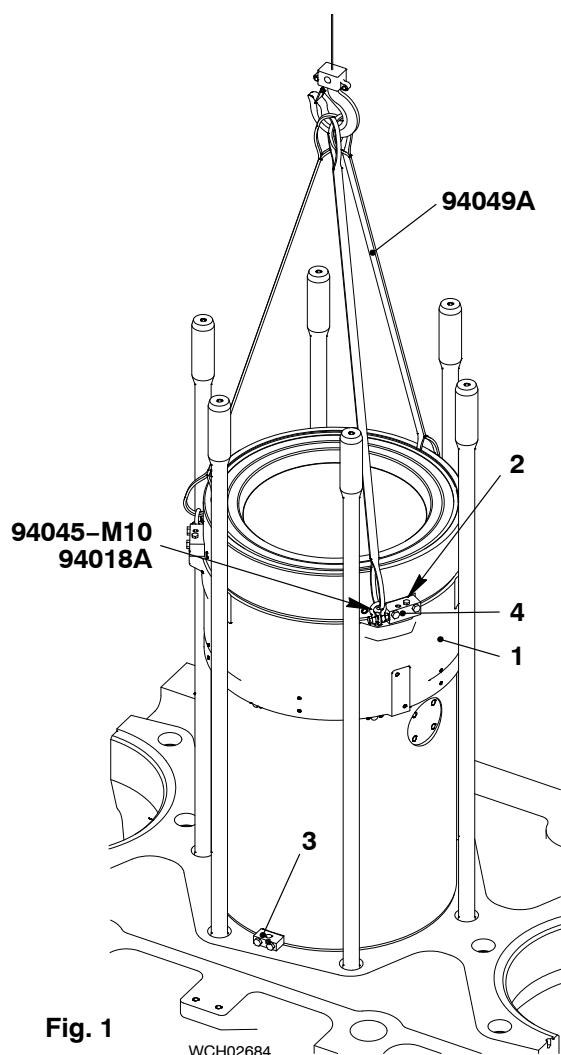
- 16) For the maximum permitted inner diameter, refer to 0330-1 Clearance Table, Cylinder liner.
- 17) Remove all waste particles from the cylinder liner bore.
- 18) Clean the bore of the cylinder liner.

Removal and Fitting

Tools:

3 Shackle	94018A	3 Round sling	94049A
1 Lifting tool	94201	3 Eye bolt	94045-M10
1 Assembly tool	94233	1 Chain	94202L

1. Preparation	1
2. Lower Water Guide Jacket – Removal	1
3. Install the lifting tool	2
4. Cylinder Liner – Safe Storage	3
5. Insulation Bandage – Removal	4
6. Insulation Bandage – Installation	4
7. Cylinder Liner and Water guide jacket – installation	5



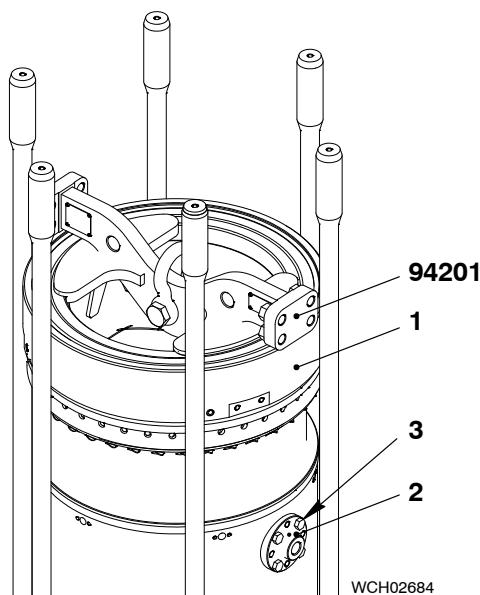
1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Drain the cylinder cooling water from the related cylinder (see the Operating Manual 8017-1).
- 3) Remove the cylinder cover (see [2708-1](#)).
- 4) Remove the piston together with the piston rod gland (see [3403-1](#) and [2303-1](#)).
- 5) Remove all lubricating quills (see [2138-1](#)).

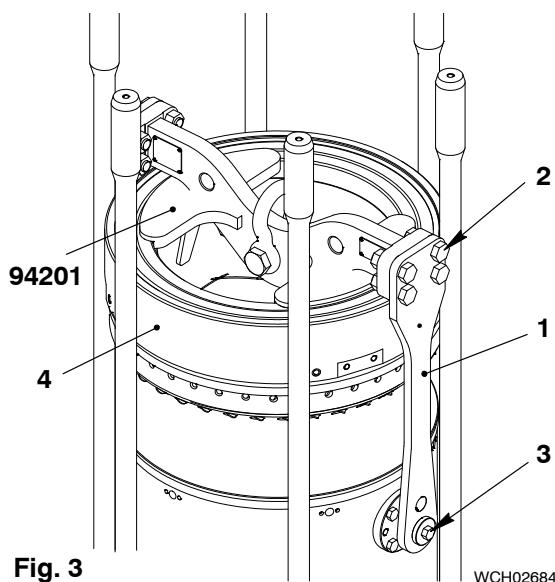
2. Lower Water Guide Jacket – Removal

- 1) Remove the cylinder holder (3).
- 2) Attach three eye bolts 94045-M10 to the lower water guide jacket (1).
- 3) Attach three round slings 94049A with shackles 94018A to the eye bolts on the water guide jacket and to the crane hook.
- 4) Slightly move the hook upwards to tension the slings.
- 5) Remove the three screws (2).
- 6) Carefully lower the water guide jacket.
- If the water guide jacket (1) does not come loose by its own weight, use bolts (2) and the threaded hole next to it to push the water guide jacket down.
- 7) Remove the holder (4).

Cylinder Liner: Removal and Fitting

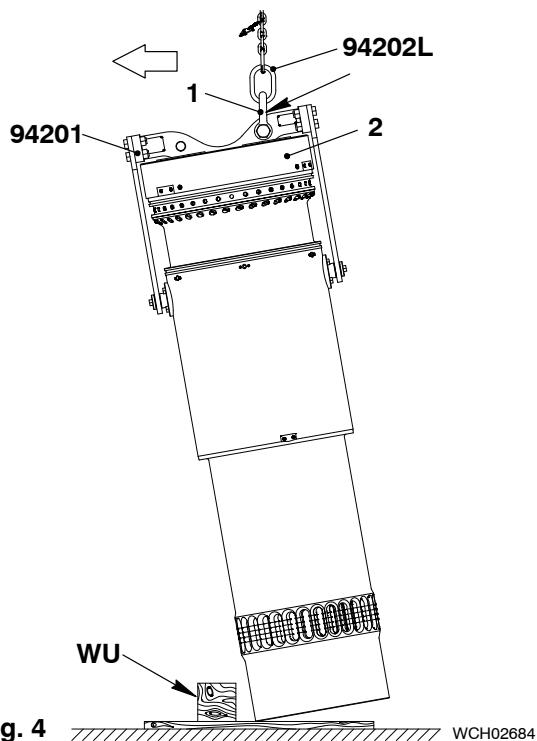
**3. Install the lifting tool**

- 1) Position the upper part of the lifting tool 94201 on top of cylinder liner (1), as shown in [Fig. 2](#).
- 2) Position the two flanges (2) (part of lifting tool 94201) on the side of cylinder liner, apply Molyslip Copaslip on the threads and tighten the screws (3) with 140 Nm.



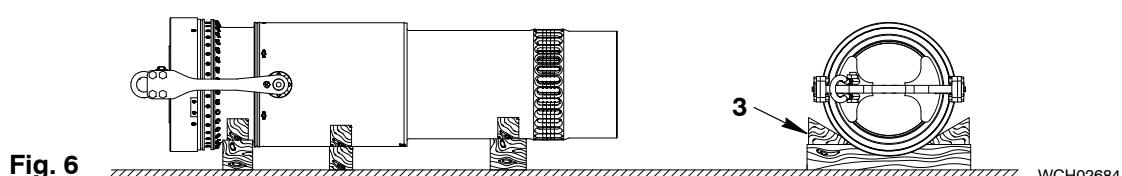
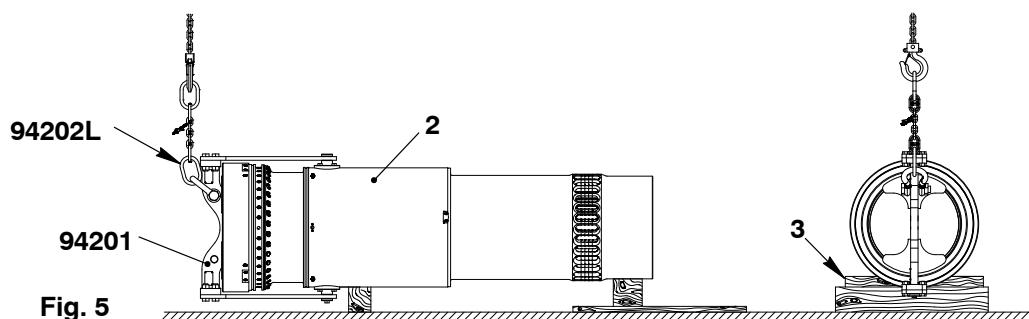
- 3) Install the two holders (1, part of lifting tool 94201) as shown in [Fig. 3](#), apply Molyslip Copaslip on the threads of screws (2) and tighten the screws (2) with minimum of 300 Nm and maximum of 960 Nm.
- 4) Apply Molyslip Copaslip to the thread of the two special screw (3) and tighten them with 205 Nm.
- 5) Carefully lift the cylinder liner (4, 3600 kg) and place it on a wooden underlay.

Cylinder Liner: Removal and Fitting



4. Cylinder Liner – Safe Storage

- 1) Install the lifting tool (94201) on the cylinder liner (see [paragraph 3](#)).
- 2) Attach the shackle (1) of the lifting tool (94201) in the position shown in [Fig. 4](#).
- 3) Attach the chain (94202L) to the shackle (1) and the crane hook.
- 4) Put the wooden underlay 'WU' in position as shown in [Fig. 4](#).
- 5) Carefully push the cylinder liner in the direction shown and at the same time lower the cylinder liner.
- 6) Put the wooden chocks (3, best with a 20° angle) in position to prevent movement of the cylinder liner (see [Fig. 5](#)).
- 7) Fully lower the cylinder liner.
- 8) Remove the chain (94202L) from the lifting tool.
- 9) Carefully turn the cylinder liner 90°.
- 10) Put more wooden underlays in position (see [Fig. 6](#)).
- 11) Put the two wooden chocks 14 in the position shown to prevent movement.
- 12) Remove the lifting tool from the cylinder liner.
- 13) Remove the insulation bandage, refer to [paragraph 5](#).



Cylinder Liner: Removal and Fitting

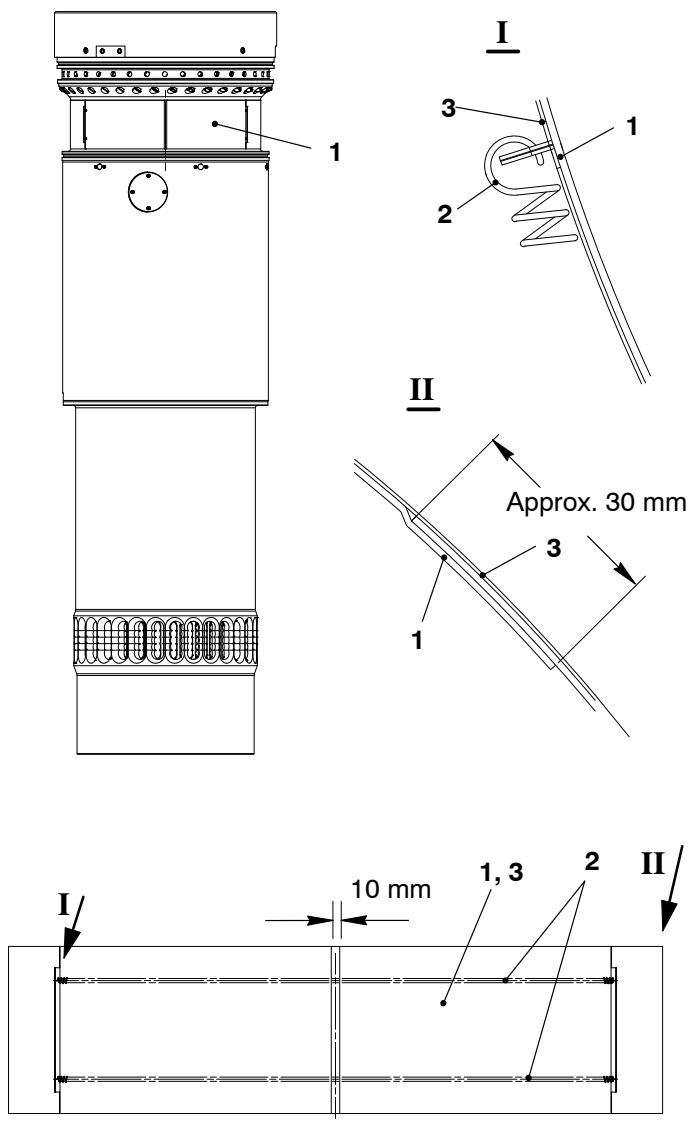


Fig. 7

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5. Insulation Bandage – Removal

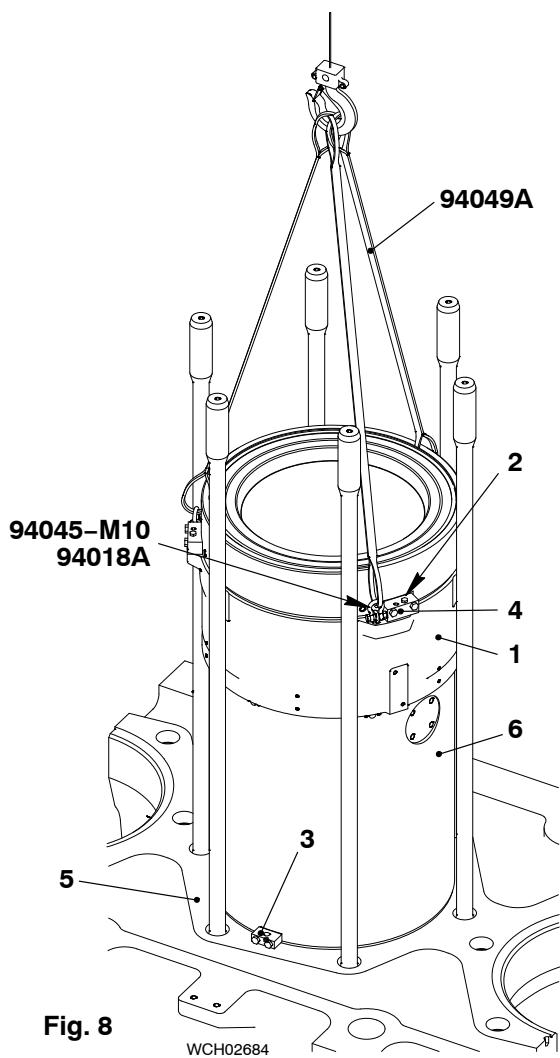
- Water guide jacket is removed, refer to paragraph 2.

 - Use the assembly tool (94233) to unhook all the tension springs (2) of the insulation bandage (1), Fig. 7.
 - Remove the plate (3).
 - Remove insulation bandage (1).

6. Insulation Bandage – Installation

- Wrap the insulation bandage (1, Fig. 7) around the water channel on the cylinder liner.
- Make sure the insulation bandage overlaps approximately 30 mm (View II).
- Wrap the plate (3) over the insulation bandage (1).
- Use the assembly tool (94233) to hook in the tension springs (2).
- There must be a gap of 10 mm between the plate endings.

Cylinder Liner: Removal and Fitting



7. Cylinder Liner and Water Guide Jacket – Installation

- 1) Install the insulation bandage, refer to [paragraph 6](#).
- 2) Clean the seat on the cylinder liner (6) and on the cylinder block (5) and apply a non hardening sealing compound (e.g. Hylomar Universal Blue) to the cylinder block.
- 3) Attach three eye bolts 94045-M10 to the lower water guide jacket (1, [Fig. 8](#)).
- 4) Attach three round slings 94049A with shackles 94018A to the eye bolts on the water guide jacket and to the crane hook.
- 5) Put the water guide jacket (1) on three wooden blocks on top of the cylinder block (5) to make room (< 100 mm) for the installation of the cylinder holder (3) afterwards.
 - Make sure the water pipe is in the right position.
- 6) Unhook the slings 94049A.
- 7) Attach the lifting tool (94201) to the cylinder liner (6) (see [paragraph 3](#)).
- 8) Lift, move and lower the cylinder liner (6) in the correct alignment of the pin for the cylinder holder (3) and the threads in the cylinder liner.
 - Be careful not to damage the water guide jacket.
 - Stop to lower the cylinder liner 100 mm above seat.
- 9) Install cylinder holder (3) to the cylinder liner.
- 10) Lower the cylinder liner while the centering hole in the cylinder holder is aligned to the pin.
- 11) Remove the lifting tool 94201.
- 12) Make sure that all O-rings on the cylinder liner are in perfect condition and properly installed.
- 13) Apply oil to the O-rings.
- 14) Lift the water guide jacket 3 to the correct position on the cylinder liner. Make sure that you keep the water guide jacket level.
- 15) Attach the water guide jacket (1) to the cylinder liner apply Never Seez to the thread of bolts (2) and tighten them with 60 Nm.
- 16) Install all lubricating quills (see [2138-1](#)).
- 17) Operate the flex lube pump on the related cylinder liner until oil flows from all the lubricating grooves (see [2138-1](#), paragraph 5).

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

Tools:

- 1 Wear ridge grinding device 94299

1. General

During operation, the cylinder liner becomes worn and an edge of unwanted material collects immediately above the location where the top piston ring travel stops. Also, the lubricating grooves decrease in depth and the corner radii of the scavenge ports become smaller.

Before each piston removal, you measure the bore of the cylinder liner (for more data see [2124-1](#)).

- 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. Preparation

- 1) Remove the cylinder cover (see [7208-1](#)).
- 2) Remove all lubricating quills (see [2138-1](#)).
- 3) Put suitable protection below the cylinder liner. This will keep particles out of the area below the cylinder liner.

3. Unwanted material – removal

CAUTION



Make sure that you do no cause damage to the running surface of the cylinder liner when you remove the unwanted material.

- 1) Read the data in the Instruction Manual for the grinding tool.
- 2) Attach the grinding tool (94299) to the cylinder liner (see the Instruction Manual and Fig. 1).
- 3) Connect the grinding tool to a suitable air supply.
- 4) Use the grinding tool to carefully remove the unwanted material from the cylinder liner.
- 5) Make sure that you get a radius as given in Fig. 1 ($r = 8 \text{ mm}$).

Removing the Wear Ridge, Re-dressing Lubricating Grooves and Scavange Ports

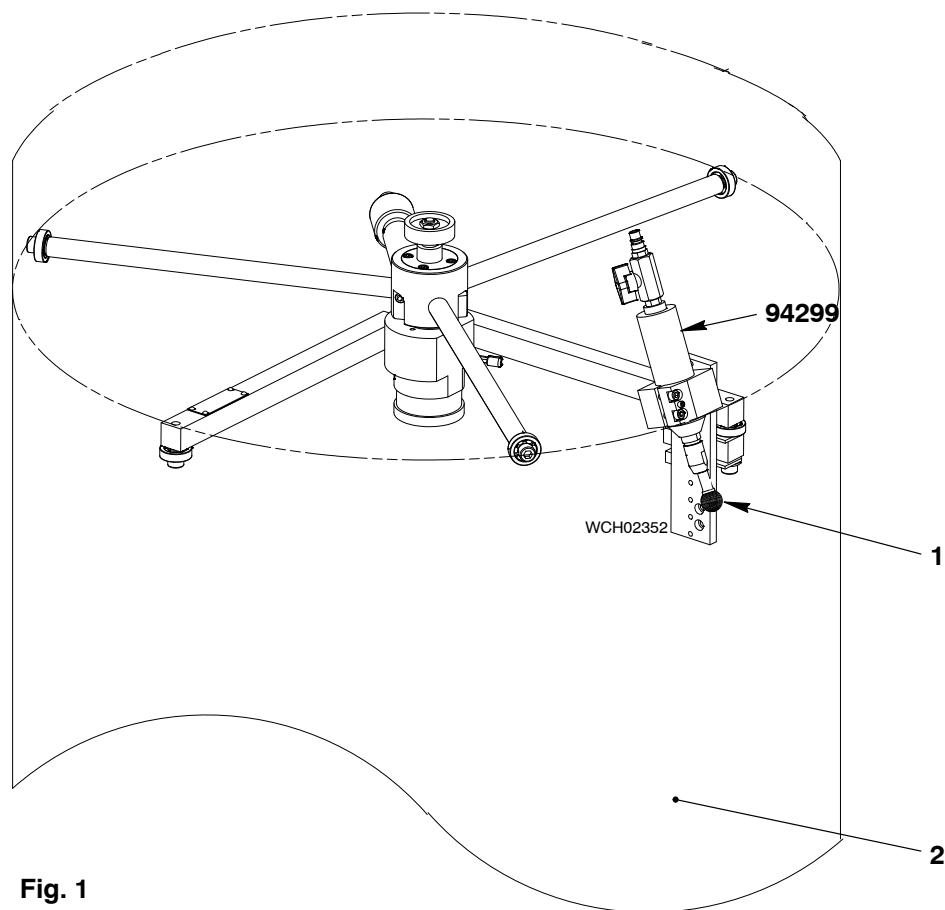
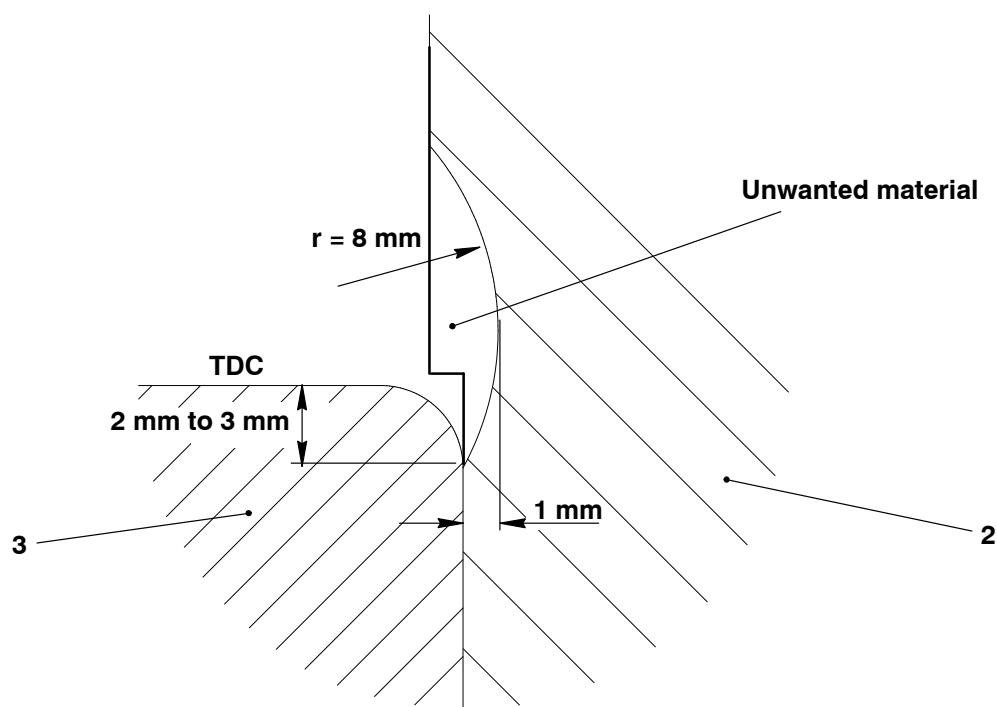


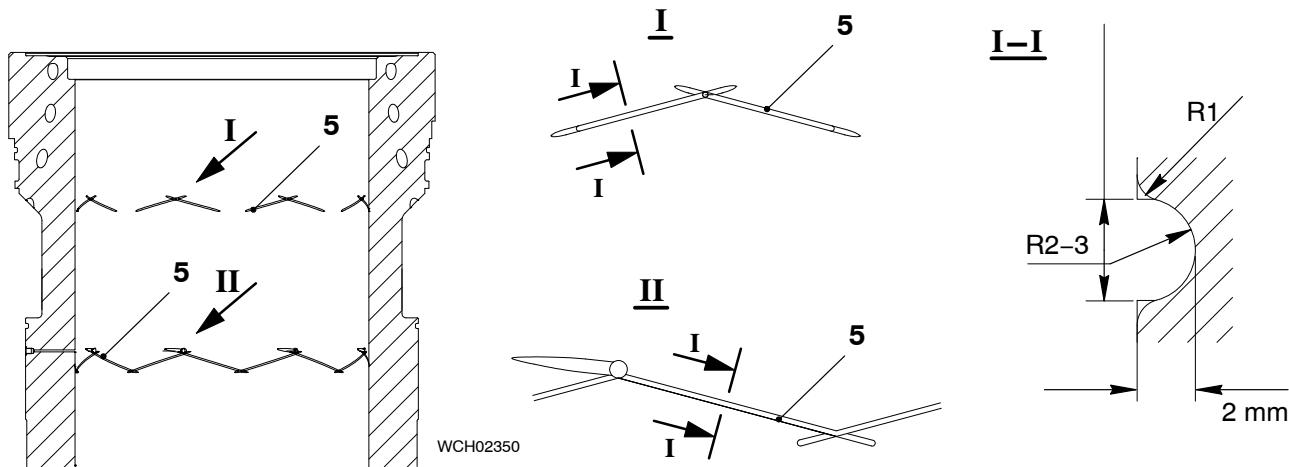
Fig. 1



Removing the Wear Ridge, Re-dressing Lubricating Grooves and Scavenger Ports

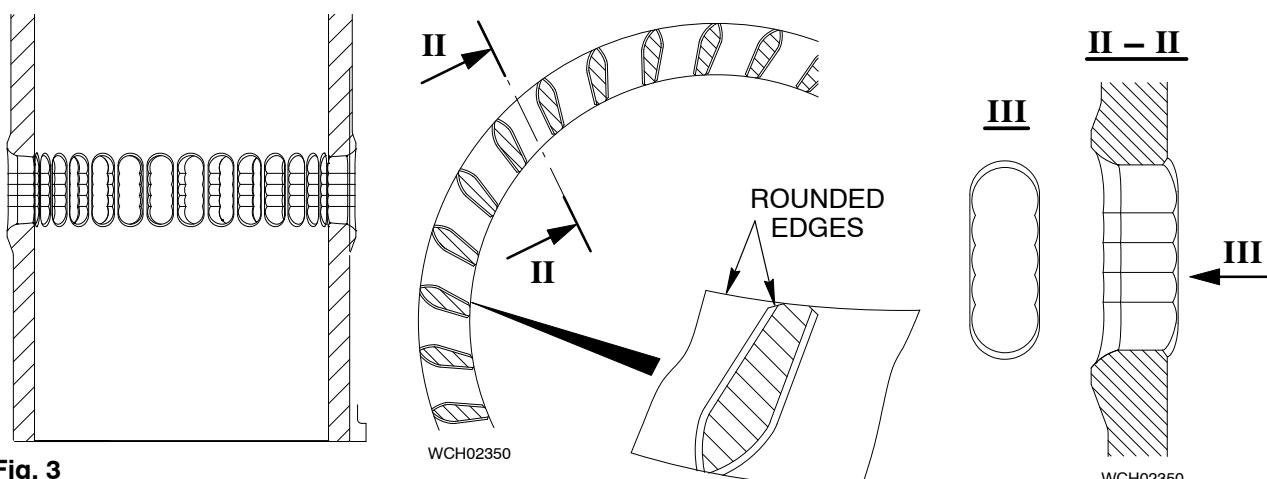
4. Lubricating grooves**CAUTION**

- 1) If the depth of the lubricating grooves has decreased to less than 1.5 mm, do as follows:
 - a) Use emery cloth or an oil stone to get the lubricating grooves 5 back to their original depth (see Fig. 2).

**Fig. 2****5. Scavenger ports****CAUTION**

Note: The scavenger ports shown in Fig.3 view III relate to new cylinder liners.

- 1) Use emery cloth to polish the surfaces of the scavenger ports. Make sure that you keep the shape of the scavenger ports the same as those shown in Fig. 3, view III.

**Fig. 3**

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Lubricating Quill

Removal and Installation

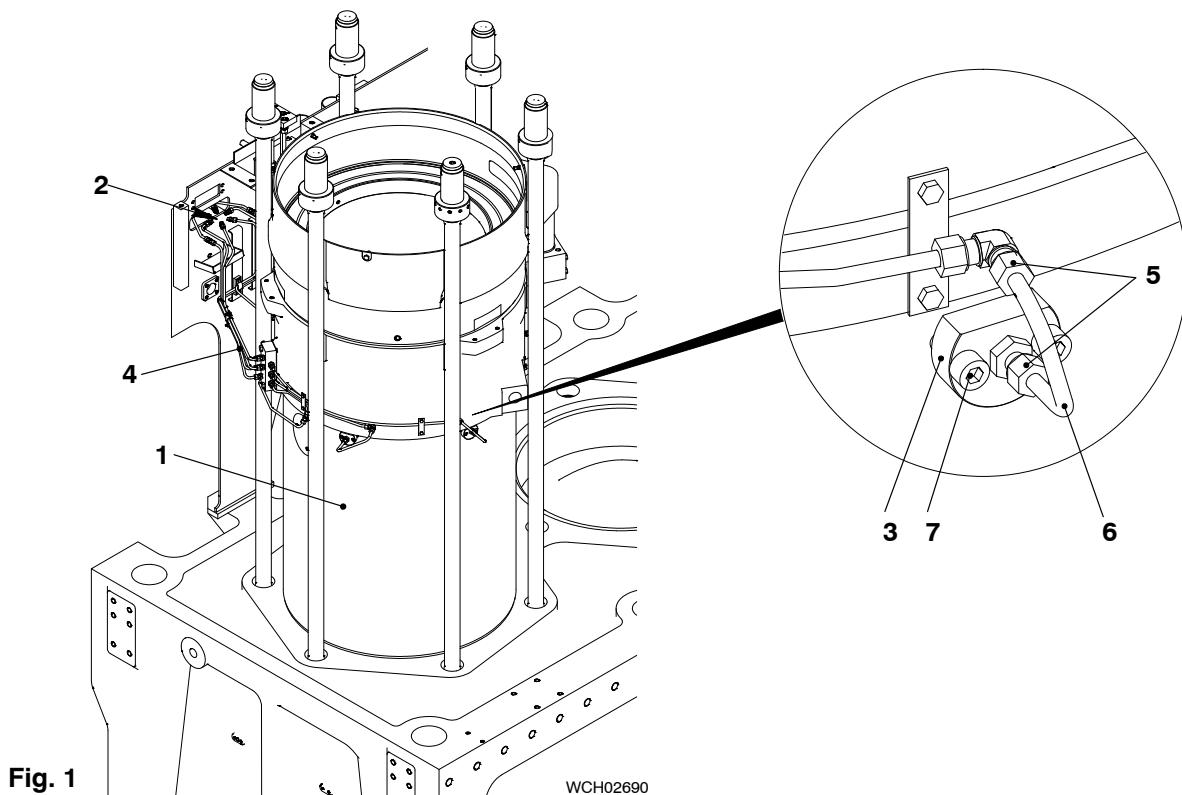
Tools:

1 HP oil pump	94931	1 Connection nipple (G1/4")	94934I
1 Pressure gauge 0–20 bar	94934B	1 Tredo Joint	94934J
		1 HP hose	94935

1. General

If the cylinder liner (1) is installed and it is necessary to remove a lubricating quill (3), you must not drain the cylinder cooling water.

If you have to remove the cylinder liner (1, Fig. 1), remove all lubricating quills (3) as described below and disconnect the tubes (4) from the cylinder liner (2).



2. Removal and installation procedure

2.1 Removal

- 1) Loosen the nuts (5) of the screw-in union and angle union and disconnect the tube (6) from the lubricating quill (3).

Note: Make sure that you do not damage the oil pipe (6).

- 2) Seal the oil pipes (4) and (6) with an applicable plug to keep dirt or other unwanted materials out of the system.
- 3) Remove the bolts (7).
- 4) Remove the lubricating quill (3).
- 5) If necessary, do a function check of the lubricating quills (see paragraph 3).

2.2 Installation

CAUTION



The surfaces of the cylinder liner (1) and the nozzle tip (2) make a metallic seal. The seat angles in the cylinder liner and on the nozzle tip are different. Do not use a gasket between the cylinder liner and the nozzle tip.

Note: Replace all components of the lubricating quill (3) at the same time, i.e. nozzle tip 2, non-return valve (6) and holder (5).

- 1) Make sure that the sealing surfaces SS are clean and have no damage.
- 2) Put the lubricating quill (3) in position.
- 3) Apply oil to the threads and surfaces of the screws (7).
- 4) Torque the screws (7) with 10 Nm.
- 5) Remove the plugs from the oil pipe (6, Fig. 1).
- 6) Connect the oil line (6, Fig. 1) to the lubricating quill (3).
- 7) Tighten the nuts (5 Fig. 1) of the screw-in union and angle union
- 8) Bleed the oil pipes (6, Fig. 1), see 7218-1, paragraph 3.2.
- 9) If necessary, bleed the flex lube pump (2, Fig. 1), see 7218-1, paragraph 3.1.
- 10) Do a function check of the cylinder lubricating system, see 7218-1, paragraph 1.2.

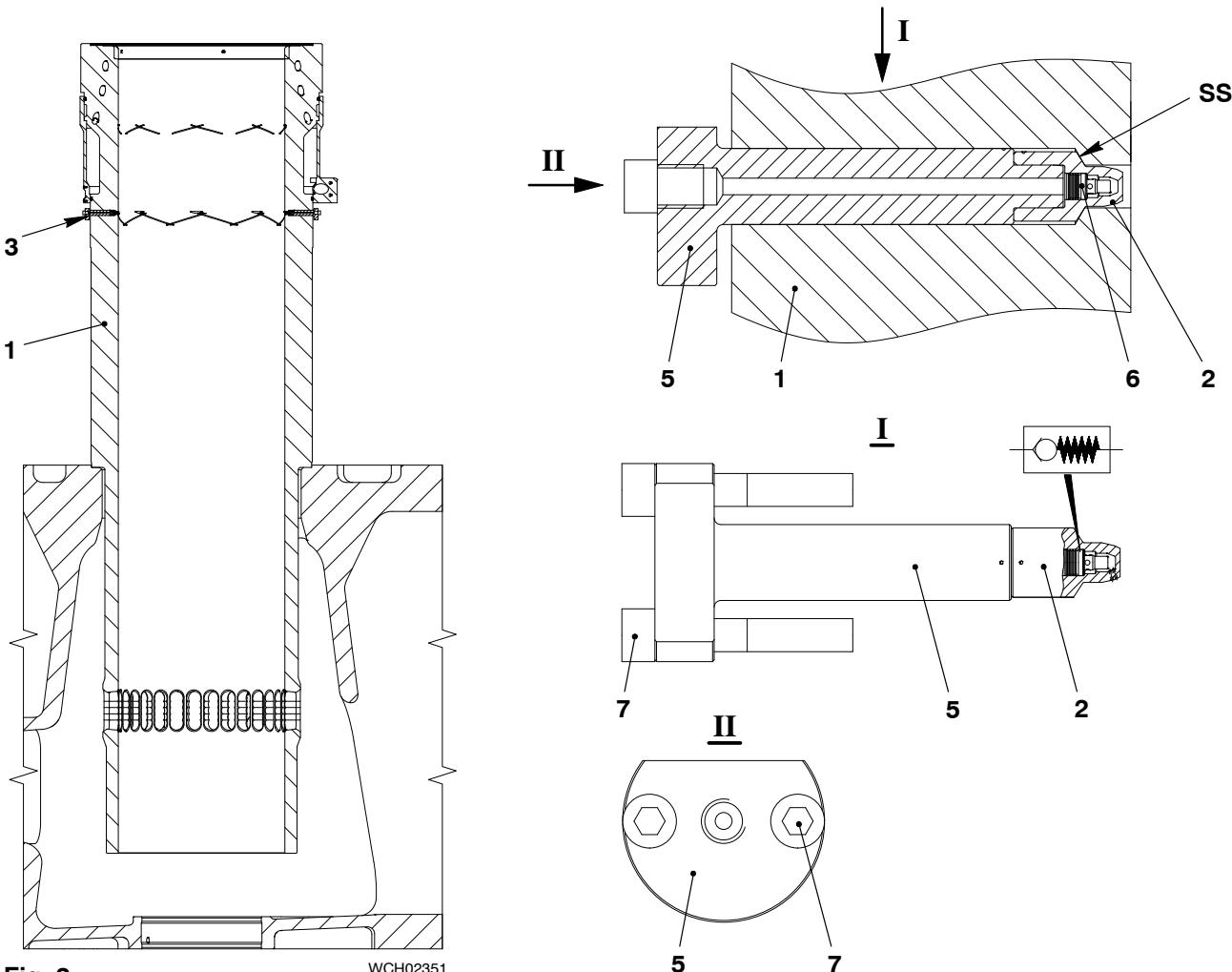


Fig. 2

WCH02351

3. Function check non-return valve

3.1 General

You do a function check to make sure that the non-return valve (6, Fig. 2) operates correctly. The pressure that opens the non-return valve (6) is **5 bar**.

During the function check, keep the lubricating quill (3) in a horizontal position.

For the function check, use an oil with a viscosity as given in the specifications that follow:

- SAE 50 at 40°C (approx. 200 cSt)
- SAE 30 at 25°C (approx. 190 cSt).

3.2 Procedure

- 1) If necessary, remove the screw-in union of the lubricating quill.
- 2) Install the connection nipple 94934I with the tredo joint 94934J to the lubricating quill 3 (see Fig. 3), see Fig. 3.
- 3) Connect the HP hose 94935 to the connection nipple 94934I.
- 4) Hold the lubricating quill (3) up and operate the pump until oil that flows has no air.
- 5) Open the relief valve RV and decrease the pressure to 2 bar.
- 6) Close the relief valve RV.
- 7) Hold the lubricating quill (3) in a horizontal position.
- 8) Operate the pump and increase the pressure in steps of 1 bar until the non-return valve (6) opens.
- 9) Record the pressure shown on the pressure gage 94934B.

Note: The minimum permitted opening pressure is 4.25 bar. If necessary, replace the defective lubricating quill (3) (see paragraph 2).

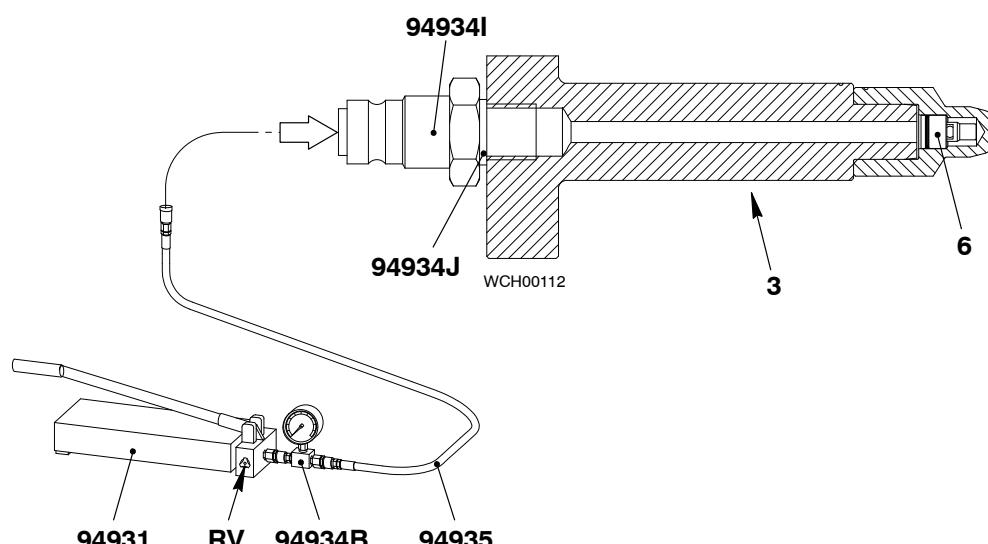


Fig. 3

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Piston Rod Gland

Replace, Assembling, Wear Measurement

Tools:

2	Working platforms	94142	1	Distance piece (11 mm)	94231C
2	Working supports	94143	1	Distance piece (9 mm)	94231D
2	Distance holders	94230	2	Spring assembly tool	94233
1	Clamp ring (2-parts)	94231A	1	Piston supporting device	94350
1	Distance piece (12 mm)	94231B			
1	Template	94231E			

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1. General

CAUTION

Do not turn the crankshaft when the working platforms 94142 or the working supports 94143 are installed in the crankcase.

For safety, always use the working platform 94142 and the working supports 94143 for all maintenance work in the crankcase. Make sure that the grids and working supports are correctly attached. For more data, see [3301-1](#).

Examine the piston rod gland for wear and damage on each overhaul of the piston (see [0380-1](#)). If necessary, replace the unserviceable parts.

When you assemble the piston rod gland, make sure that all parts are in a serviceable condition.

2. Procedure

2.1 Piston rod gland – removal

CAUTION

You must prevent an unwanted movement of the crankshaft when you do the procedure.

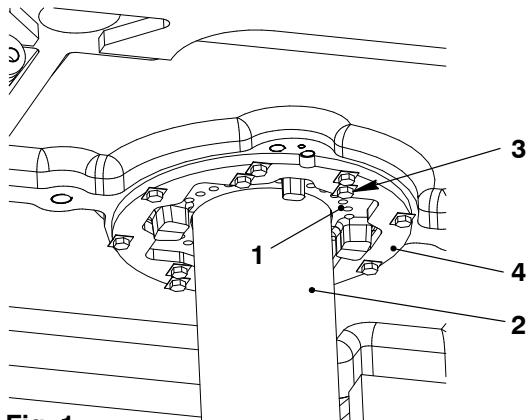


Fig. 1

- 1) Use the turning gear to turn the piston to BDC.
- 2) Attach the two distance holders 94345 to the piston rod 2 (see Fig. 2).
- 3) Remove the four inner bolts 3 from the support 4 (see Fig. 1).
- 4) Remove the piston and the piston rod gland (1) (see 3403-1 Removal of the Piston, paragraph 3).
- 5) Make sure that the piston rod gland 1 is in the correct position on the two hinged covers (5).

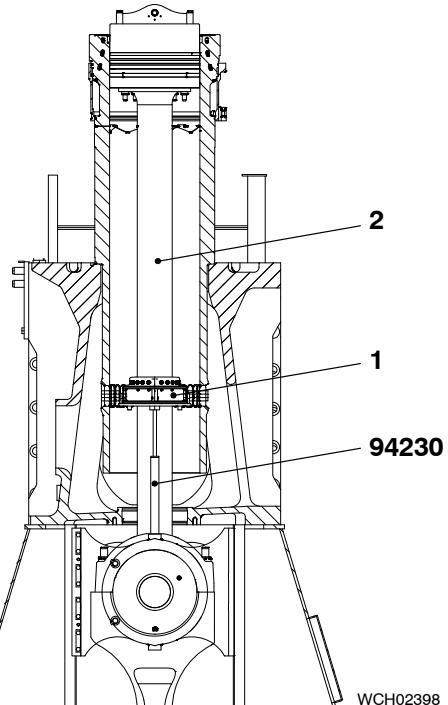


Fig. 2

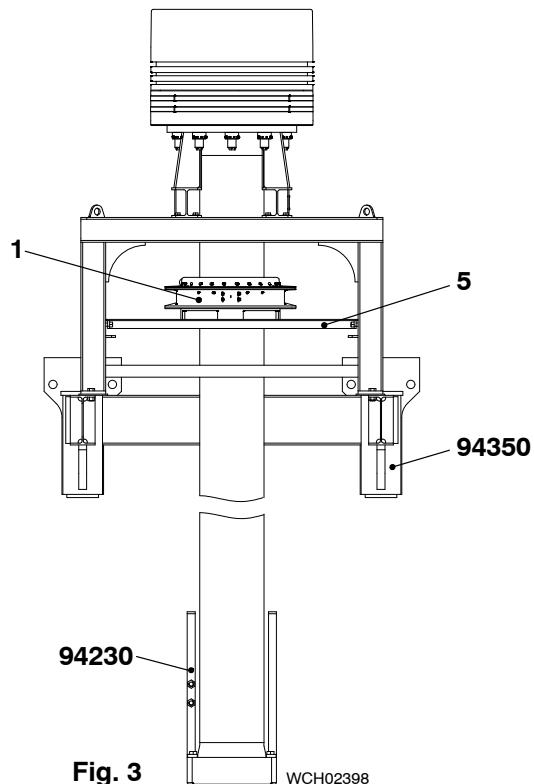
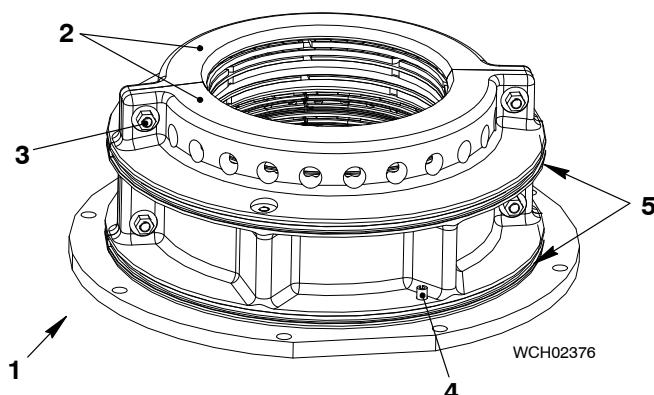
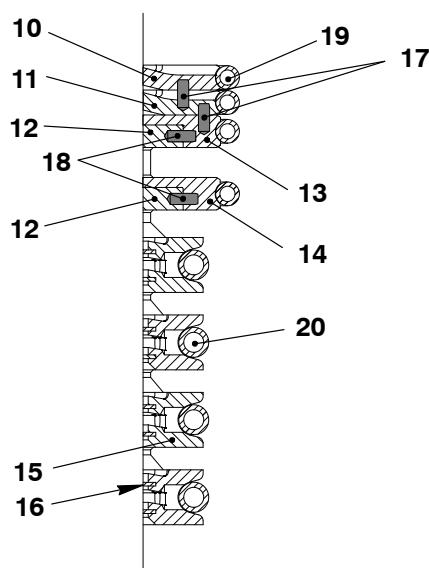


Fig. 3

Replace, Assembling, Wear Measurement

2.2 Piston rod gland – disassemble**Fig. 4**

- 1) Remove the four screws (3) (see Fig. 4).
- 2) Remove the O-Rings (5).
- 3) Push the two parts of the housing (2) away from the piston rod.
- 4) Remove the two parts of the housing (2).
- 5) Remove the spring dowel pin (4).

**Fig. 5**

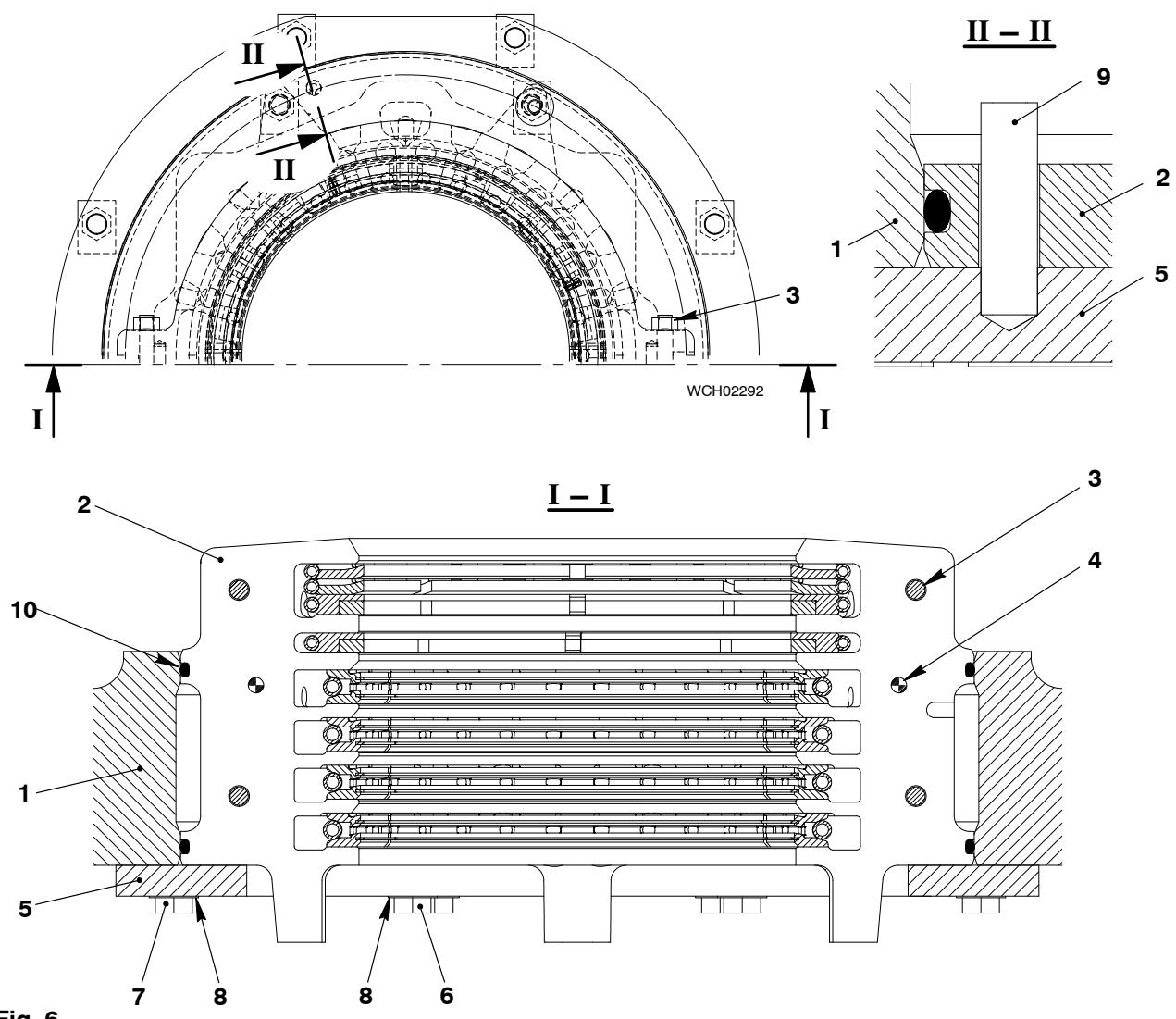
- 6) Remove the parts that follow (see Fig. 5):
 - Tension springs (19, 20)
 - Scraper rings (10, 11, 16)
 - Gaskets (12, 13, 14)
 - Spring dowel pins (17, 18)
 - Ring supports (15).

2.3 Wear Measurement

Note: You can find the maximum permitted wear in [0330-1 Clearance Table, Piston Rod Gland](#). If necessary, replace the worn parts.

- 1) Compare the wear of the parts that follow (see Fig. 5):
 - Scraper rings (10, 11, 16)
 - Gaskets (12, 13, 14).
- 2) Make sure that the tension springs (19, 20, Fig. 5) and O-ring (5, Fig. 4) are serviceable. If necessary, replace the unserviceable parts.

Replace, Assembling, Wear Measurement

**Fig. 6****Fig. 6: Gland Box, Overview**

- | | |
|-----------------------------|----------------------|
| 1 Cylinder Block | 6 Inner Bolt M16x100 |
| 2 Gland box housing, 2-part | 7 Outer Bolt M16x100 |
| 3 Bolt M12x55 | 8 Locking Plate |
| 4 Dowel Pins | 9 Spring Dowel Pin |
| 5 Support | 10 O-Rings |

Replace, Assembling, Wear Measurement

2.4 Piston rod gland – assemble

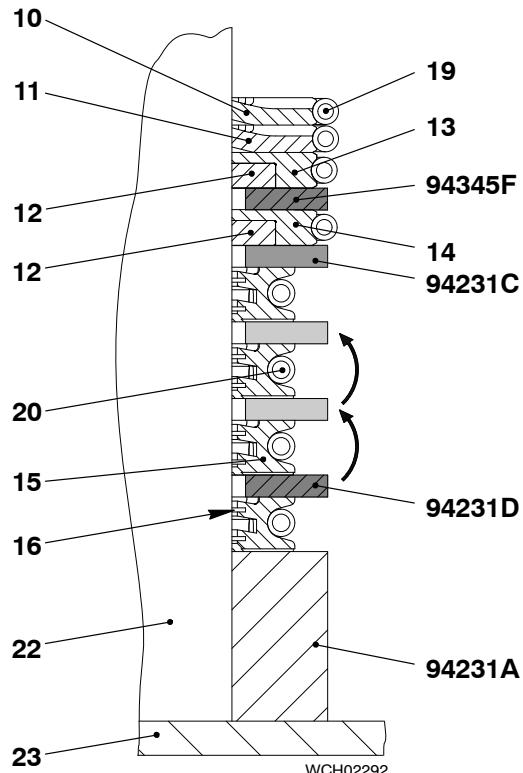


Fig. 7

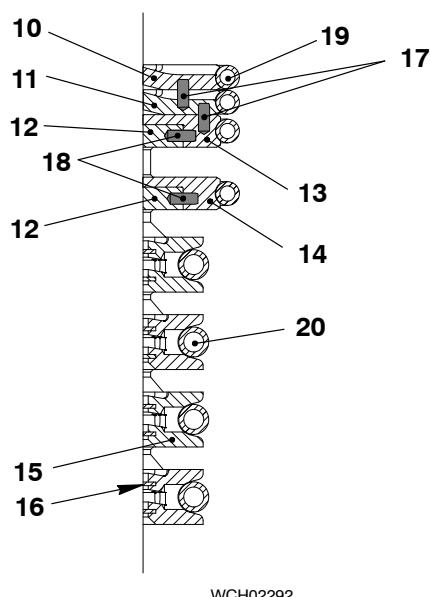


Fig. 8

- 1) Attach the two parts of the clamp ring 94231A to the piston rod (see Fig. 7).
- 2) Put the three parts of the ring support (15) and the scraper rings (16) on the clamp ring 94231A.
- 3) Use the assembly tool 94233 to attach the tension spring (20) to the ring support (15).
- 4) Put the two parts of the distance piece 94231D (9 mm height) on the ring support (15) (see Fig. 7).

Note: The height of the distance piece 94231C is the same as the distance between the ring grooves in the housing.

- 5) Put the next three parts of the ring support (15) and the scraper rings (16) on the distance piece. Make sure that there is an equal distance between the three parts.
- 6) Use the assembly tool 94233 to attach the tension spring (20) to the ring support (15).
- 7) Remove the distance piece 94231D.
- 8) Do the steps 4) – 7) above again until the four ring supports (15) are attached to the piston rod 22.
- 9) Put the two parts of the distance piece 94231C (11 mm height) on the top ring support (15).

Note: One segment of the gaskets (12, 13, 14) has two holes for the horizontal spring dowel pins (18) (see Fig. 8). The other three segments have only one hole. On the top of one segment of the gasket (13) there is one hole for a vertical spring dowel pin (17).

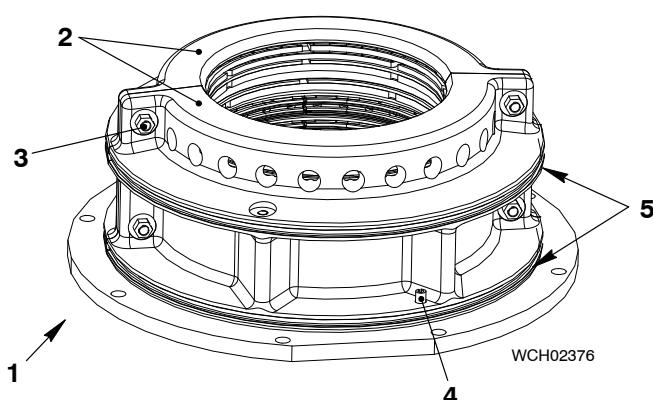
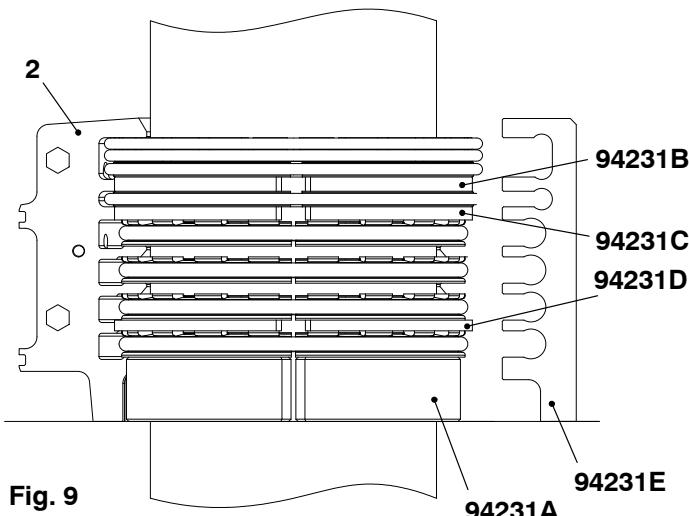
- 10) Put the four parts of the gaskets (12, 14) on the distance piece 94231C (see Fig. 7).
- 11) Make sure that all horizontal spring dowel pins (18) are installed (see Fig. 8).
- 12) Use the assembly tool 94233 to attach the tension spring (19) to the gaskets (12, 14).
- 13) Remove the distance piece 94231C.

- 14) Put the two parts of the distance piece 94231B (12 mm height) on the gaskets 12, 14 (see Fig. 7).
- 15) Put the four parts of the gaskets 12, 13 on the distance piece 94231B. Make sure that there is an equal distance between the four parts.
- 16) Make sure that all horizontal spring dowel pins 18 and the vertical spring dowel pin 17 are installed (see Fig. 8).

Note: On top of the scraper rings 11 there is one hole for a vertical spring dowel pin.

- 17) Put the scraper ring 11 on the gaskets 12, 13. Make sure that there is an equal distance between the four parts.
- 18) Make sure that the vertical spring dowel pin 17 (Fig. 4) is installed.
- 19) Use the assembly tool 94233 to attach the tension spring 19 to the scraper ring 11.

Note: There is no hole for a vertical spring dowel pin on the top of the scraper ring 10.



- 1) Put the scraper ring 10 on the top of the scraper ring 11. Make sure that there is an equal distance between the four parts.
- 2) Make sure that the vertical spring dowel pin 17 between the scraper ring 10 and the scraper ring 11 is correctly installed (see Fig. 6).
- 3) Use the assembly tool 94233 to attach the tension spring 19 to the scraper ring 10.
- 4) Remove the distance piece 94231B.
- 5) Remove the clamp ring 94231A.
- 6) Put the template 94231E over the assembled rings (see Fig. 9). Make sure that all parts are in the correct position. If necessary, correct the position.
- 7) Apply bearing oil to the piston rod and the assembled rings.
- 8) Push the two parts of the housing (2) over the assembled rings (see Fig. 9). Make sure that the dowel pins (4, Fig. 6) are installed.
- 9) Torque the screws (3, Fig. 10) to the value given in 0352-2 Torque Values for Standard Screws, paragraph 1.
- 10) Attach oiled O-rings (5) to the housing (2).
- 11) Put dowel pin (4) in place, see Fig. 10.

Replace, Assembling, Wear Measurement

2.5 Piston rod gland – installation

To install the piston rod gland 1, do the steps that follow:

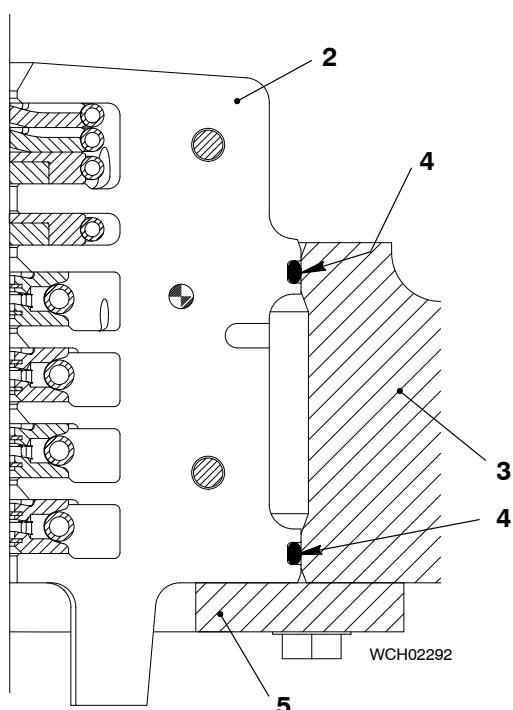


Fig. 11

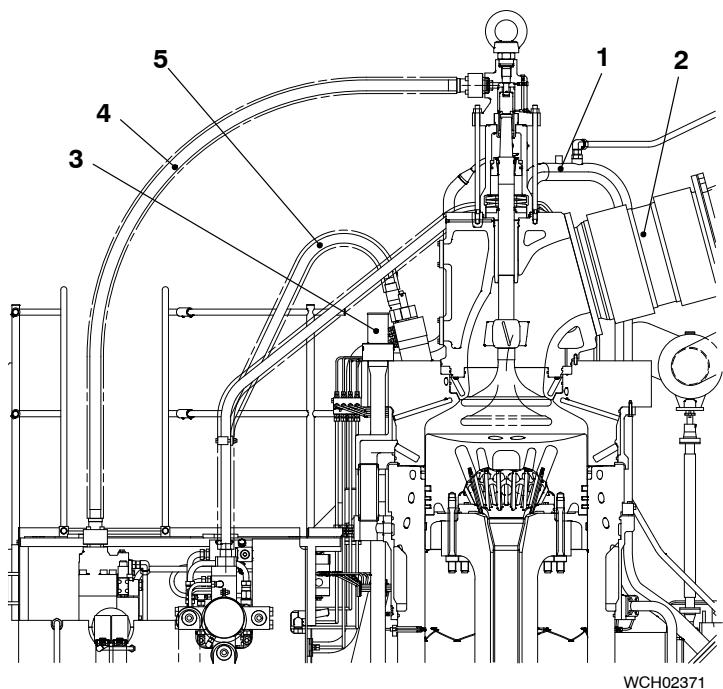
- 1) Apply lubricating oil to the opening in the cylinder jacket (3) and to the area of the O-rings (4) on the housing (2, [Fig. 11](#)).
- 2) Make sure that the distance holders 94230 are attached to the piston rod (see [Fig. 3](#)).
- 3) Make sure that the support (5) is installed onto the cylinder jacket (3) (see [Fig. 4](#)). If necessary, torque the outer bolts 7 to 150 Nm.
- 4) Install the piston with the piston rod gland, refer to [3403-1](#) (Installation of the Piston, paragraph 4)
- 5) Remove all tools and equipment from the area.

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Removal and Installation of Cylinder Cover, Water Guide Jacket, Exhaust Valve

Tools:

1 Lifting tool	94215	1 Connection block	94934
6 Pre-tensioning jacks	94215A	1 Pressure gauge	94934A
1 Suspension device	94265	3 HP hose	94935
1 Hydraulic unit	94942	5 Flexible hose	94935A


Fig.1

1. Preparation

- 1) Stop the engine, see the procedure in Operation Manual 4002-2.
- 2) Let the engine temperature decrease before you start the removal procedure.
- 3) Make sure that all tools and equipment are clean.
- 4) Close the starting air supply valves and the control air valves 930-V03 and 930-V04 manually, see the control diagram in Operation Manual 4003-2.

WARNING

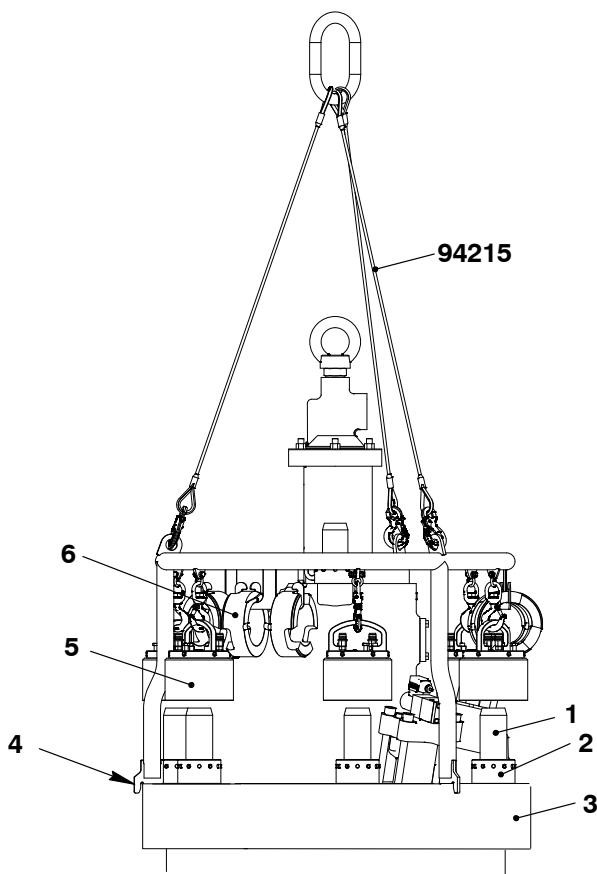

Injury Hazard: You must put on safety goggles and gloves when you do work on hot components. Oil can come out as a spray and cause injury.

- 5) Close the cylinder inlet butterfly valves to the cooling water system.
- 6) Open the drain valve to the cylinder cooling water from the applicable cylinder, see the Operating Manual in 8017-1.
- 7) Close the valves from the fuel supply and make sure there is no pressure in HP fuel pipe (5, Fig.1).
- 8) Remove the hydraulic pipe (4) for exhaust valve drive, refer to 8460-1.
- 9) Remove the HP fuel pipe (5), refer to 8733-1.
- 10) Make sure that there is no pressure in the cooling water pipe (1) and remove it.
- 11) Remove the expansion piece (2) with the slings, see 2751-1.
- 12) Close the starting air valve and disconnect the air pipe from the cylinder cover.
- 13) Disconnect all other connections to the cylinder cover and to the exhaust valve.
- 14) Loosen the nuts of the elastic studs (3), refer to paragraph 2.
- 15) Remove the round nuts of elastic studs (3).

Removal and Installation of Cylinder Cover, Water Guide Jacket, Exhaust Valve

2. Elastic Stud – Loosening and Tensioning

2.1 Loosening

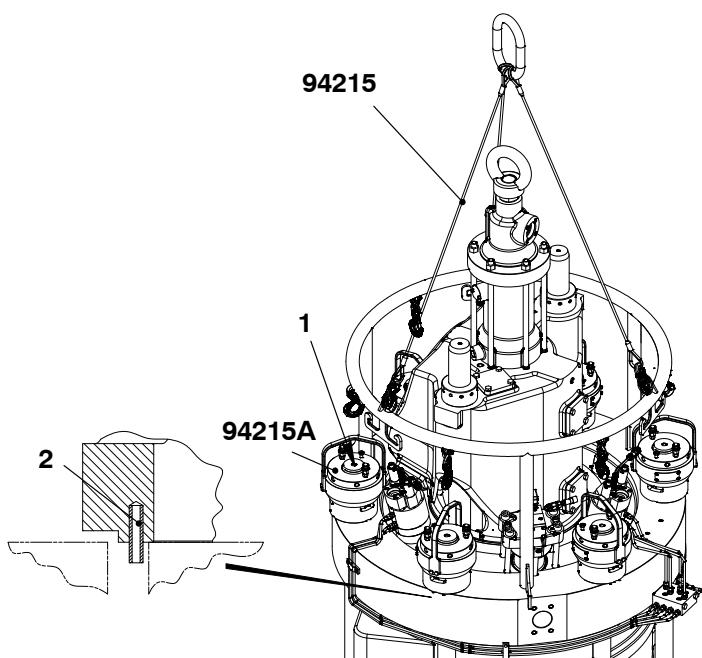

CAUTION

Injury Hazard: The weight of the pre-tensioner is 24.5 kg. Use the correct equipment to lift and move the pre-tensioner.

- 1) Use the crane and put the lifting tool (94215, [Fig.2](#)) with the six pre-tensioning jacks (94215A) above the cylinder cover (3).
- 2) Lower the lifting tool (94215) slowly until the three brackets (4) are on the cylinder cover (3).
- 3) Take the lower parts of the pre-tensioner (6) down and put it on the elastic studs (1) in that way, that the pin (2, [Fig.3](#)) is out of the cylinder cover.
- 4) Do the same procedure for each lower part of the pre-tensioner (6, [Fig.2](#)).
- 5) Take one of the upper part of the pre-tensioner (5) down (24.5 kg each) and attach it to the elastic studs (1).
- 6) Do the same procedure for each upper part pre-tensioner (5).
- 7) Connect the pre-tensioning jacks (94215A, [Fig.3](#)) to the hydraulic pump, refer to [9403-2](#).
- 8) Loosen the elastic studs (1) in accordance with General Application Instruction [9403-4](#).
- 9) Remove the round nuts (2, [Fig.2](#)) from the elastic studs (1).

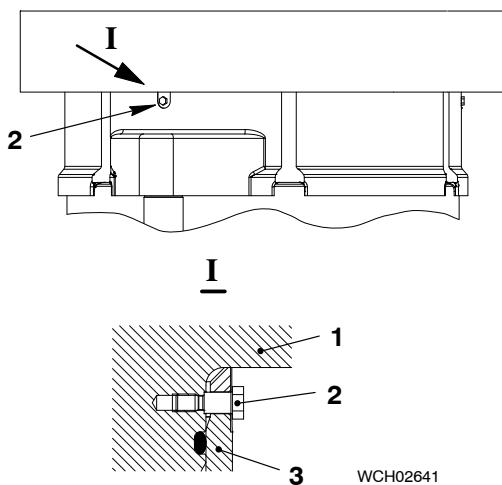
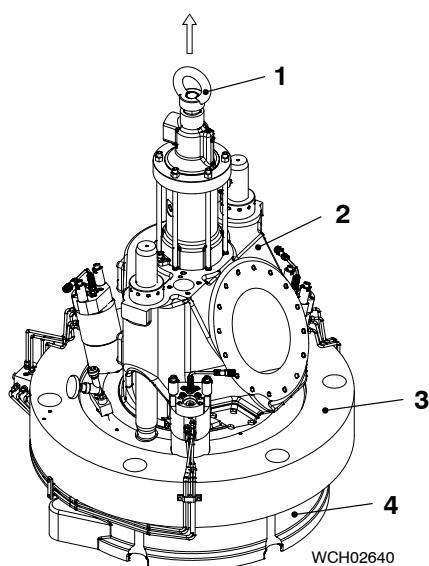
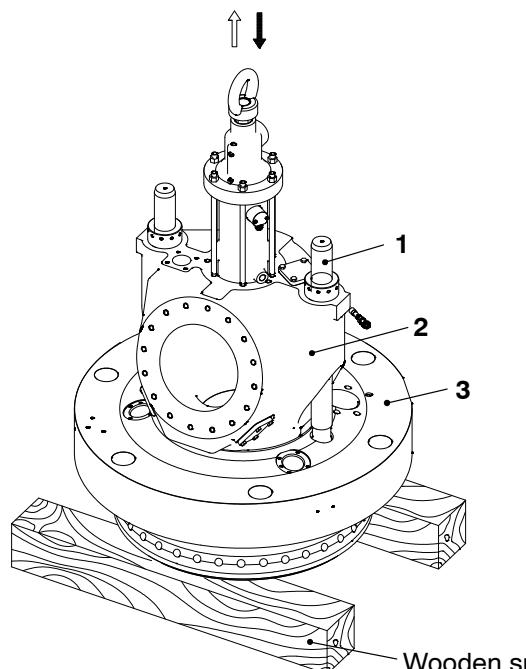
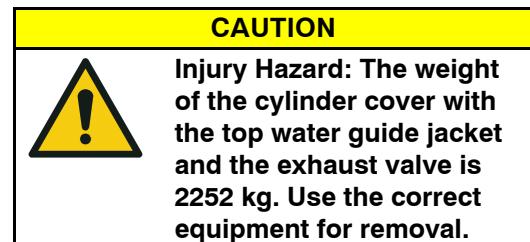
2.2 Tensioning

- 1) Clean the threads of the elastic studs (1, [Fig. 3](#)) and lubricate them with oil.
- 2) Attach the pre-tensioning jacks (94215A) to the elastic studs (1), refer to paragraph [2.1](#), steps 1 to 7.
- 3) Tension the elastic studs (1), refer to [9403-4](#).



Removal and Installation of Cylinder Cover, Water Guide Jacket, Exhaust Valve

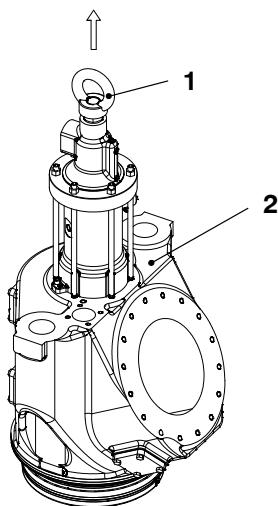
3. Cylinder Cover, Water Guide Jacket, Exhaust Valve – Removal

**Fig.4****Fig.5****Fig.6**

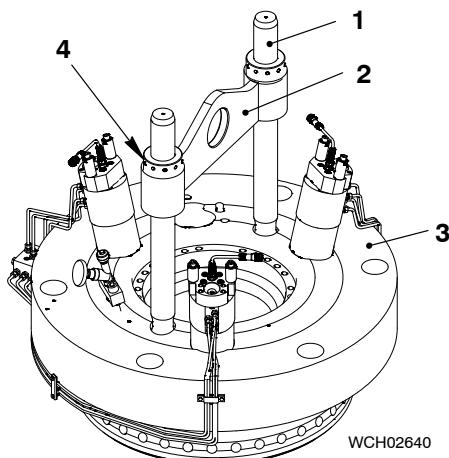
- 1) Remove the three retaining screws (2, [Fig.4](#)) to loose the top water guide jacket (3) from the cylinder cover (1).
- 2) Connect the crane hook to the bolt of the exhaust valve cage (1, [Fig.5](#)).
- 3) Lift the cylinder cover (3) with the exhaust valve cage (2) and the top water guide jacket (4).
- 4) Put a wooden support on the top main platform.

- 5) Use the crane and move the cylinder cover (3, [Fig.6](#)) with exhaust valve (2) above the wooden support.
- 6) Lower the crane until the cylinder cover (3) and the exhaust valve (2) are on the wooden support.
- 7) Loosen the elastic studs (1) of the exhaust valve (2), refer to [9403-4](#) and remove the round nuts (1).

Removal and Installation of Cylinder Cover, Water Guide Jacket, Exhaust Valve

**Fig.7**

- 8) Connect the crane hook to the bolt of the exhaust valve cage (1, [Fig.7](#)).
- 9) Use the engine room crane to move the exhaust valve cage (2) in an applicable area.
- 10) Disconnect the crane hook from the eye bolt (1).

**Fig.8**

- 11) Use the crane to attach the suspension device (34.9 kg) (2, [Fig.8](#)) to the elastic studs (1).
- 12) Tighten the nuts (4).
- 13) Use the engine room crane to move the cylinder cover (3) in an applicable area.

Removal and Installation of Cylinder Cover, Water Guide Jacket, Exhaust Valve

4. Cylinder Cover, Water Guide Jacket, Exhaust Valve – Installation

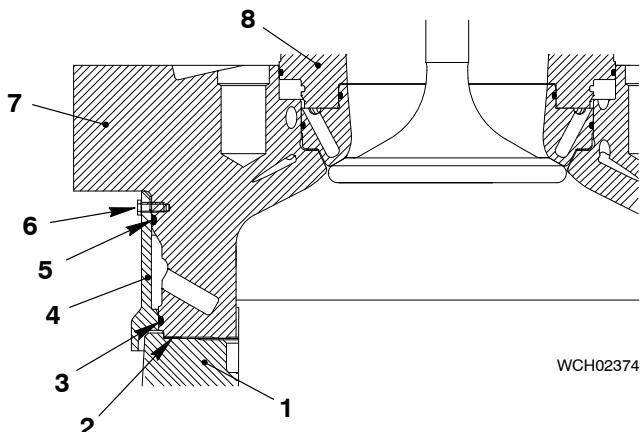


Fig. 12

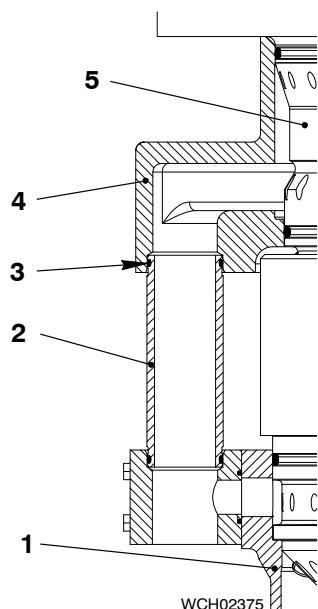


Fig. 13

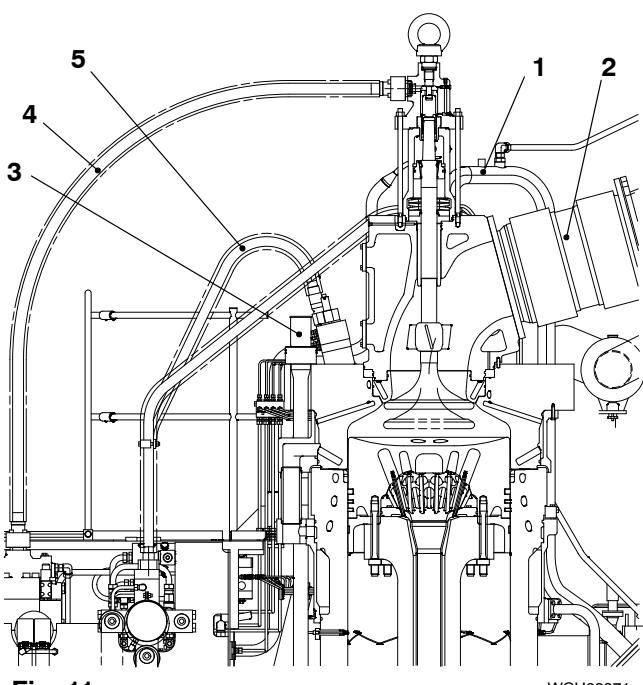


Fig. 11

- 1) Clean all contact faces and O-ring grooves.
- 2) Take the new O-rings (3, Fig.9) and (5), apply oil to them and install them.
- 3) Lift the cylinder cover (7) and guide it into the top water guide jacket (4).
- 4) Tighten the retaining screws (6).
- 5) Install the exhaust valve (8) on the engine, refer to 2751-1, paragraph 3.
- 6) Clean the seating surface of cylinder liner (1) and place the new soft iron joint ring (2).

- 7) Install the new O-ring (3, Fig10) on the transition tube (2) and apply oil to it.
- 8) Lift the cylinder cover (5) in accordance with paragraph 3 and clean the lower seating face.
- 9) Bring the cylinder cover (5) in position over the cylinder liner (1) that the transition tube (2) is in line with the same bore of the water guide jacket (4).
- 10) Carefully lower the cylinder cover (5) and guide the transition tube (2) into the water guide jacket (4).

- 11) Clean the threads of the elastic studs (3, Fig.11) and apply oil to them.
- 12) Tension the elastic studs (3), refer to paragraph 2.
- 13) Install the hydraulic pipe (4) for exhaust valve drive, refer to: 8460-1.
- 14) Install the three HP fuel pipes (5), refer to 8733-1.
- 15) Connect the cooling pipe (1).
- 16) Install the expansion piece (2) with round slings, refer to 2751-1.
- 17) Connect the air pipe to the cylinder cover.
- 18) Connect all other connections to the cylinder cover and to the exhaust valve.
- 19) **Do a leak test after installing a cylinder cover. Turn on the cooling water pump at normal operating pressure.**

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Machining of Sealing Face for Injection Valve

Tools:

1 Cutting device 94270

1. General

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

2. Machining of sealing face

Dirty or slightly damaged sealing faces can be re-conditioned on the spot by using cutting device 94270 for injection valve with Fuel Actuated Sacless Technology (FAST).

- 1) Apply Molyte G-paste to running surface 'RS'.
- 2) Apply sticky grease on the profile cutter to prevent that shavings fall into the combustion chamber.
- 3) Carefully insert the cutting device 94270 with profile cutter 94270A into the valve bush (2) in cylinder cover (1).
- 4) Fasten guide flange (3) with two screws.
- 5) Cutting is done by pressing down lightly with the hand on cutter holder and turning the hexagon evenly with the other hand using a ring spanner.
- 6) Remove as little material as possible but sufficient to obtain a perfect seating area.

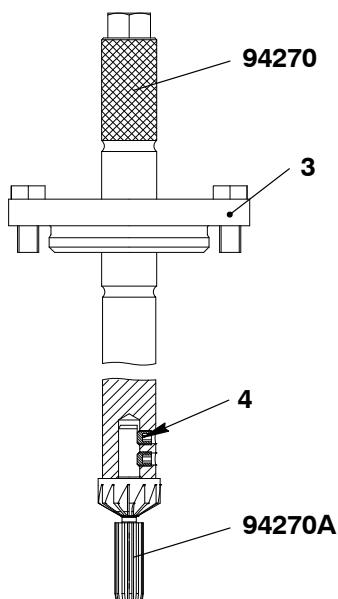


Fig. 1

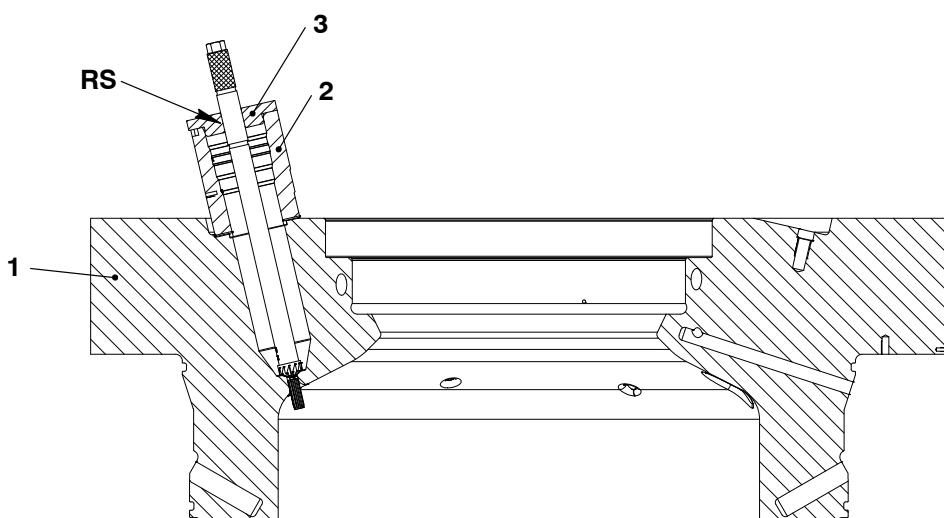


Fig. 2

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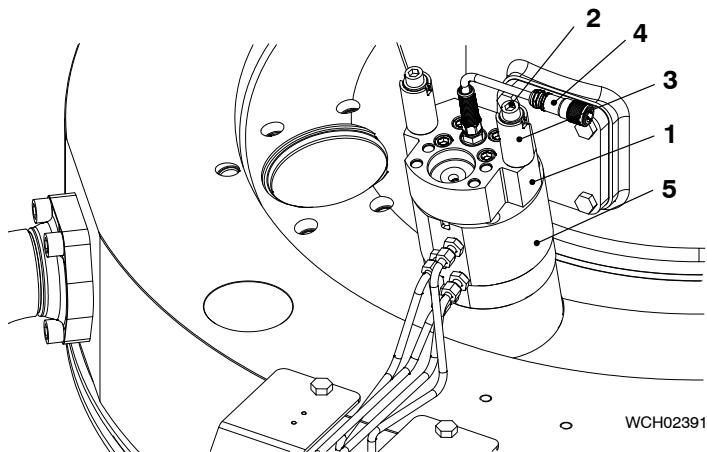
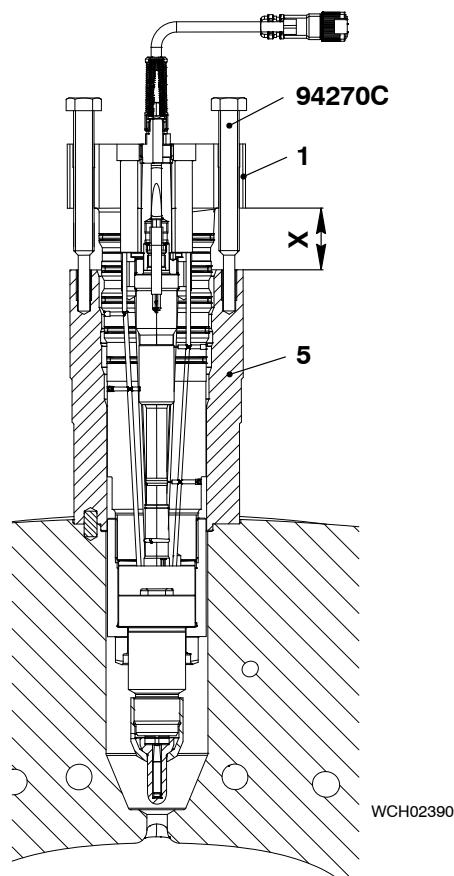
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Injection Valve

Replacement

Tools:

- 2 Hexagon head bolt 94270C
2 Stud bolts 94270D

**Fig. 1****Fig. 2**

1. Removal of injection valve

- 1) Remove HP fuel pipe, refer to [8733-1](#).
- 2) Disconnect cable (4) at terminal box 95.4.
- 3) Make sure the cooling for the injection valve is stopped, see operation manual 8016-1, chapter 3.
- 4) Remove the screws (2) with their spring cage (3).

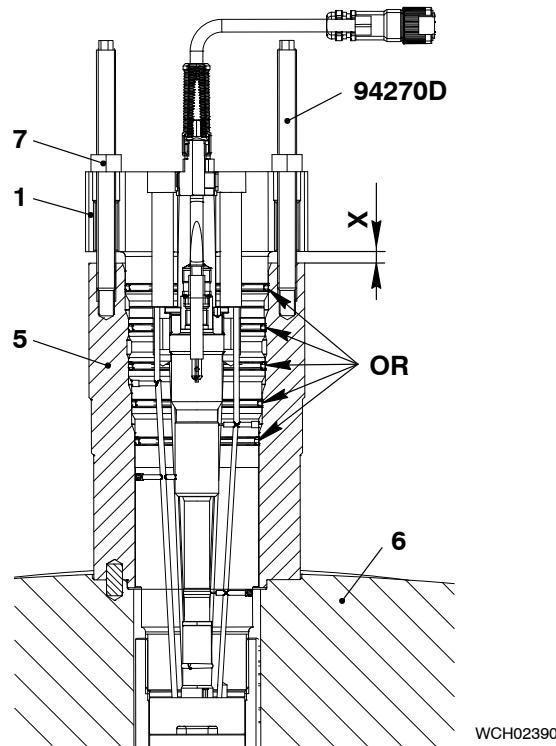
- 5) Put the two bolts 94270C in the position as shown in [Fig. 2](#).
- 6) Turn the two bolts until they stop at the thread end in the valve bush (5)
- 7) Turn the two bolts equally to lift the injection valve.
- When distance X is about 50 mm you should be able to lift the injection valve by hand (20 kg).

2. Storage and handling

- 1) Protect the nozzle tip integrated in the injection valve against damage. Handle the whole injection valve with care.
- 2) Store an injection valve in a dry place but not in a place contaminated with exhaust gases or any other corrosive atmosphere.
- 3) Use white spirit for cleaning, e.g. Shellsol TD, Shellsol T or Solvent FP68. Always wear gloves and safety goggles with closed side frame!

CAUTION

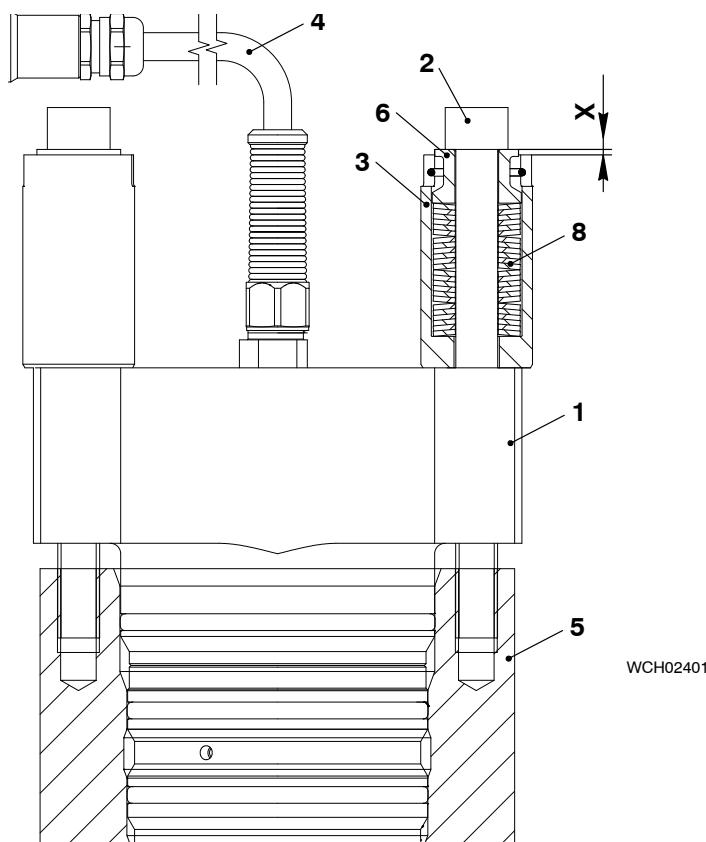
Do not open vacuum packed injection valve before the installation on the engine.

**Fig. 3**

3. Installation of injection valve

Clean and check the condition of the sealing face in the cylinder cover (6) and recut it if necessary according to 2708-3.

- 1) Replace the five O-rings 'OR' with new ones and oil them before install.
- The (5) O-rings are part of the 'injector valve spare parts' set.
- 2) Place the injection valve (1) carefully into the valve bush (5).
- 3) Place the two stud bolts 94270D as shown in Fig 3 and turn them into the valve bush (5).
- 4) Insert the injection valve by turning the nuts (7) equally.
- The injection valve is fully inserted when the distance X is 7.2 mm.

**Fig. 4**

- 5) If the spring cage (3) was disassembled, make sure the cup springs (8) are fitted as shown in Fig. 4', e.g. 4x6 cup springs.
- 6) Apply Never-Seez NSBT to the threads and the seating surface of the screws (2).
- 7) Tighten the Screws (2) equally until the spring guide (6) is flush with the spring cage, X = 0.
- 8) Connect the cable (4) to the flow limiting valve.
- 9) Install HP fuel pipe, refer to 8733-1.

Disassemble, Checks, Assemble Injection Valve with FAST

Tools:

1	Torque spanner	94011-03	1	Valve holder	94273
1	Slugging wrench	94269A-65	1	HP hose	94275
1	Hydraulic cylinder	94269B	1	Cable	94275A
1	Torque wrench extension	94269C-41	1	Nozzle removal tool	94278A
1	Torque wrench extension	94269C-65	1	Nozzle installation tool	94278B
	Injector test bench	94272	1	T-handle	94289A
1	Connecting piece	94272B	1	Bush	94289B
			1	Bush	94289C

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1. General

The test bench 94272 and calibration fluid must be used for the tasks that follow:

- To do checks
- To disassemble
- To assemble

The properties of the calibration fluid (e.g. Shell Calibration Fluid S.9365, Univar Calibration Fluid 1487) are as follows:

- The density at 15°C is 827 kg/m³ (ISO 12185)
- The kinematic viscosity at 40°C is 2.6 mm²/s (ASTM D445)
- The pour point is -27°C (ISO 3016)

If calibration fluid is not available, you can use clean diesel oil (gas oil). If clean diesel oil (gas oil) is used, install the injection valve immediately after you complete the checks.

Note: It is not recommended that diesel oil (gas oil) is used if the injection valve is put into storage after these checks. The injection valve can get corrosion.

On some injection valves the quantity of leakage flow can be more than others. If the test bench flow is not sufficient to open the needle, you can use a clean additive-type crankcase (system) oil of SAE 30 viscosity. For more data see the Operation Manual 0750, paragraph 2 System oil).

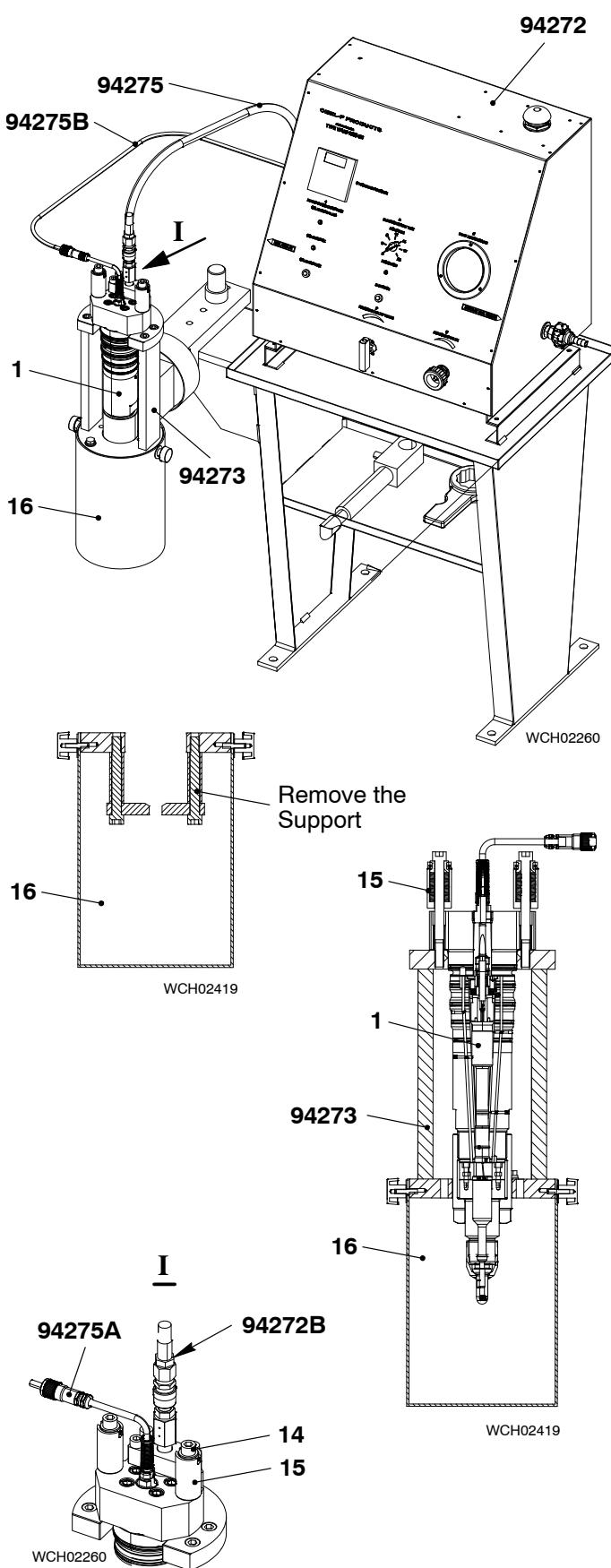


Fig. 1

2. Preparation

WARNING

Fire Hazard. Do not use welding or grinding equipment near the work area.

WARNING

Health Hazard. Calibration fluid is harmful to your health.

- 1) Read and obey the data in the instruction manual of the test bench manufacturer.
- 2) Make sure that the work station is clean.
- 3) Make sure that the support is removed from the valve holder 94273 (see Fig. 1).
- 4) Use a brass wire brush to remove combustion particles from the external parts of the nozzle.
- 5) Put the injection valve in position in the valve holder (94273). Make sure that the injection valve points down.
- 6) Attach the injection valve to the valve holder with the spring cages 15 and Allen screws (14).
- 7) Attach the HP hose 94275 to the connecting piece 94272B.
- 8) Connect cable 94275A to the injection valve.

3. Procedure

3.1 Checks

- 1) Start the test bench.
- 2) At regular intervals, use a master pressure gage to do checks of the pressure gages on the test bench. If necessary, adjust the pressure gages.

WARNING

Injury Hazard. Do not put your fingers near the holes in the nozzle tip. Fuel can go through your skin and cause injury or death.

- 3) Follow the manufacturer's instruction and set the pressure of the test bench to **600 bar**.
- 4) Press INJECT BUTTON. Check whether injection valve functions normally.
- 5) Do a check of the seating surface between the needle seat and nozzle as follows:
 - a) Keep the pressure in the test bench constant at approximately 400 bar.
 - b) Monitor the injection valve for 30 seconds. Observe if fuel comes out of the nozzle.
- 6) Check opening pressure:
 - a) Set the pressure to 350 bar and press INJECT BUTTON.
 - b) No oil should leak.
 - c) Set the pressure to 500 bar and press INJECT BUTTON.
 - d) Fuel should spray out of the nozzle.

3.2 Results

- 1) For the correct function and to use an injection valve again, read the data below:
 - The opening pressure is between 370 and 500 bar, refer to the test above.
 - Most of the fuel will come out as a spray from the top set of holes in the nozzle tip at the specified opening pressure.
 - At the end of an injection, no fuel must come out of the nozzle.
- 2) If the injection valve does not function satisfactorily, disassemble as given in paragraph 4.

You must replace nozzle tips that have worn spray holes. It is not recommended but possible to replace the nozzle tip with the needle installed. If you do so, proceed carefully.

Only the injection valve manufacturer, or an authorized company can repair or replace nozzle holders, Intermediate plates and nozzle bodies that have unsatisfactory sealing surfaces.

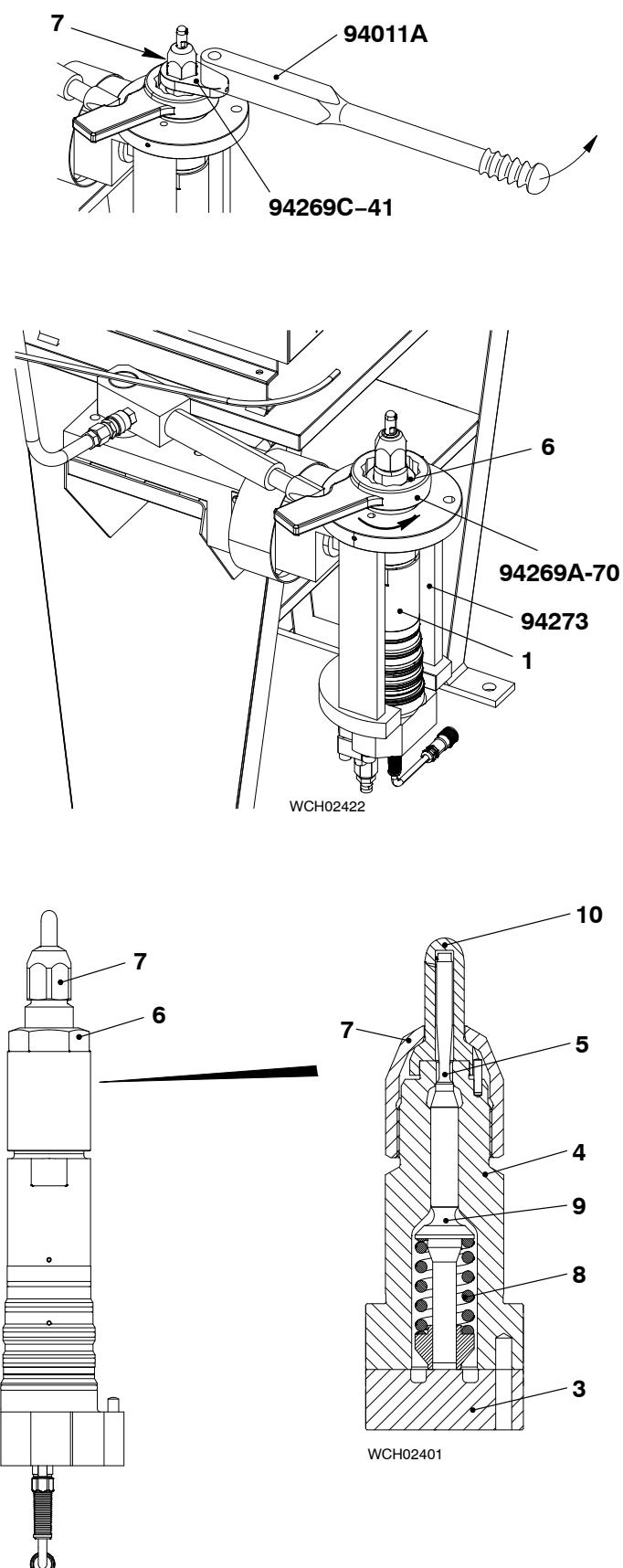


Fig. 2

4. Disassemble

4.1 Injection valve

- 1) Make sure that the test bench has no pressure.
- 2) Remove the receiver (16) from the valve holder (94273) (see Fig. 1).
- 3) Make sure that the HP hose 94275 is disconnected from the connecting piece 94272B.
- 4) Make sure that the leakage oil hose 94275B is disconnected from the injection valve.
- 5) Turn the valve holder through 180° into the vertical position (see Fig. 2).
- 6) Use a torque spanner 94011A and adapter 94269C-55 to carefully loosen the locknut (7) (AF55).
- 7) Use the wrench 94269A-65 and the hydraulic cylinder 94269B to loosen coupling nut (6).
- 8) Remove the locknut (7) and the coupling nut (6).
- 9) Remove the nozzle body (4) together with the:
 - Intermediate plate (3)
 - Compression spring (8).
 - Tappet (9)
 - Needle (5)
 - Nozzle tip (10).

Note: The needle (5) and nozzle body (4) are machined together so that their sealing surfaces have the same contours. You must keep these items together. If it is necessary to replace the needle or the nozzle body, you must replace the two items. Do not replace only one item.

- 10) If it is necessary to remove the nozzle tip (10) from the nozzle body (4), do the procedure in paragraph (4).
- 11) Remove the intermediate plate (3).
- 12) Remove the compression spring (8), the tappet (9) and the needle (5).

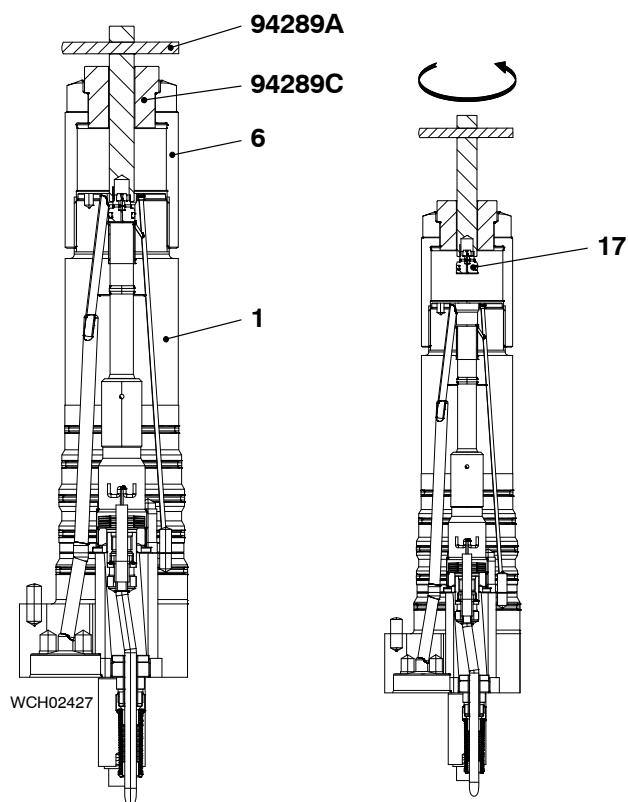


Fig. 3

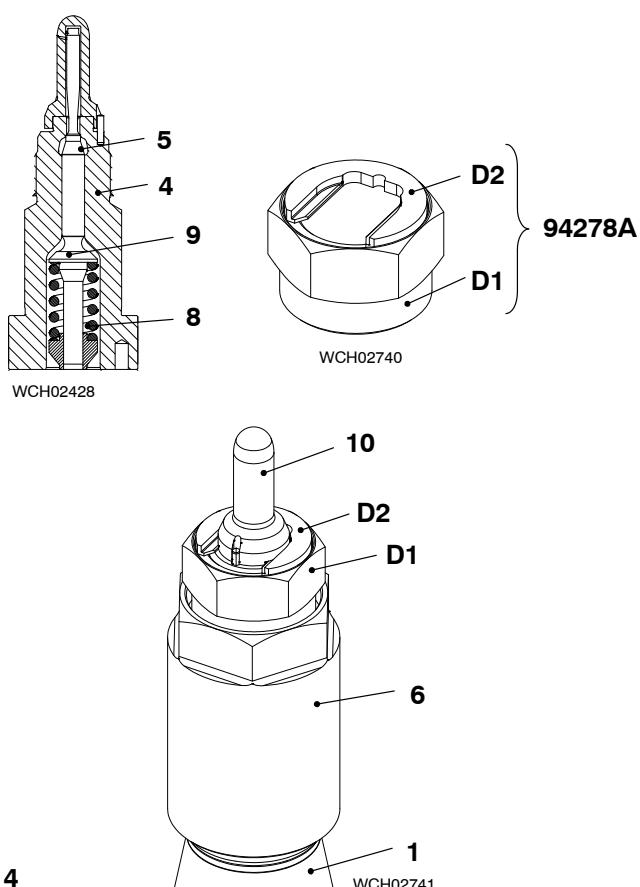


Fig. 4

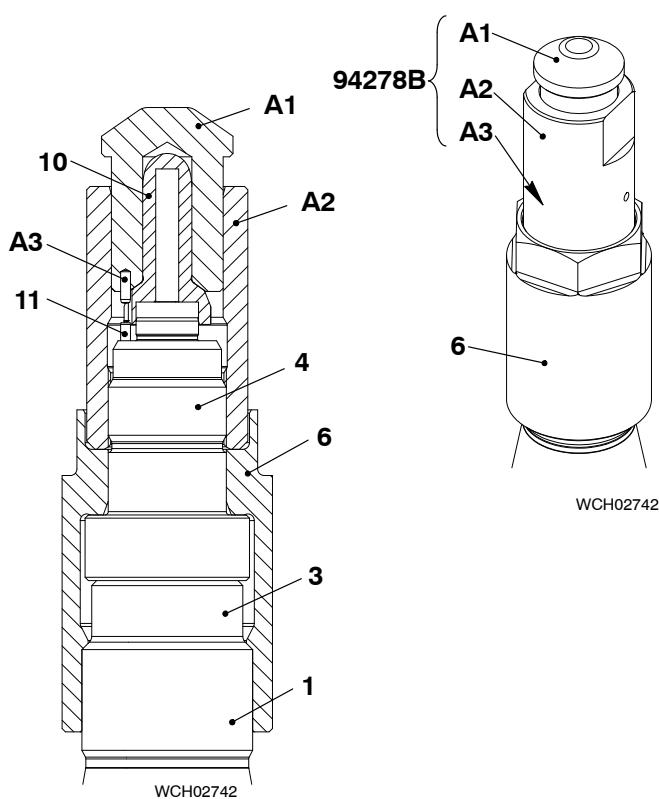
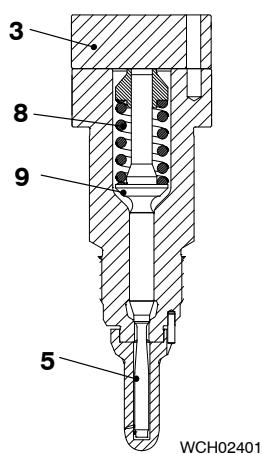
4.2 Pilot valve – removal

- 1) Remove the pilot valve (17, Fig. 3) from the injection valve (1) as follows:
Note: When you do the step blow, it is not necessary to torque the coupling nut (6).
- 2) Attach the coupling nut (6) to the injection valve (1).
- 3) Attach the bush 94289C to the coupling nut (6).
- 4) Put the T-handle 94289A in position as shown.
- 5) Engage the T-handle with the pilot valve (17).
- 6) Turn the T-handle to remove the pilot valve (17).
- 7) Examine all parts for damage and corrosion. Replace parts that have damage or corrosion.

5. Nozzle tip – replace

5.1 Removal

- It is not recommended but possible to replace the nozzle tip with the needle installed. Remove only lock nut (7) according to paragraph (4) and proceed with disassembly tool 94278A.
- 1) Disassemble the injection valve, see paragraph (4).
 - 2) Make sure that the needle (5), compression spring (8) and tappet (9) are removed from the nozzle body (4, see Fig. D).
 - 3) Attach the nozzle body (4) with coupling nut (6) to the injection valve (1) on the injection test bench.
 - 4) Screw the hex nut D1 (94278A) over the nozzle body (4).
 - 5) Put the plate D2 in the clearance between the nozzle body (4) and the nozzle tip (10).
 - 6) Turn the hex nut D1 upwards to withdraw the nozzle tip (10). Do it carefully if the needle is installed.
 - 7) Remove the nozzle tip (10) from the nozzle body (4).
 - 8) Remove the tool 94278A from the nozzle tip (10).

**Fig. 5****Fig. 6**

5.2 Installation

- 1) Make sure that the needle (5), compression spring (8) and tappet (9) are removed from the nozzle body (4) (see Fig. E).
- 2) Attach the nozzle body (4) with coupling nut (6) to the injection valve (1) on the injection test bench.
- 3) Make sure the dowel pin (11) is installed.
- 4) Screw the guide bush (A2) of tool 94278B onto the nozzle body (4).
- 5) Put the nozzle tip (10) into mounting cylinder (A1) of tool 94278B and align the recess in the nozzle tip with the dowel pin (A3).
- 6) Guide the mounting cylinder (A1) with the inserted nozzle tip (10) into the guide bush (A2).
- 7) Turn the mounting cylinder (A1) until the recess of the nozzle tip aligns with the dowel pin (11).
- 8) The mounting cylinder lowers a little bit and can not be turned anymore.
- 9) Use copper or rubber hammer to tap the mounting cylinder (A1) fully down.
- 10) Screw the guide bush (A2) out to remove the nozzle assembly tool 94278B.
- 11) Remove coupling nut (6) and nozzle body (4).
- 12) Use clean diesel oil, or clean kerosene to clean the needle (5) compression spring (8), and tappet (9, Fig.6).
- 13) Use a clean, low-pressure air supply to dry the needle (5) compression spring (8), and tappet (9).
- 14) Put the needle (5) into the nozzle body (5) / nozzle tip (10). Make sure that the needle moves freely.
- 15) Put the tappet (9) and compression spring (8) in the nozzle body (4).
- 16) Attach the intermediate plate (3) to the nozzle body (4). Make sure that dowel pin (12) engages in the hole in the nozzle body.
- 17) Assemble the injection valve, see paragraph 6.

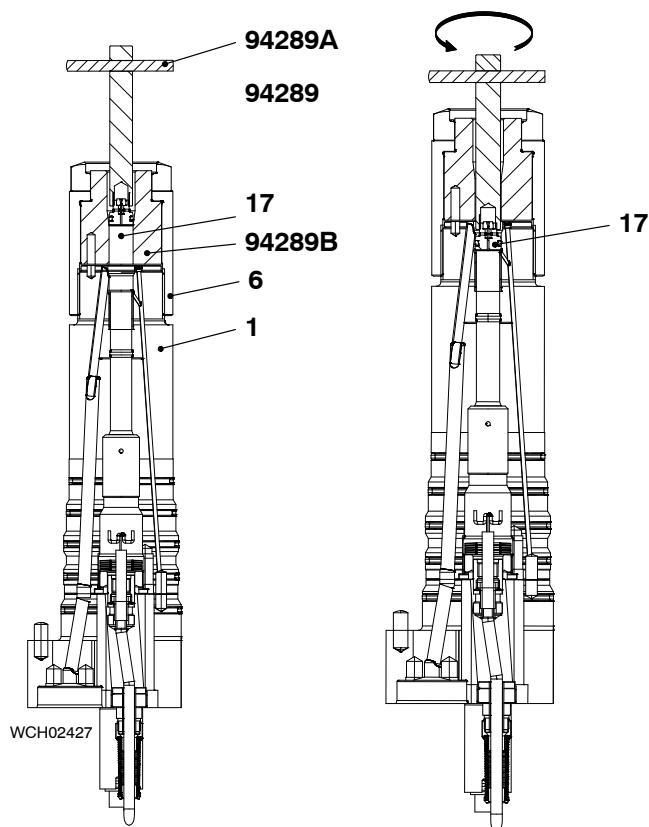


Fig. 7

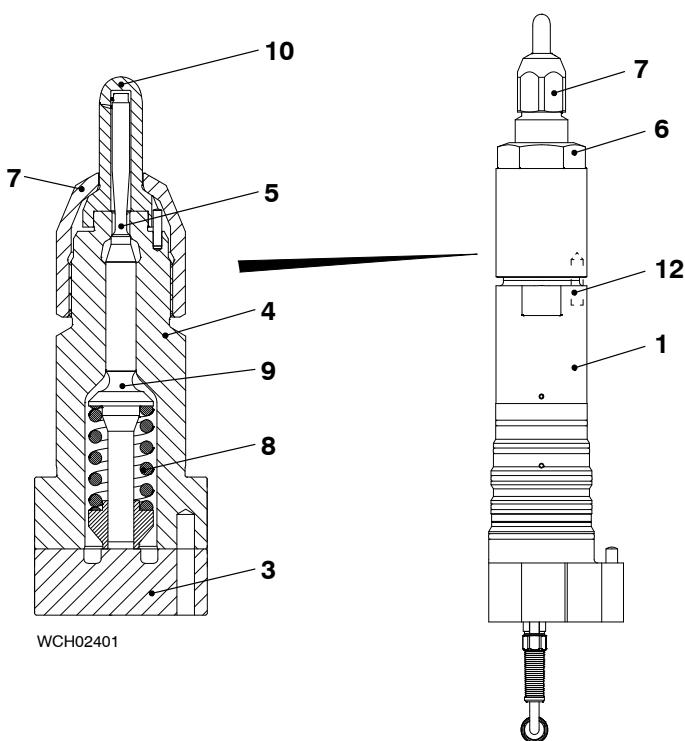
6. Assemble

6.1 Pilot valve – install

- 1) Install the pilot valve (17, Fig.7) in the injection valve 1 as follows:

Note: When you do the step below, it is not necessary to torque the coupling nut (6, Fig. 3).

- 2) Attach the coupling nut (6) to the injection valve (1).
- 3) Attach the bush 94289B to the coupling nut (6).
- 4) Engage the T-handle with the pilot valve (17).
- 5) Put the T-handle 94289A through the bush as shown.
- 6) Turn the T-handle to install the pilot valve (17).



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

TS for coupling nut 6: $\frac{100 \times 530}{75 + 530} = 88 \text{ Nm}$

TS for locknut 7: $\frac{190 \times 530}{65 + 530} = 169 \text{ Nm}$

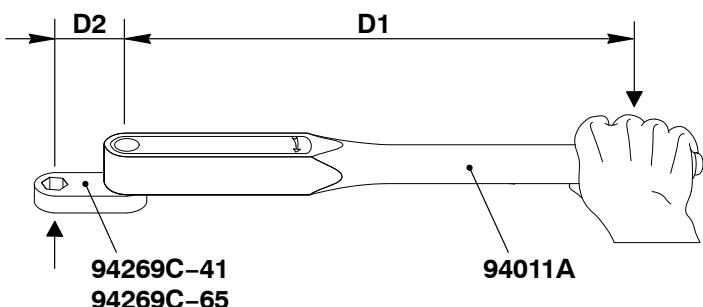


Fig. 8

6.2 Injection valve – assemble

Note: When you do the step blow, make sure that the dowel pin (12) engages with the hole in the intermediate plate (3, Fig. 7).

- 1) Put the nozzle body (4) together with the intermediate plate (3) in position on the injection valve (1).
- 2) Make sure that the sealing faces of the intermediate plate (3) and the related faces in the injection valve (1):
 - Are clean and dry
 - Are in a satisfactory condition
 - Have no lubricant.
- 3) Apply a thin layer of Never-Seez NSBT to the thread and seating face of the coupling nut (6).
- 4) Attach the coupling nut (6) to the nozzle body (4) with your hand.
- 5) See the formula shown in Fig. 7 where:
 - TS = the applicable torque setting for the torque spanner.
 - TT = the specified torque setting for the coupling nut and locknut.
 - D1 = the distance from the center of the square drive to the center of the hand grip.
 - D2 = the distance from the center of the square drive to the center of the adapter.
- 6) Use the torque spanner 94011A and the wrench extension 94269C-65 to torque the coupling nut (6) to 88 Nm.
- 7) Use the wrench 94269A-65 and the cylinder on the test bench to add between 35° and 40° to the position of the coupling nut (6).
- 8) Apply a thin layer of Never-Seez NSBT to the thread and seating face of the locknut (7).
- 9) Attach the locknut (7) to the nozzle body (4) with your hand.
- 10) Use the torque spanner 94011A and the wrench extension 94269C-41 to torque the locknut (7) to 169Nm.
- 11) Do a check of the injection valve, see paragraphs 3.1 and 3.2.

Starting Air Valve**Removal, Disassemble, Grinding, Assemble, Installation**

1. General	1
2. Preparation	1
3. Removal	2
4. Disassemble	2
5. Grinding	3
6. Assemble	4
7. Installation	4

1. General

You must remove and disassemble the starting air valve for maintenance if:

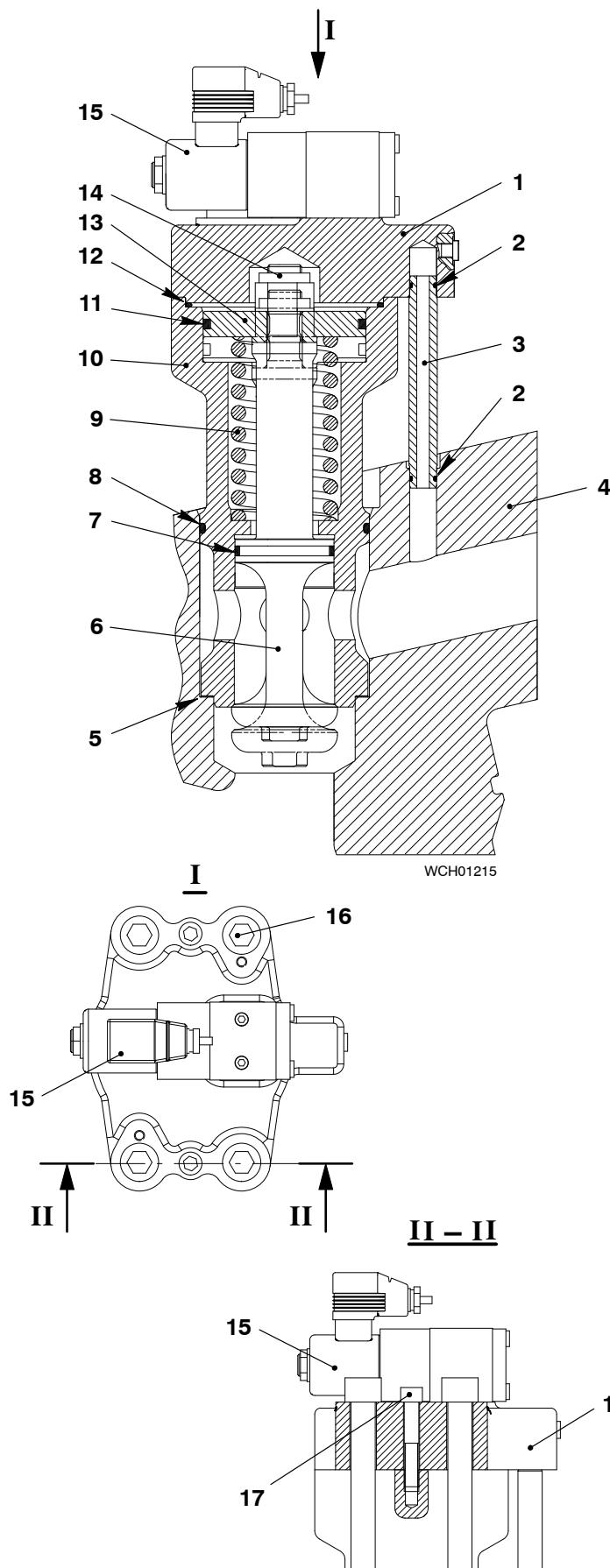
- The starting air valve does not operate correctly during the engine start procedure
- The starting air pipe becomes hotter than on adjacent cylinders during operation.

Read the data in the Maintenance Manual [0380-1](#) Group 2728-1, for the applicable intervals to do checks on the starting air valve.

2. Preparation

- 1) Stop the engine.
- 2) Release the pressure in the starting air system as follows:
 - 3) Close the shut-off valves on the starting air bottles.
 - 4) Turn the handwheel of the starting air shut-off valve 30-4325_E0_1 to the position CLOSED.
 - 5) Open the ball valves 30-8605_E0_6 and 30-8605_E0_7 to release the pressure (see [4003-2](#) Control Diagram and [4003-5](#) Air Systems).
 - 6) Remove the control air pipe from the starting air valve.

Starting Air Valve: Removal, Disassemble, Grinding, Assemble, Installation

**Fig. 1****3. Removal**

- 1) Disconnect the electrical connection from the 3/2-way solenoid valve (15).

- 2) Remove the four screws (16).

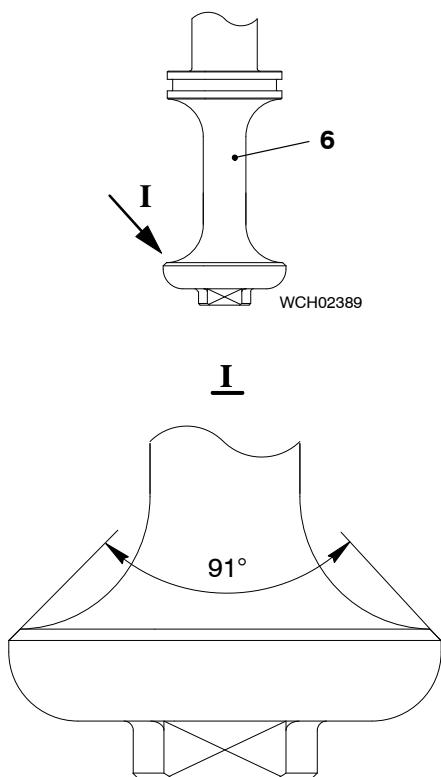
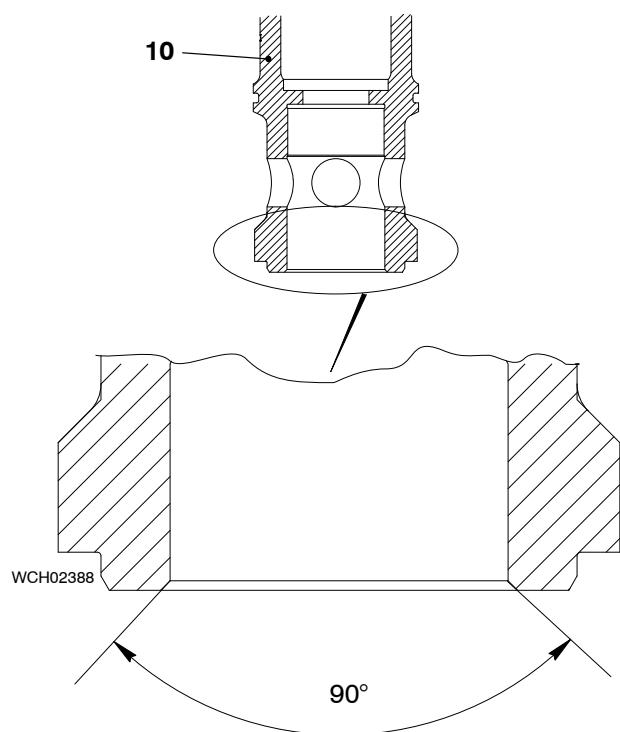
Note: When you do the step below, make sure that you do not damage the pipe (3).

- 3) Carefully remove the starting air valve from the cylinder cover (4).
- 4) Remove and discard the gasket (5).
- 5) Put applicable protection over the opening in the cylinder cover (4).
- 6) Remove the pipe (3) from the cover (1).

4. Disassemble

- 1) Put the starting air valve in a vice. Make sure that the vice jaws do not damage the starting air valve.
- 2) Remove the two screws (17).
- 3) Remove the cover (1) together with the 3/2-way solenoid valve (15).
- 4) Remove the self-locking nut (14).
- 5) Remove the piston (13) from the valve spindle (6).
- 6) Remove the compression spring (9) from the housing (10).
- 7) Remove the valve spindle (6) from the housing (2).
- 8) Remove and discard the O-rings (2, 8 and 12).

Starting Air Valve: Removal, Disassemble, Grinding, Assemble, Installation



5. Grinding

- 1) If the seating faces of the housing (10) and the valve spindle (6) have minimum damage, do as follows:
 - 2) Manually grind the seat faces of the housing (10) and the valve spindle (6).
 - 3) Make sure that you keep the radius to the values given in Fig. 2.
 - 4) If the seating faces of the housing (10) and the valve spindle (6) have more than minimum damage, do as follows:
 - 5) Use a machine tool to grind the seating face of the housing (10) and valve spindle (6).
 - 6) Manually grind the seating faces of the housing (10) and the valve spindle (6) to get a good finish.
 - 7) Make sure that you keep the radius to the values given in Fig. 2.

Fig. 2

Starting Air Valve: Removal, Disassemble, Grinding, Assemble, Installation

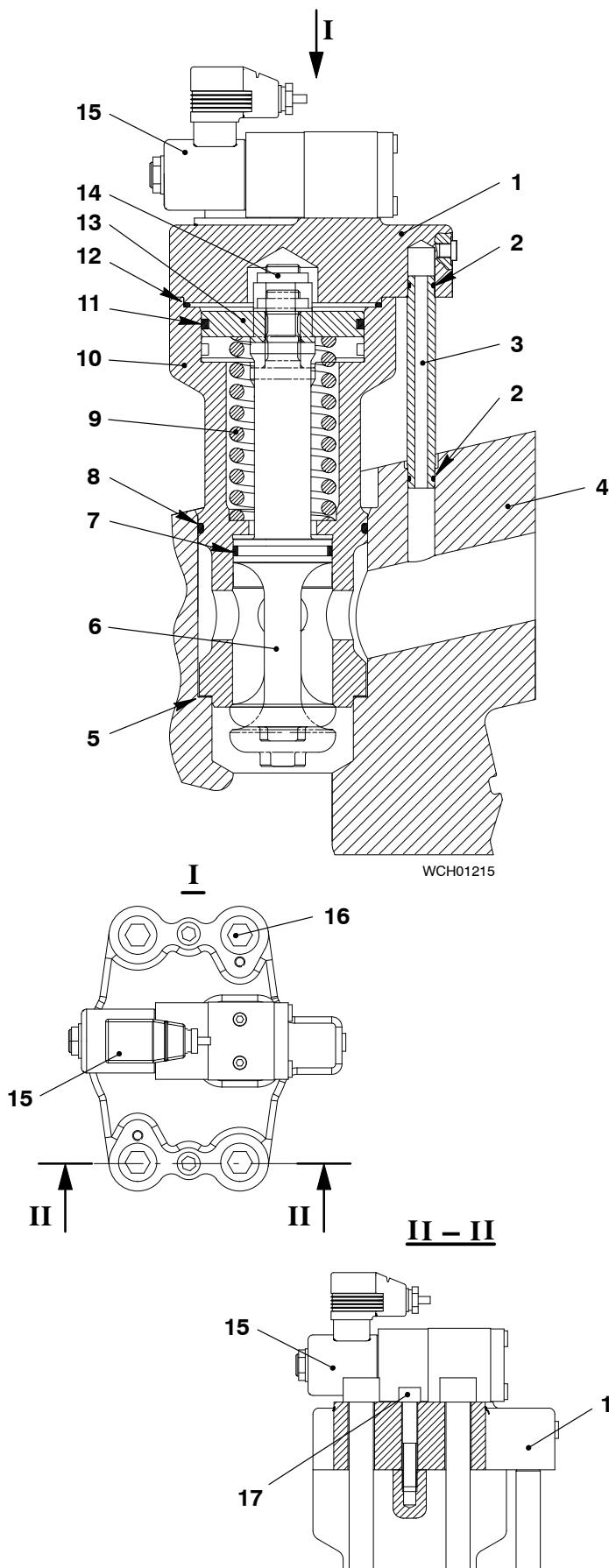


Fig. 3

6. Assemble

- 1) Clean all the parts of the starting air valve.
- 2) Put a small quantity of oil on the all the parts and O-rings (2, 8 and 12)
- 3) Put two new O-rings (2) on the pipe (3, see Fig. 3).
- 4) Put new O-rings (8) and (12) in the housing (2).
- 5) Put the the valve spindle (6) into the housing (2).
- 6) Put the compression spring (9) into the housing (2).
- 7) Put the piston (13) in position on the valve spindle (6).

Note: Do not get Molykote paste G on the thread of the valve spindle (6) where the insert of the self-locking nut (14) will go.

- 8) Apply a thin layer of Molykote paste G to the thread of the valve spindle.
- 9) Attach the self-locking nut (14) to the valve spindle (6).
- 10) Torque the self-locking nut to 300 Nm.
- 11) Tap the top of the valve spindle (6) with a hammer. The valve spindle must spring back to its initial position.
- 12) Attach the cover (1), together with the solenoid valve (15), to the housing (2) with the two screws (17).
- 13) Torque the two screws (17) to 70 Nm.
- 14) Put the pipe (3) in position in the cover (1).

7. Installation

- 1) Put a new gasket 5 in the bore in cylinder cover (4),see Fig. 3.
- 2) Apply a thin layer of oil to the to the bore of the cylinder cover (4).
- 3) Carefully put the starting air valve in the cylinder cover (4). Make sure that the pipe (3) goes into the bore of the cylinder cover (4) correctly.
- 4) Apply a thin layer of oil to the threads of the four screws (16).
- 5) Put the four screws in position in the cover (1).
- 6) Torque the four screws to 350 Nm.

