

WÄRTSILÄ

W-X62DF

Maintenance Manual

“Marine”

Vessel:

Type:

Engine No.:

Document ID: DBAD220106

Winterthur Gas & Diesel Ltd.
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Page No.	Modification		Title	Subject	Page or Manual	
	Date	No.			new	exch.
	2015			Maintenance Manual, Issue 2015	x	
				Date of publication 2015-12-09		

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2	Cylinder Liner and Cylinder Cover
3	Crankshaft, Connecting Rod and Piston
4	Driving Wheels and Shut-off Valve for Starting Air
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General Information

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For Your Attention

1. General

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

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

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

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

2. Spare Parts

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

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

3. Data

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

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

4. Personnel

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

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

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Preface

The instructions 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 Wärtsilä Switzerland Ltd).

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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Basic Engine Data

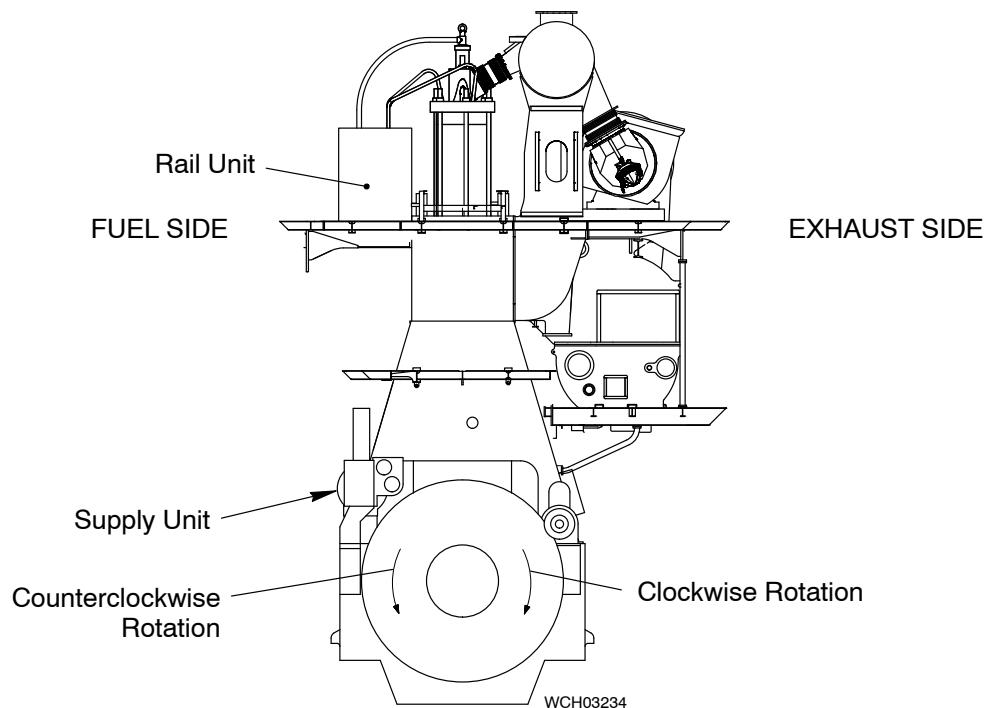
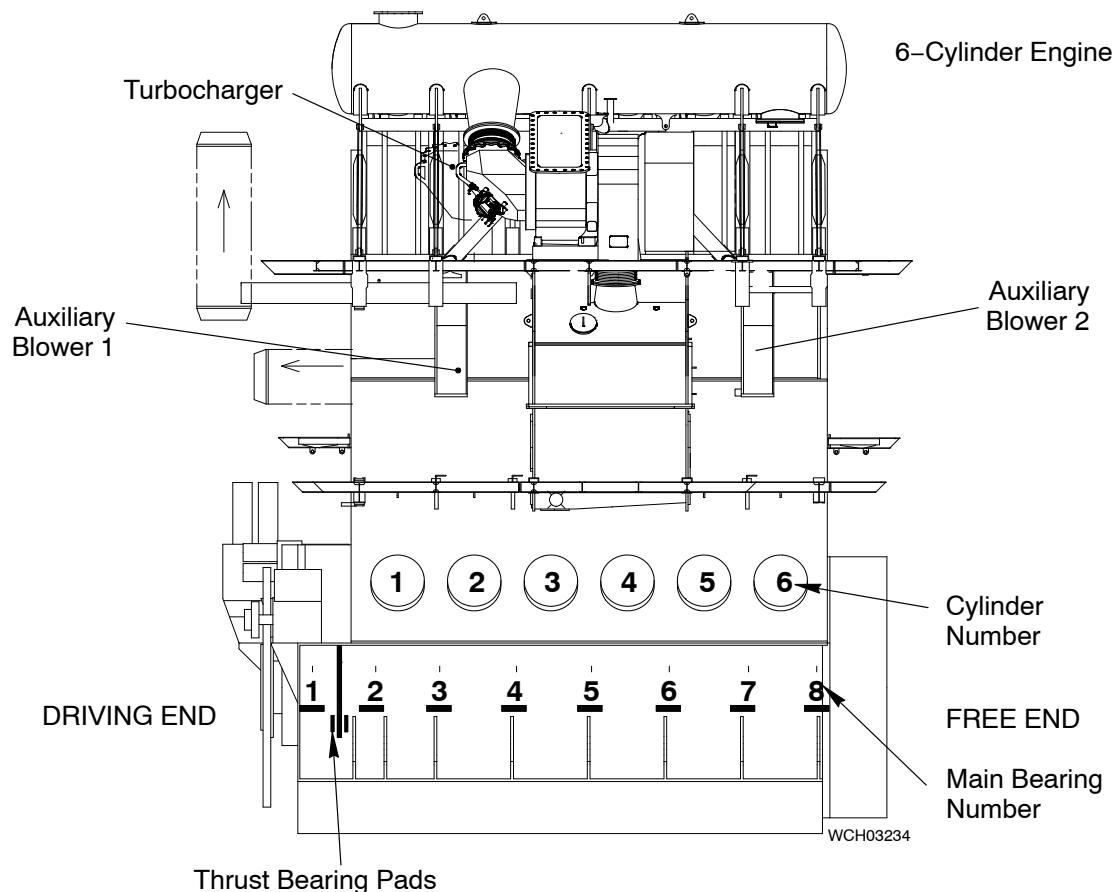


Fig. 1: Outline View

Unic Parts:

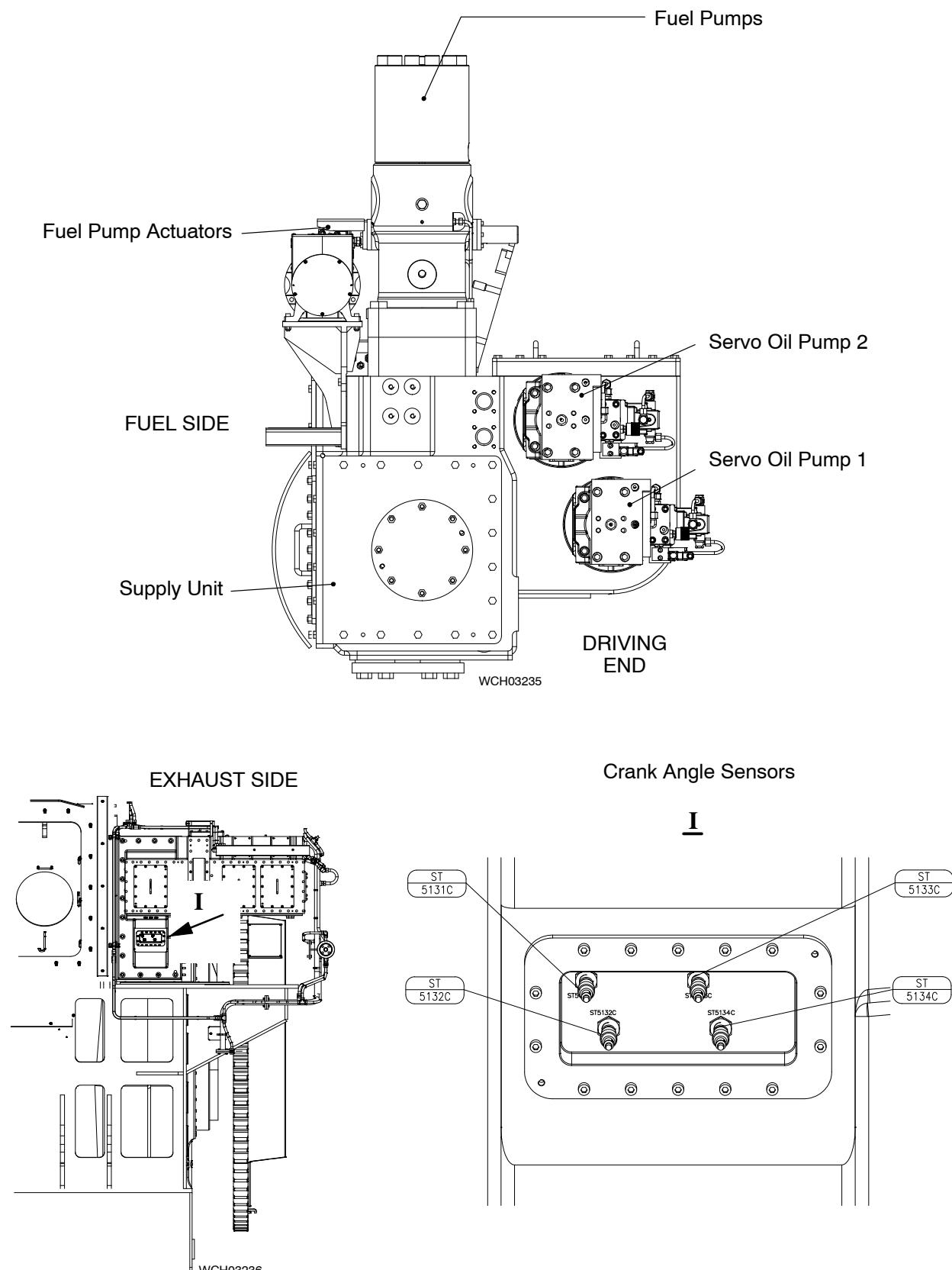


Fig. 2: Unic Parts

General Guidelines for Maintenance

Safety Precautions and Warnings

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1. General

The maintenance work, which must be done on the engine at regular intervals, is described in the Maintenance Schedule 0380-1. 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 be extended or decreased.

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 general safety conditions are as follows:

- All personnel must know the fire fighting procedures.
- All personnel must know the health and safety data and environment protection data related to the operation and maintenance of diesel engines.
- All personnel must know the dangers, functions and operation of cranes and lifting devices.
- The safety officer must make sure that all precautions are done to prevent dangerous conditions.
- The operator must select a supervisor to give work tasks to each person who does maintenance work.
- Make sure that fluids that drain or are released cannot cause explosions, fires or accidents during maintenance. Keep the engine and the areas around the engine clean to help prevent accidents and increase the quality of the work.
- Before you start maintenance on the engine, make sure that if necessary, the pressure in the related systems is released and fluids are drained. Make sure that you record the pressures and quantities.
- Some media, e.g. fuel, oil are very flammable, thus you must keep such media away from fire, hot parts etc.
- Make sure that personnel do not smoke in the engine room.
- To prevent injury, make sure that all surfaces where personnel can walk or stay do not have oil, fuel etc and are kept clean and dry.

3. Precautions before the Start of Maintenance

CAUTION



Damage Hazard: Do not use water or cleaning fluid to clean the electronic components and control boxes on the engine and the rail unit. Damage can occur if water goes into these electronic components or control boxes.

CAUTION



Damage Hazard: When electric welding is done near or on the engine, electromagnetic fields or peak voltage can occur. This can cause damage to the electronic components of the Engine Control System.

Before you do electric welding, you must do the procedure that follows:

- 1) Stop the engine.
- 2) Set to off the electronic system. There must be an elapsed time of one minute before you continue.
- 3) If the welding area is in a radius of two meters from an electronic module and/or a sensor, disconnect the modules and/or sensors.
- 4) Close the covers of all electronic boxes and apply protection to the cables, sensors, etc. to prevent damage from sparks and heat.
- 5) Use a conductive material connected to earth to give protection to the check and control units.
- 6) Make sure that the welding cable goes directly to the welding point without unnecessary loops. Also, make sure that the welding cables are not parallel to cables of the electronic units.

Before you start the maintenance on the engine, specially the running gear, do the procedure that follows:

- 1) Close the shut-off valves on the starting air bottles.
- 2) Close all the shut-off valves in the control air supply unit.
- 3) Open the drains on each starting air bottle to release all the pressure.
- 4) On the starting air shut-off valve, operate the handwheel to move the shut-off valve to the position CLOSED.
- 5) On the main starting air pipe, open the vent and drain valve. Keep the vent and drain valve in the open position until maintenance is completed.
- 6) On the starting air shut-off valve, open the vent valves. Keep the vent valves in the open position until maintenance is completed.
- 7) Open all indicator valves on the cylinder covers. Keep the indicator valves in the open position until maintenance work is completed.
- 8) Engage the turning gear and lock the lever (refer to the Operation Manual, 3206-1 and 0750-1). The gear pinion must be in the engaged position.

Note: If the engine was stopped because the running gear or bearings have become too hot, do not open the crankcase doors before an elapsed time of 20 minutes.

Note: During all engine operations (short or usual), the crankcase doors must be locked with the clamps.

Note: Where carbon dioxide (CO₂) is used to extinguish a fire in the engine, there is a risk of suffocation. Make sure that all related spaces have good airflow to remove all CO₂ gas before

4. Special Safety Procedures

WARNING



Injury Hazard: After engine operation in gas mode, gas can stay in the gas inlet pipes. There is a risk of explosion. You must replace the unwanted gas with inert gas (e.g. nitrogen). For the procedure, refer to the documentation of the gas valve unit manufacturer.

WARNING



Danger: Gas Hazard. Poisonous gas can stay in the cylinder liner. There is a risk of suffocation. You must put on protective equipment, a respirator and a harness before you do work in cylinders where gas can stay.

WARNING



Injury Hazard: Make sure that no personnel and components are in the danger areas (crankcase, piston underside, propeller shaft, etc). The propeller coupling also turns.

WARNING



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

A safety person must be in position outside the engine when personnel do work inside the engine. If necessary, the safety person can give the applicable aid.

Personnel who do work in the engine must put on the correct safety equipment. Safety equipment to prevent suffocation must also be included.

The permitted load capacity of the equipment that follows must be sufficient for the parts to be lifted:

- The engine room crane.
- Lifting tools, ropes, slings and chains.

You must make sure that the lifting equipment is correctly attached to the item (i.e. balanced to make sure that the equipment does not tilt or fall).

For more data, refer to [0012-1](#) and [0360-1](#).

Use wood, leather or guards between the item and the rope or chain to give protection to sharp edges, mating faces etc.

Always put on gloves, a face shield and safety goggles when you operate hydraulic tools.

Keep your hands away from ropes, slings and chains that have tension. Do not go under loads that hang.

Parts removed from the engine must be safely attached in the engine room to prevent movement.

Make sure that when engine components are removed, covers are put in position over the openings.

Note: For more data, refer to the Operation Manual, [0210-1 Safety Precautions and Warnings \(General Information\)](#).

5. Recommendations

- 1) Read the data in [3301-1](#) Work Platform.
- 2) Do the work carefully. Make sure that all parts and equipment are clean. Use only the applicable tools and equipment for the maintenance tasks. For data about the tools and equipment, refer to [9403-5](#) Tool List.
- 3) Make sure that the tools and equipment are serviceable before you use them.
- 4) Calibrate gauges before you use them. Also, calibrate gauges at regular intervals.
- 5) Do regular checks of hydraulic tools to make sure they are serviceable.
- 6) Apply protection to the running surfaces and sealing faces of parts that were removed to prevent damage.
- 7) When pipes are removed, dirt can go into the openings. Apply protection to the openings in the pipe and the part.
- 8) Before you start the engine, make sure that repaired parts, replaced parts, or parts that had an overhaul are serviceable.
- 9) Make sure that all pipes that were removed and installed are tightened correctly.
- 10) Do regular checks of parts that move. If the maximum permitted value is the same or more than that given in [0330-1](#) Clearance Tables, the parts must be replaced.
- 11) Use spare parts from the spares stock on board. When you order new parts, get the code numbers and description from the Spare Parts Catalog.
- 12) When you tighten nuts, bolts or screws, make sure that you do not cause damage to the thread. Turn the nut, bolt or screw with your hand until the metal parts touch. Use only the specified lubricants on the threads.
- 13) Where torque values are shown, refer to the data given in [0352-1](#) and [0352-2](#).
- 14) Devices that lock nuts, bolts etc must be correctly installed. Use lockwire, tab washers and lock plates once only.
- 15) For threads of screws and studs in very hot areas, (e.g. exhaust pipe or turbocharger) apply a lubricant that is resistant to high temperatures before assembly. This will help when it becomes necessary to remove these items.
- 16) Always replace O-rings during an overhaul of components, or during removal and installation procedures. The O-rings must be of the correct dimensions in accordance with Wärtsilä specifications.
- 17) The installation of piston sealing rings and rod seal rings must be done carefully to prevent deformation and distortion. Before installation, put the rings into very hot water.

General Guidelines for Lifting Tools**Wire Rope Slings, Span Sets, Eye Bolts, etc.**

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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 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.

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.

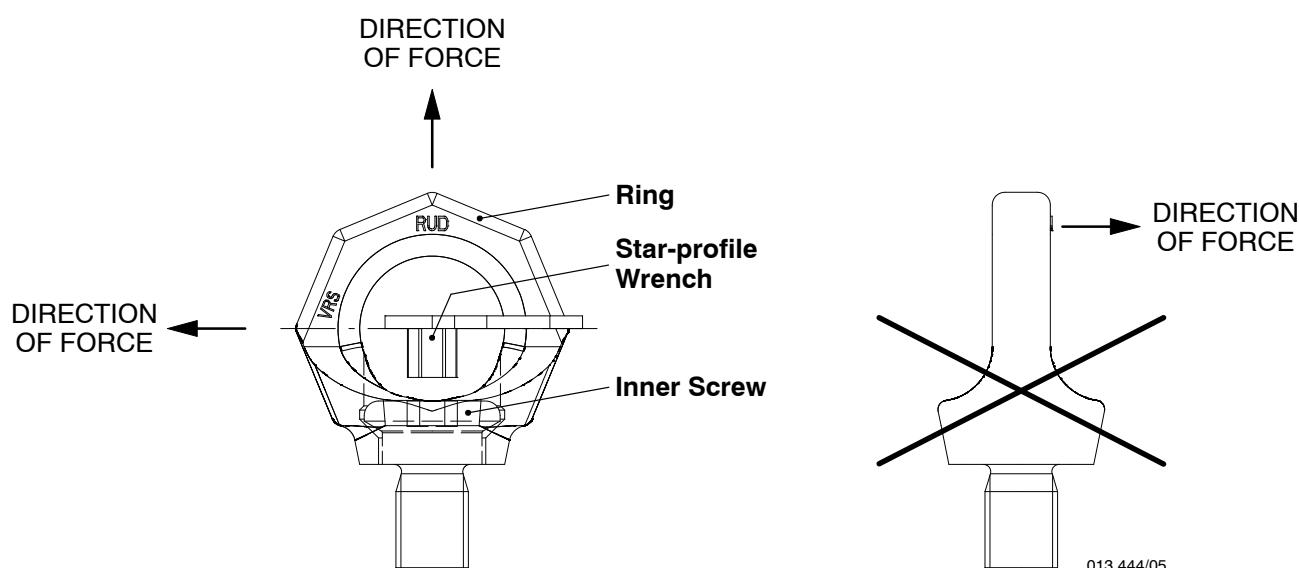


Fig. 1: RUD Eye Bolts

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.

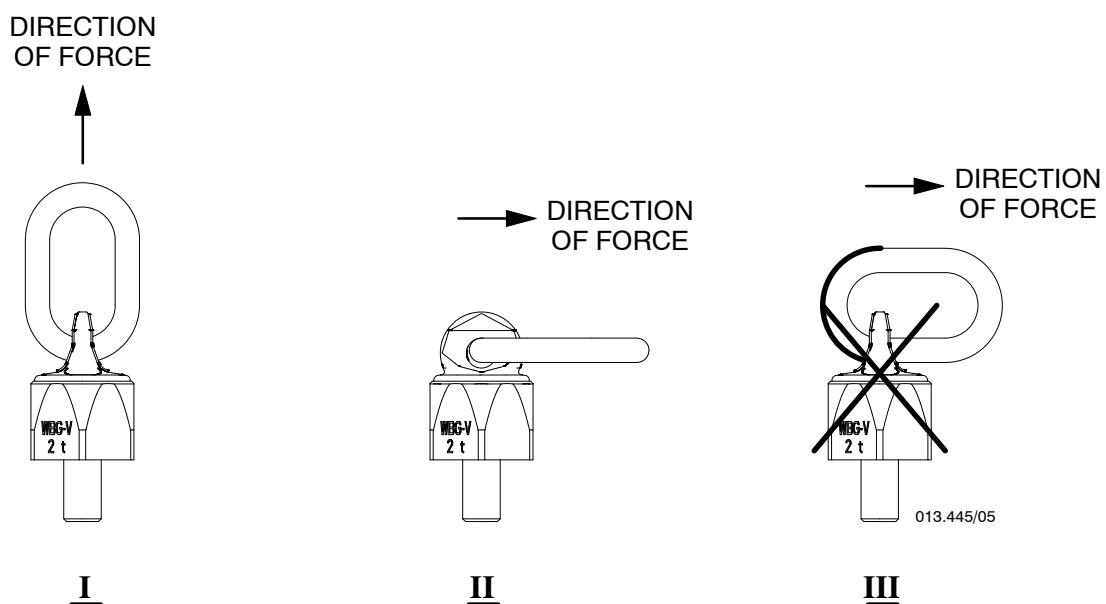


Fig. 2: RUD Swivel Lugs

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

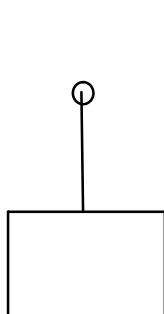
WARNING



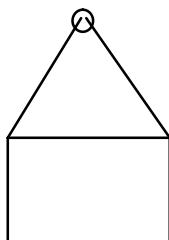
Danger: Do not go under a load that hangs. If the lifting equipment has a failure, the load can kill you or cause serious injury.

Read the data that follow:

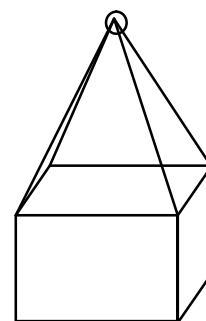
- A sling with one strand has the total weight of the load ([Fig. 3](#)).
- With two strands of equal distance from the center, each strand has half the weight of the load when the sling is in a middle position.
- With four strands of equal distance from the center , each strand has one quarter of the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



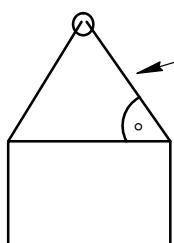
One Strand:
Total Load
Weight



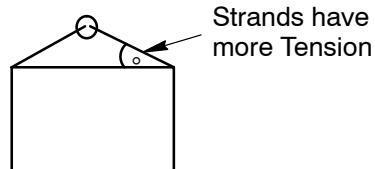
Two Strands:
Half the Load
Weight



Four Strands:
One Quarter of
the Load Weight



Strands have
less Tension



Strands have
more Tension

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.

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Clearance Table

1. General	1
Crankshaft and Thrust Bearing	2
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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.

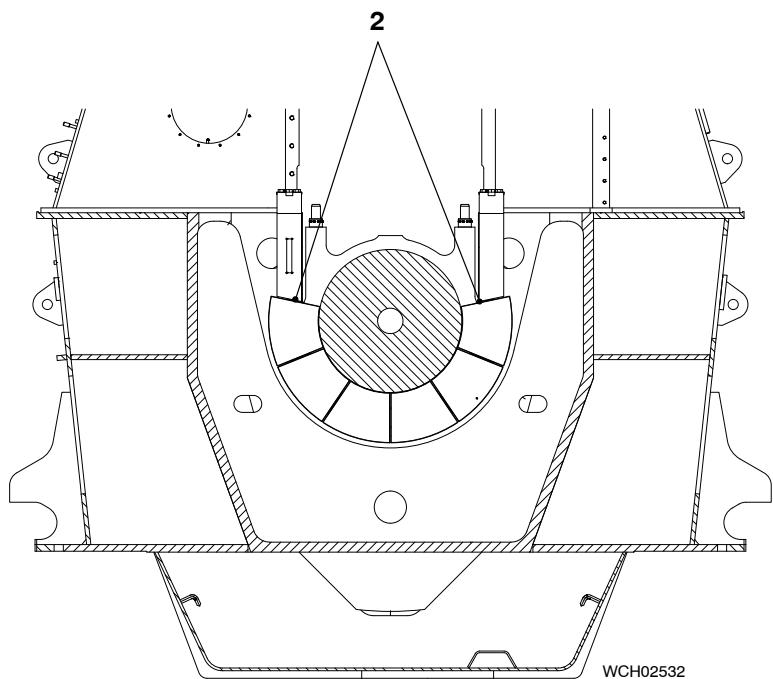
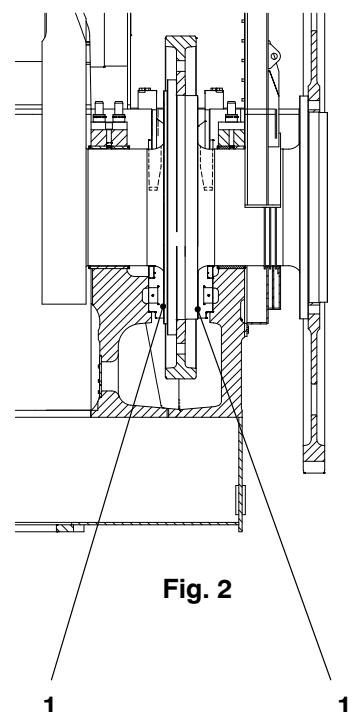
The values given in the columns Maximum Clearance, Dimension are the possible results after a long period of operation. The differences in the clearances must not be less than or more than those given.

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:

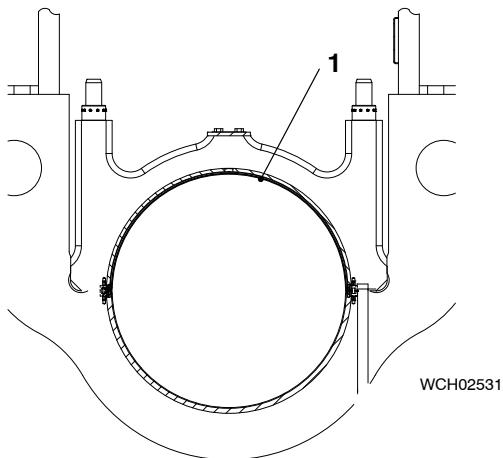
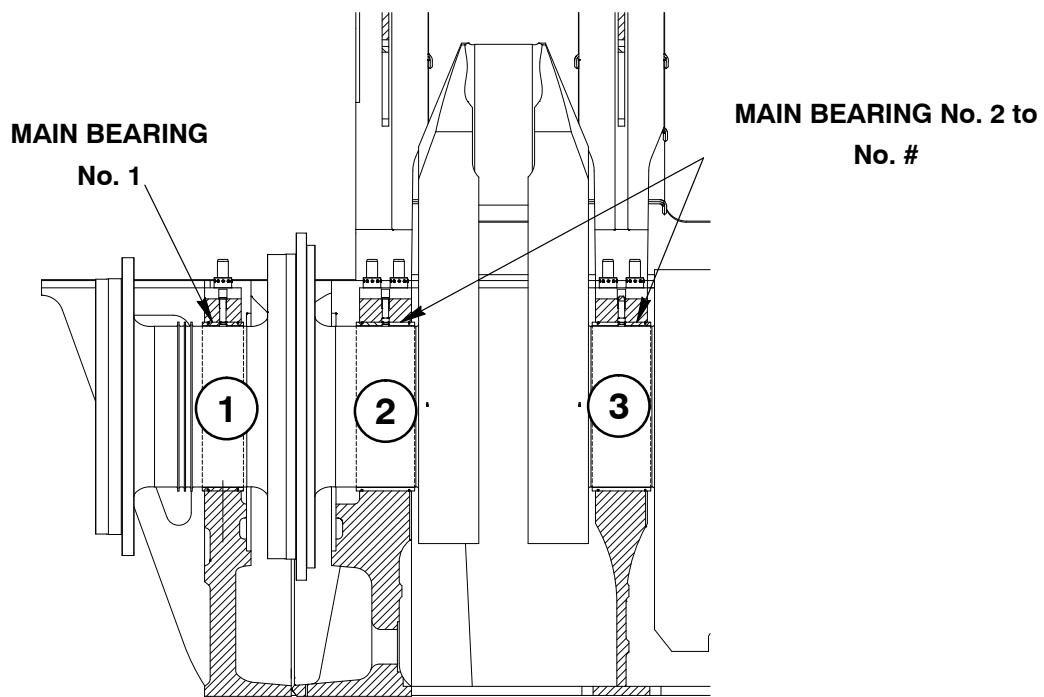
- Replace a component, or
- Let the component stay installed until the next overhaul.

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	

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

Clearance Table

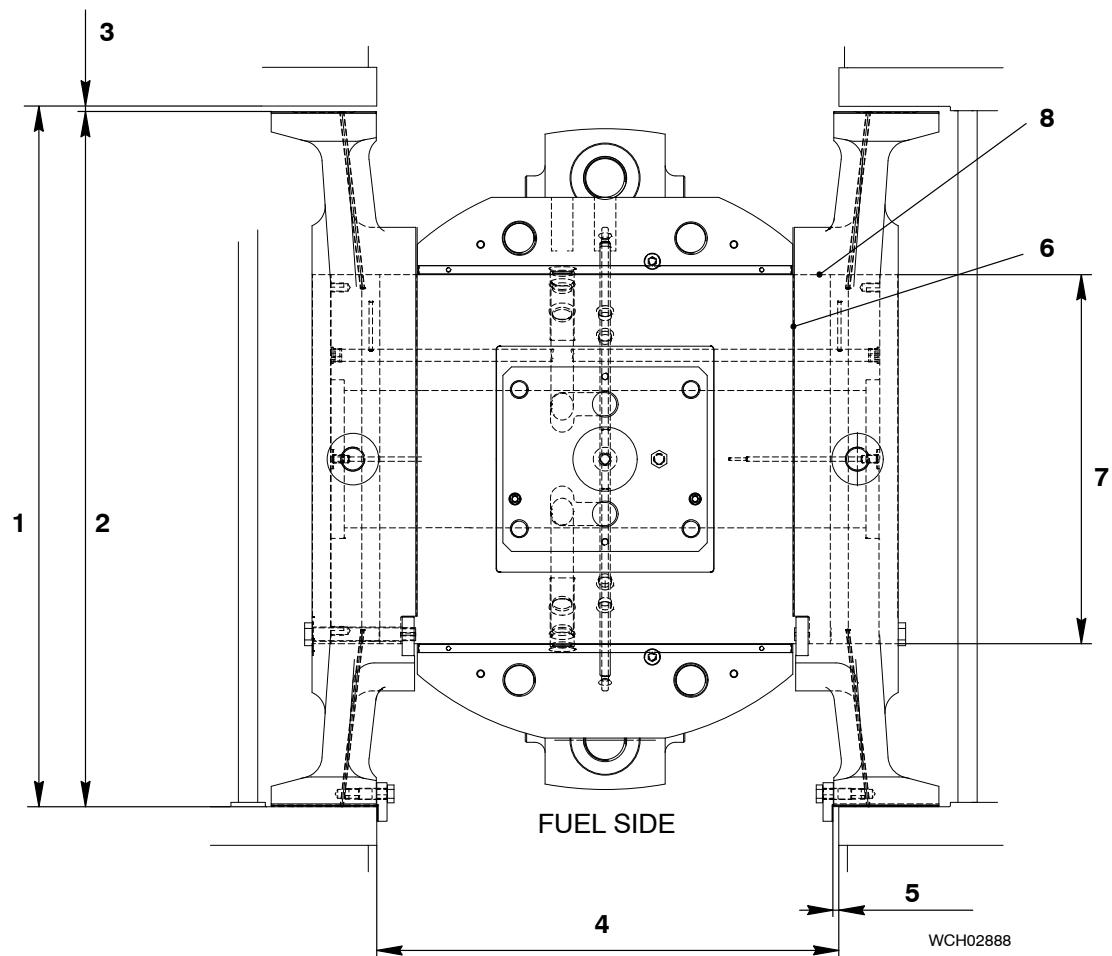
Crankshaft and Main Bearing

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**

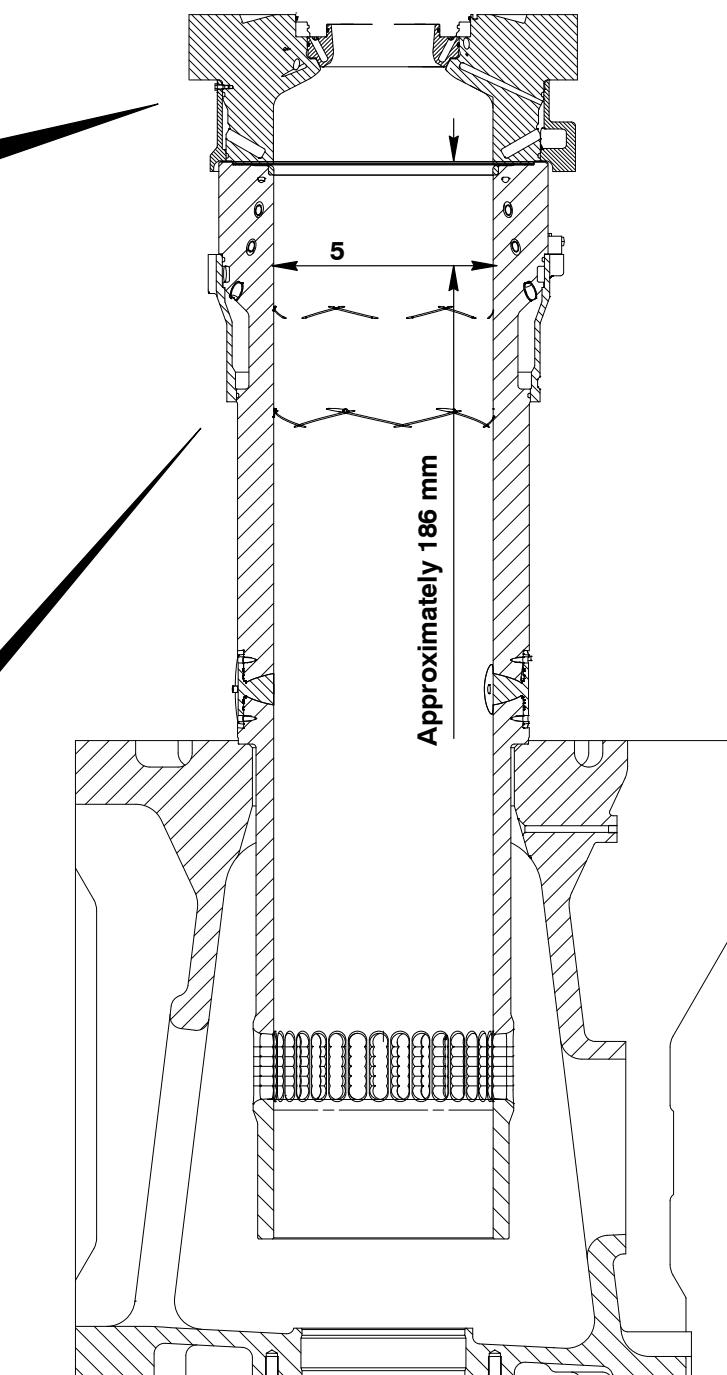
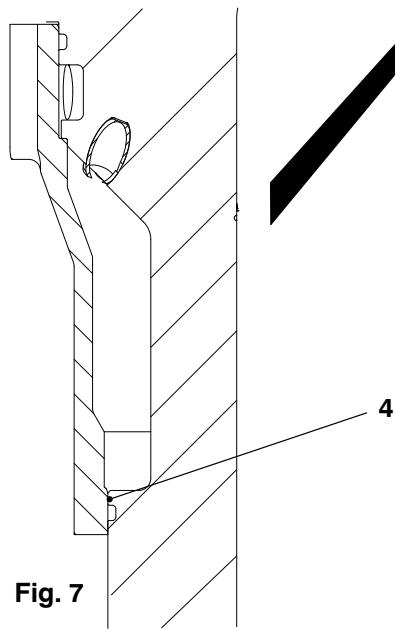
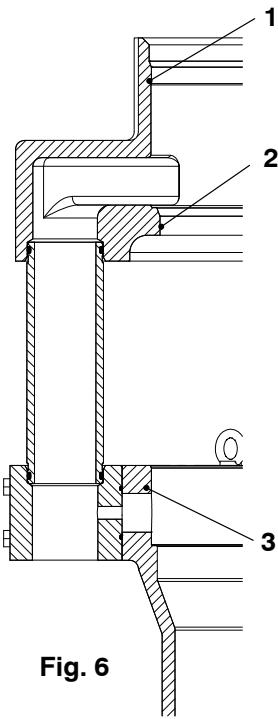
Clearance Table

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 $^{+ 0.25}_0$	
	2	Guide shoe	transverse	1096 $^{- 0.20}_{- 0.30}$	
	*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 Ø	580 $^{0}_{- 0.08}$	
		Guide shoe, bearing bore	inner Ø	580 $^{+ 0.11}_{+ 0.07}$	
	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**

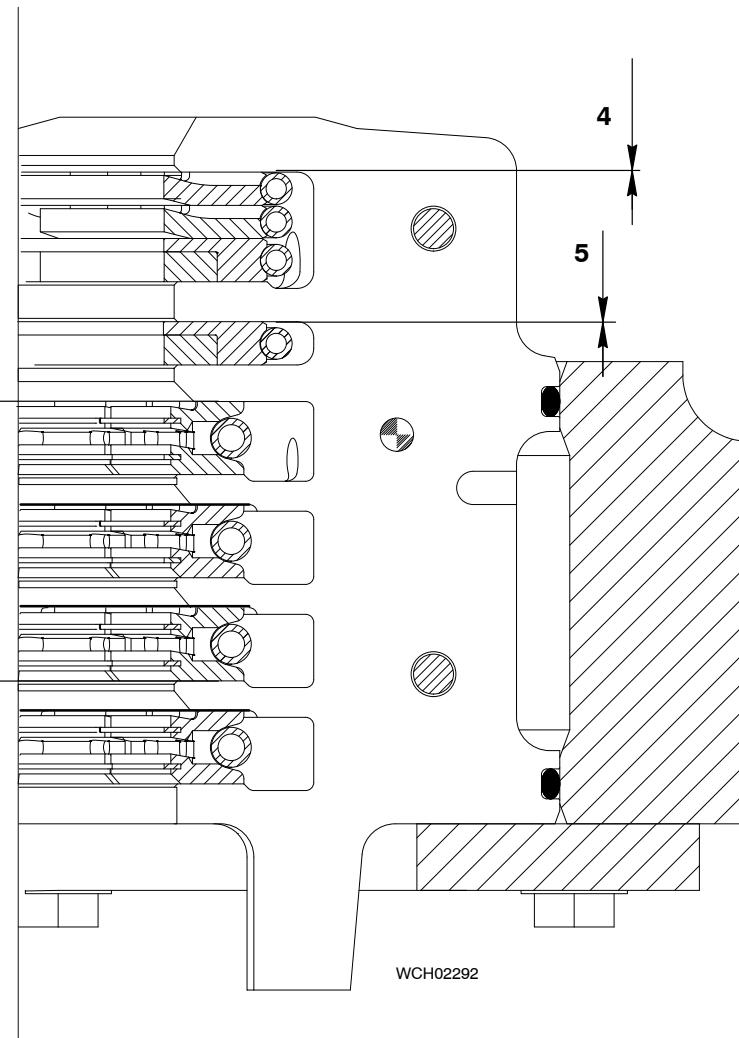
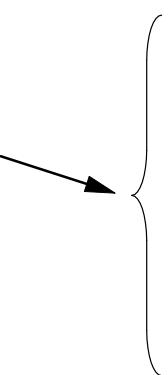
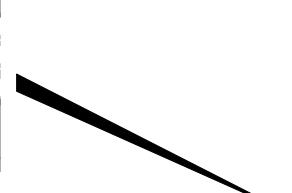
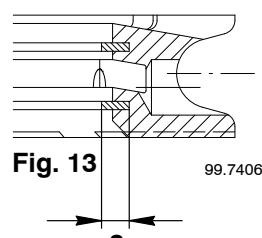
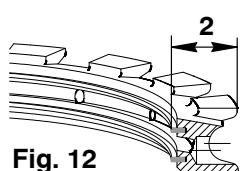
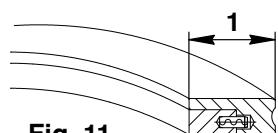
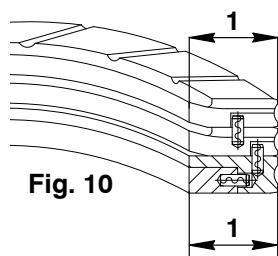
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Clearance Table

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	Ø	870 ^{+ 0.50} _{+ 0.30}	
	1	Clearance	total	0.40 to 0.70	
		Water guide jacket top part	Ø	850 ^{+ 0.50} _{+ 0.30}	
	2	Clearance	total	1.30 to 1.60	
		Water guide jacket bottom part	Ø	870 ^{+ 0.50} _{- 0.30}	
	3	Clearance	total	0.10 to 0.650	
		Water guide jacket bottom part	Ø	856 ^{+ 0.70} _{+ 0.50}	
2124		Cylinder liner			
	*5	Cylinder liner bore	radial	620	625.50

* Make sure that you measure at the correct point.

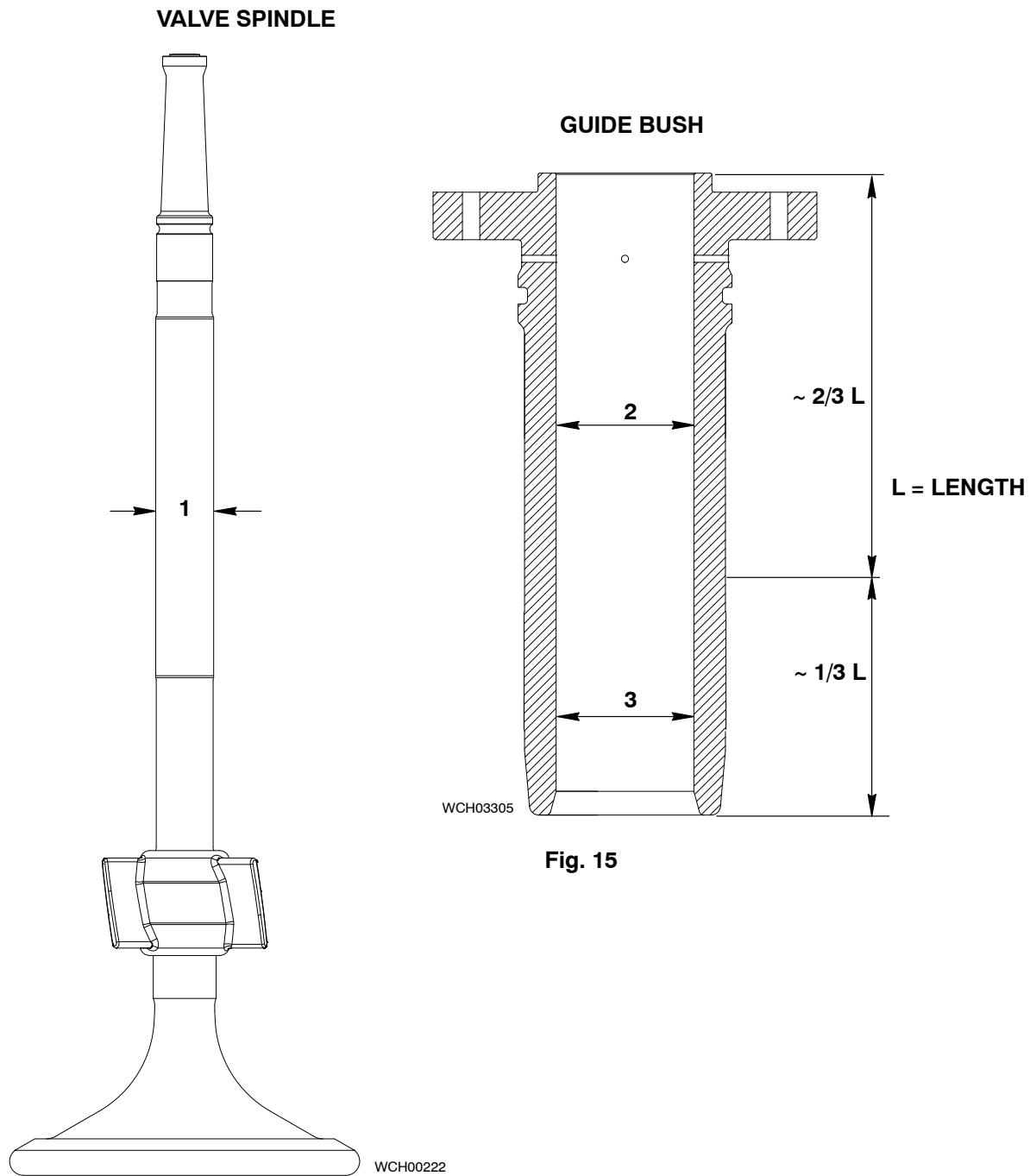
Clearance Table**Piston Rod Gland****Fig. 9**

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**

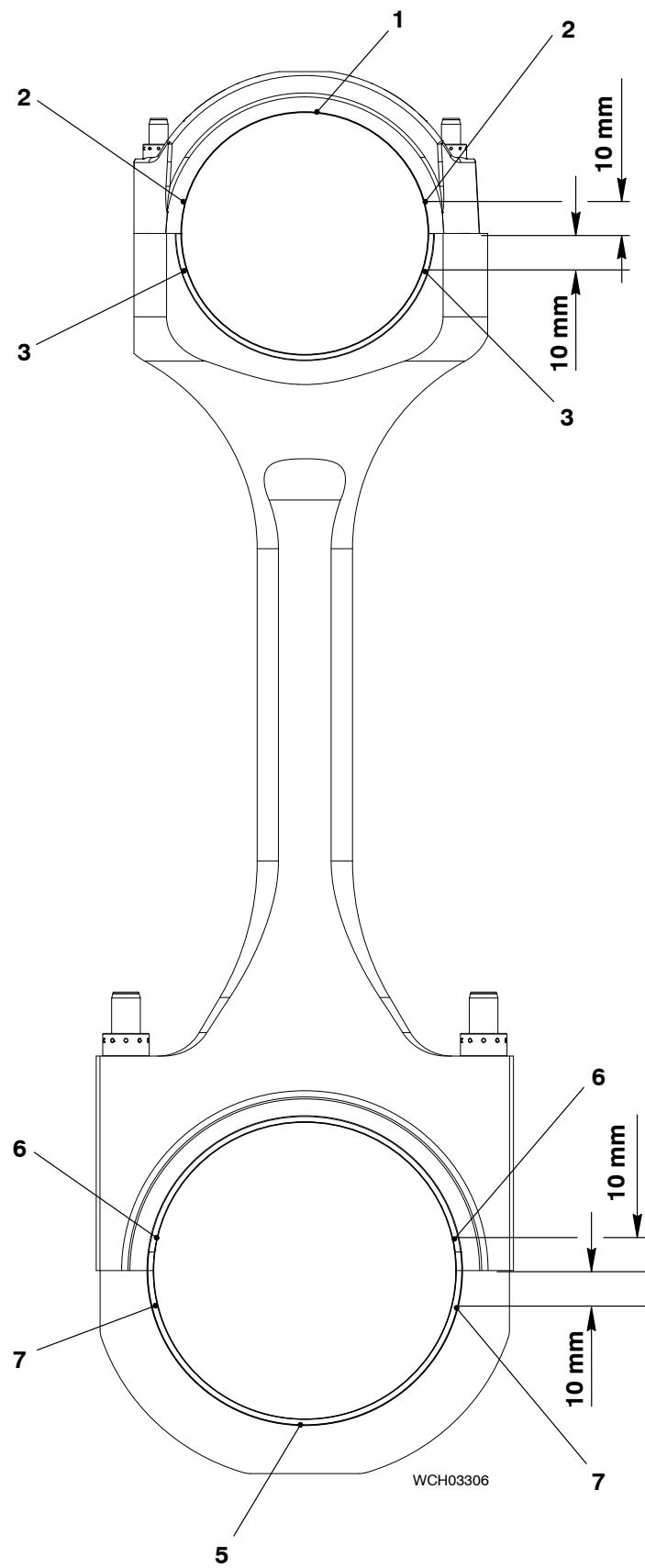
The difference in value between the nominal dimension and maximum wear is equal for all rings, i.e. also for smaller rings.

Clearance Table**Exhaust Valve**

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	49.50
2751		Guide Bush			
	*2	Bore	inner Ø	58 $+0.030$ 0.0	58.40
	*3	Bore	inner Ø	58 $+0.030$ 0.0	51.25

* Make sure that you measure at the correct points.

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

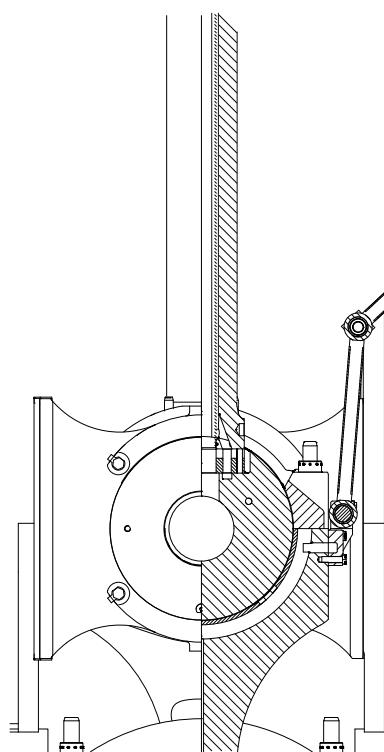
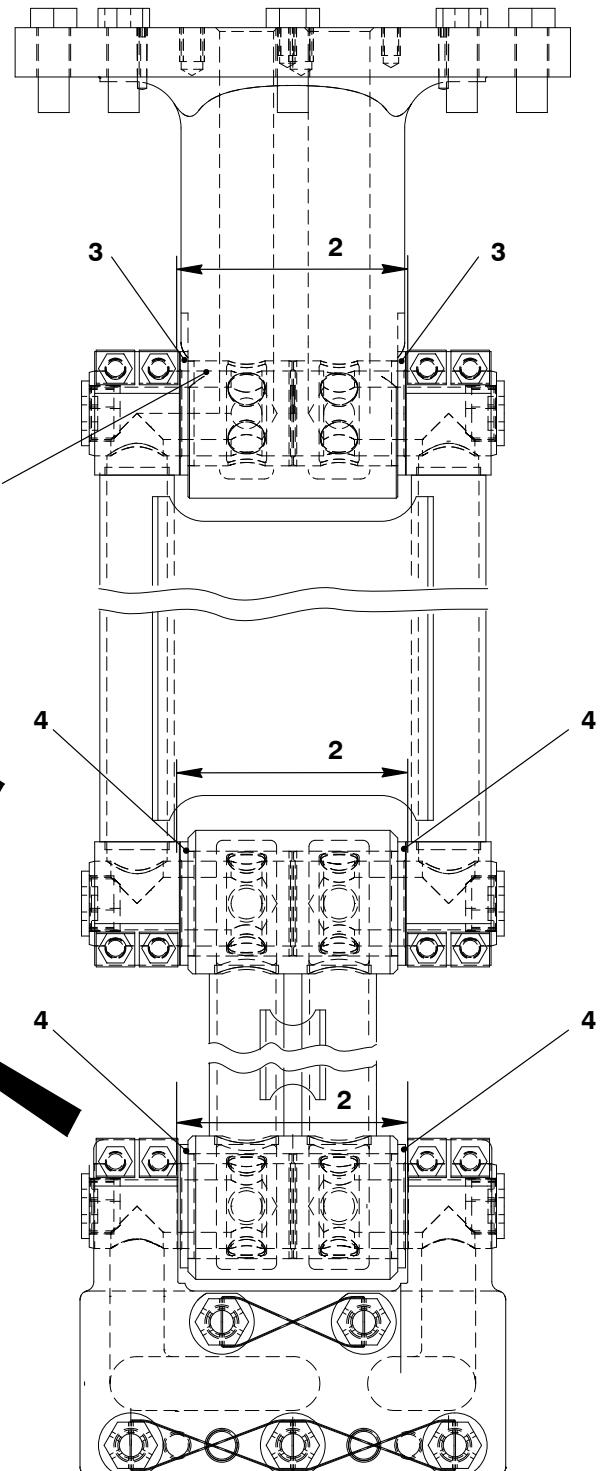
Clearance Table

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 Ø	620 $^{+ 0.62}_{+ 0.56}$	
		Bearing	inner Ø	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 Ø	760 $^{+ 0}_{- 0.08}$	
		Bearing	inner Ø	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	

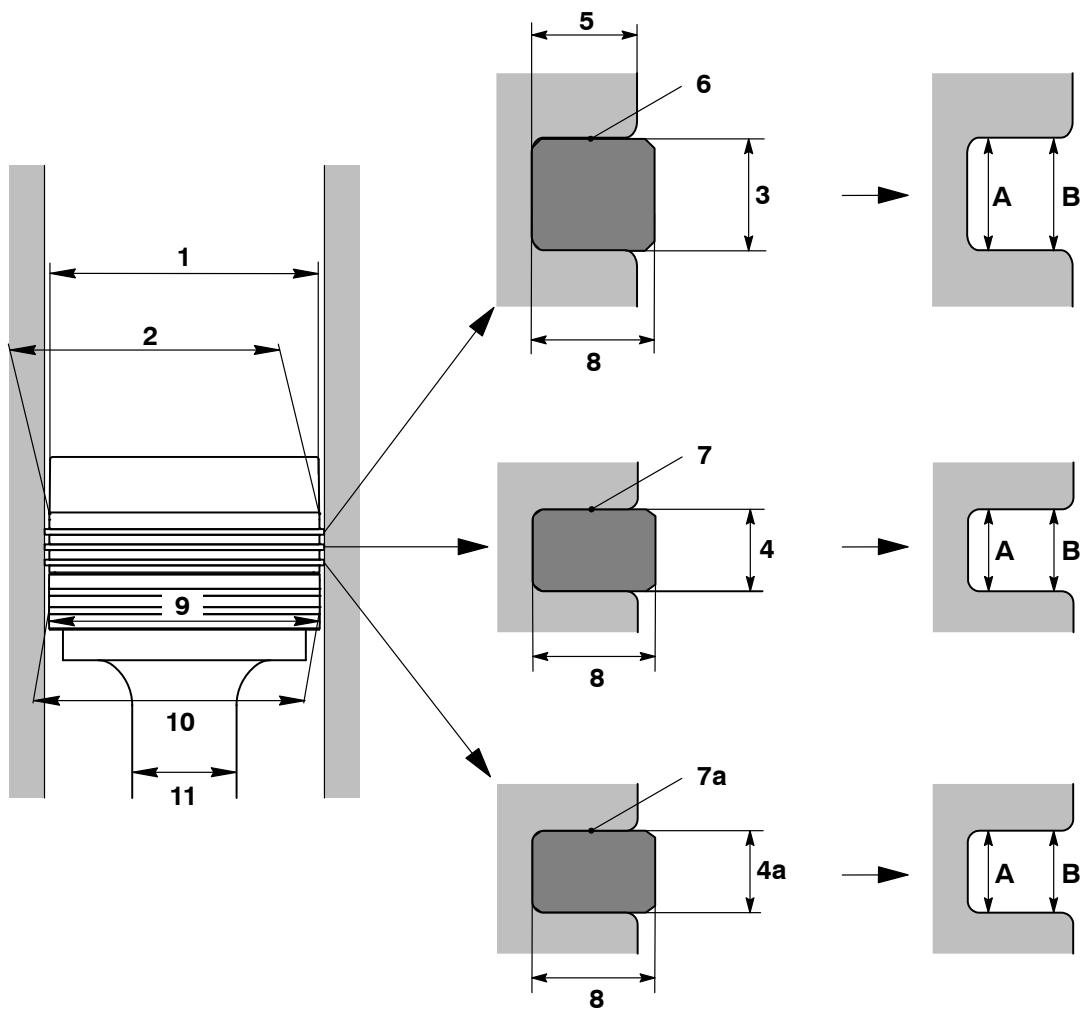
* Make sure that you measure at the correct points.

Clearance Table

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 Ø	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	

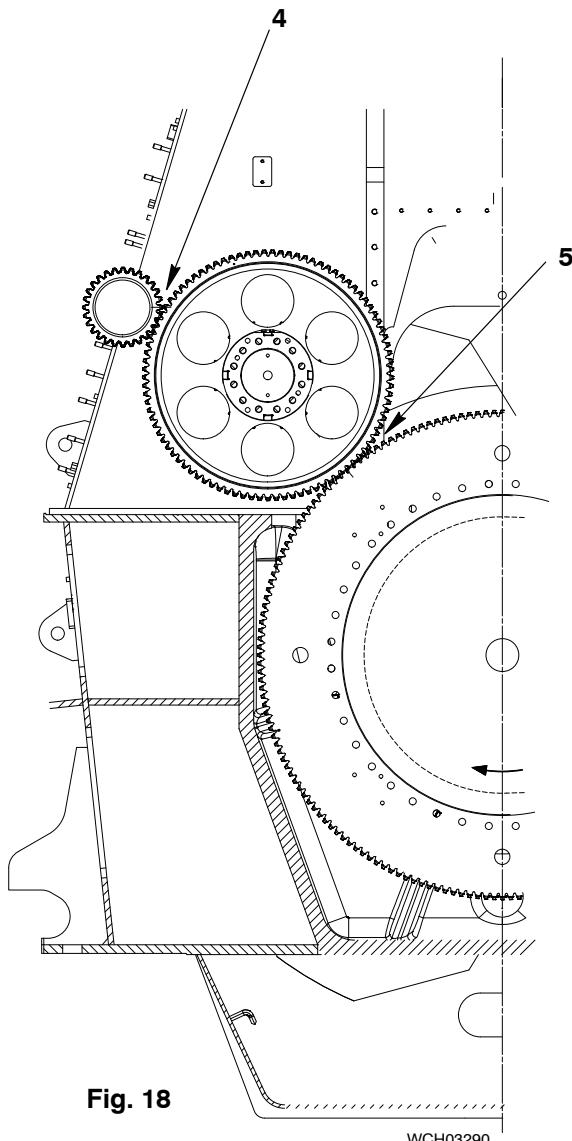
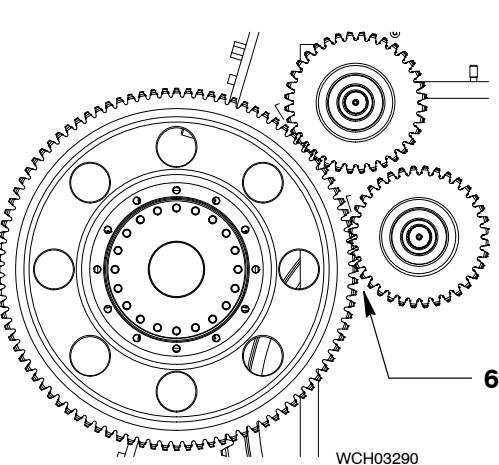
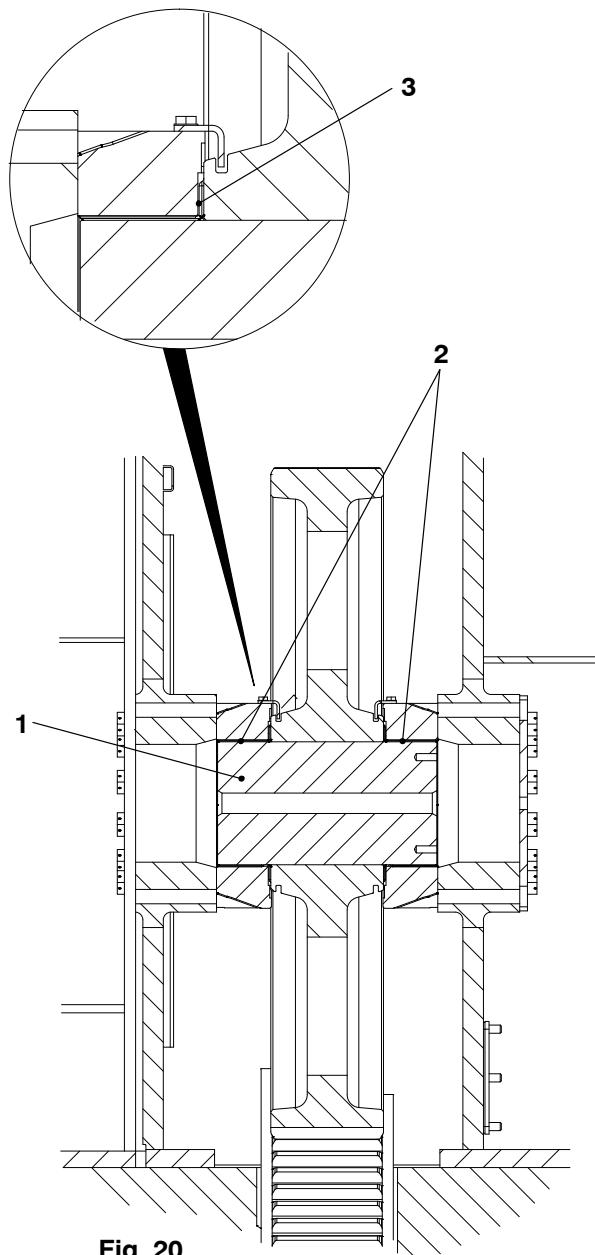
Clearance Table**Piston and Piston Rings**

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 ${}^0_{-0.2}$	
	2	Head	outer Ø	616 ${}^0_{-0.2}$	
3406		Piston Ring Grooves			
	3	Height of the top groove	vertical	20 ${}^{+0.45}_{+0.40}$	
	4	Height of the middle groove	vertical	12 ${}^{+0.40}_{+0.35}$	
	4a	Height of the bottom groove	vertical	12 ${}^{+0.40}_{+0.35}$	
	5	Groove depth	radial	21 ${}^{+0.2}_{+0}$	
3425		Piston Rings			
	3	Ring height	vertical	20 ${}^0_{-0.03}$	
	4	Ring height	vertical	12 ${}^0_{-0.03}$	
	4a	Ring height	vertical	12 ${}^0_{-0.03}$	
	6	Ring clearance	vertical	0.40–0.48	Point A
	7	Ring clearance	vertical	0.35–0.43	0.60
	7a	Ring clearance	vertical	0.35–0.43	0.75
	8	Ring width	radial	20 ± 0.25	Point B
3403		Piston Skirt			
	9	Skirt	outer Ø	619.2 ${}^0_{-0.1}$	Minimum 618.1
	10	Rubbing ring	outer Ø	619.4 ${}^0_{-0.1}$	
3403		Piston Rod			
	11	Rod	outer Ø	240 ${}^{-0.050}_{-0.096}$	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](#)).

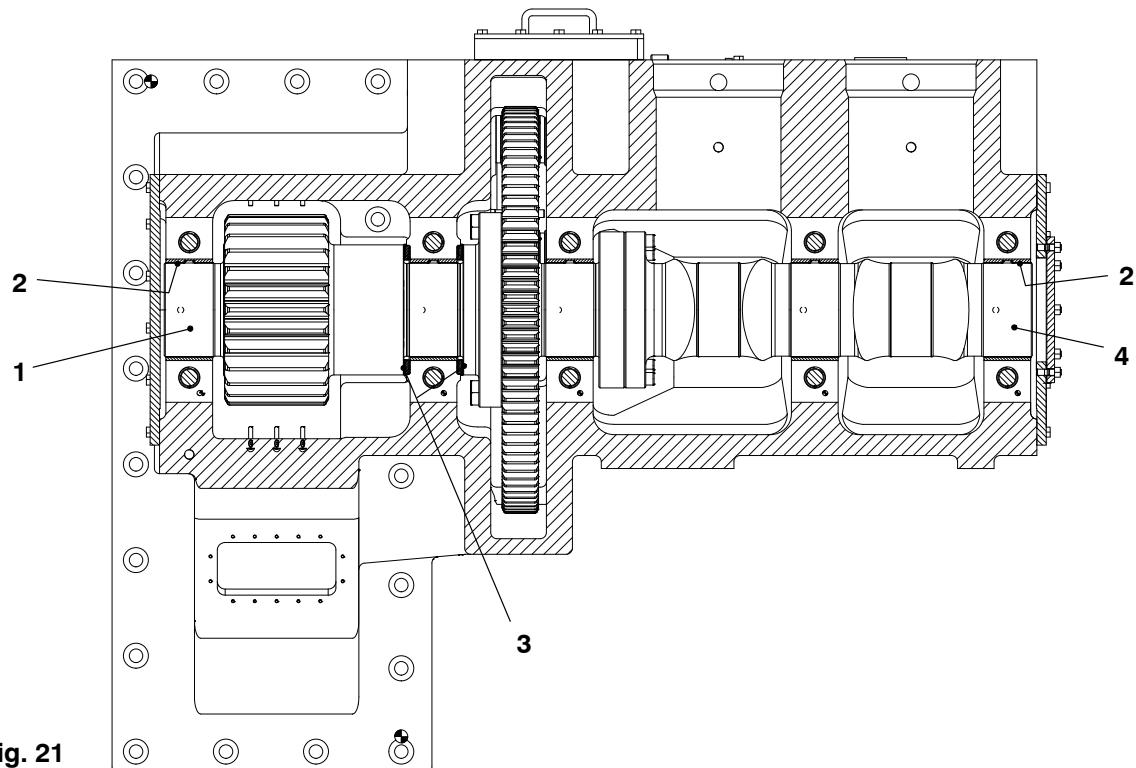
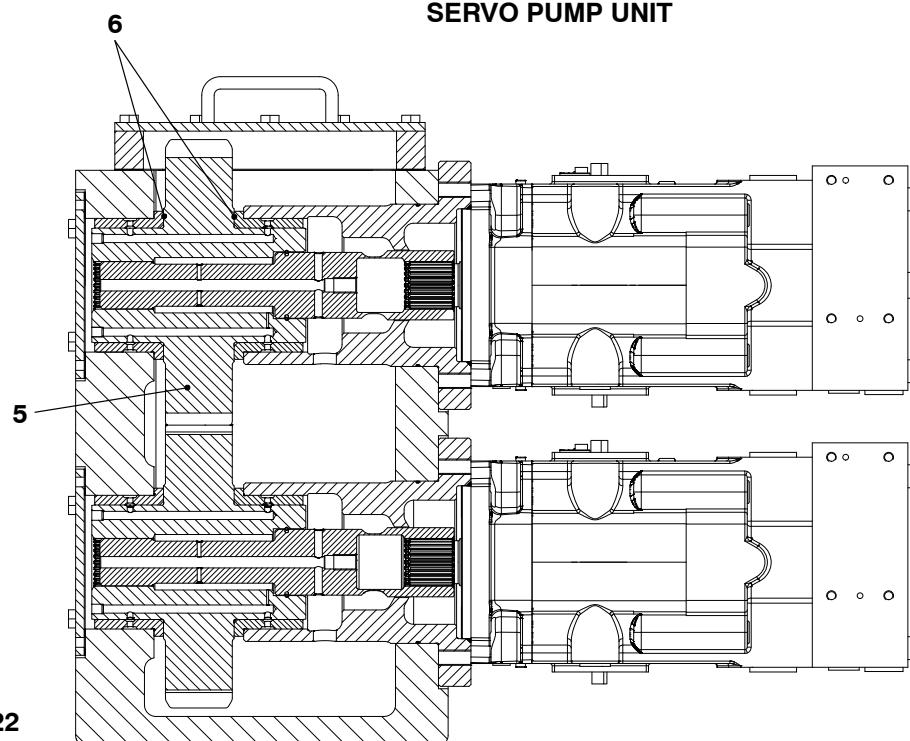
Clearance Table**Driving Wheels for Supply Unit****INTERMEDIATE WHEEL FOR SUPPLY UNIT****Fig. 19**

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 Ø	240	
	2	Bearing clearance	vertical	0.15 to 0.18	0.20
	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**FUEL PUMP UNIT****Fig. 21****SERVO PUMP UNIT**

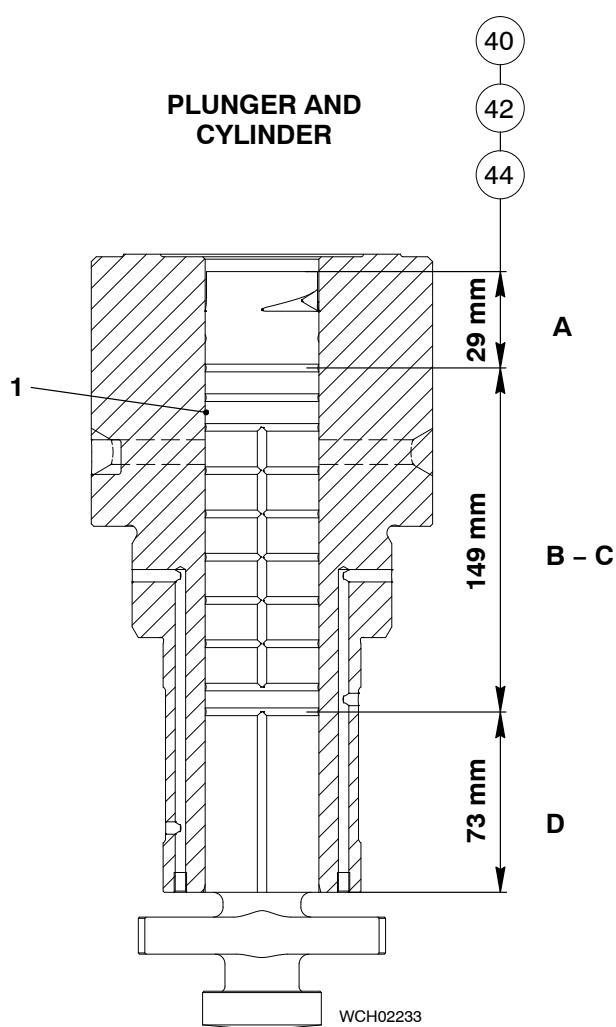
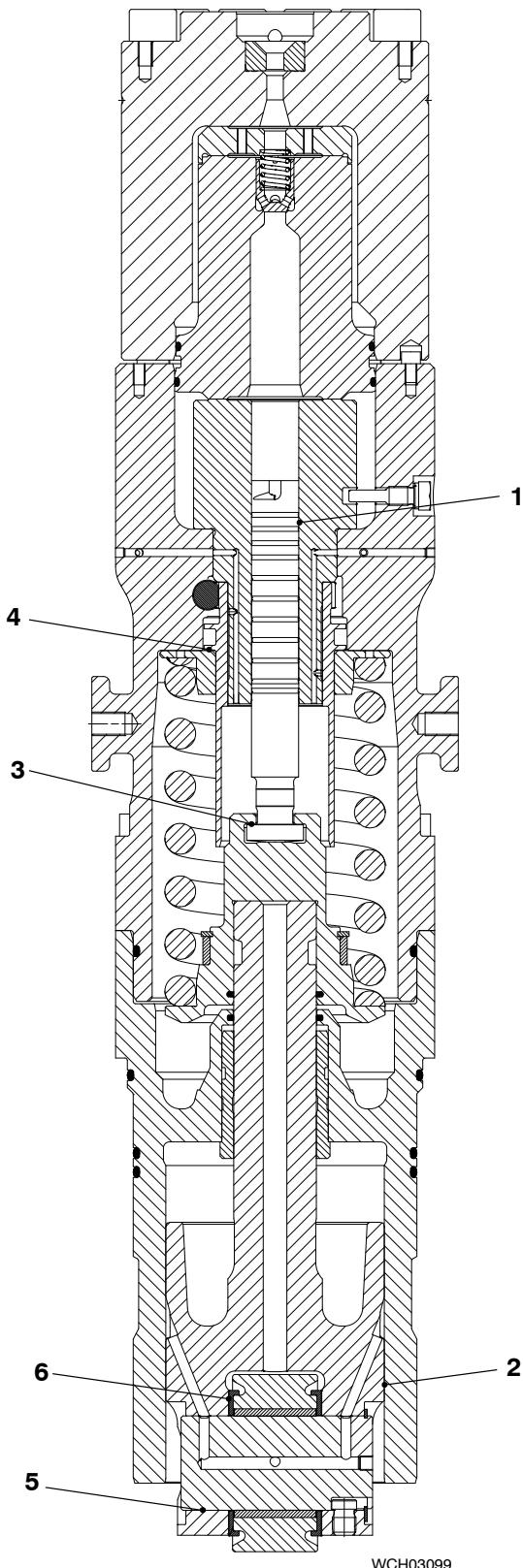
WCH02232

Fig. 22

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			0.33
	1	Gear Wheel	outer Ø	180 ⁰ _{- 0.025}	
	2	Bearing clearance	radial	0.153–0.237	
	3	Axial clearance	total	0.30–0.65	0.81
	4	Camshaft	outer Ø	180 ⁰ _{- 0.025}	
5552		Servo Pump Unit			0.85
	5	Pinion	outer Ø	120 ⁰ _{- 0.022}	
	6	Axial clearance	total	0.30 to 0.65	0.85

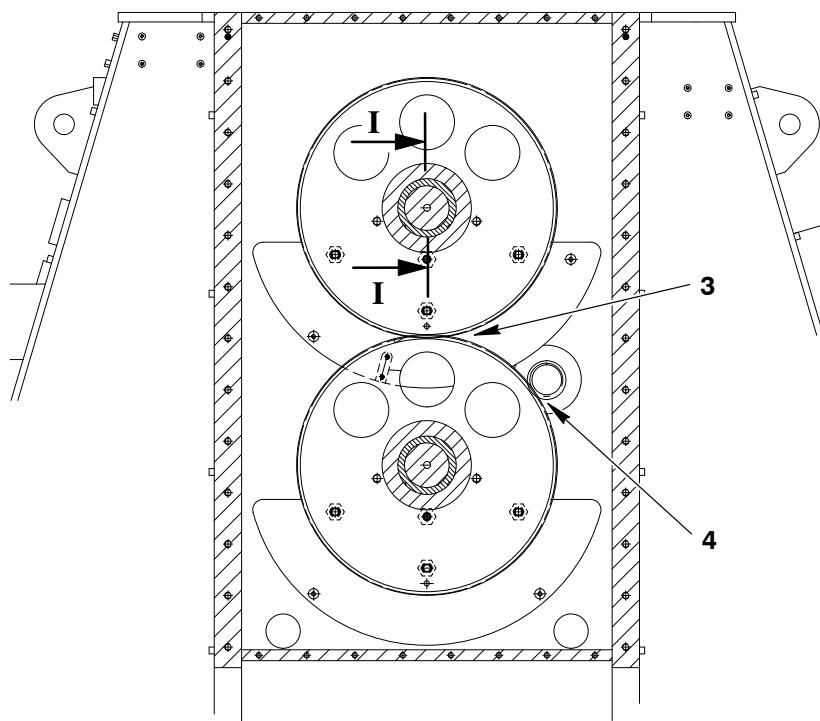
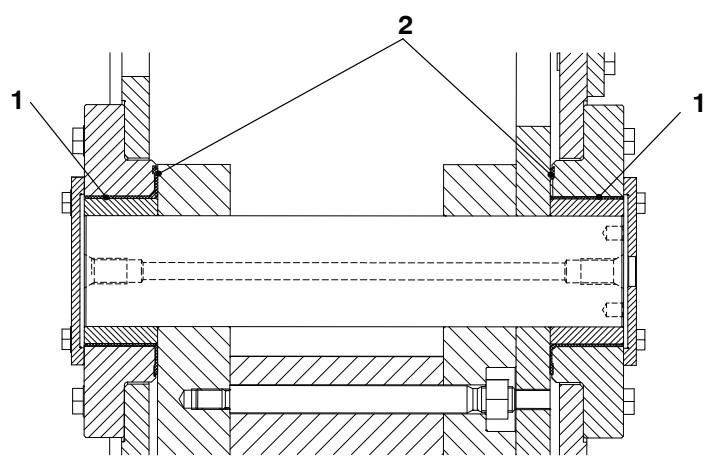
Clearance Table**Fuel Pump**

Clearance Table**Fuel Pump**

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

* Plunger conically machined in the range C-D; i.e. the clearance increases in diameter to 0.015 mm.

Clearance Table

Integrated Electric BalancerI - I

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 Ø	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.

