WIN GD
Winterthur Gas & Diesel

WIN GD X72DF

Maintenance Manual

"Marine"

Vessel:

Type:

Engine No.:

Document ID: DBAD226888

Winterthur Gas & Diesel Ltd.
Schützenstrasse 1–3
CH-8400 Winterthur
Switzerland

24hrs Support:
Wärtsilä Services Switzerland Ltd.
Zürcherstrasse 12
CH 8400 Winterthur
Switzerland
+41 52 262 80 10
technicalsupport.chts@wartsila.com

WIN G2D
Winterthur Gas & Diesel

WIN G2D X72DF

Maintenance Manual

"Marine"

Vessel:

Type:

Engine No.:

Document ID: DBAD226888

Winterthur Gas & Diesel Ltd.
Schützenstrasse 1–3
CH-8400 Winterthur
Switzerland

24hrs Support:
Wärtsilä Services Switzerland Ltd.
Zürcherstrasse 12
CH 8400 Winterthur
Switzerland
+41 52 262 80 10
technicalsupport.chts@wartsila.com

X72DF				Summary for Maintenance Manual		
Page No.	Modification		Title	Subject	Page or Manual	
	Date	No.			new	exch.
	2016			**Maintenance Manual, Issue 2016**	x	
				Date of publication 2016-8-26		
2140-1/A1	2018-01	Update WinGD	GAV: Removal, Desassemble, Assemble and Installation	Pge 5: Para 5, Steps 10 to 12 changed.		x
2751-2/A1	2017-02	Update WinGD	Exhaust Valve: Disassemble and Assemble	Pge 6, para 3.4. Table removed. Text changed.		x
Group 5 ToC	2018-01	Update WinGD	ToC	5555-2/A1 added		x
5555-2/A1	2018-01	Update WinGD	Fuel Pressure Control Valve	New document	x	
9403-5/A1	2018-01	Update WinGD	Tools List	Pge 36: New tool 94573 added. 94844 Lubrication device added		x
				Date of publication 2018-01		
2138-1/A1	2018-02	WinGD Input	Lubricating Quill	Pge 1: Dismantling tool 94213 added to tool list. Pge2: Replace procedure added.		X
2722-1/A1	2018-02	WinGD Input	Injection Valve: Removal and Installation	Pge 2: Warning about copper paste added		X
2722-2/A1	2018-02	WinGD Input	Injection Valve: Disassemble, Checks, Assemble	Pge 8: Warning about copper paste added		X
Group 5 ToC	2018-02	Wartsila Input	Lubrication of Supply Unit during Maintenance	New Titles Added: 5552-5/A1, 5562-1/A2	X	
5552-5/A1	2018-02	Wartsila Input	Lubrication of Supply Unit during Maintenance	New document added	X	
5562-1/A2	2018-02	Wartsila Input	Fuel Pressure Control Valve: Manual relase Valve - Clean	New document added	X	
9223-1/A1	2018-02	WinGD input	Crank Angle Sensor Unit: Proximity Sensor - Replace	para 2.1: Procedure updated, tolerance changed		x
9403-5/A1	2018-02	WinGD Input and EAAD087159	Tools List	Pge 36: 94929 move to Special Recommended Tools on Pge 41. Pge 17: New tool 94289E added.		x
				Date of publication 2018-02		
6606-1/A1	2018-08	WinGD Input	Scavenge Air Cooler - Removal and Installation	Pges 12 and 15. Procedure changed and data added.:		x
				Date of publication 2018-08		
Grp 2 ToC	2018-10	EAAD087592		Pge 1. 2708-4/A1 and 2708-5/A1 added		x
2708-3/A1	2018-10	EAAD087592	Sealing Face for Fuel Injection Valve Position − Grind	Pge 1. Procedure changed and data added.		x
2708-4/A1	2018-10	EAAD087592	Sealing Face for Pilot Injection Valve Position − Grind	New procedure.	x	
	2018-10	EAAD087592	Sealing Face for the Prechamber − Grind	New procedure.	x	
9403-5/A1	2018-10	EAAD087592	Tools List	Pge15. New tools added (Grinding devices for the pilot injection valve bore, fuel injection valve bore and prechamber),		x
				Date of publication 2018-08		
3403-1/A1	2019-08	WinDG input	Piston - Removal and Installation	Pges 1 -10: Procdure is revised.		x
9403-4A1	2019-08	WinDG input	Hydraulic Pre-tensioning Jacks - General Instructions	Pge 4: Cylinder cover Reset Jack/Round Nut turns changed.		x
				Date of publication 2019-08		

Table of Contents

General Information — Group 0

Bedplate, Tie Rod, Main Bearings, Engine Stays, Tie Rods — Group 1

Cylinder Liner, Cylinder Cover and Fuel Injection — Group 2

Crankshaft, Connecting Rod and Piston — Group 3

Driving Wheels and Shut-off Valve for Starting Air — Group 4

Supply Unit and Rail Unit

Group 5

Scavenge Air Receiver and Auxiliary Blower — Group 6

Cylinder Lubrication and Balancer — Group 7

Piping — Group 8

Crank Angle Sensor Unit, Tools — Group 9

Intentionally blank

General Information — Group 0

Intentionally blank

For Your Attention

1. General

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

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

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

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

2. Spare Parts

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

All supplies and services are set only to the related supply contract.

3. Data

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

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

4. Personnel

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

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

Intentionally blank

Preface

The instructions in this Maintenance Manual are to help make sure that maintenance is done correctly at the specified intervals.

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

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

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

The Maintenance Manual has the primary data that follow:

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

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

Intentionally blank

Basic Engine Data

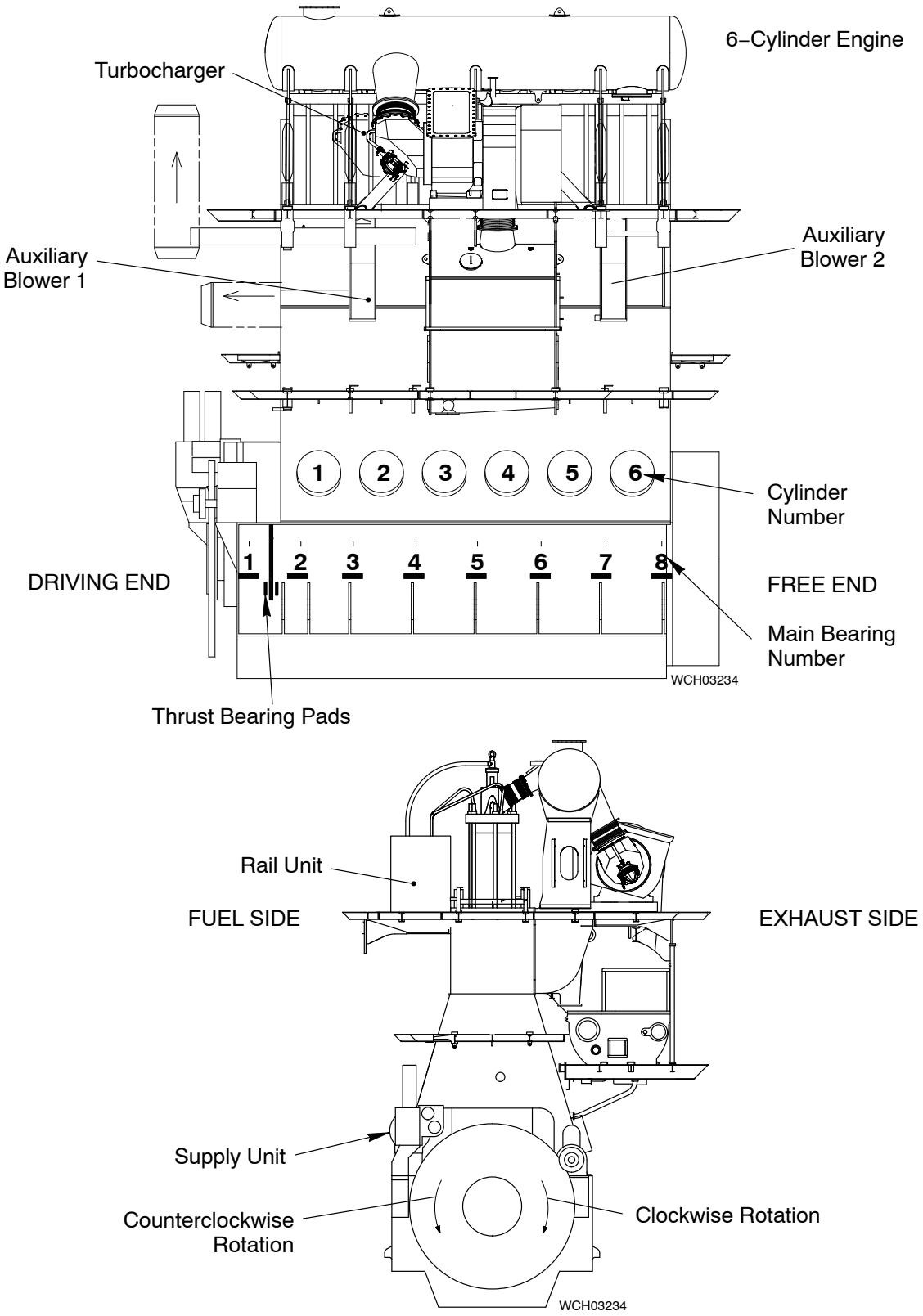
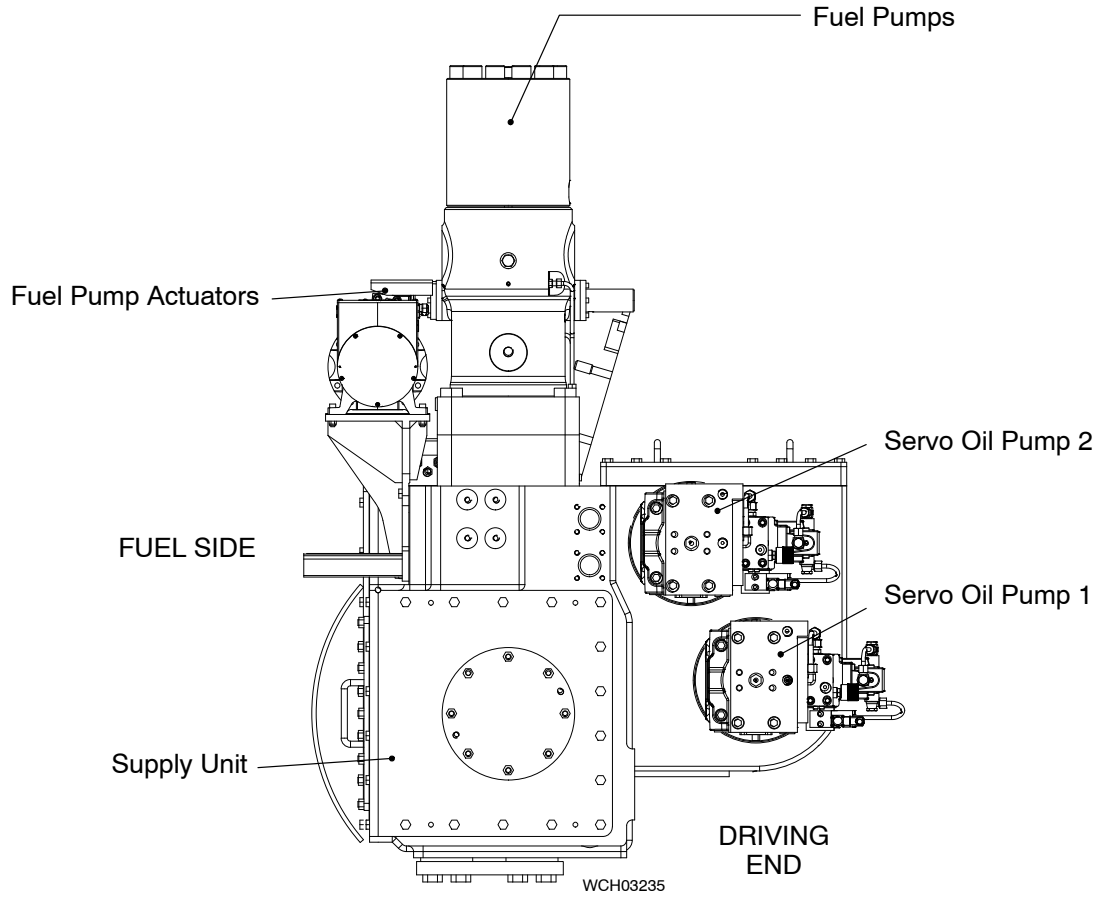


Fig. 1: Outline View



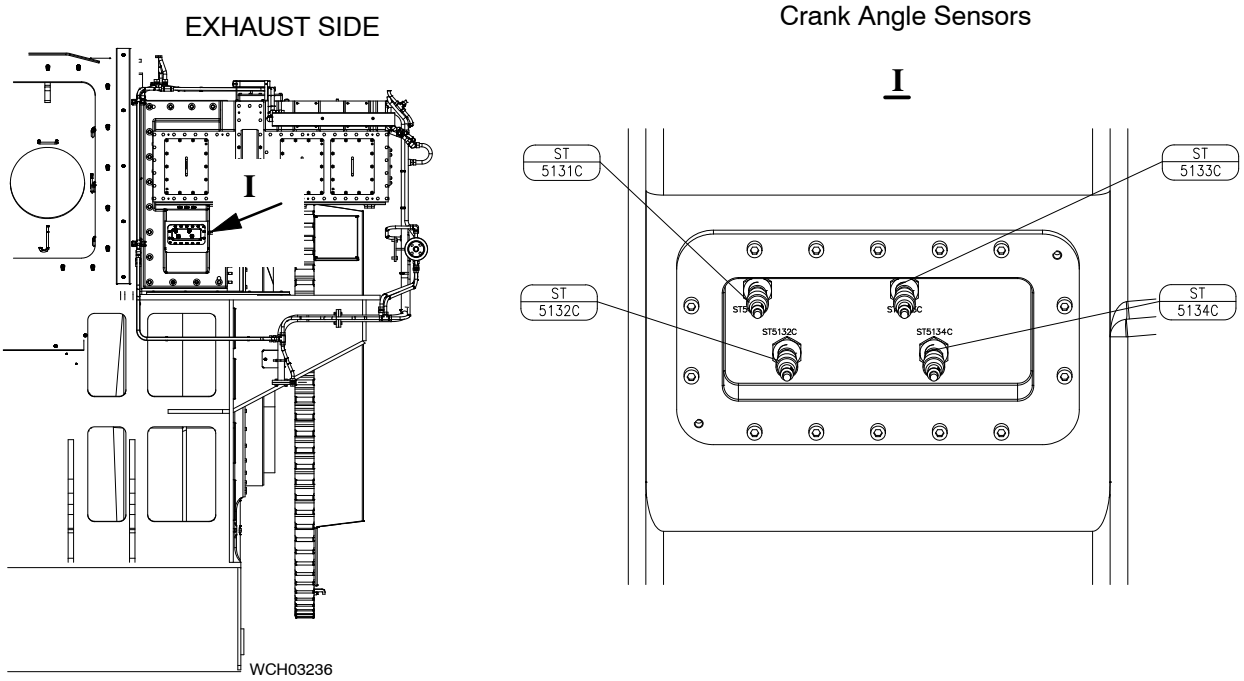


Fig. 2: ECS Parts

General Guidelines for Maintenance
Safety Precautions and Warnings

1. General

The maintenance work, which must be done on the engine at regular intervals, is given 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 dual fuel 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. 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 (CO_2) 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 CO_2 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 a position when personnel do work in 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 the 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, 0100–1 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 related 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 you 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 WinGD 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.

1. General

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

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

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

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

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

2. Equipment

2.1 Wire Rope Slings

The WLL of the wire rope slings is given with their tool numbers in 9403–5 Tool List.

2.2 Span Sets

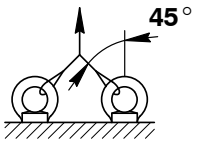
Span sets are easy to use. The code and the color usually show the maximum permitted load. Loops and knots in the span-sets decrease their WLL by one third.

2.3 Eye Bolts and Eye Nuts

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

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

Table 1: Lifting capacity (for data only)

Eye Bolts and Eye Nuts: Thread Size	Lifting Capacity (kg)	
	Single Strand 	Double Strand (45°)[1] 
M8	140	100
M10	230	170
M12	340	240
M16	700	500
M20	1200	860
M24	1800	1290
M30	3200	2300
M36	4600	3300
M42	6300	4500
M48	8600	6100
M56	11 500	8300

Note: The data given in Table 1 above are from DIN 580 and 582:2003–08

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

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

Also, you must make sure that you:

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

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

2.4 Eye Bolts and Swivel Lugs

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

Manufacturer:

RUD Ketten

Rieger & Dietz GmbH u. Co

Friedensinsel

D–73432 Aalen

Germany

http://www.rud.com

2.4.1 RUD Eye Bolts

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

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

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

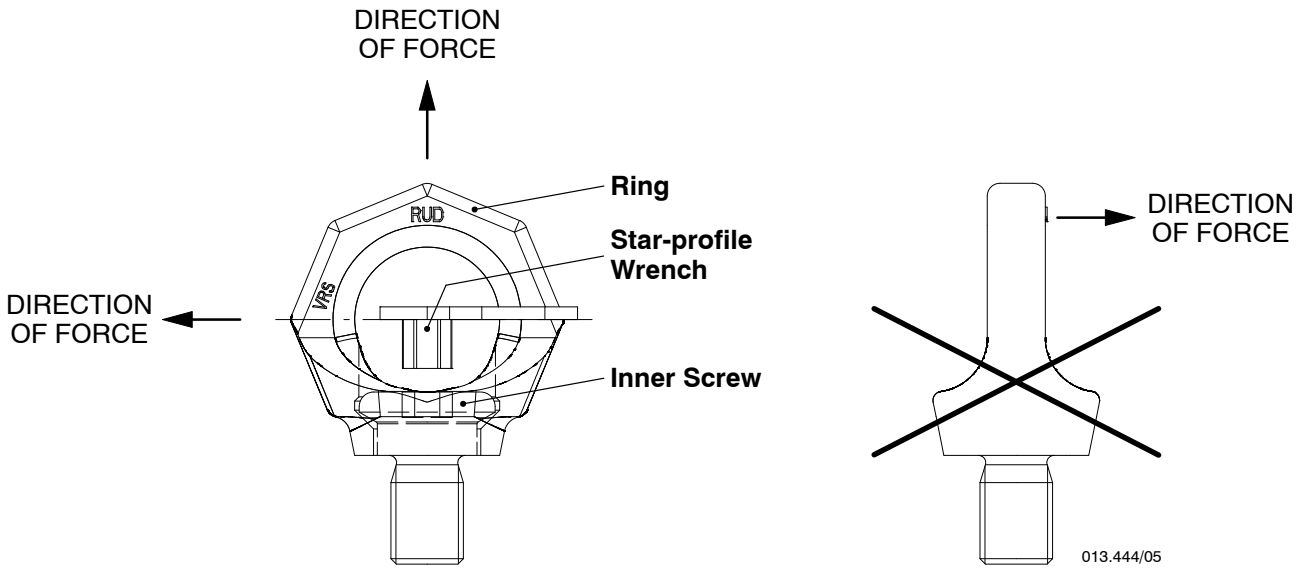


Fig. 1: RUD Eye Bolts

2.4.2 RUD Swivel Lugs

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

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

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

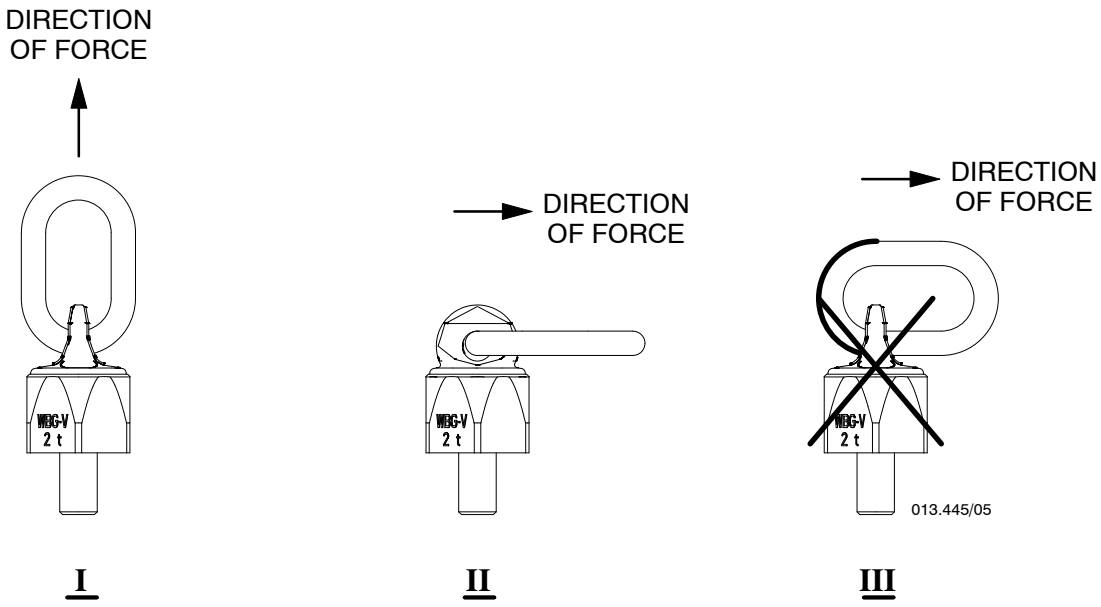


Fig. 2: RUD Swivel Lugs

2.5 Shackles

CAUTION

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

Note: For more data, refer to 9403–5 Tool List

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

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

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

3. Lifting Equipment – Attach and Remove

WARNING

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

Read the data that follow:

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

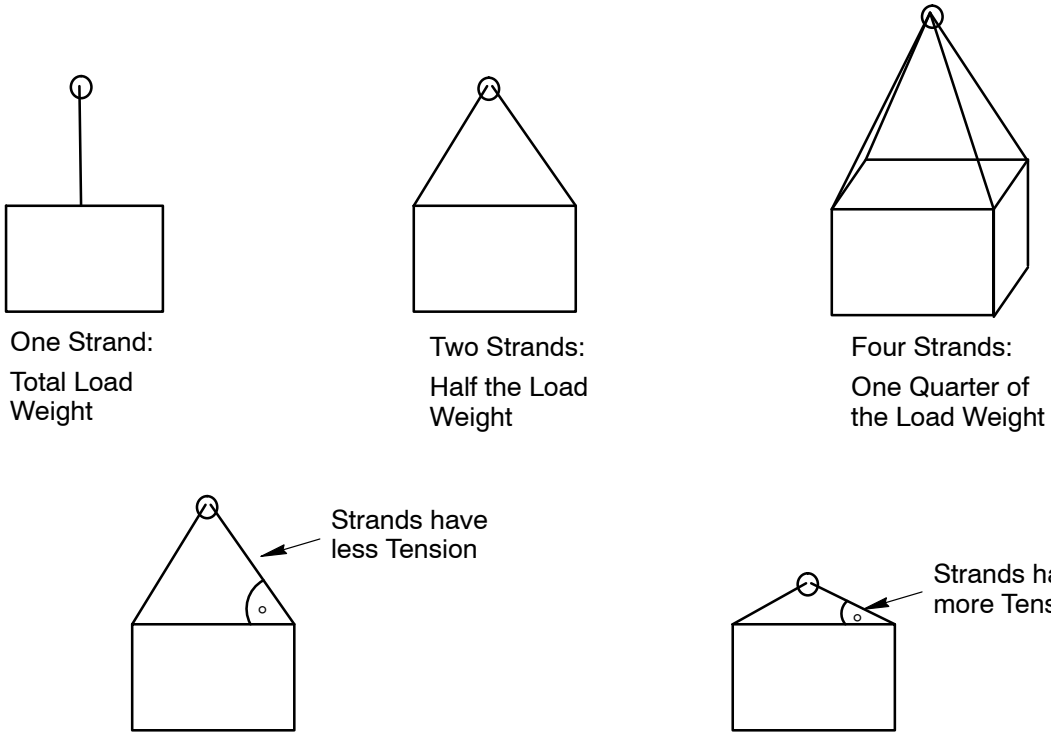


Fig. 3: Strand Angles

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

Intentionally blank

Clearance Table

1. General

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

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

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

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

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

This is related, for example, on the length of the next operation period until the next overhaul and what the rate of wear will be.

Crankshaft and Thrust Bearing

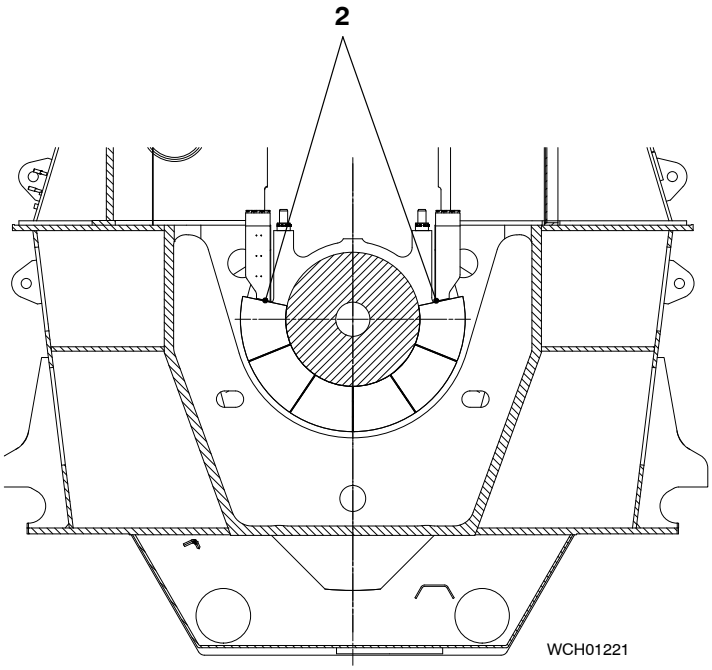


Fig. 1

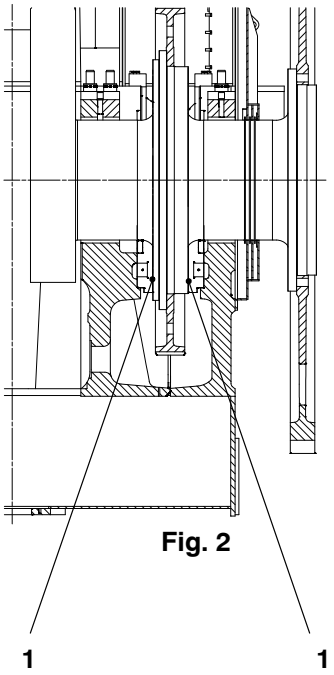


Fig. 2

Crankshaft and Thrust Bearing

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance, Dimension (because of worn parts) [mm]
1203 1224		**Thrust bearing**			
		Thrust bearing pad	thickness	$115^{-0.5}_{-0.6}$	
	1	Thrust bearing clearance	axial (total)	0.8 to 1.3	2.5
	2	Clearance between thrust pad and bracket	total	6	

Crankshaft and Main Bearing

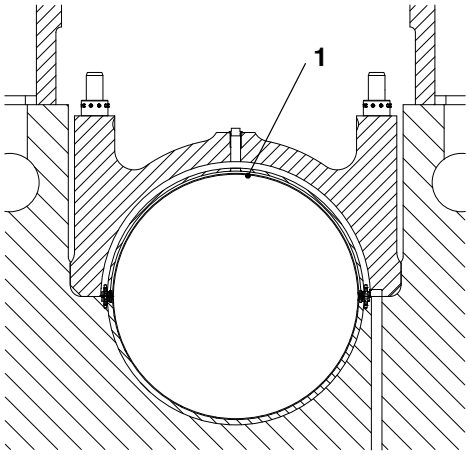


Fig. 3

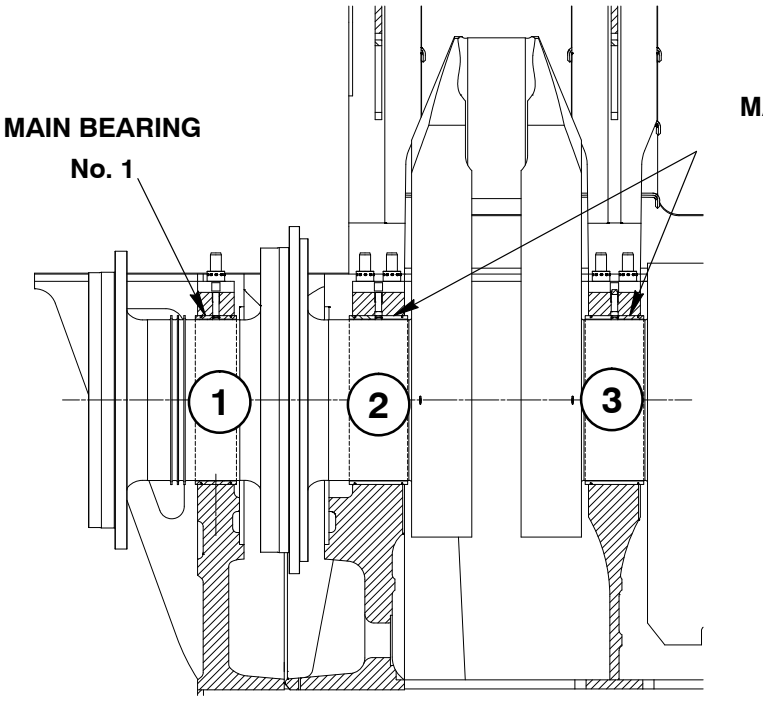


Fig. 4

Crankshaft and Main Bearing

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
1132		**Main bearing No. 1**			
		Crankshaft	outer ∅	880 $^{0}_{-0.09}$	
		Main bearing	inner ∅	880	
	1	Bearing clearance	vertical	0.4 to 0.7	0.90
1132		**Main bearing No. 2, No. 3 etc.**			
		Crankshaft	outer ∅	880 $^{0}_{-0.09}$	
		Main bearing	inner ∅	880	
	2	Bearing clearance	vertical	0.3 to 0.6	0.80

All main bearing clearances are only applicable when the tie rods and main bearing studs are tight.

Crosshead Guide

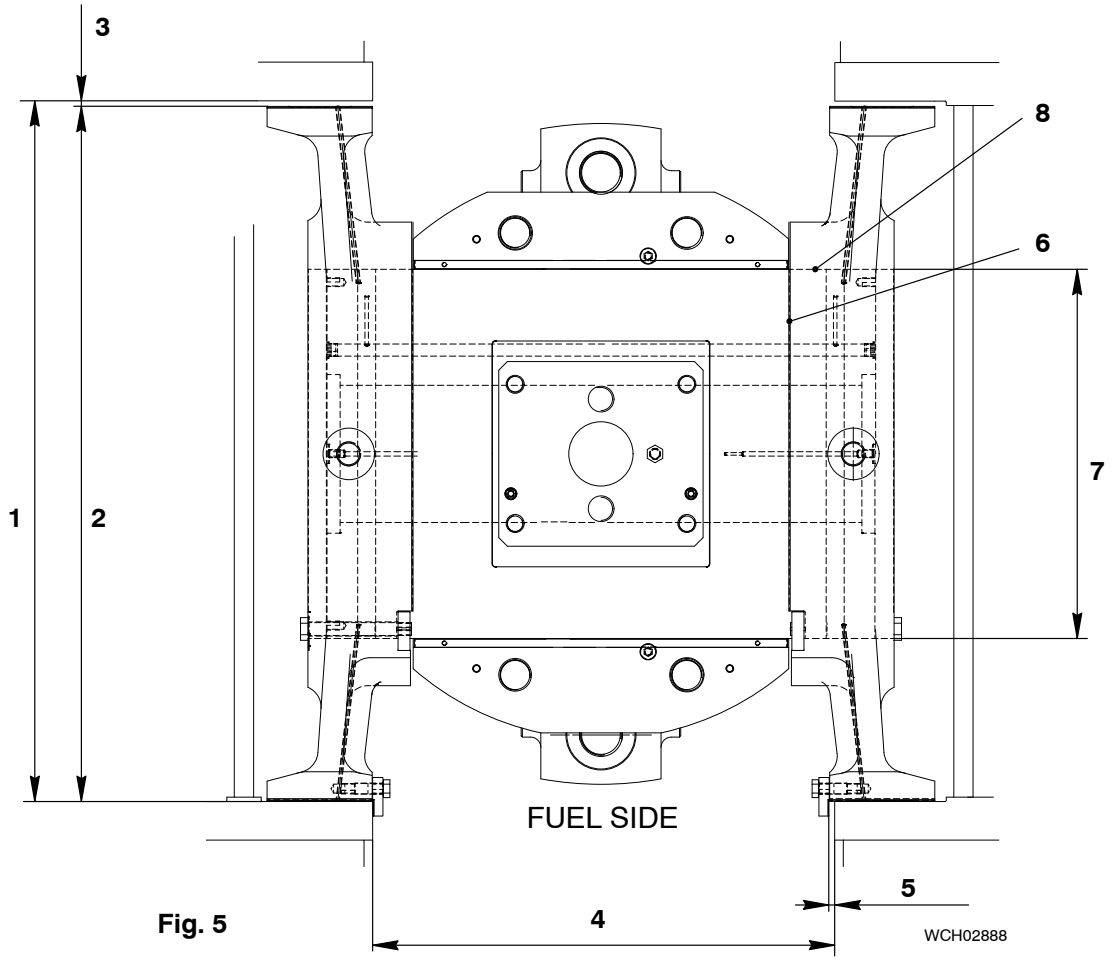


Fig. 5

Crosshead Guide

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
3326		**Crosshead guide**			
	1	Guide bar (column)	transverse	1270 $^{+\ 0.25}_{0}$	
	2	Guide shoe	transverse	1270 $^{-\ 0.20}_{-\ 0.30}$	
	*3	Guide way clearance		0.20 to 1.05	1.25
	4	Guide rail	longitudinal	823.52 to 824.28	
	5	Guide rail, lateral clearance	total	0.76 to 1.34	1.85
	6	Guide shoe, lateral clearance	total	0.22 to 0.60	0.9
	7	Crosshead pin	outer ∅	670 $^{0}_{-\ 0.08}$	
		Guide shoe, bearing bore	inner ∅	670 $^{+\ 0.084}_{+\ 0.05}$	
	8	Bearing clearance	radial	0.05 to 0.164	0.20

To meaure the clearances, refer to the data given in 3326–1.

* This clearance is applicable only with the tie rods tightened.

Cylinder Liner

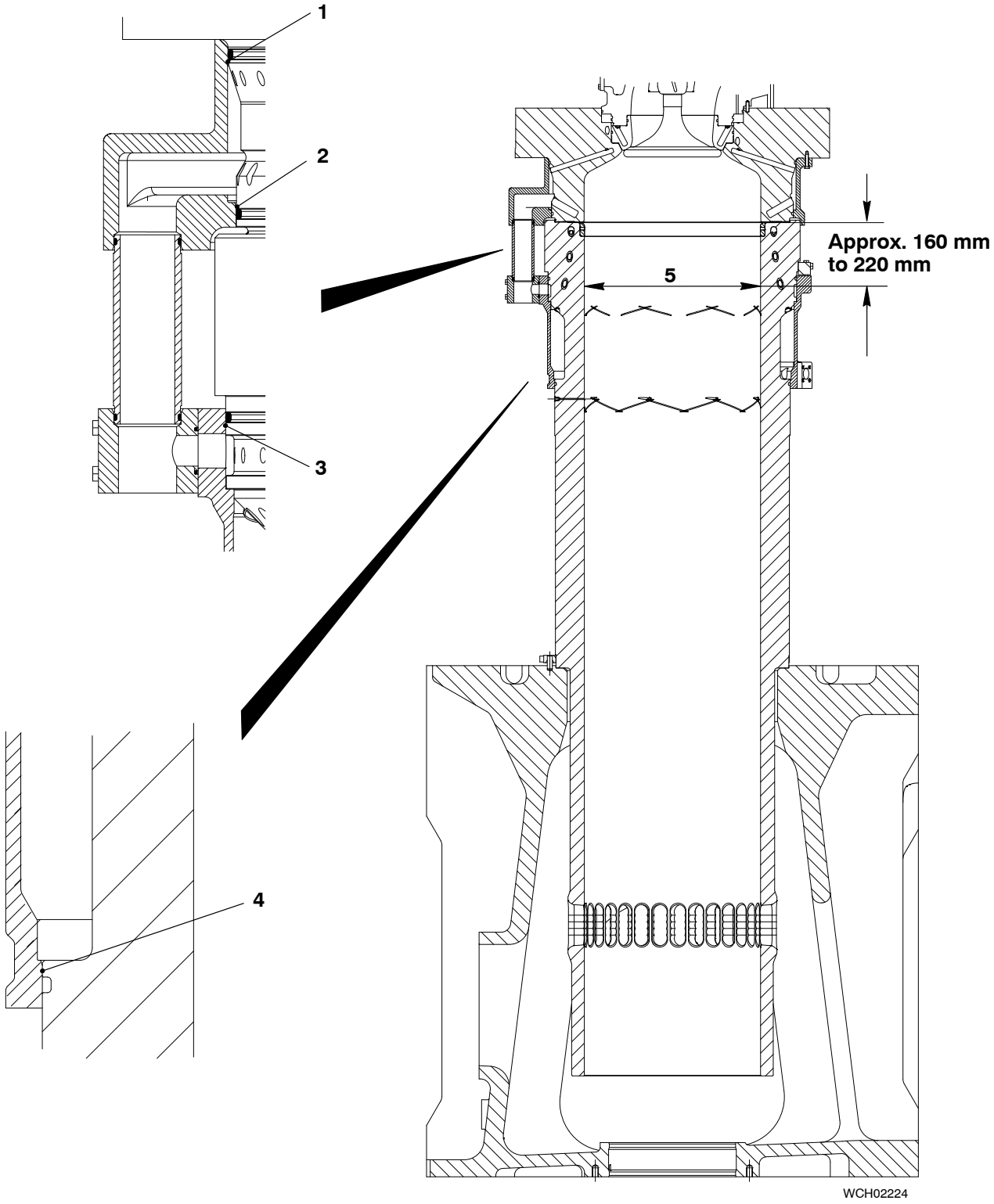


Fig. 6

Cylinder Liner

Group	Key No.	Description	Measured Direction	Nominal dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
2130		**Water guide jacket on cylinder cover**			
		Water guide jacket top part	Ø	$1010^{+\ 0.30}_{+\ 0.10}$	
	1	Clearance	total	0.40 to 0.80	
		Water guide jacket top part	Ø	$989^{+\ 0.30}_{+\ 0.10}$	
	2	Clearance	total	1.40 to 1.80	
		Water guide jacket bottom part	Ø	$1016^{+\ 0.10}_{-\ 0.10}$	
	3	Clearance	total	0.10 to 0.60	
		Water guide jacket bottom part	Ø	$962^{+\ 0.30}_{+\ 0.10}$	
	4	Clearance	total	0.30 to 0.70	
2124		**Cylinder liner**			
	*5	Cylinder liner bore	radial	720	725.0

* Make sure of the correct location to measure the cylinder liner bore.

Piston Rod Gland

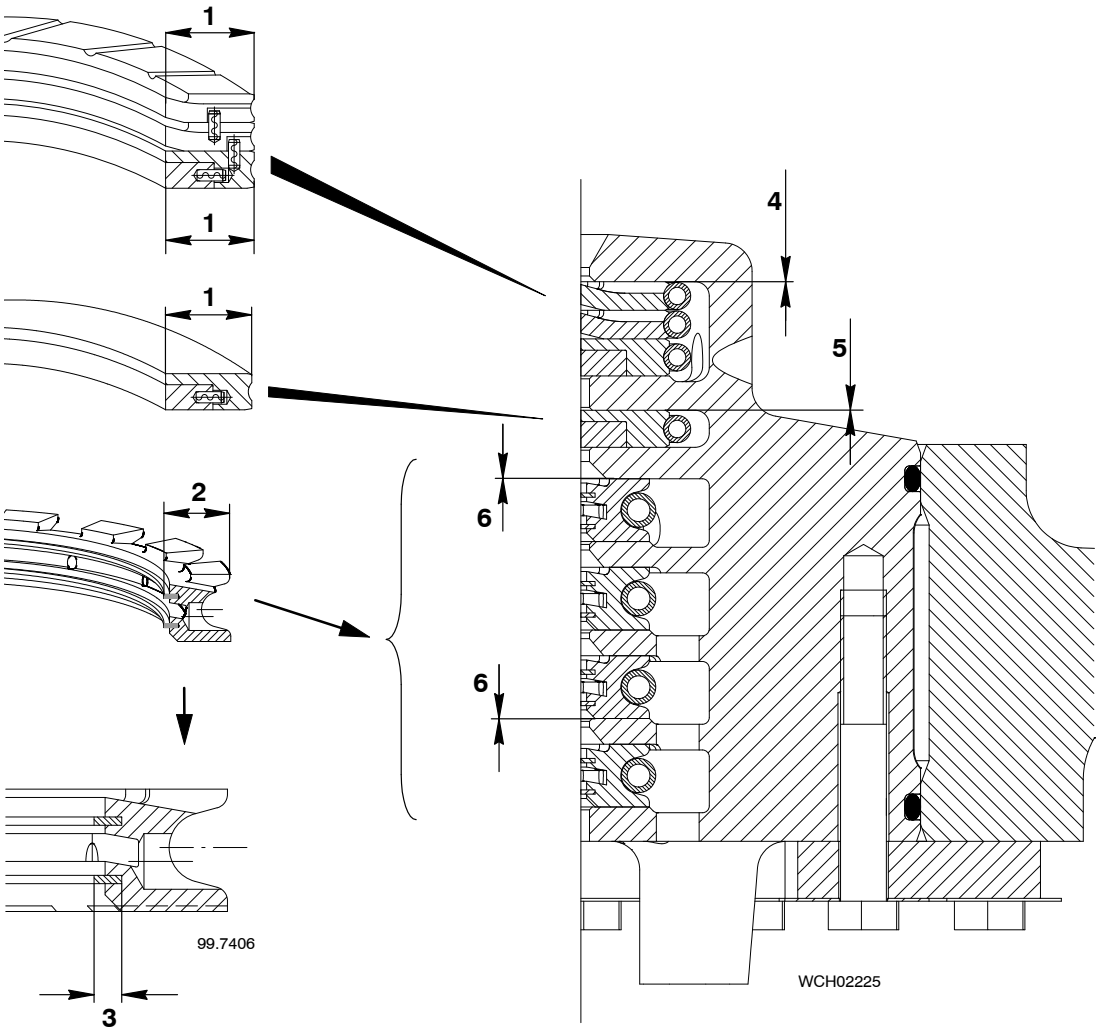


Fig. 7

Piston Rod Gland

Group	Key No.	Description	Measured Direction	Nominal dimension (usual, new) [mm]	Maximum clearance, dimension (because of worn parts) [mm]
2303		**Piston rod gland**			
	*1	Ring width	radial	31	min. 25
	*2	Ring width	radial	24	min. 20.20
	*3	Ring width	radial	5	min. 3.20
	4	Ring clearance	axial	0.05 to 0.19	0.40
	5	Ring clearance	axial	0.05 to 0.13	0.40
	6	Ring clearance	axial	0.10 to 0.17	0.40

* **Ring wear**

The different values between the nominal dimension and maximum wear is equal for all rings, (also for smaller rings).

Exhaust Valve

VALVE SPINDLE

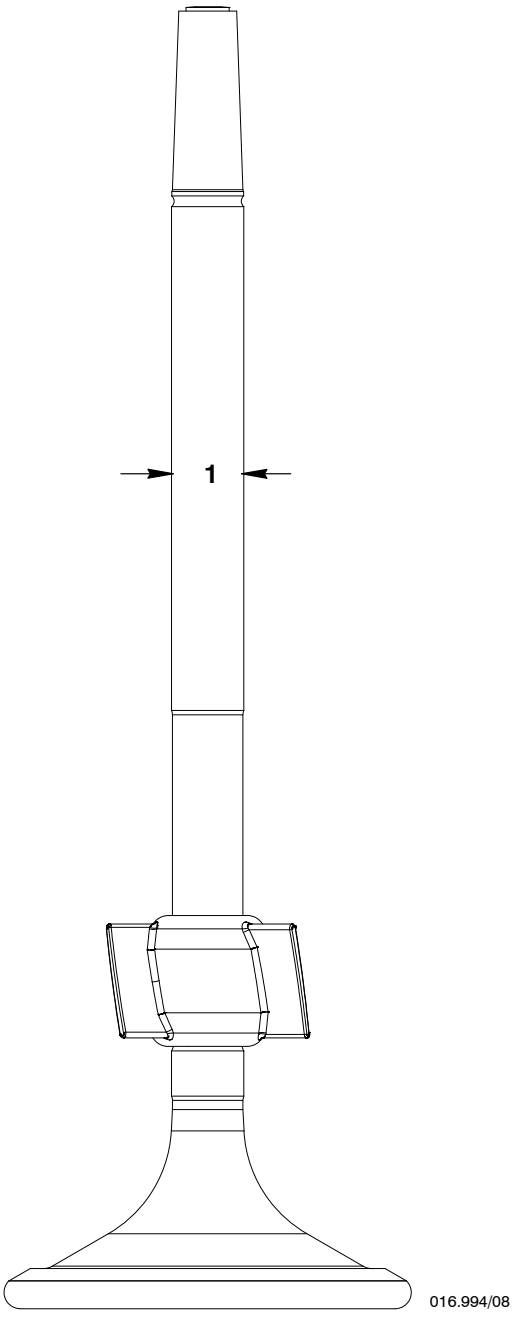


Fig. 8

GUIDE BUSH

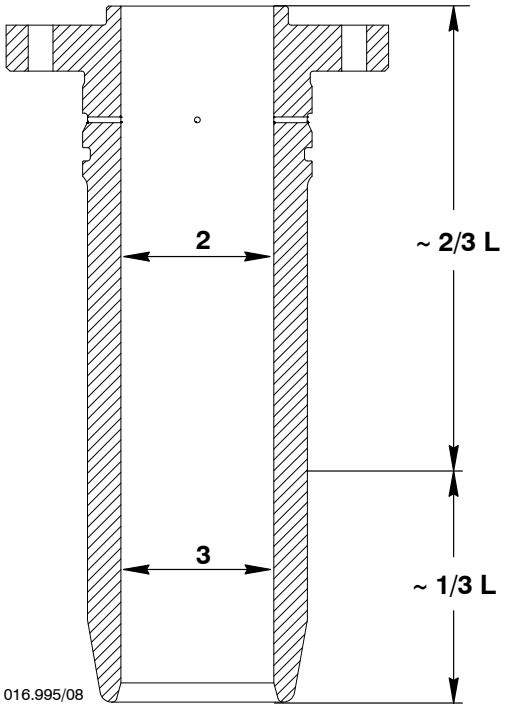


Fig. 9 **L = LENGTH**

Exhaust Valve

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
2754		**Valve spindle**			
	1	Spindle	outer ∅	70 $^{-\ 0.26}_{-\ 0.29}$	69.50
2751		**Guide bush**			
	*2	Bore	inner ∅	70 $^{+\ 0.030}_{0.0}$	70.40
	*3	Bore	inner ∅	70 $^{+\ 0.030}_{0.0}$	71.25

* Make sure that you measure the bore at the correct location.

Top and Bottom End Bearings to Connecting Rod

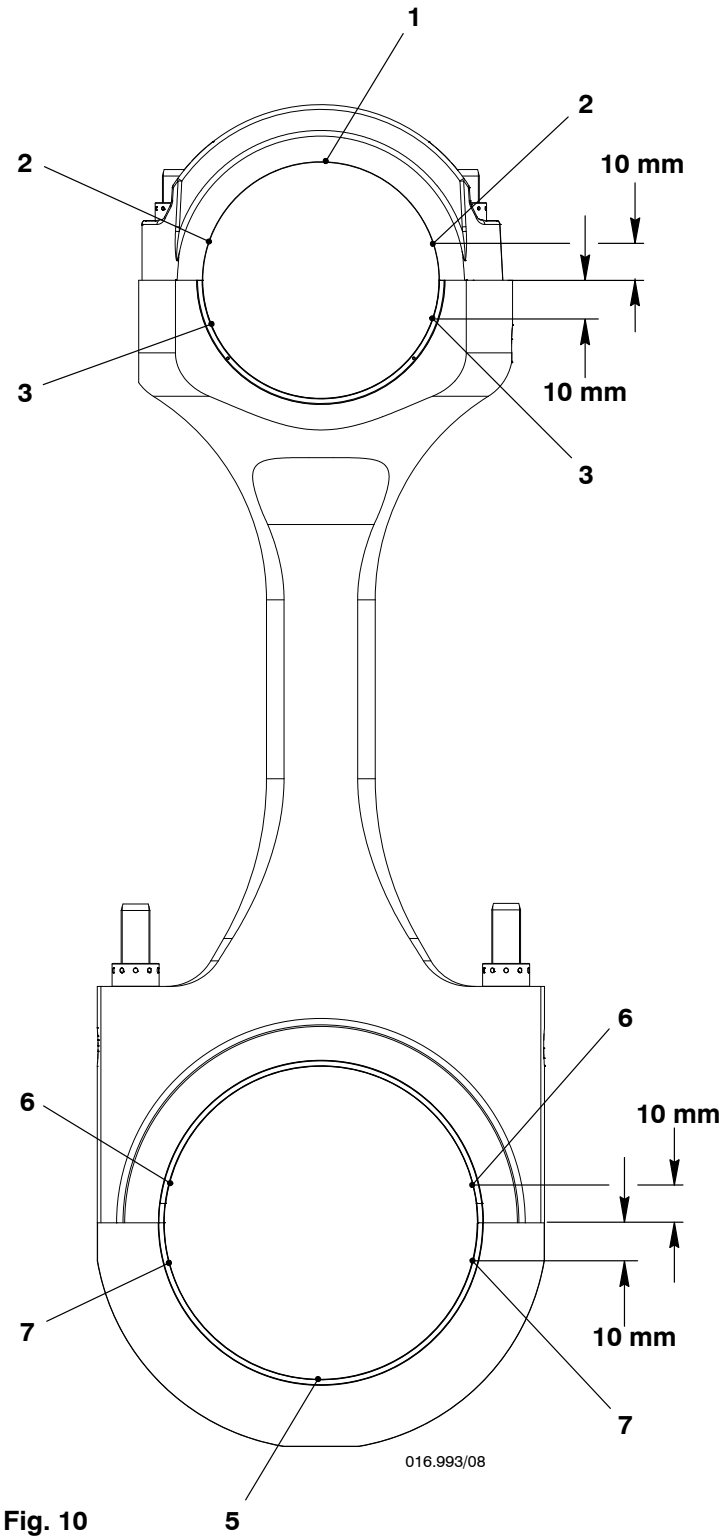


Fig. 10

Top and Bottom End Bearings to Connecting Rod

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum clearance, dimension (because of worn parts) [mm]
3303 3326		**Top end bearing**			
		Crosshead pin	outer ∅	$670\ ^{0}_{-0.08}$	
		Bearing	inner ∅	670	
	1	Bearing clearance	vertical	0.50 to 0.70	0.9
	*2	Lateral clearance	total	0.45 to 0.65	
	*3	Lateral clearance	total	0.35 to 0.60	
3303		**Bottom end bearing**			
		Crankshaft	outer ∅	$880\ ^{0}_{-0.09}$	
		Bearing	inner ∅	880	
	5	Bearing clearance	vertical	0.55 to 0.75	0.95
	*6	Lateral clearance	total	0.55 to 0.80	
	*7	Lateral clearance	total	0.55 to 0.80	

* Make sure that you measure the clearances at the correct locations.