Relief Valve on Cylinder Cover

Blow-off Pressure Check

Tools:

1	OBEL test bench	94272
1	Valve holder	94272C
1	HP oil pump	94931
2	Pressure gage	94934A
1	HP hose	94935

1. General

Some cylinder covers have an indicator valve installed together with a relief valve. Other cylinder covers have only an indicator valve. This procedure is only applicable for the cylinder covers that have an indicator valve together with a relief valve (see Fig. 1).

If the pressure in the compression chamber is more than the specified blow-off setting of the relief valve, the relief valve opens. The pressure is immediately released. You must then replace the relief valve as soon as possible. Relief valves cannot be adjusted or repaired. You must replace a relief valve that leaks.

It is not necessary to do maintenance on the relief valves.

Relief valves that leak, or have damage must be returned the manufacturer for inspection and repair.

2. Preparation

- 1) Stop the engine.

Relief Valve: Blow-off Pressure Check

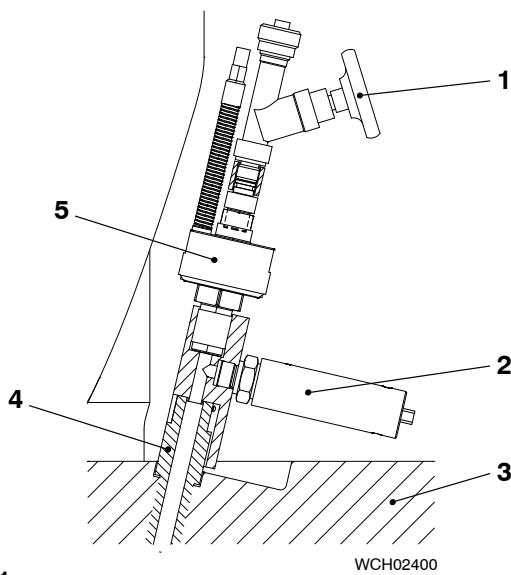


Fig. 1

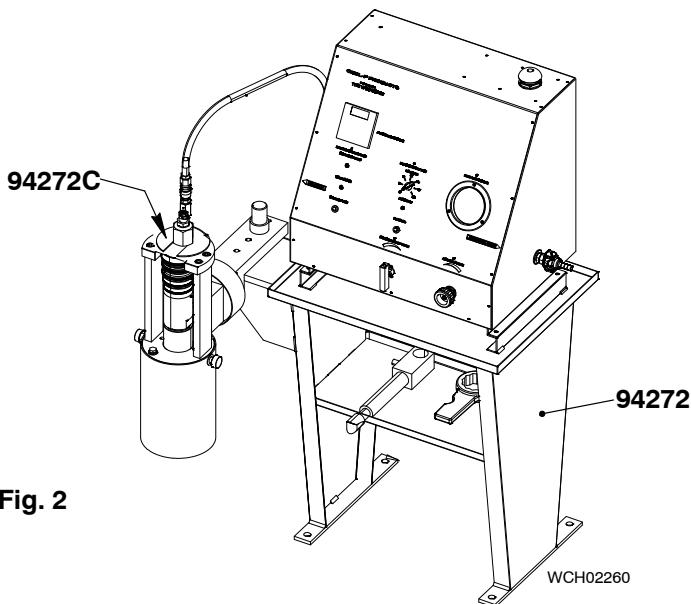


Fig. 2

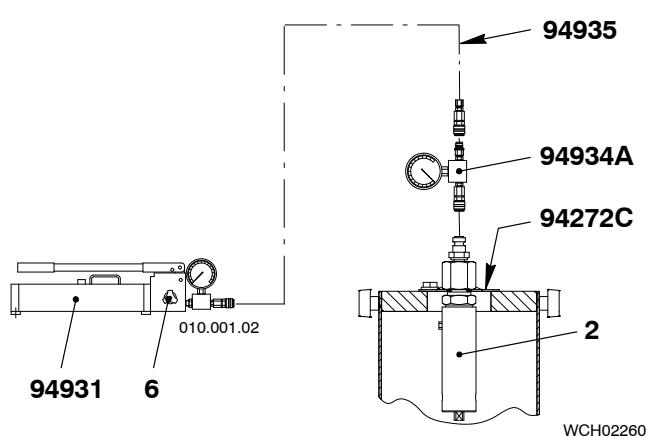


Fig. 3

3. Removal

- 1) Open the indicator valve (1, Fig. 1) to make sure that there is no pressure in the compression chamber.
- 2) Remove the relief valve (2) from the adapter (4).

4. Relief valve check

There are two alternative procedures to do a check of the relief valve (2).

4.1 Procedure One

- 1) Read the data in the manual for the test bench (94272).
- 2) Read the data 2722-1, paragraph 1.1. You can use the test and calibration fluid, or a low viscosity oil as a test fluid.
- 3) Attach the valve holder (94272C), to the test bench (94272, see Fig. 2).
- 4) Attach the relief valve (2) to the valve holder (94272C).
- 5) Do a check of the blow-off pressure on the relief valve (2).
- 6) Make sure that the relief valve is set to blow-off at 235 bar. This relates to a firing pressure of between 166 bar to 169 bar.
- 7) Release the pressure in the test bench (94272).
- 8) Remove the relief valve (2) from the valve holder (94272C).

4.2 Procedure Two

- 1) Attach the relief valve (2) to the valve holder (94272C).
- 2) Connect the HP oil pump (94931) and the hose (94935) to the pressure gage (94934A).
- 3) Connect the pressure gage to the valve holder (94272C).
- 4) Close the relief valve (6) on the HP oil pump.
- 5) Operate the HP oil pump (94931).
- 6) Do a check of the blow-off pressure on the relief valve (2).

Relief Valve: Blow-off Pressure Check

- 7) Make sure that the relief valve (2, [Fig. 1](#)) is set to blow-off at 235 bar. This relates to a firing pressure of between 166 bar to 169 bar.
- 8) Open the relief valve (6, [Fig. 3](#)) on the HP oil pump to release the pressure in the hose (94935).
- 9) Disconnect the hose and the HP oil pump from the relief valve (2).
- 10) Remove the relief valve (2) from the valve holder (94272C).

5. Installation

- 1) Apply Never-Seez NSBT to the thread of the relief valve (2).
- 2) Install the relief valve (2, [Fig. 1](#)) to the adapter (4).
- 3) Close the indicator valve (1).

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Exhaust Valve**Exhaust Valve – Removal and Installation****Tools:**

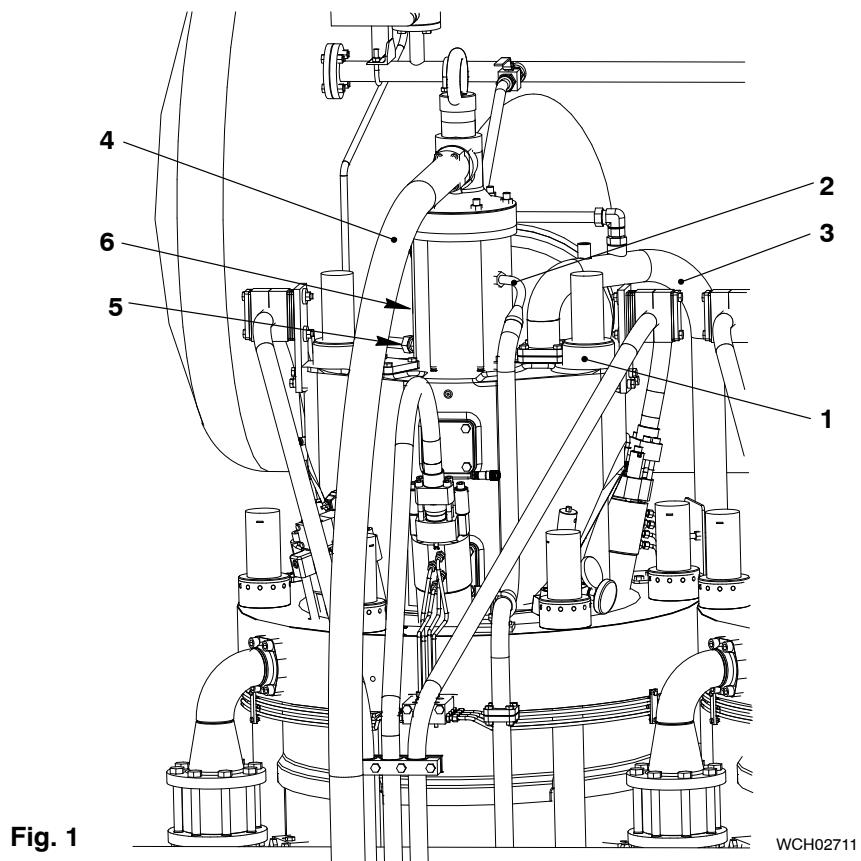
2 Sling 94049A

1. Preparation

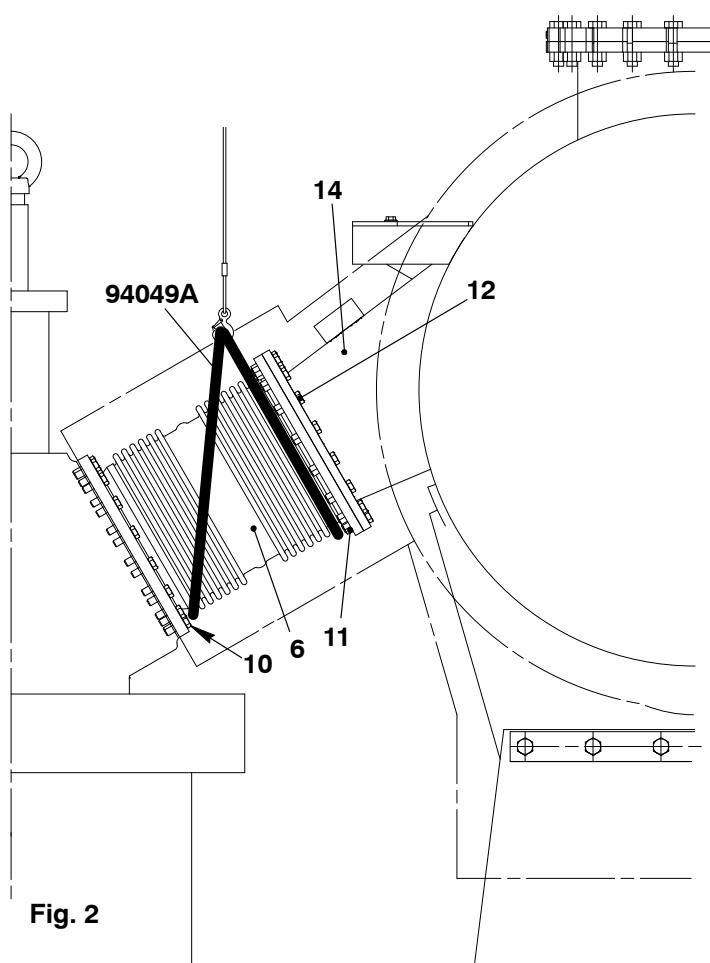
- 1) Drain the cylinder cooling water from the related cylinder (see [2708-1](#)).
- 2) Close the air inlet to the air spring at the control air supply.
- 3) Remove the hydraulic pipe (4, [Fig. 1](#)) from the related exhaust valve, see [8460-1](#), paragraph 1.
- 4) Disconnect the the cooling water pipe (3, Fig. 1).
- 5) Disconnect the the oil drain pipe (2).
- 6) Disconnect cable to valve stroke sensor.
- 7) Disconnect the air supply for the air spring (5).

2. Removal

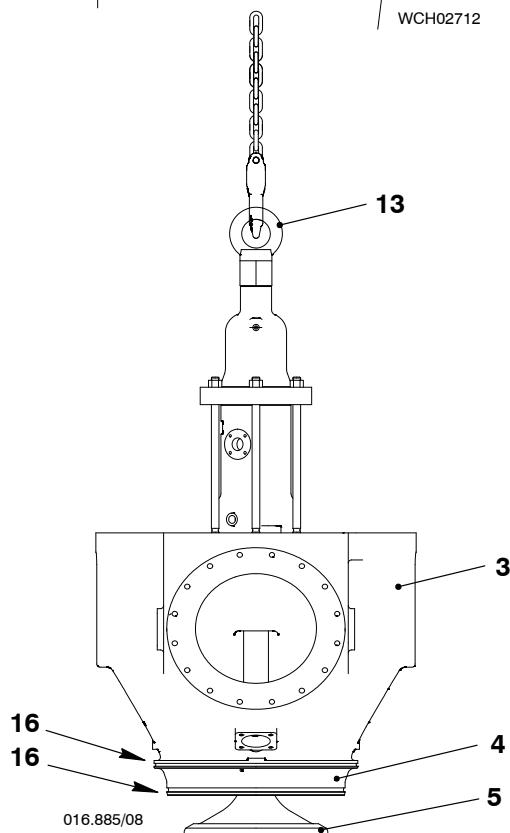
- 1) Remove two round nuts (1), see the procedure given in [9403-4](#), paragraphs 1 and 2.
- 2) Disconnect the plug (2) of the valve stroke sensor (see [Fig. 1](#)).



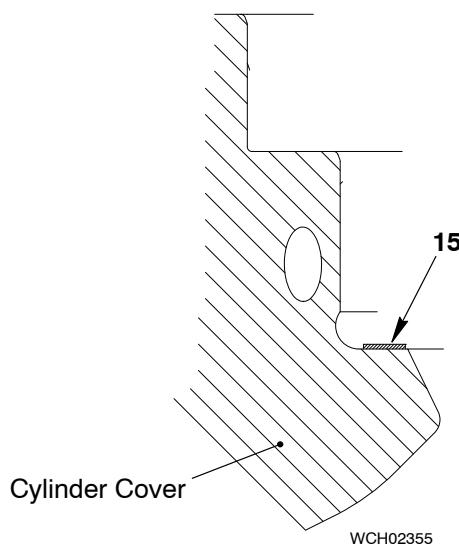
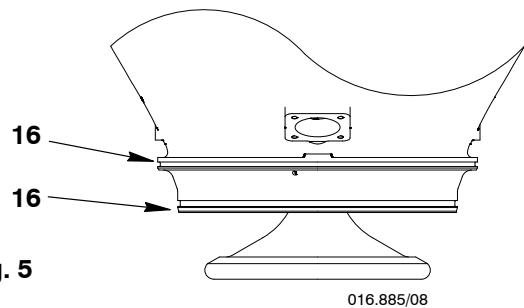
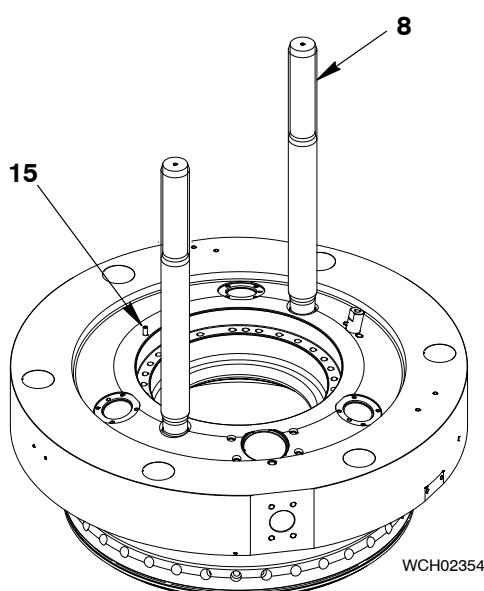
Exhaust Valve – Removal and Installation



- 3) Put the slings (94049A) in position on the expansion piece as shown in (Fig. 2).
- 4) Connect the slings to the hook on the crane.
- 5) Use the crane to put a light tension on the slings.
- 6) Remove the 16 screws (10).
- 7) Remove the 16 nuts (11) and the bolts (12).
- 8) Move the expansion piece (6) to one side.
- 9) Lower the expansion piece on to a suitable surface.
- 10) Attach the crane hook to the eye bolt (13).
- 11) Use the crane to lift the exhaust valve from the cylinder cover.
- 12) Carefully lower the exhaust valve on to a wooden underlay.
- 13) Remove and discard the O-rings (16) from the valve cage and valve seat.

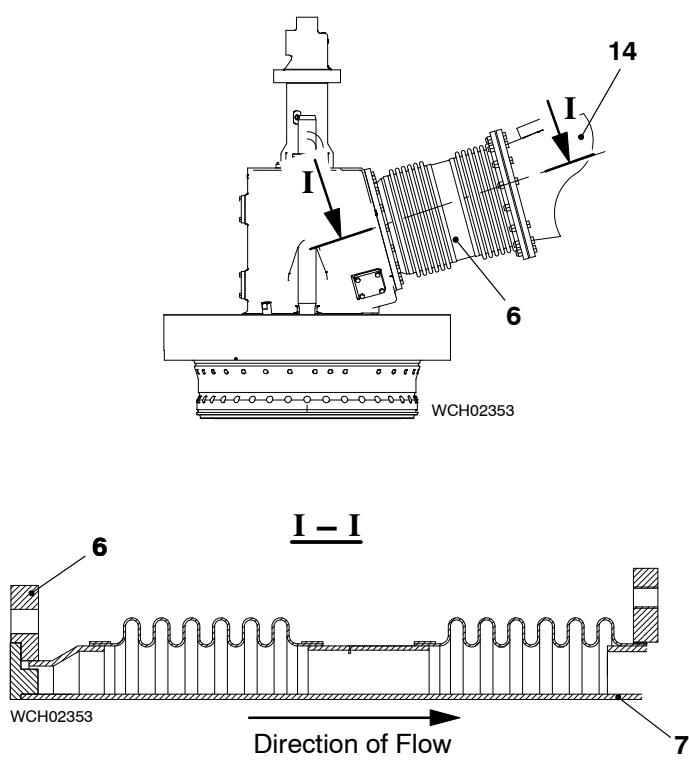
**Fig. 3**

Exhaust Valve – Removal and Installation

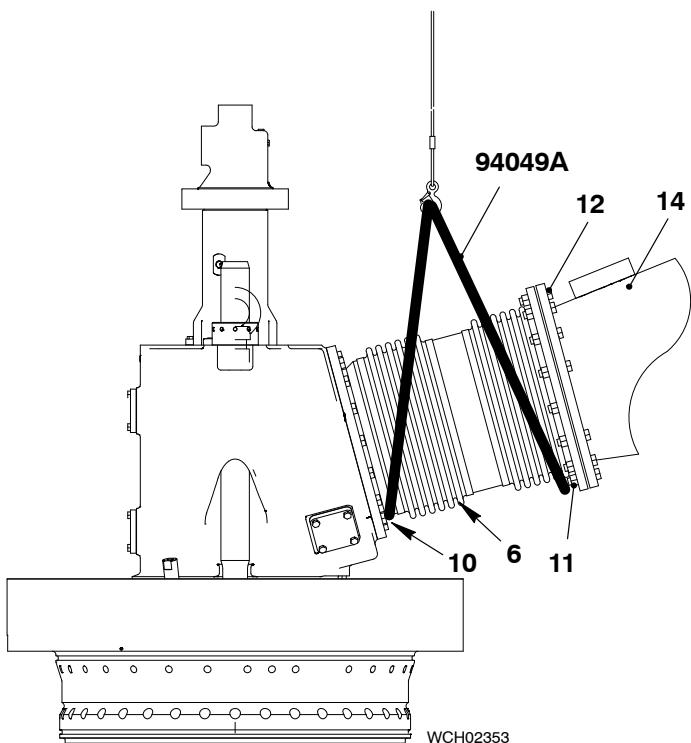
**Fig. 4****Fig. 5****Fig. 6****3. Installation**

- 1) Clean all the sealing surfaces of the exhaust valve and the cylinder cover.
- 2) Examine the sealing surfaces of the exhaust valve and cylinder cover for damage.
- 3) Remove the 2 mm metal gasket (15) from the cylinder cover (see Fig. 4).
- 4) Clean the the 2 mm metal gasket.
- 5) Examine the 2 mm metal gasket for damage. Make sure that the dimension of the 2 mm metal gasket is correct.
- 6) If the 2 mm metal gasket has no damage, and the dimension is correct, put the gasket in position in the cylinder cover.
- 7) If the 2 mm metal gasket has damage, or the dimension is not correct, replace the gasket with a new one.
- 8) Install new O-rings in the valve cage and valve seat (see Fig. 5).
- 9) Apply a thin layer of oil on to the new O-rings.
- 10) Connect the lifting tool (94209) to the eye bolt (13, see Fig. 3).
- 11) Use the crane to lift the exhaust valve.
- 12) **Remark:** When you do the step below, make sure that you do not damage the threads of the elastic studs.
- 13) Put the exhaust valve in the correct position in the cylinder cover (see Fig. 6). The cylindrical pin (15) in the cylinder cover will help you get the correct position.
- 14) Install the round nuts, see the procedure given in 9403-4, paragraphs (1) and (3).

Exhaust Valve – Removal and Installation



- 15) Clean the sealing surfaces of the expansion piece (6) and the related faces on the valve cage and exhaust pipe (14, see Fig. 7).
- 16) Apply a thin layer of heat-resistant lubricant to the sealing faces and the screws (12 and 10).
- 17) Put the slings (94049A) in position on the expansion piece.
- 18) Connect the slings to the hook on the crane.
- 19) Use the crane to lift the expansion piece (6).
- 20) Put the expansion piece in position between the valve cage and the exhaust pipe. Make sure that the direction of flow is correct see view I - I.
- 21) Install the screws (10) and (12) and nuts (11).
- 22) Remove the slings.

**Fig. 7**

Exhaust Valve**Disassemble and Assemble****Tools:**

1	Thrust pin	94259	2	Eye bolts	94045-M12
2	Jack screws	94263	1	Torque wrench	
1	Depth gauge	94126			

1.	General	1
2.	Exhaust valve – disassemble	3
2.1	Valve drive – disassemble	3
2.2	Valve spindle – remove	3
2.3	Guide bush – removal	4
3.	Exhaust valve – assemble	4
3.1	Guide bush – installation	4
3.2	Valve spindle – installation	5
3.3	Valve drive – assemble	5
3.4	Damper setting	6
3.5	Valve stroke sensor – installation	7
3.6	Throttle	7
3.7	Non-return valve	7
3.8	Oil supply to valve guide	7

1. General

There are two complete exhaust valves on board, as recommended by the International Association of Classification Societies (IACS).

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

For the inspection and overhaul intervals, see [0380-1](#) Maintenance Schedule.

Read the data in [0012-1](#) General Guidelines for Lifting Tools.

Exhaust Valve: Disassemble and Assemble

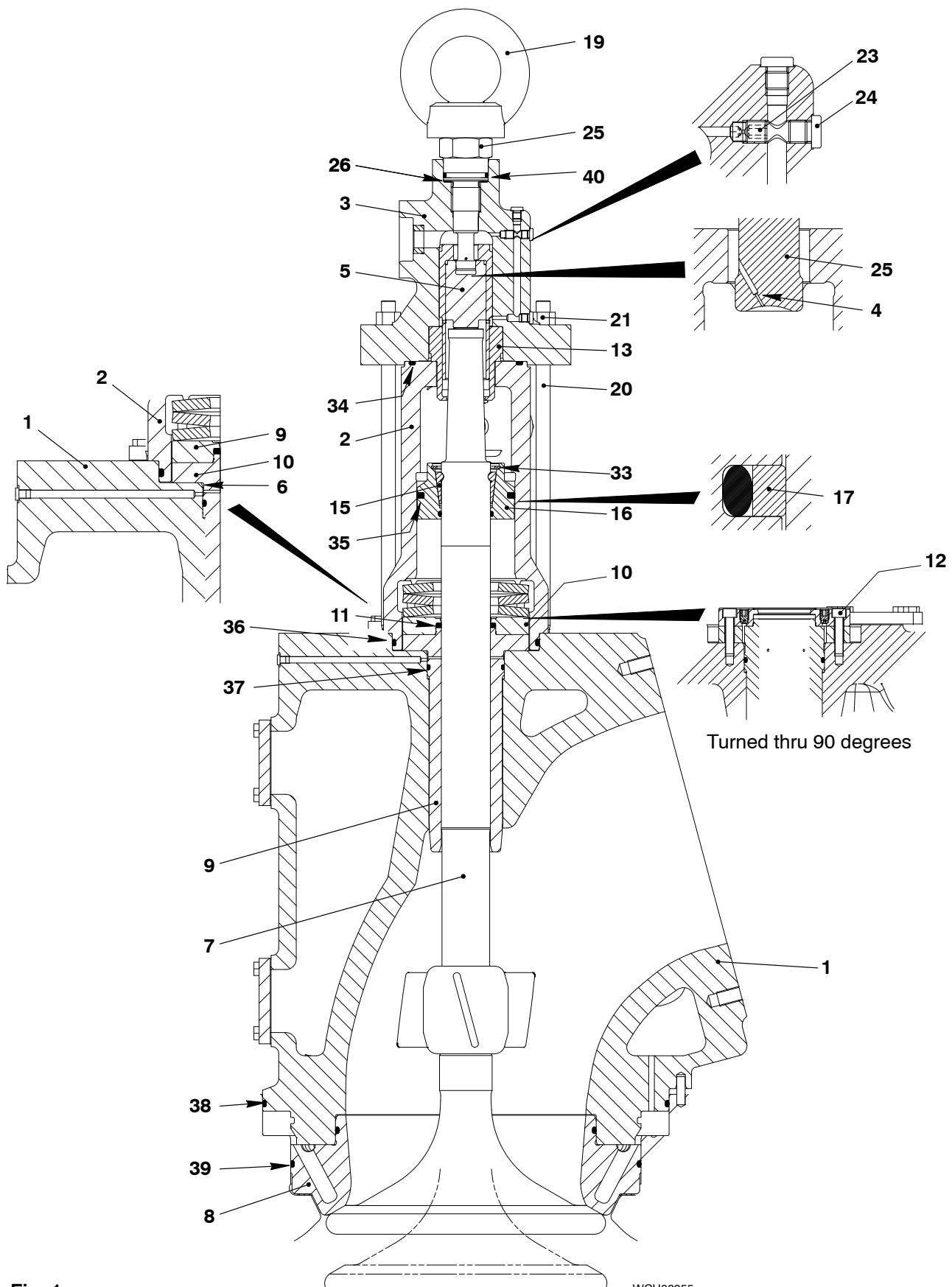
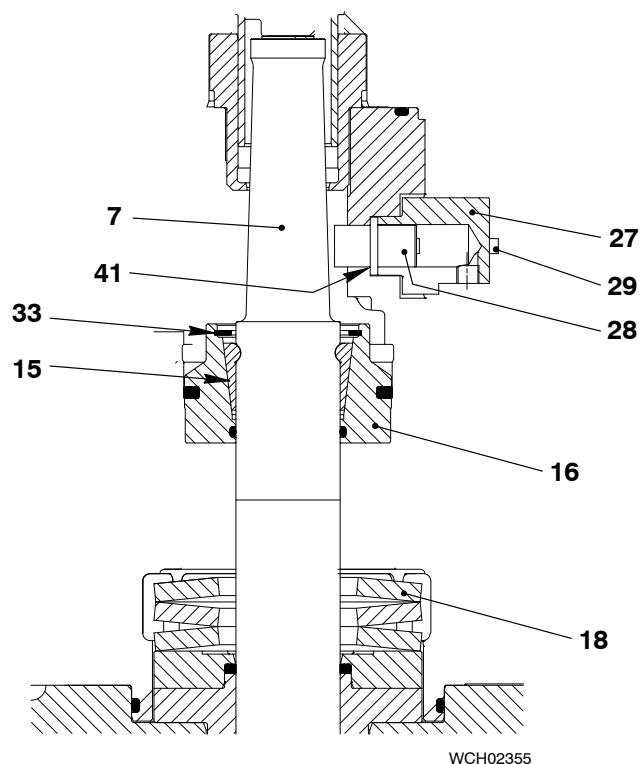
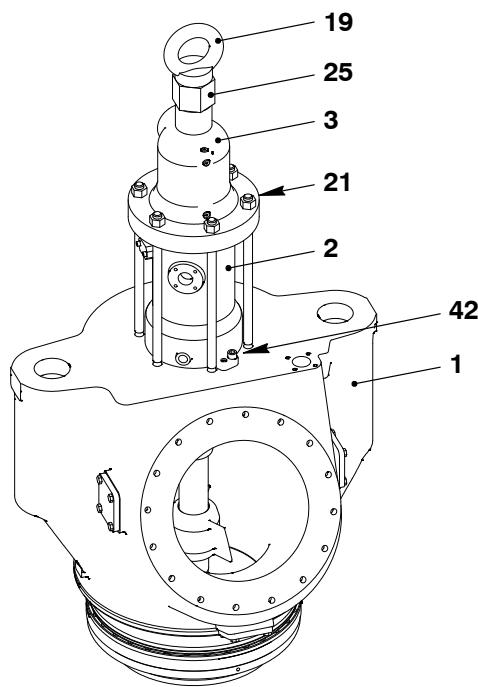


Fig. 1

WCH02355

Exhaust Valve: Disassemble and Assemble

**Fig. 2**

2. Exhaust valve – disassemble

CAUTION



During this procedure, do the work in a clean area. Electrical welding is not permitted.

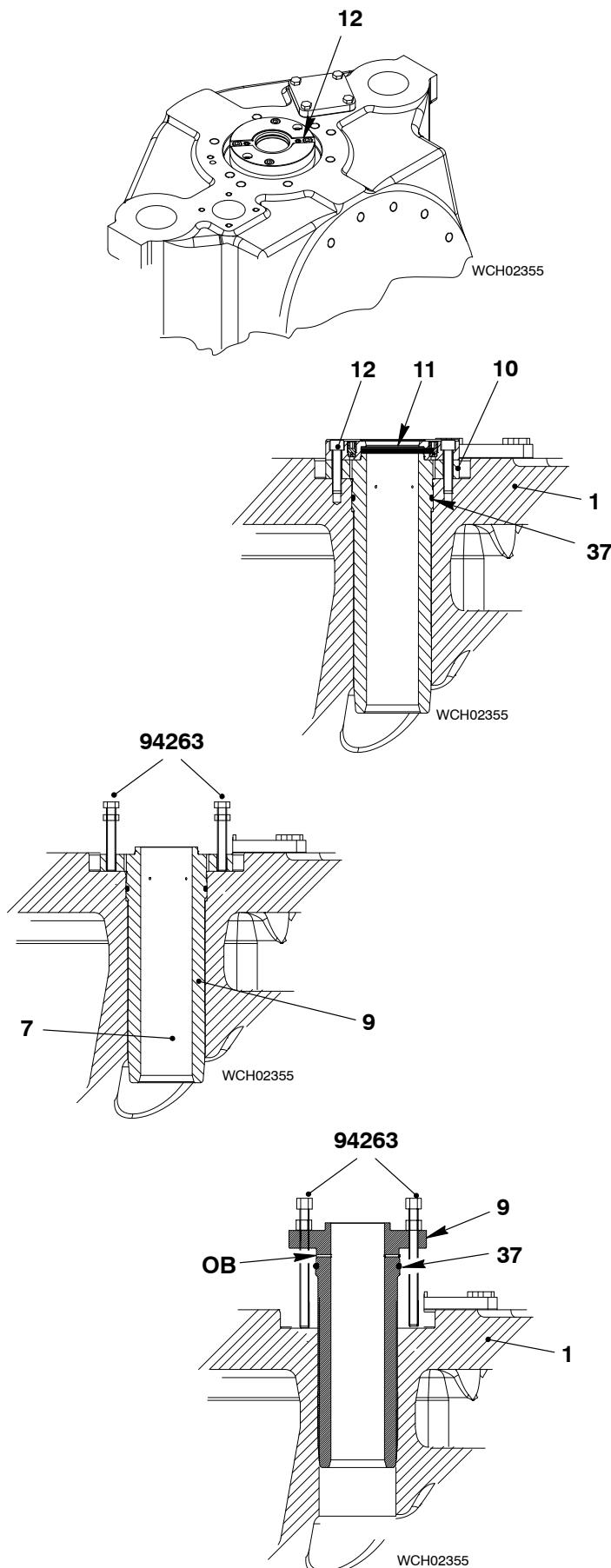
2.1 Valve drive – disassemble

- 1) Attach the crane hook to the eye bolt (19).
- 2) Remove the six nuts (21, Fig. 2).
- 3) Remove the top housing (3).
- 4) Disconnect the electrical connection from the valve stroke sensor (28).
- 5) Remove the two screws (29).
- 6) Remove the transmitter housing (27).
- 7) Remove the valve stroke sensor (28).
- 8) Remove the O-ring (41).
- 9) Remove the six cap screws (42).
- 10) Remove the bottom housing (2).

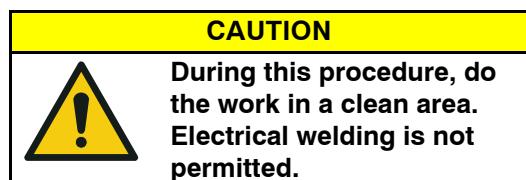
2.2 Valve spindle – remove

- 1) Remove the circlip (33).
- 2) Push the piston (16) down, then remove the valve cotters (15).
- 3) Remove the piston (16) from the valve spindle (7).
- 4) Remove the cup springs (18).
- 5) Use two M12 eye bolts and two ropes or lifting tool 94209 to lift the valve cage (530 kg) to the top of the valve spindle (7). Make sure that the valve spindle does not move.
- 6) Lower the valve cage (1) on to its side.

Exhaust Valve: Disassemble and Assemble

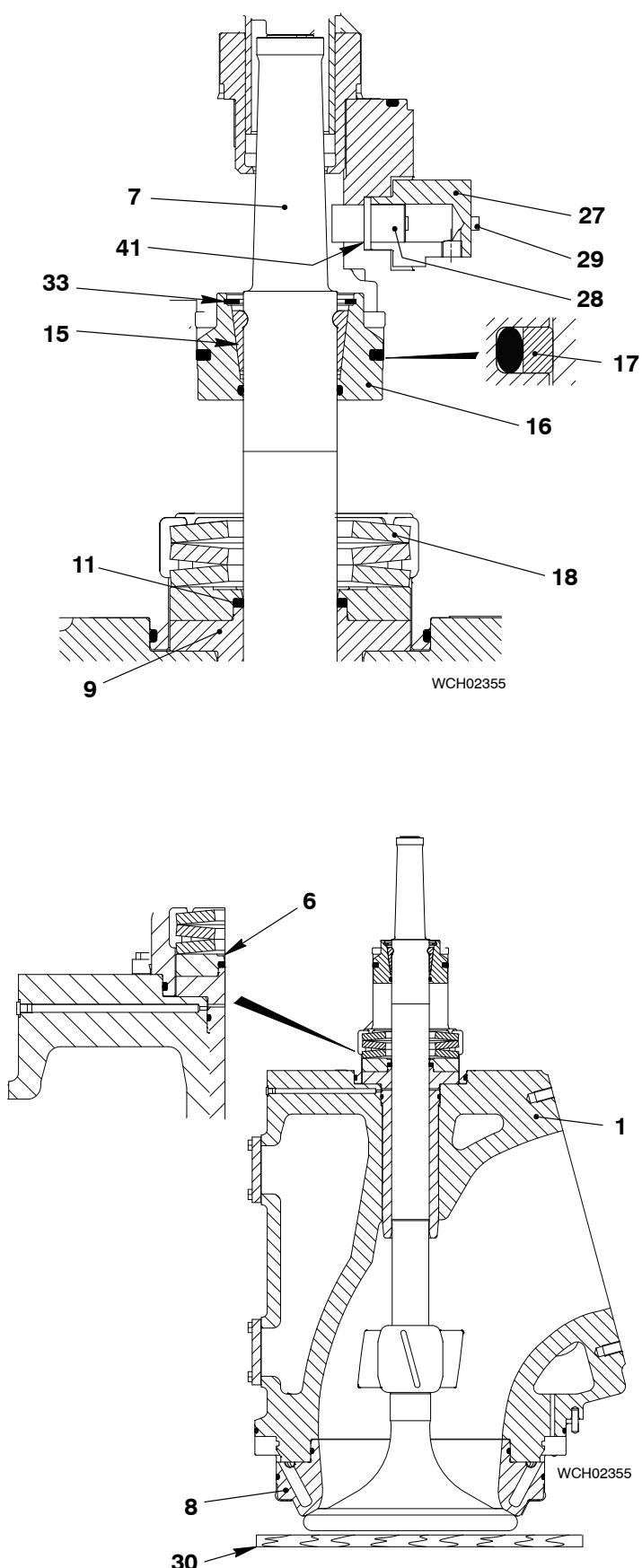
**Fig. 3****2.3 Guide bush – removal**

- 1) Remove the four cap screws (12, see Fig. 3).
- 2) Remove the spacer (10).
- 3) Remove and discard the rod seal (11).
- 4) Put the jack screws (tool 94263) into the flange of the guide bush (9).
- 5) Turn the jack screws to lift the guide bush from the valve spindle (7).
- 6) Remove and discard the O-ring (37).
- 7) Measure the inner diameter of the guide bush (9).
- 8) Compare the measurement with the values given in [0330-1 Exhaust Valve](#) table.

3. Exhaust valve – assemble**3.1 Guide bush – installation**

- 1) Clean the bore in the valve cage (1).
- 2) Clean the bore in the guide bush (9).
- 3) Make sure that the oil bores OB in the guide bush (9) are clear.
- 4) Install a new O-ring (37).
- 5) Put oil on the guide bush (9).
- 6) Put the guide bush (9) in position in the valve cage (1).
- 7) Use the jack screws 94263 to push the guide bush fully into the valve cage (1).

Exhaust Valve: Disassemble and Assemble

**Fig. 4****3.2 Valve spindle – installation**

- 1) Measure the dimensions of the valve spindle (7, [Fig. 4](#)).
- 2) Compare the values with those given in [0330-1 Exhaust Valve table](#).
- 3) Do a check of the piston seal ring (17) for damage. If you find damage, replace the piston seal ring.
- 4) If necessary, replace all O-rings.
- 5) Put oil on the valve spindle (7).
- 6) Use two M12 eye bolts and two ropes or lifting tool 94209 to lift the valve cage (530 kg) to the top of the valve spindle (7). Make sure that the valve spindle does not move.
- 7) Lower the valve cage very carefully over the valve spindle. Do not damage the guide bush.
- 8) Put oil on a new rod seal (11).
- 9) Put the new rod seal (11) in position on the guide bush (9).
- 10) Before you install a new piston seal ring (17), do as follows:
 - 11) Put the new piston ring seal (17) in boiling water for some minutes.
 - 12) Carefully put the piston ring seal (17) in the correct position on the piston (16, [Fig. 4](#)).

3.3 Valve drive – assemble

- 1) Push the valve spindle (7) against the valve seat (8).
- 2) Install the cup springs (18).
- 3) Put the piston (16) in position on the valve spindle (7).
- 4) Install the valve cappers (15).
- 5) Push the piston (16) up and install the circlip (33).
- 6) Fill the oil bath (6) with system oil.

Exhaust Valve: Disassemble and Assemble

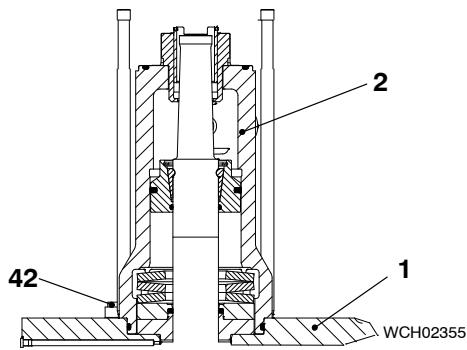


Fig. 5

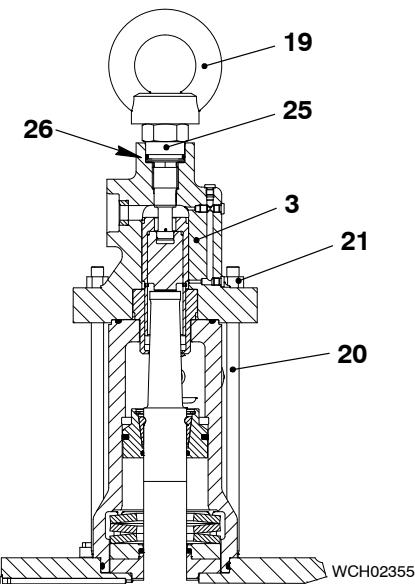


Fig. 6

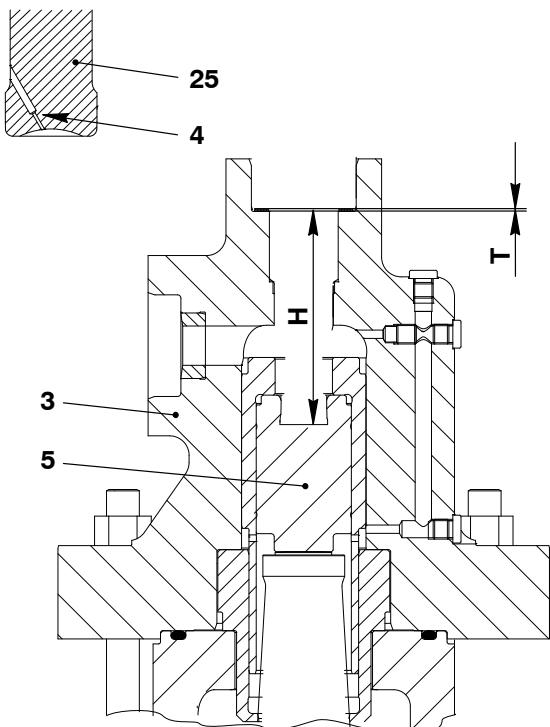


Fig. 7

- 7) Attach two eye bolts M8 to the housing (2, Fig. 5).
- 8) Lift, then lower the bottom housing 2 on to the valve cage (1).
- 9) Install the six cap screws (42).
- 10) Attach the crane hook to the eye bolt (19 Fig. 6).
- 11) Lift, then carefully lower the top housing (3) on to the housing (2).
- 12) Remove the lifting tool from the top housing (3) and the crane.
- 13) Put oil on to the threads of the elastic studs (20).
- 14) Put the six nuts (21) on to the elastic studs (20).
- 15) Torque the oiled nuts (21) equally to 150 Nm in a diagonal sequence.

3.4 Damper setting

You set the damper (25 Fig. 7) only after you replace a valve spindle or valve seat, or after the one of the seating faces is ground.

- 1) Remove the damper (25).
- 2) Make sure that the bores (4) in the damper are clear.
- 3) Make sure that the exhaust valve is closed.
- 4) Use a feeler gage to make sure there is no clearance between the valve plate and valve seat (8, Fig. 4).
- 5) Use a depth gage to measure the height H from the seat of the damper to the bottom of the damper bore.

Install shims (26, Fig. 6) with a total thickness T in relation to the measured Height H given in the table that follows:

Height \pm 0.5 mm	Total Thickness T
110.7 mm	1 mm
109.7 mm	2 mm
108.7 mm	3 mm
107.7 mm	4 mm
106.7 mm	5 mm
105.7 mm	6 mm

- 6) Install the damper (25) and the shims to give the total applicable thickness.
- Shims of dimension 1 mm are available.
- 7) Install the eye nut (19) with Loctite 271.

Exhaust Valve: Disassemble and Assemble

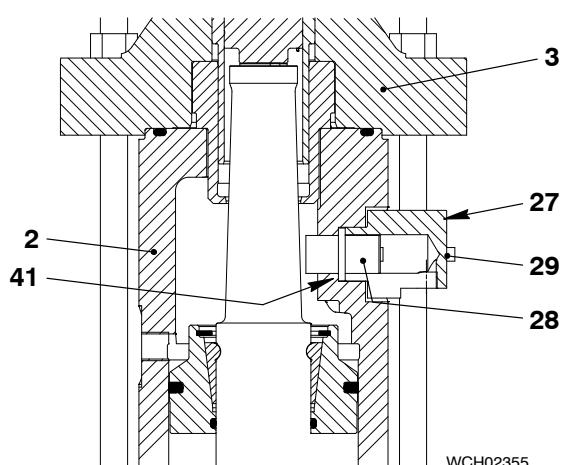


Fig. 8

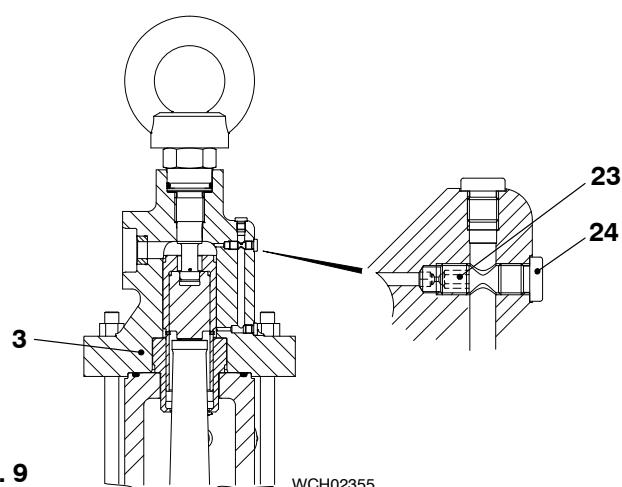


Fig. 9

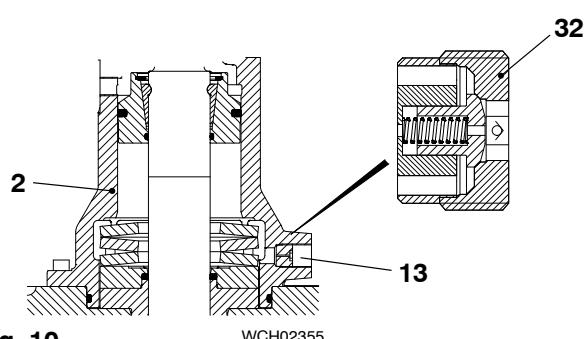


Fig. 10

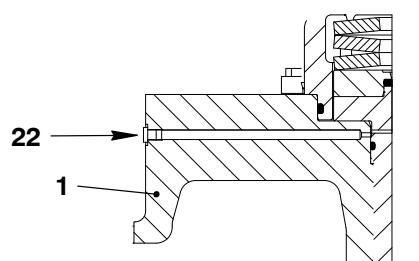


Fig. 11

3.5 Valve stroke sensor – installation

- 1) Clean the parts that follow:
 - The valve stroke sensor (28).
 - The transmitter housing (27).
 - The bore and collar in the housing (3)
- 2) Put oil on the O-ring (41) and the valve stroke sensor (28).
- 3) Carefully put the O-ring (41) and the valve stroke sensor (28) into the housing (3).
- 4) Attach the transmitter housing (27) with the two screws (29).
- 5) Connect the electrical connection to the valve stroke sensor (28).

3.6 Throttle

- 1) Do a check of the throttle as follows:
- 2) Remove the screw plug (24, Fig. 9).
- 3) Remove the throttle (23).
- 4) Make sure that the throttle (23) is clear.
- 5) Put oil on the threads of the throttle (23).
- 6) Put the throttle (23) in position.
- 7) Torque the throttle (23) to 20 Nm.

3.7 Non-return valve

- 1) Do a check of the non-return valve (32, Fig. 10) as follows:
- 2) Remove the non-return valve (32) from the housing (2).
- 3) Make sure that the non-return valve operates correctly.
- 4) Install the non-return valve (32) to the housing (2).

3.8 Oil supply to valve guide

- 1) Make sure that the oil bore to the valve guide (22, Fig. 11) is clear.

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Valve Seat – Replace / Grind

Tools:

1	Feeler gauge	94122
1	Valve seat dismantling device	94261
1	Template	94279
1	Tool, grinding	94291

1.	General	1
2.	Preparation	1
3.	Valve seat – removal	2
3.1	Recommended procedure	2
3.2	Alternative procedure	2
4.	Valve seat – grinding	3
5.	Valve seat – check	4
6.	Valve seat – installation	5

1. General

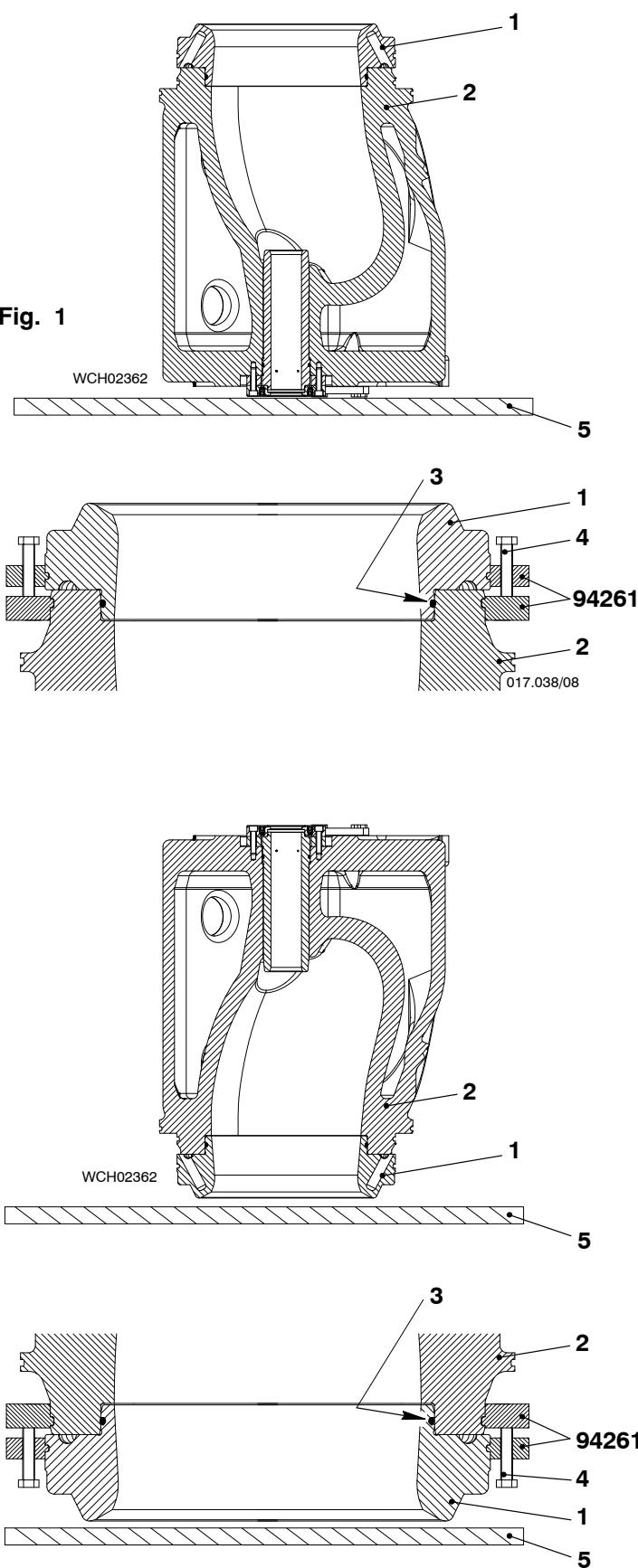
You must replace the valve seat when:

- The sealing surface has too much damage, or
- Frequent grinding has worn the valve seat to more than the specified limit.

2. Preparation

- 1) Disassemble the valve and remove the valve spindle, (see [2751-2](#), paragraphs 2.1 and 2.2).

Valve Seat – Replace / Grind

**3. Valve seat – removal**

- 1) If a valve seat is removed e.g. to replace an unserviceable O-ring, you must:
- 2) Grind the valve seat before installation (paragraph 4), or:
- 3) Mark the position of the valve seat in the valve cage before you start the removal procedure.

3.1 Recommended procedure

- 1) Turn the valve cage until the valve seat points up (see Fig. 1).
- 2) Carefully put the valve cage on to an applicable wooden underlay.
- 3) Install the top two halves of the dismantling device 94261 into the groove of the valve seat (1).
- 4) Install the bottom two halves of the dismantling device 94261 into the groove of the valve cage (2).
- 5) Turn the three jack screws (4) equally to push out the valve seat from the valve cage (2).
- 6) Remove and discard the O-ring (3).
- 7) Remove the dismantling device 94261.

3.2 Alternative procedure

If it is necessary to remove the valve seat when the valve cage must stay in the usual position (i.e. the top of the valve cage points up), do the procedure that follows:

- 1) Use the crane and an applicable lifting tool to hold the valve cage immediately above an applicable wooden underlay (5), see Fig. 2.
- 2) Use applicable wooden chocks to keep the valve cage in position and prevent movement.
- 3) Install the top two halves of the tool (94261) into the groove of the valve cage (2).
- 4) Install the bottom two halves of the tool (94261) into the groove of the valve seat (1).

Note: The valve seat weighs 100 kg. Be careful when you do the step below.

Valve Seat – Replace / Grind

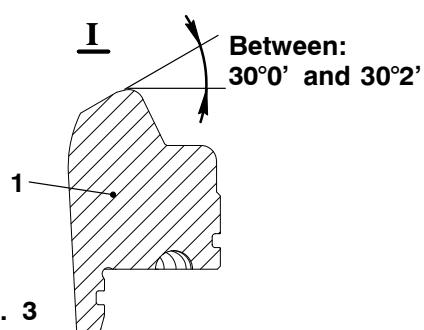
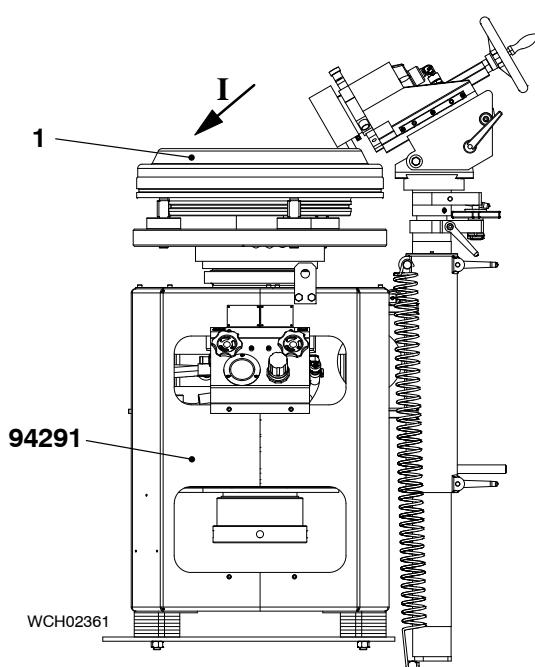


Fig. 3

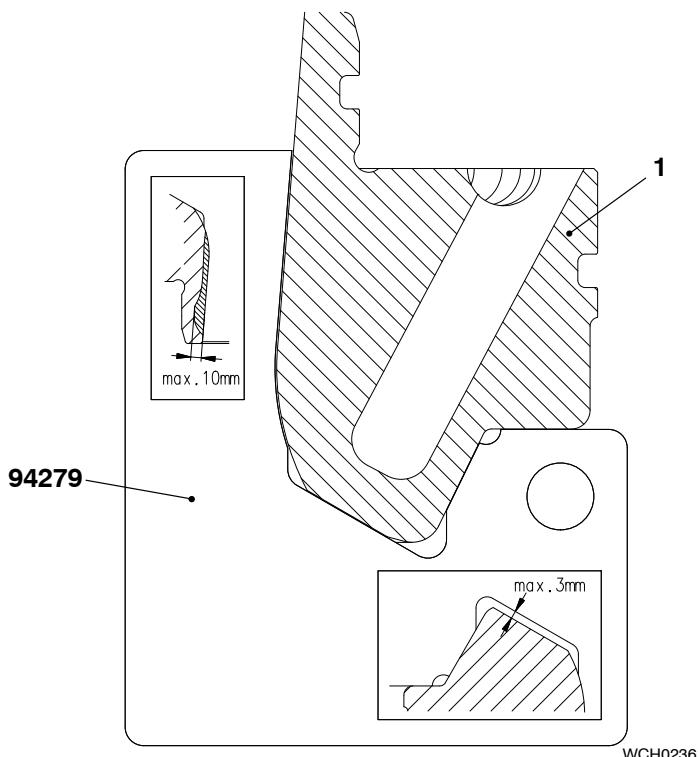


Fig. 4

- 5) Carefully turn the three jack screws (4) equally until the valve seat (1) falls out of the valve cage (2).
- 6) Lift and move the valve cage (2) away from the valve seat (1).
- 7) Remove and discard the O-ring (3).
- 8) Remove the tool (94261).

4. Valve seat – grinding

Use only the tool 94291 (see Fig. 3) to grind the valve seats.

- 1) Read the data in the manufacturer's manual for the tool 94291.
- 2) Put the valve seat (1) in the correct position on the tool 94291.
- 3) Put the Template 94279 on the valve seat (see Fig 4).

Note: The data on the Template 94279 shows the maximum permitted limits for the valve seat (1).

- 4) Use the feeler gage 94122 to measure the values.
- 5) If the measured values are more than the limits given on the gage 94122, you must replace the valve seat (1).
- 6) If the values are less than the limits given, do the procedure that follows:
- 7) Use the tool 94291 to grind the sealing face of the valve seat (1). Make sure that you get a smooth and flat surface.
- 8) Keep the valve seat angle to between 30°0' and 30°2'.

Valve Seat – Replace / Grind

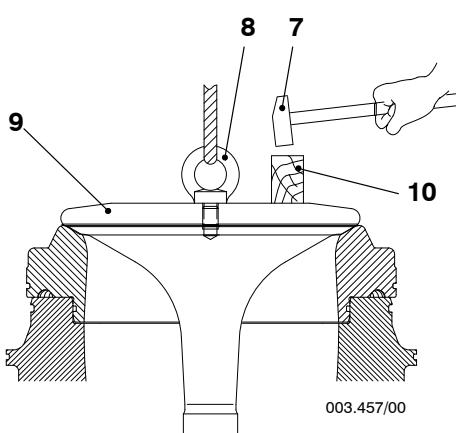


Fig. 5

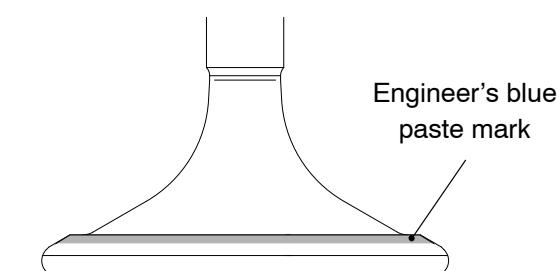
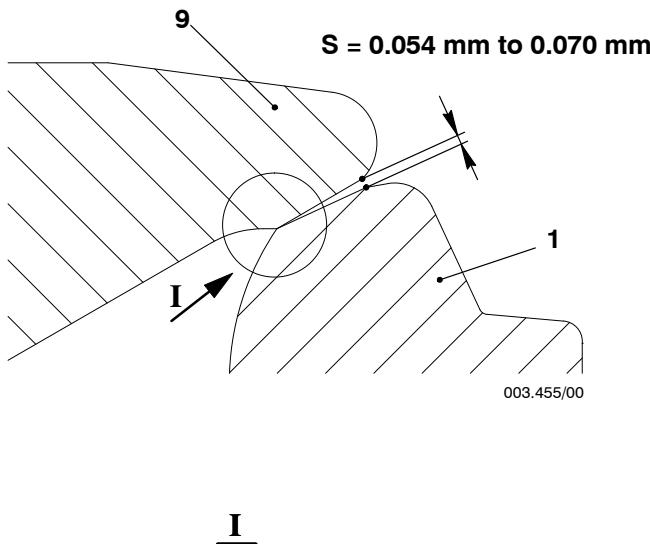


Fig. 6

5. Valve seat – check

You do this procedure to make sure that the sealing face of the valve spindle correctly touches the sealing face of the valve seat.

- 1) Put a thin layer of engineer's blue paste on the sealing face of the valve spindle (9), see Fig. 5.
- 2) Put the valve spindle (9) in position in the valve guide bush.
- 3) Put the wooden block (10) on the valve spindle (9).

Note: During the step below, do not turn the valve spindle (9) because this can cause the sealing faces to seize.

- 1) Tap the wooden block (10) with the hammer (7) three or four times.
 - 2) Use the feeler gage 94122 to do a check of the clearance between the sealing faces of the valve spindle (9) and valve seat (1), see Fig. 6.
 - 3) Remove the valve spindle (9) from the guide bush.
 - 4) Do a check of the engineer's blue paste. The blue paste must only show on the inner part of the full circumference of the valve spindle (see View I).
 - 5) Remove the valve seat from the tool 94291.
- The clearance between must be as shown ($S = 0.054 \text{ mm to } 0.070 \text{ mm}$).

Valve Seat – Replace / Grind

(G)

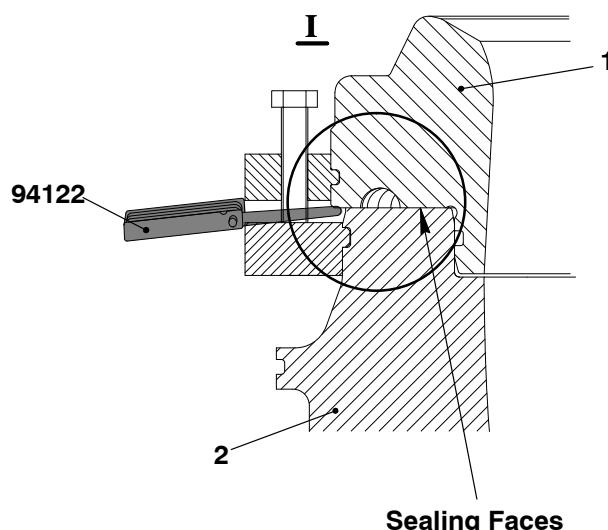
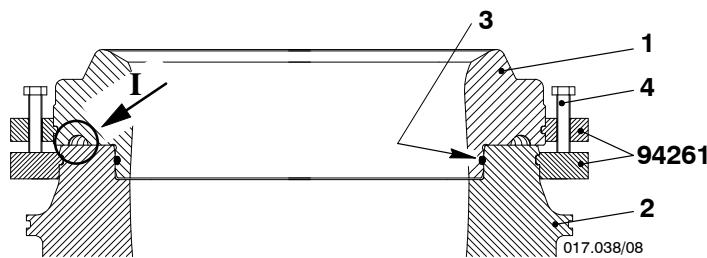


Fig. 7

6. Valve seat – installation

- 1) Clean the bores and the sealing faces of the valve cage (2) and the valve seat (1, Fig. 7).
- 2) Apply oil (or lubricants e.g. Never-Seez NBST, or Loctite anti-seize compound) on to the bores and sealing faces of the valve seat 1 and the valve cage (2).
- 3) Put the same lubricant on the new O-ring (3).
- 4) Put the new O-ring (3) on to the valve seat (1).
- 5) If the valve seat was removed to replace the O-ring, do the step below:
- 6) Align the marks on the valve seat (1) with the marks on the valve cage (2).
- 7) Push the valve seat (1) into the bore of the valve cage (1).
- 8) Install the top two halves of the tool 94261 into the groove of the valve seat (1).
- 9) Install the bottom two halves of the tool 94261 into the groove of the valve cage (2).
- 10) Turn the three jack screws (4) equally to fully push the valve seat (1) into the valve cage (2).
- 11) Use the feeler gage 94122 to make sure that there is no clearance between the sealing faces.
- 12) Remove the tool 94261.

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Exhaust Valve

Grinding the Seating Surface on the Valve Head

Tools:

1 Feeler gauge	94122
1 Tool valve grinding device	94291
1 Template	94292

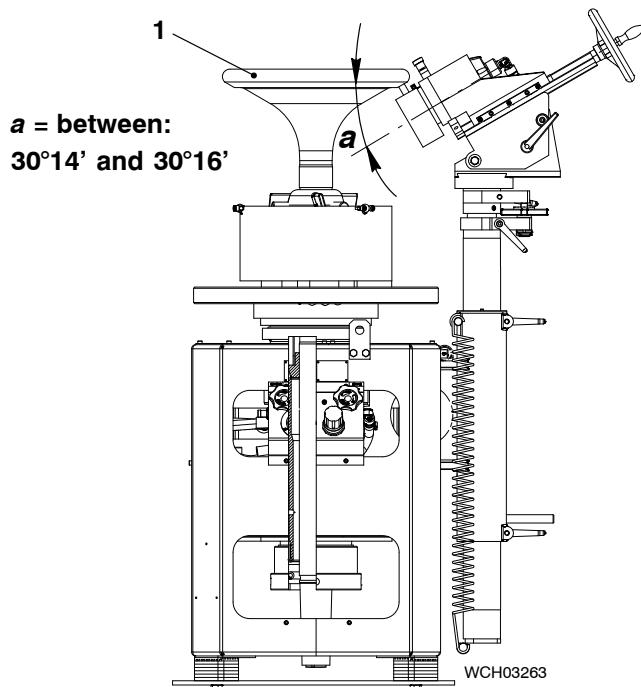


Fig. 1

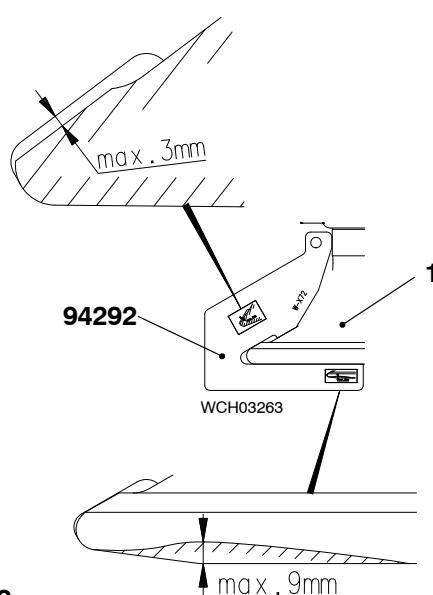


Fig. 2

1. General

Use only the grinding device 94291 (see Fig. 1) to grind the valve head.

You must grind valve heads that have damage or corrosion on the seating surface.

If the rotation wing is missing from the valve spindle, do not grind the valve head.

2. Valve head – grinding

- 1) Read the data in the manufacturer's manual for the grinding device 94291.
- 2) Put the grinding device 94291 in an area where there is no vibration.
- 3) Put the valve spindle in position in the grinding device 94291, see Fig. 1.
- 4) Put the template 94292 on the valve head (1), see Fig. 2.

Note: The data shown on the template 94292 shows the maximum limits for the valve head.

- 5) Use the feeler gage 94122 to measure the values.
- 6) If the values are less than the limits given, do the procedure that follows:
 - a) Use the grinding device 94291 to grind the surface of the valve head (1). Remove only the minimum material necessary to get a smooth, flat surface.
 - b) Use an applicable coolant to keep the valve head (1) cool.
 - c) Keep the angle of the valve head 1 to between 30°16' and 30°18'.

Note: You can grind off a maximum of 3 mm from the seating surface.

- 7) Do a check of the valve seat and valve spindle, see 2751-3, paragraph 5.

Exhaust Valve: Grinding the Seating Surface on the Valve Head

- 8) If the measured values are more than the limits given on the gage 94122, you can repair the valve spindle (see the data below).
- 9) If more than 3 mm is ground off, do the procedure that follows:
 - d) Use a build-up welding procedure to repair the valve seating surface.
 - e) Grind the seating surface of the valve spindle again (see paragraph 2).

3. Corrosion

Corrosion can occur at the bottom of the valve plate when engines operate for a long time (e.g. in rough weather conditions).

If the corrosion is less than or equal to 9 mm (see [Fig. 2](#)), the valve spindle can be repaired.

Note: The repair procedure can only be done in a Wärtsilä Switzerland Ltd authorized repair workshop.

Valve spindles cannot be repaired when the corrosion is more 9 mm, but can continue to operate until the corrosion has a depth of 21 mm.

Crankshaft, Connecting Rod and Piston

Group 3

Crankshaft: Measuring Crank Deflection	3103-1/A1
Vibration Damper	
Inspection (GEISLINGER Vibration Damper)	3130-2/A1
Axial Damper: Disassembly and Assembly	3140-1/A1
Turning Gear: Teeth and Screwed Connections – Check	3206-1/A1
Crankcase: Work Platform	3301-1/A1
Connecting Rod	
Bottom End Bearing – Removal, Inspection and Installation	3303-2/A1
Top End Bearing – Removal, Inspection and Installation	3303-3/A1
Removal and Installation	3303-4/A1
Top End Bearing Cover – Removal, Inspection and Installation	3303-5/A1
Crosshead	
Clearance Checks	3326-1/A1
Crosshead Pin – Removal / Installation / Clearance Checks	3326-2/A1
Piston	
Removal and Installation	3403-1/A1
Disassemble and Assemble	3403-3/A1
Top Surface – Check	3403-4/A1
Piston Rings: Wear of Piston Rings and Ring Grooves	3425-1/A1

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Crankshaft

Measuring Crank Deflection

Tools:

- 1 Crankshaft equipment (dial gage) 94305

1. General

It is sufficient to measure the crank-web deflection in accordance with the intervals specified in the class rules. It can be necessary to measure the crank-web deflection in unusual conditions, for example:

- Important change of crank-web deflection results compared to the data before.
- Bearing temperature alarms, or bearing damage.
- After the primary bearing shells were replaced and again after approximately 100 service hours.
- If the ship has touched the sea bed.

For the examples given above, it is recommended that you speak to Wärtsilä for support.

2. Preparation

- The indicator valves must be open.
- The ship must float freely in the water as horizontal as possible.
- The crankshaft must be in position on all the main bearings.

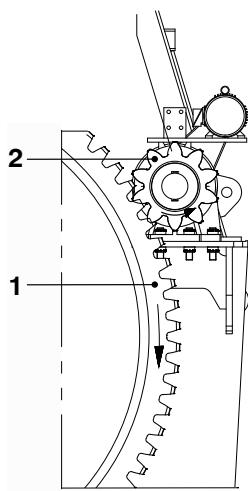


Fig. 1
TURNING GEAR
EXHAUST SIDE

The data that follow have an effect when you measure the crank-web:

- The engine is cold, or has service temperature.
- The temperature difference between the lubricating oil sump and the seawater.
- The loaded condition of the ship (the draught).
- Strong sunshine.

It is recommended that you include these data in the records.

3. Measurement

WARNING

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

Note: Make sure that you turn the flywheel (1, Fig. 1) and pinion (2) in the correct direction (The arrows show the correct direction.)

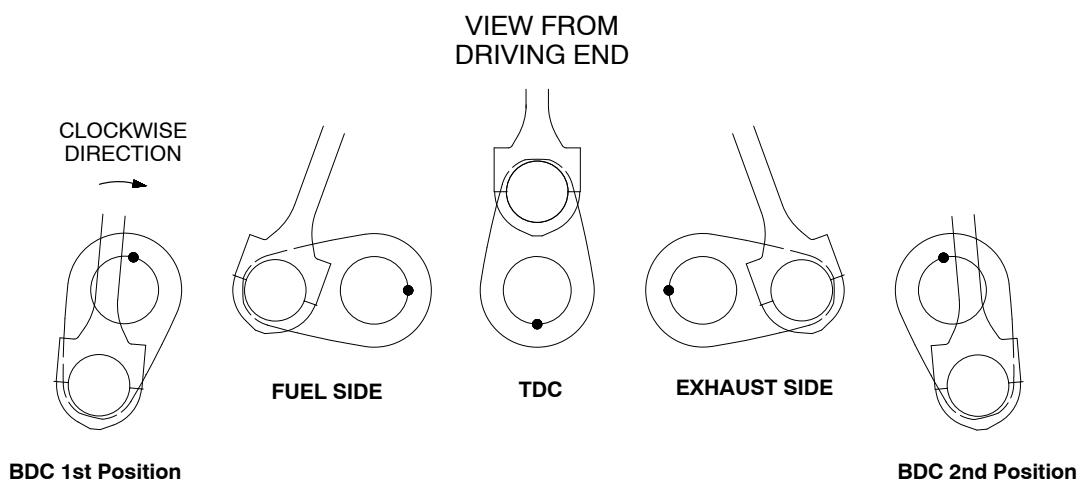
Measuring Crank Deflection

Note: Step 1) is applicable only for a cold engine. If the engine has usual operation temperature, continue from step 2).

- 1) Make sure that the tank heater and lubricating oil separator are set to off a minimum of eight hours.
 - 2) Use the turning gear to move the crank into the BDC 1st position (see Fig. 2).
 - 3) Attach the dial gage (94305) to the connecting rod. Make sure that the dial gage goes into the center punch marks.
 - 4) Turn the rod of the dial gage to apply tension.
 - 5) Set the dial gage to zero. The dial gage must not have a difference of more than 0.01 mm.
 - 6) Use the turning gear to move the crank to each position shown. At each position, record the indications on the dial gage.

Note: The change in the distance between the crank webs can be read from the dial gage. The smaller the difference, the better the crankshaft is aligned.

- 7) If the difference between the two BDC positions is more than 0.05 mm, you must do the check again.



CRANK DEFLECTION SIGN ON DIAL GAGE

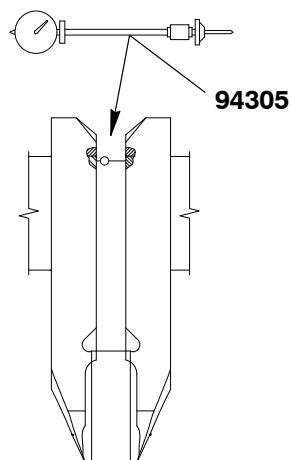
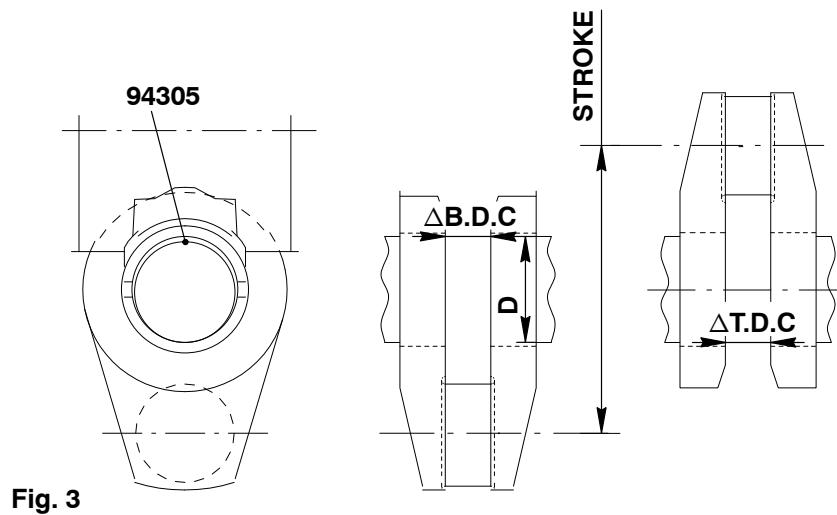


Fig. 2

Measuring Crank Deflection

4. Date Evaluation



The difference between the indicated values shows the crank deflection during one full turn ([Fig. 2](#)).

Where values are measured, which are above the maximum permitted limits, you must find the cause (e.g. defective main bearing, engine stay changed because hull deformation, loose hold-down bolts, defective propeller shaft bearings, equipment 94305 etc.).

The limits are applicable for all conditions of ship operation after delivery i.e.:

- The draught and trim of the ship are in the limits for usual operation.
- The engine is hot or cold.

Table 1: Deflection Limits

Usual Ship Operation: Crank-web Deflection Limits (mm)				
Vertical			Horizontal	
Cylinder No. 1 (Driving End)	Cylinder No. 2 to Last but One cylinder	Last Cylinder (Free End)	All Cylinders	
		Note 1) Note 2)		
0.56 -0.56	0.40 -0.40	0.40 -0.40	0.40 -0.56	0.18 -0.18

- 1) For engines without a torsional vibration damper, front disc or free end Power Take Off.
- 2) For engine with a torsional vibration damper, front disc or free end Power Take Off.

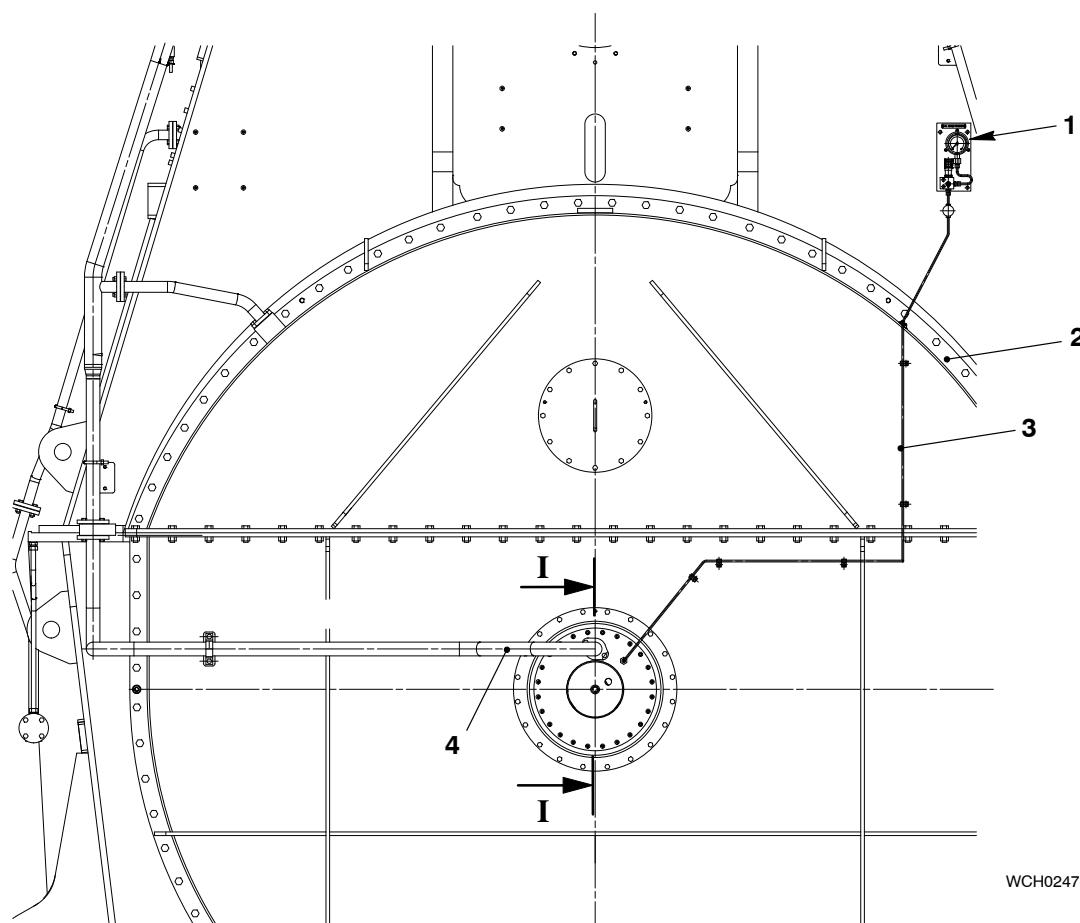
Speak to Wärtsilä Switzerland, if the last data is more than the limits given in the table above.

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Vibration Damper**Inspection (GEISLINGER Vibration Damper)****1. General**

Depending on the design execution of an engine, a GEISLINGER vibration damper 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.

**Fig. 1****Fig. 1: Vibration damper, front view**

- | | |
|-------------------------------|-------------------|
| 1 Vibration damper monitoring | 3 Monitoring pipe |
| 2 Damper casing | 4 Oil supply pipe |

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).

CAUTION



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 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.

CAUTION



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.

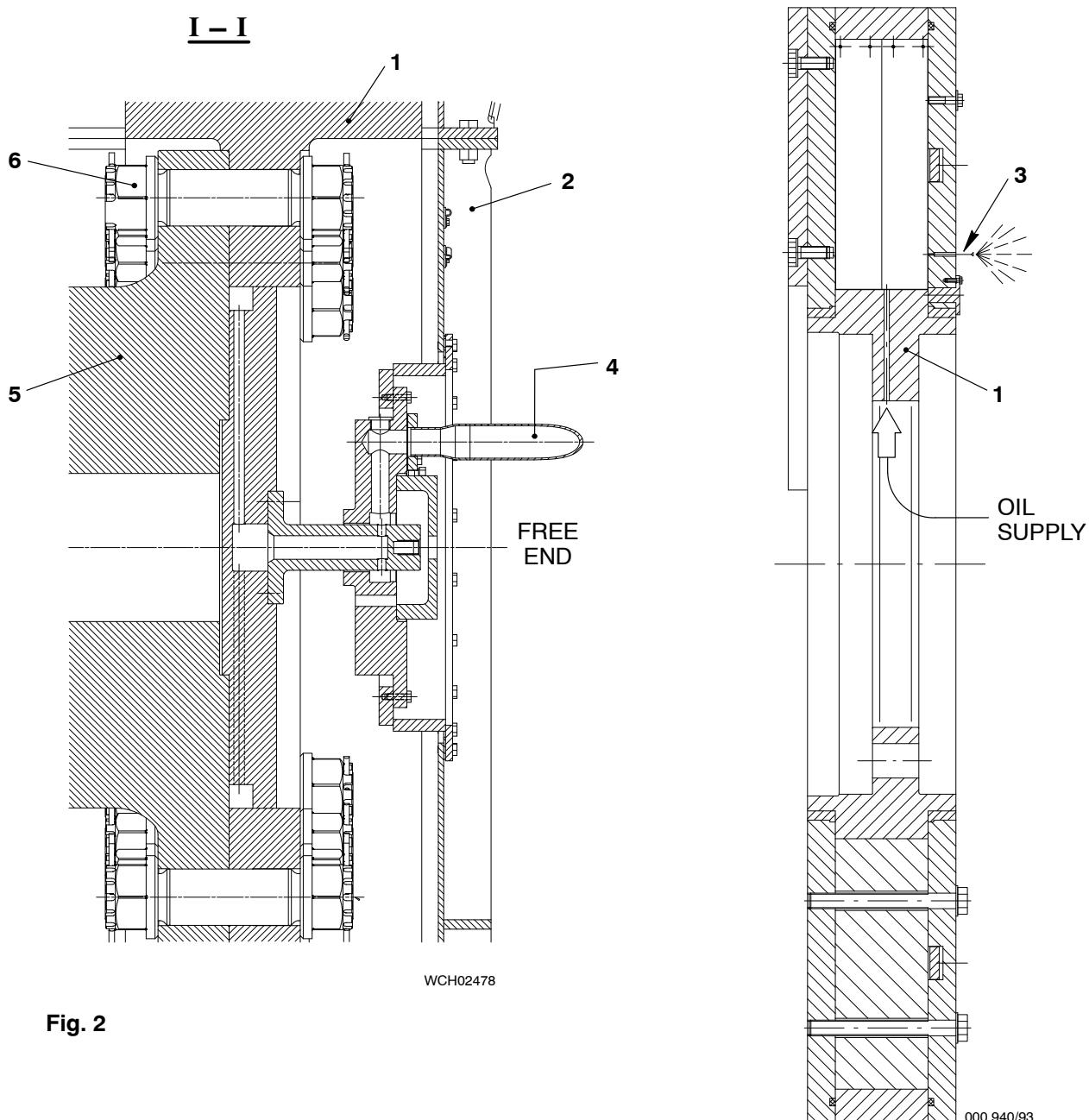
- For tightening values of coupling bolts 6 see 0352-1.

Note: 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)

**Fig. 2****Fig. 2: Vibration damper, front view**

- | | |
|--------------------|-------------------|
| 1 Vibration damper | 4 Oil supply pipe |
| 2 Damper casing | 5 Crankshaft |
| 3 Vent nozzle | 6 Coupling bolt |

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Axial Detuner

Disassembly and Assembly

Tools:

1 Spur-gearied chain block	94017-005	2 Eye bolt	94045-M20
1 Shackle	94018A	1 Chain	94335A

1. Preparation	1
2. Disassembly	2
3. Assembly	4
4. Completion	5

1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Stop the engine.
- 3) Remove the copper pipe (2, [Fig. 1](#)) from the needle valve (1), the damper housing (4) and the hose clips (3).
- 4) Remove the oil inlet pipe (7) from the flange (8).
- 5) Remove the two pipes from the screw-in unions (6).

Note: For data about the axial damper monitor, see the Operating Manual 3140-1, paragraph 3.

- 6) Remove the top housing (5, 640 kg) with a suitable lifting device.

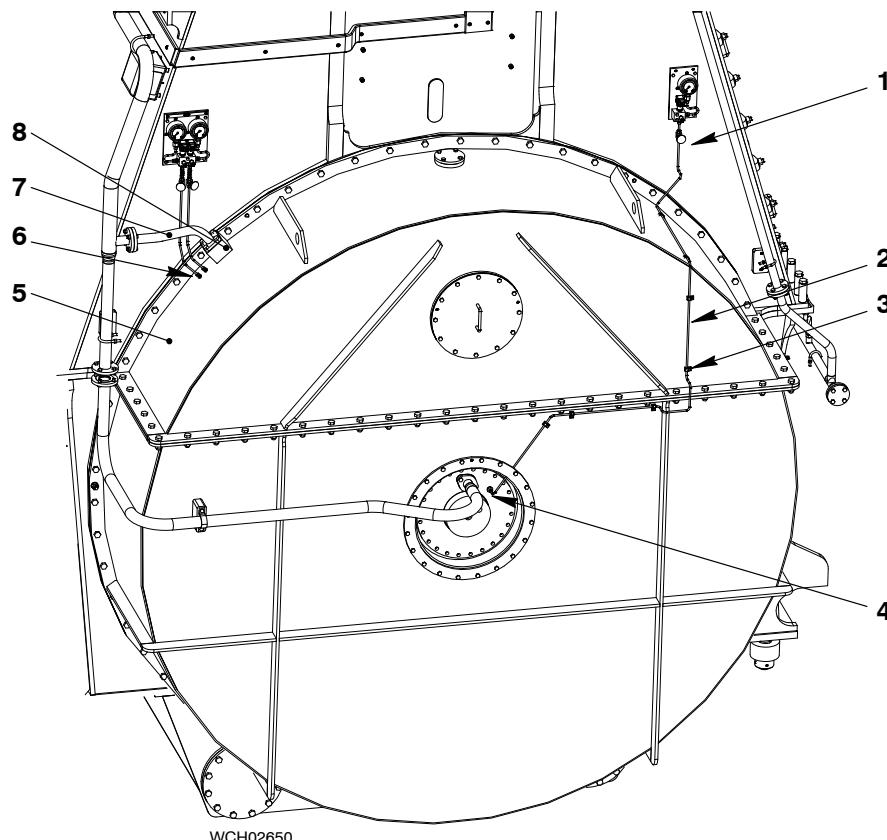


Fig. 1

2. Disassembly

- 1) Remove the two pipes (4, Fig. 2).
- 2) Remove the oil inlet pipe (5) and the two non-return valves (6).
- 3) Remove the six bolts (3).
- 4) Remove the four bolts (1).

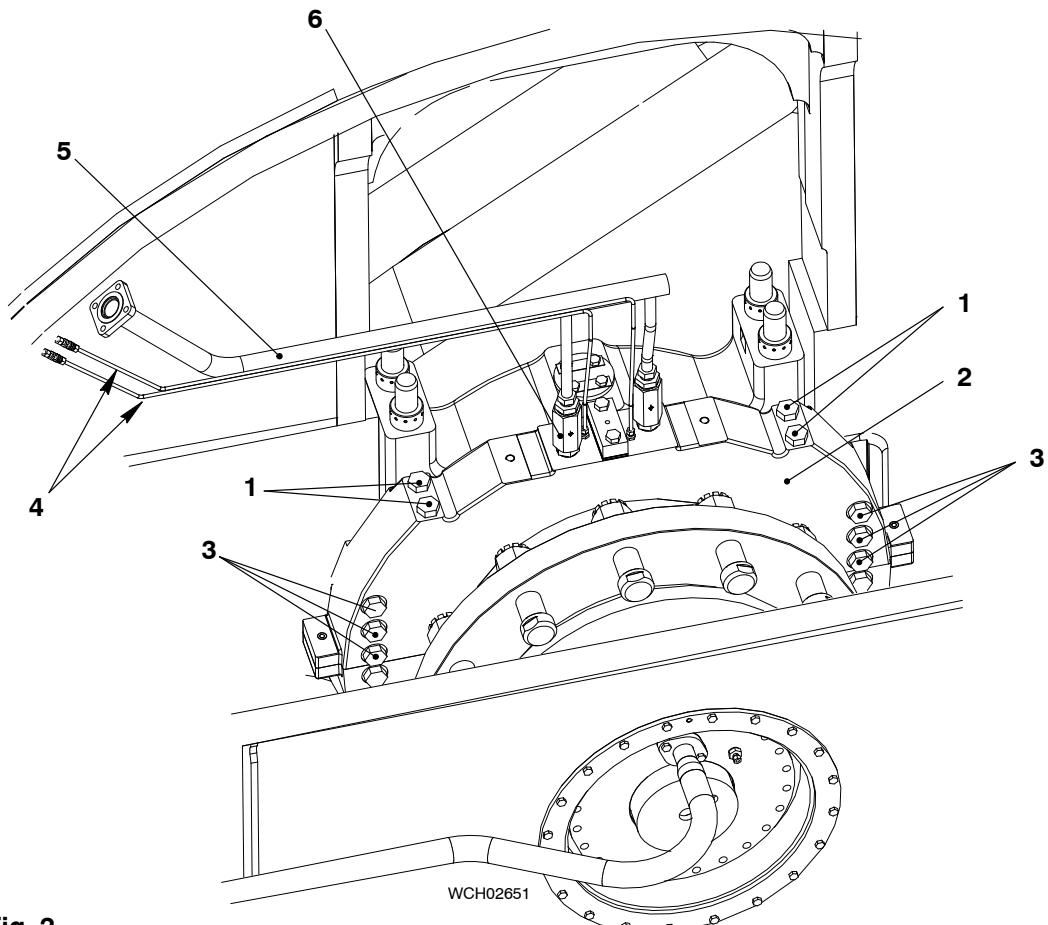
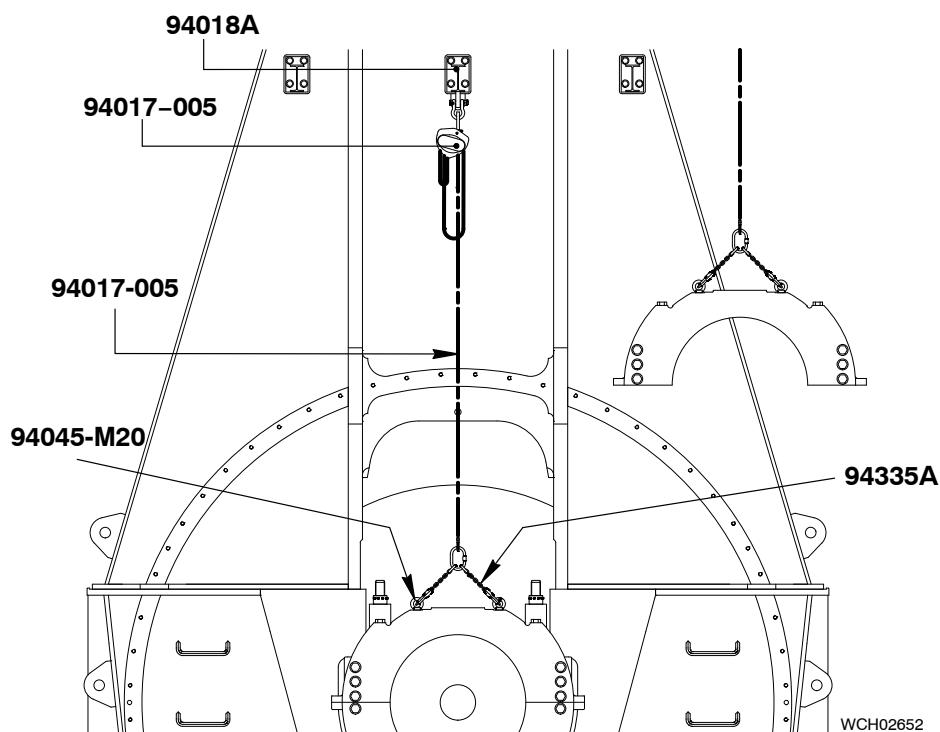


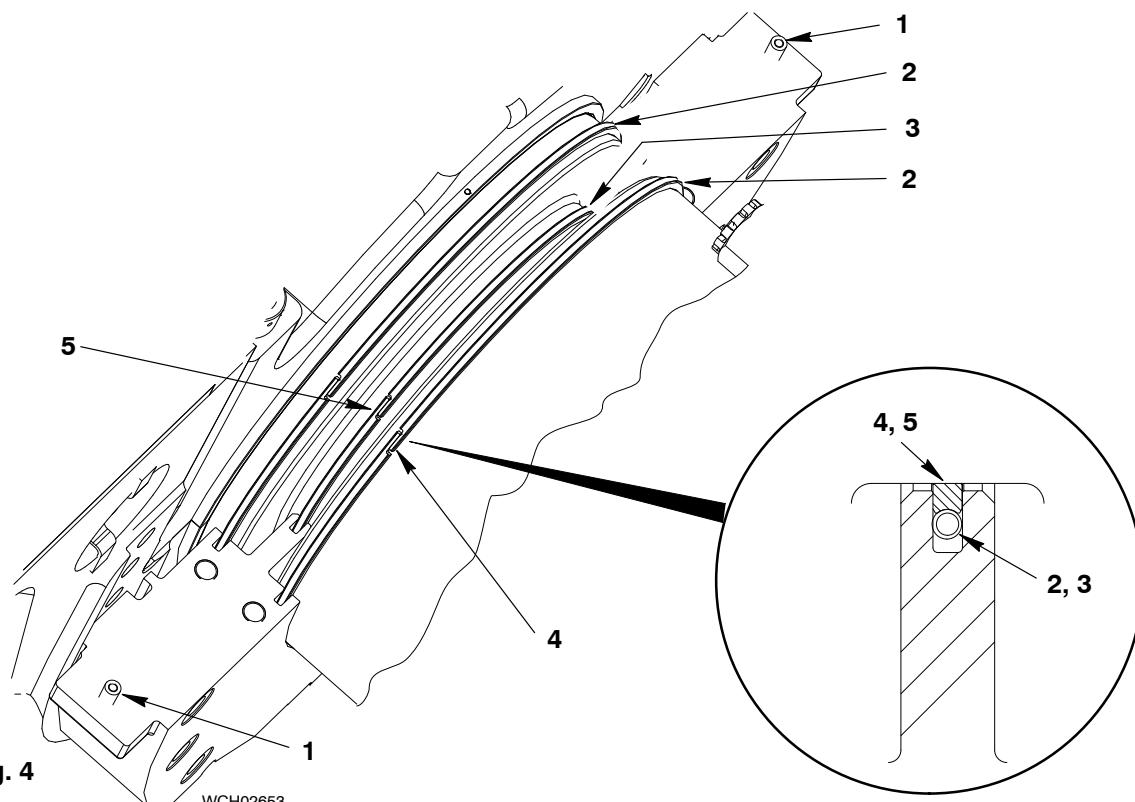
Fig. 2

- 5) Attach two eye bolts (94045-M20, Fig. 3) to the top cylinder.
- 6) Attach the chain (94335A) to the eye bolts (94045-M20).
- 7) Attach the shackle (94018A) to the strong-point.
- 8) Attach the spur-gearied chain block (94017-005) to the shackle (94018A) and the chain (94335A).
- 9) Attach the engine room crane to the chain (94335A).
- 10) Operate the spur-gearied chain block (94017-005) and the engine room crane to lift and move the top cylinder to an applicable area.
- 11) Lower the top cylinder on to an applicable surface.

Axial Detuner: Disassembly and Assembly

**Fig. 3**

- 12) Do a check of the two part gaskets (2 and 3, Fig. 4). If the 2-part gaskets have damage or contamination, do step a) and step b).
- Carefully remove the tension springs (4, 5).
 - Remove and discard the 2-part gaskets (2, 3).

**Fig. 4**

3. Assembly

- 1) Apply clean engine oil to the new 2-part gaskets.
- 2) Attach the new 2-part gaskets (2 and 3, [Fig. 4](#)) to the axial detuner.
- 3) Make sure that the new 2-part gaskets (2, 3) can move freely around the axial detuner.
- 4) Put the tension springs (4, 5) around the 2-part gaskets (2, 3).
- 5) Use the engine room crane and spur-geared chain block (94017-005, [Fig. 3](#)) to move the top cylinder into position above the bottom cylinder.
- 6) Remove the hook of the engine room crane from the top cylinder.
- 7) Use the spur-geared chain block (94017-005) to carefully lower the top cylinder into position on the bottom cylinder. Make sure that you do not damage the tension springs and 2-part gaskets.

Note: Use the two taper pins (1, [Fig. 4](#)) to help you get the top cylinder in the correct position.

- 8) Install the four M30 bolts (1, [Fig. 5](#)). Refer to [0352-2](#), paragraph 1 for the applicable torque value.
- 9) Apply Molykote paste to the threads of the six bolts (3).
- 10) Torque the six M30 bolts (3) to 900 Nm (40°).
- 11) Attach the two pipes (4) to the top cylinder (2).
- 12) Attach the oil inlet pipe (5) and the two non-return valves (6).

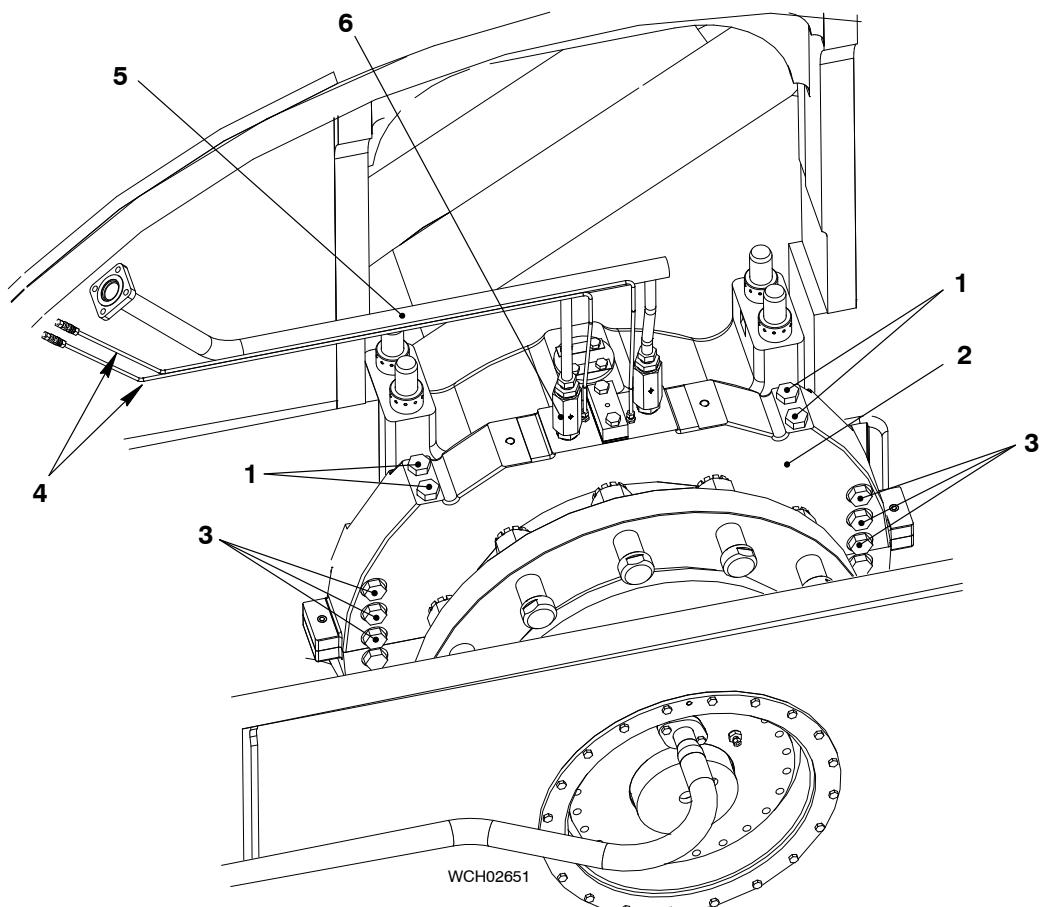


Fig. 5

Axial Detuner: Disassembly and Assembly

4. Completion

- 1) Attach the top housing (5, Fig. 6).
- 2) Connect the two pipes to the screw-in unions (6).
- 3) Attach the oil inlet pipe (7) to the flange (8).
- 4) Connect the copper pipe (2) to the needle valve (1), hose clips (3) and damper housing (4).

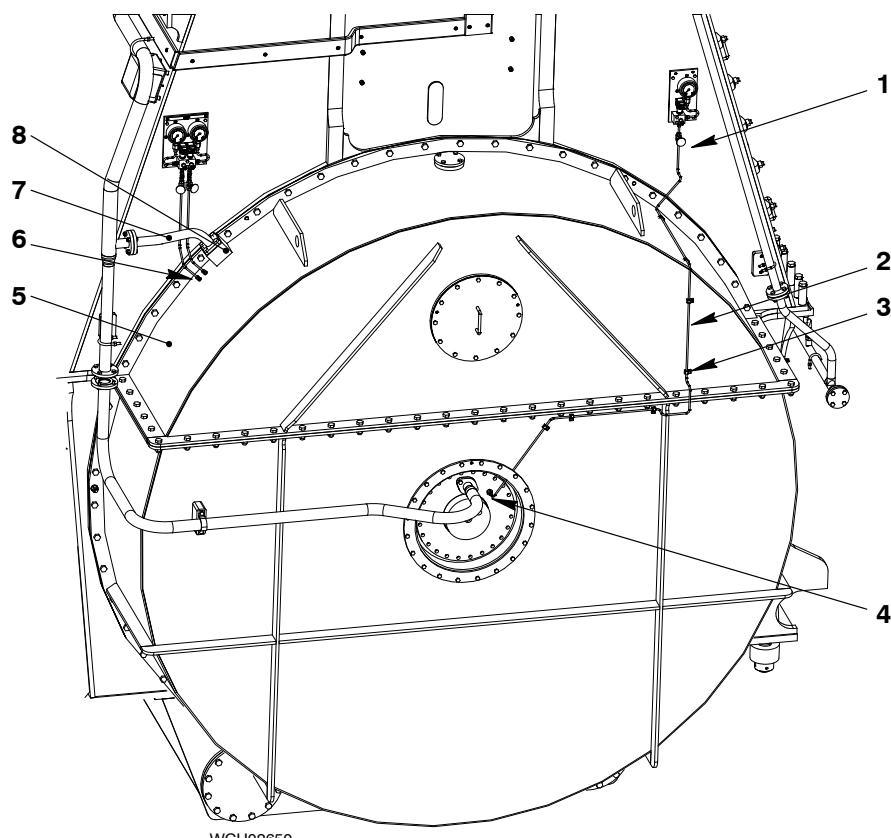


Fig. 6

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Turning Gear

Teeth and Screwed Connections – Check

Tools:

1 Pre-tensioning jack 94320

1. General

Before you operate the turning gear (1, Fig. 1) you must do a check of the condition of the tooth flanks on the pinion (2) and the flywheel (3). Also you must make sure that there is lubricant applied to these components.

For maintenance of the turning gear, refer to the instructions given in the supplier documentation.

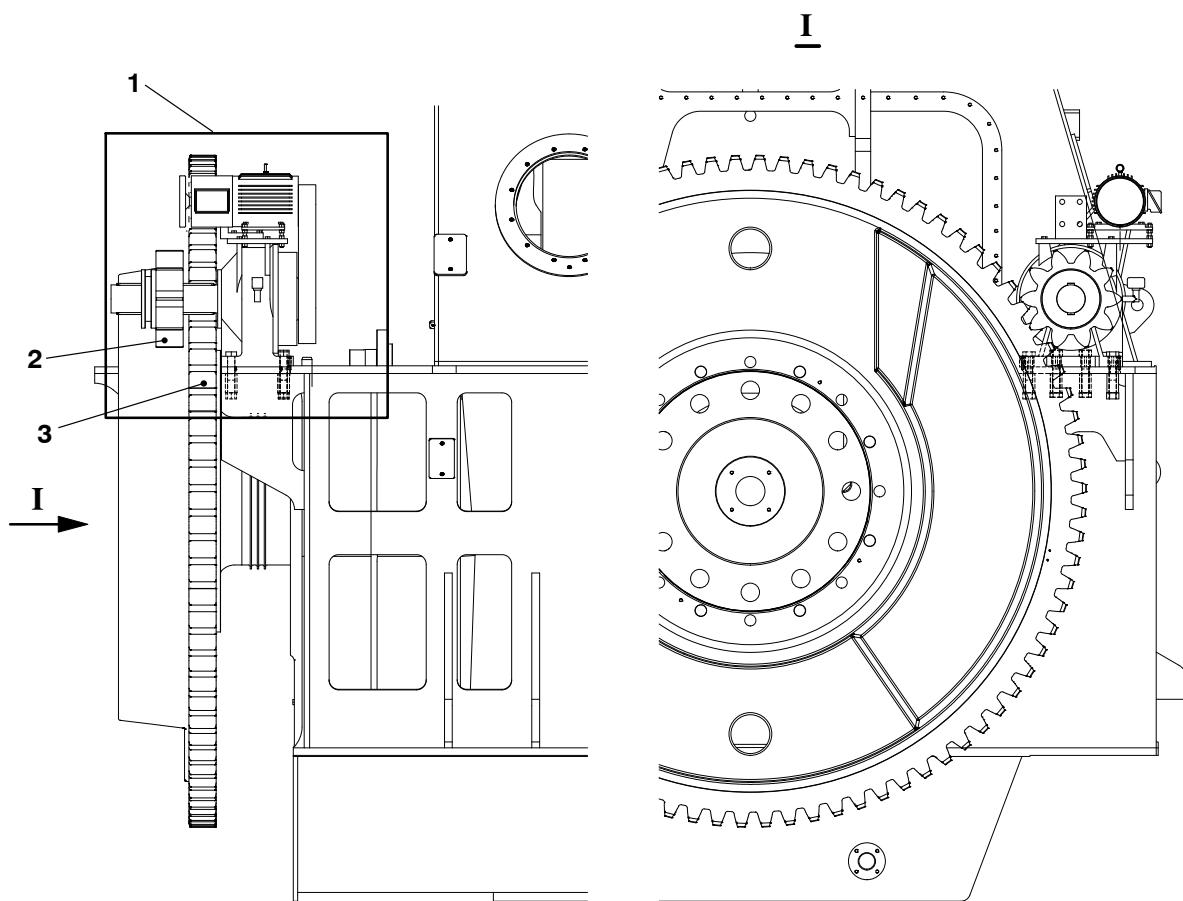


Fig. 1

2. Tooth Checks

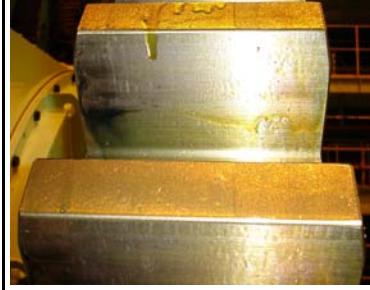
2.1 Lubricant Instructions

Apply a very thin, equal layer of lubricant to the tooth flanks of the pinion (2, Fig. 1) and the flywheel (3). Refer to Table 1 and Table 2.

Table 1: Instructions – Pyroshield

	Manufacturer	Location	Instruction
	LE 5182 Pyroshield		Apply a thin layer of the lubricant to the teeth as shown in the photograph.

Table 2: Instructions – Klüberfluid

	Manufacturer	Location	Instruction
	Klüberfluid C-F 3 Ultra		Increase the temperature of the Klüberfluid. Put an applicable quantity of Klüberfluid into a container. Put the container into warm water until the Klüberfluid is at approximately 35°C. Apply the Klüberfluid as shown in the photograph.

2.2 Lubrication Intervals

- 1) Look at the tooth flanks. If the highest loaded areas of the tooth flanks do not have much lubricant, apply the lubricant as given in Table 1, or Table 2.
- 2) Apply the lubricant each 2000 operation hours, or as necessary.

2.3 Recommended Suppliers

Lubrication Engineers Inc.
 300 Bailey Avenue
 Fort Worth, TX
 USA
<http://www.lelubricants.com/>
 Email: info@le-inc.com

Klüber Lubrication München KG
 Geisenhausenerstrasse 7
 81379 München
 Germany
<http://www.klueber.com>
 Email: info@klueber.com

Crankcase

Work Platform

Tools:

- | | |
|--|-------|
| 2 Platform, each platform includes three grids | 94142 |
| 2 Support | 94143 |

1. General

You use the platform (94142, Fig. 1) and platform (94143) when you do work in the crank area and between the columns. The platforms help to prevent accidents in these areas.

You install the platform (94143) on the longitudinal beam (1) and the crank (2).

You install the platform (94142) at the applicable height on the steps (3) between the columns. This support is adjustable between 725 mm and 902 mm.

WARNING

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

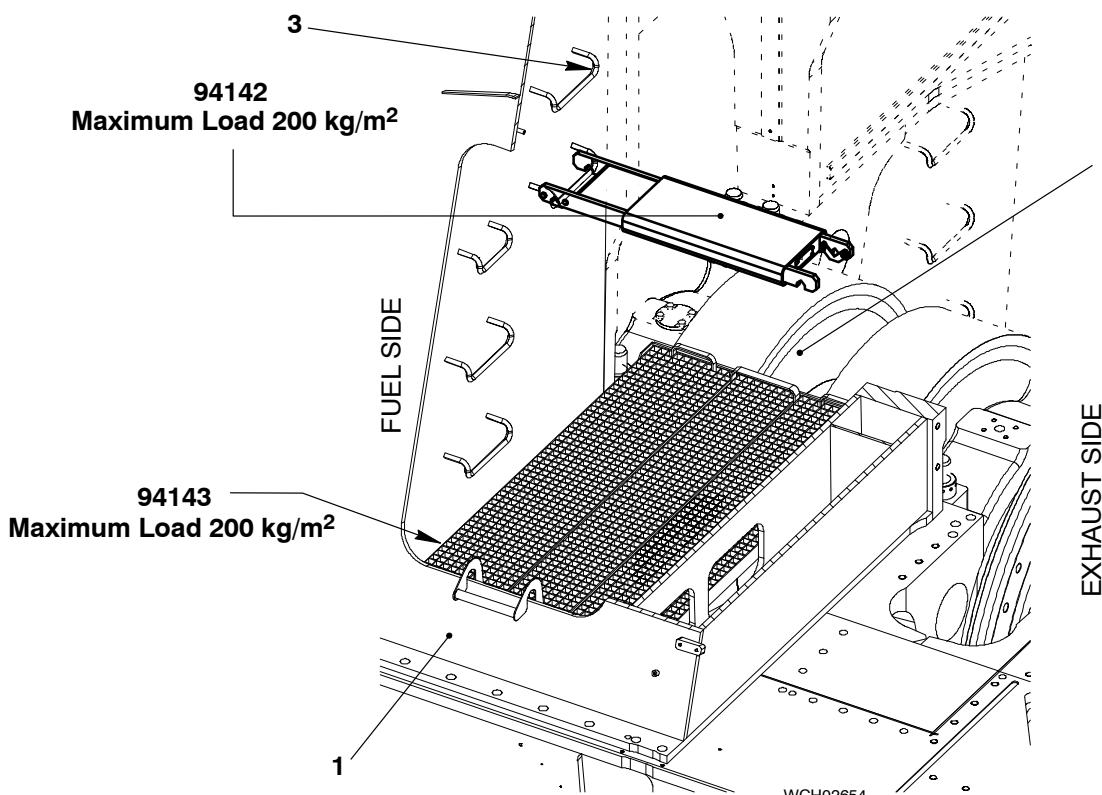


Fig. 1

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Connecting Rod

Bottom End Bearing – Removal, Inspection and Installation

Tools:

2	Manual ratchet H1/H5 1600kg	94016-009	4	Eye bolt M8	94045-M8
2	Manual ratchet H2/H3, 2500kg	94016-011	1	Deviation pipe	94117B
1	Manual ratchet H4, 6300kg	94016-017	1	Chain	94327
4	Shackle, 4750	94018B	1	Console Frame	94326
2	Shackle, 8500	94018C	2	Support	94322
1	Chain, 5300kg	94019B	1	Support (for ELBA)	94322A

1.	Preparation	1
2.	Bearing Cover – Removal	1
3.	Bearing Shell – Removal	2
4.	Top Bearing Shell – Inspection	3
5.	Top Bearing Shell – Removal	4
6.	Top Bearing Shell – Installation	5
7.	Bottom Bearing Shell – Installation	6
8.	Bearing Cover – Installation	6

1. Preparation

WARNING

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

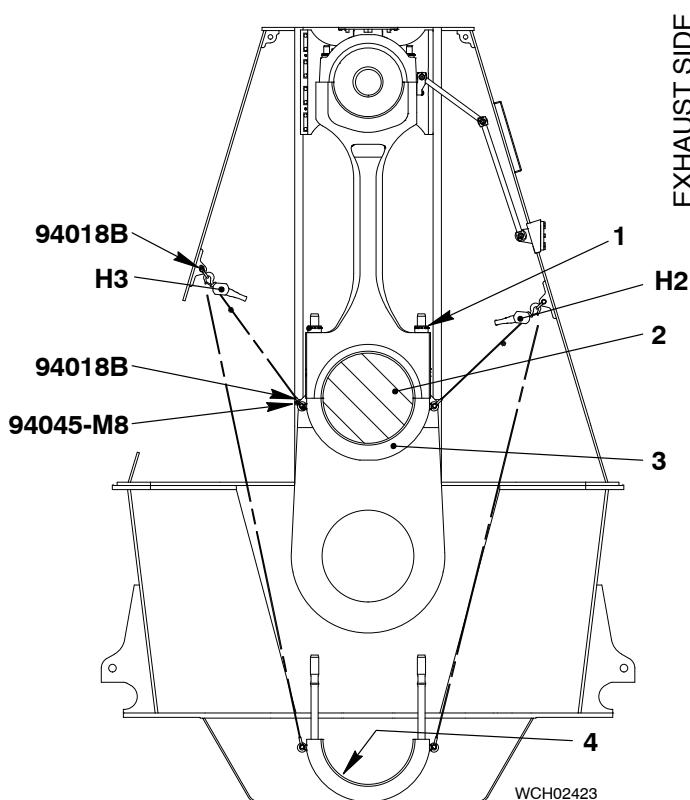


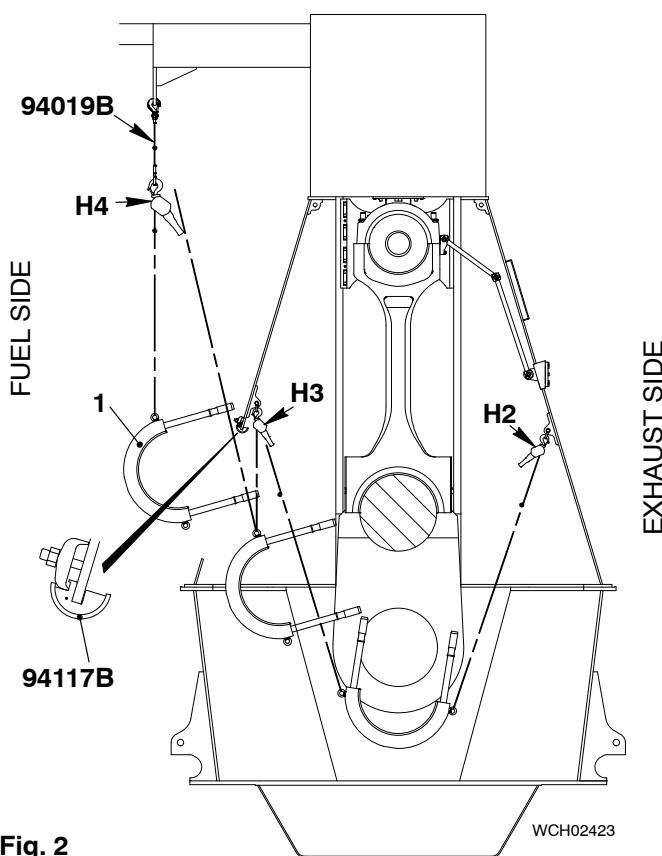
Fig. 1

- 1) Use the turning gear to turn the crankshaft until the applicable crank (2) is at TDC.
- 2) Lock the turning gear.
- 3) Attach the eye bolts (94045-M8, Fig. 1) to the bearing cover (3).
- 4) Attach the manual ratchets (H2, H3) and shackles (94018B) to the column.
- 5) Connect the hooks and shackles (94018B) to the eye bolts on the bearing cover (3).
- 6) Apply a light tension to the manual ratchets (H2, H3).

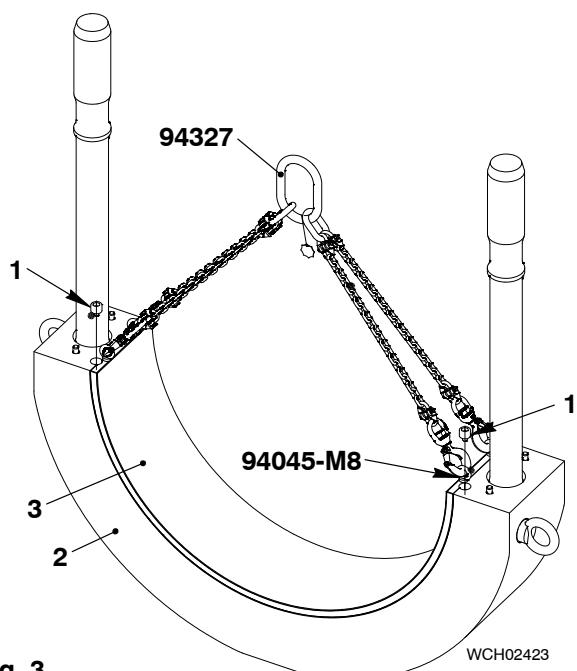
2. Bearing Cover – Removal

- 1) Loosen, then remove the round nuts (1) (see 9403-4 paragraph 2).
- 2) Operate the manual ratchets (H2, H3) to carefully lower the bearing cover (3).
- 3) Do an inspection of the bearing shell (4).
- 4) If the bearing shell (4) is in good condition, lower the bearing cover to the bottom of the crankcase.

Bottom End Bearing – Removal, Inspection and Installation



- 5) Attach the chain (94019B, Fig. 2) to the gallery.
- 6) Attach manual ratchet (H4) to the chain (94019B).
- 7) Install the deviation pipe (94117B) to the column.
- 8) Operate the manual ratchet (H2, H3) to move the bearing cover (1) to the fuel side.
- 9) Disconnect the manual ratchet (H2) from the bearing cover (1).
- 10) Connect the hook of the manual ratchet (H4) to the bearing cover (1).
- 11) Lift bearing cover (1) out of the crankcase.



3. Bearing Shell – Removal

- 1) Remove the two screws (1, Fig. 3).
- 2) Install the four eye bolts (94045-M8).
- 3) Attach chain (94327) to the four eye bolts (94045-M8).
- 4) Lift the bearing shell (3) from the bearing cover (2).

Bottom End Bearing – Removal, Inspection and Installation

4. Top Bearing Shell – Inspection

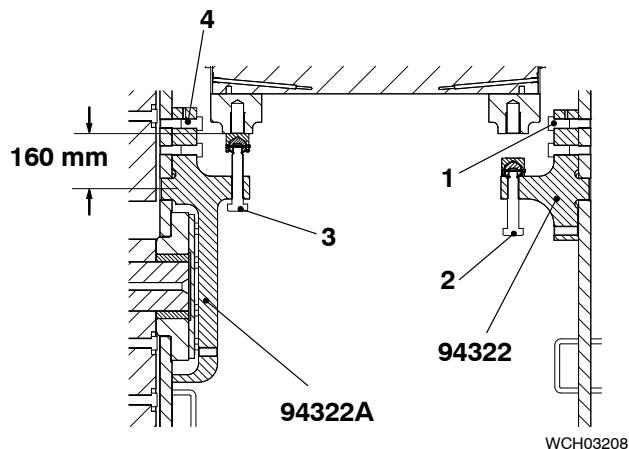
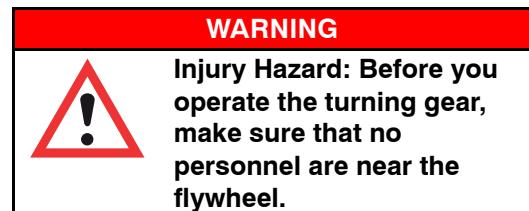


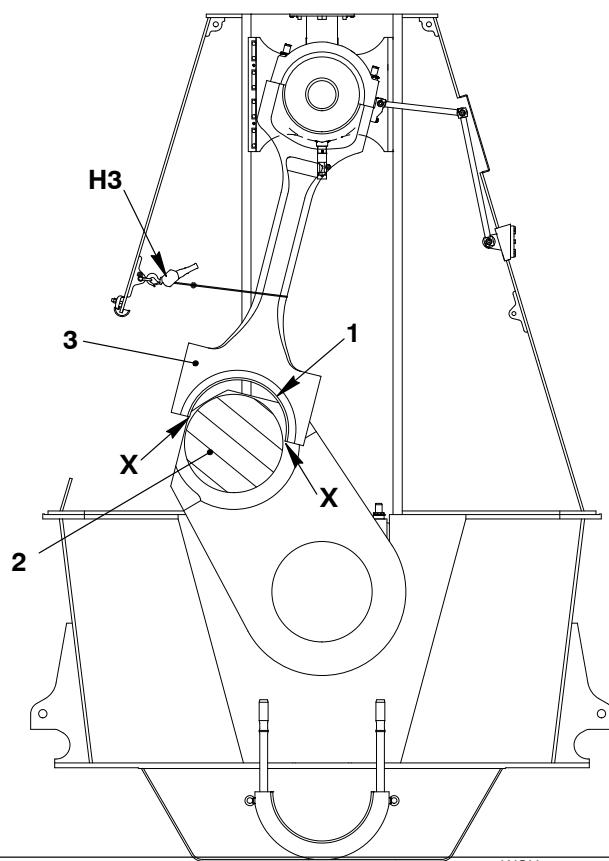
Fig. 4



- 1) Unlock the turning gear.
- 2) Use the turning gear to turn the crank to fuel side until the crosshead is approximately 300 mm above the plug bore center (see Fig. 4).

Note: Fig. 4 shows an engine with electric Balancer (iELBA). Use two supports 94322 for engines without balancer.

- 3) Put a small quantity of clean oil on the four bolts(1, 4).
- 4) Attach the two supports (2x 94322 or for iELBA: 1x 94322A and 1x 94322) with the four bolts (1, 4).
- 5) Torque the four bolts (1, 4) to 300 Nm.
- 6) Use the turning gear to lower crosshead for 140 mm (160 mm above plug bore center).
- 7) Tighten the special screws (2, 3) on each support.



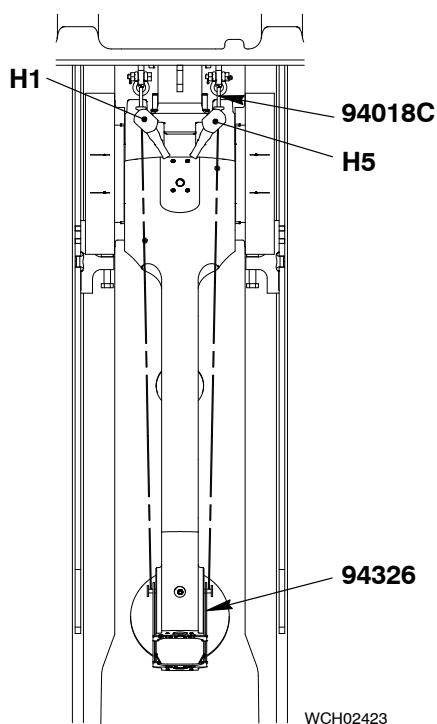
- 8) Put the chain of the manual ratchet (H3, Fig. 5) around the connecting rod (3).
- 9) Use the turning gear to turn the crank to the fuel side. At the same time, operate the manual ratchet (H3) to keep a light tension on the chain.

Note: Make sure that there is no load on the corners (X) of bearing shell (1).

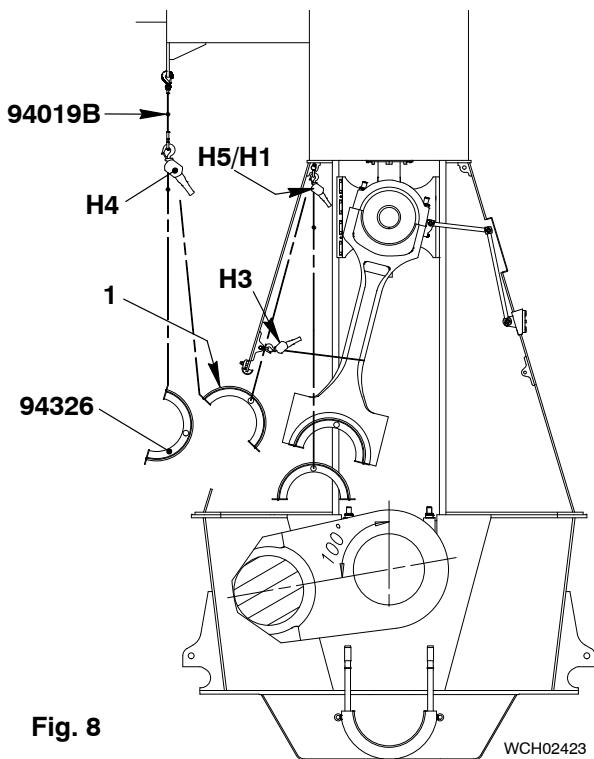
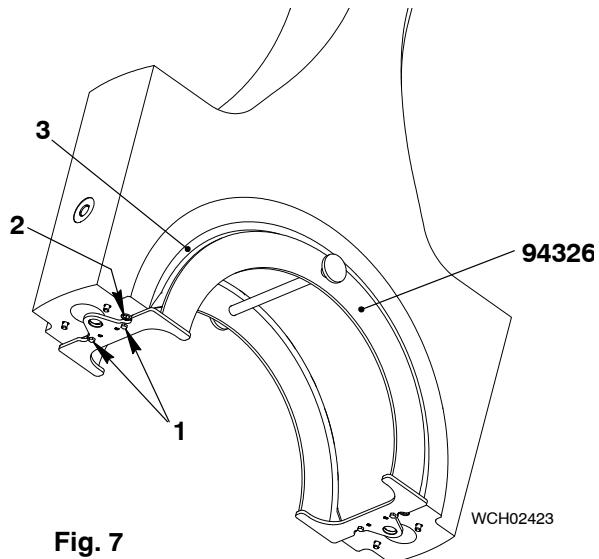
- 10) Use the turning gear to turn the crank to 100° after TDC.
- 11) Do an inspection of the top bearing shell.

Bottom End Bearing – Removal, Inspection and Installation

5. Top Bearing Shell – Removal

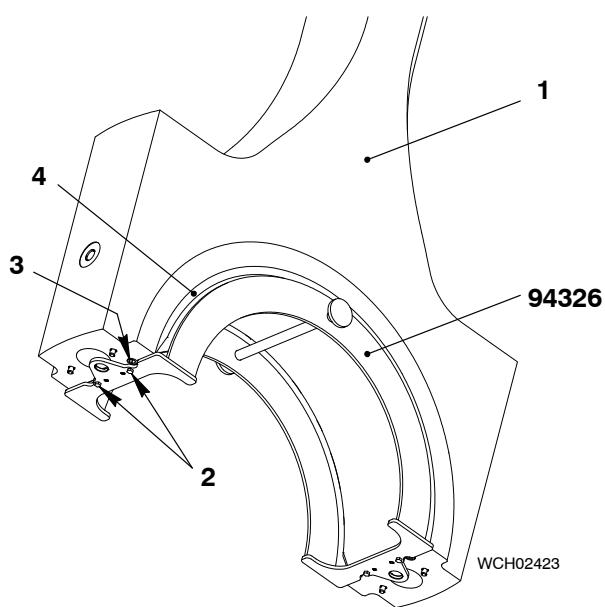
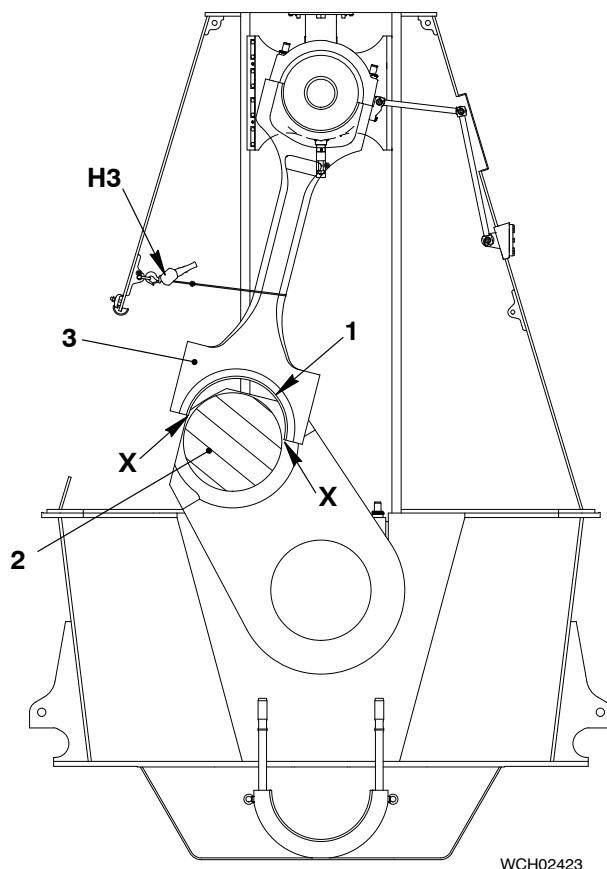


- 1) Attach the manual ratchets (H1, H5) [Fig. 6](#)) and the shackle (94018C) to the column.
- 2) Attach the console frame (94326, [Fig. 7](#)) to the bearing shell (3) with the four screws (1).
- 3) Connect the hooks of the manual ratchets (H1, H5) to the console frame (94326).
- 4) Apply a light tension the chains ([Fig. 6](#)).
- 5) Remove the two screws (2, [Fig. 7](#)).