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Tightening Values of Important Screwed Connections

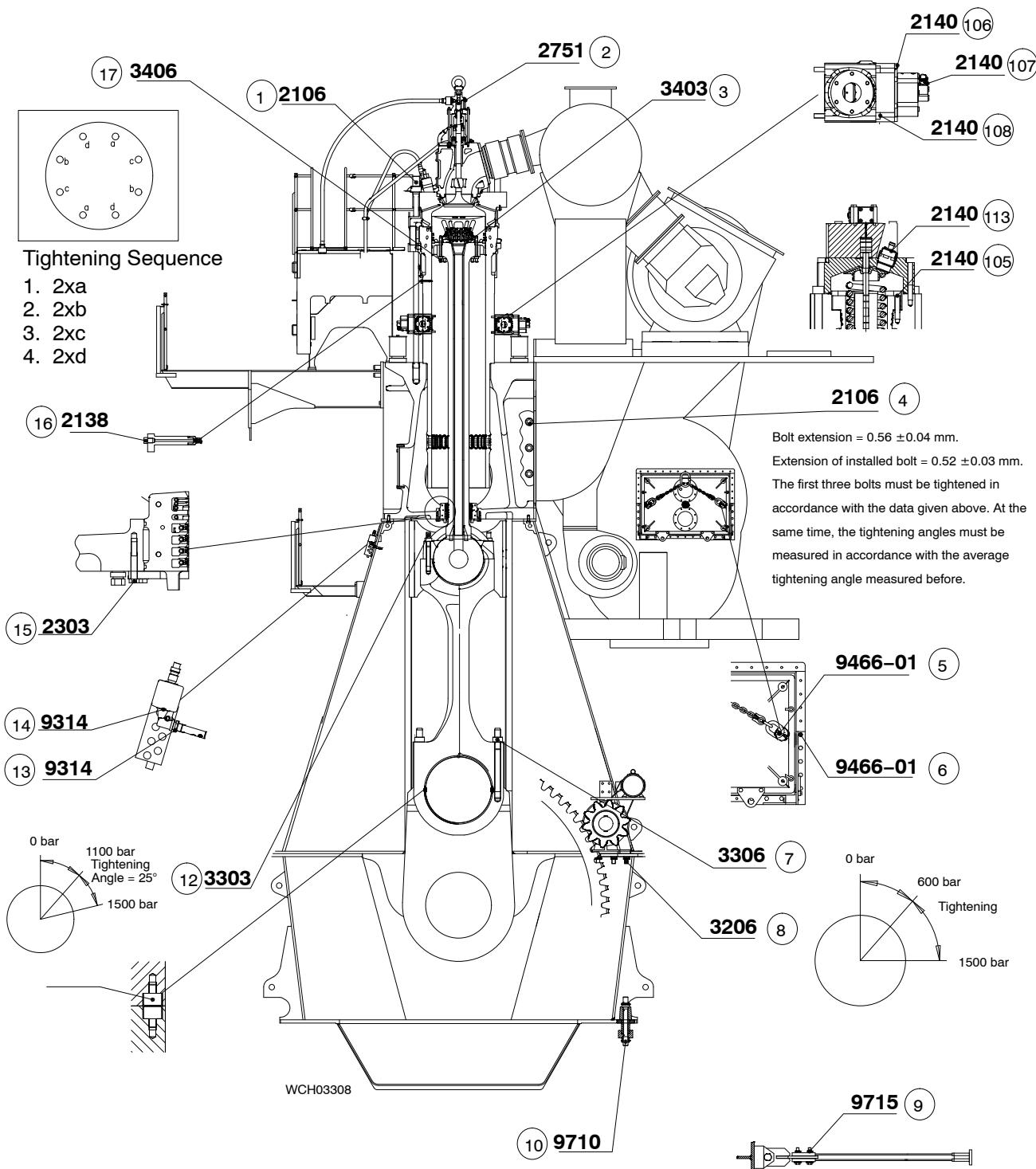
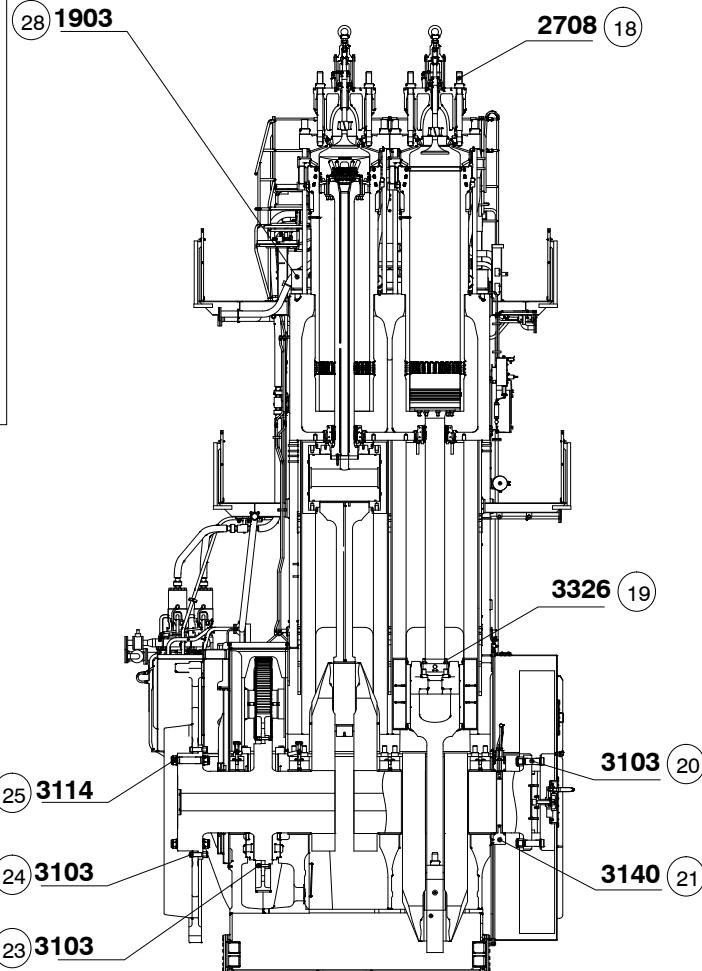
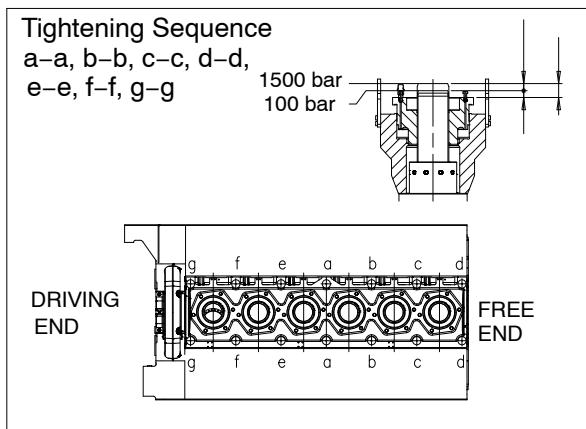
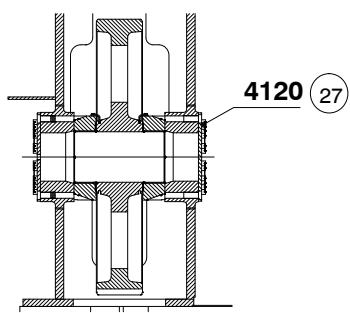
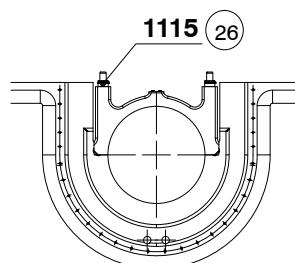
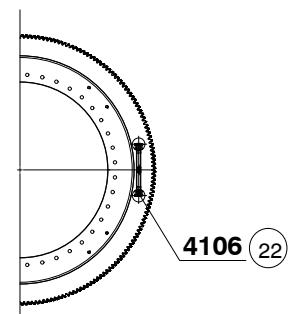


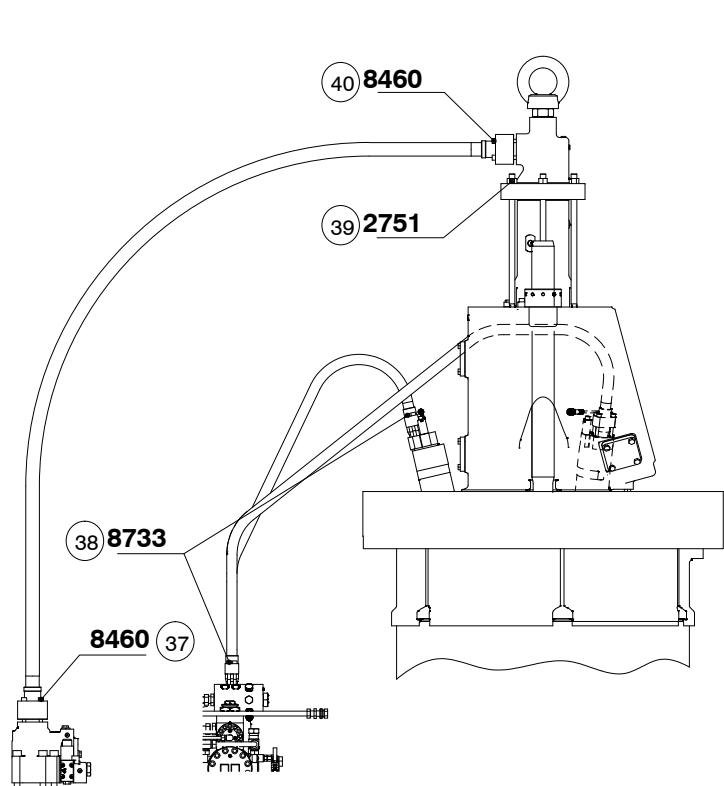
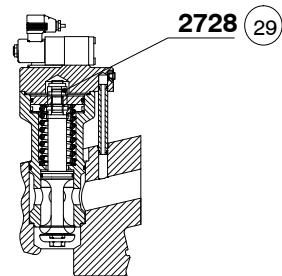
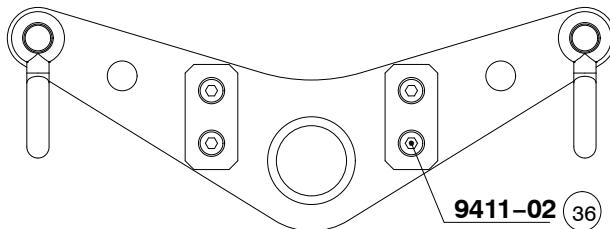
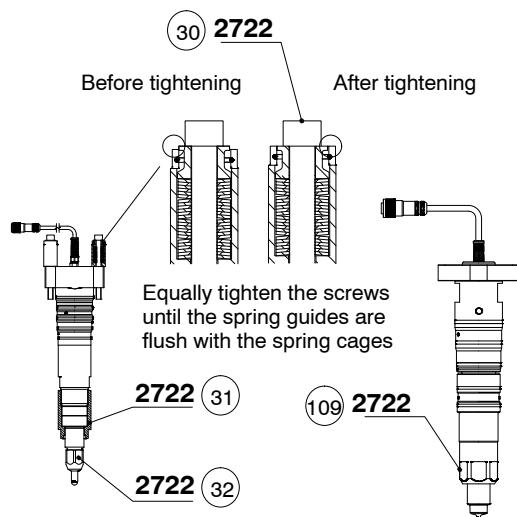
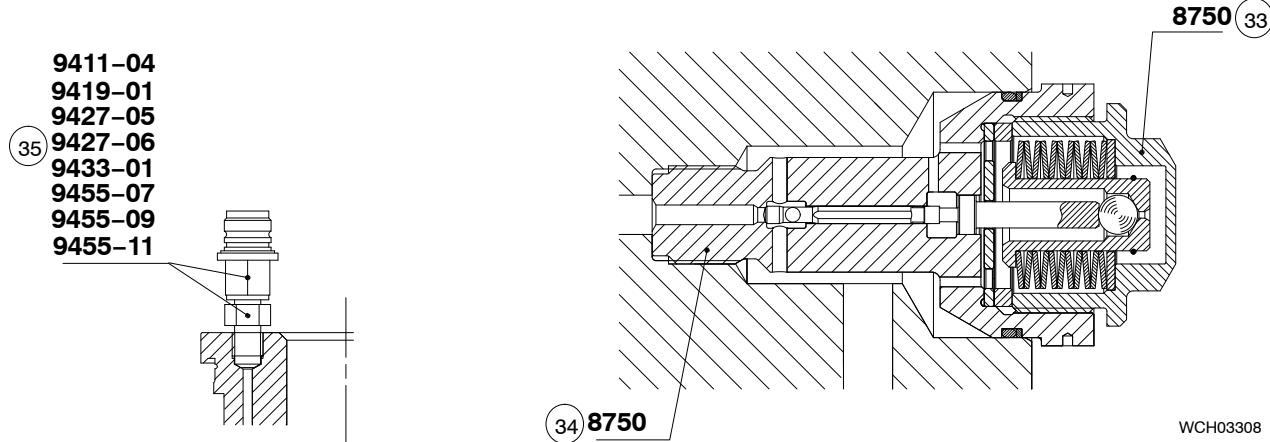
Fig. 1:

Tightening Values of Important Screwed Connections

TIE ROD**INTERMEDIATE WHEEL – SUPPLY UNIT****MAIN BEARING****CRANKSHAFT GEAR WHEEL**

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Fig. 2:

HP PIPE – INJECTION VALVE**STARTING AIR VALVE****MAIN BEARING****INJECTION VALVE****RELIEF VALVE****Fig. 3:**

Tightening Values of Important Screwed Connections

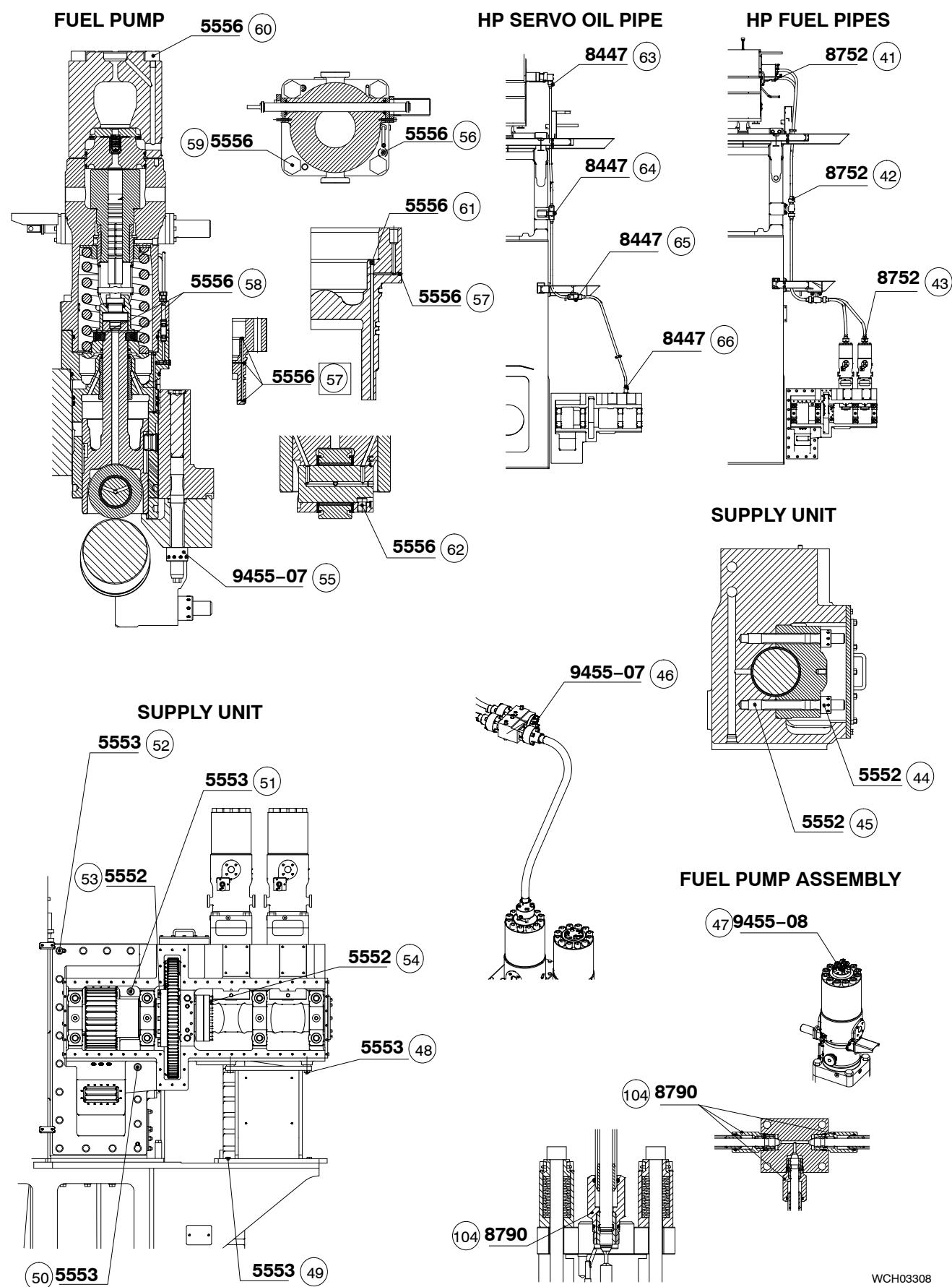
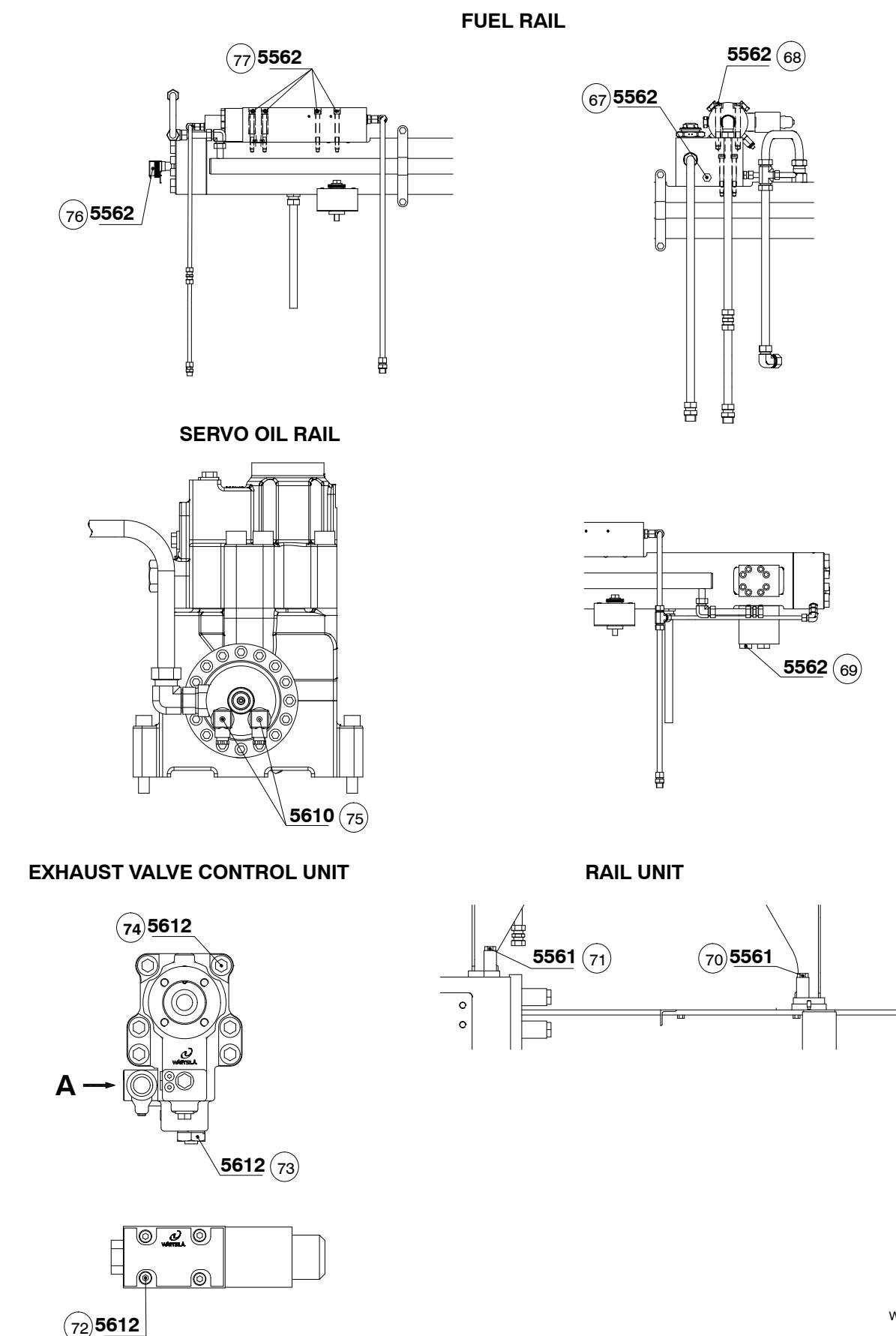


Fig. 4:

Tightening Values of Important Screwed Connections



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Fig. 5:

Tightening Values of Important Screwed Connections

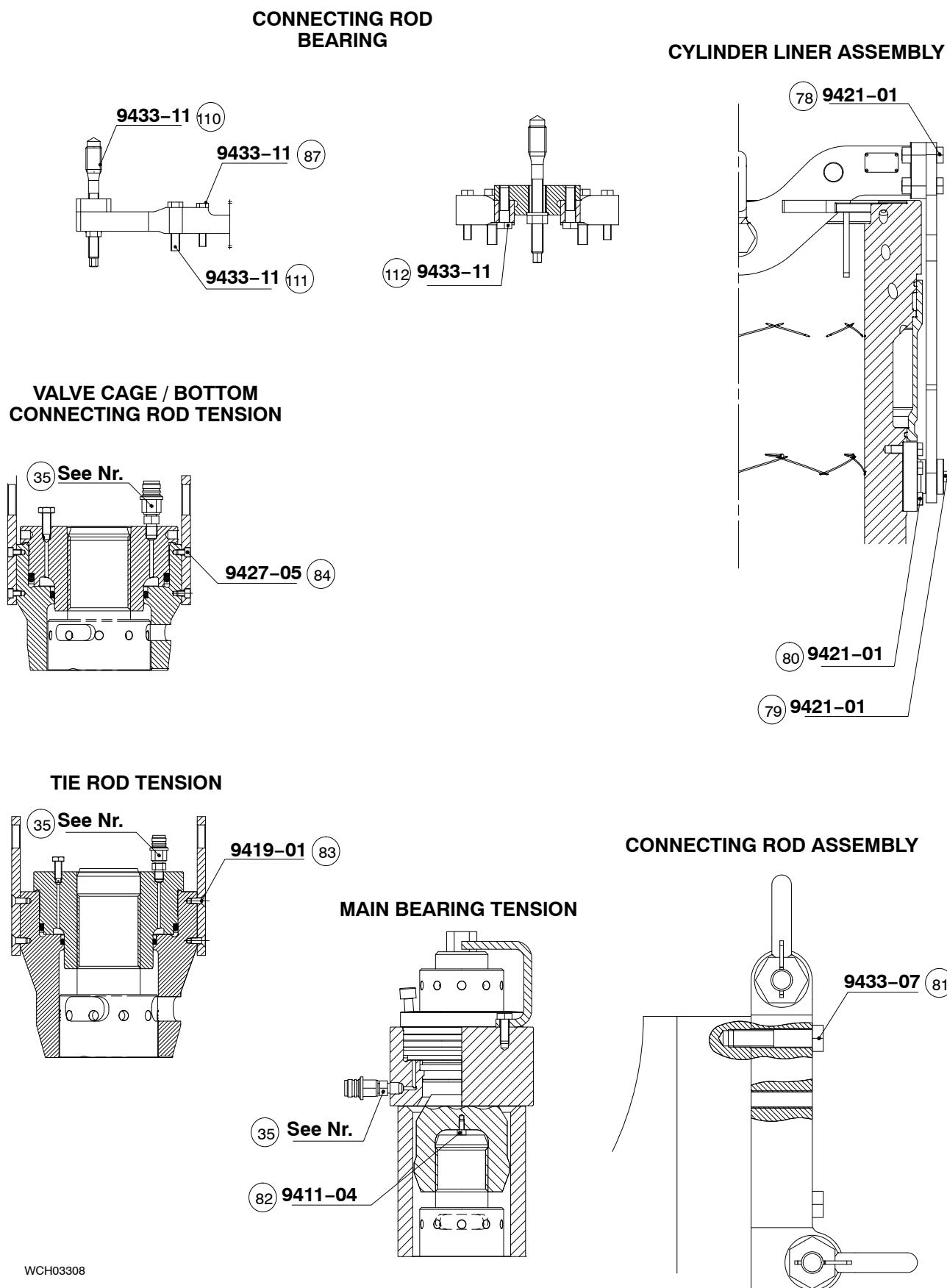
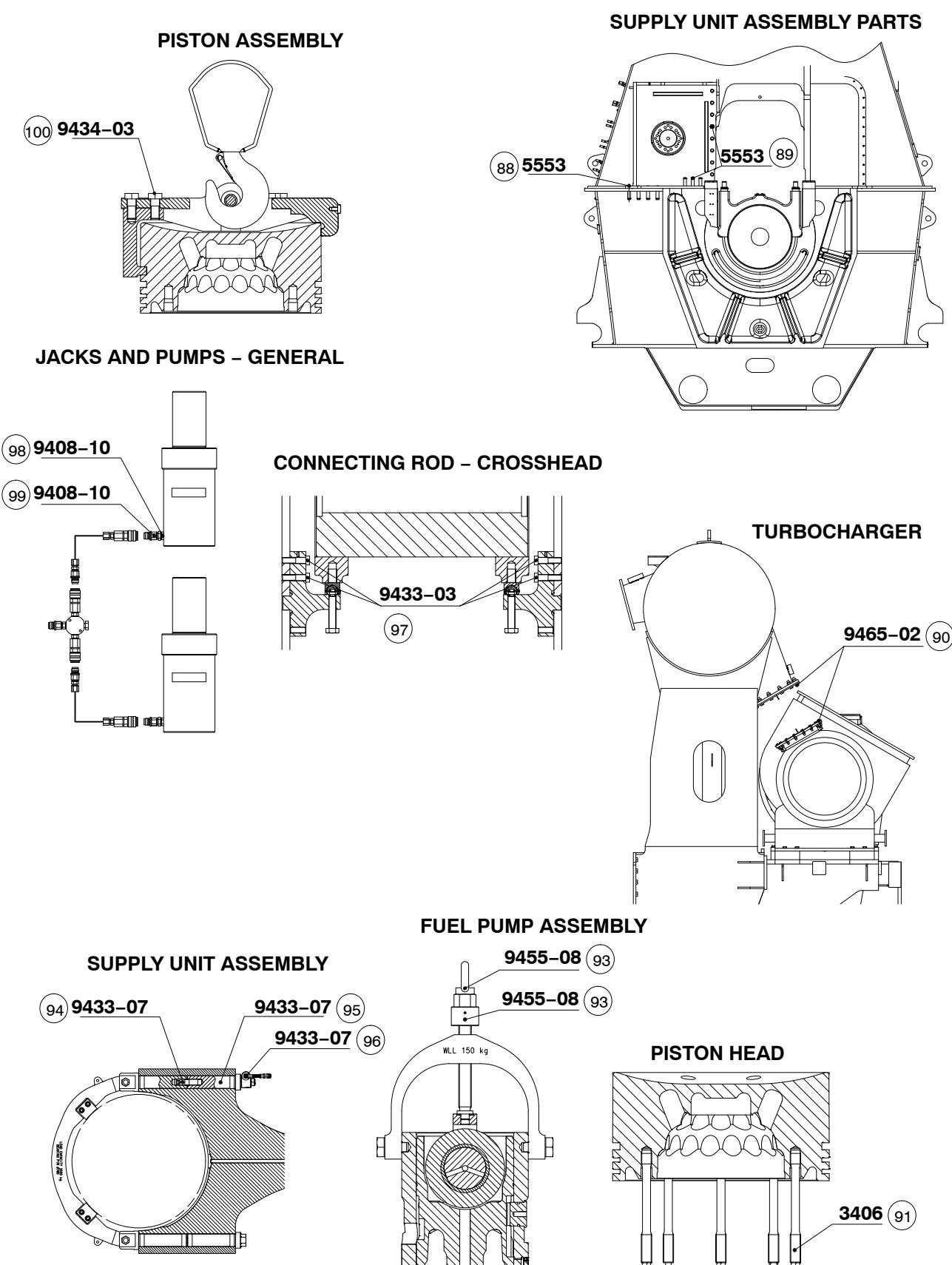


Fig. 6:

Tightening Values of Important Screwed Connections



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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					(470)		O	M64x6	
2		20						O	M12x1.5	
3		(75)	20 Nm	45°				K	M12	
4					0.56 ±0.04			O	M48	Refer to Fig. 1, Position 4
5								O	M30	Use an open-ended spanner to tighten with your hand
6		136						O	M16	
7	1500		600 bar	1500 bar			80	O	M72	
8		(2000)				60		M	M36	Refer to Fig. 1, Position 8
9	170							K	M64	Hydraulic jack, Group 1715-1
10	1500		1000 bar	1500 bar				K	M64	
11		10						K	M10	
12	1500		1100 bar	1500 bar			25	O	M48	
13		14–15						M	G ³ / ₄ "	
14		1.7–2.3						K	–	
15		150						O	M16	
16		10						O	M10	
17	1500					(85)		O	M30	Refer to Fig. 1, Position 17
18	1500					(200)		O	M72x6	
19	1500		1000 bar	1500 bar			20	O	M30	
20		(3900)				25		M	M56	
21		(900)				40		M	M30	
22					1.3 ±0.06			M	M39	
23		(1600)				80		K	M30x2	Apply Loctite 262 to the thread
24		3900				(25)		M	M56	
25		(14000)				50		M	M85	
26	1500							O	M52	
27		(1200)				60		M	M30	
28	1500				12.0 to 14.0			M	M95x6	
29		300						K	M24	
30								N	M12	Refer to Fig. 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	
33		600						N	M60	
34		300						N	M30	
35		45						O	G ¹ / ₄ "	
36		1.6						K	M8	
37		40						O	M10	
38		60						N	M12	
39		150						O	M16	
40		40						O	M10	
41		80						N	M14	
42		80						N	M14	
43		80						N	M14	
44	1500							O	M39	
45		100						O	M39	
46		80						N	M14	
47		10						K	M12	Apply Loctite 240 to the thread
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	Bonded in position with Loctite 0243
58		80						K	M22x1.5	
59		(1250)			64			O	M30	
60		480						N	M27	
61		7						K	M8	Bonded in position with Loctite 0243
62		60						K	M20	

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

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [Nm]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [*]	Control angle from step 1 to step 2 [*]	Lubricant	Thread size	Comments
63	20							O	M10	
64	20							O	M10	
65	20							O	M10	
66	20							O	M10	
67	70							N	M20x2	
68	190							N	M16	
69	110							N	M14	
70	350							O	M20	
71	350							O	M20	
72	9							O	M5	
73	225							O	M33x2	
74	350							O	M20	
75	25							O	G1/4"	
76	25							N	M14x1.5	
77	70							N	M12	
78	min. 290							C	M30	Minimum 290 Nm – maximum 960 Nm
79	270							C	M48	
80	140							C	M20	
81	175							O	M20	
82	7							K	M6	Bonded in position with Loctite 2701
83	35							O	M10	
84	7							O	M6	
85										
86										
87	145							O	M16	
88	600							O	M24	
89	600							O	M24	

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

Tightening Values of Important Screwed Connections

Position	Pre-tensioning pressure (bar)	Tightening torque or reference torque (in brackets) [Nm]	Step 1	Step 2	Delta L [mm]	Tightening angle or control angle (in brackets) [°]	Control angle from step 1 to step 2 [*]	Lubricant	Thread size	Comments
90	60						O	M16		
91	25						O	M30		
92	10						K	M24	Bonded in position with Loctite 2701	
93	10						K	M16	Bonded in position with Loctite 2701	
94	140						K	M36	Screw bonded in position with Loctite 268	
95	70						C	M36		
96	400						K	M27	Lug bonded in position with Loctite 268	
97	240						O	M24		
98	45						K	G1/4"		
99	45						O	G1/4"	Closing Valve sealed with Loc-tite 542	
100	170						M	M30		
101	35						C	M10		
102	4.2						C	M5		
103	7.2						C	M6		
104	30						N	M24x1.5		
105	40						N	M10		
106	40						N	M10		
107	4						O	M4		
108	170						N	M16		
109	815						M	M56x1.5	Minimum 800 Nm to Maximum 830 Nm	
110	35						O	M36		
111	280						O	M20		
112	190						O	M20		
113	90						N	M30x1.5		

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

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

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.

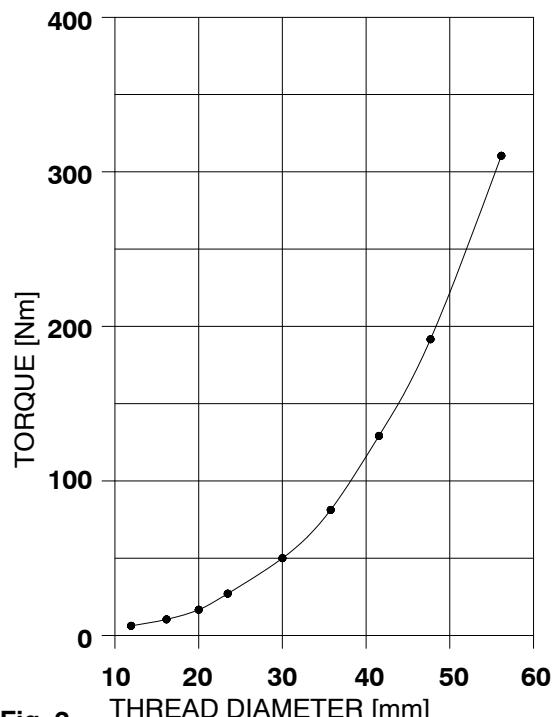
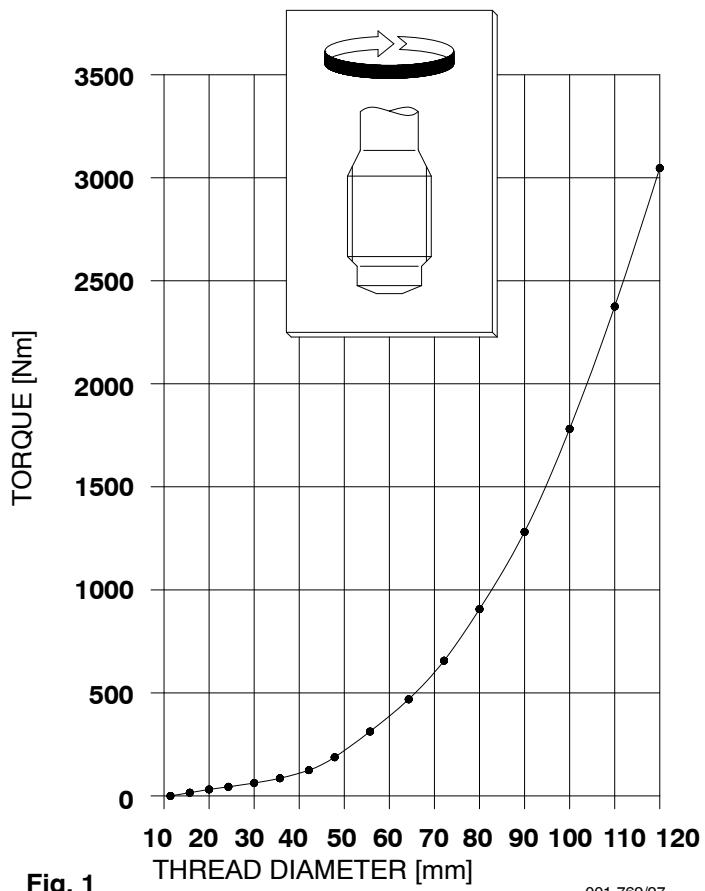
These torques values do not apply to turbocharger installations. Refer to the documents of the turbocharger manufacturer for the correct torque values.

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

2. Elastic Studs – Replacement

2.1 Procedure

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



Torque Values – Standard Screws and Elastic Studs

- 10) 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).

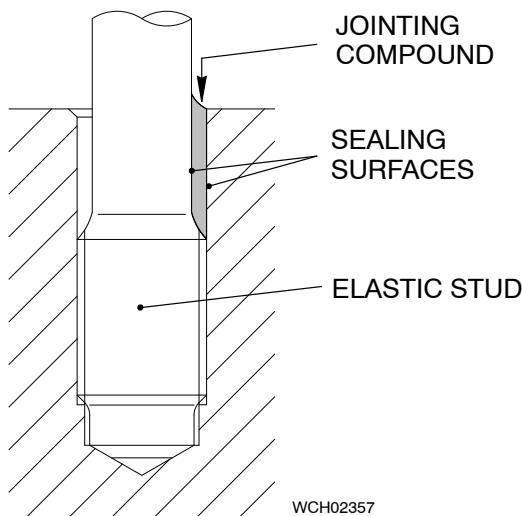


Fig. 3

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2.2 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.

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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		318 6.69 7.6
2			
2106	Elastic bolt in cylinder jacket		50.5
2124	Cylinder liner		3535
2130	Water guide jacket (top part) Water guide jacket (bottom part)		91.9 156
2140	Gas admission valve		69.8
2303	Piston rod gland	Complete	109
2708	Elastic bolt for valve cage Cylinder cover without accessories Cylinder cover with exhaust valve unit, all valves and upper water guide jacket	Complete	26.8 1487 2283.9
2722	Injection valve	Complete	19.9
2728	Starting valve	Complete	34.0
2751	Exhaust valve housing with spindle	Complete	677.5
2754	Exhaust valve spindle		65.5
2790	Pilot injection valve	complete	34.2
3			
3122	Flywheel		3390-11003
3140	Axial damper cylinder	2-part	793
3206	Turning gear with planetary gear		1266

Individual Components per Piece in kg

Group	Component	Design/Position	kg
3306	Connecting rod With elastic stud and nut for bottom end bearing	Complete	2443
3306	Bearing cover for bottom end bearing with elastic studs	Complete	360
3310	Bearing shell for bottom end bearing		35.0
3312	Bearing cover for top end bearing		297
3315	Bearing shell for top end bearing		65.0
3326	Crosshead pin Crosshead with guide shoes Guide shoe	Complete Complete	1460 2214 349
3403	Piston with piston rod Piston crown Piston skirt Piston rod Spraying plate with oil pipe Piston rings	Complete	1800.2 444 112 1160 72.4 11.8
3603	Toggle lever to piston cooling and crosshead lubrication	Complete	100
4			
4106	Crankshaft gear wheel	2-part, complete	1598
4325	Starting air shut-off		246
5			
5551	Servo oil pump		114
5552	Supply unit with 3 fuel pumps and 2 oil pumps		5863
5556	Fuel pump	complete	420
5581	Camshaft with gear wheels	Complete (for three fuel pumps)	745
5612	Exhaust valve control unit	Complete	37.4

Individual Components per Piece in kg

Group	Component	Design/Position	kg
6 6506	Turbocharger	MET 42MB MET 53MB MET 60MB MET 66MB MET 71MB MET 83MB ABB A265 ABB A270 ABB A275 ABB A280	1600 4100 4500 6500 800 12500 2700 3800 6300 8600
6545	Auxiliary blower with electric motor Electric motor	complete	946 450
6509	Expansion piece between exhaust manifolds and upstream of turbocharger		50–70
6606	Scavenge air cooler	GEA A9	2740
6708	Water separator		202
7 7758	Electric balancer compensating shaft (gear wheel, counter weight and bearing pin) Electric motor		1326 180
8 8103	Expansion piece 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	Lubricating oil	– Laboratory analysis	3000 Op. h (operating hours)
	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 – Check condition of rubber gasket in the vertical oil drain to sump tank (see SPC 9722)	12000 Op. h 6000 Op. h
	Crankcase	– Do a visual examination 100 Op. h after overhaul	1500–3000 Op. h
1132-2	Main bearing	– Remove top half of bearing for inspection, Random inspection each 12 000 Op. h – Check bearing clearance, see 0330-1 – Remove bottom bearing shell for inspection Estimated service life: Main bearing shell	In accordance with the classification society 6000 Op. h In accordance with the classification society 90000
1203-1	Thrust bearing	– Do a check of the axial and radial clearances – Make sure that the bottom drain is not blocked – Remove the thrust bearing pads for inspection	6000–8000 Op. h 6000–8000 Op. h acc. to class. society
1224-1			
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
1715-1	Hydraulic engine stays	– Do a check of the oil pressure at the gauge	monthly
1903-1	Tie rod	– Do a check of the tension, if necessary apply tension again First time after one year	24000–30000 Op. h
2			
2124-1	Cylinder liner	– Find the wear in the bore (in installed condition)	At each piston removal

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
2124-2	Cylinder liner	<ul style="list-style-type: none"> - Remove the cylinder liner - Replace the O-rings - Replace the (soft iron) joint ring between the cylinder liner and the cylinder cover - Water guide jacket and transition tubes, replace the O-rings - Do a check of the condition of the antipolishing ring - Grind off the wear ridge in the bore - Clean the scavenge ports and polish the surface finish of their edges - Refinish the lubricating grooves <p>Estimated service life: Cylinder Liner</p>	As necessary At each liner removal At each piston removal At each liner removal At each piston removal At each piston removal As necessary As necessary Up to 90000 Op. h
2124-3			
2138-1	Lubricating quill (pulse lubrication)	<ul style="list-style-type: none"> - Do a check of the function and tightness - Do a check of the function of non-return valves 	At each piston removal At each liner removal
2140-1	Gas admission valve (GAV)	<ul style="list-style-type: none"> - Do a check of the function and tightness of GAV - Do a visual check of the compensator at the gas inlet pipe - Overhaul the valve seat of GAV <p>Estimated service life: Valve spindle, guide, stroke sensor and rail valve</p> <p>Estimated service life: GAV housing and servo drive</p>	6000 Op.h at each GAV removal 18000 – 21000 Op. h 36000 Op. h Engine lifetime
2303-1	Piston rod gland	<ul style="list-style-type: none"> - Clean the piston rings, calculate worn parts <p>Estimated service life: Piston rod gland</p>	At each piston removal 36000 Op.h (refers to rings)
2708-1	Cylinder cover	<ul style="list-style-type: none"> - Do a check of the combustion space for damage and worn areas <p>Estimated service life: Cylinder cover</p>	At each piston removal Service life of engine
2722-1	Fuel Injection valve (FAST)	<ul style="list-style-type: none"> - Do an external check for tightness - Do a check of the opening pressure - Replace O-rings <p>Estimated service life: nozzle tip</p> <p>Estimated service life: nozzle needle, nozzle body</p>	Before engine start after a longer engine stop 6000 Op. H 6000 Op. H 12000 Op.h 12000 Op.h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
2728-1	Starting air valve	<ul style="list-style-type: none"> - Do a check of the pipe upstream of the valve during operation, If the pipe is too hot, disassemble the starting valve - Remove and disassemble one starting valve at . From its condition, calculate the time of overhaul for the remaining valves - Make sure that the nut on the solenoid is tight, If necessary, tighten the nut - Solenoid valve, do a random functional check Overhaul 	Weekly 12000 Op. h Monthly 6000 Op. h 18 000 Op. h
2751-1 to 2751-4	Exhaust valve	<ul style="list-style-type: none"> - General inspection of valve housing, valve spindle and valve seat (without disassembly of exhaust valve) - Do a check of the condition and worn parts of the valve spindle (if necessary grind the valve seat) - Do a check of the piston seal ring / rod seal ring / guide bush - Do a check of the condition and worn parts of the valve seat (if necessary grind the valve seat) - Do a random check of the valve drive, outer and inner pistons, damper, thrust piece - Do a random check of screwed connections <p>Estimated service life: Exhaust valve spindle</p> <p>Estimated service life: Valve seat</p>	At each piston removal 36000 Op. h (initial inspection 18000) 36000 Op. h (initial inspection 18000) 36000 Op. h (initial inspection 18000) 18000 Op. h 12000 Op. h 108000 Op.h (remanufacturing as required) 72000 Op.h (remanufacturing as required)
2790-1	Pilot injection Valve	<ul style="list-style-type: none"> - Check externally for tightness - Check opening pressure - Replace nozzle spare parts set - Replace O-rings - Replace pilot injection valve complete - Replace pre-chamber <p>Estimated service life: Nozzle spare parts set</p>	Before starting engine after a long engine stop 8000 Op. h 8000 Op. h 8000 Op. h 24000 Op. h 18000 Op. h 8000 Op.h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
<u>3</u>			
3103-1	Crankshaft	<ul style="list-style-type: none"> - Measure the crank deflection: (always if the ship is grounded. Also, before and after each docking) 	9000 Op. h
3130-1	Torsional vibration damper	<ul style="list-style-type: none"> - 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		<ul style="list-style-type: none"> - Disassembly and inspection of vibration damper 	In accordance with instructions of the damper manufacturer
3140-1	Axial damper	<ul style="list-style-type: none"> - Disassembly and inspection 	36000 to 48000 Op. h
3206-1	Turning gear	<ul style="list-style-type: none"> - Inspection of turning gear - Lubrication of tooth flanks of pinion and flywheel, related to visual inspections - Check screwed connections, first time after one year 	In accordance with the instructions of turning gear manufacturer 2000 Op.h 12000 Op.h
3303-2	Connecting rod bearings	<ul style="list-style-type: none"> - Do a check of the bearing clearances (refer to 0330-1) - Inspect the bottom end bearing (service life of bearing shell: 60 000 Op hrs to 72 000 Op hrs) 	6000 to 8000 Op. h 30 000 to 36 000 Op. h or in accordance with the classification society
3303-3		<ul style="list-style-type: none"> - Inspect the top end bearing <p>Estimated service life: Connecting rod bottom bearing</p> <p>Estimated service life: Connecting rod top bearing</p>	30 000 to 36 000 Op. h or in accordance with the classification society 90000 Op.h 90000 Op.h
3326-1	Guide shoe, crosshead pin	<ul style="list-style-type: none"> - Do a check of the clearances. 	6000 to 8000 Op. h
3425-1	Piston rings	<ul style="list-style-type: none"> - Measure the thickness of the chrome-ceramic layer - Replace the piston rings (related to remaining thickness of chrome-ceramic layer) 	1500 to 2000 Op. H 18000 to 36000 Op. H (condition based)

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
3403-1	Piston	<ul style="list-style-type: none"> - Remove, clean and measure ring grooves (cylinder liner with antipolishing ring and chrome-ceramic piston rings) - Do a check of the tightness on the installed piston and with running oil pump. Do a visual check through the scavenge ports 	18000–36000 Op. h (condition based) After installation
3403-3		<ul style="list-style-type: none"> - Disassemble and assemble (open and clean the cooling space, minimum one piston three yearly) 	As necessary
3403-4		<ul style="list-style-type: none"> - Top surface of the piston: do a check of the condition. - Full remanufacturing of piston head surface - Do a visual check through scavenge ports of the piston, piston rings and cylinder liner (operate the turning gear to turn the crankshaft) 	Each piston removal 72000 Op. h 500 to 1000 Op. h
	Piston underside	<ul style="list-style-type: none"> - Do a check of the condition of the piston underside. Clean as necessary. - Make sure that the drains are clear 	1500 to 3000 Op. h 1500 to 3000 Op. h
<u>4</u>	Start interlock	<ul style="list-style-type: none"> - Do a check of the electrical and pneumatic interlocks (see Operating Manual 4003-1) 	Quarterly
4103-1	Driving wheels	<ul style="list-style-type: none"> - Do a check of the condition of the teeth - Do a check of the running clearance and backlash of the teeth 	6000 to 8000 Op. h 6000 to 8000 Op. h
4325-1	Starting air shut-off valve	<ul style="list-style-type: none"> - Release the air - Disassemble, clean and examine (valve seat, springs and seal rings) - Do an overhaul of the common start valve 	After each manoeuvring period 30000 to 36000 Op. h 18000 Op. h
	Control air filter	<ul style="list-style-type: none"> - Drain the filter - Clean the filter 	Weekly 6000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
5			
5555-1	Pilot fuel supply unit	<ul style="list-style-type: none"> – Lubricate the flexible coupling of the pilot fuel pump – Replace the pilot fuel pump – Replace the pilot fuel oil filter cartridges (the cartridges must be replaced earlier if the pressure difference indicator shows high pressure increase.) – Clean the wire gauze and filter housing <p>Estimated service life: Pilot fuel pump</p>	1500 – 3000 Op. h 24000 Op. h 1000 Op. h (or according to filter manufacturer) 1000 Op. h 24000 Op. h
5556-1	Fuel pump	<ul style="list-style-type: none"> – Random flow check of lubricating oil – Full reconditioning of fuel pump <p>Estimated service life: Fuel pump</p>	6000 Op. h 18000 Op. h 18000 Op. h
5562-1	Fuel pressure control valve (PCV)	<ul style="list-style-type: none"> – Check shut down function (see Operating Manual 4003-1) – Function check (see Operation Manual 5562-1) – General overhaul <p>Estimated service life: Fuel pressure control valve</p>	3000 Op. h 6000 Op. h Only if PCV fails Engine lifetime
5562-2	Fuel overpressure safety valve / relief valve	<ul style="list-style-type: none"> – Do a function check on the test bench 	24000 – 36000 Op. h
5564-1	Flow limiting valve	<ul style="list-style-type: none"> – Inspect and clean piston rod and piston running surface – Overhaul unit or replace it with a new one <p>Estimated service life: Flow limiting Valve (FLV)</p>	12000 Op. h 24000 Op. h 24000 Op.h
5581-1	Fuel pump drive	<ul style="list-style-type: none"> – Camshaft, check running surface of cams, rollers & roller guides (first time after 500 Op. h) – Camshaft, check bearing clearances at random – Camshaft, check thrust bearing clearances <p>Estimated service life: Camshaft bearings</p>	3000 Op. h 12 000 Op. h 36 000 Op. h 90000 Op.h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
5591-1	Servo oil pump and drive	<ul style="list-style-type: none"> – Replace servo oil pump with new item, or an item that had an overhaul in a Wärtsilä workshop (see paragraphs 3 and 4) – Do a check of the bearing bushes (see paragraph 3.1) – Do a check of the pinion and gear wheels to the servo pump drive (see paragraph 2.2) – Do a check of the filter (see paragraph 2.1) <p>Estimated service life: Pinion bearing bushes</p>	36000 Op. h 24000 Op. h 3000 Op. h 2000 Op. h 90000 Op.h
5612-1	Exhaust valve control unit	<ul style="list-style-type: none"> – Check piston and slide rod – Replace 4/2-way solenoid valve – Check filter (servo oil) 	18 000 Op. h 24000 – 36000 Op. h 18 000 Op. h
5583-1	Fuel pump actuator arrang.	<ul style="list-style-type: none"> – Check connecting elements for free movement, lubricate movable parts 	3000 Op. h
<u>6</u>			
6420-1	Scavenge air receiver	<ul style="list-style-type: none"> – Check and clean the flaps – Clean the scavenge air receiver – Make sure that the drain pipes are not blocked 	4000–6000 Op. h 4000–6000 Op. h 1500–3000 Op. h
	Turbocharger	<ul style="list-style-type: none"> – Wash-clean the blower in service – Wash-clean or dry clean the turbine in service 	(see Turbocharger Manual) (see Turbocharger Manual)
	Air filter	<ul style="list-style-type: none"> – Check filter – Cleaning of filter at a Δp increase of 50% compared to shop test value at same engine load (see Operating Manual 6510-1) 	half yearly as required
6545-1	Auxiliary blower	<ul style="list-style-type: none"> – Clean impeller and casing – Replace ball bearing 	24000–36000 Op. h 24000–36000 Op. h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
6606-1	Scavenge air cooler	<ul style="list-style-type: none"> - Cleaning of scavenge air cooler (air side) in service at the beginning weekly, later if Δp (pressure drop through SAC) increases compared to shop test value at same engine load (see Operating Manual 6606-1) - Check condensate collector through sight glass (see Operating Manual 8345-1) - Check condensate collector/filter for free passage (see Operating Manual 8345-1) - Check scavenge air cooler sealing - Bleed - Remove scavenge air cooler for general overhaul 	as required daily 1500–3000 Op. h quarterly daily as required
6708-1	Water separator	<ul style="list-style-type: none"> - Check condensate collector through sight glass (see Operating Manual 8345-1) - Check condensate collector/filter for free passage (see Operating Manual 8345-1) - Check water separator elements (if necessary clean them) - Remove water separator for general overhaul 	daily 1500–3000 Op. h 1500–3000 Op. h as required
6420-1	Scavenge Air Waste Gate	<ul style="list-style-type: none"> - Check function (see Operating Manual 6735-1) 	half yearly
7			
7218-1	Lubricating pump (Pulse lubrication)	<ul style="list-style-type: none"> - Replace the lubricating pump with new item, or a pump overhauled by a Wärtsilä workshop. <p>Estimated service life: Cylinder lubrication pump</p>	As necessary 30000 Op.h
7758-1	Electric balancer iElba	<ul style="list-style-type: none"> - Check bearing clearance, see 0330-1 	6000 Op. h.
8			
8135-1	Exhaust Waste Gate (LLT)	<ul style="list-style-type: none"> - During a longer operation period at low engine load, manually open butterfly valve at least once per week (see Operating Manual 8135-1) - General inspection 	according to instruction of valve manufacturer
	Servo oil automatic filter	<ul style="list-style-type: none"> - Follow manufacturer's instructions, if installed 	
	Starting air pipe	<ul style="list-style-type: none"> - Drain 	before and after every manoeuvring period
	Pressure gauges and pyrometers	<ul style="list-style-type: none"> - Compare and calibrate according to master instruments 	6000–8000 Op.h

Inspection and Overhaul Intervals (Guidelines)

Group	Component	Work to be Done	Intervals
8135-1	Fuel and lubricating oil filters	- Clean or replace filter elements (depending on make, follow manufacturer's instructions)	as required
	Pipe holders	- Check fastenings periodically, if necessary retighten screws	half yearly (first time after 100 Op. h)
8447-1	Servo oil pipes	- Regrind sealing faces	as required
	Non-return valve	- Random check	18000 Op.h
8460-1	Hydraulic pipe to exhaust valve	- Regrind sealing faces	as required
8733-1	HP injection pipe	- Regrind sealing faces	as required
8744	Supply unit fuel drain pipe	- Check regularly for free passage at least once a year	6000 Op.h
8752-1	HP fuel pipes	- Regrind sealing faces	as required
2140-1	Gas distributor pipe	- Shut off and vent valves: Check tightening of ball valves and of shaft sealing	6000 Op. h
		- Visual check of compensators	6000 Op. h
		Estimated service life: Valves and compensator	engine lifetime
9			
9223-1	Crank Angle Sensor Unit	- Function check - Replace proximity sensors	36000–50000 Op.h 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) - Visual cabling check	48000–50000 Op. h quarterly

Inspection and Overhaul Intervals (Guidelines)

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

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

On the engine sectional drawings [0803-1](#), those parts are marked with group numbers, as they are found in the Maintenance Manual.

Engine Cross Section and Longitudinal Section

1. Cross Section

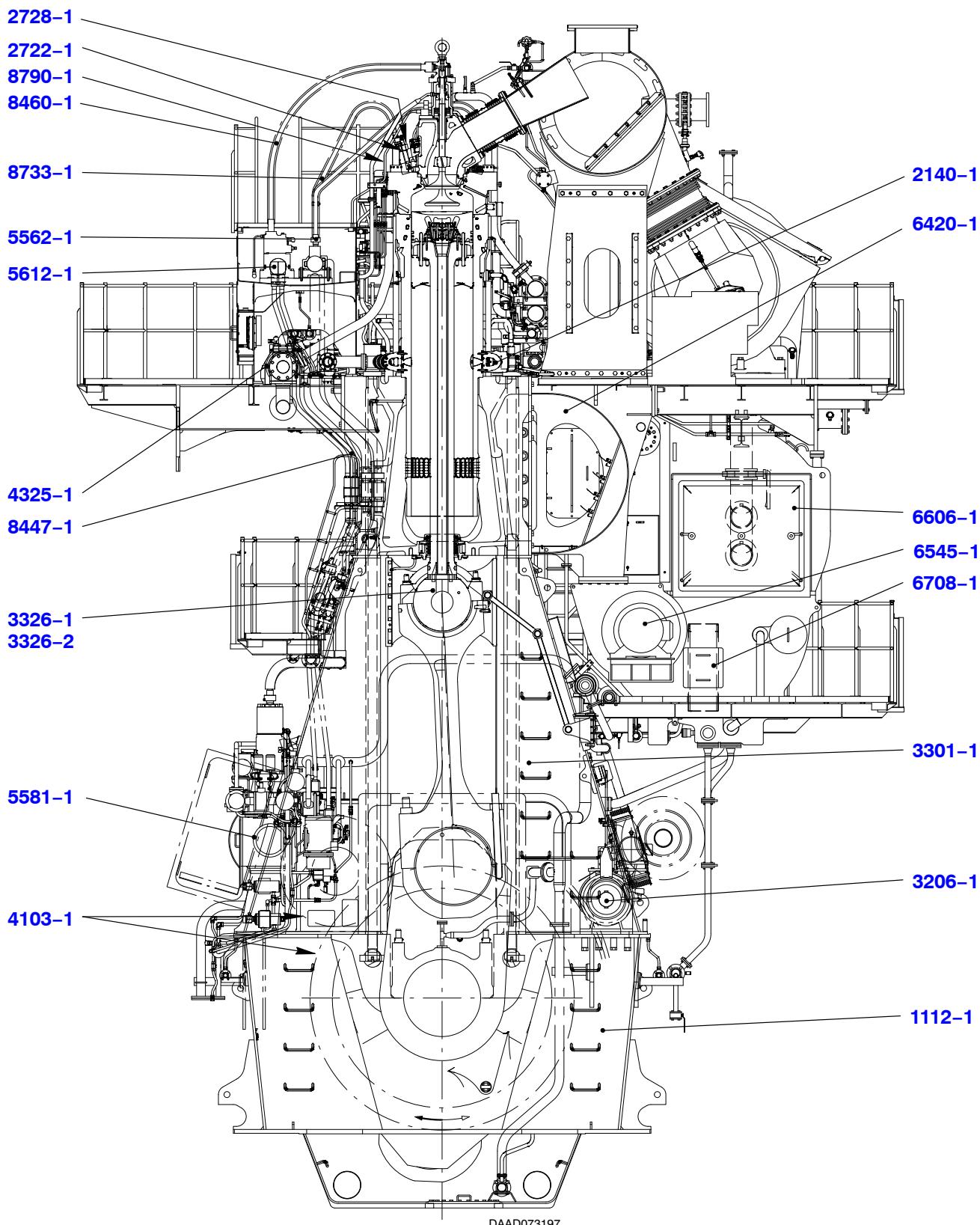


Fig. 1: Cross Section

2. Longitudinal Section

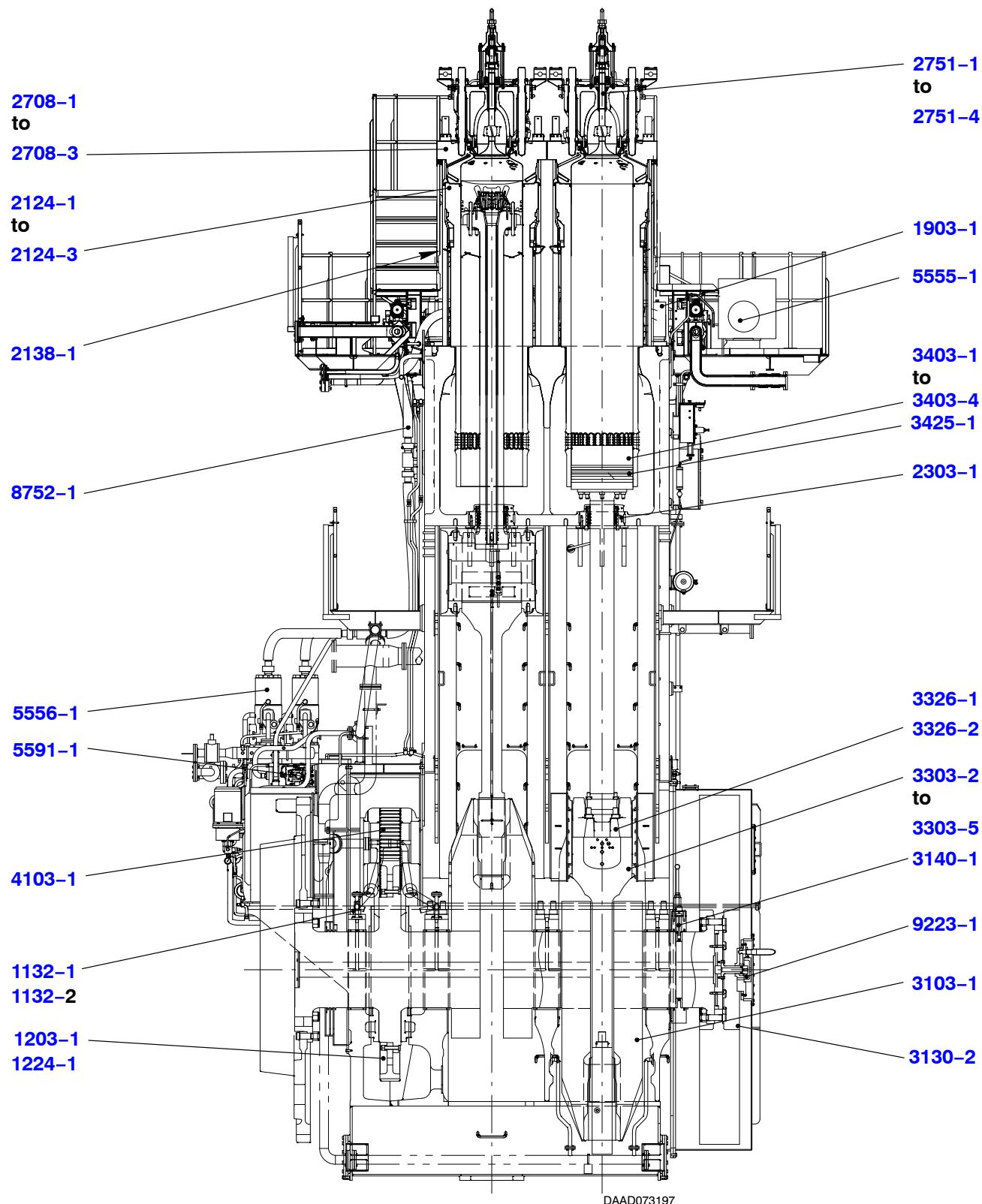


Fig. 2: Longitudinal Section

Bedplate and Tie Rod

Group 1

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

Main Bearing

Elastic Studs – Loosen 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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Bedplate and Thrust Bearing**Foundation Bolts – Check****Tools:**

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

1. General

You must do a check of the tension of the foundation bolts (studs) at longer intervals e.g. during overhauls, refer to [0380-1](#).

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

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

1.1 Foundation Bolts – Loose and Apply Tension

To loosen and apply tension to the foundation bolts, start at the driving end and continue from one side to the other to the free end.

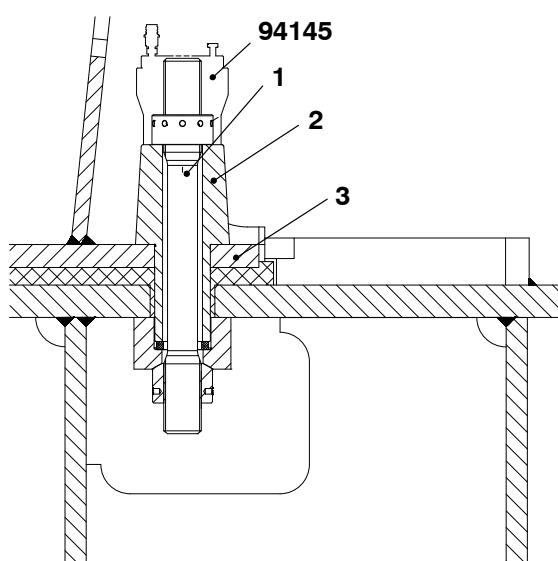
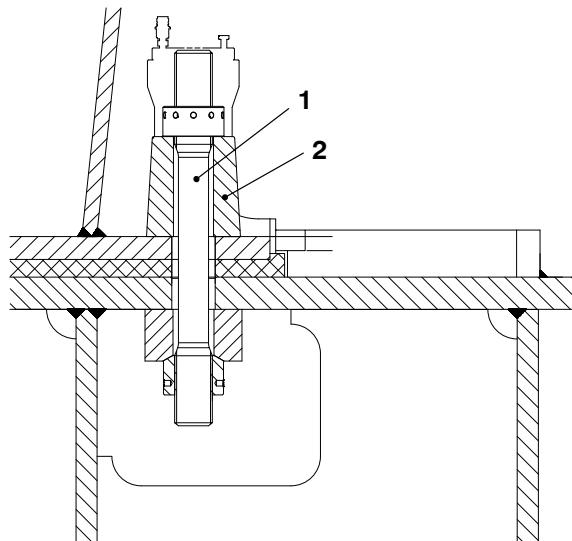
1.1.1 Loosen

- 1) To loosen the foundation bolts (1), use the pre-tensioner (94145, [Fig.1](#)).
- 2) Connect the pre-tensioners (94145) to the hydraulic pump (94931, [Fig. 3](#)), refer to [9403-4](#), paragraph [2.1](#) Version 1.
- 3) Do the procedure to loosen as given in [9403-4](#), paragraph [2.3](#).

1.1.2 Apply Tension

Note: Apply tension in two steps: for metal chocks or epoxy resin chocks, i.e. first apply tension to all foundation bolts to 1000 bar (1st step), then to 1500 bar (2nd step).

- 1) Do the procedure for Version 1 given in [9403-4](#), paragraph [3](#) and [3.1](#).
- 2) Do the procedure to apply tension given in [9403-4](#), paragraph [3.3](#).

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

WCH02697

2. Tension Check

- 1) Clean the threads of the foundation bolts (4, Fig.3) and the seating surfaces.
- 2) Attach the pre-tensioner (94145) to the foundation bolt (4).
- 3) Make sure that the vent screw (8) is fully open.
- 4) Make sure that there is little or no clearance at (X).
- 5) Connect the pre-tensioner (94145) to the HP oil pump (94931), refer to [9403-2](#).
- 6) Close the relief valve (9)
- 7) Operate the HP oil pump (94931) until oil that has no air flows from the vent screw (8).
- 8) Close the vent screw (8).
- 9) Torque the foundation bolt (4) to 1500 bar and keep the pressure constant.
- 10) Do not move the piston (1) to more than the red limit groove (2).
- 11) Put the feeler gauge (94122) into the slot (3). Do a check for clearance between the round nut (6) and the bush (5).
- 12) If there is clearance between the round nut (6) and the bush (5), keep the pressure at 1500 bar and use the round bar (7) to fully tighten the round nut.
- 13) Open the relief valve (9) to release the the pressure to zero.
- 14) Remove the pre-tensioner (94145).

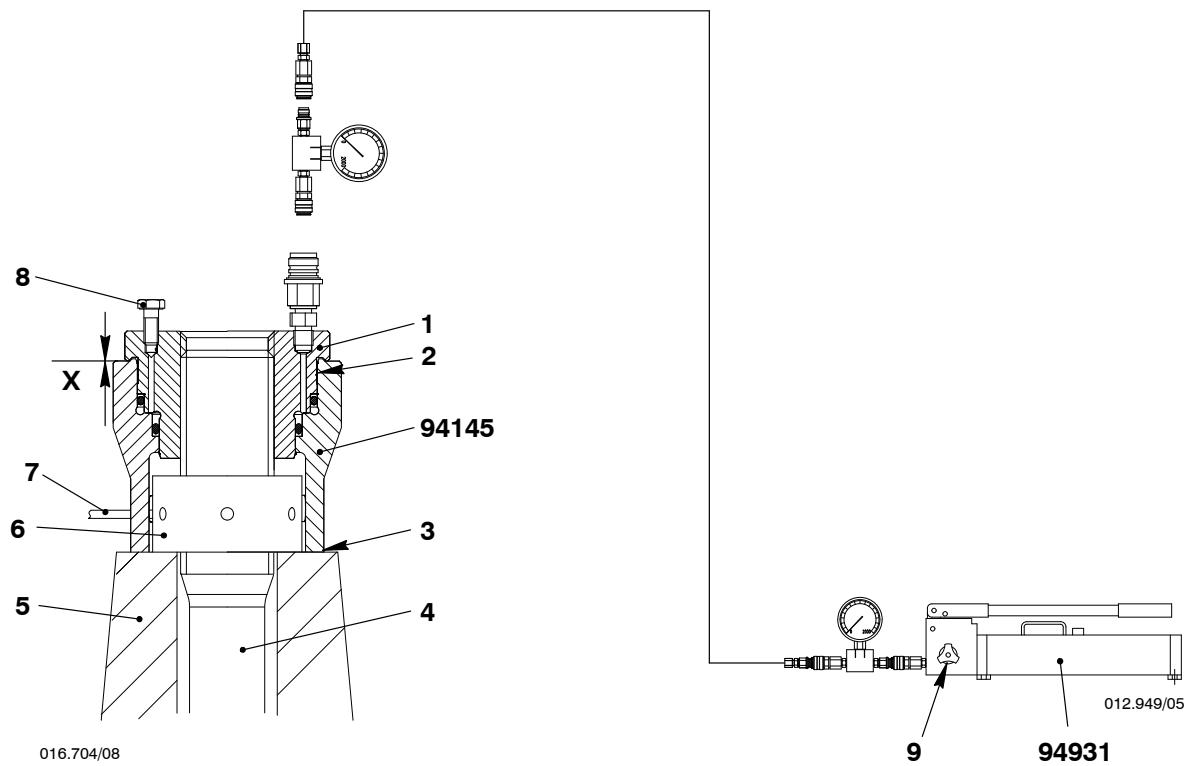


Fig. 3:

Main Bearing**Elastic Studs – Loosen and Apply 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 loosen 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 threads of the elastic studs (1).
- 4) To loosen, 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.

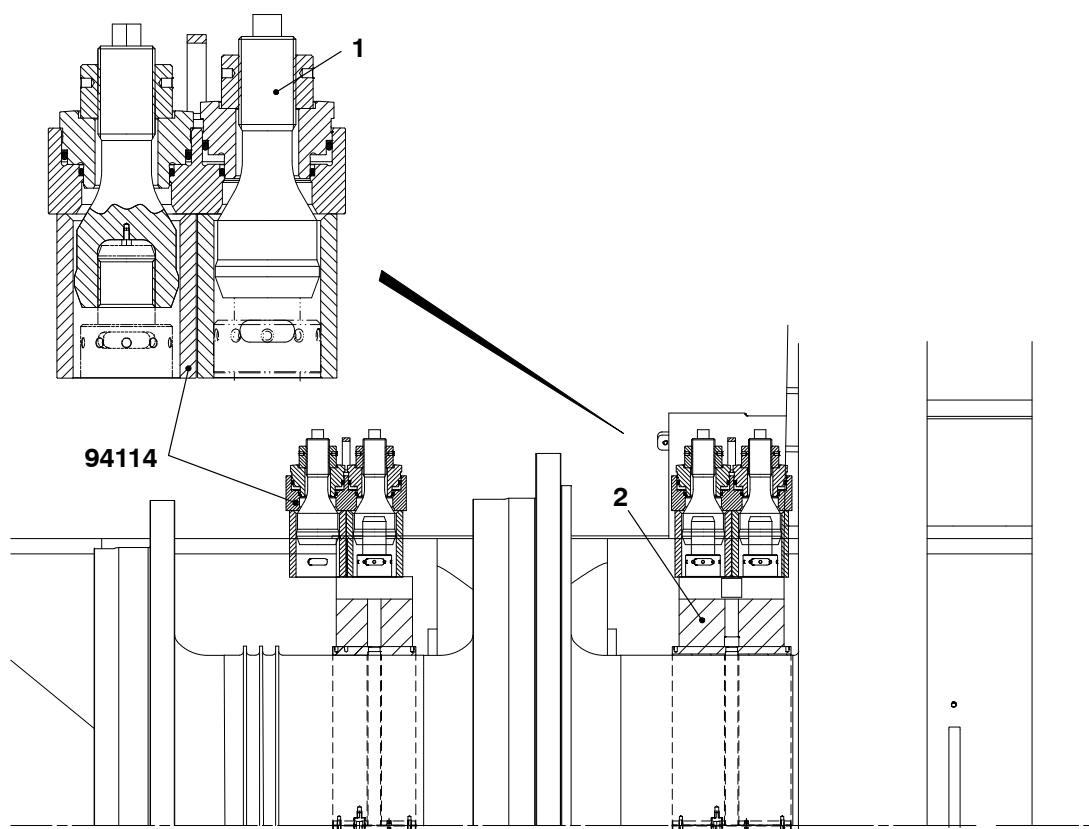


Fig. 1

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

2	Manual ratchet 1000 kg	94016-006	1	Dismantling device	94118A
1	Manual ratchet 6300 kg	94016-017		(narrow bearing shell)	
1	Manual ratchet 500 kg	94016-024	1	Dismantling device	94118B
1	Chain block 1000 kg	94017-009	1	Lifting plate	94119
2	Shackle 8500 kg	94018C	1	Feeler gauge	94123
1	Shackle 4750 kg	94018B	1	Bracket	94141A
1	Eye bolt	94045-M36	1	Work platform	94143
1	Thrust device	94110	1	HP oil pump	94931
1	Lifting tool (wide bearing shell)	94116A	1	Connection block	94934
1	Lifting tool (narrow bearing shell)	94116B	2	Pressure gauges	94934A
1	Lug	94116C	1	Adapter	94934C
1	Roller support	94117	3	HP hoses	94935
1	Chain (symmetric/asymmetric)	94019A/B	2	Hydraulic ram	94936
1	Deviation pipe	94117B	2	Hydraulic ram	94936

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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 or in the engine.

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

Main Bearing – Removal and Installation

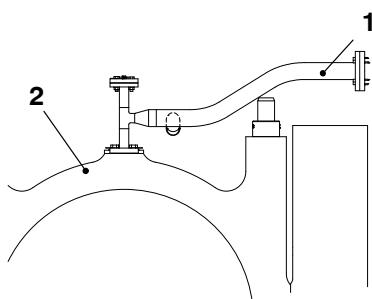


Fig. 1

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).
- 2) Apply protection to all openings.
- 3) Attach the work platform (94143, Fig.2)
- 4) Use the feeler gauge (94123) to do a check of the bearing clearance, refer to 0330-1, 1132.
- 5) Loosen the elastic studs (1) refer to 1132-1.
- 6) Remove the round nuts.
- 7) Attach the manual ratchet (94016-006) to the column.

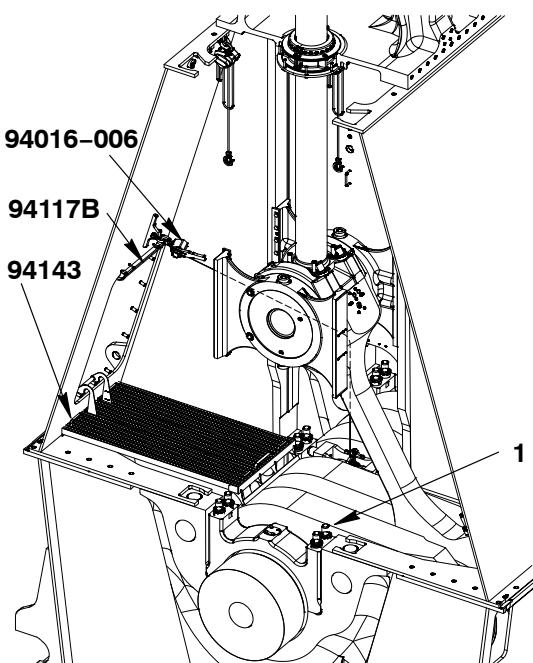


Fig. 2

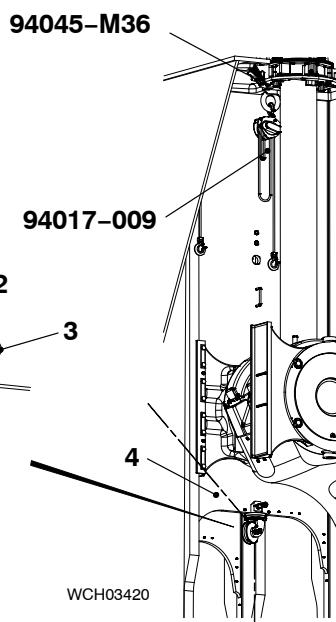


Fig. 3

- 8) Attach the roller support (94117, Fig. 3) to the column (4).
- 9) Attach the eye bolt (94045-M36) as shown.
- 10) Attach the chain block (94017-009) to the eye bolt (94045-M36).
- 11) Lock the pin (2) with the double spring clip (3).
- 12) Attach the deviation pipe (94117B) to the column.

Main Bearing – Removal and Installation

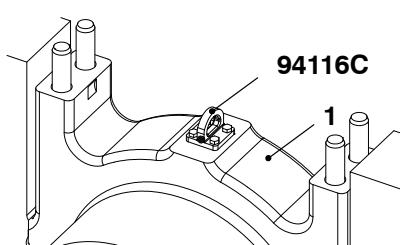


Fig. 4

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

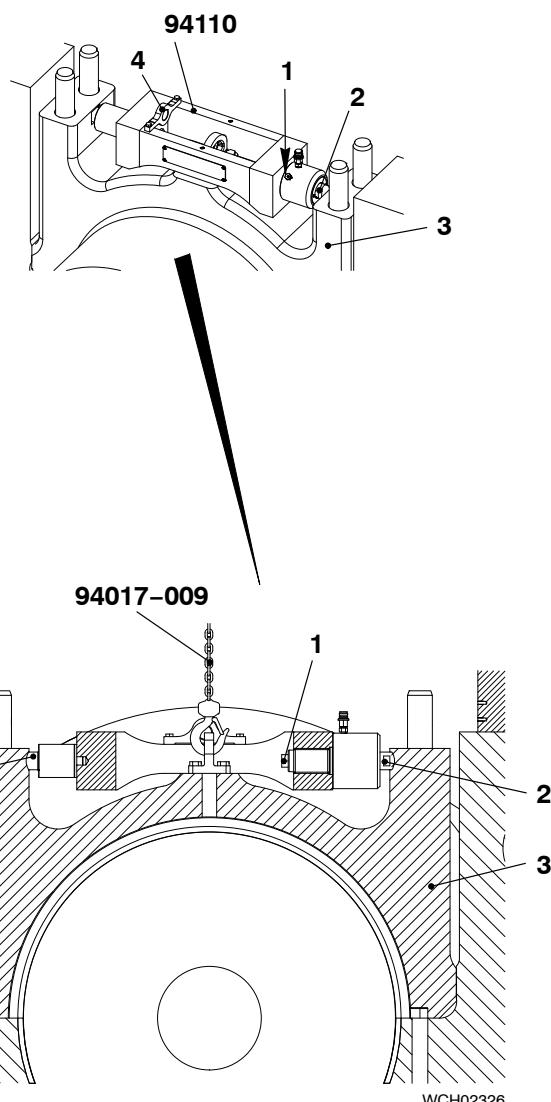


Fig. 5

- 14) Make sure that the thrust device (94110, Fig. 5) is clean.

WARNING

Injury Hazard: Do not use the thrust device 94110 as a lifting device. Injury to personnel can occur.

CAUTION

Damage Hazard: Use the thrust device 94110 only for removal of the main bearing covers No.2 to No.8. Damage to equipment can occur if you use incorrect equipment

Note: Only use the lifting plate (4) to move and install the thrust device (94110). If it is not necessary to use the lifting plate (4), attach it to the thrust device as shown.

- 15) Apply copper paste to the thread and the surface of the screw (1).
- 16) Open the vent screw (1) and make sure that the piston (2) is fully engaged.
- 17) Put the thrust device (94110) in position on the main bearing cover (3), as shown.
- 18) Make sure that the tappet (4) and the piston (2) are in the cutout of the main bearing cover (3).
- 19) Connect the thrust device (94110) to the HP oil pump (94931), refer to 9403-2.
- 20) Operate the HP oil pump.
- 21) Close the vent screw (1) when the oil that has no air flows out.
- 22) Increase slowly the pressure to 1500 bar.
- 23) Tighten manually the screw (1).
- 24) Release the pressure to zero
- 25) Disconnect the HP hose.

Main Bearing – Removal and Installation

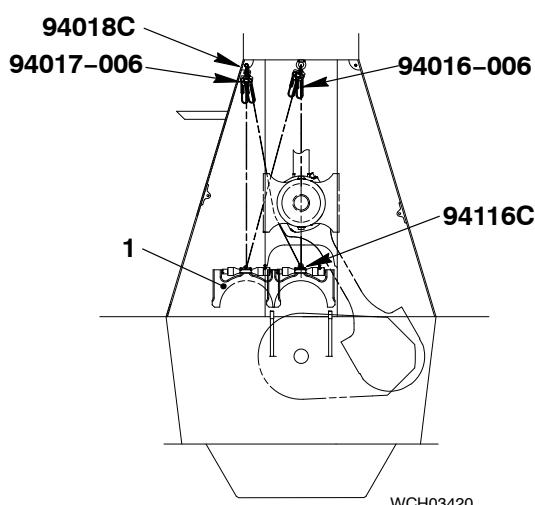
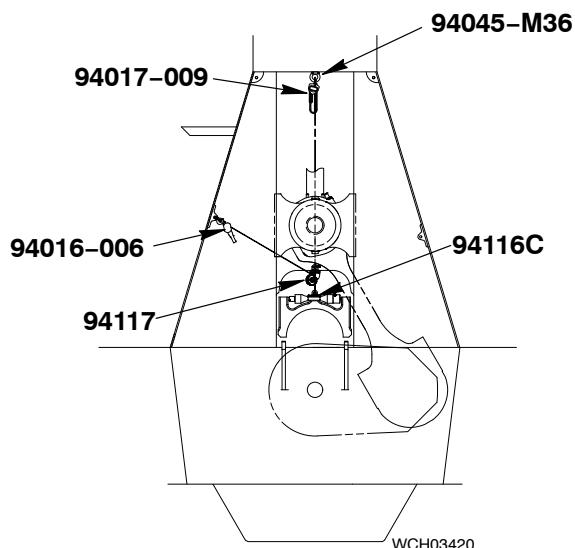
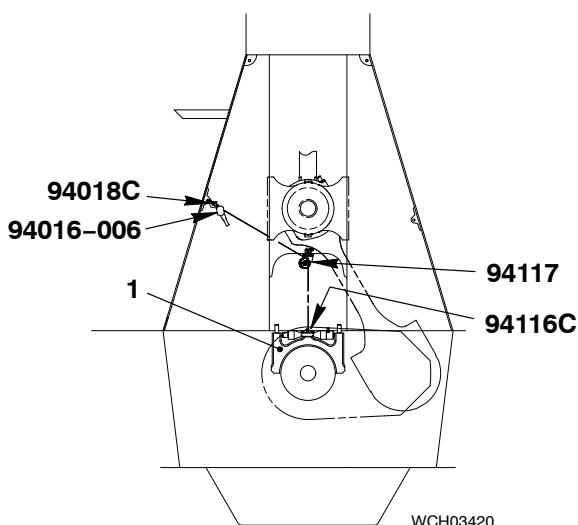
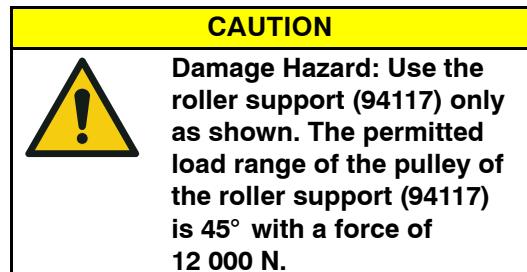


Fig. 6

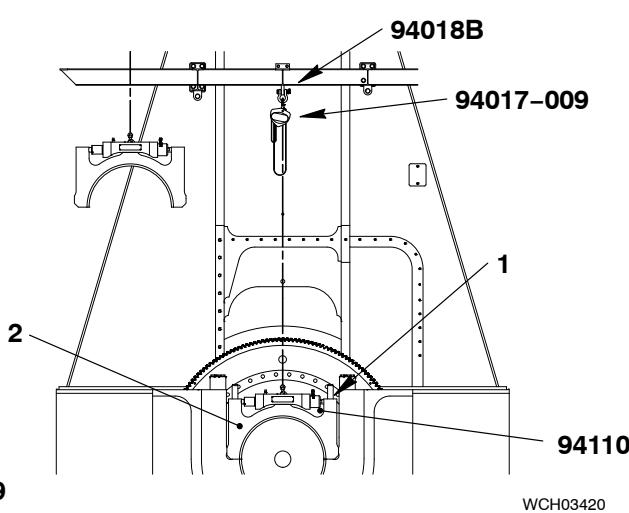
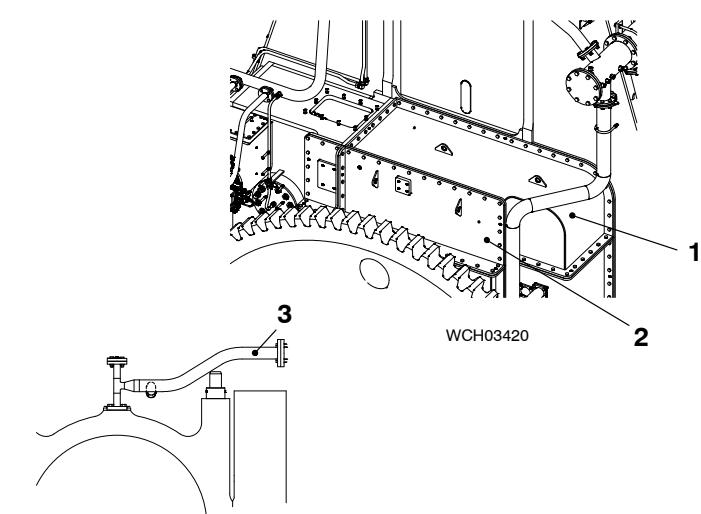
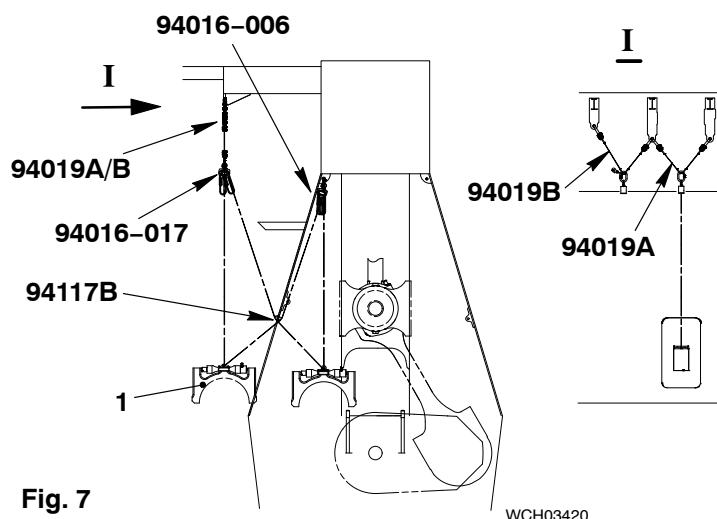
2.2 Main Bearing Cover – Removal

- 1) Attach the chain of the manual ratchet (94016-006), through the roller support (94117) to the lifting lug (94116C) as shown in Fig. 6.



- 2) Operate the manual ratchet (94016-006) to lift the main bearing cover (1).
- 3) Attach the chain block (94017-009) to the lug (94116C).
- 4) Operate the chain block (94017-009) to apply a light tension to the chain.
- 5) Remove the manual ratchet (94016-006).
- 6) Attach the manual ratchet (94016-006) to the shackle (94018C) on the column and the lug (94116C).
- 7) Move the main bearing cover (1) to the fuel side, until it hangs vertically on the manual ratchet (94016-024) as shown.

Main Bearing – Removal and Installation



- 8) Attach the chains (94019A/B, [Fig. 7](#)). to the shackle (94018C).
- 9) Attach the manual ratchet (94016-017) to the chain (94019A/B).
- 10) Attach the manual ratchet (94016-017) to the lug (94116C).
- 11) Remove the chain block (94017-009) from the lug (94116C),
- 12) Operate the the manual ratchets (94016-006, 94016-017) to move the main bearing cover (1) until it is on the fuel side.
- 13) Lower the main bearing cover (1) on to a wooden underlay.
- 14) Connect the thrust device (94110) to the HP oil pump (94931).
- 15) Open the relief valve on the HP pump to release the pressure to zero, refer to [9403-2](#).
- 16) Remove the thrust device (94110) from the main bearing cover (1).

3. Main Bearing Cover No.1 – Removal

- 1) Remove the covers (1 and 2, [Fig. 8](#)).
- 2) Remove the oil pipe (3) from the main bearing cover.

- 3) Attach the shackle (94018B, [Fig. 9](#)) to the platform.
- 4) Attach the chain block (94017-009) to the shackle (94018B).
- 5) Remove the round nuts from the elastic studs (1), refer to [1132-1](#).
- 6) Do a check of a bearing clearance, refer to [0330-1](#).
- 7) In paragraph 2.1, do steps [13](#) to [25](#)
- 8) Operate the chain block (94017-009) to lift the main bearing cover (1).
- 9) Attach the crane to the bearing cover (1).
- 10) Remove the chain block (94017-009).
- 11) Operate the crane to move the main bearing cover (2).
- 12) Lower the bearing cover on to an applicable wooden underlay.

Main Bearing – Removal and Installation

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 to the engine can occur.

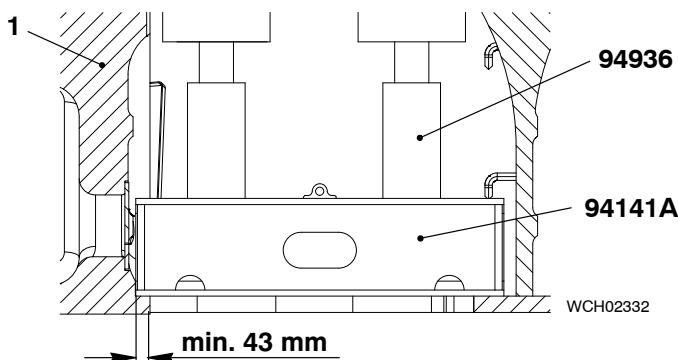


Fig. 10

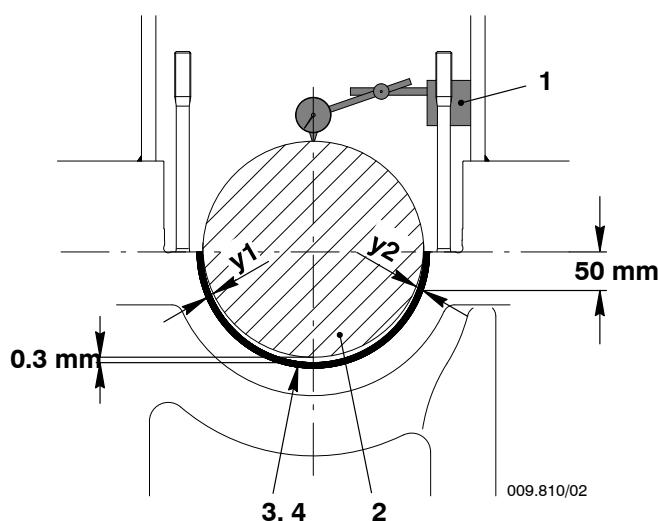


Fig. 11

Note: Make sure that the work platform (94143) is removed.

- 1) Operate the turning gear to turn the crank to the exhaust side approximately 90° after TDC.
- 2) Put the bracket (94141A, Fig. 10) on the two main bearing girders (1) parallel to the engine axis.
- 3) Make sure that the bracket is a minimum of 43 mm from the trust bearing side.
- 4) Put the hydraulic jacks (94936) on the bracket (94141A).
- 5) Connect the hydraulic jacks (94936) to the HP oil pump (94931), refer to 9403-2.

4.2 Crankshaft – Lift

- 1) Measure and record the lateral clearances (y_1 and y_2) between the crankshaft (2, Fig. 11) and the bottom main bearing shell (3,4) approximately 50 mm below the bearing.
- 2) Put the dial gauge (1) above the crankshaft (2) as shown.
- 3) Set the dial gauge to zero.
- 4) Install the jacks (94936).
- 5) Start the HP oil pump (94931).
- 6) Operate the hydraulic jacks (94936) to lift the crankshaft (2) to 0.3 mm.
- 7) Make sure that the value on the dial gauge is 0.3 mm.
- 8) Make sure that there is no clearance between the adjacent bearing cover and the crankshaft.
- 9) Keep the pressure constant.
- 10) 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

- 11) If the value of the lateral bearing clearance is more than 0.1 mm, lower the crankshaft and do step a) to step c):
- Install the hydraulic jacks (94936, Fig. 11) in position where the lateral bearing clearance is smaller.
 - Start the HP oil pump (94931).
 - Lift the crankshaft (1) to 0.3 mm.

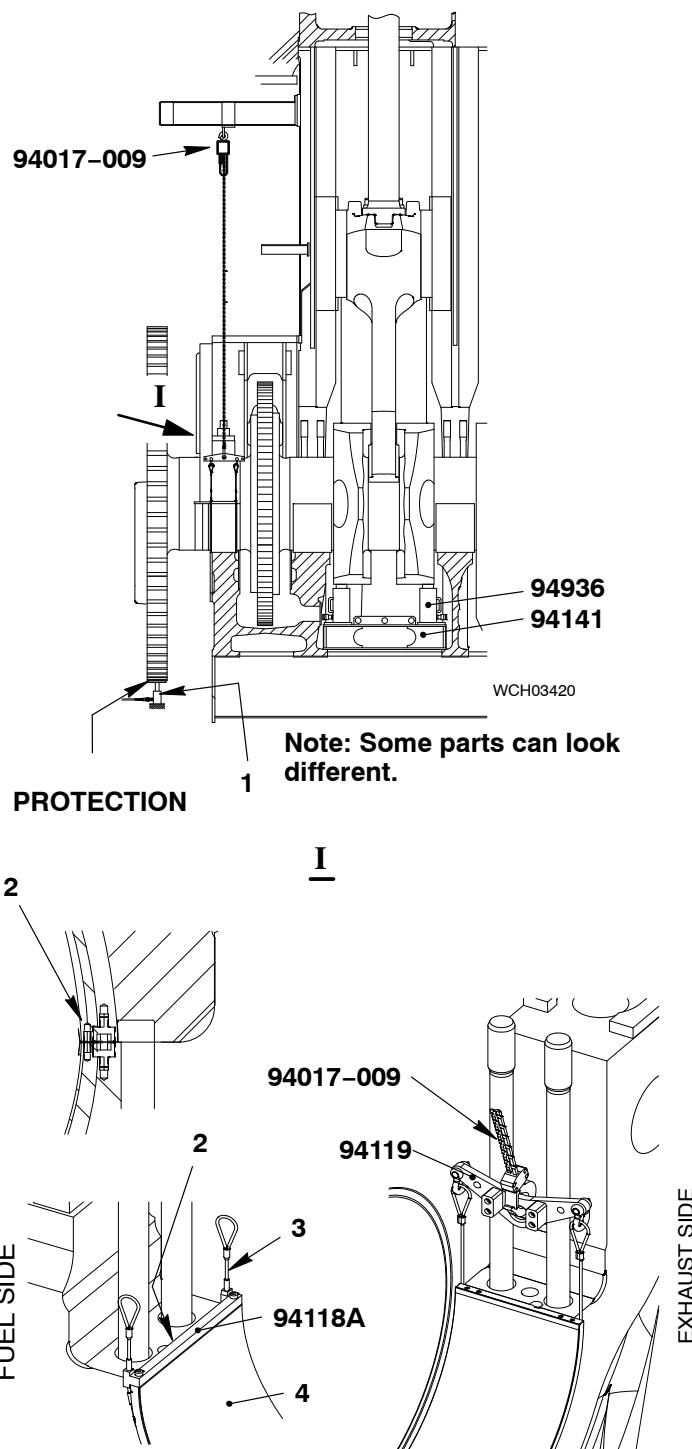


Fig. 12

4.3 Bearing Shell No.1 (narrow) – Removal

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

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

CAUTION



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.

- Make sure that the crankshaft is lifted to 0.3 mm. Refer to paragraph 4.1 and paragraph 4.2.
- Attach the spur-gearied chain block (94017-009, Fig. 12) to the eye bolt on the bottom of the platform.
- Remove the Allen screws (2) from the bearing girder.
- Attach the shackle of the chain block (94017-009) to the middle hole in the lifting plate (94119).
- Attach the dismantling tool (94118A) to the bottom main bearing shell (4).
- Put the ropes (4) along the outer edges of the main bearing shell (3) to the other side and attach them to the lifting plate (94119) as shown.

Main Bearing Removal and Installation

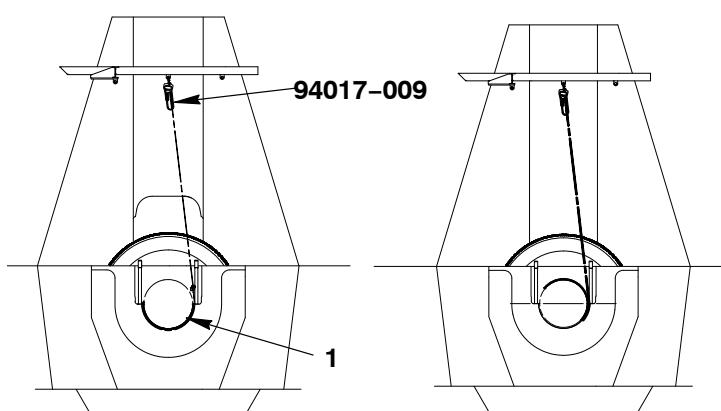


Fig. 13

Fig. 14

- 7) Operate the chain block (94017-009, [Fig. 19](#)) to turn the bearing shell (1) as shown in [Fig. 13](#) and [Fig.20](#).

Note: If the bearing shell (1) does not move, the lifting plate (94119, [Fig. 12](#)) must be attached to the other side of the dismantling tool (94118A). The bearing shell must be moved back to its initial condition and the removal procedure done again.

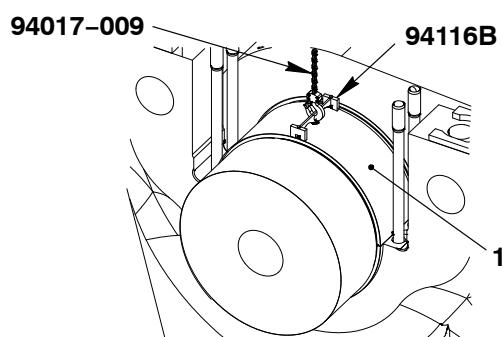


Fig. 15

- 8) Remove the bearing shell (1, [Fig. 15](#)) as shown in [Fig. 16](#).
- 9) Remove the dismantling device (94118A).
- 10) Install the lifting tool (94116B) to the bearing shell (1).
- 11) Remove the chain block (94017-009) from the lifting plate (94119)
- 12) Attach the chain block (94017-009) to the lifting tool (94116B).
- 13) Remove the lifting plate (94119).

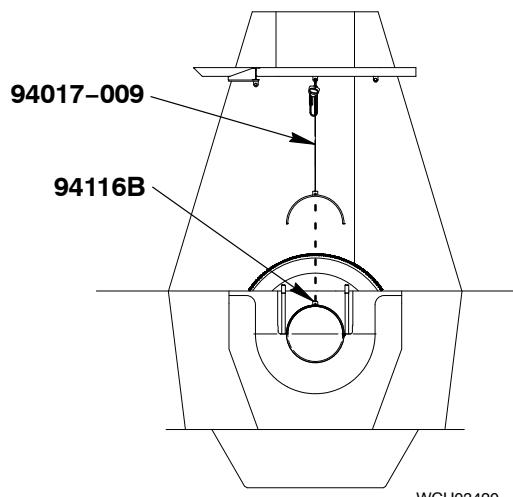
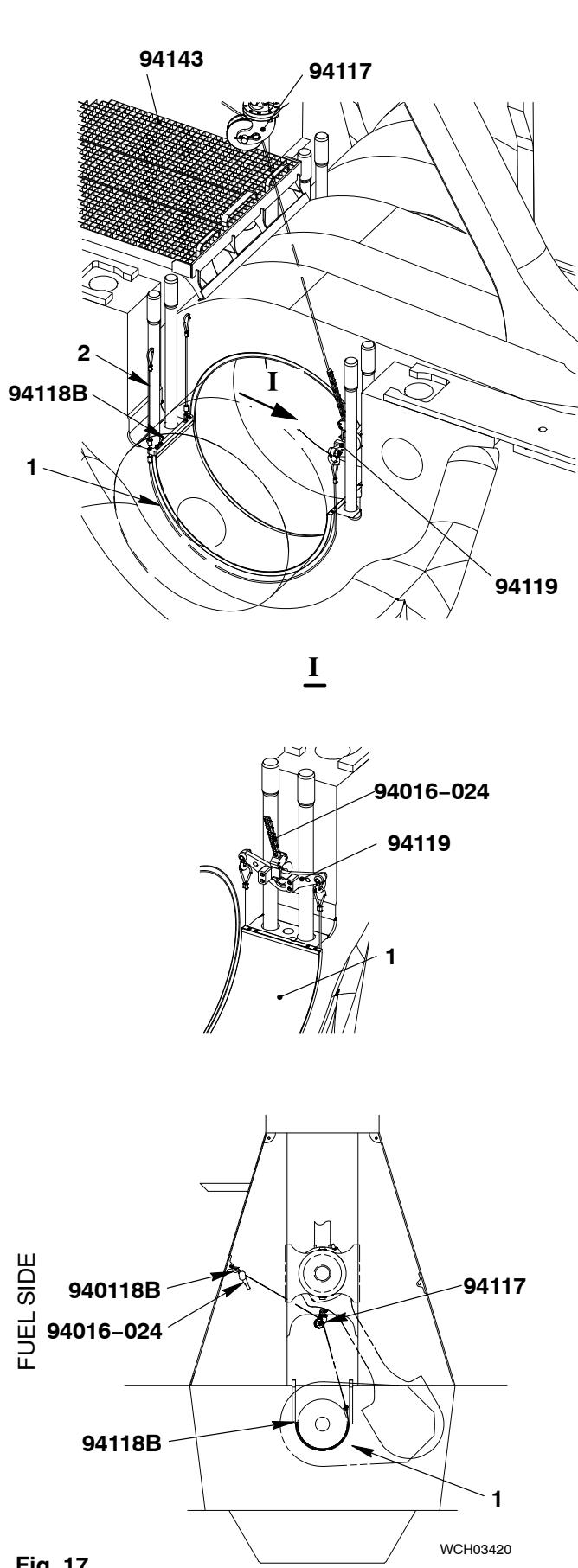


Fig. 16

- 14) Operate the chain block (94017-009) to lift the bearing shell (1).
- 15) Attach the engine room crane to the bearing shell.
- 16) Remove the chain block (94017-009).
- 17) Operate the engine room crane to move the bearing shell to a safe area.