Piston Cooling and Crosshead Lubricating Link

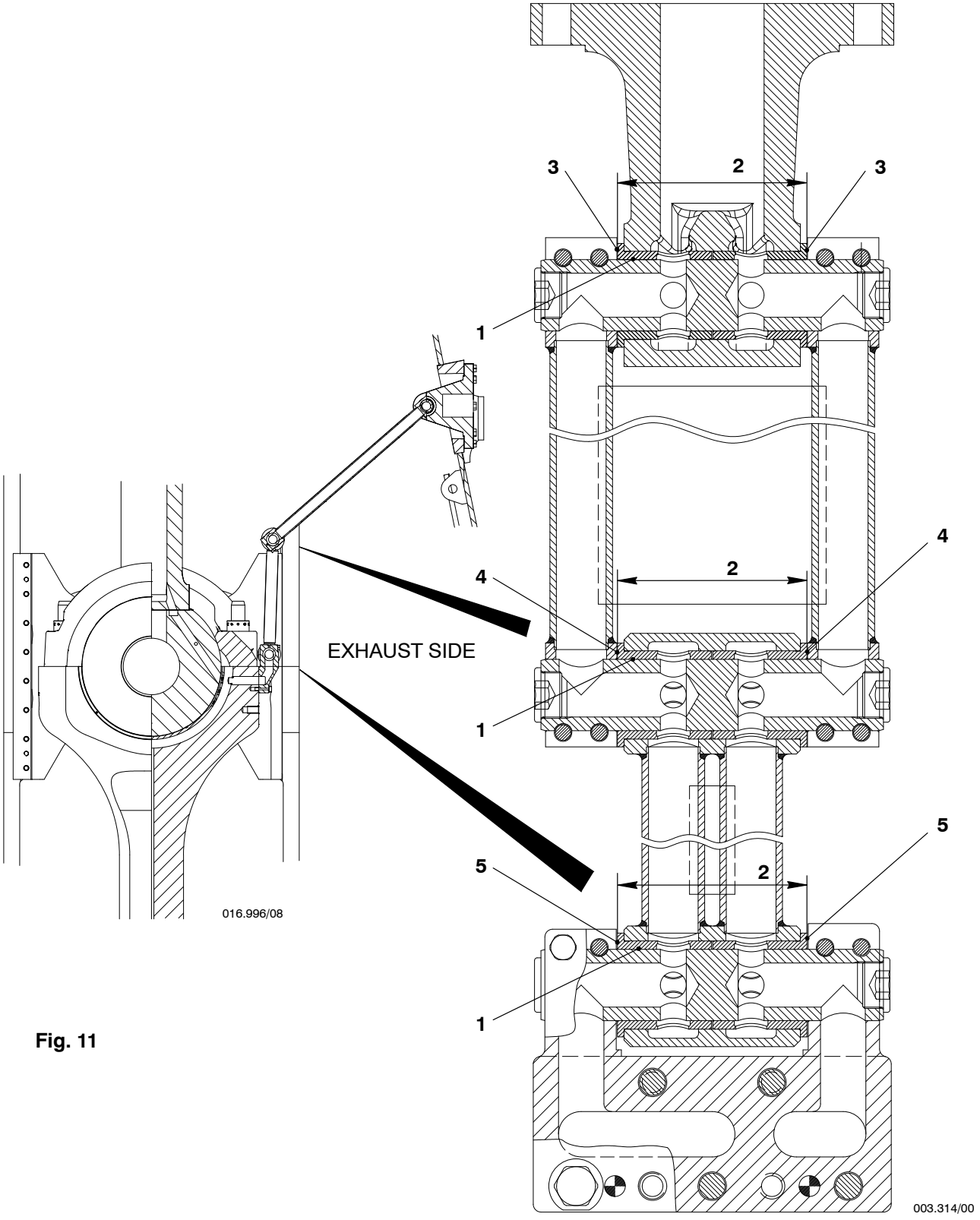


Fig. 11

Piston Cooling and Crosshead Lubricating Link

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
3603		**Piston cooling and crosshead lubricating link**			
		Pin	outer ∅	55	
	1	Bearing clearance	radial	0.03 to 0.09	0.20
	2	Bearing	width	146	
	3	Lateral clearance	each side	min. 0.5	
	4	Lateral clearance	each side	min. 0.5	
	5	Lateral clearance	each side	min. 1.0	

Piston and Piston Rings

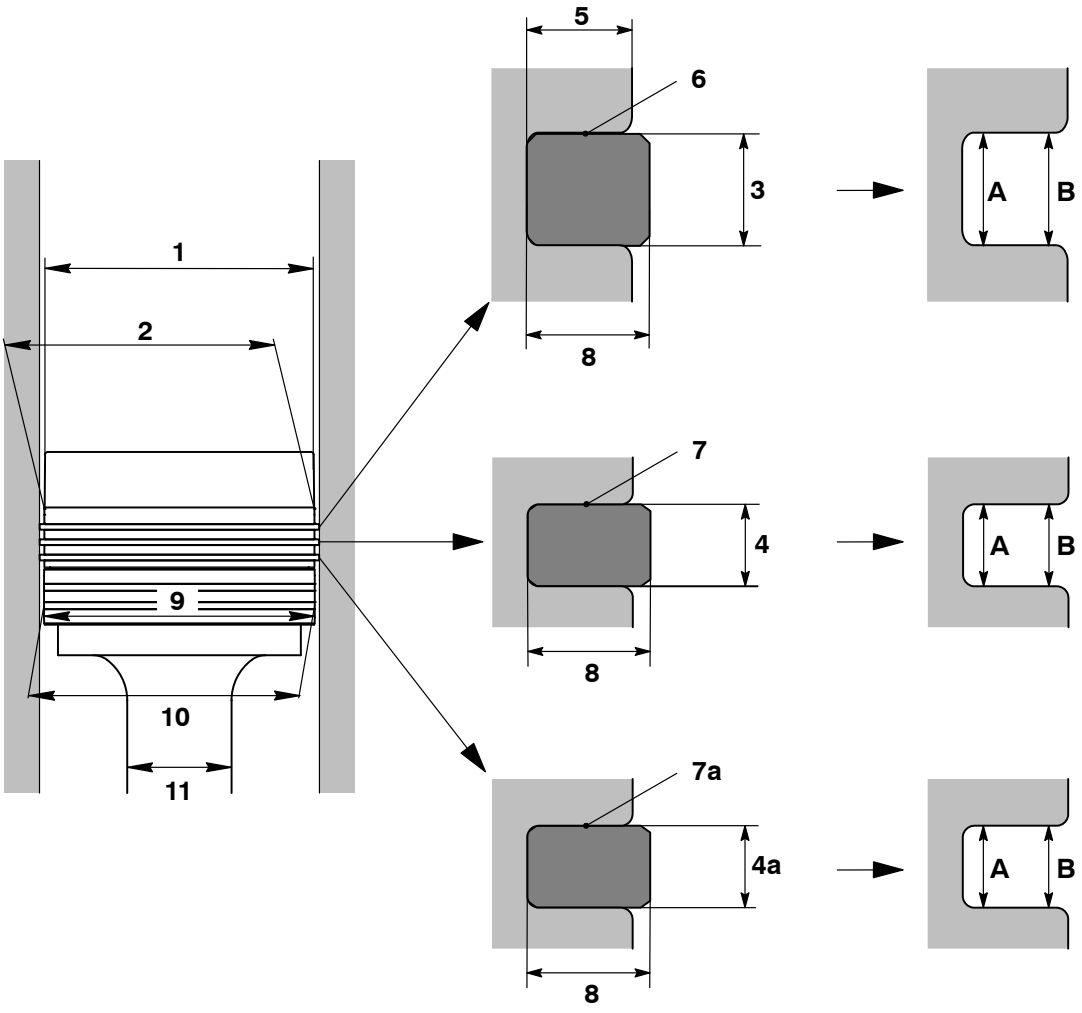


Fig. 12

Piston and Piston Rings

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]	
3406		**Piston head**				
	1	Head (tapered part)	outer ∅	$714.6^{-0}_{-0.2}$		
	2	Head	outer ∅	$716.5^{-0}_{-0.2}$		
3406		**Piston ring grooves**				
	3	Height of the uppermost groove	vertical	$22^{+0.55}_{+0.50}$		
	4	Height of the middle groove	vertical	$13^{+0.50}_{+0.45}$		
	4a	Height of the lowest groove	vertical	$13^{+0.50}_{+0.45}$		
	5	Groove depth	radial	$24^{+0.2}_{+0}$		
3425		**Piston rings**				
	3	Ring height	vertical	$22^{0}_{-0.03}$		
	4	Ring height	vertical	$13^{0}_{-0.03}$		
	4a	Ring height	vertical	$13^{0}_{-0.03}$		
					Point A	**Point B**
	6	Ring clearance	vertical	0.50 to 0.58	0.80	1.00
	7	Ring clearance	vertical	0.45 to 0.53	0.75	0.95
	7a	Ring clearance	vertical	0.45 to 0.53	0.75	0.95
	8	Ring width	radial	23 ±0.25		
3403		**Piston skirt**				
	9	Skirt	outer ∅	$719^{-0}_{-0.1}$	min. 717.9	
	10	Rubbing ring	outer ∅	$719.3^{-0}_{-0.1}$		
3403		**Piston rod**				
	11	Rod	outer ∅	$278^{-0.056}_{-0.108}$	min. 277.05	

Used piston rings can be installed again if they are in their minimum ring width until the next overhaul (to estimate and install piston rings, refer to also 3425–1).

To make an analysis and to use piston heads again, refer to 3425–1.

Drive Wheels for Supply Unit

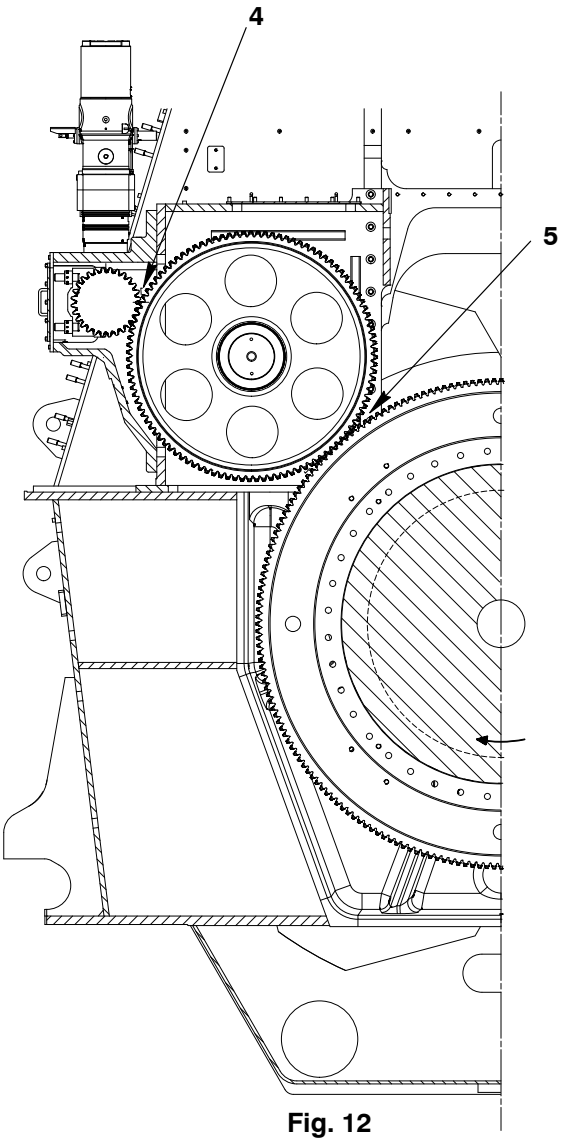


Fig. 12

INTERMEDIATE WHEEL
FOR SERVO PUMP UNIT

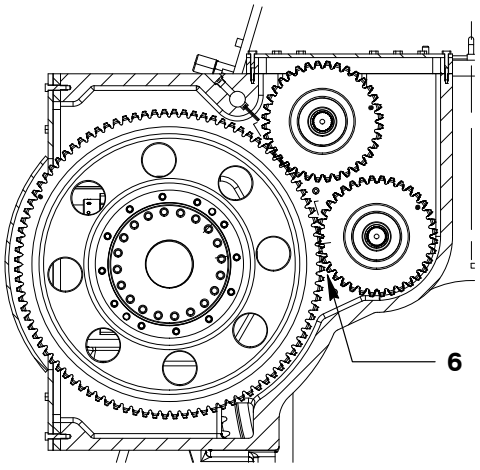


Fig. 13

INTERMEDIATE WHEEL
FOR SUPPLY UNIT

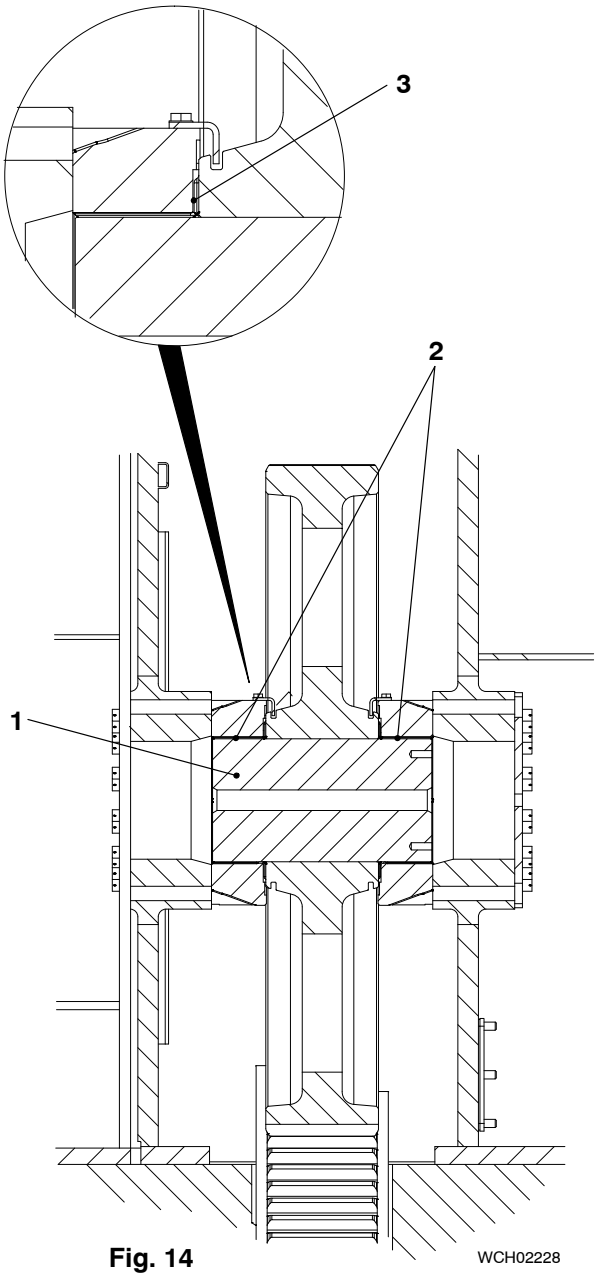


Fig. 14 WCH02228

Driving Wheels for Supply Unit

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
4103		**Intermediate wheel**			
	1	Shaft	outer ∅	240	
	2	Bearing clearance	vertical	*0.121 to 0.21	0.30
	3	Axial clearance	total	0.6 to 1.1	1.5
	4	Tooth backlash		0.24 to 0.40	0.43
	5	Tooth backlash		0.33 to 0.53	0.56
	6	Tooth backlash		0.16 to 0.30	0.34

*This clearance can only be measured when the intermediate wheel is disassembled. Measure the tooth flanks in a longitudinal direction.

Fuel and Servo Pump Units

FUEL PUMP UNIT

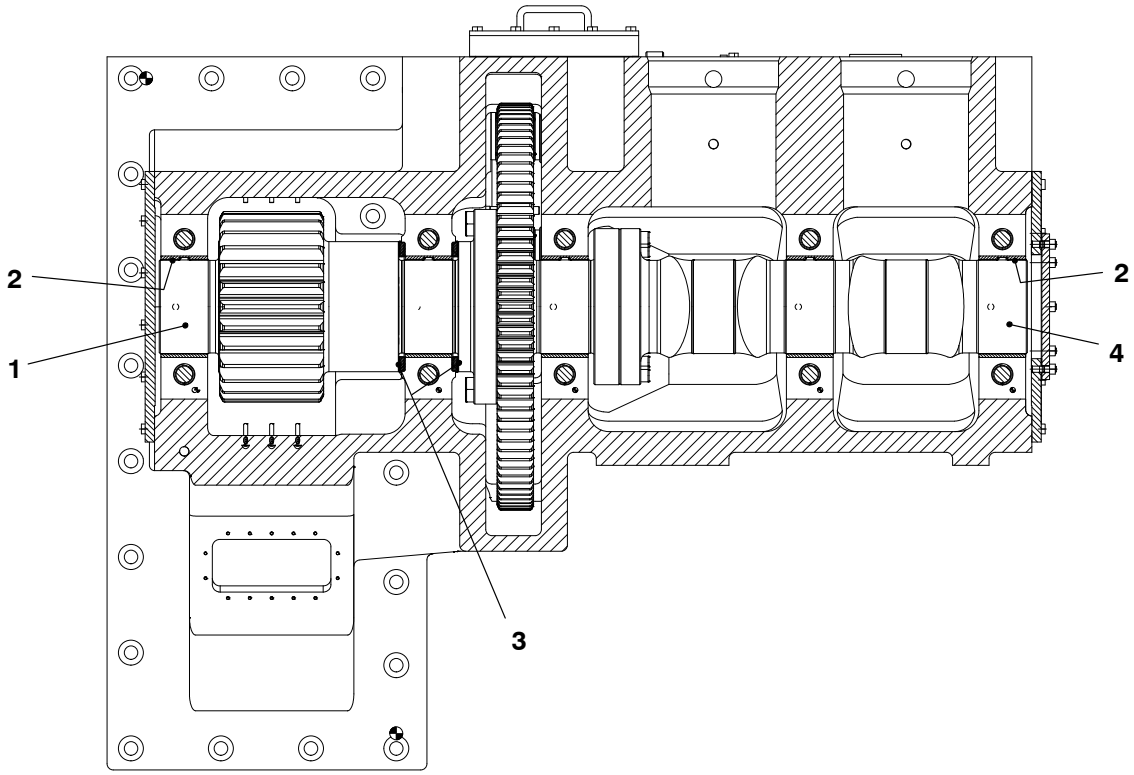


Fig. 15

SERVO PUMP UNIT

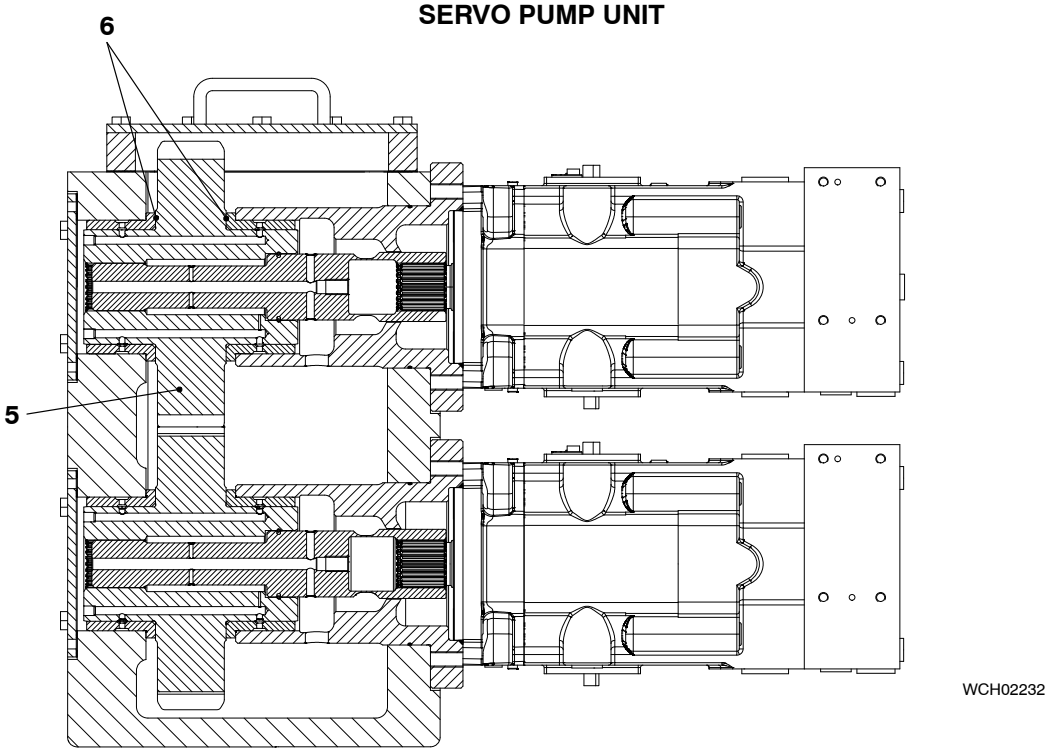


Fig. 16

Fuel and Servo Pump Units

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum clearance, dimension (because of worn parts) [mm]
5552		**Fuel pump unit**			
	1	Gear Wheel	outer ∅	180 $^{0}_{-0.025}$	
	2	Bearing clearance	radial	0.153–0.237	0.33
	3	Axial clearance	total	0.30–0.65	0.81
	4	Cam shaft	outer ∅	180 $^{0}_{-0.025}$	
5552		**Servo pump unit**			
	5	Pinion	outer ∅	120 $^{0}_{-0.022}$	
	6	Axial clearance	total	0.30 to 0.65	0.85

Fuel Pump

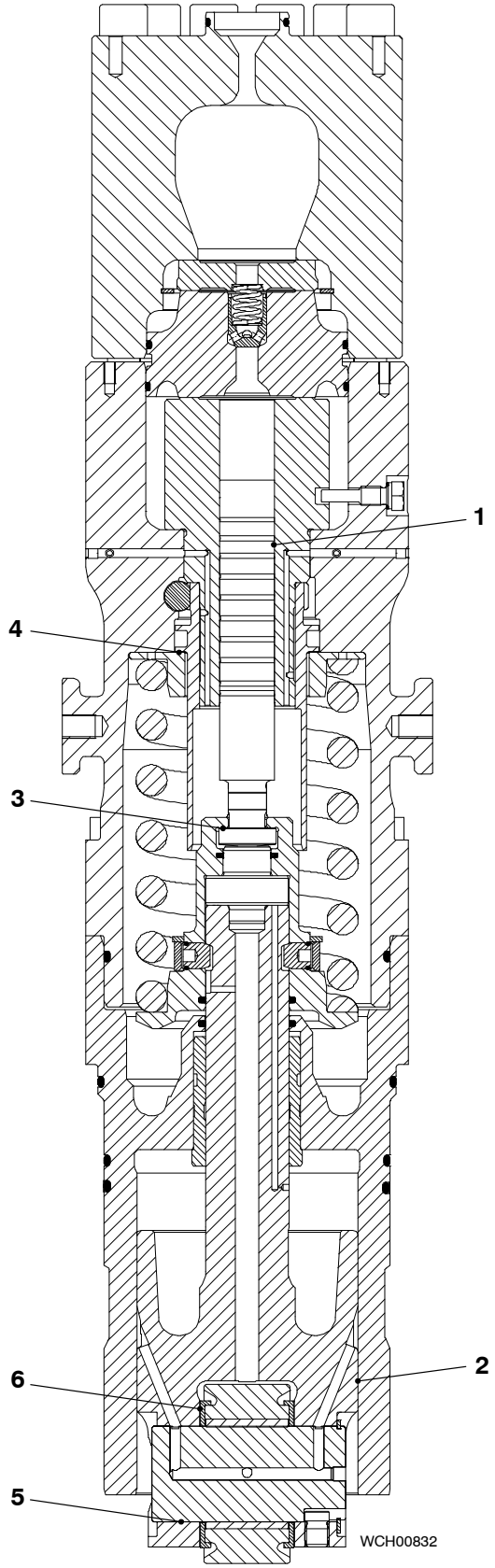


Fig. 17

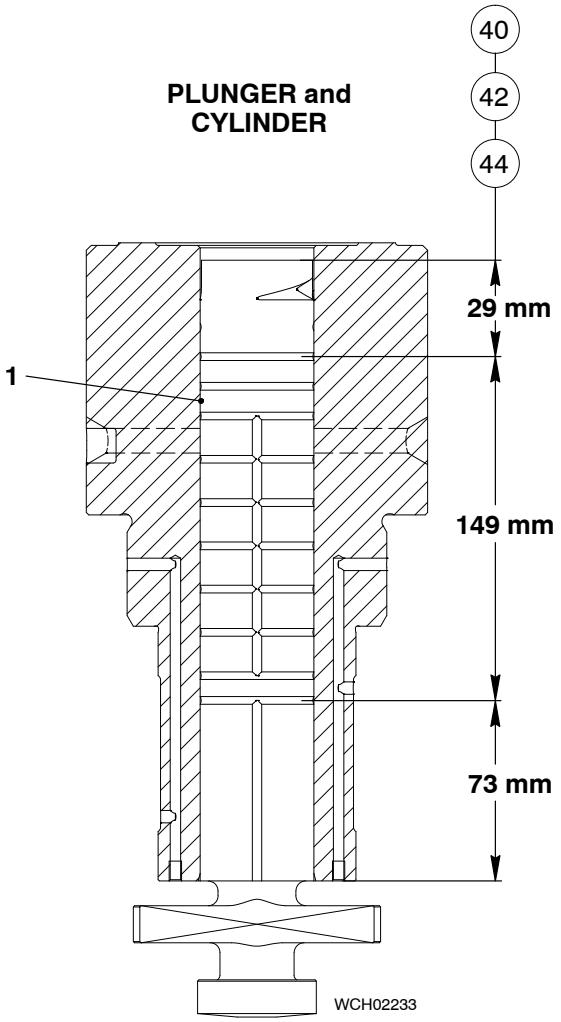


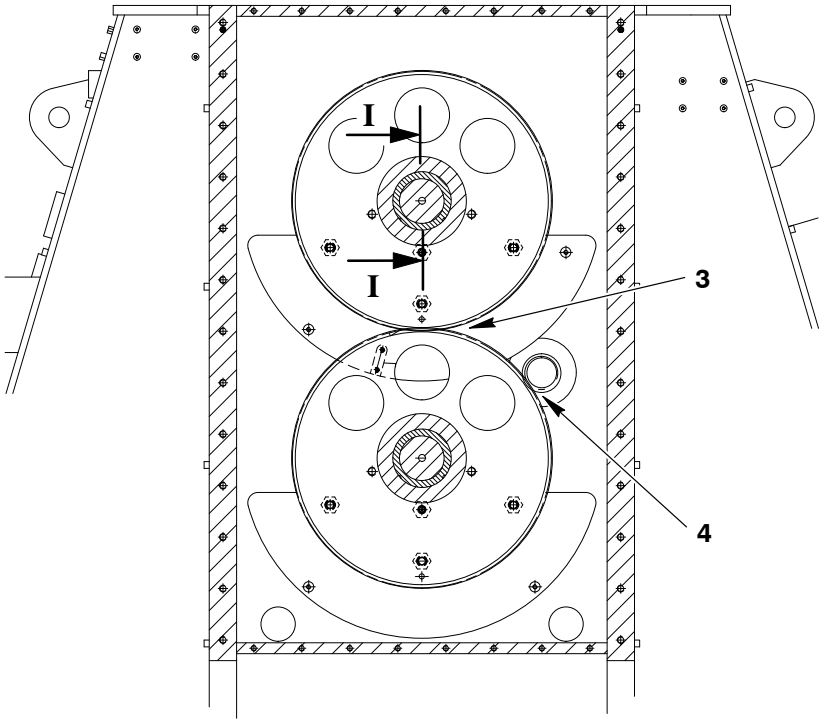
Fig. 18

Fuel Pump

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
5556		**Fuel pump**			
		Plunger (40, 42 and 44 mm)			
	1	Clearance (plunger / cylinder) A to B	radial	0.035 to 0.038	0.045
		Clearance (plunger / cylinder) B to C	radial	0.025 to 0.028	0.035
	*	Clearance (plunger / cylinder) C to D	radial	0.040 to 0.043	0.5
		Guide piston	outer ∅	185	
		Lower housing	inner ∅	185	
	2	Clearance	radial	0.22 to 0.68	0.8
	3	Piston / lower spring carrier	axial	0.12 to 0.24	0.3
	4	Regulating sleeve / upper spring carrier	axial	0 .5 to 0.7	0.8
5556		**Roller guide**			
		Pin	outer ∅	80 $^{0}_{-\ 0.013}$	
		Guide piston (bore)	inner ∅	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

* The plunger is machined in the range C to D; i.e. there is an increase in the clearance diameter of 0.015 mm.

Integrated Electric Balancer



I – I

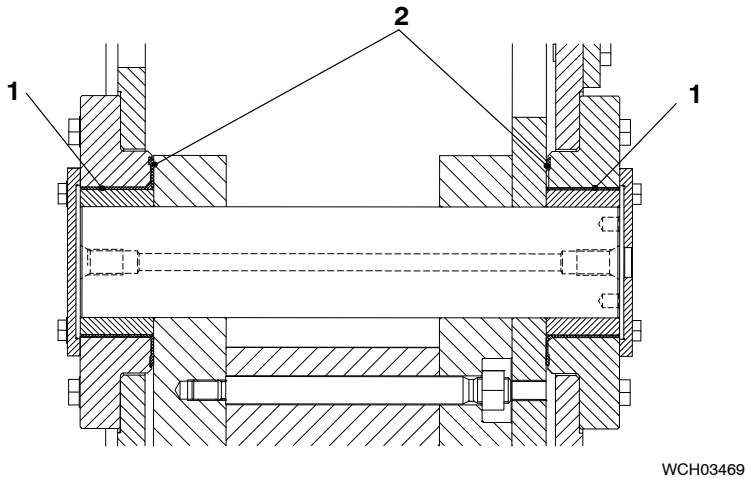


Fig. 19

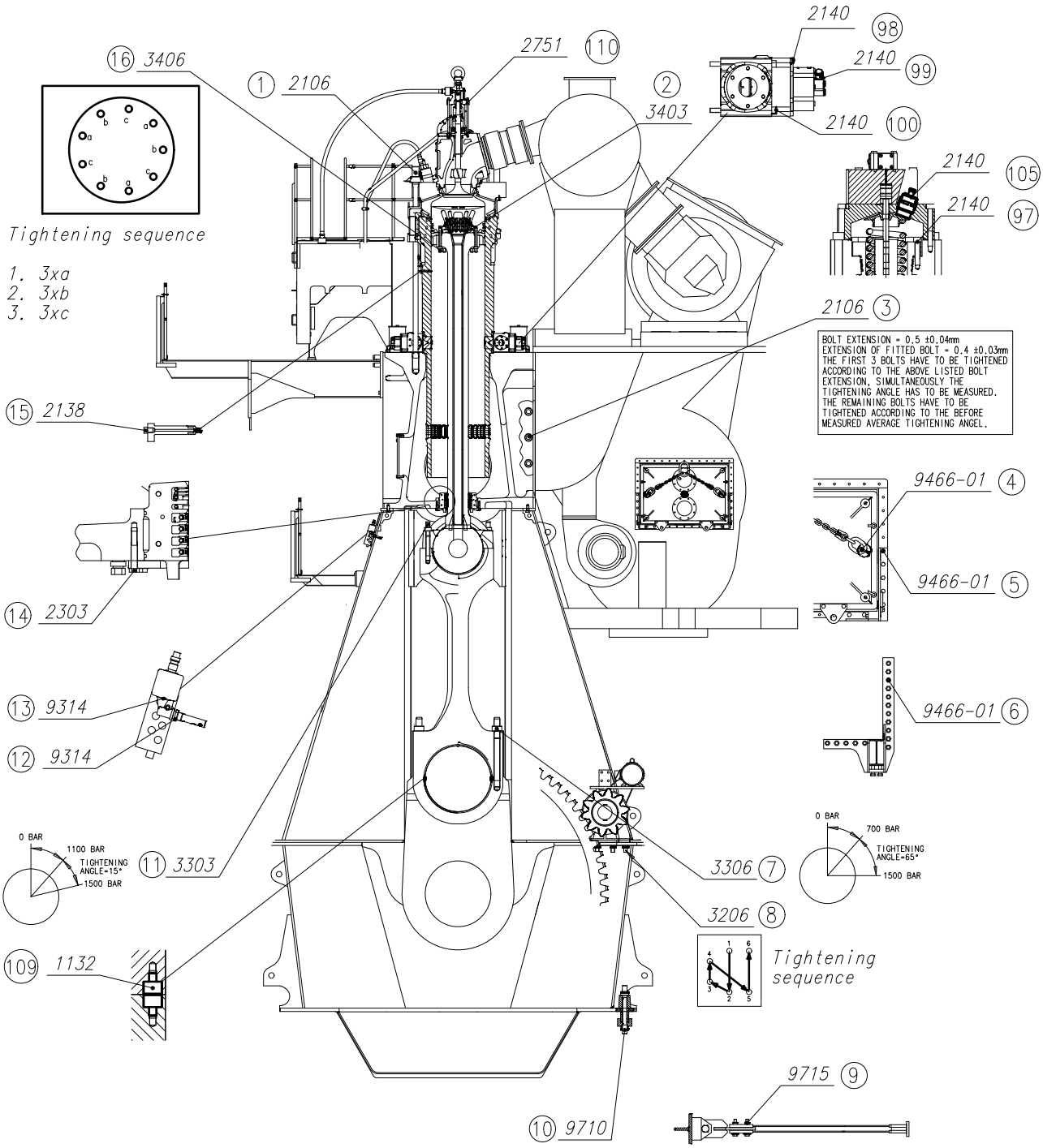
Integrated Electric Balancer

Group	Key No.	Description	Measured Direction	Nominal Dimension (usual, new) [mm]	Maximum Clearance Dimension (because of worn parts) [mm]
7758		**Bearing**			
	1	Bearing pin	outer ∅	200	
	1	Bearing clearance	radial	0.16 to 0.28	0.32
	2	Axial clearance	total	0.5 to 1.1	1.5
7758		**Compensating shaft**			
	3	Tooth backlash*		0.20 to 0.25	
	3	Difference over width		0.02	
	4	Tooth backlash*		0.30 to 0.35	
	4	Difference over width		0.02	

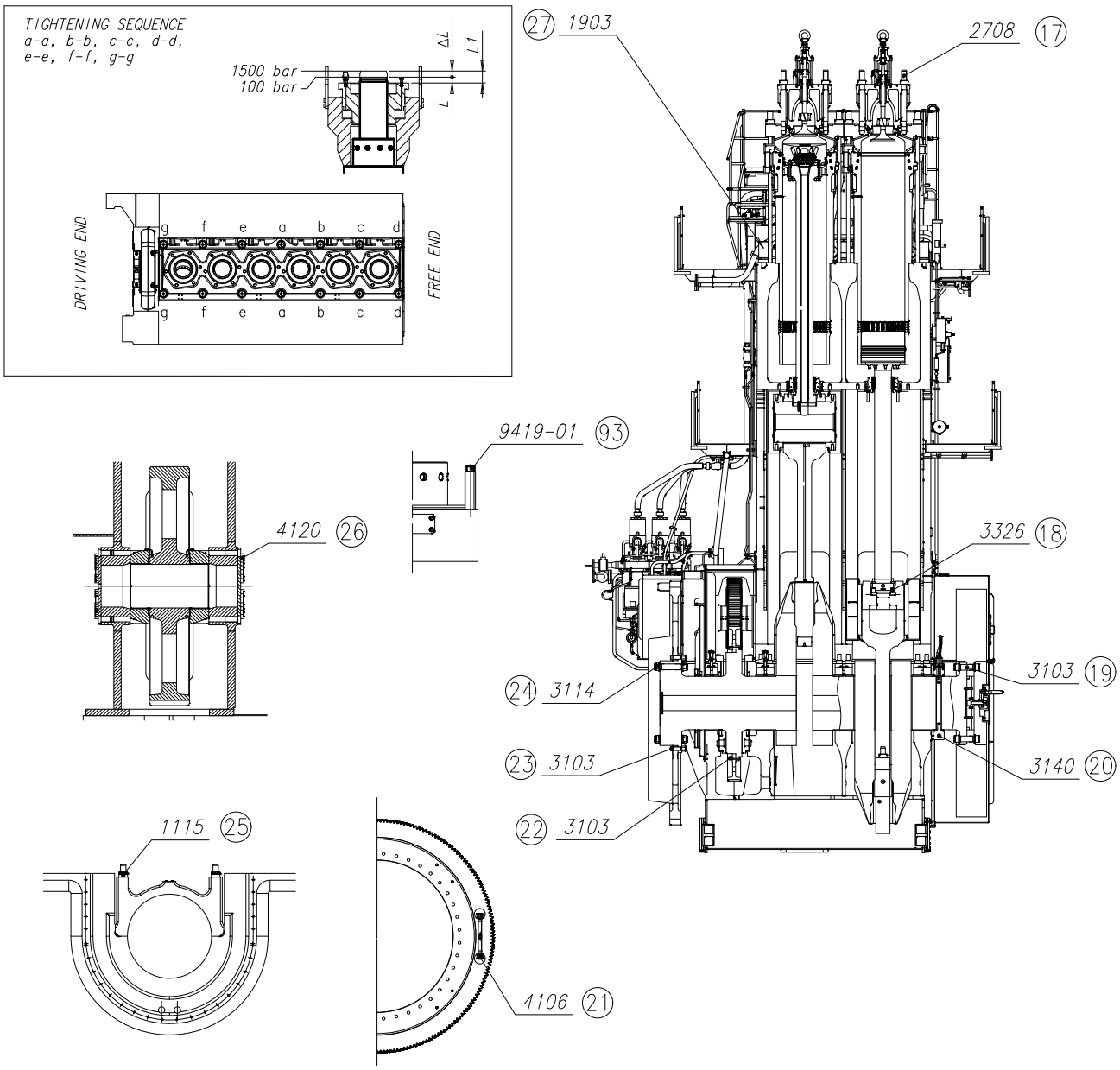
*Measure the tooth backlash longitudinally along the tooth crown. Use lead wire of Pb99.9 fine and 1 mm diameter

Intentionally blank

Tightening Values of Important Screwed Connections

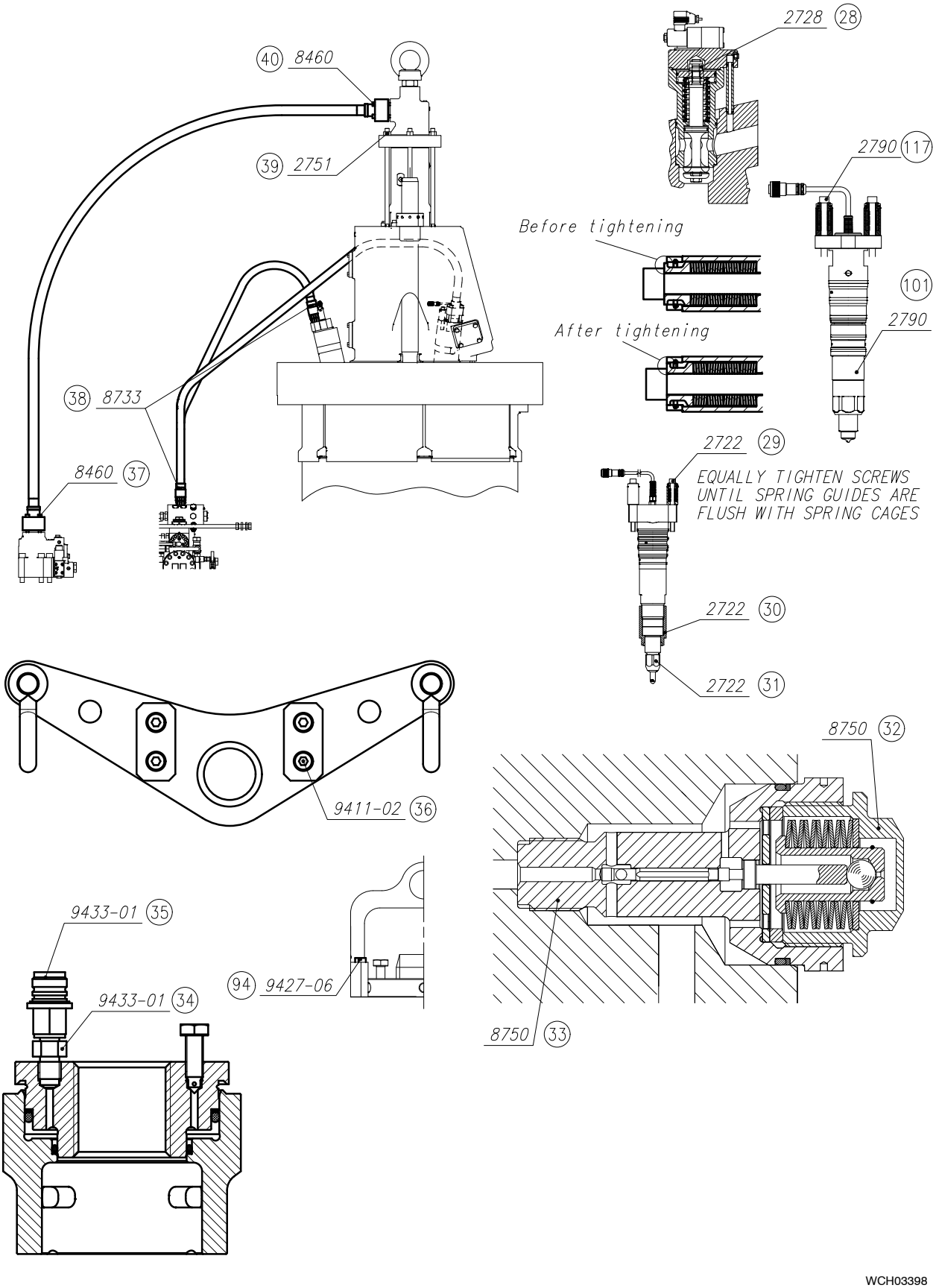


WCH03398

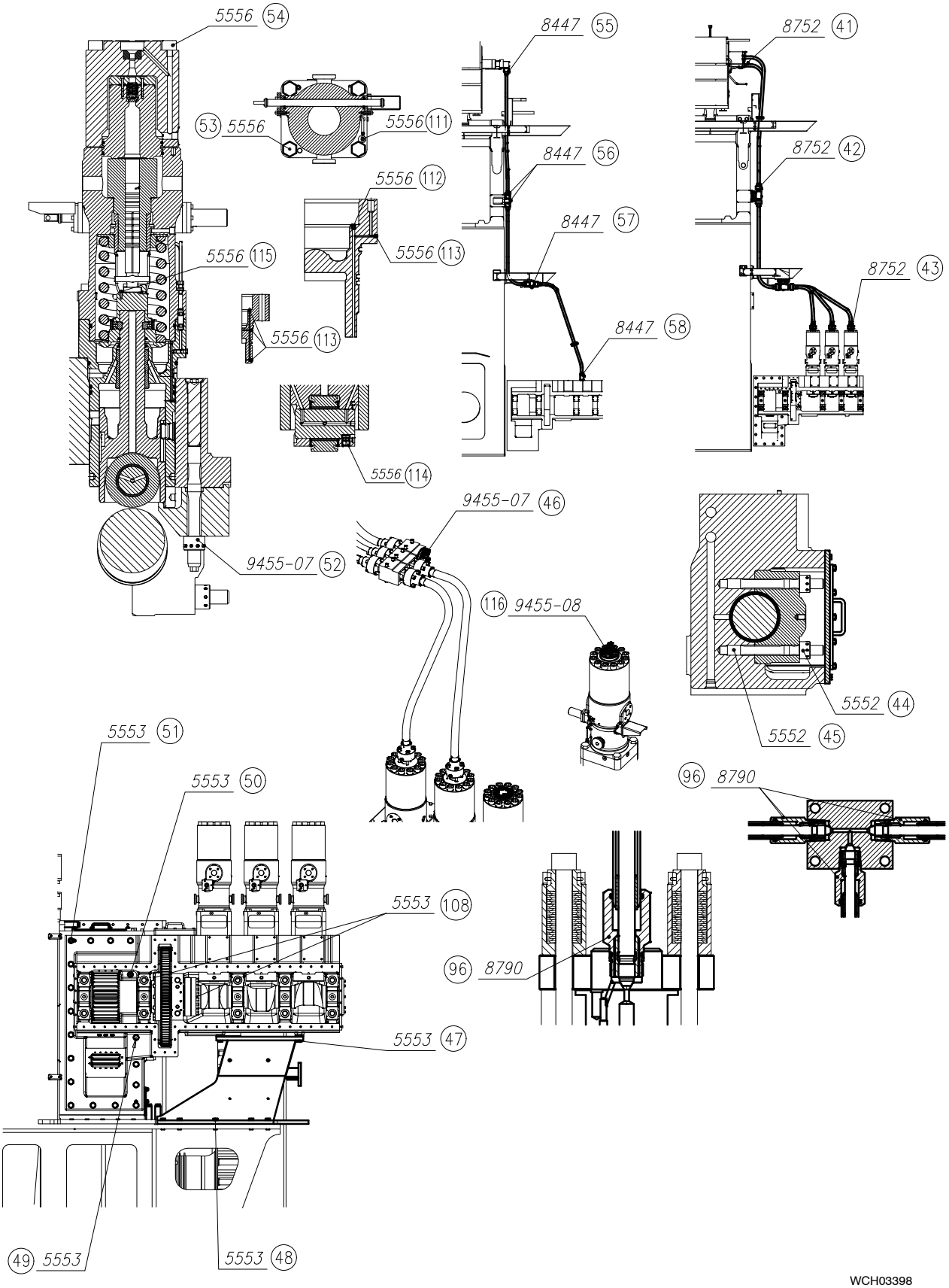

TIGHTENING SEQUENCE
a-a, b-b, c-c, d-d,
e-e, f-f, g-g
1500 bar
100 bar
ΔL
L1
L
DRIVING END
FREE END
g f e a b c d
g f e a b c d
27 1903
2708 17
9419-01 93
4120 26
3326 18
3103 19
24 3114
23 3103
3140 20
22 3103
1115 25
4106 21

WCH03398

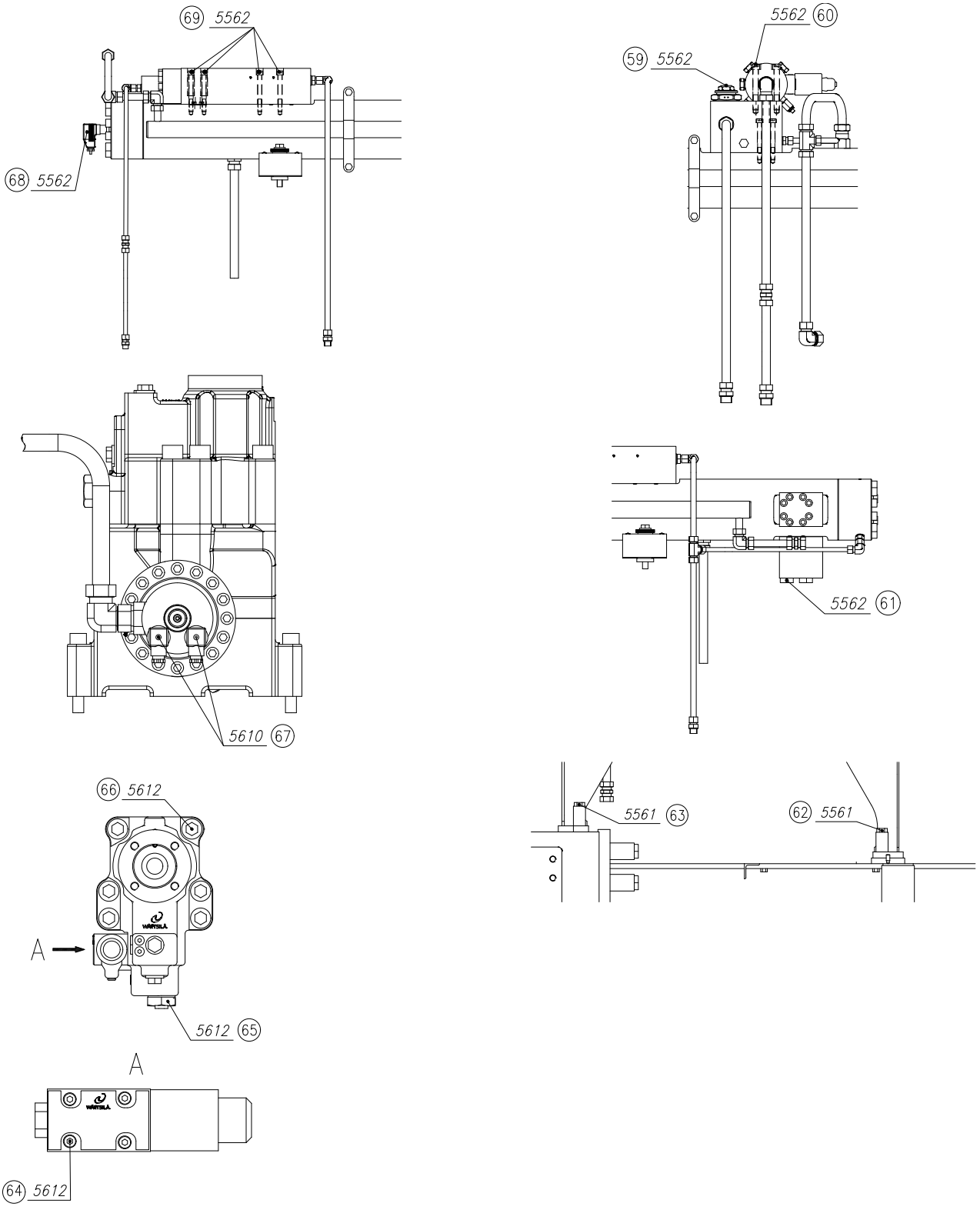
Tightening Values of Important Screwed Connections



WCH03398

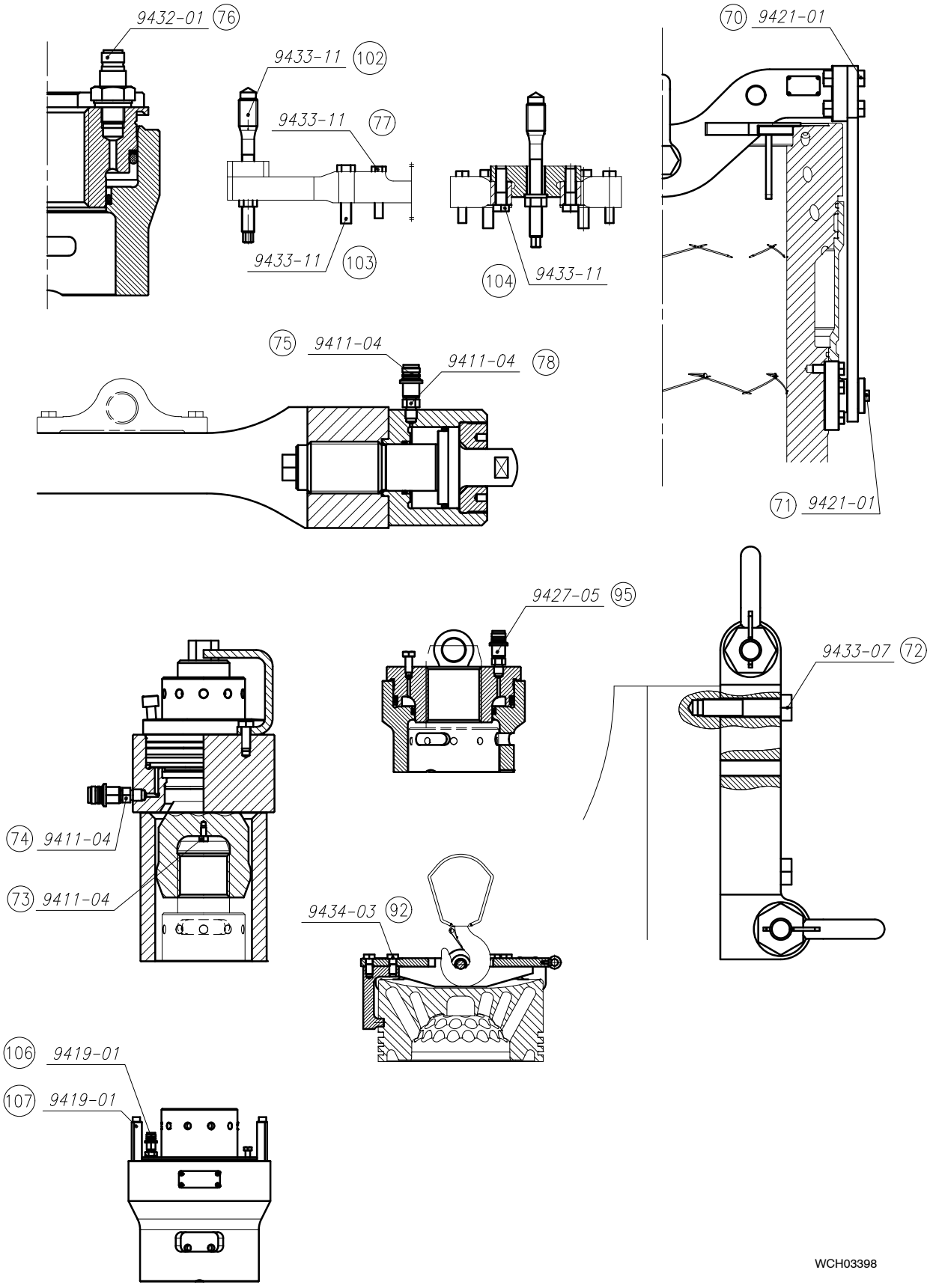

5556 54
53 5556
5556 111
5556 112
5556 115
5556 113
5556 113
5556 114
8447 55
8447 56
8447 57
8447 58
8752 41
8752 42
8752 43
9455-07 46
9455-07 52
116 9455-08
5552 44
5552 45
5553 51
5553 50
5553 108
5553 47
96 8790
96 8790
49 5553
5553 48
WCH03398

Tightening Values of Important Screwed Connections

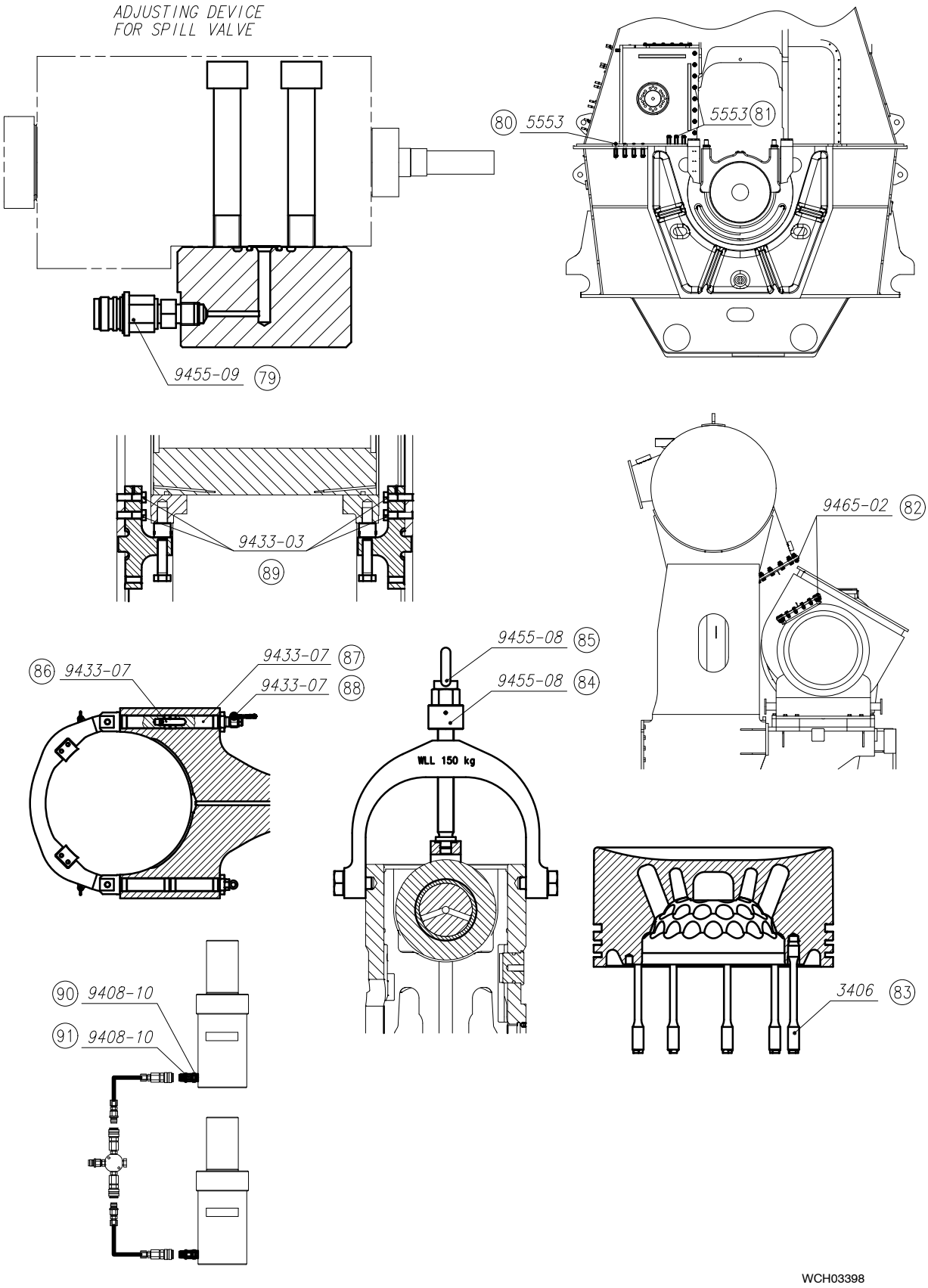


WCH03398

Tightening Values of Important Screwed Connections



Tightening Values of Important Screwed Connections



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					(645)		O	M85	
2			20 Nm	45°				K	M12	
3					0.5 ±0.04			O	M56	See on page 1 position 3
4		225						O	M30	Or hand-tight with a spanner
5		136						O	M16	
6		136						O	M16	
7	1500		700 bar	1500 bar			65	O	M80	
8	1500		All screws to 600 bar	All screws to 1500 bar				O	M48	See on page 1 position 8
9	170							K	M64	Hydraulic jack Group 9710
10	1500		1000 bar	1500 bar				K	M64	
11	1500		1100 bar	1500 bar			15	O	M56	
12		14–15						M	G¾“	
13		5						K	–	
14		150						O	M16	
15		10						O	M10	
16	1500					(75)		O	M33	See on page 1 position 16
17	1500					(165)		O	M80	
18	1500		1000 bar	1500 bar			20	O	M33	
19		(15800)				41		M	M85	
20		(900)				50		M	M30	
21					1.3 ±0.06			M	M39	
22		1600				(80)		K	M30	
23		3900				(25)		M	M56	
24		(15000)				57		M	M85	
25	1500							O	M60	
26		(1200)				65		M	M30	
27	1500				14.0 to 16.0			M	M105	
28		300						K	M24	
29								N	M12	See on page 3 position 29
30			100Nm	35° to 40°				N	M72	
31		190						N	M36x1.5	

M	MOLYKOTE PASTE G–N On threads and surfaces that touch	**C**	MOLYSLIP COPASLIP On threads and surfaces that touch	**N**	NEVER SEEZ NSBT8 On threads and surfaces that touch
K	DO NOT ADD LUBRICATION	**O**	LUBRICATING OIL SAE 30 On threads and surfaces that touch		

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		600						N	M60	
33		300						N	M30	
34		45						O	G¼“	
35		45						O	G¼“	
36		1.6						K	M8	
37		40						O	M12	
38		60						N	M12	
39		290						O	M20	
40		40						O	M12	
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		600						O	M24	
48		600						O	M24	
49		600						O	M24	
50		600						O	M24	
51		600						O	M24	
52	1500					84		K	M36	
53		1250				64		O	M30	
54		480						N	M27	
55		20						O	M10	
56		20						O	M10	
57		20						O	M10	
58		20						O	M10	
59		300						N	M30	
60		190						N	M16	
61		110						N	M14	
62		350						O	M20	

M	MOLYKOTE PASTE G–N On threads and surfaces that touch	**C**	MOLYSLIP COPASLIP On threads and surfaces that touch	**N**	NEVER SEEZ NSBT On threads and surfaces that touch
K	DO NOT ADD LUBRICATION	**O**	LUBRICATING OIL SAE 30 On threads and surfaces that touch		

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		350						O	M20	
64		9						O	M5	
65		225						O	M33x2	
66		350						O	M20	
67		25						O	G¼“	
68		25						N	M14	
69		70						N	M16	
70		960						C	M30	
71		290						C	M56	
72		150						O	M20	
73		7						K	M6	Locked with Loctite 2701
74		45						O	G¼“	
75		45						O	G¼“	
76		105						O	G¼“	
77		145						O	M16	
78		45						O	G¼“	
79		45						O	G¼“	
80		600						O	M24	
81		600						O	M24	

M	MOLYKOTE PASTE G–N On threads and surfaces that touch	**C**	MOLYSLIP COPASLIP On threads and surfaces that touch	**N**	NEVER SEEZ NSBT8 On threads and surfaces that touch
K	DO NOT ADD LUBRICATION	**O**	LUBRICATING OIL SAE 30 On threads and surfaces that touch		

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
82		60						O	M16	
83		60						O	M33	
84		10						K	M24	Locked with Loctite 2701
85		10						K	M16	Locked with Loctite 2701
86		90						K	M42	Locked with Loctite 268
87		90						C	M42	
88		500						K	M30	Lug locked with Loctite 268
89		300						O	M30	
90		45						K	G¼“	Valve sealed with Loctite 542
91		45						O	G¼“	
92		260						M	M30	
93		35						C	M10	
94		18						O	M8	
95		45						O	G¼“	
96		30						N	M24x1.5	
97		40						N	M10	
98		40						M	M10	
99		4						O	M4	
100		170						N	M16M24	
101		815						M	M56x1.5	Min. 800 Nm to max. 830 Nm
102		55						O	M42	
103		280						O	M20	
104		190						O	M20	
105		90						N	M30x1.5	
106		45						O	G¼“	
107		35						C	M10	
108		215						O	M16	
109		10						K	M10	
110		290						O	M20	
111		140						N	M16	
112		7						K	M8	Locked with Loctite 0243
113		3						K	M6	Locked with Loctite 0243
114		60						K	M20	Locked with Loctite 0243
115		9						K	M6	Locked with Loctite 0243
116		10						K	M12	Locked with Loctite 0240
117		50						N	M12	

M	MOLYKOTE PASTE G–N On threads and surfaces that touch	**C**	MOLYSLIP COPASLIP On threads and surfaces that touch	**N**	NEVER SEEZ NSBT8 On threads and surfaces that touch
K	DO NOT ADD LUBRICATION	**O**	LUBRICATING OIL SAE 30 On threads and surfaces that touch		

Name: Short form:	LUBRICATION OIL SAE 30 0	Name: 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
Name: 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	Name: Short form: K factor: Manufacturer:	NEVER SEEZ NSBT8 N 0.13 Bostik, Inc. Bostik Americas Technology Center 11320 W. Watertown Plank Road Wauwatosa, VI 53226 414 United States

Torque Values – Standard Screws and Elastic Studs

1. Torque Values – Standard Screws

We recommend the torque values given in the table below for all standard metric screws of grade 8.8. This applies to all threaded connections not shown 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 heat resistant lubricant, e.g. NEVER SEEZ NSBT8, is recommended.