- 6) Operate the manual ratchets (H5, H1 [Fig. 8](#)) to lower the console frame (94326) together with the bearing shell (1).
- 7) Attach the hook of manual ratchet (H4) to the eyelet in the console frame (94326).
- 8) Operate the manual ratchets (H1, H5) to move the console frame from the column.
- 9) Lower the console frame (94326) and bearing cover (1) to an applicable area.
- 10) Remove the manual ratchets (H1/H5).
- 11) Remove the console frame (94326).

Bottom End Bearing – Removal, Inspection and Installation

**Fig. 9****Fig. 10**

6. Top Bearing Shell – Installation

- 1) Clean the seating surface bearing shell.
- 2) Put the bearing shell on the console frame (94326, [Fig 9](#)), then tighten the four screws (2).
- 3) Clean the seating surface of the connecting rod (1) and the bearing shell (4).
- 4) Attach the manual ratchet (H4) to the console frame (94326).
- 5) Operate the manual ratchet (H4) to lift the console frame (94326) into position.
- 6) Attach the manual ratchets (H5, H1 [Fig. 8](#)) to the console frame (94326).
- 7) Remove the manual ratchet (H4).
- 8) Put oil on the surface of the bearing shell.
- 9) Operate the manual ratchets (H1, H5) to move the console frame 94326 and bearing shell into position.

Note: Make sure that the distance between each end of the bearing shell and the connecting rod rod is the same.

- 10) Attach the bearing shell (4, [Fig 9](#)) to the connecting rod (1) with the two screws (3).
- 11) Remove console frame 94326.
- 12) Make sure that the surface of the crank pin (2, [Fig. 10](#)) is in a satisfactory condition.
- 13) Put oil on the crank pin.

WARNING

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

- 14) Use the turning gear to move the crank to TDC. At the same time, make sure that there is no load at points (X).
- 15) Remove the two supports (94322, [Fig. 4](#)).

Bottom End Bearing – Removal, Inspection and Installation

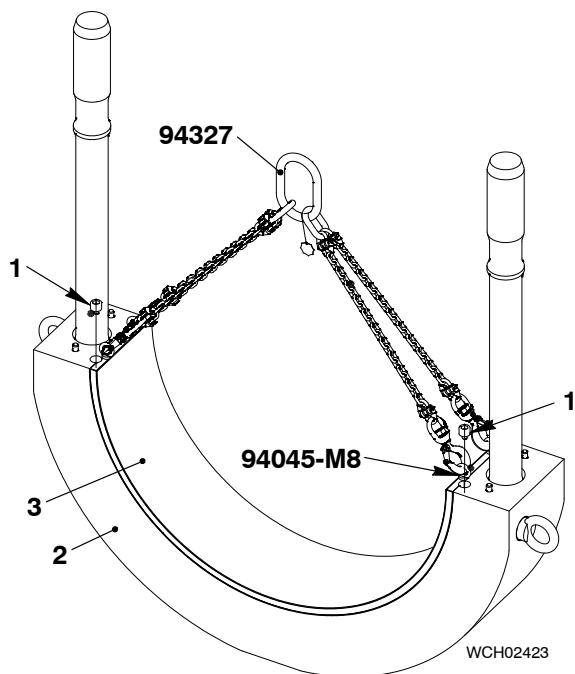


Fig. 11

7. Bottom Bearing Shell – Installation

- 1) Attach the four eye bolts (94045-M8, Fig. 11) to the bottom bearing shell (3).
- 2) Attach the chain (94327) to the four eye bolts (94045-M8).
- 3) Lift the bottom bearing shell (3).
- 4) Clean the seating surface of the bearing cover (2) and the bearing shell (3).
- 5) Put oil on the surface of the bearing shell.
- 6) Attach the bottom bearing shell (3) to the bearing cover (2) with four screws (1).

Note: Make sure that the distance between each end of the bearing shell and the connecting rod rod is the same.

- 7) Remove the chain (94327) and the four eye bolts (94045-M8).

8. Bearing Cover – Installation

- 1) Attach the chain (94019B, Fig. 12) to the gallery.
- 2) Attach the manual ratchet (H4) to the chain (94019B) and the eye bolt on the bearing cover (1).
- 3) Move the bearing cover (1) into the crankcase.
- 4) Attach the manual ratchets (H2, H3) to the column and the bearing cover (1).
- 5) Remove the manual ratchet (H4).
- 6) Operate the manual ratchets (H2 H3) to lift the bearing cover (1) into position.

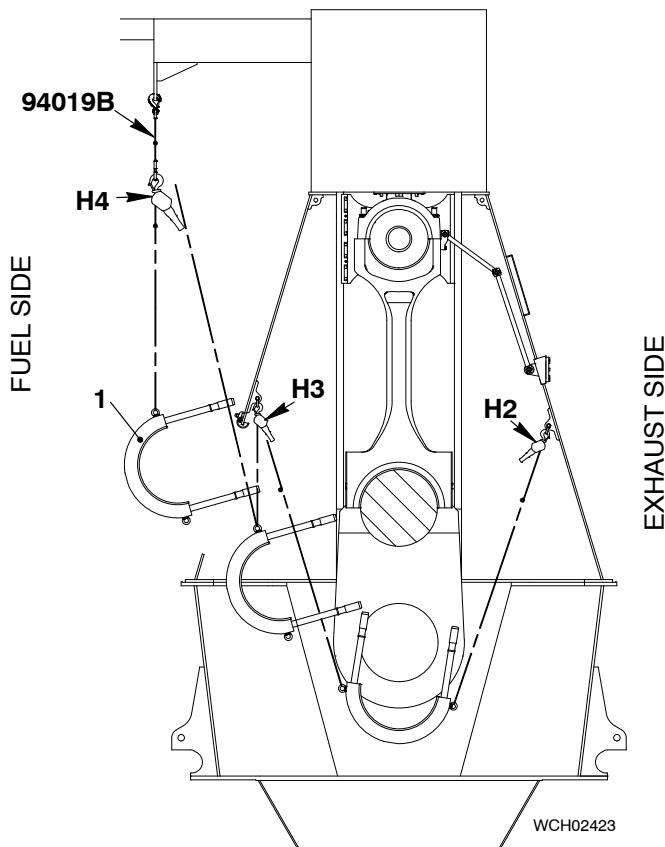


Fig. 12

Bottom End Bearing – Removal, Inspection and Installation

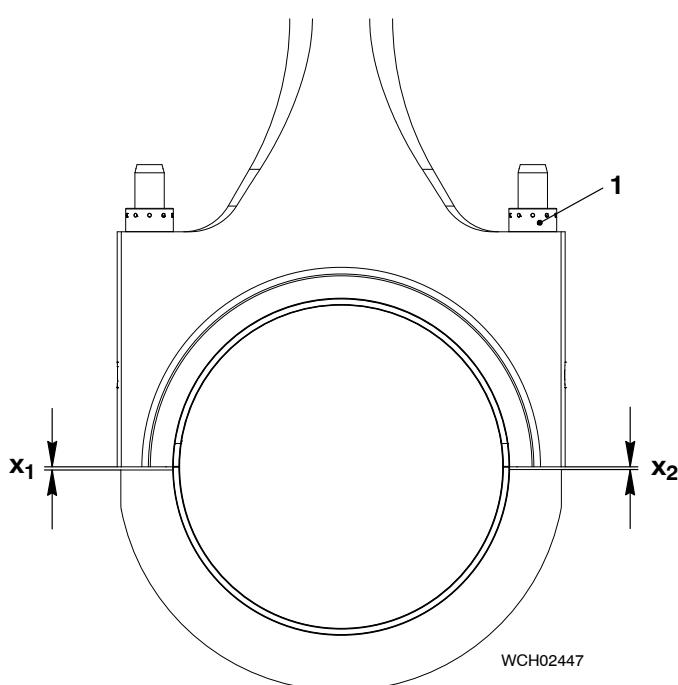


Fig. 13

- 7) Make sure that the bearing shell is clean.
- 8) Put oil on the bearing shell as follows:
 - a) If you start the engine immediately after completion of this procedure, use only bearing oil.
 - b) If the engine has stopped for some days, use a mixture of high-viscosity oil (steam engine cylinder oil, ISO VG 1000/1500) and bearing oil. The ratio is two thirds ISO VG 1000/1500 to one third bearing oil.

Note: A list of suppliers for ISO VG 1000/1500 high viscosity oils is given in Table 1.

- 9) Put the round nuts (1, Fig. 13) on the elastic studs.
- 10) Tighten the round nuts (1) equally with a round bar.
- 11) Measure the distances (X1, X2) between the edges of the bearing shells and the bearing cover.
- 12) Refer to 0330-1 Group 3303 to get the clearance values (X1, X2) for new bearing shells.
- 13) Apply tension to the elastic studs, refer to 9403-4, paragraph 3.
- 14) Remove all tools and equipment from the area.

Table 1: ISO G 1000/1500 Suppliers

Supplier	Type	Viscosity at 40°C mm ² /s	Viscosity at 100°C mm ² /s	Weight at 15°C g/ml
BP	ENERGOL DC 1000	980	49.0	0.913
BP	ENERGOL DCW 1000	920	40.0	0.913
CHEVRON	CYLINDER OIL 1000	1000	43.1	0.937
EXXON/ESSO	CYLESSO 1000	950	44.0	
EXXON/ESSO	CYLESSO TK 1000	925	46.7	
MOBIL	EXTRA HECLA SUPER Cylinder Oil	680	39.0	0.905
SHEEL	FIONA Oil 1500	1500	37.0	0.958
SHEEL	VALVATA OIL 1000	1000	45.4	0.924
TEXACO	650T MINERAL Cylinder Oil	985	44.0	0.919

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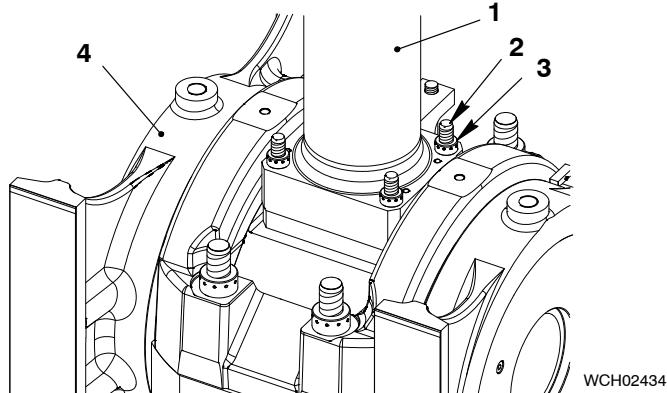
Connecting Rod

Top End Bearing – Removal, Inspection and Installation

Tools:

2	Manual ratchet, 2500kg, H1,H2	94016-011	1	Flange	94336
1	Manual ratchet, 6300kg, H3	94016-017	1	Lifting tool	94337
1	Chain 1120 kg	94327	1	Protection tool	94117B
1	Chain, 5300 kg	94019C	1	Platform	94143
2	Chain block, 3000kg, H4, H5	94017-017	2	Support	94322
4	Eye bolt	94045-M8	1	Support (for ELBA)	94322A
2	Eye bolt	94045-M36	1	Chain, 4-Sling, 1120kg	94327
2	Shackle, 8500kg	94018C	2	Pre-tensioning jack	94340
1	Stop plate	94335	2	Pre-tensioning jack	94315
2	Holders	94333	1	Lifting tool	94324

1.	Piston – Preparation	1
2.	Preparation	2
3.	Crosshead – Lift	3
4.	Bearing Shell – Removal	4
5.	Bearing Shell – Installation	5
6.	Completion	7
7.	Bearing Lubrication	8

**Fig. 1**

1. Piston – Preparation

WARNING


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

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Use the turning gear to turn the crank (4, [Fig. 1](#)) to BDC.
- 3) Loosen the elastic stud (2) of the piston rod foot (1) with pre-tensioning jack (94340), refer to [9403-4](#).
- 4) Remove the four round nuts (3).
- 5) Use the turning gear to turn the crank to TDC.

Top End Bearing – Removal, Inspection Installation

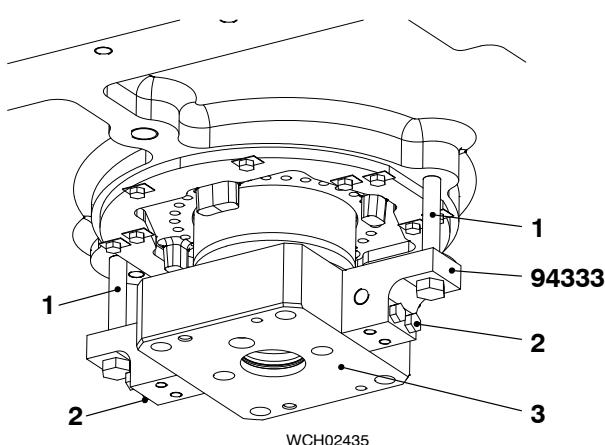


Fig. 2

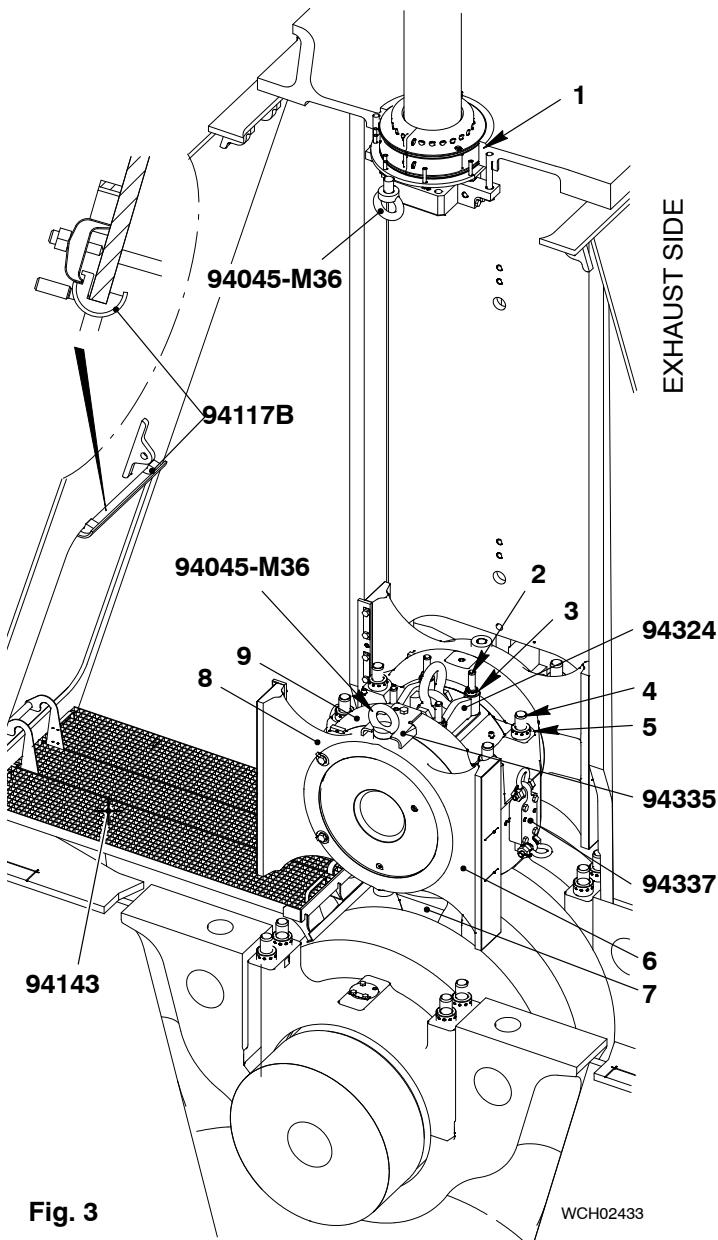


Fig. 3

- 6) If necessary, put oil on the two bolts (2, Fig. 2).
- 7) Install the two holders (94333) with the four bolts (2) to the piston rod foot (3).
- 8) Torque the four bolts (2) to 200 Nm.
- 9) Tighten the two bolts (1).
- 10) Use the turning gear to turn the crank to BDC. The connecting rod moves down away from the piston rod foot.
- 11) Lock the turning gear to prevent movement of the crankshaft.

2. Preparation

- 1) Install the platform (94143, Fig. 3).
- 2) Install an eye bolt (94045-M36) to a position near the gland box (1).
- 3) Install an eye bolt (94045-M36) to the guide shoe (8) (below the eye bolt near the gland box).
- 4) Install the protection tool (94117B) to the top of column opening.
- 5) Loosen the four elastic studs (4) of the connecting rod, refer to 9403-4.
- 6) Remove the four round nuts (5).
- 7) Put the lifting tool (94324) on to the elastic studs (2).
- 8) Attach the round nuts (5) to the elastic studs (4).
- 9) Tighten the round nuts (5) with the round bar (94005).
- 10) Install the stop plate (94335) to the bearing cover (9).
- 11) Install the lifting tool (94337) to each side of the connecting rod.
- 12) Tighten the four bolts of the lifting tool (94337) to 175 Nm.

Top End Bearing – Removal, Inspection Installation

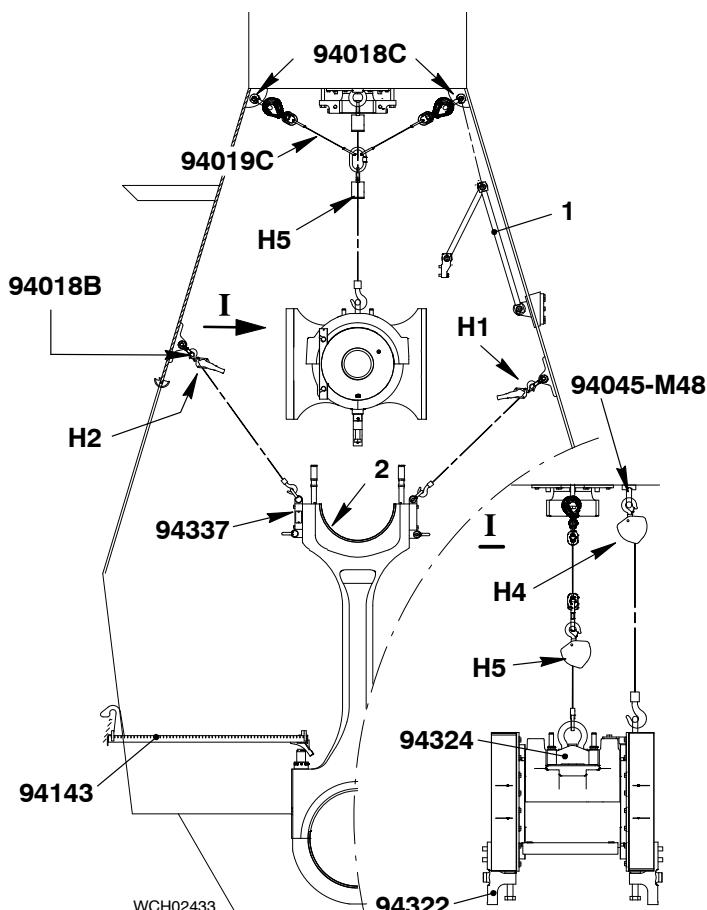


Fig. 4

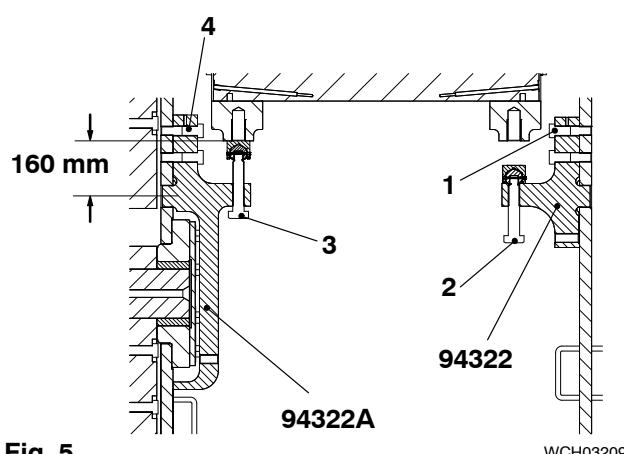


Fig. 5

- 13) Disconnect the toggle lever (1, Fig. 4) from the connecting rod.

3. Crosshead – Lift

- 1) Attach the shackles (94018B) to each side of the column.
- 2) Attach the manual ratchets (H1, H2) to the shackles (94018B) and the two lifting tools (94337).
- 3) Apply a light tension to the manual ratchets H1 and H2.
- Note:** If the cylinder cover and piston are removed you can use the engine room crane and chain block H4 to lift the crosshead.
- 4) Attach the chain (94019C) to the two shackles (94018C).
- 5) Attach the chain block (H5) to the chain (94019C) and the lifting tool (94324).
- 6) Attach the chain block (H4) to the eye bolt (94045-M36) at the top of the column and the eye bolt (94045-M36) on the bearing cover (see View I).

- 7) Operate the chain block (H3) to lift the crosshead approximately 300 mm above the plug bore center (see Fig. 5) in the column.
- 8) Keep the tension on the chain block (H4, Fig. 4).

Note: Fig. 5 shows an engine with electric Balancer (iELBA). Use two supports 94322 for engines without balancer.

- 9) Attach the two supports (2x 94322 or for iELBA: 1x 94322A and 1x 94322) with the four bolts (1, 4, Fig. 5).
- 10) Torque the four bolts (1,4) to 300 Nm.
- 11) Lower the crosshead for 140 mm (160 mm above plug bore center).
- 12) Tighten the special screws (2, 3).
- 13) Inspect the bearing shell 13.
- 14) If it is necessary to replace the bearing shell, refer to paragraph 4, step 1) to step 10).
- 15) Remove the platform (94143, Fig. 4).

Top End Bearing – Removal, Inspection Installation

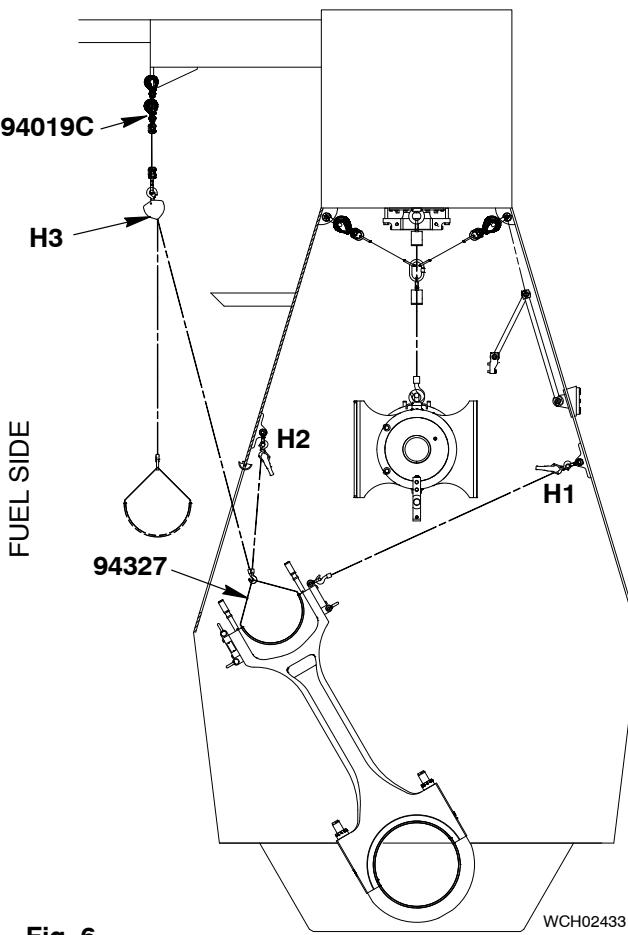


Fig. 6

4. Bearing Shell – Removal

- 1) Attach the chain (94019C, Fig. 6) to the gallery.
- 2) Attach the manual ratchet (H3) to the chain (94019C).
- 3) Use the manual ratchets (H1 and H2) to move the connecting rod to the fuel side.
- 4) Install the four eye bolts (94045-M8, Fig. 7) into the bearing shell (2).
- 5) Attach the chain (94327, Fig. 6) to the manual ratchet (H6) and the four eye bolts in the bearing shell (1).
- 6) Disconnect the manual ratchet (H2) from the connecting rod.
- 7) Connect the manual ratchet (H2) to the chain (94327).
- 8) Remove the two screws (1, Fig. 7) that hold the bearing shell in position.
- 9) Carefully operate the manual ratchets (H2, H3) to lift the bearing shell (2) from the connecting rod.
- 10) Lower the bearing shell (2) on to an applicable surface.
- 11) Remove the chain (94327) and the manual ratchets (H2, H3).
- 12) Remove the four eye bolts (94045-M8).

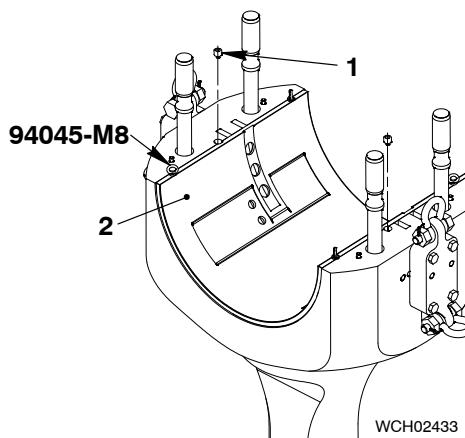


Fig. 7

Top End Bearing – Removal, Inspection Installation

5. Bearing Shell – Installation

- 1) Clean the seating surface of the bearing shell (2, Fig. 7).
- 2) Put oil on the surface of the bearing shell as follows:
 - a) If you start the engine immediately after completion of this procedure, use only bearing oil.
 - b) If the engine has stopped for some days, use a mixture of high-viscosity oil (steam engine cylinder oil, ISO VG 1000/1500) and bearing oil. The ratio is two thirds ISO VG 1000/1500 to one third bearing oil.

Note: A list of suppliers for ISO VG 1000/1500 high viscosity oils is given in **Table 1**.

- 3) Clean the seating surface of the connecting rod and make sure that there is no damage.
- 4) Make sure that the surface of crosshead pin is in a satisfactory condition.
- 5) Install the four eye bolts (94045-M8) into the bearing shell (2).
- 6) Attach the chain (94327, Fig. 6) to the manual ratchet (H3) and the four eye bolts in the bearing shell (1).
- 7) Connect the manual ratchet (H2) to the chain (94327).
- 8) Carefully operate the manual ratchets (H2, H3) to lift, then lower the bearing shell on to the connecting rod.
- 9) Install the two screws (1, Fig. 7) to the bearing shell (2).

- 10) Remove the manual ratchet (H2, Fig. 7) and the chain (94327).
- 11) Remove the four eye bolts (94045-M8).
- 12) Attach the manual ratchet (H2, Fig. 8) to the lifting tool (94337).
- 13) Use the manual ratchets (H1 and H2) to move the connecting rod to the center position below the crosshead.
- 14) Install the platform (94143, Fig. 3).
- 15) Make sure that there is tension on the chain blocks (H4 and H5, Fig. 8).
- 16) Remove the two supports (94322).
- 17) Operate the chain blocks (H4, H5) to carefully lower the crosshead into position on the connecting rod.
- 18) Connect the toggle lever (1) to the connection piece.

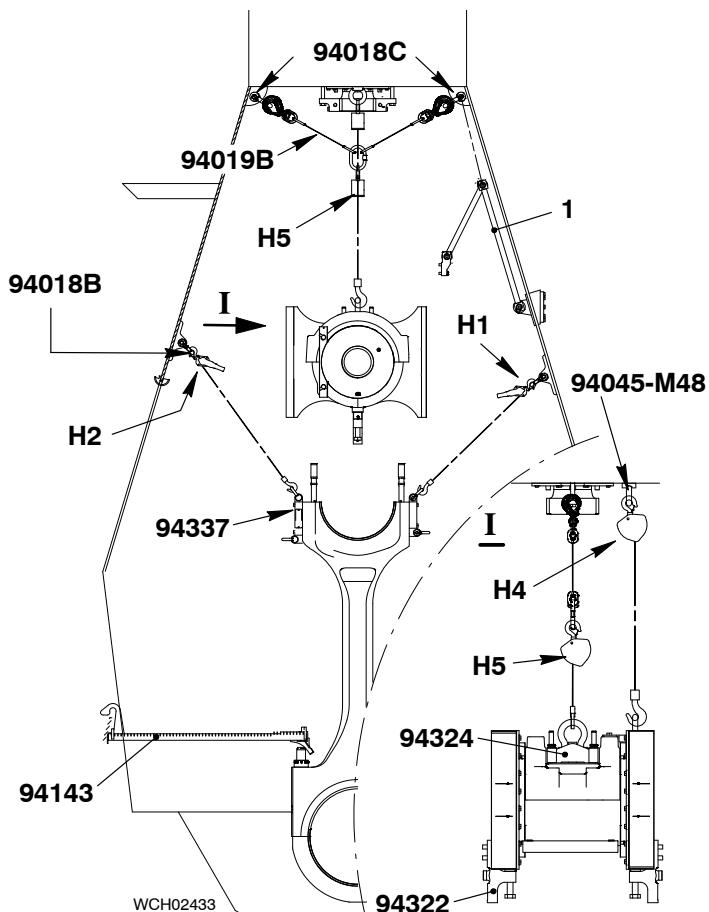
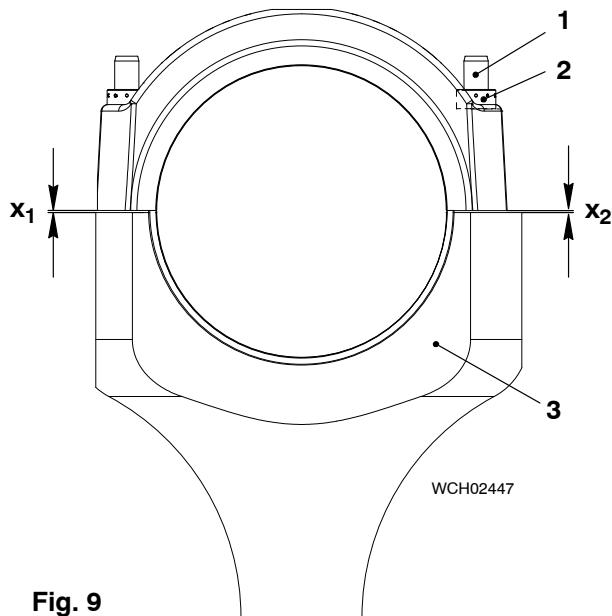


Fig. 8

Top End Bearing – Removal, Inspection Installation



- 19) Put the round nuts (2, Fig. 9) on the elastic studs (1).
- 20) Tighten the round nuts (2) equally with a round bar.
- 21) Measure the distance (X1, X2) between the edges of the bearing shells and the connecting rod (3).
- 22) Refer to 0330-1 Group 3303 to get the clearance values (X1, X2) for new bearing shells.
- 23) Apply tension to the elastic studs (2), refer to 9403-4, paragraph 3.
- 24) Remove all tools and equipment used for this installation procedure.

Note: Do not remove the holders (94333) at this step.

Table 1: ISO G 1000/1500 Suppliers

Supplier	Type	Viscosity at 40°C mm ² /s	Viscosity at 100°C mm ² /s	Weight at 15°C g/ml
BP	ENERGOL DC 1000	980	49.0	0.913
BP	ENERGOL DCW 1000	920	40.0	0.913
CHEVRON	CYLINDER OIL 1000	1000	43.1	0.937
EXXON/ESSO	CYLESSO 1000	950	44.0	
EXXON/ESSO	CYLESSO TK 1000	925	46.7	
MOBIL	EXTRA HECLA SUPER Cylinder Oil	680	39.0	0.905
SHEEL	FIONA Oil 1500	1500	37.0	0.958
SHEEL	VALVATA OIL 1000	1000	45.4	0.924
TEXACO	650T MINERAL Cylinder Oil	985	44.0	0.919

Top End Bearing – Removal, Inspection Installation

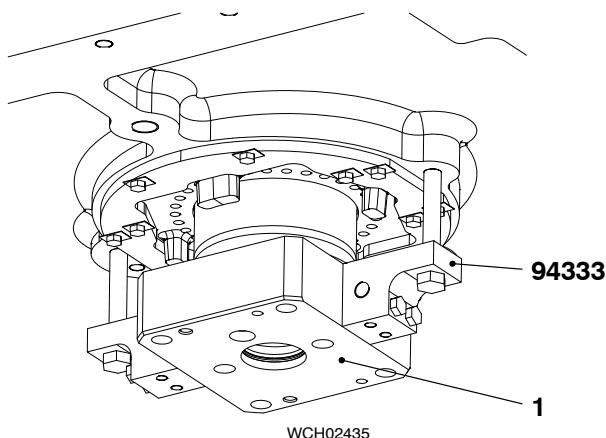


Fig. 10

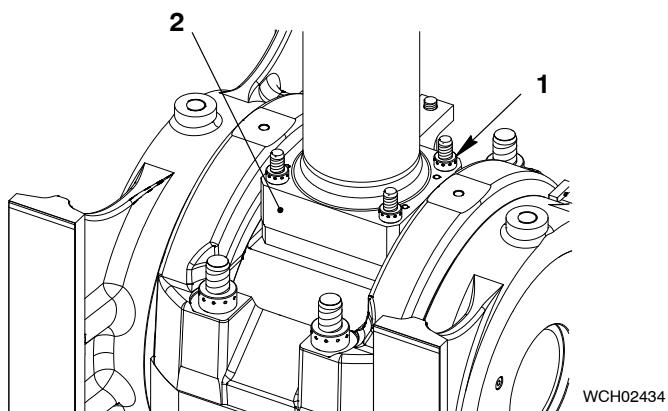


Fig. 11

6. Completion

WARNING



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

- 1) Make sure that the piston rod foot (1, Fig. 10) is clean and has no damage.
- 2) Make sure that the compression shim (2, Fig. 11) is clean and has no damage.
- 3) Remove the platform (94143).
- 4) Unlock the turning gear.
- 5) Use the turning gear to move the crankshaft to TDC.
- 6) Remove the holders (94333, Fig. 10).
- 7) Use the pre-tensioning jack (94315) to tighten the four round nuts (1, Fig. 11) refer to 9403-4.
- 8) Remove all tools and equipment from the area.

7. Bearing Lubrication

To decrease the risk of dry-running on new bearing shells, it is necessary to apply a mixture of high-viscosity oil (steam engine cylinder oil, ISO VG 1000/1500) and bearing oil.

- 1) Remove the oil inlet pipe (2, Fig. 12).
 - 2) Attach the flange (94336) to the support (1).
 - 3) Connect the hose (4) to the flange (94336).
 - 4) Fill the lubricating pump (3) with steam-engine cylinder oil (see Table 1).
 - 5) Operate the lubricating pump (3) until oil flows from the sides of the bearing.
- Note: Do step 5 weekly if the engine does not operate for some weeks.**
- 6) Before you operate the engine do step a) to step d):
 - a) Make sure that the hose (4) has no pressure.
 - b) Disconnect the hose (4) from the flange (94336).
 - c) Remove the flange (94336).
 - d) Install the oil inlet pipe (3) to the support (1).

Note: The steam-engine cylinder oil can stay in the oil system.

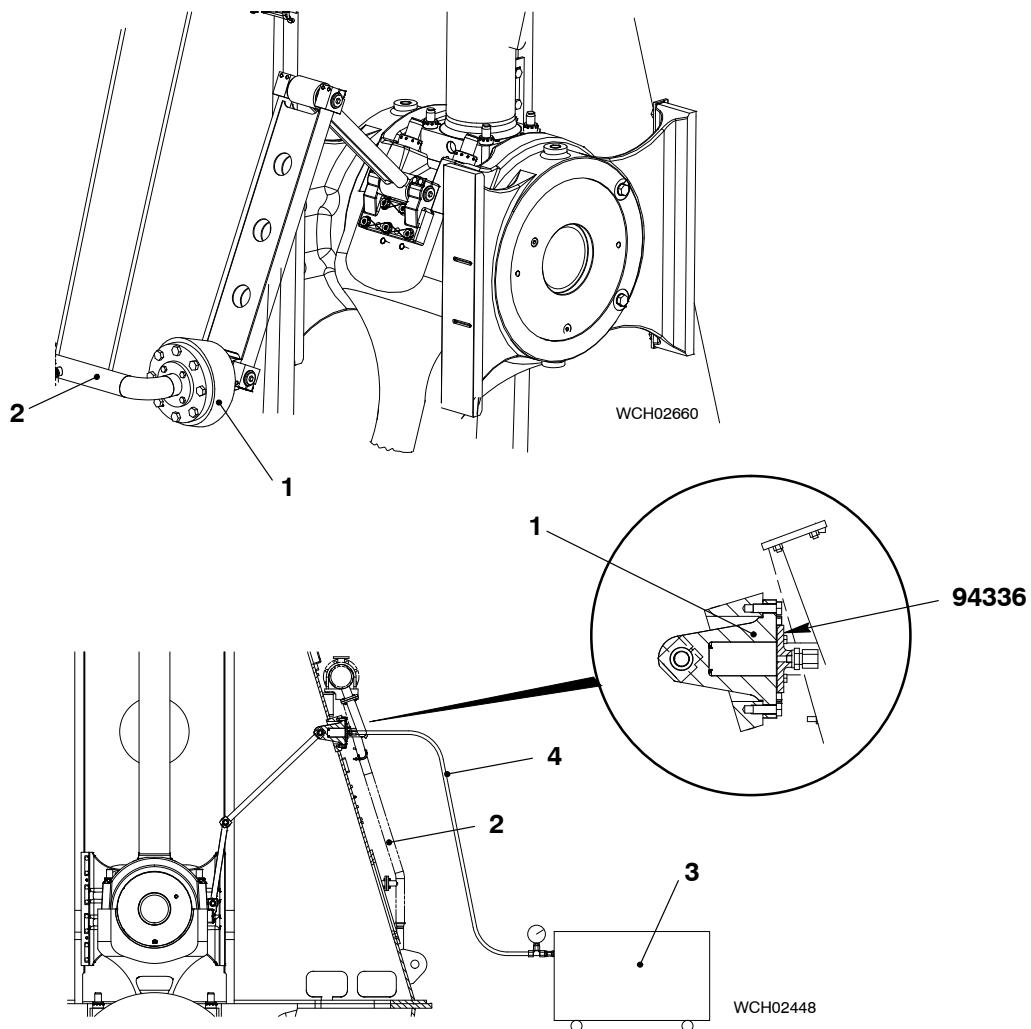


Fig. 12

Connecting Rod

Removal and Installation

Tools:

4 Manual ratchet, 3200 kg, (H1 to H3, H5)	94016-015	1 Chain asymmetrical	94019B
1 Manual ratchet, 6300 kg (H4)	94016-017	1 Plate	94334
1 Shackle, 8500kg	94018C	1 Connecting element	94334A
1 Chain symmetrical	94019A	4 Shackle, 3250 kg	94018A

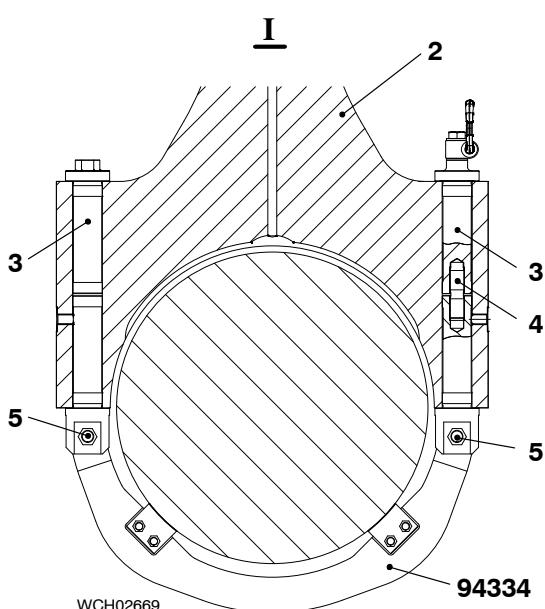
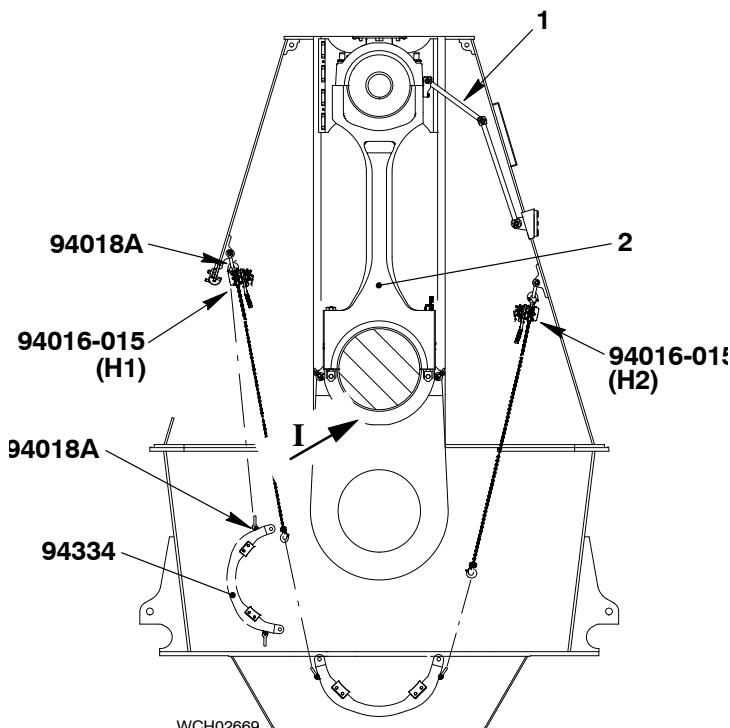
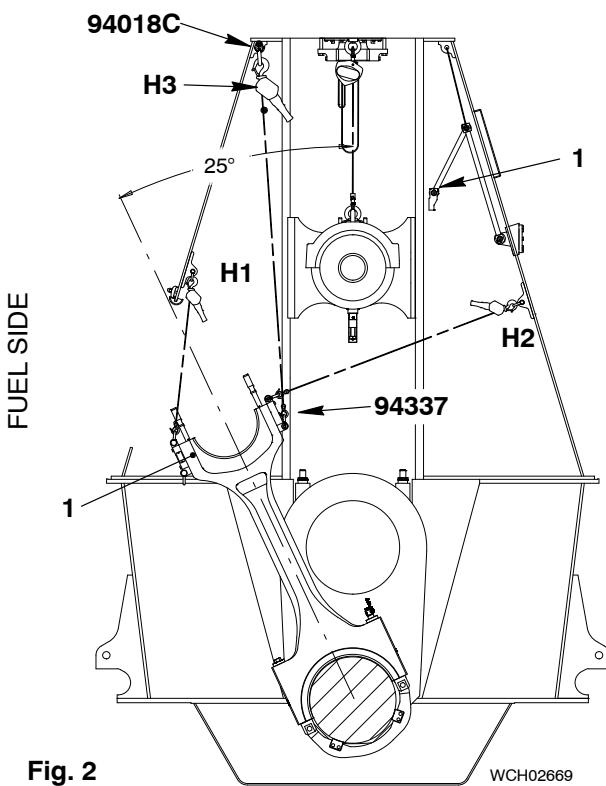


Fig. 1

1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Prepare the piston, refer to [3303-3, paragraph 1](#).
- 3) Remove the bottom end bearing cover from the connecting rod (see [3303-2, paragraph 1](#) and [paragraph 2](#)).
- 4) Attach two shackles (94018A, [Fig. 1](#)) and the the two manual ratchets (94016-011 H1, H2) to the column.
- 5) Attach two shackles (94018A) to the plate (94334).
- 6) Attach the hooks of manual ratchets (H1, H2) to the shackles on the plate (94334).
- 7) Apply copper paste to the thread of the bolts (4).
- 8) Put the rods (3) into the connecting rod (2).
- 9) Use the manual ratchets (H1, H2) to lift the plate (94334) into position on the the rods (3).
- 10) Tighten the nuts and bolts (5).
- 11) Torque the rods (3) to 70 Nm.
- 12) Lift the crosshead, refer to [3303-3, paragraph 2](#) and [paragraph 3](#).
- 13) Remove the the manual ratchets (H1, H2) from the plate (94334).
- 14) Disconnect the toggle lever (1) from the connecting rod (2).

Removal and Installation



2. Removal

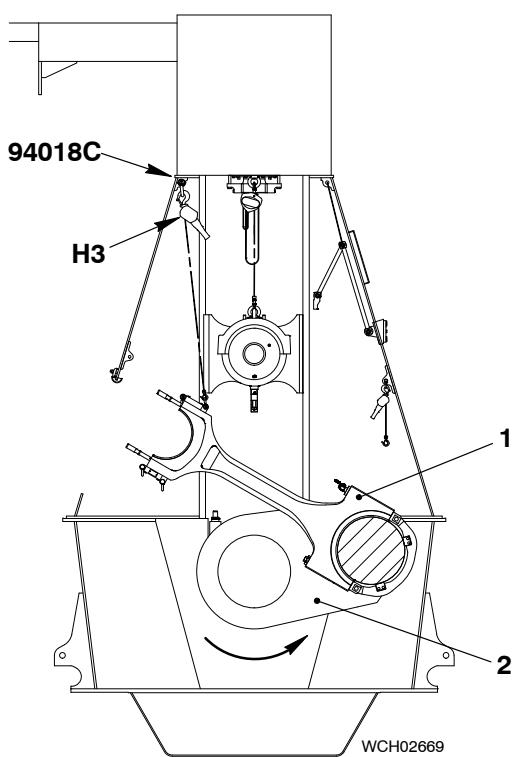
WARNING

Injury Hazard: The connecting rod weighs 3600 kg. To prevent injury, be careful when you move the connecting rod.

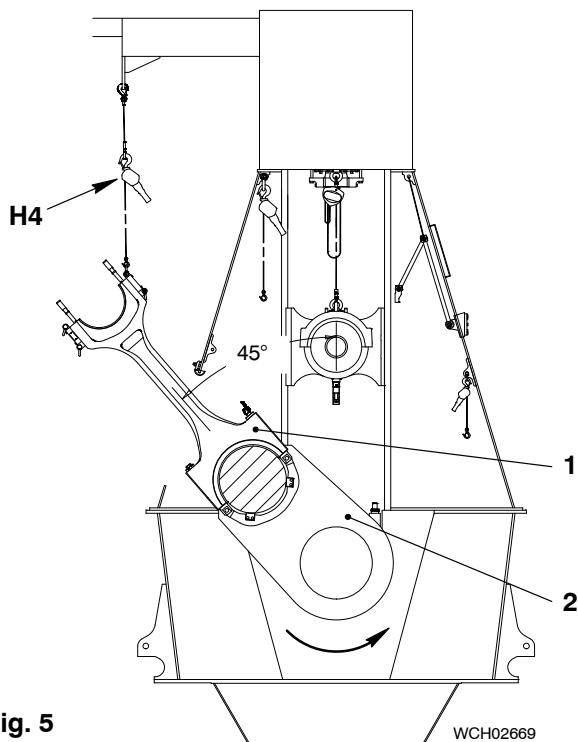
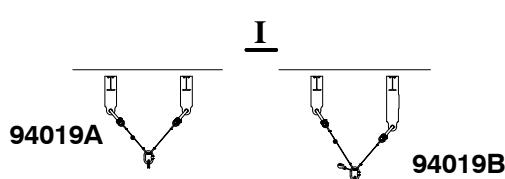
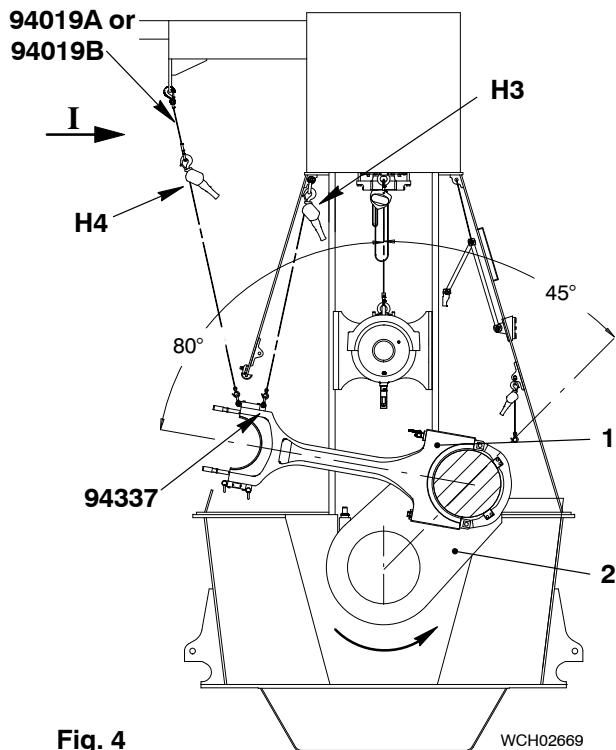
WARNING

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

- 1) Use the manual ratchets (H1, H2 [Fig. 2](#)) to move the connecting rod (1) to the fuel side.
- 2) Attach the shackle (94018C) and the manual ratchet (H3) to the top of the column.
- 3) Attach the manual ratchet (H3) to the bottom shackle of the lifting tool (94337).
- 4) Apply a light tension to the chain of the manual ratchet (H3).
- 5) Remove the manual ratchet (H1).
- 6) Remove the hook of the manual ratchet (H2) from the top shackle of the lifting tool (94337).
- 7) Use the turning gear and the manual ratchet (H3, [Fig. 3](#)) to move the crank (2) and connecting rod (1) counterclockwise to the position shown.



Removal and Installation



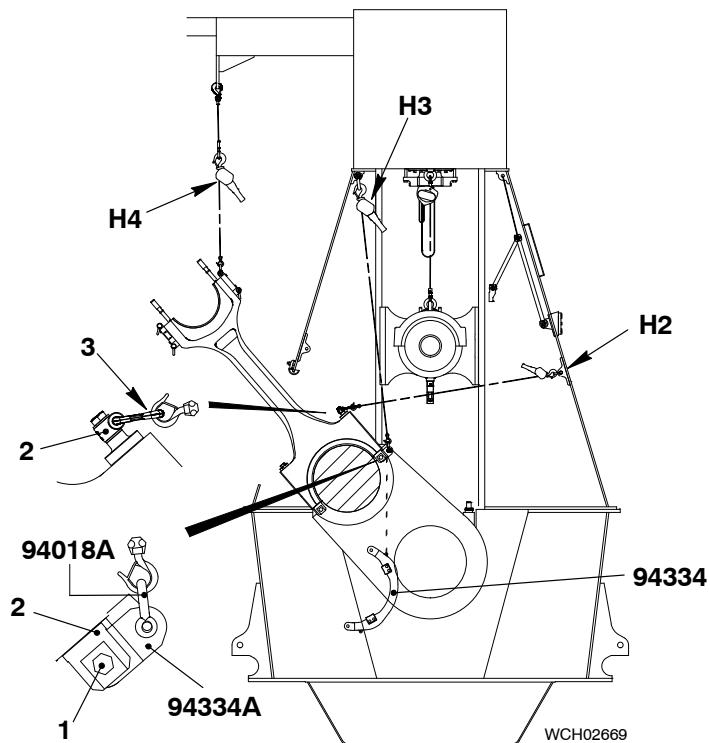
- 8) Use the turning gear and manual ratchet (H3) to move the crankshaft (2, [Fig. 4](#)) and the connecting rod (1) to the position shown.
- 9) Attach the applicable chain (94019A or 94019B) to the gallery.
- 10) Attach manual ratchet (94016-017, H4) to the applicable chain (94019A or 94019B).

Note: The chain 94019A is used at cylinder positions 1, 3, 4 and 6.
The chain 94019B is used at cylinder positions 2 and 5.

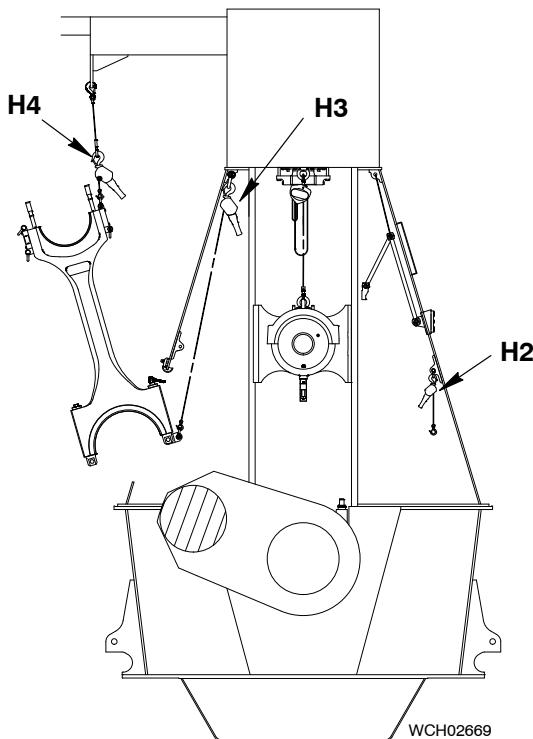
- 11) Attach the manual ratchet (H4) to the top shackle of the lifting tool (94337).
- 12) Apply tension to the manual ratchet (H4).
- 13) Remove the manual ratchet (H3) from the bottom shackle of the lifting tool (94337).

- 14) Use the turning gear and manual ratchet (H4) to move the crankshaft (2, [Fig. 5](#)) and the connecting rod (1) to the position shown.

Removal and Installation

**Fig. 6**

- 15) Attach the manual ratchet (H2, Fig. 6) to the lug (3) on top of the rod (2).
 - 16) Apply a light tension to the chain of the manual ratchet (H2).
 - 17) Attach the manual ratchet (H3) to the shackle (94018A) on the connecting element (94334A).
 - 18) Apply a light tension to the chain of the manual ratchet (H3).
- Note: When you do step 19), hold the plate (94334) in position.**
- 19) Carefully remove the bottom nut and bolt (1) from the plate (94334).
 - 20) Lower the plate (94334) to the floor.
 - 21) Remove the manual ratchet (H3) and the shackle from the plate (94334).
 - 22) Attach the connecting element (94334A) to the bottom of the rod (2) with the nut and bolt (1).
 - 23) Attach the shackle (94018A) and the manual ratchet (H3) to the connecting element (94334A).

**Fig. 7**

- 24) Remove the manual ratchet (H2 Fig. 7) from the lug (3) on top of the rod (2).
- 25) Use the turning gear and manual ratchets (H3, H4) to carefully move the connecting rod out of the column.

Removal and Installation

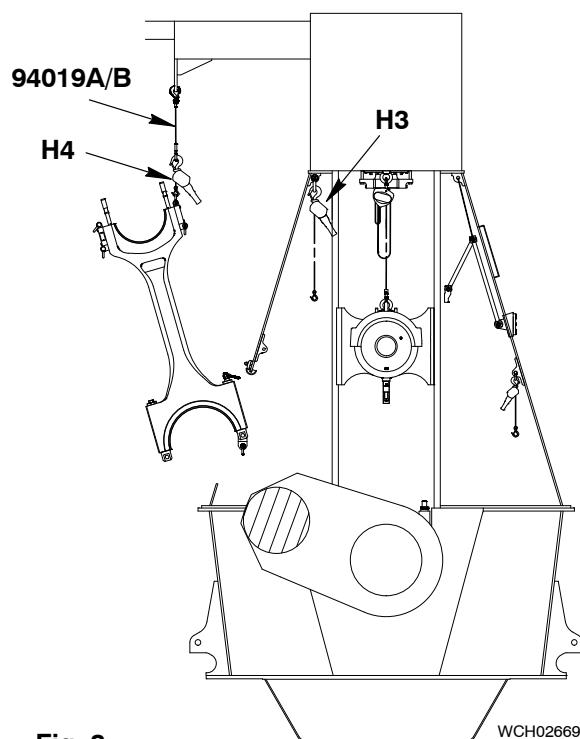


Fig. 8

- 26) Remove the manual ratchet (H3, [Fig. 8](#)) from the shackle (94018A) on the connecting element (94334A).

3. Connecting Rod – Move

If it necessary to move the connecting rod away from the area, do step 1) to step 12).

- 1) Read the applicable safety precautions.
- 2) Put on the applicable personal protective equipment.
- 3) Lower the connecting rod to the floor (see [Fig. 9](#)).
- 4) Remove the chain (94019A or 94019B).
- 5) Attach the two manual ratchets 94016-015 (1, 2) to the connecting rod and the eyelets in the gallery as shown.

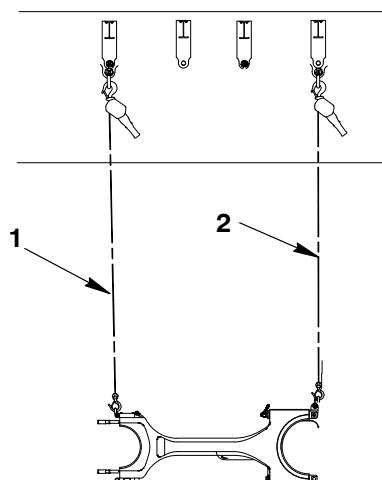
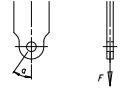
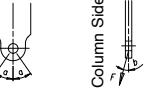
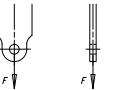
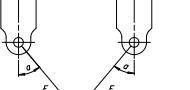
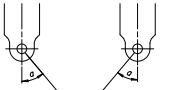


Fig. 9

Removal and Installation

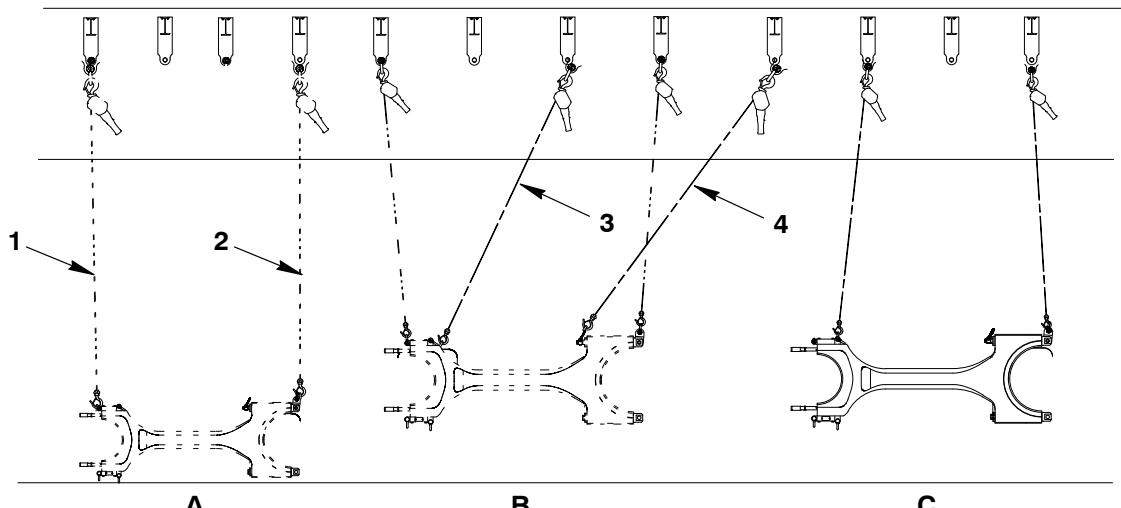
- 6) Read and obey the data given in Fig. 10.

Load Condition 1	Load Condition 2	Permitted Load on Gallery Eyelets
 $F = \text{WLL} = 15000 \text{ N}$	 $F = \text{WLL} = 10300 \text{ N}$	$a = \text{maximum } 35^\circ$ $b = \text{maximum } 20^\circ$
Load Condition 3	Load Condition 4	Note: only one load is permitted on each eyelet.
 $F = \text{WLL} = 24600 \text{ N}$	 $F = \text{WLL} = 10300 \text{ N}$	
Load Condition 5: Application with 2-leg chain (94019A or 94019B)	 $F = \text{WLL} = 10300 \text{ N}$	
Load Condition 6: Application with 2-leg chain (94019A or 94019B)	 $F = \text{WLL} = 15000 \text{ N}$	

WCH02669

Fig. 10: Load Condition Data

- 7) Lift the connecting rod (5, Fig. 11) a small distance.
- 8) Attach two more manual ratchets 90146-015 (3, 4) to the connecting rod as shown in step (B).
- 9) Loosen the tension on the manual ratchets (1, 2). At the same time, operate the manual ratchets (3, 4) to move the connecting rod.
- 10) Remove and attach the manual ratchets (1 to 4) as given in step 9) to continue to move the connecting rod a sufficient distance (step C).
- 11) Lower the connecting rod to the floor.
- 12) Attach the engine room crane, then remove the manual ratchets.

**Fig. 11**

Removal and Installation

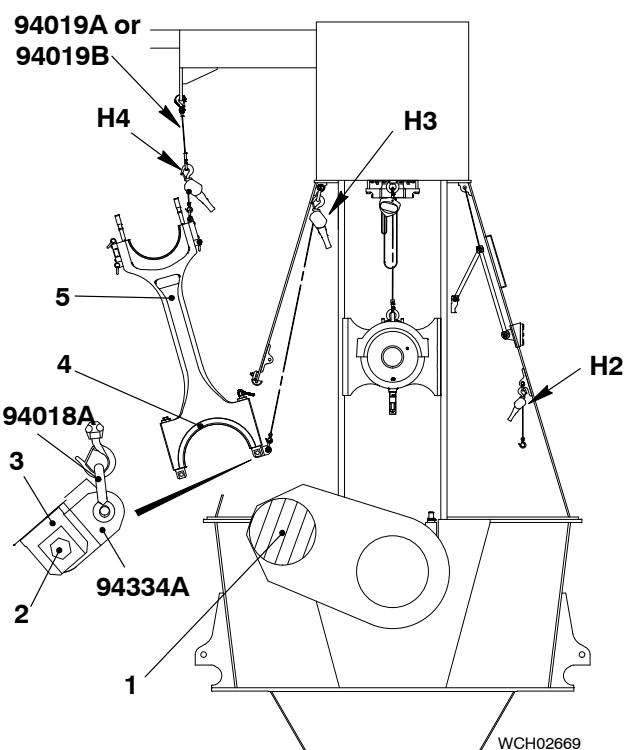


Fig. 12

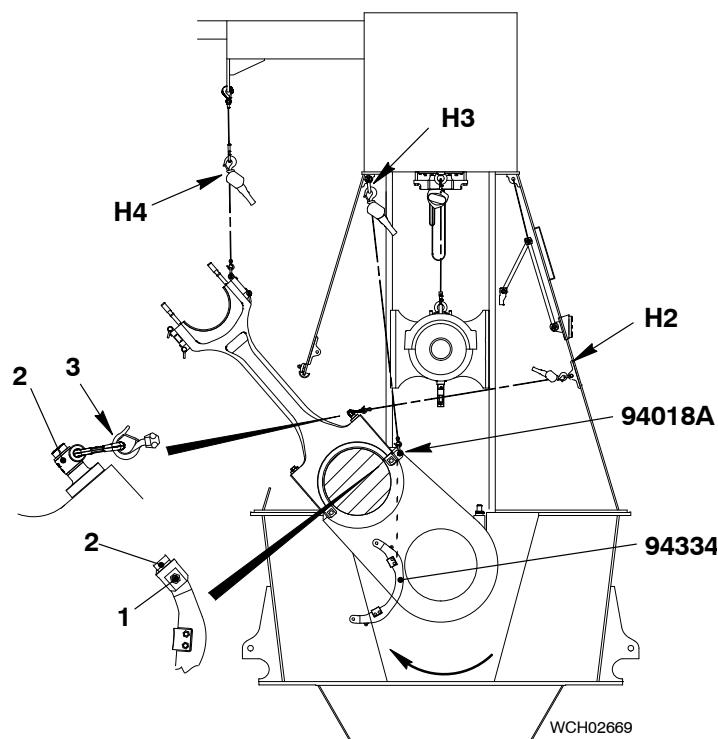


Fig. 13

4. Installation

WARNING



Injury Hazard: The connecting rod weighs 3600 kg. To prevent injury, be careful when you move the connecting rod.

WARNING



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

- 1) Clean the bearing shell (4, Fig. 12) and the crank pin (1).
- 2) Put oil on the bearing shell (4) and the crank pin (1).
- 3) Attach the manual ratchet (H3) to the shackle (94018A) on the connecting element (94334A).
- 4) Attach the manual ratchet (H2, Fig. 13) to the lug (3) on the top rod (2).
- 5) Use the turning gear and the manual ratchets (H4, H3 and H2) to move the connecting rod and the crankshaft clockwise into the position shown.
- 6) Remove the manual ratchet (H3) from the shackle (94018A).
- 7) Remove the shackle (94018A) and the connecting piece (94334).
- 8) Attach the manual ratchet (H3) to the top eyelet on the plate (94334).
- 9) Use the manual ratchet (H3) to lift the plate (94334) into position on the crank pin.
- 10) Attach the plate (94334) to the bottom of the rod (2) with the nut and bolt (1).
- 11) Remove the manual ratchet (H3) from the top eyelet of the plate (94334).
- 12) Attach the manual ratchet (H3) to the bottom eyelet on the plate (94334).
- 13) Use the manual ratchet (H3) to lift the plate (94334).

Removal and Installation

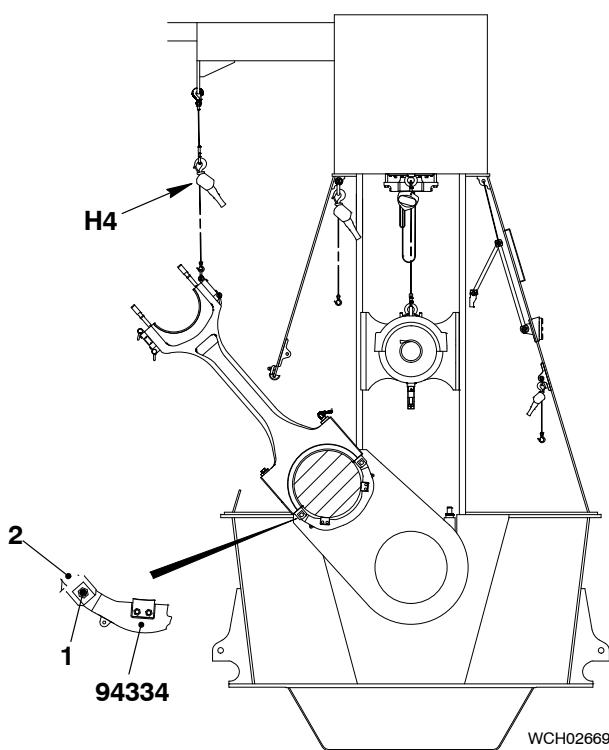


Fig. 14

- 15) Attach the bottom end of the plate (94334, Fig. 14) to the bottom rod (2) with the nut and bolt (1).
- 16) Remove the manual ratchet (H3) from the bottom eyelet of the plate (94334).
- 17) Remove the manual ratchet (H2) from the lug on the top rod.

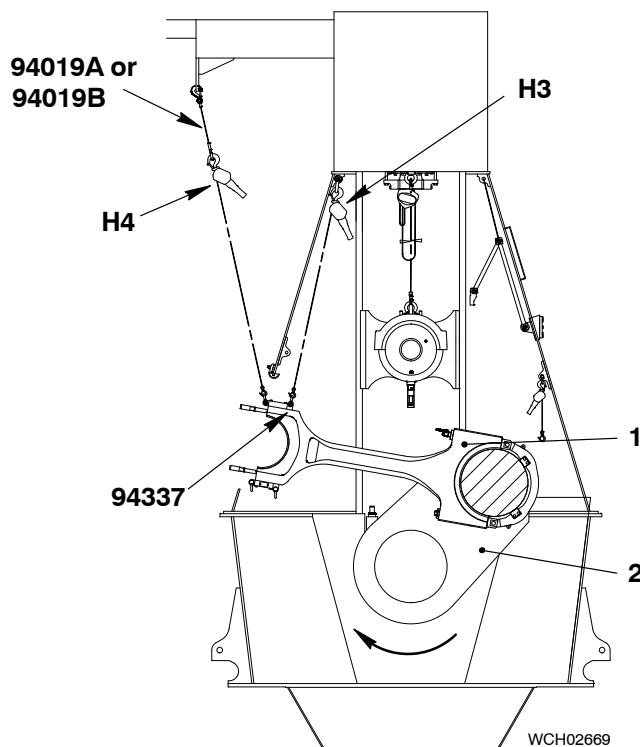


Fig. 15

- 18) Use the turning gear and the manual ratchet (H4, Fig. 15) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.
- 19) Attach the manual ratchet (H3) to the bottom shackle on the lifting tool (94337).
- 20) Remove the manual ratchet (H4) and the chain (94019A or 94019B).

Removal and Installation

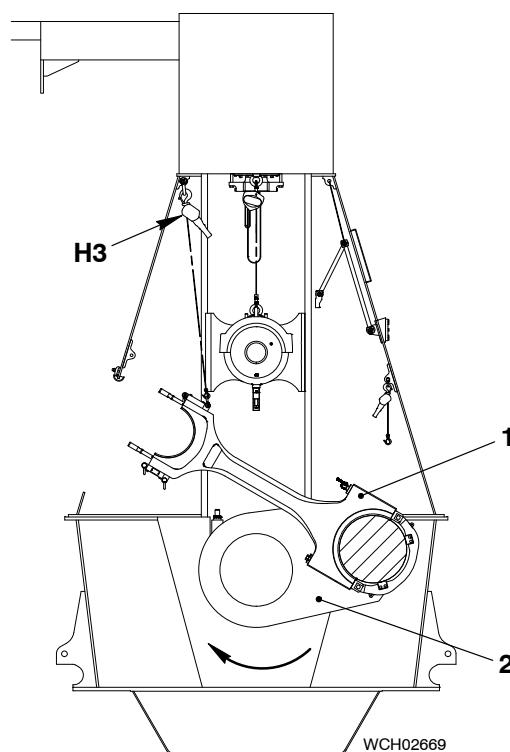


Fig. 16

- 21) Use the turning gear and the manual ratchet (H3, Fig. 16) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.

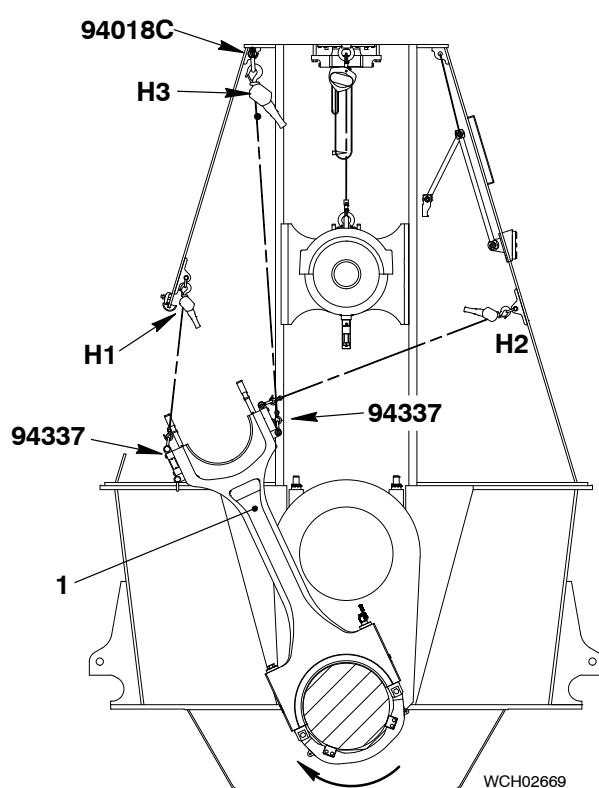
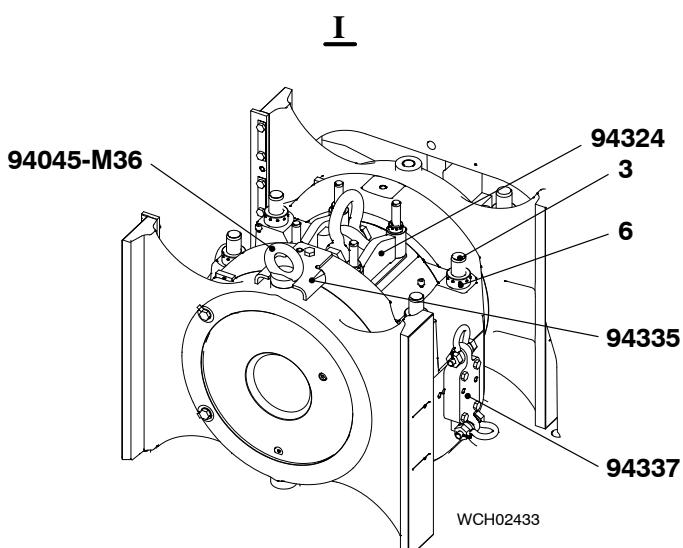
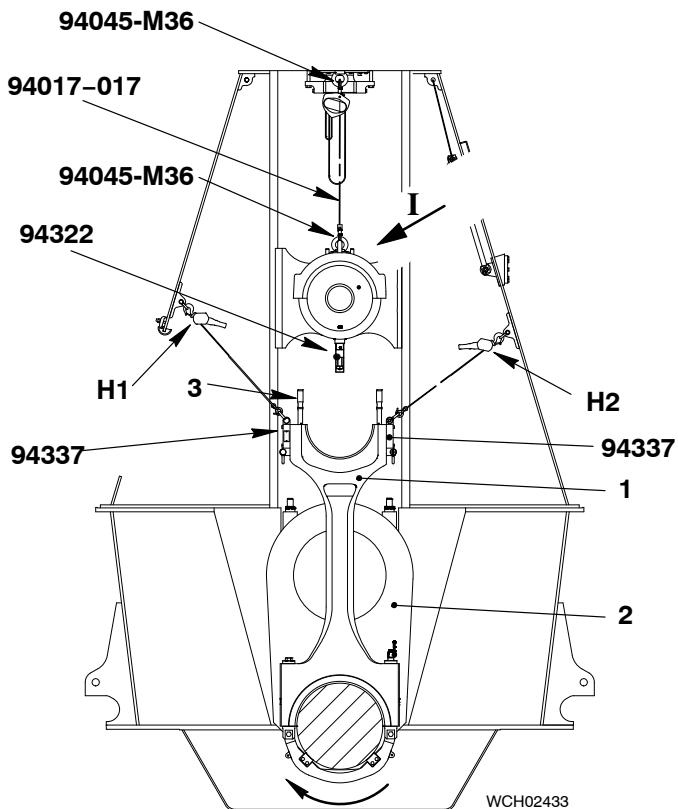


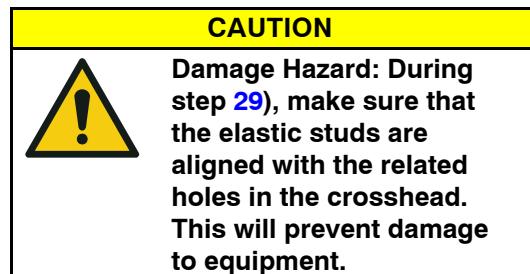
Fig. 17

- 22) Attach the manual ratchet (H2, Fig. 17) to the top shackle of the lifting tool (94337).
- 23) Attach the manual ratchet (H1) to the lifting tool (94337).
- 24) Remove the manual ratchet (H3) from the bottom shackle of the lifting tool (94337) and the top of the column.
- 25) Use the turning gear and the manual ratchet (H3) to move the connecting rod (1) and crankshaft clockwise into the position shown.

Removal and Installation



- 26) Use the turning gear and the manual ratchets (H1 and H2, [Fig. 18](#)) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.
- 27) Make sure that there is tension on the chain block (94017-017).
- 28) Remove the two supports (94332).



- 29) Operate the chain block (94017-017) to lower the crosshead on to the connecting rod (1).
- 30) Attach the four round nuts (6) to the elastic studs (3).
- 31) Remove the chain block (94017-017).
- 32) Remove the tool (94324).
- 33) Remove the manual ratchets (H1, H2) from the lifting tool (94337).
- 34) Remove the lifting tool (94324).
- 35) Remove the eye bolt (94045-M36).
- 36) Remove the stop plate (94355).
- 37) Remove the manual ratchets (H1, H2) from the lifting tools (94337).

Fig. 18

Removal and Installation

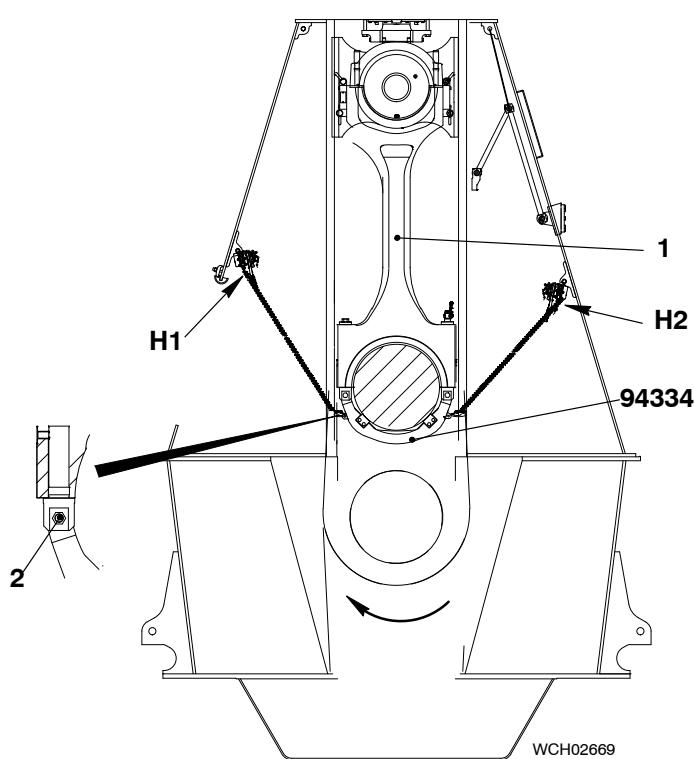


Fig. 19

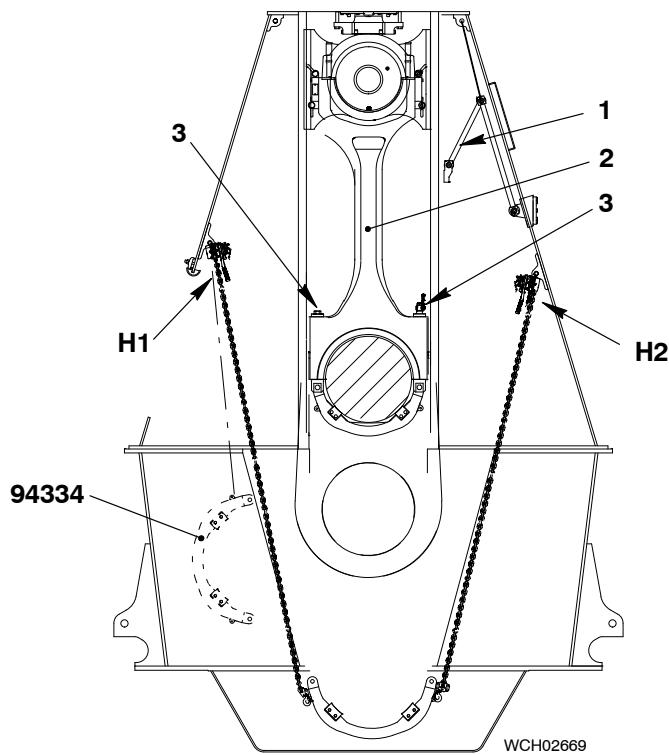


Fig. 20

- 38) Use the turning gear to move the connecting rod (1, [Fig. 19](#)) clockwise to TDC.
- 39) Attach the manual ratchets (H1, H2) to the eyelets on the the plate (94334).
- 40) Apply a light tension to the chains of the manual ratchets (H1, H2).
- 41) Remove the two nuts and bolts (2) from the plate (94334).

- 42) Operate the manual ratchets (H1 and H2, [Fig. 20](#)) to lower the plate (94334).
- 43) Remove the manual ratchet (H2) from the eyelet on the plate (94334).
- 44) Use the manual ratchet (H1) to remove the plate (94334) from the crankcase.
- 45) Connect the toggle lever (1) to the connection piece on the connecting rod (2).
- 46) Remove the rods (3) from the connecting rod (2).

5. Completion

- 1) Install the bearing cover, refer to [3303-2](#), paragraph 8.
- 2) Install the platform, (see [3303-1](#)).
- 3) Attach the crosshead to the piston rod foot, refer to [3303-3](#), paragraph 6.
- 4) Make sure that all tools and equipment are removed from the area.

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Top End Bearing Cover – Removal, Inspection and Installation

Tools:

2 Manual ratchet, 500 kg	94016-025	1 Chain, 3150 kg	94019B
1 Manual ratchet, 6300kg	94016-017	1 Chain, 1000kg	94019C
2 Eye bolt	94045-M20	1 Protection tool	94117B
2 Shackle, 4750 kg	94018B	1 Platform	94143
2 Shackle, 8500 kg	94018C	2 Pre-tensioning jack	94315

1. Preparation	1
2. Removal	2
3. Installation	3

1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Prepare the piston, refer to [3303-3](#), paragraph 1.
- 3) Install the platform (94143, [Fig. 1](#)).
- 4) Install the protection tool (94117B) to the top of column opening.
- 5) Make sure that the turning gear is locked to prevent movement of the crankshaft.

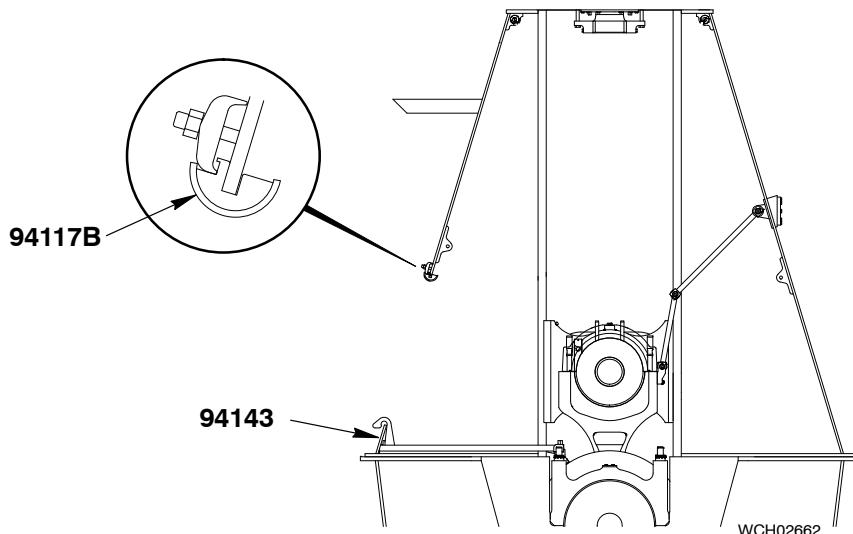
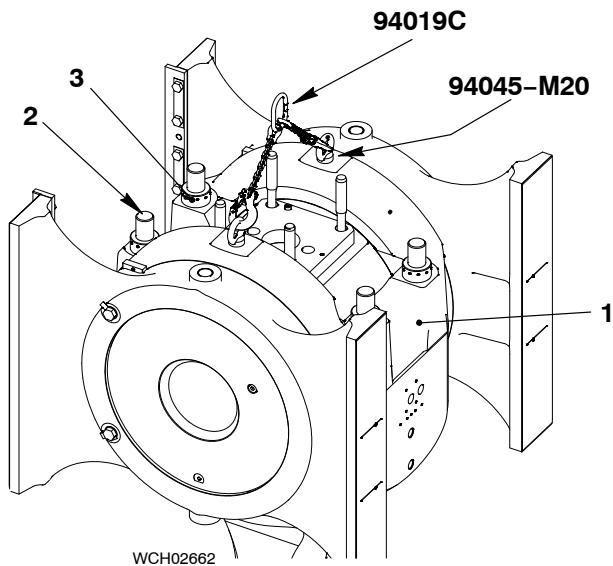
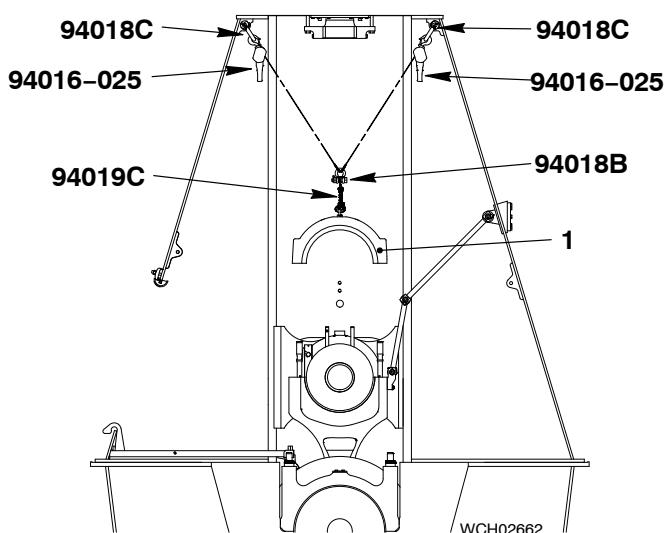


Fig. 1

Top End Bearing Cover – Removal, Inspection and Installation

**Fig. 2****Fig. 3****2. Removal**

- 1) Use the pre-tensioning jack (94315) to loosen the four round nuts (3, [Fig. 2](#)), refer to [9403-4](#).
- 2) Remove the four round nuts (3) from the elastic bolts (2).
- 3) Attach the two eye bolts (94045-M20) to the bearing cover (1).
- 4) Attach the chain (94019C) to the two eye bolts (94045-M20).

- 5) Attach the two shackles (94018C, [Fig. 3](#)) to the strong-points on the frame.
- 6) Attach the two manual ratchets (94016-025) to the shackles (94018C).
- 7) Attach the two manual ratchets (94016-025) to the shackle (94018B). Make sure that the chain lengths of the manual ratchets are equal.
- 8) Attach the chain (94019C) to the shackle (94018B).

CAUTION

 **Damage Hazard:** Before you operate the manual ratchets, make sure that the chain is vertically aligned with the center of the bearing cover. This will prevent damage to the elastic bolts.

- 9) Operate the two manual ratchets (94016-025) to carefully lift the bearing cover (1).

Top End Bearing Cover – Removal, Inspection and Installation

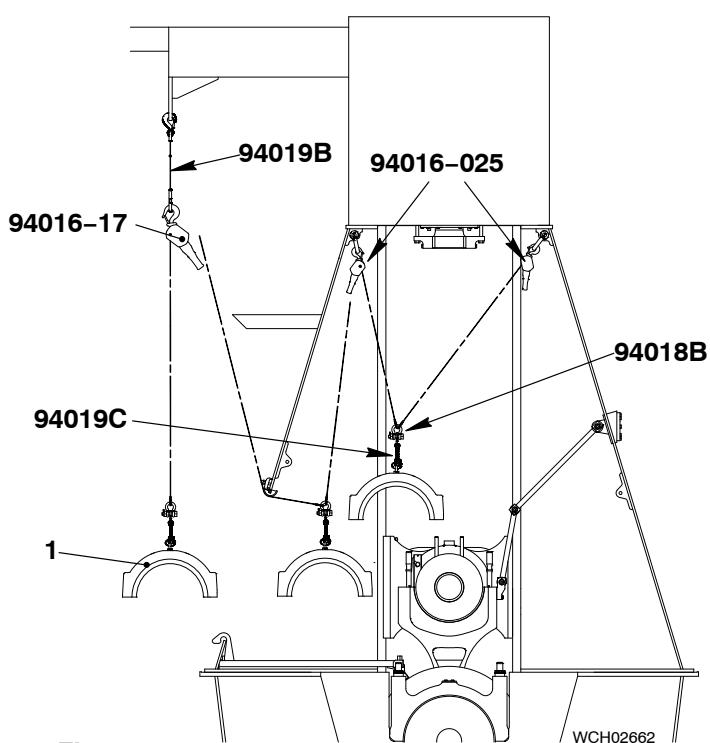


Fig. 4

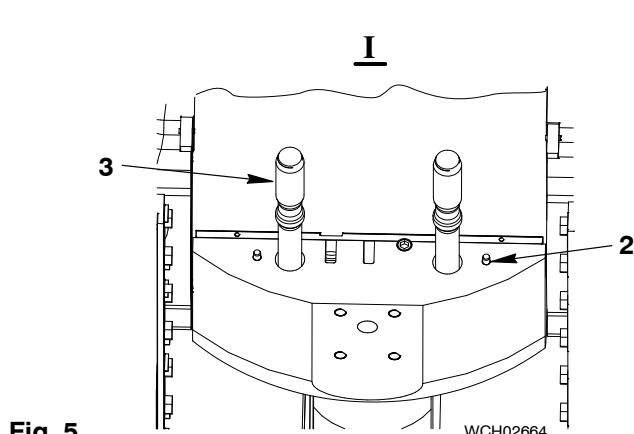
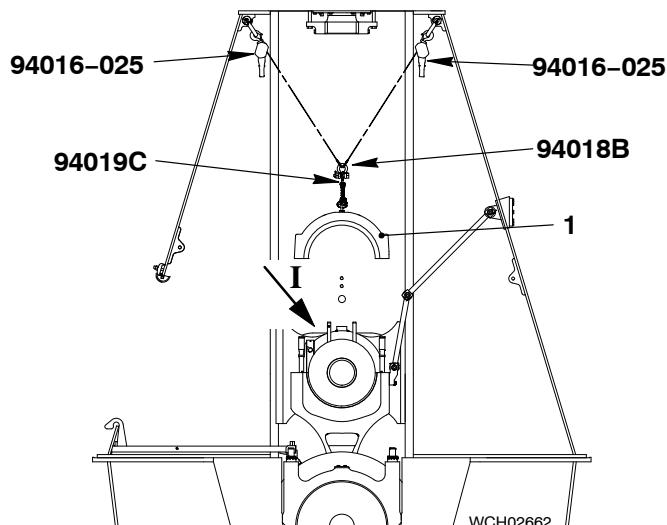


Fig. 5

- 10) Attach the chain (94019B, [Fig. 4](#)) to the gallery.
- 11) Attach the manual ratchet (94016-017) to the chain (94019B).
- 12) Operate the two manual ratchets (94016-025) to move the bearing cover to the fuel side.
- 13) Lower the bearing cover a small distance.
- 14) Attach the manual ratchet (94016-017) to the shackle (94018B).
- 15) Operate the manual ratchets (94016-017 and 94016-025) to move the bearing cover (1) to the fuel side.
- 16) Lower the bearing cover (1) on to an applicable surface.
- 17) If necessary, remove the chain (94019C) from the bearing cover (1).

3. Installation

- 1) Make sure that the bearing cover (1) has no damage.
- 2) If necessary, attach the chain (94019C) to the bearing cover (1).
- 3) Operate the manual ratchets (94016-017 and 94016-025) to move the bearing cover (1) to a position near the crosshead.
- 4) Carefully remove the manual ratchet (94016-017) from the shackle (94018B).
- 5) Operate the manual ratchets (94016-025) to move the bearing cover (1, [Fig. 5](#)) to a position directly above the elastic bolts.

CAUTION



Damage Hazard: Before you operate the manual ratchets, make sure that the bearing cover is level and vertically aligned with the center of the crosshead pin. This will prevent damage to the elastic bolts.

- 6) Carefully lower the bearing cover (1) on to the crosshead pin. Make sure that you do not damage the elastic bolts (2).
- 7) Make sure that the holes in the bearing cover (1) engage with the four dowel pins (2).

Top End Bearing Cover – Removal, Inspection and Installation

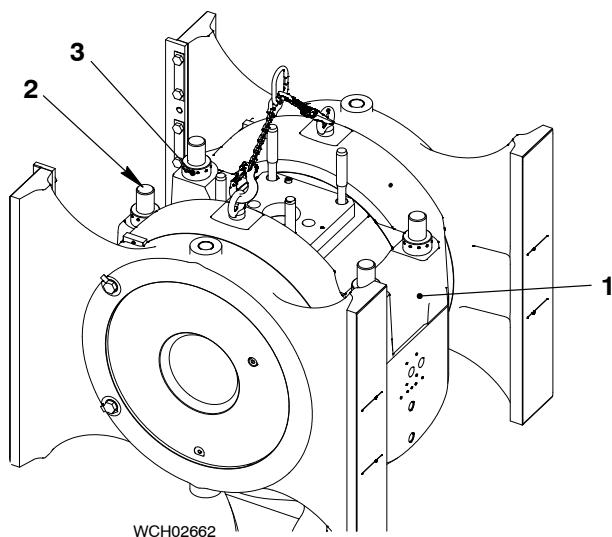


Fig. 6

- 8) Attach the round nuts (3, [Fig. 6](#)) to the elastic bolts (2).
- 9) Use the pre-tensioning jack (94315) to tighten the four round nuts (3) refer to [9403-4](#).

4. Completion

- 1) Attach the piston to the crosshead, refer to [3303-3](#), paragraph 6.
- 2) Remove all tools and equipment from the area.

Crosshead

Clearance Checks

Tools:

1 Feeler gauge 94238

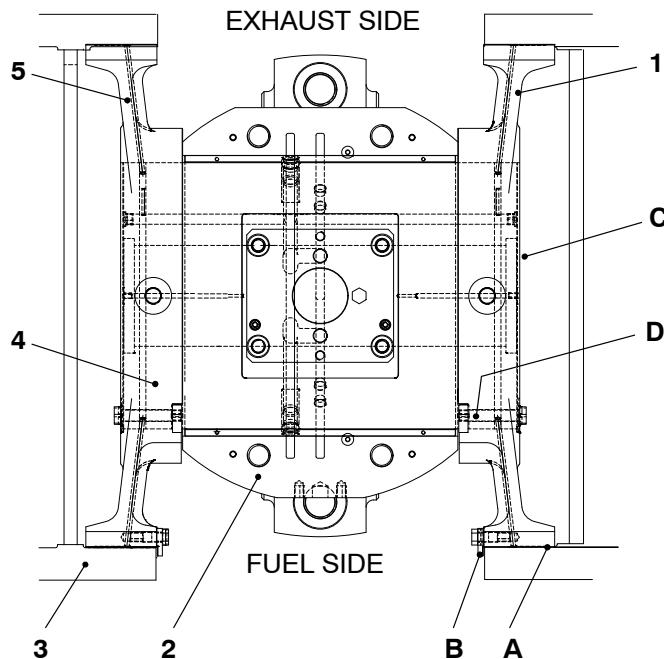


Fig. 1

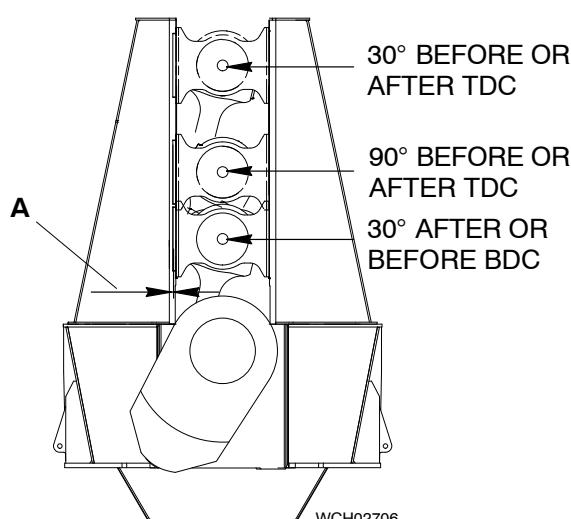


Fig. 2

1. General

During an overhaul or after the installation of the crosshead, you must do as follows:

- 1) Measure and record the clearances shown in Fig. 1 and Fig. 2.
- 2) Compare the clearances with those given in 0330-1 Clearance Table.

2. Clearance checks

2.1 Guide Shoe and Guide Way

- 1) Make sure that the related crosshead pin (4) is in a position so that the guide shoes (1) and (5) touch the guide ways (3) (on the fuel side or exhaust side).
- 2) Measure the clearance (A) between the guide shoe (1) and the guide way 3.

Note: The clearance (A) is applicable for the full length of the guide way (3) and measured at the position shown in Fig. 2.

2.2 Crosshead

- 1) Measure the lateral clearance (B) at each position of the crosshead as follows:
 - a) Use an applicable hardwood wedge (or an item that is almost the same) to push the crosshead axially to one side. Make sure that you apply the pressure only to the guide shoe.

2.3 Guide Shoe and Top End Bearing

- 1) Measure the full lateral clearance (C) between the top end bearing (2) and the the guide shoes (1, 5).

2.4 Radial Clearance

- 1) Measure the radial clearance (D) between the guide shoe (5) and the crosshead pin (4) at all positions of the crosshead.

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Crosshead

Crosshead Pin – Removal / Installation / Clearance Checks

Tools:

1	Protection tool	94117B	2	Eye bolt M20	94045–M20
1	Platform	94142	2	Eye bolt M30	94045–M30
1	Lifting tool	94324	4	Eye bolt M48	94045–M48
2	Spur geared chain block	94017–021	1	Chain	94325
2	Manual ratchet	94016–017	1	Chain	94019A/B
2	Manual ratchet	94016–011	1	Link	94321
2	Manual ratchet	94016–031	2	Lifting tools	94337
4	Shackle	94018B	2	Supports	94322
4	Shackle	94018C			

1.	Preparation	1
2.	Crosshead Pin – Removal	2
3.	Guide Shoes – Removal	5
4.	Guide shoes – Installation	6
5.	Crosshead Pin – Installation	6
6.	Clearance Checks	9
7.	Completion	9

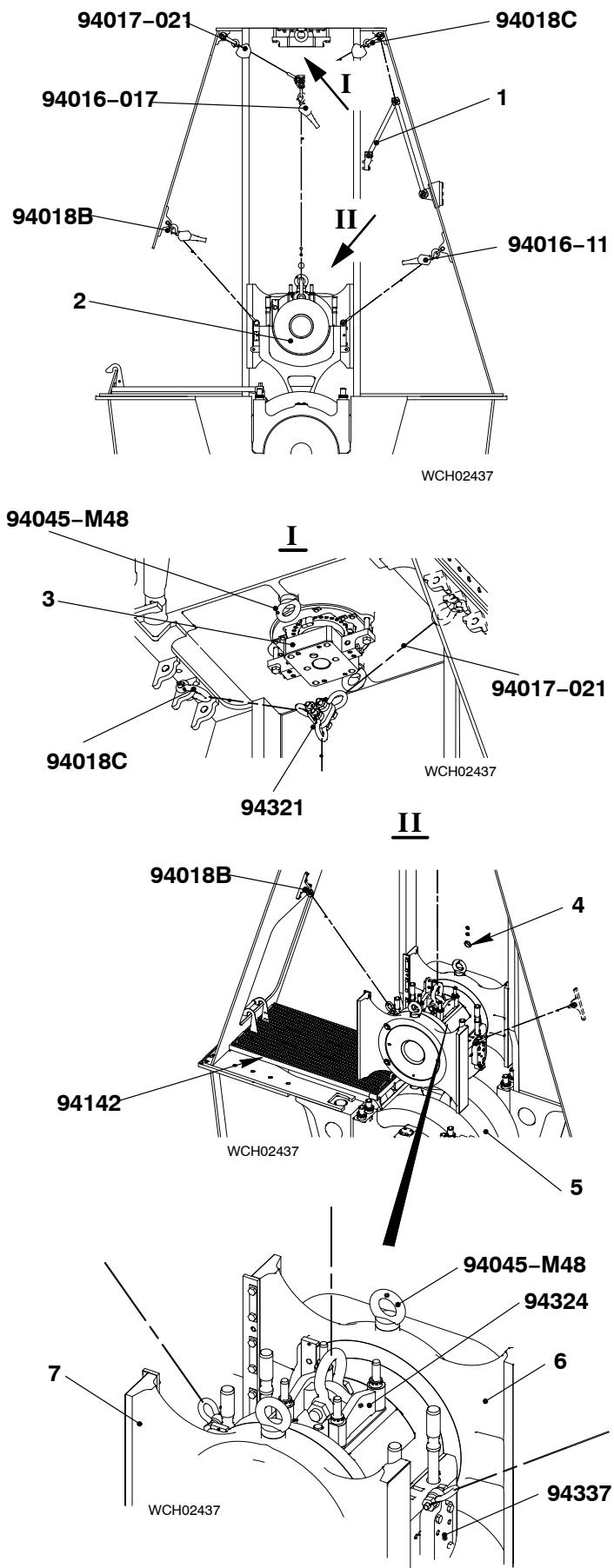
1. Preparation

WARNING

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

- 1) Read the data in [0012–1 General Guidelines for Lifting Tools](#).
- 2) Use the turning gear to turn the crank of the related cylinder to BDC.
- 3) Keep the turning gear engaged to prevent an accidental engine start.
- 4) Install the platform (94143), see [3301–1](#).
- 5) Disconnect the toggle lever (1, [Fig. 1](#)) from the crosshead pin (2). Let the toggle lever hang in the column.
- 6) Remove the round nuts from the elastic studs on the connecting rod, see [9403–4](#).
- 7) Remove the top bearing cover, see [3303–5](#).
- 8) Put protection on the oil inlets of the crosshead pin to prevent damage and contamination.

Crosshead Pin – Removal / Installation / Clearance Checks



2. Crosshead Pin – Removal

- 1) Attach the lifting tool (94234) to the crosshead (see Fig. 1 View II).
- 2) Attach the two eye bolts (94045-M48) to the bottom of the cylinder jacket.
- 3) Attach the two shackles (94018C) to the top of the column.
- 4) Attach the two spur gear chain blocks (94017-021) to the shackles.
- 5) Attach the link (94321) to the spur gear chain blocks.
- 6) Attach the manual ratchet (94016-017) to the link and the eye bolt (94045-M48) on the lifting tool.
- 7) Attach the two eye bolts (94045-M48) to the guide shoes (6) and (7).
- 8) Attach the two lifting tools (94337) to the connecting rod (5).
- 9) Attach the two manual ratchets (94016-011) to the shackles (94018B) and the lifting tools (94337). Apply a light tension to the chains.

Fig. 1

Crosshead Pin – Removal / Installation / Clearance Checks

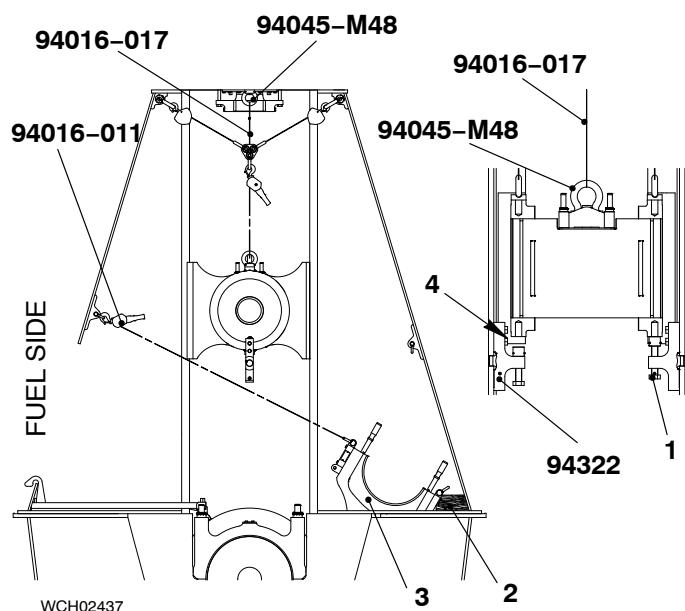


Fig. 2

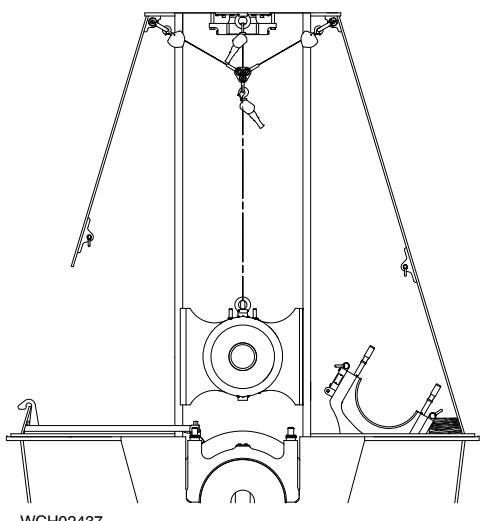


Fig. 3

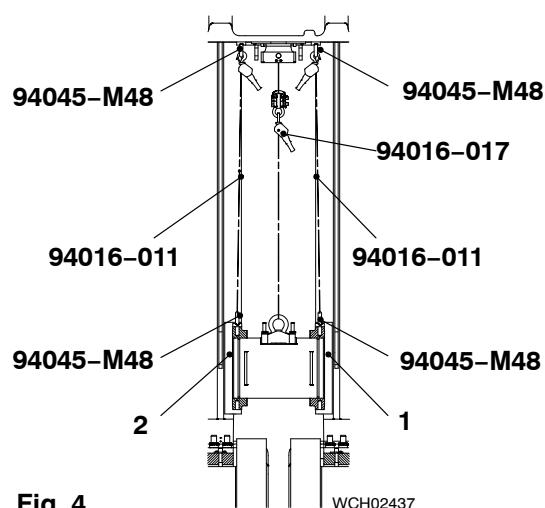


Fig. 4

- 10) Use the manual ratchet (94016-017) to lift the crosshead approximately 160 mm above the center of the pin hole (4, Fig. 1 view II and Fig 2).
- 11) Attach the two supports (94322) to the guide way as shown.
- 12) Torque the four bolts (4) to 300 Nm.
- 13) Tighten the two set screws (1).
- 14) Lower the crosshead on to the supports (94322).
- 15) Put the wooden block (2) in position as shown.

Note: During the step below, slowly move the connecting rod to the exhaust side.

- 16) On the fuel side, gradually loosen the manual ratchet (94016-11). At the same time, keep tension on the chain of the manual ratchet on the exhaust side.
- 17) Continue with step 16) until the connecting rod (3) touches the wooden block (2).
- 18) Loosen the two set screws (1).
- 19) Lift the crosshead a small distance.
- 20) Remove the two supports (94322).
- 21) Remove the two manual ratchets (94016-011).
- 22) Lower the crosshead to the same height as the column door frame (see Fig. 3).
- 23) Attach the manual ratchets (94016-011, Fig. 4) to the eye bolts (94045-M48) on the guide shoes (1) and (2). Apply a light tension to the chains.
- 24) Apply a light tension to the chain of the manual ratchets (94016-017). Make sure that the primary load stays on the chain of the manual ratchet (94016-017)

Crosshead Pin – Removal / Installation / Clearance Checks

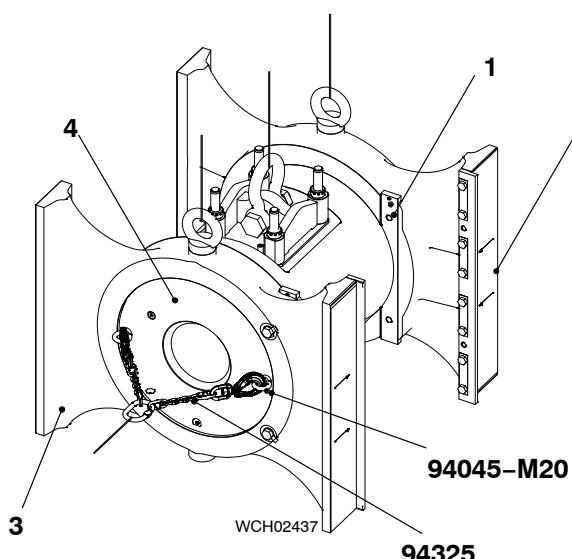


Fig. 5

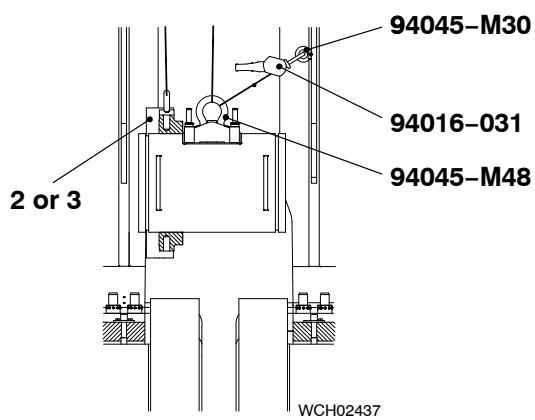
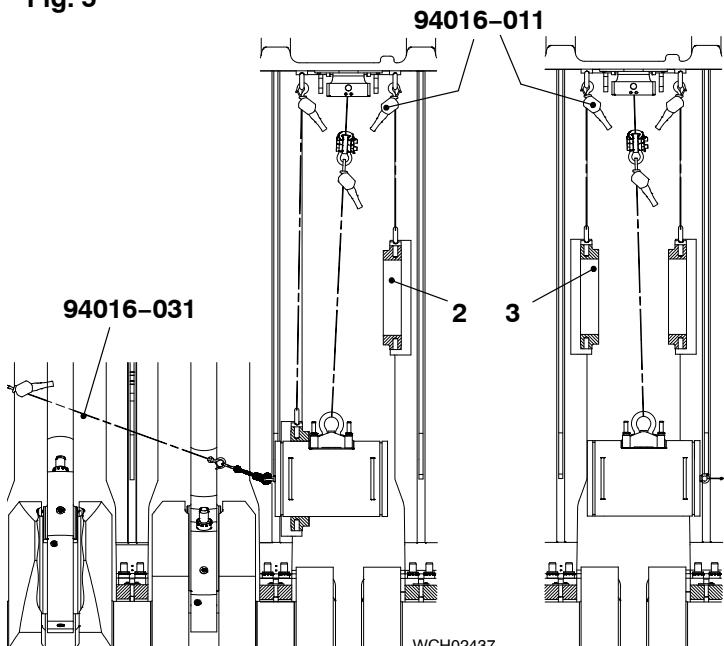


Fig. 6

- 25) Remove the two bolts, tab washers and holding plates (1, Fig. 5) from the from the guide shoe (2).
- 26) Attach the two eye bolts (94045-M20) and the the chain (94325) to the crosshead pin (4).
- 27) Attach the shackle (94018B) to an applicable position on the column.
- 28) Attach the manual ratchet (94016-031) to the chain (94325) and the shackle (94018B).
- 29) Use the manual ratchet (94016-031) to pull the crosshead pin (4) until the guide shoe (2 or 3) is clear.
- 30) Use the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 31) Remove the chain (94325), manual ratchet (94016-031), shackle 94018B and eye bolts (94045-M20).
- 32) Attach the eye bolts (94045-M20), chain (94325), shackle (94018B) and manual ratchet (94016-031) to the other side of the crosshead pin (4).
- 33) Do step 29) to step 31) for the other guide shoe.
- 34) When the crosshead (4) is in the first or last cylinder position, do step 35) to step 41).
- 35) Attach the eye bolt (94045-M30, Fig. 6) an applicable hole in the column.
- 36) Attach the manual ratchet 94016-031 to the eye bolt 94045-M30 and the eye bolt 94045-M48.
- 37) Use the manual ratchet to pull the crosshead pin from the guide shoe (2 or 3).
- 38) Use the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 39) Remove the manual ratchet (94016-031) and the eye bolt (94045-M30).
- 40) Attach the eye bolt (94045-M30) and manual ratchet (94016-031) to the other side of the column.
- 41) Do step 37) to step 39 for the other guide shoe).
- 42) Remove the manual ratchet 94016-031 and the eye bolt 94045-M30.

Crosshead Pin – Removal / Installation / Clearance Checks

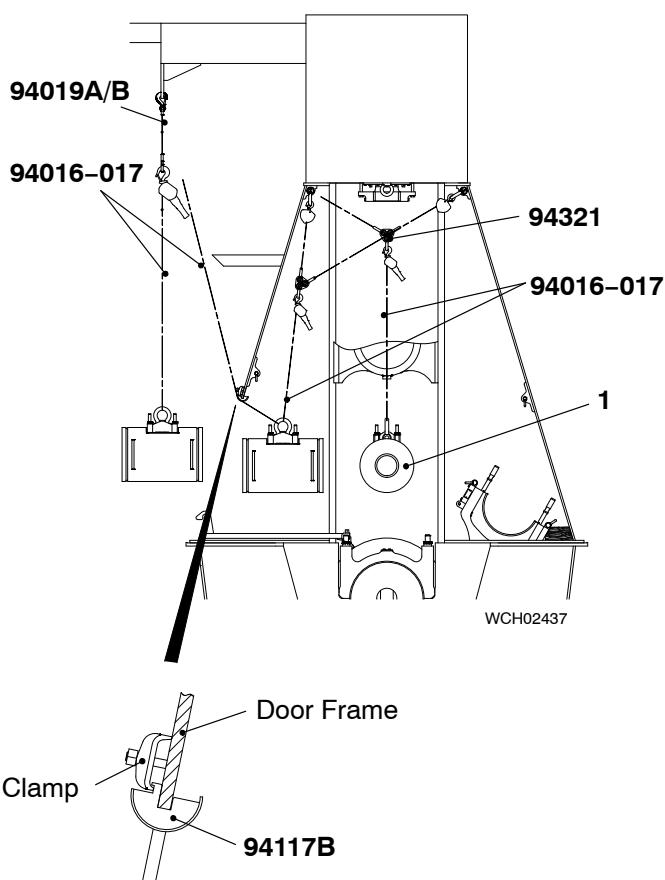


Fig. 7

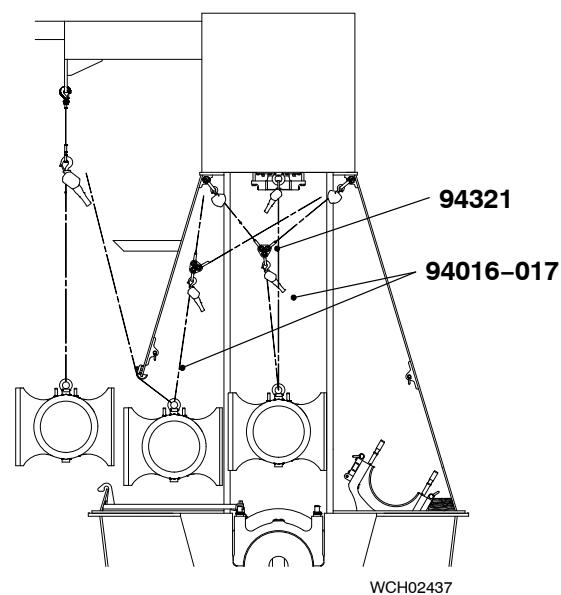


Fig. 8

- 43) Attach the protection tool (94117B, Fig. 7) to the door frame.
 - 44) Attach the chain (94019A/B) to the attachment point on the gallery.
 - 45) Attach the manual ratchet (94016-017) to the chain (94019A/B) and the eye bolt on the crosshead (1).
 - 46) Turn the crosshead pin (1) 90°.
- Note: When you do step 47) and step 48) keep the tension on the two manual ratchets (94016-017).**
- 47) Tighten the manual ratchet that is attached to the gallery. At the same time, carefully loosen the manual ratchet that is attached to the link 94321.
 - 48) Lower the crosshead on to an applicable wooden underlay.
 - 49) Remove the manual ratchets from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

- 1) Record the positions of the guide shoes. The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.
 - 2) Use the manual ratchets (94016-011, Fig 5) to lower the guide shoe (2) to the door frame.
 - 3) Attach the two manual ratchets (94016-017, Fig. 8) to the eye bolt on the guide shoe.
 - 4) Apply a light tension to the chains of the manual ratchets (94016-017).
 - 5) Remove the manual ratchet (94016-011) from the guide shoe.
- Note: When you the steps below, keep the tension on the two manual ratchets.**
- 6) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet that is attached to the gallery. At the same time, carefully loosen the manual ratchet that is attached to the link 94321.
 - b) Lower the guide shoe (1) on to an applicable wooden underlay.
 - 7) Do step 2) to step 6) for the other guide shoe.

Crosshead Pin – Removal / Installation / Clearance Checks

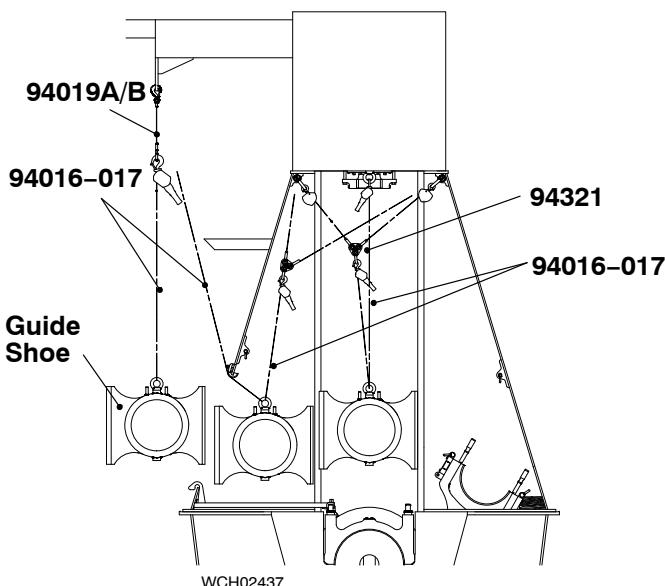


Fig. 9

4. Guide shoes – Installation

Note: When you the steps below, make sure that you install the guide shoes in their original positions.

- 1) Attach the two manual ratchets (94016-017, Fig. 9) to the eye bolt on the guide shoe.

- 2) Apply a light tension to the chains of the manual ratchets (94016-017).

Note: When you step 3) to step 5), keep the tension on the two manual ratchets.

- 3) Move the guide shoe (1) through the door frame as follows:

- a) Tighten the manual ratchet that is attached to the link (94321). At the same time, carefully loosen the manual ratchet that is attached to the gallery.

- 4) Attach the manual ratchet (94016-011, Fig. 5) to the guide shoe (2 or 3).

- 5) Use the manual ratchet 94016-011 to lift the guide shoe (2 or 3).

- 6) Remove the two manual ratchets (94016-017) from the guide shoe (2 or 3).

- 7) Do step 1) to step 6) for the other guide shoe.

5. Crosshead Pin – Installation

- 1) Clean the crosshead pin and the guide and bearing surfaces.

- 2) Apply bearing oil to the crosshead pin and all guide and bearing surfaces

- 3) Make sure that the surfaces of the crosshead pin are clean and have no damage.

- 4) Attach the two manual ratchets (94016-017, Fig. 10) to the eye bolt on the crosshead pin (1).

Note: When you step 5) keep the tension on the two manual ratchets (94016-017).

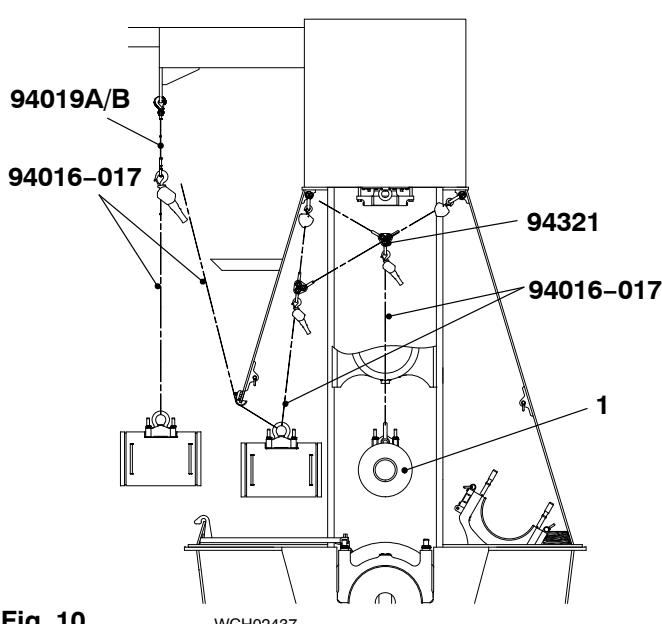


Fig. 10

Crosshead Pin – Removal / Installation / Clearance Checks

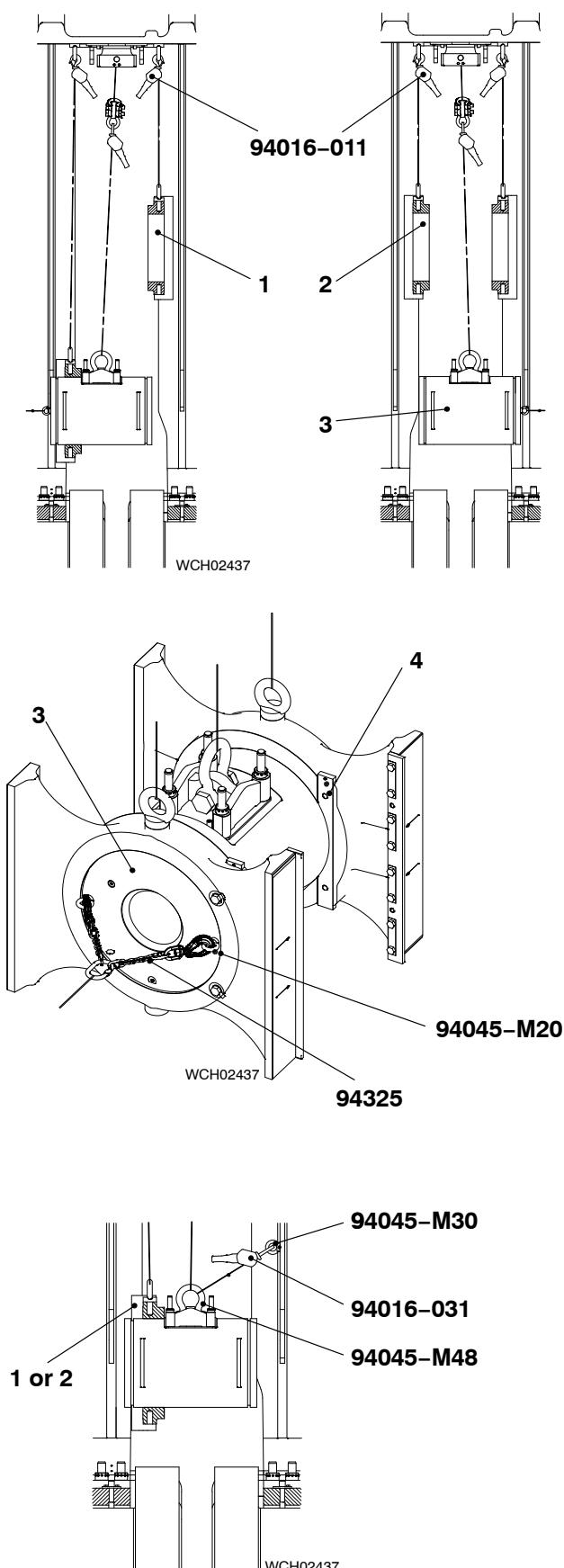


Fig. 11

- 5) Move the crosshead pin (1, Fig. 10) through the door frame as follows:
 - a) Tighten the manual ratchet that is attached to the link (94321). At the same time, carefully loosen the manual ratchet that is attached to the gallery.
- 6) Remove the manual ratchet that is attached to the chain (94019A/B) in the gallery.
- 7) Turn the crosshead pin 90°.
- 8) Remove the protection tool (94117B) from the door frame.
- 9) Lower and align the guide shoe (2, Fig. 11) with the crosshead pin (3).
- 10) Attach the two eye bolts (94045-M20) and the chain (94325) to the crosshead pin (3).
- 11) Attach the eye bolt (94045-M30) to an applicable position on the column.
- 12) Attach the manual ratchet (94016-031) to the eye bolt (94045-M30) and the chain (94325).
- 13) Use the manual ratchet (94016-031) to pull the crosshead pin (3) into the guide shoe (2).
- 14) Remove the chain (94325), eye bolts (94045-M20, 94045-M30) and manual ratchet (94016-031).
- 15) Attach the eye bolts 94045-M20, and chain 94325, to the other side of the crosshead pin.
- 16) Attach the eye bolt (94045-M30) to an applicable position on the column.
- 17) Use the manual ratchet (94016-031) to pull the crosshead pin (3) into the guide shoe (1).
- 18) Remove the chain (94325), eye bolts, (94045-M20, 94045-M30) and manual ratchet 94016-031.

Crosshead Pin – Removal / Installation / Clearance Checks

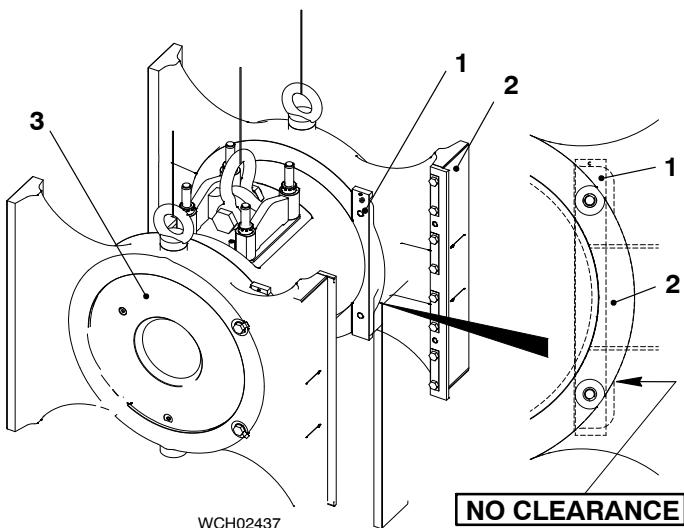


Fig. 12

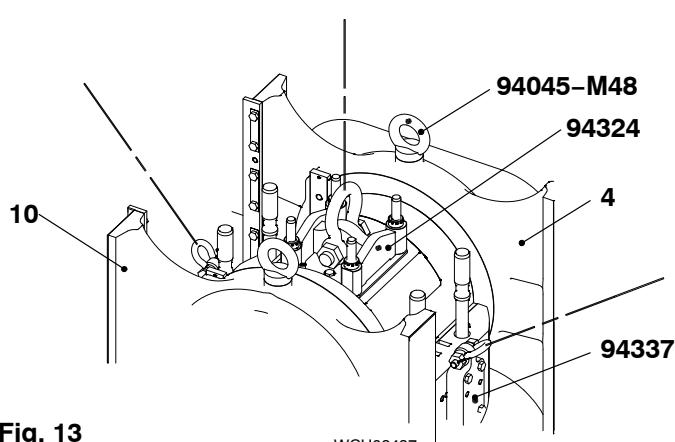
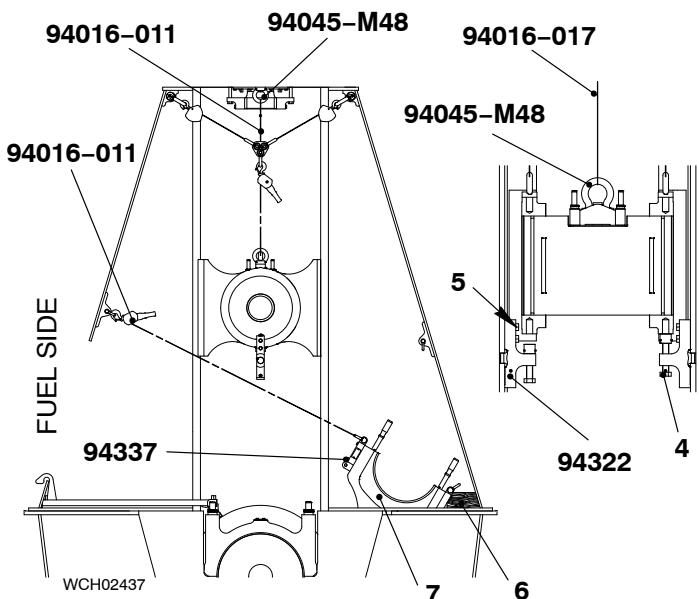


Fig. 13

- 19) Attach the two holding plates (1, Fig. 12) to the guide shoe (2) with the tab washers and bolts.
- 20) Make sure that there is no clearance between the holding plates (1) and crosshead pin (3).
- 21) Use the manual ratchet (94016-017, Fig. 1) to lift the crosshead approximately 160 mm above the center of the pin hole (4).

Note: The two supports (94322) hold the weight of the crosshead while you move the connecting rod.

- 22) Attach the two supports (94322, Fig. 13) to the guide way.
- 23) Tighten the four bolts (5) to 300 Nm.
- 24) Tighten the two set screws (4).
- 25) Attach the two manual ratchets 94016-011 to the shackles (94018B) and the lifting tools (94337) on the connecting rod (7). Apply a light tension to the chains.

Note: During the step below, slowly move the connecting rod to the fuel side.

- 26) On the fuel side, gradually tighten the manual ratchet. At the same time, keep tension on the chain of the manual ratchet on the exhaust side.
- 27) Continue with the step above until the connecting rod (7) aligns with the crosshead.
- 28) Remove the wooden block 8.
- 29) If necessary, lift the crosshead a small distance.
- 30) Loosen the two set screws 5.
- 31) Remove the two supports 94322.

Crosshead Pin – Removal / Installation / Clearance Checks

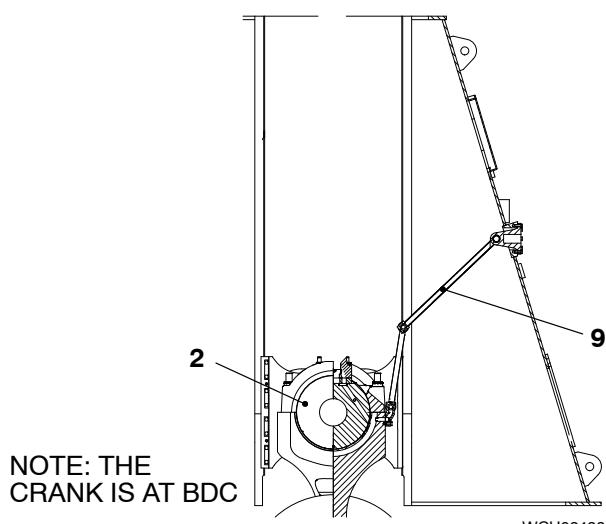


Fig. 14

Note: During the step below, make sure that the elastic bolts in the connecting rod align with the holes in the crosshead pin.

- 32) Carefully lower the crosshead pin (2, [Fig.14](#)) on to the connecting rod.
- 33) Remove the lifting tools (94337).
- 34) Remove all manual ratchets, eye bolts and spur gear chain blocks.
- 35) Remove the protection from the crosshead pin (2).

CAUTION

Damage Hazard: Damage will occur to an incorrectly connected toggle lever. Make sure that you connect the toggle lever correctly.

