

Maintenance Manual

X62-B

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Winterthur Gas & Diesel Ltd.
Winterthur Gas & Diesel AG
Winterthur Gas & Diesel S.A.

Schützenstrasse 3
P.O. Box 414, 8401
Winterthur, Switzerland

Tel. +41 (0)52 264 8844
Fax +41 (0)52 264 8866
www.wingd.com

WINGD
Winterthur Gas & Diesel

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				Date of publication 2020-04		
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5612-1/A1	2020-04	Update WinGD	Exhaust Valve Control Unit - Pilot valve: Removal and Installation	Page 361 and 362 updated		x
2722-2/A1	2020-04	Update WinGD	Injection Valve: Installation	Page 167 to 168 updated		x
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5583-1/A2	2020-04	Update WinGD	Faults in High Pressure Fuel Systems	New document	x	
5583-1/A1	2020-04	Update WinGD	Fuel Pump Actuator: Connection to Fuel Pump	Page 345 to 347 updated		x
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0011-1/A1	2021-12	WinGD Input	General Guidelines for Maintenance	Procedure Updated		x

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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.

All supplies and services are set only 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 WinGD. 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 are permitted to 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 in this Maintenance Manual are to help make sure that maintenance is done correctly at the specified intervals.

It is a condition that the personnel who do important work have the applicable training and experience.

Data about the operation of the engine and descriptions of the function of the different systems are part of the Operation Manual. Chapter 0010 1 in the Operation Manual, gives descriptions about the Operation and Maintenance Manuals and data about symbols, signs and special characters.

More instructions about the operation and maintenance of components from sub-suppliers are found in the instruction leaflets of the related manufacturers (for example, engine components, tools or devices that are not manufactured in accordance with production drawings from WinGD).

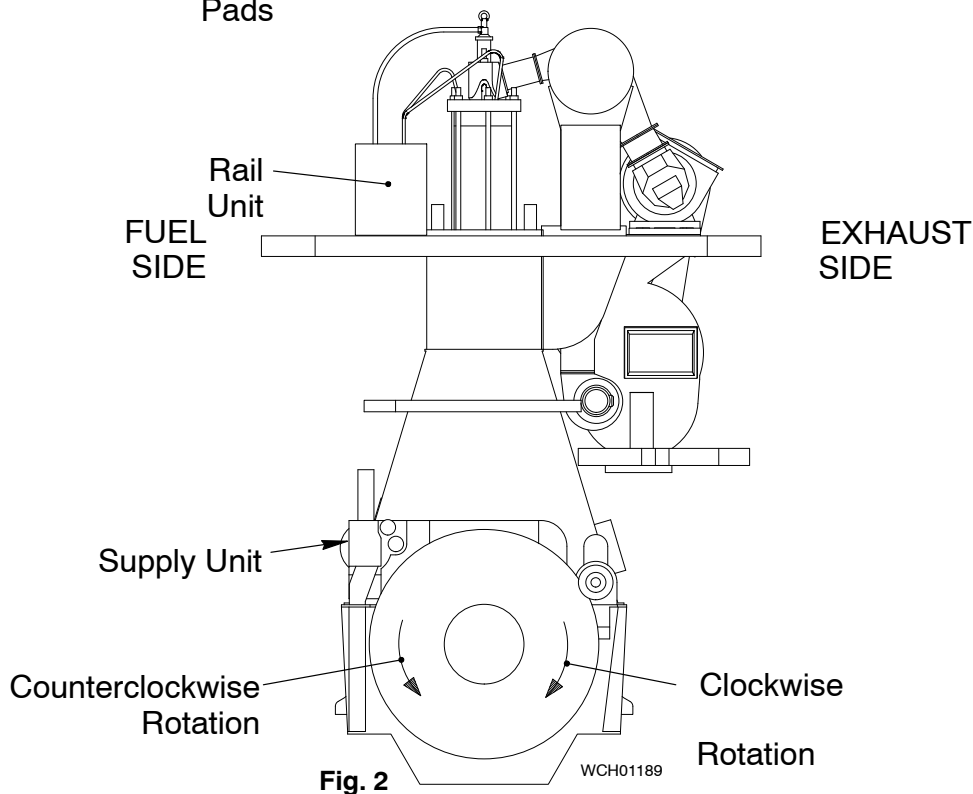
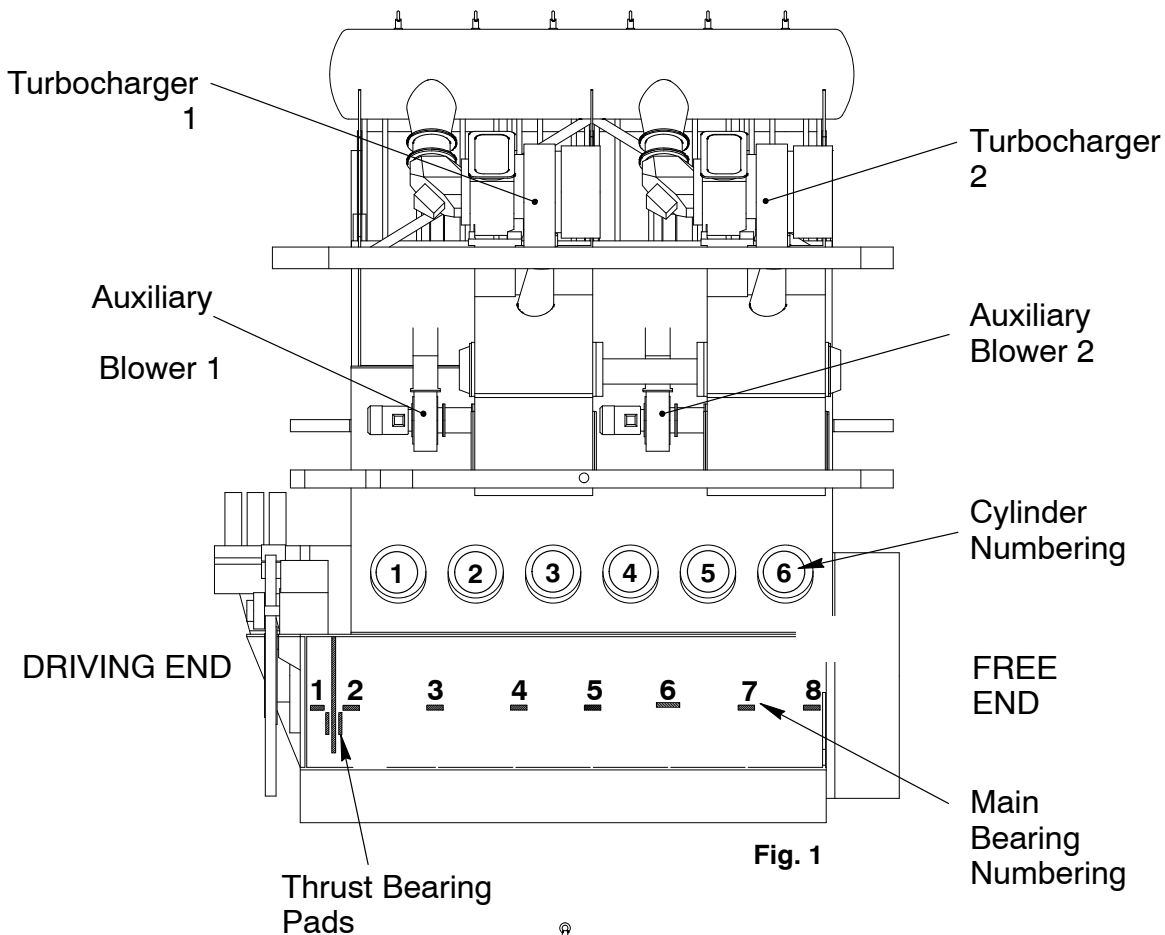
The Maintenance Manual has the primary data that follow:

- General Guidelines for Maintenance. These give recommendations about precautions and applicable procedures.
- Clearance tables, tightening values of screwed connections, masses (weights). These give data about usual and maximum permitted clearances, engine components, type and use of different sealing rings etc.
- Maintenance Schedule. This schedule shows the nominal intervals when the different maintenance operations must be done during standard operation conditions.
- Design Groups give the instructions and procedures for maintenance work on specified engine parts.
- Tool Lists give data about the applicable tools and devices necessary to do the maintenance work. The tools and devices are usually supplied with the engine.

All data in this manual (text and illustrations) are correct at the date of issue. Modification of data is done regularly.

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Engine Numbering and Designations



DRAWN FOR TWO A175 TURBOCHARGERS

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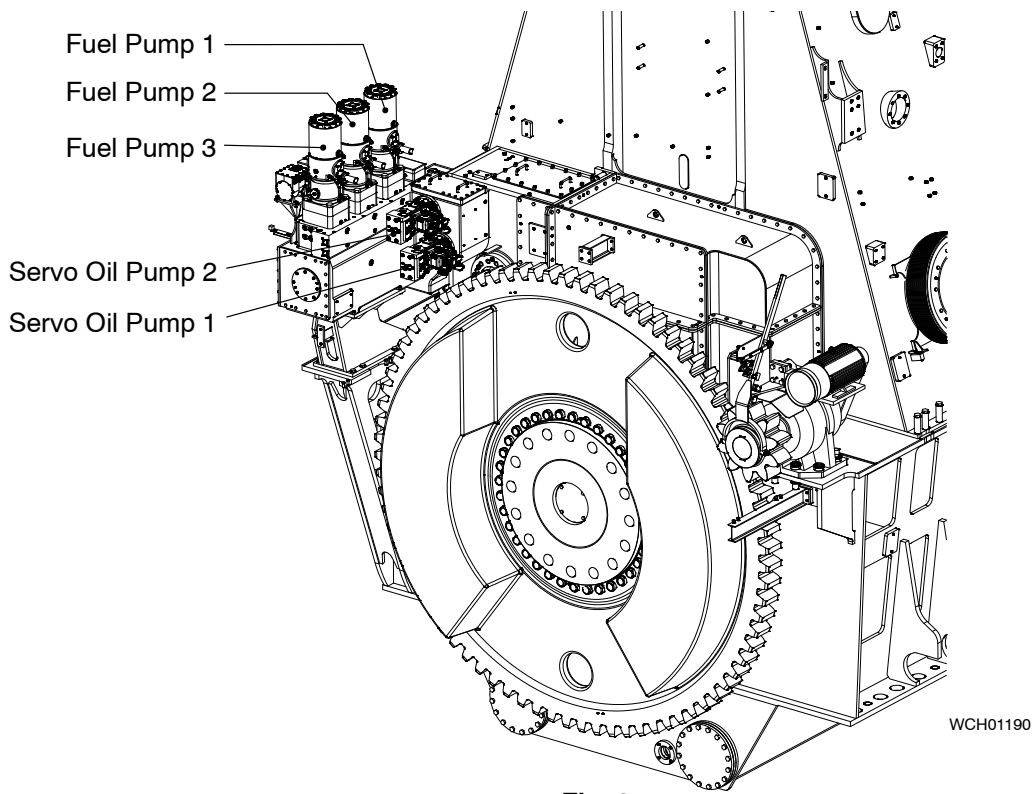
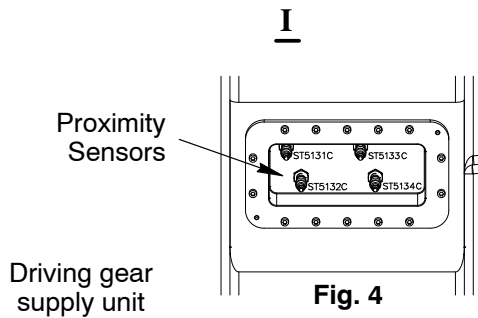


Fig. 3



Crank Angle Sensor Unit

Fig. 4

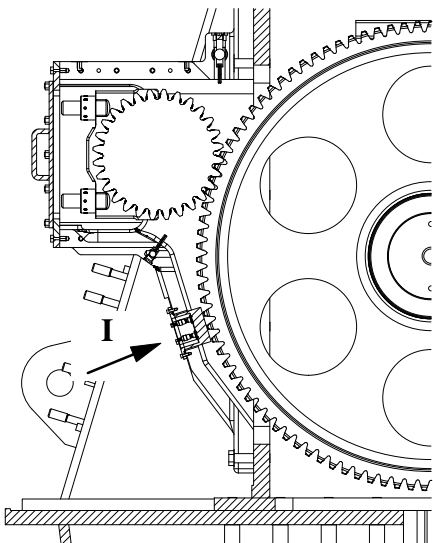


Fig. 5

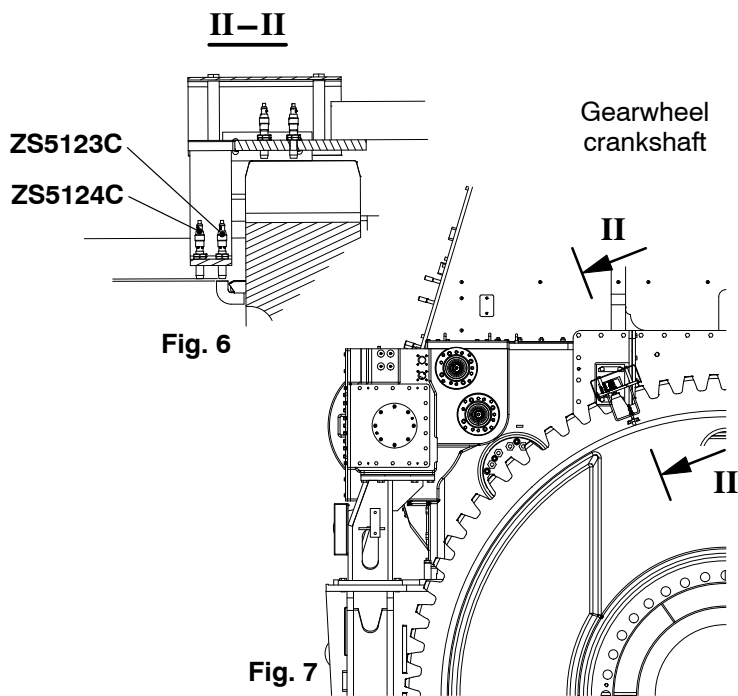


Fig. 6

Fig. 7

General Guidelines for Maintenance

Safety Precautions and Warnings

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1. General

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

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

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

2. General Safety Precautions

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

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

• Lighting

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

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

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

• Cleanliness

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

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

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

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

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

- **Fire**

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

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

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

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

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

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

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

- **Tools**

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

Make sure that all tools have protection from corrosion.

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

- **Spare Parts**

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

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

Replace used spare parts as soon as possible.

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

- **Low temperature - Freezing**

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

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

- **Check and Maintain**

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

- **Frost hazard**

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

- **Alarms**

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

All the alarms are important and most serious alarm are with slow- down and

shut- down functions.

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

- **Sealing Materials**

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

- **Entering Crankcase or Cylinder**

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

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

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

- **Turning Gear and Slow turning**

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

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

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

- **IMO and NOX components number**

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

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

o Fx fuel valve nozzle or TC diffuser etc.

o Pictures that show the number.

o Technical files descriptions.

3. Safety notes

- **Danger**

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

- **Warning**

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

- **Caution**

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

- **Note**

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

4. General safety warnings and cautions

WARNING

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

WARNING

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

WARNING

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

WARNING

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

WARNING

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

WARNING

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

WARNING

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

WARNING

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

WARNING

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

CAUTION

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

CAUTION

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

5. Personal safety and protection equipment

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

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

6. General safety guidelines for Hot work

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

- Guidelines for hot work: General

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

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

Always use safe workspaces to perform any hot work.

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

- Guidelines for hot work: Outside of safe workspaces

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

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

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

Another safety officer must ensure that safety procedures are followed.

All officers follow a written instruction plan.

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

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

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

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

- Guidelines for hot work: inside the engine room

Stop the engine before proceed any hot work in the engine room.

Set the engine room fire extinguisher to Manual mode.

Isolate the work area.

Make sure that emergency exists are open and cleared.

Make sure that telecommunication or radio communication operates correctly.

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

Disconnect the electronic modules and sensors near the work area.

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

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

Make sure that welding cables have no loops.

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

Only use DC power supply and OCV below 70 volts.

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

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

- Guidelines for work with hydraulic tools

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

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

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

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

7. General safety lifting instructions

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

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

General Guidelines for Lifting Tools

General Guidelines for Lifting Tools

Wire Rope Slings, Span Sets, Eye Bolts, etc.

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2.2	Span Sets	1
2.3	Eye Bolts and Eye Nuts	1
2.4	Eye Bolts and Swivel Lugs	2
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3.	Lifting Equipment – Attach and Remove	5

1. General

The permitted capacities of the engine room crane, lifting equipment, ropes, chains, eye bolts, etc must always be related to the weights of the parts to be lifted. For more data, refer to [0360 1 Masses \(Weights\)](#).

Note: The maximum permitted load in kg is related to the Work Load Limit (WLL).

For the removal, installation and movement of engine components, use only the correct serviceable tools and equipment. Replace damaged equipment with serviceable items.

For the safe and correct operation of the engine room crane, it is recommended that you do as follows:

- Make sure that you know the weight of the load.
- Find the centers of the load.
- Use only the applicable equipment.
- Make sure that you correctly attach and remove the the equipment.

2. Equipment

2.1 Wire Rope Slings

The WLL of the wire rope slings is given with their tool numbers in [9403 5 Tool List](#).

2.2 Span Sets

Span sets are easy to use. The code and the color usually show the maximum permitted load. Loops and knots in the span-sets decrease their WLL by one third.


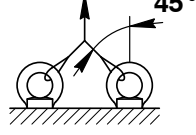
2.3 Eye Bolts and Eye Nuts

Use only eye bolts and eye nuts that have the standards given in DIN 580 and DIN 582: 2003 08.

Where eye bolts and eye nuts are used, the standards are calculated from DIN 580 and DIN 582: 2003 08 and the results shown in [Table 1](#) below.

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

Table 1: Lifting capacity (for data only)

Eye Bolts and 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 data given in Table 1 above are from DIN 580 and 582:2003-08

You must make sure that the eye bolt / eye nut:

- Has no damage e.g. corrosion, deformation etc
- Is correctly attached
- The seating surfaces fully touch (i.e. turned fully in)
- Is in the correct position. ¹⁾The full load is permitted only as shown (see Table 1). Distance rings can be used if necessary.

Also, you must make sure that you:

- Do not apply an angle of more than 45°.
- Do not apply a lateral load.

Note: If there are through holes, put a washer on the opposite side under the nut or screw head.

2.4 Eye Bolts and Swivel Lugs

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

Manufacturer:

RUD Ketten

Rieger & Dietz GmbH u. Co

Friedensinsel

D 73432 Aalen

Germany

<http://www.rud.com>

2.4.1 RUD Eye Bolts

These eye bolts (Fig. 1) have an inner screw that can be turned independently of the ring part. You must make sure that:

- The eye bolt has no damage e.g. corrosion, deformation etc
- The eye bolt is correctly attached
- You use the star profile wrench to tighten the inner screw (do not use an extension)
- The seating surfaces fully touch (i.e. the inner screw is turned fully in)
- The ring can freely turn
- Before you attach a load, align the ring with the direction of the force.

Note: Do not apply a lateral load to the eye bolt.

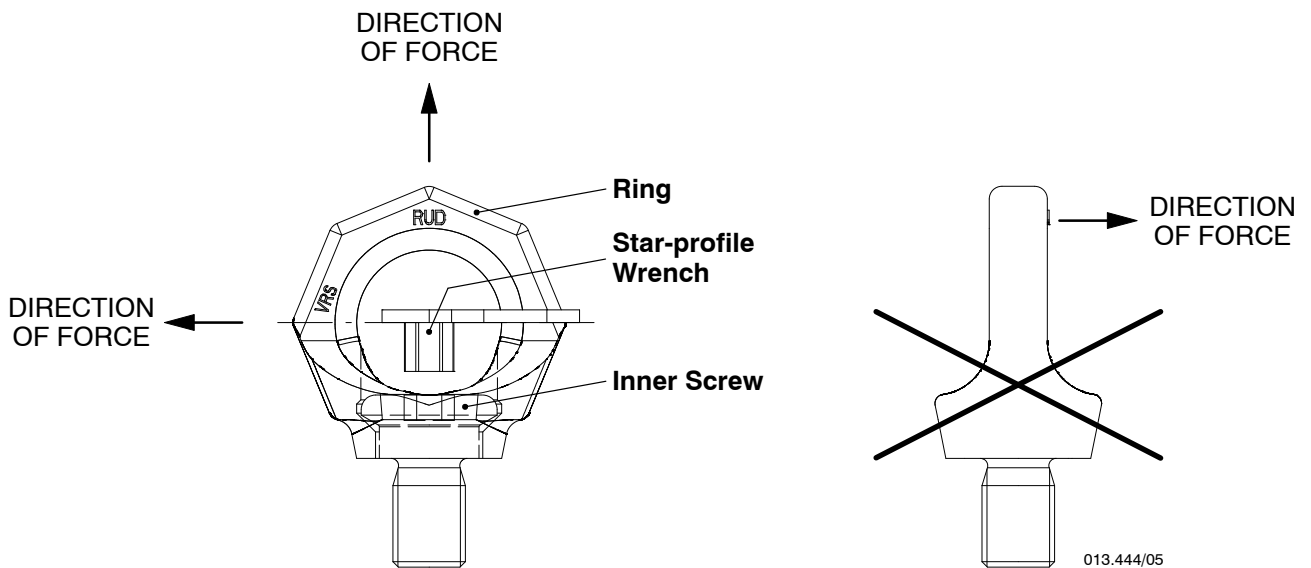


Fig. 1: RUD Eye Bolts

2.4.2 RUD Swivel Lugs

When you use these swivel lugs (Fig. 2), you must make sure that:

- The swivel lug has no damage e.g. corrosion, deformation etc
- You use an open-ended wrench to correctly attach the swivel lug
- The seating surfaces fully touch
- Before you attach a load, align the swivel lug with the direction of the force.

Note: Do not apply a force to the swivel as shown in View III.

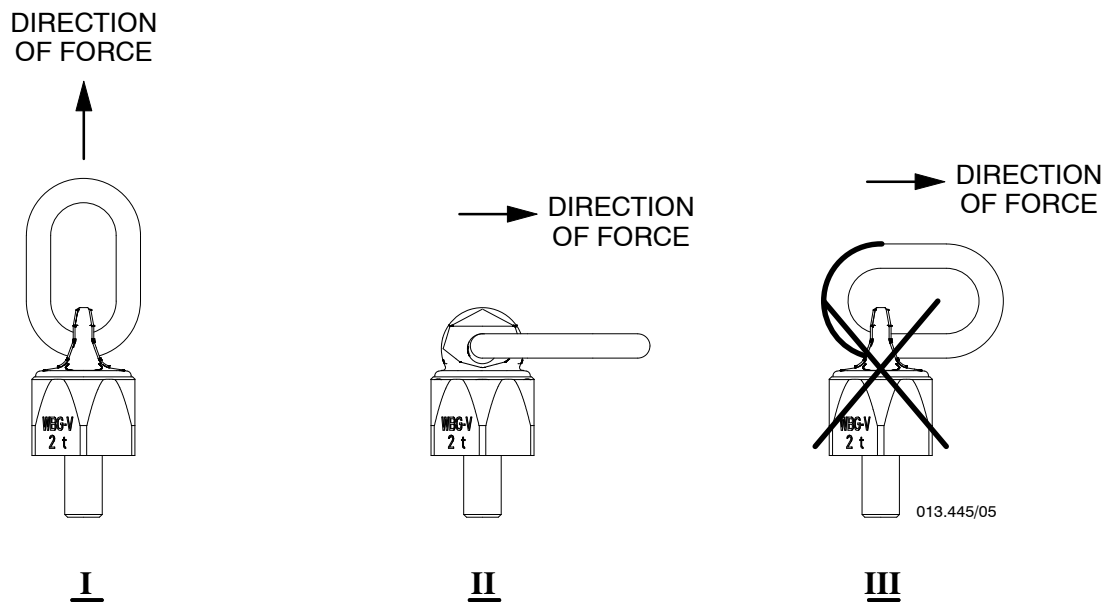


Fig. 2: RUD Swivel Lugs

2.5 Shackles

CAUTION



Damage Hazard: If tools are used together (e.g. beams with shackles, RUD-eye bolts or RUD-swivel lugs and ropes, etc.), it is always the weakest part which has the maximum lifting capacity.

Note: For more data, refer to [9403-5 Tool List](#)

Use only shackles that have the standards given in American Standard RR C 271A.

Where shackles are used, the standards are calculated from American Standard RR C 271A, which includes the safety factor.

Usually, the permitted lifting capacity of the shackles is specified for one item.

3. Lifting Equipment – Attach and Remove

WARNING



Danger: Do not go under a load that hangs. If the lifting equipment has a failure, the load can kill you or cause serious injury.

Read the data that follow:

- A sling with one strand has the total weight of the load (Fig. 3).
- With two strands of equal distance from the center, each strand has half the weight of the load when the sling is in a middle position.
- With four strands of equal distance from the center, each strand has one quarter of the load when the sling is in a middle position.

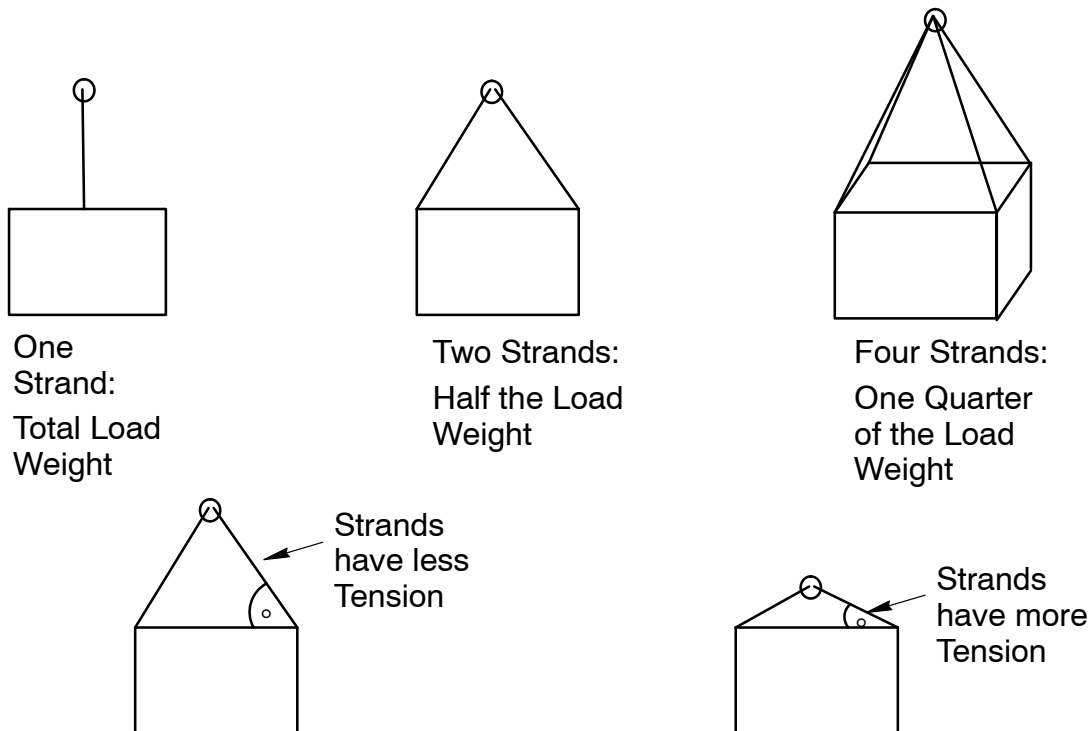


Fig. 3: Strand Angles

Note: A large angle between the strands gives more tension. A small angle between the strands give less tension.

- Put a flat piece of softwood between the sling and the component to prevent movement of the load (e.g. pipes, shafts etc).
- Use a wooden pallet or thick cloth to prevent damage to slings, ropes etc. Sharp edges can cut steel cables.
- Make sure that you can always keep control of the load.
- When slings or ropes are wound around the load two times, friction increases. This prevents movement of loads that have oil on their surfaces.
- Hemp rope strands wound around the crane hook prevent movement. Do not wind steel ropes around the hook. As an alternative, cross the steel ropes.

- Hold the ropes in the flat of your hands and keep your fingers straight.
- Hold the load at the side. Do not hold the load at the bottom.
- Always lower the load on to a flat area of sufficient dimensions.

Clearance Table

1. General	1
Crankshaft and Thrust Bearing	2
Crankshaft and Main Bearing	4
Crosshead Guide	6
Cylinder Liner	8
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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 repaired parts 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, or
- Let the component stay installed until the next overhaul.

This is related, for example, to the length of the next operation period until the next overhaul and how much components are worn.

Clearance Table

Crankshaft and Thrust Bearing

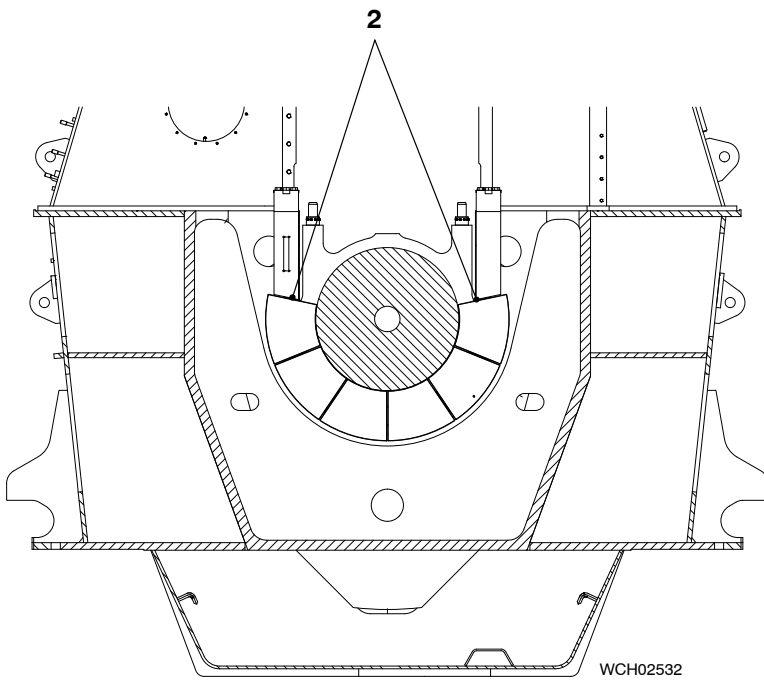


Fig. 1

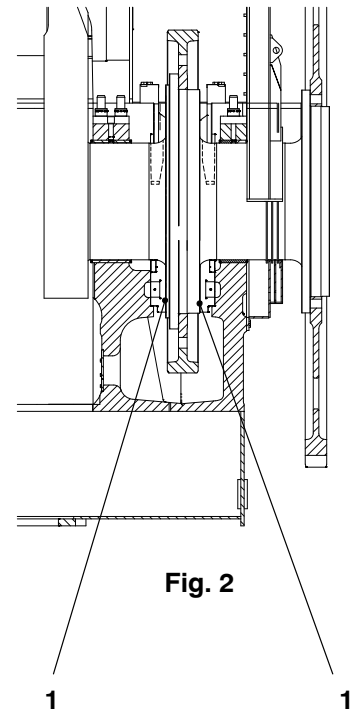


Fig. 2

Clearance Table

Crankshaft and Thrust Bearing

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

Crankshaft and Main Bearing

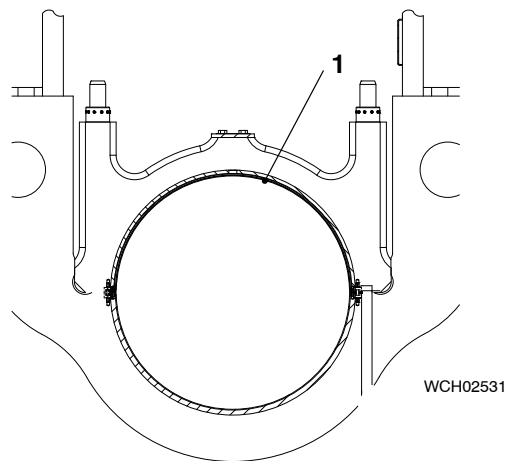


Fig. 3

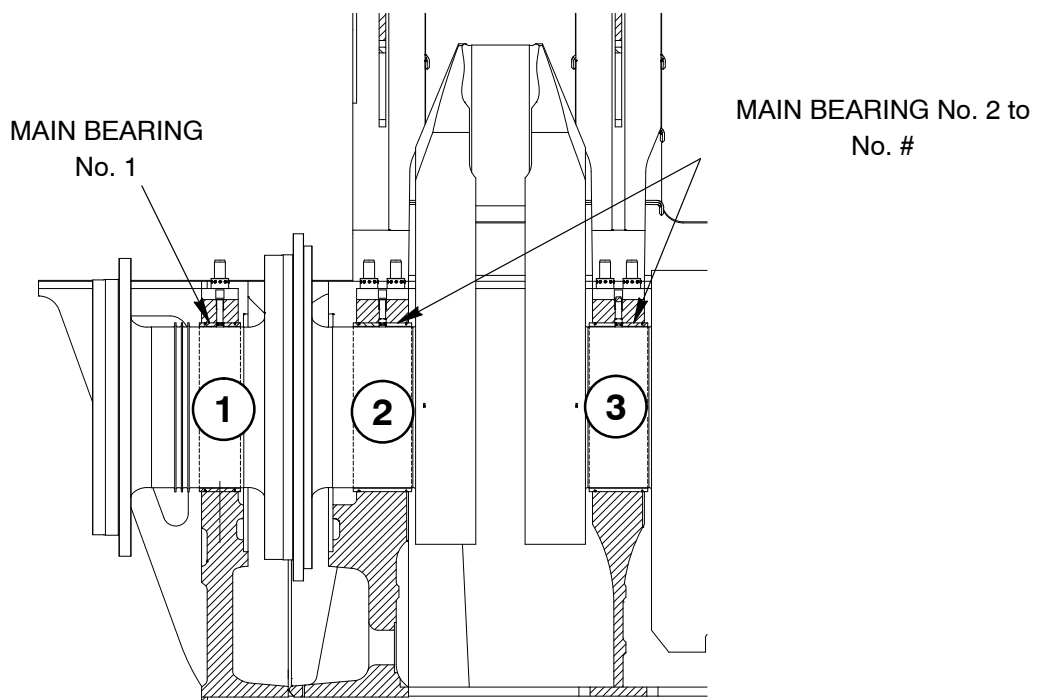


Fig. 4

Clearance Table

Crankshaft and Main Bearing

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
1132		Main Bearing No. 1			
		Crankshaft	outer Ø	760 ⁰ / _{0.08}	
		Main bearing	inner Ø	760	
	1	Bearing clearance	vertical	0.25 to 0.55	0.75
1132		Main Bearing No. 2 to No. #			
		Crankshaft	outer Ø	760 ⁰ / _{0.08}	
		Main bearing	inner Ø	760	
	2	Bearing clearance	vertical	0.25 to 0.55	0.75

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

Clearance Table

Crosshead Guide

Note: Some parts can look different.

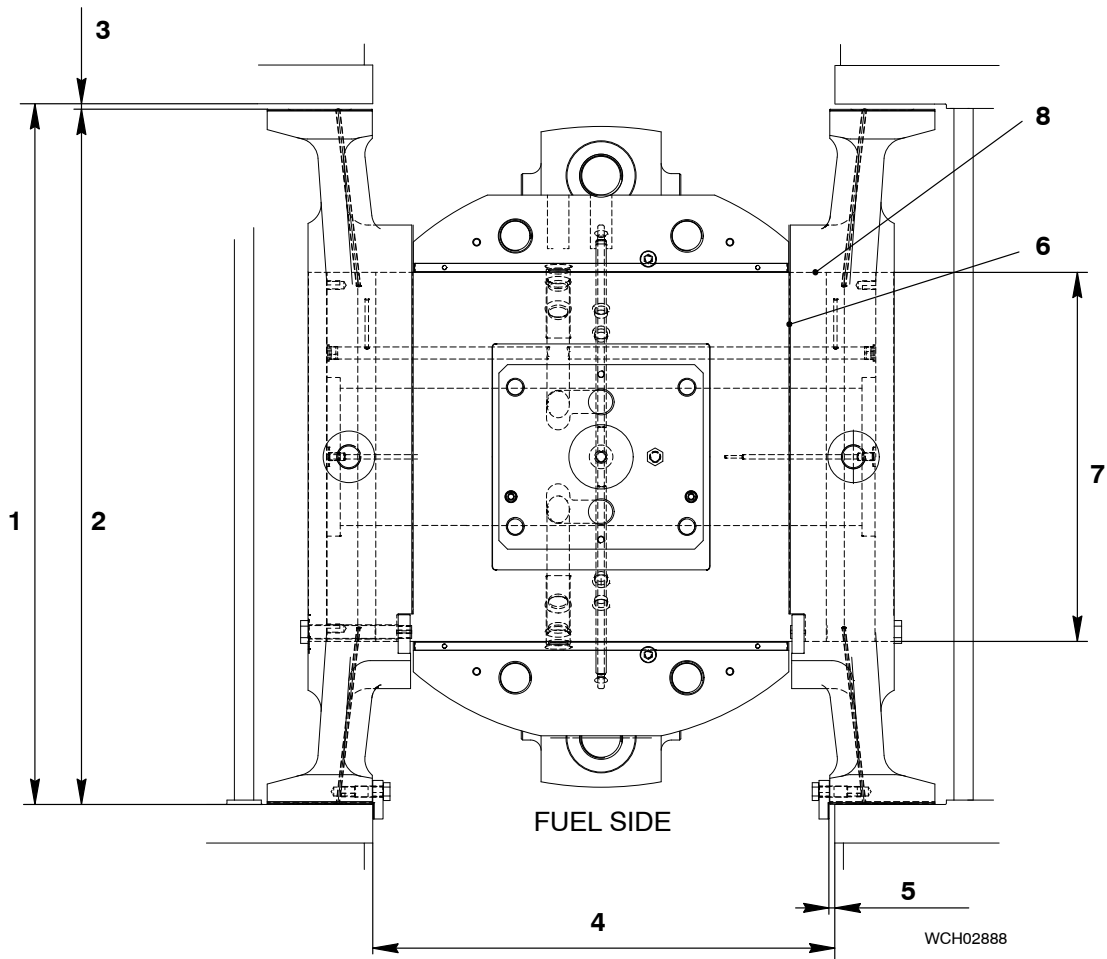


Fig. 5

Clearance Table

Crosshead Guide

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
3326		Crosshead Guide			
	1	Guide bar (column)	transverse	1096 $\begin{matrix} + 0.25 \\ 0 \end{matrix}$	
	2	Guide shoe	transverse	1096 $\begin{matrix} 0.20 \\ 0.30 \end{matrix}$	
	*3	Guide way clearance		0.20 to 1.10	1.25
	4	Guide rail	longitudinal	707.52 to 708.28	
	5	Guide rail, lateral clearance	total	0.30 to 1.00	1.5
	6	Guide shoe, lateral clearance	total	0.20 to 0.60	0.9
	7	Guide shoe, bearing pin	outer \varnothing	580 $\begin{matrix} 0 \\ 0.08 \end{matrix}$	
		Guide shoe, bearing bore	inner \varnothing	580 $\begin{matrix} + 0.11 \\ + 0.07 \end{matrix}$	
8	Bearing clearance	radial	0.07 to 0.19	0.2	

To measure the clearances, refer to [3326 1](#).

* Clearance 3 is only correct with tie rods tightened.

Clearance Table

Cylinder Liner

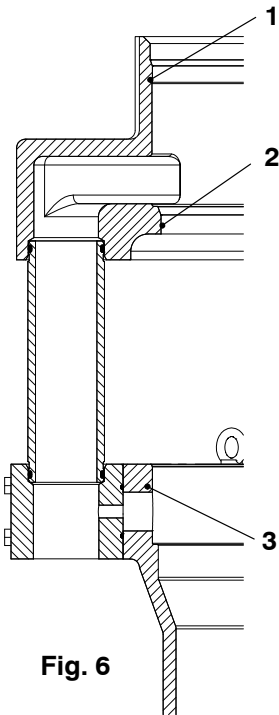


Fig. 6

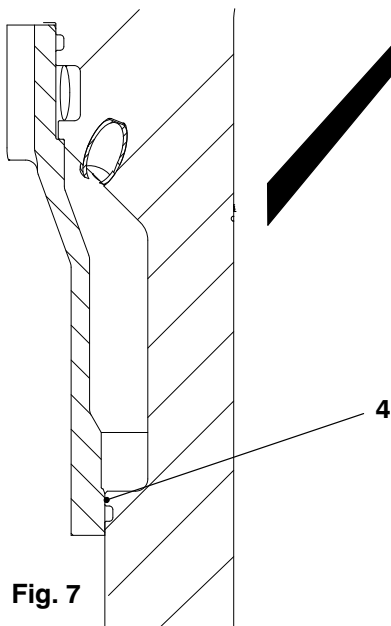
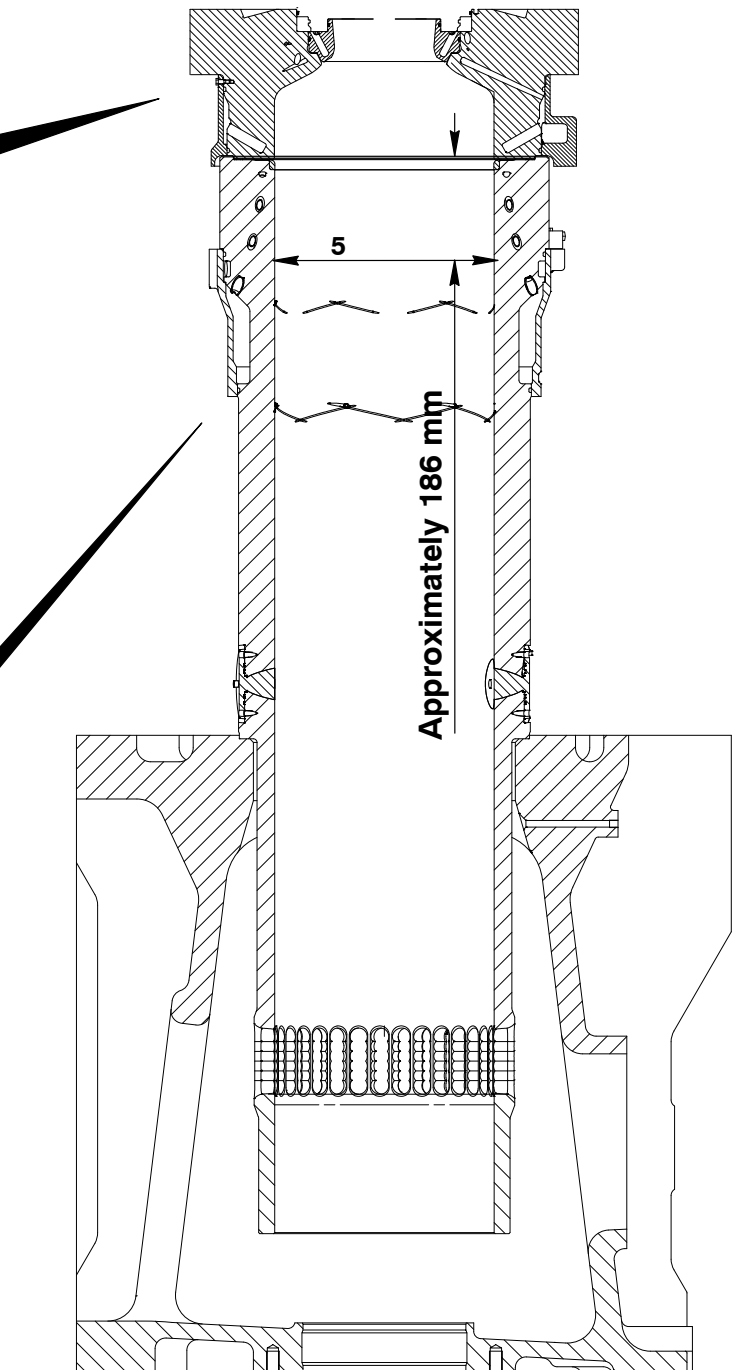


Fig. 7



WCH03255

Fig. 8

Clearance Table

Cylinder Liner

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
2130		Water Guide Jacket on Cylinder Cover			
		Water guide jacket top part	∅	870 + 0.50 + 0.30	
	1	Clearance	total	0.40 to 0.70	
		Water guide jacket top part	∅	850 + 0.50 + 0.30	
	2	Clearance	total	1.30 to 1.60	
		Water guide jacket bottom part	∅	870 + 0.50 0.30	
	3	Clearance	total	0.10 to 0.650	
		Water guide jacket bottom part	∅	856 + 0.70 + 0.50	
4	Clearance	total	0.40 to 0.80		
2124		Cylinder liner			
	*5	Cylinder liner bore	radial	620	625.50

* Make sure that you measure at the correct point.

Clearance Table

Piston Rod Gland

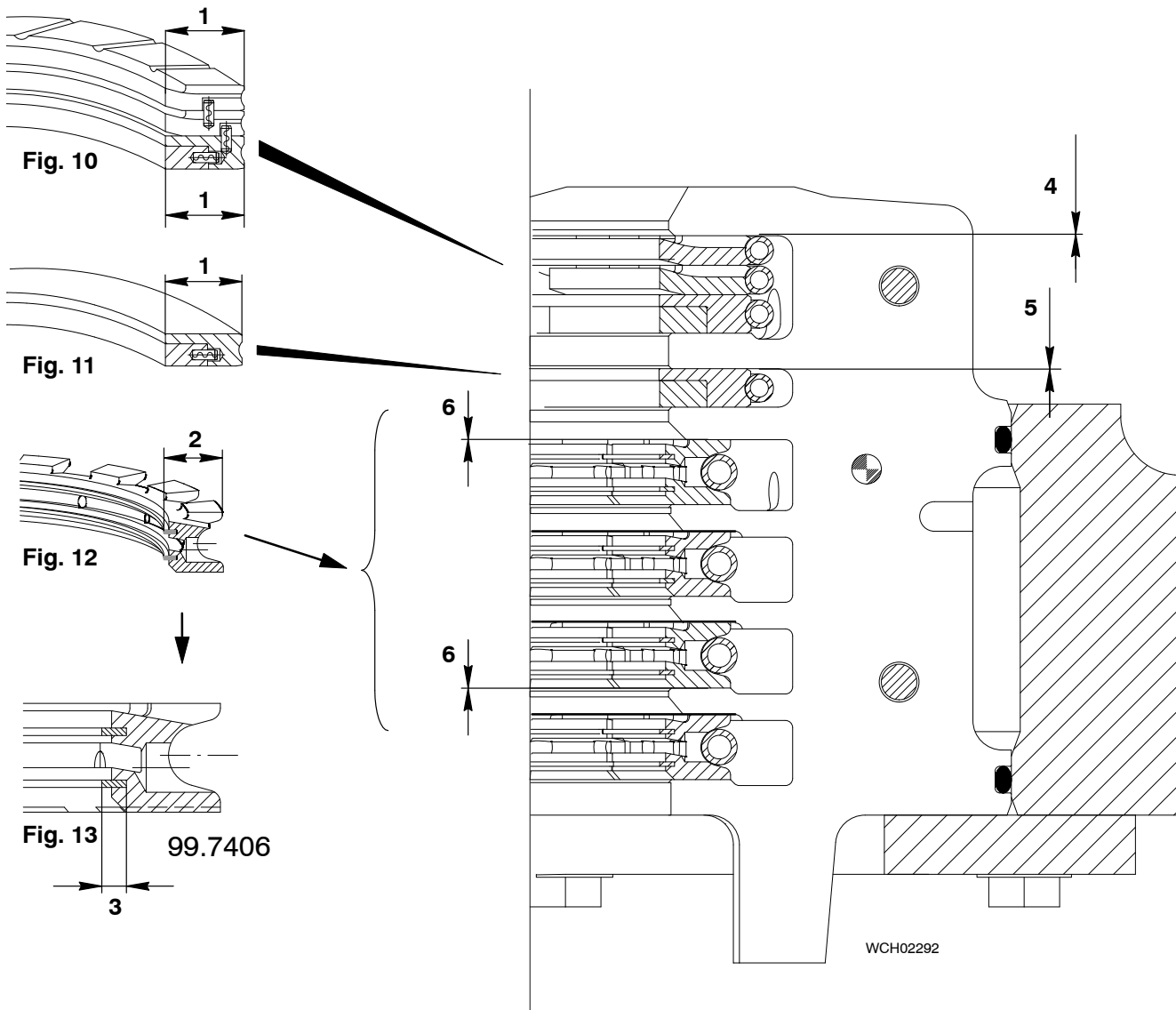


Fig. 9

Clearance Table

Piston Rod Gland

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
2303		Piston Rod Gland			
	*1	Ring width	radial	31	Minimum 25.00
	*2	Ring width	radial	24	Minimum 20.20
	*3	Ring width	radial	5	Minimum 3.20
	4	Ring clearance	axial	0.05 to 0.19	0.30
	5	Ring clearance	axial	0.05 to 0.13	0.25
	6	Ring clearance	axial	0.10 to 0.17	0.20

*** Ring wear**

The difference in value between the nominal dimension and maximum wear is equal for all rings, i.e. also for smaller rings.

Clearance Table

Exhaust Valve

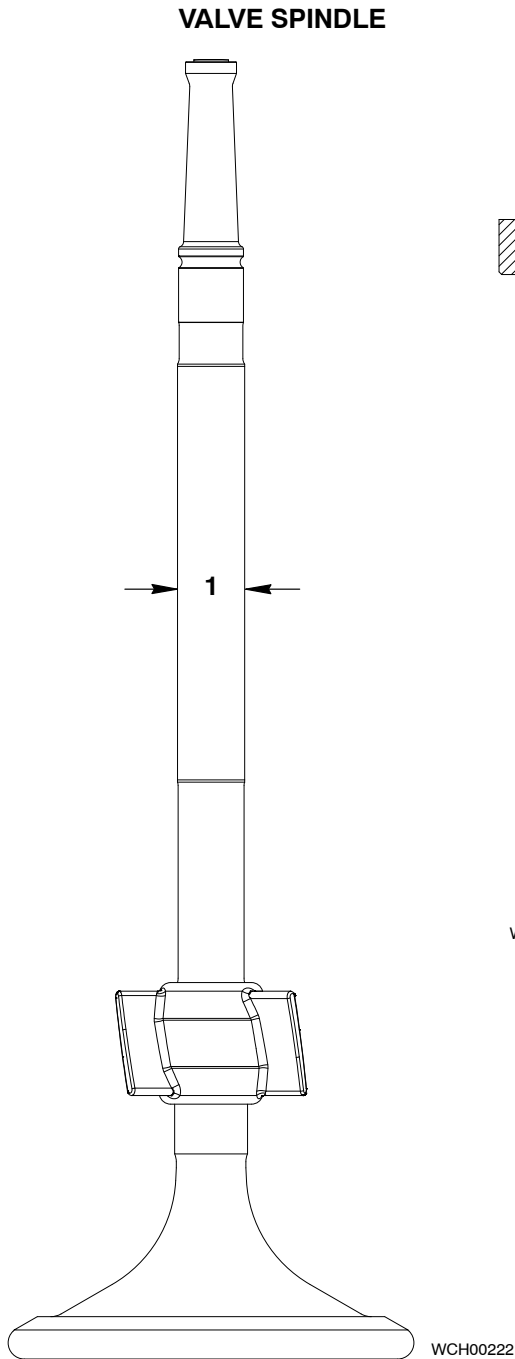


Fig. 14

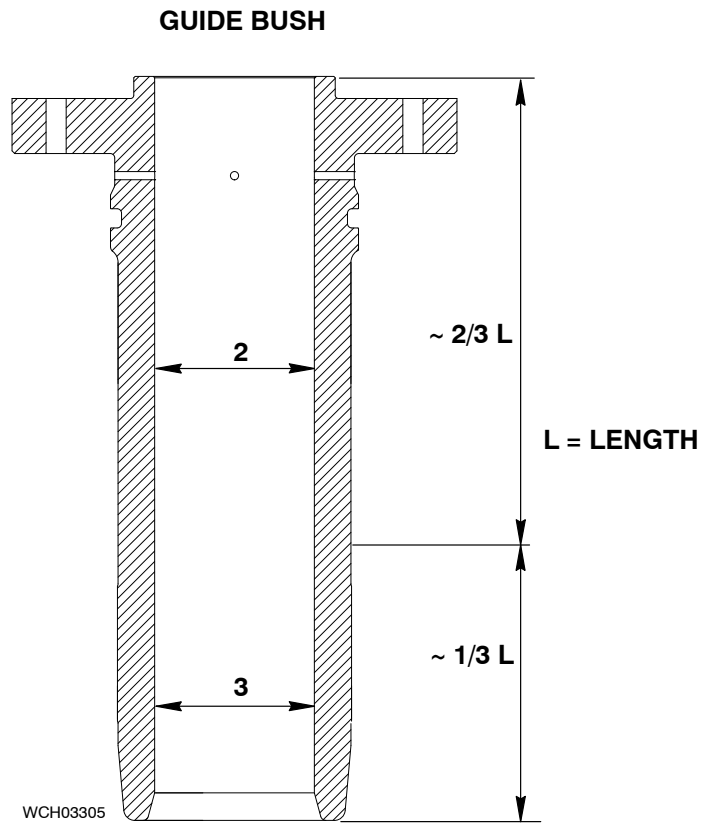


Fig. 15

Clearance Table

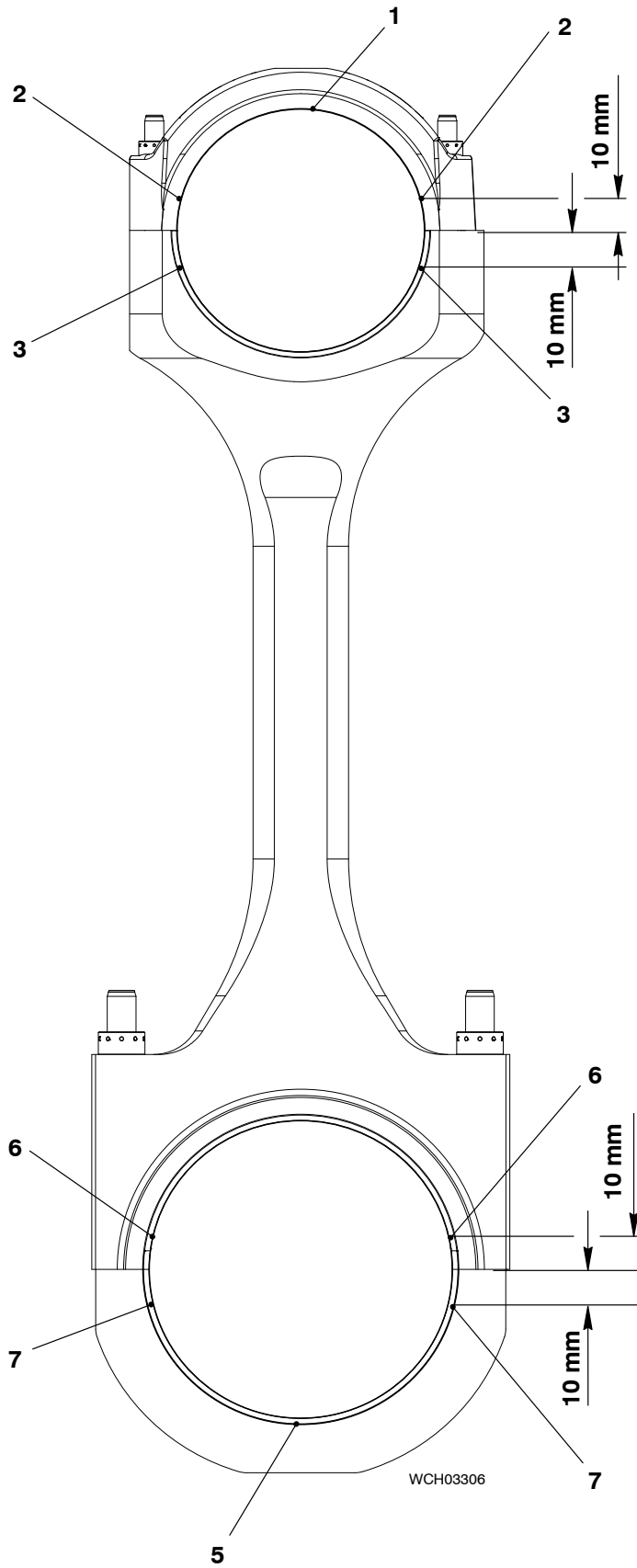
Exhaust Valve

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
2754		Valve Spindle			
	1	Spindle	outer Ø	58 ^{0.21} / _{0.24}	57.40
2751		Guide Bush			
	*2	Bore	inner Ø	58 ^{+ 0.030} / _{0.0}	58.35
	*3	Bore	inner Ø	58 ^{+ 0.030} / _{0.0}	59.05

* Make sure that you measure at the correct points.

Clearance Table

Top and Bottom End Bearings to Connecting Rod



Clearance Table

Top and Bottom End Bearings to Connecting Rod

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
3303 3326		Top End Bearing			
		Crosshead pin	outer \varnothing	620 $\begin{matrix} + 0.62 \\ + 0.56 \end{matrix}$	
		Bearing	inner \varnothing	620	
	1	Bearing clearance	vertical	0.40 to 0.65	0.8
	*2	Lateral clearance	total	0.40 to 0.65	
	*3	Lateral clearance	total	0.30 to 0.60	
3303		Bottom End Bearing			
		Crankshaft	outer \varnothing	760 $\begin{matrix} 0 \\ 0.08 \end{matrix}$	
		Bearing	inner \varnothing	760	
	5	Bearing clearance	vertical	0.40 to 0.65	0.85
	*6	Lateral clearance	total	0.50 to 0.70	
	*7	Lateral clearance	total	0.50 to 0.70	

* Make sure that you measure at the correct points.

Piston Cooling and Crosshead Lubricating Link

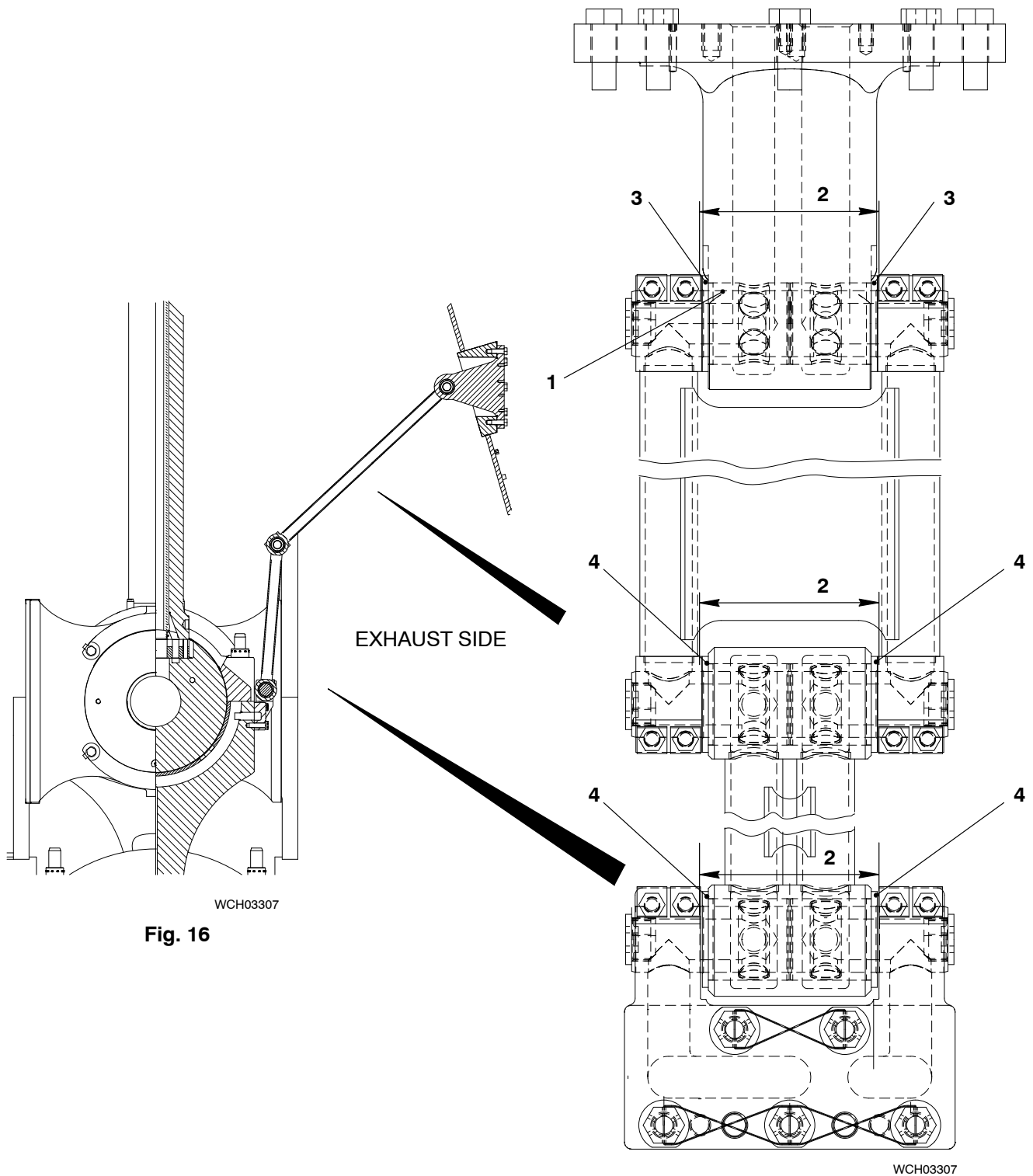


Fig. 16

Fig. 17

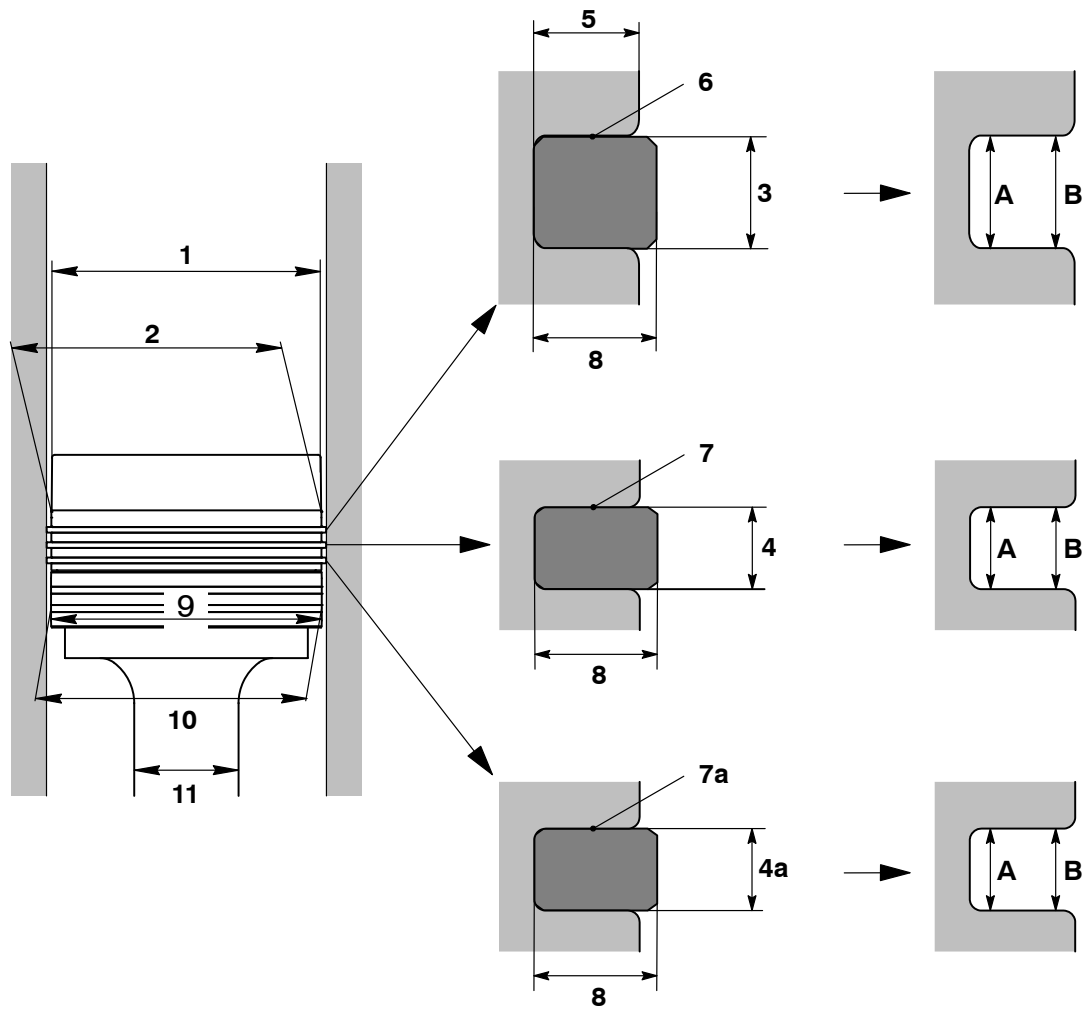
Clearance Table

Piston Cooling and Crosshead Lubricating Link

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
3603		Piston Cooling and Crosshead Lubricating Link			
		Pin	outer \varnothing	55	
	1	Clearance	radial	0.03 to 0.06	0.20
	2	Bush	width	145	
	3	Lateral clearance	Each side	Minimum 0.5	
	4	Lateral clearance	Each side	Minimum 0.5	
	5	Lateral clearance	Each side	Minimum 1.0	

Clearance Table

Piston and Piston Rings



Clearance Table

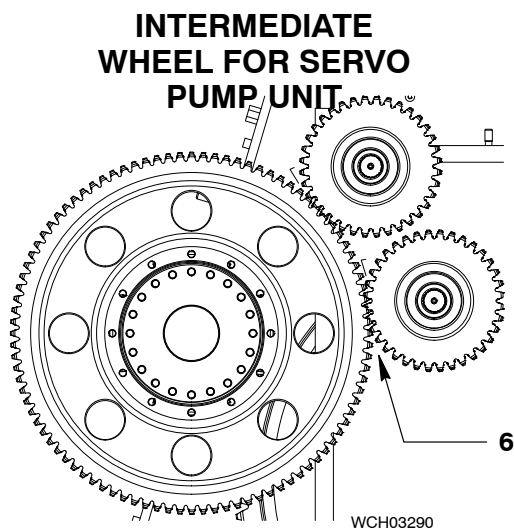
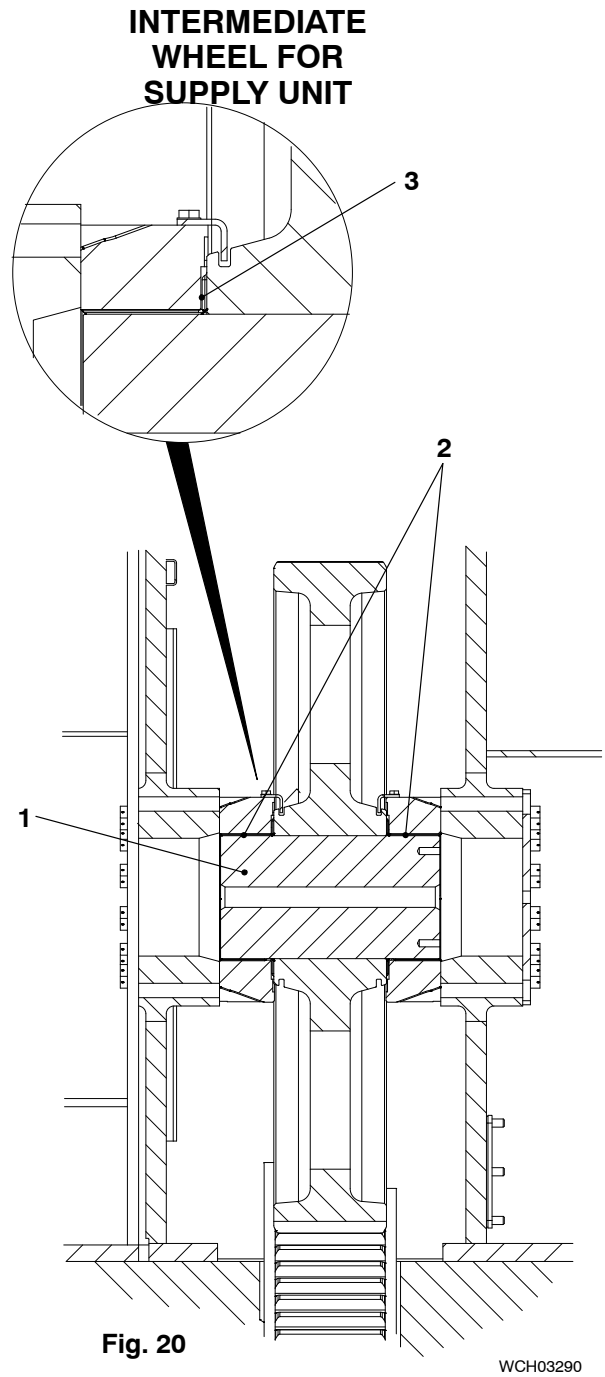
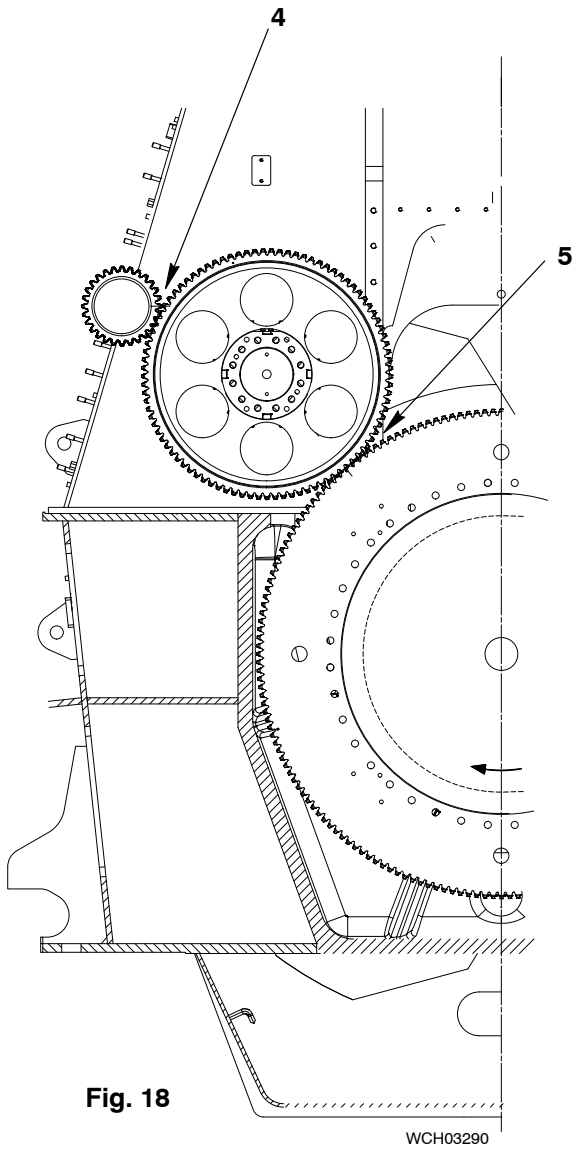
Piston and Piston Rings

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)	
3406		Piston Head				
	1	Head (tapered part)	outer Ø	615 $\begin{smallmatrix} 0 \\ 0.2 \end{smallmatrix}$		
	2	Head	outer Ø	617 $\begin{smallmatrix} 0 \\ 0.2 \end{smallmatrix}$		
3406		Piston Ring Grooves				
	3	Height of the top groove	vertical	20 $\begin{smallmatrix} + 0.45 \\ + 0.40 \end{smallmatrix}$		
	4	Height of the middle groove	vertical	12 $\begin{smallmatrix} + 0.40 \\ + 0.35 \end{smallmatrix}$		
	4a	Height of the bottom groove	vertical	12 $\begin{smallmatrix} + 0.40 \\ + 0.35 \end{smallmatrix}$		
	5	Groove depth	radial	21 $\begin{smallmatrix} + 0.2 \\ + 0 \end{smallmatrix}$		
3425		Piston Rings				
	3	Ring height	vertical	20 $\begin{smallmatrix} 0 \\ 0.03 \end{smallmatrix}$		
	4	Ring height	vertical	12 $\begin{smallmatrix} 0 \\ 0.03 \end{smallmatrix}$		
	4a	Ring height	vertical	12 $\begin{smallmatrix} 0 \\ 0.03 \end{smallmatrix}$		
					Point A	Point B
	6	Ring clearance	vertical	0.40 0.48	0.60	0.80
	7	Ring clearance	vertical	0.35 0.43	0.55	0.75
	7a	Ring clearance	vertical	0.35 0.43	0.55	0.75
	8	Ring width	radial	20 ± 0.25		
3403		Piston Skirt				
	9	Skirt	outer Ø	619.2 $\begin{smallmatrix} 0 \\ 0.1 \end{smallmatrix}$	Minimum 618.1	
	10	Rubbing ring	outer Ø	619.4 $\begin{smallmatrix} 0 \\ 0.1 \end{smallmatrix}$		
3403		Piston Rod				
	11	Rod	outer Ø	240 $\begin{smallmatrix} 0.050 \\ 0.096 \end{smallmatrix}$	Minimum 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 refer to [3425 1](#)).

Clearance Table

Driving Wheels for Supply Unit



Clearance Table

Driving Wheels for Supply Unit

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
4103		Intermediate Wheel			
	1	Shaft	outer \varnothing	240	
	2	Bearing clearance	vertical	0.12 to 0.21	0.30
	3	Axial clearance	total	0.6 to 1.1	1.5
	4	Tooth backlash		0.24 to 0.39	0.41
	5	Tooth backlash		0.33 to 0.51	0.53
	6	Tooth backlash		0.16 to 0.30	0.34

When you measure the tooth backlash, look at the tooth crown of the tooth flanks in the longitudinal direction.

Clearance Table

Fuel and Servo Pump Units

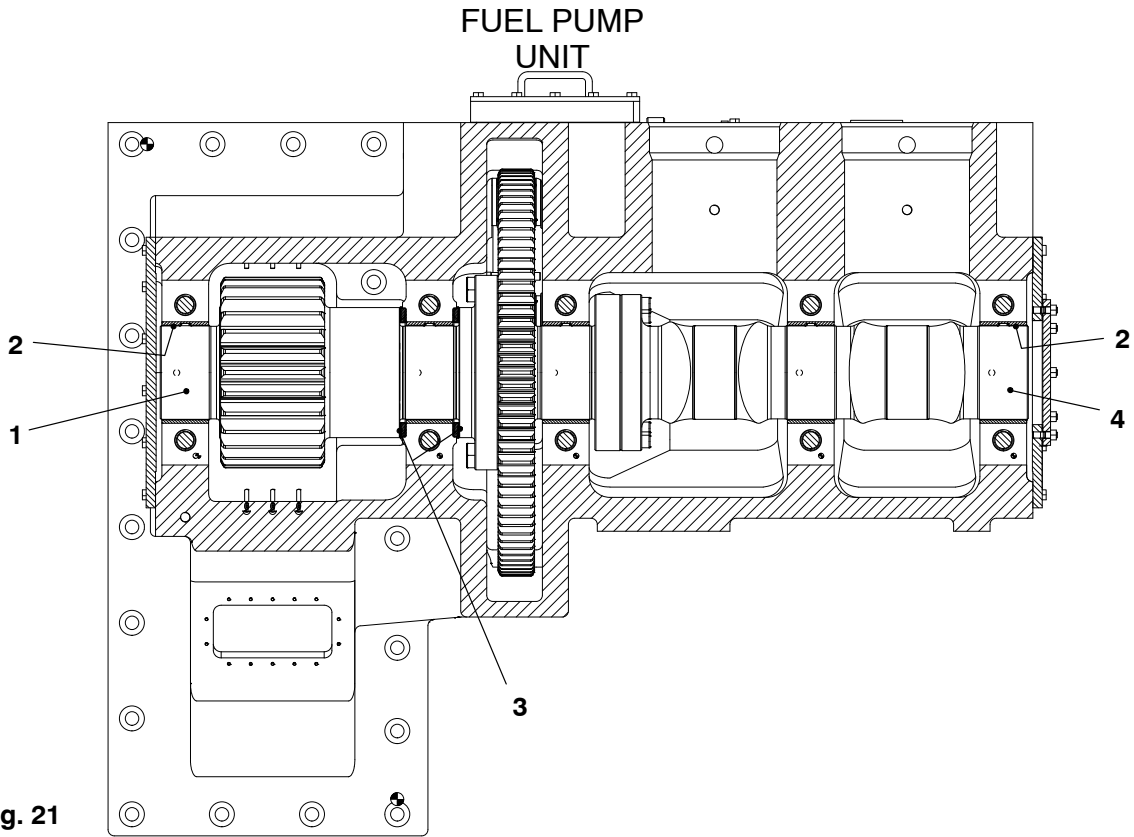


Fig. 21

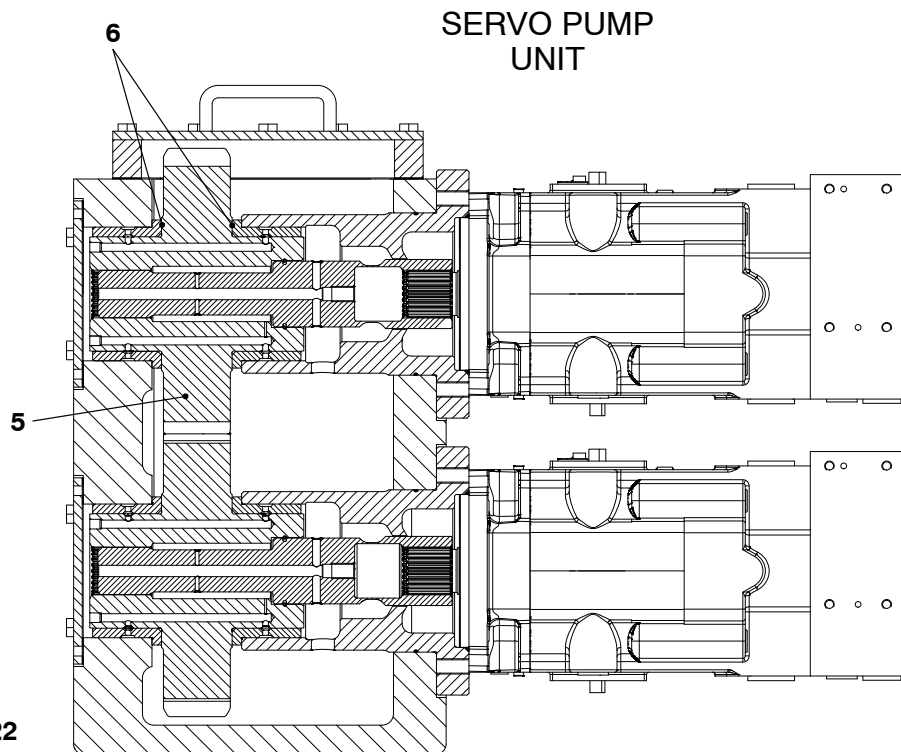


Fig. 22

WCH02232

Clearance Table

Fuel and Servo Pump Units

Group	Key No.	Description	Measured Direction	Nominal Dimension (mm) (usual, new)	Maximum Clearance, Dimension (mm) (because of wear)
5552		Fuel Pump Unit			
	1	Gear Wheel	outer \varnothing	180 $\begin{smallmatrix} 0 \\ 0.025 \end{smallmatrix}$	0.33
	2	Bearing clearance	radial	0.153 0.237	
	3	Axial clearance	total	0.30 0.65	0.81
	4	Camshaft	outer \varnothing	180 $\begin{smallmatrix} 0 \\ 0.025 \end{smallmatrix}$	
5552		Servo Pump Unit			
	5	Pinion	outer \varnothing	120 $\begin{smallmatrix} 0 \\ 0.022 \end{smallmatrix}$	0.85
	6	Axial clearance	total	0.30 to 0.65	

Clearance Table

Fuel Pump

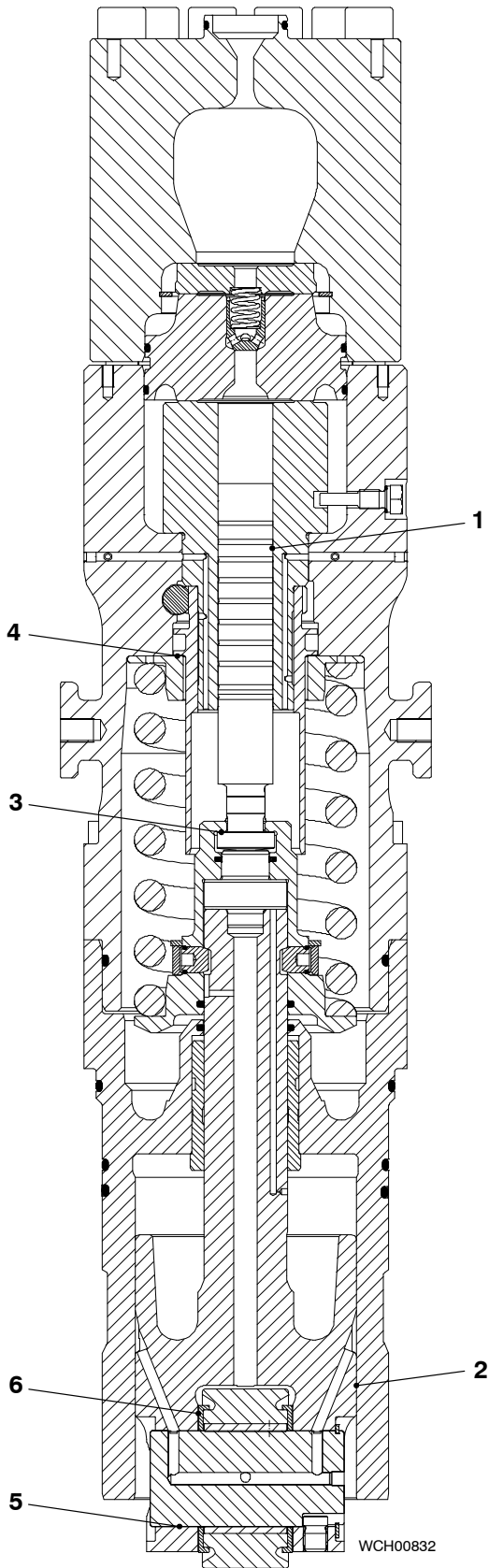


Fig. 23

PLUNGER & CYLINDER

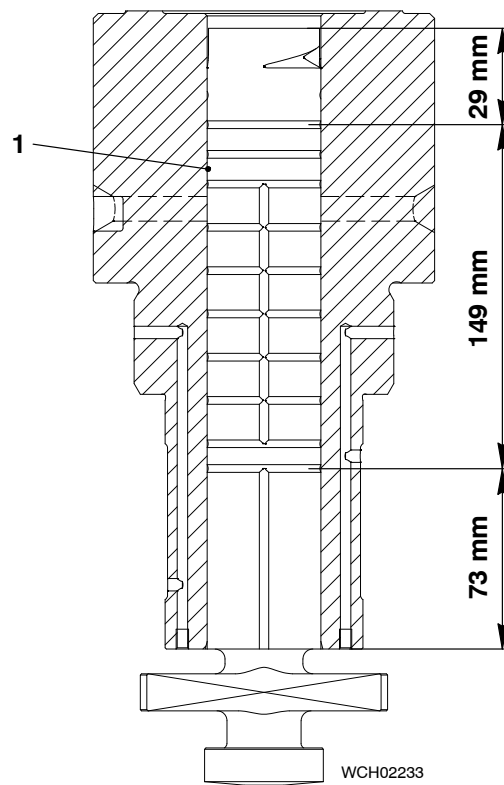


Fig. 24

Clearance Table

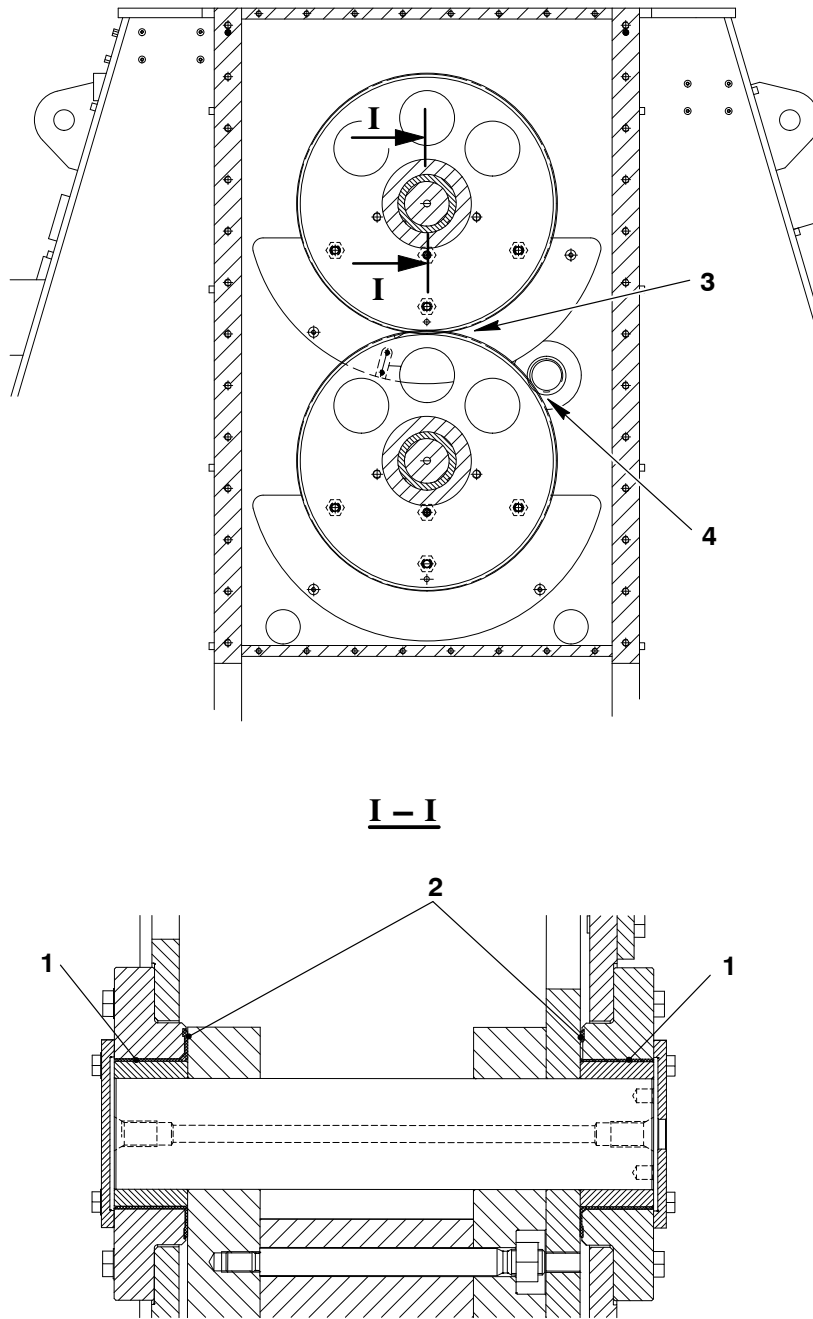
Fuel Pump

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
		Guide piston	outer \varnothing	185	
		Lower housing	inner \varnothing	185	
	2	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 \varnothing	80 ⁰ / _{0.013}	
		Guide piston (bore)	inner \varnothing	80 ^{+ 0.04} / _{+ 0.01}	
	5	Clearance	radial	0.010 0.053	0.08
	6	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



WCH03469

Fig. 25

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 \varnothing	170	
	1	Bearing clearance	radial	0.25 0.325	0.375
	2	Axial clearance	total	0.5 1.1	1.5
7758		Compensating shaft			
	3	Tooth backlash		0.12 0.29	
	4	Tooth backlash		0.12 0.27	

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

Intentionally blank

Tightening Values of Important Screwed Connections

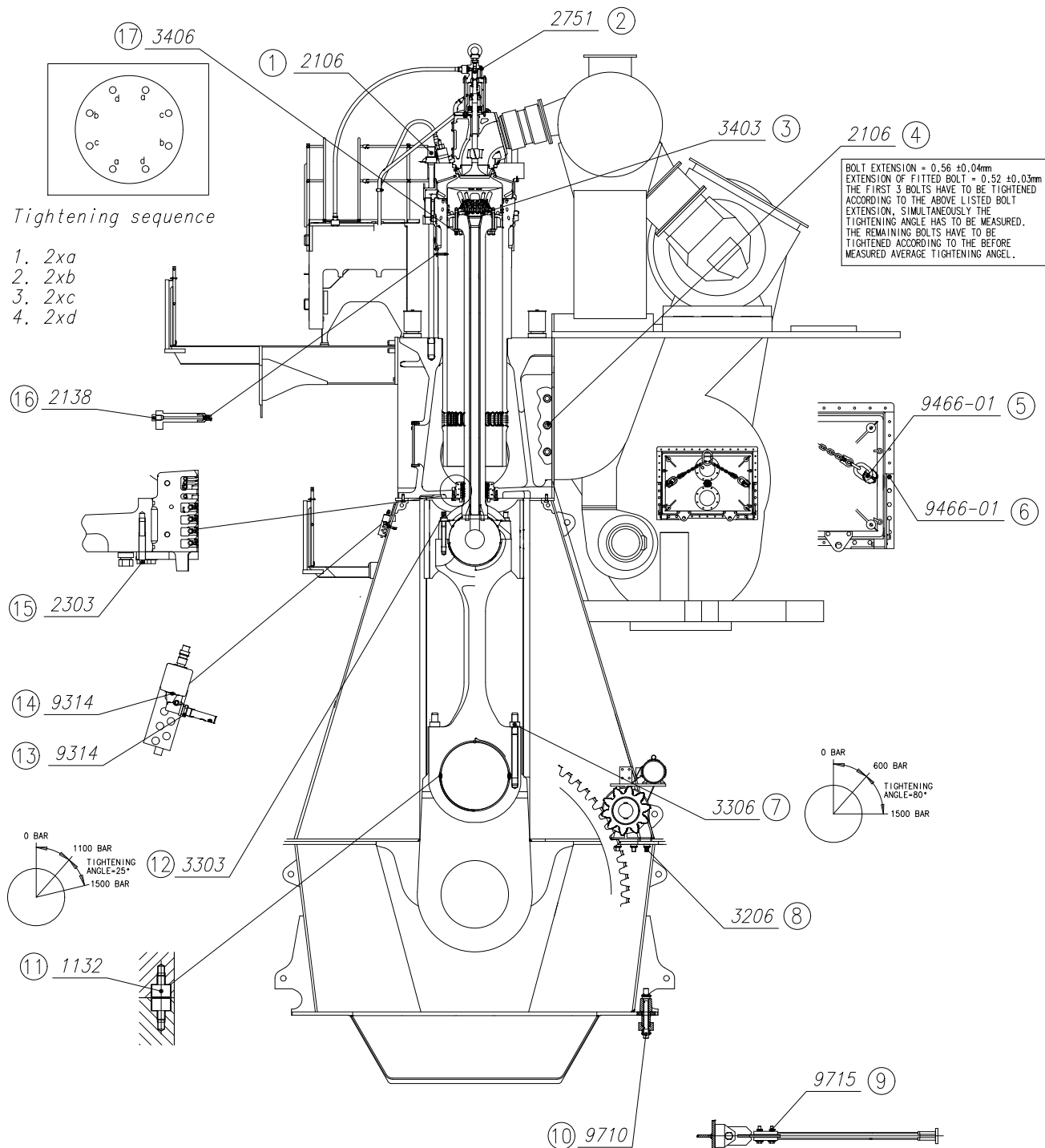
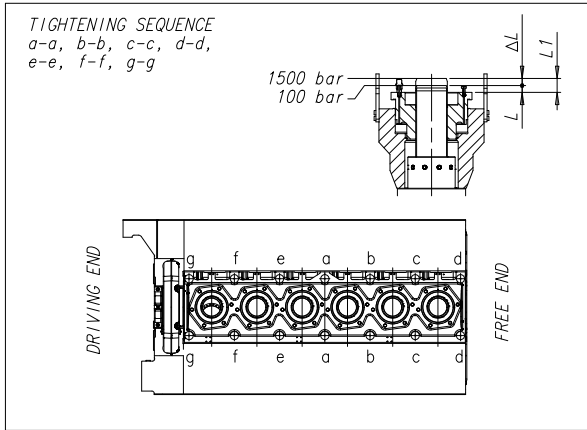


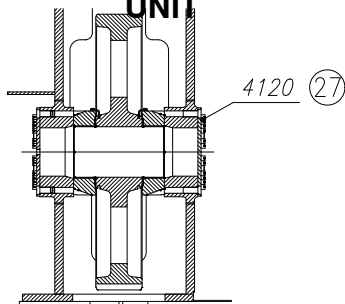
Fig. 1:

Tightening Values of Important Screwed Connections

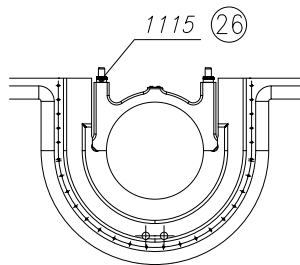
TIE ROD



INTERMEDIATE WHEEL SUPPLY UNIT



MAIN BEARING



GEAR WHEEL CRANKSHAFT

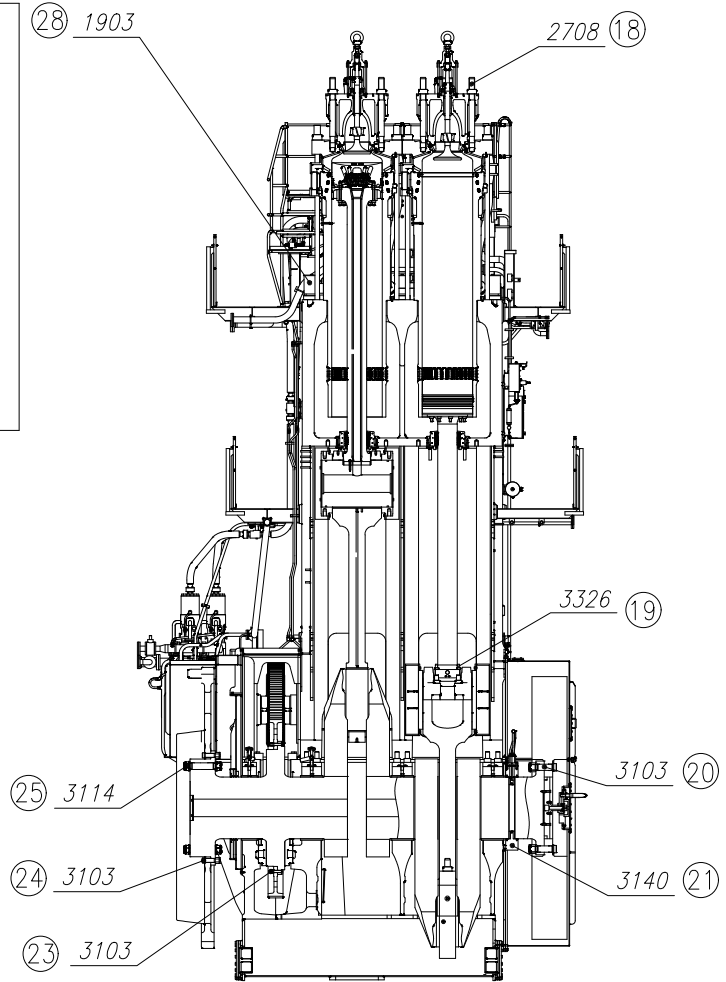
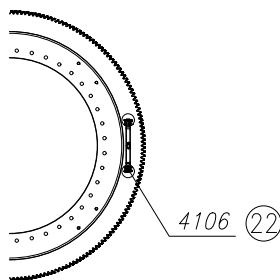


Fig. 2:

Tightening Values of Important Screwed Connections

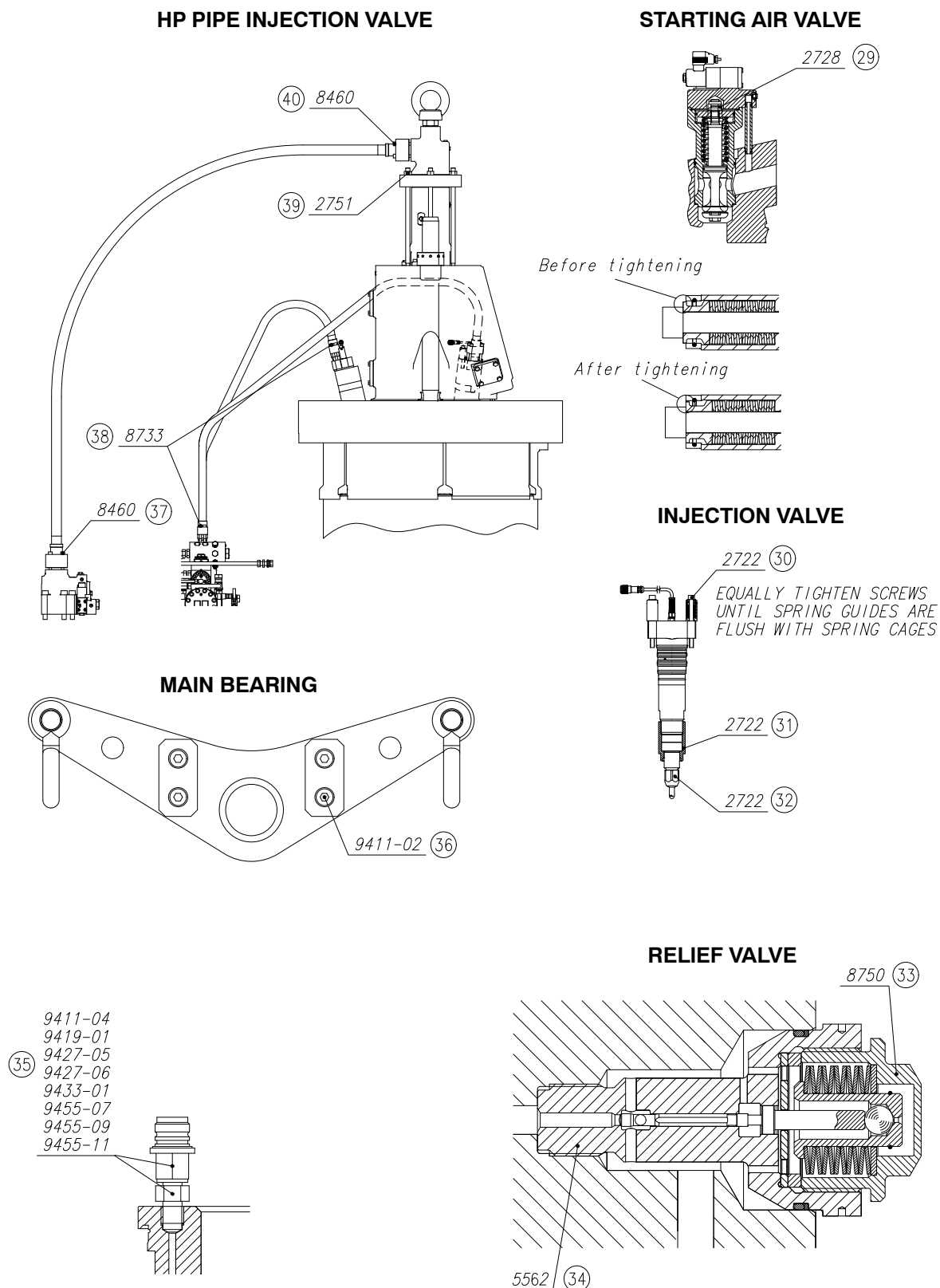


Fig. 3:

Tightening Values of Important Screwed Connections

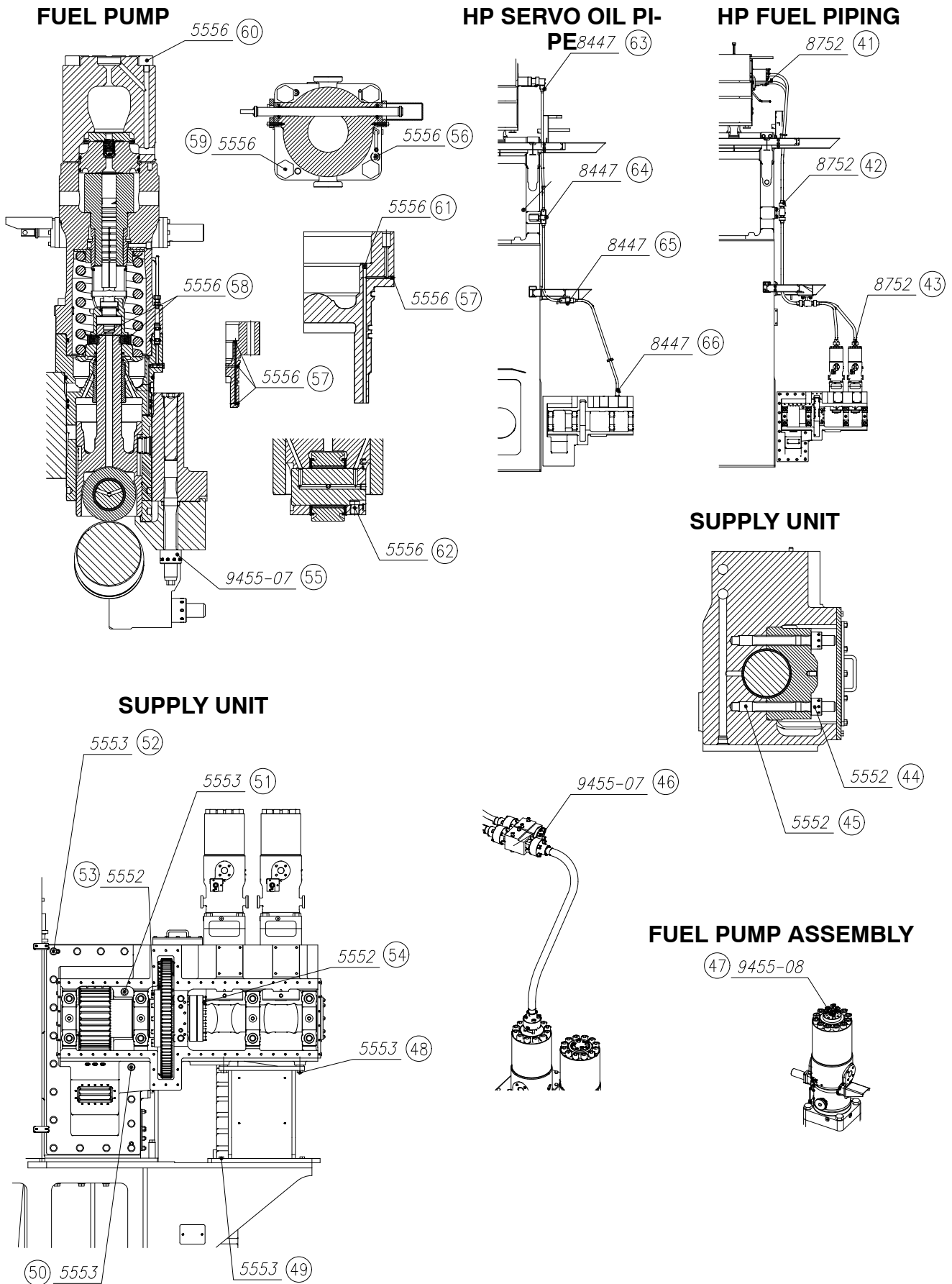
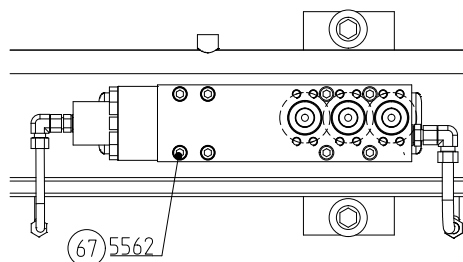
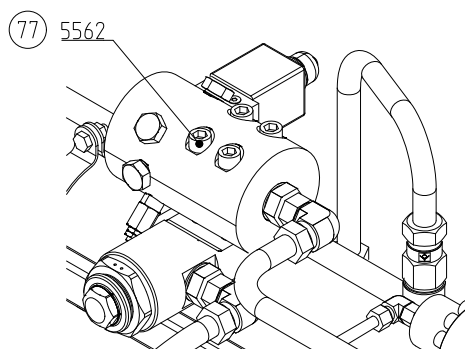


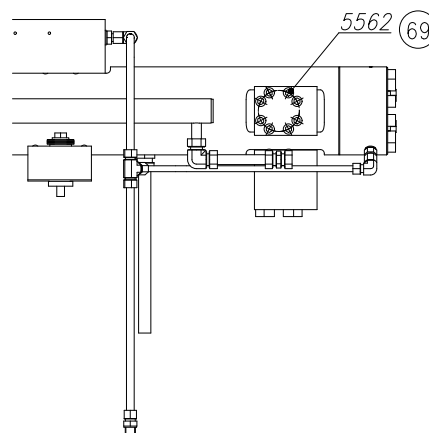
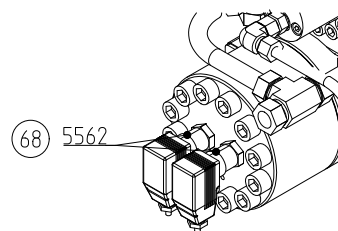
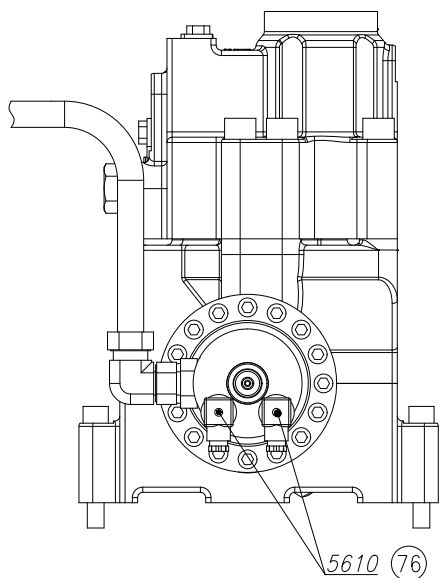
Fig. 4:

Tightening Values of Important Screwed Connections

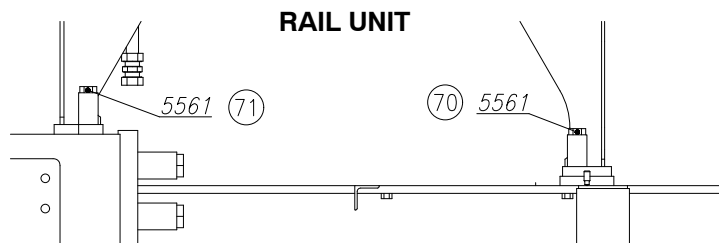
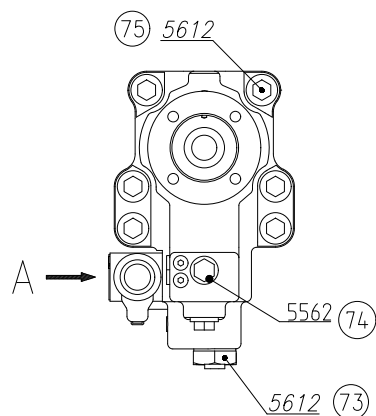
FUEL RAIL



SERVO OIL RAIL



EXHAUST VALVE CONTROL UNIT



RAIL UNIT

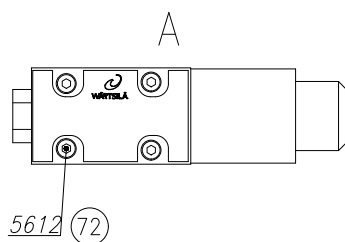
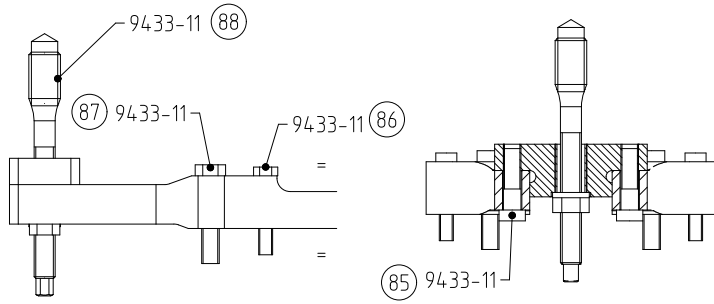


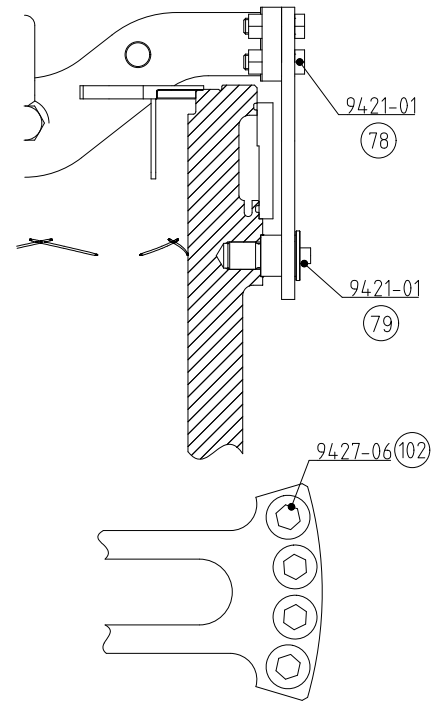
Fig. 5:

Tightening Values of Important Screwed Connections

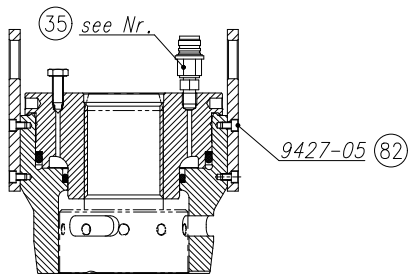
CONNECTING ROD BEARNG



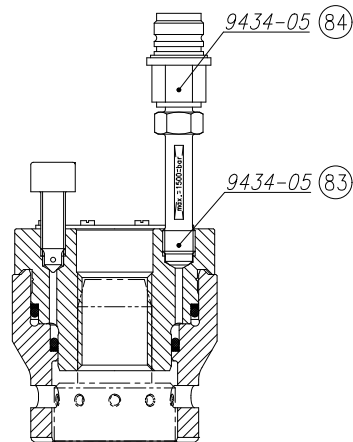
CYLINDER LINER ASSEMBLY



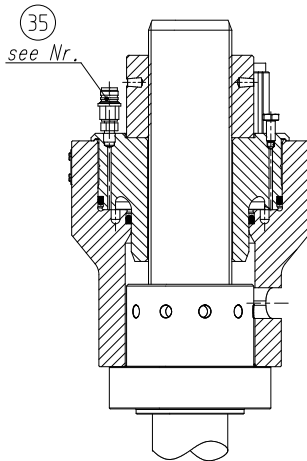
VALVE CAGE / LOWER CONNECTING ROD PRE-TENSIONING



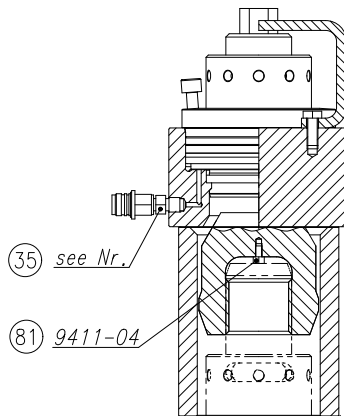
CONNEC. ROD BEARING PRE-TENSIONING



TIE ROD PRE-TENSIONING



MAIN BEARING PRE-TENSIONING



CONNECTING ROD ASSEMBLY

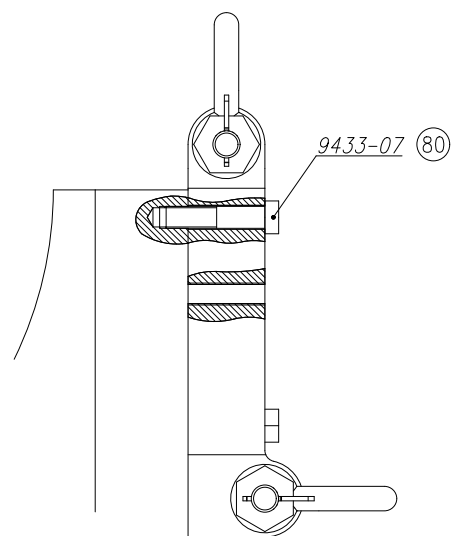
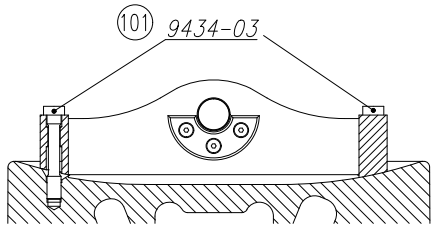


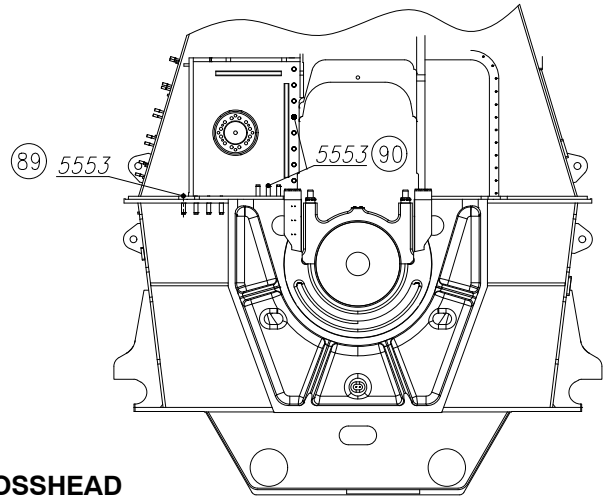
Fig. 6:

Tightening Values of Important Screwed Connections

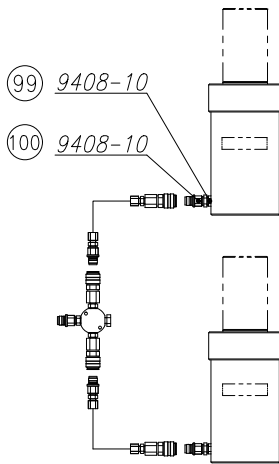
PISTON ASSEMBLY



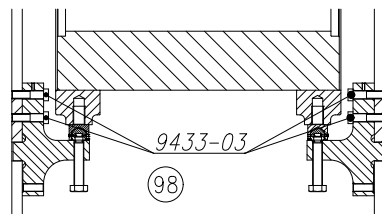
SUPPLY UNIT ASSEMBLY PARTS



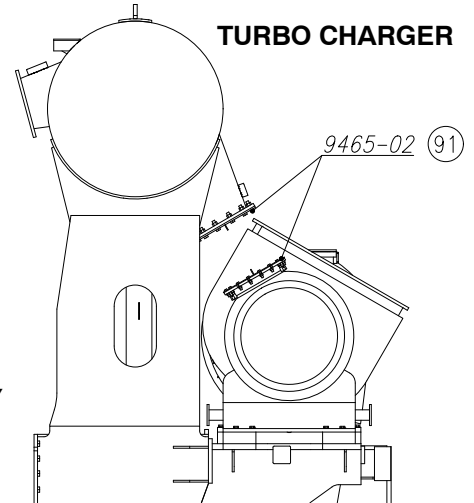
(GENERAL) JACKS AND PUMPS



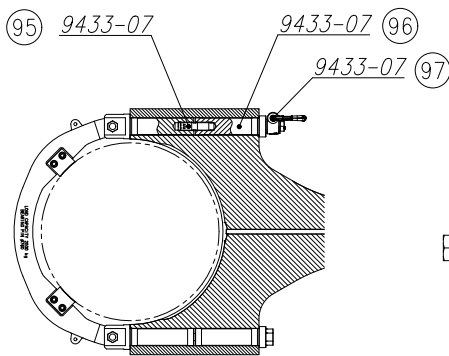
CONNECTING ROD CROSSHEAD



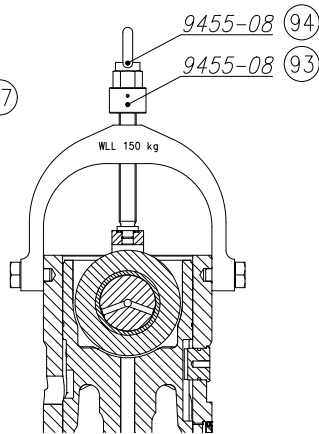
TURBO CHARGER



SUPPLY UNIT ASSEMBLY



FUEL PUMP ASSEMBLY



PISTON HEAD

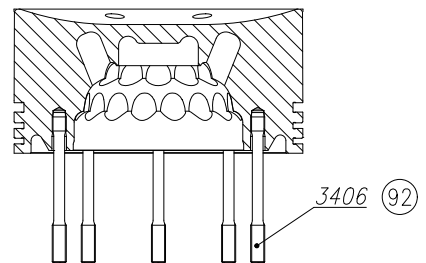


Fig. 7:

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	G¾"	
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		(5000)				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	35°– 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	G¼"	
35		45						O	G¼"	
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	M12x4	
68		25						N	M14	
69		110						N	M14	
70		350						O	M20	
71		350						O	M20	
72		9						O	M5	
73		225						O	M33x2	
74		100						O	M22	
75		350						O	M20	
76		25						O	G1/4"	
77		190						N	M16	
78		min. 660						C	M30	Min. 660 Nm max. 980 Nm
79		250						C	M52	
80		175						C	M20	
81		7						K	M6	Secured with Loctite 2701
82		7						O	M6	
83		45						O	G1/4"	
84		45						O	G1/4"	
85		190						O	M20	
86		145						O	M16	
87		280						O	M20	
88		35						O	M36	
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		600						O	M24	
91		60						O	M16	
92		50						O	M30	
93		10						K	M24	Secured with Loctite 2701
94		10						K	M16	Secured with Loctite 2701
95		140						K	M36	Bolt glued in with Loctite 268
96		70						C	M36	
97		400						K	M27	Lifting Lug glued in with Loctite 268
98		240						O	M24	
99		45						O	G1/4"	
100		45						O	G1/4"	Closing Valve sealed with Loctite 542
101		60						O	M20	
102		7.2						C	M6	

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:	LUBRICATION OIL SAE 30	Designation:	MOLYSLIP COPASLIP
Short form:	0	Short form:	C
		K factor:	0.16
		Manufacturer:	Molyslip Atlantic Ltd A1 Danebrook Court Oxford Office Village Langford Lane, Kidlington Oxfordshire OX5 1LQ England

Designation:	MOLYKOTE PASTE G N Plus	Designation:	NEVER SEEZ NSBT8
Short form:	M	Short form:	N
Coefficient of friction: (M12, 8.8 blackened)	Thread: 0.12 Head: 0.06	K factor:	0.13
Manufacturer:	Dow Corning Corporation Corporate Center PO Box 994 MIDLAND MI 48686 0994 United States	Manufacturer:	Bostik, Inc, Bostik Americas Technology Center 11320 W. Watertown Plank Road Wauwatosa, WI 53226 414 United States

Torque Values – Standard Screws and Elastic Studs

1. Torque Values – Standard Screws

It is recommended that the torque values given in the table below are for all standard metric screws of grade 8.8. This applies to all threaded connections not shown in [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 lubricant resistant to heat (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.

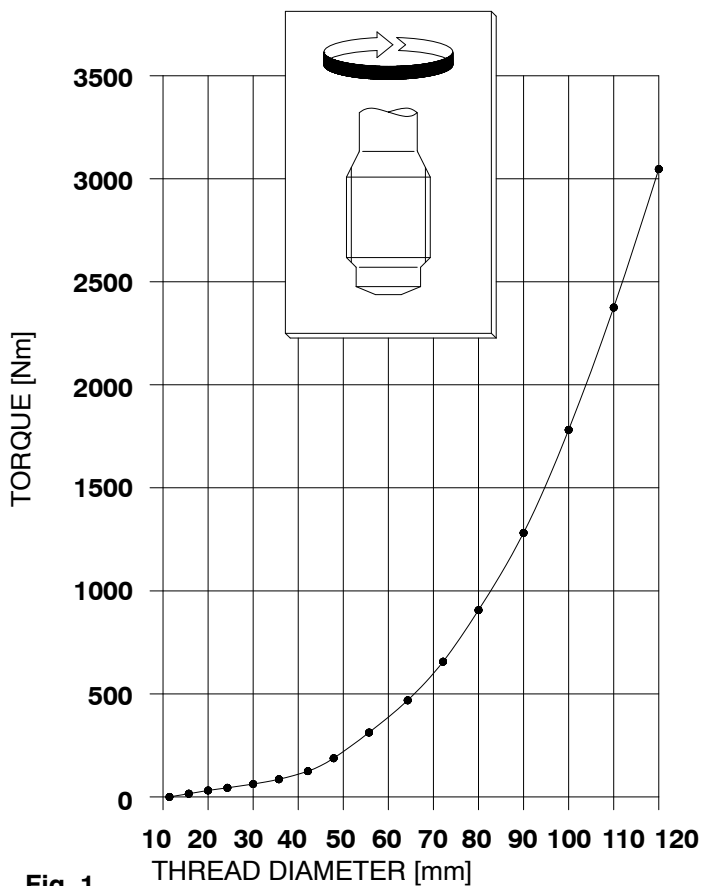
These torque values do not apply to turbocharger installations. Refer to the documents of the turbocharger manufacturer for the correct torque values.

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

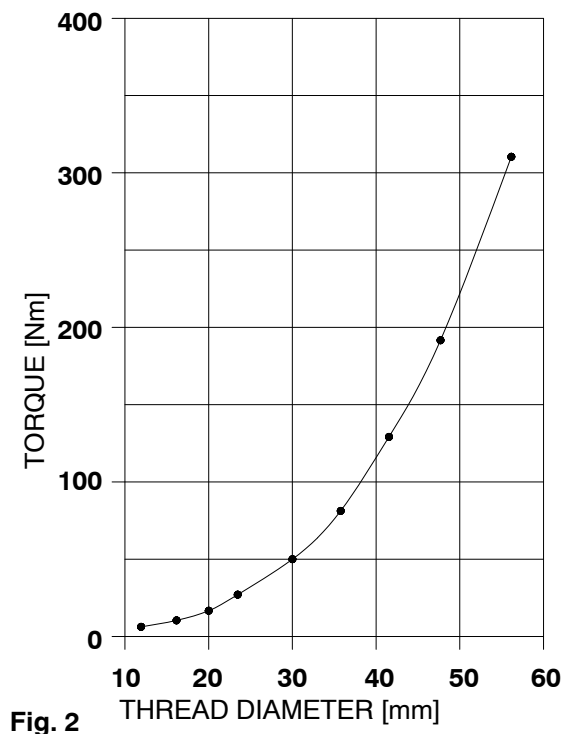
1. Elastic Studs – Replacement

1.1 Procedure

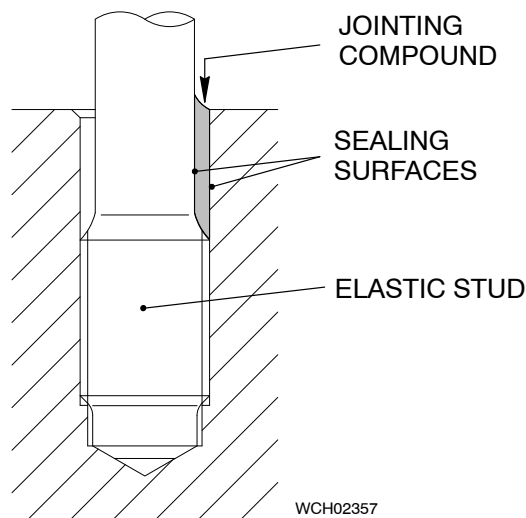
- 18) Read the data in the manual of the jointing compound manufacturer.
- 19) Remove the unserviceable elastic stud.
- 20) Remove the grease.
- 21) Clean the sealing surfaces of the new elastic stud.
- 22) Remove the grease and other unwanted material from the tap hole and the area where the elastic stud will be installed.
- 23) Clean the tap hole and the area where the elastic stud will be installed.
- 24) If necessary, apply an adhesive primer to the shank of the elastic stud. Make sure that no adhesive primer goes on to the threads.
- 25) Use only a stud driver (or two nuts locked together) to fully install the stud into the tap hole.
- 26) Torque the elastic stud to the applicable value given in the table below:



001.769/97



27) 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).



1.2 Jointing compound

Refer to 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 (refer to 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.
- The materials must be easy to prepare and combine.
- The surface shrinkage must be very small, or none.

- The jointing compound must stay in an elastic condition. This will help you if it becomes necessary to remove the elastic studs.

Masses (Weights)

Individual Components Each Piece in kg

Group	Component	Design/Position	kg
1__			
1115	Main bearing cover (1st)		328 (252)
1134	Main bearing shell		43.0
1224	Thrust bearing pad		67.0
1717	Casing (bottom part) Casing (top part)	Free end	1158 639
1719	Casing, right Casing, left	Driving end	161 52
1720	Oil baffle, top half Oil baffle, bottom half		259 161
1903	Tie rod Tie rod nut Intermediate ring for tie rod nut		352 7.32 7.4
2__			
2106	Elastic bolt in cylinder jacket		45.2
2124	Cylinder liner		4031
2130	Water guide jacket (top part) Water guide jacket (bottom part)		131 254
2303	Piston rod gland	Complete	95.89
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 1913 2835.8
2722	Injection valve	Complete	19.9
2728	Starting valve	Complete	34.0
2751	Exhaust valve housing with spindle	Complete	675
2754	Exhaust valve spindle		63
2790	Pilot injection valve	complete	34.2
3__			
3122	Flywheel		3391 11004
3140	Axial damper cylinder	2-part	793
3206	Turning gear with planetary gear		1256

Individual Components per Piece in kg

Group	Component	Design/Position	kg
3306	Connecting rod With elastic stud and nut for bottom end bearing	Complete	2436
3306	Bearing cover for bottom end bearing with elastic studs	Complete	340
3310	Bearing shell for bottom end bearing		35.6
3312	Bearing cover for top end bearing		313
3315	Bearing shell for top end bearing		65.0
3326	Crosshead pin Crosshead with guide shoes Guide shoe	Complete Complete	1684 2467 340
3403	Piston with piston rod Piston crown Piston skirt Piston rod Spraying plate with oil pipe Piston rings	Complete	1689.6 1694.5 440 68.8 71.3 1098.2 74 76.4 8.6
3603	Toggle lever to piston cooling and crosshead lubrication	Complete	127
4 __			
4106	Crankshaft gear wheel	2-part, complete	2207
4325	Starting air shut-off		246
5 __			
5551	Servo oil pump	BOSCH HAWE	90 116
5552	Supply unit with 3 fuel pumps and 2 oil pumps		2520 2572
5556	Fuel pump	complete	399
5581	Camshaft with gear wheels	Complete (for three fuel pumps)	745
5612	Exhaust valve control unit	Complete	35.5

Individual Components per Piece in kg

Group	Component	Design/Position	kg
6__			
6506	Turbocharger	MET 42MB MET 48MB MET 60MB MET 66MB MET 71MB ABB A165 ABB A170 ABB A175 ABB A180 ABB A265 ABB A270 ABB A275	1600 3100 4600 6500 8000 2300 3300 5600 7500 2600 3800 6300
6545	Auxiliary blower with electric motor Electric motor	Complete 250SMA 280SMA	960 1195 480 700
6509	Expansion piece between exhaust manifolds and upstream of turbocharger		32 88.7
6606	Scavenge air cooler	SAC B65 SF SAC B66 SF SAC B67 SF	3400 4000 4000
6708	Water separator		194
7__			
7758	Electric balancer compensating shaft (gear wheel, counter weight and bearing pin) Electric motor		1326 180
8__			
8103	Expansion piece downstream of exhaust valve	DN 500	80.0

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Maintenance Schedule

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
0	System oil	- Laboratory analysis	3000 Op. h (operating hours)
	Main fuel and lubricating oil filters	- Check filter elements - in particular for white metal particles (clean or replace filter as necessary). Follow manufacturer's instructions	3000 Op. h
	Cooling water	- Calculate the quality, concentration of inhibitor and pH value (do the instructions of the inhibitor manufacturer)	weekly
1 1112-1	Bedplate	- Do a check of the tension of foundation bolts, first time after 1500 Op. h	12000 Op. h
		- Check condition of rubber gasket in the vertical oil drain to sump tank (see SPC 9722), first time at the earliest opportunity after ship delivery.	30000 Op. h (replacement recommended)
		Estimated service life: Bedplate foundation bolts	Engine lifetime
	Crankcase	- Do a visual examination 100 Op. h after overhaul works: search for white metal particles from bearings and for abnormalities in general.	1500-3000 Op. h
1132-2	Main bearing	- Bearing shell inspection is only necessary if bearing clearance, crankshaft deflection, wire check, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage
		- Bearing edge check by wire	6000 Op. h
		- Check bearing clearance, see 0330-1	6000 Op. h
		Estimated service life: Main bearing shell	>100000 Op. h
1203-1	Thrust bearing	- Do a check of the axial and vertical clearances	6000 Op. h
		- Make sure that the bottom drain is not blocked	6000-8000 Op. h
1224-1		- Thrust bearing pads inspection is only necessary if bearing clearance, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage.
		Estimated service life: Thrust bearings	Engine lifetime. (replacement if required)
1715-1	Engine stays with friction shims	- Do a check of the tension of the screws First time after sea trial	6000-8000 Op. h
	Hydraulic engine stays	- Do a check of the oil pressure at the gauge	monthly

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
1903-1	Tie rod	- Do a check of the tension, if necessary apply tension again First time after one year	24000-30000 Op. h
		Estimated service life: Tie rod	Engine lifetime.
2			
2124-1	Cylinder liner	- Find the wear in the bore (in installed condition)	At each piston removal
2124-2	Cylinder liner	- Remove the cylinder liner	As necessary
		- Replace the O-rings	At each liner removal
		- Replace the (soft iron) joint ring between the cylinder liner and the cylinder cover	At each piston removal
		- Replace the O-rings of water guide jacket and transition tubes.	At each liner removal
		- Do a check of the condition of the antipolishing ring	At each piston removal
2124-3		- Grind off the wear ridge in the bore	At each piston removal
		- Clean the scavenge ports and polish the surface finish of their edges	As necessary
		- Refinish the lubricating grooves	As necessary
		Estimated service life: Cylinder Liner	Up to 90000 Op. h
2138-1	Lubricating quill (pulse lubrication)	- Do a check of the function and tightness	At each piston removal
		- Do a check of the function of non-return valves	At each liner removal
2303-1	Piston rod gland	- Clean the piston rings, calculate worn parts Estimated service life: Piston rod gland	At each piston removal 36000 Op.h (refers to rings)
2708-1	Cylinder cover	- Do a check of the combustion space for damage and worn areas. Make sure that the seat sealing faces have no damage	At each cylinder cover removal
		Estimated service life: Cylinder cover	Engine lifetime (re-manufacturing as required)
2722-1	Fuel Injection valve (FAST)	- Do an external check for tightness	After engine stop, before a longer standstill
		- Function check (nozzle tip inspection, check LPOP, confirm tightness), replace O-rings	4000 - 6000 Op. h
		- Exchange nozzle tip (FAST) and replace O-rings	8000 - 12000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
		- Replace nozzle spare kit (nozzle & coupling nut, valve plate & pilot valve) and check function	8000 – 12000 Op. h
		- Replace injection valve complete	24000 Op. h
2728-1	Starting air valve	- Do a check of the pipe upstream of the valve during operation, If the pipe is too hot, disassemble the starting valve	Weekly
		- Remove and disassemble one starting valve at . From its condition, calculate the time of overhaul for the remaining valves	12000 Op. h
		- Make sure that the nut on the solenoid is tight, If necessary, tighten the nut	Monthly
		- Solenoid valve, do a random functional check Overhaul on board	6000 Op. h 18 000 Op. h
		Estimated service life: Starting air valve	Engine lifetime
2745-1	Relief valve to cylinder cover	- Check blow-off pressure	As necessary
2751-1 to 2751-4	Exhaust valve	- General inspection of valve housing, valve spindle and valve seat (without disassembly of exhaust valve)	At each piston removal
		- Do a check of the condition and worn parts of the valve spindle (if necessary grind the valve seat)	36000 Op. h (initial inspection 18000)
		- Do a check of the piston seal ring / rod seal ring / guide bush	36000 Op. h (initial inspection 18000)
		- Do a check of the condition and worn parts of the valve seat (if necessary grind the valve seat)	36000 Op. h (initial inspection 18000)
		- Do a random check of the valve drive, outer and inner pistons, damper, thrust piece	18000 Op. h
		Estimated service life: Exhaust valve spindle	108000 Op.h (remanufacturing as required)
		Estimated service life: Valve seat	72000 Op.h (remanufacturing as required)

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
3			
3103-1	Crankshaft	- Measure the crank deflection: (always if the ship is grounded. Also, before and after each docking)	6000 Op. h
3130-1	Torsional vibration damper	- Get a silicon oil sample from the viscous vibration damper, in accordance with the manufacturers instruction.	First time after 15 000 to 18 000 Op. h
3130-2		- Disassembly and inspection of vibration damper	In accordance with instructions of the damper manufacturer
3140-1	Axial damper	- Disassembly and inspection	36000 to 48000 Op. h
3206-1	Turning gear	- Inspection of turning gear	In accordance with the instructions of turning gear manufacturer
		- Lubrication of tooth flanks of pinion and flywheel, related to visual inspections	2000 Op.h
		- Check screwed connections, first time after one year	12000 Op.h
3303-2 3303-3	Connecting rod bearings	- Do a check of the bearing clearances (refer to 0330-1)	6000 Op. h
		- Bearing edge check by wire	6000 Op. h
		- Bottom end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage
		- Top end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection indicates excessive wear or damage.	at indications of excessive wear or damage
		- Random inspection of connecting rod top end bearing and bottom end bearing	7000 Op. h
		Estimated service life: Connecting rod bottom bearing	90000 Op.h (replacement if required)
		Estimated service life: Connecting rod top bearing	90000 Op.h (replacement if required)
3326-1	Guide shoe, crosshead pin	- Do a check of the clearances.	6000 to 8000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
3403-1	Piston	- Remove and clean	18000-36000 Op. h (condition based)
		- Do a check of the tightness on the installed piston and with running oil pump. Do a visual check through the scavenge ports	After installation
3403-3		- Disassemble and assemble (open and clean the cooling space, minimum one piston three yearly)	As necessary
		- Top surface of the piston: do a check of the condition.	Each piston removal
3403-4		- Full remanufacturing of piston head surface	72000 Op. h
		- Do a visual check through scavenge ports of the piston, piston rings and cylinder liner (operate the turning gear to turn the crankshaft)	500 to 1000 Op. h
		Measure ring grooves, inspect the chromium plating and re-chrome as necessary	18000 - 36000 Op. h (condition based)
	Piston underside	Estimated service life: Piston head ring grooves	18000 - 36000 Op. h
		- Do a check of the condition of the piston underside. Clean as necessary.	1500 to 3000 Op. h
		- Make sure that the drains and orifices are clear	1500 to 3000 Op. h
3425-1	Piston rings	- Measure thickness of chrome-ceramic layer	1500 to 2000 Op. h
		Replace piston rings based on remaining coating thickness	18000 - 36000 Op. h (condition based)
		Estimated service life: Piston rings	18000 - 36000 Op. h
4	Start interlock	- Do a check of the electrical and pneumatic interlocks (see Operating Manual 4003-1)	Quarterly
4103-1	Driving wheels	- Do a check of the condition of the teeth	6000 to 8000 Op. h
		- Do a check of the running clearance and backlash of the teeth	6000 to 8000 Op. h
		Estimated service life: driving wheels	Engine lifetime
4325-1	Starting air shut-off valve	- Release pressure / vent starting air inlet (manifold) pipe	After each manoeuvring period
		- Disassemble, clean and examine (valve seat, springs and seal rings)	30000 to 36000 Op. h
		- Do an overhaul of the common start valve	18000 Op. h
		Estimated service life: starting air shut-off valve	Engine Lifetime
	Control air filter	- Drain the filter	Weekly
		- Clean the filter	6000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
5			
5555-1	Servo oil pump	Replace servo oil pump with new one for serial number 54-160200014	36000 (Hawe)
		Replace servo oil pump either with new one or a pump remanufactured by WIN GD service provider	36000 (Bosch)
5552-1	Servo oil pump drive	Check pinion and driving wheels to servo oil pump drive	3000 Op. h
		Check filter below the plug in the compensator for particles	2000 Op. h
		Estimated service life: Supply unit pinion bearing bushes	90000 Op. h (replacement if required)
5552-2	Fuel oil pump drive	Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h)	3000 Op. h
		Check pinion and driving wheels to fuel oil pump drive	3000 Op. h
		Camshaft, check thrust bearing clearances	36000 Op. h
		Estimated service life: Supply unit camshaft bearings	90000 Op. h (replacement if required)
5556-1	Fuel pump	- Random flow check of lubricating oil	6000 Op. h
		- Do a check of the fuel oil leakage from the fuel pump cover (the O-ring in the non-return valve can become weak)	weekly
		- Re-manufacture fuel pump or overhaul on board	18000 - 22000 Op. h
5562-1	Fuel pressure control valve (PCV)	- Check shut down function (see Operating Manual 4003-1)	3000 Op. h
		Removal and pressure check	6000 Op.h
		General overhaul	Only if PCV fails
		Estimated service life: Fuel pressure control valve (PCV)	Engine lifetime
5562-2	Fuel overpressure safety valve / relief valve	- Do a function check on the test bench	24000 - 36000 Op. h
5564-1	Flow limiting valve	- Inspect and clean piston rod and piston running surface	12000 Op. h
		- Replace it with a new one	48000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
5564-4	Servo oil rail	- Replace hoses (at least every 5 years)	30000 Op. h
5612-1	Exhaust valve control unit	- Check piston and slide rod	36000 Op. h
		- Check VCU last chance filter	18000 Op. h
		- Replace 4/2-way solenoid valve	24000 - 36000 Op. h
		Estimated service life: Exhaust valve control unit	Engine lifetime
5583-1	Fuel pump actuator arrang.	- Check connecting elements for free movement, lubricate movable parts and relief valve	3000 Op. h
		- Replace fuel pump actuator (WEA-40) with a new item or a re-manufactured fuel pump actuator from maker	24000 Op. h
6 6420-1	Scavenge air receiver	- Check and clean the flaps	4000-6000 Op. h
		- Clean the scavenge air receiver	4000-6000 Op. h
		- Make sure that the drain pipes are not blocked	1500-3000 Op. h
	Turbocharger	- Wash-clean the blower in service	(see Turbocharger Manual)
		- Wash-clean or dry clean the turbine in service	(see Turbocharger Manual)
	Air filter	- Check filter	half yearly
		- Cleaning of filter at a Δp increase of 50% compared to shop test value at same engine load (see Operating Manual 6510-1)	as required
	6545-1	Auxiliary blower	- Clean impeller and casing	24000-36000 Op. h
- Replace ball bearing			24000-36000 Op. h
6606-1	Scavenge air cooler	- Cleaning of scavenge air cooler (air side) in service at the beginning weekly, later if Δp (pressure drop through SAC) increases compared to shop test value at same engine load (see Operating Manual 6606-1)	as required
		- Check condensate collector through sight glass (see Operating Manual 8345-1)	daily
		- Check condensate collector/filter for free passage (see Operating Manual 8345-1)	1500-3000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
		- Check scavenge air cooler sealing	quarterly
		- Bleed	daily
		- Remove scavenge air cooler for general overhaul	as required
6708-1	Water separator	- Check condensate collector through sight glass (see Operating Manual 8345-1)	daily
		- Check condensate collector/filter for free passage (see Operating Manual 8345-1)	1500-3000 Op. h
		- Check water separator elements (if necessary clean them)	1500-3000 Op. h
		- Remove water separator for general overhaul	as required
7 7218-1	Cylinder Lubricating pump (Pulse lubrication)	- Re manufacture cylinder lubricating pump or overhaul on board	45000 Op. h
7758-1	Electric balancer iElba	- Check bearing clearance, see 0330-1	6000 Op. h.
8 8135-1	Exhaust Waste Gate (LLT)	- During a longer operation period at low engine load, manually open butterfly valve at least once per week (see Operating Manual 8135-1) - General inspection	According to instruction of valve manufacturer
	SCR butterfly valves (HP-SCR)	- Test of the function of the SCR butterfly valves during engine standstill by use of the function "SCR Manual Valve Control"	Regularly during engine standstill. In accordance with instructions of valve manufacturer
	Servo oil service pump (engine mounted)	- Check rate of flow at max. pressure	According to manufacturer
	Starting air pipe	- Drain (remove water)	before and after every manoeuvring period
	Pressure gauges and pyrometers	- Compare and calibrate according to master instruments	6000-8000 Op.h
	Pipe holders	- Check fastenings at intervals if necessary, tighten the screws (first time after 100 Op.h.)	Half yearly
8447-1	Servo oil pipes	- Grind sealing faces	As necessary
8460-1	Hydraulic pipe for exhaust valve drive (Group 8460)	- Grind sealing faces	As necessary
8733-1	HP pipe to injection valve (on cylinder cover)	- Grind sealing faces	As necessary

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
8744-1	Supply unit fuel drain pipe	- Check regularly for free passage at least once a year	6000 Op.h
8752-1	HP fuel pipes	- Re grind sealing faces	as required
<u>9</u> 9223-1	Crank Angle Sensor (on gear wheel)	- Replace proximity sensors	as required
	Oil mist detector	- Follow manufacturer's instructions	half yearly
	UNIC electronic components	- Replace CCM-20, MCM-11 and LDU-20 modules. (see Operating Manual 4002-4)	66000 Op. h
		- Replace exhaust valve stroke sensor and TDC sensors if defective	66000 Op. h (replacement if required)
		- Visual cabling check	quarterly

Inspection and Overhaul Intervals (Guidelines)

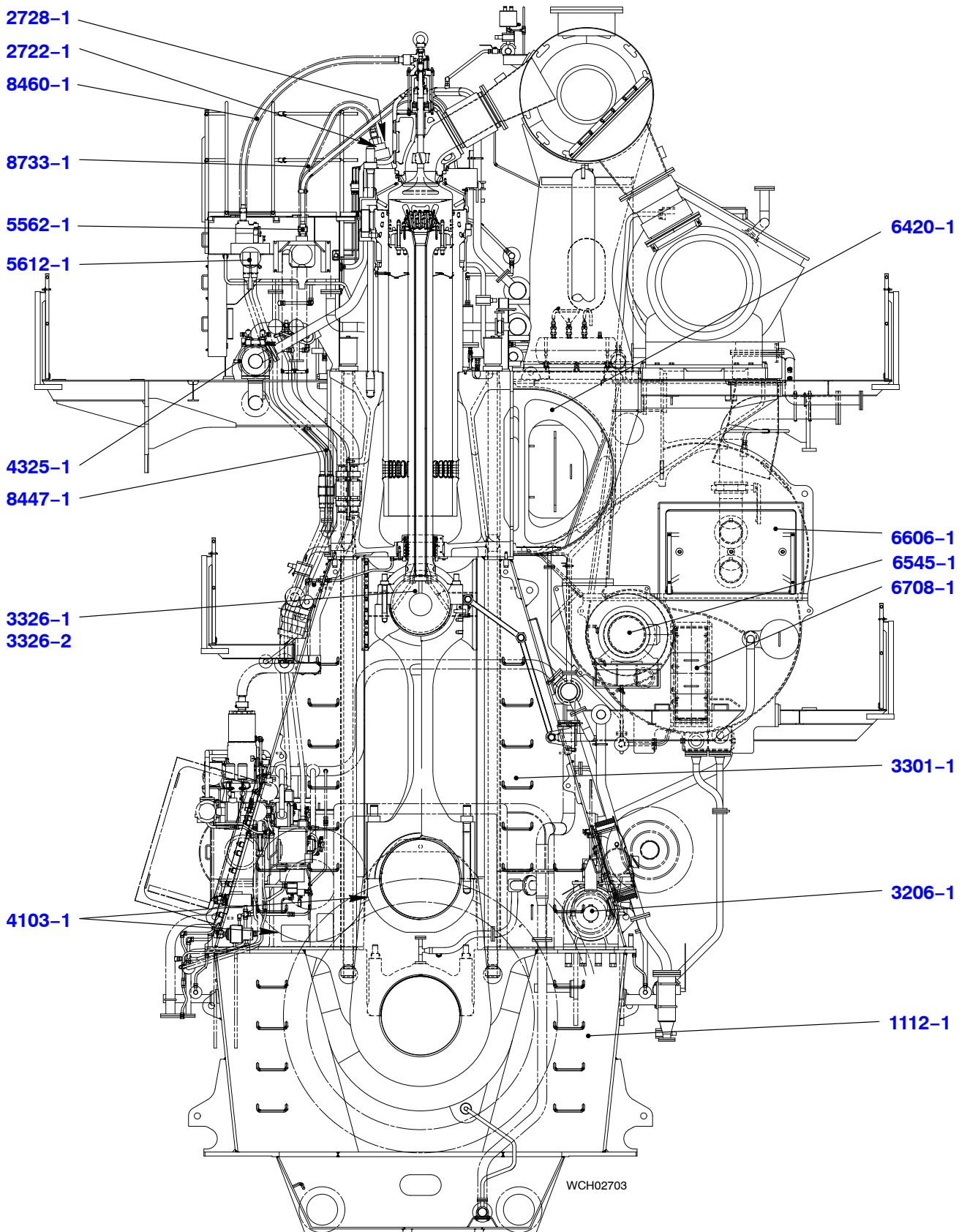
The indicated maintenance intervals must be taken as guidance and may vary depending on the installation. The proper intervals are subject to the points mentioned below. Experience will show whether these intervals can be extended or must be shortened.

- 28) Environmental and operating conditions
- 29) Heavy fuel oil and lubricating oil qualities (see Operating Manual 0710 1 and 0750 1)
- 30) Engine load
- 31) Fuel, lubricating oil and cooling water care (see Operating Manual 0720 1 and 0760 1)
- 32) Overhaul according to Maintenance Manual
- 33) Genuine spare parts used
- 34) Engine monitoring
- 35) Engines according to specifications of WinGD.

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



Engine Cross Section and Longitudinal Section

2. Longitudinal section

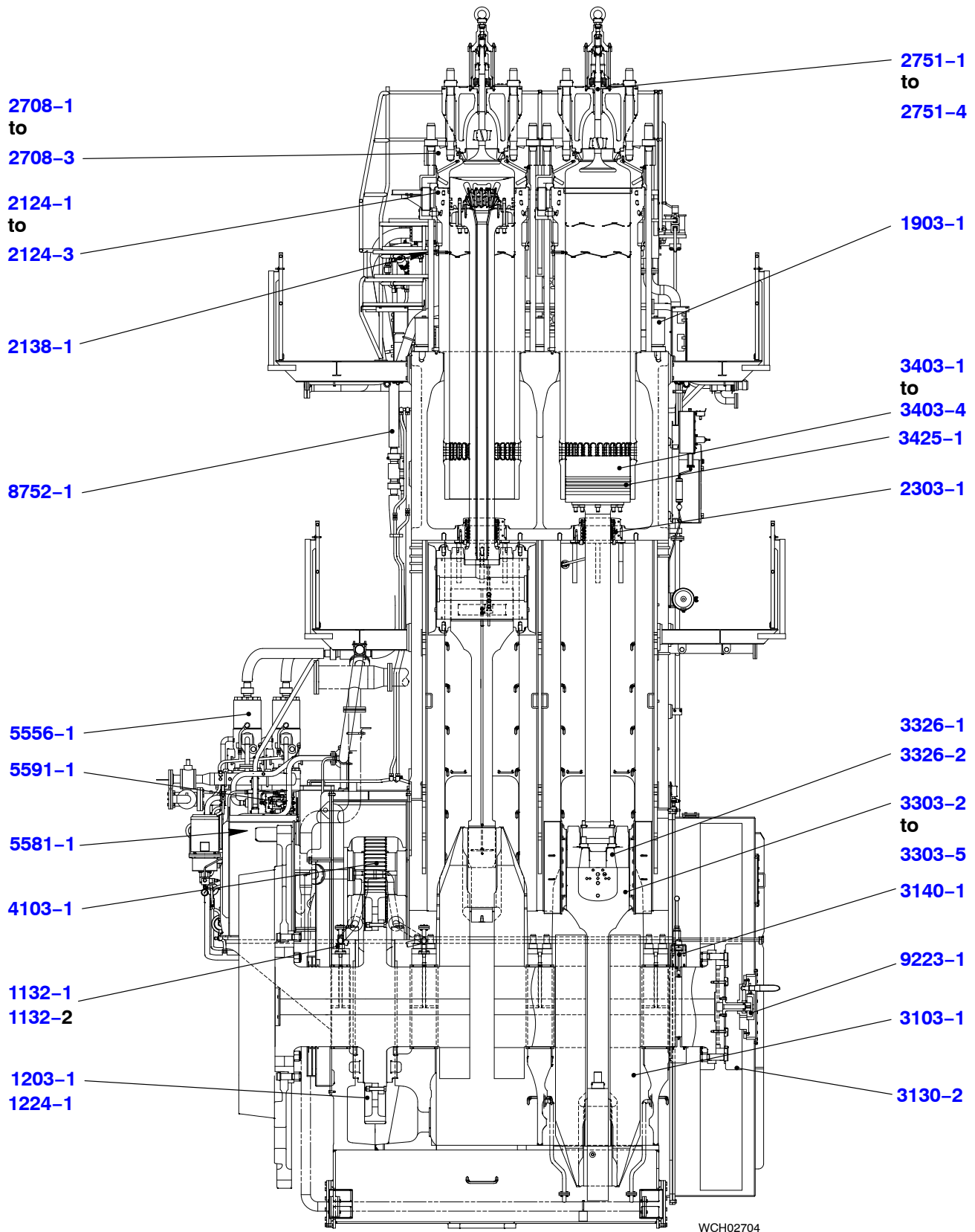


Fig. 4: Longitudinal Section

Bedplate, Tie Rod, Main Bearings, Engine Stays, Tie Rods

Group 1

Bedplate and Thrust Bearing: Foundation Bolts – Check	1112	1/A1
Main Bearing		
Elastic Studs Release and Apply Tension	1132	1/A1
Main Bearing Removal and Installation	1132	2/A1
Thrust Bearing		
Axial Clearance Checks	1203	1/A1
Thrust Bearing Pads Removal and Installation	1224	1/A1
Engine Stays with Friction Shims: Tension Checks	1715	1/A1
Hydraulic Engine Stays: Oil Pressure Checks	1715	1/A2
Tie Rod: Tension Checks and Replacement Procedure	1903	1/A1

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Foundation Bolts – Checks

Tools:

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

1. General

You must do a check of the tension of the foundation bolts (hold-down studs) at longer intervals eg during overhauls. Refer to 0380 1, [Bedplate](#).

In the area of the thrust bearing, the bedplate (7, [Fig.1](#)) and the foundation must be attached with foundation bolts (2) and the long bushes (3).

The remaining area is attached with the foundation bolts (2, [Fig.2](#)) and the short bush (8).

1.1 Foundation Bolts – Release or Apply Tension

You start the procedure to apply tension to the foundation bolt at the driving end, and from one side to the other. The procedure is completed at the free end.

- 1) To release and apply tension to the foundation bolts (2), 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 2](#).
- 3) Do the Version 1 procedure as given in [9403 4](#).
- 4) Apply tension in two steps as follows:
 - a) Step 1 For metal chocks or epoxy resin chocks, first apply tension to all foundation bolts to 1000 bar.
 - b) Step 2 Apply tension to 1500 bar.

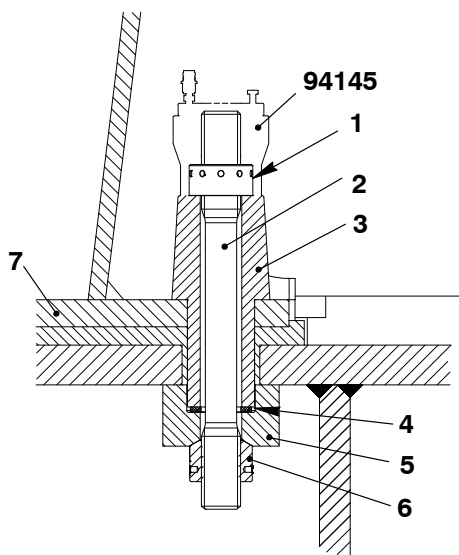


Fig. 1

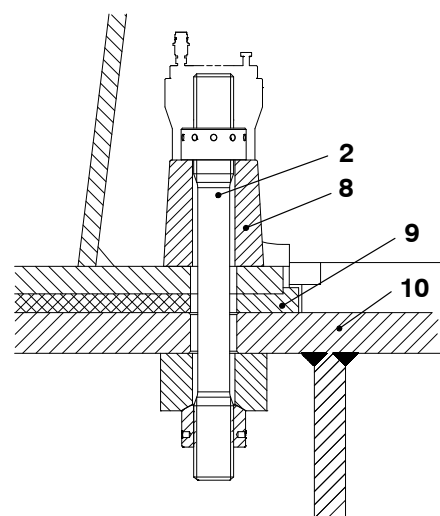


Fig. 2

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2. Tension Check

- 1) Clean the threads of the foundation bolts (5, Fig.3) and the seating surfaces.
- 2) Attach the pre-tensioning jack (94145) to the foundation bolt (5).
- 3) Open the vent screw (9).
- 4) Turn the foundation bolt (5) fully down until there is a small clearance, or no clearance between the foundation bolt and the round nut (7).
- 5) Connect the pre-tensioning jack (94145) to the HP oil pump (94931), refer to 9403 2.
- 6) Close the relief valve (10).
- 7) Operate the HP oil pump (94931) until oil that has no air flows from the vent screw (9).
- 8) Close the vent screw (9).
- 9) Torque the foundation bolt (5) to 1500 bar and keep the pressure constant.
- 10) Do not move the piston (1) of the pre-tensioning jack (94145) to more than the red limit groove (2).
- 11) Put the feeler gauge (94122) through the slot (4). Do a check for clearance between the round nut (7) and the bush (6). If you find a clearance do step a) and step b).
 - a) Keep the pressure of 1500 bar.
 - b) Use the round bar (8) to fully tighten round nut (7).
- 12) Decrease the pressure to zero.
- 13) Remove the pre-tensioning jack (94145).

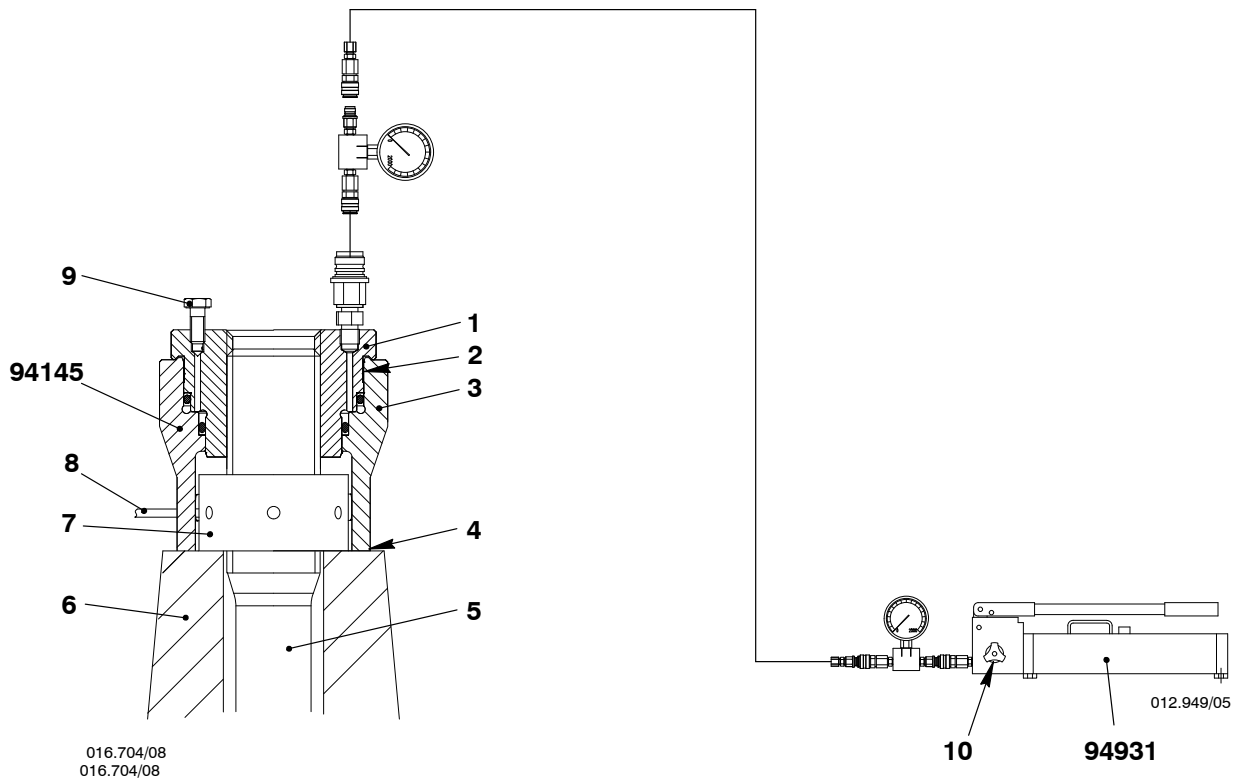


Fig. 3

Main Bearing

Elastic Studs Apply Tension and Release Tension

Tools:

2	Double pre-tensioner	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			

Note: Use only the hydraulic double pre-tensioner (94114, Fig. 1) to release tension and apply tension to the main bearing elastic studs (1), and the 1st main bearing cover (2) that has two elastic studs (1).