Main Bearing – Removal and Installation



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

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

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

CAUTION



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.

- 1) Attach the work platform (94143, Fig. 17).
- 2) Make sure that the crankshaft is lifted, to 0.3 mm refer to paragraph 4.1 and paragraph 4.2.
- 3) Attach the manual ratchet (94016–024) to the shackle (94018B).
- 4) Attach the dismantling tool (94118B) to the bottom main bearing shell (1).
- 5) Put the ropes (2) along the outer 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 with the dowel pin.
- 7) Lock the dowel pin with the double spring clip.
- 8) Attach the chain of the manual ratchet (94016–024) through the roller support (94117) to the middle hole of the lifting plate (94119).

Main Bearing Removal and Installation

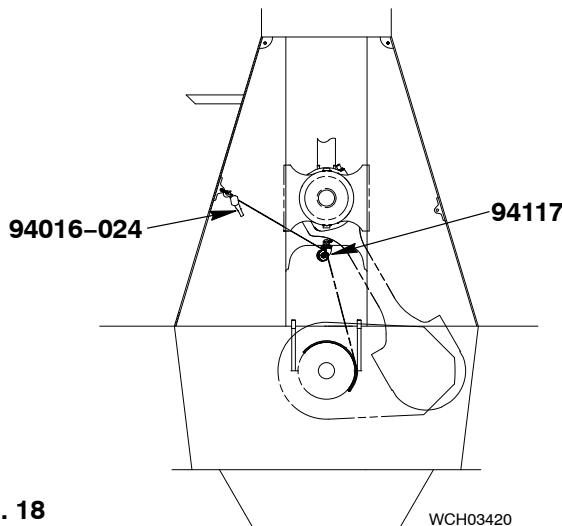


Fig. 18

- 9) Operate the manual ratchet (94016-006, Fig. 18) to move the bottom bearing shell until the chain hook is adjacent to the roller support (94117).

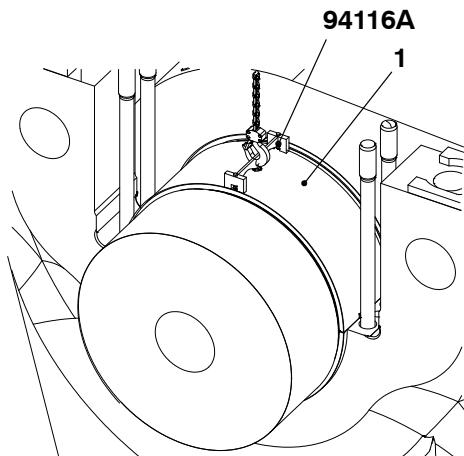


Fig. 19

- 10) Attach the lifting tool (94116A) to the bearing shell (1, Fig. 19).
- 11) Attach the chain of the (94016-006) to the middle of the lifting tool (94116A).
- 12) Remove the dismantling tool (94118B) and the lifting plate (94119).

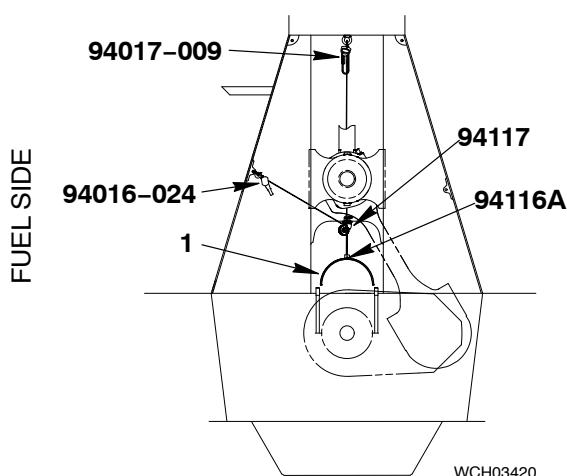


Fig. 20

- 13) Operate the manual ratchet (94016-024, Fig. 20) and the lifting tool (94116A) to lift the bearing shell (1).
- 14) Attach the chain block (94017-009) to the lifting tool (94116A).
- 15) Remove the roller support (94117) and the manual ratchet (94016-006).

Main Bearing – Removal and Installation

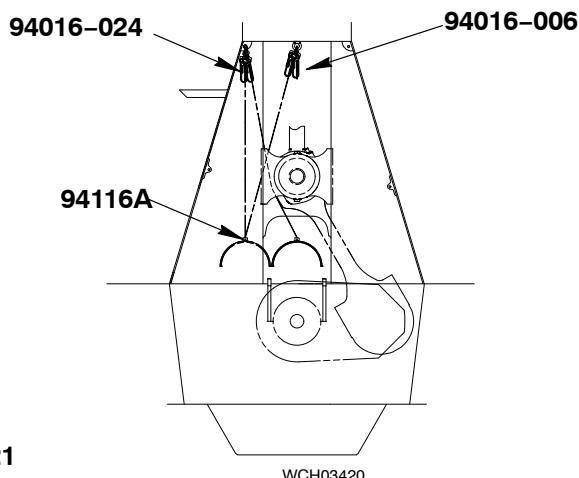


Fig. 21

16) Attach the manual ratchets (94016-006 and 94016-024, [Fig. 21](#)) to the gallery and the lifting tool (94116A).

17) Operate the two manual ratchets (94016-006, 94016-024) to move the bearing shell to the fuel side as shown.

18) Install the deviation pipe (94117A, [Fig. 22](#)) to the column.

19) Attach the chains (94019A/B) to the gallery as shown.

20) Attach the chains (94019B) to the manual ratchet (94016-017) to move the bearing shell to the fuel side as shown.

21) Put the bearing shell on to a wooden underlay on the bottom platform.

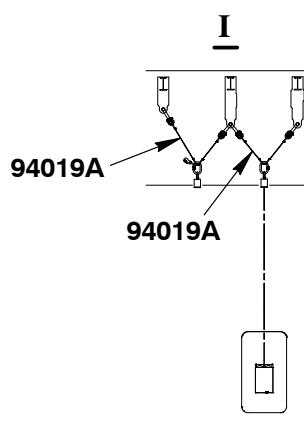
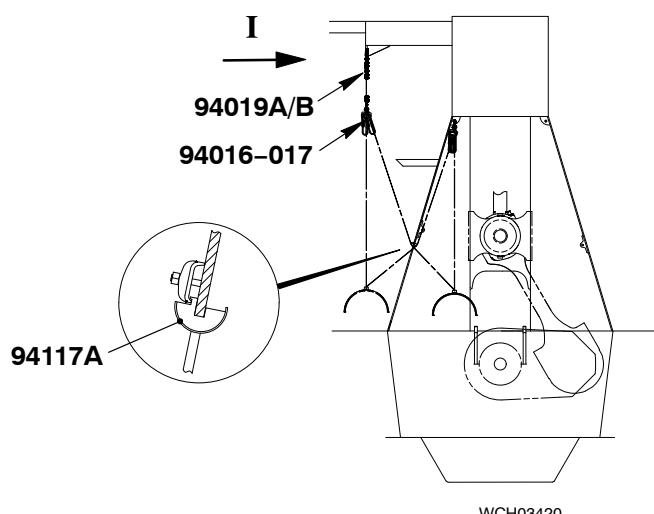


Fig. 22

Main Bearing – Removal and Installation

5. Main Bearing Shell – Inspection

- 1) Use a soft cloth to clean the bearing shell.
- 2) Do a check the bearing shell for damage such as breakouts or cracks.
- 3) Use Scotchbrite™ to remove light scratches and running marks.

CAUTION



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

- 4) If the running marks are not symmetrical (axial or radial) speak to, or send a message to Wärtsilä Service.
- 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



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 dismantling tool 94118B and the lifting plate 94119. For bearing shells No. 2 to No 8 use the dismantling tool 94119C and the lifting plate 94119A.

- 3) Install the dismantling device (94118A/B) to the front face of the bottom bearing shell.
- 4) Attach the lifting tool (94116A/B) to the bearing shell.
- 5) Use the applicable equipment as follows:
 - For bearing shell No.1, use the engine room crane and the chain block to lower the bearing shell into position on the crankshaft.
 - For bearing shells No.2 to No. 8, use the chain blocks, the roller support (94117A) and the manual ratchet to lower the bearing shell into position on the crankshaft.
- 6) Put the ropes of the dismantling device (94118A/B) below the crankshaft pin and connect it to the lifting plate (94119).
- 7) Remove the lifting tool (94116A/B).

Main Bearing – Removal and Installation

- 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, 94936) and the hydraulic pump (94931).

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 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. 23). The spring dowel pins (1) help to get the bearing cover (3) in position during the installation.

- 4) Clean all surfaces on 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. 24).
- 9) Put the pipes (1), their gaskets and new tab washers (4) in position.
- 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, step 4), with the value given in the Clearance Table 0330-1.

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

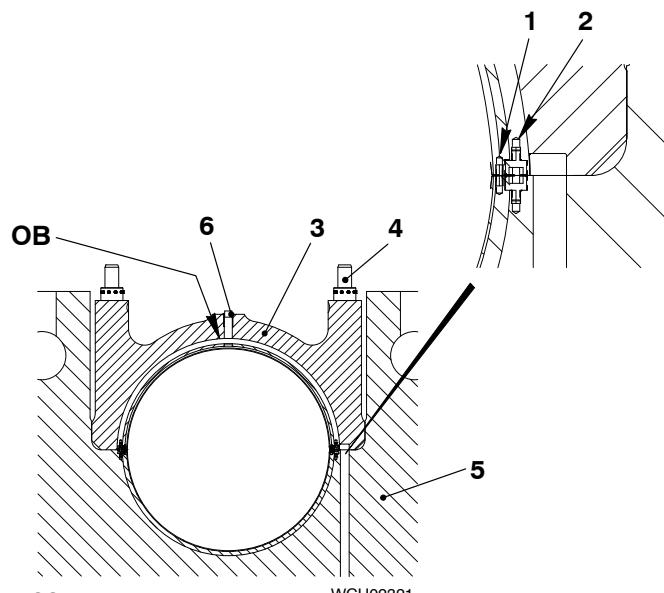


Fig. 23

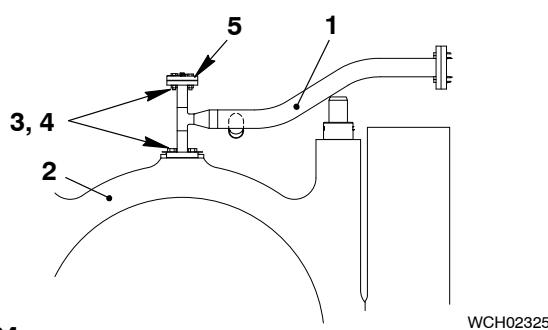


Fig. 24

Main Bearing – Removal and Installation

- 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.

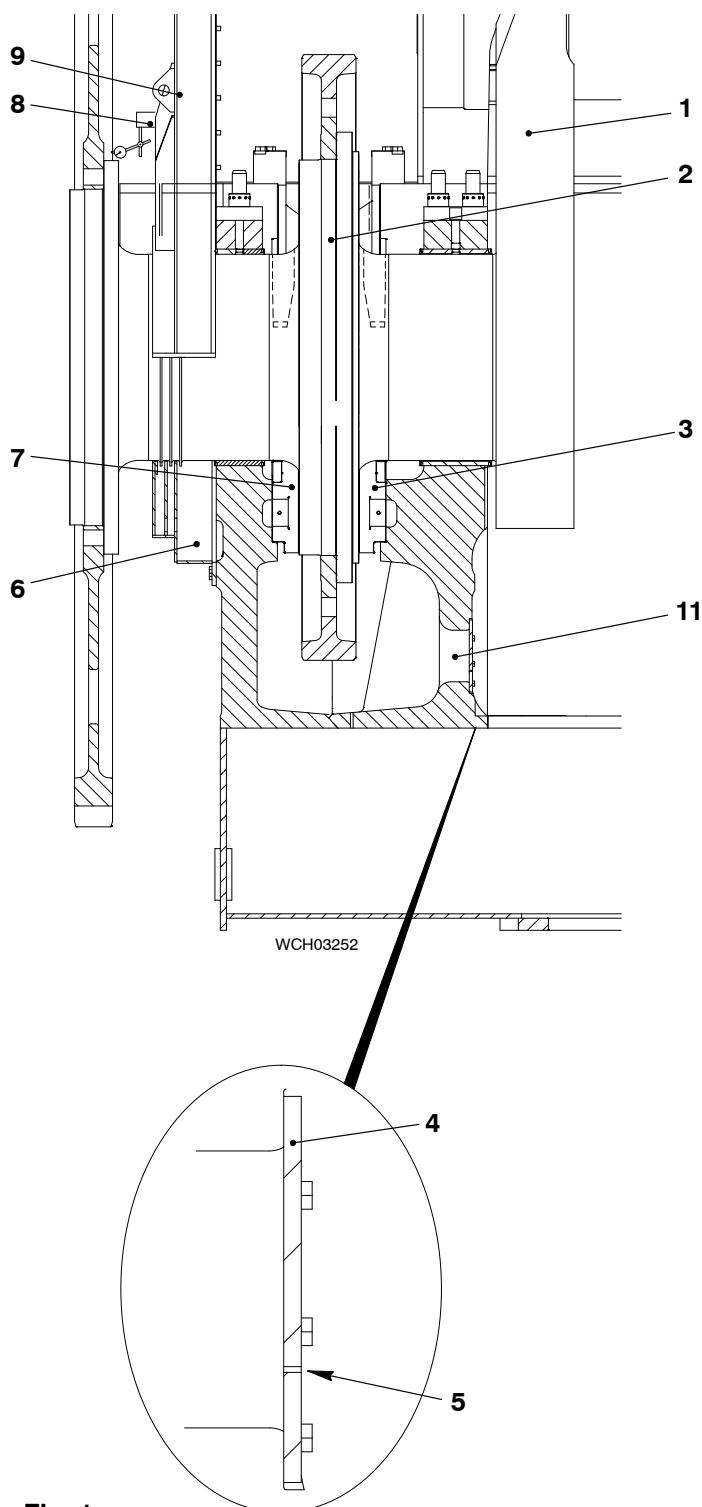
7. Main Bearing – Lubrication

After an overhaul of the bearing shells, more lubricant can be added to prevent damage to the surface of the bearing shells. Refer to the Operation Manual, 0750-1 Lubricating Oils.

- 1) To fill the bearing shell with the lubricant do the procedure that follows:
 - a) Remove the blank flange (6, [Fig. 24](#)).
 - b) Remove the screw plug (5).
 - c) Fill the bearing shell with the applicable lubricant.

Thrust Bearing**Axial Clearance – Checks****Tools:**

1 Inside micrometer 94101

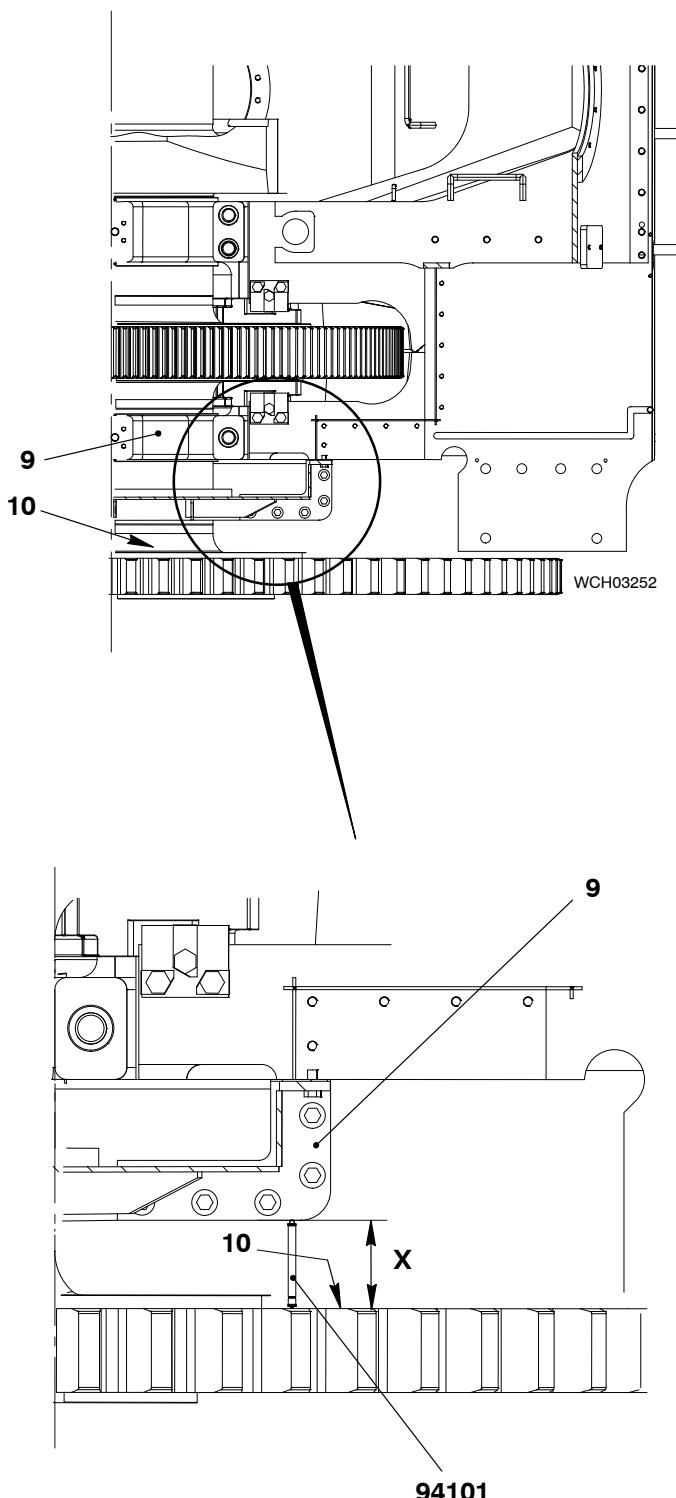
**Fig. 1****1. Procedure One**

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

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

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

Axial Clearance – Checks

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

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

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

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

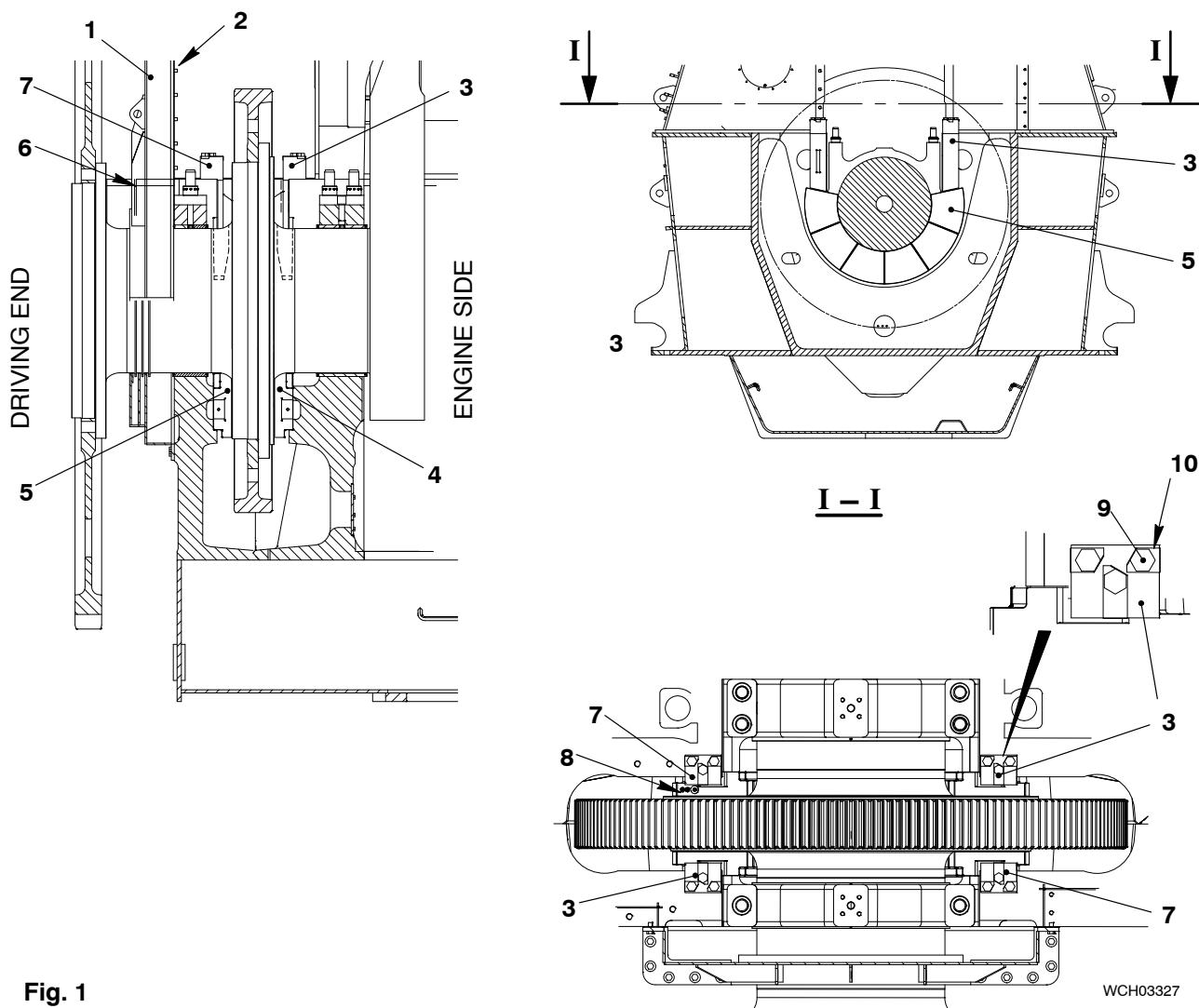
The difference between the distance X and the value given in the engine documents is related to the wear of the thrust pads (7, [Fig. 1](#)).

Thrust Bearing**Thrust Bearing Pads – Removal and Installation****Tools:**

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

1. Removal

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Remove the cover (2, 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**

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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

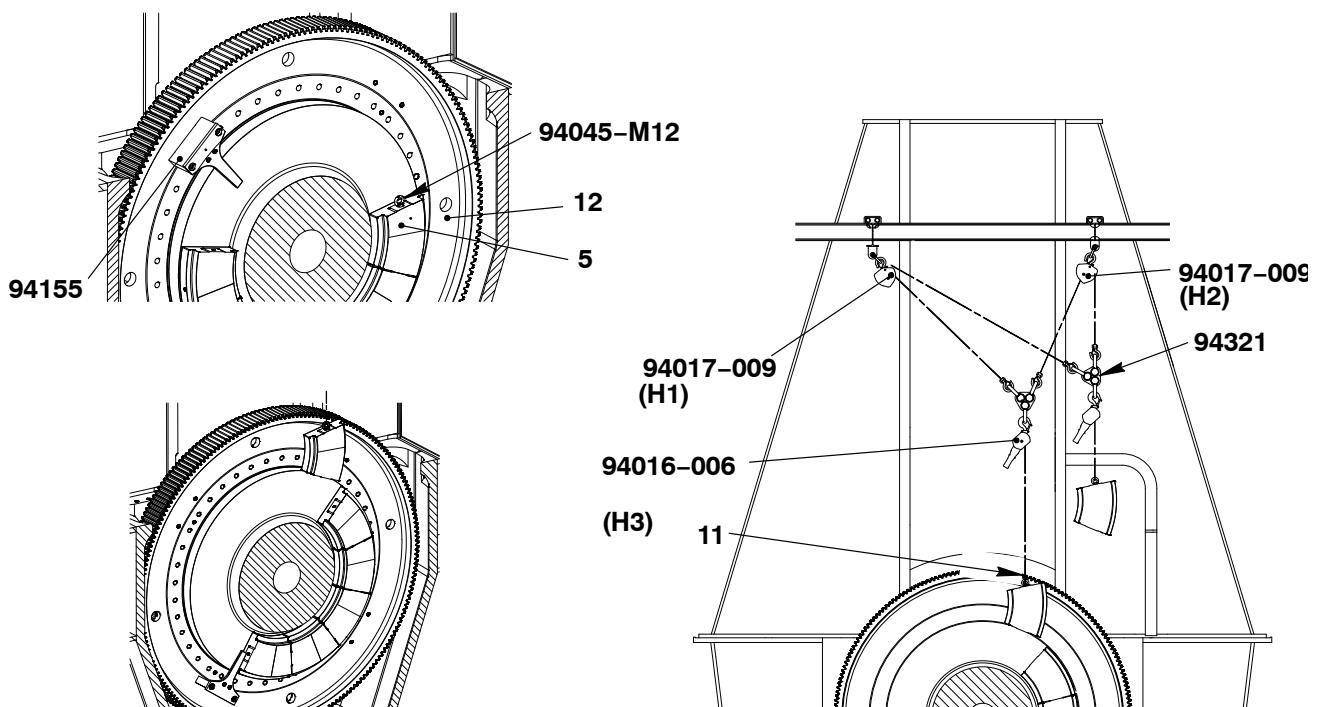
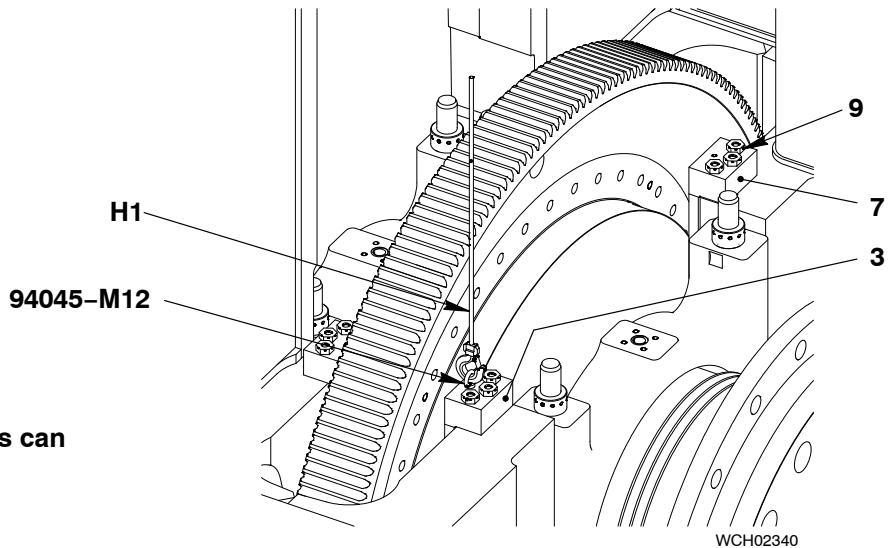


Fig. 2

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

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

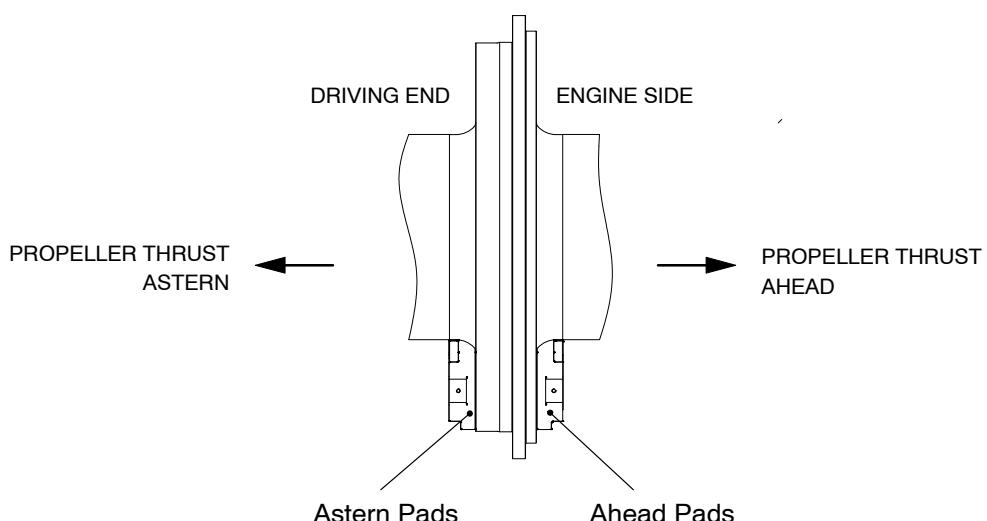
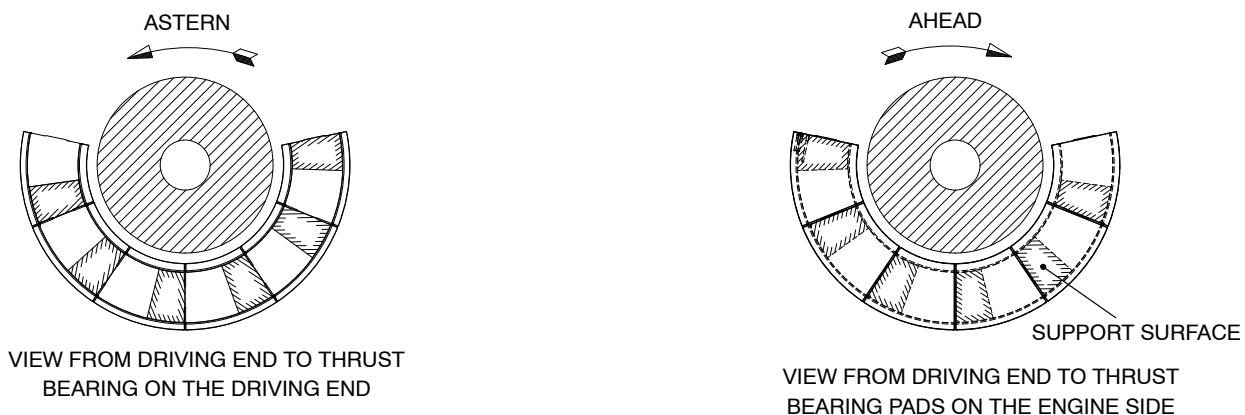


Fig. 3

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 foundation bolts. The nameplate has the stamp 1500 bar. The tension value for the engine stays is 170 bar only

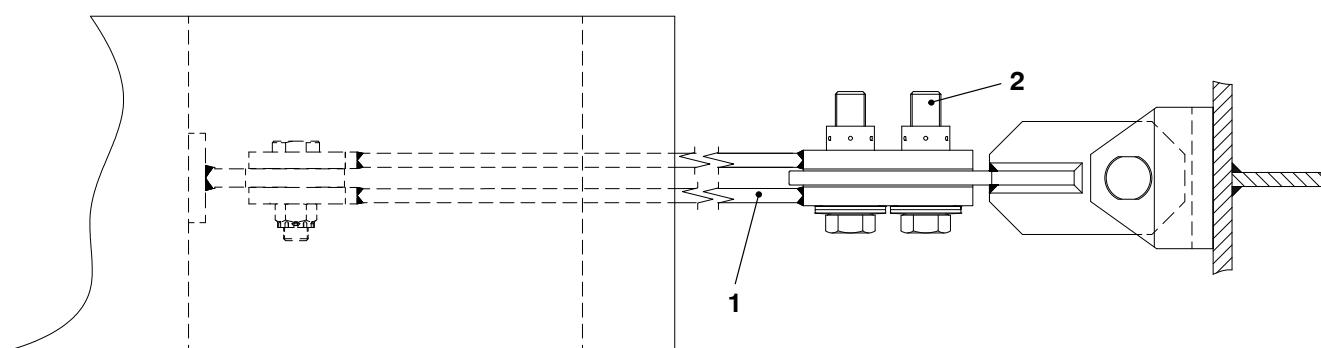
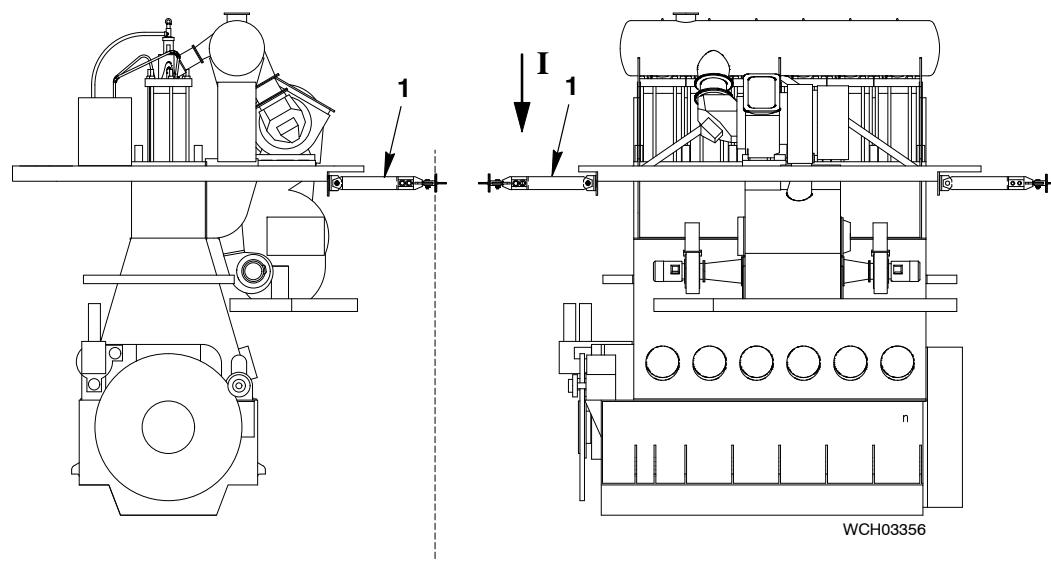


Fig. 1

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.

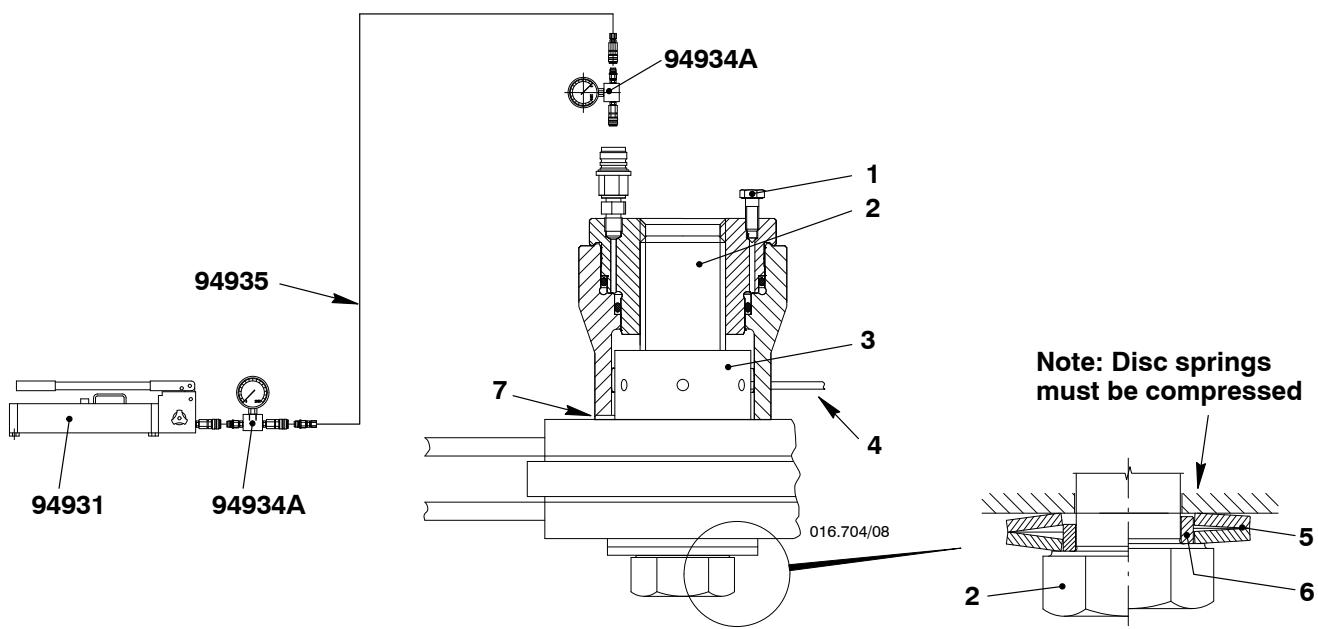


Fig. 2

Hydraulic Engine Stays

Oil Pressure Checks

1. General

Usually two hydraulic engine stays (1) are installed on the exhaust side and two on the fuel side of the engine. This can be different due to special installations.

You must compare the oil pressures on the pressure gauges (7) of the hydraulic cylinders (2) at regular intervals.

If one of the pressure gauges (7) shows a pressure of less than 30 bar, (defective O-rings, valves that have leaks, defective screwed connections, or accumulator) you must do the procedure that follows:

- 1) Decrease to 30 bar the pressure in the other hydraulic cylinder.
- 2) Repair the defective engine stay as soon as possible.
- 3) Adjust the oil pressure of the engine stays to the correct setting. Refer to the instructions in the manufacturer's manual.

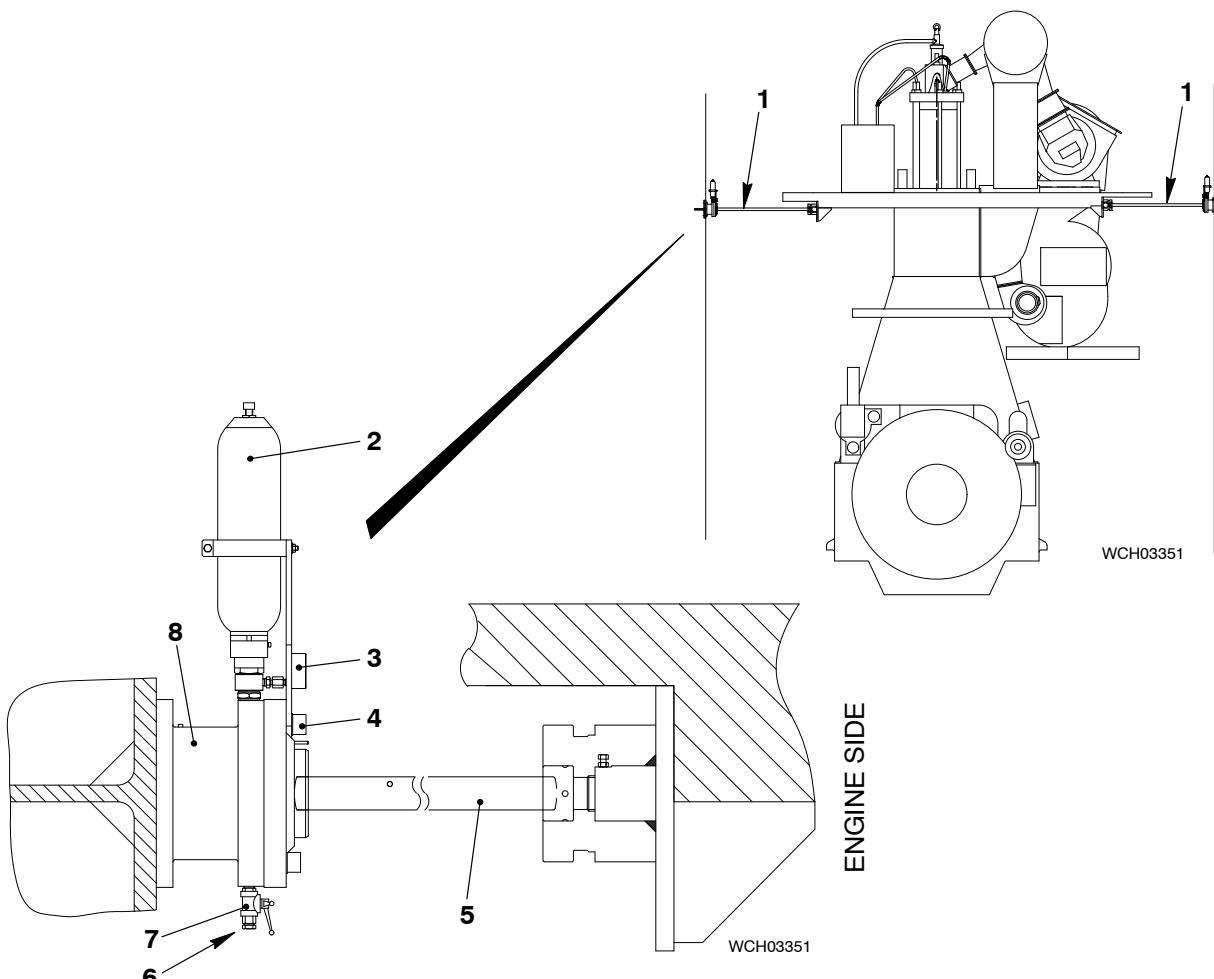


Fig. 1

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

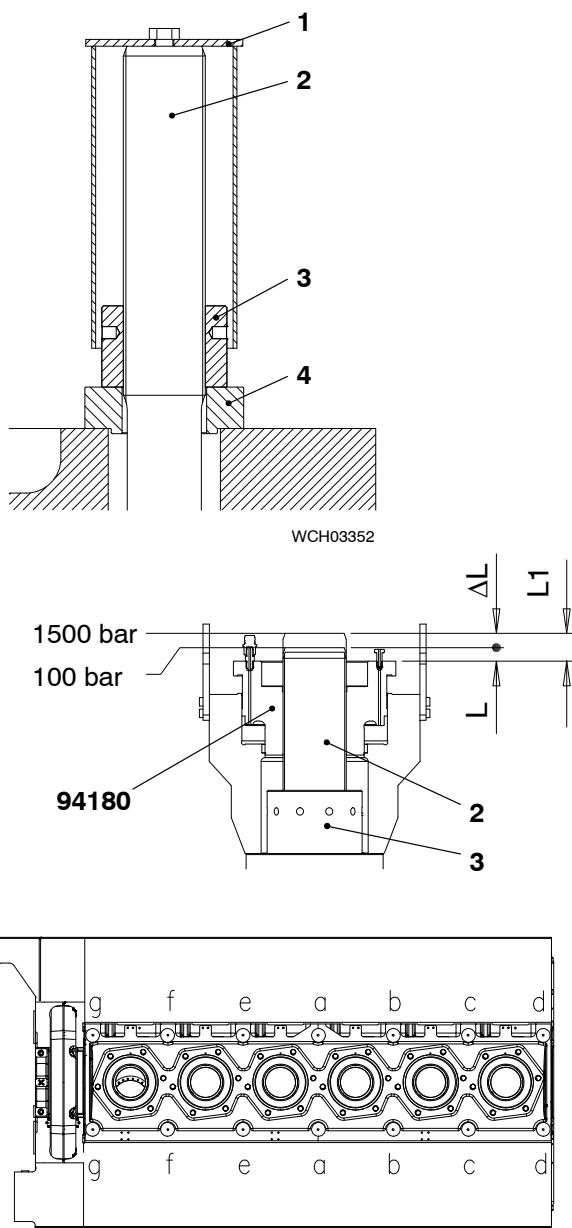
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Tie Rod**Tension Checks and Replacement Procedure****Tools:**

1 Feeler gauge	94122	1 Pressure gauge	94934A
2 Pre-tensioner	94180	3 HP hoses	94935
1 Adapter	94934	1 Hydraulic unit	94942

1. General

We recommend that you do a check of the tension of all tie rods one year after commissioning, refer to 0380-1 Maintenance Schedule, [Tie rod](#). If necessary, apply tension to the specified value.

2. Tension Check**Fig. 1**

- 1) Remove the protection cover (1, [Fig.1](#)) from all tie rods (2).
 - 2) Clean the surfaces of the intermediate ring (4).
- Note: Start with the tie rods (a-a) in the middle of the engine, then b-b, etc.)**
- 3) Attach the two pre-tensioners (94180) to two tie rods (2, a-a).
 - 4) Apply a tension of 1500 bar to the tie rods (2), refer to [9403-4](#).
 - 5) If possible, tighten the round nuts (3).
 - 6) If the round nut (3) cannot move, do step a) to step b):
 - a) Put a brass or copper bar through the opening of 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-tensioners, refer to [9304-1](#).
 - 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.

Tension Checks and Replacement Procedure

3. Tie Rods – Replace

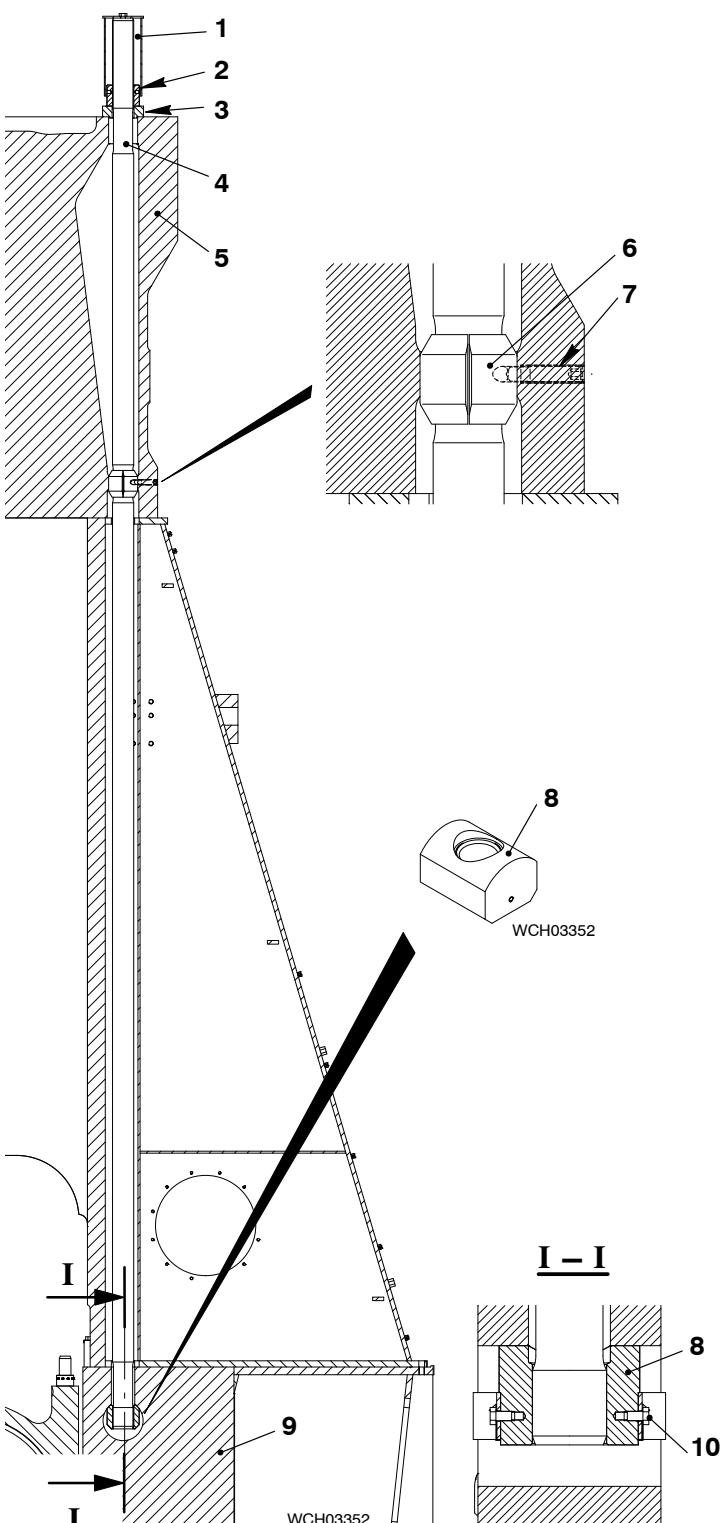


Fig. 2

- 12) Attach the round nut (2) to the tie rod (4).
- 13) Lift the tie rod (4), then fully tighten the round nut (3).
- 14) Make sure that the nut (8) is fully up, then install the holders (10).

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 protection cover (1, Fig. 2) from the tie rods (4).
- 2) Clean the surface of the intermediate ring (3).
- 3) Refer to 9403-4, then attach the two pre-tensioners (94180) to two tie rods (4), e.g. a-a). See Fig. 1.
- 4) Loosen the round nuts (2), refer to 9403-1.

3.2 Removal

- 1) Remove the set screws (7, Fig. 2).
- 2) Use two round nuts screwed together to remove the tie rod (4).
- 3) Attach an applicable eye bolt (e.g. 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 hook of 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 two the holders (10).
- 2) Make sure that the nut (8) is correctly attached.
- 3) Apply Molykote paste G to the bottom thread of the tie rod (4).
- 4) Attach an applicable eye bolt to the tie rod (4).
- 5) Attach the hook of the engine room crane to the eye bolt.
- 6) Make sure that the bush (6) is installed.
- 7) Lower the tie rod (4) into the cylinder jacket (9).
- 8) Turn the tie rod (4) until the bottom is flush with the nut (8).
- 9) Clean the top surfaces of the cylinder block (1).
- 10) Install the intermediate ring (3).
- 11) Apply Molykote paste G paste to the top thread of the tie rod (4) and to the top surface of intermediate ring (3).

Tension Checks and Replacement Procedure

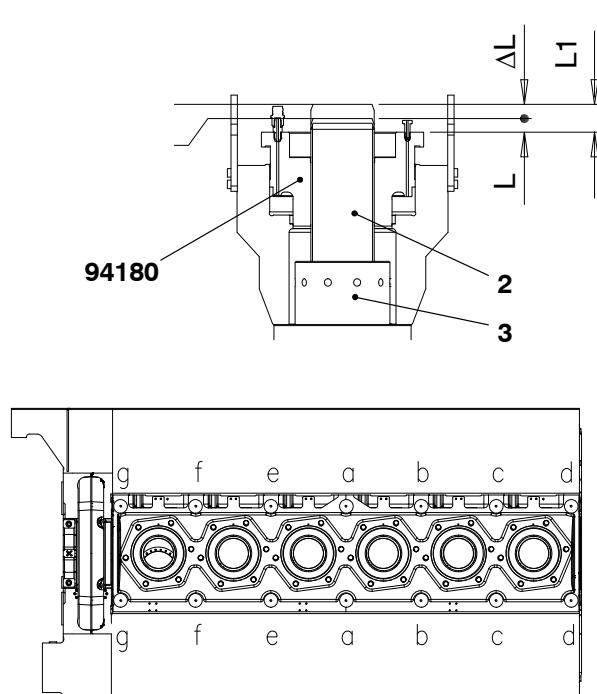


Fig. 3

WCH03352

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 to two tie rods (2).
- 2) Apply a tension of 100 bar, refer to 9403-4.
- 3) Record the length of the tie rods (2) at L.
- 4) Apply a tension of 1500 bar.
- 5) Record the length of the tie rods (2) at L1.

Note: The extension ΔL of the tie rod (2) must be between 12.0 mm and 14.0mm ($\Delta L = L1 - L$).

- 6) Do step 1) to step 5) for the remaining tie rods.

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Cylinder Liner and Cylinder Cover

Group 2

Cylinder Liner

Measure the Bore	2124-1/A1
Removal and Installation	2124-2/A1
Remove Unwanted Material, Dress the Lubricating Grooves and Scavenge Ports	2124-3/A1

Lubricating Quill: Removal and Installation 2138-1/A1

Gas Admission Valve (GAV): Replace, Assemble 2140-1/A1

Piston Rod Gland: Remove, Disassemble, Measure Worn Parts, Assemble, Install 2303-1/A1

Cylinder Cover

Cylinder Cover and Water Guide Jacket – Removal and Installation	2708-1/A1
Grind Sealing Face	2708-3/A1

Injection Valve: Removal and Installation 2722-1/A1

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

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

Exhaust Valve

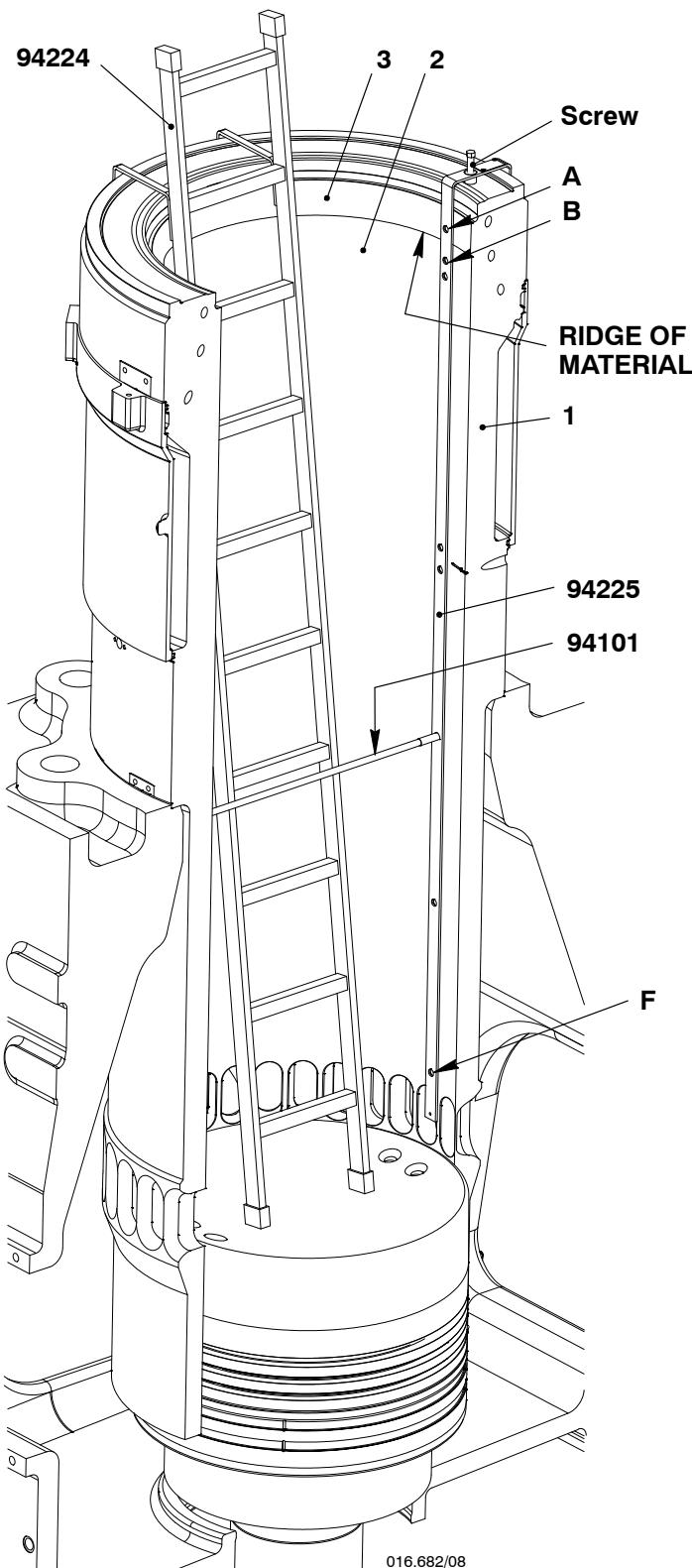
Exhaust Valve – Removal and Installation	2751-1/A1
Disassemble and Assemble	2751-2/A1
Valve Seat – Removal, Grind and Installation	2751-3/A1
Valve Head – Grind Seating Surface	2751-4/A1

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Cylinder Liner

Measure the Bore**Tools:**

1 Inside micrometer	94101
1 Ladder	94224
1 Gauge	94225

**Fig. 1****WARNING**

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

WARNING

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

CAUTION

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

Note: Measure the cylinder liner before you remove a piston.

- 1) Remove the cylinder cover, (refer to 2708-1).
- 2) Operate the turning gear to move the piston to BDC.
- 3) Put on a harness that is attached to a safety person. If necessary, the safety person can pull you out of the cylinder liner if there is an emergency.
- 4) Lock the lever of the cooling water valve in the closed position. This makes sure that no cooling water can go into the cylinder liner.
- 5) Clean the area (3) above the running surface (2).
- 6) Remove the bottom part of the gauge (94225).

Measure the Bore

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

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

Where:

WR = Rate of Wear (mm/1000 hours)

T1 = Total running hours (h)

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

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

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

Cylinder Liner

Removal and Installation

Tools:

1	Manual ratchets	94016-006	1	Sling	94049F
2	Manual ratchets	94016-015	1	Assembly tool	94233
1	Lifting tool	94201	3	Shackle	94018A

1.	Preparation	1
2.	Cylinder Liner – Removal	1
2.1	Lifting Tool – Install	2
2.2	Cylinder Liner – Lift	2
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6.	Insulation Bandage – Removal	6
7.	Insulation Bandage – Installation	6
8.	Cylinder Liner – Safe Storage	7

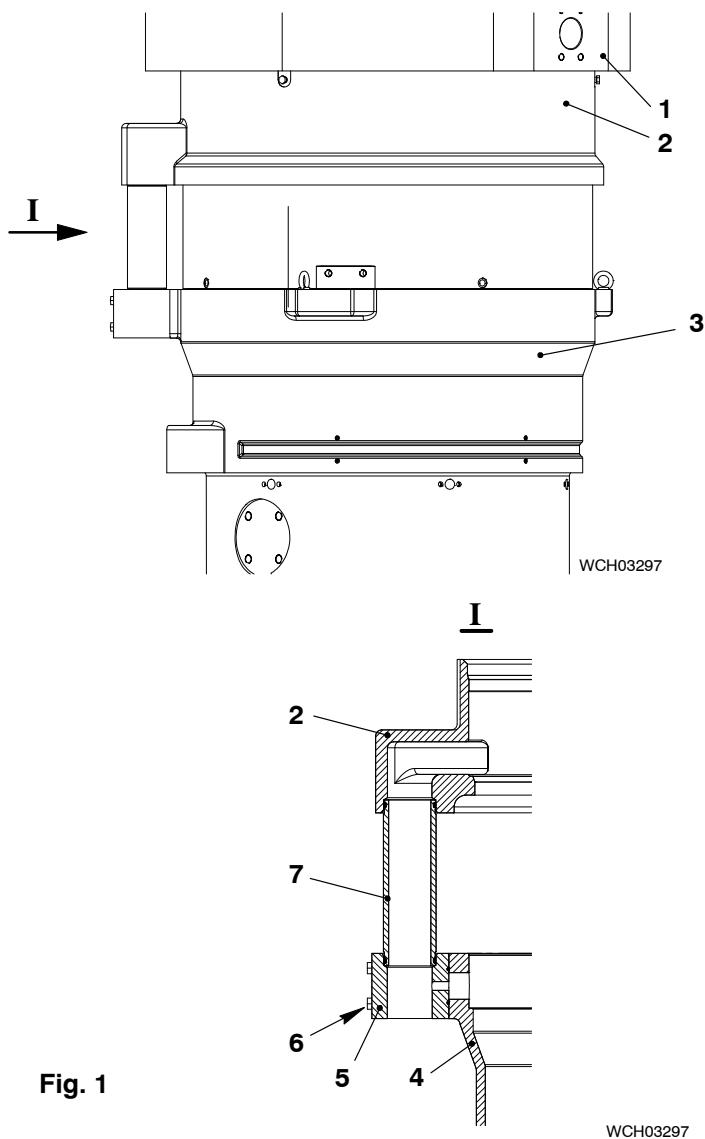


Fig. 1

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 Operation Manual 8017-1).
- 3) Remove the cylinder cover (1) together with the top water guide jacket (4) (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](#)).
- 6) Remove the gas admission valve, (refer to 2140-1, paragraph 1 and paragraph 2).

2. Cylinder Liner – Removal

- 1) Remove the screws (6, [Fig. 1](#)).
- 2) Remove the pipe connection (7) and the transition tubes (7) from the water guide jacket (4).

Note: The transition tubes (7) are a push-fit into the pipe connection (5).

Cylinder Liner: Removal and Fitting

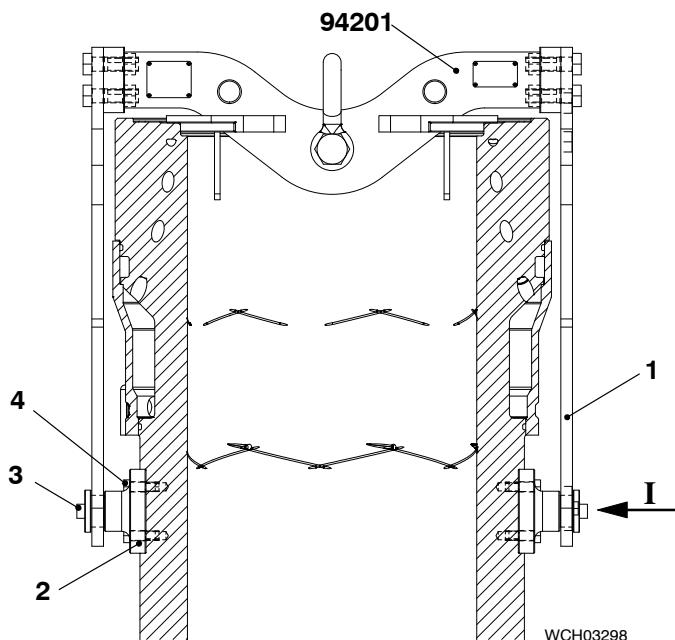


Fig. 2

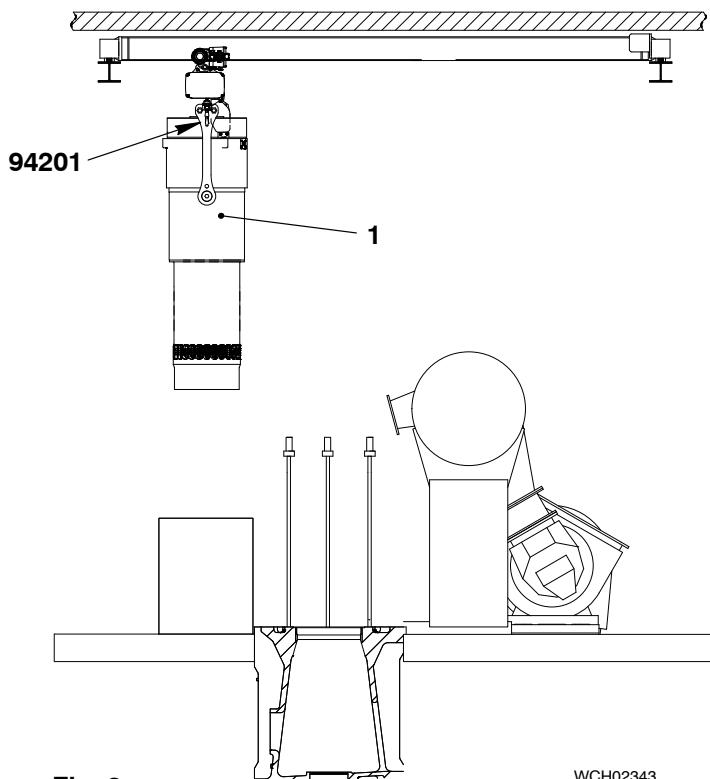
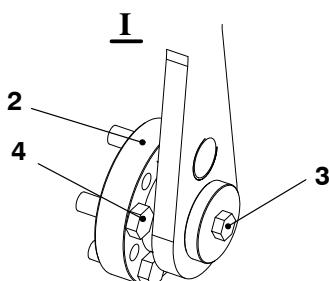


Fig. 3

2.1 Lifting Tool – Install

- 1) Put the two flange couplings (2, Fig. 2) in position on the cylinder liner.
- 2) Apply Molyslip Copaslip paste to the threads of the screws (4).
- 3) In each flange coupling (2), torque the four screws (4) 140 Nm.
- 4) Put the lifting tool (94201) in position on top of the cylinder liner.
- 5) Apply Molyslip Copaslip paste to the threads of the special screws (3).
- 6) Attach the two holders (1) to the flange couplings (2) with the special screws (3).
- 7) Torque the special screws (3) to 270 Nm.

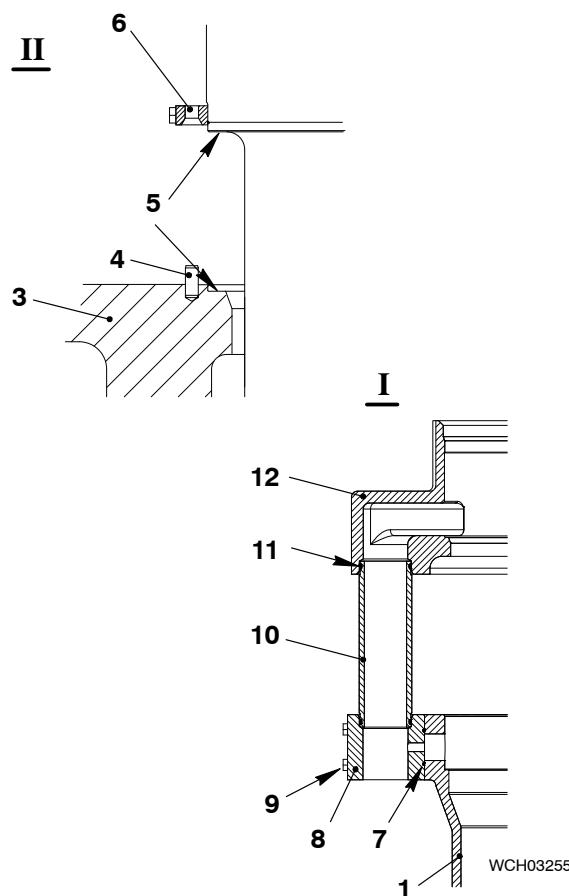
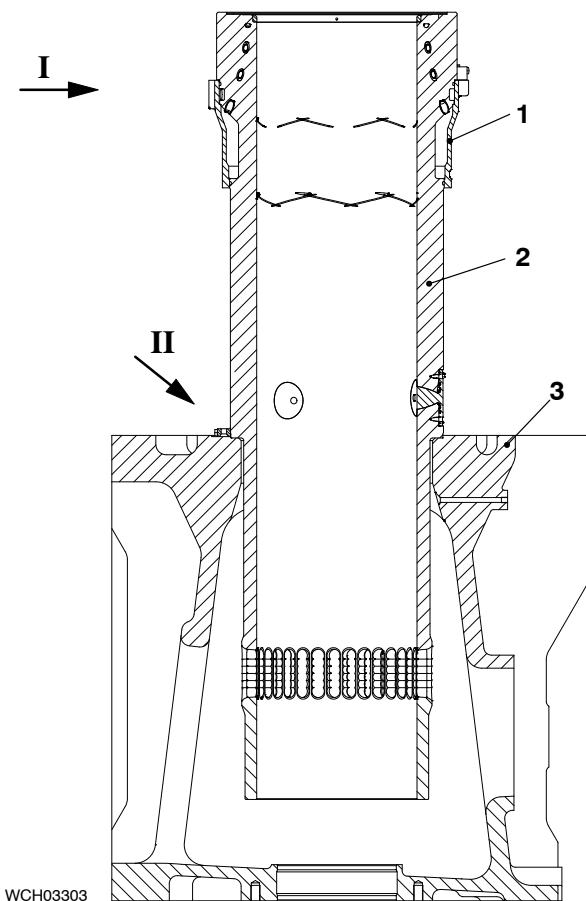
2.2 Cylinder Liner – Lift

- 1) Connect the crane hook to the shackle on the lifting tool (94201, Fig. 3).
- 2) Carefully lift the cylinder liner (1).
- 3) Move the cylinder liner (1) over the rail unit as shown.
- 4) Lower the cylinder liner on to an applicable wooden underlay.

2.3 Lifting Tool – Removal

- 1) Remove the two special screws (3, Fig. 2).
- 2) Remove the lifting tool (94201) from the cylinder liner.
- 3) Remove the screws (4), then remove the two flanges (2).
- 4) Remove the crane hook from the shackle.

Cylinder Liner: Removal and Fitting

**Fig. 4**

3. Cylinder Liner – Installation

- 1) Install the lifting tool (94201), refer to the procedure in paragraph 2.1.
- 2) Clean the seating surfaces (5, Fig. 4) on the cylinder liner (2) and cylinder jacket (3).
- 3) Carefully lower the cylinder liner (2) almost on to the cylinder jacket (3).
- 4) Align the hole in the holder (6) with the pin (4) on the cylinder jacket (3).
- 5) Fully lower cylinder liner (2).
- 6) Replace O-rings (11, 7).
- 7) Attach the connection pieces (8) and the transition tubes (10) to the water guide jacket (1) with the screws(9).
- 8) Install all lubricating quills, refer to 2138-1, paragraph 2.2.

Cylinder Liner: Removal and Fitting

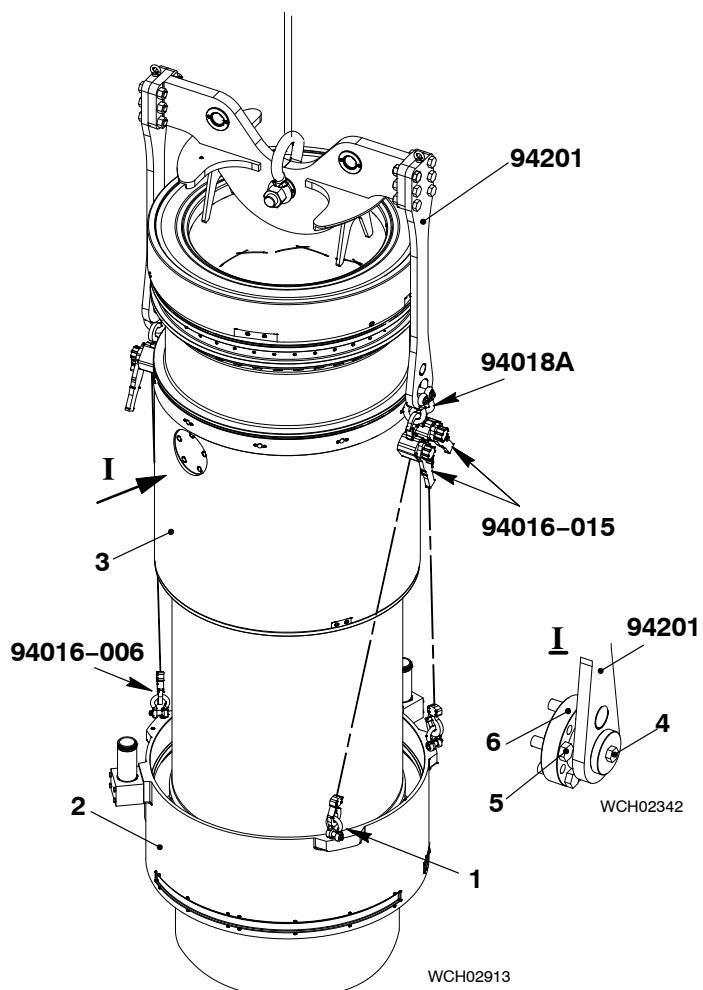


Fig. 5

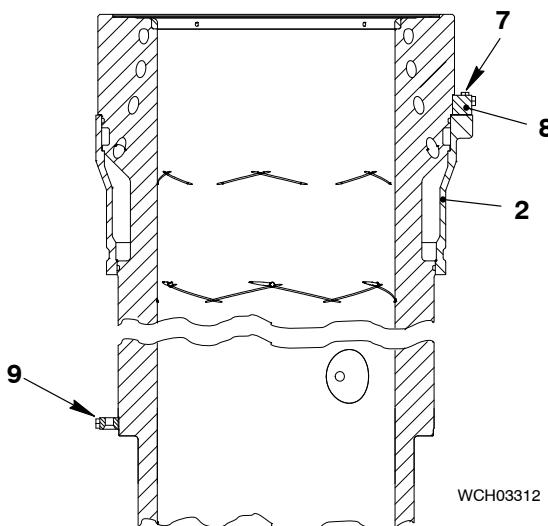


Fig. 6

4. Water Guide Jacket – Removal

- 1) Remove the cylinder liner, refer to the procedures in paragraph 1 to paragraph 2.2.
- 2) Remove the two special screws (4, Fig. 5).
- 3) Lift the lifting tool (94201) sufficiently to get access to the flanges (6)
- 4) Remove the screws (5).
- 5) Attach the three shackles (94018A) to the lifting tool (94201).
- 6) Attach the eye bolts (1) to the water guide jacket (2).
- 7) Attach the three manual ratchets (94016-006, 94016-015) to the three eye bolts (1) and the shackles (94018A) on the lifting tool (94201).

Note: Make sure that you do not cause damage to the top of the cylinder liner.

- 8) Remove the holder (9, Fig. 6).
- 9) Loosen the three screws (7).
- 10) If the water guide jacket (2) does not come away from the cylinder liner, do step a) and step b):
 - a) Put the three screws (7) in the threaded holes of the holder (8).
 - b) Turn equally the three screws (7) to push down the water guide jacket.
- 11) Operate the manual ratchets to lower the water guide jacket on to the wooden underlay. Make sure that you keep the water guide jacket level.
- 12) Remove the manual ratchets (94016-006, 94016-015) from the three eye bolts (1) and the shackles (94018A).
- 13) Attach the lifting tool (94201) to the cylinder liner (see paragraph 2.1).
- 14) Carefully lift then move the cylinder liner to a different position.

Cylinder Liner: Removal and Fitting

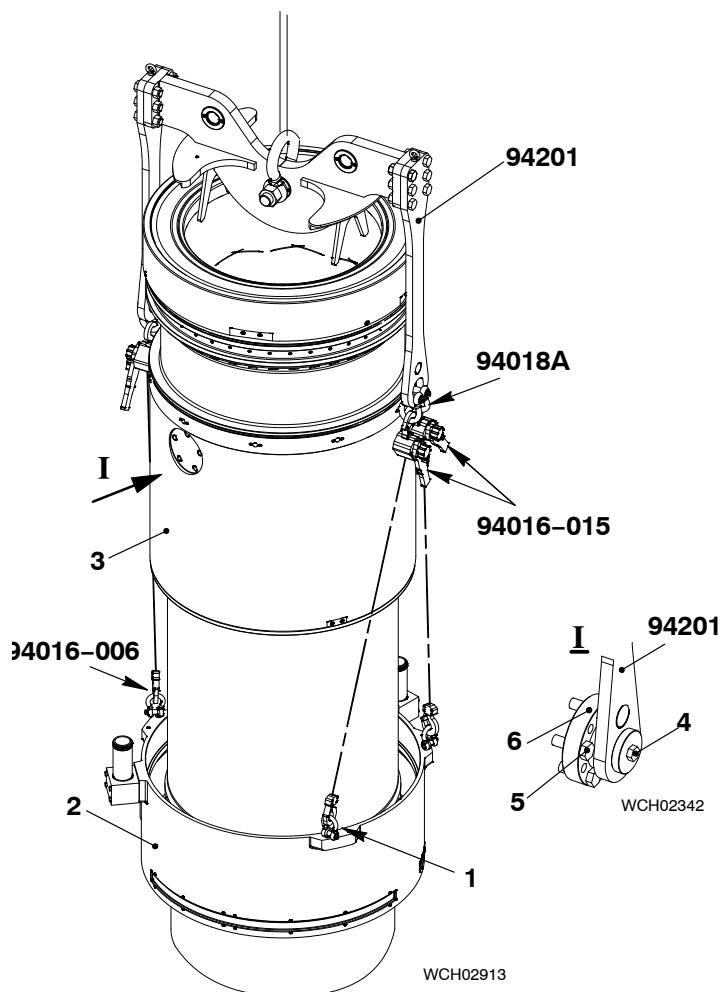


Fig. 7

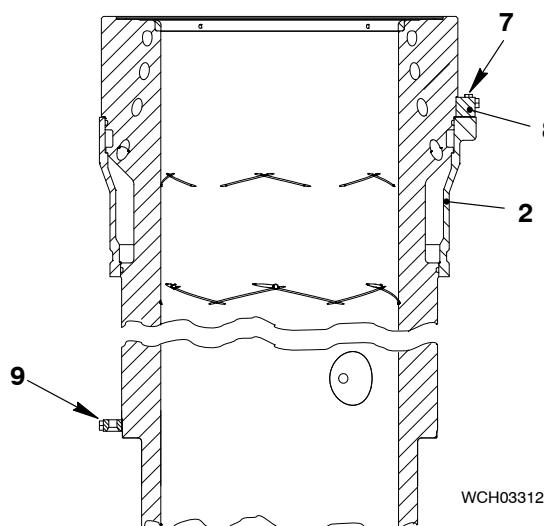


Fig. 8

5. Water Guide Jacket – Installation

- 1) Install the insulation bandage, refer to paragraph 7.
- 2) Remove the two special screws (4, Fig. 7).
- 3) Attach the lifting tool (94201) to the cylinder liner (see paragraph 2.1).
- 4) Lift, move and lower the cylinder liner in the water guide jacket (2).
- 5) Lift the lifting tool (94201) sufficiently to get access to the flanges (6)
- 6) Remove the screws (5).
- 7) Attach the three shackles (94018A) to the lifting tool (94201).
- 8) Attach the eye bolts (1) to the water guide jacket (2).
- 9) Attach the three manual ratchets (94016-006, 94016-015) to the three eye bolts (1) and the shackles (94018A) on the lifting tool (94201).

Note: Make sure that you do not cause damage to the top of the cylinder liner.

- 10) Operate the manual ratchets (94016-006, 94016-015) to lift the water guide jacket (2) to the applicable position on the cylinder liner. Make sure that you keep the water guide jacket level.
- 11) Attach the water guide jacket (2, Fig. 8) to the cylinder liner with the three screws (7).
- 12) Attach the holder (9).
- 13) Remove the manual ratchets (94016-006, 94016-015), the shackles (94018A) and the lifting tool (94201).
- 14) Remove the eye bolts (1).

Cylinder Liner: Removal and Fitting

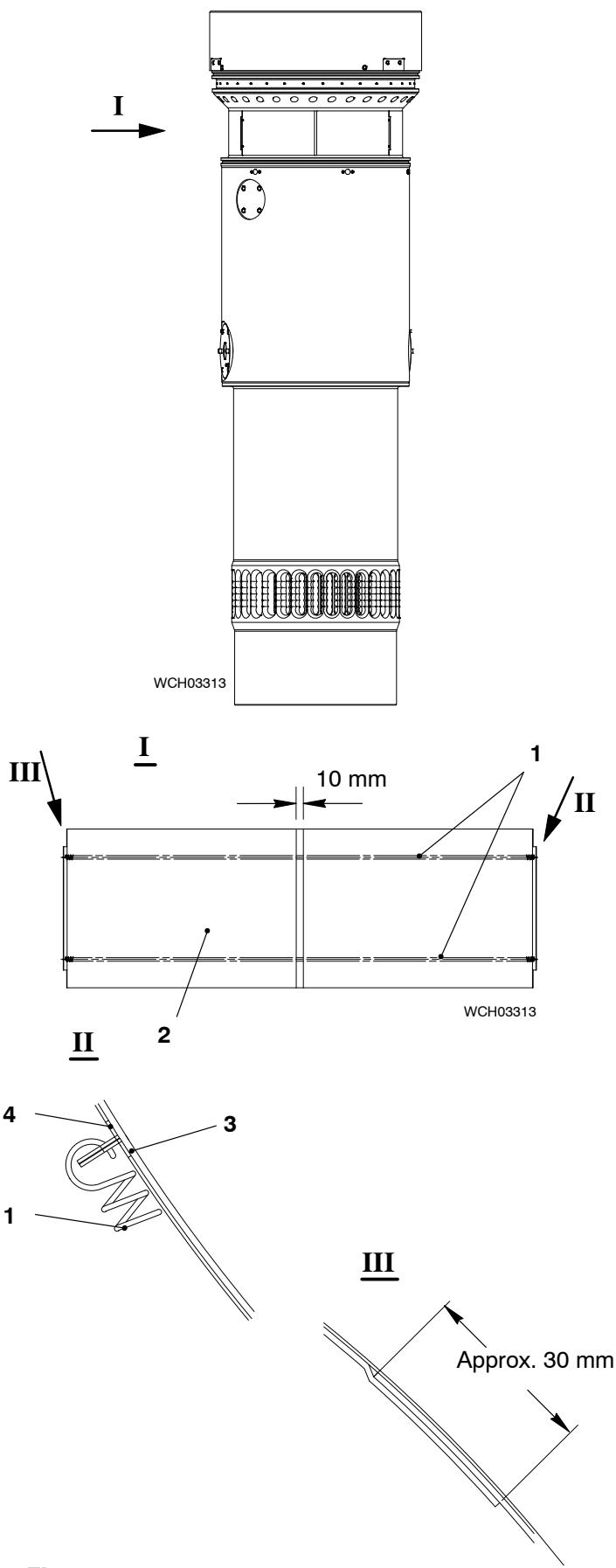


Fig. 9

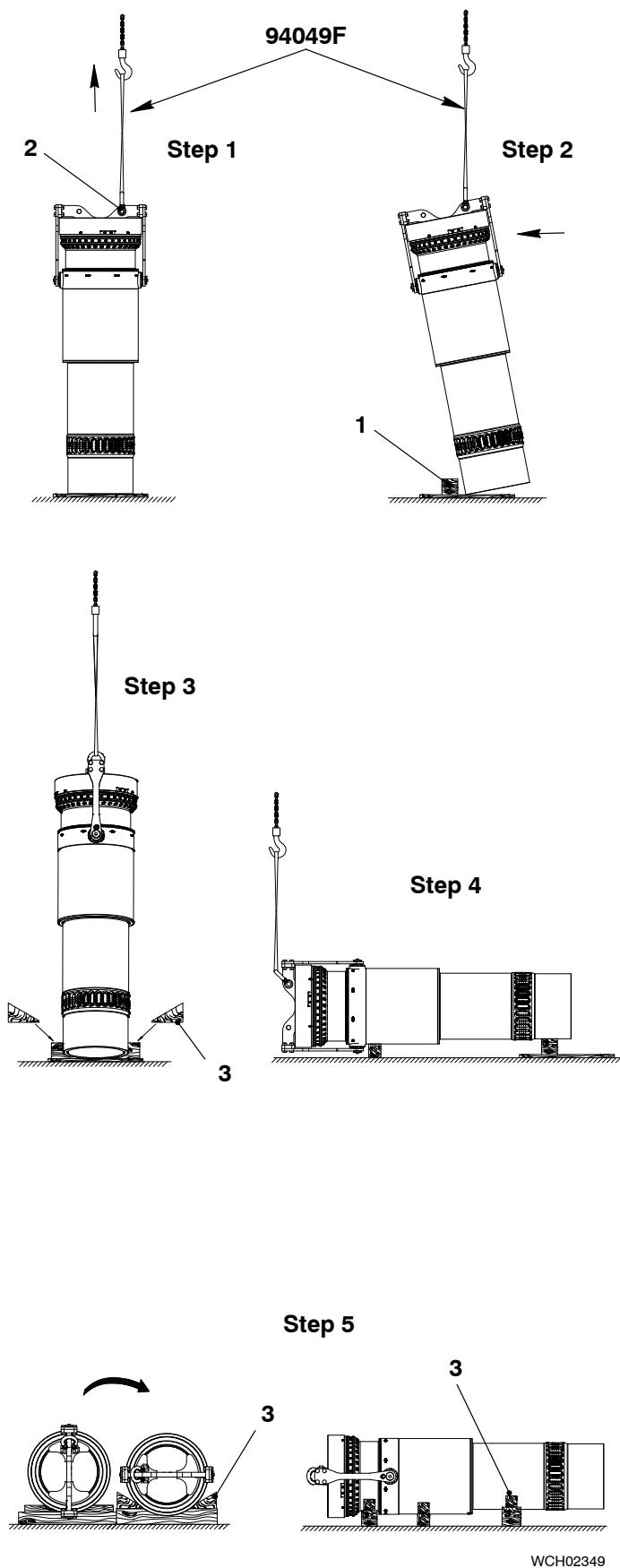
6. Insulation Bandage – Removal

- 1) Remove the cylinder liner (refer to paragraphs 1 to 2.2).
- 2) Remove the water guide jacket (refer to paragraph 4).
- 3) Use the assembly tool (94233, Fig. 9) to remove all the tension springs (1).
- 4) Remove the plate (4).
- 5) Remove insulation bandage (2).

7. Insulation Bandage – Installation

- 1) Put the insulation bandage (2) in position on the cylinder liner.
- 2) Put the plate (4) in position.
- 3) Use the assembly tool (94233) to attach all the tension springs (1).
- 4) Install the water guide jacket (refer to paragraph 5).

Cylinder Liner: Removal and Fitting

**Fig. 10**

8. Cylinder Liner – Safe Storage

- 1) Make sure that the water guide jacket is removed (refer to paragraph 4).
- 2) Make sure that the insulation bandage is removed (refer to paragraph 6).
- 3) Install the lifting tool (94201) to the cylinder liner (see paragraph 2.1).
- 4) Attach the shackle (2, Fig. 10) to the lifting tool (94201) in the position shown in Step 1.
- 5) Attach the sling (94049F) to the shackle (2) and the crane hook.
- 6) Operate the crane to put a light tension on the sling (94049F).
- 7) Put the wooden underlay (1) in position as shown in Step 2.
- 8) Carefully push the cylinder liner in the direction shown and at the same time lower the cylinder liner.
- 9) Put the wooden chocks (3) in position to prevent movement of the cylinder liner (see Step 3).
- 10) Fully lower the cylinder liner (Step 4).
- 11) Remove the sling (94049F) from the lifting tool.
- 12) Put more wooden underlays in position (see Step 5).
- 13) Remove the wooden chocks (3).
- 14) Carefully turn the cylinder liner 90°.
- 15) Put the two wooden chocks (3) in the position shown to prevent movement.
- 16) Remove the lifting tool (94201) from the cylinder liner.

9. Cylinder Liner – Preparation

- 1) Attach the lifting tool (94201) to the cylinder liner (see paragraph 2.1).
- 2) Make sure that shackle (24) is in the position shown in Step 1.
- 3) Put more wooden underlays (16) in position (see Step 5).
- 4) Remove the wooden chocks (14).
- 5) Carefully turn the cylinder liner 90°.
- 6) Attach the sling (94049F) to the lifting tool.
- 7) Carefully lift the cylinder liner to the vertical position.

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Remove Unwanted Material, Dress the Lubricating Grooves and Scavenge Ports

Tools:

1 Grinding device 94299

1. General

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

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

2. Preparation

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

3. Unwanted Material – 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 unwanted material from the cylinder liner (1).
- 5) Make sure that you get the radius $r = 8.0$ mm as given.

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

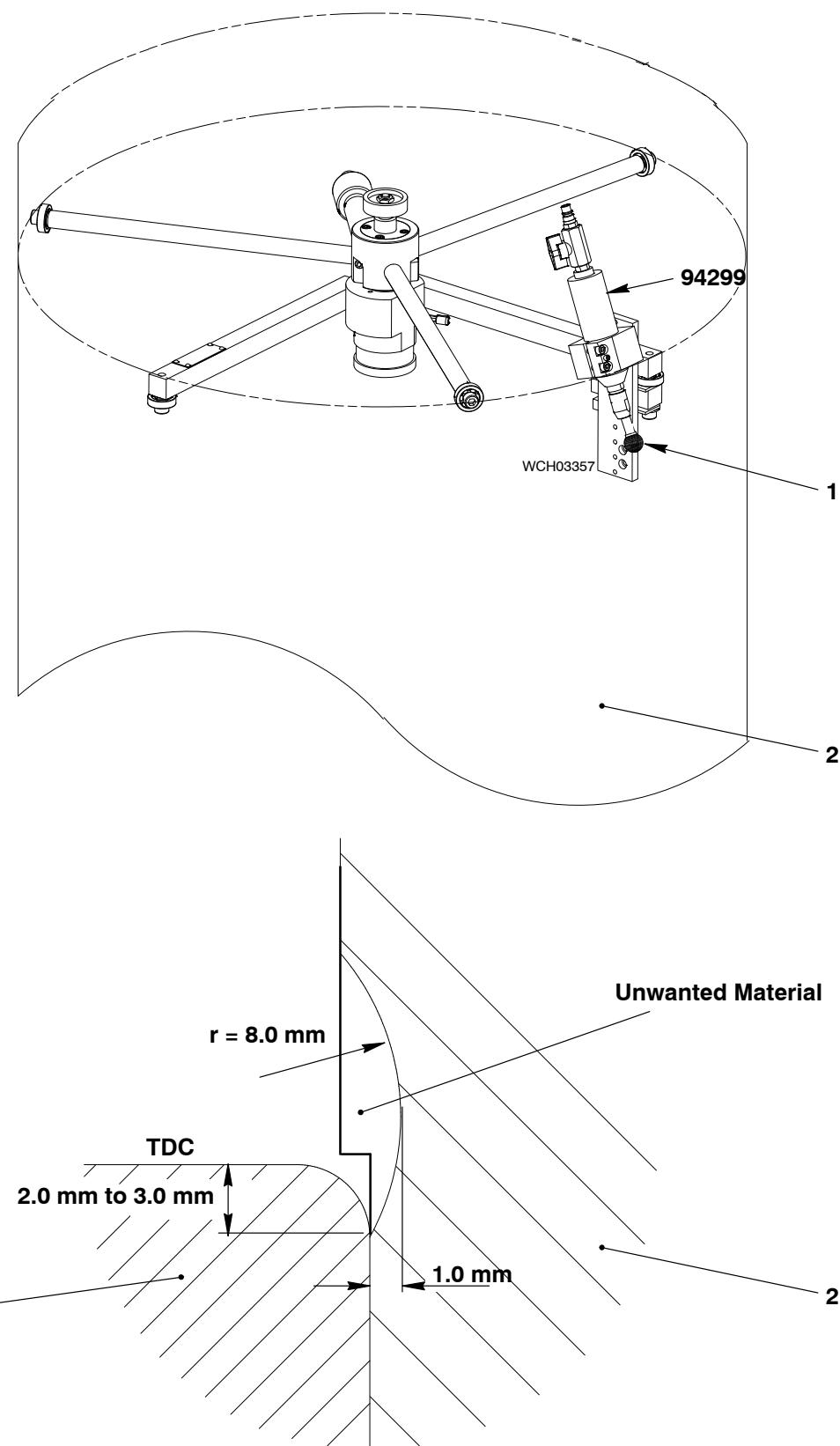


Fig. 1

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

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 lubricating grooves (1) back to their original depth (see Fig. 2).