- 36) Connect the toggle lever (9) to the crosshead pin (2). make sure that the toggle lever is in the position shown.

6. Clearance Checks

- 1) Do the clearance checks, refer to [3326-1](#).

7. Completion

- 1) Install the round nuts to the elastic studs on the connecting rod, refer to [9403-4](#).
- 2) Install the top bearing cover, refer to [3303-5](#).
- 3) Disengage the turning gear.
- 4) Set the lubricating oil pump to on.
- 5) Make sure that the crosshead and the bottom end bearings of the connecting rod have sufficient lubrication.

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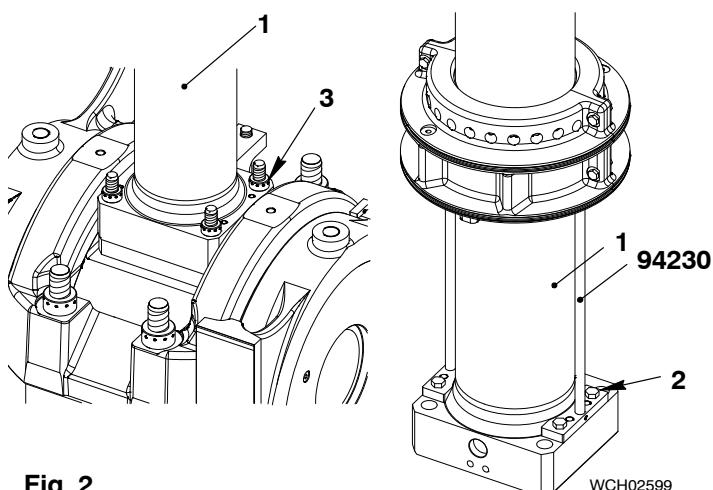
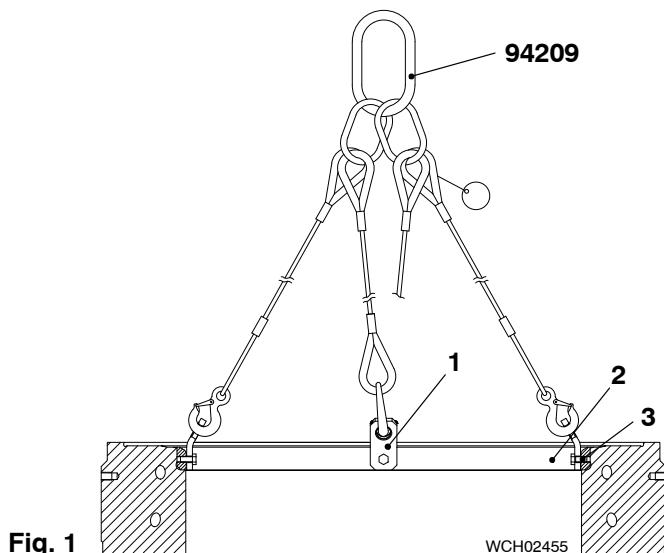
Piston**Removal and Installation****Tools:**

1 Lifting tool	94209
2 Distance holders	94230
1 Piston suspension device	94341
2 Distance plates	94341A

1 Insertion funnel	94342
1 Cover plate	94345D
1 Device	94350

1. Preparation**WARNING**

Injury Hazard: Before you operate the turning gear, make sure that no personnel are on and inside the engine, near propeller shaft and the flywheel.



- 1) Stop the engine, see the procedure in Operation Manual 4002-2.
- 2) Let the engine temperature decrease before you start the removal procedure.
- 3) Make sure that all tools and equipment are clean.
- 4) Remove the cylinder cover, see the procedure in 2708-1.
- 5) Attach the four plates (1, Fig. 1) to the antipolishing ring (2) with the four screws (3).
- 6) Connect the crane hook to the lifting tool (94209).
- 7) Attach the lifting tool (94209) to remove the antipolishing ring (2).
- 8) Look at the area of the piston ring stroke. If there is a wear edge, see the procedure in 2124-3.
- 9) Use the turning gear to turn the crank to BDC.
- 10) Remove the four round nuts (3, Fig. 2) of the piston rod foot (1), see the procedure in 9403-4.
- 11) Attach the two distance holders (94230) to the piston rod foot (1) with the four screws (2).

Piston: Removal and Installation

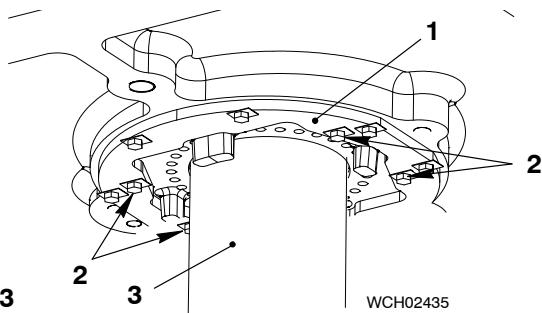


Fig. 3

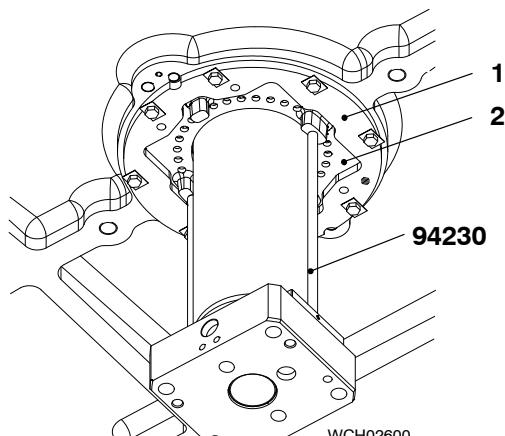


Fig. 4

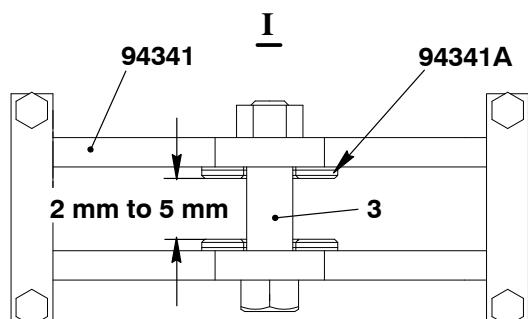
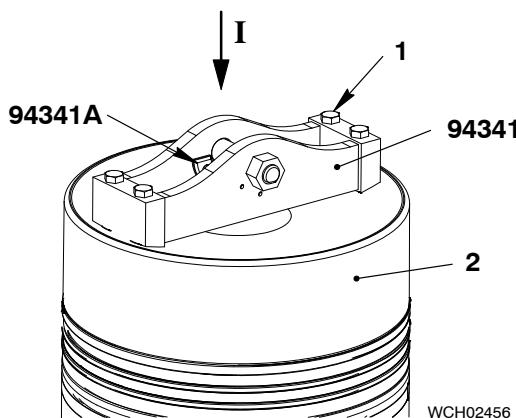


Fig. 5

- 12) Remove the four inner bolts (2, Fig.3) from the support (1).

- 13) Use the turning gear to turn the crank to TDC until the two distance holders (94230) are near to the piston rod gland (2, Fig. 4). Piston rod gland (2) is pushed out of the support (1).
- 14) Make sure that the two distance holders (94230) stay in line with the gland box.

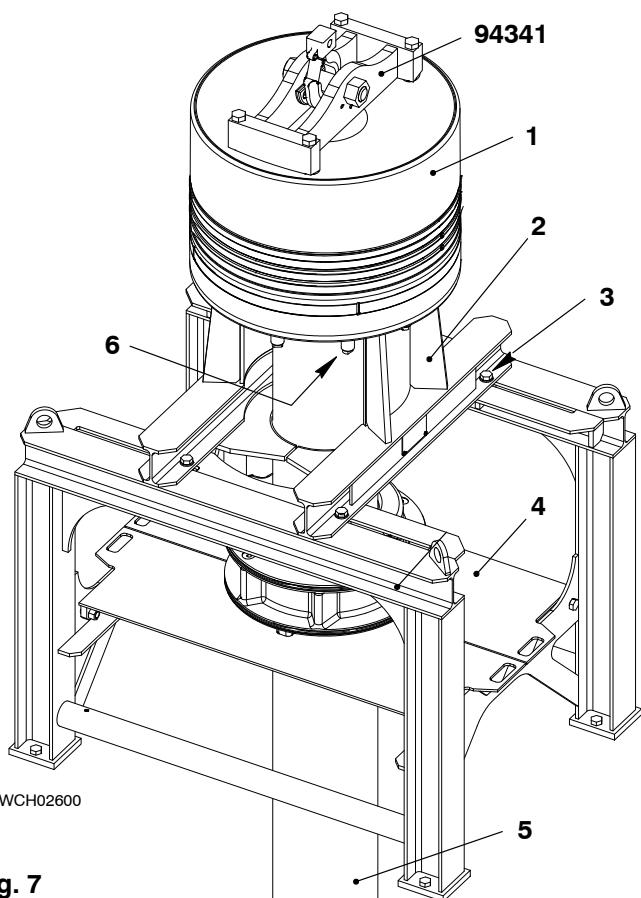
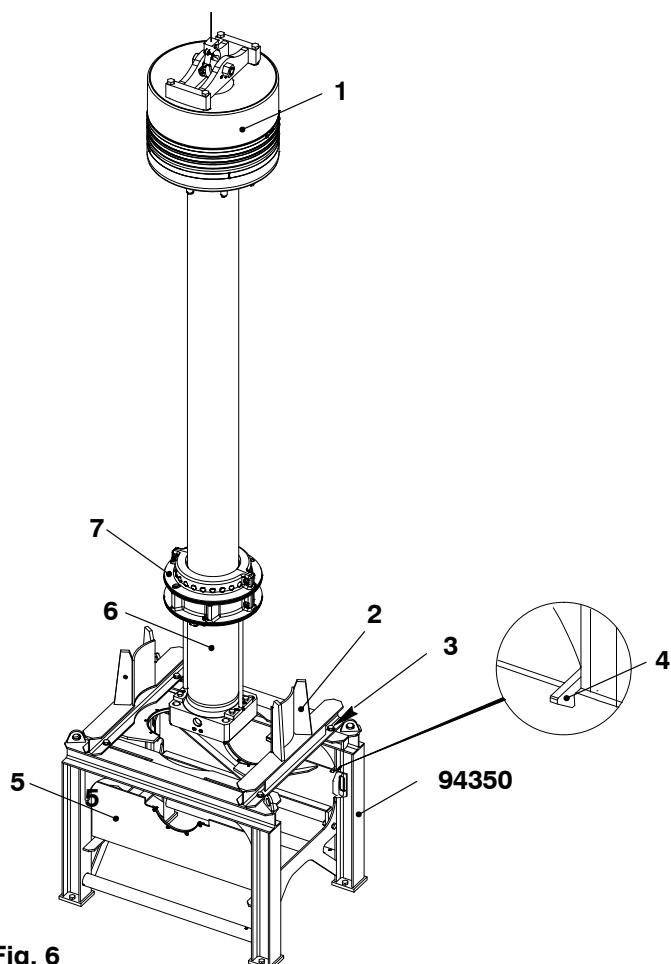
- 15) Clean the threads of the piston suspension device (94341, Fig.5) with water.
- 16) Put oil on the threads and the surfaces of the four screws (1).
- 17) Attach the piston suspension device (94341) to the piston (2) with four screws (1).
- 18) Torque the screws (1) to 60 Nm.

Note: Before you use the suspension device (94341) for the first time, the axial clearance between the crane hook and suspension device must be adjusted.

Note: The axial clearance between the plates of the suspension device is related to the size of the crane hook. You use the plates (94341A) to adjust this clearance.

- 19) Put the applicable quantity of plates (94341A) in position to get the axial clearance to between 2 mm and 5 mm.
- 20) Connect the crane hook to the piston suspension device (94341).
- 21) Measure the clearance between the crane hook and the shaft (3) of the suspension device (94341). Make sure that the clearance is between 2 mm and 5 mm.

Piston: Removal and Installation

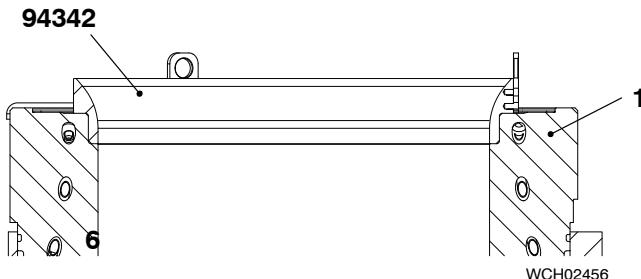
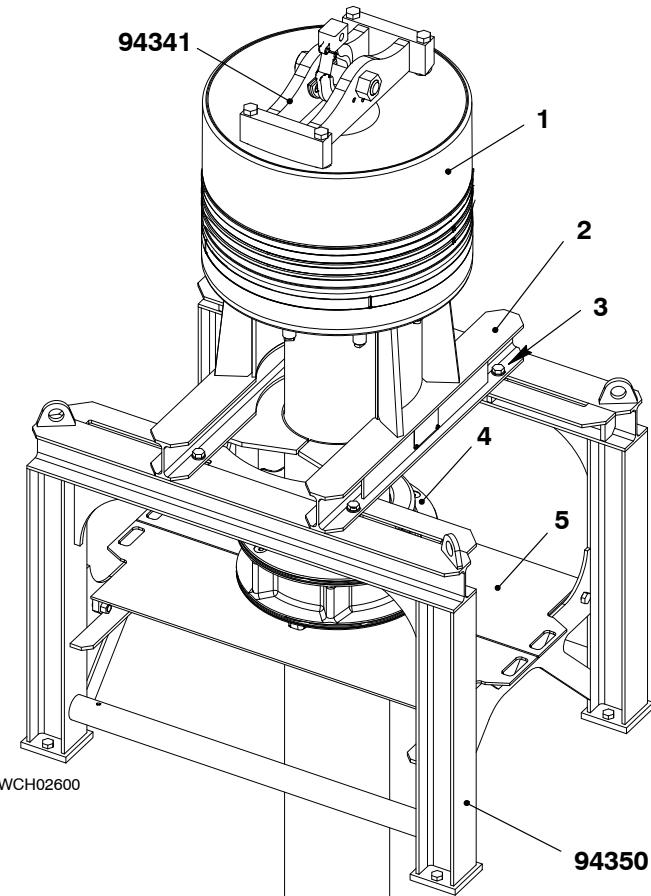


2. Removal

- 1) Make sure that the device (94350, [Fig.6](#)) is installed correctly on the top platform.
- 2) Use the crane to carefully lift the piston (1) from the cylinder. Make sure the piston rod foot (6) (does not touch the support of the piston rod gland (7).
- 3) Loosen the screws (3) of the device (94350) and push the supports (2) fully outwards.
- 4) Open the two hinged plates (5).
- 5) Make sure that the bars (4) lock the hinged plates (5) in the open position.

- 6) Lower and align the piston (1, [Fig.7](#)) between the supports (2). Make sure that the supports (2) will go between the round nuts (6).
- 7) Close the hinged plates (4) when the piston rod foot (5) is below them.
- 8) Push the supports (2) in.
- 9) Tighten the screws (3).
- 10) Lower the piston on to the supports (2). Make sure that the supports are between the round nuts (6).
- 11) Remove the crane hook from the piston suspension device (94341).
- 12) Remove the distance holders (94230, [Fig.2](#)) from the piston rod foot (1).
- 13) Install the cover plate 94345D to the piston rod bore.
- 14) To disassemble the piston, refer to [3403-3](#).
- 15) Do a check of the top surface of the piston, refer to [3403-4](#).
- 16) Do a check of the piston rings and grooves, refer to [3425-1](#).
- 17) Refer to the Maintenance Schedule for other work on each piston [0380-1](#). Select the related data.

Piston: Removal and Installation

**Fig. 8****Fig. 9****3. Installation**

- 1) Put oil on the bore of the cylinder liner (1, [Fig. 8](#)) and the surfaces of the insertion funnel (94342).
- 2) Put the insertion funnel (94342) in position on the cylinder liner (1).
- 3) Use the turning gear and turn the crank to TDC.
- 4) Make sure the items that follow are clean:
 - The piston rod gland
 - The piston and the piston rings.
- 5) Make sure that the O-rings in the piston rod gland are in a satisfactory condition.
- 6) Put oil on the bore and the O-rings of the piston rod gland.
- 7) Remove the cover plate 94345D from the piston rod bore.
- 8) Install the piston suspension device (94341, [Fig.9](#)) on top of the piston (1).
- 9) Make sure that the piston rod gland is correctly installed on the piston rod.
- 10) Attach the two distance holders (94230, [Fig.2](#)) to the piston rod foot (1) with the four screws (4).
- 11) Lift the piston until the distance holders (94230, [Fig.4](#)) touch the piston rod gland (2).
- 12) Loosen the screws (3, [Fig.9](#)) and push the supports (2) fully out.
- 13) Lift the piston (1) together with the piston rod gland (4) from the device (94350).
- 14) Turn the two hinged plates (5) up before the piston rod foot touches them.
- 15) Make sure that the bars (4, [Fig.6](#)) lock the hinged plates (5) in the open position.

Piston: Removal and Installation

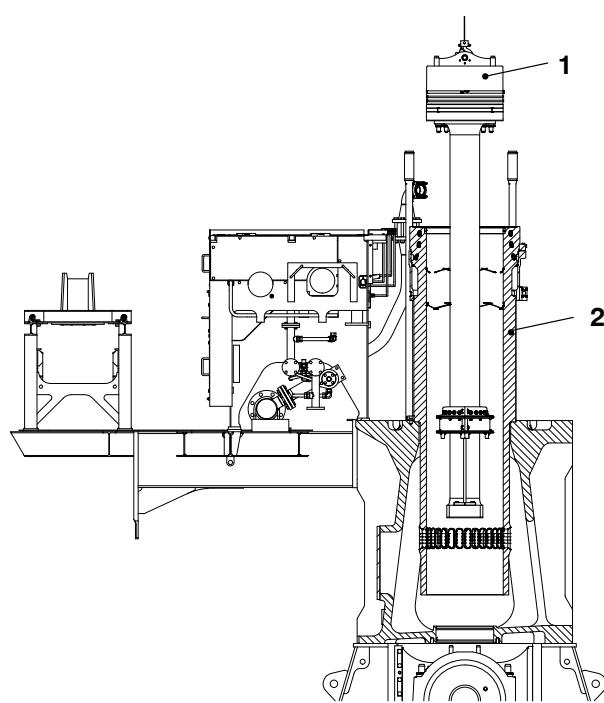
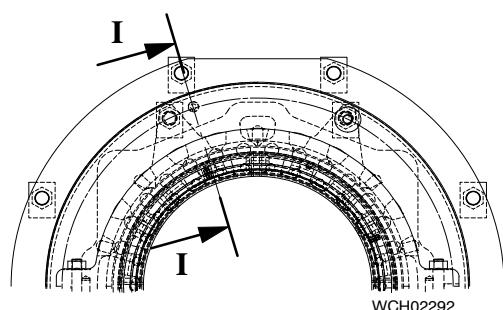


Fig. 10



- 16) Do a function check of the cylinder lubricating system. See 7218-1, paragraph 1.2.
- 17) Carefully lower the piston (1, Fig.10) into the cylinder liner (2).
- 18) Use the turning gear to turn the crank to BDC.



- 19) Make sure that the piston rod gland is in the correct position for the dowel pin (1) to align with the crosshead.

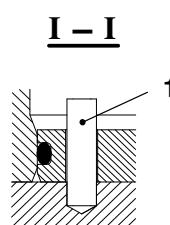


Fig. 11

Piston: Removal and Installation

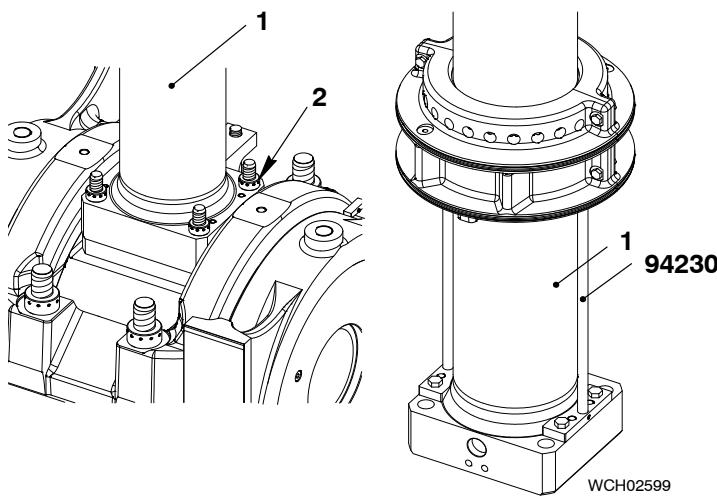


Fig. 12

- 20) Put oil on the four bolts (2, [Fig.3](#)).
- 21) Attach the piston rod gland (2, [Fig.4](#)) in the cylinder block with the four bolts (2, [Fig.3](#)) and new locking plates.
- 22) Torque the bolts (2, [Fig.3](#)) to 150 Nm.
- 23) Bend the locking plates to lock the bolts.
- 24) Remove the distance holders (94230, [Fig.12](#)).
- 25) Tighten the round nuts (2) on the piston rod foot (1). See the procedure in [9403-4](#).

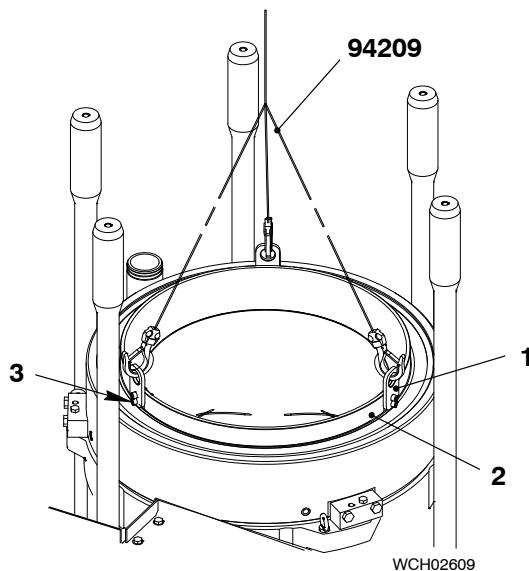


Fig. 13

- 26) Make sure that the cylinder liner and the antipolishing ring are clean and in a satisfactory condition.
- 27) Put oil on the surfaces of antipolishing ring.
- 28) Connect the crane hook to the lifting tool (94209, [Fig.13](#)).
- 29) Attach the four plates (1) to the antipolishing ring (2) with the four screws (3).
- 30) Put the antipolishing ring (2) into the cylinder liner.
- 31) Remove the lifting tool (94209).
- 32) Remove all tools and equipment from the work area.

Disassemble and Assemble

Tools:

3 Pre-tensioning jacks 94340

3* Jacking screws 94364A

2* Jacking screws 94364B

3* Jacking screws 94364C

* Use available screws from piston assembly

1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Remove the piston, refer to [3403-1](#), paragraph 1 and paragraph 2.

Note: You disassemble a piston to clean the cooling chamber in the piston head, do an overhaul of the ring grooves etc.

CAUTION



Damage Hazard: When you disassemble or assemble a piston, make sure that you do not damage the pipes or nozzles.

Note: When you do step 3), apply tension to the elastic bolts in the sequence given in Fig. 1.

- 3) Apply tension to the elastic bolts (1) to loosen the eight round nuts, refer to [9403-4](#), paragraph 1 and paragraph 2.
- 4) Remove the eight round nuts.

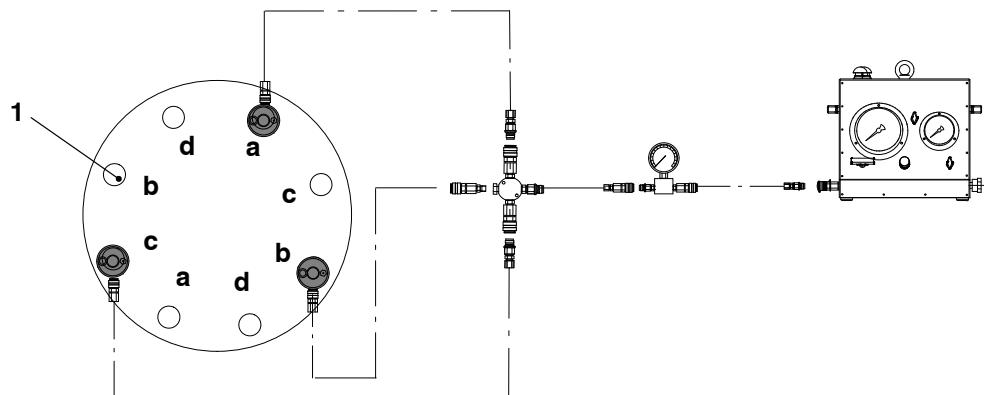


Fig. 1: Sequence to Apply Tension to the Elastic Bolts

Piston: Disassemble and Assemble

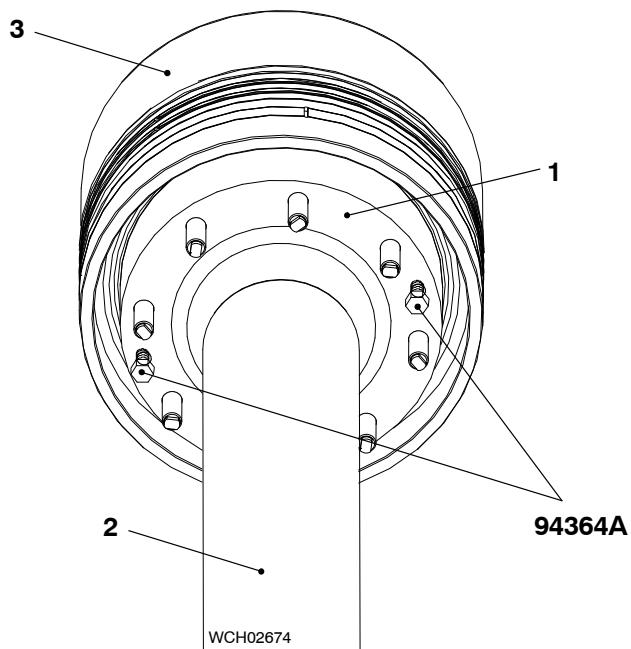


Fig. 2

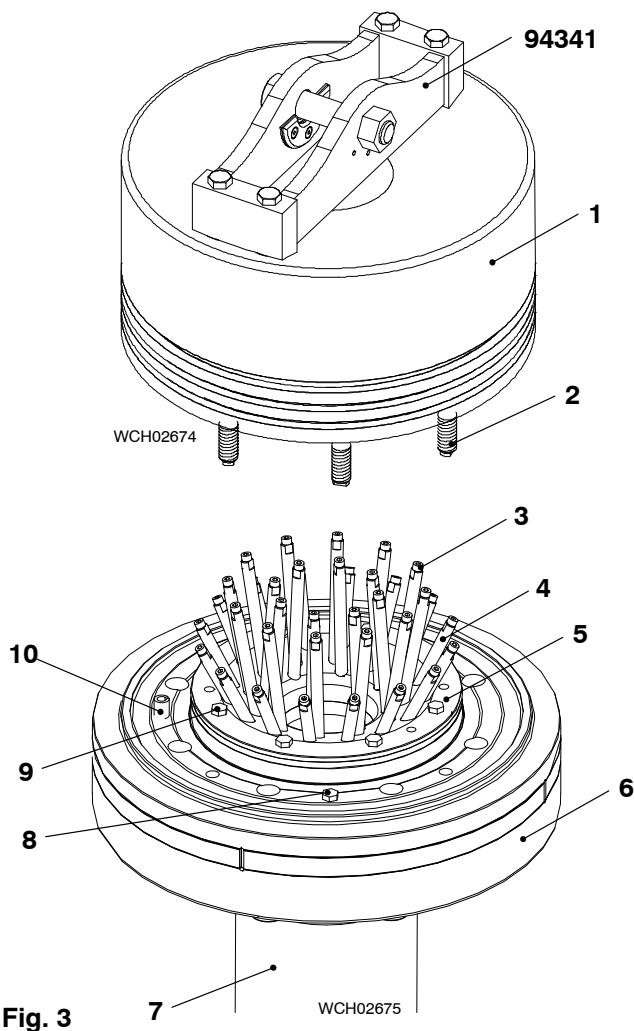


Fig. 3

2. Disassemble

CAUTION



Damage Hazard: When you disassemble the piston, make sure that you do not damage the pipes or nozzles on the spray plate.

- 1) Put the two jacking screws (94364A, Fig. 2) fully into the two tap holes in the top of the piston rod (1). Make sure that the jacking screws touch the piston head (3).
- 2) Equally tighten the two jacking screws until there is a clearance between the piston head (3) and the piston rod (2).
- 3) Attach the engine room crane to the tool (94341, Fig 3)
- 4) Use the engine room crane to lift the piston head (1).
- 5) Move the piston head (1) to an applicable area.
- 6) Remove the jacking screws (94364A) from the top of the piston rod (2).

CAUTION



Damage Hazard: If it becomes necessary to remove the the elastic bolts, do not use a pipe wrench. This could cause damage to the bolt shank.

- 7) Remove the piston skirt (6) from the piston rod (7) as given in step a) to step c):
 - a) Remove the two screws (8).
 - b) Use the jacking screws 94364C to separate the piston skirt (6) from the piston rod (7).
 - c) Lift the piston skirt (6) away from the piston rod (7).
- 8) Remove the eight screws (9).
- 9) Use the two jacking screws (94364B) to remove the spray plate (5) from the piston rod (7).
- 10) If necessary, remove the pipes (4) and nozzles (3).
- 11) Do a check of the top surface of the piston head, refer to 3403-4.

Piston: Disassemble and Assemble

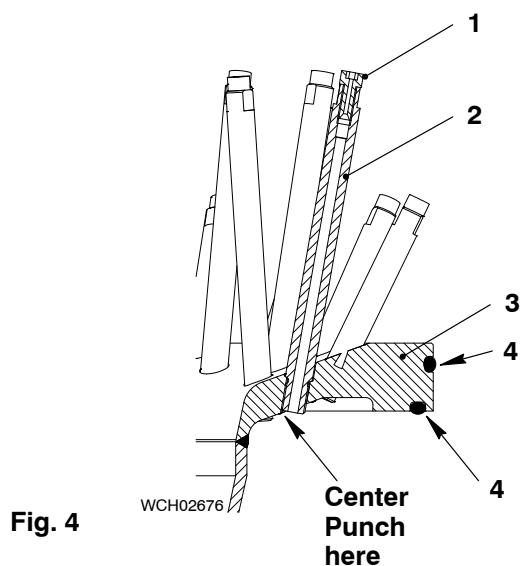


Fig. 4

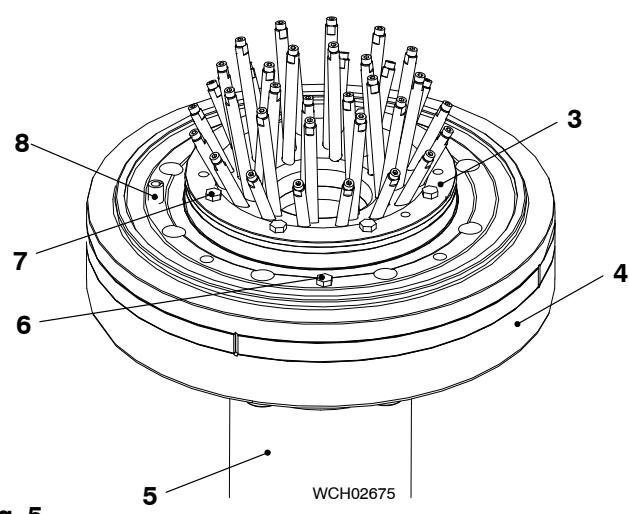
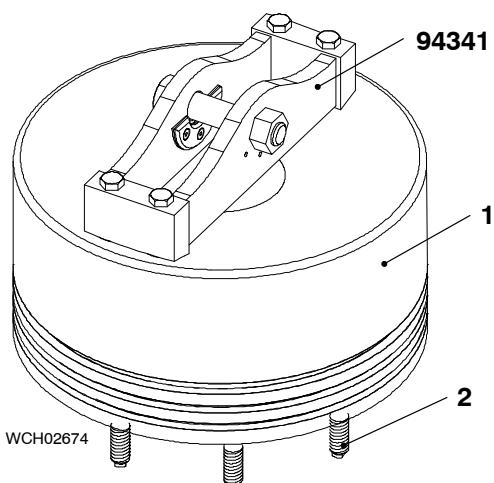


Fig. 5

3. Assemble

Note: Do not install pipes or nozzles that have damage.

- 1) Apply Loctite No. 0270 to the thread of the pipe (2, Fig. 4).
- 2) Use the applicable tool to install the pipe (2) to the spray plate (3).
- 3) Use a center punch to lock the pipe (2) in position.
- 4) Apply Loctite No. 0270 to the thread of the nozzle (1).
- 5) Use the applicable tool to install the nozzle (1) to the pipe (2).
- 6) Put oil on the new O-rings (4).
- 7) Install two new O-rings (4) on the spray plate (3).
- 8) Install a new O-ring to the piston rod.
- 9) Attach the spray plate (3, Fig. 5) to the piston rod (5) with the eight screws (7).
- 10) Torque the eight screws (7) as follows:
 - a) Symmetrically torque the eight screws to 20 Nm.
 - b) Symmetrically torque the eight screws to 75 Nm.

Note: When you do step 11), make sure that the dowel pin (8) engages in the related hole in the piston skirt (4).

- 11) Attach the piston skirt (4) to the piston rod (5) with the two screws (6).
- 12) Use the engine room crane to lower the piston head (1) on the piston skirt (4). Make sure that the dowel pin (8) engages with the hole in the piston head (1).
- 13) Attach the eight round nuts to the elastic bolts (2).
- 14) Apply tension to the elastic bolts. Refer to Fig. 1 for the sequence to apply tension.
- 15) Tighten the round nuts on the elastic bolts (2).
- 16) Install the piston, refer to 3403-1 paragraph 3.

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Piston**Top Surface – Check****Tools:**

1 Feeler gage 94122
 1 Template 94366
 1 Template 94366A

1. General	1
2. Procedure – Piston Removed	1
3. Procedure – Piston Installed	2

1. General

Each time you remove a piston, you must do a check of the top surface of the piston head for damage (burn scars).

The causes of burn scars are as follows:

- Poor combustion
- Worn nozzles
- Heavy local carbon particles on top of the piston head etc.

Note: You can also do this check with the piston installed.

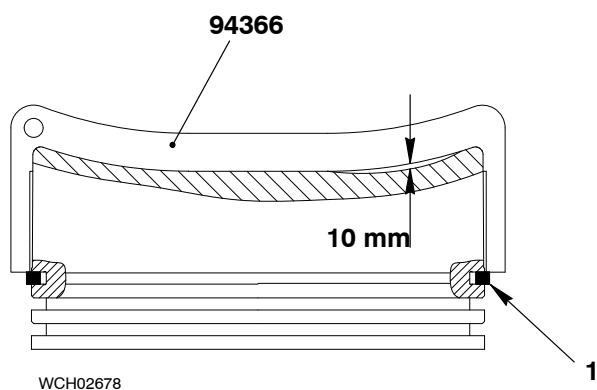


Fig. 1

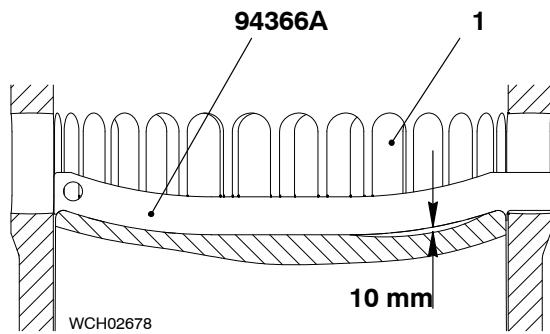
2. Procedure – Piston Removed

- 1) Put the template (94366, Fig. 1) in position on the top piston ring (1).
- 2) Turn the template (94366) around the axis of the piston head.
- 3) Use the feeler gage (94122) to measure the depth of the burn scar(s).
- 4) Remove the template (94366).

Note: You can also use a depth gage to measure the depth of the burn scar(s).

- 5) If the burn scars are less than 10 mm, do step a) and step b):
 - a) Use an applicable tool to grind the burn scars.
 - b) Use emery paper to make sharp edges smooth.
- 6) If the burn scars are more than 10 mm deep, do step a) to step c):
 - a) Remove the piston head (see 3403-3, paragraph 1 and paragraph 2).
 - b) Use surface welding to repair the piston head to its original thickness.
 - c) Assemble the piston (see 3403-3, paragraph 3).

Note: Before you start the engine, find the cause of the burn scars.

**Fig. 2**

3. Procedure – Piston Installed

WARNING



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

- 1) Use the turning gear to move the piston to BDC.
- 2) Look at the piston head through the scavenge ports (1, Fig. 2) to find burn scars.
- 3) Put the template (94366A) through the related scavenge port (1).
- 4) Use the feeler gage (94122) to measure the depth of the burn scar(s).

Note: You can also use a depth gage to measure the depth of the burn scar(s).

- 5) Remove the template (94366A).
- 6) If there are more burn scars, put the template (94366A) through the related scavenge port (1) and do step 2) and 3) again.
- 7) If the burn scars are less than 10 mm, do step a) and step b):
 - a) Use an applicable tool to grind the burn scars.
 - b) Use emery paper to make sharp edges smooth.
- 8) If the burn scars are more than 10 mm, do step a) to step d).
 - a) Remove the piston, refer to 3403-1, paragraph 1 and paragraph 2.
 - b) Remove the piston head, refer to 3403-3, paragraph 1 and paragraph 2).
 - c) Use surface welding to repair the piston head to its original thickness.
 - d) Assemble the piston (see 3403-3, paragraph 3).

Note: Before you start the engine, find the cause of the burn scars.

Piston Rings

Wear of Piston Rings and Ring Grooves

Tools:

1	Inside micrometer	94101	1	Permascope MP0 (with instruments to measure chrome-ceramic layers)	94356
1	Feeler gauge	94122			
1	Piston ring tool	94338	1	Calliper gauge	

1.	General	1
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1. General

Use the data in paragraph 2.1 and paragraph 2.3 to make an analysis of the condition of the cylinder liner, piston and piston rings.

The wear rates are related to the type of fuel used, the engine load profile, ambient conditions etc, during engine operation.

Visual inspections will show critical conditions of cylinder liners and piston rings after a short time. For more data to monitor the cylinder liner and piston ring conditions, see the Operation Manual 0750-1 Lubricating Oils.

When you measure and record the piston ring grooves, the data is used to calculate the wear.

Refer to 0380-1, [Piston Rings](#) for the scheduled intervals.

2. Piston Ring Wear Rate

2.1 Chrome-Ceramic Layer – Measure (Piston Installed)

WARNING



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

- 1) Read the data in the supplier documentation for the tool Permascope MP0 (94356).
- 2) Calibrate the Permascope MP0 (94356). Use the calibration foils and the top flank of a spare top piston ring to get a correct setting.
- 3) Use the turning gear to move the piston almost to BDC (so that you can see the piston rings).
- 4) Clean the surface of the piston ring (1, Fig. 1) at the locations P1 to P9.
- 5) Put the sensor of the Permascope MP0 (94356) against the middle of the piston ring (1).
- 6) Record the value on the digital display of the Permascope MP0 (94356).
- 7) Compare the measured data with the limits given in [0330-1 Clearance Table, Piston and Piston Rings](#). If the recorded data is not in the limits given, you must do an overhaul of the piston head.

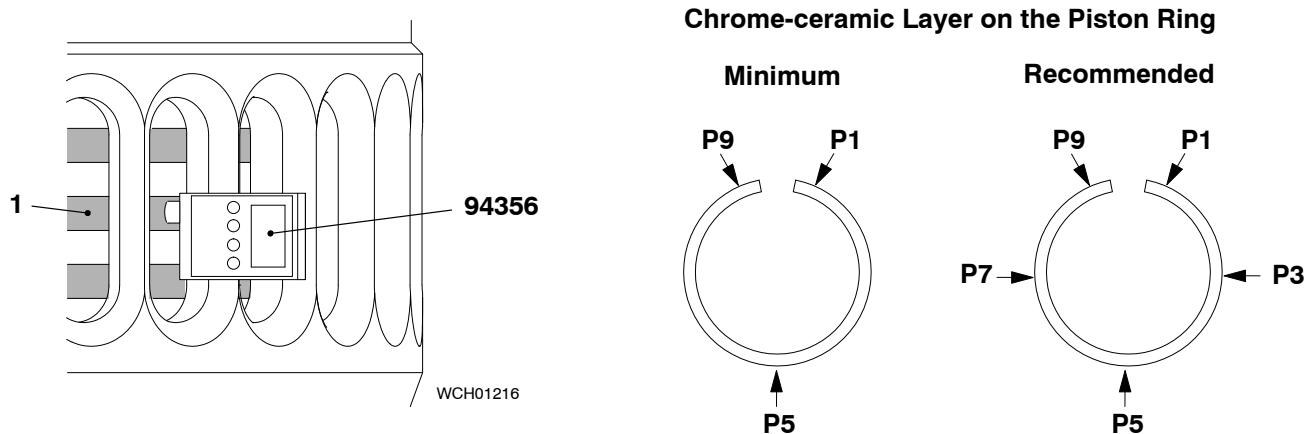


Fig. 1

Piston Rings: Wear of Piston Rings and Ring Grooves

2.2 Wear Rate

The wear of the chrome-ceramic layer is related to the operation conditions. If a piston ring that has some wear of the chrome-ceramic layer is found (see Fig. 2), do an overhaul of the unit as soon as possible.

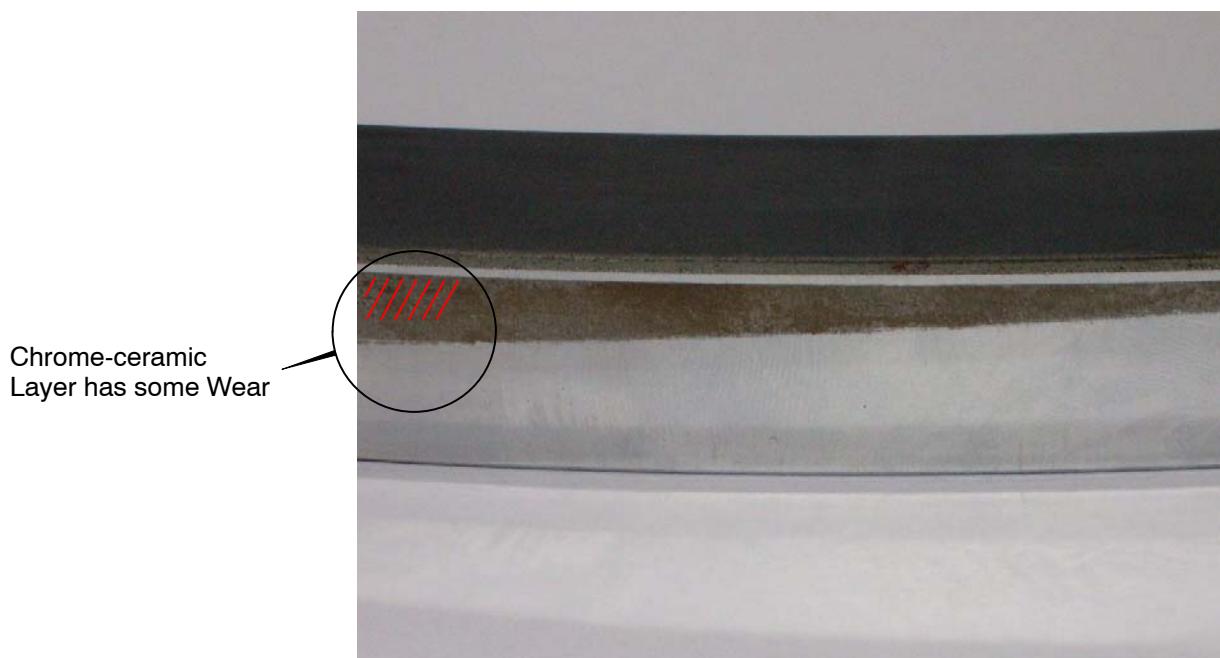


Fig. 2 Chrome-ceramic Layer

With regular procedures to measure the chrome-ceramic layer, you can calculate the wear rate for each piston ring.

You can continue to use the piston rings if the remaining chrome-ceramic layer is more than the limits that follow:

- Top piston ring, more than 0.05 mm
- Middle and bottom piston rings, more than 0.02 mm

If the thickness of the chrome-ceramic layer is less than the limits given, you must replace the applicable piston ring.

2.3 Service Life – Calculate

Use the formula below to calculate the wear rate of a piston ring:

$$WR = \frac{(D_1 - D_2) \times 1000}{T_2 - T_1}$$

Where:

- WR = Wear rate (mm/1000 hrs)
- T2 = Hours (hrs)
- T1 = First recorded operation hours (hrs)
- D2 = Second recorded thickness of the chrome-ceramic layer (mm)
- D1 = First recorded thickness of the chrome-ceramic layer (mm).

See [Table 1](#) for examples of wear rate results.

Table 1: Examples of Wear Rate

D1	D2	T1	T2	WR
0.382	0.367	0 (new)	1500	0.01
0.351	0.340	3500	5000	0.0073

Use the formula below to calculate the remaining piston ring service life:

$$LT = \frac{(D_2 - D_{min}) \times 1000}{WR}$$

Where:

- LT = Remaining in-service time (hrs)
- D2 = second recorded thickness of chrome-ceramic layer (mm)
- Dmin = Minimum thickness of the chrome-ceramic layer (mm) (see paragraph [2.2](#))
- WR = Calculated wear rate (mm/1000 hrs)

Table 2: Example for Remaining Service Life

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

Piston Rings: Wear of Piston Rings and Ring Grooves

3. Piston Ring Grooves

Do a check of all dimensions and record them (see [0330-1 Pistons and Piston Rings](#)). These records are important for an analysis of the running gear and must include the data that follow:

- All dimensions
- The date of the overhaul
- The operation hours of the different components
- The operation hours of the engine.

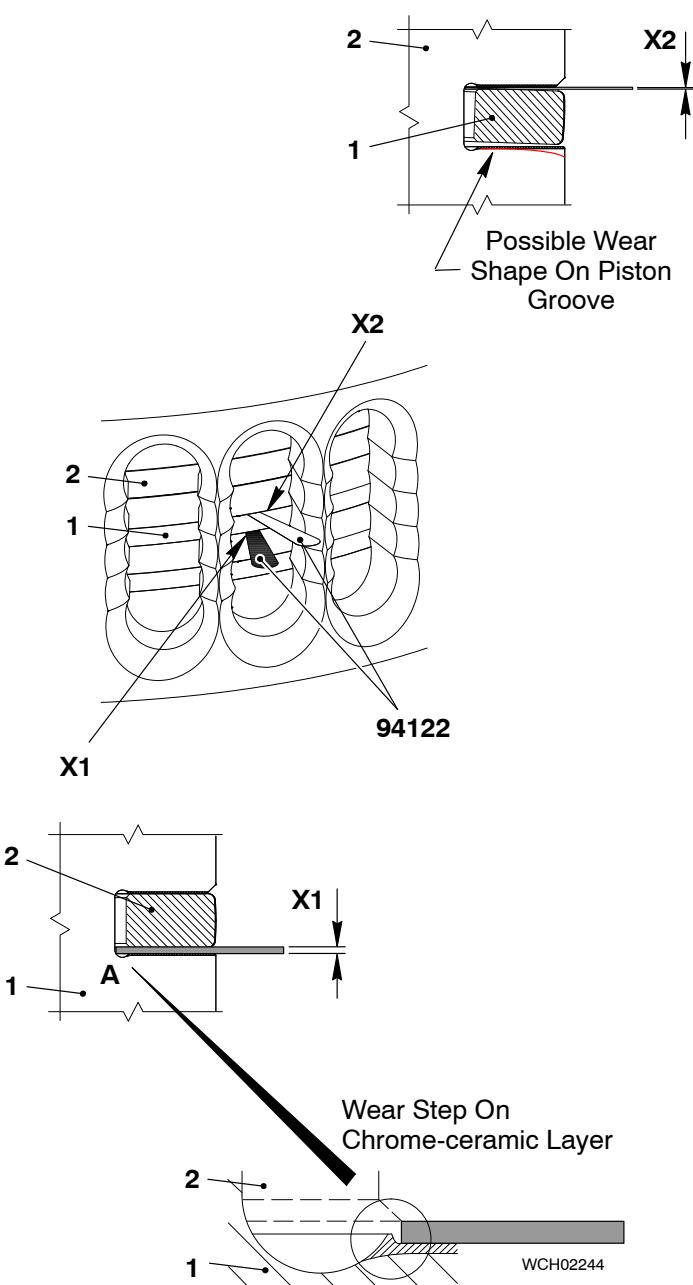


Fig. 3

3.1 Piston Ring Clearance (Piston Installed)

WARNING

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

- 1) Use the turning gear to move the piston (2, [Fig. 3](#)) down.

Note: Push the feeler gage fully into the piston ring groove. This will make sure that the feeler gage will touch the inner diameter of the groove.

- 2) Measure the clearance X1 at Point A. If there is a wear step on the chrome-ceramic layer, you can push the feeler gage only to that point.
- 3) Measure the clearance at X2.
- 4) Do step 2) and step 3) at between two and four different locations around the piston (2).

The sum of each value from X1 and X2 will give the total piston ring clearance.

The maximum clearance is at point A. For the maximum wear data, refer to [0330-1 Pistons and Piston Rings](#).

- 5) If the clearance at point A is more than the permitted value, do step a) and step b)
 - a) Replace the piston rings.
 - b) Repair the piston head.

Note: For the repair of piston heads, speak to the nearest Wärtsilä Service Center.

3.2 Piston Rings – Removal

CAUTION



Damage Hazard: Do not open the piston rings too far. This will cause damage to the piston rings.

- 1) Use the tool (94338, Fig. 4) to remove the top, middle and bottom piston rings (1). Make sure that you do not cause damage to the chrome-ceramic surface.
- 2) If the same piston rings will be installed again, record their positions.
- 3) Clean the piston ring grooves.

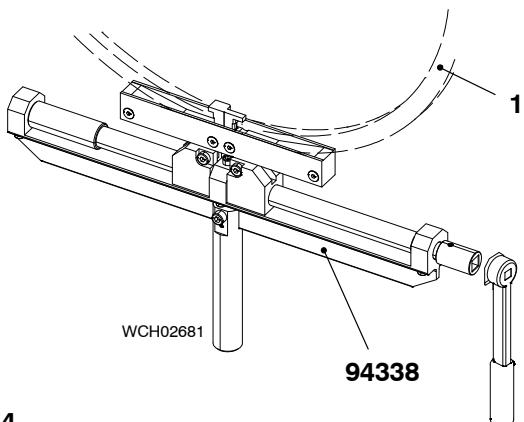


Fig. 4

3.3 Piston Ring Clearance (Piston Removed)

Note: You can use a calliper gage, an inside micrometer set 94101 (paragraph 3.3.1), or a piece of piston ring (paragraph 3.3.2) to measure the piston ring grooves.

3.3.1 Procedure with Calliper Gage or Inside Micrometer Set

- 1) Use the calliper gage (1, Fig. 5) or inside micrometer set (94101) to measure the groove height at point A and point B. You must measure the groove height at a minimum of four locations around the circumference of the piston head.
- 2) Record the value from the calliper gage (1) or inside micrometer set (94101).
- 3) If the clearance at point A or point B is more than the permitted value, you must repair the piston head.

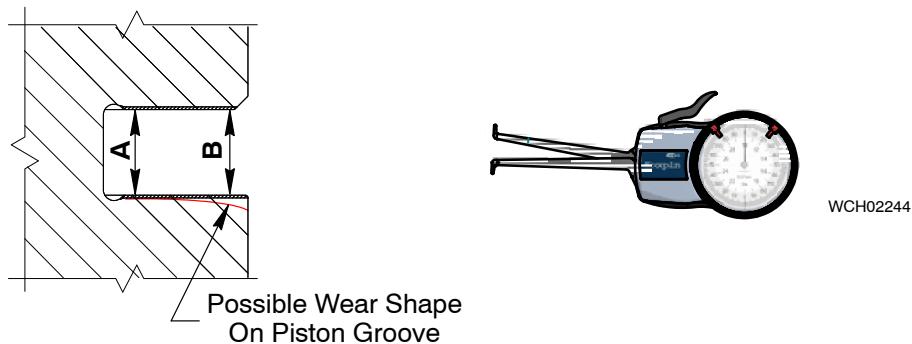


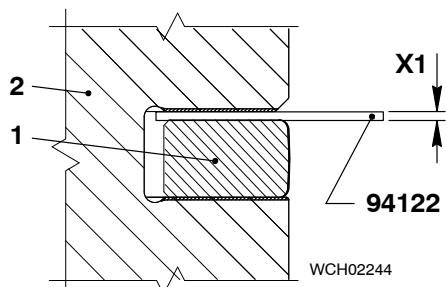
Fig. 5

Note: If the clearance at point A and, or point B is more than the permitted value, you must repair the piston head. For the maximum wear values, refer to 0330-1, Piston and Piston Rings.

Piston Rings: Wear of Piston Rings and Ring Grooves

3.3.2 Alternative Procedure with Piston Ring Piece

- 1) Measure the thickness of the piece of piston ring (1, Fig. 6).

**Fig. 6**

- 2) Put the piece of piston ring (1) into the piston ring groove.
- 3) Use the feeler gage (94122) to measure the clearance X1 between the face of piston ring and the groove.

Note: You must measure the groove height at a minimum of four locations around the circumference of the piston head (2).

- 4) Use the data that follow to calculate the piston ring clearance:

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

Where:

- C = Clearance
- GH = the measured height of the piston ring groove (mm)
- RT = the nominal piston ring thickness (mm).

Note: If the clearance at X1 is more than the permitted value, you must repair the piston head. For the maximum wear values, refer to 0330-1, Piston and Piston Rings. For the repair of piston heads, speak to the nearest Wärtsilä Service Center.

Do not install a piston head that has clearances near the maximum value. This is because the service life will be too short.

3.4 Used Piston Rings – Installation

For the ring types and their locations, see [Table 3](#).

Table 3: Standard Piston Ring Locations

Ring Type	Material	Application
Top Piston Ring 1 x GTP1CC22 (gas tight)	chrome-ceramic layer	For new and fully honed cylinder liners and used cylinder liners in good condition
Middle Piston ring 1 x SCP2CC13 (straight cut)	chrome-ceramic layer	
Bottom Piston ring 1 x SCP2CC13 (straight cut)	chrome-ceramic layer	

CAUTION



Damage Hazard: Do not open the piston rings too far. This will cause damage to the piston rings.

Note: Only install piston rings that are in a satisfactory condition. Make sure that the mark TOP, on the piston ring, points up.

Note: The piston rings must be installed in the same position as before. Use your recorded notes.

Note: Make sure that you use the tool (94338, [Fig. 4](#)) to install the piston rings.

- 1) Install the bottom piston ring (4, [Fig. 7](#)) to the piston head.
- 2) Use the tool (94338) to install the middle piston ring (3) to the piston head.
- 3) Use the tool (94338) to install the top piston ring (1) to the piston head. Make sure that the ring clearance (5) is opposite the ring clearance (2) of the middle piston ring (3).

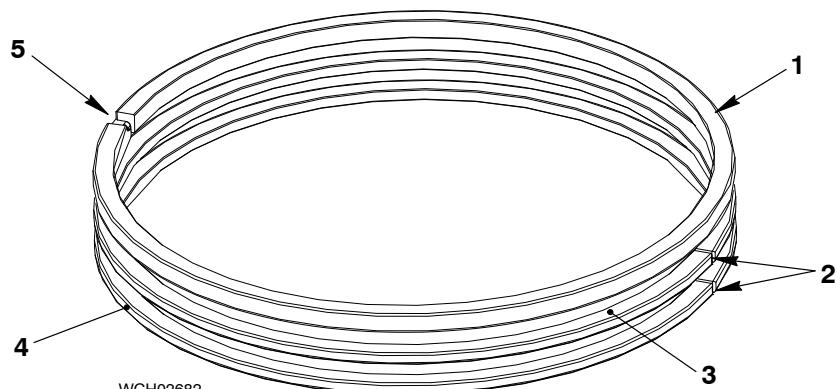


Fig. 7

3.5 New Piston Rings – Installation

CAUTION

Damage Hazard: Do not open the piston rings too far. This will cause damage to the piston rings.

Note: Make sure that the mark TOP, on the piston ring, points up.

Note: For the ring types and their locations, see [Table 3](#).

- 1) Measure and record the thickness of the chrome-ceramic layer on each piston ring. This will help you monitor the wear rate during operation.
- 2) Use the tool (94338, [Fig. 4](#)) to install the bottom piston ring (4, [Fig. 7](#)) to the piston head.
- 3) Use the tool (94338) to install the middle piston ring (3) to the piston head.
- 4) Use the tool (94338) to install the top piston ring (1) to the piston head. Make sure that the ring clearance (5) is opposite the ring clearance (2) of the middle piston ring (3).
- 5) Refer to the Operation Manual, 0410-1 for the running-in procedure for new piston rings.

4. Piston Rings – Storage

Keep the piston rings in their original packages in a dry area. Make sure that the piston rings are in a horizontal position on a flat surface.

To prevent damage, be careful when you prepare the piston rings for installation and during movement.

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Driving Wheels and Shut-off Valve for Starting Air

Group 4

Driving Wheels

Running and Backlash Clearances and Tooth Condition 4103-1/A1

Shut-off Valve for Starting Air: Cleaning and Function Check 4325-1/A1

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Running and Backlash Clearances and Tooth Condition

Tools:

- | | | |
|---------------|-------|-----------------------------|
| 1 Feeler gage | 94122 | 1 Dial gauge |
| 1 Micrometer | | 1 Lead wire 1.5 mm diameter |

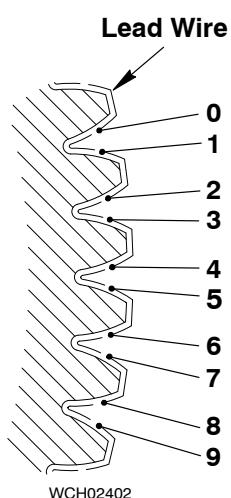
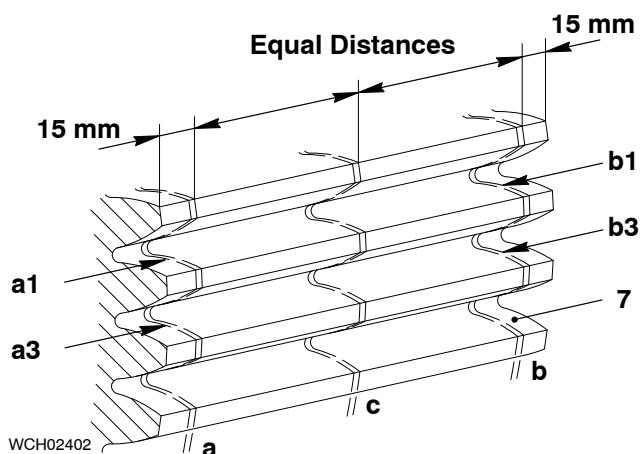
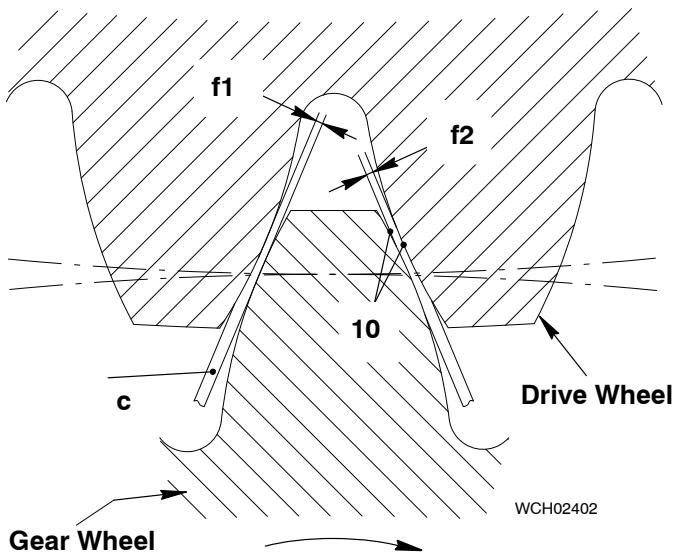
1. General

On new engines during the running-in period, you must do a visual check of the gear wheels after approximately one and two operation hours. You must do the same checks on used engines that have new gear wheels installed.

2. Checks

- 1) Use the turning gear to turn the crankshaft while you do an inspection of all teeth.
- 2) Set to on the service pump.
- 3) Make sure that oil flows freely from all nozzles.
- 4) Set to off the service pump
- 5) Make sure that all screws are correctly locked.
- 6) After the running-in period, do a check of the drive wheels each three months as given above. If faults show during this period, repair them.
- 7) If you hear unusual noises in the area of the gear train, you must find the cause. Replace defective drive wheels as soon as possible to prevent damage to adjacent drive wheels.
- 8) Do the inspection given above one time each year when the drive wheels have operated correctly for between 6000 hours and 8000 hours.

To do checks of the clearances and tooth marks, you must tighten the tie rods and elastic studs of the main bearings.

**Fig. 1**

3. Gear tooth backlash checks

Refer to [0330-1](#), Driving Wheels for Supply Unit (Group 4103) for data about the gear tooth backlash values.

There are three procedures to measure the backlash.

3.1 Feeler gage (94122)

- Measure the clearance between the tooth flanks (10, [Fig. 1](#)). Do this procedure at a minimum of four positions around the circumference of the gear wheel.

3.2 Dial gage

- Put the dial gage in a position where you can read the backlash value when the gear wheel moves.
- Make sure that the drive wheel does not move.
- Use the turning gear to carefully move the gear wheel a sufficient distance.
- Measure the backlash when one tooth of the gear wheel moves between the profiles of two gear wheel teeth.

3.3 Lead wire

Note: Use a new lead wire of 1.5 mm diameter (Pb 9.99 fine) for each measurement.

- Attach three lengths of lead wire (approximately 200 mm) in the positions shown with Scotch tape.
- Put marks (0 to 9) on the tooth profiles as shown.
- Use the turning gear to turn the gear wheel so that the lead wire goes once through the teeth of the gear wheel and drive wheel.

The lead wire (c) shows the full backlash (f). The lead wires (a) and (b) show the parallelity of the tooth profile.

The obliquity Δf is the difference between the values of the wires on the drive flanks 10 between e.g. a1 – b1.

- Remove the lead wire.

Running and Backlash Clearances and Tooth Condition

- 5) Use the micrometer to measure the lead wire.
- 6) Calculate as follows:
 - The full tooth backlash: $f = f_1 + f_2$
 - The obliquity: $\Delta f = a_1 - b_1$ or $a_3 - b_3$.

The permitted difference of the tooth profile parallelity is between 0.0% and 0.2% across the width of the tooth.

4. Performance

Do a check of the performance of the gear train after commissioning as follows:

- 1) Apply a thin layer of oil resistant engineer's blue ink to three of the teeth on each of the gear wheels.
- 2) Use the turning gear to turn the engine.
- 3) Do a check of the marks on the gear wheel teeth and driving wheel teeth. This is make sure that the teeth engage correctly and are parallel.

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

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3.	Disassembly	2
4.	Servicing	2
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6.3	Automatic mode	6
7.	Completion	6

1. General

Read the data in [0380-1 Maintenance Schedule](#) for the necessary maintenance and intervals on the shut-off valve for starting air (shut-off valve).

See the data in the Operation Manual 4003-2, Engine Control Diagram and 4003-9, Pipe Diagram – Air Systems.

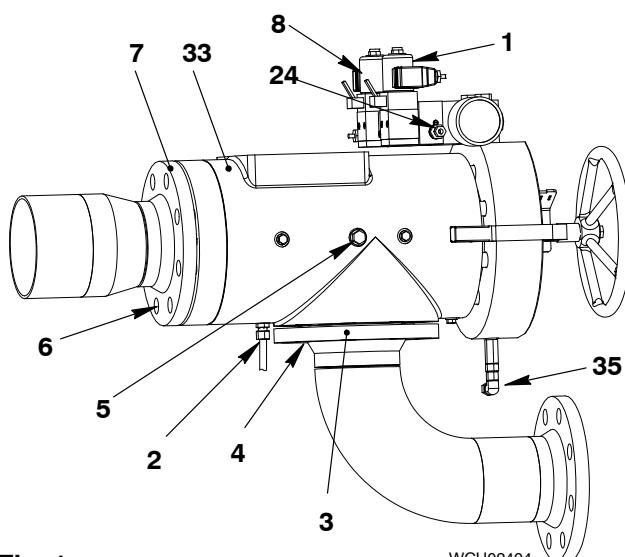


Fig. 1

2. Preparation

- 1) On the starting air bottles, close the stop valves 930-V03 and 930-V04.
- 2) Engage the turning gear.
- 3) Open the ball valves 30-8605_EO_7 and 30-8605_EO_8 to release air in the system.
- 4) Disconnect the electrical connections from the pressure transmitter 5 and the solenoid valves (1) and (8).
- 5) Remove the pipe (2).
- 6) Remove the pipe (35).
- 7) Remove the pipe (24).
- 8) Remove the eight screws (6) from the flange (7).
- 9) Remove the eight screws (4) from the flange (3).
- 10) Remove the shut-off valve from the engine.
- 11) Do a check of the two gaskets that are installed on the flanges (3) and (7). If the gaskets are unserviceable, replace them.

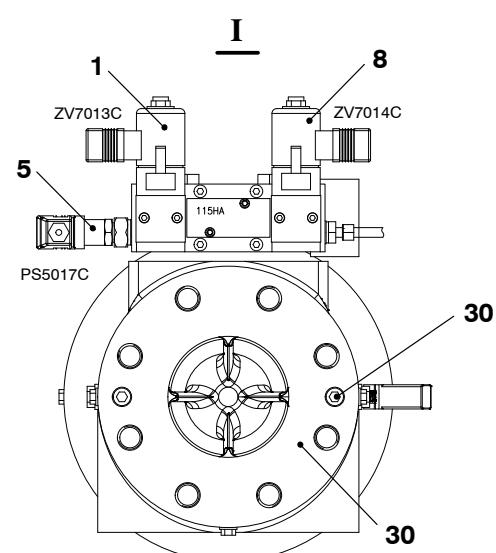
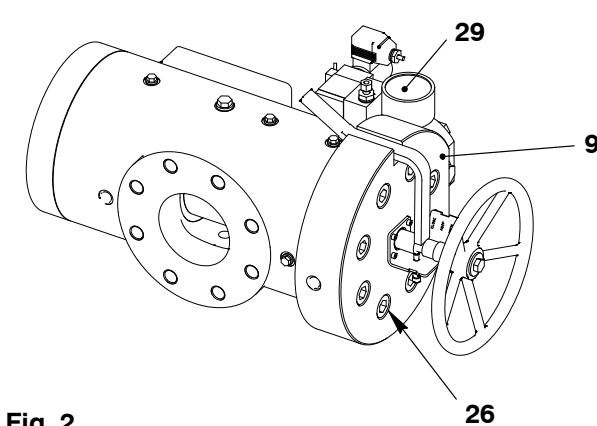
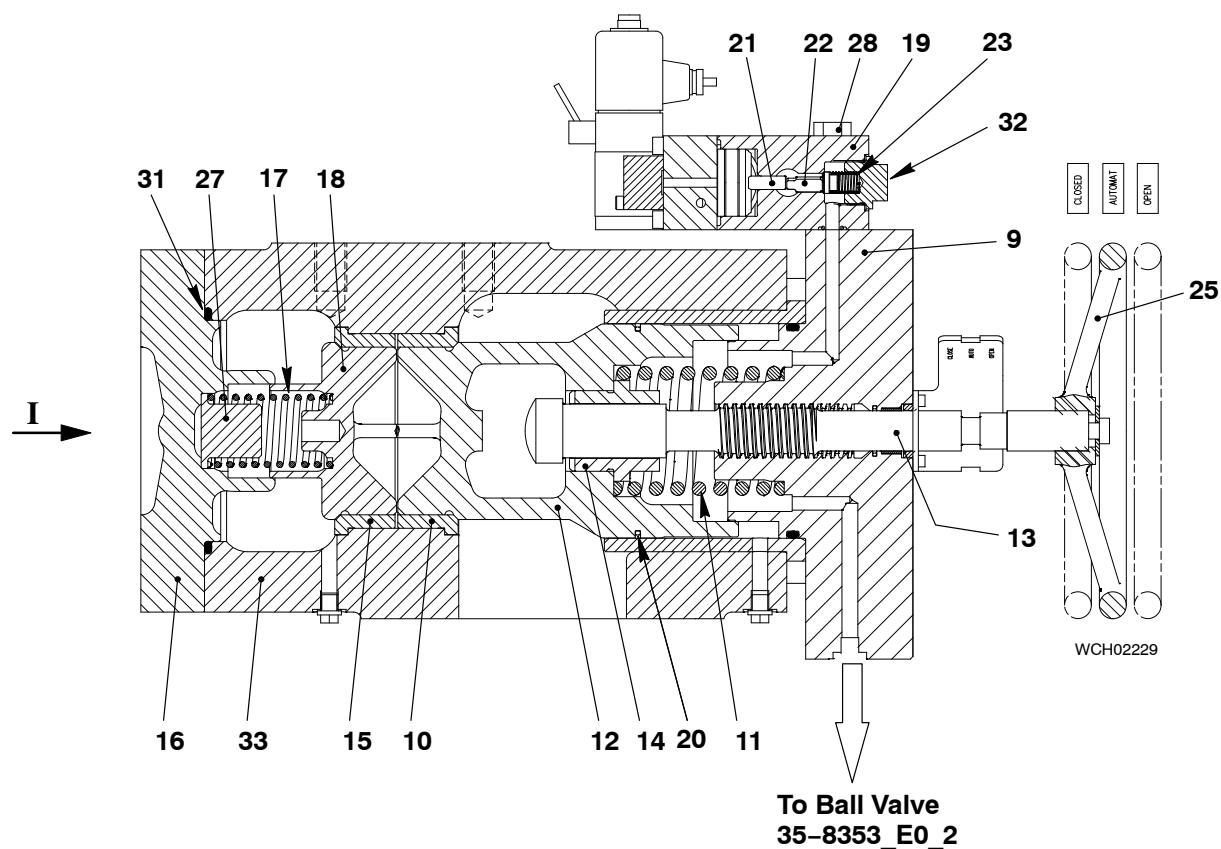
3. Disassembly

- 1) Remove the eight screws (26, Fig. 2) from the cover (9).
- 2) Turn the handwheel fully in. This will move the cover (9) out of spindle (13).
- 3) Remove the handwheel (25), the cover (9) and the spring (11).
- 4) Use an AF 60 swan neck spanner to remove the spindle nut (14).
- 5) Remove the spindle (13).
- 6) Remove the two screws (30) from the valve guide (16).
- 7) Remove the valve guide (16).
- 8) Remove the stopper (27) together with the spring (17) and valve body (18).
- 9) Remove the two bolts (28) from the control valve (19).
- 10) Remove the control valve (11) from the cover (2).
- 11) Remove the silencer (29) and its gasket.
- 12) Remove the screw plug (32) and its gasket from the control valve (11).
- 13) Remove the two bolts (28) from the control valve (19).
- 14) Remove the control valve (19).
- 15) Remove the screw plug (32) together with the spring (23), valve (22) and piston (21) from the control valve (19).
- 16) Remove the silencer (29).

4. Servicing

- 1) If necessary, clean the items of the control valve (that follow:
 - Valve (22)
 - Piston (21)
 - Spring (23).)
- 2) If necessary, clean the items from the shut-off valve that follow:
 - Springs (11) and (17)
 - Stopper (27)
 - Valve body (18)
 - Valve guide (16)
 - Valve (12)
 - Spindle (13).
- 3) If you find corrosion on the springs (11, 17 and/or 23) you must replace them.
- 4) Do a check of all gaskets and O-rings that you removed for damage. If you find damage, replace the applicable gaskets and/or O-rings.
- 5) Do a check of the piston joint ring (20). If you find damage, replace the piston joint ring.
- 6) Do a check of the valve seats (10, 15). If necessary, grind the sealing surfaces.

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



5. Assembly

- 1) Make sure that all bores are clear.
- 2) Remove grease from the surfaces of the spindle (13, Fig. 2) and the threads of the spindle nut (14).
- 3) Apply a thin layer of Molykote paste to the stopper (27), the spring (17) and the valve body (18).
- 4) Put the O-ring (31) and valve body (18) into the housing (33).
- 5) Put the stopper (27) and spring (17) into the valve guide (16), then attach the valve guide to the housing (33) with the two screws (30).
- 6) Torque the two screws (30) to the value given in [0352-2](#), paragraph 1.
- 7) Apply Molykote paste to the bore of spindle nut (14). Put the spindle nut (14) on the spindle (13).
- 8) Apply Loctite 0243 to the threads of the spindle nut (14).
- 9) Put the spindle nut (14) on the spindle (13).
- 10) Put the spindle (13) and spindle nut (14) into valve (12).
- 11) Attach the valve (12) together with spindle (13) and piston joint ring (20) to housing (33).
- 12) Apply Molykote paste to the inner cylinder of cover (9).
- 13) Put the spring (11) on to the spindle (13) in the cover (9).
- 14) Attach the cover (9), spring (11) and spindle (13) to the housing (33) with the eight screws (26).
- 15) Torque the eight screws (26) to value given in [0352-2](#), paragraph 1.
- 16) Install the handwheel (25).
- 17) Attach the control valve (19) to the cover (9) with the two bolts (28).
- 18) Torque the two bolts (28) to the value given in [0352-2](#), paragraph 1.
- 19) Put the piston (21), valve (22), spring (23) and screw plug (32) in position in the control valve (19), see [Fig. 3](#).

Note: When you do the step below, look through the hole in the control valve (19).

- 20) Make sure that the clearance between the valve (22) and the piston (21) is 1.0 ± 0.2 mm.

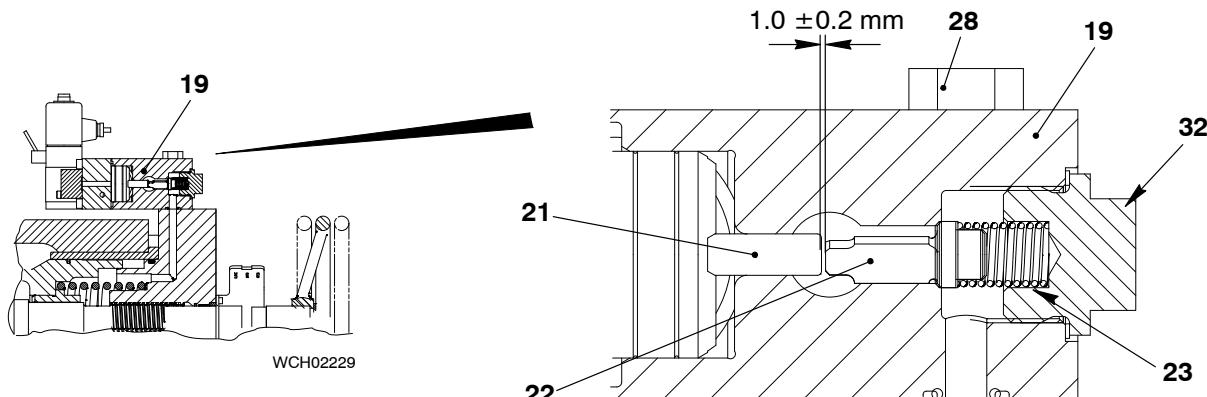


Fig. 3

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

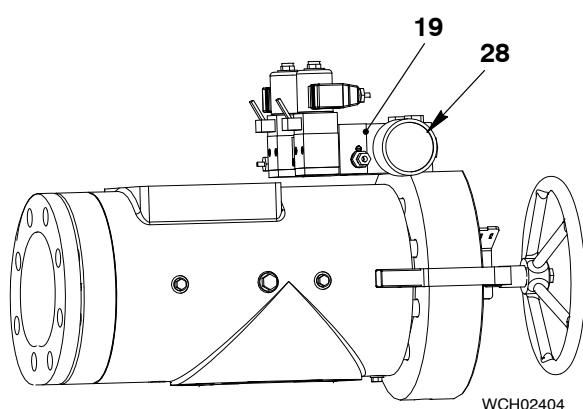


Fig. 4

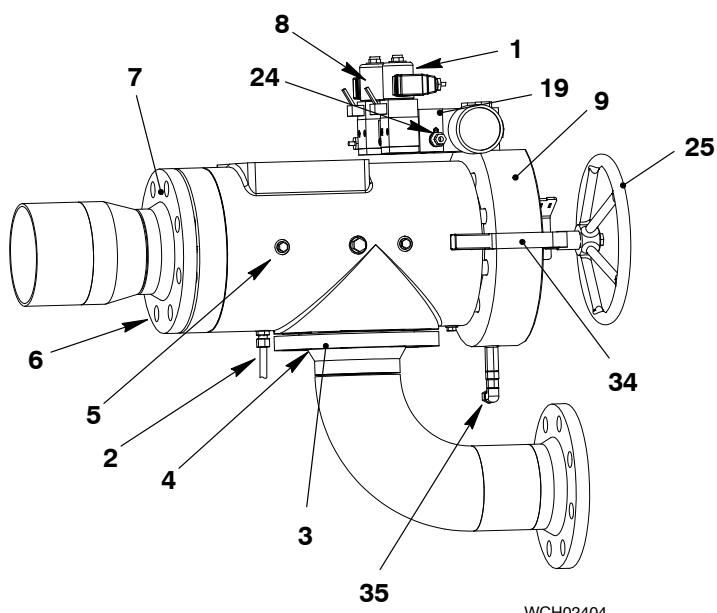


Fig. 5

- 21) Attach the silencer (28) to the control valve (19, Fig. 4).
- 22) Put the assembled shut-off valve in position as shown in Fig. 5.
- 23) Attach the flange (7) to the valve guide (16) with the eight screws (6).
- 24) Torque the eight screws (6) to the value given in 0352-2, paragraph 1.
- 25) Attach the flange (3) to the shut-off valve with the eight screws (4).
- 26) Torque the eight screws (6) to the value given in 0352-2, paragraph 1.
- 27) Connect the check-pipe (35) to the pipe connection on the cover (9).
- 28) Connect the pipe (2) to the valve body.
- 29) Connect the control air pipe to the pipe connection (24).

6. Shut-off Valve – Test

6.1 Initial Position

Note: You must only do this test on a fully assembled engine that is ready to start.

- 1) Make sure that the stop valves 930-V03 and 930-V04 are closed.
- 2) Use the handwheel (25) to move the shut-off valve in the position CLOSED.
- 3) Disengage the turning gear.

6.2 Test Procedure

WARNING



Injury hazard. During this test, do not select START. Injury to personnel can occur.

- 1) Close the ball valve 30-8605_E0_6.
- 2) Slowly open the stop valves 930-V03 and 930-V04.
- 3) Slowly loosen the screw plug (5). Make sure that no air flows out.
- Note: If air flows out, tighten the screw plug (5). The shut off valve is not airtight.**
- 4) Remove the screw plug (5).
- 5) Slowly turn the handwheel (25) to move the shut-off valve to the position OPEN.
- 6) Make sure that air flows from the bore of the screw plug (5). When air flows, the manual function of the shut-off valve operates correctly.

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

- 7) Use the handwheel (25, Fig. 5) to move the shut-off valve to the position AUTOMAT. Make sure that the lever (34) engages with the groove in the spindle.
- 8) Make sure that no air flows from the bore of the screw plug (5). When no air flows, the automatic function of the shut-off valves operates correctly.

6.3 Automatic Mode

- 1) Make sure that the shut-off valve is in the position AUTOMAT.

Note: When you do the step below, air will flow through the pipe. This activates the control valve (19), which shows that the valve body and valve operate.

- 2) Open the ball valve 35-8353_E0_2 to activate the control valve (19). The shut-off valve opens automatically.
- 3) Make sure that air flows from the bore of the screw plug (5).
- 4) Close the ball valve 35-8353_E0_2.
- 5) Make sure that no air flows from the bore of the screw plug (5).

7. Completion

- 1) Use the handwheel to move the shut-off valve to the position CLOSED.
- 2) Install the screw plug (5).

Supply Unit, Injection and Exhaust Valve Control

Group 5

Fuel Pump

Disassemble, Assemble	5556-1/A1
Removal of a Seized Pump Plunger	5556-2/A1

Fuel Pressure Control Valve: Removal, Check, Installation 5562-1/A1

Fuel Overpressure Safety Valve: Removal, Check, Installation 5562-2/A1

Flow Limiting Valve FLV: Removal, Inspection, Installation 5562-3/A1

Supply Unit

Camshaft and Bearing Shells – Removal and Installation	5581-1/A1
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Fuel Pump Actuator

Connection to Fuel Pump	5583-1/A1
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Servo Pump Unit

Servo Oil Pump – Removal and Installation	5591-1/A1
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Servo Oil Rail: Exhaust Valve Control Unit: Removal, Disassemble, Assemble, Installation ... 5612-1/A1

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Fuel Pump**Disassemble, Assemble****Tools:**

1	Circlip plier	94007-A41	1	Assembling device	94593
1	Handle	94009-M10		Consisting of:	
1	Manual ratchet	94016-031	1	Ring	94593A
1	2-part clamping ring	94550	2	Ring (2-part)	94593B
1	Spindle press	94551	2	Guide rods	94593C
1	Lifting tool	94552	2	Screws	94593D
1	Rod	94553	2	Step rods	94593E
1	Distance piece	94555	4	Screws with special nuts	94593F
1	Fuel pump rack	94592	4	Screws	94593G
	Consisting of:		1	Mandrel (\varnothing 70 mm)	94597
1	Oil tray	94592A	1	Mandrel (\varnothing 40 mm)	94597A
2	Limiters	94592B	1	Pneum. impact wrench	94598
2	Screws	94592C	2	Extensions	94598A
4	Screws	94592D	1	Socket spanner insert	94598B
2	Screws	94592E			

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1. Preparation

- 1) Stop the engine and set the fuel supply and lubrication oil pumps to off.
- 2) Make sure the fuel return valve is open, refer to the control diagram 4003-2 and 4003-11 in the Operation Manual.
- 3) Close the fuel inlet valve, refer to the control diagram 4003-2 and 4003-11 in the Operation Manual.
- 4) Wait until the pressure in the supply unit decreases to zero.
- 5) Control the casing temperature of the pump. Wait until the pump has cooled down.
- 6) Clean the activity area and make sure that there are no dust particles.

WARNING



Fire hazard. Do not weld or grind materials in the area.

WARNING



Injury hazard. Use gloves and eye protection. Hot fuel can come out as a spray and cause injury.

- 7) Remove the fuel pressure pipes, refer to [8752-1](#).
- 8) Make sure, that there is no pressure in the pump unit and that the valves to the fuel pumps are closed.
- 9) If necessary, remove the casing, the fuel inlet and the outlet pipes of the fuel pump.
- 10) Set to off the power supply to the actuators.

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

2. Fuel pump – removal

CAUTION



Do not operate the engine with a fuel pump removed. This will decrease the supply of oil, i.e. there could be a decrease of lubrication to the other fuel pumps.

Fuel Pump: Disassemble, Assemble

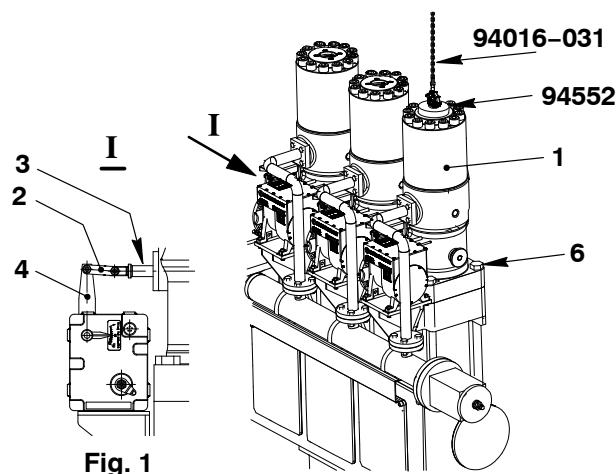


Fig. 1

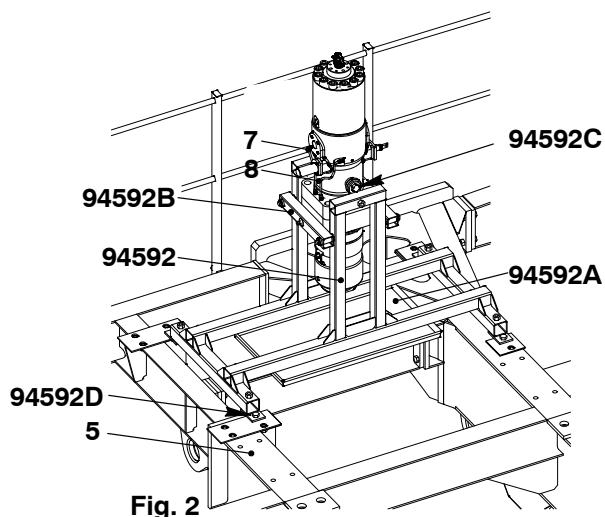
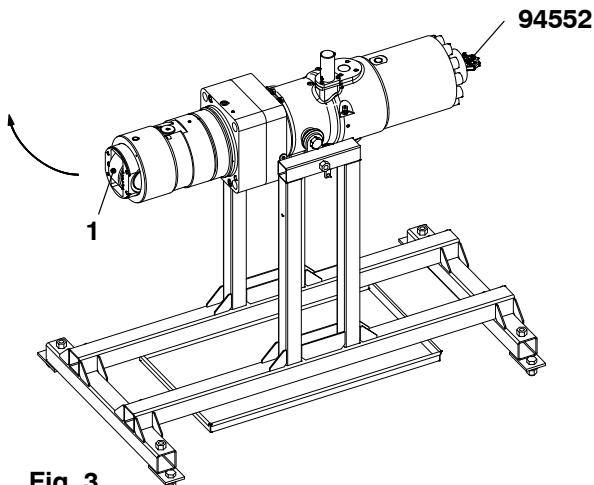
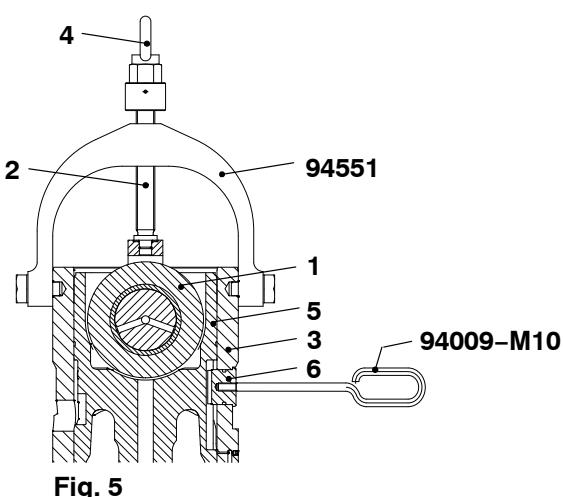
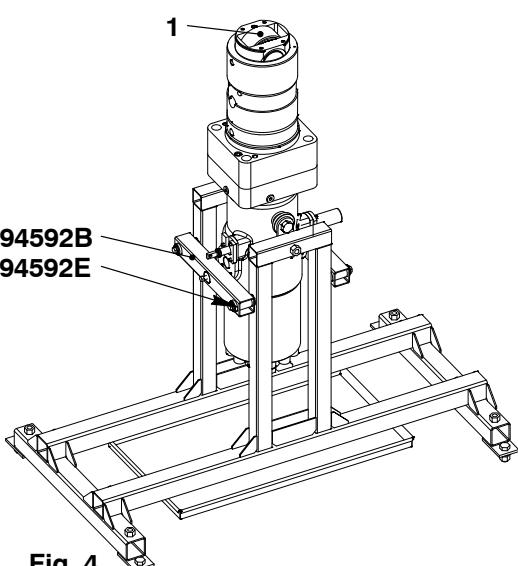


Fig. 2

- 1) Attach the lifting tool 94552 to the pump cover (1, Fig. 1).
- 2) Disconnect the connecting element (2) between toothed rack (3) and the actuator lever (4), refer to the chapter 5583-1 in the Maintenance Manual.
- 3) Attach the fitting and fuel pump rack 94592 to the upper main platform (5, Fig. 2) with the screws 94592D.
- 4) Remove the screws (6, Fig. 1) of the fuel pump.
- 5) Attach the manual ratchet 94016-031 to the engine crane.
- 6) Attach the manual ratchet to the lifting tool 94552.
- 7) Carefully lift the pump.
- 8) Attach covers to all open flanges to prevent contamination in the pipes.
- 9) Attach the fuel pump to the fuel pump rack 94592 with the screws 94592C (Fig. 2).
- 10) Put the limiters 94592B on both sides on the rack 94592.
- 11) Put the oil tray 94592A below the pump.
- 12) Remove the manual ratchet 94016-031.

Fuel Pump: Disassemble, Assemble**2.1 Guide pin - removal**

- 1) Remove the two limiters 94592B with the screws 94592E, see [Fig. 4](#).
- 2) Turn the fuel pump according [Fig. 3](#) until the roller (1) points up.
- 3) Attach the limiters 94592B to each side of the fuel pump with the screws 94592E to hold the pump in the new position.
- 4) Remove the tool 94552. Drain the fuel oil into the oil tray 94592A.



- 5) Lubricate the spindle (2) of the press 94551 with lubrication paste MOLYKOTE G-RAPID PLUS.
- 6) Attach the spindle press 94551 with its screws to the bottom housing (3).
- 7) Use the eye bolt (4) and slowly turn the spindle (2) clockwise.
This pushes the roller (1) and the guide piston (5) into the fuel pump housing (3).
- 8) Use the handle 94009-M10 and remove the guide pin (6).

Fuel Pump: Disassemble, Assemble

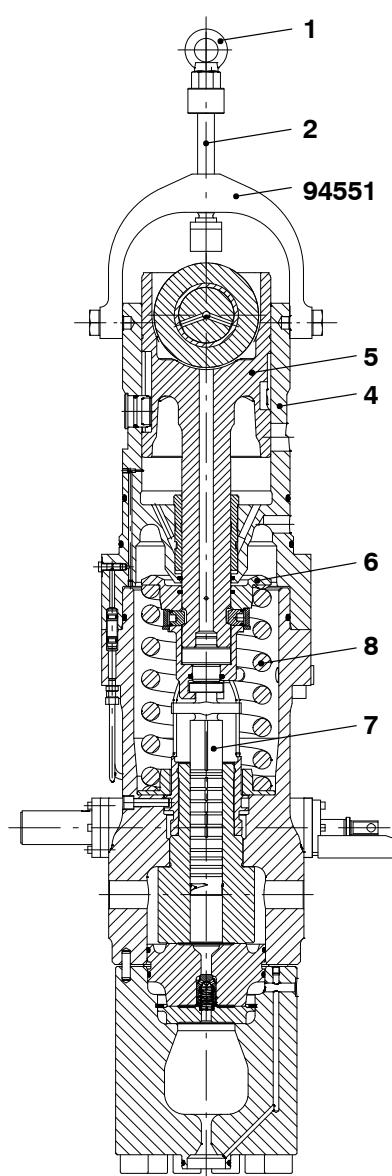


Fig. 6

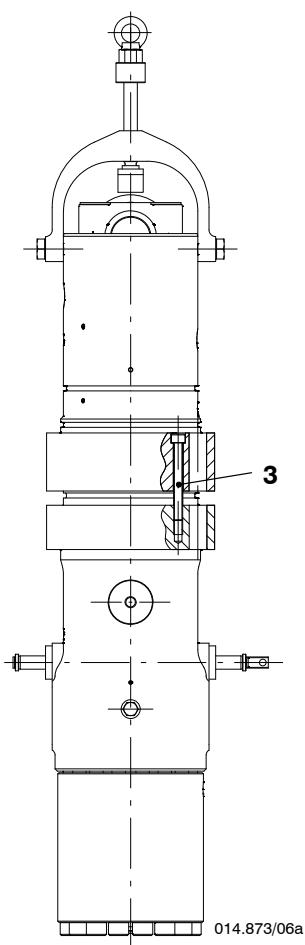


Fig. 7

2.2 Disconnect lower housing

- 1) Use the M16 eye bolt (1) and turn the spindle (2) back.
- 2) Loosen equally the two Allen screws (3, [Fig. 7](#)) and remove them.
- 3) Carefully lift the bottom housing (4, [Fig. 6](#)) together with the guide piston (5), the lower spring carrier (6) and pump plunger (7).
- 4) Remove the compression spring (8).
- 5) Remove the circlip (9, [Fig. 8](#)) and push the retaining ring (10) down.
- 6) Use the Allen wrench (AW 10) to loosen the connection pins (11) with O-rings (12).
- 7) Pull the pump plunger (7) out of the lower spring carrier (6).
- If the plunger does not come out, refer to [5556-2](#).
- 8) Put the pump plunger (7) into a safe storage.
- 9) Remove the tool 94551.

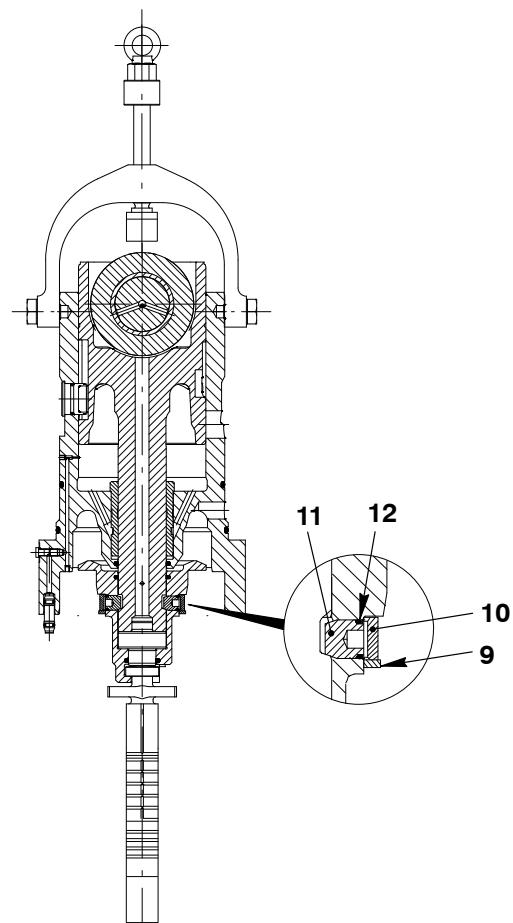


Fig. 8

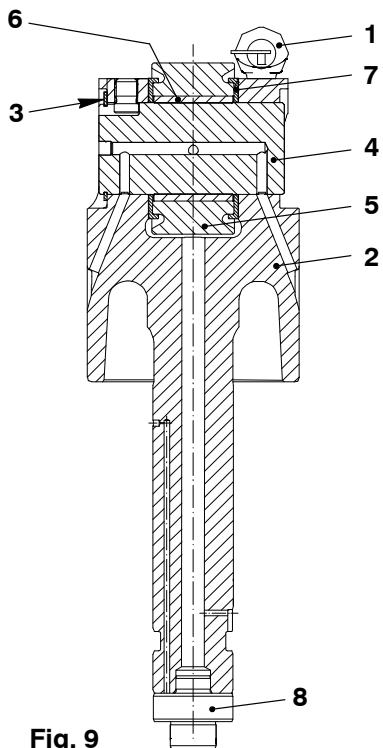
Fuel Pump: Disassemble, Assemble

Fig. 9

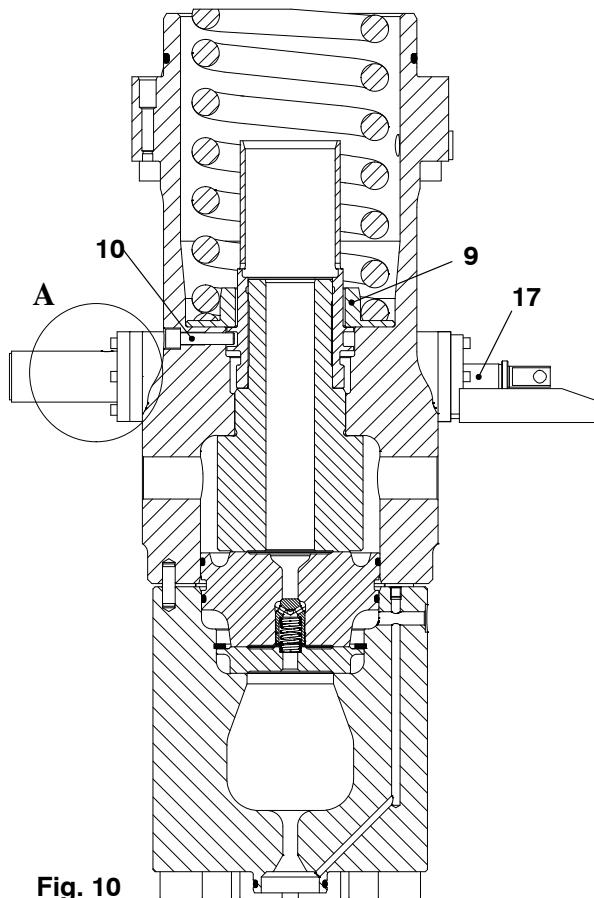


Fig. 10

2.3 Guide piston disassemble

- 1) Screw the two M10 eye bolts (1, Fig. 9) into the guide piston (2) and remove it from the housing.
- 2) Remove the circlip (3).
- 3) Press the roller pin (4) out and remove the roller (5) with the shrunken bush (6) and pressure discs (7).
- 4) Withdrawal of thrust piece (8) by using a handle form guide piston bottom hole.

2.4 Toothed rack - removal

- 5) Remove upper spring carrier (9) by using a M8 bolt.
- 6) Turn regulating sleeve until the guide pin (10) is in line with the cut in the regulating sleeve and lift the regulating sleeve off.
- 7) Unscrew the screws (11, Fig. 11) and remove the cover (12).
- 8) Remove the two circlips (13) with the rings (14).
- 9) Remove the intermediate flange (15) with the rod seal rings (16) and pull the toothed rack (17) out.

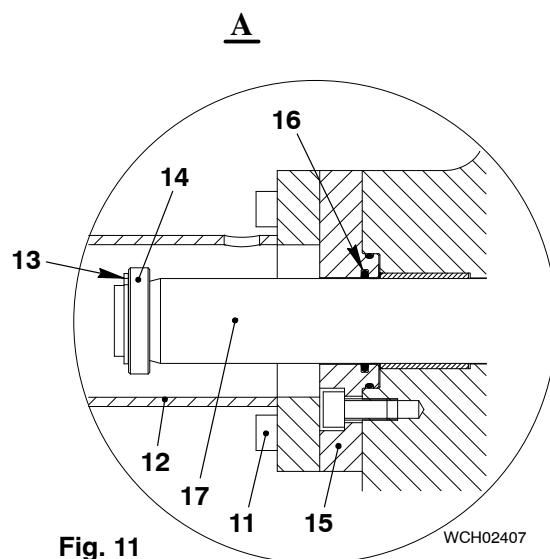


Fig. 11

Fuel Pump: Disassemble, Assemble

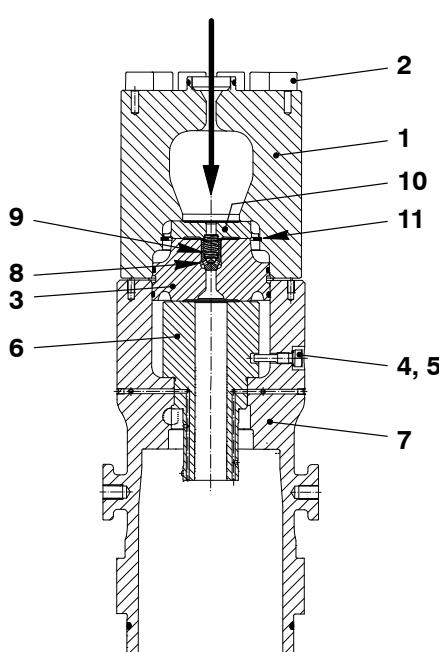


Fig. 12

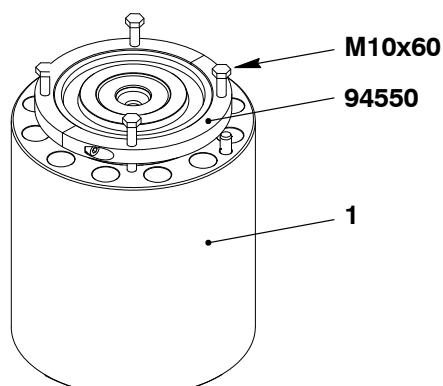


Fig. 13

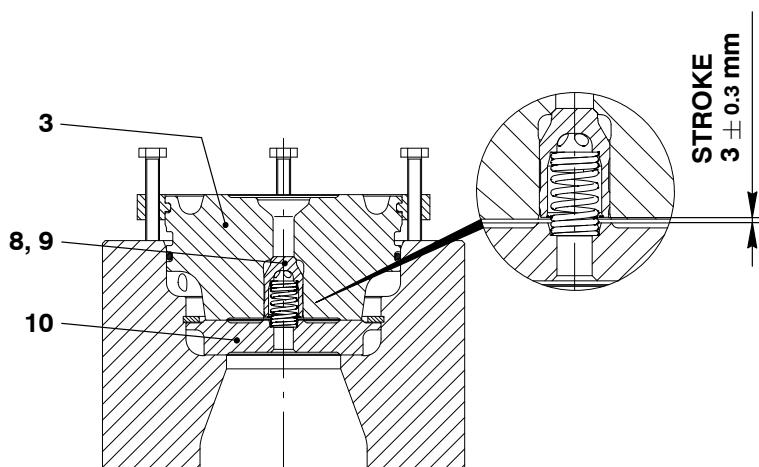


Fig. 14

2.5 Pump cylinder - removal

Note: Pump cylinder and the pump plunger are matched pairs. Do not interchange them.

- 1) Turn the fuel pump until the pump cover (1) points upward.
- 2) Loosen the screws (2) crosswise.
- 3) Attach the lifting tool 94552.
- 4) Remove the pump cover (1) with valve block (3).
- 5) Remove the retaining screw (4) with its fluted seal ring (5).
- 6) Remove the pump cylinder (6) from the housing (7).

2.6 Non-return valve - removal

Note: Always replace the non-return valve as a unit , i.e. valve block (3), valve body (8) with compression spring (9) and the intermediate disc (10).

- 1) Attach the 2-part clamping ring 94550 to the valve block (3).
- 2) Withdraw the valve block (3) from the pump cover (1) with four screws M10x60.
- 3) Remove the valve body (8) with spring (9) from valve block (3).
- 4) Remove the circlip (11) with a circlip plier 94007.
- 5) Remove intermediate piece (10).

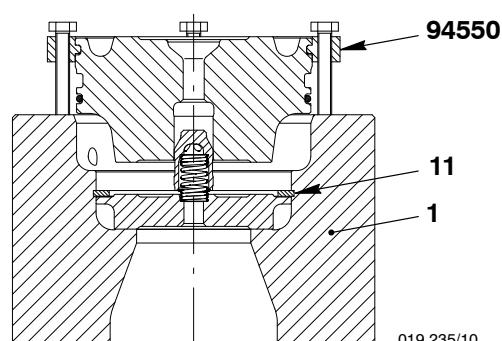


Fig. 15

Fuel Pump: Disassemble, Assemble

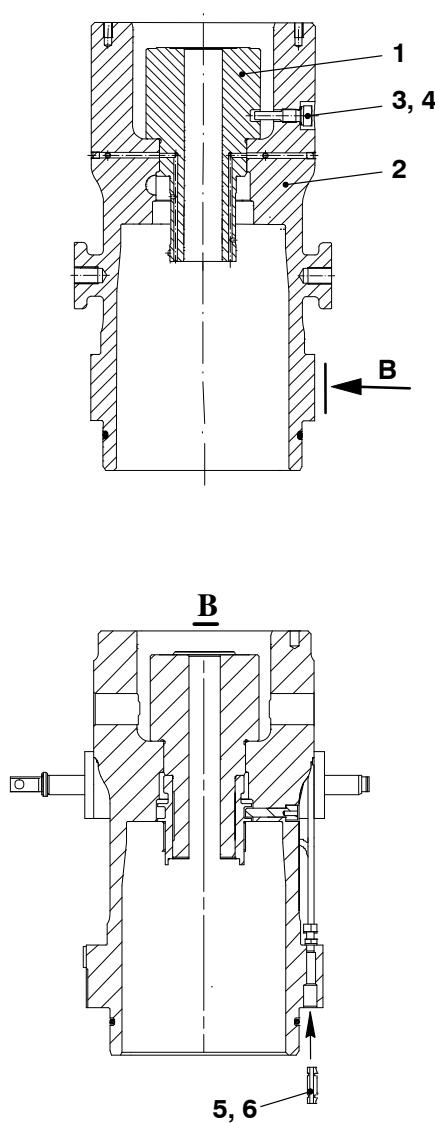


Fig. 16

3. Fuel pump – assemble

- 1) Clean all parts of a fuel pump and check their condition. If any parts are damaged, use new parts.
- 2) Replace all O-rings and rod seal rings.
- 3) Use a compressed air and check the lubricating oil bores in the housings and in the pump cylinder (1) for free passage.

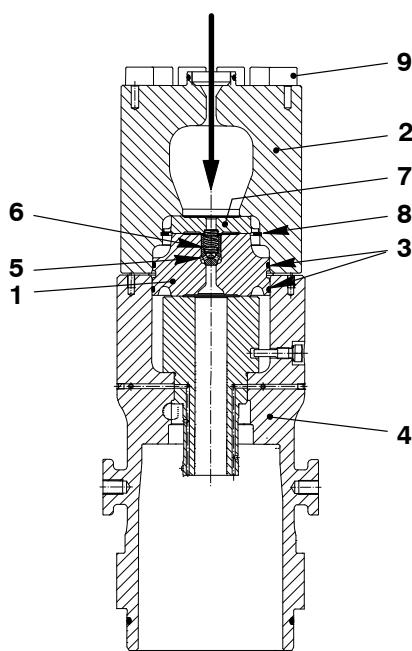
3.1 Pump cylinder - assemble

- 1) Put the top housing (2) in a vertical position on rack 94592.
- 2) Attach the pump cylinder (1) carefully.
- 3) Align the groove in the pump cylinder (1) with the bore in the top housing (2).
- 4) Put the retaining screw (3) with the seal ring (4).

Note: Make sure there is a clearance between the retaining screw (3) and the groove base in the pump cylinder (1).

- 5) Oil and put the two adapter pieces (5) with the O-rings (6) into the top housing (2).

Fuel Pump: Disassemble, Assemble

**Fig. 17**

3.2 Non-return valve and the pump cover - assemble

- 1) Check and clean the sealing surfaces of the valve block (1, Fig. 17) and the pump cover (2).
- 2) Oil and put the O-rings (3) to the valve block (1).
- 3) Insert the valve block (1) carefully into the top housing (4).
- 4) Oil and attach the valve body (5).
Check if the valve body moves easily.
- 5) Put the compression spring (6) in position.
- 6) Install the intermediate disc (7) with the circlip (8) to the pump cover (2).
- 7) Place the pump cover (2) carefully on top. Do not damage the compression spring (6).
- 8) Make sure that the compression spring (6) fits to the hole in the intermediate disc (7). Use a flashlight.
- 9) Apply Never-Seez NSBT-8 to the threads and head seating surfaces of the M27 head screws (9).
- 10) Tighten the head screws (9) crosswise in three steps:
First torque the screw to 100 Nm, then to 200 Nm and finally to **480 Nm**.

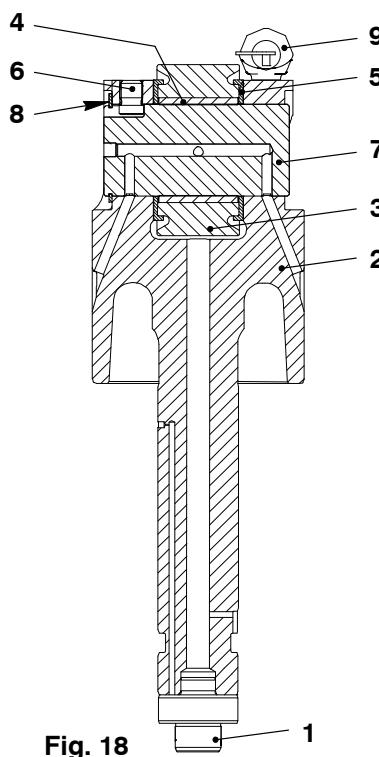
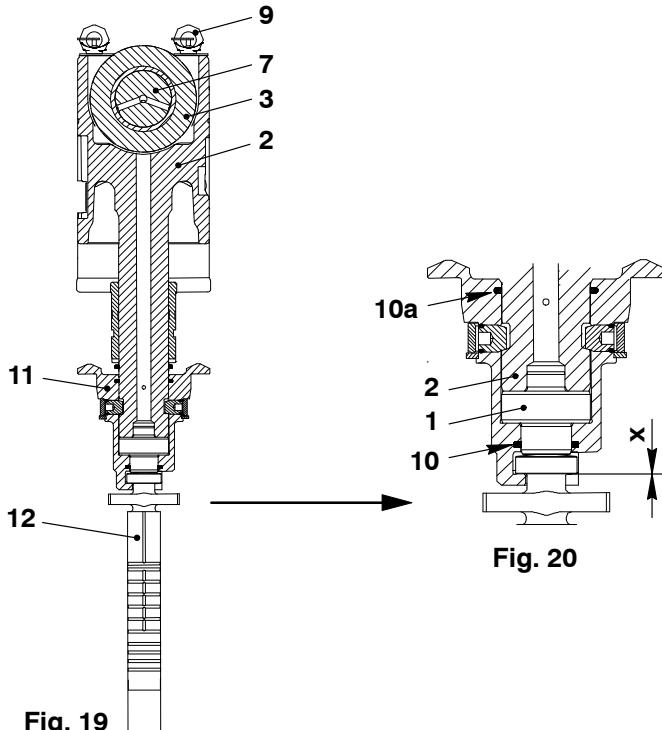
Fuel Pump: Disassemble, Assemble

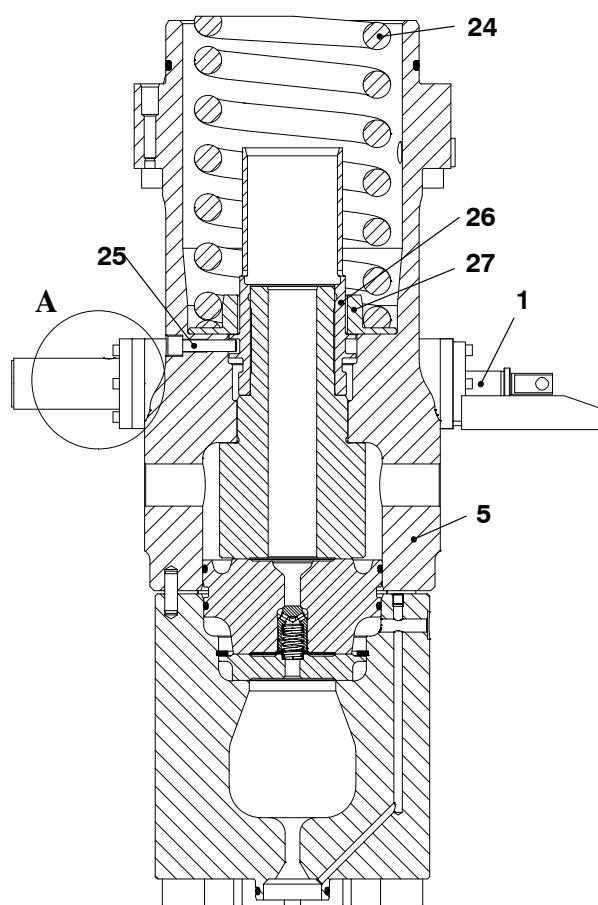
Fig. 18

3.3 Guide piston – assemble

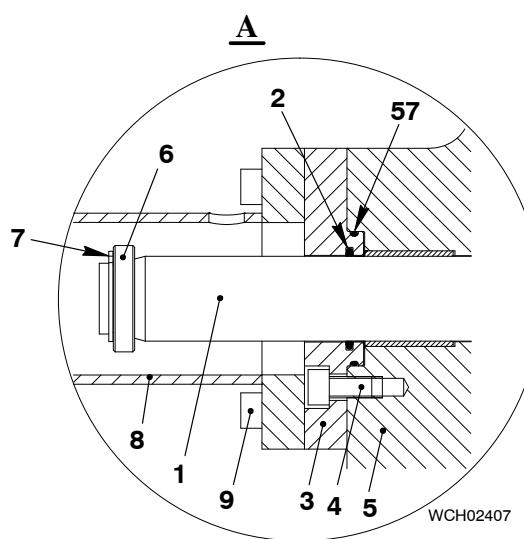
- 1) Clean and oil all bores and parts of a guide piston.
- 2) Push the thrust piece (1) into the guide piston (2).
- 3) Oil the flanks of the roller and place the roller (3) with its shrunken bush (4), pressure disc (5) into the guide piston (2).
- 4) Make sure that the locating pin (6) is in a correct position.
- 5) Align the rabbet of the roller pin (7) with the locating pin (6) and push roller pin into guide piston (2) and roller (3).
- 6) Use the circlip (8) to secure the roller pin (7).

**3.4 Pump piston – axial clearance check**

- 1) Lift the guide piston with two diagonally mounted M10 eye bolts (9) and a sling.
- 2) Put new seals (10) and (10a) to the lower spring carrier (11), refer to paragraph 3.8.
- 3) Attach the pump plunger (12) to the lower spring carrier (11).
- 4) Push up the lower spring carrier (11) together with the pump plunger (12) against the guide piston (2).
- 5) Push the lower spring carrier (11) with hands against the thrust piece (1) and make sure there is a clearance $x = 0.12-0.24$.
- 6) Remove the lower spring carrier (11) and the pump plunger (12).

Fuel Pump: Disassemble, Assemble**Fig. 21****3.5 Toothed rack – assemble**

- 1) Turn the fuel pump until it points downwards.
- 2) Put the toothed rack (1) in position.
Check if the toothed rack (1) moves easily. .
- 3) Oil the rod seal ring (2) into the intermediate flange (3).
- 4) Install the intermediate flange (3) at the top housing (5).
- 5) Tighten the screws (4) to the top housing (5).
- 6) Attach the rings (6) and the circlips (7).
- 7) Install the cover (8) with screws (9).



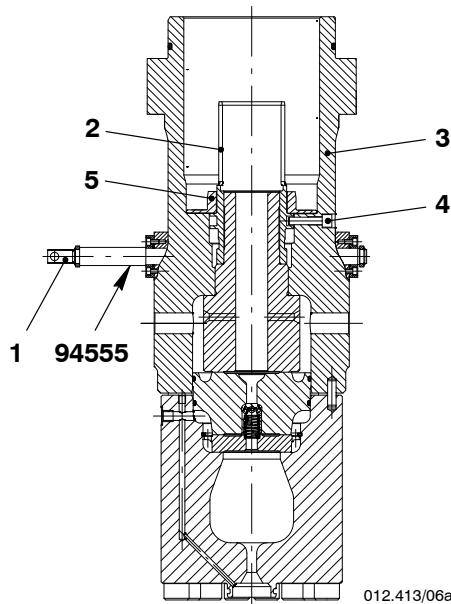
Fuel Pump: Disassemble, Assemble

Fig. 22

3.6 Regulating sleeve – assemble

- 1) Pull the toothed rack (1, Fig. 22).
- 2) Attach the spacer 94555 on one side of the toothed rack (1).
- 3) Put the regulating sleeve (2) into the top housing (3). Turn it until the cut in the regulating sleeve is in line with the guide pin (4).
- 4) Remove the spacer 94555.

Check if the toothed rack (1) moves easily over the all range of movement.

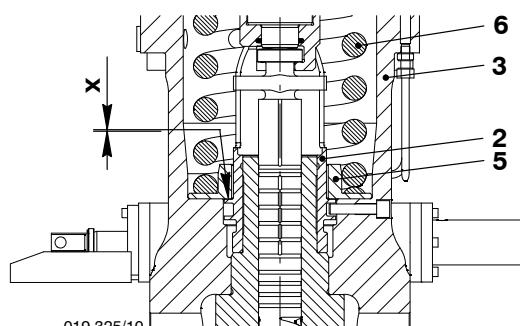


Fig. 23

3.7 Spring carrier – assemble and axial clearance check of the regulating sleeve

- 1) Put the upper spring carrier (5) into the top housing (3).
- 2) At the same time push the top spring carrier (5) with hands against the top housing (3) and move the regulating sleeve (2) up and down.
- 3) During that procedure take a magnetic dial gauge and check the clearance x of the regulating sleeve (2), $x = 0.5\text{--}0.7 \text{ mm}$.
- 4) Position the compression spring (6).
- 5) Put the regulating rack (1) in the middle position.

Fuel Pump: Disassemble, Assemble

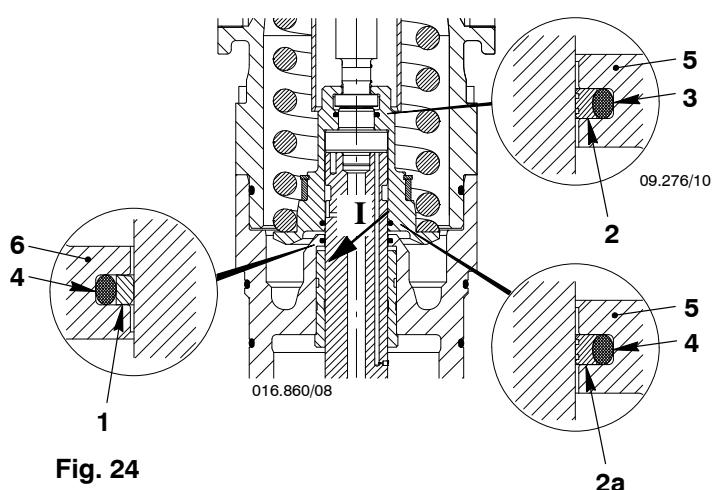


Fig. 24

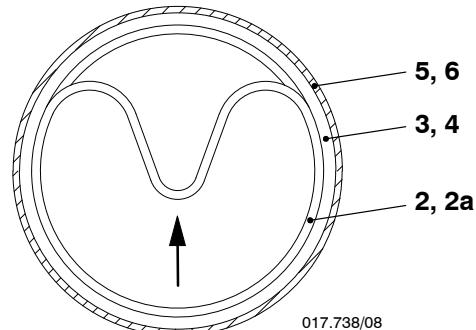


Fig. 25

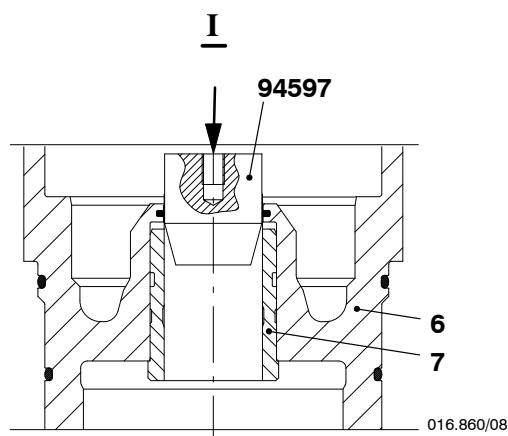


Fig. 26

3.8 Rod seal ring (1) and the seals (2), (2a) – assemble

- 1) Put new oiled O-rings (3) and (4) into the related grooves of the lower spring carrier (5) and the bottom housing (6).
- 2) Make the 'kidney' shape to the new oiled rod seal ring (1) and seals (2) and (2a).
- 3) Put the rod seal ring (1) and seals (2) and (2a) into the applicable grooves.
- 4) Push the seals (2) and (2a) into the groove in direction of the arrow.

- 5) Use the handle screw M16 and push the oiled mandrel 94597 (\varnothing 70 mm) through the lower spring carrier (5) and the bush (7).
- 6) If necessary, put the seals (2) and (2a) in a position again.
- 7) Use the handle screw M10 and push the oiled mandrel 94597A (\varnothing 40 mm) into the upper groove of the lower spring carrier (5).

Fuel Pump: Disassemble, Assemble

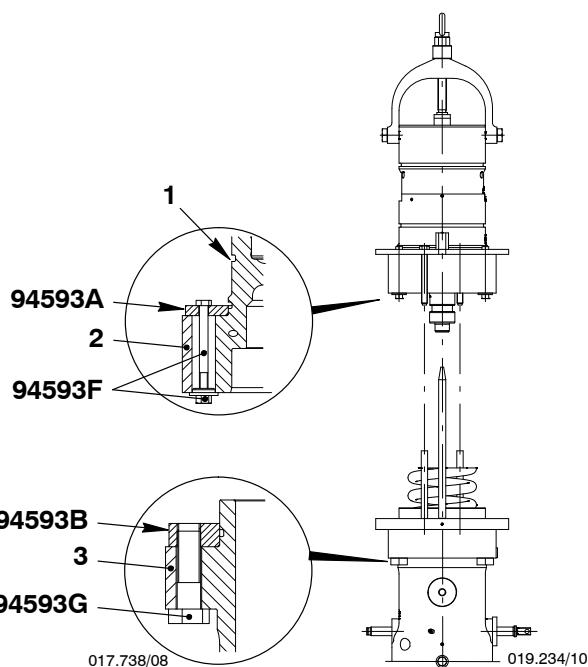


Fig. 27

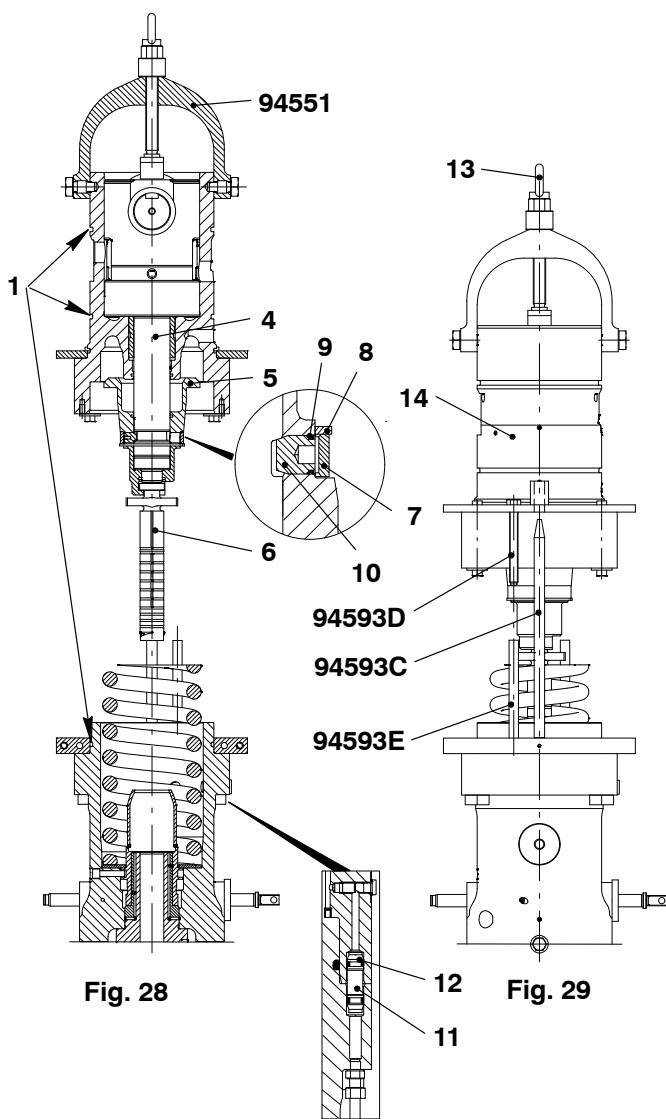


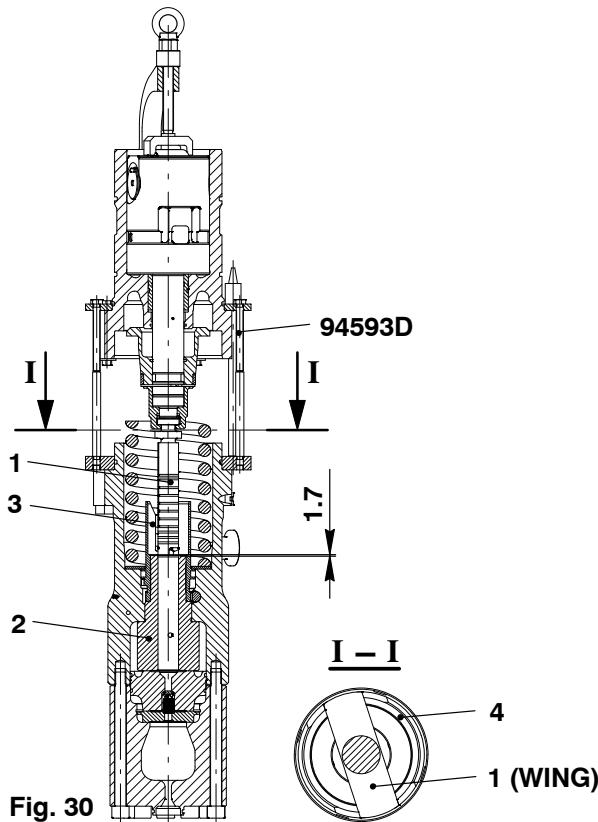
Fig. 28

Fig. 29

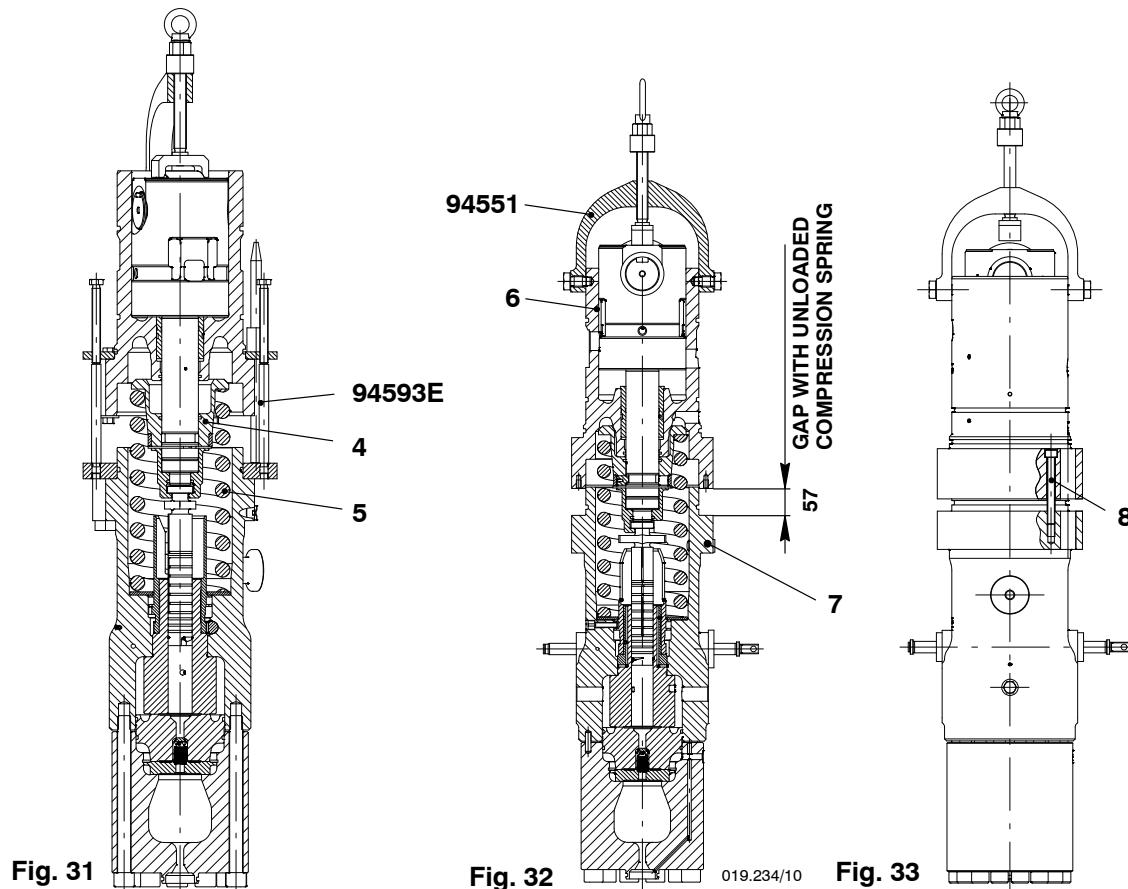
3.9 Fuel pump – final assemble

- 1) Remove the O-rings (1) from the bottom housing (2, [Fig. 27](#)).
- 2) Attach the device 94551 on the bottom housing (2).
- 3) Attach the device 94593.
- 4) Use the screws with special nuts 94593F and attach the ring 94593A to the bottom housing (2).
- 5) Check if the screws 94593D are fully turned down.
- 6) Use the screws 94593G and attach the 2 - part ring 94593B with the step rods 94593E to the top housing (3).
- 7) Oil the guide piston (4) and attach it to the bottom housing (2).
- 8) Attach the lower spring carrier (5) with the pump plunger (6) to the guide piston (4).
- 9) Put the retaining rings (7) and the circlips (8).
- 10) Put the connection pins (9) with the O-rings (10).
- 11) Tighten the connection pins (9) crosswise in four steps to the torque **80 Nm**.
- 12) Put the O-rings (1) to the top housing (3).
- 13) Put the adapter pieces (11) with O-rings (12) into the bottom housing (2).
- 14) Attach the lifting device to the eye bolt (13).
- 15) Lower the bottom housing (14) over the guide rods 94593C until the screws 94593D are on the step screws 94593E.