- 1) Connect only the jack that you will use to the hydraulic unit.
- 2) Do the general preparation for hydraulic jacks (94114), refer to 9403 4, paragraph 1.
- 3) If necessary, put oil on the the threads of the elastic studs (1).
- 4) To release tension, do the procedure given in 9403 4, paragraph 2.2 and 2.3.
- 5) To apply tension, do the procedure given in 9403 4, paragraph 3, 3.2 and 3.3.

Note: The value for the pre-tensioner (94114) is 1500 bar in one step.

- 6) 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 applicable only with tightened elastic studs and tie rods.

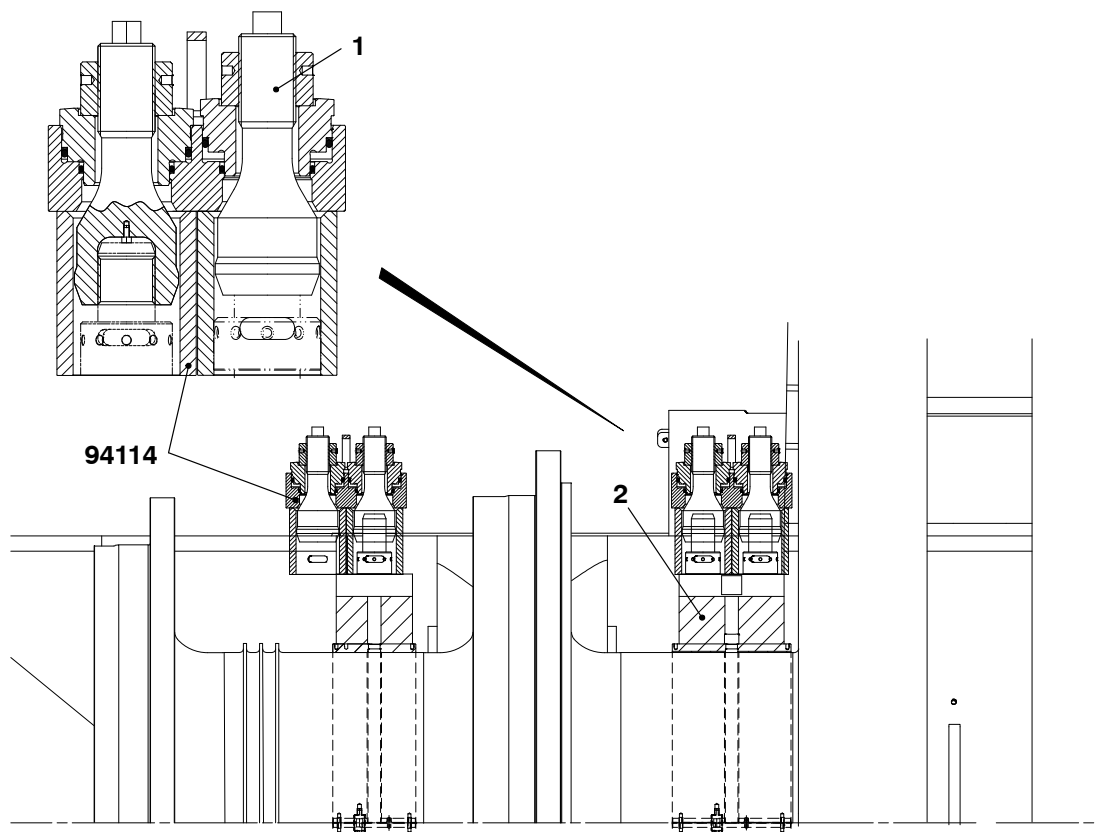


Fig. 1

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Main Bearing


Main Bearing – Removal and Installation

Tools:

1	Manual ratchet (H1)	94016-006	1	Turning-out device (wide bearing shell)	94118B
2	Spur-gear chain block (H2, H3)	94017-005	1	Lifting plate	94119
1	Chain (asymmetric)	94019A	1	Feeler gauge	94123
1	Chain (symmetric)	94019B	1	Bracket	94141A
1	Eye bolt	94045-M48	1	Work platform	94143
1	Thrust device	94110	1	HP oil pump	94931
1	Lifting tool (narrow bearing shell)	94116A	1	Connection block	94934
1	Lifting tool (wide bearing shell)	94116B	2	Pressure gauge	94934A
1	Lifting lug	94116C	3	HP hoses	94935
1	Roller support	94117	2	Hydraulic ram (100t)	94936
1	Deviation pipe	94117B	4	Shackle 4750 kg	94018B
1	Turning-out device (narrow bearing shell)	94118A	4	Shackle 8500 kg	94018C

1.	Preparation	1
2.	Main Bearing Covers No. 2 to No. 8 – Removal	2
2.1	Tools – 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 – Lift	6
4.3	Bearing Shell No.1 (narrow) – Removal	7
4.4	Bearing Shell No. 2 to No. 8 – Removal	9
5.	Main Bearing Shell – Inspection	12
6.	Main Bearing Shell and Bearing Cover – Installation	12
6.1	Bearing Shell – Installation	12
6.2	Main Bearing Cover – Installation	13
7.	Main Bearing – Lubrication	14

1. Preparation

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.

- 1) Read the data in [0012](#) 1 General Guidelines for Lifting Tools.
- 2) Read the data in [3301](#) 1 Work Platform.
- 3) Operate the turning gear to turn the crank to the exhaust side approximately 90° after TDC.
- 4) Set to off the main oil supply pumps.
- 5) Close the lubrication to the main bearing.

Main Bearing Removal and Installation

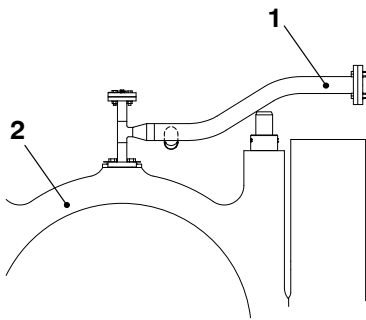


Fig. 1

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

2.1 Tools – Installation

- 1) Remove the oil pipe (1, [Fig. 1](#)) from the main bearing cover (2).

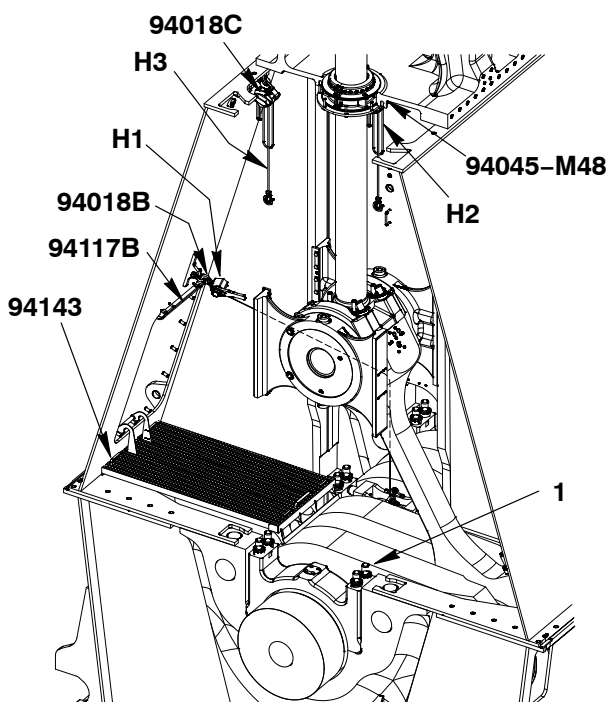


Fig. 2

- 2) Attach the work platform (94143, [Fig. 2](#)).
- 3) Use the feeler gauge (94123) to do a check of the bearing clearance, refer to 0330 1, [Top and Bottom End Bearings](#).
- 4) Apply tension to the elastic studs (1) and remove their nuts, refer to 1132 1.
- 5) Install the chain block (H2, [Fig. 3](#)) and the eye bolt (94045 M48) near the gland box.
- 6) Attach the manual ratchet (H1, [Fig. 2](#)) and the shackle (94018B) to the column above the door.
- 7) Attach the chain block (H3) and the shackle (94018C) to the column roof.

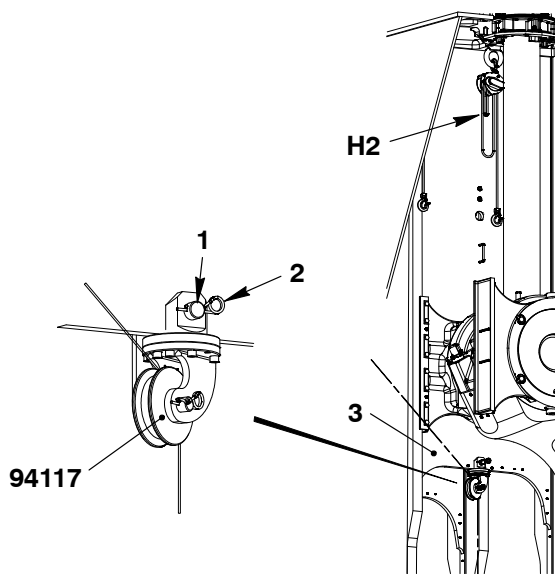


Fig. 3

- 8) Attach the roller support (94117, [Fig. 3](#)) to the column (3) with the pin (1).
- 9) Lock the pin (1) with the double spring clip (2).
- 10) Attach the deviation pipe (94117B, [Fig. 2](#)) to the column.

Main Bearing Removal and Installation

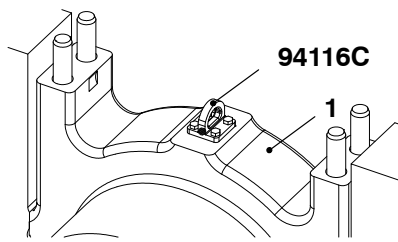



Fig. 4

- 11) Install the lug (94116C, Fig. 4) to the main bearing cover (1).

WARNING	
	<p>Injury Hazard: Do not use the thrust device 94110 as a lifting device. Injury to personnel can occur.</p>

CAUTION	
	<p>Damage Hazard: Use the thrust device 94110 only for removal of the main bearing covers No.2 to No.8.</p>

Note: Use the lifting plate (4) only for the movement and installation of the thrust device (94110). If the lifting plate is not in use, attach it as shown in Fig. 5.

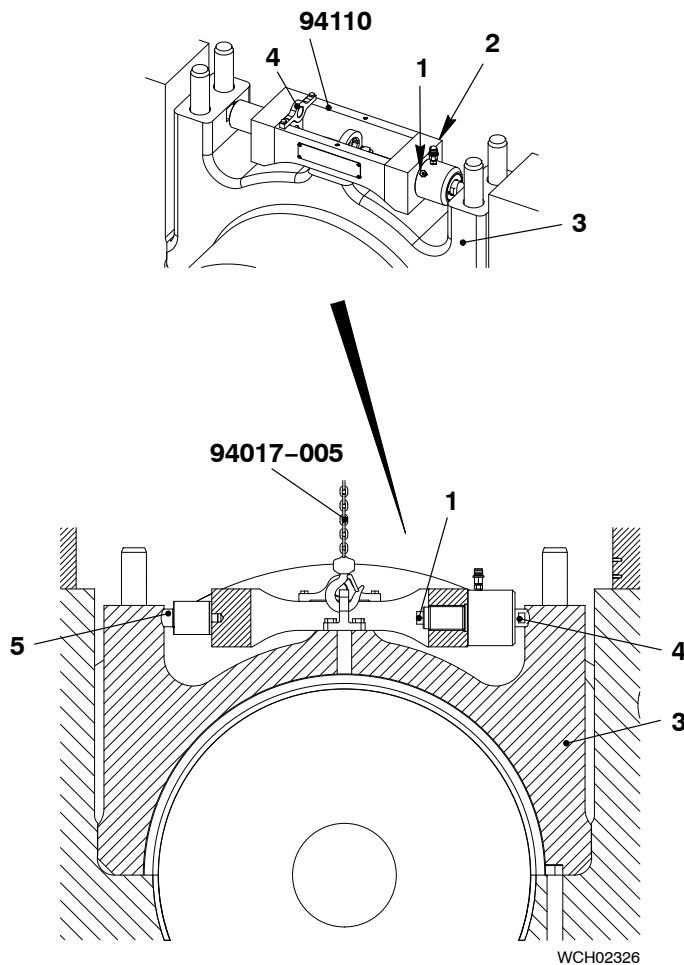


Fig. 5

- 12) Make sure that the thrust device (94110) is clean.
- 13) Apply copper paste to the thread and the surface of the screw (1).
- 14) Open the vent screw (2) and make sure that the piston (4) is fully engaged.
- 15) Put the thrust device (94110) in position on the main bearing cover (3).
- 16) Make sure that the tappet (5) and the piston (4) are in the cut-out of the main bearing cover (3).
- 17) Connect the thrust device (94110) to the HP oil pump (94931), refer to 9403 2.
- 18) Operate the HP oil pump.
- 19) Close the vent screw (2) when oil that has no air flows out.
- 20) Slowly increase the pressure to 1500 bar.
- 21) Tighten the screw (1).
- 22) On the HP oil pump, release the pressure to zero.
- 23) Disconnect the HP hose.

Main Bearing Removal and Installation

FUEL SIDE

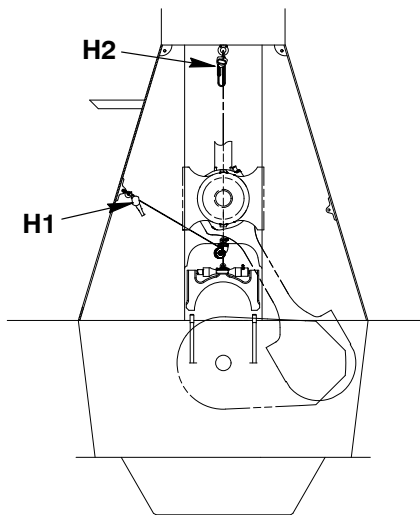
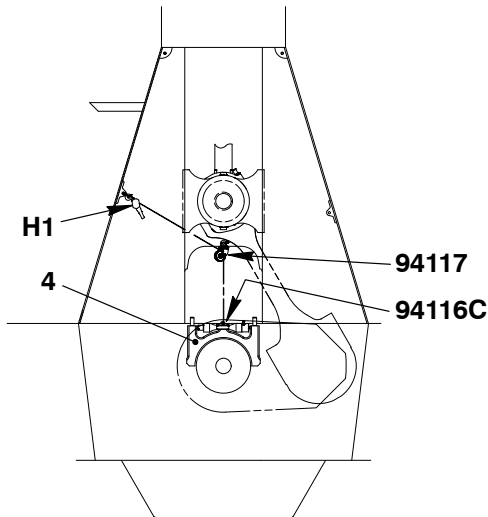


Fig. 6

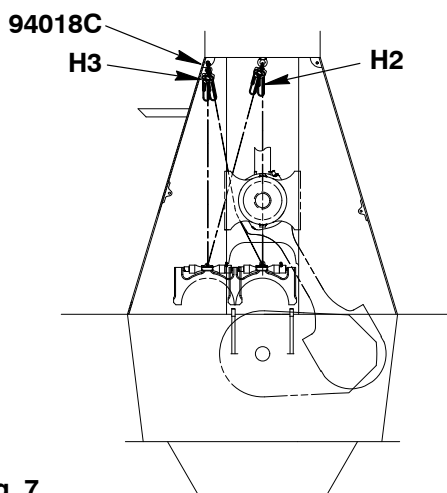


Fig. 7

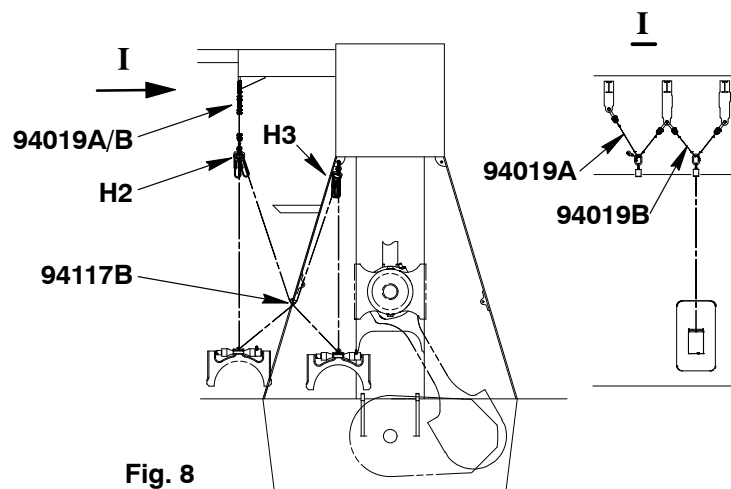


Fig. 8

2.2 Main Bearing Cover – Removal

- 1) Operate the manual ratchet (H1, Fig. 6) to lift the main bearing cover (4).

CAUTION	
	Damage Hazard: Use the roller support 94117 only as shown with a maximum angle of the manual ratchet chain at 45° and a force of 12 000 N.

- 2) Attach the chain block (H2) to the bearing cover. Apply tension to the chain block.
- 3) Remove the roller support (94117) and manual ratchet (H1).
- 4) Attach the chain block (H3, Fig. 7) to the column.
- 5) Move the bearing cover to the fuel side until it hangs vertically on the chain block (H3).
- 6) Remove the chain block (H2).
- 7) Attach the chain (94019A/B, Fig. 8) to the chain block H2. Continue to move the bearing cover to the fuel side.
- 8) Lower the bearing cover on to a wooden support on the bottom plate.
- 9) Apply protection to the bearing shell.

Main Bearing Removal and Installation

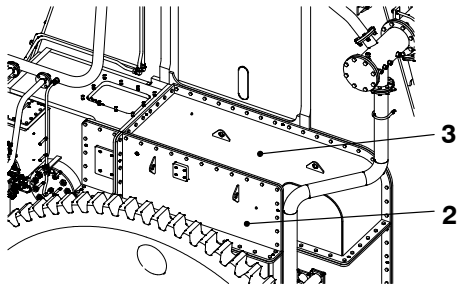


Fig. 9

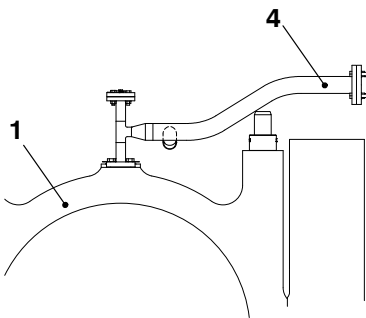


Fig. 10

3. Main Bearing Cover No. 1 – Removal

1) Remove the covers (2 and 3, Fig. 9).

2) Remove the oil pipe (4, Fig. 10) from the main bearing cover (1).

3) Do a check of the bearing clearance, refer to 0330 1, [Top and Bottom End Bearings](#). Compare results.

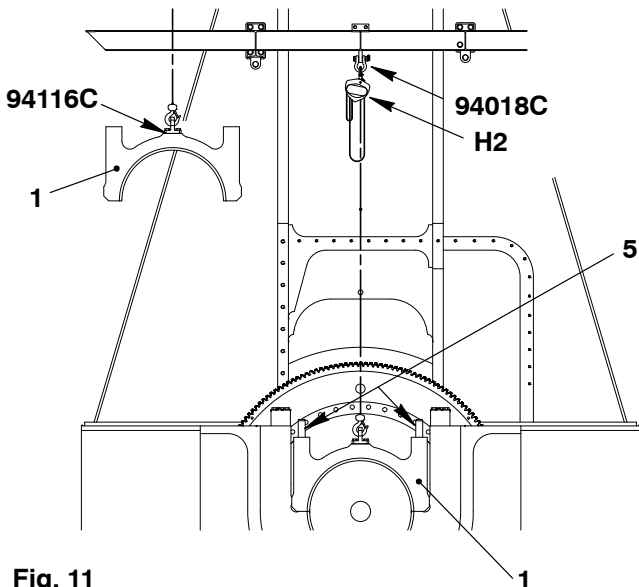


Fig. 11

4) Apply tension to the elastic studs (5, Fig. 11), refer to [1132 1](#)

5) Remove the round nuts.

6) Attach the lug (94116C) to the main bearing cover (1).

7) Attach the shackle (94018C) to the column.

8) Attach the chain block (H2) to the shackle (94018C) and the bearing cover (1).

9) Operate the chain block (H2) to lift the bearing cover (1).

10) Attach the engine room crane to the bearing cover (1).

11) Remove the chain block (H2).

12) Operate the engine room crane to move the bearing cover (1) to an applicable area.

4. Main Bearing Shell – Removal

4.1 Hydraulic Jacks – Installation

WARNING



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

CAUTION



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

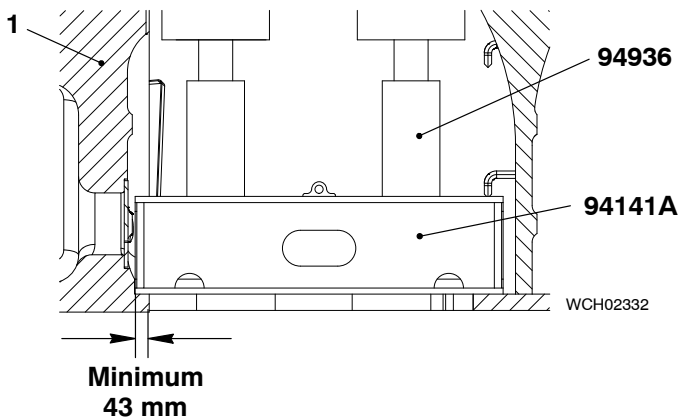


Fig. 12

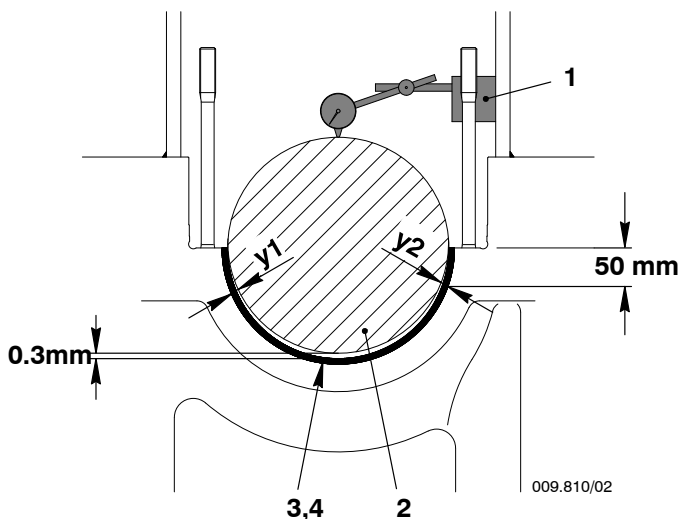


Fig. 13

- 1) Remove the work platform (94143).
- 2) If necessary, operate the turning gear to turn the crank to approximately 90° after TDC.
- 3) Put the bracket (94141A, Fig.12) on the two main bearing girders (1) as shown.
- 4) Make sure that the bracket is a minimum of 43 mm from the thrust bearing side.
- 5) Put the hydraulic rams (94936) on the bracket (94141A).
- 6) Connect the hydraulic rams (94936) to the HP oil pump (94931), refer to 9403 2.


4.2 Crankshaft – Lift

- 1) Record the values of the lateral clearances (y_1 and y_2 , Fig.13) between the crankshaft (2) and the bottom main bearing shell (3,4) at approximately 50 mm below the bearing.
- 2) Install the dial gauge (1) above the crankshaft (2) as shown
- 3) Set the dial gauge (1) to zero.
- 4) Operate the HP oil pump (94931) to lift the crankshaft (2) to 0.3 mm.
- 5) Make sure that the value on the dial gauge is 0.3 mm.
- 6) Make sure that there is no clearance between the adjacent bearing cover and the crankshaft.
- 7) Keep the pressure constant.
- 8) Measure the lateral bearing clearances y_1 and y_2 . Compare these values with the values recorded in step 1).

Main Bearing Removal and Installation

- 9) If the value of the lateral bearing clearance is more than 0.1 mm, lower the crankshaft and do step a) to step b):
 - a) Install the hydraulic rams (94936, Fig.13) in a position where the lateral bearing clearance is smaller.
 - b) Operate the HP oil pump (94931) to lift the crankshaft (1) to 0.3 mm.

4.3 Bearing Shell No.1 (narrow) – Removal

CAUTION	
	<p>Damage Hazard: During this procedure, use only the applicable tools. Do not attach external installations. Do not use the thrust device (94110) for removal. Damage to equipment can occur.</p>

Note: The bearing cover and the top main bearing shell are removed.

Note: The crank is at the exhaust side at TDC.

- 1) Make sure that the crankshaft is lifted to 0.3 mm, refer to paragraph 4.1 and 4.2.
- 2) Attach the chain block (H2, Fig. 14) to the eye bolt on the platform.
- 3) Remove the Allen screws (1) from the bearing girder.
- 4) Attach the chain block (H2) to the middle hole of the lifting plate (94119).
- 5) Attach the tool (94118A) to the bottom main bearing shell (3).
- 6) 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.

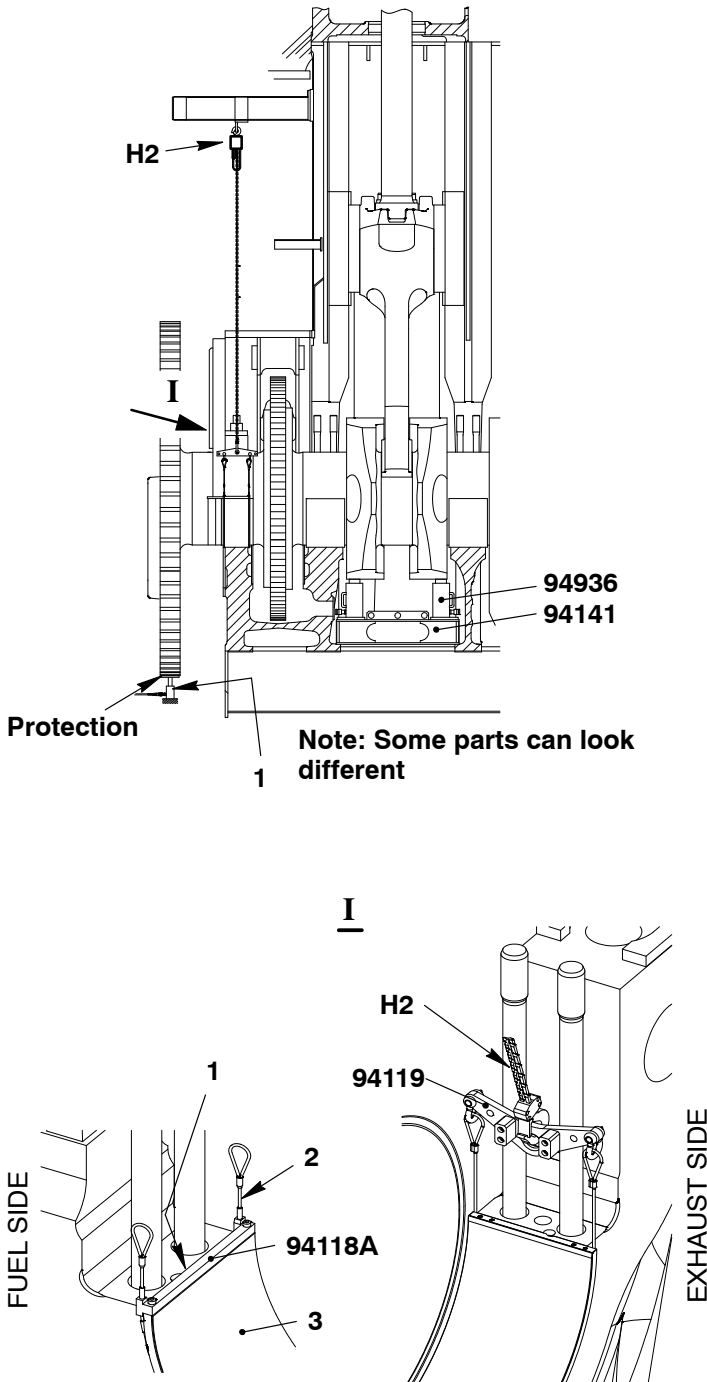


Fig. 14

Main Bearing Removal and Installation

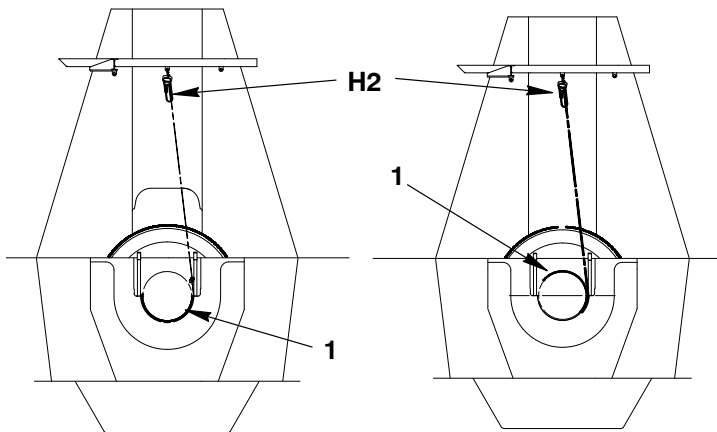


Fig. 15

- 7) Operate the chain block (H2, Fig. 15) to turn the bearing shell (1) as shown in Fig. 18 and Fig. 19.

Note: If the bearing shell (1) does not move, the lifting plate (94119, Fig. 16) must be attached to the other side of the dismantling tool (94118A). The bearing shell must be moved back to its initial condition and you must do the removal procedure again.

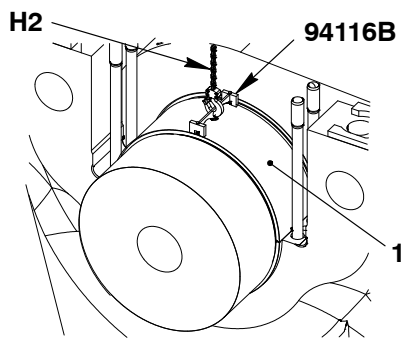


Fig. 16

- 8) Remove the bearing shell (1, Fig. 16) as shown in Fig. 17.
 9) Remove the device (94118A).
 10) Install the lifting tool (94116B) to the bearing shell (1).
 11) Remove the chain block (H2) from the lifting plate (94119).
 12) Attach the chain block (H2) to the lifting tool (94116B).
 13) Remove the lifting plate (94119).

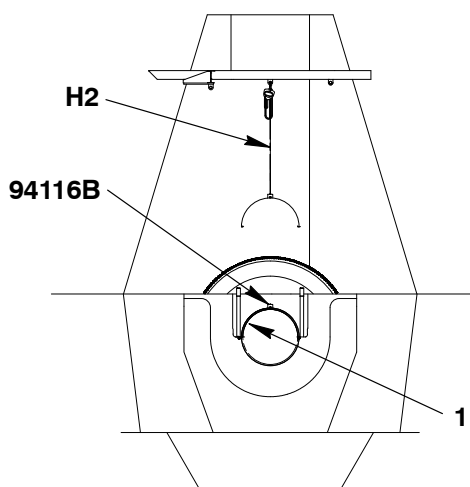


Fig. 17

- 14) Operate the chain block (H2) to lift the bearing shell (1).
 15) Move the bearing shell (1) to an area where you can operate the engine room crane.
 16) Attach the engine room crane to the bearing shell.
 17) Remove the spur-gear chain block (H2).
 18) Operate the engine room crane to move the bearing shell to a safe area.

Main Bearing Removal and Installation

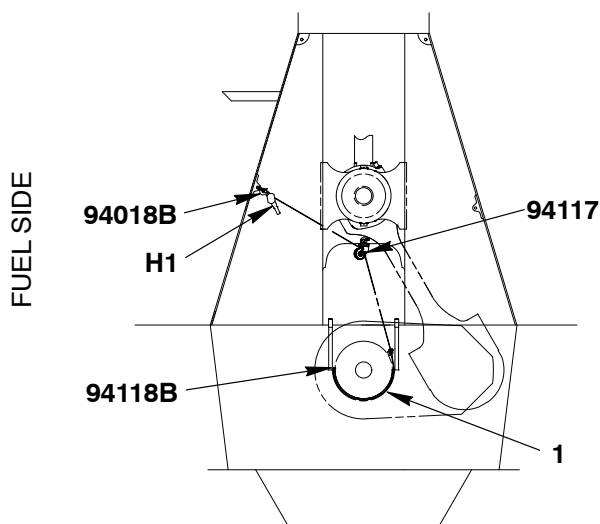
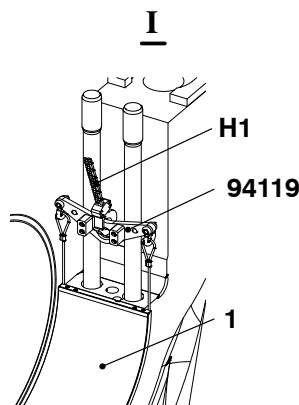
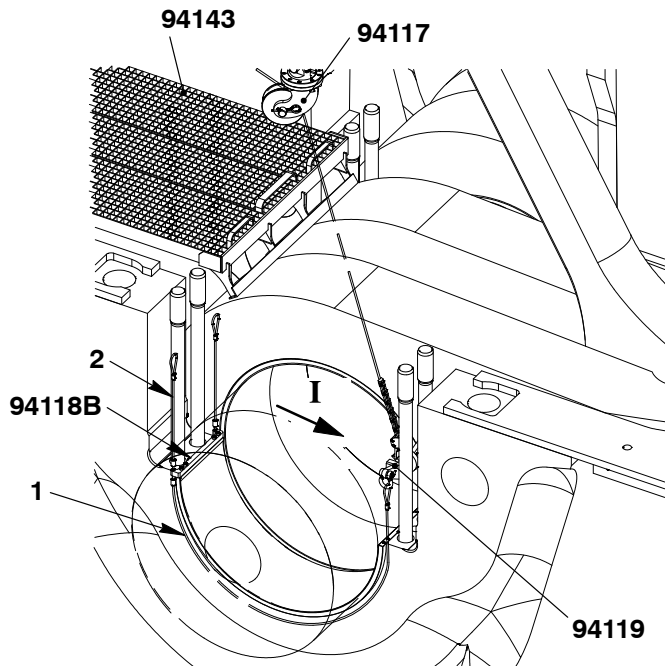


Fig. 18

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

CAUTION	
	<p>Damage Hazard: During this procedure, use only the applicable tools. Do not attach external installations. Do not use the thrust device 94110 for removal. Damage to equipment can occur.</p>

Note: The bearing cover and the top main bearing shell are removed.

Note: The crank is at the exhaust side.

- 1) Attach the work platform (94143, Fig. 18).
- 2) Make sure that the crankshaft is lifted to 0.3 mm, refer to paragraph 4.1 and 4.2.

Note: The two Allen screws from the top bearing shell must be removed.

- 3) Attach the manual ratchet (H1) to the shackle (94018B).
- 4) Attach the tool (94118B) to the bottom main bearing shell (1).
- 5) Put the ropes (2) along the lateral edges of the main bearing shell (1) to the other side and attach them to the lifting plate (94119).
- 6) Attach the roller support (94117) to the column.
- 7) Use the dowel pin to lock the roller support (94117) in position .
- 8) Put the chain of the manual ratchet (H1) through the roller support (94117).
- 9) Attach the chain of manual ratchet (H1) to the lifting plate (94119).
- 10) Make sure the the chain of the manual ratchet (H1) is in the middle of the lifting plate (94119).

Main Bearing Removal and Installation

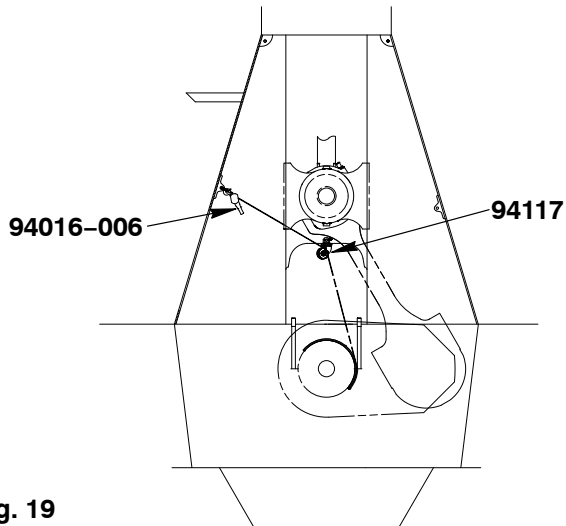


Fig. 19

- 11) Operate the manual ratchet (H1, Fig. 19) to move the bottom bearing shell until the chain hook is adjacent to the roller support (94117).

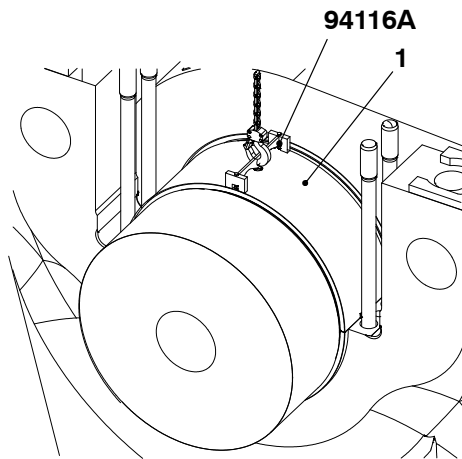


Fig. 20

- 12) Attach the lifting tool (94116A) to the bearing shell (1, Fig. 20).
- 13) Attach the manual ratchet (H1) to the middle of the lifting tool (94116A).
- 14) Remove the tool (94118B) and the lifting plate (94119).

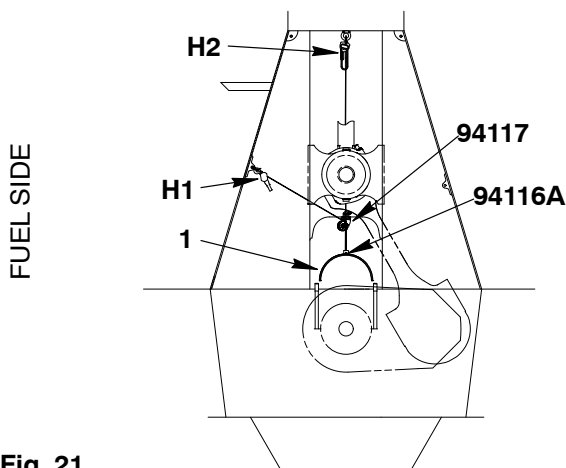


Fig. 21

- 15) Operate the manual ratchet (H1, Fig. 21) and the lifting tool (94116A) to lift the bearing shell (1).
- 16) Attach the chain block (H2) to the lifting tool (94116A).
- 17) Remove the roller support (94117) and the manual ratchet (H1).

Main Bearing Removal and Installation

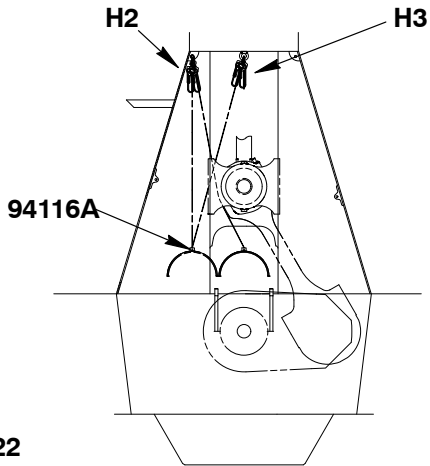
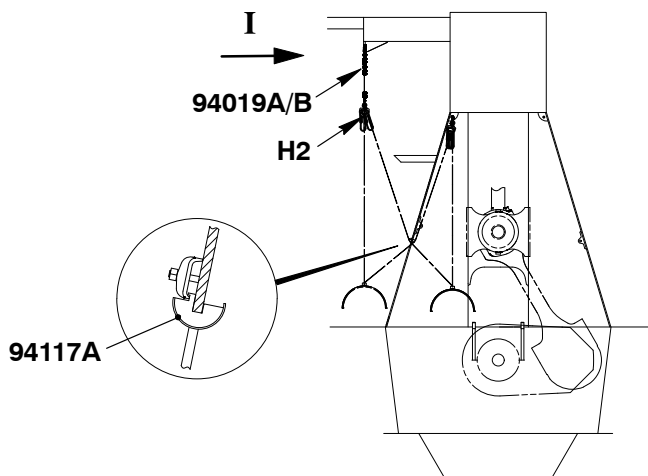


Fig. 22

- 18) Attach the chain block (H3, Fig. 22) to the gallery and the lifting tool (94116A)
- 19) Operate the chain blocks (H2, H3) to move the bearing shell to the fuel side as shown.



- 20) Attach the deviation pipe (94117A, Fig. 23) to the column.
- 21) Attach the chains (94019A/B) to the gallery as shown.
- 22) Attach the chains (94019A and 94019B) to the chain block (H2)
- 23) Use the chain and the chain block (H2) to move the bearing shell to the fuel side as shown.
- 24) Put the bearing shell on to wooden support on the bottom plate.

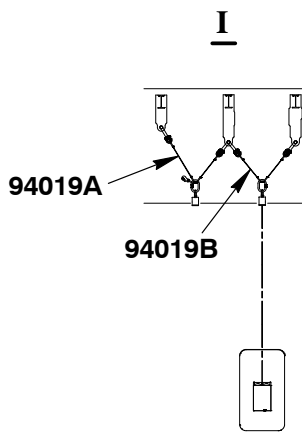




Fig. 23

5. Main Bearing Shell – Inspection

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

- 1) Use a soft cloth to clean the bearing shell.
- 2) Do a check of the bearing shell for damage eg breakouts or cracks.
- 3) Use Scotchbrite™ to remove light scratches and running marks.
- 4) If the running marks are not symmetrical (axial or radial), speak to, or send a message to WinGD.
- 5) Replace the bearing shells if necessary.
- 6) Do an inspection of the surface of the bearing pin. If necessary, repair the surfaces that have scratches.

6. Main Bearing Shell and Bearing Cover – Installation

CAUTION	
	Damage Hazard: Use only the applicable tools for installation. The sizes of the bearing shells are different (narrow and wide).

The bearing cover and bearing shell have the marks DRIVING END and must be installed in the bearing girder in their initial positions.

Before installation, make sure that the items that follow are clean and in good condition:

- All tools
- The crankshaft pin
- The girder bore for the bearing shell
- Bearing shells.

6.1 Bearing Shell – Installation

- 1) Apply a very thin layer of Molykote paste G to the rear face of the bottom bearing shell, before each installation.
- 2) Make sure that the crankshaft pin and the running surface of the bearing shell are clean and fully lubricated with clean engine oil.

Note: The bearing shells have different dimensions. For bearing shell No. 1, use the tool (94118B) and the lifting plate (94119). For bearing shells No. 2 to No 8 use the tool (94119C) and the lifting plate (94119A).

- 3) Attach 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) Use the applicable equipment as follows:
 - For the bearing shell No.1, use the engine room crane and the spur-gear chain block to lower the bearing shell in position on to the crankshaft.
 - For the bearing shells No.2 to No. 8, use the chain blocks (H2, H3), the roller support (94117A) and the manual ratchet (H1) to lower the the bearing shell in position on to the crankshaft.
- 6) Put the ropes of the device (94118A/B) below the crankshaft pin and connect them to the lifting plate (94119).
- 7) Remove the lifting tool (94116A/B).

Main Bearing Removal and Installation

Note: To prevent bearing shell movement into the bearing girder, hold the bearing shell and move it slowly into the bearing girder (on fuel side) at the rope ends.

- 8) Carefully move the bearing shell into the bearing girder (on the fuel side).
- 9) Carefully put the Allen screws into the bearing shell.
- 10) Release the pressure of the HP oil pump (94931) to fully lower the crankshaft.
- 11) Remove the hydraulic rams (94936) and the HP oil pump (94931).

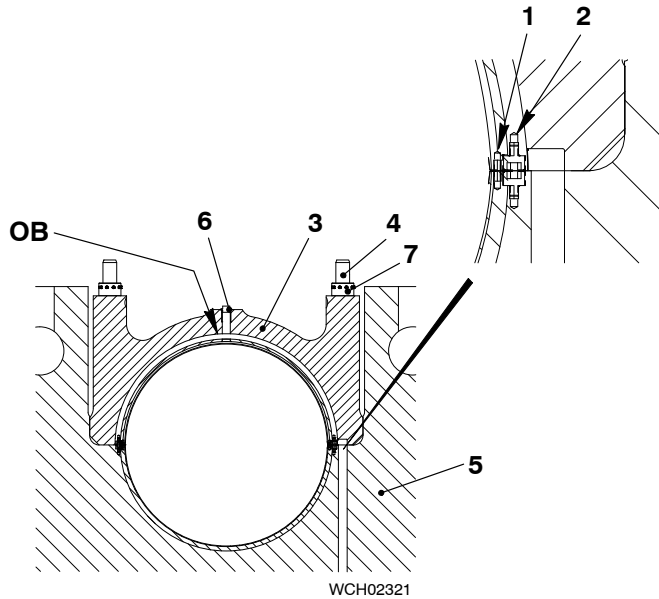


Fig. 24

6.2 Main Bearing Cover – Installation

- 1) Make sure that the work area and all tools and equipment are clean and in good condition.
- 2) Remove all plugs from the oil bore (OB).
- 3) Use the applicable equipment to get the bearing cover in the correct position above the crankshaft as follows:
 - For bearing covers No. 2 to No. 8 refer to paragraph 2.
 - For bearing cover No. 1, refer to paragraph 3).

Note: The top bearing shell is attached to the cover with two Allen screws (2, Fig. 24). The spring dowel pins (1) help to get the bearing cover (3) in position during the installation.

- 4) Clean all surfaces on the the bearing cover (3) and the bearing girder (5).
- 5) Lower the bearing cover (3) on to the bearing girder (5). Make sure that the two spring dowel pins engage correctly.
- 6) Apply tension to the elastic studs (4), refer to 1132 1.
- 7) Tighten the round nuts (7).
- 8) Clean the pipes (1, Fig. 25).
- 9) Install the pipes (1), their gaskets and new tab washers (4).
- 10) Tighten the screws (3).
- 11) Lock the screws (3) with the new tab washers (4).
- 12) Remove all tools and equipment from the work area.
- 13) Measure the bearing clearance and compare the value measured in paragraph 2, with the value given in the Clearance Table 0330 1, Group 3303.

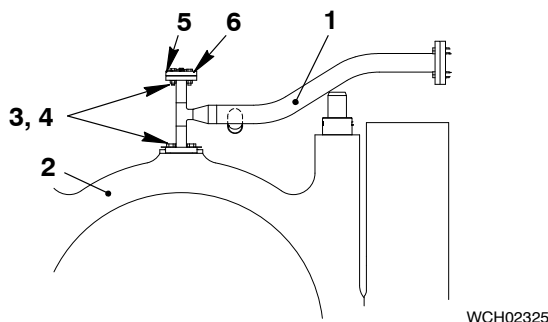


Fig. 25

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

- 14) After each installation of a new bearing shell, measure the crank deflection, refer to [3103 1](#).
- 15) Do a check of the oil supply to the main bearing.

7. Main Bearing – Lubrication

After an overhaul of the bearing shells, more lubricant can be added to prevent damage to the surface of the bearing shells.

- 1) To fill the bearing shell with the lubricant do the procedure that follows:
 - a) Remove the blank flange (6, [Fig. 25](#)).
 - b) Remove the screw plug (5).
 - c) Fill the bearing shell with the applicable lubricant.
 - d) Attach the blank flange (6) with the screw plug (5).

Thrust Bearing

Thrust Bearing – Axial Clearance Check

Tools:

- 1 Inside micrometer 94101

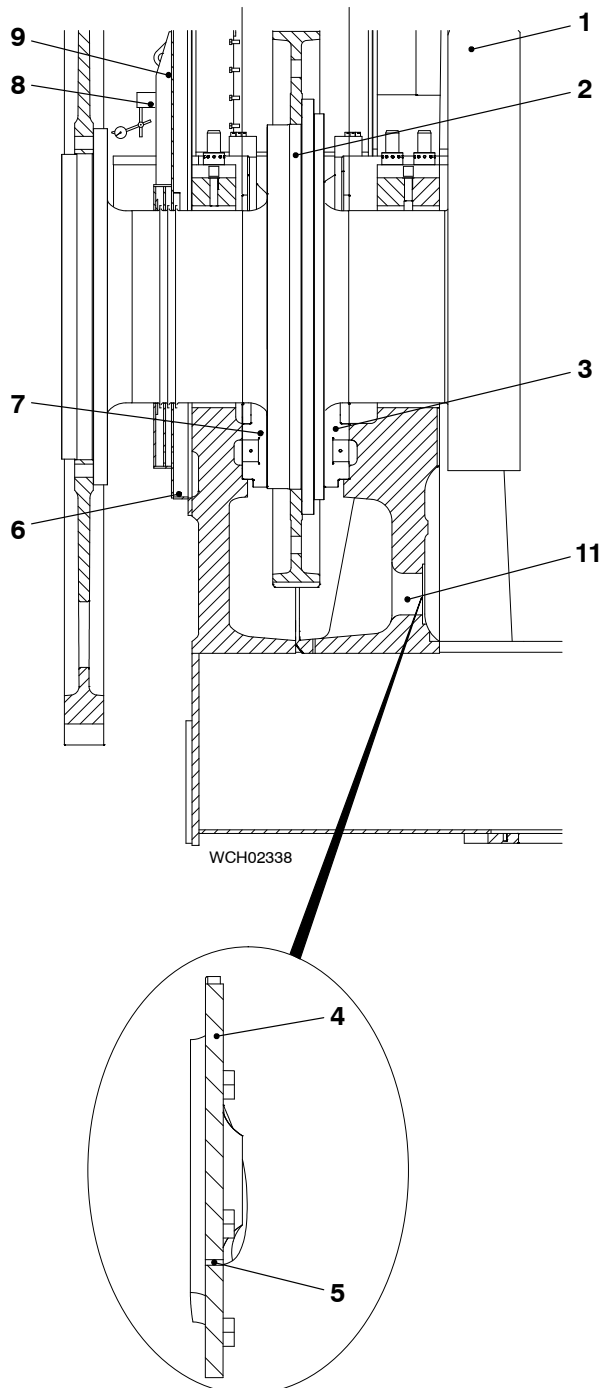


Fig. 1

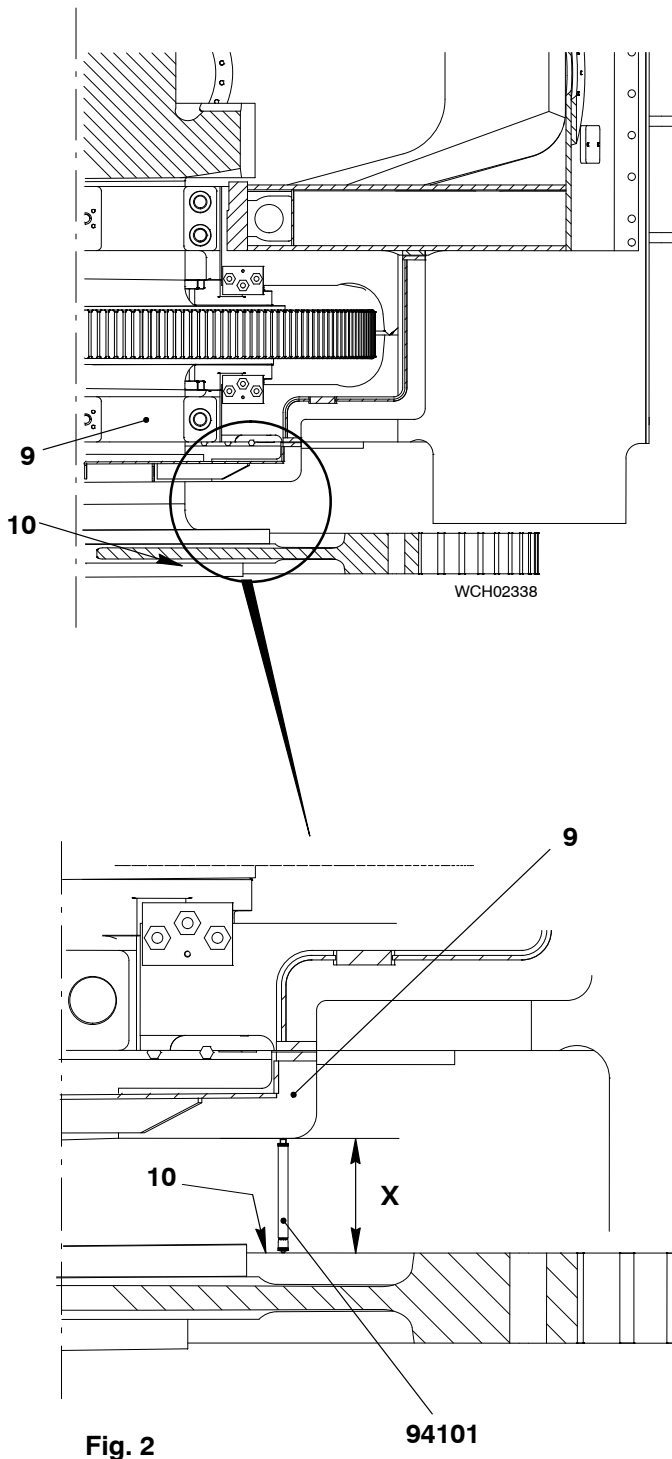
1. Procedure One

- 1) Start the engine in the direction AHEAD to move the crankshaft fully forward.
- 2) Stop the engine.
- 3) Put the dial gauge (8, Fig. 1) in position on the oil baffle (top part) (9) 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 (refer also to 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



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, Fig. 2) and the oil baffle (top part) (9).
- 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 (refer also to 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 worn 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).
- 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, Fig. 2) and the oil baffle (top part) (9).
- 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 (refer also to 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

Thrust Bearing

Thrust Bearing Pads Removal and Installation

Tools:

1 Manual ratchet	94016-006 (H3)		
2 Spur-geared chain block	94017-009 (H1, H2)	1 Carrier	94155
2 Eye bolt	94045-M12	1 Link	94321

1. Removal

- 1) Read the data in 0012 1 General Guidelines for Lifting Tools.
- 2) Remove the cover (2, Fig. 1) from the casing (1).
- 3) Record the positions of the thrust bearing pads.
- 4) Remove the three bolts (9) from the applicable arbor supports (3, 7).
- 5) Discard the locking plates (10).
- 6) On the engine side, remove the temperature sensors (8) from the applicable thrust pads.

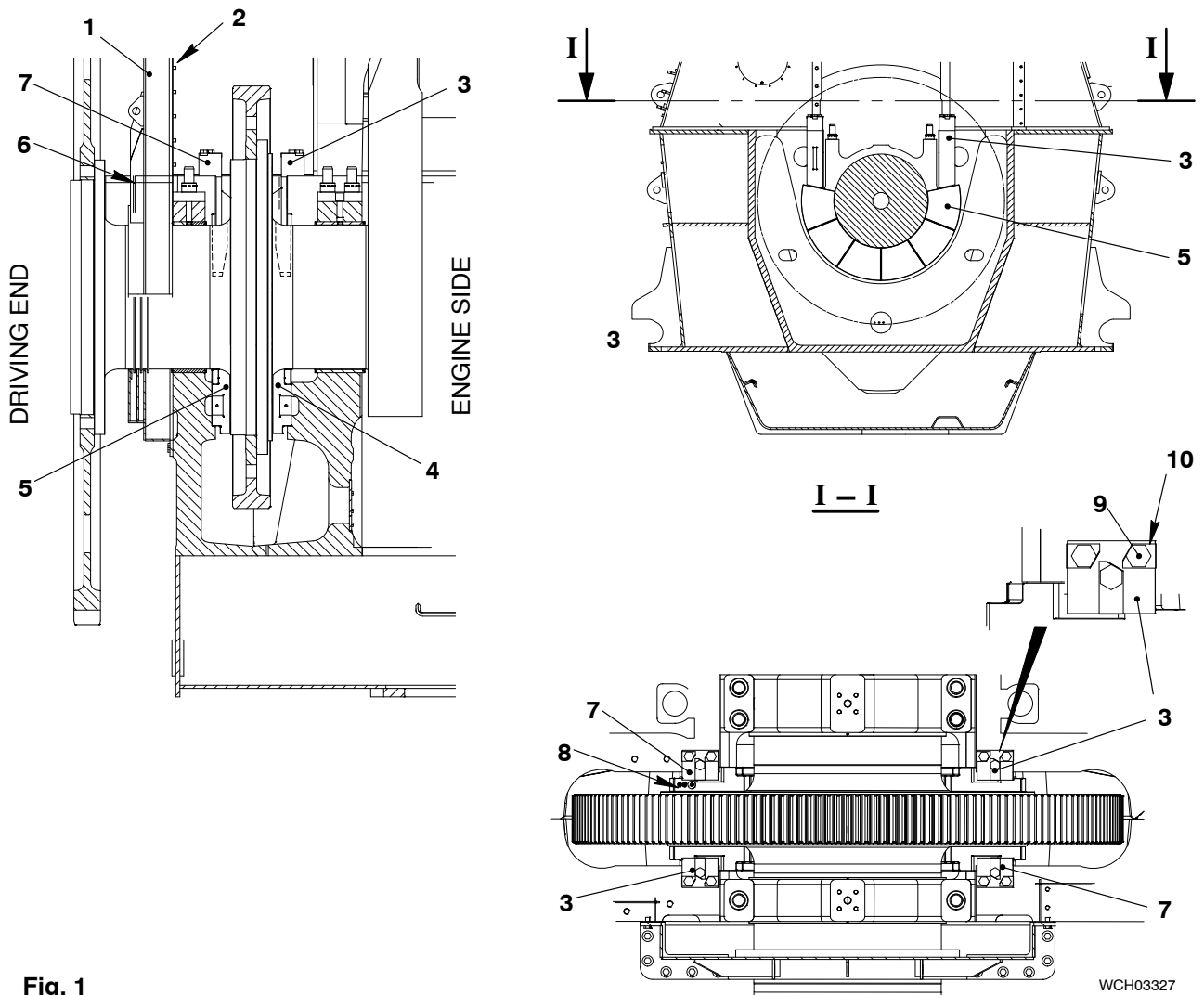


Fig. 1

WCH03327

Thrust Bearing Pads Removal and Installation

- 7) Attach the eye bolt (94045-M12, Fig. 2) to the arbor support (3 or 7).
- 8) Attach the chain blocks (H1 and H2) to the gallery.
- 9) Remove the applicable arbor supports (3 or 7).
- 10) Attach the chain blocks (H1, H2) to the link (94321).
- 11) Install the carrier (94155) on the gear wheel (12) as shown.

Note: Some parts can look different

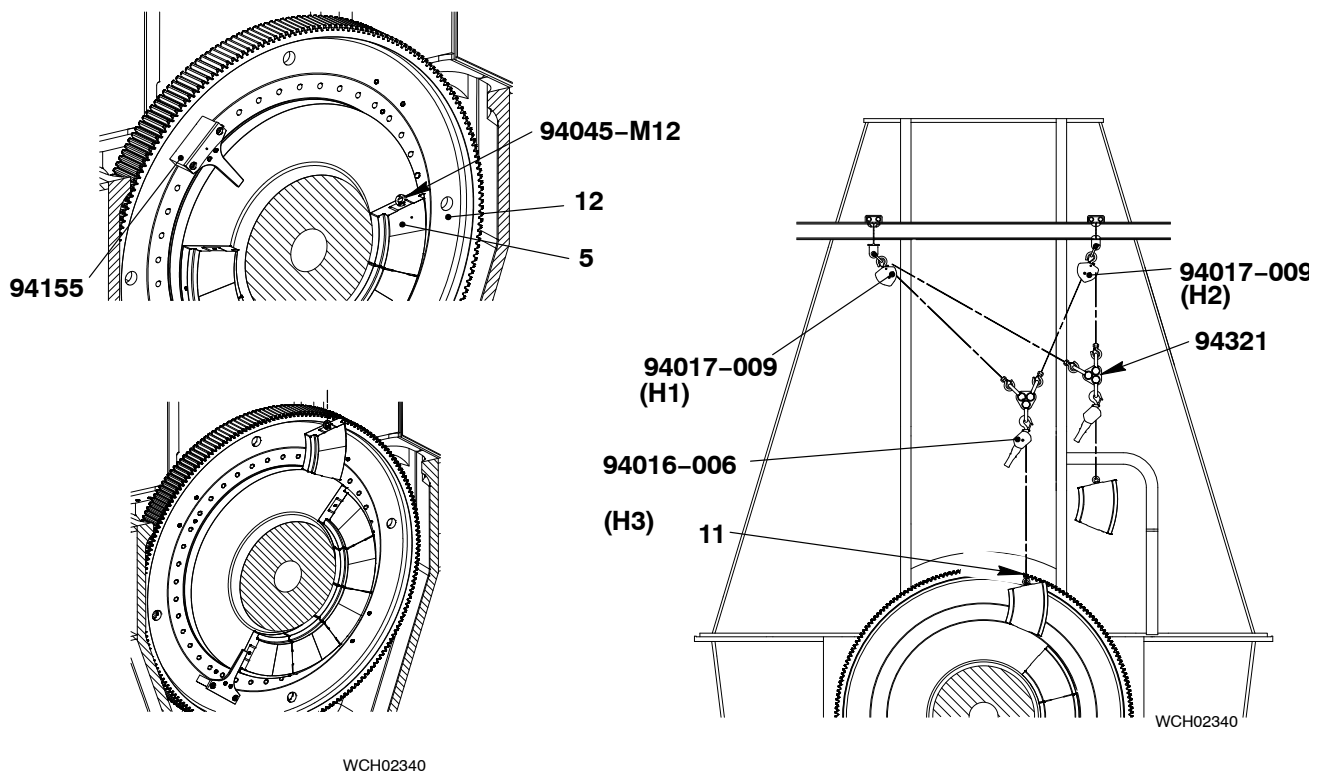
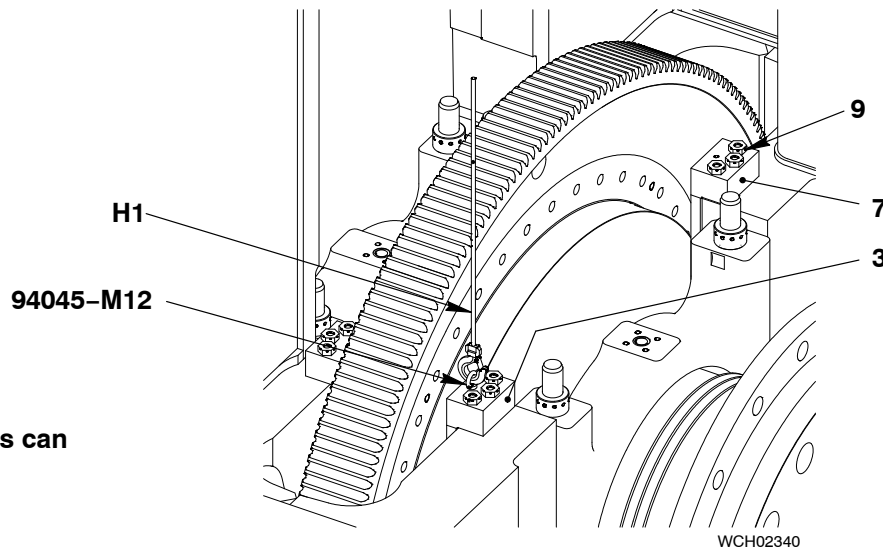


Fig. 2

Thrust Bearing Pads Removal and Installation

WARNING

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

12) Operate the turning gear to turn the crankshaft in the applicable direction.

Note: While the gear wheel (12, Fig. 2) turns, the carrier (94155) moves the thrust bearing pads. The first thrust bearing pad will come out.

13) Attach the eye bolt (94045-M12) to the thrust bearing pad (5).

14) Attach manual ratchet (H3) to the link (94321) and to the eye bolt (94045-M12).

15) Operate the manual ratchet (H3) to lift the thrust pad.

16) Move the thrust bearing pad to the exhaust side.

17) Lower the thrust bearing pad on to a stable area.

18) Do the procedure above for the remaining thrust bearing pads that you must remove.

Note: 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.

19) To prevent crankshaft movement, do as follows:

- a) Get a piece of hardwood that has the same dimensions as a thrust bearing pad.
- b) 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: The thrust bearing pads that you removed before, must be installed in the same positions. Use your recorded notes and refer to Fig. 3 for the correct positions.

3) If necessary, remove the piece of hardwood.

4) Attach the eye bolt (94045-M12) to the thrust bearing pad (5).

5) Operate the manual ratchet (H3) to lift the thrust bearing pad (5).

6) Put the first thrust bearing pad (5) in position. Make sure that the thrust bearing pad touches the carrier (94155).

7) Operate the turning gear to turn the crankshaft in the applicable direction.

8) Put the subsequent thrust bearing pad in position.

9) Do step 1) to step 7) for each thrust bearing pad.

10) On the engine side, install the temperature sensors (8, Fig. 1) to the applicable thrust pads.

Note: 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:

- a) Attach the eye bolt (94045-M12) to the applicable arbor support.
- b) Lift then lower the arbor support (3) into position.
- c) Remove the eye bolt (94045-M12) from the arbor support (3, 7).
- d) Put the three new locking plates (10) and bolts (9) in position on the arbor support (3, 7).
- e) Tighten the three bolts (9), then lock them with the new locking plates (10).

Thrust Bearing Pads Removal and Installation

- 13) Do a check of the clearances between the arbor supports and the thrust bearing pads (refer to 0330 1 Clearance Table, Crankshaft and thrust bearing).

Note: When you replace 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.

Note: 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 (refer to 0330-1 Clearance Table, **Crankshaft and Thrust Bearing** and 1203-1 Axial Clearance - Checks)

- 14) Install the cover (2, Fig. 1) to the casing (1).

- 15) Remove all tools and equipment the work area.

CONFIGURATION OF THRUST BEARING PADS WITH FIXED PITCH PROPELLER

CLOCKWISE ROTATING ENGINE

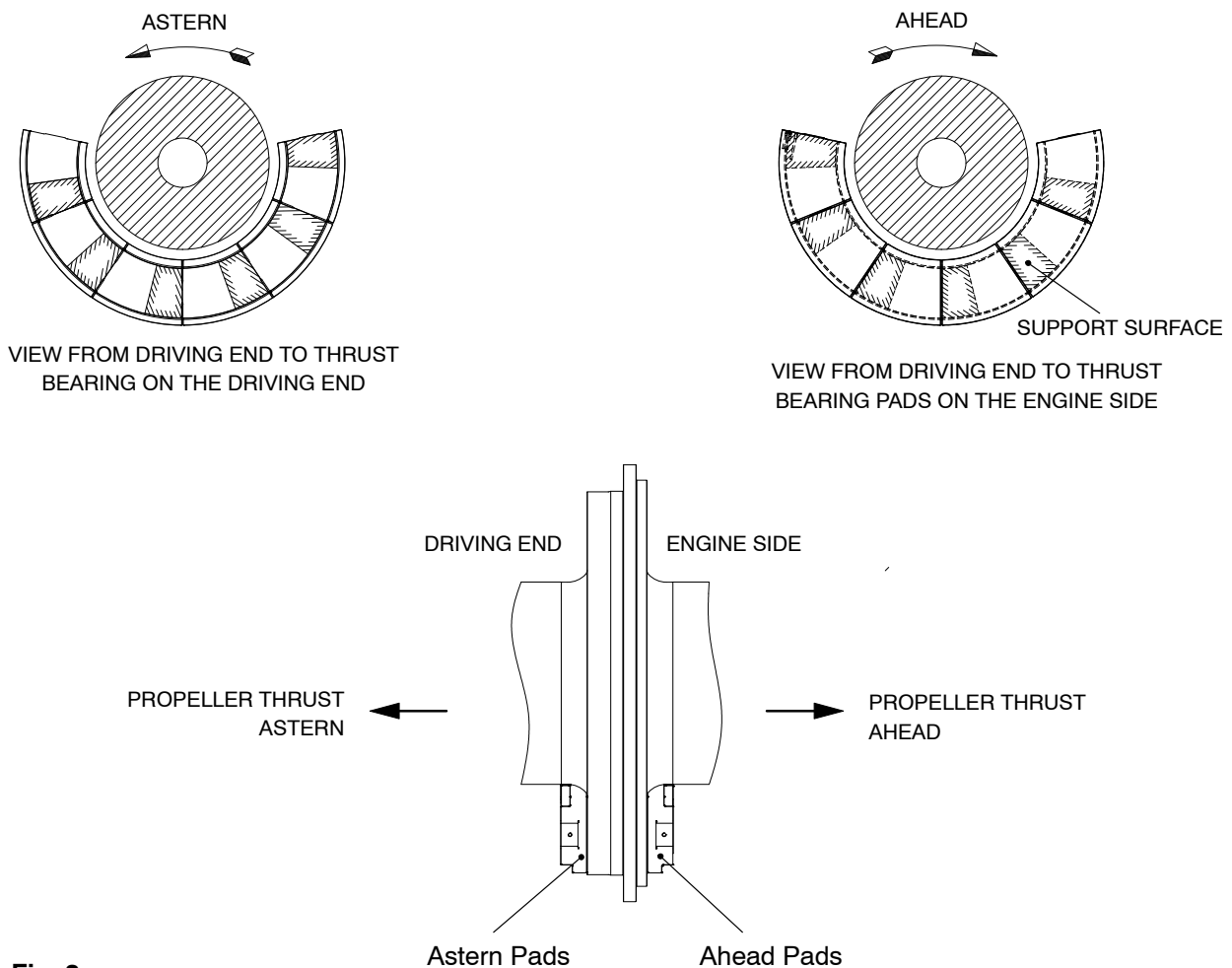


Fig. 3

Engine Stays with Friction Shims

Tension Checks

Tools:

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

1. General

The engine stays (1, Fig. 1) are related to the design of the ship. The engine stays are installed as follows:

- Two or four engine stays are installed on the exhaust side, or the fuel side.
- Two engine stays are installed at the free end.
- Two engine stays are installed at the driving end.

The engine stays have friction shims.

You must do a tension check of the bolts (2) at the specified intervals (refer to 0380 1, Engine stays with friction shims).

Note: To do the tension checks on the engine stays, you use the same jack (94145) as that used for the the foundation bolts. The nameplate has the stamp 1500 bar. The tension value for the engine stays is 170 bar only

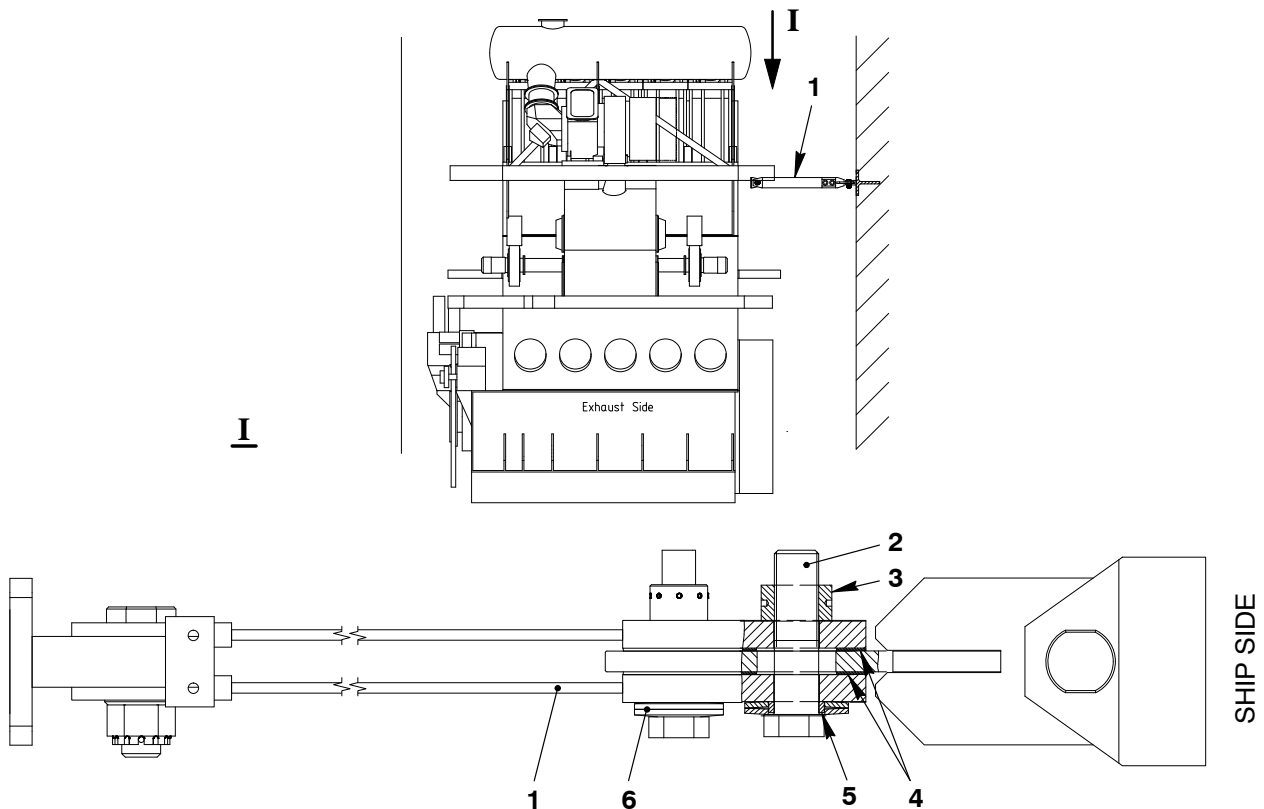


Fig. 1

Engine Stays with Friction Shims: Tension Checks

2. Tension Checks

- 1) Clean the threads of the bolts (2, Fig.1) and the seating surfaces.
- 2) Apply Molykote paste G to the threads of the bolts (2).
- 3) Refer to 9403 2 and 9403 4. Attach the pre-tensioner and the applicable equipment as shown in Fig. 2.
- 4) Apply a tension of 170 bar to the bolt (2).
- 5) Put the feeler gauge (94122) through the slot (7) to do a check for clearance between the nut and its seating. If there is no clearance, the bolt tension has not changed and you can do step a) and step b). If there is a clearance, do step 6).
 - a) Operate the vent screw (1) to release the pressure to zero.
 - b) Remove the tools and equipment.
- 6) If there is clearance, the tension of the bolt has changed since the last check and you must do step a) to step d) below:
 - a) Use a round bar (4) to tighten the nut (3).
 - b) Use the feeler gauge to make sure there is no clearance.
 - c) Operate the vent screw (1) to release the pressure to zero.
 - d) Remove the tools and equipment.

Note: The data to loosen the bolts is given in 9403-4.

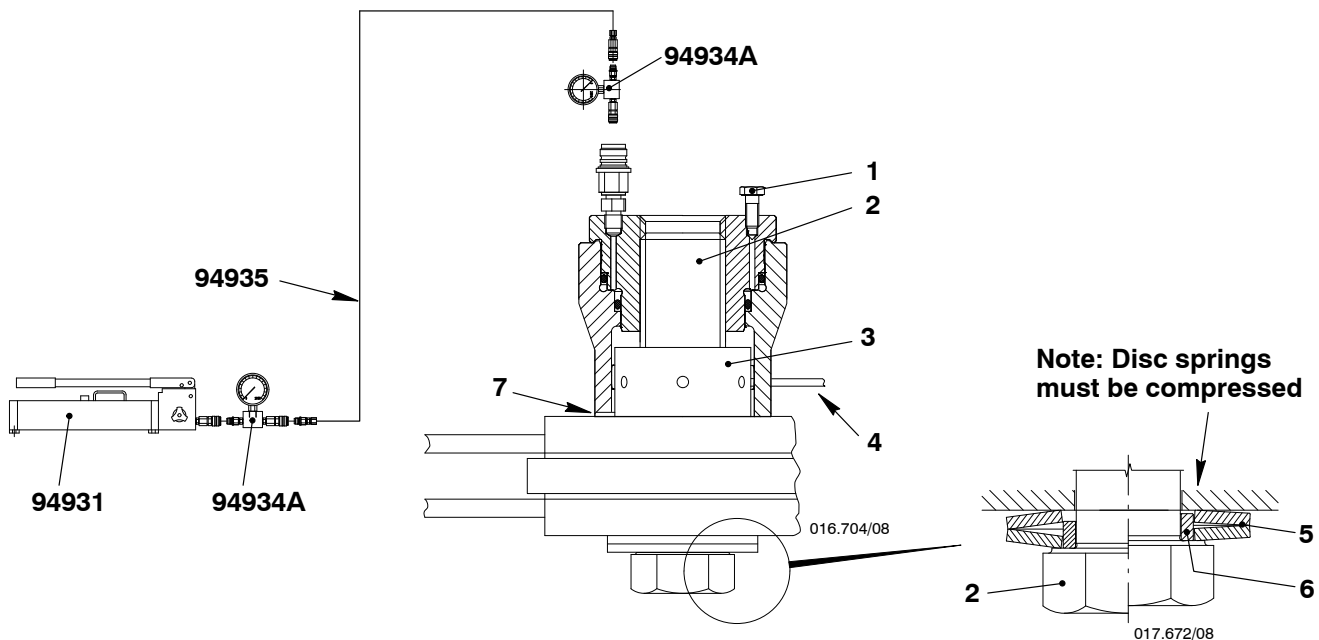


Fig. 2

- | | |
|--------------|---------------|
| 1 Vent screw | 5 Disc spring |
| 2 Bolt | 6 Ring |
| 3 Nut | 7 Slot |
| 4 Round bar | |

Oil Pressure Checks

1. General

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

Nitrogen gas in a bladder in the accumulator causes the vibration damping. The usual oil and gas pressure is 80 bar during operation.

You must do regular checks of the two opposite engine stays at the pressure gauges (3) to compare their values. The values must be the same if the vessel is level.

The faults that can cause a pressure decrease in a hydraulic cylinder are as follows:

- Defective O-rings
- Valves that have leaks
- Defective pipe connections
- Gas that goes out of the bladder accumulator.

2. Procedure

- 1) Do a check of the distance (X) to make sure that the engine is not tilted. The distance (X) must be zero before you do a check of the pressure gauges (7).
- 2) Do a check of the oil pressure values at the gauges (3). If the values of two opposite engines stays added together are less than 120 bar, do as follows:
 - a) Refer to the documentation of the manufacturer, then do step b) to step e).
 - b) Decrease fully the oil pressure.
 - c) Fill the accumulator with nitrogen to a pressure of 40 bar.
 - d) Make sure that the pressure stays constant. If not, there is a leak in the gas system.
 - e) Increase the oil pressure to 80 bar.
 - f) Make sure that the pressure stays constant. If the pressure does not stay constant, change the piston seals.
 - g) Make sure that the values on the pressure gauges are the same as the opposite engine stay.

Oil Pressure Checks

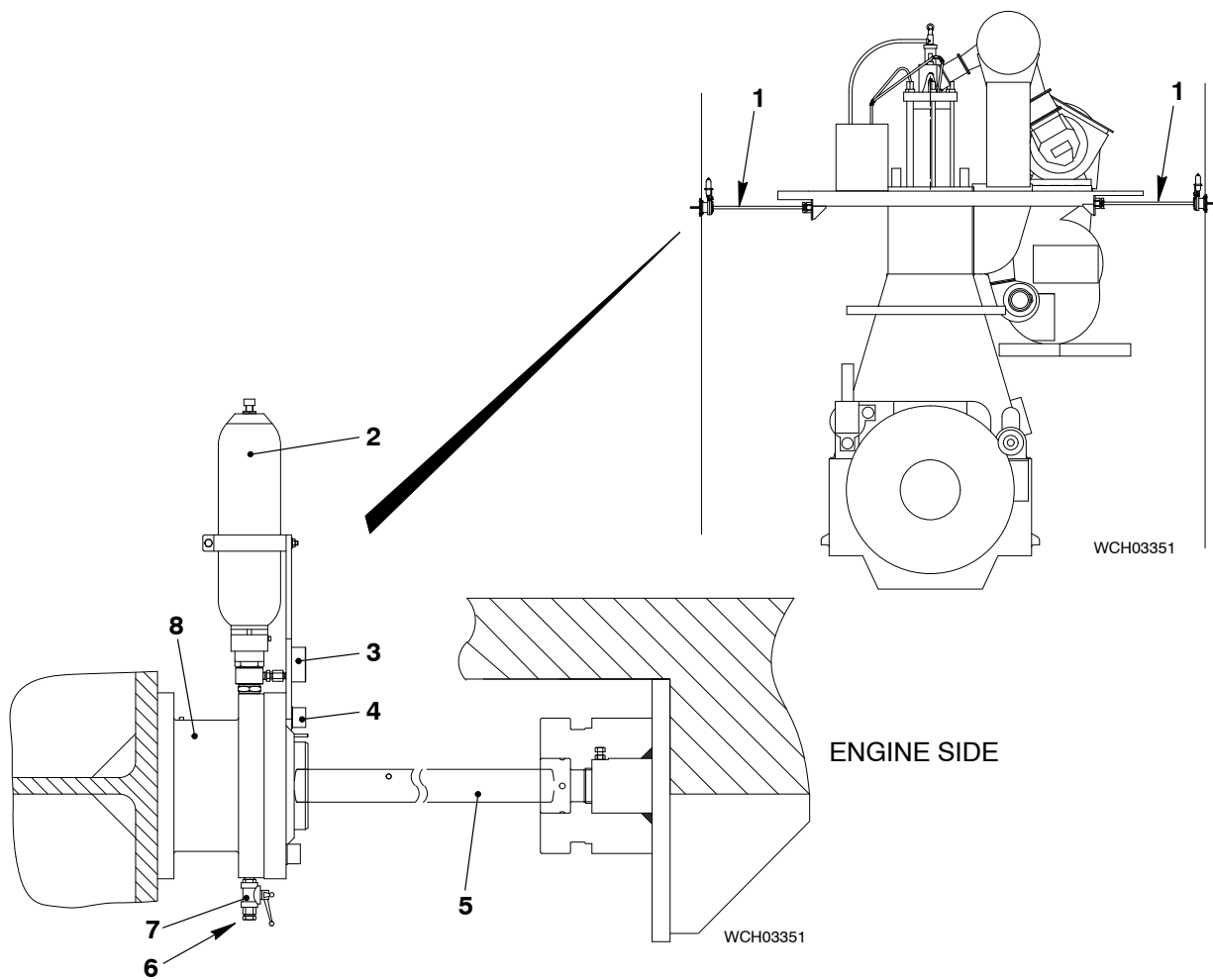


Fig. 1

Fig. 1 Key

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

Pre-tension Checks and Tie Rod 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 that you do a check of the tension of all the tie rods one year after commissioning. If necessary, apply tension to the tie rods to the specified value. Do the pre-tension checks at the intervals given in 0380 1 Maintenance Schedule, [Group 1903 1](#).

2. Pre-tension Check

- 1) Remove the cover (1, [Fig. 1](#)) from all tie rods (2).
- 2) Clean the surfaces of the intermediate rings (4).

Note: Start with the tie rods in the middle of the engine a-a, then b-b etc).

- 3) Attach the two pre-tensioning jacks (94180) to the two tie rods (2, a-a) refer to [9403 4](#).
- 4) Apply 1500 bar to the tie rods (2).
- 5) Tighten the round nuts (3) if possible.
- 6) If the round nut (3) will not move, do as follows:
 - a) Put a brass or copper bar through the slot in the jack and into a hole in the round nut.
 - b) Use a hammer to loosen, then tighten the nut. Make sure that the edge of the hole has no deformation.
- 7) Remove the pre-tensioning jacks, refer to [9304 4](#).
- 8) Apply a layer of Molykote paste G to the threads of the tie rod (2) to prevent corrosion.
- 9) Install the protection cover (1).
- 10) Do step 1) to step 9) for the remaining tie rods.

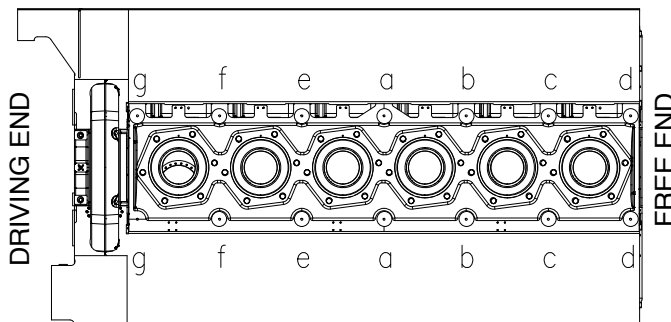
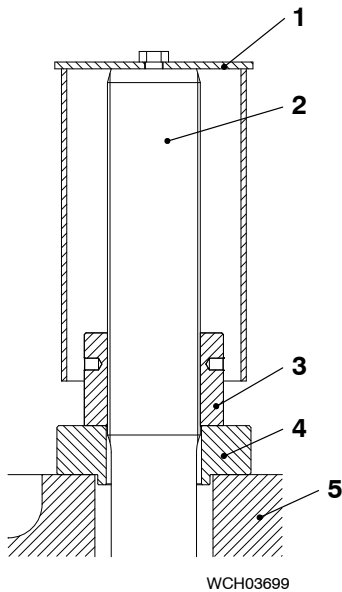


Fig. 1

WCH03699

Pre-tension Checks and Tie Rod Replacement

3. Tie Rods – Replacement

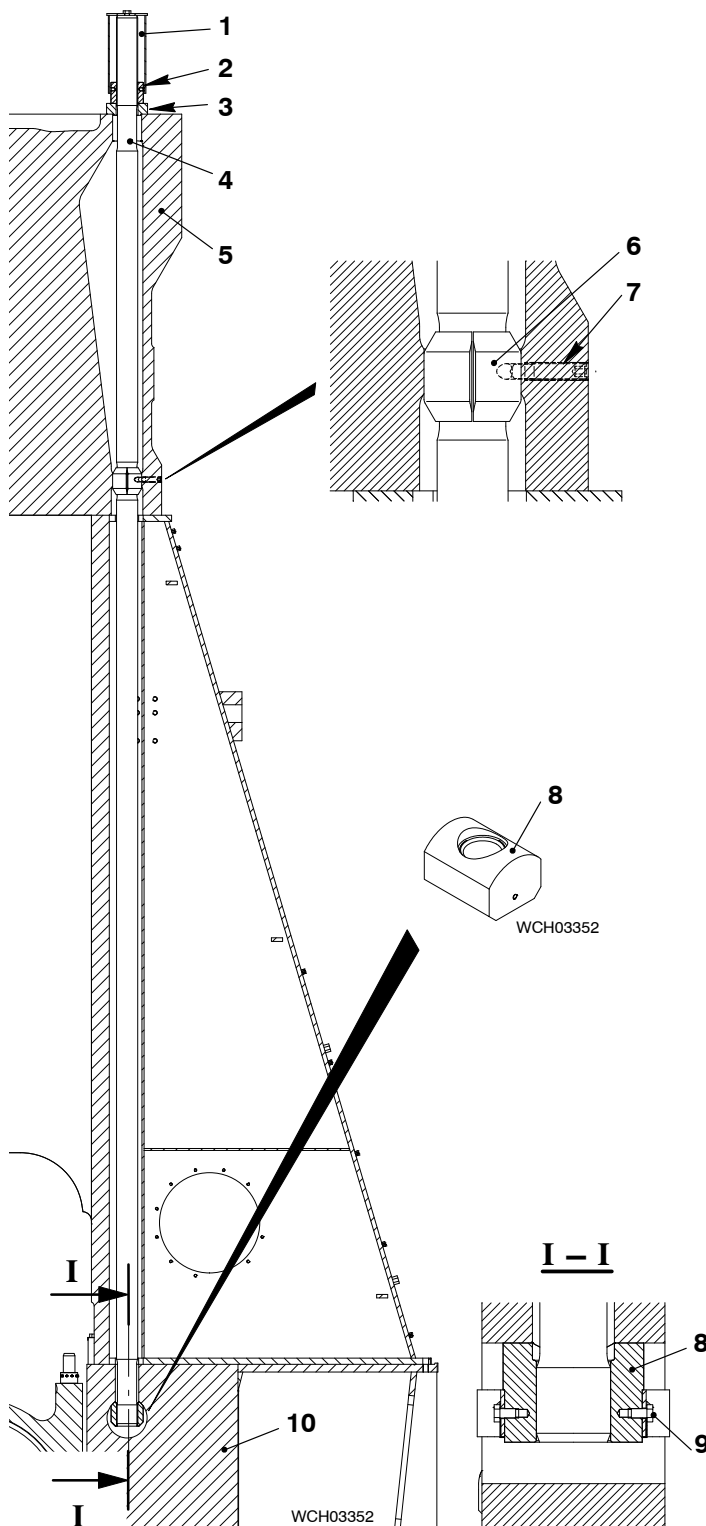


Fig. 2

- 12) Attach the round nut (2) to the tie rod (4).
- 13) Lift the tie rod (4), then fully tighten the round nut (2).
- 14) Make sure that the nut (8) is fully up, then install the holders (9).

Note: The tie rod at the first cylinder (driving end) has only one holder (9).

- 15) Apply tension to the tie rods (4), refer to paragraph 3.4.

3.1 Preparation

- 1) Remove the cover (1, Fig. 2) from all tie rods.
- 2) Clean the surface of the intermediate ring (3).
- 3) Refer to 9403 4, then attach the two pre-tensioning jacks (94180) to two tie rods (4) that are opposite each other (eg a a), see Fig. 1.
- 4) Loosen the round nuts (2), refer to 9403 4.

3.2 Removal

- 1) Remove the set screws (7).
- 2) Use two round nuts screwed together to loosen the tie rod (4).
- 3) Attach the eye bolt (M20) to the tie rod (4).

CAUTION

Injury Hazard: The weight of the tie rod is approximately 352 kg. Use the correct equipment for removal.

- 4) Attach the engine room crane to the eye bolt.
- 5) Lift the tie rod (4) fully from the cylinder jacket (5).

3.3 Install

- 1) Remove the two holders (9).
- 2) Make sure the nut (8) is correctly attached.
- 3) Apply Molykote G paste to the bottom thread of the tie rod (4).
- 4) Attach the eye bolt (M20) to the tie rod (4).
- 5) Attach the engine room crane to the eye bolt (M20).
- 6) Make sure that the bush (6) is installed.
- 7) Lower the tie rod (4) into the bearing girder (10).
- 8) Turn the tie rod (4) until the bottom is flush with the nut (8).
- 9) Clean the top surfaces of the cylinder jacket (5).
- 10) Install the intermediate ring (3).
- 11) Apply Molykote paste G to the top thread of the tie rod and the top surface of intermediate ring (3).

Pre-tension Checks and Tie Rod Replacement

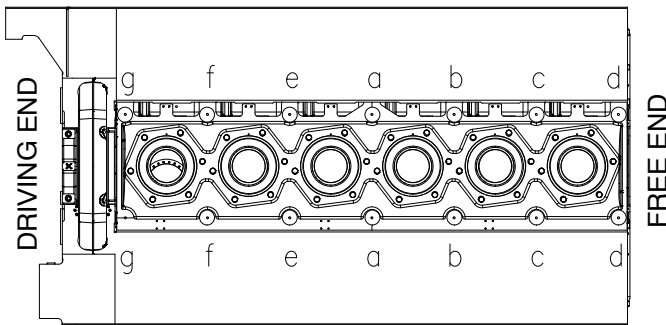
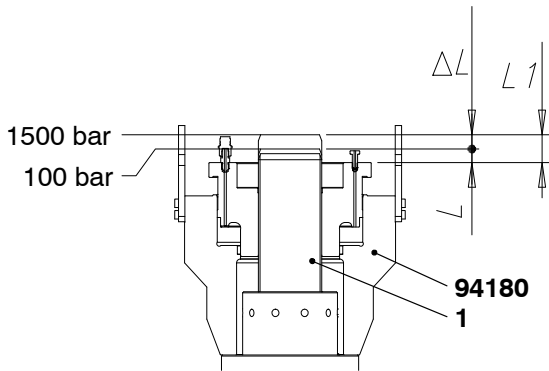


Fig. 3

WCH03699

3.4 Apply Tension

Note: Start with the tie rods in the middle of the engine (a-a), then (b-b) etc.

- 1) Put the two pre-tensioning jacks (94180, Fig. 3) on the tie rods (1).
- 2) Apply a tension of 100 bar, refer to 9403 4.
- 3) Record the length of the tie rods (1) at L.
- 4) Apply a tension of 1500 bar.
- 5) Record the extension of the tie rod (1) at L1.

Note: The extension ΔL of the tie rod (1) must be 12 mm to 14 mm ($L1 - L$).

- 6) Do step 1) to step 5) for the remaining tie rods.
- 7) Tighten the set screws (7, Fig. 2)
- 8) Apply a layer of Molykote paste G to prevent corrosion.
- 9) Install the covers (1) to the tie rods.

Cylinder Liner and Cylinder Cover

Group 2

Cylinder Liner

Measuring Bore Wear	2124	1/A1
Removal and Installation	2124	2/A1
Removing the Wear Ridge, Dress Lubricating Grooves and Scavenge Ports	2124	3/A1

Lubricating Quill: Removal and Installation	2138	1/A2
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Piston Rod Gland: Remove, Disassemble, Measure Worn Parts, Assemble, Install	2303	1/A1
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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
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Injection Valve: Installation (Injection Valve with FAST) ..	2722	2/A1
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Starting Air Valve: Removal, Disassemble, Grinding, Assemble, Installation	2728	1/A1
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Relief Valve on Cylinder Cover: Blow-off Pressure Check	2745	1/A1
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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

Cylinder Liner

Measure the Bore

Tools:

- | | | |
|---|-------------------|-------|
| 1 | Inside micrometer | 94101 |
| 1 | Ladder | 94224 |
| 1 | Gauge | 94225 |

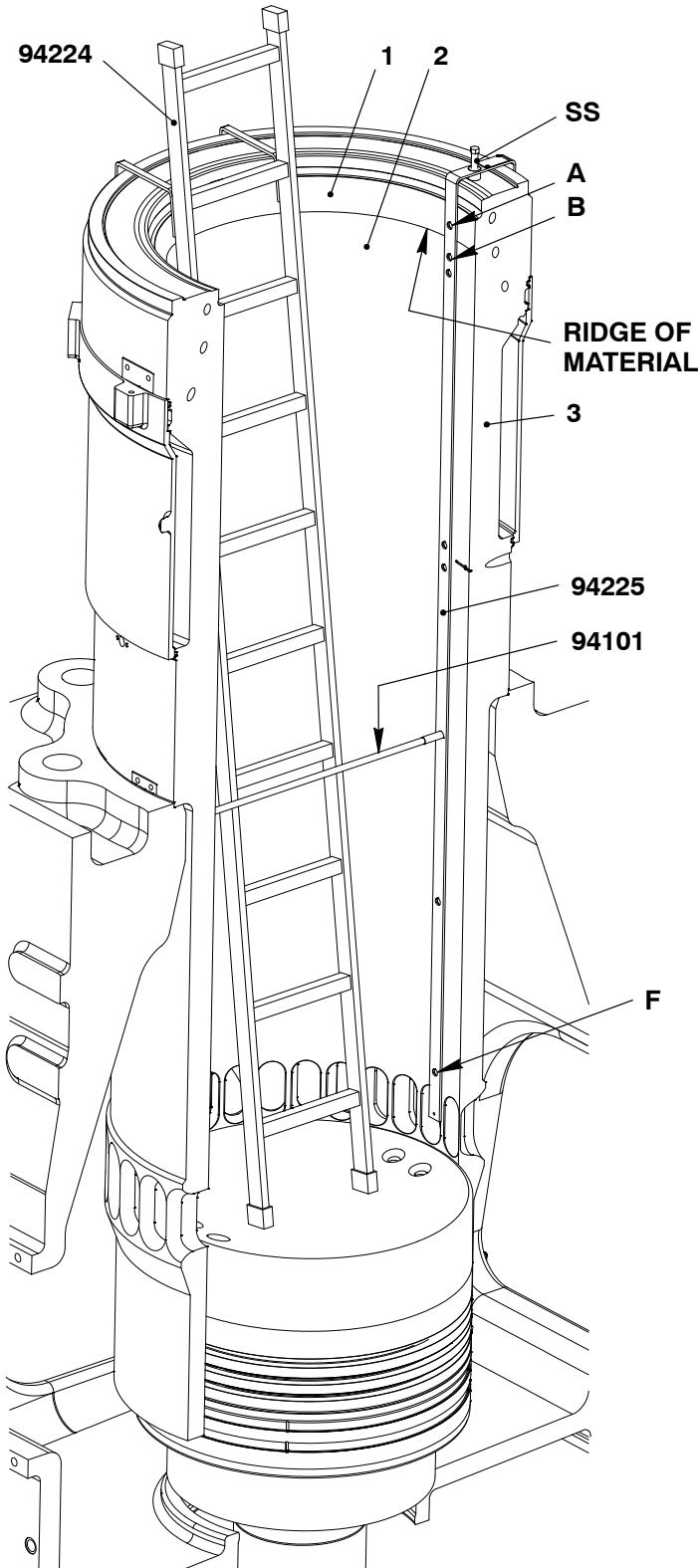



Fig. 1

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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 the 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.

Measure the Bore

- 5) Clean the area (1) above the running surface (2).
- 6) Remove the bottom part of the gauge (94225).
- 7) Put the gauge (94225, Fig. 1) in position on the top face of the cylinder liner (3) 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 (3).
- 9) Read the values from when the bore was measured before. You can compare these values with the new values.
- 10) Put the micrometer (94101) in the top hole (A) to measure the distance.
- 11) Record the value.
- 12) Put the micrometer in position in the subsequent hole (B) in the gauge (94225), then record the value.
- 13) Repeat step 11) for the remaining holes below (A and B).
- 14) Move the gauge 90° (in line with the transverse axis of the engine).
- 15) Repeat the above steps to measure the bore in the positions (F up to A).
- 16) 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)

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

Cylinder Liner

Removal and Installation

Tools:

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

1. Preparation	1
2. Bottom Water Guide Jacket – Removal	1
3. Lifting tool – Install	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

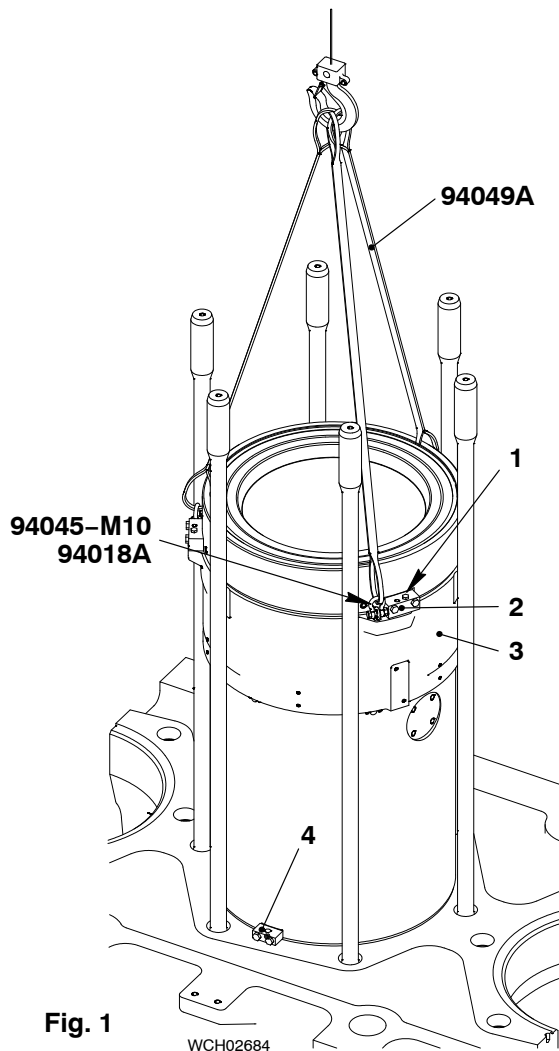


Fig. 1

WCH02684

1. Preparation

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

2. Bottom Water Guide Jacket – Removal

- 1) Remove the cylinder holder (4) , as shown in [Fig. 1](#).
- 2) Attach the three eye bolts (94045 M10) to the bottom water guide jacket (3).
- 3) Attach the three round slings (94049A) with the shackles (94018A) to the eye bolts on the bottom water guide jacket and to the crane.
- 4) Operate the engine room crane to apply a light tension to the slings.
- 5) Remove the three screws (1).
- 6) Carefully lower the bottom water guide jacket.
- 7) If the water guide jacket (3) does not move, do as follows:
 - a) Put the bolts (1) in the threaded holes.

Cylinder Liner: Removal and Installation

- b) Turn the bolts to push down the bottom water guide jacket.
- 8) Remove the holder (2).

3. Lifting Tool – Install

- 1) Put the top part of the lifting tool (94201) on the cylinder liner (1) as shown in Fig. 2.
- 2) Apply Molyslip Copaslip to the threads of the screws (2).
- 3) Attach the two flanges (part of 94201) to the cylinder liner with the screws (2).
- 4) Torque the screws to 140 Nm.

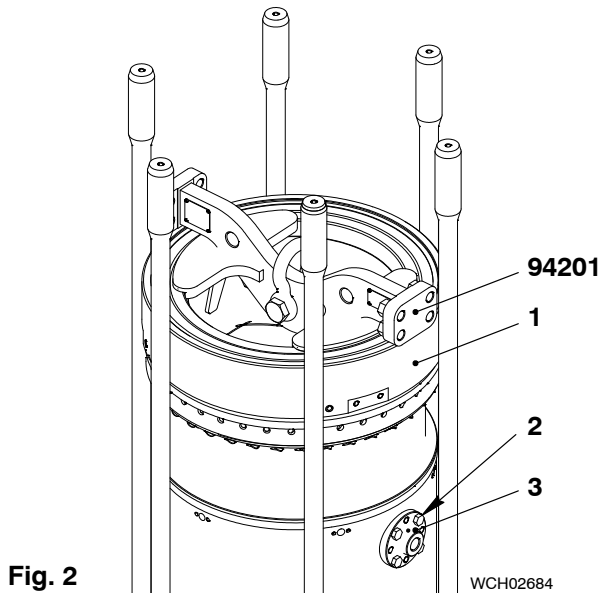


Fig. 2

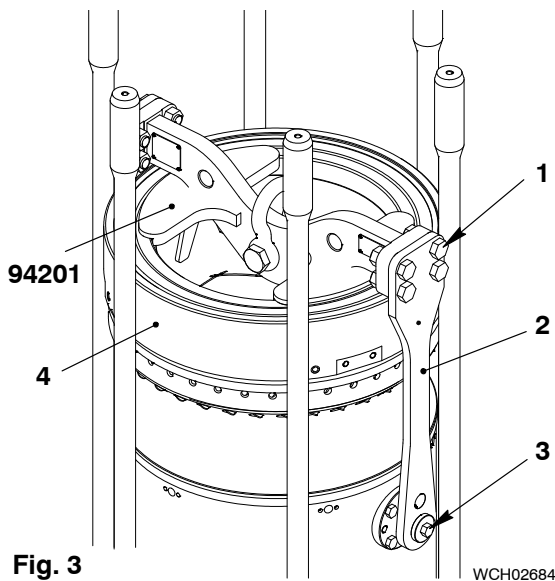



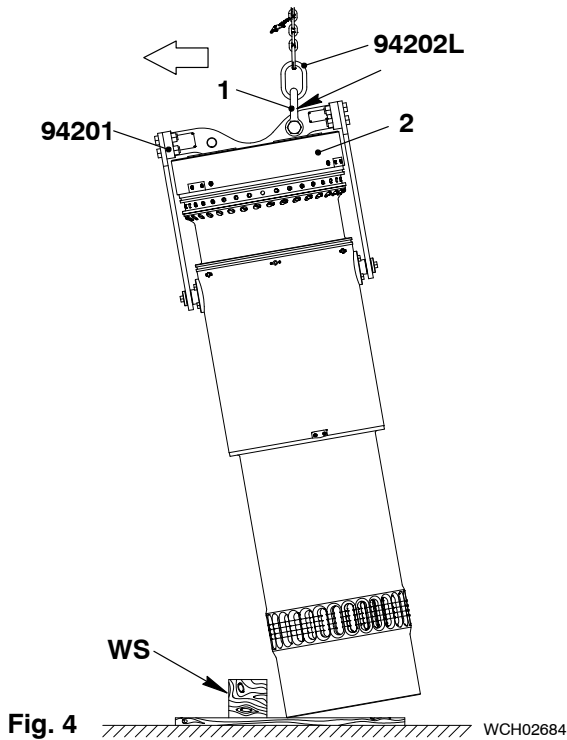
Fig. 3

- 5) Apply Molyslip Copaslip to the threads of the screws (1, Fig. 3).
- 6) Attach the two holders (2) as shown.
- 7) Torque the screws (1).
- 8) Apply Molyslip Copaslip to the threads of the two special screw (3)
- 9) Torque the two special screws (3) to 205 Nm.

WARNING	
	<p>Injury Hazard: The cylinder liner weighs approximately 3600 kg. Lift and move the cylinder liner carefully to prevent injury to the personnel.</p>

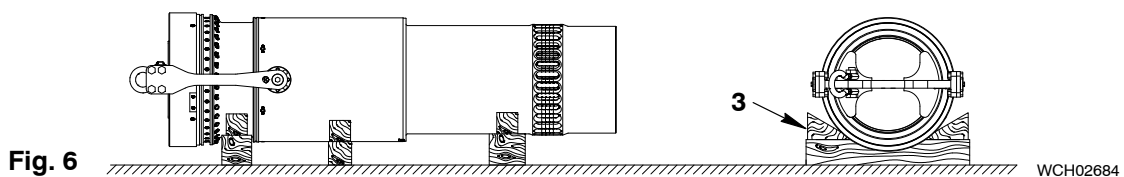
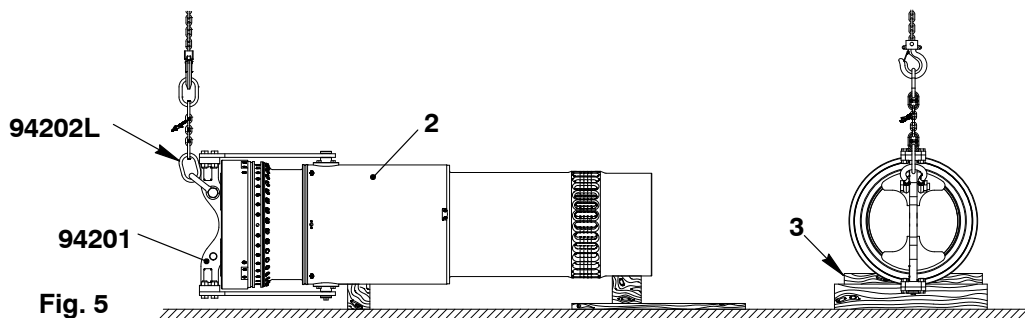
- 10) Operate the engine room crane to carefully lift the cylinder liner (4).
- 11) Carefully move the cylinder liner to an applicable area.
- 12) Lower the cylinder liner on to an applicable surface.

Cylinder Liner: Removal and Installation



4. Cylinder Liner – Safe Storage

- 1) Make sure that water guide jacket and insulation bandage is removed refer to [paragraph 2.](#) and [paragraph 5.](#)
- 2) Install the lifting tool (94210) on the cylinder liner (refer to [paragraph 3.](#)).
- 3) Attach the shackle (1) of the lifting tool (94210) in the position shown in [Fig. 4.](#)
- 4) Attach the chain (94202L) to the shackle (1) and the crane.
- 5) Put the wooden support (WS) in position as shown in [Fig. 4.](#)
- 6) Carefully push the cylinder liner in the direction shown and at the same time lower the cylinder liner.
- 7) Put the wooden chocks (3) in position to prevent the movement of the cylinder liner (see [Fig. 5.](#)).
- 8) Fully lower the cylinder liner.
- 9) Remove the chain (94202L) from the lifting tool.
- 10) Carefully turn the cylinder liner 90°.
- 11) Put more wooden supports in position (see [Fig. 6.](#)).
- 12) Remove the lifting tool from the cylinder liner.



Cylinder Liner: Removal and Installation

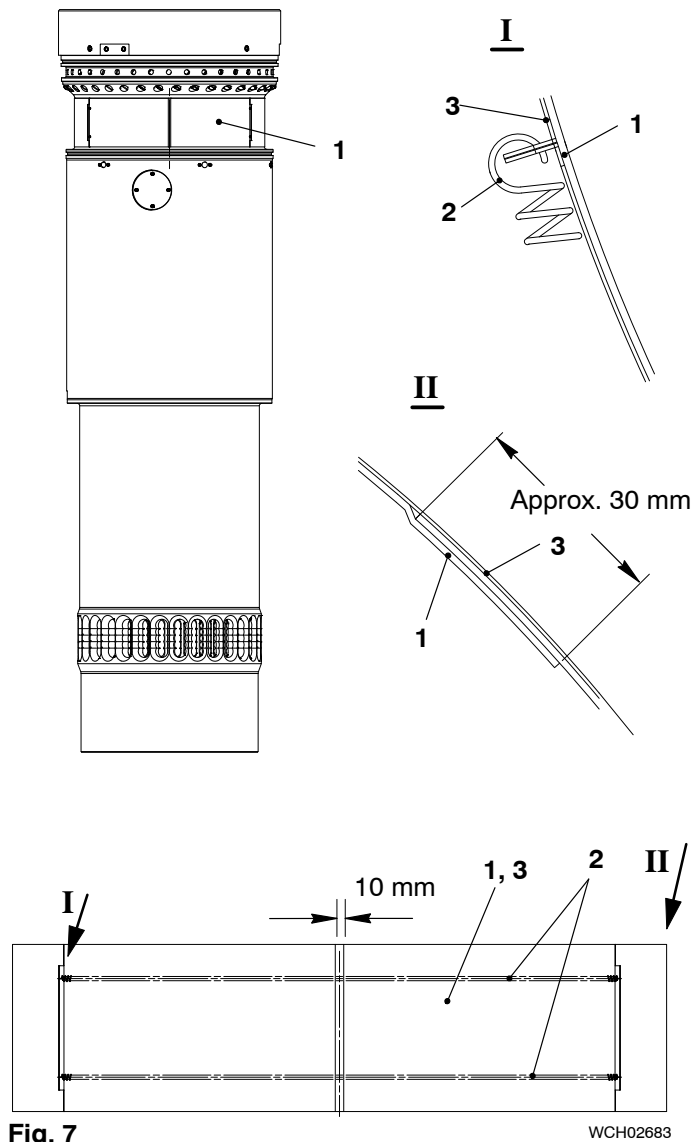


Fig. 7

WCH02683

5. Insulation Bandage – Removal

- 1) Remove the water guide jacket, refer to [paragraph 2](#).
- 2) Use the assembly tool (94233) to remove all the tension springs (2) of the insulation bandage (1, [Fig. 7](#)).
- 3) Remove the plate (3).
- 4) Remove insulation bandage (1).

6. Insulation Bandage – Installation

- 1) Put the insulation bandage (1, [Fig. 7](#)) around the water channel on the cylinder liner.

Note: Make sure that the insulation bandage overlaps approximately 30 mm.

- 2) Put the plate (3) over the insulation bandage (1).
- 3) Use the assembly tool (94233) to attach all the tension springs (2).

Note: There must be a clearance of 10 mm between the ends of the plate.

Cylinder Liner: Removal and Installation

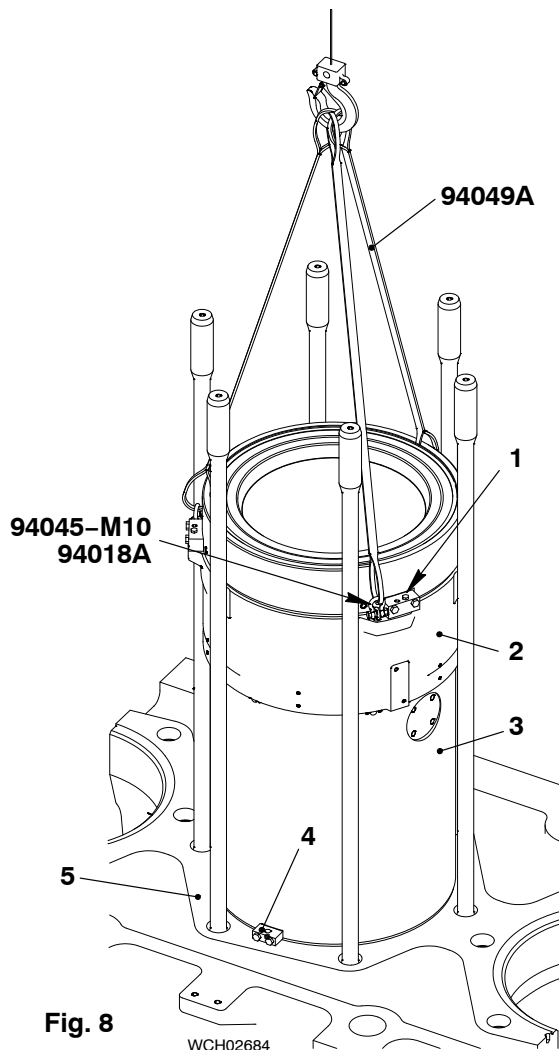


Fig. 8

WCH02684

7. Cylinder Liner and Water Guide Jacket – Installation

- 1) Install the insulation bandage, refer to [paragraph 6](#).
- 2) Clean the seat on the the cylinder liner (3) and on the cylinder block (5).
- 3) Apply a non hardening sealing compound (eg Hylomar Universal Blue) to the cylinder block.
- 4) Attach the three eye bolts (94045 M10) to the bottom water guide jacket (2, [Fig. 8](#)).
- 5) Attach the three slings (94049A) with the shackles (94018A) to the eye bolts on the water guide jacket and to the crane.
- 6) Put the water guide jacket (2) on the three wooden blocks on top of the cylinder block (5) to make room (approximately 100 mm) for the installation of the cylinder holder (4) afterwards.

Note: Make sure the water pipe is in the correct position.

- 7) Remove the slings 94049A.
- 8) Attach the lifting tool (94201) to the cylinder liner (3) (refer to [paragraph 3](#)).
- 9) Lower the cylinder liner.

Note: Make sure that you do not damage the water guide jacket.

- 10) Install the cylinder holder (4) on the cylinder liner.
- 11) Align the hole in the cylinder holder (4) with the pin on cylinder jacket, then lower the cylinder liner (3).
- 12) Remove the lifting tool (94201).
- 13) Make sure that all O-rings on the cylinder liner are in good condition and correctly installed. Apply oil to the O-rings.
- 14) Lift the water guide jacket (2) to the correct position on the cylinder liner. Make sure that you keep the water guide jacket in the correct position.
- 15) Attach the water guide jacket (2) to the cylinder liner.
- 16) Apply Never Seez™ to the threads of bolts (2).
- 17) Torque the bolts (2) with 60 Nm.
- 18) Install all lubricating quills (refer to [2138 1](#)).
- 19) Operate the cylinder lubrication pump on the related cylinder liner until oil flows from all the lubricating grooves (refer to [2138 1](#), paragraph 5).

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Removing the Ridge, Dress Lubricating Grooves and Scavenge Ports

Tools:

- 1 Grinding device 94299

1. General

During operation, the cylinder liner becomes worn and a ridge 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 must first measure the bore of the cylinder liner (refer to [2124 1](#)).

2. Preparation

- 1) Remove the cylinder cover (refer to [2708 1](#)).
- 2) Remove all the lubricating quills (refer to [2138 1](#)).
- 3) Put applicable protection in the cylinder liner. This keeps unwanted particles out of the bore.

3. Ridge – Remove

CAUTION



Damage Hazard: Make sure that you do not cause damage to the running surface of the cylinder liner when you operate the grinding tool.

- 1) Read the data in the Instruction Manual for the grinding tool.
- 2) Attach the grinding tool (94299, [Fig. 1](#)) to the cylinder liner, refer to the Instruction Manual.
- 3) Connect the grinding tool (94299) to an applicable air supply.
- 4) Operate the grinding tool (94299) to carefully remove the ridge from the cylinder liner (1).
- 5) Make sure that you get the radius $r = 8.0$ mm as shown in [Fig. 1](#).

Removing the Ridge, Dress Lubricating Grooves and Scavenge Ports

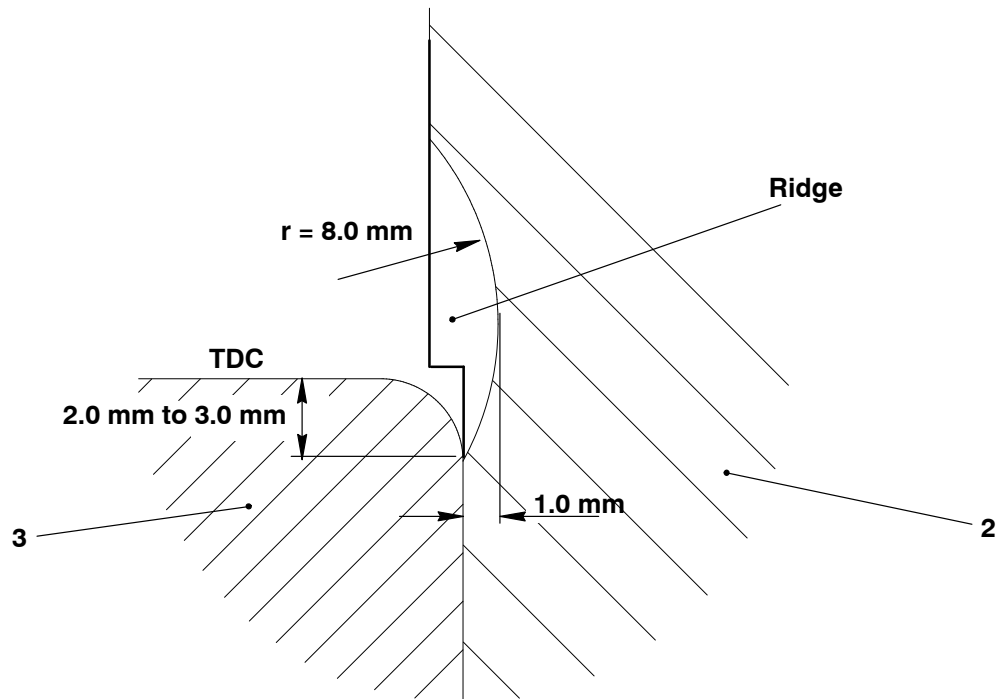
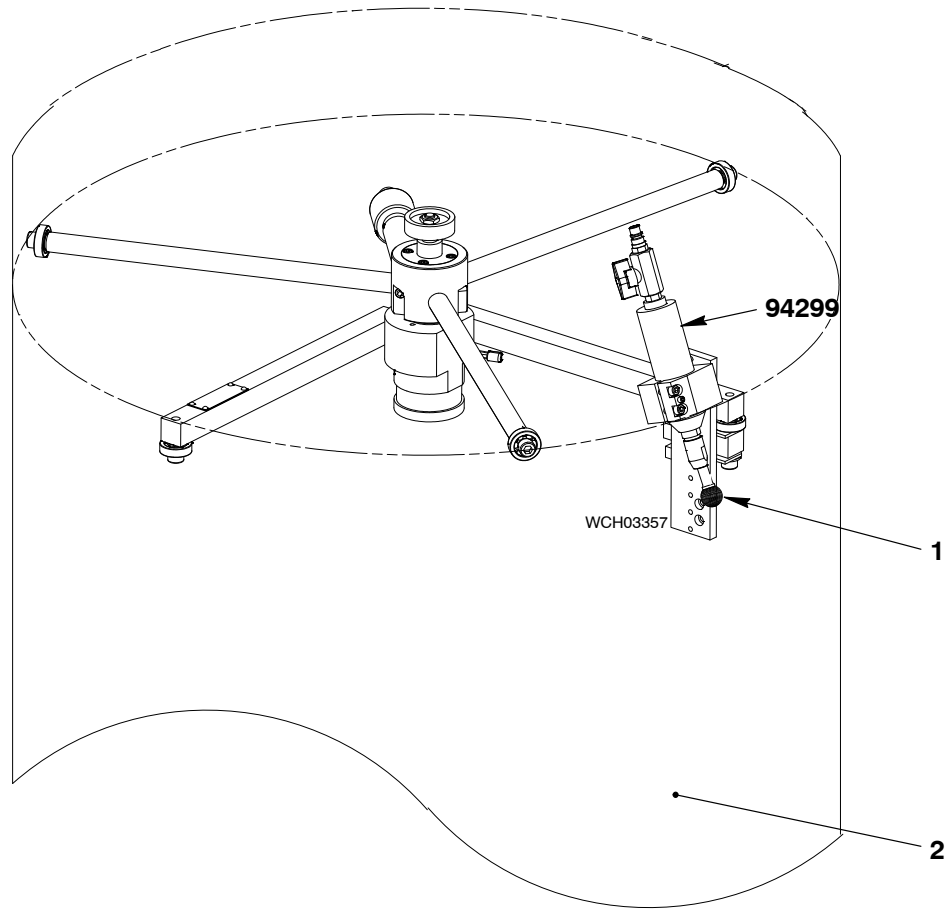


Fig. 1

4. Lubricating Grooves

CAUTION



Damage Hazard: Make sure that you keep the initial shape of the lubricating grooves when you remove sharp edges.

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

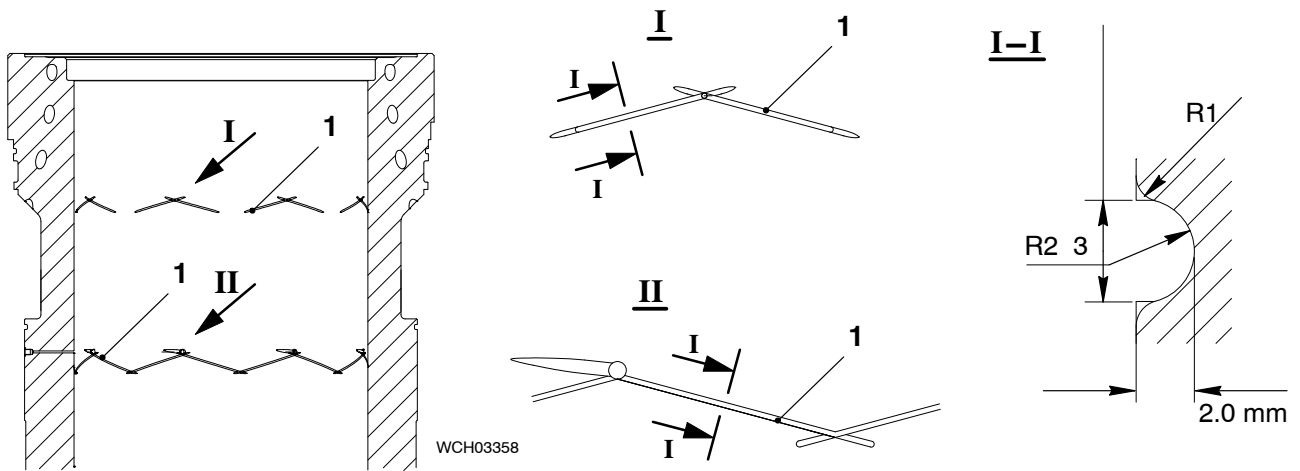


Fig. 2

5. Scavenge ports

CAUTION

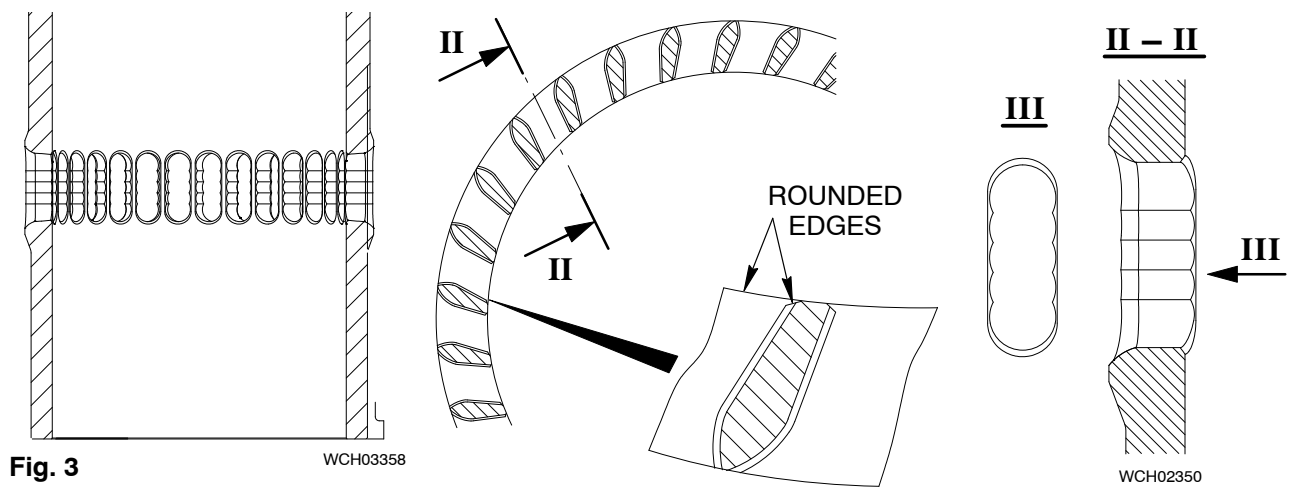


Damage Hazard: When you polish the scavenge ports, make sure that you do not cause damage to the running surface of the cylinder liner.

Note: The scavenge ports (1, Fig. 3) are as shown in new cylinder liners.

- 1) Use emery cloth to polish the surfaces of the scavenge ports. Make sure that you keep the shape of the scavenge ports the same as shown.

Removing the Ridge, Dress Lubricating Grooves and Scavenge Ports



- 2) Clean the lubricating grooves and the bore of the cylinder liner.
- 3) Manually operate the cylinder lubrication until oil flows from all the lubricating points. This will flush away unwanted metal dust.

Lubricating Quill Removal and Installation

Tools:

1 HP oil pump	94931	1 Connection nipple (G1/4")	94934I
1 HP hose	94935	1 Tredo Joint	94934J
1 Pressure gauge 0 20 bar	94934B	1 Dismantling tool	94213

1. General

If it is not necessary to remove the cylinder liner (1, Fig. 1), you must not drain the cylinder cooling water.

Do steps 1) to 3) only if cylinder liner is to be removed:

- 1) If necessary, remove the two holders (7).
- 2) Remove the six pipes (2).
- 3) Seal the pipes (2) with applicable seals to prevent contamination.

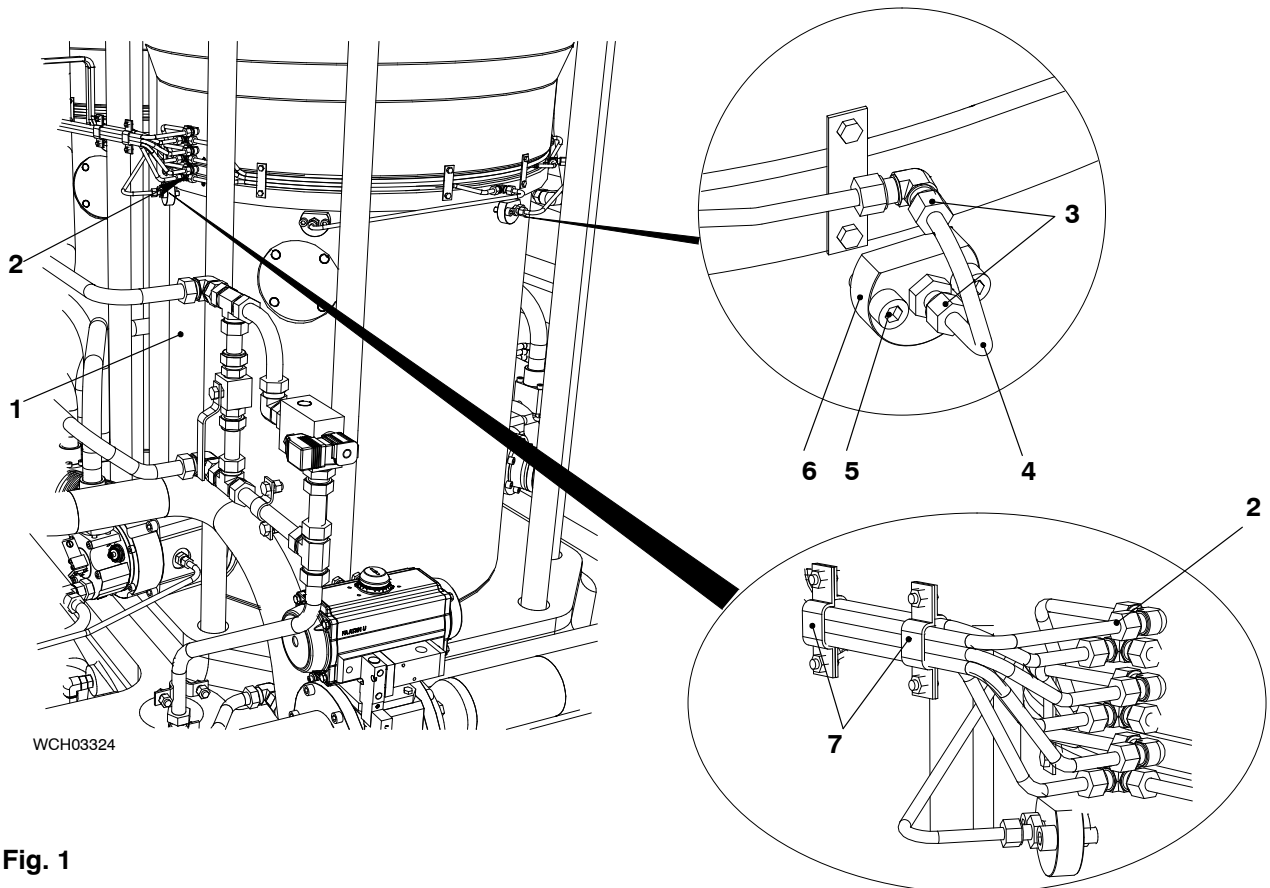


Fig. 1

2. Removal Procedure

- 1) Remove the nuts (3) of the screw-in union and angle union.
- 2) Remove the pipe (4) from the lubricating quill (6).

Note: Make sure that you do not cause damage the oil pipe (4).

- 3) Seal the oil pipe (4) with an applicable plug to prevent contamination.
- 4) Remove the two screws (5).

- 5) Remove the lubricating quill (6).
- 6) If necessary, do a function check of the lubricating quills (refer paragraph 3).

3. Nozzle Tip – Replace

- 1) Remove the two bolts (2, Fig. 2) and the plate (1) from the distance sleeve (3).
- 2) Put the distance sleeve (3) on the lubricating quill (5).
- 3) Attach the plate (1) to the nozzle tip (4).
- 4) Engage the collar on the plate with the recess on the lubricating quill (5).
- 5) Turn equally the two bolts (2) to remove the nozzle tip (4) from the holder (5).
- 6) Remove the distance sleeve (3).
- 7) Attach a new nozzle tip (4) to the holder (5).
- 8) Make sure that the nozzle tip (4) is correctly attached to the holder (5).
- 9) Do the procedure in paragraph 4.

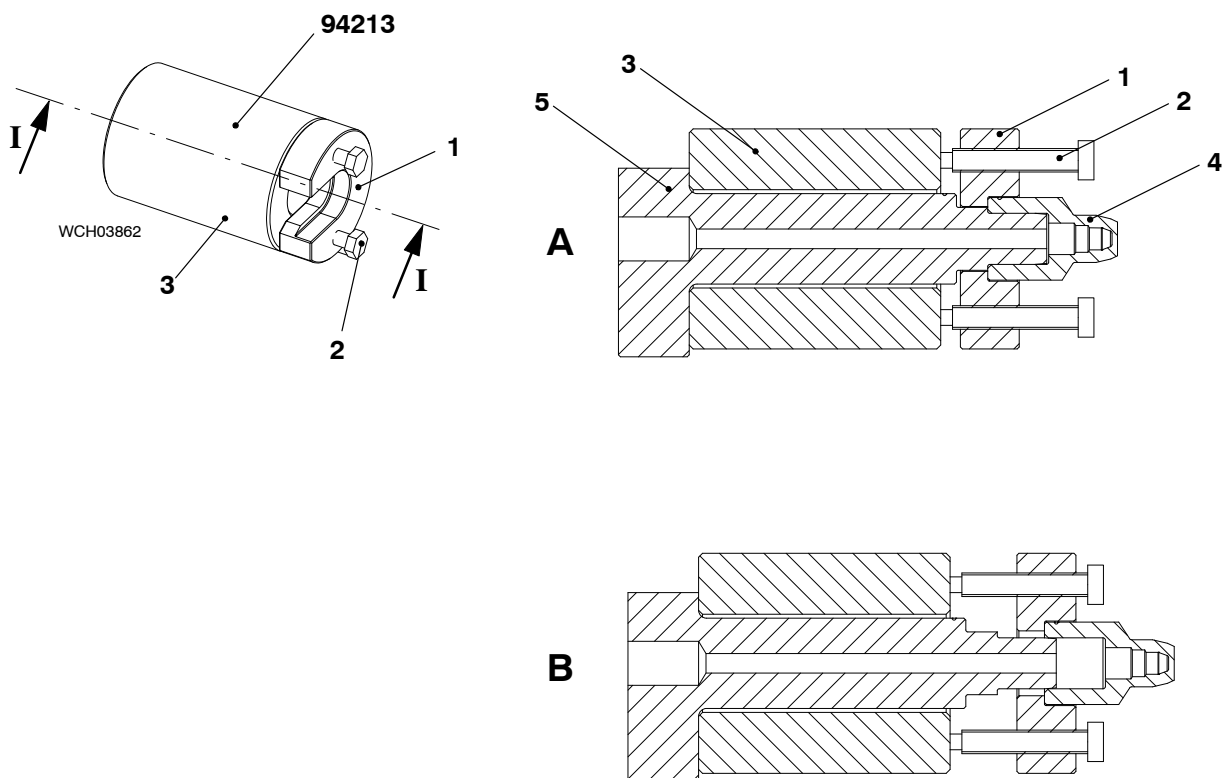


Fig. 2

4. Lubricating Quill – Function Check

4.1 General

You do a function check to make sure that the non-return valve (3, Fig. 3) operates correctly. The opening pressure of the non-return valve (6) must be between 4.0 bar and 6.0 bar.

During the function check, keep the lubricating quill (2) 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).

4.2 Procedure

- 1) If necessary, remove the screw-in union (1) from the lubricating quill (2).
- 2) Attach the nipple (94934I) and the tredo joint (94934J) to the lubricating quill (2).
- 3) Attach the low pressure gauge (94934B) to the nipple (94934I).
- 4) Connect the HP hose (94935) to the nipple (94934I).
- 5) Hold the lubricating quill (2) up and operate the HP oil pump (94931) until oil that flows has no air.
- 6) Open the relief valve (4) and decrease the pressure to 2.0 bar.
- 7) Close the relief valve (4).
- 8) Hold the lubricating quill (2) in a horizontal position.
- 9) Operate the HP oil pump (94931) to increase the pressure in steps of 1.0 bar until the non-return valve (3) opens.
- 10) Record the pressure shown on the pressure gauge (94934B).

Note: The minimum permitted opening pressure is 4.0 bar. If necessary, replace the defective lubricating quill (2).

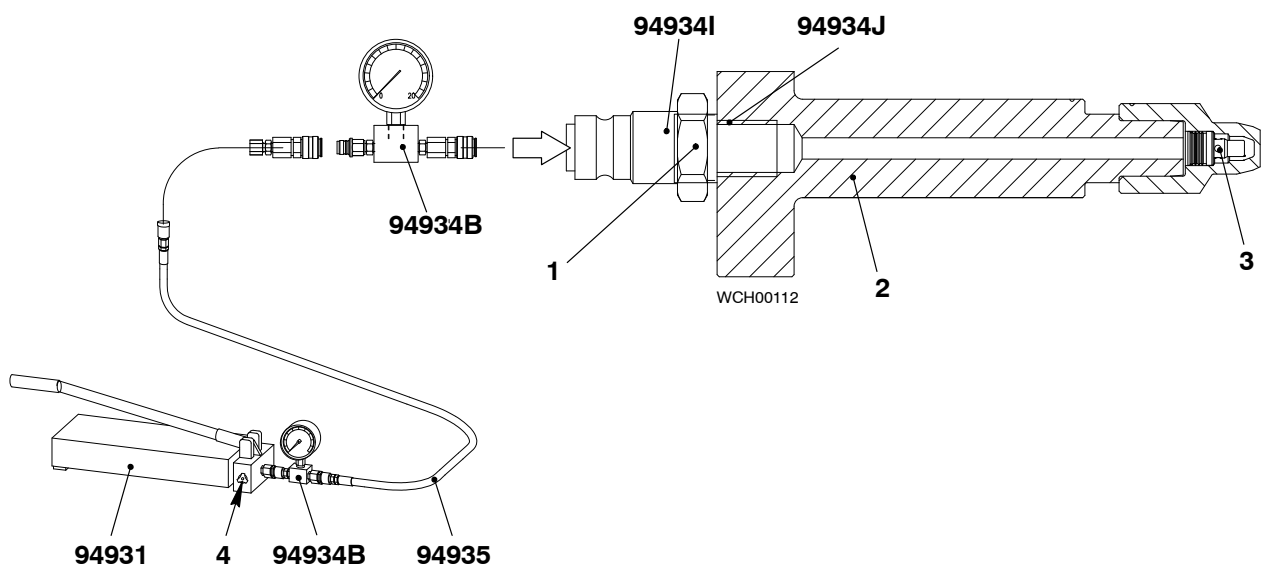


Fig. 3

5. Installation

CAUTION

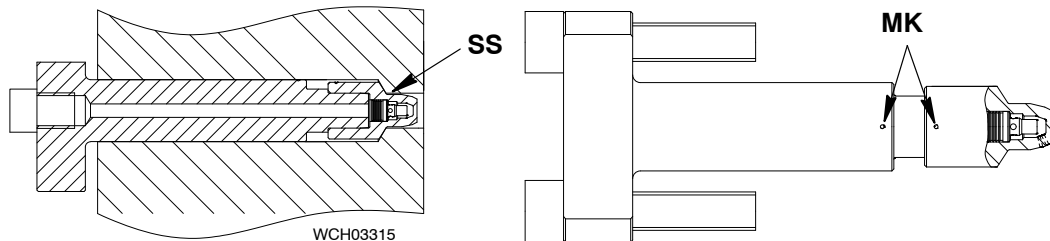


Damage Hazard: The surfaces of the cylinder liner and the nozzle tip make a metallic seal. The seat angles in the cylinder liner and on the nozzle tip are different. Do not use a gasket between the cylinder liner and the nozzle tip, or damage to the equipment can occur.

Note: When you install the lubricating quill, replace all components, ie nozzle tip, non-return valve and holder.

- 1) Make sure that the sealing surfaces (SS, Fig. 4) are clean and have no damage.
- 2) Make sure that the marks (MK) are in line. If the marks are not in line, send the lubricating quill to WinGD.

Fig. 4



- 3) Apply oil to the threads and surfaces of the screws (3, Fig. 5).
- 4) Put the lubricating quill (1) in position to the cylinder liner (2).
- 5) Torque the two screws (3) to 10 Nm.

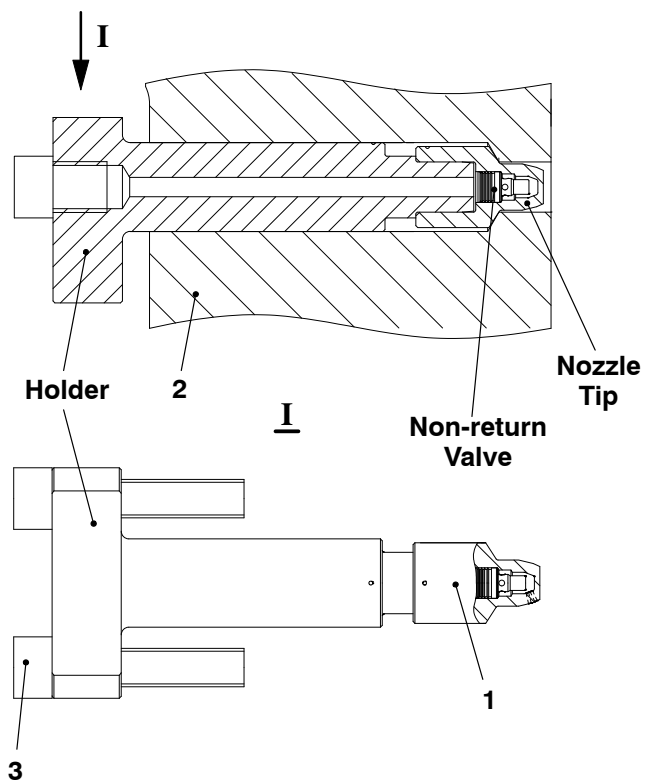
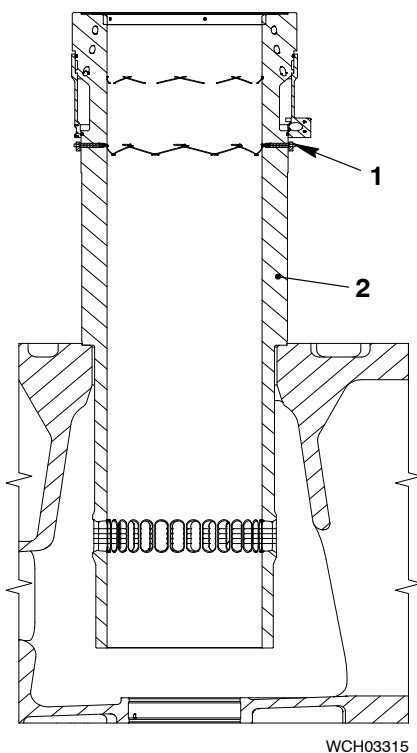


Fig. 5

Lubricating Quill

- 6) Remove the plugs from the oil pipe (4, Fig. 6).
- 7) Connect the pipe (4) to the lubricating quill (5) and the applicable pipe (6).
- 8) Tighten the nuts of the screw-in unions (3).
- 9) Step a) to step c) is only necessary if the cylinder liner was installed.
 - a) Remove the protection from the six pipes (2).
 - b) Connect the six pipes (2).
 - c) If necessary, attach the two holders (7) to the six pipes (2).
- 10) Bleed the oil pipes (2) refer to 7218, paragraph 3.2.
- 11) If necessary, bleed the cylinder lubrication pump, refer to 7218, paragraph 3.1.
- 12) Do a function check of the cylinder lubricating system, refer to 7218, paragraph 1.2.

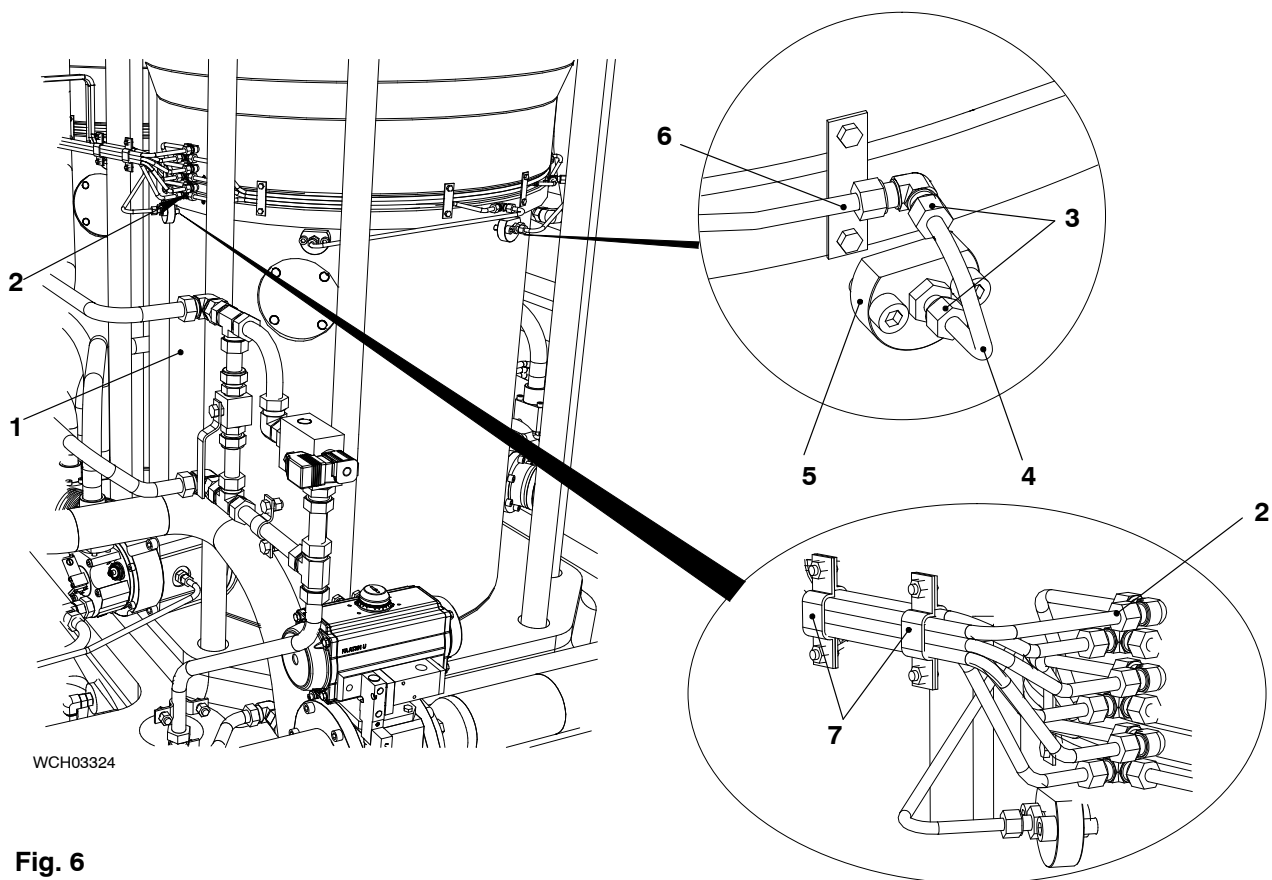


Fig. 6

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Piston Rod Gland

Piston Rod Gland

Remove, Disassemble, Measure Worn Parts, Assemble, Install

Tools:

2	Work platforms	94142	1	Distance piece (11 mm)	94231C
2	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 support device	94350
1	Distance piece (12 mm)	94231B	1	Platform	94234
1	Template	94231E			

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1. General

There are two procedures to remove the piston rod gland:

- **Procedure One:** The piston and the piston rod gland are removed together from the engine. The piston rod gland is disassembled in an external piston support device (94350). For more data, refer to paragraph 2.
- **Procedure Two:** The piston and the piston rod gland stay in the engine. The piston rod gland is disassembled in the crankcase. For more data, refer to paragraph 3.

Examine the piston rod gland for wear and damage during each overhaul of the piston (refer to 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 One

2.1 Preparation

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

- 1) Remove the piston together with the piston rod gland, refer to 3403 1 Piston Remove and Install, paragraph 1 and paragraph 2).

2.2 Removal

CAUTION



Injury and Damage Hazard: You must prevent an unwanted movement of the crankshaft when you do the procedure. Injury to personnel and damage to equipment can occur.

- 1) Make sure that the piston rod gland (2, Fig. 1) is in the correct position on the two hinged covers (1) of the support device (94350).
- 2) Remove the four screws (5).
- 3) Remove the O-Rings (3).
- 4) Remove the spring dowel pin (4).
- 5) Push the two parts of the housing (6) away from the piston rod.
- 6) Remove the two parts of the housing (6).

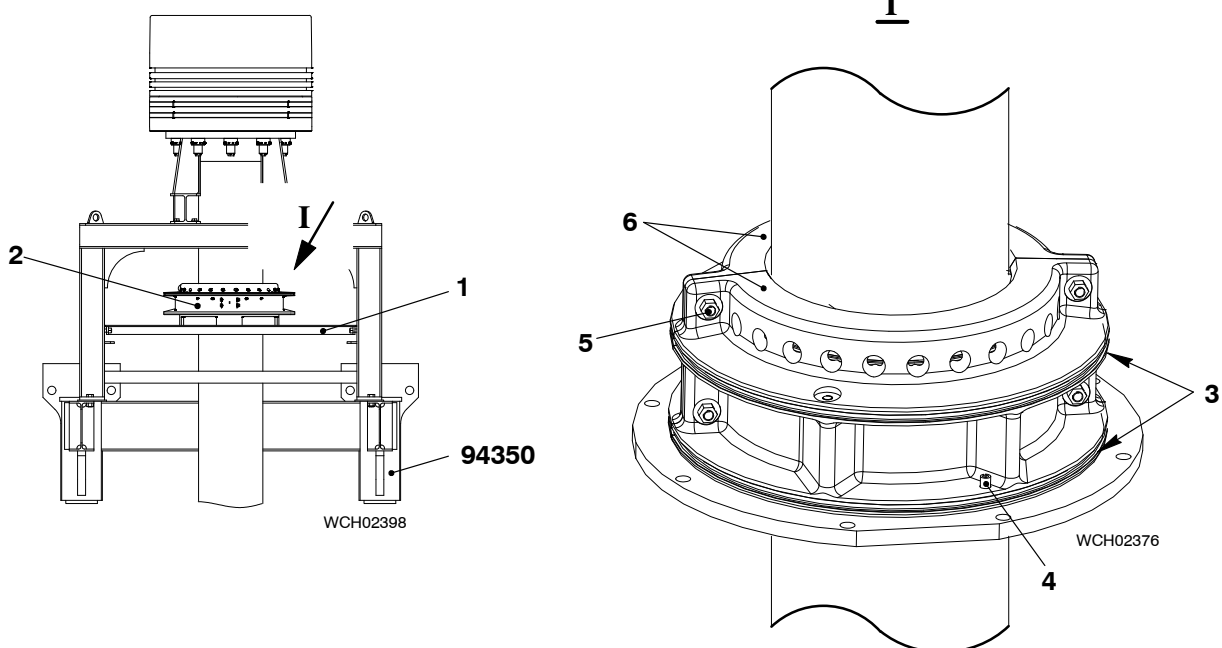
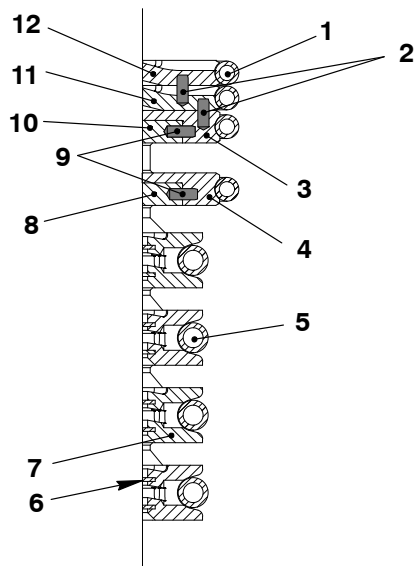


Fig. 1

2.3 Disassemble



7) Remove the parts that follow (see [Fig. 2](#)):

- Tension springs (1, 5)
- Scraper rings (2, 6, 11, 12)
- Gaskets (3, 4, 8, 10)
- Spring dowel pins (9)
- Ring supports (7).

Fig. 2

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2.4 Worn Parts – Measure

Note: Refer to 0330-1 Clearance Table, [Piston Rod Gland](#) for the maximum permitted dimensions of worn parts. If necessary, replace the worn parts.

- 1) Compare the wear of the parts that follow:
 - Scraper rings (2, 6, 11, 12)
 - Gaskets (3, 4, 8, 10).
- 2) Make sure that the tension springs (1, 5) and the O-rings (5, [Fig. 1](#)) are serviceable. If necessary, replace the unserviceable parts.

Remove, Disassemble, Measure Worn Parts, Assemble, Install

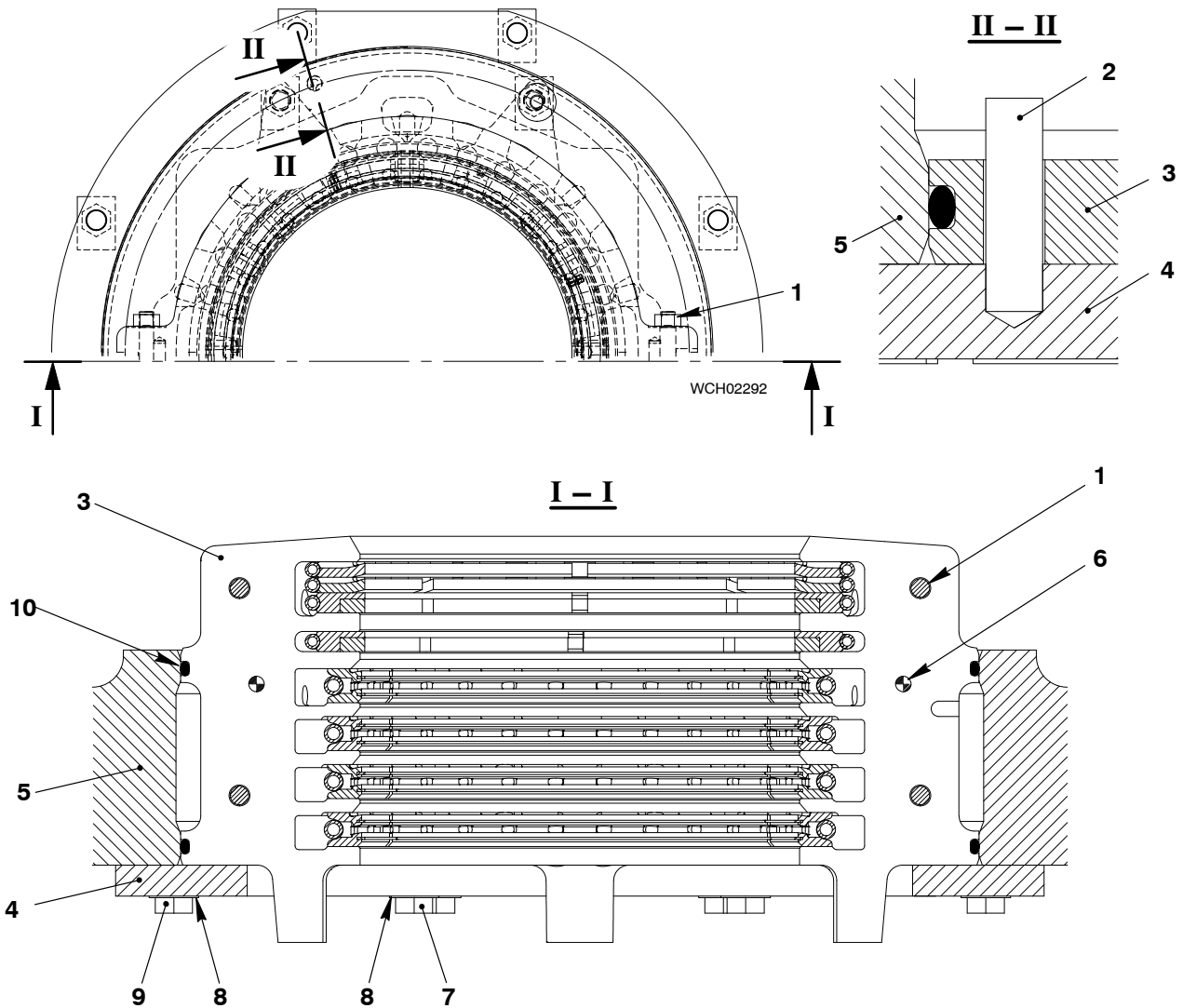


Fig. 3

Fig. 3: Gland Box – General Views

- | | |
|-----------------------------|----------------------|
| 1 Bolt M16x60 and nut M16 | 6 Dowel Pins |
| 2 Spring Dowel Pin | 7 Inner Bolt M16x100 |
| 3 Gland box housing, 2-part | 8 Locking Plate |
| 4 Support | 9 Outer Bolt M16x100 |
| 5 Cylinder Block | 10 O-Rings |

2.5 Assemble

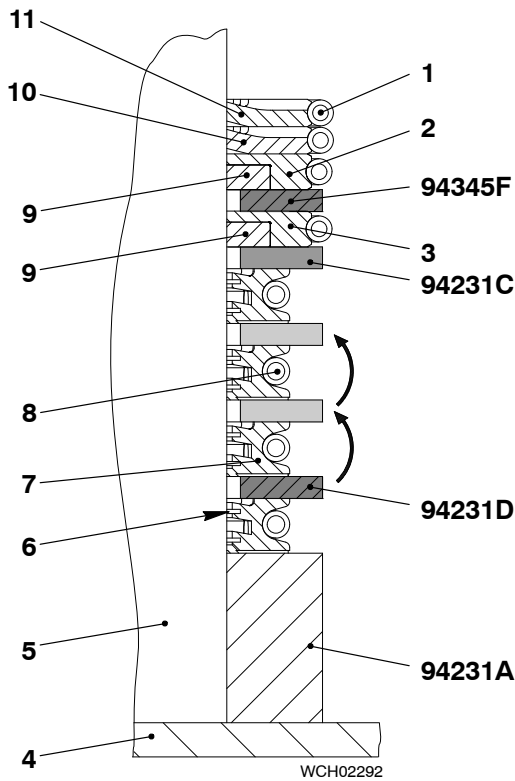


Fig. 4

- 1) Attach the two parts of the clamp ring (94231A, Fig. 4) to the piston rod.
- 2) Put the three parts of the ring support (7) and the scraper rings (6) on the clamp ring 94231A.
- 3) Use the assembly tool (94233) to attach the tension spring (8) to the ring support (7).
- 4) Put the two parts of the distance piece (94231D, 9.0 mm height) on the ring support (7).