If you use NEVER SEEZ NSBT8, there must be a decrease of 20% of the torque values given in the table below.

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 – Replace

2.1 Procedure

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

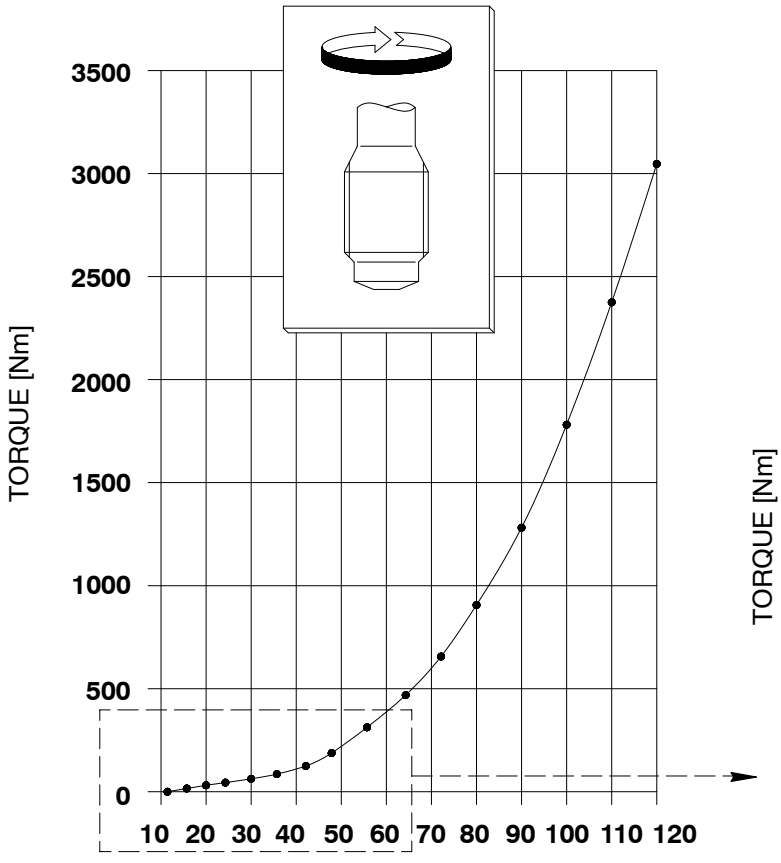


Fig. 1

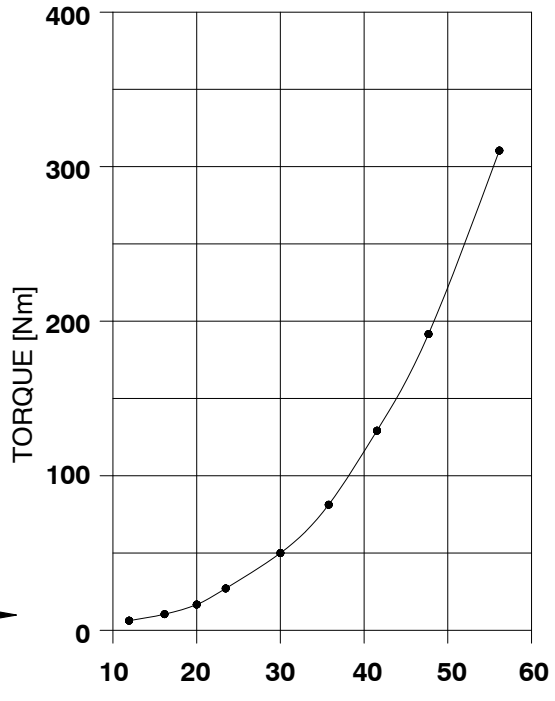


Fig. 2

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

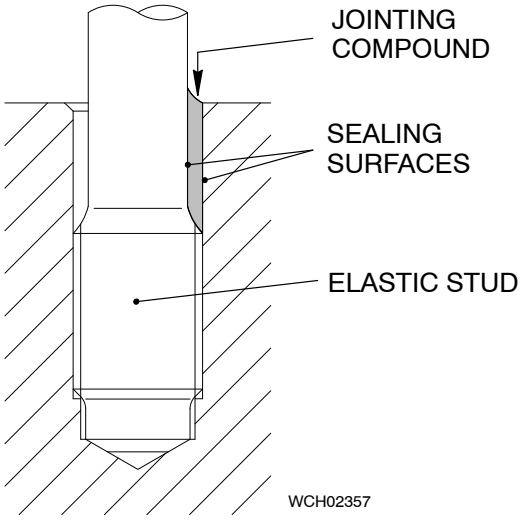


Fig. 3

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 mix.
- 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.

Intentionally blank

Component Weight – Each Piece (kg)

Group	Component	Design	kg
1__			
1115	Main bearing cover (1st)		556 (410)
1134	Main bearing shell		171
1224	Thrust bearing pad		104
1717	Casing (top part) Casing (top part)	free end driving end	877 1420
1720	Oil baffle, top part Oil baffle, bottom part		316 187
1903	Tie rod Tie rod nut Intermediate ring for tie rod nut		550 26 14.7
2__			
2106	Elastic bolt in cylinder jacket		74.6
2124	Cylinder liner		6064
2130	Water guide jacket (top part) Water guide jacket (bottom part)		175 210
2140	Gas admission valve		69.8
2303	Piston rod gland	All related parts	135
2708	Elastic bolt for valve cage Cylinder cover without accessories Cylinder cover with exhaust valve unit, all valves and top water guide jacket	 All related parts	40 2870 4900
2722	Injection valve	All related parts	20.7
2728	Starting valve	All related parts	34
2751	Exhaust valve housing with spindle	All related parts	952
2754	Exhaust valve spindle		102
2790	Pilot injection valve	All related parts	34.2
3__			
3122	Flywheel		5950 to 12790
3140	Axial damper cylinder	2-part	1142
3206	Turning gear with planetary gear		2058

Individual Components per Piece in kg

Group	Component	Design	kg
3303	Connecting rod		3932
	Elastic stud and nut for bottom end bearing		40
	Elastic stud and nut for top end bearing		10
3306	Connecting rod shaft	All related parts	4105
3306	Bearing cover for bottom end bearing with elastic studs	All related parts	511 to 705
3310	Bearing shell for bottom end bearing		60
3312	Bearing cover for top end bearing		705
3315	Bearing shell for top end bearing		122
3326	Crosshead		2694
	Crosshead and guide shoes	All related parts	3268
	Guide shoe		574
3403	Piston and piston rod	All related parts	2631
	Piston heag		700
	Piston skirt		112
	Piston rod		1702
	Spray plate and oil pipe		102
	Piston rings		17.3
3603	Toggle lever for piston cooling and crosshead lubrication	All related parts	113
4__		All related parts	
4106	Crankshaft gear wheel	2-part	2880
4325	Starting air shut-off valve		246
5__			
5555	Supply unit, pilot fuel		373
5591	Servo oil pump (Hawe)		235
5556	Fuel pump	All related parts	427
5564	Flow limiting valve		38.8
5580	Fuel pump unit with pumps, casing, and camshaft	3 fuel pumps. All related parts	4566
5581	Camshaft and gear wheel	3 fuel pumps.	Approx. 700
5591	Servo pump unit with pumps, gear wheels	2 servo oil pumps	472
	Gear wheel pair		14

Individual Components per Piece in kg

Group	Component	Design	kg
5612	Exhaust valve control unit	complete	35
6__			
6506	Turbocharger (ABB)	A165–L A170–L A175–L A180–L A185–L A190–L A265–L A270–L A280–L	2300 3300 5600 7500 10500 12000 2700 3800 8600
6545	Auxiliary blower with electric motor Electric motor	All related parts	1898 891 to 946
6606	Scavenge air cooler	A74–SD	4700
6509	Expansion piece between exhaust manifolds and upstream of the turbocharger		125
6708	Water separator, scavenge air	SAC– A11–SF	544
	Water separator, scavenge air	SAC– A7–SF	413
7__			
7758	Electric balancer compensating shaft (gear wheel, counterweight, and bearing pin) Electric motor		2170 415
8__			
8103	Expansion piece downstream of the exhaust valve	DN 500	95

Intentionally blank

Maintenance Schedule

Inspection and Overhaul Intervals

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
0			
	Lubricating oil	– Laboratory analysis	3000
	Main fuel and lubricating oil filters	– Do a check of the filter elements – specially for white metal particles (clean or replace filter as necessary). Do the procedure in the manufacturer's instructions	3000
	Cooling water	– Calculate quality, concentration of inhibitor and pH value. Do the procedure in the manufacturer's instructions	weekly
1			
1112–1	**Bedplate**	– Do a check of the pre–tension of foundation bolts, initially after 1500 Op. H	12000
		– Do a check of the condition of rubber gasket in the vertical oil drain to sump tank (see SPC 9722), first time as soon as possible after ship is supplied.	30000 (a replacement is recommended)
		– Estimated service life: Bedplate foundation bolts	service life of engine
	Crankcase	– Visual examination, 100 Operation hours after overhaul: look for white metal particles from bearings and for defects.	1500 to 3000
		– Estimated service life: crankcase	service life of engine
1132–2	**Main bearing**	– Bearing shell inspection is only necessary if bearing clearance, crankshaft deflection, oil analysis check or crankcase inspection shows too much damage or worn parts	at indications of too much damage or worn parts
		– Do a bearing edge check with wire	6000
		– Do a bearing clearance check, refer to 0330–1, Group 1132	6000
		– Estimated service life: Main bearing shell	90000 (replace if necessary)
1203–1	**Thrust bearing**	– Do a check of the axial and vertical clearances	6000 to 8000
		– Make sure that the bottom drain is not blocked	6000 to 8000
1224–1		– Thrust bearing pads inspection is only necessary if bearing clearance, oil analysis or crankcase inspection shows too much damage or worn parts	at indications of too much damage or worn parts
		– Estimated service life: Thrust bearing	90000 (replace if necessary)

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
1715–1	**Engine stays**	– Friction type: do a check of the pre–tension of screws. Remove corrosion marks from friction elements. First time after sea trial	6000 to 8000
		– Hydraulic type: do a check of the oil pressure at the gauge	monthly
1903–1	**Tie rod**	– Do a check of the pre–tension. If necessary apply tension again. First time one year after ship is supplied.	24000 to 30000
		– Estimated service life: Tie rod	service life of engine
2			
2124–1	**Cylinder liner**	– Measure the liner wear (in installed condition)	at each piston removal
2124–2		– Remove the cylinder liner	as necessary
		– Replace O–rings	at each liner removal
		– Replace the soft iron joint ring between the cylinder liner and cylinder cover	at each piston removal
		– Replace O–rings of water guide jacket and transition tubes	at each liner removal
		– Do a check of the condition of the antipolishing ring	at each piston removal
2124–3		– Grind off unwanted material in the bore	at each piston removal
		– Dress the lubricating grooves	as necessary
		– Clean scavenge ports and dress their edges	as necessary
		– Estimated service: Cylinder liner	Up to 90000
2138–1	**Lubricating quill (pulse lubrication)**	– Do a check for function and tightness	at each piston removal
		– Make sure that the non-return valves operate	at each piston removal
2140–1	**Gas admission valve (GAV)**	– Do a check of the function and tightness of the GAV	6000
		– Do an overhaul of the GAV valve seat	18000
		– Do a visual check of the compensator at the gas inlet pipe	at each GAV removal
		– Estimated service life: Valve spindle, includes the guide, stroke sensor and rail valve	36000
		– Estimated service life: Housing and servo drive	service life of engine
2303–1	**Piston rod gland**	– Clean the piston rings, calculate worn areas	at each piston removal
		– Estimated service life: Piston rod gland	36000 (refers to rings)

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
2708–1	**Cylinder cover**	– Do a check of the combustion space for damage and worn areas	at each piston removal
		– Estimated service life: Cylinder cover	Service life of engine (re-manufacturing as necessary)
2722–1	**Injection valve (main fuel injector)**	– Do an external check for tightness	before starting the engine after longer engine stop
		– Do a check of the function (nozzle tip inspection, opening pressure).	8000
		– Replace the nozzle tip (FAST type)	8000
		– Replace the O-rings	8000
		– Replace the injection valve	24000
		– Estimated service life: Injection valve	24000
		– Estimated service life: Nozzle spare parts set (e.g. coupling nut and nozzle body with needle)	8000
2728–1	**Starting air valve**	– Do a check of the pipes upstream of the valve during operation. If the pipes are too hot, disassemble the starting valve	weekly
		– Remove and disassemble one starting valve, calculate the time of overhaul for the remaining valves	12000
		– Make sure that the nut on the solenoid is tight if necessary tighten the nut.	monthly
		– Solenoid valve: Do a random check of the function	6000
		– Solenoid valve: do an overhaul	18000
		– Estimated service life: Starting valve	service life of engine
2745–1	**Relief valve on cylinder cover**	– Do a check of the blow-off pressure	as necessary

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
2751–1 to 2751–4	**Exhaust valve**	– General inspection of valve housing, valve spindle and valve seat (exhaust valve is not disassembled)	at each piston removal
		– Do a check of the condition of the valve spindle (if necessary grind the valve seat)	36000 (initial inspection at 18000)
		– Valve Drive: do a check of piston sealing ring / air spring and rod seal ring / guide bush	36000 (initial inspection at 18000)
		– Do a check of the condition of the valve seat	36000 (initial inspection 18000)
		– Do a random check of the valve drive, outer and inner pistons, damper, thrust piece	18000
		– Estimated service life: Exhaust valve spindle	108000 (re-manufacturing as necessary)
		– Exhaust valve seat	72000 (re-manufacturing as necessary)
2790–1	**Pilot injection valve**	– Do an external check for tightness	before engine start after a long engine stop
		– Do a check of the opening pressure	8000
		– Replace the nozzle spare parts set	8000
		– Replace the O-rings	8000
		– Replace the pilot injection valve	24000
		– Replace the pre-chamber	18000
		– Estimated service life: Nozzle spare parts set	8000
3			
3103–1	**Crankshaft**	– Measure the crank deflection, always after the ship touches the sea bed and after each dock in port	6000
3130–1	**Torsional vibration damper**	– Get a silicon oil sample from the viscous vibration damper (use the results of the first sample. Refer to the manufacturer's documentation for the intervals to get more samples)	first time after 15000 to 18000
3130–2		– Disassemble and do an inspection of the vibration damper	Refer to the instructions of the damper manufacturer
3140–1	**Axial damper**	– Disassemble and do an inspection	36000 to 48000

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
3206–1	**Turning gear**	– Inspection of turning gear	Refer to the instructions of the turning gear manufacturer
		– Lubrication of tooth flanks of pinion and flywheel, related to visual inspections, but latest each 2000 Operation hours of main engine	2000
		– Do a check of the screwed connections. First time after one year	12000
3303–2	**Connecting rod bearings**	– Do a check of the bearing clearances (refer to 0330–1, Group 3303)	6000
		– Do a check of the bearing edges with wire	6000
		– Bottom end bearing inspection is only necessary if the bearing clearance, wire check, oil analysis or crankcase inspection shows too much damage or worn parts.	at indications of too much damage or worn parts
3303–3		– Top end bearing inspection is only necessary if bearing clearance, wire check, oil analysis or crankcase inspection shows too much damage or worn parts.	at indications of too much damage or worn parts
		– Do a random inspection of the connecting rod top end bearing and bottom end bearing	70000
		– Estimated service life: Connecting rod bottom end bearings	90000 replace if necessary
		– Estimated service life: Connecting rod top end bearings	90000 replace if necessary
3326–1	**Guide shoe, crosshead pin**	– Do a check of the clearances	6000 to 8000
3403–1	**Piston**	– Remove and clean	18000 to 36000 (related to condition)
		– Do a check of the tightness on the piston in installed position and with running oil pump. Do a visual check through the scavenge ports	after installation
3403–3		– Disassemble and assemble (open and clean the cooling area, minimum one piston each three years)	as necessary
3403–4		– Do a check of the condition of the piston top surface	at each piston removal
		– Do a visual check through the scavenge ports of the piston, piston rings and cylinder liner	500 to 1000

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
3403−4		− Measure the ring grooves. Do an inspection of the chromium plating. Add the chromium again as necessary	18000 to 36000 (related to condition)
		− Estimated service life: Piston head ring grooves	18000 to 36000
		− Piston head surface, full re-manufacturing	72000
	Piston underside	− Do a check of the condition of the piston underside. Clean as necessary	1500 to 3000
		− Make sure that the drains and holes are not blocked	1500 to 3000
3425−1	**Piston rings**	− Measure the thickness of the chrome-ceramic layer	1500 to 2000
		− Replace the piston rings (related to remaining thickness of the layer)	18000 to 36000 (related to condition)
		− Estimated service life: Piston rings	18000 to 36000
4			
	Start interlock	− Do a check of the electric and pneumatic interlocks (refer to the Operation Manual 4003−1)	quarterly
4103−1	**Driving wheels**	− Do a check of the tooth condition	6000 to 8000
		− Do a check of the running clearance and backlash of teeth	6000 to 8000
		− Estimated service life: driving wheels	service life of engine
	Starting air shut-off valve	− Release pressure / vent starting air inlet (manifold) pipe	after each maneuvering period
4325−1		− Disassemble, clean and do a check (important parts are: seat, springs and sealing rings)	30000 to 36000
		− Do an overhaul of the common start valve (SPC: Control Valve Complete, Group 4325−2)	18000
		− Estimated service life: Starting air shut−off valve	service life of engine
	Control air filter	− Drain the filter	weekly
		− Clean the filter	6000
5			
5551−1	**Servo oil pump**	− Replace servo oil pump with new one or a pump that had an overhaul in a WinGD workshop	36000 (Hawe)

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
5552–1	**Servo oil pump drive**	– Do a check of the pinion and driving wheels to the servo oil pump drive	3000
		– Do a check of the bearing bushes to pinion	24000
		– Do a check for particles in the filter below the plug in the compensator	2000
		– Estimated service life: supply unit pinion bearing bushes	90000
5552–2	**Fuel pump drive**	– Camshaft: do a check of the running surface of cams, rollers and roller guides (first time after 500 Operation hours)	3000
		– Camshaft: do a check of the bearing clearances at random positions	12000
		– Camshaft: do a check of the thrust bearing clearances	36000
		– Estimated service life: supply unit camshaft bearings	90000
5555–1	**Pilot fuel supply unit**	– Lubricate the flexible coupling of the pilot fuel pump	1500 to 3000 (at all operation modes)
		– Replace the pilot fuel pump	24000 (at all operation modes)
		– Replace the pilot fuel filter cartridges. (the cartridges must be replaced earlier if the pressure difference indicator shows a high pressure increase	1000 (at all operation modes)
		– Clean the wire gauze and filter housing.	1000
		– Estimated service life: Pilot fuel pump	24000
5556–1	**Fuel pump**	– Do a random flow check of the lubricating oil	6000
		– Do an overhaul of the fuel pump	18000
		– Estimated service life: Fuel Pump	18000
5562–1	**Fuel pressure control valve (PCV)**	– Do a check of the shut-down function (refer to the Operation Manual 4003–1)	3000
		– Do a check of the function (refer to the Operation Manual 5562–1)	6000
		– General overhaul	only necessary if PCV becomes defective
		– Estimated service life: Fuel pressure control valve (PCV)	service life of engine

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
5562–2	**Fuel overpressure safety valve / Relief Valve**	– Do a check of the function on the test bench	24000 to 36000
5564–1	**Flow limiting Valve (FLV)**	– Do an inspection, clean the piston rod and piston running surface	12000
		– Do an overhaul of the FLV, or replace with a new item or an FLV that had a overhaul in a WinGD workshop.	24000
		– Estimated service life: FLV	24000
	Servo oil rail	– Replace hoses (a minimum of each 5 years)	30000
5612–1	**Exhaust valve control unit**	– Do a check of the piston and slide rod	36000
		– Do a check of the oil filter	18000
		– Replace the 4/2-way solenoid valve	24000 to 36000
		– Estimated service life: Exhaust valve control unit	Service life of engine
5583–1 or 5556–1	**Fuel pump Actuator**	– Make sure that the regulating linkage moves freely. Lubricate movable parts	3000
6			
6420–1	**Scavenge air receiver**	– Do a check of the flaps. Clean the flaps.	4000 to 6000
		– Clean the receiver	4000 to 6000
		– Make sure that the water drain pipes and holes are not blocked	1500 to 3000
	Turbocharger	– Wet-clean the compressor during operation	Refer to the manufacturer's documentation
		– Wet-clean or dry cleaning the turbine during operation	Refer to the manufacturer's documentation
	Air filter	– Do a check of the filter	half yearly
		– Clean the filter at an np increase of 50% compared to the shop test value at the same engine load (refer to the Operation Manual 6510–1)	as necessary
6545–1	**Auxiliary blower**	– Clean the impeller and casing	24000 to 36000
		– Replace the ball bearing	24000 to 36000

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
6606–1	**Scavenge air cooler (SAC)**	– Clean the SAC (air side) during operation, initially each week, later if np (pressure decrease through SAC) increases compared to the shop test value at same engine load (refer to the Operation Manual 6606–1)	as necessary
		– Do a check of the condensate collector through the sight glass (refer to the Operation Manual 8345–1)	daily
		– Make sure that the condensate collector is not blocked (refer to the Operation Manual 8345–1)	1500 to 3000
		– Do a check of the SAC sealing	quarterly
		– Bleed the system	daily
		– Remove the SAC for general overhaul	as necessary
6708–1	**Water separator scavenge air**	– Do a check of the condensate collector through the sight glass (refer to the Operation Manual 8345–1)	daily
		– Make sure that the condensate collector is not blocked (refer to the Operation Manual 8345–1)	1500 to 3000
		– Do a check of the water separator elements (if necessary clean them)	1500 to 3000
		– Remove the water separator for general overhaul	as necessary
7			
7218–1	**Lubricating pump**	– Replace the lubricating pump with new item, or a pump that had a overhaul in a WinGD workshop.	as necessary
		– Re-manufacture	30000
		– Estimated service life: Cylinder lubricating pump	30000
	Filter replacement	– Replace the filter element upstream of the cylinder lubricating system	as necessary
7758–1	**Electric Balancer iElba**	– Do a check of the bearing clearance, refer to 0330–1, Group 7758	6000
8			
8135–1	**Exhaust waste gate (LLT)**	– General Inspection. During a longer operation period at low engine load, manually open the butterfly valve (refer to the Operation Manual 8135–1)	in accordance with instructions of valve manufacturer
	Servo oil service pump (engine mounted)	– Do a check of the flow rate and maximum pressure	in accordance with instructions of valve manufacturer

Group	Component	Work to be Done	Intervals and Service Life (Operation Hours)
	Starting air pipes on and upstream of the engine	– Drain (remove water)	before and after each maneuvering period
8135−1	**Pressure gauges and pyrometers**	– Calibrate and compare with the master instruments	6000 to 8000
	Pipe holders	– Do a check of the pipe holders if necessary. Tighten the screws (first time after 100 operation hours)	half yearly
8447−1	**Servo oil pipes**	– Grind the sealing faces	as necessary
	Non−return valve	– Do a random check	18000
8460−1	**Hydraulic pipe for exhaust valve drive**	– Grind the sealing faces	as necessary
8733−1	**HP pipe to injection valve (on cylinder cover)**	– Grind the sealing faces	as necessary
8744−1	**Supply unit fuel drain pipes**	– Make sure that the pipes are not blocked	6000
8752−1	**HP fuel pipe**	– Grind the sealing faces	as necessary
8903	**Gas supply pipe**	– Shut off and vent valves: do a check of the tightness of ball valves. Do a check of the shaft sealing – Do a visual check of the compensators – Estimated service life	6000 6000 service life of engine
9 9223−1	**Crank angle sensor (CAS) unit**	– Replace the proximity sensor	as necessary
9308−1	**Cylinder cover – Relief valve**	– Do a check of the blow-off pressure – Replace the relief valve	as necessary when blown off
	Oil mist detector	– Do the procedure in the manufacturer's instructions	half yearly
	ECS	– Replace the modules: CCM−20, MCM−11 and LDU−20, refer to the Operation Manual 4002−4 – Do a visual check of the cables	48000 to 50000 quarterly

The indicated maintenance intervals are a guide only and can be different.

The intervals are estimates only. It is possible that these intervals can be less than or more than the recommended intervals.

Different conditions can have an effect on the service life such as the conditions given below:

- Environmental and operating conditions
- Heavy fuel oil, gas fuel and lubricating oil qualities (refer to the Operation Manual 0300–1, 0340–1 and 0320–1)
- Engine load
- Fuel, lubricating oil and cooling water (refer to the Operation Manual 0300–1, 0340–1 and 0330–1)
- Do overhauls in accordance with the Maintenance Manual
- Original spare parts used
- Continuous engine monitoring
- Engines in accordance with the specifications of WinGD.

Note: The group numbers and their locations are shown in 0803–1 Engine Cross Section and Longitudinal Section.

Intentionally blank

Engine Cross Section and Longitudinal Section

1. Cross section

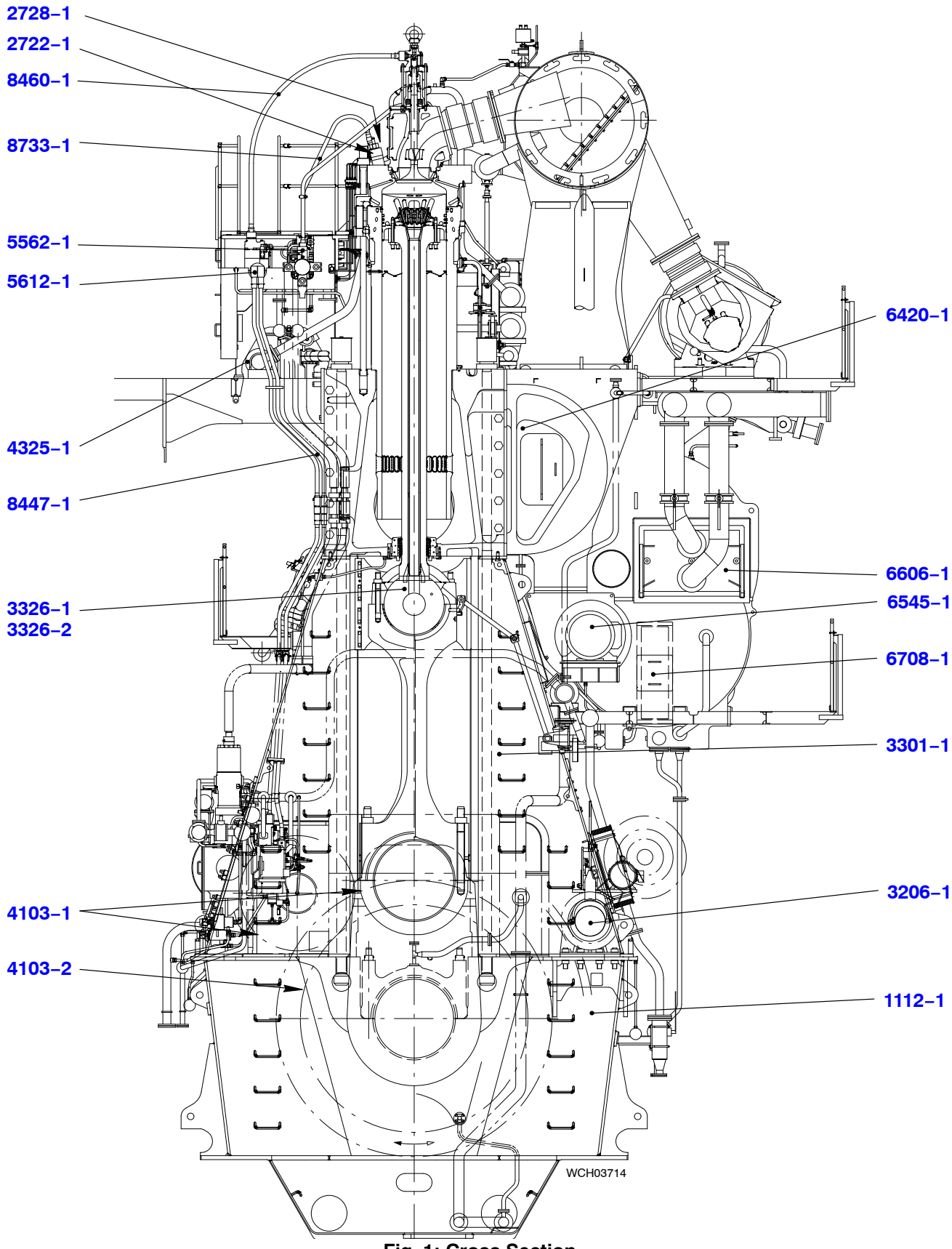


Fig. 1: Cross Section

2. Longitudinal section

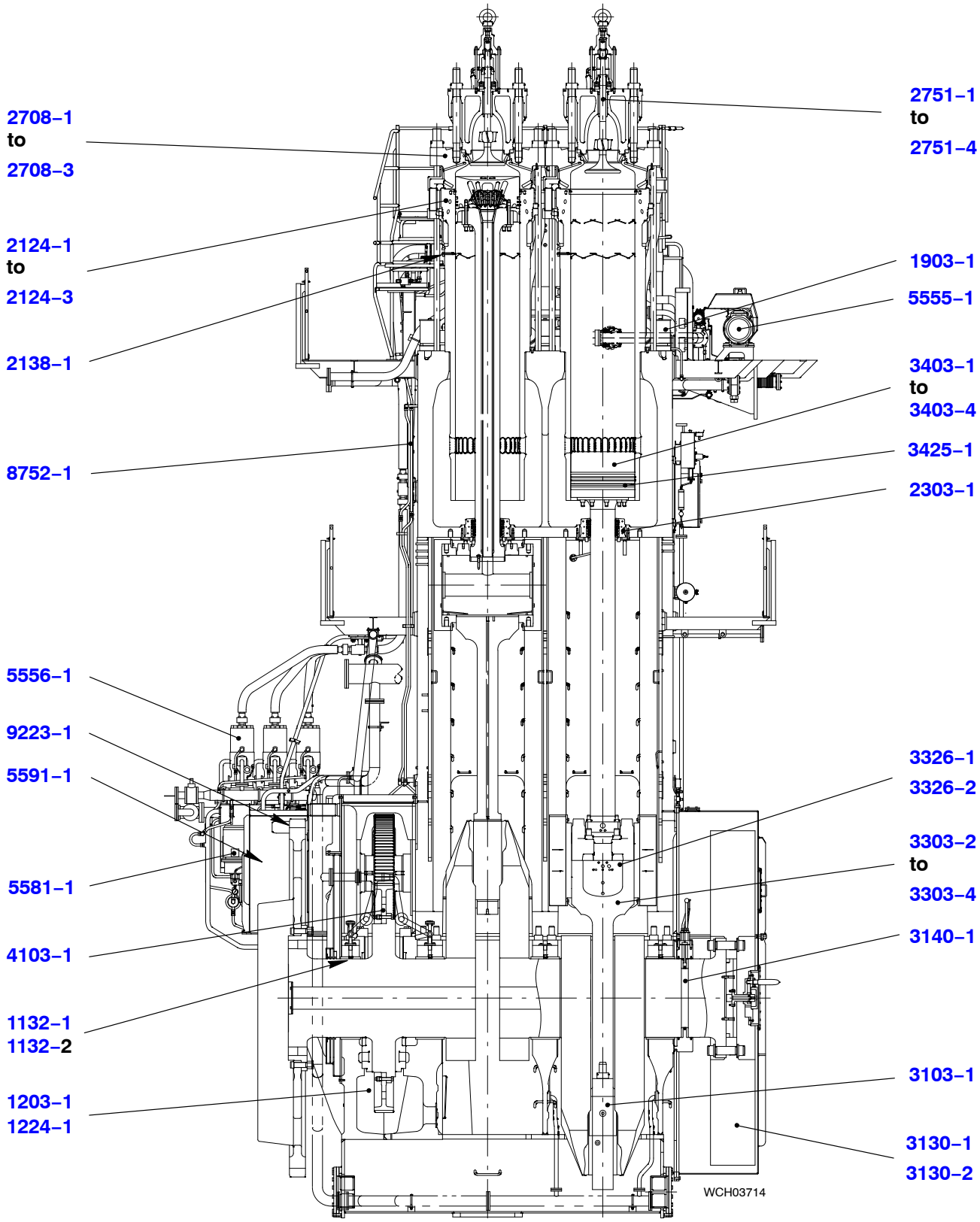


Fig. 2: Longitudinal Section

Bedplate and Tie Rod

Group 1

Intentionally blank

Work Card
Bedplate: Foundation Bolts – Pre-tension Checks

Necessary Conditions

– Engine stopped
– Starting air supply shut off
– Cooling water shut off
– Servo oil shut off
–
–

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

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

Primary Task

Foundation Bolts – Pre-tension Checks
refer to the Maintenance Manual 1112–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.5 hours	Qty 2

Related Data

Overhaul intervals	0380–1/A1

Related Procedures

Pre-tensioning jacks – connect	9403–2/A1
Pre-tensioning jacks – attach	9403–4/A1

Intentionally blank

Work Card
Crankcase: Visually Examine

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation)		
Visually examine the crankcase	Ship Engineer	2.5 hours	Qty 1

Related Data

Overhaul intervals	0380–1/A1

Related Procedures

Intentionally blank

Work Card

Bedplate: Rubber Gasket on the Sump Tank − Do a Check

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Rubber gasket	EX 97221	Qty 1

Preparation

Not applicable

Tools and Consumables

Not applicable

Primary Task

Do a check of the rubber gasket

Time and Personnel Necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Crew	0.5 hours	Qty 1

Related Data

Overhaul intervals 0380−1/A1

Related Procedures

Intentionally blank

Foundation Bolts – Checks

Tools:

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

1. General

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

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

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

1.1 Foundation Bolts – Loosen or Apply Tension

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

1) To loosen and apply tension to the foundation bolts (2), use the pre-tensioning jack (94145, Fig.1).
2) Connect the pre-tensioning jacks (94145) to the hydraulic pump (94931, Fig.3), refer to 9403–2.
3) Do the Version 1 procedure as given in 9403–4.
4) Apply tension in two steps as follows:
   a) Step 1 – For metal chocks or epoxy resin chocks, first apply tension to all foundation bolts to 1000 bar.
   b) Step 2 – Apply tension to 1500 bar.

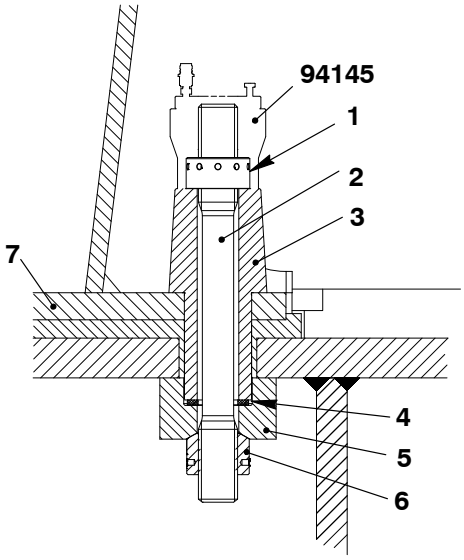


Fig. 1

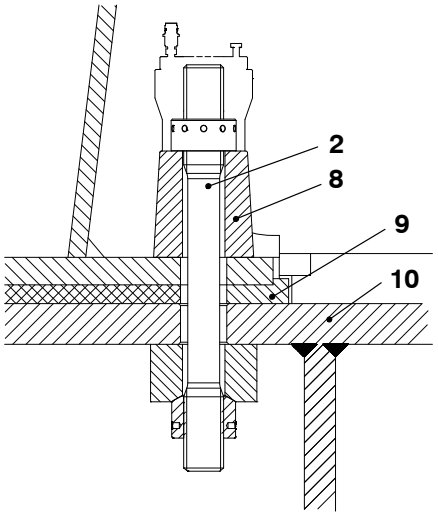


Fig. 2

WCH03620

2. Tension Check

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

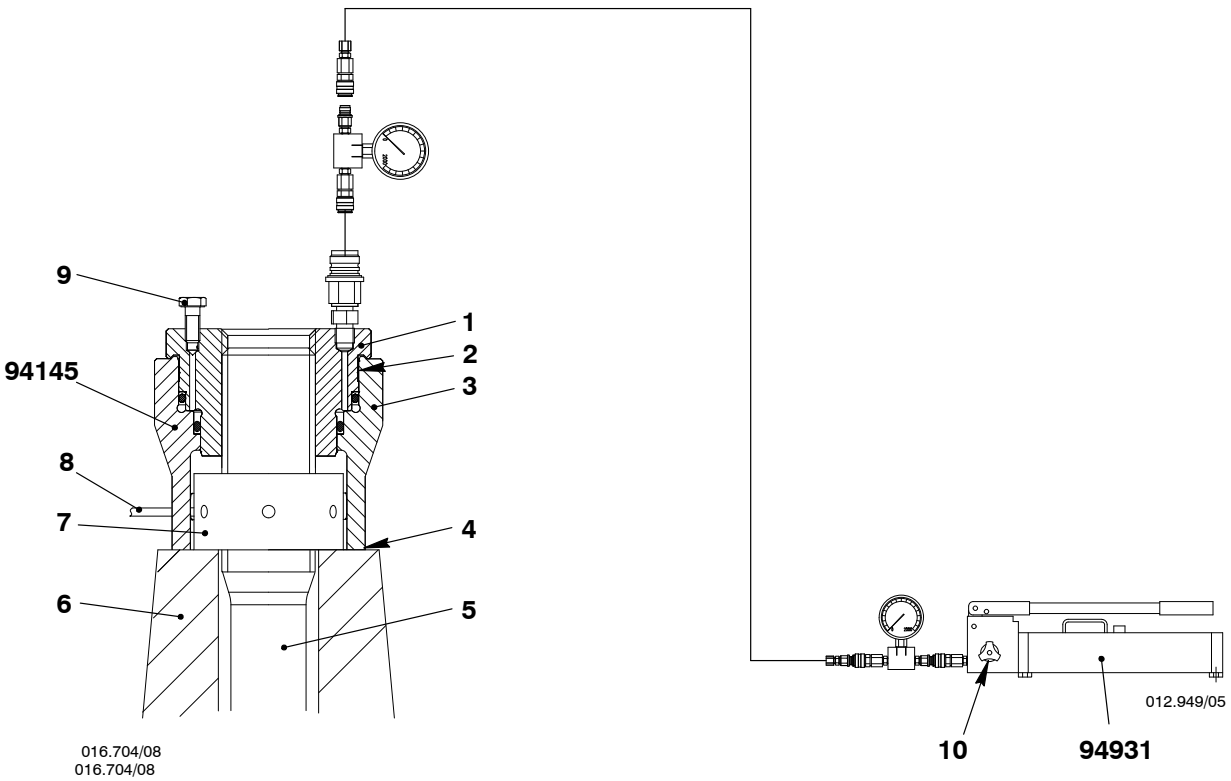


Fig. 3

Elastic Studs – Loosen and Apply Tension

Tools:

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

Note: Always use the hydraulic double pre-tensioning jacks (94114, Fig.1) to loosen and apply tension to:

- **The main bearing elastic studs (1)**
- **The 1st main bearing cover (2) that has two elastic studs (1).**

1) Connect only the jack that is in use to the hydraulic unit.

2) Do the general preparation for hydraulic jacks (94114), refer to 9403–4, paragraph 1.

3) Make sure that there is oil on the threads of the elastic studs (1).

4) To loosen, do the procedure in 9403–4, paragraph 2.2 and 2.3.

5) To apply tension, do the procedure in 9403–4, paragraph 3, 3.2 and 3.3.

Note: The value for the pre-tensioning jacks (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, Crankshaft and Main Bearing.

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

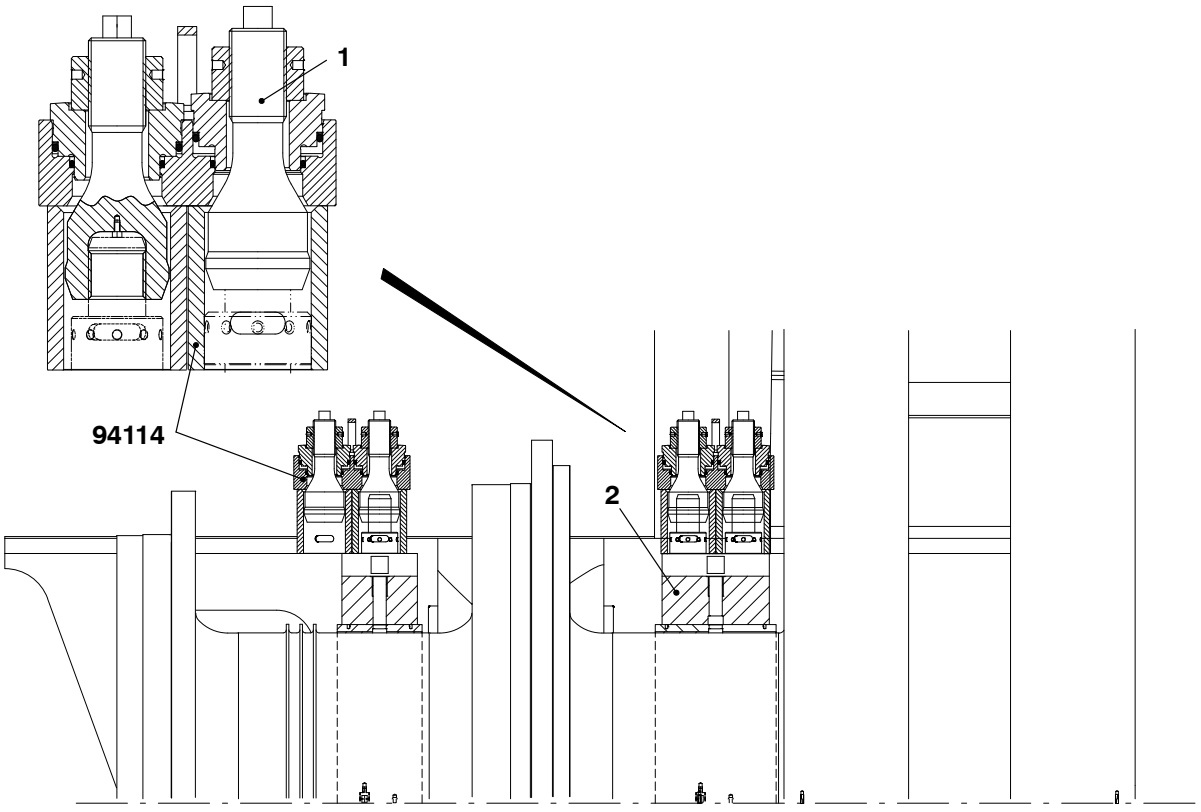


Fig. 1

Intentionally blank

Work Card

Main Bearing: Bearing Edge and Bearing Clearance

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

More time and personnel necessary for preparation.
Do a check of applicable work cards.

Tools and Consumables

Feeler gauge	94123	Qty 1

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do check of the bearing edge and bearing clearance	Service Engineer	3.0 hours	Qty 2

Related Data

Overhaul intervals	0380–1/A1
Tolerances and Clearances, refer to	0330–1/A1
Component weights, refer to	0360–1/A1

Related Procedures

Intentionally blank

Work Card
Main Bearing Shell: Removal and Installation

Necessary Conditions

- Engine stopped
- Crank turned to exhaust side approximately 90°
- Main oil supply: set to off
- Main bearing lubrication: set to off

Necessary Spare Parts

Main bearing shell	EX 11344	Qty 1
Main bearing shell	EX 11354	Qty 1

Preparation

More time and personnel necessary for preparation.
Do a check of applicable work cards.

Tools and Consumables

Manual ratchet	94016-009	Qty 1
Spur-geared chain block	94017-006	Qty 2
Chain (asymmetric / symmetric)	94019A/B	Qty 1
Bracket	94141	Qty 1
Eye bolt	94045-M48	Qty 1
Thrust device	94110	Qty 1
Lifting tool (narrow bearing shell)	94116A/B	Qty 1
Lifting plate	94119	Qty 1
Lifting lug	94116C	Qty 1
Roller support	94117	Qty 1
Turning-out device	94118A/B	Qty 1
HP oil pump	94931	Qty 1
Connection block	94934	Qty 1
Pressure gauge	94934A	Qty 2
HP hoses	94935	Qty 3
Hydraulic ram (100t)	94936	Qty 2
Shackle 4750 kg	94018B	Qty 2
Work platform	94143	Qty 1
Molykote paste G		

Primary Task

Removal and Installation of Main Bearing
refer to the Maintenance Manual 1132–2/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	8.0 hours	Qty 2
Crew	8.0 hours	Qty 1

Related Data

Overhaul intervals	0380–1/A1
Tolerances and Clearances, refer to	0330–1/A1
Component weights, refer to	0360–1/A1

Related Procedures

Remove / Install elastic studs, refer to	1132–1
Measure crank deflection, refer to	3103–1
Measure bearing clearance, refer to	0330–1

Intentionally blank

Main Bearing – Removal and Installation

Tools:

1	Manual ratchet (H1)	94016-009	1	Turning-out device (wide bearing shell)	94118B
2	Spur-geared chain block (H2, H3)	94017-006			
1	Chain (asymmetric)	94019A	1	Lifting plate	94119
1	Chain (symmetric)	94019B	1	Feeler gauge	94123
1	Eye bolt	94045-M48	1	Bracket	94141
1	Thrust device	94110	1	Work platform	94143
1	Lifting tool (narrow bearing shell)	94116A	1	HP oil pump	94931
1	Lifting tool (wide bearing shell)	94116B	1	Connection block	94934
1	Lifting lug	94116C	2	Pressure gauge	94934A
1	Roller support	94117	3	HP hoses	94935
1	Deviation pipe	94117B	2	Hydraulic ram (100t)	94936
1	Turning-out device (narrow bearing shell)	94118A	2	Shackle 4750 kg	94018B

1. Preparation

WARNING

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

WARNING

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

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

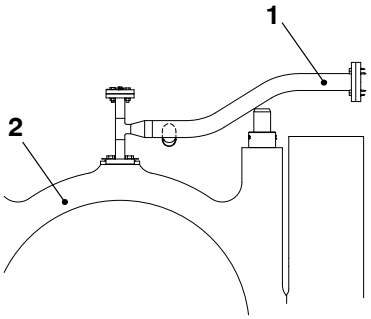


Fig. 1

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

2.1 Tools – Installation

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

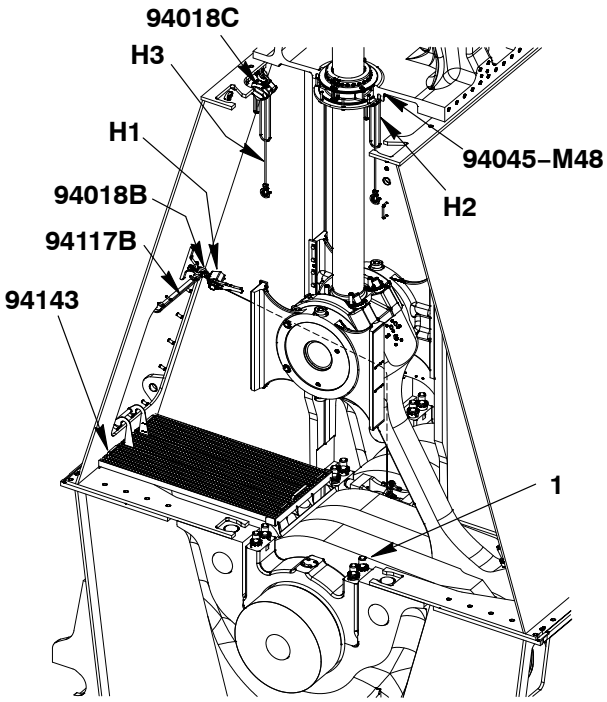


Fig. 2

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

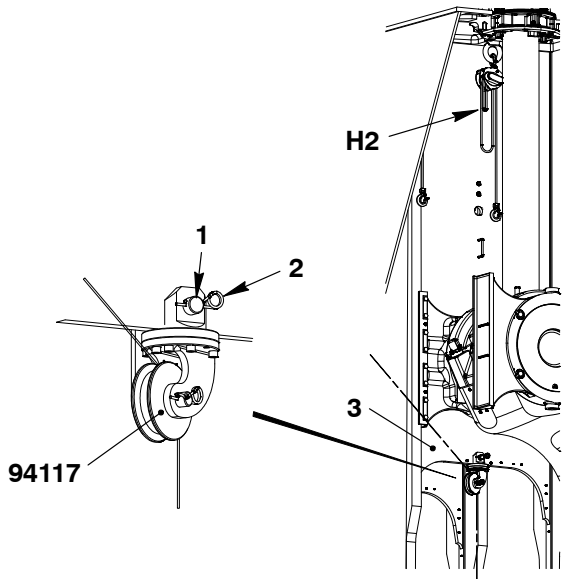


Fig. 3

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

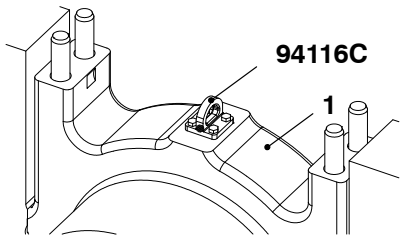


Fig. 4

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

WARNING

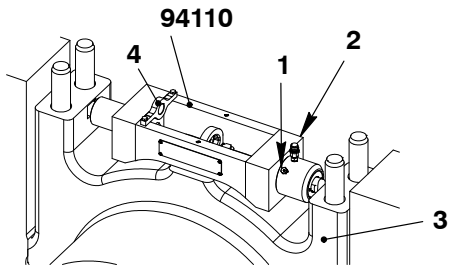
Injury Hazard: Do not use the thrust device 94110 as a lifting device. Injury to personnel can occur.