Fuel Pump: Disassemble, Assemble



- 16) Adjust the pump plunger (1) to the centre of the bore in the pump cylinder (2).
- 17) Turn the pump plunger (1) until its wings align the slots in the regulating sleeve (3).
- 18) Start to loosen the screws 94593D and during this procedure make sure that:
 - The wings of the pump plunger (1) goes into the slots.
 - The pump plunger (1) goes into the pump cylinder (2).
- 19) Make sure that the lower spring carrier (4) is on the compression spring (5) and remove the device 94593 with its parts from the bottom (6) and the top housing (7).
- 20) Lower the bottom housing (6) carefully until it is on the compression spring (5).
- 21) Attach the bottom (6) and the top housing (7) together with the Allen screws (8).
- 22) Make sure the bottom (6) and the top housing (7) are in a correct position.
- 23) Tighten the Allen screws (8) to **140 Nm**.



Fuel Pump: Disassemble, Assemble

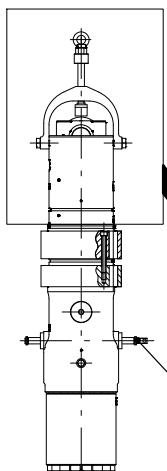


Fig. 34

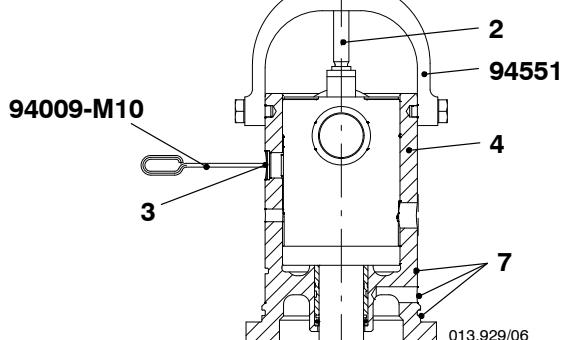


Fig. 35

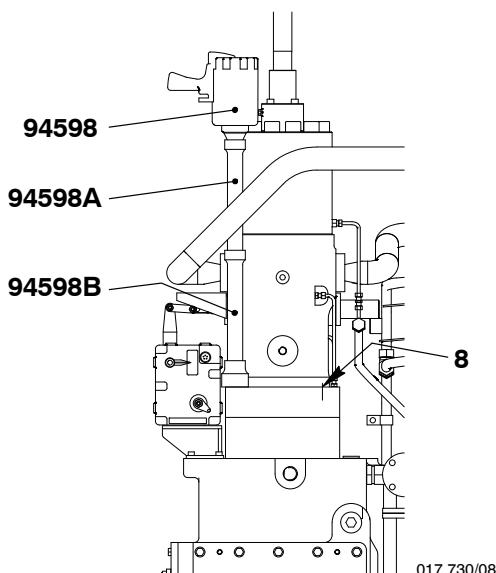


Fig. 36

- 24) Use the eye bolt (1) and start to turn the spindle (2) clockwise slowly.
 - 25) Attach the guide pin (3) to the handle 94009-M10.
 - 26) Continue to turn the spindle (2) until you can insert the guide pin (3) into the guide piston in a bottom housing (4).
- Note:** If you cannot insert the guide pin (3), turn the spindle (2) back and do the procedure again.
- 27) Use the eye bolt (1), turn the spindle (2) and push the pump plunger (5) into T.D.C position.
 - 28) Check the toothed rack (6) for easy movement.
 - 29) Release the device 94551 and remove it.

4. Fuel pump – attachment to the supply unit

- 1) Turn die engine until the cam of the fuel pump is on the base circle.
- 2) Do a check of the housing and all guide parts of the fuel pump.
- 3) Make sure that the seating surfaces of the fuel pump are clean and have no damage.
- 4) Put the remaining O-rings (7).
- 5) Oil the guide parts and attach it to the fuel pump .

Note: Take care you do not cause damage to the locating pin and the regulating shaft.

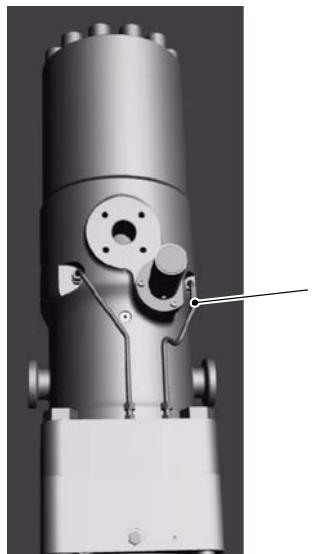
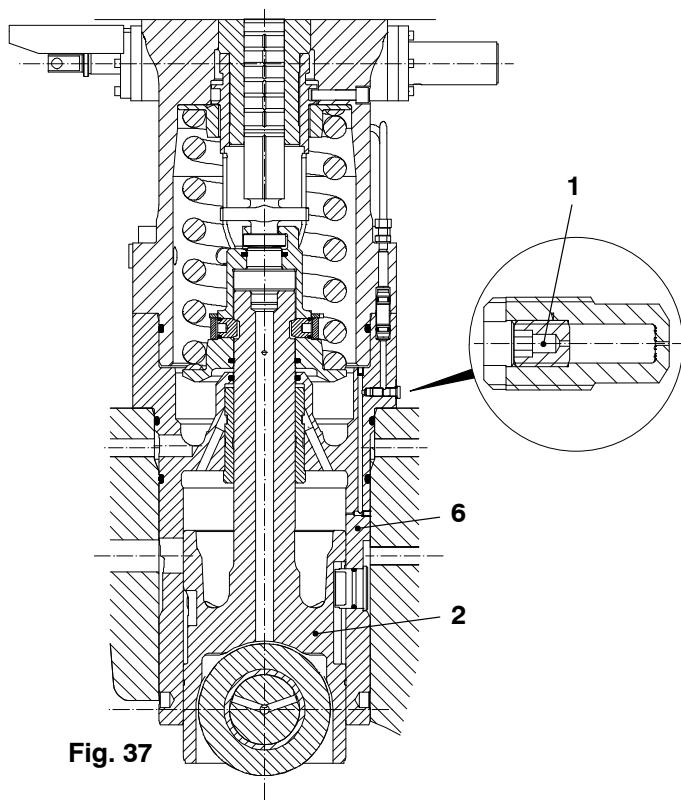
Do not use a jointing agent.

- 6) Oil the head seating surfaces and the threads of the screws (8).
- 7) Use the socket wrench insert 94598B, the extensions 94598A and the pneum. impact wrench 94598 and tighten the screws (8) to **1250 Nm (64°)**.

Check the connections between the fuel pump and the actuator, refer to 5583-1.

- 8) Attach the HP fuel pipes as given in 8752-1.
- 9) Make sure that the fuel return valve and the fuel inlet valve are open, refer to the control diagram 4003-2 and 4003-11.
- 10) Operate the pump and do a leakage check.
- 11) If the pump works correctly attach the casing.

Fuel Pump: Disassemble, Assemble



5. Oil flow check

- 1) Do a check of the oil flow after every disassemble and assemble of the fuel plump or plunger.

The oil flows through the orifice (1) to the bottom housing and the guide piston (2).



Do not operate the lubricating pump.

- 2) Remove the fuel drain pipe (3) from the fuel pump.
- 3) Start the lubricating pump.
- 4) Turn the turning gear in the 'AHEAD' direction.

Check if the oil flows from the fuel drain pipe (3).

If the oil does not flow, check for unwanted particles in the oil supply system and remove them or replace the pump unit.

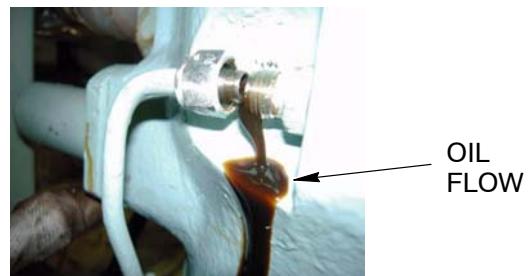


Fig. 39

6. Storage

For safety storage:

- 1) Make sure that the storage area is clean and dry.
- 2) Put the pump in a **vertical** position and oil it.
- 3) Oil the open inlet and outlet holes of the fuel pump with Vaseline.
- 4) Put the plastic stoppers into the open spaces.
- 5) Put a cover (material or plastic) on a fuel pump to protect it.

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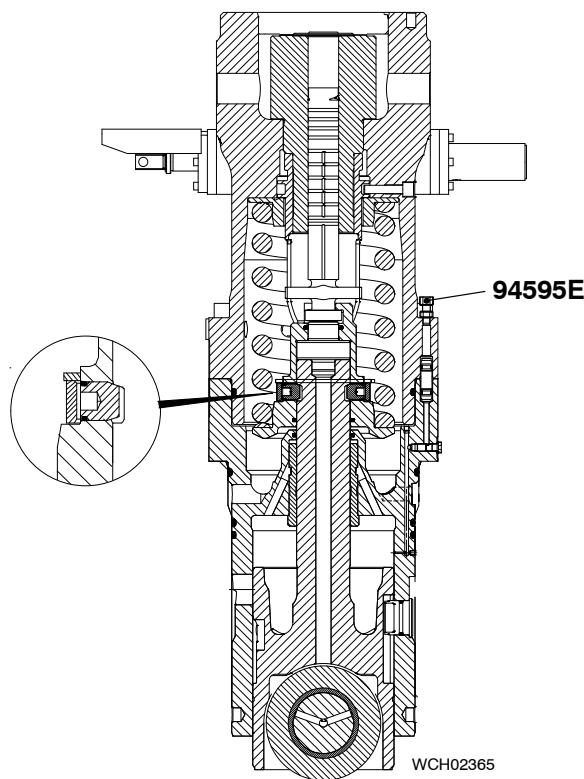
Fuel Pump**Removal of a Seized Pump Plunger****Tools:**

1	Tool, removal and installation	94592	2	Screws	94595E
1	Hydraulic ram	94595	1	HP oil pump	94931
1	Short push rod	94595B	1	Pressure gage	94932
1	Long push rod	94595C	1	HP hose	94935
1	Piston reset tool	94595D			

1. Fuel pump-preparation 1
2. Hydraulic ram – preparation 2
3. Hydraulic ram – install 2
4. Removal with tool 94595B 3
5. Removal with 94595C 4

1. Fuel Pump – Preparation

- 1) Remove the fuel pump (see [5556-1](#)).
- 2) Disassemble the fuel pump until the condition is as shown in [Fig. 1](#).

**Fig. 1**

Fuel Pump: Removal of a Seized Pump Plunger

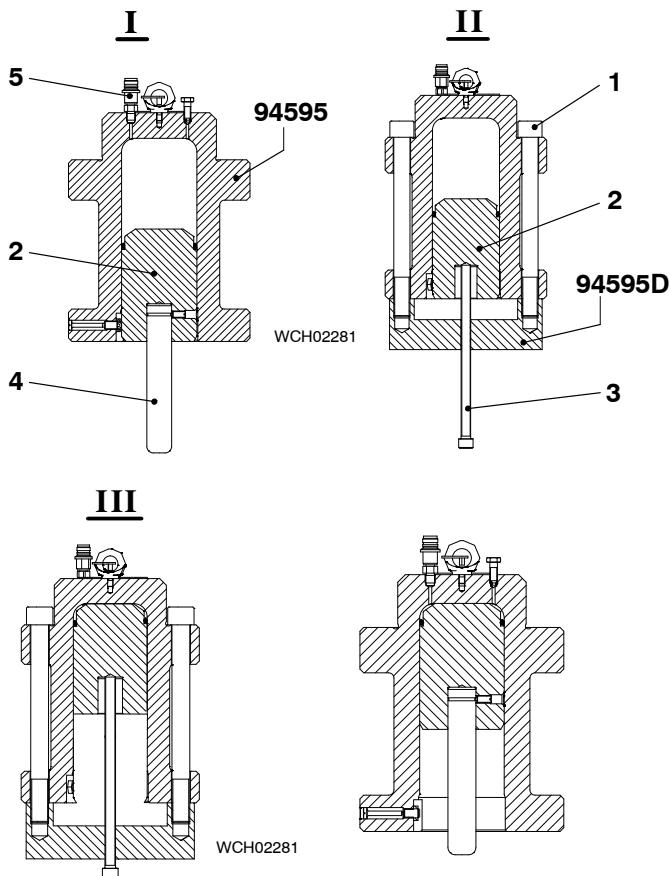


Fig. 2

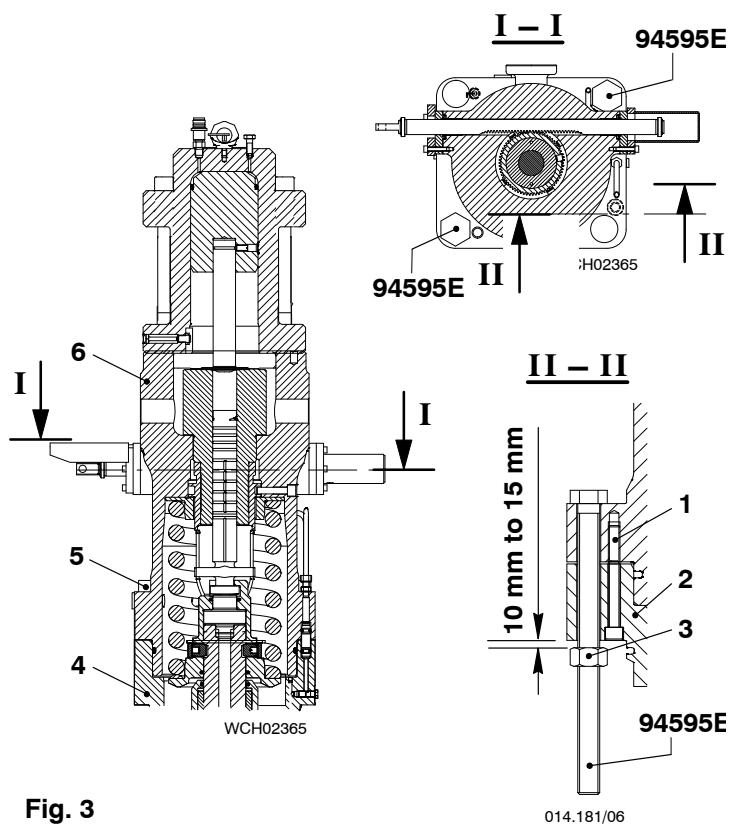


Fig. 3

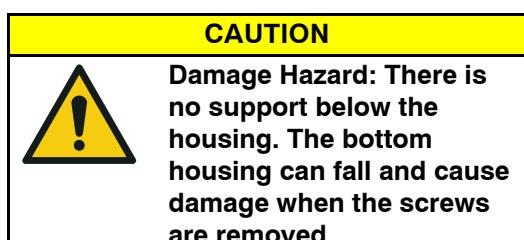
2. Hydraulic Ram – Preparation

- 1) Open the vent screw (5, Fig. 2) and push the piston (2) to the top of the cylinder of the hydraulic ram 94595.
- 2) If you cannot move the piston (2) with your hand, do step a) to step c):
 - a) Remove the push rod (4) (94595B or 94595C) from the piston (5).
 - b) Attach the piston reset tool (94595D) to the hydraulic ram (94595) with two of the screws (1).
 - c) Use the spindle (3) to push the piston (2) to the top of the cylinder.
- 3) Remove the piston reset tool (94595D).
- 4) Put the short push rod (4) (94595B) into the piston (5).

Note: The screws (1) are from the fuel pump cover.

3. Hydraulic Ram – Installation

- 1) Attach the hydraulic ram (94595) to the fuel pump with the twelve screws (1).



- 2) Hold the bottom housing (4, Fig. 3) in position, then remove the four bolts (5) from the top housing (6).
- 3) Put the two screws (94595E) through the bores of the flange in the top and bottom housings (6, 4) in the positions shown (view I-I).
- 4) Put the nuts (3) on the screws (94595E).
- 5) Adjust the nuts (3) to get a minimum clearance of between 10 mm to 15 mm (view II-II).
- 6) Remove the two screws (1).

Fuel Pump: Removal of a Seized Pump Plunger

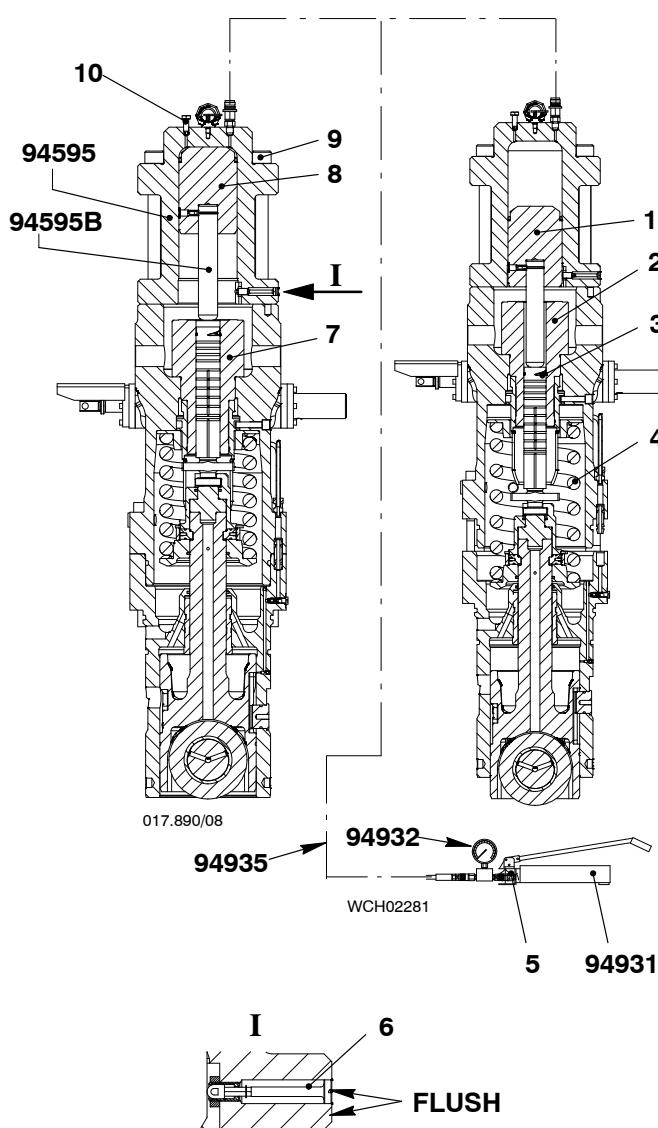


Fig. 4

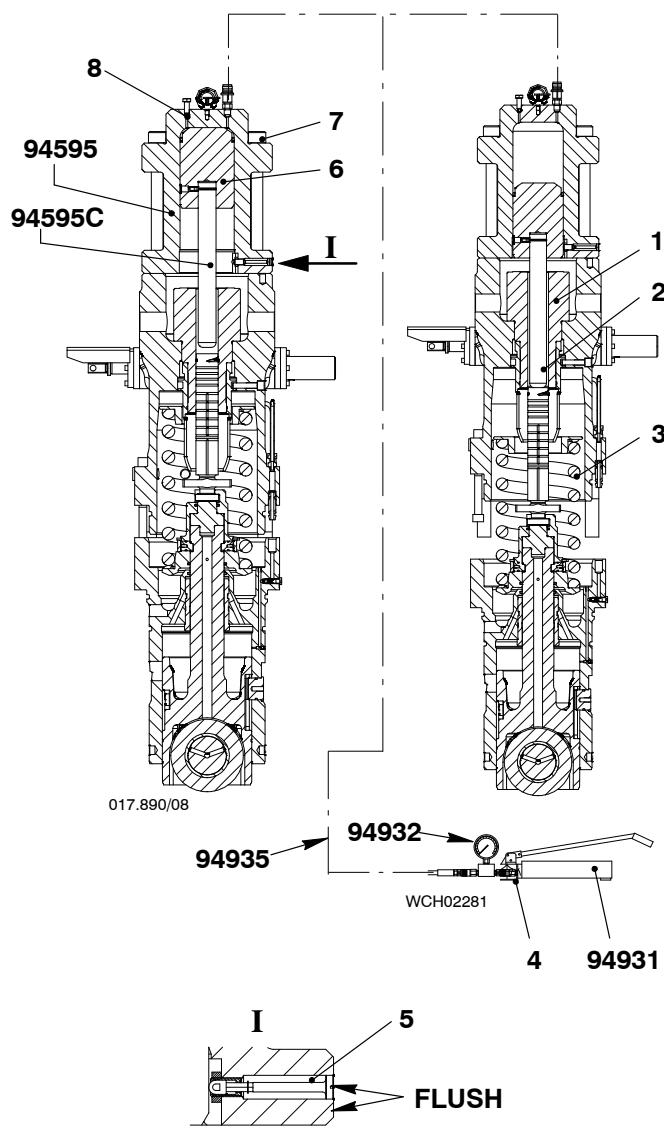
4. Removal with Tool 94595B

- 1) Connect the hydraulic ram (94595, [Fig. 4](#)) to the HP oil pump (94931).
- 2) Close the relief valve (5).
- 3) Make sure that the vent screw (10) is open.
- 4) Operate the HP oil pump until oil that has no air flows from the vent screw (10).
- 5) Close the vent screw (10).

Note: During the step below, make sure that you keep a clearance of between 10 mm and 15 mm between the nuts (3, [Fig. 3 II-II](#)) and the bottom housing (4).

- 6) Slowly operate the HP oil pump until:
 - The compression spring (4) pushes the plunger (2) out of the cylinder (7), or
 - The indicator (6) is flush with the housing. (This shows that the piston is at the end of its stroke.)
- 7) Open the relief valve (5) to release the pressure in the HP oil line.
- 8) Disconnect the HP oil pump from the hydraulic ram (94595).
- 9) Remove the screws (9).
- 10) Remove the hydraulic ram (94595).
- 11) Remove the plunger 3.
- 12) Move the piston (8) to the initial position, see paragraph [2](#).
- 13) Continue to disassemble the fuel pump (see [5556-1](#)).
- 14) If you cannot remove the plunger (2), do the procedure given in paragraph [5](#).

Fuel Pump: Removal of a Seized Pump Plunger

**Fig. 5**

5. Removal with Tool 94595C

- 1) Remove the short push rod (94595B) from the hydraulic ram 94595.
- 2) Put the long push rod (94595C) into the hydraulic ram 94595.
- 3) Install the hydraulic ram (94595) to the fuel pump (see paragraph 3).
- 4) Connect the hydraulic ram (94595) to the HP oil pump (see Fig. 5).
- 5) Close the relief valve (4).
- 6) Open the vent screw (8).
- 7) Operate the HP oil pump until oil that has no air flows from the vent screw (8).
- 8) Close the vent screw (8).

Note: During the step below, make sure that you keep a clearance of between 10 mm and 15 mm between the nuts (3, Fig. 3 view II-II) and the bottom housing (4).

- 9) Slowly operate the HP oil pump until:
 - The compression spring (3, Fig. 5) pushes the plunger (5) out of the cylinder (1), or
 - The indicator (5) is flush with the housing. (This shows that the piston is at the end of its stroke.)
- 10) Remove the screws (7)
- 11) Remove the hydraulic ram.
- 12) Remove the plunger (2).
- 13) Continue to disassemble the fuel pump (see 5556-1).

Fuel Pressure Control Valve

Removal, Check, Installation

Tools:

1	HP oil pump	94931	1	HP hose	94935
1	Pressure gage	94934A	1	PCV test block with tube	94556

1.	General	1
2.	Preparation	1
3.	Removal	2
4.	PCV check	3
4.1	Preparation	3
4.2	Adjustment procedure	4
4.3	Setpoint check	4
5.	Installation	5

1. General

To prevent failure of the pressure control valve (PCV), Wärtsilä recommends that you only do the procedures that follow:

- Do a check and adjust the PCV.
- Replace the PCV.

For the maintenance intervals of the PCV refer to the Maintenance Schedule [0380-1](#), Group 5.

2. Preparation

- 1) Stop the engine.
- 2) Release the pressure in the fuel rail. Do the procedure given in the Operation Manual 0515, paragraph 5.

WARNING

 Injury hazard. Use gloves and eye protection. Hot fuel can come out as a spray and cause injury.

WARNING

 Fire hazard. Do not weld or grind materials in the area. Sparks can cause a fire.

- 3) Make sure that the work area is clean.

Fuel Pressure Control Valve: Removal, Check, Installation

3. Removal

- 1) Make sure that the fuel rail (4, Fig. 1) has no pressure.
- 2) Disconnect the electrical connection from the solenoid valve (2).
- 3) Loosen the angle union (7), then remove the fuel return pipe (5) from the PCV (1).
- 4) Remove the four screws (8).
- 5) Remove the PCV (1) from the valve block (3).
- 6) Put protection on the valve block (3) to prevent contamination.

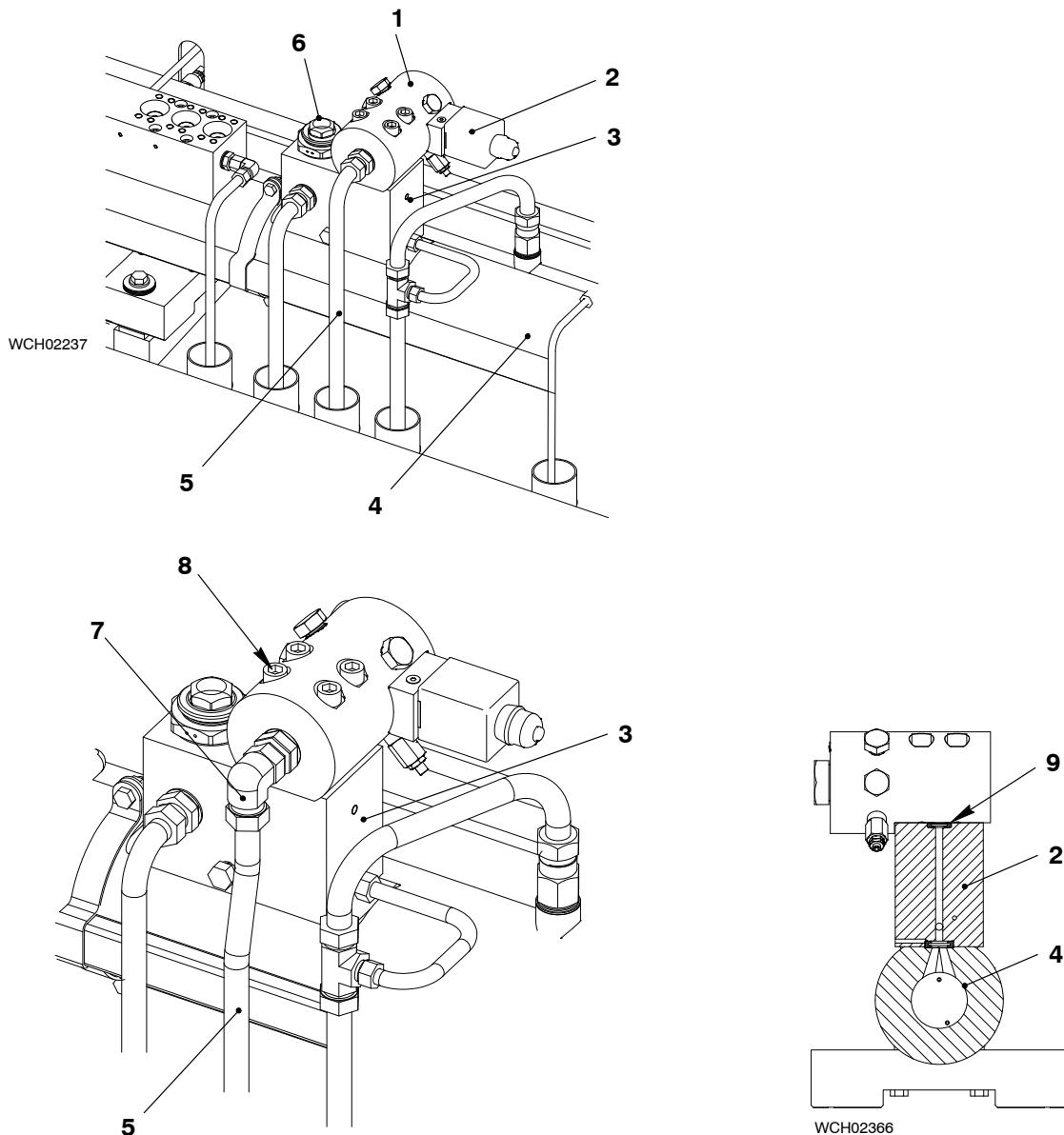


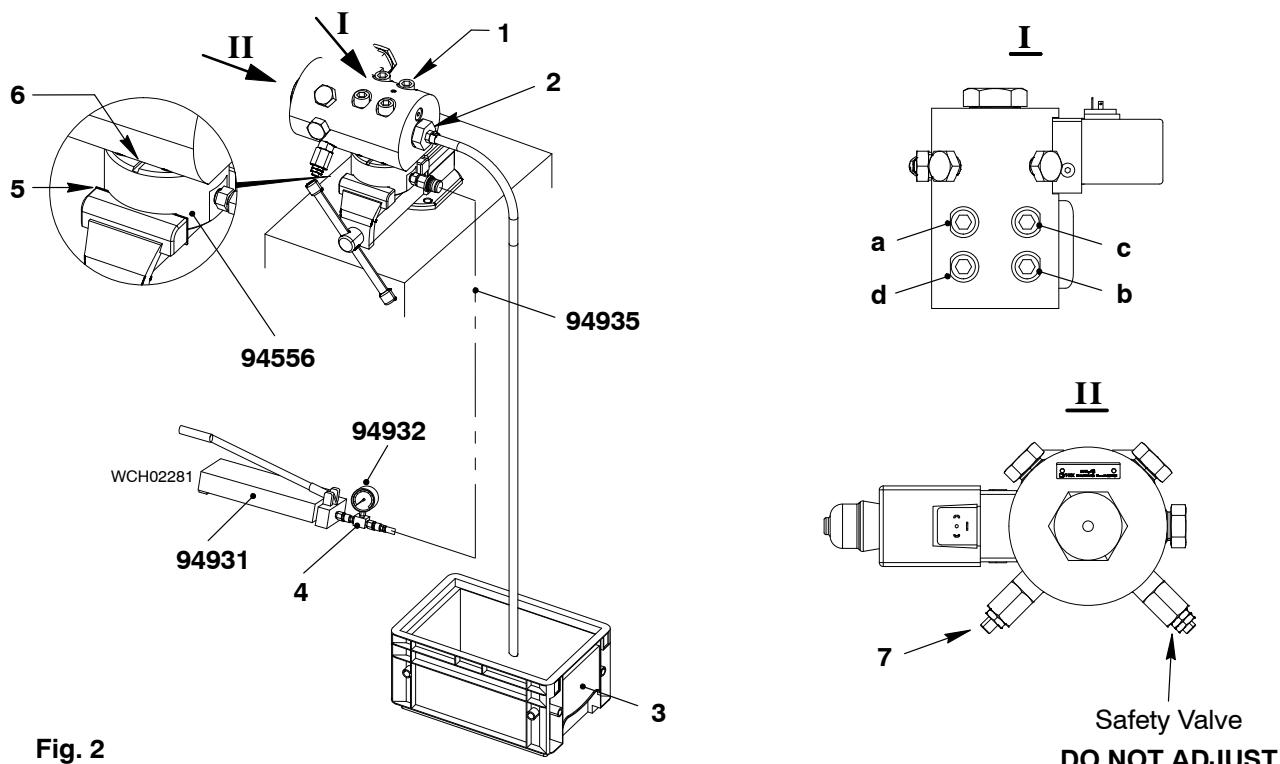
Fig. 1

Fuel Pressure Control Valve: Removal, Check, Installation

4. PCV Check

4.1 Preparation

- 1) Put protection (6, Fig. 2) around the PCV test block 94556.
- 2) Put the test block (94556) in a bench vice.
- 3) Make sure that the sealing surfaces of the PCV and the test block (94556) are clean and have no damage.
- 4) Put the PCV in position on the test block (94556).
- 5) Put oil on the threads of the four screws (1).
- 6) Put the four screws (1) in position in the PCV, then tighten the screws in the sequence given in view I:
 - a) Tighten the screws with your hand.
 - b) Torque the screws to 80 Nm.
 - c) Torque the screws to 190 Nm.
- 7) Attach the flexible tube (part of test block 94556) to the PCV outlet (2). Put the other end of the flexible tube into an applicable container (3).
- 8) Connect the HP oil pump (94931), pressure gage (94932) and HP hose (94935) to the test block (94556).
- 9) Identify each of the two pressure control set screws.
- 10) On the setpoint adjustment valve (SAV) (7), loosen the locknut.
- 11) Fully loosen the SAV (7).



4.2 Adjustment Procedure

CAUTION



Damage Hazard. Do not connect the solenoid valve. Damage to the PCV can occur.

- 1) Operate the HP oil pump (4, [Fig. 2](#)).
- 2) Tighten the SAV (7) to get a value of 100 bar.
- 3) Do a check for leaks.

Note: If oil flows into the groove (5) the PCV has a leak, or the O-ring in the tool (94556) has damage.

- 4) Continue to tighten the SAV (7) and do checks for leaks at the same time.
- 5) Adjust the SAV (7) so that the PCV opens at 1050 bar.
- 6) On the SAV (7), tighten the locknut.
- 7) On the HP oil pump, open the relief valve (4) to decrease the pressure to zero.

4.3 Setpoint Check

- 1) On the HP oil pump, close the relief valve (4).
- 2) Operate the HP oil pump.
- 3) Make sure that the PCV opens at 1050 ± 30 bar.
- 4) If the PCV opens at less than 1020 bar or more than 1080 bar, do the procedure in paragraph [4.2](#) again.

If the PCV does not open at less than 1300 bar or opens at less than 1020 bar (when the SAV (7) is fully closed), the PCV has a malfunction.

You must find and repair the malfunction before you install the PCV.

- 5) On the HP oil pump, open the relief valve (4) to decrease the pressure to zero.
- 6) Disconnect the flexible tube from the PCV outlet (2).
- 7) Disconnect the HP hose (94935) from the tool (94556).
- 8) Remove the four screws (1) from the PCV.
- 9) Remove the PCV from the bench vice.

5. Installation

- 1) Do a check of the lip seal (9, [Fig. 1](#)). Replace the lip seal if necessary.
- 2) Remove the protection from the valve block (3).
- 3) Make sure that the sealing surfaces of the PCV and the valve block (3) are clean and have no damage.
- 4) Put the PCV in position on valve block (3).
- 5) Put oil on the threads of the four screws (1).
- 6) Put the four screws (1) in position in the PCV, then tighten the screws in the sequence given in [Fig. 2](#), view I as follows:
 - a) Tighten the screws with your hand.
 - b) Torque the screws to 80 Nm.
 - c) Torque the screws to 190 Nm.
- 7) Attach the fuel return pipe (5, [Fig. 1](#)) to the PCV (1).
- 8) Tighten the angle union (7).
- 9) Connect the electrical connection to the solenoid valve (2).

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Fuel Overpressure Safety Valve

Removal, Check, Installation

Tools:

1 HP oil pump	94931	2 Pressure gauge	94934A
1 Adapter piece	94234L	2 HP hoses	94935
1 Adapter piece	94234K	1 Valve holder	94273

1. General

The fuel overpressure safety valve (also known as „relief valve“) is installed on the valve block of the pressure control valve (PCV), see [5562-1](#).

The fuel overpressure safety 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.

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

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

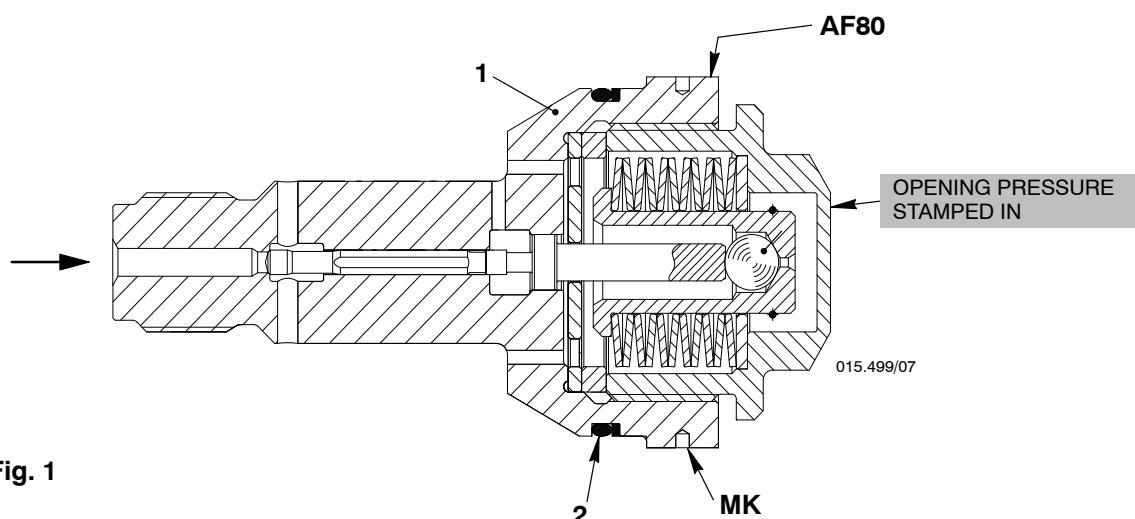


Fig. 1

2. Checking

Use calibration fluid (e.g. Shell Calibration Fluid S.9365, Univar Calibration Fluid 1487) specified as follows:

- The density at 15°C is 827 kg/m³ (ISO 12185)
- The kinematic viscosity at 40°C is 2.6 mm²/s (ASTM D445)
- The pour point is -27°C (ISO 3016)

If calibration fluid is not available, you can use clean diesel oil (gas oil). If clean diesel oil (gas oil) is used, install the injection valve immediately after you complete the checks.

2.1 Preliminary works

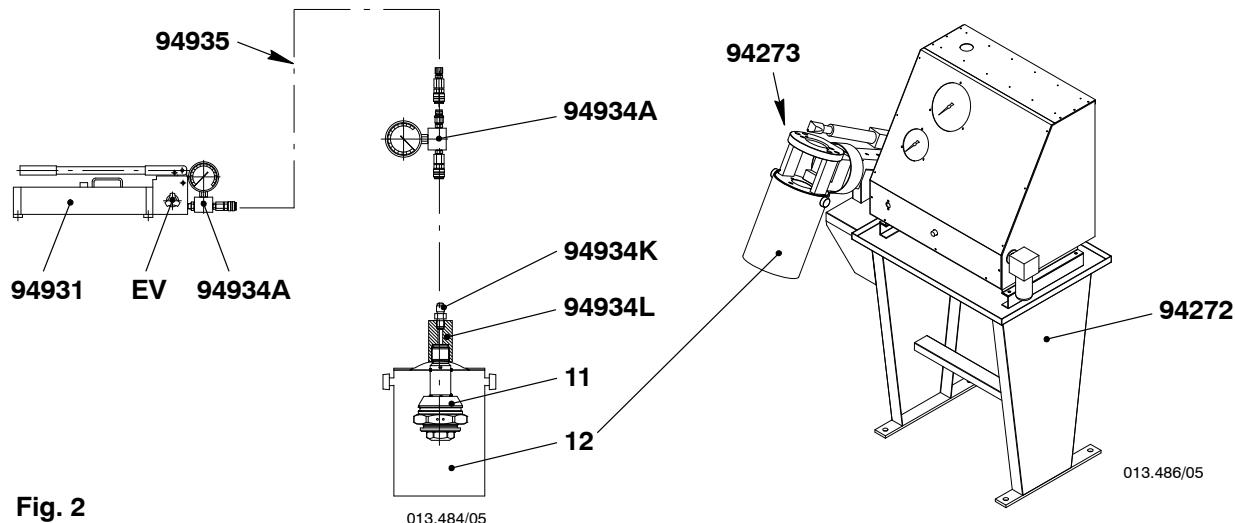
- 1) Use a spanner AF80 on housing (1, Fig. 1) to remove the safety valve from the valve block.
- 2) Fasten the safety valve (11, Fig. 2) together with the adapter piece 94934L into the spray can (12) of valve holder 94273.
- 3) Install adapter piece 94934K to the adapter piece 94934L.
- 4) Connect safety valve (11) together with the adapter pieces to HP oil pump 94931 (or hydraulic unit 94942).
- 5) Close relief valve 'EV'.

2.2 Checking the sealing pressure

- 1) 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

- 1) Increase the pressure by means of HP oil pump and observe at what value the safety valve opens.
 - Correct opening pressure = **1250 bar ± 100**
- 50



3. Install fuel pressure safety valve

- 1) Replace O-rings (2, Fig. 1).
- 1) Apply Never-Seez NSBT to the thread of valve housing (1).
- 2) Screw the safety valve into the valve block of fuel pressure control valve 3.06 and tighten it with a torque of **300 Nm** by means of a spanner with AF80.

Flow Limiting Valve

Removal and Installation

Tools:

No tools needed

1. General	1
2. Preparation	2
3. Removal	3
4. Inspection	3
5. Installation	4
6. Completion	5
7. Storage	5

1. General

It is possible to do the maintenance of the flow limiting valve (FLV) on board. Speak to, or send a message to Wärtsilä Services Switzerland to get a repair kit including instruction:

Maintenance on the flow limiting valve must only be done by approved personnel who have the special knowledge of the flow limiting valve. If personnel are not approved, send the FLV to a Wärtsilä service station for overhaul.

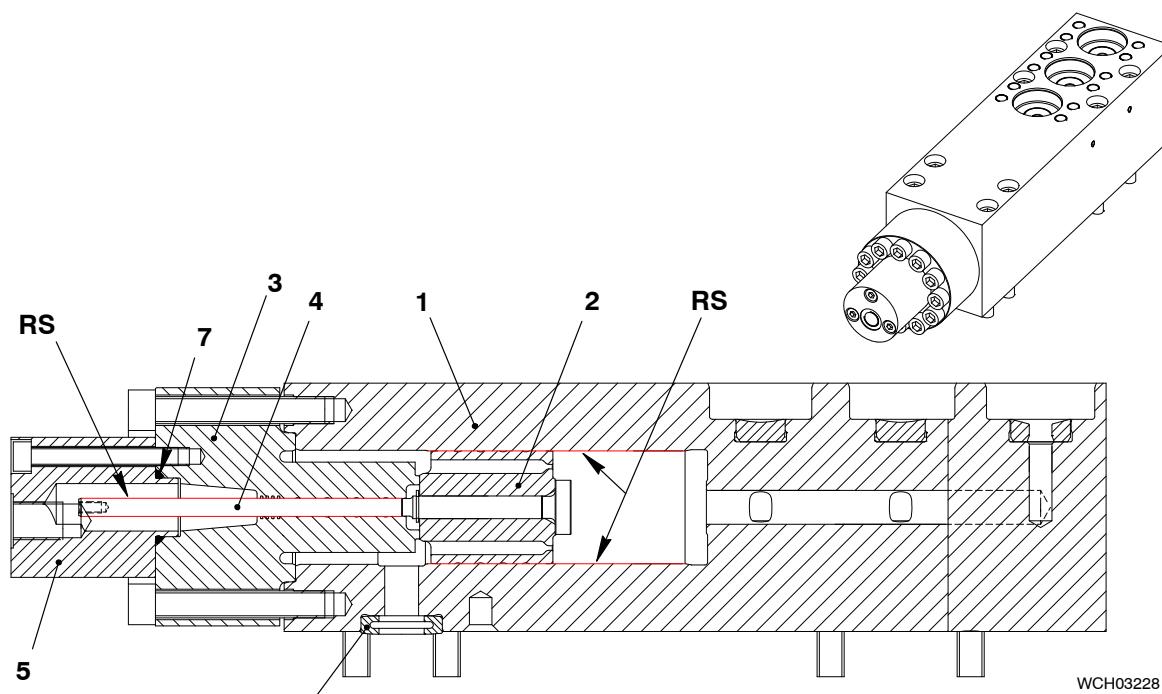
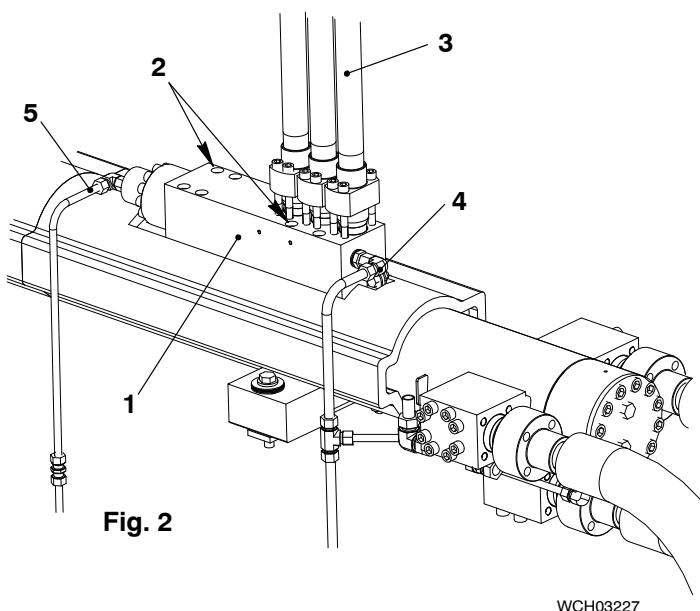


Fig. 1

Fig. 1 Flow Limiting Valve

- 1 Valve block
- 2 Piston
- 3 Flange
- 4 Piston rod

- 5 Cover
- 6 Lip seal
- 7 O-ring
- RS Running surface

Flow Limiting Valve

2. Preparation

- 1) Cut out the injection, refer to the Operation Manual 0510-1.
- 2) Let the engine temperature decrease.
- 3) Let the pressure in the fuel rail decrease to zero.
- 4) Make sure that the fuel injection system has no pressure.
- 5) Make sure that all tools and equipment are clean and in good condition.
- 6) Clean the work area adjacent to the flow limiting valve (1, Fig. 2).

WARNING



Fire Hazard: Do not weld or grind materials in the work area. Sparks can cause a fire.

WARNING



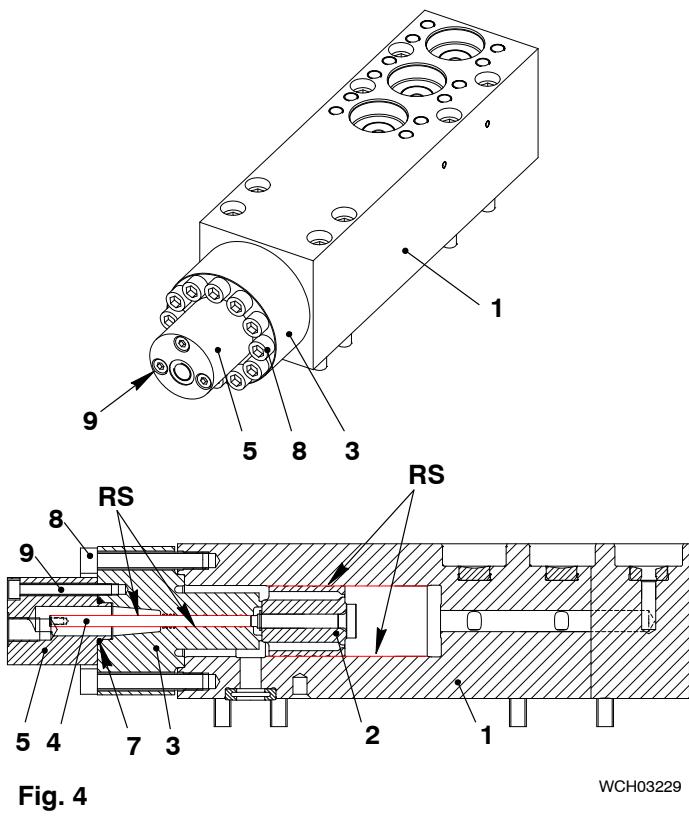
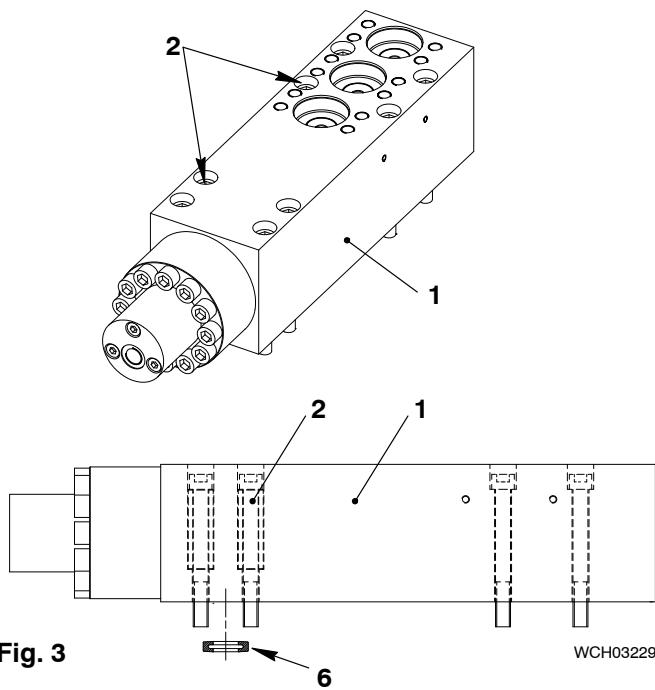
Injury Hazard: Put on gloves and safety goggles before you do work on hot components. Fuel and oil can come out as a spray and cause injury.

WARNING



Injury Hazard: Do not operate the turning gear. Fuel can come out of the opening in the fuel rail.

- 7) Remove the HP fuel pipes (3), refer to [8733.1](#).
- 8) Remove the leakage pipes (4), (5) from the flow limiting valve (1).
- 9) Apply protection to the openings on the flow limiting valve.
- 10) Apply protection to the open ends of the pipes that you removed.

Injection Control Unit**3. Removal**

- 1) Remove the eight bolts (2, Fig. 3) from the flow limiting valve (1).
- 2) Lift the flow limiting valve (36kg) with help fo another person or with an M12 eye bolt (94045-M12) and a crane.
- 3) Take out the lip seal (6) and put it to a safe place. Surface must not be scratched.
- 4) Make sure that the dowel pins stay in the fuel rail.
- 5) Lower the flow limiting valve (1) on to an applicable clean surface.

4. Inspection

- 1) Remove the three bolts (9, Fig. 4) and cover (5) from the flow limiting valve (1).
- 2) Remove the twelve bolts (8).
- 3) Carefully remove flange (3) together with piston rod (4) and piston (2).
- 4) Clean piston rod (4) with a Scotch Brite™ and a cleaning solvent like brake cleaner, Neoval®, WD40® or similar.
- 5) Pull the piston (2) together with piston rod (4) out of flange (3). If you feel a slight resistance, push it back and clean the piston rod again.
- 6) Inspect the running surfaces (RS) of piston rod (4) and flange (3), piston (2) and valve block (1).
- 7) Contact Wärtsilä Services Switzerland for replacement parts and instruction or send it to a Wärtsilä Service Station for an overhaul.
- 8) Clean all parts and running surfaces (RS).

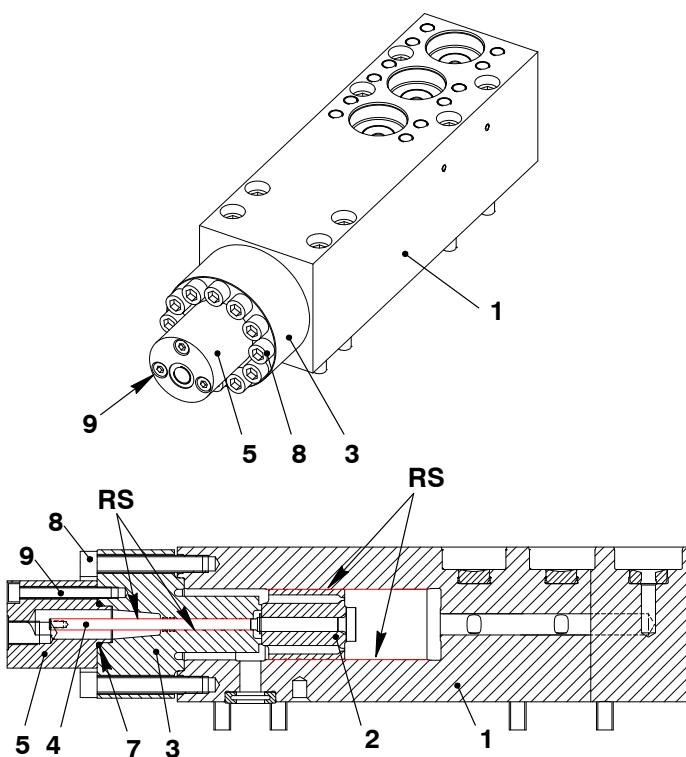
Injection Control Unit: Removal and Installation

Fig. 5

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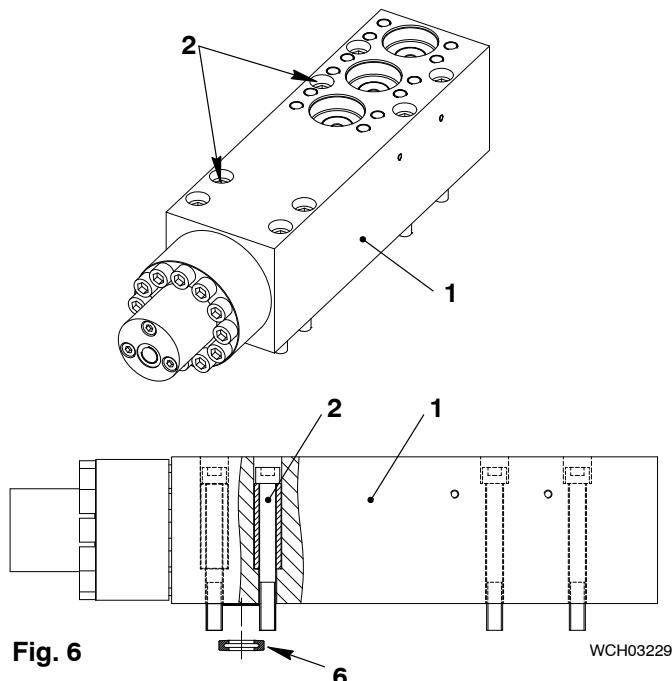


Fig. 6

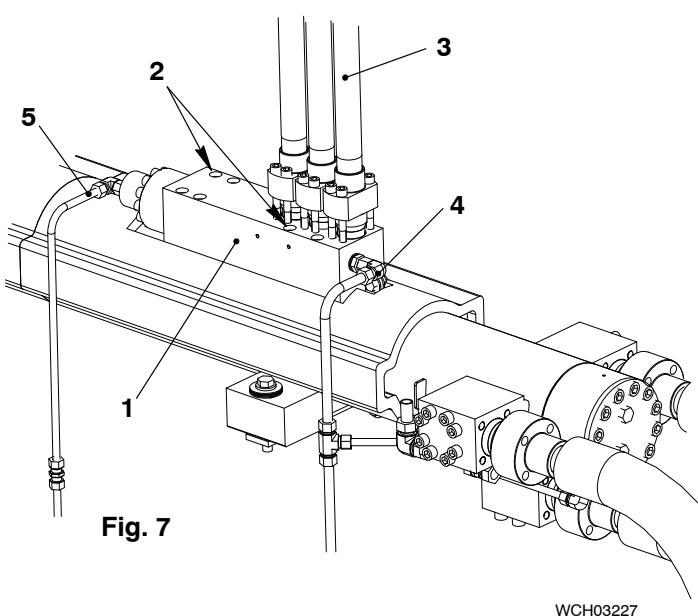
WCH03229

- 9) Apply lubricating oil to all running surfaces (RS).
- 10) Push piston rod (4, Fig. 5) together with piston (2) into flange (3). Check for smooth running (full stroke and turning).
- 11) Slide the piston (2) together with flange into the valve block (1).
- 12) Apply Never Seez NSBT to the threads and contact surfaces of the twelve screws (8).
- 13) Tighten the twelve screws (8) equally by hand and check for smooth running.
- 14) Tighten the twelve screws (8) with 60Nm and check again for smooth running.
- 15) Put a new O-ring (7) to the cover (5).
- 16) Install the cover (5) and tighten the three screws (9).

5. Installation

- 1) Make sure that the dowel pins are in the fuel rail.
- 2) Clean the sealing surface in the valve block (1, Fig. 6) and the lip seal (6). It is highly recommended to install a new lip seal (6).
- 3) Install the lip seal (6).
- 4) Clean the mounting area on the fuel rail and the valve block.
- 5) Put the flow limiting valve carefully on the correct position on the fuel rail.
- 6) Apply Never Seez NSBT to the threads and contact surfaces of the eight bolts (2).
- 7) Put in the eight bolts (2) together with distance sleeves into the valve block and tighten the bolts (2) by hand.
- 8) Tighten the eight bolts (2) with a torque of 60Nm.

Injection Control Unit: Removal and Installation



6. Completion

- 1) Install the leakage pipes (4), (5) to the flow limiting valve (1, Fig. 7).
- 2) Install the HP fuel pipes, refer to [8733.1](#).
- 3) Cut in the injection, refer to the Operation Manual, 0510-1.
- 4) Operate the engine for a minimum of one hour with marine diesel oil. For more data, refer to the Operation Manual 0510-1.

7. Storage

Before you put an flow limiting valve (FLV) into storage, do the procedure that follows:

- 1) Use a vacuum cleaner to remove dirt from all openings.
- 2) Clean the FLV.
- 3) Lubricate the FLV correctly.
- 4) Put the FLV in a plastic bag.
- 5) Remove as much air as possible from the plastic bag.
- 6) Seal the plastic bag.

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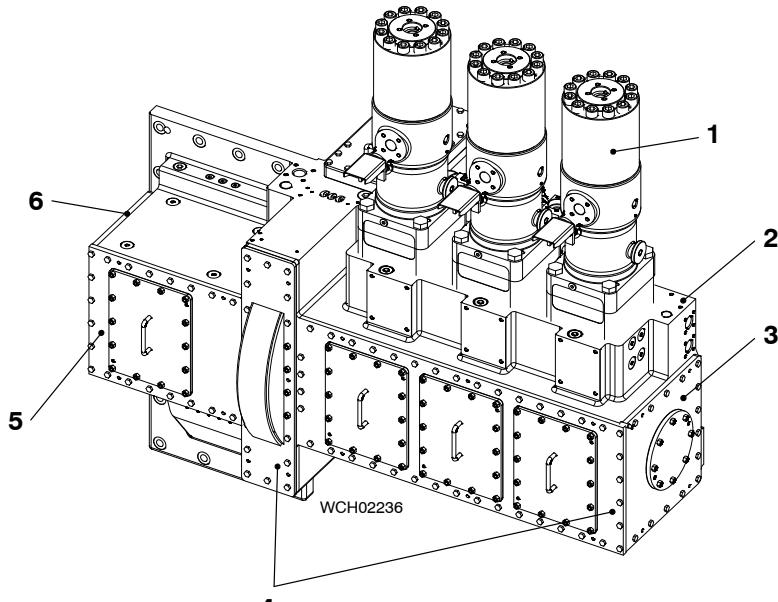
Supply Unit**Camshaft and Bearing Shells – Removal and Installation****Tools:**

2	Pre-tensioning jack	94557	1	Screwjack	94567B
2	Support	94566	1	Connection block	94934
1 or 2	Holders	94566B	1	Pressure gages	94934A
1	Holder	94566C	3	HP hoses	94935
1	Assembly template	94567	1	Hydraulic unit	94942
1	Assembly template	94567A			

1.	Preparation	1
2.	Bearing Shells – Removal	3
3.	Camshaft – removal	4
4.	Camshaft and bearing shells – installation	4
5.	Completion	6

1. Preparation

- 1) Remove the covers (3, 4, 5 and 6, [Fig. 1](#)) from the housing (2).
- 2) Remove the fuel pumps (1) refer to [5556-1](#), or as an alternative lift the rollers (see step 3) to step 4).

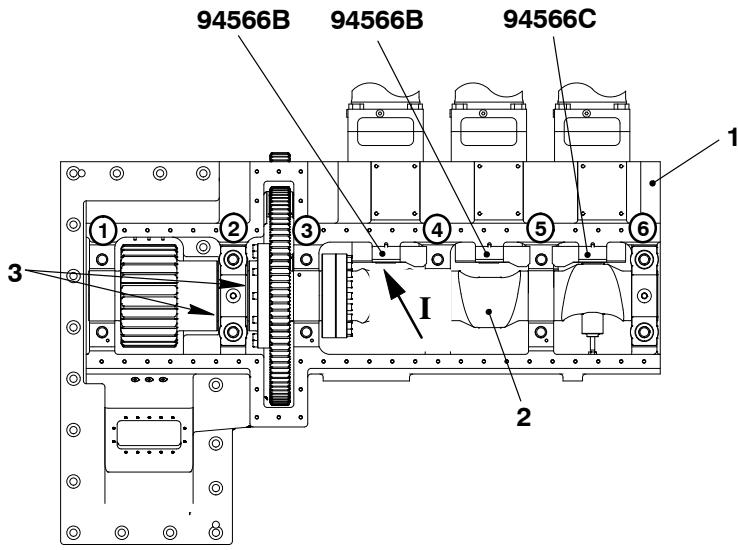
**Fig. 1**

Camshaft and Bearing Shells – Removal and Installation

- 3) Make sure that the bearing covers at positions No. 3, No 4 and No. 5 Fig. 2 and the housing (1), have marks to identify them as a set.

Note: The bearing at position No. 2 has the two thrust bearing ring halves (3).

- 4) Install the holders (94566B and 94566C) to lift up the rollers and guide pistons of the fuel pumps.



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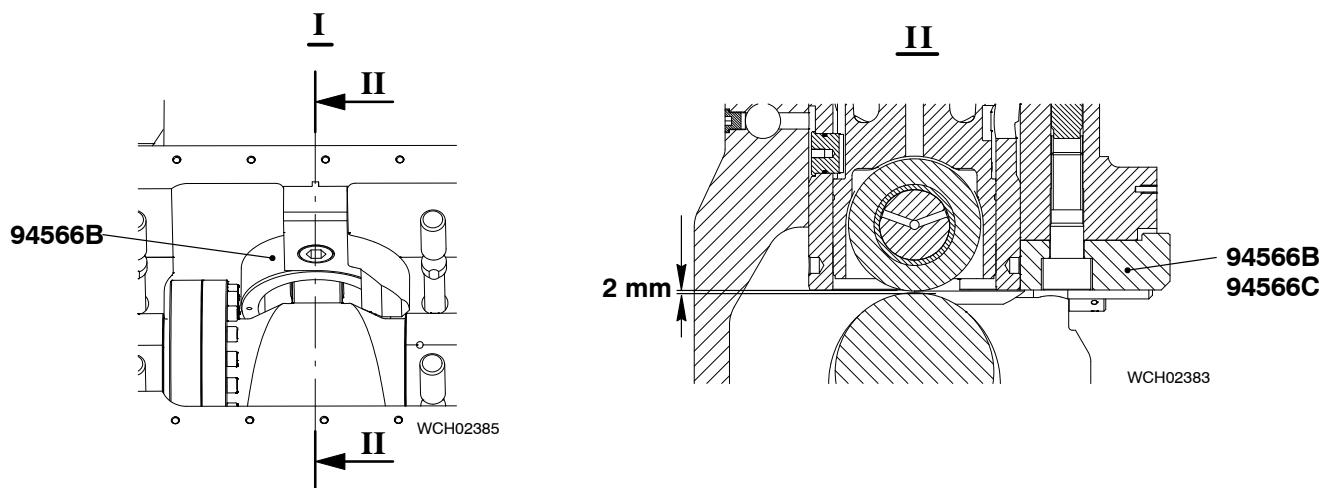


Fig. 2

Camshaft and Bearing Shells – Removal and Installation

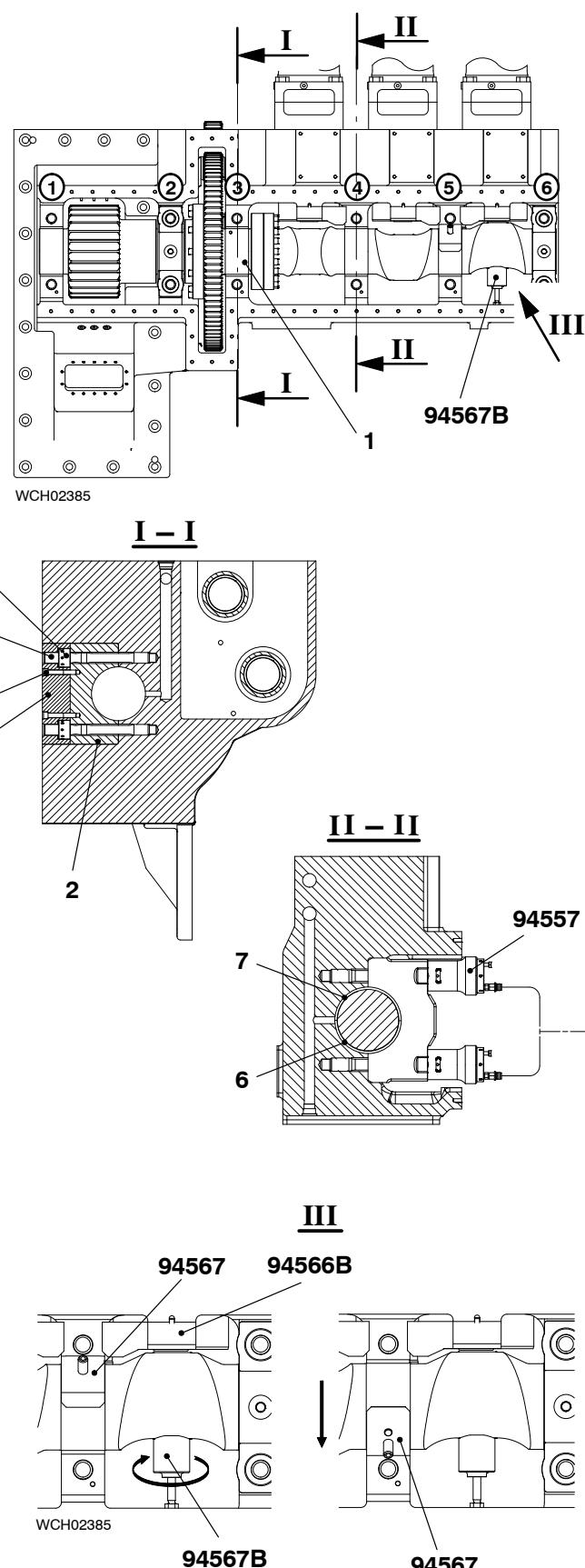


Fig. 3

2. Bearing Shells – Removal

- 1) Loosen the two Allen screws (3, Fig. 3) and remove the filling piece (1) from bearing cover No.3.
- 2) Use the pre-tensioning jacks (94557) to loosen the round nuts (5) of the bearing covers No.1, No.3, No.4 and No.5, refer to 9403-4.
- 3) Remove the round nuts (5) and the bearing covers No.1, No.3, No.4 and No.5.
- 4) Put the screwjack (94567B) in position under the last cam.
- 5) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm and 0.15 mm.
- 6) Put the tool (94567) in position on the top bearing shell (7) of bearing No.5 (see View III).
- 7) Use the assembly template (94567) to turn the top and bottom bearing shells (6, 7) 90° (see View III).

Note: If you cannot turn the bearing shells, adjust the screwjack (94567B) again.

- 8) Hold the top bearing shell (7), then remove the assembly template (94567).
- 9) Put marks on the top bearing shells to identify their positions. This will help you when you install the bearing shells.
- 10) Remove the top bearing shell (7).
- 11) Do step 3) to step 10) to remove the remaining top bearing shells at positions No.3 and No.5.

Camshaft and Bearing Shells – Removal and Installation

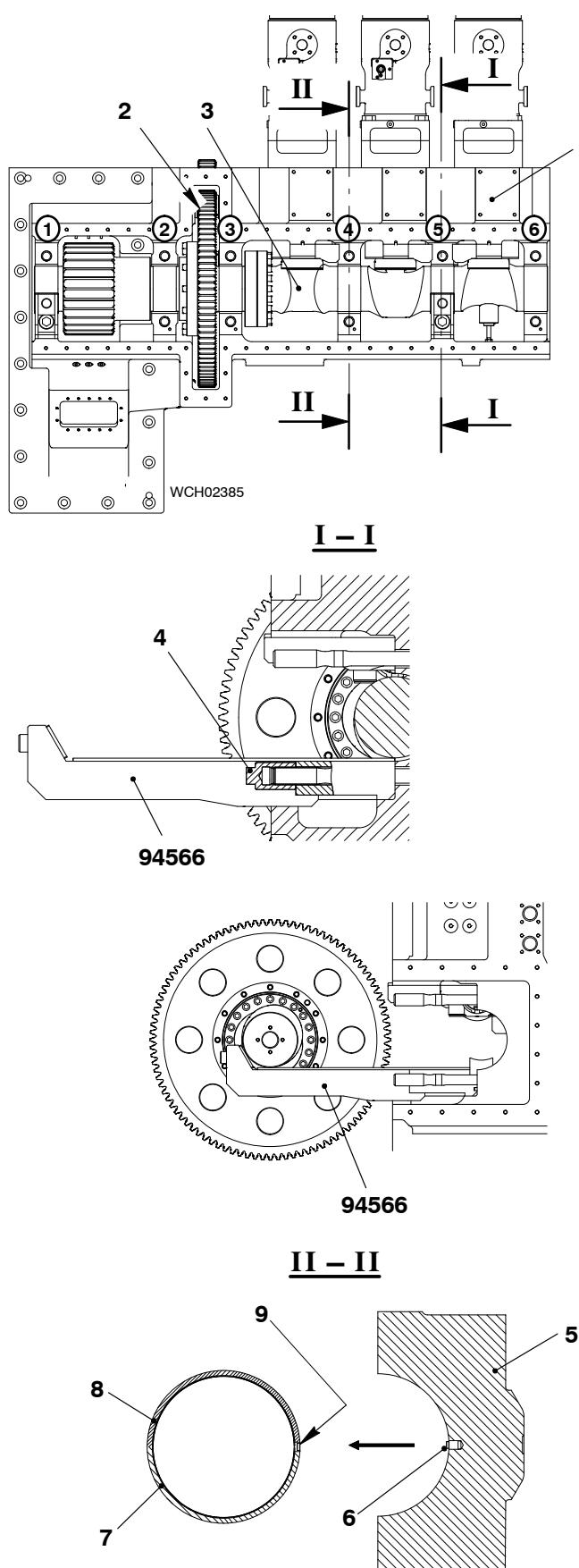


Fig. 4

3. Camshaft – Removal

- 1) Put the two supports (94566) in the positions at No.1 and No.5 (Fig. 4).
- 2) On the two supports (94566), tighten the nuts (4).
- 3) Make sure that the camshaft stays in position before you remove the last bearing cover.
- 4) Remove the remaining bearing covers and top bearing shells at positions No.2 and No.6 (see the procedure in paragraph 2, step 2) to step 11).
- 5) Remove the screwjack (94567B, Fig. 3).
- 6) Carefully move the camshaft (3, Fig. 4) and the gear wheel (2) on to the two supports (94566).
- 7) Make sure that the camshaft (3) and gear wheel (2) do not move.
- 8) Make a mark on the remaining bottom bearing shells to identify their positions. This will help you when you install the bearing shells.
- 9) Remove the remaining bearing shells.

4. Camshaft and Bearing Shells – Installation

- 1) Make sure that all items are clean and do not have damage.
- 2) Apply oil to the bearing shells and the camshaft (3).
- 3) Put all bottom bearing shells into the casing in their correct positions. Refer to the marks you made before.
- 4) Put the camshaft (3) and gear wheel (2) in position on the two supports (94566).
- 5) Carefully move the camshaft (3) and the gear wheel (2) into the housing (1). Make sure that the bearing shells stay in position and do not fall.
- 6) Make sure the camshaft does not move.

Camshaft and Bearing Shells – Removal and Installation

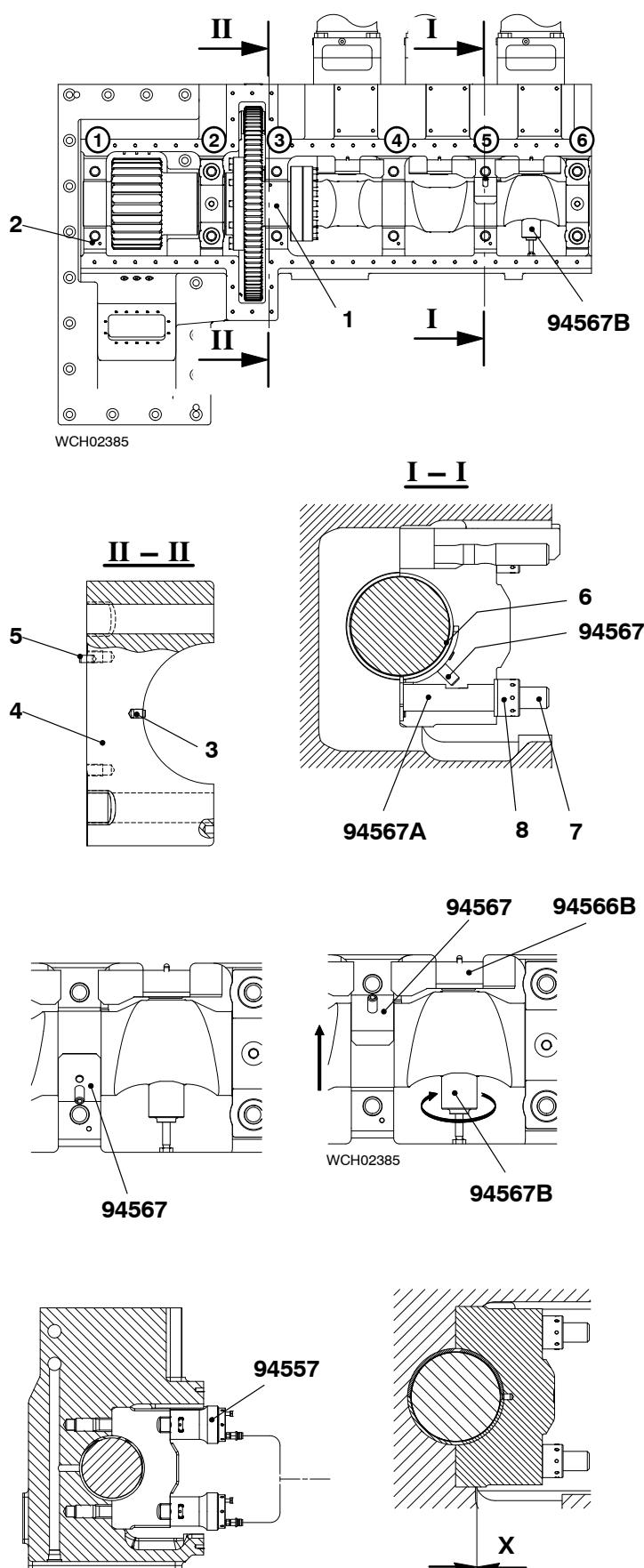


Fig. 5

- 7) Put the screwjack (94567B, Fig. 5) in position.
- 8) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm and 0.15 mm.
- 9) Put the assembly template (94567A) on the bottom elastic bolt (7).
- 10) Put the round nut (8) on the elastic bolt (7). Tighten the round nut with your hand.
- 11) Put the top bearing shell (6) in position on the camshaft.
- 12) Put the assembly template (94567) in position on the bottom half of the top bearing shell. Use the assembly template (94567A) to help you get the bearing shell in the center.
- 13) Use the assembly template (94567) to turn the bearing shells (7, 8 Fig. 4) 90° upwards.
- 14) Make sure that the semicircular slots of the two bearing shells (7, 8) are in a horizontal position.
- 15) Remove the assembly templates 94567 and 94567A.
- 16) Remove the holder (94566A or 94566B)
- 17) Make sure that the pin (3, Fig. 5) is in the bearing cover (4).
- 18) Attach the bearing cover (4).
- 19) Put the round nuts (8) on the elastic bolts (7). Tighten the round nuts with your hand.
- 20) Do the steps 1) to 19) for the remaining bearing shells.
- 21) Remove the two supports (94566).
- 22) Put the bearing cover (4) that has the dowel pin (5) on to position No. 3.
- 23) Install the tool (94557) on to the elastic bolts (7) (see 9403-4).
- 24) Tighten the round nuts (8) to the value specified in 9403-4.
- 25) Make sure that there is no clearance at (X).

5. Completion

- 1) Refer to [0330-1 Clearance Table](#), Group [5552](#) for the axial clearances.
- 2) If the axial clearances are not in the specified range, loosen the round nuts on one of the bearing covers (see the paragraph [2](#), step [2](#)).
- 3) Put the bearing cover in position again, see paragraph [4](#), step [17](#) ,step [18](#), step [19](#)) and step [22](#) to step [25](#)).
- 4) Attach the filling piece (1, [Fig. 3](#)) to the bearing cover 5 with the two Allen screws 9 (see [Fig. 3](#), view [I-I](#)).
- 5) If the fuel pumps (1, [Fig. 6](#)) were not removed, do step [a](#)). If the fuel pumps were removed, do step [b](#)).
 - a) Remove the holders (94566B and 94566C).
 - b) Install the fuel pumps. See [5556-1](#).
- 6) Apply sealing compound to the sealing surfaces of the covers (3, 4 and 6).
- 7) Install the covers (3, 4, 5 and 6) to the housing (2).
- 8) Set to on the oil pump.
- 9) Use the turning gear to turn the engine.
- 10) Make sure that lubricating oil flows to all lubricating points and bearings.

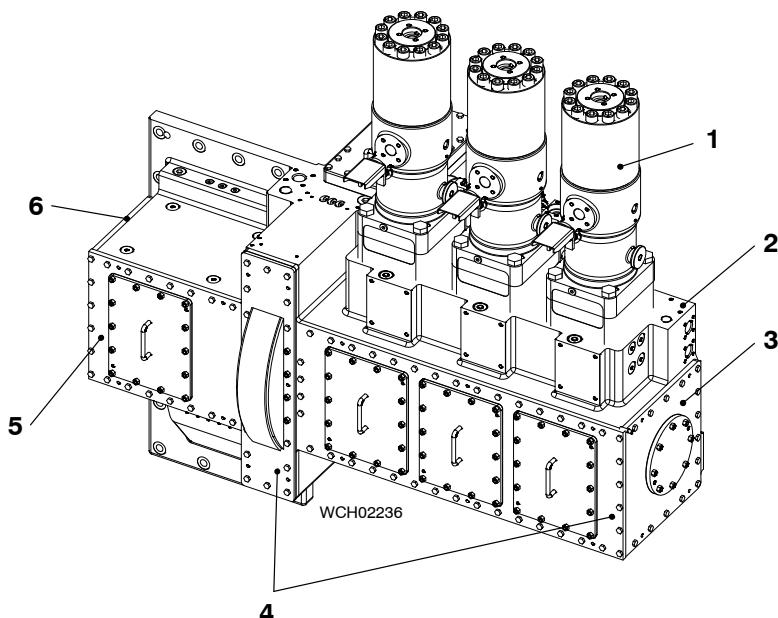


Fig. 6

Fuel Pump Actuator

Connection to Fuel Pump

1. General

Maintenance of the connection between the fuel pump and the actuator is not necessary.

- 1) Do a check of the connecting element (1, Fig. 1) as follows:
 - a) Make sure that the connecting element is lubricated with MOLYKOTE paste G.
 - b) Make sure that the connecting element can move freely.

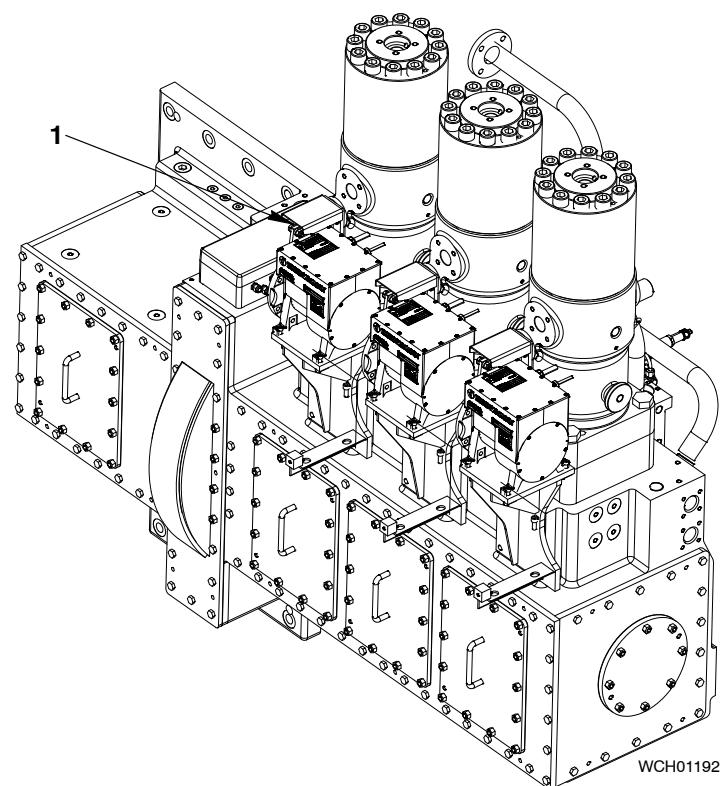


Fig. 1

2. Actuator and Fuel Pump – Align

If there was an overhaul on the actuator, or the actuator was replaced do step 1) to step 9):

- 1) Make sure that the actuator is electrically disconnected.
- 2) Make sure that the connecting element (1, Fig 2) is disconnected from the lever (2).
- 3) Move the shaft (3) to get the indicator (5) to the 50% fuel position.
- 4) Remove the six screws (9), then remove the cover (10).
- 5) Move the toothed rack (6) to get a distance of 48 mm at each end.
- 6) Attach the cover (10) to the actuator (11) with the six screws (9).
- 7) Put the lever (2) in position on the shaft (3). Make sure that the center-line of the lever aligns with the 50% fuel indication on the actuator (11).
- 8) Attach the lever (2) to the connecting element (1) with the screw (8) and the self-locking nut (7).
- 9) Tighten the screw (4) on the shaft (3).

Note: For data about emergency operation with defective fuel actuators, see the Operation Manual 0515-1.

Fuel Pump Actuator: Connection to Fuel Pump

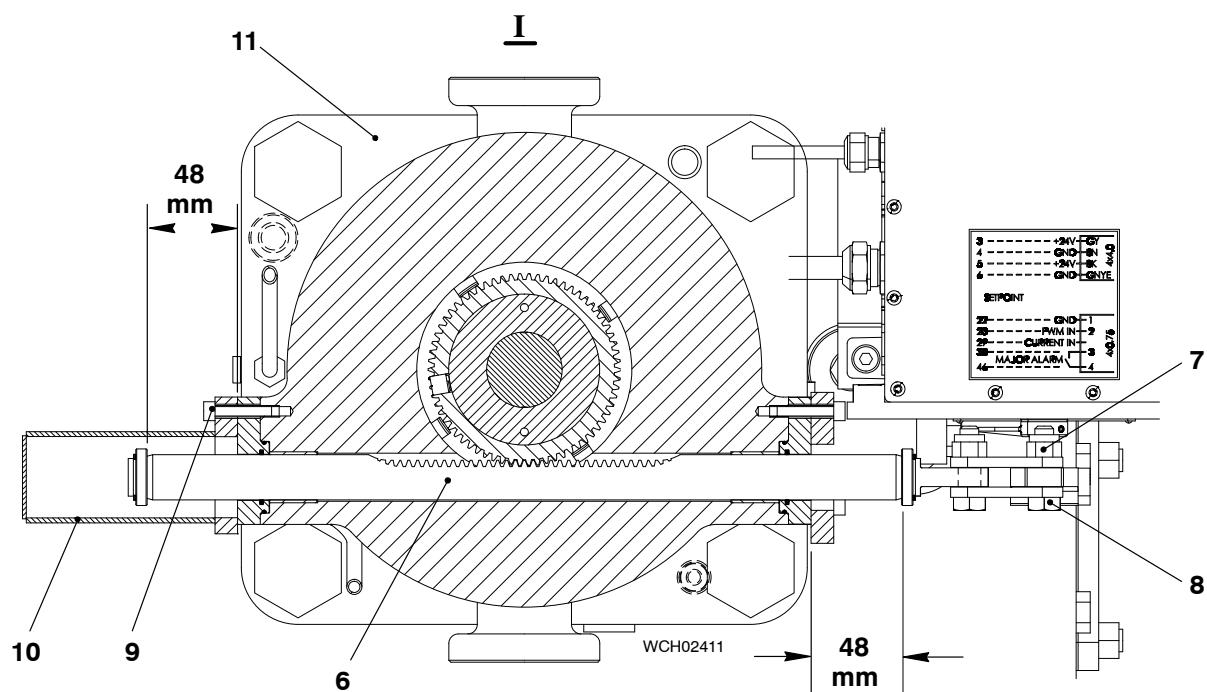
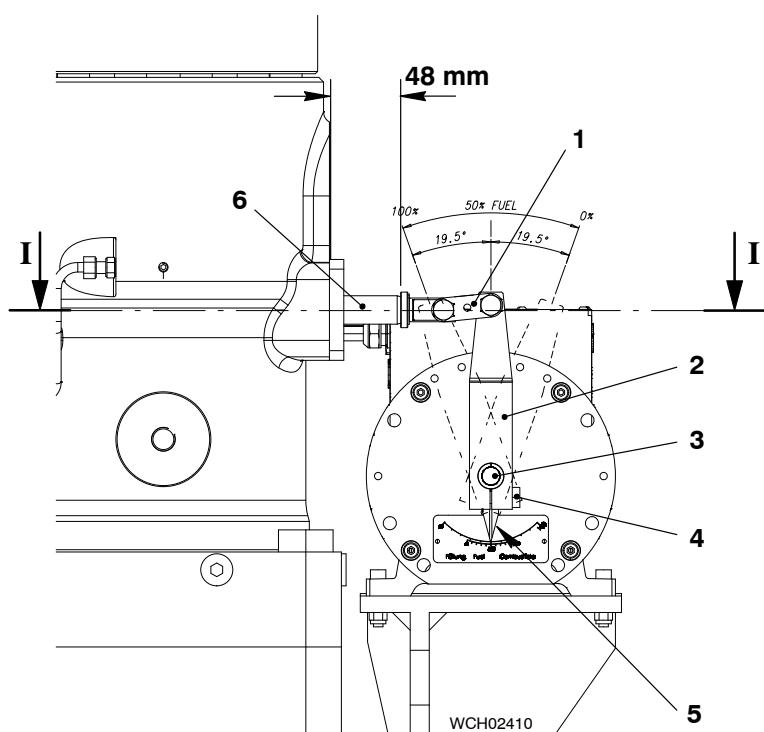


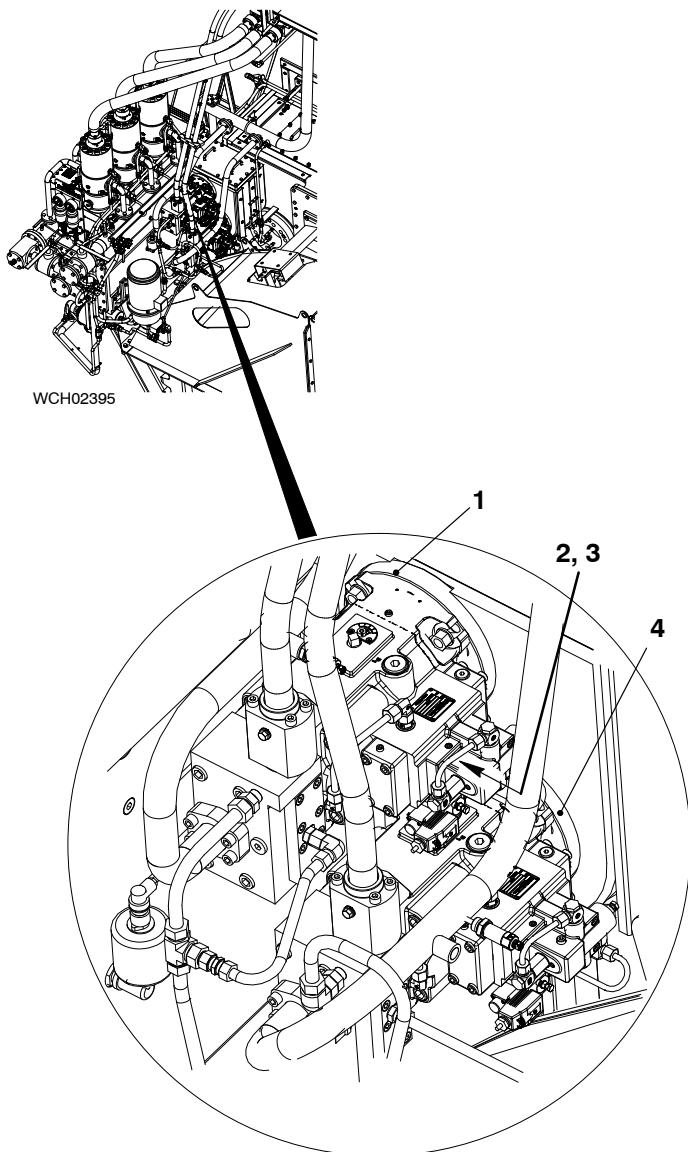
Fig. 2

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Servo Pump Unit**Servo Oil Pump – Removal and Installation****Tools:**

2 Sling 94202K

1.	General	1
2.	Checks	1
2.1	Servo Oil Pump	1
2.2	Pinions and Camshaft Gear Wheel	2
3.	Servo Oil Pump – Removal	3
3.1	Preparation	3
3.2	Removal	4
3.3	Bearing Bushes	5
4.	Servo Oil Pump – Installation	7
5.	Completion	8

**Fig. 1****1. General**

Data about operation, maintenance and servicing of the servo oil pumps are given in the related documentation of the servo oil pump manufacturer.

Do the related maintenance in [0380-1 Maintenance Schedule, Servo Pump Unit](#).

For more data, see the Operation Manual 5551-1 Servo Oil Pump.

2. Checks**2.1 Servo Oil Pump**

- 1) While the servo oil pumps (1 and 4, [Fig. 1](#)) operate, listen for unusual noises. If you hear unusual noises, you must find the cause and correct the malfunction immediately.
- 2) Compare the temperatures of the two servo oil pumps (1, 4). If there is a temperature difference, you must find the cause and correct the malfunction immediately.

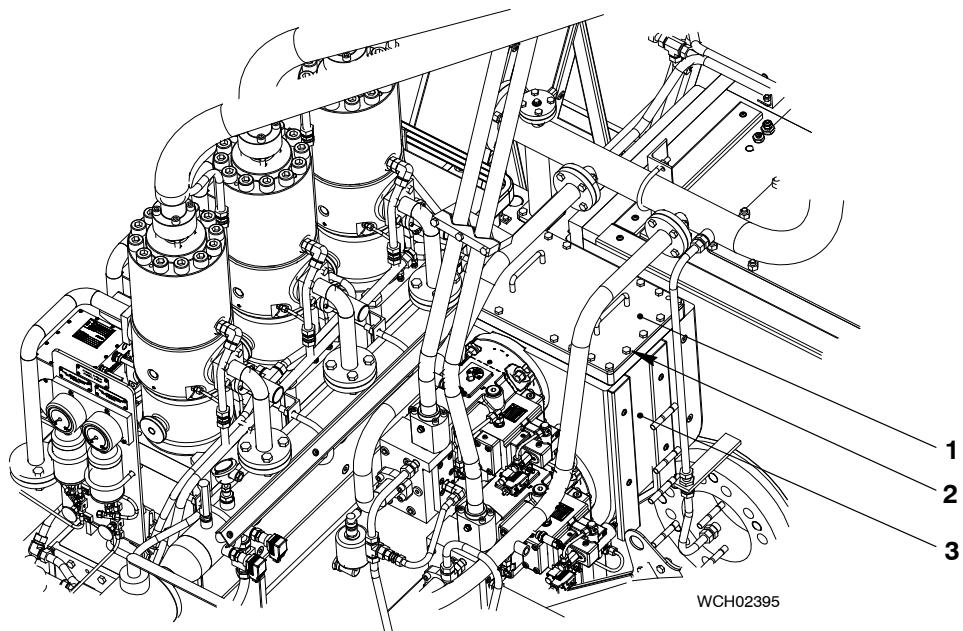
Note: The filter (3) is installed in the pipe (2).

- 3) Each time the ship is in port, do a check of the filter as follows:
 - a) Make sure that the servo oil pumps do not operate.
 - b) Remove the pipe (2).
 - c) Do a check of the filter (3) for dirt or particles.
 - d) If necessary, clean the filter (3).
 - e) Install the pipe (2)

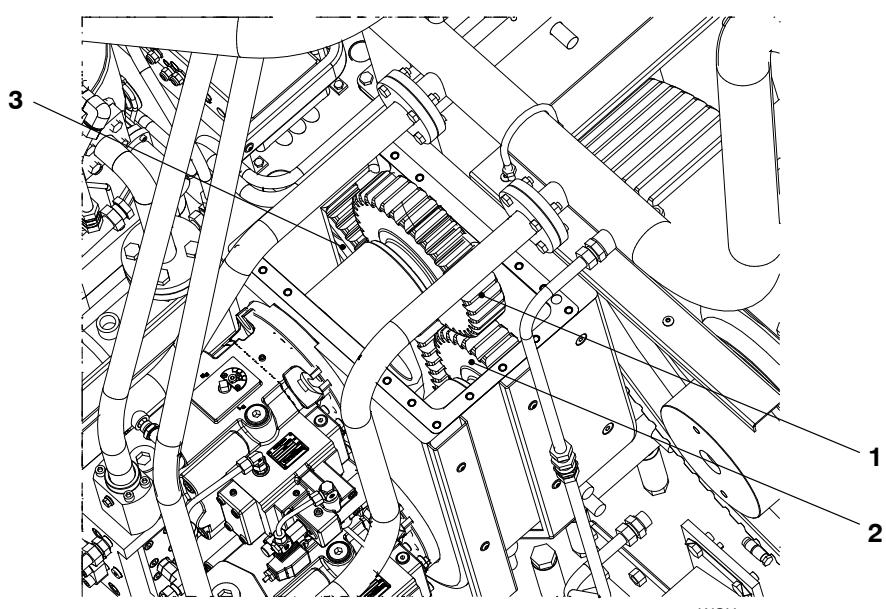
Servo Oil Pump – Removal and Installation

2.2 Pinions and Camshaft Gear Wheel

- 1) Remove the 20 screws (2, Fig. 2).
- 2) Remove the cover (1) from the supply unit casing (3).

**Fig. 2**

- 3) Do a check of the pinions (1, and 2 Fig. 3) and the camshaft gear wheel (3) for wear and damage (see 0330-1 Clearance Table, Fuel and Servo Pump Units).
- 4) If there is too much wear and / or damage, you must replace the pinions (1, 2) and the camshaft gear wheel (3).
- 5) Attach the cover (1, Fig. 2) with the 20 screws (2) to the supply unit casing (3).

**Fig. 3**

Servo Oil Pump – Removal and Installation

3. Servo Oil Pump – Removal

3.1 Preparation

- 1) Stop the engine (see the Operation Manual 4002-2).
- 2) Set to off the main bearing oil pump.
- 3) Remove the HP servo oil pipes (12, Fig. 4) (see 8447-1).
- 4) For engines with three fuel pumps, do step a).
For engines with two fuel pumps, do step b).
 - a) Remove the two rear HP fuel pipes (3) from the fuel pumps (2) (see 8752-1).
 - b) Remove the two HP fuel pipes from the fuel pumps (see 8752-1).
- 5) Disconnect the electrical connections (7).

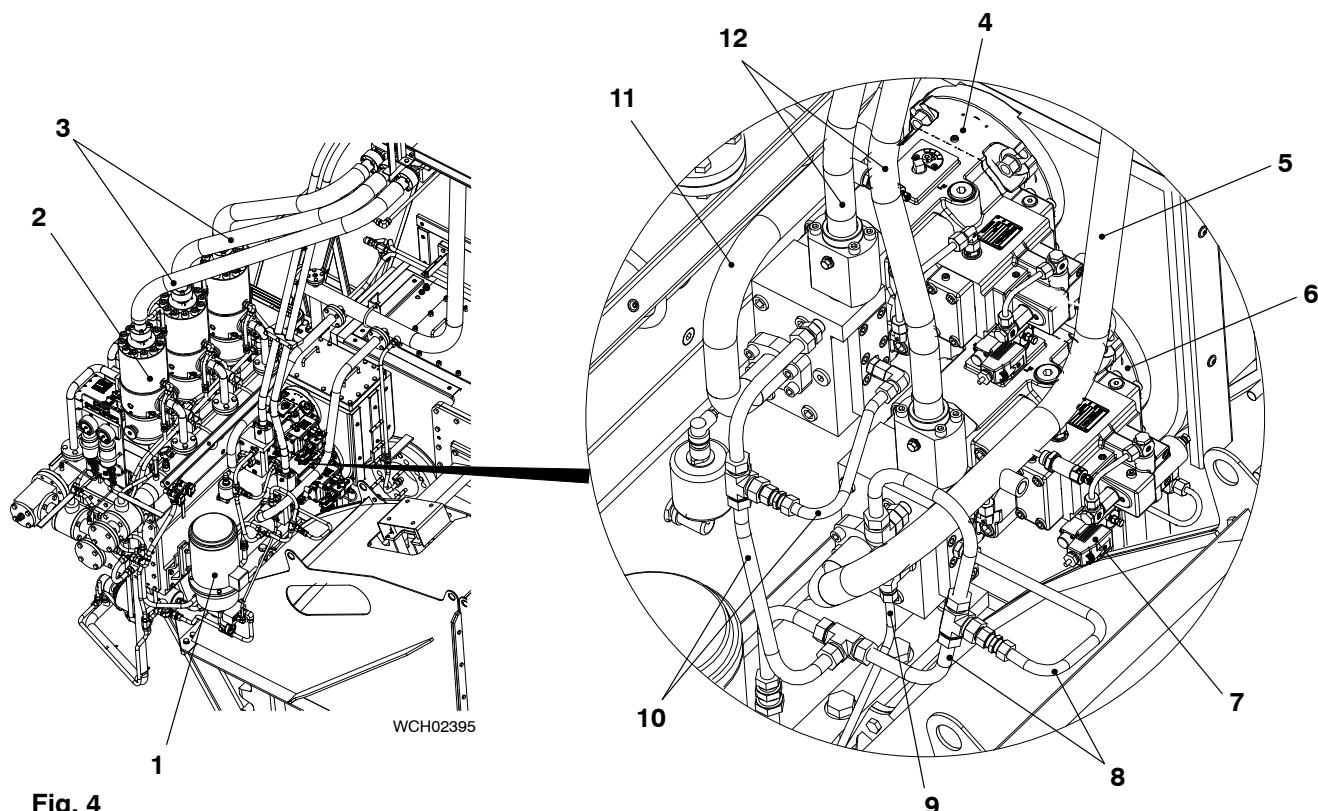


Fig. 4

- 6) Remove the drain pipes (8 and 10).
- 7) Remove the inlet pipes (5 and 11).

Note: Step 8) is applicable only for the servo oil pump (6). The pipe (9) connects the servo oil service pump (1) to the servo oil pump (6).

- 8) Remove the oil pipe (9) from the servo oil pump (6).

Servo Oil Pump – Removal and Installation

3.2 Removal

CAUTION



Injury Hazard: The weight of the servo oil pump is 114 kg. Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

- 1) Put the sling (94202K, Fig. 5) around the servo oil pump (1) two times.

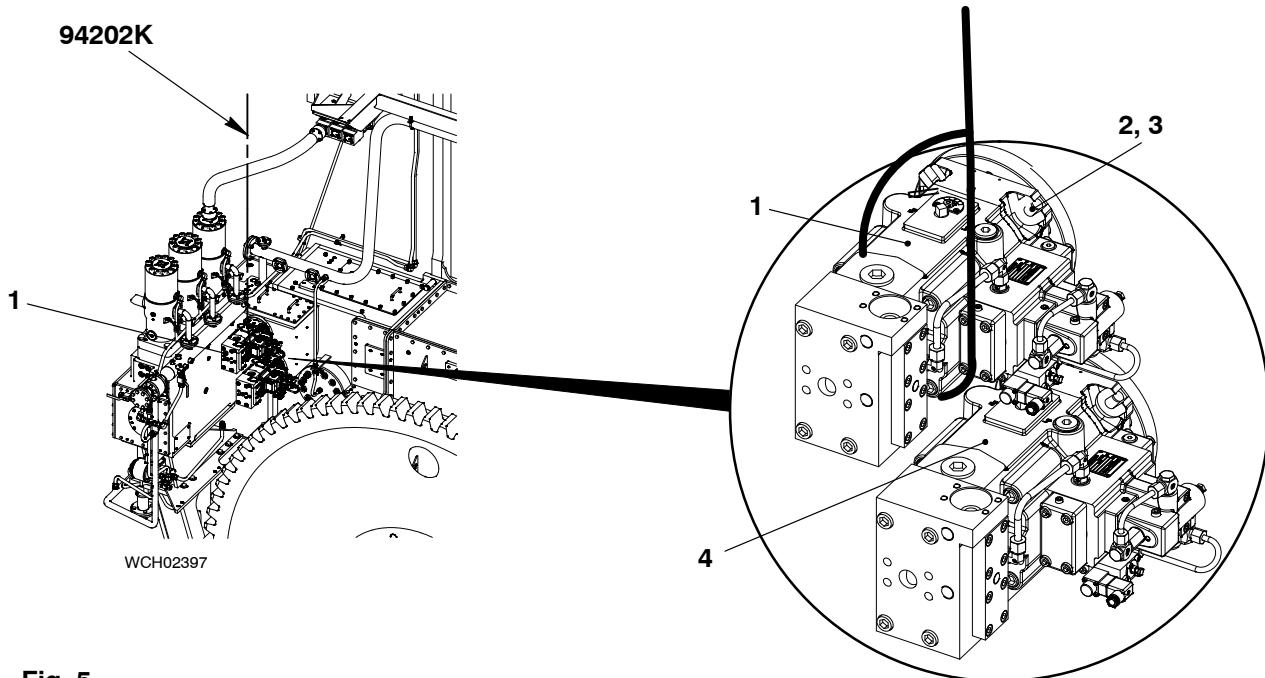


Fig. 5

- 2) Attach the sling (94202K) to the engine room crane.
- 3) Operate the engine room crane and put sufficient tension on the sling to hold the weight of the servo oil pump (1).
- 4) Remove the four nuts (2) and washers (3).
- 5) Remove the servo oil pump (1) and the O-ring (not shown).
- 6) Move the servo oil pump (1) to an applicable area.
- 7) Lower the servo oil pump (1) to the floor.
- 8) Remove the sling (94202K) from the servo oil pump.
- 9) Do step 1) to step 8) above to remove the servo oil pump (4).
- 10) If it is necessary to remove the bearing bushes, refer to paragraph 3.3.

Servo Oil Pump – Removal and Installation

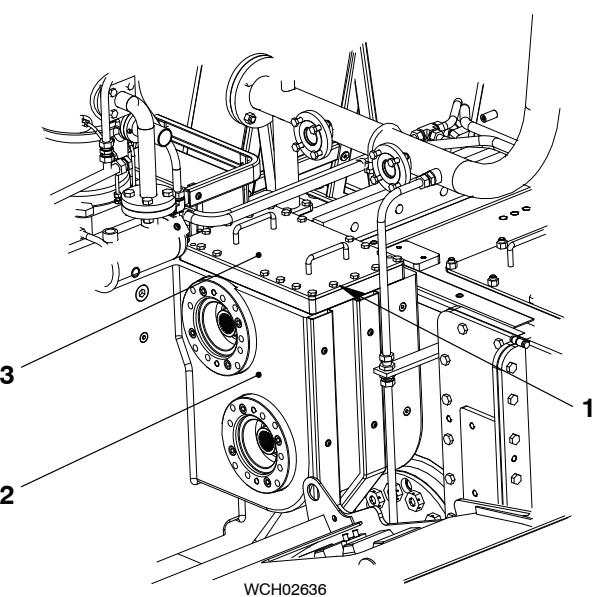


Fig. 6

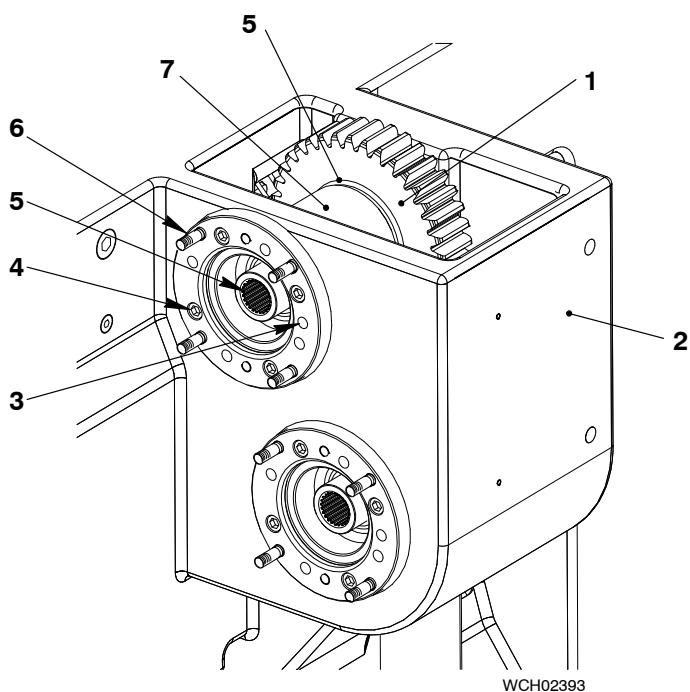


Fig. 7

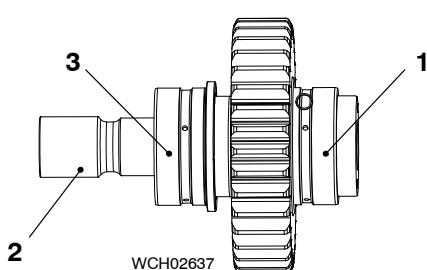


Fig. 8

3.3 Bearing Bushes

CAUTION



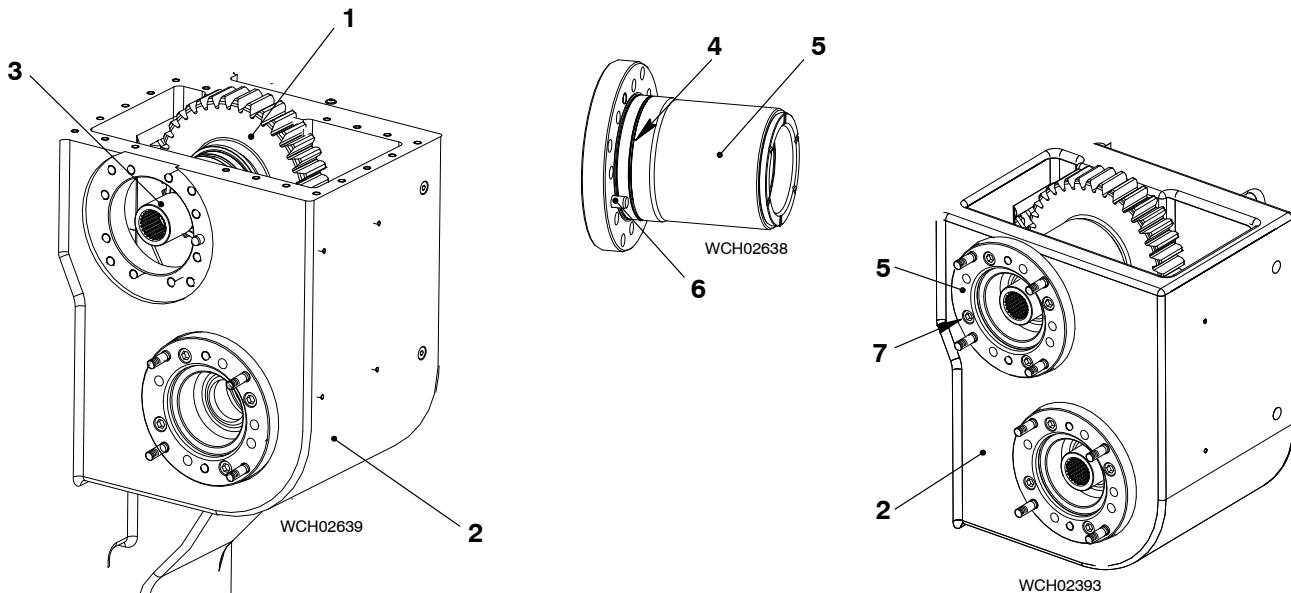
Injury Hazard: The weight of the pinion and shaft is approximately 50 kg. Use the correct equipment to lift and move the pinion and shaft. This will prevent injury to personnel.

Note: You do this procedure only if it is necessary to do a check of the bearing bushes.

- 1) Remove the 20 screws (1, Fig. 6) from the cover (3).
- 2) Remove the cover (3) from the casing (2).
- 3) Remove the four screws (4, Fig. 7).
- 4) Move the pump support (7) a small distance away from the casing (2).
- 5) Put the sling (94202K) around the shaft (5) two times.
- 6) Attach the sling (94202K) to the engine room crane.
- 7) Put sufficient tension on the sling (94202K) to hold the shaft (5) and pinion (1) in position.
- 8) Remove the pump support (7) and the O-ring.
- 9) Carefully move the pinion (1) and shaft (5) in the direction of the driving end approximately 30 mm out of the casing (2).
- 10) Put one more sling (94202K) around the pinion (1) and shaft (5).
- 11) Attach the sling (94202K) to the engine room crane.
- 12) Make sure that the two slings have equal tension.
- 13) Carefully tilt the pinion (1) and shaft (5).
- 14) Carefully lift the pinion (1) and shaft (5) fully out of the casing (2).
- 15) Lower the pinion (1) and shaft (5) to an applicable area.
- 16) Examine the two bearing bushes (1, 3 Fig. 8) for wear and damage.
- 17) If necessary, replace the bearing bushes.

Servo Oil Pump – Removal and Installation

- 18) Put oil on the two bearing bushes (1, 3 [Fig. 8](#)) and the shaft (2) of the pinion.
- 19) Use the engine room crane and the two slings (94202K, [Fig. 9](#)) to lift the pinion (1) and shaft (5) into position above the casing (2).
- 20) Carefully tilt the pinion (1) and shaft (5), then lower the pinion (1) and shaft (5) into the casing (2)..

**Fig. 9**

- 21) Put a small quantity of oil on the O-ring (4).
- 22) Remove one of the two slings (94202K) from the pinion (1) and shaft (5).
- 23) Put the pump support (5) in position. Make sure that the dowel pin (6) in the pump support engages with the related hole in the casing (2).
- 24) Torque the four M16 screws (7) to the value given in [0352-2](#), paragraph 1.
- 25) Remove the other sling (94202K) from the pinion (1) and shaft (5).
- 26) Do the procedures given in steps [3](#) to [26](#) for the bearing bushes of the other servo oil pump.
- 27) Attach the cover (3, [Fig. 6](#)) to the casing (2) with the 20 screws (1).

Servo Oil Pump – Removal and Installation

4. Servo Oil Pump – Installation

CAUTION

Injury Hazard: The weight of the servo oil pump is 114 kg. Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

- 1) Put a new O-ring (1, Fig. 10) in the pump support.
- 2) Apply a small quantity of oil to the the O-ring (1).

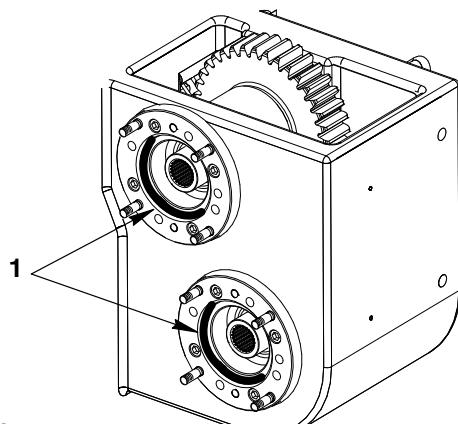


Fig. 10

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- 3) Put the sling (94202K, Fig 11) around the servo oil pump (1) two times.
- 4) Attach the sling (94202K) to the engine room crane.
- 5) Use the engine room crane to put the servo oil pump (4) in position.
- 6) Attach the servo oil pump (4) to the casing with the four washers (3) and nuts(2).

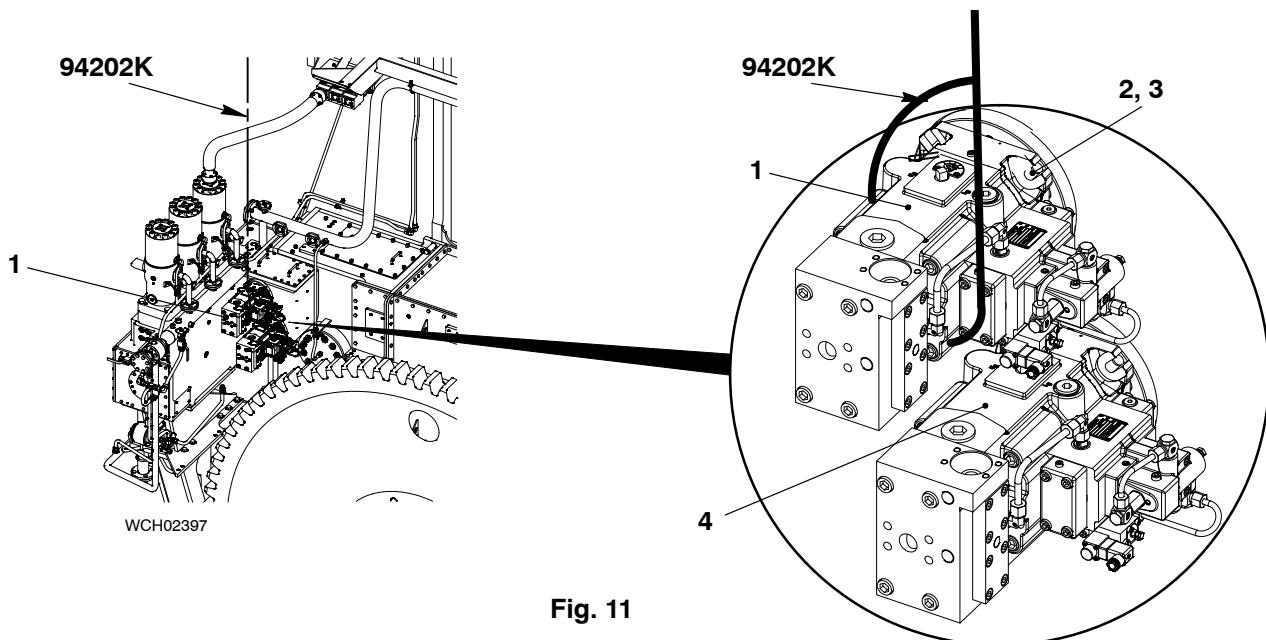


Fig. 11

- 7) Remove the sling (94202K) from the servo oil pump (4).
- 8) Do steps 1) to 7) to install the servo oil pump (1).

Servo Oil Pump – Removal and Installation

5. Completion

- 1) Attach the oil inlet pipes (11, Fig. 12) to the servo oil pumps (4, 6).

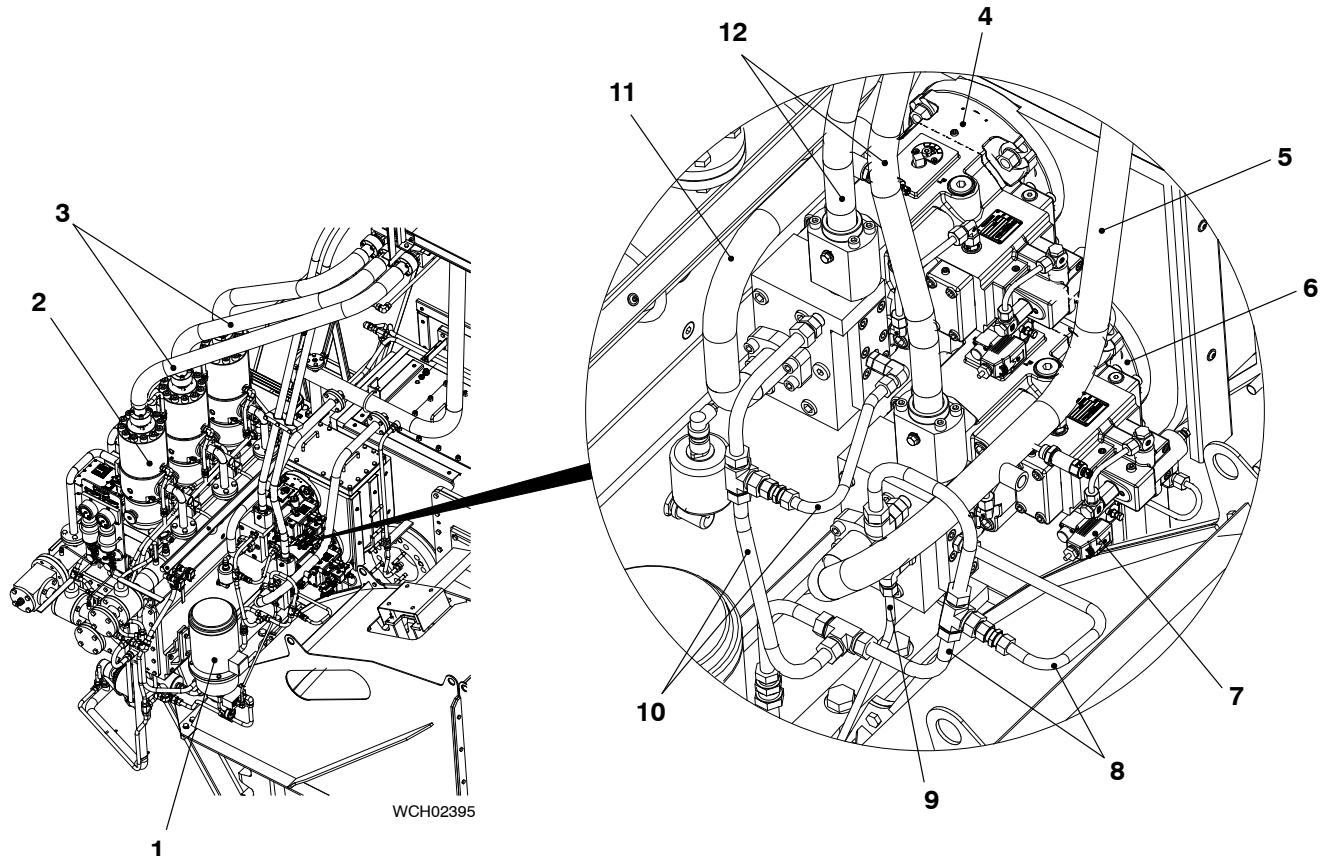


Fig. 12

- 2) Attach the drain pipes (8, 10) to the servo oil pumps (4, 6).
- 3) Attach the oil pipe (9) to the servo oil pump (6).
- 4) Install the HP servo oil pipes (12) to the servo oil pumps (4, 6) (see [8447-1](#) paragraph 5).
- 5) Attach the two rear HP fuel pipes (3) to the fuel pumps (2) (see [8752-1](#) paragraph 3).
- 6) Connect the electrical connections (7).
- 7) Set to on the main bearing oil pump.
- 8) Set to on the servo oil service pump (1).
- 9) Do a check for leaks.
- 10) Set to off the servo oil service pump (1).

Exhaust Valve Control Unit: Removal, Disassemble, Assemble, Installation

1.	General	1
2.	Preparation	1
3.	Removal	2
4.	Disassemble	2
5.	Assemble	2
6.	Installation	3
7.	Completion	3
8.	Relief Valve	4

1. General

For more data, see the Operation Manual 8016-1.

2. Preparation

WARNING

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

- 1) Stop the engine.
- 2) Release the pressure in the servo oil rail, see the Operation Manual 0520-1 paragraph 2.3.
- 3) Remove the related hydraulic pipe, see [8460-1](#), paragraph 1 and paragraph 2.

Exhaust Valve Control Unit: Removal, Disassemble, Assemble, Installation

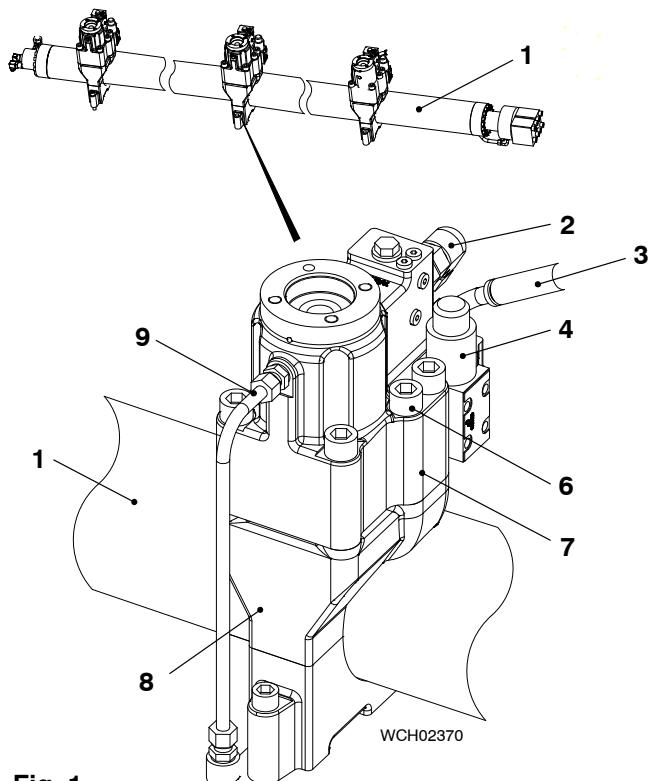


Fig. 1

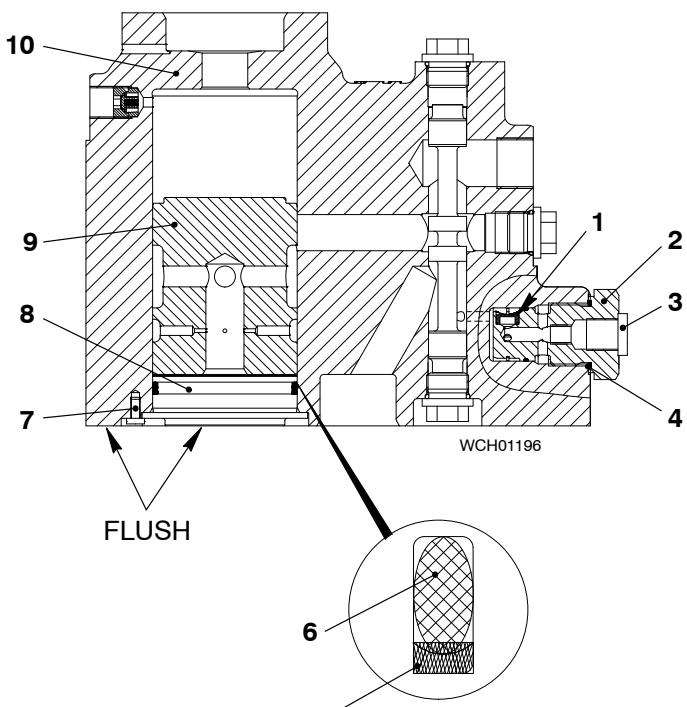


Fig. 2

3. Removal

- 1) Make sure that the servo oil rail (1, Fig. 1) has no pressure.
- 2) If the valve control unit (VCU) to be removed is nearest the driving end of the servo oil rail, do step a):
 - a) Remove the HP hose (3) from the VCU (7).
- 3) Disconnect the electrical connection from the 4/2-way solenoid valve (4).
- 4) Remove the return pipe (2) from the VCU (7).
- 5) Remove the supply pipe (9) from the VCU (7).
- 6) Remove the six screws (6) from the VCU (7).
- 7) Carefully remove the VCU (7).
- 8) Put protection over the bore in the holder (8) and the servo oil rail (1).
- 9) Install blanks to the ports on the VCU (7).

4. Disassemble

- 1) Remove the pan head screw (7, Fig. 2).
- 2) Remove the plug (8).
- 3) Remove and discard the O-ring (6) and the back-up ring (5).
- 4) Make sure that the piston (9) moves freely.
- 5) Remove the filter holder (2) and the screw plug (3) from the valve control block (10).
- 6) Make sure that the oil filter (1) is clean and has no damage. If necessary, replace the oil filter.
- 7) Make sure that the seal (4) has no damage. If necessary, replace the seal.

5. Assemble

- 1) Apply oil to the thread of the filter holder (2).
- 2) Put the filter holder (2) and the screw plug (3) into the valve control block (10).
- 3) Torque the filter holder (2) to 225 Nm.
- 4) Put a new O-ring (6) and back-up ring (5) on the screw plug (3).
- 5) Push the plug (8) into the valve control block (10).
- 6) Install the pan head screw (7).
- 7) Make sure that the plug (8) is flush with the bottom of the valve control block (10).

Exhaust Valve Control Unit: Removal, Disassemble, Assemble, Installation

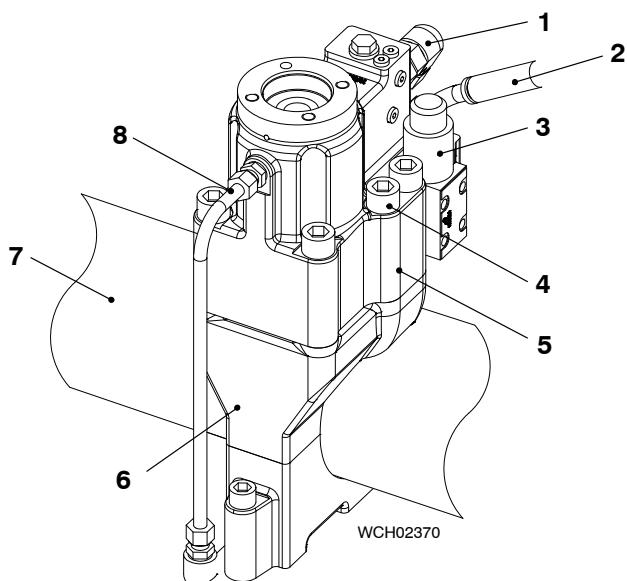


Fig. 3

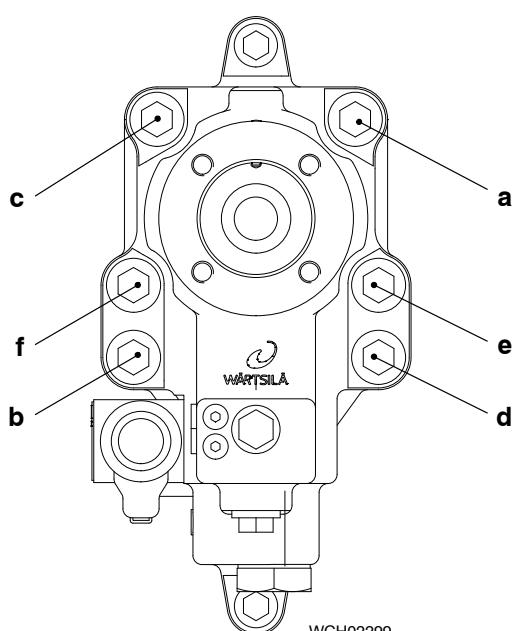


Fig. 4

6. Installation

- 1) If the VCU (1) is a new item, carefully remove it from its package.

WARNING

Injury Hazard: You must put on gloves and eye protection when you use white spirit. White spirit can damage the skin and eyes.

- 2) Use white spirit, e.g. Shellsol TD, Shellsol T or Solvent FP68 to clean the VCU.
- 3) Remove the blanks from the ports in the VCU (5, Fig. 3).
- 4) Remove the protection from the holder (6) and the servo oil rail (7).
- 5) Clean the seating surfaces of the VCU (5) and the holder (6).
- 6) Make sure that the seating surfaces of the holder (6) and the VCU (5) have no damage.
- 7) Carefully put the VCU (5) in position on the holder (6).
- 8) Apply oil to the threads of the six screws (4).
- 9) Tighten with your hand the six screws (4).
- 10) In the sequence given in Fig. 4, torque the six screws to 350 Nm.
- 11) Install the supply pipe (8, Fig. 3) to the VCU (5).
- 12) Install the return pipe (1) to the VCU (5).
- 13) If the VCU (5) installed is nearest the driving end of the servo oil rail (7), do the step a):
 - a) Install the HP hose (2) to the VCU (5).
- 14) Connect the electrical connection to the 4/2-solenoid valve (3).

7. Completion

- 1) Install the hydraulic pipe, see 8460-1, paragraph 4.
- 2) Put the replaced VCU in its original package.
- 3) Put the replaced VCU in an applicable dry storage area. The storage area must not be contaminated (e.g. with exhaust gases or corrosive air).

8. Relief Valve

Maintenance of the relief valve (1, Fig. 5) is not necessary.

The relief valve has a factory-set opening pressure of 350 bar.

- 1) At each major engine overhaul, do a check of the relief valve.

Note: A relief valve that has damage or has a leak, must be replaced with a new item. A relief valve that has an incorrect setpoint can be adjusted.