Note: The height of the distance piece (94231C, 11.0 mm) is the same as the distance between the ring grooves in the housing.

- 5) Put the next three parts of the ring support (7) and the scraper rings (6) 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 (8) to the ring support (7).
- 7) Remove the distance piece (94231D).
- 8) Do step 4) to step 7) again until the four ring supports (7) are attached to the piston rod (5).
- 9) Put the two parts of the distance piece (94231C, 11.0 mm height) on the top ring support (7).

Note: One segment of the gaskets (3, 4, and 8, Fig. 5) has two holes for the horizontal spring dowel pins (9). The other three segments have only one hole. On the top of one segment of the gasket (3) there is one hole for a vertical spring dowel pin (2).

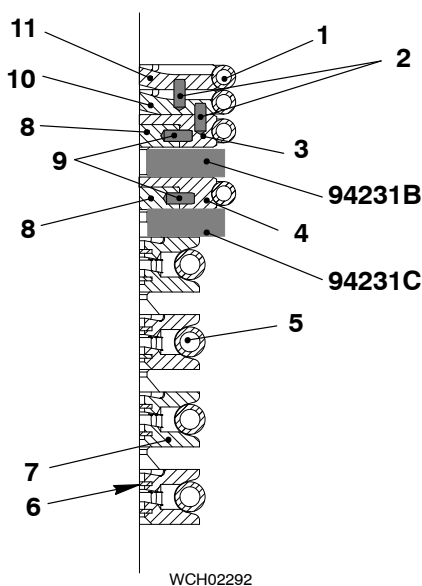


Fig. 5

- 10) Put the four parts of the gaskets (8, 4) on the distance piece (94231C).
- 11) Make sure that all the horizontal spring dowel pins (9) are installed.
- 12) Use the assembly tool (94233) to attach the tension spring (1) to the gaskets (4,8).
- 13) Remove the distance piece (94231C).

Remove, Disassemble, Measure Worn Parts, Assemble, Install

- 14) Put the two parts of the distance piece (94231B, Fig. 5 (12.0 mm height) on the gaskets (4, 8).
- 15) Put the four parts of the gaskets (3, 8) 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 (9) and the vertical spring dowel pins (2) are installed.

Note: On top of the scraper rings (10) there is one hole for a vertical spring dowel pin.

- 17) Put the scraper ring (10) on the gaskets (3, 8). Make sure that there is an equal distance between the four parts.
- 18) Make sure that the vertical spring dowel pins (2) are installed.
- 19) Use the assembly tool (94233) to attach the tension spring (1) to the scraper ring (10).

Note: There is no hole for a vertical spring dowel pin on the top of the scraper ring (11).

- 20) Put the scraper ring (11) on the top of the scraper ring (10). Make sure that there is an equal distance between the four parts.
- 21) Make sure that the vertical spring dowel pins (2) between the scraper rings (10, 11) are correctly installed.
- 22) Use the assembly tool (94233) to attach the tension spring (1) to the scraper ring (11).

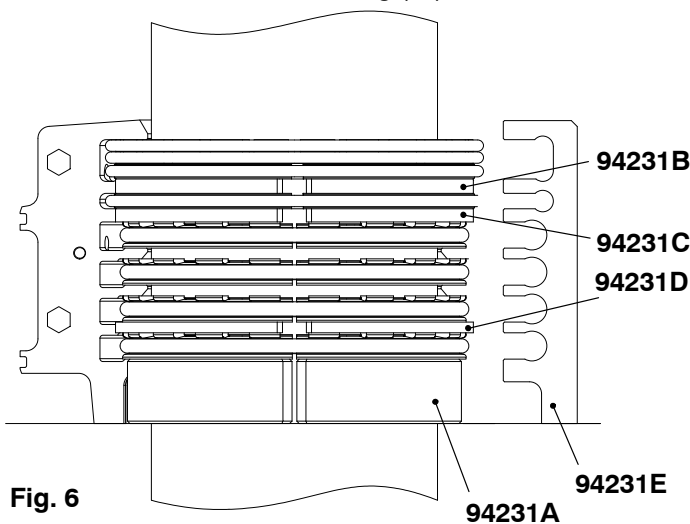


Fig. 6

- 23) Remove the distance piece (94231B).
- 24) Remove the clamp ring (94231A).
- 25) Put the template (94231E, Fig. 6) over the assembled rings. Make sure that all parts are in their correct positions.
- 26) Apply bearing oil to the piston rod and the assembled rings.
- 27) Push the two parts of the housing (4, Fig. 7) over the assembled rings. Make sure that the dowel pins (2) are installed.
- 28) Torque the M12 x 55 bolts (3) to the value given in 0352 2, Torque Values for Standard Screws, paragraph 1.
- 29) Put oil on the O-rings (1).
- 30) Attach the O-rings (1) to the housing (4).

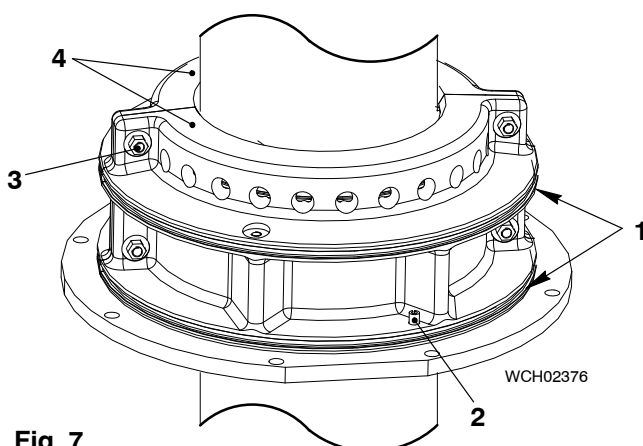


Fig. 7

2.6 Installation

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

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

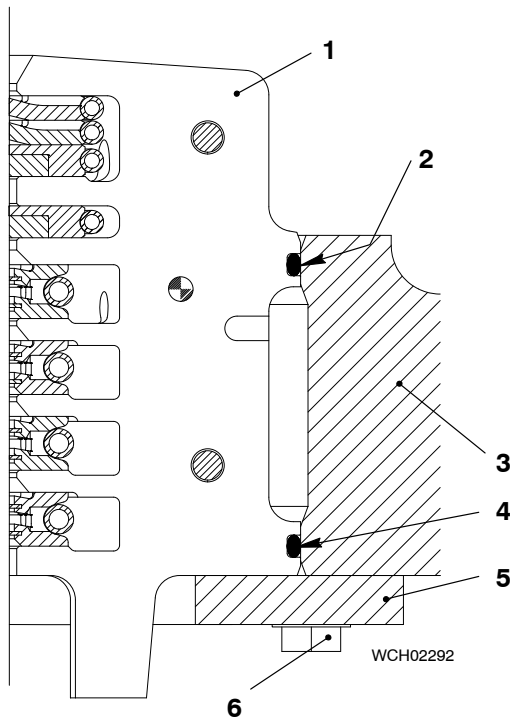


Fig. 8

- 1) Apply lubricating oil to the opening in the cylinder jacket (3, Fig. 8) and to the area of the O-rings (4) on the housing (1).
- 2) Make sure that the distance holders (94230) are attached to the piston rod.
- 3) Make sure that the support (5) is installed onto the cylinder jacket (3).
- 4) If necessary, torque the outer bolts (6) to 150 Nm.
- 5) Install the piston and piston rod gland, refer to 3403 1, (Installation of the Piston, paragraph 3)
- 6) Remove all tools and equipment from the area.

3. Procedure Two

3.1 Removal

WARNING



Injury Hazard: You must prevent unwanted movement of the crankshaft when you do the maintenance.

WARNING



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

CAUTION



Damage Hazard: Do not get on the platform (94234). The maximum permitted weight is 130 kg.

Remove, Disassemble, Measure Worn Parts, Assemble, Install

- 1) Operate the turning gear to move the piston to BDC.
- 2) Attach the platform (94234, [Fig. 9](#)) with the elastic studs (2) to the piston rod (10).

CAUTION

Damage Hazard: Each time you operate the turning gear, you must remove the platform (94142). This will prevent damage to equipment. After you operate the turning gear, you can install the platform (94142) again.

- 3) Clean the bottom area of the piston rod (10) and the threads of the elastic studs (8).
- 4) Attach the two halves of the platform (94234) around the piston rod (10). Make sure that the platform engages with the round nuts (9).
- 5) Tighten the screws and nuts (3).
- 6) Operate the turning gear to carefully move the piston to TDC until the platform (94234) is in a position below the lowest point of the piston rod gland (1) (approximately 10 mm to 20 mm).

CAUTION

Injury Hazard: When you remove the outer bolts (6) the platform (94234) and the piston rod gland (1) can suddenly move down. Do not put your hands between the platform and the piston rod gland.

- 7) Remove the eight outer bolts (6) and the locking plates (5) of the support (2).
- 8) If the piston rod gland (1) does not move down, remove two opposite inner bolts (4). Pull the inner bolts (4) down to move the piston rod gland (1) out of the cylinder jacket (7).
- 9) Put the piston rod gland (1) and the support (2) on the platform (94234). Make sure that the support (2) is in the cutout of the platform (94234).
- 10) Operate the turning gear to carefully move the piston to BDC.
- 11) Remove the four inner bolts (4) and the locking plates (5).
- 12) Disassemble the piston rod gland (1), refer to paragraph [2.3](#).
- 13) Measure the dimensions of the related parts, refer to paragraph [2.4](#).
- 14) Assemble the piston rod gland, refer to paragraph [2.5](#).

Remove, Disassemble, Measure Worn Parts, Assemble, Install

Note: Some parts can look different.

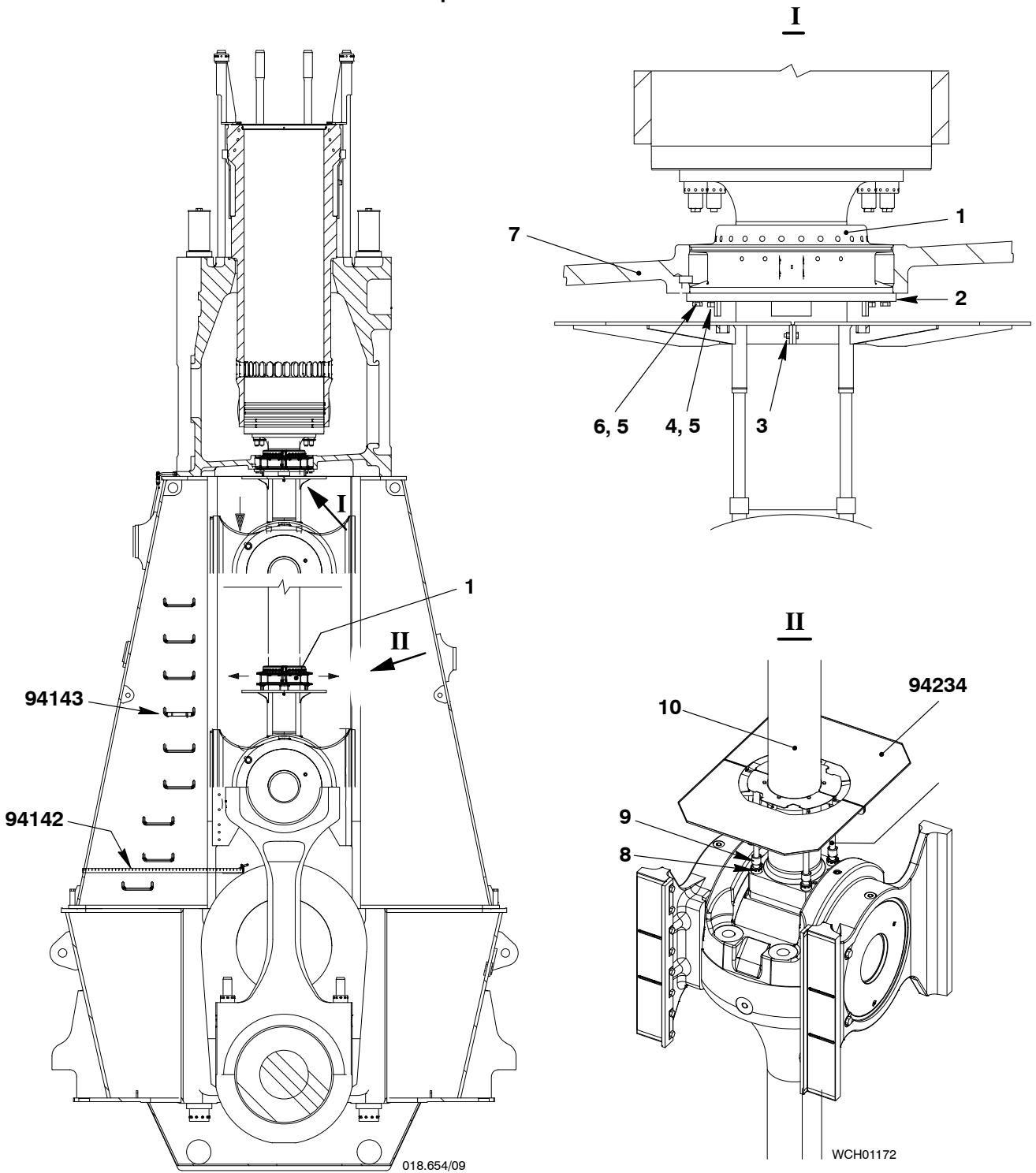


Fig. 9

3.2 Installation

WARNING

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

CAUTION

Damage Hazard: Each time you operate the turning gear, you must remove the platform (94142). This will prevent damage to equipment. After you use the turning gear, you can install the platform (94142) again.

- 1) Make sure that the piston rod gland (1, [Fig. 9](#)) and the spring dowel pin are in the correct position.
- 2) Apply oil to the inner bolts (4).
- 3) Put the new locking plates (5) and the inner bolts (4) in position.
- 4) Torque the inner bolts (4) to 150 Nm.
- 5) Bend the locking plates (5) to lock the inner bolts (4).
- 6) Apply lubricating oil to the opening in the cylinder jacket (3, [Fig. 8](#)) and to the area of the O-rings (4) on the housing (1).

Note: Make sure that the piston rod gland moves freely into the cylinder jacket (3) and does not tilt.

- 7) Operate the turning gear to carefully move the piston to TDC until the piston rod gland is in the correct position in the cylinder jacket (3).
- 8) Apply oil to the outer bolts (6, [Fig. 9](#)).
- 9) Put new locking plates (5) and the outer bolts (6) in position.
- 10) Torque the outer bolts (6) to 150 Nm.
- 11) Bend the locking plates (5) to lock the outer bolts (6).
- 12) Operate the turning gear to carefully move the piston to BDC.
- 13) Remove all tools and equipment.

Cylinder Cover, Water Guide Jacket and Exhaust Valve

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

Tools:

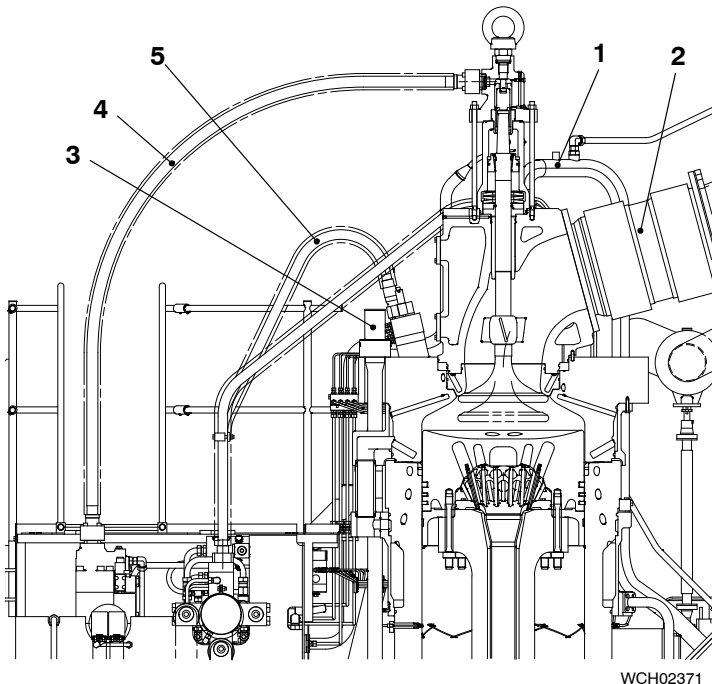
1 Lifting tool	94215	1 Connection block	94934
6 Pre-tensioning jacks	94215A	1 Pressure gauge	94934A
1 Suspension device	94265	3 HP hose	94935
1 Hydraulic unit	94942	5 Flexible hose	94935A

1. Preparation

- 1) Stop the engine, refer to the procedure in Operation Manual 4002 2.
- 2) Let the engine temperature decrease.
- 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, refer 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.



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Fig.1

Note: Some parts can look different.

- 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, refer the Operating Manual in 8017-1.
- 7) Close the valves from the fuel supply and make sure that 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 the cooling water pipe.
- 11) Remove the expansion piece (2) with the slings, refer to 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) Apply tension to the nuts of the elastic studs (3), refer to paragraph 2.
- 15) Remove the round nuts of elastic studs (3).

2. Elastic Stud – Apply and Release Tension

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.

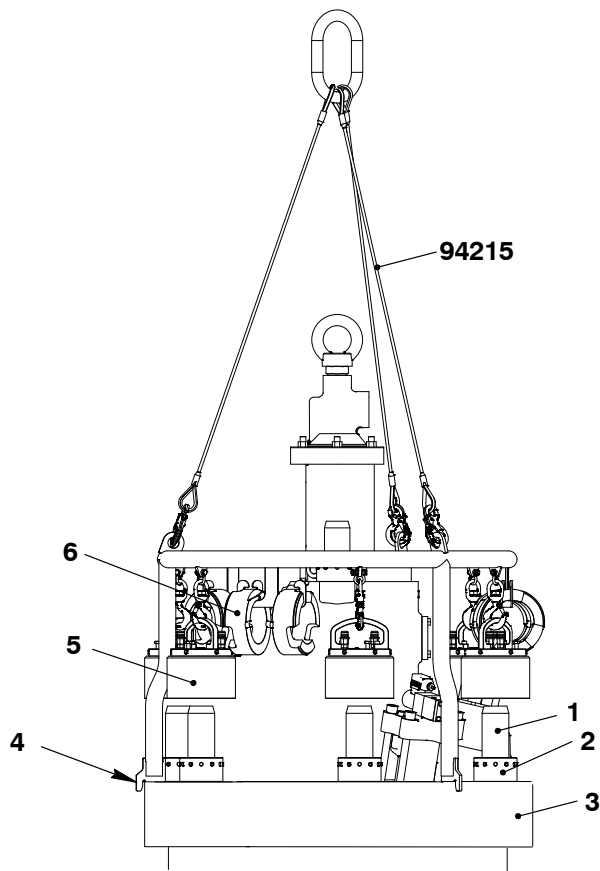


Fig.2

Note: Some parts can look different.

- 1) Operate the crane to put the lifting tool (94215, Fig.2) and 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) Put the bottom parts of the pre tensioner (6) on the elastic studs (1). Make sure that the pin (2, Fig.3) is out of the cylinder cover.
- 4) Do the same procedure for each bottom part of the pre tensioner (6, Fig.2).
- 5) Attach the top parts of the pre tensioner (5) to the elastic studs (1).
- 6) Connect the pre tensioning jacks (94215A, Fig.3) to the hydraulic pump, refer to 9403 2.
- 7) Remove the round nuts (2) from the elastic studs, refer to 9403 4.

2.2 Apply Tension

- 1) Clean the threads of the elastic studs (1, Fig. 3) and apply oil for lubrication.
- 2) Attach the pre-tensioning jacks (94215A) to the elastic studs (1), refer to paragraph 2.1, steps 1 to 7.
- 3) Apply tension the elastic studs (1), refer to 9403 4.

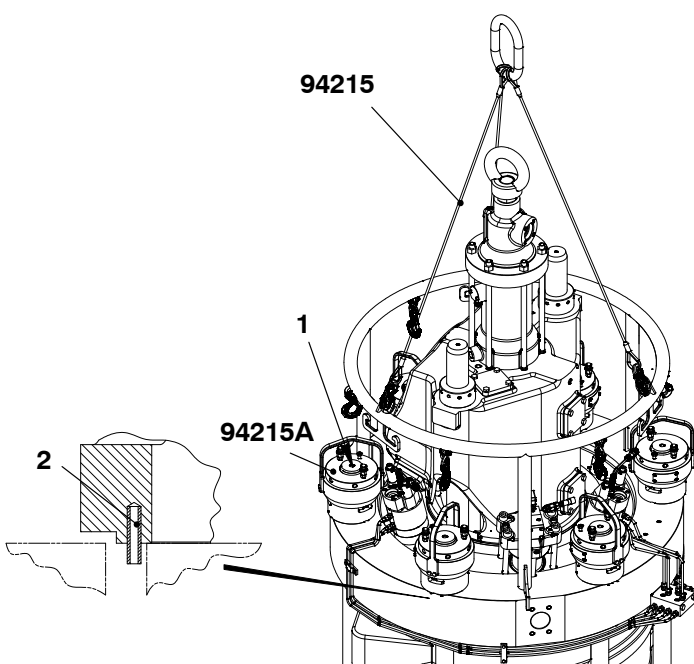


Fig.3

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

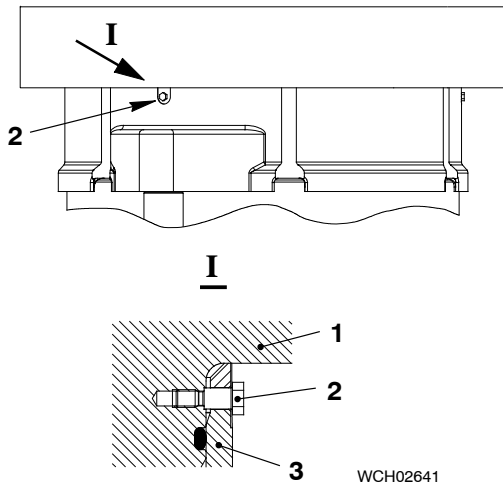


Fig.4

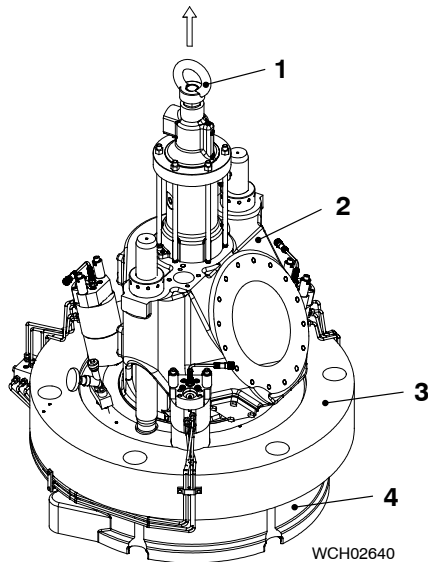


Fig.5

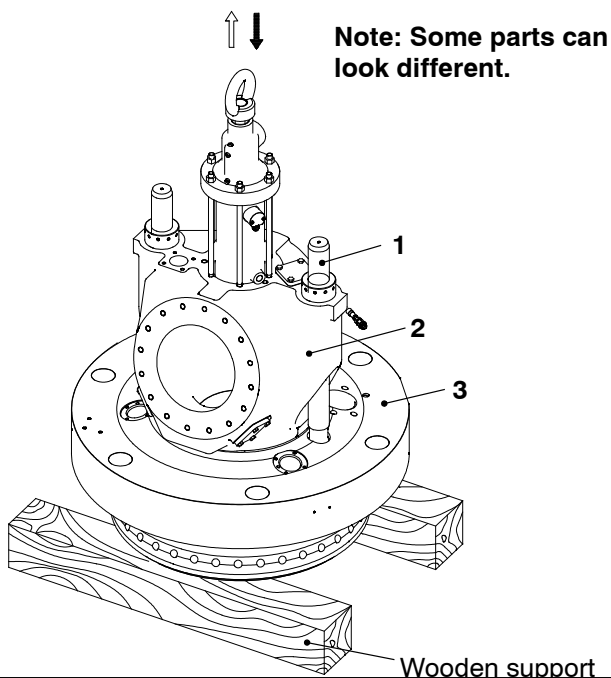



Fig.6

CAUTION



Injury Hazard: The weight of the cylinder cover, top water guide jacket and exhaust valve is 2252 kg. Use the correct equipment for removal.

- 1) Remove the three screws (2, Fig.4) to loosen the top water guide jacket (3).

WARNING



Injury Hazard: Heavy parts can fall down. Do not stand under the hanging parts. Injury to personnel can occur. Heavy parts can crush body parts. Always use correct personal protective equipment.

- 2) Attach the engine room crane to the eye bolt of the exhaust valve (1, Fig.5).
- 3) Lift the cylinder cover (3), exhaust valve (2) and the top water guide jacket (4).
- 4) Place a wooden support on the top of the main platform.
- 5) Operate the crane to move the cylinder cover (3, Fig.6) with exhaust valve (2) above the wooden support.
- 6) Operate the engine room crane to lower the cylinder cover (3) and exhaust valve (2) on to the wooden support.
- 7) Remove the round nuts from the elastic studs (2), refer to 9403-4.
- 8) Attach the engine room crane to the eye bolt (1, Fig.7).

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

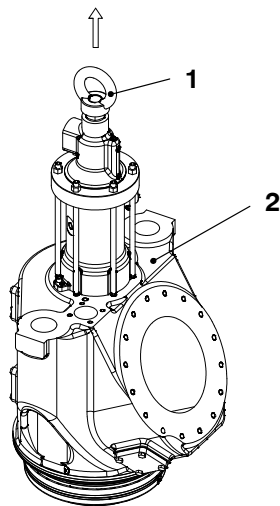


Fig.7

- 9) Operate the engine room crane to lift the exhaust valve (2, Fig.7). Make sure that the cylinder cover stays on the wooden supports.
- 10) Operate the engine room crane to move the exhaust valve (2) to an applicable area.
- 11) Carefully lower the exhaust valve (2, Fig. 6) on to a wooden support.
- 12) Disconnect the engine room crane from the eye bolt (1).

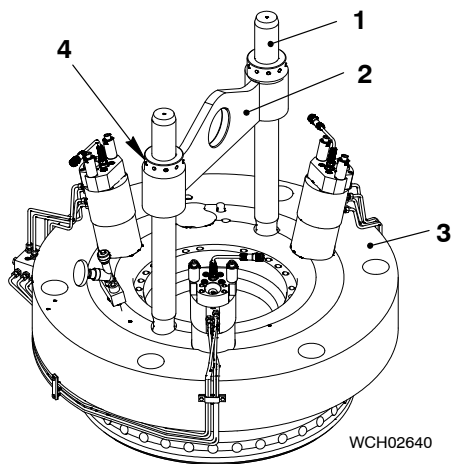


Fig.8

- 13) Operate the engine room crane to lower the suspension device (34.9 kg) (2, Fig.8) on to the elastic studs (1).
- 14) Attach the round nuts (4) to the elastic studs (1).
- 15) Operate the engine room crane to move the cylinder cover (3) to an applicable area.

Note: Some parts can look different.

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

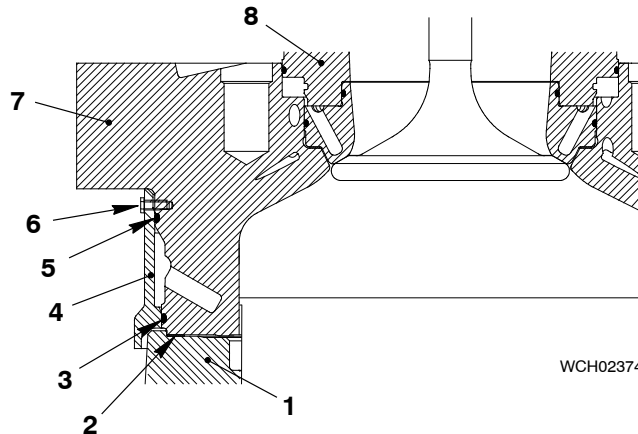


Fig. 9

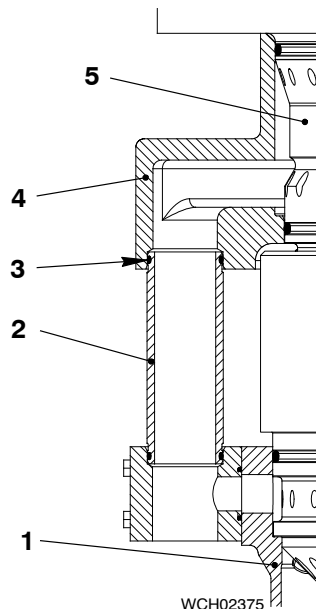


Fig. 10

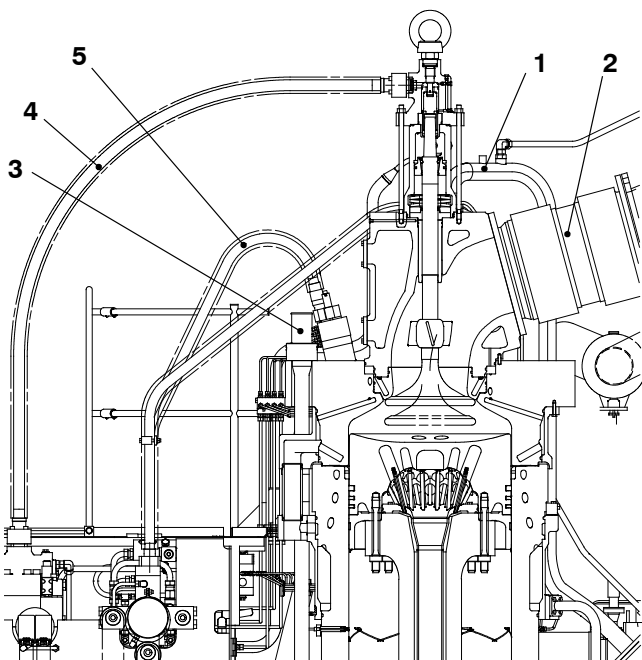


Fig. 11

- 1) Clean all sealing surfaces of the cylinder cover and O-ring grooves.
- 2) Apply oil to the new O-rings (3, Fig.9).
- 3) Install the new O-rings (3).
- 4) Operate the engine room crane to lift and lower the cylinder cover (7) on to the top water guide jacket (4).
- 5) Tighten the screws (6).
- 6) Install the exhaust valve (8), refer to 2751-1, paragraph 3.
- 7) Clean the seating surface of cylinder liner (1)
- 8) Attach a new soft joint ring (2) to the cylinder liner (1).
- 9) Apply oil to new O-ring (3, Fig.10)
- 10) Attach the new O-ring (3) to the transition tube (2).
- 11) Lift the cylinder cover (5) refer paragraph 3
- 12) Clean the bottom seating surfaces.

WARNING	
	<p>Injury Hazard: Heavy parts can fall down. Do not stand under the hanging parts. Injury to personnel can occur. Heavy parts can crush body parts. Always use correct personal protective equipment.</p>

- 13) Operate the engine room crane to move the cylinder cover (5) above the cylinder liner (1). Make sure that you align the transition tube (2) with the bore in the water guide jacket (4).
- 14) Operate carefully the engine room crane to lower the cylinder cover (5) on to the water guide jacket (4). Make sure that the transition tube goes into the bore of the water guide jacket (4).
- 15) Clean the threads of the elastic studs (3, Fig.11)
- 16) Apply oil to threads of the elastic studs.
- 17) Install the round nuts to the elastic studs (3), refer to 9403-4.
- 18) Install the hydraulic pipe (4), refer to: 8460-1.
- 19) Install the three HP fuel pipes (5), refer to 8733-1.

- 20) Attach the cooling pipe (1).
- 21) Install the expansion piece (2) with the slings, refer to [2751- 1](#).
- 22) Attach the air pipe to the cylinder cover.
- 23) Connect all other connections to the cylinder cover and to the exhaust valve.
- 24) Do a leak test
- 25) Set to on the cooling water pump.

Cylinder Cover

Sealing Face - Grind

Tools:

- 1 Grinding device 94270-1 1 Stencil

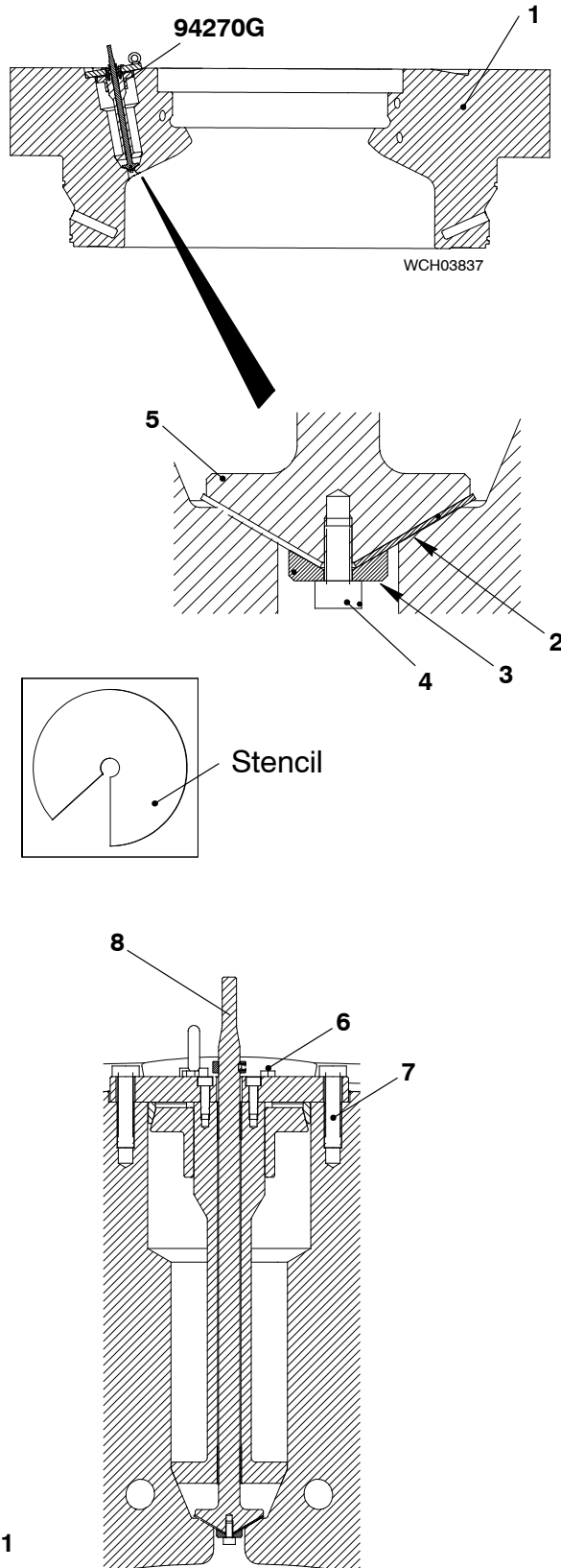


Fig. 1

1. General

The sealing face in the cylinder cover for the injection valve must be clean and have no damage.

WARNING



Injury Hazard: Heavy parts can fall down. Do not stand under the hanging parts. Injury to personnel can occur. Heavy parts can crush body parts. Always use correct personal protective equipment.

2. Sealing Face

- 1) Clean the injection valve bore in the cylinder cover (1, Fig. 1).
- 2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
- 3) Put the stencil on the rear side of the emery cloth.
- 4) Use a pencil or a ball pen to make the shape.
- 5) Cut out accurately the shape from the emery cloth.
- 6) Put the shape on the cone (5).
- 7) Attach the shape to the cone (5) with the clamp ring (3) and the screw (4).
- 8) Torque the allen screw (4) to 4.0 Nm.
- 9) Carefully put the tool (94270G) into the bore.
- 10) Torque the two bolts (7) to 1.0 Nm to align the tool (94270G) in the center of the bore.
- 11) Torque the four bolts (6) to 3.5 Nm
- 12) Torque the two bolts (7) to 6.0 Nm.
- 13) Attach an electric drill to the spindle (8).
- 14) Operate the electric drill to turn the spindle (8) to grind the sealing face (2).
- 15) Make sure that the circular marks around the sealing face are concentric.
- 16) If necessary, replace the emery cloth with a smoother grade.

- 17) Remove the tool 94270G.
- 18) Clean the injection valve bore.

Injection Valve

Injection Valve Removal and Installation

Tools:

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

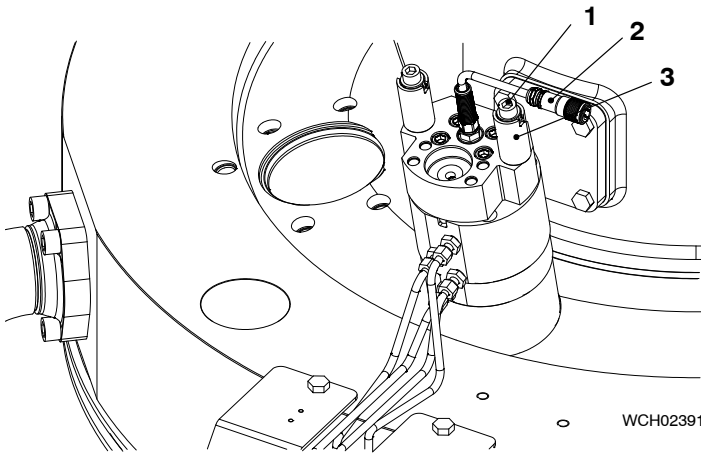


Fig. 1 Note: Some parts can look different.

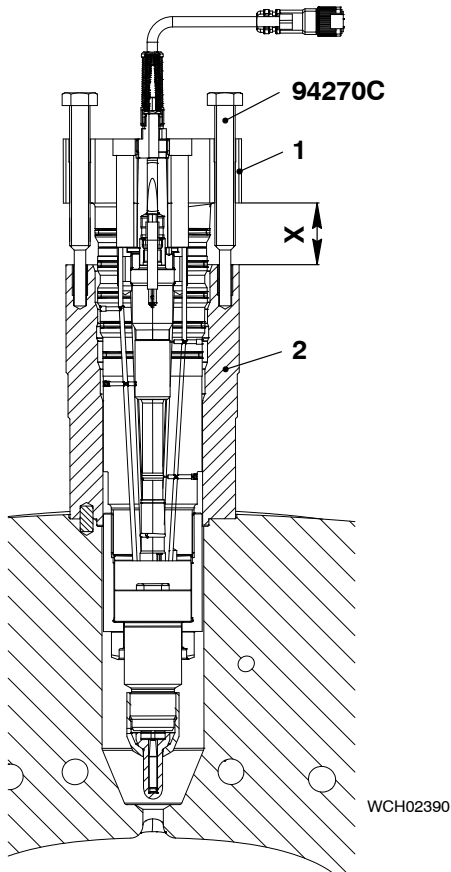



Fig. 2

1. Removal of injection valve

- 1) Remove the HP fuel pipe, refer to 8733 1.
- 2) Disconnect the cable (2, Fig. 1) from the terminal box 95.4.
- 3) Make sure that the cooling for the injection valve is stopped, refer to operation manual 8016 1, chapter 3.
- 4) Remove the screws (1) and 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 (2)
- 7) Turn the two bolts equally to lift the injection valve.
- 8) Remove the injection valve.

2. Storage and handling

CAUTION	
	<p>Injury Hazard: When you do work with white spirit, always put on gloves and safety goggles that have a closed side frame. White spirit can cause damage to your skin and eyes.</p>

- 1) Apply protection to the nozzle tip.
- 2) Be careful when you move the injection valve.
- 3) Use white spirit to clean to the injection valve (eg Shellsol TD, Shellsol T or Solvent FP68).
- 4) Put the injection valve in an applicable package.

Note: Do not remove an injection valve from its package before installation.

- 5) Keep the injection valve in a clean, dry area that has no contamination.

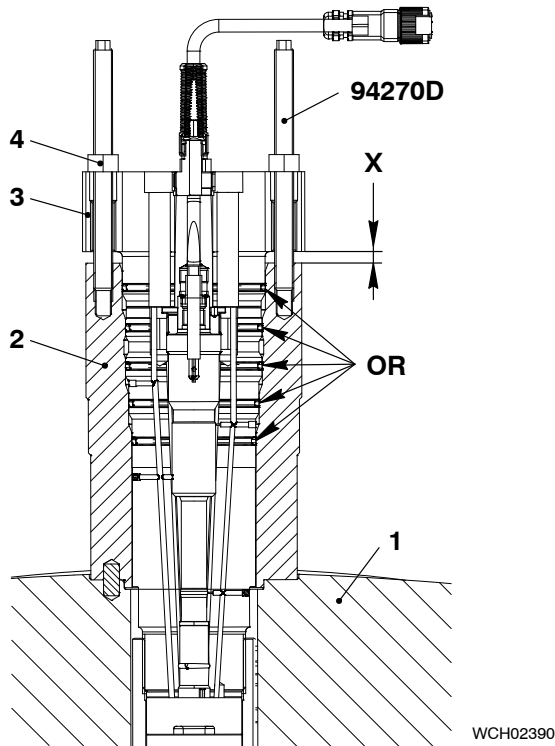


Fig. 3

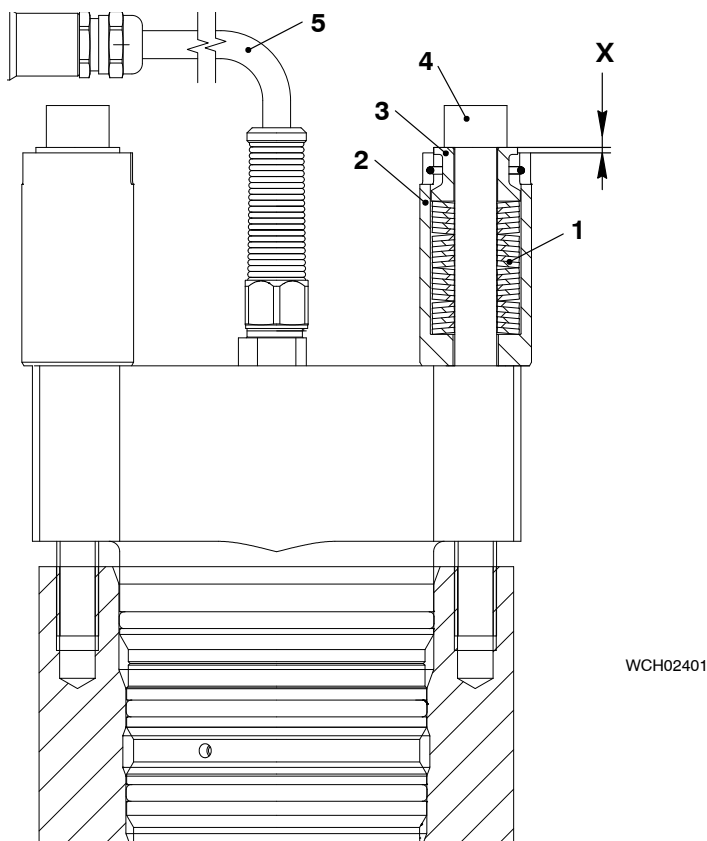


Fig. 4

3. Installation

WARNING



Injury and Damage Hazard:
Do not use copper paste in this procedure. Copper paste can be a conductor of electricity. Injury to personnel and damage to equipment can occur.

- 1) Clean the sealing face of the cylinder cover (1, Fig 3).
- 2) Make sure that the sealing face is serviceable. If necessary, do the procedure given in 2708 3.
- 3) Put oil on the five new O rings (OR).
- 4) Put the five O rings in their correct position.

Note: The five O-rings are part of the spare parts set for the injection valve.

- 5) Put the injection valve (3) carefully into the valve bush (2).
- 6) Put the two stud bolts (94270D) and nuts (4) in position as shown in Fig 3.
- 7) Turn equally the two nuts (4) to push the injection valve.

Note: When the injection valve is installed correctly the distance $X = 7.2$ mm.

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

Injection Valve

Installation of Injection Valve with FAST

1. General	1
2. Installation	2

1. General

Inspect the Injector seat in the cylinder cover.

Check the spring pack height (must be according [Fig.1](#)).If a spring pack is not according to the requirements and it is the only available spring pack, the same tightening instructions are to be followed. The old spring pack must be repaired or replaced as soon as you get the new spring pack.

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.

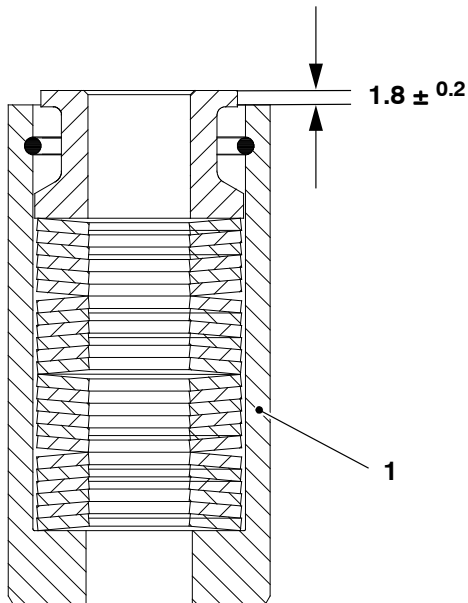


Fig. 1

2. Installation

Remove and discard the old O-rings.

2 Install new O-rings (3, Fig.2).

Put oil on the new O-rings

Make sure that the work station is clean.

Carefully position the injector valve assembly (4) into the chamber.

Apply a thin layer of Never Seez on the threads of two M12 Hexagon socket head cap screw (2).

Tighten the screws in two steps:

Equally tighten the screws spring guides are flush with each other.

Check the screws are tightened to at least 35 Nm.

Connect the injector cable in the terminal box.

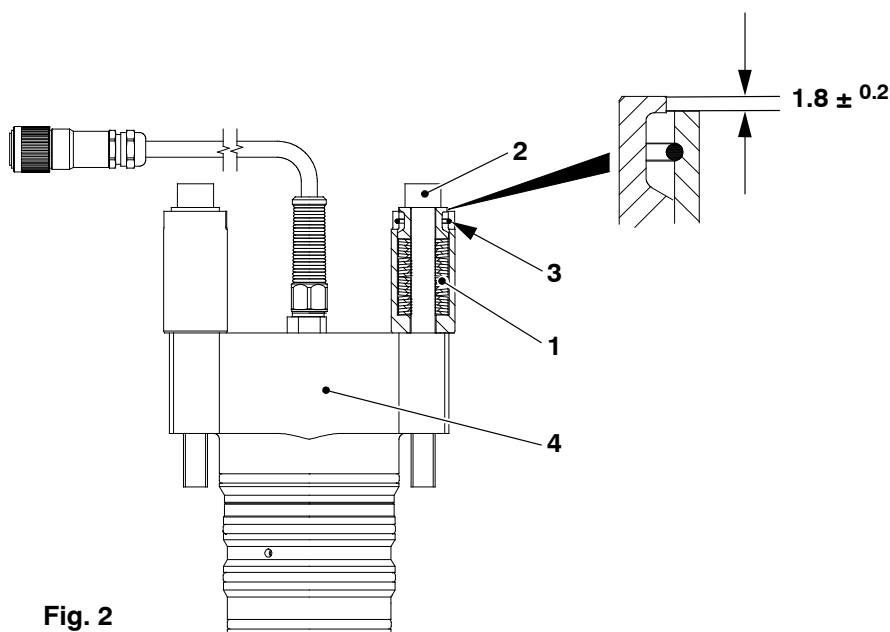


Fig. 2

Starting Air Valve

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.
 - a) Turn the handwheel of the starting air shut-off valve 30-4325_E0_1 to the position CLOSED.
 - b) Open the ball valves 30-8605_E0_6 and 30-8605_E0_7 to release the pressure (for more data, refer to the Operation Manual 4003 2 Control Diagram, Page 1 and 4003 5 Air Systems).
- 4) Remove the control air pipe from the starting air valve.

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

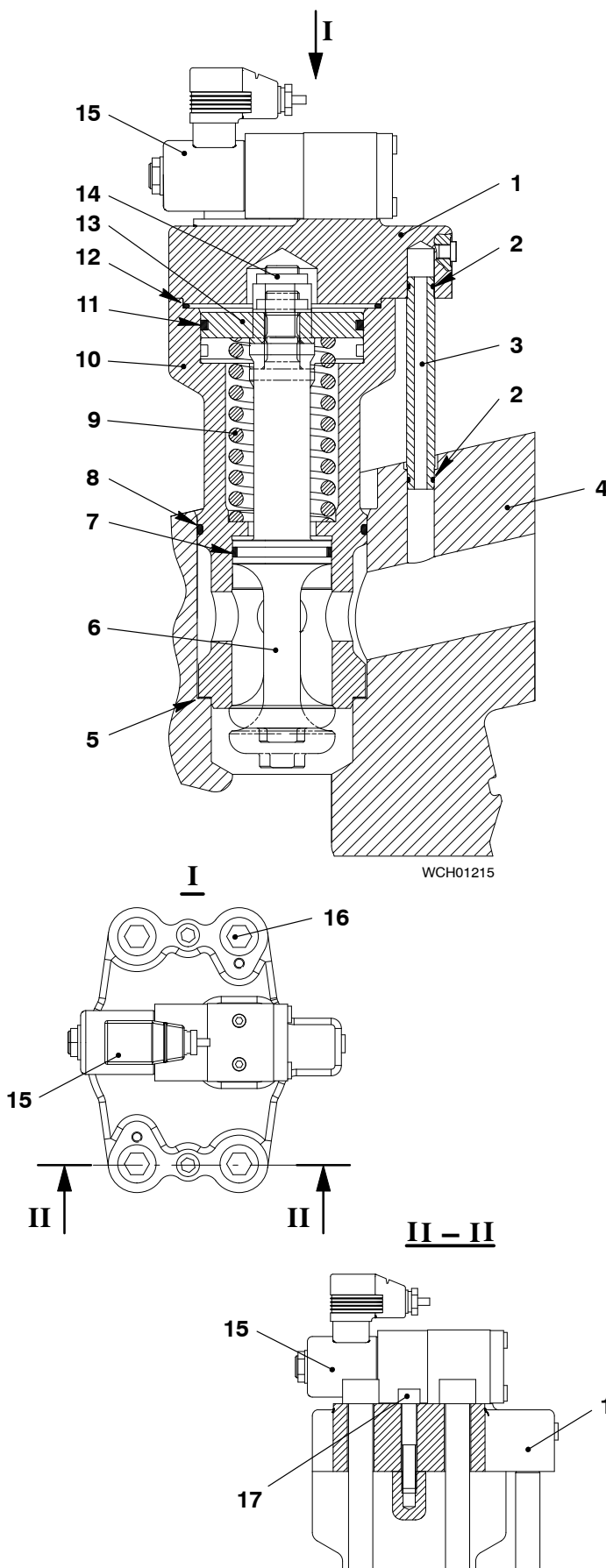


Fig. 1

3. Removal

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

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 an 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 cause damage to the starting air valve.

2) Remove the two screws (17).

3) Remove the cover (1) together with the 3/2-way solenoid valve (15).

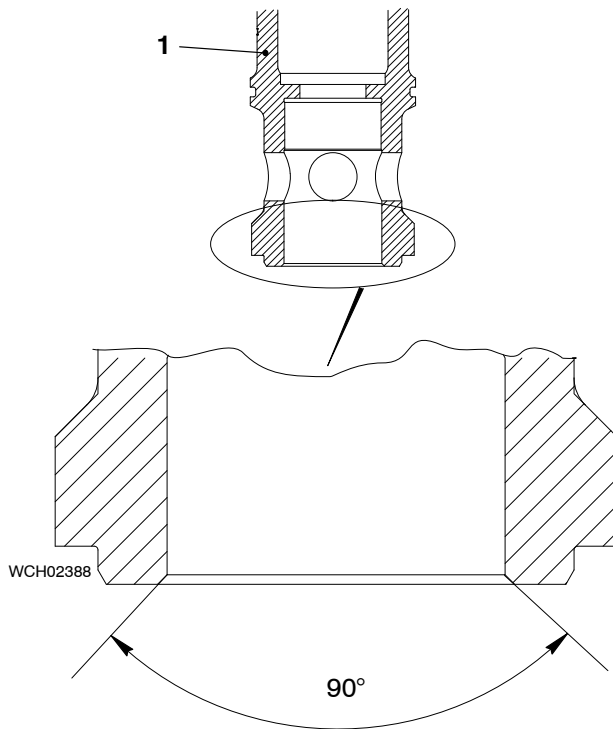
4) Remove the self-locking nut (14).

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).



5. Grinding

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

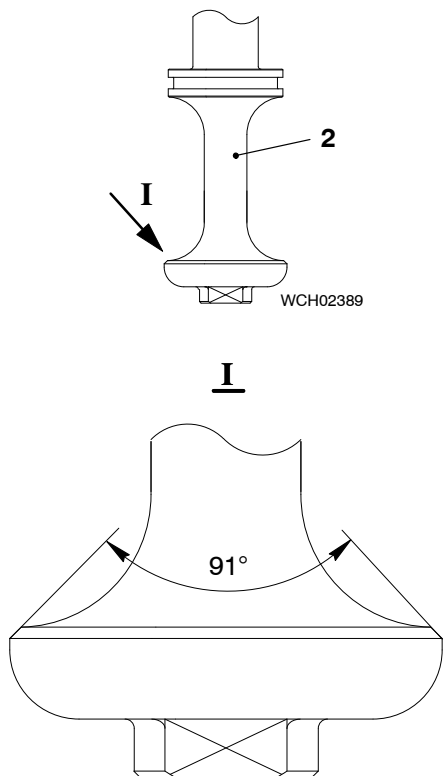


Fig. 2

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

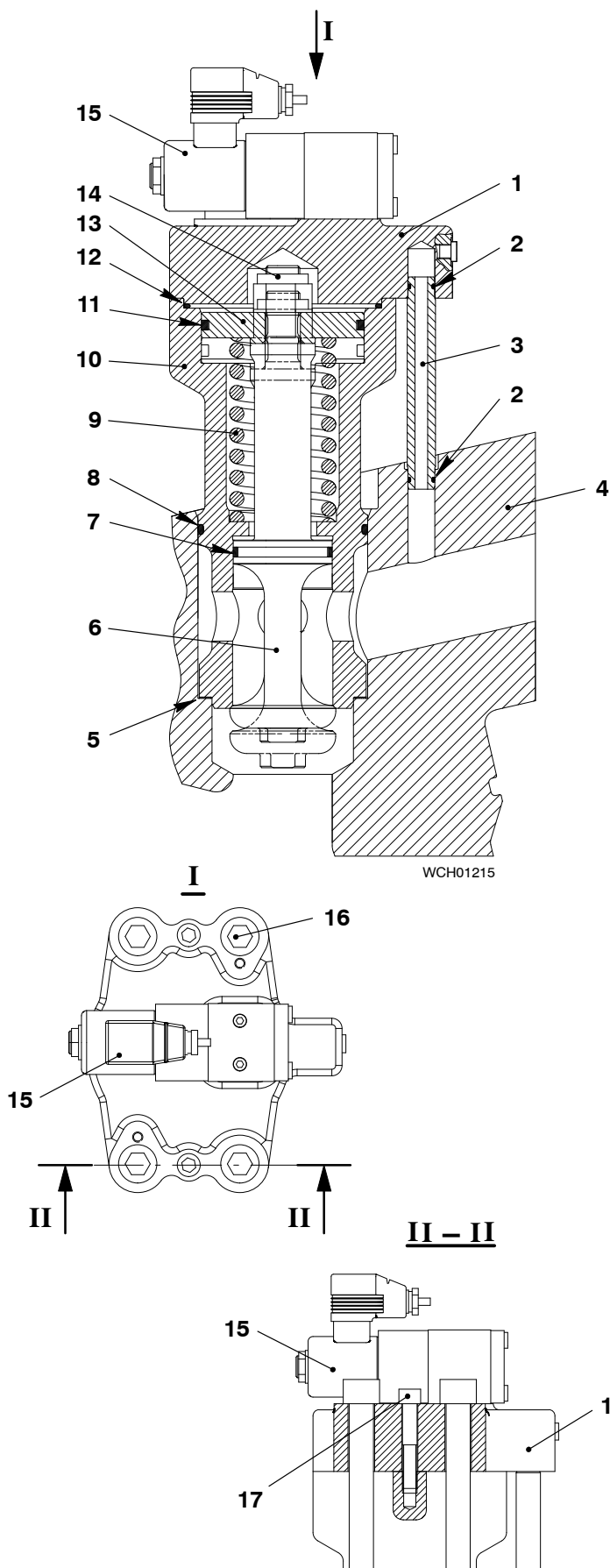


Fig. 3

6. Assemble

- 1) Clean all the parts of the starting air valve.
- 2) Put a small quantity of oil on all the parts and the new O-rings (2, 8 and 12, Fig. 3)
- 3) Put the two O-rings (2) on the pipe (3).
- 4) Put the 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 apply 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 (6).
- 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) inside the cover (1).

7. Installation

- 1) Put a new gasket (5) in the bore in cylinder cover (4).
- 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) Place the four screw inside 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 (refer to [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.

Note: A relief valve cannot be repaired nor adjusted after a blow-off

Relief valves require no maintenance, however you must do a check at each engine overhaul. Valves that have damage, or leak must be returned to the manufacturer for inspection and repair.

2. Preparation

- 1) Stop the engine.

Relief Valve: Blow-off Pressure Check

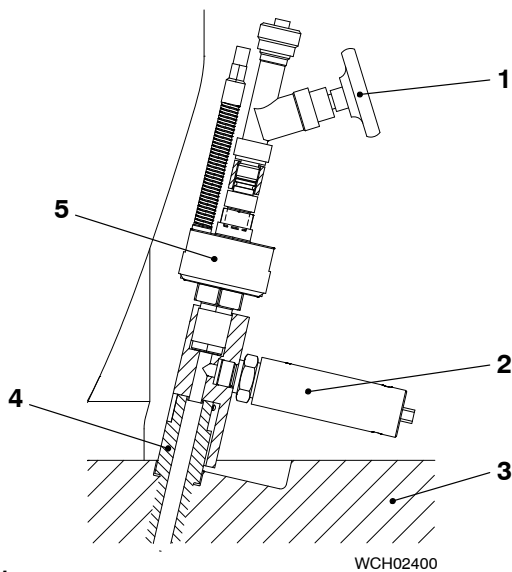


Fig. 1

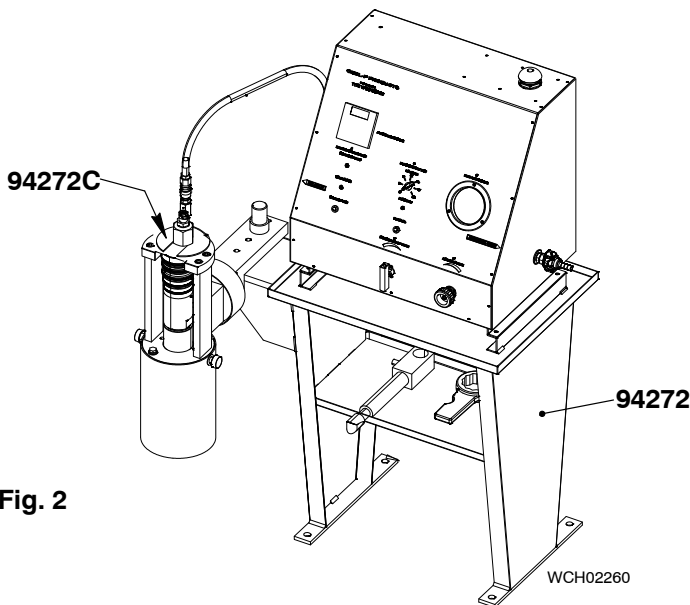


Fig. 2

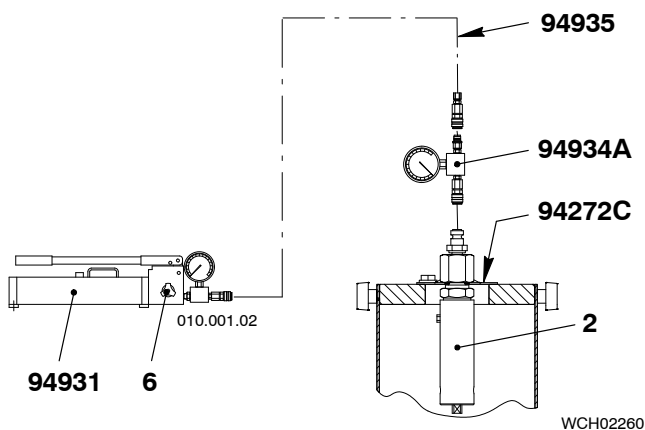


Fig. 3

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 gauge (94934A).
- 3) Connect the pressure gauge 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, refer to the Operation Manual 8017 1, paragraph 3.1 step 1).
- 2) Close the air inlet to the air spring at the control air supply.
- 3) Remove the hydraulic pipe (6, Fig. 1) from the related exhaust valve, refer to 8460 1, paragraph 1 and paragraph 2.
- 4) Remove the the cooling water pipe (2).
- 5) Remove the the oil drain pipe (1).
- 6) Remove the air supply pipe from the air spring (4).

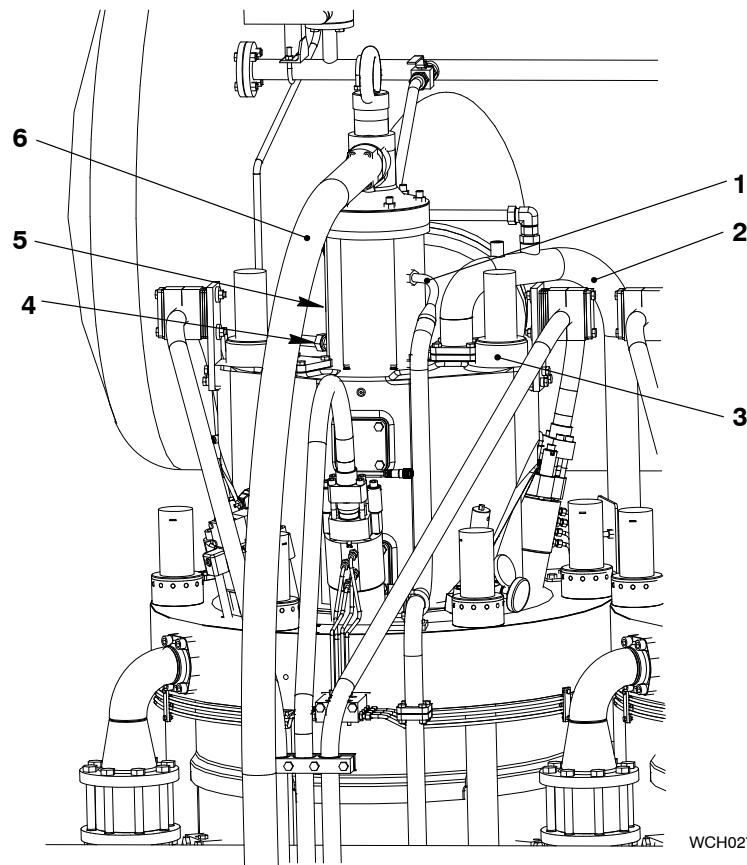
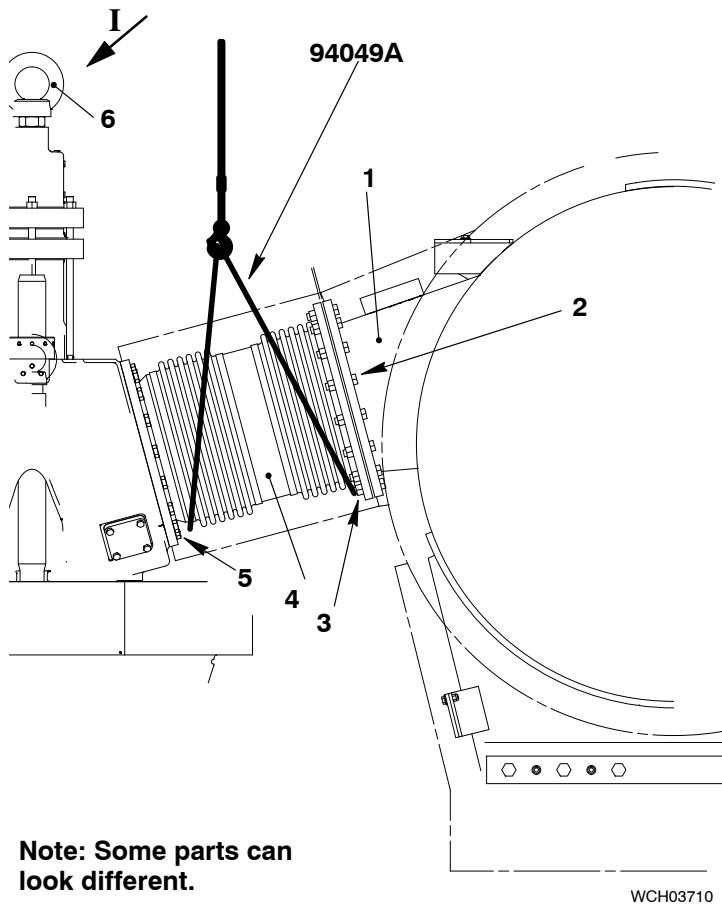


Fig. 1

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Note: Some parts can look different.

Exhaust Valve Removal and Installation



2. Removal

- 1) Remove the two round nuts (3), refer to the procedure given in 9403 4, paragraph 1 and paragraph 2.
- 2) Disconnect the electrical connection (7) from the valve stroke sensor.
- 3) Put the slings (94049A, Fig. 2) in position on the expansion piece (4) as shown.
- 4) Attach the slings (94049A) to the engine room crane.
- 5) Operate the crane to put a light tension on the slings (94049A).
- 6) Remove the 16 screws (5).
- 7) Remove the 16 nuts (3) and the bolts (2).
- 8) Move the expansion piece (4) to one side.
- 9) Lower the expansion piece (4) on to an applicable surface.
- 10) Attach the engine room crane to the eye bolt (6).

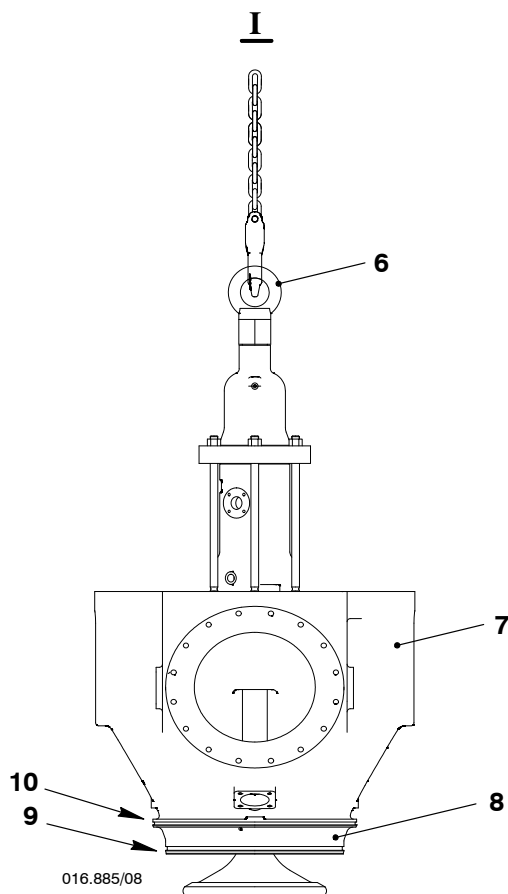


Fig. 2

- 11) Operate the crane to lift the exhaust valve (7) from the cylinder cover.
- 12) Carefully lower the exhaust valve (7) on to a wooden support.
- 13) Remove and discard the O-rings (9, 10) from the valve cage (8)

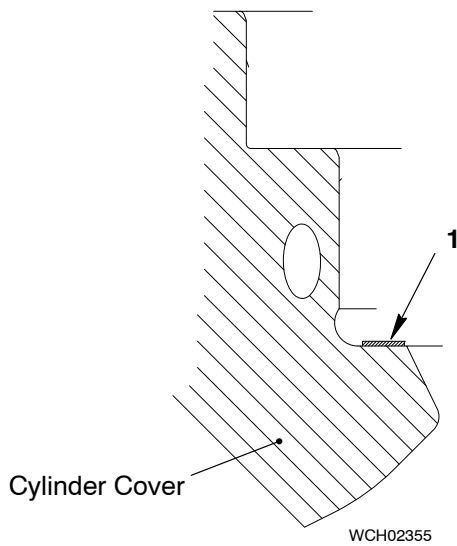


Fig. 3

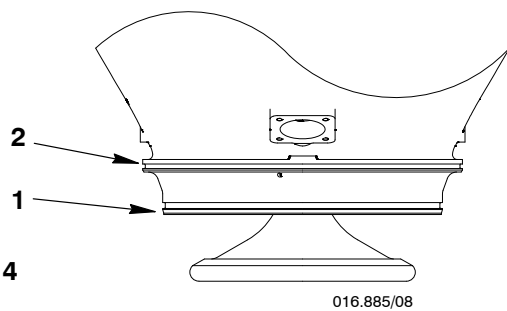


Fig. 4

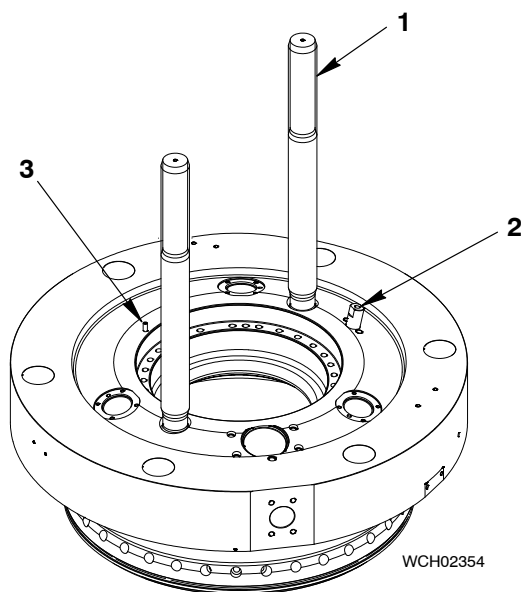


Fig. 5

3. Installation

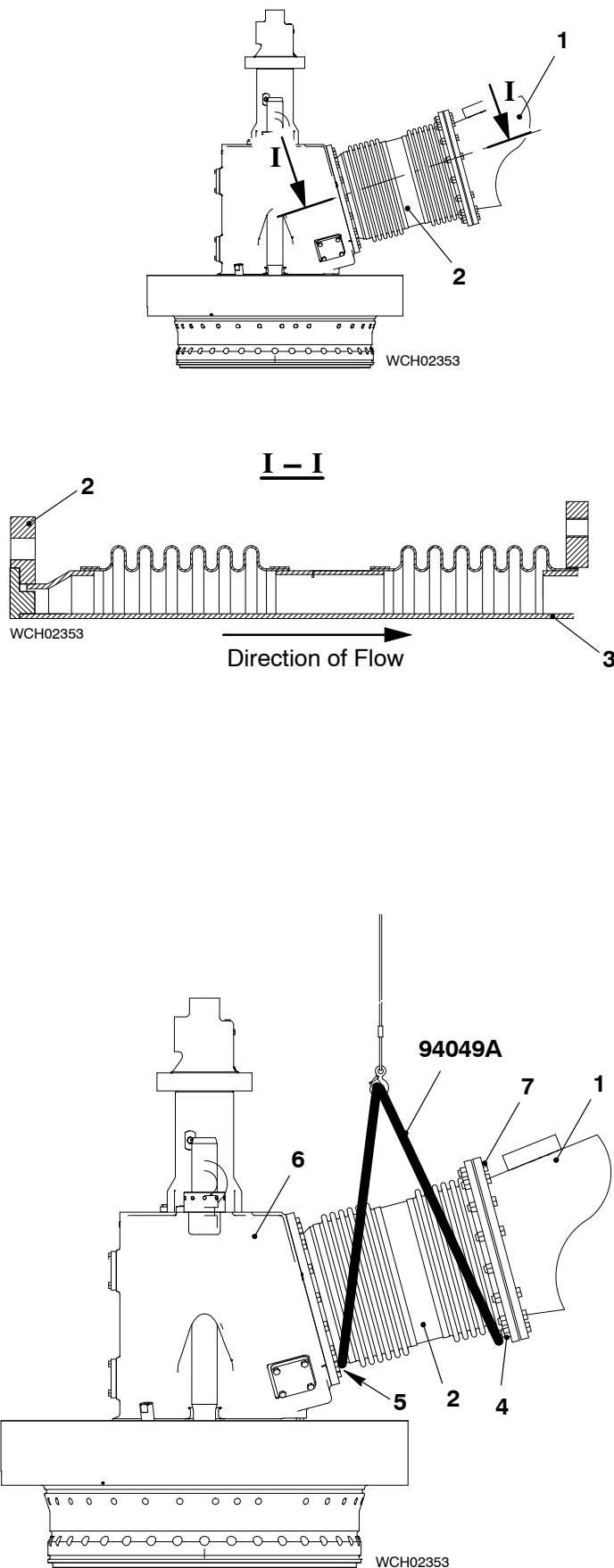
- 1) Clean all the sealing surfaces of the exhaust valve and the cylinder cover.
- 2) Examine the sealing surfaces of the exhaust valve and cylinder cover for damage.
- 3) Remove the 2.0 mm metal gasket (1, Fig. 3) from the cylinder cover.
- 4) Clean the the 2.0 mm metal gasket (1).
- 5) Examine the 2.0 mm metal gasket (1) for damage. Make sure that the dimension of the metal gasket is correct.
- 6) If the 2.0 mm metal gasket (1) has damage, or the dimension is not correct, replace the gasket.
- 7) Put the 2.0 mm gasket (1) in position in the cylinder cover.
- 8) Put a thin layer of oil on the new O-rings (1 and 2, Fig.4).
- 9) Put the new O-rings on the valve cage.
- 10) Attach the lifting tool (94209) to the eye bolt (13, Fig. 2).
- 11) Operate the crane to lift the exhaust valve.

Note: When you do step 12), make sure that you do not damage the threads of the elastic studs (1, Fig. 5).

- 12) Carefully lower the exhaust valve into the correct position in the cylinder cover. The cylindrical pin (2) in the cylinder cover will help you get the correct position.
- 13) Install the round nuts, refer to the procedure given in 9403 4, paragraph 1 and paragraph 3.

Note: Some parts can look different.

Exhaust Valve Removal and Installation



- 14) Clean the sealing surfaces of the expansion piece (2, Fig. 6) and the related faces on the valve cage and exhaust pipe (1).
- 15) Apply a thin layer of lubricant, that is resistant to heat, to the sealing faces and the screws (5, 7).
- 16) Put the slings (94049A) in position on the expansion piece (2).
- 17) Attach the slings (94049A) to the engine room crane.
- 18) Operate the crane to lift the expansion piece (2).
- 19) Put the expansion piece (2) in the correct position between the valve cage (6) and the exhaust pipe (1). Make sure that the direction of flow is correct (refer to view I-I).
- 20) Lock the expansion piece (2) in position with the 16 screws (5, 7) and the 16 nuts (4).
- 21) Remove the slings (94049A).

Fig. 6

Note: Some parts can look different.

4. Completion

- 1) Connect the electrical connection (5, Fig. 7) to the valve stroke sensor.
- 2) Open the air inlet to the air spring (4) at the control air supply.
- 3) Install the applicable hydraulic pipe (6) to the exhaust valve, refer to 8460 1, paragraph 5.
- 4) Connect the air inlet pipe to the air spring supply (4).
- 5) Connect the cooling water pipe (2).
- 6) On the applicable cylinder, fill the cylinder cooling water.
- 7) Open the valves you closed before (one valve each time) and do a check for leaks.

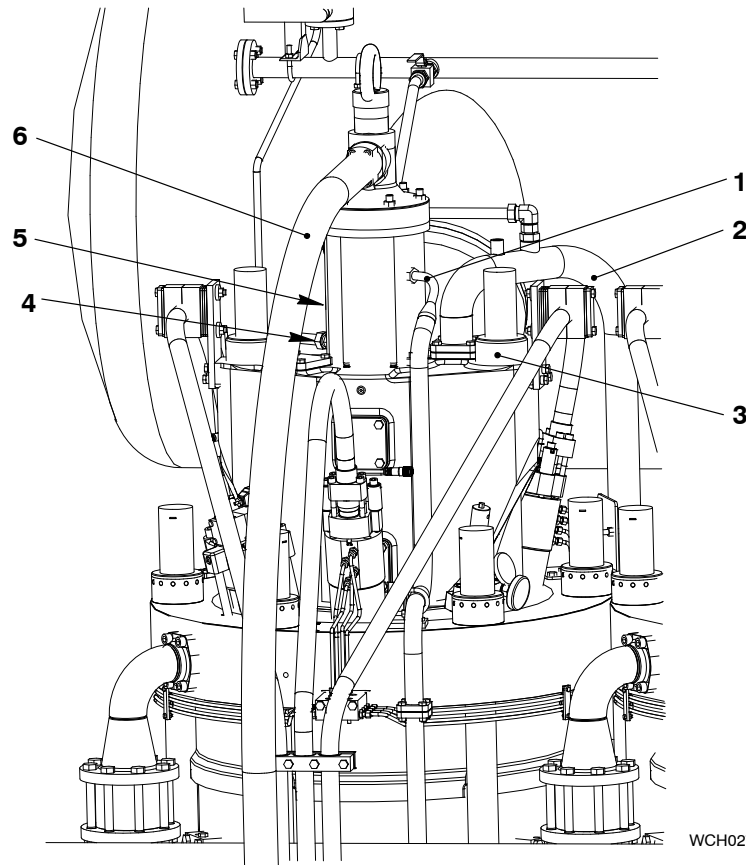


Fig. 7

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Note: Some parts can look different.

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Exhaust Valve

Disassemble and Assemble

Tools:

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

- 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

The International Association of Classification Societies (IACS) recommends that there are two exhaust valves on board.

Only qualified personnel can repair defective exhaust valves.

For the inspection and overhaul intervals, refer to 0380 1, [Exhaust valve](#).

Read the data in 0012 1 General Guidelines for Lifting Tools.

WARNING

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

CAUTION

Injury Hazard: The weight of the valve cage is approximately 830 kg. Always use the correct equipment to lift and move the valve cage. This will prevent injury to personnel.

Note: Make sure that the work area is clean.

Exhaust Valve: Disassemble and Assemble

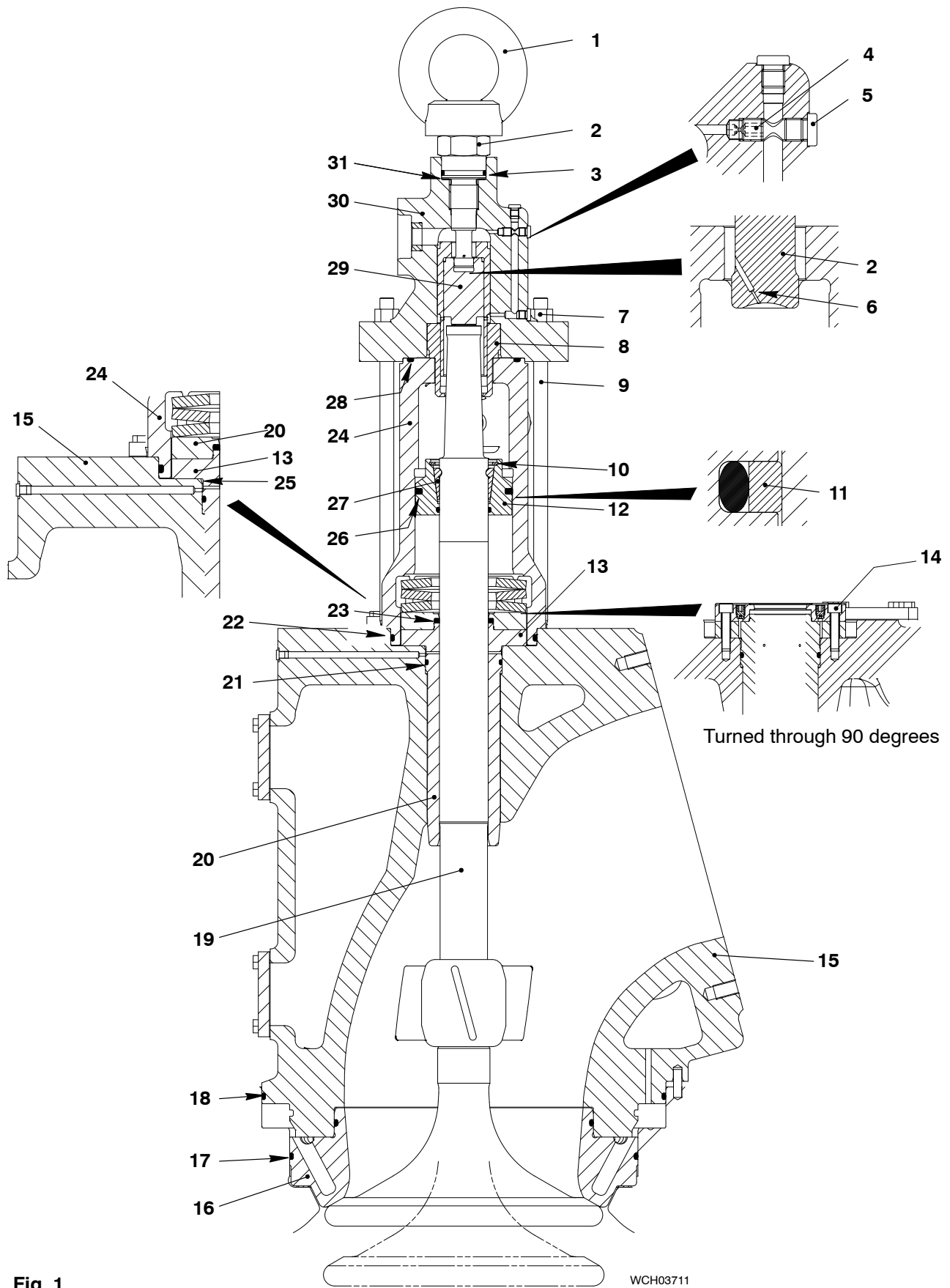
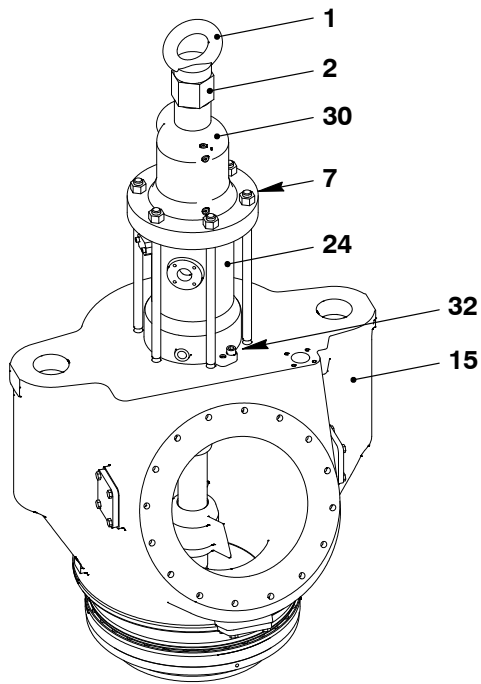


Fig. 1

Exhaust Valve: Disassemble and Assemble



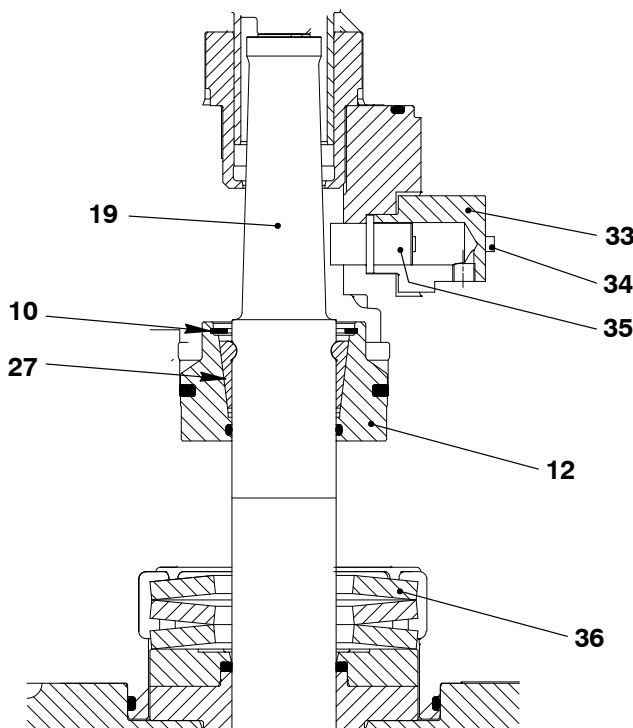
2. Exhaust Valve – Disassemble

2.1 Valve Drive – Disassemble

- 1) Attach the lifting tool (94209) to the crane and the eye bolt (1, Fig. 2).
- 2) Remove the six nuts (7).
- 3) Operate the crane to remove the top housing (30).
- 4) Disconnect the electrical connection from the valve stroke sensor (35).
- 5) Remove the two screws (34).
- 6) Remove the transmitter housing (33).
- 7) Remove the valve stroke sensor (35).
- 8) Remove the six cap screws (32).
- 9) Remove the bottom housing (24).

2.2 Valve Spindle – Remove

- 1) Remove the circlip (10).
- 2) Push the piston (12) up, then remove the valve cotters (27).
- 3) Remove the piston (12) from the valve spindle (19).
- 4) Remove the cup springs (36).
- 5) Use the lifting tool (94209) and the crane to lift the valve cage (15) to the top of the valve spindle (19). Make sure that the valve spindle does not move.
- 6) Lower the valve cage (15) on applicable surface.



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Fig. 2

Exhaust Valve: Disassemble and Assemble

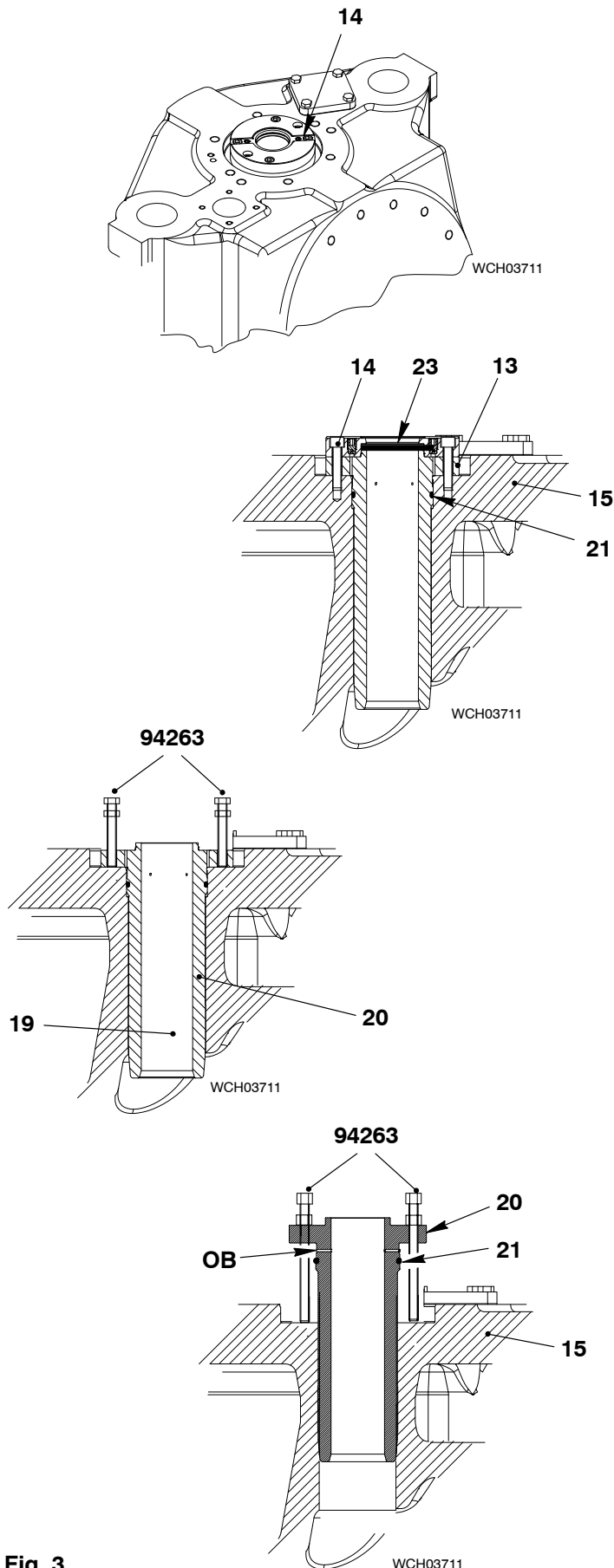


Fig. 3

2.3 Guide Bush – Removal

- 1) Remove the four screws (14, Fig. 3).
- 2) Remove the spacer (13).
- 3) Remove and discard the rod seal (23).
- 4) Put the jack screws (94263) into the flange of the guide bush (20).
- 5) Turn the jack screws (94263) to lift the guide bush from the valve spindle (19).
- 6) Remove and discard the O-ring (21).
- 7) Measure the inner diameter of the guide bush (20).
- 8) Compare the dimension with the values given in 0330 1, Exhaust Valve.

3. Exhaust Valve – Assemble

3.1 Guide Bush – Installation

- 1) Clean the bore in the valve cage (15).
- 2) Clean the bore in the guide bush (20).
- 3) Make sure that the oil bores (OB) in the guide bush (20) are clear.
- 4) Install a new O-ring (21).
- 5) Put oil on the guide bush (20).
- 6) Put the guide bush (20) in position in the valve cage (15).
- 7) Use the jack screws (94263) to push the guide bush fully into the valve cage (15).

Exhaust Valve: Disassemble and Assemble

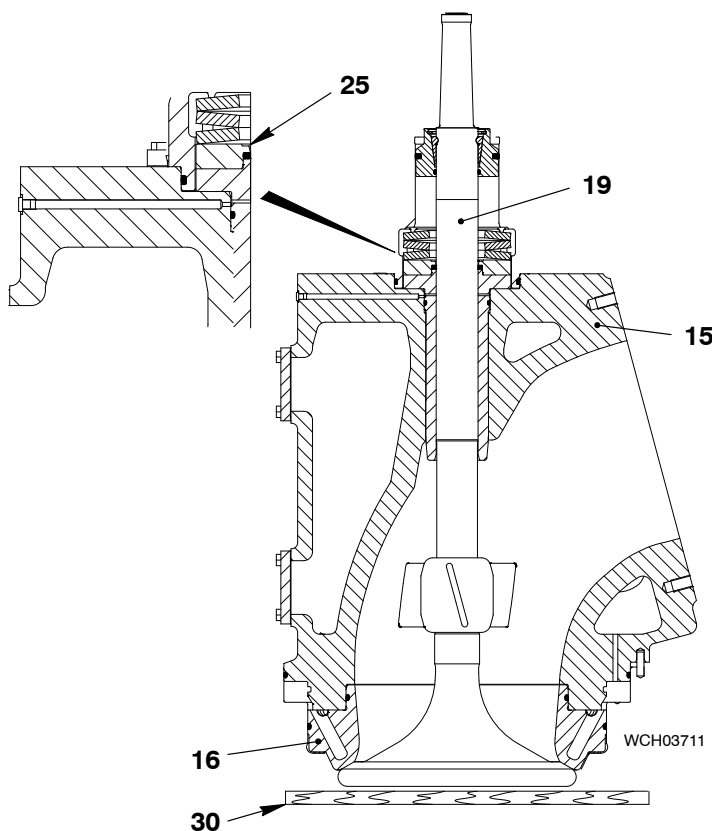
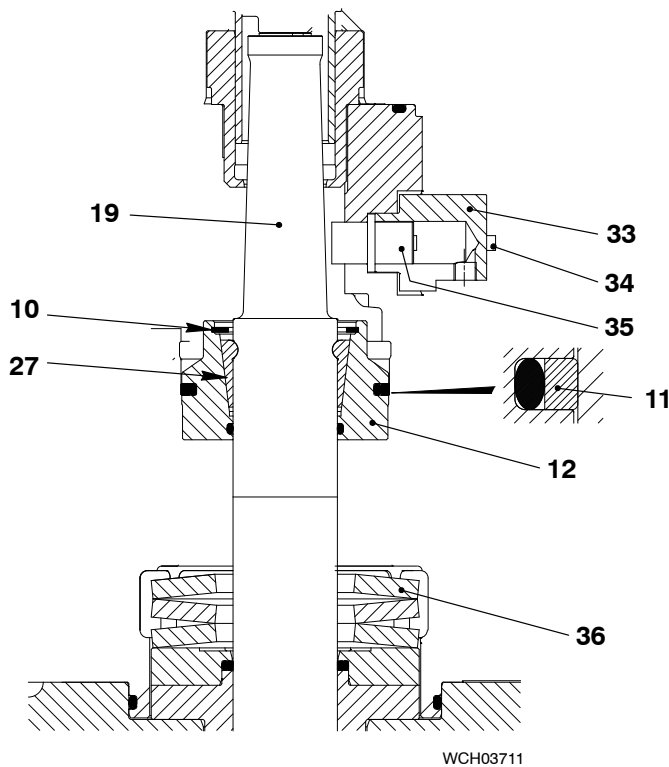


Fig. 4

3.2 Valve Spindle – Installation

- 1) Measure the dimensions of the valve spindle (19, Fig. 4).
- 2) Compare the values with those given in 0330 1, Exhaust Valve.
- 3) Do a check of the piston seal ring (11) for damage. If you find damage, replace the piston seal ring.
- 4) Replace all O-rings.
- 5) Put oil on the valve spindle (19).
- 6) Use the two M20 eye bolts and two ropes or the lifting tool (94209) to lift the valve cage to the top of the valve spindle (19). Make sure that the valve spindle does not move.
- 7) Carefully lower the valve cage over the valve spindle. Make sure that you do not damage the guide bush.
- 8) Put oil on the new rod seal (23).
- 9) Put the new rod seal (23) in position on the valve spindle (19, Fig. 3).
- 10) Before you install a new piston seal ring (11, Fig. 4), do as follows:
 - a) Put the new piston seal ring in very hot water for some minutes.
 - b) Carefully put the piston seal ring in the correct position on the piston (12).

3.3 Valve Drive – Assemble

- 1) Push the valve spindle (19) against the valve seat (16).
- 2) Install the cup springs (36).
- 3) Put the piston (12) in position on the valve spindle (19).
- 4) Attach the valve cotters (15) to the valve spindle (19) with the circlip (10).
- 5) Attach the lifting tool (94209) to the valve cage (27) and the crane.
- 6) Operate the crane to lift the valve cage (1) to the vertical position.
- 7) Lower the valve cage (15) on to a suitable wooden underlay (30).
- 8) Remove the lifting tool (94209) from the valve cage (15).
- 9) Fill the oil bath (25) with system oil.

Exhaust Valve: Disassemble and Assemble

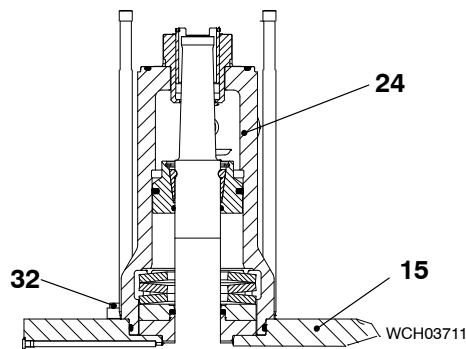


Fig. 5

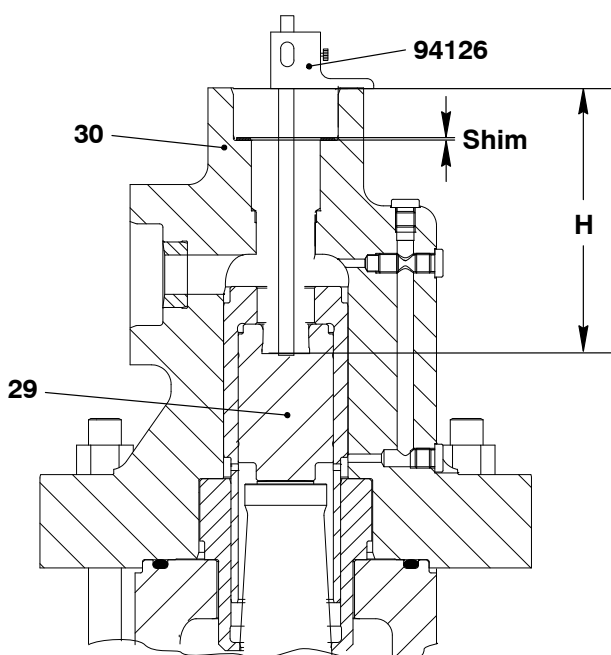
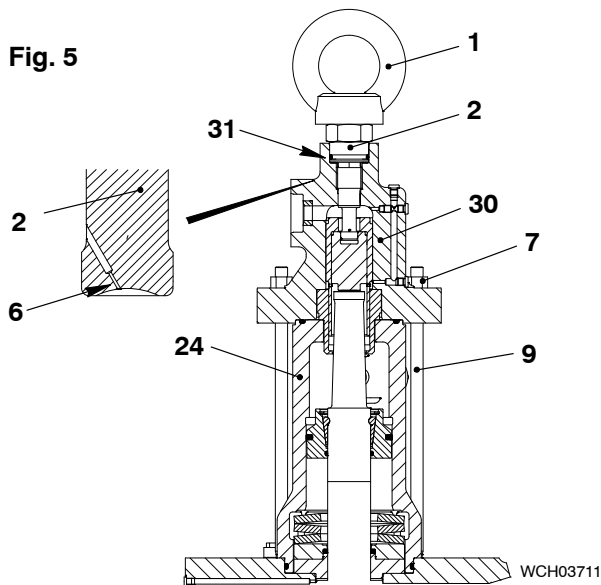


Fig. 6

- 10) Attach the lifting tool (94209) to the housing (24, Fig. 5) and the crane.
- 11) Lift, then lower the bottom housing (24) on to the valve cage (15).
- 12) Install the six screws (32).
- 13) Attach the lifting tool to the eye bolt (1, Fig. 6).
- 14) Lift, then carefully lower the top housing (30) on to the housing (24).
- 15) Remove the lifting tool (94209) from the top housing (30) and the crane.
- 16) Put oil on to the threads of the elastic studs (9).
- 17) Put the six nuts (7) on to the elastic studs (9).
- 18) Torque symmetrically the six nuts (7) to 290 Nm.

3.4 Damper Setting

You set the damper (2) only after you replace a valve spindle or valve seat, or after one of the seating faces is ground.

- 1) Remove the damper (2).
- 2) Make sure that the bores (6) in the damper are clear.
- 3) Make sure that the exhaust valve is closed.
- 4) Use a feeler gauge to make sure that there is no clearance between the valve plate and valve seat.
- 5) Use the depth gauge (94126) to measure the height H from the edge of the top housing (30) to the bottom of the damper bore.
- 6) Install the damper (2) and the applicable shims (31) to get the total thickness.

Note: The distance H must be a total of 165.2 ± 0.5 mm. For example, if the measured distance H is 163 mm, you must install two shims. Each shim has a thickness of 1.0 mm.

- 7) Install the correct quantity of shims to make sure that the distance is 165.2 ± 0.5 mm.

Exhaust Valve: Disassemble and Assemble

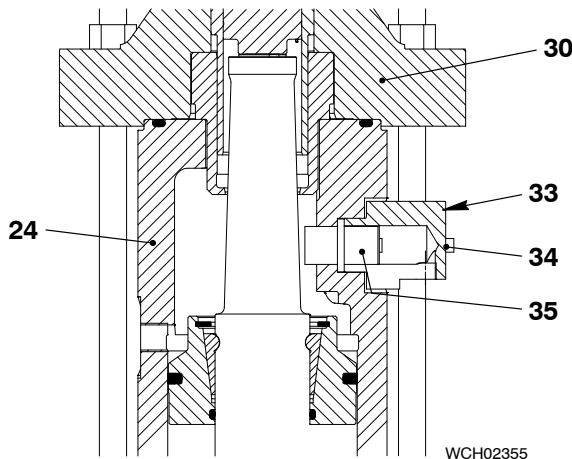


Fig. 7

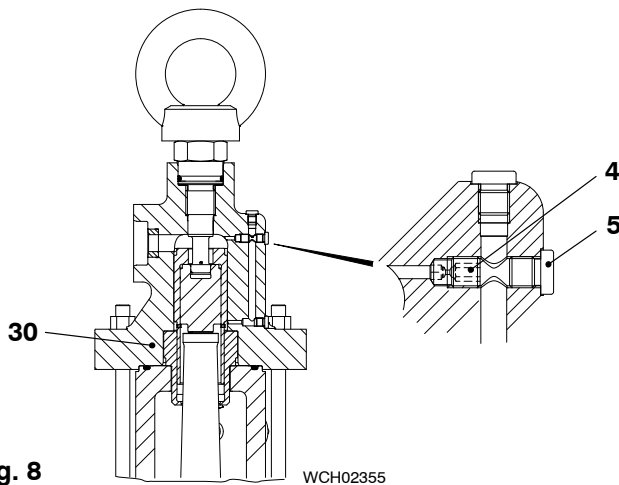


Fig. 8

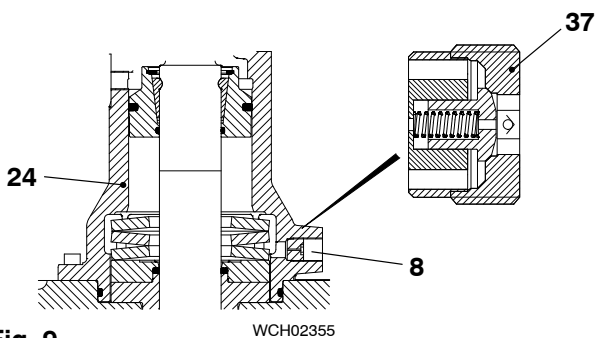


Fig. 9

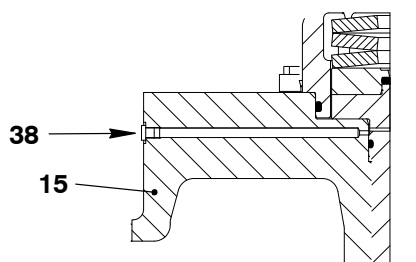


Fig. 10

3.5 Valve Stroke Sensor – Installation

- 1) Clean the parts that follow:
 - The valve stroke sensor (35, Fig. 7).
 - The transmitter housing (33).
 - The bore and collar in the housing (30).
- 2) Attach the transmitter housing (33) to the bottom housing (24) with the two screws (34).
- 3) Connect the electrical connection to the valve stroke sensor (35).

3.6 Throttle

- 1) Do a check of the throttle as follows:
 - a) Remove the screw plug (5, Fig. 8).
 - b) Remove the throttle (4).
 - c) Make sure that the throttle (4) is clear.
 - d) Put oil on the threads of the throttle (4).
- 2) Put the throttle (4) in position.
- 3) Torque the throttle (4) to 4.0 Nm.

3.7 Non-return Valve

- 1) Do a check of the non-return valve (37, Fig. 9) as follows:
 - a) Remove the non-return valve (37) from the housing (24).
 - b) Make sure that the non-return valve operates correctly.
- 2) Install the non-return valve (37) to the housing (24).

3.8 Oil Supply to Valve Guide

- 1) Make sure that the oil bore to the valve guide (38, Fig. 10) is clear.

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Exhaust Valve

Exhaust Valve
Valve Seat Removal, Grind and Installation

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 – Grind** 3
- 5. **Valve Seat – Check** 4
- 6. **Valve Seat – Installation** 5
- 7. **Completion** 5

1. General

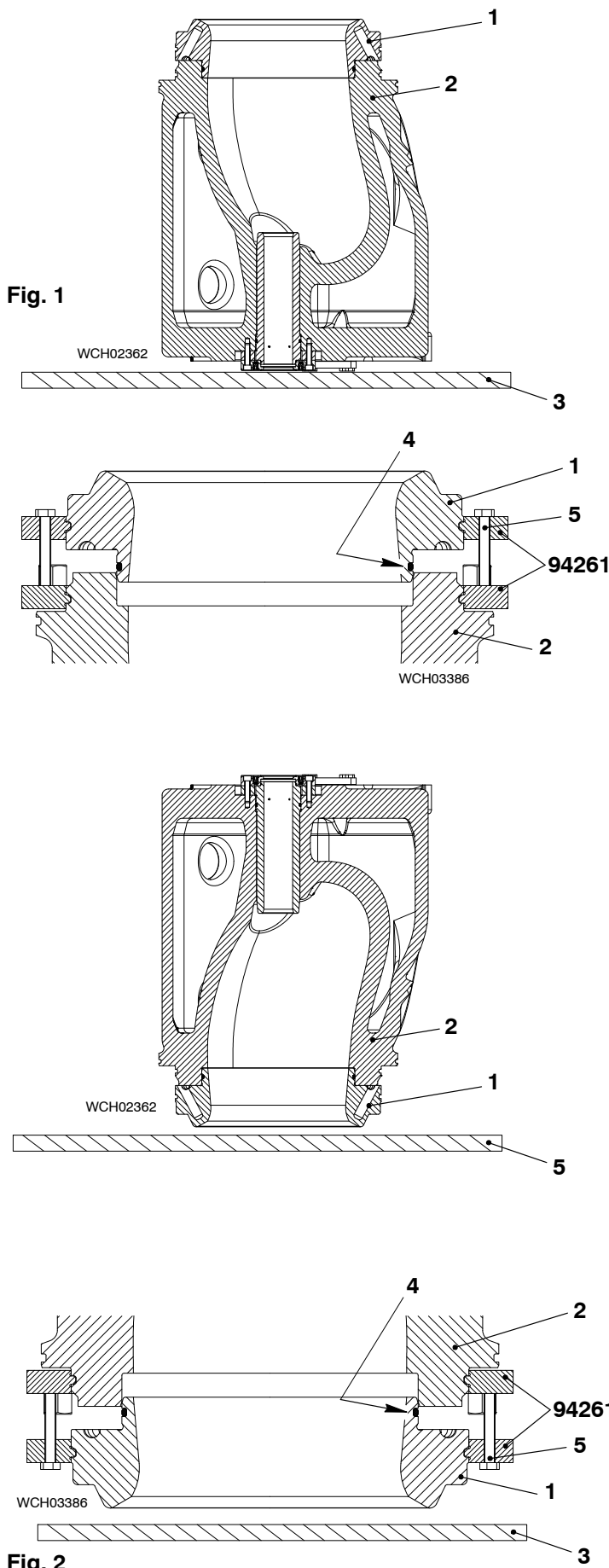
You must replace the valve seat when:

- 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 exhaust valve and remove the valve spindle, refer to 2751 2, paragraphs 2.1 and 2.2.

Valve Seat Removal, Grind and Installation



3. Valve Seat – Removal

- 1) If a valve seat is removed eg to replace an unserviceable O-ring, you must:
 - a) Grind the valve seat before installation (paragraph 4), or:
 - b) Record 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 (2, Fig. 1) until the valve seat (1) points up.
- 2) Carefully put the valve cage on to an applicable wooden support (5).
- 3) Install the top two halves of the device (94261) into the groove of the valve seat (1).
- 4) Install the bottom two halves of the device (94261) into the groove of the valve cage (2).
- 5) Turn the three jack-screws (5) equally to push out the valve seat (1) from the valve cage (2).
- 6) Remove and discard the O-ring (4).
- 7) Remove the 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 (ie the top of the valve cage points up), do the procedure that follows:

- 1) Operate the crane and an applicable lifting tool to hold the valve cage immediately above an applicable wooden support (3, 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 step 5).

- 5) Carefully turn the three jack screws (5) 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).

Valve Seat Removal, Grind and Installation

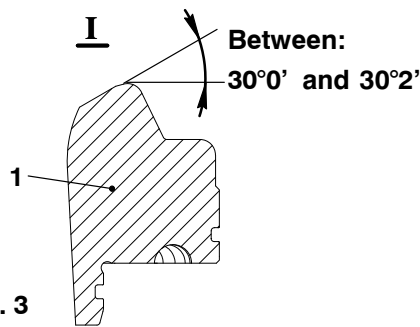
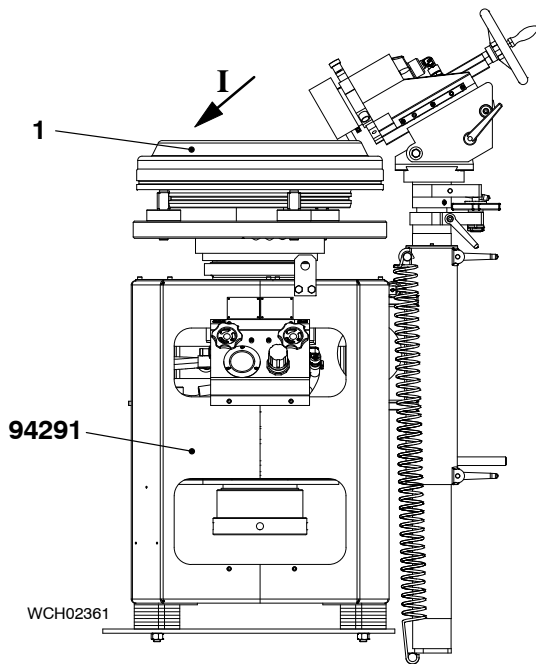


Fig. 3

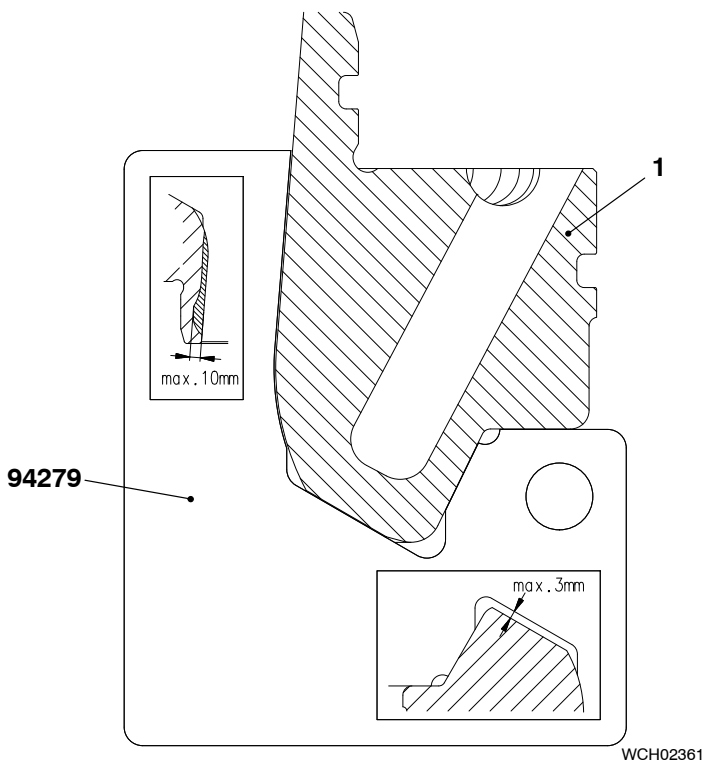


Fig. 4

- 7) Remove and discard the O-ring (4, Fig. 2).
- 8) Remove the tool (94261).

4. Valve Seat – Grind

Use only the tool (94291, 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, Fig 4) on the valve seat.

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

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

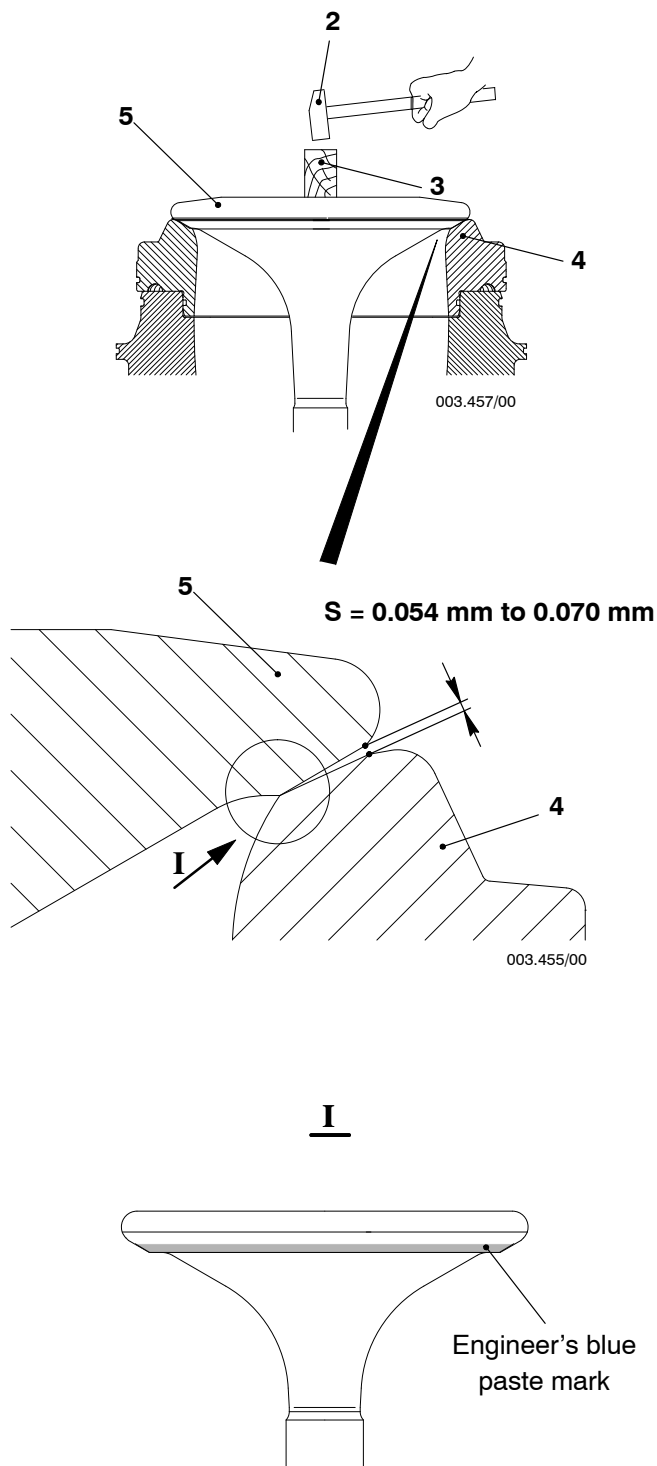


Fig. 5

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 (5), refer Fig. 5.
- 2) Put the valve spindle (5) in position in the valve guide bush.
- 3) Put the wooden block (3) on the valve spindle (5).

Note: During the step below, do not turn the valve spindle (5) because this can cause the sealing faces to catch.

- 4) Tap the wooden block (3) with the hammer (2) three or four times.
- 5) Use the feeler gauge (94122) to do a check of the clearance between the sealing faces of the valve spindle (5) and valve seat (4).

Note: The clearance between the valve spindle (4) must be as shown, ($S = 0.054 \text{ mm to } 0.070 \text{ mm}$).

- 6) Remove the valve spindle (5) from the guide bush.
- 7) 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 (refer View I).
- 8) Remove the valve seat from the tool (94291).

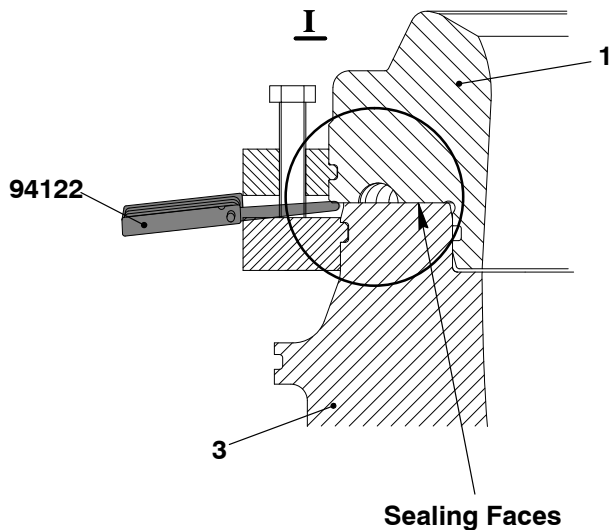
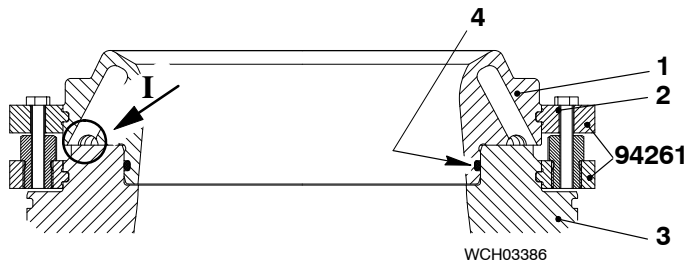


Fig. 6

6. Valve Seat – Installation

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

7. Completion

- 1) Assemble the exhaust valve and install the valve spindle, refer to 2751 2, paragraphs 3.2 and 3.3.

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Exhaust Valve

Valve Head: Seating Surface – Grind

Tools:

- | | |
|-------------------------------|-------|
| 1 Feeler gauge | 94122 |
| 1 Tool, valve grinding device | 94291 |
| 1 Template | 94292 |

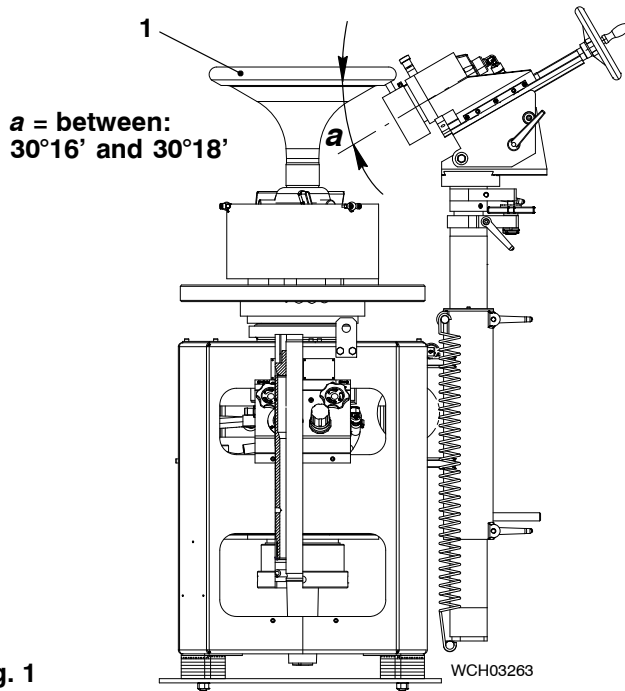


Fig. 1

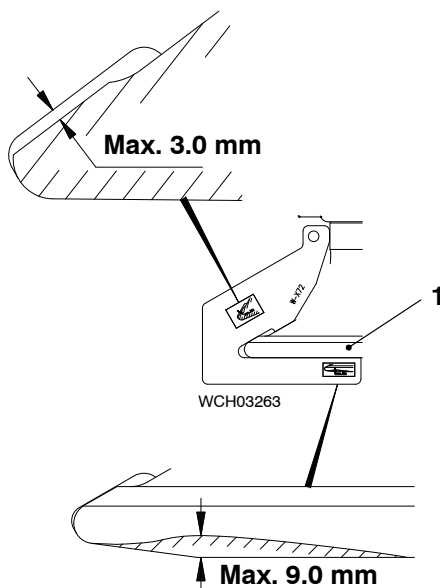


Fig. 2

1. General

Use only the tool (94291, 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 – Grind

- 1) Read the data in the manufacturer's manual for the grinding tool (94291).
- 2) Put the grinding tool (94291) in an area where there is no vibration.

Note: If necessary, put the tool on a rubber mat. This will help to prevent rough surfaces during the grinding procedure.

- 3) Put the valve spindle in position in the tool (94291).
- 4) Put the gauge (94292) on the valve head (1, Fig. 2).

Note: The data shown on the gauge (94292) shows the maximum limits for the valve head.

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

Note: You can grind off a maximum of 3.0 mm from the seating surface.

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

- 8) If the measured values are more than the limits given on the gauge (94122), you can repair the valve spindle (refer to the data below).
- 9) If more than 3.0 mm is ground off, do step [a\)](#) and step [b\)](#) below:
 - a) Use a build-up welding procedure to repair the surface of the valve seat.
 - b) Grind the seating surface of the valve spindle again (refer to paragraph [2\)](#)).

3. Corrosion

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

If the corrosion is less than or equal to 9.0 mm (refer [Fig. 2\)](#), the valve spindle can be repaired.

Note: The repair procedure can only be done in a WinGD authorized repair workshop.

Valve spindles cannot be repaired when the corrosion is more 9.0 mm, but can continue to operate until the corrosion has a depth of 21 mm.

Crankshaft, Connecting Rod and Piston

Group 3

Crankshaft: Crank Deflection – Measure	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: Piston Rings and Ring Grooves – Rate of Wear	3425	1/A1

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Crankshaft

Crank Deflection Measure

Tools:

- 1 Crankshaft equipment (dial gauge) 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:

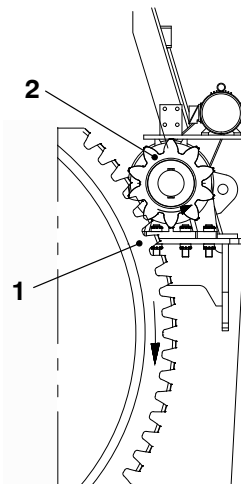
- Important change of crank-web deflection results compared to the data before.
- Bearing temperature alarms, or bearing damage.
- After the primary bearing shells were replaced and after approximately 100 service hours.
- If the ship has touched the sea bed.

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

2. Preparation

Make sure that:

- The indicator valves are open.
- The ship floats freely in the water as horizontal as possible.
- The crankshaft is in position on all the main bearings.



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Fig. 1

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. Procedure

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

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

Note: You can read from the dial gauge the change in the distance between the crank webs. 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.

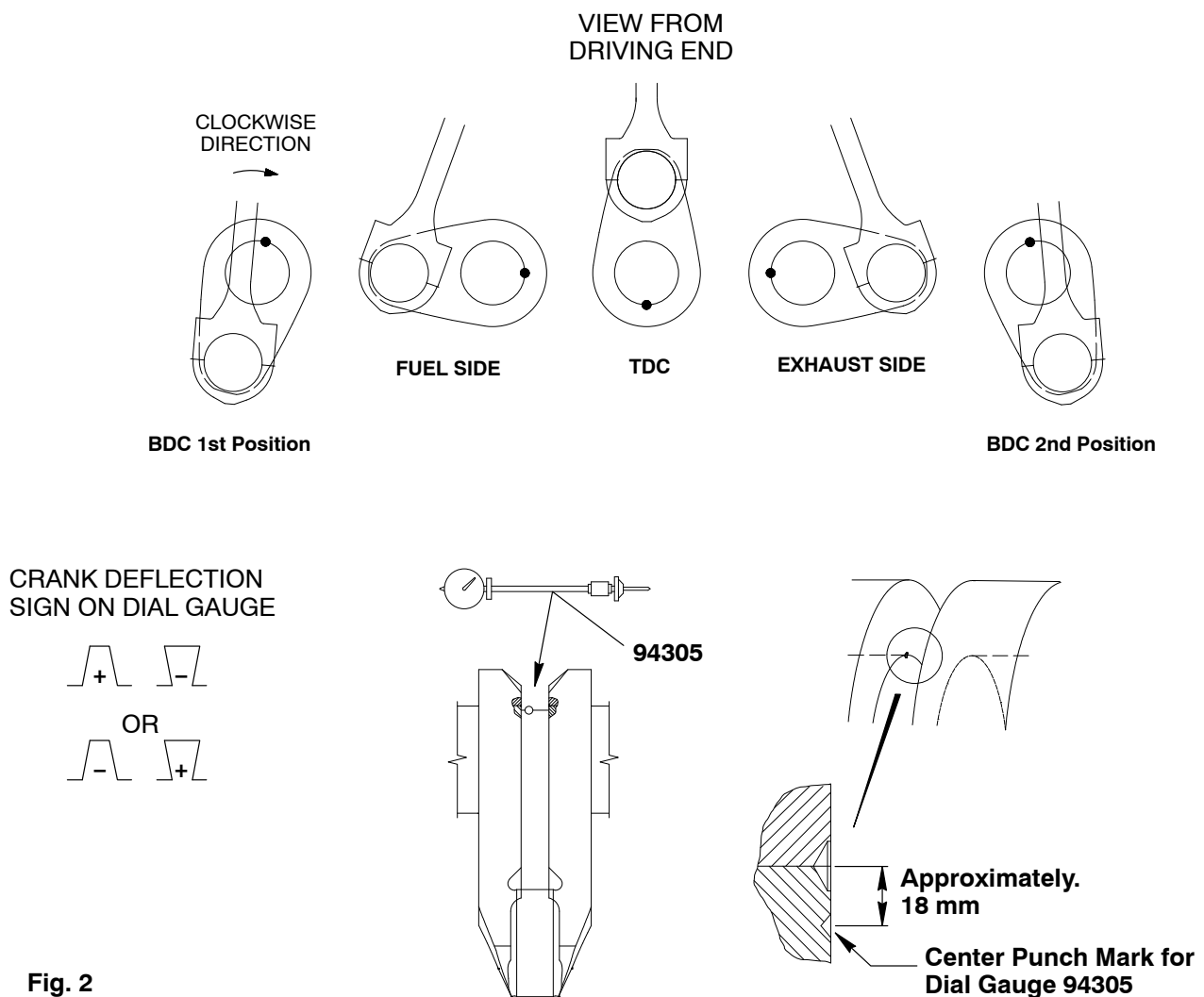


Fig. 2

4. Data Analysis

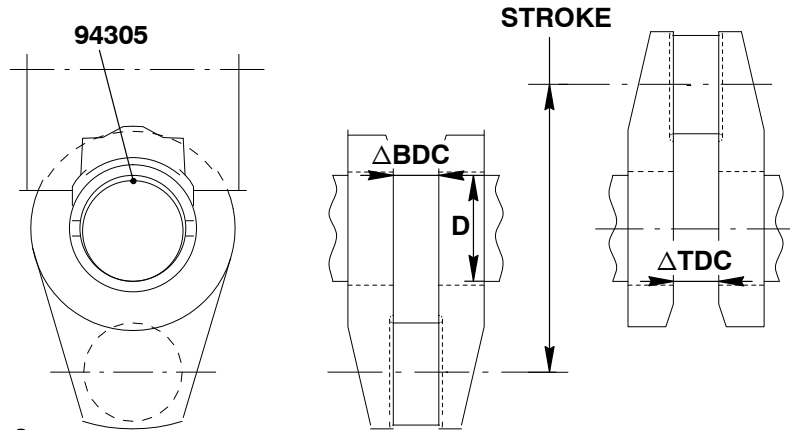


Fig. 3

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 (eg defective main bearing, engine stay changed because of full deformation, loose hold-down bolts, defective propeller shaft bearings, equipment 94305 etc).

The limits are applicable for all conditions of the ship operation after delivery ie:

- The draught and the 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 the Last but One cylinder	Last Cylinder (Free End)		All Cylinders
		Note 1)	Note 2)	
0.56	0.40	0.40	0.40	0.18
0.56	0.40	0.40	0.56	0.18

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

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

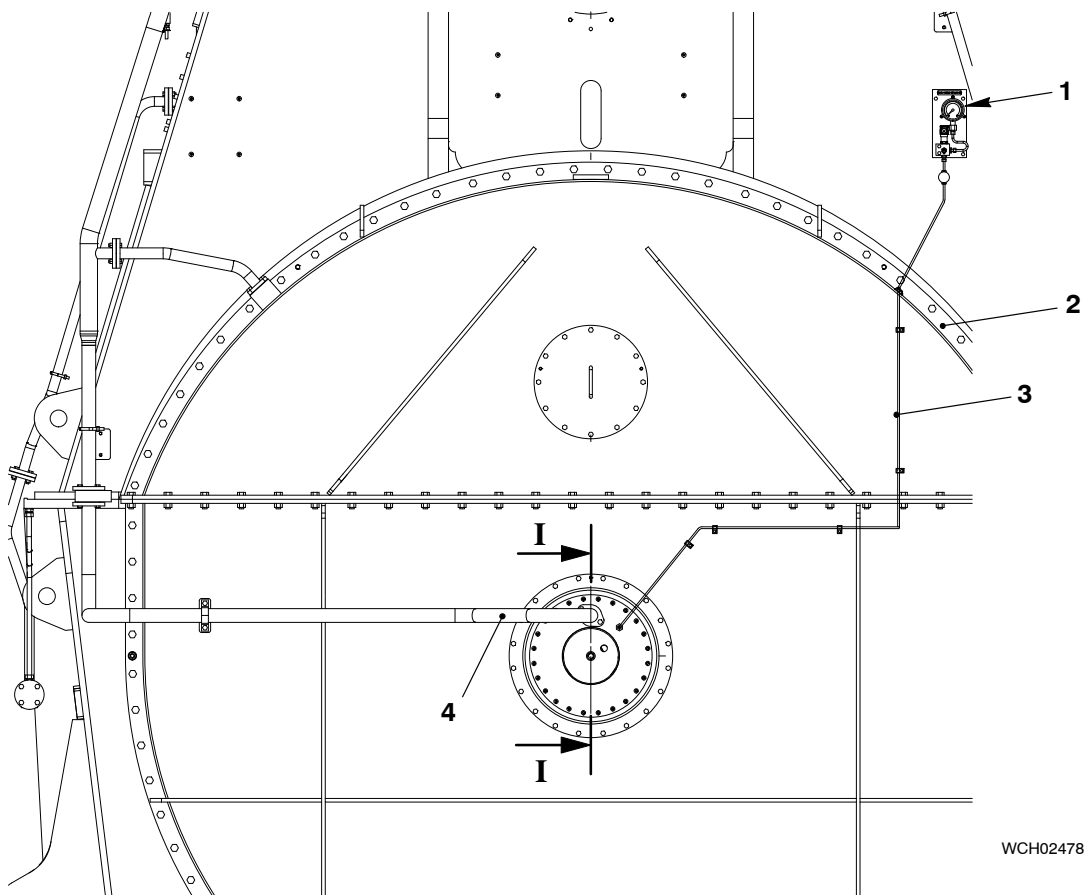
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Inspection (GEISLINGER Vibration Damper)

1. General

Some engine designs can have a Geislinger manufactured vibration damper installed at the free end of the crankshaft.

The service life of a vibration damper is related to the speed range in which the engine operates. Sea water (and other types of water) in the lubricating oil can cause the internal parts to become worn and decrease the effect of the vibration damper.



For View I-I, see Fig. 2

Fig. 1: Vibration Damper (front view)

- | | |
|----------------------------|-------------------|
| 1 Vibration damper monitor | 3 Monitor pipe |
| 2 Damper casing | 4 Oil supply pipe |

2. Checks

CAUTION



Damage Hazard: If the oil supply to the damper is stopped, the engine must be stopped immediately. Damage to the vibration damper can occur. The oil supply must flow correctly before the engine is started again.

2.1 Engine Filters

You must do regular checks of the engine filters for steel or bronze particles. If particles are found in the housing, you must speak to, or send a message to the supplier immediately.

Note: The vibration damper must not be operated until the cause is found and the problem is repaired.

If the oil pressure decreases to less than 1.0 bar, do not use the adjustable throttle in the supply pipe (4, Fig. 1 and Fig. 2). You must investigate the cause of the pressure decrease.

If damage occurs to the engine bearings because of water contamination in the lubricating oil, you must examine the vibration damper for damage as soon as possible.

2.2 Inner Spring Tips and Groove Flanks

Note: You must only disassemble the vibration damper if you think there is damage, or the parts have become worn to more than the specified limits. You must speak to the manufacturer for instructions.

Note: Only specialists can make adjustments of the vibration damper. The torsional vibrations and these adjustments must be done at the same time.

To do a check of the inner spring tips and groove flanks, do the procedure that follows:

- 1) Stop the engine.
- 2) Remove the inspection cover from the vibration damper casing.
- 3) Examine the inner spring tips and groove flanks. Refer to the manufacturer's manual for the limits.
- 4) Attach the inspection cover to the vibration damper casing.
- 5) Start the engine.

Before you remove a vibration damper and balance weight, record their positions with reference to the crankshaft position.

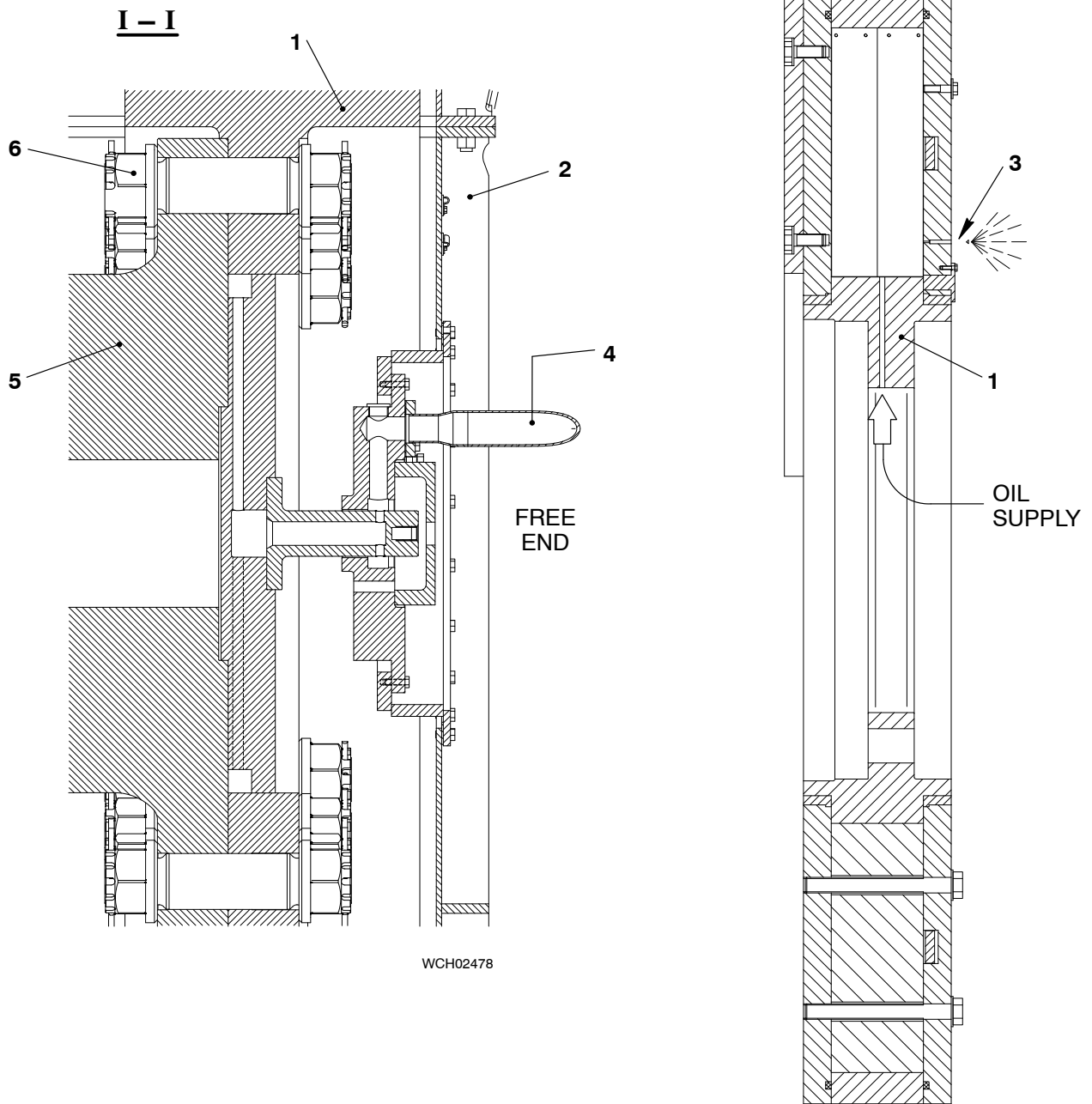
For the torque values of the coupling bolts (6), refer to [0352 1](#).

For the test run after the first commissioning, the usual checks and servicing intervals, refer to the manual of the vibration damper manufacturer.

The address for GEISLINGER vibration dampers is given below:

Geislinger GmbH
A-5300 Hallwang / Salzburg
Austria
Tel: +43 662 66 999 0
Fax: +43 662 66 999 40

Inspection (GEISLINGER Vibration Damper)



Note: Some parts can look different.

Fig. 2: Vibration Damper (section view)

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

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Removal and Installation


Tools:

1	Spur-gear 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).

CAUTION	
	<p>Damage Hazard:The top housing weighs 640 kg. Use applicable lifting equipment to lift and move the top housing. Injury to personnel and damage to equipment can occur.</p>

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

- 6) Remove the top housing (5) with an applicable lifting device.

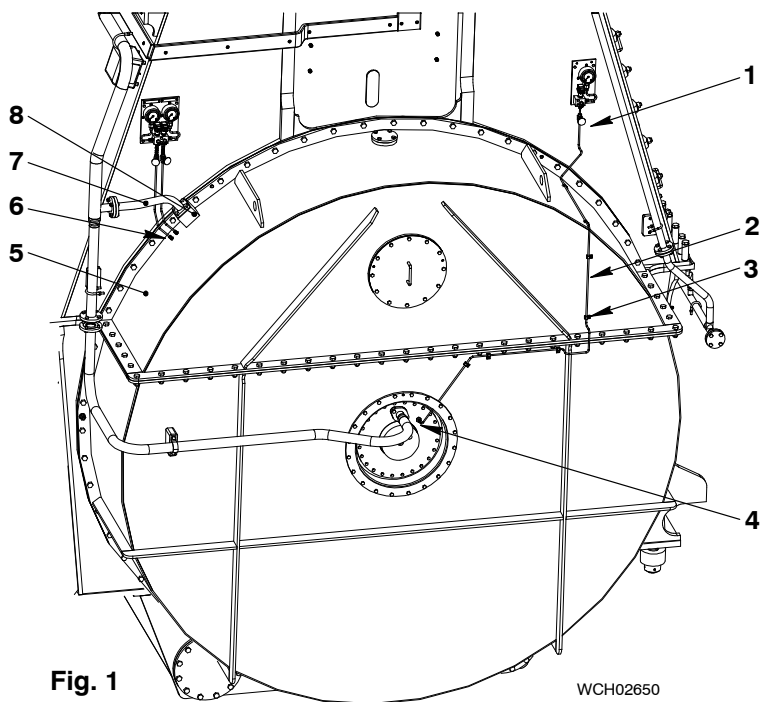


Fig. 1

WCH02650

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) and four screws (1) from the top cylinder half (2).

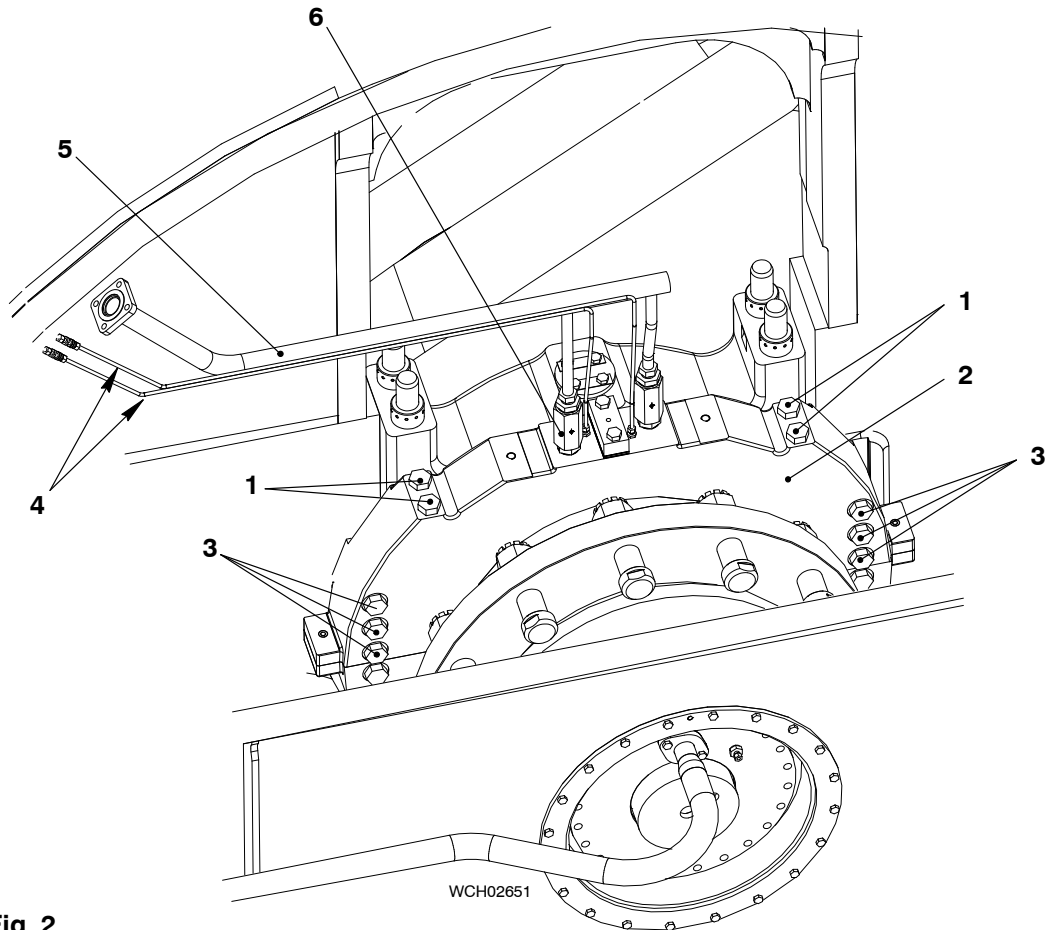


Fig. 2

- 4) Attach two eye bolts (94045-M20, Fig. 3) to the top cylinder (1).
- 5) Attach the chain (94335A) to the eye bolts (94045-M20).
- 6) Attach the shackle (94018A) to the strong-point.
- 7) Attach the spur-gear chain block (94017-005) to the shackle (94018A) and the chain (94335A).
- 8) Attach the engine room crane to the chain (94335A).
- 9) Operate the spur-gear chain block (94017-005) and the engine room crane to lift and move the top cylinder (1) to an applicable area.
- 10) Lower the top cylinder (1) on to an applicable surface.

Note: Engine operation does not usually cause the 2-part gaskets to become worn. The 2-part gaskets must be replaced if they become worn, or if contamination causes damage.

Axial Detuner: Disassembly and Assembly

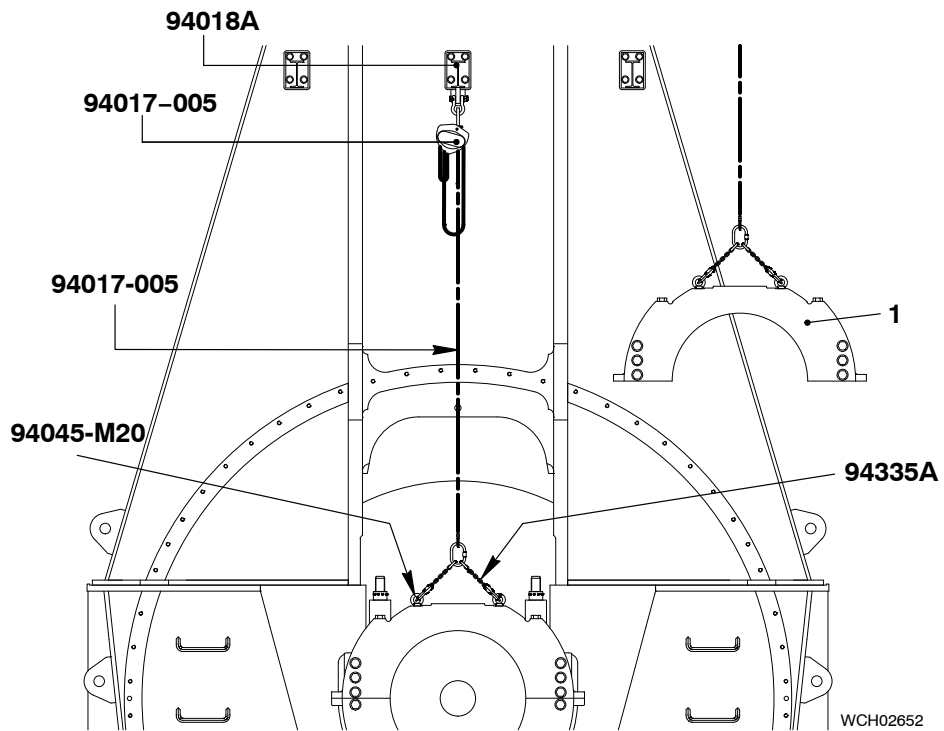


Fig. 3

- 11) 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).
 - a) Carefully remove the tension springs (4, 5).
 - b) Remove and discard the 2-part gaskets (2, 3).

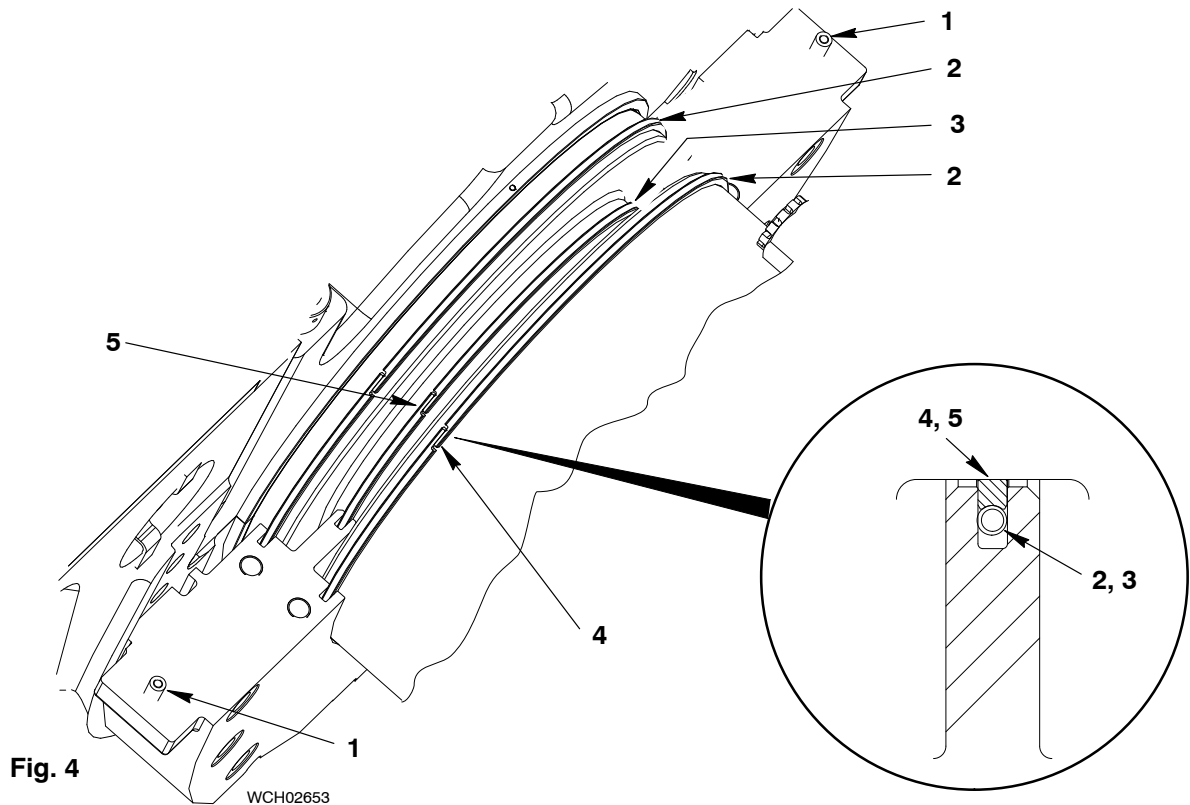


Fig. 4

3. Assembly

- 1) Apply clean engine oil to the new 2-part gaskets (2 and 3, Fig. 4).
- 2) Attach the new 2-part gaskets (2, 3) 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) Operate the engine room crane and spur-gear chain block (94017-005, Fig. 3) to move the top cylinder into position above the bottom cylinder.
- 6) Remove the engine room crane from the top cylinder.
- 7) Operate the spur-gear chain block (94017-005) to carefully lower the top cylinder into position on the bottom cylinder. Make sure that you do not cause 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).
- 13) Remove all tools and equipment from the work area.

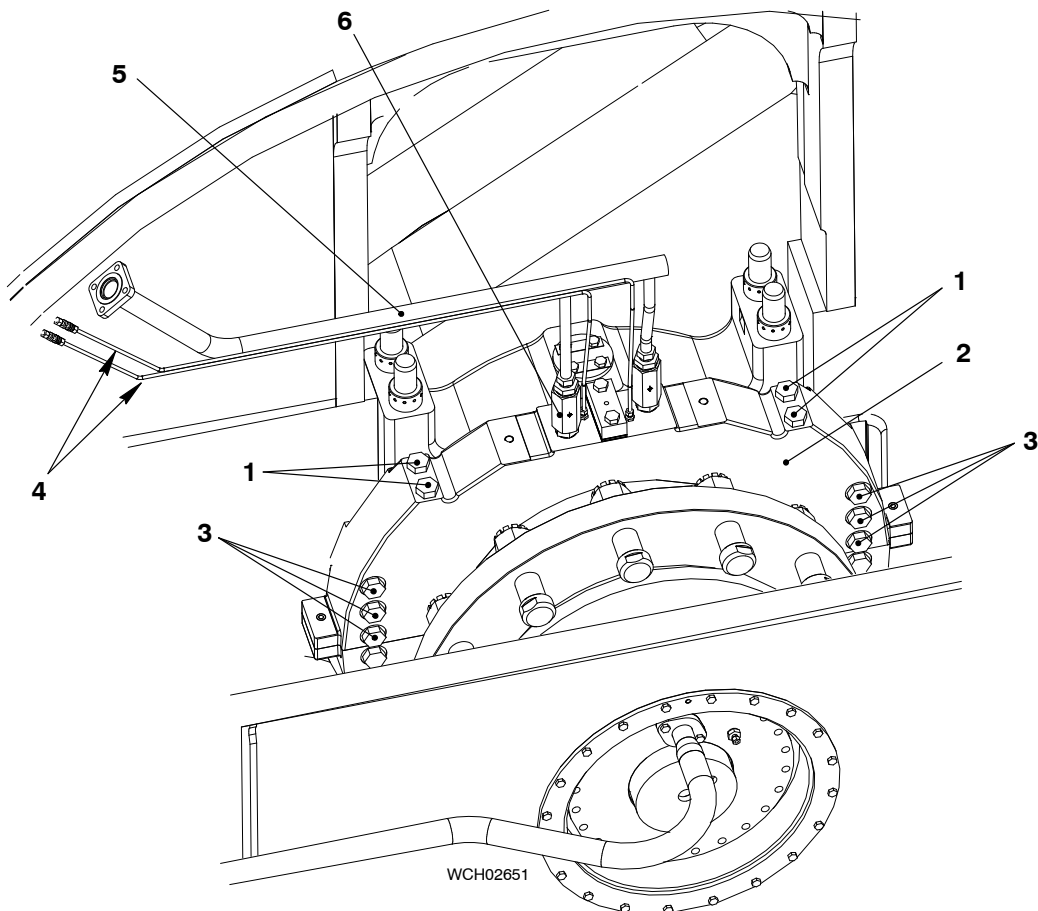


Fig. 5

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) Attach the copper pipe (2) to the needle valve (1), hose clips (3) and damper housing (4).

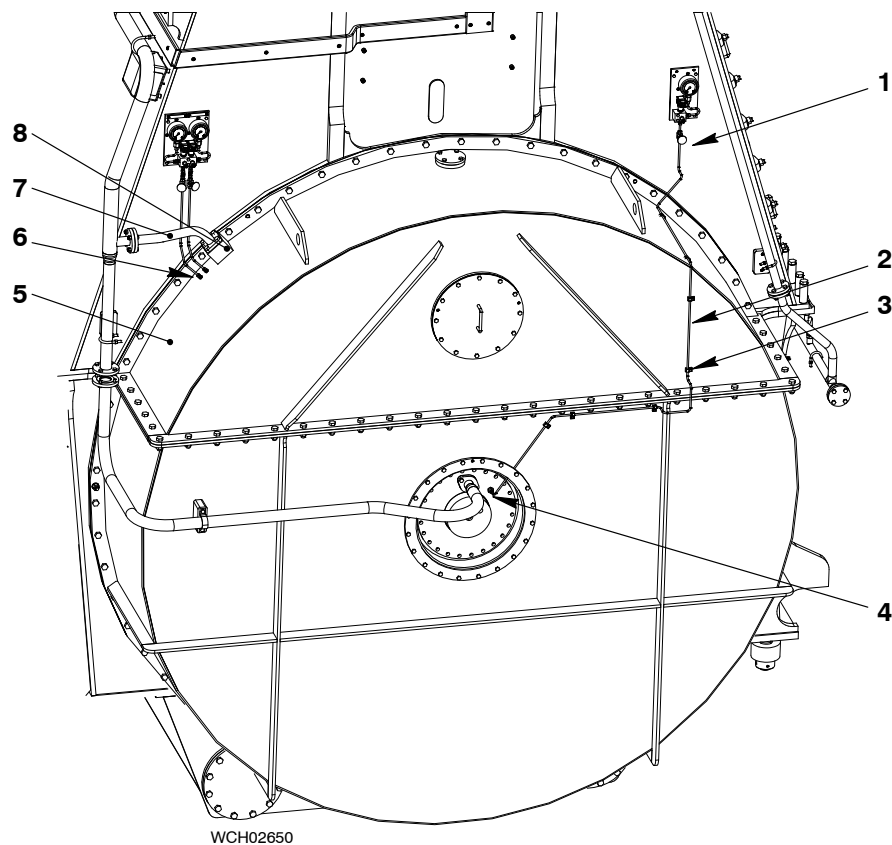


Fig. 6

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Turning Gear

Teeth and Screwed Connections – Check

Tools:

1	Pre-tensioning jack	94320	
1.	General	.....	1
2.	Pinion and Flywheel Teeth	.....	2
2.1	Procedure	.....	2
2.2	Lubrication Intervals	.....	2
2.3	Recommended Suppliers	.....	2

1. General

Before you operate the turning gear (1, Fig. 1), you must examine:

- The condition of the tooth flanks
- The lubrication of the pinion (2)
- The flywheel teeth (3).

For more data about the turning gear, refer to the Operation Manual 0750 1.

For maintenance of the turning gear (1), refer to the manufacturer’s instructions.

You must do a check of the tension of the elastic bolts (4). The intervals for the checks are given in the 0380.1, Maintenance Schedule, Inspection and Overhaul Intervals [Turning Gear](#).