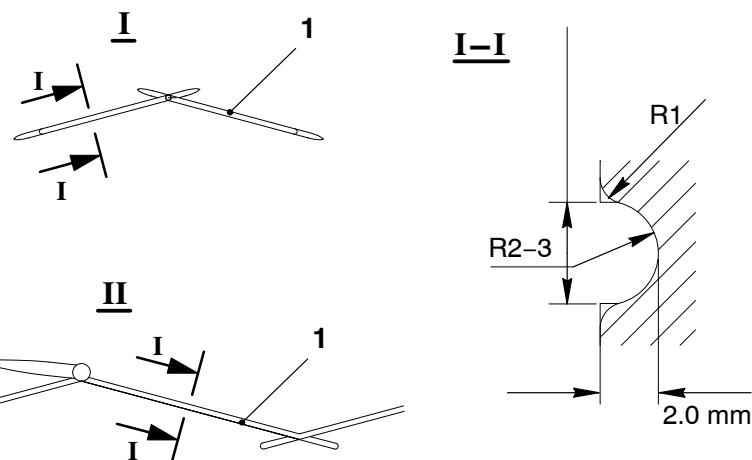
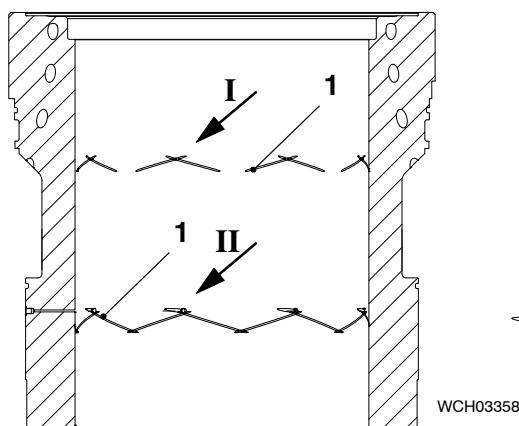


Fig. 2

5. Scavenger ports

CAUTION

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

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

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

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

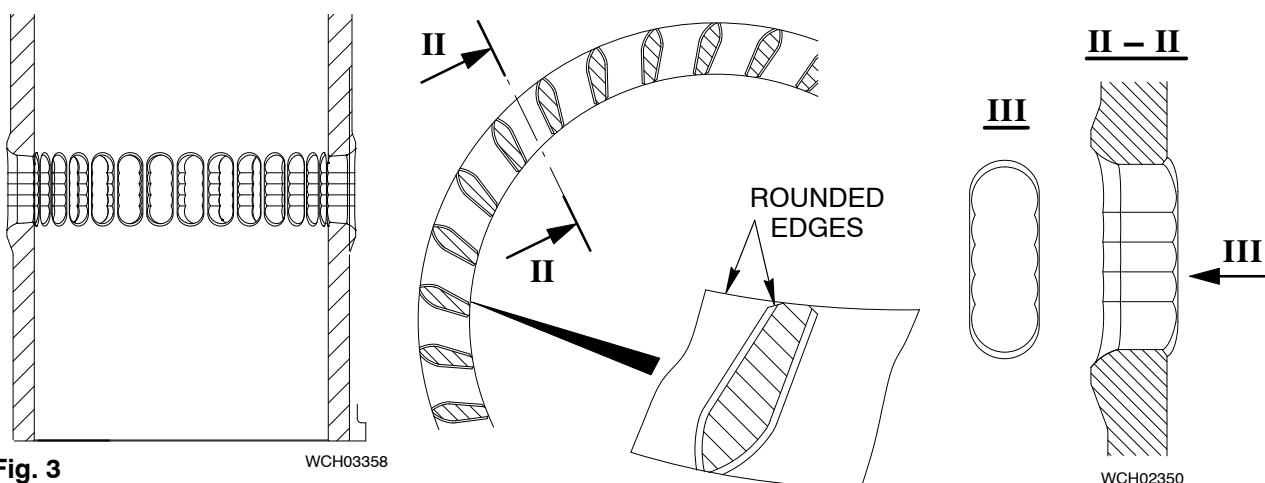


Fig. 3

- 2) After the repair is completed, fully clean the lubricating grooves and the bore of the cylinder liner.
- 3) Remove unwanted particles, which may have passed into the scavenge space through the ports.
- 4) 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. General

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

Steps 1) to 3) are only necessary if the cylinder liner (1) must be removed.

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

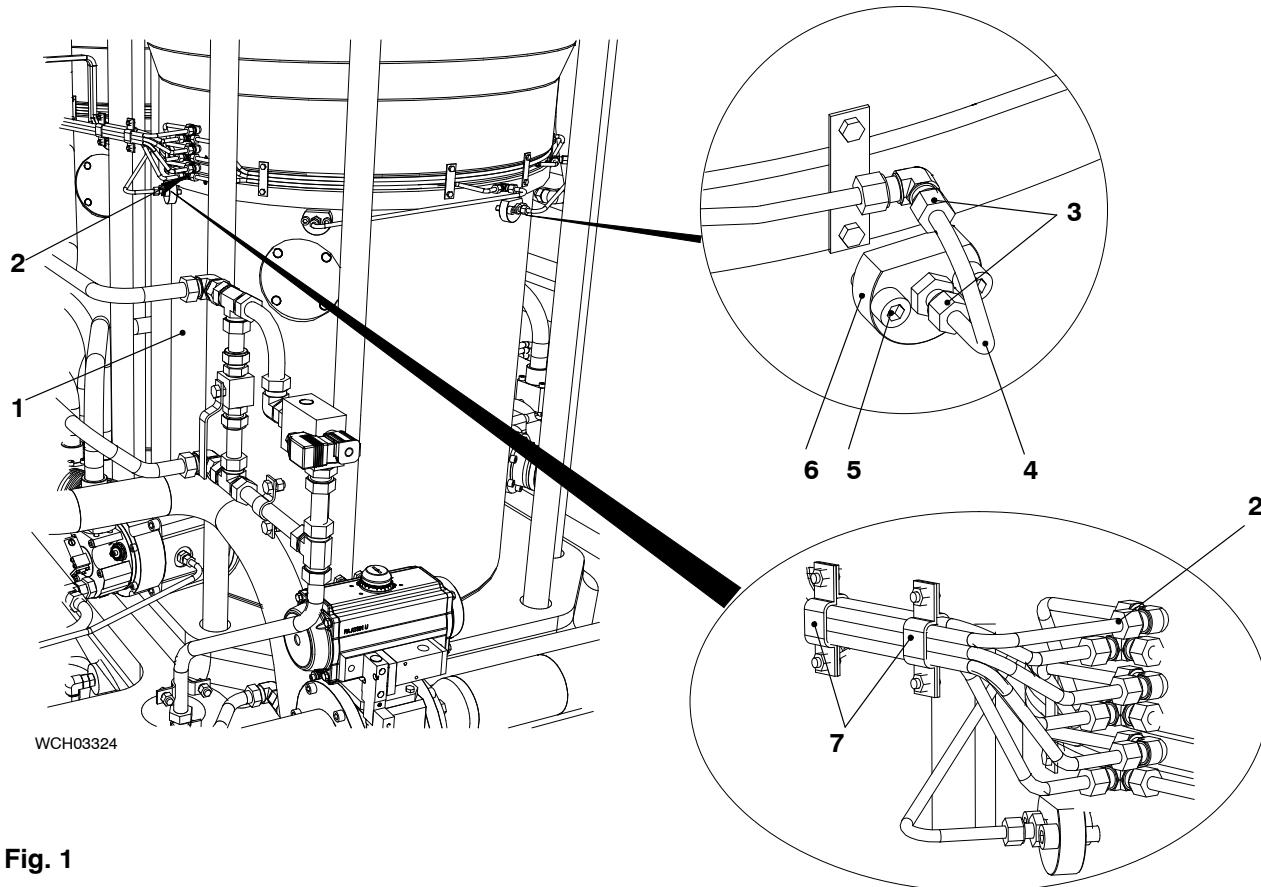


Fig. 1

2. Removal Procedure

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

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

- 2) Seal the oil pipe (4) with an applicable plug to prevent contamination.
- 3) Remove the two screws (5).
- 4) Remove the lubricating quill (6).
- 5) If necessary, do a function check of the lubricating quills (see paragraph 3).

3. Lubricating Quill – Function Check

3.1 General

You do a function check to make sure that the non-return valve (3, Fig. 2) 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).

3.2 Procedure

- 1) If necessary, remove the screw-in union (1) from the lubricating quill (2).
- 2) Install 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).

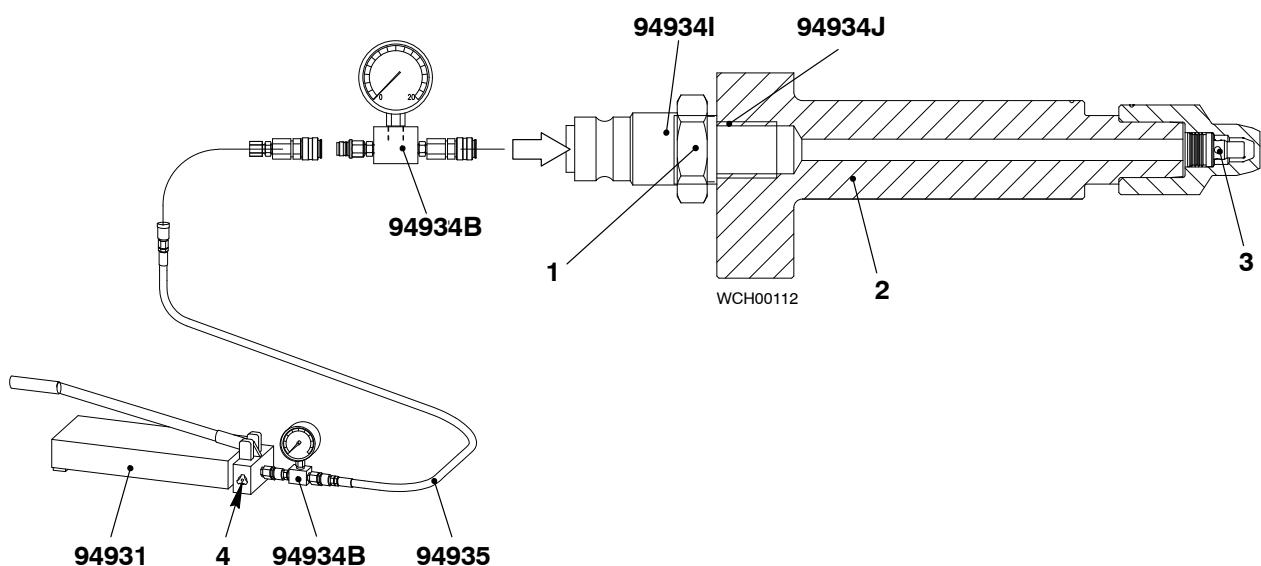


Fig. 2

4. 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, i.e. nozzle tip, non-return valve and holder.

- 1) Make sure that the sealing surfaces (SS, Fig. 3) 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 Wärtsilä.

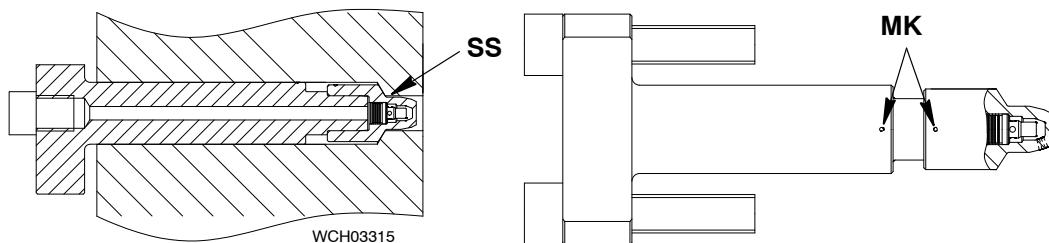


Fig. 3

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

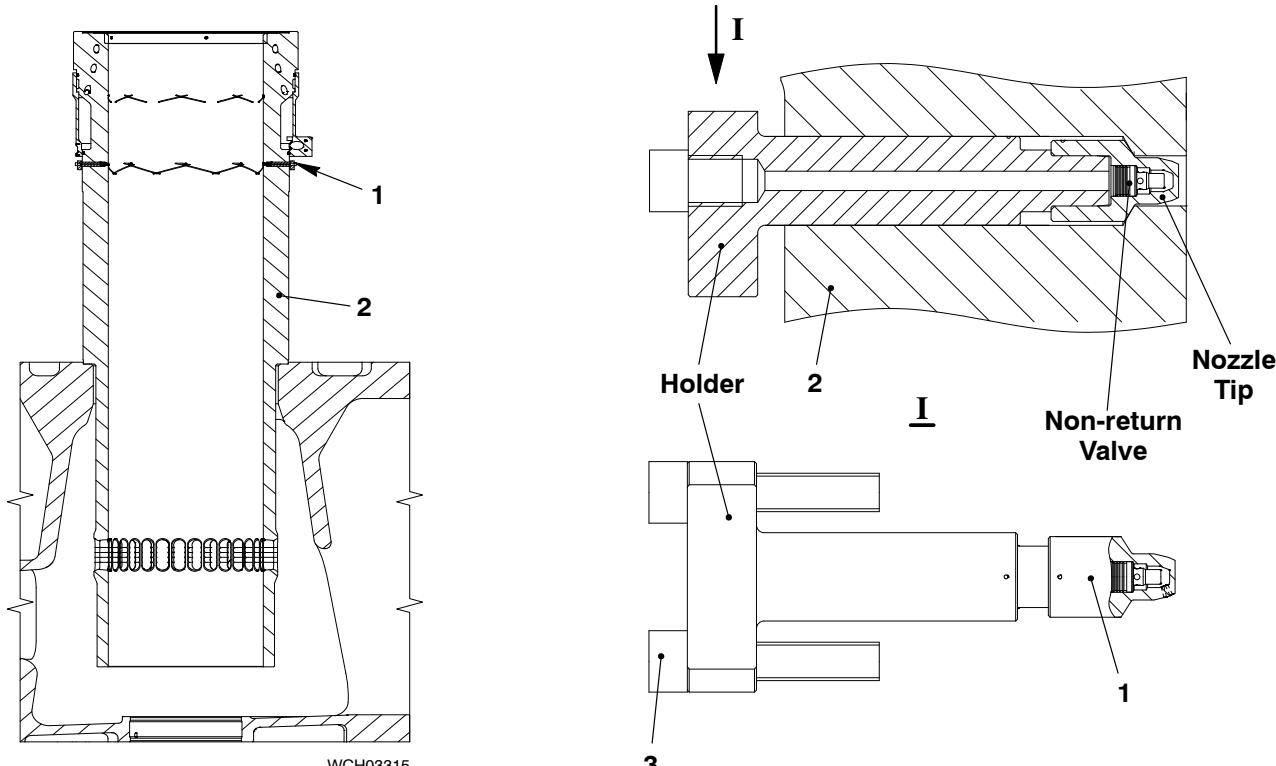


Fig. 4

Lubricating Quill

- 6) Remove the plugs from the oil pipe (4, Fig. 5).
- 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.

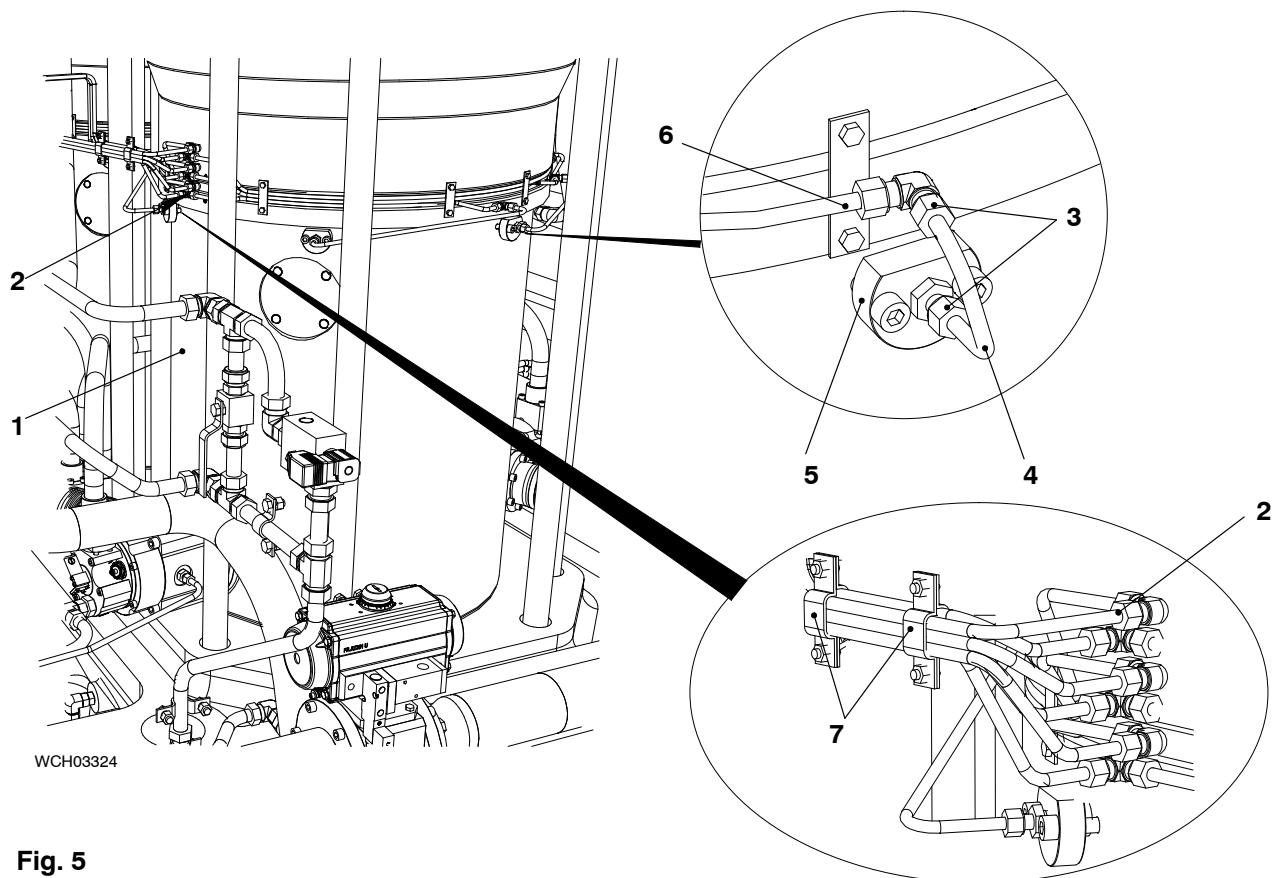


Fig. 5

Removal Disassembly and Installation

Tools:

1 Eye bolt	94045-M10	1 Pressure reducing valve	94214B
1 Dismantling tool	94214	1 Assembly tool	94023A
1 Handle	94214A	2 M10 Screws	

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1. General

- 1) Read the data in the:
 - Operation Manual, 0210-1 Safety Precautions and Warnings
 - Operation Manual, 2140 Gas Admission Valve (GAV)
 - Operation Manual, 8014-1, Gas Fuel System
 - Operation Manual, 4003-12, Diagram Gas Fuel.
- 2) For the inspection intervals, refer to the Maintenance Schedule 0380-1, Group 2140.

2. Preparation

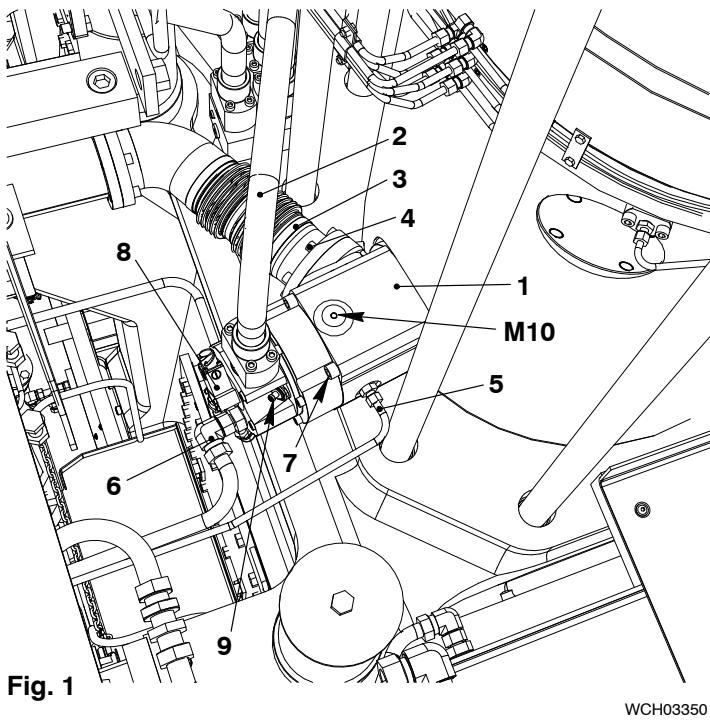
- 1) Stop the engine. Refer to the Operation Manual 0310-1.
- 2) Set to off the main bearing oil pumps (use the service pump for tests).
- 3) Make sure that the pressure in the servo oil supply pipes is zero.
- 4) Make sure that the pressure in the gas pipe, high pressure pipe and lubricating oil pipe is zero.
- 5) Make sure that the drain from the gas control valve is open.

WARNING



Danger: Some gas can leak during the removal of the GAV. Do not use equipment that can cause a spark. Make sure that all equipment that can cause a spark is not in the work area. This will prevent an explosion, or a fire.

Gas Admission Valve: Removal, Disassembly and Installation

**3. Removal**

- 1) Put an oil tray below the GAV (1).
- 1) Remove the oil pipe (2). Do not damage sealing surface.
- 2) Remove the return pipe (6) and lubrication pipe (5) from the GAV (1).
- 3) Put protection on the pipe openings.
- 4) Disconnect the electrical connections from the rail valve (8) and the valve stroke sensor (9).

Note: Use the tool 94023A to remove the plug from the valve stroke sensor (see Fig. 11).

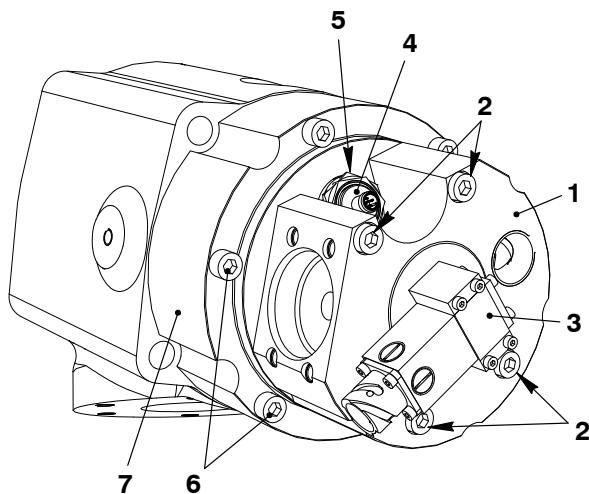
- 5) Install an eye bolt 94045-M10 (M10) on top of the GAV.
- 6) Install a suitable lifting tool (GAV=70kg) and attach the hook to the eye bolt.
- 7) Remove the four bolts (7).
- 8) Remove the six screws (4, Fig. 1) and push the gas distributor pipe (3) back small distance.
- 9) Move carefully the GAV to a clean working area.
- 10) Attach protection to the opening of the gas distributor pipe (3).

4. Disassemble

- 1) Remove four bolts (2, Fig 2).
- 2) Carefully remove the cover (1) together with the rail valve (3).

Note: Remove carefully the cover (1).
There is a piston attached to the cover.

- 3) Remove the coupling nut (5) on the valve stroke sensor (4).
- 4) Remove the valve stroke sensor (4) with its distance sleeve.
- 5) Remove symmetrically the six bolts (6).
- 6) Carefully remove cover (7).



Gas Admission Valve: Removal, Disassembly and Installation

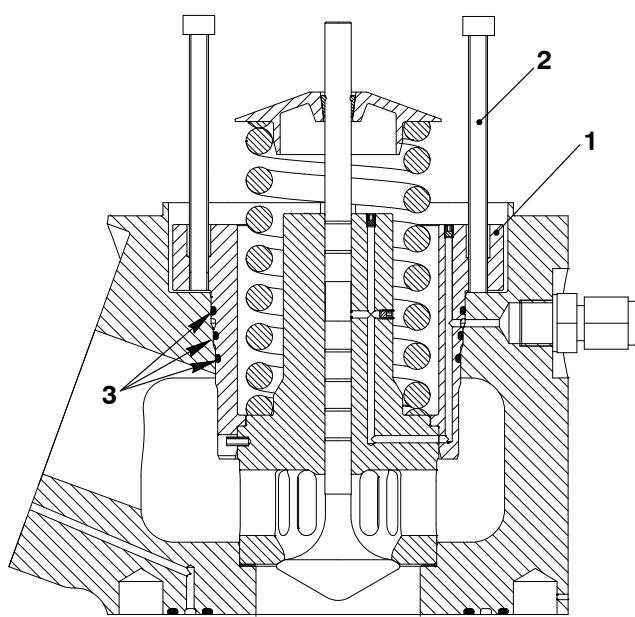


Fig. 3

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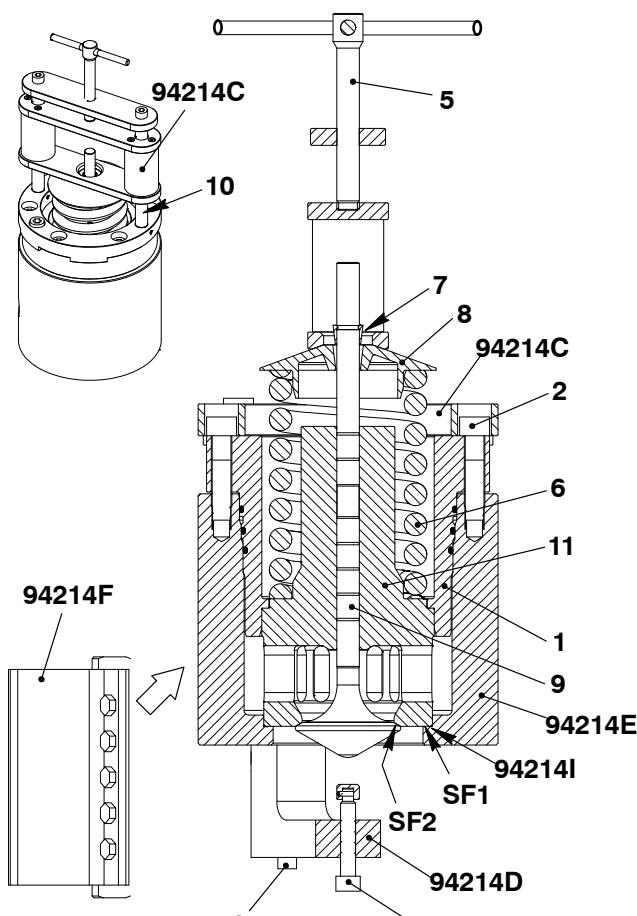


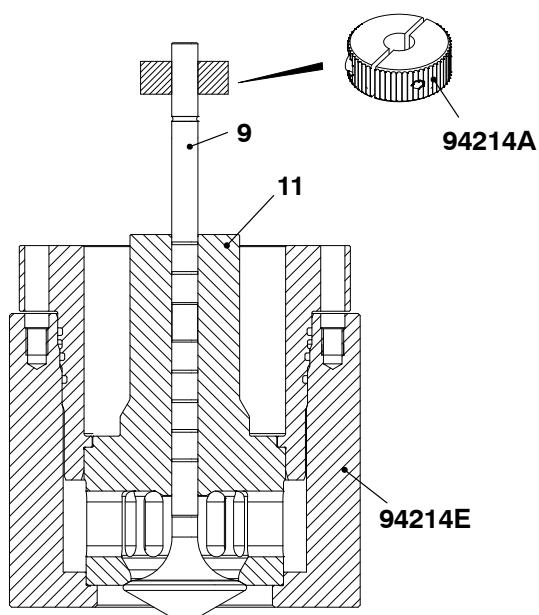
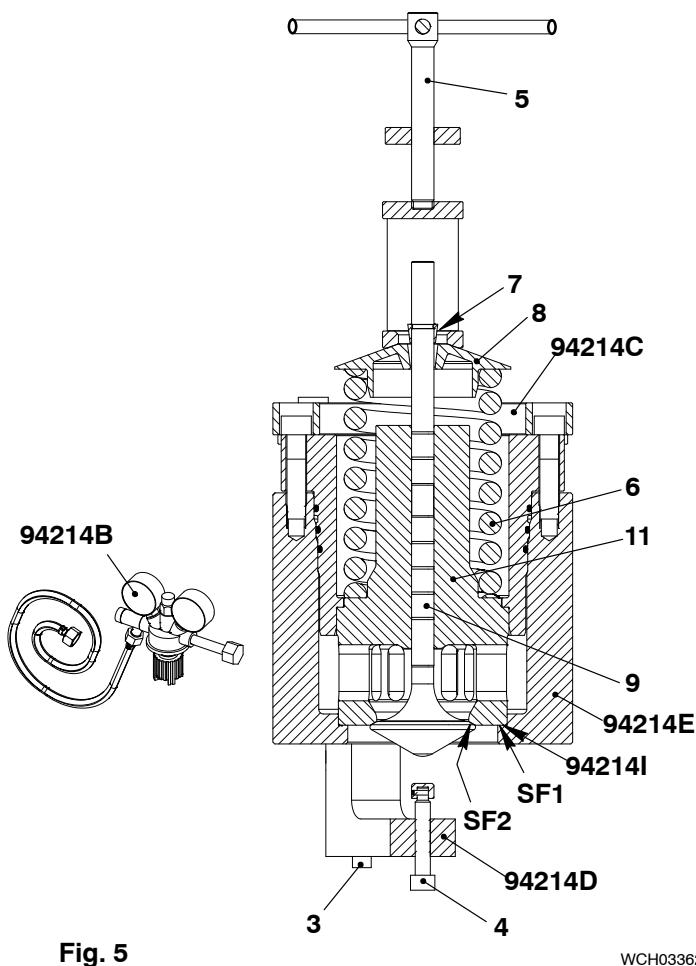
Fig. 4

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- 7) To remove the valve assembly (1), use two long M10 screws (2) and turn them equally into the two opposite M10 threads.
 - 8) Remove the valve assembly (1).
 - 9) Replace the three O-rings (3) and apply oil to them before installation.

 - 10) Attach the steel plate 94214F to the bush 94214E with the five screws (Fig. 4).
 - 11) Put the steel plate 94214F and the bush 94214E attached to it horizontally into a vice.
 - 12) Make sure that the sealing faces SF1 are clean.
 - 13) Install the soft metal gasket 94214I between sealing faces SF1.
 - 14) Put the valve assembly (1) into the bush 94214E.
 - 15) Apply Molykote G-Rapid plus to the rods of spring press 94214C.
 - 16) Attach the spring press 94214C and the valve assembly (1) with the six M10x45 screws (2) to the bush 94214E.
 - 17) Torque the screws (2) to 40 Nm.
 - 18) Install the bracket 94241D with two M6x75 screws (3) on the other side of the bush 94214E.
 - 19) Turn the special screw (4) fully in.
 - 20) Turn the spindle (5) in to compress the spring (6). This will push the valve cotter (7) out of the spring carrier (8).
 - 21) Remove the valve cotter (7).
 - 22) Turn the spindle (5) out to release the tension in the spring (6).
 - 23) Remove the bracket 94214D.
 - 24) Remove the valve spindle (9).clean the valve spindle and do a check it for damage, specially the sealing surface SF2.
 - 25) Carefully put the valve spindle (9) into the valve guide (11) and move the spindle in and out. The friction must be the same during the stroke, e.g. the valve spindle must not slip, or stay in position. The weight of valve spindle must move it down.

Gas Admission Valve: Removal, Disassembly and Installation

**5. Pressure Test**

- 1) Apply lube oil to the valve spindle (9).
- 2) Put the valve spindle (9) into the valve guide (11).
- 3) Install the bracket 94241D to the bush 94214E with the two M6x75 screws (3).
- 4) Turn the special screw (4) fully in.
- 5) Turn the spindle (5) in to compress the spring (6).
- 6) Install the valve cotter (7) on the valve spindle (9).
- 7) Turn the spindle (9) back to release the tension in the spring (6). Make sure that the valve cotter (7) is fully in the spring carrier (8).
- 8) Attach the pressure reducing valve 94214B to the bush 94214E.
- 9) Attach a pressurized nitrogen supply to the pressure reducing valve 94214B.
- 10) Set the pressure reducing valve to 15 bar.
- 11) Apply WD40 as a spray to the area of the valve seat SF2. Count the bubbles. Up to 5 bubbles per second is satisfactory.
- 12) If there are more than 5 bubbles per second, lap the valve spindle and valve seat, refer to paragraph 6.

6. Valve Seat – Lap

- 1) Remove the spring (6, Fig. 4), refer to paragraph 4.
- 2) Attach the handle 94214A to the valve spindle as shown in Fig. 6.
- 3) Apply lube oil to the valve spindle (9).
- 4) Put the valve spindle (9) into the valve guide (11).
- 5) Use oil based lapping paste with a grain size of 0.5 to 4.0 microns and lap the valve seat.
- 6) Do the pressure test again. If the leakage is unsatisfactory, replace valve spindle and the valve guide.

Gas Admission Valve: Removal, Disassembly and Installation

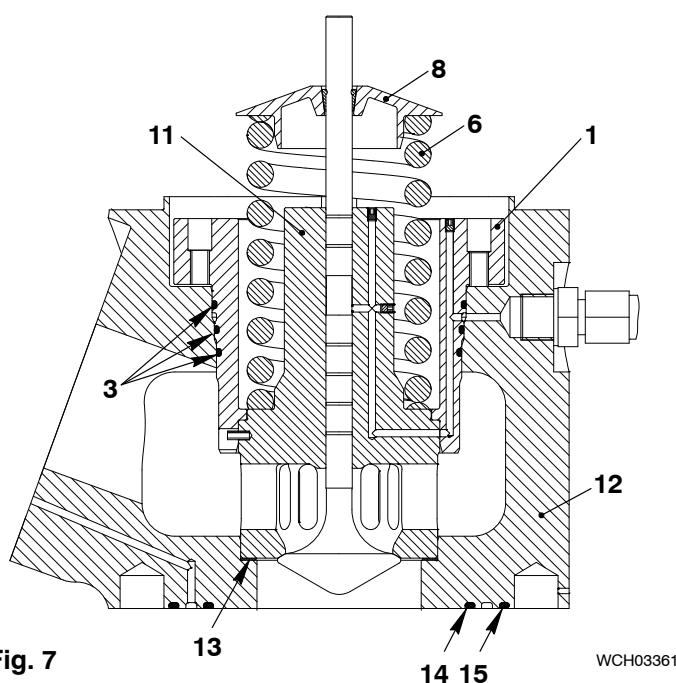


Fig. 7

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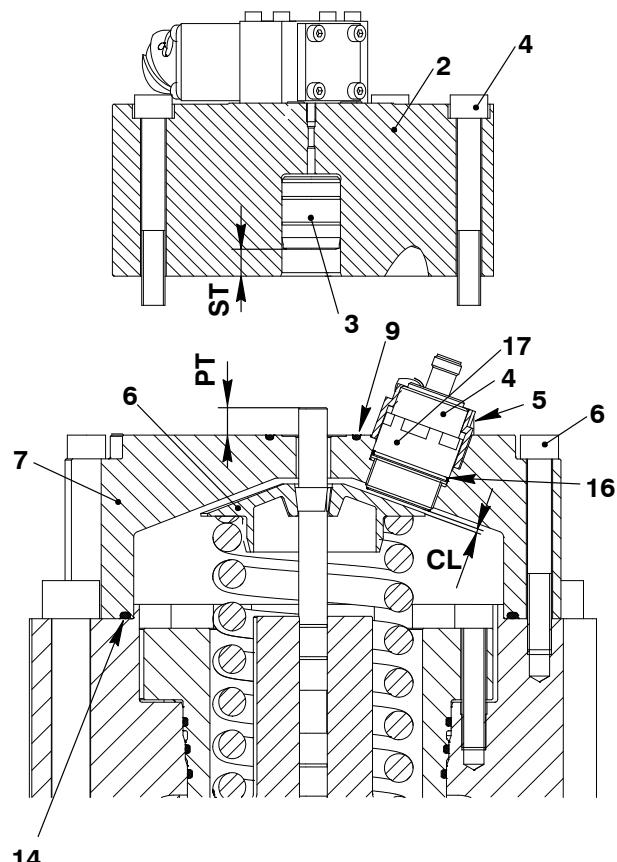


Fig. 8

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7. Assemble

- 1) Clean all parts and bores.
- 2) Make sure the O-rings (3) are in a satisfactory condition.
- 3) Apply oil to the O-rings (3).
- 4) Replace the gasket (13).
- 5) Put the valve assembly: bush (1), valve guide (11), spring (6), spring carrier (8), valve spindle (9) into the housing (12).
- 6) Replace the O-rings (14) and (15).

- 7) Replace the O-ring (14, Fig. 8).
- 8) Apply Never Seez NSBT to the six bolts M10x80 (6).
- 9) Install the cover (7) the the cover (12) with the six bolts M10x80 (6).
- 10) Torque the six bolts (6) to 40 Nm.
- 11) Measure the distance PT of the valve spindle to the cover (7).
- 12) Clean the piston hole in the cover (2).
- 13) Apply lube oil to the piston (3).
- 14) Put the piston (3) fully into the hole.
- 15) Measure the piston stroke ST.
- 16) Calculate the valve clearance ST – PT:
Note: The valve clearance ST – PT must be 0.20 to 1.37 mm. If the valve clearance is too low, the valve cannot close completely.
- 17) Replace the O-ring (9).

Gas Admission Valve: Removal, Disassembly and Installation

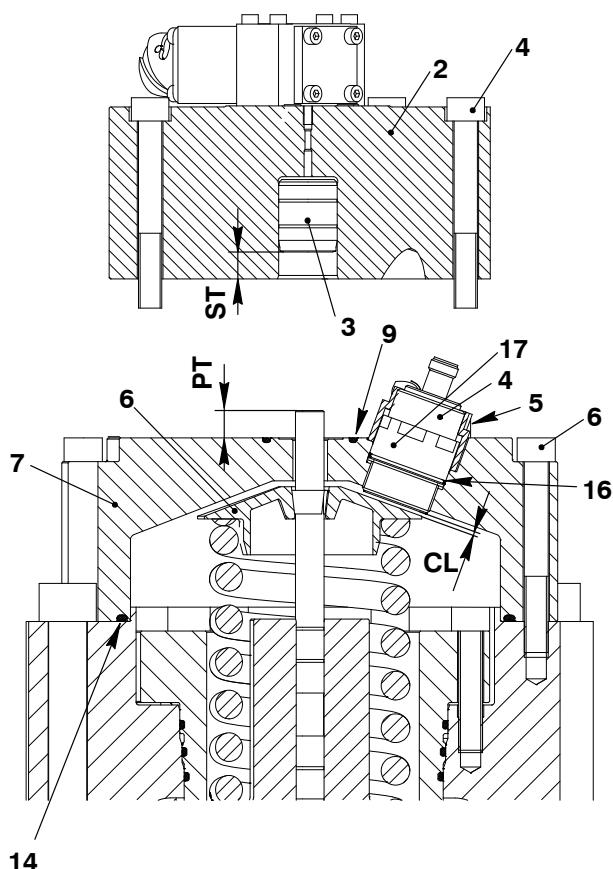


Fig. 9

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- 18) Replace the O-ring (16) on the distance sleeve (17) (the distance sleeve is bonded on).
- 19) Put the valve stroke sensor (4) into the cover (7). Turn the valve stroke sensor clockwise until it touches the spring carrier (6).
- 20) Move the valve stroke sensor (4) counterclockwise one turn. This gives the clearance where $CL = 1.5\text{ mm}$.
- 21) Apply Never Seez NSBT to the thread of coupling nut (5).
- 22) Hold the sensor (4) and torque the coupling nut to 90 Nm.
- 23) Clean the surfaces of the cover (7) and the cover (2).
- 24) Apply Never Seez to the threads of the four bolts (2).
- 25) Attach the cover (2) with the four bolts (4).
- 26) Torque the four bolts (4) to 40 Nm.

Gas Admission Valve: Removal, Disassembly and Installation

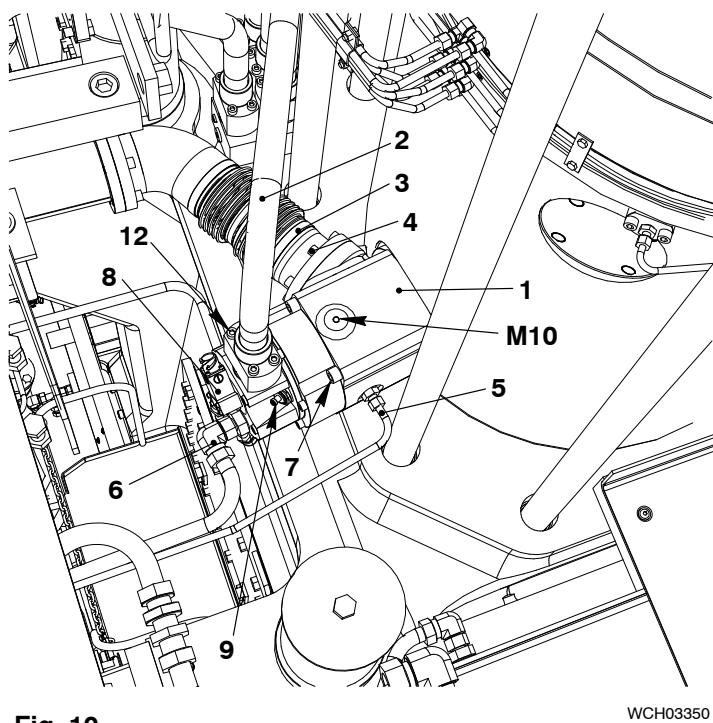
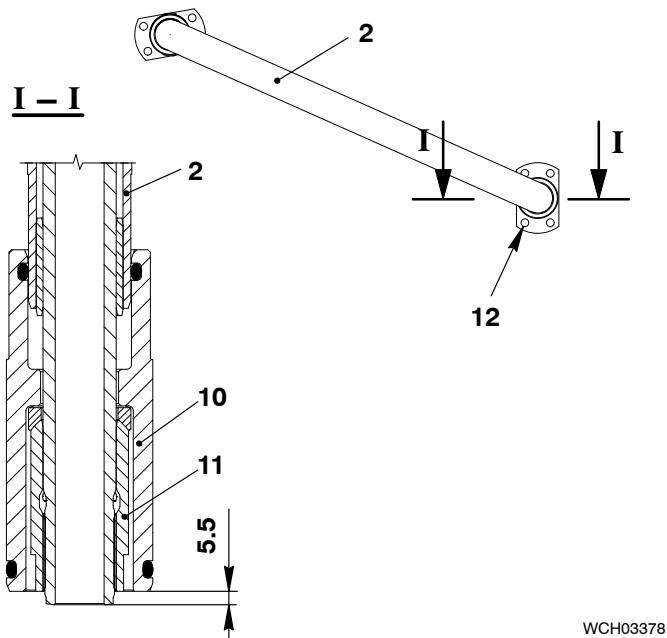


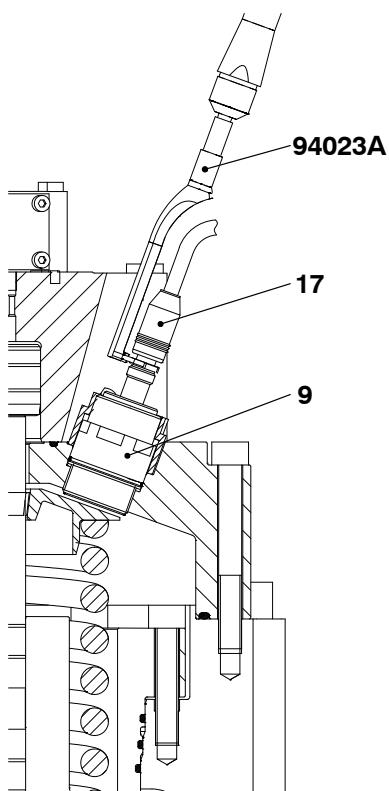
Fig. 10

**8. Installation**

- 1) Attach an M10 eye bolt (M10) to the housing of the GAV (1).
- 2) Lift and move the GAV (1) to the applicable position at the cylinder liner.
- 3) Make sure all surfaces are clean.
- 4) Apply Never Seez NSBT to the four bolts (7).
- 5) Attach the GAV (1) to the cylinder liner with the four bolts (7).
- 6) Torque equally the four bolts (7) to 170 Nm.
- 7) Remove the flange of the gas distributor pipe (3).
- 8) Replace the O-rings in the flange of gas distributor pipe (3).
- 9) Attach the gas distributor pipe (3) to the GAV (1) with the six screws (4).
- 10) Tighten the six screws (4) equally.
- 11) Attach the return pipe (6) and the lubrication pipe (5) to the GAV (1).
- 12) Connect the electrical connection to the rail valve (8).
- 13) Make sure that the sealing face of the oil pipe (2) has no damage. If there is damage, grind the sealing faces (refer to 8460-1).
- 14) Adjust the claw (11) with an open end wrench until there is a distance of 5.5 mm between the claw and the end of the pipe (2).
- 15) Apply oil to the eight screws (12).
- 16) Carefully install the oil pipe (2).
- 17) Torque the eight screws (12) equally to 40 Nm.
- 18) For a stroke signal test of the GAV, refer to the Operation Manual 4002-2, paragraph 3.14 GAV Manual Valve Test.

Gas Admission Valve: Removal, Disassembly and Installation

- 19) Use the assembly tool 94023A (Fig. 11) to attach the electrical connection (17) to the valve stroke sensor (9).
- 20) Do a check for leaks immediately.

**Fig. 11**

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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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2.5 Piston rod gland – installation	7

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

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

- 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 (1, Fig. 1) is in the correct position on the two hinged covers (2) 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).

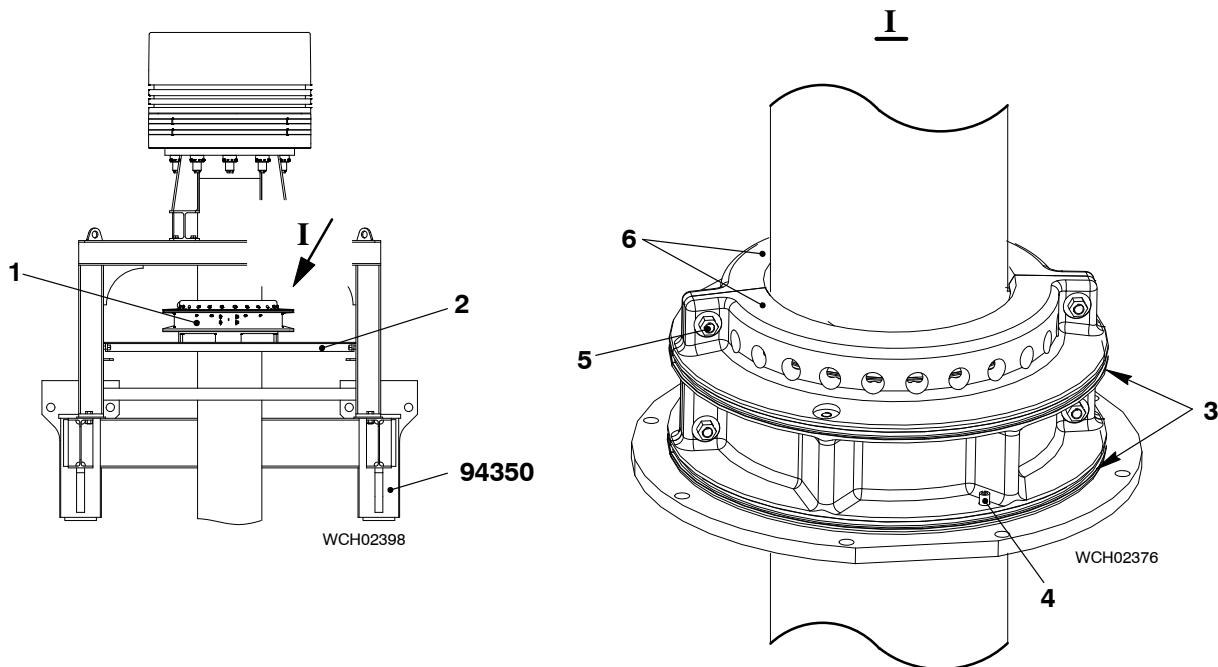


Fig. 1

2.3 Disassemble

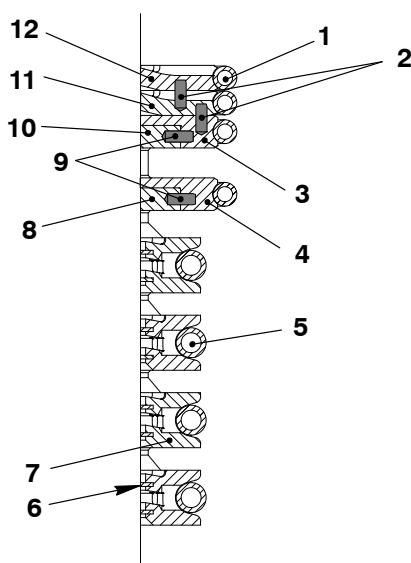


Fig. 2

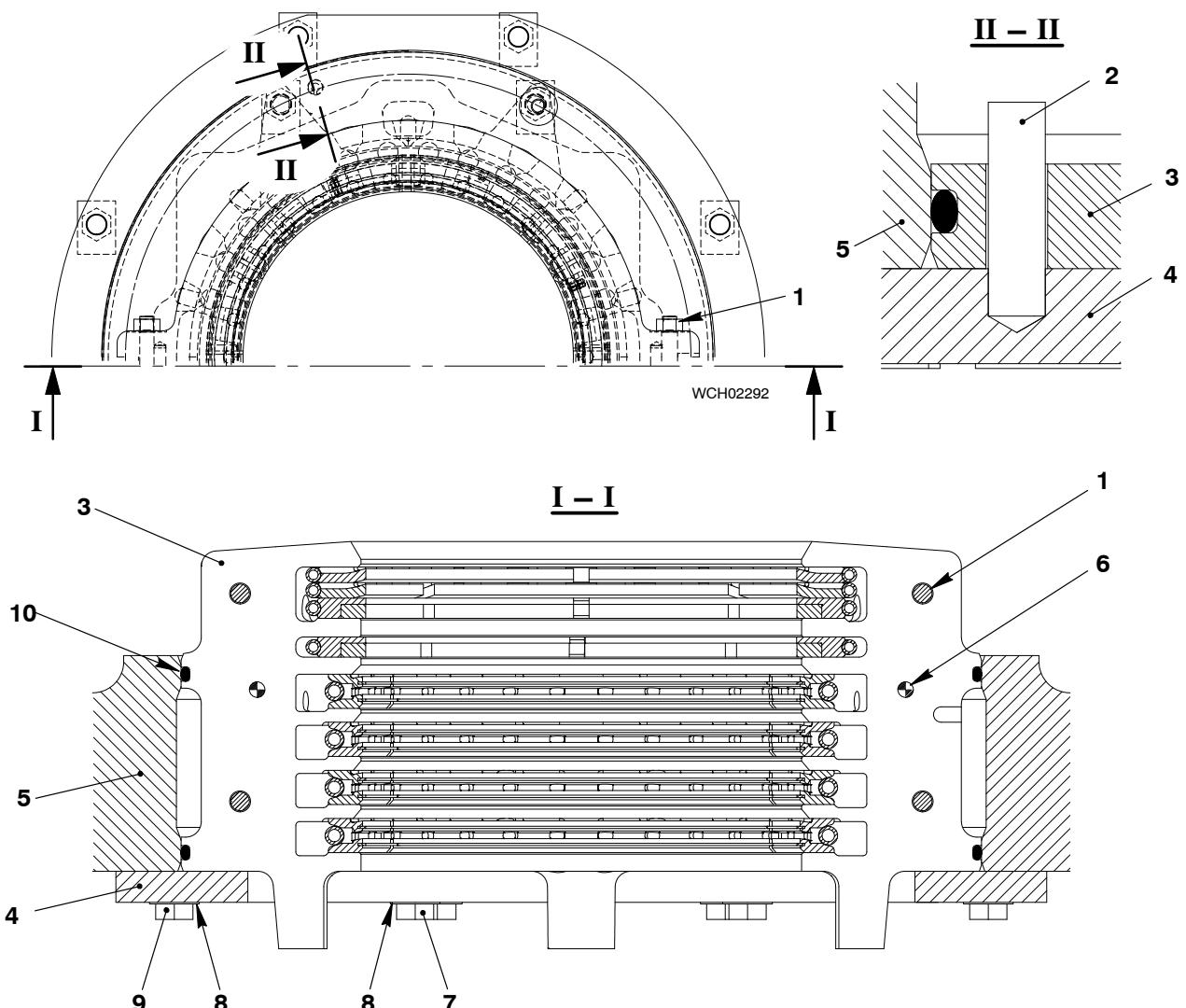
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- 7) Remove the parts that follow (see Fig. 2):
- Tension springs (1, 5)
 - Scraper rings (2, 6, 11, 12)
 - Gaskets (3, 4, 8, 10)
 - Spring dowel pins (9)
 - Ring supports (7).

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.

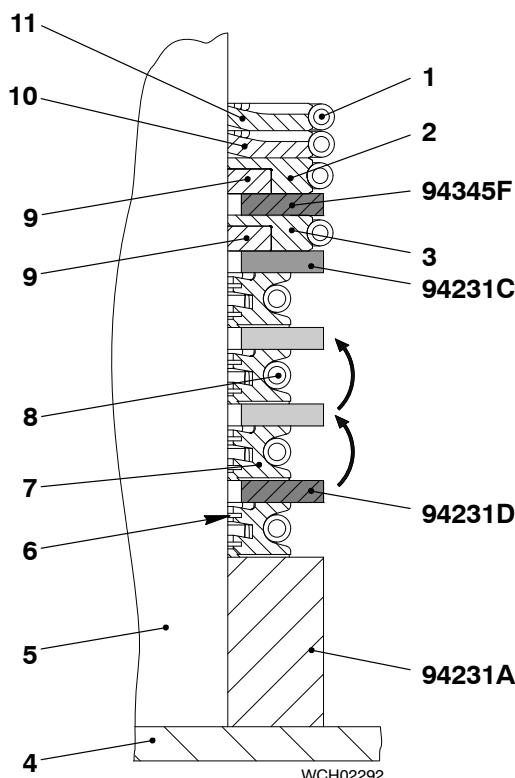
- 1) Compare the wear of the parts that follow:
 - Scraper rings (2, 6, 11, 12)
 - Gaskets (3, 4, 8, 10).
- 2) Make sure that the tension springs (1, 5) and the O-rings (5, Fig. 1) are serviceable. If necessary, replace the unserviceable parts.

**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 |

Remove, Disassemble, Measure Worn Parts, Assemble, Install

2.5 Assemble



- 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) above 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).

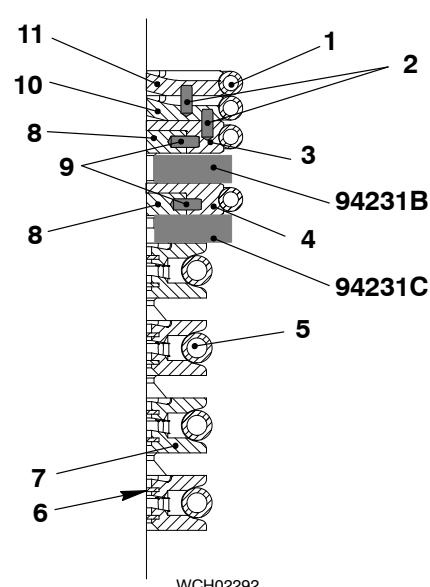


Fig. 5

- 10) Put the four parts of the gaskets (8, 4) on the distance piece (94231C).
- 11) Make sure that all 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

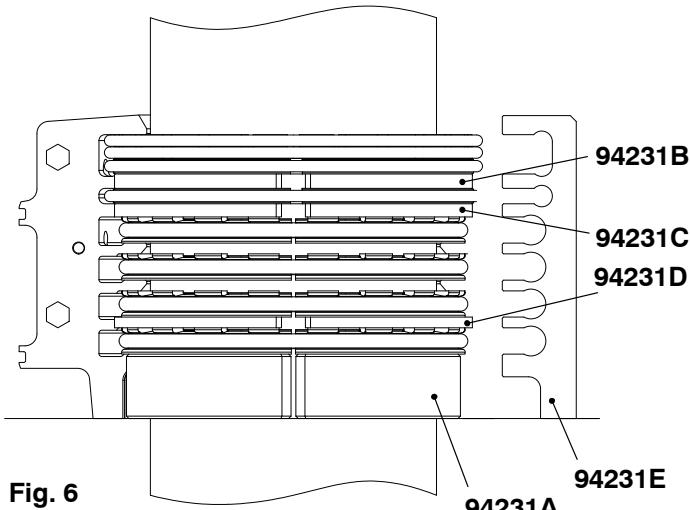
- 14) Put the two parts of the distance piece (94231B, [Fig. 5](#) (12.0 mm height) on the gaskets (4, 8).
- 15) Put the four parts of the gaskets (3, 8) on the distance piece (94231B). Make sure that there is an equal distance between the four parts.
- 16) Make sure that all horizontal spring dowel 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.

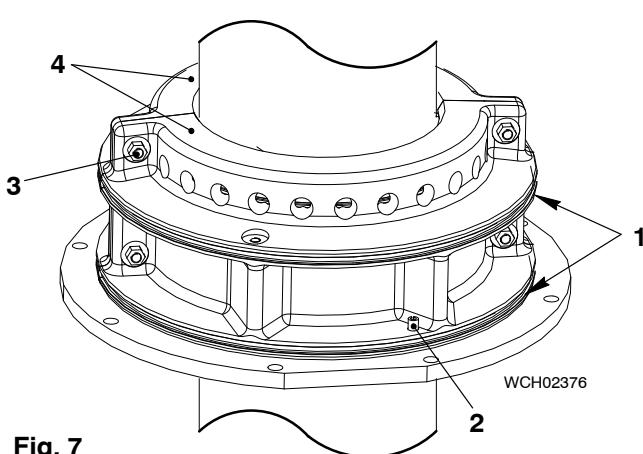
- 17) Put the scraper ring (10) on the gaskets (3, 8). Make sure that there is an equal distance between the four parts.
- 18) Make sure that the vertical spring dowel pins (2) are installed.
- 19) Use the assembly tool (94233) to attach the tension spring (1) to the scraper ring (10).

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).



- 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. If necessary, correct the 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 screws (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).



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:

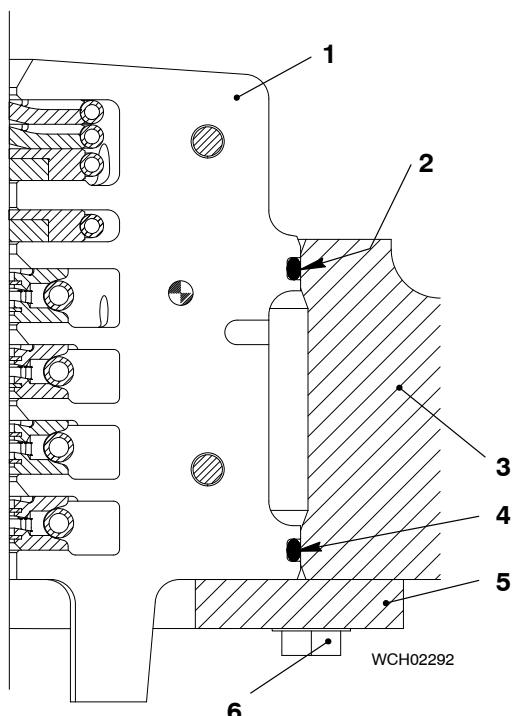


Fig. 8

- 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). If necessary, torque the outer bolts (6) to 150 Nm.
- 4) Install the piston and piston rod gland, refer to 3403-1, (Installation of the Piston, paragraph 4)
- 5) 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 turn the piston to BDC.
- 2) Attach the platform (94234, [Fig. 9](#)) to the elastic studs (2) and the piston rod (3).

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.

- 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) Use 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, loosen 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) Use the turning gear to carefully turn 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.

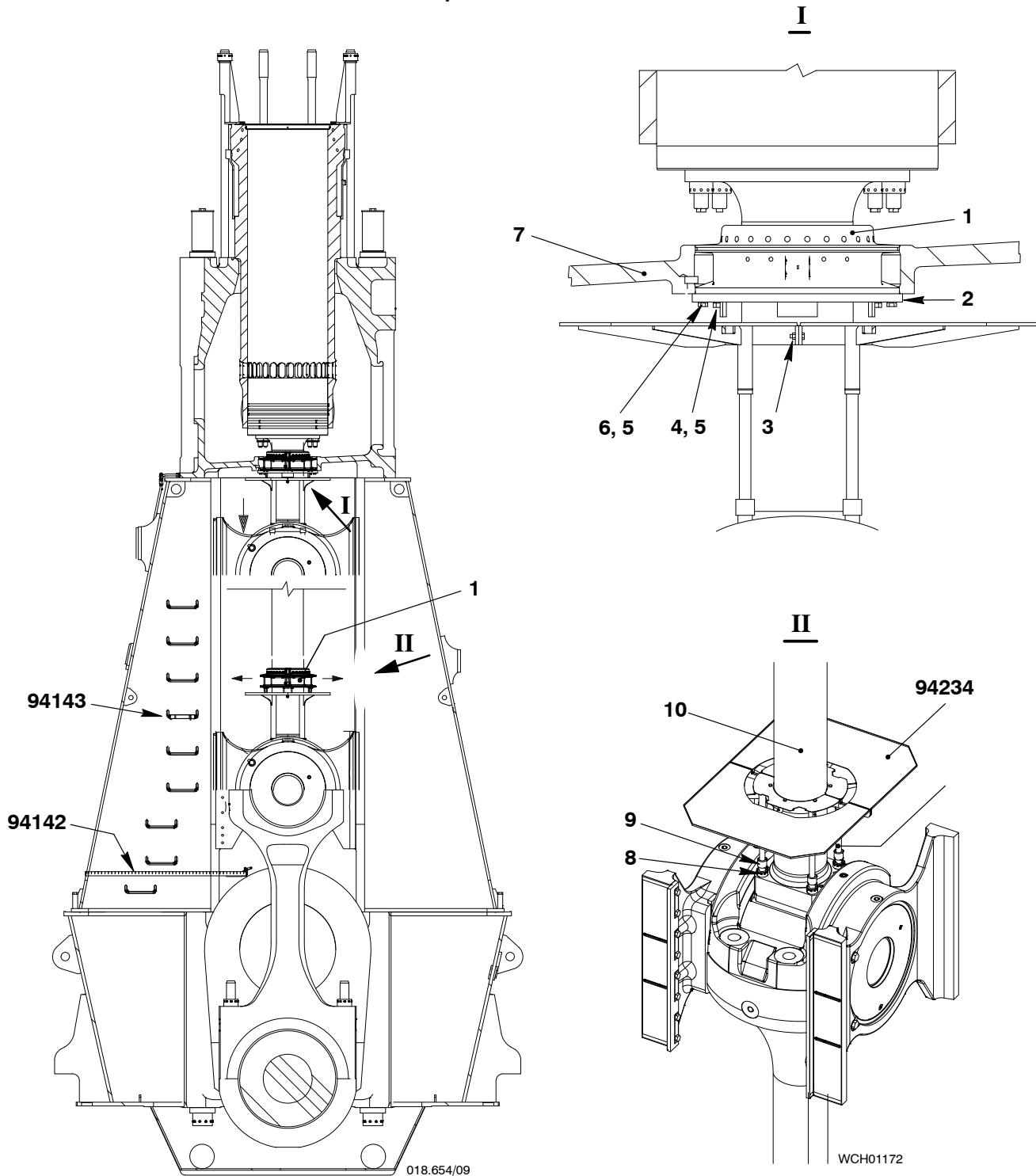


Fig. 9

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 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) Use 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

Cylinder Cover, Top Water Guide Jacket, – Removal and Installation

Tools:

8	Pre-tensioner	94215A
1	Suspension device	94265
1	Hydraulic unit	94942

1	Adapter	94934
1	Pressure gauge	94934A
3	HP hose	94935
7	Flexible hose	94935A

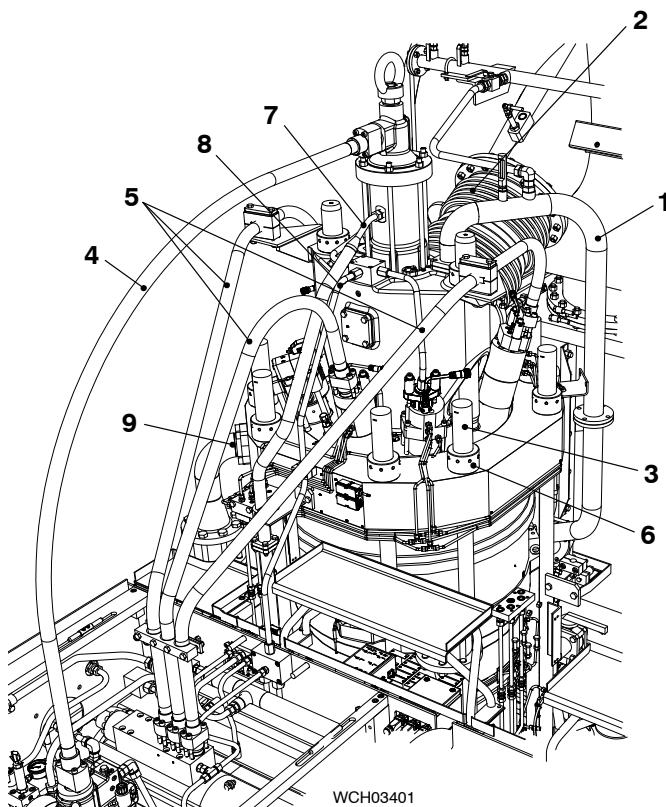


Fig.1

- 7) Close the valves from the gas supply. Make sure that there is no pressure in the gas pipes.
- 8) Close the valves from the fuel supply and pilot fuel supply. Make sure that there is no pressure in HP fuel pipes (5, Fig.1) and pilot fuel pipe (8).
- 9) Remove the hydraulic pipe (4), refer to 8460-1.
- 10) Remove the three HP fuel pipes (5), refer to 8733-1.
- 11) Remove the applicable HP pilot fuel pipes, refer to 8790-1.
- 12) Make sure that there is no pressure in the cooling water pipe (1).
- 13) Remove the cooling water pipe (1).
- 14) Remove the expansion piece (2) with the slings, refer to 2751-1, paragraph 1, step 3) to step 9).
- 15) Close the starting air valve. Disconnect the air pipe (9) from the cylinder cover.
- 16) Remove the oil leakage pipe (7) and the pilot fuel pipe (8).
- 17) Disconnect the air pipe from the exhaust valve housing.
- 18) Record the positions of the connections to the injectors.
- 19) Disconnect all connections from the injectors.
- 20) Disconnect all other connections from the cylinder cover and the exhaust valve.
- 21) Apply tension to the elastic studs (3) on the cylinder liner, refer to 9403-4 and remove the round nuts (6) (see, 9403-2 for hydraulic arrangement).

1. Preparation

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.

- 1) Stop the engine, refer to the procedure in the Operation Manual 0310-1.
- 2) Let the engine temperature decrease.
- 3) Make sure that all tools and equipment are clean.
- 4) Close manually the starting air supply valves and the control air valves 930-V03 and 930-V04, refer to the control diagram in the Operation Manual 4003-2.
- 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 to the Operation Manual in 8017-1.

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

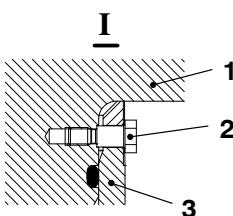
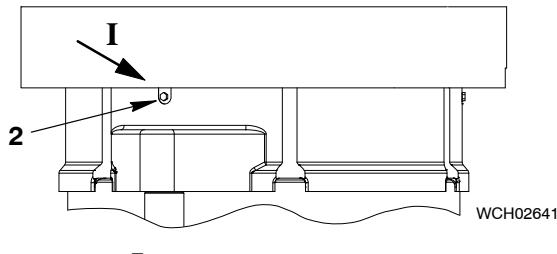
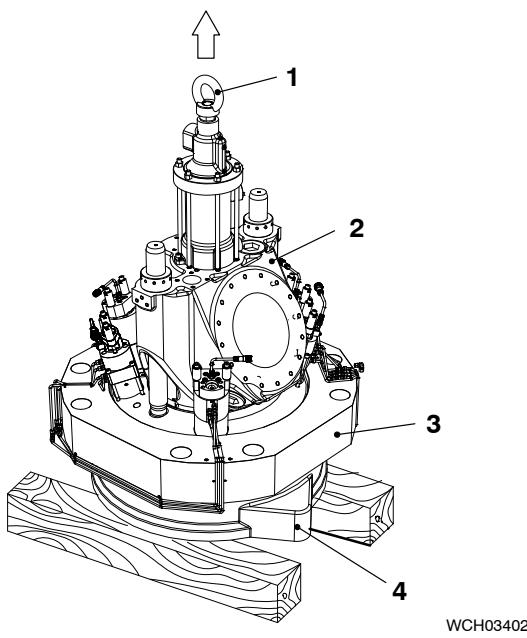
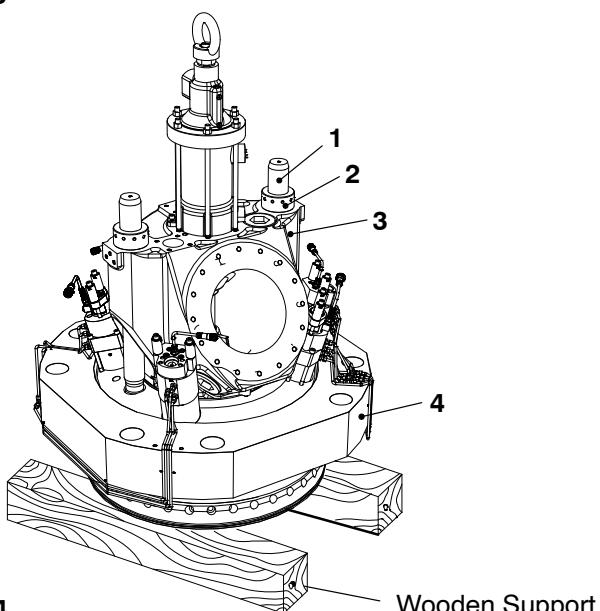


Fig. 3



2. Removal

CAUTION



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

- 1) Attach the engine room crane to the eye bolt (1, Fig. 2) on the exhaust valve.
- 2) Carefully lift the cylinder cover (3) together with the exhaust valve cage (2) and the top water guide jacket (4).
- 3) Lower the cylinder cover, exhaust valve cage (2) and the top water guide jacket (4) on to wooden supports.
- 4) Remove the three screws (2) from the cylinder cover (1).
- 5) Operate the engine room crane to lift the exhaust valve assembly approximately 10 mm. Make sure that the top water guide jacket stays on the wooden supports.
- 6) Lift, then lower the cylinder cover (4, Fig. 4) and the exhaust valve assembly (3) on to wooden supports.
- 7) Apply tension to the elastic studs (1), refer to 9403-4
- 8) Remove the round nuts (2).

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

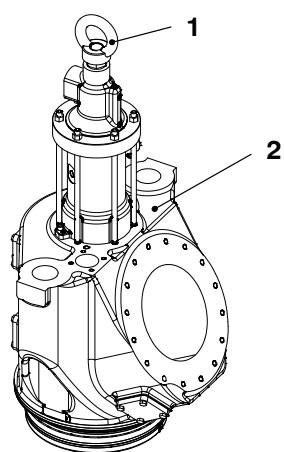


Fig. 5

- 9) Operate the engine room crane to lift the exhaust valve assembly (2, Fig. 5) approximately 10 mm. Make sure that the cylinder cover stays on the wooden supports.
- 10) Fully lift the exhaust valve assembly (2) from the cylinder cover.
- 11) Use the engine room crane to move the exhaust valve cage (2) to an applicable area.
- 12) Carefully lower the exhaust valve assembly (2, Fig. 6) on to a wooden support.
- 13) Disconnect the crane hook from the eye bolt (1).

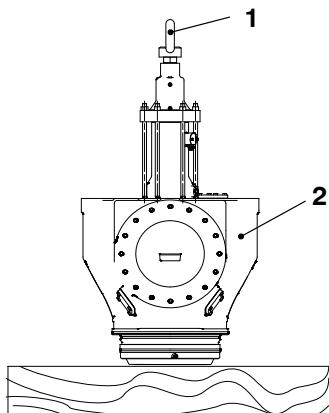


Fig. 6

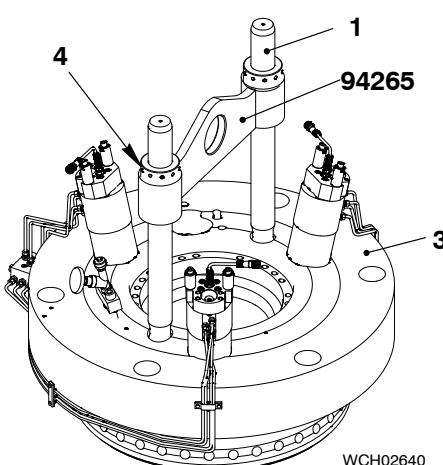
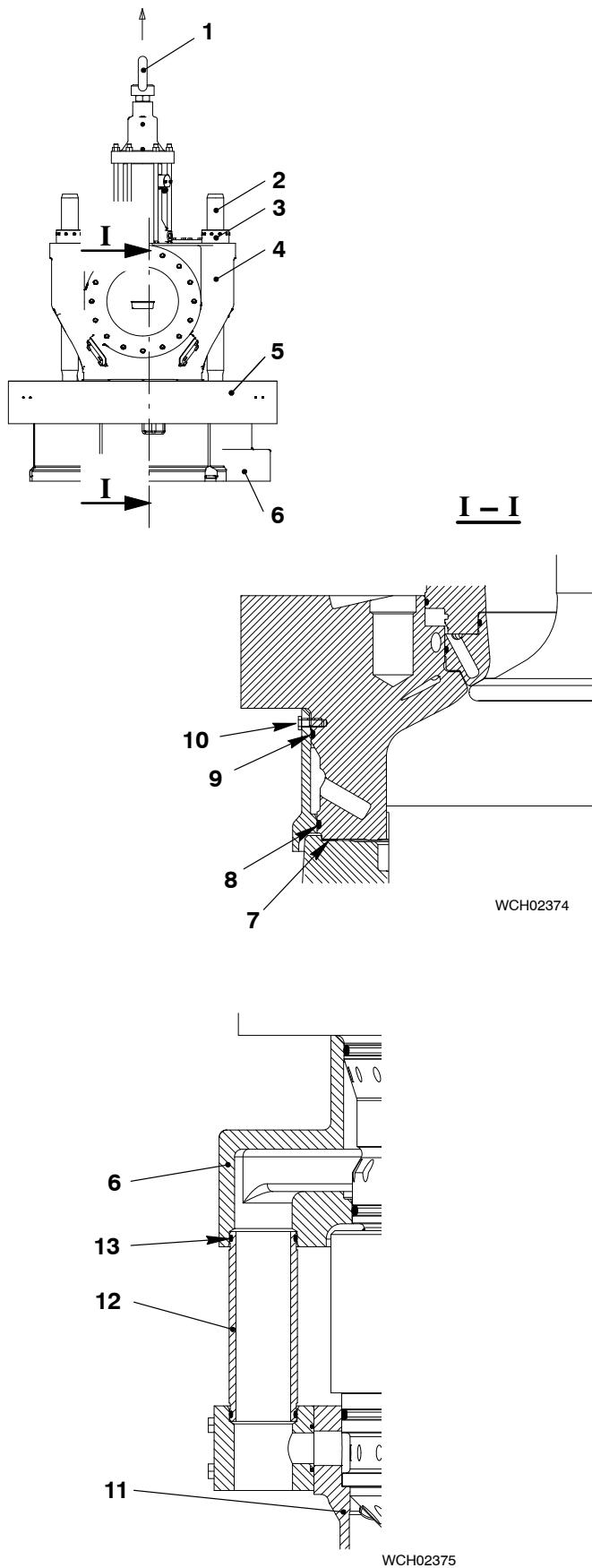


Fig. 7

- 14) Attach the tool (94265, Fig. 7) to the cylinder cover as shown.
- 15) Attach the round nuts (4) to the elastic studs. Tighten the round nuts.
- 16) Attach the the engine room crane to tool (94265).
- 17) Operate the engine room crane to move the cylinder cover (3) to an applicable area.
- 18) Remove the tool (94265).
- 19) Remove and discard all O-rings.
- 20) Remove and discard the soft iron joint ring.

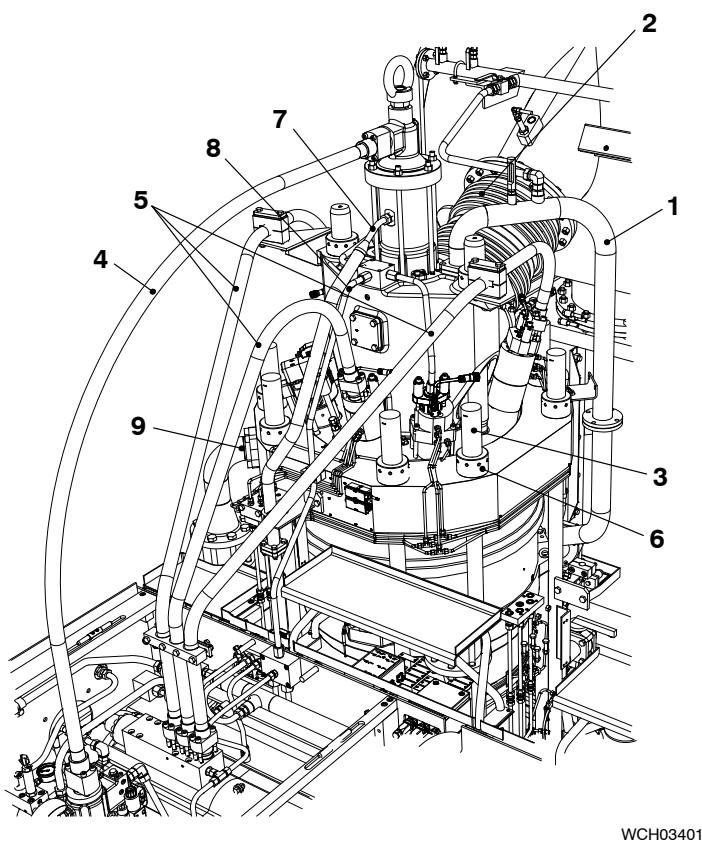
Removal and Installation of Cylinder Cover, Top Water Guide Jacket, Exhaust Valve

**3. Installation**

- 1) Clean the O-ring grooves.
- 2) Clean the sealing surfaces of the cylinder cover.
- 3) Put oil on the new O-rings (8 and 10, Fig. 8).
- 4) Install new O-rings (8, 10).
- 5) Put a new soft iron joint ring (7) in position in the cylinder liner.
- 6) Put oil on the new O-ring (13).
- 7) Put the O-ring (13) in position on the transition tube (12).
- 8) Clean the threads of all elastic studs.
- 9) Put oil on the threads of all elastic studs.
- 10) Attach the engine room crane to the eye bolt (1).
- 11) Lift the exhaust valve assembly (4).
- 12) Carefully lower the exhaust valve (4) assembly on to the cylinder cover (5).
- 13) Attach the round nuts (3) to the elastic studs (2).
- 14) Apply tension to the elastic studs (2), refer to 9403-4, then tighten the round nuts (3).
- 15) Lift exhaust valve assembly (4) together with the cylinder cover (5).
- 16) Carefully lower the exhaust valve assembly (4) together with the cylinder cover (5) and top water guide jacket (6) on to the top water guide jacket (6).
- 17) Tighten the screws (10).
- 18) Lift the exhaust valve assembly (4), together with the cylinder cover (5) and top water guide jacket (6).
- Note: During step 19), make sure that the tube (12) goes into the bore in the top water guide jacket (6).**
- 19) Carefully lower the exhaust valve assembly (4), together with the cylinder cover (5) and top water guide jacket (6) on to the cylinder liner (11).
- 20) Remove the engine room crane from the eye bolt (1).

Fig. 8

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

**Fig. 9**

3.1 Completion

- 1) Attach the round nuts (6) to the elastic studs (3).
- 2) Apply tension to the elastic studs (3), refer to [9403-4](#).
- 3) Install the expansion piece (2), refer to [2751-1](#), paragraph 3.
- 4) Install the hydraulic pipe (4), refer to [8460-1](#).
- 5) Install the pilot fuel pipe (8), refer to [8790-1](#).
- 6) Install the oil leakage pipe (7).
- 7) Connect the air pipe to the exhaust valve housing.
- 8) Install the three HP fuel pipes (5), refer to [8733-1](#).
- 9) Connect the cooling pipe (1).
- 10) Connect the starting air pipe to the cylinder cover.
- 11) Connect the electrical connections to all injectors.
- 12) Connect all other connections to the cylinder cover and exhaust valve.
- 13) Open the valves you closed before (one valve each time) and do a check for leaks.
- 14) Set to on the cooling water pump.
- 15) Make sure that the cooling water is at the usual operation pressure and temperature.
- 16) Do a check for leaks.
- 17) Remove all tools and equipment from the work area.

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Cylinder Cover

Grind Sealing Face

Tools:

1 Cutting device	94270	1 Profile cutter	94270A
1 Ring spanner AF24	94000-24		

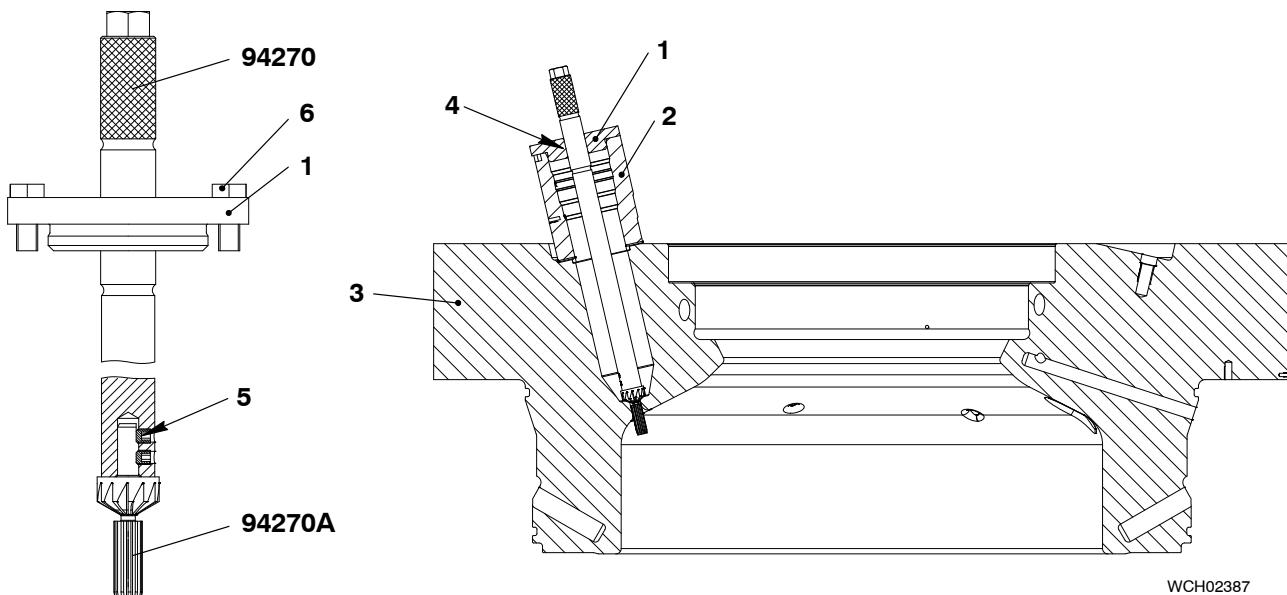
1. General

The sealing face in the cylinder cover for the primary injection valve is a metallic seal. Thus, this sealing face must be clean and have no damage.

2. Sealing Face – Machining

For the Fuel Actuated Sacless Technology (FAST) injection valve, you use the cutting device (94270) to repair sealing faces that are dirty, or have light damage.

- 1) Apply Molykote G paste to the running surface (4, Fig. 1).
- 2) Apply tacky grease to the profile cutter (94270A). This will make sure that shavings do not fall into the combustion chamber.
- 3) Make sure that the two set screws (5) are tight.
- 4) Carefully put the cutting device (94270) and the profile cutter (94270A) into the valve bush (2) in the cylinder cover (3).
- 5) Attach the guide flange (1) to the valve bush (2) with the two screws (6).
- 6) Put a ring spanner on the top of the cutting device (94270).
- 7) Push down lightly with your hand on the cutting device (94270) and use the ring spanner to turn the profile cutter (94270A).
- 8) Remove only the sufficient quantity of material to get a satisfactory seating area.

**Fig. 1**

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Injection Valve

Removal and Installation

Tools:

2 Hexagon head bolt 94270C 2 Stud bolts 94270D

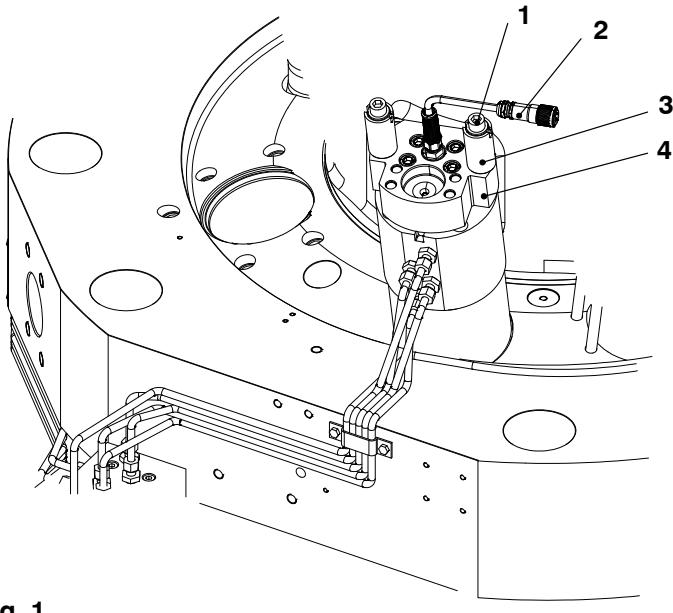


Fig. 1

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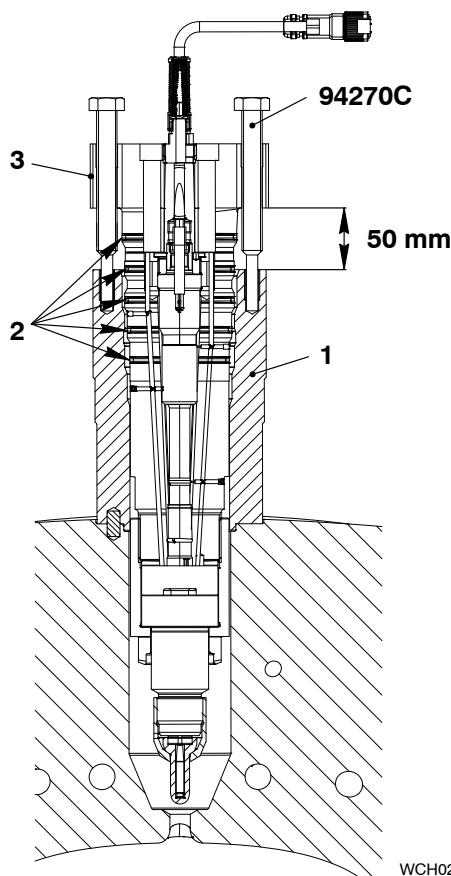


Fig. 2

WCH02390

1. Removal

CAUTION

Injury Hazard: The weight of the injection valve is 20 kg. Use sufficient personnel to lift and move heavy items.

- 1) Remove the HP fuel pipe, refer to 8733-1.
- 2) At the terminal box 95.4, disconnect the cable (2, Fig. 1).
- 3) Make sure that the cooling for the injection valve (4) is stopped, refer to Operation Manual 8016-1, paragraph 3.
- 4) Remove the screws (1) together with the spring cage (3).
- 5) Put the two bolts (94270C, Fig. 2) in position as shown.
- 6) Turn fully the two bolts until they touch the thread end in the valve bush (1).
- 7) Turn equally the two bolts to lift the injection valve approximately 50 mm.
- 8) Remove the injection valve.
- 9) Remove and discard the five O-rings (2).
- 10) If necessary, disassemble the spring cage (3).

2. Storage

- 1) Apply protection to the nozzle tip.
- 2) Be careful when you move the injection valve.

CAUTION

Injury Hazard: White spirit is a harmful substance. Put on gloves and safety goggles when you use white spirit.

- 3) Use white spirit to clean the injection valve (e.g. Shellsol TD, Shellsol T or Solvent FP68).
- 4) Put the injection valve in an applicable package.
- 5) Put the injection valve in a clean, dry area that has no contamination.