CAUTION

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

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

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



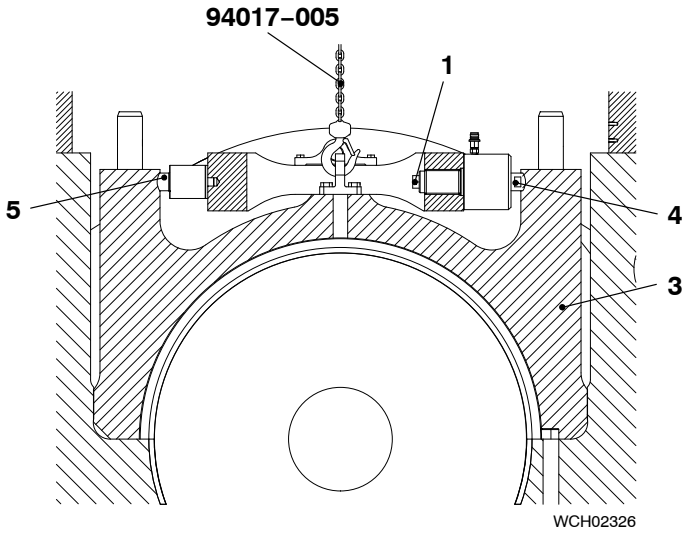


Fig. 5

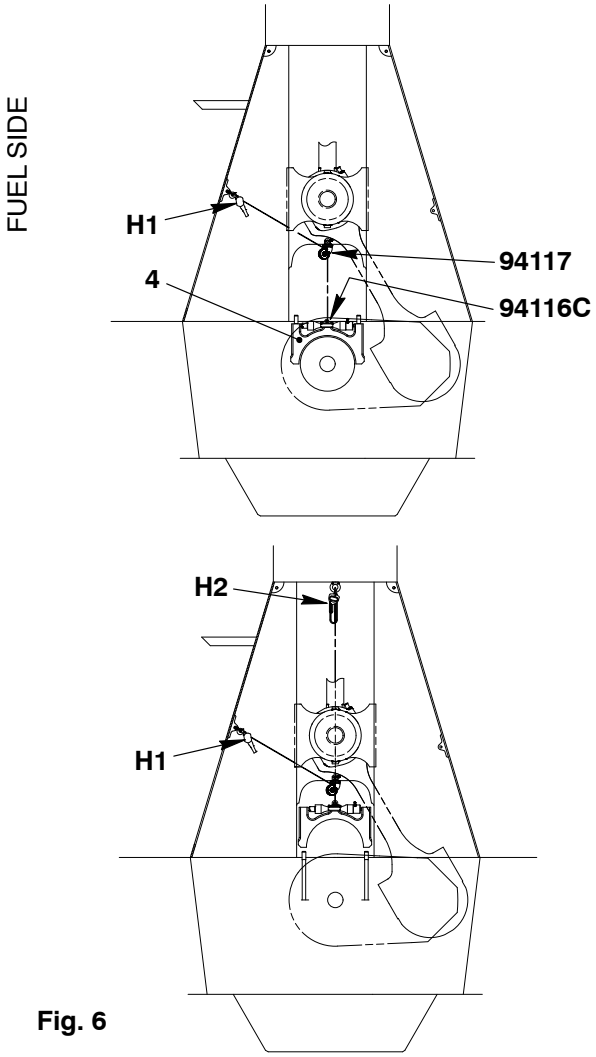


Fig. 6

2.2 Main Bearing Cover – Removal

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

CAUTION

Damage Hazard: Use the roller support 94117 only as shown with a maximum angle of the manual ratchet chain at 45° and a force of 12000 N.

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

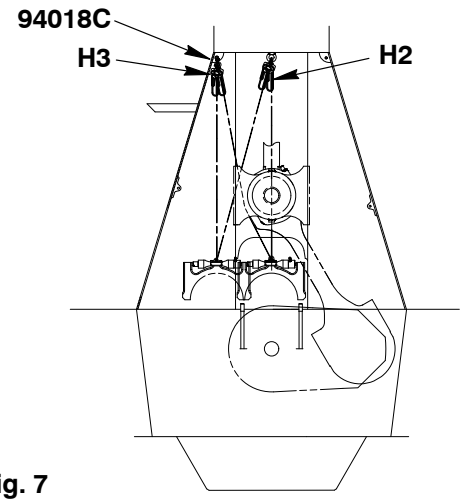


Fig. 7

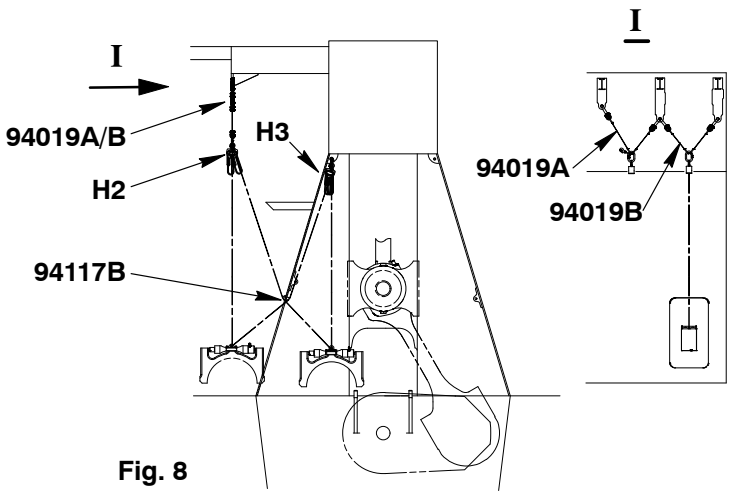


Fig. 8

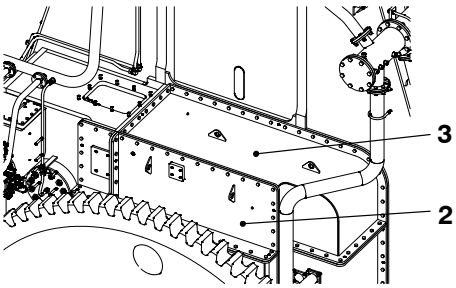


Fig. 9

3. Main Bearing Cover No. 1 – Removal

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

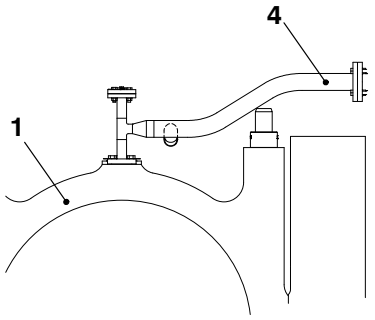


Fig. 10

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

3) Do a check of the bearing clearance for comparison, refer to 0330–1, Top and Bottom End Bearings.

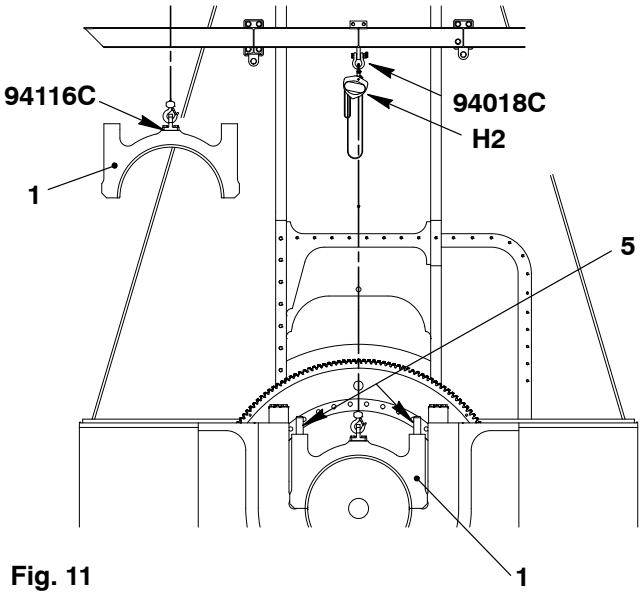


Fig. 11

4) Loosen the elastic studs (5, Fig. 11) and remove their nuts, refer to 1132–1.

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

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

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

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

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

10) Remove the chain block (H2).

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

4. Main Bearing Shell – Removal

4.1 Hydraulic Jacks – Installation

WARNING

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

CAUTION

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

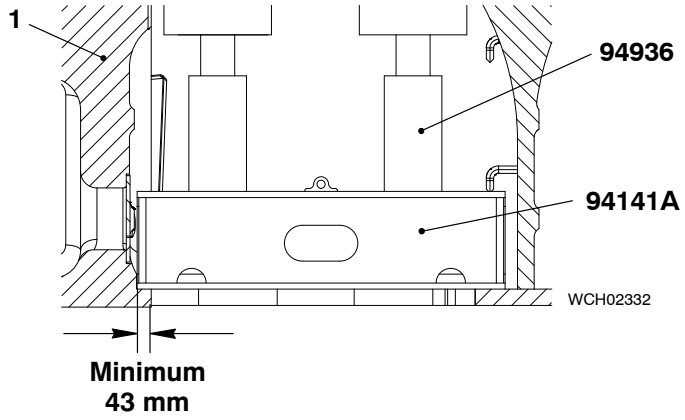


Fig. 12

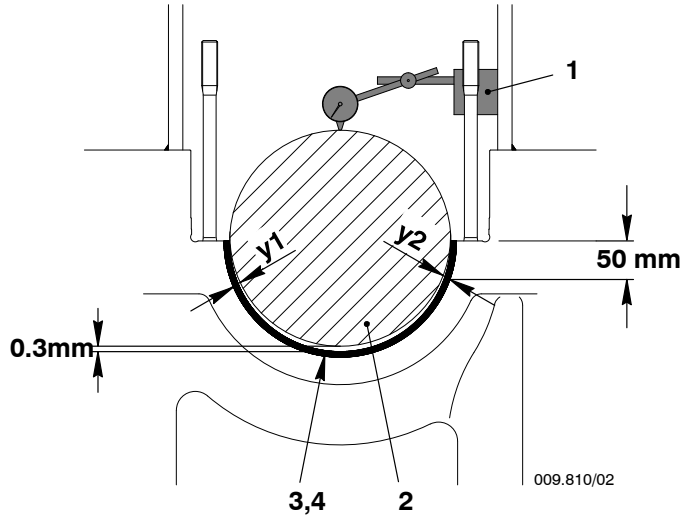


Fig. 13

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

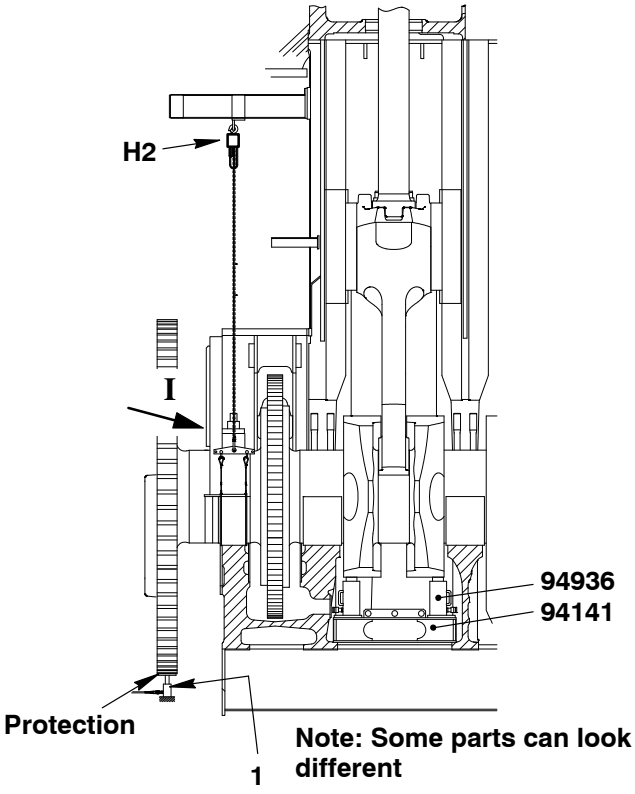
4.2 Crankshaft – Lift

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

9) If the value of the lateral bearing clearance is more than 0.1 mm, lower the crankshaft and do step a) to step b):

   a) Install the hydraulic rams (94936, Fig.13) in a position where the lateral bearing clearance is smaller.

   b) Operate the HP oil pump (94931). To lift the crankshaft (1) to 0.3 mm.



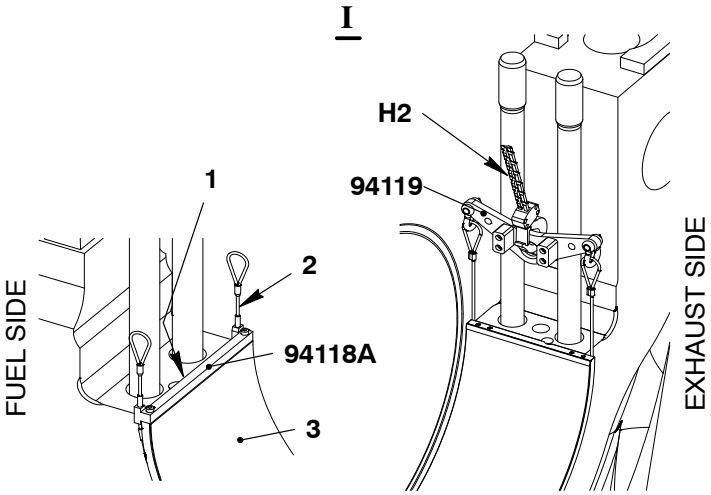


Fig. 14

4.3 Bearing Shell No.1 (narrow) – Removal

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.

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

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

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

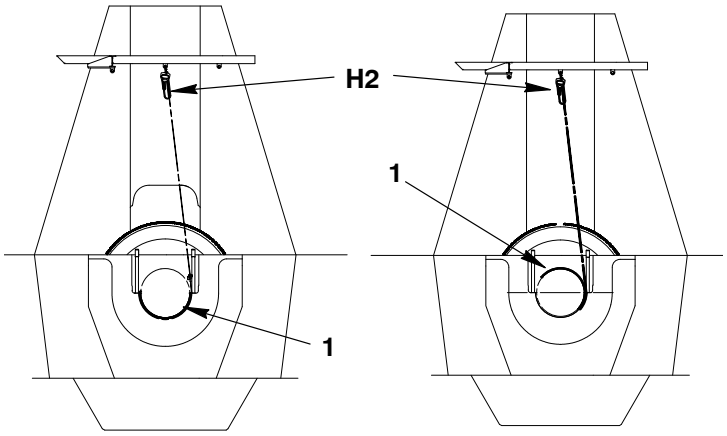


Fig. 15

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

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

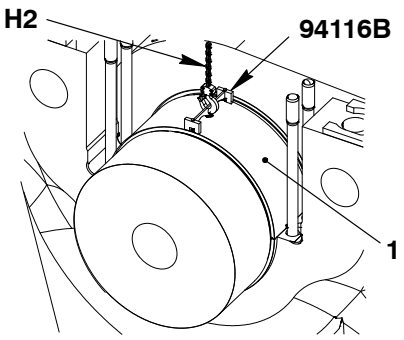


Fig. 16

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

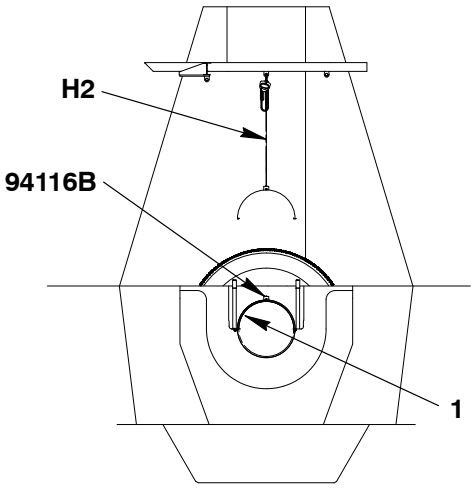


Fig. 17

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

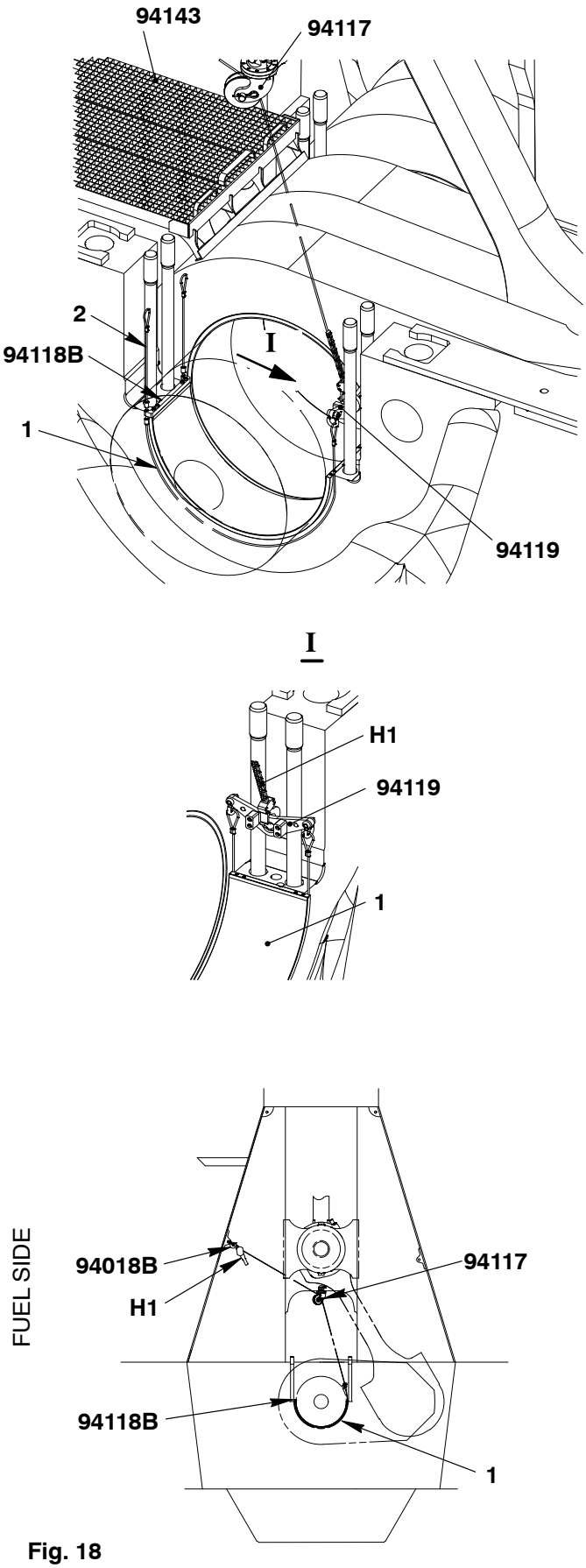


Fig. 18

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

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.

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

Note: The crank is at the exhaust side.

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

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

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

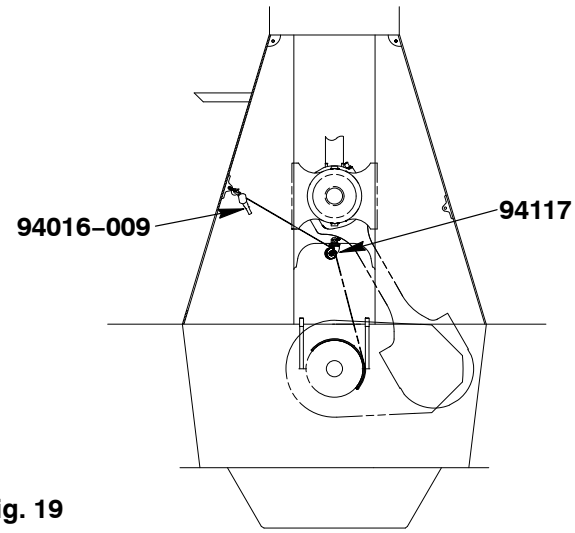


Fig. 19

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

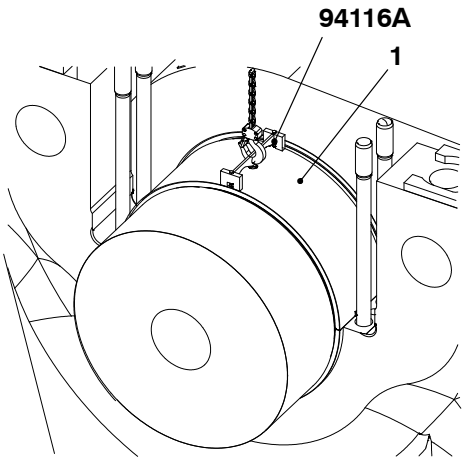


Fig. 20

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

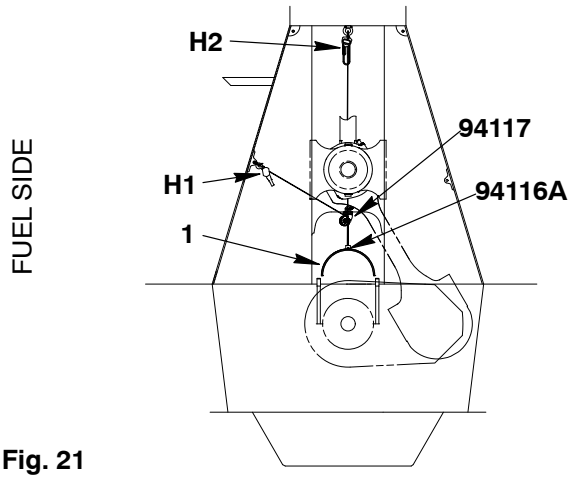


Fig. 21

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

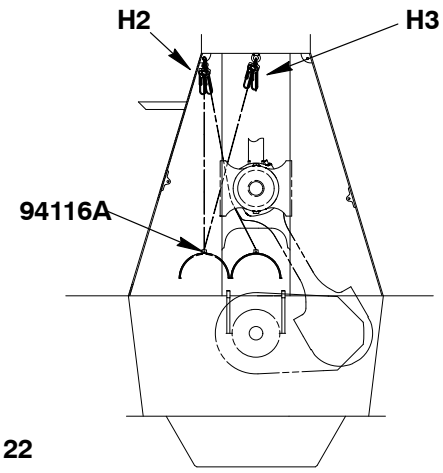


Fig. 22

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

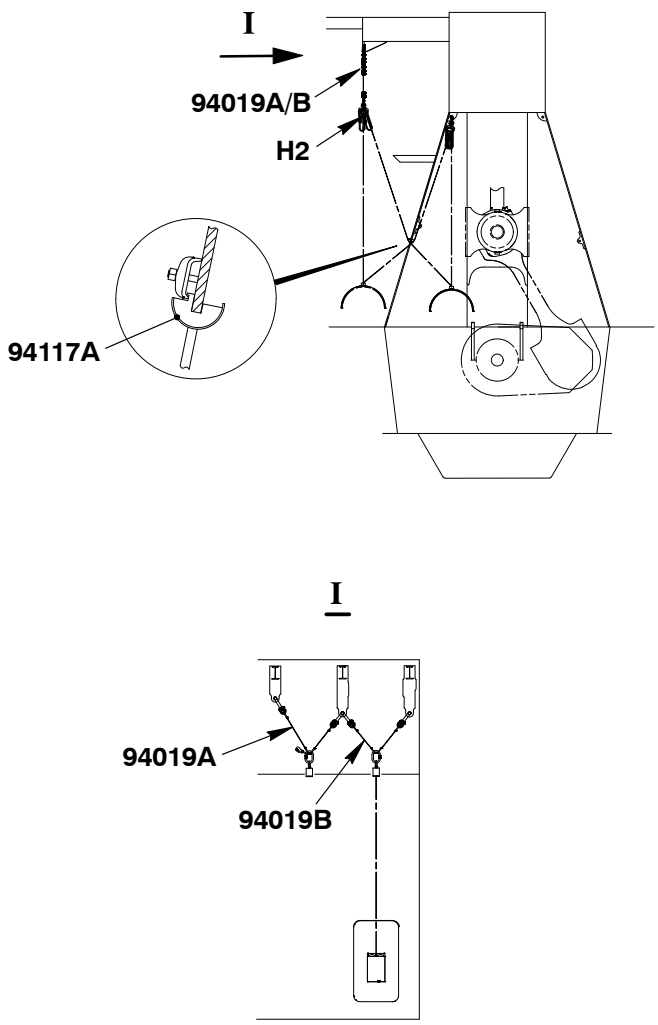


Fig. 23

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

5. Main Bearing Shell – Inspection

CAUTION

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

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

6. Main Bearing Shell and Bearing Cover – Installation

CAUTION

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

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

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

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

6.1 Bearing Shell – Installation

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

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

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

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

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

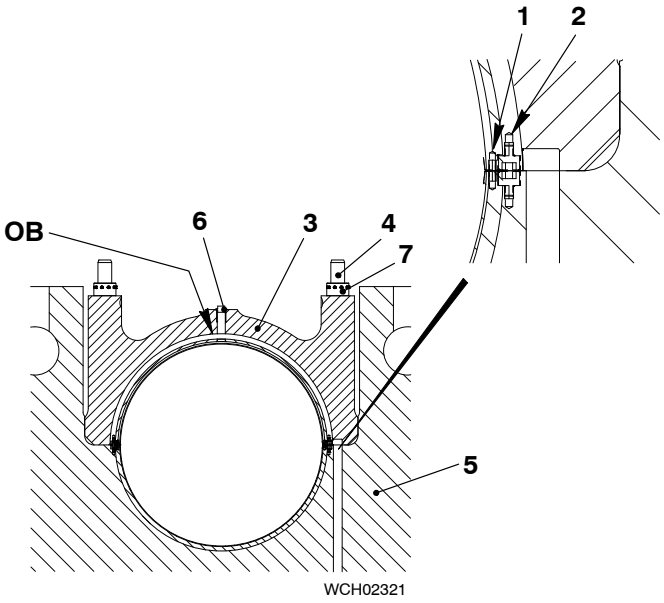


Fig. 24

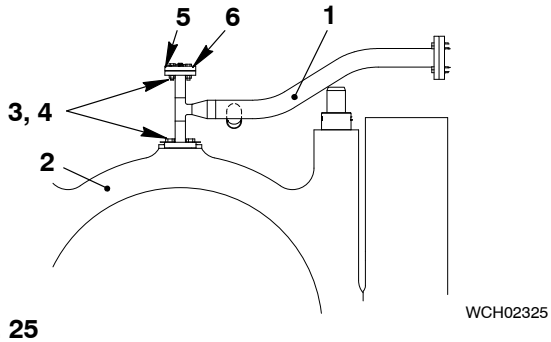


Fig. 25

6.2 Main Bearing Cover – Installation

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

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

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

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

14) After each installation of a new bearing shell, measure the crank deflection, refer to 3103–1.

15) Do a check of the oil supply to the main bearing.

7. Main Bearing – Lubrication

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

1) To fill the bearing shell with the lubricant do the procedure that follows:

   a) Remove the blank flange (6, Fig. 25).

   b) Remove the screw plug (5).

   c) Fill the bearing shell with the applicable lubricant.

   d) Attach the blank flange (6) with the screw plug (5).

Work Card
Thrust Bearing: Axial and Vertical Clearance

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

Inside micrometer	94101	Qty 1

Primary Task

Do a check of the axial and vertical clearances

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Overhaul intervals	0380–1/A1
Tolerances and Clearances, refer to	0330–1/A1

Related Procedures

Not applicable

Intentionally blank

Work Card
Thrust Bearing: Bottom Drain

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

Inside micrometer	94101	Qty 1

Primary Task

Do a check of the bottom drain

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.0 hours	Qty 1

Related Data

Overhaul intervals 0380−1/A1
Tolerances and Clearances, refer to 0330−1/A1

Related Procedures

Thrust Bearing − Axial Clearance Check
1203−1

Intentionally blank

Thrust Bearing – Axial Clearance Check

Tools:

1 Inside micrometer 94101

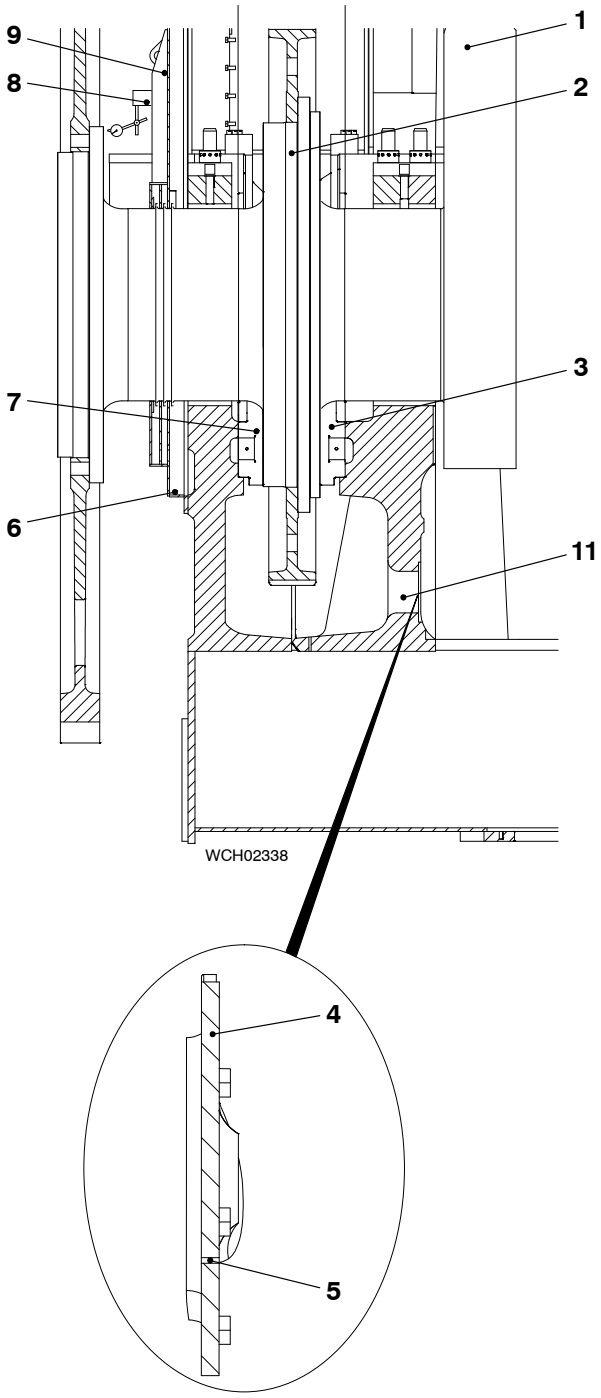


Fig. 1

1. Procedure One

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

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

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

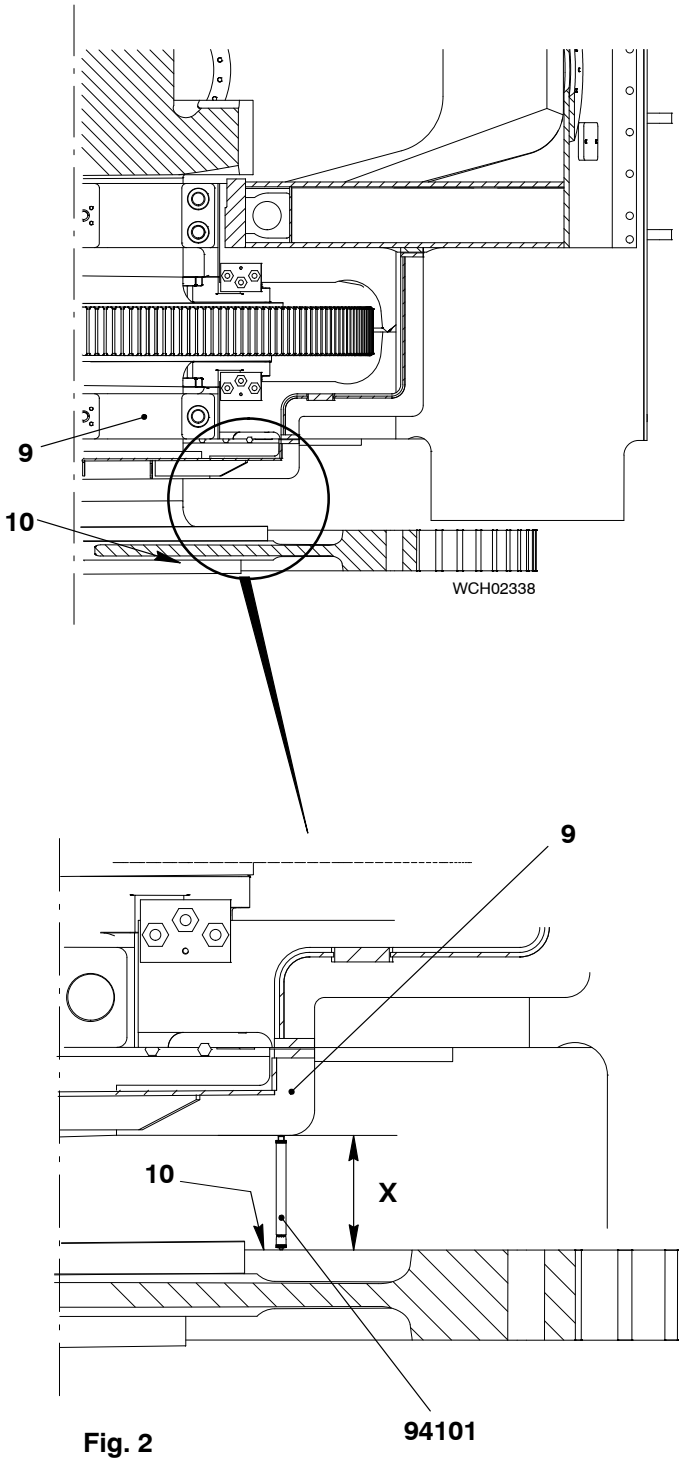


Fig. 2

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, Fig. 2) and the oil baffle (top part) (9).
5) Record the value.
6) Remove the micrometer (94101).
7) Compare the value with those given in the engine documents on the Check Dimensions page (refer also to 0330–1 Clearance Table, Crankshaft and Thrust Bearing).

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

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

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

Work Card
Thrust Bearing Pads: Replace

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Thrust pads	ES 12240	Qty 11
Thrust pads	ES 12241	Qty 1

Preparation

Not applicable

Tools and Consumables

Manual ratchet	94016-009	Qty 1
Spur-geared chain block	94017-006	Qty 2
Shackle	94018A	Qty 2
Eye bolt	94045-M12	Qty 1
Eye bolt	94045-M16	Qty 1
Carrier	94155	Qty 1
Link	94321	Qty 1
Lockwire		

Primary Task

Replace the thrust bearing pads

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	4.0 hours	Qty 2
Ship Engineer	4.0 hours	Qty 2

Related Data

Overhaul intervals	0380–1/A1
Tolerances and Clearances, refer to	0330–1/A1

Related Procedures

Thrust Bearing Pads – Removal and Installation, refer to the Maintenance Manual 1224–1/A1
Thrust Bearing – Axial Clearance Check 1203–1

Intentionally blank

Thrust Bearing Pads – Removal and Installation

Tools:

1	Manual ratchet	94016-009 (H3)	1	Eye bolt	94045-M16
2	Spur-geared chain block	94017-006 (H1, H2)	1	Carrier	94155
2	Shackle	94018A	1	Link	94321
1	Eye bolt	94045-M12			

1. Preparation

1) Read the data in 0012–1 General Guidelines for Lifting Tools.
2) Remove the cover (2, Fig. 1).
3) Attach the shackles (94018A) and chain blocks (H1, H2) to the gallery.
4) Record the positions of the thrust bearing pads (thrust pads).

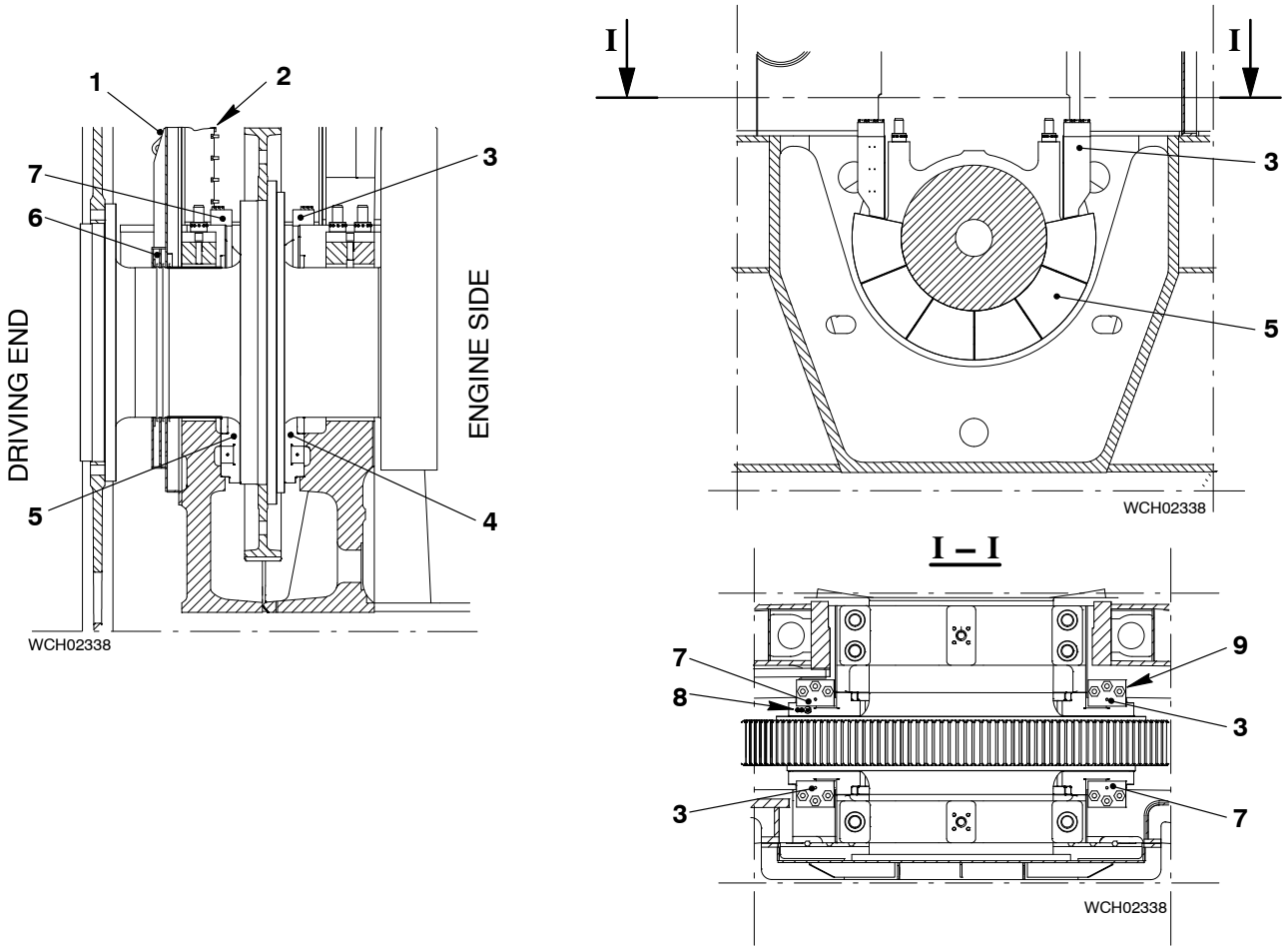
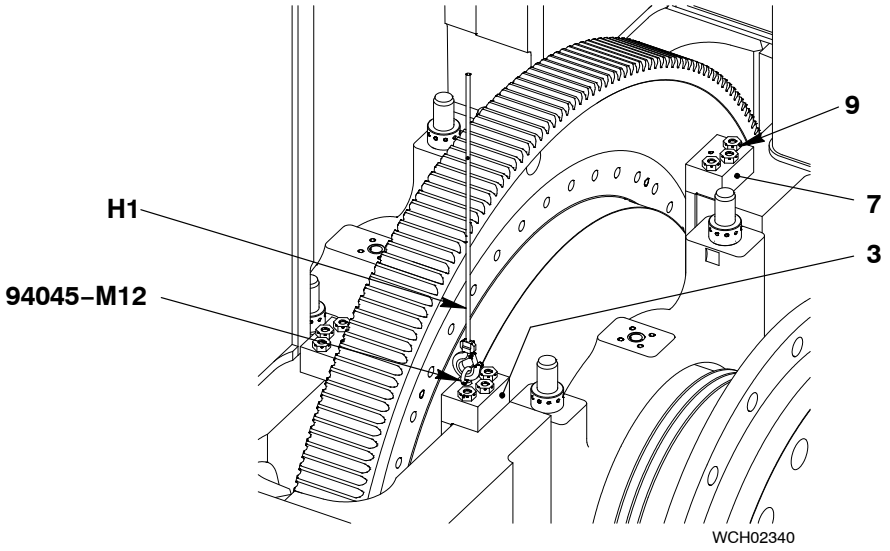


Fig. 1

2. Removal

1) Remove and discard the lockwire from the three bolts (9, Fig. 2) on the arbor supports (3, 7) of the applicable thrust pads (5).
2) Remove the bolts (9) from the arbor support (3 or 7) of the applicable thrust pads.
3) Attach the eye bolt (94045-M12) to the arbor support (3 or 7).
4) Attach the the shackle (94018A) and chain blocks (H1, H2) to the gallery (16).
5) Remove the applicable arbor support (3 or 7).
6) Attach the chain blocks (H1, H2) to the lifting plate (94321).
7) Attach the link (94321) to the chain blocks (H1, H2).



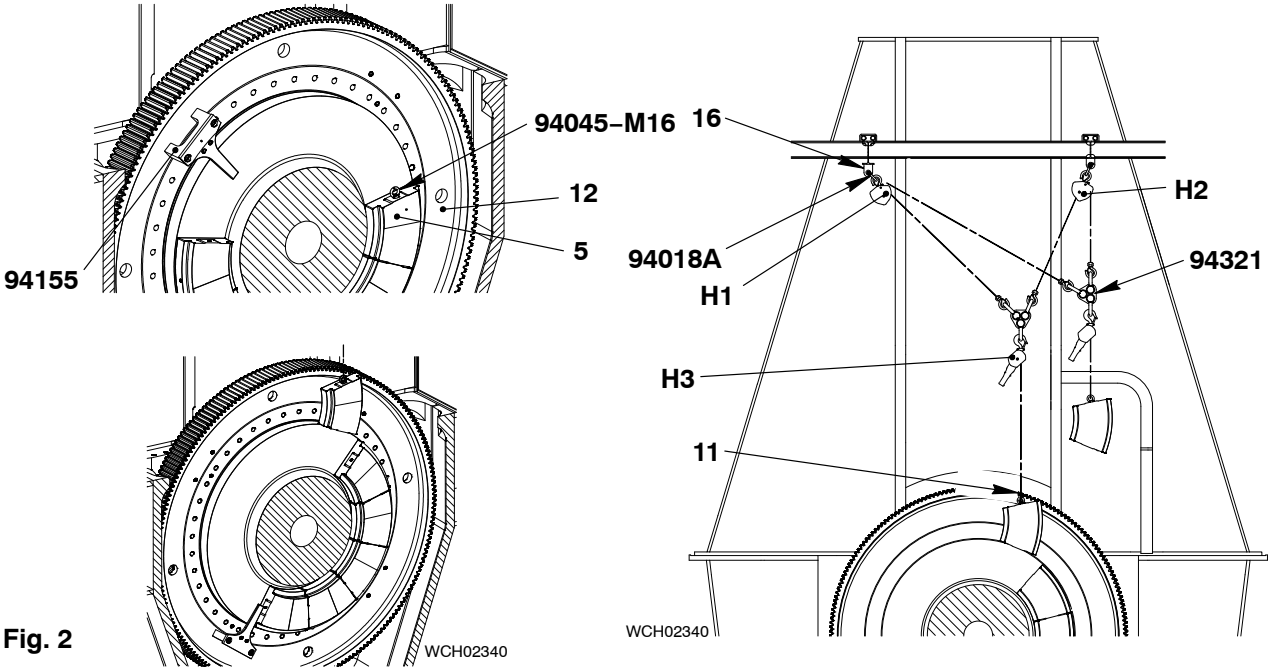


Fig. 2

8) Install the carrier (94155) on the gear wheel (12) as shown.
9) Remove the temperature sensors (8, Fig. 1)
10) Attach the eye bolt (94045–M12) to the thrust pad (5, Fig. 2).

WARNING

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

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

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

12) Keep a light tension on the chain blocks (H1, H2) while the thrust pad moves up.
13) Remove the thrust pad (1).
14) Move the thrust pad (1) to the exhaust side.
15) Lower the thrust pad on to a stable area.
16) Do step 10) to step 15) above for the remaining thrust pads that you must remove.

Note: If some of the thrust pads are removed, the remaining thrust pads will keep the crankshaft in position. If all thrust pads from the same side are removed, e.g. all the astern pads, the crankshaft can move.

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

3. Installation

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

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

3) Attach the eye bolt (94045–M12) to the thrust pad (5).
4) Attach the manual ratchet (H3) to the eye bolt (94045–M12).
5) Operate the manual ratchet (H3) to lift the thrust pad (5).
6) Move the thrust pad into position above the gear wheel.
7) Lower the thrust pad. Make sure that the thrust pad touches the carrier (94155).

WARNING

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

8) Operate the turning gear to turn the crankshaft in the applicable direction.
9) Put the subsequent thrust bearing pad in position.
10) Do the step 3) to step 9) for each thrust bearing pad.
11) When all thrust pads are in position, make sure that the top, outer thrust pads are at equal height.
12) Remove the carrier (94155).
13) Install the arbor supports (3, 7) as follows:
    a) Attach the eye bolt (94045-M16) to the applicable arbor support.
    b) Attach the chain block (H1) to the eye bolt (94045-M16).
    c) Lift the arbor support (3) lower it into position.

14) Remove the chain block and eye bolt.

15) Install the three bolts (9, Fig. Fig. 2) to the arbor support (3).

16) Lock the bolts (9, Fig. 3) with lockwire as shown.

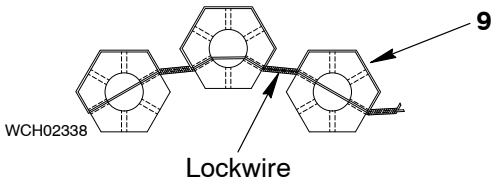


Fig. 3

17) Install the temperature sensors (8, Fig. 1).

18) Do a check of the clearances between the arbor supports and the thrust pads (refer to 0330–1, Crankshaft and Thrust Bearing).

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

When you replace a full set of thrust pads (or a full set of thrust pads that have new metal), you must adjust the clearances to the original values (refer to 0330–1, Crankshaft and Thrust Bearing and 1203–1 Axial Clearance Check).

19) For the configuration of the thrust pads, refer to Fig. 4.

CONFIGURATION OF THRUST PADS WITH FIXED PITCH PROPELLER

ENGINES WITH CLOCKWISE ROTATION

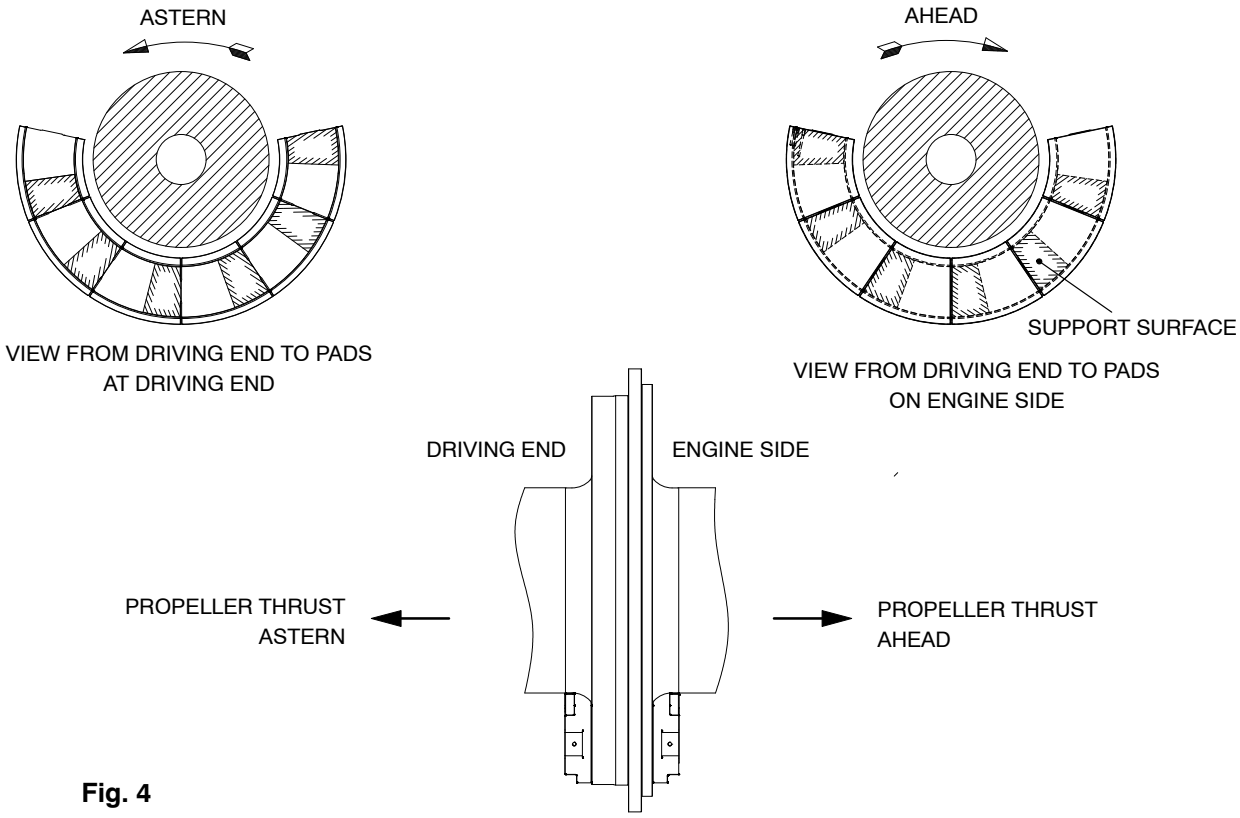


Fig. 4

4. Completion

1) Install the cover (2, Fig. 1).
2) Remove all tools and equipment from the work area.

Intentionally blank

Work Card
Engine Stays (Friction Type)

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Preparation

Not applicable

Tools and Consumables

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

Primary Task

Do the pre-tension checks on the engine stays

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Overhaul intervals 0380–1/A1
Tolerances and Clearances, refer to 0330–1/A1

Related Procedures

Pre-tension Jack – Attach 9403–2
Pre-tension Jack – General Instructions 9403–4

Intentionally blank

Work Card
Engine Stays (Hydraulic Type)

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

Nitrogen (N2)

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do the pre-tensionn checks on the engine stays	Ship Engineer	0.5 hours	Qty 1

Related Data

Overhaul intervals 0380–1/A1
Tolerances and Clearances, refer to 0330–1/A1

Related Procedures

Manufacturer’s documentation

Intentionally blank

Pre-tension Checks

Tools:

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

1. General

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

- 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 pre-tension check of the bolts (2) at the specified intervals (refer to 0380–1, Engine stays with friction shims.

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

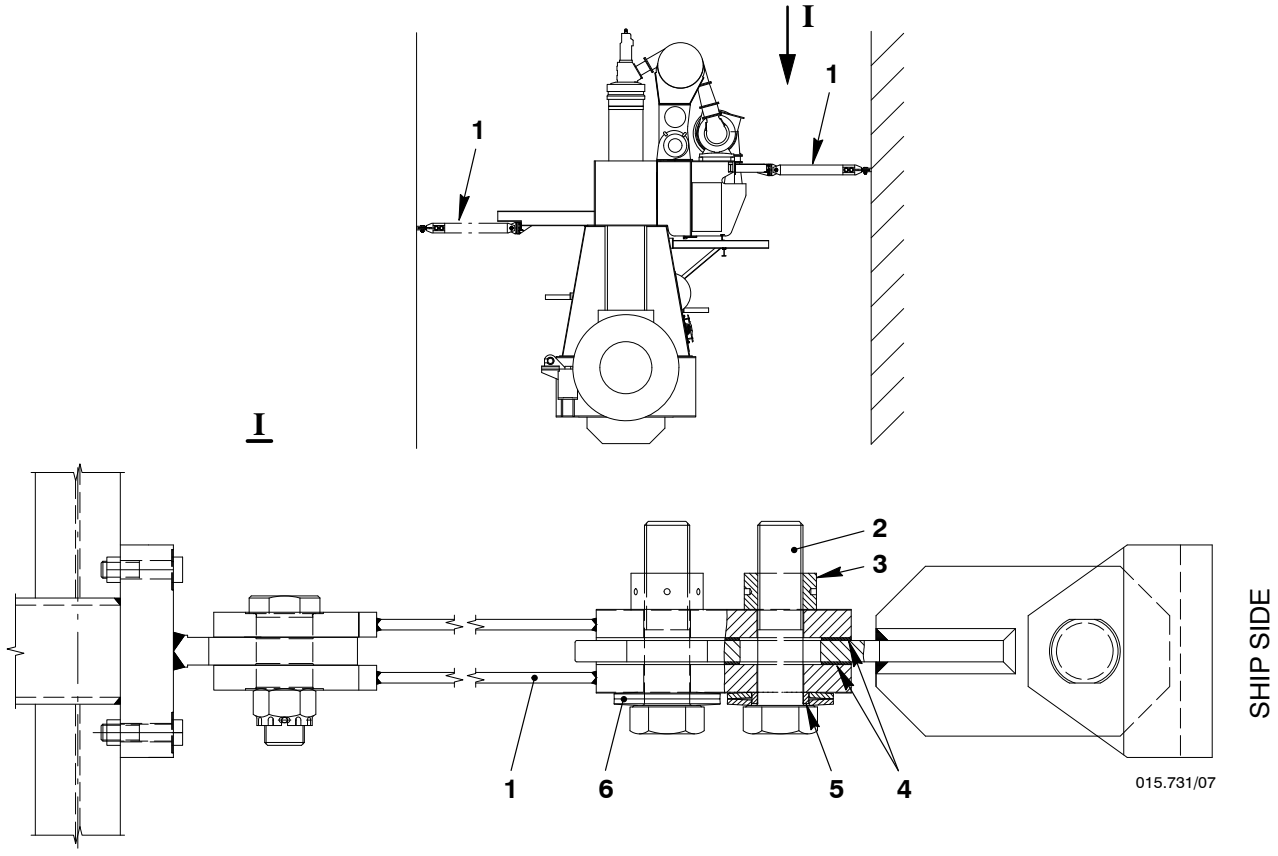


Fig. 1

2. Pre-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-tensioning jack 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 steps a) and 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 steps a) to 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.