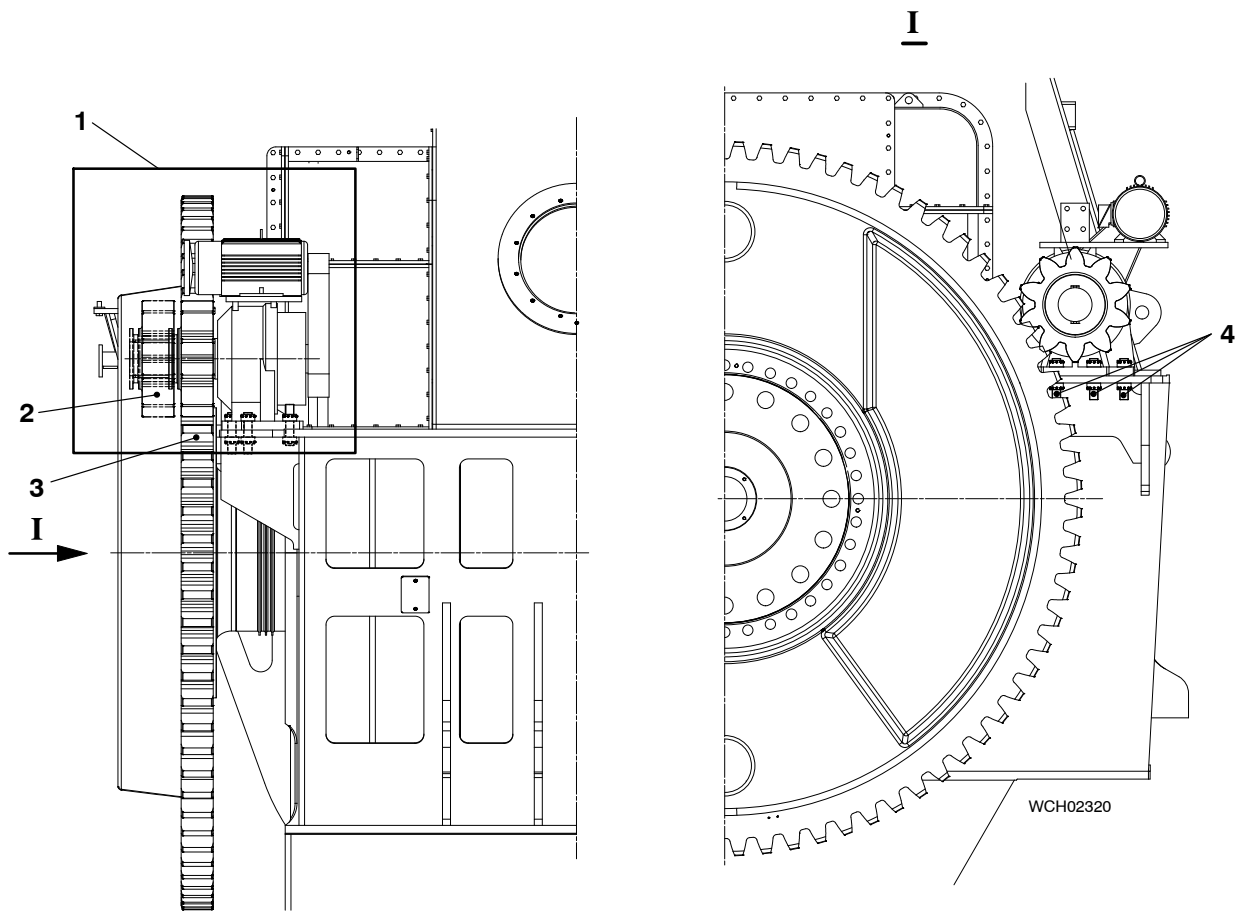


Fig. 1

2. Pinion and Flywheel Teeth

2.1 Procedure

Note: Make sure that only a thin layer of lubricant is applied to the tooth flanks of the pinion (2) and the flywheel (3). This makes sure that the lubricant stays on the tooth surfaces during engine operation.

Table 1: Instructions – Pyroshield


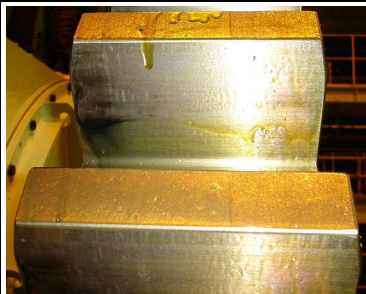
	Manufacturer	Location	Instruction
	LE 5182 Pyroshield		Apply a thin layer of the lubricant to the teeth as shown in the photograph.

Table 2: Instructions – Klüberfluid

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

2.2 Lubrication Intervals

Examine the teeth approximately each 2000 operation hours, or more frequently if necessary. When there is a minimum of lubricant remaining on the teeth (eg when the teeth are almost dry) lubricate the teeth.

2.3 Recommended Suppliers

Lubrication Engineers Inc.
300 Bailey Avenue
Forth Worth, TX
USA
<http://www.l Lubricants.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

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.

You use the platform (94142, Fig. 1) and support (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 (94142) on the longitudinal beam (2) and the crank (1).

You install the support (94143) at the applicable height on the steps (3) between the columns. This support is adjustable between 725 mm and 902 mm.

To prevent accidents, the platform (94142) and supports (94143) must be used for inspections or work in the crankcase.

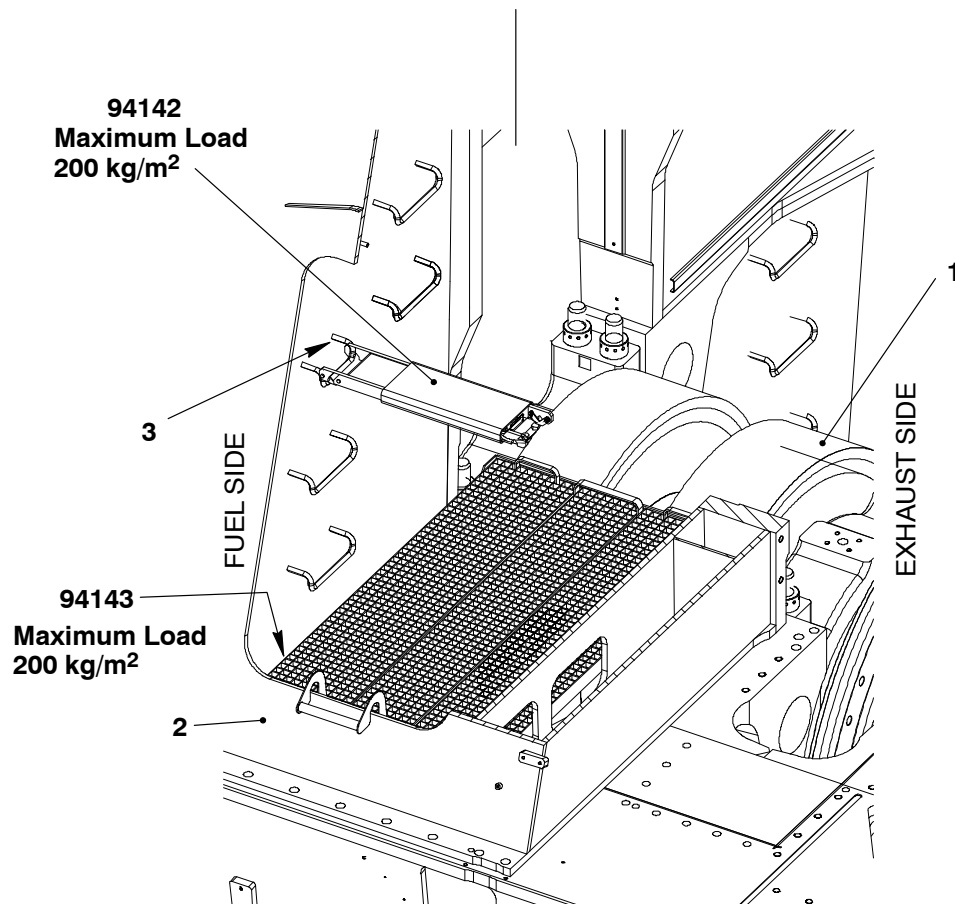


Fig. 1

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Bottom End Bearing – Removal, Inspection and Installation

Tools:

2 Manual ratchet H1/H5 1600 kg	94016-009	4 Eye bolt M8	94045-M8
2 Manual ratchet H2/H3, 2500 kg	94016-011	1 Deviation pipe	94117B
1 Manual ratchet H4, 6300 kg	94016-017	1 Pre-tensioning jack	94252
4 Shackle, 4750 kg	94018B	1 Chain	94327
2 Shackle, 8500 kg	94018C	1 Console Frame	94326
1 Chain, 5300kg	94019B	1 Support	94322
		1 Support (for iELBA)	94322A

1. Preparation	1
2. Bearing Cover – Removal	1
3. Bearing Shell – Removal	2
4. Top Bearing Shell – Check	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, or in the engine.

- 1) Operate the turning gear to turn the crankshaft until the applicable crank (2, Fig. 1) is at TDC.
- 2) Lock the turning gear.
- 3) Attach the eye bolts (94045-M8) to the bearing cover (3).
- 4) Attach the shackles (94018B) to the column.
- 5) Attach the manual ratchets (H2, H3) to the shackles (9418B) and the eye bolts on the bearing cover (3).
- 6) Apply a light tension the manual ratchets (H2, H3).

2. Bearing Cover – Removal

- 1) Apply tension to the elastic studs (1), refer to 9304 4 paragraph 2.
- 2) Remove the elastic studs (1).
- 3) Carefully lower the bearing cover (3).
- 4) Examine the bearing shell (4).

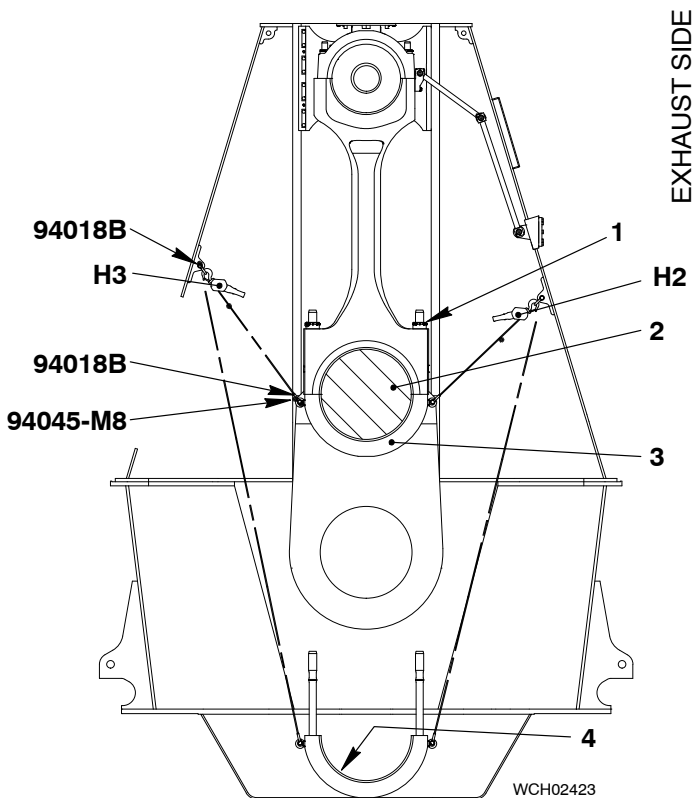


Fig. 1

Bottom End Bearing Removal, Inspection and Installation

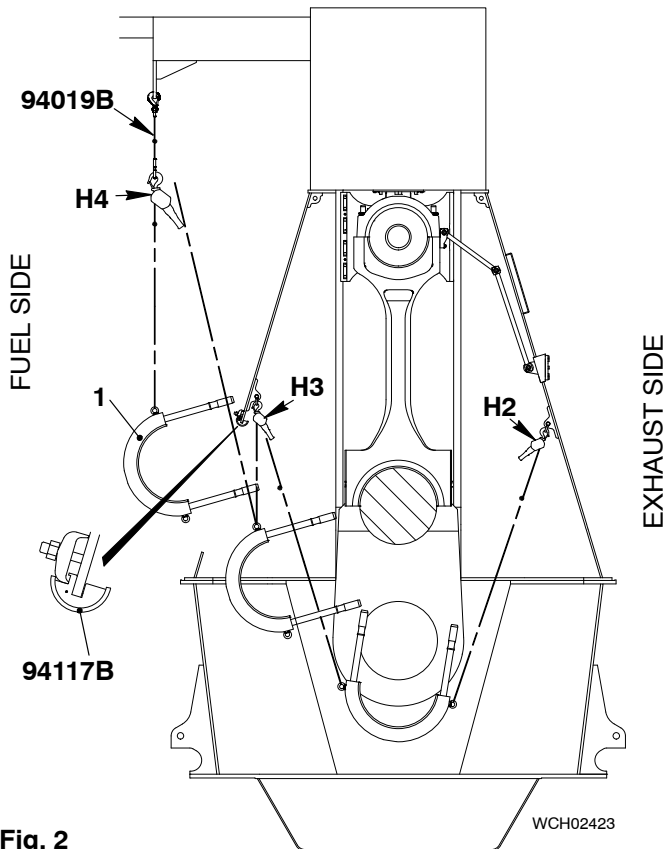


Fig. 2

Note: If the bearing shell is in good condition, lower the bearing cover on to the bottom of the crankcase.

- 5) Attach the chain (94019B) to the gallery.
- 6) Attach the manual ratchet (H4) to the chain (94019B).
- 7) Install the deviation pipe (94117B) to the column.
- 8) Operate the manual ratchets (H2, H3) to move the bearing cover (1) to the fuel side.
- 9) Remove the manual ratchet (H2) from the eye bolt on the bearing cover.
- 10) Attach the manual ratchet (H4) to the eye bolt on the bearing cover (1).
- 11) Operate the manual ratchets (H3, H4) to remove the bearing cover (1) from the crankcase.
- 12) Lower the bearing cover (1) on to an applicable surface.

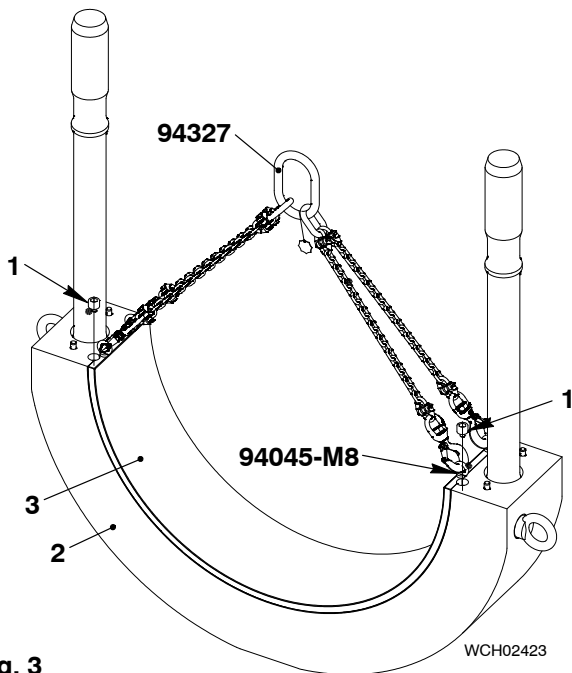
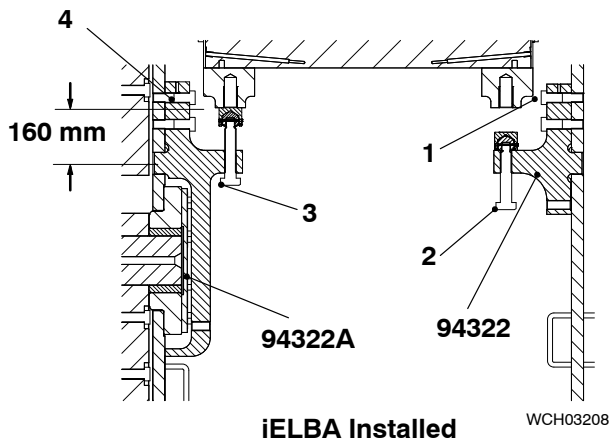


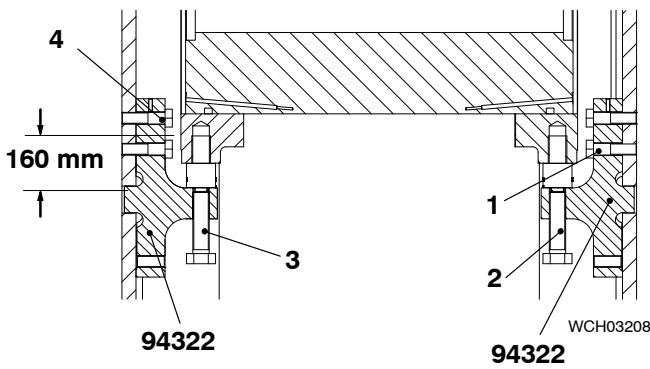
Fig. 3

3. Bearing Shell – Removal

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



iELBA Installed



iELBA Not Installed

Fig. 4

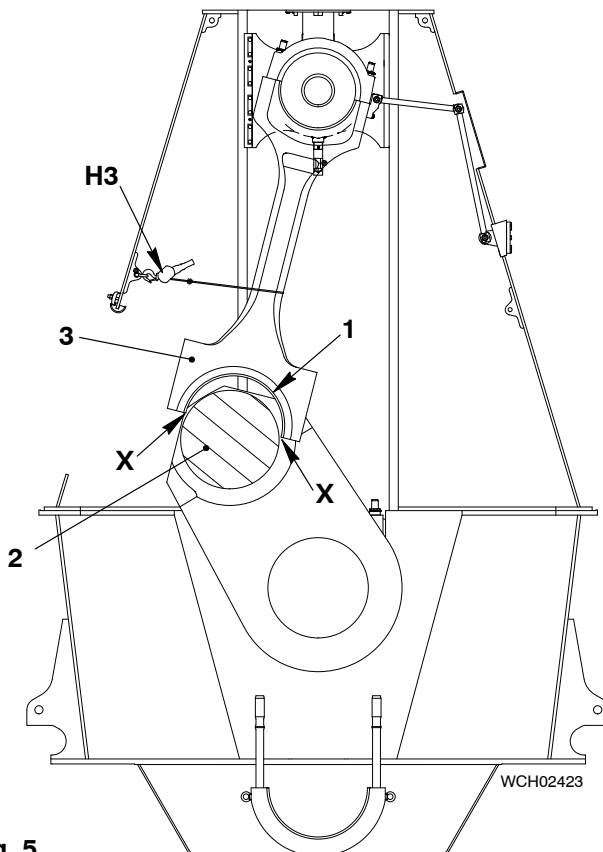


Fig. 5

4. Top Bearing Shell – Check

WARNING



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

- 1) Unlock the turning gear.
- 2) Operate the turning gear to move the crank to the fuel side. Continue to operate the turning gear until the crosshead is approximately 300 mm above the plug bore center (Fig. 4).
- 3) Apply a small quantity of clean oil to the four bolts(1, 4).
- 4) Attach the supports as follows:
 - a) For an engine with an iELBA installed, attach one support (94322A) and one support (94322) with the four bolts (1, 4).
 - b) For an engine with no iELBA installed, attach two supports (94322) with the four bolts (1, 4).
- 5) Torque the four bolts (1, 4) to 300 Nm.
- 6) Operate the turning gear to lower the crosshead to 160 mm above the 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) Operate the turning gear to turn the crank (2) to the fuel side. Keep the tension on the manual ratchet (H3).
- 10) Make sure that there is no load on the corners (X) of the bearing shell (1).
- 11) Operate the turning gear to turn the crank (2) to 100° after TDC.
- 12) Do a check of the bearing shell (1).

5. Top Bearing Shell – Removal

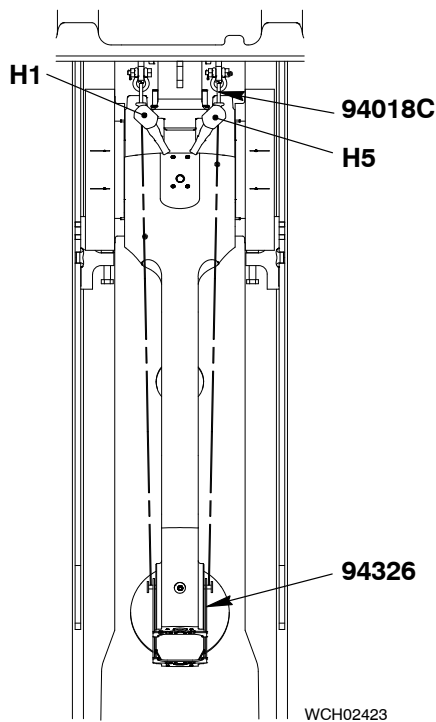


Fig. 6

- 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).

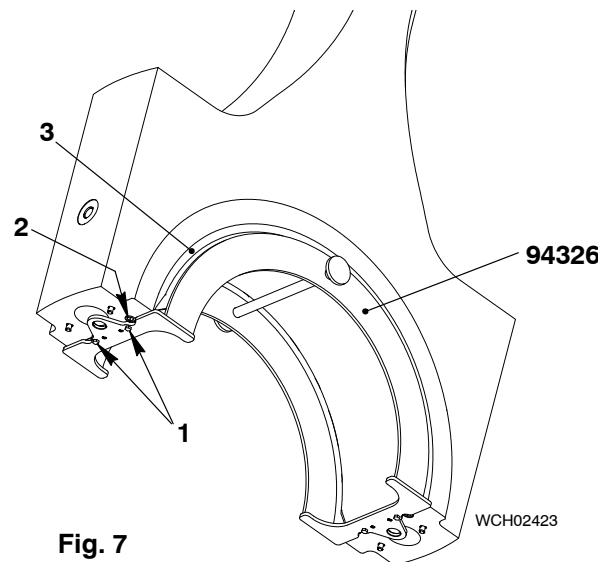


Fig. 7

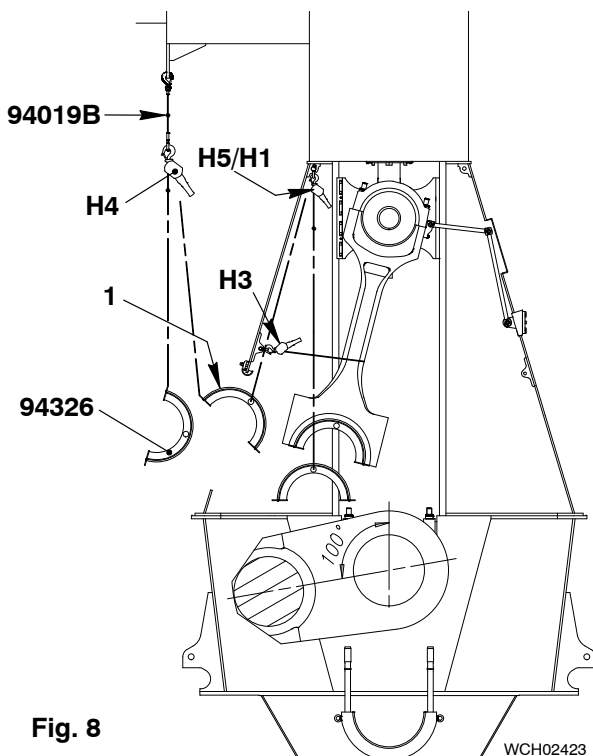


Fig. 8

- 6) Operate the manual ratchets (H5, H1 Fig. 8) to lower the console frame (94326) together with the bearing shell (1).
- 7) Attach the 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).

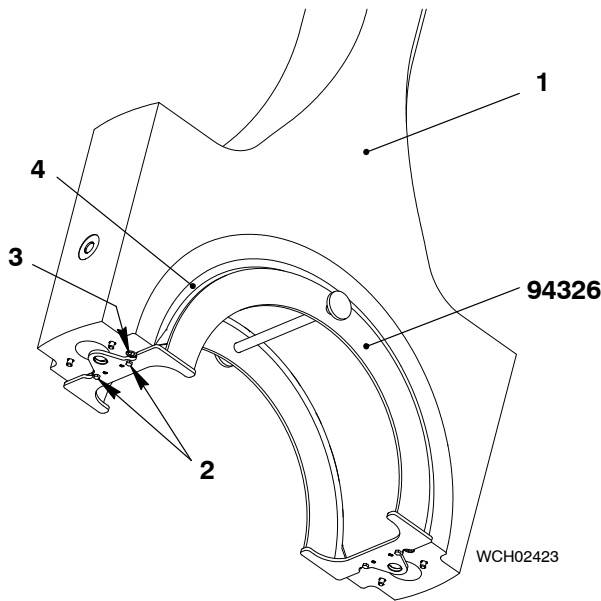


Fig. 9

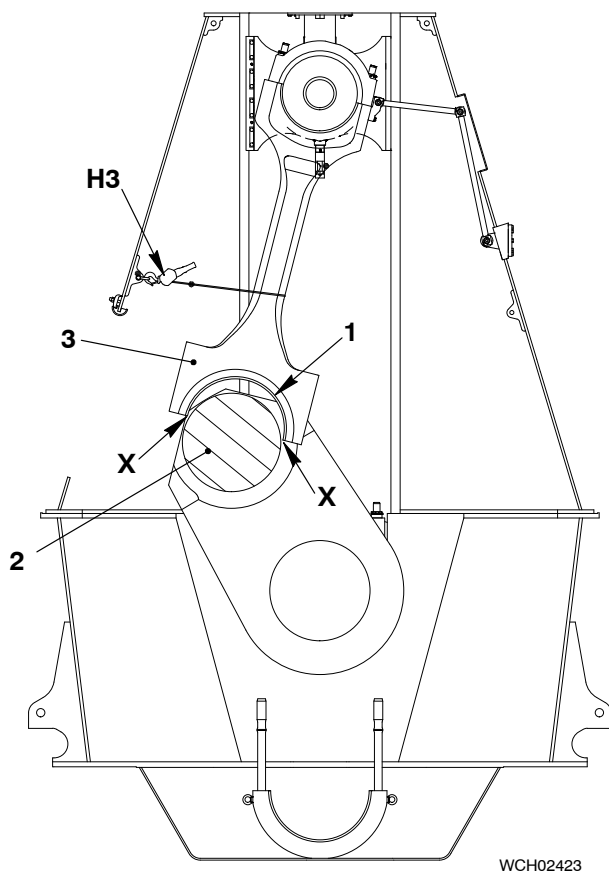



Fig. 10

6. Top Bearing Shell – Installation

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

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

WARNING	
	<p>Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel.</p>

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

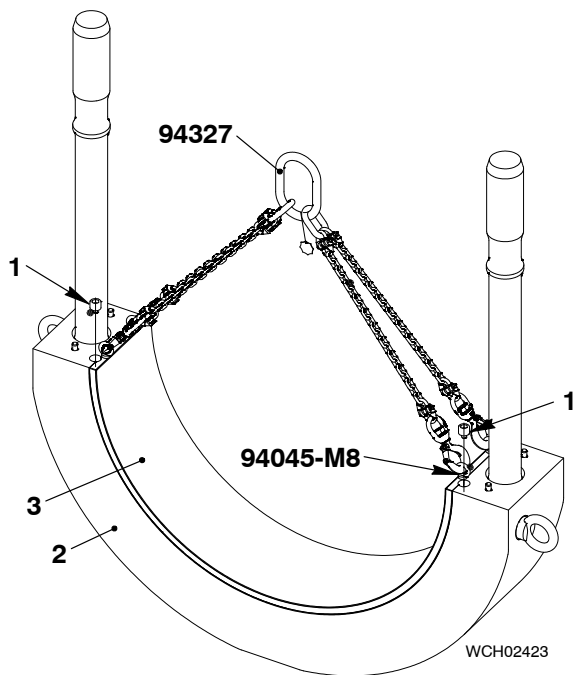


Fig. 11

7. Bottom Bearing Shell – Installation

- 1) Attach the four eye bolts (94045-M8, Fig. 11) to the bearing shell (3).
- 2) Attach the chain (94327) to the four eye bolts (94045-M8).
- 3) Attach the manual ratchet (H4) to the chain (94327).
- 4) Operate the manual ratchet (H4) to lift the bottom bearing shell (3).
- 5) Clean the seating surface of the bearing cover (2) and the bearing shell (3).
- 6) Apply a small quantity of clean oil to the surface of the bearing shell (3).
- 7) Attach the bearing shell (3) to the bearing cover (2) with the four screws (1).

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

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

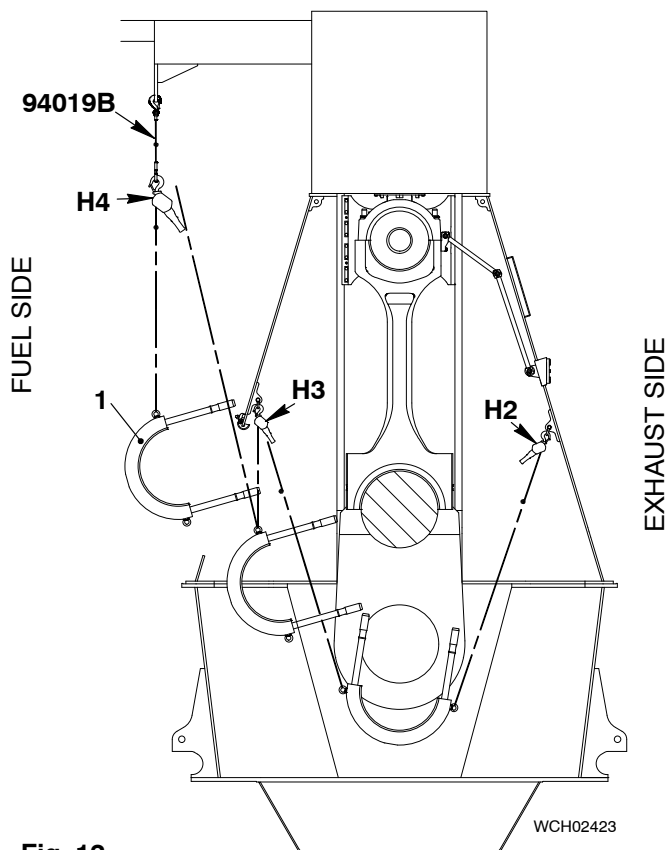


Fig. 12

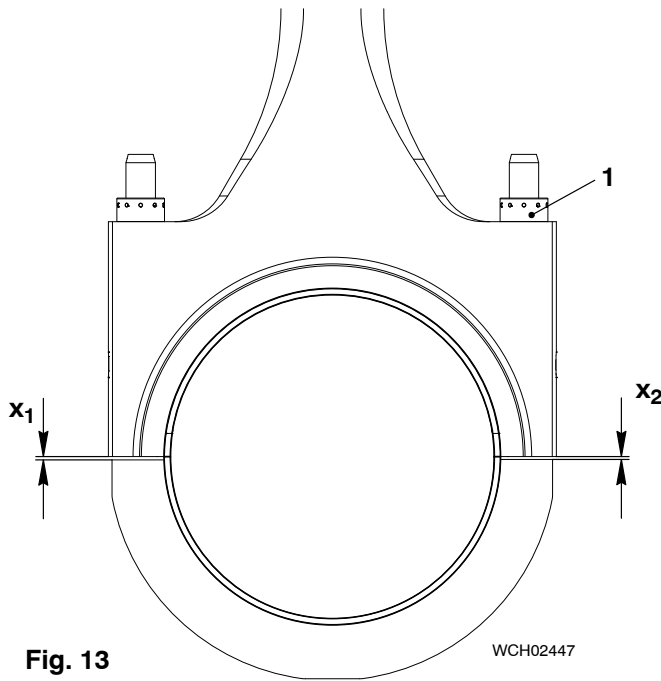


Fig. 13

- 8) Make sure that the bearing shell is clean.
- 9) 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.

- 10) Put the elastic studs (1, Fig. 13) on the elastic studs.
- 11) Use a round bar to tighten equally the elastic studs (1).
- 12) Measure the distance (X1, X2) between the edges of the bearing shells and the bearing cover.
- 13) For new bearing shells, the dimensions X1 plus X2 must be between 1.18 mm to 1.34 mm.
- 14) Apply tension to the elastic studs, refer to 9403 4, paragraph 3.
- 15) Remove all the tools and equipment from the work 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	CYLESO 1000	950	44.0	
EXXON/ESSO	CYLESO TK 1000	925	46.7	
MOBIL	EXTRA HECLA SUPER Cylinder Oil	680	39.0	0.905
SHELL	FIONA Oil 1500	1500	37.0	0.958
SHELL	VALVATA OIL 1000	1000	45.4	0.924
TEXACO	650T MINERAL 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

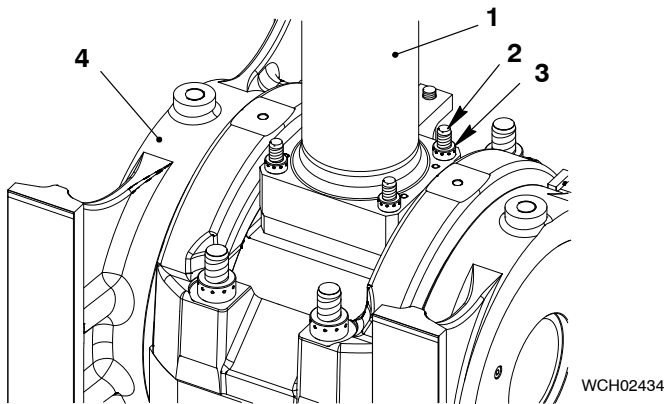


Fig. 1

1. Piston – Preparation

WARNING

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

- 1) Read the data in [0012 1](#) General Guidelines for Lifting Tools.
- 2) Operate the turning gear to turn the crank (4, [Fig. 1](#)) to BDC.
- 3) Apply tension to 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) Operate the turning gear to turn the crank to TDC.

Top End Bearing Removal, Inspection Installation

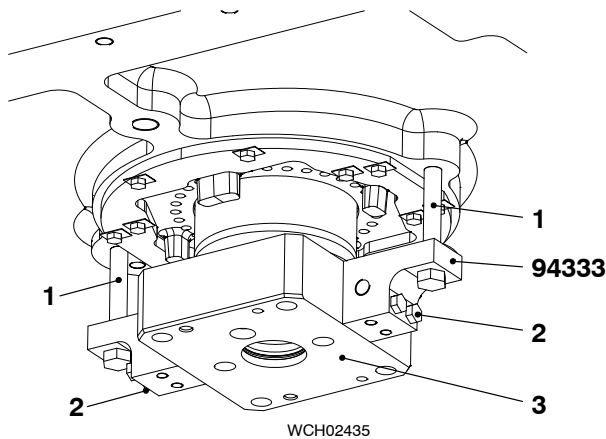


Fig. 2

- 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) Operate the turning gear to turn the crank to BDC. The connecting rod moves away from the piston rod foot.
- 11) Lock the turning gear to prevent movement of the crankshaft.

2. Preparation

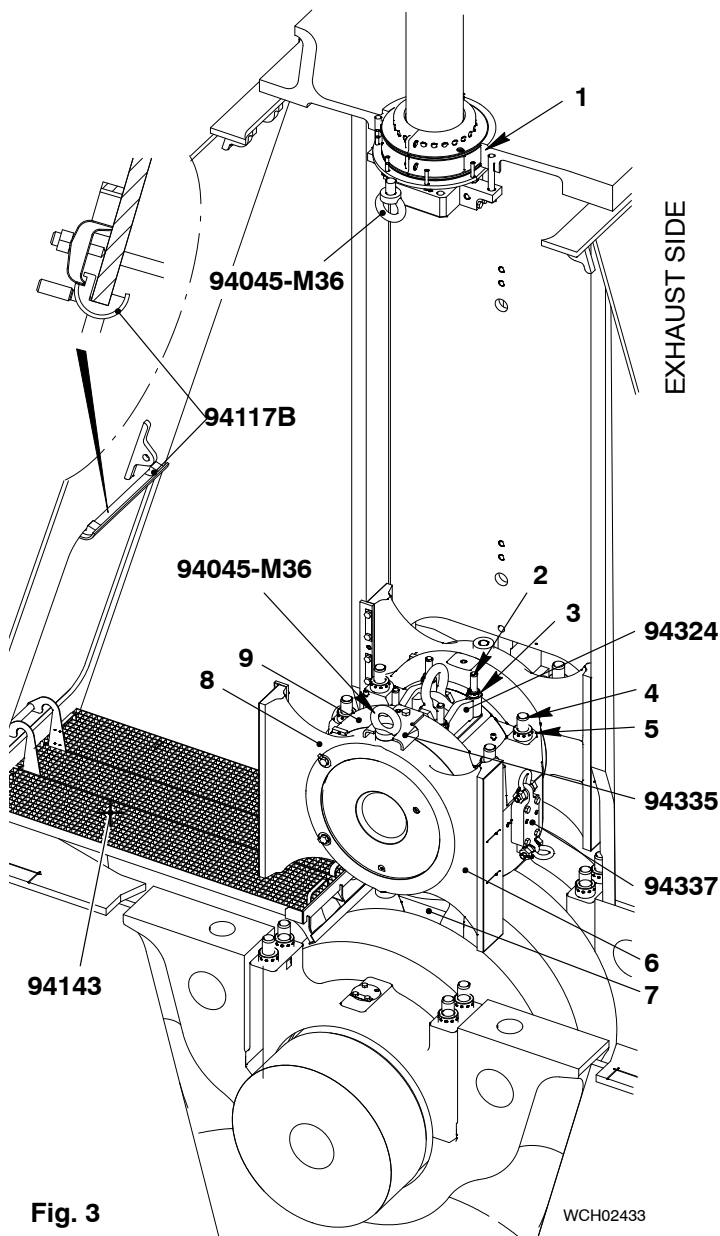


Fig. 3

- 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) Apply tension to 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 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) Torque the four bolts of the lifting tool (94337) to 175 Nm.

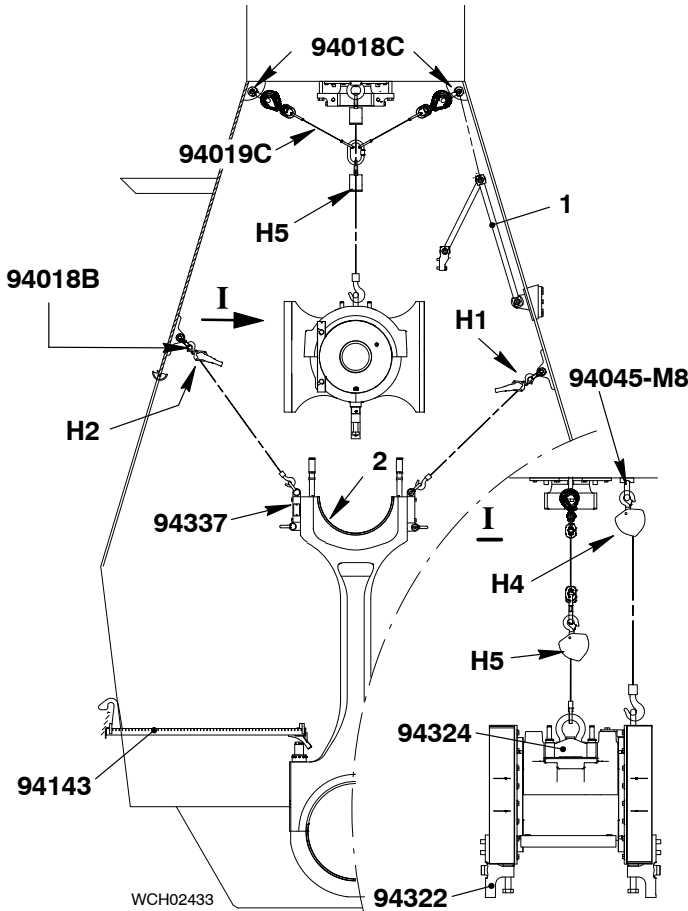
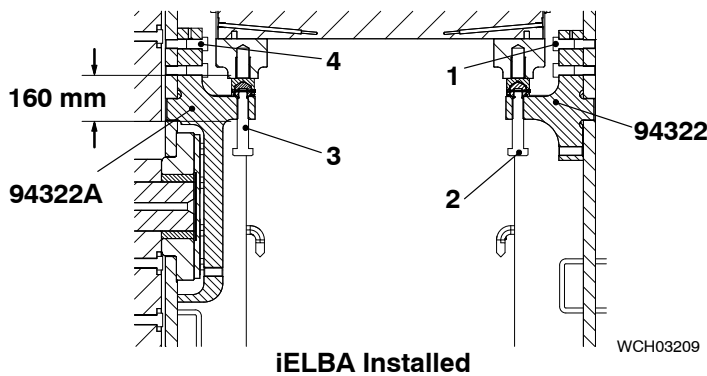


Fig. 4



iELBA Installed

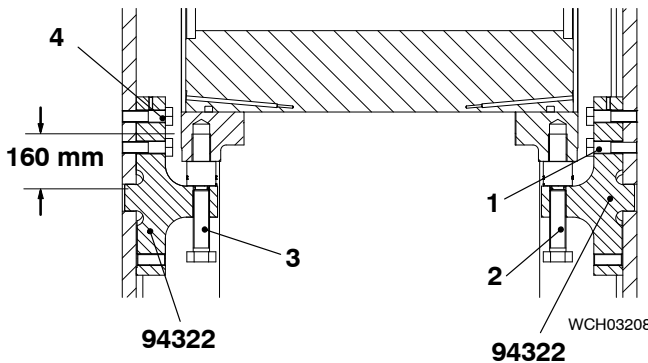


Fig. 5 iELBA Not Installed

- 13) Remove 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, 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-M8) at the top of the column
- 7) Attach the eye bolt (94045-M36) to the bearing cover, see View I.
- 8) Operate the chain block (H5) to lift the crosshead to 160 mm above the plug bore (2, Fig. 5) in the column.
- 9) Keep the tension on the chain block (H4, Fig. 4).
- 10) Attach the supports as follows:
 - a) For an engine with an iELBA installed, attach one support (94322A) and one support (94322) with the four bolts (1, 4).
 - b) For an engine with no iELBA installed, attach two supports (94322) with the four bolts (1, 4).
- 11) Torque the four bolts (3) to 240 Nm.
- 12) Tighten the special screws (2, 3) on each support.
- 13) Examine the bearing shell.
- 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).

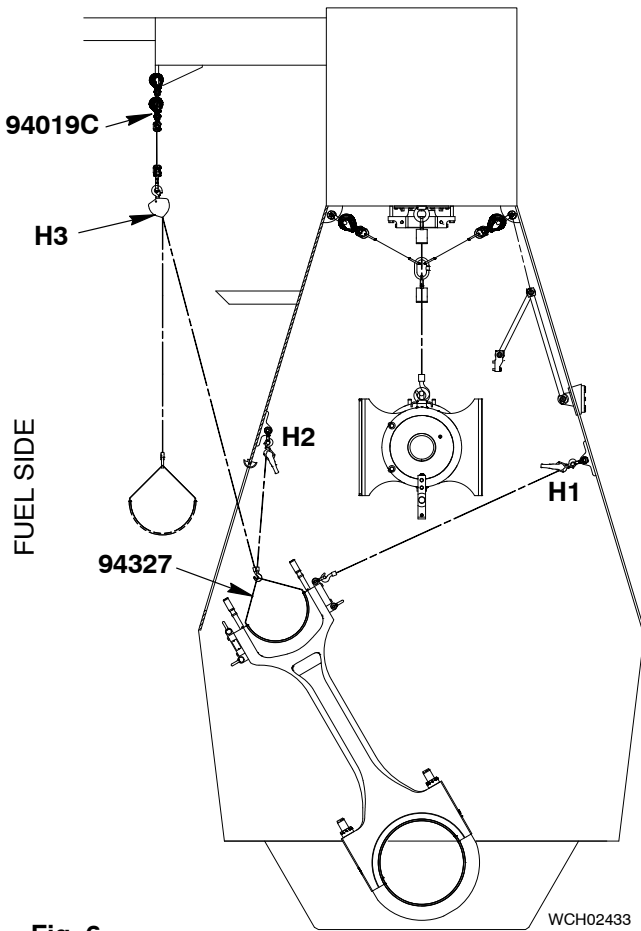


Fig. 6

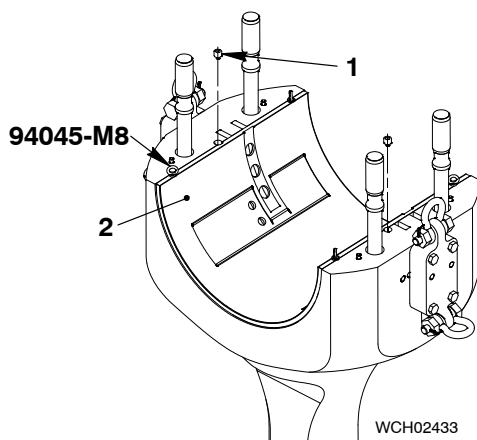


Fig. 7

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) Operate 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) Remove the manual ratchet (H2) from the connecting rod.
- 7) Attach 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).

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) Attach 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).

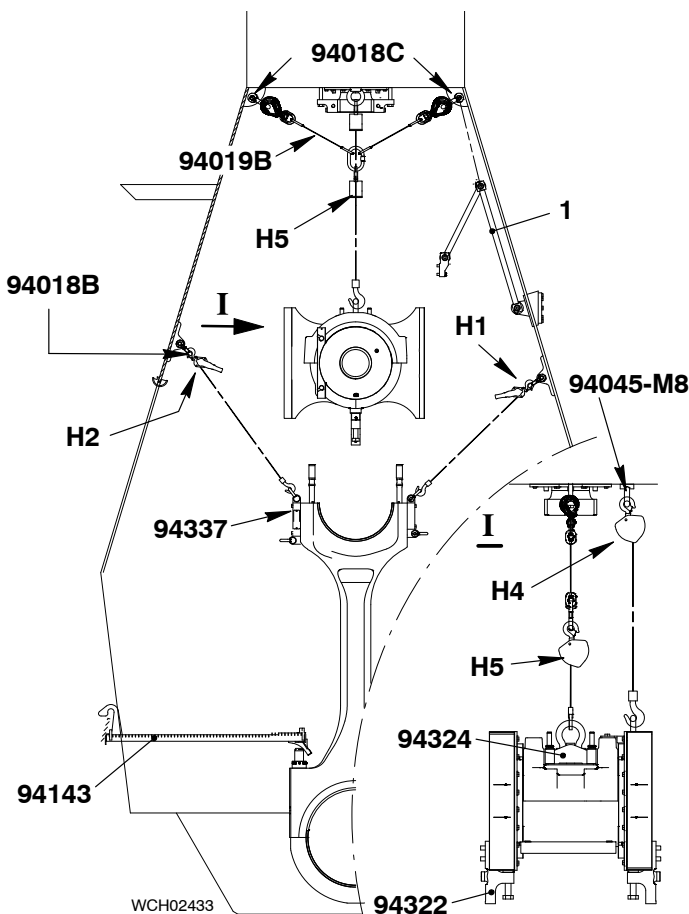


Fig. 8

- 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) Operate 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.

Top End Bearing Removal, Inspection Installation

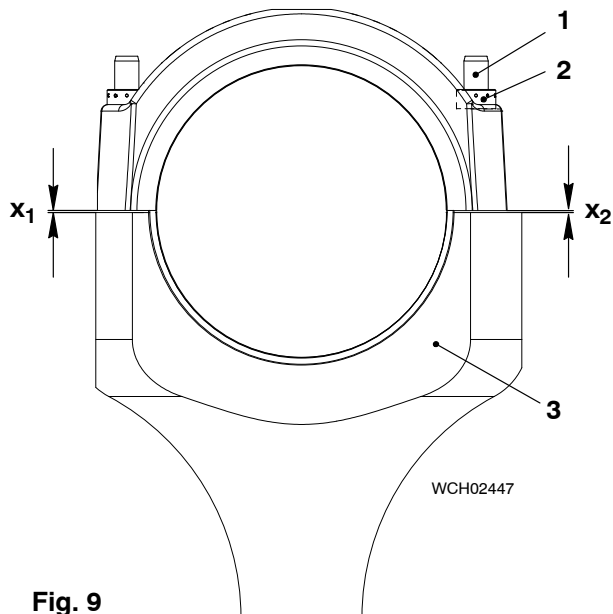


Fig. 9

- 19) Put the round nuts (2, Fig. 9) on the elastic studs (1).
 - 20) Use a round bar to tighten equally the round nuts (2).
 - 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.
- Note: During step 23), do not remove holders (94333).**
- 24) Remove all the tools and equipment used for this installation procedure.

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
SHELL	FIONA Oil 1500	1500	37.0	0.958
SHELL	VALVATA OIL 1000	1000	45.4	0.924
TEXACO	650T MINERAL Cylinder Oil	985	44.0	0.919

6. Bearing Lubrication

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

- 1) Remove the oil inlet pipe (2, Fig. 10).
- 2) Attach the flange (94336) to the support (1).
- 3) Connect the hose (3) to the flange (94336).
- 4) Fill the lubricating pump (4) with the steam-engine cylinder oil (refer to Table 1).
- 5) Operate the lubricating pump (4) until oil flows from the sides of the bearing.

Note: Do step 1) to 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 (3) has no pressure.
 - b) Disconnect the hose (3) from the flange (94336).
 - c) Remove the flange (94336).
 - d) Install the oil inlet pipe (2) to the support (1).

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

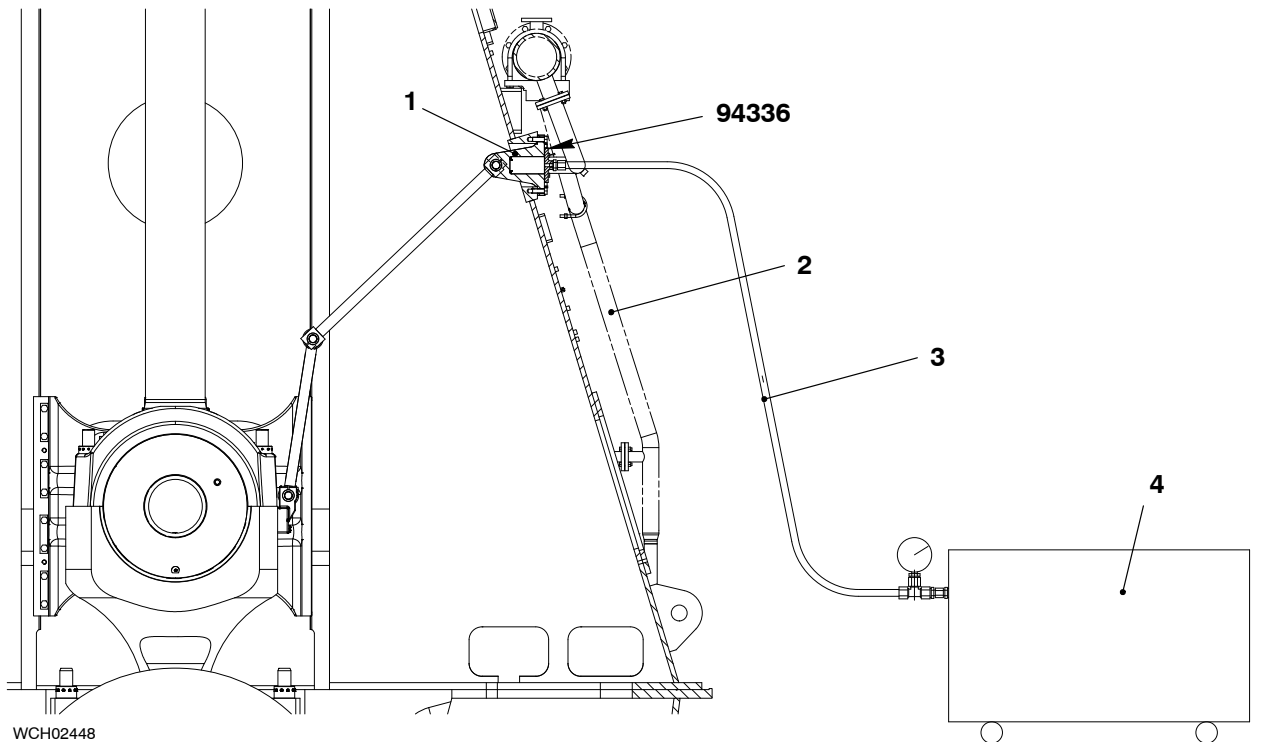


Fig. 10

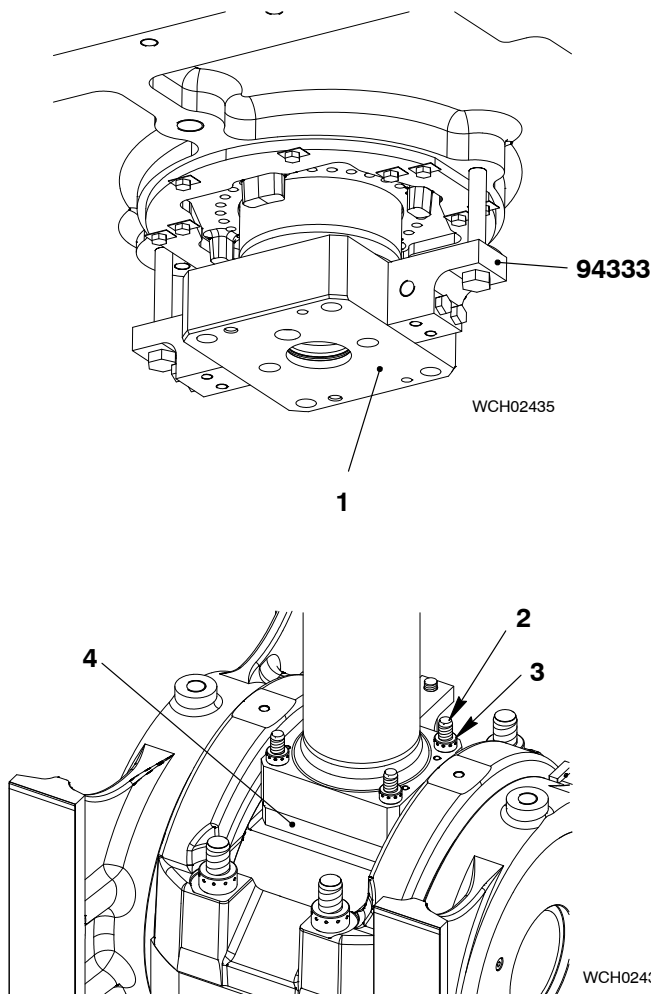


Fig. 11

7. Completion

WARNING



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

- 1) Make sure that the piston rod foot (1, Fig. 11) is clean and has no damage.
- 2) Make sure that the compression shim (4) is clean and has no damage.
- 3) Remove the platform (94143).
- 4) Unlock the turning gear.
- 5) Operate the turning gear to move the crankshaft to TDC. Make sure that the crosshead touches the piston rod foot (1).
- 6) Remove the holders (94333).
- 7) Operate the turning gear to lower the piston to BDC. Make sure that the piston rod foot (1) and the crosshead stay together.
- 8) Put the four round nuts (3) on the elastic studs (2).
- 9) Use the pre-tensioning jack (94315) to apply tension to the elastic studs (2), refer to 9304 4, paragraph 3.
- 10) Use the round bar to tighten the round nuts (3).
- 11) Remove all tools and equipment from the area.

Connecting Rod Removal and Installation

Tools:

4 Manual ratchet, 3200 kg, (H1 and H2 H3, H5)	94016-015	1 Chain asymmetrical	94019B
1 Manual ratchet, 6300 kg (H4)	94016-017	1 Holder	94334
1 Shackle, 8500kg	94018C	1 Connecting element	94334A
1 Chain symmetrical	94019A	4 Shackle, 3250 kg	94018A

1. Preparation	1
2. Removal	2
3. Connecting Rod – Move	5
4. Installation	7
5. Completion	11

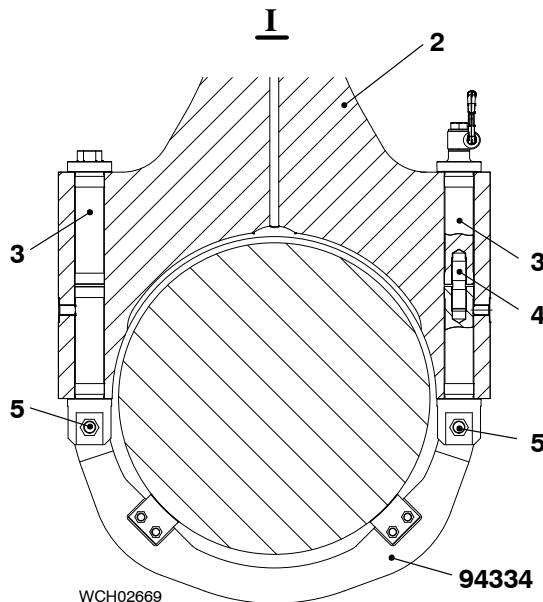
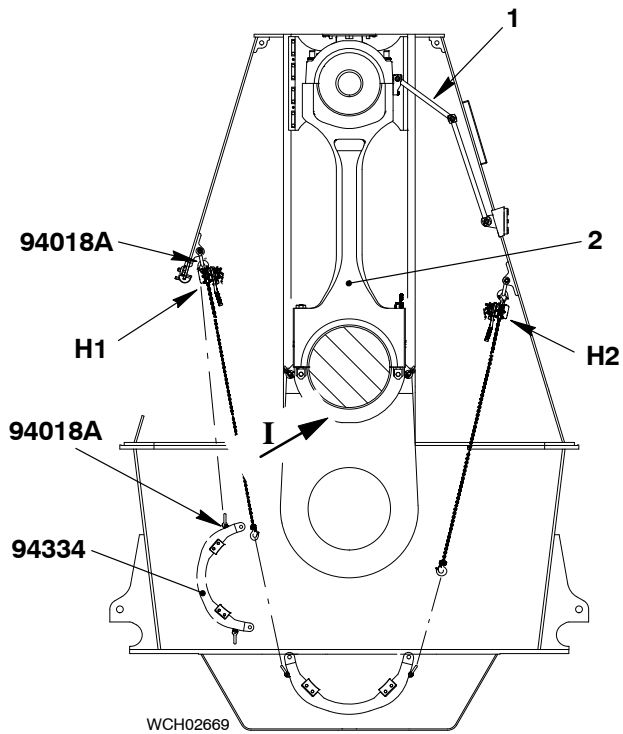


Fig. 1 WCH02669

1. Preparation

- 1) Read the data in 0012 1 General Guidelines for Lifting Tools.
 - 2) Prepare the piston, refer to 3303 3, paragraph 1 and paragraph 2.
- Note: During step 2), do not move the crosshead to BDC.**
- 3) Remove the bottom end bearing cover from the connecting rod (refer to 3303 2, paragraph 1 and paragraph 2).
 - 4) Attach two shackles (94018A, Fig. 1) to the column.
 - 5) Attach the two manual ratchets (H1 and H2) to the column.
 - 6) Attach two shackles (94018A) to the holder (94334).
 - 7) Attach the manual ratchets (H1 and H2) to the shackles on the holder (94334).
 - 8) Apply copper paste to the thread of the bolts (4).
 - 9) Put the rods (3) into the connecting rod (2).
 - 10) Operate the manual ratchets (H1 and H2) to lift the holder (94334) into position on the the rods (3).
 - 11) Tighten the nuts and bolts (5).
 - 12) Torque the rods (3) to 70 Nm.
 - 13) Lift the crosshead, refer to 3303 3, paragraph 2 and paragraph 3.
 - 14) Remove the the manual ratchets (H1 and H2) from the holder (94334).
 - 15) Remove the toggle lever (1) from the connecting rod (2).

Removal and Installation

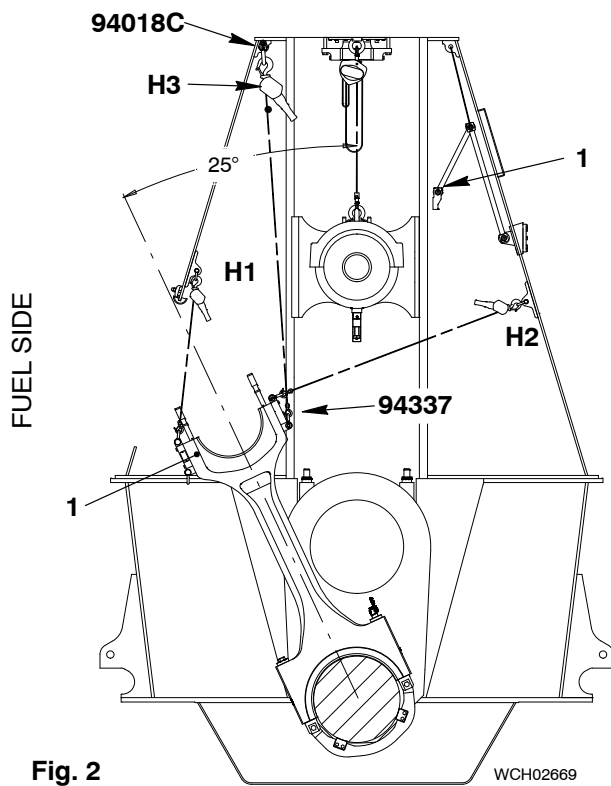


Fig. 2

2. Removal

WARNING

Injury Hazard: The connecting rod weighs 2436 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, or in the engine.

- 1) Operate the manual ratchets (H1 and 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 manual ratchet (H2) from the top shackle of the lifting tool (94337).
- 7) Operate 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

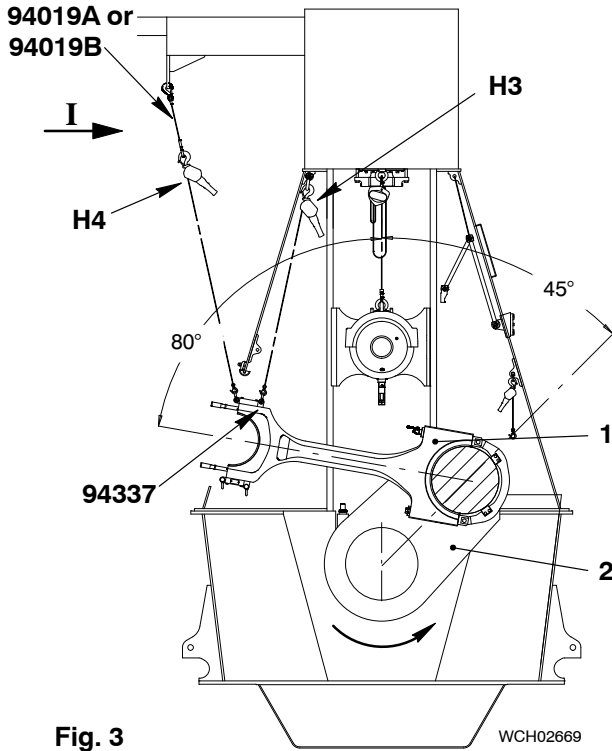
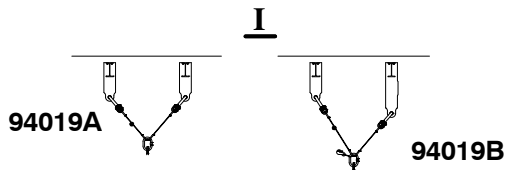


Fig. 3



- 8) Attach the applicable chain (94019A or 94019B) to the gallery.
- 9) Attach the manual ratchet (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.

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

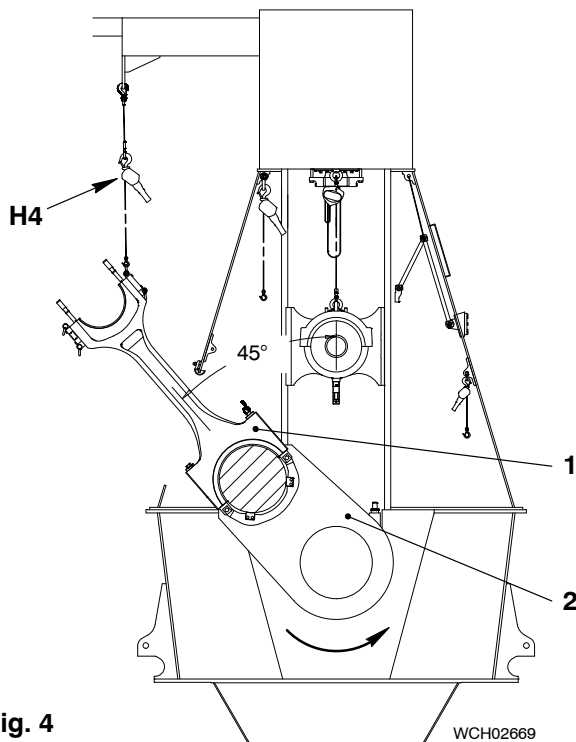


Fig. 4

- 13) Operate the turning gear and manual ratchet (H4) to move the crankshaft (2, Fig. 4) and the connecting rod (1) to the position as shown.

Removal and Installation

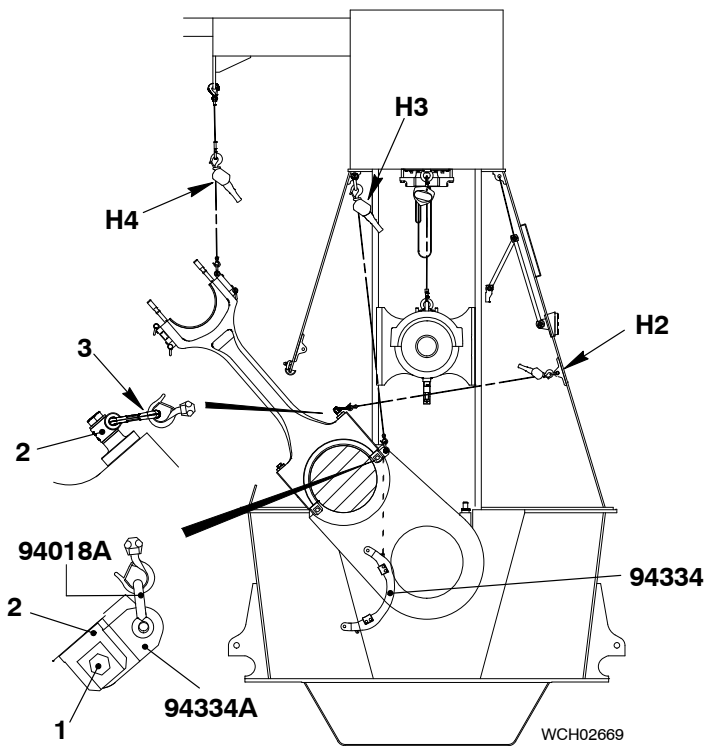


Fig. 5

- 14) Attach the manual ratchet (H2, Fig. 5) to the lug (3) on top of the rod (2).
- 15) Apply a light tension to the chain of the manual ratchet (H2).
- 16) Attach the manual ratchet (H3) to the shackle (94018A) on the connecting element (94334A).
- 17) Apply a light tension to the chain of the manual ratchet (H3).

Note: When you do step 18), hold the holder (94334) in position.

- 18) Carefully remove the bottom nut and bolt (1) from the holder (94334).
- 19) Lower the holder (94334) to the floor.
- 20) Remove the manual ratchet (H3) and the shackle from the holder (94334).
- 21) Attach the connecting element (94334A) to the bottom of the rod (2) with the nut and bolt (1).
- 22) Attach the shackle (94018A) and the manual ratchet (H3) to the connecting element (94334A).

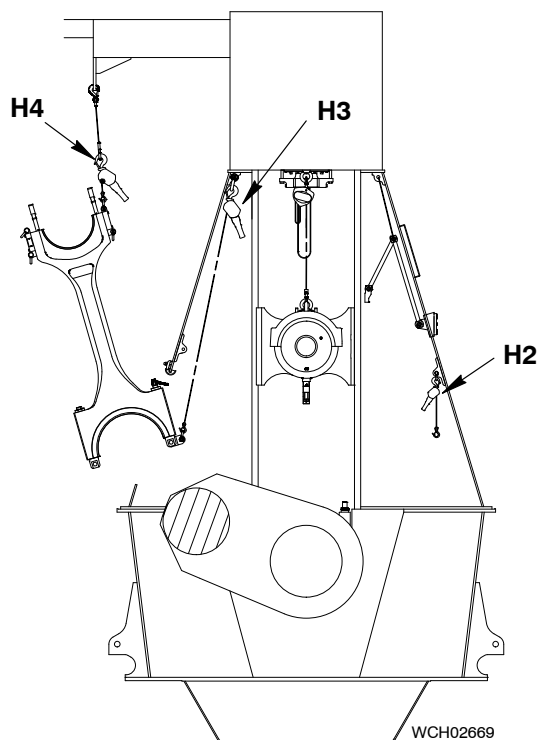


Fig. 6

- 23) Remove the manual ratchet (H2 Fig. 6) from the lug (3) on the top of the rod (2).
- 24) Operate the turning gear and manual ratchets (H3, H4) to carefully move the connecting rod out of the column.

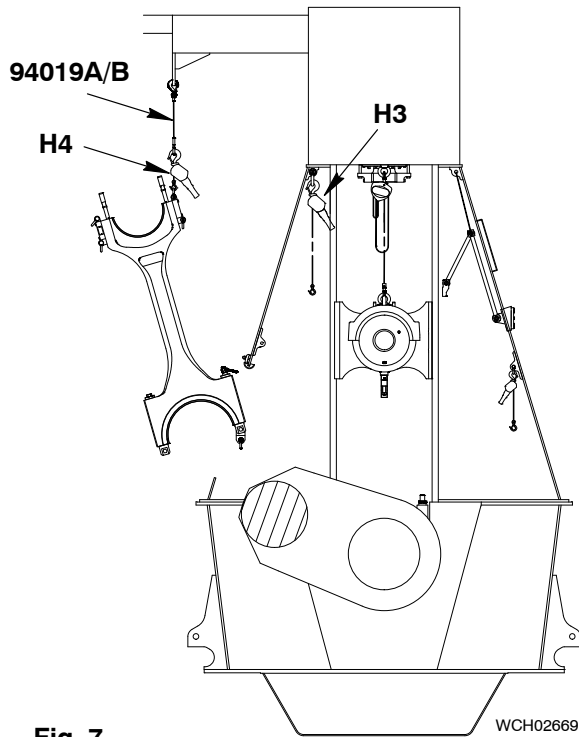


Fig. 7

- 25) Remove the manual ratchet (H3, Fig. 7) from the shackle (94018A) on the connecting element (94334A).

3. Connecting Rod – Move

If it is necessary to move the connecting rod away from the area, do step 1) to step 10).

- 1) Lower the connecting rod to the floor (see Fig. 8).
- 2) Remove the chain (94019A or 94019B).
- 3) Attach the two manual ratchets 94016-015 (1 and 2) to the connecting rod and the eyelets in the gallery as shown.

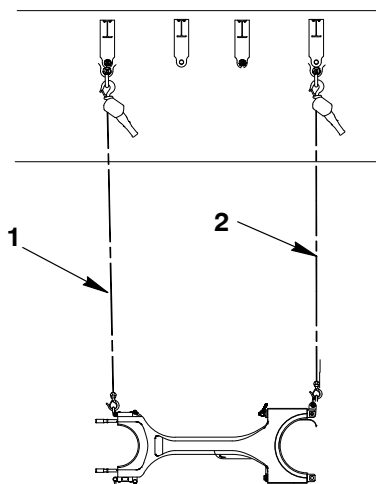


Fig.8

Removal and Installation

- 4) Read and obey the data given in Fig. 9.

<p>Load Condition 1</p> <p>$F = WLL = 15000 \text{ N}$</p>	<p>Load Condition 2</p> <p>$F = WLL = 10300 \text{ N}$</p>	<p>Permitted Load on Gallery Eyelets</p> <p>$a = \text{maximum } 35^\circ$</p> <p>$b = \text{maximum } 20^\circ$</p> <p>Note: Only one load is permitted on each eyelet.</p>
<p>Load Condition 3</p> <p>$F = WLL = 24600 \text{ N}$</p>	<p>Load Condition 4</p> <p>$F = WLL = 10300 \text{ N}$</p>	
<p>Load Condition 5: Application with 2-leg chain (94019A or 94019B)</p> <p>$F = WLL = 10300 \text{ N}$</p>		
<p>Load Condition 6: Application with 2-leg chain (94019A or 94019B)</p> <p>$F = WLL = 15000 \text{ N}$</p>		
<p>WCH02669</p>		

Fig. 9: Load Condition Data

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

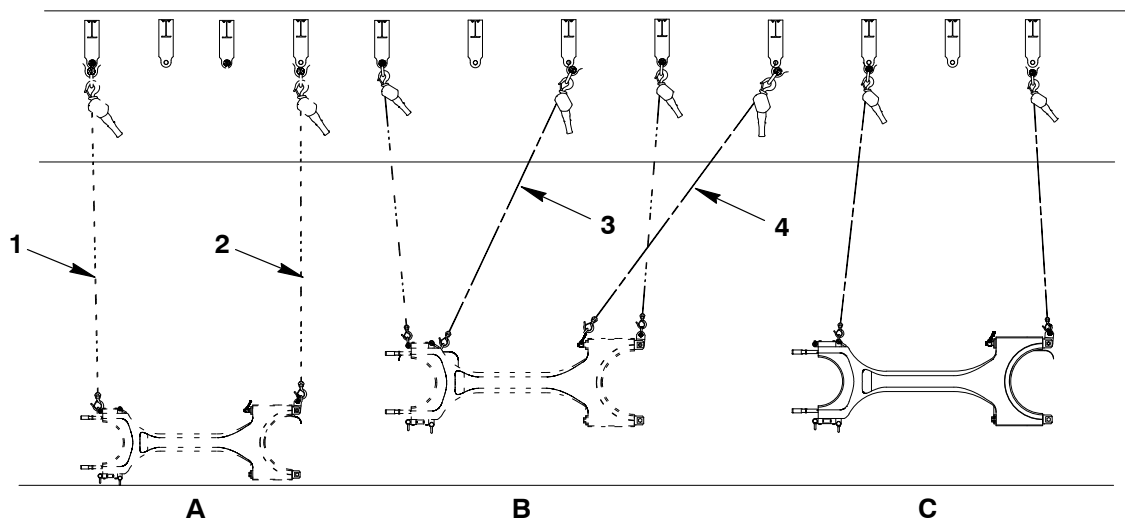


Fig. 10

Removal and Installation

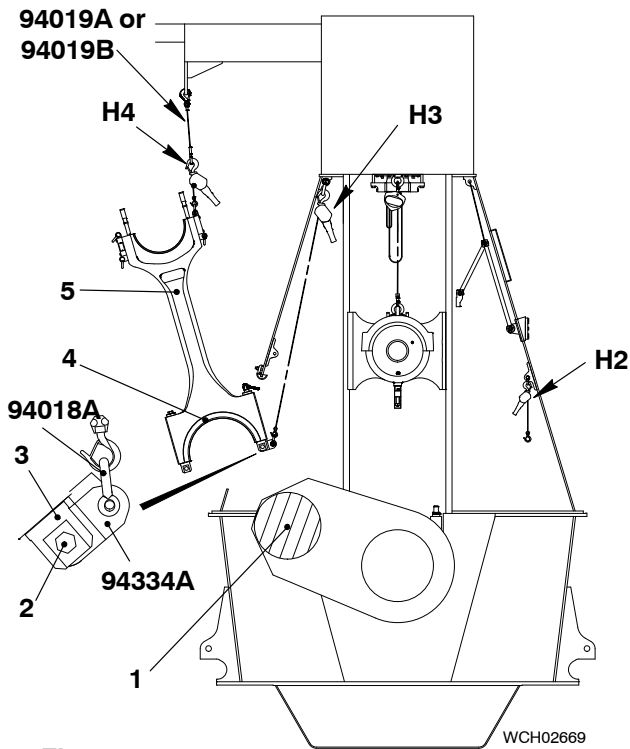


Fig. 11

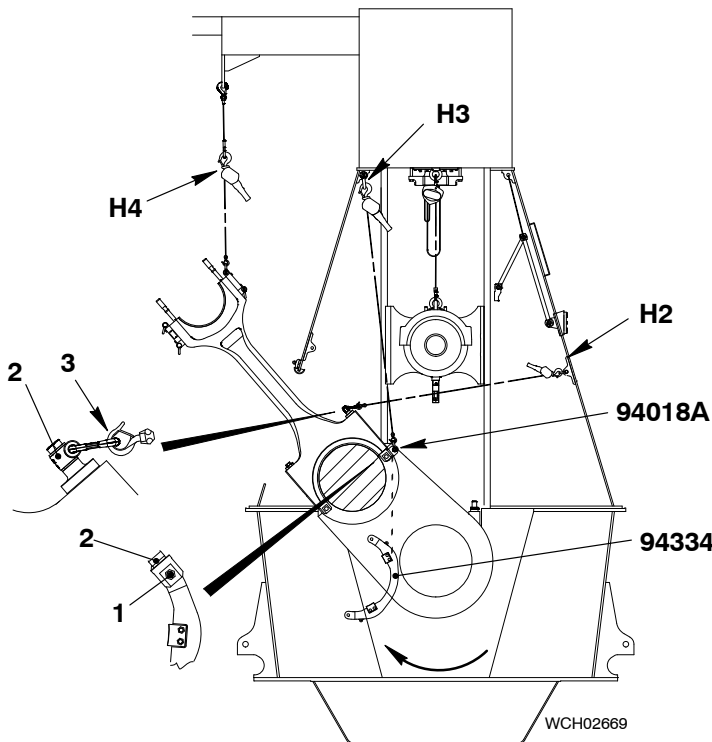




Fig. 12

4. Installation

WARNING


Injury Hazard: The connecting rod weighs 2436 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. 11) 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. 12) to the lug (3) on the top rod (2).
- 5) Operate the turning gear and the manual ratchets (H4, H3 and H2) to move the connecting rod and the crankshaft in clockwise position as shown.
- 6) Remove the manual ratchet (H3) from the shackle (94018A).
- 7) Remove the shackle (94018A) and the connecting element (94334A).
- 8) Attach the manual ratchet (H3) to the top eyelet on the holder (94334).
- 9) Operate the manual ratchet (H3) to lift the holder (94334) into position on the crank pin.
- 10) Attach the holder (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 holder (94334).
- 12) Attach the manual ratchet (H3) to the bottom eyelet of the holder (94334).
- 13) Operate the manual ratchet (H3) to lift the holder (94334).
- 14) Operate the manual ratchets (H4) and (H3) to move the connecting rod (5) clockwise to the position shown.

Removal and Installation

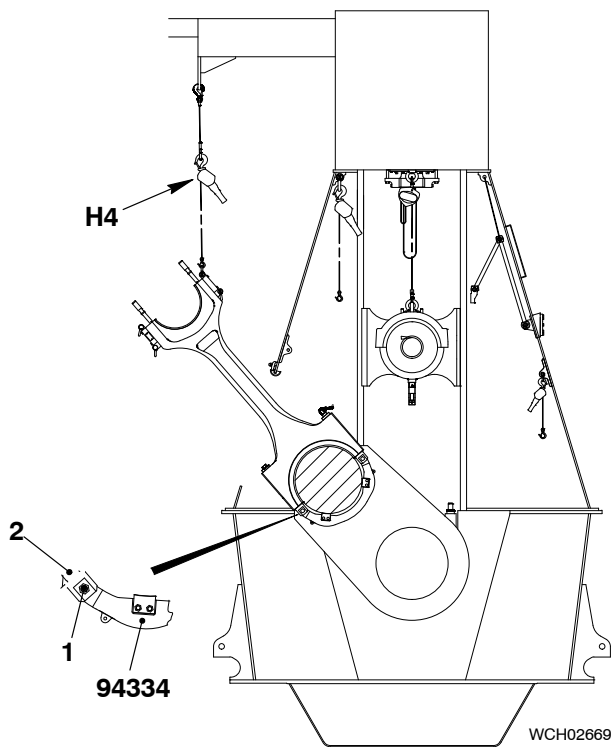


Fig. 13

- 16) Attach the bottom end of the holder (94334, Fig. 13) to the bottom rod (2)
- 17) Lock the holder and the bottom rod (2) with the nut and bolt (1).
- 18) Remove the manual ratchet (H3) from the bottom eyelet of the holder (94334).
- 19) Remove the manual ratchet (H2) from the lug on the top rod.

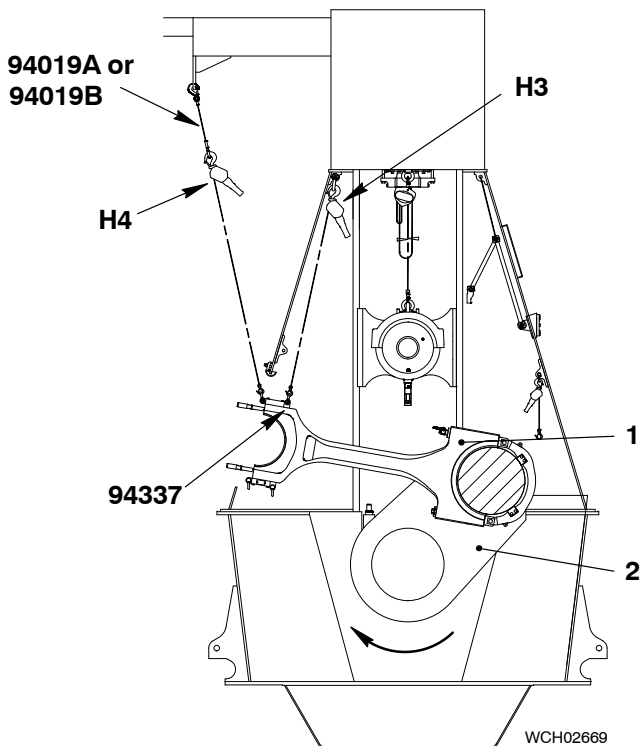


Fig. 14

- 20) Operate the turning gear and the manual ratchet (H4, Fig. 14) to move the connecting rod (1) and crankshaft (2) clockwise to the position shown.
- 21) Attach the manual ratchet (H3) to the bottom shackle on the lifting tool (94337).
- 22) Remove the manual ratchet (H4) and the chain (94019A or 94019B).

Removal and Installation

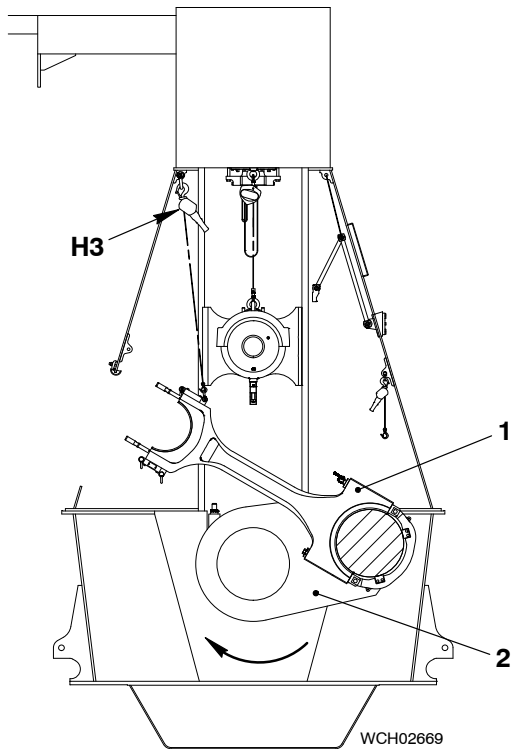


Fig. 15

- 23) Operate the turning gear and the manual ratchet (H3, Fig. 15) to move the connecting rod (1) and crankshaft (2) clockwise to the position shown.

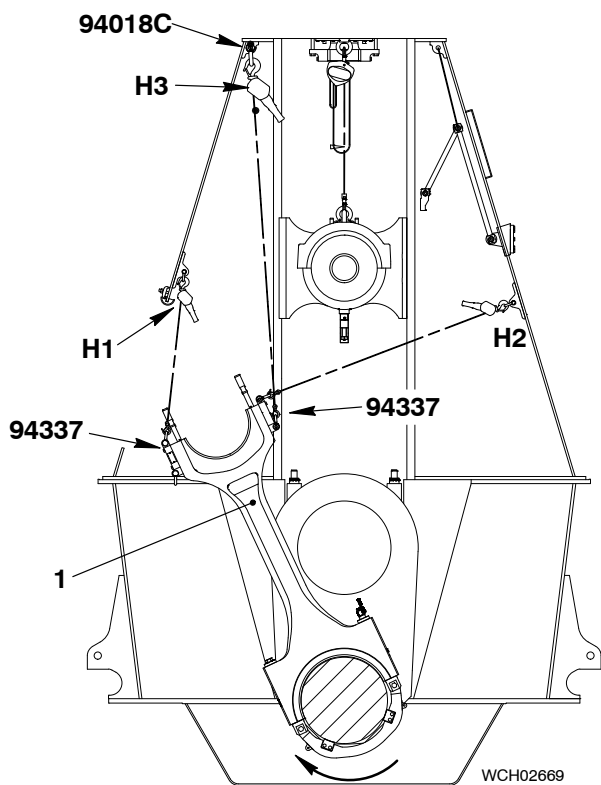
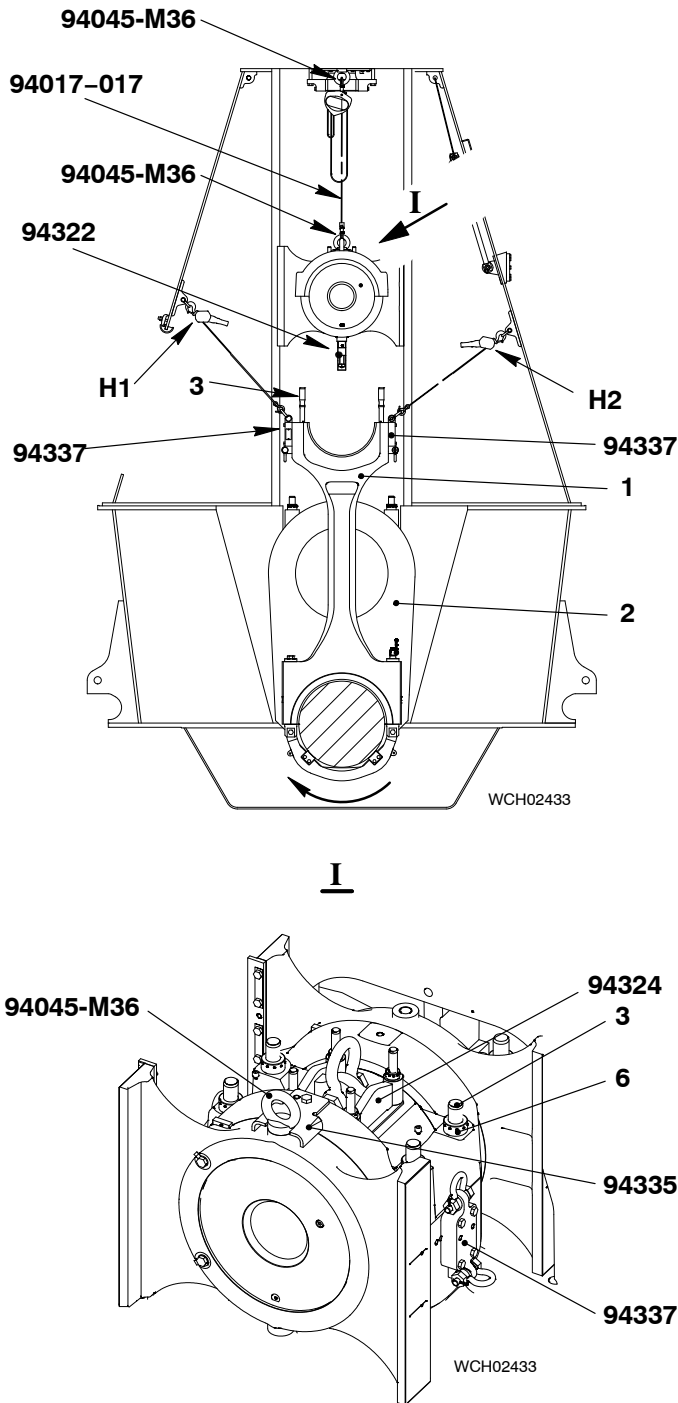


Fig. 67

- 24) Attach the manual ratchet (H2, Fig. 16) to the top shackle of the lifting tool (94337).
- 25) Attach the manual ratchet (H1) to the lifting tool (94337).
- 26) Remove the manual ratchet (H3) from the bottom shackle of the lifting tool (94337) and the top of the column.
- 27) Operate the turning gear and the manual ratchet (H3) to move the connecting rod (1) and crankshaft clockwise to the position shown.

Removal and Installation



- 28) Operate the turning gear and the manual ratchets (H1 and H2, Fig. 17) to move the connecting rod (1) and crankshaft (2) clockwise to the position shown.
- 29) Make sure that there is a light tension on the manual ratchet (H4).
- 30) Remove the two supports (94332).
- 31) Operate the manual ratchet (H4) to lower the crosshead on the connecting rod (1). Make sure that the elastic studs are aligned with the related holes in the crosshead.
- 32) Attach the four round nuts (6) to the elastic studs (3).
- 33) Remove the manual ratchet (H4).
- 34) Remove the tool (94324).
- 35) Remove the manual ratchets (H1 and H2) from the lifting tool (94337).
- 36) Remove the lifting tool (94324).
- 37) Remove the eye bolt (94045 M36).
- 38) Remove the stop plate (94355).
- 39) Remove the manual ratchets (H1 and H2) from the lifting tools (94337).

Fig. 17

Removal and Installation

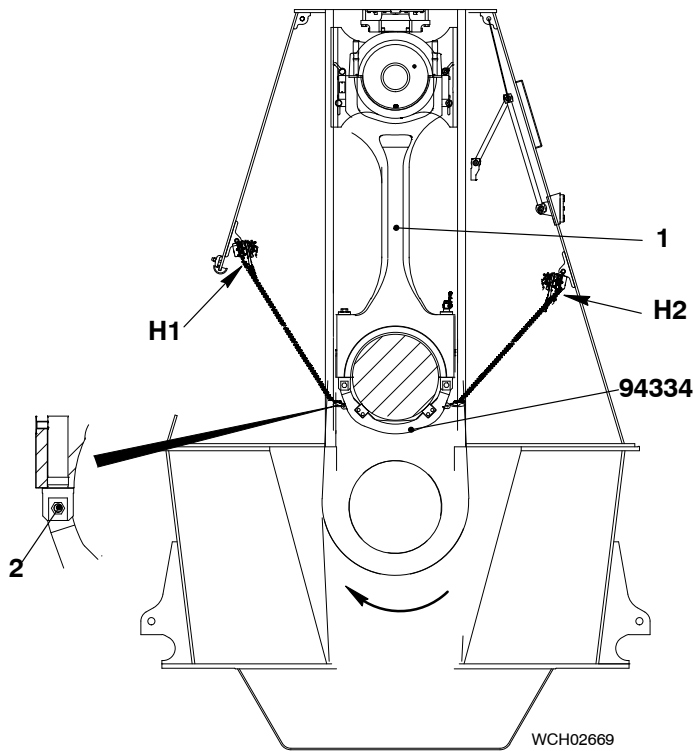


Fig. 18

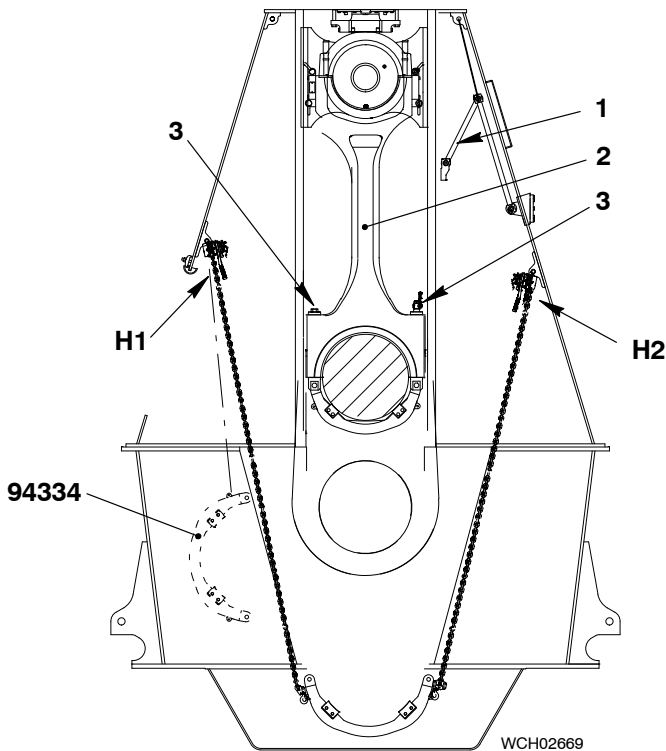


Fig. 19

- 40) Operate the turning gear to move the connecting rod (1, Fig. 18) in clockwise to TDC.
- 41) Attach the manual ratchets (H1 and H2) to the eyelets on the the holder (94334).
- 42) Apply a light tension to the chains of the manual ratchets (H1 and H2).
- 43) Remove the two nuts and bolts (2) from the holder (94334).

- 44) Operate the manual ratchets (H1 and H2, Fig. 19) to lower the holder (94334).
- 45) Remove the manual ratchet (H2) from the holder (94334).
- 46) Operate the manual ratchet (H1) to remove the holder (94334) from the crankcase.
- 47) Attach the toggle lever (1) to the connection piece on the connecting rod (2).
- 48) 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, (refer to 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 (H1, H2)	94016-025	1 Chain 3150 kg	94019B
1 Manual ratchet 6300 kg (H3)	94016-017	1 Chain 1000 kg	94019C
2 Eye bolt	94045-M20	1 Deviation pipe	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
4. Completion	4

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 deviation pipe (94117B) to the top of column opening.
- 5) Make sure that the turning gear is locked to prevent movement of the crankshaft.

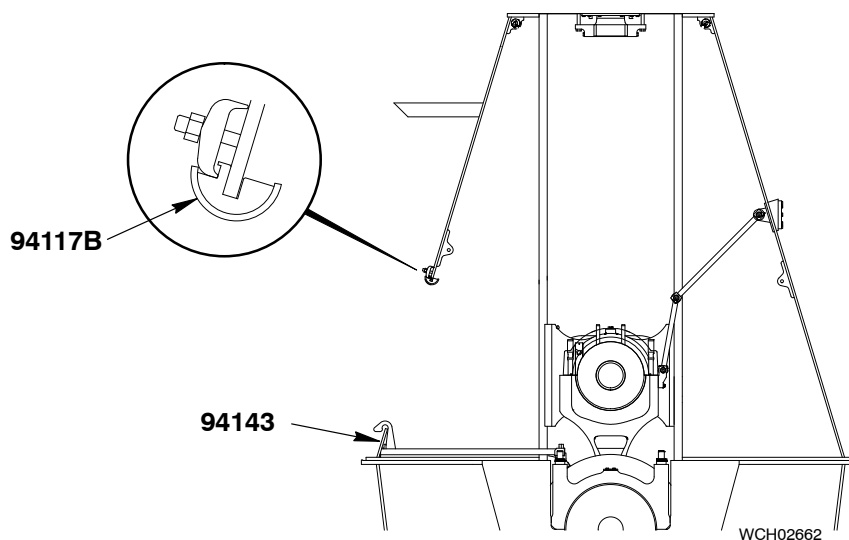


Fig. 1

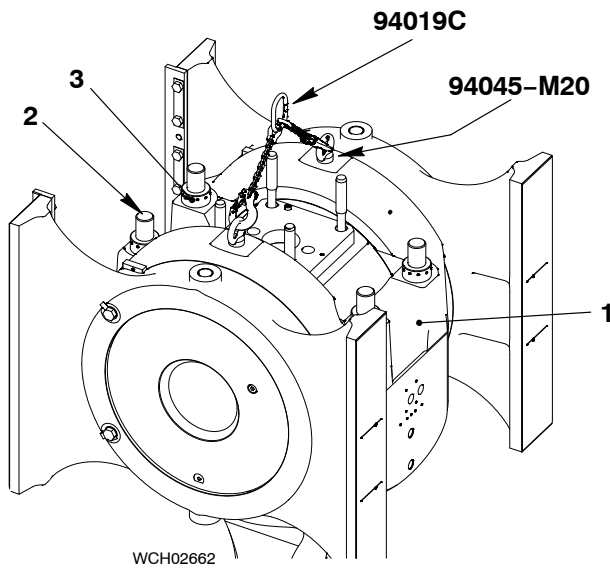


Fig. 2

2. Removal

- 1) Use the pre-tensioning jack (94315) to apply tension to the four elastic studs (2, 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).

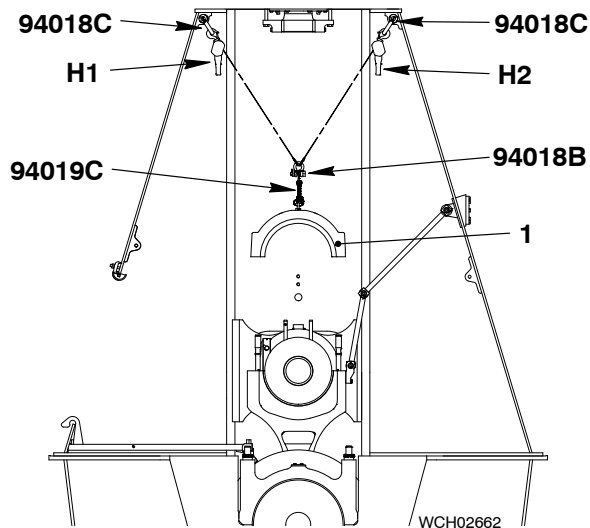


Fig. 3

- 5) Attach the two shackles (94018C, Fig. 3) to the attachment points on the frame.
- 6) Attach the two manual ratchets (H1, H2) to the shackles (94018C).
- 7) Attach the two manual ratchets (H1, H2) 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 carefully the two manual ratchets (H1, H2) to lift the bearing cover (1).

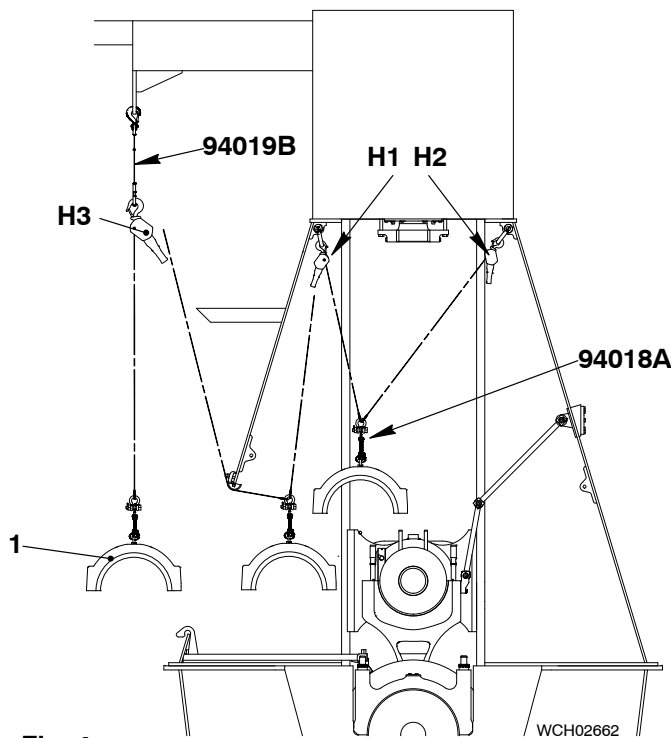


Fig. 4

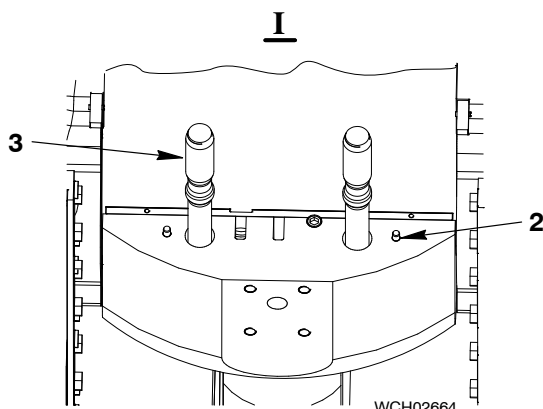
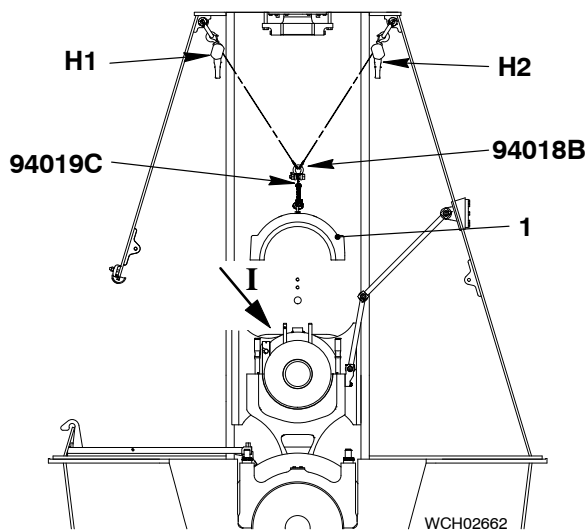


Fig. 5

- 10) Attach the chain (94019B, Fig. 4) to the gallery.
- 11) Attach the manual ratchet (H3) to the chain (94019B).
- 12) Operate the two manual ratchets (H1, H2) to move the bearing cover to the fuel side.
- 13) Lower the bearing cover a small distance.
- 14) Attach the manual ratchet (H3) to the shackle (94018B).
- 15) Remove carefully the manual ratchet (H1).
- 16) Operate the manual ratchets (H2, H3) to move the bearing cover (1) to the fuel side.
- 17) Lower the bearing cover (1) to an applicable surface.
- 18) If necessary, remove the chain (94019C) from the bearing cover (1).
- 19) Do an inspection of the bearing cover (1). If necessary, replace the bearing cover.

3. Installation

- 1) Make sure that the bearing cover (1, Fig. 5) has no damage.
- 2) Attach the chain (94019C) to the bearing cover (1).
- 3) Attach the manual ratchets (H2, H3) to the chain (94019C).
- 4) Operate the manual ratchets (H2, H3) to move the bearing cover (1) to a position above the crosshead.
- 5) Attach the manual ratchet (H1) to the chain (94019A).
- 6) Carefully remove the manual ratchet (H3) from the shackle (94018B).
- 7) Operate the manual ratchets (H1, H2) to move the bearing cover (1) to a position directly above the elastic bolts.

Note: During step 8), make sure that you do not cause damage to the elastic bolts (3).

- 8) Lower carefully the bearing cover (1) on to the crosshead pin.
- 9) Make sure that the holes in the bearing cover (1) engage with the four dowel pins (2).

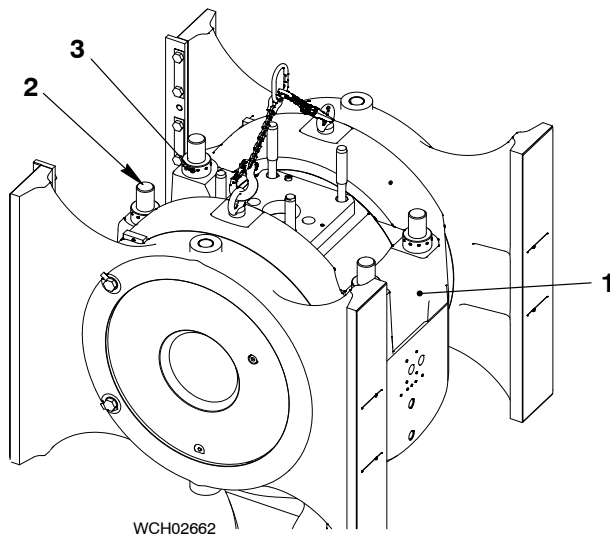


Fig. 6

- 10) Attach the round nuts (3, Fig. 6) to the elastic bolts (2).
- 11) Use the pre-tensioning jack (94315) to apply tension to the elastic studs (2) refer to 9403 4.
- 12) Use a round bar to tighten the round nuts (3).

4. Completion

- 1) Attach the piston to the crosshead, refer to 3303 3, paragraph 7.
- 2) Remove all tools and equipment from the area.

Crankcase

Clearance Checks

Tools:

- 1 Feeler gauge 94238

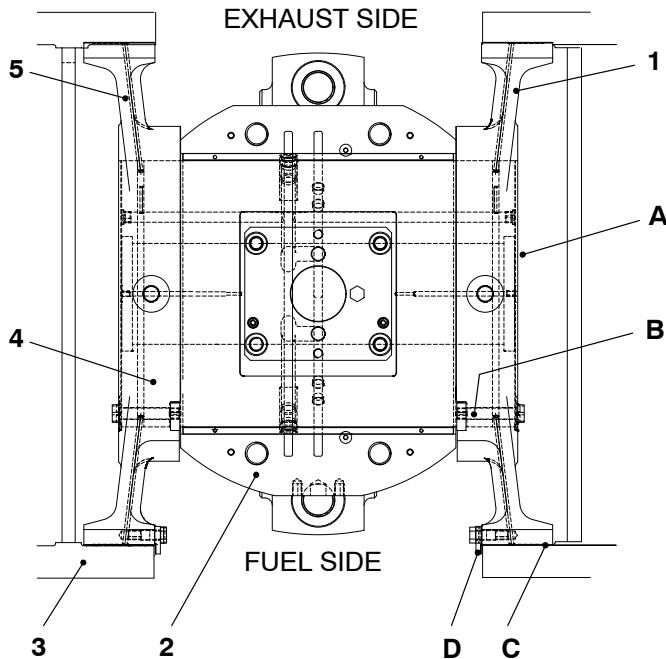


Fig. 1

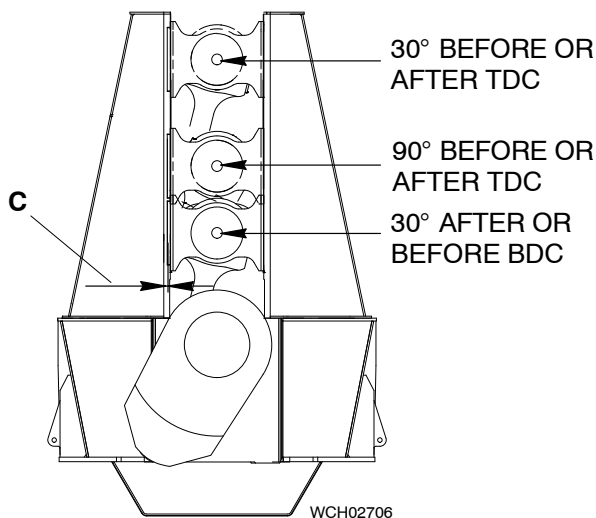


Fig. 2

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.
- 2) The guide shoes (1) and (5) must touch the guide ways (3) (on the fuel side or exhaust side).
- 3) Measure the clearance (C) between the guide shoe (1) and the guide way (3).

Note: The clearance (C) 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 (D) 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.
 - b) 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 (A) between the top end bearing (2) and the the guide shoes (1, 5).

2.4 Radial Clearance

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

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Crosshead Pin – Removal / Installation / Clearance Checks

Tools:

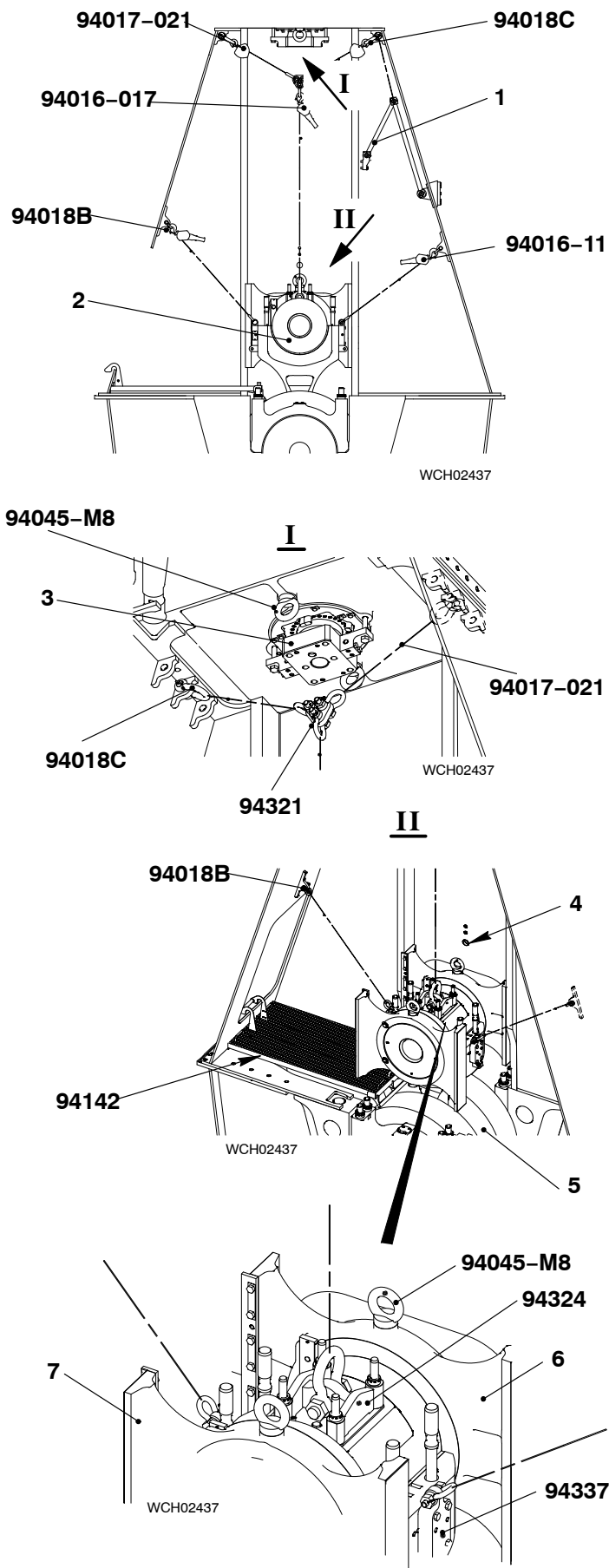
1	Protection tool	94117B	2	Eye bolt M20	94045 M20
1	Platform	94142	2	Eye bolt M30	94045 M30
1	Lifting tool	94324	4	Eye bolt M48	94045 M8
2	Spur geared chain block	94017 021	1	Chain	94325
2	Manual ratchet	94016 017	1	Chain	94019A/B
2	Manual ratchet	94016 011	1	Link	94321
2	Manual ratchet	94016 031	2	Lifting 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	
	<p>Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel.</p>

- 1) Read the data in [0012 1](#) General Guidelines for Lifting Tools.
- 2) Operate 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), refer to [3301 1](#).
- 5) Remove 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, refer to [9403 4](#).
- 7) Remove the top bearing cover, refer to [3303 5](#).
- 8) Put protection on the oil inlets of the crosshead pin to prevent damage and contamination.



2. Crosshead Pin – Removal

- 1) Attach the lifting tool (94234, Fig. 1) to the crosshead.
- 2) Attach the two eye bolts (94045 M8) 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 (94321) and the eye bolt (94045 M8) on the lifting tool.
- 7) Attach the two eye bolts (94045 M8) to the guide shoes (6, 7).
- 8) Attach the two lifting tools (94337) to the connecting rod (2).
- 9) Attach the two manual ratchets (94016 011) to the shackles (94018B) and the lifting tools (94337).
- 10) Apply a light tension to the chains.

Fig. 1

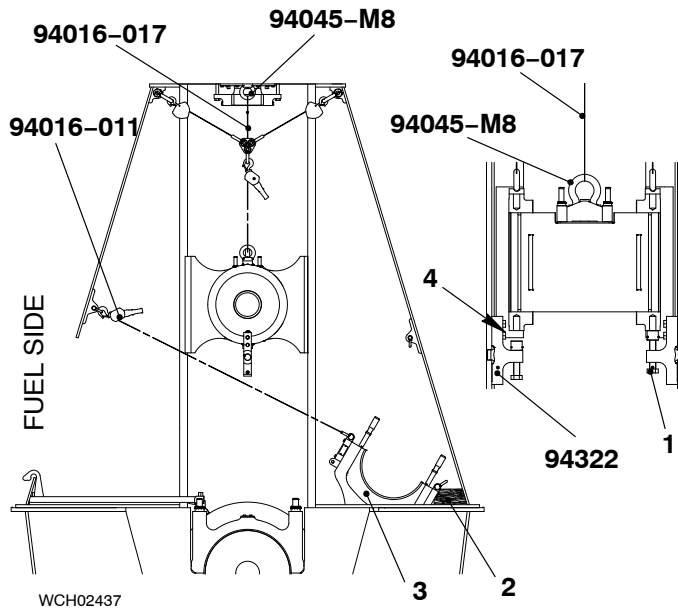


Fig. 2

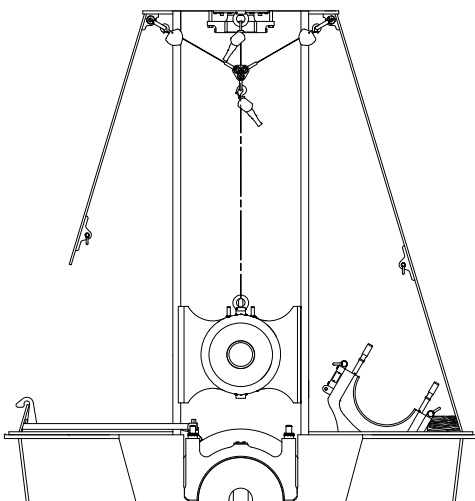


Fig. 3

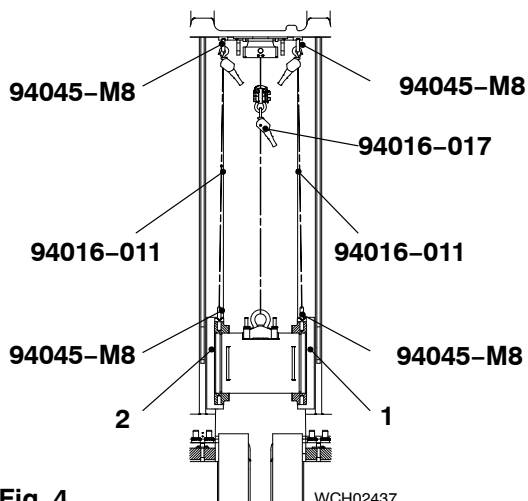


Fig. 4

- 11) Operate the manual ratchet (94016-017) to lift the crosshead approximately 160 mm above the center of the pin hole (4). Refer to Fig. 1 view II and Fig 2).
 - 12) Attach the two supports (94322) to the guide way with the four bolts (1) as shown.
- Note: The two supports (94322, Fig 2) hold the weight of the crosshead while you move the connecting rod (4).**
- 13) Torque the four bolts (4) to 300 Nm.
 - 14) Tighten the two set screws (1).
 - 15) Lower the crosshead on to the supports (94322).
 - 16) Put the wooden block (2) in position as shown.
- Note: During the step below, slowly move the connecting rod to the exhaust side.**
- 17) On the fuel side, gradually release tension from the manual ratchet (94016-011). At the same time, keep a light tension on the chain of the manual ratchet on the exhaust side.
 - 18) Continue with step 17) until the connecting rod (3) touches the wooden block (2).
 - 19) Release tension from the two set screws (1).
 - 20) Lift the crosshead a small distance.
 - 21) Remove the two supports (94322).
 - 22) Remove the two manual ratchets (94016-011).
 - 23) Lower the crosshead to the same height as the column door frame (refer to Fig. 3).
 - 24) Attach the manual ratchets (94016-011, Fig. 4) to the eye bolts (94045-M8) on the guide shoes (1 and 2).
 - 25) Apply a light tension to the chain of the manual ratchets (94016-017).
 - 26) Make sure that the primary load stays on the chain of the manual ratchet (94016-017)

Crosshead Pin Removal / Installation / Clearance Checks

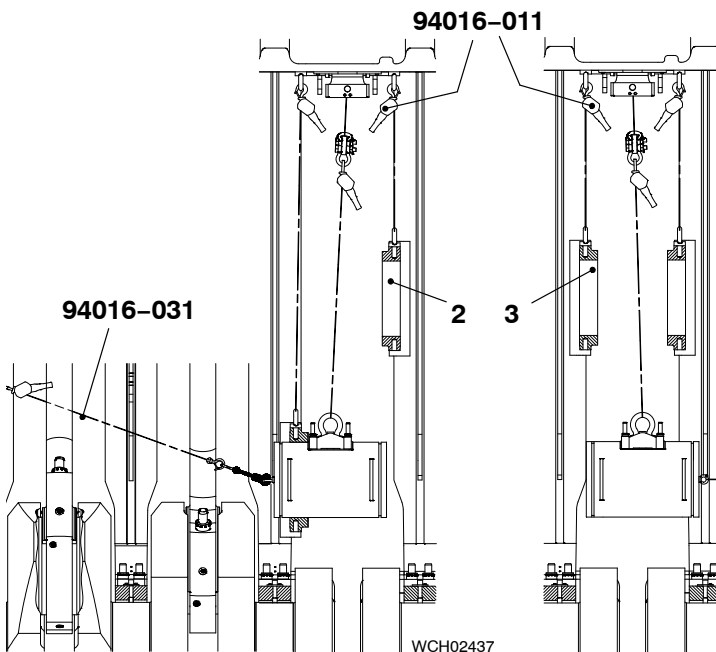
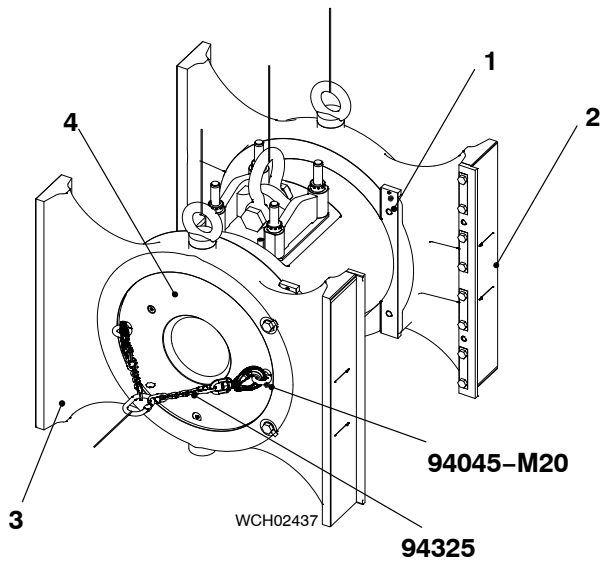


Fig. 5

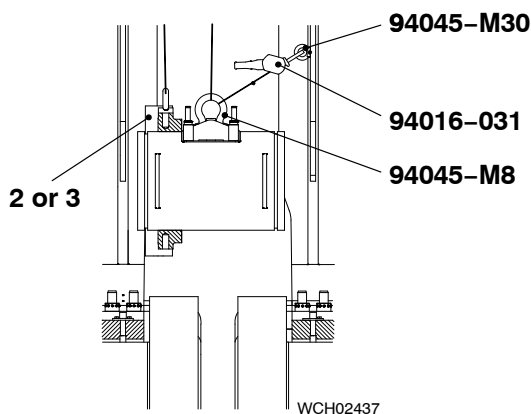


Fig. 6

- 27) Remove the two bolts, tab washers and holding plates (1, Fig. 5) from the from the guide shoe (2).
- 28) Attach the two eye bolts (94045 M20) and the the chain (94325) to the crosshead pin (4).
- 29) Attach the shackle (94018B) to an applicable position on the column.
- 30) Attach the manual ratchet (94016 031) to the chain (94325) and the shackle (94018B).
- 31) Operate the manual ratchet (94016 031) to pull the crosshead pin (4) until the guide shoe (2 or 3) is clear.
- 32) Operate the manual ratchet (94016 011) to lift the guide shoe (2 or 3).
- 33) Remove the chain (94325), manual ratchet (94016 031), shackle 94018B and eye bolts (94045 M20).
- 34) Attach the eye bolts (94045 M20), chain (94325), shackle (94018B) and manual ratchet (94016 031) to the other side of the crosshead pin (4).
- 35) Do step 31) to step 33) for the other guide shoe.
- 36) When the crosshead (4) is in the first or last cylinder position, do step 37) to step 43).
- 37) Attach the eye bolt to (94045 M30, Fig. 6) an applicable hole in the column.
- 38) Attach the manual ratchet (94016 031) to the eye bolt (94045 M30) and the eye bolt (94045 M8).
- 39) Operate the manual ratchet to pull the crosshead pin from the guide shoe (2 or 3).
- 40) Operate the manual ratchet (94016 011) to lift the guide shoe (2 or 3).
- 41) Remove the manual ratchet (94016 031) and the eye bolt (94045 M30).
- 42) Attach the eye bolt (94045 M30) and manual ratchet (94016 031) to the other side of the column.
- 43) Do step 39) to step 41) for the other guide shoe.
- 44) Remove the manual ratchet (94016 031) and the eye bolt (94045 M30).

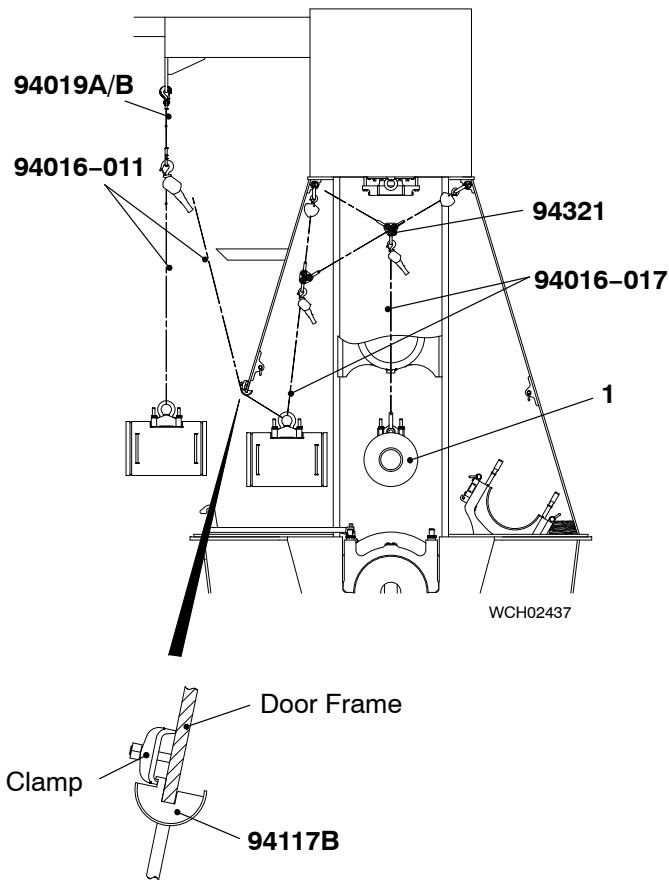


Fig. 7

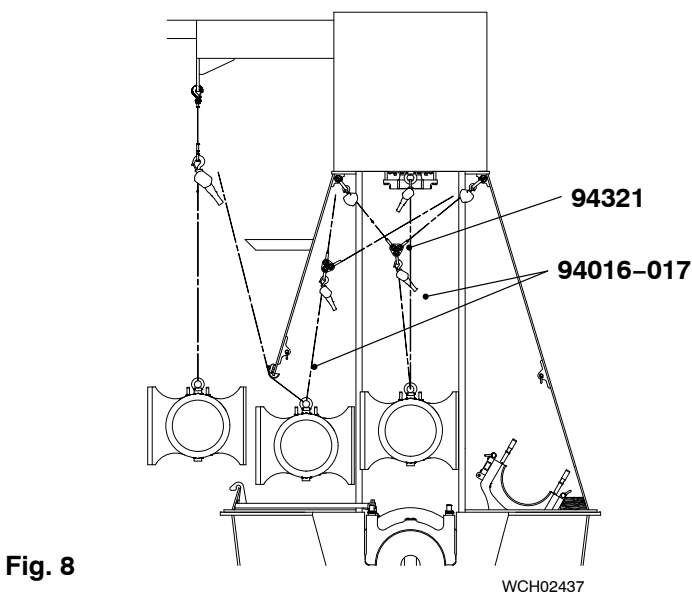


Fig. 8

- 45) Attach the protection tool (94117B, Fig. 7) to the door frame.
 - 46) Attach the chain (94019A/B) to the attachment point on the gallery.
 - 47) Attach the manual ratchet (94016-017) to the chain (94019A/B) and the eye bolt on the crosshead (1).
 - 48) Turn the crosshead pin (1) 90°.
- Note: When you do step 49) keep a light tension on the two manual ratchets (94016-017).**
- 49) Move the crosshead pin (1) through the door frame as follows:
 - a) Tighten the manual ratchet (94016-011) at the same time, carefully release tension from the manual ratchet (94016-017).
 - b) Lower the crosshead on to an applicable wooden support.
 - c) Remove the manual ratchets (94016-011 and 94016-017) from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

- 1) Record the positions of the guide shoes.

Note: The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.

- 2) Operate 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 do the step 7) keep a light 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 release tension from the manual ratchet that is attached to the link 94321.
 - b) Lower the guide shoe (1) on to an applicable wooden support.
- 7) Do step 2) to step 7) for the other guide shoe.

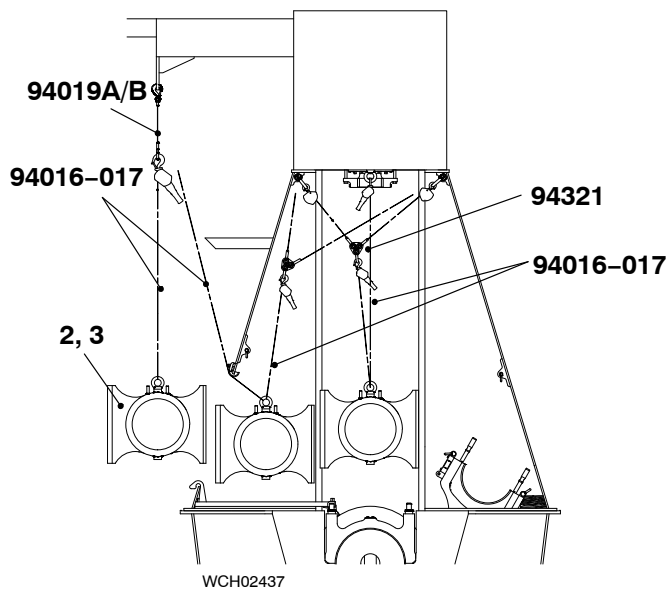


Fig. 9

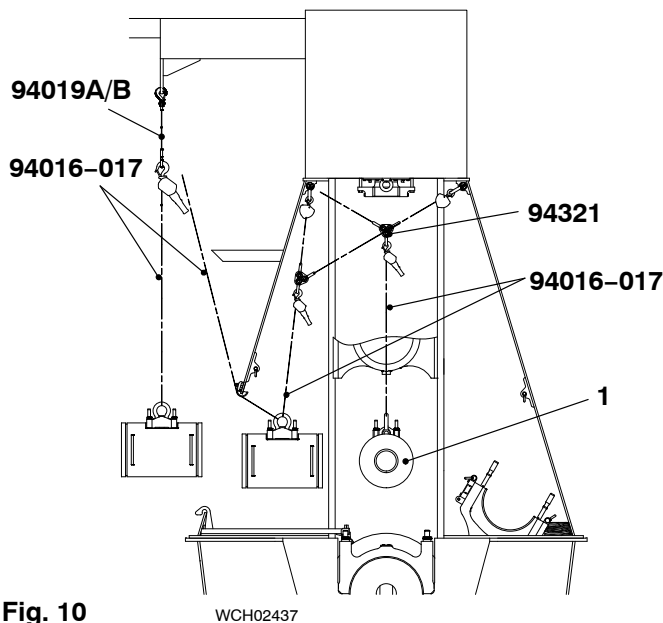


Fig. 10

4. Guide shoes – Installation

Note: When you do step 1) to step 7), 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 do step 3) to step 5), keep a light tension on the two manual ratchets.

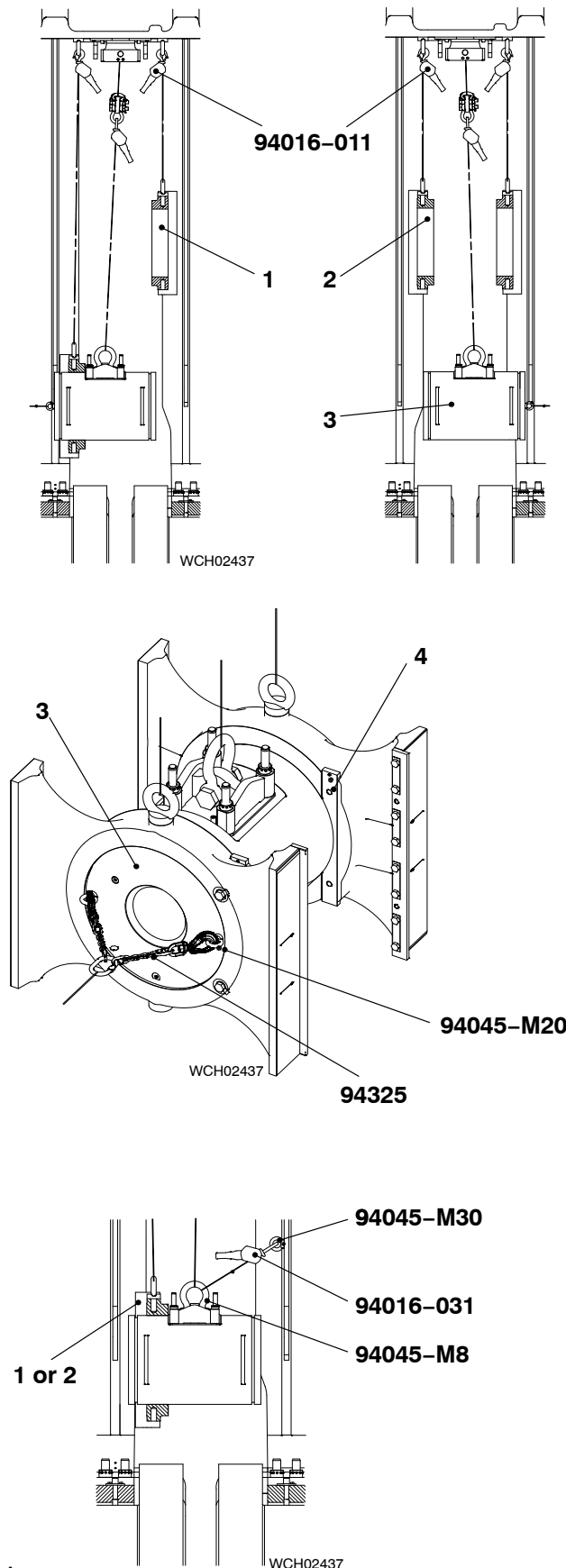
- 3) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet that is attached to the link (94321). At the same time, carefully release tension from the manual ratchet that is attached to the gallery.
- 4) Attach the manual ratchet (94016 011, Fig. 5) to the guide shoe (2 or 3).
- 5) Operate 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 to all the guide and the 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 a light tension on the two manual ratchets (94016-017).

Crosshead Pin Removal / Installation / Clearance Checks



- 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 release tension from the manual ratchet that is attached to the gallery.
- 6) Remove the manual ratchet that is attached to the chain (94019A and 94019B) in the gallery.
- 7) Turn the crosshead pin (3, Fig. 11) 90°.
- 8) Remove the protection tool (94117B) from the door frame.
- 9) Lower and align the guide shoe (2) 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) Operate 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) Operate 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).

Fig. 11

Crosshead Pin Removal / Installation / Clearance Checks

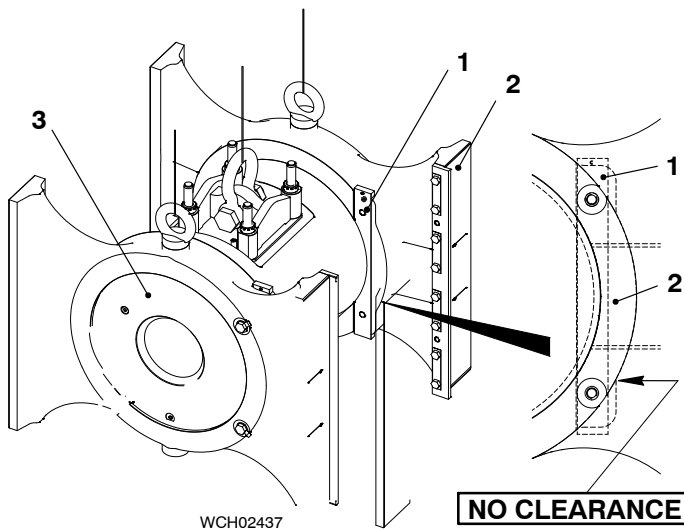


Fig. 12

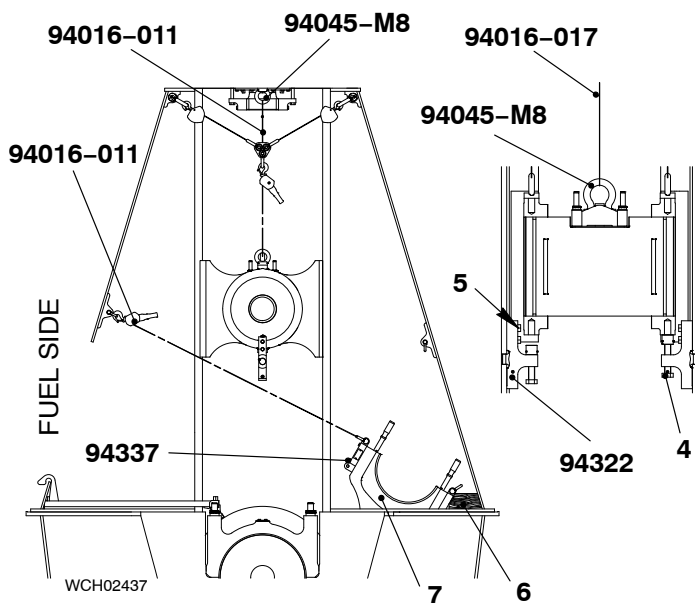


Fig. 13

19) Attach the two holding plates (1, Fig. 12) to the guide shoe (2) with the tab washers and the bolts.

20) Make sure that there is no clearance between the holding plates (1) and crosshead pin (3).

21) Operate 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) Torque 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).

26) Apply a light tension to the chains.

Note: During the step 27), slowly move the connecting rod to the fuel side.

27) On the fuel side, gradually tighten the manual ratchet. At the same time, keep a light tension on the chain of the manual ratchet on the exhaust side.

28) Continue with the step 27) until the connecting rod (7) aligns with the crosshead.

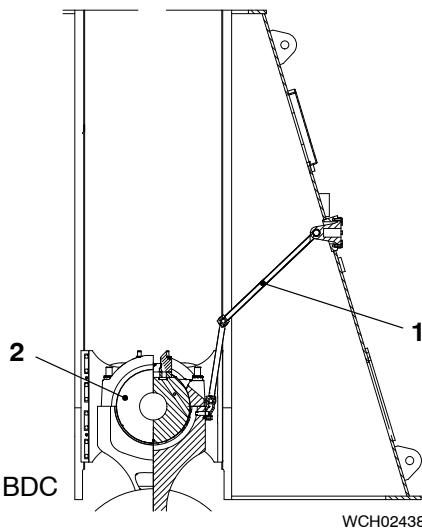
29) Remove the wooden block (6).

30) If necessary, lift the crosshead to a small distance.

31) Loosen the two set screws (4).

32) Remove the two supports 94322.

Note: During step 33), make sure that the elastic bolts in the connecting rod align with the holes in the crosshead pin.



NOTE: THE CRANK IS AT BDC

Fig. 14

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

CAUTION



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

- 37) Attach the toggle lever (1) to the crosshead pin (2)
- 38) Make sure that the toggle lever is in the position shown.

6. Clearance Checks

- 1) Do the clearance checks, refer to [3326 1](#).
- 2) Compare the clearances with those given in 0330 – 1 Clearance Table, [Crosshead Guide](#).

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) Make sure that all tools and equipment are removed from the work area.
- 4) Disengage the turning gear.
- 5) Set the lubricating oil pump to on.
- 6) 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:

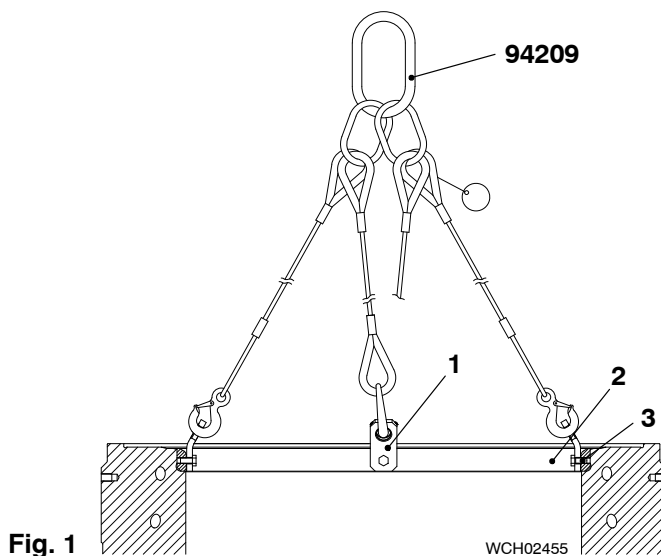
1 Lifting tool	94209	1 Insertion funnel	94342
2 Distance holders	94230	1 Cover plate	94345D
1 Piston suspension device	94341	1 Device	94350
2 Distance plates	94341A		

1. Preparation

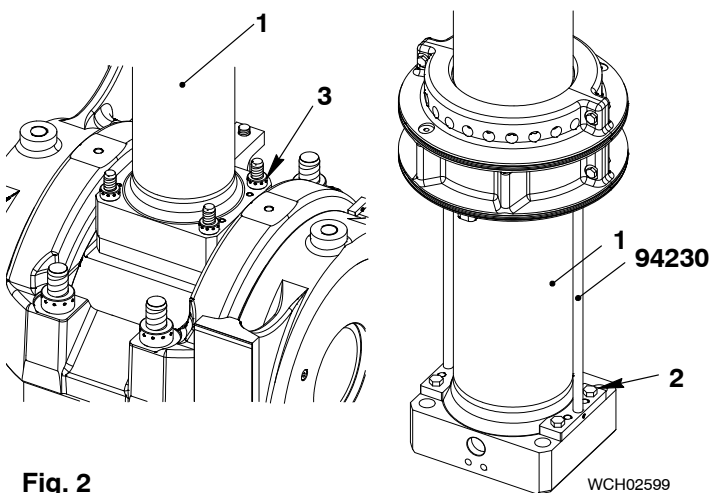
WARNING



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



- 1) Stop the engine, refer to the procedure in the 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, refer to the procedure in 2708 1.
- 5) Attach the four plates (1, Fig. 1) to the antipolishing ring (2) with the four screws (3).
- 6) Attach the engine room crane to the lifting tool (94209).
- 7) Attach the lifting tool (94209) to the four plates (1).
- 8) Operate the engine room crane to remove the antipolishing ring (2).
- 9) Move the antipolishing ring (2) to an applicable area.
- 10) Look at the area of the piston ring stroke, if there is a wear edge, refer the procedure in 2124 3.
- 11) Operate the turning gear to turn the crank to BDC.
- 12) Remove the four round nuts (3, Fig.2) of the piston rod foot (1), refer the procedure in 9403 4.
- 13) Attach the two distance holders (94230) to the piston rod foot (1) with the four screws (2).



Piston: Removal and Installation

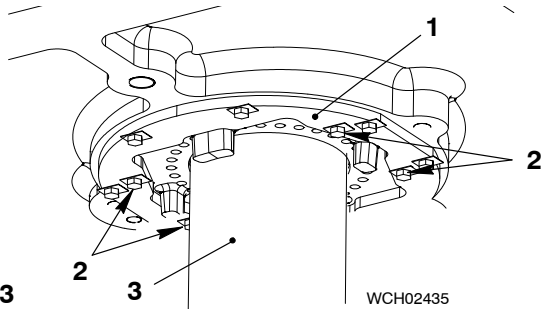


Fig. 3

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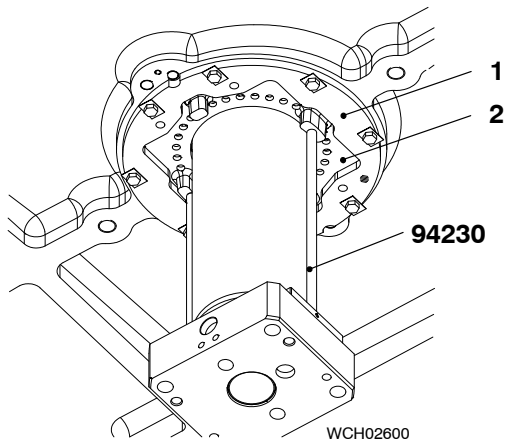
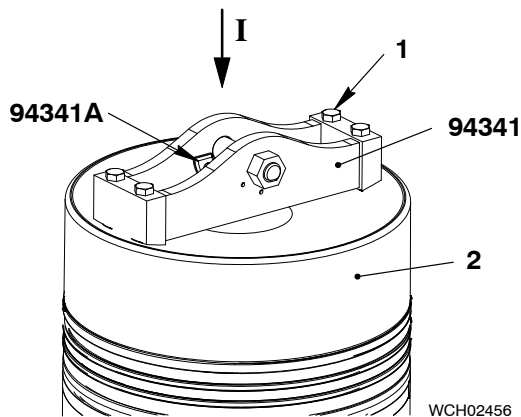


Fig. 4

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WCH02456

Note: Some parts can look different.

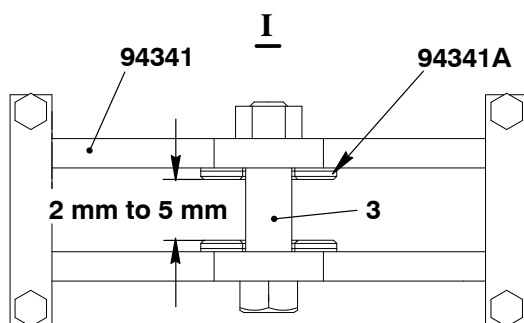


Fig. 5

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

15) Operate 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).

16) Remove the piston rod gland (2) from the support (1).

17) Make sure that the two distance holders (94230) stay in line with the gland box.

18) Use water to clean the threads of the piston support device (94341, Fig.5).

19) Put oil on the threads and the surfaces of the four screws (1).

20) Attach the piston suspension device (94341) to the piston (2) with the four screws (1).

21) 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 must use the plates (94341A) to adjust this clearance.

22) Put the applicable quantity of the plates (94341A) in position to get the axial clearance between 2 mm and 5 mm.

23) Connect the engine room crane to the piston suspension device (94341).

24) 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

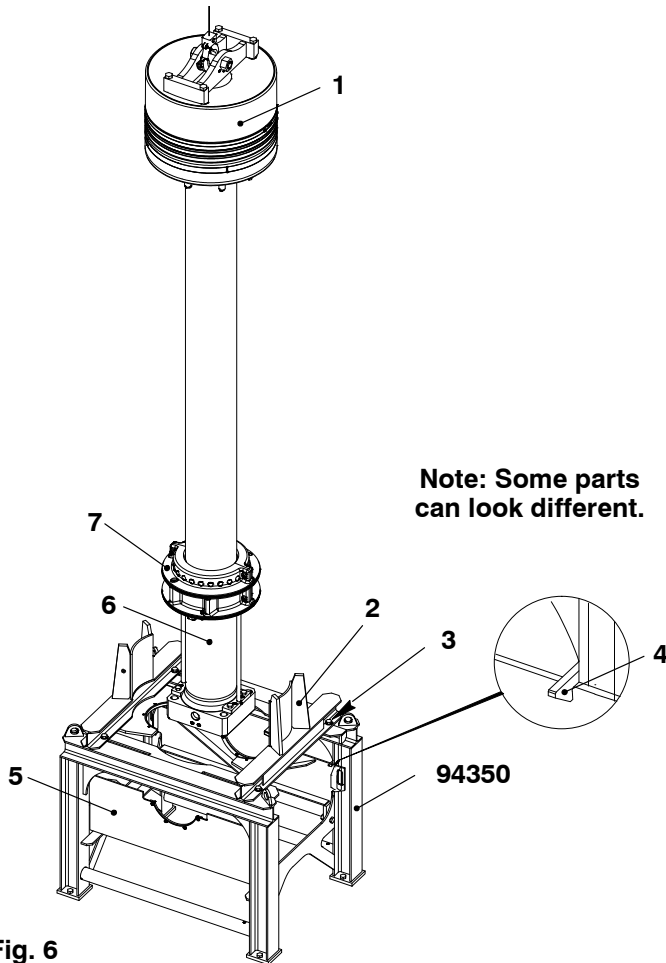


Fig. 6

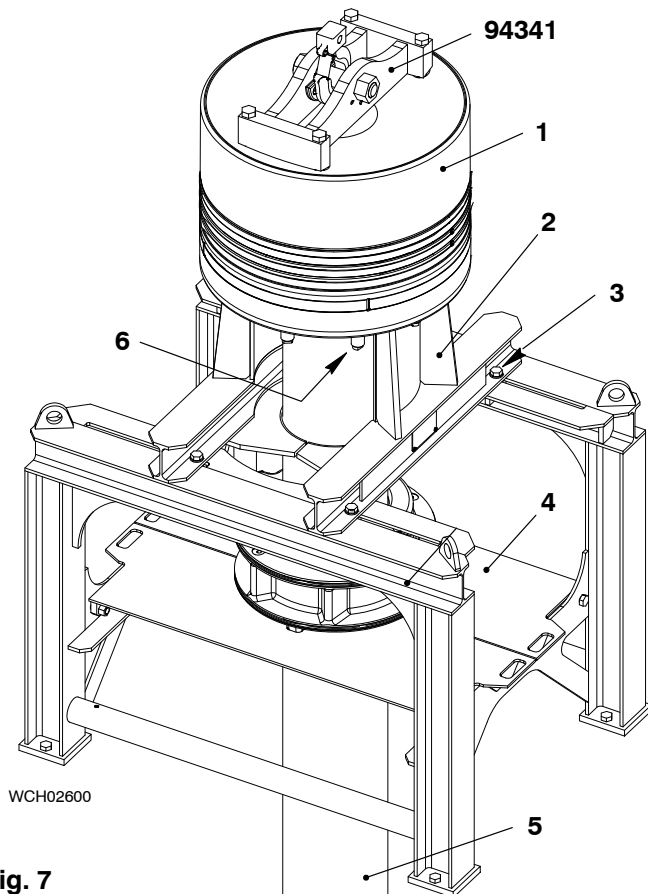


Fig. 7

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.
- 3) Make sure that the piston rod foot (6) does not touch the support of the piston rod gland (7).
- 4) Loosen the screws (3) of the device (94350).
- 5) Move the supports (2) out.
- 6) Open the two hinged plates (5).
- 7) Make sure that the bars (4) lock the hinged plates (5) in the open position.

- 8) Lower and align the piston (1, Fig.7) between the supports (2).

Note: Make sure that the supports (2) will go between the round nuts (6).

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

Piston: Removal and Installation

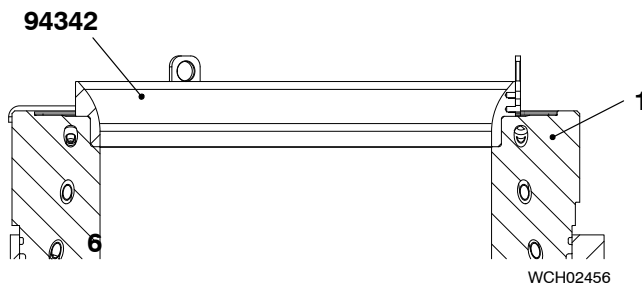


Fig. 8

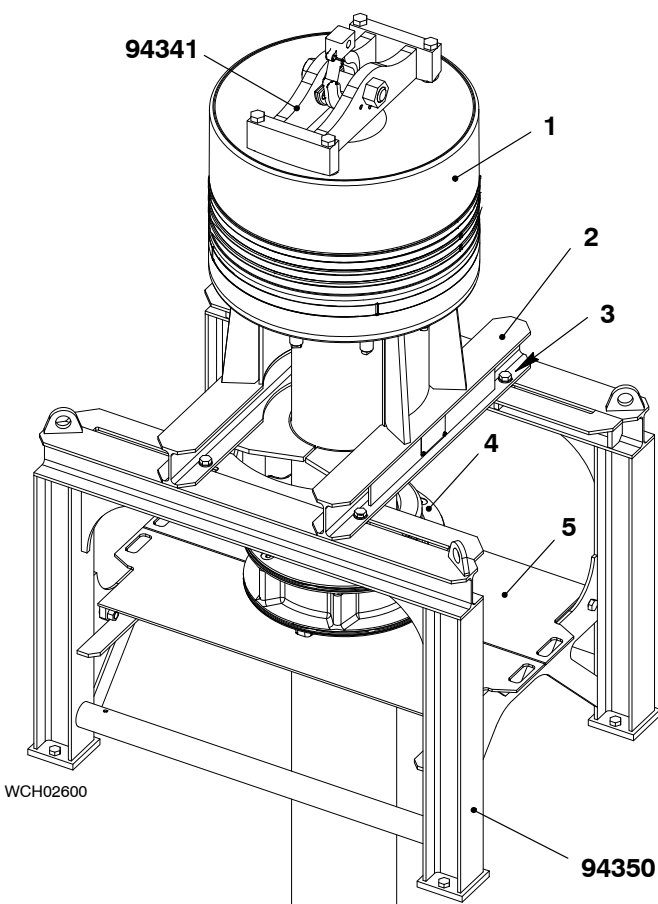


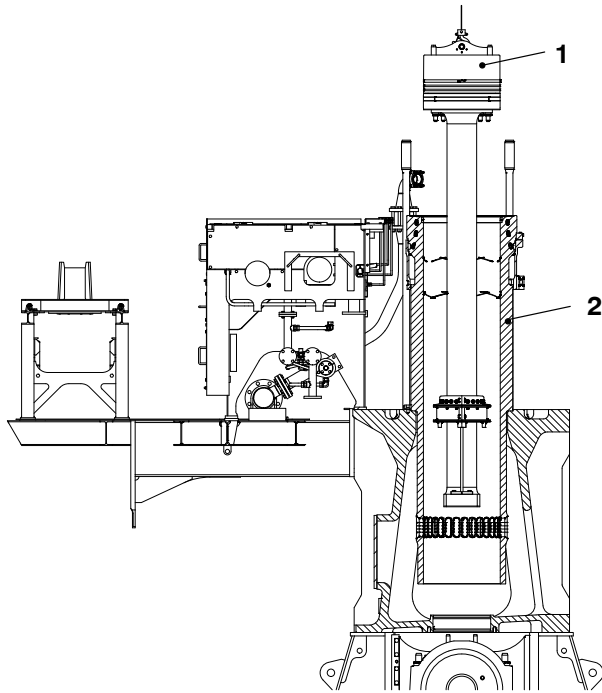
Fig. 9

**Note: Some parts
can look different.**

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) Operate the turning gear to turn the crank to TDC.
- 4) Make sure that 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) to 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)
- 13) Move out the two supports (2).
- 14) Lift the piston (1) together with the piston rod gland (4) from the device (94350).
- 15) Lift up two hinged plates (5) before the piston rod foot touches them.
- 16) Make sure that the bars lock the hinged plates (5) in the open position.

Piston: Removal and Installation



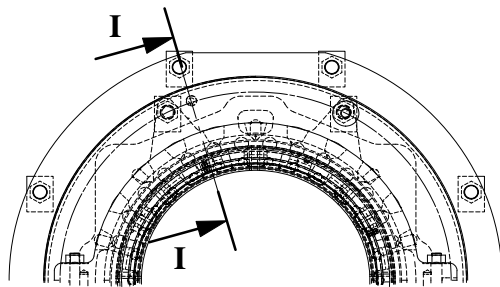
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Fig. 10

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.

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



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

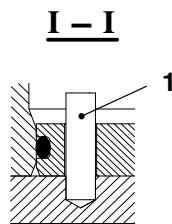


Fig. 11

Piston: Removal and Installation

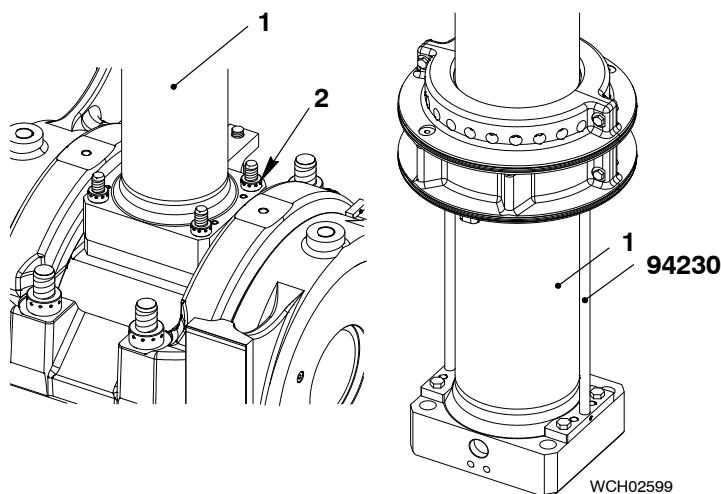


Fig. 12

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

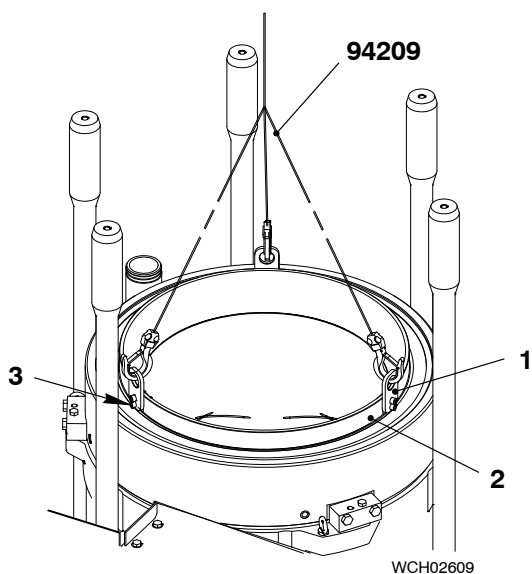


Fig. 13

- 27) Make sure that the cylinder liner and the antipolishing ring are clean and in a satisfactory condition.
- 28) Put oil on the surfaces of antipolishing ring.
- 29) Attach the engine room crane to the lifting tool (94209, Fig.13).
- 30) Attach the four plates (1) to the antipolishing ring (2) with the four screws (3).
- 31) Put the antipolishing ring (2) into the cylinder liner.
- 32) Remove the lifting tool (94209).
- 33) Remove all the tools and the 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 the 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: 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), refer to 9403 4, paragraph 1 and paragraph 2.
- 4) Remove the eight round nuts.

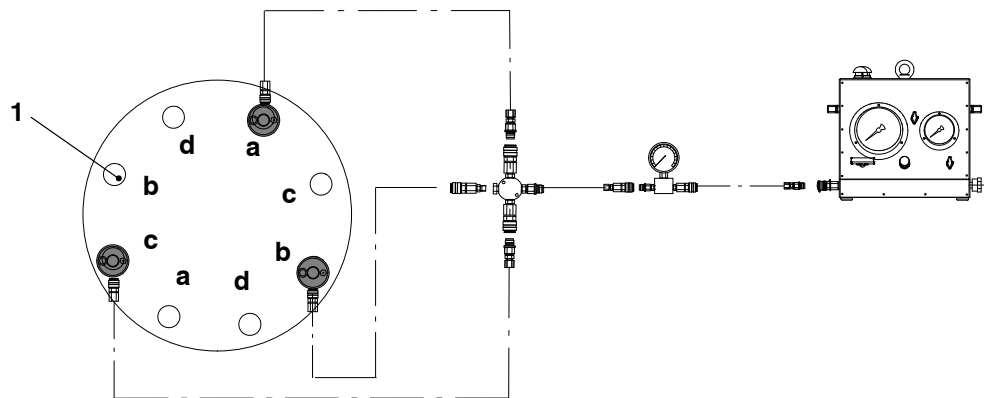


Fig. 1: Sequence to Apply Tension to the Elastic Bolts

Piston: Disassemble and Assemble

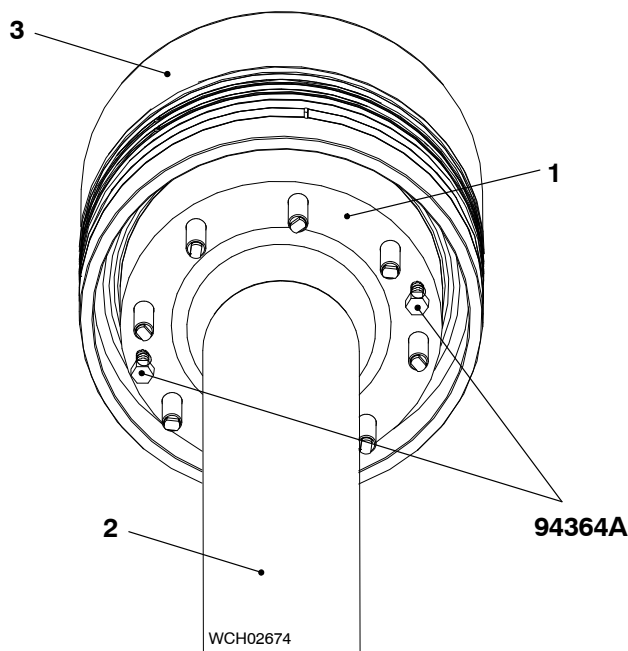


Fig. 2

Note: Some parts can look different.

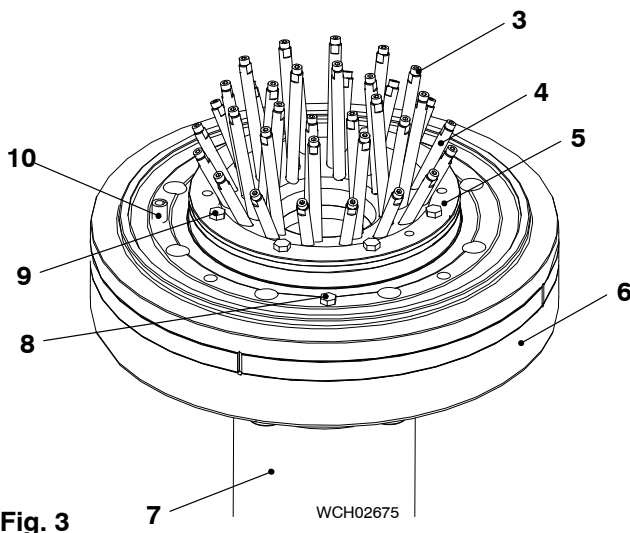
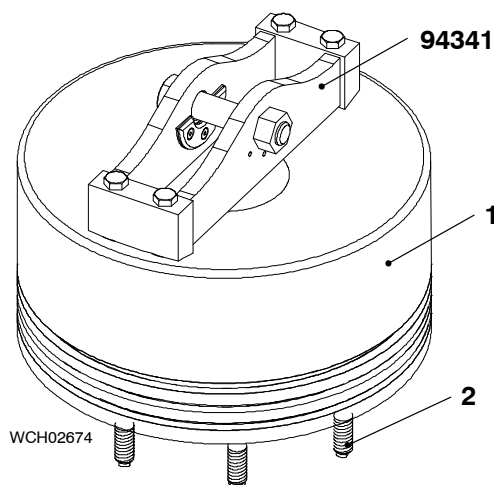


Fig. 3

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) Operate 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).
- 8) Remove the eight screws (9).
- 9) Use the two jacking screws (94364B) to remove the spray plate (5) from the piston rod (7).