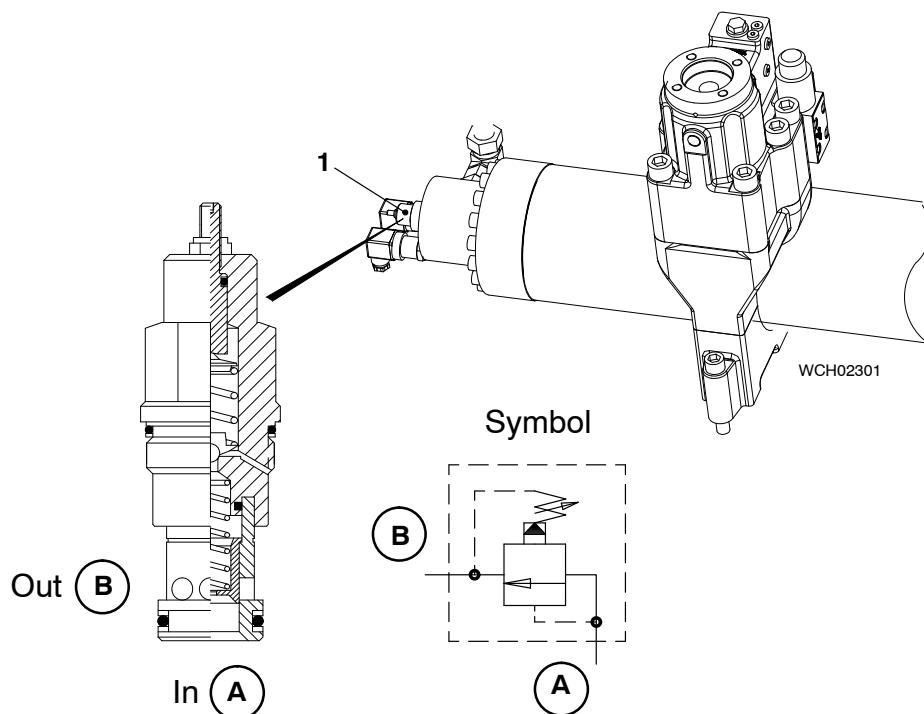


Fig. 5

Scavenge Air Receiver and Auxiliary Blower

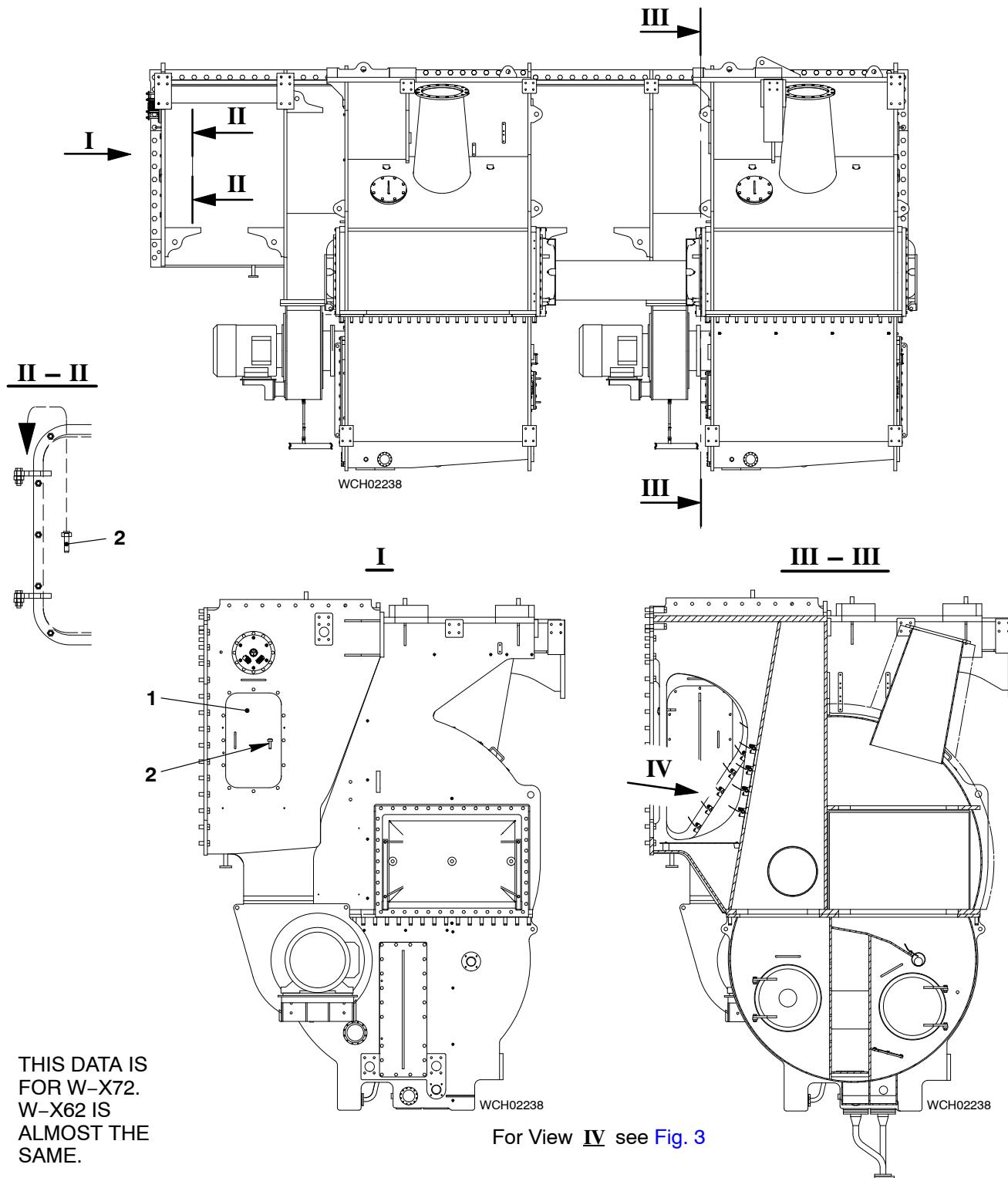
Group 6

Scavenge Air Receiver – Clean and do Checks	6420-1/A1
Auxiliary Blower – Maintenance	6545-1/A1
Scavenge Air Cooler – Removal and Installation	6606-1/A1
Water Separator – Removal and Installation	6708-1/A1
Scavenge Air Waste Gate –Disassembly and Assembly	6735-1/A1

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Scavenge Air Receiver**Clean and do Checks**

1.	Scavenge Air Receiver – Clean and do Checks	2
2.	Flaps	3
2.1	Removal	3
2.2	Installation	3
3.	Relief Valve – Check	4

**Fig. 1: Scavenge Air Receiver**

Scavenge Air Receiver – Clean and do Checks

1. Scavenge Air Receiver – Clean and do Checks

Read the data in [0380-1 Scavenge Air Receiver](#) for the applicable Inspection and Overhaul Intervals to clean the scavenge air receiver. You must also clean and do a check of the scavenge air receiver after each piston overhaul.

- 1) Open the covers (1, [Fig. 1](#)).
- 2) Lock the covers (1) in position with the pins (2). This will prevent unwanted movement.
- 3) Clean the scavenge air receiver.
- 4) Do the checks that follow:

Note: The level switches LS4071A and LS4075A (3, [Fig. 2](#)) monitor the water level in the condensate collectors (4). For engines with two turbochargers, there are two more level switches (LS4072A and LS4076A) installed. For more data, see the Operation Manual 4003-4 Pipe Diagram – Water Systems.

- a) At regular intervals, look at the sight glasses (2) of the condensate collector (4) to make sure that water flows.
- b) If necessary clean the filters (7) and the drain pipes (5, 6). For more data, see the Operation Manual 8345-1.
- c) Do a check of the flaps (10) for damage, free movement and dirt. If necessary, clean or replace the flaps (see paragraph [2](#)).

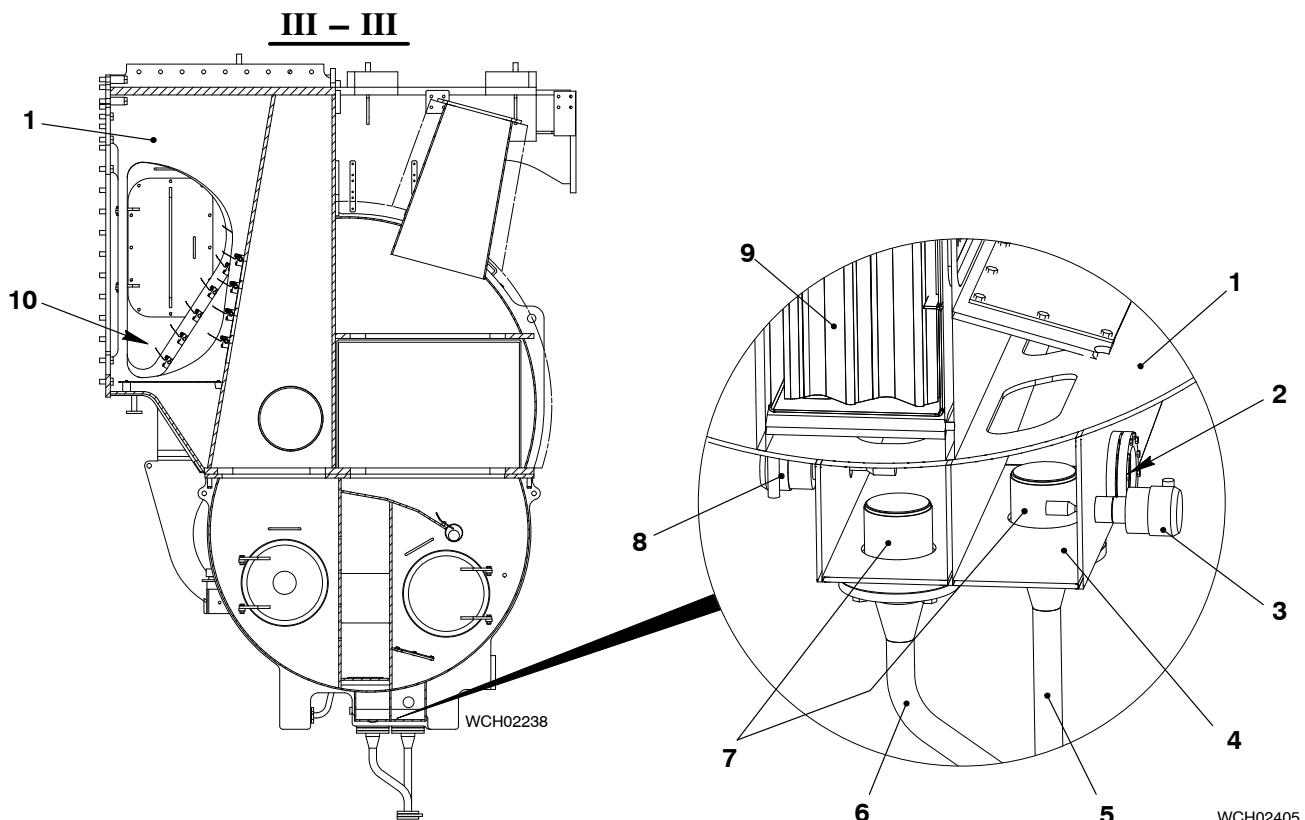


Fig. 2: Condensate Collectors

Scavenge Air Receiver – Clean and do Checks

2. Flaps

2.1 Removal

- 1) Remove the three screws (7, Fig. 3) and the tab washers (4).
- 2) Remove the two flat bars (9, 10) and the stop plate 6.
- 3) Remove the screw (3) and the tab washer (4).
- 4) Remove the guide (2), distance ring (8), flap (5) and axle (1).

2.2 Installation

- 1) Put the axle (1), distance ring (8), guide (2) and flap (5) in position.
- 2) Put the the flat bar (9), stop plate (6), flat bar (10) new locking plates (4), and screws (7) in position. Do not tighten the screws at this step.
- 3) Put the screw (3) and new locking plates (4) in position. Do not tighten the screws at this step.
- 4) Make sure that the axle (1) and the flap (5) can move freely.
- 5) Tighten the screws (3, 7).
- 6) Bend the tab washers (4) to lock the screws (3, 7).

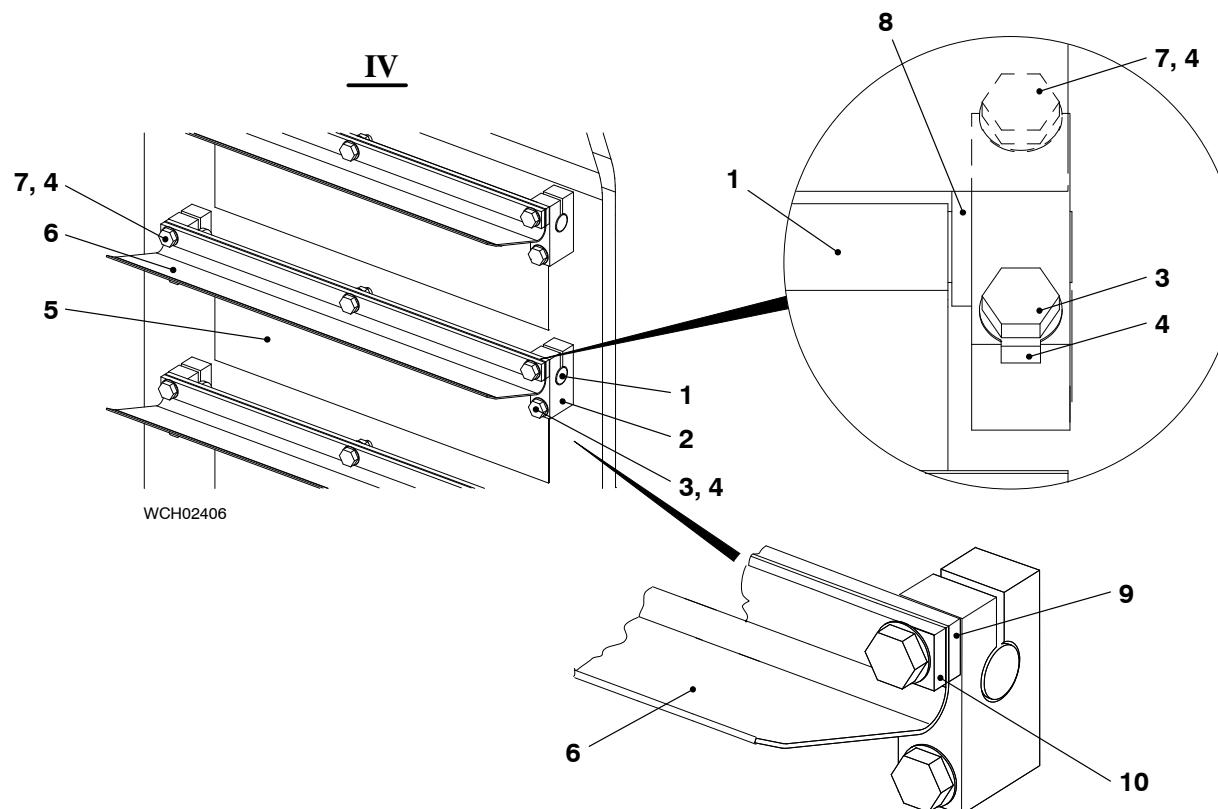


Fig. 3: Flaps

- 7) Remove the pins (2, Fig. 1).
- 8) Close the covers (1).
- 9) Install the pin (2) in the stowage position.

Scavenge Air Receiver – Clean and do Checks

3. Relief Valve – Check

WARNING



Injury Hazard! If the disc springs are compressed, do not disassemble the relief valve. Parts can eject at high speed and cause injury. If there is damage or a malfunction, speak to the manufacturer of the relief valve or Wärtsilä Switzerland Ltd.

- 1) Do a check of the relief valve during each engine overhaul as follows:
 - a) Do a visual check for damage and corrosion. If necessary, replace the relief valve (1, Fig. 4).
 - b) Make sure that there is a clearance Y between the flange (4) and the seal plate (3), i.e. the O-ring (5) is serviceable.
 - c) Make sure that the distance X is 133 mm, i.e. the pressure of the disc springs (2) is sufficient.

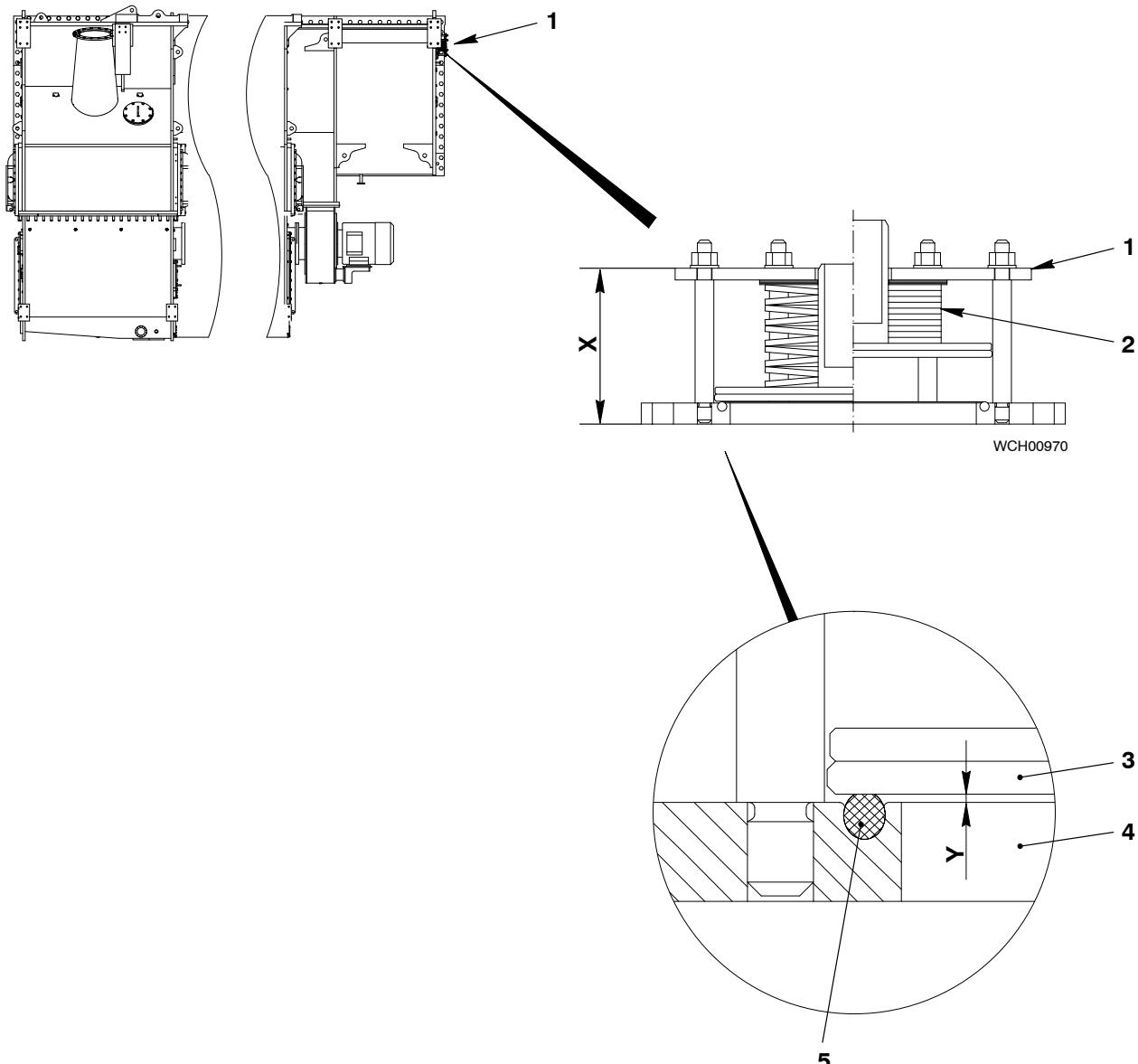


Fig. 4: Relief Valve

Auxiliary Blower**Maintenance****Tools:**

2 Lever chain hoist	94016-006	2 Round Sling	94049F
2 Round sling	94049A		

1. General	1
2. Procedure 1	2
2.1 Preparation	2
2.2 Removal	2
2.3 Installation	4
2.4 Auxiliary Blower – Operate	5

1. General

Two auxiliary blowers (2, Fig. 1 and Fig. 2) are attached to the scavenge air receiver (1). For more data about the auxiliary blower, see the Operation Manual 6545-1 Auxiliary Blower and Switch Box.

There are two procedures to remove the auxiliary blowers (2):

- Procedure One: The auxiliary blowers are installed on the outer part of the scavenge air receiver (see paragraph 2.1). For engines with one turbocharger (3, Fig. 1), see the procedure given in paragraph 2.1. This procedure is for each of the two electric motors.
- Procedure Two: The auxiliary blowers are installed between the two scavenge air receivers (see paragraph 2.2). For engines with two turbochargers (3, Fig. 2), the procedure is not yet defined.

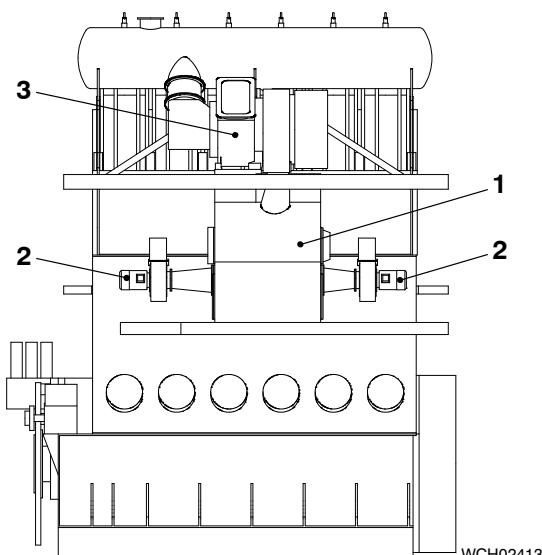


Fig. 1 Engine with One Turbocharger

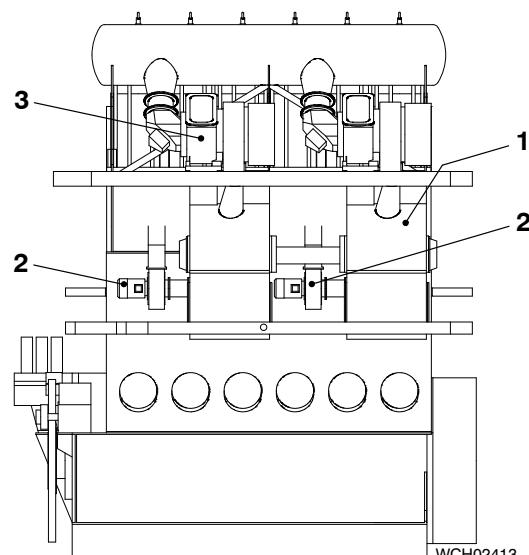
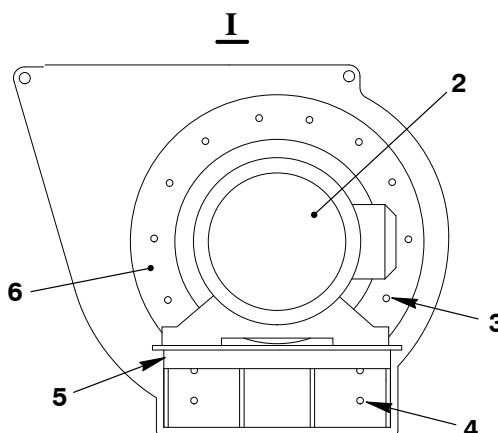
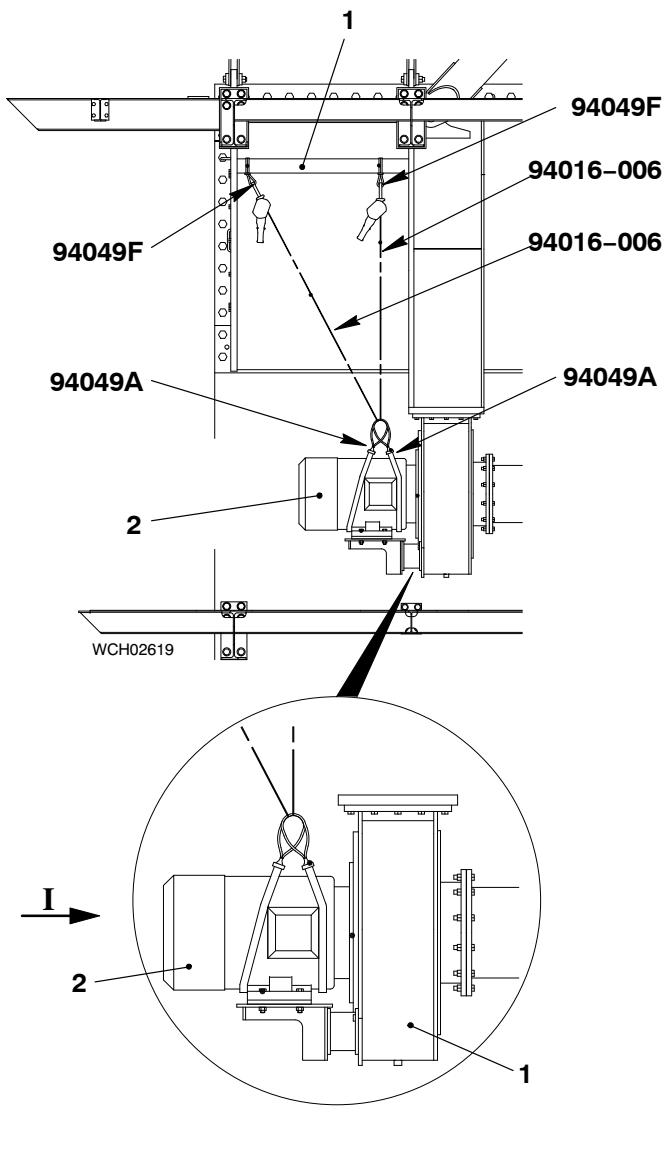


Fig. 2 Engine with Two Turbochargers

Auxiliary Blower: Maintenance**Fig. 3****2. Procedure 1****2.1 Preparation**

- 1) Stop the engine.
- 2) Set the power supply to off.
- 3) Disconnect the electrical connection from the electric motor (2, Fig. 3).
- 4) Read and obey the data given in [0012-1 General Guidelines for Lifting Tools](#).

2.2 Removal

Note: The procedure that follows is for each of the two electric motors.

- 1) Attach two slings 94049F to the spar (1), see Fig. 3.
- 2) Attach two lever chain hoists 94016-006 to the slings 94049F as shown.
- 3) Attach two slings 94049A to the electric motor (2) and to the chain hoists.
- 4) Operate the lever chain hoists 94016-006 to apply sufficient tension on the slings 94049A to hold the mass of the electric motor (2).
- 5) Remove the four screws (4) from the support (5).
- 6) Remove the screws (3) from the flange (6).

Auxiliary Blower: Maintenance

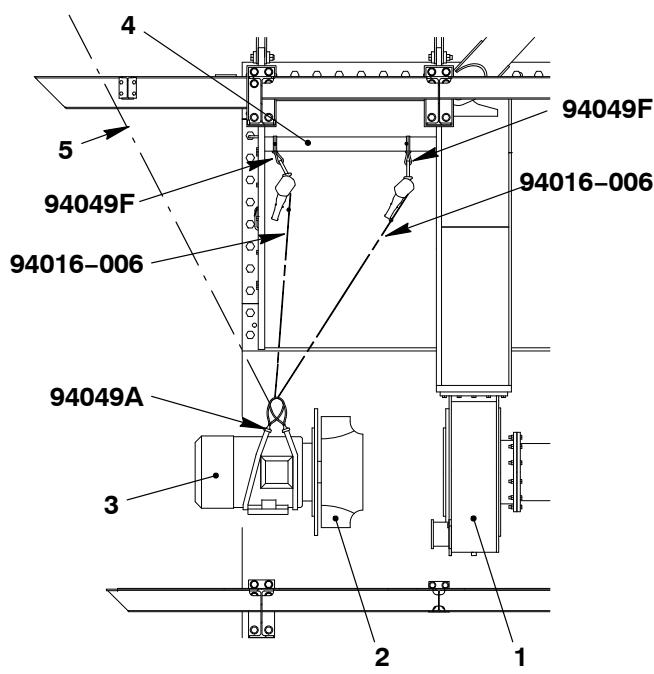
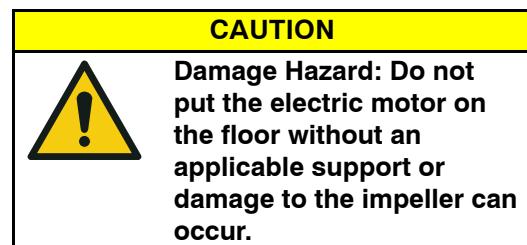


Fig. 4



- 7) Use the two lever chain hoists 94016-006 together to carefully remove the electric motor (3, Fig. 4) from the casing (1).
- 8) Move the electric motor (3) to the left and take it over with engine crane (5).
- 9) Use the engine room crane to carefully move the electric motor to an applicable area.

Note: For data about the procedure to clean the impeller (2) and to replace the ball bearing, see the documentation of the auxiliary blower manufacturer.

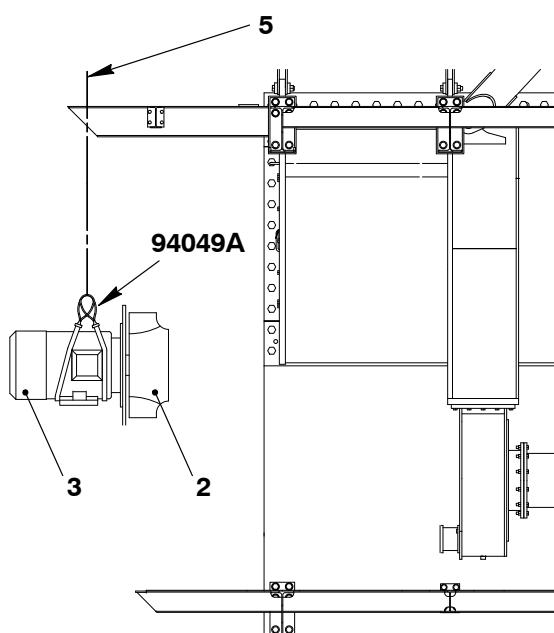
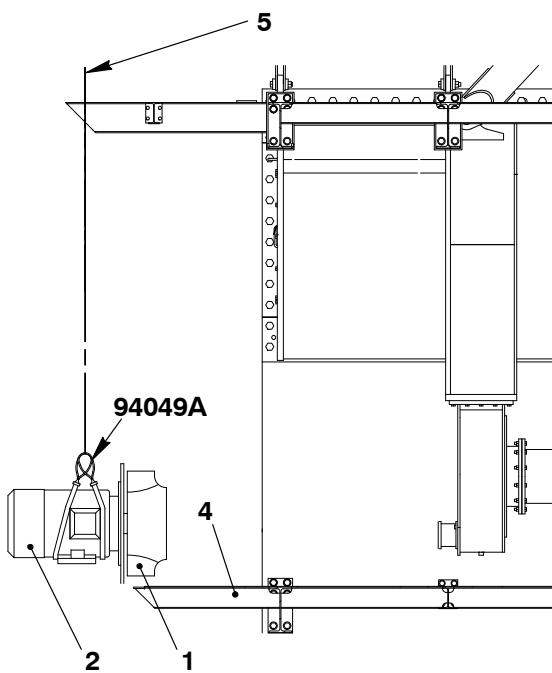


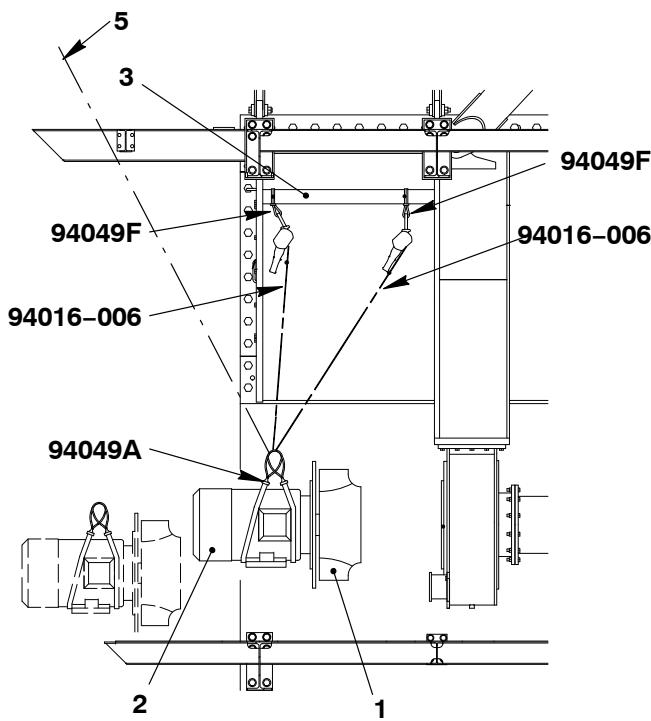
Fig. 5

Auxiliary Blower: Maintenance**Fig. 6****2.3 Installation**

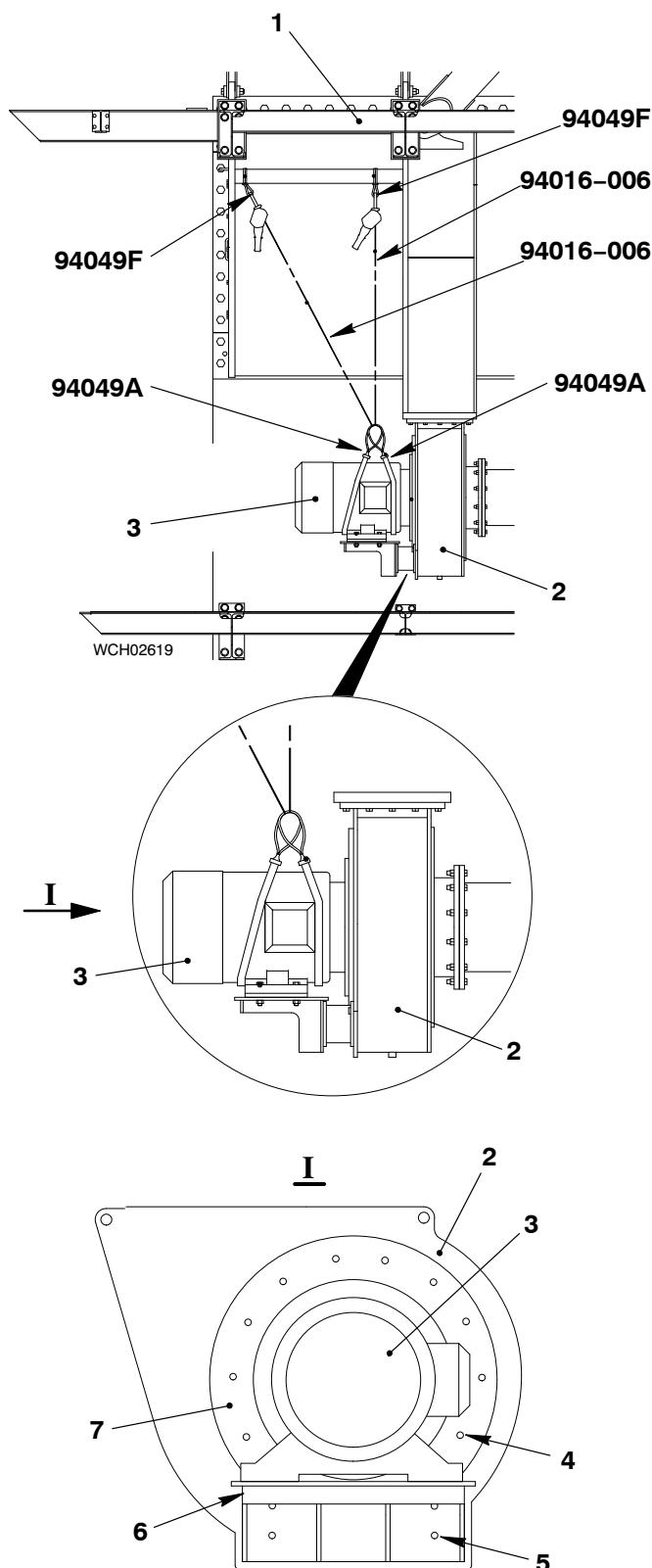
- 10) Attach two slings 94049A to the electric motor (2) with impeller (1) and to the engine crane (5), see Fig. 6.

Note: Align the flange (7, Fig. 8) with the casing (2, Fig. 8).

- 11) Lift the electric motor up to the gallery (4).
- 12) Attach the two slings 94049F to the spar (3, Fig. 7).
- 13) Attach the two lever chain hoists 94016-006 to the slings 94049F.
- 14) Attach the hooks of the two lever chain hoists 94016-006 to the slings 94049A on the electric motor (2).
- 15) Take over the electric motor with the two lever chain hoists 94016-006.

**Fig. 7**

Auxiliary Blower: Maintenance

**Fig. 8**

- 16) Use the lever chain hoists 94016-006 to move the electric motor (3) into the casing (2).
- 17) Attach the casing (2) to the flange (7) with the screws (4).
- 18) Attach the support (6) to the casing (2) with the four screws (5).
- 19) Connect the electrical connection to the electric motor (3).
- 20) Remove all tools and equipment from the work area.

2.4 Auxiliary Blower – Operate

- 1) In the LDU-20, get the MAIN page see 4002-2, paragraph 3.3).
- 2) Set the auxiliary blower 1 to on.
- 3) Make sure that the electric motor operates in the correct direction.

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Scavenge Air Cooler**Removal and Installation****Tools:**

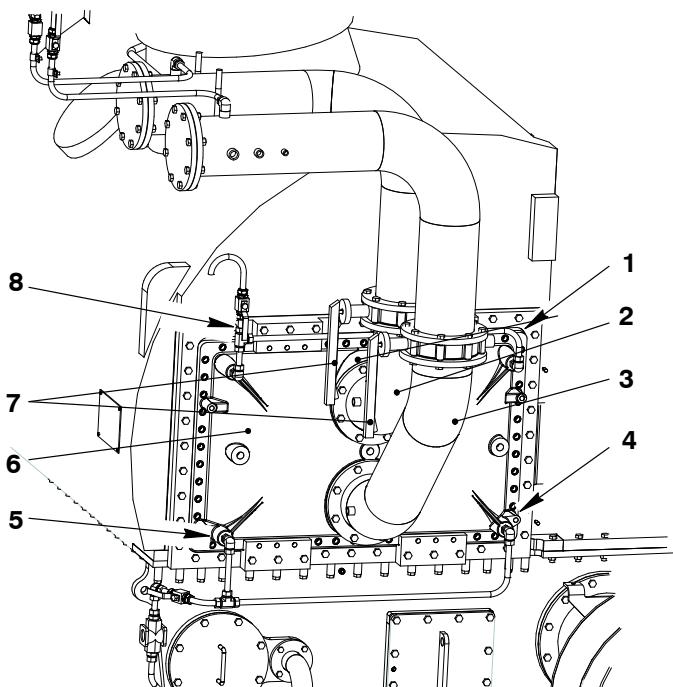
2 Trolleys (WLL3000kg)	94021	2 Safety lugs	94663C
1 Spur/geared chain block (WLL5000kg)	94017-013	2 Safety chains	94663D
1 Manual ratchet (WLL2500kg)	94016-011	1 Support	94663I
1 Manual ratchet (WLL1000kg)	94016-006	1 Chain	94019A
1 Left Support	94663A	6 Lugs	94048-M30
1 Right Support	94663B	1 Chain	94019C

1. Preparation	1
2. Removal	2
3. Installation	6
4. Completion	10

Note: The procedures that follow in paragraphs **1** to **3** are for engines with one scavenge air cooler (SAC) installed.

1. Preparation

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Stop the engine.
- 3) Stop the cooling water pump.
- 4) Close the butterfly valves (7, [Fig. 1](#)).
- 5) Drain the water from the (SAC) (6).
- 6) Remove the drain pipes (4, 5).
- 7) Remove the vent pipes (7, 8).
- 8) Remove the outlet pipe (2).
- 9) Remove the inlet pipe (3).



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Fig. 1

Scavenge Air Cooler: Removal and Installation

2. Removal

- 1) At the driving end, remove the four screws (1, Fig. 2).
- 2) Remove the two rollers (2) from the SAC (4).
- 3) Remove the screws (6), then remove the flange (3).
- 4) Remove the collar (5)
- 5) Remove and discard the O-ring (7).
- 6) At the free end, attach the two rollers (2) to the SAC (4).
- 7) Remove the four clamps (9).
- 8) Remove the collar (10).
- 9) Remove the flange (8).
- 10) Remove and discard the O-ring (11).

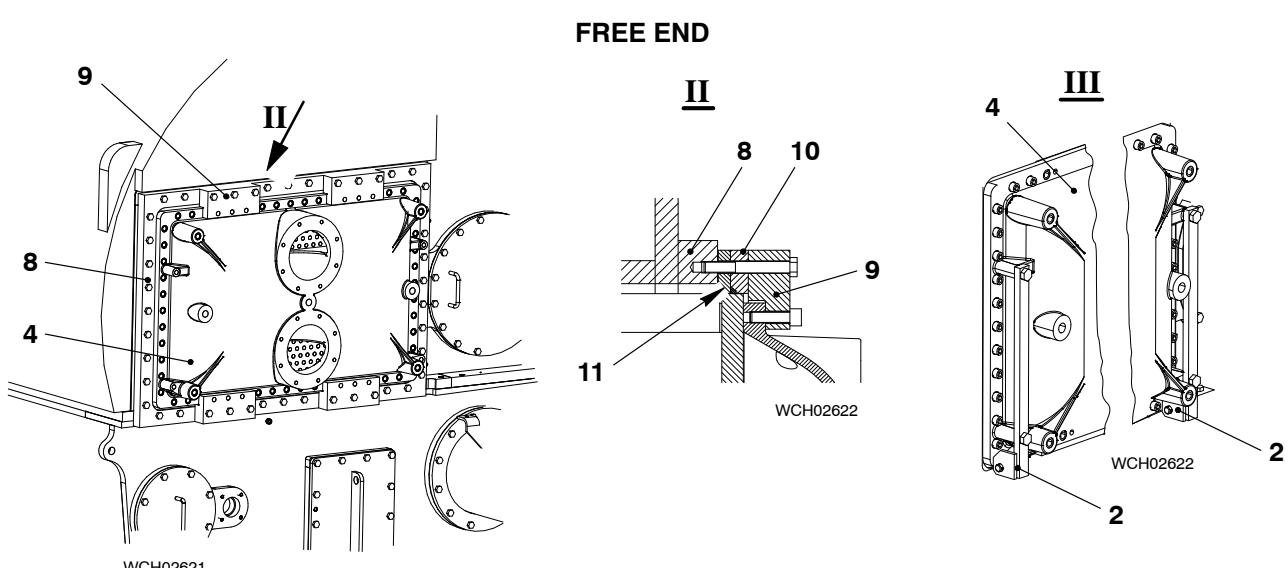
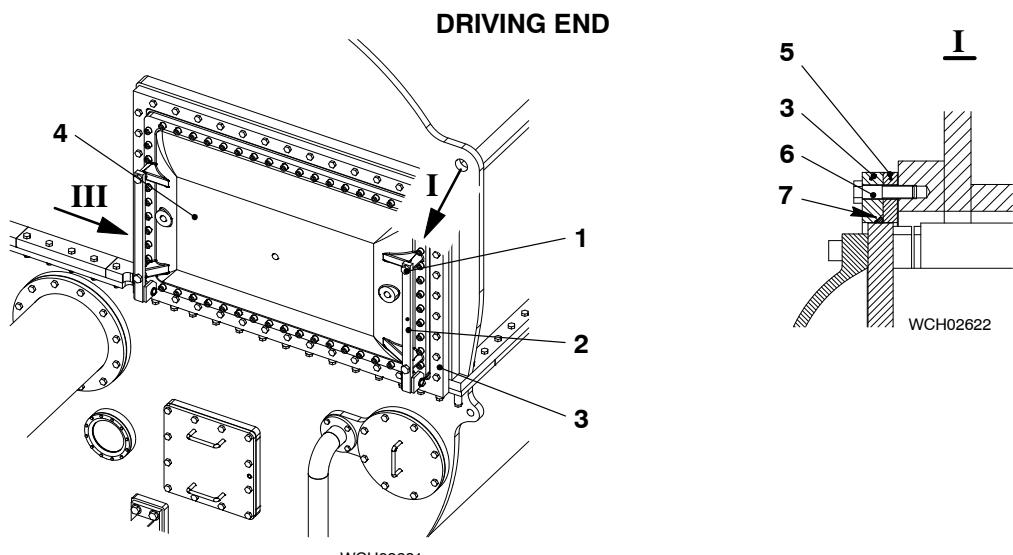


Fig. 2

Scavenge Air Cooler: Removal and Installation

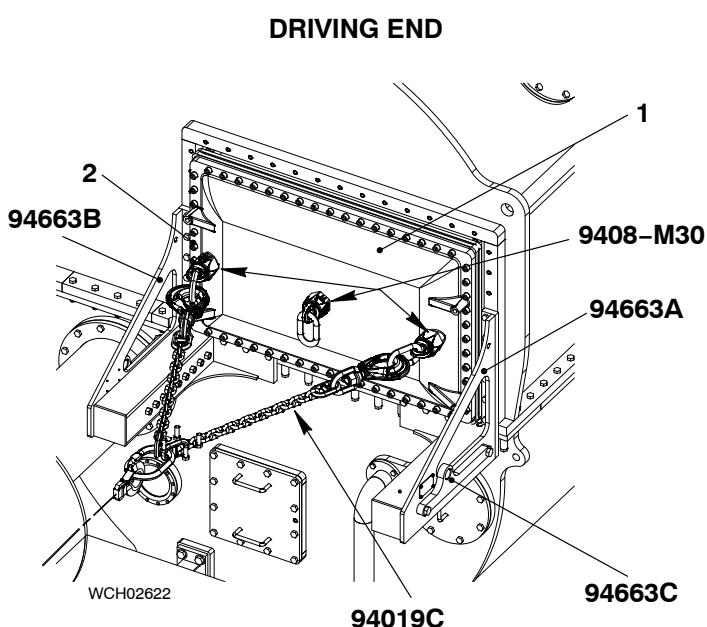


Fig. 3

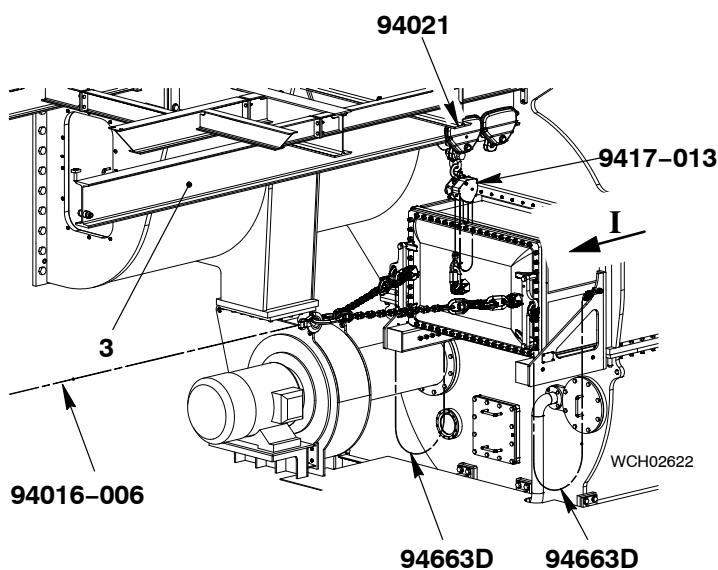
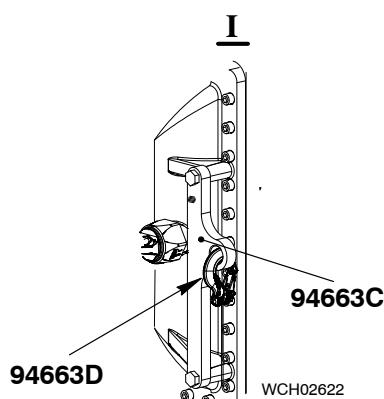
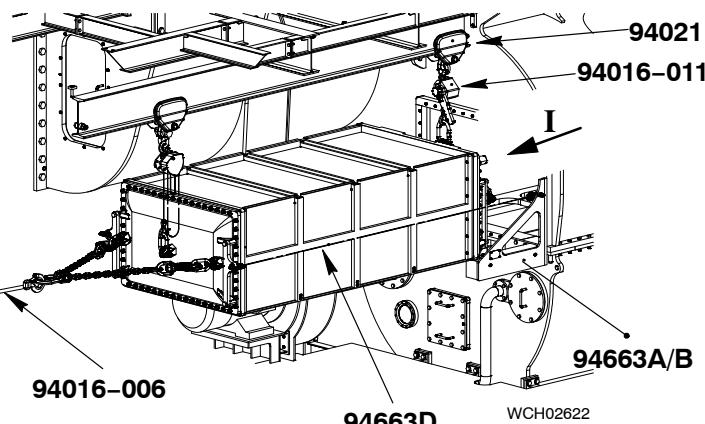


Fig. 4



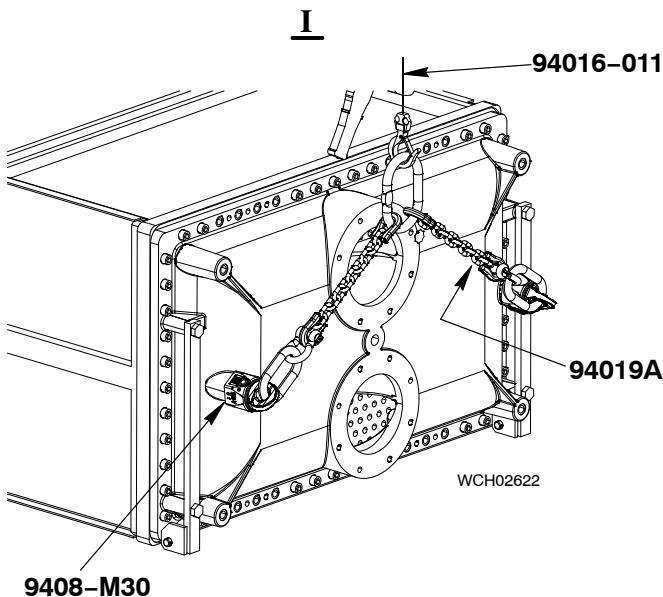
- 11) At the driving end, attach the three lugs (94048-M30) to the SAC (1, [Fig. 3](#)).
- 12) Attach the left and right supports (94663A, 94663B) to the receiver with the screws (2).
- 13) Torque the screws (2) to 136 Nm.
- 14) Attach the chain (94019C) to the outer lugs (94048-M30).
- 15) Remove the safety lugs (94663C) from their stowage positions the left and right supports.
- 16) Attach the safety lugs (94663C) to the SAC (3, [Fig. 4](#)).
- 17) Attach the safety chains (94663D) to the safety lugs and the left and right supports.
- 18) Put the two trolleys (94021) in position on the beam (3).
- 19) Attach the manual ratchet (94016-006) to the chain (94019C) and an applicable strong-point on the engine room wall.
- 20) Operate the the manual ratchet (94016-006) to pull the SAC a small distance from the receiver.
- 21) Attach the spur geared chain block (9417-013) to the center lug and the trolley (94921).
- 22) Operate the spur geared chain block (9417-013) to get sufficient tension to hold the mass of the SAC.

Scavenge Air Cooler: Removal and Installation

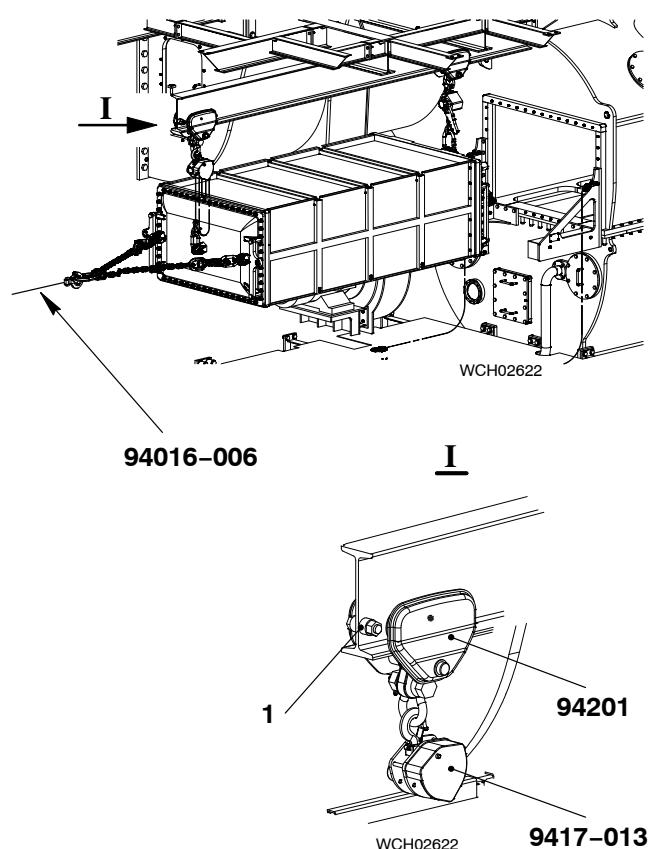
**WARNING**

Injury Hazard! The mass of the SAC is approximately 2700 kg. To prevent injury, be careful when you move the SAC.

- 23) Operate the the manual ratchet (94016-006) until the rear of the SAC is on the left and right supports (94663A, 94663B) (see Fig. 5).
- 24) Attach the two lugs (9408-M30) to the SAC.
- 25) Attach the chain (94019A) to the two lugs (9408-M30).
- 26) Attach the manual ratchet (94016-011) to the trolley (94021) and the chain (94019A).
- 27) Operate the manual ratchet (94016-011) to get sufficient tension to hold the mass of the SAC.
- 28) Remove the safety chains (94663D) from the left and right supports (94663A/B).

**Fig. 5**

Scavenge Air Cooler: Removal and Installation



- 29) Operate the manual ratchet (94016-006) until the SAC is clear of the left and right supports (see Fig. 6).
- 30) Continue to operate the manual ratchet (94016-006) until the trolley (94201) touches the end stop (1).
- 31) Carefully lower the SAC on to an applicable surface.
- 32) Use the engine room crane to move the SAC to an applicable area.

Fig. 6

Scavenge Air Cooler: Removal and Installation

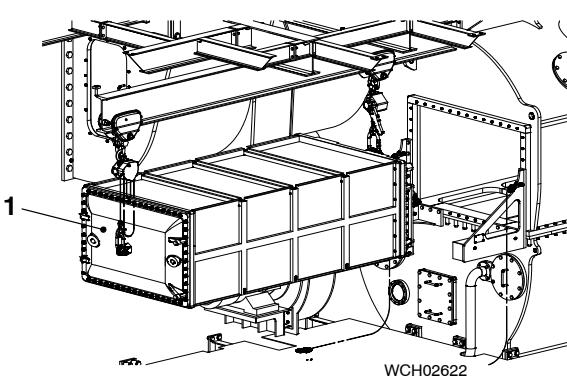


Fig. 7

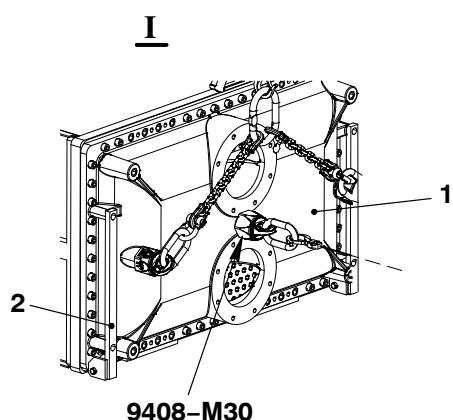
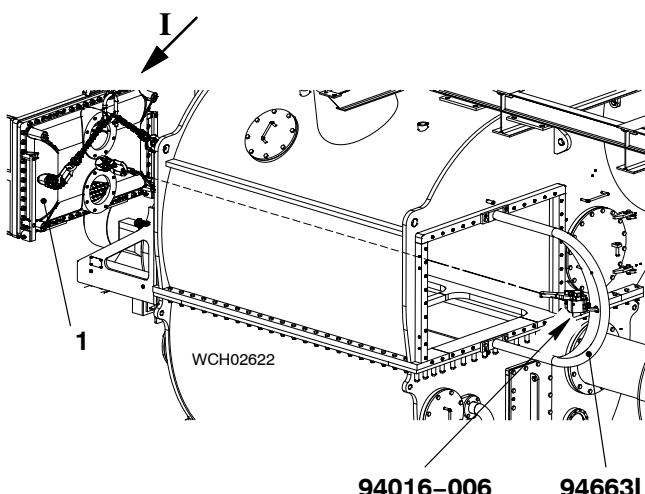


Fig. 8

3. Installation

- 1) Make sure that all the surfaces of the SAC (1) and the related surfaces in the receiver are clean and have no damage.
- 2) Apply a layer of silicon compound to each side of the SAC (1) and the related surfaces in the housing in the receiver.
- 3) Use the tools that follow to move the SAC (1) to the position shown in [Fig. 7](#).
 - Engine room crane
 - Trolleys (94021)
 - Manual ratchet (94016-011)
 - Spur geared chain block (94017-013)
 - Lugs (9408-M30).
- 4) Attach the support (94663I) to the receiver as shown in [Fig. 8](#).
- 5) Attach the rollers (2) to the SAC (1).
- 6) Attach the lug (94048-M30) to the center location on the SAC (1).
- 7) Attach the manual ratchet (94016-006) to the support (94663I) and center lug (9408-M30) on the SAC (1).

Scavenge Air Cooler: Removal and Installation

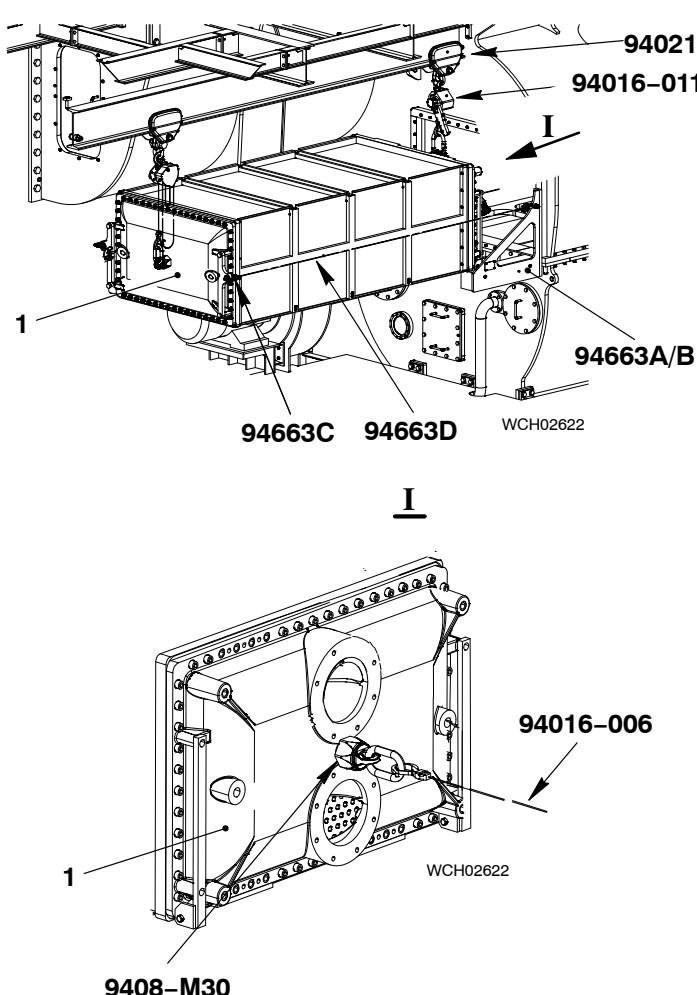


Fig. 9

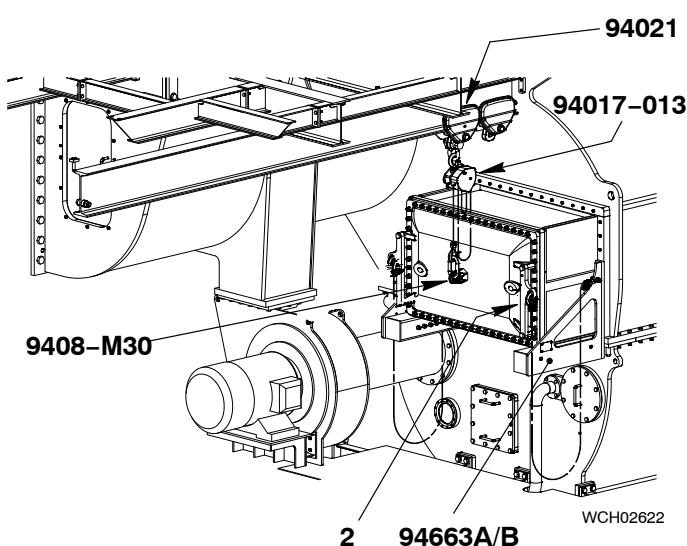
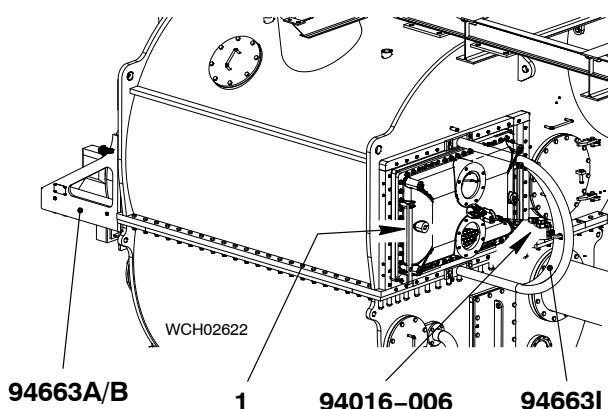


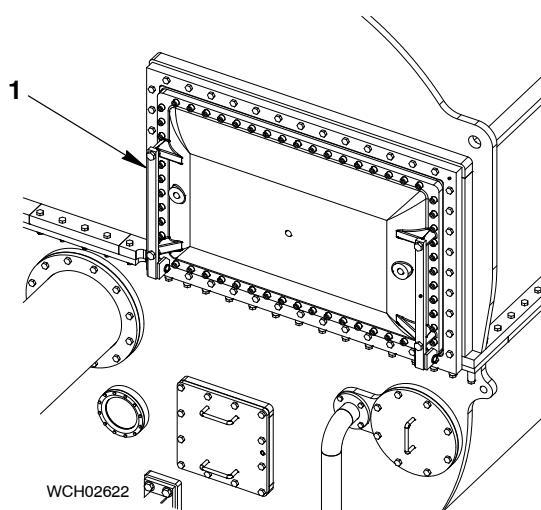
Fig. 10

- 8) Operate the manual ratchet (94016-006) to move the SAC (1) to the left and right supports (94663A/B, Fig. 9).
- 9) Make sure that the end of the SAC (1) is on the left and right supports.
- 10) Attach the safety lugs (94663C) and safety chains (94663D) to the SAC (1).
- 11) Remove the manual ratchet (94016-011) from the chain 94019A.
- 12) Remove the chain 94019A and the two lugs (9408-M30).
- 13) Operate the manual ratchet 94016-011 to move the SAC (1) almost fully into the receiver (see Fig. 10).
- 14) Remove the spur-gearred chain block (94017-013).
- 15) Remove the lug 9408-M30 from the center position in the SAC.
- 16) Remove the safety lugs (94663C) from the plates (2).
- 17) Remove the plates (2) from the SAC.
- 18) Attach the plates (2) to their stowage position on the left and right supports (94663A/B).
- 19) Remove the two trolleys (94021).

Scavenge Air Cooler: Removal and Installation

**Fig. 11**

- 20) Operate the manual ratchet (94016-006) to move the SAC fully into the receiver (see [Fig. 11](#)).
- 21) Remove the manual ratchet (94016-006) from the center lug and the support (94663I).
- 22) Remove the left and right supports (94663A/B).
- 23) Remove the two rollers (1) from the free end of the SAC.
- 24) Install the two rollers (1, [Fig. 12](#)) to the driving end of the SAC.

**Fig. 12**

Scavenge Air Cooler: Removal and Installation

- 25) At the driving end, put a new O-ring (5, Fig. 13) in position.
- 26) Put the collar (3) in position.
- 27) Attach the flange (2) to the SAC (4) with the screws (6).
- 28) Torque the screws (6) to the value given in 0352-1.
- 29) At the free end, put a new O-ring (10) in position.
- 30) Put the collar (6) in position.
- 31) Put the flange (7) in position.
- 32) Attach the four clamps (9) to the SAC (1) with the screws (8).
- 33) Torque the screws (8) to the value given in 0352-1.

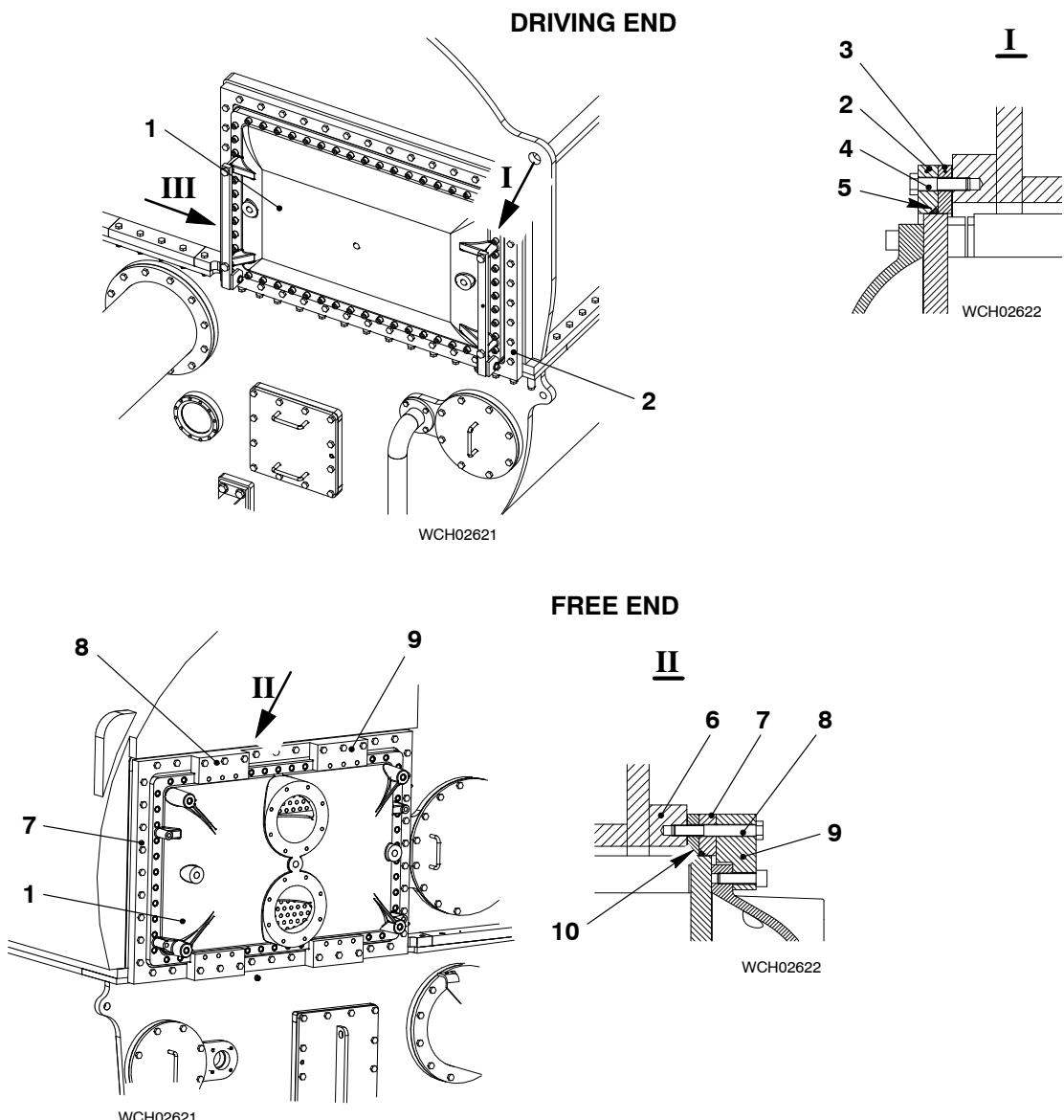
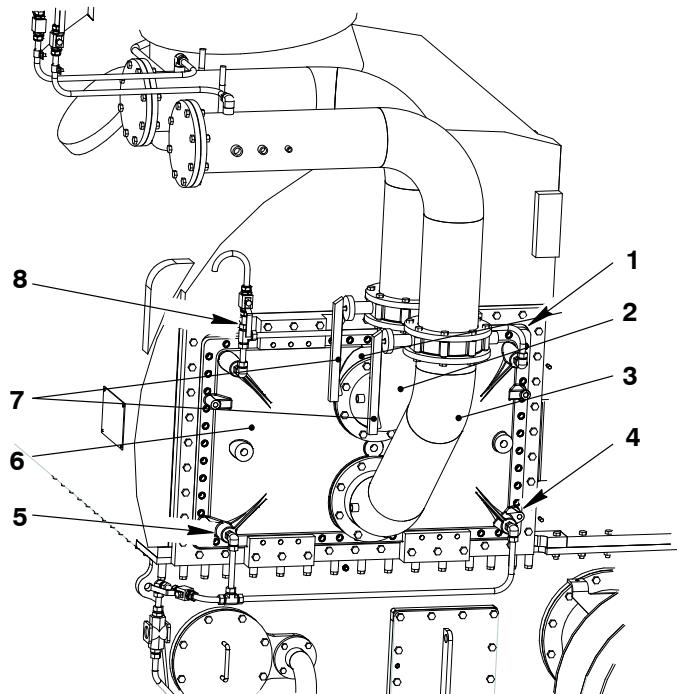


Fig. 13

Scavenge Air Cooler: Removal and Installation

4. Completion



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Fig. 14

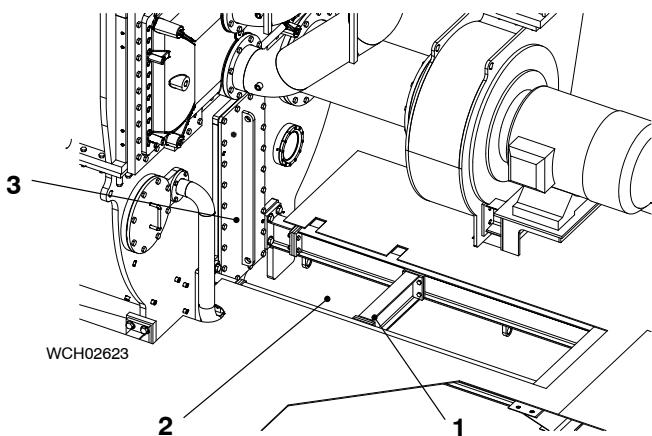
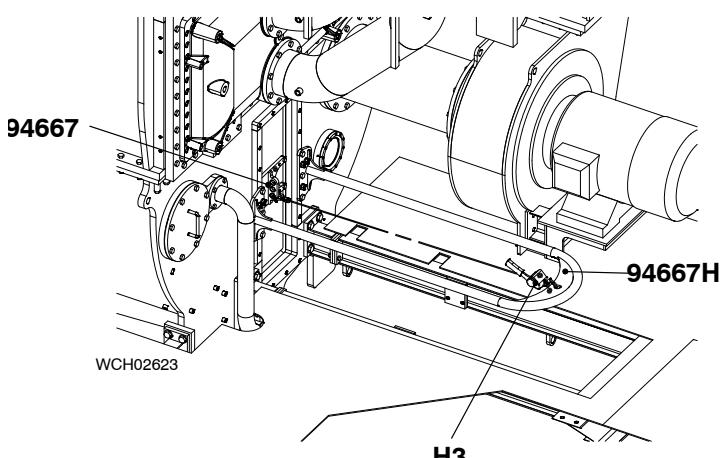
- 1) Install the drain pipes (4, 5, [Fig. 14](#)).
- 2) Install the vent pipes (7, 8)
- 3) Install the outlet pipe (2).
- 4) Install the inlet pipe (3).
- 5) Open the butterfly valves (7).
- 6) Release the air in the SAC (6).
- 7) Start the cooling water pump.
- 8) Make sure that there are no leaks.
- 9) Make sure that no scavenge air flows between the SAC (6) and the SAC housing.
- 10) Stop the cooling water pump.

Water Separator**Removal and Installation****Tools:**

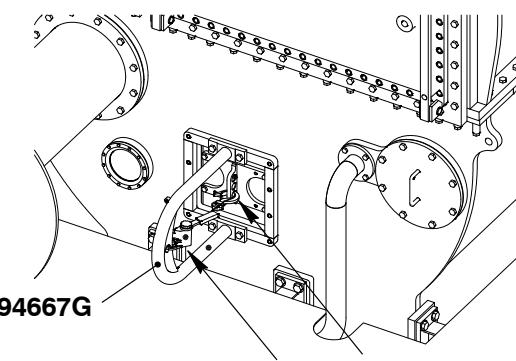
1	Spur-gearied chain block, H1	94017-005	2	Shackle, WLL 3250 kg	94018A
	WLL 1000 kg		3	Tool	94667
1	Spur-gearied chain block H2	94016-031	1	Holder	94667G
	WLL 500 kg		1	Holder	94667H

2	Manual ratchet H3, H4	94016-006
	WLL 1000 kg	

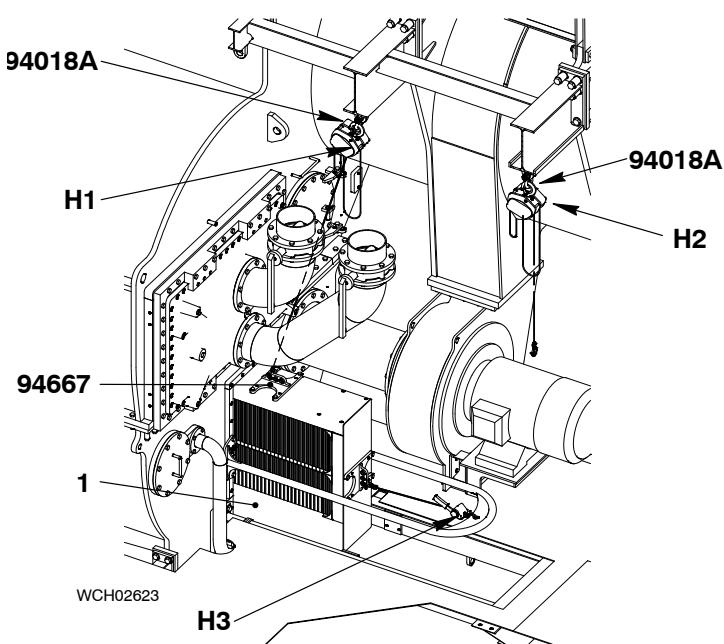
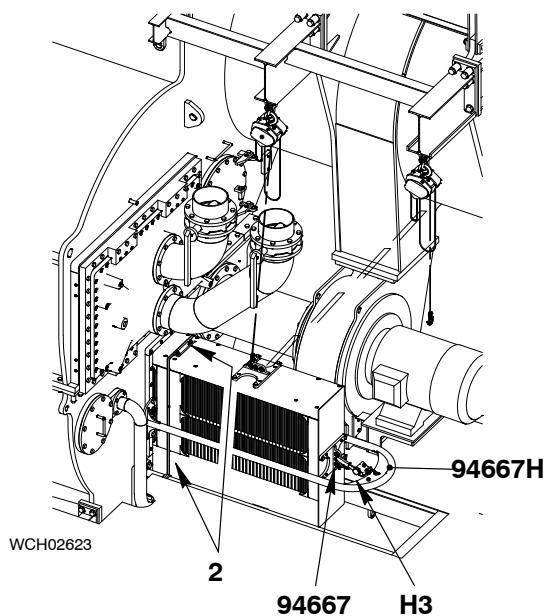
1.	Preparation	1
2.	Removal	2
2.1	Front Water Separator	2
2.2	Rear Water Separator	3
3.	Installation	5
3.1	Rear Water Separator	5
3.2	Front Water Separator	7

**Fig. 1****Fig. 2****1. Preparation**

- 1) Read the General Guidelines for Lifting Tools [0012-1](#).
- 2) Remove the front cover (3, [Fig. 1](#)) from the housing of the water separator.
- 3) Remove bottom plate (2) and the beam (1).
- 4) Install the tool (94667) to the front of the water separator (see [Fig. 2](#)).
- 5) Install the holder (94667H) to the middle of the housing on the receiver.
- 6) Attach the manual ratchet H3 to the tool (94667H) and the tool (94667).
- 7) Install the tool (94667) to the rear of the water separator (see [Fig. 3](#)).
- 8) Install the holder (94667G) to the rear of the water separator.
- 9) Attach the manual ratchet (H4) to the holder (94667G) and the tool (94667). This will help you during the installation procedure.

**Fig. 3**

Water Separators: Removal and Installation

**Fig. 4****Fig. 5**

- 10) Attach the two shackles (94018A, Fig. 4) to the gallery above water separator.
- 11) Attach the spur-gear chain blocks (H1, H2) to the two shackles (94018A).

2. Removal

2.1 Front Water Separator

- 1) Operate the manual ratchet (H3) to pull the water separator (1) sufficiently so that you can attach the tool (94667) to the water separator (1).
- 2) Attach the tool (94667) to top of the water separator (1).
- 3) Attach the spur-gear chain block (H1) to the tool (94667).
- 4) Apply a light tension to the spur-gear chain block (H1).
- 5) Operate the manual ratchet (H3) to pull the water separator (1) from the receiver. At the same time, operate the spur-gear chain block (H1) to hold the mass of the water separator.
- 6) Remove the two top screws (2, Fig. 5) and the two bottom screws (1) from between the front and rear water separators.
- 7) Remove the manual ratchet (H3) and the tool 94667H.
- 8) Remove the tool 94667 from the front of the water separator.

Water Separators: Removal and Installation

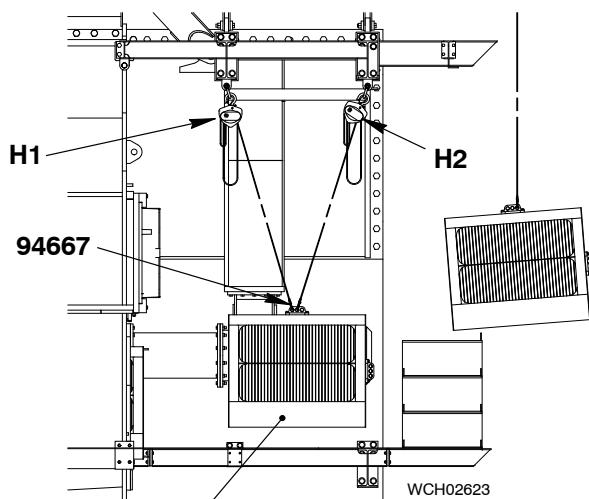


Fig. 6

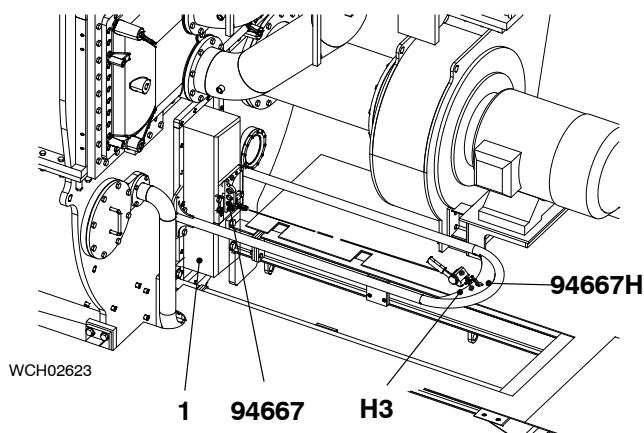


Fig. 7

- 9) Attach the spur-gearied chain block (H2, Fig. 6) to the tool (94667).
- 10) Apply a light tension to the spur-gearied chain block (H2).
- 11) Loosen the spur-gearied chain block (H1). At the same time, tighten the spur-gearied chain block (H2) to move the water separator under the engine room crane.
- 12) Lower the water separator (1) to the floor.
- 13) Remove the spur-gearied chain blocks (H1, H2) from the tool (94667) on the water separator (1).
- 14) Attach the engine room crane to the tool 94667 on the water separator.
- 15) Use the engine room crane to move the water separator (1) to an applicable area.
- 16) Remove the engine room crane from the water separator.
- 17) Remove the tool (94667) from the water separator.

2.2 Rear Water Separator

- 1) Attach the tool (94667, Fig. 7) to the front of the water separator.
- 2) Install the holder (94667H) to the middle of the housing on the receiver.
- 3) Attach the manual ratchet (H3) to the holder (94667H) and the tool (94667).

Water Separators: Removal and Installation

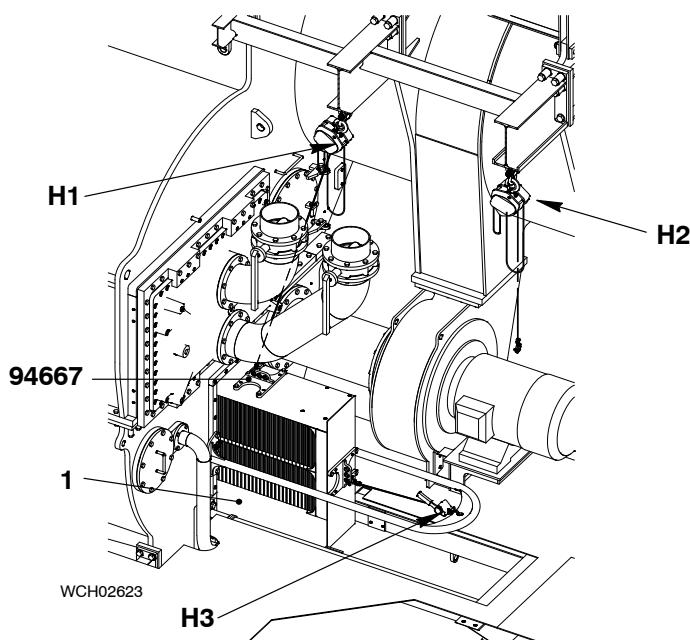


Fig. 8

- 4) Operate the manual ratchet to pull the water separator (1, Fig 8) sufficiently so that you can attach the tool (94667).
- 5) Attach the tool (94667) to top of the water separator (1).
- 6) Attach the spur-gear chain block (H1) to the tool (94667).
- 7) Apply a light tension to the spur-gear chain block (H1).
- 8) Operate the manual ratchet (H3, Fig. 9) to pull the water separator (1) from the receiver. At the same time, operate the spur-gear chain block (H1) to hold the mass of the water separator.
- 9) Remove the manual ratchet (H3) and the tool 94667H.
- 10) Remove the tool 94667 from the front of the water separator.
- 11) Attach the spur-gear chain block (H2) to the tool (94667) on top the water separator.

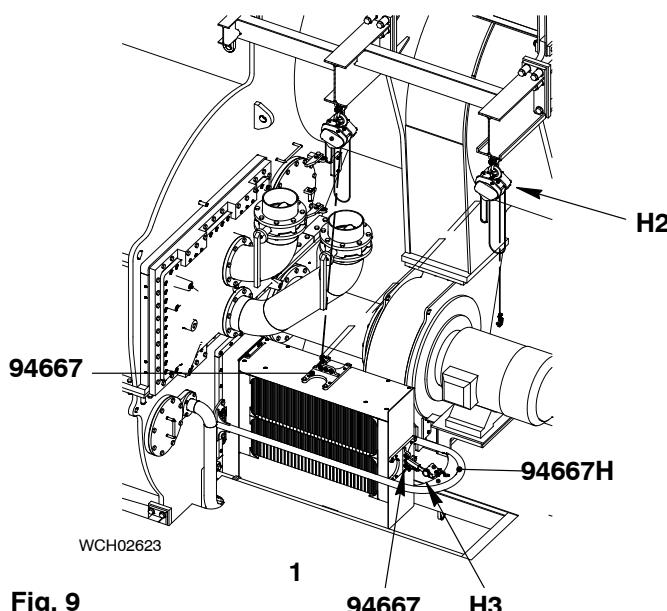


Fig. 9

Water Separators: Removal and Installation

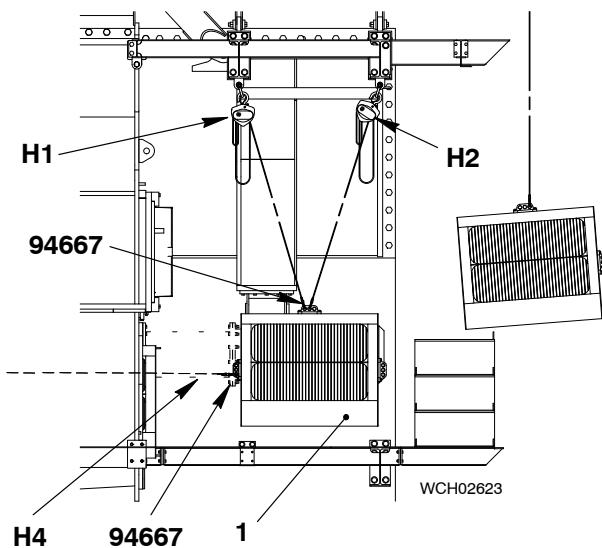


Fig. 10

- 12) Remove the manual ratchet (H4, Fig. 10) from the rear of the water separator (1).
- Note:** Do not remove the manual ratchet (H4) from the holder (94667G).
- 13) Apply a light tension to the spur-gearied chain block (H2).
- 14) Loosen the spur-gearied chain block (H1). At the same time, tighten the spur-gearied chain block (H2) to move the water separator under the engine room crane.
- 15) Lower the water separator (1) to the floor.
- 16) Remove the spur-gearied chain blocks (H1, H2) from the tool (94667) on the water separator (1).
- 17) Attach the engine room crane to the tool 94667 on the water separator.
- 18) Use the engine room crane to move the water separator (1) to an applicable area.
- 19) Remove the engine room crane from the water separator.
- 20) Remove the tools (94667) from the water separator.

3. Installation

3.1 Rear Water Separator

- 1) Attach the tools (94667) to the top and front of the water separator (1).
- 2) Use the engine room crane and the spur-gearied chain blocks (H1, H2, Fig. 11) to get the water separator in position.
- 3) Connect the manual ratchet H4 to the tool 94667 on the water separator.
- 4) Operate the manual ratchet (H4) to move the water separator (1) into the receiver a small distance.

Note: When you do step (5), keep the tension on the spur-gearied chain blocks (H1, H2) to hold the mass of the water separator (1).

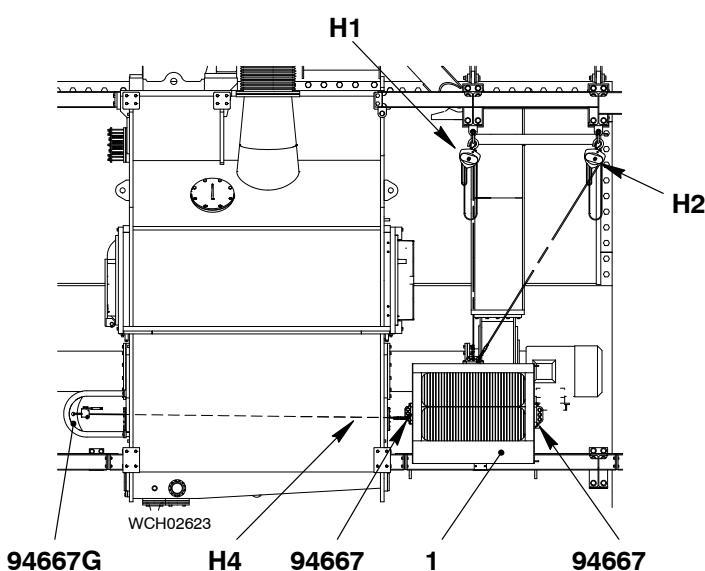


Fig. 11

Water Separators: Removal and Installation

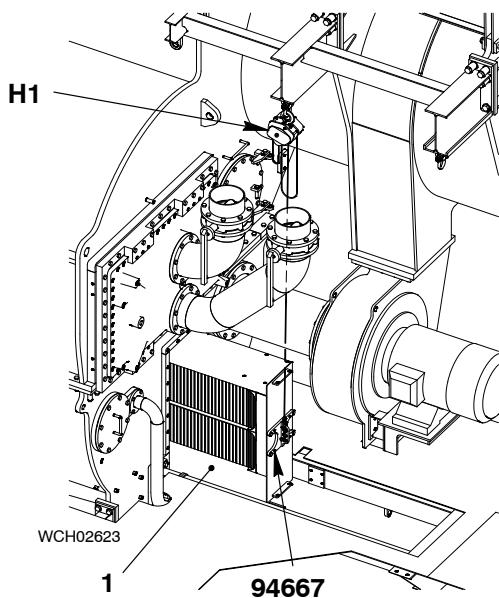


Fig. 12

- 5) Remove the spur-gear chain blocks (H1, H2 [Fig. 12](#)) from the water separator (1).
- 6) Remove the tool (94667) from the top of the water separator (1).
- 7) Attach the spur-gear chain block (H1) to the tool (94667) on the front of the water separator (1).
- 8) Operate the manual ratchet (H4, [Fig. 13](#)) to pull the water separator (1) almost fully into the receiver. At the same time, operate the spur-gear chain block (H1) to hold the mass of the water separator.
- 9) Remove the spur-gear chain block (H1) from the tool (94667) on the front of the water separator (1).
- 10) Remove the tool (94667) from the front of the water separator (1).

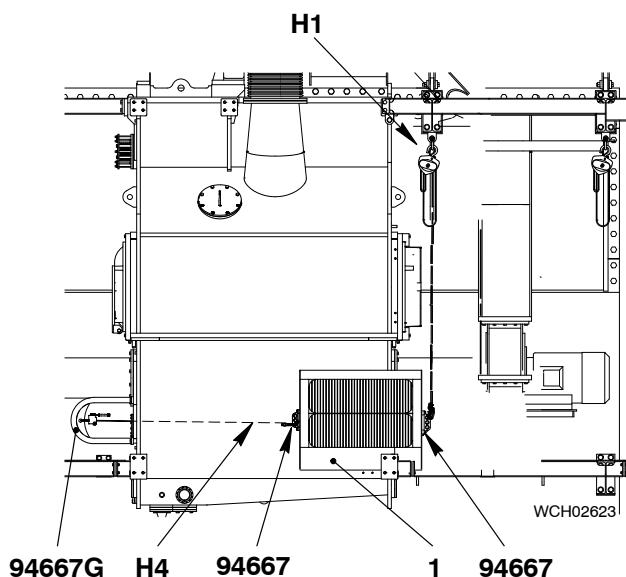


Fig. 13

Water Separators: Removal and Installation

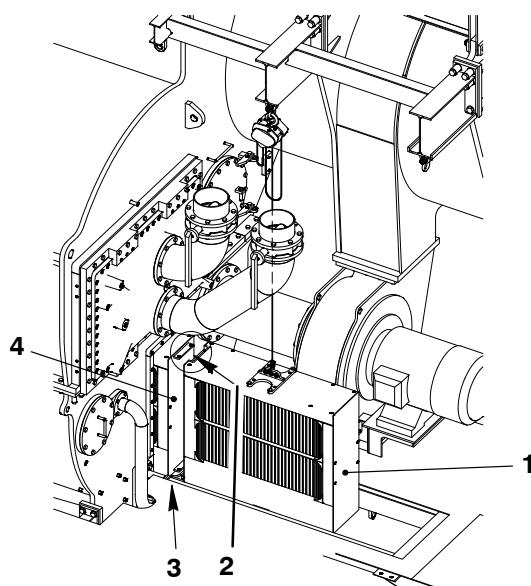


Fig. 14

3.2 Front Water Separator

- 1) In paragraph 3.1, do steps (1 to (8 for the front water separator, then continue with step (2 below.
- 2) Align the front and rear water separators (1 and 4, Fig. 14).
- 3) Install the two top screws (2) and the two bottom screws (3) to keep the water separators together.
- 4) Operate the manual ratchet (H4) to pull the water separators a small distance into the receiver.
- 5) Remove the spur-gearied chain block (H1) from the tool (94667).
- 6) Remove the tool (94667) from the water separator (1).
- 7) Operate the manual ratchet (H4) to pull the water separators (1, 4) fully into the receiver (see Fig. 15).
- 8) Remove the spur-gearied chain blocks (H1, H2).
- 9) Remove the shackles (94018A).
- 10) Remove the tool (94667) and the holder (94667G).

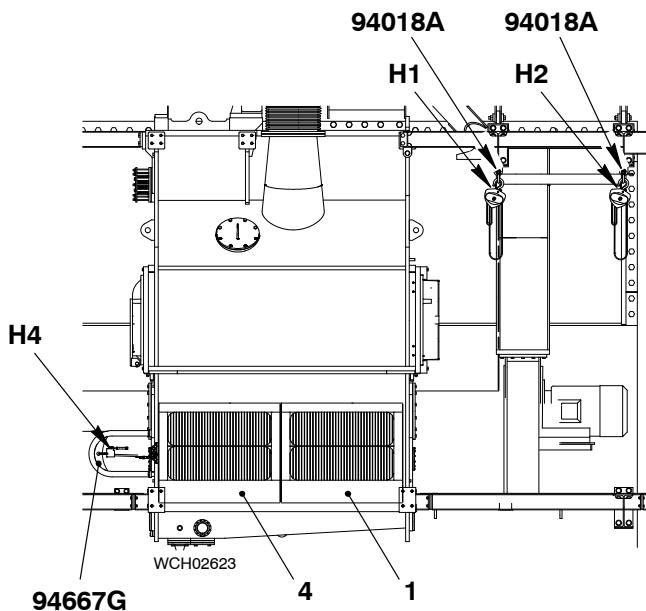
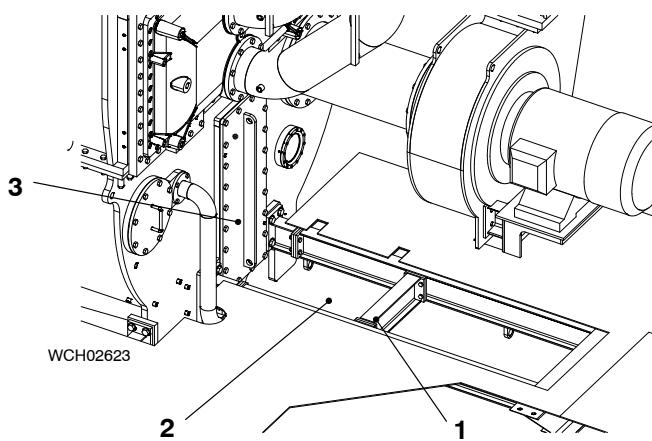
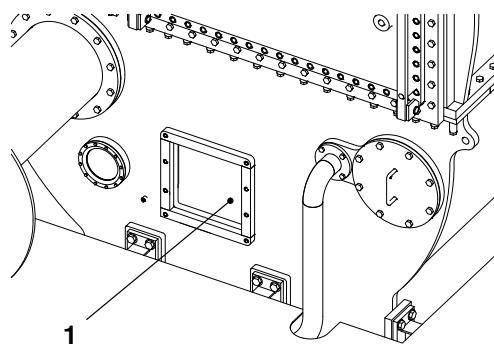
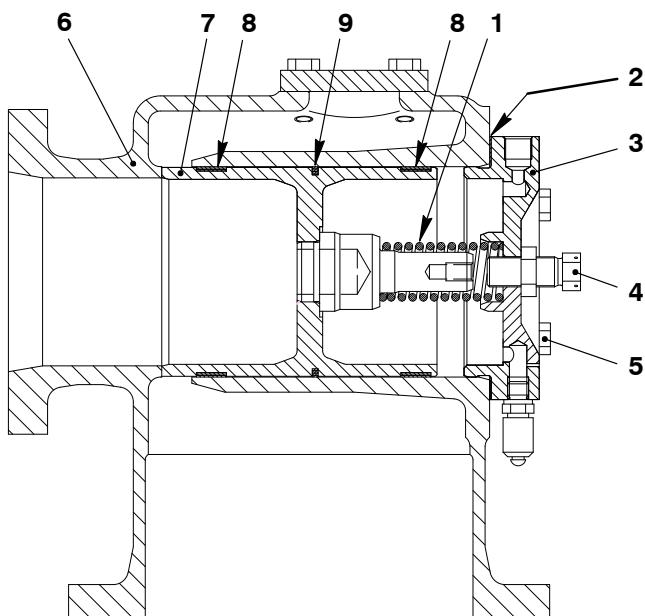


Fig. 15

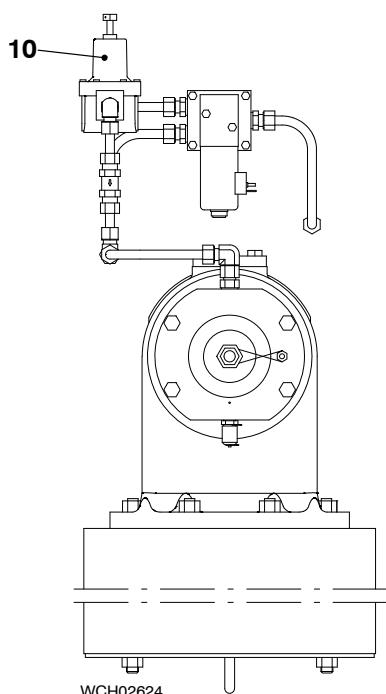
Water Separators: Removal and Installation**Fig. 16**

- 11) Install the cover (3, Fig. 16) to the receiver.
- 12) Install the bottom plate (2).
- 13) Install the beam (1).
- 14) Install the cover (1, Fig. 17) to the receiver.
- 15) Remove all tool and equipment from the work area.

**Fig. 17**

Scavenge Air Waste Gate**Disassembly and Assembly**

WCH02624

**Fig. 1****1. Disassembly**

If a malfunction in the waste gate valve occurs, do the procedure below as soon as possible:

CAUTION

Injury Hazard! Be careful when you remove the screws from the cover. The compressed spring can push the cover off quickly and cause injury.

- 1) Carefully remove the four screws (5, Fig. 1) from the cover (3).
- 2) Remove the piston (7) from the housing (6).
- 3) Clean the piston (7) and the housing (6).
- 4) Do a check of piston joint ring (9) the two guide rings (8) and the seal (2). If necessary, replace the piston joint ring guide rings and seal.

2. Assembly**CAUTION**

Damage Hazard: If it is necessary to replace the seal (2), make sure that a seal of the same dimensions is installed to prevent damage.

- 1) Apply a small quantity of clean oil to the spring (1), piston (7), joint ring (9) and guide rings (8).

Note: The pressure reducing valve (10) is used to adjust the opening pressure. For more data, see the Operation Manual, 6735-1.

- 2) Put the piston (7) in position in the housing (6).
- 3) Make sure that the piston (7) moves freely in the housing (6).
- 4) Put the spring (1) in position in the housing (6).
- 5) Attach the cover (3) to the housing (6) with the four screws (8).
- 6) Do a function check of the valve (see the Operation Manual, 6735-1, paragraph 4).

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Cylinder Lubrication

Group 7

Cylinder Lubricating System [7218-1/A1](#)

Integrated Electric Balancer (iELBA)

 Replacement of Proximity Sensors [7762-1/A1](#)

 Bearing Replacement and Adjustment [7758-1/A1](#)

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Cylinder Lubrication System

1.	Cylinder Lubricating System	1
1.1	Cylinder Lubricating System – Operate	1
1.2	Function Check	3
2.	Cylinder Lubrication Pump	3
2.1	Checks	3
3.	Cylinder Lubricating System – Bleed	4
3.1	Cylinder Lubrication Pump	4
3.2	Oil Pipes	4
4.	Duplex Filter	5
4.1	Clogged Filter Element – Replace	5
4.2	Filter Element – Clean	5

1. Cylinder Lubricating System

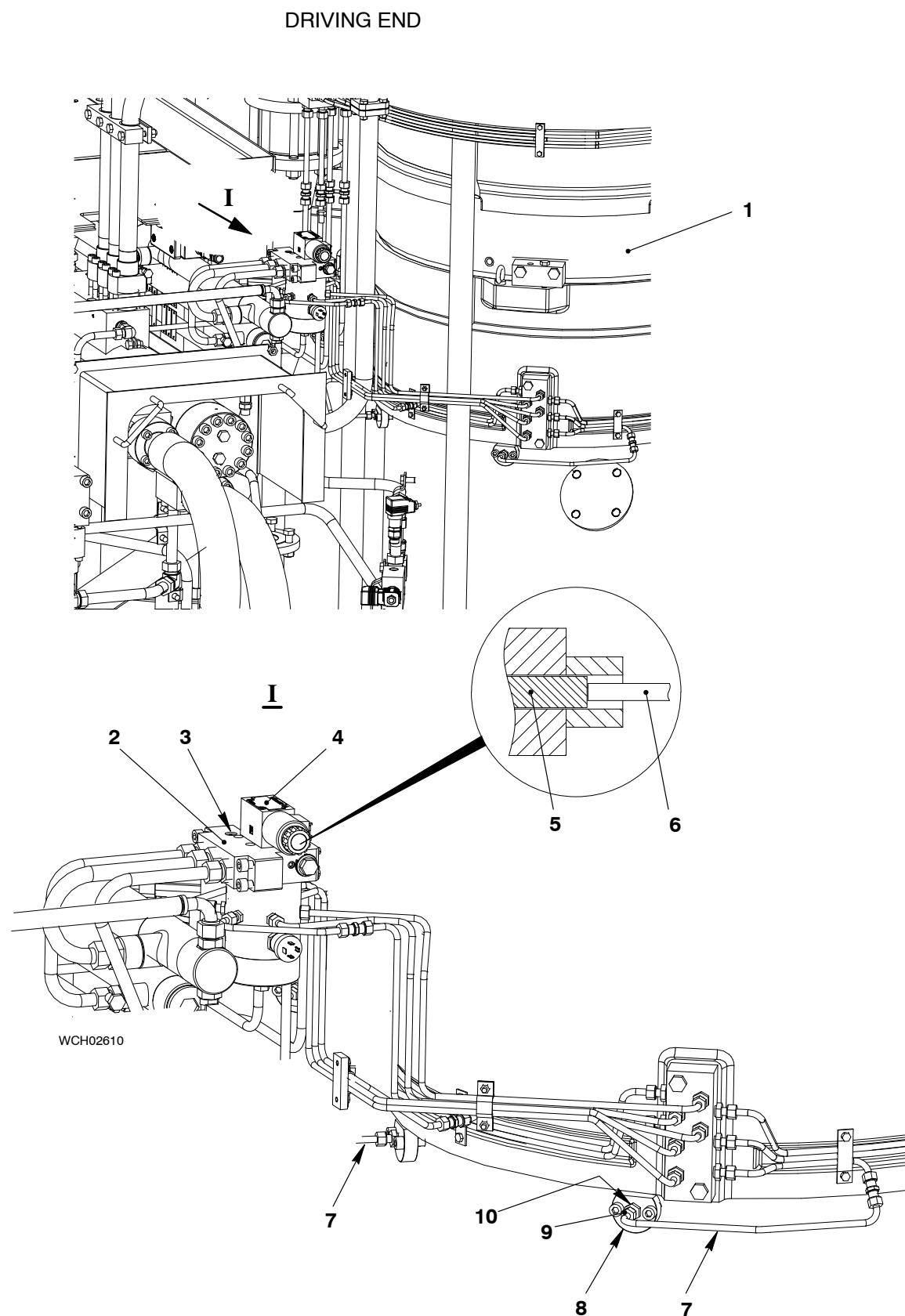
For more data about the cylinder lubricating system, see the Operation Manual, 7218-1.

1.1 Cylinder Lubricating System – Operate

For more data, see the Operation Manual, 4002-2, paragraph 3.2 and paragraph 3.8.

- 1) In the LDU-20, get the MAIN page.
- 2) In the navigation menu, select Cylinder Lubrication.
- 3) In the CYL. LUBRICATION page, field Manual lub. to Cyl. #, select the applicable cylinder number.
- 4) If necessary, change the number of lube pulses (in the range 0 to 200) in the field # of Manual Lub. Pulses.

Note: You can operate the 4/2-way solenoid valve (4, Fig. 1) to release manually one lube pulse.

Cylinder Lubricating System**Fig. 1: Cylinder Lubrication Pump – Location**

Cylinder Lubricating System

1.2 Function Check

- 1) If necessary, bleed the cylinder lubricating system (see paragraph 3).

WARNING

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

- 2) Make sure that the applicable piston is in the TDC position. If the piston is not in the TDC position, do the steps that follow:
 - a) Engage the turning gear.
 - b) Use the turning gear to get the applicable piston in the TDC position.
 - c) Disengage the turning gear.
- 3) Set to on the cylinder lubricating system for the related cylinder (see paragraph 1.1).

Note: During usual operation, the UNIC system controls the cylinder lubricating pulses.

- 4) Manually release a lube pulse as follows:
 - a) Use a pin or a screwdriver (6) to push in the plunger (5) of the 4/2-way valve (4).
 - b) Look through the scavenge air ports in the cylinder liner (1, Fig. 1) while the lubricating system operates.
 - c) Make sure that the lubricating oil is correctly injected on to the cylinder liner wall (see the Operation Manual 7218-1, paragraph 6.2 and paragraph 6.3).
 - d) Make sure that the oil that flows has no air. If necessary, bleed the cylinder lubricating pump (2) and the oil lines (7) (see paragraph 3).
 - e) Set to off the cylinder lubricating system for the related cylinder.

2. Cylinder Lubrication Pump

For data about the cylinder lubricating pump (2), see the Operation Manual 7218-1, paragraph 4.

2.1 Checks

- 1) Examine the cylinder lubricating pump (2) for damage and leaks.
- 2) Do a function check of the cylinder lubricating system (see paragraph 1.2).

3. Cylinder Lubricating System – Bleed

Bleed the cylinder lubrication pump and oil pipes each time you do maintenance on the cylinder lubricating system.

3.1 Cylinder Lubrication Pump

To bleed the cylinder lubrication pump (2, Fig. 1), do the steps that follow:

Note: When you bleed the cylinder lubricating system, always start at the first cylinder at the free end. The hydrostatic pressure in the cylinder lubricating system helps you bleed the cylinder lubrication pump (2).

- 1) Make sure that the cylinder lubrication pump (2) is set to off.
- 2) Loosen the vent screw (3).
- 3) Keep the vent screw (3) open until oil that flows has no air.
- 4) Tighten the vent screw (3).
- 5) Clean the external surface of the cylinder lubrication pump (2).
- 6) If necessary, bleed the oil pipes (7), (see paragraph 3.2).
- 7) Do a function check of the cylinder lubricating system, (see paragraph 1.2).

3.2 Oil Pipes

To bleed the oil pipes (7), do the steps that follow:

- 1) Set to on the cylinder lubricating system, (see paragraph 1.1).
- 2) Use an open-ended spanner to hold the screw-in union (10) in position.
- 3) Loosen the nut (9) of the screw-in union (10) a maximum of two turns.
- 4) Keep the nut (9) of the screw-in union (10) open until oil that flows has no air.
- 5) Tighten the nut (9) of the screw-in union (10).
- 6) Clean the external surface (8) of the lubricating quill.
- 7) If necessary, bleed the flex lube pump (2) (see paragraph 3.1).
- 8) Do a function check of the cylinder lubricating system (see paragraph 1.2).

4. Duplex Filter

For data about the duplex filter (1, [Fig. 2](#)), see the Operation Manual 7218-1, paragraph 2.

4.1 Clogged Filter Element – Replace

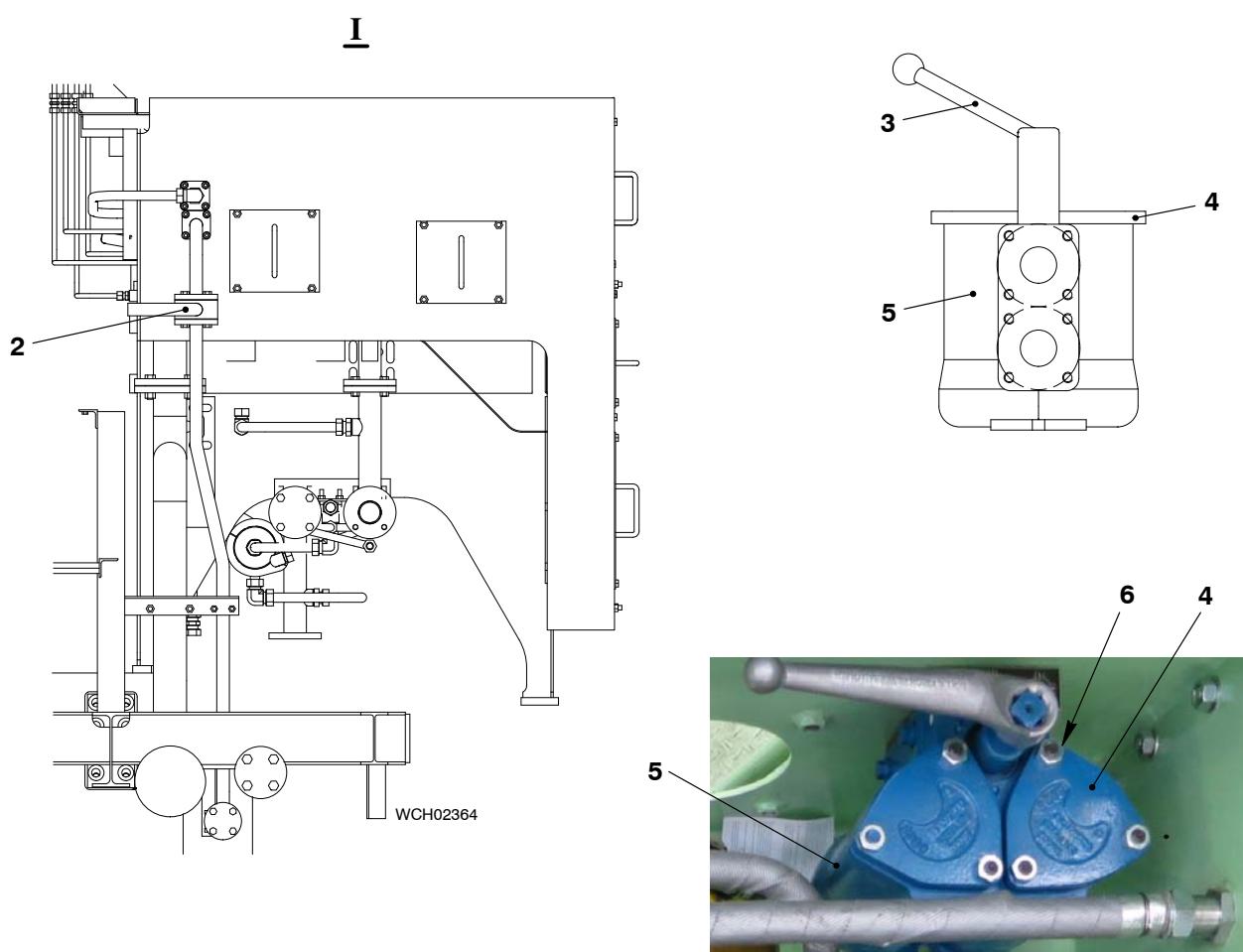
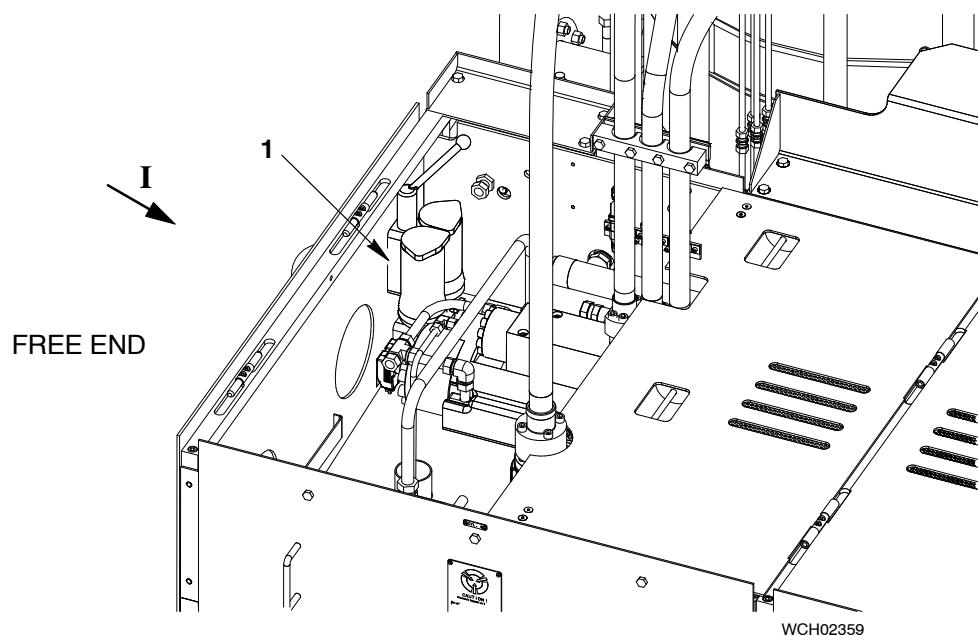
- 1) Close the ball valve (2).
- 2) Remove the cover from the rail unit.
- 3) Move the lever (3) to select the clean filter element.
- 4) Remove the three nuts (6) on the applicable filter chamber (5), then remove the cover (4).
- 5) Replace the clogged filter element.

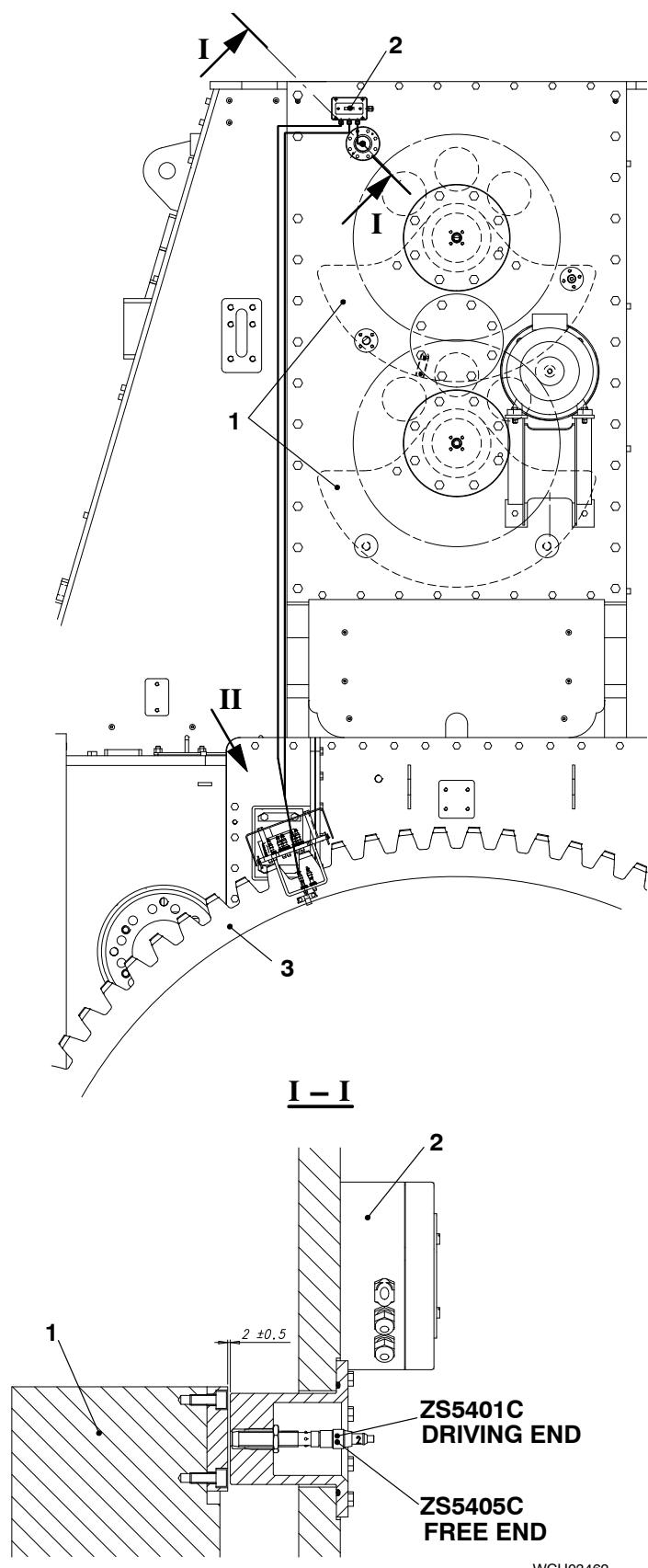
Note: As an alternative, you can clean the clogged filter element (see paragraph [4.2](#)).

- 6) Attach the cover (4) to the filter chamber (5) with the three nuts (6).
- 7) Clean the external surface of the duplex filter (1).
- 8) Install the cover you removed before to the rail unit.
- 9) Open the ball valve (2).

4.2 Filter Element – Clean

For data about the procedure to clean the filter element, see the documentation of the filter element manufacturer.

Cylinder Lubricating System**Fig. 2: Duplex Filter**

Electric Balancer Sensor Unit**Replacement of Proximity Sensor****1. General**

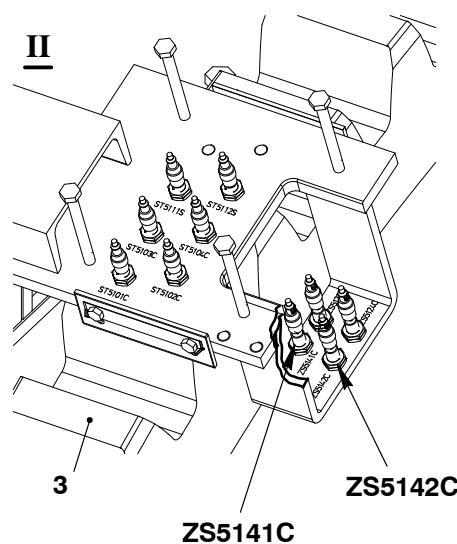
For position and speed of the balance weights (1) one proximity sensor is installed on each end of the engine:

ZS5401C on Driving End

ZS5405C on Free End

Both are connected to the terminal box (2).

Another two proximity sensors (ZS5141C und ZS5142C) for engine speed and crank position are installed at the flywheel near the crank angle sensors.

**Fig. 6**

Crank Angle Sensor Unit: Replacement of Proximity Sensor

2. Replacement

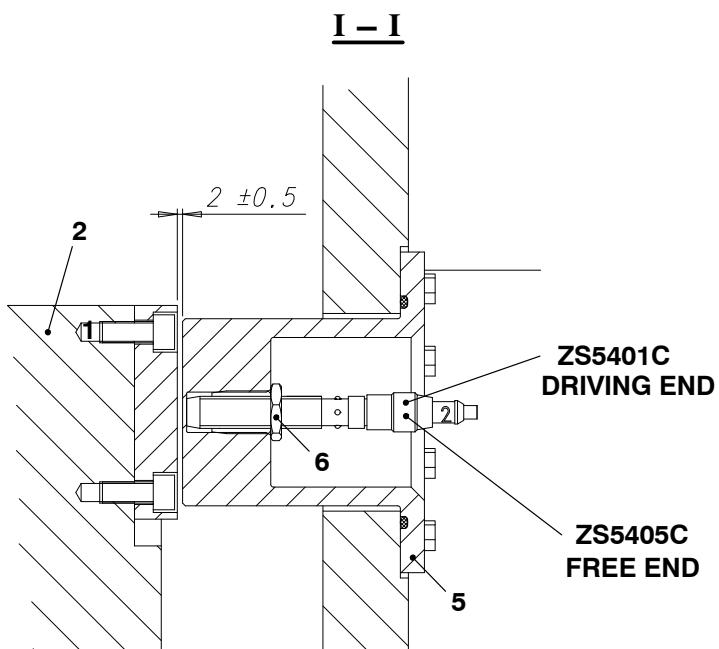


Fig. 7

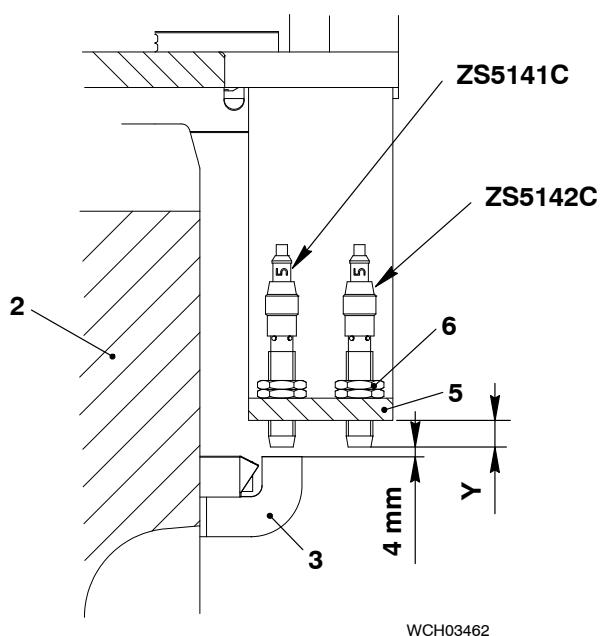


Fig. 8

2.1 Replacement of proximity sensors for balance weights

- 10) Disconnect the plug with cable from the proximity sensor (ZS540xC).
- 11) Loosen the nut (4).
- 12) Remove the sensor (ZS540xC)
- 13) Screw the new sensor into the sensor adapter (5) to the end stop.
- 14) Tighten the lock nut (6).
- 15) Connect the sensor cable with the proximity sensor.
- 16) Check at LDU Alarm System for Signal failure, see also operating manual 4002-2.

Early executions might not be connected to the Alarm System. They have a control box called „Lenze Drive“ which shows a signal failure. This is installed in the control cabinet.

2.2 Replacement of proximity sensors flywheel

See Fig. 1, view II for location of proximity sensors.

- 1) Disconnect the applicable proximity sensor.
- Instead of turning the engine later, measure distance Y and adjust the new proximity sensor accordingly.
- 2) Loosen the nut and lock nut (6) and remove the proximity sensor.
- 3) Screw the new proximity sensor into holder (5) to the measured distance Y.
- If not possible, screw the new proximity sensor into holder (5) until the sensor touches the crank angle mark (3) at the flywheel (2) and turn it back four turns (4mm).
- 4) Tighten nut and lock nut (6).
- 5) Connect the plug with cable.
- 6) Check at LDU Alarm System for Signal failure, see also operating manual 4002-2.

Integrated Electric Balancer

Integrated Electric Balancer, Bearing Replacement and Adjustment

Tools:

1	Adjusting tool	94701	1	Lifting tool	94704
1	Transportation tool	94702	2	Alignment tools	94705
1	Turning device	94703		Magnetic drill Reamer for taper pin	

1.	General	2
2.	Preparation	3
3.	Counterweights – Lock	3
3.1	Top Counterweight	3
3.2	Bottom Counterweight	3
4.	Bearings – Replace	4
4.1	Bearing – Engine Side	4
4.2	Bearing – Outer Side	7
5.	Check	9
5.1	Bearing clearance	9
5.2	Measure Backlash	9
5.3	Adjust bearings	11
6.	Final steps:	13

1. General

The Integrated Electronic Balancer (iELBA) can be installed as follows:

- One ELBA installed at the driving end, or
- One ELBA installed at the free end, or
- Two ELBA installed – one at the driving end and one at the free end.

It is only necessary to replace the bearings and replace the bearings always as a pair. If replacing the bearing the first time, it's recommended to call Wärtsilä Services Switzerland for expert advice.

For data about the Integrated Electrical Balancer, refer to the Operation Manual, chapter 7752-1.

For the maintenance schedule, refer to 0380-1.

For the clearances, refer to the Clearance Table 0330-1, Group 7758.

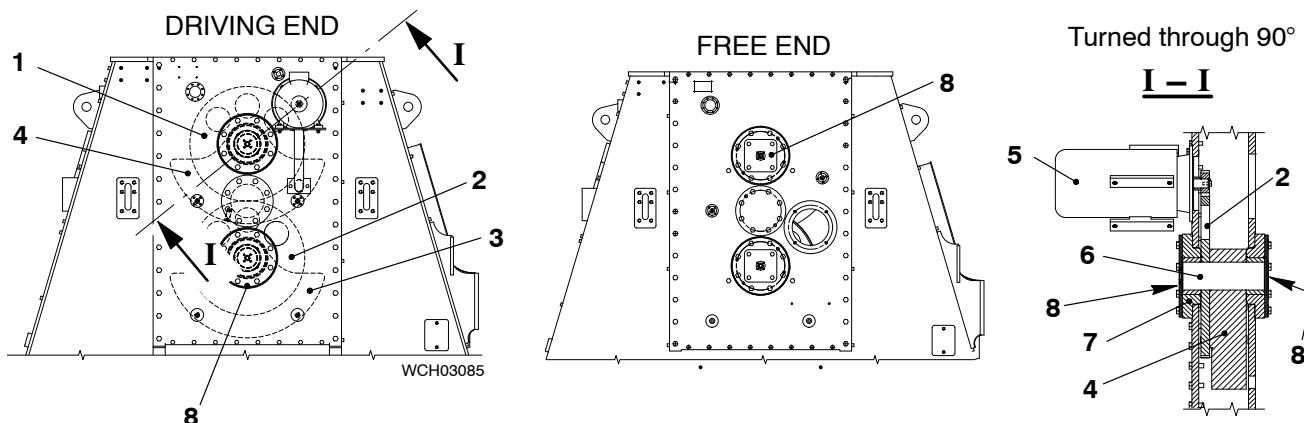


Fig. 1

Fig. 1: Location of ELBA

- | | |
|-----------------------|------------------|
| 1 Upper gear wheal | 5 Electric motor |
| 2 Lower gear wheal | 6 Bearing pin |
| 3 Lower counterweight | 7 Bearing |
| 4 Upper counterweight | 8 Bearing cover |

Integrated Electric Balancer

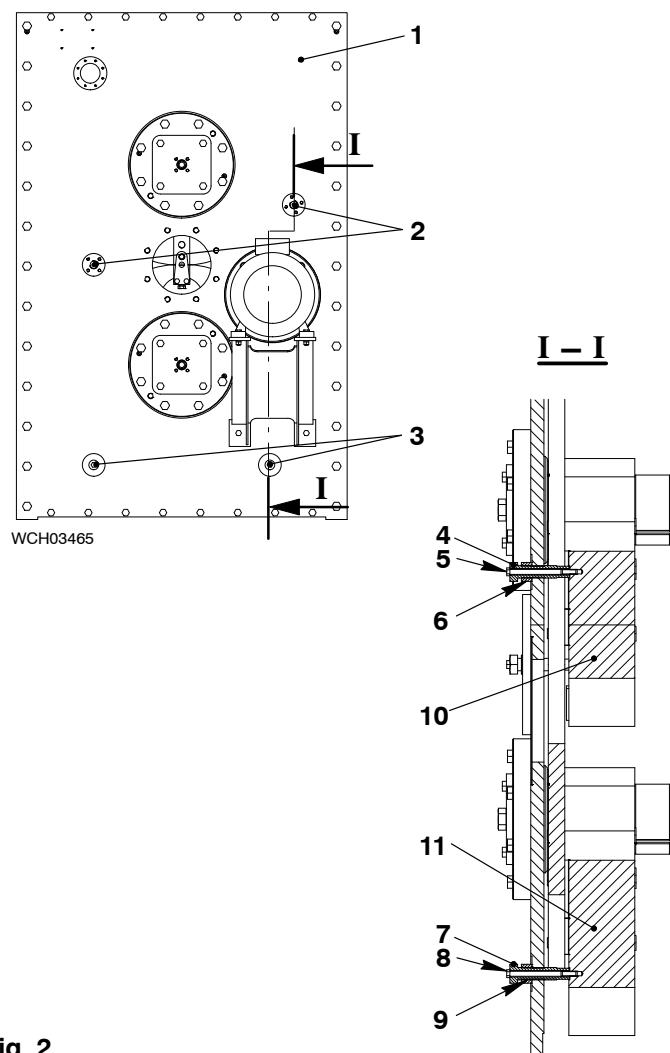
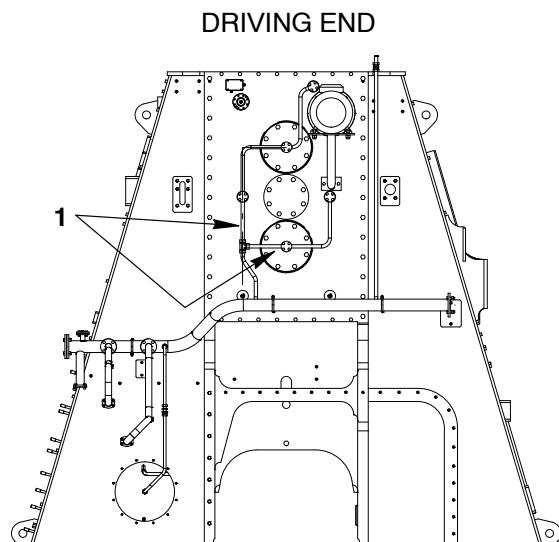


Fig. 2

2. Preparation

- 1) Stop the engine, refer to Operation Manual, 0310-1.
- 2) Make sure that the electric motor (5, Fig. 1) has stopped.
- 3) Stop the lubricating oil supply and close the oil inlet.
- 4) At driving end, put an oil tray under applicable oil pipe (1, Fig.2).
- 5) Remove the applicable oil pipe (1) to get access to the balancer shafts.