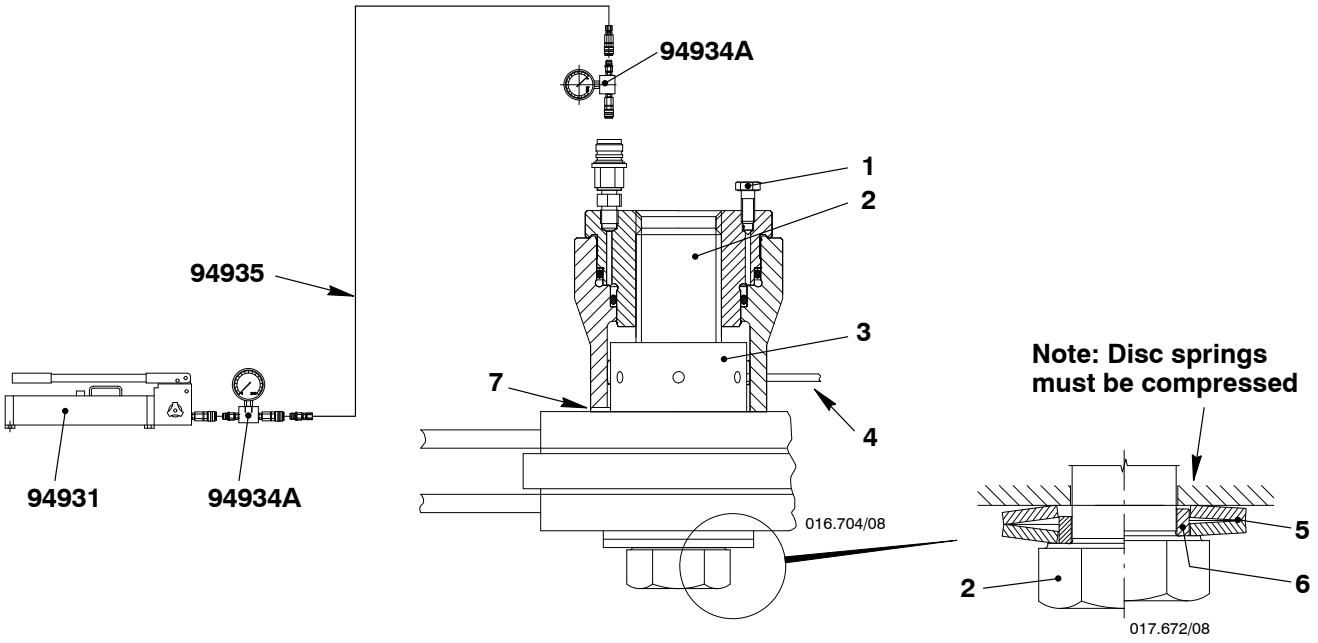


Fig. 2

Oil Pressure Checks

1. General

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

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

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

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

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

2. Procedure

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

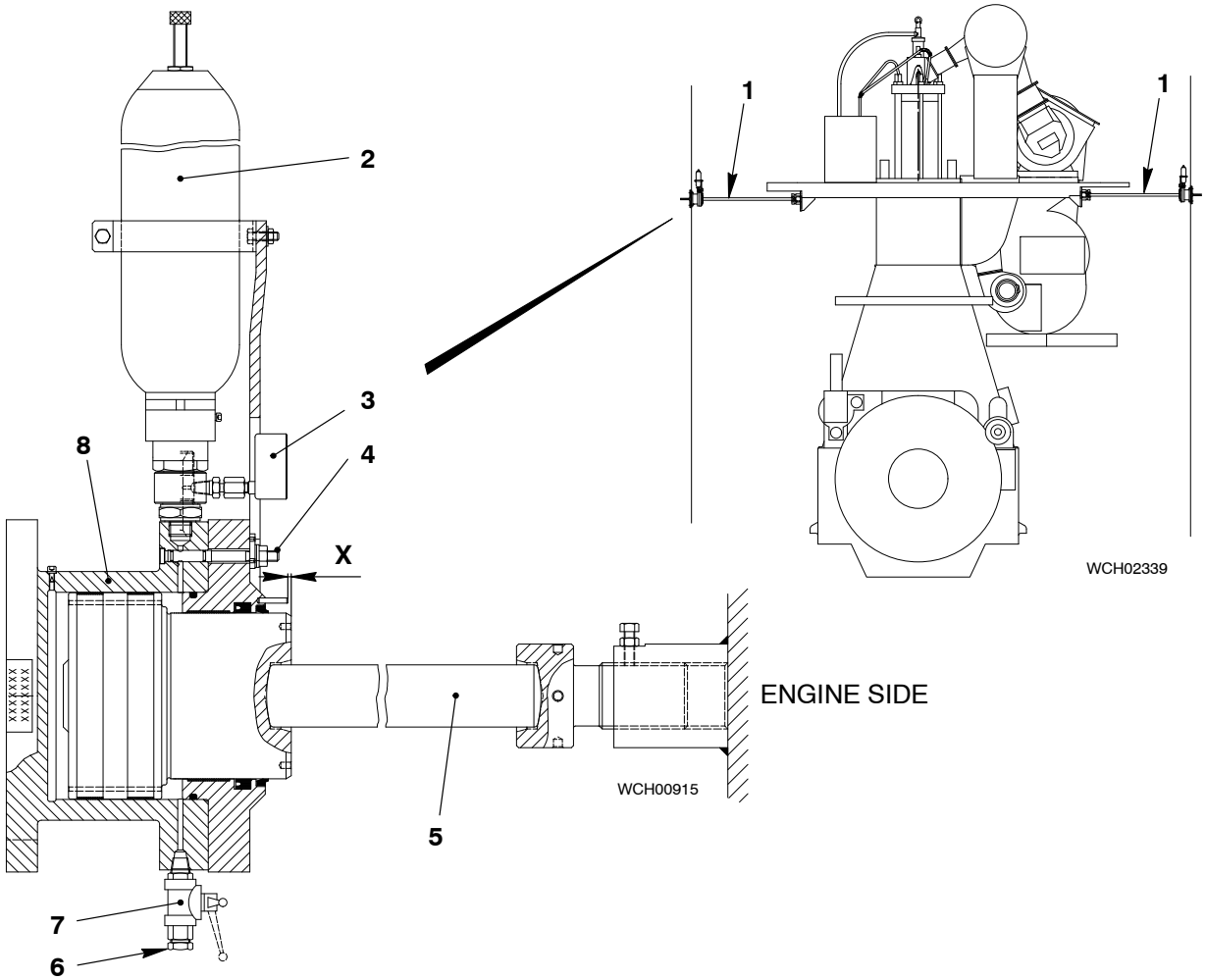


Fig. 1

Fig. 1 Key

1 Hydraulic engine stays
2 Accumulator body (internal bladder)
3 Pressure gauge
4 Damping control valve
5 Rod
6 Plug ⅜ inch NPT
7 Ball valve
8 Hydraulic cylinder

Work Card
Tie Rods

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Not applicable

Tools and Consumables

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

Molykote paste G

Primary Task

Do the pre-tension checks on the tie rods

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.5 hours	Qty 2
Ship Engineer	1.5 hours	Qty 1

Related Data

Overhaul intervals	0380–1/A1
Hydraulic Pre-tensioning Jacks	9403–4/A1

Related Procedures

Intentionally blank

Pre-tension Checks and Tie Rod Replacement

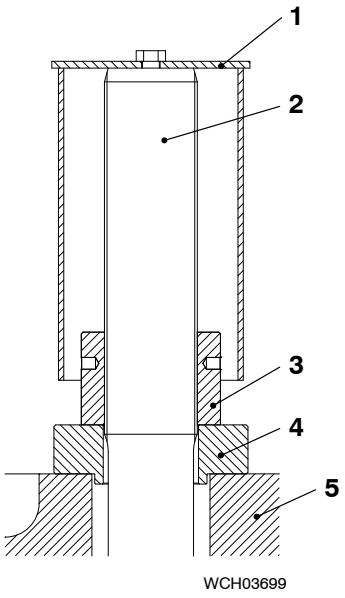
Tools:

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

1. General

We recommend that you do a check of the tension of all the tie rods one year after commissioning. If necessary, apply tension to the tie rods to the specified value. Do the pre-tension checks at the intervals given in 0380–1 Maintenance Schedule, Group 1903–1.

2. Pre-tension Check



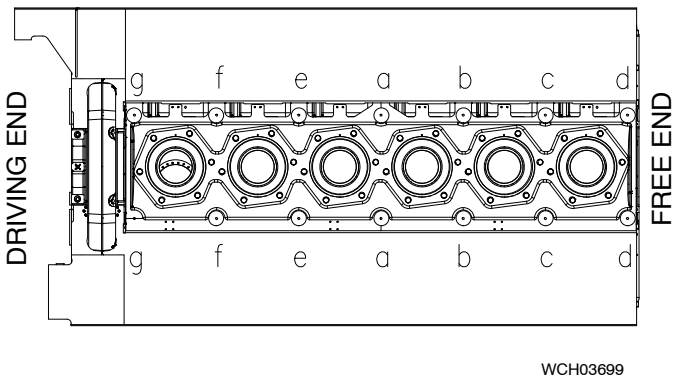


Fig. 1

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

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

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

3. Tie Rods – Replacement

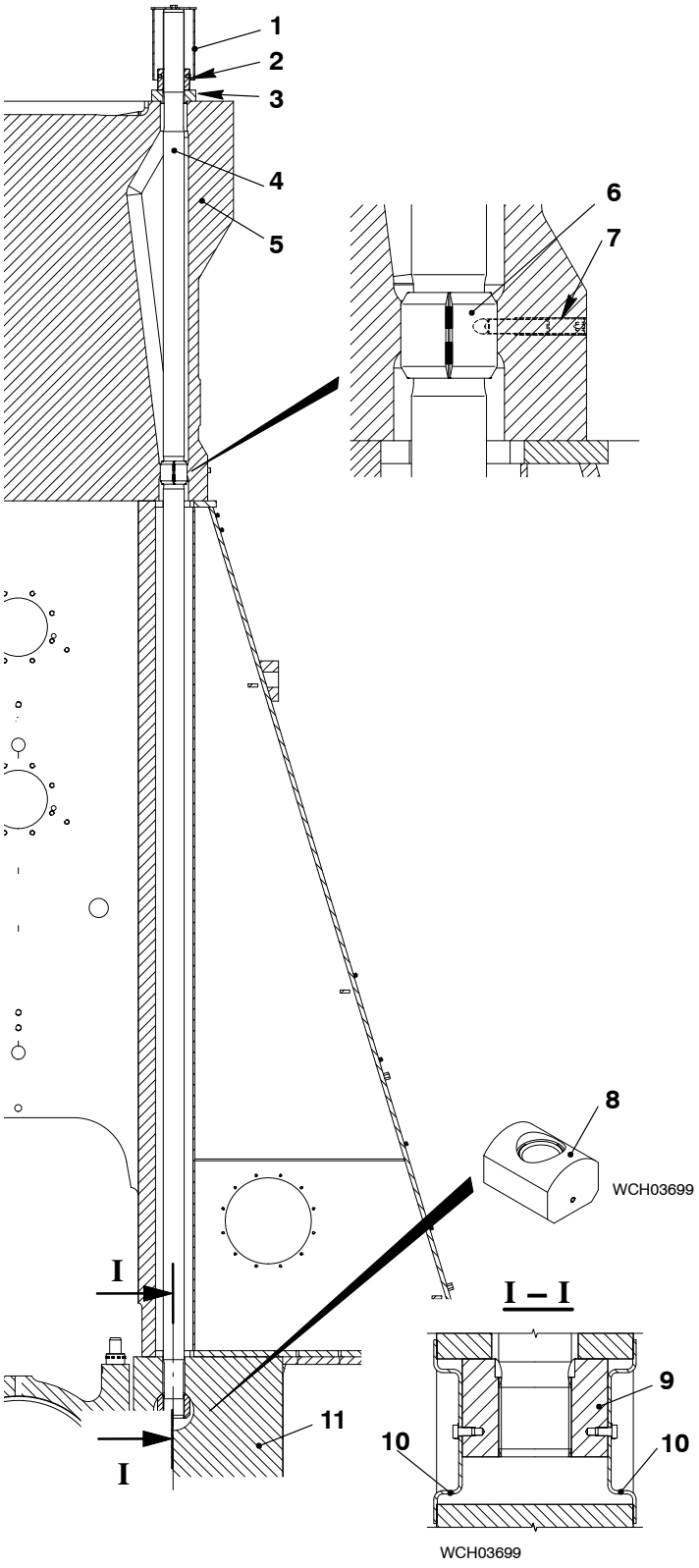


Fig. 2

3.1 Preparation

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

3.2 Removal

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

CAUTION

Injury Hazard: The weight of the tie rod is approximately 550 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 (11).

3.3 Install

1) Remove the two holders (10).
2) Make sure the nut (8) is correctly attached.
3) Apply Molykote G paste to the bottom thread of the tie rod (4).
4) Attach the eye bolt (M20) to the tie rod (4).
5) Attach the hook of the engine room crane to the eye bolt (M20).
6) Make sure that the bush (6) is installed.
7) Lower the tie rod (4) into the cylinder jacket (11).
8) Turn the tie rod (4) until the bottom is flush with the nut (9).
9) Clean the top surfaces of the cylinder block (5).
10) Install intermediate ring (3).
11) Apply Molykote paste G to the top thread of the tie rod and the top surface of intermediate ring (3).
12) Attach the round nut (2) to the tie rod (4).
13) Lift the tie rod (4), then fully tighten the round nut (2).
14) Make sure that the nut (8) is fully up, then install the holders (10).

Note: The tie rod at the first cylinder (driving end) has only one holder (10).

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

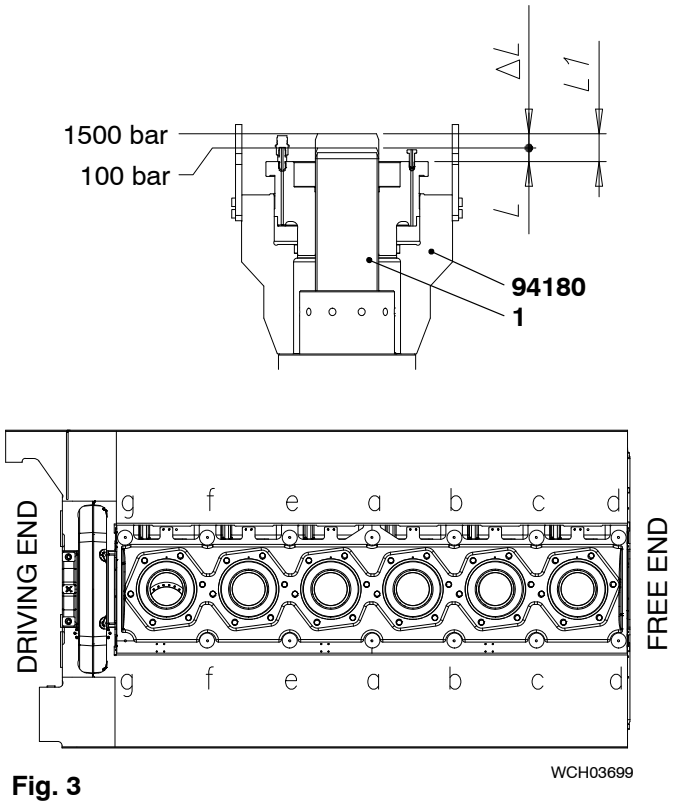


Fig. 3

3.4 Tensioning

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

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

Note: The extension ΔL of the tie rod (1) must be 14 mm to 16 mm (L1 – L).

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

Intentionally blank

Cylinder Liner, Cylinder Cover and Fuel Injection Group 2

Cylinder Liner, Cylinder Cover and Fuel Injection — Group 2

Work Card
Cylinder Liner: Measure the Bore

Necessary Conditions

– Engine stopped
– Starting air supply shut off
– Cooling water shut off
– Servo oil shut off
– Fuel shut off
– Cooling water drained

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the cylinder cover, refer to 2708–1/A1

Tools and Consumables

Inside micrometer	94101	Qty 1
Ladder	94224	Qty 1
Gauge	94225	Qty 1
Safety harness		

Primary Task

Measure the bore in the cylinder liner

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1
Crew	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1

Related Procedures

Cylinder liner removal
WC2124–1.1/A1

Intentionally blank

Work Card
Cylinder Liner – Removal and Installation

Necessary Conditions

– Engine stopped
– Starting air supply shut off
– Cooling water supply shut off
– Servo oil shut off
– Fuel supply shut off
– Gas line purged with inert gas
– Lube oil supply stopped
– Cooling water drained

Necessary Spare Parts (each cylinder)

Cylinder liner	EX 21240	Qty 1
O-ring: gas distributor pipe	EX 89091	Qty 2
O-ring: water pipe connection	EX 21310	Qty 1
O-ring: bottom water guide jacket	EX 21251	Qty 1
O-ring: bottom water guide jacket	EX 21252	Qty 1
O-ring: for gas nozzle	EX 21256	Qty 2
O-ring: gas admission valve	EX 21435	Qty 2
O-ring: gas admission valve	EX 21434	Qty 2

Preparation

More spare parts, time and personnel necessary for preparation. Do a check of applicable work cards.

Cylinder Cover Removal, refer to	WC2708/A1
Piston Removal, refer to	WC3403/A1

Tools and Consumables

Manual ratchets	94016-009	Qty 1
Manual ratchets	94016-031	Qty 2
Lifting tool	94210	Qty 1
Sling	94202K	Qty 1
Lifting tool	94215	Qty 1
Assembly tool	94345E	Qty 1

Oil
Never Seez High Temperature
Stainless

Primary Task

Cylinder Liner – Removal and Installation
refer to the Maintenance Manual 2124–2/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Superintendent	7 hrs	Qty 1
Service Engineer	7 hrs	Qty 2

Related Data

Tolerances and Clearances, refer to	0330–1/A1
Overhaul intervals, refer to	0380–1/A1
Component weights, refer to	0360–1/A1

Related Procedures

Cylinder Liner – Measure the Bore	2124–1/A1
Gas Admission Valve – Disassemble	2140–1/A1

Intentionally blank

Work Card
Antipolishing Ring

Necessary Conditions

– Engine stopped
– Starting air supply shut off
– Cooling water supply shut off
– Servo oil shut off
– Fuel supply shut off
– Gas line purged with inert gas
– Lube oil supply stopped
– Cooling water drained

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

More spare parts, time and personnel necessary for preparation. Do a check of applicable work cards.

Cylinder Cover Removal, refer to	WC2708/A1
Piston Removal, refer to	WC3403/A1

Tools and Consumables

Not applicable

Primary Task

Do a check of the antipolishing ring

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	0.5 hrs	Qty 1

Related Data

Tolerances and Clearances, refer to	0330–1/A1
Overhaul intervals, refer to	0380–1/A1
Component weights, refer to	0360–1/A1

Related Procedures

Cylinder Liner – Measure the Bore	2124–1/A1
Gas Admission Valve – Disassemble	2140–1/A1

Intentionally blank

Work Card
Cylinder Liner: Remove Unwanted Material

Necessary Conditions

– Engine stopped
– Cylinder cover removed

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

More spare parts, time and personnel necessary for preparation. Do a check of applicable work cards.

Tools and Consumables

Not applicable

Primary Task

Remove unwanted material from the cylinder liner bore

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Crew	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Remove piston	WC3403/A1
Exhaust valve replacement	2751–1/A1

Intentionally blank

Measure the Bore

Tools:

1	Inside micrometer	94101
1	Ladder	94224
1	Gauge	94225

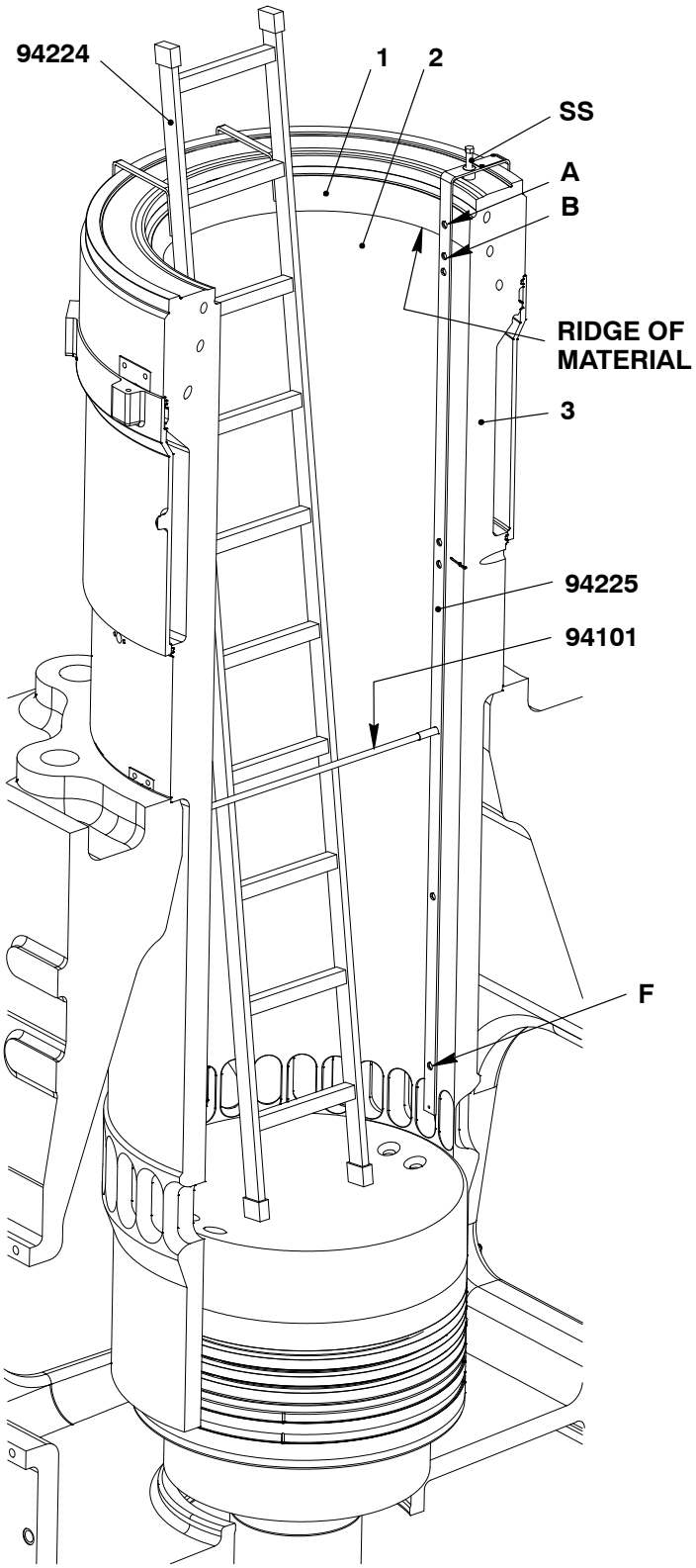


Fig. 1 016.682/08

WARNING

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

WARNING

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

CAUTION

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

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

Note: Measure the 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 (1) above the running surface (2).
6) Remove the bottom part of the gauge (94225).

7) Put the gauge (94225) in position on the top face of the cylinder liner (3, Fig. 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 (3).
9) Read the values from when the bore was measured before. You compare these values with the new values.
10) Put the micrometer (94101) in the top hole (A) to measure the distance. Record the value.
11) Put the micrometer in position in the subsequent hole (B) in the gauge (94225), then record the value.
12) Do the step above for the remaining holes below (A and B).
13) Move the gauge 90° (in line with the transverse axis of the engine).
14) Do the steps above again to measure the bore in the positions (F up to A).
15) Use the formula below to calculate the rate of wear:

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

Where:

WR = the 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 waste particles from the cylinder liner bore.
18) Clean the bore of the cylinder liner.

Removal and Installation

Tools:

1	Manual ratchets	94016–009	1	Chain	94202L
2	Manual ratchets	94016–031	1	Assembly tool	94233
1	Lifting tool	94201			

1. General

1) Read the data in the:
   - 0012–1 General Guidelines for Lifting Tools.
   - Operation Manual, 0100–1, specially for natural gas.
   - Operation Manual, 2140–1, 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

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 case a spark is not in the work area. This will prevent an explosion, or a fire.

1) Stop the engine.
2) Set to off the main bearing oil pumps.
3) Make sure that the pressure in the servo oil supply pipes is zero.
4) Release the pressure in the gas fuel system.
5) Replace the remaining gas with inert gas. Refer to the Operation Manual 4002–2, paragraph 3.12 to purge the gas fuel system.

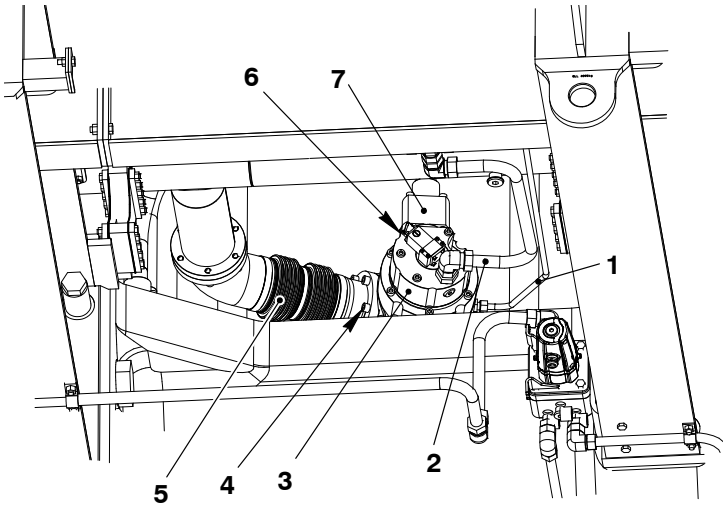


Fig. 1

6) Remove the applicable cylinder cover, refer to 2708–1.

7) Remove the piston together with the piston rod gland, refer to 3403–1 and 2303–1.

8) Put an oil tray below the GAV (3, Fig. 1).

9) Remove the oil pipe (7). Do not damage sealing surface.

10) Disconnect the return pipe (2) and lubrication pipe (1) from the GAV (3).

11) Disconnect the electrical connections from the rail valve (6) and the valve stroke sensor

12) Remove the six screws (4).

13) Push the gas supply pipe (5) back a small distance.

14) Put protection on the pipe openings.

15) Do step 8) to step 14) on the GAV at exhaust side.

16) Make sure that all pipes and platforms do not prevent the removal of the cylinder liner together with each GAV.

3. Cylinder Liner – Removal

1) Remove the screws (6, Fig. 2).

2) Remove the pipe connection (5) and the transition tubes (8) from the water guide jacket (3).

Note: The transition tubes (8) are a push-fit into the connection tubes (5).

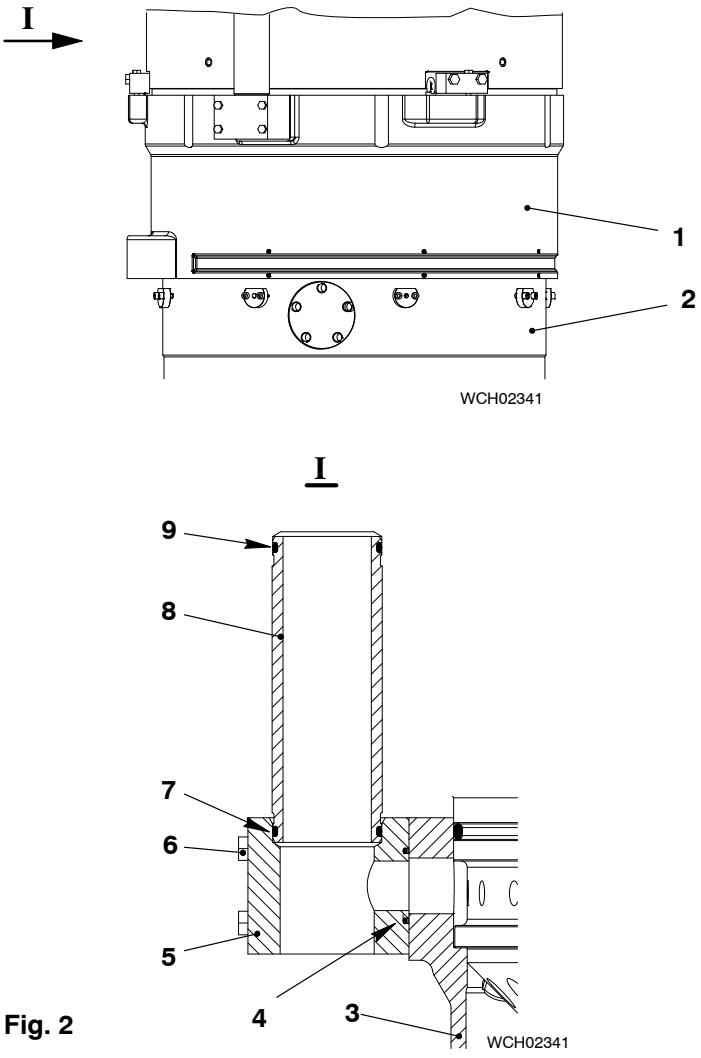
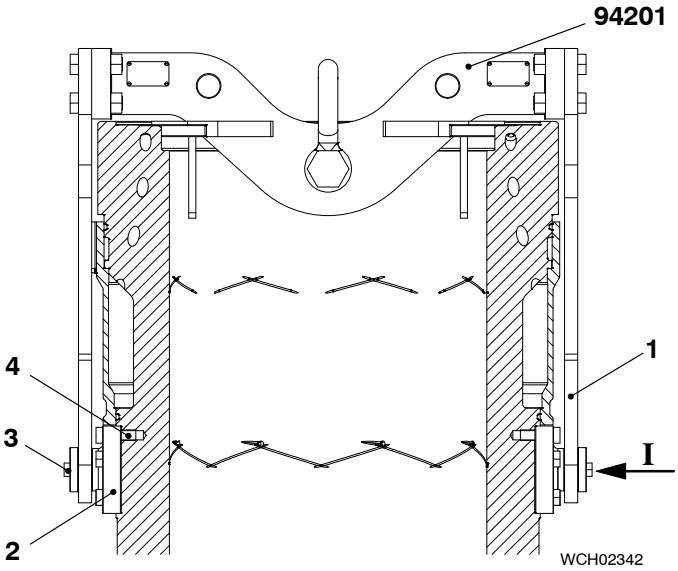


Fig. 2



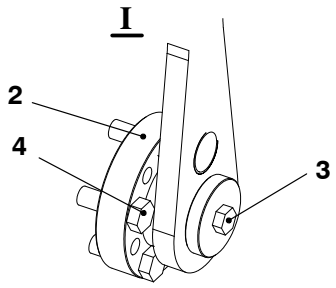


Fig. 3

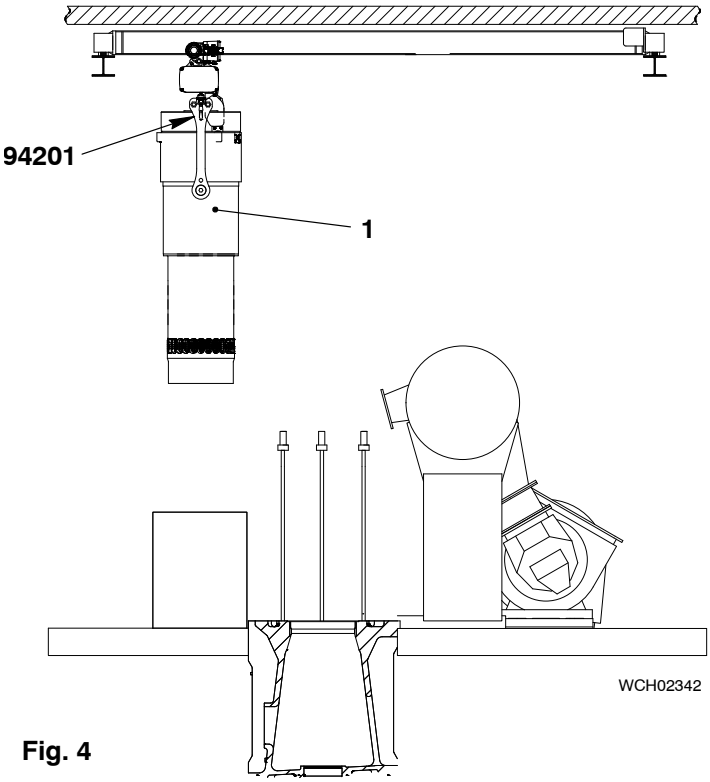


Fig. 4

3.1 Lifting Tool – Install

CAUTION

Damage Hazard: The cylinder liner and gas admission valves weigh approximately 6600 kg. Use only the correct lifting equipment to lift and move the cylinder liner to prevent damage to equipment.

1) Put the two flange couplings (2, Fig. 3) in position on the cylinder liner.
2) Tighten the five screws (4) in each flange coupling.
3) Put the lifting tool (94201) in position on top of the cylinder liner.
4) Apply copper paste to the threads of the special screws (3).
5) Attach the two holders (1) to the flange couplings (2) with the special screws (3).
6) Torque the special screws (3) to 230 Nm.
7) Connect the crane hook to the shackle on the lifting tool (94201).
8) Carefully lift the cylinder liner (2, Fig. 4). If necessary, turn the cylinder liner to prevent damage to the gas admission valves (GAV).
9) Move the cylinder liner (2) over the rail unit as shown.
10) Lower the cylinder liner (1) on to an applicable wooden underlay.

3.2 Lifting Tool – Removal

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

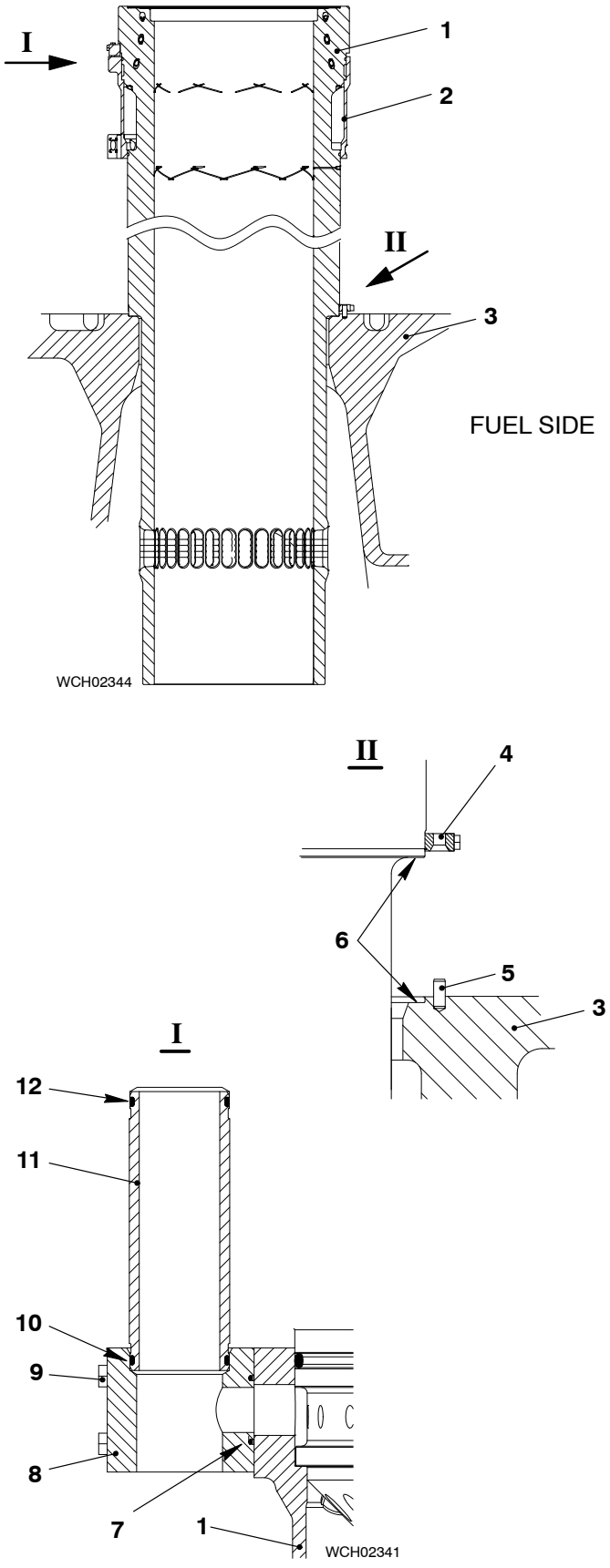


Fig. 5

4. Cylinder Liner – Installation

1) Install the lifting tool (94201), refer to the procedure in paragraph 3.1.
2) Clean the seating surfaces (6, Fig. 5) on the cylinder liner (1) and cylinder jacket (3).
3) Carefully lower the cylinder liner (1) almost on to the cylinder jacket (3). If necessary, turn the cylinder liner to prevent damage to the two GAV.
4) Align the hole in the holder (4) with the pin (5) on the cylinder jacket (3).
5) Fully lower cylinder liner (1).
6) Attach the connection pieces (8) and the transition tubes (11) to the water guide jacket (3) with the screws (9).

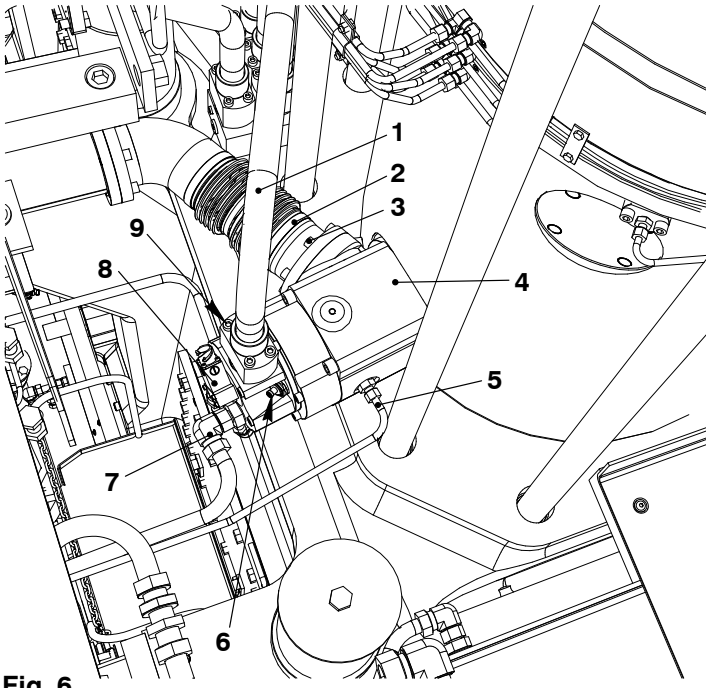
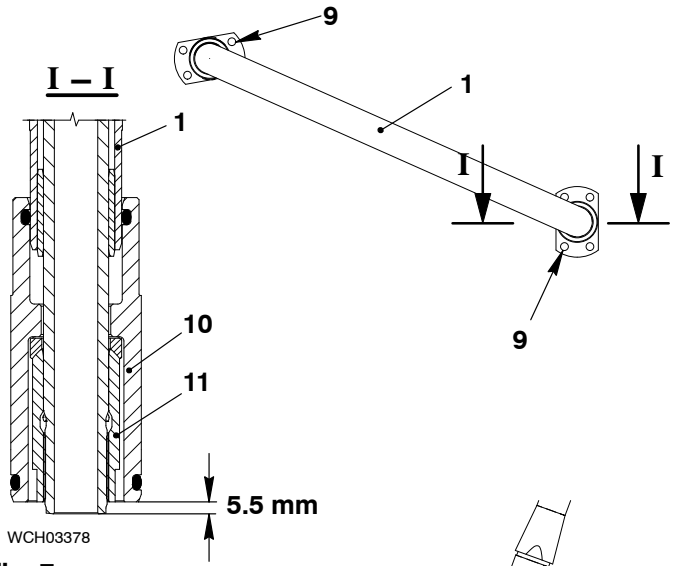


Fig. 6 WCH03350



WCH03378

Fig. 7

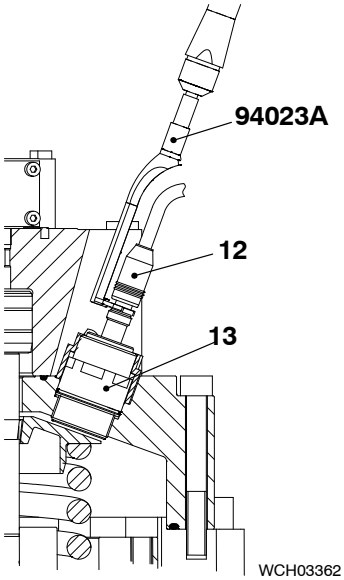


Fig. 8 WCH03362

7) Replace the O-ring in the flange of the gas supply pipe (2, Fig 6).
8) Attach the gas supply pipe (2) to the GAV (4) with six M12x35 screws (3).
9) Tighten equally the six M12x35 screws (3).
10) Attach the return pipe (7) and the lubrication pipe (5) to the GAV (4).
11) Connect the electrical connection to the rail valve (8).
12) Make sure that the sealing face of the oil pipe (1) has no damage. If there is damage, grind the sealing faces (refer to 8460 paragraph 3).
13) 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 (1) .
14) Apply oil to the eight screws (9).
15) Carefully install the oil pipe (1).
16) Torque symmetrically the eight screws (9) to 40 Nm.
17) Use the assembly tool (94023A, Fig. 8) to attach the electrical connection (12) to the valve stroke sensor (13).
18) Do step 7) to step 17) for the other GAV.
19) Do a stroke signal test of a the GAV, refer to the Operation Manual 4002–2, paragraph 3.14 GAV Manual Valve Test.
20) Do a leak test of the Gas System, refer to Operation Manual, 4002–2, 3.13 Gas Leak Test.
21) Do a test of the GAV, see Operation Manual, 4002–2, 3.14 GAV Manual Test.

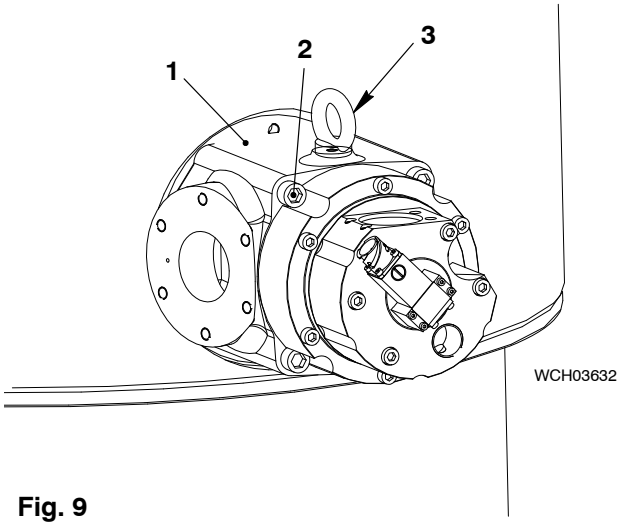


Fig. 9

5. Water Guide Jacket – Removal

5.1 GAV – Removal

CAUTION

Damage Hazard: The GAV weighs approximately 70 kg. Use only the correct lifting equipment to lift and move the GAV to prevent damage to equipment.

1) Remove the cylinder liner, refer to paragraph 3.
2) Remove all lubricating quills (refer to 2138–1 paragraph 1).
3) Install the M10 eye bolt (3, Fig. 9) to gas admission valve (1).
4) Attach an applicable lifting tool (e.g. chain block to the crane hook) to the eye bolt.
5) Apply a light tension to the chain block to hold the weight of the GAV.
6) Remove the four screws (2).
7) Remove the GAV.
8) Put the GAV in a clean dry area.

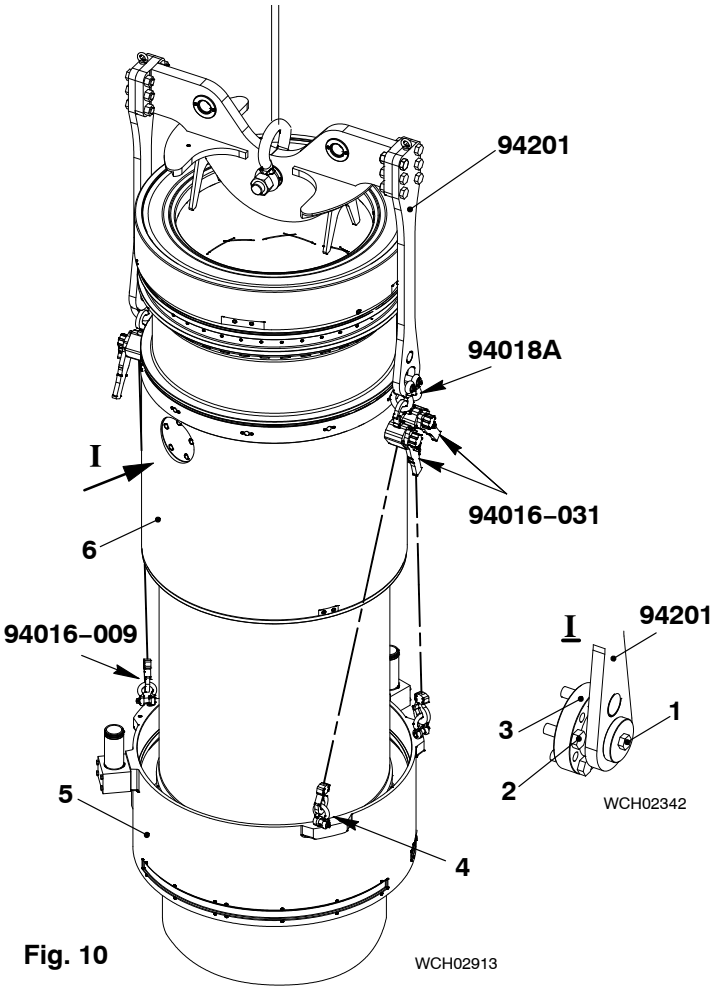


Fig. 10

9) Remove the flanges of the lifting tool (94201, Fig. 10) from the cylinder liner (6).

10) Attach the eye bolts (4) to the water guide jacket (5).

11) Attach the three manual ratchets (94016–031, 94016–009) to the three eye bolts (4) and the shackles (94018A) on the lifting tool (94201).

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

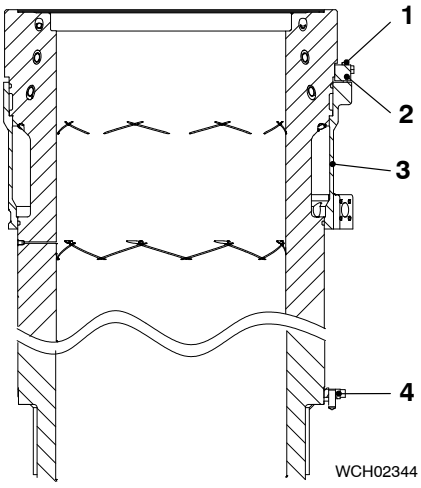


Fig. 11

12) Remove the holder (4, Fig.11)

13) Loosen the three screws (1).

14) If the water guide jacket (3) does not come away from the cylinder liner, do as follows:

a) Put the three screws (1) in the threaded holes of the holder (2).

b) Turn equally the three screws (1) to push down the water guide jacket.

Note: During step 18), make sure that you keep the water guide jacket level.

15) Operate the manual ratchets to lower the water guide jacket on to the bottom plates.

16) Attach the lifting tool (94201) to the cylinder liner (refer to paragraph 2.1).

17) Carefully lift then move the cylinder liner to a different position on the bottom plates.

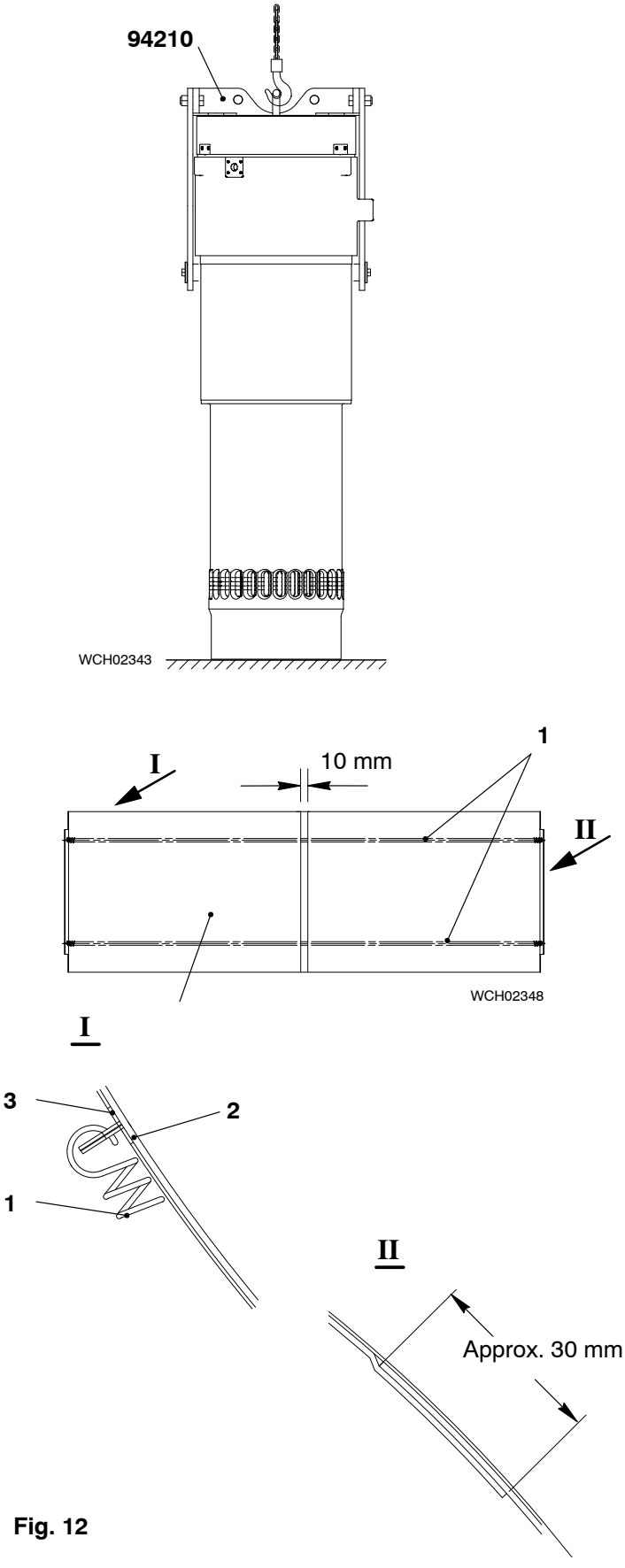


Fig. 12

6. Insulation Bandage – Removal

1) Remove the cylinder liner (refer to paragraph 3).
2) Remove the water guide jacket (see paragraph 5).
3) Use the tool (94233) to remove all the tension springs (1, Fig. 13).
4) Remove the plate (3).
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 (3) in position.
3) Use the assembly tool (94233) to attach all the tension springs (1).
4) Install the water guide jacket (refer to paragraph 8).

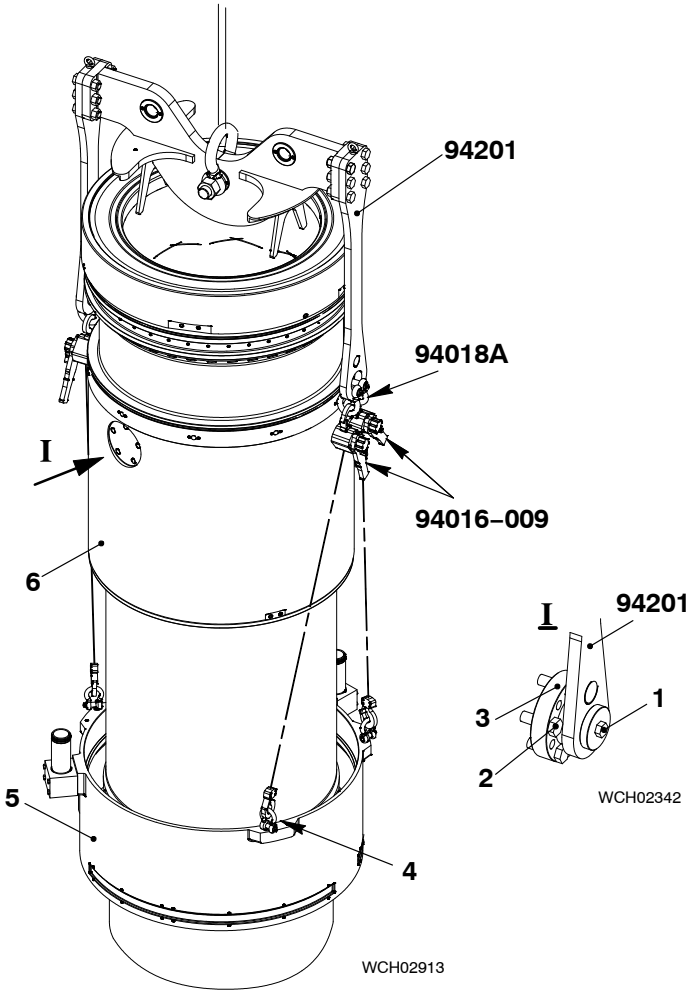


Fig. 13

8. Water Guide Jacket – Installation

1) Install the insulation bandage, refer to paragraph 7.
2) Replace all O-rings.
3) Apply oil to the O-rings.
4) Attach the lifting tool (94201) to the cylinder liner (refer to paragraph 3.1).
5) Lift, move and lower the cylinder liner into the water guide jacket (5, Fig. 13).
6) Remove special screw (1) and the flange (3) from the lifting tool (94201).
7) Attach the three manual ratchets (94016–031, 94016–009) and the shackles (94018A) to:

- The lifting tool (94201)
- The three eye bolts (4) on the water guide jacket (3).

Note: During step 8), make sure that you keep the water guide jacket level.

8) Operate the manual ratchets (94016–031, 94016–009) to lift the water guide jacket (5) to the applicable position on the cylinder liner.

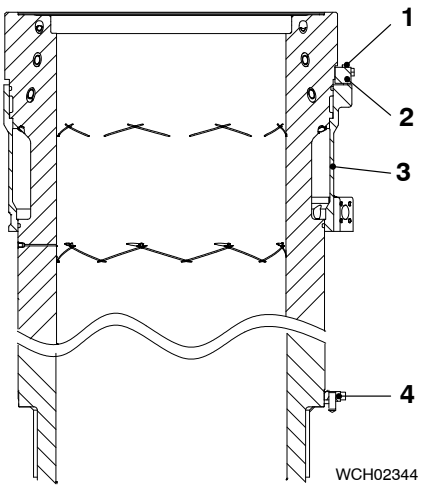
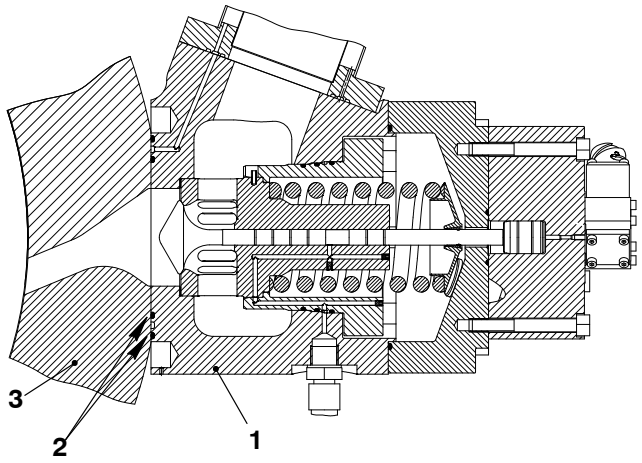
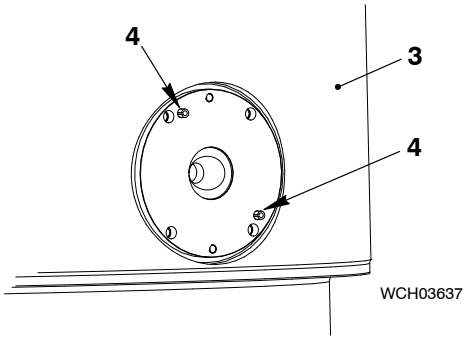


Fig. 14

9) Attach the water guide jacket (3, Fig. 14) to the cylinder liner with the three screws (1).
10) Attach the holder (4).
11) Remove the manual ratchets (94016–031, 94016–009) and the lifting tool (94201).
12) Install all lubricating quills, refer to 2138–1 paragraph 2.