Note: When you lift the piston skirt (6) make sure that the spring dowel pin (9) does not catch.

- c) Lift the piston skirt (6) away from the piston rod (7).
- 10) If necessary, remove the pipes (4) and the nozzles (3).
- 11) Do a check of the top surface of the piston head, refer to 3403 4.

Piston: Disassemble and Assemble

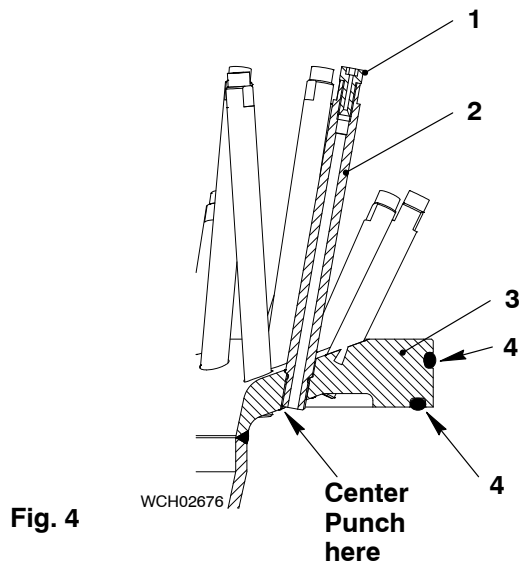


Fig. 4

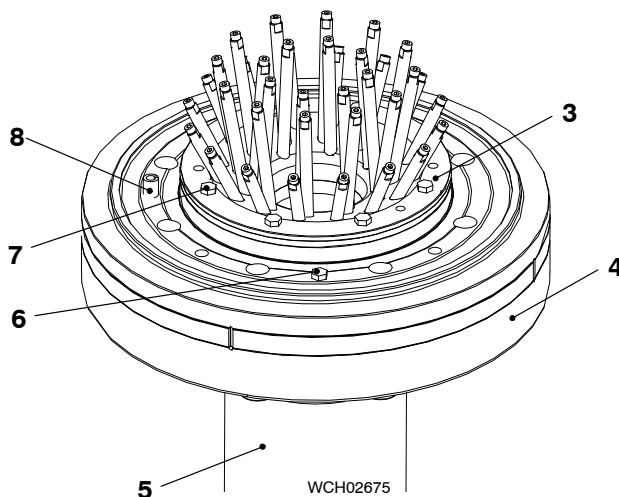
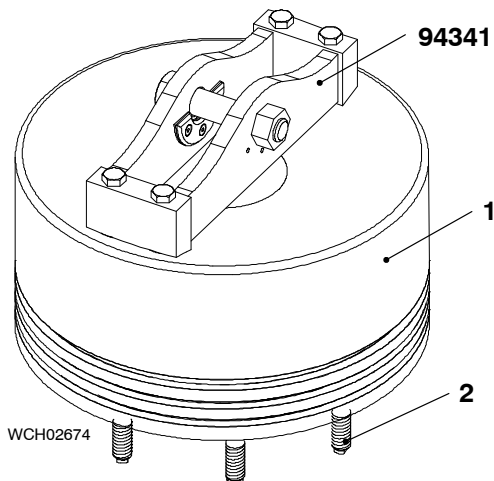


Fig. 5

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) Operate the engine room crane to lower the piston head (1) on to 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

Piston

Top Surface Check

Tools:

- 1 Feeler gauge 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.

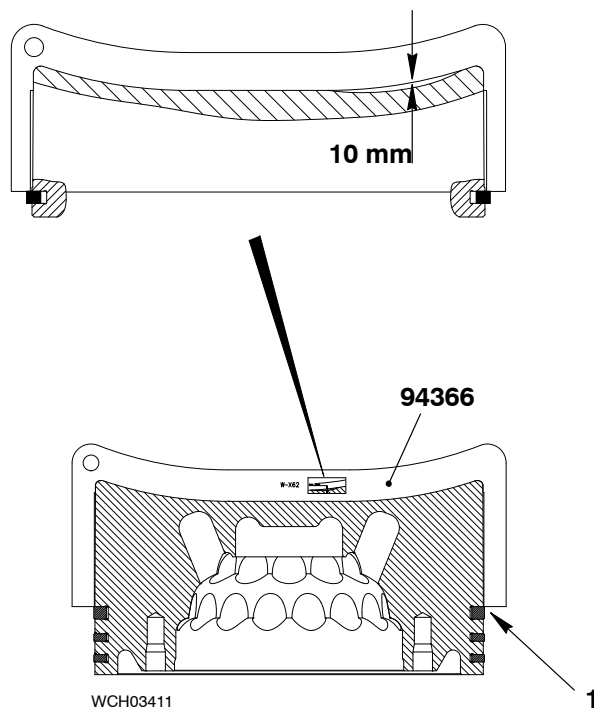


Fig. 1

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 gauge (94122) to measure the depth of the burn scar(s).
- 4) Remove the template (94366).

Note: You can also use a depth gauge 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 (refer to 3403 3, paragraph 1 and paragraph 2).
 - b) Use surface welding to repair the piston head to its original thickness.
 - c) Assemble the piston (refer to 3403 3, paragraph 3).

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

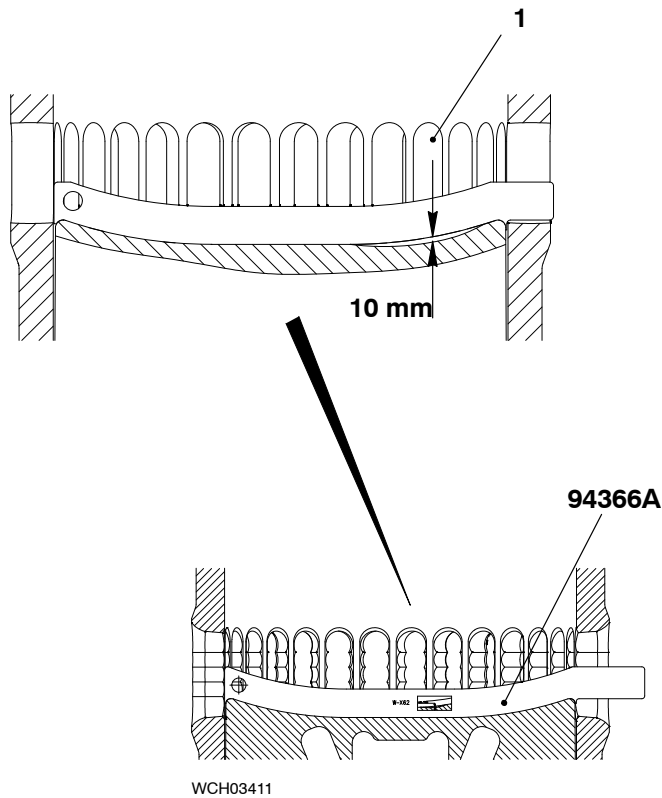


Fig. 2

3. Procedure – Piston Installed

WARNING



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

- 1) Operate 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 gauge (94122) to measure the depth of the burn scar(s).

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

- 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 3) and 4) 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, refer to 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 | 94356 |
| 1 | Feeler gauge | 94122 | | (with instruments to | |
| 1 | Piston ring tool | 94338 | | measure chrome-ceramic | |
| | | | | layers) | |
| | | | 1 | Calliper gauge | |

- 1. **General** 1
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 - 3.4 **Used Piston Rings – Installation** 8
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- 4. **Piston Rings – Storage** 9

1. General

Use the data in paragraph 2.1 and paragraph 2.3 to make an analysis of the 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 in 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) Operate 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 given limits, you must do an overhaul of the piston head.

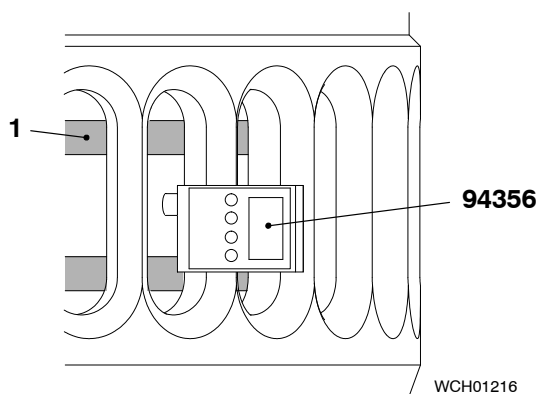
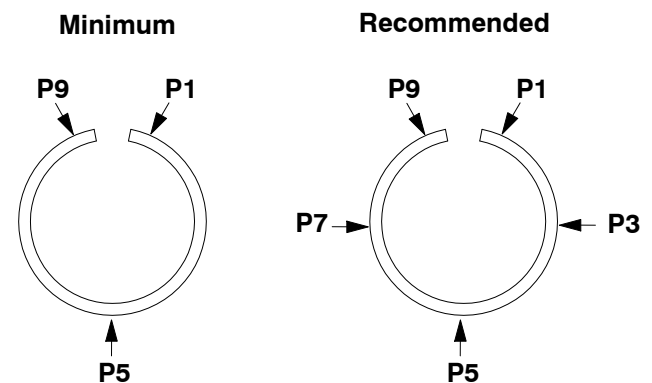


Fig. 1

Locations to Measure the Thickness of the Chrome-ceramic Layer on the Piston Ring



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 (refer to [Fig. 2](#)), do an overhaul of the unit as soon as possible.

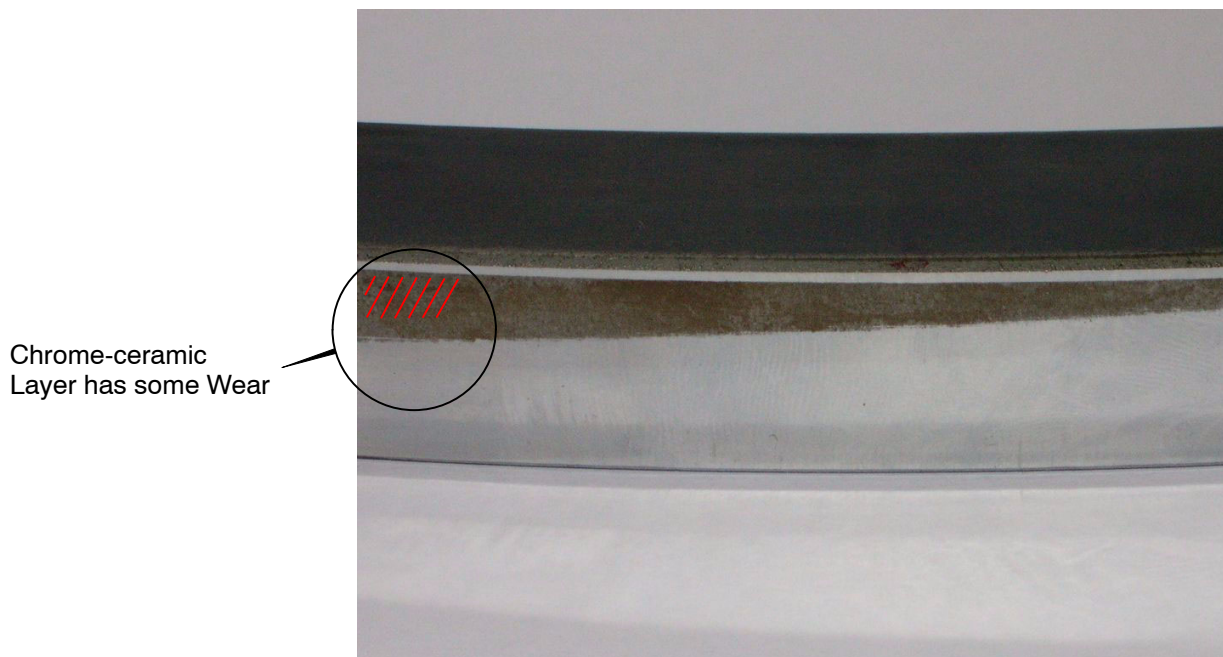


Fig. 2 Chrome-ceramic Layer

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:

$$WR = \frac{(D1 - D2) \times 1000}{T2 - T1}$$

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).

Refer to [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:

$$LT = \frac{(D2 - Dmin) \times 1000}{WR}$$

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) (refer to 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

3. Piston Ring Grooves

Do a check of all the dimensions and record them (refer to [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.

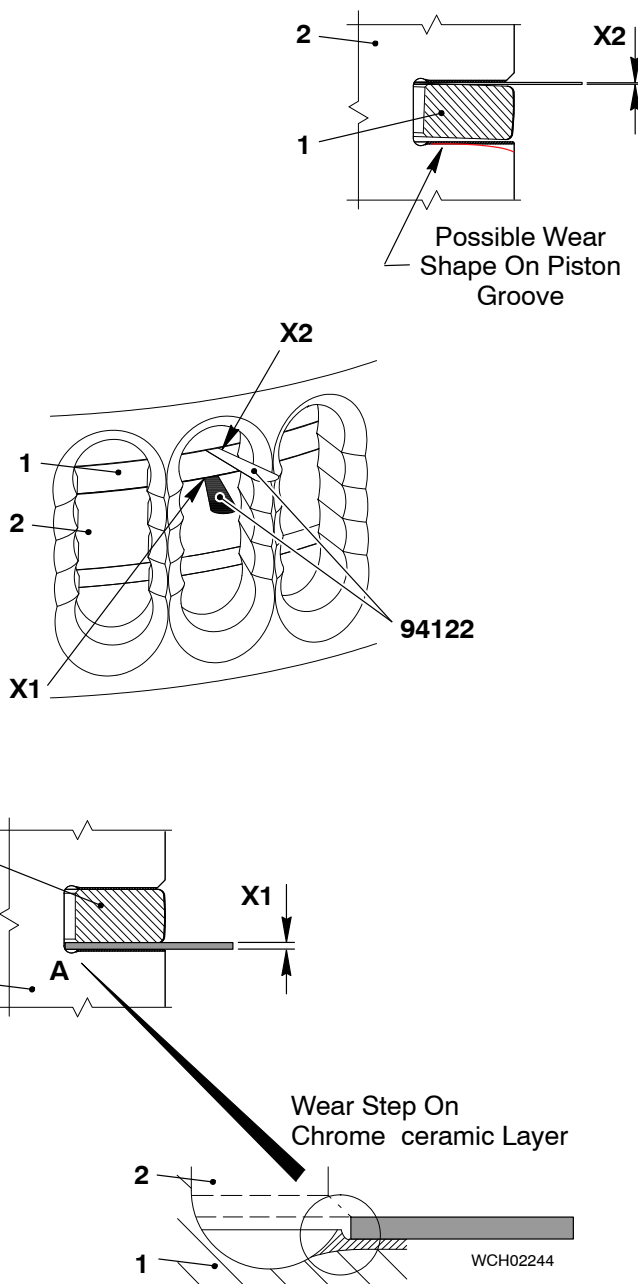


Fig. 3

3.1 Piston Ring Clearance (Piston Installed)

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

- 1) Operate the turning gear to move the piston (2, Fig. 3) down.

Note: Push the feeler gauge fully into the piston ring groove. This will make sure that the feeler gauge 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 gauge 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 WinGD 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 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.

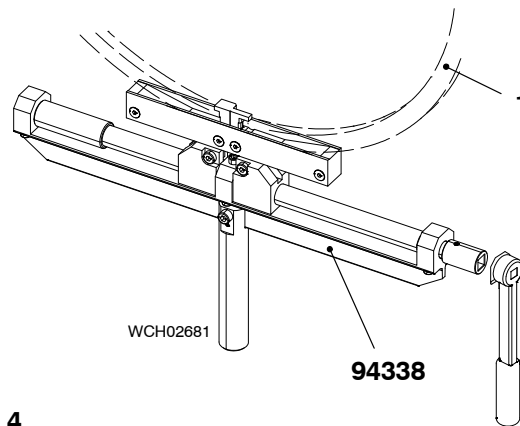


Fig. 4

3.3 Piston Ring Clearance (Piston Removed)

Note: You can use a calliper gauge, 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 gauge (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 gauge (1) or inside micrometer set (94101).

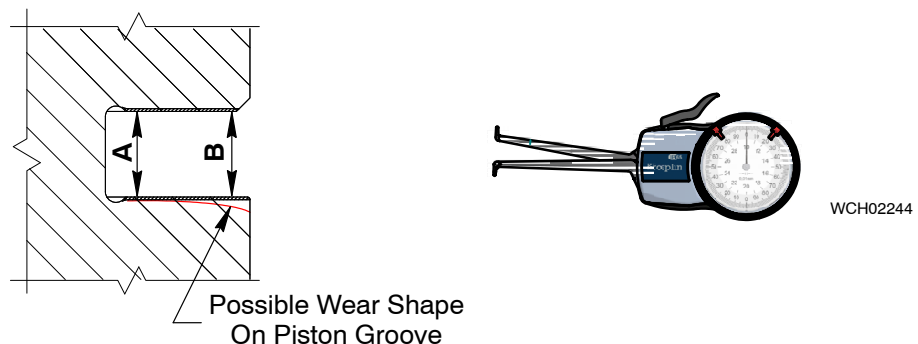


Fig. 5

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](#).

3.3.2 Alternative Procedure with Piston Ring Piece

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

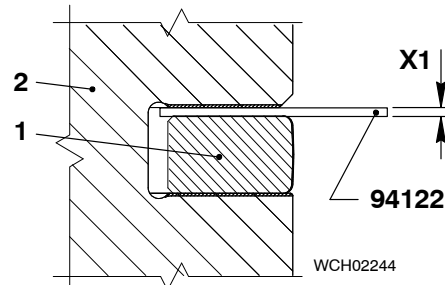


Fig. 6

- 2) Put the piece of piston ring (1) into the piston ring groove.
- 3) Use the feeler gauge (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 WinGD 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 GTP1CC13 (gas tight)	chrome-ceramic layer	For new and fully honed cylinder liners and used cylinder liners in good condition
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 (3, [Fig. 7](#)) to the piston head.
- 2) Use the tool (94338) to install the top piston ring (1) to the piston head. Make sure that the ring clearance (4) is opposite the ring clearance (2) of the bottom piston ring (3).

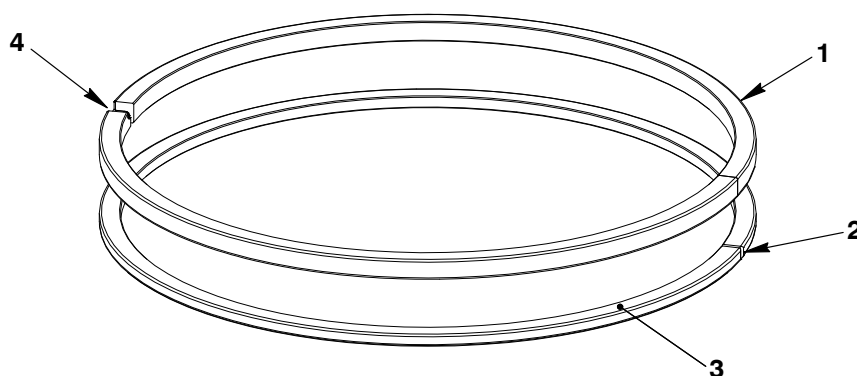



Fig. 7

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 (3, [Fig. 7](#)) 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 (4) is opposite the ring clearance (2) of the bottom piston ring (3).
- 4) 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 gauge 94122 | 1 Dial gauge |
| 1 Micrometer | 1 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 in-service engines that have new gear wheels installed.

2. Checks

WARNING



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

- 1) Operate 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 the nozzles.
- 4) Set to OFF the service pump.
- 5) Make sure that all the 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 occur 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 the damage to the adjacent drive wheels.
- 8) Do the inspection given above one time each year when the drive wheels have operated correctly for between 6000 hours to 8000 hours.

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

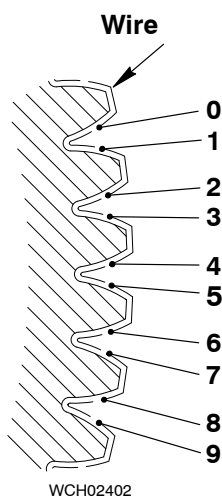
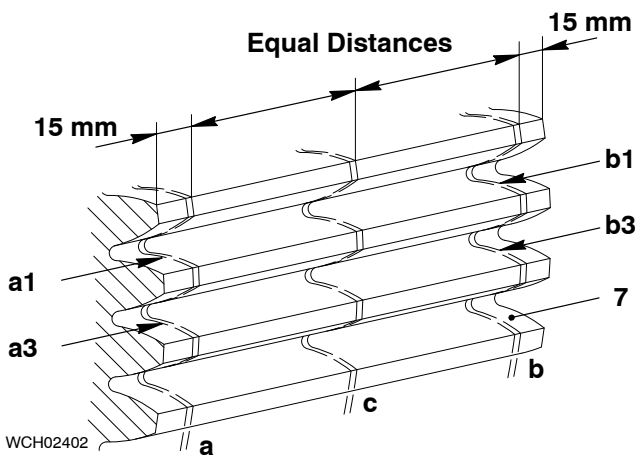
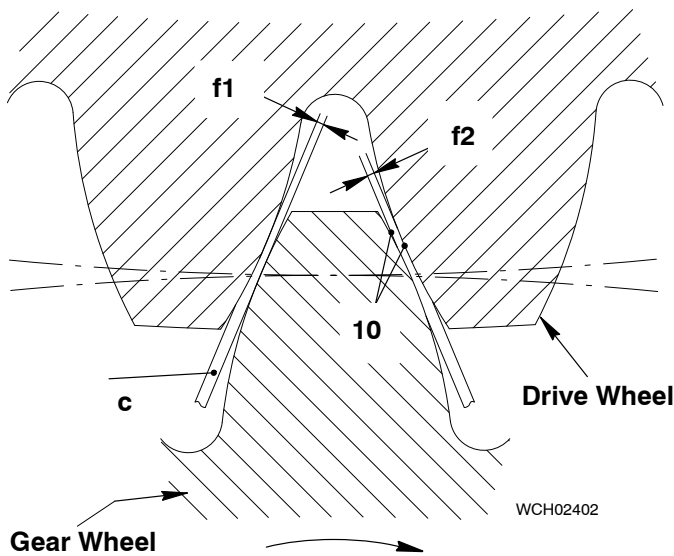


Fig. 1

3. Gear Tooth Backlash Checks

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

There are three procedures to measure the backlash.

3.1 Feeler Gauge (94122)

- 1) 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 Gauge

- 1) Put the dial gauge in a position where you can read the backlash value when the gear wheel turns.
- 2) Make sure that the drive wheel does not move.
- 3) Operate the turning gear to carefully move the gear wheel a sufficient distance.
- 4) Measure the backlash when one tooth of the gear wheel moves between the profiles of the two gear wheel teeth.

3.3 Wire

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

- 1) Attach three lengths of wire (approximately 200 mm) in the positions shown with Scotch™ tape.
- 2) Put marks (0 to 9) on the tooth profiles as shown in Fig. 1.
- 3) Operate the turning gear to turn the gear wheel so that the wire goes once through the teeth of the gear wheel and drive wheel.

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

The parallelism Δf is the difference between the values of the wires on the drive flanks (10) between eg a1 b1.

- 4) Remove the wire.

Running and Backlash Clearances and Tooth Condition

- 5) Use the micrometer to measure the wire.
- 6) Calculate as follows:
 - The full tooth backlash: $f = f_1 + f_2$
 - The parallelity: $\Delta f = a_1 - b_1$ 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) Operate 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 to make sure that the teeth engage correctly and are parallel.

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Shut-off Valve for Starting Air

Cleaning and Function Check

1. General	1
2. Preparation	1
3. Disassemble	2
4. Servicing	2
5. Assemble	4
6. Shut-off Valve – Test	5
6.1 Initial Position	5
6.2 Test Procedure	5
6.3 Automatic Mode	6
7. Completion	6

1. General

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

Refer to the data in the Operation Manual 4003 2, Engine Control Diagram and 4003 9, Pipe Diagram Air Systems.

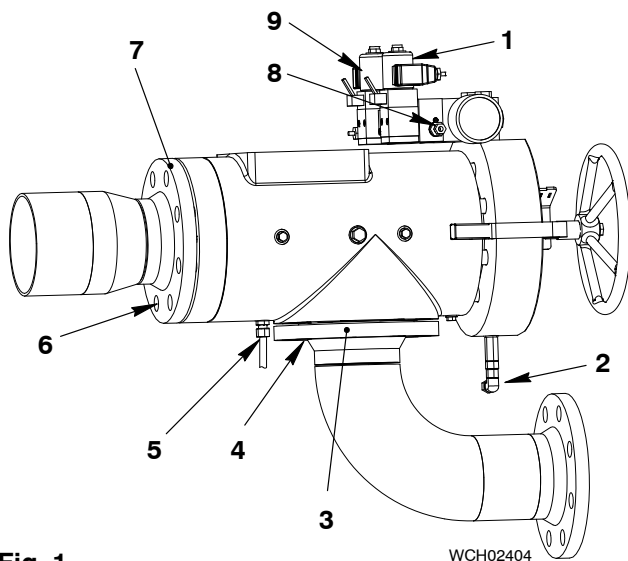


Fig. 1

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_E0_6 and 30 8605_E0_7 to release the air in the system.
- 4) Disconnect the electrical connections from the pressure transmitter (8, Fig. 1) and the solenoid valves (1, 9).
- 5) Remove the pipe (5).
- 6) Remove the pipe (2).
- 7) Remove the eight screws (6) from the flange (7).
- 8) Remove the eight screws (4) from the flange (3).
- 9) Remove the shut-off valve from the engine.
- 10) Do a check of the two gaskets that are installed on the flanges (3) and (7). If the gaskets are unserviceable, replace them.

3. Disassemble

- 1) Remove the eight screws (23, Fig. 2) from the cover (6).
- 2) Turn the handwheel (7) fully in. This moves the cover (6) from the spindle (8).
- 3) Remove the handwheel (7), the cover (6) and the spring (9).
- 4) Use an AF 60 swan neck spanner to remove the spindle nut (11).
- 5) Remove the spindle (8).
- 6) Remove the two screws (25) from the valve guide (16).
- 7) Remove the valve guide (16).
- 8) Remove the stopper (18) together with the spring (19) and valve body (20).
- 9) Remove the silencer (22) and its gasket.
- 10) Remove the screw plug (5) together with the spring (4), valve (1) and piston (21) from the control valve (19).
- 11) Remove the two bolts (2) from the control valve (3).
- 12) Remove the control valve (3) from the cover (6).

4. Servicing

- 1) If necessary, clean the items that follow:
 - Valve (1)
 - Piston (21)
 - Spring (4)
 - Springs (9) and (19)
 - Stopper (18)
 - Valve body (20)
 - Valve guide (16)
 - Valve (12)
 - Spindle (8).
- 2) If you find corrosion on the springs (9, 19 and 4) you must replace them.
- 3) Do a check of all gaskets and O-rings that you removed for damage. If you find damage, replace the applicable gaskets and O-rings.
- 4) Do a check of the piston joint ring (10). If you find damage, replace the piston joint ring.
- 5) Do a check of the valve seats (13, 14). If necessary, grind the sealing surfaces.

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

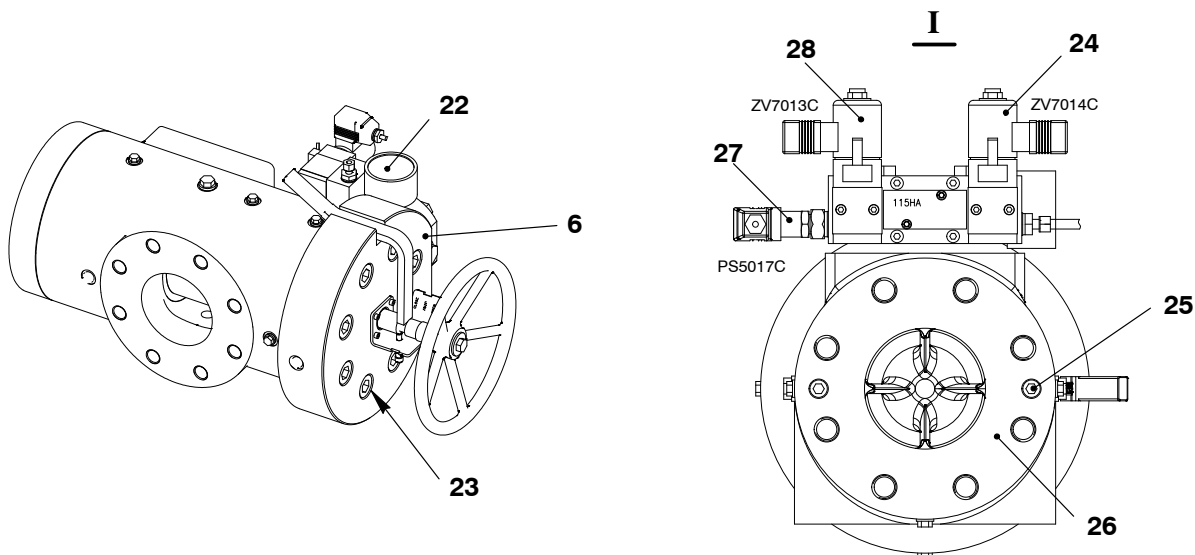
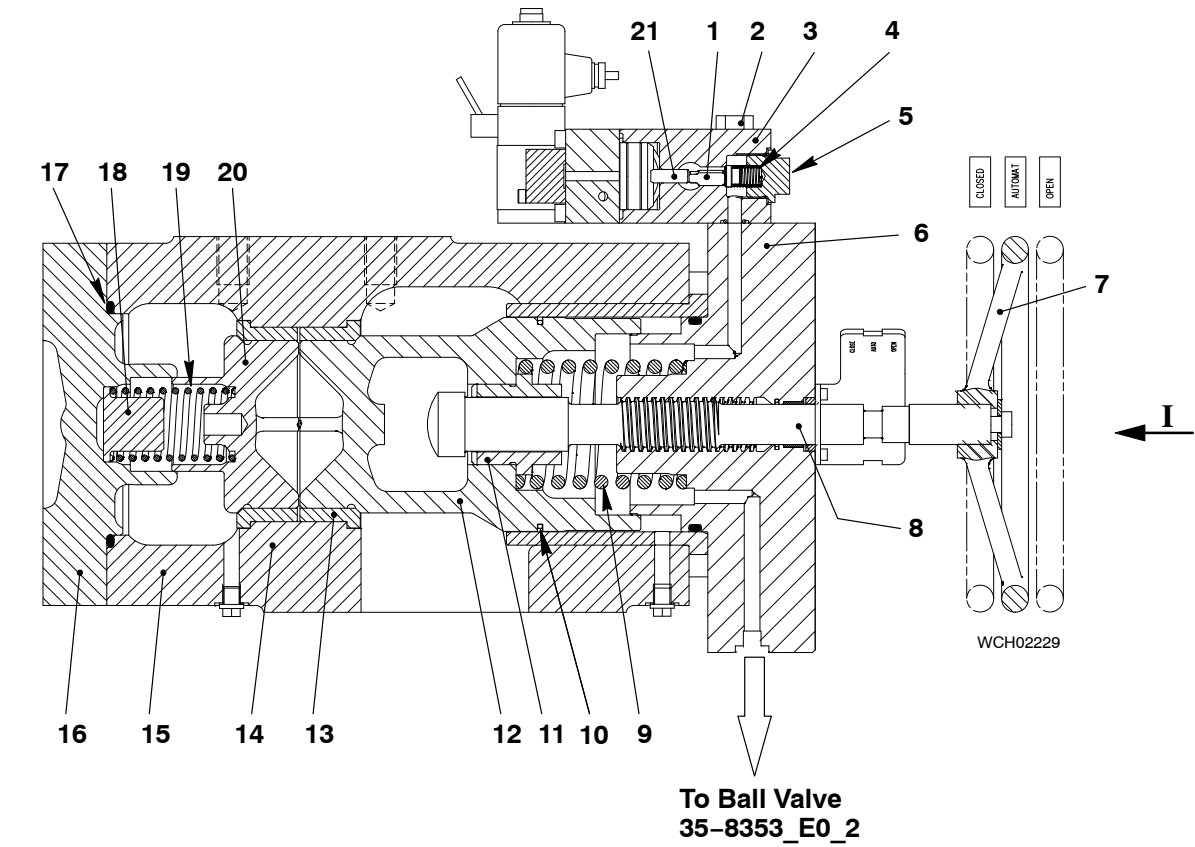


Fig. 2

5. Assemble

- 1) Make sure that all the bores are clear.
 - 2) Remove the grease from the surfaces of the spindle (8, Fig. 2) and the threads of the spindle nut (11).
 - 3) Apply a thin layer of Molykote paste to the stopper (18), the spring (19) and the valve body (20).
 - 4) Put the O-ring (17) and valve body (20) into the housing (15).
 - 5) Put the stopper (18) and spring (19) into the valve guide (16), then attach the valve guide to the housing (15) with the two screws (25).
 - 6) Torque the two screws (25) to the value given in 0352 1, paragraph 1.
 - 7) Apply Molykote paste to the bore of spindle nut (11).
 - 8) Put the spindle nut on the spindle (8).
 - 9) Apply Loctite 0243 to the threads of the spindle nut (11).
 - 10) Put the spindle (8) and spindle nut (11) into valve (12).
 - 11) Attach the valve (12) together with spindle (8) and piston joint ring (10) to the housing (15).
 - 12) Apply Molykote paste to the inner cylinder of the cover (6).
 - 13) Put the spring (9) on to the spindle (8) in the cover (6).
 - 14) Attach the cover (6), spring (9) and spindle (8) to the housing (5) with the eight screws (23).
 - 15) Torque the eight M24x100 screws (23) to value given in 0352 1, paragraph 1.
 - 16) Install the handwheel (7).
 - 17) Attach the control valve (3) to the cover (6) with the two bolts (2).
 - 18) Tighten the two bolts (2) to the value given in 0352 1, paragraph 1.
 - 19) Put the piston (6), valve (5), spring (4) and screw plug (3) in position in the control valve (2), refer to Fig. 3.
- Note: When you do step 20), look through the hole in the control valve (2).**
- 20) Make sure that the clearance between the valve (5) and the piston (6) is 1.0 ± 0.2 mm.

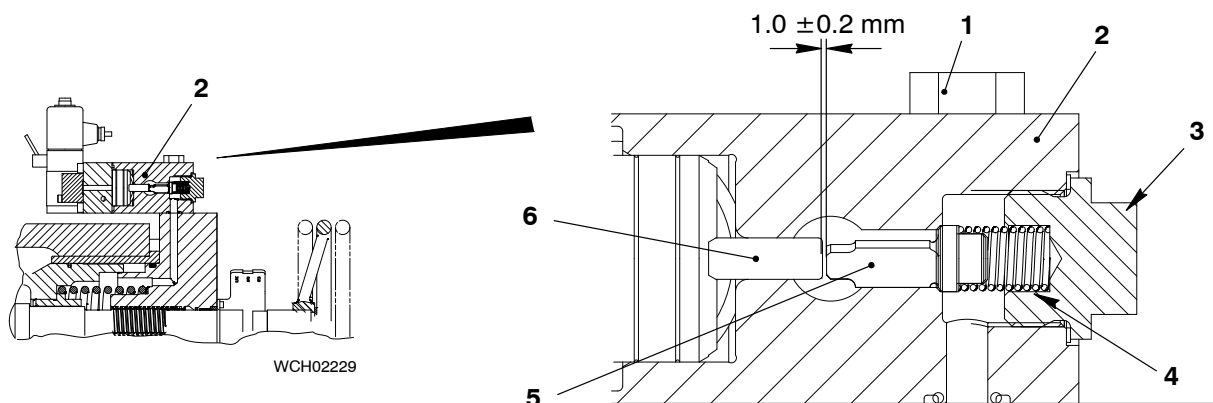


Fig. 3

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

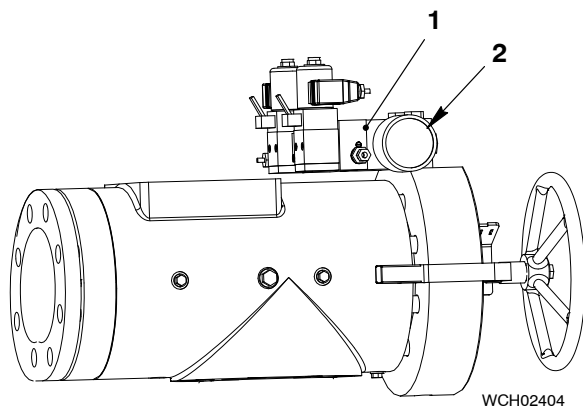


Fig. 4

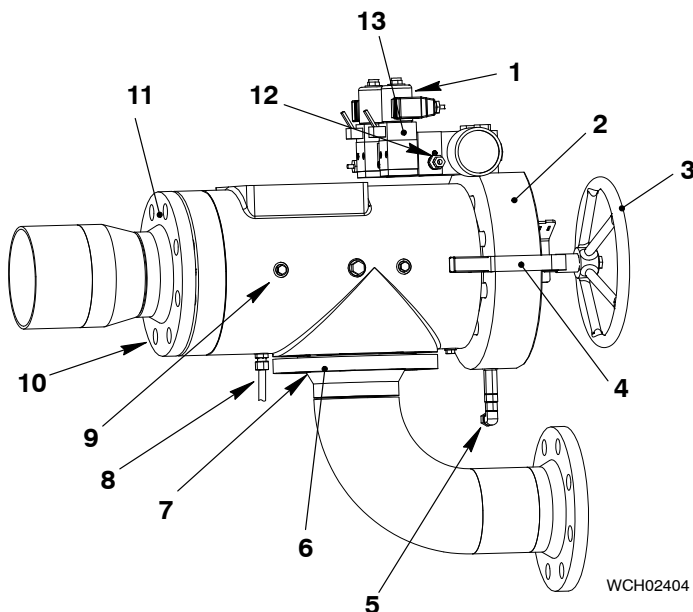


Fig. 5

- 21) Attach the silencer (2, Fig. 4) to the control valve (1).
- 22) Put the assembled shut-off valve in position as shown in Fig. 5.
- 23) Attach the flange (11) to the valve guide with the eight M24x100 screws (10).
- 24) Torque the eight M24x100 screws (10) to the value given in 0352 1, paragraph 1.
- 25) Attach the flange (6) to the shut-off valve with the eight M24x55 screws (7).
- 26) Tighten the eight M24x55 screws (7) to the value given in 0352 1, paragraph 1.
- 27) Attach the check-pipe (8) to the pipe connection on the valve body.
- 28) Attach the control air pipe to the pipe connection (12).


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) Operate the handwheel (3) to move the shut-off valve to the CLOSED position.
- 3) Disengage the turning gear.

6.2 Test Procedure

WARNING	
	<p>Injury hazard: During this test, do not select START. Injury to personnel can occur.</p>

- 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 (9). Make sure that no air flows out.
Note: If air flows out, tighten the screw plug (9). The shut off valve is not airtight.
- 4) Remove the screw pug (9).
- 5) Slowly turn the handwheel (3) to move the shut-off valve to the OPEN position.

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

- 6) Make sure that air flows from the bore of the screw plug (9). When air flows, the manual function of the shut-off valve operates correctly.
- 7) Operate the handwheel (3, Fig. 5) to move the shut-off valve to the position AUTOMAT. Make sure that the lever (4) engage with the groove in the spindle.
- 8) Make sure that no air flows from the bore of the screw plug (9). 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 AUTOMAT position.

Note: When you do the step below, air will flow through the pipe. This activates the control valve (13), which shows that the valve body and the valve operate.

- 2) Open the ball valve 35 8353_E0_2 to activate the control valve (13). The shut-off valve opens automatically.
- 3) Make sure that air flows from the bore of the screw plug (9).
- 4) Close the ball valve 35 8353_E0_2.
- 5) Make sure that no air flows from the bore of the screw plug (9).

7. Completion

- 1) Operate the handwheel to move the shut-off valve to the CLOSED position.
- 2) Install the screw plug (9).

Supply Unit, Rail Unit

Group 5

Supply Unit

..... 5552 /A1

Fuel Pump

Removal, Disassemble, Assemble, Installation 5556 1/A1

Seized Pump Plunger Removal 5556 2/A1

Fuel Pressure Control Valve: Removal, Check, Installation 5562 1/A1

... .. 55 2 1/A2

Fuel Overpressure Safety Valve: Removal, Check, Installation 5562 2/A1

Flow Limiting Valve: Removal, Check and Installation 5562 3/A1

Supply Unit

Camshaft and Bearing Shells Removal and Installation 5581 1/A1

Fuel Pump Actuator

Connection to Fuel Pump 5583 1/A1

..... 5583 1/ 2

Servo Pump Unit

Servo Oil Pump Removal and Installation 5591 1/A1

Servo Oil Rail: Exhaust Valve Control Unit: Removal and Installation .. 5612 1/A1

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Supply Unit

Lubrication of Supply Unit during Maintenance

Tools:

1	Lubricating tool	94844	1	Adapter
1	Adapter			

1. General

The engine has a manual lubrication system. This system prevents damage to the bearings and bushes of the supply unit (7, Fig. 1) during dry-running of the engine.

Clean system oil is used for the lubrication.

2. Procedure

- 1) Clean the surface of the supply unit casing.
- 2) Remove the blind flange from the lubricating tool (94844).
- 3) Attach a flange with a G1/2" thread to the lubricating tool (94844).
- 4) Remove the applicable pipe from the supply unit (7).
- 5) Make sure that the ball valve (9) is closed.
- 6) Attach the adapter (1) to the flange (6) on the lubricating tool (94844).
- 7) Attach the flexible hose (2) to the adaptor (1) with the hose clip (5).
- 8) Attach the lubricating tool (94844) to an applicable position approximately 2.0 m above the supply unit as shown.
- 9) Attach the flexible hose (2) to the adaptor (3) with the hose clip (4).
- 10) Remove the inspection covers from the supply unit (7).
- 11) Fill the lubricating tool (94844) with system oil.
- 12) Open the ball valve (9).
- 13) Make sure that the system oil flows on to the bearings and camshaft (8).

WARNING



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

- 14) After a period of 15 minutes, operate the turning gear.

Note: If the turning gear operates for long periods, keep the system full to make sure that the bearings and camshaft (8) have sufficient lubrication.

- 15) Make sure that the bearings and camshaft (8) have sufficient lubrication.
- 16) Install the inspection covers to the supply unit (7) that you removed before.
- 17) Close the ball valve (9).
- 18) Remove the lubricating tool (94844), flexible hose (2) and adaptors (1, 3).
- 19) Install the pipe that you removed before to the supply unit (7).

Lubrication of Supply Unit during Maintenance

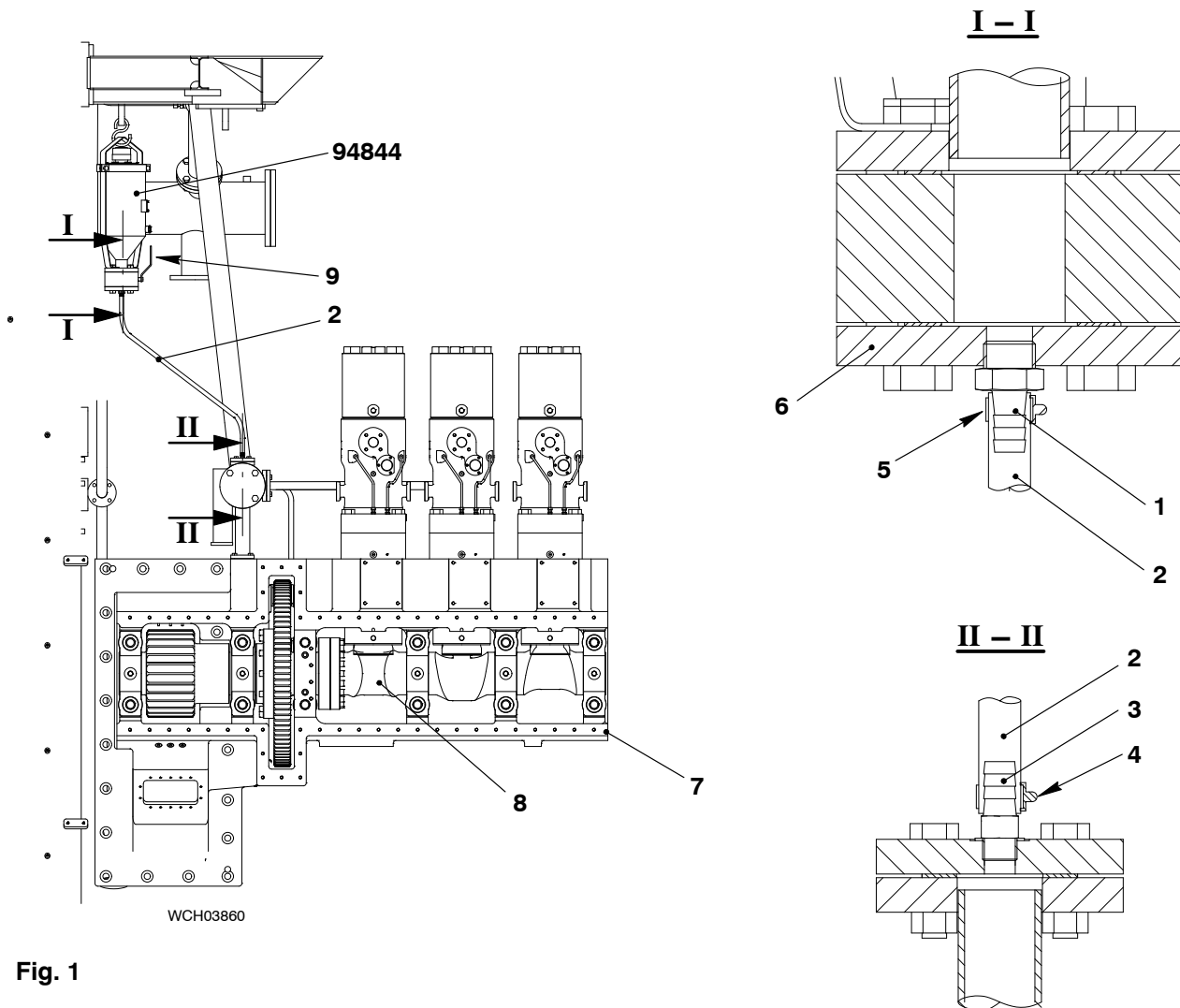


Fig. 1

Fuel Pump

Disassemble, Assemble

Tools:

1	Circlip pliers	94007 A41	1	Guide bracket	94593
1	Handle	94009 M10		Which includes:	
1	Manual ratchet	94016 015	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	4	Screws M12x130	94593D
1	Rod	94553		With special nuts	
1	Distance piece	94555	2	Screws M30x110	94593E
1	Fuel pump rack	94592	1	Mandrel (Ø 70 mm)	94597
	Which includes:		1	Pneumatic impact wrench	94598
1	Oil tray	94592A	2	Extensions	94598A
2	Limiters	94592B	1	Socket spanner insert	94598B
2	Screws	94592C			
4	Screws	94592D			
2	Screws	94592E			

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1. Preparation

WARNING



Fire Hazard. Do not weld or grind materials in the area. Sparks can cause a fire to occur.

WARNING



Injury Hazard. Put on gloves and eye protection. Fuel can come out as a spray and cause injury.

CAUTION



Damage Hazard: Do not operate the engine with a fuel pump removed. This will decrease the supply of oil, ie there could be a decrease of lubrication to the other fuel pumps. Damage to equipment can occur.

Note: Read the data in 0012 1 General Guidelines for Lifting Tools.

- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 2) Set to off the fuel supply
- 3) Set to off the main oil supply.
- 4) Make sure that the fuel return valve is open, refer to the Operation Manual, Control Diagram 4003 2 and Pipe Diagram 4003 11.
- 5) Close the fuel inlet valve, refer to the Operation Manual, Control Diagram 4003 2 and the Pipe Diagram 4003 11.
- 6) Make sure that the pressure in the supply unit decreases to zero.
- 7) Set to off the power supply to the fuel pump actuators.
- 8) Make sure that there is no pressure in the fuel system.
- 9) Make sure that the temperature of the fuel has decreased to ambient.
- 10) Clean the work area and make sure that there are no dust particles.
- 11) Set to off the power supply to the actuators.
- 12) Make sure that the valves to the fuel pumps are closed.
- 13) Remove the applicable HP fuel pipe(s), refer to 8752 1.
- 14) Attach the pump rack 94592 (Fig. 1) to the top primary platform (1) with the screws 94592D.

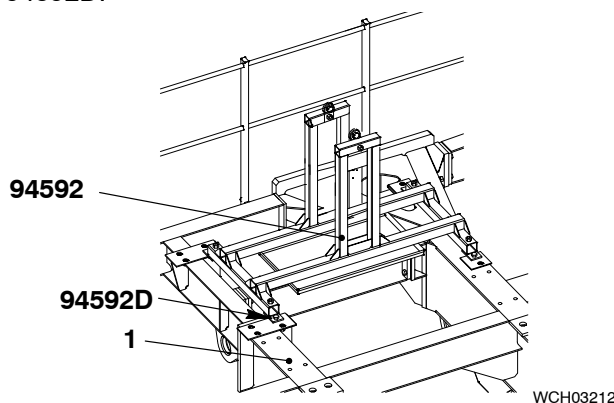


Fig. 1

WCH03212

Fuel Pump: Disassemble, Assemble

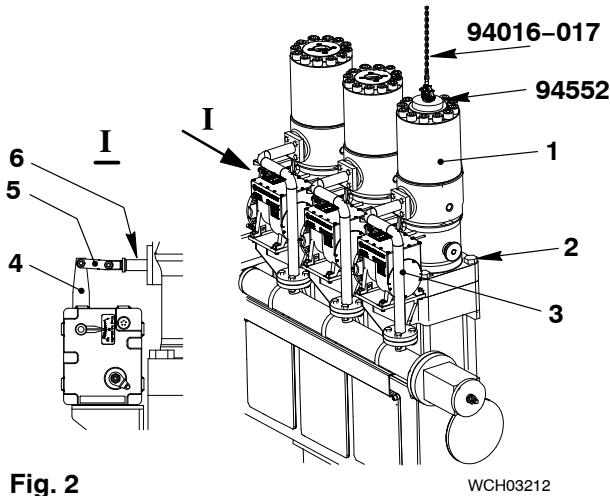


Fig. 2

WCH03212

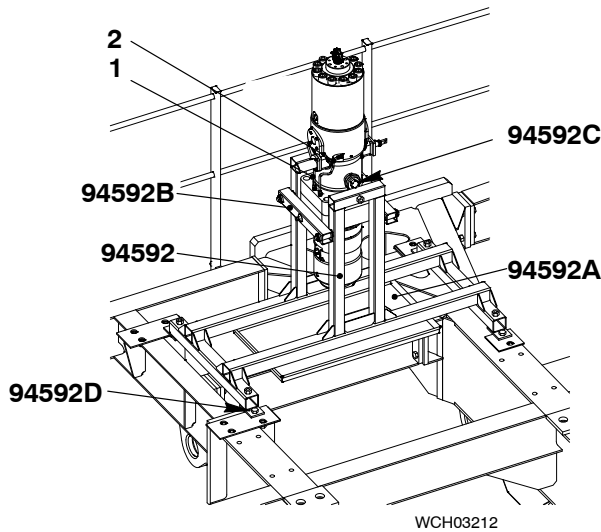


Fig. 3

WCH03212

2. Fuel Pump – Removal

- 1) Operate the turning gear to get the applicable cam in the supply unit to BDC.
- 2) Remove the applicable oil pipe (3, Fig. 2).
- 3) Attach the lifting tool (94552) to the pump cover.
- 4) Remove the connecting element (5) between the toothed rack (6) and the actuator lever (4).
- 5) Remove the screws (2) from the fuel pump (1).
- 6) Attach the manual ratchet (94016 017) to the engine room crane.
- 7) Attach the manual ratchet (94016 017) to the lifting tool (94552).
- 8) Carefully lift the fuel pump (1).
- 9) Attach covers to all open flanges to prevent contamination in the pipes.
- 10) Operate the manual ratchet (94016 017) to lower the fuel pump into the rack (94592).
- 11) Attach the fuel pump to the fuel pump rack (94592, Fig. 3) with the screws (94592C).
- 12) Attach the limiters (94592B) to both sides of the rack (94592).
- 13) Put the oil tray (94592A) below the fuel pump.
- 14) Remove the manual ratchet (94016 017).
- 15) Remove the oil inlet pipe (1) and the oil drain pipe (2).

Fuel Pump: Disassemble, Assemble

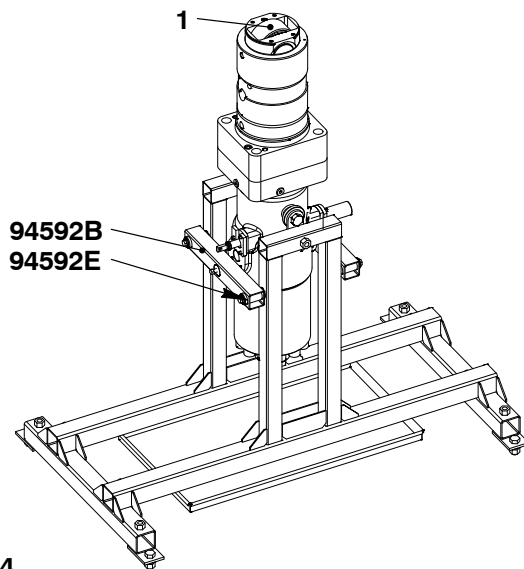
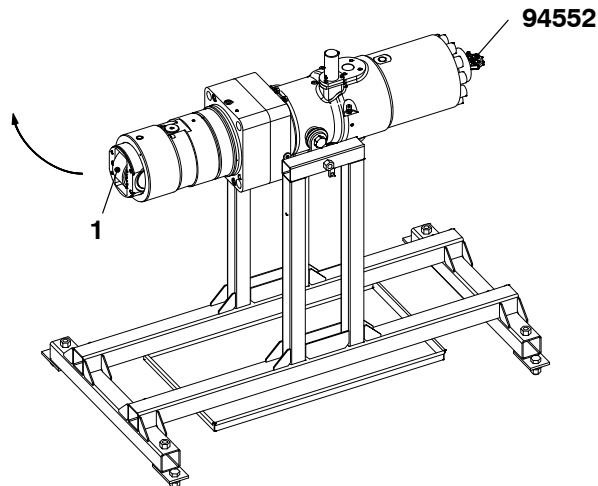


Fig. 4

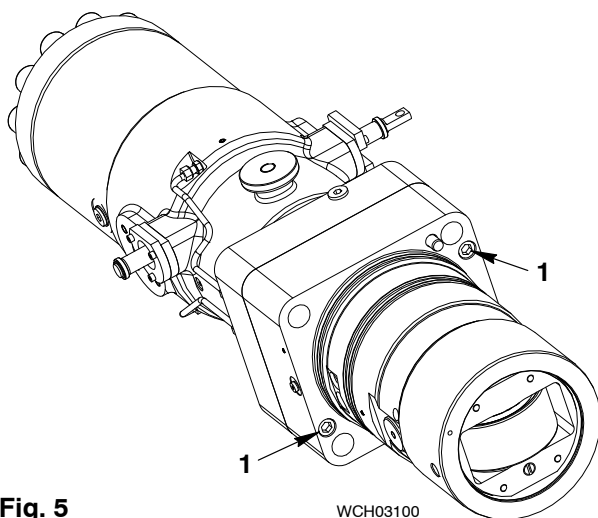


Fig. 5

3. Disassemble

- 1) Remove the screws (94592E, Fig. 3), then remove the two limiters (94592B).
- 2) Turn the fuel pump until the roller (1) points up.
- 3) Attach the two limiters (94592B) to each side of the rack.
- 4) Lock the limiters with the screws (94592E) to hold the pump in position.
- 5) Remove the tool (94552) and let the fuel drain into the oil tray (94592A, Fig.3).
- 6) Loosen equally the two Allen screws (1, Fig. 5).
- 7) Remove the two Allen screws (1).
- 8) Apply Molykote G Rapid plus to lubricate the spindle (5, Fig. 6).
- 9) Attach the spindle press (94551) to the bottom housing (3).
- 10) Turn slowly clockwise the eye bolt (6) and the spindle (5) to push the roller (1) into the bottom housing.
- 11) Use the handle (94009 M10) to remove the guide pin (4).

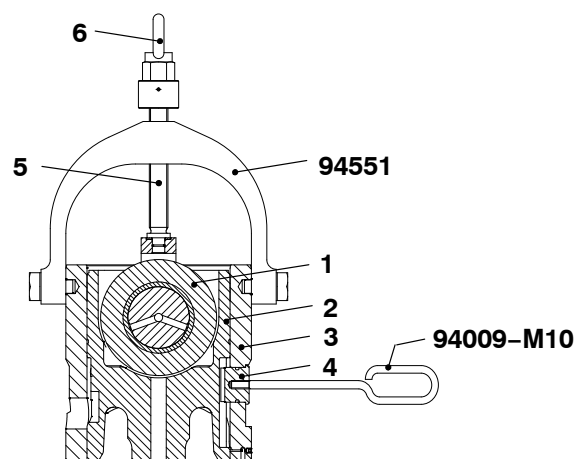


Fig. 6

Fuel Pump: Disassemble, Assemble

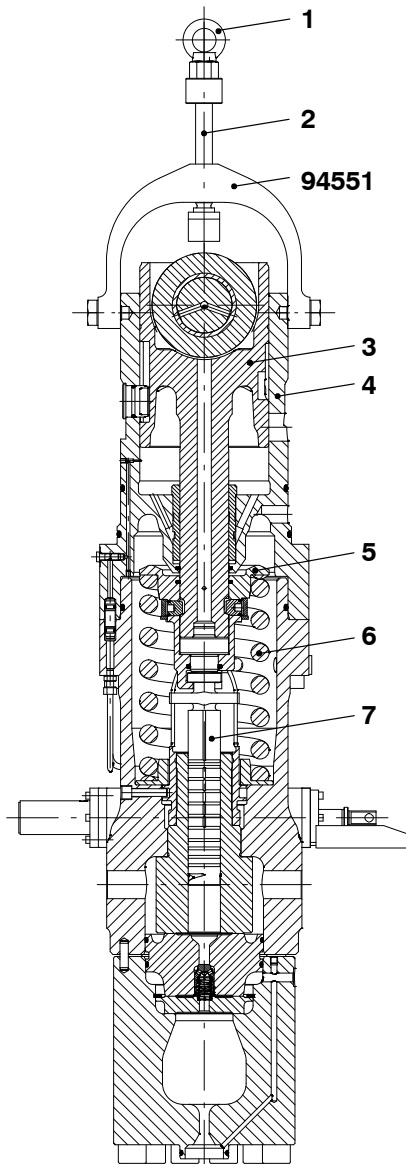
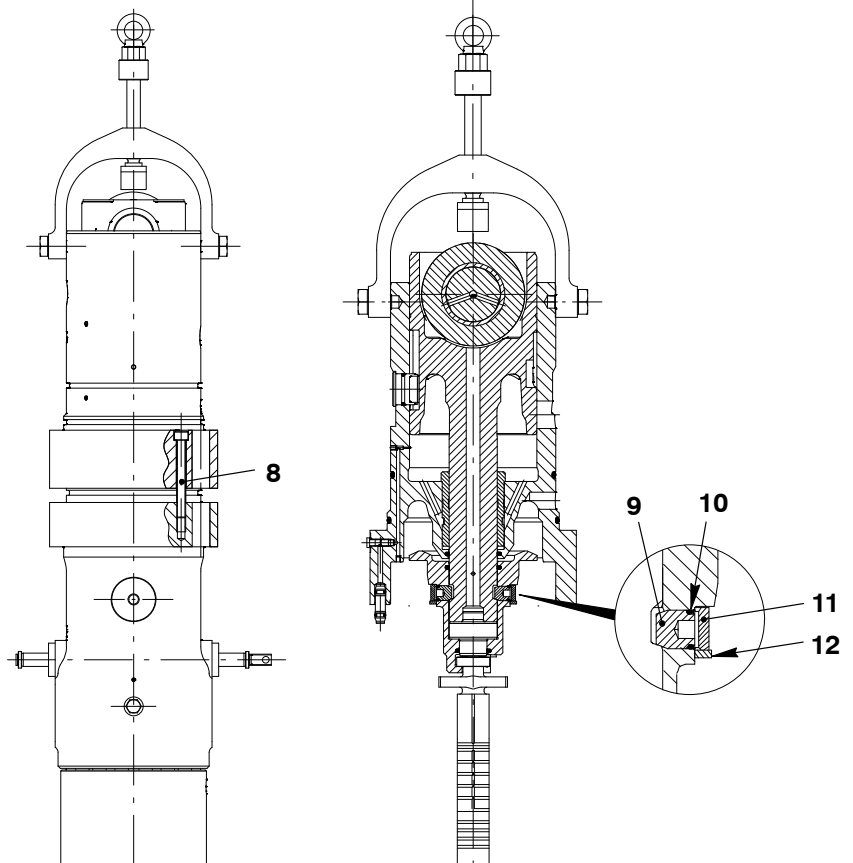


Fig. 7



- 12) Turn the eye bolt (1, Fig. 7) counterclockwise to move the spindle (2) up.
 - 13) Carefully lift the bottom housing (4) together with the guide piston (3), the bottom spring carrier (5) and pump plunger (7).
 - 14) Remove the compression spring (6).
 - 15) Remove the screw (8).
 - 16) Remove the pump plunger (7) from the bottom spring carrier (5).
- Note: If you cannot remove the pump plunger (7), refer to 5556-2.**
- 17) Remove the circlip (12) and push the retaining ring (11) down.
 - 18) Hold the bottom spring carrier (5) while you remove the two connection pins (9).
 - 19) Put the bottom housing (4) on an wooden support.
 - 20) Put the pump plunger (7) into a clean, dry storage area.
 - 21) Remove the tool 94551.

Fuel Pump: Disassemble, Assemble

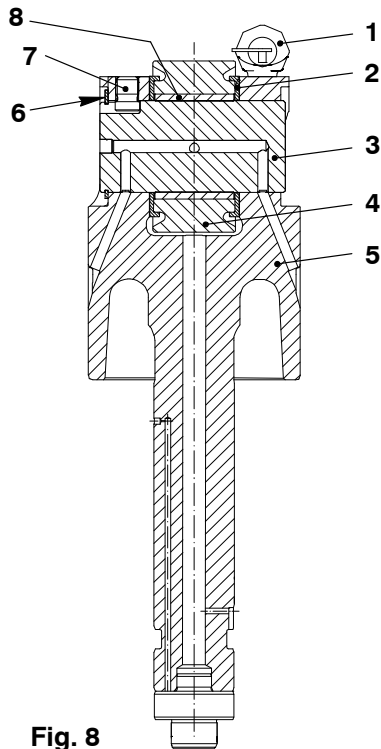


Fig. 8

3.1 Guide Piston – Disassemble

- 1) Attach the two M10 eye bolts (1, Fig. 8) to the guide piston (5).
- 2) Remove the guide piston (5) from the housing.
- 3) Remove the circlip (6).
- 4) Remove the pin (7).
- 5) Push out the roller pin (3).
- 6) Remove the roller (4), bush (8) and the two pressure discs (2).
- 7) Put the parts in a clean, dry area.

3.2 Toothed Rack - Removal

- 1) Use the two M8 bolts (or handles) to remove the top spring carrier (1, Fig. 9)
- 2) Turn the regulating sleeve (4) until the guide pin (3) is in line with the cut-out.
- 3) Remove the regulating sleeve (4).
- 4) Remove the six screws (7).
- 5) Remove the cover (8).
- 6) Remove the two circlips (9).
- 7) Remove the ring (10).
- 8) Remove the three screws (11).
- 9) Remove the intermediate flange (6) and the rod joint ring (5).
- 10) Remove the toothed rack (2).

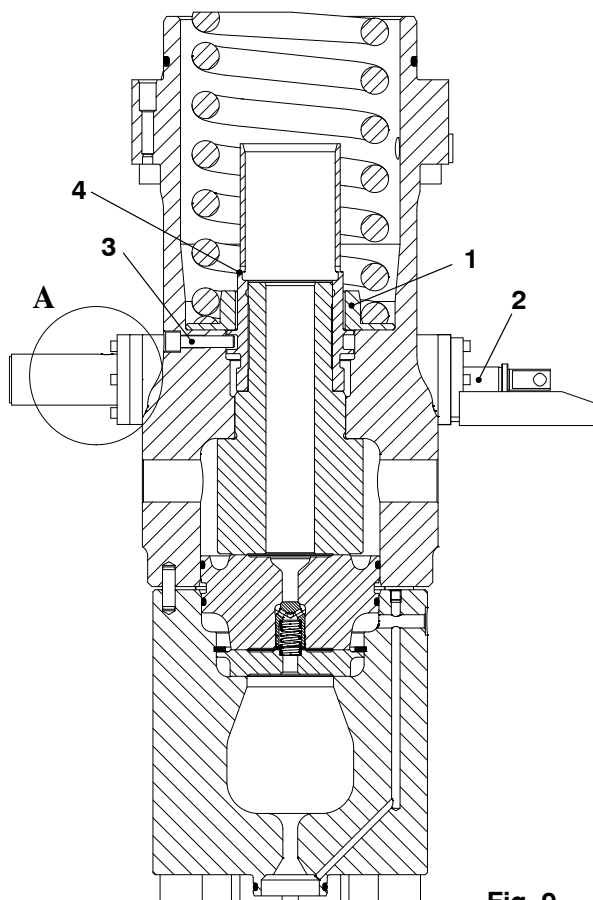
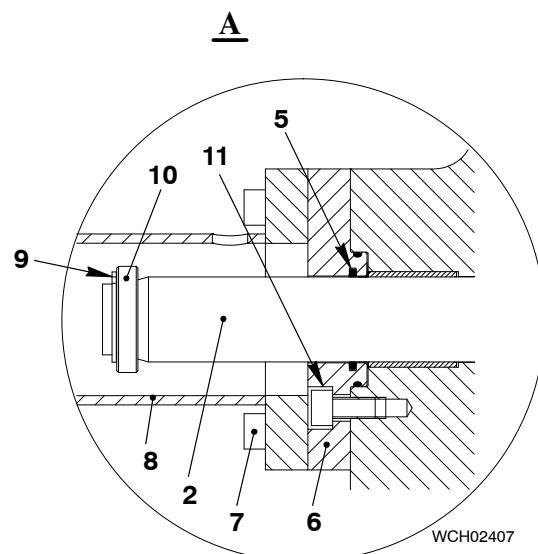


Fig. 9



WCH02407

Fuel Pump: Disassemble, Assemble

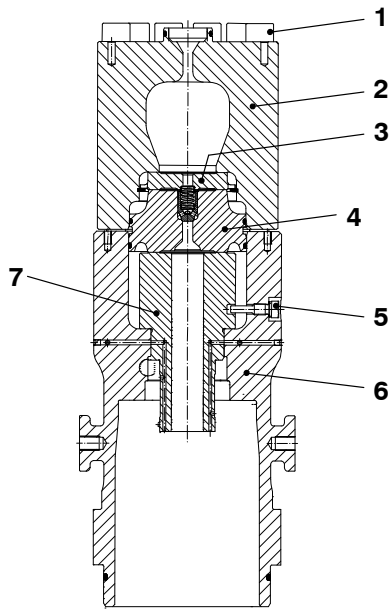


Fig. 10

3.3 Pump Cylinder – Removal

Note: The pump cylinder (7, Fig. 10) and pump plunger are not interchangeable and must stay together as a unit.

- 1) Turn the fuel pump until the pump cover (2) points up.
- 2) Remove symmetrically the twelve screws (1).
- 3) Attach the lifting tool (94552) to the pump cover (2).
- 4) Remove the pump cover (2).

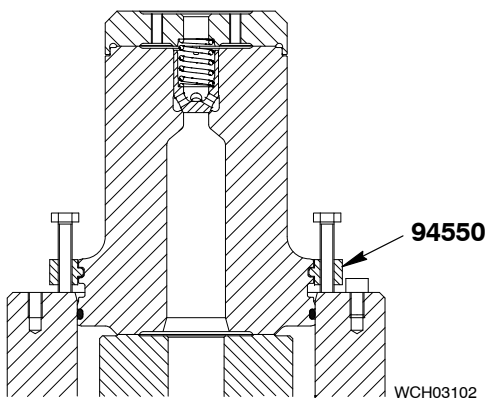


Fig. 11

- 5) Attach the clamp ring (94550, Fig. 11) to the valve block.
- 6) Use the clamp ring (94550) to remove the valve block (4).
- 7) Remove the retaining screw (5) and fluted seal ring.
- 8) Carefully remove the pump cylinder (7) from the housing (6).
- 9) Put all parts in a clean, dry storage area.

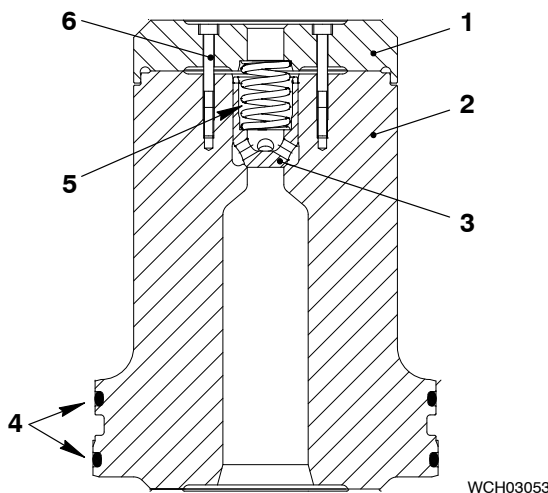


Fig. 12

3.4 Non-return Valve – Removal

- 1) Remove the two screws (6, Fig. 12).
- 2) Remove the intermediate piece (1) and the spring (5).
- 3) Remove the valve body (3) from the valve block (2).
- 4) Remove the two O-rings (4).

Fuel Pump: Disassemble, Assemble

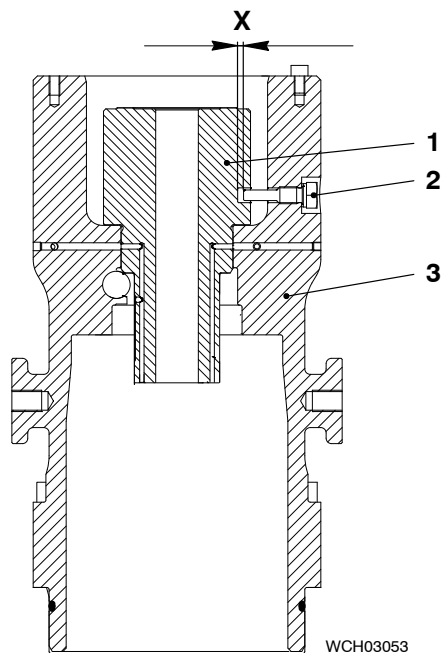


Fig. 13

4. Fuel Pump – Assemble

- 1) Clean all parts of the fuel pump and check their condition.
- 2) Examine all parts of the fuel pump for damage. Replace damaged parts with new items.
- 3) Replace all O-rings and rod seal rings.
- 4) Use a low-pressure air supply to make sure that the bores in the housings and the pump cylinder (1, Fig. 13) are clear.
- 5) Make sure that the top housing (3) points up.

4.1 Pump Cylinder – Assemble

- 1) Carefully put the pump cylinder (1) in the top housing (3).
- 2) Align the opening in the pump cylinder (1) with the bore in the top housing (3).
- 3) Install the seal ring and screw (2).

Note: Make sure that there is a clearance (X) between the end of the screw (2) and the opening in the pump cylinder (1).

4.2 Non-return Valve – Assemble

- 1) Make sure that the sealing surfaces of the valve block (2, Fig. 14) are clean and have no damage.
- 2) Put oil on the new O-rings (4).
- 3) Put the new O-rings (4) on the valve block (2).
- 4) Put the spring (5) in position in the valve body (3).
- 5) Attach the intermediate disc (1) to the valve body (2) with the two bolts (6).
- 6) Torque the two bolts (6) to 4.0 Nm.

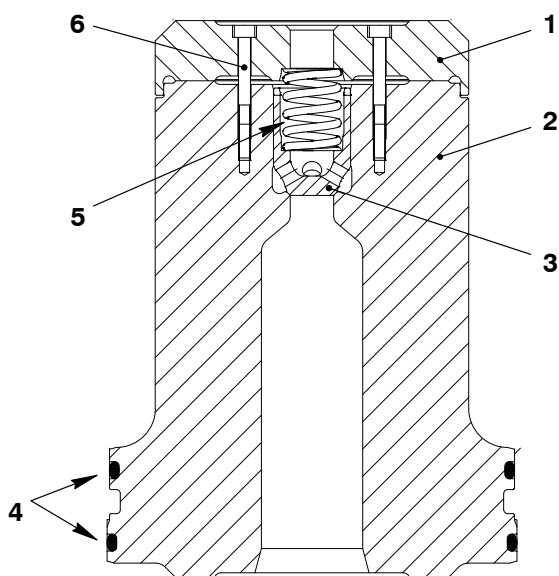


Fig. 14

Fuel Pump: Disassemble, Assemble

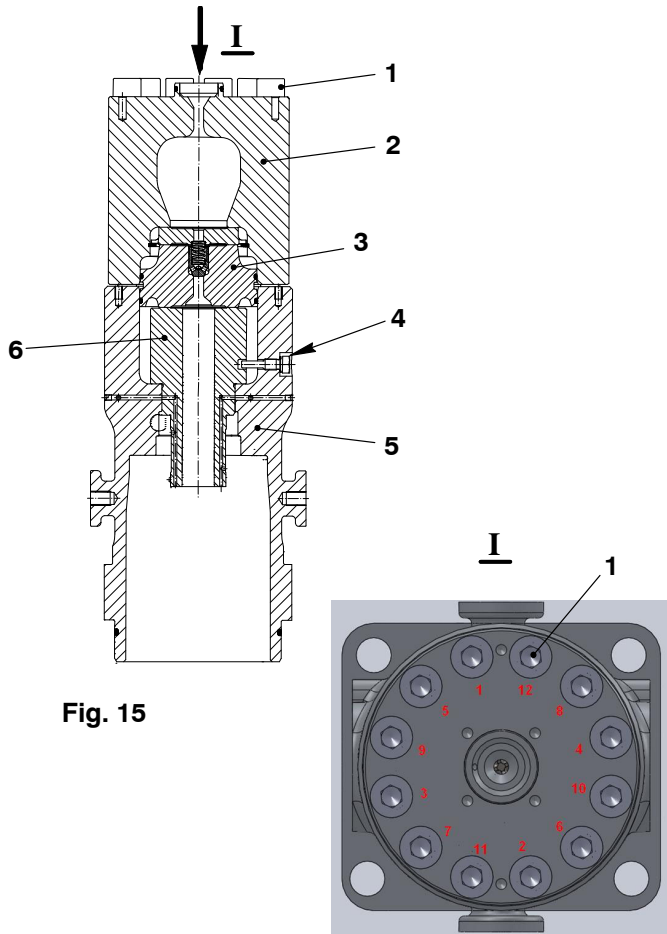


Fig. 15

4.3 Pump Cover – Assemble

- 1) Put oil on the bottom part of the non-return valve (3, Fig. 15).
- 2) Carefully put the assembled non-return valve (3) into the top housing (5).
- 3) Put the pump cover (2) in position on the top housing (5). Make sure you do not damage the compression spring.
- 4) Apply NeverSeez NSBT to the threads and the bottom faces of the 12 bolts (1).
- 5) Put the 12 bolts (1) in position in the pump cover (2).
- 6) Torque the 12 bolts (1) as follows:
 - a) Torque the 12 bolts in the sequence shown to 100 Nm.
 - b) Torque the 12 bolts in the sequence shown to 300 Nm.
 - c) Torque the 12 bolts in the sequence shown to 480 Nm.

4.4 Guide Piston – Assemble

- 1) Clean all parts of the guide piston (5, Fig. 16).
- 2) Put oil on all parts of the guide piston.

Note: In step 3), the pin (7) is installed from the inner surface of the guide piston (5).

- 3) Put the pin (7) in position in the guide piston (5).
- 4) Torque counterclockwise the pin to 60 Nm.
- 5) Put oil on the flanks of the roller (4).
- 6) Put the roller (4), bush (8) and the two pressure discs (2) in the guide piston (5).
- 7) Hold the roller pin (3) in position and align the groove with the pin (7).
- 8) Push the roller pin (3) into the guide piston (5) and the roller (4).
- 9) Attach the circlip (6) to hold the roller pin (3) in position.

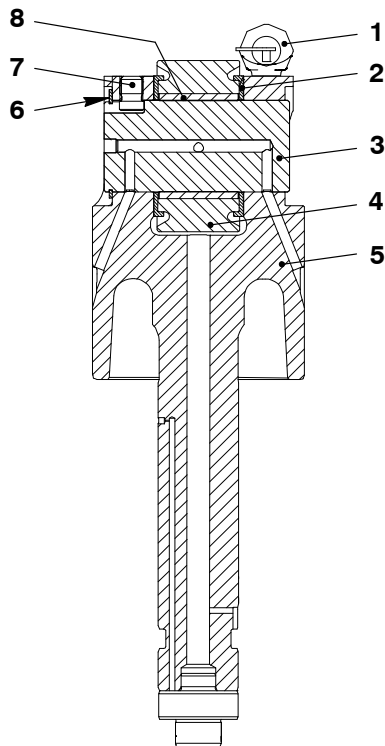


Fig. 16

Fuel Pump: Disassemble, Assemble

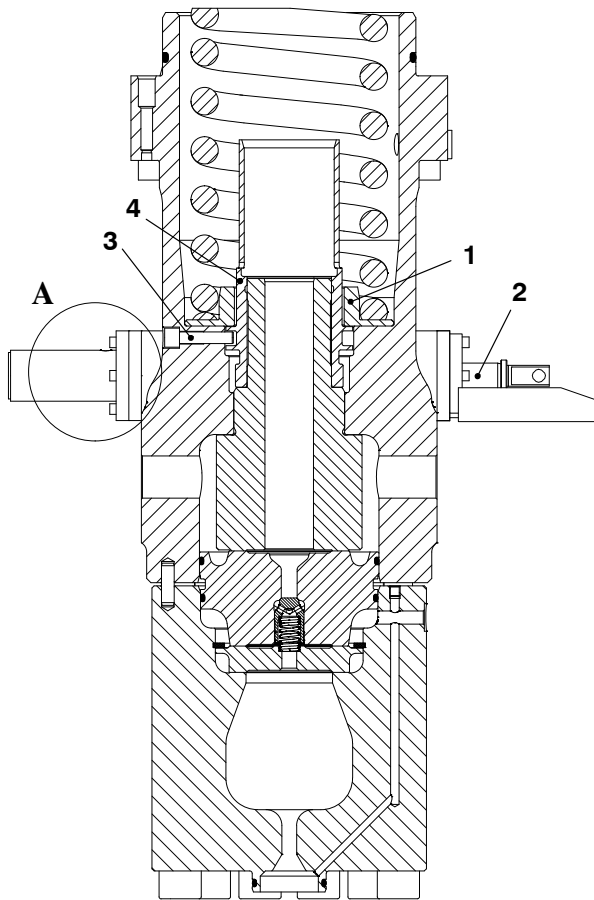


Fig. 17

4.5 Top Housing – Assemble

1) Turn the fuel pump into the position shown in Fig. 17.

2) Put the toothed rack (2) in position.

Note: Make sure that the toothed rack (2) moves easily.

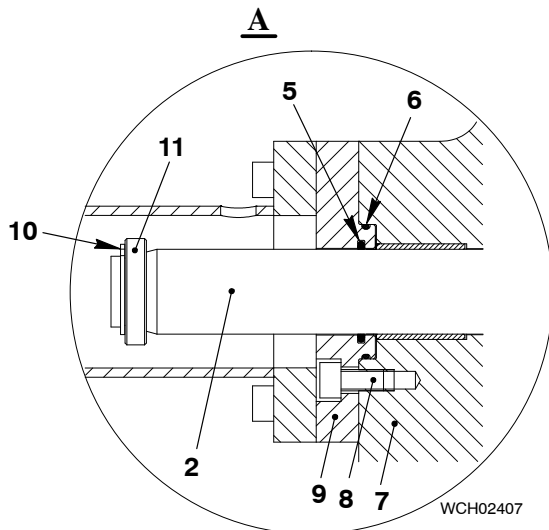
3) Put oil on the rod seal ring (5).

4) Put the rod seal ring (5) into the intermediate flange (9).

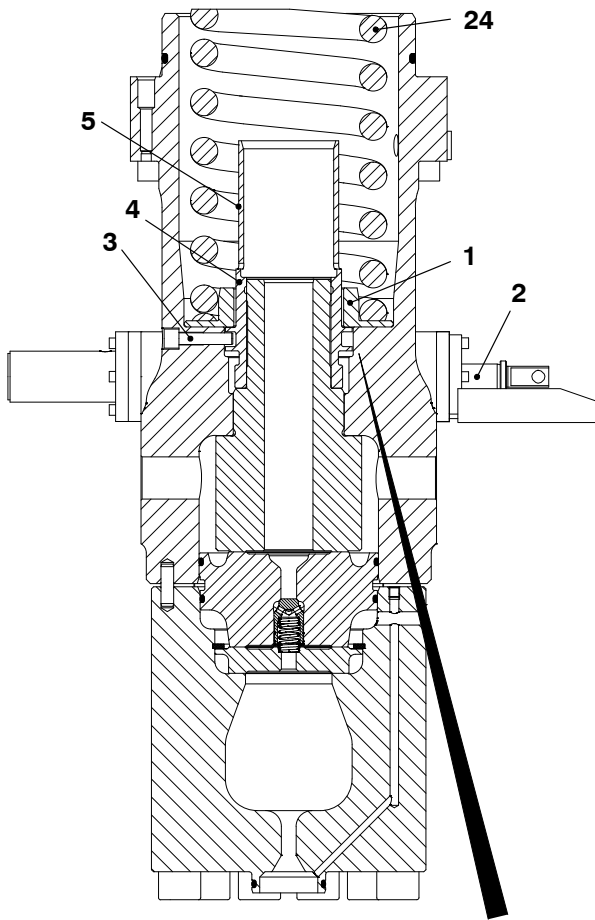
5) Put the intermediate flange (9) together with the O-ring (6) into the top housing (7).

6) Install the three screws (8).

7) Attach the rings (11) and the circlips (10).

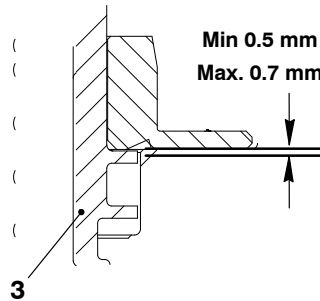


WCH02407



- 8) Move the toothed rack (2, Fig. 18) fully out.
- 9) Put the regulating sleeve (5) in position in the top housing (3).
- 10) Turn the regulating sleeve (5) until the guide pin (4) is in line with the cut-out.
- 11) Move the toothed rack through the full range of movement.
- 12) Put the top spring carrier (1) in position in the top housing.
- 13) Push the top spring carrier (1) against the top housing
- 14) Move the regulating sleeve (5) up and down.
- 15) Use a dial gauge to measure the axial clearance between the regulating sleeve (5) and the top spring carrier (1).
- 16) Make sure that the axial clearance is between 0.5 mm and 0.7 mm.

Fig. 18



Fuel Pump: Disassemble, Assemble

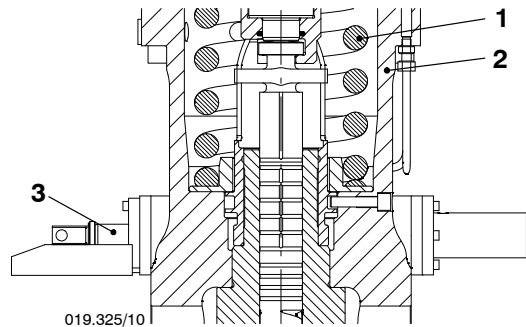


Fig. 19

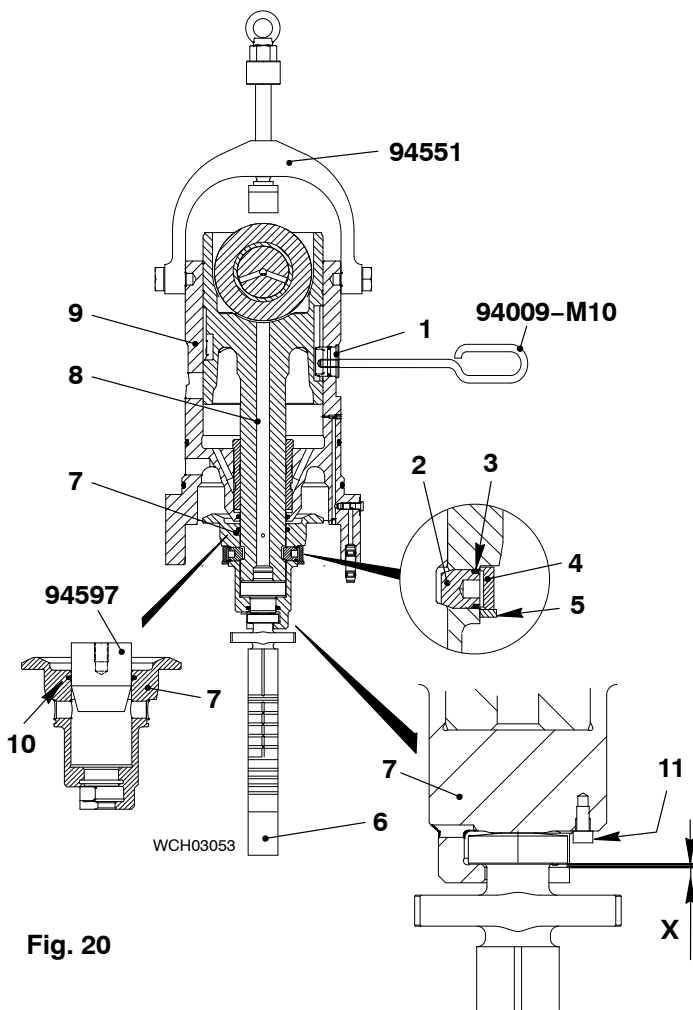


Fig. 20

- 17) Move the toothed rack (3, Fig. 19) to the middle position.
- 18) Put the compression spring (1) in position in the top housing (2).

4.6 Bottom Housing – Assemble

- 1) Attach the spindle press (94551) to the bottom housing (9, Fig. 20).
- 2) Put a new O-ring on the guide pin (1).
- 3) Put the assembled guide piston (8) in the bottom housing (9). Make sure that the groove in the guide piston aligns with the bore in the bottom housing.
- 4) Use the handle (94009 M10) to install the guide pin (1).
- 5) Use the mandrel (94597) to install a new seal (10) to the bottom spring carrier (7).
- 6) Put the bottom spring carrier (7) in position on the guide piston (8).
- 7) Put new O-rings (3) on the connection pins (2).
- 8) Put the two connection pins (2) through the bores in the top spring carrier. Make sure that the connection pins engage with the groove in the guide piston (8).
- 9) Attach the retaining rings (4) to the connection pins (2).
- 10) Attach the circlips (5) to hold the connection pins (2) and the retaining rings (4) in position.
- 11) Lift the assembly into position above the top housing.
- 12) Attach the pump plunger (6) to the bottom spring carrier (7).
- 13) Make sure that there is a clearance (X) of between 0.12mm and 0.24mm.
- 14) Apply Loctite 243 the thread of the screw (11).
- 15) Torque the screw (11) to 9.0 Nm.

Fuel Pump: Disassemble, Assemble

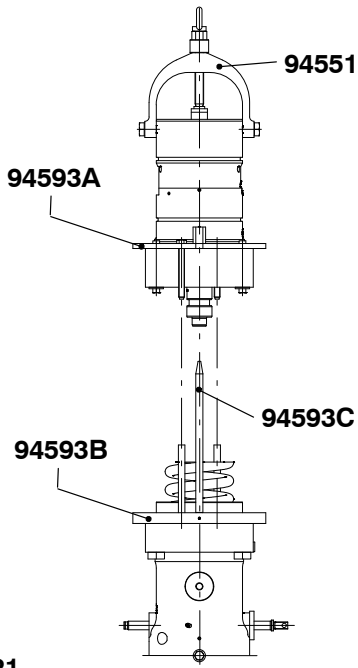


Fig. 21 019.234/10

4.7 Fuel pump

- 1) Attach the ring (94593A, Fig. 21) to the bottom housing (2).
- 2) Attach the two part ring (94593B) to the top housing (3). Make sure that the guide rods (94593C) align with the holes in the ring (94593A).
- 3) Attach the engine room crane to the spindle press (94551).

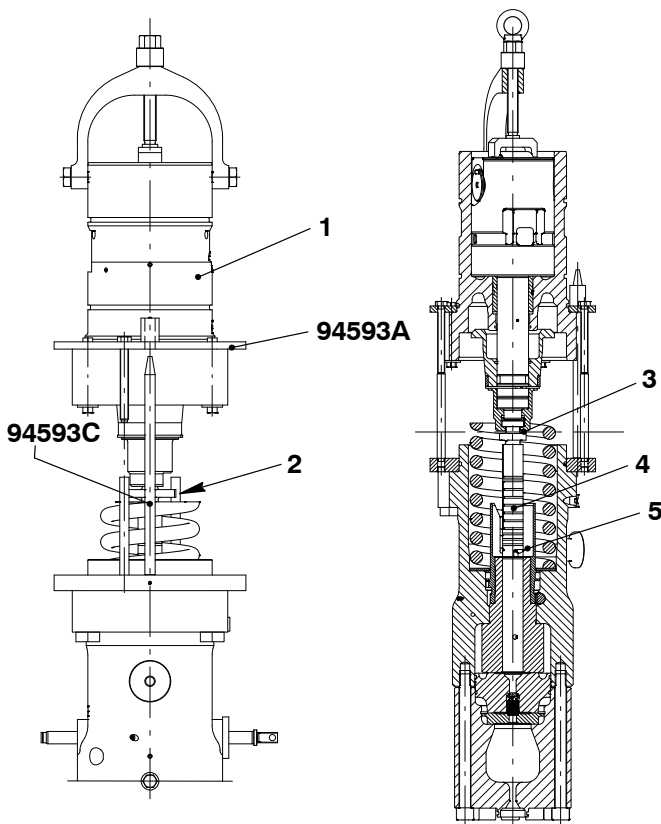


Fig. 22

- 4) Carefully lower the bottom housing (1, Fig. 22) sufficiently to engage the rods (94593C) with the holes in the ring (94593A).
- 5) Continue to lower the bottom housing (1) until the pump plunger (4) is a small distance from the regulating sleeve (5).

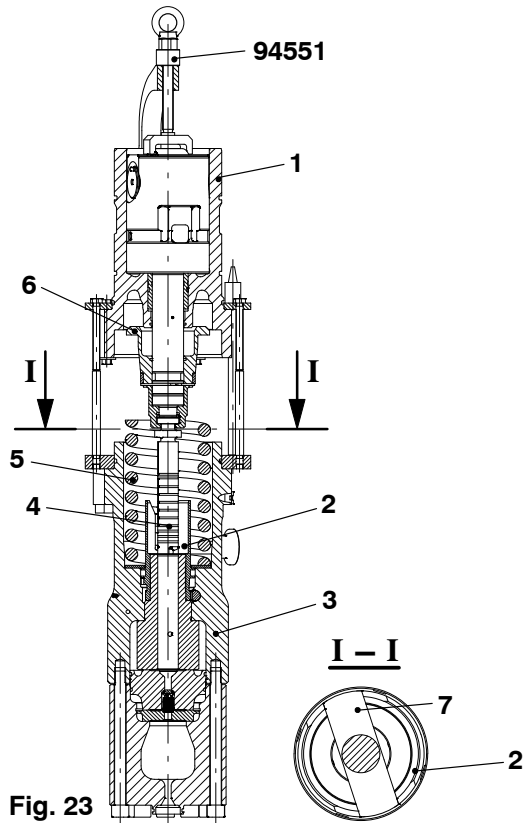


Fig. 23

- 6) Lower the bottom housing (1, Fig. 23) on to the top housing (7) until the spring carrier (6) above the spring (5).
- 7) Align the tabs (7) on the pump plunger (4) with the holes in the regulating sleeve (2).
- 8) Continue to lower the bottom housing (1) until the spring carrier (6) touches the spring (5).
- 9) Remove the engine room crane from the spindle press. (94551).
- 10) Remove the ring (94593A) and the two-part ring (94593B).

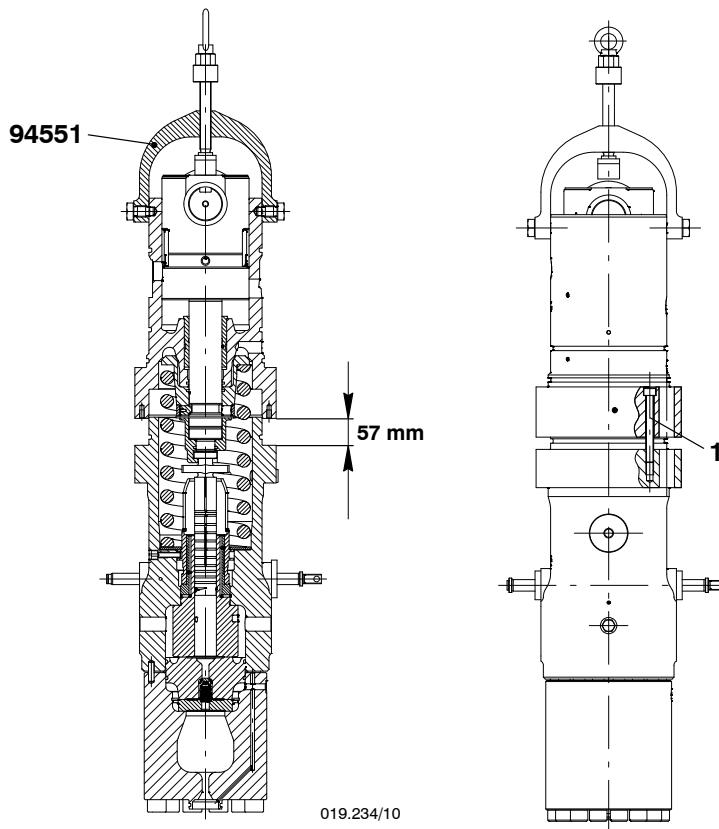


Fig. 24

- 11) Make sure that there is a clearance of 57 mm between the top housing and the bottom housing (refer to Fig. 24).
- 12) Put the two Allen screws (1) in position as shown.
- 13) Torque symmetrically the two Allen screws to 140 Nm.

Fuel Pump: Disassemble, Assemble

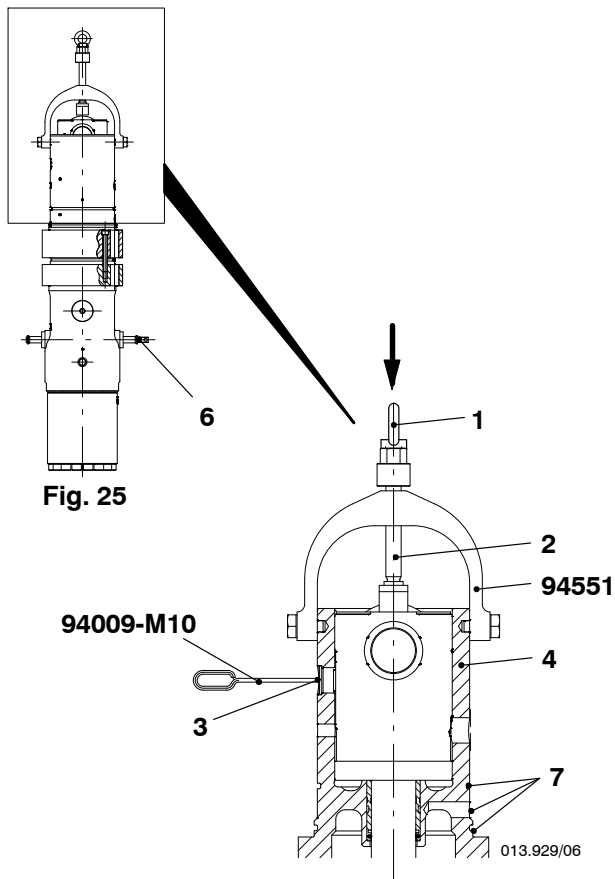


Fig. 25

Fig. 25

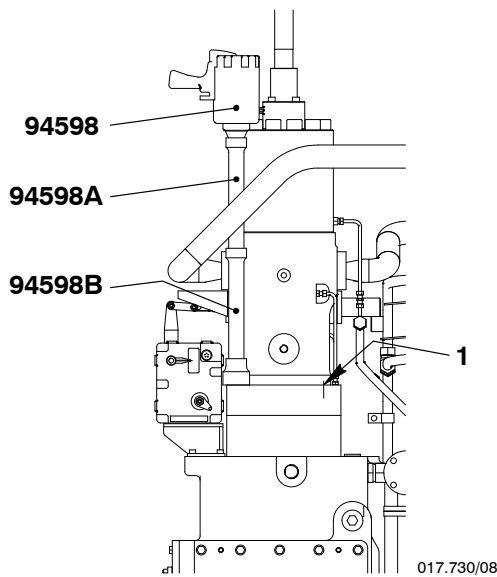


Fig. 26

5. Fuel pump – attachment to the supply unit

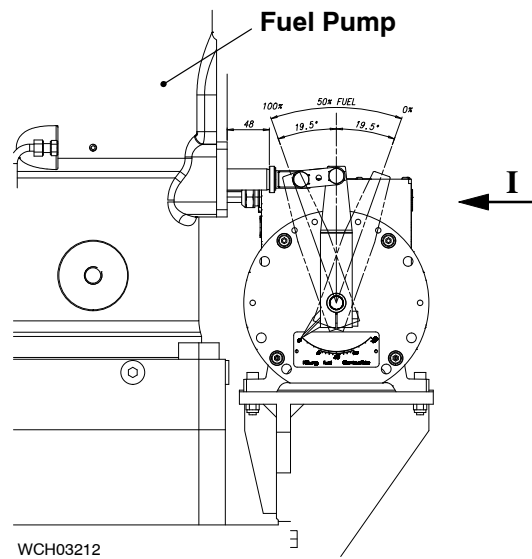
WARNING



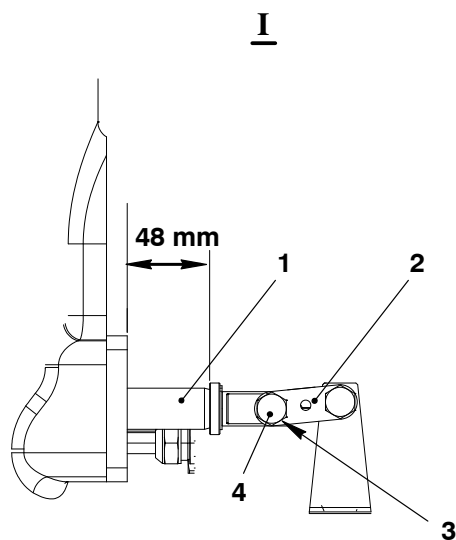
Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, or in the engine.

- 1) Operate the turning gear to turn the camshaft until the applicable cam is at BDC.
- 2) Do a check of all parts of the fuel pump.
- 3) Make sure that the seating surfaces of the fuel pump are clean and have no damage.
- 4) Put new O-rings (7, Fig. 25) on the bottom housing.
- 5) Put oil on the threads and seating surfaces of the four bolts (2).
- 6) Attach the manual ratchet (94016 003) to the lifting tool (94552) and the engine room crane.
- 7) Lift the fuel pump.
- 8) Put the fuel pump directly above the applicable position of the supply unit.
- 9) Carefully lower the fuel pump into position.
- 10) Torque the bolts (1, Fig. 26) to the value given in 0352 1. Use the socket wrench insert (94598B), the extensions (94598A) and the pneumatic impact wrench (94598).
- 11) Install the applicable HP fuel pipe(s), refer to 8752 1.
- 12) Make sure that the fuel return valve and the fuel inlet valve are open. Refer to the Operation Manual, 4003 2 and 4003 11.

Fuel Pump: Disassemble, Assemble



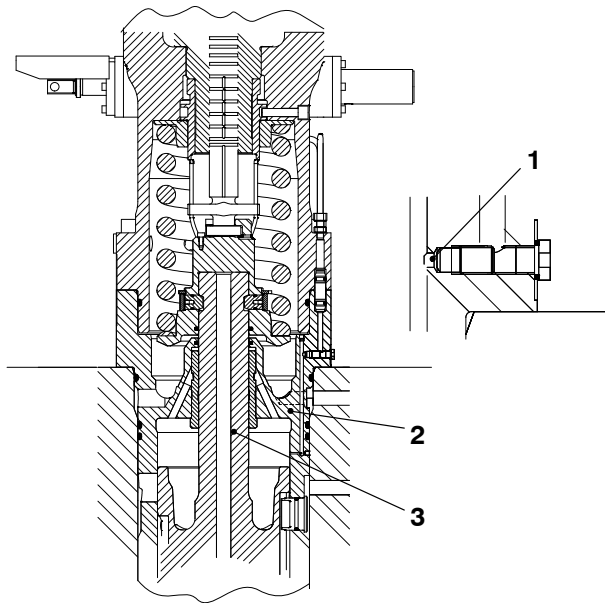
- 13) Make sure that the connecting element (2, Fig. 27) moves freely.
- 14) Apply Molykote paste G to the connecting element (2).
- 15) Attach the connecting element (2) to the toothed rack (1) with the screw and new self-locking nut (4).
- 16) Move the the toothed rack (1) to the middle position as shown. Make sure that there is 48 mm at each end of the the toothed rack.
- 17) Make sure that the indicator on the actuator shows 50% fuel.



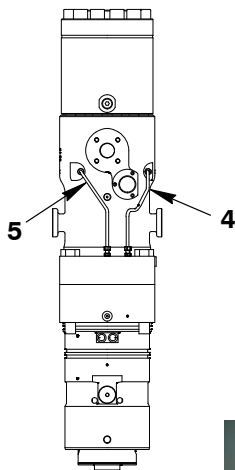
Note: Cover not shown

Fig. 27

Fuel Pump: Disassemble, Assemble



WCH02790



WCH02790

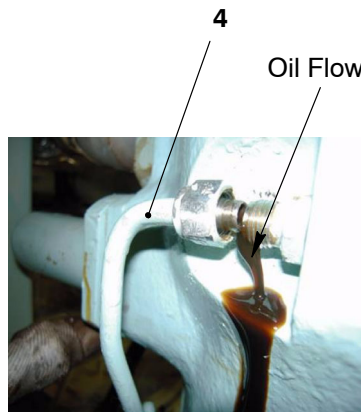


Fig. 28

6. Oil Flow Check

WARNING



Injury Hazard: Do not operate the engine. Injury to personnel can occur.

WARNING



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

Note: The oil flows through the throttle (1, Fig. 28) to the bottom housing (2) and the guide piston (3).

- 1) The engine must be stopped.
 - 2) Operate the turning gear to move the roller of the related fuel pump to its highest position (TDC).
 - 1) Remove the oil drain pipe (4) from the fuel pump.
 - 2) Set to on the service pump.
 - 3) After one minute, make sure that you can see the oil flow as shown in Fig. 28.
 - 4) If the oil does not flow as shown, read the data in Technical Bulletin RT 180.
 - 5) Make sure that the the oil flows in the inlet pipe (5).
- Note: If the oil in the inlet pipe (5) does not flow freely, it is possible that there are unwanted particles in the oil supply system. If you find particles, remove them.**
- 6) If there is incorrect oil flow, or no flow on the drain bore do as follows:
 - a) If the oil cannot flow freely, flush the bores with eg WD 40.
 - b) If there is no oil flow, use a heat gun to apply heat to the clogged drain bore.
 - c) Use a small drill bit to open the bore.
 - d) Remove the particles with a nylon brush.
 - 7) Install all unions and plugs.
 - 8) Connect the oil drain pipe (4) and (5) to the fuel pump.

7. Storage

Do the procedure that follows to put the fuel pump into storage:

- 1) Make sure that the storage area is clean, dry.
- 2) Put oil on the fuel pump to prevent contamination.
- 3) Put the pump in a vertical position.
- 4) Put petroleum jelly (eg Vaseline™) in the oil inlet and oil drain holes of the fuel pump.
- 5) Put the plastic stoppers into the open spaces.
- 6) Put a cover (material or plastic) on the fuel pump.

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 Tool 94595C	.....	4

1. Fuel Pump – Preparation

- 1) Remove the fuel pump (refer to [5556 1](#)).
- 2) Disassemble the fuel pump until the condition is as shown in [Fig. 1](#).

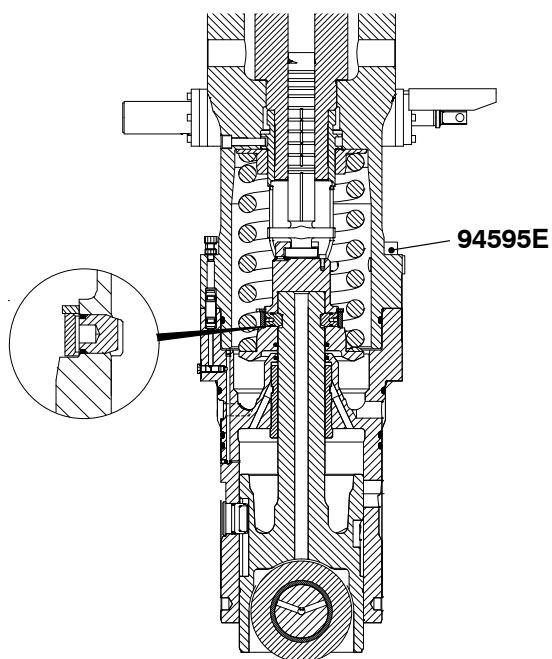


Fig. 1

WCH03016

Fuel Pump: Removal of a Seized Pump Plunger

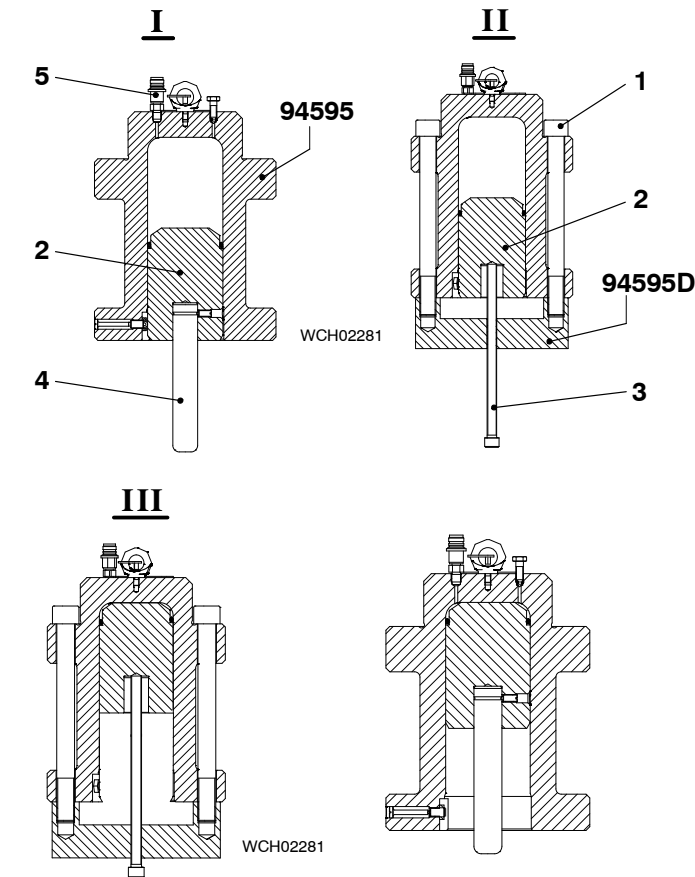


Fig. 2

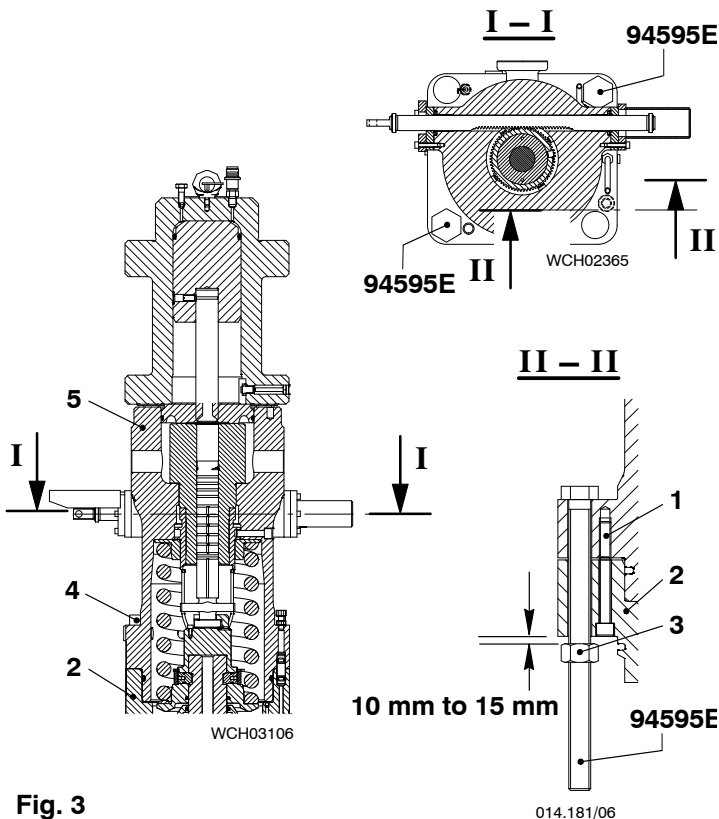


Fig. 3

2. Hydraulic Ram – Preparation

- 1) Open the vent screw (5, Fig. 2).
- 2) Use the push rod (4) to push the piston (2) to the top of the cylinder of hydraulic ram (94595).
- 3) 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 (2).
 - b) Attach the piston reset tool (94595D) to the hydraulic ram (94595) with two of the screws (1).

Note: The screws (1) are from the fuel pump cover.

- c) Use the spindle (3) to push the piston (2) to the top of the cylinder.
- 4) Remove the piston reset tool (94595D).
- 5) Put the short push rod (4, 94595B) into the piston (2).

3. Hydraulic Ram – Install

- 1) Attach the hydraulic ram (94595) to the fuel pump with the 12 screws (1).

CAUTION



Damage Hazard: There is no support below the housing. The bottom housing can fall and cause damage when the screws are removed.

- 2) Hold the bottom housing (2, Fig. 3) in position, then remove the four bolts (4) from the top housing (5).
- 3) Put the screws (94595E) through the bores in the flange in the top and bottom housings in the diagonal positions shown (view I-I).
- 4) Put the nuts (3) on to 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

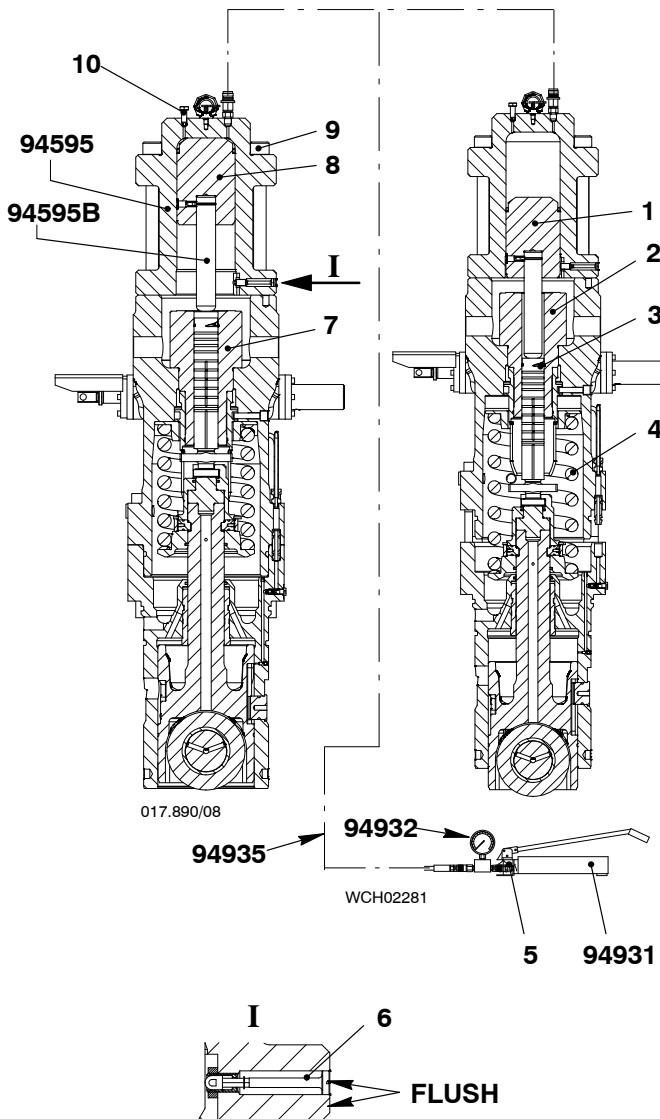


Fig. 4

4. Removal with Tool 94595B

Note: Some internal parts of the fuel pump can look different.

- 1) Attach 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 (94931) until oil that has no air flows from the vent screw (10).
- 5) Close the vent screw (10).

Note: During step 6), 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 (2).

- 6) Slowly operate the HP oil pump until:
 - The compression spring (4, Fig. 4) pushes the pump plunger (2) out of the cylinder (7).
 - 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 pipe.
- 8) Remove the HP oil pump from the hydraulic ram (94595).
- 9) Remove the screws (9).
- 10) Remove the hydraulic ram (94595).
- 11) Remove the pump plunger (3).
- 12) Move the piston (8) to the initial position, refer to paragraph 2.
- 13) Continue to disassemble the fuel pump (refer to 5556 1).
- 14) If you cannot remove the plunger (3), do the procedure given in paragraph 5.

Fuel Pump: Removal of a Seized Pump Plunger

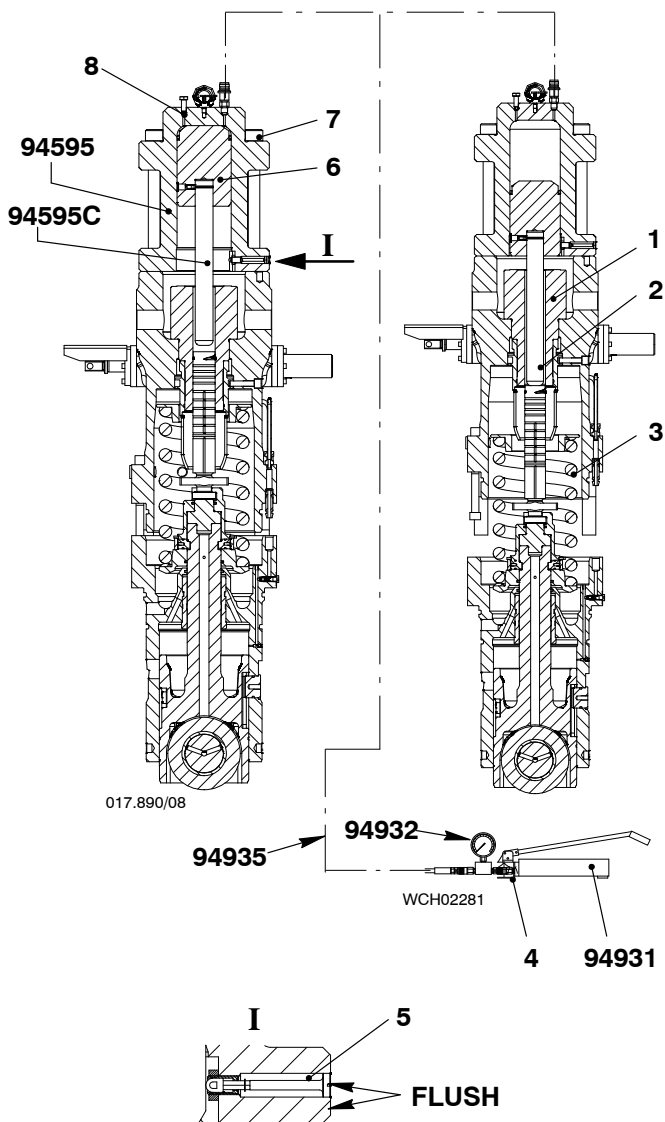


Fig. 5

5. Removal with Tool 94595C

Note: Some internal parts of the fuel pump can look different.

- 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 (refer to paragraph 3).
- 4) Connect the hydraulic ram (94595, Fig. 5) to the HP oil pump.
- 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 step 9, 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 pump plunger (2) 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 pump plunger (2).
- 12) Remove the hydraulic ram.
- 13) Continue to disassemble the fuel pump (refer to 5556 1).

Fuel Pressure Control Valve Removal, Check, Installation

Tools:

1	HP oil pump	94931	1	HP hose	94935
1	Pressure gauge	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), WinGD recommends that you only do the procedures that follow:

- Do a check and adjust the PCV.
- Adjust the PCV.
- Replace the PCV.

For the maintenance intervals of the PCV, refer to the Maintenance Schedule 0380 1, [Fuel pressure control valve](#).

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.

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

Stop the engine, refer to the Operation Manual, 0310 1.

- 2 Release the pressure in the fuel rail. Do the procedure given in the Operation Manual 0515, paragraph 5.3.

Make sure that the work area is clean.

3. Removal

- 1) Disconnect the electrical connection from the solenoid valve (1, Fig. 1).
- 2) Loosen the angle union (3).
- 3) Remove the fuel return pipe (4) from the pressure control valve (PCV) (9).
- 4) Loosen the angle union (3).
- 5) Remove the fuel return pipe (6) from the relief valve (7).
- 6) Remove the four Allen screws (2).
- 7) Remove the PCV (9) from the fuel rail (8).
- 8) Examine the lip seal (10) for damage. If you find damage, remove and discard the lip seal.

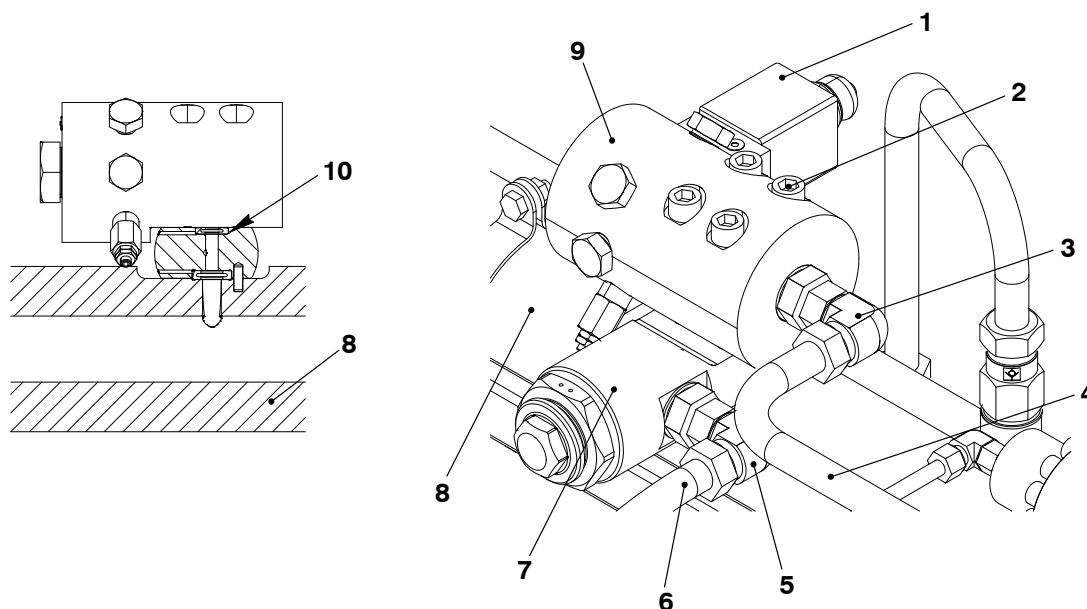


Fig. 1

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.
- 7) Tighten the screws in the sequence given in 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.
- 8) Attach the flexible tube (a part of the test block 94556) to the PCV outlet (2). Put the other end of the flexible tube into an applicable container (3).
- 9) Connect the HP oil pump (94931), pressure gauge (94932) and HP hose (94935) to the test block (94556).
- 10) Identify each of the two pressure control set screws.
- 11) On the setpoint adjustment valve (SAV) (7), loosen the locknut.
- 12) Fully loosen the SAV (7).

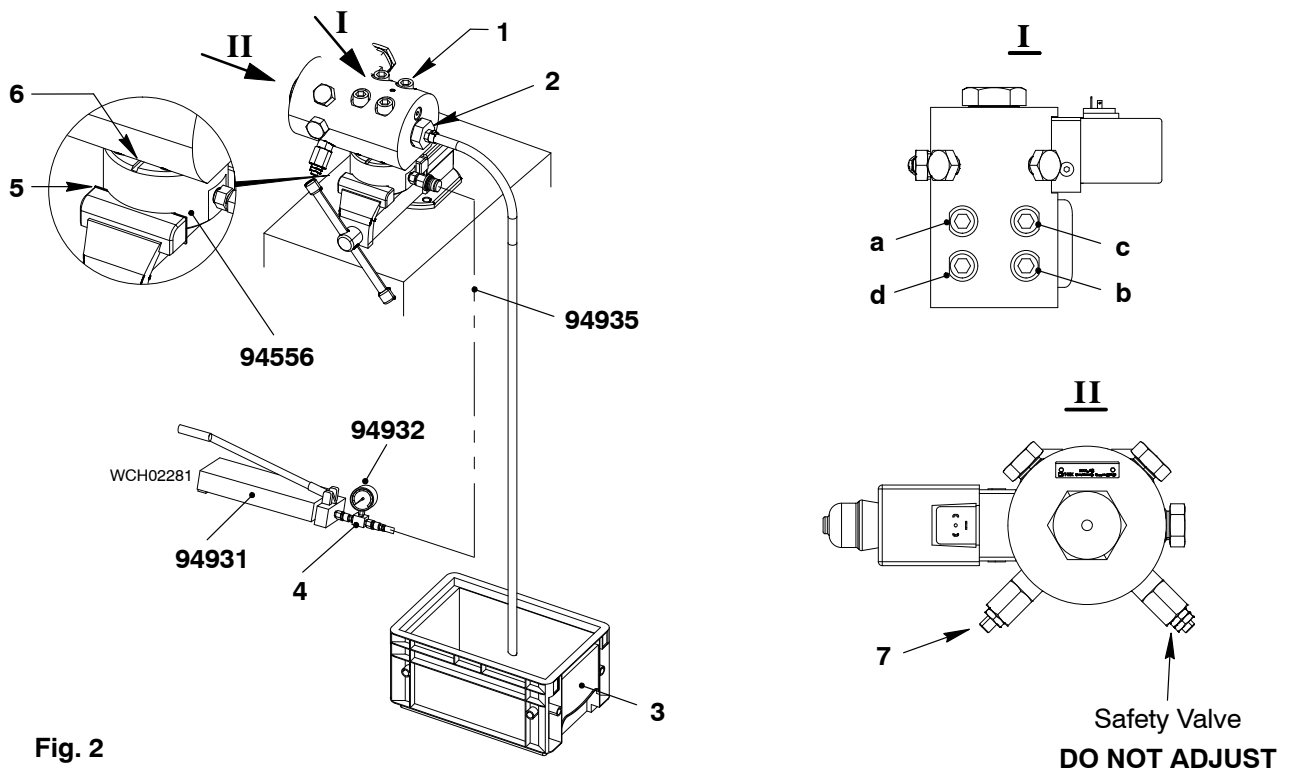



Fig. 2

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) until the PCV opens at 1050 bar.
- 6) On the SAV (7), tighten the locknut.
- 7) On the HP oil pump (94931), open the relief valve (4) to decrease the pressure to zero.

4.3 Setpoint Check

- 1) On the HP oil pump (94931), close the relief valve (4).
- 2) Operate the HP oil pump (94931).
- 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.

Note: 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 (10, [Fig. 1](#)). Replace the lip seal if necessary.
- 2) Make sure that the sealing surfaces of the PCV (9) are clean and have no damage.
- 3) Put oil on the threads of the four screws (2).
- 4) Put the four screws (2) in position in the PCV (9).
- 5) Tighten the screws (1) 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.
- 6) Attach the fuel return pipe (4, [Fig. 1](#)) to the PCV (9).
- 7) Tighten the angle union (3).
- 8) Connect the electrical connection to the solenoid valve (1).

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Fuel Pressure Control Valve

Fuel Pressure Control Valve: Manual Release Valve Clean

1. General

If the pressure control valve does not close correctly, do the pressure given in paragraph 2.

2. Procedure

2.1 Disassemble

Note: It is not necessary to remove the Pressure control valve PCV (1, Fig. 1) from the fuel rail (2) to do this procedure.

Note: For the full PCV overhaul instructions, speak to or send a message to WinGD.

9) Stop the engine.

10) Make sure that the PCV (1) is open.

Note: If HFO is used, the drain port will be hot when the PCV is open.

11) Operate the pressure release button more than two times to release pressure.

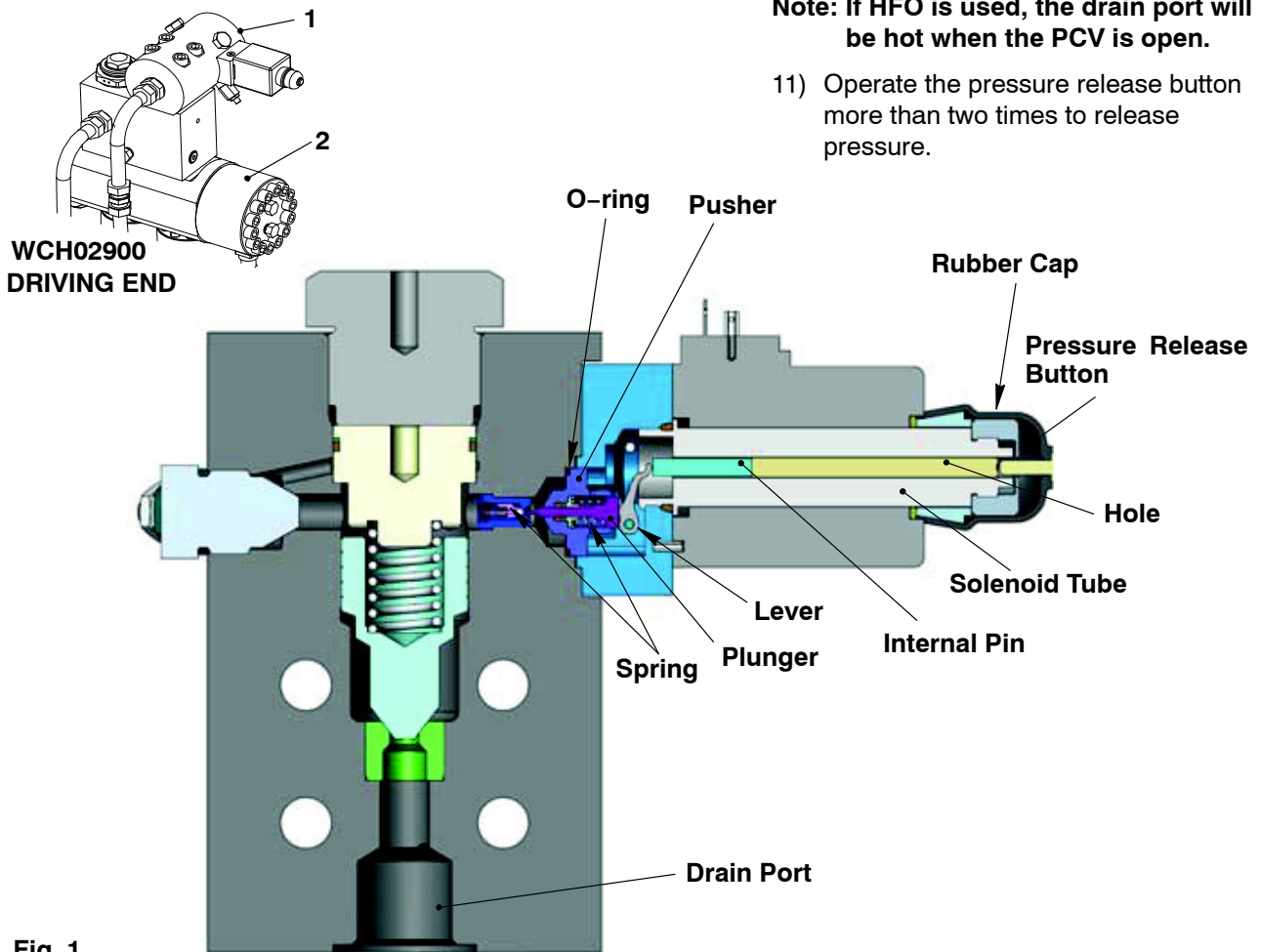


Fig. 1

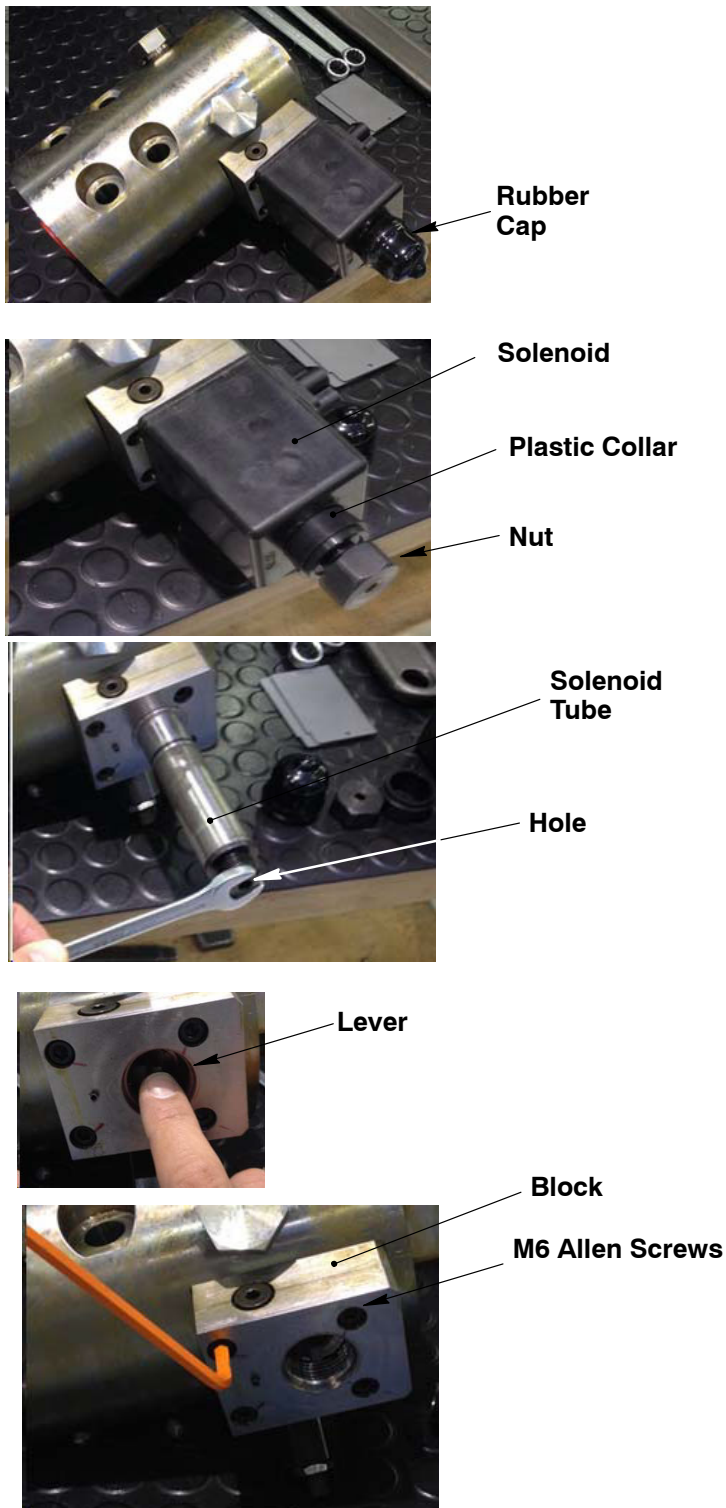


Fig. 2

12) Carefully remove the rubber cap (Fig. 2).

13) Record the installed position of the plastic collar.

14) Remove the nut, plastic collar and solenoid.

15) Remove the solenoid tube.

16) Use your finger to push the lever. Make sure that you can feel two different spring tensions.

Note: If the valve closes and you can get rail pressure, it is not necessary to continue the procedure. Refer to [paragraph 2.3, step 5](#)) to step 9) to assemble the PCV.

CAUTION



Injury Hazard: Make sure that there is no pressure in the fuel rail or the drain side of the system. High pressure fuel can cause injury to personnel.

17) Remove the four M6 Allen screws from the block.

18) Remove the block.

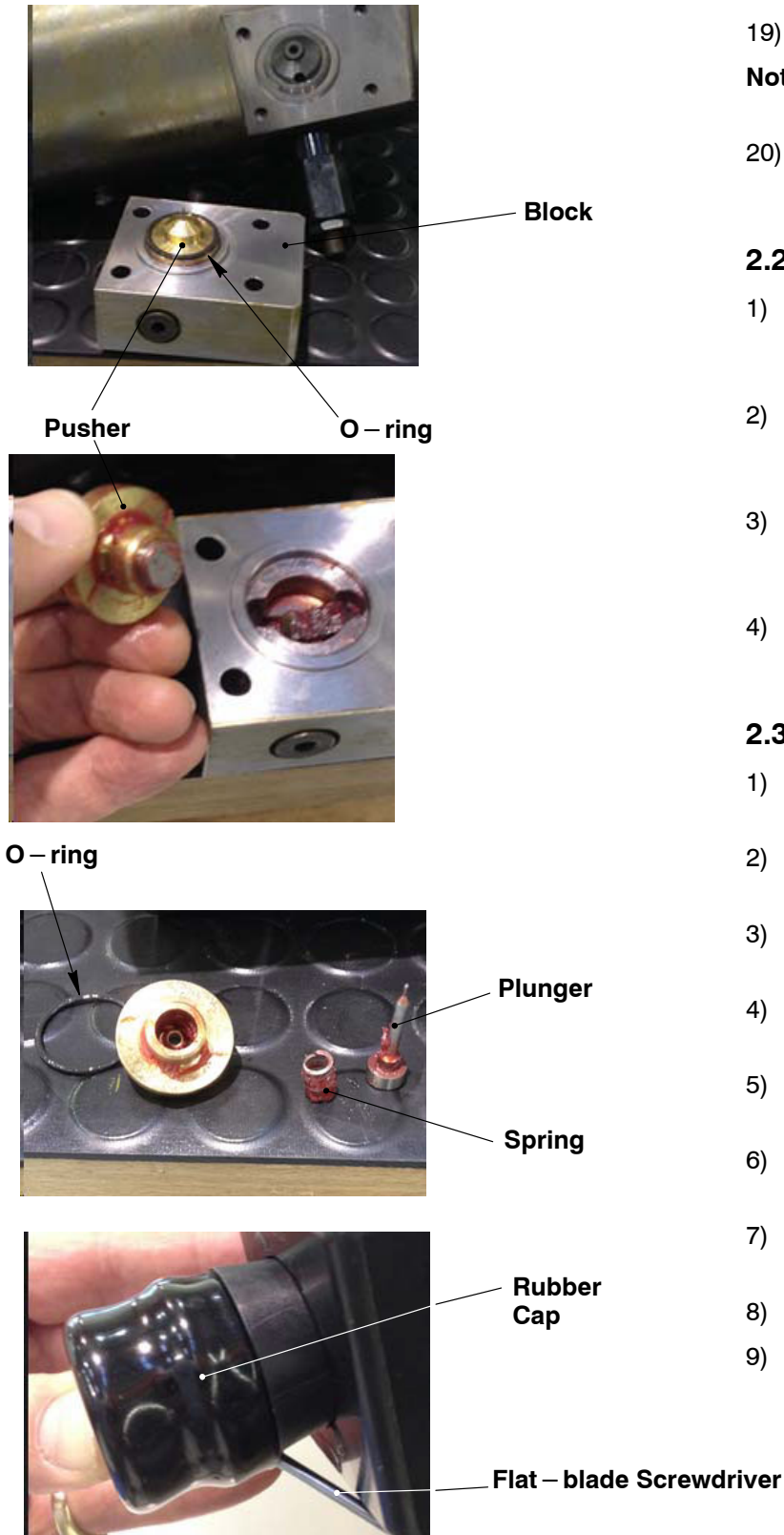


Fig. 3

19) Carefully remove the pusher (Fig. 3).

Note: It is possible that the pusher will stay on the PCV body.

20) Remove the plunger and spring from the PVC.

2.2 Clean and Apply NeverSeez

- 1) Remove the grease from all components (pusher, plunger, spring and O ring).
- 2) Apply a thin layer of NeverSeez to all components (plunger, spring and pusher).
- 3) Put NeverSeez into the hole in the solenoid tube (refer to Fig. 1 and Fig. 2).
- 4) Push the internal pin in and out with your hand to apply the NeverSeez.

2.3 Assemble

- 1) Put the plunger and spring into the pusher assembly.
- 2) Put the O ring and pusher in position in the valve block.
- 3) Attach the valve block to the PCV with the four M6 Allen screws.
- 4) Torque the for M6 Allen screws to 15 Nm.
- 5) Attach the solenoid tube to the valve block.
- 6) Put the solenoid in position on the valve block.
- 7) Put the thick part of the collar against the solenoid.
- 8) Attach the nut to the solenoid.
- 9) Tighten the nut.

Note: During step 9), hold in the pusher with your hand to help you attach the rubber cap (Fig. 3).

- 10) Use a small flat blade screwdriver to attach the rubber cap on the plastic collar.

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Fuel Overpressure Safety Valve

Removal, Check, Installation

Tools:

1	HP oil pump	94931	2	Pressure gauge	94934A
2	HP hoses	94935	1	Valve holder	94273
1	Valve Block	94272A			
1	Hydraulic unit (optional)	94942			

1. General

Maintenance of the relief valve (1, Fig. 1) is not usually necessary, but you must do a function check at regular intervals. Refer to the Maintenance Schedule 0380 1 Relief Valve for the frequency to do the function test. Unserviceable relief valves must be sent to the manufacturer, or to a WinGD authorized repair workshop for inspection and repair.

The International Association of Classification Societies (IACS) approval is given for:

- The type of test
- The type of certificate
- The frequency of the test.

The results of the test must be recorded on the Inspection Report.

Note: The two bores (2) identify the relief valve (1) as a new item.

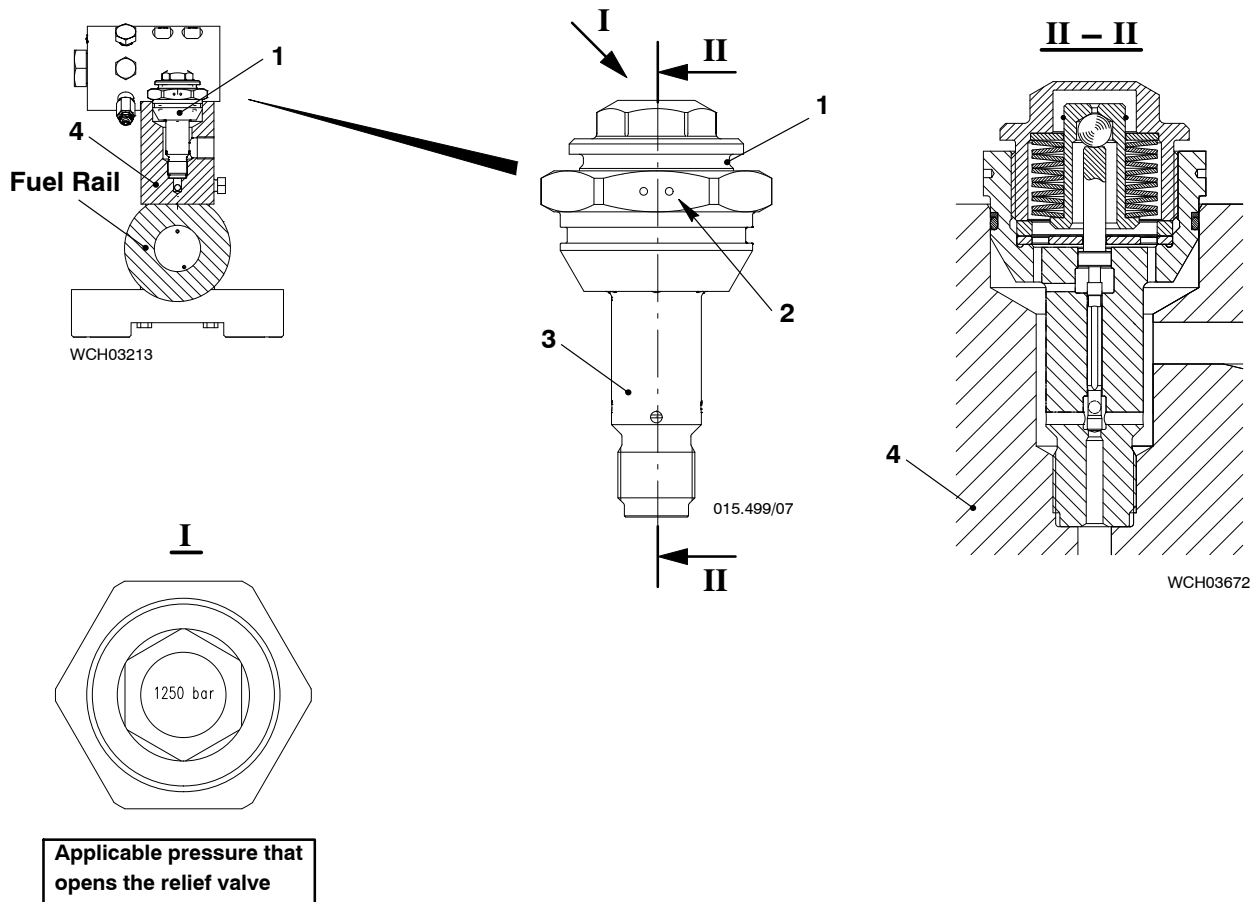


Fig. 1

2. Removal

- 1) Stop the engine (refer to the Operation Manual 0310 1).
- 2) Make sure that the fuel rail has no pressure.
- 3) Use an applicable wrench to remove the relief valve (1) from the connecting piece (4).

3. Relief Valve Test

3.1 Test and Calibration Fluid – Physical Conditions

You use the test bench (94272) and the test and calibration fluid (eg Shell Calibration Fluid S.9365) to do a test of the relief valve. Table 1 gives the mandatory data for the test and calibration fluid.

Table 1

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

3.2 Preparation

Note: Read the data in the instructions from the manufacturer about the specifications of the test bench.

- 1) Put the relief valve (1, Fig. 2) in the valve holder (94272A).
- 2) Tighten the relief valve (1).
- 3) Connect the valve holder (94272A) to the HP oil pump (94931) or the hydraulic unit (94942).
- 4) Close the valve (3).

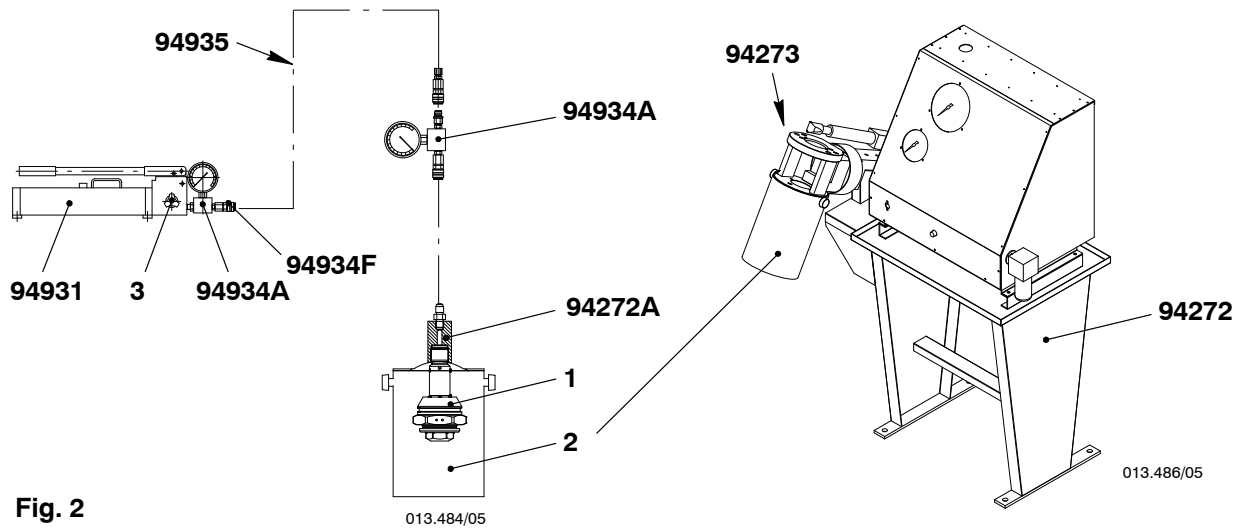
3.3 Sealing Pressure Check

- 1) Operate the HP oil pump (94931) to increase the pressure to 1150 bar.
- 2) Keep the pressure constant for one minute.
- 3) Make sure that there are no leaks.

3.4 Operation Pressure Check

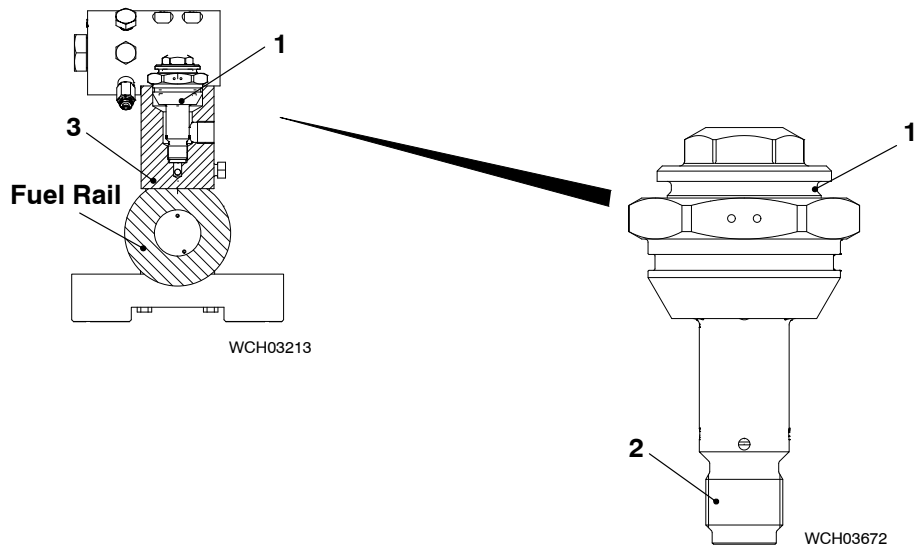
- 1) Operate the HP oil pump to increase the pressure until the relief valve (1) opens.
- 2) Make sure that the relief valve opens at between 1200 bar and 1350 bar (1250 bar +100, 50 bar).
- 3) Operate the valve (3) to release the pressure in the HP hoses (94935).
- 4) Remove the relief valve (1) from the valve holder (94272A).

PCV Relief Valve: Removal, Check, Installation



4. Installation

- 1) Apply Never-Seez NSBT to the thread of valve housing (2, Fig. 3).
- 2) Install the relief valve (1) in the connecting piece (3).
- 3) Torque the relief valve (1) to 300 Nm.



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Flow Limiting Valve

Inspection, Removal and Installation

Tools:

No special tools are necessary

1. General	1
2. Inspection	1
3. Removal	3
4. Installation	4
5. Completion	5

1. General

The engine must be stopped and made safe for maintenance, refer to the Operation Manual, 0310- 1. Only qualified personnel are permitted to do this procedure

2. Inspection

- 1) Make sure that the pressure in the fuel rail is zero.
- 2) Remove the fuel leakage pipe.

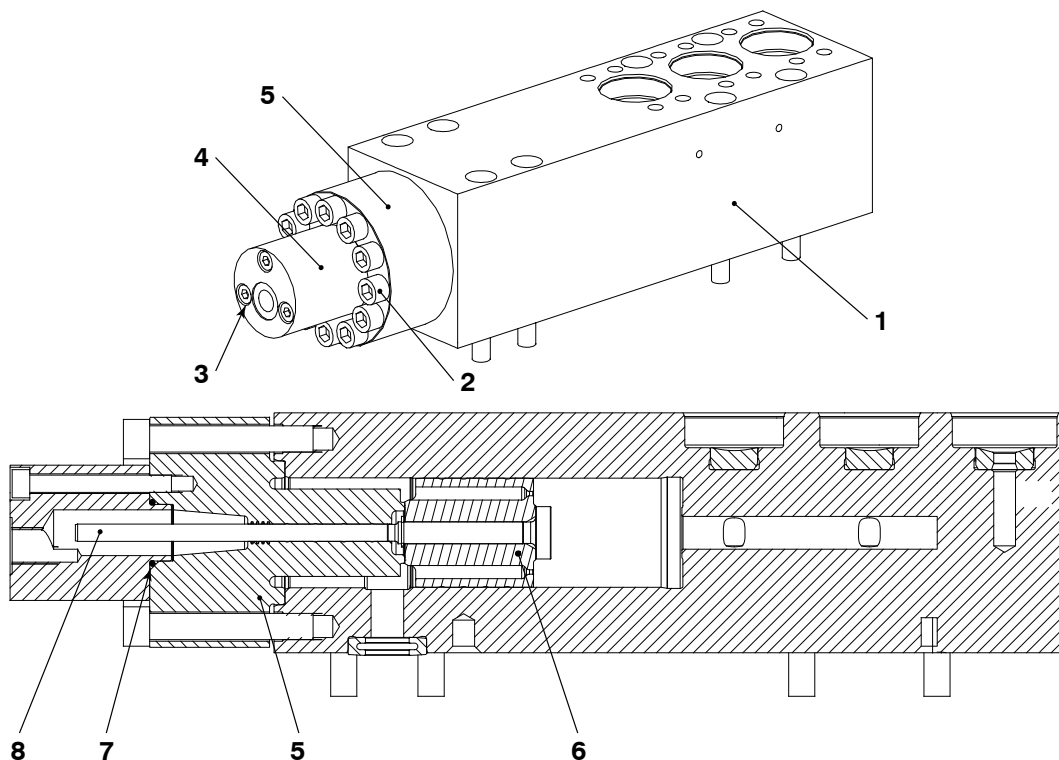


Fig. 1: Flow Limiting Valve

- | | |
|-----------------------|--------------|
| 1 Flow limiting valve | 5 Flange |
| 2 Allen Screws | 6 Piston |
| 3 Allen Screws | 7 O-ring |
| 4 Cover | 8 Piston rod |

Flow Limiting Valve

- 3) Remove the Allen screws (3, [Fig. 1](#)) and the cover (4) from the flange (5).
- 4) Remove and discard the O- ring (7).
- 5) Use Scotchbrite and WD40 or similar to clean the part of the piston rod (8) that you have access to.

Note: You can use an applicable screw at the thread of the hole to hold or move the piston rod (8).

- 6) Move the piston rod (8) into the flow limiting valve (1).
- 7) If you feel resistance because of contamination, pull the piston rod (8) and clean it again.
- 8) If you again feel resistance because of contamination, replace the flange (5) and the piston rod (8) or the complete flow limiting valve (1), refer to section, **Flow limiting valve - Remove**.
- 9) Clean all remaining parts of the flow limiting valve.
- 10) Put oil on the new O- ring (7).
- 11) Replace the new O- ring (7) to the cover (4).
- 12) Attach the cover (4) to the flange (5) with the Allen screws (3).
- 13) Tighten the Allen screws (3).
- 14) Install the fuel leakage pipe.

Flow Limiting Valve

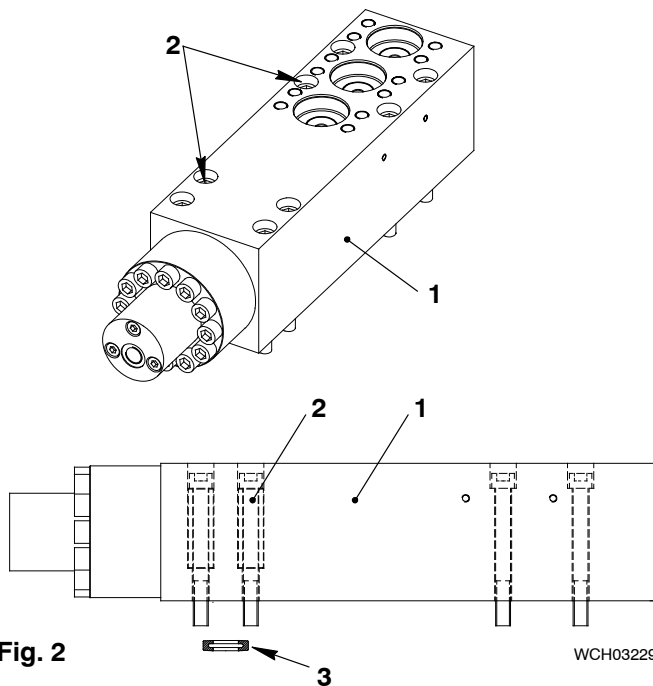


Fig. 2

3. Removal

CAUTION	
	<p>Injury hazard: To prevent injury, use two or more personnel to lift and move the flow limiting valve.</p>

- 1) Make sure that the pressure in the fuel rail is zero.
- 2) Prepare the flow limiting valve (FLV) for removal.
 - a) Clean the work area adjacent to the FLV.
 - b) Remove the HP fuel pipes.
 - c) Remove the leakage pipes.
 - d) Apply protection to the openings on the FLV.
 - e) Apply protection to the open ends of the pipes.

- 3) Remove the bolts (2, Fig. 2) from the FLV.
- 4) Lift the FLV and put it on an applicable clean surface.
- 5) Make sure that the dowel pins stay in the fuel rail.
- 6) Remove and discard the lip seal (3).
- 7) Remove the three bolts (5, Fig. 3) and the cover (4).
 - a) Remove the Allen screws (3) and the cover (4) from the flange (5).
 - b) Remove and discard the O- ring (7).

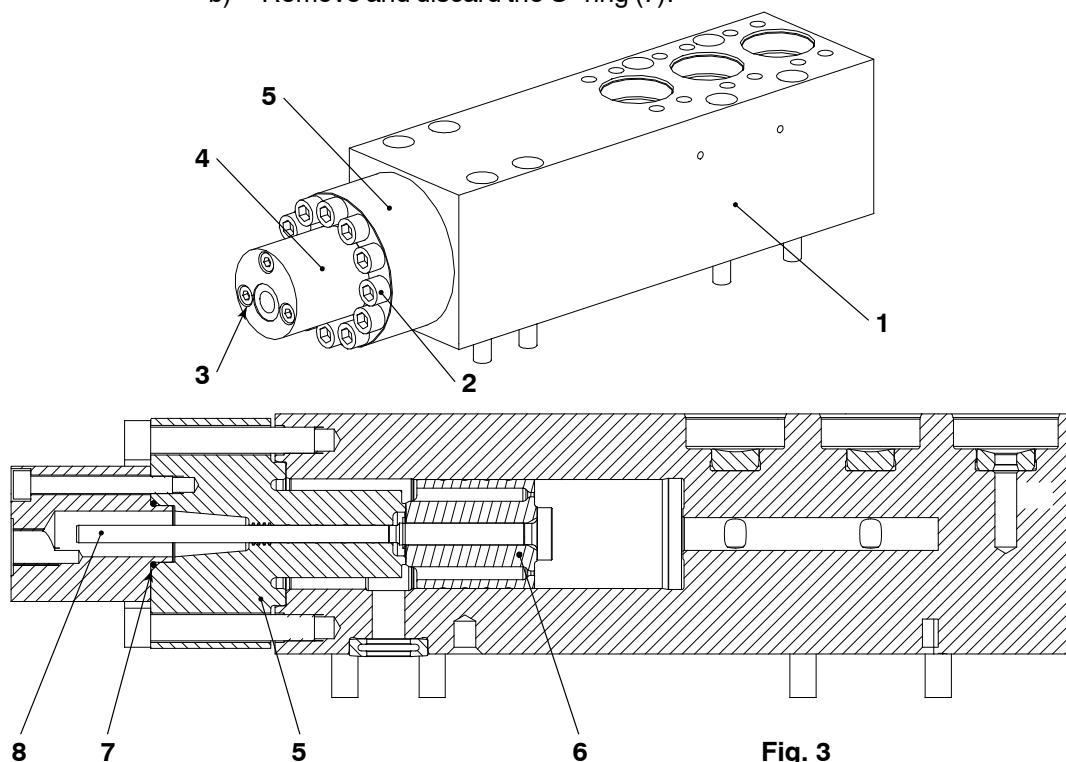


Fig. 3

Flow Limiting Valve

- c) Remove the Allen screws (2).
- d) Remove carefully the flange (5) together with the piston rod (8) and the piston (6).