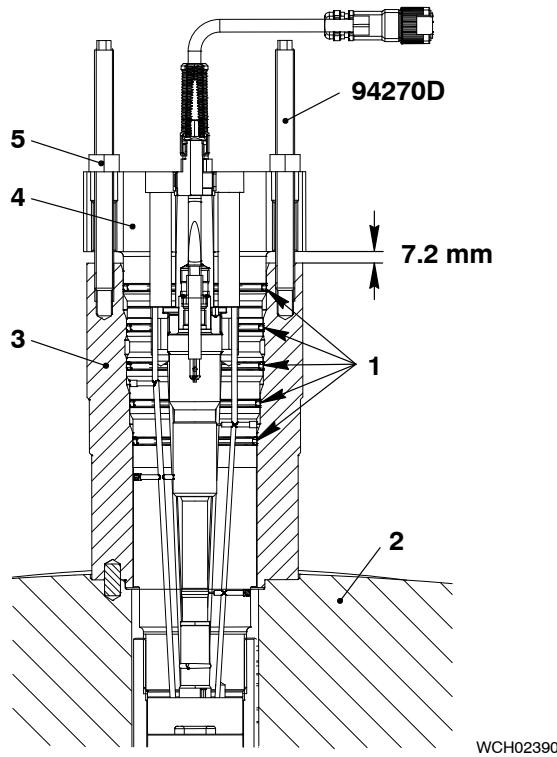
Injection Valve: Removal and Installation

Fig. 3

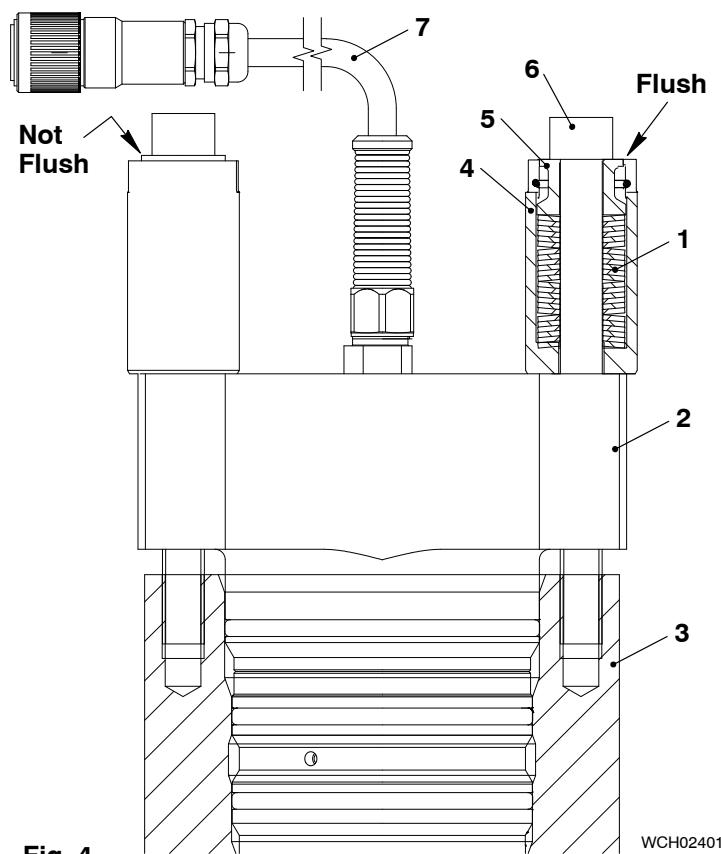


Fig. 4

3. Installation

- 1) Do a check of the condition of the sealing face in the cylinder cover (2, Fig 3). If necessary, grind the sealing face in the cylinder cover, refer to 2708-3.
- 2) If necessary, remove the injection valve from the package.
- 3) Put oil on the five new O-rings (1).
- 4) Put the five O-rings in their correct positions.
- 5) Carefully put the injection valve (4) into the valve bush (3).
- 6) Put the two stud bolts (94270D) in position as shown.
- 7) Turn the stud bolts fully into the valve bush (3).
- 8) Turn equally the nuts (5) to push the injection valve (4) fully in.

Note: The injection valve is fully installed when the distance between the valve bush (3) and the injection valve (4) is 7.2 mm.

- 9) If the spring cage (4, Fig. 4) was disassembled, make sure that the 24 cup springs (1) are installed as shown.
- 10) Apply Never-Seez NSBT to the threads and the seating surface of the screws (6).
- 11) Tighten equally the screws (6) until the spring guide (5) is flush with the spring cage (6).
- 12) Connect the cable (7) to the terminal box 95.4.
- 13) Install the HP fuel pipe, refer to 8733-1.

Disassemble, Checks, Assemble Injection Valve with FAST

Tools:

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

1.	General	1
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5.	Nozzle Tip – Replace	5
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5.2	Installation	6
6.	Assemble	7
6.1	Pilot Valve – Install	7
6.2	Injection Valve – Assemble	8

1. General

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

- To do checks
- To disassemble
- To assemble.

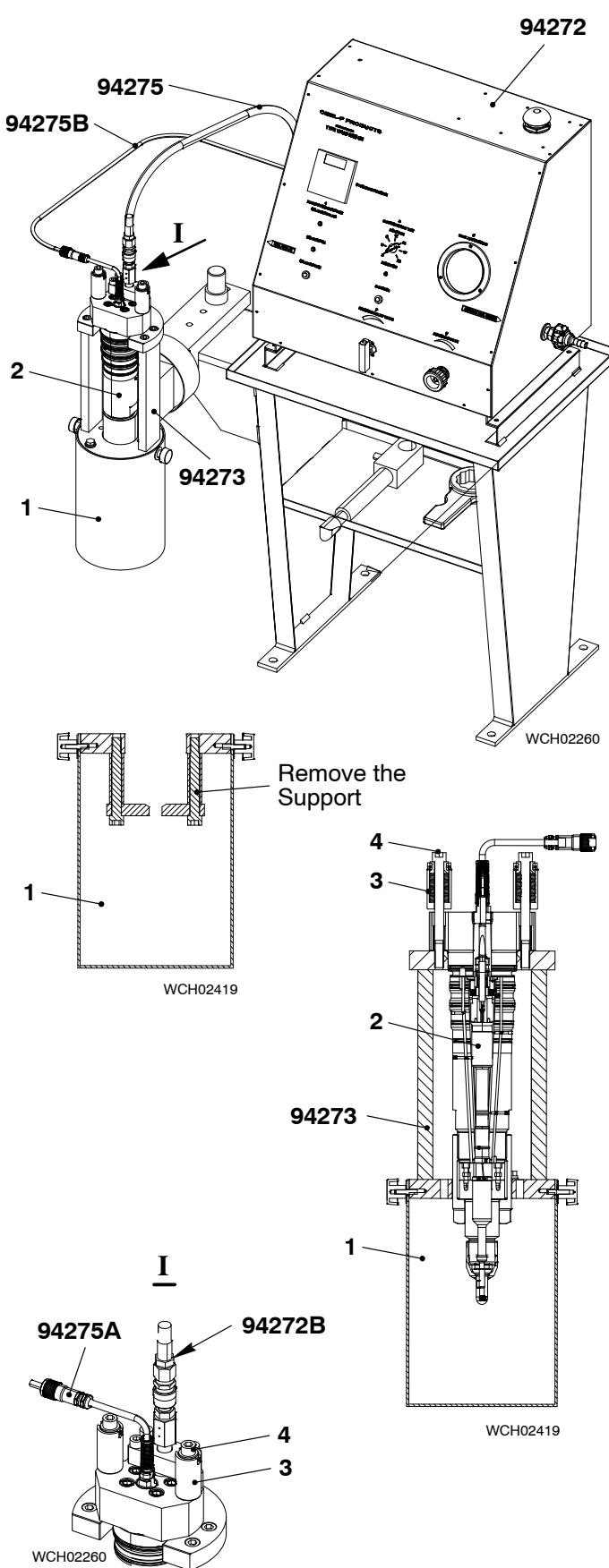
The properties of the calibration fluid (e.g. Shell Calibration Fluid S.9365, Univar Calibration Fluid 1487) are as follows:

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

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

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

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



2. Preparation

WARNING



Fire Hazard. Do not use welding or grinding equipment near the work area. Fuel and solvents are flammable.

WARNING



Injury Hazard. Calibration fluid is a harmful substance. Always read the manufacturer's safety instructions before you use calibration fluid.

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

3. Procedure

3.1 Checks

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

DANGER



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

Fig. 1

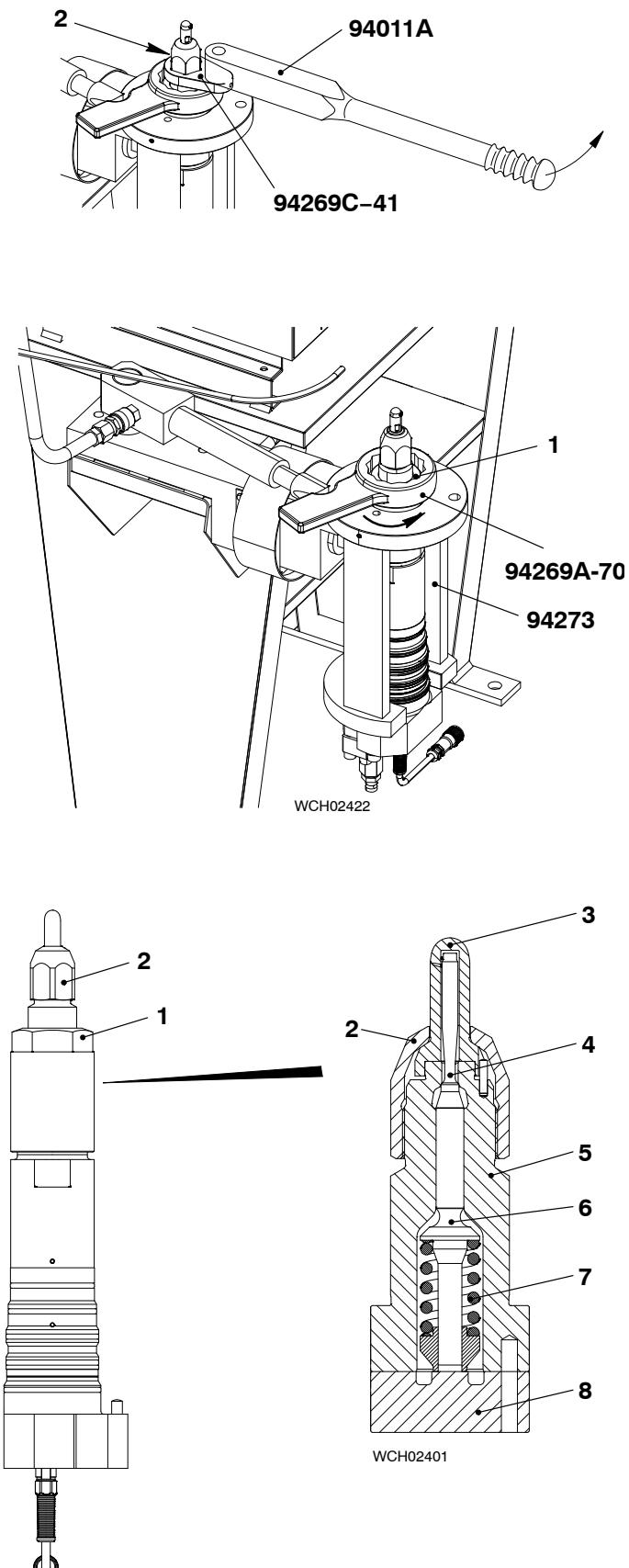
- 3) Read the data in the manufacturer's instruction and set the pressure of the test bench to 600 bar.
- 4) Push the inject button. The injection valve must operate correctly.
- 5) Do a check of the seating surface between the needle seat and nozzle as follows:
 - a) Keep the pressure in the test bench constant at approximately 400 bar.
 - b) Monitor the injection valve for 30 seconds. No fuel must come out of the nozzle.
- 6) Do a check of the pressure as follows:
 - a) Set the pressure to 350 bar, then push the INJECT button. No fuel must come out of the nozzle.
 - b) Set the pressure to 450 bar, then push the INJECT button. Fuel must come out of the nozzle as a spray.

3.2 Results

- 1) For the correct function and to use an injection valve again, read the data below:
 - The pressure to operate the injection valve is between 350 and 450 bar, refer to the test above. The pressure to operate a new injection valve is approximately 400 bar.
 - For used injection valves, a pressure decrease of 30 bar is permitted.
 - Most of the fuel will come out as a spray from the top set of holes in the nozzle tip at the specified pressure.
 - At the end of an injection, no fuel must come out of the nozzle.
- 2) If the injection valve does not function satisfactorily, disassemble as given in paragraph 4.

You must replace nozzle tips that have worn holes in the nozzle. It is not recommended, but possible, to replace the nozzle tip with the needle installed. If you replace the nozzle tip with the needle installed, make sure that this is done carefully.

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

**Fig. 2**

4. Disassemble

4.1 Injection Valve

- 1) Make sure that the test bench has no pressure.
- 2) Remove the receiver (1, Fig.1) from the valve holder (94273).
- 3) Make sure that the HP hose (94275) is disconnected from the connecting piece (94272B).
- 4) Make sure that the leakage oil hose (94275B) is disconnected from the injection valve.
- 5) Turn the valve holder (94273, Fig. 2) through 180° into the vertical position.
- 6) Use the torque spanner (94011-03) and adapter (94269C-55, (AF55)) to carefully loosen the locknut (2).
- 7) Remove the locknut (2).
- 8) Use the wrench (94269A-65). and the hydraulic cylinder (94269B) to loosen the coupling nut (1).
- 9) Remove the locknut (2) and the coupling nut (1).
- 10) Remove the nozzle body (5) together with the:
 - Intermediate plate (8)
 - Compression spring (7).
 - Tappet (6)
 - Needle (4)
 - Nozzle tip (3).

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

- 11) If it is necessary to remove the nozzle tip (3) from the nozzle body (5), do the procedure in paragraph 5).
- 12) Remove the intermediate plate (8).
- 13) Remove the compression spring (7), the tappet (6) and the needle (4).

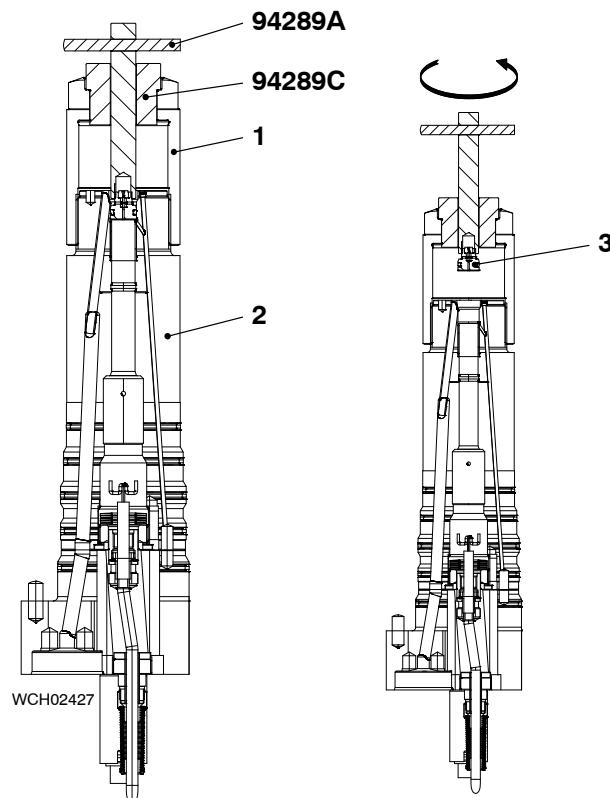


Fig. 3

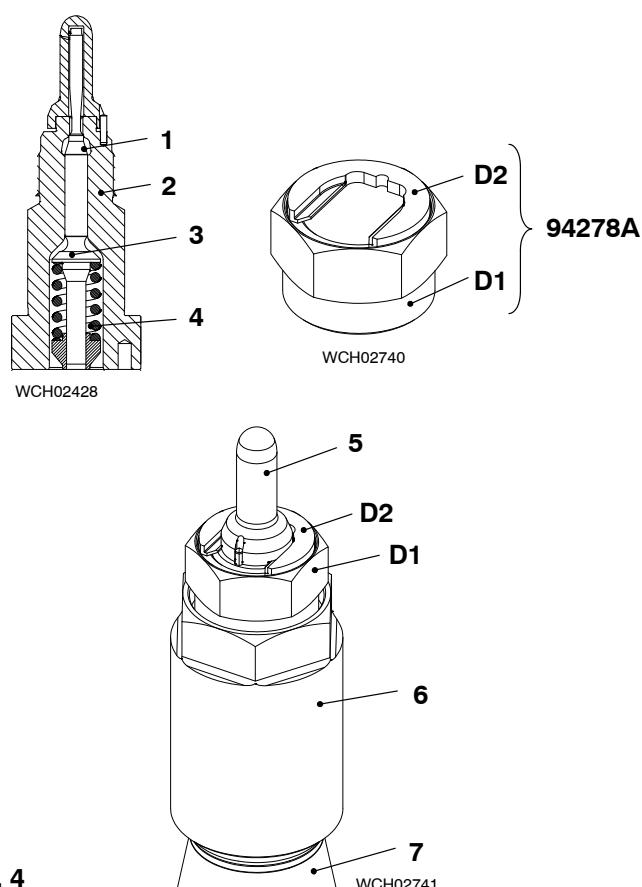


Fig. 4

4.2 Pilot Valve – Removal

- 1) Remove the pilot valve (3, Fig. 3) from the injection valve (2) as follows:

Note: When you do the step below, it is not necessary to torque the coupling nut (1).

- 2) Attach the coupling nut (1) to the injection valve (2).
- 3) Attach the bush (94289C) to the coupling nut (1).
- 4) Put the T-handle (94289A) in position as shown.
- 5) Engage the T-handle (94289A) with the pilot valve (3).
- 6) Turn the T-handle (94289A) to remove the pilot valve (3).
- 7) Examine all parts for damage and corrosion. Replace parts that have damage or corrosion.

5. Nozzle Tip – Replace

5.1 Removal

Note: It is not recommended, but possible, to replace the nozzle tip with the needle installed. Remove only the locknut.

- 1) Do the procedure given in paragraph 4.1), step 1) to step 7).
- 2) Make sure that the needle (1, Fig. 4), compression spring (4) and tappet (3) are removed from the nozzle body (2).
- 3) Attach the nozzle body (2) with coupling nut (6) to the injection valve (7) on the test bench.
- 4) Attach the hexagonal nut D1 (94278A) to the nozzle body (2).
- 5) Put the plate D2 in the clearance between the nozzle body (2) and the nozzle tip (5).
- 6) Carefully turn the hexagonal nut D1 up to remove the nozzle tip (5).
- 7) Remove the nozzle tip (5) from the nozzle body (2).
- 8) Remove the tool (94278A) from the nozzle tip (5).

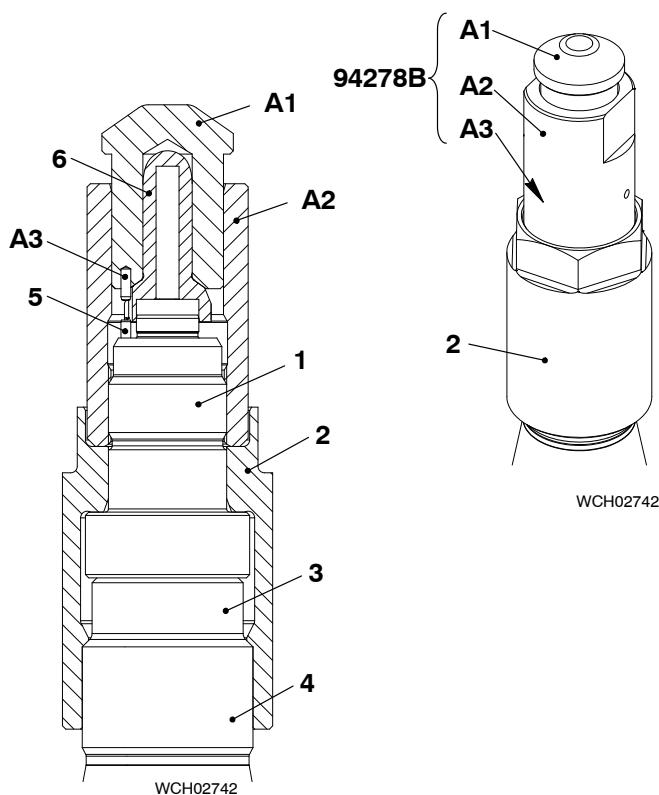


Fig. 5

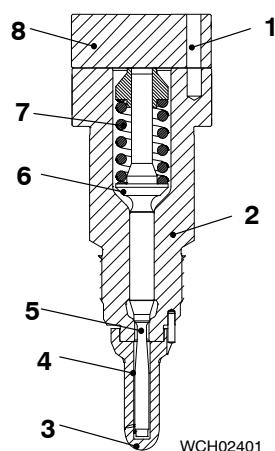


Fig. 6

5.2 Installation

- 1) Attach the nozzle body (1, Fig. 5) with coupling nut (2) to the injection valve (4) on the injection test bench.
- 2) Make sure the dowel pin (5) is installed.
- 3) Attach the guide bush (A2, 94278B) to the nozzle body (1).
- 4) Put the nozzle tip (6) into the cylinder (A1, 94278B). Align the recess in the nozzle tip with the dowel pin (A3).
- 5) Put the cylinder (A1) and the nozzle tip (6) into the guide bush (A2).
- 6) Turn the cylinder (A1) until the recess of the nozzle tip aligns with the dowel pin (5).

Note: The cylinder (A1) moves down a small distance and cannot be moved more with your hand.

- 7) Use copper or rubber hammer to tap the cylinder (A1) fully down.
- 8) Turn the guide bush (A2) counterclockwise to remove the nozzle assembly tool (94278B).
- 9) Remove coupling nut (2) and nozzle body (1).
- 10) Use clean diesel oil, or clean kerosene to clean the needle (5, Fig. 6), tappet (6) and compression spring (7).
- 11) Use a clean, low-pressure air supply to dry the needle (5) tappet (6) and compression spring (7).
- 12) Put the needle (5) into the nozzle tip (3). Make sure that the the needle moves freely.
- 13) Put the tappet (5) and compression spring (7) in the nozzle body (2).
- 14) Attach the intermediate plate (8) to the nozzle body (2). Make sure that the dowel pin (1) engages in the hole in the nozzle body.
- 15) Do the procedure in paragraph 6 to assemble the injection valve.

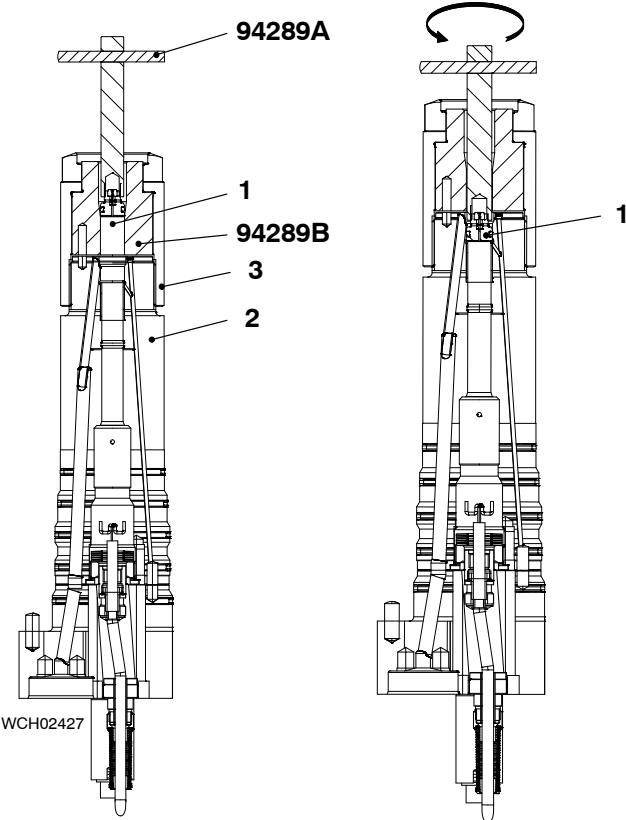


Fig. 7

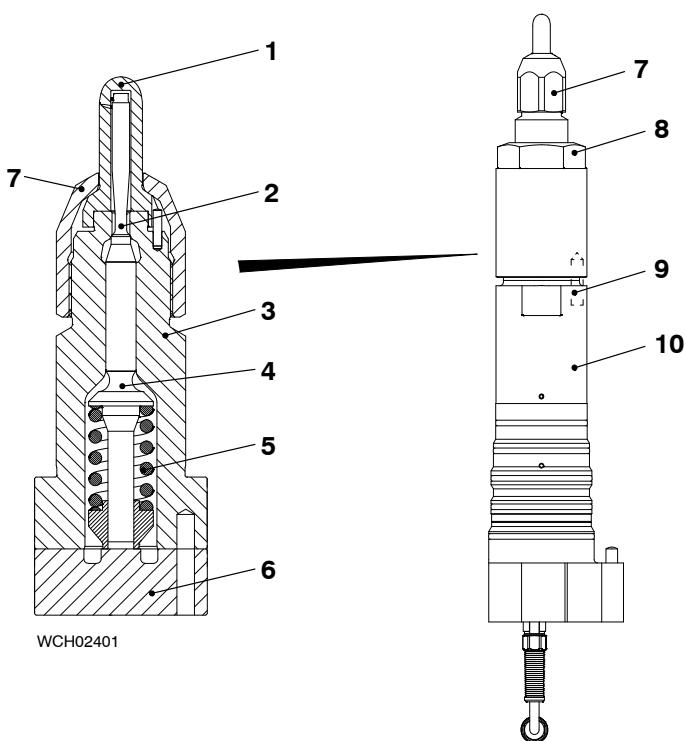
6. Assemble

6.1 Pilot Valve – Install

- 1) Install the pilot valve (1, Fig. 7) in the injection valve (2) as follows:

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

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



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

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

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

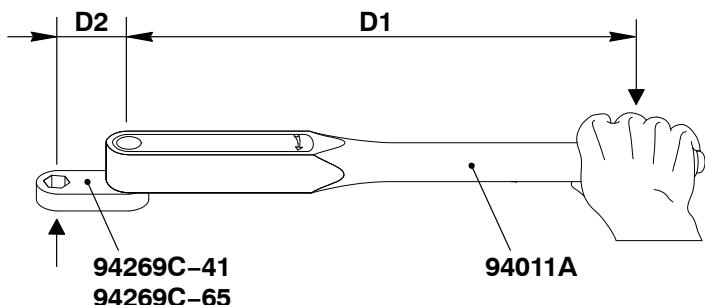


Fig. 8

6.2 Injection Valve – Assemble

- 1) Make sure that the sealing faces of the intermediate plate (6, Fig. 8) and the related faces in the injection valve (10):
 - Are clean and dry
 - Are in a satisfactory condition
 - Have no lubricant.

Note: When you do the step below, make sure that the dowel pin (9) engages with the hole in the intermediate plate (6).

- 2) Put the nozzle body (3) together with the intermediate plate (6) in position on the injection valve (10).
- 3) Apply a thin layer of Never-Seez NSBT to the thread and seating face of the coupling nut (8).
- 4) Attach the coupling nut (8) to the nozzle body (3) with your hand.
- 5) Refer to the formulas shown, where:
 - TS = the applicable torque setting for the torque spanner.
 - TT = the specified torque setting for the coupling nut and locknut.
 - D1 = the distance from the center of the square drive to the center of the hand grip.
 - D2 = the distance from the center of the square drive to the center of the adapter.
- 6) Use the torque spanner (94011A) and the wrench extension (94269C-65) to torque the coupling nut (8) to 88 Nm.
- 7) Use the wrench (94269A-65) and the cylinder on the test bench to add between 35° and 40° to the position of the coupling nut (8).
- 8) Apply a thin layer of Never-Seez NSBT to the thread and seating face of the locknut (7).
- 9) Attach the locknut (7) to the nozzle body (3) with your hand.
- 10) Use the torque spanner (94011A) and the wrench extension (94269C-41) to torque the locknut (7) to 169Nm.
- 11) Do a check of the injection valve, refer to paragraphs 3.1 and 3.2.

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

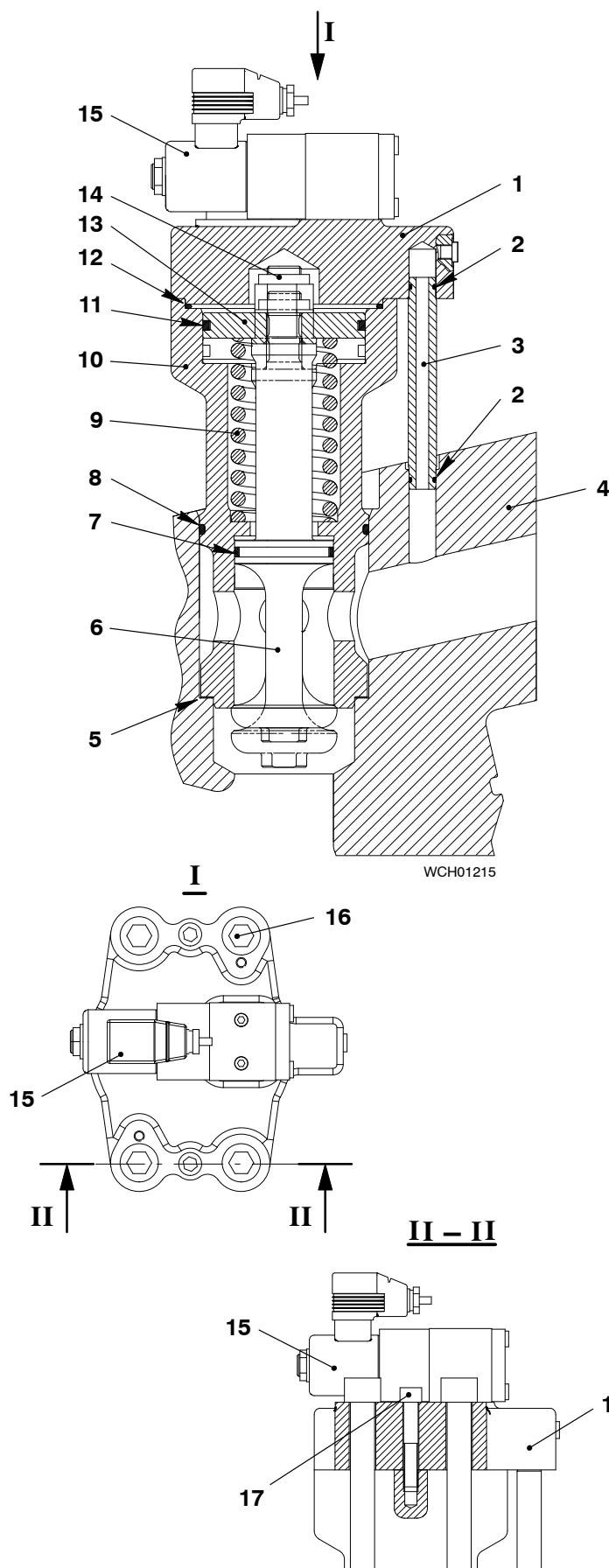


Fig. 1

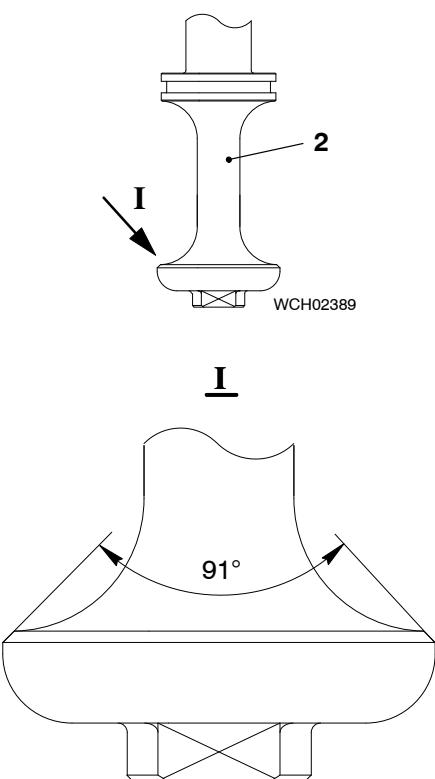
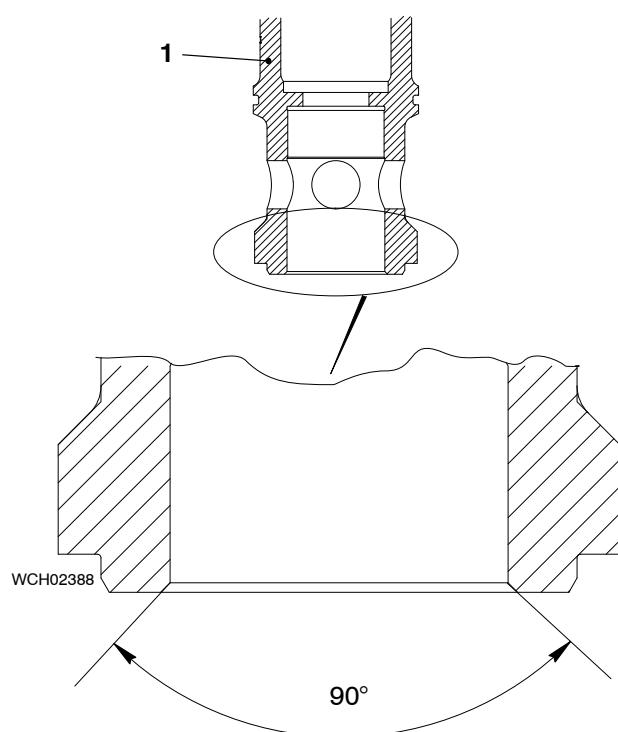
3. Removal

- 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 applicable protection over the opening in the cylinder cover (4).
 - 6) Remove the pipe (3) from the cover (1).

4. Disassemble

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

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



5. Grinding

- 1) If the seating faces of the housing (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

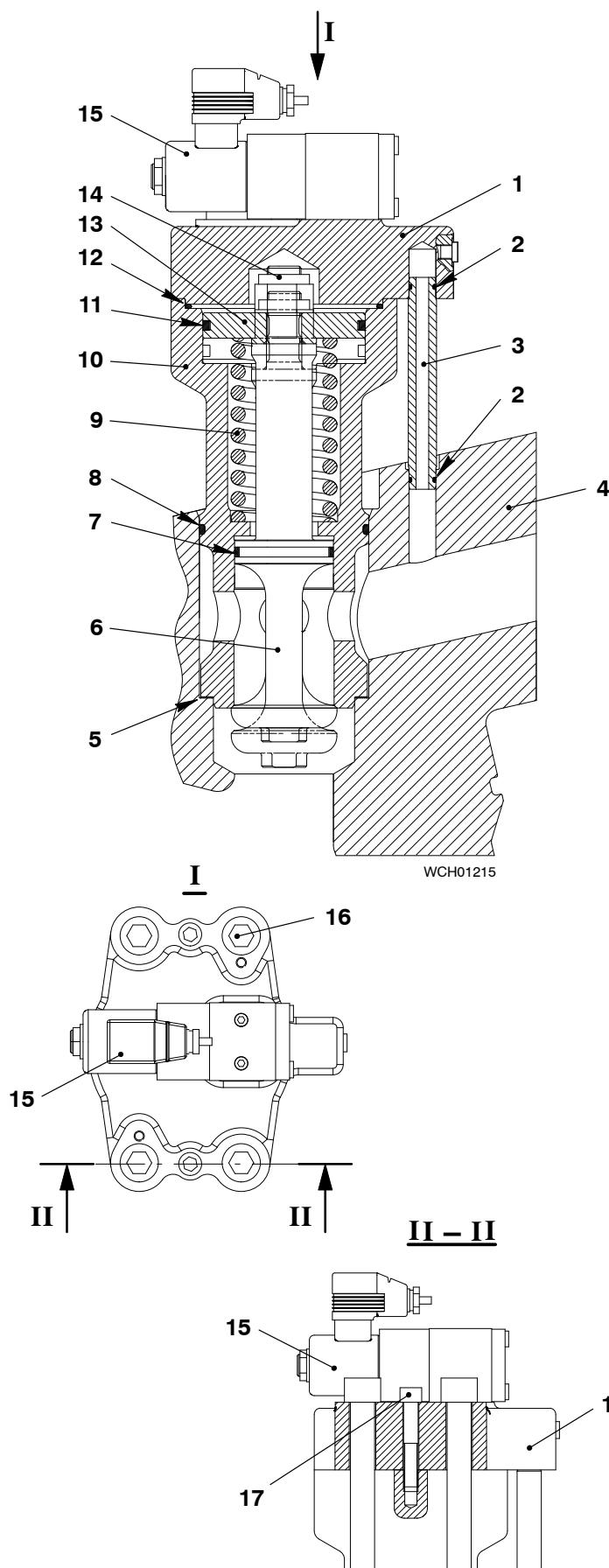


Fig. 3

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 get Molykote paste G on the thread of the valve spindle (6) where the insert of the self-locking nut (14) will go.

- 8) Apply a thin layer of Molykote paste G to the thread of the valve spindle (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) in position in 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) Put the four screws in position in the cover (1).
- 6) Torque the four screws to 350 Nm.

Exhaust Valve

Exhaust Valve – Removal and Installation

Tools:

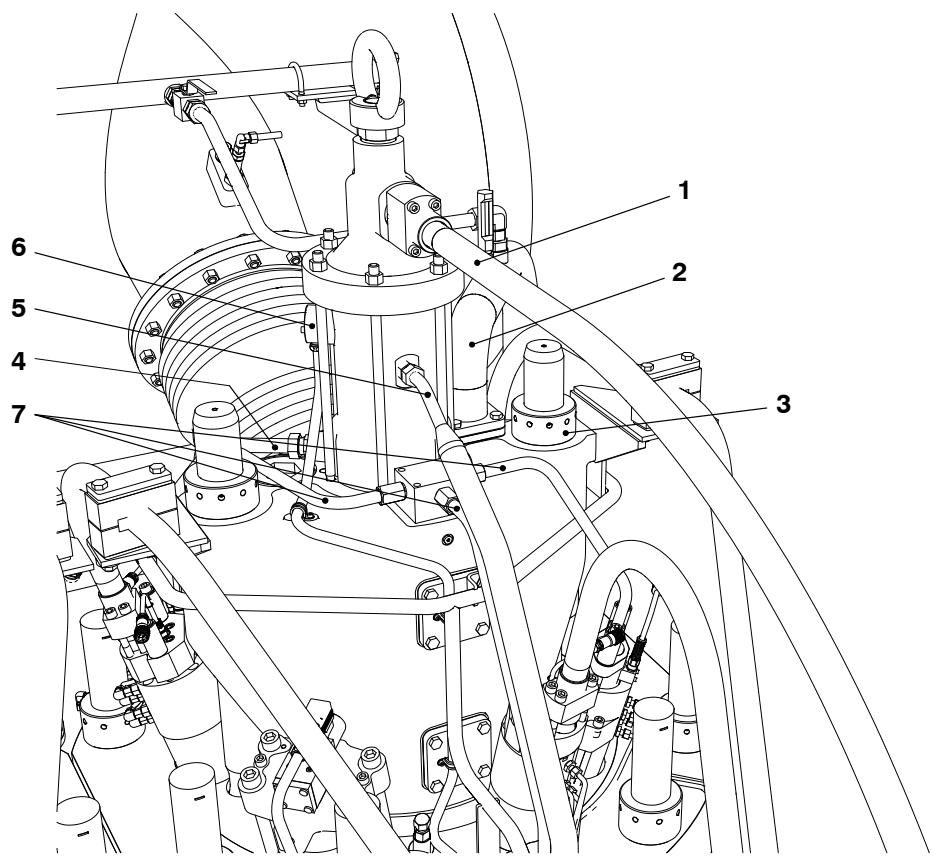
2 Sling 94049A

1. Preparation

- 1) Drain the cylinder cooling water from the related cylinder (refer to the Operation Manual 8017-1).
- 2) Close the air inlet to the air spring at the control air supply.
- 3) Remove the hydraulic pipe (1, Fig. 1) from the related exhaust valve, refer to 8460-1, paragraph 1 and paragraph 2.
- 4) Disconnect the the cooling water pipe (2).
- 5) Disconnect the the oil drain pipe (5).
- 6) Disconnect the air supply pipe (4) from the air spring.
- 7) Close the valves from the pilot fuel supply. Make sure that there is no pressure in and pilot fuel pipes (7).
- 8) Remove the three HP pilot fuel pipes (7), refer to 8790-1.

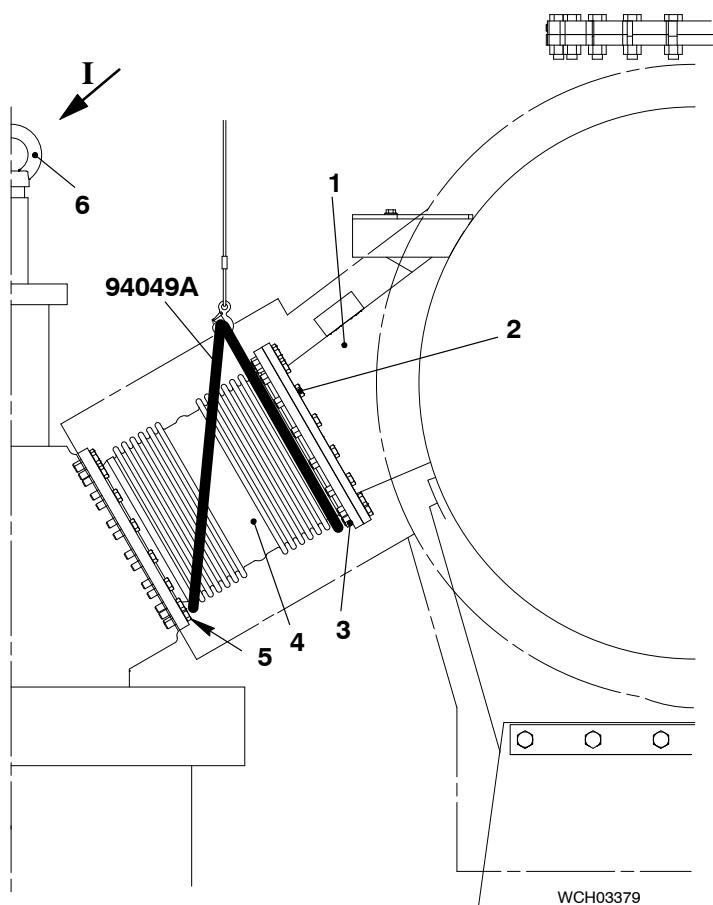
2. Removal

- 1) Remove two round nuts (3), refer to the procedure given in 9403-4, paragraph 1 and paragraph 2.
- 2) Disconnect the electrical connection (6) from the valve stroke sensor.

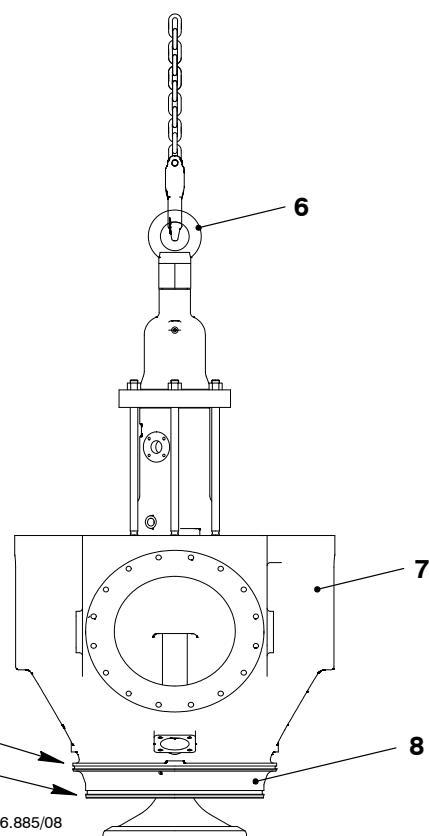
**Fig. 1**

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Exhaust Valve – Removal and Installation

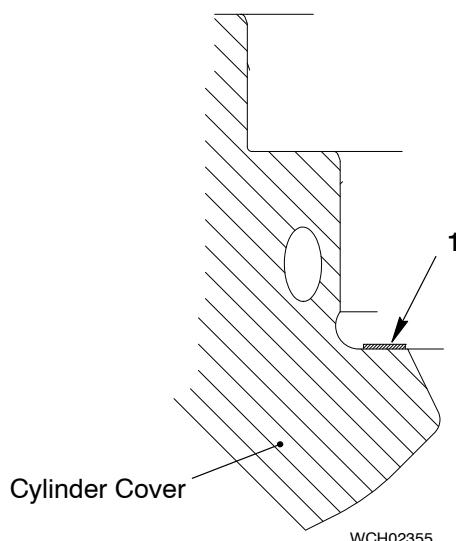
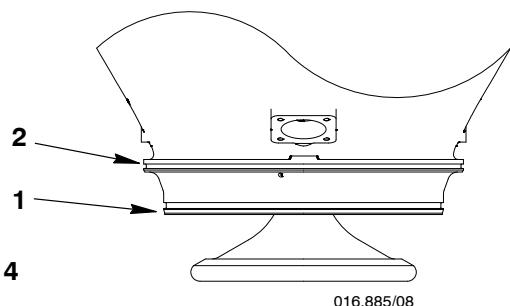
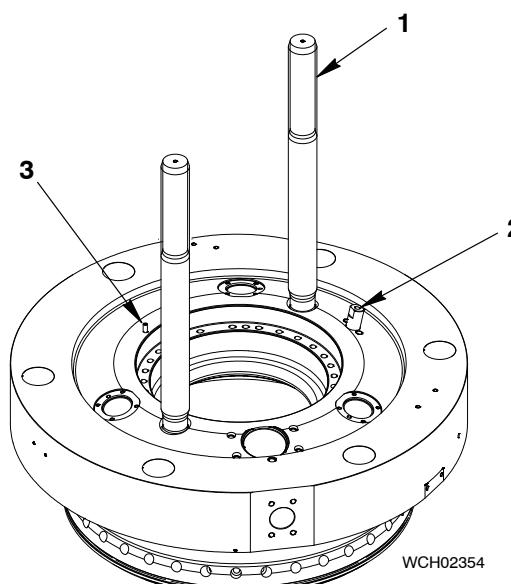


- 3) Put the slings (94049A, Fig. 2) in position on the expansion piece (4) as shown.
- 4) Connect the slings (94049A) to the hook on the crane.
- 5) Use the crane to put a light tension on the slings (94049A).
- 6) Remove the 16 screws (5).
- 7) Remove the 16 nuts (3) and the bolts (2).
- 8) Move the expansion piece (4) to one side.
- 9) Lower the expansion piece (4) on to an applicable surface.
- 10) Attach the crane hook to the eye bolt (6).

I**Fig. 2**

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

Exhaust Valve – Removal and Installation

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

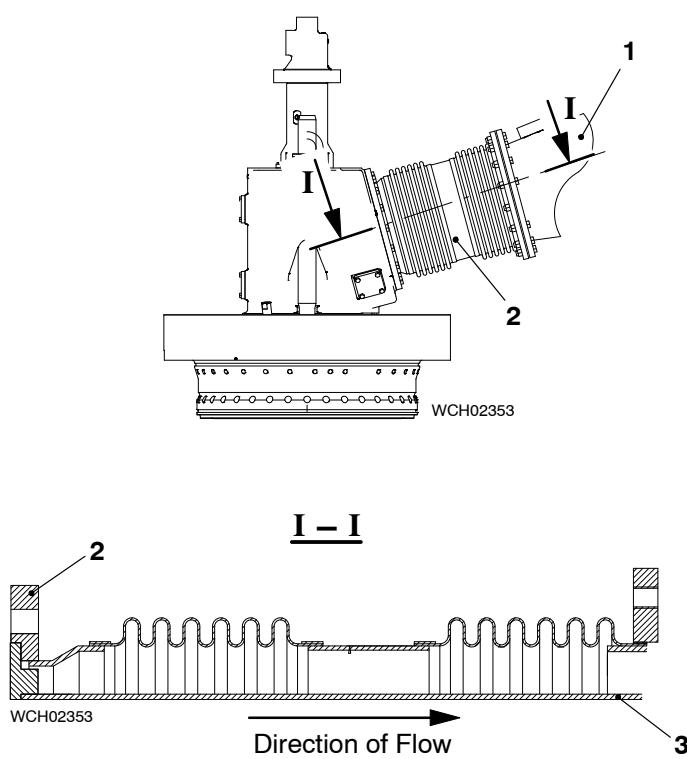
- 1) Clean all the sealing surfaces of the exhaust valve and the cylinder cover.
- 2) Examine the sealing surfaces of the exhaust valve and cylinder cover for damage.
- 3) Remove the 2.0 mm metal gasket (1, [Fig. 3](#)) from the cylinder cover.
- 4) Clean the the 2.0 mm metal gasket (1).
- 5) Examine the 2 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 to 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, see [Fig. 2](#)).
- 11) Operate the crane to lift the exhaust valve.

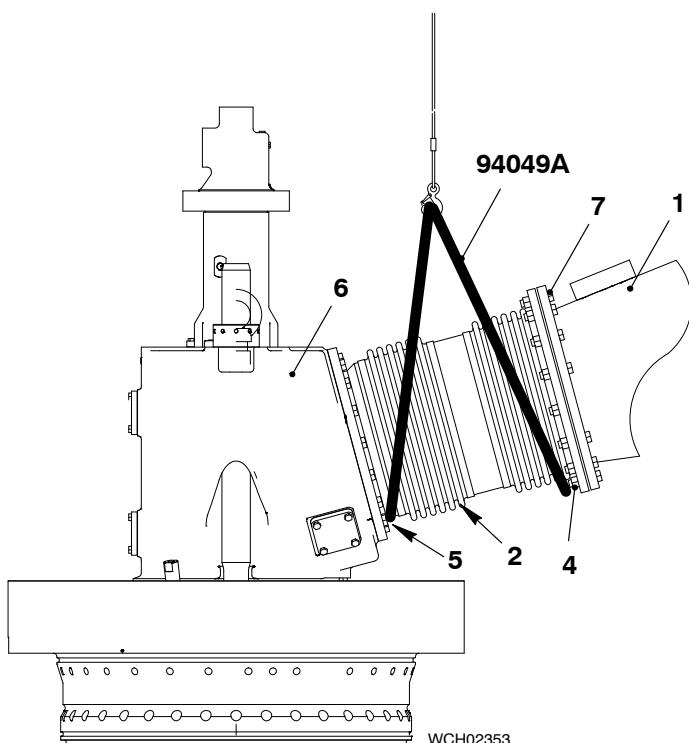
Note: When you do the step 12), make sure that you do not damage the threads of the elastic studs (1, [Fig. 5](#)).

- 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.

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) Connect the slings (94049A) to the hook on the crane.
- 18) Operate the crane to lift the expansion piece (2).
- 19) Put the expansion piece (2) in position between the valve cage (6) and the exhaust pipe (1). Make sure that the direction of flow is correct (see view I - I).
- 20) Install the 16 screws (5) and (7) and 16 nuts (4).
- 21) Remove the slings (94049A).

**Fig. 6**

Exhaust Valve – Removal and Installation

4. Completion

- 1) Connect the electrical connector to the valve stroke sensor (6, [Fig. 7](#)).
- 2) Open the air inlet to the air spring at the control air supply.
- 3) Install the applicable hydraulic pipe to the exhaust valve, refer to 8460-1, paragraph [4](#).
- 4) Connect the air inlet pipe (4) to the air spring supply.
- 5) Install the three HP pilot fuel pipes (7), refer to [8790-1](#).
- 6) Connect the oil supply pipe (5) to the valve guide.
- 7) Connect the cooling water pipe (2).
- 8) Fill the cylinder cooling water to the applicable cylinder (refer to the Operation Manual 8017-1).
- 9) Open the valves you closed before (one valve each time) and do a check for leaks.

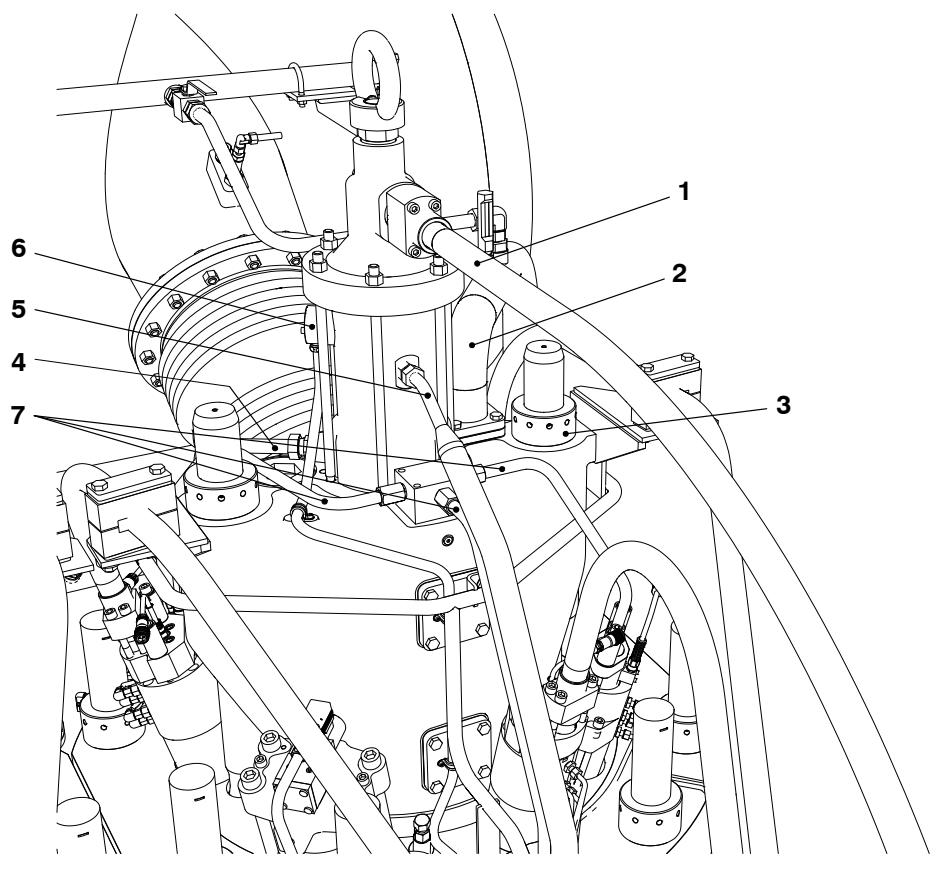


Fig. 7

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Exhaust Valve

Disassemble and Assemble

Tools:

1 Depth gauge	94126	2 Eye bolts	94045-M12
2 Jack screws	94263	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 Valve Guide – Oil Supply	7

1. General

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 530 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.

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

Only qualified personnel, or a Wärtsilä Switzerland Ltd. authorized repair workshop can repair defective exhaust valves.

For the inspection and overhaul intervals, refer to 0380–1 Maintenance Schedule.

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

Exhaust Valve: Disassemble and Assemble

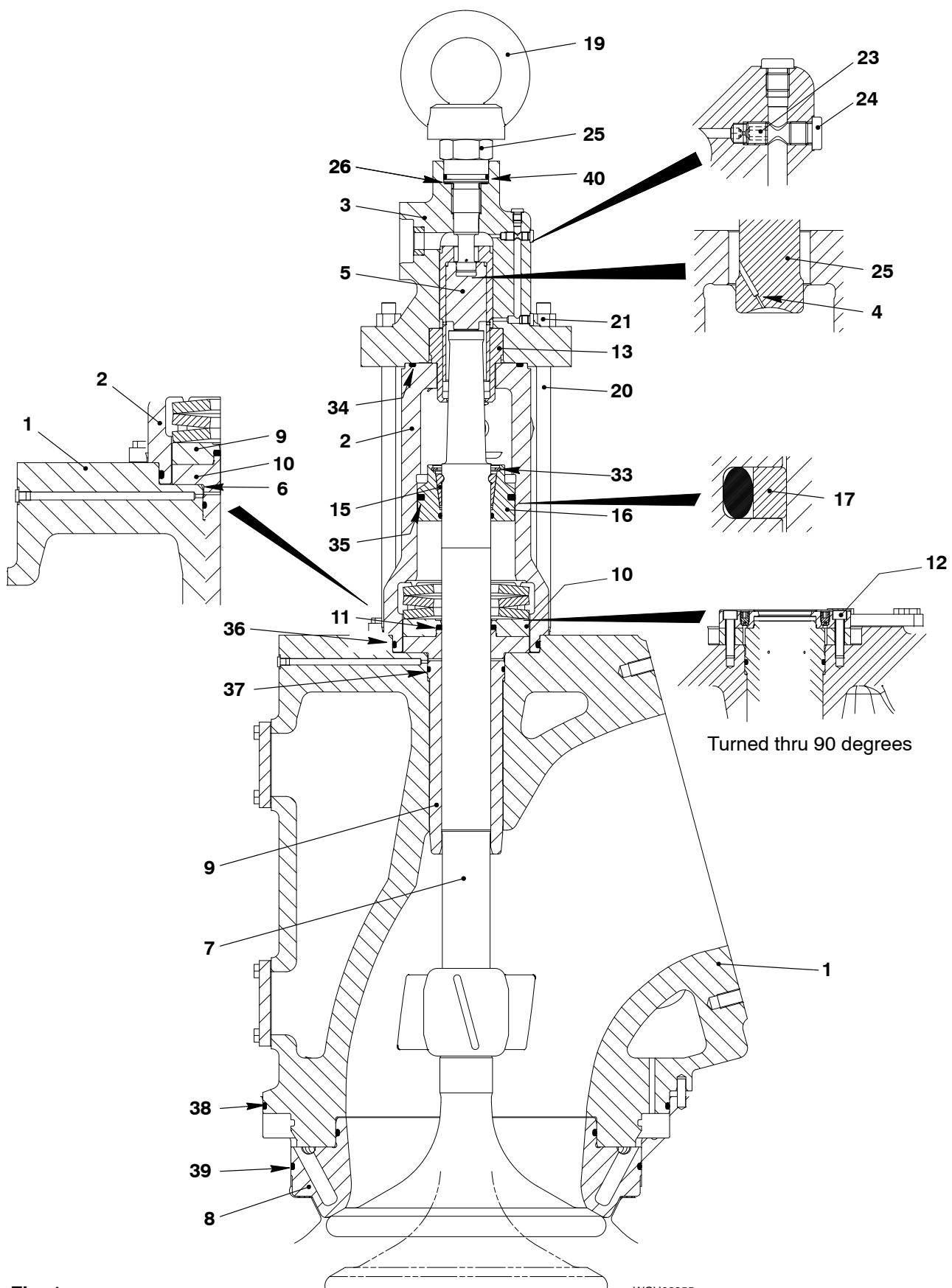
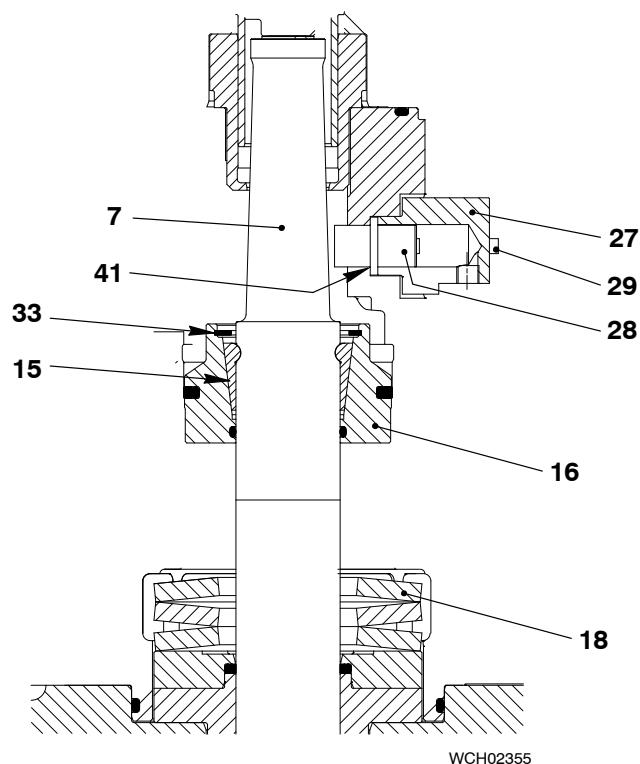
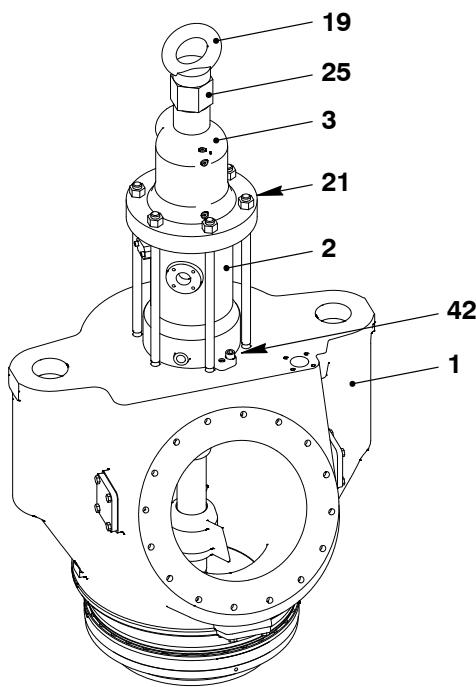


Fig. 1

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Exhaust Valve: Disassemble and Assemble

**Fig. 2**

2. Exhaust Valve – Disassemble

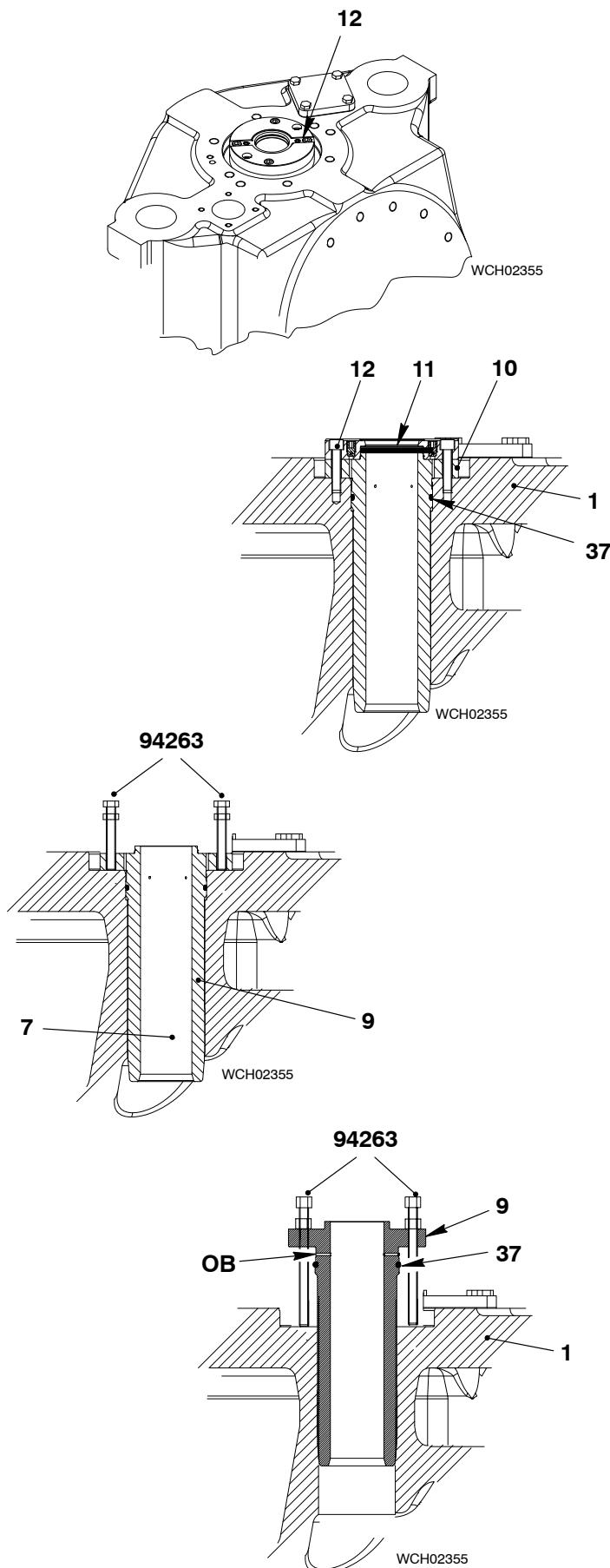
2.1 Valve Drive – Disassemble

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

2.2 Valve Spindle – Remove

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

Exhaust Valve: Disassemble and Assemble

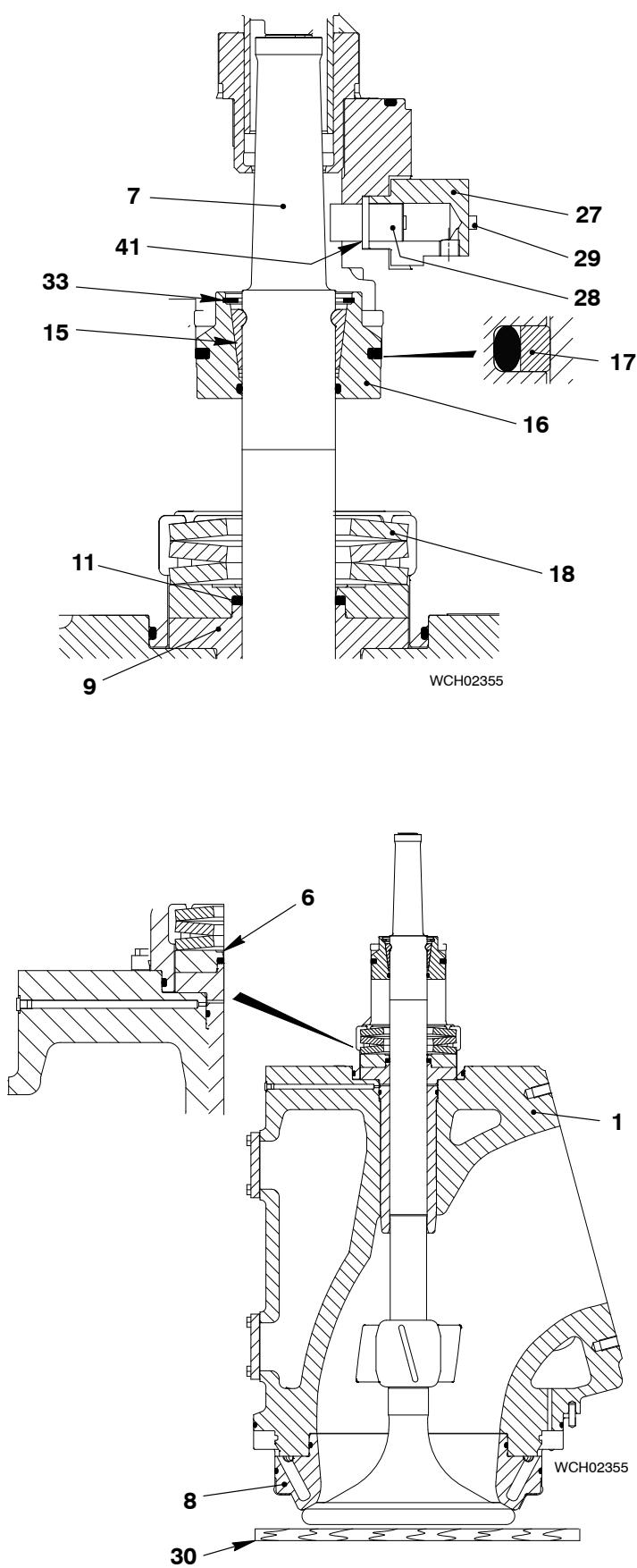
**Fig. 3****2.3 Guide Bush – Removal**

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

3. Exhaust Valve – Assemble**3.1 Guide Bush – Installation**

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

Exhaust Valve: Disassemble and Assemble

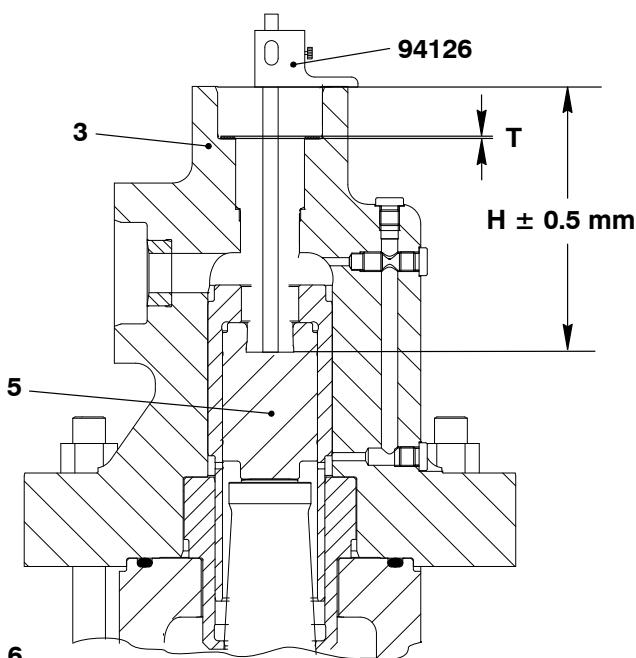
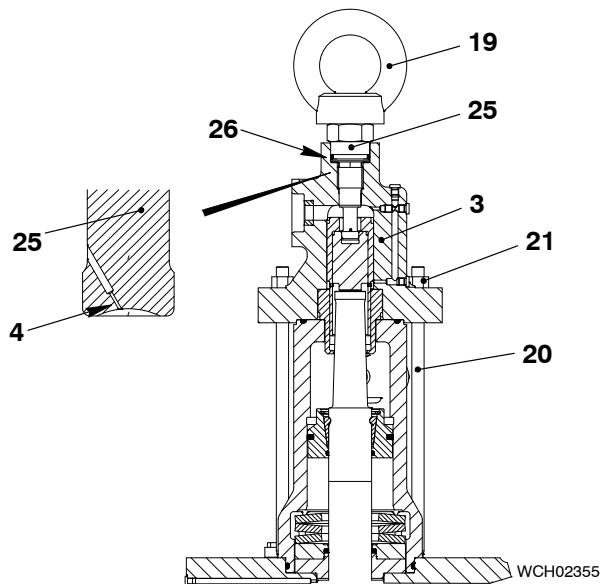
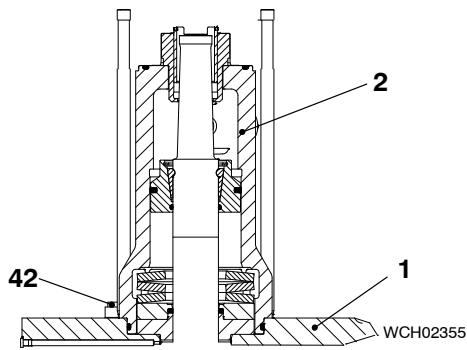
**Fig. 4****3.2 Valve Spindle – Installation**

- 1) Measure the dimensions of the valve spindle (7, Fig. 4).
- 2) Compare the values with those given in **0330-1 Exhaust Valve** table.
- 3) Do a check of the piston seal ring (17) for damage. If you find damage, replace the piston seal ring.
- 4) If necessary, replace all O-rings.
- 5) Put oil on the valve spindle (7).
- 6) Use two M12 eye bolts and two ropes or the lifting tool (94209) to lift the valve cage to the top of the valve spindle (7). 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 a new rod seal (11).
- 9) Put the new rod seal (11) in position on the guide bush (9).
- 10) Before you install a new piston seal ring (17), do as follows:
 - a) Put the new piston ring seal in very hot water for some minutes.
 - b) Carefully put the piston seal ring in the correct position on the piston (16).

3.3 Valve Drive – Assemble

- 1) Push the valve spindle (7) against the valve seat (8).
- 2) Install the cup springs (18).
- 3) Put the piston (16) in position on the valve spindle (7).
- 4) Attach the valve coppers (15) to the valve spindle (7) with the circlip (33).
- 5) Attach the lifting tool (94209) to the valve cage (1) and the crane.
- 6) Operate the crane to lift the valve cage (1) to the vertical position.
- 7) Lower the valve cage (1) onto a suitable wooden underlay (30).
- 8) Remove the lifting tool (94209) from the valve cage (1).
- 9) Fill the oil bath (6) with system oil.

Exhaust Valve: Disassemble and Assemble



- 10) Attach two eye bolts M8 to the housing (2, Fig. 5).
- 11) Lift, then lower the bottom housing (2) on to the valve cage (1).
- 12) Install the six screws (42).
- 13) Attach the crane hook to the eye bolt (19 Fig. 6).
- 14) Lift, then carefully lower the top housing (3) on to the housing (2).
- 15) Remove the lifting tool (94209) from the top housing (3) and the crane.
- 16) Put oil on to the threads of the elastic studs (20).
- 17) Put the six nuts (21) on to the elastic studs (20).
- 18) Torque symmetrically the six nuts (21) to 150 Nm.

3.4 Damper Setting

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

- 1) Remove the damper (25).
- 2) Make sure that the bores (4) in the damper are clear.
- 3) Make sure that the exhaust valve is closed.
- 4) Use a feeler gauge to make sure there is no clearance between the valve plate and valve seat.
- 5) Use the depth gauge (94216) to measure the height H from the seat of the damper to the bottom of the damper bore.

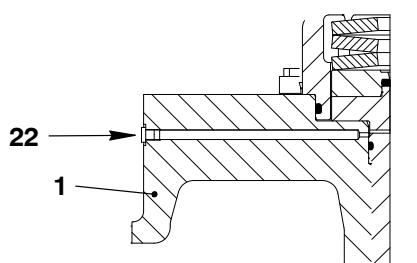
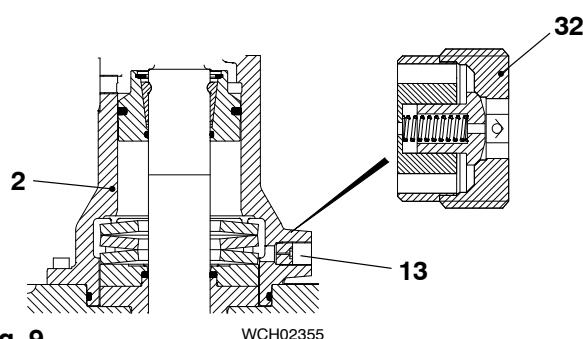
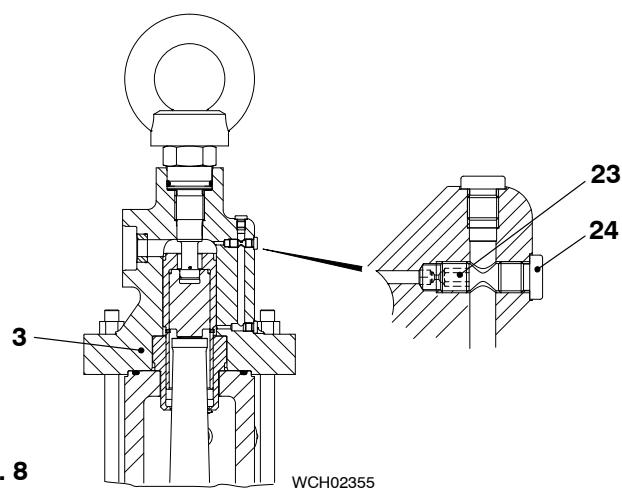
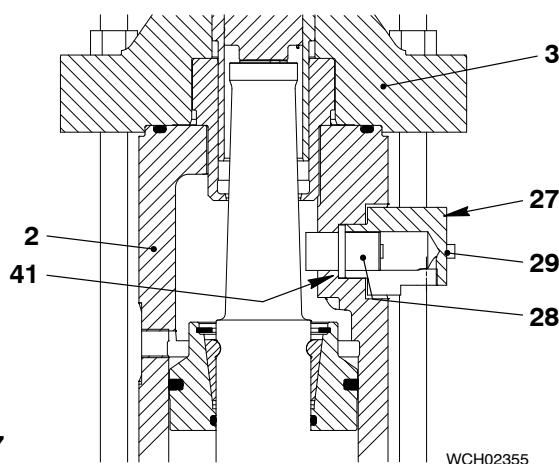
Note: The total thickness T of the shims used to measure the height H is given in the table that follows:

Height \pm 0.5 mm	Total Thickness T
110.7 mm	1.0 mm
109.7 mm	2.0 mm
108.7 mm	3.0 mm
107.7 mm	4.0 mm
106.7 mm	5.0 mm
105.7 mm	6.0 mm

- 6) Install the damper (25) and the applicable shims to get the total thickness.

Note: Shims of dimension 1.0 mm are available.

Exhaust Valve: Disassemble and Assemble



3.5 Valve Stroke Sensor – Installation

- 1) Clean the parts that follow:
 - The valve stroke sensor (28, Fig. 7).
 - The transmitter housing (27).
 - The bore and collar in the housing (3)
- 2) Put oil on the O-ring (41) and the valve stroke sensor (28).
- 3) Carefully put the O-ring (41) and the valve stroke sensor (28) into the housing (3).
- 4) Attach the transmitter housing (27) to the bottom housing (2) with the two screws (29).
- 5) Connect the electrical connection to the valve stroke sensor (28).

3.6 Throttle

- 1) Do a check of the throttle as follows:
 - a) Remove the screw plug (24, Fig. 8).
 - b) Remove the throttle (23).
 - c) Make sure that the throttle (23) is clear.
 - d) Put oil on the threads of the throttle (23).
- 2) Put the throttle (23) in position.
- 3) Torque the throttle (23) to 20 Nm.

3.7 Non-return Valve

- 1) Do a check of the non-return valve (32, Fig. 9) as follows:
 - a) Remove the non-return valve (32) from the housing (2).
 - b) Make sure that the non-return valve operates correctly.
- 2) Install the non-return valve (32) to the housing (2).

3.8 Valve Guide – Oil Supply

- 1) Make sure that the oil bore to the valve guide (22, Fig. 10) is clear.

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Valve Seat – Replace / Grind

Tools:

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

1.	General	1
2.	Preparation	1
3.	Valve Seat – Removal	2
3.1	Recommended Procedure	2
3.2	Alternative Procedure	2
4.	Valve Seat – Grind	3
5.	Valve Seat – Check	4
6.	Valve Seat – Installation	5

1. General

You must replace the valve seat when:

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

2. Preparation

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

Valve Seat – Replace / Grind

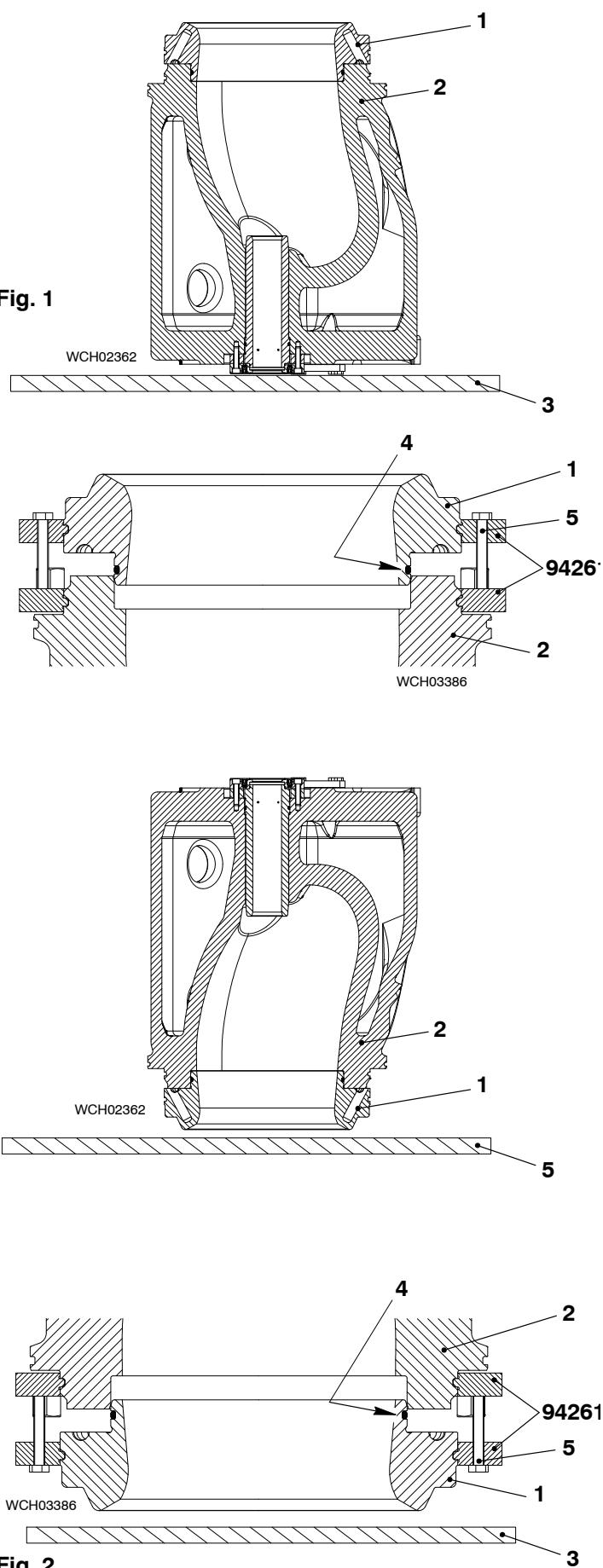


Fig. 2

3. Valve Seat – Removal

- 1) If a valve seat is removed e.g. 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 underlay (5).
- 3) Install the top two halves of the dismantling device (94261) into the groove of the valve seat (1).
- 4) Install the bottom two halves of the dismantling device (94261) into the groove of the valve cage (2).
- 5) Turn the three jack-screws (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 dismantling device (94261).

3.2 Alternative Procedure

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

- 1) Use the crane and an applicable lifting tool to hold the valve cage immediately above an applicable wooden underlay (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 – Replace / Grind

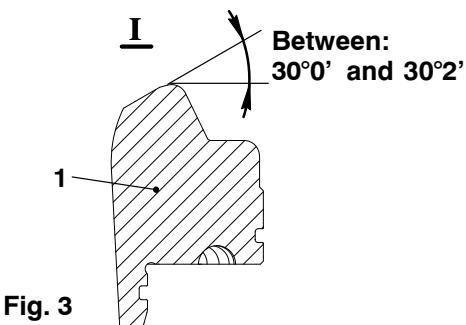
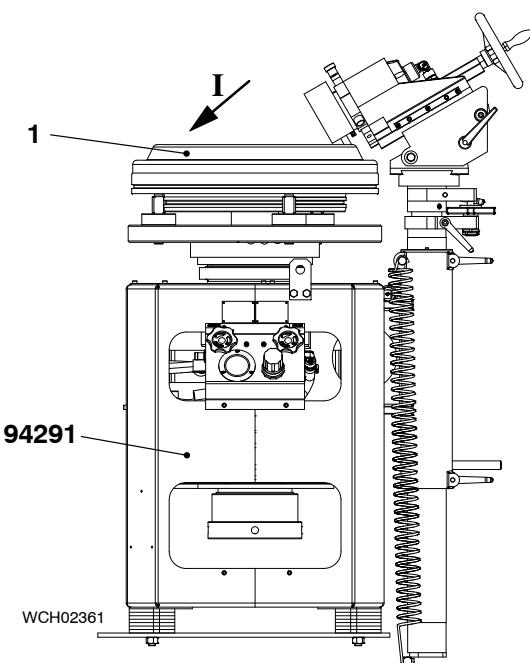


Fig. 3

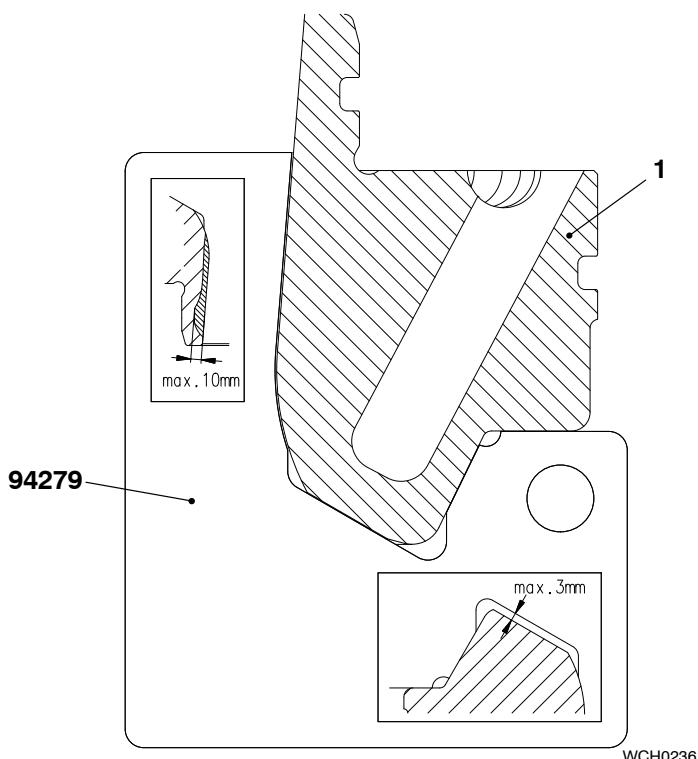


Fig. 4

- 7) Remove and discard the O-ring (3, Fig. 2).

- 8) Remove the tool (94261).

4. Valve Seat – Grind

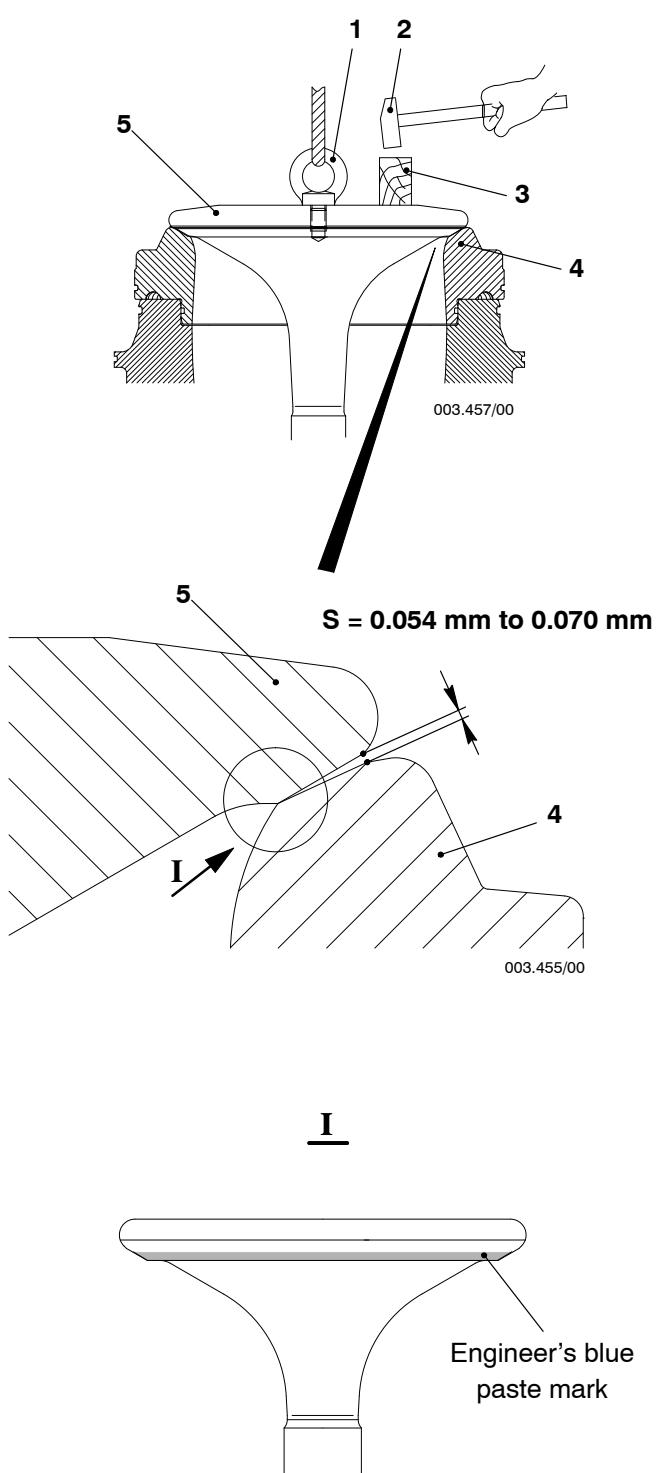
Use only the tool (94291, Fig. 3) to grind the valve seats.

- 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'.

Valve Seat – Replace / Grind

**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), see [Fig. 5](#).
- 2) Attach an applicable eye bolt (1) and sling to the valve spindle (5).
- 3) Put the valve spindle (5) in position in the valve guide bush.
- 4) 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 seize.

- 5) Tap the wooden block (3) with the hammer (2) three or four times.
- 6) 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, ($S=0.054 \text{ mm to } 0.070 \text{ mm}$).

- 7) Remove the valve spindle (5) from the guide bush.
- 8) Do a check of the engineer's blue paste. The blue paste must only show on the inner part of the full circumference of the valve spindle (see View I).
- 9) Remove the valve seat from the tool (94291).

Valve Seat – Replace / Grind

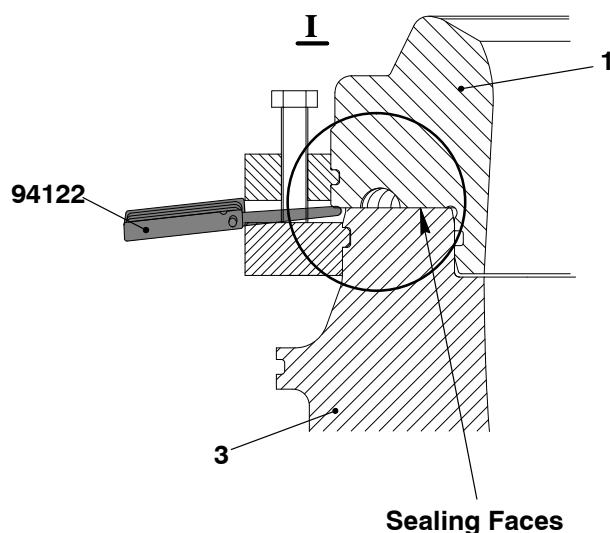
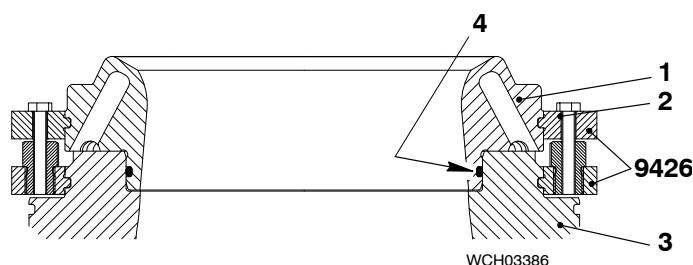


Fig. 6

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 e.g. 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).