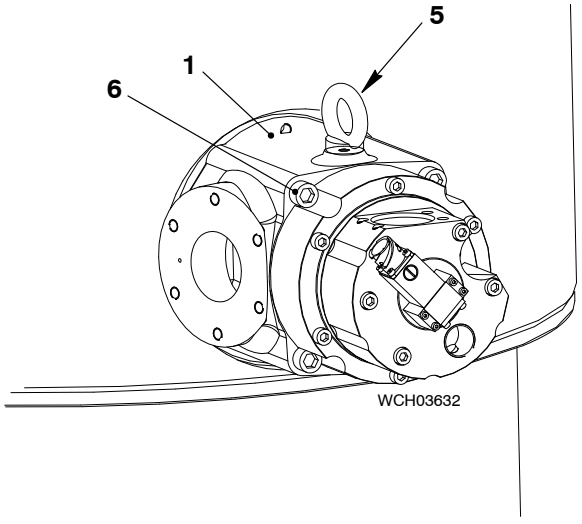


Fig. 15

8.1 GAV – Installation

1) Clean all surfaces of the GAV (1, Fig. 15) and the cylinder liner (3) that touch.
2) Install new O–rings (2), to the GAV (1).
3) Attach the M10 eye bolt (5) to the GAV (1).
4) Attach the applicable lifting equipment to the M10 eye bolt (5).
5) Use the applicable lifting equipment to move the GAV in position against the cylinder liner (3). Make sure that the two spring dowel pins (4) engage with the related holes in the GAV (1).
6) Apply Never Seez High Temperature Stainless to the thread and head of the four bolts (6).
7) Torque the four bolts (6) to 170 Nm.

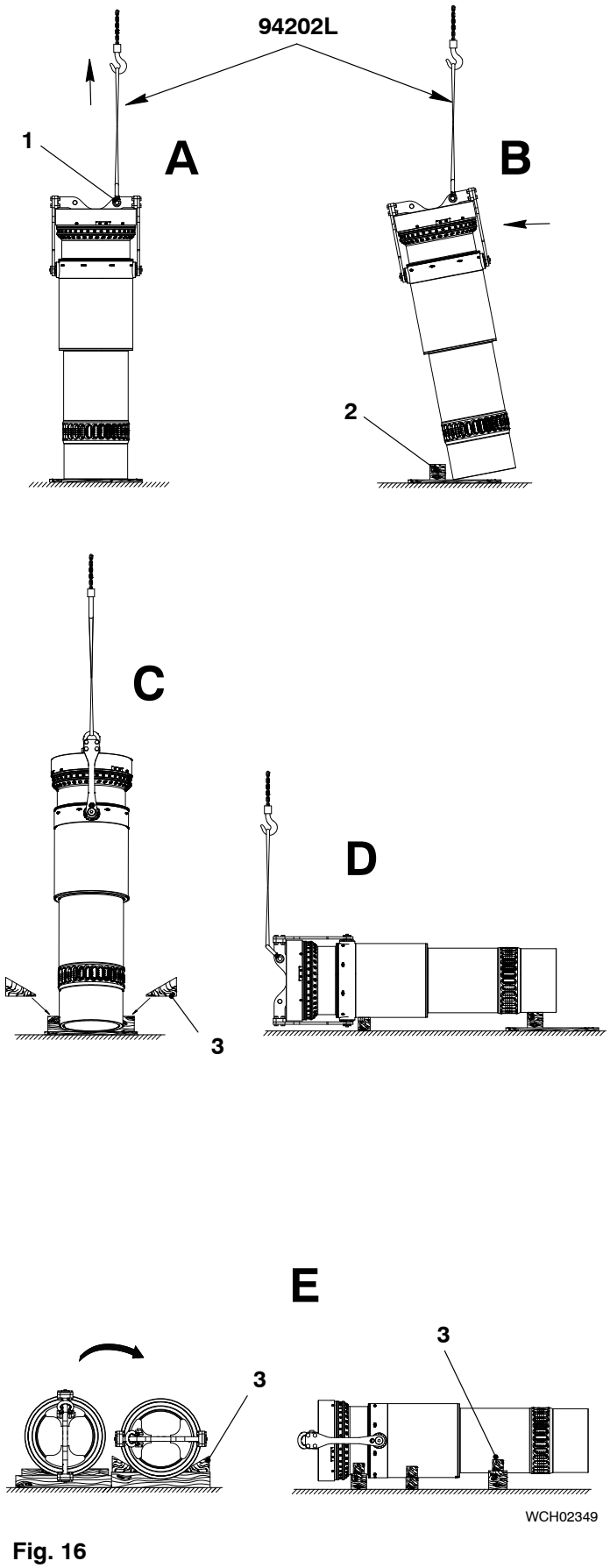


Fig. 16

9. Cylinder Liner – Safe Storage

1) Make sure that the water guide jacket is removed (refer to paragraph 5).
2) Make sure that the insulation bandage is removed (refer to paragraph 6).
3) Install the lifting tool (94210) to the cylinder liner (see paragraph 3.1).
4) Attach the shackle (1, Fig. 16) to the lifting tool (94210) in the position shown in step A.
5) Attach the sling (94202L) to the shackle (1) and the crane hook.
6) Operate the crane to put a light tension on the sling (94202L).
7) Put the wooden underlay (2) in position as shown in step B.
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 C).
10) Fully lower the cylinder liner (step D).
11) Remove the sling (94202L) from the lifting tool.
12) Put more wooden underlays in position (see E).
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 (94210) from the cylinder liner.

10. Cylinder Liner – Preparation

1) Attach the lifting tool (94210) to the cylinder liner (refer to paragraph 3.1).
2) Make sure that shackle (1) is in the position shown in step A.
3) Put more wooden underlays (2) in position (see step E).
4) Remove the wooden chocks (3).
5) Carefully turn the cylinder liner 90°.
6) Attach the sling (94202L) to the lifting tool.
7) Carefully lift the cylinder liner to the vertical position.

Intentionally blank

Remove Unwanted Material, Dress the Lubricating Grooves and Scavenge Ports

Tools:

1 Grinding device (opt.) 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 movement 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 see 2124–1).

2. Preparation

1) Remove the cylinder cover, refer to 2708–1, paragraph 1 and paragraph 2.
2) Remove all lubricating quills, refer to 2138–1, paragraph 1.
3) Put applicable protection in the cylinder liner. This keeps unwanted particles out of the bore.

3. Unwanted Material – Remove

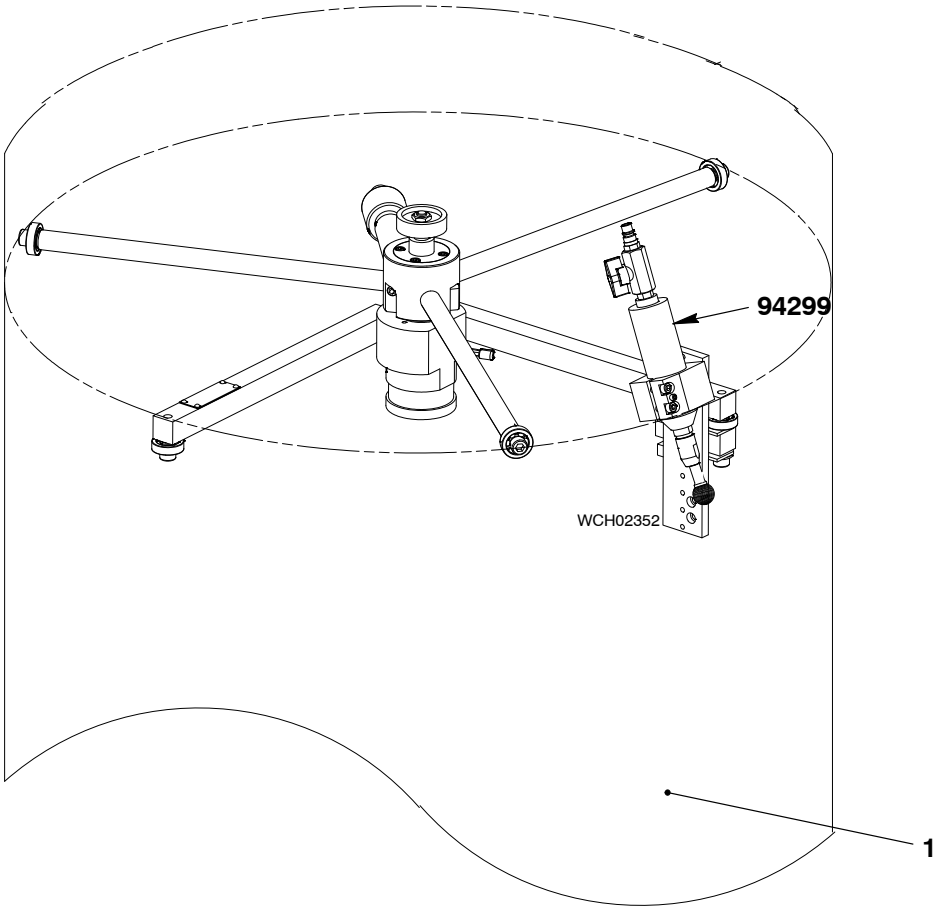
CAUTION

Damage Hazard: Make sure that you do no 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) to the cylinder liner (1, Fig. 1), refer to the Instruction Manual.
3) Connect the grinding tool (94299) to an applicable air supply.
4) Make sure that the milling cutter (2) has a diameter of 16 mm.
5) Align the middle of the milling cutter (2) to the edge of the unwanted material, refer to A.
6) Operate the grinding tool (94299) to carefully remove the unwanted material from the cylinder liner (1).
7) Make sure that you get a maximum angle of 40° at the cylinder liner (1).

Note: With a cutter of 16 mm diameter, you can remove a maximum of 1.9 mm of material horizontally to stay below the maximum angle of 40°.

Remove Unwanted Material, Dress the Lubricating Grooves and Scavenge Ports



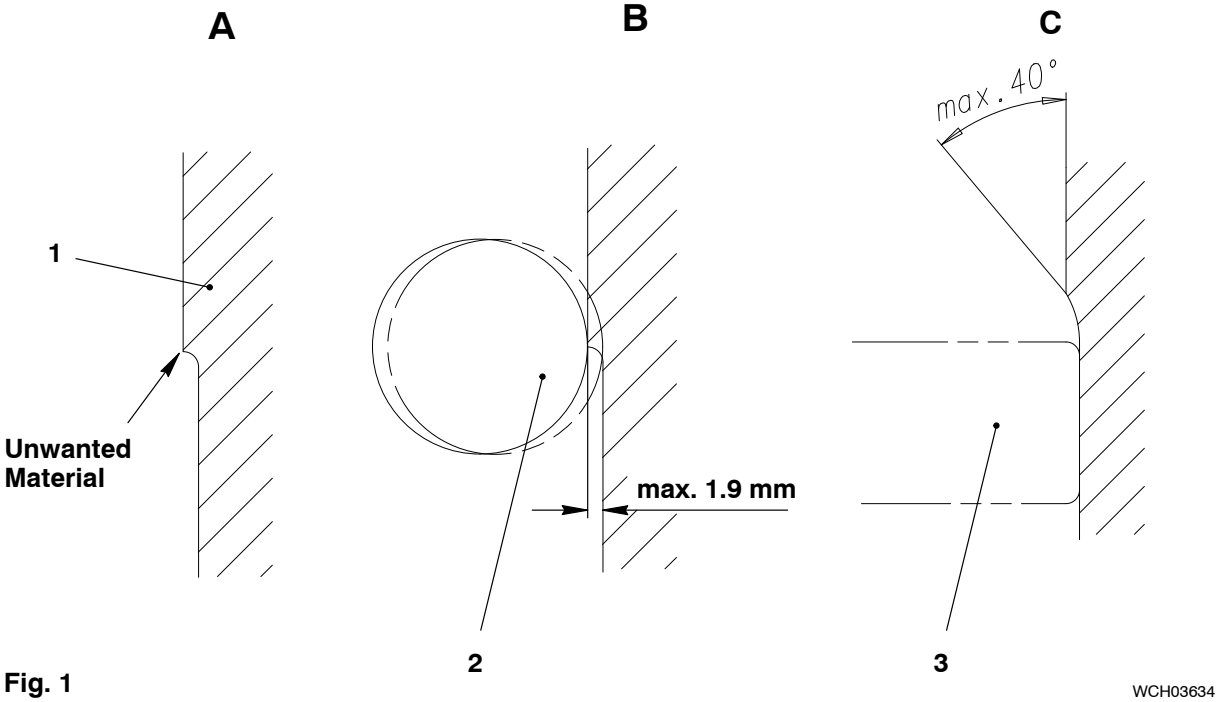


Fig. 1

4. Lubricating Grooves

CAUTION

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

1) If the depth of the lubricating grooves (1, Fig. 2) has decreased to less than 1.5 mm, do as follows:

   a) Use emery cloth or an oil stone to get the the lubricating grooves back to their initial depth.

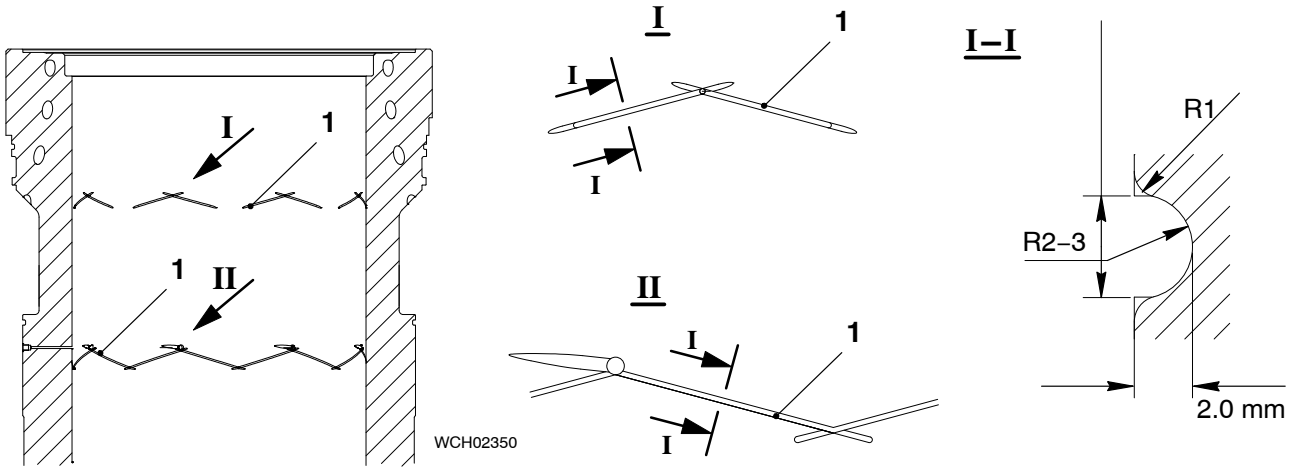


Fig. 2

5. Scavenge Ports

CAUTION

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

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

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

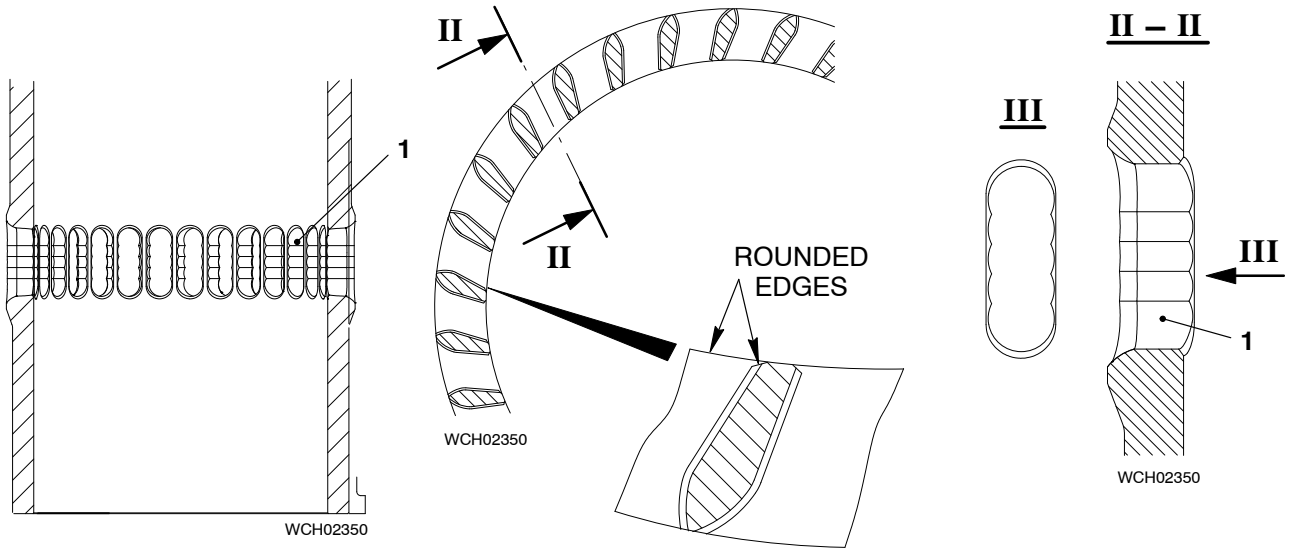


Fig. 3

2) After the repair is completed, clean fully the lubricating grooves and the bore of the cylinder liner.

3) Remove unwanted particles that could 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 unwanted metal dust.

Work Card
Cylinder Lubricating Quill

Necessary Conditions

– Engine stopped
– Lubricating quill removed

Preparation

Necessary Spare Parts (each cylinder)

Not applicable

Tools and Consumables

HP oil pump	94931	Qty 1
Hydraulic distributor	94934H	Qty 1
Connection nipple (G¼ inch)	94934I	Qty 1
HP hose	94935	Qty 1

Cylinder lubricating oil:
SAE 50 at 40°C (200 cSt)
SAE 30 at 25°C (190 cSt)

Primary Task

Do a check of the tightness of the and function of the lubricating quill and the NRV

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1
Bleed oil pipes	7218–1/A1
Bleed flex lube pump	7218–1/A1

Related Procedures

Bleed oil pipes 7218–1/A1
Bleed flex lube pump 7218–1/A1

Intentionally blank

Removal and Installation

Tools:

1	HP oil pump	94931	1	Connection nipple (G¼ inch)	94934I
1	Hydraulic distributor (with pressure gauge 0 bar to 25 bar)	94934H	1	HP hose	94935
			1	Dismantling tool	94213

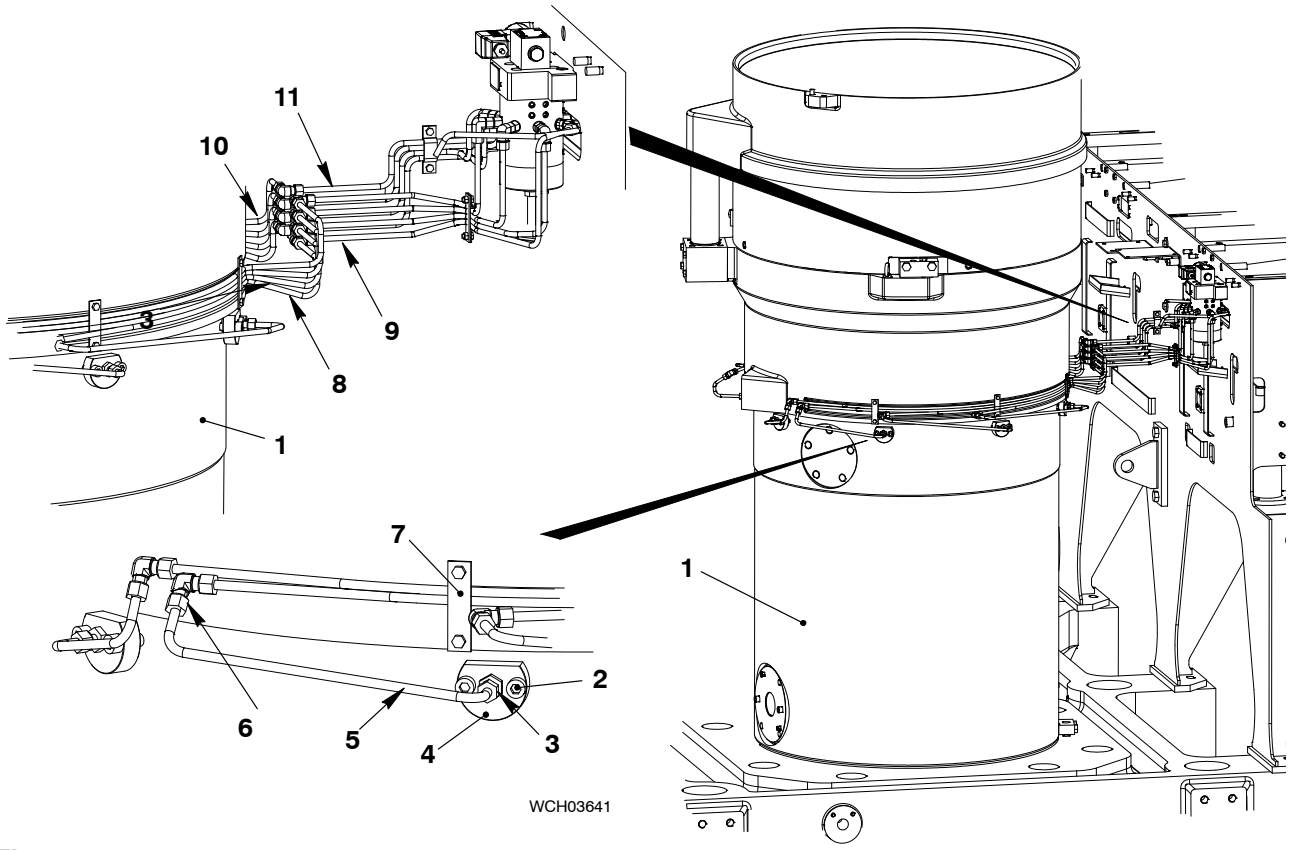


Fig. 1

1. Removal Procedure

Note: If it is not necessary to remove the cylinder liner (1, Fig. 1), do not drain the cylinder cooling water.

1) Loosen the nuts of the lubrication quill unions (3).

Note: Make sure that you do not cause damage to the oil pipe (5).

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

Note: Steps 7) to 10) are only necessary if the cylinder liner (2) must be removed.

7) Remove all holders (7) on the cylinder liner (1).
8) Remove the eight pipes (8, 10) from the pipes (9, 11).
9) Seal the pipes (8, 10) from the pipes (9, 11) with applicable seals to prevent contamination.
10) Remove the cylinder liner (1), refer to 2124–2, paragraphs 1, 2 and 3.

2. Nozzle Tip – Replace

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

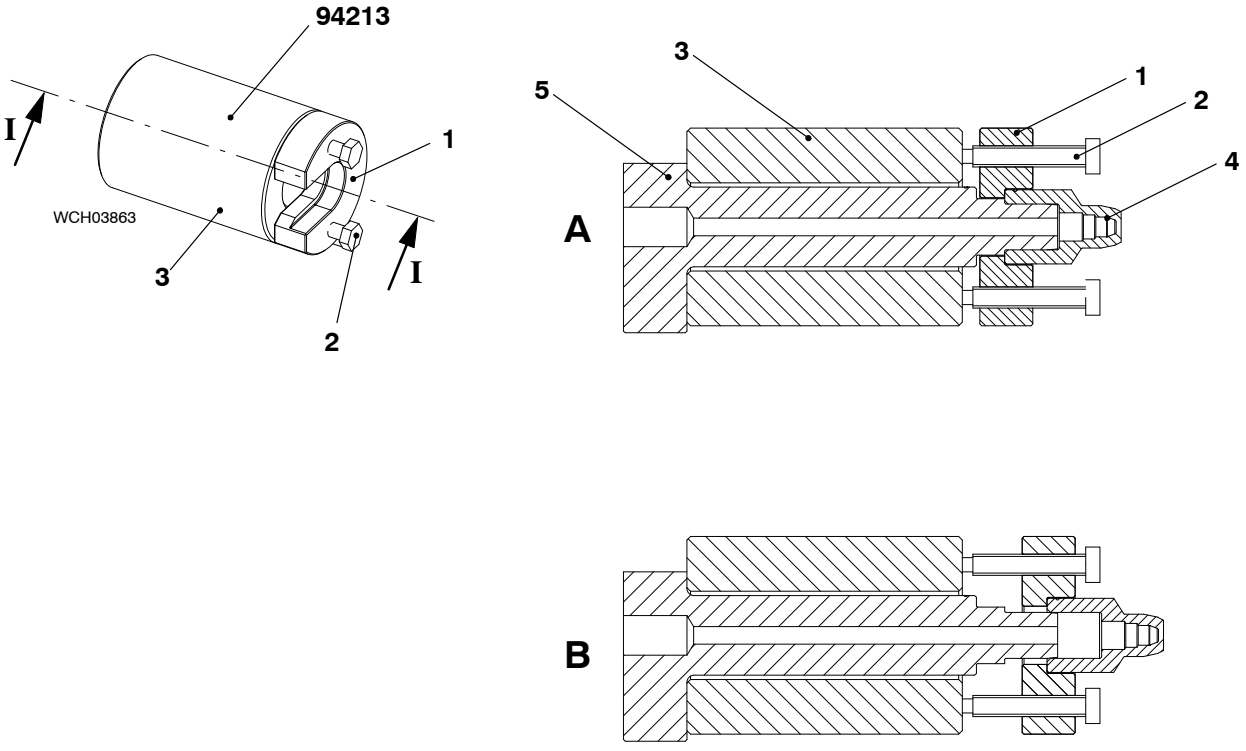


Fig. 2

3. Lubricating Quill – Function Check

3.1 General

Note: During the function check, keep the lubricating quill (2, Fig. 3) in a horizontal position.

You do a function check to make sure that the non-return valve (3) operates correctly. The pressure that opens the non-return valve is 5.0 bar.

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

Note: The minimum permitted pressure to open the non-return valve is 4.25 bar. If necessary, replace a defective lubricating quill (2).

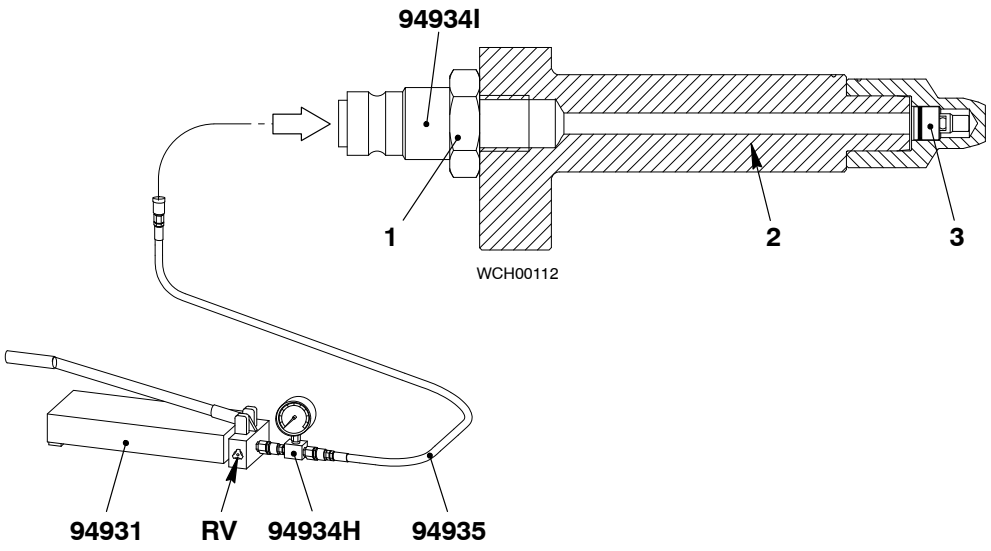


Fig. 3

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. Damage to the equipment can occur.

Note: When you install the lubricating quill, replace all components.

1) Make sure that the sealing surfaces (1, Fig. 4) are clean and have no damage.

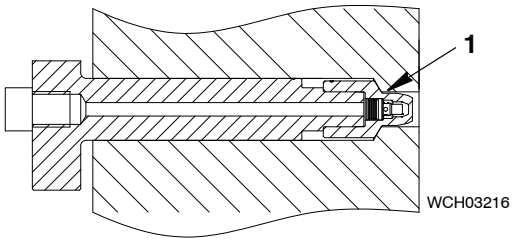


Fig. 4

2) Apply oil to the threads of the two screws (3, Fig. 5).
3) Put the lubricating quills (5) in position.
4) Torque the two screws (3) to 10 Nm.
5) Step a) to step f) is only necessary if the cylinder liner was removed.
   a) Install the cylinder liner (2), refer to 2124–2, paragraph 4.
   b) Remove the protection from the eight pipes (9, 11.
   c) Install the eight pipes (9,11).
   d) Attach the holders (8) to the cylinder liner (2).
   e) Remove the plugs from the oil pipes (10, 12).
   f) Connect the oil pipes (9, 11) to the oil pipes (10, 12).
6) Connect the oil pipe (6) to the pipe union (4) and the pipe union (7).
7) Tighten the nuts of the pipe unions (4, 7).
8) Bleed the oil pipes (6) (refer to 7218–1, paragraph 3.2).
9) If necessary, bleed the flex lube pump (1), refer to 7218–1, paragraph 3.1.
10) Do a function check of the cylinder lubricating system, refer to 7218–1, paragraph 1.2.

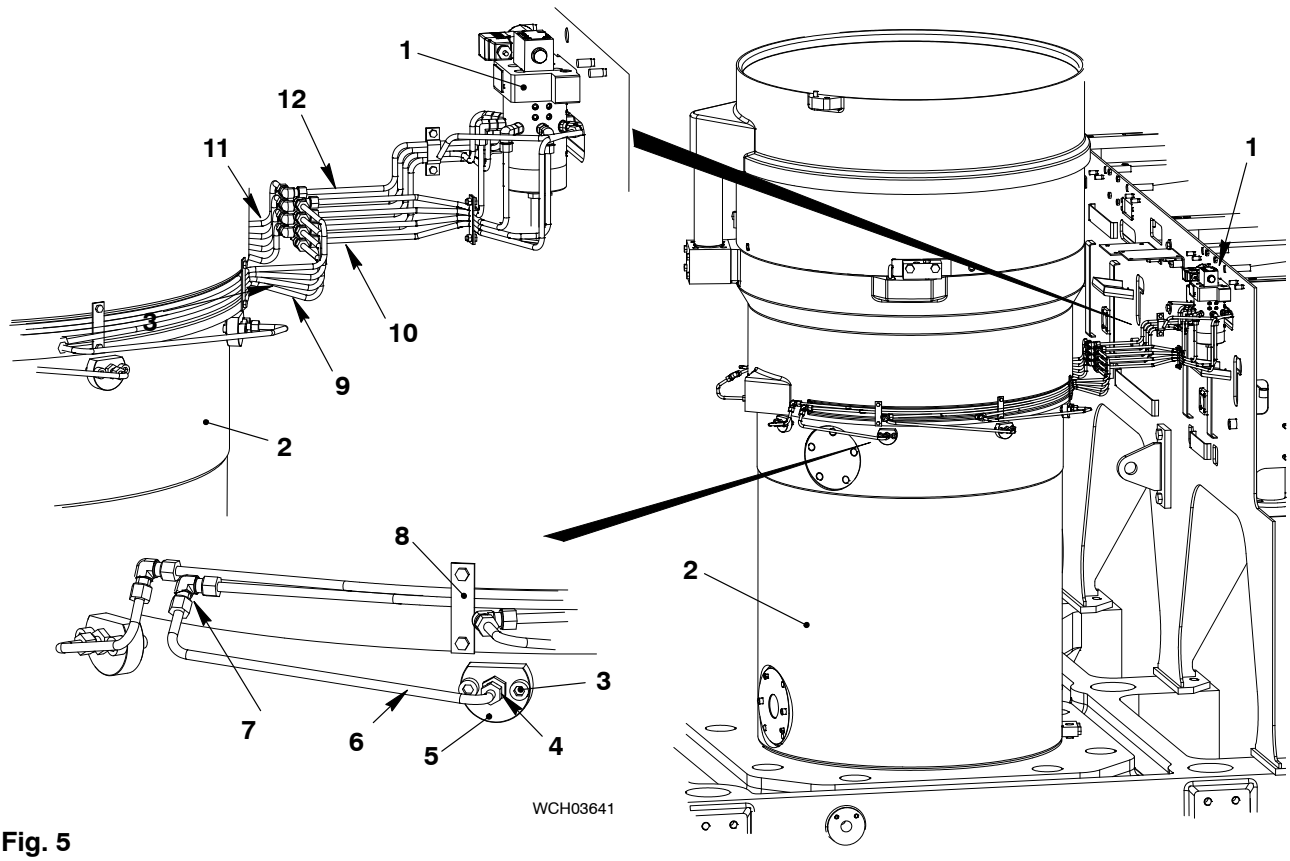


Fig. 5

Intentionally blank

Work Card
Gas Admission Valve: Check

Necessary Conditions

– Engine stopped
– Gas admission valve removed, 2140–1/A1

Necessary Spare Parts (each cylinder)

O-ring	EX 21418	Qty 2
O-ring	EX 21429	Qty 2
O-ring	EX 21430	Qty 2
O-ring	EX 21431	Qty 2
O-ring	EX 21432	Qty 2
O-ring	EX 21434	Qty 2
O-ring	EX 21435	Qty 2

Preparation

Tools and Consumables

Pressure reducing valve	94241B	Qty 1
Bush	94214E	Qty 1
Bracket	94241D	Qty 1
Spring press	94214C	Qty 1
Oil tray		
Plugs etc for pipe protection		
Nitrogen supply		
WD 40		
Molykote G Rapid Plus		

Primary Task

Do a check of the tightness and function of the GAV

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	4.0 hours	Qty 1
Ship Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card

Gas Admission Valve: Do an Overhaul of the Valve Seat

Necessary Conditions

− Engine stopped
− Gas admission valve removed, 2140−1/A1

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Tools and Consumables

Knurled nut	94214A	Qty 1
Lube oil Lapping paste (0.5 to 4.0 microns		

Primary Task

Do an overhaul of the valve seat

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Gas Admission Valve − Pressure Test 2140−1/A1

Intentionally blank

Work Card
Gas Admission Valve: Check of the Compensator

Necessary Conditions

– Engine stopped
– Gas admission valve removed, 2140–1/A1

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do a check of the compensator	Service Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card
Gas Admission Valve: Replace

Necessary Conditions

– Engine stopped
– Gas admission valve removed, 2140–1/A1
– Disassemble the gas admission valve 2140–1/A1

Preparation

Necessary Spare Parts (each cylinder)

Gas admission valve	EX 21404	Qty 2
Rail valve	EX 21415	Qty 2
Valve stroke sensor	EX 21417	Qty 2

Tools and Consumables

Not applicable

Primary Task

Replace the Valve Spindle, Guide, Valve Stroke Sensor and Rail Valve

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Gas Admission Valve

Removal, Disassemble, Assemble and Installation

Tools:

1	Eye bolt	94045–M10	1	Assembly tool	94023A
1	Dismantling tool	94214	2	Screw M10	94214L
1	Handle	94214A	2	Hexagon nut M10	94214M
1	Pressure reducing valve	94214B			

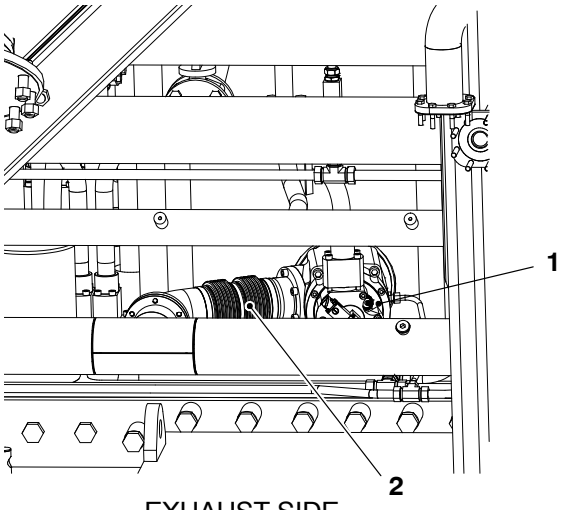
1. General

1) Read the data in the:

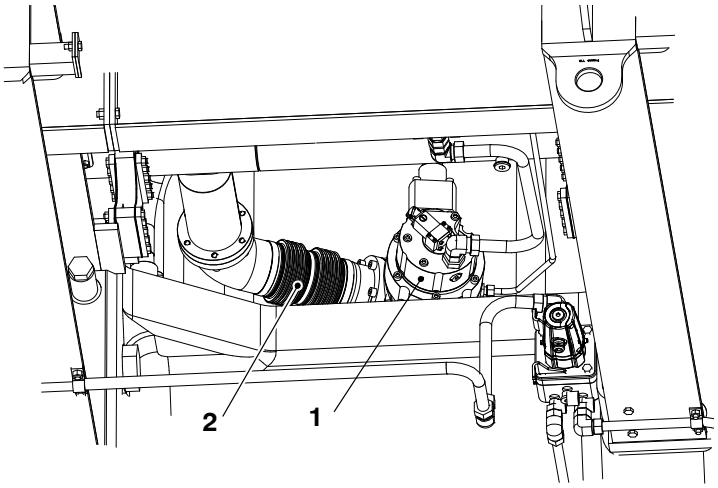
- Operation Manual, 0210–1 Safety Precautions and Warnings
- Operation Manual, 2140 Gas Admission Valve (GAV)
- Operation Manual, 8014–1, Gas Fuel System
- Operation Manual, 4003–12, Diagram Gas Fuel.
- Operation Manual, 4002–2, 3.14 GAV Manual Test

2) For the inspection intervals, refer to the Maintenance Schedule 0380–1, Group 2140.

Note: Because removal of the gas admission valve (GAV, 1 Fig. 1) cannot be done easily, it is recommended that you disassemble the GAV in the installed position. The housing and the gas supply pipe (2) can stay on the cylinder liner.



EXHAUST SIDE



FUEL SIDE

Fig. 1

2. Preparation

1) Stop the engine.
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 case a spark is not in the work area. This will prevent an explosion, or a fire.

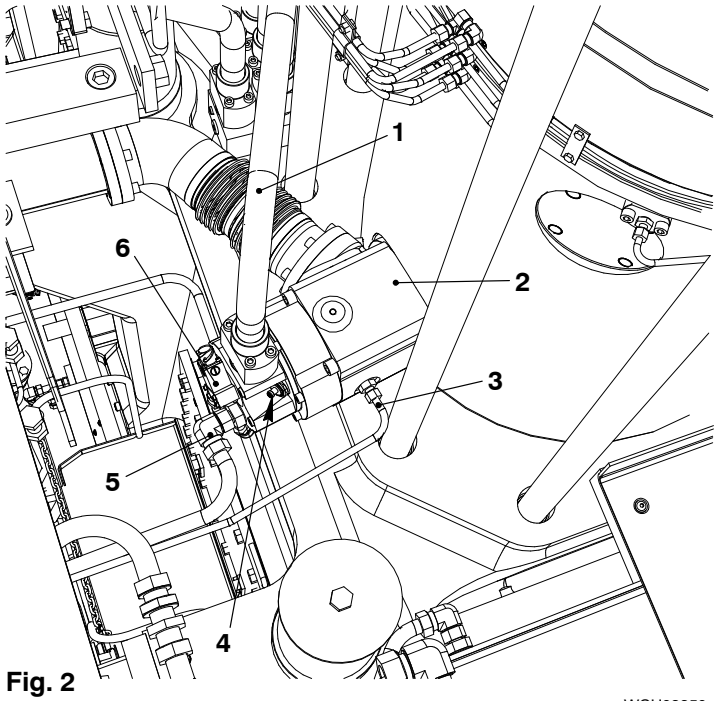


Fig. 2

WCH03350

3. Removal

1) Put an oil tray below the GAV (2, Fig. 2).
1) Remove the oil pipe (1). Do not damage sealing surface.
2) Remove the return pipe (5) and lubrication pipe (3) from the GAV (2).
3) Put protection on the pipe openings.
4) Disconnect the electrical connection from the rail valve (6).

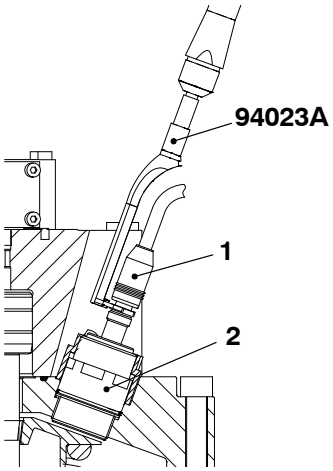
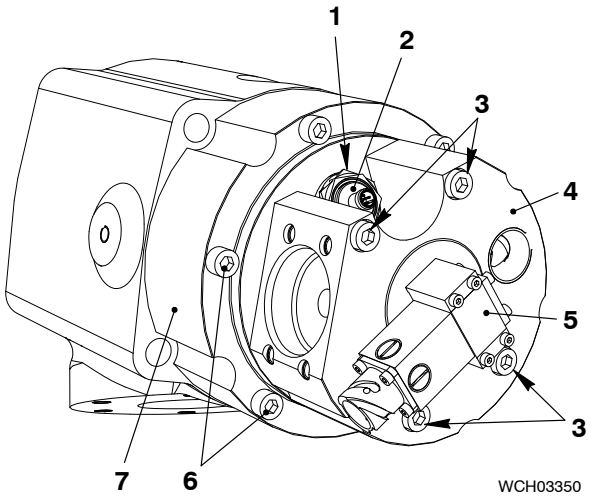


Fig. 3

5) Use the tool (94023A, Fig. 3) to disconnect the electrical connection (1) from the valve stroke sensor (2).



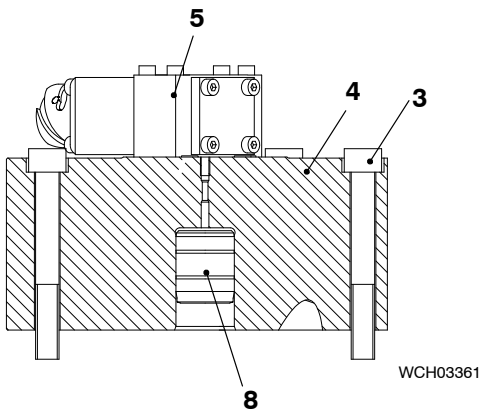


Fig. 4

4. Disassemble

1) Remove four bolts (3, Fig 4).
2) Carefully remove the cover (4) together with the rail valve (5). Make sure that the piston (8) does not go into the cover (7).
3) Remove the coupling nut (1) on the valve stroke sensor (2).
4) Remove the valve stroke sensor (2) and its distance sleeve.
5) Remove symmetrically the six bolts (6).
6) Carefully remove cover (7).

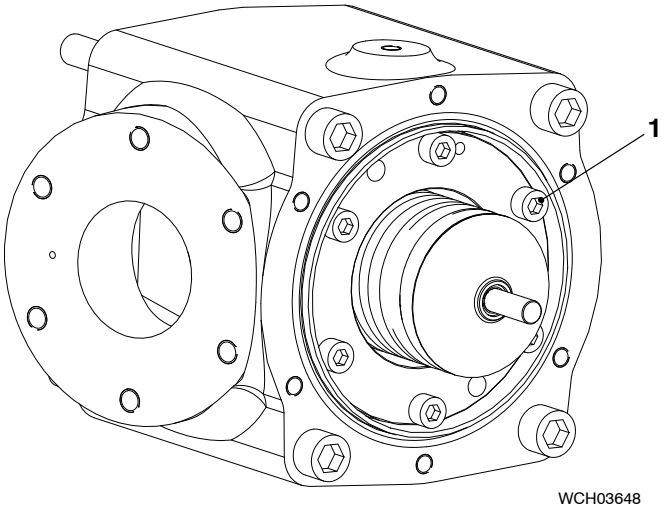


Fig. 5

7) Remove the six screws (1, Fig. 5).

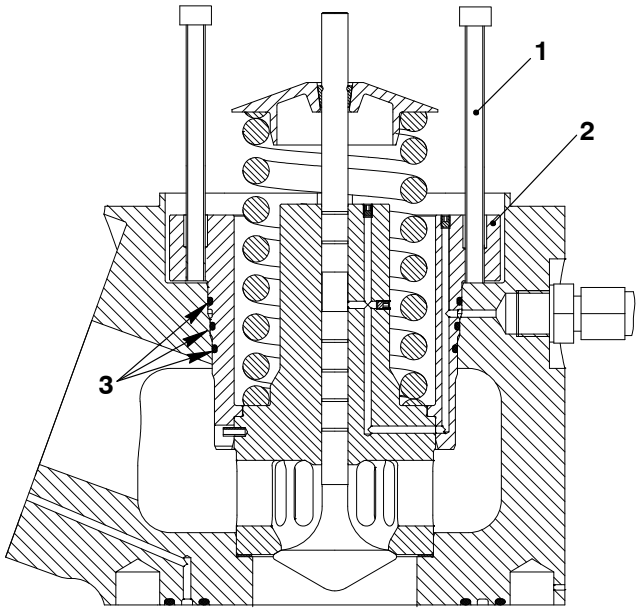
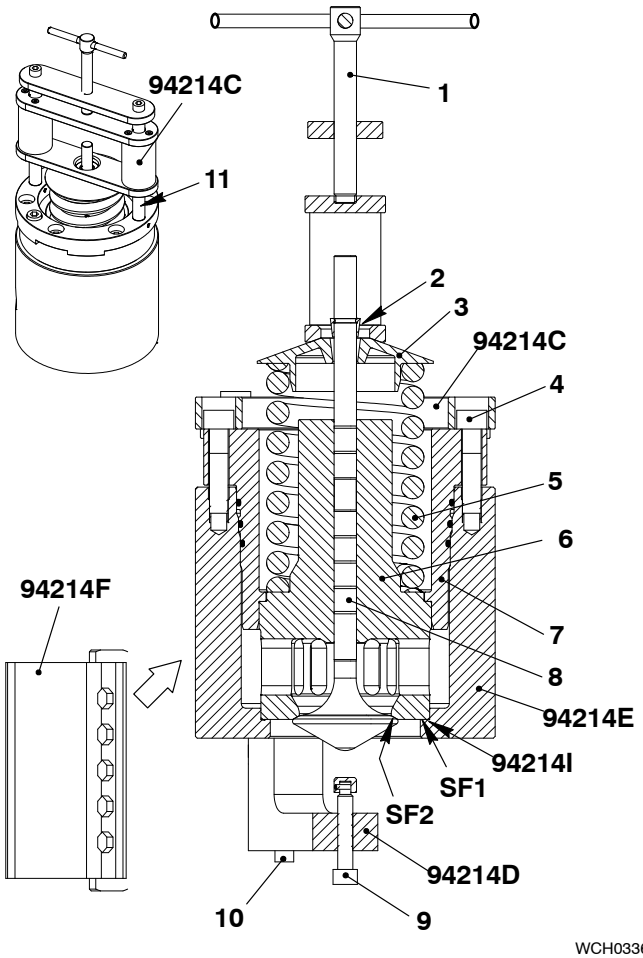


Fig. 6 WCH03361



WCH03362

Fig. 7

8) Put the two M10 screws 94214L (1, Fig. 6) in position in the M10 threads.
9) Turn equally the two M10 94214L screws to remove the valve assembly (2).

4.1 Valve Assembly – Disassemble

1) Attach the steel plate (94214F, Fig. 7) to the bush (94214E) with the five screws.
2) Put the steel plate (94214F) and the attached bush (94214E) horizontally into a vice.
3) Make sure that the sealing faces (SF1) are clean.
4) Put the soft metal gasket (94214I) between the sealing faces (SF1).
5) Put the valve assembly (7) into the bush (94214E).
6) Apply Molykote G-Rapid plus to the rods of the spring press (94214C).
7) Attach the spring press (94214C) and the valve assembly (7) to the bush (94214E) with the six M10x45 screws (4).
8) Torque the six screws (4) to 40 Nm.
9) Attach the bracket (94241D) to the other side of the bush (94214E) with the two M6x75 screws (10).
10) Turn the special screw (9) fully in.
11) Turn the T-handle (1) clockwise to compress the spring (5). This pushes the valve cotter (2) out of the spring carrier (3).
12) Remove the valve cotter (2).
13) Turn the T-handle (1) counterclockwise to release the tension in the spring (5).
14) Remove the bracket (94214D).
15) Remove the valve spindle (8).
16) Clean the valve spindle (8) and do a check for damage, specially the sealing surface (SF2).
17) Carefully put the valve spindle (8) into the valve guide (6).
18) Move the valve (8) spindle fully 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 valve spindle must move down smoothly.

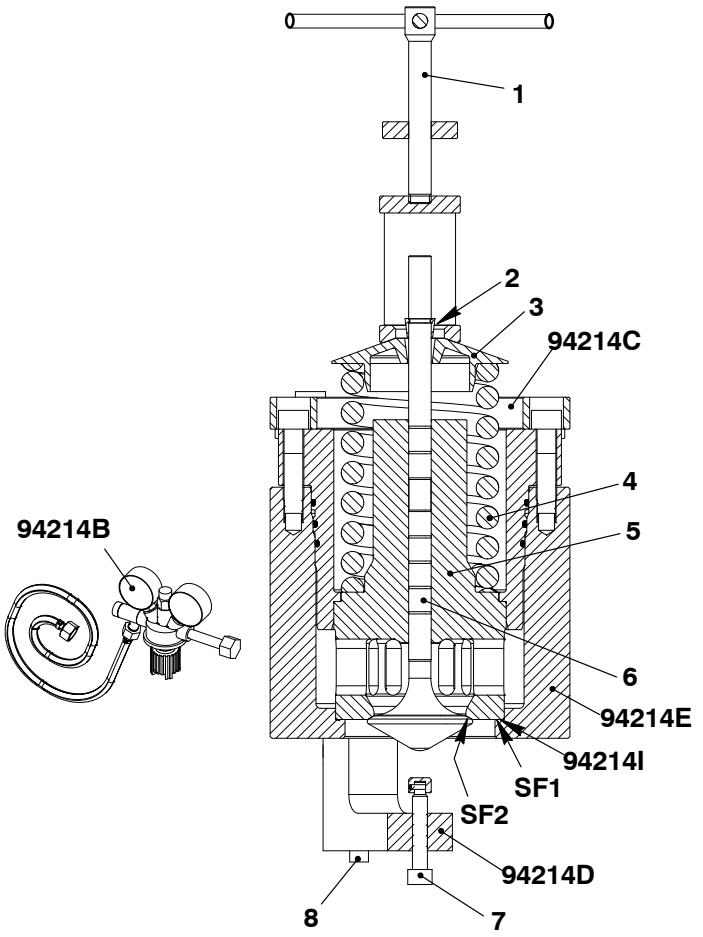


Fig. 8

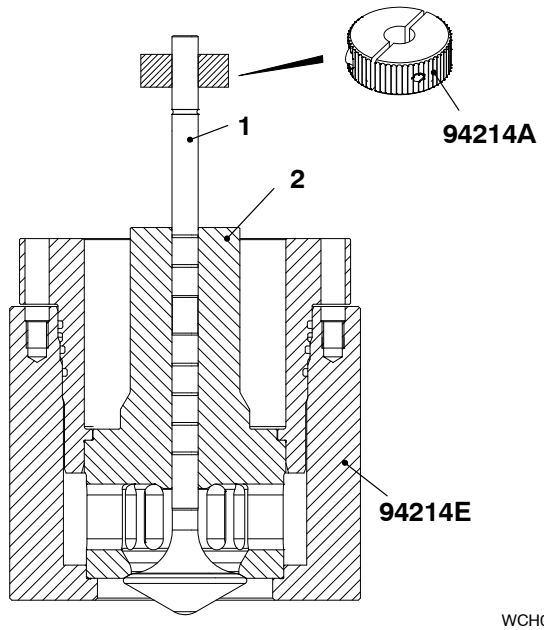


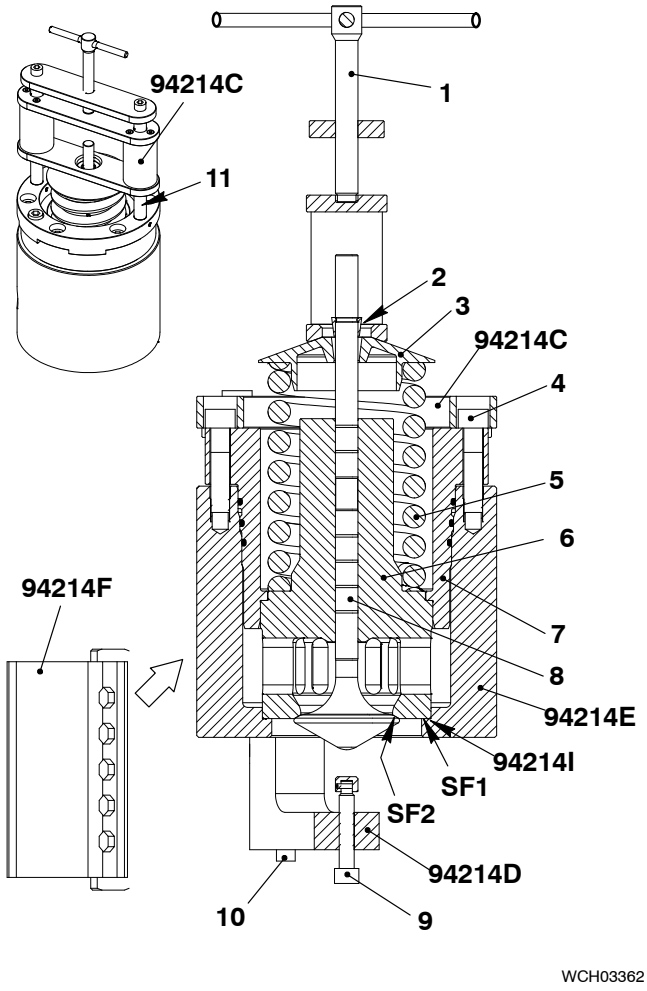
Fig. 9

5. Pressure Test

1) Apply lube oil to the valve spindle (6, Fig. 8).
2) Put the valve spindle (6) into the valve guide (5).
3) Install the bracket (94241D) to the bush (94214E) with the two M6x75 screws (8).
4) Turn the special screw (7) fully in.
5) Turn the T-handle (1) in to compress the spring (4).
6) Install the valve cotter (2) on the valve spindle (6).
7) Turn the T-handle (1) back to release the tension in the spring (4). Make sure that the valve cotter (2) is fully in the spring carrier (3).
8) Attach the pressure reducing valve (94241B) to the bush (94214E).
9) Attach a pressurized nitrogen supply to the pressure reducing valve (94241B).
10) Set the pressure reducing valve to 10 bar.
11) Apply a thin layer of WD40 (or an approved alternative) as a spray to the area of the valve seat SF2.
12) The test is satisfactory if:
    a) Up to five bubbles each second come from the valve seat.
    b) No bubbles come from the soft metal seal.
13) If the test results are different than those given, do the procedure given in paragraph 6.

6. Valve Seat – Lap

1) Remove the spring (5, Fig. 7), refer to paragraph 4.1.
2) Attach the knurled nut(94214A, Fig. 9) to the valve spindle as shown.
3) Apply lube oil to the valve spindle (1).
4) Put the valve spindle (1) into the valve guide (2).
5) Use oil-based lapping paste with a grain size of 0.5 to 4.0 microns to lap the valve seat.
6) Do the pressure test again (refer to paragraph 5). If the leakage is is unsatisfactory, replace valve spindle and the valve guide.