4. Installation

CAUTION



Injury hazard: To prevent injury, use two or more personnel to lift and move the flow limiting valve.

- 1) If it is necessary to assemble the flange (5, Fig. 3) and the piston rod (8), do as follows:

Note: If possible do this step with the FLV in vertical position.

- a) Clean the sealing surfaces of the flange (5) and of the valve block (1)
- b) Put the flange (5) together with the piston rod (8) and the piston (6) in position on the valve block (1).

Note: Always use the flange (5) and the related piston rod (8) as a pair.

- c) Apply Never Seez NSBT to the threads of the Allen screws (2).
- d) Tighten symmetrically with your hand the Allen screws (2).
- e) Torque symmetrically the Allen screws (2) in two steps to 60 Nm.
- f) Make sure that the piston rod (8) moves freely.
- g) Put oil on the new O- ring (7).
- h) Attach the new O- ring to the cover (4).
- i) Attach the cover (4) to the flange.

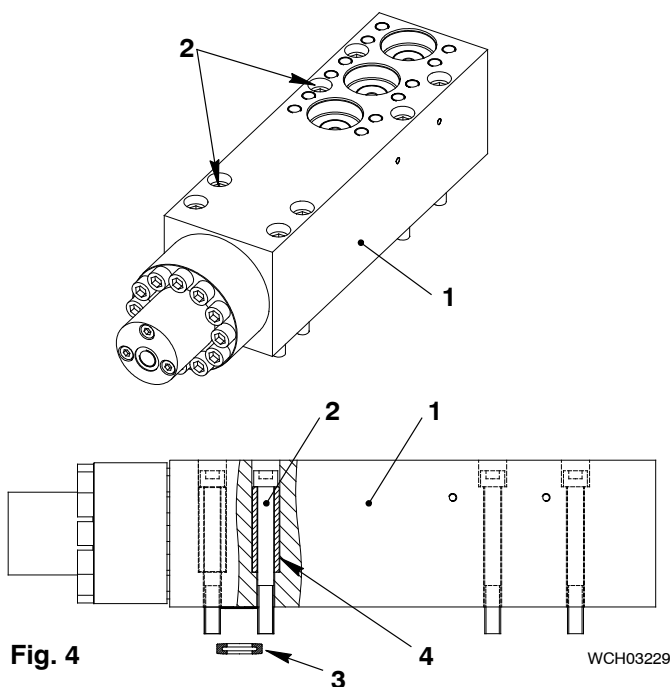


Fig. 4

WCH03229

- 2) Make sure that the dowel pins are in the fuel rail.
- 3) Turn over the valve block (1, Fig. 4)
- 4) Clean the sealing surface in the valve block (1).
- 5) Put the new lip seal (3) into the valve block (1).
- 6) Turn over the valve block (1).
- 7) Clean the seating areas on the valve block (1) and on the fuel rail.
- 8) Apply Never Seez NSBT to the threads and surfaces that touch on the Allen screws (2).
- 9) Make sure that the distance sleeves (4) are in the positions shown.
- 10) Attach the valve block (1) to the fuel rail

Flow Limiting Valve

with the Allen screws (2).

- 11) Torque symmetrically the Allen screws (2) to the correct value, refer to section [0352- 1/A1, Tightening instructions](#).
- 12) If possible, put an applicable device through the hole of the return pipe connection and make sure that the position of the piston rod (8, Fig. 3) is correct.
- 13) Install the leakage pipes (2 and 4, [Fig. 5](#)) to the flow limiting valve (3).

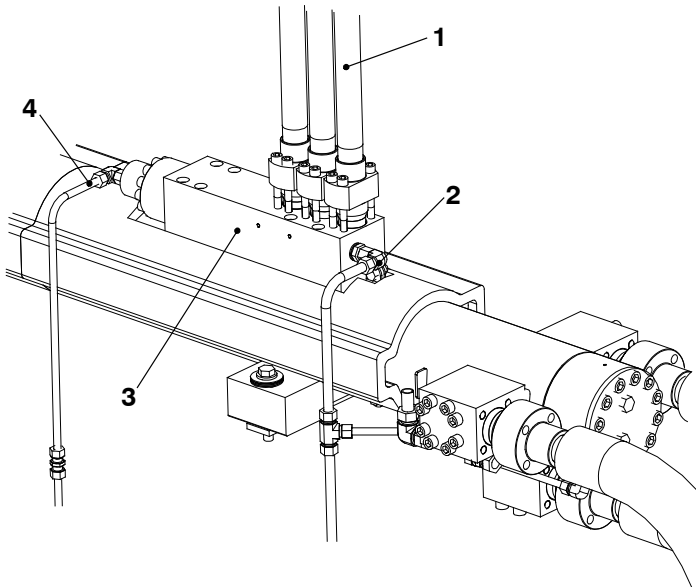


Fig. 5

WCH03227

5. Completion

- 1) Install the HP fuel pipes (1), refer to [8733- 1, paragraph 4](#).
- 2) Operate the engine for a minimum of one hour with marine diesel oil. For more data, refer to the Operation Manual [0510- 1](#).

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Camshaft and Bearing Shells Removal and Installation

Tools:

2	Pre-tensioning jacks	94557	1	Screwjack	94567B
2	Support	94566	1	Connection block	94934
1 or 2	Holder	94566B	1	Pressure gauges	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, paragraph 1 and paragraph 2. As an alternative, lift the rollers (refer to step 3) and step 4).

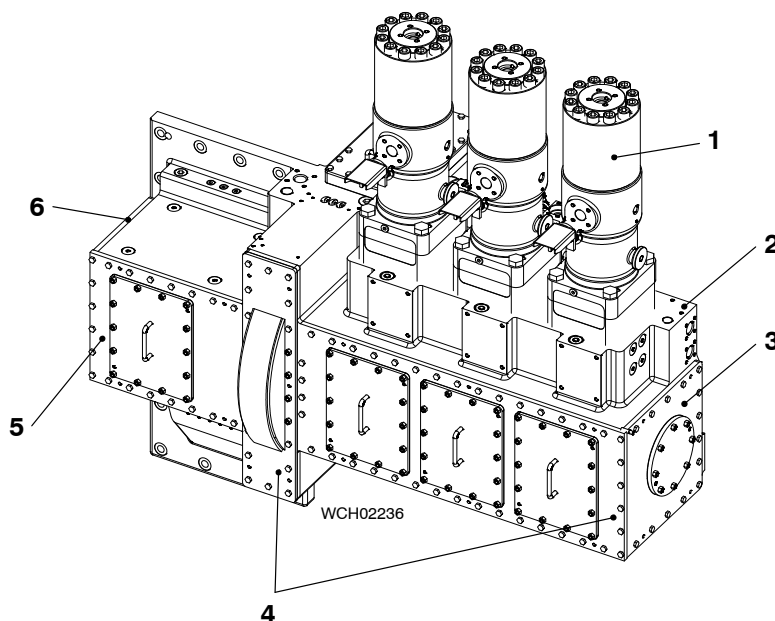


Fig. 1

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, 94566C) to lift the rollers and guide pistons of the fuel pumps.

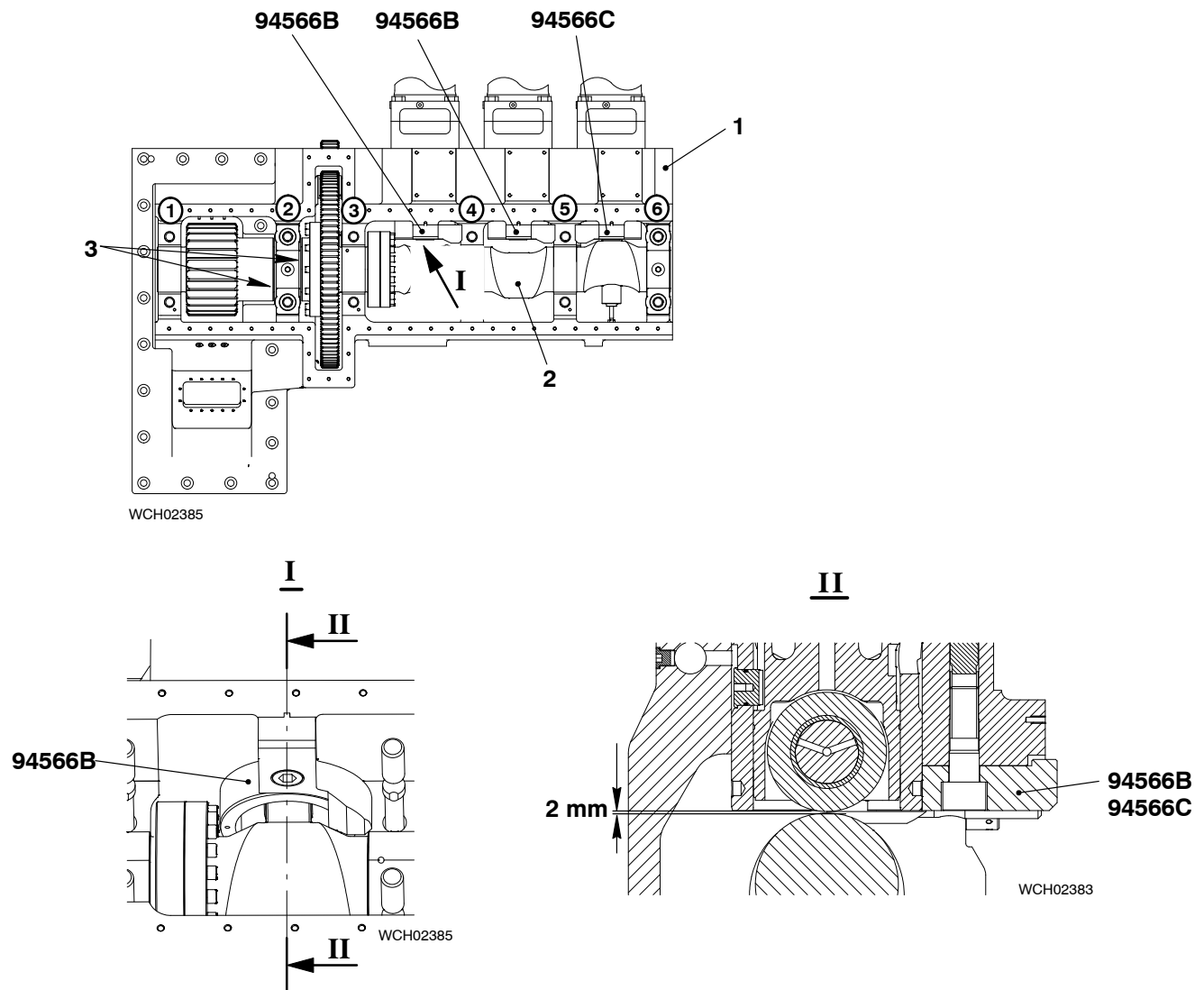
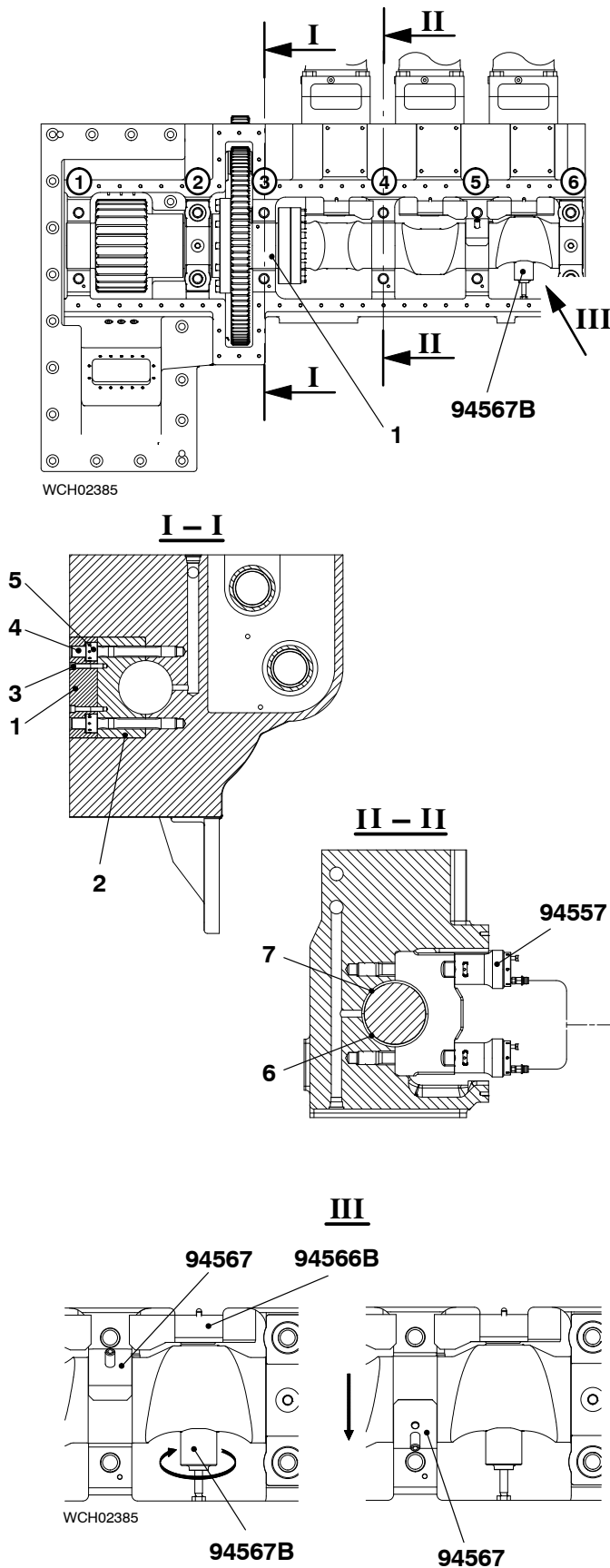


Fig. 2

Camshaft and Bearing Shells Removal and Installation



2. Bearing Shells – Removal

- 1) Loosen the two Allen screws (3, Fig. 3).
 - 2) Remove the filling piece (1) from bearing cover No.3.
 - 3) Use the pre-tensioner (94557) to apply tension to the elastic studs (5) of the bearing covers No.1, No.3, No.4 and No.5, refer to 9403 4.
 - 4) Remove the round nuts (5) and the bearing covers No.1, No.3, No.4 and No.5.
 - 5) Put the screwjack (94567B) in position under the last cam.
 - 6) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm and 0.15 mm.
 - 7) Put the assembly template (94567) in position on the top bearing shell (7) of bearing No.5 (refer to View III).
 - 8) Use the assembly template (94567) to turn the top and bottom bearing shells (6, 7) 90° (refer to View III).
- Note: If you cannot turn the bearing shells, adjust the screwjack (94567B).**
- 9) Hold the top bearing shell (7), then remove the assembly template (94567).
 - 10) Put marks on the top bearing shells to identify their positions. This will help you when you install the bearing shells.
 - 11) Remove the top bearing shell (7).
 - 12) Do step 4) to step 11) to remove the remaining top bearing shells at positions No.3 and No.5.

Fig. 3

Camshaft and Bearing Shells Removal and Installation

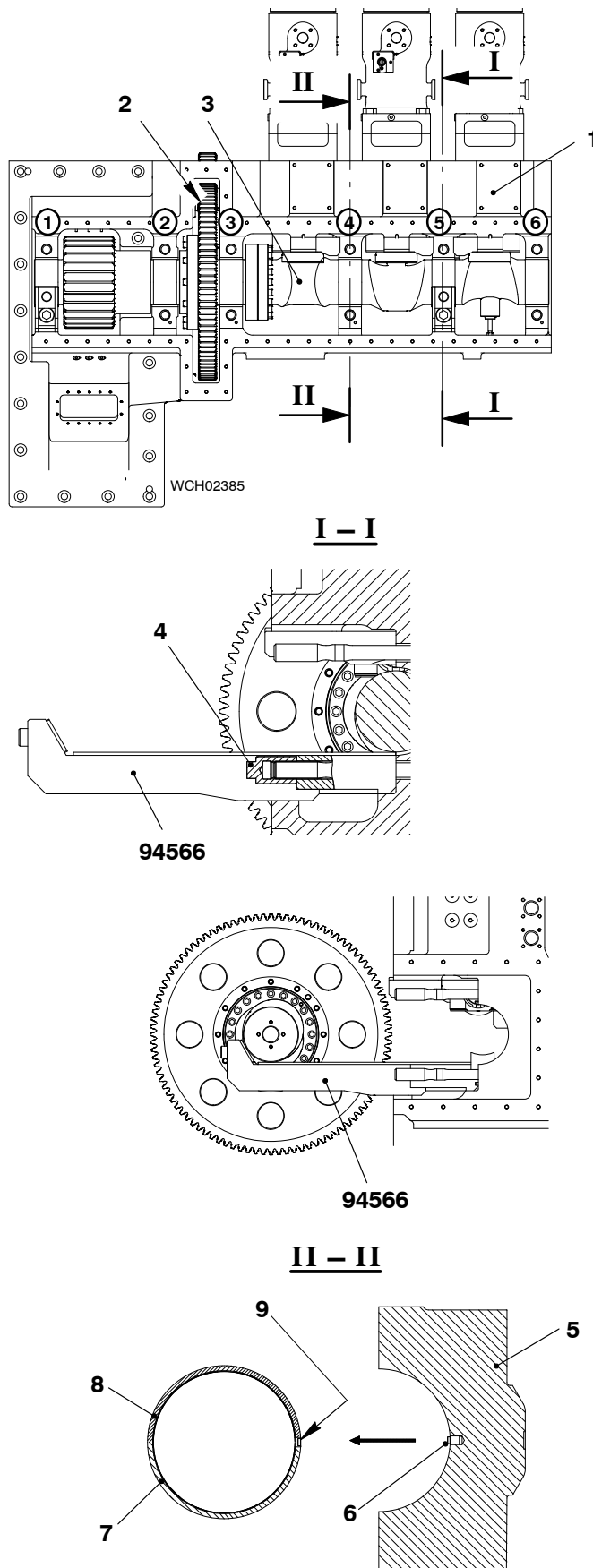


Fig. 4

3. Camshaft – Removal

- 1) Put the two supports (94566) in the positions at No.1 and No.5 (Fig. 4).
- 2) Tighten the nuts (4) on the two supports (94566).
- 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 (refer to the procedure in paragraph 2, step 3) to step 12)).
- 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) Put marks 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

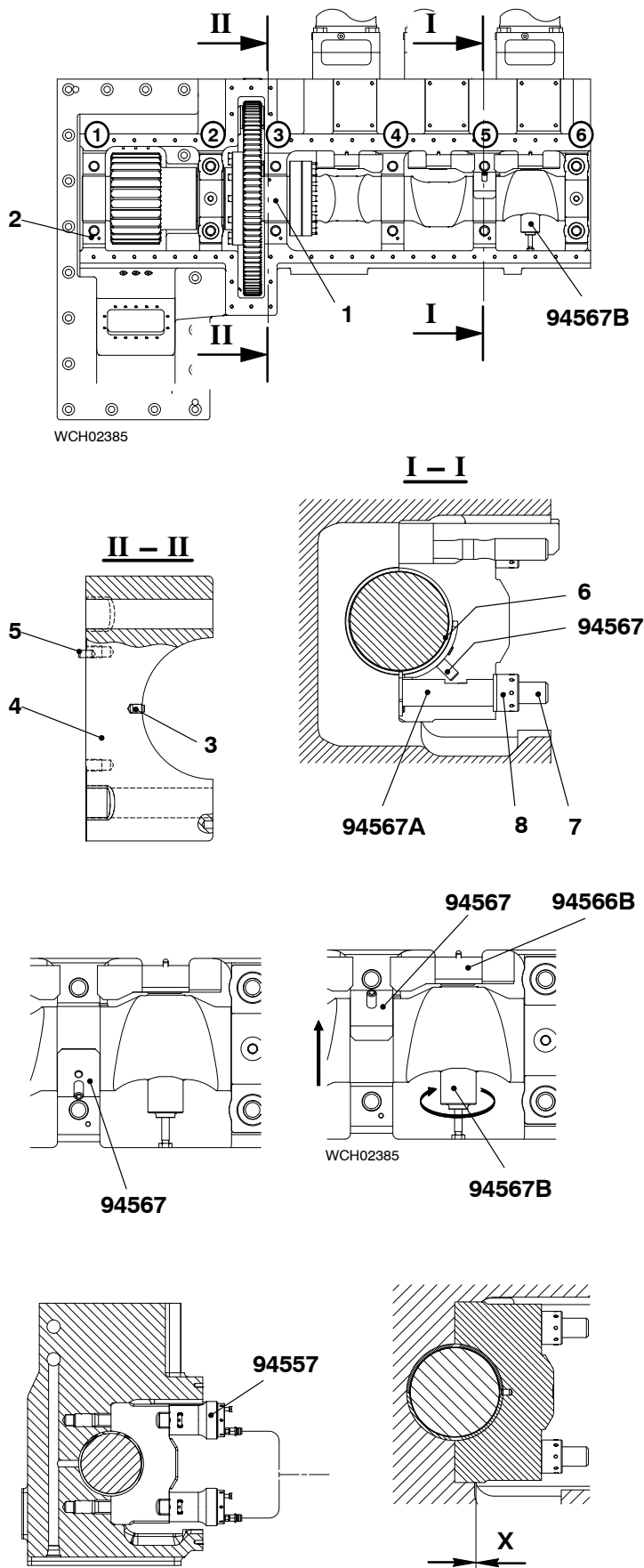



Fig. 5

- 7) Put the screwjack (94567B, Fig. 5) in position.
- 8) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm to 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 get the bearing shell in the center.
- 13) Use the assembly template (94567) to turn the bearing shells (7, 8 Fig. 4) up to 90°.
- 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, 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).
- 20) Tighten the round nuts with your hand.
- 21) Do step 1) to step 19) for the remaining bearing shells.
- 22) Remove the two supports (94566).
- 23) Put the bearing cover (4) that has the dowel pin (5) on to position No. 3.
- 24) Install the tool (94557) on to the elastic bolts (7) (refer to 9403 4).
- 25) Tighten the round nuts (8) to the value specified in 9403 4.
- 26) 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 (refer to paragraph 2, step 3)).
- 3) Put the bearing cover in position again, refer to paragraph 4, step 17) to step 20) and step 23) to step 26).
- 4) Attach the filling piece (1, Fig. 3) to the bearing cover (5) with the two Allen screws (9).
- 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, refer to paragraph 5.
- 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.

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

- 9) Operate the turning gear to turn the engine.
- 10) Make sure that lubricating oil flows to all lubricating points and bearings.

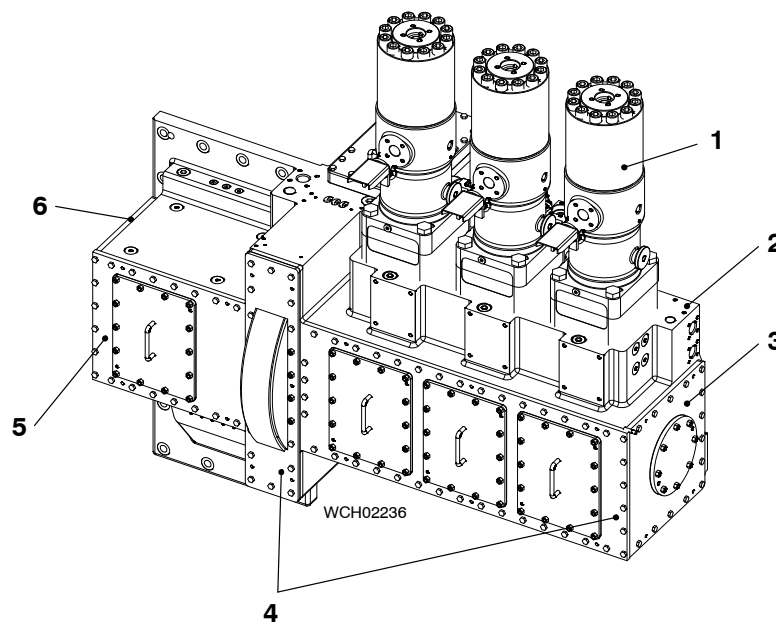


Fig. 6

Fuel Pump Actuator

Connection to Fuel Pump

1. General

The Heinzmann WEA-40 electrical actuator connects to the regulating rack of the high-pressure fuel pump to regulate the fuel flow to the engine and thus the common rail pressure.

Table 1 - Sense of rotation - Engine specific

Engine Type	Sense of Rotation	Input Signal	Order Number
RT-flex50DF	CW	PWM	504-00-100-13
RT-flex68-D	CCW	mA	504-00-100-16
W-X62/DF	CCW	PWM	504-00-100-14
W-X72/DF	CCW	PMW	504-00-100-14
W-X82/DF	CCW	mA	504-00-100-16
W-X92/DF	CW	mA	504-00-100-15

CW - Clockwise rotation

CCW - Counter clockwise rotation

Note: Make sure that the cable glands of the actuator are correctly tightened. Make sure that the gasket on the top cover of the actuator terminal box is in the correct position the bolts are tight. It is imperative that no foreign particles or liquid can enter the actuator.

2. Actuator and Fuel Pump - Align

- 1) Make sure that the actuator is electrically disconnected (Open knife terminals if applicable of corresponding power supply in E85).
- 2) Make sure that the connecting element (1, [Fig 1](#)) is disconnected from the lever (2).
- 3) Put the lever (2) in position on the shaft (3).
- 4) Temporarily tighten the screw (4) on the shaft (3). Move the shaft (3) to get the indicator (5) to the **50%** fuel position. Loosen the screws (4) from the shaft (3).
- 5) Remove the six screws (9), then remove the cover (10).
- 6) Move the toothed rack (6) to get a distance of **48 mm** at each end. The distance between both rack ends must be equal.
- 7) Attach the lever (2) to the connecting element (1) with the screw (8) and the self-locking nut (7). Make sure that the toothed rack (6) stays in position and the indicator (5) position shows **50%**.
- 8) Tighten the screw (4) on the shaft (3).
- 9) Attach the cover (10) to the fuel pump (11) with the six screws (9).

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

Fuel Pump Actuator: Connection to Fuel Pump

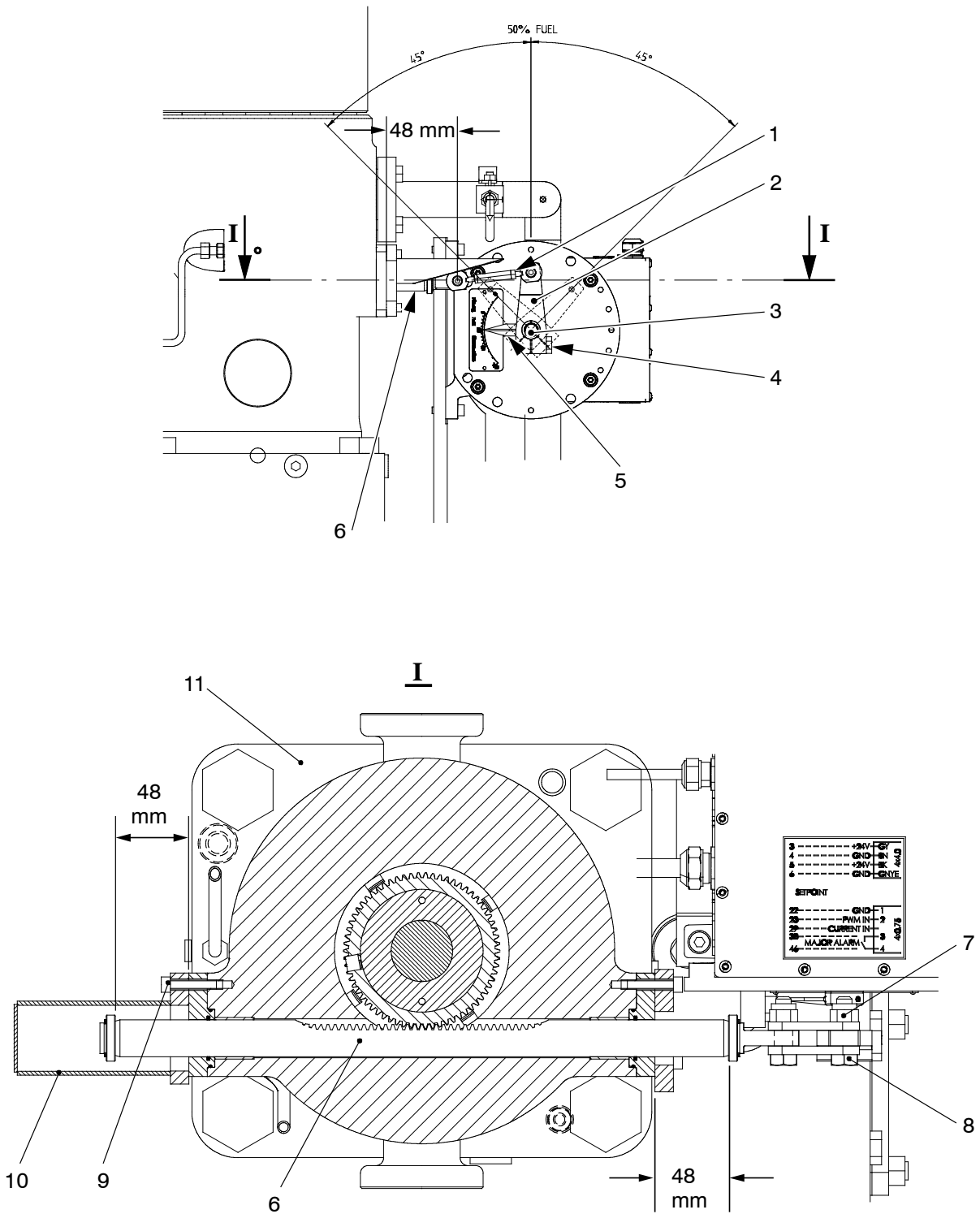


Fig. 1

Fuel Pump Actuator: Connection to Fuel Pump

3. Actuator and Fuel Pump - Calibration

The end position of the actuator are not factory set. Thus, calibration is always necessary after a fuel pump actuator is replaced. Refer [Fig 2](#)

In E85, turn OFF the related power supply.

- 2 Remove the top cover from the actuator terminal box. Make sure no particles or liquid can enter the box.

Put a bridging wire between terminals 6 and 35, (yellow wire 1).

Put a bridging wire between terminals 5 and 43, (red wire 2).

In E85, turn ON the related power supply.

Use an applicable tool to gently push the switch (3). The actuator automatically moves to the maximum and minimum position (self-adjustment).

When movement of the fuel pump actuator stops, continue to the next step.

In E85, turn OFF the related power supply.

Remove the two bridging wires attached in step 3 and 4 above.

- 0 Attach the top cover, including sealing gasket to the actuator terminal box and tighten the screws properly.

Make sure that the cable glands are tight.

- 2 In E85, turn ON the related power supply.

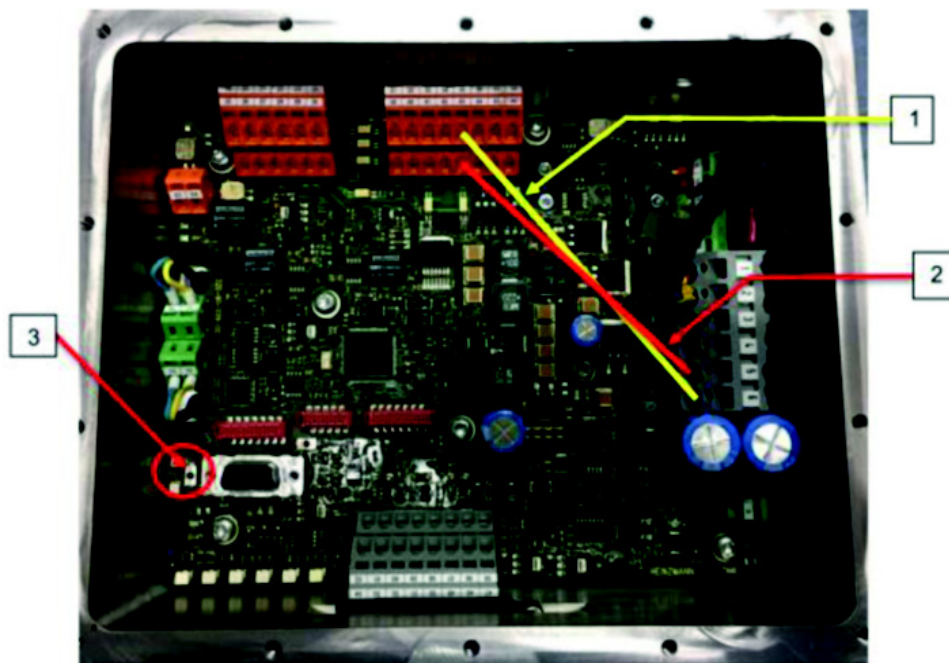


Fig. 2

Faults in High Pressure Fuel System

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1.2	Causes	1
1.3	Procedure	1

1. Defective Fuel Pump Actuator

1.1 Fault Identification

If an actuator becomes defective, its output stays the same or changes slowly to zero supply. The toothed rack does not change when the load changes.

A failure message shows in the ECS (see [4002-2](#), paragraph 3.15 Log Messages).

The fuel pumps stay in their last position when no control signal is received.

At high engine load, the remaining serviceable fuel pump actuators control the fuel quantity.

At low engine load, the pressure control valve (PCV) 10-5562_E0_5 controls the fuel pressure control function.

Note: The fuel quantity released from the pressure control valve flows into the fuel return.

Operation with these control functions must be prevented if possible, or kept for only a short time (see [5562-1](#) Pressure Control Valve).

If there is an overpressure in the HP fuel system (i.e. the PCV becomes defective), the pressure relief valve (which is part of the PCV) opens and the level switch LS3426A activates an alarm.

1.2 Causes

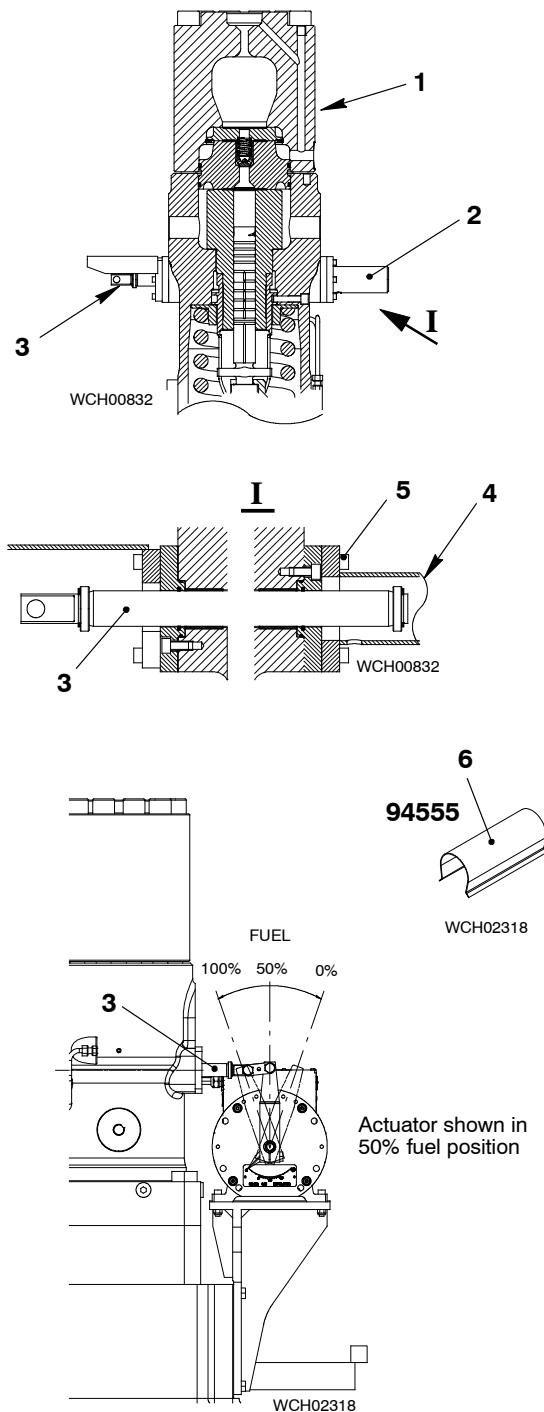
The causes of a defective fuel pump actuator are as follows:

- Electrical interference (defective cable connections, broken cable etc.).
- A fuel pump actuator is defective, triggers an alarm.

1.3 Procedure

- 1) Connect the correct cable connections between the related CCM-20 and the fuel pump actuator as soon as possible.

Faults in High Pressure Fuel System



1.3.1 One Actuator is Defective- 0% F.O delivery

- 1) Do a check of the control signals from the ECS and the electrical cables. If necessary, replace the electrical cables.
- 2) Disconnect the electrical cable from the actuator.
- 3) Make sure that the toothed rack (3) moves freely (see Fig. 1).
- 4) Move the toothed rack (3) to the 0% fuel position.
- 5) Install two distance pieces (6, tool 94555) to the toothed rack (3) on the fuel pump (1) that has the defective actuator.
- 6) Replace the defective actuator as soon as possible.

1.3.2 One Actuator is Defective- 50% or 100% F.O delivery

- 1) If different power outputs are necessary, lock the actuator in other positions (**50% fuel, or 100% fuel**) see step 3 to step 4.
- 2) Remove the six screws from the cover (2) then remove the cover.
- 3) For 50% fuel, do steps a) and step b):
 - a) Move the toothed rack (3) to the 50% fuel position.
 - b) Install one distance piece (6) on each end of the toothed rack (3).
- 4) For 100% fuel, do step a) and step b):
 - a) Move the toothed rack to the 100% fuel position.
 - b) Install two distance pieces (6) on the toothed rack.

Note: Fuel pressure control through the PCV must be prevented if possible.

Fig. 1: Fuel Pump Actuator

1.3.3 All Actuators are Defective

- 1) To install the distance pieces (6, [Fig. 1](#)) to the toothed racks (3), see steps [a\)](#) and [b\)](#):
 - a) For engines with two fuel pumps, install the distance pieces (6) to get:
 - One fuel pump in the 0% fuel position and the other fuel pump in the 100% position.
 - b) For engines with three fuel pumps, install the distance pieces (6) to get:
 - One of the fuel pumps in the 0% fuel position and the other two fuel pumps in the 100% position.

Note: For higher loads, set more fuel pumps to the 100% position.

If the distance pieces tools are not available on board, the tools can be made easily. Length of the bracket 72 mm, Diameter 25 mm see [Fig 2](#).

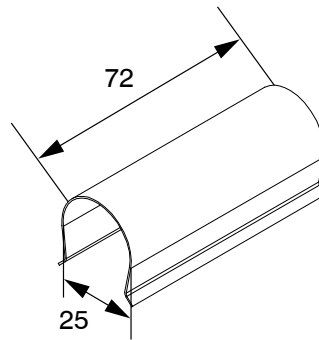


Fig. 2: Distance piece

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Servo Pump Unit

Servo Oil Pump Removal and Installation

Tools:

2 Sling 94202K

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2.	Checks	1
2.1	Servo Oil Pump	1
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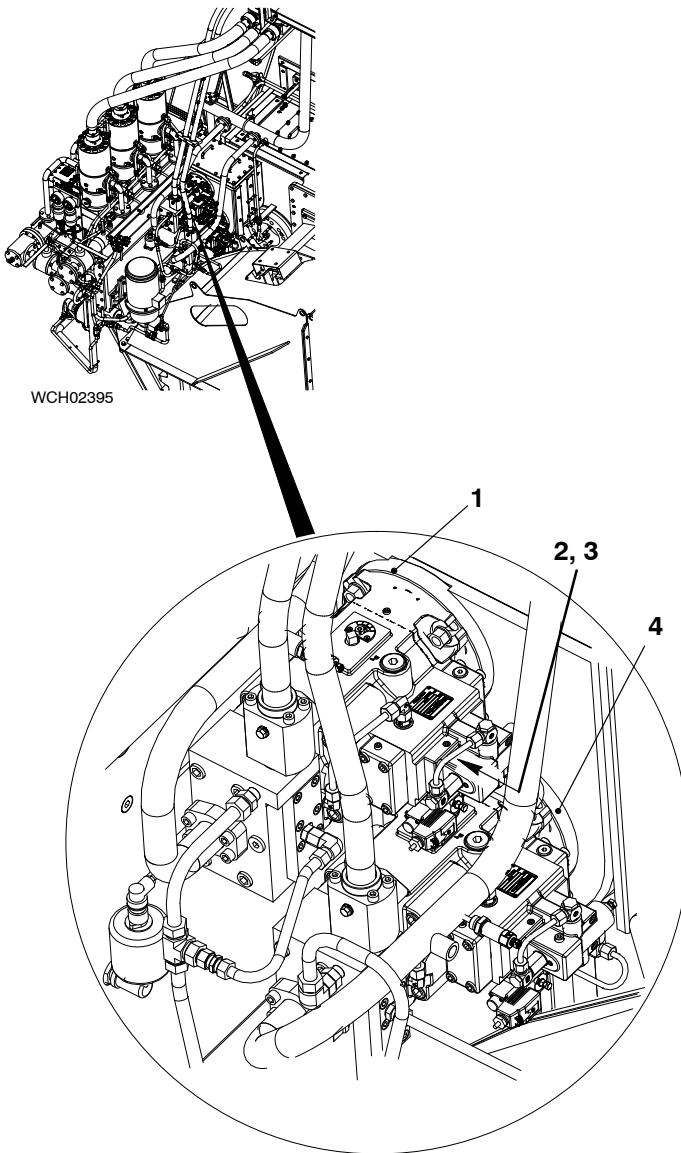


Fig. 1

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 Oil Pump](#) and [Servo Oil Pump Drive](#).

For more data, refer to 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)

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).

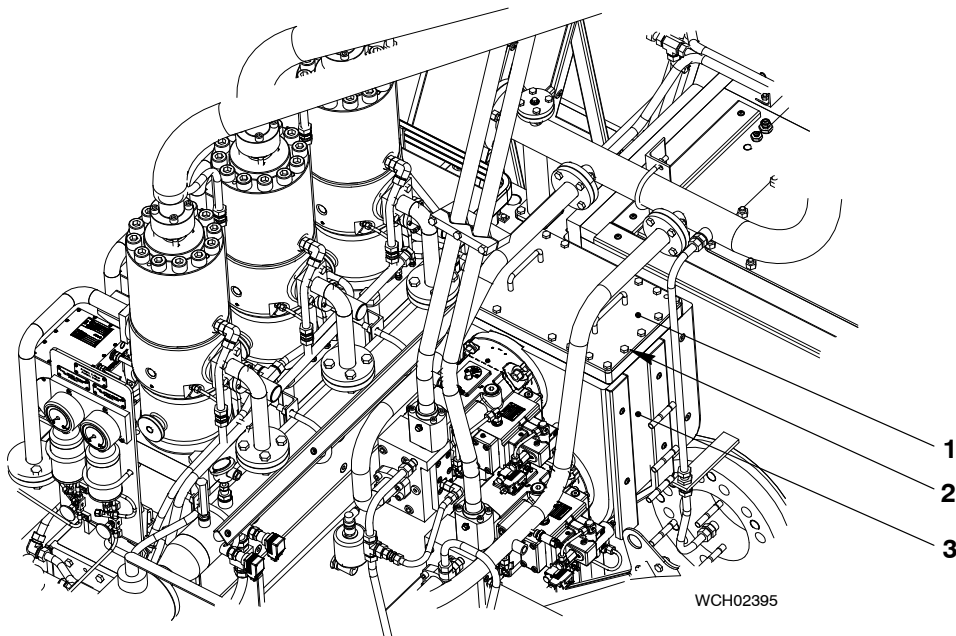


Fig. 2

- 3) Do a check of the pinions (1, and 2 Fig. 3) and the camshaft gear wheel (3) for wear and damage (refer to 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) to the supply unit casing (3) with the 20 screws (2).

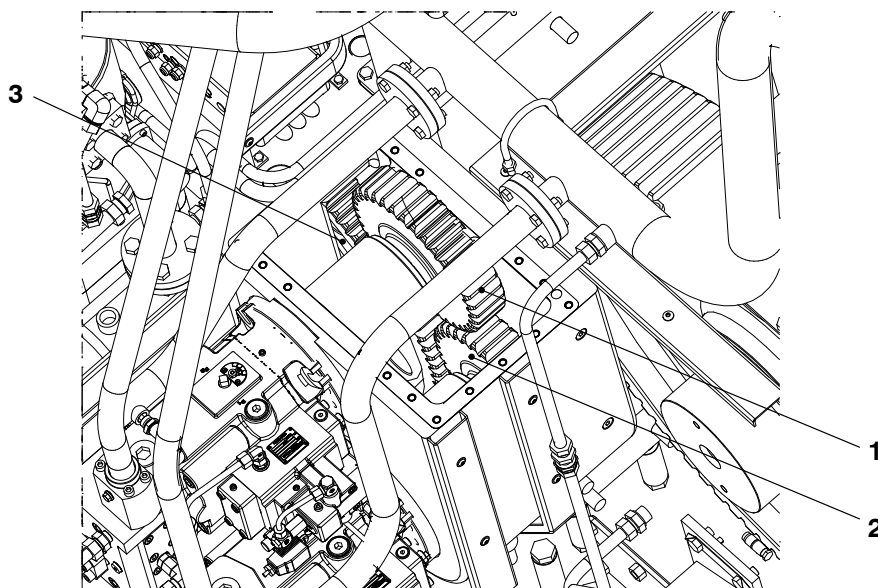


Fig. 3

3. Servo Oil Pump – Removal

3.1 Preparation

- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 2) Set to off the main bearing oil pump.
- 3) Remove the HP servo oil pipes (12, Fig. 4) (refer to 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) (refer to 8752-1).
 - b) Remove the two HP fuel pipes from the fuel pumps (refer to 8752-1).
- 5) Disconnect the electrical connections (7).

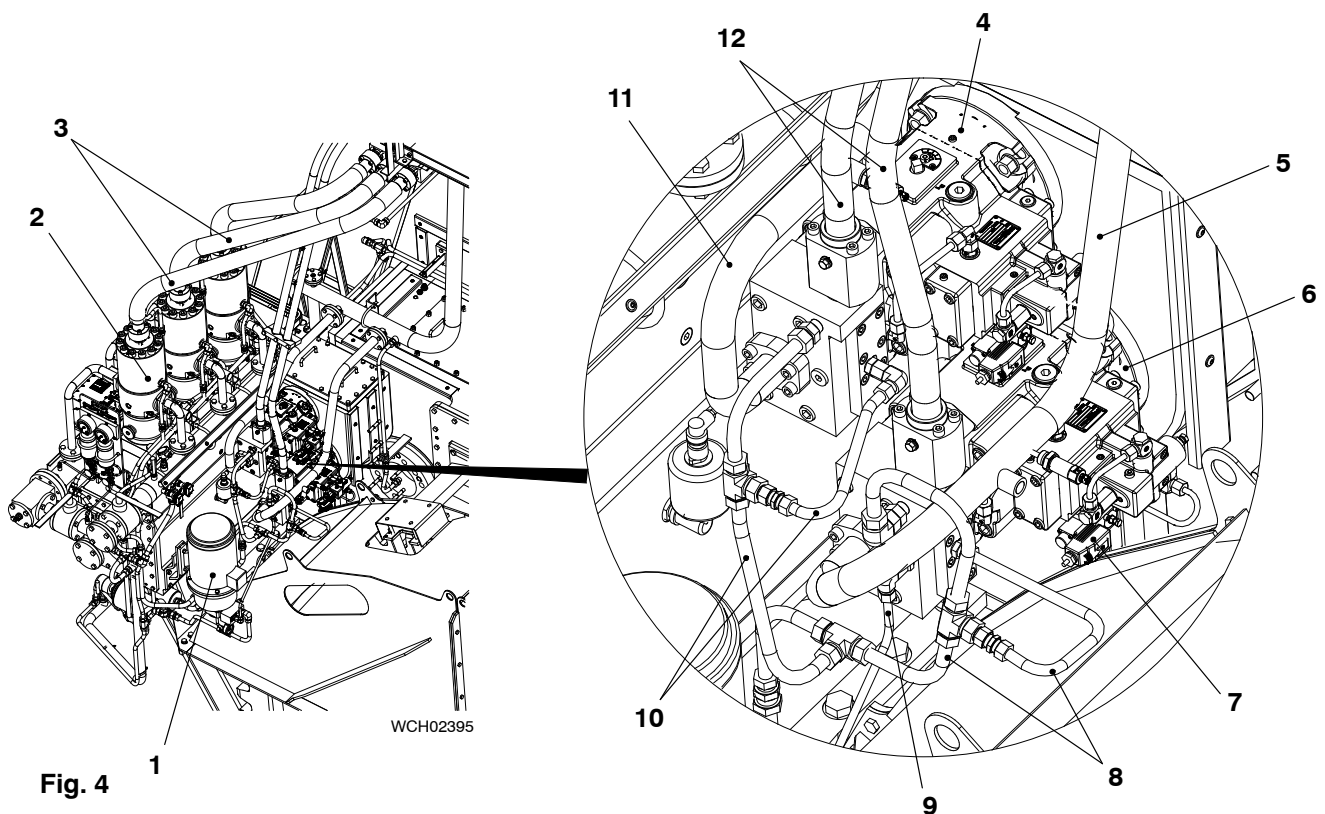


Fig. 4

- 6) Remove the drain pipes (8, 10).
- 7) Remove the inlet pipes (5, 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).

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.

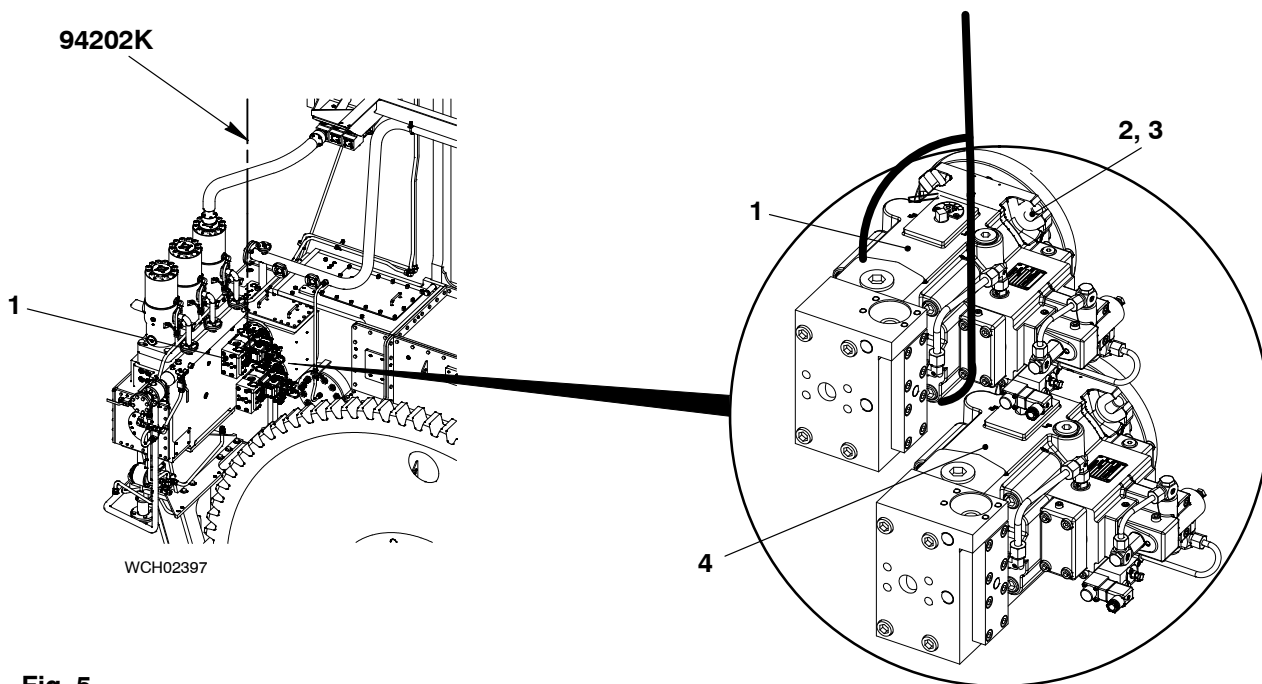


Fig. 5

- 2) Attach the sling (94202K) to the engine room crane.
- 3) Operate the engine room crane and put sufficient tension on the sling (94202K) 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

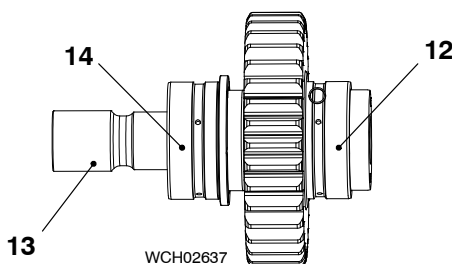
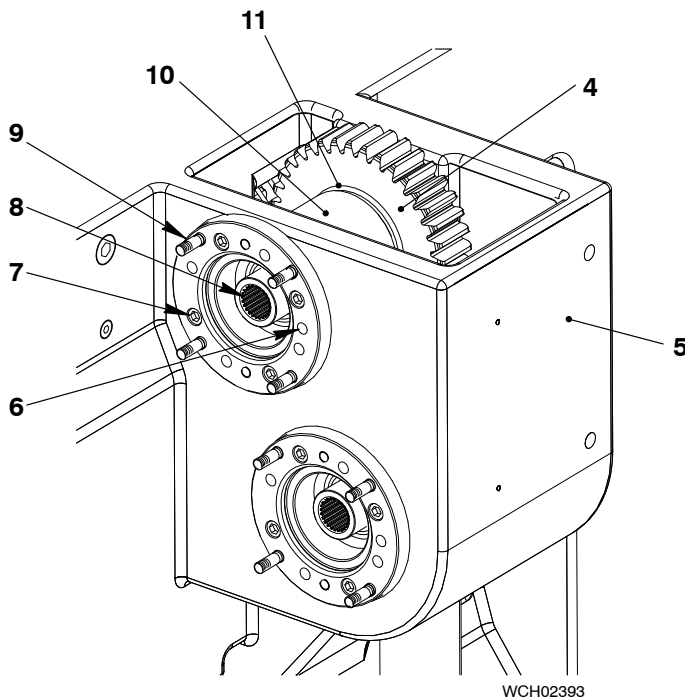
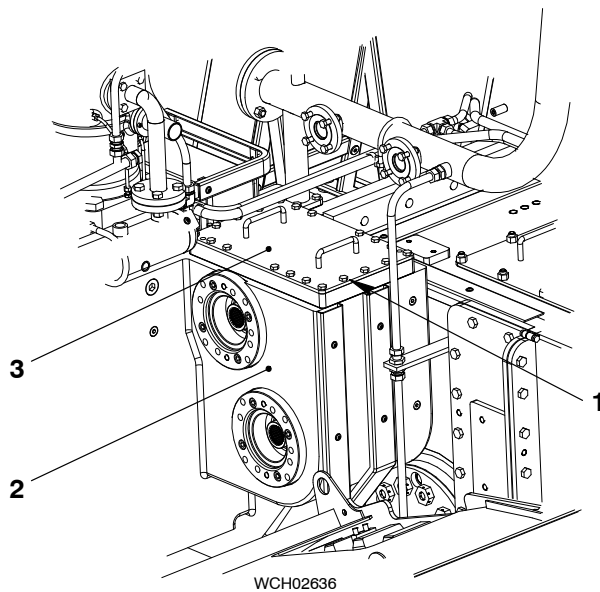


Fig. 6

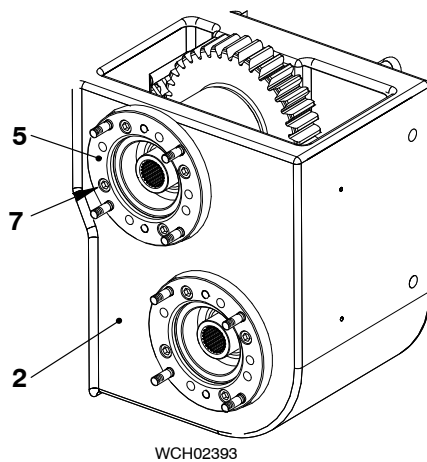
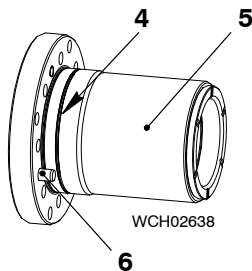
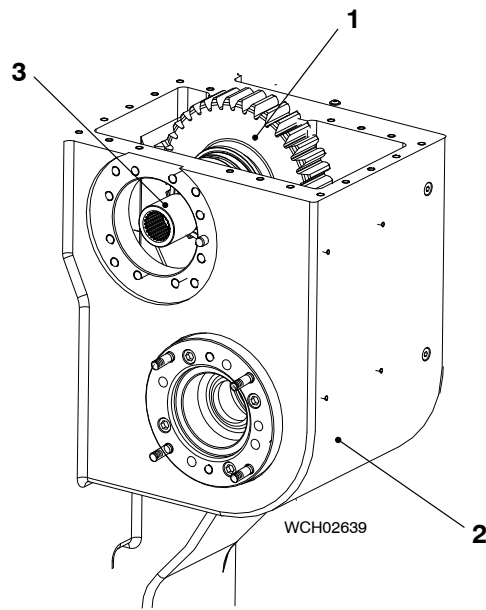
3.3 Bearing Bushes

CAUTION	
	<p>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.</p>

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 (7).
- 4) Move the pump support (10) a small distance away from the casing (5).
- 5) Put the sling (94202K) around the shaft (11) two times.
- 6) Attach the sling (94202K) to the engine room crane.
- 7) Put sufficient tension on the sling (94202K) to hold the the shaft (11) and pinion (4) in position.
- 8) Remove the pump support (10) and the O ring.
- 9) Carefully move the pinion (4) and shaft (11), in the direction of the driving end, approximately 30 mm out of the casing (5).
- 10) Put one more sling (94202K) around the pinion (4) and shaft (11).
- 11) Attach the sling (94202K) to the engine room crane.
- 12) Make sure that the two slings (94202K) have equal tension.
- 13) Carefully tilt the pinion (4) and shaft (11).
- 14) Carefully lift the pinion (4) and shaft (11) fully out of the casing (5).
- 15) Lower the pinion (4) and shaft (11) to an applicable area.
- 16) Examine the two bearing bushes (12, 14) for wear and damage.
- 17) If necessary, replace the bearing bushes (12, 14).

Servo Oil Pump Removal and Installation



- 18) Put oil on the two bearing bushes (12 and 14, Fig. 6) and the shaft (13) of the pinion.
- 19) Use the engine room crane and the two slings (94202K) to lift the pinion (1, Fig. 7) and shaft (3) into position above the casing (2).
- 20) Carefully tilt the pinion (1) and shaft (3), then lower the pinion and shaft into the casing (2).
- 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 (3).
- 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 (3).
- 26) Do the procedures given in step 3) to step 25) 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).

Fig. 7

4. Servo Oil Pump – Installation

CAUTION



Injury Hazard: The weight of the servo oil pump is 116 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. 8) in the pump support.
- 2) Apply a small quantity of oil to the the O-ring (1).

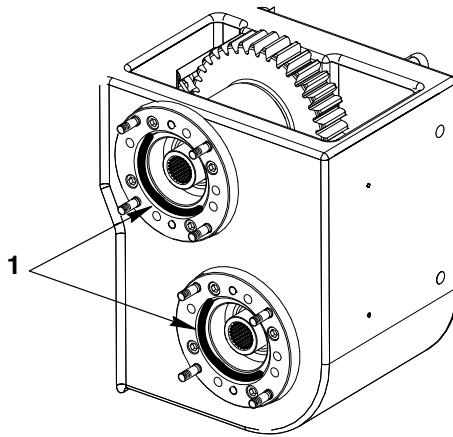


Fig. 8

WCH02393

- 3) Put the sling (94202K, Fig 9) 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).

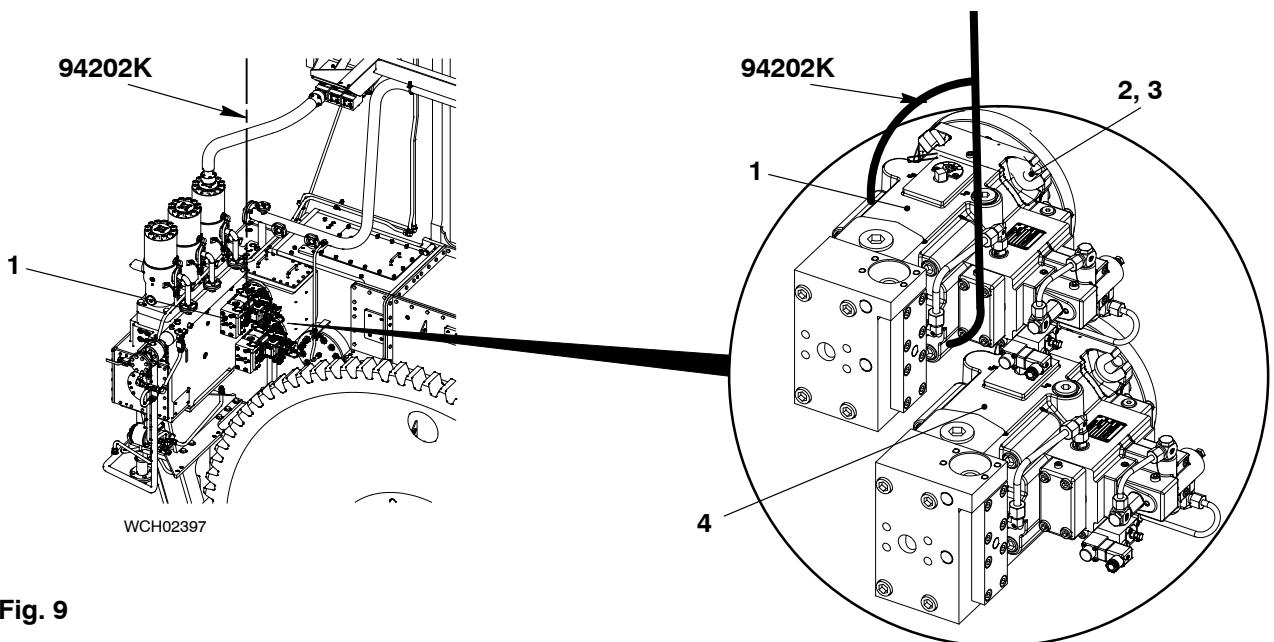


Fig. 9

WCH02397

- 7) Remove the sling (94202K) from the servo oil pump (4).
- 8) Do step 1) to step 7) to install the servo oil pump (1).

5. Completion

- 1) Attach the oil inlet pipes (5, 11 Fig. 10) to the servo oil pumps (4, 6).

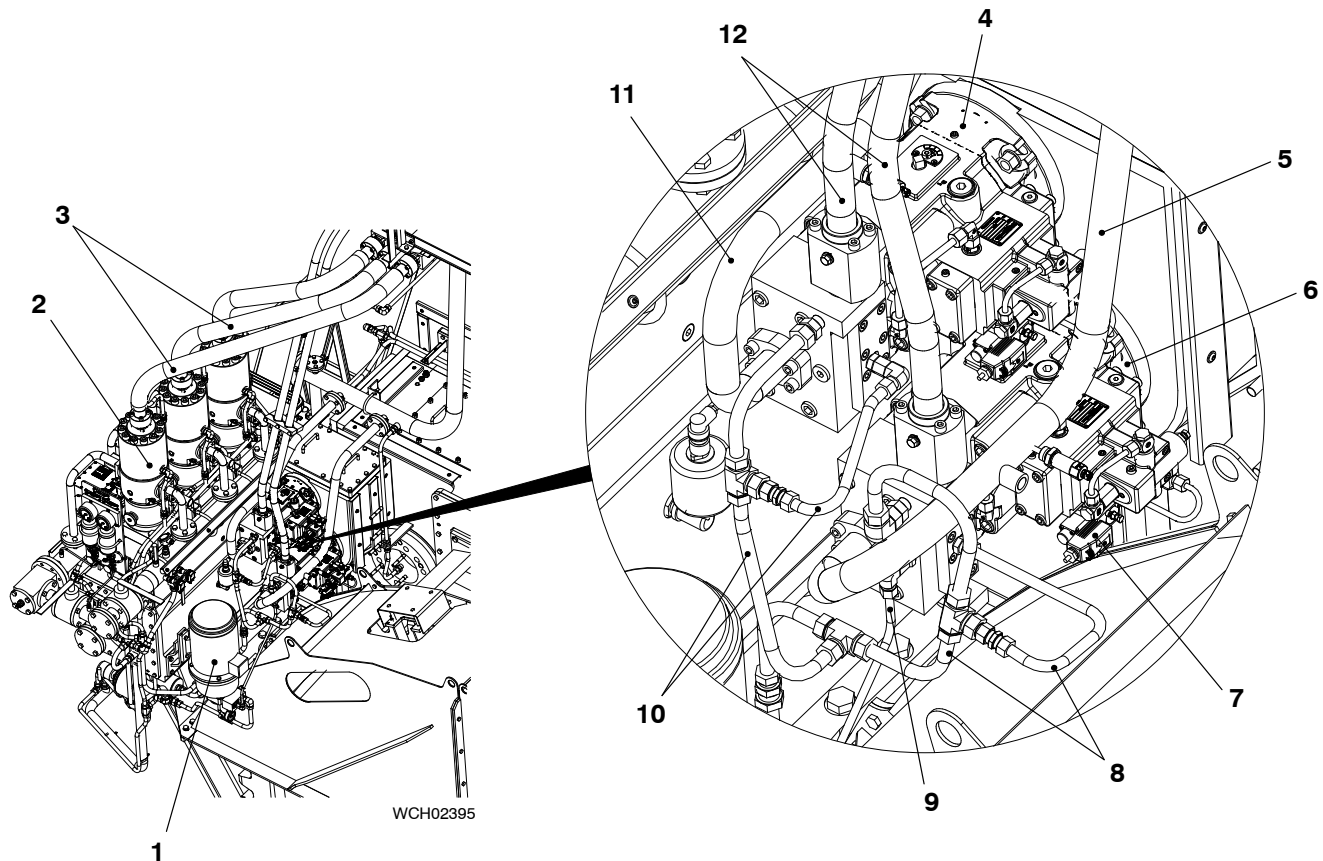


Fig. 10

- 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) (refer to 8447 1, paragraph 5).
- 5) Attach the two rear HP fuel pipes (3) to the fuel pumps (2) (refer to 8752 1, paragraph 4)
- 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).

Servo Oil Rail

Exhaust Valve Control Unit – Pilot valve : Removal and Installation

1. General	1
2. Preparation	1
3. Removal and Installation	2
4. Completion	2

1. General

The pilot valve for each VCU for cylinder can be replaced individually.

2. Preparation

- 1) Stop the engine, refer to 0310-1.
- 2) Release the pressure in the servo oil rail, refer the Operation Manual 0520-1 paragraph 2.3.
- 3) Remove the applicable hydraulic pipe, refer to 8460-1, paragraph 1 and paragraph 2.

Exhaust Valve Control Unit - Pilot valve: Removal and installation

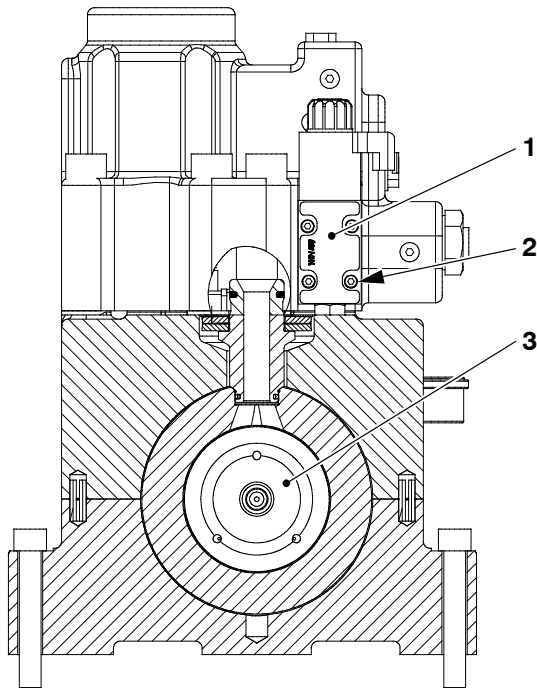


Fig. 1

3. Removal and installation

- 1) Make sure that the servo oil rail (3, Fig. 1) has no pressure.
- 2) Disconnect the electrical connection from the pilot valve (1).
- 3) Replace and install the new pilot valve, and make sure that O-ring are in the correct position.
- 4) Tighten the pilot valve screws (2) at 9 Nm.
- 5) Connect the electrical connection from the pilot valve (1).

4. Completion

- 1) Install the hydraulic pipe, refer to 8460-1, paragraph 4.
- 2) Put the replaced VCU in its original package.
- 3) Close any drain for servo oil rail.
- 4) Start the service pump.
- 5) Check for any leakages from the pilot valve.
- 6) Stop the service pump.

Scavenge Air Receiver and Auxiliary Blower

Group 6

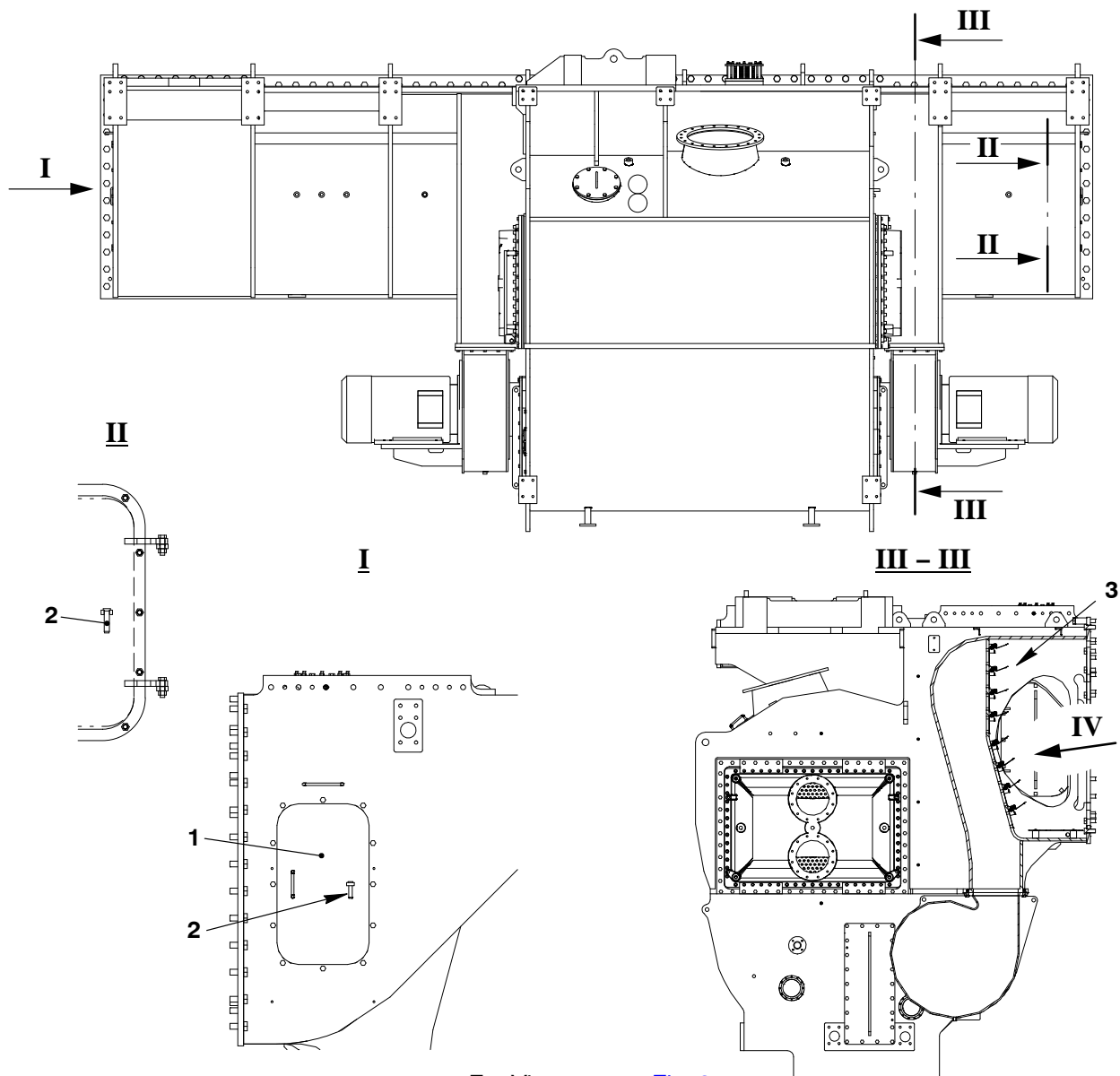
Scavenge Air Receiver – Clean and do Checks	6420-1/A1
Auxiliary Blower – Removal and Installation	6545-1/A1
Scavenge Air Cooler – Removal and Installation	6606-1/A1
Scavenge Air Cooler – Cleaning instructions	6606-1/A2
Water Separator – Removal and Installation	6708-1/A1

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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



For View IV, see [Fig. 3](#)

Fig. 1: Scavenge Air Receiver

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 the open position with the pins (2) to prevent unwanted movement.
- 3) Clean the scavenge air receiver.
- 4) Do the checks that follow:
 - a) At regular intervals, look at the sight glasses (6, [Fig. 2](#)) to make sure that water flows through the pipes.
 - b) If necessary clean the filters (1), the plates (2, 5) and the drain pipes (3, 4). For more data, refer to the Operation Manual 8345-1.
 - c) Do a check of the flaps (3, [Fig. 1](#)) for damage, free movement and dirt. If necessary, clean or replace the flaps (see paragraph [2](#)).

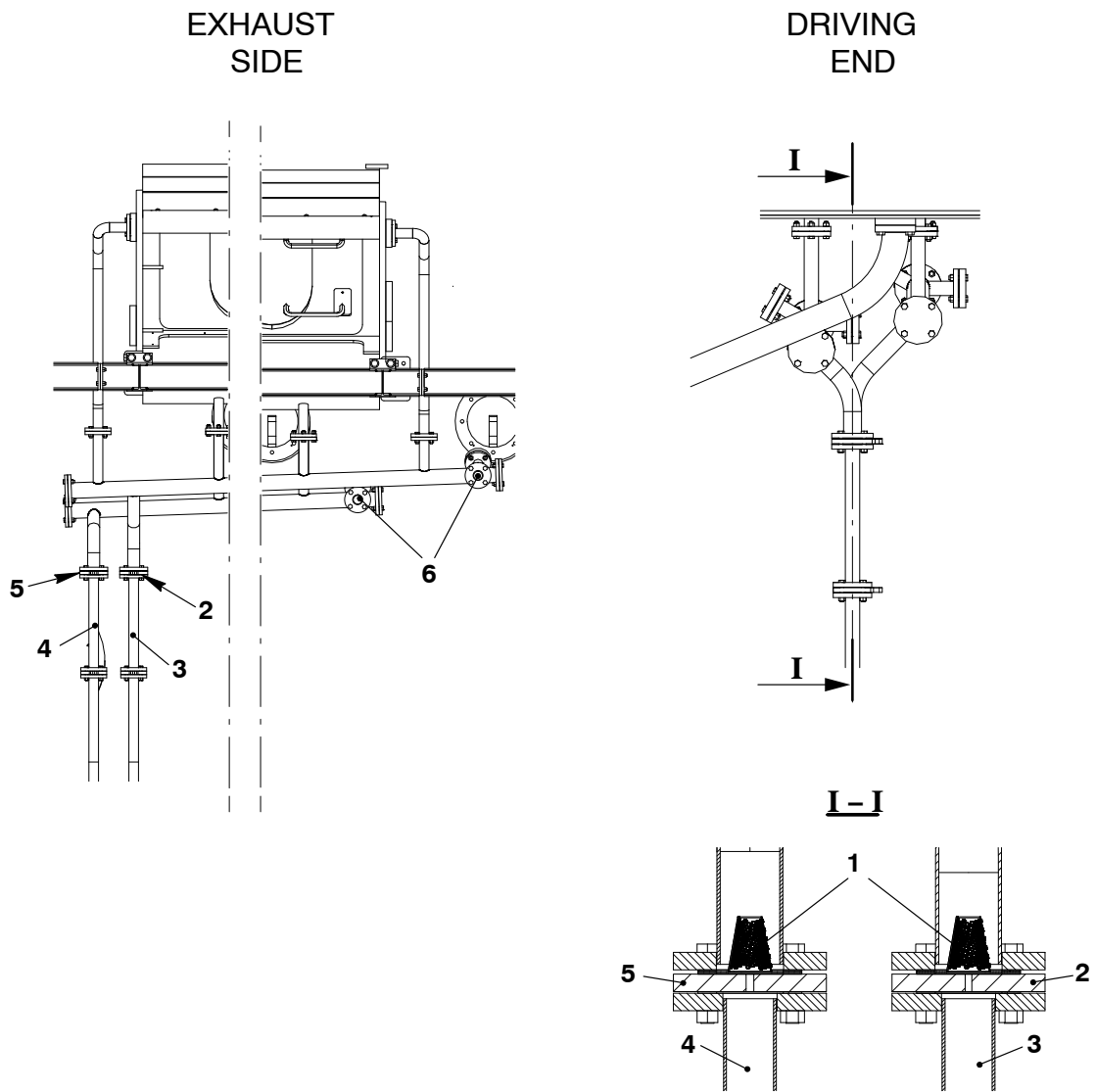


Fig. 2

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), spacer (8), flap (5) and axle (1).

2.2 Installation

- 1) Put the axle (1), spacer (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).

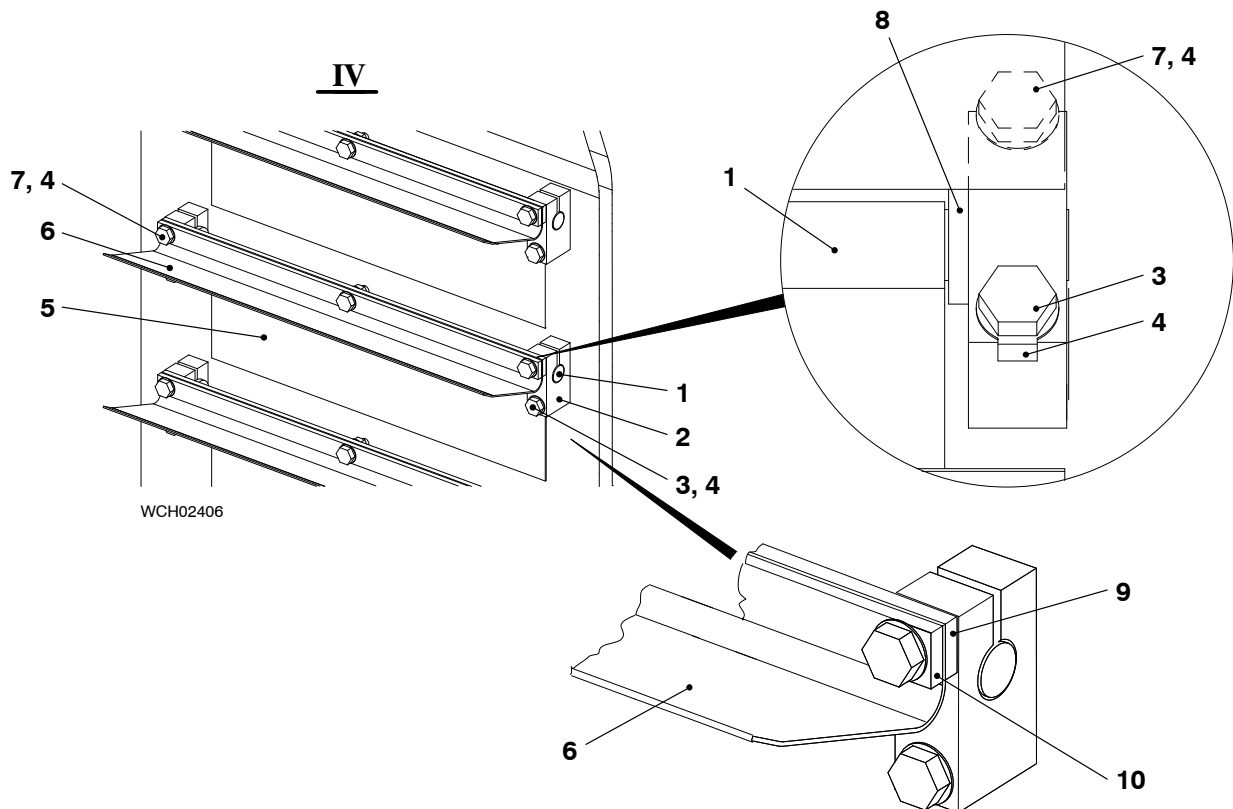


Fig. 3: Flaps

- 7) Remove the pins (2, Fig. 1).
- 8) Close the covers (1).
- 9) Install the pin (2) in the stowage position.

3. Relief Valve – Check

WARNING	
	Injury Hazard! Do not disassemble the relief valve. Parts can eject at high speed and cause injury.

Note: If there is damage or a malfunction, speak to the manufacturer of the relief valve or to WinGD.

- 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), ie the O-ring (5) is serviceable.
 - c) Make sure that the distance X is 133 mm, ie the pressure of the disc springs (2) is sufficient.

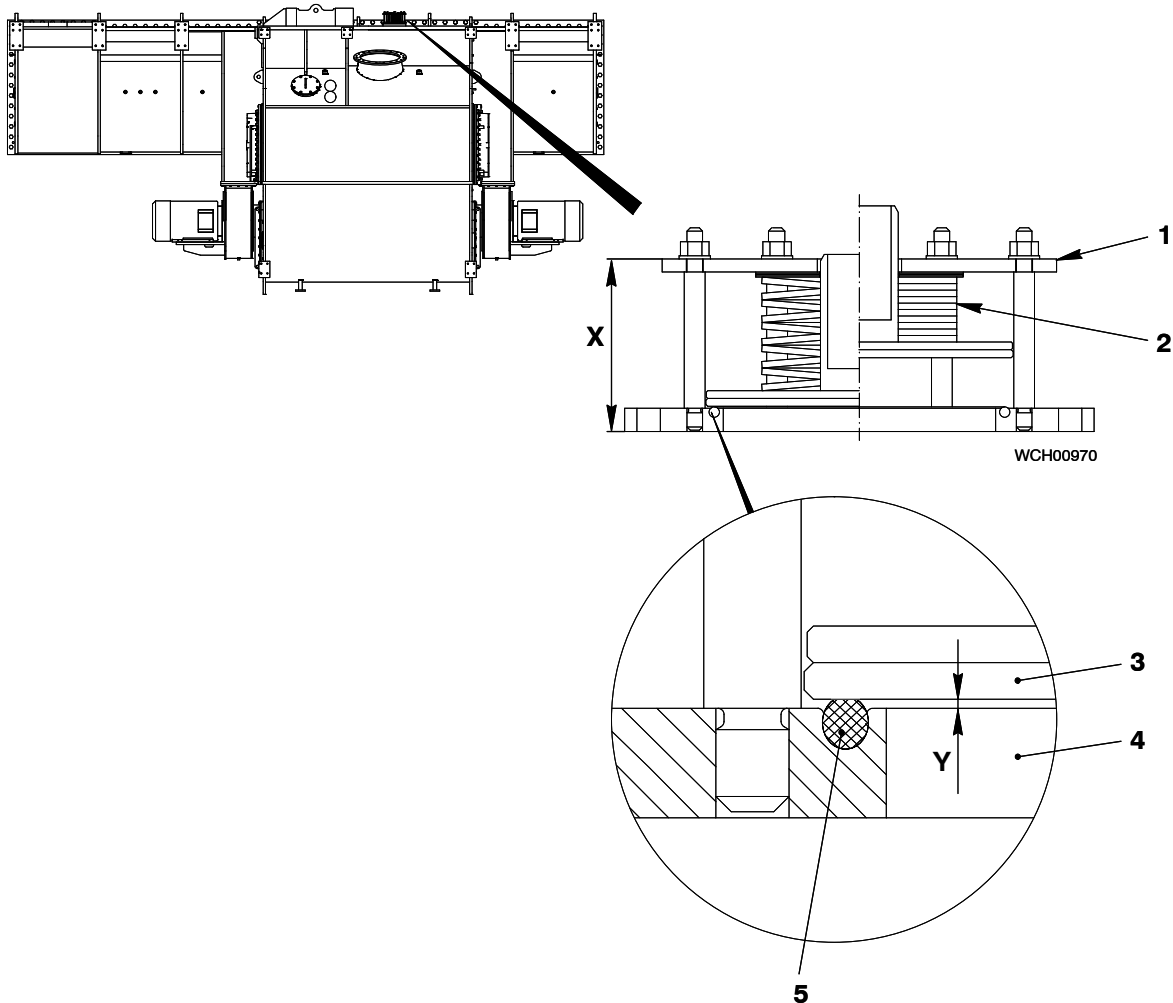


Fig. 4: Relief Valve

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Auxiliary Blower

Maintenance

Tools:

2	Manual ratchet (H1, H2)	94016 006	2	Sling	94049F
2	Sling	94049A			

1.	General	1
2	Preparation	2
2	Removal	2
2	Installation	4
2	Auxiliary Blower – Operate	5

1. General

Two auxiliary blowers (2, Fig. 1) are attached to the scavenge air receiver (1). For more data about the auxiliary blower, refer to the Operation Manual 6545-1 Auxiliary Blower and Switch Box.

The auxiliary blowers are installed on the outer part of the scavenge air receiver.

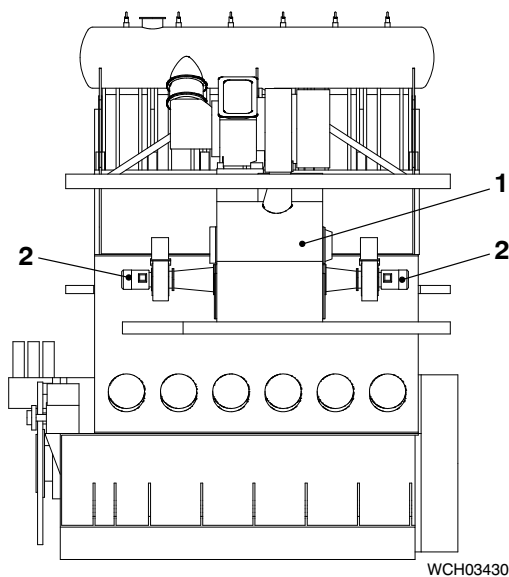


Fig. 1 Engine with One Turbocharger

Auxiliary Blower: Maintenance

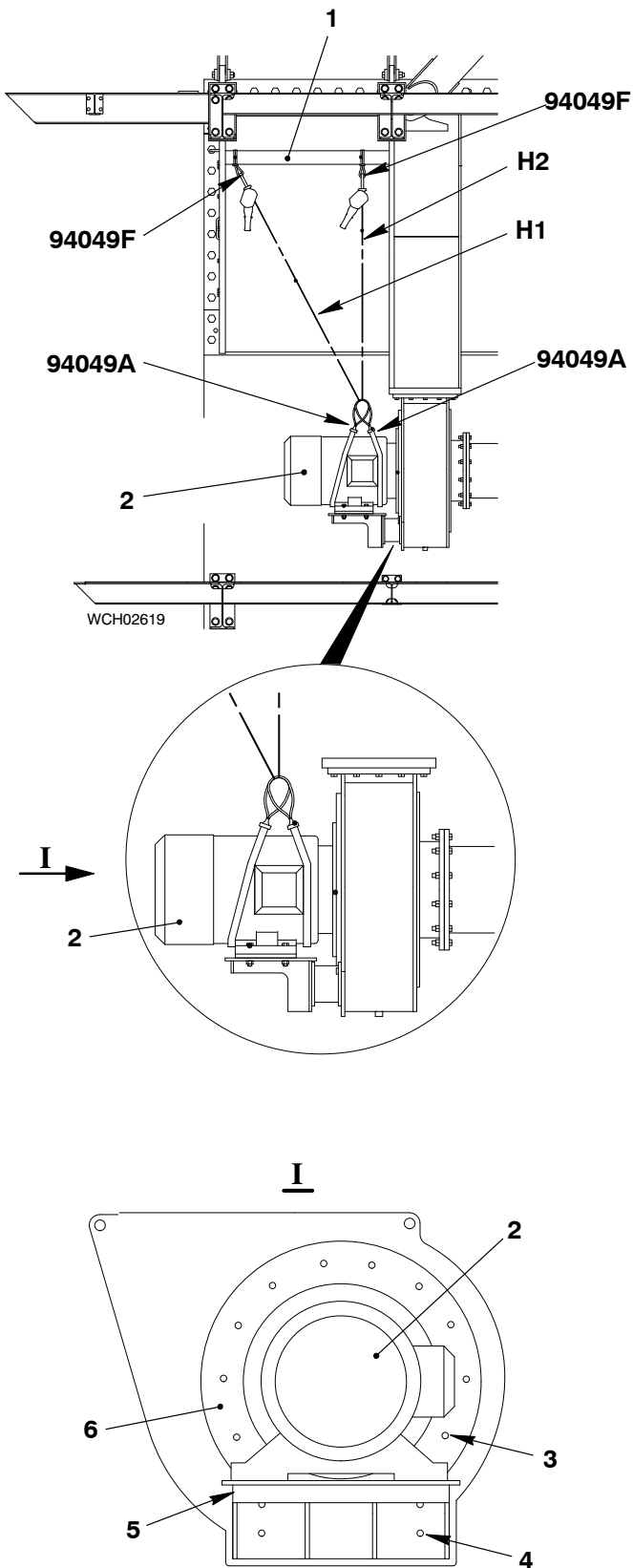


Fig. 2

2. Preparation

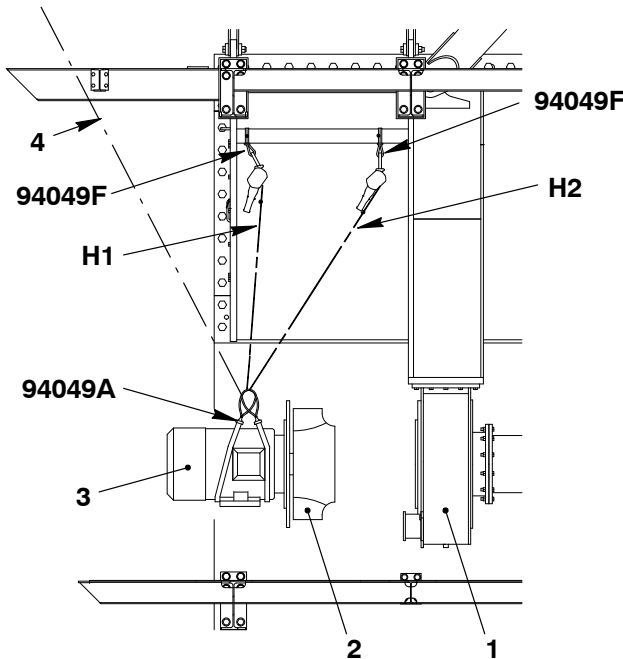
- 1) Read and obey the data given in [0012-1](#), General Guidelines for Lifting Tools.
- 2) Stop the engine.
- 3) Set to off the power supply.
- 4) Disconnect the electrical connection from the electric motor (2, [Fig. 2](#)).


3. Removal

Note: The procedure that follows is for each of the two electric motors.

- 1) Attach the two slings (94049F) to the spar (1).
- 2) Attach the two manual ratchets (H1, H2) to the slings (94049F) as shown.
- 3) Attach the two slings (94049A) to the electric motor (2) and to the manual ratchets (94016 006).
- 4) Operate the manual ratchets (H1, H2) to apply sufficient tension to the slings (94049A) to hold the weight 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



CAUTION	
	<p>Damage Hazard: Do not put the electric motor on the floor without an applicable support. Damage to the impeller can occur.</p>

- 7) Operate carefully the two manual ratchets (H1, H2) to remove the electric motor (3, Fig. 3) from the casing (1).
- 8) Operate the two manual ratchets (H1, H2) to move the electric motor until you can attach the engine room crane (4).
- 9) Attach the engine room crane (4) to the two slings (94049A).
- 10) Operate the engine room crane (4) to put a light tension on the two slings (94049A).
- 11) Remove the manual ratchet (H1).
- 12) Operate the engine room crane (4) and the manual ratchet (H2) until the electric motor (3) hangs vertically.
- 13) Remove the manual ratchet (H2).
- 14) Operate carefully the engine room crane (4) to 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, refer to the documentation of the auxiliary blower manufacturer.

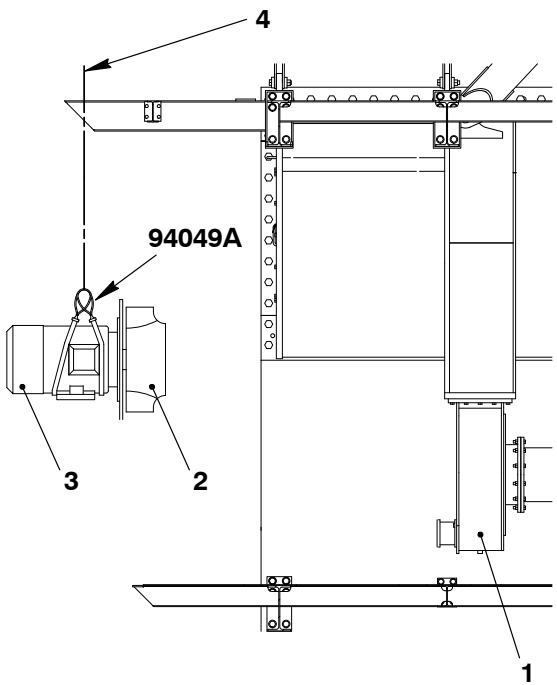


Fig. 3

Auxiliary Blower: Maintenance

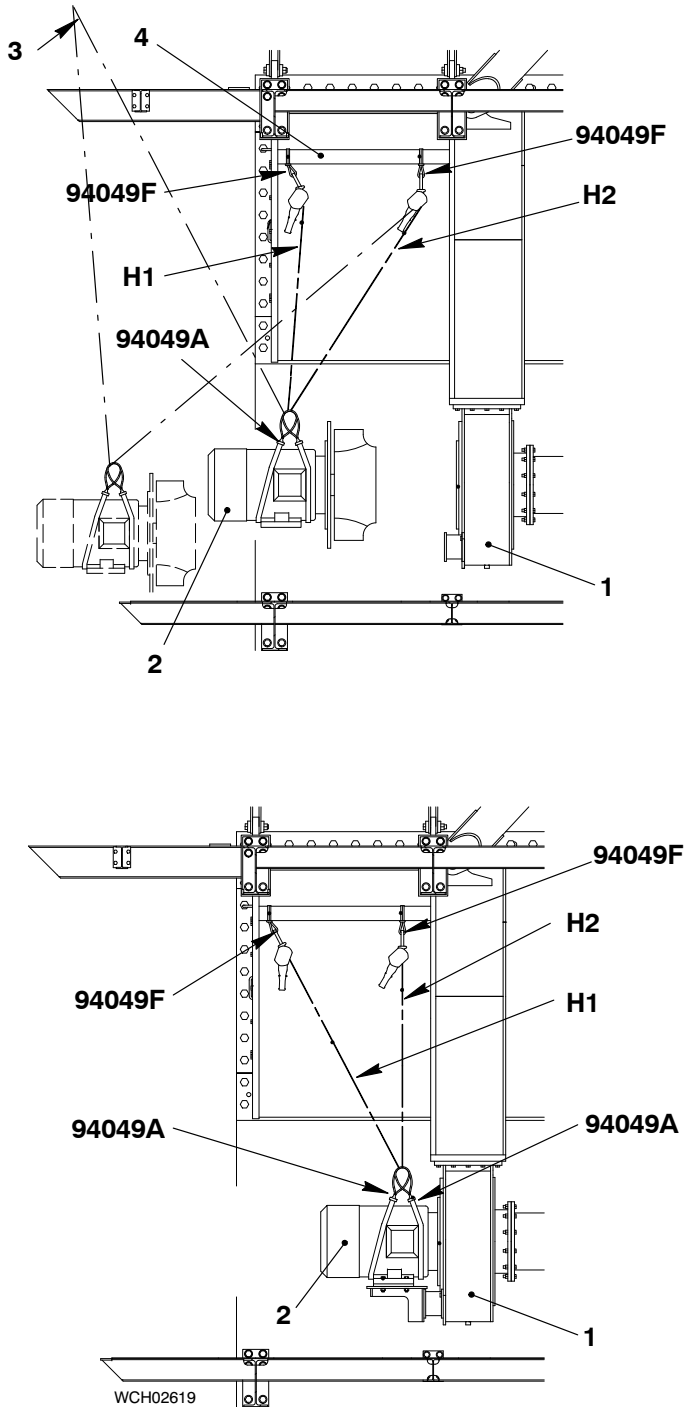
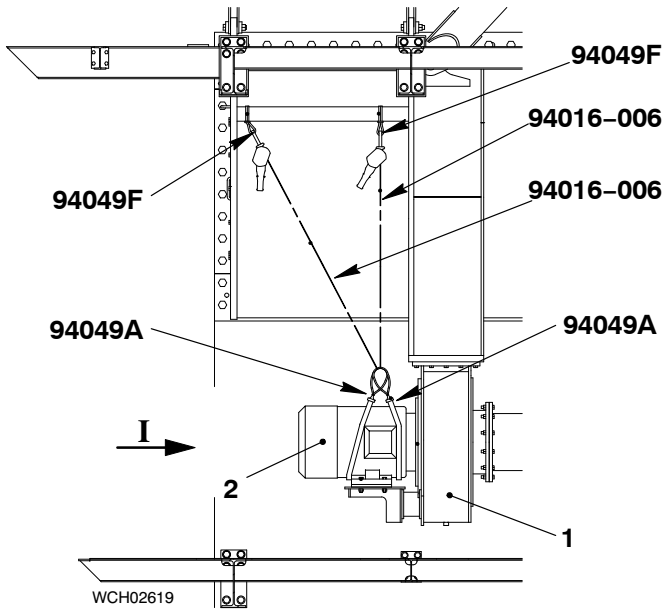


Fig. 4

4. Installation

- 1) Attach the two slings (94049A, Fig. 4) to the electric motor (2).
- 2) Attach the two slings (94049F) to the spar (4).
- 3) Attach the two manual ratchets (H1, H2) to the slings (94049F).
- 4) Attach the engine room crane to the two slings (94049A).
- 5) Operate the engine room crane (3) to lift the electric motor (2) until you can attach the manual ratchet (H2).
- 6) Attach the manual ratchet (H2) to the slings (94049A).
- 7) Operate the engine room crane and the manual ratchet (H2) to move the electric motor (1) to a position below the manual ratchet (H1).
- 8) Operate the engine room crane and the manual ratchet (H2) to align the electric motor (2) with the casing (1).
- 9) Attach the manual ratchet (H1) to the two slings (94049A).
- 10) Remove the engine room crane (3) from the two slings (94049A).
- 11) Operate the manual ratchets (H1, H2) to move the electric motor (2) into the casing (1).

Auxiliary Blower: Maintenance



- 12) Attach the flange (7, Fig. 5) to the casing (1) with the screws (4).
- 13) Attach the support (6) to the casing (2) with the four screws (5).
- 14) Connect the electrical connection to the electric motor (2).
- 15) Remove all tools and equipment from the work area.

5. Auxiliary Blower – Operate

- 1) In the LDU 20, get the MAIN page, (refer to the Operation Manual 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.

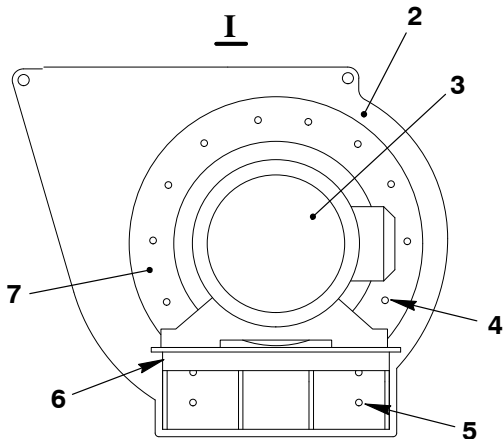


Fig. 5

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Scavenge Air cooler

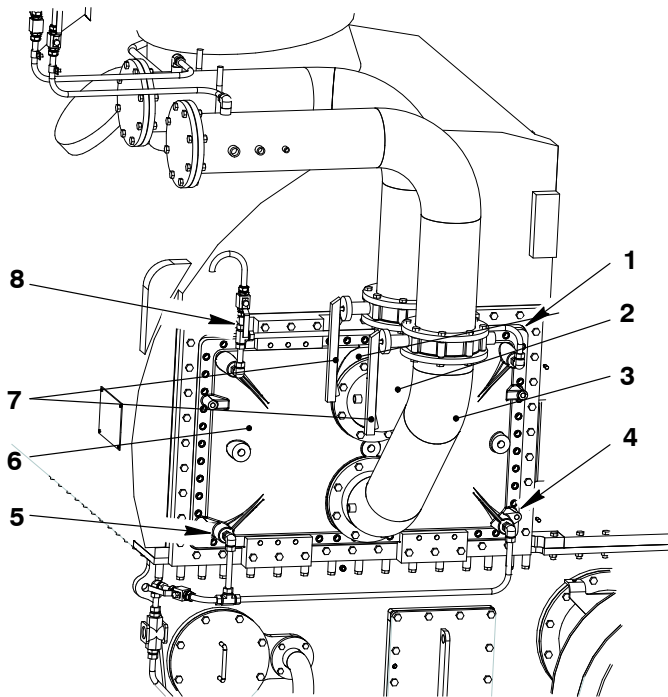
Scavenge Air Cooler Removal and Installation

Tools:

2 Trolleys (3000 kg)	94021	2 Safety lugs	94663C
1 Chain block (5000 kg)	94017-039	2 Safety chains	94663D
1 Manual ratchet (2500 kg)	94016-011	1 Support	94663I
1 Manual ratchet (1000 kg)	94016-006	1 Chain 3150 kg	94019A
1 Left Support	94663A	6 Lugs	94048 M30
1 Right Support	94663B	1 Chain 5300 kg	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.



WCH02621

1. Preparation

- 1) Read the data in 0012 1 General Guidelines for Lifting Tools.
- 2) Stop the engine, refer to the Operation Manual 0310 1.
- 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).

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).

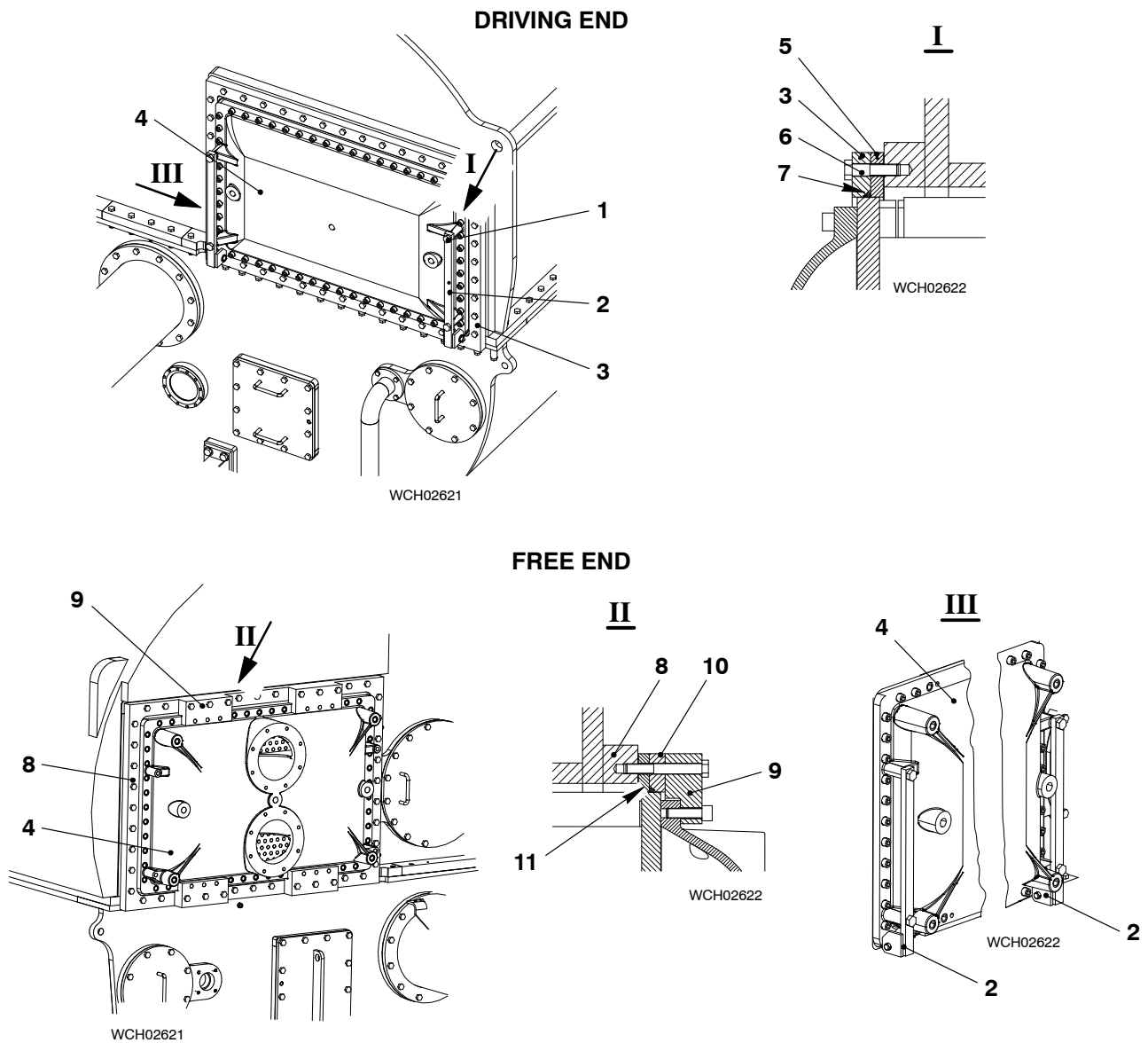


Fig. 2

Scavenge Air Cooler: Removal and Installation

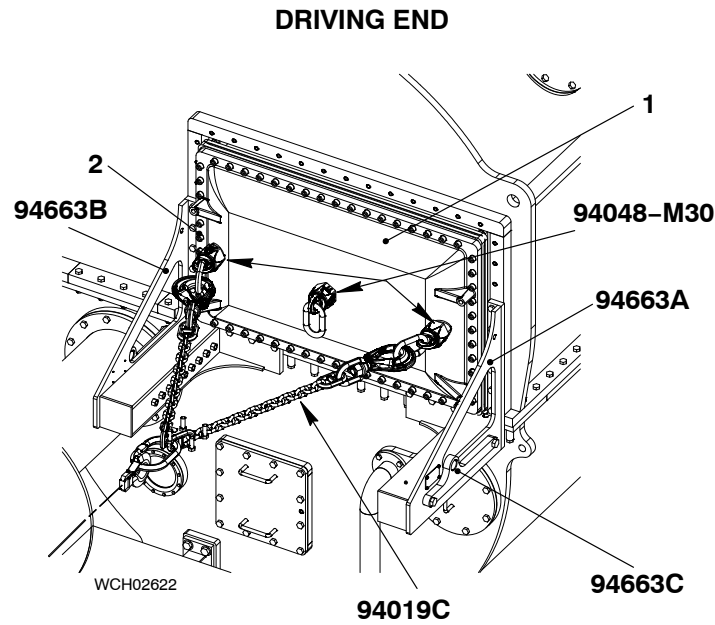


Fig. 3

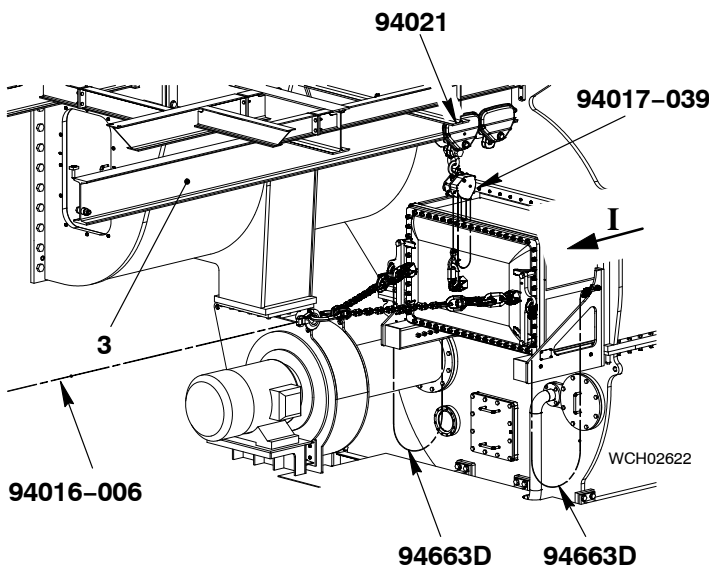
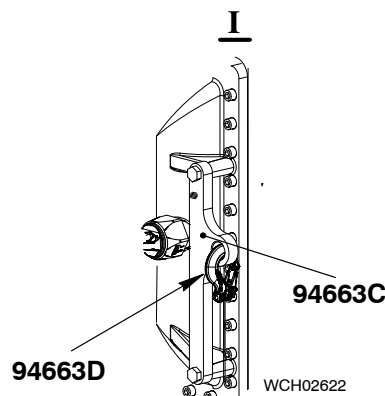


Fig. 4

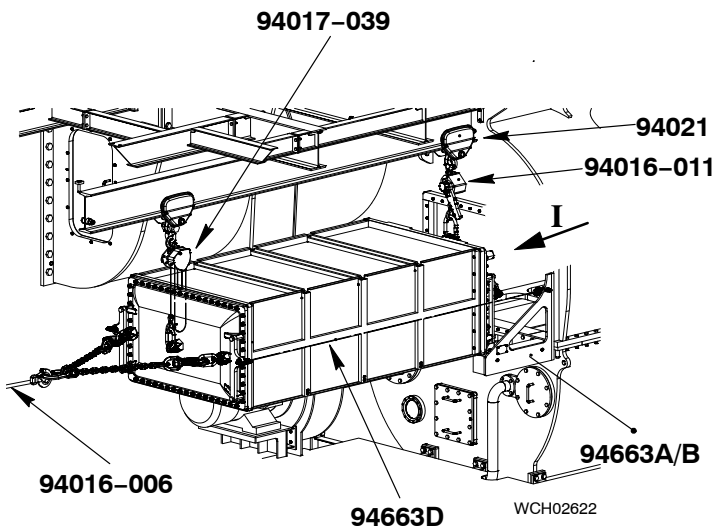


- 11) At the driving end, attach the three lugs (94048 M30) to the SAC (1, Fig. 3).
- 12) Attach the two supports (94663A, 94663B) to the scavenge air receiver with the screws (2).
- 13) Torque the screws (2) to 136 Nm.
- 14) Attach the chain (94019C) to the outer lugs (94048 M30).
- 15) Remove the safety lugs (94663C) from their positions on the two supports.
- 16) Attach the safety lugs (94663C) to the beam (3, Fig. 4).
- 17) Attach the safety chains (94663D) to the safety lugs and the two 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 scavenge air receiver.
- 21) Attach the chain block (94017-039) to the center lug and the trolley (94021).
- 22) Operate the spur geared chain block (94017-039) to get sufficient tension to hold the SAC.

Scavenge Air Cooler: Removal and Installation

WARNING

Injury Hazard! The weight of the SAC is approximately 2700 kg. When you do the step below, make sure that you do not move the SAC too far. This will prevent injury to personnel



- 23) Operate carefully the manual ratchet (94016 006, Fig. 5) until the rear of the SAC is on the two supports (94663A, 94663B).
- 24) Attach the two lugs (94048 M30) to the SAC.
- 25) Attach the chain (94019A) to the two lugs (94048 M30).
- 26) Attach the manual ratchet (94016 011) to the trolley (94021) and the chain (94019A).
- 27) Apply light tension to the manual ratchet (94016 011) .
- 28) Remove the safety chains (94663D) from the two supports (94663A, 94663B).

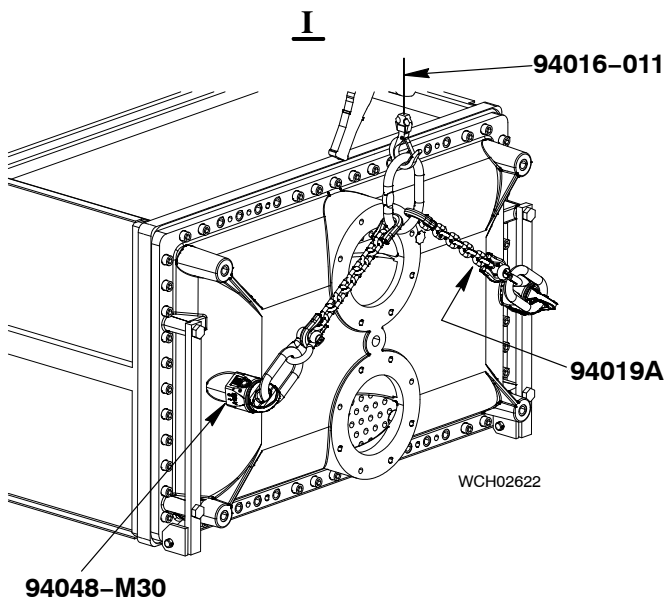


Fig. 5

Scavenge Air Cooler: Removal and Installation

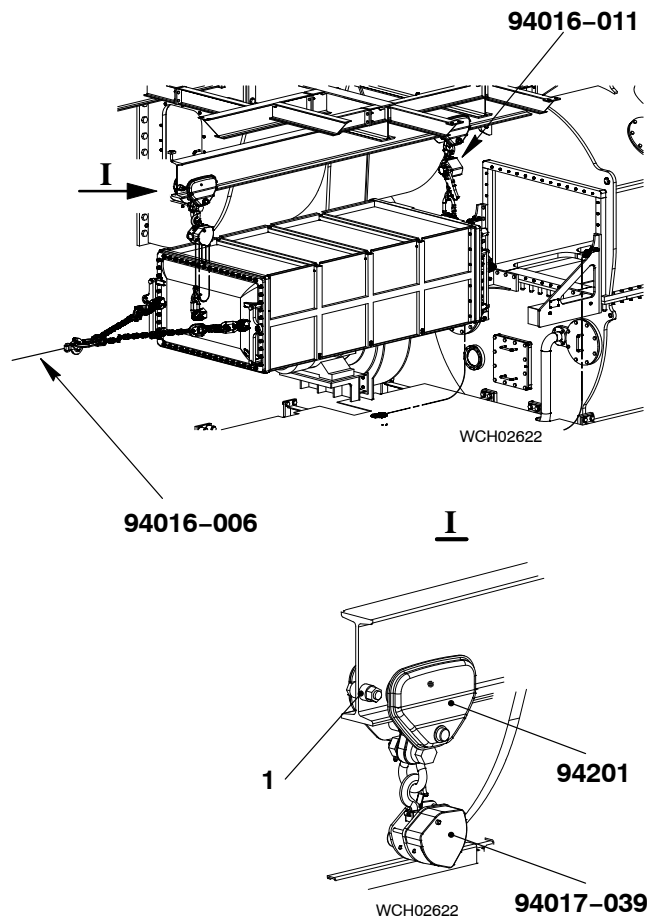


Fig. 6

- 29) Operate the the manual ratchet (94016 006, Fig. 6) until the SAC is clear of the two supports.
- 30) Continue to operate the manual ratchet (94016 006) until the trolley (94201) touches the end stop (1).
- 31) Operate the chain block (94017 039) and manual ratchet (94016 011)
- 32) Carefully lower the SAC on to an applicable surface.
- 33) Remove the manual ratchet (94016 006) and chain block (94017 039).
- 34) Remove the two lugs (94048 M30) from the SAC.

Scavenge Air Cooler: Removal and Installation

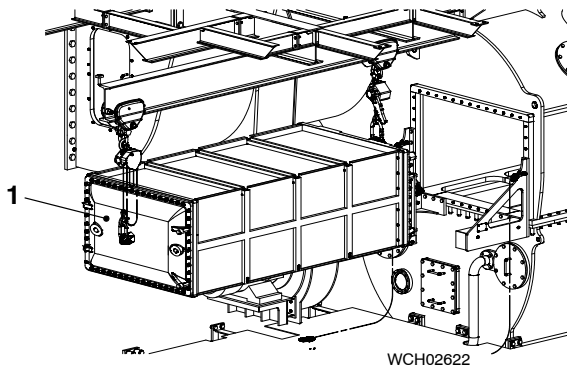


Fig. 7

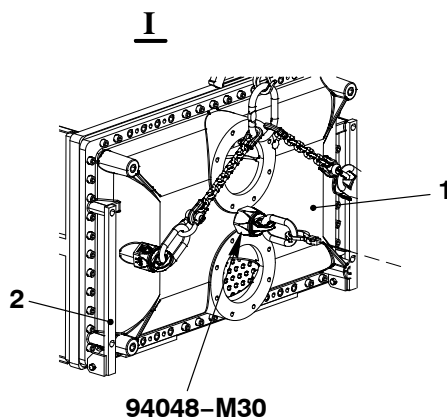
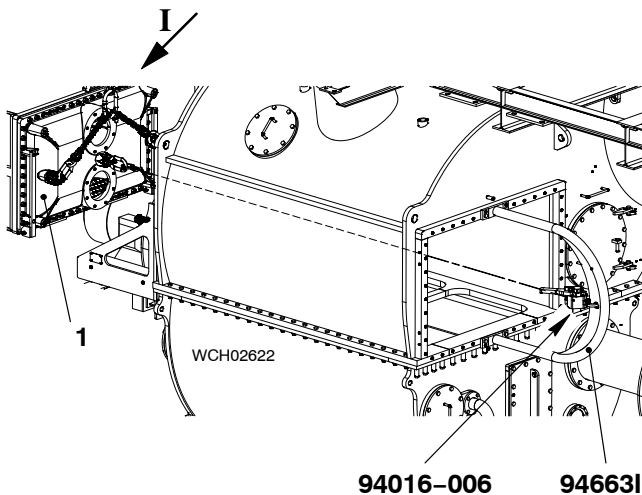
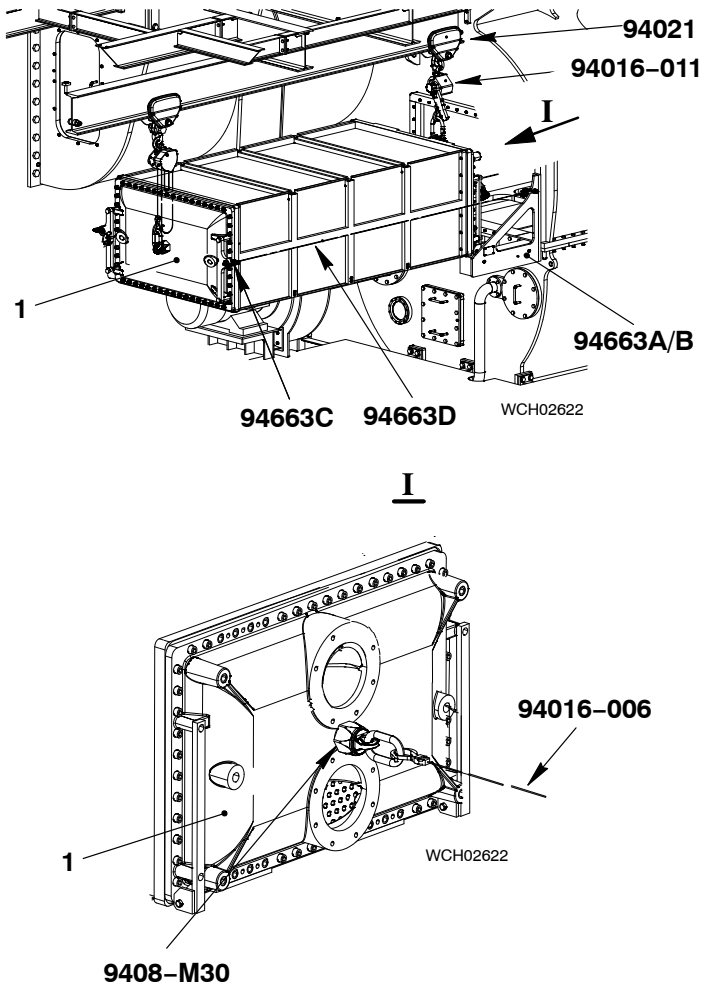


Fig. 8

3. Installation

- 1) Make sure that all the surfaces of the SAC (1, Fig. 7) and the related surfaces in the scavenge air 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 scavenge air receiver.
- 3) Use the tools that follow to move the SAC (1) to the position shown.
 - Engine room crane
 - Trolleys (94021)
 - Manual ratchet (94016-011)
 - Chain block (94017-039)
 - Lugs (94048 M30).
- 4) Attach the support (94663I, Fig. 8) to the scavenge air receiver.
- 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 the center lug (94048 M30) on the SAC (1).

Scavenge Air Cooler: Removal and Installation



- 8) Operate the manual ratchet (94016 006, Fig. 8) to move the SAC (1) on to the two supports (94663A and 94663B, Fig. 9).
- 9) Make sure that the end of the SAC (1) is on the two supports (94663A, 94663B).
- 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 (94048 M30).
- 13) Operate the manual ratchet (94016 011) to move the SAC (1) to the position as shown in Fig. 10.
- 14) Remove the chain block (94017-039).
- 15) Remove the lug (94048 M30) from the center position in the SAC.
- 16) Remove the safety lugs (94663C) from the rollers (2).
- 17) Remove the rollers (2) from the from the SAC.
- 18) Attach the rollers (2) to their stowage position on the two supports (94663A, 94663B).
- 19) Remove the two trolleys (94021).

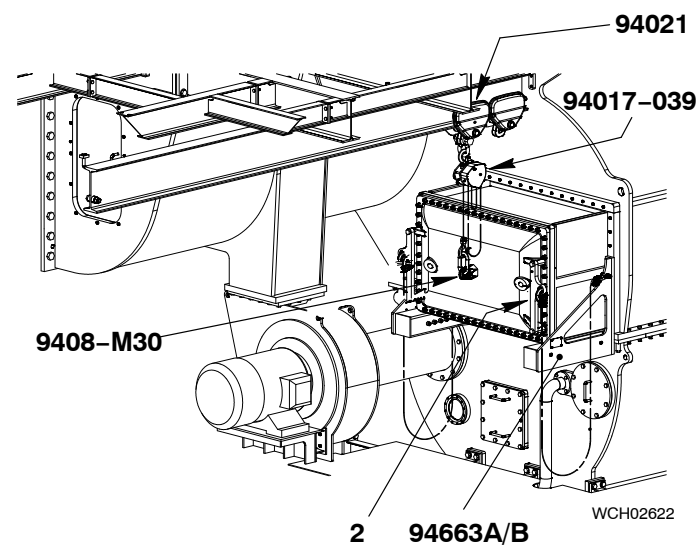


Fig. 10

Scavenge Air Cooler: Removal and Installation

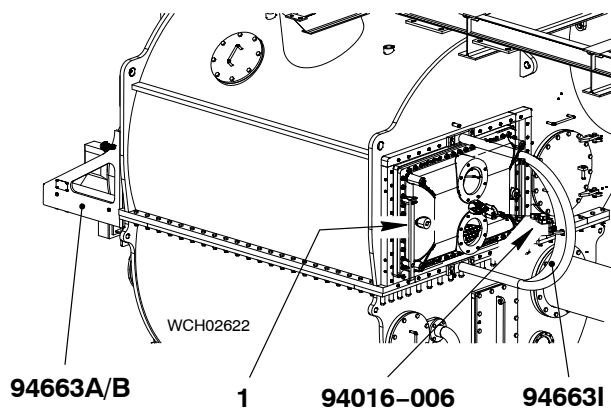


Fig. 11

- 20) Operate the the manual ratchet (94016 006) to move the SAC fully into the scavenge air receiver (refer to Fig. 11).
- 21) Remove the manual ratchet (94016 006) from the center lug and the support (94663I).
- 22) Remove the two supports (94663A, 94663B).
- 23) Remove the two rollers (1) from the SAC.
- 24) Install the two rollers (1, Fig. 12) to the driving end of the SAC.

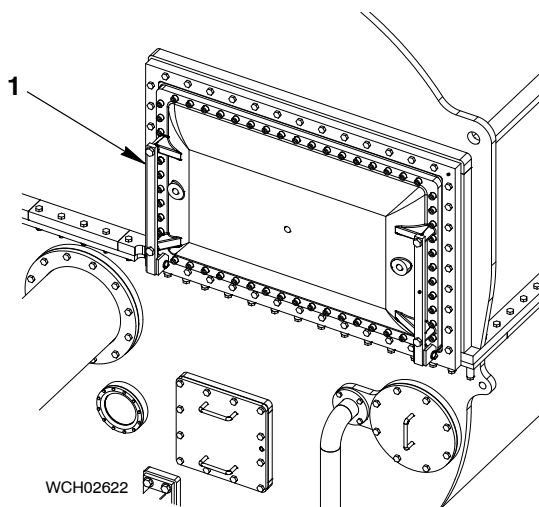


Fig. 12

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 (1) with the screws (6).
- 28) Torque the M20 screws (4) 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 M20 screws (8) to the value given in 0352 1.

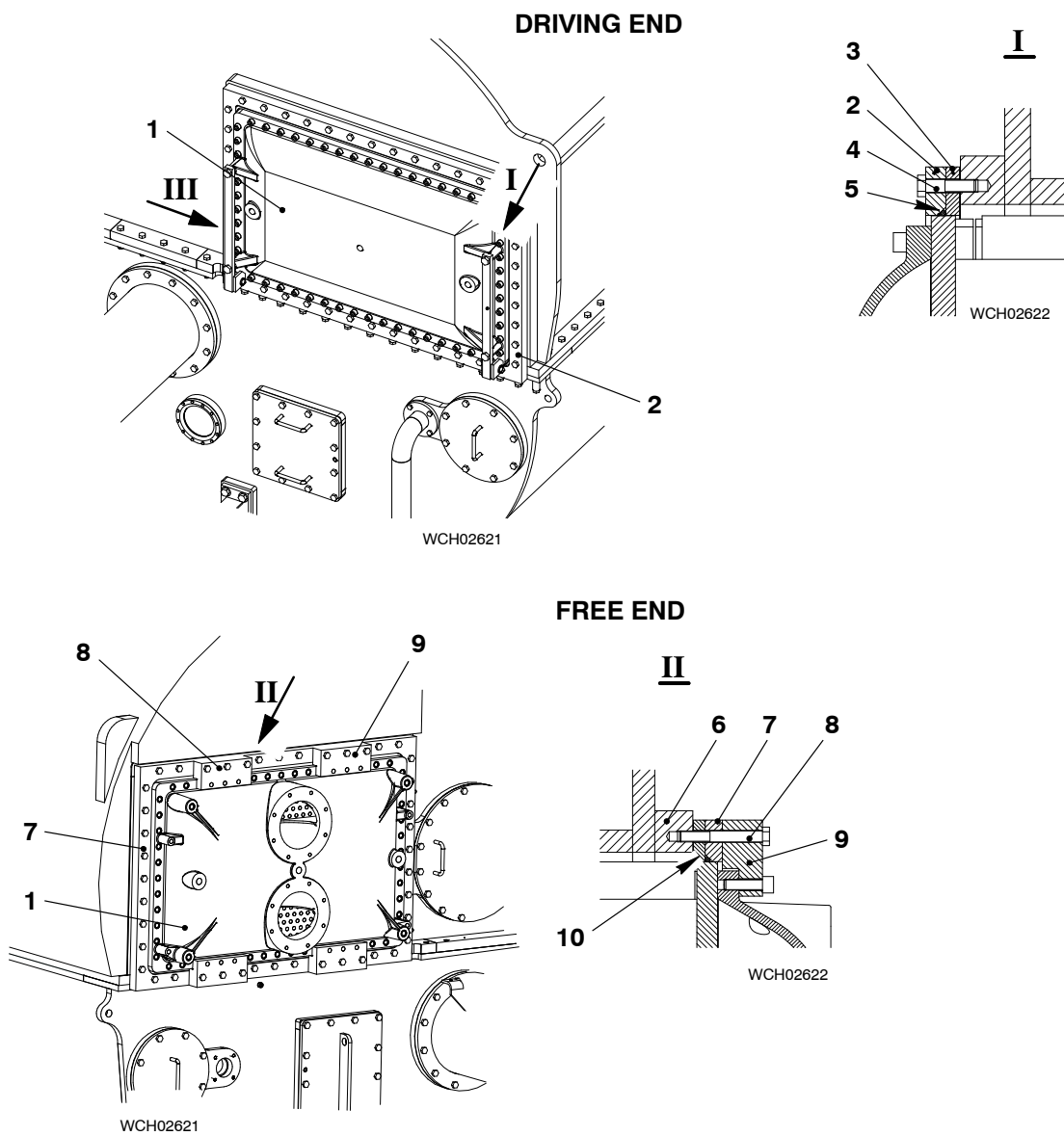
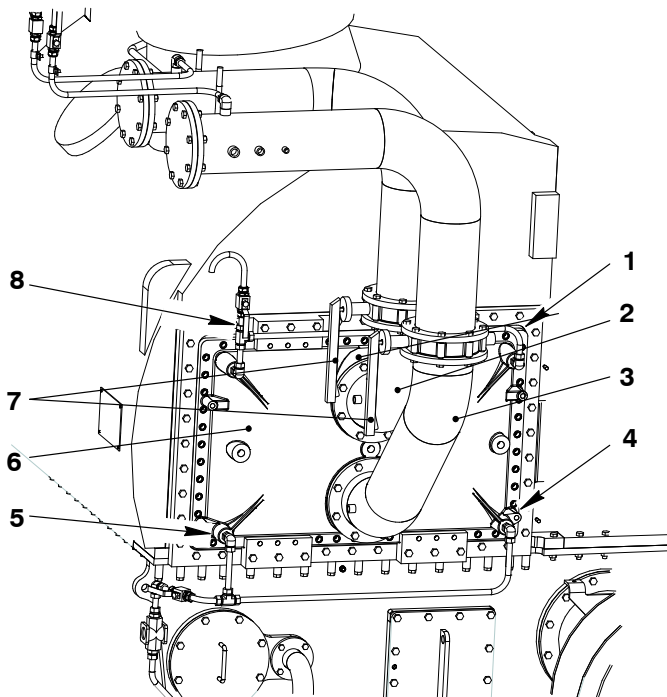


Fig. 13

Scavenge Air Cooler: Removal and Installation

4. Completion



WCH02621

- 1) Install the drain pipes (4 and 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.

Fig. 14

Cleaning Instructions

1. General	1
2. Cleaning the air side	1
3. SAC Air Side - Clean during Operation	3
3.1 Procedure	3

1. General

For the day-to-day checking of the scavenge air cooler, measure the drop in pressure and temperature of the scavenge air across the cooler while the engine is running.

Compare these measurements with the testbed data.

An **increase** in the **air pressure** drop across the scavenge air cooler indicates fouling of the air side of the cooler.

A **decrease** in the **air temperature** drop across the scavenge air cooler indicates fouling of the water side of the cooler.

If the measurements indicate fouling of the water side of the air cooler element, the element must be overhauled/cleaned.

If the measurements indicate fouling of the air side of the air cooler element, it is necessary to inspect the air cooler element.

If the air side of the element is fouled, clean the element using the spray pipe arrangement fitted above the air cooler element.

- SAC air side can be cleaned during engine operation.
- SAC water side can only be cleaned when engine is stopped.

2. Cleaning the air side

The air side of the cooler is cleaned by injecting a chemical fluid through the spray pipe arrangement fitted to the air chamber above the cooler element.

- 1) Product: ACC 9, produced by Drew Chemical Corp., New York, USA.
- 2) Product: 80B, produced by Vecom Int., Maassluis, Holland

Scavenge Air Cooler

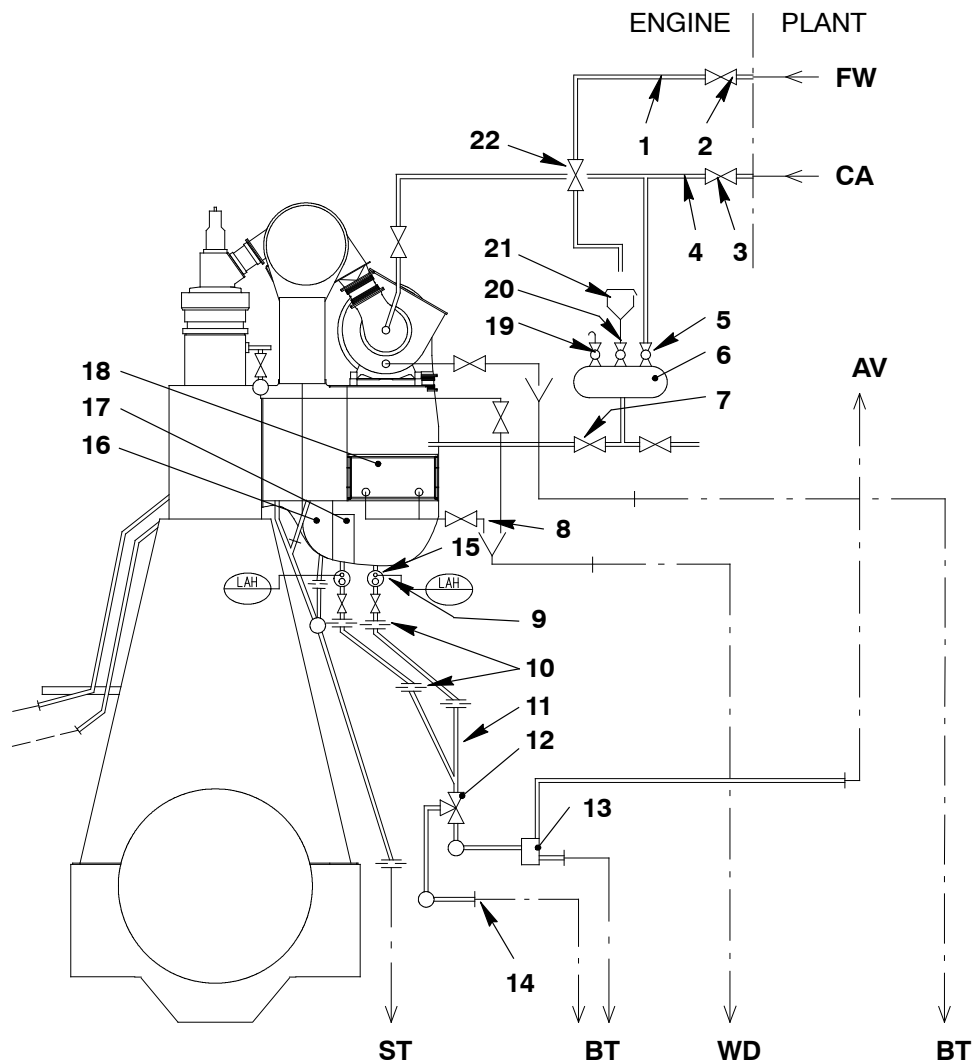


Fig. 1: Location of Wash-water System Parts

- | | |
|--|--|
| 1 Fresh water supply pipe | 16 Receiver |
| 2 Ball valve | 17 Water separator |
| 3 Ball valve | 18 Scavenge air cooler (SAC) |
| 4 Compressed air supply pipe | 19 Shut-off valve (vent) |
| 5 Shut-off valve | 20 Shut-off valve |
| 6 Container | 21 Funnel |
| 7 Ball valve | 22 Shut-off valve |
| 8 SAC drain | |
| 9 Condensate collector | |
| 10 Throttle disc | AV Vent |
| 11 Condensate and wash-water drain | BT Drain to bilge water tank |
| 12 3-way ball valve | CA Compressed air from board system 7.0 bar to 8.0 bar |
| 13 Vent unit | FW Fresh water 2.5 bar |
| 14 Cleaning fluid and wash-water drain | ST Drain to sludge water tank (oleiferous) |
| 15 Level switch | WD Drain to water drain tank |

Scavenge Air Cooler

3. SAC Air Side - Clean during Operation

The equipment necessary to clean the air side of the SAC is installed on the engine.

The quantity of contamination in the SAC is related to the condition of the airflow into the SAC and the maintenance of the air suction filter on the turbocharger.

Note: It is recommended that you clean the SAC in tropical conditions because of increased condensation.

3.1 Procedure

Clean the SAC while the engine operates at less than 50% load (see also the instruction panel on the engine). The air temperature downstream of the compressor (turbocharger) must not be more than 100°C. This is because heat will change too much of the cleaning agent to evaporated.

Make sure that compressed air and fresh water are available at the shut-off valves (1 and 12, Fig. 2).

- 2 Open the ball valves (2 and 10, Fig. 2).

Fill the mixture tank with recommended chemical doses at the funnel (11).

Open the freshwater valve (12), fill the tank up to desire level.

Close the ball valves for air vent and freshwater (2 and 10).

Open the ball valve for compressed air (1).

Open the ball valves (4 and 9). The mixed fluid comes out of the nozzles (5) as a spray into the SAC (6) for approximately one minute.

- 8) Close the ball valve compressed air (1).
- 9) Close the ball valves (4 and 9).
- 10) Open the ball valve (2) for depressurization of the mixing tank.
- 11) After approx. 10 min flush the system by fresh water, step 2 to 11 without chemical.

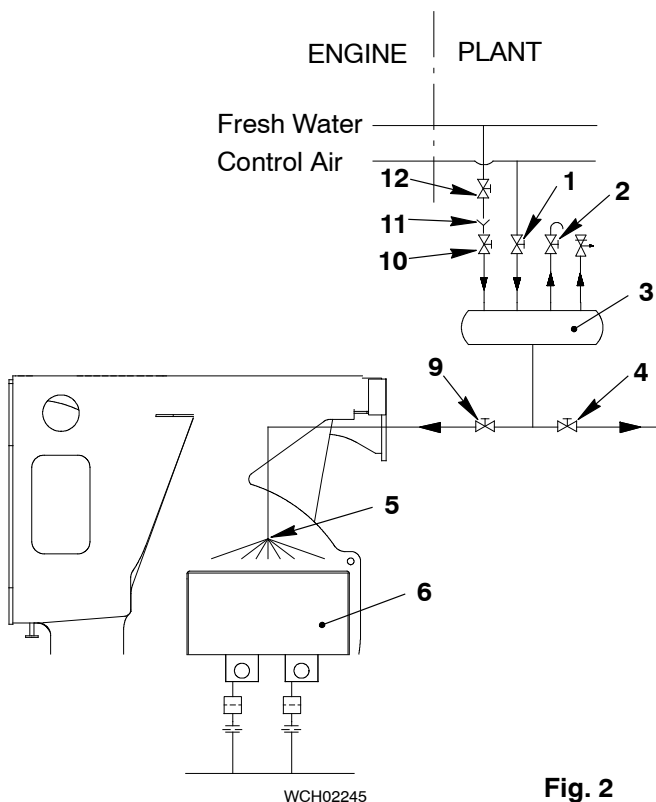


Fig. 2

Water Separator

Removal and Installation

Tools:

2	Chain block (H1) (H2) 1000 kg	94017 009	2	Shackle 3250 kg	94018A
1	Manual ratchet (H3) 1000 kg	94016 006	2	Tool	94667
1	Manual ratchet (H4) 500 kg	94016 025	1	Holder	94667G
1	Holder	94667H			

1.	Preparation	1
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	2.1 Front Water Separator	2
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	3.1 Rear Water Separator	5
	3.2 Front Water Separator	7

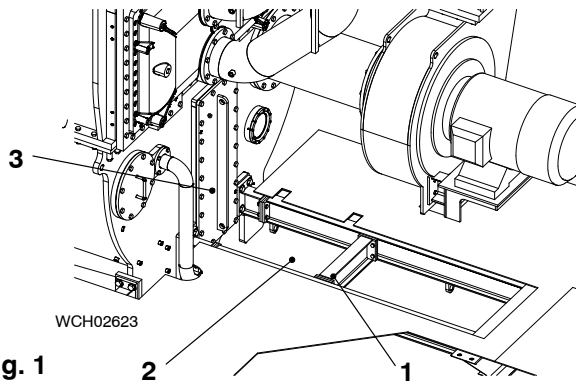


Fig. 1

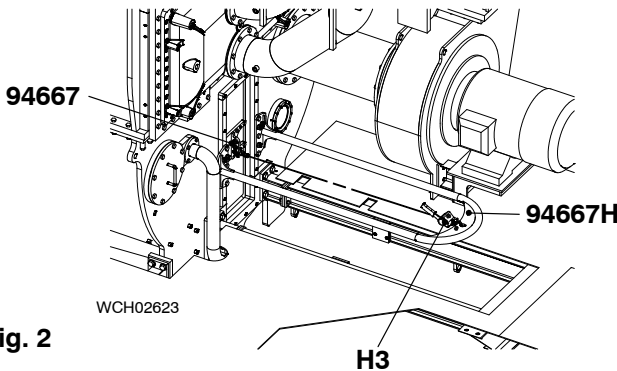


Fig. 2

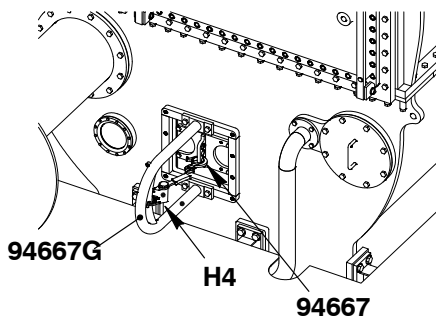


Fig. 3

1. Preparation

- 1) Read and obey the data in 0012 1, General Guidelines for Lifting Tools.
- 2) Remove the front cover (3, Fig. 1) from the housing of the water separator.
- 3) Remove the beam (1) and the bottom plate (2).
- 4) Install the tool (94667, Fig.2) to the front of the water separator.
- 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) Remove the cover from the rear of the water separator.
- 8) Install the tool (94667) to the rear of the water separator (refer to Fig. 3).
- 9) Install the holder (94667G) to the rear of the water separator.
- 10) Attach the manual ratchet (H4) to the holder (94667G) and the tool (94667).

Water Separators: Removal and Installation

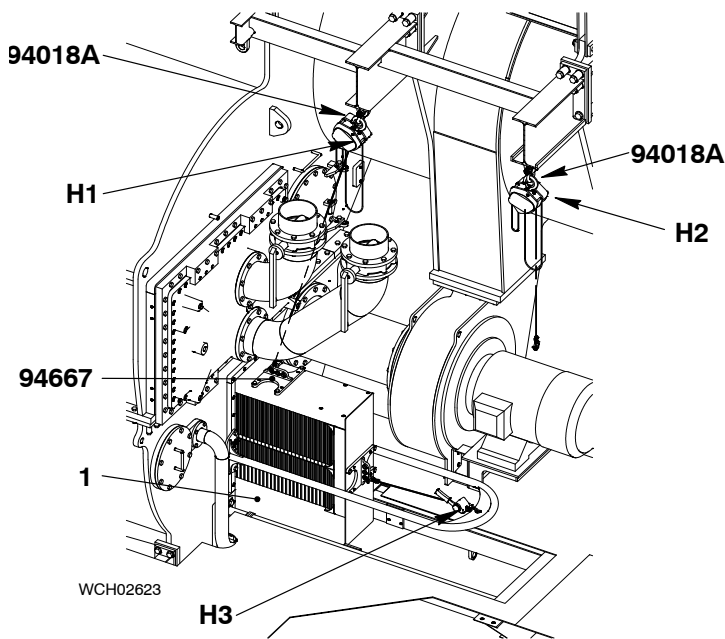


Fig. 4

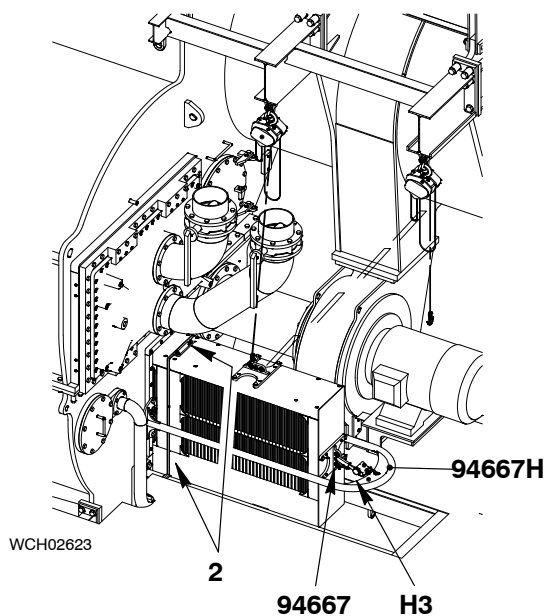


Fig. 5

- 11) Attach the two shackles (94018A, Fig. 4) to the gallery.
- 12) Attach the 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 you can attach the tool (94667) to the water separator (1).
- 2) Attach the tool (94667) to the top of the water separator (1).
- 3) Attach the chain block (H1) to the tool (94667).
- 4) Apply a light tension to the chain block (H1).
- 5) Operate the manual ratchet (H3) to pull the water separator (1) from the receiver. At the same time, operate the chain block (H1) to hold the water separator.
- 6) Remove the two top screws (2, Fig. 5) and the two bottom screws 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

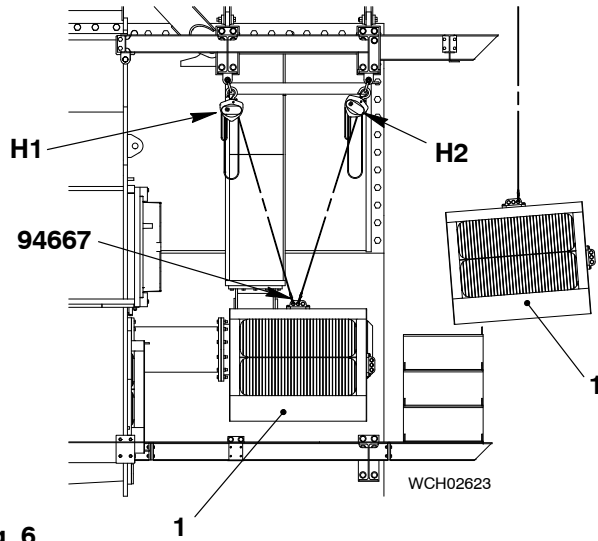


Fig. 6

- 9) Attach the chain block (H2, Fig. 6) to the tool (94667).
- 10) Apply a light tension to the chain block (H2).
- 11) Loosen the chain block (H1). At the same time, tighten the chain block (H2) to move the water separator under the engine room crane.
- 12) Lower the water separator (1) on to an applicable surface.
- 13) Remove the 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) Operate 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.

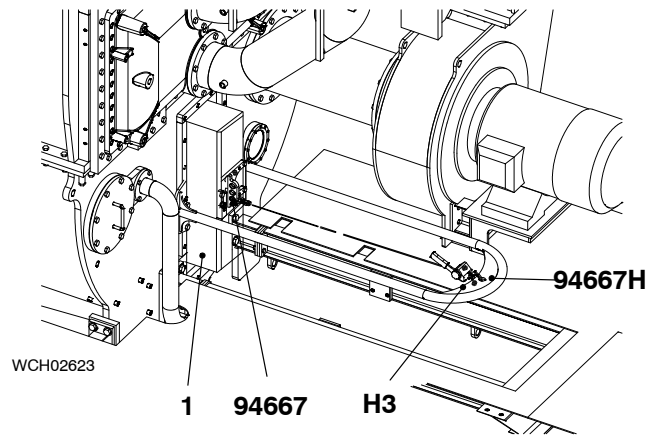


Fig. 7

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

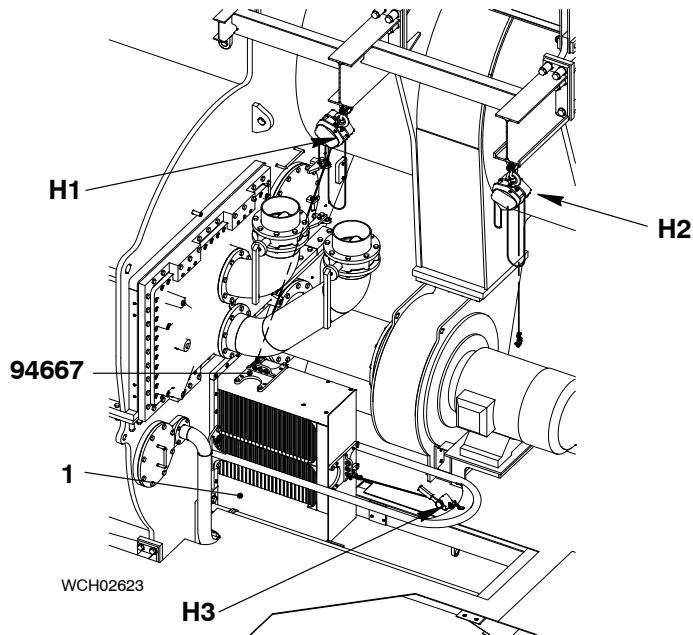


Fig. 8

- 4) Operate the manual ratchet to pull the water separator (1, Fig 8) sufficiently until you can attach the tool (94667).
- 5) Attach the tool (94667) to top of the water separator (1).
- 6) Attach the chain block (H1) to the tool (94667).
- 7) Apply a light tension to the chain block (H1).

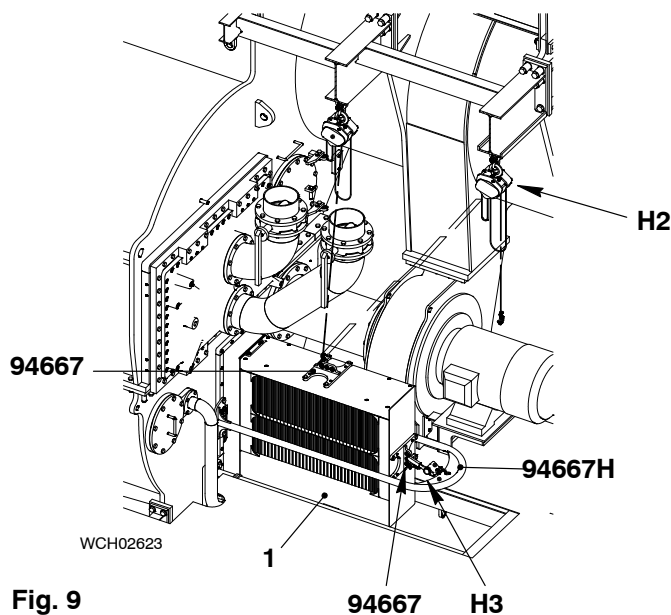


Fig. 9

- 8) Operate the manual ratchet (H3, Fig. 9) to pull the water separator (1) from the receiver. At the same time, operate the chain block (H1) to hold the weight 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 (1).
- 11) Attach the chain block (H2) to the tool (94667) on top of the water separator (1).

Water Separators: Removal and Installation

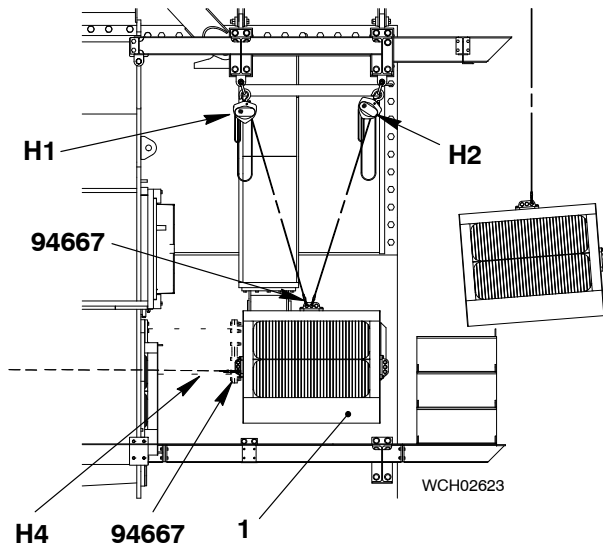


Fig. 10

- 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 chain block (H2).
- 14) Loosen the chain block (H1). At the same time, tighten the chain block (H2) to move the water separator below the engine room crane.
- 15) Lower the water separator (1) on to an applicable area.
- 16) Remove the 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) Operate the engine room crane to move the water separator (1) to an applicable area.
- 19) Remove the engine room crane from the water separator (1).
- 20) Remove the tools (94667) from the water separator.

3. Installation

3.1 Rear Water Separator

- 1) Attach the tools (94667, Fig. 11) to the top and front of the water separator (1).
- 2) Operate the engine room crane and the chain blocks (H1, H2) to move the water separator into position.
- 3) Attach the manual ratchet (H4) to the tool (94667) on the water separator.

Note: When you do step (4), keep the tension on the chain blocks (H1, H2) to hold the water separator (1).

- 4) Operate the manual ratchet (H4) to move the water separator (1) to the position shown in Fig. 12.

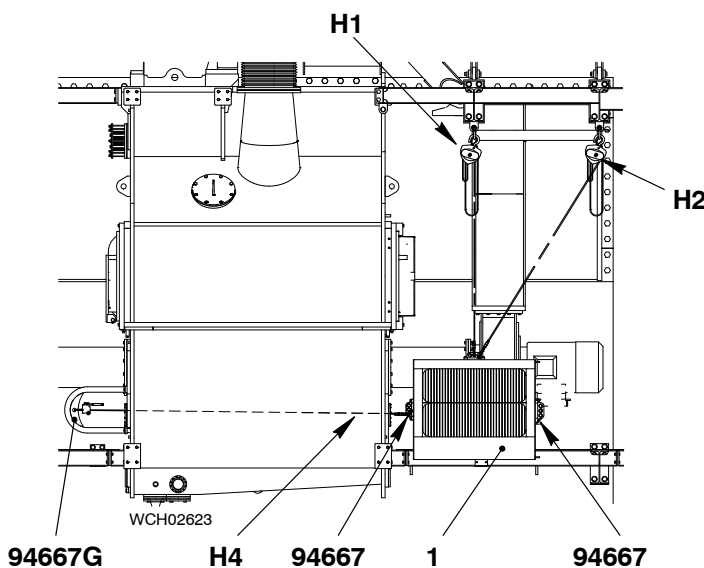


Fig. 11

Note: Some part can look different

Water Separators: Removal and Installation

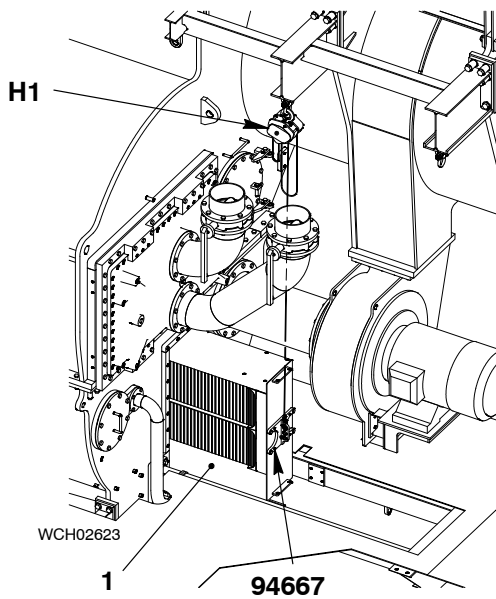


Fig. 12

Note: Some part can look different

- 5) Remove the 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 chain block (H1) to the tool (94667) on the front of the water separator (1).

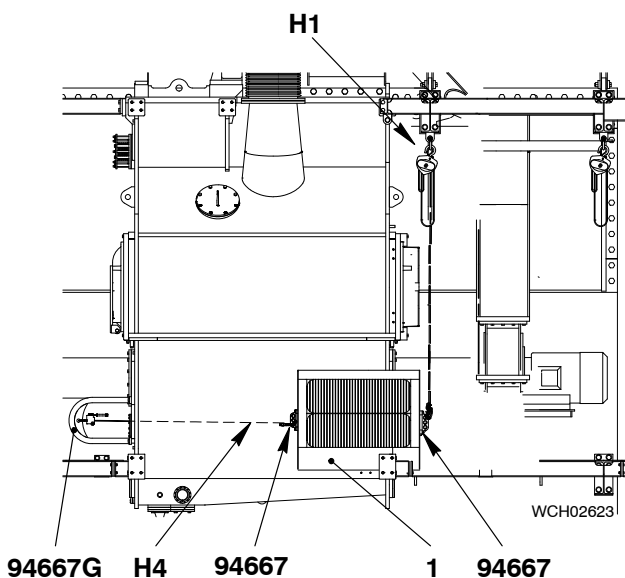


Fig. 13

- 8) Operate the manual ratchet (H4, [Fig. 13](#)) to pull the water separator (1) as shown. At the same time, operate the chain block (H1) to hold the weight of the water separator.
- 9) Remove the 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).