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Exhaust Valve

Grinding the Seating Surface on the Valve Head

Tools:

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

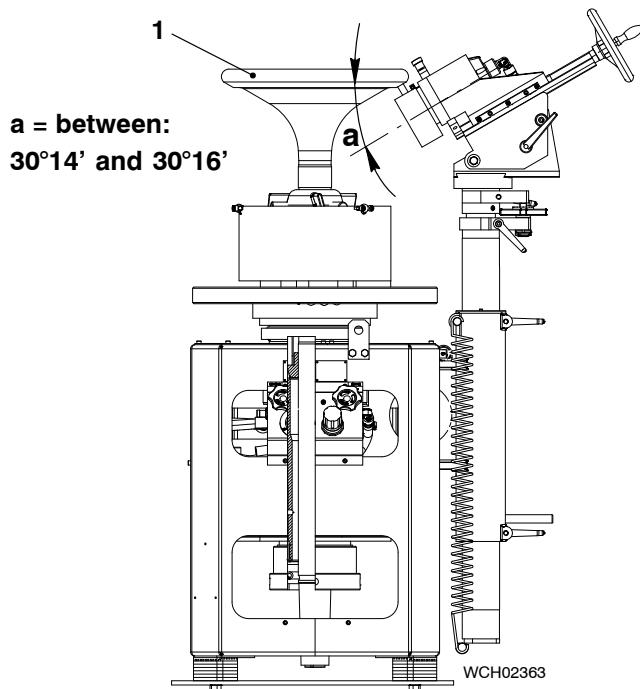


Fig. 1

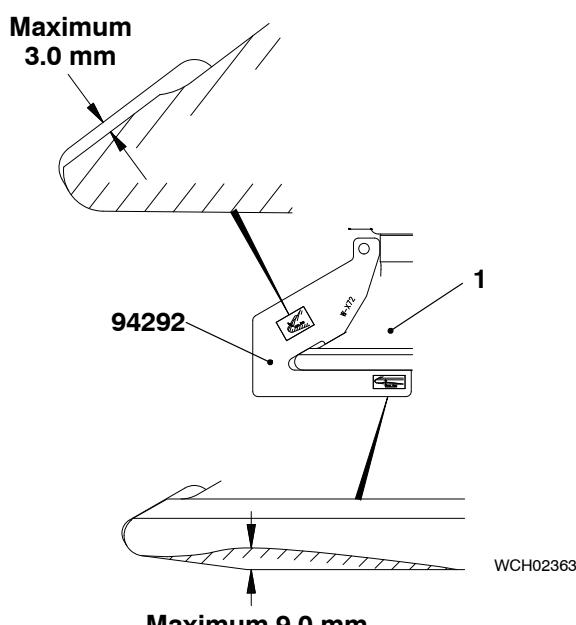


Fig. 2

1. General

Use only the grinding device (94291, 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 device (94291).
- 2) Put the grinding device (94291) in an area where there is no vibration.

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

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

Note: The data shown on the template (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 the procedure that follows:
 - a) Use the grinding device (94291) to grind the surface of the valve head (1). Remove only the minimum material necessary to get a smooth, flat surface.
 - b) Use an applicable coolant to keep cool the valve head (1).
 - c) Keep the angle of the valve head (1) to between 30°16' and 30°18'.

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

- 7) Do a check of the valve seat and valve spindle 9 (refer to 2751-3, paragraph 5).

Exhaust Valve: Grinding the Seating Surface on the Valve Head

- 8) If the measured values are more than the limits given on the gauge (94122), you can repair the valve spindle (refer to the data below).
- 9) If you grind off more than 3.0 mm, do the procedure that follows:
 - a) Use a build-up welding procedure to repair the valve seating surface.
 - 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 (e.g. in rough weather conditions).

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

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

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

Remove and Install

Tools:

1	Obel test bench complete	94272	1	Socket wrench insert	94269C-55
1	Supporting plate	94270F	2	Stud bolts	94270E
2	Screw for supporting plate	94270G			

1. General

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

- To do checks
- To disassemble
- To assemble.

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

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

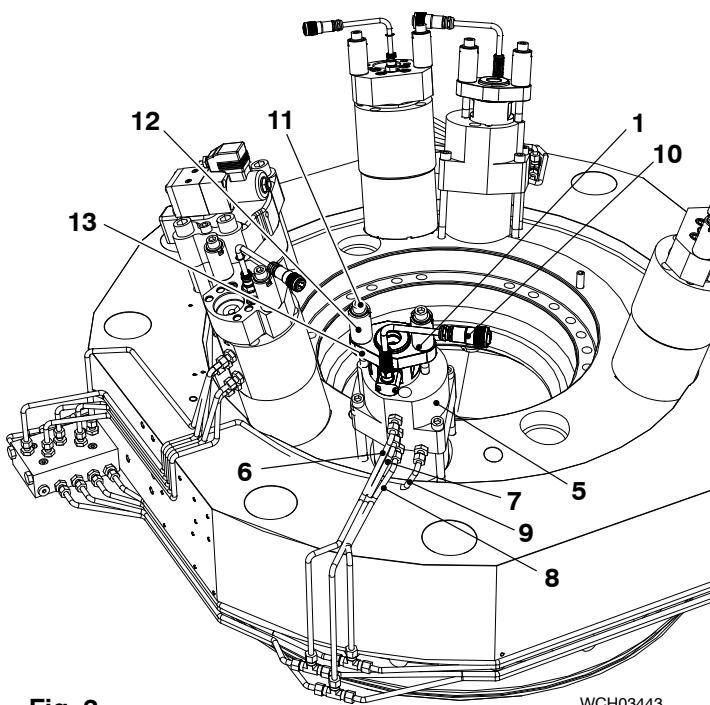
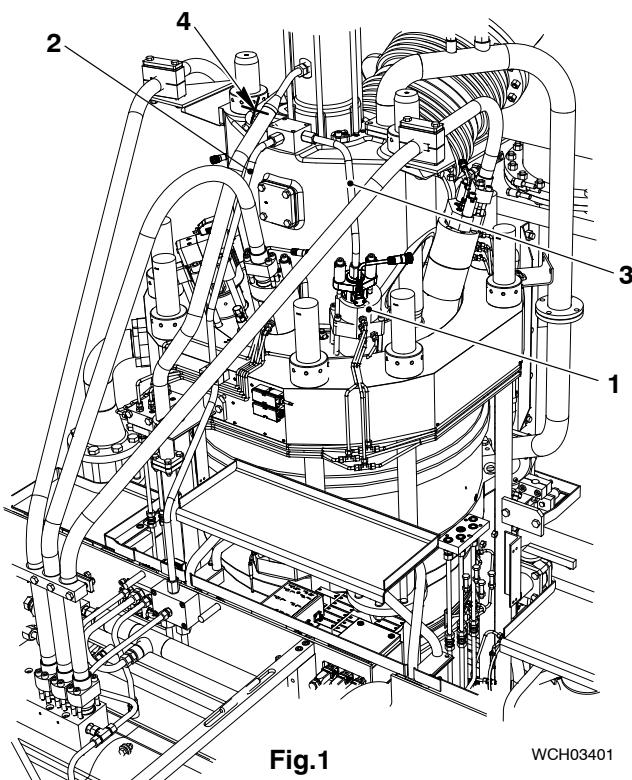
If calibration fluid is not available, you can use clean diesel oil (gas oil). If clean diesel oil (gas oil) is used, install the injection valve immediately after you complete the checks.

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

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

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

Pilot Injection Valve: Replacement

**2. Preparation**

- 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) Close the valves from the fuel supply and pilot fuel supply. Make sure that there is no pressure in the pilot fuel pipe (2, Fig. 1).
- 4) Fuel supply must be closed.
- 5) Lube oil supply must be closed.
- 6) Drain from pilot inection valve to sludge tank must be open.
- 7) Remove the applicable pilot fuel pipe (3) or (4), refer to [8790-1](#).

- 8) Make sure the pipes to the holder (5) of the pilot fuel valve (1) have no pressure:
 - c) Lube oil return (6)
 - d) Lube oil inlet (7)
 - e) Leakage fuel/lube oil (8)
 - f) Control fuel oil return (9)
- 9) Disconnect the plug (10)

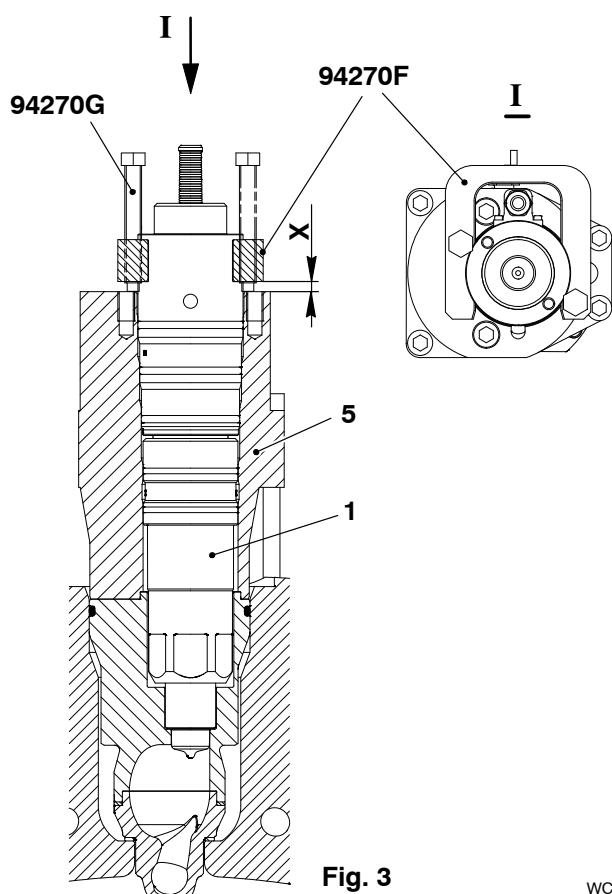
3. Removal

- 1) Remove bolts (11, Fig. 2) together with the spring cages (12) and flange (13).

WARNING

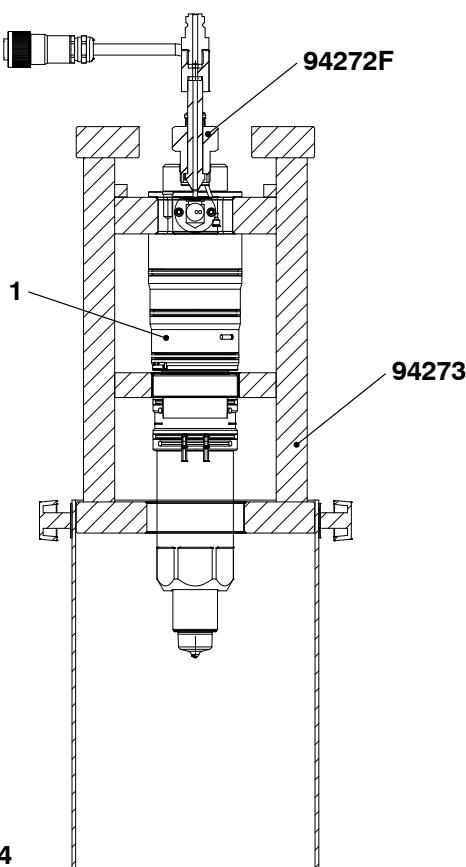
Fire Hazard: Do not use welding equipment near the work area.

Pilot Injection Valve: Replacement



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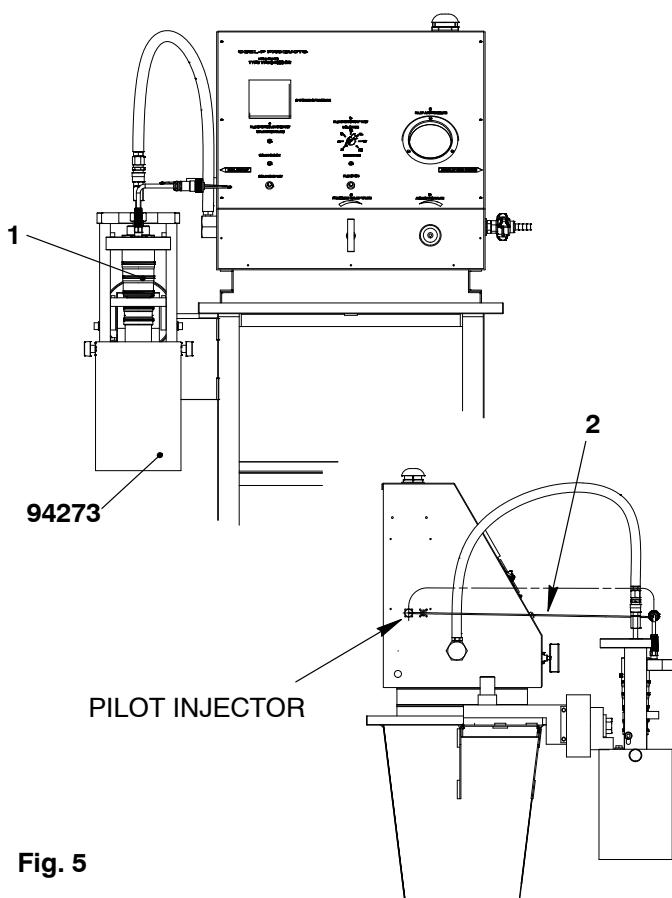
- 2) Install the supporting plate 94270F with screws 94270G on the pilot injection valve (1), see fig. 3.
- 3) Turn the two screws equally in to lift the pilot injection valve until $X = 44$ mm.
- 4) Lift the pilot injection valve (12 kg) out of the holder (5).
- 5) Do a check of the pilot injection valve, refer to paragraph 4.
- 6) To clean the injection valve, use white spirit, e.g. Shellsol TD, Shellsol T or Solvent FP68. Always wear gloves and goggles with closed side frame.
- 7) If you have to store the injection valve, do it in a dry and clean (no corrosive gases) place and protect the nozzle tip.



4. Check

- 8) Put the injection valve (1) in position in the valve holder 94273. Make sure that the injection valve points down.
- 1) Make sure the contact surface of connecting piece 94272F and pilot injector (1) are clean.
- 2) Install the connecting piece 94272F on the pilot injector (1).
- 1) Read the data in the instruction manual of the test bench manufacturer.
- 2) Make sure that the work station is clean.
- 3) Use a brass wire brush to remove combustion particles from the external parts of the nozzle.

Pilot Injection Valve: Replacement



- 4) Attach the HP hose to the connecting piece (94272F).
- 5) Connect the injector cable (2) to the socket for "pilot injector".

4.1 Procedure

WARNING


Fire Hazard. Do not use welding or grinding equipment near the work area. Fuel and solvents are flammable.

WARNING


Injury Hazard. Calibration fluid is a harmful substance. Always read the manufacturer's safety instructions before you use calibration fluid.

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

DANGER


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

- 3) Read the data in the manufacturer's instruction and set the pressure of the test bench to 600 bar.
- 4) Push the inject button. The injection valve must operate correctly.
- 5) Do a check of the seating surface between the needle seat and nozzle as follows:
 - a) Keep the pressure in the test bench constant at approximately 400 bar.
 - b) Monitor the injection valve for 30 seconds. No fuel must come out of the nozzle.
- 6) Do a check of the pressure as follows:
 - a) Set the pressure to 250 bar, then push the INJECT button. No fuel must come out of the nozzle.
 - b) Set the pressure to 400 bar, then push the INJECT button. Fuel must come out of the nozzle as a spray.

Pilot Injection Valve: Replacement

4.2 Results

- 1) For the correct function and to use an injection valve again, read the data below:
 - The pressure to operate the pilot injection valve is between 300 and 400 bar, refer to the test above. The pressure to operate a new injection valve is approximately 350 bar.
 - For used injection valves, a min. opening pressure of 250 bar and a max opening pressure of 500 bar is permitted.
 - Most of the fuel will come out as a spray.
 - At the end of an injection, no fuel must come out of the nozzle.
- 2) If the injection valve does not function satisfactorily, replace the nozzle body as given in paragraph 5.

Only the injection valve manufacturer, or an authorized company can repair or replace nozzle bodys that operates unsatisfactorily.

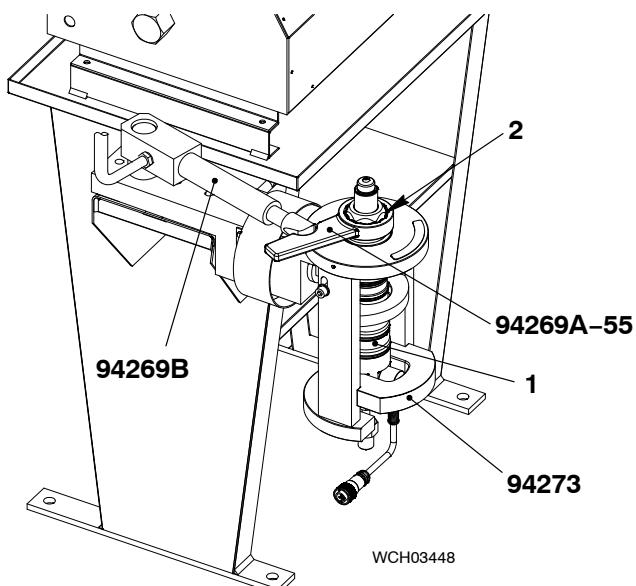
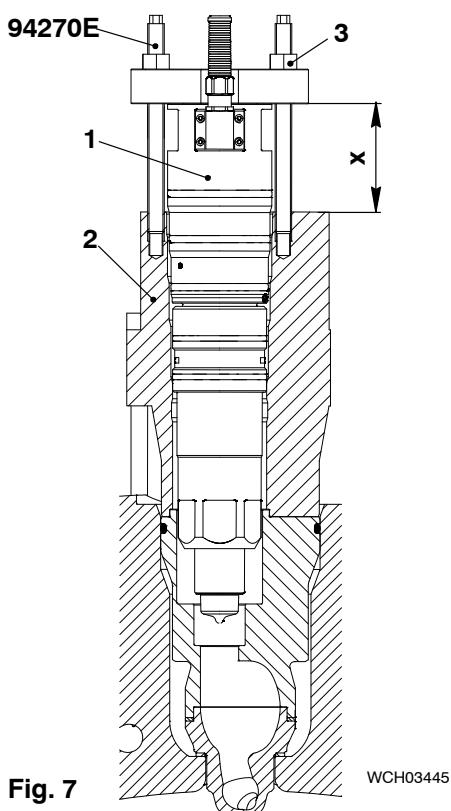


Fig. 6

5. Replace Nozzle body

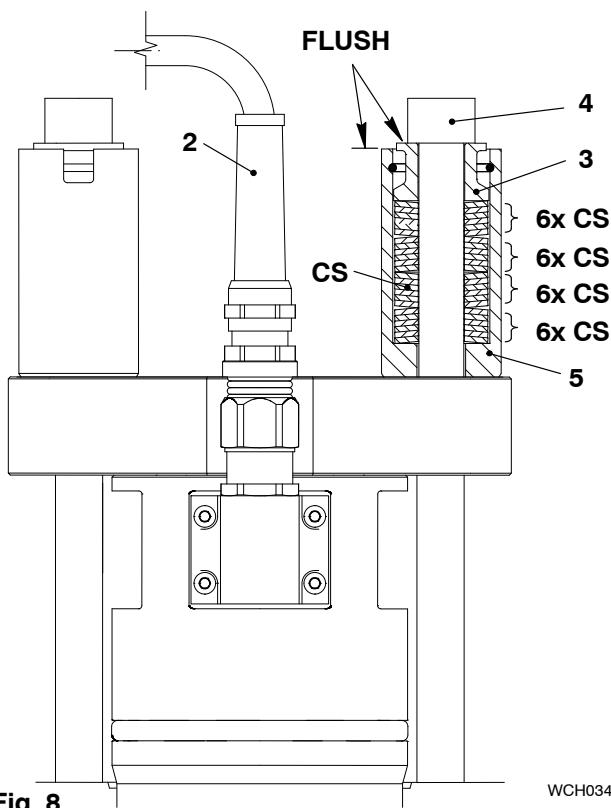
- 1) Fasten the injection valve (1) in the valve holder 94273 as shown in Fig. 6.
- 2) Make sure that the test bench has no pressure.
- 3) Use the wrench 94269A-55 and the hydraulic cylinder 94269B to loosen the coupling nut (2) of the pilot injection valve (1).
- 4) Remove coupling nut (2) and replace nozzle body if necessary (Spare Parts Code FX96236).
- 5) For assembly apply Molykote paste G-n to the contact surfaces and thread of the coupling nut (2).
- 6) Tighten the coupling nut (2) with a torque of 800 – 830 Nm by using a torque wrench and socket wrench insert 94269C-55. See torque formula for wrench insert here: [2722-2](#), chapter 6.
- 7) Replace the O-rings on the pilot injector (Spare Parts Code FX96237).

Pilot Injection Valve: Replacement



6. Installation

- 1) Apply oil to the O-rings of the pilot injection valve (1).
- 2) Put the injection valve (1) into the holder (2).
- 3) Screw the stud bolts 94270E into the holder (2) as shown in Fig. 7.
- 4) Screw the two nuts (3) equally down until $X = 41$ mm.
- 5) Remove the stud bolts 94270E.



- 6) If the spring cage (5, Fig. 8) was disassembled, make sure the cup springs (CS) are installed correctly, which is; four packs with six cup springs each.
- 7) Apply Never Seez NSBT to the threads and contact surfaces of bolts (4).
- 8) Install the bolts (4) together with the spring cage (5) as shown in Fig. 8.
- 9) Tighten the bolts (4) equally until the top of the spring guide (3) is flush with the top of the spring cage (5).
- 10) Install the applicable pilot fuel pipe (3 or 4, Fig. 1), refer to 8790-1.
- 11) Connect the injector cable (2) to terminal box E95.4.
- 12) Open fuel supply.
- 13) Open lube oil supply.

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

Crosshead Pin – Removal / Installation / Clearance Checks (Engines with Integrated ELBA) .. 3326–2/A2

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:

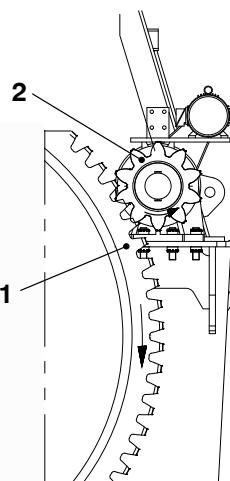
- Important change of crank-web deflection results compared to the data before.
- Bearing temperature alarms, or bearing damage.
- After the primary bearing shells were replaced, and again after approximately 100 service hours.
- If the ship has touched the sea bed.

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

2. Preparation

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.



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.

Fig. 1

WCH02320

3. Measure

WARNING

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

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

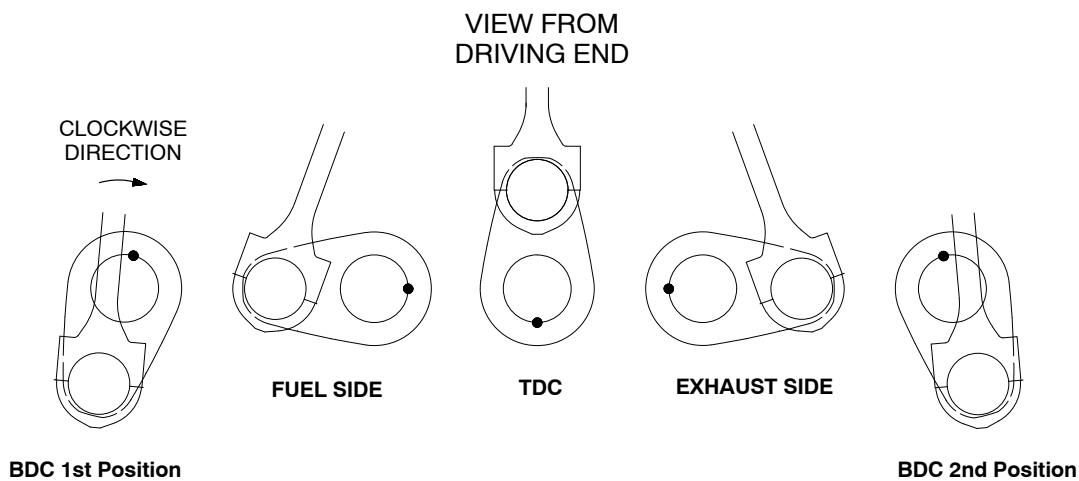
Measuring Crank Deflection

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

- 1) Make sure that the tank heater and lubricating oil separator are set to off 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) Use 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.



CRANK DEFLECTION
SIGN ON DIAL GAUGE

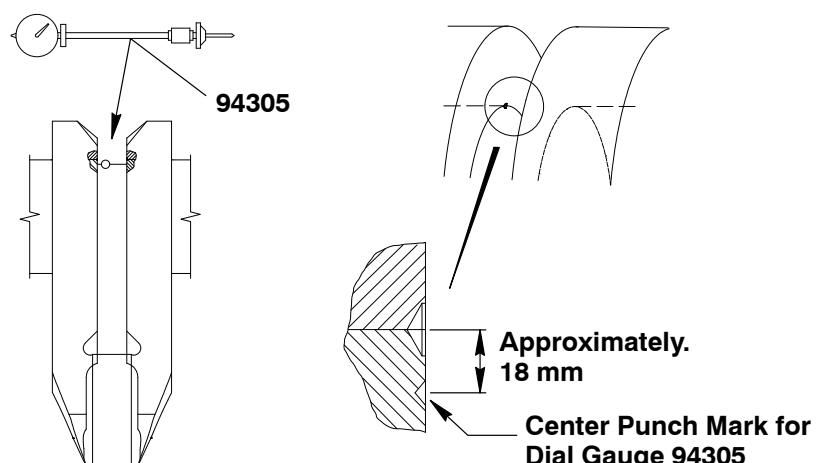
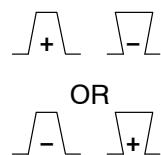


Fig. 2

4. Date Analysis

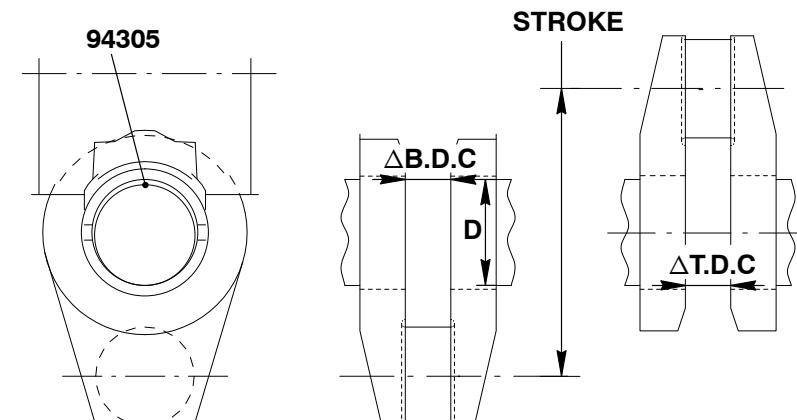


Fig. 3

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 (e.g. defective main bearing, engine stay changed because hull deformation, loose hold-down bolts, defective propeller shaft bearings, equipment 94305 etc.).

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

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

Table 1: Deflection Limits

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

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

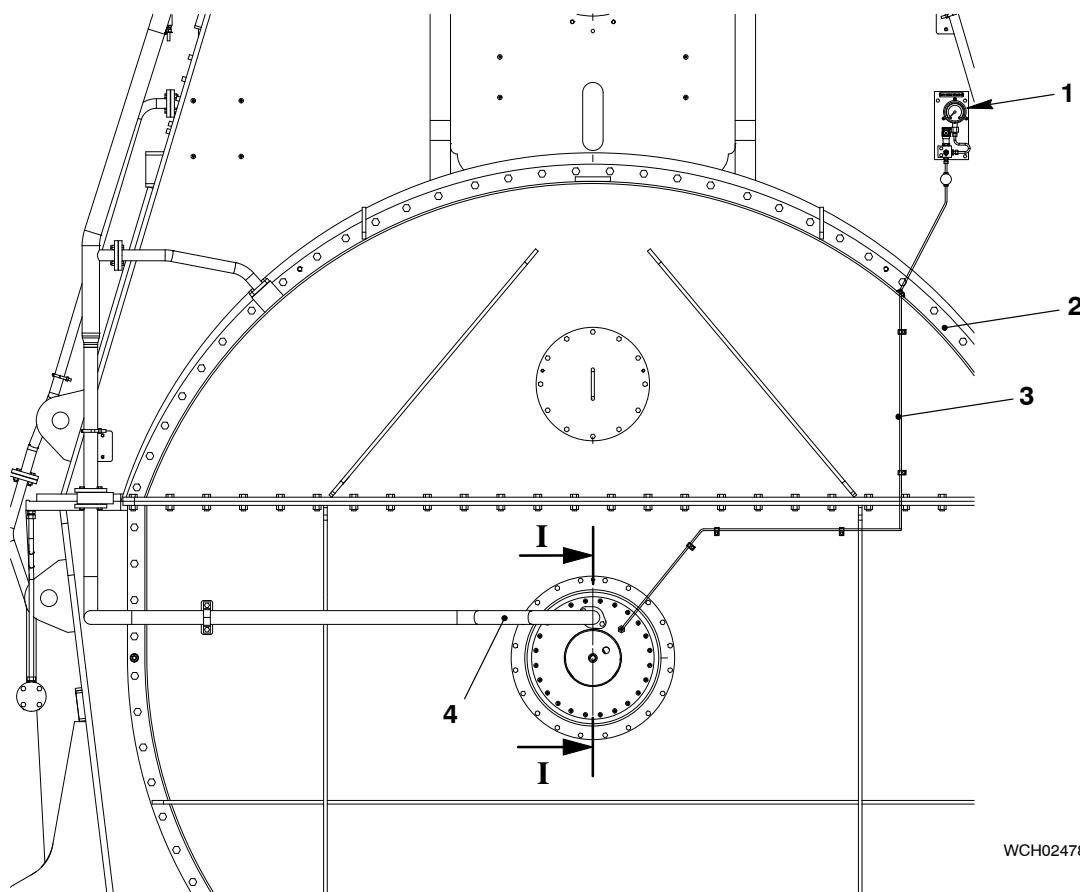
Speak to Wärtsilä Services Switzerland, if the last data is more than the limits given in the table above.

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

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

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

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.

If damage occurs to 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.

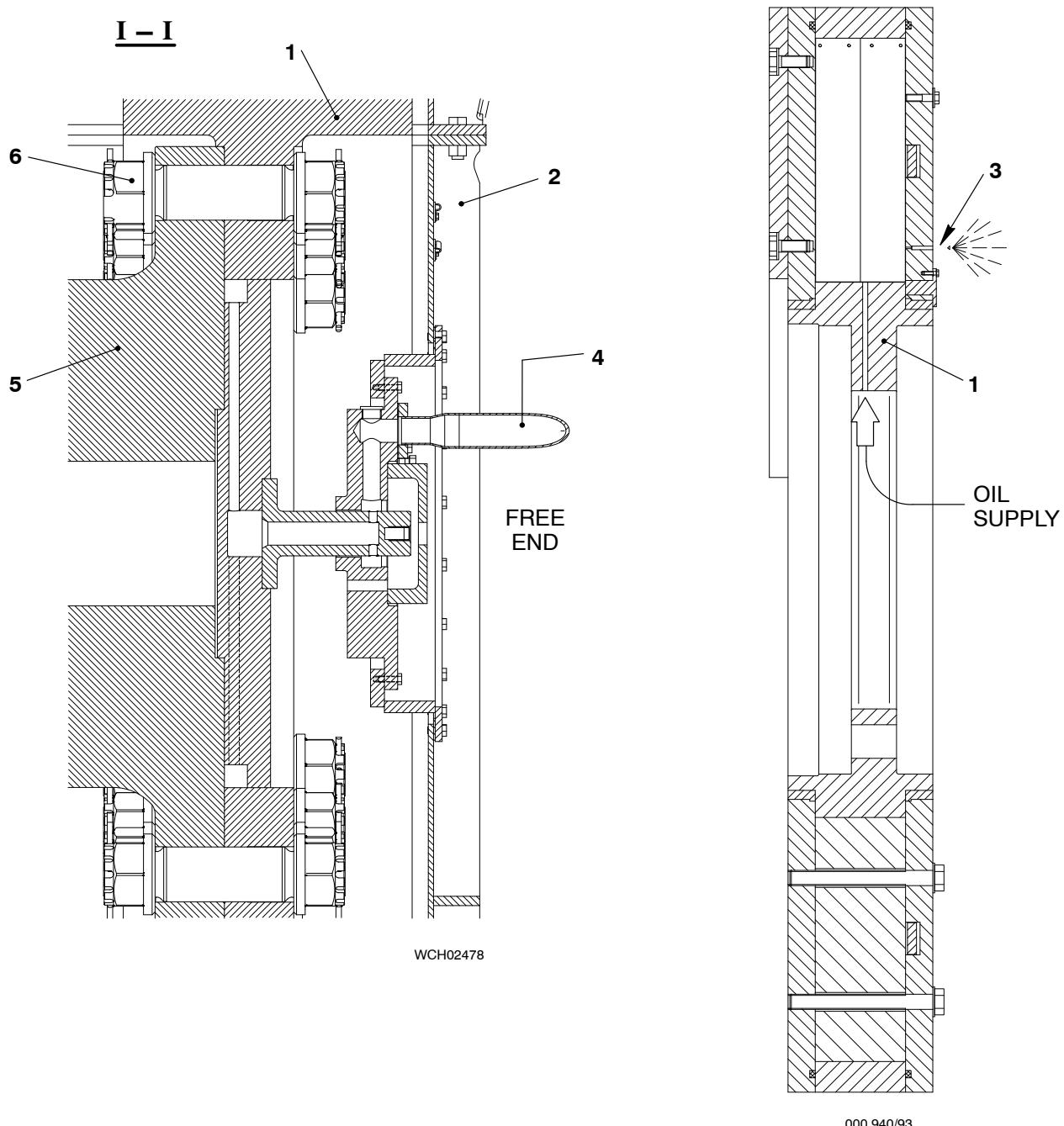
For the torque values of coupling bolts (6) see [0352-1](#).

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)



000.940/93
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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Axial Detuner

Disassembly and Assembly

Tools:

1 Spur-gearied chain block	94017-009	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

CAUTION


Injury Hazard: The weight of the top housing is approximately 640 kg. Use the correct equipment to lift and move the top housing. This will prevent injury to personnel.

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

- 1) Read the data in [0012-1 General Guidelines for Lifting Tools](#).
- 2) Stop the engine, refer to the Operation Manual 0310-1.
- 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).
- 6) Use applicable lifting equipment to remove the top housing (5).

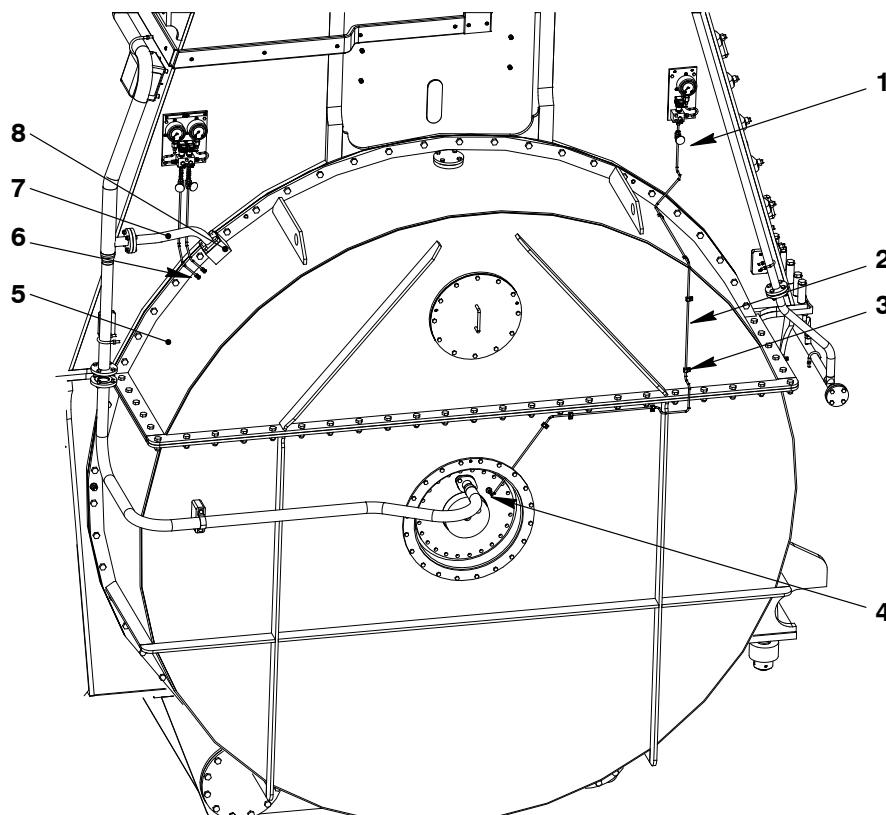


Fig. 1

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).
- 4) Remove the four bolts (1).

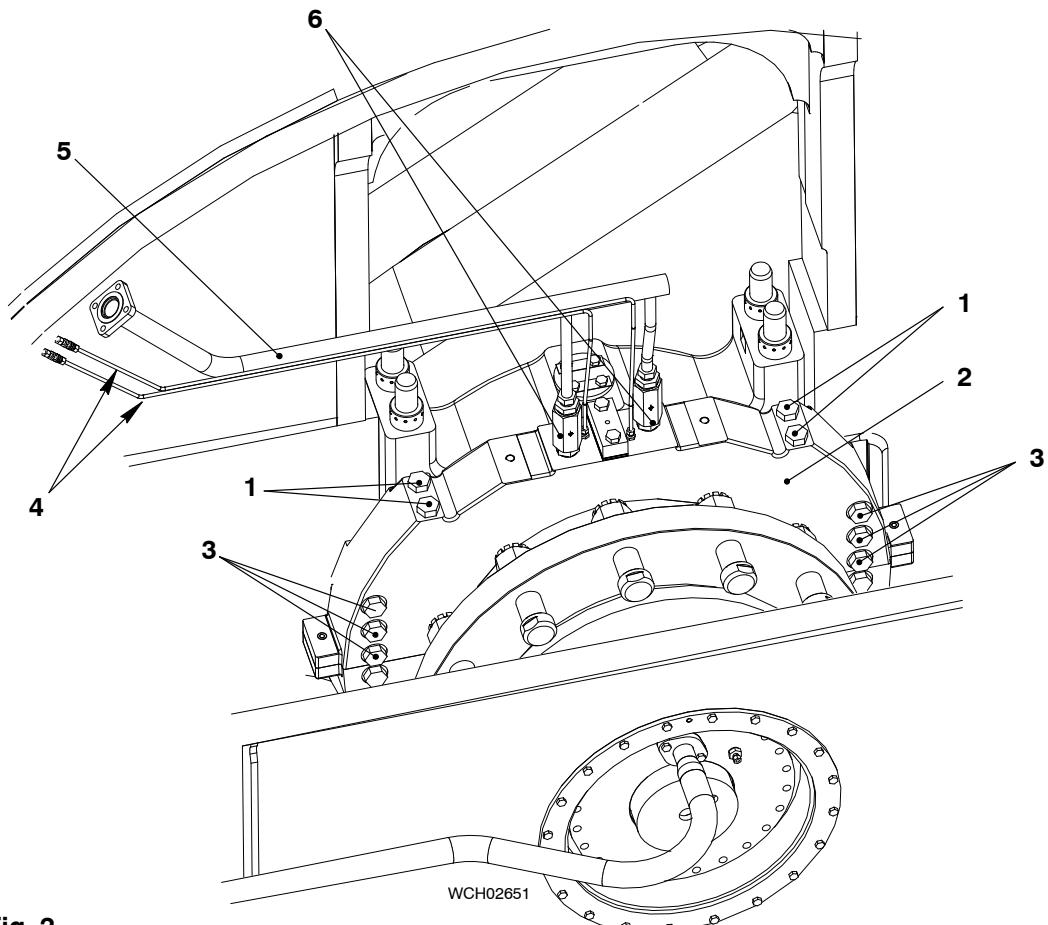


Fig. 2

- 5) Attach two eye bolts (94045-M20, Fig. 3) to the top part of the cylinder.
- 6) Attach the chain (94335A) to the eye bolts (94045-M20).
- 7) Attach the shackle (94018A) to the strong-point.
- 8) Attach the spur-gearied chain block (94017-009) to the shackle (94018A) and the chain (94335A).
- 9) Attach the engine room crane to the chain (94335A).
- 10) Operate the spur-gearied chain block (94017-009) and the engine room crane to lift and move the top part of the cylinder to an applicable area.
- 11) Lower the top part of the cylinder on to an applicable surface.

Axial Detuner: Disassembly and Assembly

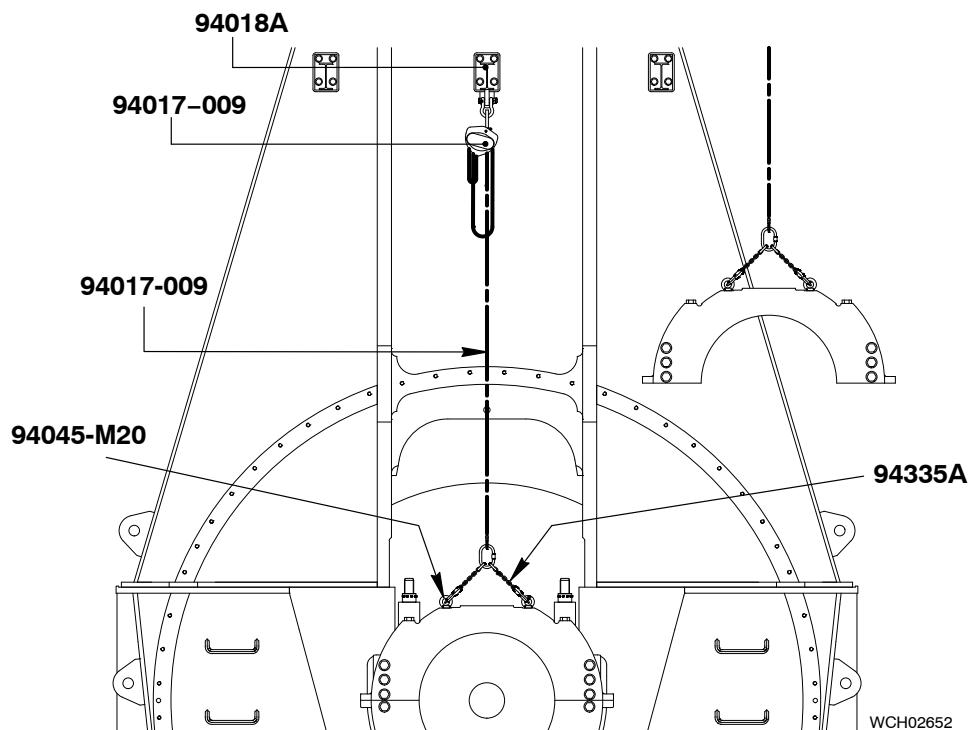


Fig. 3

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

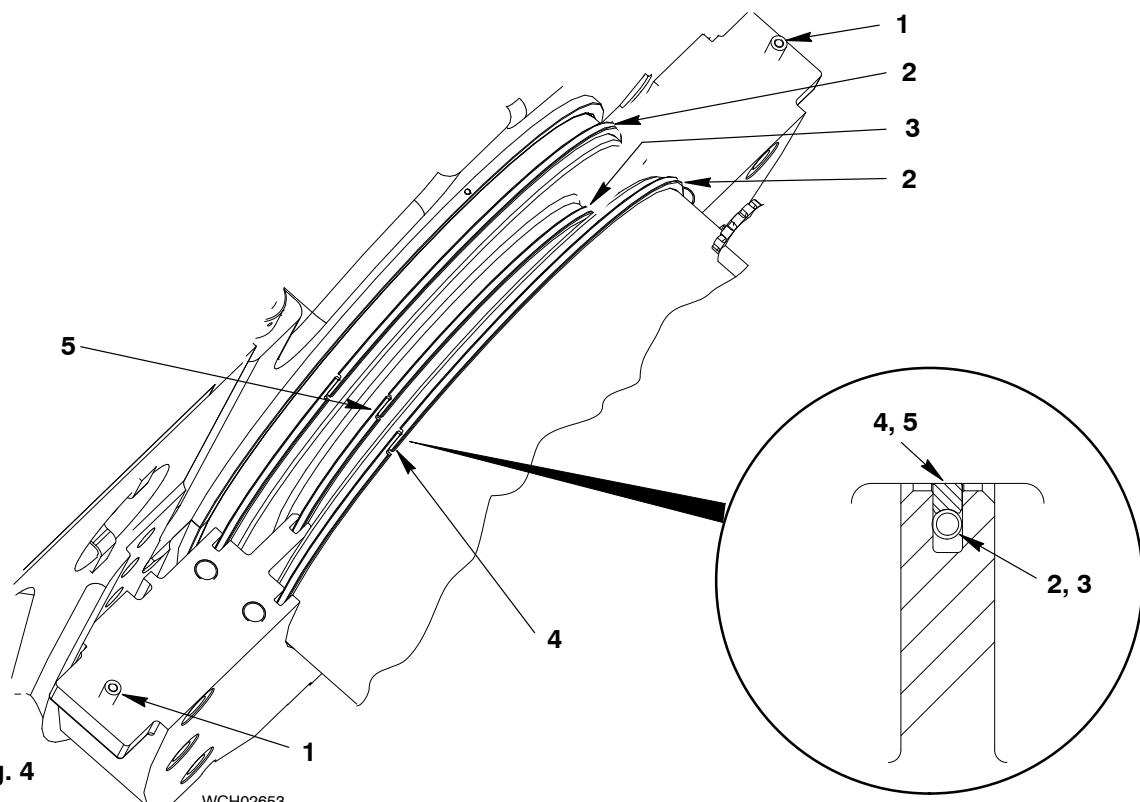


Fig. 4

Axial Detuner: Disassembly and Assembly

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 the spur-gear chain block (94017-009, [Fig. 3](#)). Move the top part of the cylinder into position above the bottom part of the cylinder.
- 6) Remove the hook of the engine room crane from the top part of the cylinder.
- 7) Operate the spur-gear chain block (94017-009). Carefully lower the top part of the cylinder into position on to the bottom part of the cylinder. Make sure that you do not damage the tension springs (4, 5) and 2-part gaskets (2, 3).

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 M30 bolts (3).
- 10) Torque the six M30 bolts (3) to 900 Nm (40°).
- 11) Attach the two pipes (4) to the top cylinder (2).
- 12) Attach the oil inlet pipe (5) and the two non-return valves (6).

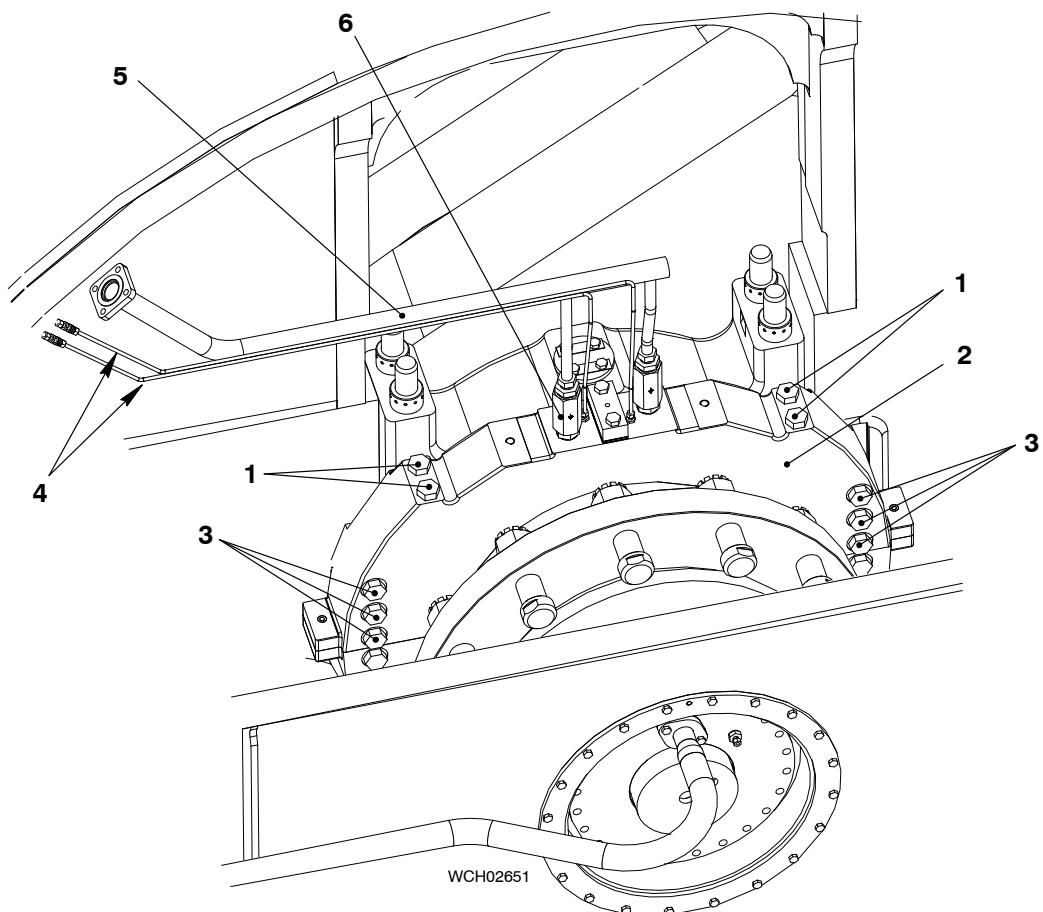


Fig. 5

Axial Detuner: Disassembly and Assembly

4. Completion

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

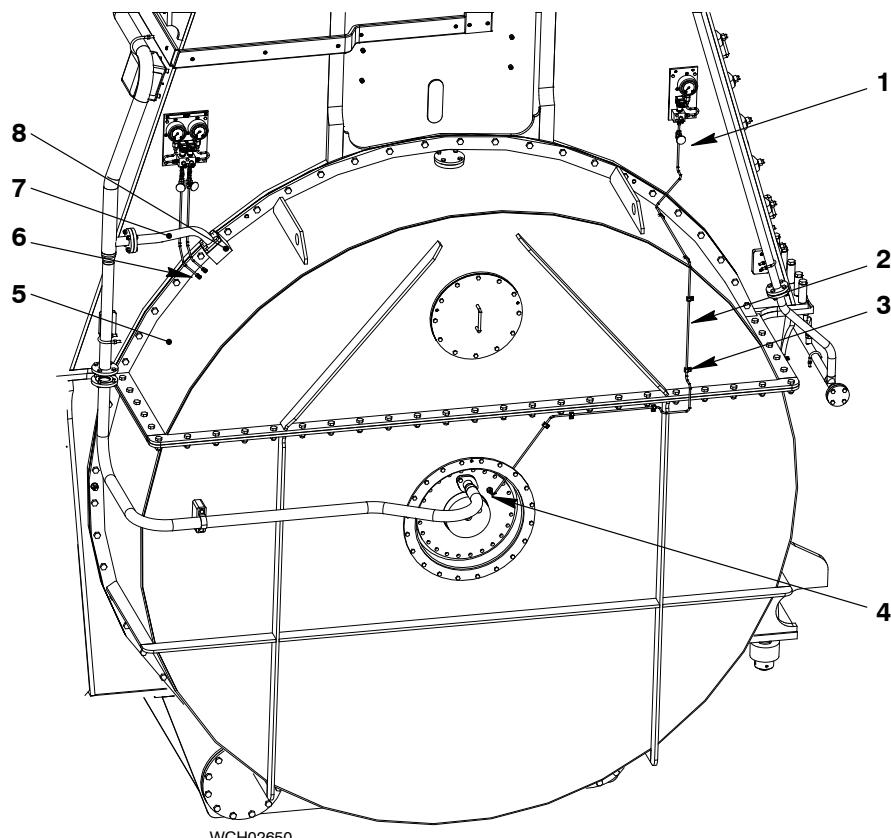


Fig. 6

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Turning Gear

Teeth and Screwed Connections – Check

1. General

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

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

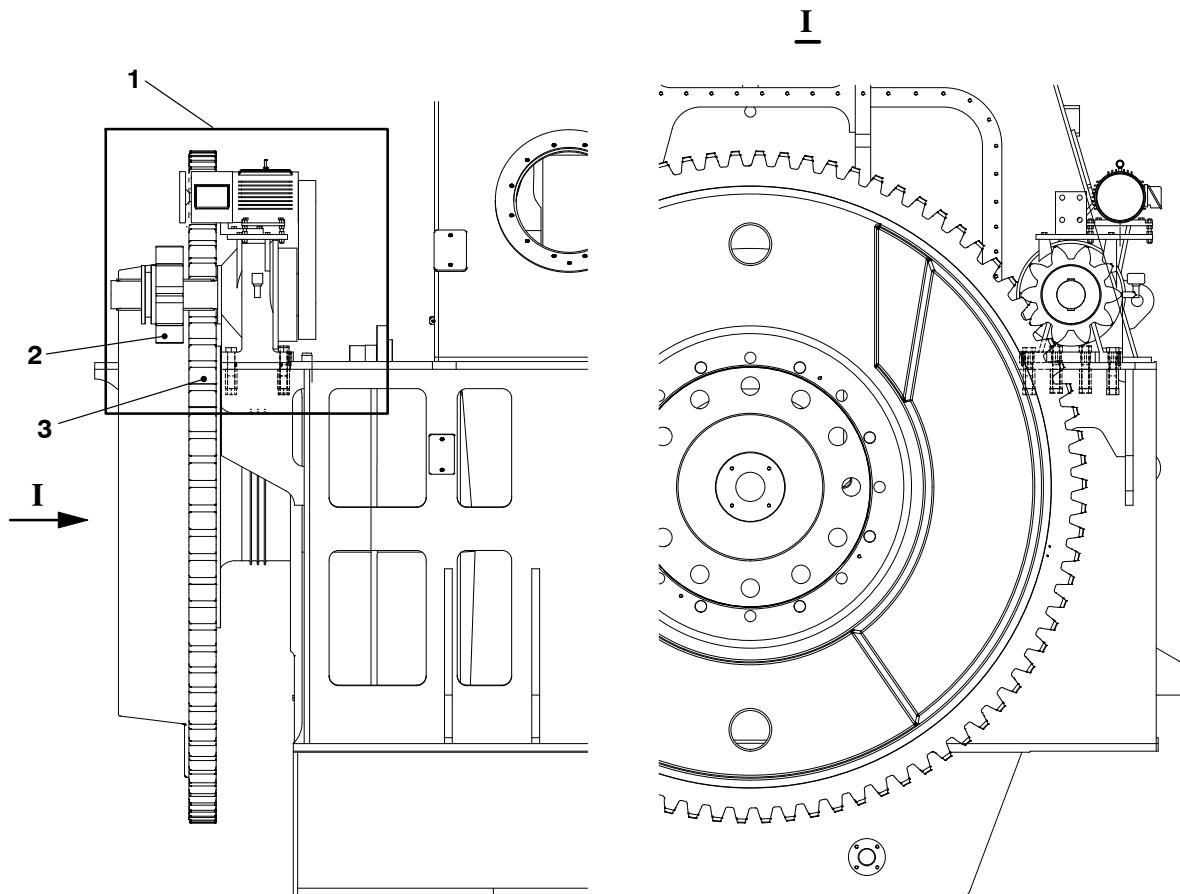


Fig. 1

2. Tooth Checks

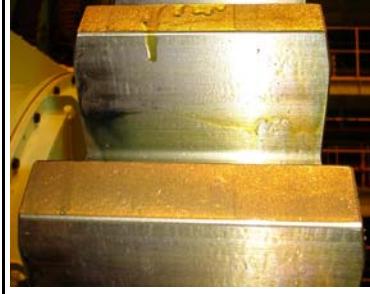
2.1 Lubricant Instructions

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

Table 1: Instructions – Pyroshield

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

Table 2: Instructions – Klüberfluid

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

2.2 Lubrication Intervals

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

2.3 Recommended Suppliers

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

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

Work Platform

Tools:

- | | |
|---|-------|
| 2 Platform | 94142 |
| 2 Support, each support has three grids | 94143 |

1. General

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

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

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

WARNING

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

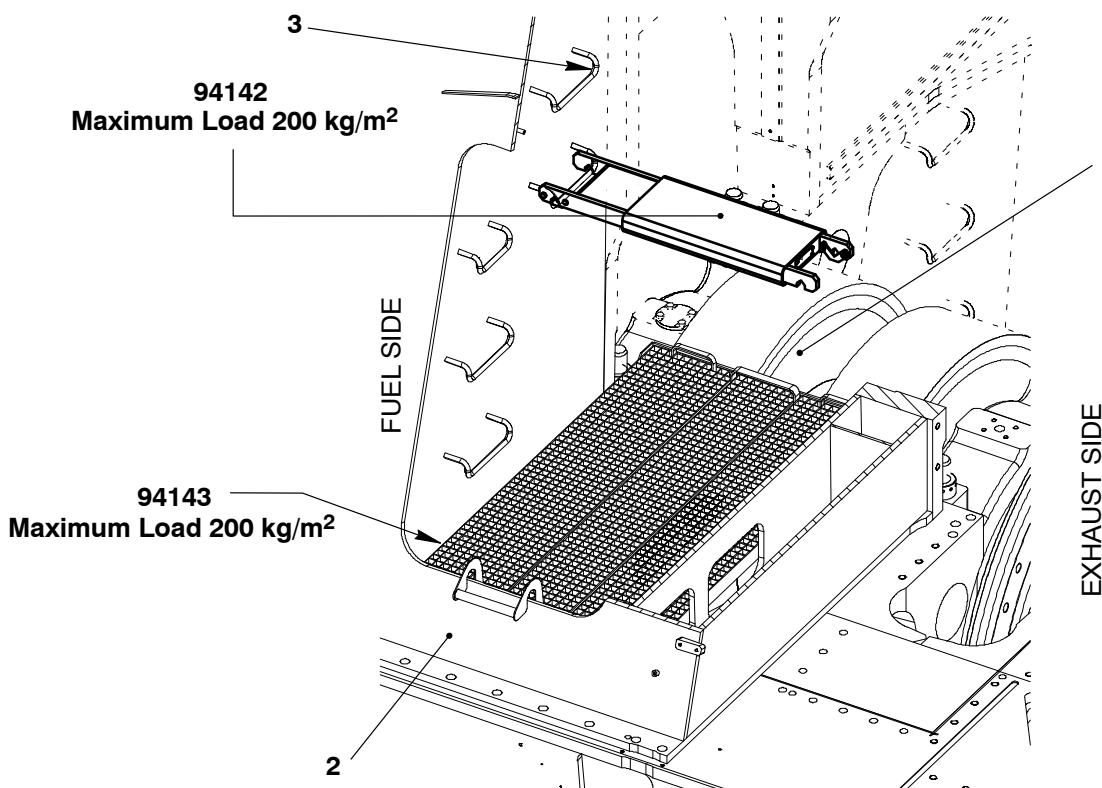


Fig. 1

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Connecting Rod

Bottom End Bearing – Removal, Inspection and Installation

Tools:

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

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

1. Preparation

WARNING

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

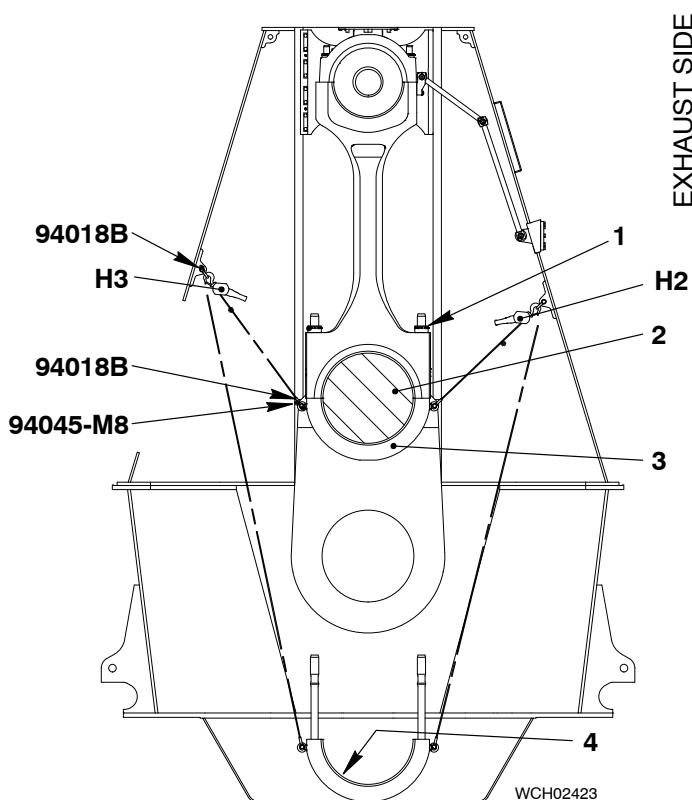


Fig. 1

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

2. Bearing Cover – Removal

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

Bottom End Bearing – Removal, Inspection and Installation

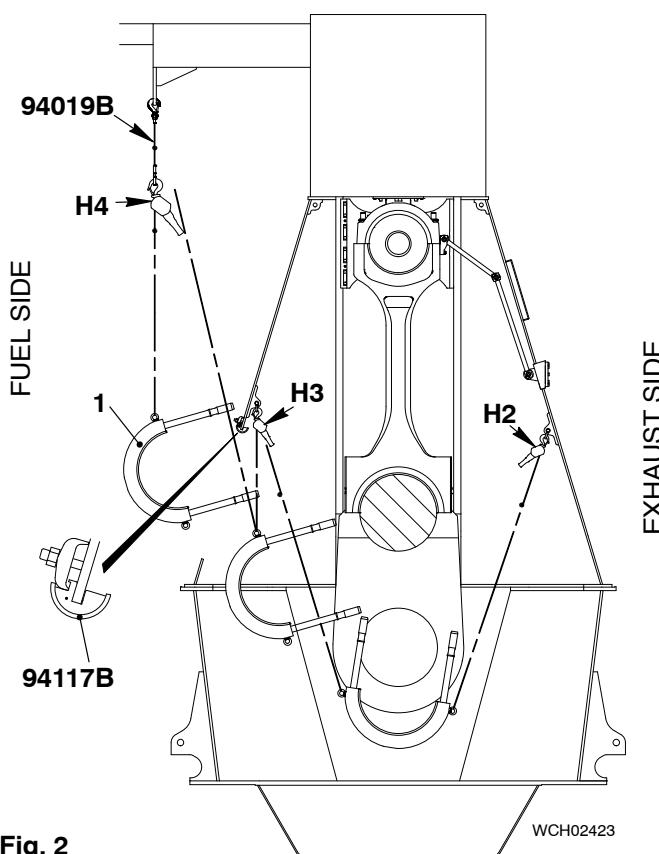


Fig. 2

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

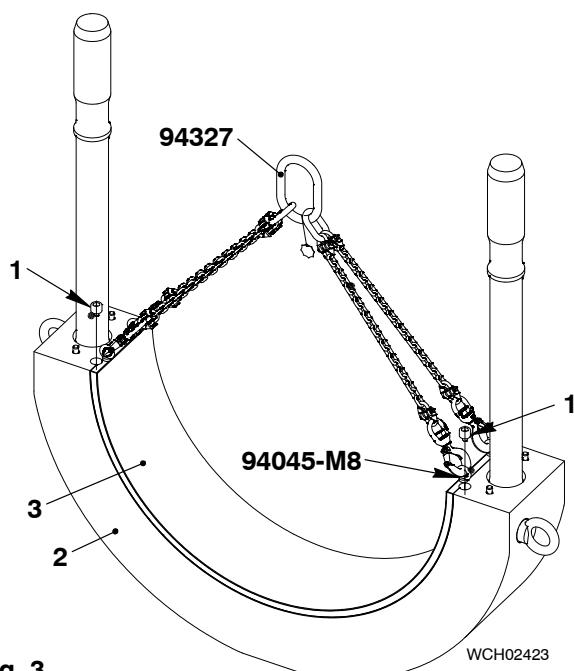


Fig. 3

3. Bearing Shell – Removal

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

4. Top Bearing Shell – Inspection

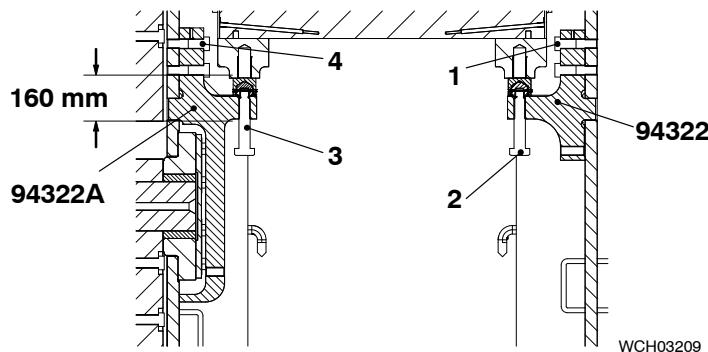
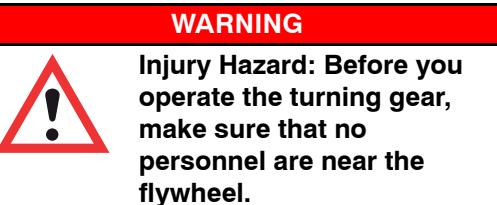


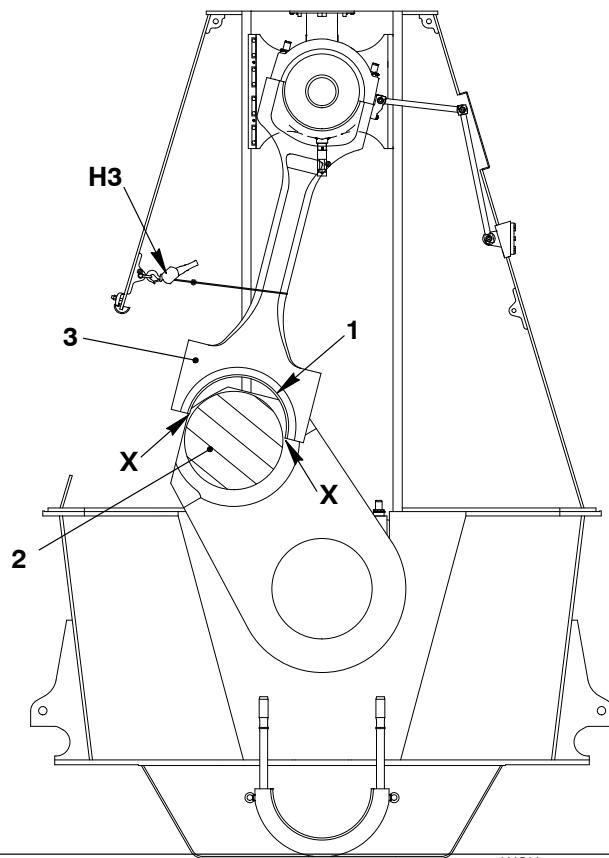
Fig. 4



- 1) Unlock the turning gear.
- 2) Use the turning gear to turn the crank to the fuel side until the crosshead is approximately 160 mm above the plug bore (see Fig. 4).

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

- 3) Put a small quantity of clean oil on the four bolts(1, 4).
- 4) Attach the two supports (94322 and 94322A) with the four bolts (1, 4).
- 5) Torque the four bolts (1, 4) to 240 Nm.
- 6) Tighten the special screws (2, 3) on each support.

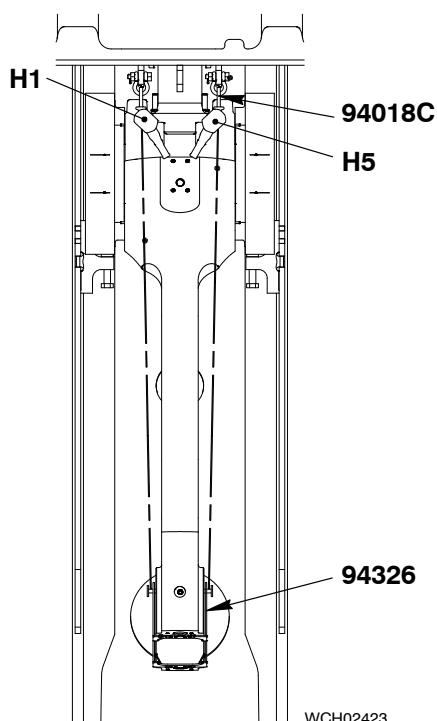


- 7) Put the chain of the manual ratchet (H3, Fig. 5) around the connecting rod (3).
- 8) Use the turning gear to turn the crank to the fuel side. At the same time, operate the manual ratchet (H3) to keep a light tension on the chain.

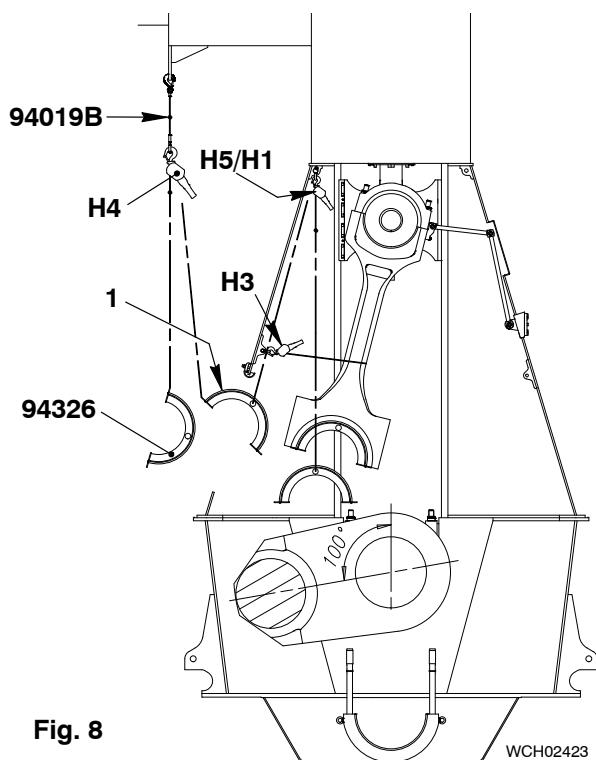
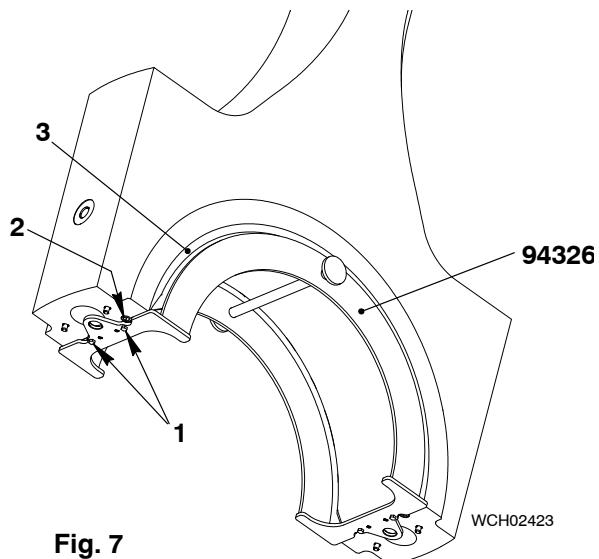
Note: Make sure that there is no load on the corners (X) of bearing shell (1).

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

5. Top Bearing Shell – Removal

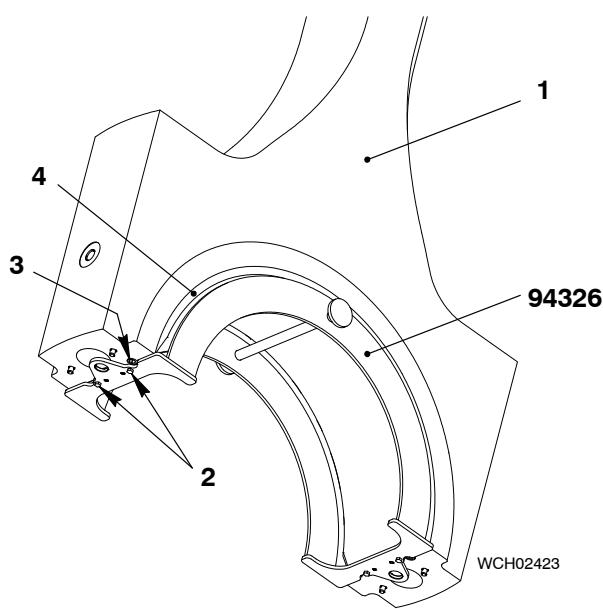
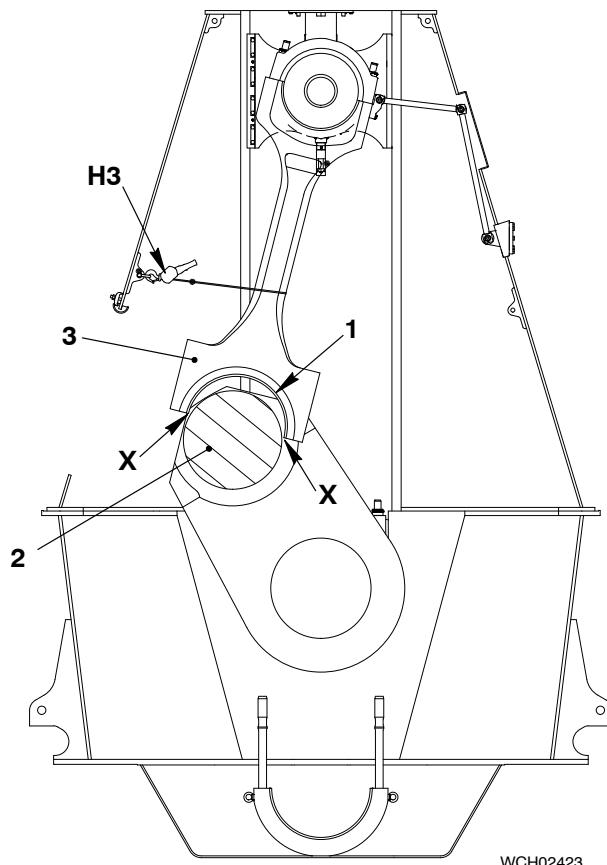


- 1) Attach the manual ratchets (H1, H5) [Fig. 6](#)) and the shackle (94018C) to the column.
- 2) Attach the console frame (94326, [Fig. 7](#)) to the bearing shell (3) with the four screws (1).
- 3) Connect the hooks of the manual ratchets (H1, H5) to the console frame (94326).
- 4) Apply a light tension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



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

Bottom End Bearing – Removal, Inspection and Installation

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

6. Top Bearing Shell – Installation

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

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

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

WARNING

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

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

Bottom End Bearing – Removal, Inspection and Installation

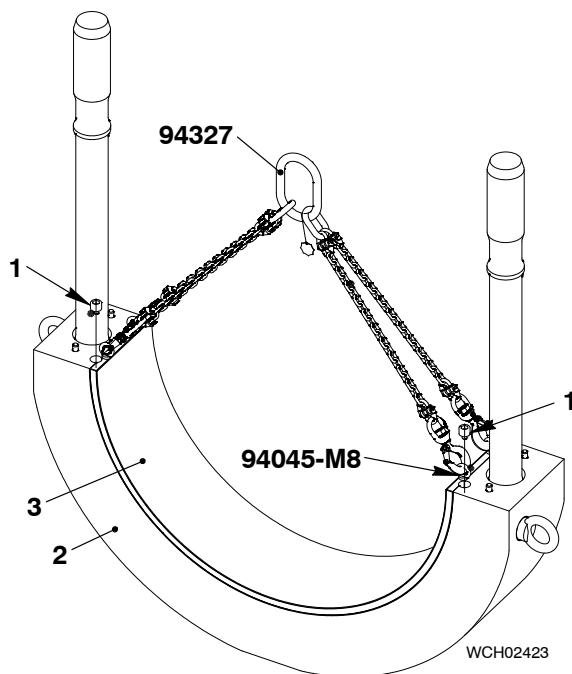


Fig. 11

7. Bottom Bearing Shell – Installation

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

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

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

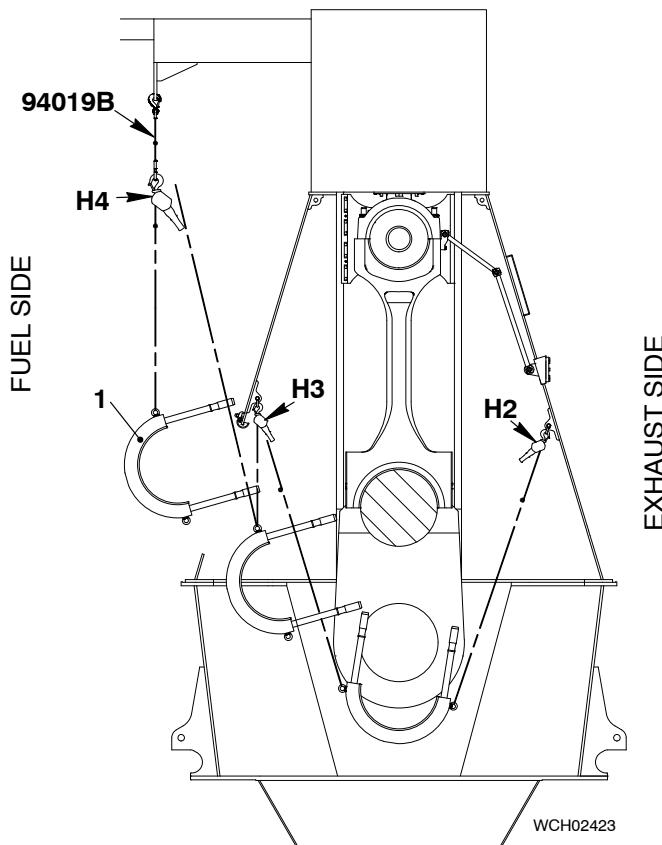
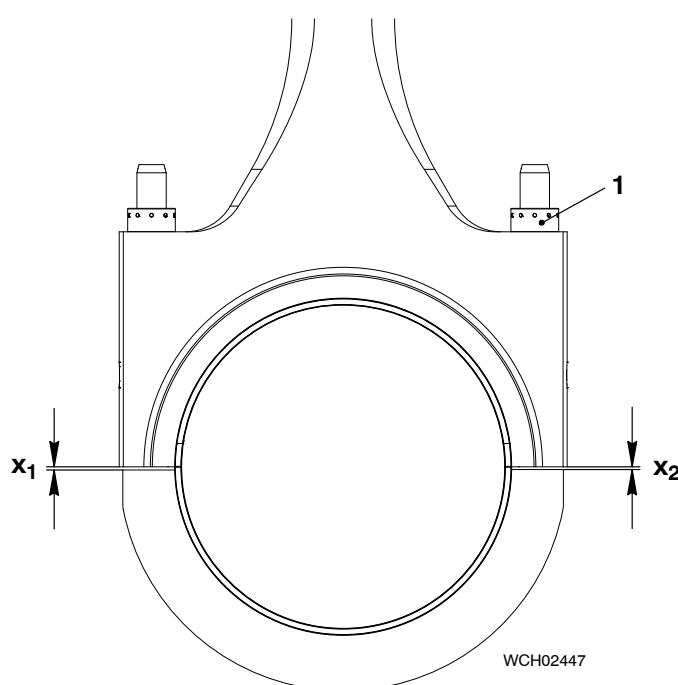


Fig. 12

8. Bearing Cover – Installation

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

Bottom End Bearing – Removal, Inspection and Installation

**Fig. 13**

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

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

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

Table 1: ISO G 1000/1500 Suppliers

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

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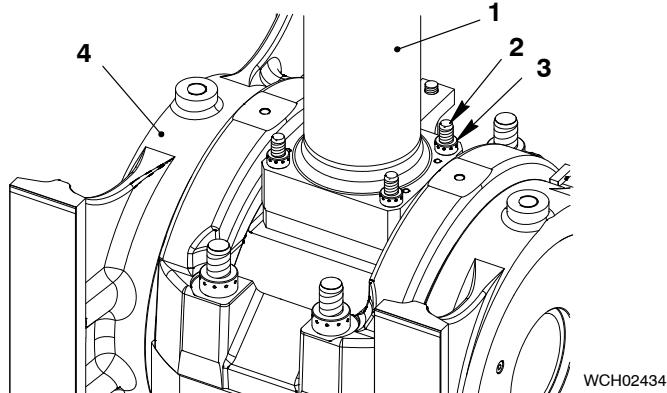
Connecting Rod

Top End Bearing – Removal, Inspection and Installation

Tools:

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

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

**Fig. 1**

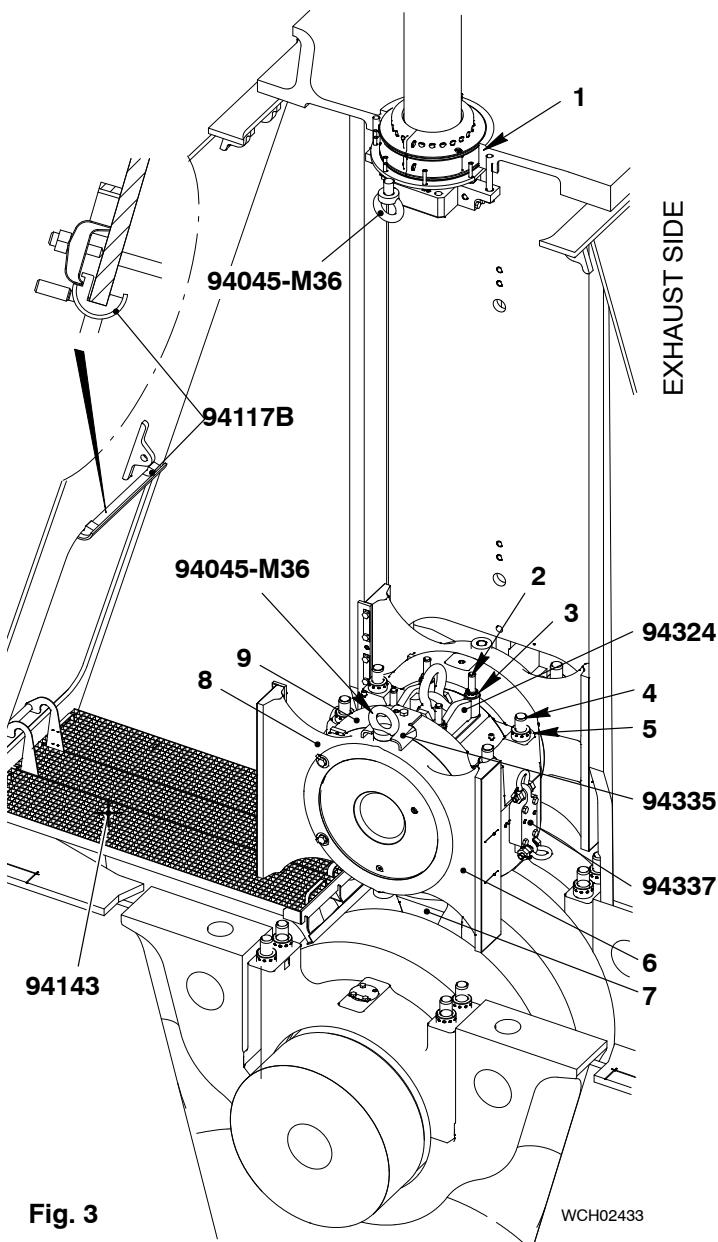
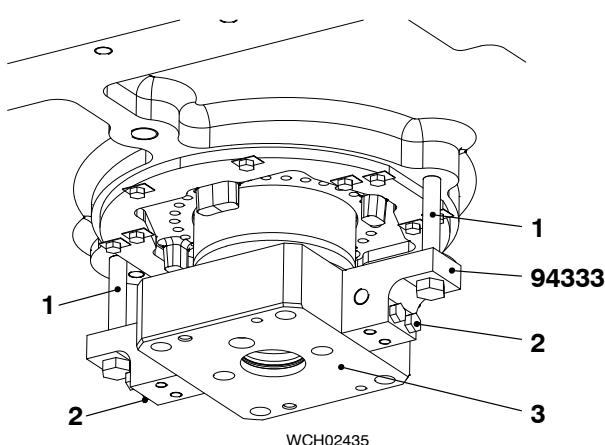
1. Piston – Preparation

WARNING


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

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

Top End Bearing – Removal, Inspection Installation



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

2. Preparation

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

Top End Bearing – Removal, Inspection Installation

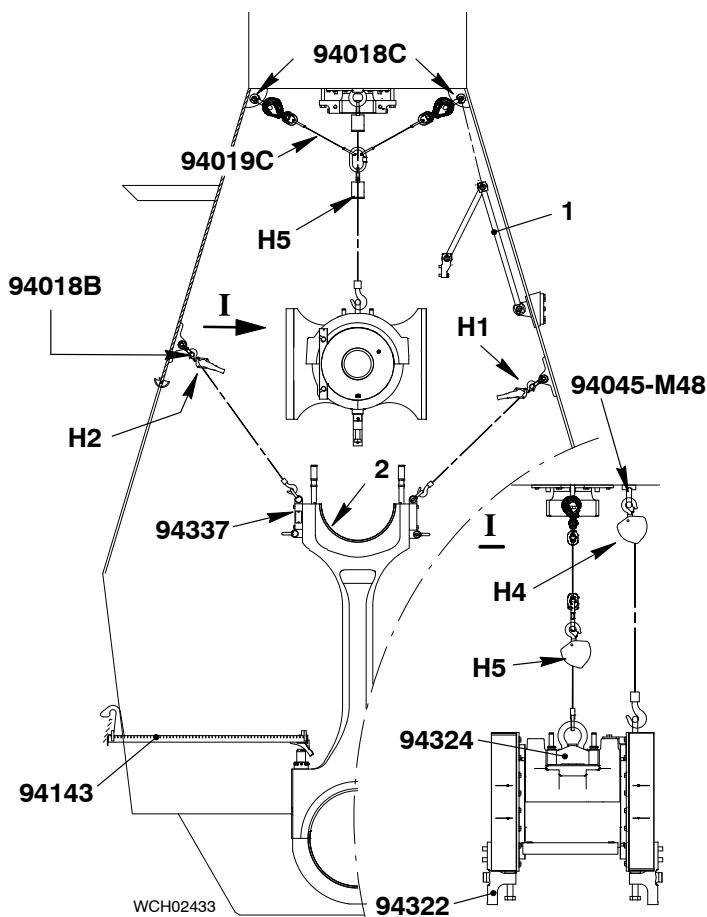


Fig. 4

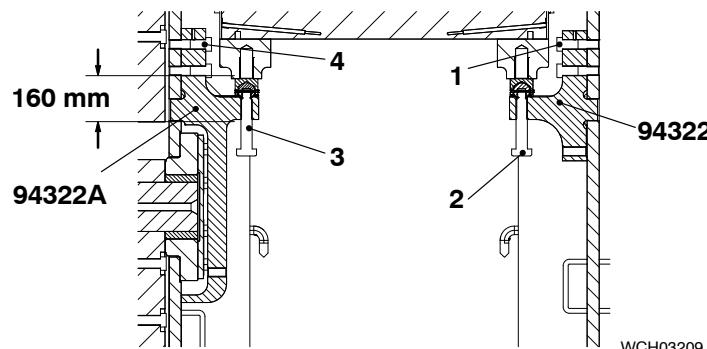


Fig. 5

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

3. Crosshead – Lift

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

- 7) Operate the chain block (H5) to lift the crosshead to 160 mm above the plug bore (2, Fig. 5) in the column.

- 8) Keep the tension on the chain block (H4, Fig. 4).

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

- 9) Attach the two supports (94322, 94322A) to the column with the four bolts (1, 4, Fig. 5).
- 10) Torque the four bolts (3) to 240 Nm.
- 11) Tighten the special screws (2, 3).
- 12) Inspect the bearing shell 13.
- 13) If it is necessary to replace the bearing shell, refer to paragraph 4, step 1) to step 10).
- 14) Remove the platform (94143, Fig. 4).