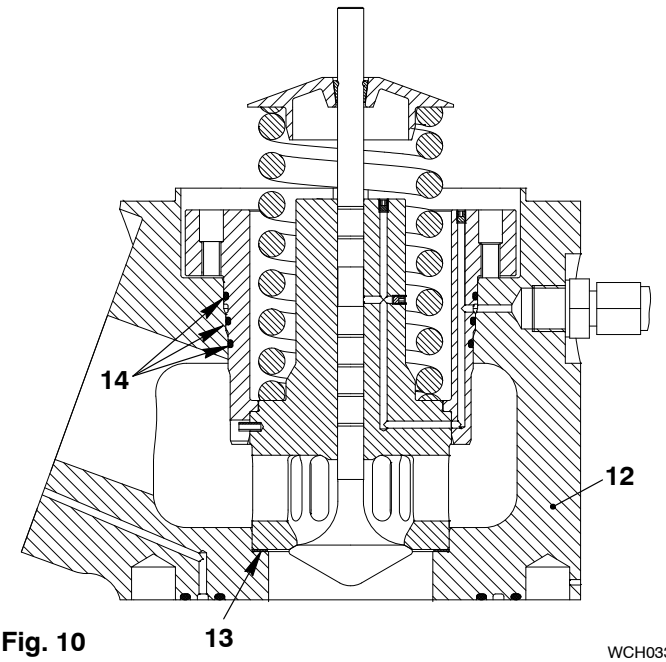
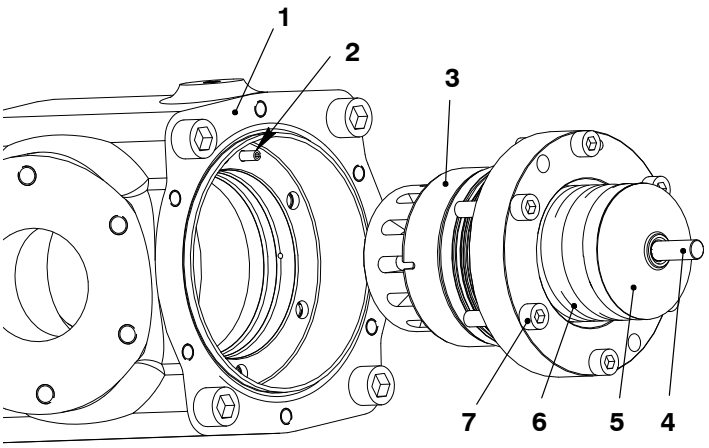


Fig. 10

7. Assemble

1) Insert the valve assembly (valve guide (7, Fig. 10), valve spindle (8), spring (5) and spring carrier (3)) into the bush (94214E).
2) Attach the spring press (94214C) and the valve assembly to the bush (94214E) with the six M10x45 screws (4).
3) Tighten the screws (4).
4) Attach the bracket (94241D) on the other side of the bush (94214E) with the two M6x75 screws (10) .
5) Turn the special screw (4) fully in.
6) Turn the T-handle (1) clockwise to compress the spring (5).
7) Put the valve cotter (2) on the spring carrier (3) in the groove of the valve spindle (8).
8) Slowly turn the T-handle (1) counterclockwise. Make sure the valve cotter (2) stays in the correct position.
9) Remove the spring press (94214C) and remove the valve assembly from the bush (94214E).
10) Clean all surfaces and bores of the housing (12).
11) Replace the O-rings (14) with new ones.
12) Apply oil to the O-rings (14).
13) Replace the gasket (13).



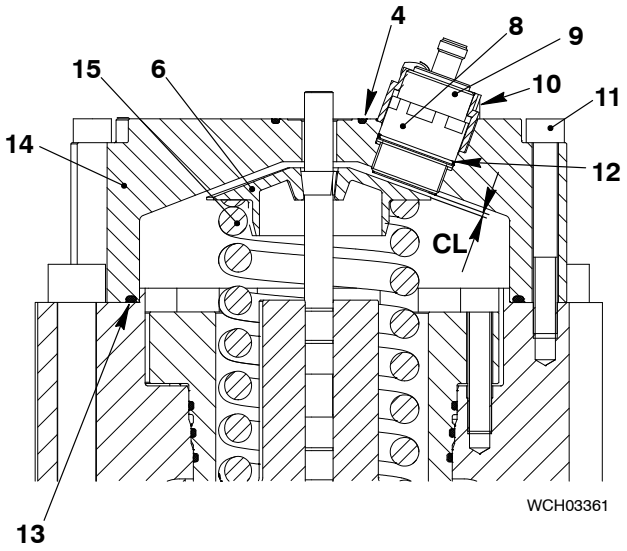


Fig. 11

14) Make sure the spring dowel pin (2, Fig. 11) is installed in the housing (1).

15) Put the valve assembly (valve guide (3), spring (15), spring carrier (6), valve spindle (4)) in the correct position in the housing (1) in the cylinder liner.

16) Apply Never Seez High Temperature Stainless to the six M10x50 screws (7).

17) Torque the six M10x50 screws (7) to 40 Nm.

18) Make sure the spring dowel pin (2) is installed in the housing (1).

19) Replace the O-ring (13) in the cover (14).

20) Apply Never Seez High Temperature Stainless to the six M10x80 bolts (11).

21) Make sure the surfaces of the cover (14) that touch are clean.

22) Install the cover (14) with the six M10x80 bolts (11).

23) Torque the six bolts (11) to 40 Nm.

24) Replace the O-ring (12) on the distance sleeve (8) (the distance sleeve is bonded on).

25) Put the valve stroke sensor (9) into the cover (14). Turn the valve stroke sensor clockwise until it touches the spring carrier (6).

26) Turn the valve stroke sensor (8) counterclockwise one turn. This gives a clearance (CL) of 1.5 mm.

27) Apply Never Seez High Temperature Stainless to the thread of sleeve (10).

28) Hold the sensor (9) and torque the sleeve (10) to 90 Nm.

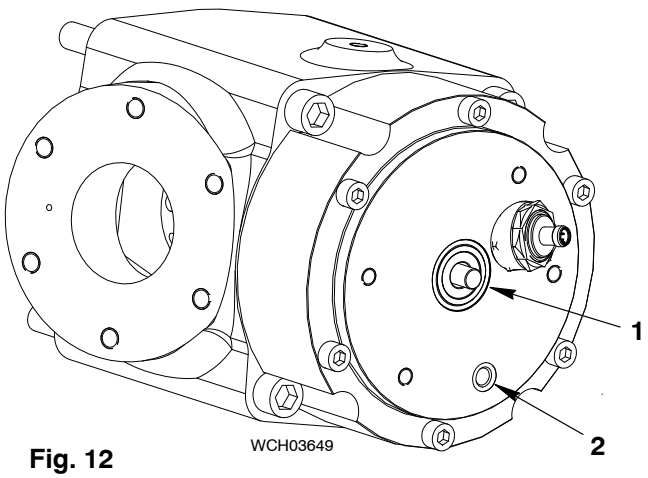


Fig. 12

29) Replace the O-ring (1, Fig. 12) and O-ring (2).

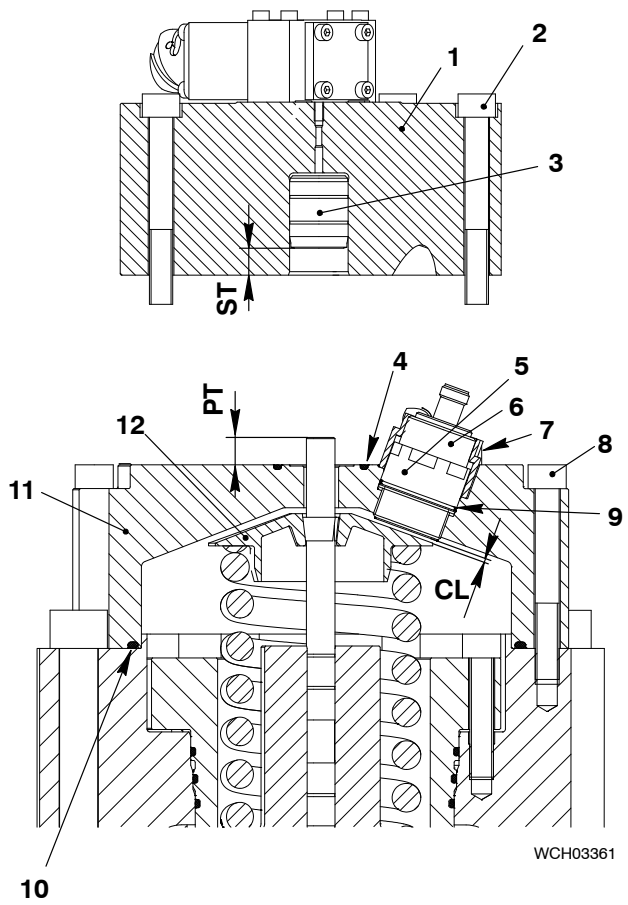
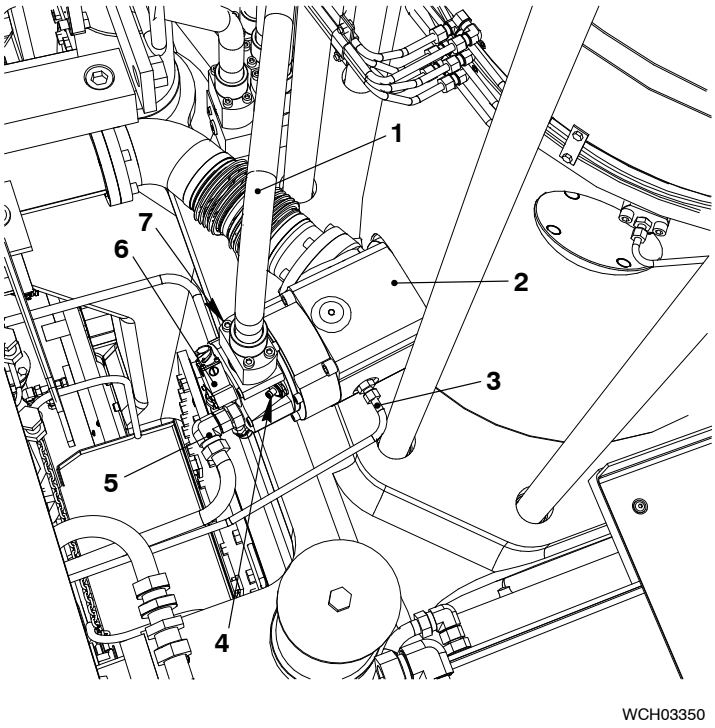


Fig. 13

30) Measure the distance (PT, Fig. 13) of the valve spindle to the cover (11).
31) Clean the piston hole in the cover (1).
32) Apply lubricating oil to the piston (3).
33) Put the piston (3) fully into the hole.
34) Measure the piston stroke (ST).
35) 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 fully close.

36) Clean the surfaces of the cover (11) and the cover (1).
37) Apply Never Seez High Temperature Stainless to the threads of the four bolts (2).
38) Attach the cover (1) with the four bolts (2).
39) Torque the four bolts (2) to 40 Nm.



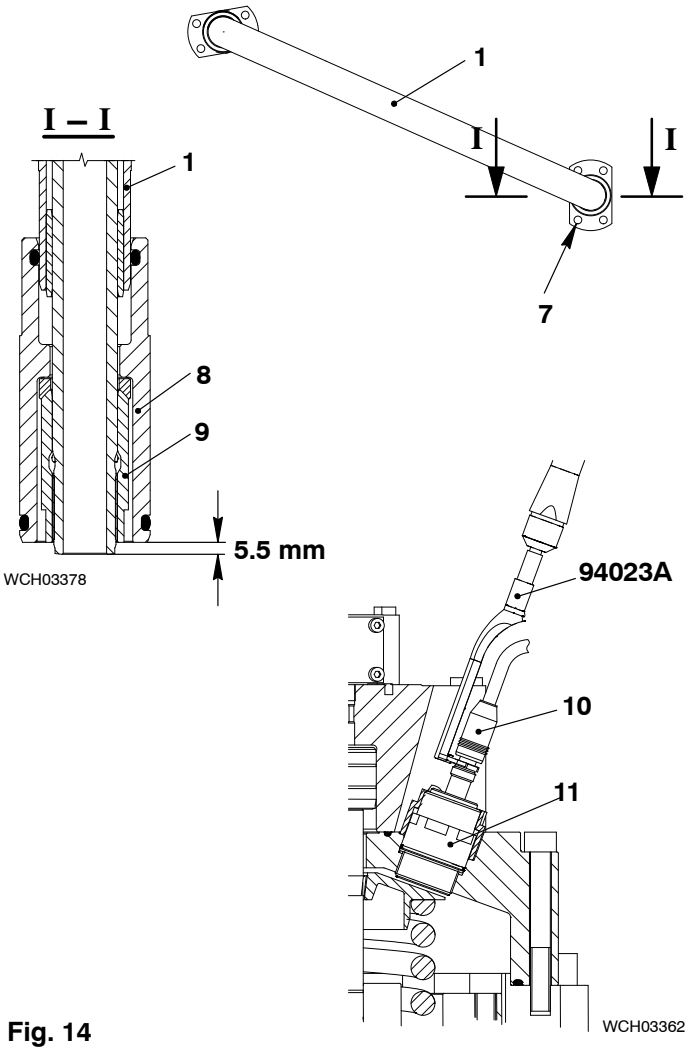


Fig. 14

8. Installation

1) Attach the return pipe (5, Fig. 14) and the lubrication pipe (3) to the GAV (2).
2) Connect the electrical connection to the rail valve (6).
3) Make sure that the sealing face of the oil pipe (1) has no damage. If there is damage, grind the sealing faces (refer to 8460–1, paragraph 3).
4) Adjust the claw (9) with an open end wrench until there is a distance of 5.5 mm between the claw and the end of the pipe (1) .
5) Apply oil to the eight screws (7).
6) Carefully attach the oil pipe (1) to the GAV (2) with the eight screws (7).
7) Torque symmetrically the eight screws (7) to 40 Nm.
8) Use the assembly tool (94023A) to attach the electrical connection (10) to the valve stroke sensor (11).
9) Do a stroke signal test of the GAV, refer to the Operation Manual 4002–2, paragraph 3.14 GAV Manual Valve Test.
10) Do a leak test of the Gas System, refer to the Operation Manual, 4002–2, 3.14 Gas Leak Test.
11) Do a test of the GAV, refer to the Operation Manual, 4002–2, 3.14 GAV Manual Test.

Intentionally blank

Work Card

Piston Rod Gland: Clean the Rings and Measure Worn Parts

Necessary Conditions

– Engine stopped
– Piston rod gland disassembled

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the piston rod gland, refer to 2303–1/A1

Tools and Consumables

Not applicable

Note: There are two procedures to remove and install the piston rod gland.

Primary Task

Clean the rings and measure worn parts

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	5.0 hours	Qty 1
Crew	5.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card
Piston Rod Gland: Replace the Rings

Necessary Conditions

– Engine stopped
– Piston rod gland disassembled

Necessary Spare Parts (each cylinder)

Extension spring	EX 23111	Qty 4
Extension spring	EX 23112	Qty 4
O-ring set and locking plates	EX 23145	Qty 1
Scraper ring set	EX 23200	Qty 1

Preparation

Remove the piston rod gland, refer to 2303–1/A1

Note: There are two procedures to remove and install the piston rod gland.

Tools and Consumables

Not applicable

Primary Task

Replace the rings

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	5.0 hours	Qty 1
Crew	5.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Assemble the Piston Rod Gland, 2303–1/A1

Intentionally blank

Removal, Disassemble, Measure Worn Parts, Assemble, Installation,

Tools:

2	Work platforms	94142	1	Distance piece (11 mm)	94231C
2	Work 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	2	Manual ratchets (H1, H2)	94016–009
1	Lifting tool	94235			

1. General

CAUTION

Damage Hazard: Do not turn the crankshaft when the work platforms (94142) or the work supports (94143) are installed in the crankcase. Damage to the equipment can occur.

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

Examine the piston rod gland for damage and worn parts on each overhaul of the piston (refer to 0380–1, Group 2303–1). If necessary, replace the unserviceable parts.

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

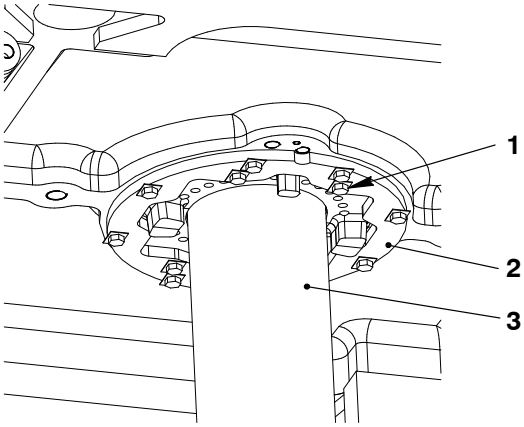
- Procedure One: The piston with the piston rod gland is removed from the engine. The piston rod gland is disassembled and assembled in the external piston support device (94350). For more data, refer to paragraph 2.1.
- Procedure Two: The piston stays in position. The piston rod gland is disassembled and assembled in the crankcase. For more data, refer to paragraph 3.

2. Procedure One

2.1 Piston Rod Gland – Removal

WARNING

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



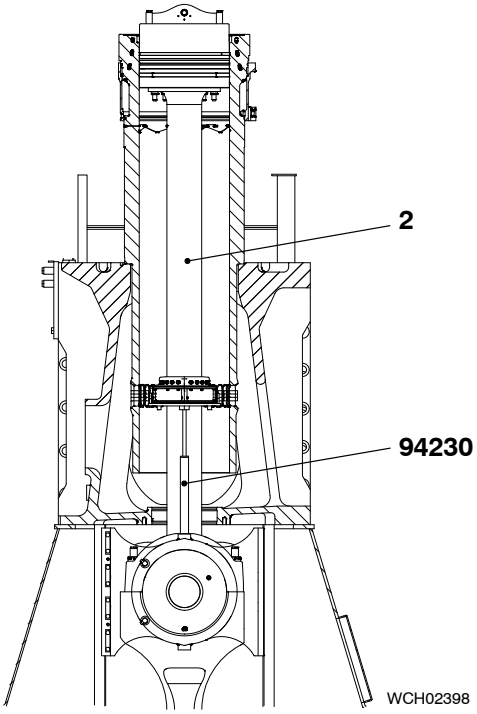


Fig. 1

1) Operate the turning gear to move the piston to BDC.
2) Lock the turning gear to prevent movement of the crankshaft.
3) Attach the two distance holders (94230, Fig. 1) to the piston rod (3).
4) Remove the four inner bolts (1) from the support (2).
5) Remove the piston and the piston rod gland, refer to 3403–1, paragraph 1, and paragraph 2.
6) Make sure that the piston rod gland (2, Fig. 2) is in the correct position on the two hinged covers (1).

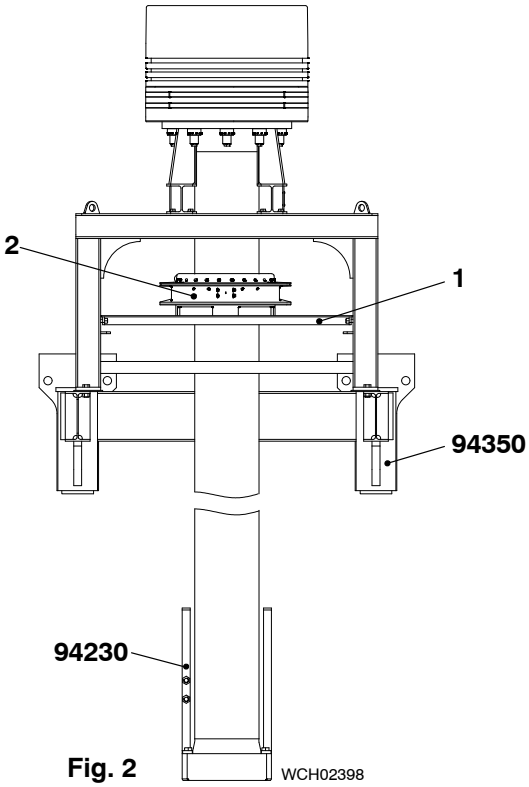


Fig. 2

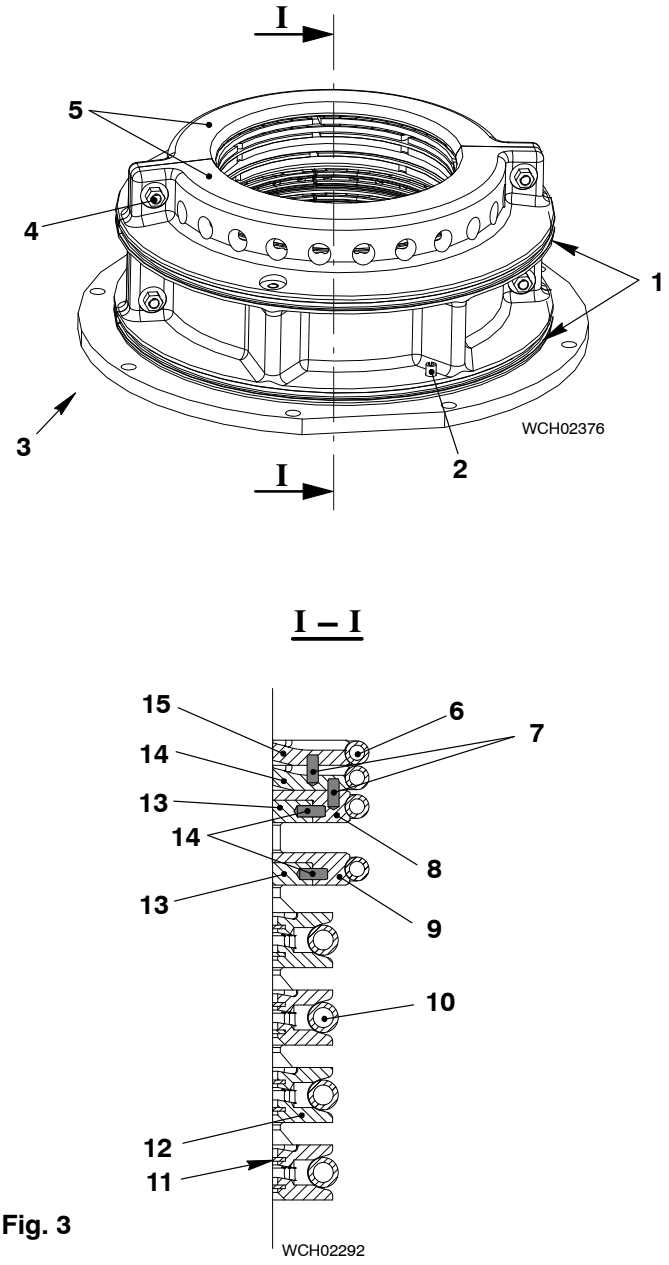


Fig. 3

2.2 Piston Rod Gland – Disassemble

1) Remove the four screws (4, Fig. 3) from the piston rod gland (3).
2) Remove the O-Rings (1).
3) Push the two parts of the housing (5) away from the piston rod.
4) Remove the two parts of the housing (5).
5) Remove the spring dowel pin (2).
6) Remove the parts that follow:
   - Tension springs (6, 10)
   - Scraper rings (15, 13, 11)
   - Gaskets (13, 8, 9)
   - Spring dowel pins (7, 14)
   - Ring supports (12).

2.3 Worn Parts – Measure

Note: You can find the maximum permitted dimensions of worn parts in 0330–1, Piston Rod Gland. If necessary, replace the worn parts.

1) Compare the dimension of the worn parts that follow:
   - Scraper rings (15, 13, 11)
   - Gaskets (14, 8, 9).
2) Make sure that the tension springs (6, 10) and O-ring (1) are serviceable. If necessary, replace the unserviceable parts.

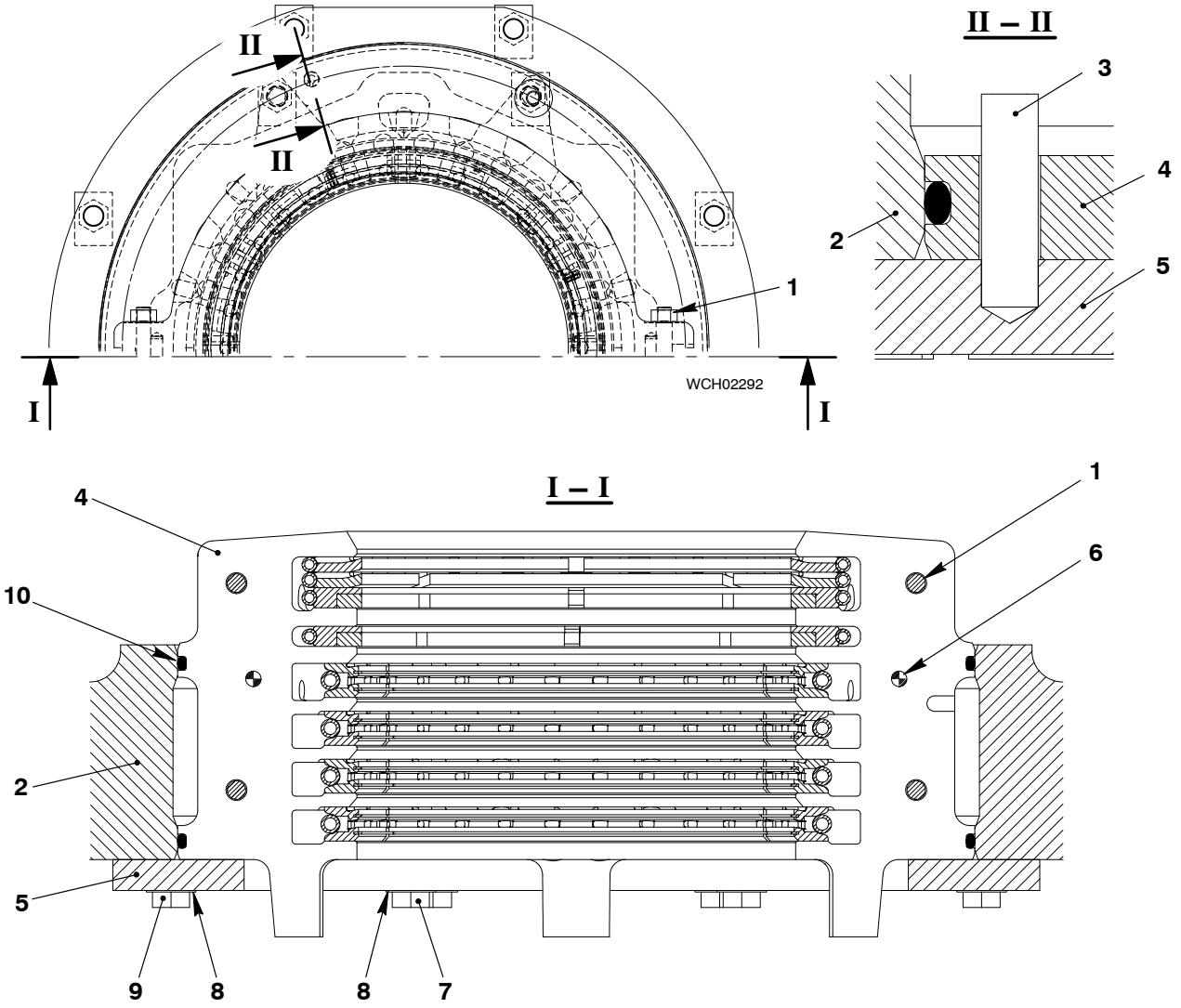
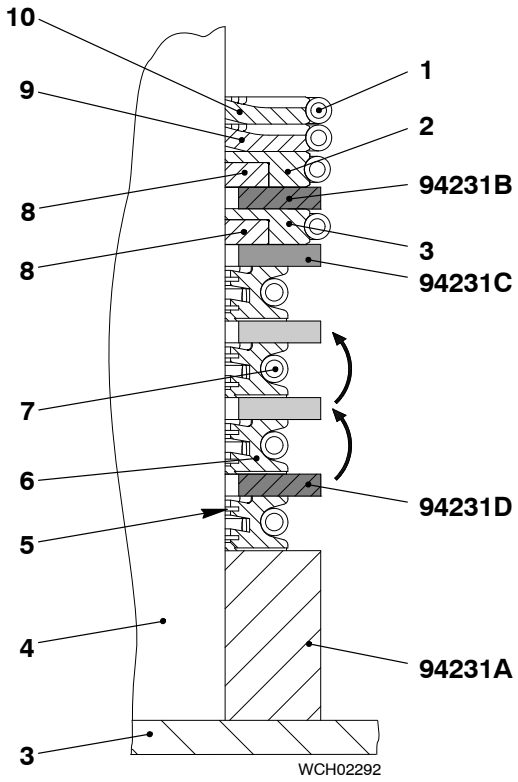


Fig. 4: Piston Rod Gland – Key to Parts

1 Bolt M12x55
2 Cylinder Block
3 Spring dowel pin
4 Housing, 2-part
5 Support
6 Dowel Pins
7 Inner Bolt M16x100
8 Lock-plate
9 Outer Bolt M16x100
10 O-Rings



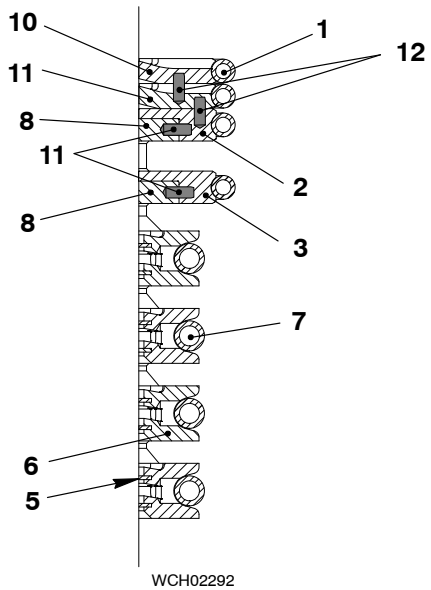


Fig. 5

2.4 Piston Rod Gland – Assemble

1) Attach the two parts of the clamp ring (94231A, Fig. 5) to the piston rod.
2) Put the three parts of the ring support (6) and the scraper rings (5) on the clamp ring (94231A).
3) Use the assembly tool 94233 to attach the tension spring (7) to the ring support (6).
4) Put the two parts of the distance piece 94231D (9.0 mm height) on the ring support (6).

Note: The height of the distance piece (4231C) is the same as the distance between the ring grooves in the housing.

5) Put the next three parts of the ring support (6) and the scraper rings (5) 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 (7) to the ring support (6).
7) Remove the distance piece (94231D).
8) Do the step 4) to step 7) above again until the four ring supports (6) are attached to the piston rod (4).
9) Put the two parts of the distance piece (94231C) (11.00 mm height) on the top ring support (6).

Note: One segment of the gaskets (8, 2, 3) has two holes for the horizontal spring dowel pins (11). The other three segments have only one hole. On the top of one segment of the gasket (2) there is one hole for a vertical spring dowel pin (12).

10) Put the four parts of the gaskets (8, 3) on the distance piece (94231C).
11) Make sure that all horizontal spring dowel pins (8) are installed.
12) Use the assembly tool (94233) to attach the tension spring (1) to the gaskets (8,3).
13) Remove the distance piece (94231C).

14) Put the two parts of the distance piece (94231B, Fig. 5) (12 mm height) on the gaskets (8, 3).

15) Put the four parts of the gaskets (8, 2) 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 (8) and the vertical spring dowel pin (12) are installed.

Note: On top of the scraper rings (9) there is one hole for a vertical spring dowel pin.

17) Put the scraper ring (9) on the gaskets (8, 12). Make sure that there is an equal distance between the four parts.

18) Make sure that the vertical spring dowel pins (12) are installed.

19) Use the assembly tool (94233) to attach the tension spring (1) to the scraper ring (9).

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

20) Put the scraper ring (10) on the top of the scraper ring (11). Make sure that there is an equal distance between the four parts.

21) Make sure that the vertical spring dowel pins (12) between the scraper ring (10) and the scraper ring (11) is correctly installed.

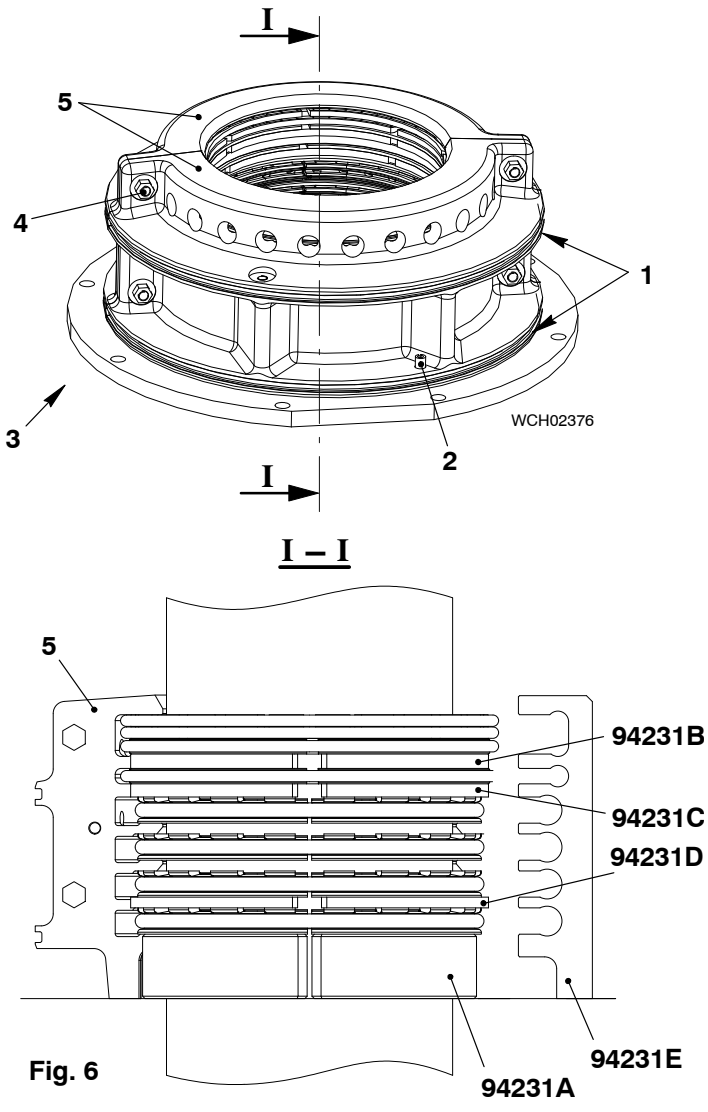


Fig. 6

22) Use the assembly tool (94233) to attach the tension spring (1) to the scraper ring (10).

23) Remove the distance piece (94231B).

24) Remove the clamp ring (94231A, Fig. 6).

25) Put the template (94231E) over the assembled rings. Make sure that all parts are in the correct position. If necessary, correct their positions.

26) Apply bearing oil to the piston rod and the assembled rings.

27) Push the two parts of the housing (5) over the assembled rings. Make sure that the dowel pins (2) are installed.

28) Torque the two screws (4) to the value given in 0352-2 Torque Values for Standard Screws, paragraph 1.

29) Apply oil to the new O-rings (1).

30) Attach the O-rings (1) to the two parts of the housing (5).

31) Put the dowel pin (2) in position.

2.5 Piston Rod Gland – Installation

To install the piston rod gland (1, Fig. 7), do the steps that follow:

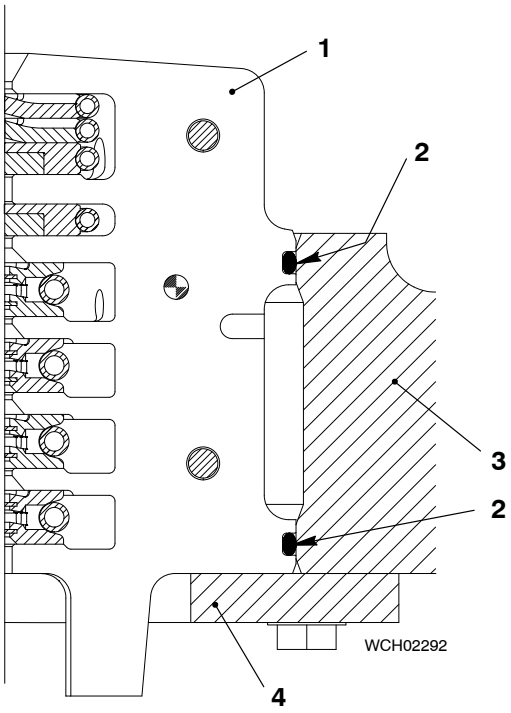


Fig. 7

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

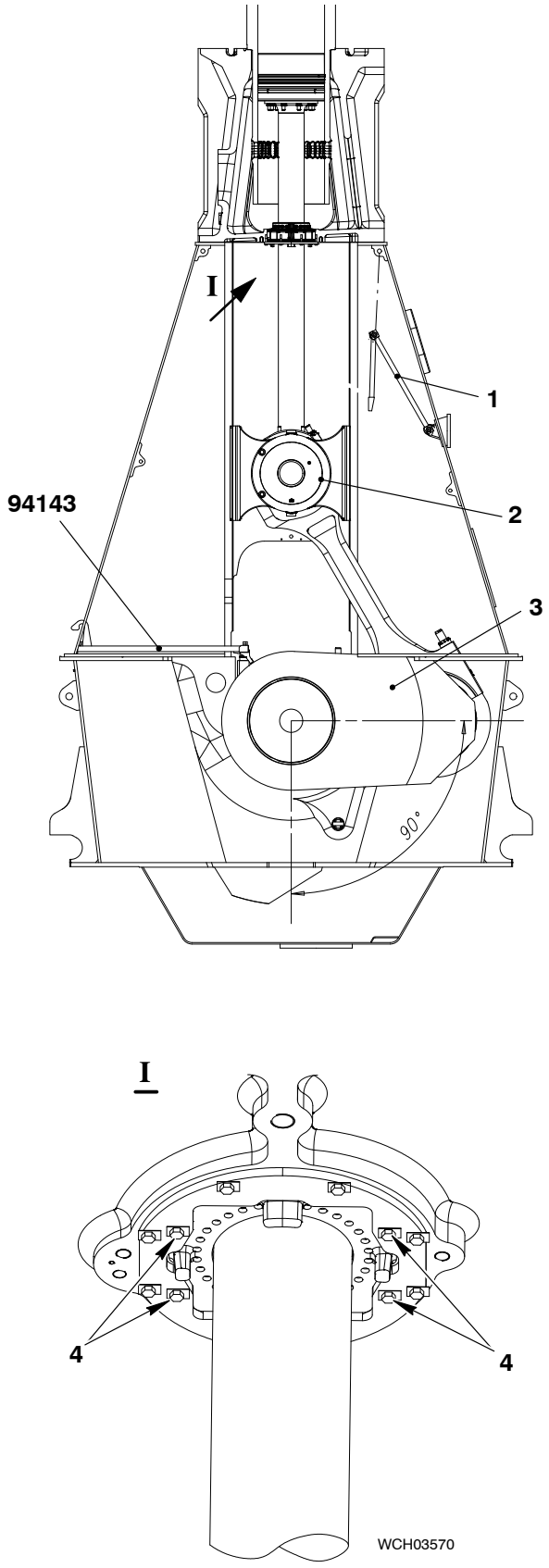


Fig. 8

3. Procedure Two

3.1 Piston Rod Gland – Removal

WARNING

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

1) Disconnect the toggle lever (1, Fig. 8) from crosshead (2).
2) Use a chain block to lift and hold the toggle lever (1) in the position shown.
3) Operate the turning gear to turn the crankshaft (3) 90° counterclockwise from TDC.
4) Install the work support (94143).
5) Lock the turning gear to prevent movement.
6) Remove four bolts (4) together with the lock-plates.

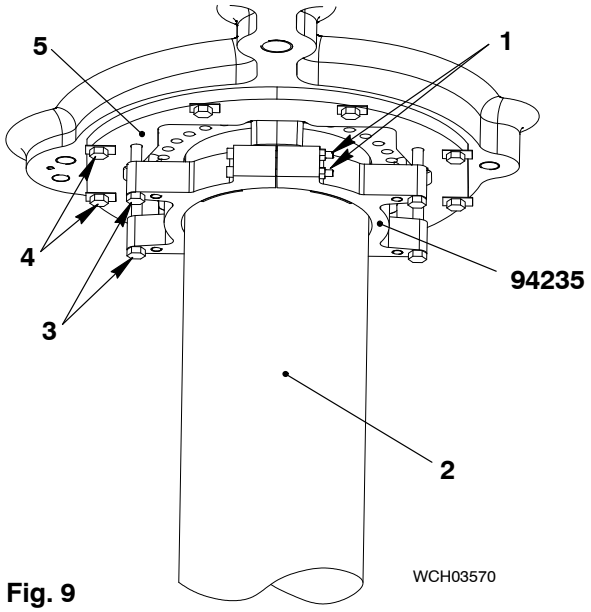


Fig. 9

7) Install the lifting tool (94235, Fig. 9) below the piston rod gland (5). Make sure that the piston rod gland touches the lifting tool.
8) Lightly tighten the four bolts (3).
9) Torque the four bolts (1) to 30 Nm.
10) Remove the eight bolts (4) together with the lock-plates.

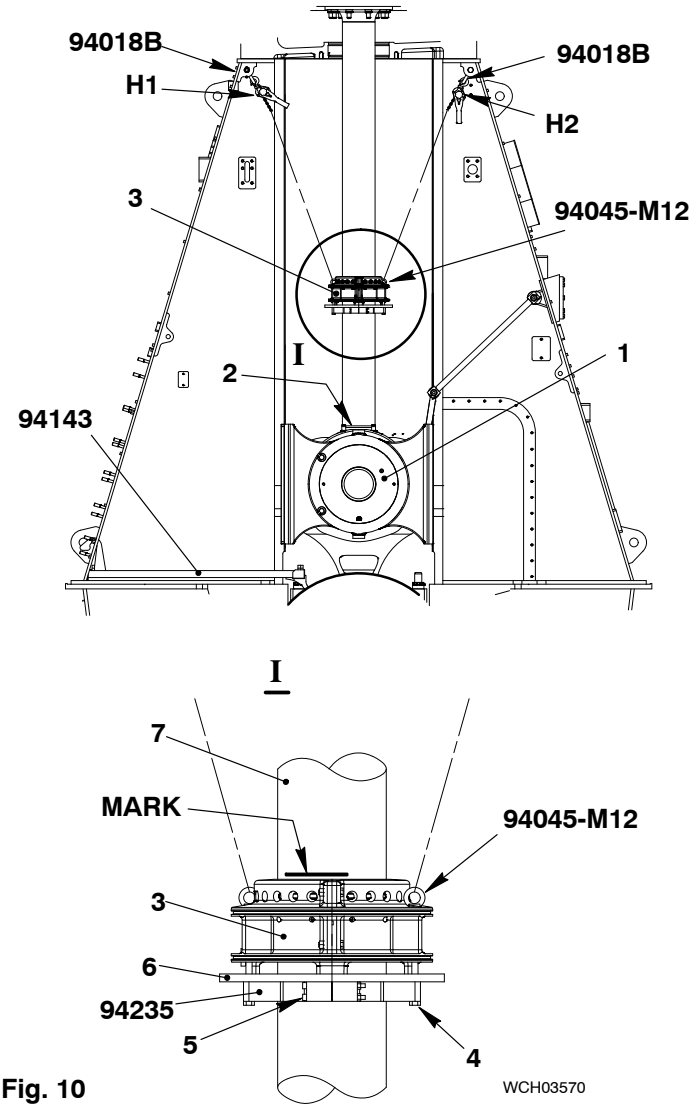


Fig. 10

11) Remove the work support (94143, Fig. 10).
12) Operate the turning gear to move the crosshead (1) to BDC.
13) Install the work support (94143).
14) Attach the shackles (94018B) to each side of the column.
15) Attach the manual ratchets (H1, H2) to the shackles (94018B).
16) Install the two eye bolts (94045-M12) to the piston rod gland (3).
17) Attach the manual ratchets (H1, H2) to the eye bolts (94045-M12) on the piston rod gland (3).
18) Operate the manual ratchets (H1, H2) to apply a light tension to the chains.
19) Make a mark as shown on the piston rod (7) to record the position of the piston rod gland (3).
20) Remove the four bolts (4) from the piston rod gland (3).
21) Slowly loosen the four bolts (5) on the tool (94235), sufficiently to pull down the tool together with the support (6).
22) Pull the tool (94235) down to the piston rod foot (2).

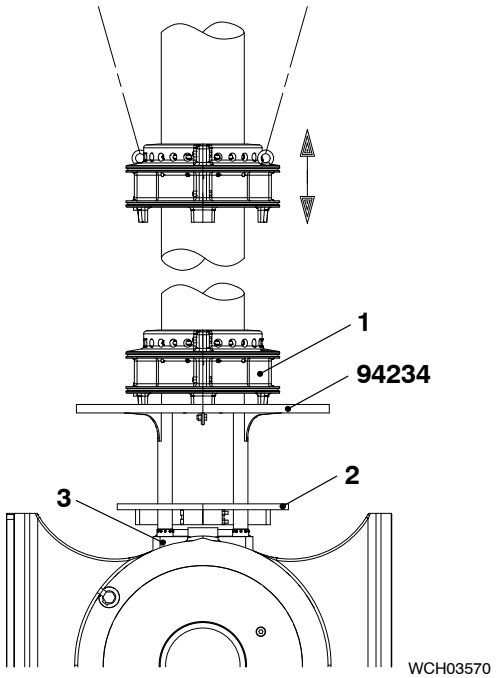


Fig. 11

CAUTION

Equipment Hazard. Do not get on the support (94344). The maximum permitted weight is 140 kg. Damage to equipment can occur.

23) Install the assembly platform (94234, Fig. 11) through the support plate (2) on the studs of the piston rod foot (3).

24) Operate the manual ratchets (H1, H2) to lower the piston rod gland on to the assembly platform (94234).

To disassemble the piston rod gland, do the procedure given in paragraph 2.2.

To measure worn parts, do the procedure given in paragraph 2.3.

To assemble the piston rod gland, do the procedure given in paragraph 2.4.

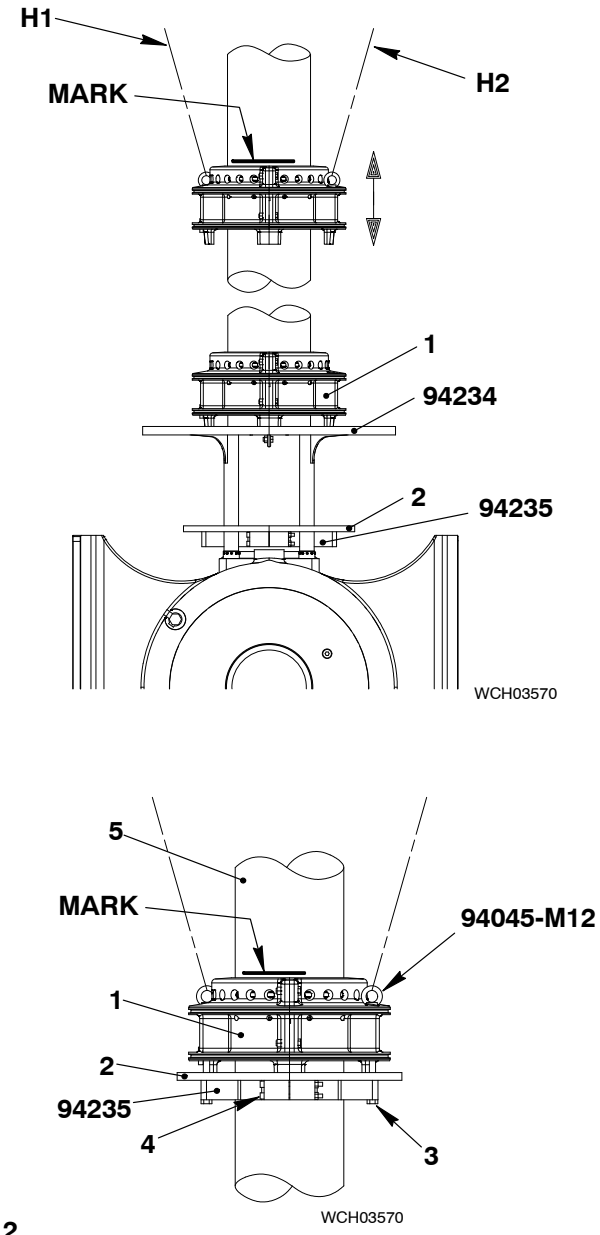


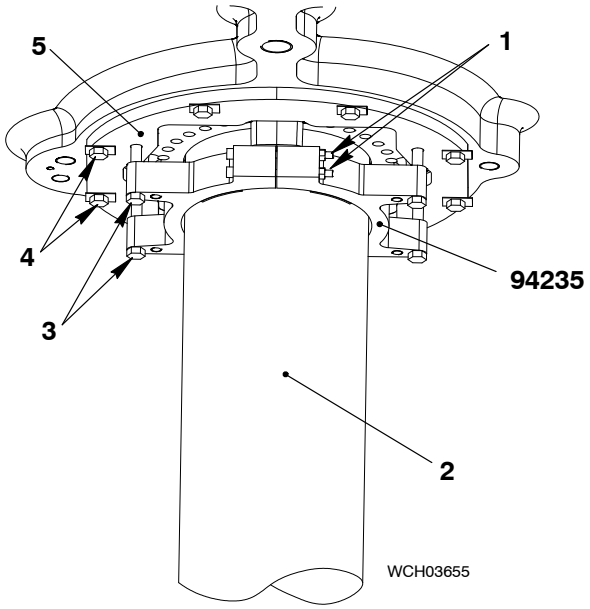
Fig. 12

3.2 Piston Rod Gland – Installation

1) Operate the manual ratchets (H1 and H2, Fig. 12) to lift the piston rod gland (1) to the mark you made before.
2) Remove the assembly platform (94234).
3) Lift the tool (94235) together with the support plate (2) up to the piston rod gland (1).
4) Attach the tool (94235) to the piston rod gland (1) with the four bolts (4).

Note: Make sure the dowel pin in the piston rod gland (1) is at the same position as the hole in the support plate (2).

5) Torque the four bolts (3) to 30 Nm.
6) Remove the work support (94143).
7) Operate the turning gear to move the piston rod gland (1) into the cylinder block (to TDC). Make sure that the dowel pin in the piston rod gland engages with hole in the support plate (2).
8) Install the work support (94143).



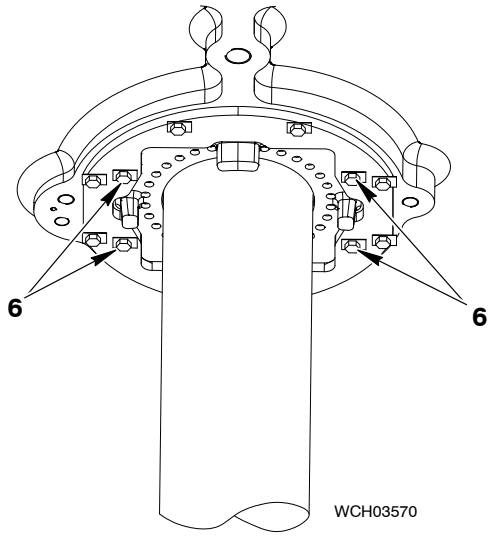


Fig. 13

9) Apply oil to the eight bolts (4, Fig. 13).
10) Install the eight new lock-plates and bolts.
11) Torque the eight bolts to 150 Nm.

Note: Make sure that the spring dowel pin in the piston rod gland goes into the hole in the support plate (5).

12) Bend the lock-plates to lock the eight bolts (4).
13) Remove the four bolts (3).
14) Loosen the four bolts (1).
15) Remove tool (94235).
16) Apply oil to the four bolts (6).
17) Install the four new lock-plates and bolts (6).
18) Torque the four bolts (6) to 150 Nm.
19) Bend the lock-plates to lock the four bolts (6).

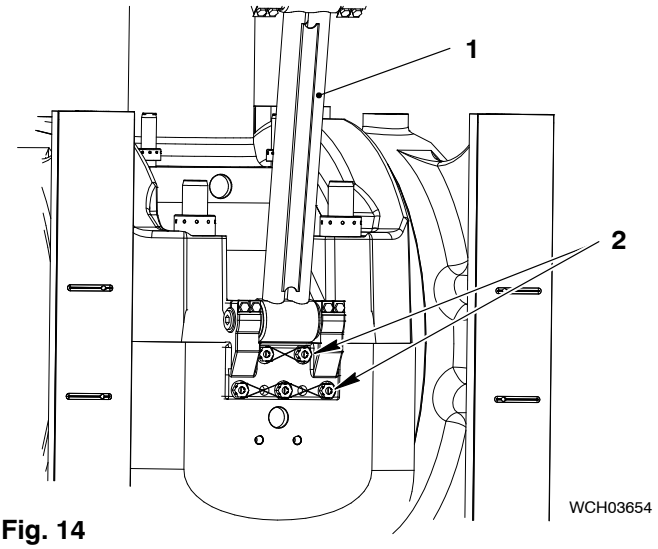


Fig. 14

20) Attach the toggle lever (1, Fig. 14) to the crosshead.
21) Tighten the five M20x70 bolts (3).
22) Lock the five bolts (2) with wire as shown.
23) Remove all tools and equipment from the work area.

Work Card
Cylinder Cover

Necessary Conditions

– Engine stopped
– Cylinder cover removed

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the cylinder cover, refer to 2708–1/A1

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do a check of the combustion space	Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1

Related Procedures

Intentionally blank

Cylinder Cover and Top Water Guide Jacket
Removal and Installation

Tools:

1	Lifting tool (option)	94215
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

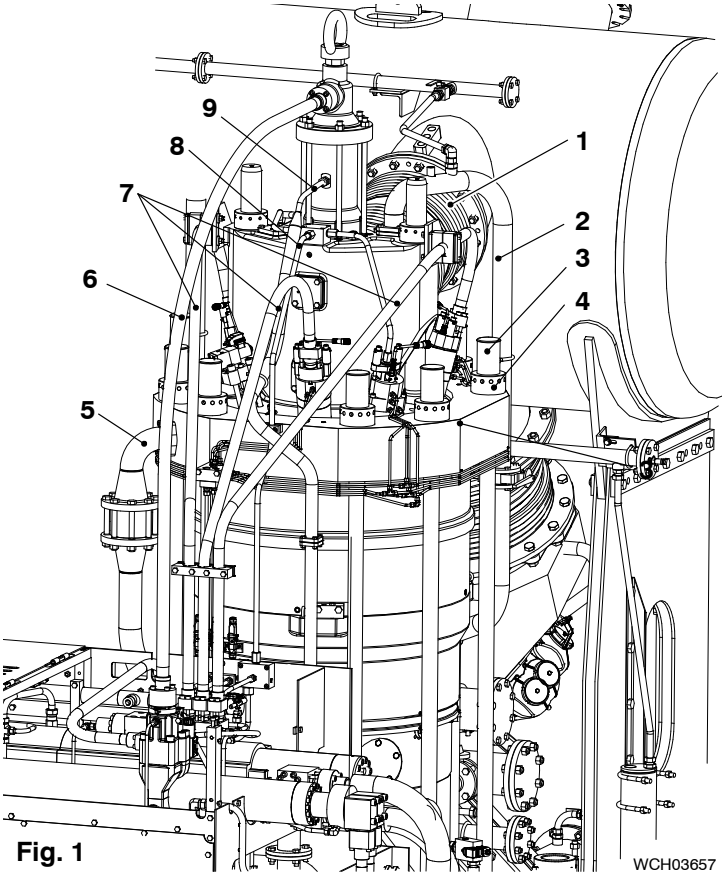


Fig. 1

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.
2) Let the engine temperature decrease.
3) Make sure that all tools and equipment are clean.
4) Close manually the starting air supply valves 930-V03 and 930-V04, refer to the Operation Manual 4003–2, Control Diagram.
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.
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 (7, Fig. 1) and pilot fuel pipe (8).
9) Remove the hydraulic pipe (6), refer to 8460–1.
10) Remove the three HP fuel pipes (7), 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 (2).
13) Remove the cooling water pipe (2).
14) Remove the expansion piece (1), refer to 2751–1, paragraph 2, step 3) to step 9).
15) Close the starting air valve. Disconnect the air pipe (5) from the cylinder cover.
16) Remove the oil leakage pipe (9) 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.