Water Separators: Removal and Installation

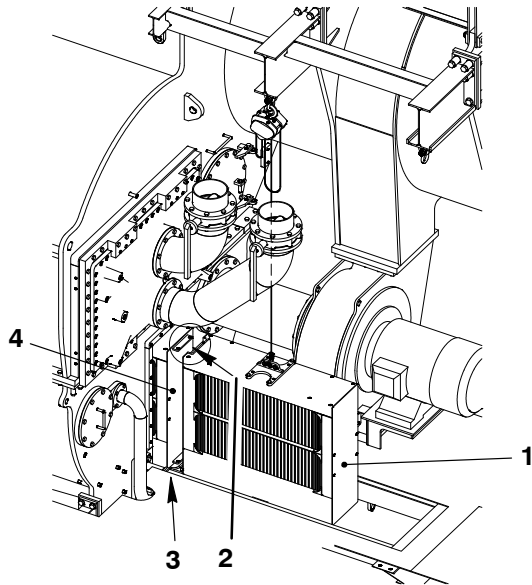


Fig. 14

Note: Some parts can look different

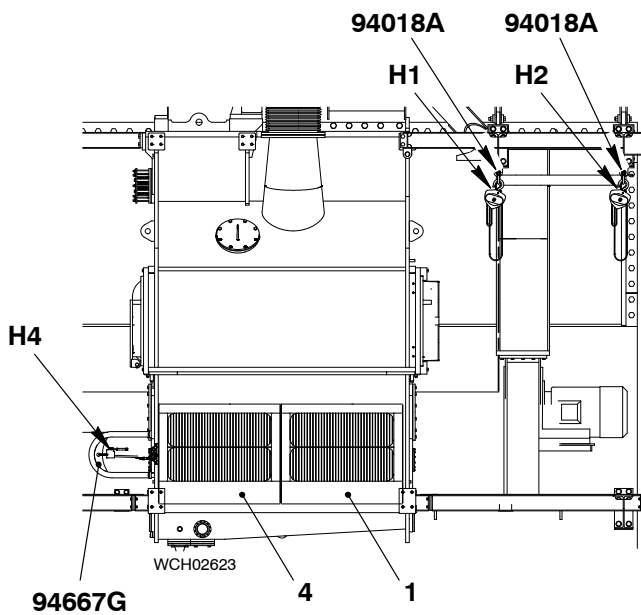


Fig. 15

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) Attach the water separators (1 and 4) together with the two top screws (2) and two bottom screws (3).
- 4) Operate the manual ratchet (H4) to pull the water separators a small distance into the receiver.
- 5) Remove the chain block (H1) from the tool (94667).
- 6) Remove the tool (94667) from the water separator (1).

- 7) Operate the manual ratchet (H4, Fig. 15) to pull the water separators (1, 4) fully into the receiver.
- 8) Remove the chain blocks (H1, H2).
- 9) Remove the shackles (94018A).
- 10) Remove the tool (94667) and the holder (94667G).

Water Separators: Removal and Installation

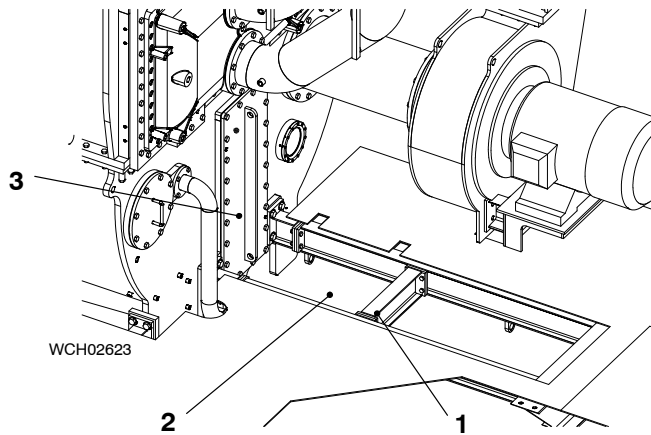


Fig. 16

- 11) Install the cover (3, [Fig. 16](#)) to the receiver.
- 12) Install the bottom plate (2).
- 13) Install the beam (1).

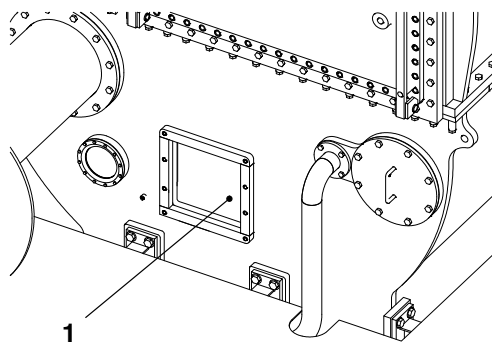


Fig. 17

- 14) Install the cover (1, [Fig. 17](#)) to the receiver.
- 15) Remove all tool and equipment from the work area.

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

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, refer to the Operation Manual, 7218-1.

1.1 Cylinder Lubricating System – Operate

For more data, refer to the Operation Manual, 4002 2, paragraph 3.2 and paragraph 3.21.

- 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

Note: Some parts can look different.

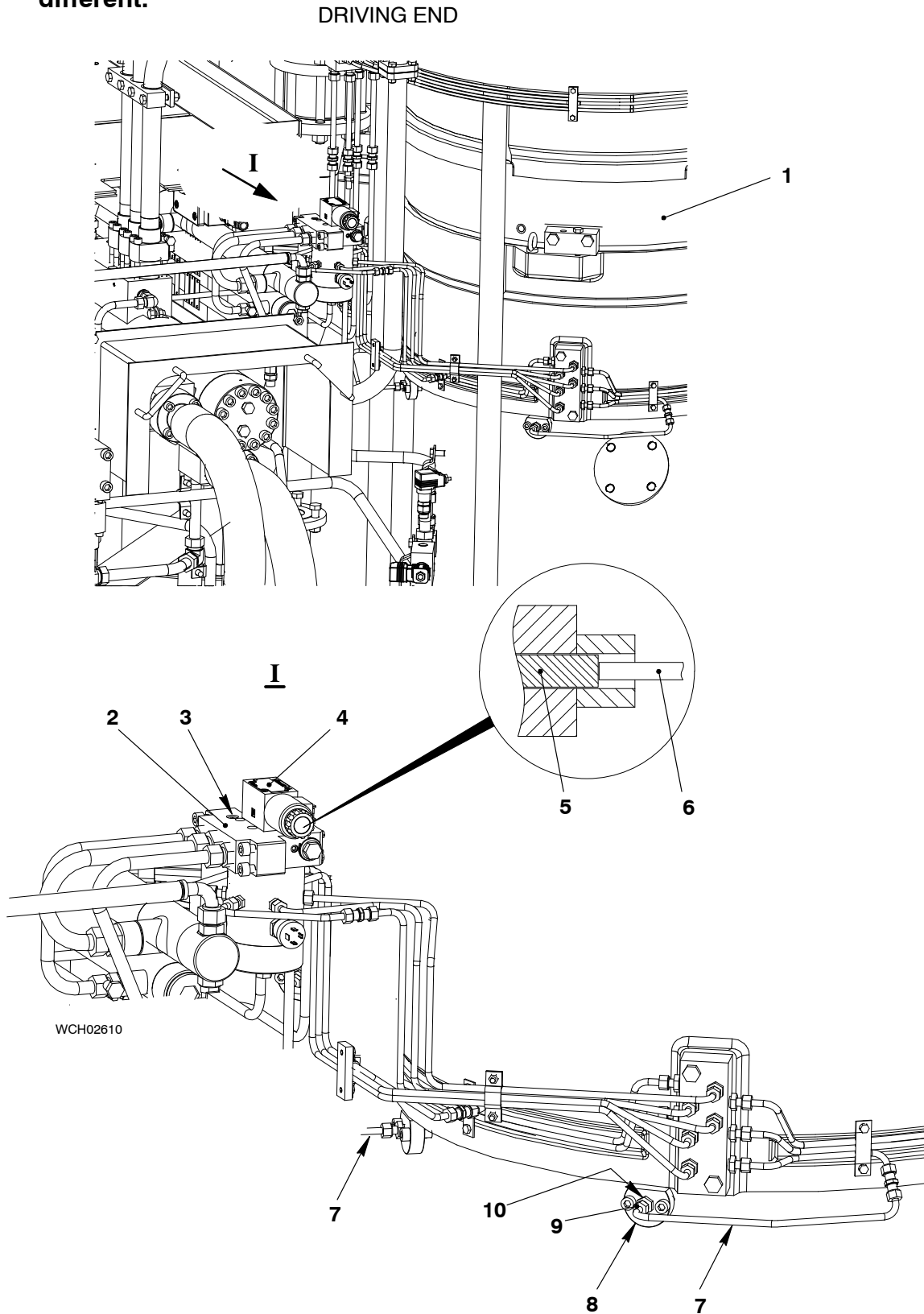



Fig. 1: Cylinder Lubrication Pump - Location

1.2 Function Check

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

- 1) If necessary, bleed the cylinder lubricating system (refer to paragraph 3).
- 2) Make sure that the applicable piston is in the TDC position. If the piston is not in the TDC position, do step a) to step c):
 - a) Engage the turning gear.
 - b) Operate 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 (refer to paragraph 1.1).

Note: During usual operation, the ECS controls the cylinder lubrication.

- 4) Operate manually one lube pulse from the cylinder lubrication system:
 - a) Use a pin or a screwdriver (6, Fig. 1) to push in the plunger (5) of the 4/2-way valve (4).
- 5) Look through the scavenge air ports in the cylinder liner while the lubricating system operates.
- 6) Make sure that the lubricating oil flows on to the cylinder liner wall (refer to the Operation Manual 7218-1, paragraph 8.2 and paragraph 8.3).
- 7) Make sure that the oil that flows has no air.
- 8) If necessary, bleed the cylinder lubricating pump (2) and the oil lines (7) (refer to paragraph 3).
- 9) Set to OFF the cylinder lubricating system for the related cylinder.

2. Cylinder Lubrication Pump

For data about the cylinder lubricating pump (2), refer to the Operation Manual 7218-1, paragraph 5.

2.1 Checks

- 1) Examine the cylinder lubricating pump (2) for damage and leaks.
- 2) Do a function check of the cylinder lubricating system (refer to 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 from 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), (refer to paragraph 3.2).
- 7) Do a function check of the cylinder lubricating system, (refer to 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, (refer to paragraph 1.1).
- 2) Use an open-ended spanner to hold the screw-in union (10) in position.
- 3) Loosen a maximum of two turns the screw in union (10).
- 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 cylinder lubrication pump (2) (refer to paragraph 3.1).
- 8) Do a function check of the cylinder lubricating system (refer to paragraph 1.2).

4. Duplex Filter

For data about the duplex filter (1, [Fig. 2](#)), refer to the Operation Manual 7218-1.

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)
- 5) Remove the cover (4).
- 6) Replace the clogged filter element.

Note: As an alternative, you can clean the clogged filter element (refer to [paragraph 4.2](#)).

- 7) Attach the cover (4) to the filter chamber (5) with the three nuts (6).
- 8) Clean the external surface of the duplex filter (1).
- 9) Install the cover you removed before to the rail unit.
- 10) Open the ball valve (2).

4.2 Filter Element – Clean

For data about the procedure to clean the filter element, refer to the documentation of the filter element manufacturer.

Cylinder Lubricating System

Note: Some parts can look different.

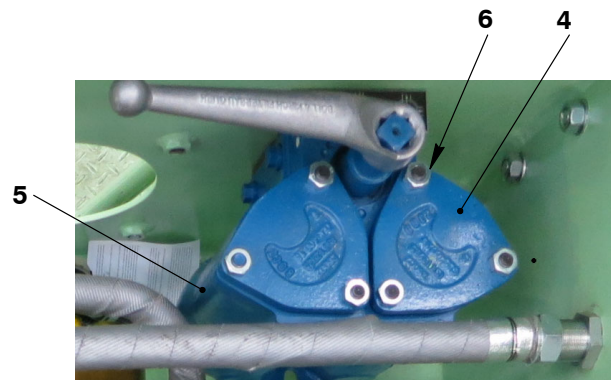
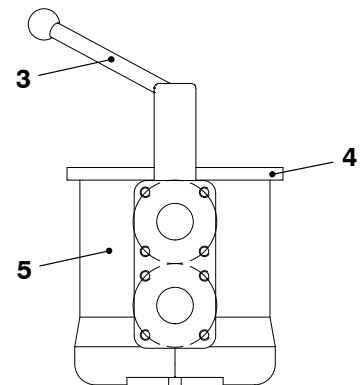
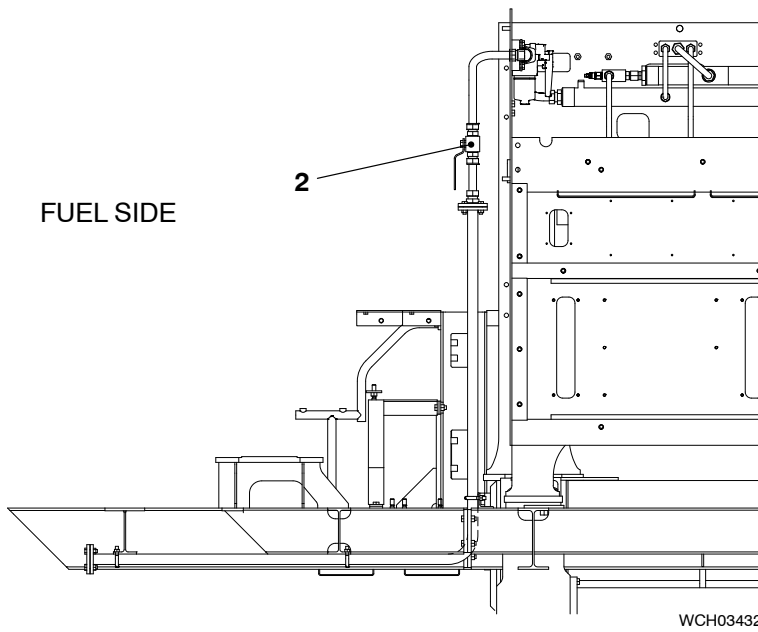
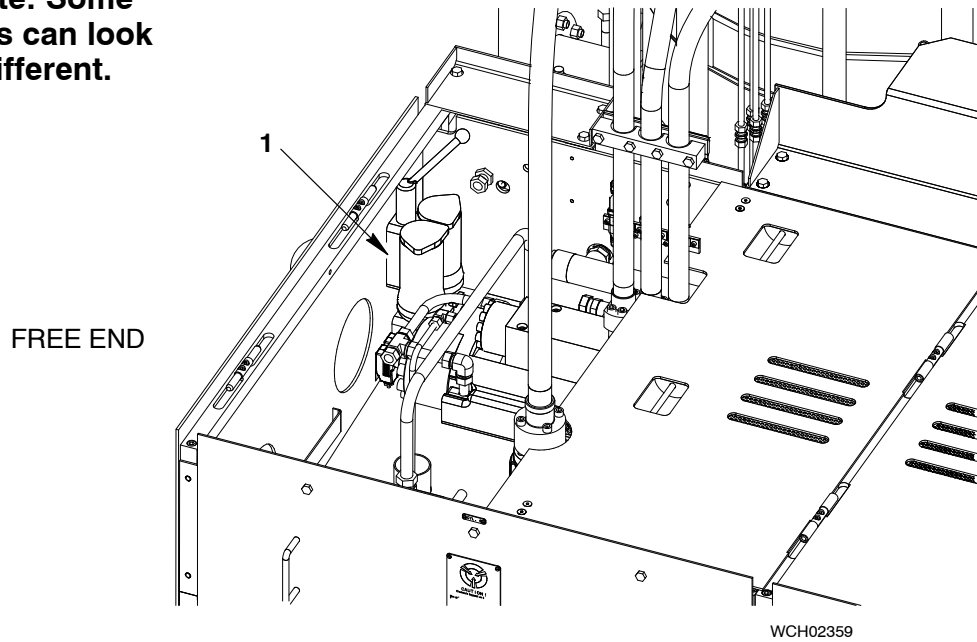


Fig. 2: Duplex Filter

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	

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6.	Completion	13

Integrated Electric Balancer

1. General

The Integrated Electric 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. You must always replace the bearings as a pair.

For the first bearing replacement, speak to, or send a message to WinGD to get data from approved personnel.

For more data about the Integrated Electric 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.

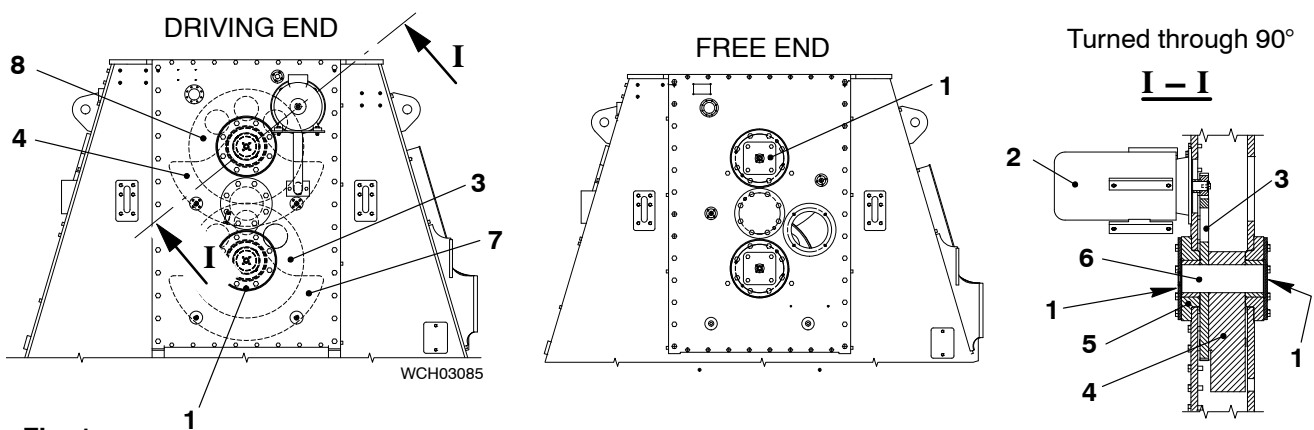


Fig. 1

Fig. 1: Location of ELBA

- | | |
|---------------------|------------------------|
| 1 Bearing cover | 5 Bearing |
| 2 Electric motor | 6 Bearing pin |
| 3 Bottom gear wheel | 7 Bottom counterweight |
| 4 Top counterweight | 8 Top gear wheel |

Integrated Electric Balancer

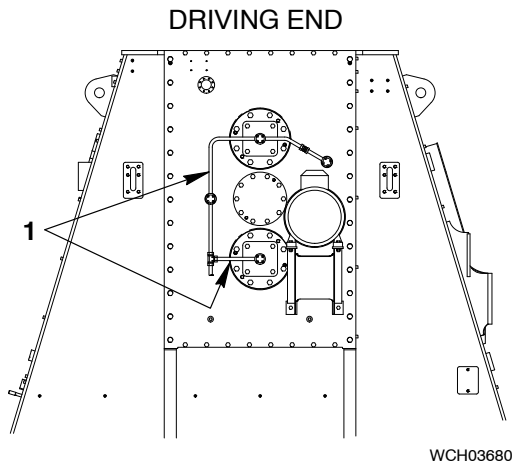


Fig. 2

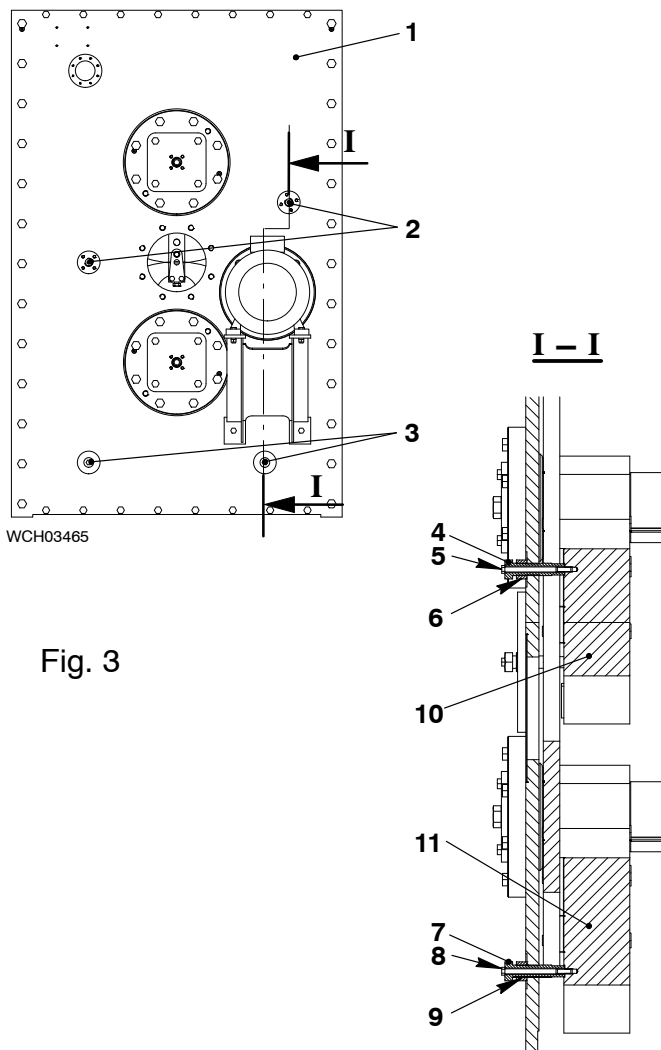


Fig. 3

2. Preparation

- 1) Stop the engine, refer to Operation Manual, 0310 1.
- 2) Make sure that the electric motor (2, 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 pipes (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 screw (4, Fig. 3) and the nut (6).
- 2) Remove the two screws (2) from the main cover (1).
- 3) Put the two screws (4) and the nuts (6) in position on the top counterweight (10).
- 4) Torque the screws (4) to 60 Nm.
- 5) Torque the nut (6) to 60 Nm.
- 6) Put the the M12 bolt (5) in position through the 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 screw (7) and the nut (9).
- 2) Remove the two screws (3) from the cover (1).
- 3) Put the two screws (7) and the nuts (9) in position on the bottom counterweight (11).
- 4) Torque the screws (7) to 60 Nm.
- 5) Torque the nut (9) to 60 Nm.
- 6) Put the M12 bolt (8) in position through the screw (7).
- 7) Torque the M12 bolt (8) to 60 Nm.

Integrated Electric Balancer

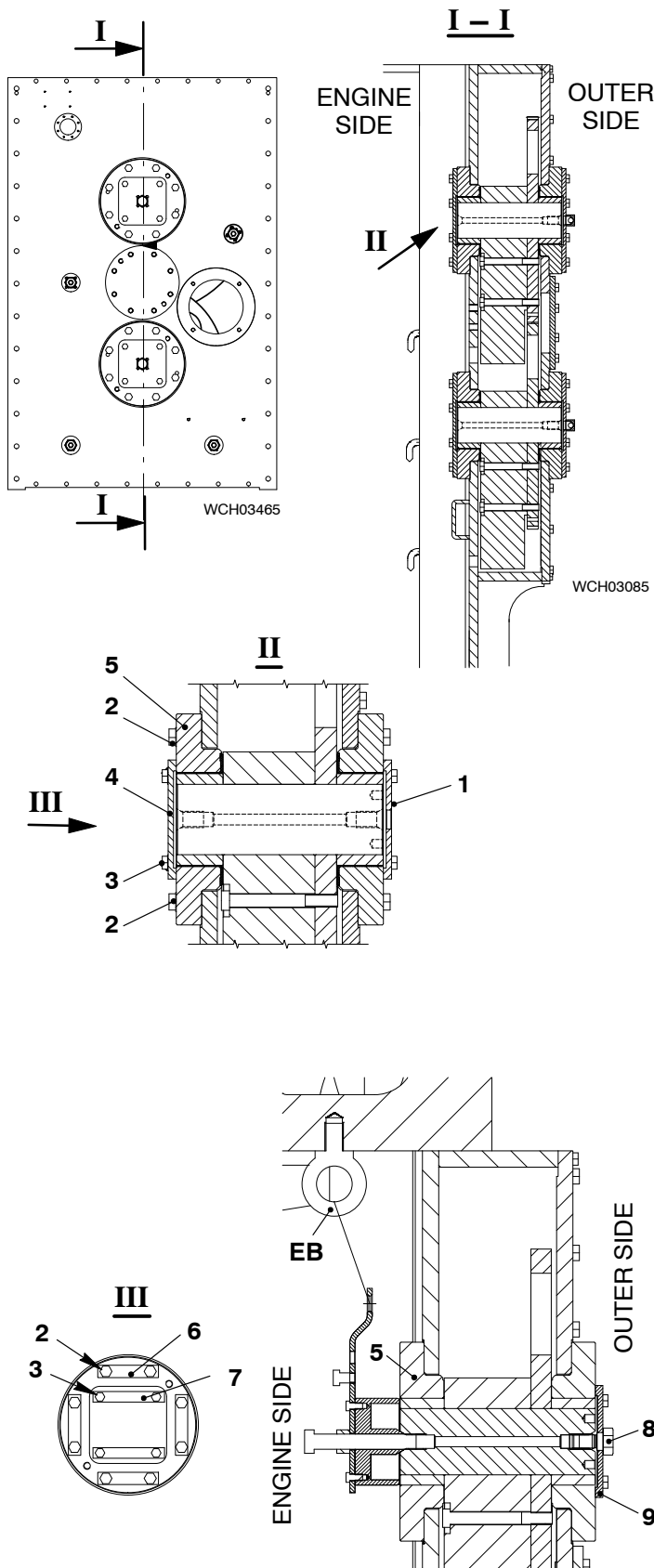


Fig. 4

4. Bearings - Replace

CAUTION

Injury Hazard: The weight of the bearing is 70 kg. Use the correct equipment to lift and move the bearing. This will prevent injury to personnel and damage to equipment.

CAUTION

Damage Hazard: To prevent damage to equipment, do not remove two bearings at the same time.

Note: On the outer side, use the crane and an applicable manual ratchet to lift and move the bearing.

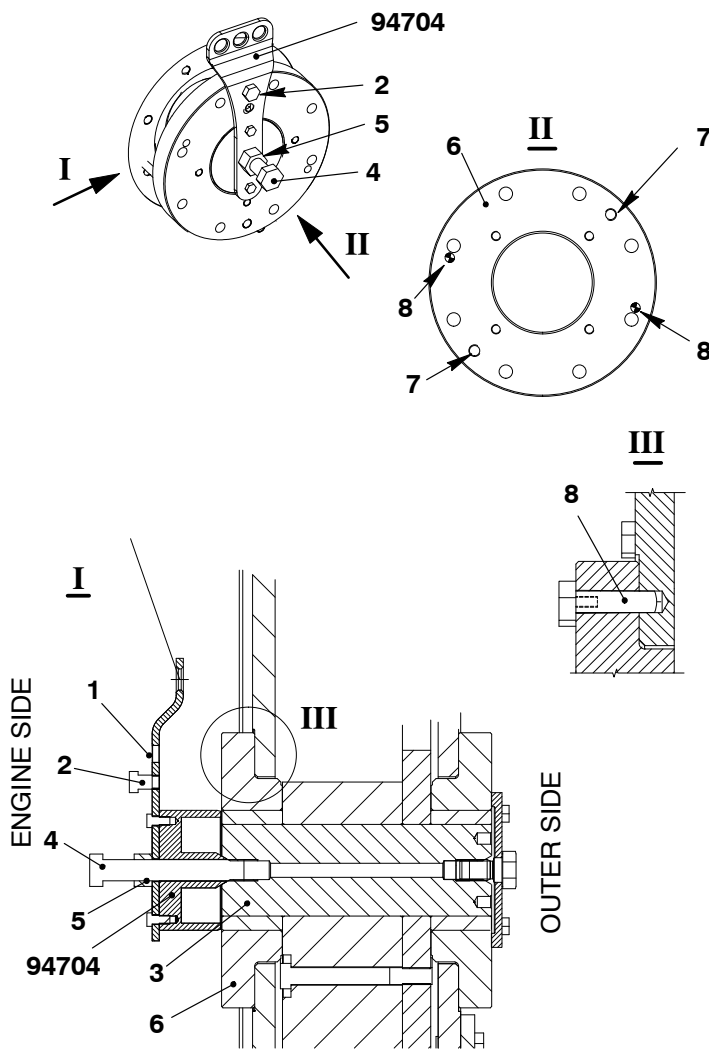
Note: On the engine side, use an applicable manual ratchet and an eye bolt to lift and move the bearing.

4.1 Bearing - Engine Side

4.1.1 Removal

- 1) Attach an eye bolt to the applicable position in the gallery above the 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 150 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).

Integrated Electric Balancer



- 8) Attach the lifting tool (94704) to the manual ratchet. Move the lifting tool in front of the bearing (6, Fig. 5).
- 9) Tighten the screw (4) with your hand.
- 10) Turn the nut (5) against the bearing (6) to push the lifting tool (94704) against the pin (3).
- 11) Put two M20 x 140 mm bolts into the two threads (7) in the bearing (6).
- 12) Tighten equally the two M20 x 140 mm bolts to push out the bearing (6).

Note: The bearing (6) will move on to the lifting tool (94704), refer to Step A.

- 13) Tighten the screw (2) to hold the bearing (6).
- 14) Loosen the nut (5).
- 15) Operate the manual ratchet to hold the weight of the bearing (6), refer to Step B.
- 16) Carefully remove the screw (4).
- 17) Operate the manual ratchet to move the bearing (6) to an applicable area.
- 18) Remove the two taper pins (8).
- 19) Lower the bearing (6).
- 20) Remove the lifting tool (94704).
- 21) Remove the two bolts (7).

Step A

Step B

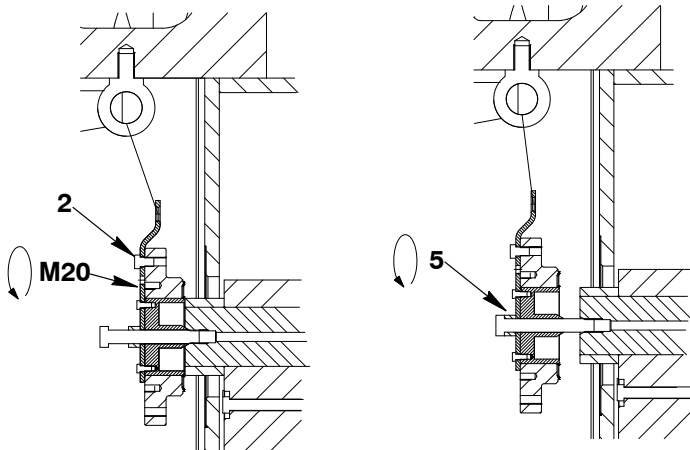


Fig. 5

Integrated Electric Balancer

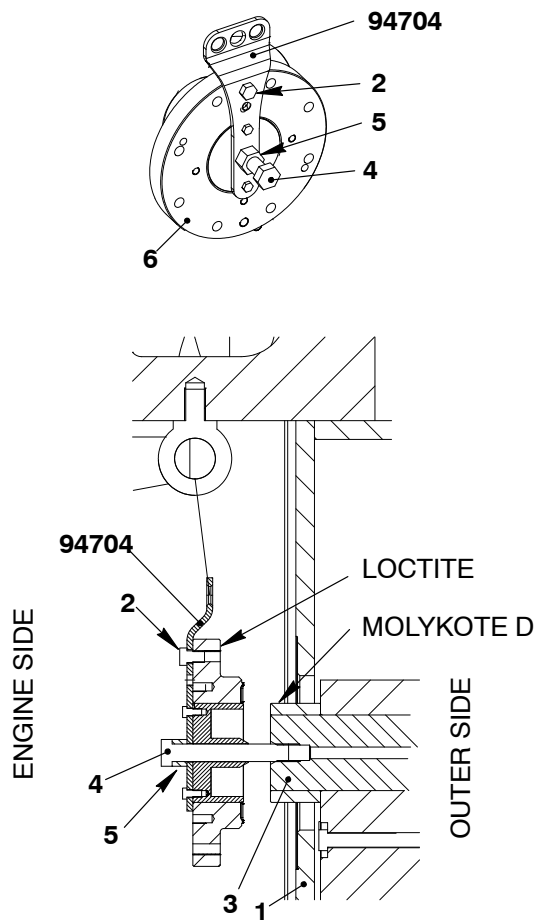


Fig. 6

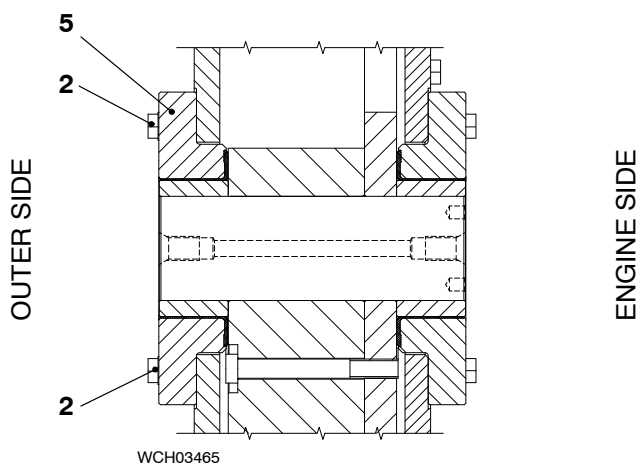


Fig. 7

4.1.2 Installation

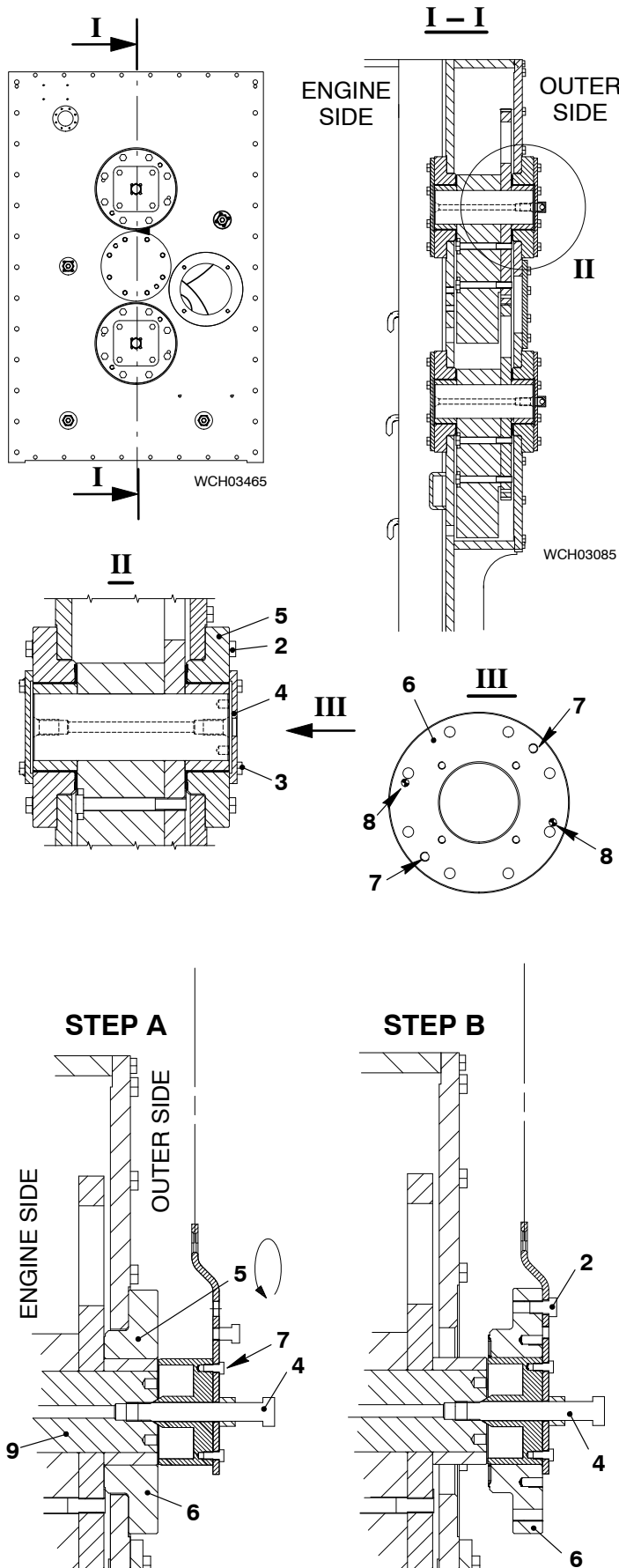
- 1) Make sure that the new bearing is clean, dry and in good condition. Apply Molykote D to the bearing surface.

Note: Do not install the two taper pins (8, Fig. 5).

- 2) Attach the lifting tool (94704) to the bearing (6, Fig. 6).
 - 3) Attach the manual ratchet to the lifting tool (94704).
 - 4) Tighten the screw (2).
 - 5) Operate the manual ratchet to move the bearing (6) in front of the pin (3).
 - 6) Apply Loctite No. 640 to the surface of the bearing (6).
 - 7) Apply Molykote D to the surface of the pin (3).
 - 8) Install the screw (4) together with the nut (5) through the bearing (6) into the pin (3).
 - 9) Remove the screw (2).
 - 10) Align the taper pin holes with the column (1).
 - 11) Turn the bearing (6) until the pin holes in the bearing are at 90° to the holes in the column (1).
 - 12) Tighten the nut (5) and move the bearing (6) into the correct position on the column (1).
- Note: Operate the manual ratchet if the pin (3) is too low.**
- 13) Remove the lifting tool (94704).

- 14) Put four (of the eight) bolts M20x70 (2, Fig. 7) in position. Do not tighten the four bolts at this step.
- 15) Adjust the backlash and the parallelism of the gear wheels, refer to paragraph 5.2.

Integrated Electric Balancer



4.2 Bearing – Outer Side

4.2.1 Removal

- 1) Remove the four screws (3, Fig. 8) from 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 A).
- 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 (9).
- 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).

Note: The bearing (6) will move on to the lifting tool (94704) (STEP B).

- 9) Tighten the 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).

Fig. 8

Integrated Electric Balancer

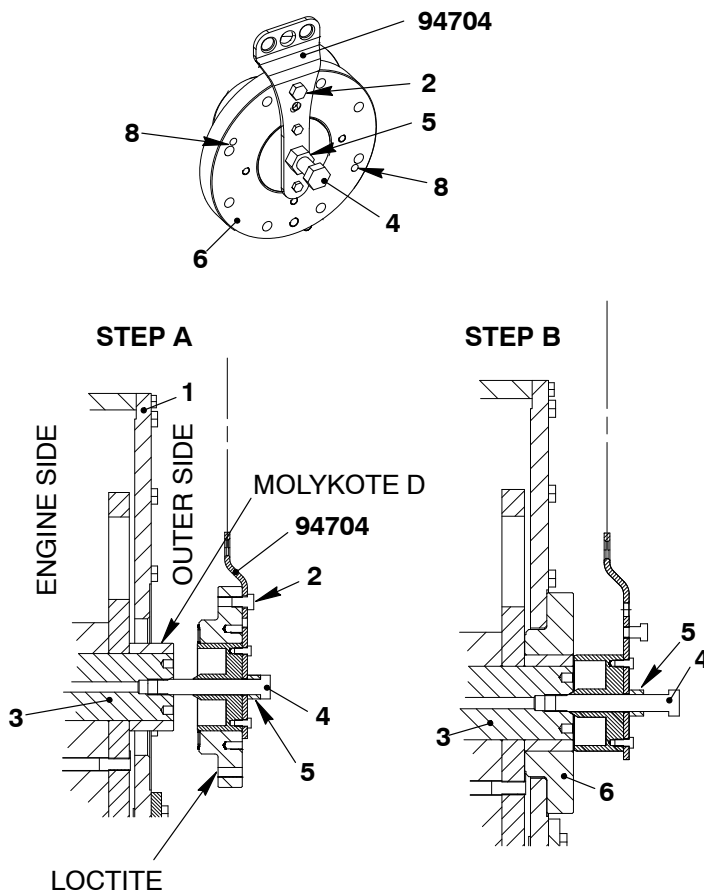


Fig. 9

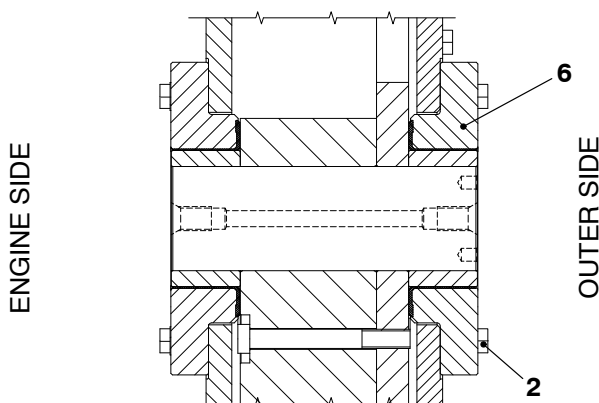


Fig. 10

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4.2.2 Installation

- 1) Make sure that the bearing (6, Fig. 9) is clean, dry and in good condition. Apply Molykote D to the surface of the bearing.

Note: Do not install the two taper pins (8).

- 2) Attach the lifting tool (94704) to the bearing (6).
 - 3) Attach the crane to the tool (94704).
 - 4) Tighten the screw (2).
 - 5) Operate the crane to move the bearing (6) in front of the pin (3).
 - 6) Apply Loctite No. 640 to the surface of the bearing (6).
 - 7) Apply Molykote D to the surface of the pin (3).
 - 8) Install the screw (4) together with the nut (5) through the bearing (6) into the pin (3).
 - 9) Remove screw (2).
 - 10) Align the taper pin holes with the cover (1).
 - 11) Turn the bearing (6) until the pin holes in the bearing are at 90° to the holes in the column (1).
 - 12) Tighten the nut (5) and move the bearing (6) to the correct position on the column (1) (STEP B).
- Note: Operate the crane if the pin (3) is too low.**
- 13) Remove the lifting tool (94704).

- 14) Install four (of the eight) bolts M20x70 (2, Fig. 10) in position. Do not tighten the four bolts at this step.
- 15) Adjust the backlash and the parallelism of the gear wheels, refer to paragraph 5.2.

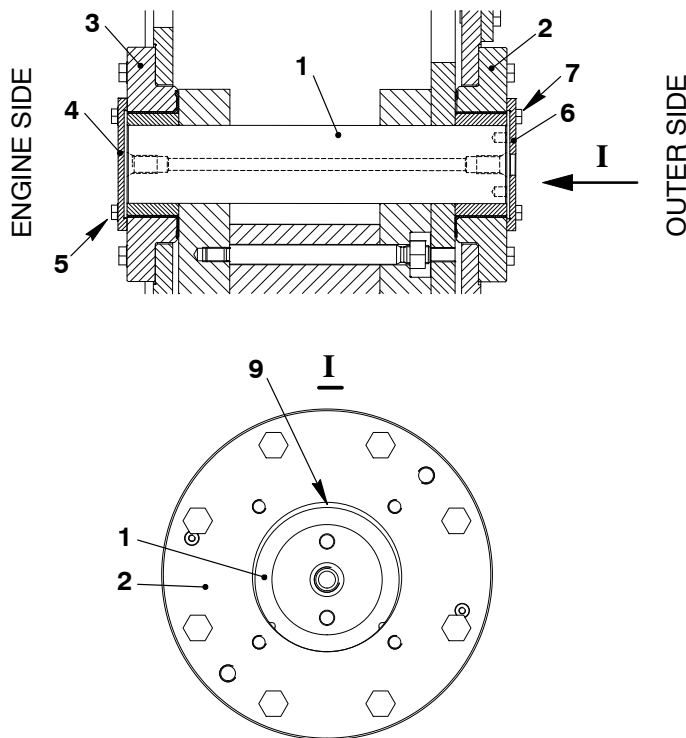


Fig. 11

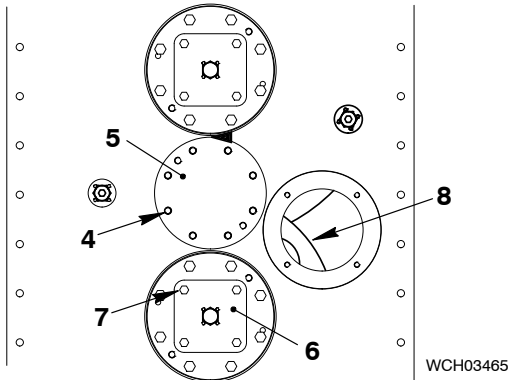


Fig. 12

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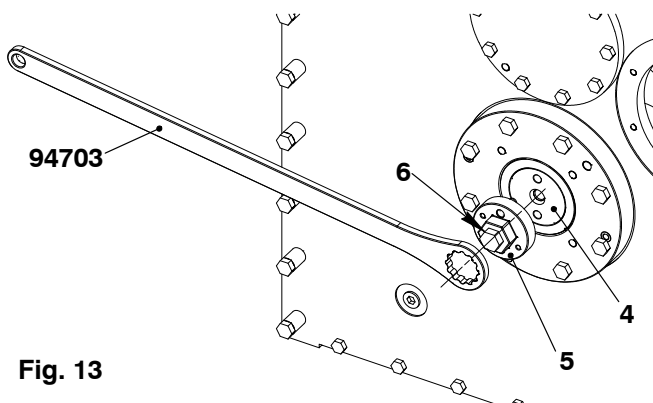


Fig. 13

5. Check

5.1 Bearing Clearance

Note: For the first bearing replacement, speak to, or send a message to WinGD to get data from approved personnel.

- 1) On the engine side, remove the four screws (5, Fig. 11) and the locking plates from the bearing cover (4).
- 2) Remove the bearing cover (4).
- 3) On the outer side, remove the four screws (7) from the bearing cover (6).
- 4) Remove the bearing cover (6).
- 5) Use a feeler gauge to measure the clearance between the pin (1) and the bearings (2, 3) at the top position (9).
- 6) Compare clearance with the data given in 0330 1, Group 7758.
- 7) If the clearance is more than the permitted maximum, replace the bearing.

5.2 Backlash – Measure

- 1) Remove the eight screws (4, Fig. 12) and the cover (5).
- 2) Make sure that the screws (4, Fig. 3) are removed.

Note: You can get access to the service hole (8, Fig. 12) in the engine.

- 3) Measure the backlash between the motor pinion and the bottom gear wheel.
- 4) Remove the four screws (7) on the bottom bearing cover (6) at the outer side.
- 5) Attach the device (94703) as follows:
 - a) Install the socket insert (5, Fig 13) with the screw (6) on the pin (4) of the bottom bearing.
 - b) Torque the screw (6) to 100 Nm.

Integrated Electric Balancer

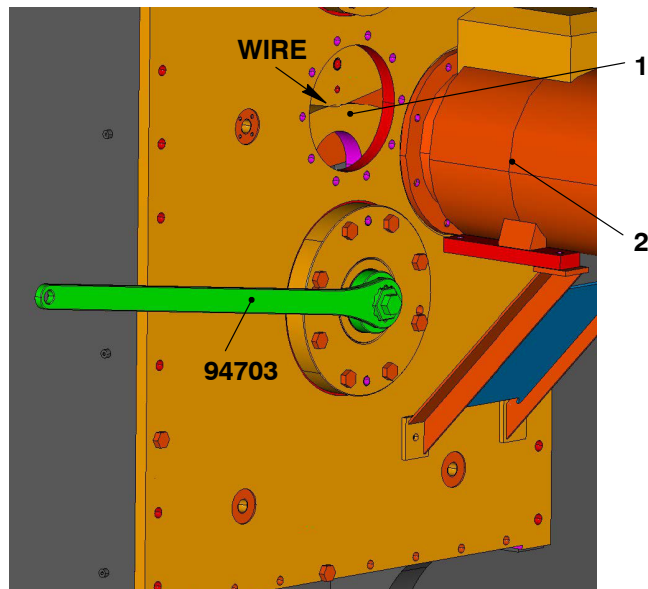


Fig. 14

CAUTION

Injury Hazard: Do not put your hands between the gears that move. This can prevent injury to personnel.

Note: You can get access to the pinion and bottom gear wheel (1, Fig. 14) through a hole at the inner area behind the column.

Note: When you do step 6), use pliers to attach the wire.

- 6) Attach wire of Pb99.9 fine and a diameter of 1.00 mm between the electric motor pinion (2) and the bottom gear wheel (1).
- 7) Refer to 0330 1 Group 7758 to get backlash data.
- 8) Operate the device (94703) to turn the gears. The wire moves between the electric motor pinion (2) and the bottom gear wheel (1).
- 9) Measure the backlash.
- 10) If the backlash of the bottom gear wheel (1) and the electric motor pinion (2) is in the permitted tolerance, do as follows:
 - a) Loosen the bearings of the top gear wheel.

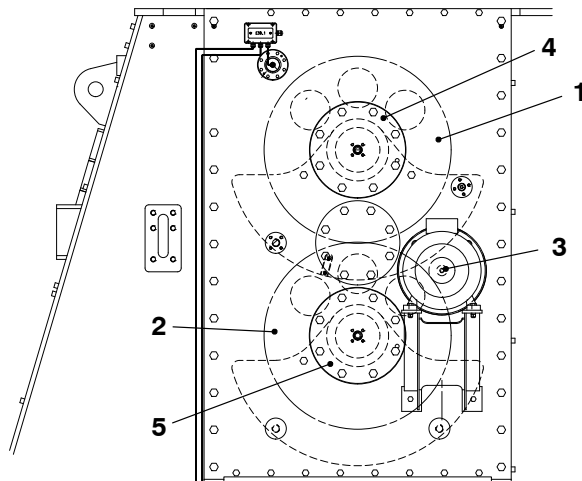


Fig. 15

5.3 Bearings – Adjust

Note: Before you do this task for the first time, speak to, or send a message to WinGD.

- 1) Loosen all bearings.
- 2) Remove the taper pins from all bearings.
- 3) Lift the top bearing.
- 4) Lift the bottom bearings until the backlash between the pinion and the bottom gear wheel is in the permitted tolerance.
- 5) Lower the bottom bearing until the backlash in the permitted tolerance.
- 6) Turn the bearings 90°.
- 7) Use a drill to make new holes for the taper pins.
- 8) Measure the backlash.
- 9) If the backlash of the bottom gear wheel (2, Fig. 15) and the electric motor pinion (3) is in the permitted tolerance, do as follows:
 - a) Loosen the bearings of the top gear wheel.

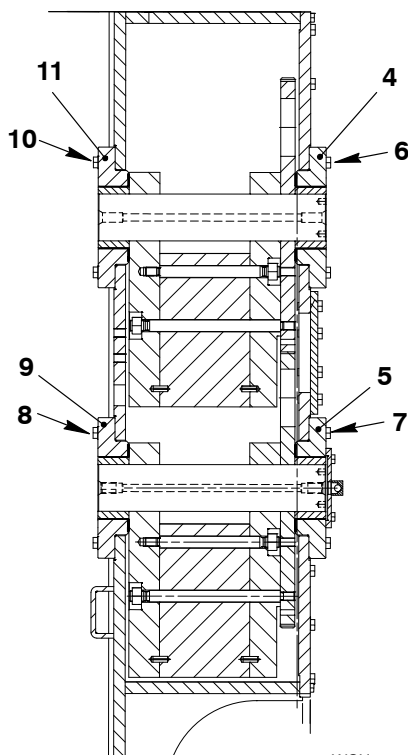


Fig. 16

WCH03469

- 10) Make sure that all the screws (6, 10, 7, and 8, Fig. 16) are loose or removed. One screw for each bearing must stay in position to hold the bearing.
- 11) If you have installed new bearings (4, 11, 5, 9) turn the bearings 90°.
- 12) Use a drill to make new holes for the taper pins after the adjustment procedure.

Integrated Electric Balancer

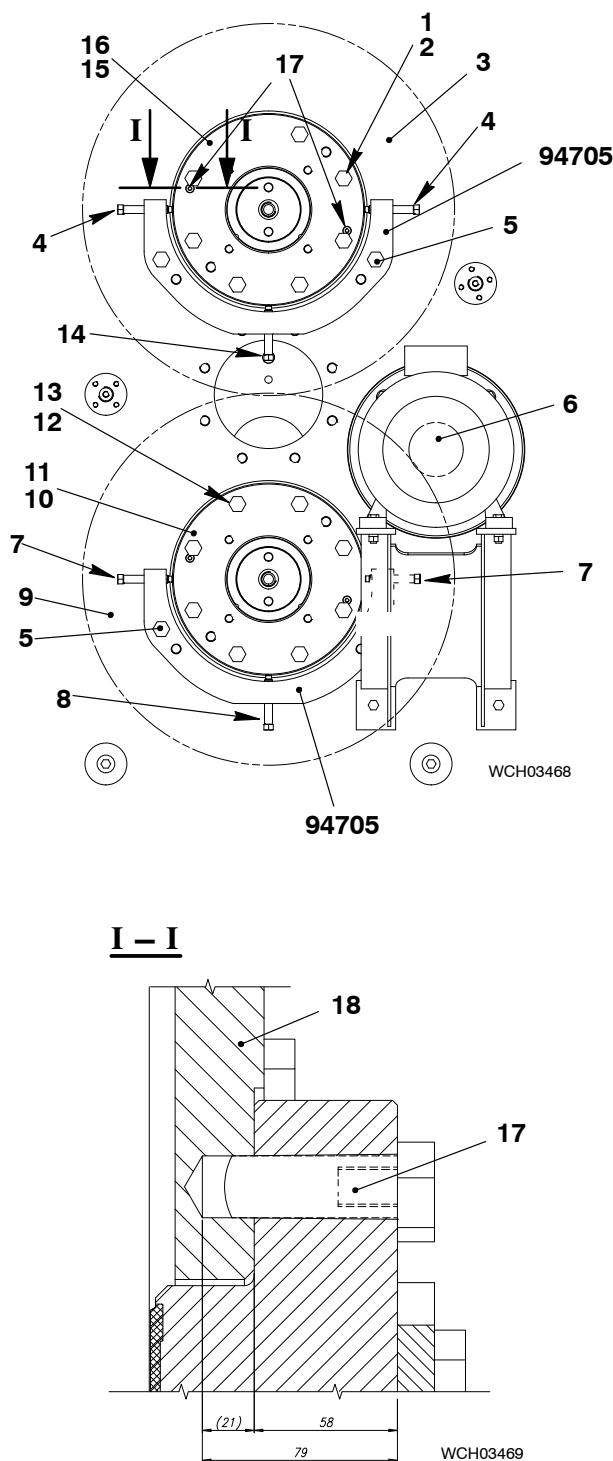


Fig. 17

- 13) Apply oil to the eight screws (5, Fig. 17).
 - 14) Attach the four alignment tools (94705) with the eight screws (5) (two tools for the front and rear of each bearing).
 - 15) Torque the eight screws (5) to 490 Nm.
 - 16) Turn the two screws (14) to lift the front and rear top bearings (15, 16), which removes the load from the bottom gear wheel (9).
 - 17) Adjust the backlash between the electric motor pinion (6) and the bottom gear wheel (9).
 - 18) Measure the backlash, refer to paragraph 5.2.
- Note: During step 19) and step 20), make sure that the top and bottom bearings are parallel.**
- 19) Adjust the bottom bearings (10, 11) as follows:
 - a) Turn the two screws (8) to adjust the height of the bottom bearings.
 - b) Turn the four screws (7) to adjust the horizontal position of the bottom bearings.
 - 20) Adjust the top bearings (15, 16) as follows:
 - a) Turn the two screws (14) to adjust the height of the top bearings.
 - b) Turn the four screws (4) to adjust the horizontal position of the top bearings.
 - 21) Make sure that the adjusted bearings are turned 90°.
 - 22) Measure the backlash again, refer to paragraph 5.2.
 - 23) Use a magnetic drill and a reamer to make holes of depth 21 mm in the covers (18) for the 25x70 mm taper pins (two holes for each of the four covers).
 - 24) Put two taper pins (17) for each bearing into the new holes.

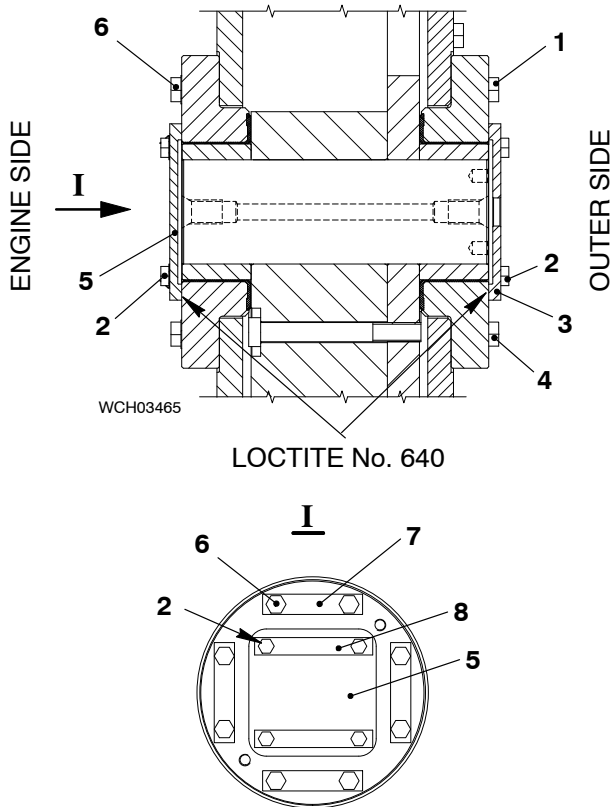


Fig. 18

6. Completion

- 1) Attach the eight M20x70 bolts (1, Fig. 18) to the outer side of each bearing.
- 2) Torque the eight M20x70 bolts (1) to the value given in 0352 2, paragraph 1.
- 3) Apply Loctite No. 640 to the surfaces that touch on the bearing cover (3).
- 4) Attach the bearing cover (3) to the bearing with the four M16x35 screws (3).
- 5) Torque the four M16x35 (3) to the value given in 0352 2, paragraph 1.
- 6) Attach the locking plates (7) to the engine side of each bearing with the eight M20x70 bolts (6).
- 7) Torque the eight M20x70 bolts (6) to the value given in 0352 2, paragraph 1.
- 8) Remove the four alignment tools 94705.
- 9) Apply Loctite No. 640 to the surfaces that touch on the bearing cover (2).
- 10) Attach the bearing cover (5) to the bearing on the engine side with the four M16x35 screws (2).
- 11) Torque the four M16x35 screws (2) to the value given in 0352 2, paragraph 1.
- 12) Install the oil pipes (1, Fig.2) that you removed before.
- 13) Open the oil inlet.
- 14) Set to on the lubricating oil supply.

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Electric Balancer Sensor Unit

Replacement of Proximity Sensor

1. General

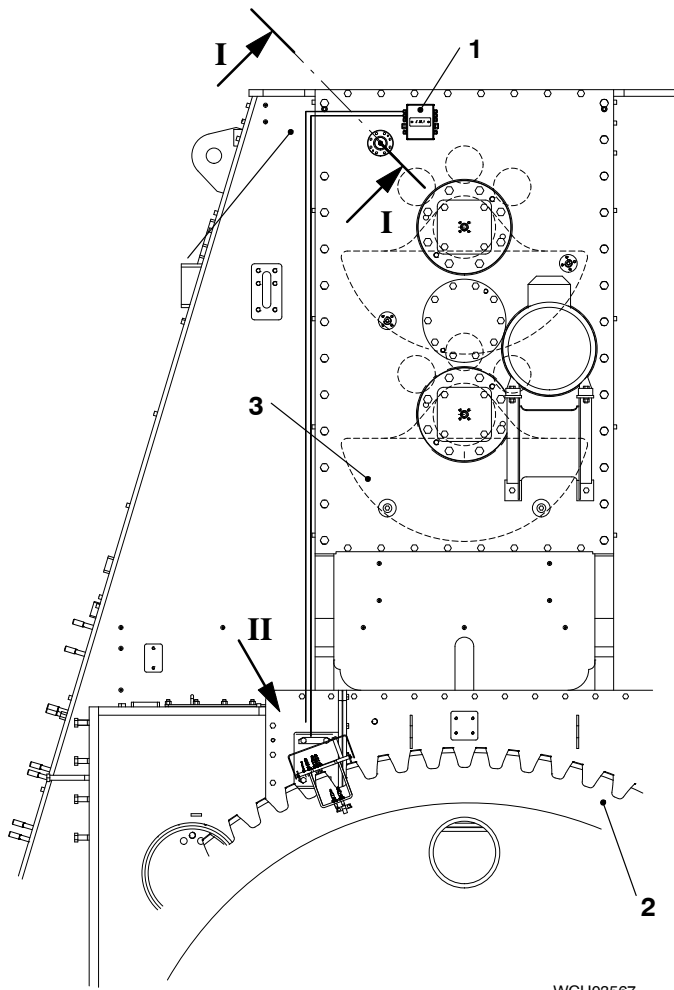
One proximity sensor is installed on each end of the engine. The proximity sensors give the position and speed of the balance weights (3, Fig. 1).

The proximity sensors are installed in the positions that follow:

- ZS5401C on the Driving End
- ZS5405C on the Free End

The proximity sensors are connected to the terminal box (1).

Two more proximity sensors (ZS5141C and ZS5142C) for engine speed and crank position are installed above the flywheel (2) near the crank angle sensors (view II).



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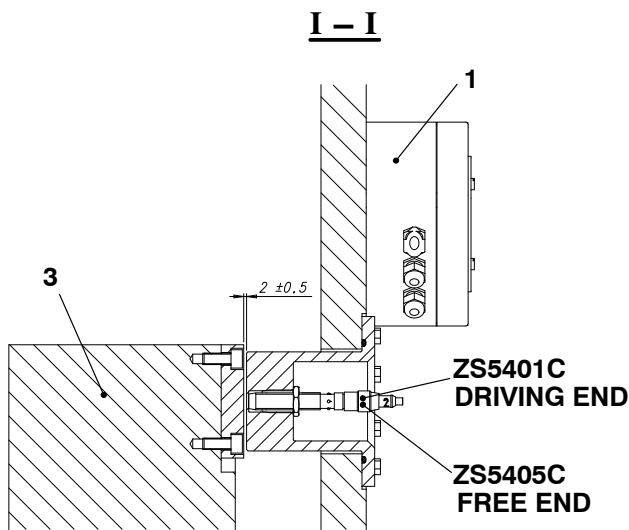
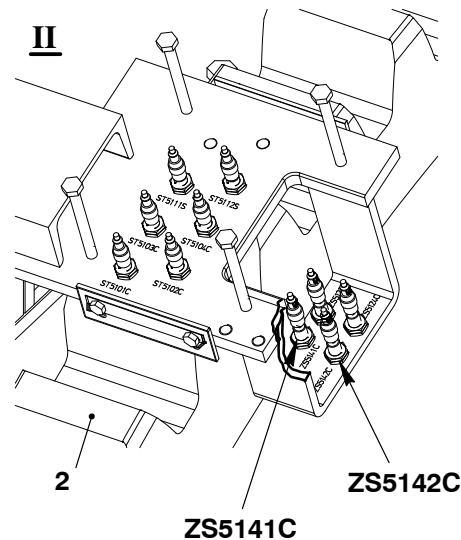


Fig. 1



WCH03463

Crank Angle Sensor Unit: Replacement of Proximity Sensor

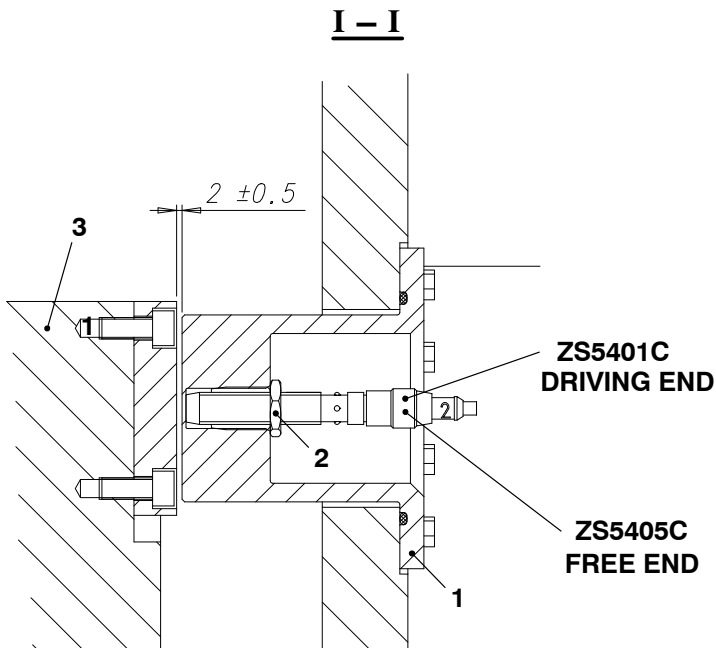


Fig. 2

WCH03462

2. Procedures

2.1 Balance Weights Proximity Sensors – Replace

- 1) Disconnect the electrical connection from the applicable proximity sensor (ZS5401C or ZS5405C, Fig. 2).
- 2) Loosen the nut (2).
- 3) Remove the applicable proximity sensor (ZS5401C or ZS5405C).
- 4) Attach the new sensor fully into the sensor adapter (1).
- 5) Tighten the lock nut (2).
- 6) Connect the electrical connection the proximity sensor.
- 7) Do a check of the Alarm System in the LDU for Signal Failure (refer also to the Operation Manual, Chapter 4002 2).

Note: Some designs do not have a connection to the Alarm System. These designs have a control box (Lenze Drive), which shows a signal failure. This control box is installed in the control cabinet.

2.2 Flywheel Proximity Sensors – Replace

Note: Refer to Fig. 1, view II for the location of the proximity sensors.

- 1) Disconnect the electrical connection from the applicable proximity sensor (ZS5141C or ZS5142C, Fig. 3).
- 2) Measure the distance (Y). Use this distance when you install the new proximity sensor.
- 3) On the applicable proximity sensor, loosen the nut and lock nut (1).
- 4) Remove the applicable proximity sensor.
- 5) Put the new proximity sensor in the holder (2) to the measured distance (Y).

Note: If the proximity sensor (ZS5141C) is directly above the crank angle mark, do step 6) and step 7), then continue from step 8).

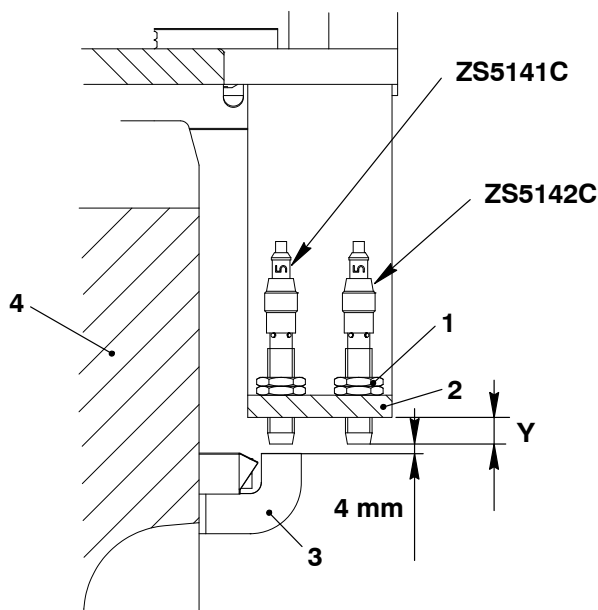


Fig. 3

WCH03462

Electric Balancer Sensor Unit: Replacement of Proximity Sensor

- 6) Put the new proximity sensor (ZS5141C) in the holder (2, [Fig. 3](#)) until the sensor touches the crank angle mark (3).
- 7) Turn the proximity sensor (ZS5141C) back four turns (4.0 mm).
- 8) Tighten the nut and lock nut (1).
- 9) Connect the electrical connection to the applicable proximity sensor.
- 10) Do a check of the Alarm System in the LDU for Signal Failure (refer also to the Operation Manual, Chapter 4002 2).

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Piping

Group 8

Exhaust Waste Gate (Low-load Tuning)	8135	1/A1
Selective Catalytic Reduction System	8135	2/A1
SCR Valve – Removal and Installation	8155	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

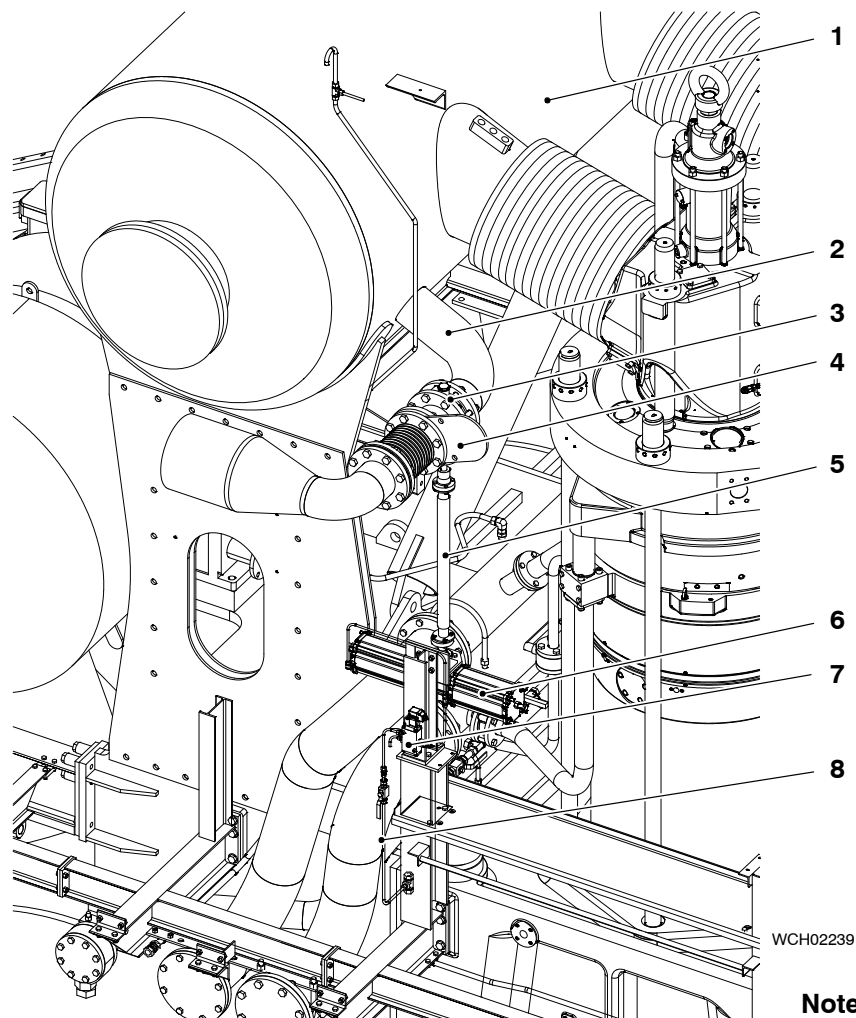
The Low-load Tuning (LLT) uses a specially designed turbocharger system and specified engine parameters. These parameters are related to fuel injection and exhaust valve control and get the best decreased part-load BSFC in LLT.

For more data about the exhaust waste gate and LLT, refer to 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, refer to 8135 1 in the Operation Manual and the Maintenance Schedule 0380 1, [Exhaust Waste Gate](#) (LLT).



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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Exhaust Waste Gate (Low-load Tuning)

4. General

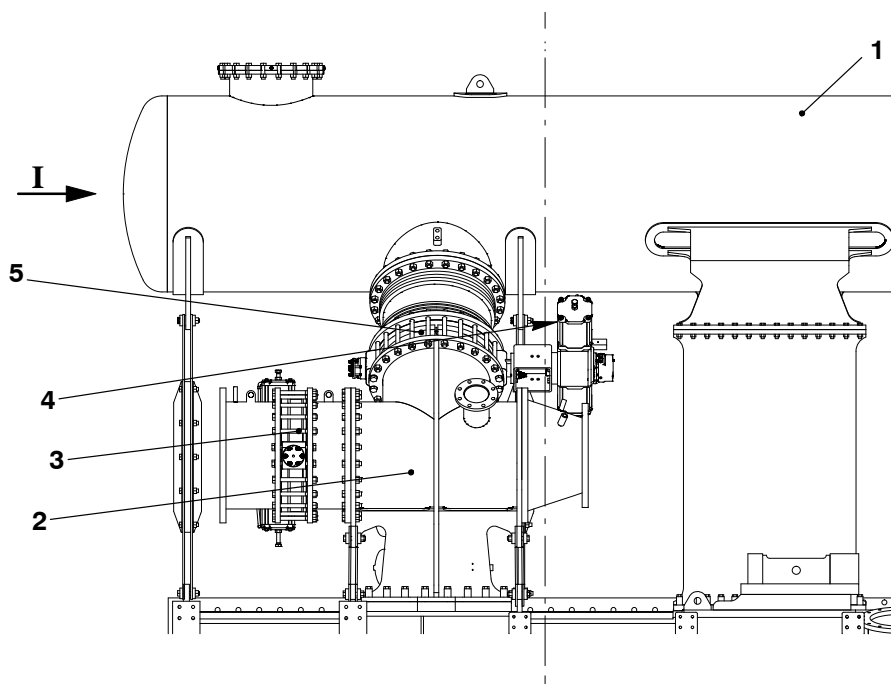
The high pressure Selective Catalytic Reduction System (SCR) is an optional system to decrease the level of nitrogen oxides in the exhaust gas. This makes sure that the emissions of nitrogen oxides obey the Tier III regulation of the International Maritime Organisation (IMO).

Nitrogen oxides are dangerous and are made in secondary reactions in the engine during fuel combustion.

5. Maintenance

Special maintenance of the butterfly valves (3 and 5, [Fig. 1](#)) is not necessary. For a general inspection, refer to the instructions in the documentation of the manufacturer.

To remove the butterfly valves (3 and 5) refer to 8155 1.



For View I, refer to [Fig. 2](#)

Fig. 1: SCR Bypass System

- | | |
|--------------------|-------------------|
| 1 Exhaust manifold | 3 Butterfly valve |
| 2 Bypass pipe | 4 Actuator |
| 5 Butterfly valve | |

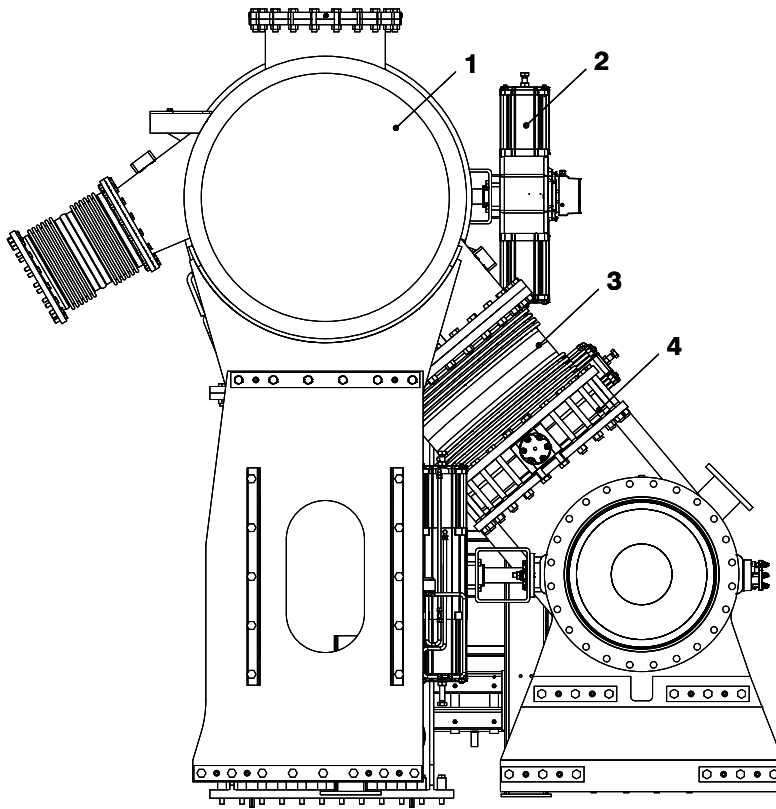


Fig. 2: SCR Bypass System

- | | |
|--------------------|-------------------|
| 1 Exhaust manifold | 3 Butterfly valve |
| 2 Bypass pipe | 4 Actuator |
| 5 Butterfly valve | |

SCR Valve – Removal and Installation

Tools:

- 1 Lifting tool 94815 1 Sling 94049F

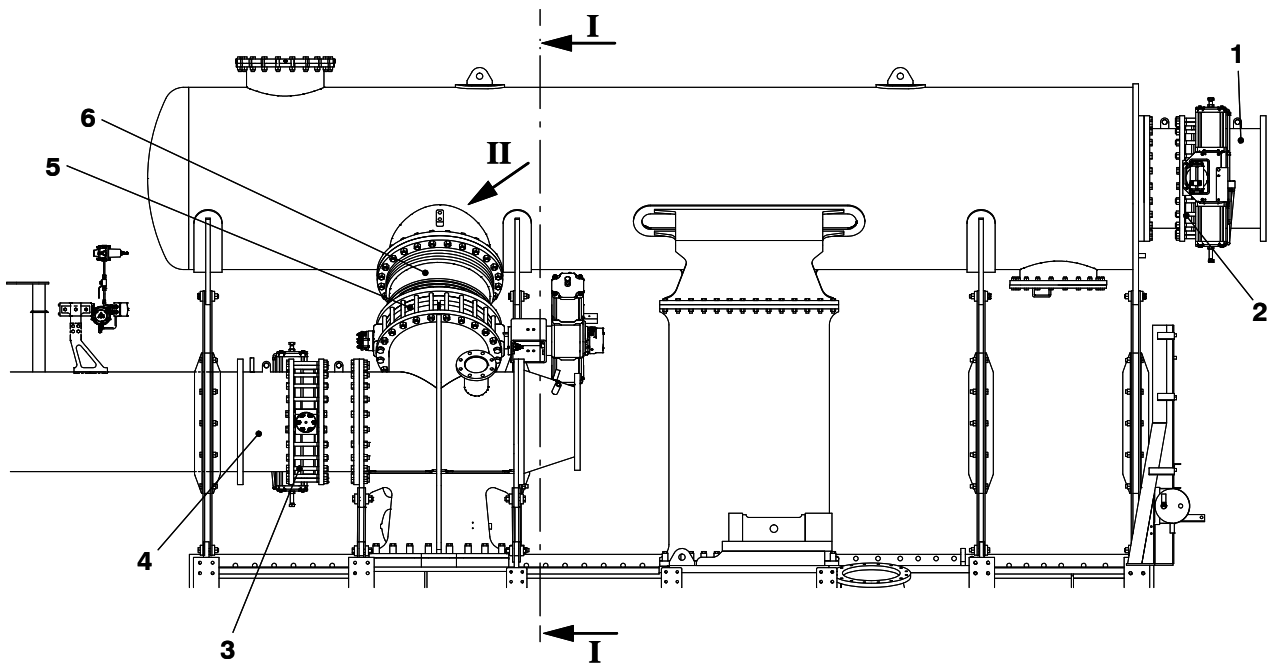
1. Preparation

Note: The preparation, removal and installation procedures that follow are for the SCR valve (6). The procedures for the other SCR valves (2, 3) are almost the same.

- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 2) Stop the SCR system, refer to the Operation Manual 9270 1.
- 3) Stop the control air supply, refer to the Operation Manual 4605 1.
- 4) Close the ball valve 50 8135_E0_3, refer to Operation Manual 4003 10.
- 5) Make sure that the SCR valve (2, Fig. 1) is in the closed position, refer to the documentation of the valve supplier.

2. Procedure

2.1 Removal



For Views and I I and II, refer to Fig. 2

Fig. 1: SCR System – Overview

- | | |
|-------------|-------------------|
| 1 Pipe | 4 Pipe |
| 2 SCR Valve | 5 Expansion piece |
| 3 SCR Valve | 6 SCR valve |

SCR Valve Removal and Installation

- 1) Disconnect the electrical connections from the feedback positioner (12, Fig. 2).
- 2) Remove the four bolts (11) from the holder (10).
- 3) Remove the actuator (9) and the holder (10) from the SCR valve (3).
- 4) Put the sling (94049F) around the expansion piece (6).
- 5) Attach the sling to the engine room crane.
- 6) Operate the engine room crane to put a light tension on the sling (94049F).

Note: The expansion piece has an extension of 17 mm.

- 7) Carefully remove the 24 M27x110 nuts (7) and bolts (8).
- 8) Operate the engine room crane to remove the expansion piece (6).
- 9) Remove the 20 nuts (1) and M27x280 bolts (5).
- 10) Remove the flange (4).
- 11) Remove the gasket (not shown).

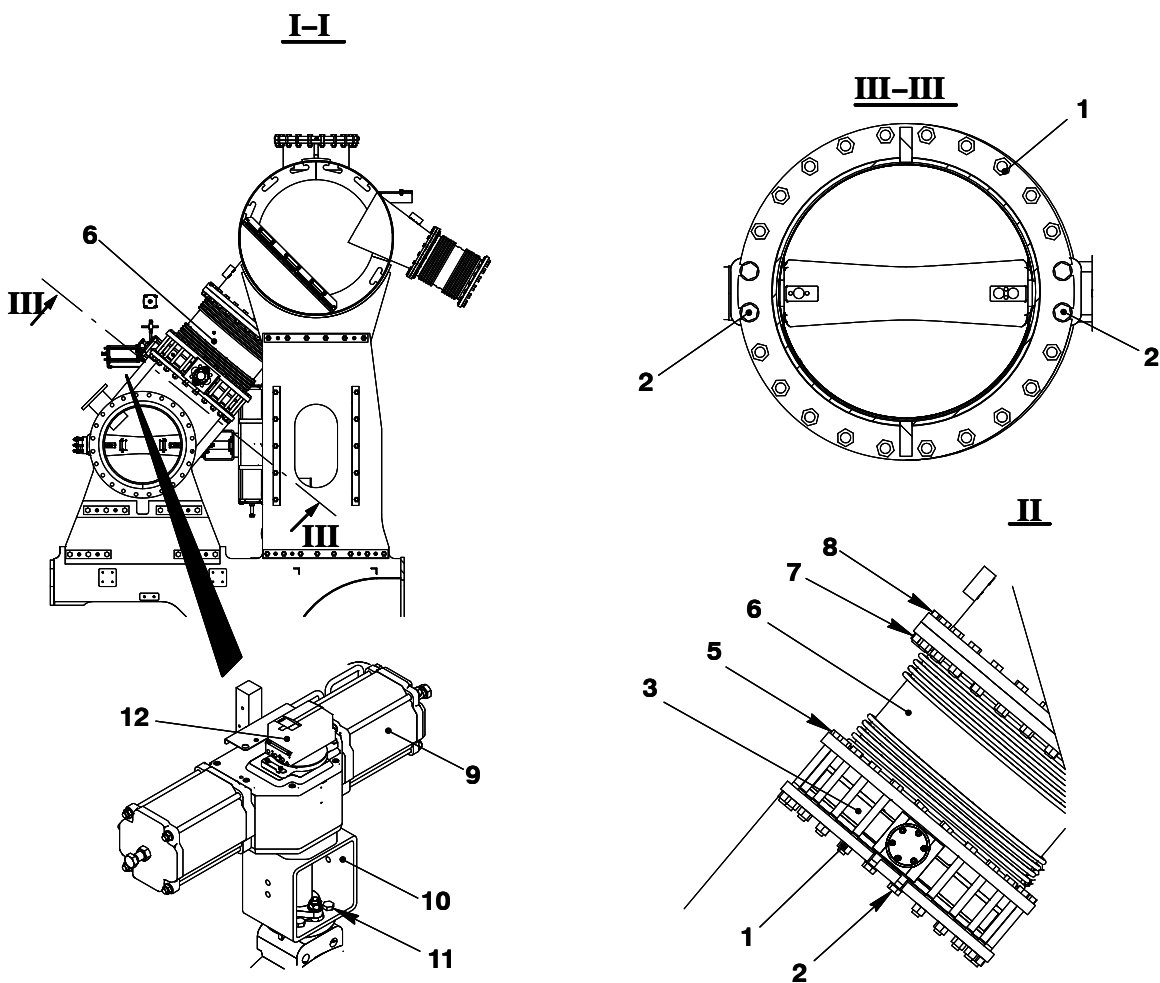


Fig. 2: SCR Valve – Removal

CAUTION

Injury Hazard: The lifting tool (94815) and the plate weighs approximately 50 kg. The SCR valve weighs approximately 300 kg. Use only applicable equipment to lift and move the lifting tool and the SCR valve.

- 12) Record the position of the SCR valve (2).
- 13) Attach the lifting tool (94815) to the SCR valve (2, Fig. 3)
- 14) Lock the lifting tool (94815) with the four M16x55 screws (1).
- 15) Torque the four screws (1) to 200 Nm.
- 16) Attach the plate (4) to the lifting tool (94815) in a vertical position
- 17) Lock the plate (4) with the screws (3).
- 18) Torque the two screws (3) to 145 Nm.
- 19) Attach the engine room crane to the shackle on the plate (4)
- 20) Remove the four screws (2, Fig. 2).
- 21) Operate carefully the engine room crane to lift the SCR valve (2, Fig. 3).
- 22) Move the SCR valve (2) to an applicable area.
- 23) Remove the lifting tool (94815) from the SCR valve (2).
- 24) Remove the plate (4) from the lifting tool (94815).

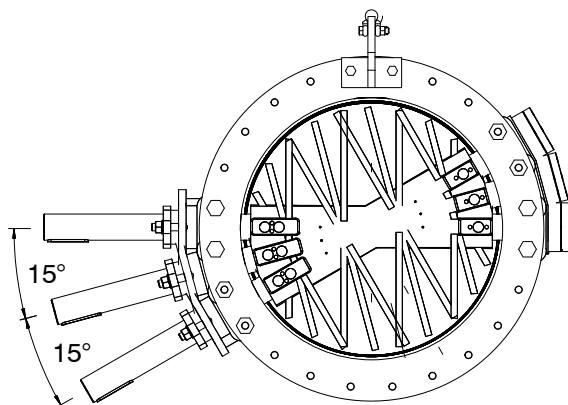
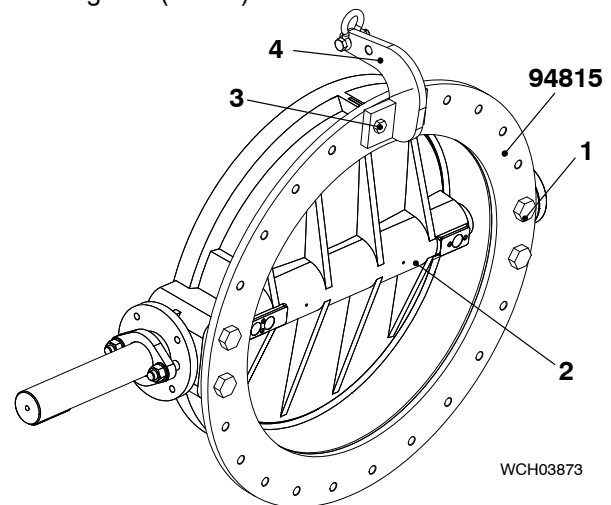


Fig. 3



2.2 Installation

- 1) Attach the lifting tool (94815) to the SCR valve (2).
- 2) Lock the lifting tool (94815) with the four M16x55 screws (1).

Note: When you do step 3), make sure that you attach the plate in the correct position.

- 3) Attach the plate (4) to the lifting tool (94815) in a vertical position with the two screws (3).
- 4) Torque the two screws (3) to 145 Nm.
- 5) Attach the engine room crane to the shackle on the plate (4).

SCR Valve Removal and Installation

- 6) Operate the engine room crane to lift the SCR valve (2).
- 7) Operate the engine room crane to lower the SCR valve into position (Fig. 4).
- 8) Remove the lifting tool (94815).
- 9) Put a new gasket (not shown) in position.
- 10) Attach the SCR valve (4) to the flange (3) with the four M27x80 screws (2).
- 11) Torque the four screws (2) to the value given in 0352 2/A1.
- 12) Put the sling (94049F) around the expansion piece (7).
- 13) Attach the engine room crane to the sling (94049F).
- 14) Operate the engine room crane to lift and move the expansion piece (7) into position.
- 15) Lower the expansion piece (7) into position on to the SCR valve (4).
- 16) Put the flange (5) in position.
- 17) Attach two of the M27x280 bolts (6) and nuts (1) to the top and bottom of the flanges (3, 5).
- 18) Attach the expansion piece (7) with the 24 nuts (8) and M27x110 bolts (9).
- 19) Attach the remaining M27x280 bolts (6) and nuts (1) to the top and bottom of the flanges (3, 5).
- 20) Remove the sling (94049F) from the expansion piece (7).
- 21) Torque symmetrically the M27x280 bolts (6) and nuts (1) to the value given in 0352 2/A1.
- 22) Torque symmetrically the 24 nuts (8) and M27x110 bolts (9) to the value given in 0352 2/A1.

3. Completion

- 1) Make sure that the SCR valve (4) can move freely, refer to the documentation of the valve supplier.
- 2) Open the ball valve 50 8135_E0_3, refer to Operation Manual 4003 10.
- 3) Start the control air supply, refer to the Operation Manual 4605 1.
- 4) Start the SCR system, refer to the Operation Manual 9270 1.
- 5) Start the automatic valve movement procedure to make sure that the SCR valve operates correctly, refer to the Operation Manual 9270 1.

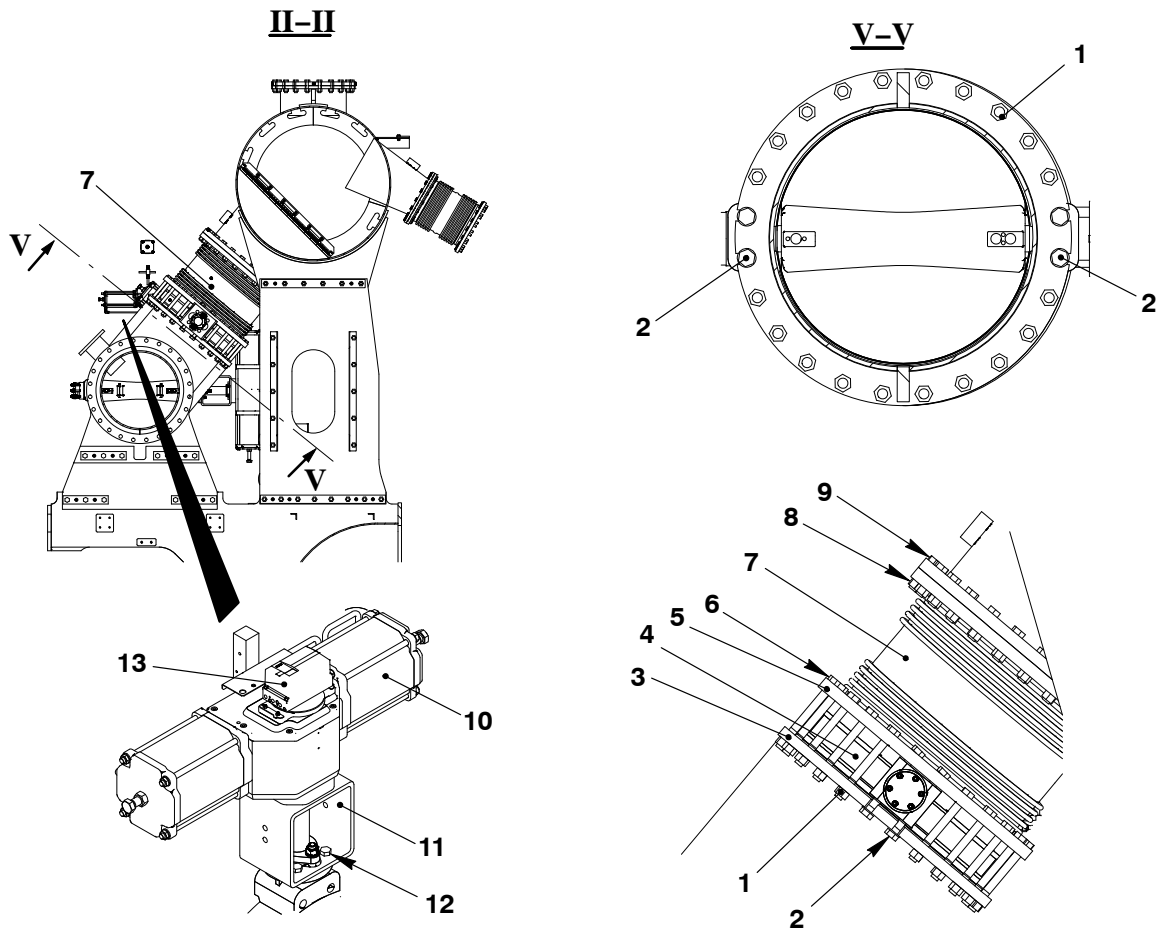


Fig. 4

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HP Servo Oil Pipe

Removal, Grind Sealing Faces and Installation (with DYNEX Servo Oil Pipe)

Tools:

- 1 Grinding tool 94841 Emery cloth (as necessary)
- 1 Template 94841A 1 Hand drill

- 1. Preparation 1
- 2. Removal 1
 - 2.1 HP servo oil pipe (3) – Remove 2
 - 2.2 HP servo oil pipes (1 and 2) – Remove 2
- 3. Sealing Faces – Grind 3
- 4. Adjustment 4
- 5. Installation 4

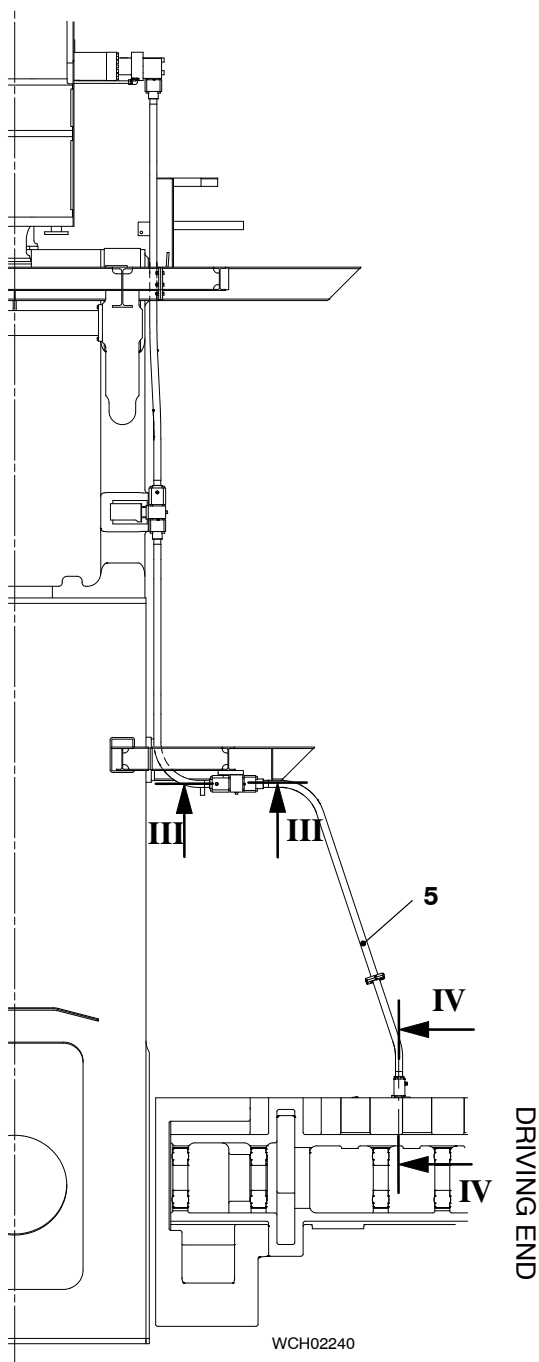


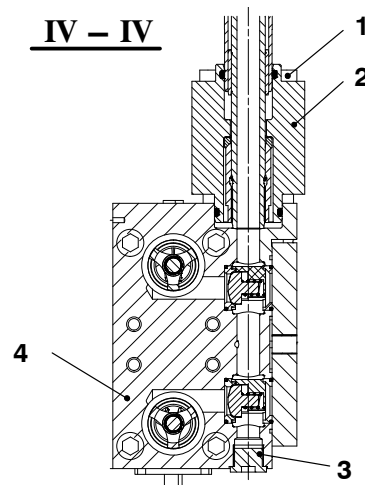
Fig. 1

WCH02240


1. Preparation

- 26) Stop the engine, refer to the Operation Manual 0310 1.
- 27) Make sure that the servo oil service pump is set to off.
- 28) Put an oil tray under the applicable servo oil pump.
- 29) Loosen the screw plug (3, Fig.1) to drain the HP servo oil pipes.
- 30) Loosen the four screws (1) on the flange (2).
- 31) Push down the flange (2) to get air into the HP servo oil pipe (5).

After approximately one minute, the oil will drain from the HP servo oil pipes.



2. Removal

CAUTION	
	Damage Hazard: Make sure that you do not cause damage to the sealing faces or the HP servo oil pipes.

2.1 HP Servo Oil Pipe (3) – Remove

- 1) Remove the bottom clamp (4).
- 2) Remove the screws (1) of the bottom flange (2).
- 3) Push back the flange (2) until they disengage.
- 4) Remove the HP servo oil pipe (5).

2.2 HP Servo Oil Pipes (1 and 2) – Remove

- 1) Remove the clamp (8, [Fig. 2](#)) from HP servo oil pipe (7).
- 2) Loosen the screws (2) of bottom flange (1).
- 3) Remove the screws (6) and bottom intermediate pieces (5).
- 4) Loosen the screws (3) of the top flange (4).
- 5) Carefully remove the HP servo oil pipe.
- 6) Apply protection to the sealing faces (SF) to prevent damage.

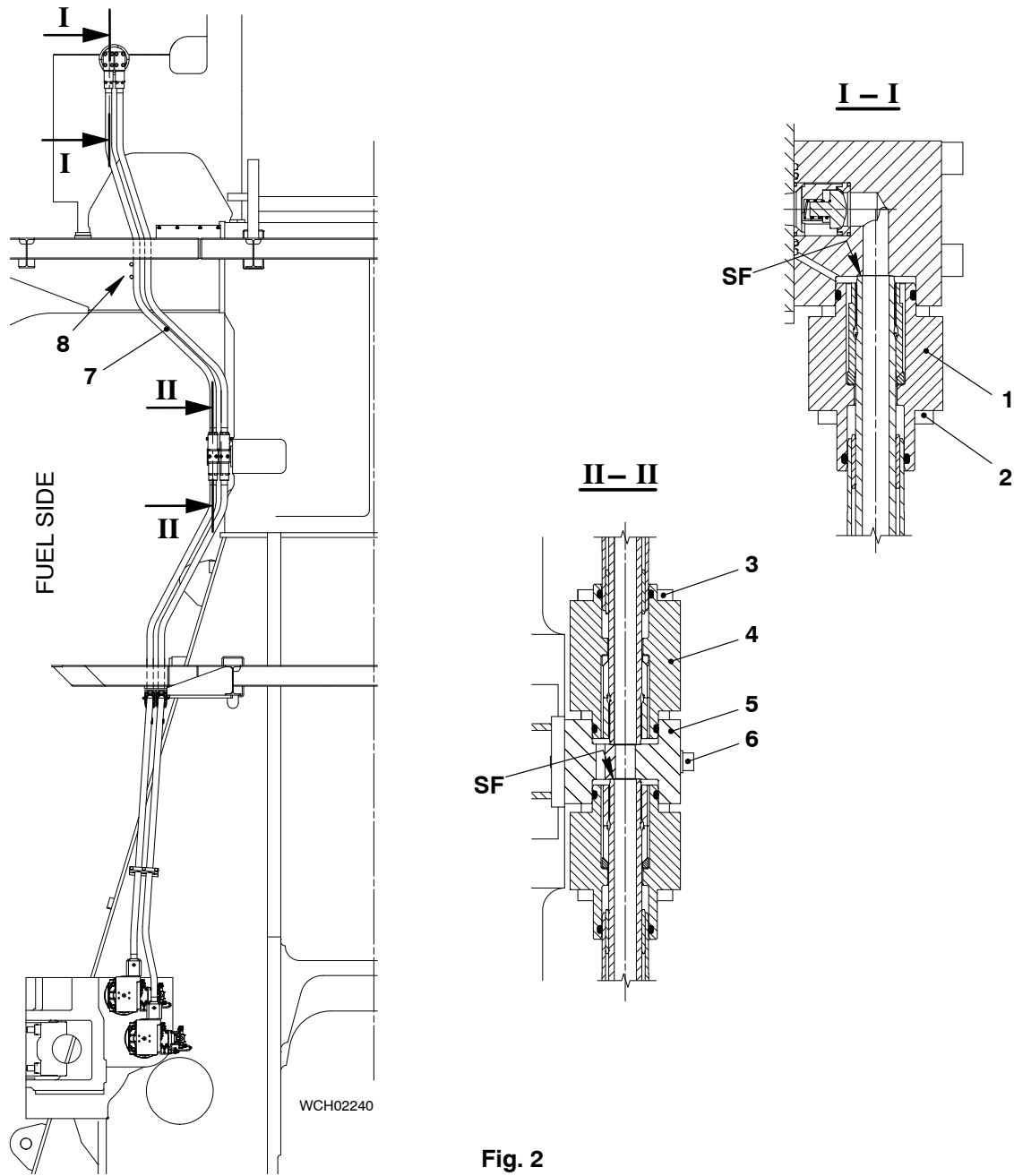
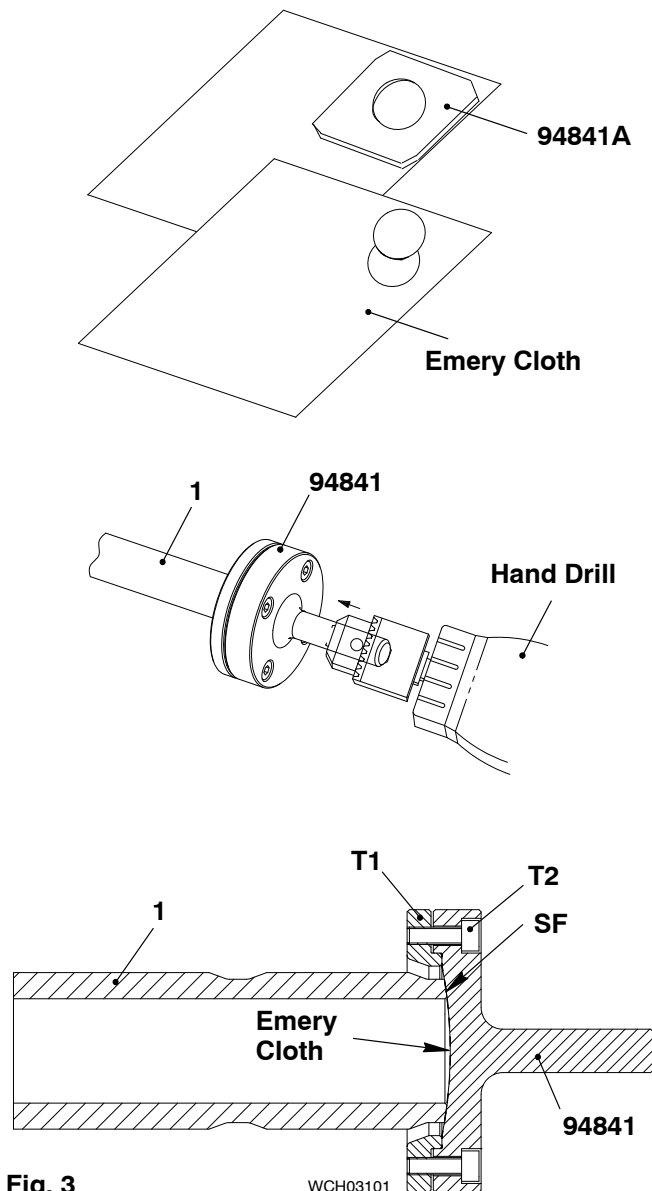


Fig. 2

3. Sealing Faces – Grind

To get a clean and smooth finish on the hydraulic pipe, do step 1) to step 18):

- 1) Put the stencil (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 hydraulic pipe (1) in a vice, as vertically as possible.
 - 10) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the hydraulic pipe (1).
 - 11) Torque symmetrically the four screws (T2) to 2.0 Nm.
 - 12) Adjust the speed of the hand drill 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).
- Note: Make sure that the circular marks around the sealing face of the pipe are concentric.**
- 16) Change the emery cloth for a smoother grade, then do step 1) to step 15) again until you get a smooth finish.
 - 17) Replace the emery cloth with a polishing cloth as a last step to polish the HP servo oil pipe.
 - 18) Clean the HP servo oil pipe (1).
 - 19) If necessary, do step 1) to step 18) for the other servo oil pipes.



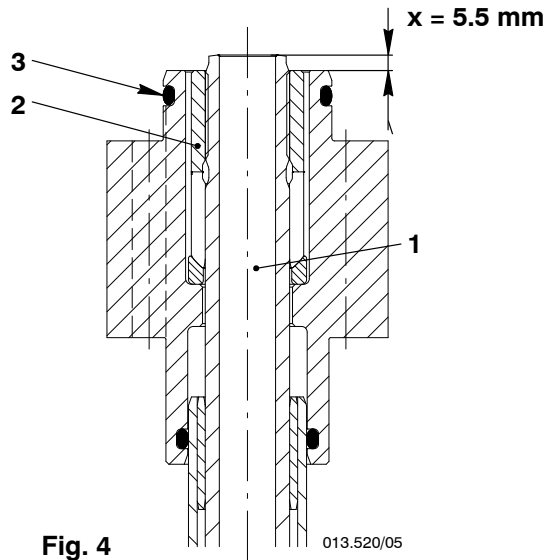
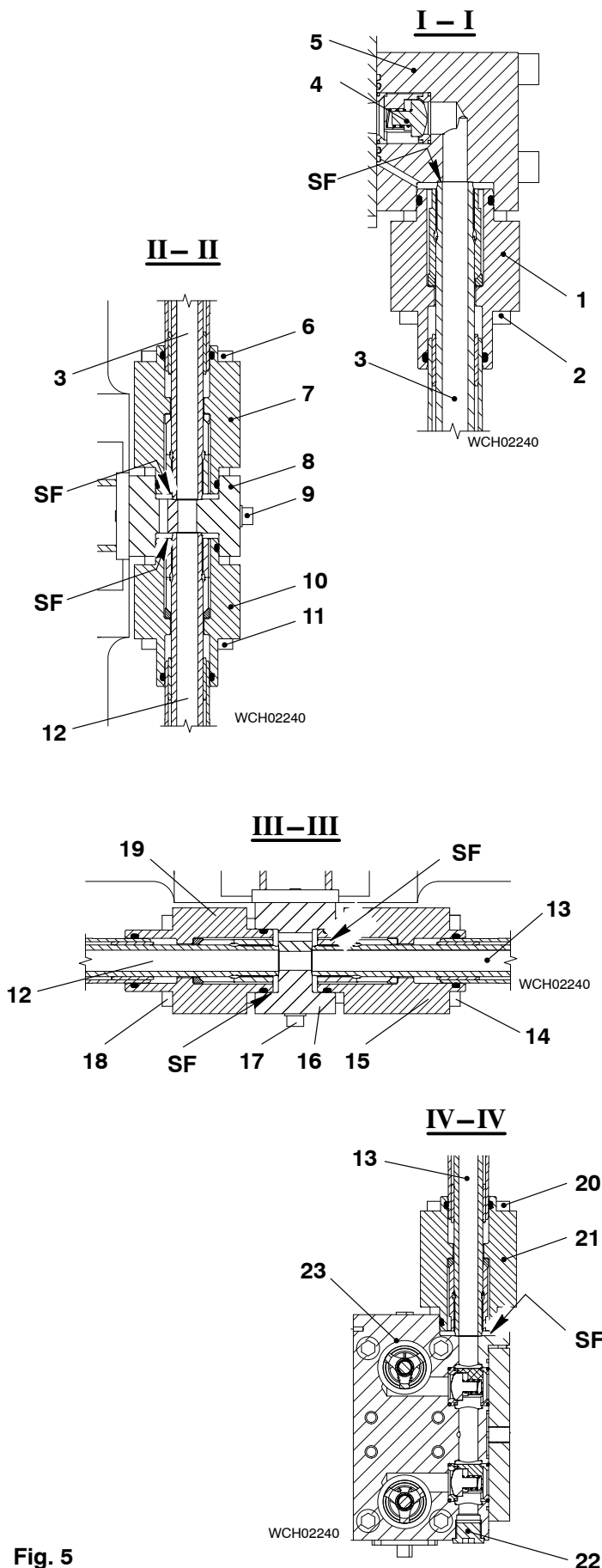


Fig. 4

4. Adjustment

- 1) Make sure that the claw (2, Fig. 4) is correctly attached to the HP servo oil pipe (1).
- 2) Do a check of the O-ring (3). If the O-ring is unserviceable, remove and discard it.
- 3) Make sure that there is a distance of 5.5 mm between the end of the HP servo oil pipe (1) and the claw (2).

Note: You can adjust the claw (2) with an open-ended wrench.



5. Installation

- 1) Remove all of the protection from the sealing faces (SF) in the valve housing (5, Fig. 5), the intermediate pieces (8, 16) and the servo oil pump (23).
- 2) Apply oil to the threads of all the screws (2, 6, 11, 14, 18, and 20)
- 3) Carefully put the HP servo oil pipe (3) in position in the valve housing (5) and the intermediate piece (8).
- 4) Torque symmetrically the screws (2 and 6) to 20 Nm.
- 5) Attach the intermediate piece (16) to the plate (20). Do not torque the screws (17) at this step.
- 6) Carefully put the HP servo oil pipe (12) in position in the intermediate piece (8) and the intermediate piece (16).
- 7) Torque symmetrically the screws (11 and 18) to 20 Nm.
- 8) Carefully put the HP servo oil pipe (13) in position in the intermediate piece (16) and the servo oil pump (23).
- 9) Torque symmetrically the four screws (14 and 20) to 20 Nm.
- 10) Torque the screws (9) on the intermediate piece (8) to 20 Nm.
- 11) Torque the two screws (17) on the intermediate piece (16) to 20 Nm.

Fig. 5

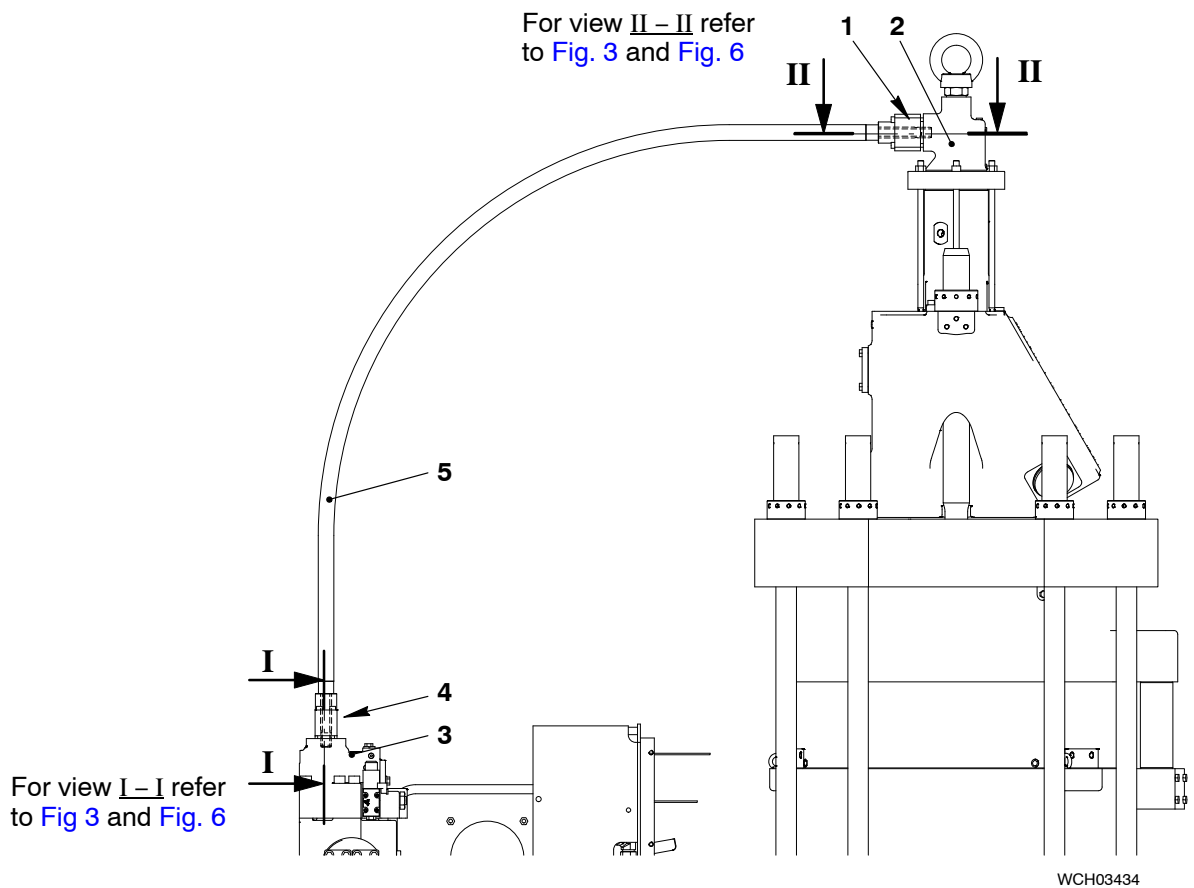
Hydraulic Pipe for Exhaust Valve Drive

Hydraulic Pipe – 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



WCH03434

Fig. 1 Exhaust Valve Control Unit

- 1 Flange
- 2 Top housing
- 3 Exhaust valve control unit (VCU)
- 4 Flange
- 5 Hydraulic pipe

1. Preparation

WARNING



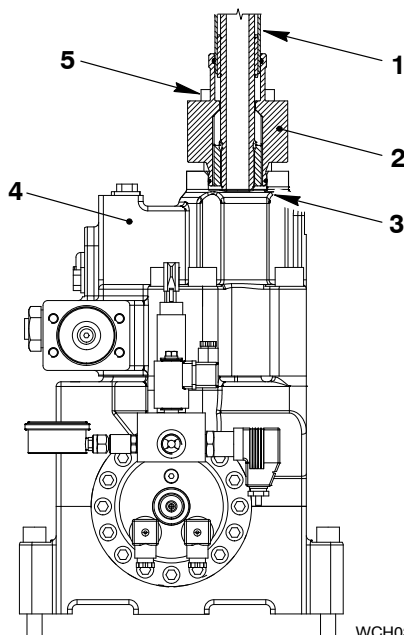
Injury Hazard: The servo oil system has high pressure. Replace a defective hydraulic pipe only when the engine has stopped.

WARNING



Injury Hazard: You must 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.

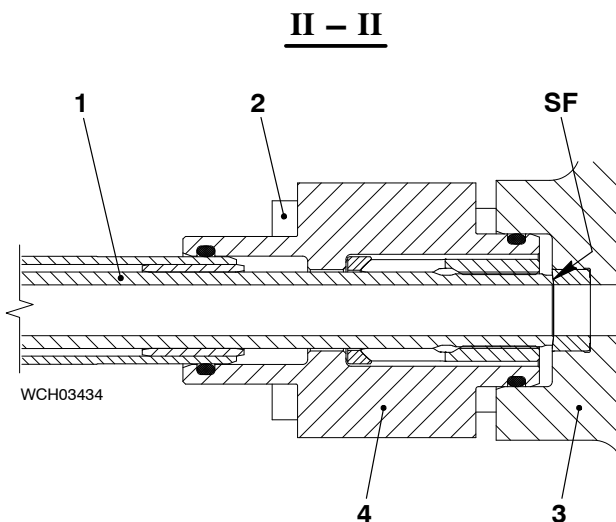
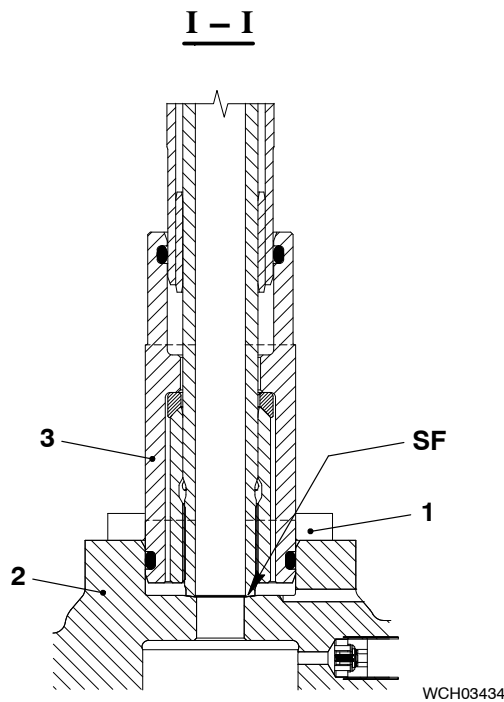
- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 2) Set to off the servo oil service pump.
- 3) Make sure that there is no pressure in the servo oil system, refer to the Operation Manual 0520-1, paragraph 2.3.
- 4) Set to off the main bearing oil supply.



- 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).

Fig. 2

WCH03434



2. Removal

CAUTION



Damage Hazard: Make sure that you do not damage the sealing faces or the hydraulic pipes.

- 1) Remove the four screws (1) (View I-I, Fig. 3) from the flange (3).
- 2) Carefully move the flange (3) away from the VCU (2).

- 3) Remove the four screws (2) (View II-II, Fig. 3) 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 18 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.

Fig. 3

Hydraulic Pipe Exhaust Valve Drive: Removal, Grind Sealing Faces and Installation

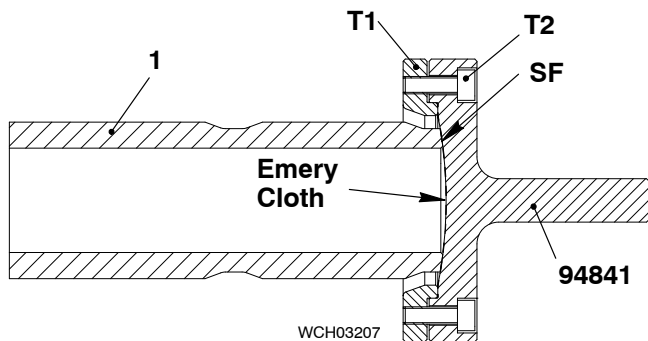
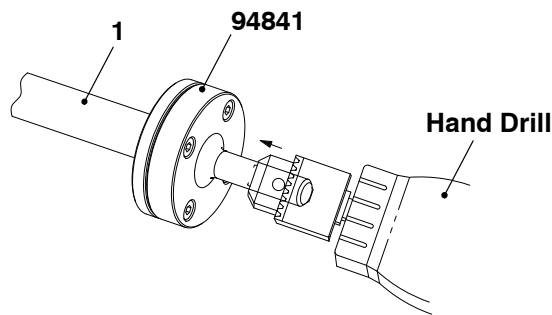
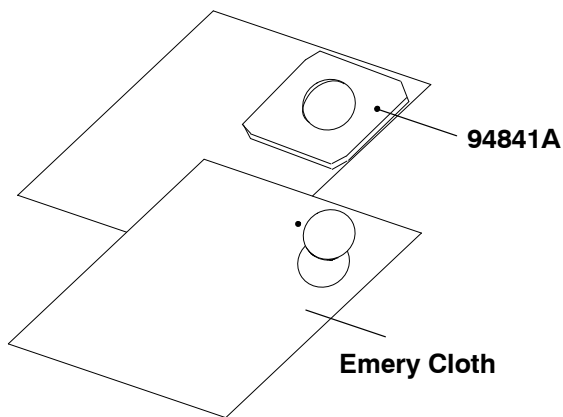


Fig. 4

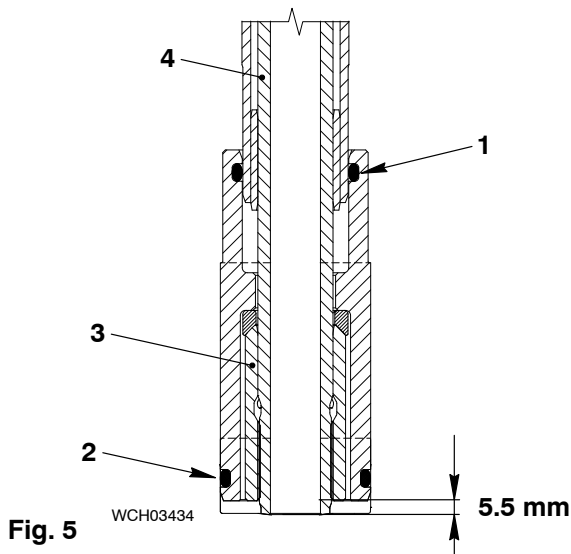
3. Sealing Faces – Grind

To get a clean and smooth finish on the hydraulic pipe (1, Fig. 4), do step 1) to step 18):

- 1) Put the template (94841A) on to 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 hydraulic pipe (1) in a vice, as horizontally as possible.
- 10) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the hydraulic pipe (1).
- 11) Torque symmetrically the the four screws (T2) to 2.0 Nm.
- 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).

Note: Make sure that the circular marks around the sealing face of the hydraulic pipe (1) are concentric.

- 16) Change the emery cloth for a smoother grade, then do step 1) to step 15) again until you get a smooth finish.
- 17) Replace the emery cloth with a polishing cloth as a last step to polish the hydraulic pipe (1).
- 18) Clean the hydraulic pipe (1).
- 19) If necessary, do step 1) to step 18) for the other hydraulic pipes.



4. Adjustment

- 1) Remove the protection from the hydraulic pipe (4)
- 2) Make sure that the claw (3, Fig. 5) is correctly attached to the hydraulic pipe (4).
- 3) Do a check of the O-rings (1, 2). If the O-rings are unserviceable, replace them.
- 4) Make sure that there is a distance of 5.5 mm between the end of the hydraulic pipe (4) and the claw (3).

Note: You can adjust the claw (3) with an open-ended wrench.

5. Installation

CAUTION	
	<p>Damage Hazard: Make sure that you do not cause damage to the sealing faces (SF) or the hydraulic pipes. Do not apply lateral force to the hydraulic pipe and the flanges.</p>

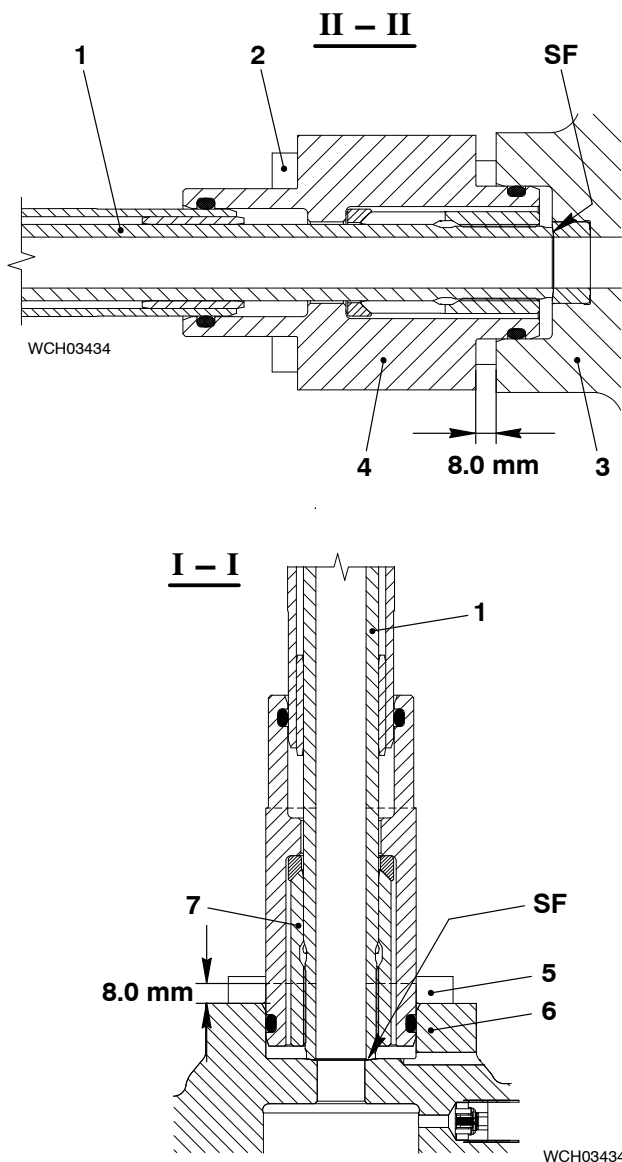


Fig. 6

- 1) Remove all of the protection from the sealing faces (SF, Fig. 6) in the top housing (3) and the VCU (6).
- 2) Apply oil to the threads of the screws (2, 5).
- 3) Carefully put the hydraulic pipe (1) in position in the top housing (3) and the VCU (6).
- 4) Torque symmetrically the four screws (2) to 40 Nm.
- 5) Make sure that there is a distance of 8.0 mm between the flange (4) and the top housing (3).
- 6) Torque symmetrically the four screws (5) to 40 Nm.
- 7) 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 4) to step 7) again.

- 8) Set to on the main bearing oil supply.

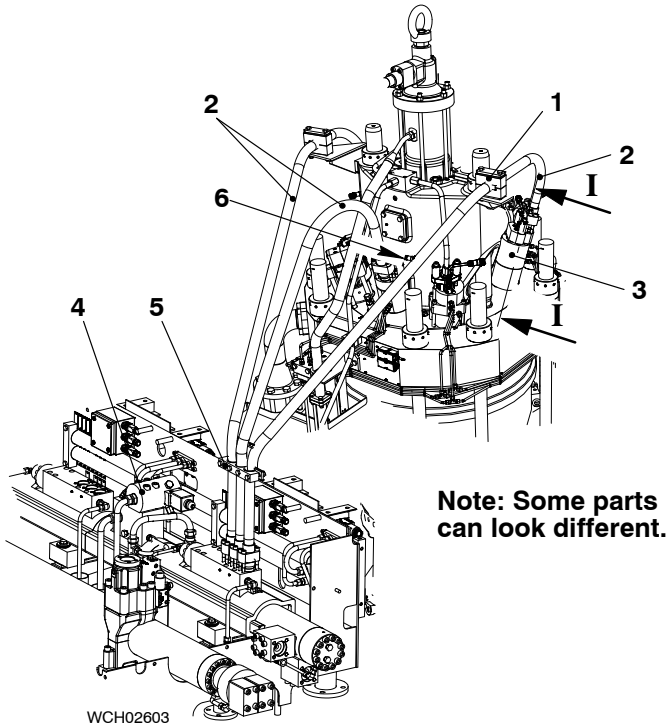
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HP Fuel Pipe

Removal, Grinding and Installation

Tools:

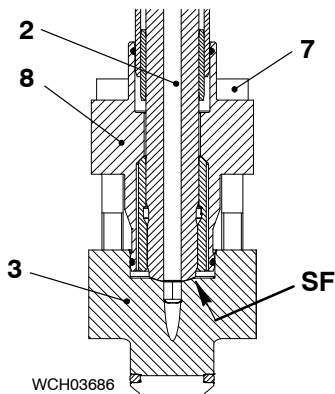
- 1 Grinding tool 94871
- 1 Stencil 94871A



Note: Some parts can look different.

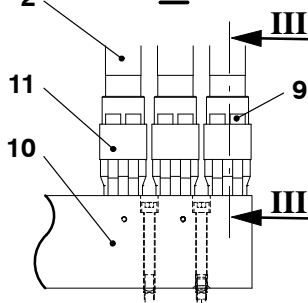
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I - I



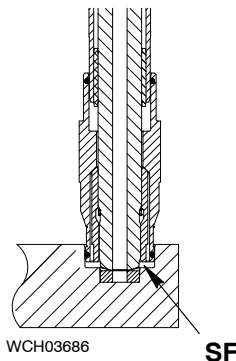
WCH03686

II



WCH03686

III - III




WCH03686

SF

1. Preparation

- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 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) Push 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	
	<p>Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP injection pipes.</p>

- 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).

Fig. 1

HP Fuel Pipe (Injection Valve): Removal, Grinding and Installation

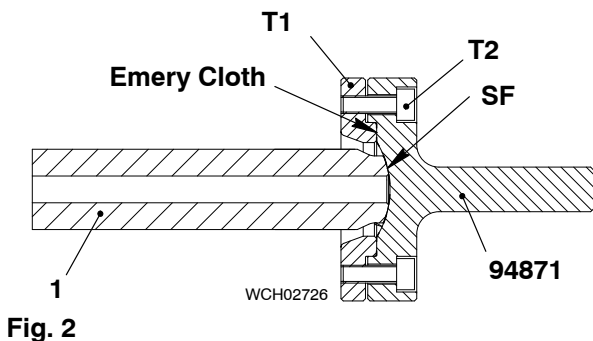
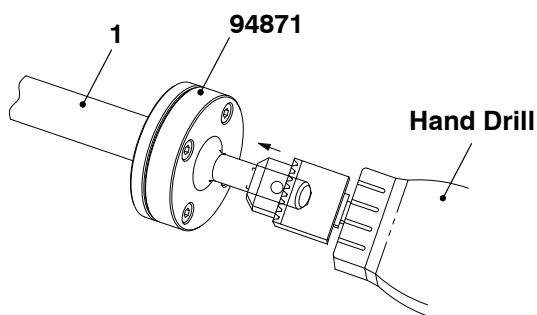
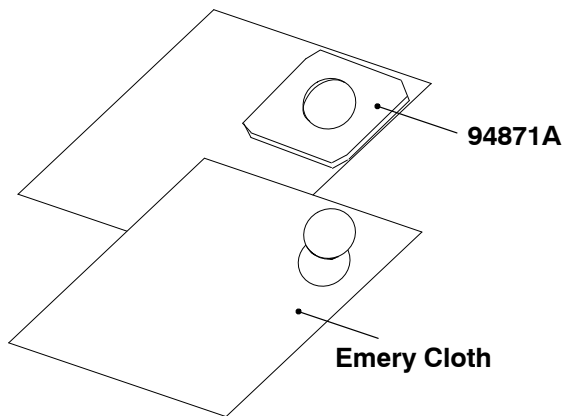


Fig. 2

3. Sealing Faces – Grind

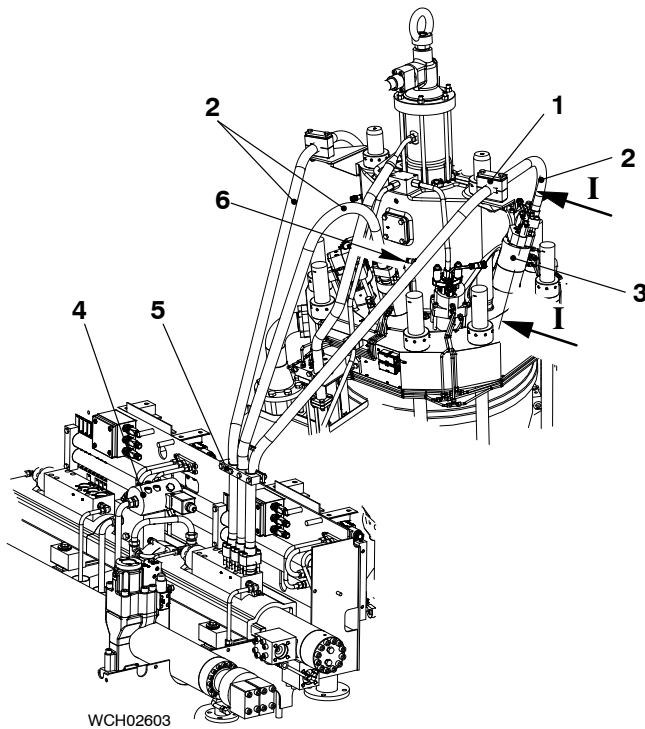
To get a clean and smooth finish on the HP injection pipe, do the procedure that follows:

- 1) Put the template (94871A, Fig. 2) on the back of emery cloth.
- 2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
- 3) Use a pencil or a ball pen to make the the inner shape.
- 4) Cut out accurately the shape.
- 5) Remove the four screws (T2) and the grinding tool (94871).
- 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 with the HP injection pipe (1).
- 10) Torque symmetrically the four screws (T2) to 2.0 Nm.
- 11) Put the HP injection pipe (1) in a vice, as vertically as possible.
- 12) Adjust the speed of the hand drill between 200 rpm and 500 rpm.
- 13) Align the hand drill and the grinding tool (94841) accurately with the HP injection pipe (1) as shown.
- 14) Use light pressure and start grinding.
- 15) Regularly remove unwanted material from the grinding tool (94871).

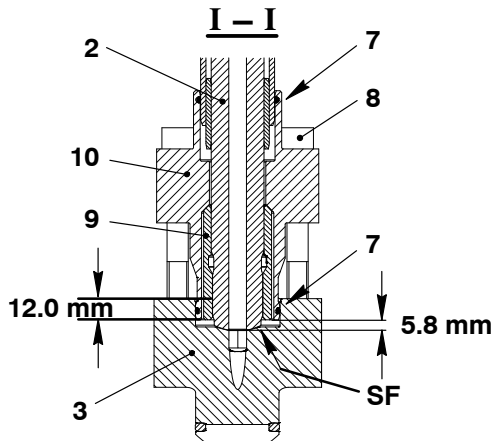
Note: Make sure that the circular marks around the sealing face of the pipe are concentric.

- 16) Change the emery cloth for a smoother grade, then do step 1) to step 15) again until you get a smooth finish.
- 17) Replace the emery cloth with a polishing cloth as a last step to polish the HP injection pipe.
- 18) Clean the HP injection pipe (1).
- 19) If necessary, do step 1) to 18) for the remaining HP injection pipes.

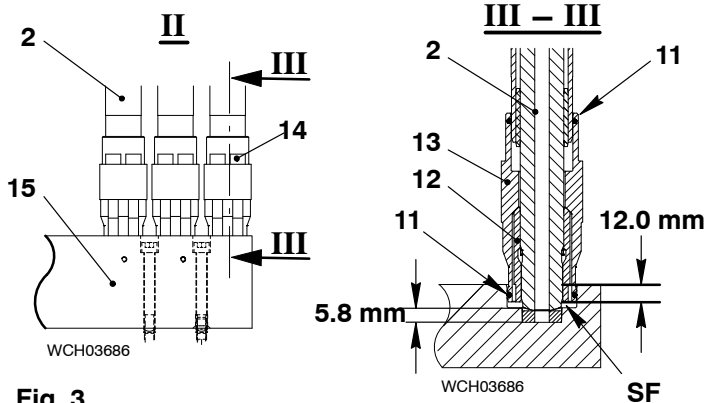
HP Fuel Pipe (Injection Valve): Removal, Grinding and Installation



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WCH03686

WCH03686

Fig. 3

4. Installation

CAUTION



Damage Hazard: Make sure that you do not cause damage to the sealing faces or the HP injection pipes.

- 1) If necessary, replace the O-rings (7 and 11, Fig. 3).
- 2) Make sure that the claws (9 and 12) are correctly attached to the HP injection pipe (2).

Note: You can adjust the claws (9, 12) with an open-ended wrench.

- 3) Remove all of the protection from the sealing faces in the injection valve (3) and the flow limiter valve (15).
- 4) Make sure that there is distance of 5.8 mm between the ends of the HP injection pipe (2) and the claws (9 and 12).
- 5) Apply Never-Seez NSBT to threads of the screws (8, 14).
- 6) Carefully put the HP injection pipe (2) in position with the injection valve (3) and the flow limiter valve (15).
- 7) Torque symmetrically the four screws (8) to 60 Nm.
- 8) Make sure that there is a distance of 12.0 mm between the flange (10) and the injection valve (3).
- 9) Torque symmetrically the four screws (14) to 60 Nm.
- 10) Make sure that there is a distance of 12.0 mm between the flange (13) and the flow limiter valve (15).
- 11) If necessary, install the insulation to the HP injection pipe (2).
- 12) Install the pipe clamps (1, 5).

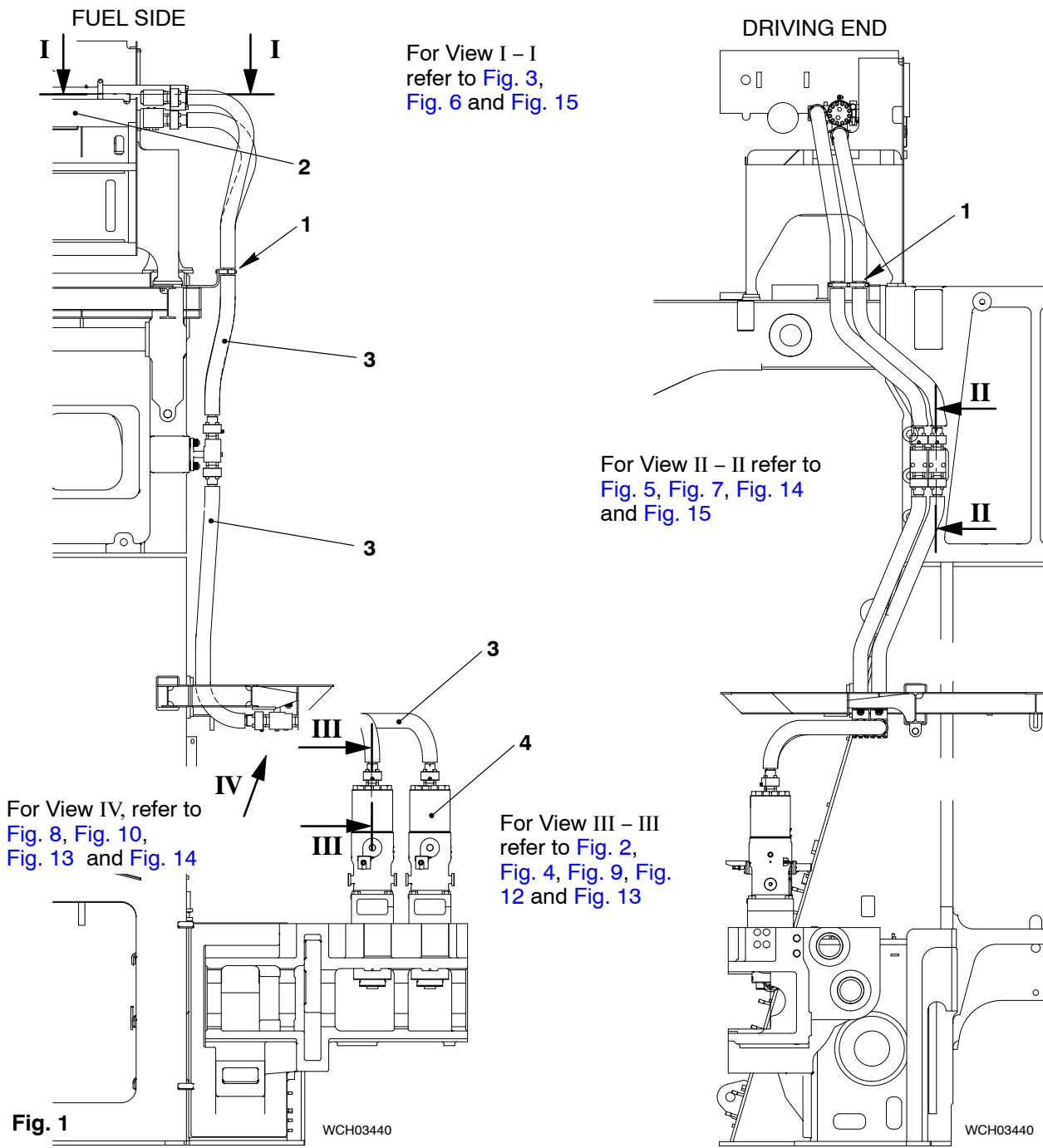
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HP Fuel Pipe

Removal, Grinding and Installation

1. Preparation 3
 2. Removal 5
 3. Sealing Faces – Grind 8
 4. Installation 9

1 Grinding tool	94870	Grinding tool	94870F
1 Screw-on sleeve	94870E	Locknut	94870G
		Template	94870H



- 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 read the data given in the Operation Manual 0520-1.

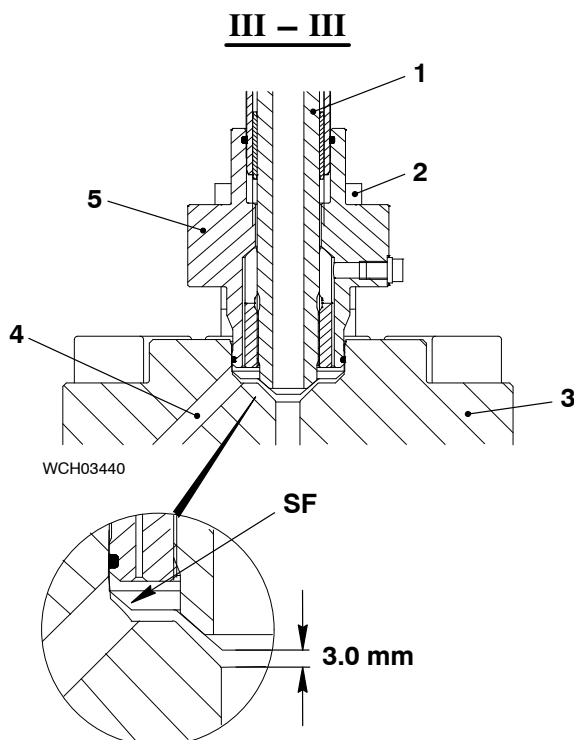
WARNING

Injury Hazard: Always put on gloves and safety goggles when you do work on hot components. When screws and plugs are opened, steam or fuel can come out and cause injury.

CAUTION

Damage Hazard: Make sure that you do not cause damage to the sealing faces or the HP fuel pipes. Do not apply lateral force to the HP fuel pipes and the flanges.

- 1) Stop the engine, refer to the Operation Manual 0310 1.
- 2) Set to off the fuel supply pump.
- 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, remove the trace heating pipes.
- 6) Put an oil tray under the applicable fuel pump.
- 7) On the flange (5, Fig. 2), loosen the screws (2) a maximum of three turns.

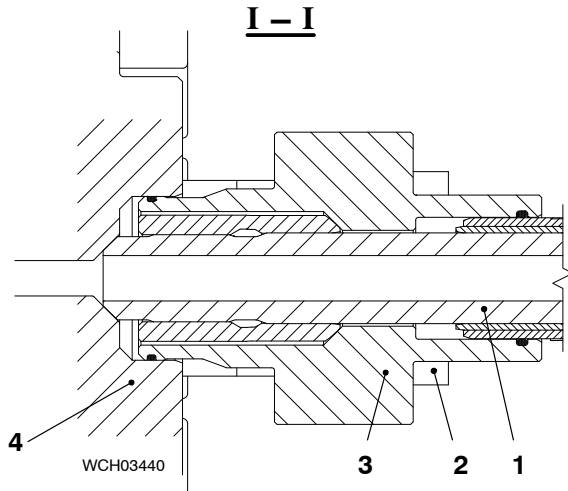


Note: The fuel will drain through the drain bore (4) into the fuel leakage pipe.

- 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 (3) and the HP fuel pipe (1).

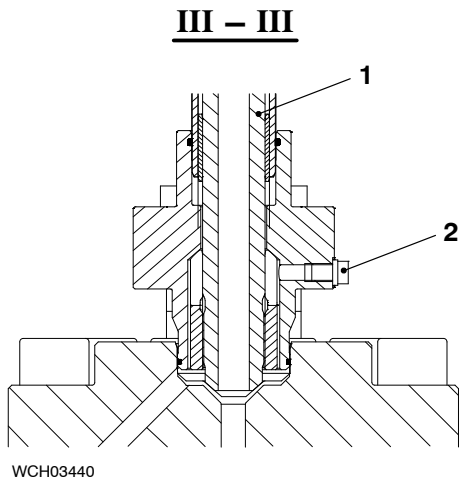
Fig. 2

HP Fuel Pipe: Removal and Installation



- 9) On the flange (3, Fig. 3), loosen the screws (2) 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).

Fig. 3



- 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).

Fig. 4

HP Fuel Pipe: Removal and Installation

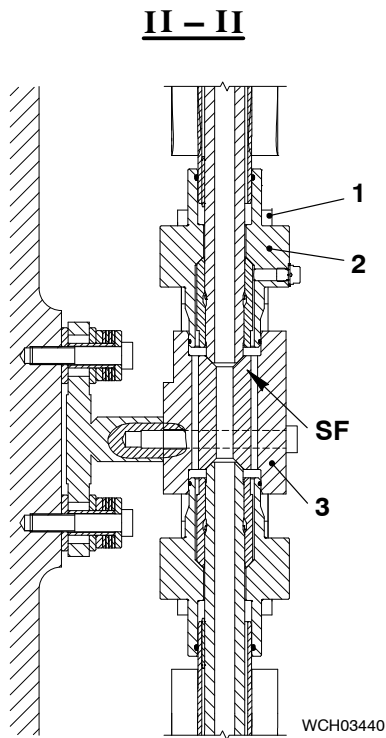


Fig. 5

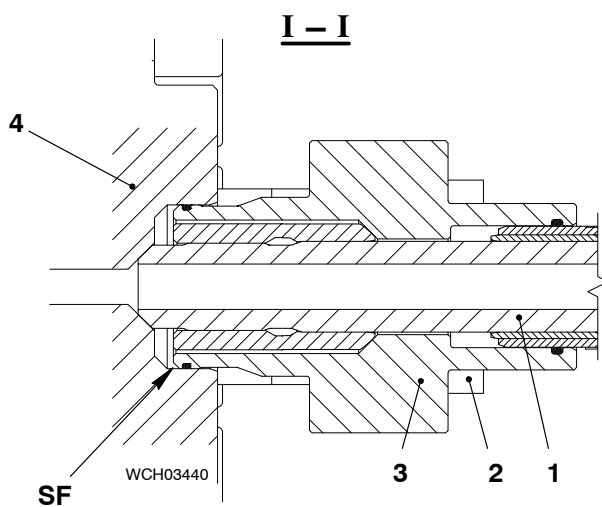


Fig. 6

2. Removal

CAUTION

Damage Hazard: Make sure that you do not cause damage to the sealing faces or the HP fuel pipes.

- 1) Remove the clamps (1, Fig. 1).
- 2) Remove the four screws (1, Fig. 5) from the flange (2).
- 3) Carefully move the flange (2) away from the intermediate piece (3).

- 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 37 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

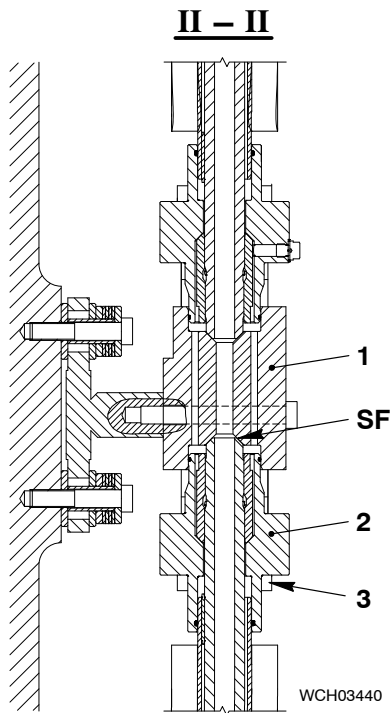


Fig. 7

- 8) Remove the four screws (3, Fig 7) from the flange (2).
- 9) Carefully move the flange (2) away from the intermediate piece (1).

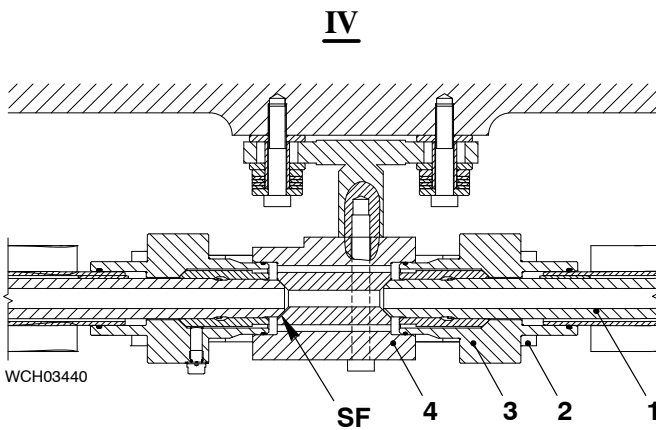



Fig. 8

- 10) Remove the four screws (2, Fig 8) from the flange (3).
- 11) Carefully move the flange (3) away from the intermediate piece (4).

CAUTION	
	<p>Injury Hazard: The weight of the HP fuel pipe is approximately 30 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.</p>

- 12) Carefully remove the HP fuel pipe (1).

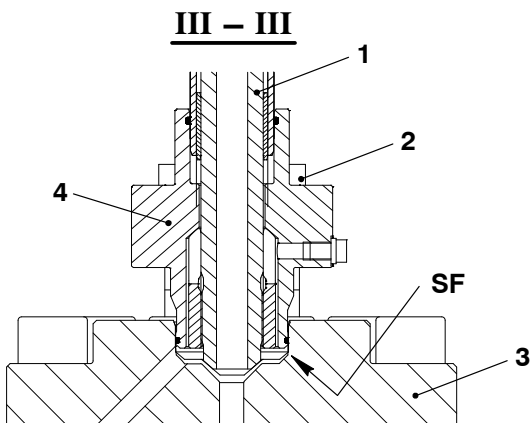


Fig. 9

- 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

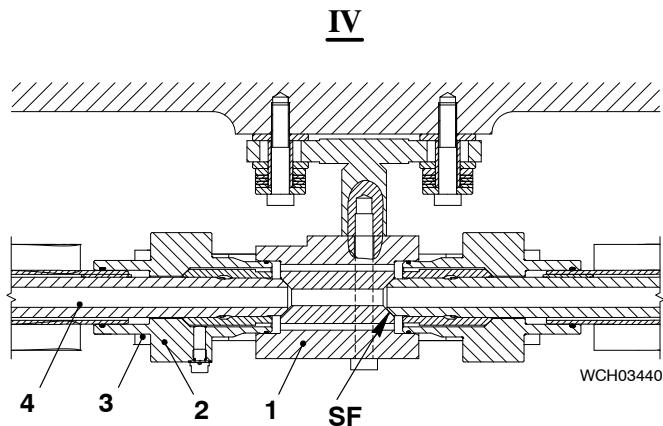


Fig. 10

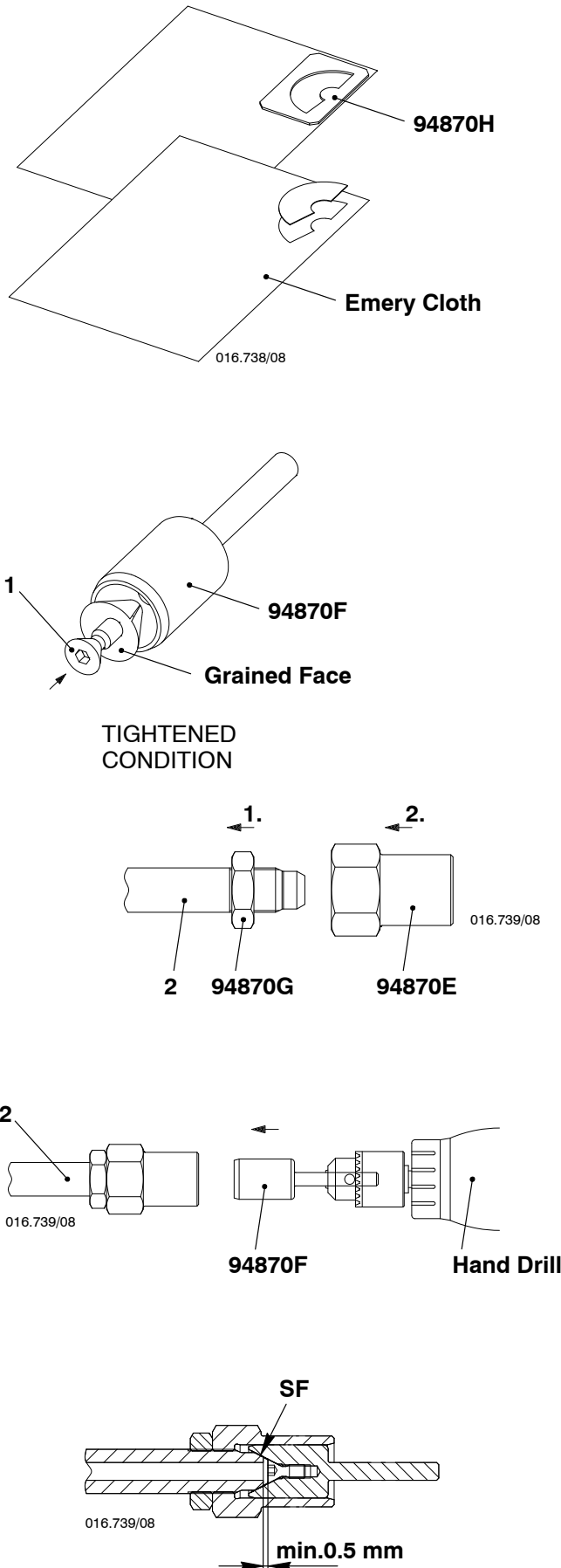
- 16) Remove the four screws (3, Fig. 10) from the flange (2).
- 17) Carefully move the flange (2) away from the intermediate piece (1).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 30 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

- 18) Carefully remove the HP fuel pipe (4).
- 19) Do a check of the sealing faces (SF). If you find damage, do the procedure given in paragraph 3.
- 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 deep notches of more than 0.1 mm, use emery cloth of medium to coarse grain (30 to 80 CAMI). Use emery cloth with fine or ultra-fine grains (100 to 600 CAMI).

To get a clean and smooth finish on the pipe, do the procedure that follows:

- 1) Put the template (94870H) on the back of the emery cloth, refer to Fig. 11.
 - 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 the shape accurately.
 - 5) Put the cut shape into the cone of the grinding tool (94870F) as shown.
 - 6) Tighten the countersunk screw (1).
 - 7) Remove the pipe claw.
 - 8) Put the HP fuel pipe in a vice.
 - 9) Attach the nut (94870G) on to the thread of the HP fuel pipe (2).
 - 10) Attach the sleeve (94870E) to the nut (94870G).
 - 11) Attach the grinding tool (94870F) to the hand drill.
 - 12) Move the grinding tool (94870F) into the sleeve (94870E) until the grinding tool lightly touches the HP fuel pipe (2).
 - 13) Adjust the hand drill speed to a maximum of 1500 rpm.
 - 14) Operate the hand drill for between 3 seconds to 5 seconds.
 - 15) Remove the grinding tool (94870F) from the sleeve (94870E).
 - 16) Use a low-pressure air supply to clean the HP fuel pipe.
 - 17) Do a check of the sealing face. If necessary, use a new piece of emery cloth and do step 3) to step 16) again.
- Note:** If the notches are large, you must decrease the length of the HP fuel pipe. Make sure that there is a distance of 0.5 mm between the countersunk screw (1) and the end face of the HP fuel pipe.
- 18) Remove the nut (94870G) and sleeve (94870E).