Top End Bearing – Removal, Inspection Installation

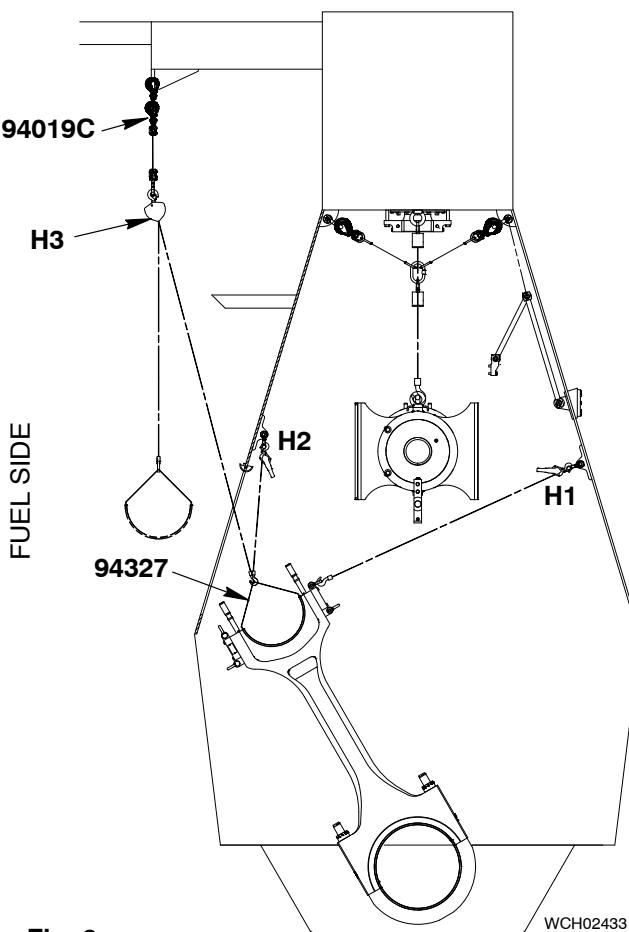


Fig. 6

4. Bearing Shell – Removal

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

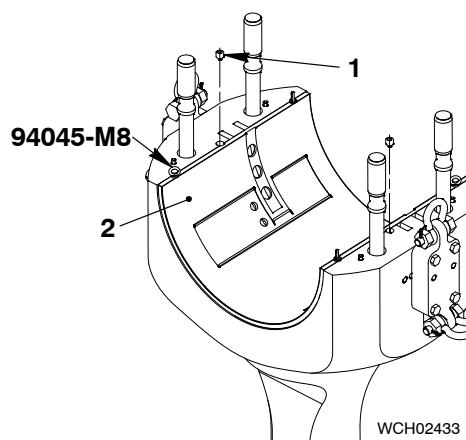


Fig. 7

5. Bearing Shell – Installation

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

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

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

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

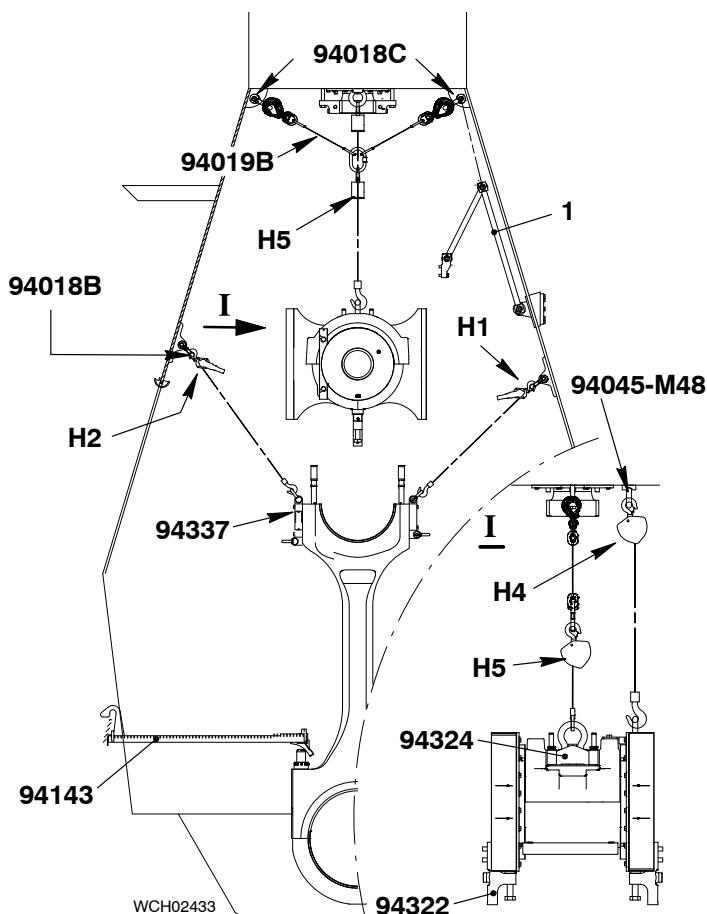
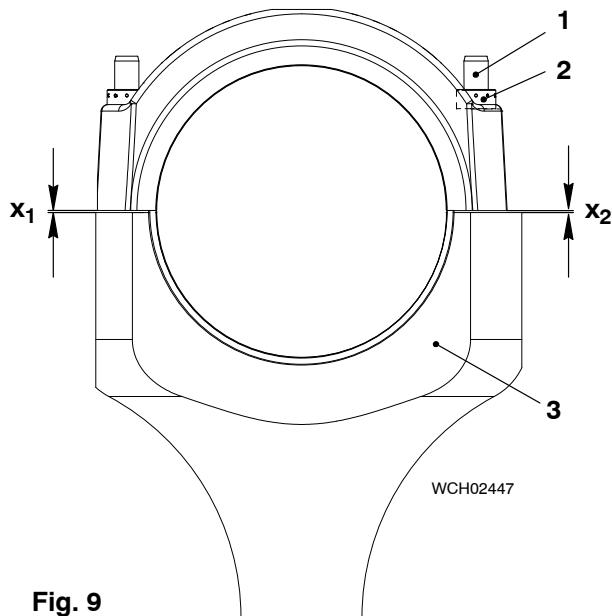


Fig. 8

Top End Bearing – Removal, Inspection Installation



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

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

Table 1: ISO G 1000/1500 Suppliers

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

Top End Bearing – Removal, Inspection Installation

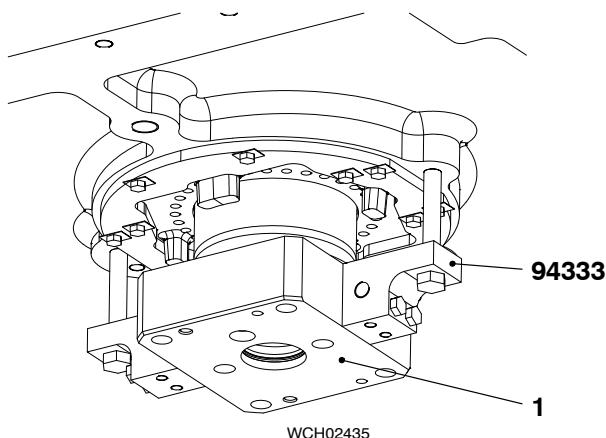


Fig. 10

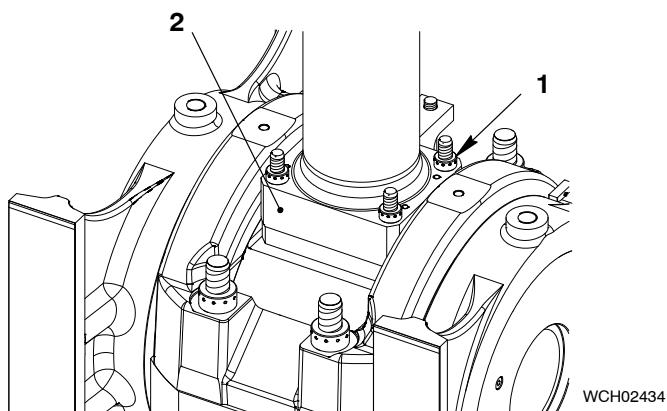


Fig. 11

6. Completion

WARNING



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

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

7. Bearing Lubrication

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

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

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

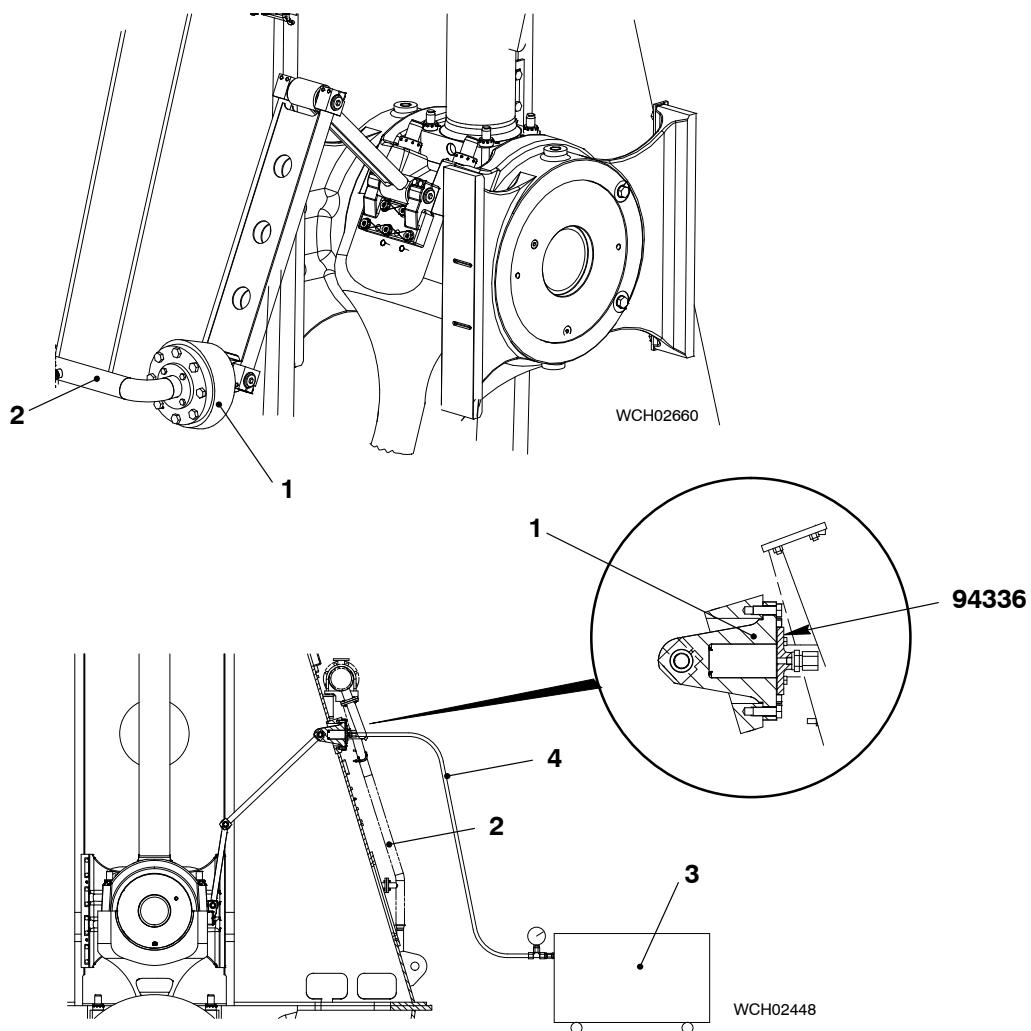


Fig. 12

Connecting Rod

Removal and Installation

Tools:

- 4 Manual ratchet, 3200 kg, (H1, H2 H3, H5)
 1 Manual ratchet, 6300 kg (H4)
 1 Shackle, 8500kg
 1 Chain symmetrical

- 94016-015 1 Chain asymmetrical 94019B
 94016-017 1 Holder 94334
 94018C 1 Connecting element 94334A
 94019A 4 Shackle, 3250 kg 94018A

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

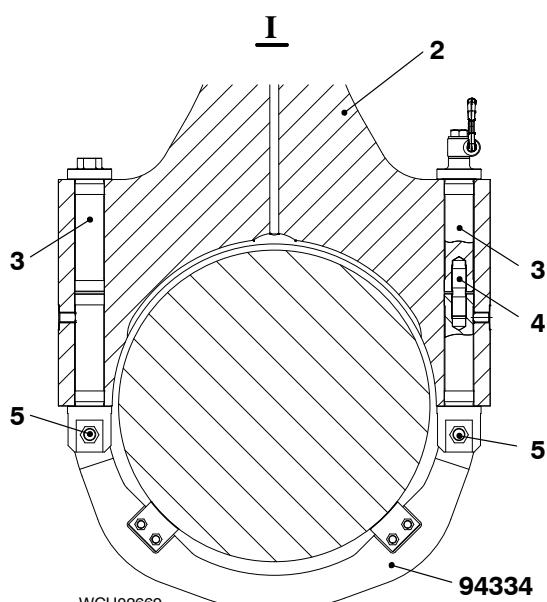
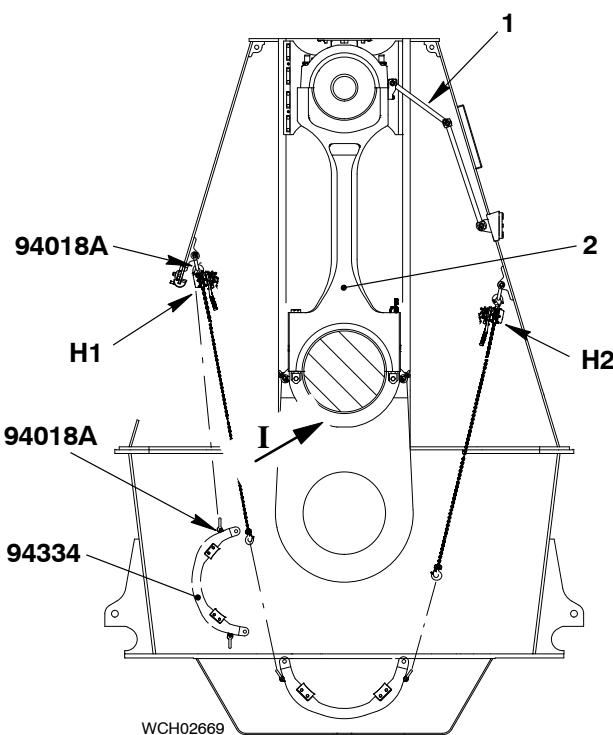
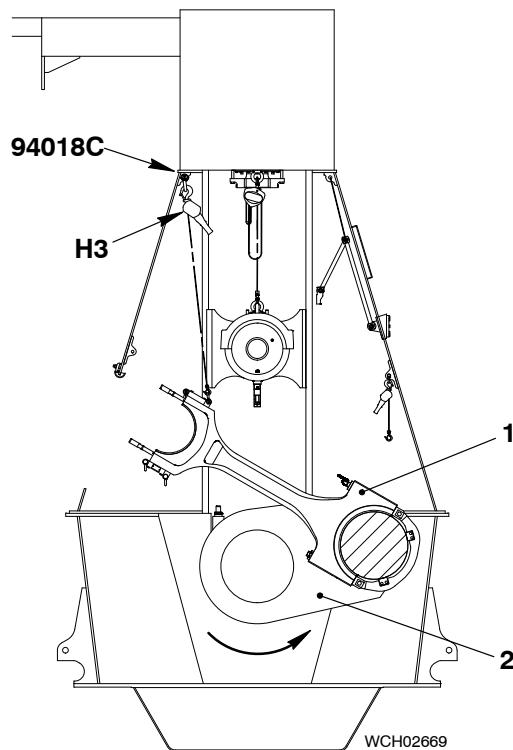
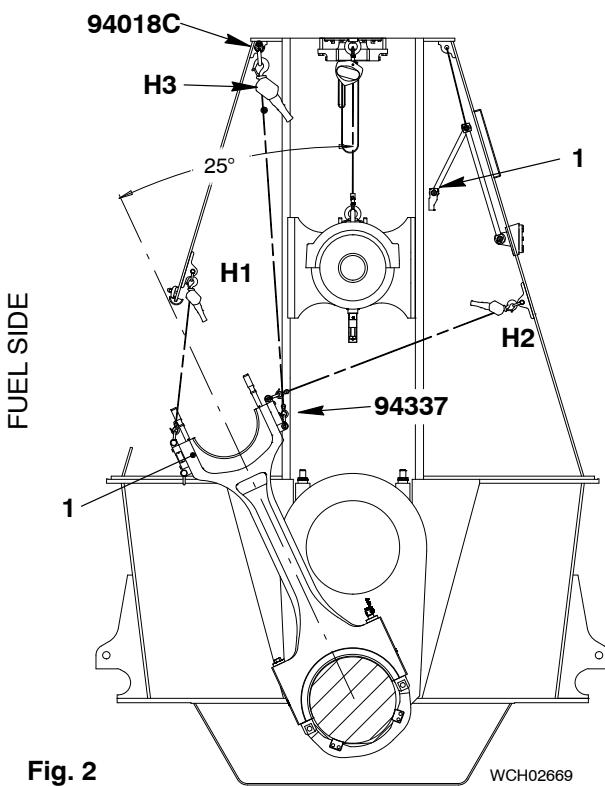


Fig. 1

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](#).
- 3) Remove the bottom end bearing cover from the connecting rod (see [3303-2, paragraph 1](#) and [paragraph 2](#)).
- 4) Attach two shackles (94018A, [Fig. 1](#)) and the the two manual ratchets (H1, H2) to the column.
- 5) Attach two shackles (94018A) to the holder (94334).
- 6) Attach the manual ratchets (H1, H2) to the shackles on the holder (94334).
- 7) Apply copper paste to the thread of the bolts (4).
- 8) Put the rods (3) into the connecting rod (2).
- 9) Operate the manual ratchets (H1, H2) to lift the holder (94334) into position on the the rods (3).
- 10) Tighten the nuts and bolts (5).
- 11) Torque the rods (3) to 70 Nm.
- 12) Lift the crosshead, refer to [3303-3, paragraph 2](#) and [paragraph 3](#).
- 13) Remove the the manual ratchets (H1, H2) from the holder (94334).
- 14) Disconnect the toggle lever (1) from the connecting rod (2).

Removal and Installation



2. Removal

WARNING

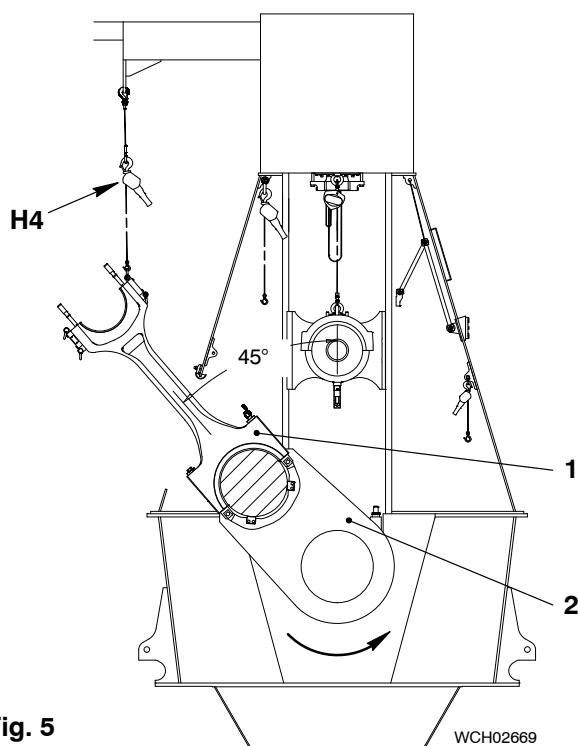
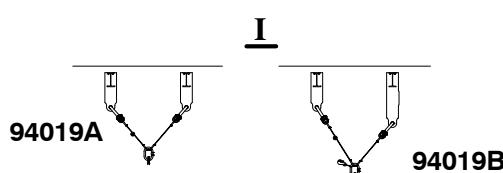
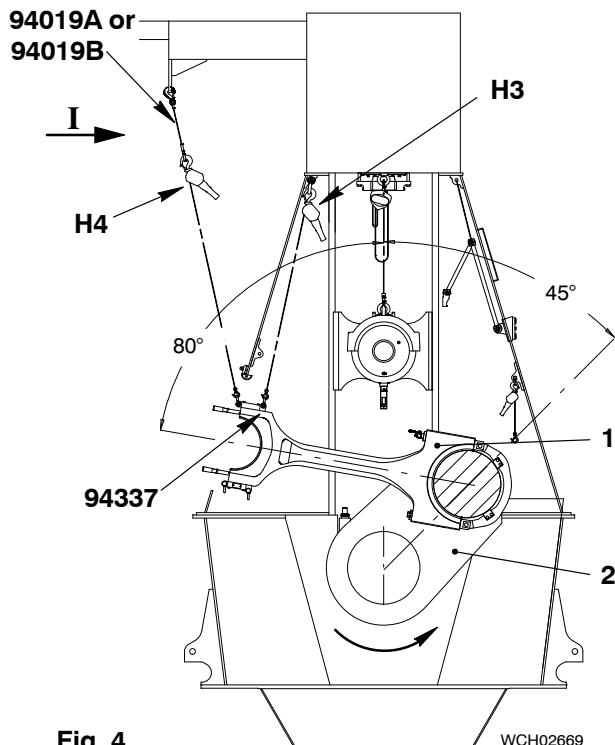
Injury Hazard: The connecting rod weighs 2549 kg. To prevent injury, be careful when you move the connecting rod.

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



8) Operate the turning gear and manual ratchet (H3, Fig. 4) to move the crankshaft (2) and the connecting rod (1) to the position shown.

9) Attach the applicable chain (94019A or 94019B) to the gallery.

10) Attach 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.

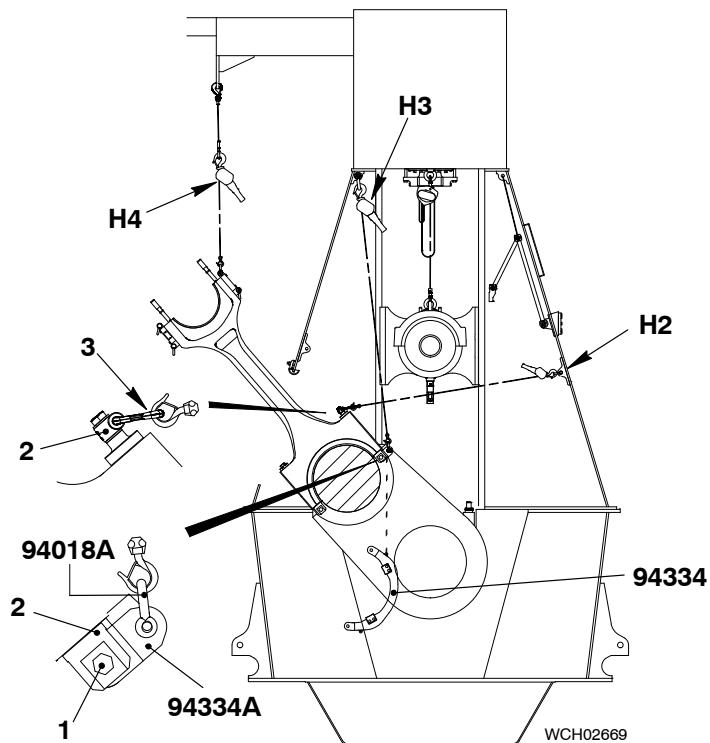
11) Attach the manual ratchet (H4) to the top shackle of the lifting tool (94337).

12) Apply tension to the manual ratchet (H4).

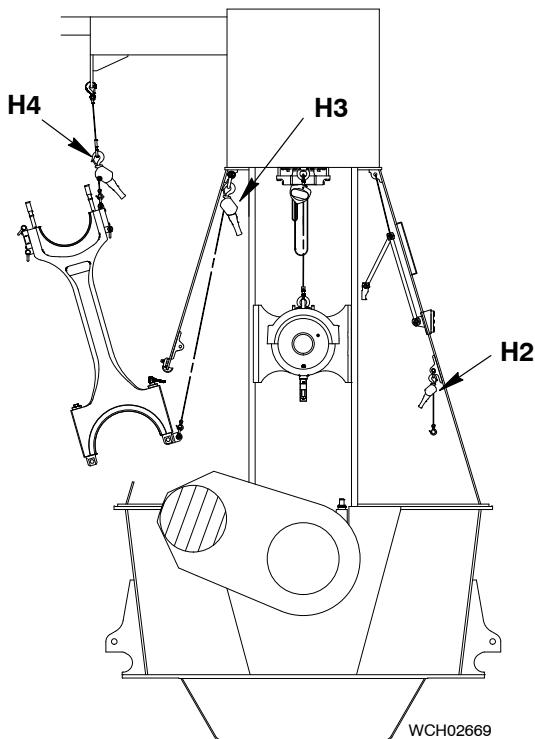
13) Remove the manual ratchet (H3) from the bottom shackle of the lifting tool (94337).

14) Operate the turning gear and manual ratchet (H4) to move the crankshaft (2, Fig. 5) and the connecting rod (1) to the position shown.

Removal and Installation

**Fig. 6**

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

**Fig. 7**

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

Removal and Installation

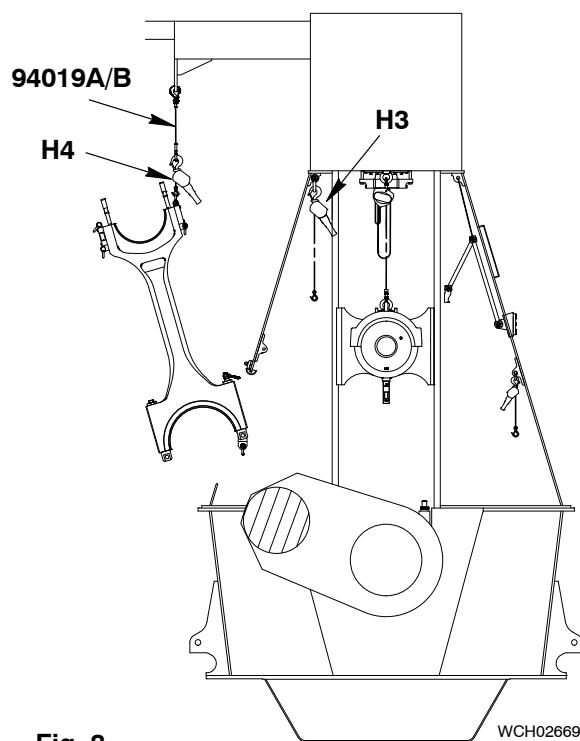


Fig. 8

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

3. Connecting Rod – Move

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

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

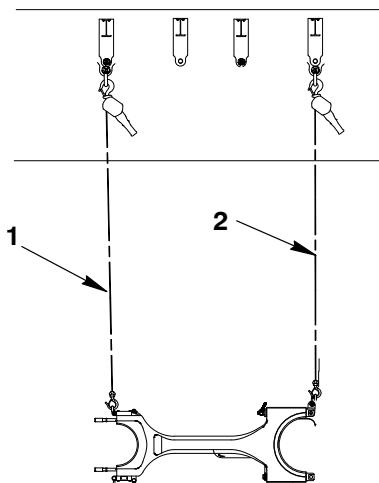
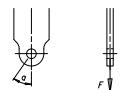
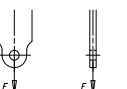
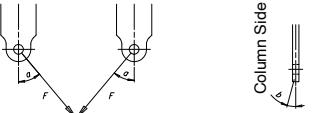
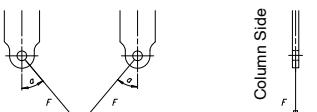


Fig. 9

Removal and Installation

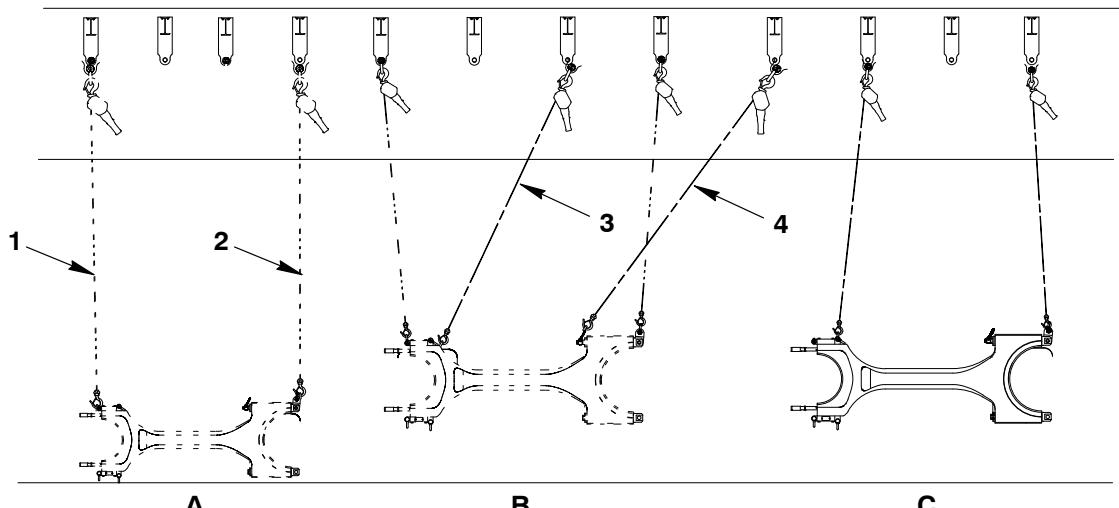
- 6) Read and obey the data given in Fig. 10.

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

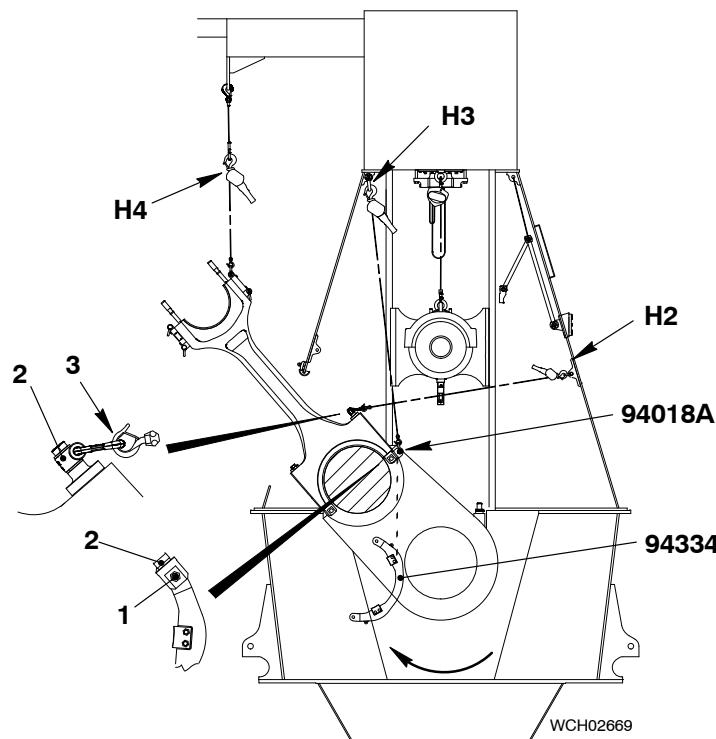
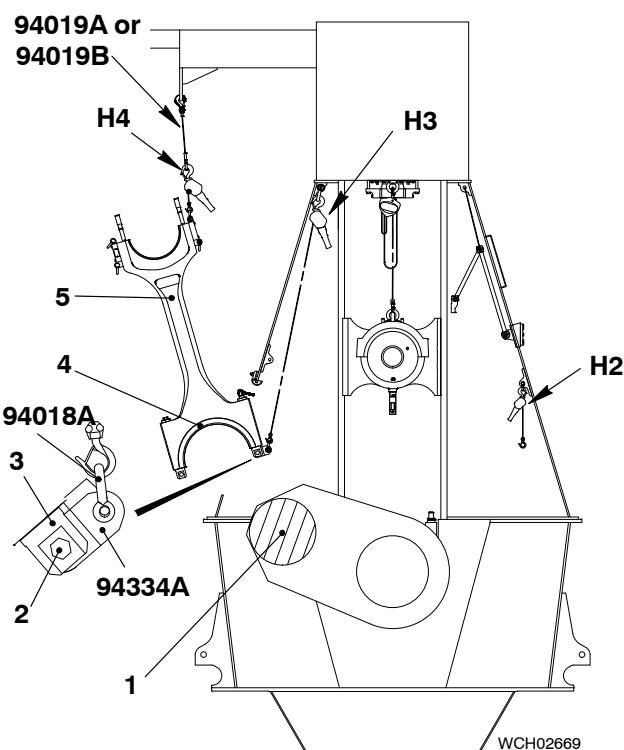
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Fig. 10: Load Condition Data

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

**Fig. 11**

Removal and Installation

**4. Installation****WARNING**

Injury Hazard: The connecting rod weighs 2549 kg. To prevent injury, be careful when you move the connecting rod.

WARNING

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

- 1) Clean the bearing shell (4, Fig. 12) and the crank pin (1).
- 2) Put oil on the bearing shell (4) and the crank pin (1).
- 3) Attach the manual ratchet (H3) to the shackle (94018A) on the connecting element (94334A).
- 4) Attach the manual ratchet (H2, Fig. 13) to the lug (3) on the top rod (2).
- 5) Operate the turning gear and the manual ratchets (H4, H3 and H2) to move the connecting rod and the crankshaft clockwise into the position shown.
- 6) Remove the manual ratchet (H3) from the shackle (94018A).
- 7) Remove the shackle (94018A) and the connecting 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 on 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

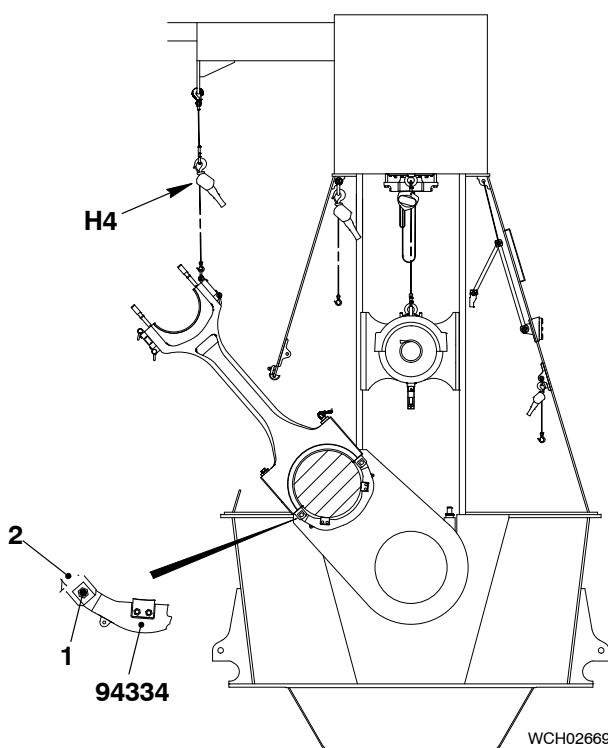


Fig. 14

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

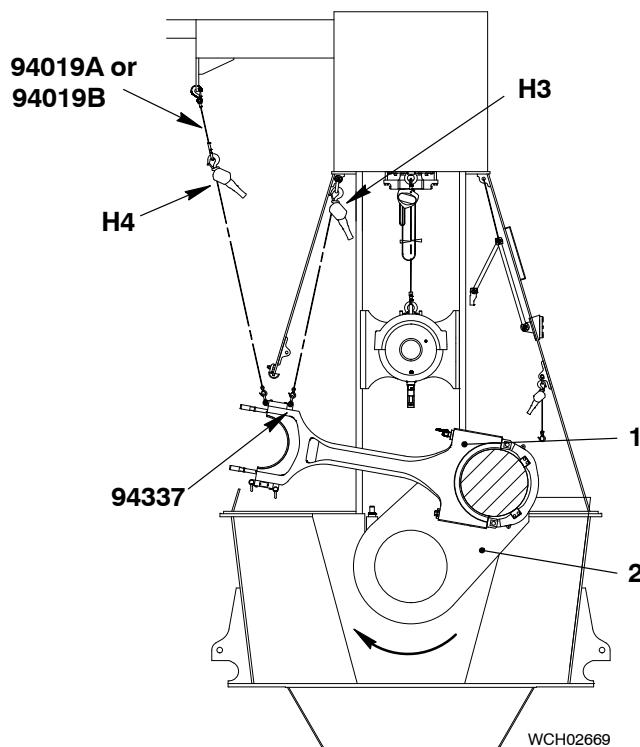


Fig. 15

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

Removal and Installation

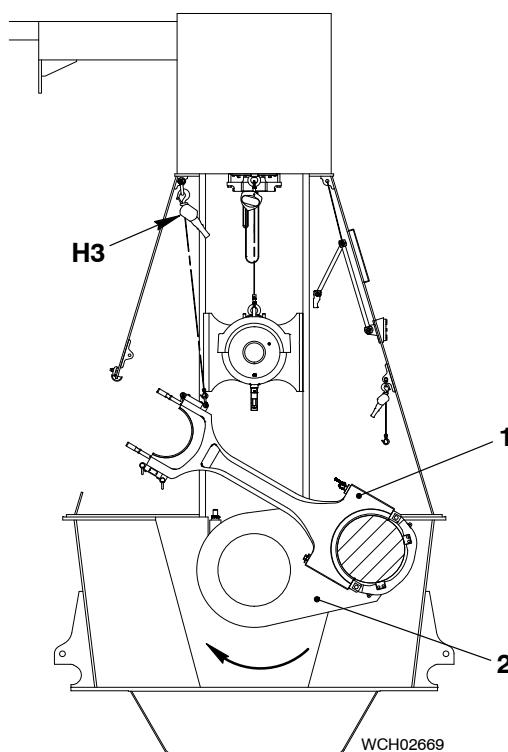


Fig. 16

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

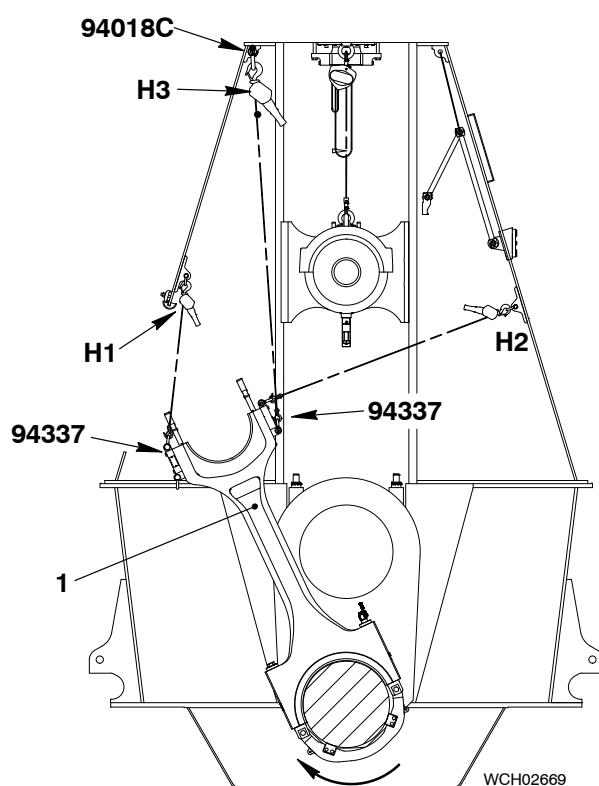
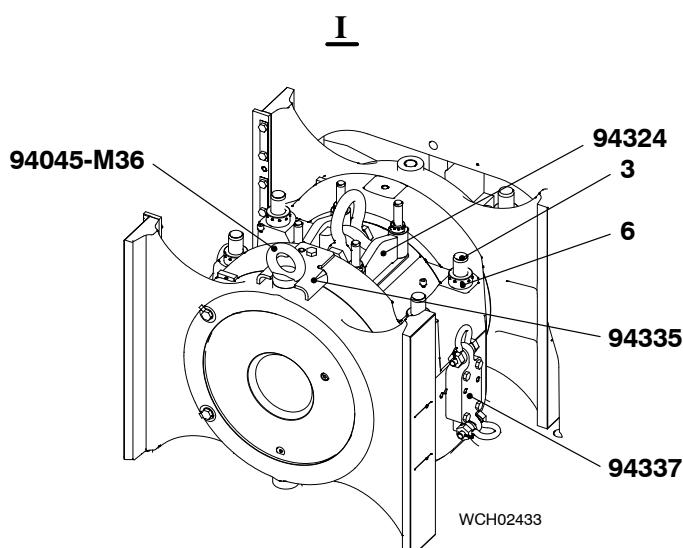
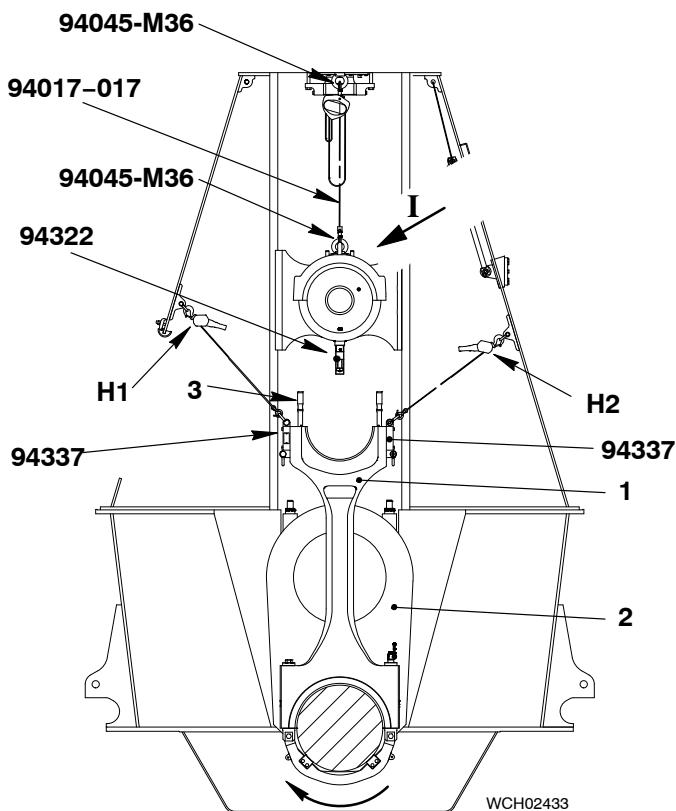


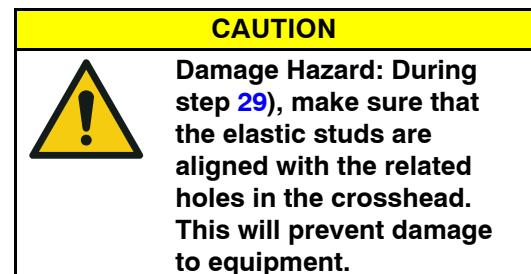
Fig. 17

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

Removal and Installation



- 27) Operate the turning gear and the manual ratchets (H1 and H2, Fig. 18) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.
- 28) Make sure that there is tension on the manual ratchet (H4).
- 29) Remove the two supports (94332).



- 30) Operate the manual ratchet (H4) to lower the crosshead on to the connecting rod (1).
- 31) Attach the four round nuts (6) to the elastic studs (3).
- 32) Remove the manual ratchet (H4).
- 33) Remove the tool (94324).
- 34) Remove the manual ratchets (H1, H2) from the lifting tool (94337).
- 35) Remove the lifting tool (94324).
- 36) Remove the eye bolt (94045-M36).
- 37) Remove the stop plate (94335).
- 38) Remove the manual ratchets (H1, H2) from the lifting tools (94337).

Fig. 18

Removal and Installation

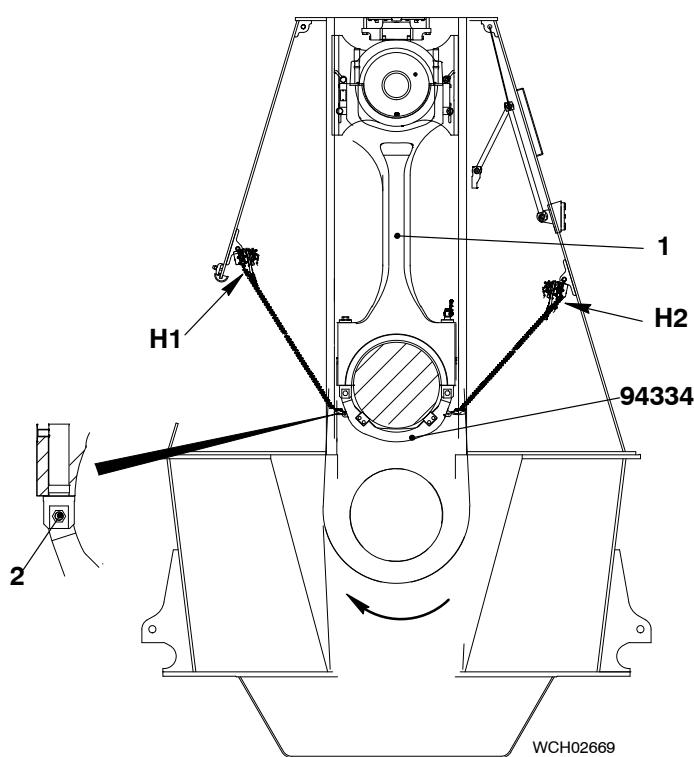


Fig. 19

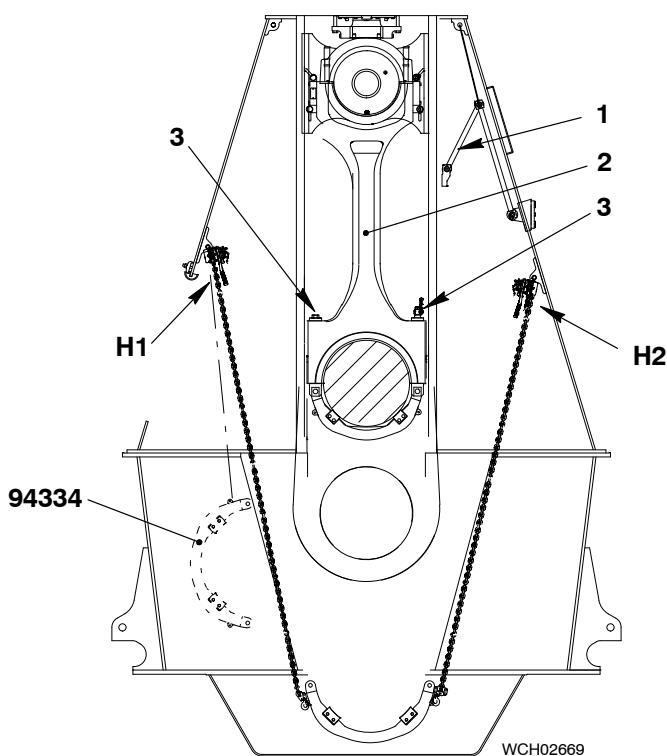


Fig. 20

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

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

5. Completion

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

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Connecting Rod

Top End Bearing Cover – Removal, Inspection and Installation

Tools:

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

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

1. Preparation

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

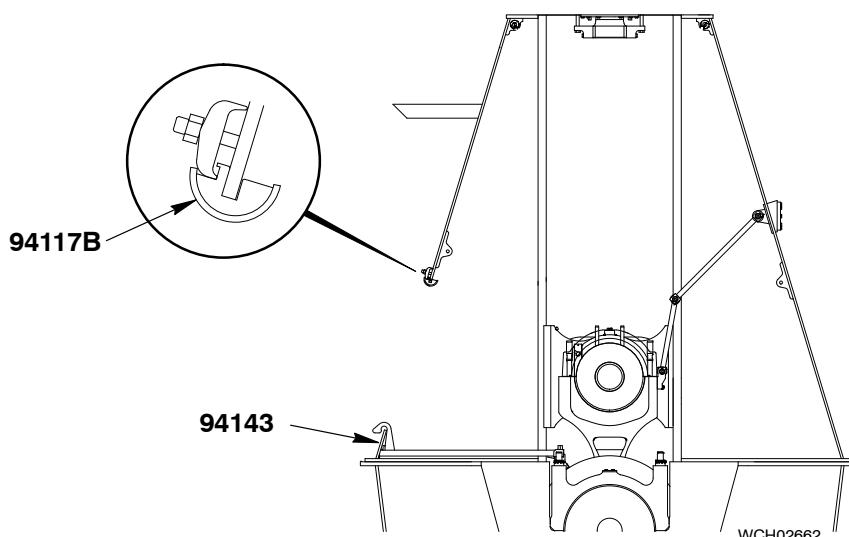
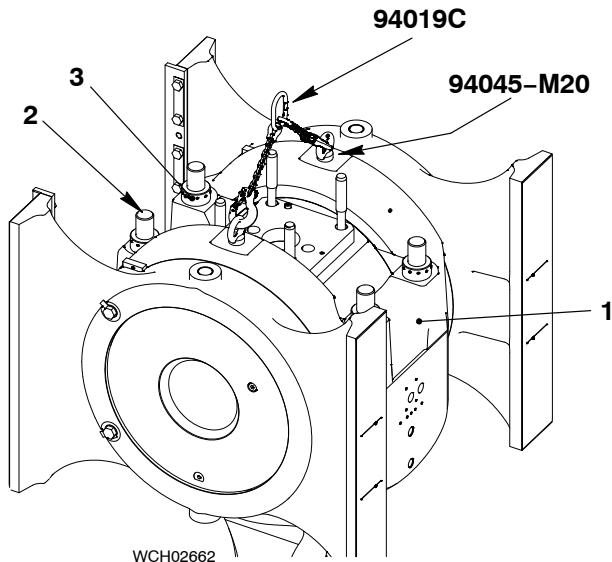
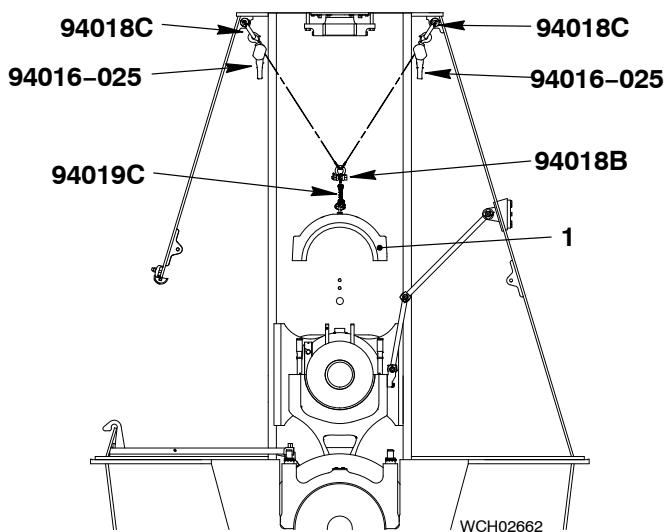


Fig. 1

Top End Bearing Cover – Removal, Inspection and Installation

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

- 1) Use the pre-tensioner (94315) to loosen the four round nuts (3, Fig. 2), refer to 9403–4, paragraph 2.
- 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 strong-points on the frame.
- 6) Attach the two manual ratchets (94016-025) to the shackles (94018C).
- 7) Attach the two manual ratchets (94016-025) to the shackle (94018B). Make sure that the chain lengths of the manual ratchets are equal.
- 8) Attach the chain (94019C) to the shackle (94018B).

	CAUTION Damage Hazard: Before you operate the manual ratchets, make sure that the chain (94019C) is vertically aligned with the center of the bearing cover. This will prevent damage to the elastic bolts.
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- 9) Operate carefully the two manual ratchets (94016-025) to lift the bearing cover (1).

Top End Bearing Cover – Removal, Inspection and Installation

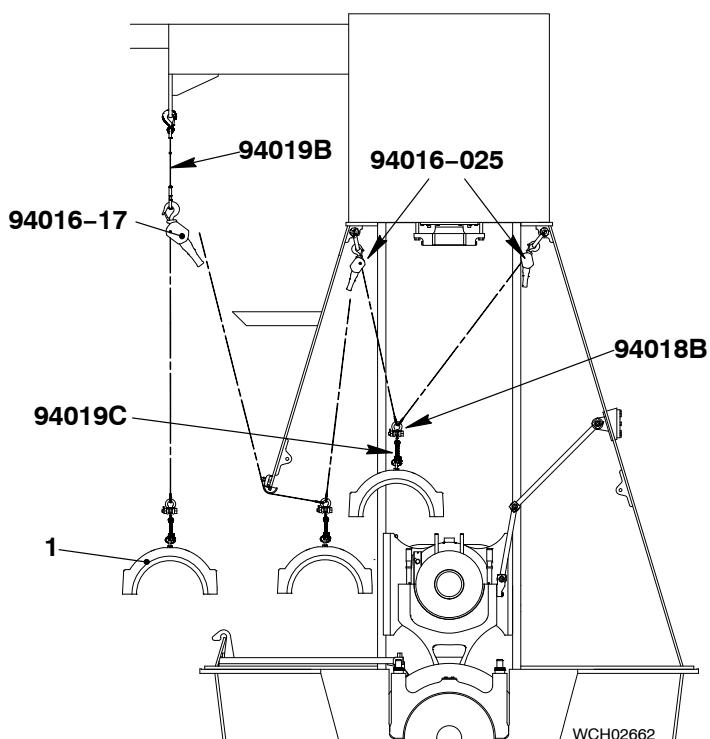


Fig. 4

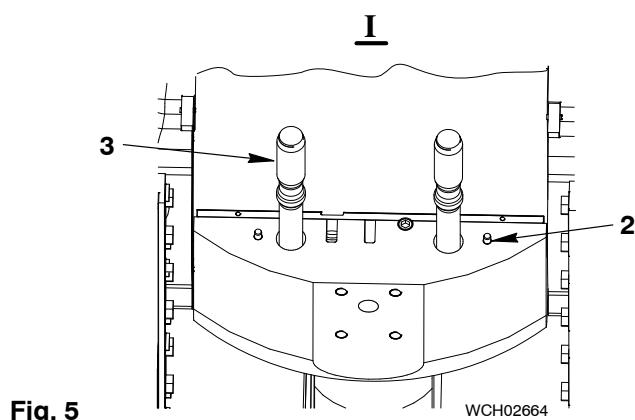
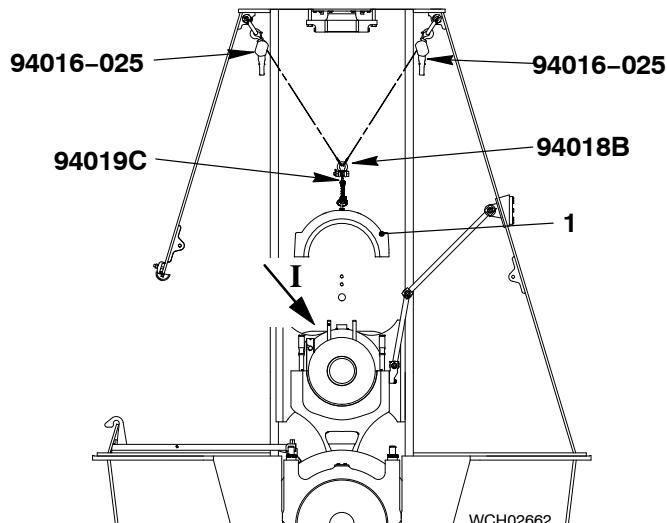


Fig. 5

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

3. Installation

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

CAUTION



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

- 6) Carefully lower the bearing cover (1) on to the crosshead pin. Make sure that you do not damage the elastic bolts (3).
- 7) Make sure that the holes in the bearing cover (1) engage with the four dowel pins (2).

Top End Bearing Cover – Removal, Inspection and Installation

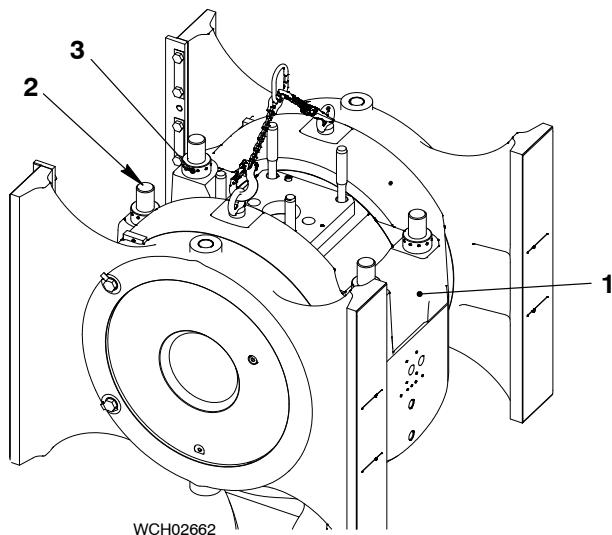


Fig. 6

- 8) Attach the round nuts (3, Fig. 6) to the elastic bolts (2).
- 9) Use the pre-tensioner (94315) to tighten the four round nuts (3) refer to 9403-4, paragraph 3.

4. Completion

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

Clearance Checks

Tools:

1 Feeler gauge 94238

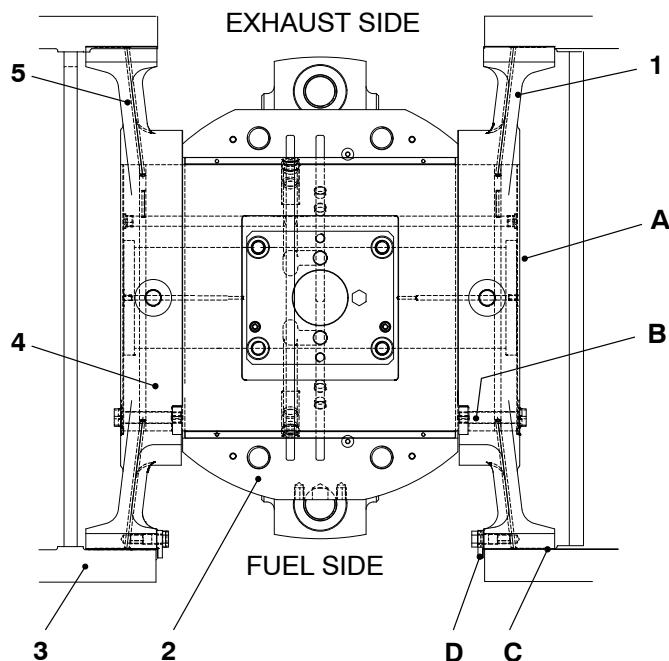


Fig. 1

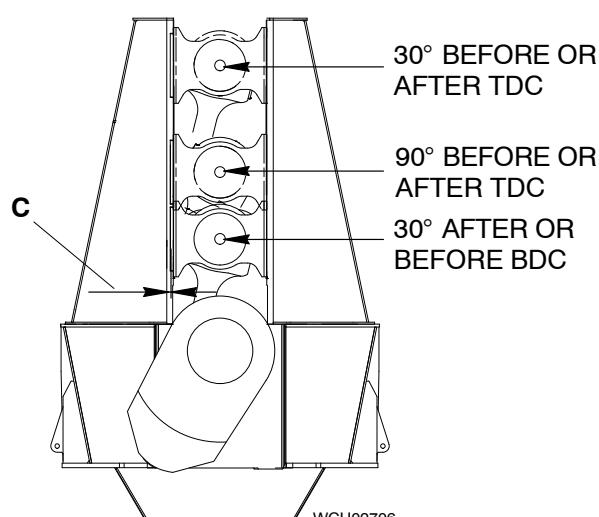


Fig. 2

1. General

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

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

2. Clearance Checks

2.1 Guide Shoe and Guide Way

- 1) Make sure that the related crosshead pin (4) is in a position so that the guide shoes (1) and (5) touch the guide ways (3) (on the fuel side or exhaust side).
- 2) Measure the clearance (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. 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 Deviation pipe	94117B	2 Eye bolt M20	94045–M20
1 Platform	94142	1 Eye bolt M24	94045–M24
1 Lifting tool	94324	4 Eye bolt M36	94045–M36
2 Chain block 5000 kg	94017–039	1 Chain	94325
1 Manual ratchet 6300 kg	94016–017	1 Chain	94019A/B
4 Manual ratchet 2500 kg	94016–011	1 Link	94321
1 Manual ratchet 500 kg	94016–024	2 Lifting tools	94337
4 Shackle	94018C	2 Supports	94322

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

1. Preparation

WARNING

Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, 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 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) Disconnect the toggle lever (1, [Fig. 1](#)) from the crosshead pin (2). Let the toggle lever hang in the column.
- 6) Remove the round nuts from the elastic studs on the connecting rod, 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.

Crosshead Pin – Removal / Installation / Clearance Checks

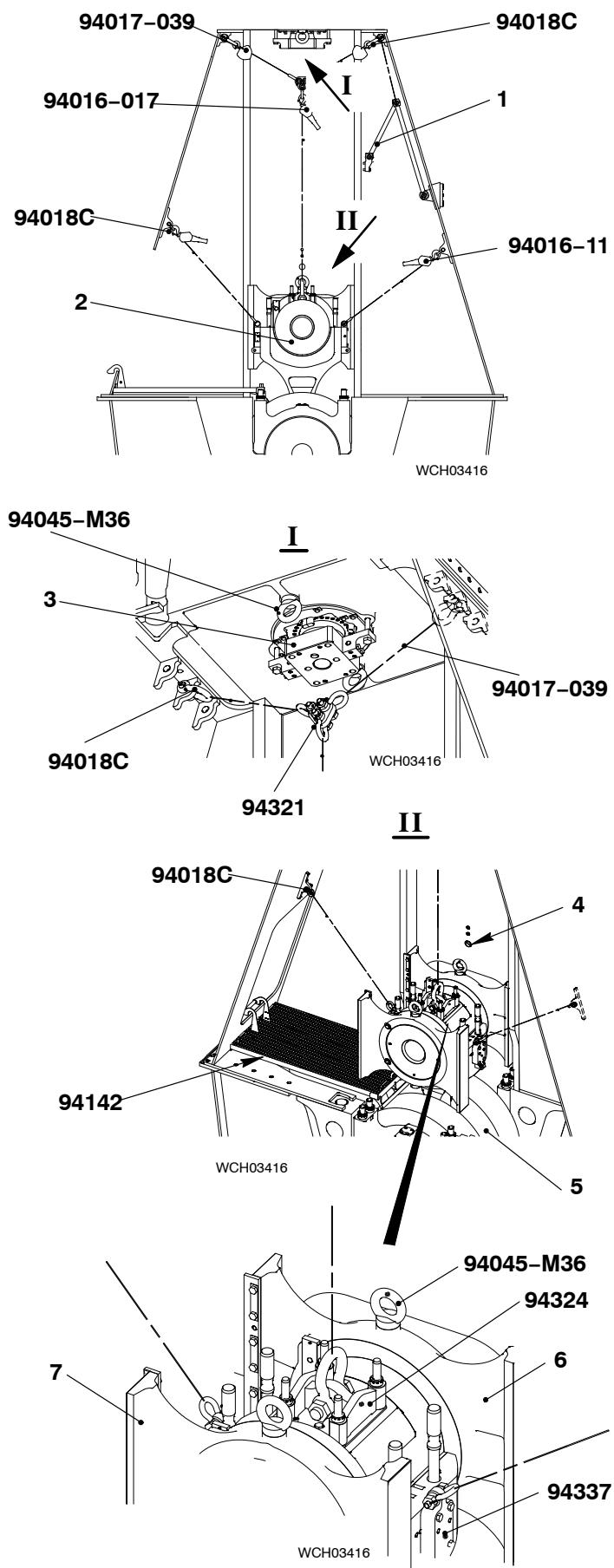


Fig. 1

2. Crosshead Pin – Removal

- 1) Attach the lifting tool (94234) to the crosshead (see Fig. 1 View II).
- 2) Attach the two eye bolts (94045-M36) to the bottom of the cylinder jacket.
- 3) Attach the two shackles (94018C) to the top of the column.
- 4) Attach the two chain blocks (94017-039) to the shackles.
- 5) Attach the link (94321) to the chain blocks (94017-039).
- 6) Attach the manual ratchet (94016-017) to the link and the eye bolt (94045-M36) on the lifting tool.
- 7) Attach the two eye bolts (94045-M36) to the guide shoes (6) and (7).
- 8) Attach the two lifting tools (94337) to the connecting rod (5).
- 9) Attach the two manual ratchets (94016-011) to the shackles (94018C) and the lifting tools (94337). Apply a light tension to the chains.

Crosshead Pin – Removal / Installation / Clearance Checks

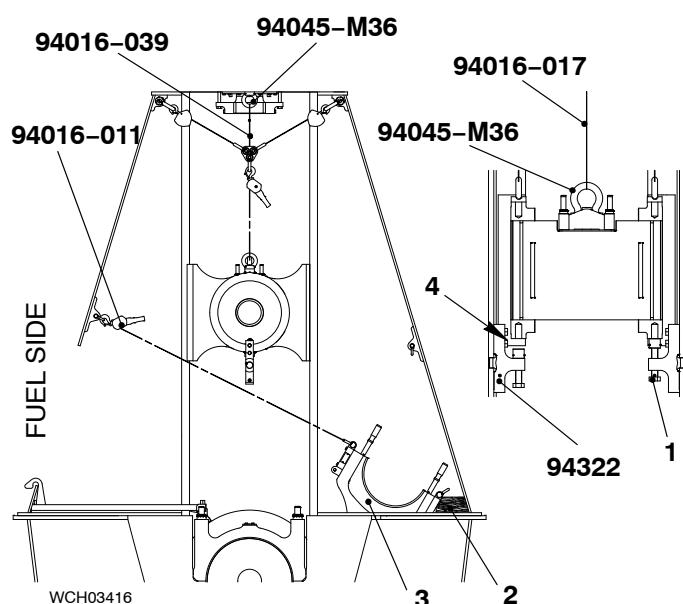


Fig. 2

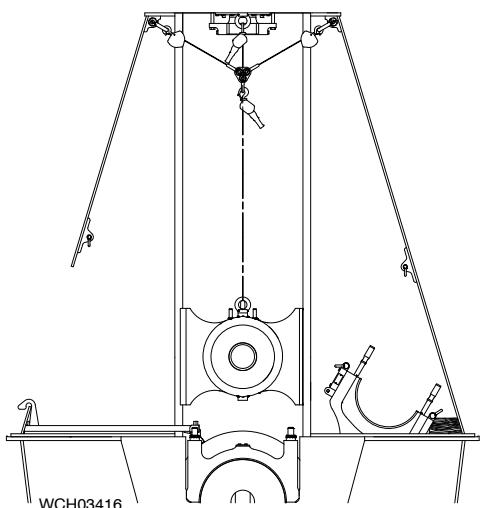


Fig. 3

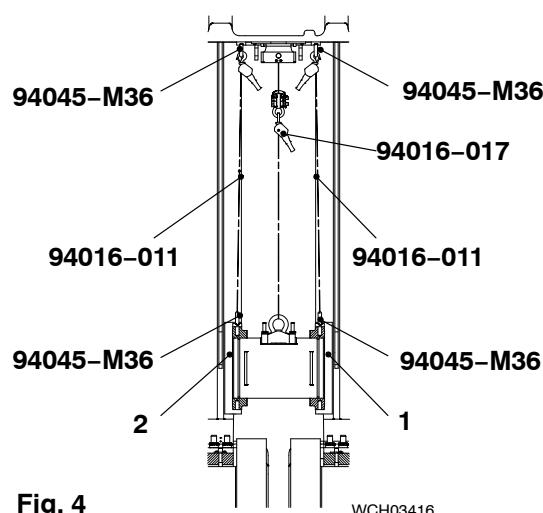


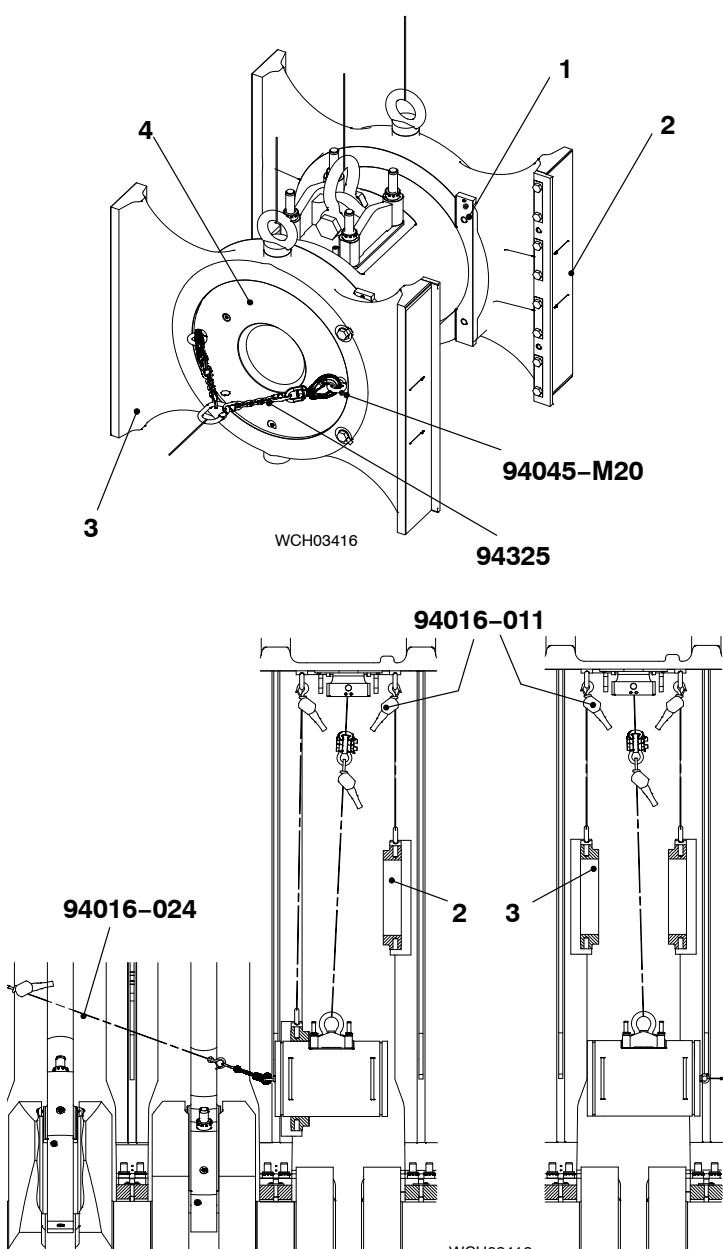
Fig. 4

- 10) Operate the manual ratchet (94016-017) to lift the crosshead approximately 160 mm above the center of the pin hole (4, [Fig. 1](#) view II and [Fig 2](#)).
- 11) Attach the two supports (94322) to the guide way as shown.
- 12) Torque the four bolts (4) to 240 Nm.
- 13) Tighten the two set screws (1).
- 14) Lower the crosshead on to the supports (94322).
- 15) Put the wooden block (2) in position as shown.

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

- 16) On the fuel side, gradually loosen the manual ratchet (94016-11). At the same time, keep tension on the chain of the manual ratchet on the exhaust side.
- 17) Continue with step 16) until the connecting rod (3) touches the wooden block (2).
- 18) Loosen the two set screws (1).
- 19) Lift the crosshead a small distance.
- 20) Remove the two supports (94322).
- 21) Remove the two manual ratchets (94016-011).
- 22) Lower the crosshead to the same height as the column door frame (see [Fig. 3](#)).
- 23) Attach the manual ratchets (94016-011, [Fig. 4](#)) to the eye bolts (94045-M36) on the guide shoes (1) and (2). Apply a light tension to the chains.
- 24) Apply a light tension to the chain of the manual ratchet (94016-017). Make sure that the primary load stays on the chain of the manual ratchet (94016-017)

Crosshead Pin – Removal / Installation / Clearance Checks



- 25) Remove the two bolts, tab washers and holding plates (1, [Fig. 5](#)) from the from the guide shoe (2).
- 26) Attach the two eye bolts (94045-M20) and the the chain (94325) to the crosshead pin (4).
- 27) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 28) Attach the manual ratchet (94016-024) to the chain (94325) and the eye bolt (94045-M24).
- 29) Operate the manual ratchet (94016-024) to pull the crosshead pin (4) until the guide shoe (2 or 3) is clear.
- 30) Operate the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 31) Remove the chain (94325), manual ratchet (94016-024), and eye bolts (94045-M20).
- 32) Attach the eye bolts (94045-M20), chain (94325), eye bolt (94045-M24) and manual ratchet (94016-024) to the other side of the crosshead pin (4).
- 33) Do step 29) to step 31) for the other guide shoe.
- 34) When the crosshead (4) is in the first or last cylinder position, do step 35) to step 41).
- 35) Attach the eye bolt (94045-M24, [Fig. 6](#)) an applicable hole in the column.
- 36) Attach the manual ratchet (94016-024) to the eye bolt (94045-M24) and the eye bolt (94045-M36).
- 37) Operate the manual ratchet (94016-024) to pull the crosshead pin from the guide shoe (2 or 3).
- 38) Operate the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 39) Remove the manual ratchet (94016-024) and the eye bolt (94045-M24).
- 40) Attach the eye bolt (94045-M24) and manual ratchet (94016-024) to the other side of the column.
- 41) Do step 37) to step 39 for the other guide shoe (2, or 3).
- 42) Remove the manual ratchet (94016-024) and the eye bolt (94045-M24).

Crosshead Pin – Removal / Installation / Clearance Checks

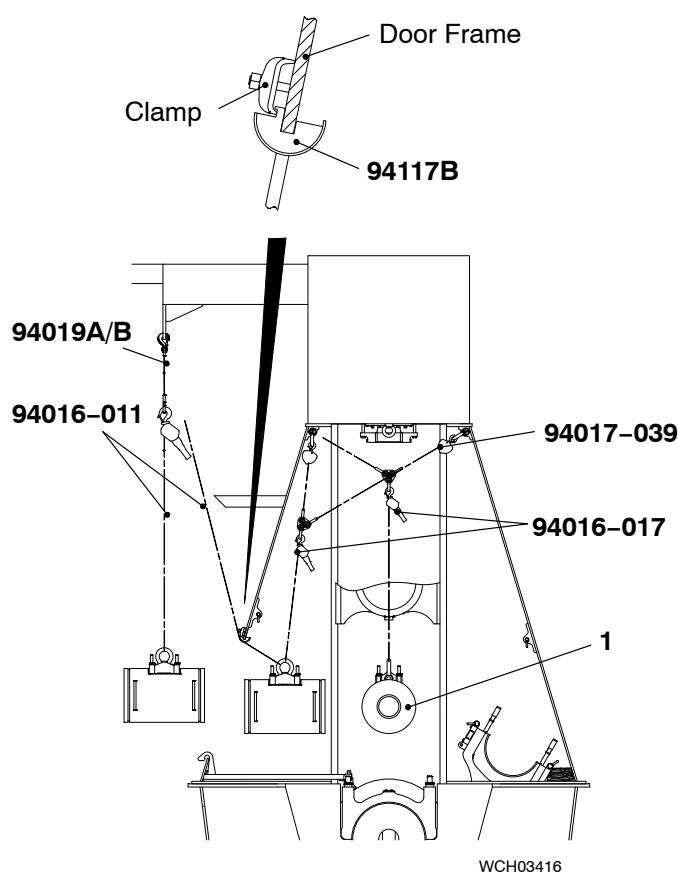


Fig. 7

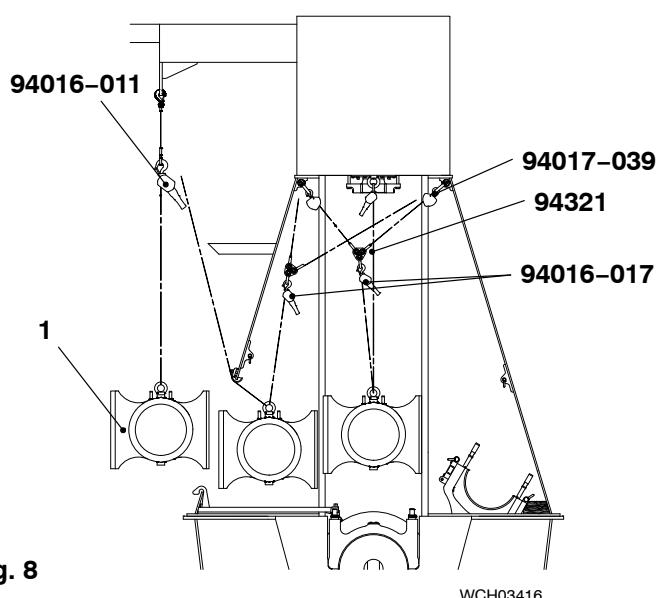


Fig. 8

- 43) Attach the deviation pipe (94117B, [Fig. 7](#)) to the door frame.
 - 44) Attach the chain (94019A/B) to the attachment point on the gallery.
 - 45) Attach the manual ratchet (94016-011) to the chain (94019A/B) and the eye bolt on the crosshead (1).
 - 46) Turn the crosshead pin (1) 90°.
- Note:** When you do step 47 and step 48) keep the tension on the two chain blocks (94017-039).
- 47) To move the crosshead pin out of the column, tighten the manual ratchet (94016-011). At the same time, carefully loosen the manual ratchet (94016-017).
 - 48) Lower the crosshead on to an applicable wooden underlay.
 - 49) Remove the manual ratchets (94016-011, 94016-017) from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

- 1) Record the positions of the guide shoes. The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.
 - 2) Operate the manual ratchet (94016-011, [Fig 5](#)) to lower the guide shoe (2) to the door frame.
 - 3) Attach the manual ratchets (94016-011, 94016-017, [Fig. 8](#)) to the eye bolt on the guide shoe.
 - 4) Apply a light tension to the chains of the manual ratchets (94016-011, 94016-017).
 - 5) Remove the manual ratchet (94016-031) from the guide shoe.
- Note:** When you the steps below, keep the tension on the two chain blocks (94017-039).
- 6) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet (94016-011). At the same time, carefully loosen the manual ratchet (94016-017).
 - b) Lower the guide shoe (1) on to an applicable wooden underlay.
 - 7) Do step 2) to step 6) for the other guide shoe.

Crosshead Pin – Removal / Installation / Clearance Checks

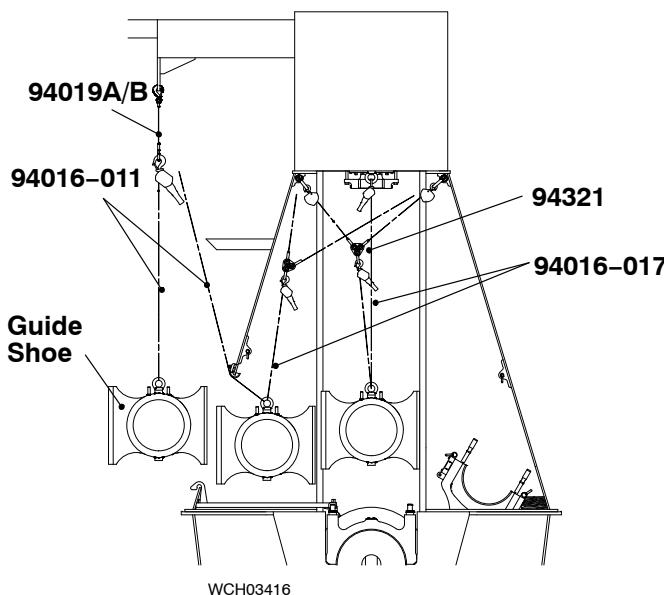


Fig. 9

4. Guide Shoes – Installation

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

- 1) Attach the two manual ratchets (94016-017 and 94016-011, Fig. 9) to the eye bolt on the guide shoe.
- 2) Apply a light tension to the chains of the manual ratchet (94016-017).

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

- 3) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet (94016-017). At the same time, carefully loosen the manual ratchet (94016-11).
- 4) Attach the manual ratchet (94016-011, Fig. 5) to the guide shoe (2 or 3).
- 5) Use the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 6) Remove the two manual ratchets (94016-017) from the guide shoe (2 or 3).
- 7) Do step 1) to step 6) for the other guide shoe.

5. Crosshead Pin – Installation

- 1) Clean the crosshead pin (1, Fig. 10) and the guide and bearing surfaces.
- 2) Make sure that the surfaces of the crosshead pin are clean and have no damage.
- 3) Apply bearing oil to the crosshead pin (1) and all guide and bearing surfaces.
- 4) Attach the two manual ratchets (94016-011, 94016-017) to the eye bolt on the crosshead pin (1).

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

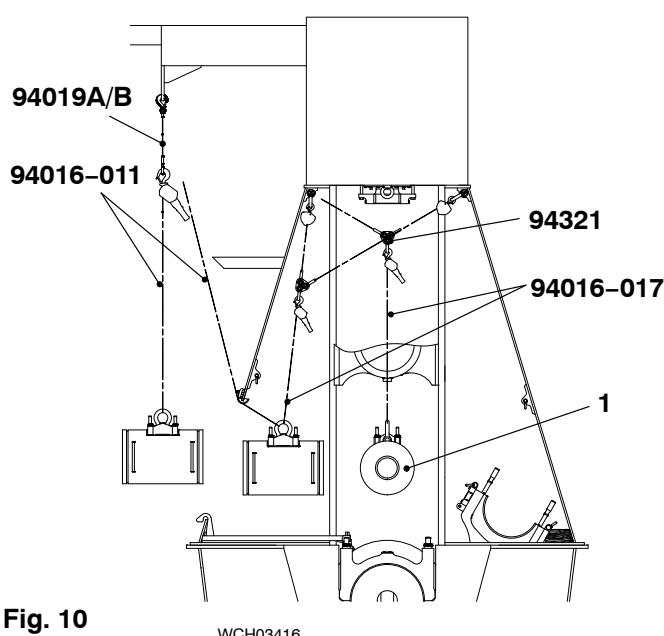


Fig. 10

Crosshead Pin – Removal / Installation / Clearance Checks

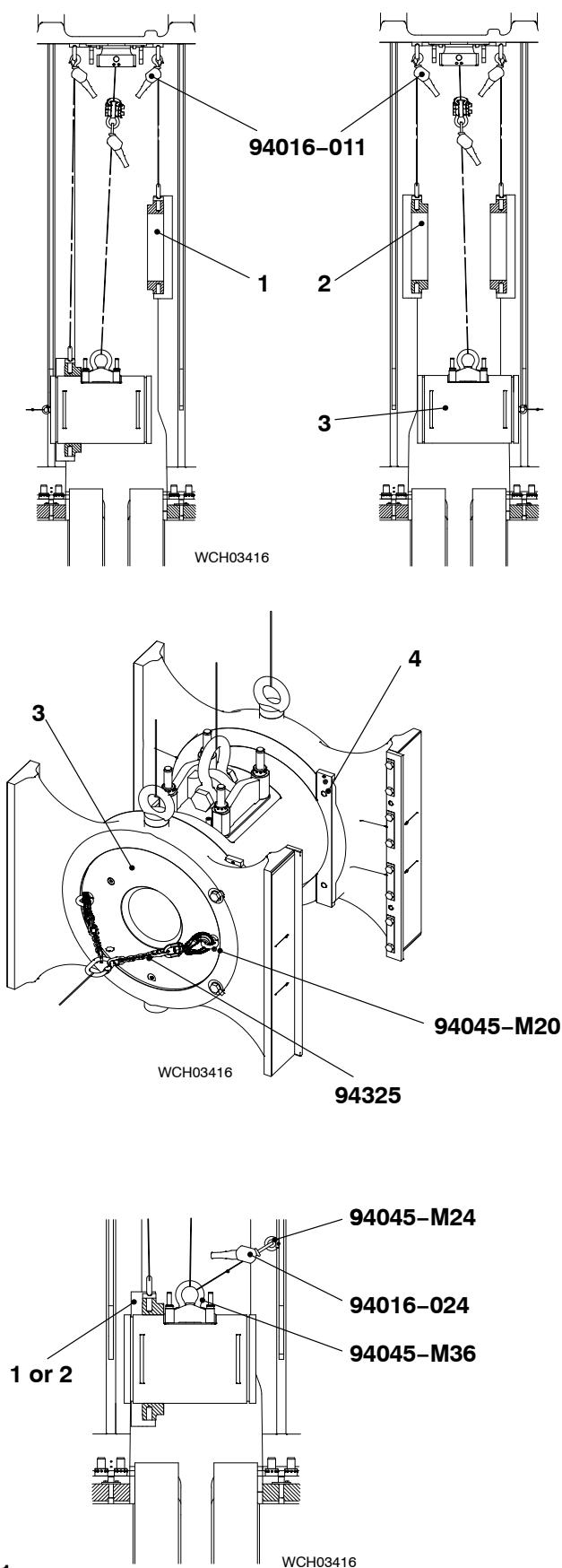


Fig. 11

- 5) Move the crosshead pin (1, Fig. 10) through the door frame as follows:
 - a) Loosen the manual ratchet (94016-011). At the same time, carefully tighten the manual ratchet (94016-017).
- 6) When the crosshead in (1) is in the column, remove the manual ratchet (94016-011).
- 7) Turn the crosshead pin 90°.
- 8) Remove the deviation pipe (94117B) from the door frame.
- 9) Lower and align the guide shoe (2, Fig. 11) with the crosshead pin (3).
- 10) Attach the two eye bolts (94045-M20) and the chain (94325) to the crosshead pin (3).
- 11) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 12) Attach the manual ratchet (94016-024) to the eye bolt (94045-M24) and the chain (94325).
- 13) Use the manual ratchet (94016-024) to pull the crosshead pin (3) into the guide shoe (2).
- 14) Remove the chain (94325), eye bolts (94045-M20, 94045-M24) and manual ratchet (94016-024).
- 15) Attach the eye bolts (94045-M20), and chain (94325), to the other side of the crosshead pin.
- 16) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 17) Use the manual ratchet (94016-024) to pull the crosshead pin (3) into the guide shoe (1).
- 18) Remove the chain (94325), eye bolts (94045-M20, 94045-M24) and manual ratchet (94016-024).

Crosshead Pin – Removal / Installation / Clearance Checks

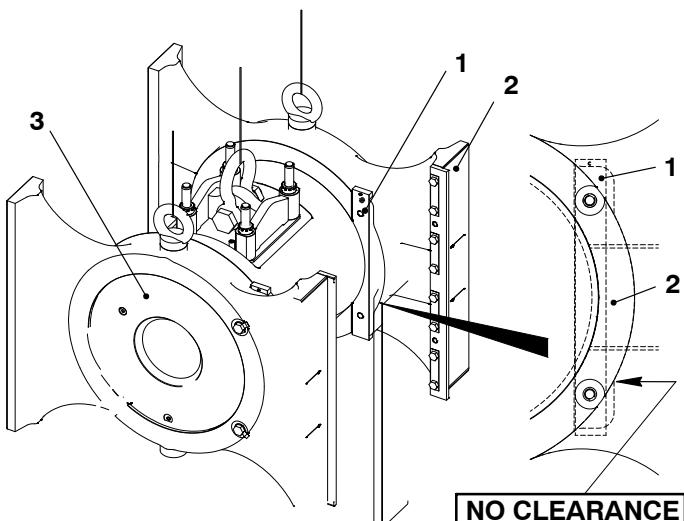
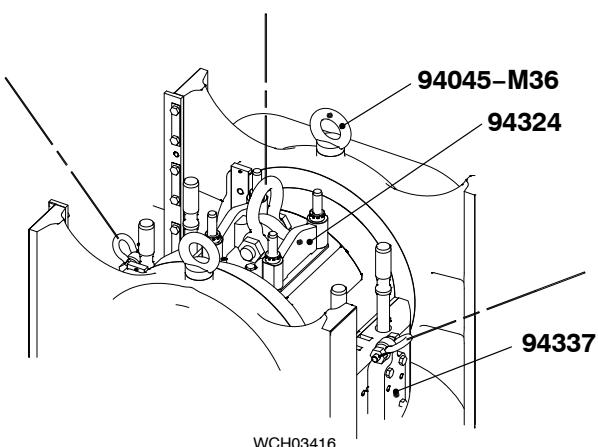


Fig. 12

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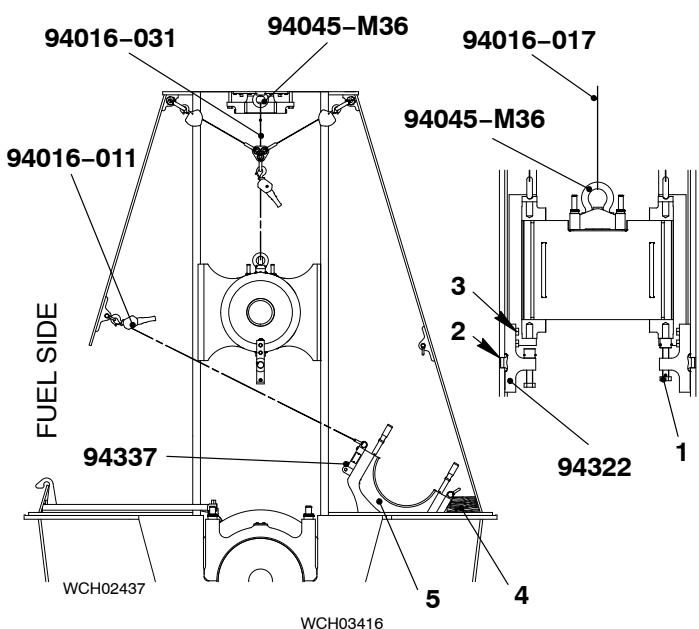


Fig. 13

- 19) Attach the two holding plates (1, [Fig. 12](#)) to the guide shoe (2) with the tab washers and bolts.
- 20) Make sure that there is no clearance between the holding plates (1) and crosshead pin (3).
- 21) Operate the manual ratchet (94016-017, [Fig. 13](#)) to lift the crosshead approximately 160 mm above the center of the pin hole (2).

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

- 22) Attach the two supports (94322) to the guide way.
- 23) Tighten the four bolts (3) to 240 Nm.
- 24) Tighten the two set screws (1).
- 25) Attach the two manual ratchets (94016-011) to the shackles (94018B) and the lifting tools (94337) on the connecting rod (5). Apply a light tension to the chains.

Note: During the step below, slowly move the connecting rod to the middle of the column.

- 26) On the fuel side, gradually tighten the manual ratchet. At the same time, keep tension on the chain of the manual ratchet on the exhaust side.
- 27) Continue with the step above until the connecting rod (5) aligns with the crosshead.
- 28) Remove the wooden block (4).
- 29) If necessary, lift the crosshead a small distance.
- 30) Loosen the two set screws (1).
- 31) Remove the four bolts (3).
- 32) Remove the two supports (94322).

Crosshead Pin – Removal / Installation / Clearance Checks

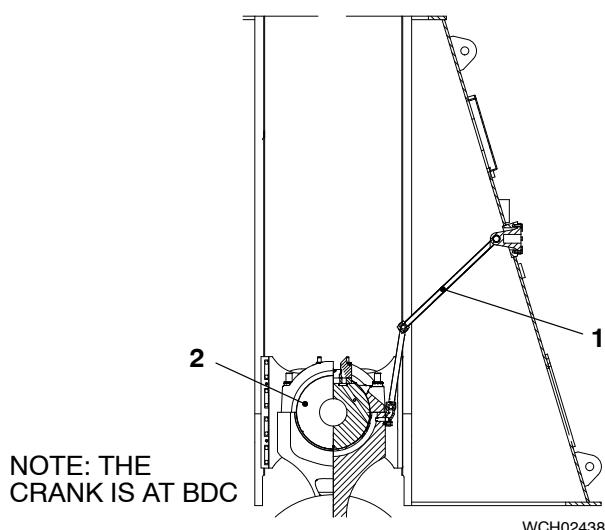


Fig. 14

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

- 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 chain blocks.
- 36) Remove the protection from the crosshead pin (2).

CAUTION

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

- 37) Connect the toggle lever (1) to the crosshead pin (2). make sure that the toggle lever is in the position shown.