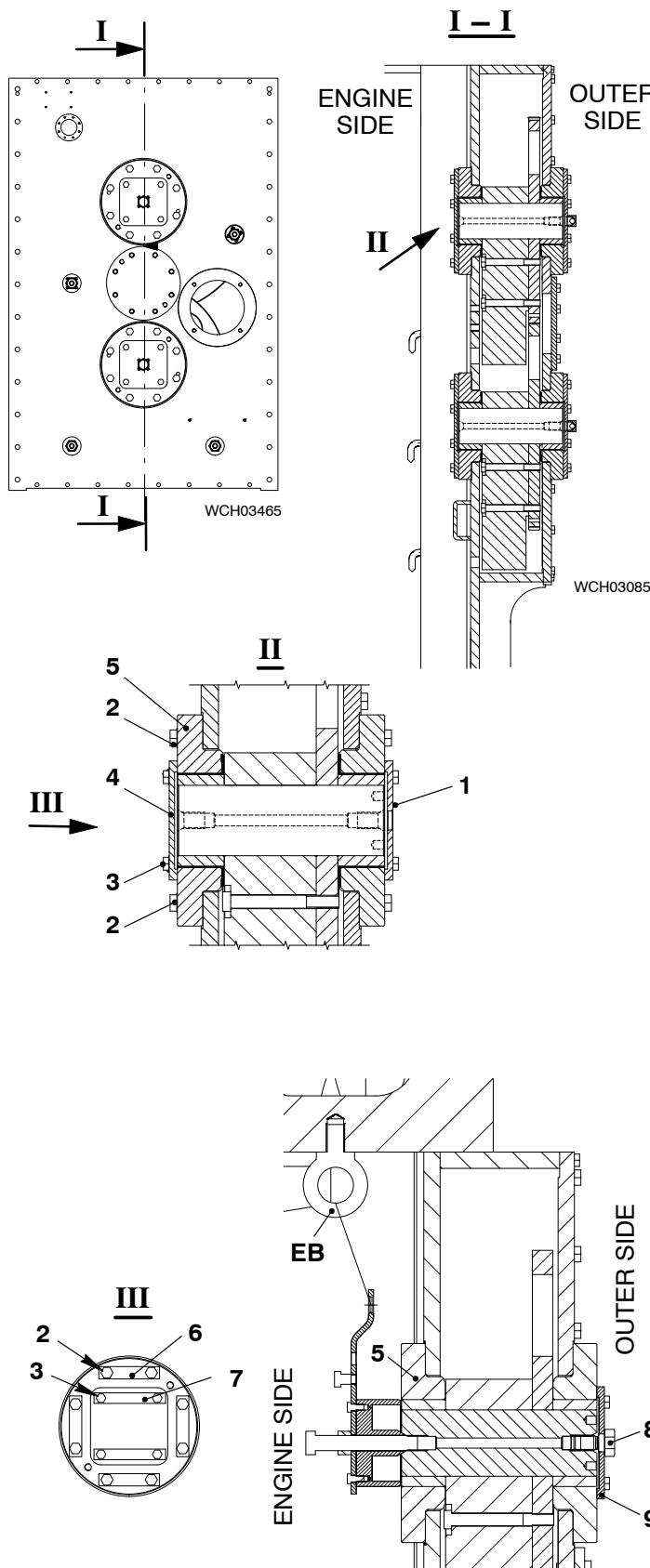
3. Counterweights – Lock**3.1 Top Counterweight**

- 1) Apply lubricating oil to the thread and bottom of the head of the clamping screw (4, Fig. 3) and the nut (6).
- 2) Remove the two screws (2) from the main cover (1).
- 3) Put the two clamping screws (4) and the nuts (6) in position on the upper counterweight (10).
- 4) Torque the clamping screws (4) to 60 Nm.
- 5) Torque the nut (6) to 60 Nm.
- 6) Put the the M12 bolt (5) in position through the clamping screw (4).
- 7) Torque the M12 bolt (5) to 60 Nm.

3.2 Bottom Counterweight

- 1) Apply lubricating oil to the thread and bottom of the clamping screw (7) and the nut (9).
- 2) Remove the two screws (3) from the cover (1).
- 3) Put the two clamping screws (7) and the nuts (9) in position on the lower counterweight (11).
- 4) Torque the clamping screws (7) to 60 Nm.
- 5) Torque the nut (9) to 60 Nm.
- 6) Put the M12 bolt (8) in position through the clamping screw (7).
- 7) Torque the M12 bolt (8) to 60 Nm.

Integrated Electric Balancer

**4. Bearings – Replace****CAUTION**

Injury Hazard: The weight of the bearing is 45 kg. Use the correct equipment to lift and move the bearing. This will prevent injury to personnel and damage to equipment.

CAUTION

Damage Hazard: Do not remove two bearings at the same time. This will prevent damage to equipment.

Note: On the outer side, use the crane and an applicable manual ratchet to lift and move the bearing.

Note: On the engine side, use an applicable manual ratchet and an eye bolt to lift and move the bearing.

4.1 Bearing – Engine Side**4.1.1 Removal**

- 1) Attach an eye bolt to the applicable position in the gallery above the the bearing (5, Fig. 4). Attach an applicable manual ratchet to the eye bolt.
- 2) Apply lubricating oil to the thread and bottom of the head of the special screw (8, part of tool 94702).
- 3) Put the special screw (8) through the bearing cover (9) on the outer side.
- 4) Torque the special screw (8) to 400 Nm.
- 5) Remove the four screws (3) and the locking plates (7) on the bearing cover at the engine side.
- 6) Remove the bearing cover (4).
- 7) Remove the eight screws (2) and the locking plates (6) from the bearing (5).

Fig. 3

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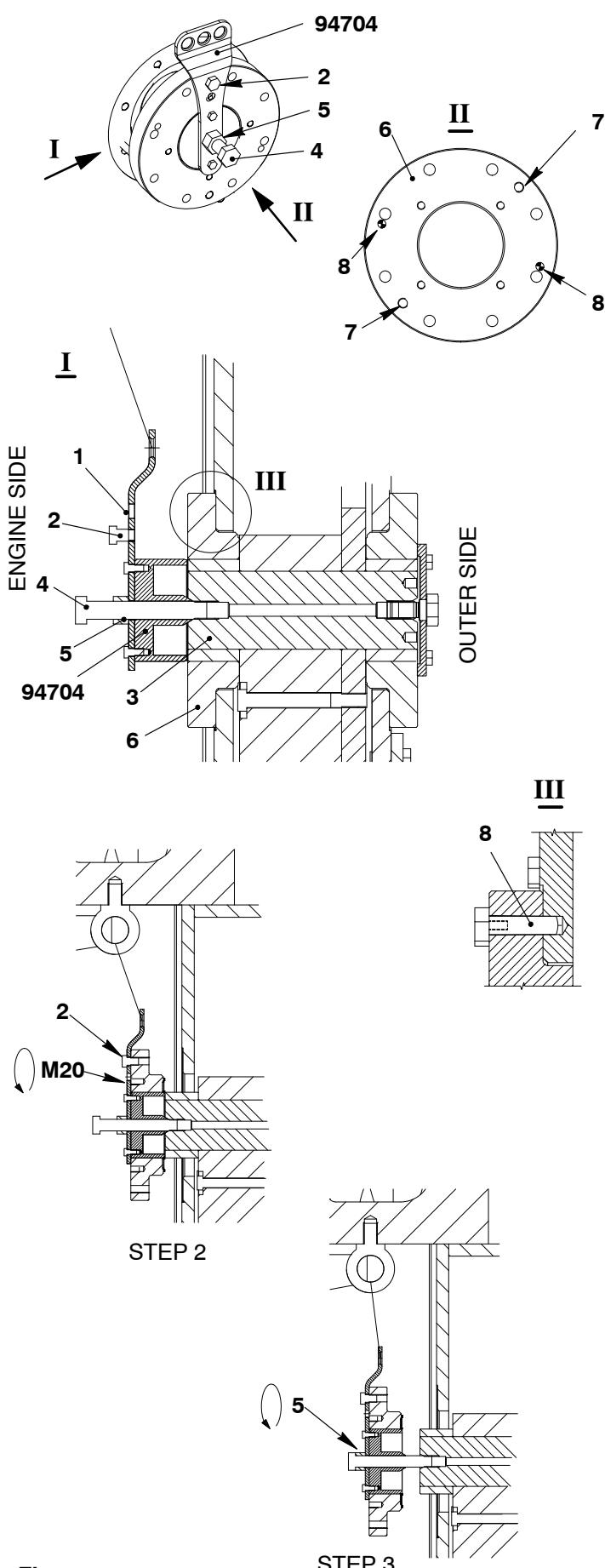
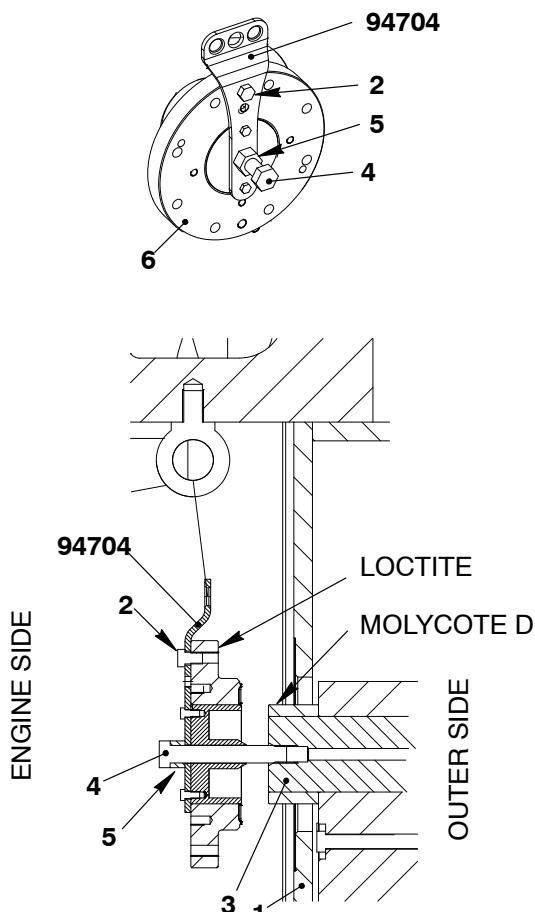


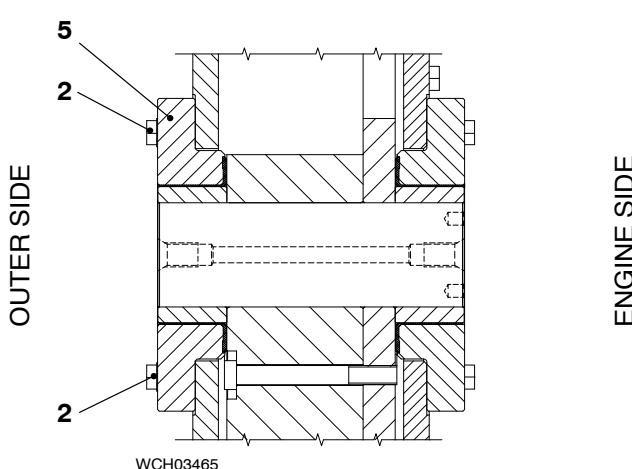
Fig. 4

- 8) Attach the lifting tool 94704 to the manual ratchet and move it in front of the bearing (6, Fig. 5).
- 9) Turn the screw (4) into the pin (3) and tighten slightly.
- 10) Turn the nut (5) against the bearing (6) in order to push the lifting tool 94704 against the pin (3).
- 11) Put two M20 x 140 mm bolts into the two threads (7) in bearing (6), see view II.
- 12) Tighten equally the two bolts to push out the bearing (6).
 - The bearing (6) will move on to the lifting tool 94704 (STEP 2).
- 13) Tighten screw (2) to hold the bearing (6)
- 14) Loosen nut (5) and operate the manual ratchet to hold the weight of the bearing (6) (STEP 3).
- 15) Carefully remove screw (4) and put the bearing in an applicable area.
- 16) Remove the two taper pins (8).
- 17) Lower the bearing (6).
- 18) Remove the lifting tool (94704).
- 19) Remove the two bolts (7).
- 20) Install new bearing, see next chapter.

Integrated Electric Balancer

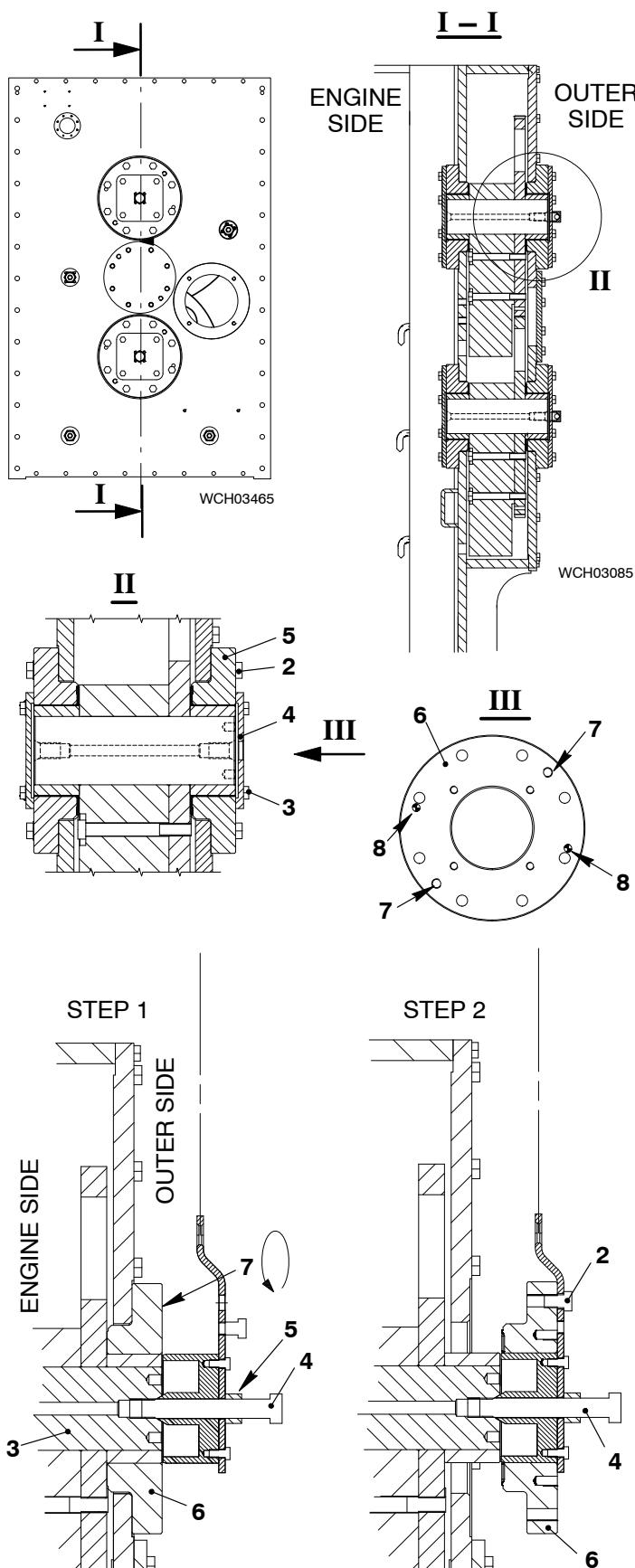
**4.1.2 Installation**

- 1) Make sure that the new bearing is clean, dry and in good condition. Apply Molycote D to the bearing surface.
- Do not install the two taper pins (8, Fig. 4).
- 2) Attach the lifting 94704 tool to the new bearing (6, Fig. 6). Tighten screw (2).
- 3) Lift bearing (6) in front of the pin (3).
- 4) Apply Loctite No. 640 to the contact surface of the bearing (6).
- 5) Apply Molycote D to the bearing surface of pin (3).
- 6) Install screw (4) together with nut (5) through the bearing (6) into the pin (3).
- 7) Remove screw (2).
- 8) Locate the taper pin bores in the column (1) and turn the new bearing until the pin bores in the bearing (6) are 90° to the ones in the column.
- 9) Tighten nut (5) and guide the bearing (6) in the correct position on the column (1).
- Use the manual ratchet if the pin (3) is too low.
- 10) Remove lifting tool 94704.



- 11) Install four (of eight) bolts M20x70 (2, Fig. 6) without tightening.
- 12) Adjust the backlash and the parallelism of the gear wheels, refer to chapter 5.2.

Integrated Electric Balancer

**Fig. 7****4.2 Bearing – Outer Side****4.2.1 Removal**

- 1) Remove the four screws (3, Fig. 7) on the bearing cover (4) at the outer side.
- 2) Remove the bearing cover (4).
- 3) Remove the eight screws (2) from the bearing (5).
- 4) Attach the lifting tool 94704 to the crane and move it in front of the bearing (6) (STEP 1).
- 5) Turn the screw (4) into the pin (3) and tighten slightly.
- 6) Tighten the nut (5) to push the lifting tool 94704 against the pin (3).
- 7) Put two M20 x 140 mm screws into the two threads (7, view III) in bearing (6).
- 8) Tighten equally the two M20 screws to push out the bearing (6).
- The bearing (6) will move on to the lifting tool 94704 (STEP 2).
- 9) Tighten screw (2) to hold the bearing (6)
- 10) Operate the crane to hold the weight of the bearing (6).
- 11) Carefully remove screw (4) and put the bearing in an applicable area.
- 12) Remove the two taper pins (8).
- 13) Remove the lifting tool 94704.
- 14) Remove the two bolts (7).
- 15) Install new bearing, see next chapter.

Integrated Electric Balancer

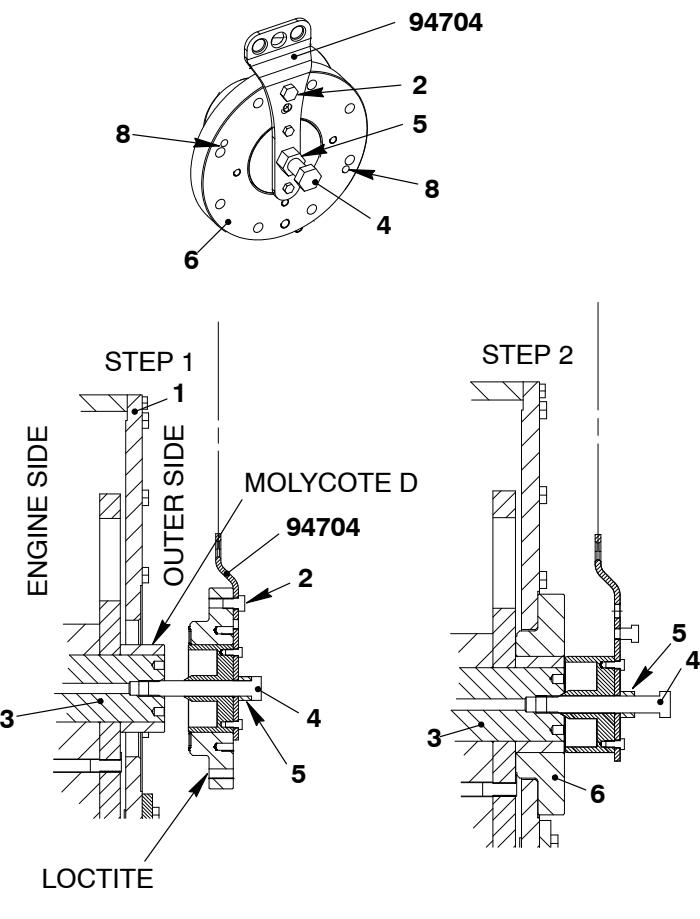


Fig. 8

4.2.2 Installation

- 1) Make sure that the new bearing (6, Fig. 8) is clean, dry and in good condition. Apply Molycote D to the bearing surface.
- Do not install the two taper pins (8, Fig. 9).
- 2) Attach the lifting 94704 tool to the new bearing (6, Fig. 6). Tighten screw (2).
- 3) Lift bearing (6) in front of the pin (3).
- 4) Apply Loctite No. 640 to the contact surface of the bearing (6).
- 5) Apply Molycote D to the bearing surface of pin (3).
- 6) Install screw (4) together with nut (5) through the bearing (6) into the pin (3).
- 7) Remove screw (2).
- 8) Locate the taper pin bores in the cover (1) and turn the new bearing until the pin bores in the bearing (6) are 90° to the ones in the cover.
- 9) Tighten nut (5) and guide the bearing (6) in the correct position on the column (1) (STEP 2).
- Use the crane if the pin (3) is too low.
- 10) Remove lifting tool 94704.

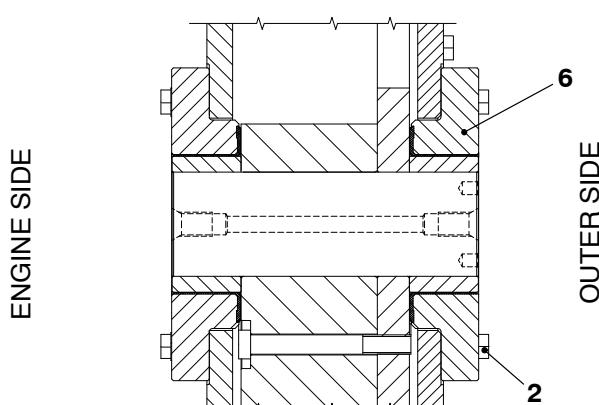


Fig. 9

WCH03465

- 11) Install four (of eight) bolts M20x70 (2, Fig. 9) without tightening.
- 12) Adjust the backlash and the parallelism of the gear wheels, refer to chapter 5.2.

Integrated Electric Balancer

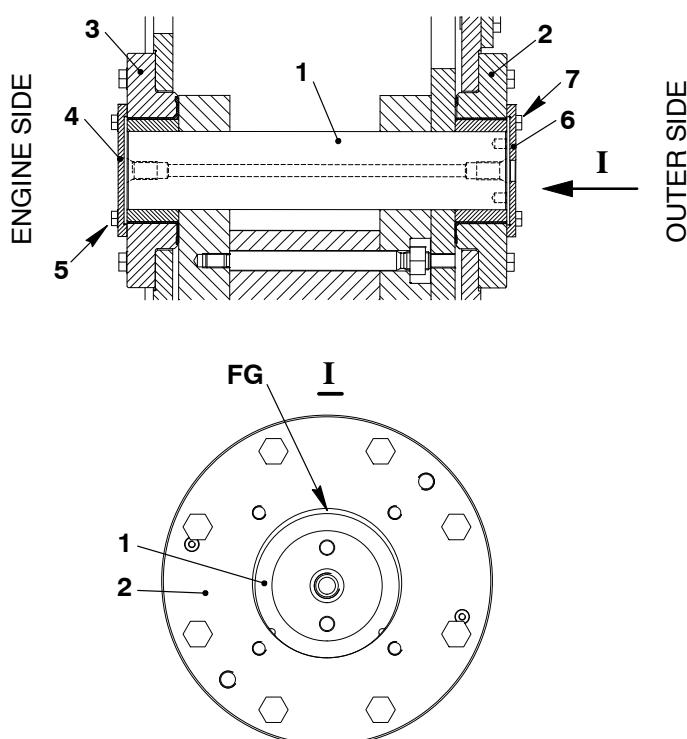


Fig. 10

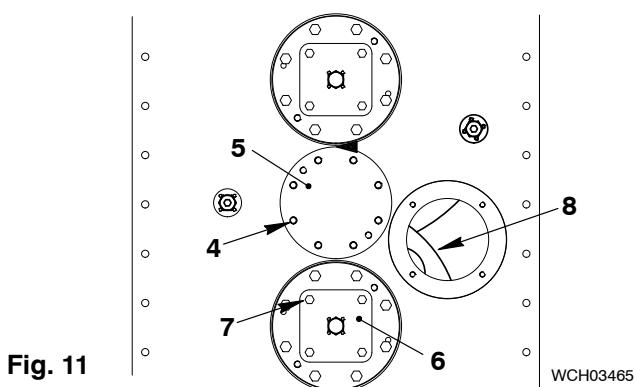


Fig. 11

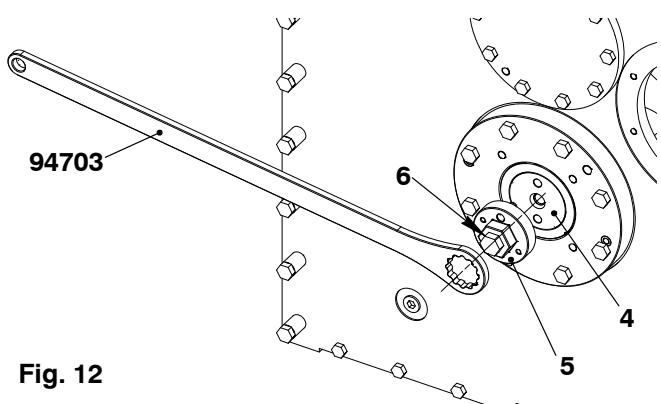


Fig. 12

5. Check**5.1 Bearing clearance**

- 1) Remove the four screws (5) and the locking plates on the bearing cover (4) at the engine side.
- 2) Remove the bearing cover on the engine side.
- 3) Remove the four screws (7) on the bearing cover (6) at the outer side.
- 4) Remove the bearing cover (6).
- 5) Use a feeler gauge to measure the clearance between pin (1) and bearing (2) and (3) at the upper position (FG).
- 6) Compare clearance with the data given in 0330-1.
- 7) Replace bearing if clearance is more than the allowed maximum clearance.
- 8) For the first time, it's recommended to call Wärtsilä Services Switzerland for expert advice.

5.2 Measure Backlash

- 1) Remove the eight screws (4, Fig. 11) and the cover (5).
- 2) Make sure the clamping screws (4, Fig. 2) are removed.
- 3) The service hole (8) to measure the backlash between motor pinion and lower gear wheel is reachable from inside the engine.
- 4) Remove the four screws (7) on the lower bearing cover (6) at the outer side.
- 5) Install turning device 94703 for turning the gear wheels, as follows:
 - Install the socket insert (5, Fig 12) with the screw (6) on the pin (4) of the lower bearing. Tighten the screw (6) with 100 Nm.

Integrated Electric Balancer

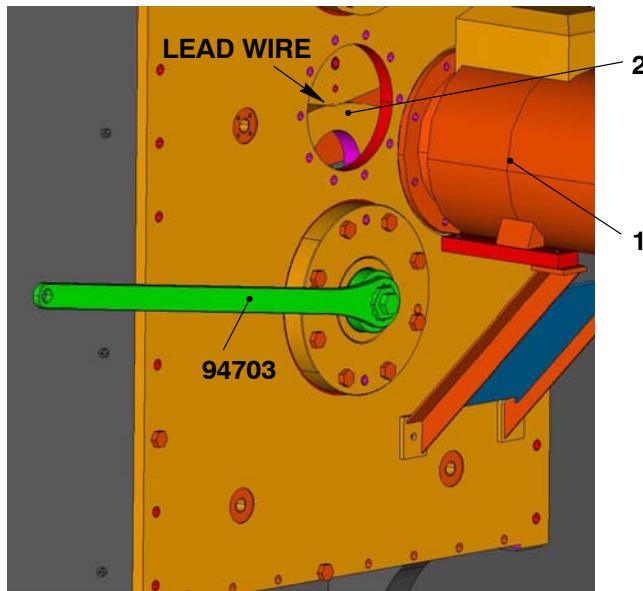
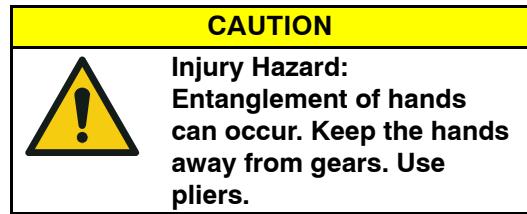
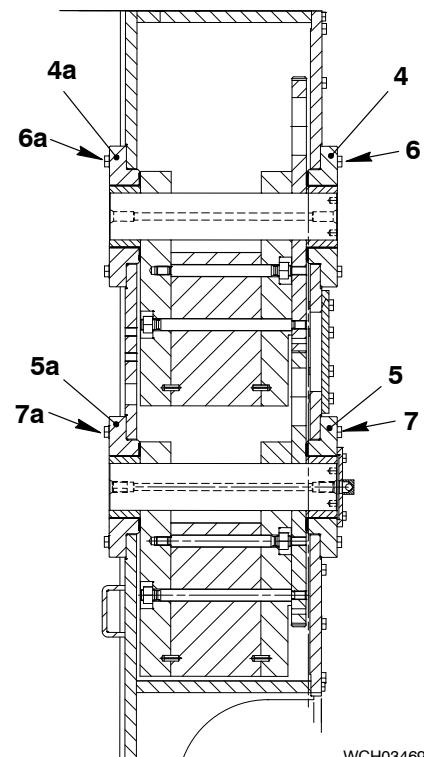
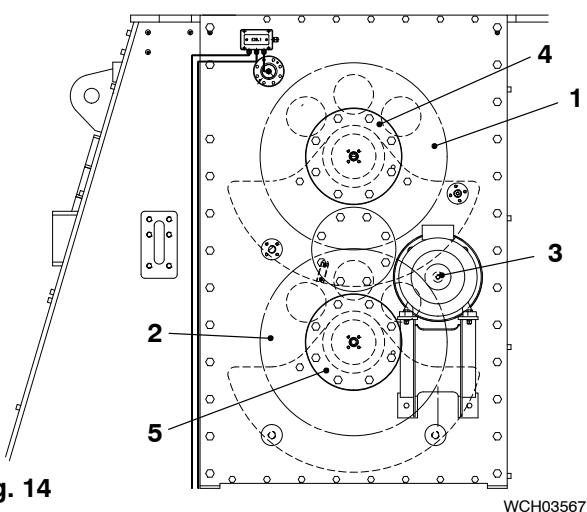


Fig. 13



- 6) Get a second person and use 1 mm lead wire to measure the backlash and the parallelism with lead wire between the pinion of the electric motor (1, Fig. 13) and the lower gear wheel (2) through a hole from inside the engine. See [0330-1](#) for data.
- If the backlash of lower gear wheel (2) to the pinion of the electric motor is within tolerances, you only have to loosen the bearings of the upper gear wheel.

Integrated Electric Balancer



5.3 Adjust bearings

It is recommended to consult a preferred service partner (e.g. Wärtsilä Switzerland) if you perform this adjustment the first time.

Principle: Loosen all bearings. Remove pins. Lift the upper bearing. Lift lower bearings until the backlash between the pinion and the lower gear wheel is within tolerances. Lower upper bearing until backlash is within tolerances. Turn the bearings by 90degree and drill new holes for the taper pins.

- If the backlash of lower gear wheel (2) to the pinion (3) of the electric motor is within tolerances, you only have to loosen the bearings of the upper gear wheel.

- 1) Make sure all the screws (6), (6a), (7), (7a) are loose or removed. One screw per bearing must stay on to hold the bearing.
- 2) If you have installed new bearings (4), (4a), (5), (5a) turn the bearings by 90 degree to drill a new hole for the taper pin later when adjustment is done.
- Taper pin must be removed on all bearings.

Integrated Electric Balancer

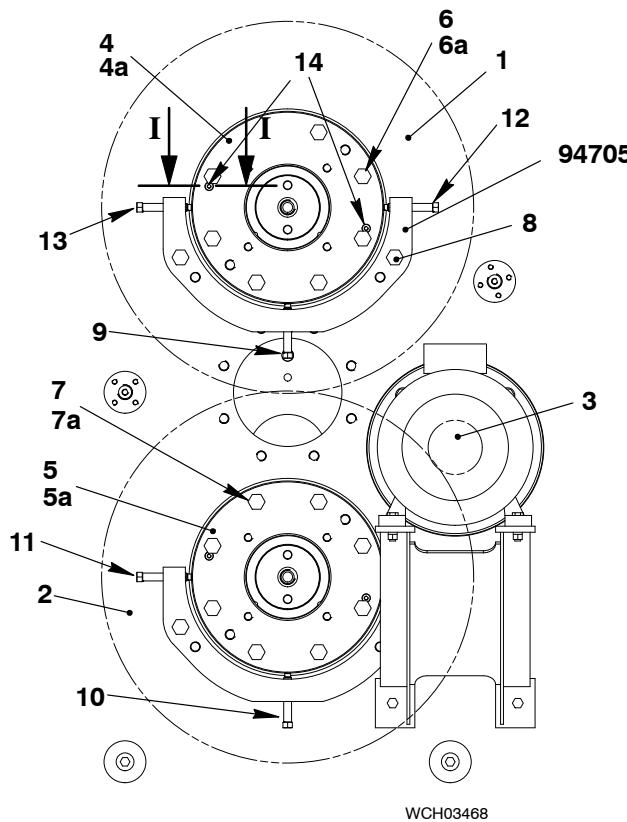
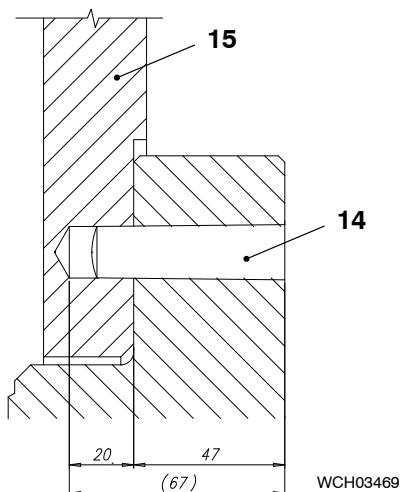


Fig. 16

I - I

- 3) Install the four alignment tools 94705 with screws (8). One for each bearing back and front. Apply oil to the screw (8) and tighten it with 280 Nm.
- 4) Lift the upper bearings rear and front (4 and 4a) with screw (9) to unload the lower gear wheel (2).
- 5) Adjust the backlash between pinion (3) of the electric motor and the gear wheel (2). See chapter 5.2 to measure the backlash.
 - Use screw (10) to adjust the height and screw (9) and the same screw on the other side to adjust the gear wheel horizontally.
 - Adjust front and rear to get a parallel gear wheel (2).
- 6) Lower and adjust the upper gear wheel (1) with the adjusting screws (9), (12) and (13) on front and rear.
- 7) Make sure all adjusted bearings are turned by 90 degree.
- 8) Measure the backlash again, refer to chapter 5.2.
- 9) Use a magnetic drill and a reamer to drill new holes into the cover (15) for taper pins (16 mm). Two holes per bearing.
 - Drill 20mm deep holes following the rules for tapered holes.
- 10) Insert two taper pins (14) per bearing.

Integrated Electric Balancer

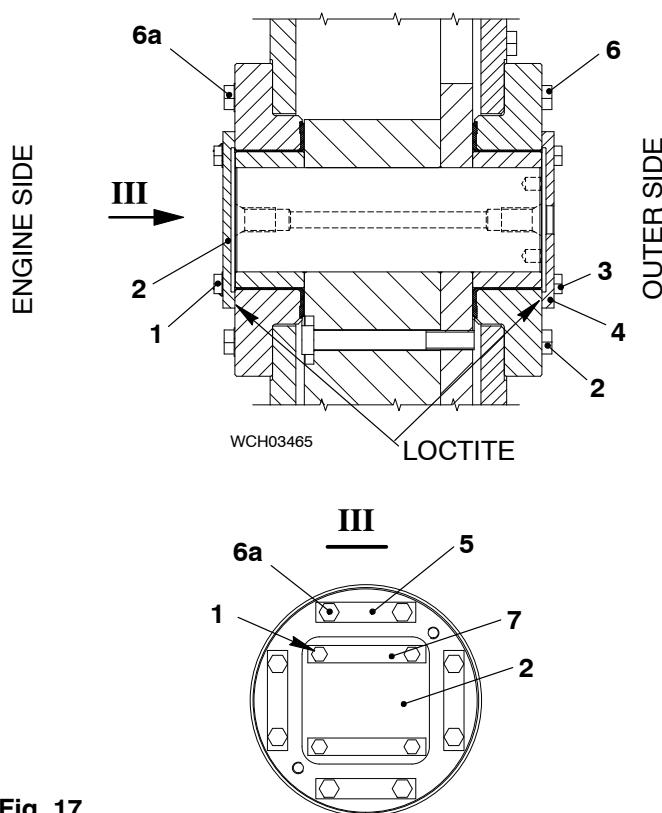


Fig. 17

6. Final steps:

- 1) Install eight bolts M20x70(6, Fig. 17) on each bearing at outer side and tighten them with standard torque.
- 2) Install eight bolts M20x70(6a) on each bearing at engine side with locking plates (5). Tighten bolts with standard torque and lock them.
- 3) Remove alignment tools 94705.
- 4) Apply Loctite No. 640 to the contact surface of bearing cover (2).
- 5) Install bearing cover (2) with four screws M16x35 (1) and locking plates (7). Tighten with standard torque and lock the screws with locking plates.
- 6) Apply Loctite No. 640 to the contact surface of bearing cover (4).
- 7) Install bearing cover (4) with four screws M16x35 (3). Tighten with standard torque.
- 8) Install the removed oil pipes.
- 9) Open the oil inlet and start the lubricating oil supply.

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Piping

Group 8

Exhaust Waste Gate (Low-load Tuning)	8135-1/A1
HP Servo Oil Pipe: Removal, Grind Sealing Faces and Installation (with HAWE SOP)	8447-1/A1
Hydraulic Pipe for Exhaust Valve Drive: Removal, Grind Sealing Faces and Installation	8460-1/A1
HP Fuel Pipe: Removal, Grinding and Installation	8733-1/A1
HP Fuel Pipe: Removal and Installation	8752-1/A1

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Exhaust Waste Gate (Low-load Tuning)

1. General

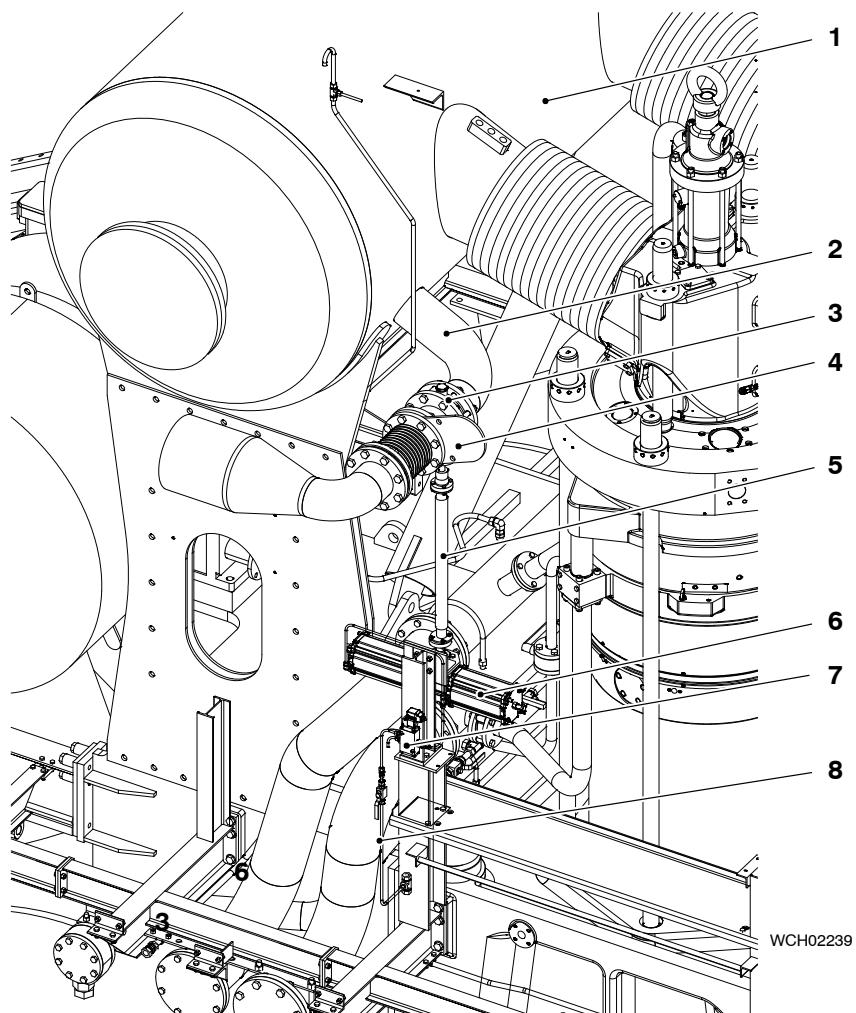
The Low-load Tuning (LLT) uses a specially designed turbocharger system and specified engine parameters. These parameters are related to fuel injection and exhaust valve control and get the best decreased part-load BSFC in LLT.

For more data about the exhaust waste gate and LLT, see the Operation Manual 8135-1.

2. Maintenance

Special maintenance of the butterfly valve (3, Fig. 1) is not necessary. For a general inspection, refer to the instructions in the documentation of the manufacturer.

To do a function check, see the Operation Manual 8135-1 and the Maintenance Schedule [0380-1](#).



Note: Some parts can look different.

Fig. 1: Exhaust Waste Gate

- | | |
|------------------------|-----------------------|
| 1 Exhaust manifold | 5 Cardan rod |
| 2 Exhaust by-pass line | 6 Control actuator |
| 3 Butterfly valve | 7 Solenoid valve |
| 4 Orifice | 8 Air spring air pipe |

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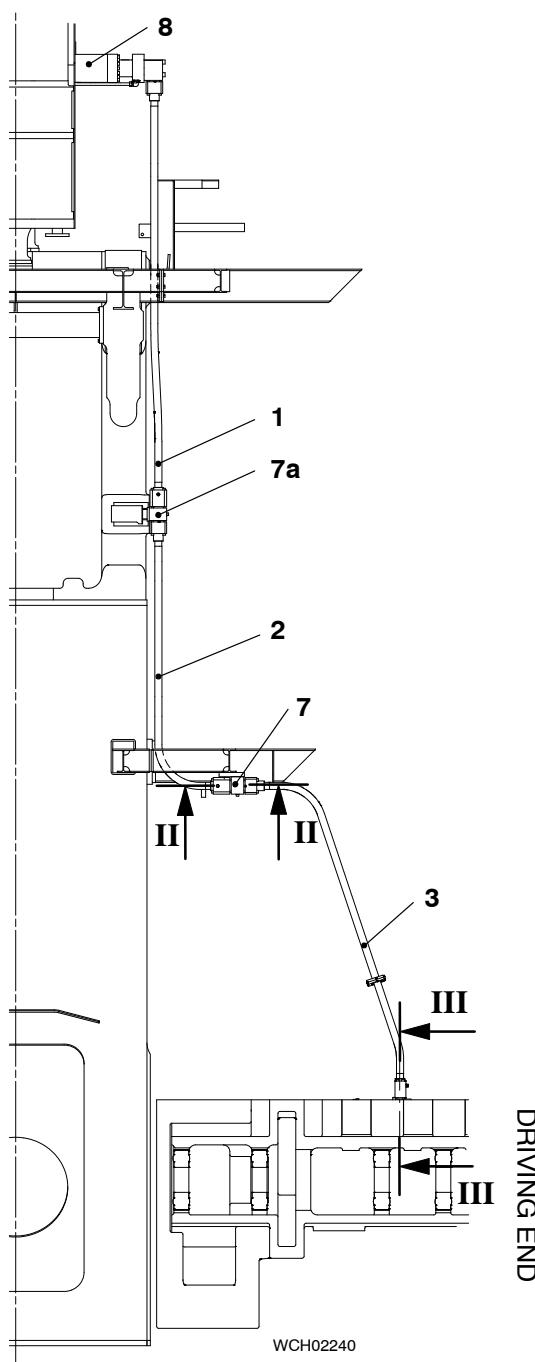
HP Servo Oil Pipe

Removal, Grind Sealing Faces and Installation (with DY-NEX SOP)

Tools:

1 Grinding tool 94841 Emery cloth (as necessary)
 1 Template 94841A 1 Hand drill

1.	General	1
2.	Removal	1
2.1	Removal of HP servo oil pipe 3	2
2.2	Removal of HP servo oil pipe 2 and 1	2
3.	Sealing Faces – Grind	3
4.	Adjusting the claws	4
5.	Fitting	4



1. General

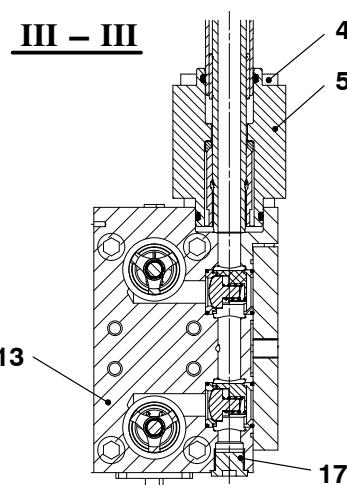
Stop the engine and drain the HP servo oil pipes.

- Place an oil tray under the relevant Servo oil pump and loosen screw plug (17) to drain the HP servo oil pipe.
- Loosen screws (4) to servo oil rail connection and push flange (5) back to get air into the pipe. Wait a minute to let the oil drain (View I-I).

Non-return valve (11) prevents servo oil rail from discharging. For further information see operating manual 8016-1.

2. Removal

- Pay attention not to damage sealing faces 'SF'.
- All connections must be closed off immediately and the sealing faces must be protected against any damages.



2.1 Removal of HP servo oil pipe 3

- 1) Remove the bottom clamp (13).
- 2) Loosen the screws (4) of the bottom flange (5) (View III-III).
- 3) Remove the screws (4) of the top flange (5) and push the flange (5) back until they disengage, then remove the servo oil pipe (3).

2.2 Removal of HP servo oil pipe 2 and 1

- 1) Remove the clamp (12a) (pipe 1) and loosen the screws (4) of bottom flange (5).
- 2) Remove the screws (6) and bottom intermediate pieces (7) and (7a).
- 3) Loosen screws (4) of the top flange (5), then carefully remove the pipe.

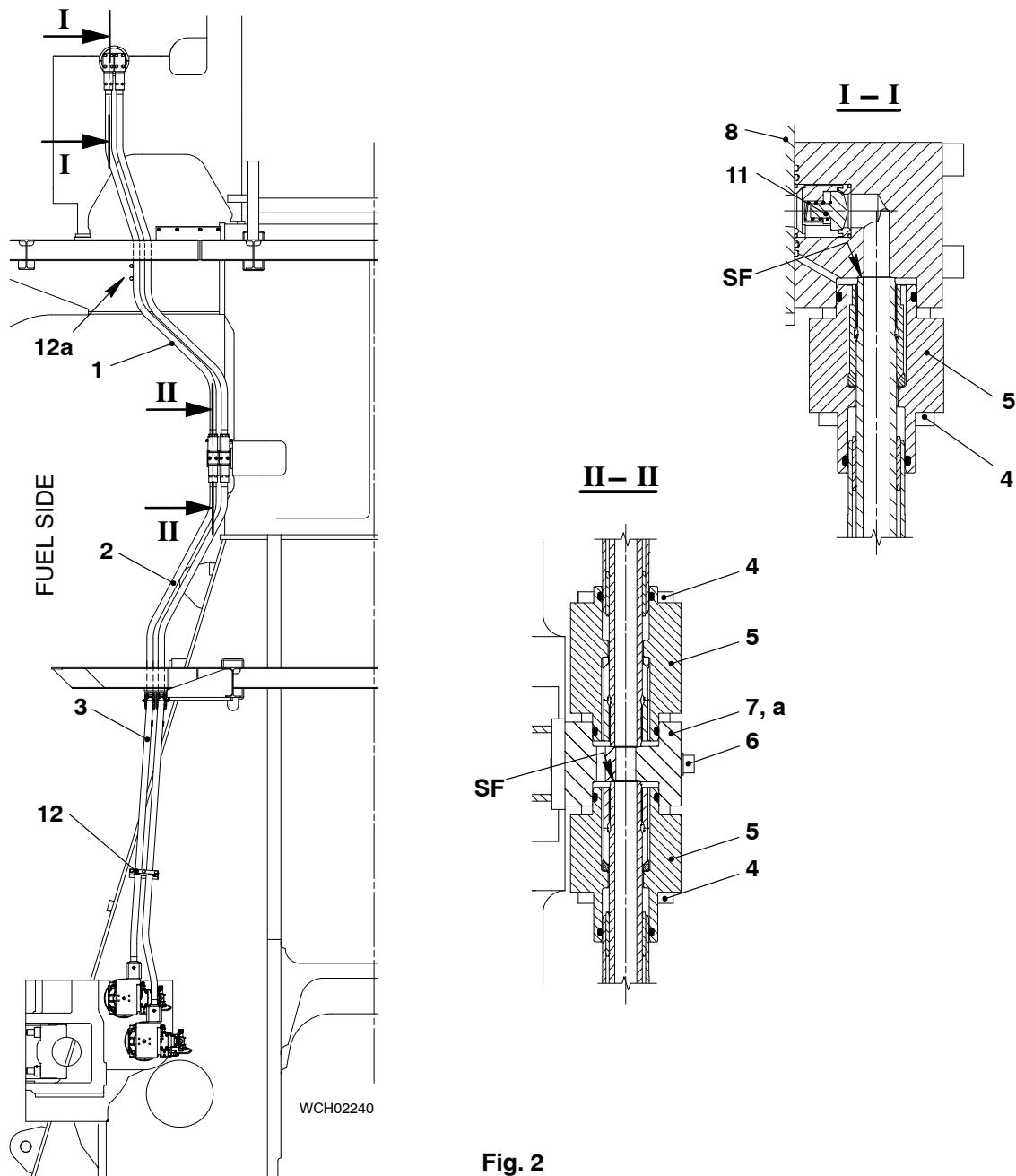
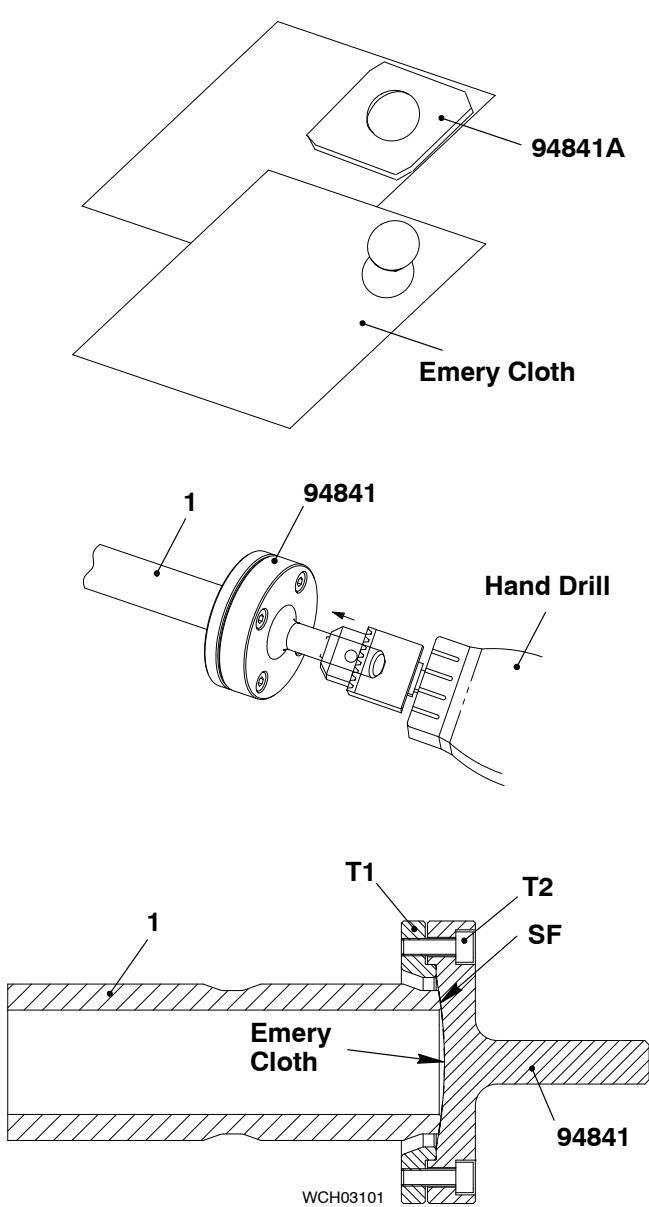


Fig. 2

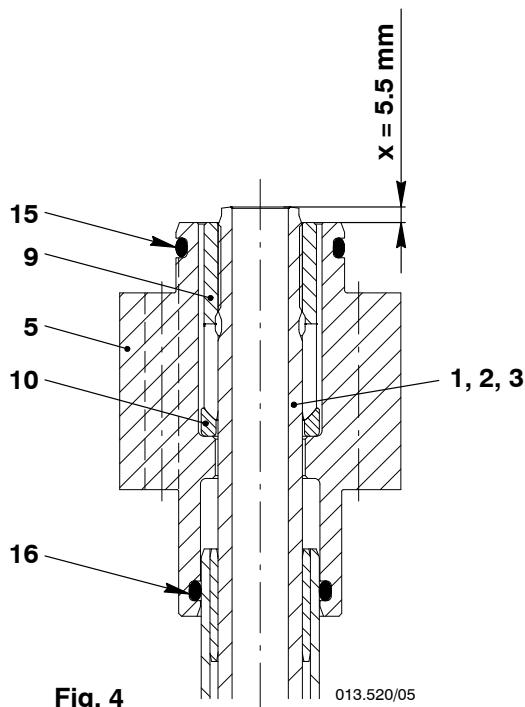
**Fig. 3**

- 16) Make sure that the circular marks around the sealing face of the pipe are concentric.
- 17) Change the emery cloth for a smoother grade, then do step 1) to step 16) again until you get a smooth finish.
- 18) Replace the emery cloth with a polishing cloth as a last step to polish the HP servo oil pipe.
- 19) Clean the HP servo oil pipe (1).
- 20) If necessary, do step 1) to step 19) for the other servo oil pipes.

3. Sealing Faces – Grind

To get a clean and smooth finish on the hydraulic pipe, do step 1) to step 20):

- 1) Put the template (94841A, Fig. 3) on the back of the emery cloth.
- 2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
- 3) Use a pencil or a ball pen to make the inner shape.
- 4) Cut out accurately the shape.
- 5) Remove the four screws (T2) and the grinding tool (94841).
- 6) Apply Molyslip Copaslip paste to the threads and faces of the four screws (T2).
- 7) Remove the cover (T1).
- 8) Put the emery cloth you cut out into the grinding tool (94841).
- 9) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the hydraulic pipe (1).
- 10) Torque symmetrically the the four screws (T2) to 2.0 Nm.
- 11) Put the hydraulic pipe (1) in a vice, as vertically as possible.
- 12) Adjust the speed of the hand drill to between 200 rpm and 500 rpm.
- 13) Align the hand drill and the grinding tool (94841) accurately with the hydraulic pipe (1) as shown.
- 14) Use light pressure and start grinding.
- 15) Regularly remove the unwanted material from the grinding tool (94841).



4. Adjusting the claws

Before fitting the HP servo oil pipe check whether its claws (9, [Fig. 4](#)) 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.

5. Fitting

Fitting is carried out analogously to the removal but in reverse sequence. The HP servo oil pipes must be installed as stress-free as possible achieving a proper sealing function. Moreover, all pipe clips and pipe brackets must be carefully fastened.

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

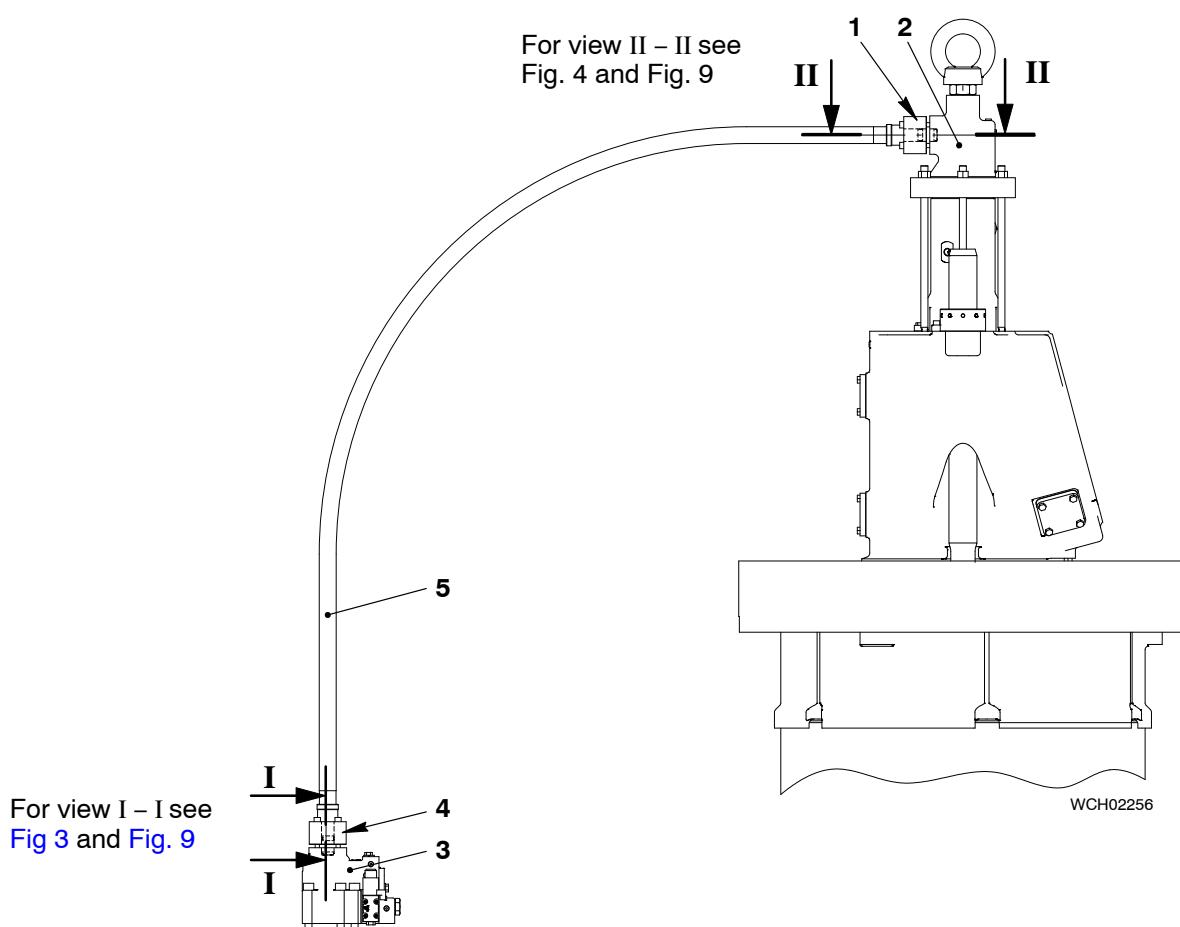
- Apply oil to the threads of screws (4 and 6) and tighten them crosswise with a torque of **20 Nm**.
- If the non-return valves ([Fig. 2](#)) have been removed maintain their flow direction and observe the following when refitting them:
 - 1) Replace O-rings on non-return valve (11).

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

Hydraulic Pipe for Exhaust Valve Drive**Removal, Grind Sealing Faces and Installation****Tools:**

- 1 Grinding tool 94841
 1 Stencil 94841A

1. Preparation	2
2. Removal	3
3. Sealing Faces – Grind	4
4. Installation	4

**Fig. 1 Exhaust Valve Control Unit**

- | | |
|------------------------------------|------------------|
| 1 Flange | 4 Flange |
| 2 Top housing | 5 Hydraulic pipe |
| 3 Exhaust valve control unit (VCU) | |

1. Preparation

WARNING



Injury Hazard: The servo oil system has high pressure. Replace a defective hydraulic pipe only when the engine has stopped.

- 1) Stop the engine (see the Operation Manual 4002-2).
- 2) Set to off the servo oil service pump.
- 3) Make sure that there is no pressure in the servo oil system (see the data given in the Operation Manual 0520-1).
- 4) Set to off the main bearing oil supply.

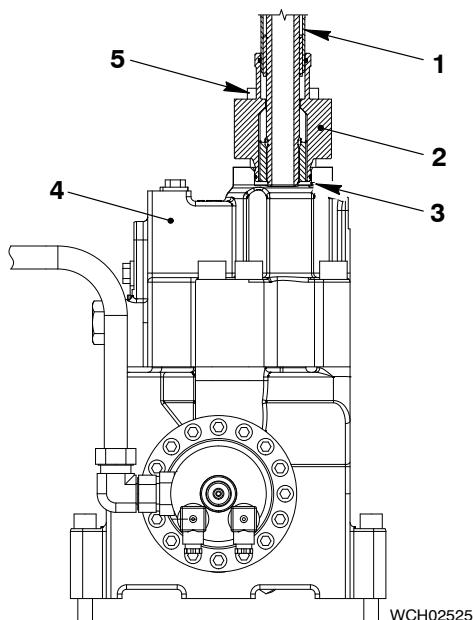


Fig. 2

WARNING



Injury Hazard: Always put on gloves and safety goggles when you do work on hot components. When drain screws and plugs are opened, servo oil can come out as a spray and cause injury.

- 5) Put an oil tray under the applicable hydraulic pipe (1, [Fig. 2](#)).
- 6) Loosen the screws (5) on the flange (2) to drain the applicable hydraulic pipe (1) through the check bore (3) in the housing of the VCU (4).

Hydraulic Pipe for Exhaust Valve Drive: Removal, Grind Sealing Faces and Installation

2. Removal

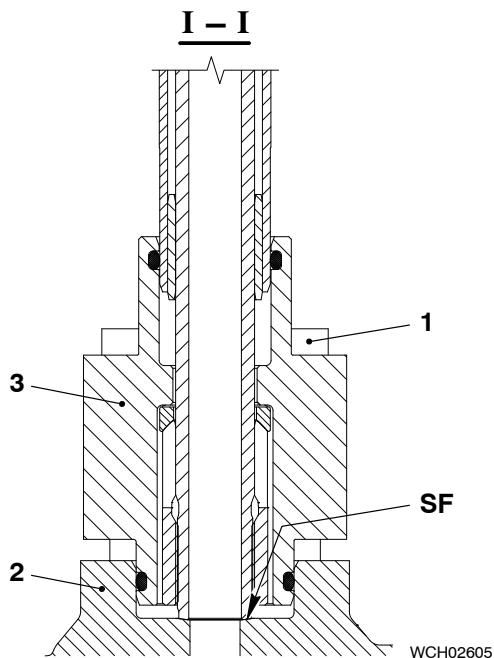


Fig. 3

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces or the hydraulic pipes.

- 1) Remove the four screws (1, Fig. 3) from the flange (3).
- 2) Carefully move the flange (3) away from the VCU (2).

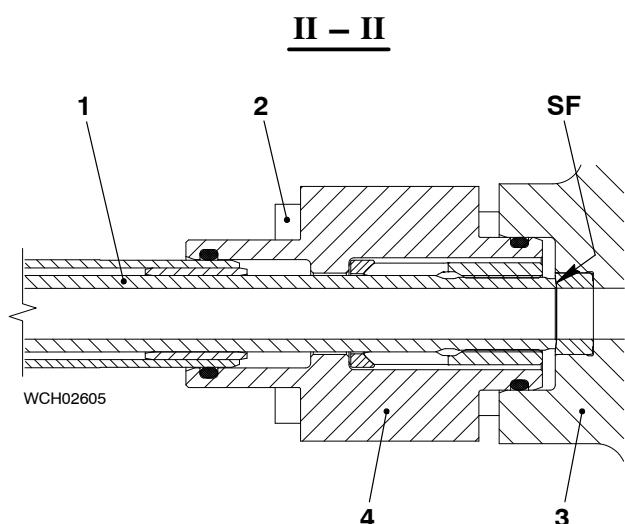


Fig. 4

- 3) Remove the four screws (2, Fig. 4) from the flange (4).

- 4) Carefully move the flange (4) away from the top housing (3).

CAUTION

Injury Hazard: The weight of the hydraulic pipe is approximately 47 kg. Use approved equipment or sufficient personnel to lift and move the hydraulic pipe.

- 5) Carefully remove the hydraulic pipe (1).
- 6) Apply protection to the sealing faces (SF) to prevent damage and contamination.

Hydraulic Pipe for Exhaust Valve Drive: Removal, Grind Sealing Faces and Installation

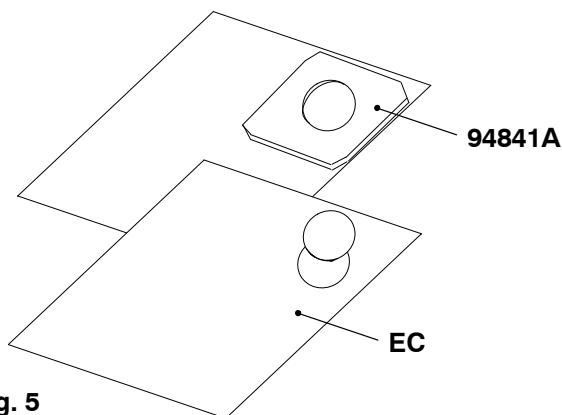


Fig. 5

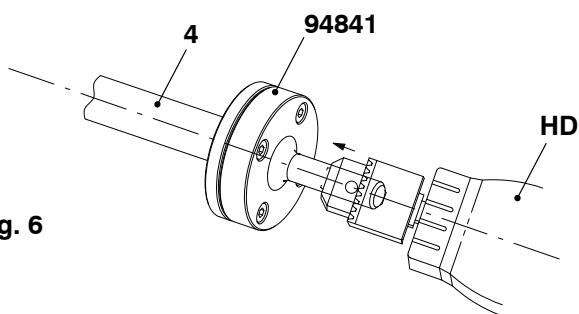


Fig. 6

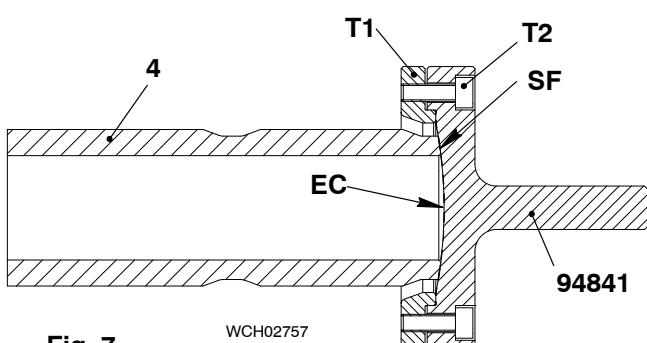


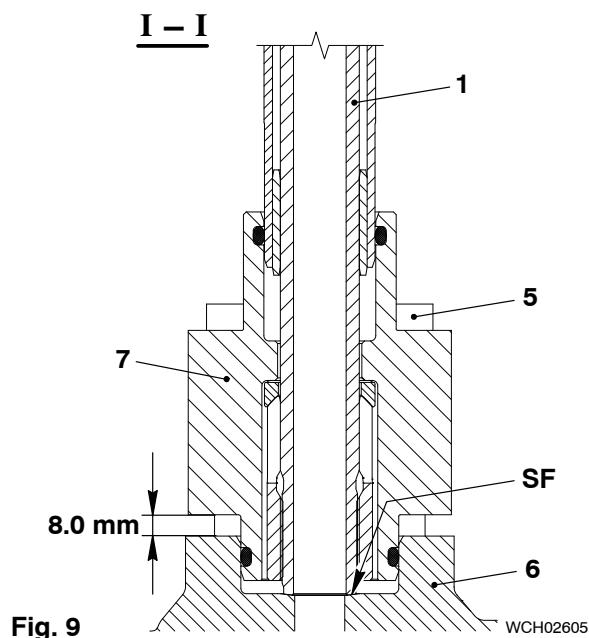
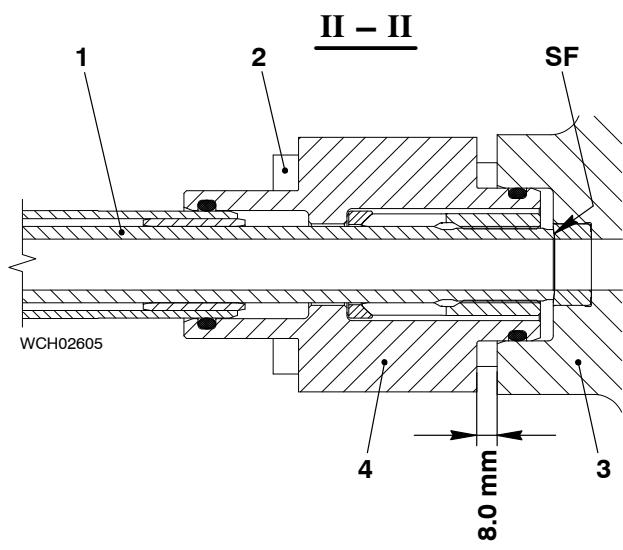
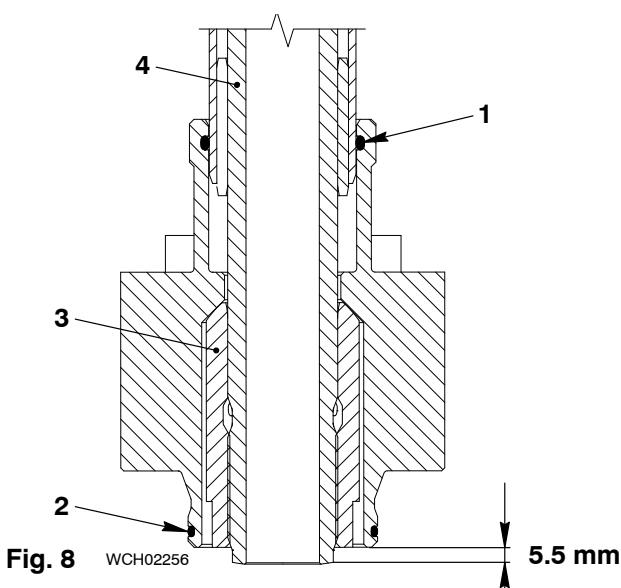
Fig. 7

3. Sealing Faces – Grind

To get a clean and smooth finish on the pipe procedure as follows:

- 7) Put the Stencil 94841A on the back of emery cloth 'EC'.
- 8) Use the grade of the emery cloth according to the amount of metal you want to grind.
- 9) Use a pointed pencil or a ball pen to sign the inner contour.
- 10) Cut out accurately the signed contour.
- 11) Loosen and remove the four screws T2, Fig. 7.
- 12) Apply Molyslip Copaslip paste to the threads and contact surface of the four crews T2.
- 13) Remove the flansh T1 and put the emery cloth in the regrinding device 94841.
- 14) Clamp the emery cloth slightly with the flansh T1 and the four screws T2.
- 15) Push the emery cloth in the spherical shape of the regrinding device.
- 16) Torque symmetrically the four screws T2 to 2 Nm.
- 17) Install the HP injection pipe (4) in a vice, as vertically as possible.
- 18) Adjust the speed of the hand drill HD between 200 and 500 rpm.
- 19) Put the hand drill with the regrinding device 94841 exactly in line on to the HP injection pipe as shown in Fig. 6.
- 20) Start grinding with a slight pressure.
- 21) Check if the grinding circles are concentric around the bore of the pipe and remove swarf from the tool.
- 22) Repeat the grinding procedure a few times and each time with a finer emery cloth. Use a polishing cloth at last.
- 23) Clean the HP injection pipe 4.
- 24) If necessary, do steps above for the other HP injection pipes.

Hydraulic Pipe for Exhaust Valve Drive: Removal, Grind Sealing Faces and Installation

**4. Installation**

- 1) Replace O-rings (1) and (2) if necessary and make sure they are in position.
- 2) Make sure that the claw (3, Fig. 8) is correctly attached to the hydraulic pipe (4).

Note: You can adjust the claw (3) with an open-ended wrench.

- 3) Make sure that there is a distance of 5.5 mm between the end of the hydraulic pipe (4) and the claw (3).

- 4) Remove all of the protection from the sealing faces SF in the top housing (3, Fig. 9) and the VCU (6).
- 5) Apply oil to the threads of all the screws (2, 5).

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces (SF) or the hydraulic pipes. Do not apply lateral force to the hydraulic pipe and the flanges.

- 6) Carefully put the hydraulic pipe (1, Fig 9) in position in the top housing (3) and the VCU (6).
- 7) Torque symmetrically the four screws (2) to 40 Nm.
- 8) Make sure that there is a distance of 8.0 mm between the flange (4) and the top housing (3).

Note: After 1000 operation hours, do step (7) and step (8) again.

- 9) Torque symmetrically the four screws (5) to 40 Nm.
- 10) Make sure that there is a distance of 8.0 mm between the flange (7) and the VCU (6).

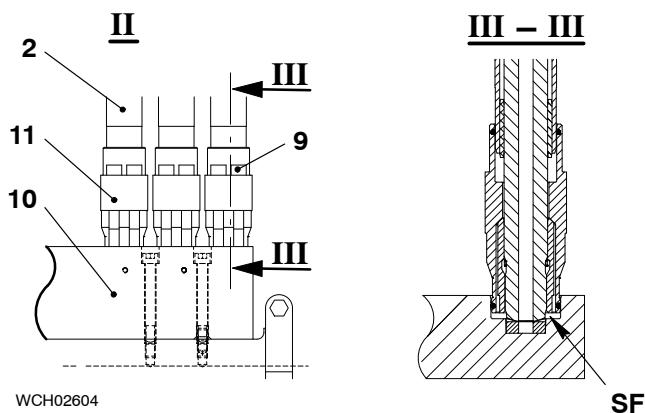
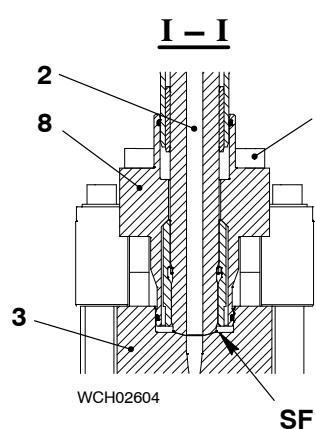
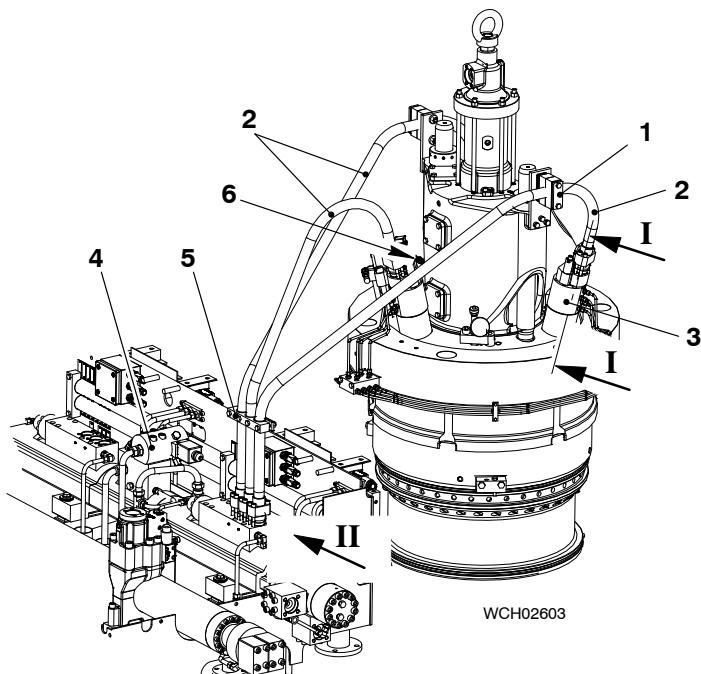
Note: After 1000 operation hours, do step (9) and step (10) again.

- 11) Set to on the main bearing oil supply.

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HP Fuel Pipe**Removal, Grinding and Installation****Tools:**

1	Grinding tool	94871
1	Stencil	94871A

**Fig. 1: HP Injection Pipes – Removal****1. Preparation**

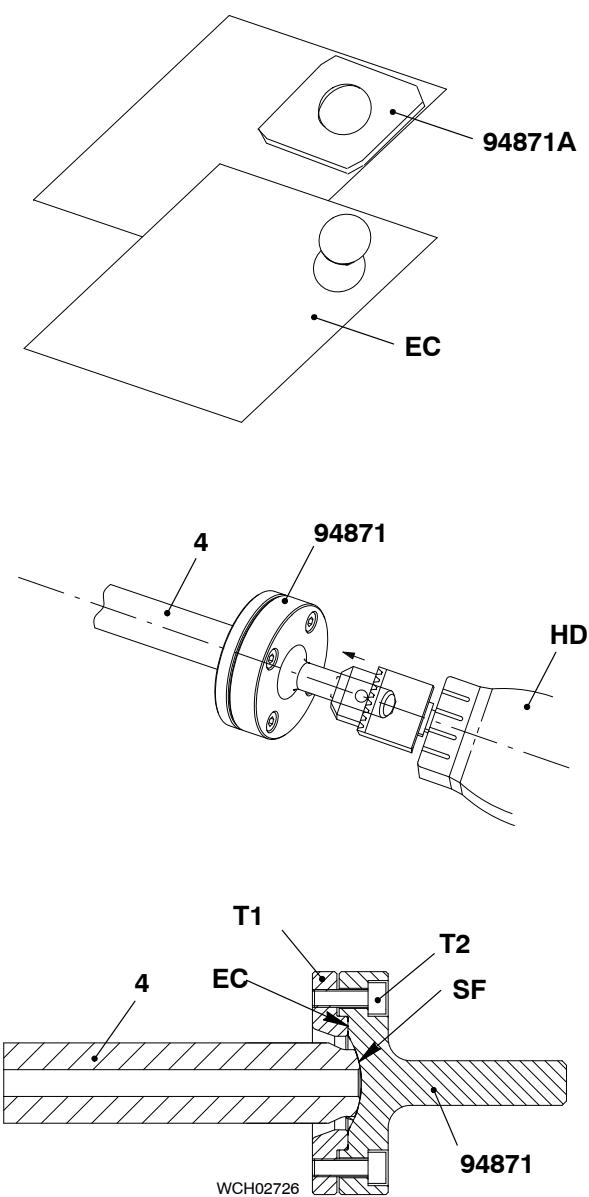
- 1) Stop the engine (see the Operation Manual 4002-2).
- 2) Make sure that there is no pressure in the fuel rail as follows:
 - a) Set to off the fuel booster pump (plant).
 - b) Close the shut-off valves to the fuel inlet and return pipes.
 - c) Operate the button on the pressure control valve (4, Fig. 1) to release the pressure in the fuel rail.
 - d) On the Local Display Unit (LDU), make sure that the pressure shows zero.
- 3) Set to off the electrical trace heating system.

2. Removal**CAUTION**

Damage Hazard: Make sure that you do not damage the sealing faces or the HP injection pipes.

- 1) On the applicable HP injection pipe (2), disconnect the electrical connection (6).
- 2) Remove the applicable pipe bracket (1).
- 3) Remove the pipe bracket (5).
- 4) On the injection valve (3) remove the four screws (7) from the flange (8).
- 5) On the flange (11), remove the four screws (9).
- 6) Carefully remove the applicable HP injection pipe (2) from the injection valve (3) and the flow limiter valve (10).
- 7) Apply protection to the sealing faces (SF) and the open ends of the HP injection pipe (2).

HP Fuel Pipe: Removal, Grinding and Installation

**Fig. 2: Grinding****3. Sealing Faces – Grind**

To get a clean and smooth finish on the pipe procedure as follows:

- 1) Put the Stencil 94871A on the back of emery cloth EC, Fig. 2.
- 2) Use the grade of the emery cloth according to amount of metal you want to grind.
- 3) Use a pointed pencil or a ball pen to sign the inner contour.
- 4) Cut out accurately the signed contour.
- 5) Remove the four screws T2 and the flange T1.
- 6) Apply Molyslip Copaslip paste to the threads and contact surface of the four crews T2.
- 7) Put the emery cloth in the regrinding device 94871.
- 8) Clamp the emery cloth slightly with the flange T1 and the four screws T2.
- 9) Push the emery cloth in the spherical shape of the regrinding device.
- 10) Torque symmetrically the four screws T2 to 2 Nm.
- 11) Install the HP injection pipe (4) in a vice, as vertically as possible.
- 12) Adjust the speed of the hand drill between 200 and 500 rpm.
- 13) Put the hand drill with regrinding device 94871 exactly in line on to the HP injection pipe and start grinding with a slight pressure.
- 14) Check if the grinding circles are concentric around the bore of the pipe and remove swarf from the tool.
- 15) Repeat the grinding procedure a few times and each time with a finer emery cloth. Use a polishing cloth at last.
- 16) Clean the HP injection pipe (4).
- 17) If necessary, do steps above for the other HP injection pipes.

HP Fuel Pipe: Removal, Grinding and Installation

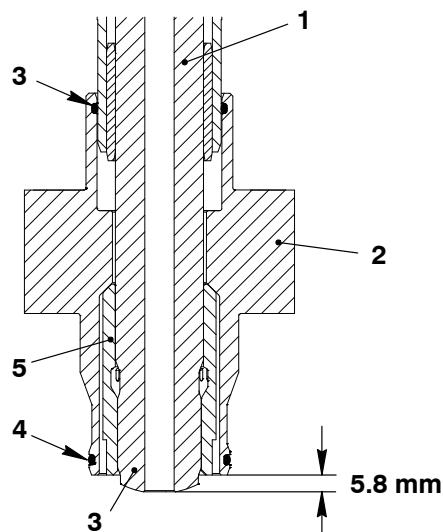


Fig. 3: Adjustment

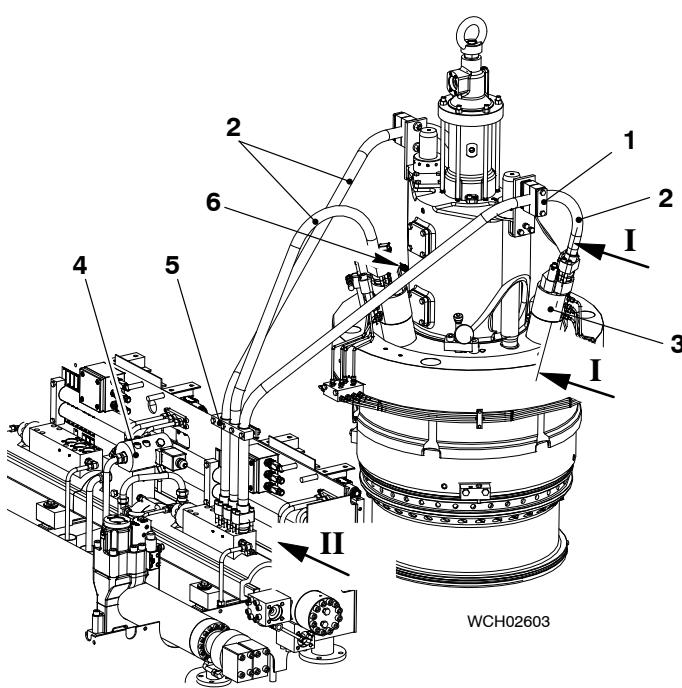
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4. Adjustment

- 1) Replace O-rings (3) and (4) if necessary.
- 2) Make sure that the claw (5) is correctly attached to the HP injection pipe (1).
- 3) Make sure that there is a distance of 5.8 mm between the end of the HP servo oil pipe (1) and the claw (5).

Note: You can adjust the claw (5) with an open-ended wrench.

HP Fuel Pipe: Removal, Grinding and Installation



5. Installation

- 1) Remove all of the protection from the sealing faces (SF) in the injection valve (3, Fig. 3) and the flow limiter valve (10).
- 2) Apply Never-Seez NSBT to threads of the screws (7 and 9).
- 3) Carefully put the HP injection pipe (2) in position in the injection valve (3) and the flow limiter valve (10).
- 4) Torque symmetrically the four screws (7) to 60 Nm.
- 5) Torque symmetrically the four screws (9) to 60 Nm.
- 6) Install the pipe clamp (5).
- 7) Install the applicable pipe clamp (1).

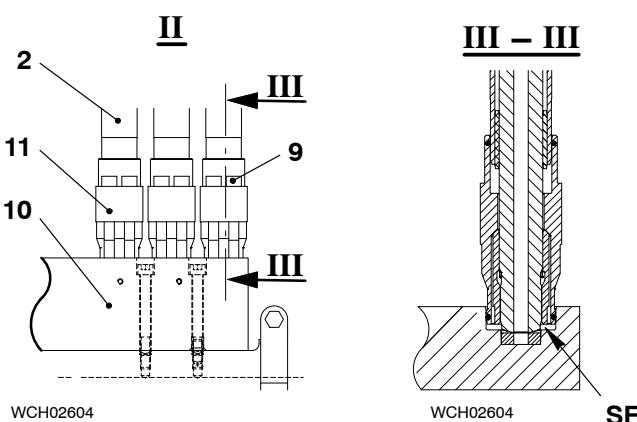
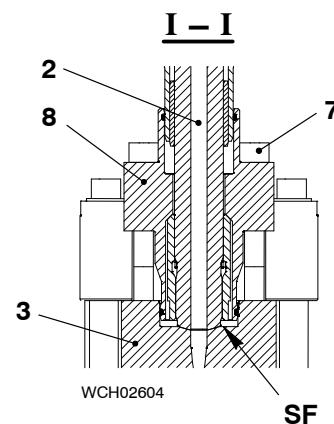


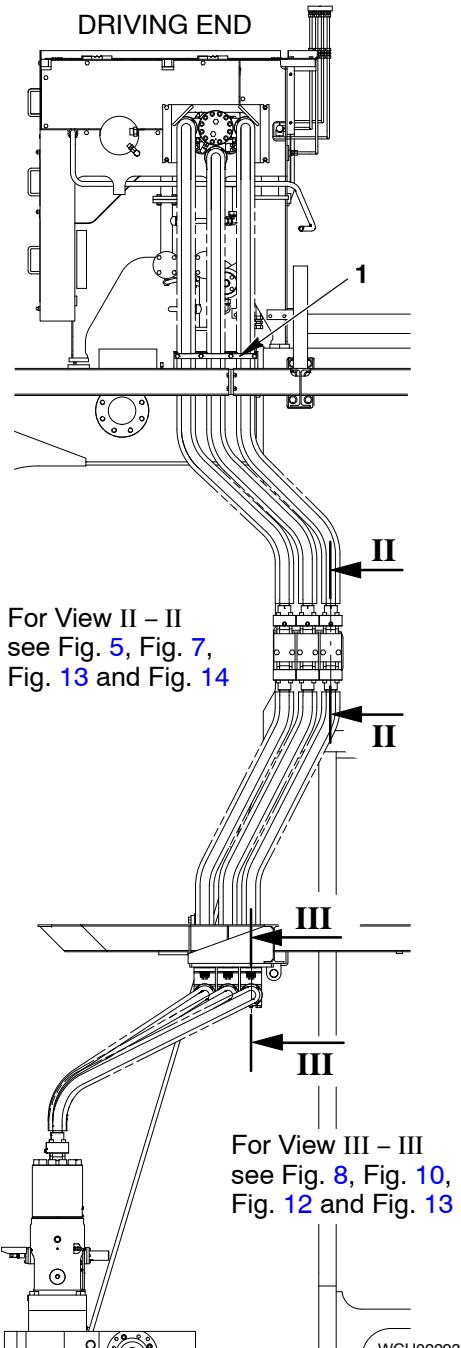
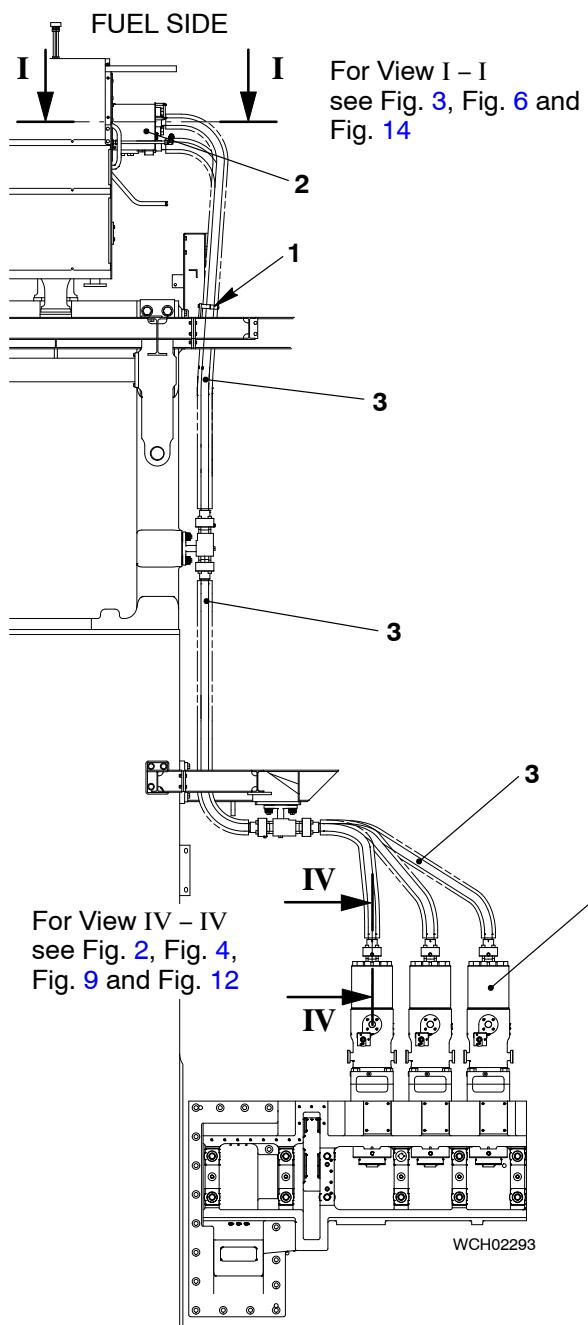
Fig. 4: HP Injection Pipe – Installation

HP Fuel Pipe**Removal, Grinding and Installation**

1. Preparation	3
2. Removal	5
3. Sealing Faces – Grind	8
4. Installation	9

Tools:

1 Grinding device 94870

**Fig. 1: HP Fuel Pipes**

- 1 Clamp
- 2 Fuel rail

- 3 HP fuel pipe
- 4 Fuel pump

HP Fuel Pipe: Removal and Installation

1. Preparation

WARNING



Injury Hazard: The fuel system has high pressure. Replace a defective HP fuel pipe only when the engine has stopped. You must obey the data given in the Operation Manual 0520-1.

- 1) Stop the engine (see the Operation Manual 4002-2).
- 2) Set to off the fuel supply pump.

WARNING



Injury Hazard: Hot Component. Always put on gloves and safety goggles when you do work on hot components. When screws and plugs are opened, steam or fuel can come out and cause injury.

- 3) Set to off the trace heating.
- 4) If the HP fuel pipes must be replaced, remove the insulation from the HP fuel pipes (1, Fig. 2).
- 5) If necessary, disconnect the trace heating pipes.

CAUTION



Damage Hazard: Make sure that you do not damage the sealing faces or the HP fuel pipes. Do not apply lateral force to the HP fuel pipes and the flanges.

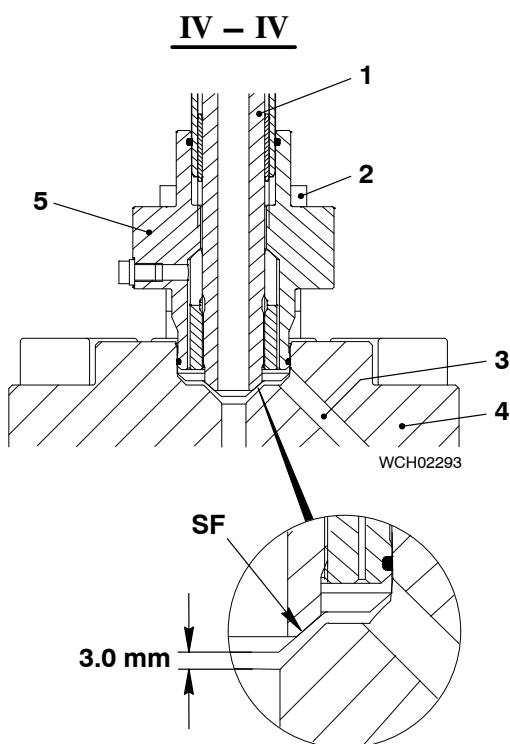


Fig. 2

- 6) Put an oil tray under the applicable fuel pump.
 - 7) Loosen the four screws (2, Fig. 2) on the flange (5) a maximum of three turns.
- Note:** The fuel will drain through the drain bore (3) into the fuel leakage pipe.
- 8) Move the HP fuel pipe (1) up. Make sure that there is a distance of approximately 3.0 mm between the fuel pump cover (4) and the HP fuel pipe (1).

HP Fuel Pipe: Removal and Installation

I – I

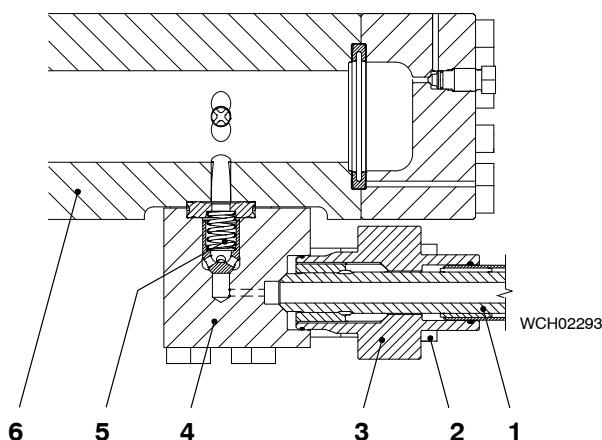


Fig. 3

- 9) Loosen the four screws (2, Fig. 3) on the flange (3) a maximum of three turns.

- 10) Move the flange (3) away from the valve housing (4) and make sure that air goes into the HP fuel pipe (1).

Note: The non-return valve (5) prevents the back-flow of fuel from the fuel rail (6).

IV – IV

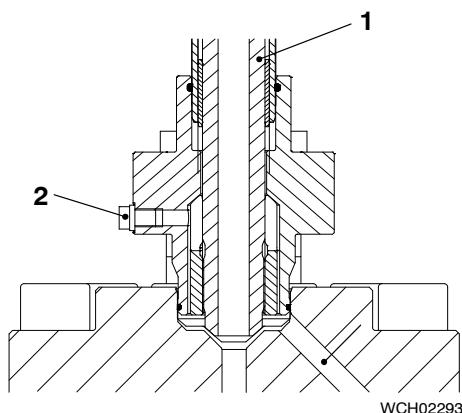


Fig. 4

- 11) Open the screw plug (2, Fig. 4). If there is no fuel, the HP fuel pipe (1) is fully drained.

- 12) Tighten the screw plug (2).

HP Fuel Pipe: Removal and Installation

2. Removal

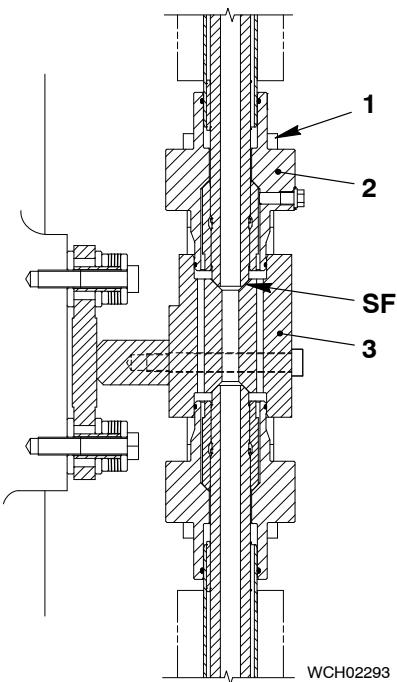
II – II

Fig. 5

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces or the HP fuel pipes.

- 1) Remove the clamps (1, Fig. 1).
- 2) Remove the four screws (1, see Fig. 5) from the flange (2).
- 3) Carefully move the flange (2) away from the intermediate piece (3).

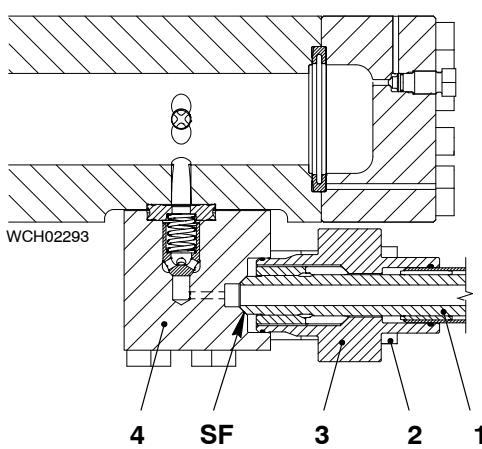
I – I

Fig. 6

- 4) Remove the four screws (2, Fig. 6) from the flange (3).

- 5) Carefully move the flange (3) away from the valve housing (4).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 43 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

- 6) Carefully remove the HP fuel pipe (1).

- 7) Apply protection to the sealing faces (SF) to prevent damage and contamination.

HP Fuel Pipe: Removal and Installation

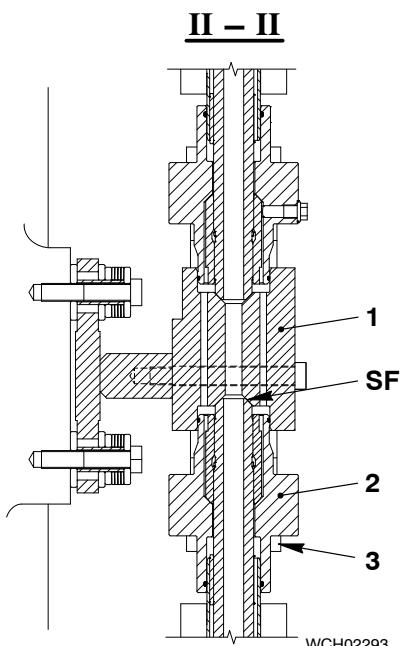


Fig. 7

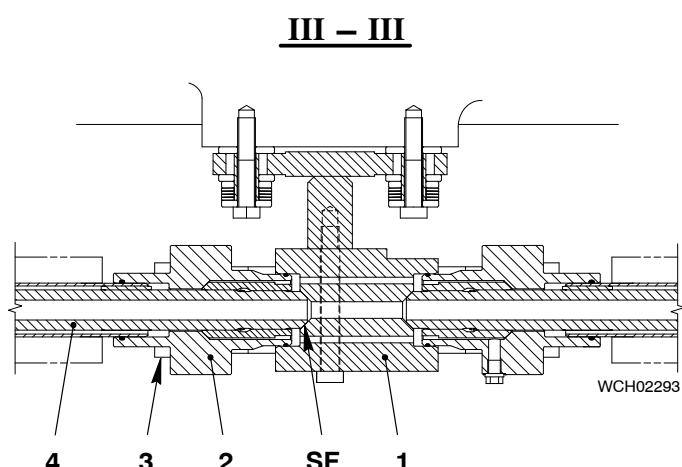


Fig. 8

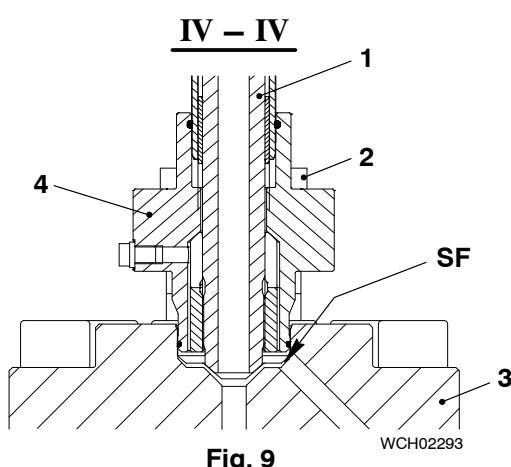


Fig. 9

- 8) Remove the four screws (3, Fig 7) from the flange (2).
- 9) Carefully move the flange (2) away from the intermediate piece (1).

10) Remove the four screws (3, Fig 8) from the flange (2).

11) Carefully move the flange (2) away from the intermediate piece (1).

CAUTION


Injury Hazard: The weight of the HP fuel pipe is approximately 32 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

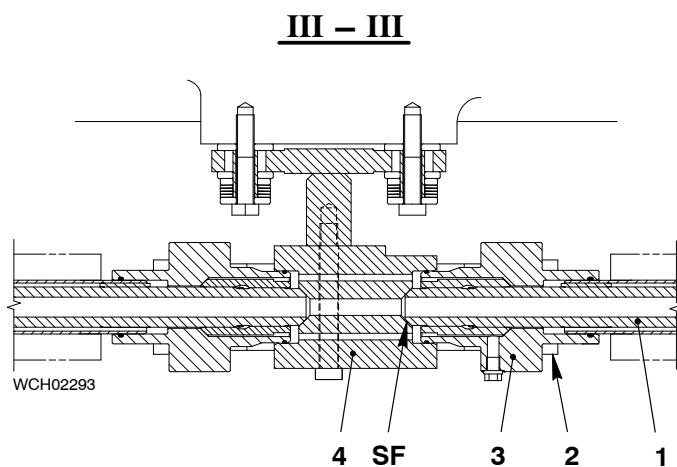
12) Carefully remove the HP fuel pipe (4).

13) Apply protection to the sealing faces (SF) to prevent damage and contamination.

14) Remove the four screws (2, Fig. 9) from the flange (4).

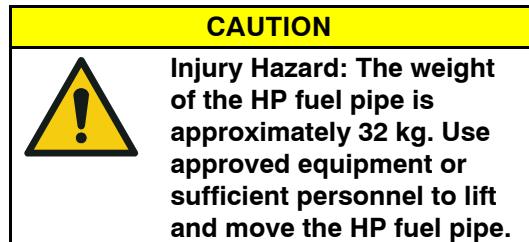
15) Carefully move the flange (4) away from the fuel pump cover (3).

HP Fuel Pipe: Removal and Installation

**Fig. 10**

16) Remove the four screws (2, Fig. 10) from the flange (3).

17) Carefully move the flange (3) away from the intermediate piece (4).

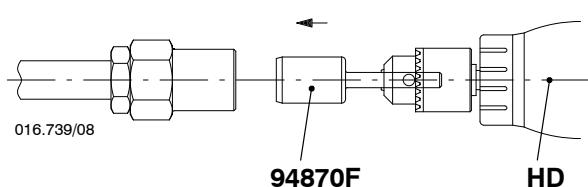
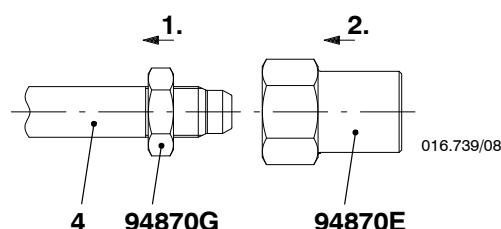
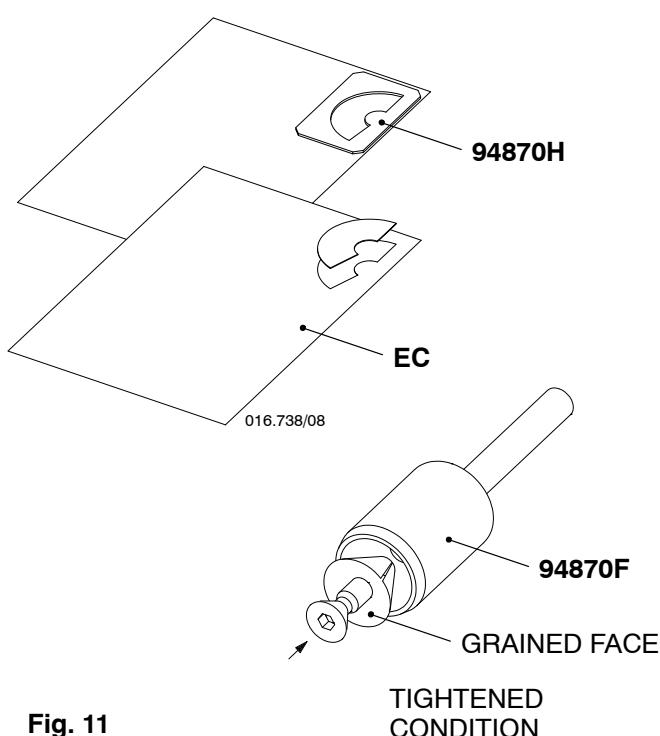


18) Carefully remove the HP fuel pipe (1).

19) Do a check of the sealing faces (SF). If you find damage, reground them.

20) Apply protection to the sealing faces (SF) to prevent damage and contamination.

HP Fuel Pipe: Removal and Installation

**3. Sealing Faces – Grind**

To remove the deep notches > 0.1 mm, use the emery cloth of medium to coarse grain (30 to 80 CAMI). For finish grinding, use the emery cloth with fine or ultra fine grains (100 to 600 CAMI).

To get a clean and smooth finish on the pipe procedure as follows:

- 1) Put the stencil 94870H on the back of emery cloth 'EC', see Fig. 11.
- 2) Use a pointed pencil or a ball pen to sign the inner contour.
- 3) Cut out accurately the signed contour.
- 4) Shape the cutted emery cloth to cone. Make sure that the grained surface of the emery cloth faces inwards (Fig. 11).
- 5) Put the emery cloth in the cone of the grinding tool 94870F and use a countersunk screw to fasten it.
- 6) Loosen and remove the pipe claw (4, Fig. 15).
- 7) Install the HP injection pipe 4 in a vice (4, Fig. 12).
- 8) Screw on counter nut 94870G until thread end of the HP injection pipe (4).
- 9) Turn screw-on sleeve 94870E up to the counter nut.
- 10) Lock the screw-on sleeve with the counter nut.
- 11) Attach the grinding tool 94870F to the hand drill 'HD'.
- 12) Move the grinding tool 94870F into the screw-on sleeve until it slightly touches the HP injection pipe (4).
- 13) Let the grinding tool 94870F rotate with a max. speed of 1500 rpm and grind for 3 to 5 seconds.
- 14) See next page ...

HP Fuel Pipe: Removal and Installation

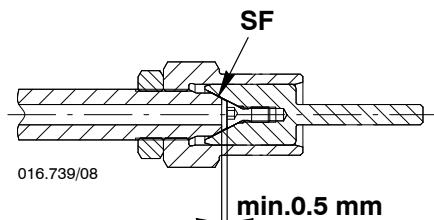


Fig. 14

- 15) Remove the grinding tool 94870F from the screw-on sleeve.
- 16) Use the pressurized air to clean the HP injection pipe.
- 17) Check the quality of the sealing surface 'SF' and if necessary use the new emery cloth 'EC' to repeat the grinding procedure.

Remark: If there are big notches, the pipe has to be shortened. Make sure there is a distance of min. 0.5 mm between the countersunk screw and the end face of the HP injection pipe.

- 18) Remove the counter nut and the screw-on sleeve.

4. Installation

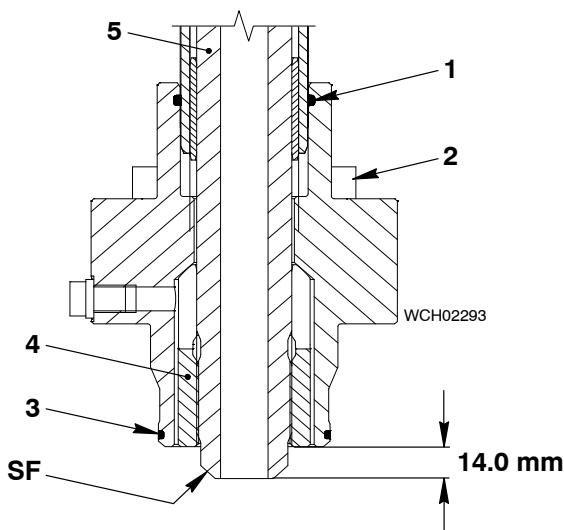
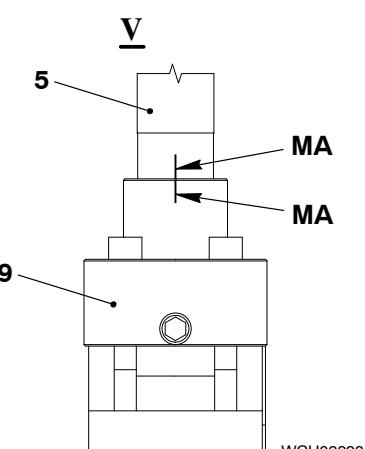
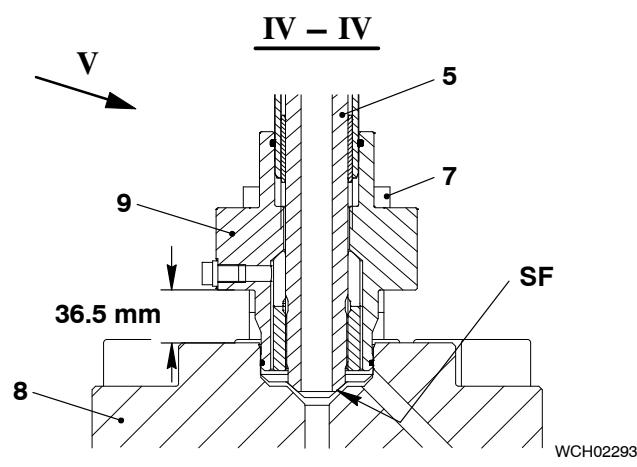
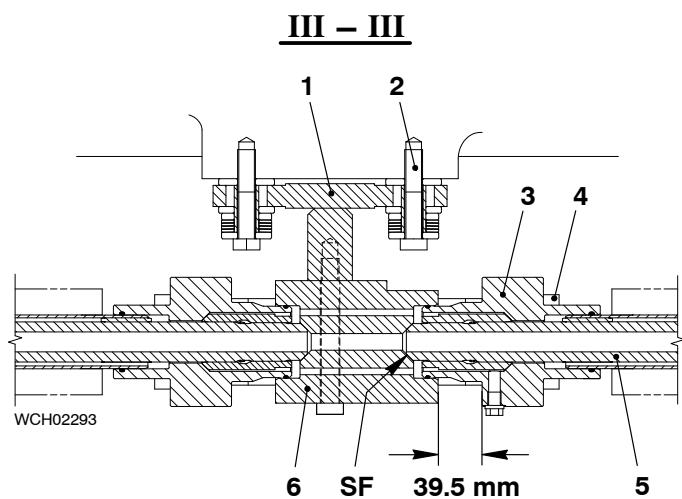
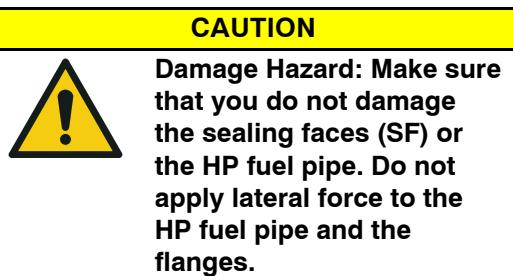


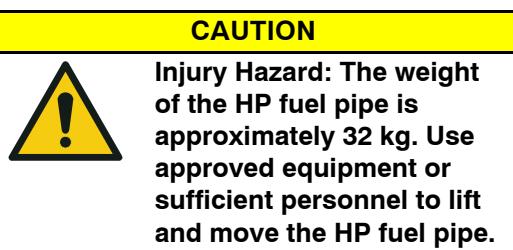
Fig. 15

- 1) Do a check for damage of the O-rings (1 and 3). If necessary, replace the O-rings.
- 2) Remove all of the protection from the sealing faces (SF).
- 3) Make sure that the claw (4) is correctly attached to the HP fuel pipe (5).
- 4) Make sure that there is a distance of 14.0 mm between the end of the HP fuel pipe (5) and the claw (4).
- 5) Make sure that the O-rings (1 and 3) are in position.
- 6) Apply Never-Seez NSBT to the threads of all the screws (2).

HP Fuel Pipe: Removal and Installation

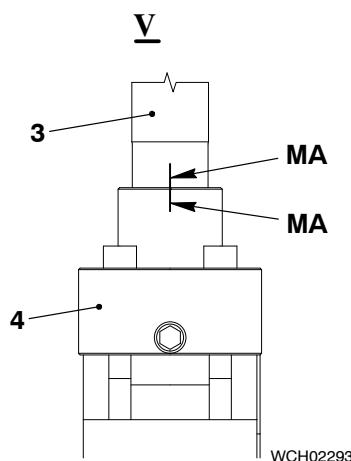
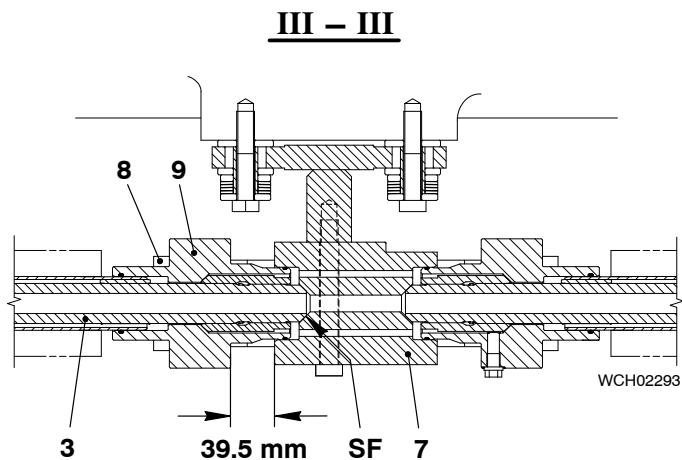
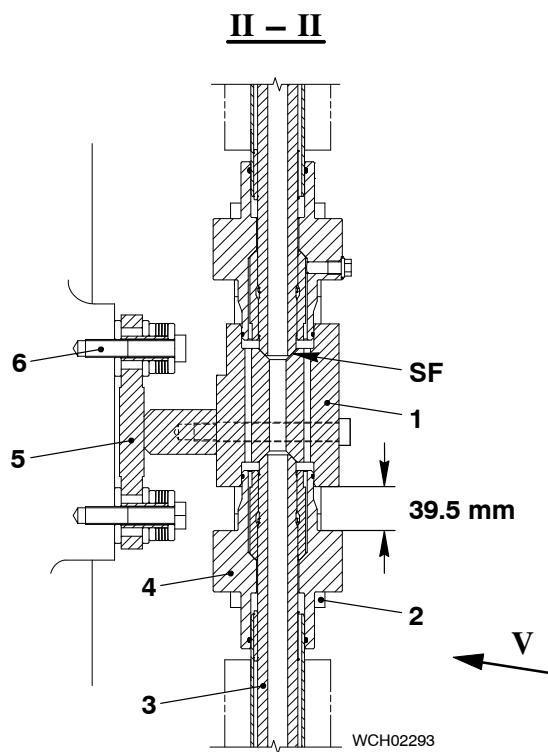
**Fig. 16**

- 7) Loosen the screws (2, Fig. 16) on the support (1) of the intermediate piece (6).

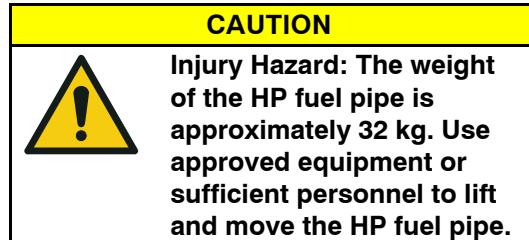


- 8) Carefully put the HP fuel pipe (5) in position in the fuel pump cover (8) and the intermediate piece (6).
- 9) Make sure that the HP fuel pipe (5) is in the correct position. Align the marks (MA) on the HP fuel pipe (5) and the flange (9).
- 10) Torque the screws (4 and 7) as follows:
 - a) Torque symmetrically the four screws (4 and 7) to 30 Nm.
 - b) Make sure that the flanges (3 and 9) are not tilted and in the correct position.
 - c) Torque symmetrically the four screws (4 and 7) to 55 Nm.
 - d) Torque symmetrically the four screws (4 and 7) to 80 Nm.
- 11) Make sure that there is a distance of 36.5 mm between the flange (9) and the fuel pump cover (8).
- 12) Make sure that there is a distance of 39.5 mm between the flange (3) and the intermediate piece (6).

HP Fuel Pipe: Removal and Installation

**Fig. 17**

- 13) Loosen the screws (6, Fig. 17) on the support (5) of the intermediate piece (1).



- 14) Carefully put the HP fuel pipe (3) in position in the intermediate piece (1) and the intermediate piece (7).
- 15) Make sure that the HP fuel pipe (3) is in the correct position. Align the marks (MA) on the HP fuel pipe (3) and on the flange (4).
- 16) Torque the screws (2 and 8) as follows:
 - a) Torque symmetrically the four screws (2 and 8) to 30 Nm.
 - b) Make sure that the flanges (4 and 9) are not tilted and in the correct position.
 - c) Torque symmetrically the four screws (2 and 8) to 55 Nm.
 - d) Torque symmetrically the four screws (2 and 8) to 80 Nm.
- 17) Make sure that there is a distance of 39.5 mm between the flange (4) and the intermediate piece (1).
- 18) Make sure that there is a distance of 39.5 mm between the flange (9) and the intermediate piece (7).

HP Fuel Pipe: Removal and Installation

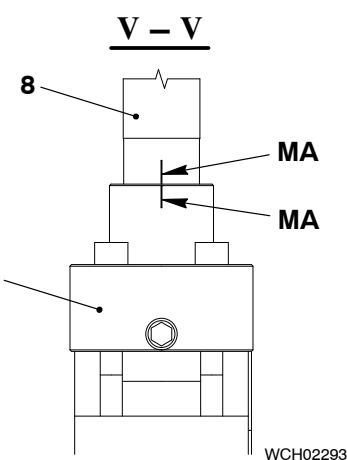
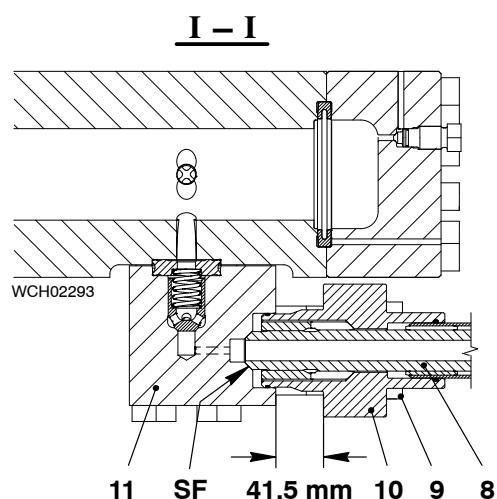
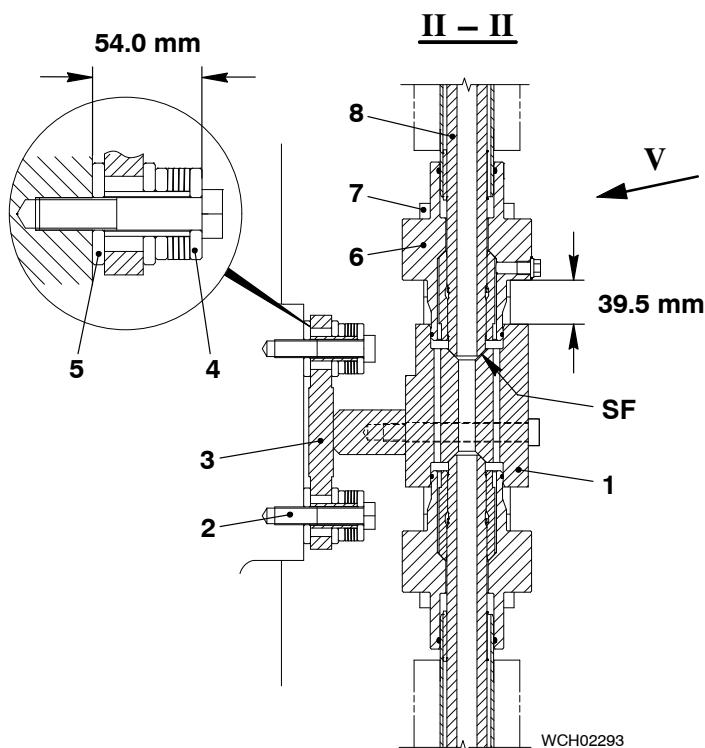
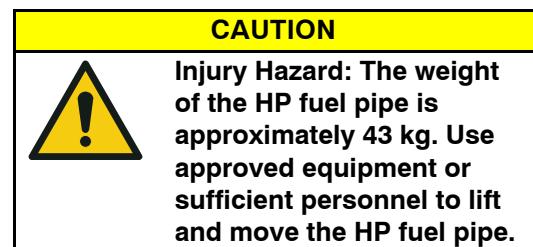


Fig. 18



- 19) Carefully put the HP fuel pipe (8, Fig. 18) in position in the intermediate piece (1) and the valve housing (11).
- 20) Make sure that the HP fuel pipe (8) is in the correct position. Align the marks (MA) on the HP fuel pipe (8) and on the flange (6).
- 21) Torque the screws (7 and 9) as follows:
 - a) Torque symmetrically the four screws (7 and 9) to 30 Nm.
 - b) Make sure that the flanges (6 and 10) are not tilted and in the correct position.
 - c) Torque symmetrically the four screws (7 and 9) to 55 Nm.
 - d) Torque symmetrically the four screws (7 and 9) to 80 Nm.
- 22) Make sure that there is a distance of 39.5 mm between the flange (6) and the intermediate piece (1).
- 23) Make sure that there is a distance of 41.5 mm between the flange (10) and the valve housing (11).
- 24) Tighten the screws (2) on the support (3).
- 25) Tighten the screws (2, Fig. 17) on the support (1).
- 26) Make sure that there is a distance of 54.0 mm between the steel ring (4, Fig. 18) and the slide ring (5).

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Crank Angle Sensor Unit, Tools

Group 9

Crank Angle Sensor Unit: Replacement of Proximity Sensor	9223-1/A1
Tools: Explanation	9403-1/A1
Hydraulic Pre-tensioning Jacks and Pumps	
Arrangement and Application	9403-2/A1
Storing, Servicing and Maintenance	9403-3/A1
General Instruction	9403-4/A1
Tool List	9403-5/A1
Standard Tools	Pages 1 to 32
Recommended Special Tools	Pages 33 to 34

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Crank Angle Sensor Unit

Replacement of Proximity Sensor

1. General

The crank angle sensor unit with four proximity sensors (5, Fig. 3) is installed on the drive supply unit at the driving end. There are two crank angle systems (redundant) that monitor the teeth on the intermediate wheel 2. The sensor adapters 3 are fix screwed onto the cover (2, Fig. 2) of the drive column.

Two more proximity sensors (3, Fig. 5) are used to find the crank angle marks for TDC and BDC.

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 CCM-20 modules (see 4002-1 Crank angle sensor, paragraph 4.5) in the Operating Manual.

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

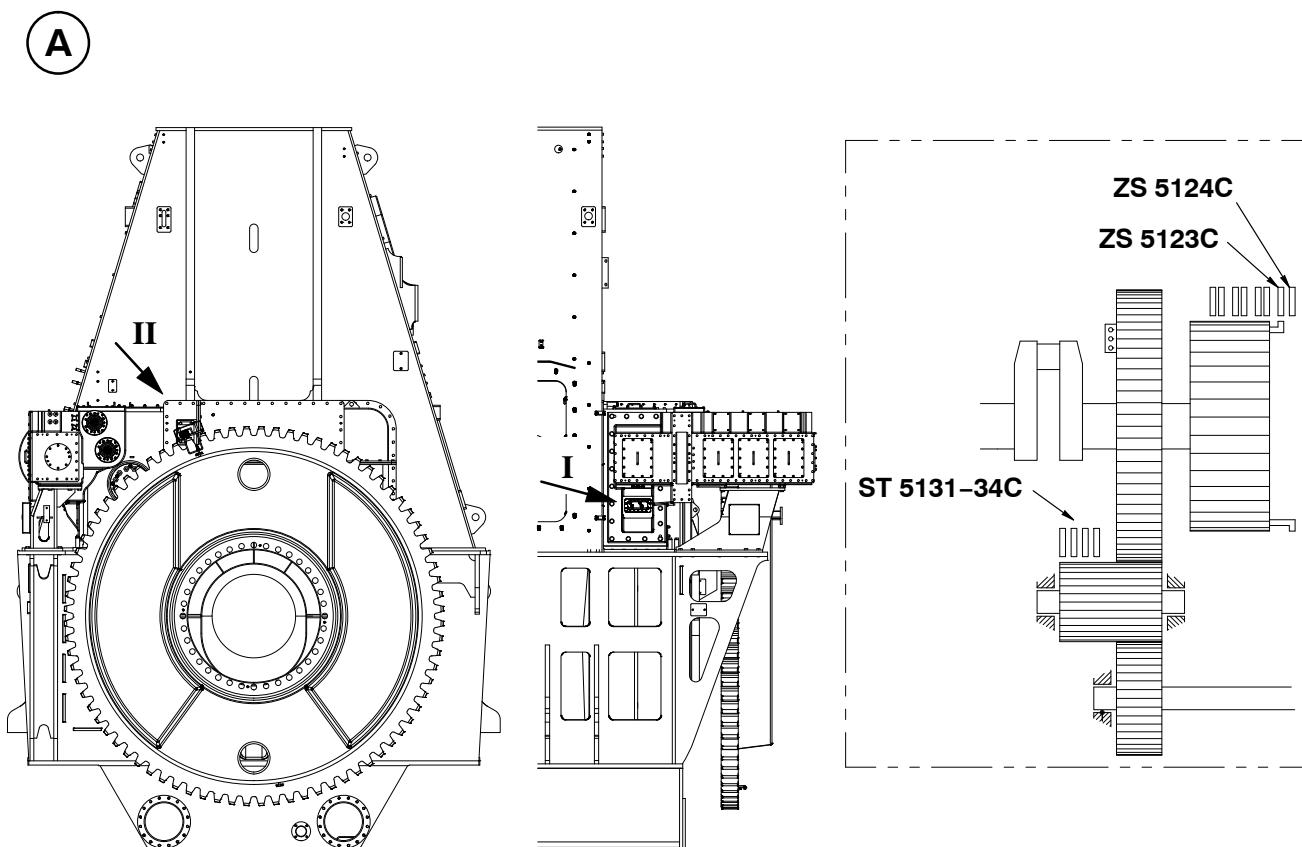


Fig. 1

Crank Angle Sensor Unit: Replacement of Proximity Sensor

2. Replacement

2.1 Replacement of proximity sensors on supply unit (ST5131C–34C)

- 1) Disconnect the plug with cable (4, Fig. 3) from the proximity sensor 5 and remove the sensor from the sensor adapter 1.
- 2) Screw in the proximity sensor (teflon) until it seats at the bottom of the sensor adapter 1. (Do not use any force).
- 3) Secure the sensor with its lock nut 3 without using any force.
- 4) Connect the plug with cable.

In case of disassemble of all sensors, mark the cables with the right sensor position.

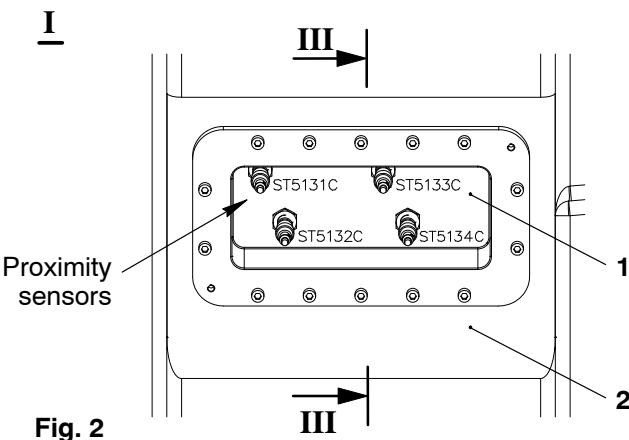


Fig. 2

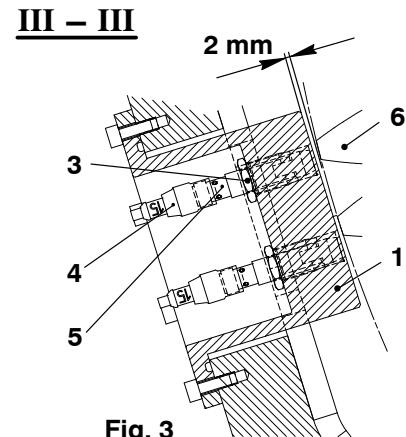


Fig. 3

2.2 Replacement of proximity sensors flywheel (ZS5123C–24C)

- 1) Disconnect the proximity sensor (3, Fig. 5) and remove it.
- 2) Apply MOLYKOTE paste G to the new sensor.
- 3) Screw in the new proximity sensor (steel) until the sensor touches the crank angle mark (2, Fig. 4) as shown below. (Do not use any force).
- 4) Screw the sensor out four turns ($4 \times 360^\circ = 4 \text{ mm}$) in anticlockwise direction. Secure the sensor with its lock nut and connect the plug with cable.

In case of disassemble of both sensors, mark the cables with the right sensor position.

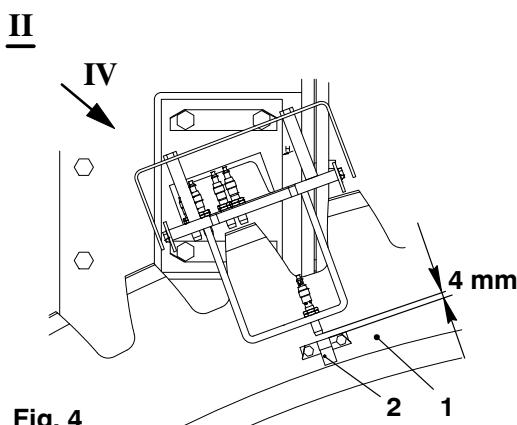


Fig. 4

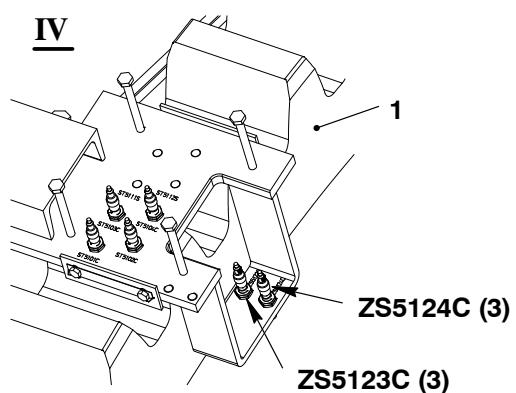


Fig. 5

Tools

Explanation

1. General

The tools required for maintenance of the engine are divided into **two groups**:

- 1) Standard tools
- 2) Recommended special tools

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, overview, storing, servicing and maintenance of the hydraulic pre-tensioning jacks are given in [9403-2](#) to [9403-4](#).

A separate set of tools is issued for certain components from sub-suppliers, which should also be stored separately from the engine tools.

Note: Several tools require special screws and/or devices which must not be lost. Therefore, tapped holes are bored additionally into these tools and the mentioned screws and/or devices must always be kept at the proper depositories 'DP' when they are not used!

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.