Fig. 11

HP Fuel Pipe: Removal and Installation

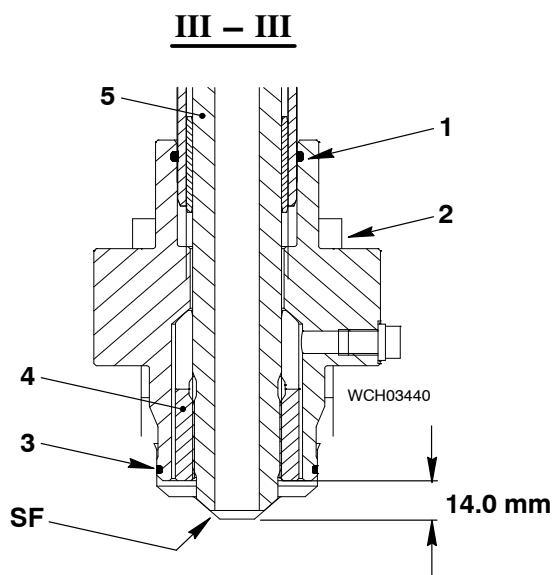


Fig. 12

4. Installation

CAUTION

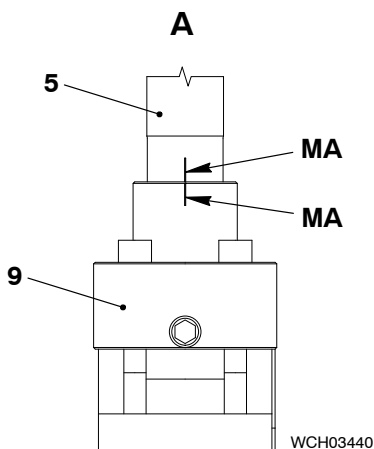
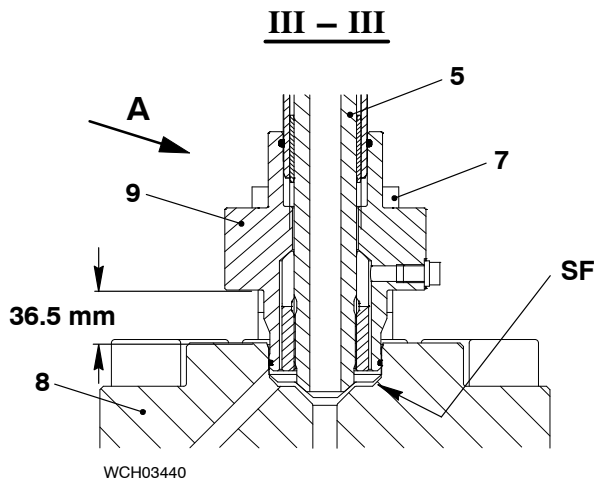
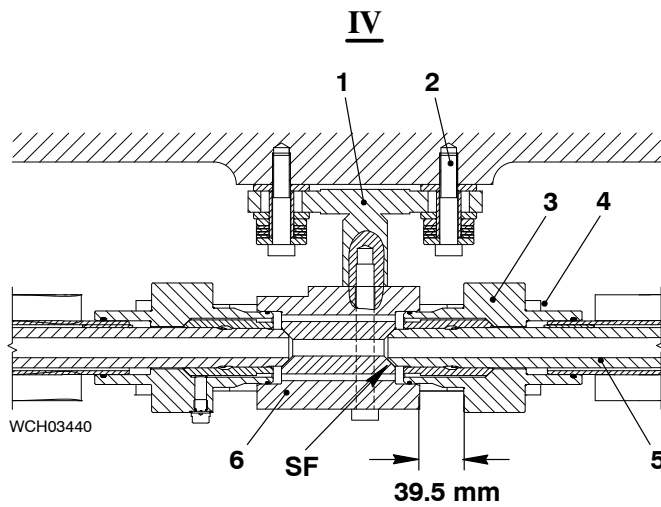
Injury Hazard: The weight of the HP fuel pipe is approximately 30 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

- 1) Make sure that the O rings (1 and 3, Fig. 12) have no damage. 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).


Note: You can adjust the claw (4) with an open-ended wrench.

- 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



CAUTION

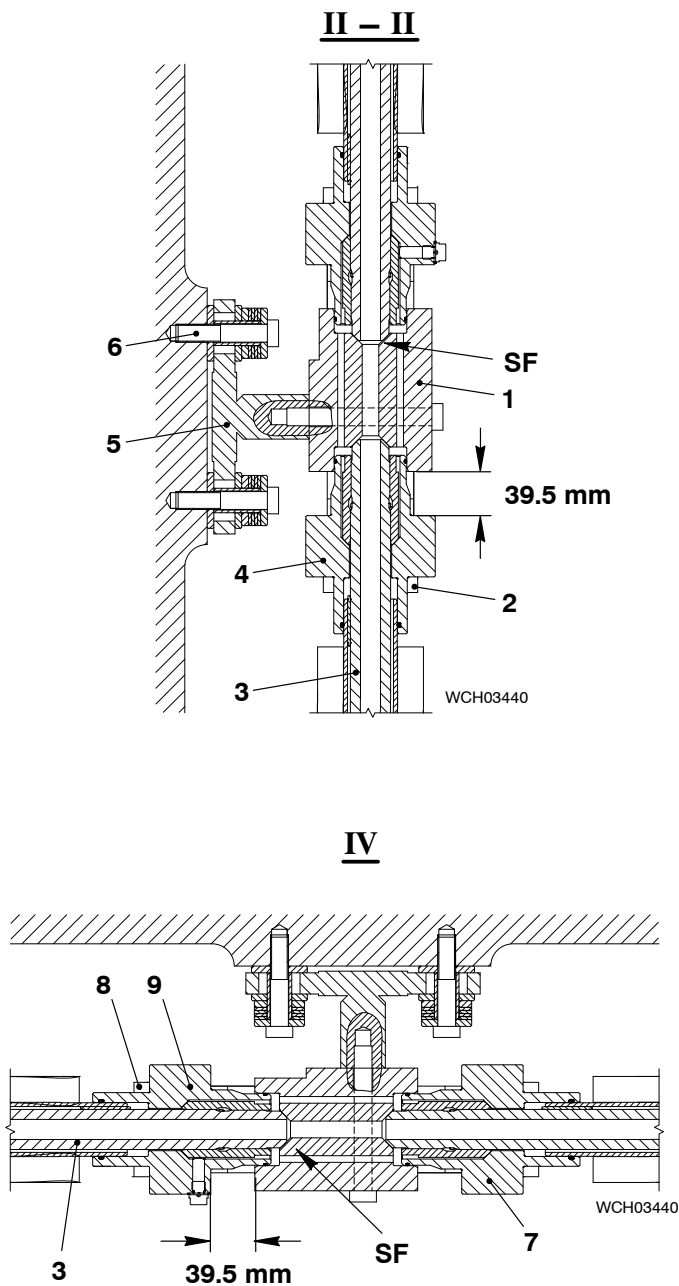


Damage Hazard: Do not apply lateral force to the HP fuel pipe and the flanges. Damage to the sealing faces (SF) and the HP fuel pipe can occur.

- 7) Loosen the screws (2, Fig. 13) on the support (1) of the intermediate piece (6).
- 8) Carefully put the HP fuel pipe (5) in position with 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, 7) as follows:
 - a) Torque symmetrically the four screws 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 to 55 Nm.
 - d) Torque symmetrically the four screws 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).

Fig. 13

HP Fuel Pipe: Removal and Installation



- 13) Loosen the screws (6, Fig. 14) on the support (5) of the intermediate piece (1).

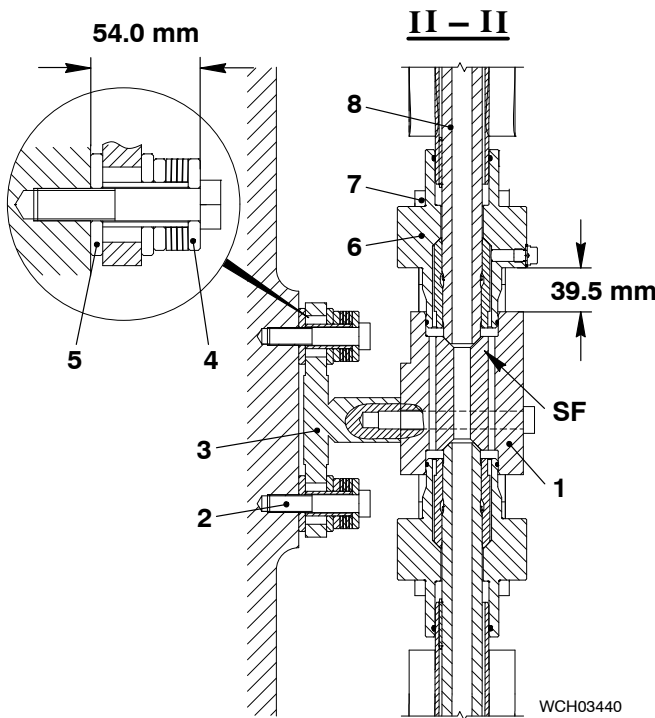
CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 30 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.


- 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, Fig. 13) on the HP fuel pipe (3, Fig. 14) and the flange (4).
- 16) Torque the screws (2, 8) as follows:
- Torque symmetrically the four screws to 30 Nm.
 - Make sure that the flanges (4, 9) are not tilted and in the correct position.
 - Torque symmetrically the four screws to 55 Nm.
 - Torque symmetrically the four screws 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).

Fig. 14

HP Fuel Pipe: Removal and Installation



CAUTION



Injury Hazard: The weight of the HP fuel pipe is approximately 30 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

- 19) Carefully put the HP fuel pipe (1, Fig. 15) in position with the intermediate piece (5) and the valve housing (4).
- 20) Make sure that the HP fuel pipe (1) is in the correct position. Align the marks (MA, Fig. 13) on the HP fuel pipe (1, Fig.15) and on the flange (6).
- 21) Torque the screws (2 and 7) as follows:
 - a) Torque symmetrically the four screws to 30 Nm.
 - b) Make sure that the flanges (6, 3) are not tilted and in the correct position.
 - c) Torque symmetrically the four screws to 55 Nm.
 - d) Torque symmetrically the four screw to 80 Nm.
- 22) Make sure that there is a distance of 39.5 mm between the flange (6) and the intermediate piece (5).
- 23) Make sure that there is a distance of 36.5 mm between the flange (3) and the valve housing (4).
- 24) Tighten the screws (8) on the support (9).
- 25) Make sure that there is a distance of 54.0 mm between the steel ring (5) and the slide ring (4).

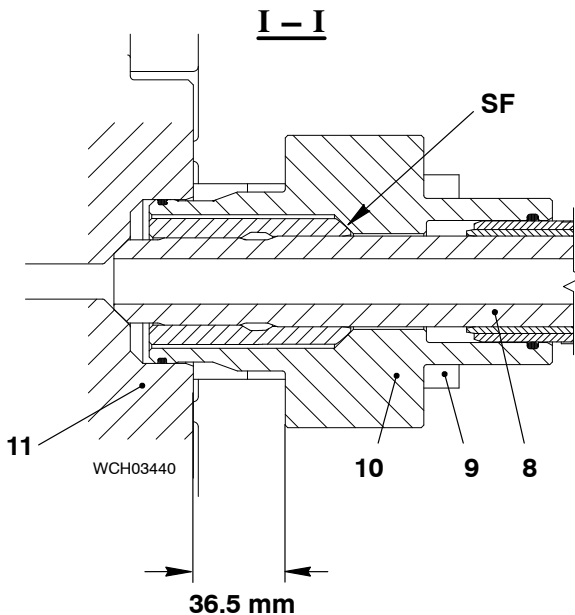


Fig. 15

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Crank Angle Sensor Unit, Tools

Group 9

Crank Angle Sensor Unit: Replacement of Proximity Sensor	9223	1/A1
Relief Valve on Cylinder Cover	930	1/A1
Tools: Description of Tool Categories	9403	1/A1
Hydraulic Pre-tensioning Jacks and Pumps		
Configuration and Application	9403	2/A1
Overview, Storage, Servicing and Maintenance	9403	3/A1
General Instructions	9403	4/A1
Tool List	9403	5/A1
Standard Tools	Pages 1 to 33	
Recommended Special Tools	Pages 34 to 36	

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Crank Angle Sensor Unit

Replacement of Proximity Sensor

1. General

The crank angle sensor (CAS) unit with four proximity sensors (2, Fig. 2) is installed on the supply unit drive at the driving end. The CAS has four proximity sensors (ST5131-34C). There are two crank angle systems (for redundancy) that monitor the teeth on the intermediate wheel. The holder is installed with screws to the cover on the drive column.

Two more proximity sensors (ZS 5123C, ZS 5124C) are used to find the crank angle marks on the flywheel for TDC and BDC (refer Fig. 3).

For the function of the Crank Angle Sensor Unit refer to General Application Instructions 9223 1. For Regular Checks and Recommendation to replace CCM 20 modules (refer to 4002 1 Crank angle sensor, paragraph 3.1) in the Operation Manual.

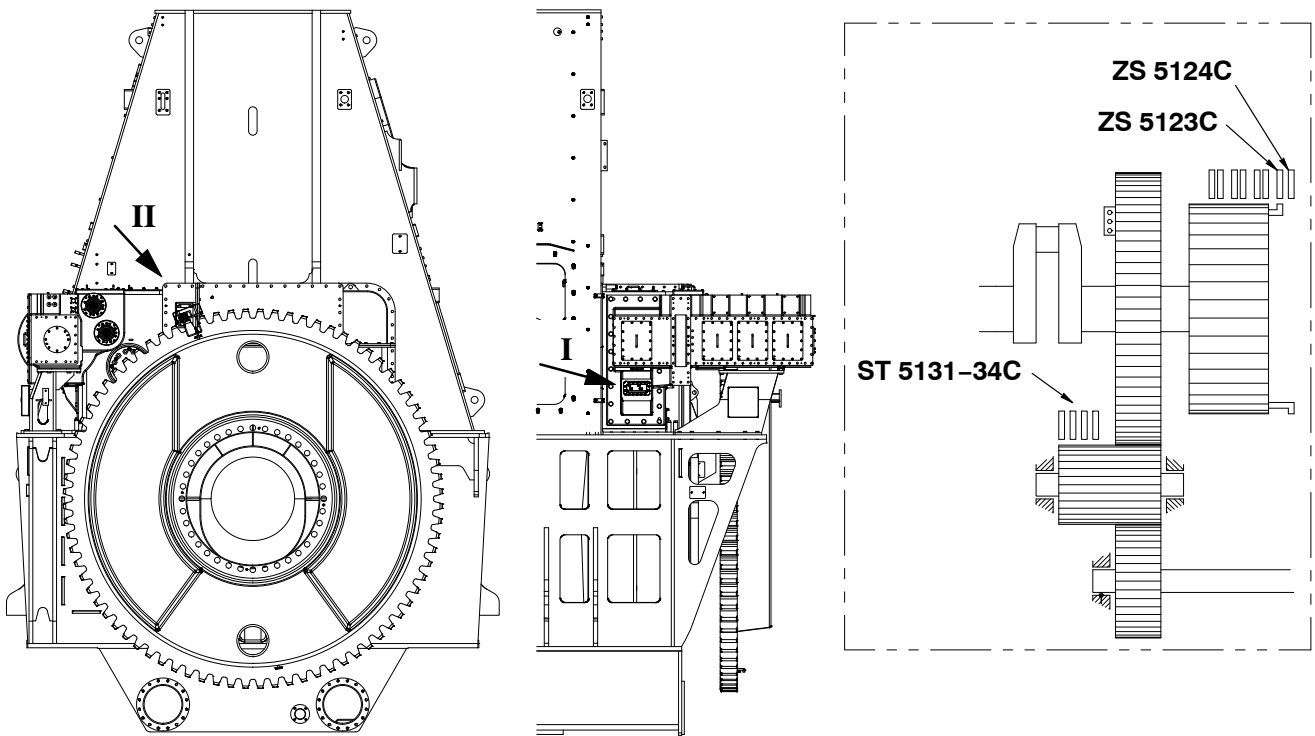


Fig. 1

2. Replacement

2.1 Proximity sensors (ST5131C-34C) – Replace

WARNING



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

- 1) Stop the engine.
- 2) Operate the turning gear to get a tooth (1, Fig. 2) of the intermediate wheel opposite the applicable proximity sensor (2).
- 3) Put a mark on the applicable cable to identify its position.
- 4) Disconnect the applicable electrical connection from the proximity sensor (2).
- 5) Loosen the locknut (4).
- 6) Remove the proximity sensor (2) from the holder (3).
- 7) Apply MOLYKOTE paste G to the new sensor.
- 8) Attach the new proximity sensor (2) to the holder (3).
- 9) Turn the proximity sensor (2) fully down until the tip of the proximity sensor (2) touches the bottom of the holder (3).

Note: During installation/commissioning the clearance between the flywheel tooth (1) and the holder (3) is set to 2.0 mm.

Note: The wall thickness of the holder (3) is 1.5 mm.

- 10) Carefully tighten the locknut (4) with your fingers.
- 11) Connect the electrical connection to the proximity sensor (2). Refer to the mark made before to identify the correct cable.

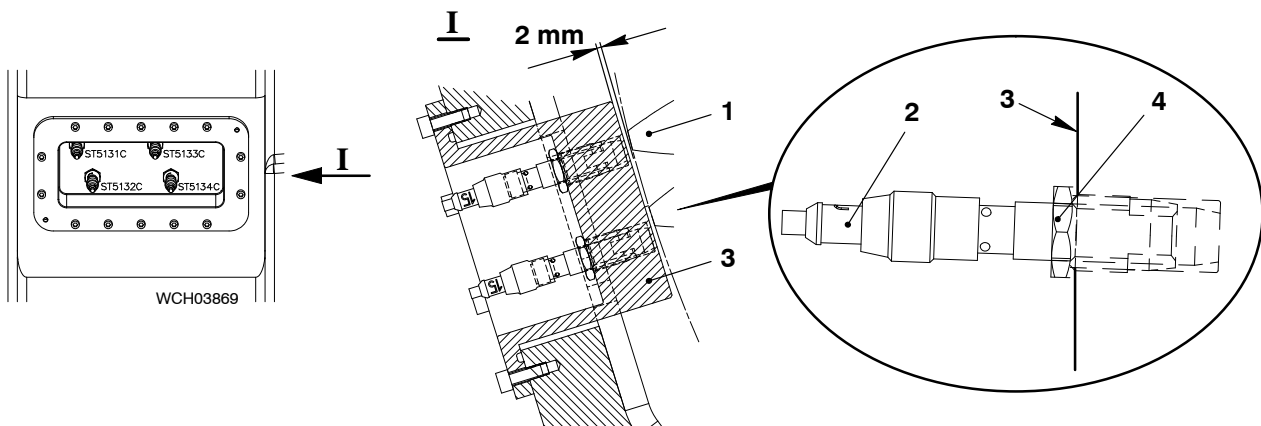


Fig. 2

Crank Angle Sensor Unit: Replacement of Proximity Sensor

2.2 Proximity sensors (ZS5123C-24C) – Replace

WARNING

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

- 1) Stop the engine.
- 2) Operate the turning gear to get the applicable crank angle mark (2, Fig. 3) on the flywheel wheel opposite the unserviceable proximity sensor.
- 3) Put a mark on the applicable cable to identify its position.
- 4) Disconnect the applicable electrical connection from the proximity sensor (4).
- 5) Remove the proximity sensor (4) from the holder (5).
- 6) Apply MOLYKOTE paste G to the new sensor.
- 7) Attach the new proximity sensor (4) to the holder (5).
- 8) Make sure that the proximity sensor (4) touches the applicable crank angle mark (2).
- 9) Loosen the proximity sensor (4) to get a clearance of 4.0 mm between the crank angle mark and the bottom face of the proximity sensor.
- 10) Carefully tighten the locknut (3) with your fingers.
- 11) Connect the electrical connection to the proximity sensor (4). Refer to the mark made before to identify the correct connection.

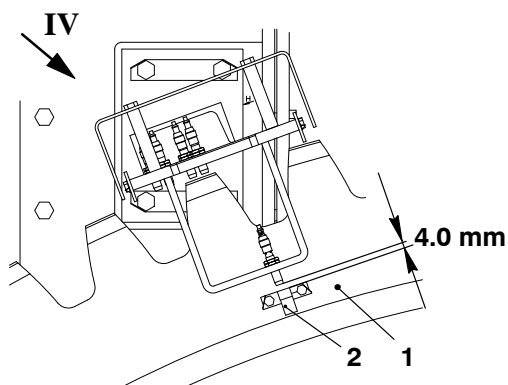
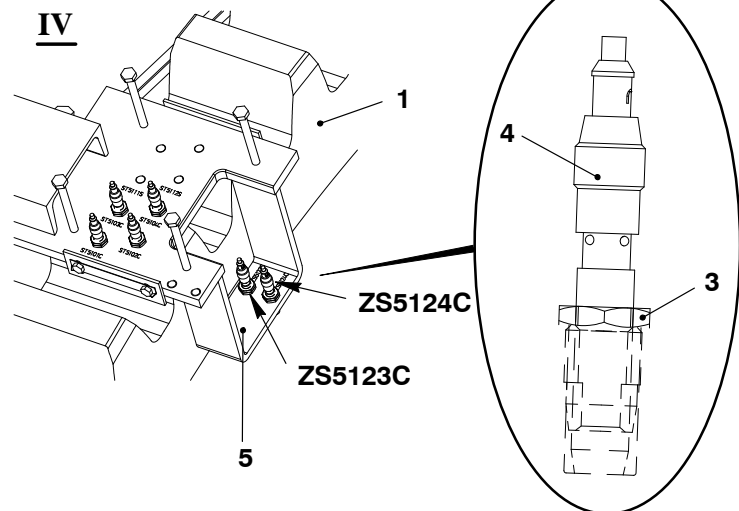
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Fig. 3

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Relief Valve on Cylinder Cover

Blow-off Pressure Check

Tools:

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

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 (refer to 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.

3. Removal

- 1) Open the indicator valve (1) to make sure that there is no pressure in the compression chamber.
- 2) Remove the relief valve (3) and gasket (2) from the adapter (5).
- 3) Do a check of the gasket (2) for damage. If necessary, replace the gasket.

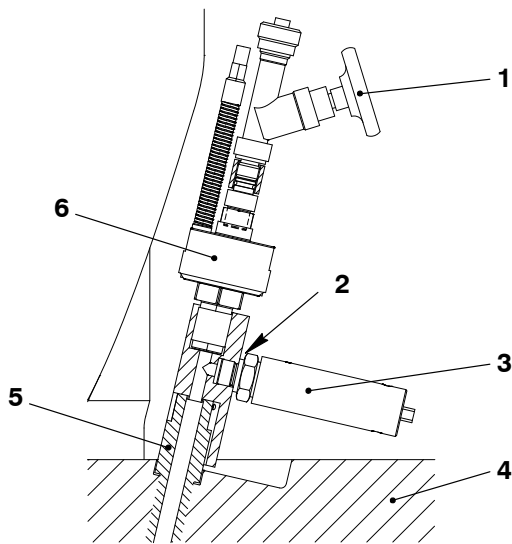


Fig. 1

Relief Valve: Blow-off Pressure Check

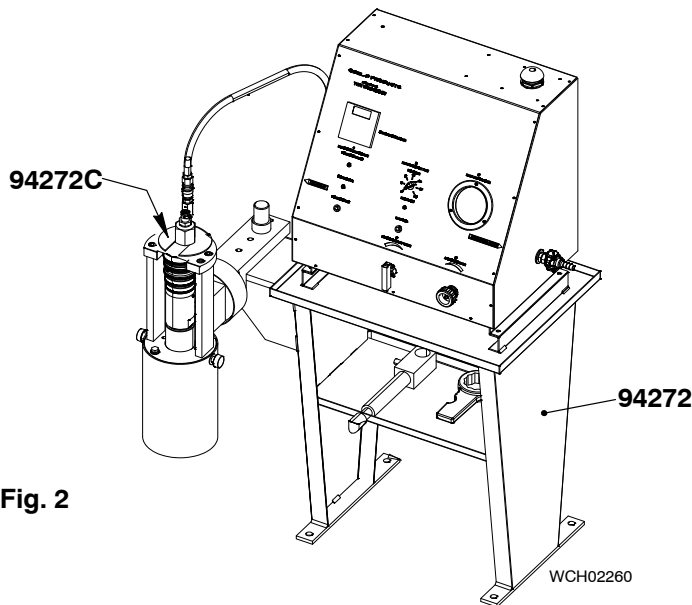


Fig. 2

4. Relief Valve Check

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

4.1 Procedure One

- 1) Read the data in the manual for the test bench (94272).
- 2) Read the data about calibration fluid in 2722 2, paragraph 1. You can use the test and calibration fluid, or a low viscosity oil as a test fluid.
- 3) Attach the valve holder (94272C, Fig. 2), to the test bench (94272).
- 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 is related 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, Fig. 3) to the valve holder (94272C).
- 2) Attach the HP oil pump (94931) and the hose (94935) to the pressure gauge (94934A).
- 3) Connect the pressure gauge (94934A) to the valve holder (94272C).
- 4) Close the relief valve (6) on the HP oil pump (94931).
- 5) Operate the HP oil pump (94931).
- 6) Do a check of the blow-off pressure on the relief valve (2).
- 7) Make sure that the relief valve (2) is set to blow-off at 235 bar. This is related to a firing pressure of between 166 bar to 169 bar.
- 8) Open the relief valve (6) on the HP oil pump to release the pressure in the hose (94935).
- 9) Remove the hose and the HP oil pump from the relief valve (2).
- 10) Remove the relief valve (2) from the valve holder (94272C).

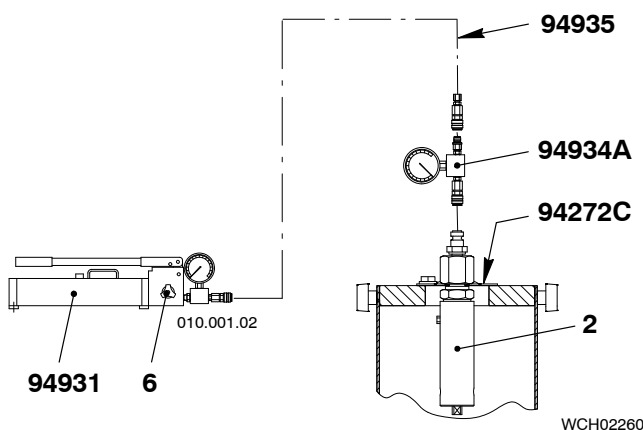
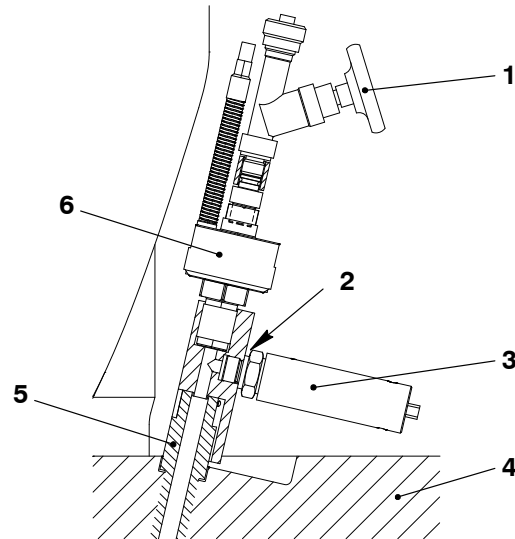


Fig. 3

5. Installation

- 1) Apply Never Seez NSBT-8 to the thread of the relief valve (3, [Fig. 4](#)).
- 2) Install the relief valve (3) and gasket (2) to the adapter (5).
- 3) Close the indicator valve (1).

**Fig. 4**

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Description of Tool Categories

1. General

The tools necessary for the maintenance of the engine are divided into three groups:

- [Standard Tools](#)
- [Recommended Special Tools](#)
- Special tools available on loan.

When it becomes necessary to order more tools, the tool number and the tool description, which must include the engine type, must be shown (refer to [9403 5](#)).

The instructions on the configuration and application, storage, servicing and maintenance of the hydraulic pre-tensioning jacks are given in [9403 2](#), [9403 3](#) and [9403 4](#).

A set of tools is supplied for important components from sub-suppliers, which must be isolated from the engine tools.

Note: Some tools have special screws and/or devices that must be kept together. Thus, tapped holes are bored into these tools. The screws and/or devices must always be kept at the correct storage positions on the tools when they are not in use.

2. Standard Tools

These tools and devices are necessary for usual maintenance on the engine.

Some of these tools and devices given in the references above are not necessary for some engine designs. Thus, are not part of the engine tools supply.

3. Recommended Special Tools

These tools and devices let you do specified maintenance more easily, and in a shorter time, than with the standard tools.

You can make an order for these tools with the engine, or after the engine is supplied.

4. Special Tools Available On Loan

These are tools and devices that are loaned for the movement and for assembly of the engine. The tools are to be given back to the engine manufacturer after the engine assembly is completed.

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Hydraulic Jacks and Pumps

Configuration and Application

Tools:

1	HP oil Pump, 2800 bar	94931	7	Coupling element	94934G
1a	Adapter piece	94934F	8	Flexible hose	94935A
2	Hydraulic unit, 2000 bar	94942	9	Oil pipe drain	94935C
3	HP hose	94935	10	Adapter piece	94934L
4	Pressure gauge 2000 bar	94934A	11	Adapter piece	94934K
5	Connection block	94934	12	Tredo joint	94934J
6	Distributing piece	94934C	13	Connection nipple	94934I
			14	Pressure gauge 20 bar	94934B

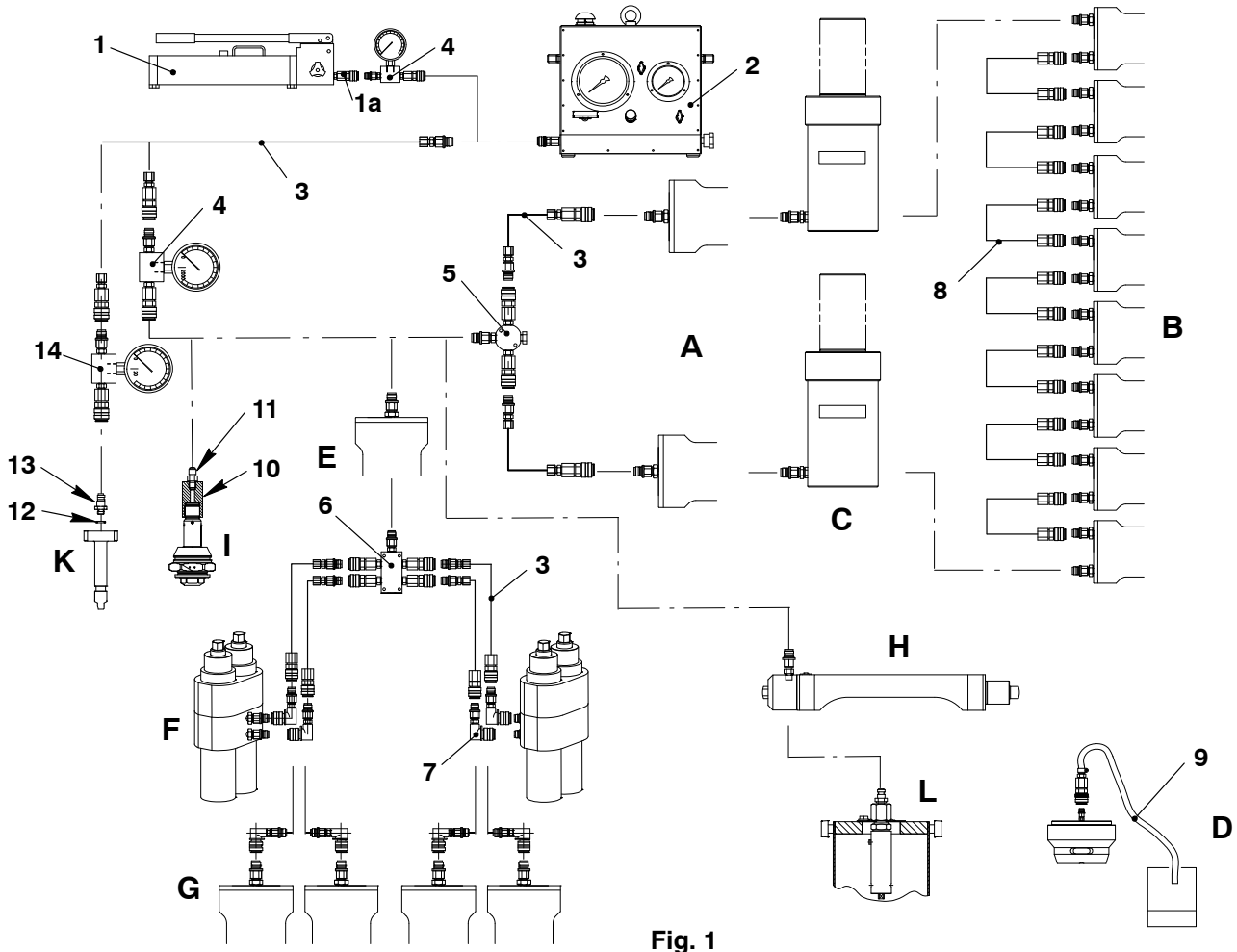


Fig. 1

- A For tie rods (jack 94180), elastic studs to exhaust valve cages and bottom connection rod bolts (94252), top connection rod bolts (94315), piston rod (94340) and elastic studs on supply unit (94557)
- B For elastic studs to cylinder cover (94215A)
- C To lift the crankshaft for removal and installation of main bearing shells (94936)
- D Oil drain after use of pre-tensioning jacks
- E For foundation bolts (94145) and for supply unit lifting tool (94430A)
- F For 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 Checks and setting of fuel overpressure safety valve (relief valve)
- K For inspection of the opening pressure of lubricating quill
- L To do a test of the safety valve

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Storage, Servicing and Maintenance

1. General

The hydraulic pre-tensioning jacks must be kept in their tool boxes when not in use. After you use the pre-tensioning jacks, close the connections with plugs and apply grease. We recommend that, for each jack, you keep a sealing kit (KJ) in stock.

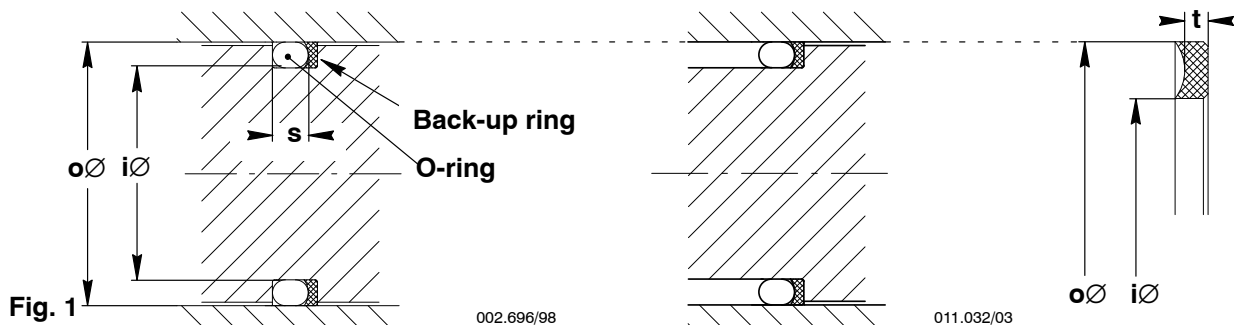
Always make sure that new back-up rings and O-rings are installed in their correct positions, as shown in the data that follows.

Note: Carefully install new back-up rings and O-rings to prevent damage. Do not use tools that have sharp edges.

Back-up rings that are not cut, must be put into hot water before you install them.

1.1 Dimensions of Back-up Rings and O-rings

Tool No.	Position and application of pre-tensioning jack	Part	Back-up Ring (uncut)	O-ring
			Dimension (mm)	
			oØ x iØ x t	iØ x 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	210 x 197.8 x 2.5 146.2 x 134 x 2.5	196.22 x 6.99 132.72 x 6.99
94215A	Elastic bolts to cylinder cover	piston cylinder	142 x 129.8 x 2.5 87.4 x 78 x 1.7	139.07 x 6.99 78.74 x 5.33
94252	Elastic bolts to exhaust valve cage and bottom 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 top 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 for 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. Pre-tensioning Jacks

Tool 94110 Thrust Device for Main Bearing Cover

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

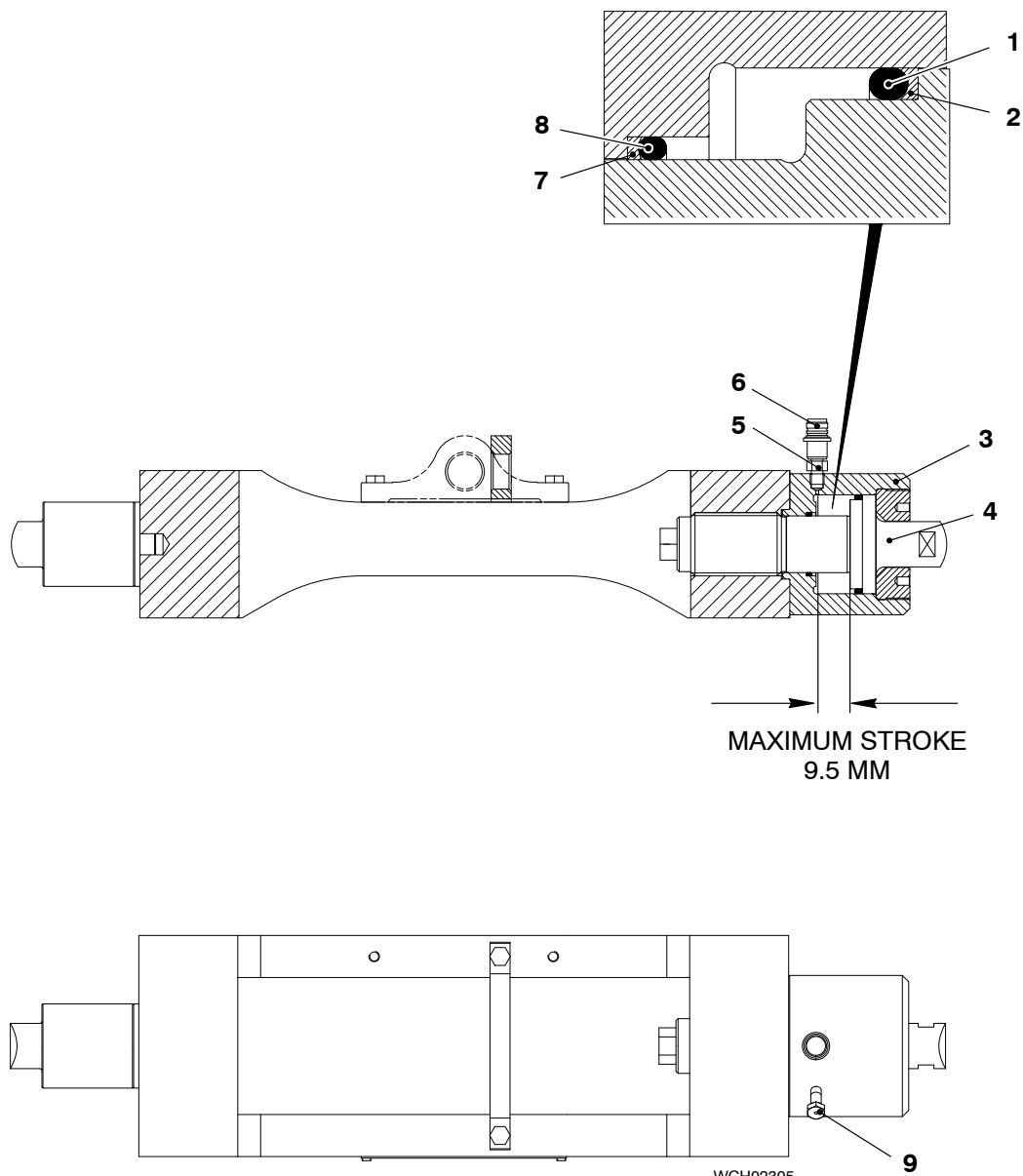


Fig. 2

WCH02305

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

- | | |
|-------------------|-------------------|
| 1 Double cylinder | 7 O-ring |
| 2 Adapter piece | 8 Back-up ring |
| 3 Closing valve | 9 Backing bush |
| 4 Vent screw | 10 Tension sleeve |
| 5 O-ring | 11 Piston |
| 6 Back-up ring | 12 Round nut |

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

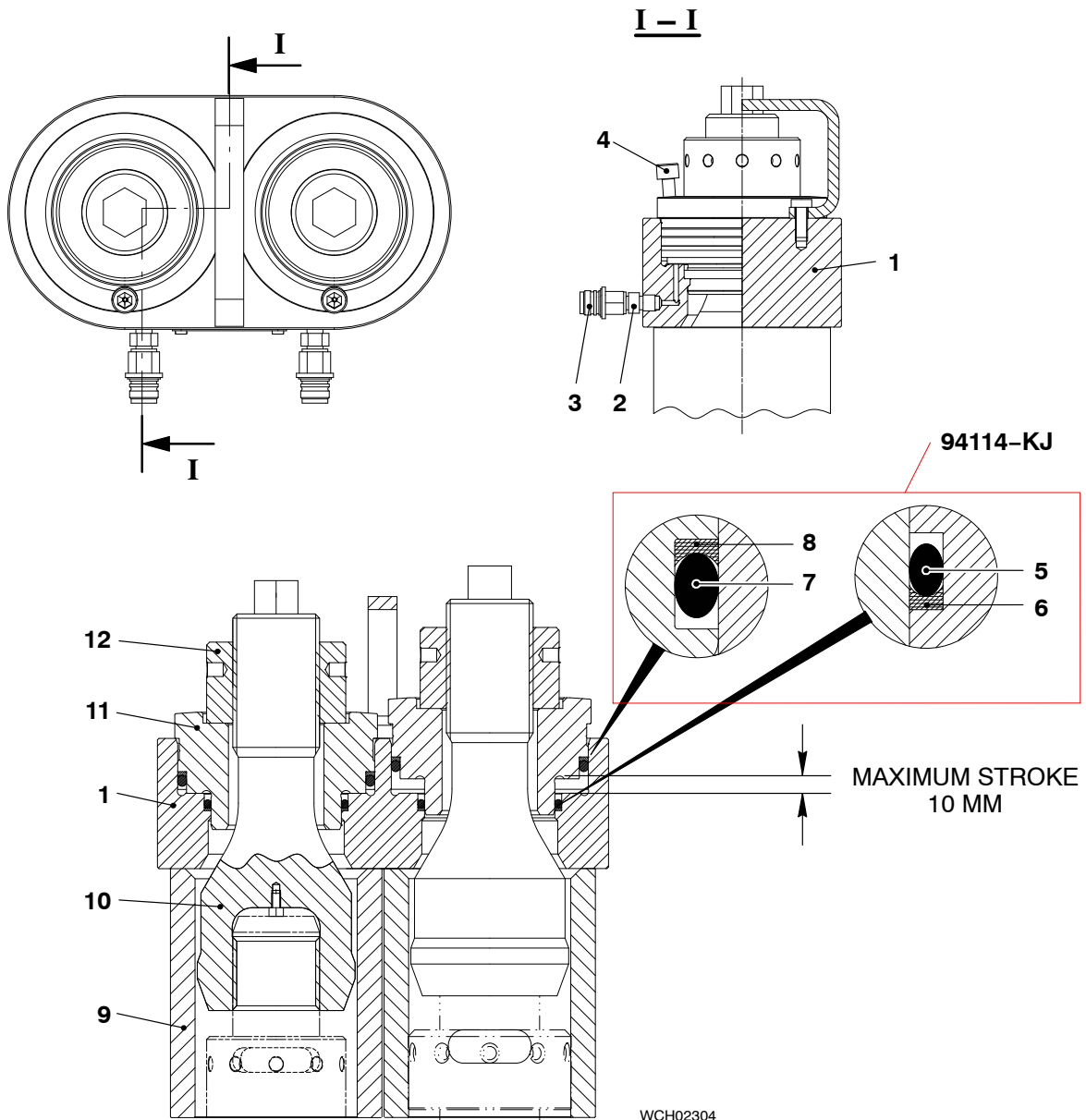


Fig. 3

Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94145 Pre-tensioning jack for foundation bolts and engine stays

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

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

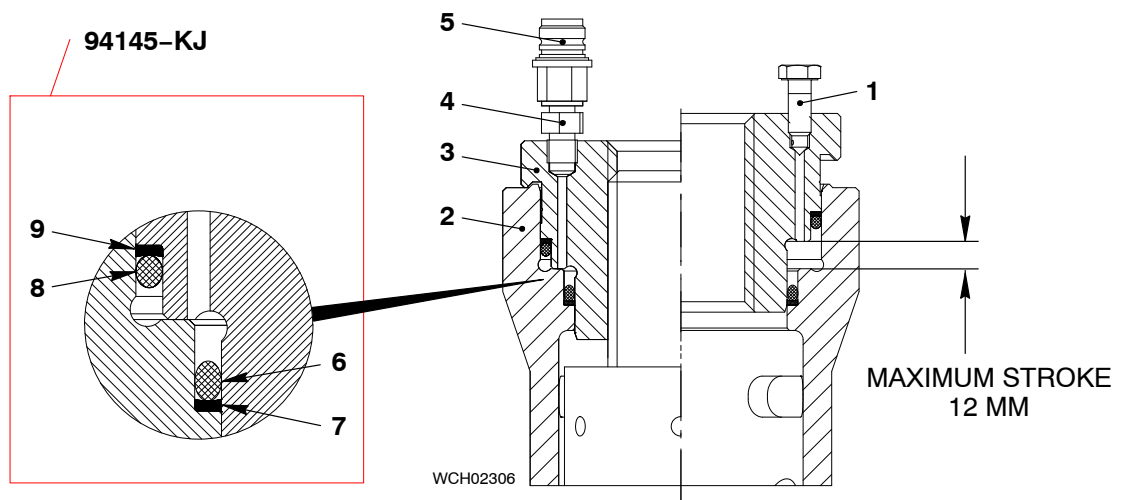


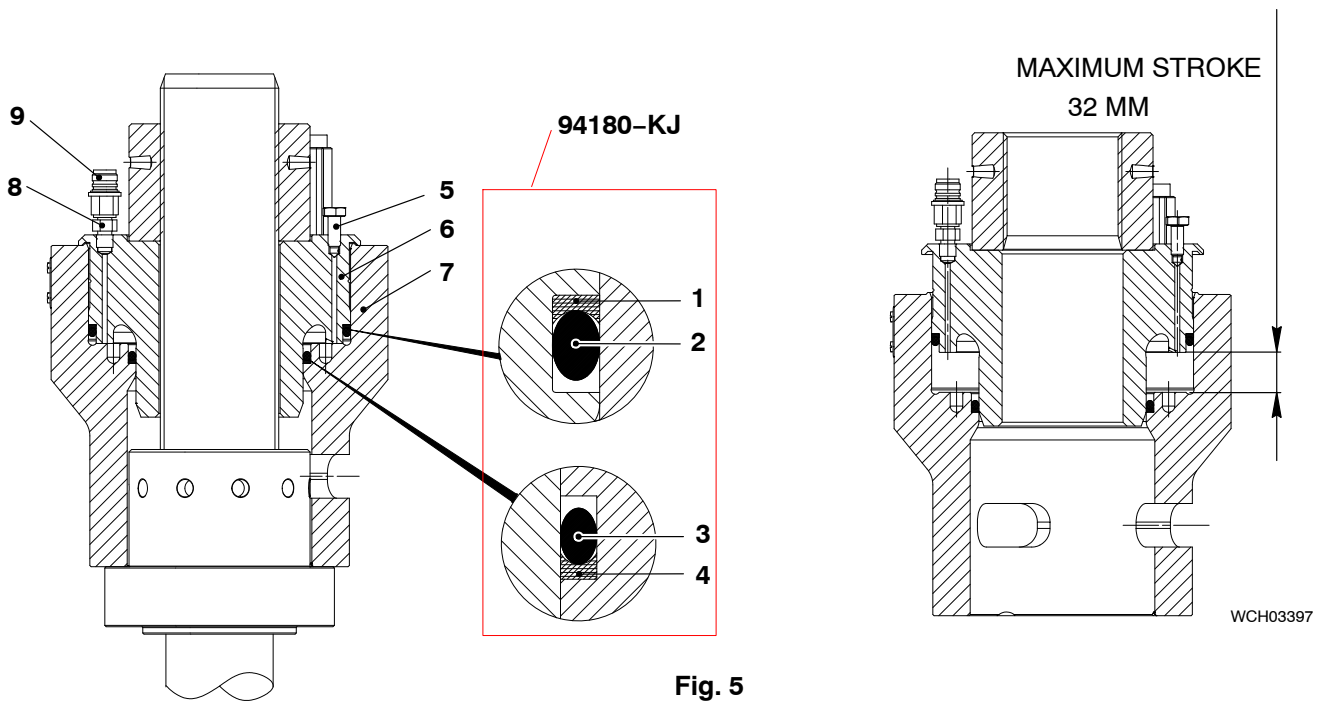
Fig. 4

Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94180 Pre-tensioning jack for tie rods

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

94180-KJ Kit with back-up and O-rings for double pre-tensioning jack



Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94215A Pre-tensioning jack for elastic bolts to cylinder cover

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

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

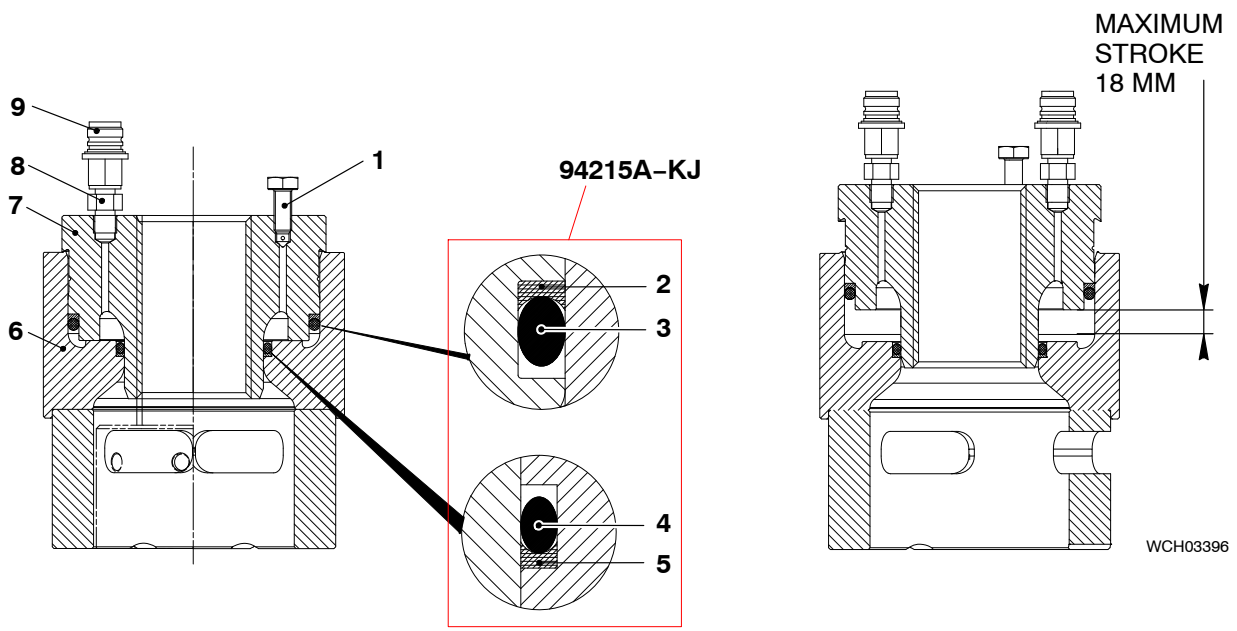


Fig. 6

Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94252 Pre-tensioning jack for elastic bolts to exhaust valve cage and bottom connecting rod studs

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

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

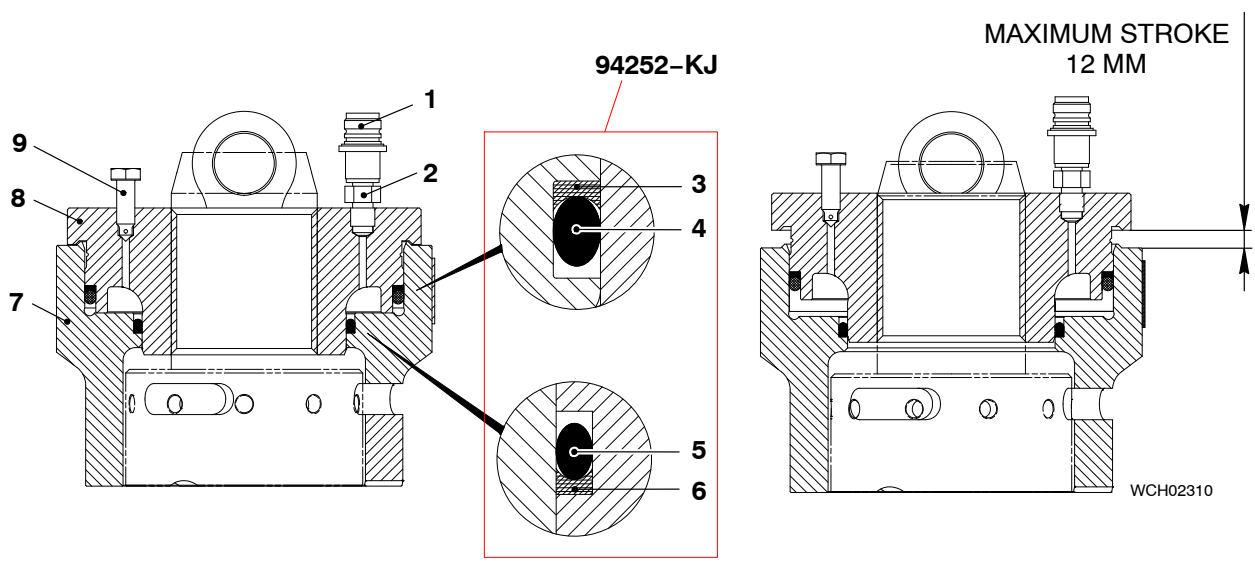


Fig. 7

Tool 94315 Pre-tensioning jacks for elastic bolts to top connecting rod bearing

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

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

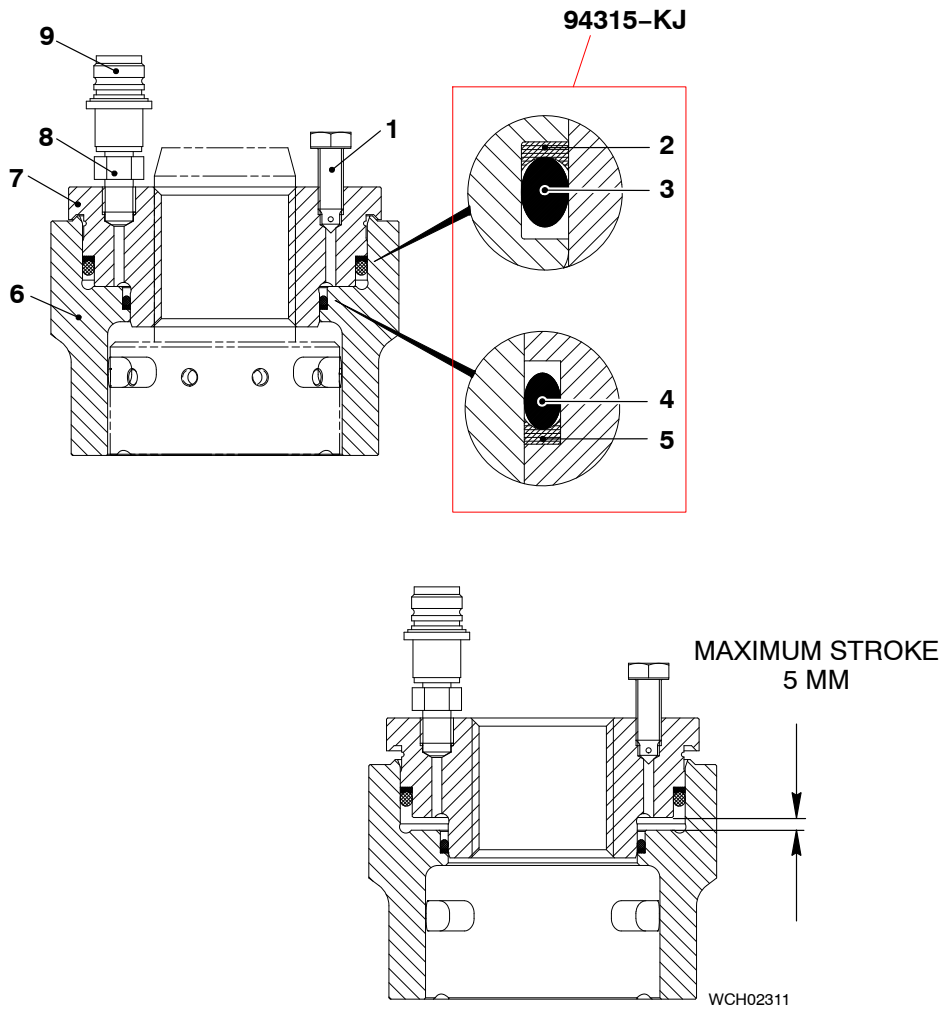


Fig. 8

Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94340 Pre-tensioning jack for piston and piston rod foot to crosshead

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

94340-KJ Kit with back-up rings and O-rings for pre-tensioning Jack

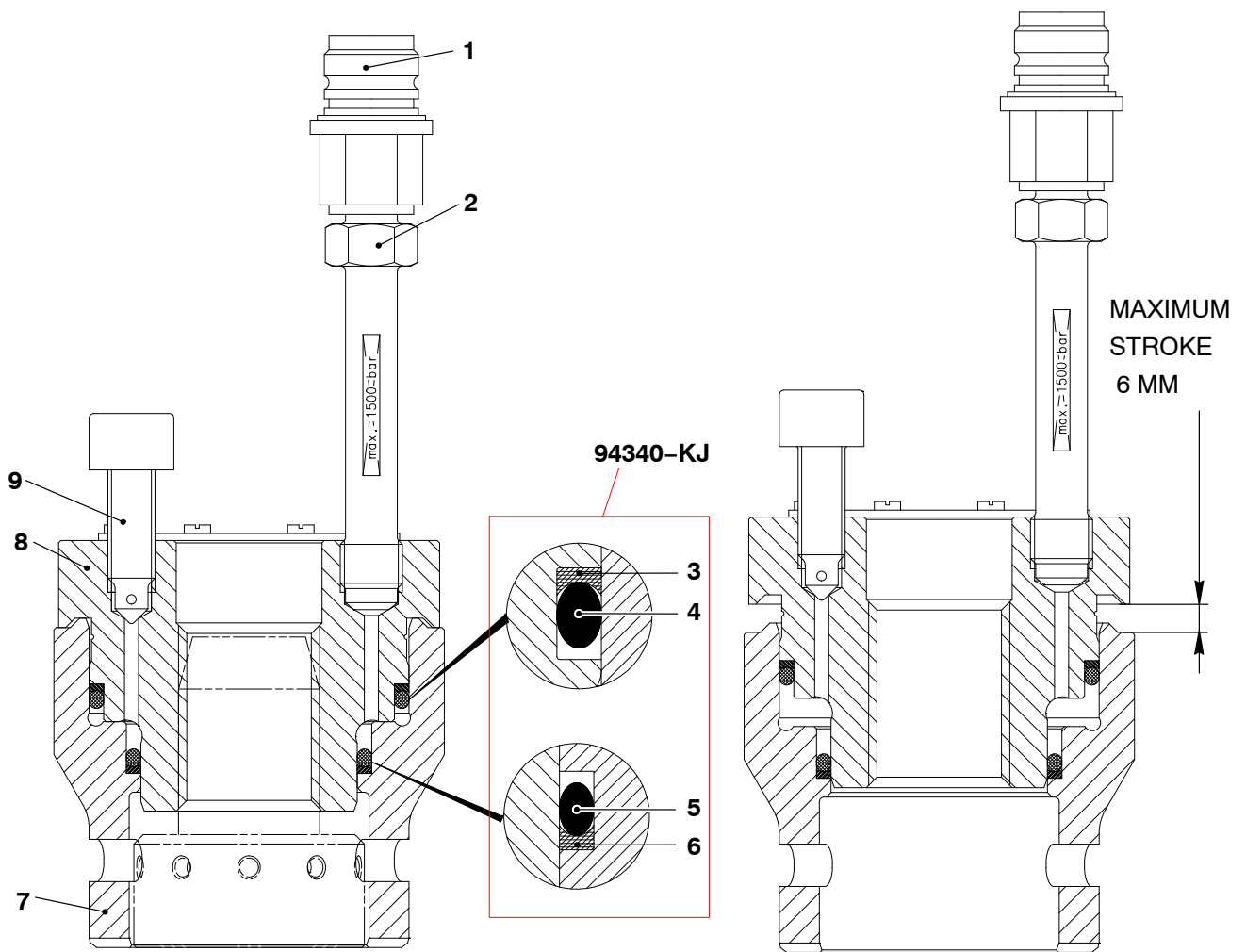


Fig. 9

WCH03398

Hydraulic Pre-tensioning Jacks: Storage, Servicing and Maintenance

Tool 94430A Pre-tensioning jack for roller lifting tool (supply unit)

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

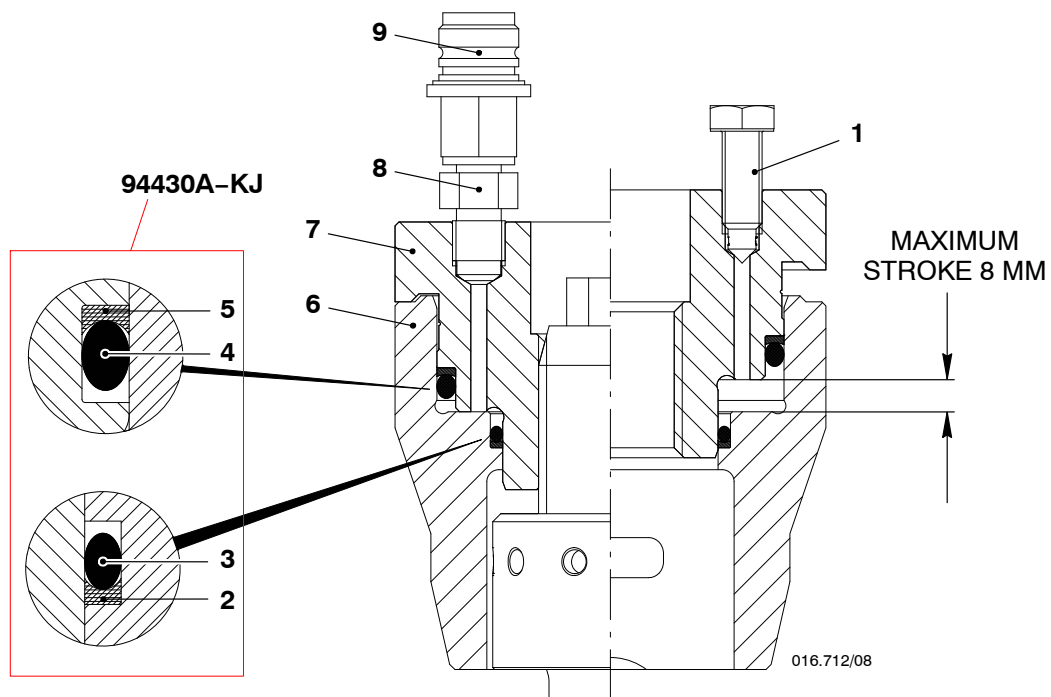
94430A-KJ Kit with back-up rings and O-rings for pre-tensioning jack

Fig. 10

Tool 94557 Pre-tensioning jacks for elastic bolts to top end bearing (supply unit)

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

94557-KJ Kit with back-up rings and O-rings for pre-tensioning jack

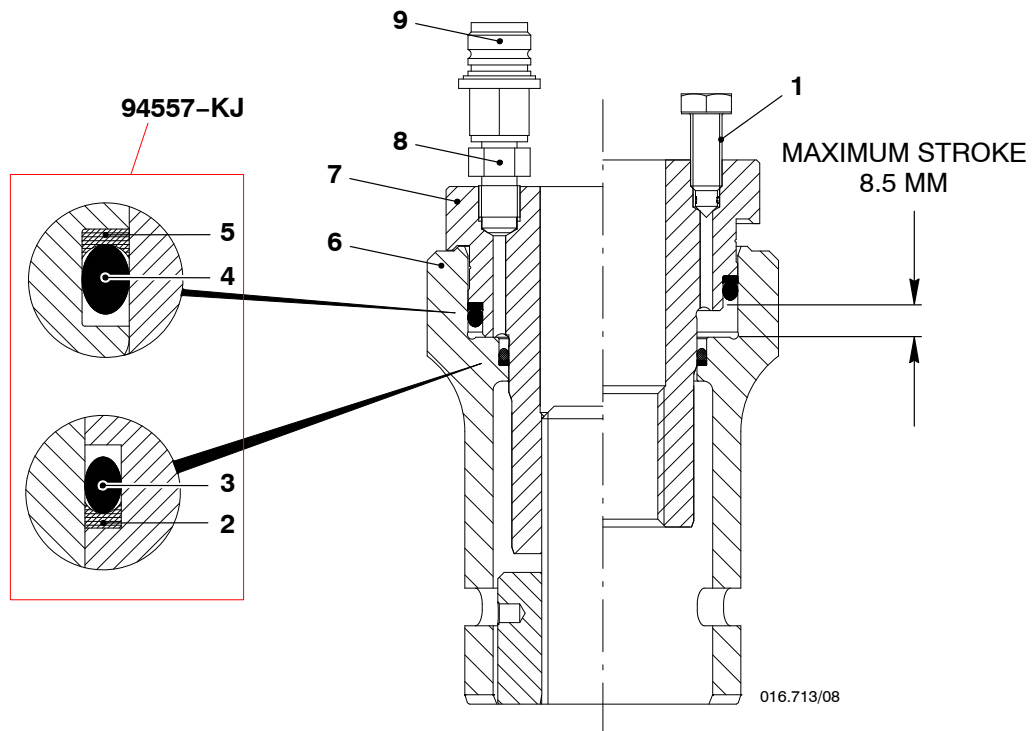


Fig. 11

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Hydraulic Pre-tensioning Jacks

General Instructions

Hydraulic pre-tensioning jacks for:

Version 1:

Foundation bolt and engine stay	94145
Tie rod	94180
Cylinder cover	94215A
Exhaust valve cage and bottom connecting rod studs	94252
Top end bearing	94315
Piston, piston rod foot	94340
Roller lifting tool (fuel pump)	94430A
Supply unit (fuel pump unit)	94557

Version 2:

Main bearing	94114
--------------	-------

1. General

WARNING



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

There are two versions of hydraulic jack preparation:

- Version 1 the piston (2) is attached directly on to the elastic bolt / elastic stud (5, [Fig. 1](#)).
- Version 2 the nut (3, [Fig. 2](#)) is used to apply tension to the elastic bolt / elastic stud.
 - 1) Make sure that the threads of elastic bolts and hydraulic jacks are smooth and clean.
 - 2) 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.
 - 5) Do a check of the oil in the HP oil pump or hydraulic unit.
 - 6) When you must add oil, read the specification of the pump manufacturer.
 - 7) Use an engine lubricating oil that has a viscosity of SAE 30 to SAE 40.

Note: In unusual conditions, you can also use cylinder lubricating oil.
 - 8) For data about the sealing rings on the hydraulic jacks, refer to [9403 3](#).
 - 9) To install elastic studs, refer to [0352 2](#).

Hydraulic Pre-tensioning Jacks: General Instructions

Version 1

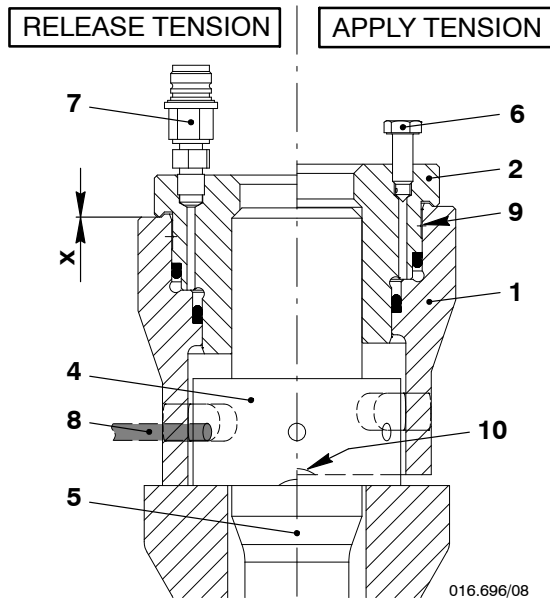


Fig. 1

Version 2

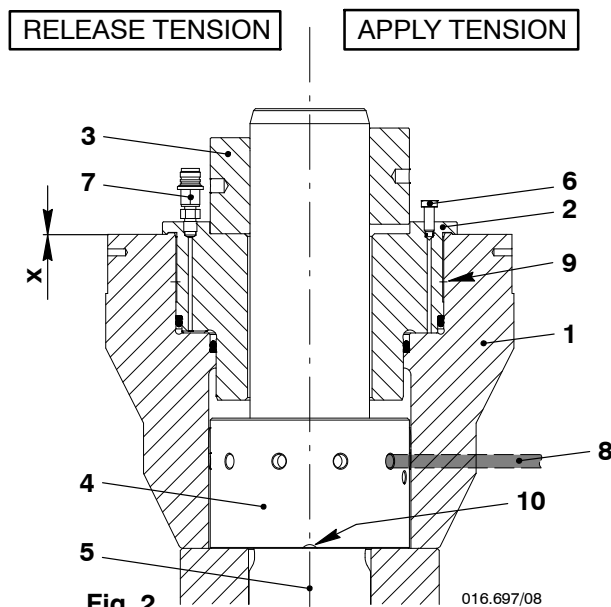


Fig. 2

2. Round Nut – Remove

2.1 Version 1 – Preparation

- 1) Make sure that the vent screw (6, Fig. 1) is open.
- 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, Fig. 2) is open.
- 2) Put the hydraulic jack over the elastic stud (5).

2.3 Procedure

- 1) Turn back the round nut (4), or the hydraulic jack (refer to 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.

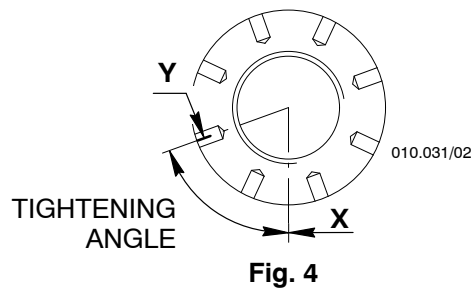
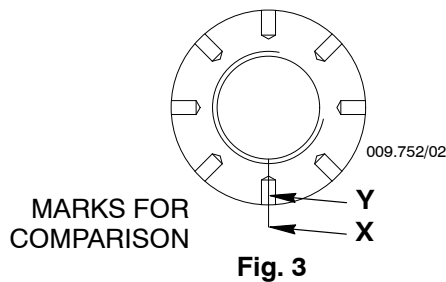
Note: Do not move the piston (2) above the limit of the red groove (9).

- 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 (refer to Table 1 below).
- 9) On the HP oil pump, or hydraulic unit, decrease the pressure to zero.
- 10) Remove the hydraulic jack.

Hydraulic Pre-tensioning Jacks: General Instructions

3. Round Nut – Install

- 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 on the part below (X) (refer to Fig. 3 and Fig. 4).



3.1 Version 1 – Preparation

- 1) Make sure that the vent screw (6, Fig 1) is open.
- 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, Fig. 2).

Note: If necessary, turn back the hydraulic jack a small distance to get access to the hole in the round nut (4).

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 (refer to the Table 1 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) Operate the round bar (8) to tighten the round nut (4).
- 9) Put the feeler gauge 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 Instructions

Table 1 – Hydraulic Jacks – Values and Comparison

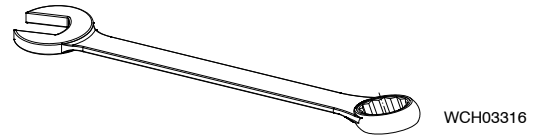
Application	Group	Jack	Tightening value [bar]	Comparison [$^{\circ}$ Δ , mm]	Reset of jack / round nut [turns]	Lubricating agent ²⁾
Foundation bolts	1112 1	94145	(1 st step 1000) 1500		1/4	No lubricant
Main bearing	1132 1	94114	1500		3/4	Oil
Engine stays	1715 1	94145	170		1/4	No lubricant
Tie rods	1903 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 $^{\circ}$	1 1/2	Oil
Exhaust valve cage	2751 1	94252	1500	200 $^{\circ}$	1	Oil
Top con rod	3303 1	94315	(1 st step 1100) 1500	1 st to 2 nd step 25 $^{\circ}$	1/2	Oil
Bottom con rod	3303 1	94252	(1 st step 600) 1500	1 st to 2 nd step 80 $^{\circ}$	1	Oil
Piston rod foot	3403 1	94340	(1 st step 1000) 1500	1 st to 2 nd step 20 $^{\circ}$	1/2	Oil
Piston head	3403 3	94340	1500	85 $^{\circ}$	1/2	Oil
Bearing, supply unit	5581 1	94557	1500		1/2	Oil
Roller lifting tool, supply unit	5556 2 ¹⁾	94430A	1500	84 $^{\circ}$	1/2	No lubricant

- 1) To cut out and cut in of a fuel pump, refer to the Operation Manual 5556 2.
- 2) For lubrication on threads and surfaces that touch.

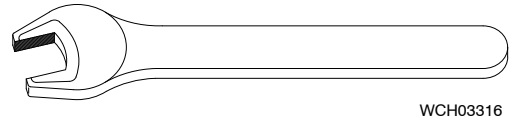
Tool List

Standard Tools

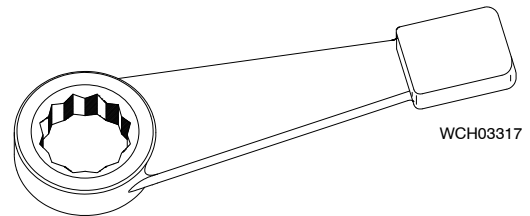
- 94000** **Combination wrenches, set compl.**
 consisting of:
34 wrenches AF6 to AF60
for ordering single wrenches state AF
Example: 94000-6
94000-6 **94000-60**



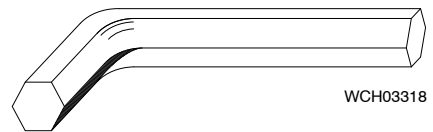
- 94001** **Open end wrenches**
 1 Piece AF70
 1 Piece AF85



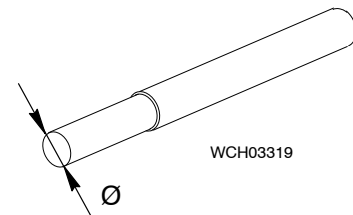
- 94002** **Ring slugging wrenches, set compl.**
 consisting of:
13 wrenches AF27 to AF85
for ordering single wrenches state AF
Example: 94002-27
94002-27 **94002-85**



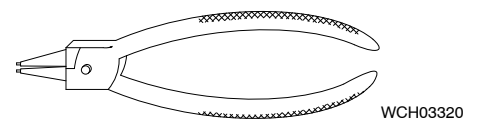
- 94003** **Allen keys, set compl.**
 consisting of:
9 Allen keys AF3 to AF17
for ordering single wrenches state AF
Example: 94003-3
94003-3 **94003-17**



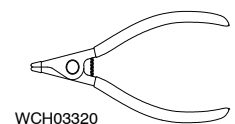
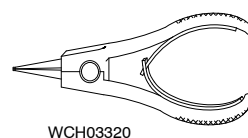
- 94005** **Round bars**
 for round nuts
- | | | | |
|------------------|------------|---------------|-------|
| 94005-4 | 1 Pieces . | Ø 4 mm (M27 | M33) |
| 94005-6 | 1 Pieces . | Ø 6 mm (M36 | M56) |
| 94005-9.5 | 1 Pieces . | Ø 9.5 mm (M60 | M80) |
| 94005-14 | 1 Pieces . | Ø 14 mm (M85 | M100) |




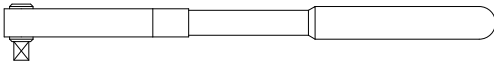

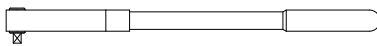
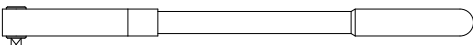
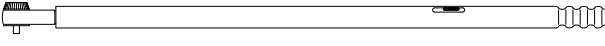


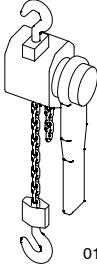
- 94007** **Circlip pliers**
- | | | |
|------------------|-------------------|-----------|
| 94007-C8 | 1 Piece | Type C 8 |
| 94007-C19 | 1 Piece | Type C 19 |
| 94007-C40 | 1 Piece | Type C 40 |
| 94007-C85 | 1 Piece | Type C 85 |



- | | | |
|------------------|-------------------|-----------|
| 94007-A10 | 1 Piece | Type A 10 |
| 94007-A19 | 1 Piece | Type A 19 |
| 94007-A40 | 1 Piece | Type A 40 |
| 94007-A85 | 1 Piece | Type A 85 |
| 94007-A41 | 1 Piece | Type A 41 |



Standard Tools

94009	Handle screw		
94009-M5	1 Pieces M5x150		
94009-M8	1 Pieces M8x100		
94009-M10	1 Pieces M10x100		
			000.372/93
94011-01	1 Torque spanner 3/8" No ratchet mechanism (Range of adjustment 2.5 11 Nm)		WCH02580
94011-01A	1 Adapter piece 3/8 to 1/2"		WCH02581
94011-02	1 Torque spanner 1/2" No ratchet mechanism (Range of adjustment 12 68 Nm)		WCH02296
94011-03	1 Torque spanner 1/2" No ratchet mechanism (Range of adjustment 50 225 Nm)		WCH02296
94012-02	1 Torque spanner 3/4" (Range of adjustment 150 750 Nm)		
94012-02A	adapter piece 3/4" - 1/2"		
94012-02B	shell type ratchet 1/2" - 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		012.233/04
94016-025	Manual ratchets WLL 500 kg, stroke 3,0 m		

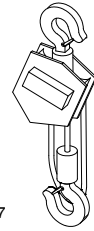
Standard Tools

94017-005 2 Spur-gearred chain block
WLL 1000 kg, stroke 4.0 m

94017-013 2 Spur-gearred chain block
WLL 2500 kg, stroke 3,0 m

94017-017 2 Spur-gearred chain block
WLL 3000 kg, stroke 4.0 m

94017-020 2 Spur-gearred chain block
WLL 5000 kg, stroke 4.0 m



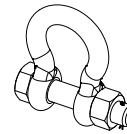
WCH02297

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

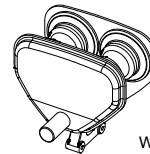
94019B 1 1207x907 mm, WLL 3150 kg

94019C 1 1088x1088 mm, WLL 5300 kg



WCH02297

94021 1 Trolley
WLL 3000 kg



WCH02582

Socket wrench inserts 1/2"

94022A-10 AF10

94022A-SC Screwdriver

Socket wrench inserts 3/4"

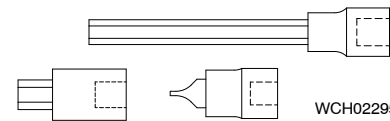
94022B-19 AF19

94022B-41 AF41

94022B-46 AF46

94022F Adapter piece 1/2" - 3/4"

94022G Adapter piece 1/2" - 3/8"



WCH02295

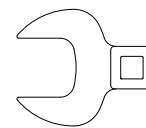
Crowfoot Wrench

94022C-22 AF22

94022C-24 AF24

94022C-27 AF27

94022C-35 AF35



WCH02295

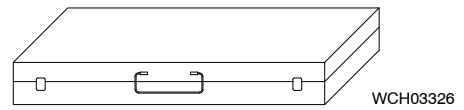
Socket wrench inserts 3/8"

94022D-04 AF04

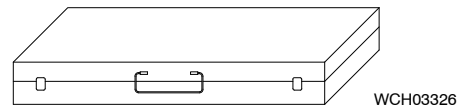
94022D-06 AF06

Standard Tools

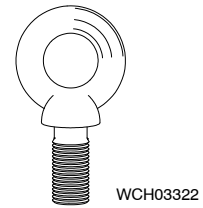
94025 **1 Tool box with socket wrench set 1/2"**
 (AF10 24, 26, 27, 28, 30,32, 33, 34, 36)



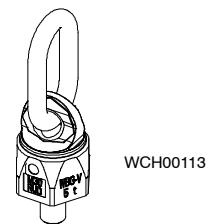
94026 **1 Tool box with hex. head drivers 1/2"**
 (AF5 10, 12, 14, 17)



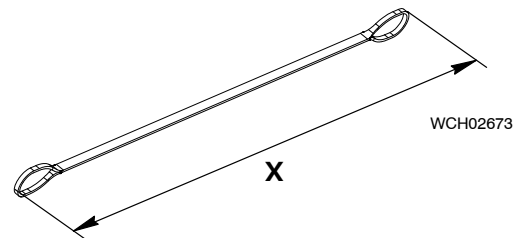
94045 **Eye bolt**
94045-M8 6 Pieces M8
94045-M10 4 Pieces M10
94045-M12 4 Pieces M12
94045-M20 4 Pieces M20
94045-M24 4 Pieces M24
94045-M36 6 Pieces M36



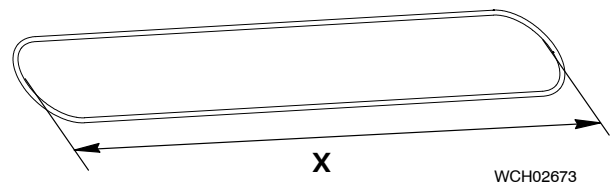
94048 **Swivel lug**
94048-M30 6 Pieces M30



94049A **3 Round sling**
 X = 1750 mm
 WLL = 1000 kg



94049F **2 Round sling**
 X = 1500 mm
 WLL = 1000 kg

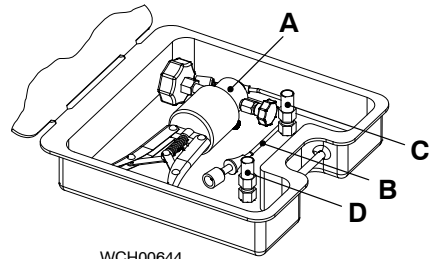


Standard Tools

94051 Tool for pressure measurement

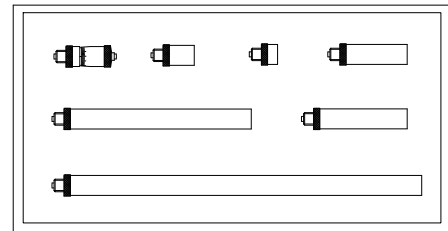
for pneumatic elements

- 94051A 1 Pressure generator 700 bar
- 94051B 1 HP hose
- 94051C 1 1/4" connector
- 94051D 1 1/4" NPT connector



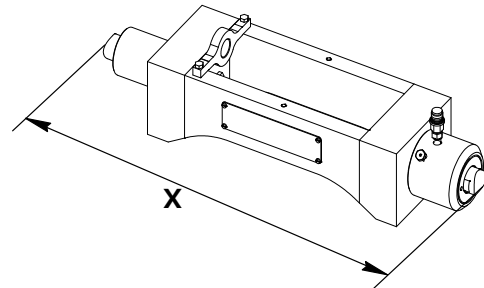
WCH00644

- 94101 1 **Inside micrometer Set**
(7 pieces with a measuring range 50 mm to 1010 mm), with case



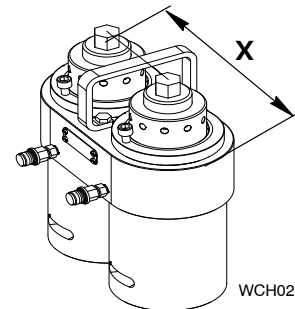
WCH02258

- 94110 1 **Thrust device**
To remove and install the main bearing cover
X = 750,5 mm
Mass approx. 58,8 kg



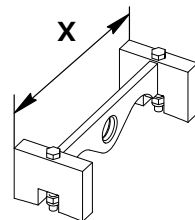
WCH02583

- 94114 2 **Double pre-tensioner**
for elastic studs to main bearing
X = 272 mm
Mass approx. 37,9 kg



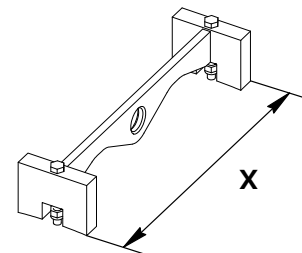
WCH02251

- 94116A 1 **Lifting tool**
To remove and install the main bearing shell
X = 264 mm
(WLL 70 kg)



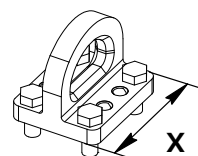
WCH02247

- 94116B 1 **Lifting tool**
To remove and install the main bearing shell
X = 185 mm
(WLL 40 kg)



WCH02247

- 94116C 1 **Lifting lug**
To remove and install the main bearing cover
X = 105 mm
(WLL 530 kg)



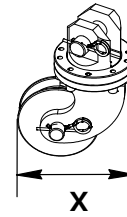
WCH02247

Standard Tools

94117 1 Roller support

To remove and install the main bearing cover

X = 232 mm
(Max. 12000 N)

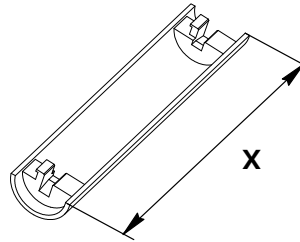


WCH02247

94117B 1 Deviation pipe

To remove and install the:
main bearing, cover, shell
connecting rod, cover, shell
etc.

X = 600 mm

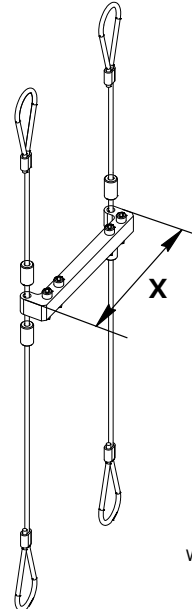


WCH02247

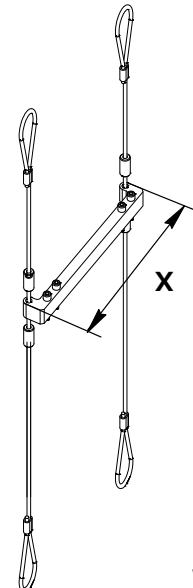
94118A 1 Turning-out device

To remove and install the main bearing shell at driving end

X = 203 mm
(WLL 800 kg)



WCH02247

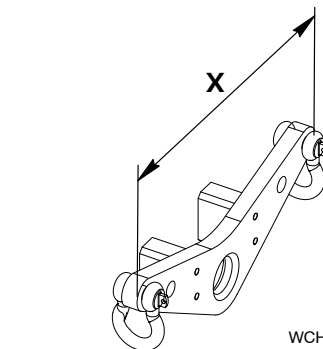


WCH02247

94118B 1 Turning-out device

To remove and install the main bearing shell

X = 272 mm
(WLL 800 kg)



WCH02247

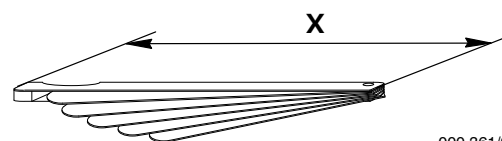
94119 1 Lifting plate

To remove and install the main bearing shell

X = 292 mm
(WLL 800 kg)

94122 1 Feeler gauge

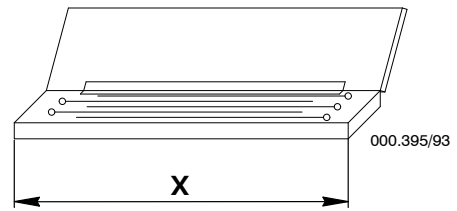
X = 100 mm
Blade thickness 0.05 ... 1.00 mm
(13-part)



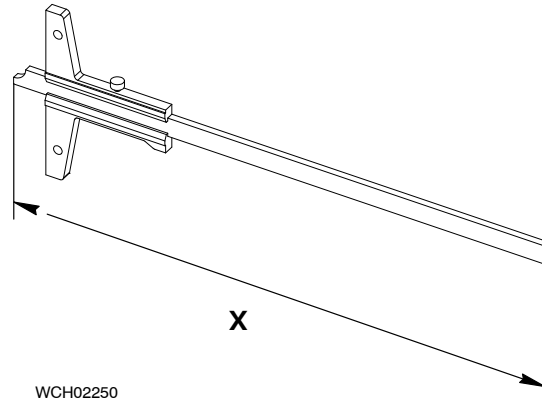
000.361/93

Standard Tools

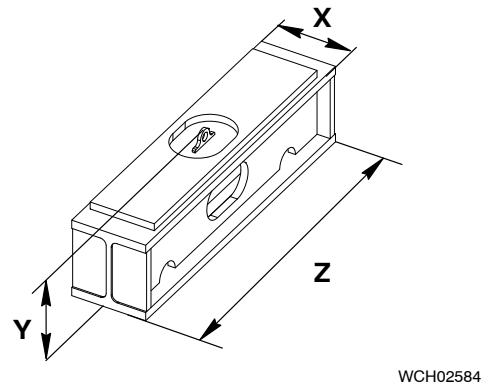
- 94123 1 Bearing feeler gauge**
 for main bearing
 X = 620 mm
 Blade thickness 0.1 ... 1.1 mm
 (11-part)



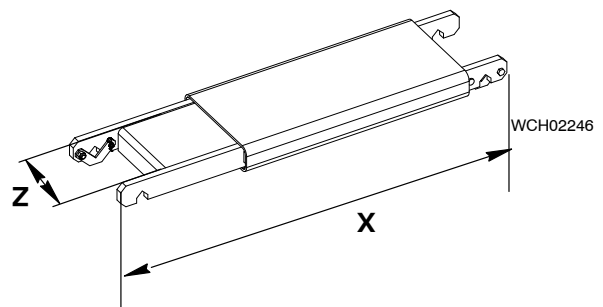
- 94126 1 Depth gauge**
 with case
 X = 310 mm



- 94141A 1 Bracket**
 To remove and install the
 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 Work supports

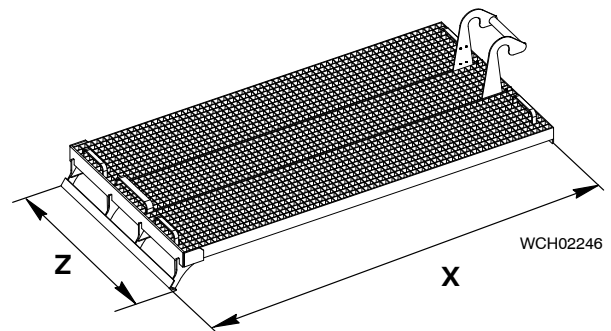
Quantity three grids each

X = 1739 mm

Z = 827 mm

Mass approx. 136 kg

(Mass of 1 grid approx. 81,3 kg)

(max. loading 200 kg/m²)

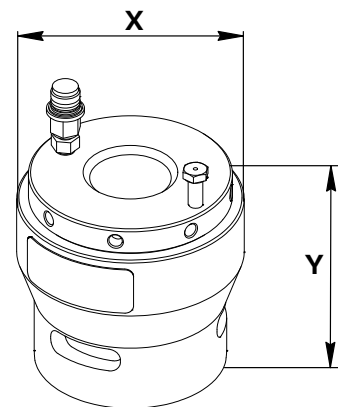
94145

1 Pre-tensioner

for foundation bolts and engine stays

X = \varnothing 156 mm

Y = 151 mm



94155

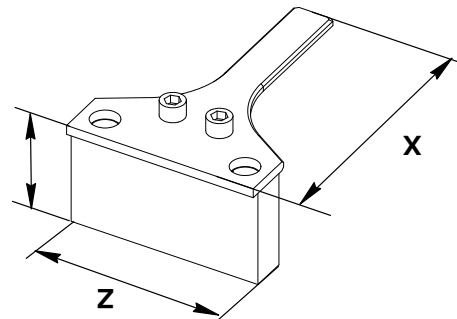
1 Carrier

for pushing out the thrust pads

X = 332 mm

Y = 134 mm

Z = 240 mm



94180

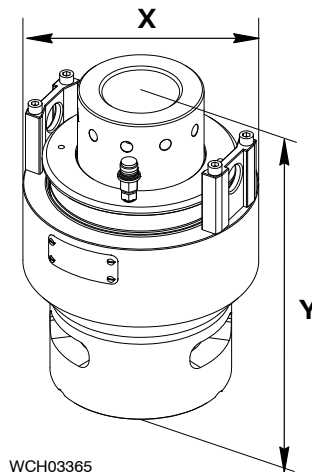
2 Pre-tensioner

for tie rods

X = 270 mm

Y = 355 mm

Mass approx 72,9 kg



Standard Tools

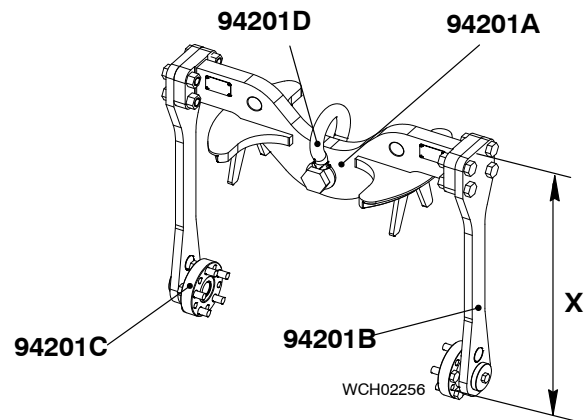
94201 **1 Lifting device**
 To remove and install the cylinder
 Liner
 X = 729 mm
 Mass approx. 187 kg
 consisting of:
 94201A, B, C, D

94201A **1 Lifting tool**
 X = 980 mm
 Mass approx. 103 kg

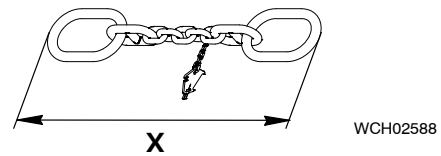
94201B **2 Holder**
 X = 994 mm
 Mass approx. 22,6 kg

94201C **2 Flange coupling**
 X = Ø180 mm

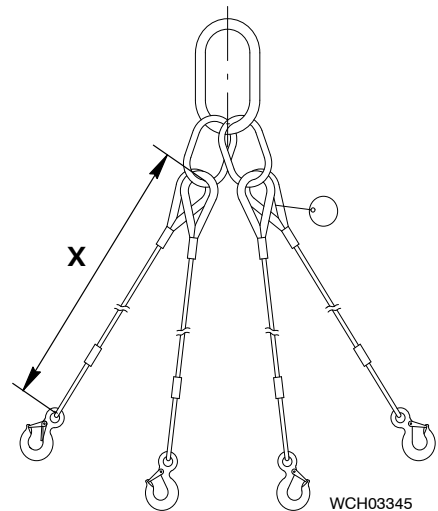
94201D **1 Shackle**



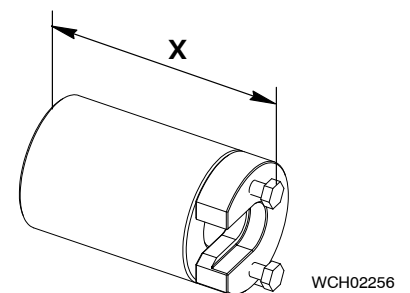
94202L **1 Chain**
 X = 729 mm
 WLL 5000 kg



94209 **1 Lifting hook**
 To remove and install the antipolishing
 ring
 X = 1000 mm
 WLL 750 kg

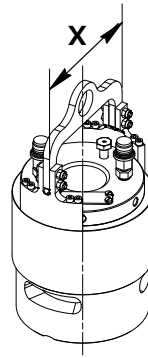


94213 **1 Dismantling tool**
 X = 90 mm



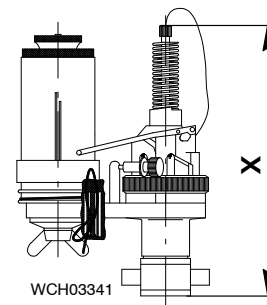
Standard Tools

- 94215A** **8 Pre-tensioner**
for cylinder cover studs
X = \varnothing 170 mm
Mass approx. 21,6 kg



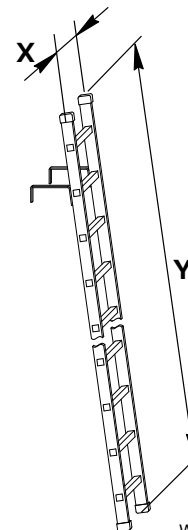
WCH03336

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



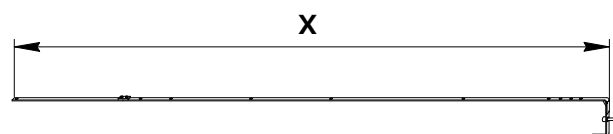
WCH03341

- 94224** **1 Ladder**
To measure the cylinder liner bore
X = 350 mm
Y = 2700 mm



WCH03332

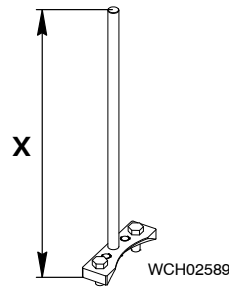
- 94225** **1 Measuring gauge**
To measure the cylinder liner bore
(accessory for it:
inside micrometer tool 94101)
X = 2420 mm



WCH03332

Standard Tools

- 94230 2 Distance holders**
 To remove and install the piston rod gland and piston, includes 4 screws M16x40
 X = 540 mm



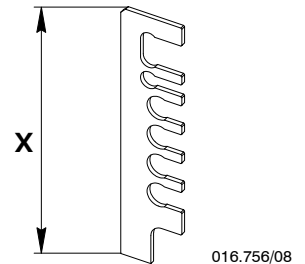
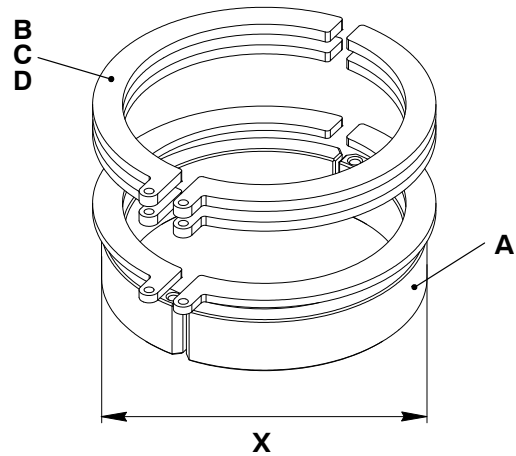
- 94231A 2 Clamping rings**
 Thick 54
 X = 280 mm

- 94231B 2 Distance pieces**
 Thick 12
 X = 300 mm

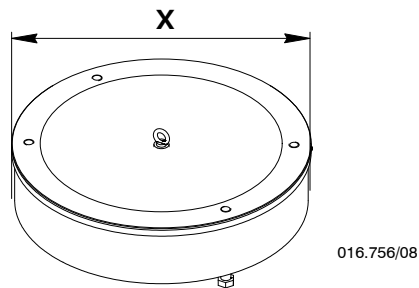
- 94231C 2 Distance pieces**
 Thick 11
 X = 300 mm

- 94231D 2 Distance pieces**
 Thick 9
 X = 300 mm

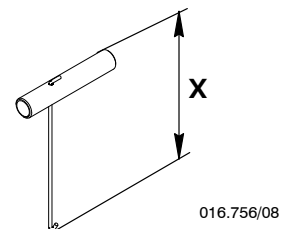
- 94231E 1 Template**
 Thick 6
 To install the scraper rings
 X = 254 mm



- 94232 1 Covering**
 To cover the bore of the piston rod gland in cylinder jacket (when piston and gland are removed)
 X = Ø 460 mm
 Mass approx. 31,9 kg



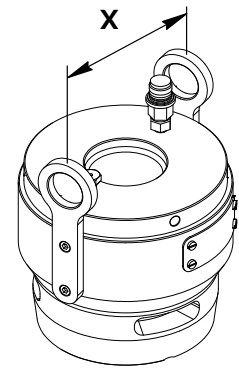
- 94233 1 Assembly tool**
 To apply tension to the springs
 In the piston rod gland and insulation bondage
 X = 150 mm



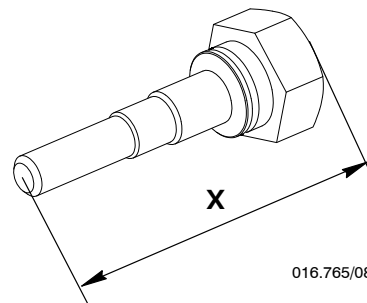
Standard Tools

- 94252 2 Pre-tensioner**
for exhaust valve cage /
bottom connecting rod
X = \varnothing 209 mm
Mass approx. 23.8 kg

WCH02591

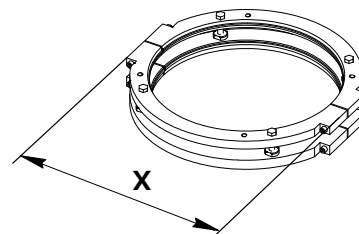


- 94259 2 Pressure element**
for exhaust valve
X = 204 mm



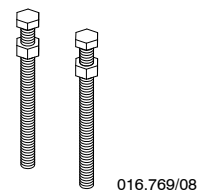
016.765/08

- 94261 1 Valve seat fitting and dismantling device**
X = 526 mm
Mass approx. 30,8 kg



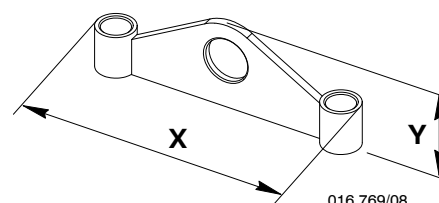
016.766/08

- 94263 2 Jack screws M12x150**
To assemble the guide bush to the
exhaust valve,
includes:
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

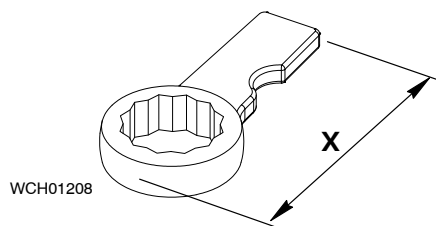


016.769/08

Standard Tools

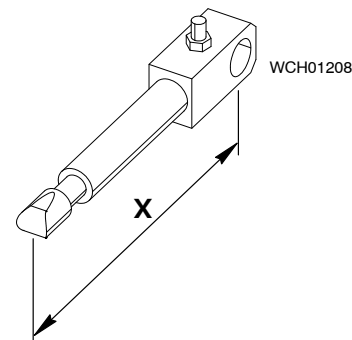
94269A-65 1 Slugging wrench

To loosen and tighten the coupling nut (AF70 on the injection valve with FAST
 X = 232 mm



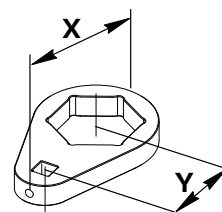
94269B 1 Hydraulic cylinder

To loosen and tighten the coupling nut on the injection valve with FAST
 X = 395 mm



94269C-41 1 Torque wrench extension

To loosen and tighten the Clamping nut (AF55) on the injection valve with FAST
 X = 106 mm
 Y = 65 mm



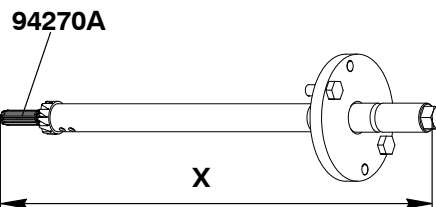
94269C-65 1 Torque wrench extension

To loosen and tighten the coupling nut (AF70) on the injection valve with FAST
 X = 144.5 mm
 Y = 75 mm

WCH01208

94270 1 Cutting device

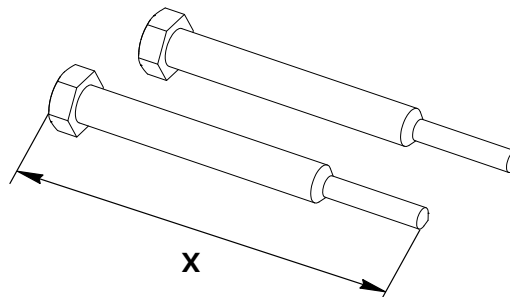
for overhauling injection valve (with FAST) seat in cylinder cover
 X = 564 mm
 includes:



WCH02302

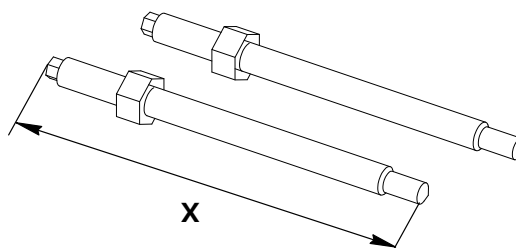
94270A 1 Profile cutter

94270C 2 Hexagon head bolt
 for the Injection valve
 X = 170 mm



WCH02263

94270D 2 Stud bolt
 for the Injection valve
 X = 176 mm

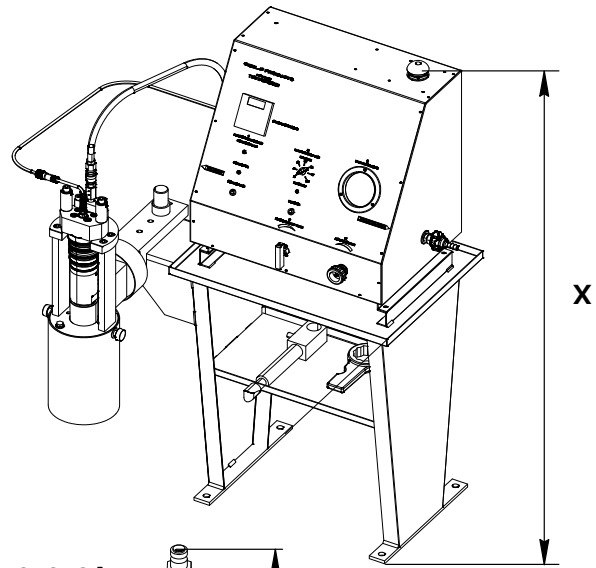


WCH02263

Standard Tools

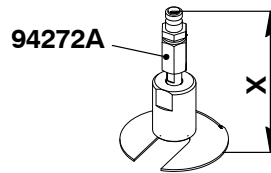
94272 1 Injector test bench

To set and do a test of:
 injection valve
 safety valve
 relief valve
 X = 1498 mm
 Mass approx. 161 kg
 includes:



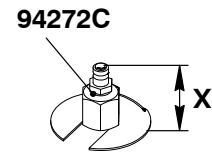
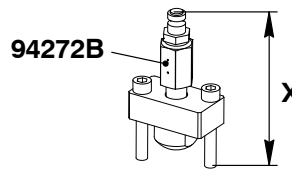
94272A 1 Valve holder
 for checking the fuel
 Overpressure safety
 valve
 X = 170 mm

94272B 1 Connecting piece
 for adjusting the injection
 Valve
 X = 130 mm



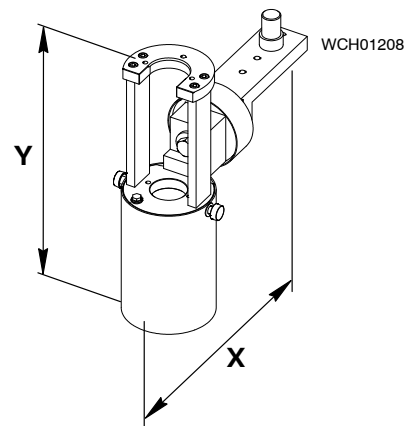
WCH02260

94272C 1 Valve holder
 for checking and
 adjusting relief valve to
 cylinder cover
 X = 68 mm



94273 1 Valve holder

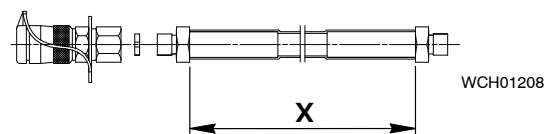
for the OBEL test bench
 To attach the injection valve with FAST
 X = 582 mm
 Y = 602 mm



WCH01208

94275 1 HP hose

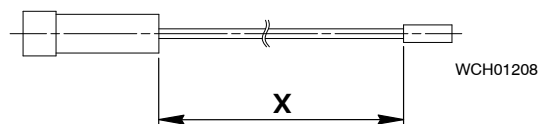
for the OBEL test bench
 To do tests and loosen / tighten the
 coupling nut on the injection valve with
 FAST
 X = 1350 mm
 Max. Operation pressure 1800 bar



WCH01208

94275A 1 Cable

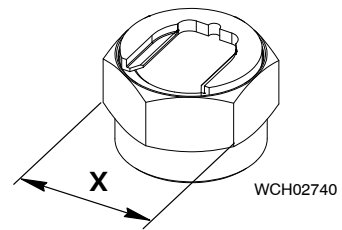
for the OBEL test bench
 Electric connection between OBEL test
 bench and injection valve with FAST
 X = 1200 mm



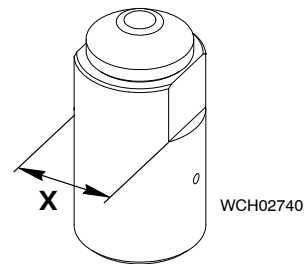
WCH01208

Standard Tools

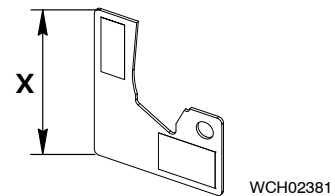
94278A 1 Nozzle disassembly tool
for injection nozzle disassembly
X = AF 46 mm



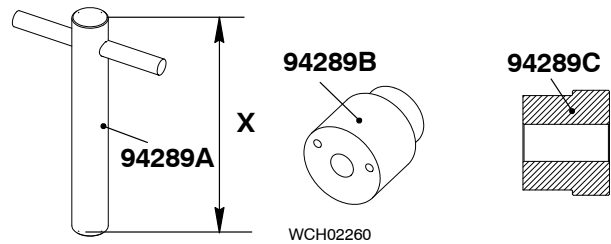
94278B 1 Nozzle assembly tool
for injection nozzle assembly
X = AF 41 mm



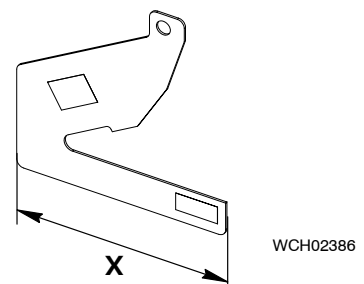
94279 1 Template
To do checks of the wear rate on the
exhaust valve seat
X = 145 mm



94289 1 Assembly tool
for mantling and dismantling of pilot
valve
Consisting of:
94289A 1 T-handle
94289B 1 Bush
94289C 1 Bush
X = 120 mm



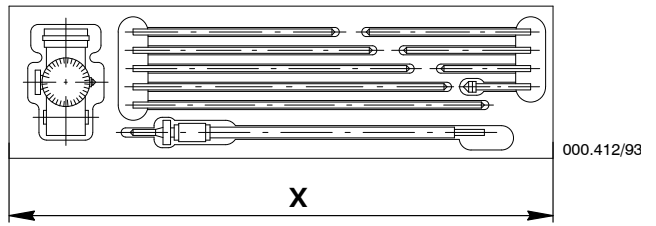
94292 1 Template
To do check of the wear rate of the
exhaust valve spindle
X = 211,5 mm



Standard Tools

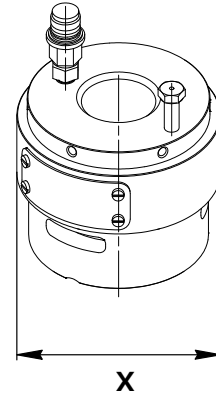
94305 1 Crankshaft checking equipment

To measure the crank deflection
(in wooden box)
X = 364 mm



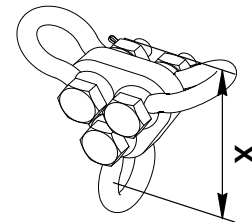
94315 2 Pre-tensioner

for the connecting rod studs on the top
end bearing
X = 130 mm



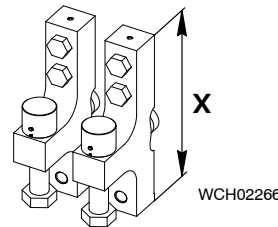
94321 1 Link

for connecting rod assembly
X = 304 mm



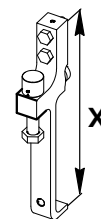
94322 1 Support

for connecting rod assembly
X = 344 mm



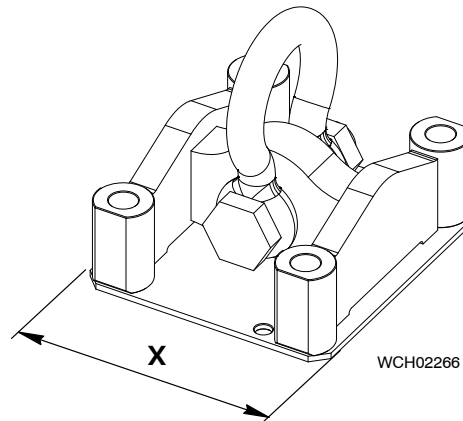
94322A 1 Support (Engines with ELBA)

for crosshead
X = 725 mm



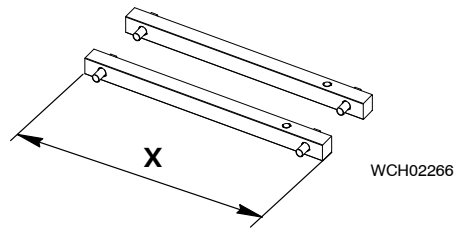
94324 1 Lifting tool

for connecting rod assembly
X = 290 mm
Mass approx. 38.8 kg
(WLL 5200 kg)
includes:

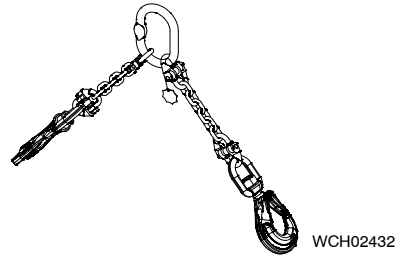


Standard Tools

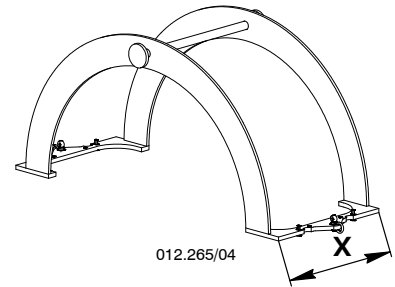
- 94324C 2 Fixing device**
 for connecting rod assembly
 X = 600 mm
 Mass approx. 15.3 kg



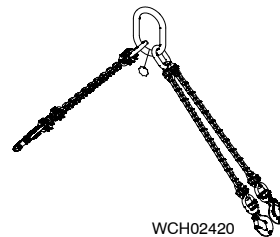
- 94325 1 Chain**
 To remove the crosshead pin
 2 slings à 424 mm
 Mass approx. 4 kg
 (WLL 1500 kg)



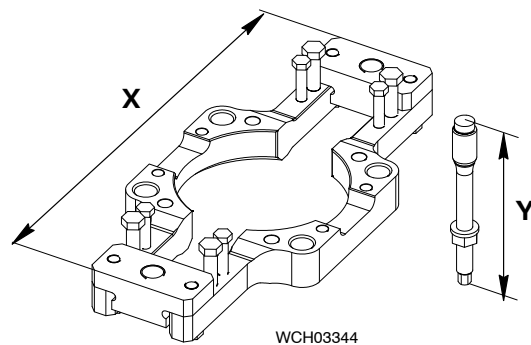
- 94326 1 Fitting and dismantling device**
 To remove and install the bottom end bearing shell
 X = 393 mm
 Mass approx. 16,8 kg
 (WLL 50 kg)



- 94327 1 Chain**
 To remove and install bottom 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 = 710 mm
 Including
94333A 2 Bolts
 Y = 299 mm

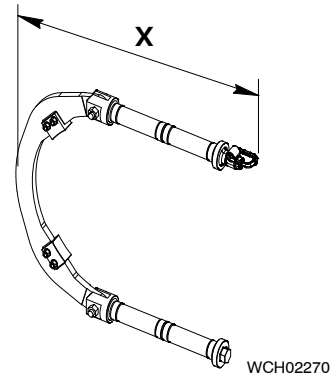


Standard Tools

94334

1 Holder

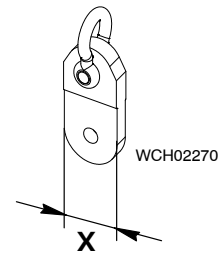
To remove and install the connecting rod (\varnothing 760 mm), includes
 $X = 1245$ mm
 Mass approx. 82.6 kg



94334A

1 Connecting element with shackle

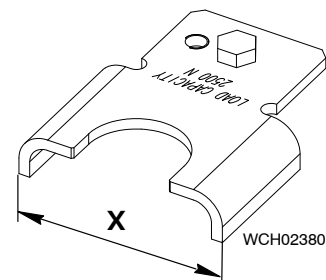
$X = 90$ mm
 (WLL 2500 kg)



94335

1 Stop plate

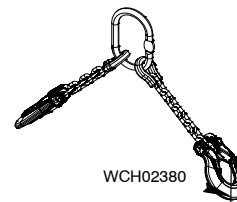
with screw M20x40
 To do an inspection of the top end bearing
 $X = 162$ mm



94335A

1 Chain

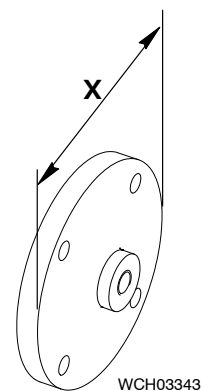
To lift / lower top bearing cover
 2 slings à 278 mm



94336

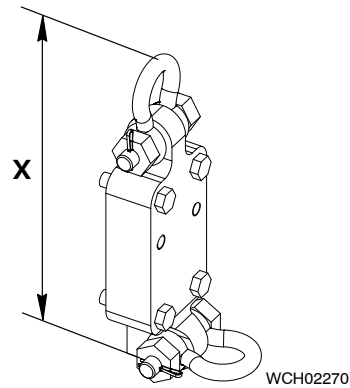
1 Connecting flange

for pre-lubrication of top and bottom end bearings
 $X = \varnothing 160$ mm

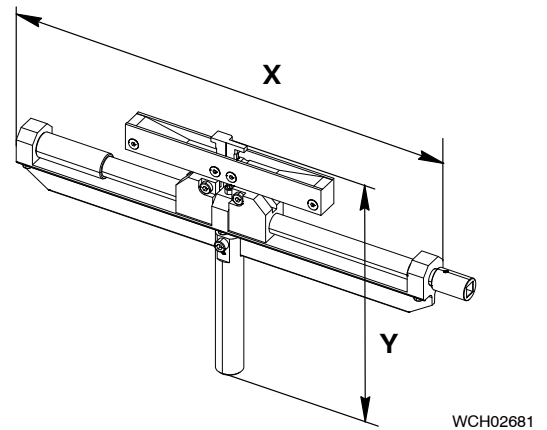


Standard Tools

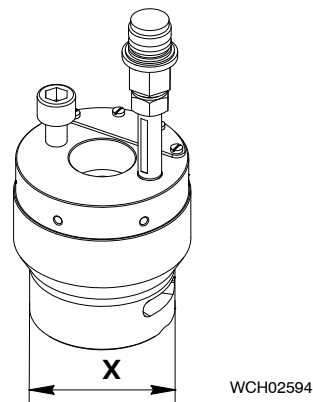
94337 **2 Lifting tools**
 with 4 screws M20x75
 for the connecting rod
 X = 384 mm
 WLL:
 vertical 2500 kg
 horizontal 1500 kg



94338 **1 Piston ring tensioning device**
 X = 500 mm
 Y = 292.1 mm

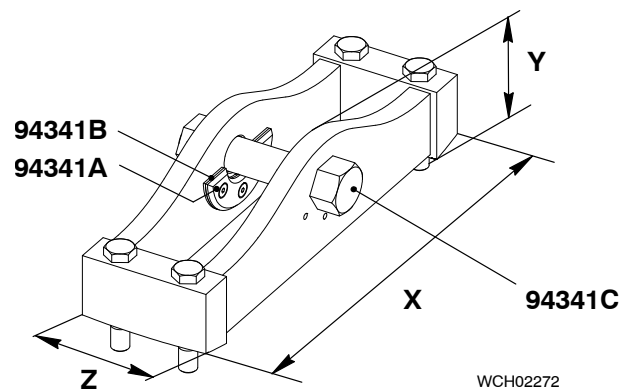


94340 **4 Pre-tensioner**
 for piston rod foot fastening
 X = Ø 83 mm



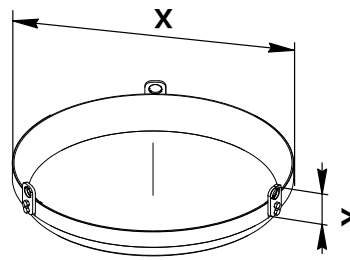
94341 **1 Piston suspension device**
 X = 494 mm
 Y = 170 mm
 Z = 220 mm
 (WLL 7350 kg)
 Mass approx. 46.2 kg

94341A **2 Distance plates**
94341B **2 Distance pieces**
94341C **1 Pin**



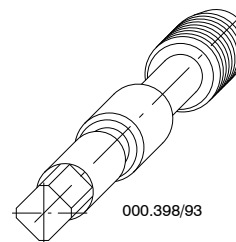
Standard Tools

- 94342 1 Insertion funnel**
 To install the piston
 $X = 719 \text{ mm}$
 $Y = 160 \text{ mm}$
 Mass approx. 36.3 kg

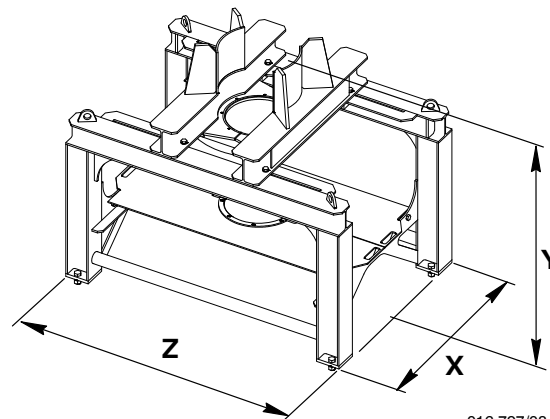


WCH02272

- 94348 1 Tap M20**
 To clean the carbon deposits in
 threaded holes of piston crown



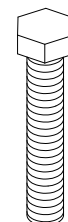
- 94350 1 Device**
 To hold piston and to remove the piston
 rod gland
 $X = 1136 \text{ mm}$
 $Y = 1271 \text{ mm}$
 $Z = 860 \text{ mm}$
 Mass approx. 272 kg



- 94364A 2 Jacking screws**
 To remove the piston head
 $M20 \times 190$

- 94364B 2 Jacking screws**
 To remove the spray plate
 $M12 \times 70$

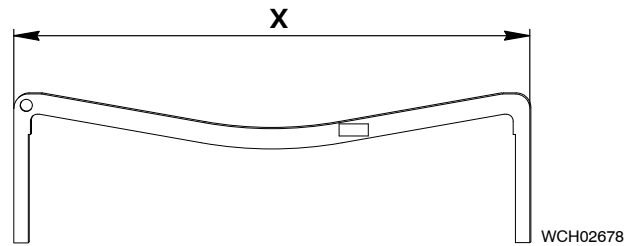
- 94364C 2 Jacking screws**
 To remove the piston skirt
 $M20 \times 65$



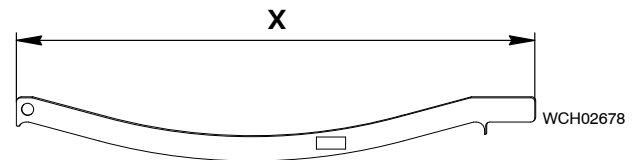
017.028/08

Standard Tools

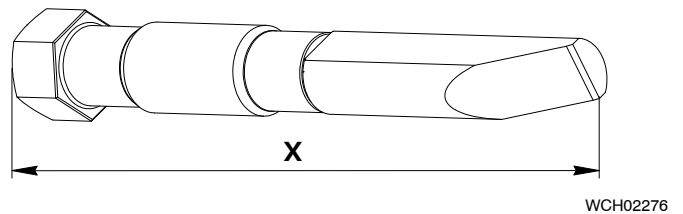
- 94366 1 Template**
 To do a check of the piston crown contour
 (piston removed)
 X = 689 mm



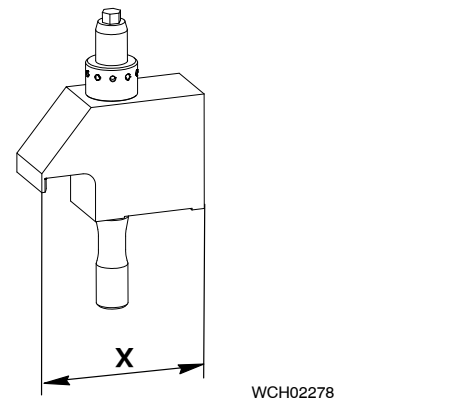
- 94366A 1 Template**
 To do a check of the piston crown contour
 (for use with piston installed)
 X = 740 mm



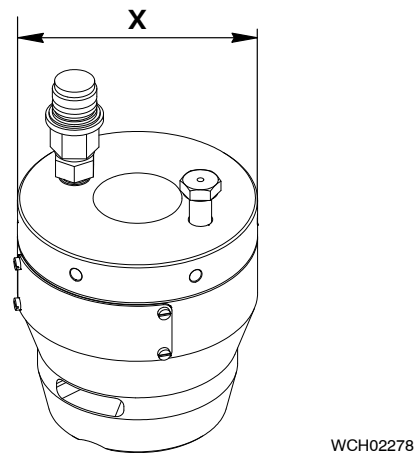
- 94410 8 Adjusting devices**
 To align the intermediate wheel
 X = 227 mm



- 94430 1 Roller lifting tools**
 for cutting out and cutting in of fuel pump,
 includes: elastic bolts and round nut
 X = 197 mm

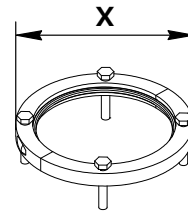


- 94430A 1 Pre-tensioner**
 for roller lifting tool
 X = Ø 108 mm



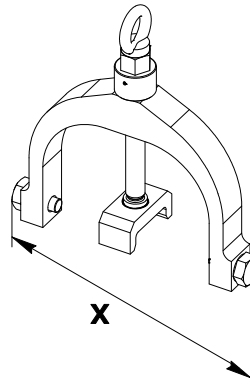
Standard Tools

- 94550 1 Clamping ring 2-parts**
 $X = \varnothing 210 \text{ mm}$



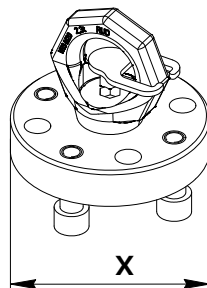
WCH02281

- 94551 1 Removal and installation device**
 To remove and install the guide pin to fuel pump
 $X = 334 \text{ mm}$



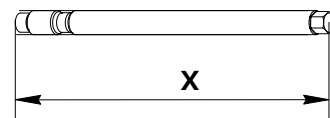
WCH02281

- 94552 1 Lifting tool**
 with hexagon head screws M14x40
 To remove and install the fuel pump
 $X = \varnothing 120 \text{ mm}$
 (WLL 600 kg)



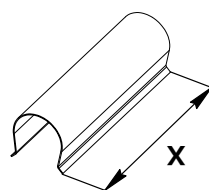
WCH02281

- 94553 1 Rod**
 Guide rod for the fuel pump
 $X = 470 \text{ mm}$



WCH02281

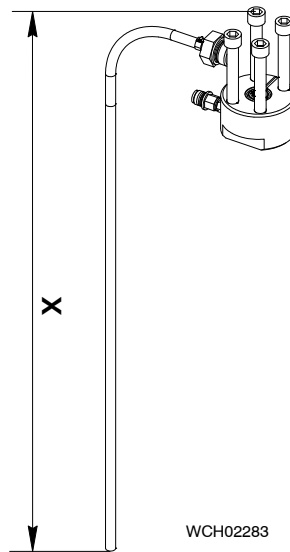
- 94555 2 Distance piece**
 for the fuel pump
 $X = 95 \text{ mm}$



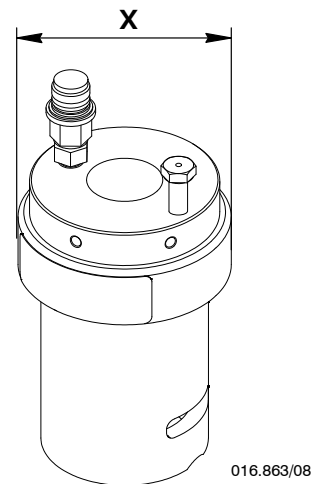
WCH02281

Standard Tools

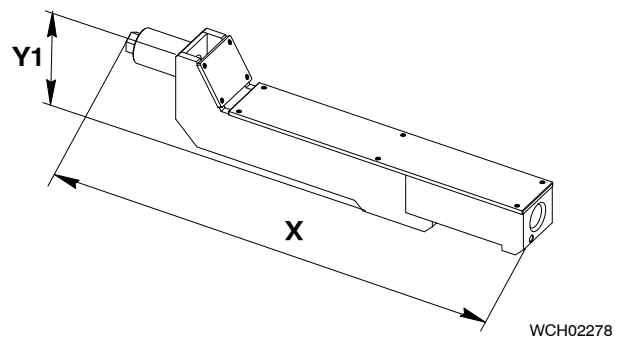
- 94556 1 PCV test block with tube**
To do a pressure check of the pressure control valve
X = 954 mm



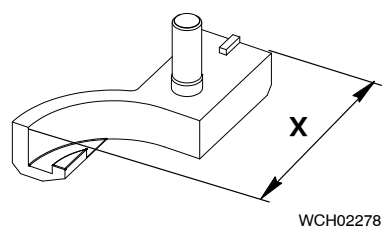
- 94557 2 Pre-tensioning jacks**
for elastic bolts on the camshaft bearing
X = \varnothing 112 mm



- 94566 2 Support**
for camshaft assembly,
includes clamping nut
X = 925 mm
Y1 = 180 mm
Mass approx. 23 kg



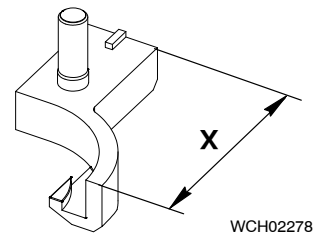
- 94566B 1 Holder**
for camshaft assembly,
includes hexagon socket screw
X = 172 mm



Standard Tools

94566C 1 Holder

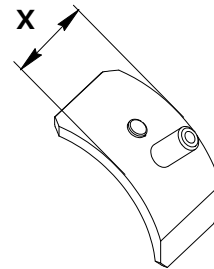
for camshaft assembly,
includes hexagon socket screw
X = 172 mm



WCH02278

94567 1 Assembly template

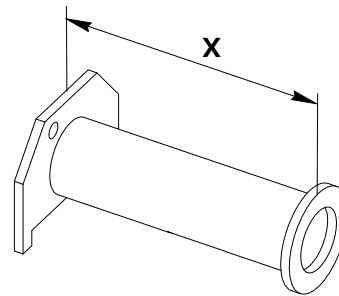
To remove and install the bearing shells
of the fuel pump unit
X = 90 mm



WCH02278

94567A 1 Assembly template

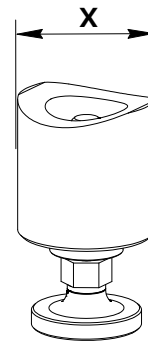
To install the of bearing shells to fuel
pump unit
X = 177 mm



WCH02278

94567B 1 Jacking screw

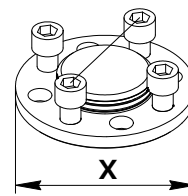
To assemble camshaft assembly
X = \varnothing 75 mm



WCH02278

94569 1 Blank flange

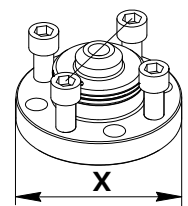
for the fuel pump,
includes screws M14x25
X = \varnothing 120 mm



WCH02278

94569A 1 Blank flange

for the intermediate piece,
includes screws M14x50
X = \varnothing 116 mm



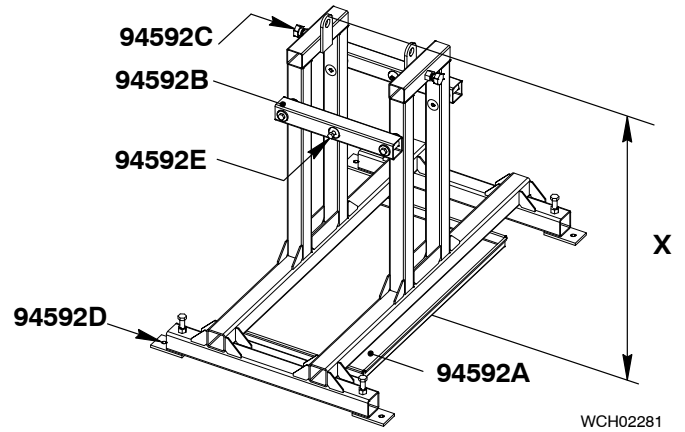
WCH02278

Standard Tools

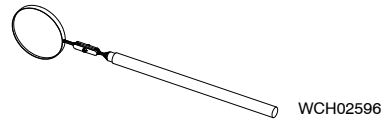
94592 1 Fuel pump rack

for the 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)**



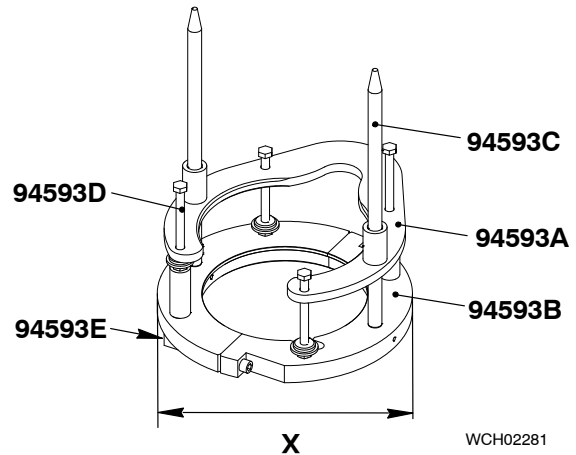
94592M 1 Mirror



94593 1 Guide bracket

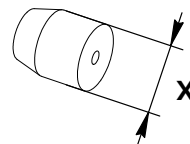
for the Pre-tensioning device
 X = Ø 370 mm
 Mass approx. 23.5 kg

- 94593A 1 Ring**
- 94593B 1 Ring (2-part)**
- 94593C 2 Guide rods**
- 94593D 4 Screws M12x130 with special nuts**
- 94593E 2 Screws M30x110**



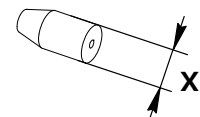
94597 1 Mandrel

To install the seal into the bottom spring carrier and the bottom housing of fuel pump
 X = Ø 70 mm

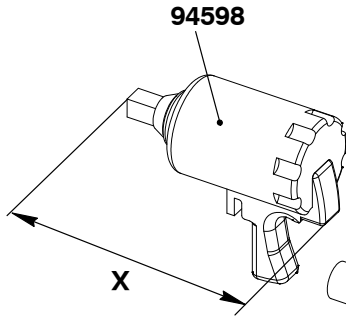
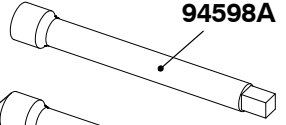
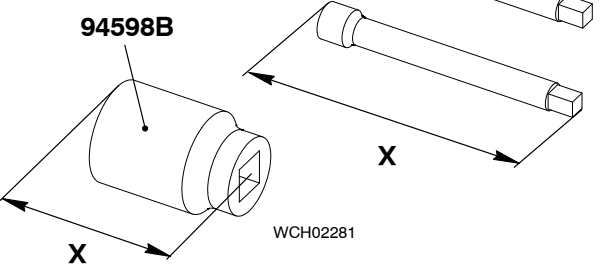


94597A 1 Mandrel

To install the seal into the bottom spring carrier
 X = Ø 40 mm



Standard Tools

94598	1 Pneumatic impact wrench To loosen and tighten the 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

If a turbocharger becomes unserviceable:

Cover to exhaust manifold outlet:

- 94653A-M60** for MET 60 MB, X = 680 mm, 12 holes
- 94653A-A175** for ABB 175, X = 948 mm, 16 holes
- 94653A-A265** for ABB 265, X = 680 mm, 12 holes
- 94653A-A270** for ABB 270, X = 763 mm, 16 holes
- 94653A-A275** for ABB 275, X = 890 mm, 16 holes
- 94653A-A180** for ABB 180, X = 872 mm, 24 holes

Cover to turbocharger inlet:

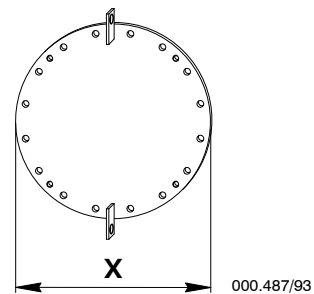
- 94653B-M60** for MET 60 MB, X = 680 mm, 16 holes
- 94653B-A175** for ABB 175, X = 726 mm, 16 holes
- 94653B-A265** for ABB 265, X = 680 mm, 12 holes
- n/a** for ABB 270, use 94653A A270
- n/a** for ABB 275, use 94653A A275
- n/a** for ABB 180, X = 872 mm, 24 holes

Cover to scavenge air receiver:

- 94653C-M60** for MET 60 MB, X = 640 mm, 16 holes
- 94653C-A175** for ABB 175, X = 680 mm, 16 holes
- 94653C-A265** for ABB 265, X = 555 mm, 16 holes
- 94653C-A270** for ABB 270, X = 668 mm, 16 holes
- 94653C-A275** for ABB 275, X = 736 mm, 20 holes
- 94653C-A180** for ABB 180, X = 686 mm, 20 holes
- 94653C-M66** for MET 66 MB, X = 580 mm, 16 holes

Cover to turbocharger outlet:

- 94653D-M60** for MET 60 MB, X = 600 mm, 16 holes
- 94653D-A175** for ABB 175, X = 900 mm, 16 holes
- n/a** for ABB 265, use 94653C A265
- 94653D-A270** for ABB 270, X = 633 mm, 16 holes
- 94653D-A275** for ABB 275, X = 686 mm, 20 holes
- n/a** for ABB 180, use 94653C A180
- n/a** for MET 66 MB, use 94653C M66



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Standard Tools

94663A

1 Support left

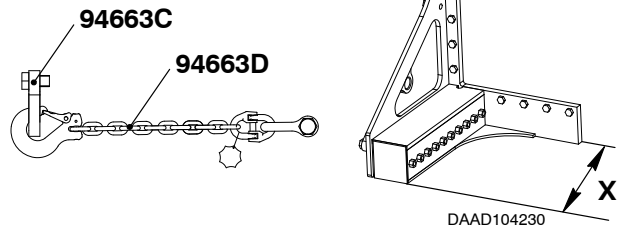
Includes safety chain **94663D** and safety lug **94663C**

To remove and install the scavenge air cooler

X = 590mm

(WLL 6200 kg)

Mass approx. 65 kg



94663B

1 Support right

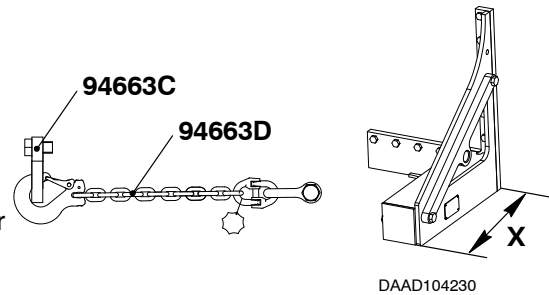
Includes safety chain **94663D** and safety lug **94663C**

To remove and install the scavenge air cooler

X = 705 mm

(WLL 6200 kg)

Mass approx. 65 kg

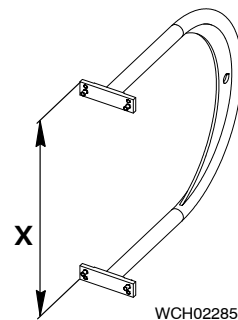


94663I

1 Support

To install the scavenge air cooler

X = 1114 mm



94667

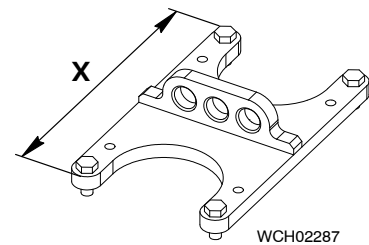
3 Lifting tool

To remove the water separator, includes:

4 Hexagon head screw M12x30

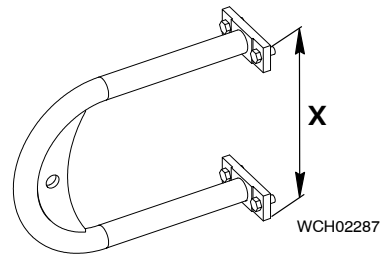
X = 300 mm

(WLL = 240 kg)

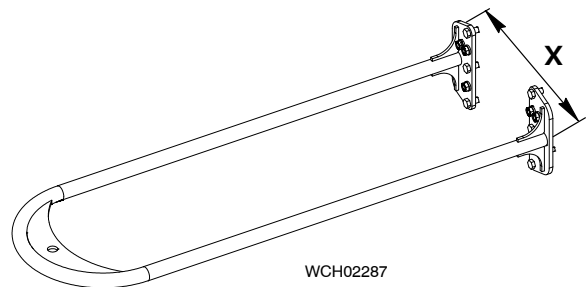


Standard Tools

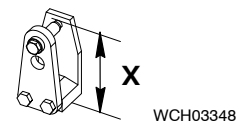
94667G **1 Holder**
for remove of water separator
X = 420 mm



94667H **1 Holder**
To install the water separator
X = 540 mm



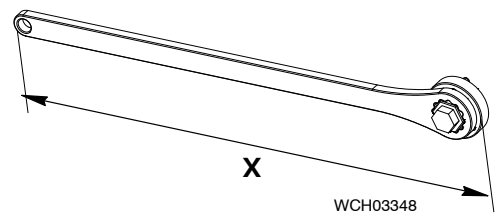
94701 **1 Adjusting tool**
for ELBA assembly
X = 139 mm



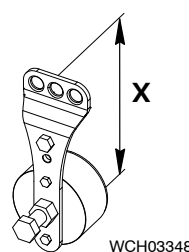
94702 **1 Transportation tool**
for ELBA assembly
X = 200 mm



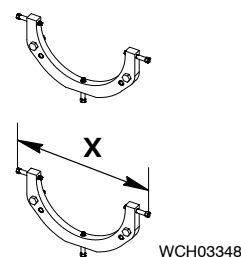
94703 **1 Turning device**
for ELBA assembly
X = 1089 mm



94704 **1 Lifting tool**
for ELBA assembly
X = 368 mm

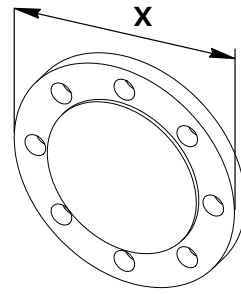


94705 **2 Aligment tools**
for ELBA assembly
X = 326 mm



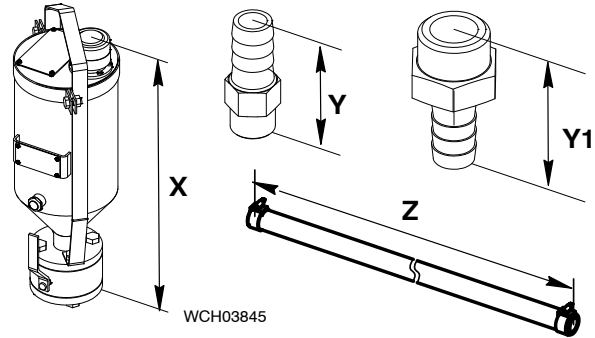
Standard Tools

- 94831 1 Blind flange**
To blank off the starting air pipe during emergency operation
X = Ø 235 mm



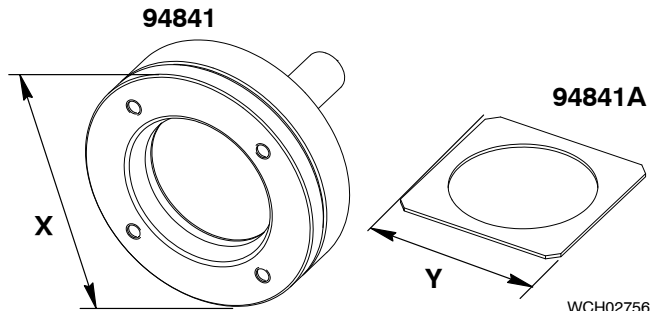
WCH02289

- 94844 1 Lubrication device**
for supply unit lubrication during maintenance
X = 600 mm
Adaptors:
Y = 40 mm
Y1 = 45 mm
Flexible hose:
Z = 3500 mm



WCH03845

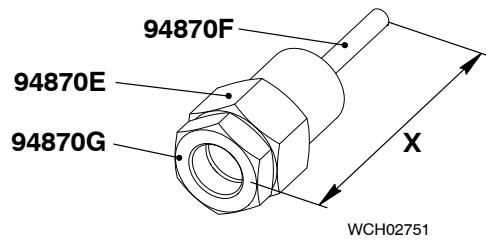
- 94841 1 Grinding tool**
for the hydraulic pipe
X = Ø 65 mm, R100



WCH02756

- 94841A 1 Stencil**
Y = 65 mm

- 94870 1 Grinding device**
for the HP fuel pipe
X = 166 mm
includes:

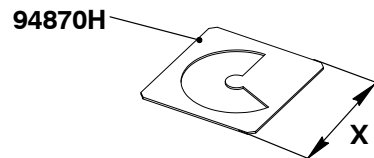


WCH02751

- 94870E 1 Screw-on sleeve**
AF60

- 94870F 1 Grinding tool**
with countersunk screw M8

- 94870G 1 Locknut**
M36x2, AF46



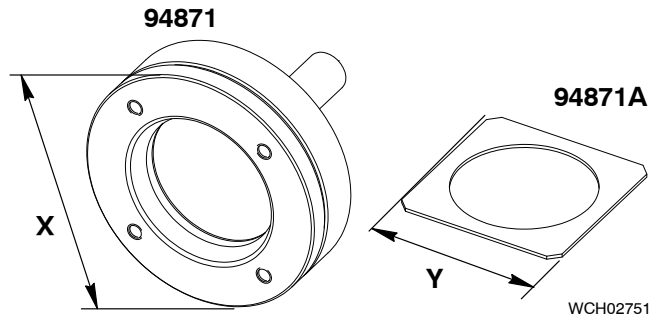
WCH02751

- 94870H 1 Stencil**
X = 70 mm

Standard Tools

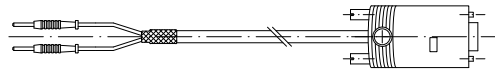
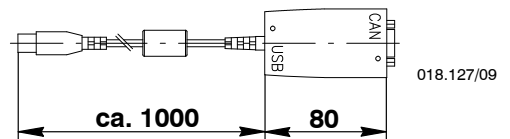
- 94871** 1 **Grinding tool**
for the injection pipe
X = Ø 60 mm, R30.5

- 94871A** 1 **Stencil**
Y = 50 mm

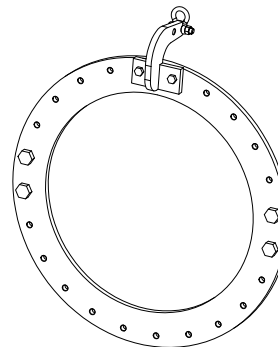


- 94930** 1 **SW-download package**
to UNIC for uni tool
consisting of:

- 94930A** 1 UBS to CAN adapter
- 94930B** 1 CAN cable (ca. 2.5 m)
- 94930C** 1 Ethernet adapter cable
(software tool)



- 94930** 1 **Lifting tool**
SCR valve disassemble
Including:
 - 1 Lifting plate
 - 1 Lifting ring
 - 4 Hexagon head screw M27x60
 - 2 Hexagon head screw M16x55
 - 2 Hexagon nut M16
 - 1 Shackle

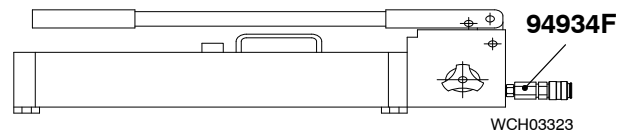


WCH03874

Standard Tools

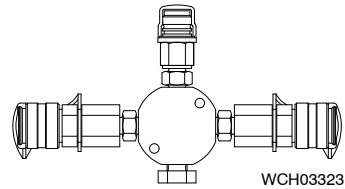
Hydraulic parts and pump

94931 **1 HP oil pump**
 Operation pressure maximum
 permitted pressure 2000 bar

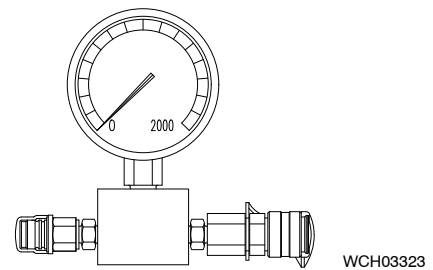


94934F **1 Adapter piece**

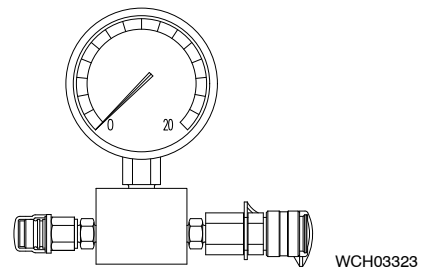
94934 **2 Adapter**



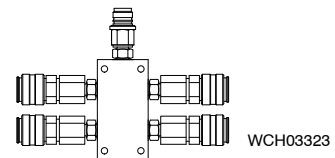
94934A **2 Pressure gauges**
 0 2000 bar



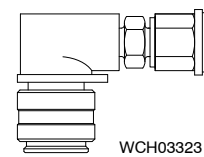
94934B **1 Pressure gauge**
 0 16 bar



94934C **1 Distributing piece**

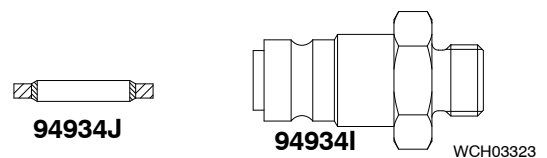


94934G **4 Coupling elements**



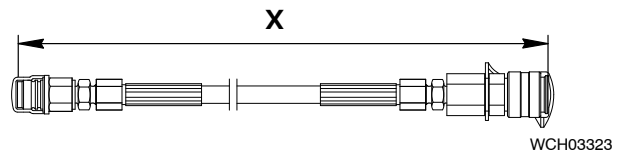
94934I **1 Connection nipple**
 To do a test of the lubrication quill

94934J **1 Tredo joint**
 To connect the nipple 94934I

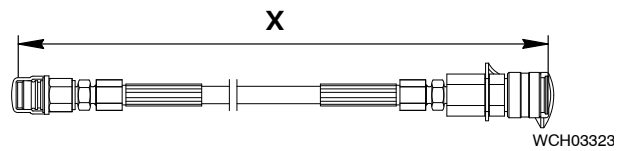


Standard Tools

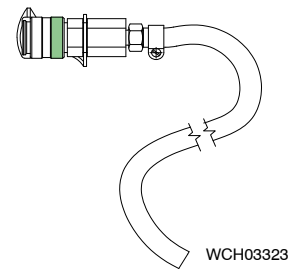
94935 **5 HP hoses**
with closing valves and coupling sockets
X = 2130 mm
Operation pressure max. 2000 bar



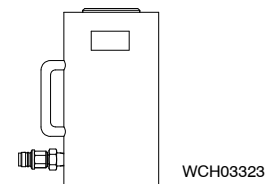
94935A **5 Flexible hoses**
with closing valves and coupling sockets
X = 1210 mm
Operation pressure max. 2500 bar



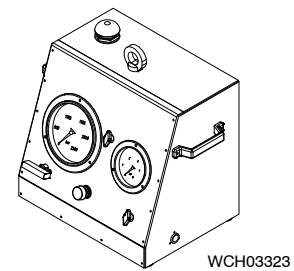
94935C **1 Hose**
To drain oil from pre-tensioning jacks



94936 **2 Hydraulic ram**
with closing valves
Operation range 933KN to 1002 kN
(95 t to 100 t)



94942 **1 Hydraulic unit**
Operation pressure max. 2000 bar



Recommended Special Tools

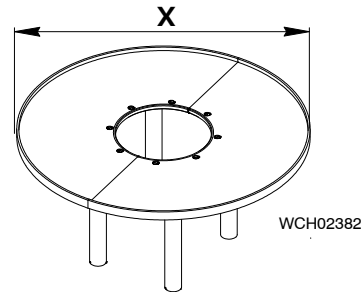
94234

1 Platform

for piston rod gland removal inside the engine

$X = \varnothing 772 \text{ mm}$

Mass approx. 30 kg



94291

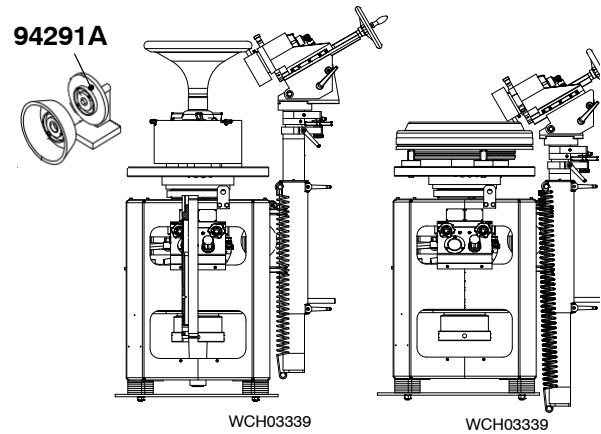
1 Valve grinding device complete

for valve spindle and valve seat

94291A

2 Grinding discs

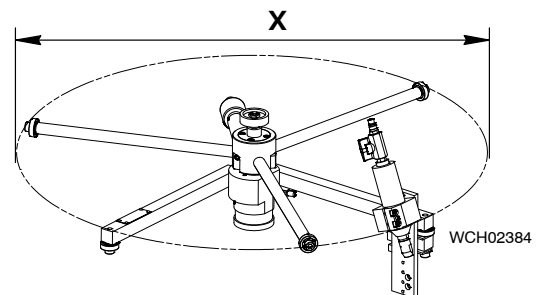
(C-M No. 11373-01-01)



94299

1 Grinding device

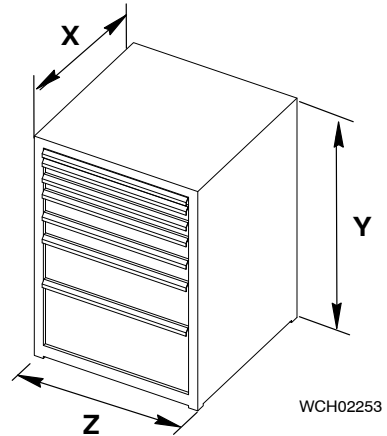
$X = \varnothing 740 \text{ mm}$



Recommended Special Tools

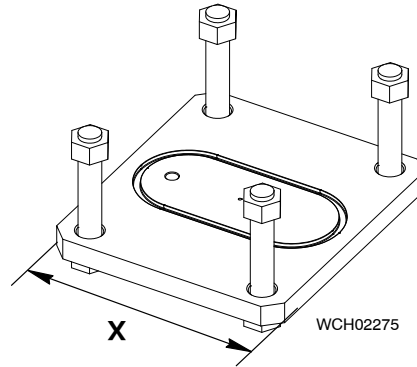
94300 1 Tool Cupboard

X = 725 mm
 Y = 1000 mm
 Z = 717 mm
 Mass approx. 133 kg



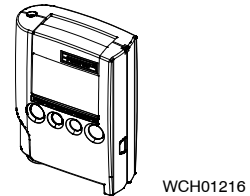
94349 1 Plate

for the piston pressure tests
 X = 290 mm
 Mass approx. 22.9 kg



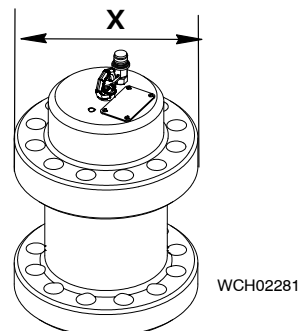
94356 1 Equipment case

with instruments
 To measure the thickness of chrome-ceramic-layer on the piston rings



94595 1 Hydraulic ram

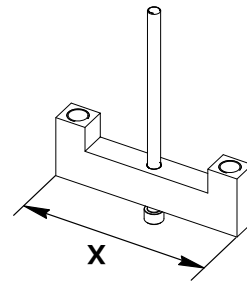
To assemble fuel pump
 X = Ø 270 mm
 Mass approx. 79.4 kg
 consisting of:



Recommended Special Tools

94595D 1 Piston reset device

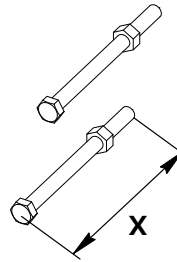
X = 255 mm



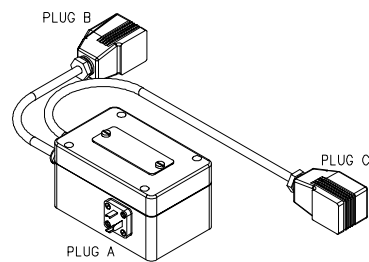
WCH02281

94595E 2 Screw M30x400

X = 418.7 mm



WCH02281

94929 1 Connecting cables with plugs
for emergency cylinder lubrication
Connector (plug C)
Plug B with cable length = 0.5 m
Plug C with cable length = 2.5 m

WCH01087

Winterthur Gas & Diesel in brief

Winterthur Gas & Diesel Ltd. (WinGD) is a leading developer of two-stroke low-speed gas and diesel engines used for propulsion power in merchant shipping. WinGD's target is to set the industry standard for reliability, efficiency and environmental friendliness. WinGD provides designs, licences and technical support to manufacturers, shipbuilders and ship operators worldwide. The engines are manufactured under licence in four shipbuilding countries. WinGD has its headquarters in Winterthur, Switzerland, where its activities were founded in 1898.

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