6. Clearance Checks

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

7. Completion

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

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Crosshead Pin – Removal / Installation / Clearance Checks (Engines with Integrated ELBA)

Tools:

1	Protection tool	94117B	2	Eye bolt M20	94045–M20
1	Platform	94142	1	Eye bolt M24	94045–M24
1	Lifting tool	94324	4	Eye bolt M36	94045–M36
2	Chain block 5000 kg	94017–039	1	Chain	94325
1	Manual ratchet 6300 kg	94016–017	1	Chain	94019A/B
4	Manual ratchet 2500 kg	94016–011	1	Link	94321
1	Manual ratchet 500 kg	94016–024	2	Lifting tools	94337
4	Shackle	94018C	1	Support	94322
			1	Support	94322A

1.	Preparation	1
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6.	Clearance Checks	9
7.	Completion	9

1. Preparation

WARNING

Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, 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 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) Disconnect the toggle lever (1, [Fig. 1](#)) from the crosshead pin (2). Let the toggle lever hang in the column.
- 6) Remove the round nuts from the elastic studs on the connecting rod, 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.

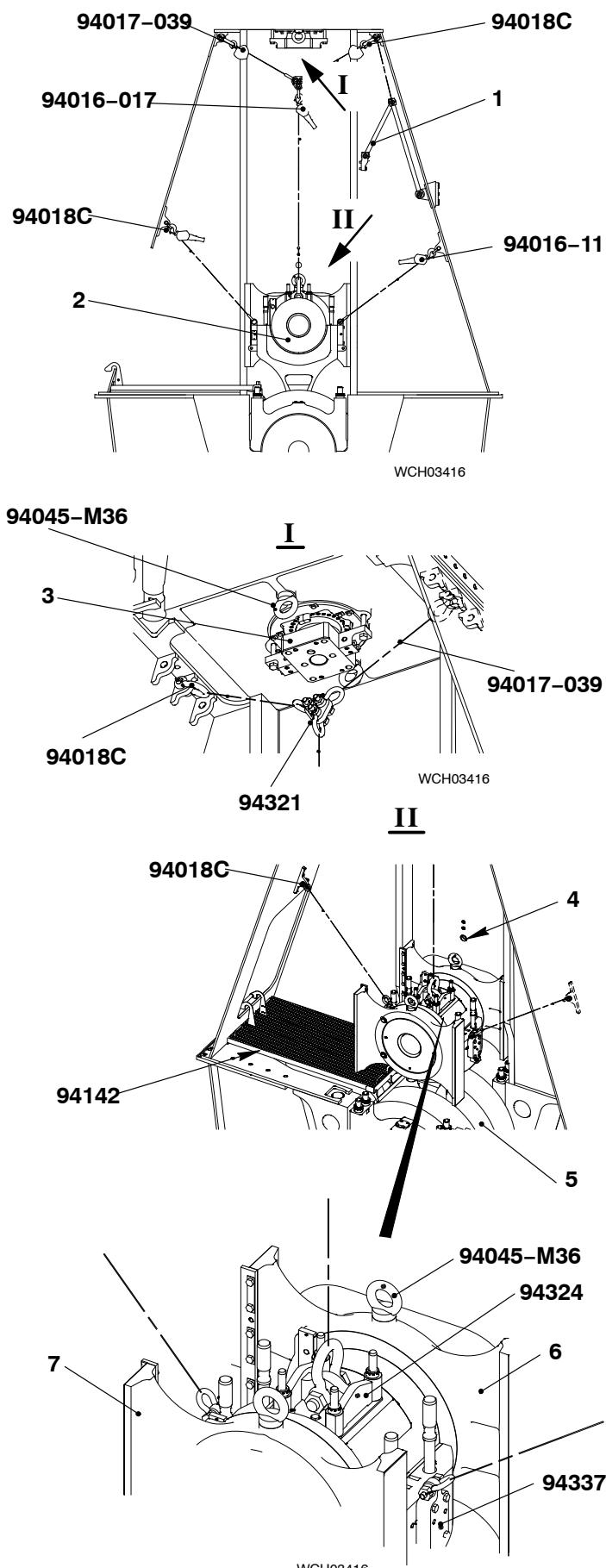
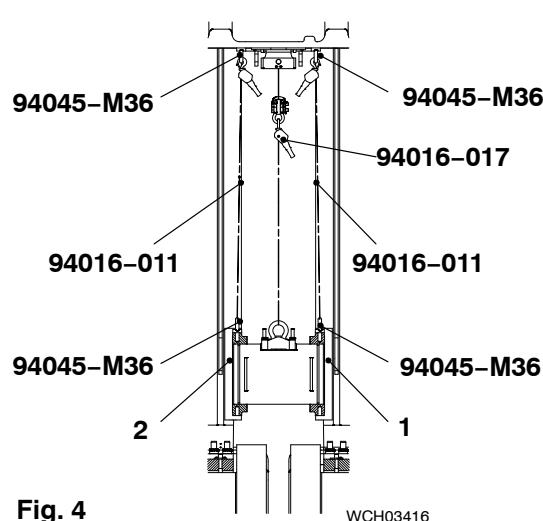
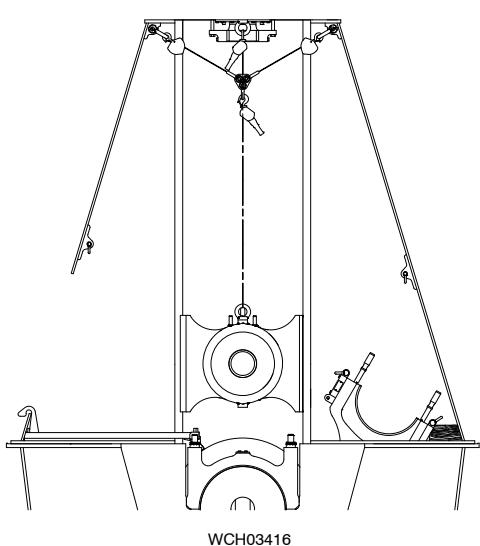
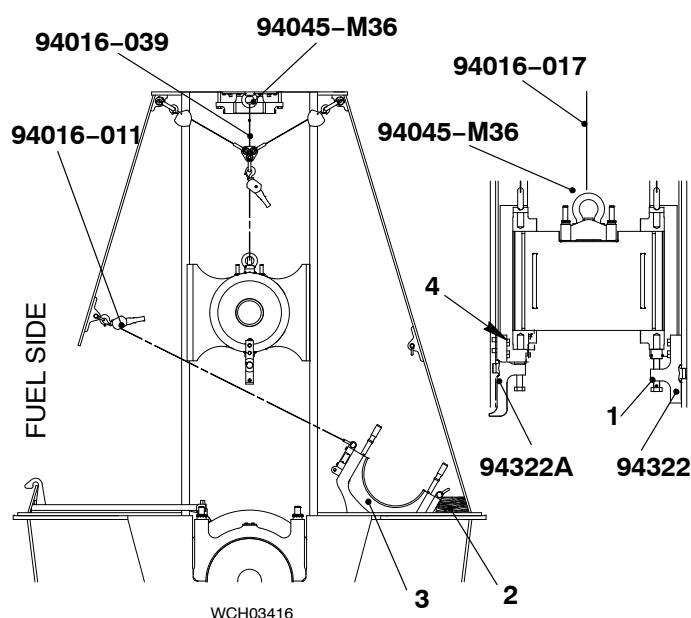


Fig. 1

2. Crosshead Pin – Removal

- 1) Attach the lifting tool (94234) to the crosshead (see Fig. 1 View II).
 - 2) Attach the two eye bolts (94045–M36) to the bottom of the cylinder jacket.
 - 3) Attach the two shackles (94018C) to the top of the column.
 - 4) Attach the two chain blocks (94017–039) to the shackles.
 - 5) Attach the link (94321) to the chain blocks (94017–039).
 - 6) Attach the manual ratchet (94016–017) to the link and the eye bolt (94045–M36) on the lifting tool.
 - 7) Attach the two eye bolts (94045–M36) to the guide shoes (6) and (7).
 - 8) Attach the two lifting tools (94337) to the connecting rod (5).
 - 9) Attach the two manual ratchets (94016–011) to the shackles (94018C) and the lifting tools (94337). Apply a light tension to the chains.

Crosshead Pin – Removal / Installation / Clearance Checks



10) Operate the manual ratchet (94016-017) to lift the crosshead approximately 160 mm above the center of the pin hole (4, [Fig. 1](#) view II and [Fig 2](#)).

11) Attach the two supports (94322, 94122A) to the guide way as shown.

12) Torque the four bolts (4) to 240 Nm.

13) Tighten the two set screws (1).

14) Lower the crosshead on to the supports (94322).

15) Put the wooden block (2) in position as shown.

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

16) On the fuel side, gradually loosen the manual ratchet (94016-11). At the same time, keep tension on the chain of the manual ratchet on the exhaust side.

17) Continue with step 16) until the connecting rod (3) touches the wooden block (2).

18) Loosen the two set screws (1).

19) Lift the crosshead a small distance.

20) Remove the two supports (94322).

21) Remove the two manual ratchets (94016-011).

22) Lower the crosshead to the same height as the column door frame (see [Fig. 3](#)).

23) Attach the manual ratchets (94016-011, [Fig. 4](#)) to the eye bolts (94045-M36) on the guide shoes (1) and (2). Apply a light tension to the chains.

24) Apply a light tension to the chain of the manual ratchet (94016-017). Make sure that the primary load stays on the chain of the manual ratchet (94016-017)

Crosshead Pin – Removal / Installation / Clearance Checks

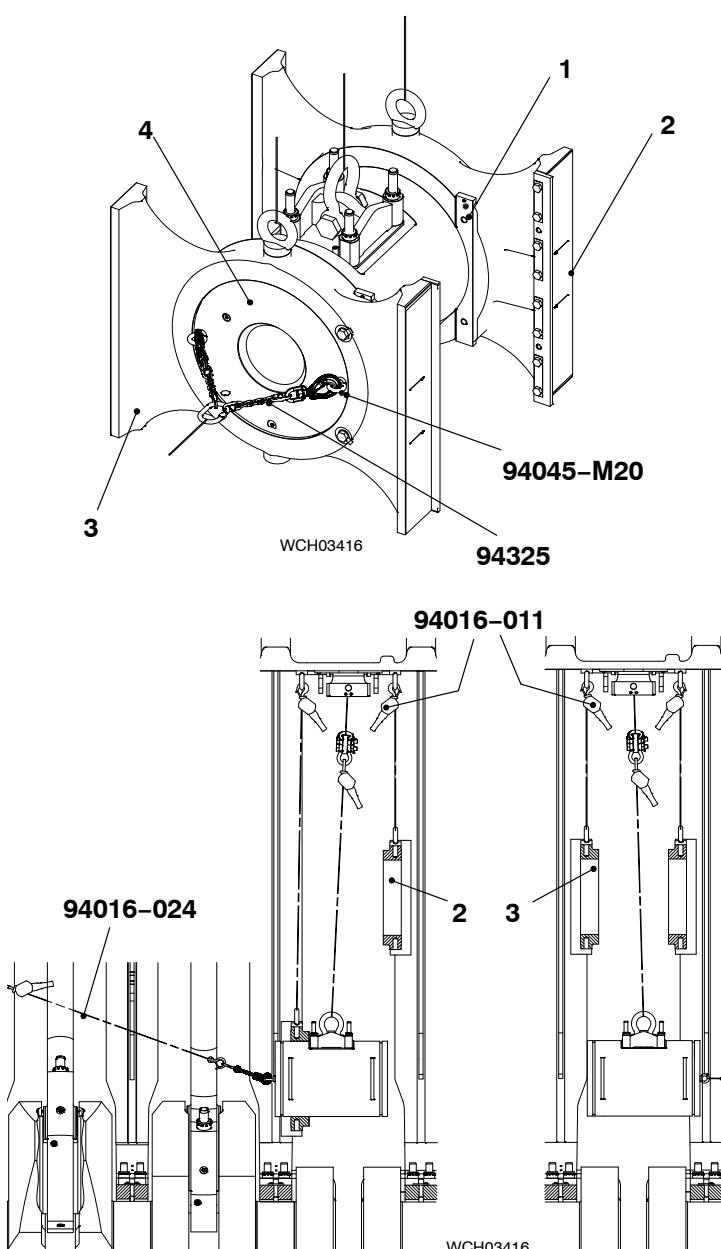


Fig. 5

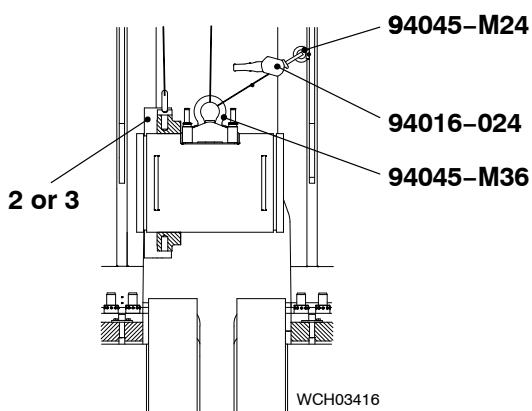
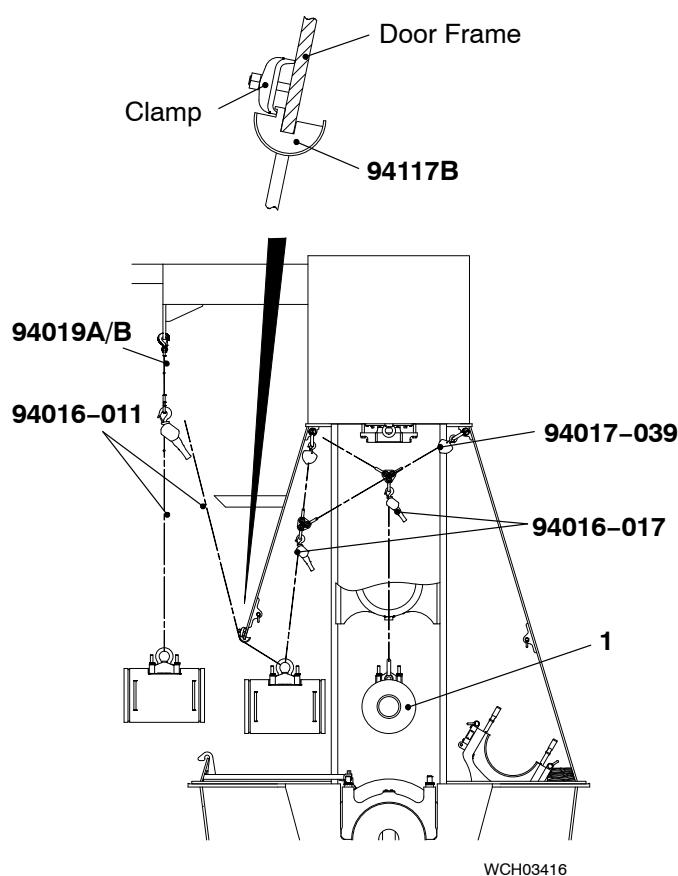


Fig. 6

- 25) Remove the two bolts, tab washers and holding plates (1, [Fig. 5](#)) from the from the guide shoe (2).
- 26) Attach the two eye bolts (94045-M20) and the the chain (94325) to the crosshead pin (4).
- 27) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 28) Attach the manual ratchet (94016-024) to the chain (94325) and the eye bolt (94045-M24).
- 29) Operate the manual ratchet (94016-024) to pull the crosshead pin (4) until the guide shoe (2 or 3) is clear.
- 30) Operate the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 31) Remove the chain (94325), manual ratchet (94016-024), and eye bolts (94045-M20).
- 32) Attach the eye bolts (94045-M20), chain (94325), eye bolt (94045-M24) and manual ratchet (94016-024) to the other side of the crosshead pin (4).
- 33) Do step 29) to step 31) for the other guide shoe.
- 34) When the crosshead (4) is in the first or last cylinder position, do step 35) to step 41).
- 35) Attach the eye bolt (94045-M24, [Fig. 6](#)) an applicable hole in the column.
- 36) Attach the manual ratchet (94016-024) to the eye bolt (94045-M24) and the eye bolt (94045-M36).
- 37) Operate the manual ratchet (94016-024) to pull the crosshead pin from the guide shoe (2 or 3).
- 38) Operate the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 39) Remove the manual ratchet (94016-024) and the eye bolt (94045-M24).
- 40) Attach the eye bolt (94045-M24) and manual ratchet (94016-024) to the other side of the column.
- 41) Do step 37) to step 39 for the other guide shoe (2, or 3).
- 42) Remove the manual ratchet (94016-024) and the eye bolt (94045-M24).

Crosshead Pin – Removal / Installation / Clearance Checks



- 43) Attach the deviation pipe (94117B, [Fig. 7](#)) to the door frame.
 - 44) Attach the chain (94019A/B) to the attachment point on the gallery.
 - 45) Attach the manual ratchet (94016-011) to the chain (94019A/B) and the eye bolt on the crosshead (1).
 - 46) Turn the crosshead pin (1) 90°.
- Note:** When you do step 47 and step 48) keep the tension on the two chain blocks (94017-039).
- 47) To move the crosshead pin out of the column, tighten the manual ratchet (94016-011). At the same time, carefully loosen the manual ratchet (94016-017).
 - 48) Lower the crosshead on to an applicable wooden underlay.
 - 49) Remove the manual ratchets (94016-011, 94016-017) from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

- 1) Record the positions of the guide shoes. The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.
 - 2) Operate the manual ratchet (94016-011, [Fig 5](#)) to lower the guide shoe (2) to the door frame.
 - 3) Attach the manual ratchets (94016-011, 94016-017, [Fig. 8](#)) to the eye bolt on the guide shoe.
 - 4) Apply a light tension to the chains of the manual ratchets (94016-011, 94016-017).
 - 5) Remove the manual ratchet (94016-031) from the guide shoe.
- Note:** When you the steps below, keep the tension on the two chain blocks (94017-039).
- 6) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet (94016-011). At the same time, carefully loosen the manual ratchet (94016-017).
 - b) Lower the guide shoe (1) on to an applicable wooden underlay.
 - 7) Do step 2) to step 6) for the other guide shoe.

Crosshead Pin – Removal / Installation / Clearance Checks

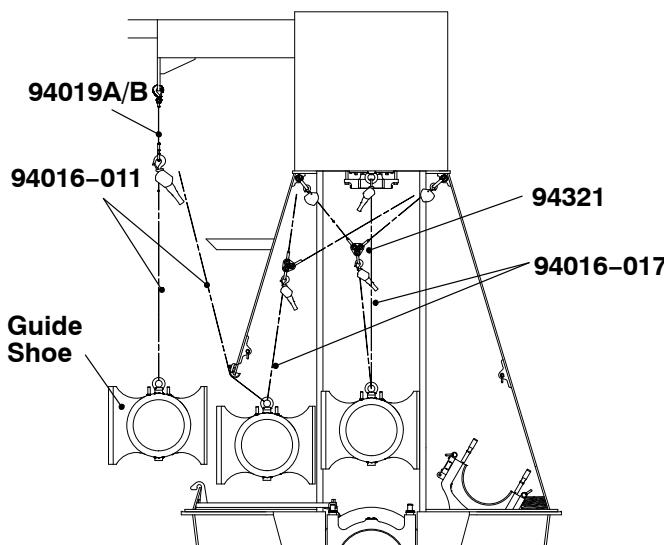


Fig. 9

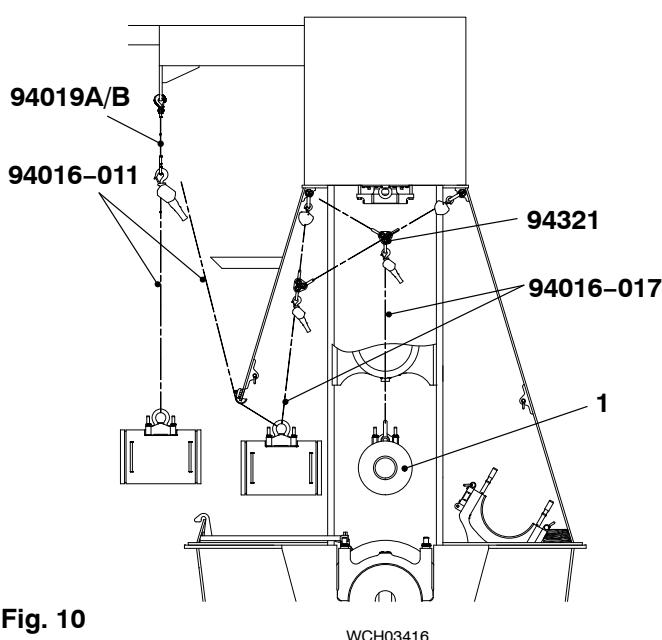


Fig. 10

4. Guide Shoes – Installation

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

- 1) Attach the two manual ratchets (94016-017 and 94016-011, [Fig. 9](#)) to the eye bolt on the guide shoe.
- 2) Apply a light tension to the chains of the manual ratchet (94016-017).

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

- 3) Move the guide shoe (1) through the door frame as follows:
 - a) Tighten the manual ratchet (94016-017). At the same time, carefully loosen the manual ratchet (94016-11).
- 4) Attach the manual ratchet (94016-011, [Fig. 5](#)) to the guide shoe (2 or 3).
- 5) Use the manual ratchet (94016-011) to lift the guide shoe (2 or 3).
- 6) Remove the two manual ratchets (94016-017) from the guide shoe (2 or 3).

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

5. Crosshead Pin – Installation

- 1) Clean the crosshead pin (1, [Fig. 10](#)) and the guide and bearing surfaces.
- 2) Make sure that the surfaces of the crosshead pin are clean and have no damage.
- 3) Apply bearing oil to the crosshead pin (1) and all guide and bearing surfaces.
- 4) Attach the two manual ratchets (94016-011, 94016-017) to the eye bolt on the crosshead pin (1).

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

Crosshead Pin – Removal / Installation / Clearance Checks

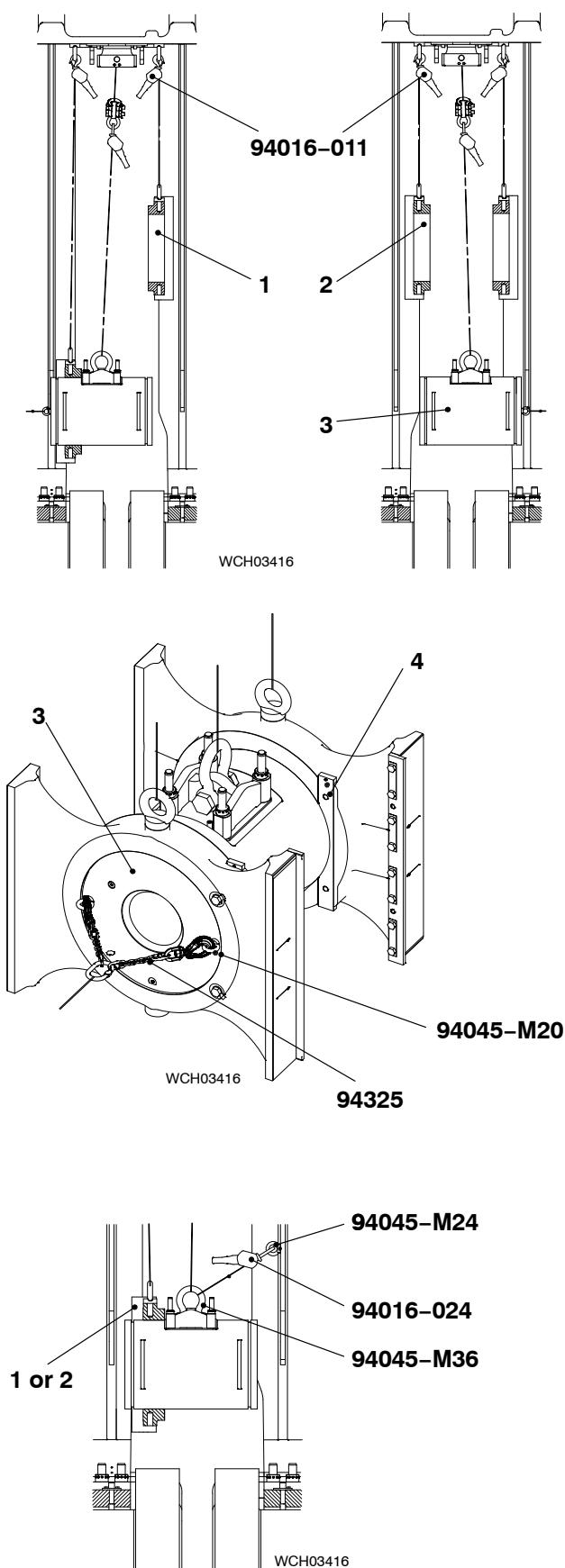


Fig. 11

- 5) Move the crosshead pin (1, Fig. 10) through the door frame as follows:
 - a) Loosen the manual ratchet (94016-011). At the same time, carefully tighten the manual ratchet (94016-017).
- 6) When the crosshead in (1) is in the column, remove the manual ratchet (94016-011).
- 7) Turn the crosshead pin 90°.
- 8) Remove the deviation pipe (94117B) from the door frame.
- 9) Lower and align the guide shoe (2, Fig. 11) with the crosshead pin (3).
- 10) Attach the two eye bolts (94045-M20) and the chain (94325) to the crosshead pin (3).
- 11) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 12) Attach the manual ratchet (94016-024) to the eye bolt (94045-M24) and the chain (94325).
- 13) Use the manual ratchet (94016-024) to pull the crosshead pin (3) into the guide shoe (2).
- 14) Remove the chain (94325), eye bolts (94045-M20, 94045-M24) and manual ratchet (94016-024).
- 15) Attach the eye bolts (94045-M20), and chain (94325), to the other side of the crosshead pin.
- 16) Attach the eye bolt (94045-M24) to an applicable position on the column.
- 17) Use the manual ratchet (94016-024) to pull the crosshead pin (3) into the guide shoe (1).
- 18) Remove the chain (94325), eye bolts, (94045-M20, 94045-M24) and manual ratchet (94016-024).

Crosshead Pin – Removal / Installation / Clearance Checks

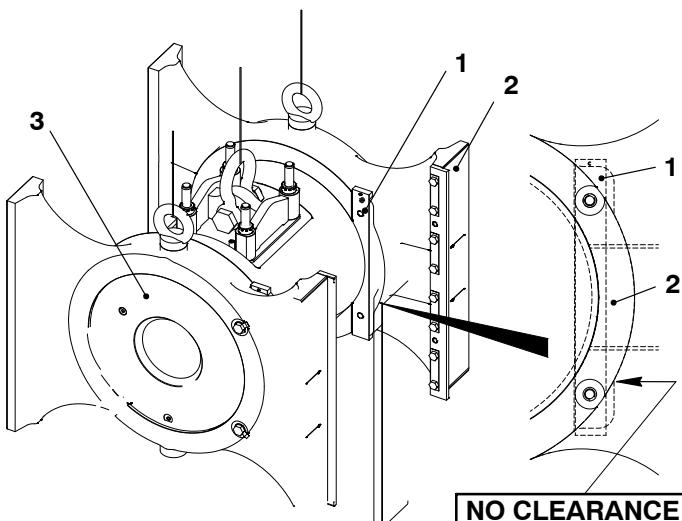


Fig. 12

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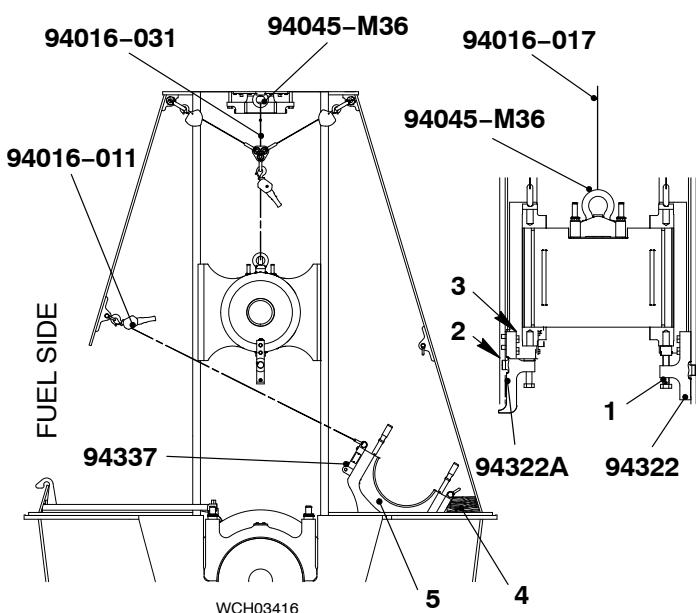
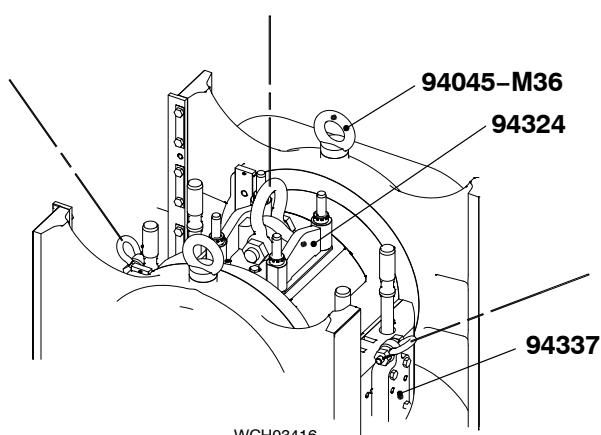
NO CLEARANCE

Fig. 13

WCH03416

- 19) Attach the two holding plates (1, Fig. 12) to the guide shoe (2) with the tab washers and bolts.
- 20) Make sure that there is no clearance between the holding plates (1) and crosshead pin (3).
- 21) Operate the manual ratchet (94016-017, Fig. 13) to lift the crosshead approximately 160 mm above the center of the pin hole (2).

Note: The two supports (94322, 94122A) hold the weight of the crosshead while you move the connecting rod.

- 22) Attach the two supports (94322, 94122A) to the guide way.
- 23) Tighten the four bolts (3) to 240 Nm.
- 24) Tighten the two set screws (1).
- 25) Attach the two manual ratchets (94016-011) to the shackles (94018B) and the lifting tools (94337) on the connecting rod (5). Apply a light tension to the chains.

Note: During the step below, slowly move the connecting rod to the middle of the column.

- 26) On the fuel side, gradually tighten the manual ratchet. At the same time, keep tension on the chain of the manual ratchet on the exhaust side.
- 27) Continue with the step above until the connecting rod (5) aligns with the crosshead.
- 28) Remove the wooden block (4).
- 29) If necessary, lift the crosshead a small distance.
- 30) Loosen the two set screws (1).
- 31) Remove the four bolts (3).
- 32) Remove the two supports (94322).

Crosshead Pin – Removal / Installation / Clearance Checks

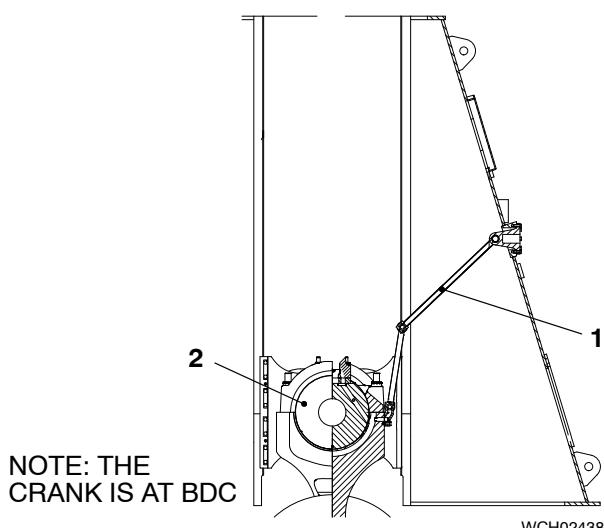


Fig. 14

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

- 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 chain blocks.
- 36) Remove the protection from the crosshead pin (2).

CAUTION

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

- 37) Connect the toggle lever (1) to the crosshead pin (2). make sure that the toggle lever is in the position shown.

6. Clearance Checks

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

7. Completion

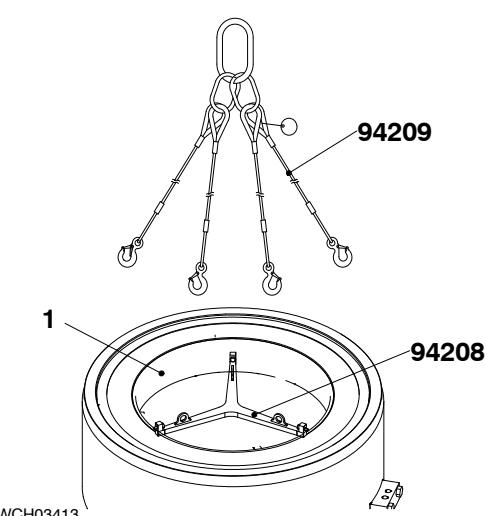
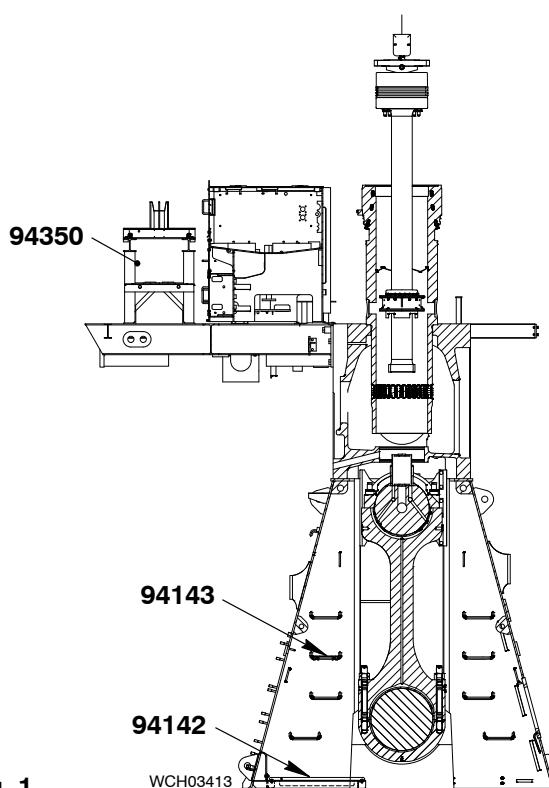
- 1) Install the round nuts to the elastic studs on the connecting rod, refer to [9403-4](#).
- 2) Install the top bearing cover, refer to [3303-5](#).
- 3) Disengage the turning gear.
- 4) Set the lubricating oil pump to on.
- 5) Make sure that the crosshead and the bottom end bearings of the connecting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

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Removal and Installation

Tools:

1 4-leg sling	94209	1 Piston positioner	94342
1 Distance piece	94344A	1 Platform	94143
1 Disassembly/assembly device	94344	1 Support	94142
1 Antipolishing ring removal tool	94208	2 Distance piece	94230
1 Piston lifting tool	94341	1 Piston support tool	94350
1 Lifting tool	94333	1 Piston ring tensioner	94338
4 Eye bolt	94045-M36		



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) Read the data in [0012-1](#), Guidelines for Lifting Tools.
- 2) Stop the engine, refer to the procedure in the Operation Manual [4002-2](#).
- 3) Let the engine temperature decrease before you start the removal procedure.
- 4) Make sure that all tools and equipment are clean.
- 5) Remove the cylinder cover, refer to [2708-1](#).
- 6) Look at the area of the piston ring stroke. If there is unwanted material, refer to the procedure in [2124-3](#).
- 7) Clean the top part of the cylinder liner.
- 8) Put the support tool (94350, Fig. 1) in position as shown.
- 9) Put the platform (94143) and support (94142) in position as shown.
- 10) Attach the tool (94208, Fig. 2) to the antipolishing ring (1) with the three screws.
- 11) Attach the sling (94209) to the tool (94208) and the engine room crane.
- 12) Operate the engine room crane to remove the antipolishing ring (1).

Piston: Removal and Installation

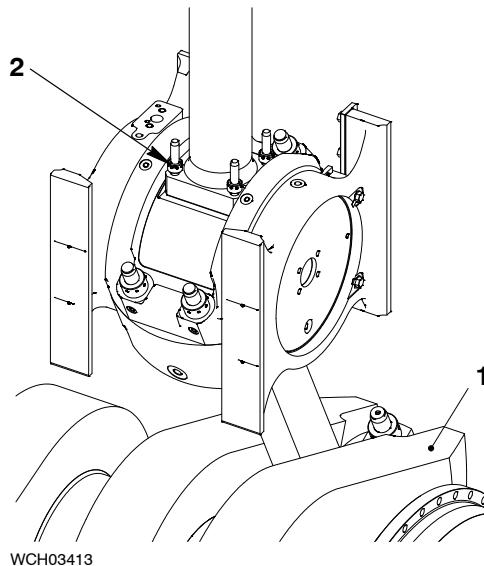


Fig. 3

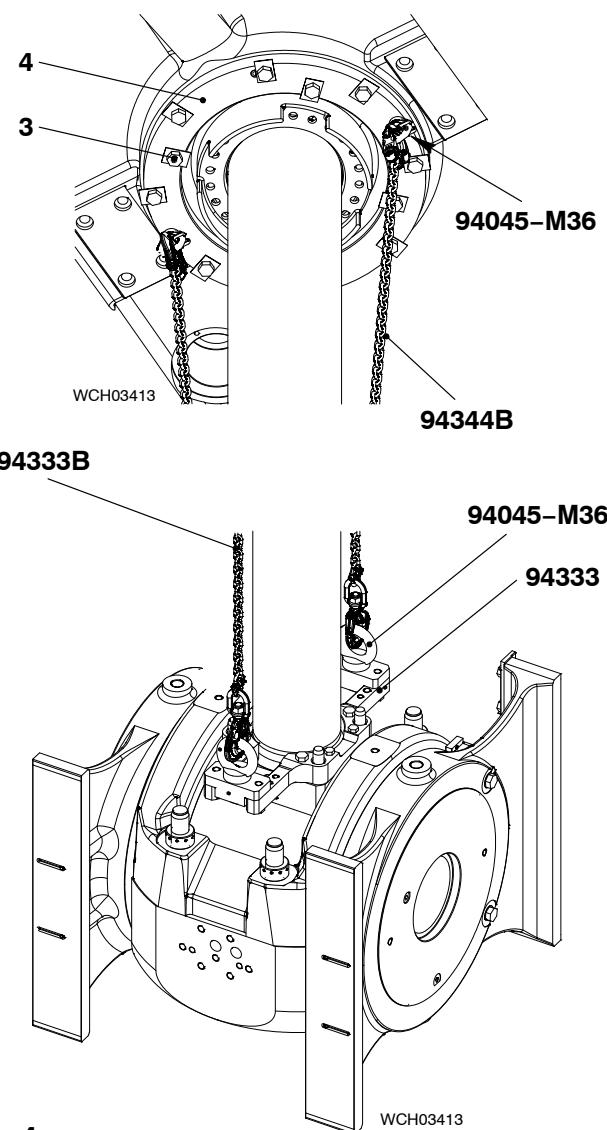


Fig. 4

2. Removal

- 1) Remove the support the platform (94142).
- 2) Operate the turning gear to turn the crank (1, Fig.3) approximately 90° to the exhaust side.
- 3) Remove the four round nuts (2) from the piston rod foot, refer to the procedure in 9403-4.

- 4) Remove the four inner bolts (1, Fig. 4) from the support (2).
- 5) Remove two applicable outer bolts from the support (2).
- 6) Attach the two eye bolts (94045-M36) to the support (2).
- 7) Attach the lifting tool (94333) to the piston rod foot.
- 8) Attach the two eye bolts (94045-M36) to the lifting tool (94333).
- 9) Attach the two chains (94333B) to the four eye bolts (94045-M36).

Note: When you do step 19), make sure that the bolts of the piston rod foot do not catch.

- 10) Operate the turning gear to move the crank to BDC until the chains are tight.

Piston: Removal and Installation

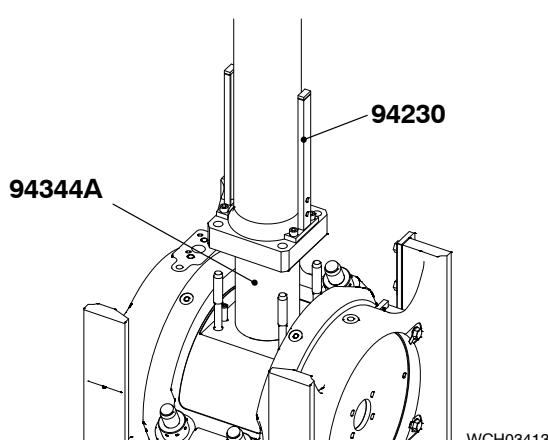


Fig. 5

- 11) Put the spacer (94344A, Fig. 5) on the crosshead pin.
- 12) Operate the turning gear to move the crosshead pin up sufficiently so there is no tension on the chains (94333B, Fig. 4).
- 13) Remove the chains (94333B) and the four eye bolts (94045-M36). Keep the spacer (94344A) in position on the crosshead pin.

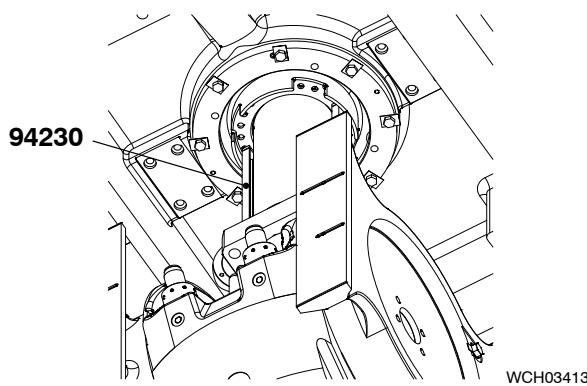


Fig. 6

- 14) Attach the two distance pieces (94230, Fig. 6) to the piston rod foot.
- 15) Make sure that:
 - The four inner bolts (3, Fig. 4) are removed
 - The distance pieces (94230, Fig. 6) are in line with the gland box.

Note: When you do step 15), the piston moves up and the the distance pieces (94230) move the gland box up.

- 16) Operate the turning gear to move the piston (1, Fig. 7) to TDC.
- 17) Clean the three holes (2) and the top part of the piston crown (1).

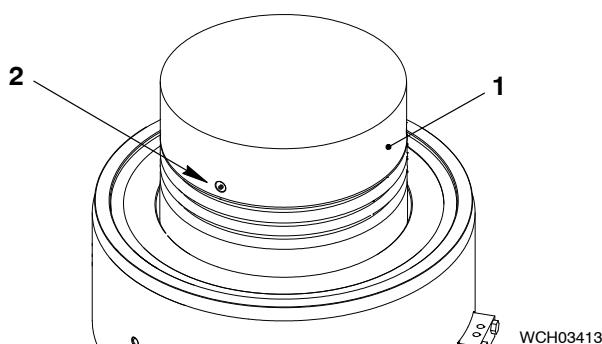


Fig. 7

Piston: Removal and Installation

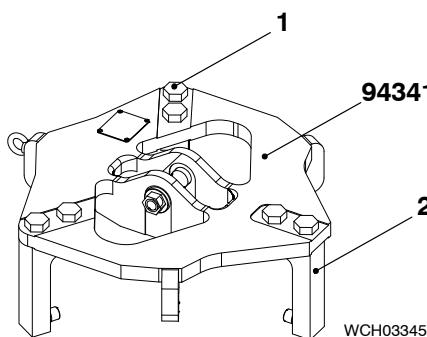
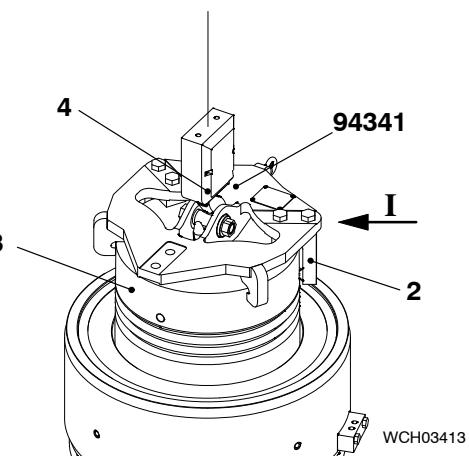


Fig. 8

- 18) Make sure that the tool (94341, Fig. 8) is clean.
- 19) Remove the six bolts (1). and the three brackets (2).
- 20) Apply Molykote past G-n to the threads of the six bolts (1).



- 21) Put the tool (94341, Fig. 9) in position on the piston crown. Make sure that the grooves for the brackets (2) align with the holes in the piston crown (3).

Note: To help you align the brackets (2), first attach one bracket to the tool (94341).

- 22) Attach the three brackets (2) to the tool (94341) with the six bolts. Make sure that the brackets fully engage in the holes in the piston crown (3).
- 23) Torque the six bolts (1) to 170 Nm.
- 24) Attach the hook (4) of the engine room crane to the tool (94341).

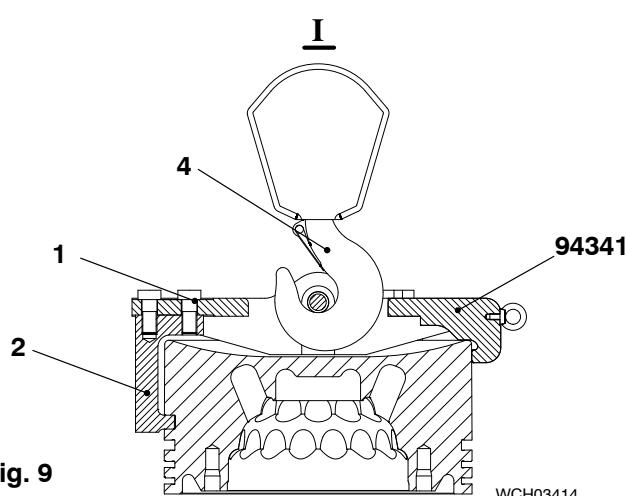
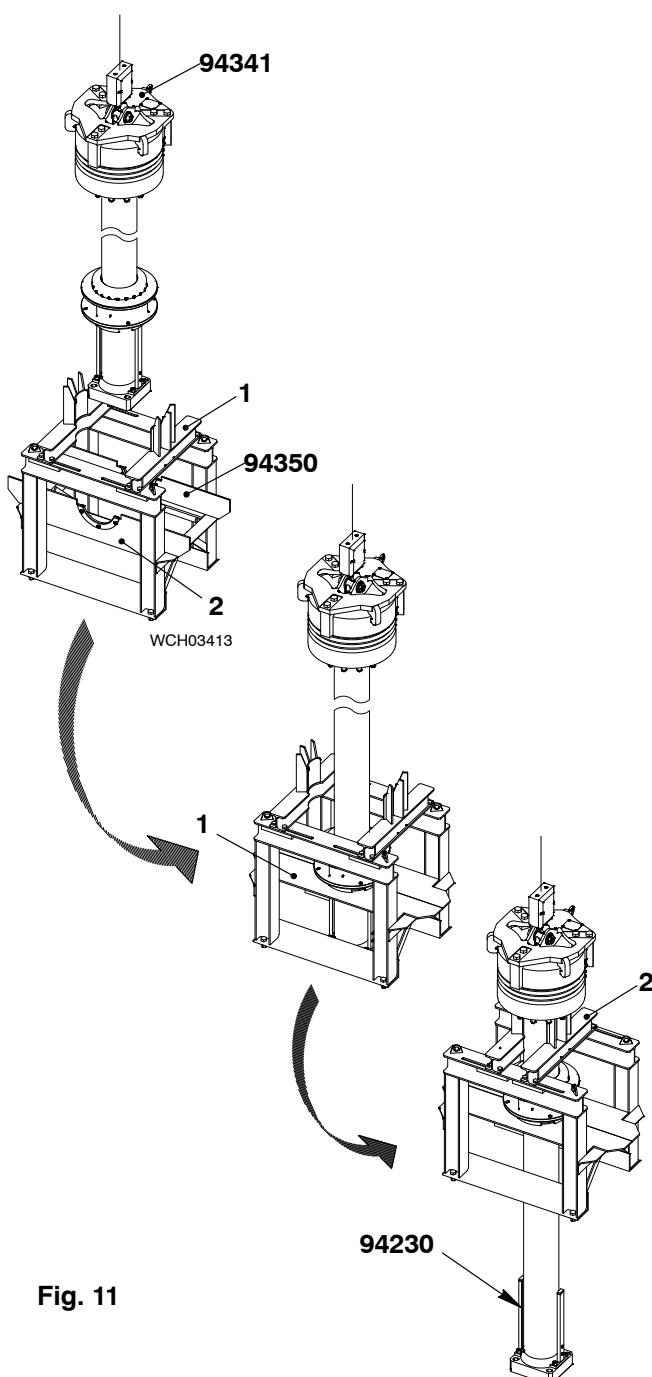
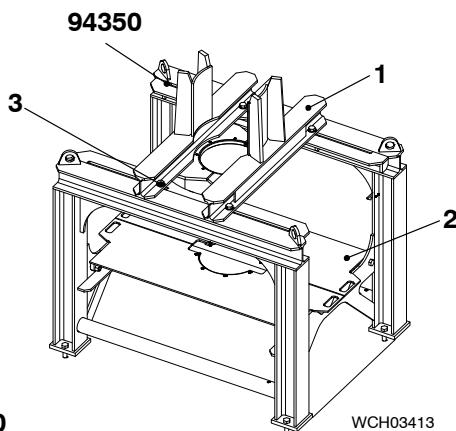


Fig. 9

Piston: Removal and Installation



- 25) Make sure that the piston support tool (94350, [Fig. 10](#)) is in the correct position on the top platform.
- 26) Loosen the four screws (3).
- 27) Move fully out the two supports (1).
- 28) Lift and lock the plates (2) in the vertical position.
- 29) Operate the engine room crane to lift the piston fully out of the cylinder liner. Make sure that the piston rod foot does not touch the support of the piston rod gland box.
- 30) Lower and align the piston between the supports (1, [Fig. 11](#)) until the piston rod foot is below the plates (2).
- 31) Close the plates (2).
- 32) Push fully in the two supports (1).
- 33) Tighten the four screws (3).
- 34) Lower the piston on to the supports (1).
- 35) Remove the crane hook from the tool (94341).
- 36) Remove the distance holders (94230) from the piston rod foot.
- 37) Remove the tool (94341).
- 38) To disassemble the piston, refer to [3403-3](#).
- 39) Do a check of the top surface of the piston, refer to [3403-4](#).
- 40) Do a check of the piston rings and grooves, refer to [3425-1](#).
- 41) Refer to the Maintenance Schedule for other work on each piston [0380-1](#). Select the related data.

Piston: Removal and Installation

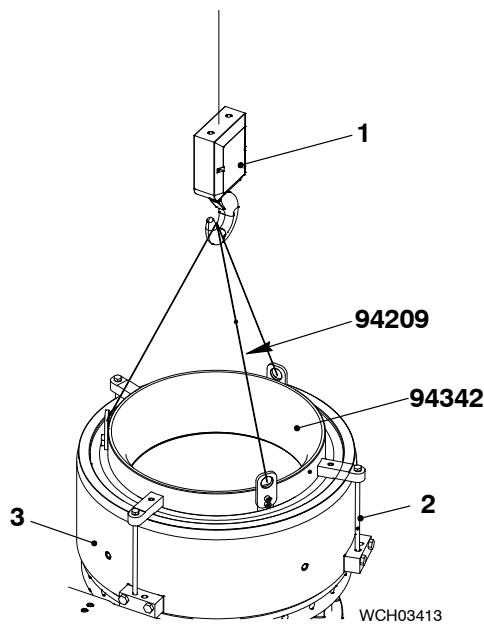


Fig. 12

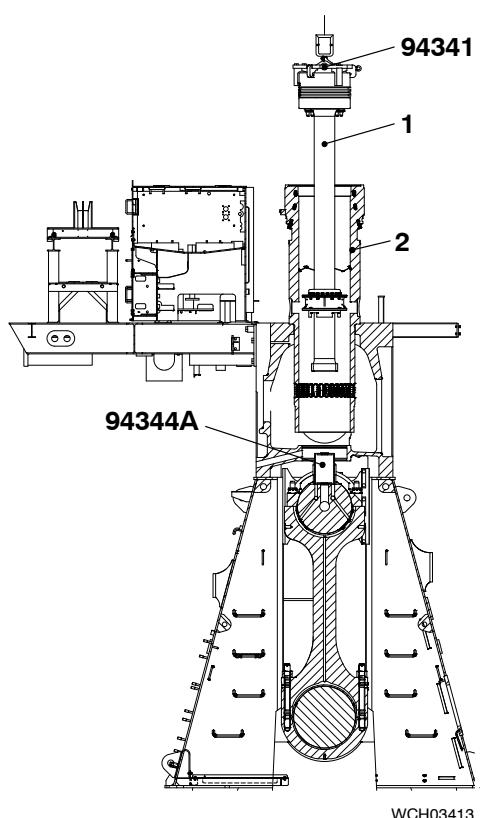


Fig. 13

3. Installation

- 1) Make sure that the items that follow are clean and in a satisfactory condition:
 - All parts of the piston rod gland
 - The piston ring grooves and the piston rings
 - All surfaces of the piston.
- 2) Make sure that the O-rings in the piston rod gland are in a satisfactory condition.
- 3) Apply oil to the bore and O-rings of the piston rod gland.
- 4) Apply oil to the piston rings, piston skirt, piston rod and running surface of the cylinder liner.
- 5) Install the piston rings, refer to 3425-1, paragraph 3.4 (Used Piston Rings), or 3.5 (New Piston Rings).
- 6) Put oil on the surfaces of the positioner tool (94342, Fig. 12).
- 7) Make sure that the piston rod gland is correctly installed on the piston rod.
- 8) Attach the sling (94209) to the positioner tool (94342).
- 9) Attach the sling to the engine room crane.
- 10) Operate the crane to put the positioner tool (94342) in position on the cylinder liner (3). Lock the tool in position with the three bolts (2).
- 11) Make sure that the spacer (94344A, Fig. 13) is in position on the crosshead pin.
- 12) Attach the tool (94341) to the piston crown, refer to step 18 to 23 above.
- 13) Attach the engine room crane to the tool (94341).
- 14) Attach the distance holders (94230, Fig. 5) to the piston rod foot.
- 15) Operate the turning gear to move the crosshead to TDC.
- 16) Loosen the screws (3, Fig. 10) on the piston support tool (94350) and push the supports (1) fully out.
- 17) Turn and lock the two plates (2) up before the piston rod foot touches them.
- 18) Lift the piston together with the piston rod gland box from the support (94350).

Piston: Removal and Installation

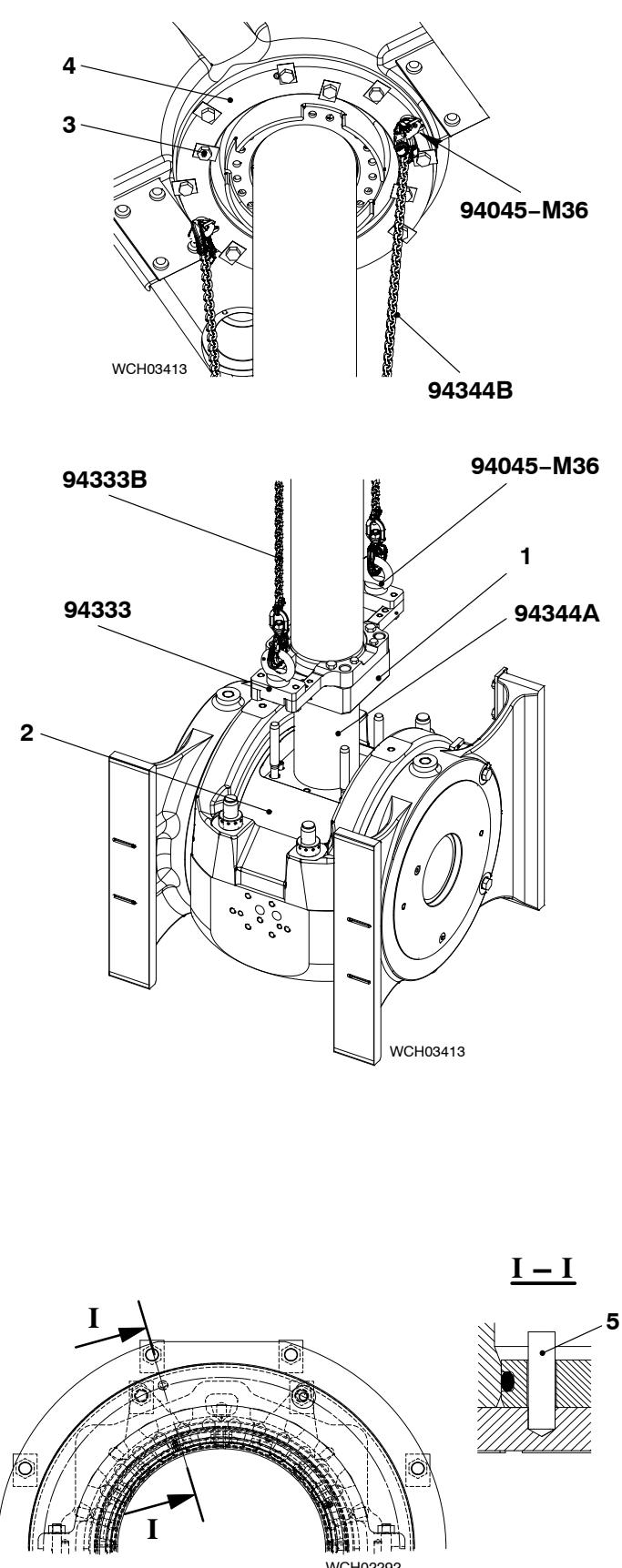


Fig. 14

19) Move the piston (1, Fig.13) into position above the cylinder liner (2).

20) Make sure that each clearance in the piston rings is opposite the clearance in the piston ring above/below.

Note: When you do step 21), make sure that you do not damage the cylinder liner (2) or the support for the piston rod gland.

21) Carefully lower the piston into the cylinder liner (2) until the piston rod foot touches the spacer (94344A).

22) Remove the tool (94341).

23) Remove the distance pieces (94230) from the piston rod.

24) Attach the lifting tool (94333, Fig. 14) to the piston rod foot (1).

25) Attach the two eye bolts (94045-M36) to the support ring (3).

26) Attach the two eye bolts (94045-M36) to the lifting tool (94333).

27) Attach the two chains (94333B) to the four eye bolts (94045-M36).

28) Operate the turning gear to move the crosshead to BDC until the two chains (94333B) have tension.

29) Continue to operate the turning gear to move the crank to BDC until you can remove the spacer (94344A).

30) Remove the spacer (94344A).

Note: When you do step 31), make sure that the bolts on the crosshead align with the holes in the piston rod foot.

31) Operate the turning gear to move the crosshead to TDC.

32) Make sure that the piston rod gland is in the correct position for the dowel pin (5) to engage with the support (4).

33) Make sure that the chains (94333B) have no tension.

34) Remove the lifting tool (94333).

35) Remove the two chains (94333B) and the four eye bolts (94045-M36).

36) Attach the piston rod gland to the support (4) with the four bolts and (3) new locking plates.

37) Torque the four bolts (3) to 150 Nm.

38) Bend the locking plates to lock the four bolts (3).

Piston: Removal and Installation

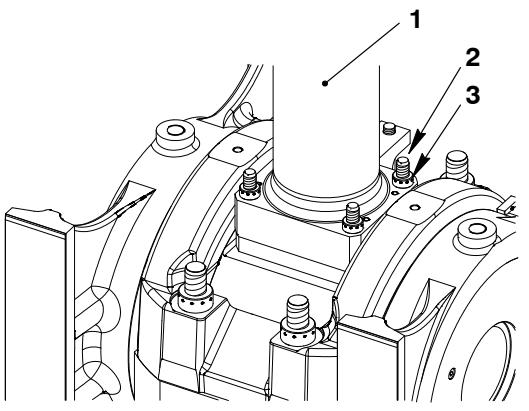


Fig. 15

- 39) Put oil on the four elastic studs (2, Fig. 15).
- 40) Attach the four round nuts (3) to the elastic studs (2).
- 41) Tighten the four round nuts (3), refer to 9403-4.
- 42) Attach the engine room crane to the tool (94209, Fig. 16).
- 43) Remove the three bolts (2).
- 44) Operate the engine room crane to remove the tool (94209) from the cylinder liner (3).

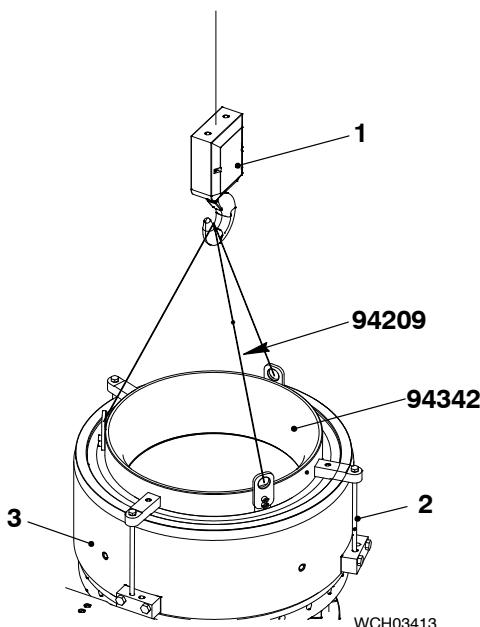


Fig. 16

- 45) Make sure that the cylinder liner and the anti-polishing ring (1, Fig.17) are clean and in a satisfactory condition.
- 46) Put oil on the surfaces of anti-polishing ring (1).
- 47) Connect the crane to the lifting tool (94209).
- 48) Attach the tool (94209) to the loops on the tool (94208).
- 49) Operate the crane to install the anti-polishing ring (1) into the cylinder liner.
- 50) Remove the lifting tool (94209) and the tool (94208).

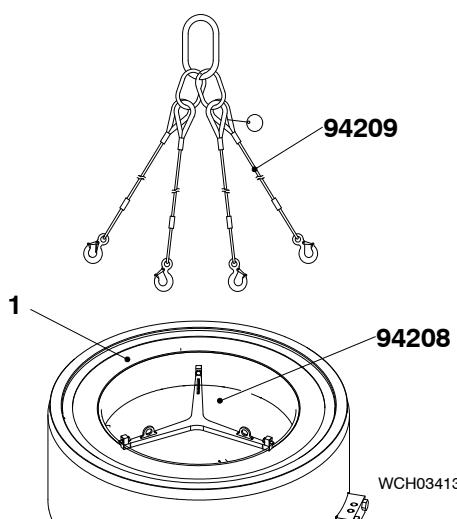
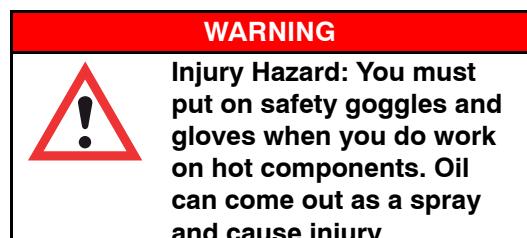


Fig. 17

4. Completion

- 1) Do a function check of the cylinder lubricating system, refer to 7218-1, paragraph 1.2.
- 2) Remove all tools and equipment from the work area.

Disassemble and Assemble

Tools:

3 Pre-tensioner	94340	3* Jacking screws	94364A
1 Lifting tool	94341	2* Jacking screws	94364B
		3* Jacking screws	94364C

* Use available screws from piston assembly

1. Preparation

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

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

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

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

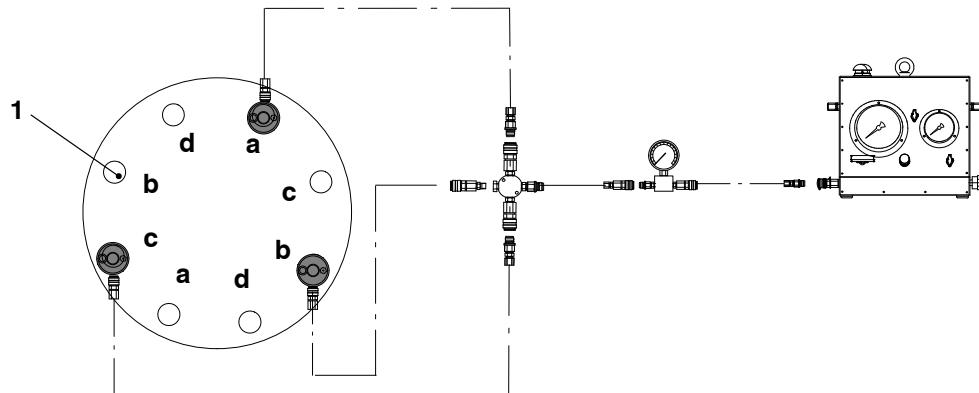
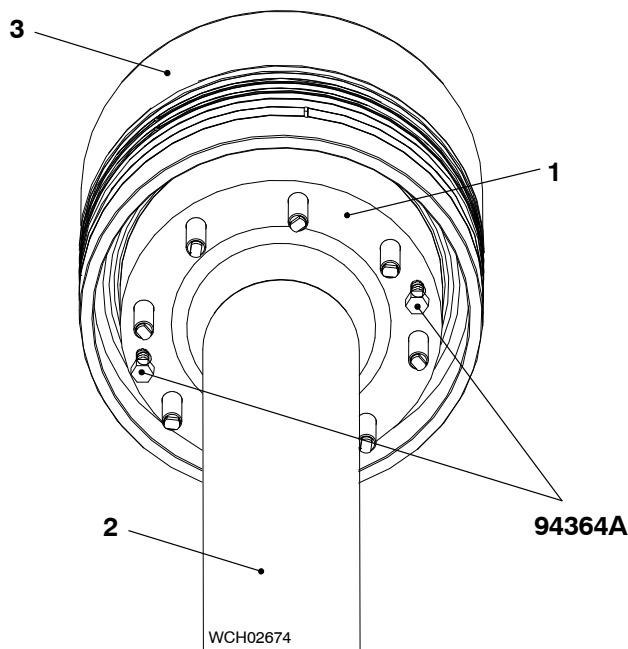
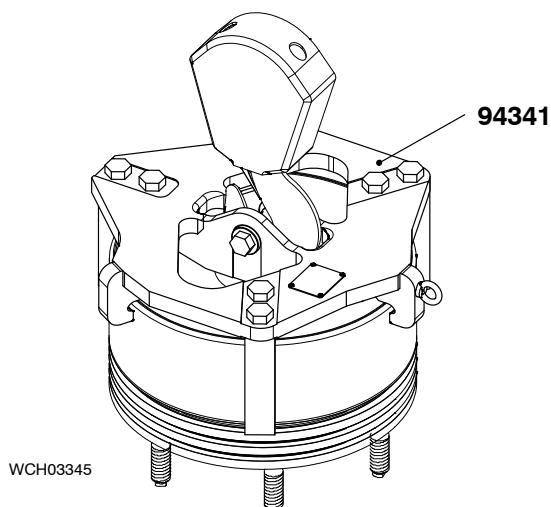


Fig. 1: Sequence to Apply Tension to the Elastic Bolts

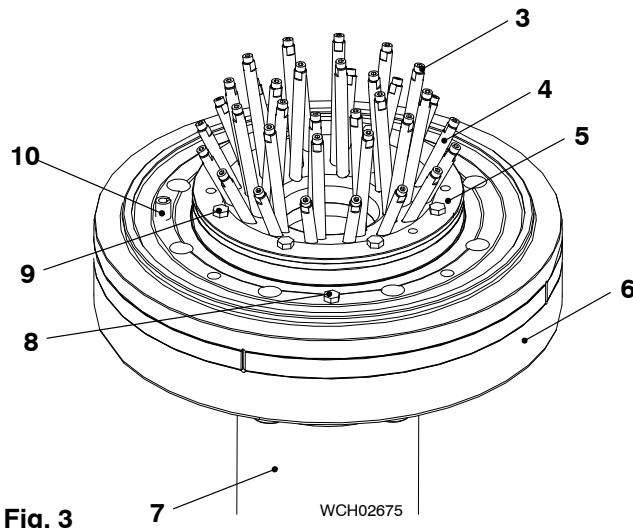
Piston: Disassemble and Assemble

**Fig. 2****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) Tighten equally 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 lifting tool (94341, Fig 3).
- To install lifting tool 94341, refer to 3403-1.
- 4) Use the engine room crane to lift the piston head.
- 5) Move the piston head to an applicable area.
- 6) Remove the jacking screws (94364A) from the top of the piston rod (2).

Piston: Disassemble and Assemble

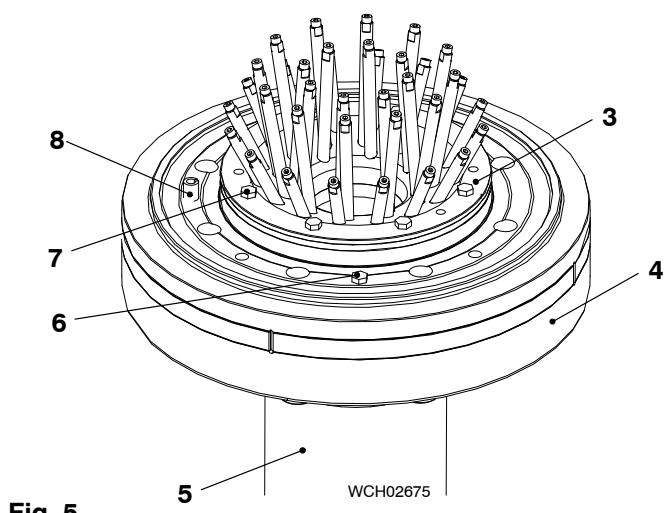
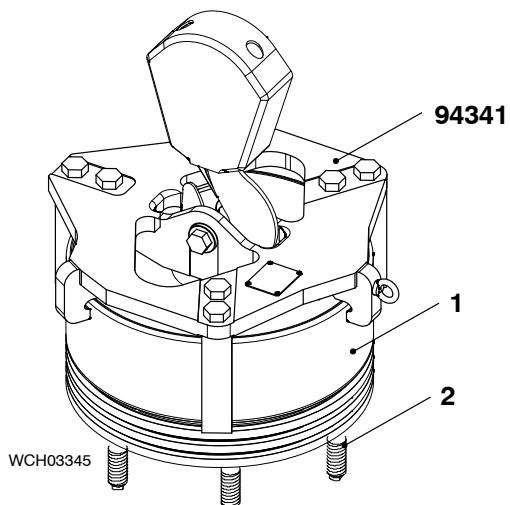
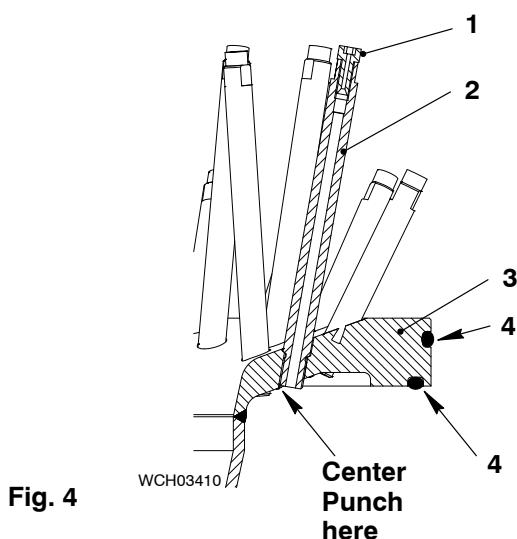
**CAUTION**

Damage Hazard: If it becomes necessary to remove 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 remove the piston skirt (6) from the piston rod (7).
 - c) Lift the piston skirt (6) away from the piston rod (7).
- 8) Remove the eight bolts (9).
- 9) Use the two jacking screws (94364B) to remove the spray plate (5) from the piston rod (7).
- 10) If necessary, remove the pipes (4) and nozzles (3).
- 11) Do a check of the top surface of the piston head, refer to [3403-4](#).

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

Piston: Disassemble and Assemble



3. Assemble

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

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

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

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

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.

2. Procedure – Piston Removed

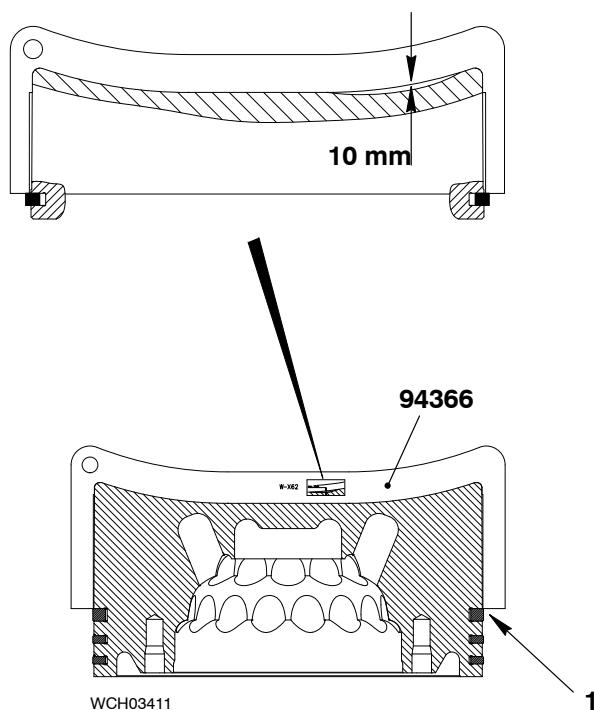


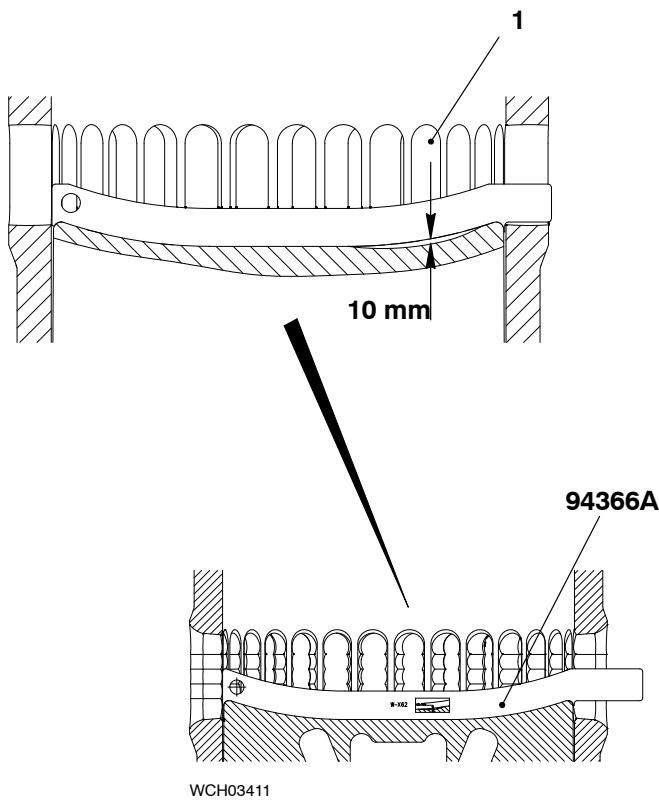
Fig. 1

- 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 (see 3403-3, paragraph 1 and paragraph 2).
 - b) Use surface welding to repair the piston head to its original thickness.
 - c) Assemble the piston (see 3403-3, paragraph 3).

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

**Fig. 2**

3. Procedure – Piston Installed

WARNING



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

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

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

Piston Rings and Ring Grooves – Rate of Wear

Tools:

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

1.	General	1
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2.1	Chrome-ceramic Layer – Measure (Piston Installed)	2
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1. General

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

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

Visual inspections show very important conditions of cylinder liners and piston rings after a short time. For more data to monitor the cylinder liner and piston ring conditions, refer to 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, [Piston Rings](#) for the scheduled intervals.

2. Piston Ring – Rate of Wear

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 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 limits given, you must do an overhaul of the piston head.

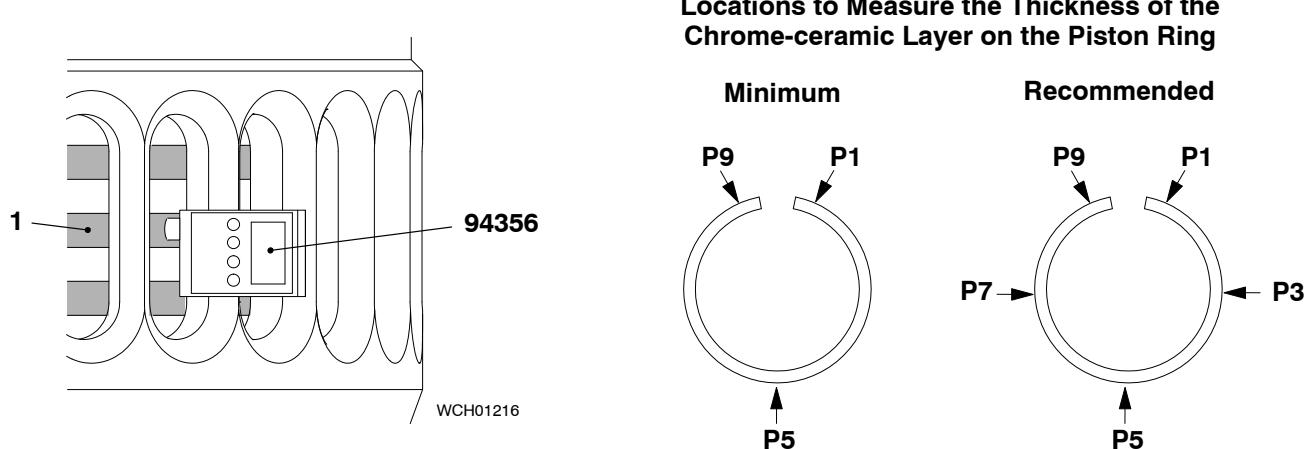


Fig. 1

2.2 Rate of Wear

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

Chrome-ceramic Layer is Worn

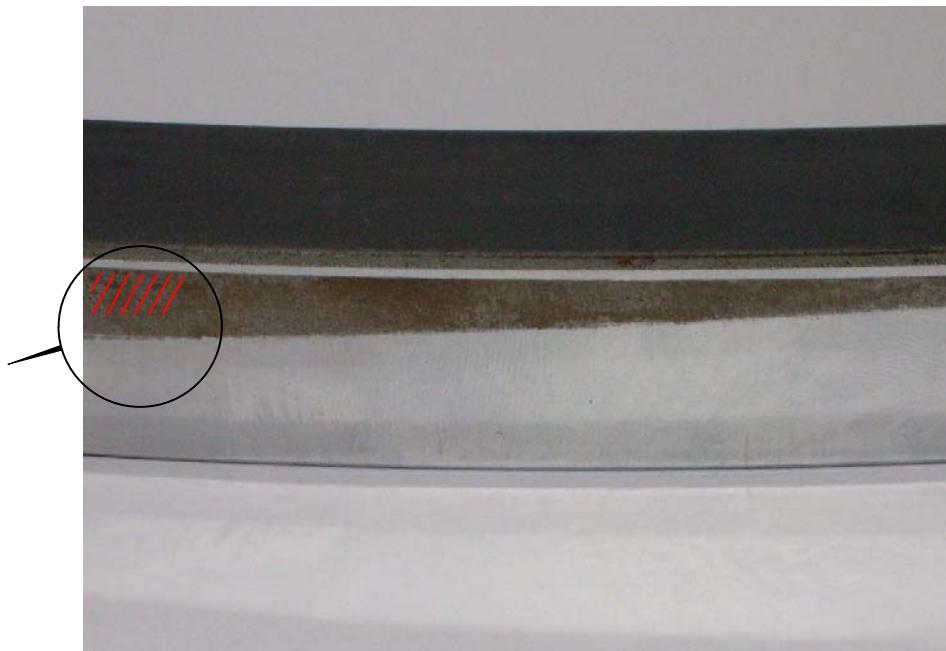


Fig. 2 Chrome-ceramic Layer

With regular procedures to measure the chrome-ceramic layer, you can calculate the rate of wear 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 rate of wear of a piston ring:

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

Where:

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

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

Table 1: Rate of Wear – Examples

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) (see paragraph [2.2](#))
- WR = Calculated rate of wear (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 dimensions and record them (see 0330-1 [Pistons and Piston Rings](#)). These records are important for an analysis of the running gear and must include the data that follow:

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

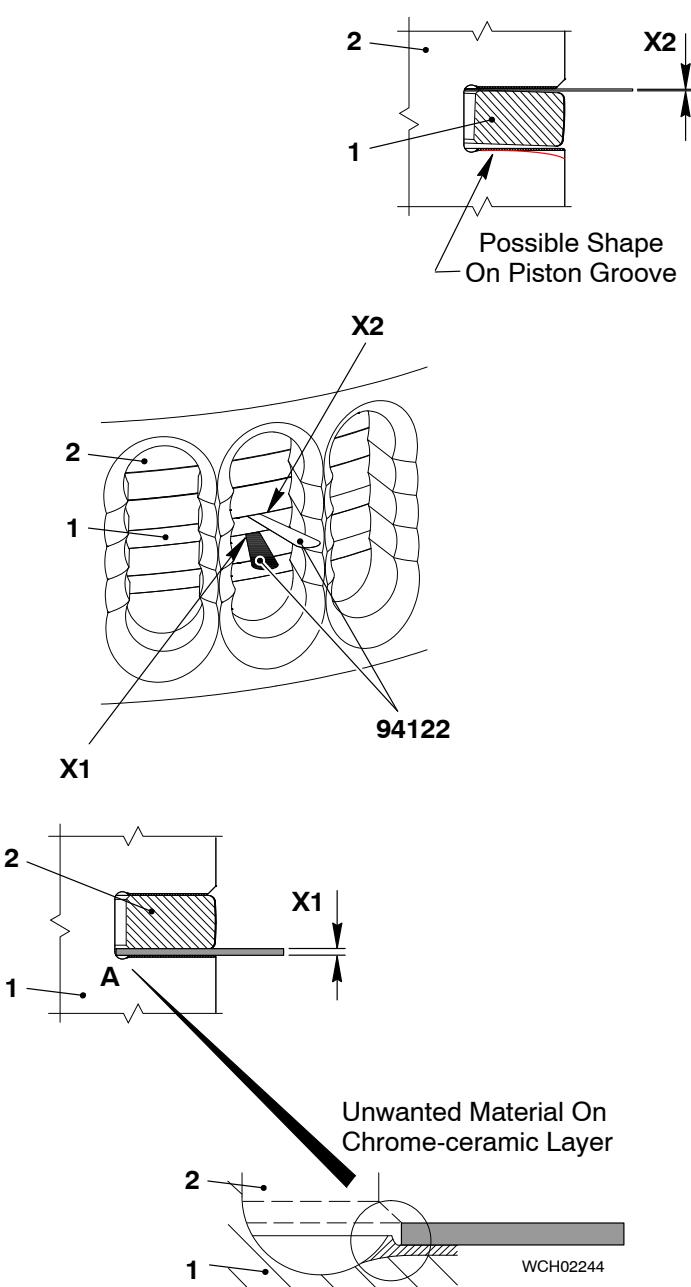


Fig. 3

3.1 Piston Ring Clearance (Piston Installed)

WARNING

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

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

Note: Push the feeler gauge fully into the groove in the piston head. 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 unwanted material 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 Wärtsilä Service Center.

3.2 Piston Rings – Removal

CAUTION



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

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

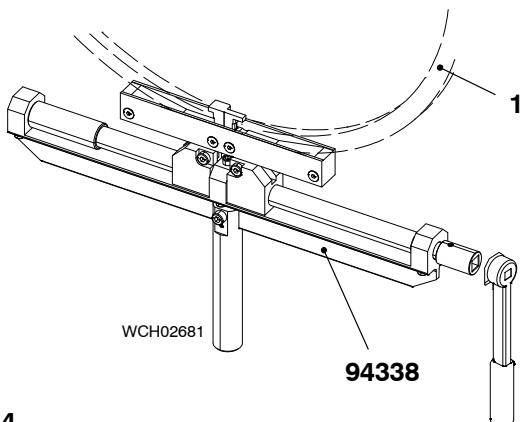


Fig. 4

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 grooves in the piston head.

3.3.1 Procedure with Calliper Gauge or Inside Micrometer Set

- 1) Use the calliper gauge (1, Fig. 5) or inside micrometer set (94101) to measure the height of the groove at point A and point B. Measure the height of the groove 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).
- 3) If the clearance at point A or point B is more than the permitted value, you must repair the piston head.

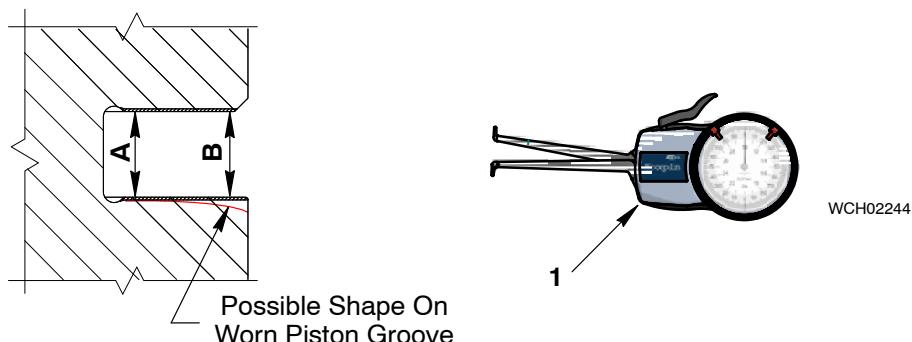


Fig. 5

Note: If the clearance at point A and, or point B is more than the permitted value, you must repair the piston head. For the maximum 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).

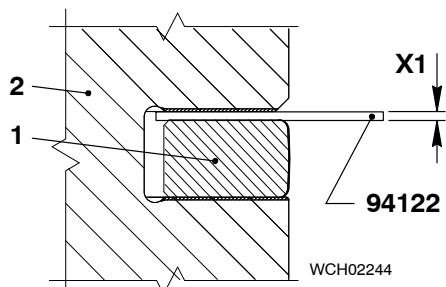


Fig. 6

- 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 height of the groove 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:

$$C = GH - RT$$

Where:

- C = Clearance (mm)
- 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 values, refer to 0330-1, Piston and Piston Rings. For the repair of piston heads, speak to the nearest Wärtsilä Service Center.

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

3.4 Used Piston Rings – Installation

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

Table 3: Standard Piston Ring Locations

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

CAUTION



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

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

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

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

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

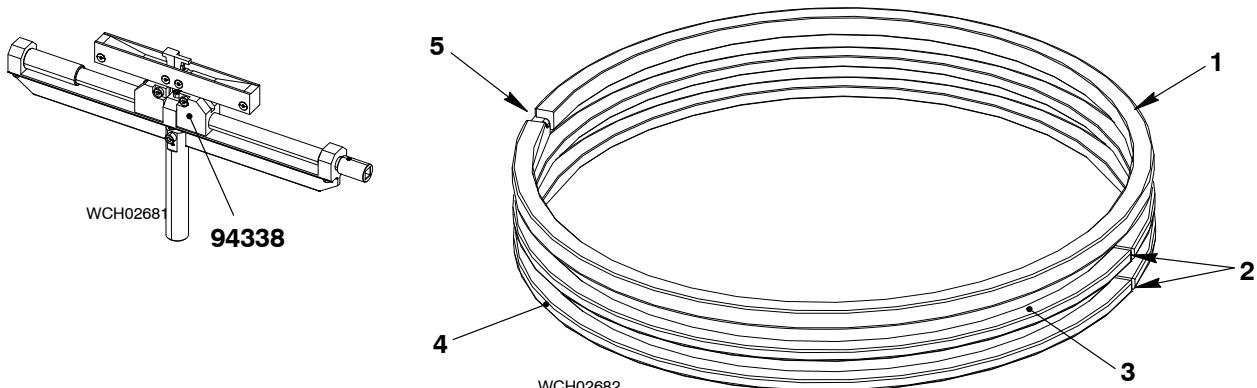


Fig. 7

3.5 New Piston Rings – Installation

CAUTION

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

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

Note: For the ring types and their locations, refer to **Table 3**.

- 1) Measure and record the thickness of the chrome-ceramic layer on each piston ring. This will help you monitor the rate of wear during operation.
- 2) Use the tool (94338, [Fig. 8](#)) to install the bottom piston ring (4) to the piston head.

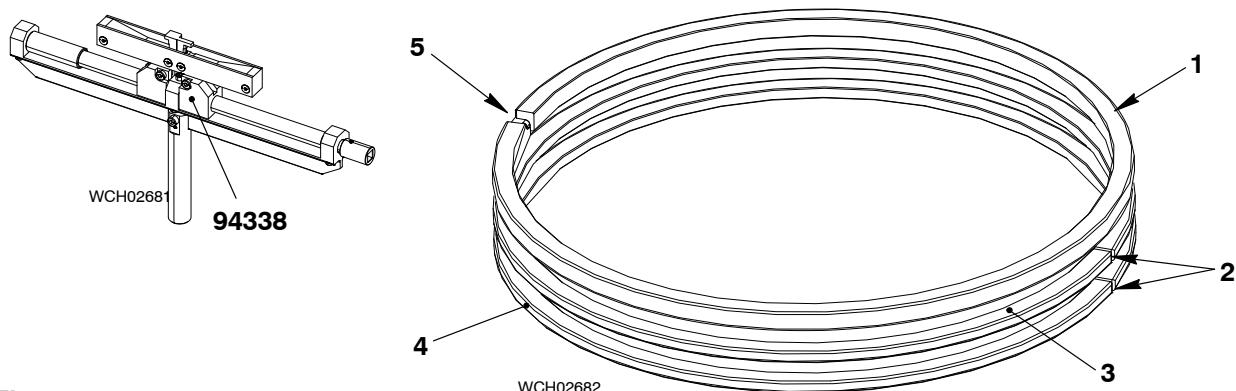


Fig. 8

- 3) Use the tool (94338) to install the middle piston ring (3) to the piston head.
- 4) Use the tool (94338) to install the top piston ring (1) to the piston head. Make sure that the ring clearance (5) is opposite the ring clearance (2) of the middle piston ring (3).
- 5) Refer to the Operation Manual, 0410-1 for the running-in procedure for new piston rings.

4. Piston Rings – Storage

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

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

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