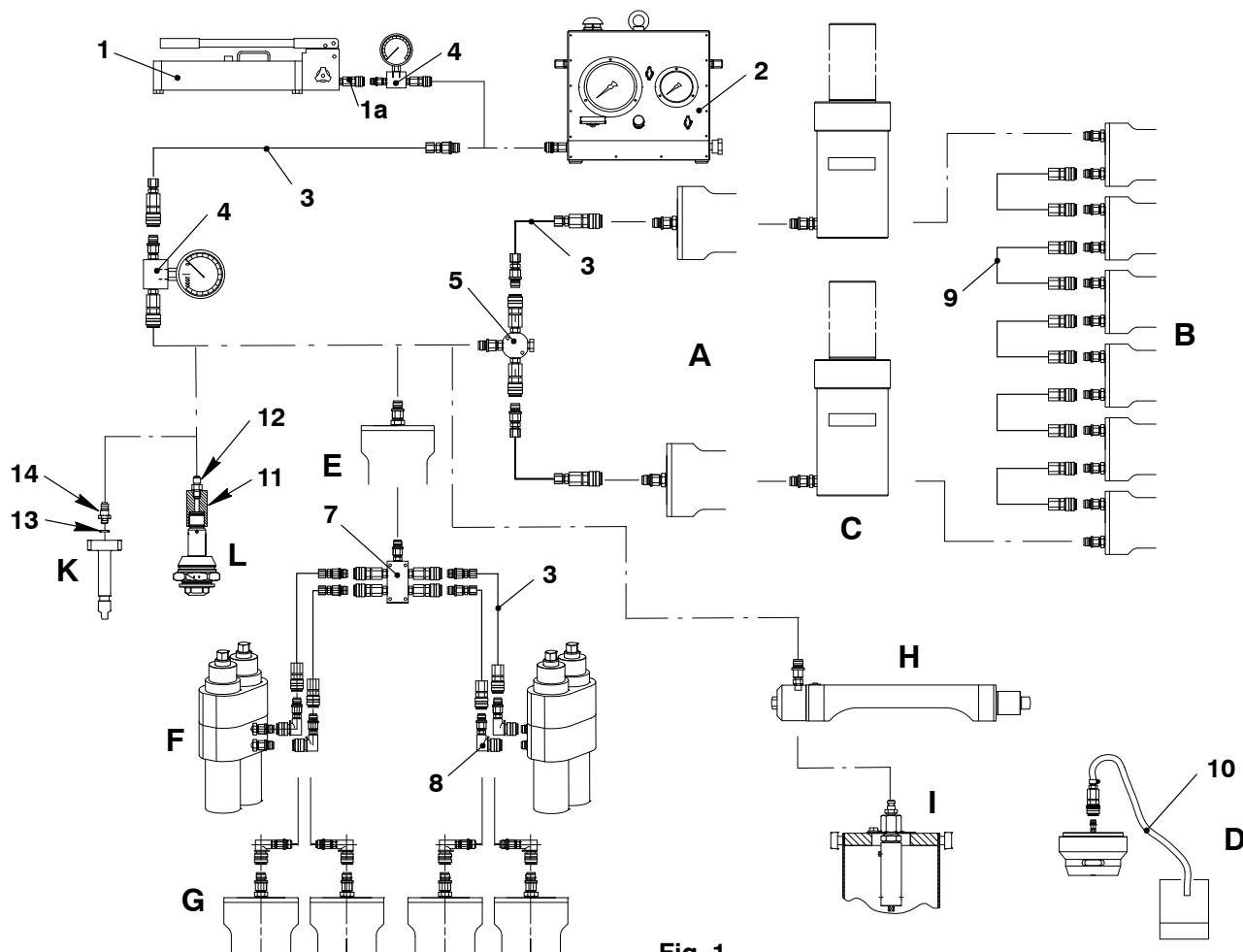
4. Special tools available on loan

... 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****Tools:**

1	HP oil Pump, 2800 bar	94931	8	Coupling element	94934G
1a	Adapter piece	94934F	9	Flexible hose	94935A
2	Hydraulic unit, 2000 bar	94942	10	Oil pipe drain	94935C
3	HP hose	94935	11	Adapter piece	94934L
4	Pressure gauge	94934A	12	Adapter piece	94934K
5	Connection block	94934	13	Tredo joint	94934J
6	Adapter piece	94934F	14	Connection nipple	94934I
7	Distributing piece	94934C			

**Fig. 1**

- A For tie rods (jack: 94180), elastic studs to exhaust valve cages and lower connection rod bolts (94252), upper connection rod bolts (94315), piston rod (94340) and elastic studs on supply unit (94557)
- B For of elastic studs to cylinder cover (94215A)
- C Lifting the crankshaft for removal and fitting of main bearing shells (94936)
- D Oil drain after use of pre-tensioning jacks
- E For foundation bolts (94145), turning gear (94320) and for supply unit lifting tool (94430A)
- F For of elastic studs to main bearing (94114)
- G For elastic studs to piston and crosshead (also piston rod) (94340)
- H Thrust device for main bearing cover (94110)
- I Checking and setting of fuel overpressure safety valve
- K For inspection of the opening pressure (pulse lubrication)
- L For testing the injector

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Hydraulic Pre-tensioning Jacks

Storing, Servicing and Maintenance

1. General

The hydraulic pre-tensioning jacks as engine tool kit are to be stored in their tool boxes when not in use. Grease them after use and close the connections with dust plugs. We recommend for each jack to keep a sealing-kit (KJ-) in stock.

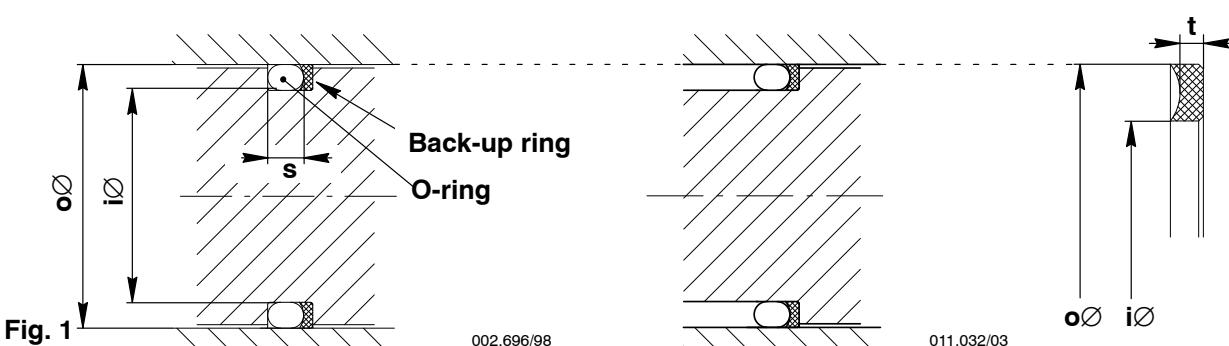
Always pay attention to the correct position when fitting new back-up and O-rings as shown on the following pages.

When inserting new back-up and O-rings proceed with care to avoid their damage; do not use any sharp edged utensils for assistance!

Heat uncut back-up rings in boiling water before fitting them.

1.1 Dimensions of back-up and O-rings

Tool No.	Place of application of pre-tensioning jack	Part	Back-up ring (uncut)	O-ring
			Dimension [mm] $\text{o} \times \text{i} \times \text{t}$	$\text{i} \times \text{s}$
94110	Thrust device for main bearing cover	piston cylinder	72 x 65.8 x 1.4 46.2 x 40 x 1.4	63.09 x 3.53 40.87 x 3.53
94114	Elastic bolts to main bearing	piston cylinder	118 x 108.6 x 1.7 85.4 x 76 x 1.7	107.32 x 5.33 75.57 x 5.33
94145	Foundation bolts and engine stays	piston cylinder	123 x 113.6 x 1.7 102.4 x 93 x 1.7	113.67 x 5.33 91.44 x 5.33
94180	Tie rods	piston cylinder	198 x 185.8 x 2.5 136.4 x 127 x 1.7	183.52 x 6.99 126.37 x 5.33
94215A	Elastic bolts to cylinder cover	piston cylinder	159 x 146.8 x 2.5 104.4 x 95 x 1.7	145.42 x 6.99 94.62 x 5.33
94252	Elastic bolts to exhaust valve cage and lower connecting rod studs	piston cylinder	161 x 148.8 x 2.5 111.4 x 102 x 1.7	148.59 x 6.99 100.97 x 5.33
94315	Elastic bolts to upper connecting rod bearing	piston cylinder	104.5 x 95.1 x 1.7 74.2 x 68 x 1.4	94.62 x 5.33 69.44 x 3.53
94340	Piston, piston rod and crosshead	piston cylinder	68 x 61.8 x 1.4 52.2 x 46 x 1.4	59.92 x 3.53 47.22 x 3.53
94430A	Roller lifting tool supply unit	piston cylinder	87 x 77.6 x 1.7 60.2 x 54 x 1.4	75.57 x 5.33 53.57 x 3.53
94557	Elastic studs on supply unit	piston cylinder	86 x 76.6 x 1.7 66.2 x 60 x 1.4	75.57 x 5.33 59.92 x 3.53

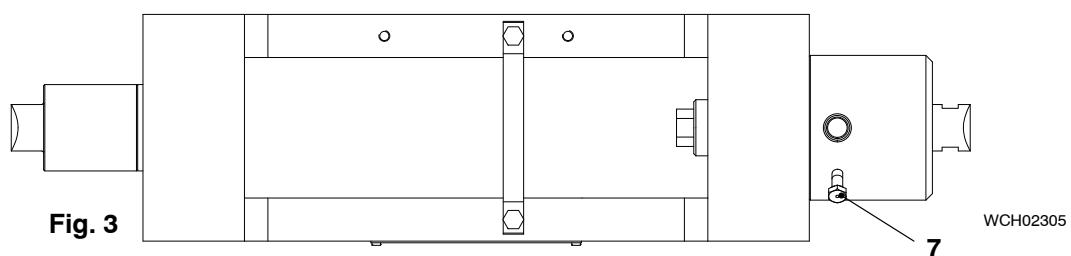
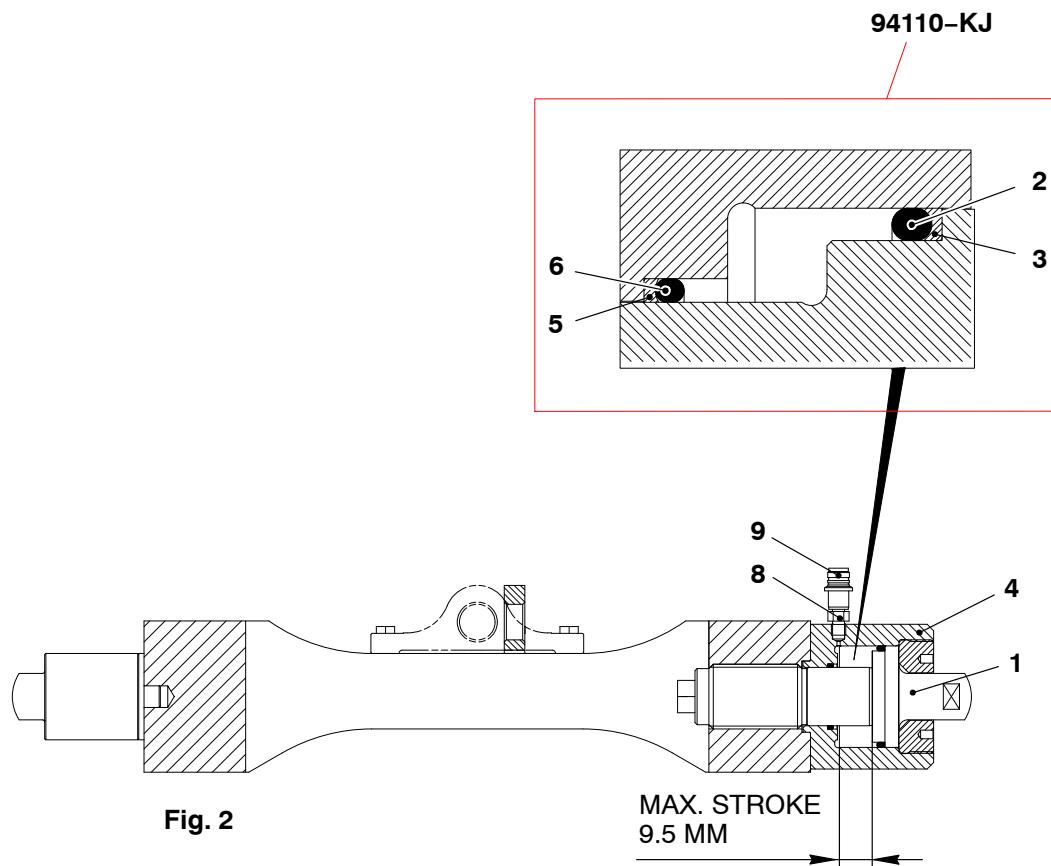


2. Overview of pre-tensioning jacks

Tool 94110 Thrust device for main bearing cover

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

94110-KJ Kit with back-up and O-rings
for pre-tensioning Jack



Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

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

1	Piston	7	Vent screw
2	Back-up ring	8	Adapter piece
3	O-ring	9	Closing valve
4	Double cylinder	11	Backing bush
5	Back-up ring	12	Tension sleeve
6	O-ring	13	Round nut

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

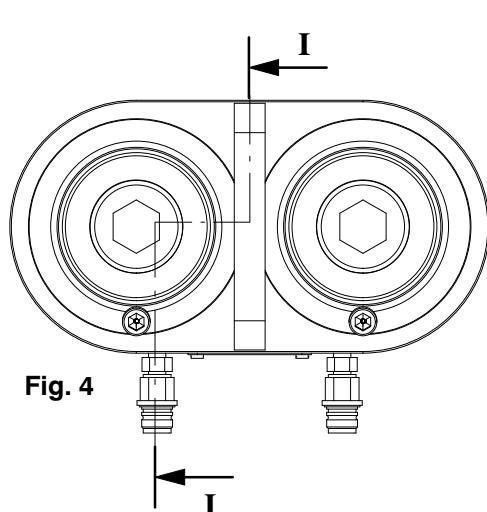


Fig. 4

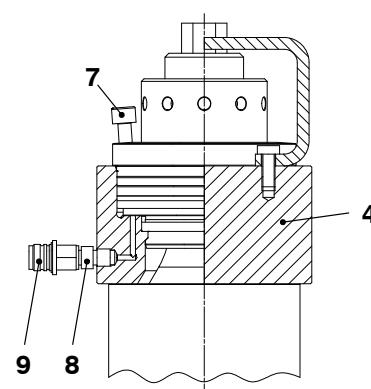
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Fig. 5

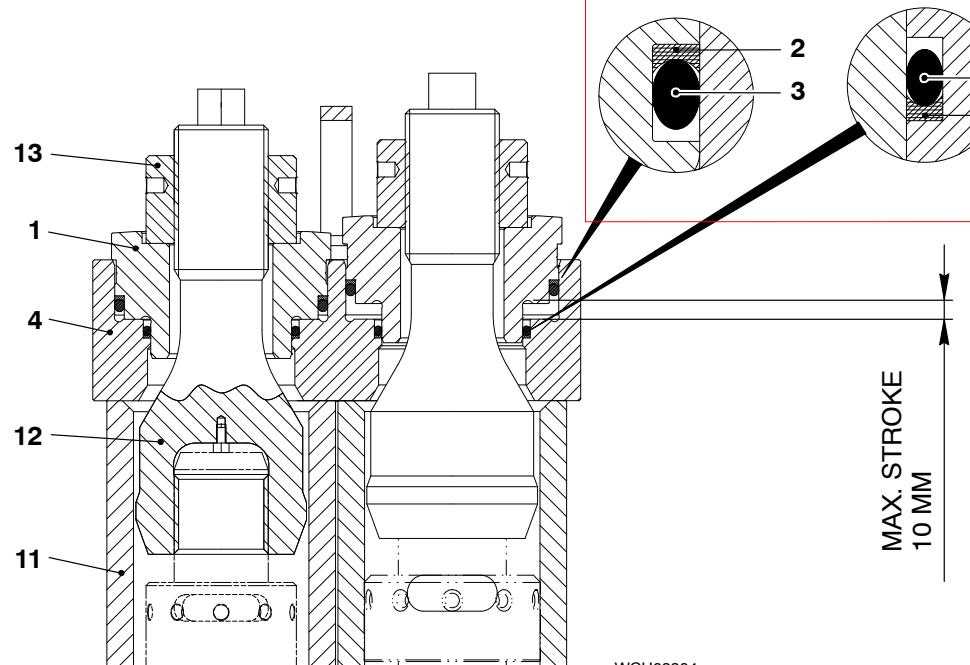


Fig. 6

WCH02304

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94145 Pre-tensioning jack for foundation bolts and engine stays

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

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

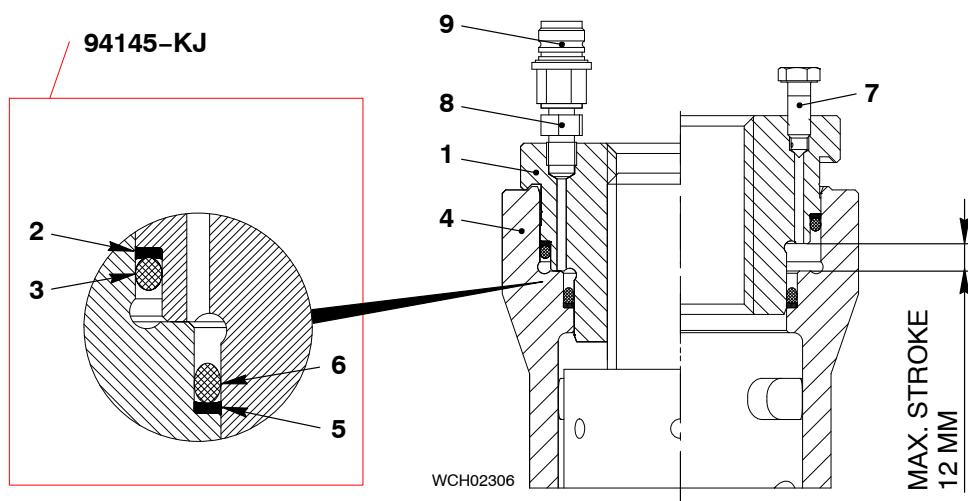


Fig. 7

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94180 Pre-tensioning jack for tie rods

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

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

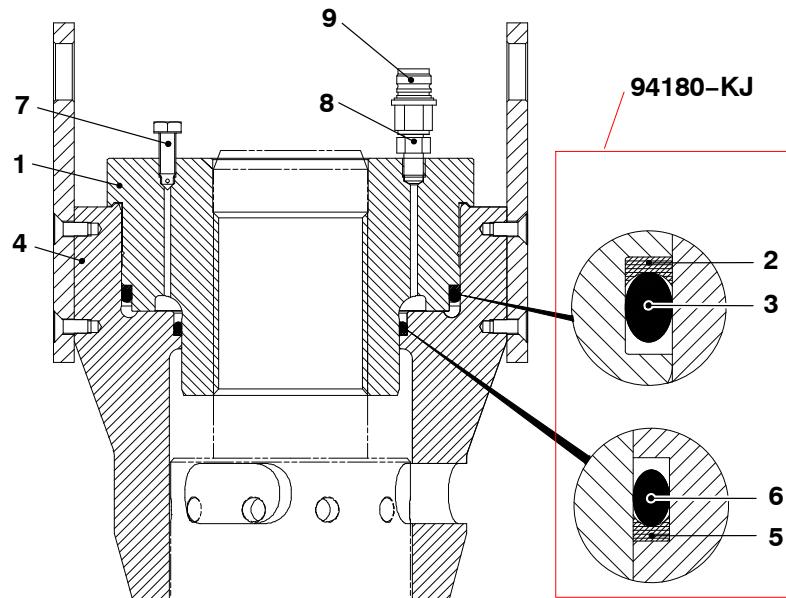


Fig. 8

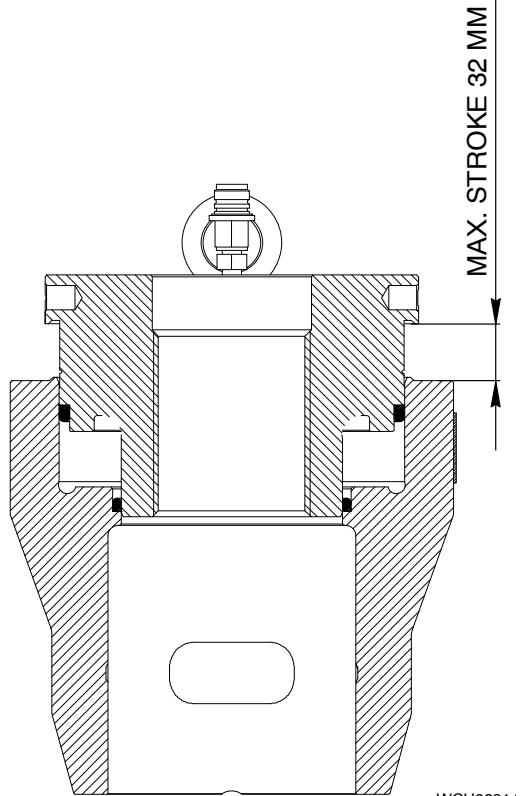


Fig. 9

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94215A Pre-tensioning jack for elastic bolts to cylinder cover

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

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

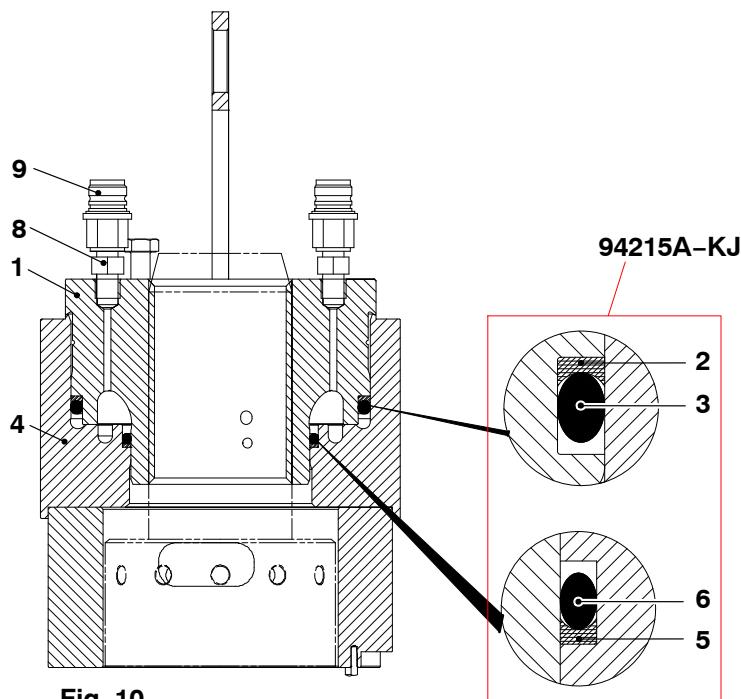


Fig. 10

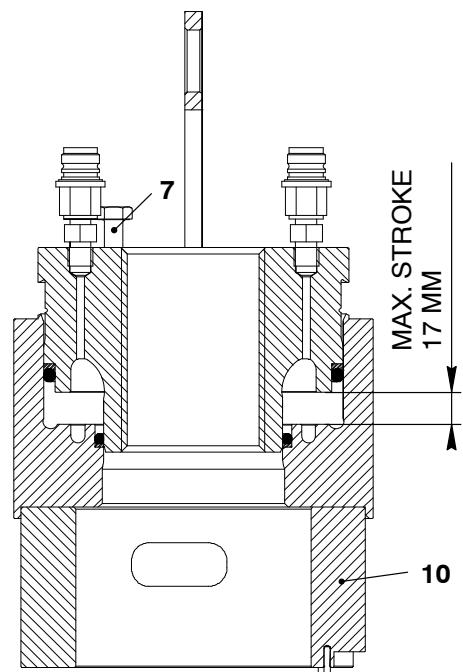


Fig. 11

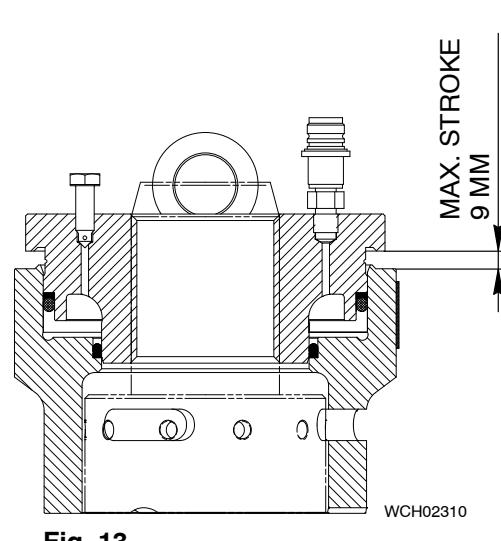
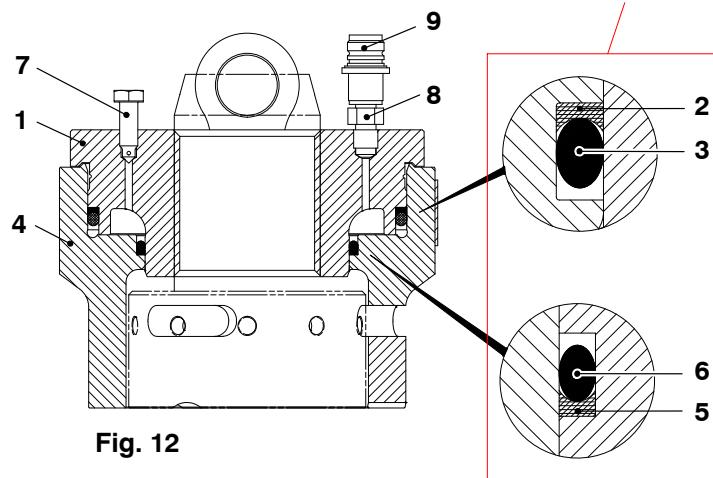
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Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94252 Pre-tensioning jack for elastic bolts to exhaust valve cage and lower connecting rod studs

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

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

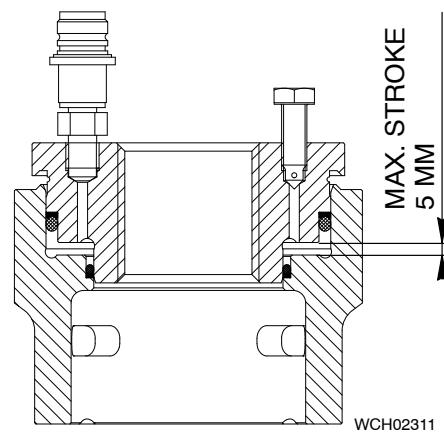
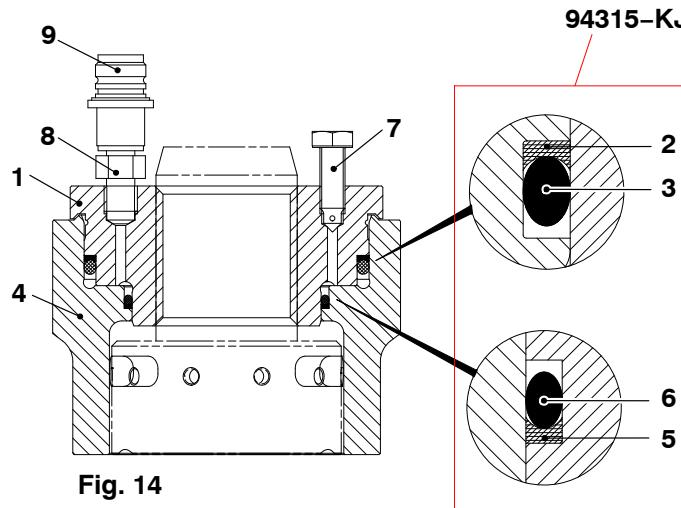


Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94315 Pre-tensioning jacks for elastic bolts to upper connecting rod bearing

- | | | | |
|---|--------------|---|---------------|
| 1 | Piston | 7 | Vent screw |
| 2 | Back-up ring | 8 | Adapter piece |
| 3 | O-ring | 9 | Closing valve |
| 4 | Cylinder | | |
| 5 | Back-up ring | | |
| 6 | O-ring | | |
| | | | Sealing ring |
| | | | Sealing 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 piston and piston rod foot to crosshead

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

94340-KJ Kit with back-up and O-rings
for pre-tensioning Jack

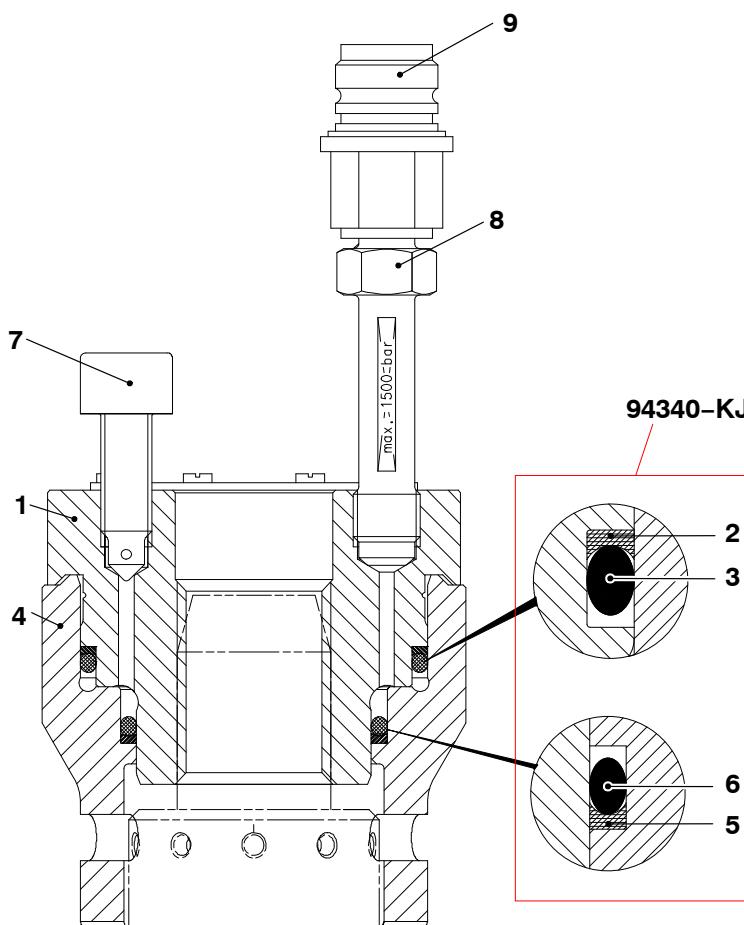


Fig. 16

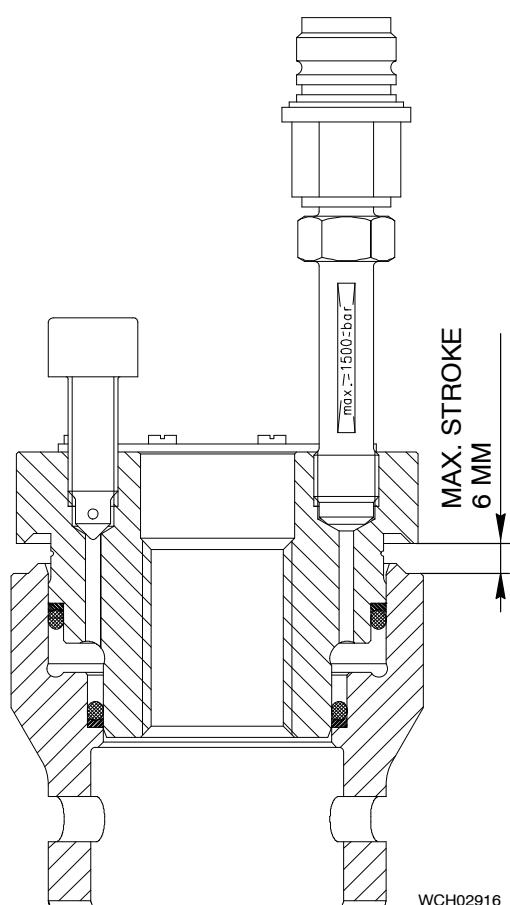


Fig. 17

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94430A Pre-tensioning jack for roller lifting tool (supply unit)

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

94430A-KJ Kit with back-up and O-rings
for pre-tensioning Jack

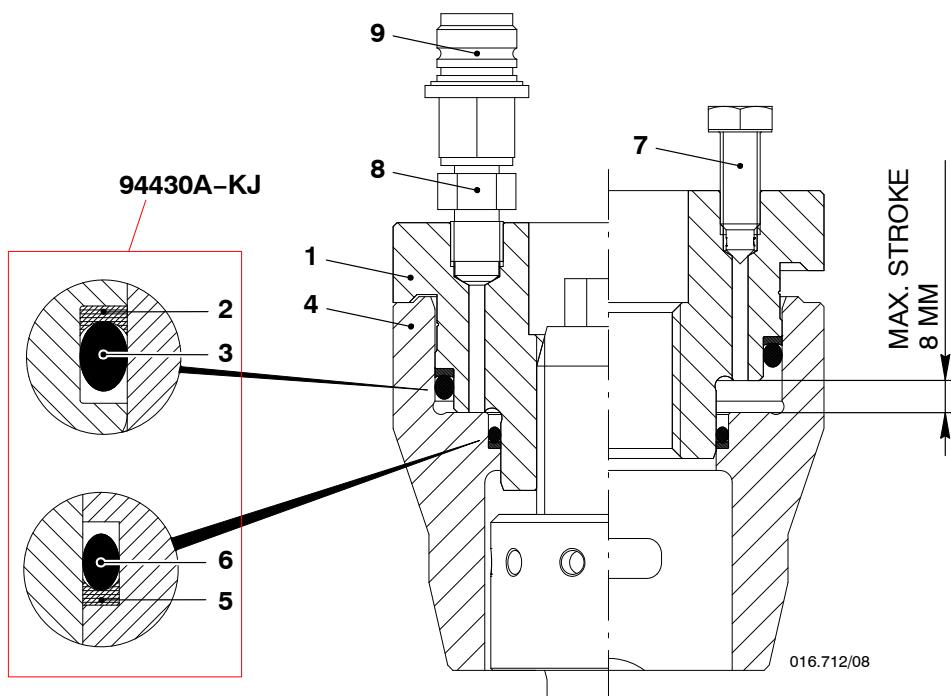


Fig. 18

Hydraulic Pre-tensioning Jacks: Storing, Servicing and Maintenance

Tool 94557 Pre-tensioning jacks for elastic bolts to top end bearing (supply unit)

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

94557-KJ Kit with back-up and O-rings
for pre-tensioning Jack

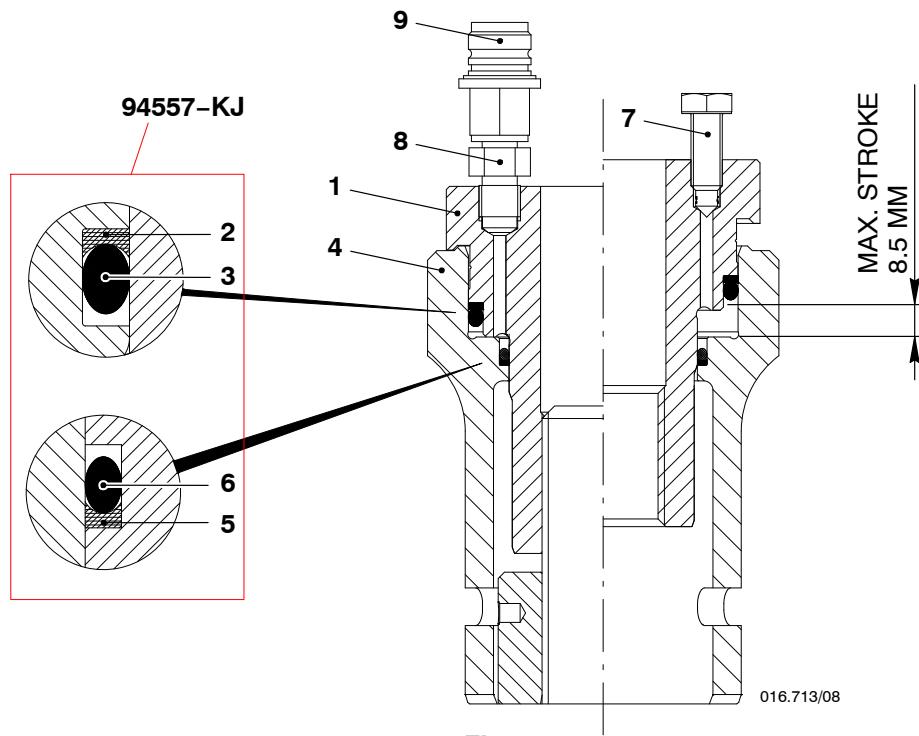


Fig. 19

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Hydraulic Pre-tensioning Jacks

General Instruction

Hydraulic pre-tensioning jacks for:

Variant 1:

Foundation bolt and engine stay	94145
Tie rod	94180
Cylinder cover	94215A
Exhaust valve cage and bottom connecting rod studs	94252
Upper connecting rod bearing	94315
Piston, piston rod foot	94340
Roller lifting tool (fuel pump)	94430A
Supply unit (fuel pump unit)	94557

Variant 2:

Main bearing	94114
--------------	-------

1. General

There are two versions of hydraulic jack preparation:

- Version 1 – the piston 2 is attached directly on to the elastic bolt / elastic stud 5 (see Fig. 1).
- Version 2 – the nut 3 is used to apply tension to the elastic bolt / elastic stud (see Fig. 2).
 - 1) You must make sure that the threads of elastic bolts and hydraulic jacks are smooth and clean.
 - 2) You must make sure that you add lubricant to the elastic bolts and hydraulic jacks, refer to 0352-1.
 - 3) Connect the hydraulic components to the hydraulic jacks, refer to 9403-2.
 - 4) Fully tighten the high pressure (HP) hoses to make sure that the built-in non-return valves can operate.

WARNING



Injury Hazard: Always put on gloves, a face shield and safety goggles when you use hydraulic tools. Hydraulic tools can cause injury.

- 5) Do a check of the oil in the HP oil pump or hydraulic unit.
 - When you must add oil, read the specification of the pump manufacturer.

Note: Use an engine lubricating oil that has a viscosity of SAE 30 to SAE 40. In unusual conditions, you can also use cylinder lubricating oil.

- For data about the sealing rings on the hydraulic jacks, see 9403-3.
- To install elastic studs, see 0352-2.

Hydraulic Pre-tensioning Jacks: General Instruction

2. Loosen

2.1 Version 1 – Preparation

- 1) Make sure that the vent screw 6 is open (see Fig. 1).
- 2) Put the hydraulic jack on to the elastic stud 5.
- 3) Turn the hydraulic jack until it is tight. Make sure that there is no clearance at X.

2.2 Version 2 – Preparation

- 1) Make sure that the vent screw 6 is open (see Fig. 2).
- 2) Put the hydraulic jack over the elastic stud 5.
- 3) Use the round bar to lightly tighten the round nut 3.

2.3 Procedure

- 1) Turn back the round nut 3, or the hydraulic jack (see Table 1 below).
- 2) On the HP oil pump, close the relief valve.
- 3) Connect the hydraulic jack to the HP oil pump or the hydraulic unit.
- 4) Put a hose on the vent screw 6 and a container below the hose to drain the oil.
- 5) Operate the HP oil pump.
- 6) Close the vent screw 6 when oil that has no air flows out.

Note: Do not move the piston 2 above the limit of the red groove 9.

- 7) Operate the HP oil pump to slowly increase the pressure to approximately 20 bar to 30 bar more than the value give in Table 1.
- 8) Keep the pressure constant and use the round bar to loosen the round nut (see the Table below).
- 9) On the HP oil pump, or hydraulic unit, decrease the pressure to zero.
- 10) Remove the hydraulic jack.

Version 1

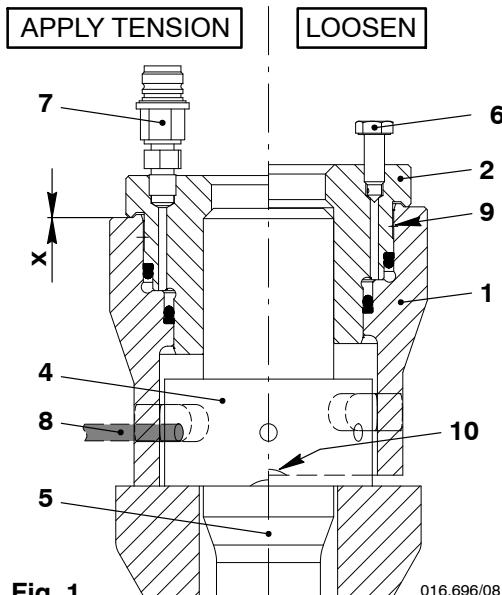


Fig. 1

Version 2

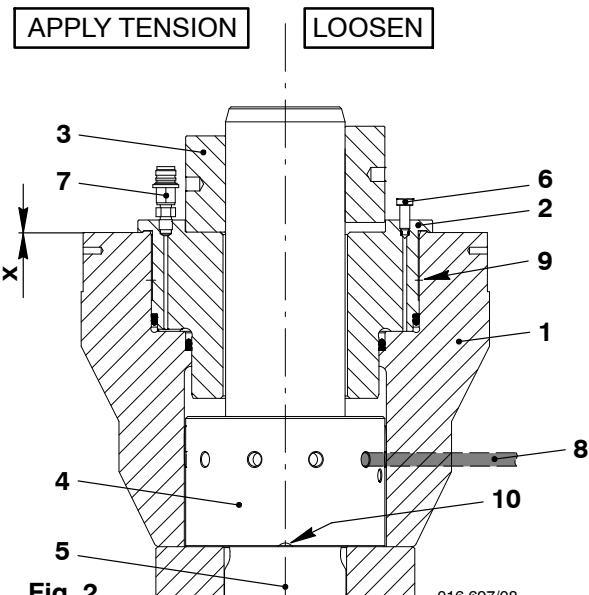


Fig. 2

Hydraulic Pre-tensioning Jacks: General Instruction

3. Apply Tension

- 1) Turn the round nut 4 fully down (Fig. 1 and Fig. 2). Make sure that there is no clearance at the slot 10.
- 2) Put one reference mark (Y) on the nut and one reference mark on the part below (X) (see Fig. 3 and Fig. 4).

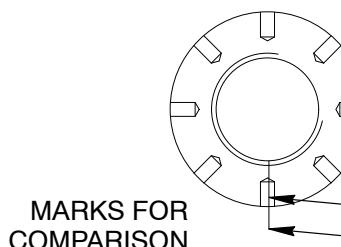


Fig. 3

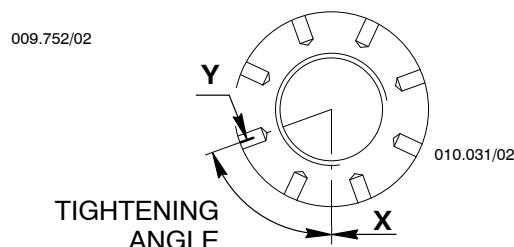


Fig. 4

3.1 Version 1 – Preparation

- 1) Make sure that the vent screw 6 is open (see Fig 1).
- 2) Put the hydraulic jack on the elastic stud 5.
- 3) Turn the hydraulic jack until it is tight. Make sure that there is no clearance at X.

3.2 Version 2 – Preparation

- 1) Put the hydraulic jack over the elastic stud 5.
- 2) Use the round bar to lightly tighten the round nut 3.
- 3) If necessary, turn back the hydraulic jack a small distance to get access to the hole in the nut 3.

3.3 Procedure

- 1) On the HP oil pump, close the relief valve.
- 2) Connect the hydraulic jack to the HP oil pump or the hydraulic unit.
- 3) Operate the HP oil pump.
- 4) Close the vent screw 6 when oil that has no air flows out.
- 5) Slowly increase the pressure to the nominal value, then keep the pressure constant (see the Table for the pressure values)
- 6) Make sure that there are no leaks.
- 7) Operate the HP oil pump to slowly increase the pressure to approximately 20 bar to 30 bar more than the value give in Table 1.

Note: Do not move the piston 2 above the limit of the red groove 9.

- 8) Use the round bar 8 to tighten the round nut 4 nut.
- 9) Put the feeler gage through the slot 10 to make sure that there is no clearance between the round nut 4 and the seating.
- 10) Compare the angle between the reference marks X and Y on the round nut 4 and the Comparison value in the Table. If there is a large difference, you must investigate the cause and do the procedure again.
- 11) On the HP oil pump, or hydraulic unit, decrease the pressure to zero.
- 12) Remove the hydraulic jack.

Hydraulic Pre-tensioning Jacks: General Instruction

Table 1 – Hydraulic Jacks – Values and Comparison

Application	Group	Jack	Tightening value [bar]	Comparison [$^{\circ}\angle$, mm]	Reset of jack / round nut [turns]	Lubricating agent ²⁾
Foundation bolts	1112-1	94145	(1 st step 1000) 1500	–	1/4	No lubricant
Main bearing	1132-1	94114	1500	–	3/4	Oil
Engine stays	1715-1	94145	170	–	1/4	No lubricant
Tie rods	1903-1	94180	1500	from 100 to 1500 bar 11.5 to 13.5 mm	3	Molykote paste G
Cylinder cover	2708-2	94215A	1500	396°	1½	Oil
Exhaust valve cage	2751-1	94252	1500	200°	1	Oil
Top con rod	3303-1	94315	(1 st step 1100) 1500	1 st to 2 nd step 25°	1/2	Oil
Bottom con rod	3303-1	94252	(1 st step 600) 1500	1 st to 2 nd step 80°	1	Oil
Piston rod foot	3403-1	94340	(1 st step 1000) 1500	1 st to 2 nd step 20°	1/2	Oil
Piston head	3403-3	94340	1500	85°	1/2	Oil
Bearing, supply unit	5581-1	94557	1500	–	1/2	Oil
Roller lifting tool, supply unit	5556-2 ¹⁾	94430A	1500	84°	1/2	No lubricant

¹⁾ For cutting out and cutting in of a fuel pump, see the Operation Manual 5556-2.

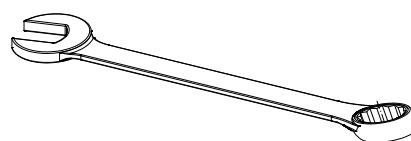
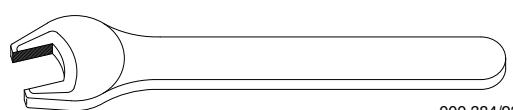
²⁾ For lubrication on threads and contact surfaces.

Tool List**Standard Tools****94000 Combination wrenches, set compl.**

consisting of:

34 wrenches AF6 to AF60

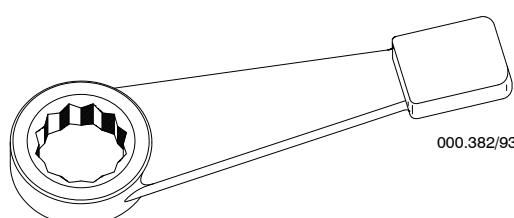
for ordering single wrenches state AF

Example: 94000-06
94000-60**94001 Open end wrenches**1 Piece AF70
1 Piece AF85**94002 Ring slugging wrenches, set compl.**

consisting of:

13 wrenches AF27 to AF85

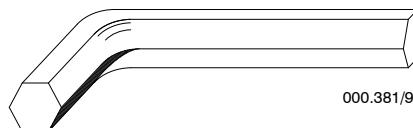
for ordering single wrenches state AF

Example: 94000-27
94000-85**94003 Allen keys, set compl.**

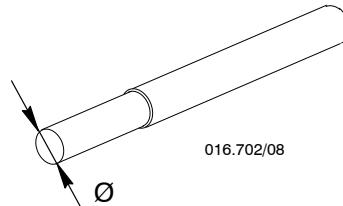
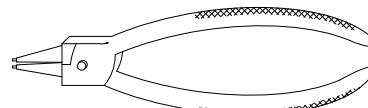
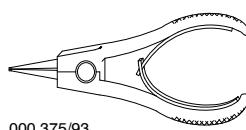
consisting of:

9 Allen keys AF3 to AF17

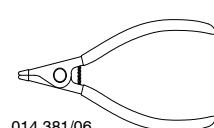
for ordering single wrenches state AF

Example: 94000-03
94000-17**94005 Round bars**

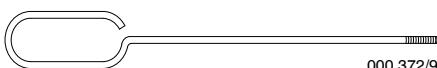
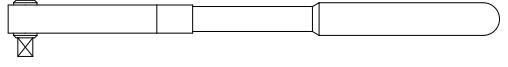
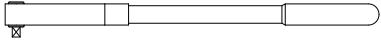
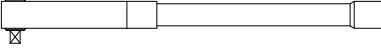
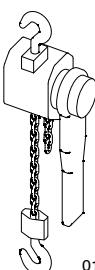
for round nuts

1 Pieces Ø 4 mm (M27 – M33)
1 Pieces Ø 6 mm (M36 – M56)
1 Pieces Ø 9.5 mm (M60 – M80)
1 Pieces Ø 14 mm (M85 – M100)**94007 Circlip pliers**1 Piece Type C 8
1 Piece Type C 19
1 Piece Type C 40
1 Piece Type C 851 Piece Type A 10
1 Piece Type A 19
1 Piece Type A 40
1 Piece Type A 85

1 Piece Type A 41



Standard Tools

94009	Handle screw		000.372/93
94009-M5	1 Pieces M5x150		
94009-M8	1 Pieces M8x100		
94009-M10	1 Pieces M10x100		
94011-01	1 Torque spanner $\frac{3}{8}$" No ratchet mechanism (Range of adjustment 2.5–11 Nm)		WCH02580
94011-01A	1 Adapter piece $\frac{3}{8}$ to $\frac{1}{2}$"		WCH02581
94011-02	1 Torque spanner $\frac{1}{2}$" No ratchet mechanism (Range of adjustment 12–68 Nm)		WCH02296
94011-03	1 Torque spanner $\frac{1}{2}$" No ratchet mechanism (Range of adjustment 50–225 Nm)		WCH02296
94012-02	1 Torque spanner $\frac{3}{4}$" (Range of adjustment 150–750 Nm)		
94012-02A	adapter piece $\frac{3}{4}$ "– $\frac{1}{2}$ ",		
94012-02B	shell type ratchet $\frac{1}{2}$ "– $\frac{1}{2}$ "		010.231/02
94016-006	2 Manual ratchets WLL 1000 kg, stroke 5,5 m		
94016-011	2 Manual ratchets WLL 2500 kg, stroke 3,5 m		
94016-015	4 Manual ratchets WLL 3200 kg, stroke 5,5 m		
94016-017	2 Manual ratchets WLL 6300 kg, stroke 3,5 m		
94016-025	Manual ratchets WLL 500 kg, stroke 3,0 m		

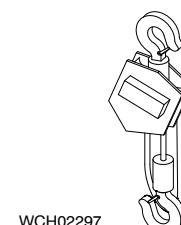
Standard Tools

94017-005 2 Spur-gearied chain block
WLL 1000 kg, stroke 4.0 m

94017-013 2 Spur-gearied chain block
WLL 2500 kg, stroke 3,0 m

94017-017 2 Spur-gearied chain block
WLL 3000 kg, stroke 4.0 m

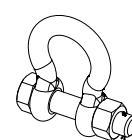
94017-020 2 Spur-gearied chain block
WLL 5000 kg, stroke 4.0 m



WCH02297

Shackle

94018A 4 WLL 3250 kg
94018B 4 WLL 4750 kg
94018C 6 WLL 8500 kg



WCH02297

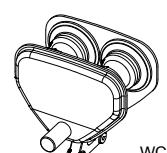
Chain

94019A 1 907x907 mm, WLL 3150 kg
94019B 1 1207x907 mm, WLL 3150 kg
94019C 1 1088x1088 mm, WLL 5300 kg



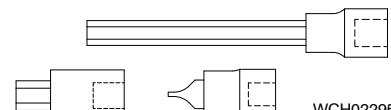
WCH02297

94021 1 Trolley
WLL 3000 kg



WCH02582

94022A-10 **Socket wrench inserts 1/2"**
AF10
94022A-SC Screwdriver



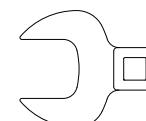
WCH02295

94022B-19 **Socket wrench inserts 3/4"**
AF19
94022B-41 AF41
94022B-46 AF46
94022F **Adapter piece 1/2"—3/4"**
94022G **Adapter piece 1/2"— 3/8 "**



WCH02295

Crowfoot Wrench
94022C-22 AF22
94022C-24 AF24
94022C-27 AF27
94022C-35 AF35

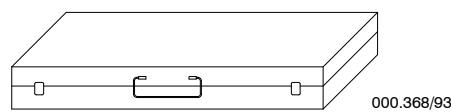


WCH02295

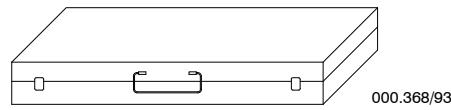
94022D-04 **Socket wrench inserts 3/8 "**
94022D-06 AF04
AF06

Standard Tools

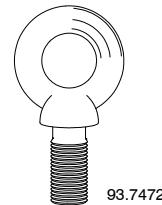
- 94025** 1 **Tool box with socket wrench set 1/2"**
(AF10-24, 26, 27, 28, 30, 32, 33, 34, 36)



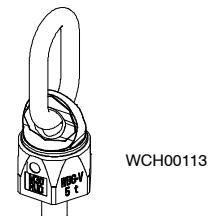
- 94026** 1 **Tool box with hex. head drivers 1/2"**
(AF5-10, 12, 14, 17)

**94045 Eye bolt**

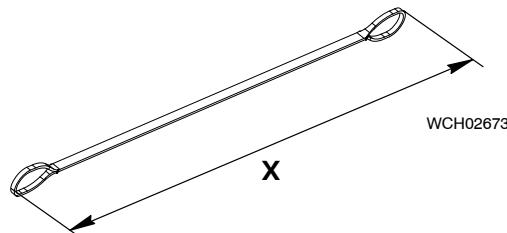
- 94045-M8** 6 Pieces M8
94045-M10 4 Pieces M10
94045-M12 4 Pieces M12
94045-M20 4 Pieces M20
94045-M24 4 Pieces M24
94045-M36 6 Pieces M36



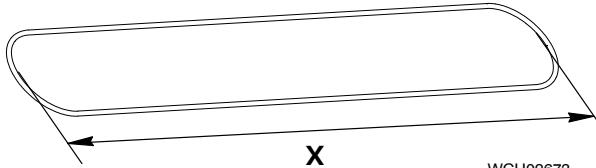
- 94048 Swivel lug**
94048-M30 6 Pieces M30



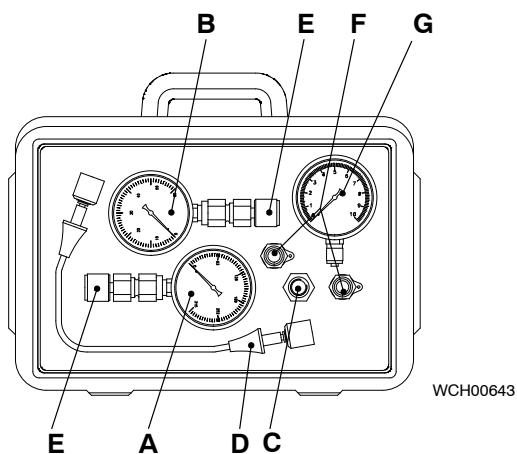
- 94049A** 3 **Round sling**
X = 1750 mm
WLL = 1000 kg



- 94049F** 2 **Round sling**
X = 1500 mm
WLL = 1000 kg



- 94050** **Tool for pressure measurement**
for pneumatic elements
- 94050A** 1 Pressure gauge 0-315 bar
94050B 1 Pressure gauge 0-60 bar
94050C 1 Adapter
94050D 1 HP hose
94050E 2 Screw couplings G1/4"x62 mm
94050F 2 Screw couplings G1/4"
94050G 1 Pressure gauge 0-10 bar



Standard Tools

94051 **Tool for pressure measurement**

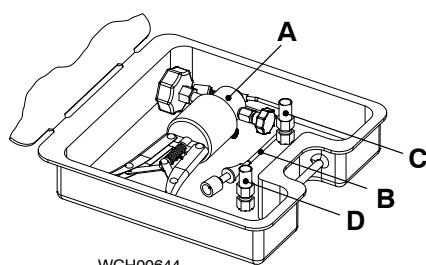
for pneumatic elements

94051A 1 Pressure generator 700 bar

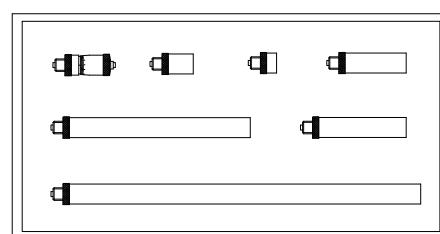
94051B 1 HP hose

94051C 1 1/4" connector

94051D 1 1/4" NPT connector



WCH00644

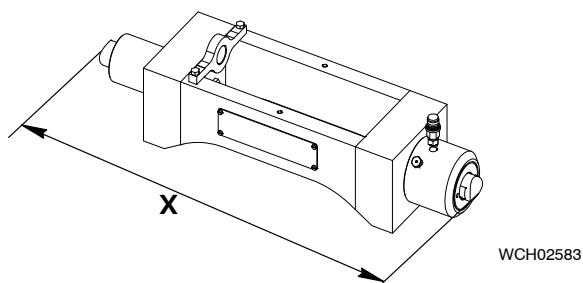
94101 1 Inside micrometer Set(7 pieces with a measuring range
50 mm to 1010 mm), with case

WCH02258

94110 1 Thrust devicefor removal and fitting of
main bearing cover

X = 750,5 mm

Mass approx. 58,8 kg



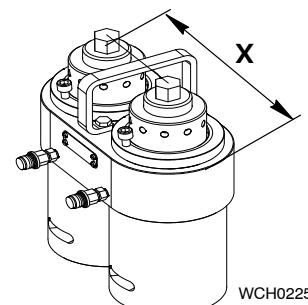
WCH02583

94114 2 Double pre-tensioner

for elastic studs to main bearing

X = 272 mm

Mass approx. 37,9 kg

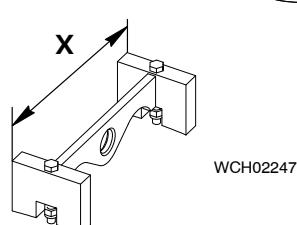


WCH02251

94116A 1 Lifting toolfor removal and fitting of main bearing
shell

X = 264 mm

(WLL 70 kg)

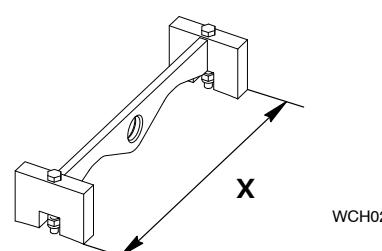


WCH02247

94116B 1 Lifting toolfor removal and fitting of main bearing
shell

X = 185 mm

(WLL 40 kg)

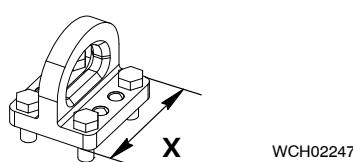


WCH02247

94116C 1 Lifting lugfor removal and fitting of main bearing
cover

X = 105 mm

(WLL 530 kg)

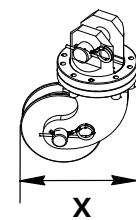


WCH02247

Standard Tools

94117 1 Roller support

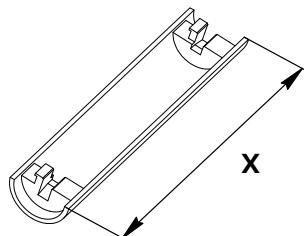
for removal and fitting of main bearing cover
 $X = 232$ mm
 $(\text{Max. } 12000 \text{ N})$



WCH02247

94117B 1 Deviation pipe

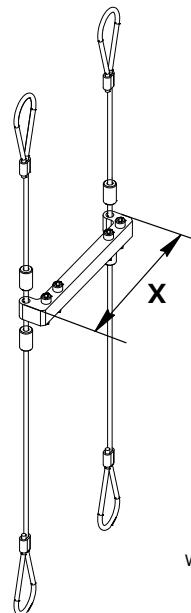
for removal and fitting of:
– main bearing, cover, shell
– connecting rod, cover, shell
– etc.
 $X = 600$ mm



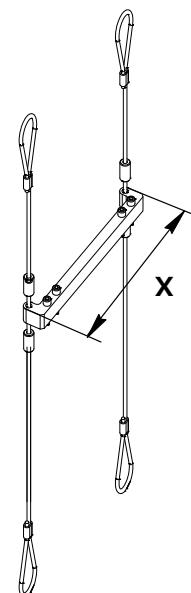
WCH02247

94118A 1 Turning-out device

for removal and fitting of main bearing shell special at driving end
 $X = 203$ mm
(WLL 800 kg)



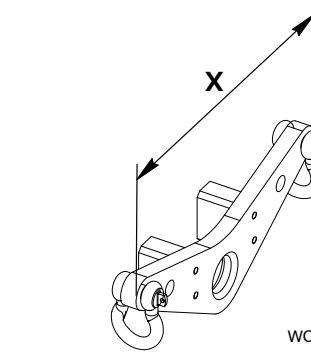
WCH02247



WCH02247

94118B 1 Turning-out device

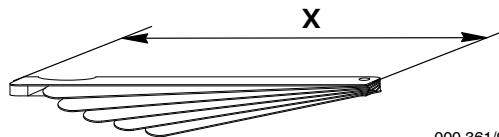
for removal and fitting of the main bearing shell
 $X = 272$ mm
(WLL 800 kg)



WCH02247

94119 1 Lifting plate

for removal and fitting of a main bearing shell
 $X = 292$ mm
(WLL 800 kg)



000.361/93

94122 1 Feeler gauge

$X = 100$ mm
Blade thickness 0.05 ... 1.00 mm
(13-part)

Standard Tools

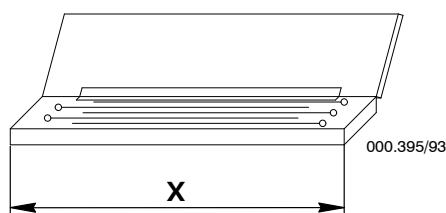
94123 1 Bearing feeler gauge

for main bearing

X = 620 mm

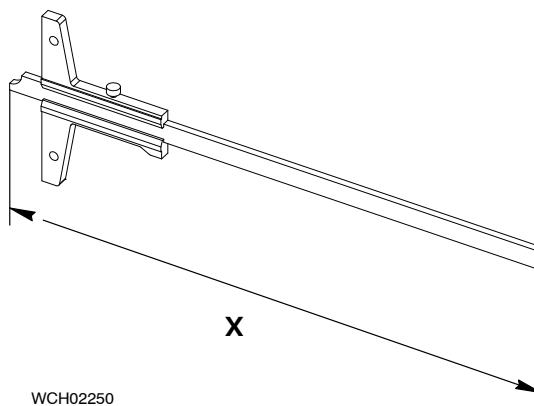
Blade thickness 0.1 ... 1.1 mm

(11-part)

**94126 1 Depth gauge**

with case

X = 310 mm

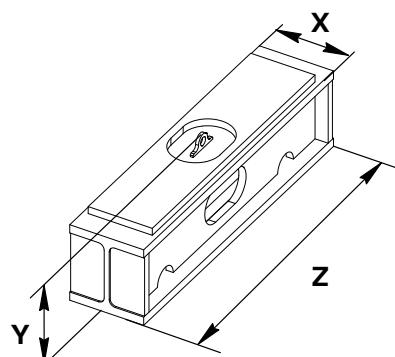
**94141A 1 Bracket**for removal and fitting of
main bearing shells

X = 255 mm

Y = 285 mm

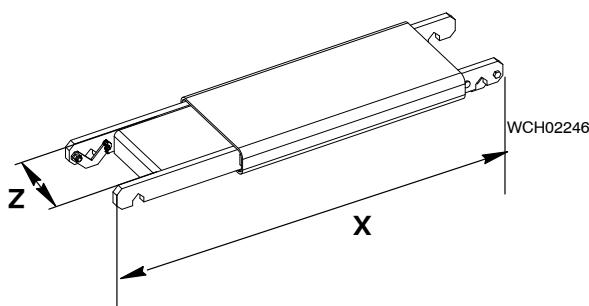
Z = 966 mm

Mass approx. 197 kg

**94142 1 Working platform (adjustable)**

X = 725 mm to 902 mm

Z = 240 mm

Mass approx. 10.4 kg
(max. loading 200 kg/m²)

Standard Tools

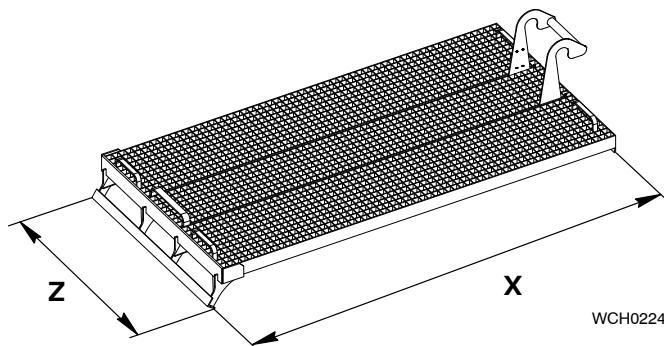
94143 1 Working supports

Quantity three grids each

 $X = 1739 \text{ mm}$ $Z = 827 \text{ mm}$

Mass approx. 136 kg

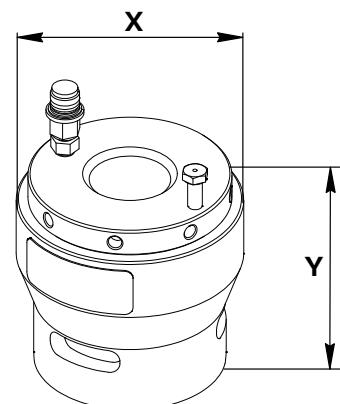
(Mass of 1 grid approx. 81,3 kg)

(max. loading 200 kg/m²)

WCH0224

94145 1 Pre-tensioner

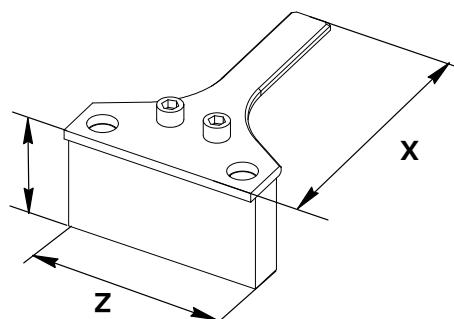
for foundation bolts and engine stays

 $X = \varnothing 156 \text{ mm}$ $Y = 151 \text{ mm}$ 

016.744/08

94155 1 Carrier

For pushing out the thrust pads

 $X = 332 \text{ mm}$ $Y = 134 \text{ mm}$ $Z = 240 \text{ mm}$ 

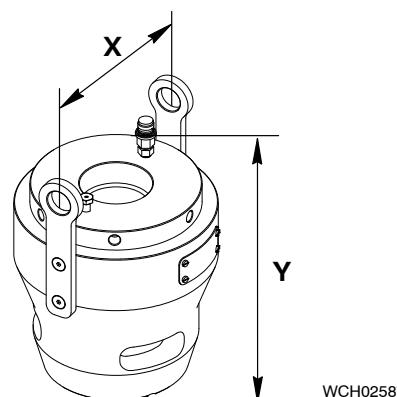
WCH02254

94180 2 Pre-tensioner

for tie rods

 $X = 277 \text{ mm}$ $Y = 344,5 \text{ mm}$

Mass approx 58,5 kg



WCH02587

Standard Tools

94201 1 Lifting device

for fitting and transporting a cylinder

Liner

 $X = 963 \text{ mm}$

Mass approx. 173 kg

(WLL 4200 kg)

consisting of:

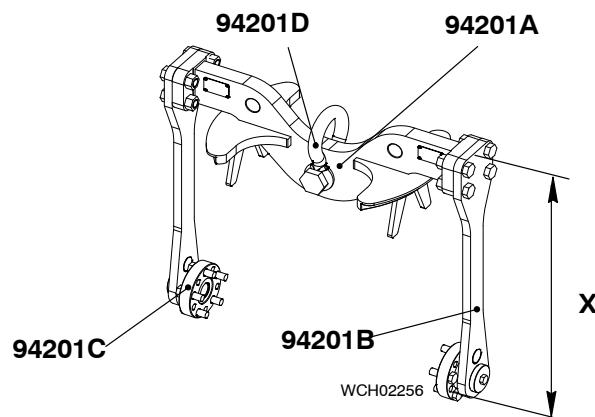
94201A, B, C, D

94201A 1 Lifting tool $X = 963 \text{ mm}$

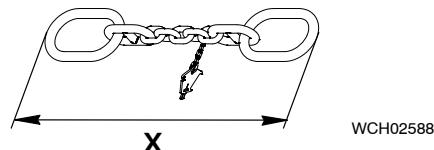
Mass approx. 100 kg

94201B 2 Holder $X = 940 \text{ mm}$

Mass approx. 19,7 kg

94201C 2 Flange coupling $X = \varnothing 176 \text{ mm}$ **94201D Shackle****94202L 1 Chain** $X = 635 \text{ mm}$

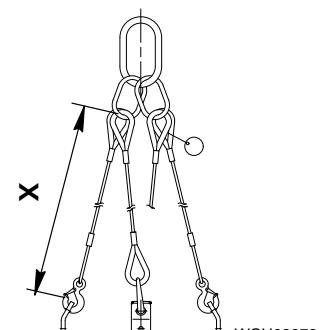
WLL 5000 kg

**94209 1 Lifting tool**

for anti-polishing ring

 $X = 1500 \text{ mm}$

(WLL 850 kg)



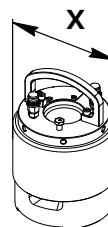
Standard Tools

94215A 6 Pre-tensioner

for cylinder cover studs

X = Ø 194 mm

Mass approx. 31,3 kg

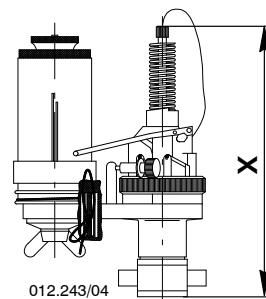


WCH02593

94219 1 Cylinder pressure measuring tool (indicator),

including a wooden box

X = 165 mm



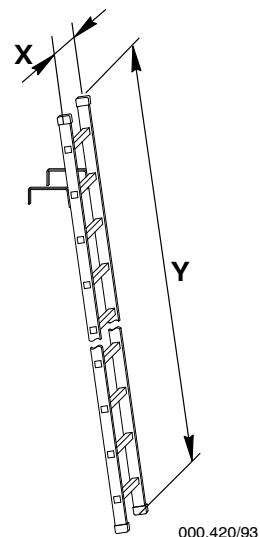
012.243/04

94224 1 Ladder

for measuring cylinder liner bore

X = 350 mm

Y = 2700 mm



000.420/93

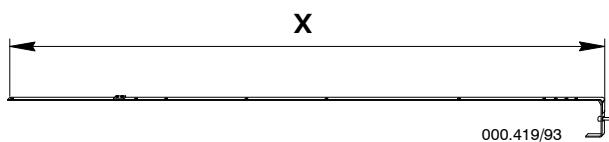
94225 1 Measuring gauge

for measuring cylinder liner bore

(accessory for it:

inside micrometer tool 94101)

X = 2895 mm

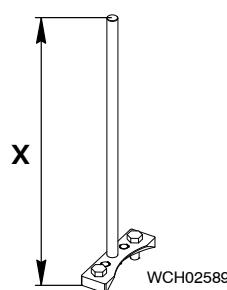


000.419/93

Standard Tools

94230 2 Distance holders

for removal and fitting of piston rod
gland and piston,
including 4 screws M16x40
 $X = 540$ mm

**94231A 2 Clamping rings**

Thick 54
 $X = 280$ mm

94231B 2 Distance pieces

Thick 12
 $X = 300$ mm

94231C 2 Distance pieces

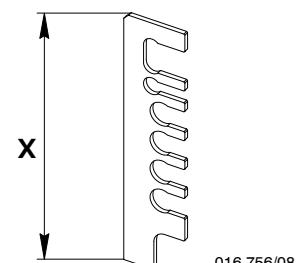
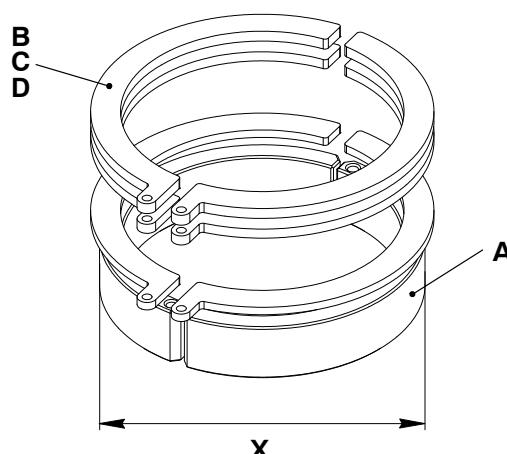
Thick 11
 $X = 300$ mm

94231D 2 Distance pieces

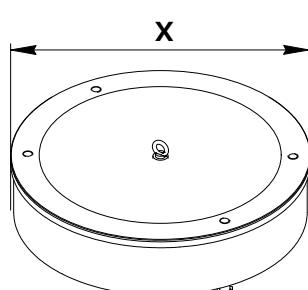
Thick 9
 $X = 300$ mm

94231E 1 Template

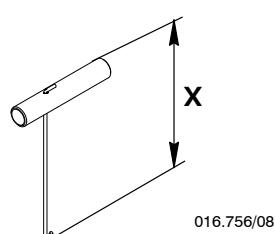
Thick 6
for fitting scraper rings
 $X = 254$ mm

**94232 1 Covering**

for covering bore of piston rod gland in
cylinder jacket (when piston and gland
are removed)
 $X = \varnothing 460$ mm
Mass approx. 31,9 kg

**94233 1 Assembly tool**

for tensioning springs
to piston rod gland and insulation
bondage
 $X = 150$ mm



Standard Tools

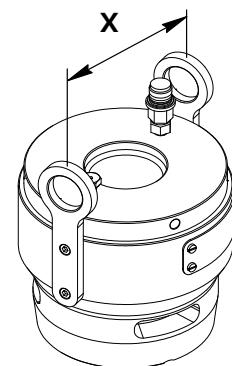
94252 2 Pre-tensioner

for exhaust valve cage /

Lower connecting rod

X = Ø 209 mm

Mass approx. 22.2 kg

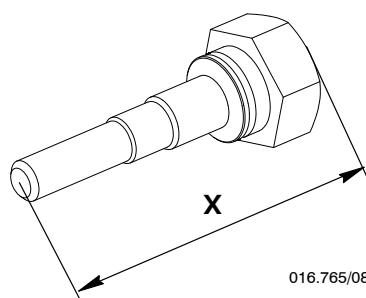


WCH02591

94259 2 Pressure element

for exhaust valve

X = 204 mm

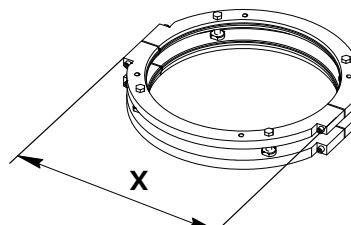


016.765/08

94261 1 Valve seat fitting and dismantling device

X = 526 mm

Mass approx. 30,8 kg

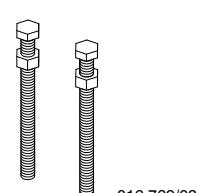


016.766/08

94263 2 Jack screws M12x150for assembling guide bush to exhaust
valve,

including:

2 hexagon nut M12



016.769/08

94265 1 Suspension device

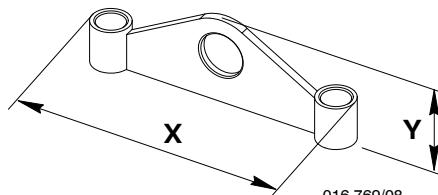
for cylinder cover

(WLL 2700 kg)

X = 730 mm

Y = 225 mm

Mass approx. 35 kg

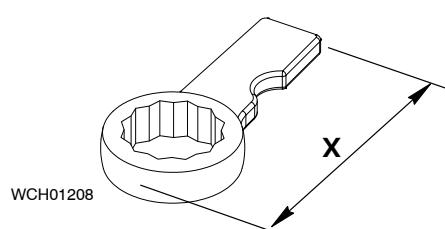


016.769/08

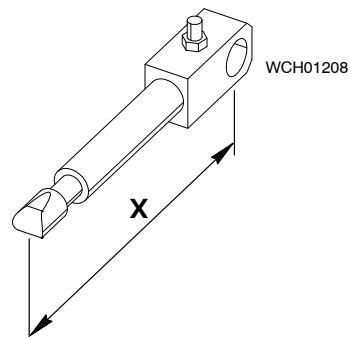
Standard Tools

94269A-65 1 Slugging wrench

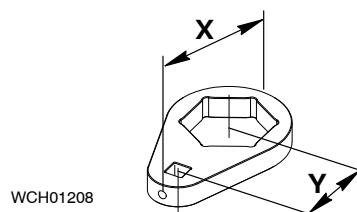
for loosening and tightening of coupling nut (AF70 to injection valve with FAST)
 X = 232 mm

**94269B 1 Hydraulic cylinder**

for loosening and tightening of coupling nut to injection valve with FAST
 X = 395 mm

**94269C-41 1 Torque wrench extension**

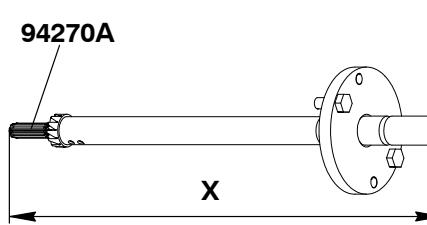
for loosening and tightening of clamping nut (AF55) to injection valve with FAST
 X = 106 mm
 Y = 65 mm

**94269C-65 1 Torque wrench extension**

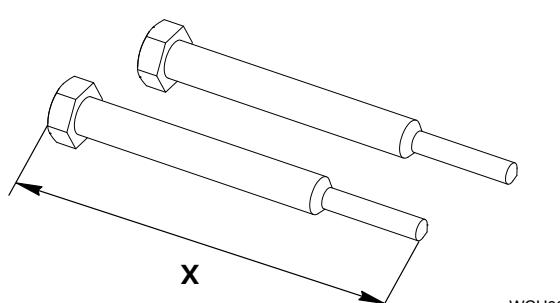
for pre-tightening of coupling nut (AF70) to injection valve with FAST
 X = 144.5 mm
 Y = 75 mm

94270 1 Cutting device

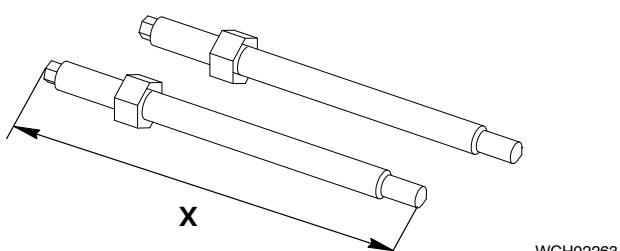
for overhauling injection valve (with FAST) seat in cylinder cover
 X = 564 mm
 including:

**94270A 1 Profile cutter****94270C 2 Hexagon head bolt**

For Injection valve
 X = 170 mm

**94270D 2 Stud bolt**

For Injection valve
 X = 176 mm



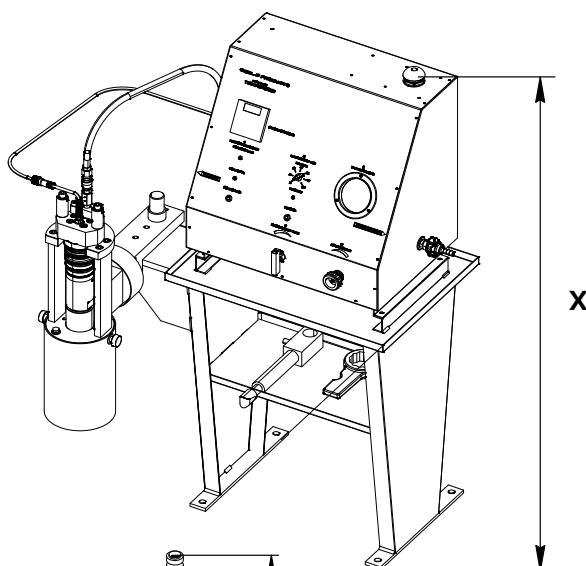
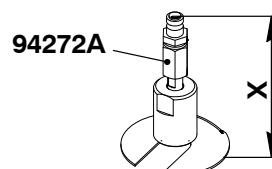
Standard Tools

94272 1 Injector test bench

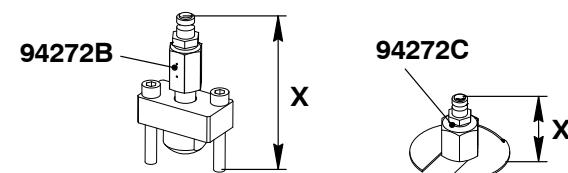
for setting and testing of:

- injection valve
- safety valve
- relief valve

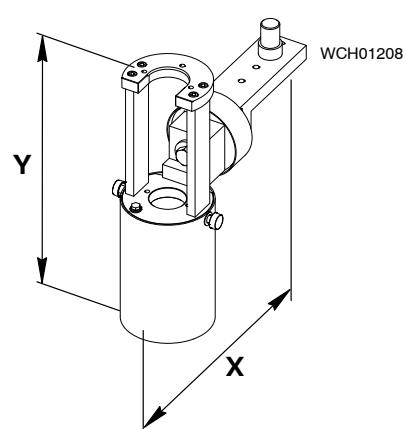
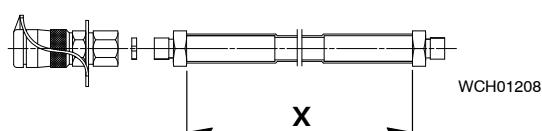
X = 1498 mm

Mass approx. 161 kg
including:**94272A 1 Valve holder**for checking the fuel
Overpressure safety
valve
X = 170 mm

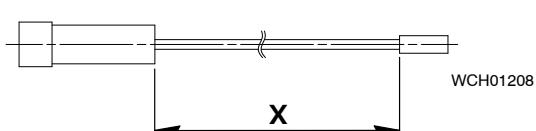
WCH02260

94272B 1 Connecting piecefor adjusting the injection
Valve
X = 130 mm

WCH01208

94272C 1 Valve holderfor checking and
adjusting relief valve to
cylinder cover
X = 68 mm**94273 1 Valve holder**to OBEL test bench
for fastening injection valve with FAST
X = 582 mm
Y = 602 mm**94275 1 HP hose**to OBEL test bench
for testing, loosening and tightening
of coupling nut to injection valve with
FAST
X = 1350 mm
Max. working pressure 1800 bar

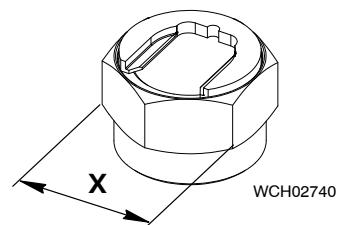
WCH01208

94275A 1 Cableto OBEL test bench
Electric connection between OBEL test
bench and injection valve with FAST
X = 1200 mm

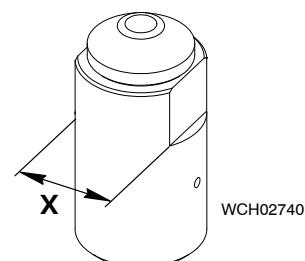
WCH01208

Standard Tools

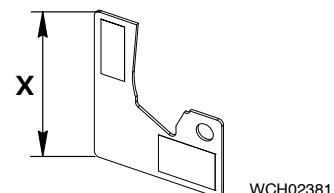
94278A 1 Nozzle disassembly tool
for injection nozzle disassembly
 $X = AF\ 46\ mm$



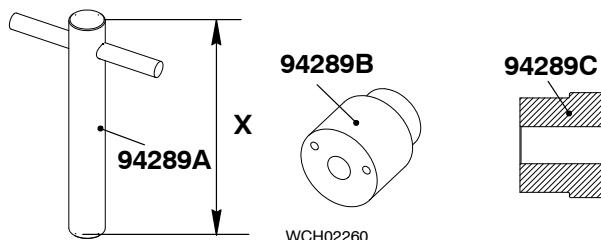
94278B 1 Nozzle assembly tool
for injection nozzle assembly
 $X = AF\ 41\ mm$



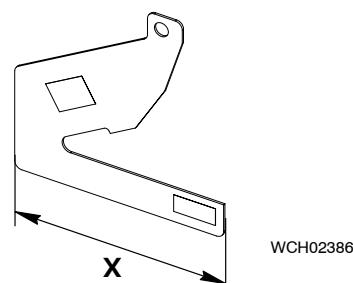
94279 1 Template
for checking wear on exhaust valve seat
 $X = 145\ mm$



94289 1 Assembly tool
Of mounting / dismounting pilot valve
Consisting of:
94289A 1 T-handle
94289B 1 Bush
94289C 1 Bush
 $X = 120\ mm$

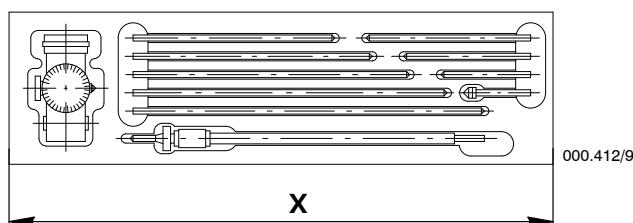


94292 1 Template
for checking wear of exhaust valve spindle
 $X = 211,5\ mm$

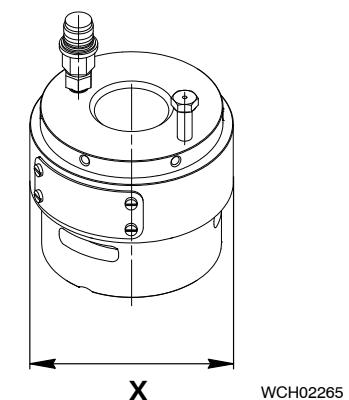


Standard Tools

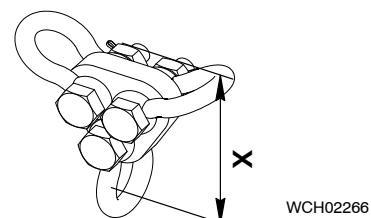
- 94305 1 Crankshaft checking equipment**
for measuring crank deflection
(in wooden box)
 $X = 364$ mm



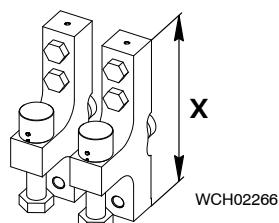
- 94315 2 Pre-tensioner**
for connecting rod studs to top end bearing
 $X = 130$ mm



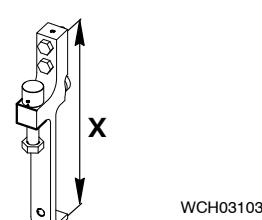
- 94321 1 Link**
For connecting rod assembly
 $X = 304$ mm



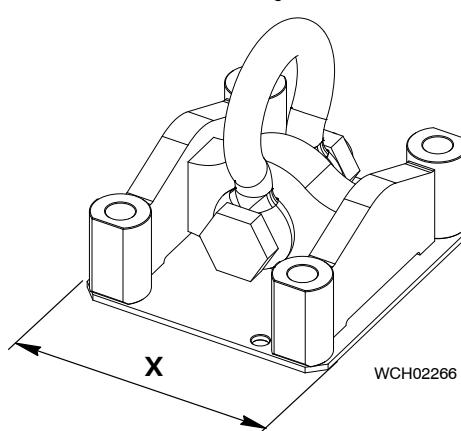
- 94322 1 Support**
For connecting rod assembly
 $X = 344$ mm



- 94322A 1 Support (Engines with ELBA)**
For crosshead
 $X = 725$ mm



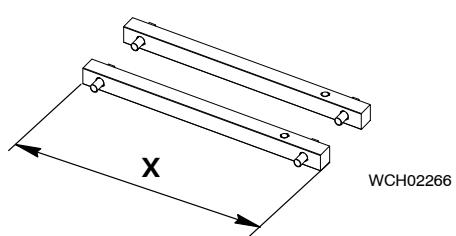
- 94324 1 Lifting tool**
For connecting rod assembly
 $X = 290$ mm
Mass approx. 38.8 kg
(WLL 5200 kg)
including:



Standard Tools

94324C 2 Fixing device

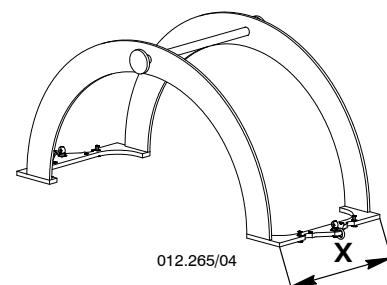
For connecting rod assembly
 $X = 600$ mm
 Mass approx. 15.3 kg

**94325 1 Chain**

For pulling the crosshead pin
 2 slings à 424 mm
 Mass approx. 4 kg
 (WLL 1500 kg)

**94326 1 Fitting and dismantling device**

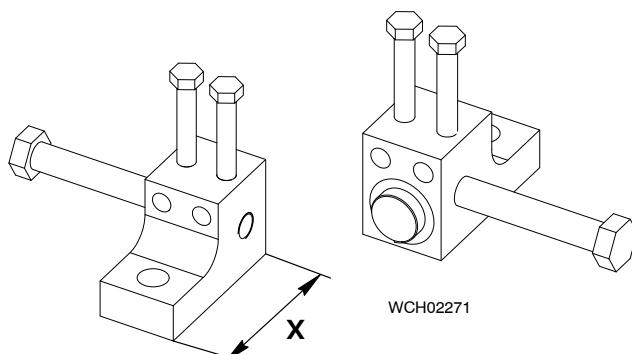
for removal and fitting of bottom end
 bearing shell
 $X = 393$ mm
 Mass approx. 16,8 kg
 (WLL 50 kg)

**94327 1 Chain**

for removal and fitting lower connecting
 rod bearing shell
 4 slings à 654 mm
 Mass approx. 5 kg
 (WLL 1120 kg)

**94333 1 Lifting tool**

For connecting rod bearing assy
 $X = 165$ mm



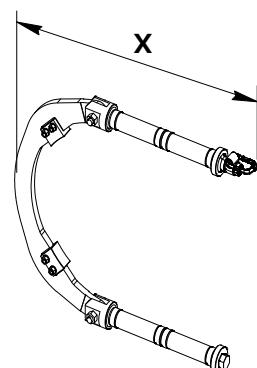
Standard Tools

94334 1 Holder

for removal and fitting of a connecting rod (\varnothing 760 mm), including

X = 1248 mm

Mass approx. 134 kg ??

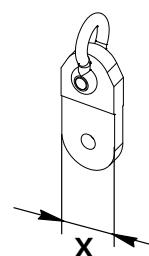


WCH02270

94334A 1 Connecting element with shackle

X = 90 mm

(WLL 2500 kg)



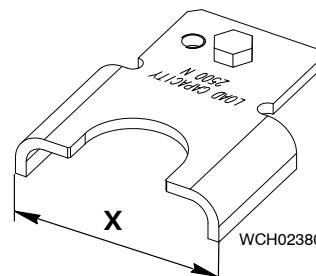
WCH02270

94335 1 Stop plate

with screw M20x40

for inspection to top end bearing

X = 162 mm

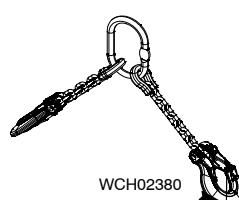


WCH02380

94335 1 Chain

For lifting upper bearing cover

2 slings à 278 mm

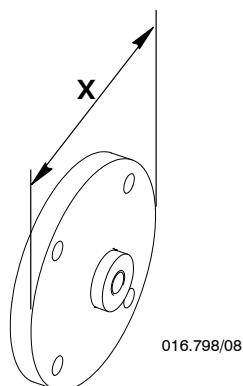


WCH02380

94336 1 Connecting flange

for pre-lubrication of top and bottom
end bearings

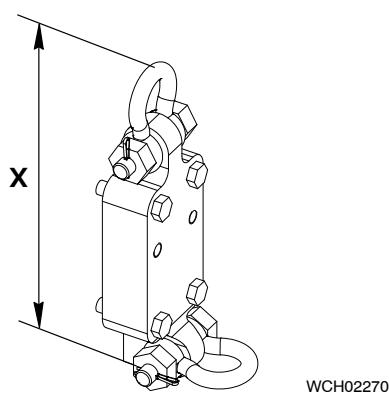
X = \varnothing 160 mm



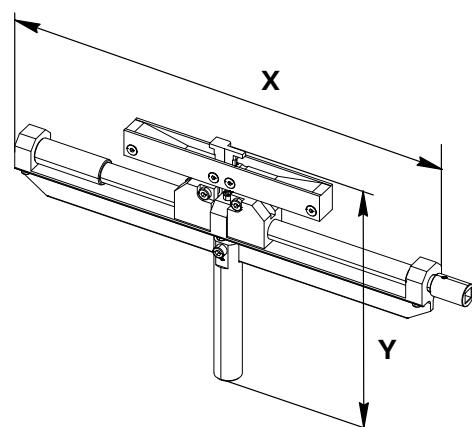
016.798/08

Standard Tools

- 94337 1 Lifting tools**
with 4 screws M20x75
for the connecting rod
 $X = 384 \text{ mm}$
WLL:
– vertical 2500 kg
– horizontal 1500 kg

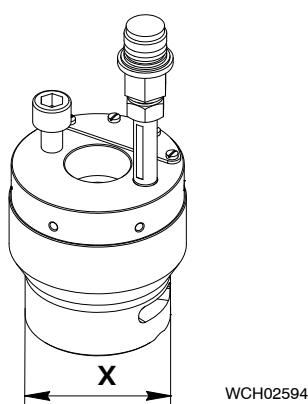


- 94338 1 Piston ring tensioning device**
 $X = 500 \text{ mm}$
 $Y = 292.1 \text{ mm}$



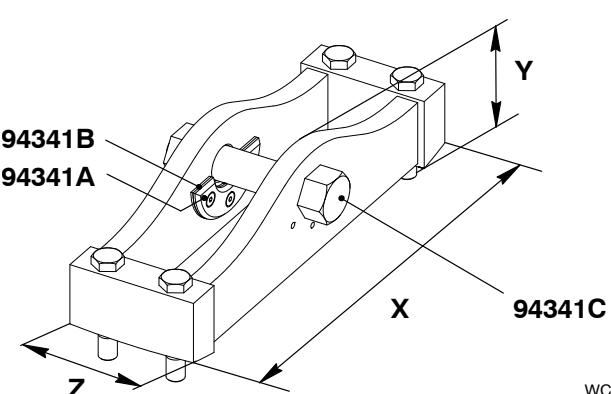
WCH02681

- 94340 4 Pre-tensioner**
for piston rod foot fastening
 $X = \emptyset 83 \text{ mm}$



WCH02594

- 94341 1 Piston suspension device**
 $X = 494 \text{ mm}$
 $Y = 170 \text{ mm}$
 $Z = 220 \text{ mm}$
(WLL 7350 kg)
Mass approx. 46.2 kg

94341A 2 Distance plates**94341B 2 Distance pieces****94341C 1 Pin**

WCH02272

Standard Tools

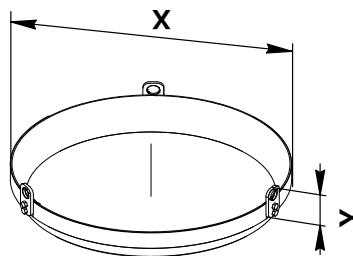
94342 1 Insertion funnel

for fitting a piston

X = 719 mm

Y = 160 mm

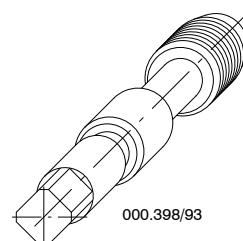
Mass approx. 36.3 kg



WCH02272

94348 1 Tap M20

for cleaning carbon deposits in threaded holes of piston crown

**94350 1 Device**

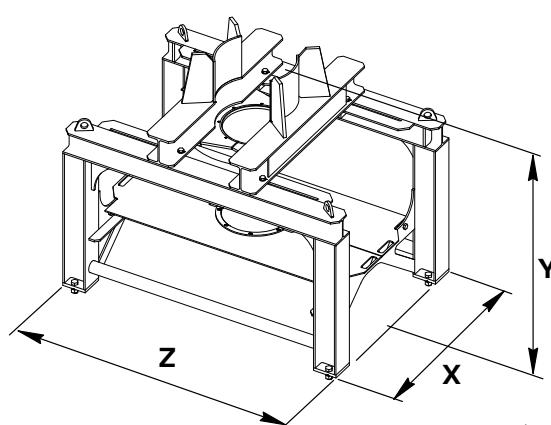
for supporting piston and removal of piston rod gland

X = 1136 mm

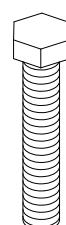
Y = 1271 mm

Z = 860 mm

Mass approx. 272 kg



016.797/08

94364A 2 Jacking screwsfor separating of piston head
M20x190

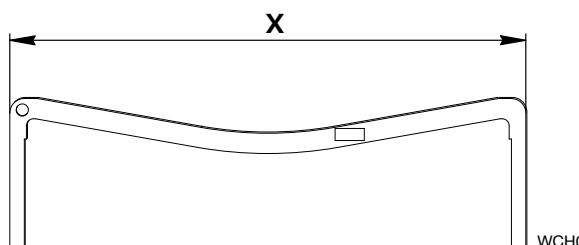
017.028/08

94364B 2 Jacking screwsfor separating of the spray plate
M12x70**94364C 2 Jacking screws**for separating of piston skirt
M20x65

Standard Tools

94366 1 Template

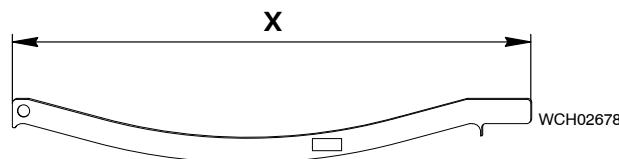
for shape of top of piston head
(piston removed)
 $X = 689 \text{ mm}$



WCH02678

94366A 1 Template

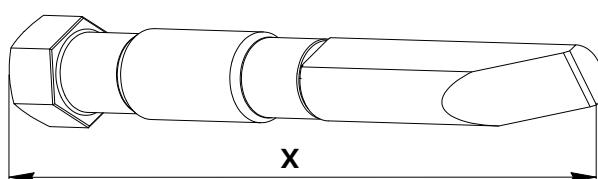
for shape of top of piston head
(for use with piston installed)
 $X = 740 \text{ mm}$



WCH02678

94410 8 Adjusting devices

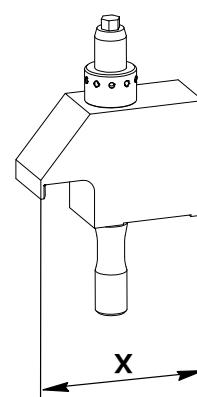
for alignment of intermediate wheel
 $X = 227 \text{ mm}$



WCH02276

94430 1 Roller lifting tools

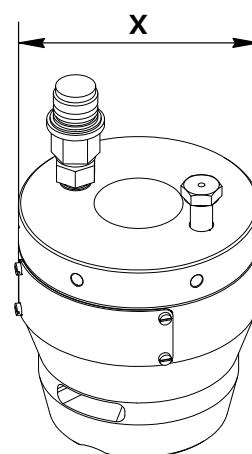
for cutting out and cutting in of fuel
pump,
including: elastic bolts and round nut
 $X = 197 \text{ mm}$



WCH02278

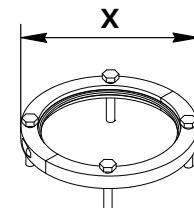
94430A 1 Pre-tensioner

for roller lifting tool
 $X = \emptyset 108 \text{ mm}$

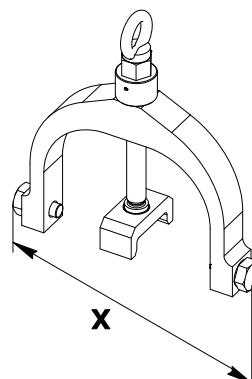


WCH02278

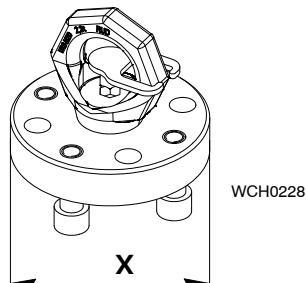
Standard Tools

94550 1 Clamping ring 2-parts $X = \emptyset 210$ mm

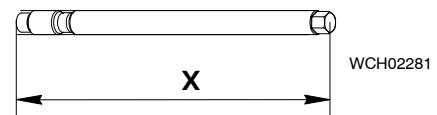
WCH02281

94551 1 Fitting and dismantling devicefor removal and fitting of guide pin to
fuel pump $X = 334$ mm

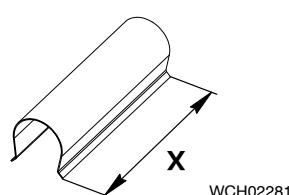
WCH02281

94552 1 Lifting toolwith head screws M14x40
for removal and fitting of a fuel pump
 $X = \emptyset 120$ mm
(WLL 600 kg)

WCH02281

94553 1 RodGuide rod to fuel pump
 $X = 470$ mm

WCH02281

94555 2 Distance pieceto fuel pump
 $X = 95$ mm

WCH02281

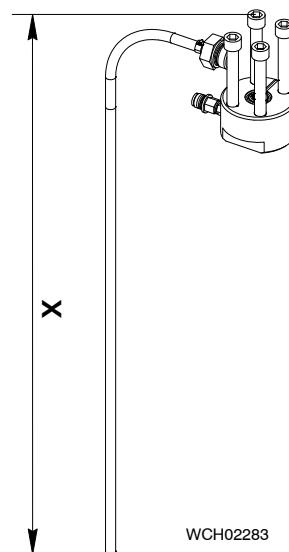
Standard Tools

94556 1 PCV test block with tube

For pressure check of pressure control

valve

X = 954 mm

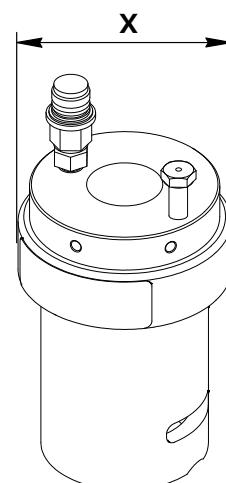


WCH02283

94557 2 Pre-tensioning jacks

for elastic bolts to camshaft bearing

X = Ø 112 mm



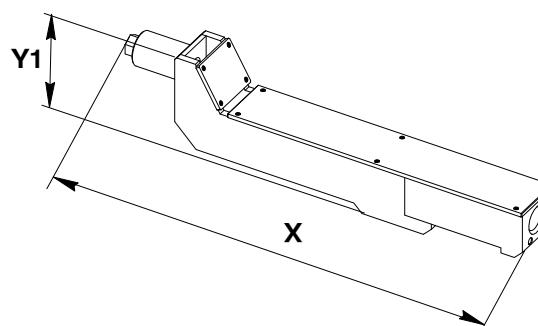
016.863/08

94566 2 Supportfor camshaft assembly,
including clamping nut

X = 925 mm

Y1 = 180 mm

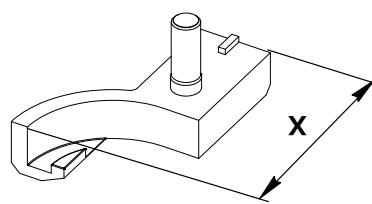
Mass approx. 23 kg



WCH02278

94566B 1 Holderfor camshaft assembly,
including hexagon socket screw

X = 172 mm

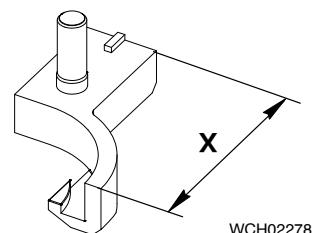


WCH02278

Standard Tools

94566C 1 Holder

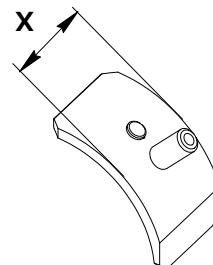
for camshaft assembly,
including hexagon socket screw
 $X = 172$ mm



WCH02278

94567 1 Assembly template

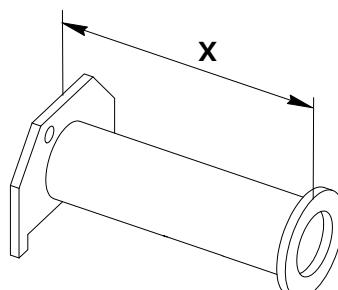
for removal and fitting of bearing shells
to fuel pump unit
 $X = 90$ mm



WCH02278

94567A 1 Assembly template

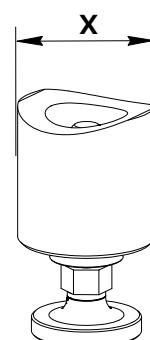
for fitting of bearing shells to fuel pump
unit
 $X = 177$ mm



WCH02278

94567B 1 Jacking screw

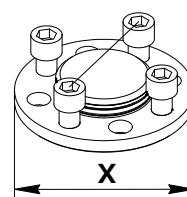
for camshaft assembly
 $X = \emptyset 75$ mm



WCH02278

94569 1 Blank flange

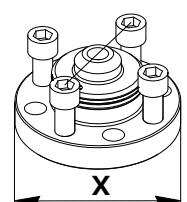
to fuel pump,
including screws M14x25
 $X = \emptyset 120$ mm



WCH02278

94569A 1 Blank flange

to intermediate piece,
including screws M14x50
 $X = \emptyset 116$ mm



WCH02278

Standard Tools

94592 1 Fuel pump rack

for fuel pump
 $X = 1039$ mm
 Mass approx. 86.6 kg
 consisting of:

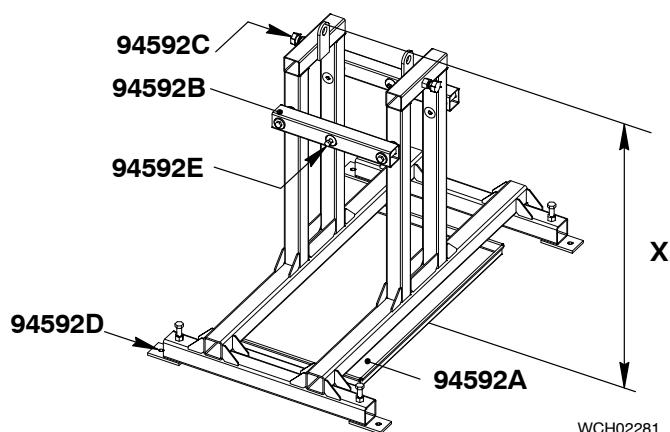
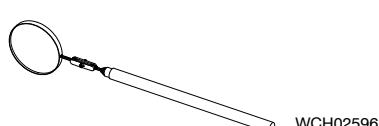
94592A 1 Oil trough

94592B 2 Limiter
 with 4 screws M16x50
 and washers

94592C 2 Screws M20

94592D 4 Screws (M16x50)

94592E 2 Screws (M12x90)

**94592M 1 Mirror****94593 1 Guide bracket**

for Pre-tensioning device
 $X = \varnothing 370$ mm
 Mass approx. 23.5 kg

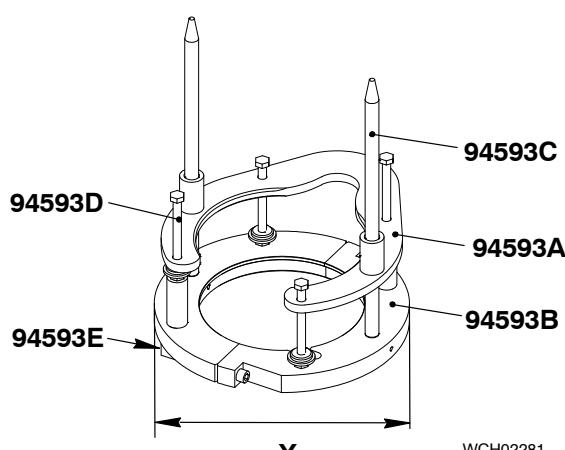
94593A 1 Ring

94593B 1 Ring (2-part)

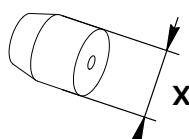
94593C 2 Guide rods

94593D 4 Screws M12x130 with special nuts

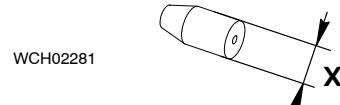
94593E 2 Screws M30x110

**94597 1 Mandrel**

for fitting seal into lower spring carrier
 and lower housing of fuel pump
 $X = \varnothing 70$ mm

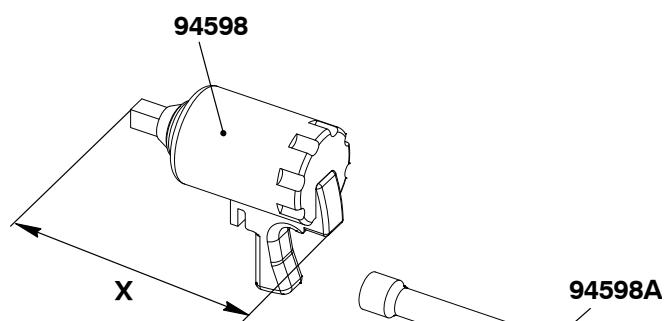
**94597A 1 Mandrel**

for fitting seal into lower spring carrier
 $X = \varnothing 40$ mm

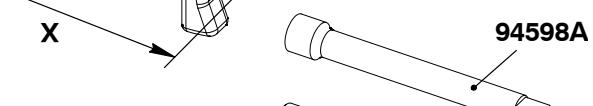


Standard Tools**94598 1 Pneum. impact wrench**

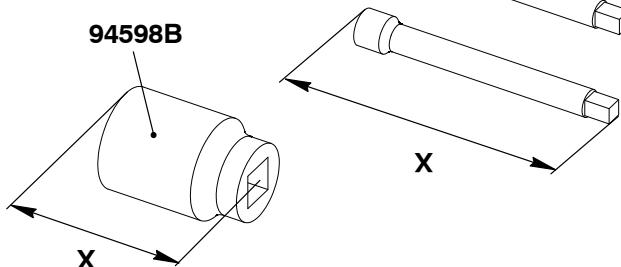
for loosening and tightening fuel pump
on fuel pump unit
 $X = 271$ mm

**94598A 2 Extensions**

$X = 400$ mm

**94598B 1 Socket wrench insert**

$X = 100$ mm



Standard Tools

In case of a turbocharger breakdown**Cover to exhaust manifold outlet:**

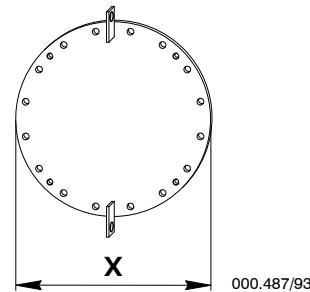
- 94653A-M60** for MET 60 MB, X = 600 mm, 16 holes
94653A-A265 for ABB 265, X = 600 mm, 12 holes

Cover to turbocharger inlet:

- 94653B-M60** for MET 60 MB, X = 600 mm, 16 holes
94653B-A265 for ABB 265, X = 600 mm, 12 holes

Cover to scavenge air receiver:

- 94653C-M60** for MET 60 MB, X = 520 mm
94653C-A265 for ABB 265, X = 475 mm

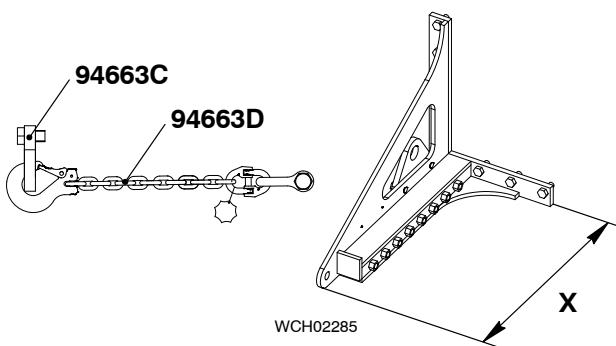
**Cover to turbocharger outlet:**

- 94653D-M60** for MET 60 MB, X = 520 mm
for ABB 265, same as for scavenge
Air receiver

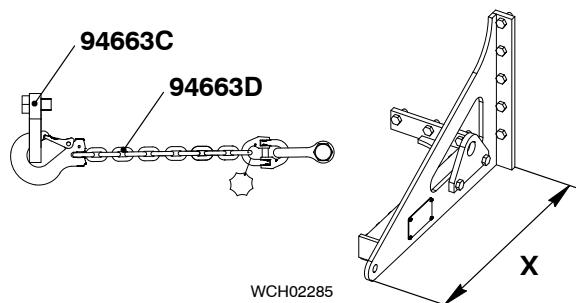
Standard Tools

94663A 1 Support left

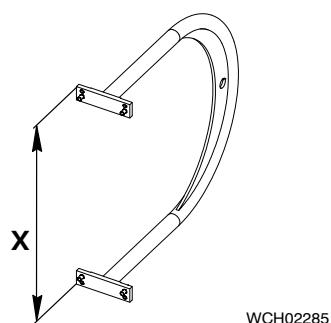
including safety chain 94663D and safety lug 94663C
for removal and fitting of scavenge air cooler
 $X = 705$ mm
(WLL 6200 kg)
Mass approx. 65 kg

**94663B 1 Support right**

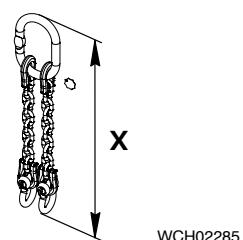
including safety chain 94663D and safety lug 94663C
for removal and fitting of scavenge air cooler
 $X = 705$ mm
(WLL 6200 kg)
Mass approx. 65 kg

**94663I 1 Support**

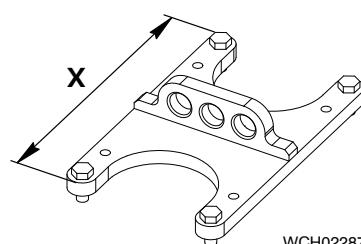
for fitting of scavenge air cooler
 $X = 960$ mm

**94666 1 Chains (double sling)**

for removal and fitting of scavenge air cooler
 $X = 625$ mm

**94667 3 Lifting tool**

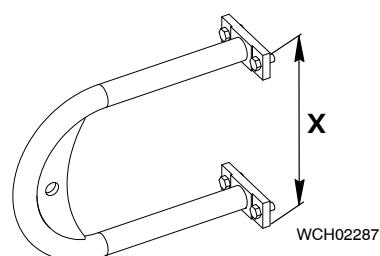
for removal of water separator,
including:
4 Hexagon head screw M12x30
 $X = 300$ mm
(WLL = 240 kg)



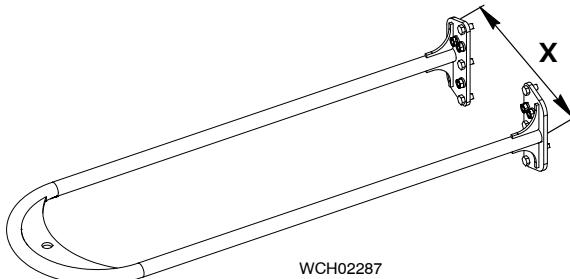
Standard Tools

94667G 1 Holder

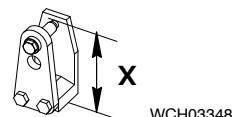
for pulling of water separator
X = 420 mm

**94667H 1 Holder**

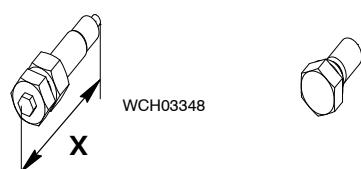
for fitting of water separator
X = 540 mm

**94701 1 Adjusting tool**

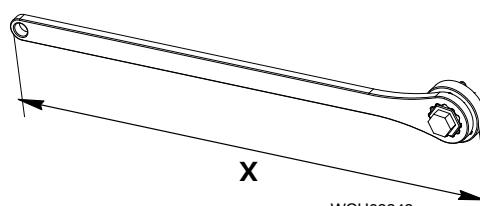
For ELBA assembly
X = 139 mm

**94702 1 Transportation tool**

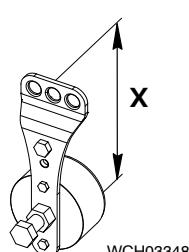
For ELBA assembly
X = 200 mm

**94703 1 Turning device**

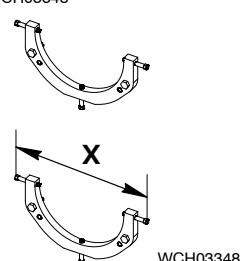
For ELBA assembly
X = 1089 mm

**94704 1 Lifting tool**

For ELBA assembly
X = 368 mm

**94705 2 Alignment tools**

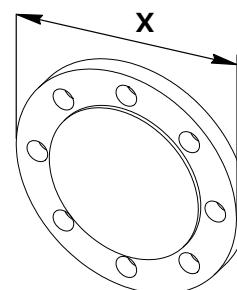
For ELBA assembly
X = 326 mm



Standard Tools

94831 1 Blind flange

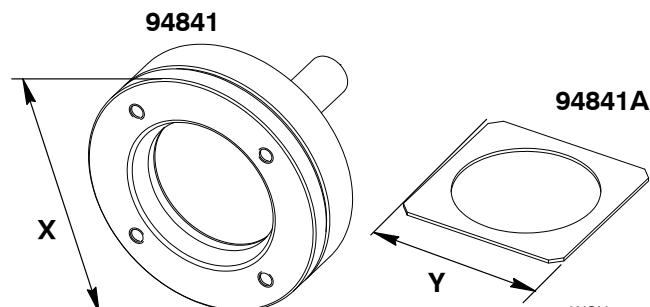
for blanking off starting air pipe during emergency operation
 $X = \text{Ø} 235 \text{ mm}$



WCH02289

94841 1 Grinding tool

for hydraulic pipe
 $X = \text{Ø} 65 \text{ mm}, R100$



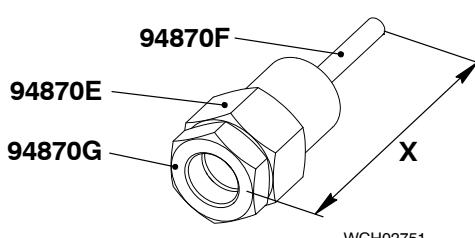
WCH02756

94841A 1 Stencil

$Y = 65 \text{ mm}$

94870 1 Grinding device

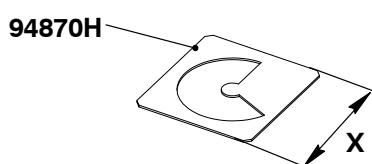
For HP fuel pipe
 $X = 166 \text{ mm}$
 including:



WCH02751

94870E 1 Screw-on sleeve

AF60



WCH02751

94870F 1 Grinding tool

with countersunk screw M8

94870G 1 Lock nut

M36x2, AF46

94870H 1 Stencil

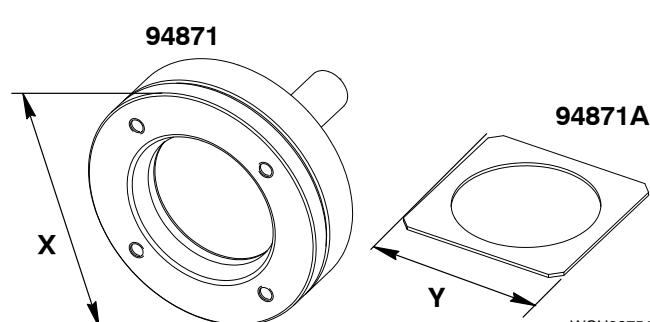
$X = 70 \text{ mm}$

94871 1 Grinding tool

for injection pipe
 $X = \text{Ø} 60 \text{ mm}, R30.5$

94871A 1 Stencil

$Y = 50 \text{ mm}$

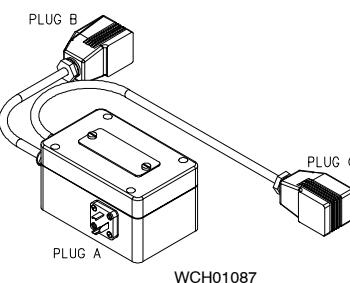


WCH02751

Standard Tools

94929 2 Connecting cables with plugs

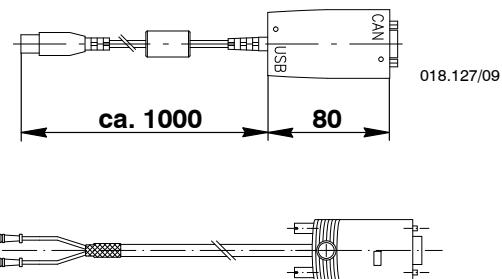
for emergency cylinder lubrication
Connector (plug 'C')
Plug 'B' with cable lenght = 0.5 m
Plug 'C' with cable lenght = 2.5 m

**94930 1 SW-download package**

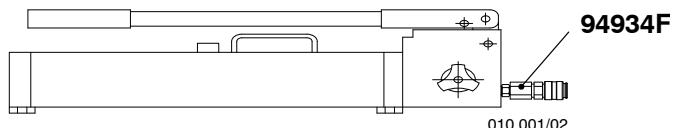
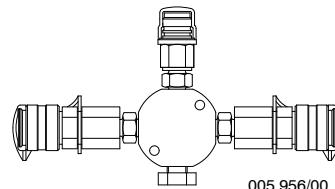
to UNIC for uni tool

consisting of:

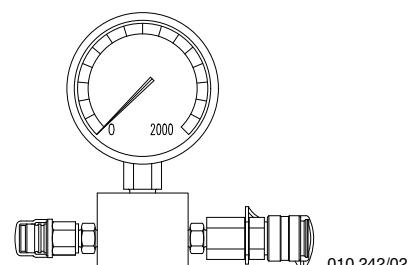
- 94930A** 1 UBS to CAN adapter
- 94930B** 1 CAN cable (ca. 2.5 m)
- 94930C** 1 Ethernet adapter cable
(software tool)



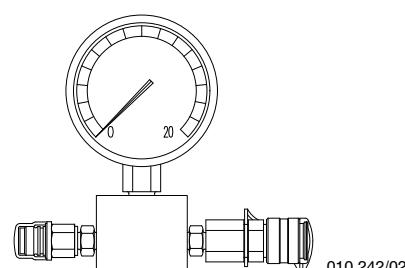
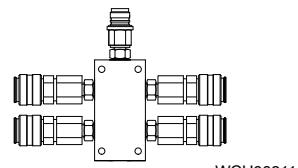
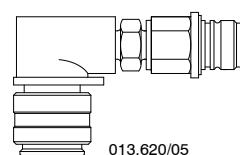
Standard Tools

Hydraulic parts and pump**94931 1 HP oil pump**working pressure maximum allowable
2000 bar**94934F 1 Adapter piece****94934 2 Connection block****94934A 2 Pressure gauges**

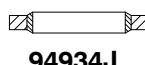
0–2000 bar

**94934B 1 Pressure gauge**

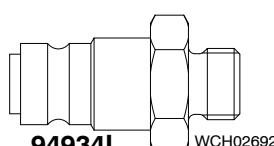
0–16 bar

**94934C 1 Distributing piece****94934G 4 Coupling elements****94934I 1 Connection nipple**

For testing the lubrication quill

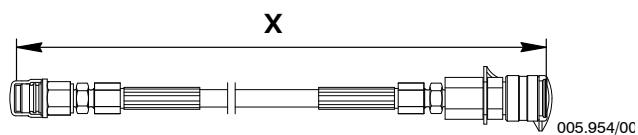
**94934J 1 Tredo joint**

For connecting nipple 94934I

**94935 5 HP hoses**with closing valves and coupling
sockets

X = 2130 mm

working pressure max. 2000 bar



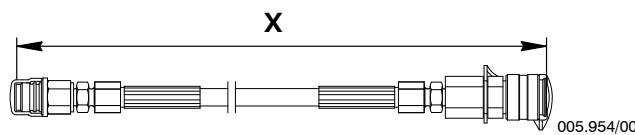
Standard Tools

94935A 5 Flexible hoses

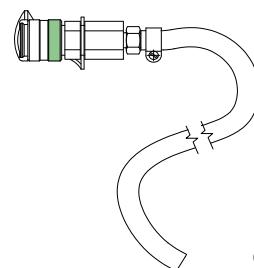
with closing valves and coupling
sockets

X = 1210 mm

working pressure max. 2500 bar

**94935C 1 Hose**

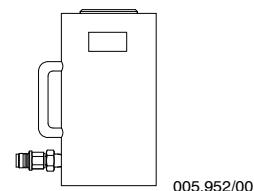
for oil drain of pre-tensioning jacks

**94936 2 Hydraulic ram**

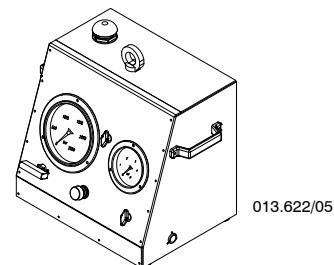
with closing valves

working range 933 ... 1002 kN

(95 ... 100 t)

**94942 1 Hydraulic unit**

working pressure max. 2000 bar



Recommended Special Tools

94215

1 Lifting tool

for cylinder cover pre-tensioners

Mass approx. 48,3 kg

Including:

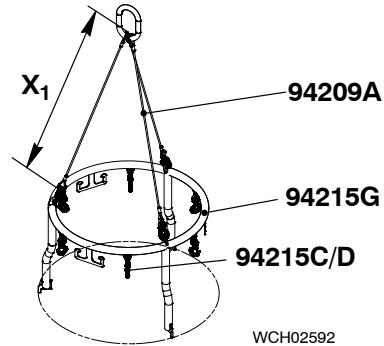
94209A 1 Wire rope sling with hook

94215C 6 Shackle

94215D 6 Hook

94215G 1 Lifting tool

$X_1 = 1252$ mm



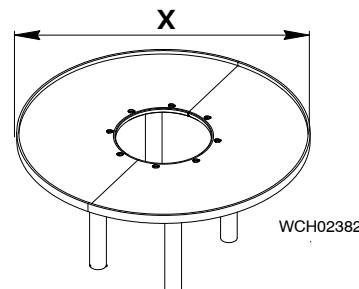
94234

1 Platform

for piston rod gland removal inside the engine

$X = \varnothing 772$ mm

Mass approx. 30 kg

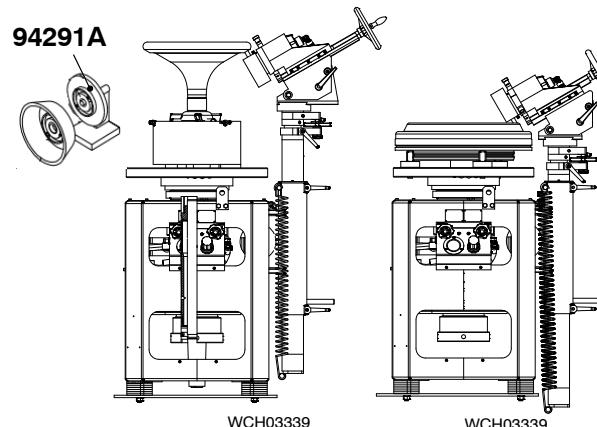


94291

1 Valve grinding device complete
for valve spindle and valve seat

94291A

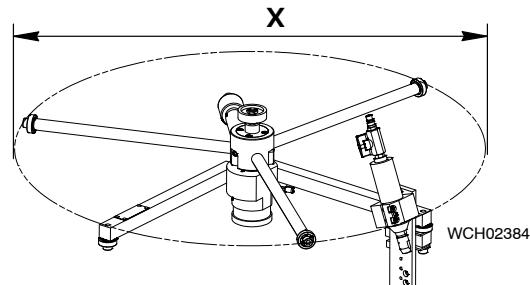
2 Grinding discs
(C-M No. 11373-01-01)



94299

1 Grinding device

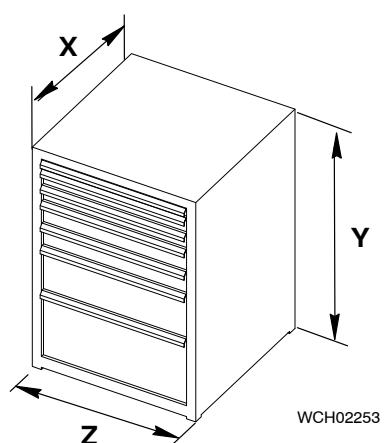
$X = \varnothing 740$ mm



Recommended Special Tools

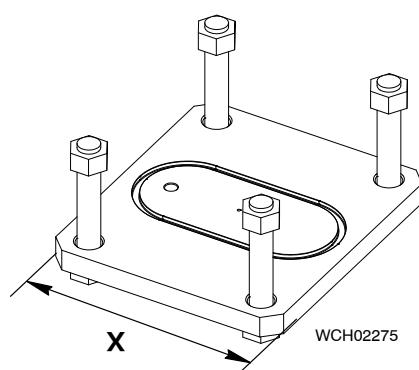
94300 1 Tool Cupboard

X = 725 mm
Y = 1000 mm
Z = 717 mm
Mass approx. 133 kg



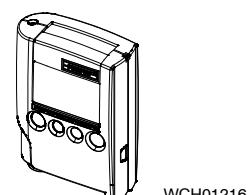
94349 1 Plate

for piston pressure testing
X = 290 mm
Mass approx. 22.9 kg



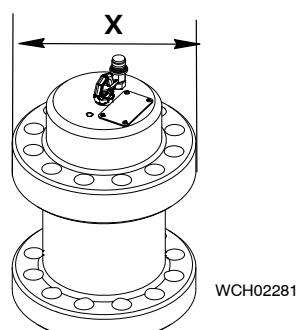
94356 1 Equipment case

with instruments
for measuring thickness of chrome-
ceramic-layer on piston rings



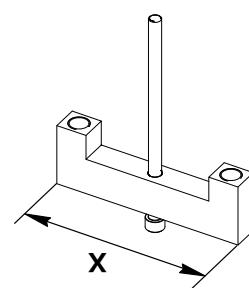
94595 1 Hydraulic ram

for assembling fuel pump
X = Ø 270 mm
Mass approx. 79.4 kg
consisting of:



Recommended Special Tools**94595D 1 Piston reset device**

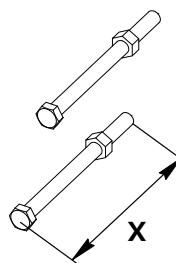
X = 255 mm



WCH02281

94595E 2 Screw M30x400

X = 418.7 mm



WCH02281