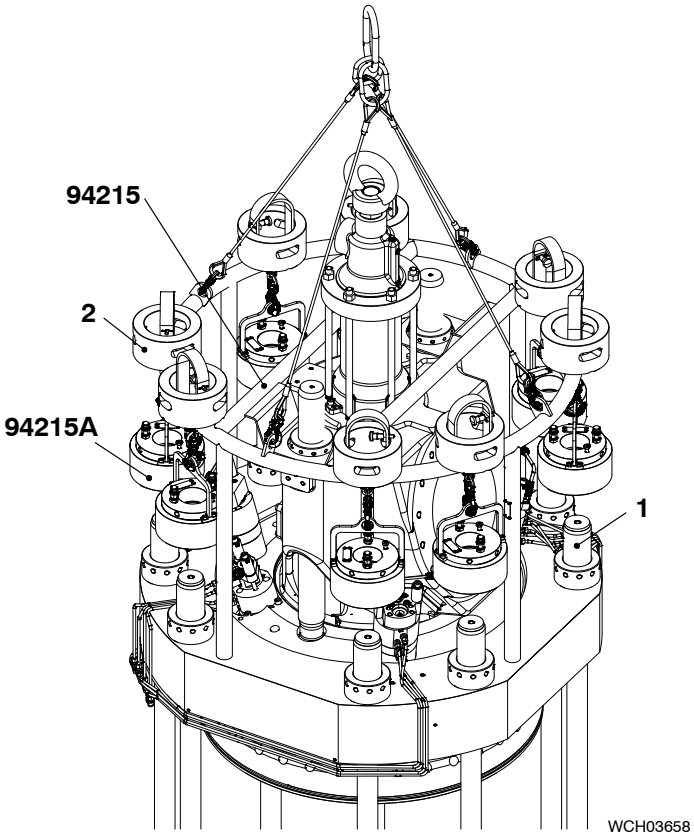


Fig. 2

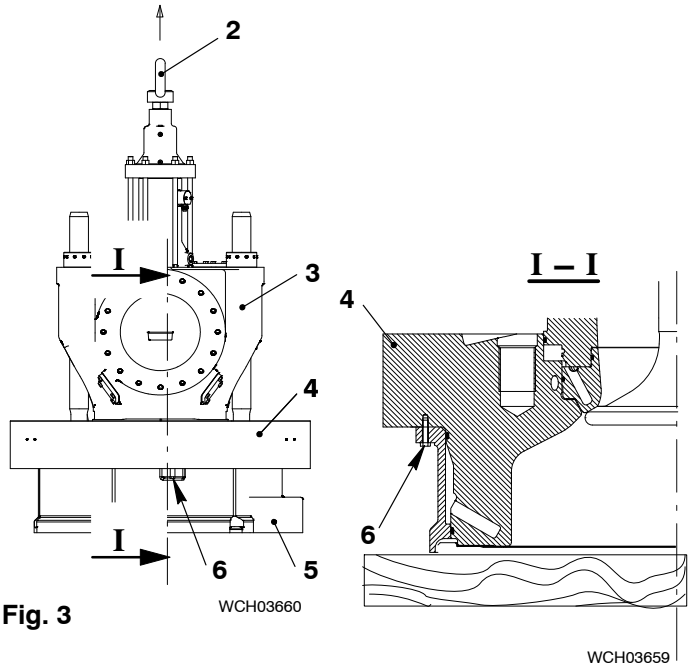


Fig. 3

2. Removal

1) Operate the engine room crane to put the lifting tool (94215, Fig. 2) in position above the cylinder cover.
2) Lower the lifting tool (94215) to get the eight pre-tensioning jacks (94215A) directly above the elastic studs (1).
3) Attach the pre-tensioning jacks (94215A) and the distance sleeves (2) on the elastic studs (1).
4) Connect the jacks to the hydraulic pump, refer to 9403–2.
5) Apply tension to the elastic bolts, refer to 9403–4.
6) Remove the six round nuts from elastic studs (1).
7) Remove the tool (94215).

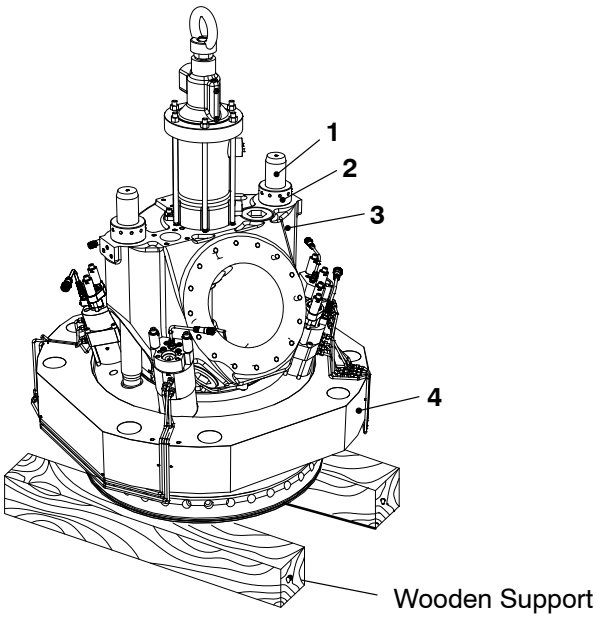
CAUTION

Injury Hazard: The weight of the cylinder cover, the top water guide jacket and the exhaust valve is approximately 3700 kg. To prevent injury, use the correct equipment for removal.

8) Attach the engine room crane to the eye bolt (1, Fig. 3) on the exhaust valve (2).
9) Carefully lift the cylinder cover (3) together with the exhaust valve (2) and the top water guide jacket (5).
10) Lower the cylinder cover on to wooden supports.
11) Remove the three screws (4) from the cylinder cover (3).

Note: During step 12) make sure that the top water guide jacket stays on the wooden supports. If this does not occur, use a mallet to move the top water guide jacket.

12) Use 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.



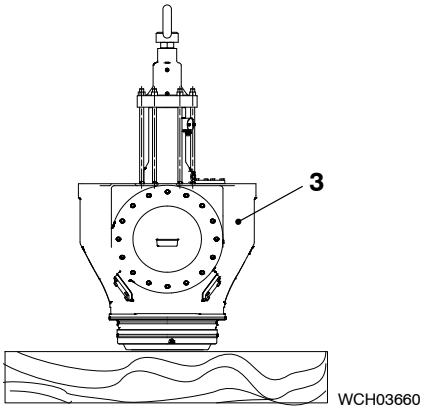


Fig. 4

13) Lift, then lower the cylinder cover (4, Fig. 4) and the exhaust valve assembly (3) on to wooden supports.
14) Apply tension to the elastic studs (1), refer to 9403–4
15) Remove the round nuts (2).
16) Operate the engine room crane to lift the exhaust valve assembly (3) approximately 10 mm. Make sure that the cylinder cover stays on the wooden supports.
17) Fully lift the exhaust valve assembly (3) from the cylinder cover.
18) Carefully lower the exhaust valve assembly (3) on to wooden supports.

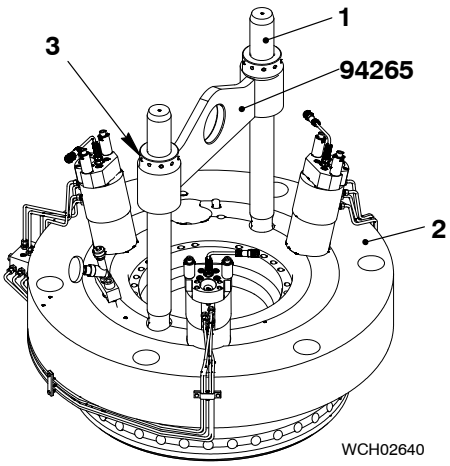


Fig. 5

19) Attach the tool (94265, Fig. 5) to the cylinder cover as shown.
20) Attach the round nuts (3) to the elastic studs. Tighten the round nuts.
21) Attach the the engine room crane to tool (94265).
22) Operate the engine room crane to move the cylinder cover (2) to an applicable area.
23) Remove the tool (942656).
24) Remove and discard all O-rings.
25) Remove and discard the soft iron joint ring.

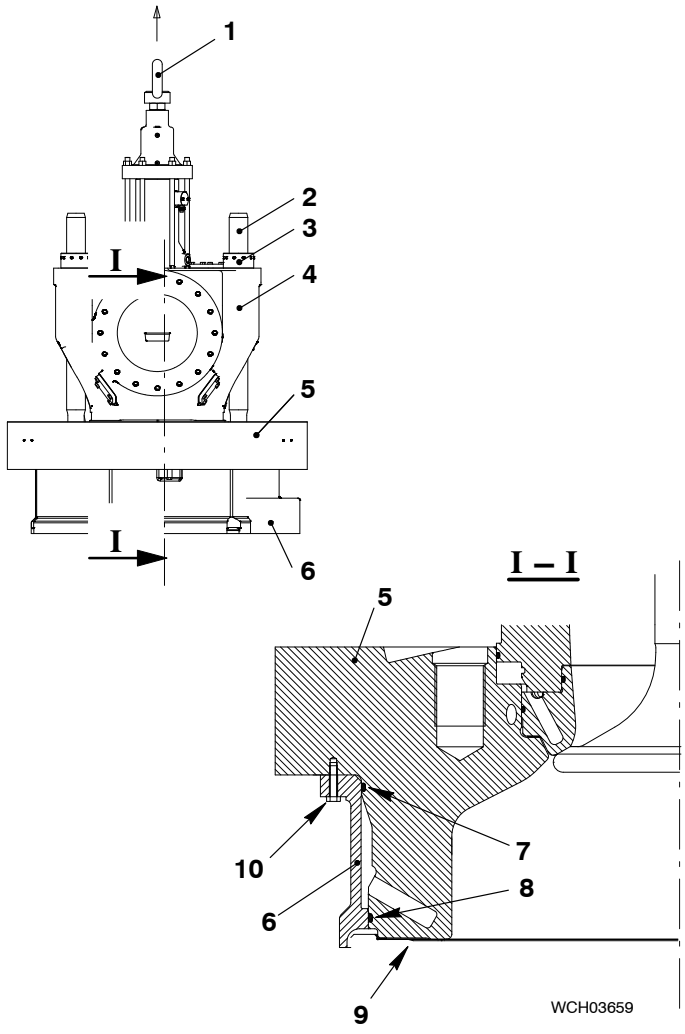


Fig. 6

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 (7 and 8, Fig. 6).
4) Install new O-rings (7, 8).
5) Put a new soft iron joint ring (9) 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 (2).
9) Put oil on the threads of all elastic studs (2).
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.
15) Tighten the round nuts (3).
16) Lift the exhaust valve assembly (4) together with the cylinder cover (5).
17)
18) Carefully lower the exhaust valve assembly (4) and the cylinder cover (5) on to the top water guide jacket (6).
19) Tighten the screws (10).
20) Lift the exhaust valve assembly (4), 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).

21) Carefully lower the exhaust valve assembly (4), cylinder cover (5) and top water guide jacket (6) on to the cylinder liner (11).
22) Remove the engine room crane from the eye bolt (1).
23) Apply tension to the elastic bolts, refer to 9403–4.
24) Remove the six round nuts from elastic studs (1).
25) Remove the tool (94215).

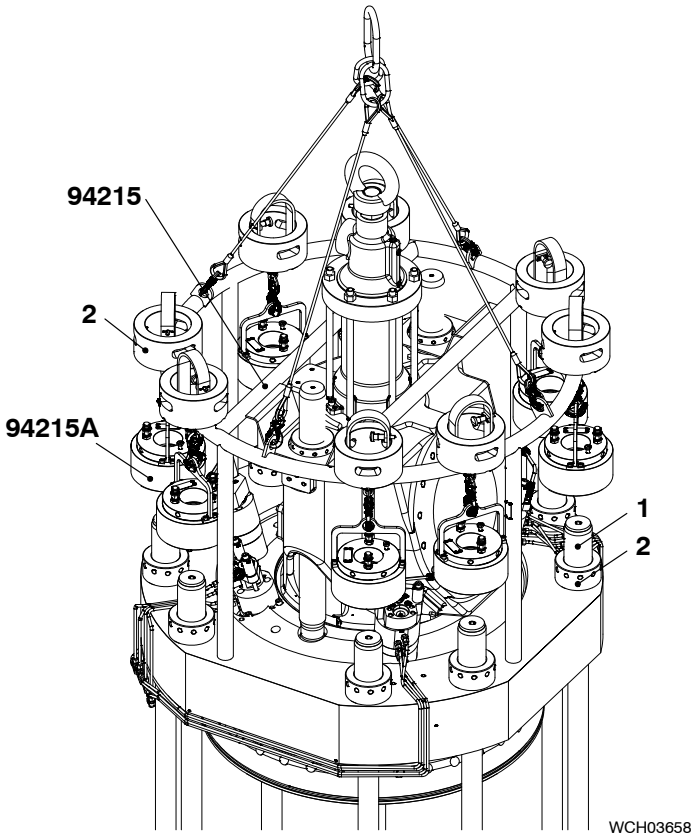


Fig. 7

26) Attach the eight round nuts (2, Fig. 7) to the elastic studs (1).
27) Use the lifting tool (94215) to move the eight pre-tensioning jacks (94215A) on to the elastic studs (1).
28) Attach the pre-tensioning jacks (94215A) and the distance sleeves (2) on the elastic studs (1).
29) Connect the jacks to the hydraulic pump, refer to 9403–2.
30) Apply tension to the elastic bolts, refer to 9403–4.
31) Tighten the eight round nuts (2).
32) Remove the tool (94215).

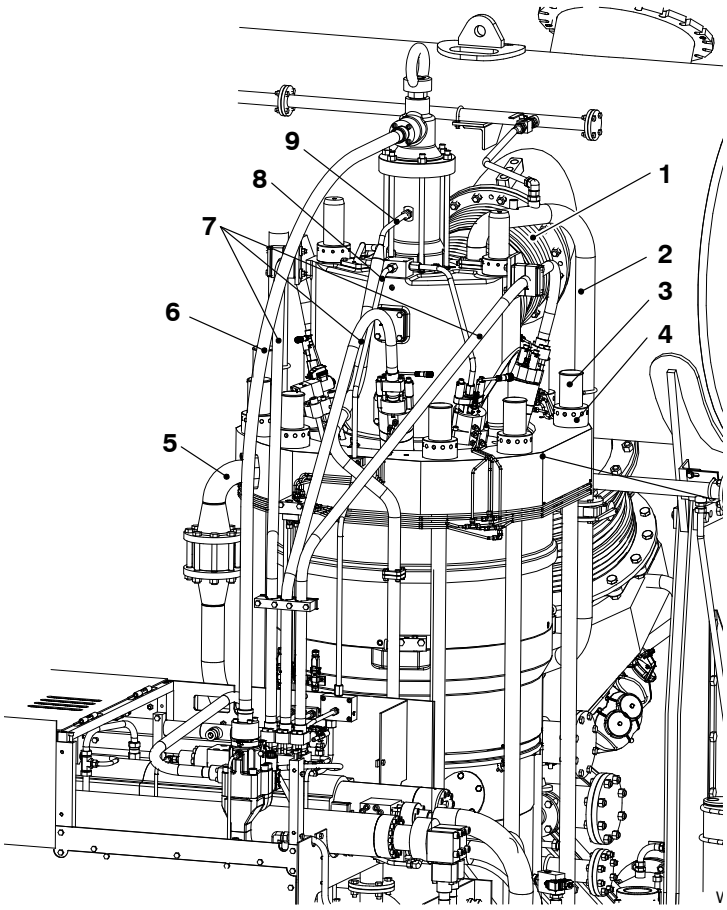


Fig. 7

3.1 Completion

1) Install the expansion piece (2), refer to 2751–1, paragraph 3.
2) Install the hydraulic pipe (6), refer to 8460–1.
3) Install the three HP fuel pipes (7), refer to 8733–1.
4) Install the applicable HP pilot fuel pipes, refer to 8790–1.
5) Install the cooling water pipe (2).
6) Install the expansion piece (1), refer to 2751–1, paragraph 2, step 14) to step 21).
7) Connect the air pipe (5) to the cylinder cover.
8) Install the oil leakage pipe (9) and the pilot fuel pipe (8).
9) Connect the air pipe to the exhaust valve housing.
10) Connect all connections from the injectors. Use your recorded notes for the correct connections.
11) Connect all other connections to the cylinder cover and the exhaust valve.
12) Open the valves you closed before (one valve each time) and do a check for leaks.
13) Set to on the cooling water pump.
14) Make sure that the cooling water is at the usual operation pressure and temperature.
15) Do a check for leaks.
16) Remove all tools and equipment from the work area.

Injection Valve – Grind Sealing Face

Tools:

1	Grinding device	94270–01
1	Stencil	94270–1D

4. Sealing Face – Grind

1) Make sure that the stop sleeve (7) is attached to the spindle (8) of the device (94270–01, Fig. 1).
2) Make sure that the O–rings (2) are serviceable.
3) Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
4) Put the stencil (94270–1D) on the emery cloth.
5) Use a pencil or a ball pen to make the inner shape.
6) Cut out accurately the shape.
7) Attach the shape (3) to the device (94270–01) with the clamp (4) and the Allen screw (5).
8) Torque the Allen screw (5) to 4.0 Nm.
9) Apply a thin layer of oil to the O–rings (2).
10) Attach the device (94270–01) to the cylinder cover (9) with the two stud bolts (1).
11) Attach an electric drill to the spindle (2).
12) Operate the electric drill at a maximum of 500 rpm.
13) Apply a light pressure and start grinding.
14) Regularly remove the unwanted material from the device (94270–01) and the bore (6).
15) Make sure that the circular marks around the sealing face are concentric.
16) Change the emery cloth for a smoother grade, then do step 3) to step 15) again until you get a smooth finish.
17) Clean the bore (6).

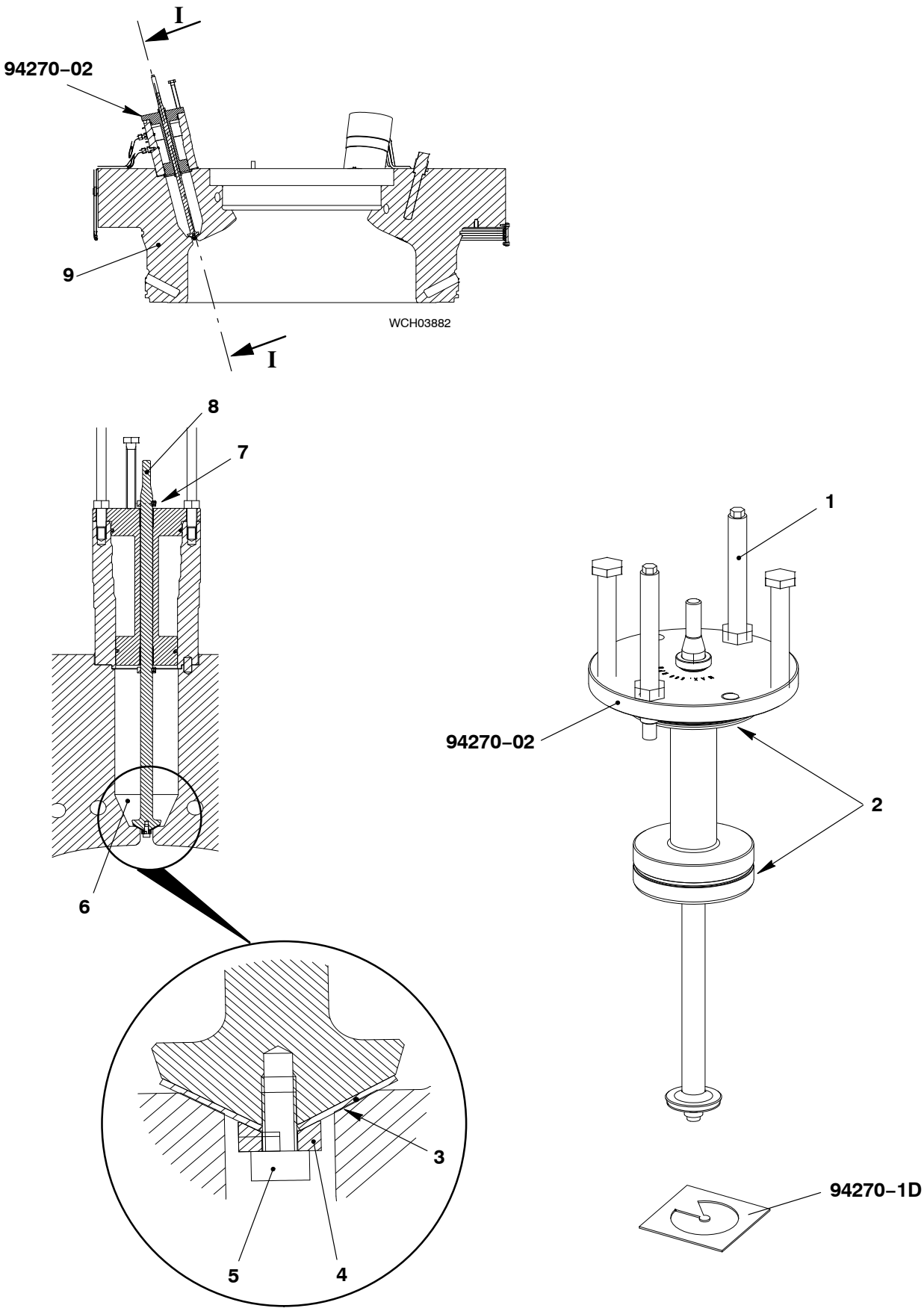


Fig. 1

Pilot injection Valve – Grind Sealing Face

Tools:

1	Grinding device	94270–02	2	Stud bolts	94270F
1	Stencil	94270–2D			

5. Sealing Face – Grind

1) Make sure that the stop sleeve (2) is attached to the spindle (1) of the grinding device (94270–02, Fig. 1).
2) Make sure that the two O–rings (7) are serviceable.
3) Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
4) Put the stencil (94270–2D) on the emery cloth.
5) Use a pencil or a ball pen to make the inner shape.
6) Cut out accurately the shape (4).
7) Attach the shape (4) to the device (94270–02) with the clamp (6) and the Allen screw (5).
8) Torque the Allen screw (5) to 8.0 Nm.
9) Apply a thin layer of oil to the O–rings (7).
10) Attach the device (94270–02) to the cylinder cover with the two stud bolts (94270F).
11) Attach an electric drill to the spindle (1).
12) Operate the electric drill at a maximum of 500 rpm.
13) Apply a light pressure and start grinding.
14) Regularly remove the unwanted material from the device (94270–02) and the bore (3).
15) Make sure that the circular marks around the sealing face are concentric.
16) Change the emery cloth for a smoother grade, then do step 3) to step 15) again until you get a smooth finish.
17) Clean the bore (3).

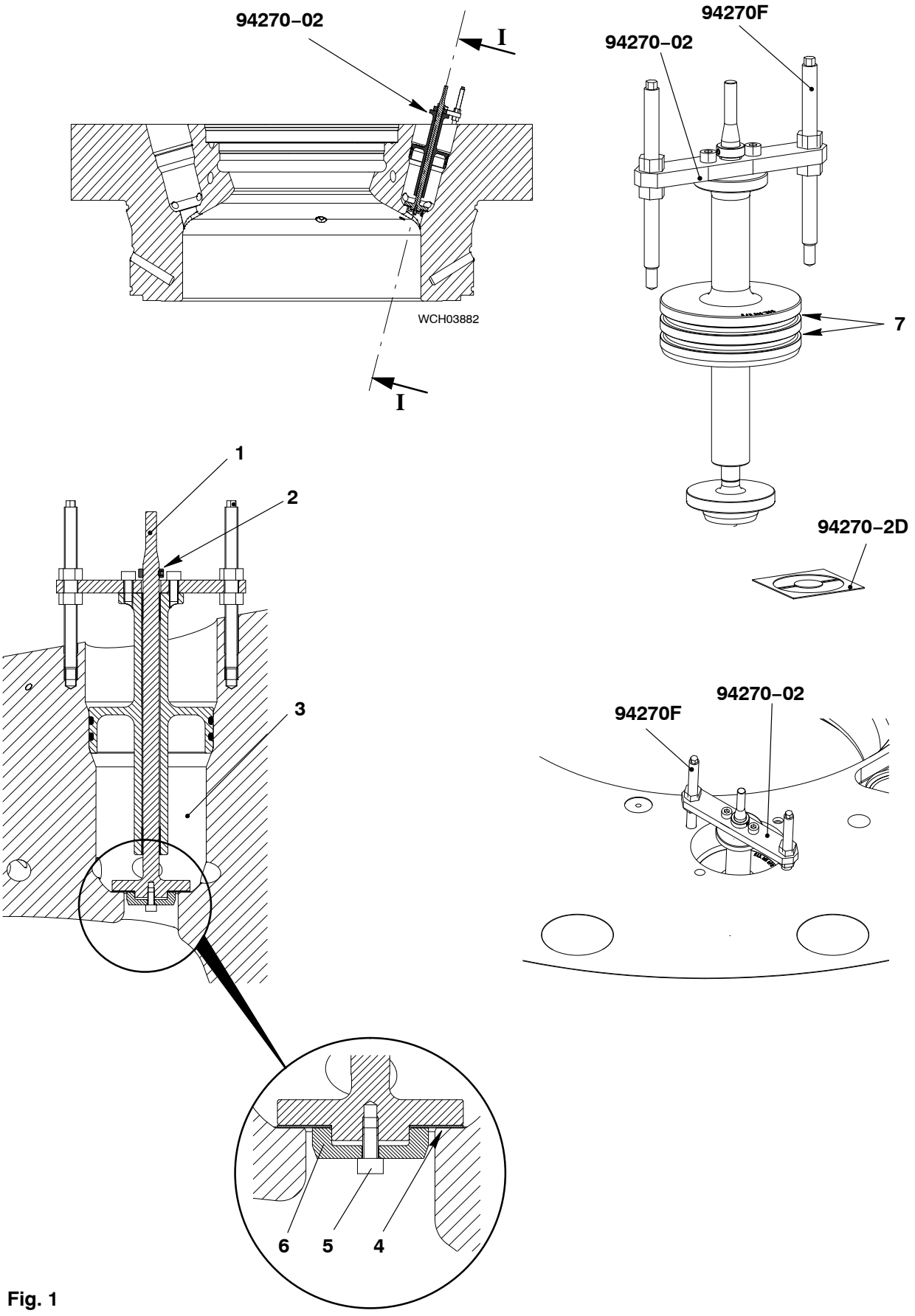

94270-02
I
WCH03882
I
94270F
94270-02
7
94270-2D
1
2
3
94270-02
94270F
6
5
4

Fig. 1

Prechamber – Grind Sealing Face

Tools:

1	Grinding device	94270–03
1	Stencil	94270–3D

6. Sealing Face – Grind

1) Make sure that the stop sleeve (2) is attached to the spindle (1) of the grinding device (94270–03, Fig. 1).
2) Use the applicable grade of emery cloth related to the quantity of metal you want to remove.
3) Put the stencil (94270–3D) on the emery cloth.
4) Use a pencil or a ball pen to make the inner shape.
5) Cut out accurately the shape (4).
6) Attach the shape (4) to the device (94270–03) with the clamp (6) and the Allen screw (5).
7) Attach the device (94270–03) with the two M12x30 Allen screws (3) as shown.
8) Attach an electric drill to the spindle (1).
9) Operate the electric drill at a maximum of 500 rpm.
10) Apply a light pressure and start grinding.
11) Regularly remove the unwanted material from the device (94270–03) and the bore (7).
12) Make sure that the circular marks around the sealing face are concentric.
13) Change the emery cloth for a smoother grade, then do step 3) to step 12) again until you get a smooth finish.
14) Clean the bore (7).

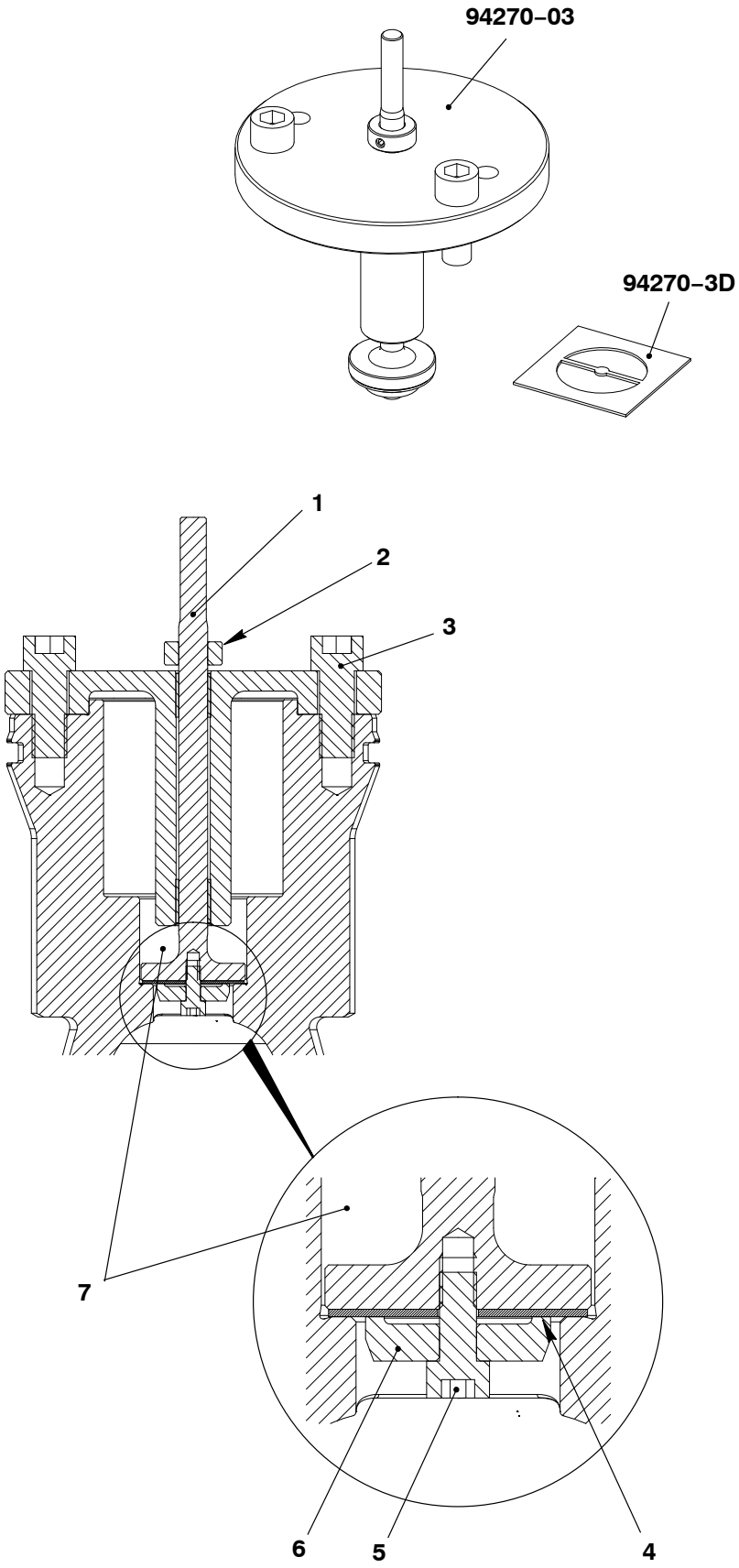


Fig. 1

Work Card

Injection Valve: Replace the Nozzle Body and Nozzle Tip

Necessary Conditions

– Engine stopped
– Injection valve removed

Necessary Spare Parts (each cylinder)

Nozzle tip	EX 27244	Qty 2
Nozzle body	EX 96144	Qty 2
Spare kit – seals	EX 96146	Qty 2

Preparation

Remove the injection valve, refer to 2722–1/A1

Tools and Consumables

Nozzle removal tool	94278A	Qty 1
Nozzle installation tool	94278B	Qty 1

Primary Task

Replace the nozzle body and nozzle tip

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card
Injection Valve: Replace

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Injection valve	EX 27200	Qty 2
Nozzle tip	EX 27244	Qty 2

Preparation

Remove the applicable HP fuel pipe, refer to 8733−1/A1

Tools and Consumables

Nozzle removal tool	94278A	Qty 1
Nozzle installation tool	94278B	Qty 1

Primary Task

Replace the injection valve

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

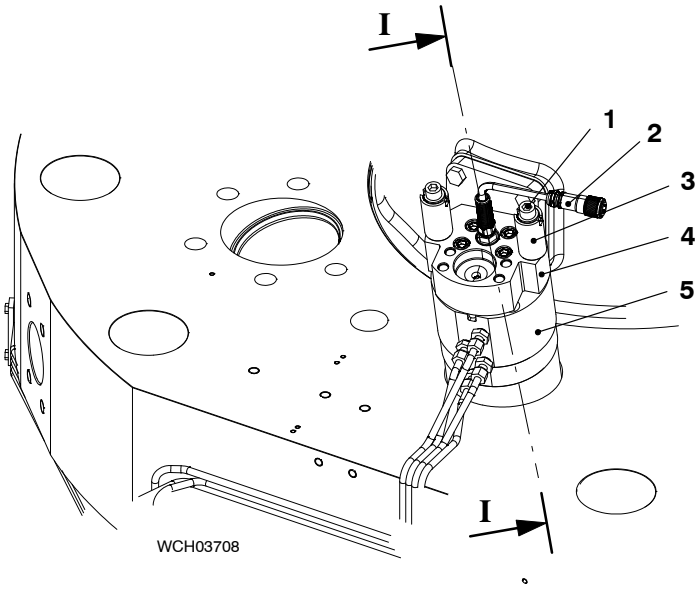
Injection Valve, Removal and Installation, refer to the Maintenance Manual 2722−1/A1

Intentionally blank

Removal and Installation

Tools:

2 Hexagon head bolt 94270C 2 Stud bolts 94270D



I – I

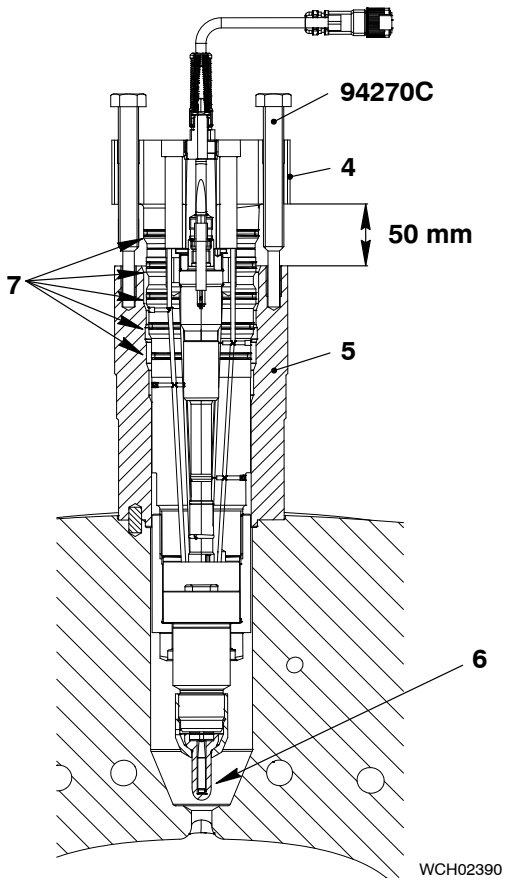


Fig. 1

1. Removal

CAUTION

Injury Hazard: The weight of the injection valve is approximately 20 kg. Use the correct equipment to lift and move the injury. This will prevent injury to personnel.

1) Remove the applicable HP fuel pipe, refer to 8733–1.
2) Disconnect the cable (2, Fig. 1) from terminal box 95.4.
3) Make sure that the injection valve cooling is stopped. Refer to the Operation Manual 8016-1.
4) Remove the two screws (1) and the spring cages (3) from the injection valve (4).
5) Put the two bolts (94270C) in the positions as shown.
6) Turn equally the two bolts (94270C) fully into the valve bush (5) (until the shoulder of the bolt touches the bush).
7) Turn equally the two bolts (94270C) to lift the injection valve (4) for a minimum of 50 mm.
8) Remove the injection valve (4).
9) Remove and discard the five O-rings (7).
10) Put protection on the nozzle tip (6).
11) Put the injection valve (4) in the correct package.
12) Put the injection valve (4) in a clean, dry storage area.

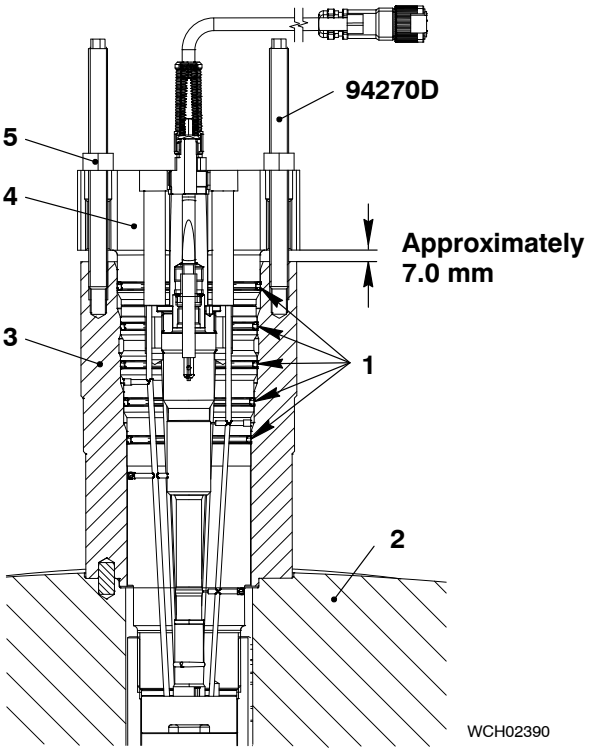


Fig. 2

2. Installation

WARNING

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

CAUTION

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

1) If applicable, remove the new injection valve from the package.
2) Use white spirit e.g. Shellsol TD, Shellsol T or Solvent FP68 to clean and remove grease from the injection valve.
3) Do a check of the condition of the sealing face in the cylinder cover (2, Fig. 2). If necessary, do the procedure given in 2708–3.
4) Put oil on the five new O-rings (1).

Note: The five O-rings (1) are included in the spare parts set for the injection valve.

5) Put the five O-rings (1) in their correct positions on the injection valve (4).
6) Carefully put the injection valve (4) into the valve bush (3).
7) Turn the two stud bolts (94270D) into the valve bush (3) as shown.
8) Turn equally the two nuts (5) to push the injection valve into the valve bush (3).

Note: A high force is necessary to install the five O-rings.

Note: The injection valve is fully in when the nozzle body (3) of the injector makes a seal with the cylinder cover (2). The distance between the bush and the nozzle body will be approx. 7 mm.

9) Remove the two stud bolts (94270D).

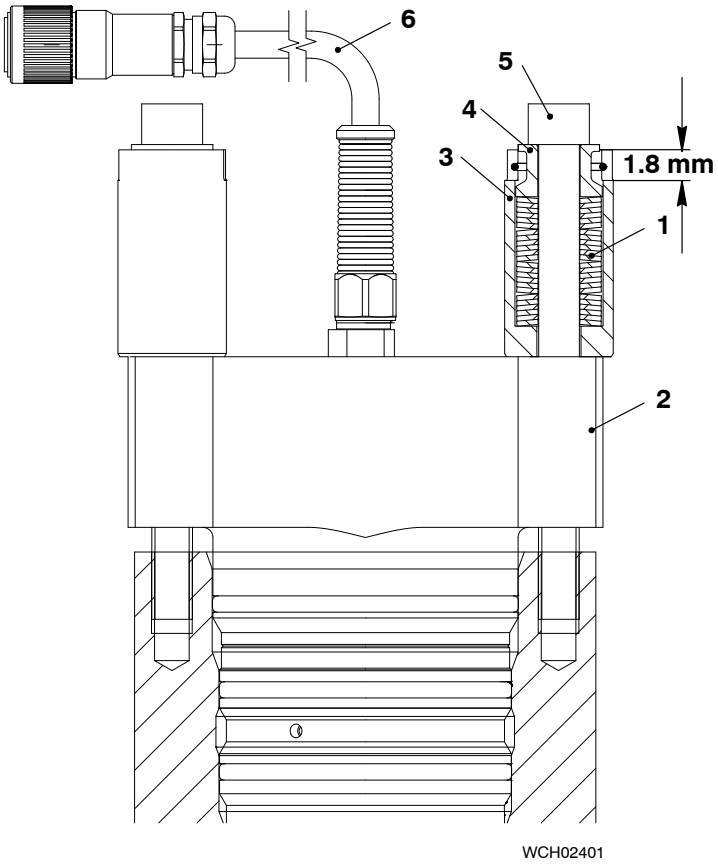


Fig. 3

10) If the spring cage (3, Fig. 3) was disassembled, make sure that the cup springs (1) are installed as shown (four sets of six cup springs).

Note: A correctly assembled spring cage has a distance of 1.8 mm between the spring guide (4) and the spring cage (3).

11) Put the spring cages (3) in position on the injection valve (2).

12) Apply Never-Seez NSBT to the threads and the seating surface of the two screws (5).

13) Tighten equally the two screws (5) until the spring guide (4) is flush with the spring cage (3).

14) Connect the cable (6) to terminal box 95.4.

15) Install the applicable HP fuel pipe, refer to 8733–1.

3. Storage Area

You must make sure that the storage area is clean, dry and has no contamination in the air.

Intentionally blank

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	Leakage oil hose	94275B
1	Torque wrench extension	94269C–41	1	Nozzle removal tool	94278A
1	Torque wrench extension	94269C–70	1	Nozzle installation tool	94278B
	Injector test bench	94272	1	T-handle	94289A
1	Connecting piece	94272B	1	Bush	94289B
			1	Bush	94289C

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/m^3 (ISO 12185)
- The kinematic viscosity at 40°C is 2.6 mm^2/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. Diesel oil (gas oil) can cause corrosion of the injection valve.

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

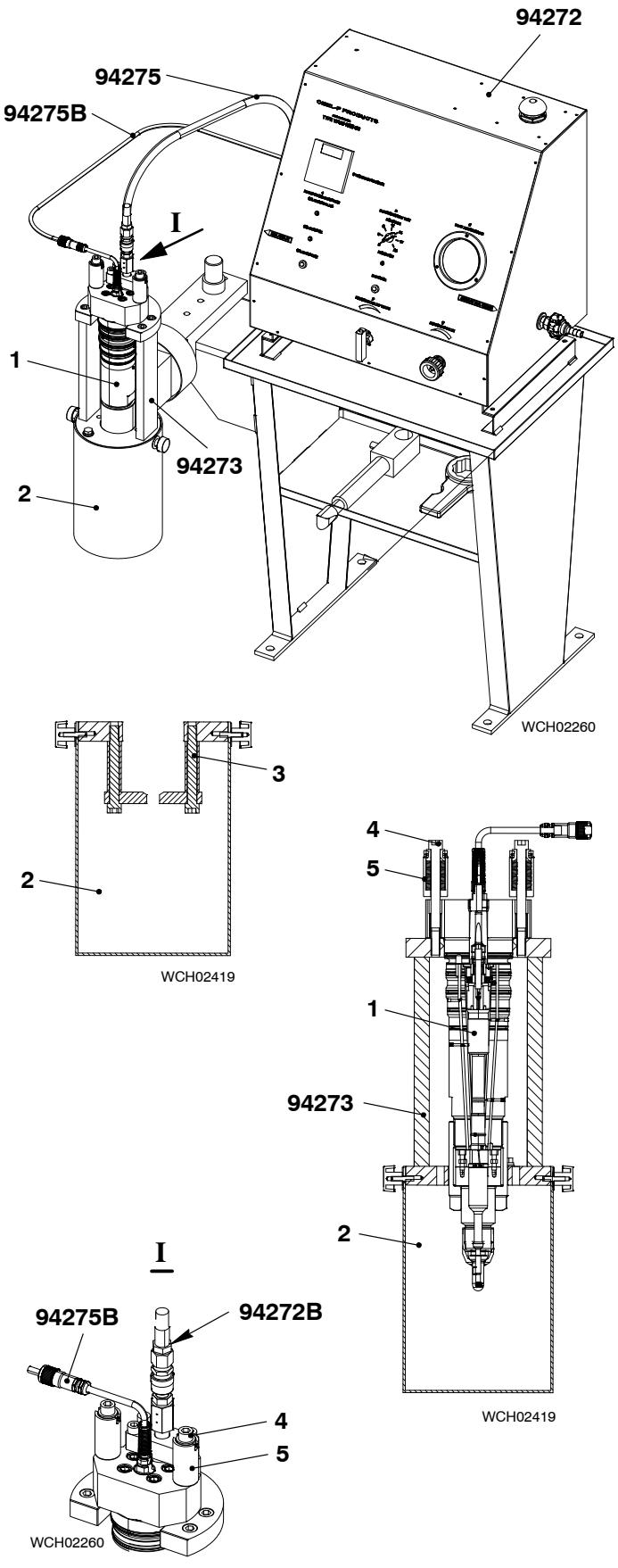


Fig. 1

2. Preparation

WARNING

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

WARNING

Health Hazard. Calibration fluid is harmful to your health.

1) Read and obey the data in the instruction manual of the test bench manufacturer.
2) Make sure that the work station is clean.
3) Make sure that the support (3) 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 in position in the valve holder (94273). Make sure that the injection valve points down.
6) Attach the injection valve (1) to the valve holder with the spring cages (5) and Allen screws (4).
7) Attach the HP hose (94275) to the connecting piece (94272B).
8) Connect the leakage oil hose (94275B) to the injection valve.

3. Procedure

3.1 Checks

DANGER

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

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.

3) Read the data in the manufacturer's instructions to set the pressure of the test bench to 600 bar.

4) Push the INJECT BUTTON. Do a check to make sure that injection valve operates correctly.

5) Do a check of the seating surface between the needle seat and the nozzle as follows:

   a) Keep the pressure in the test bench constant at approximately 400 bar.

   b) Monitor the injection valve for 30 seconds. Look to see if calibration fluid comes out of the nozzle.

6) Do a check of the opening pressure as follows:

   a) Set the pressure to 350 bar, then push the INJECT button.

   b) Make sure that no calibration fluid comes out of the nozzle.

   c) Set the pressure to 450 bar, then push the INJECT button.

   d) Make sure that calibration fluid comes out of the nozzle as a spray.

3.2 Results

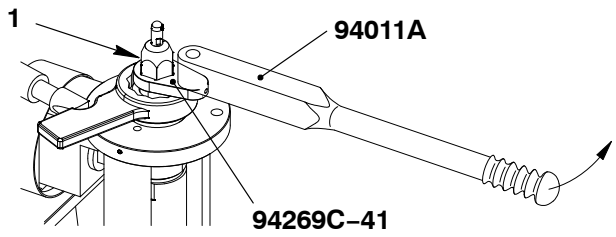
1) For the correct function and to use an injection valve again, read the data below:

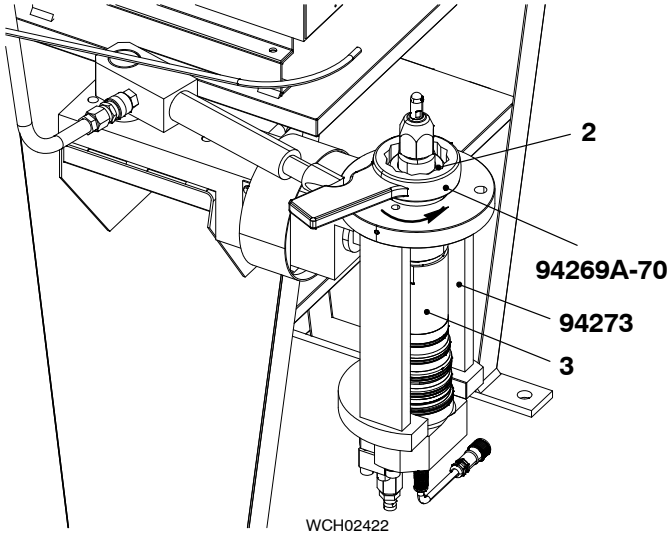
   - The opening pressure is between 350 and 450 bar, refer to the test above. The opening pressure for new injection valves is approximately 400 bar.
   - For used injection valves, a pressure decrease of 30 bar is permitted.
   - Most of the calibration fluid will come out as a spray from the top set of holes in the nozzle tip at the specified opening pressure.
   - At the end of an injection, no calibration fluid must come out of the nozzle.

2) If the injection valve does not operate satisfactorily, disassemble as given in paragraph 4.

You must replace nozzle tips that have worn holes. It is possible, but not recommended, to replace the nozzle tip with the needle installed. If it is necessary to do this, do the procedure 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.





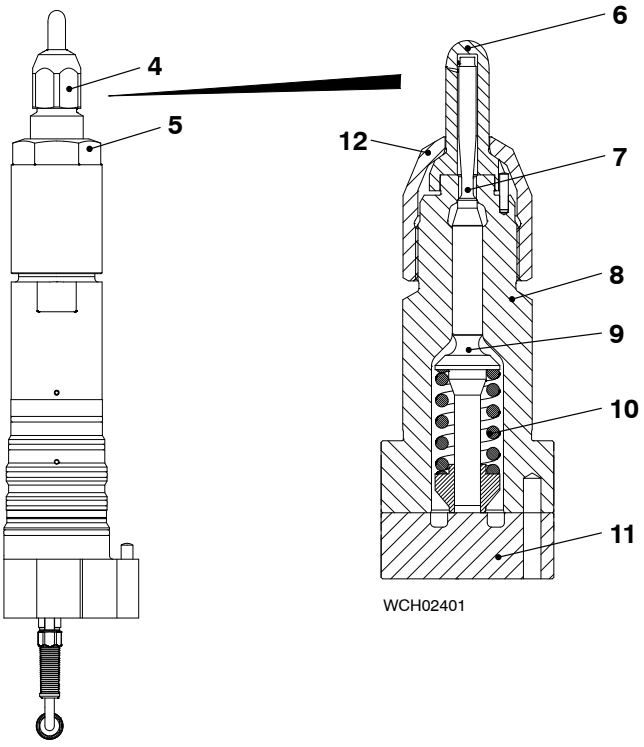


Fig. 2

4. Disassemble

4.1 Injection Valve

1) Make sure that the test bench has no pressure.
2) Remove the receiver (2, 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 through 180° into the vertical position (see Fig. 2).
6) Use the torque spanner (94011A) and adapter (94269C-41) to carefully loosen the locknut (1).
7) Remove the locknut (1).
8) Use the wrench (94269A-70) and the hydraulic cylinder (94269B) to loosen the coupling nut (2).
9) Remove the coupling nut (2).
10) Remove the nozzle body (8) together with the:

- Intermediate plate (11)
- Compression spring (10).
- Tappet (9)
- Needle (7)
- Nozzle tip (6).

Note: The needle (7) and nozzle body (8) 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 (6) from the nozzle body (8), do the procedure in paragraph 5.
12) Remove the intermediate plate (11).
13) Remove the compression spring (10), the tappet (9) and the needle (7).

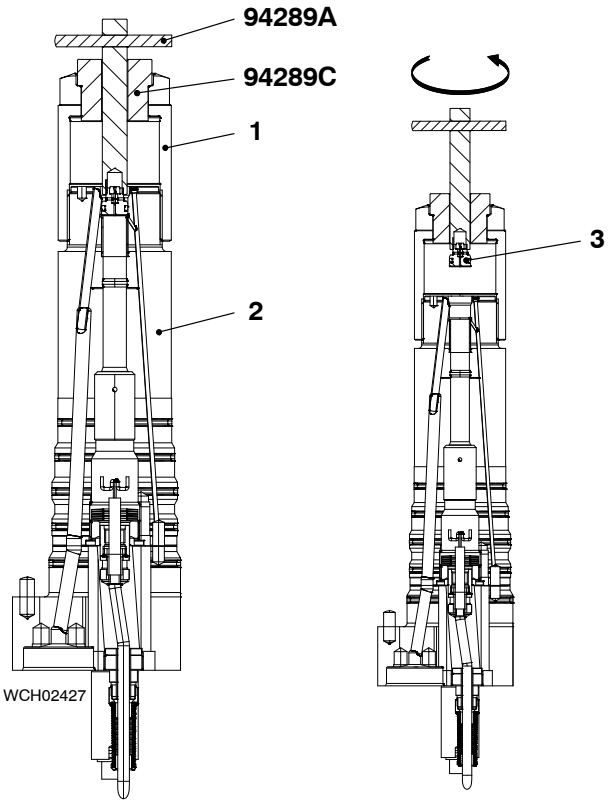


Fig. 3

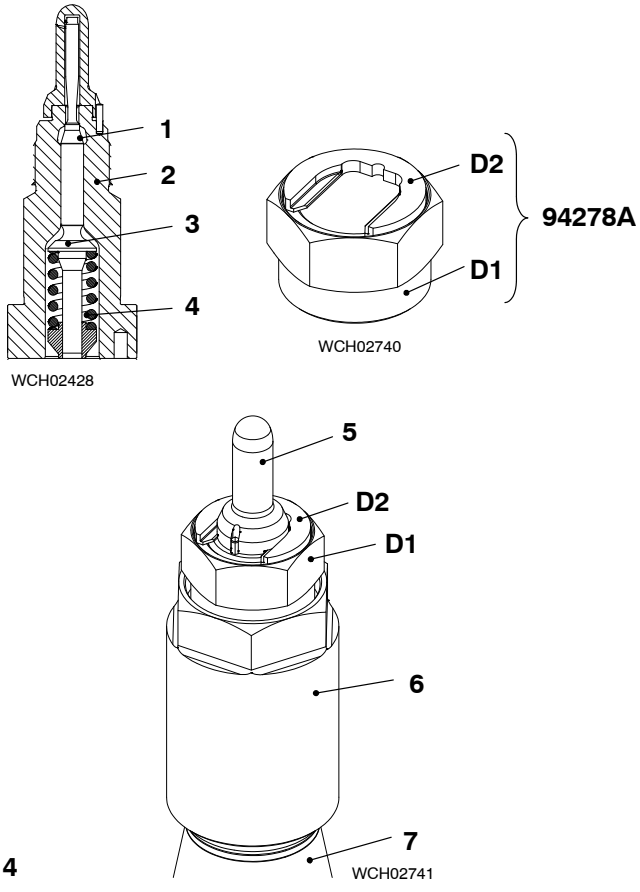


Fig. 4

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 blow, 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 possible, but not recommended, to replace the nozzle tip with the needle installed. Remove only the locknut.

1) Do the procedure given in paragraph 4, 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).

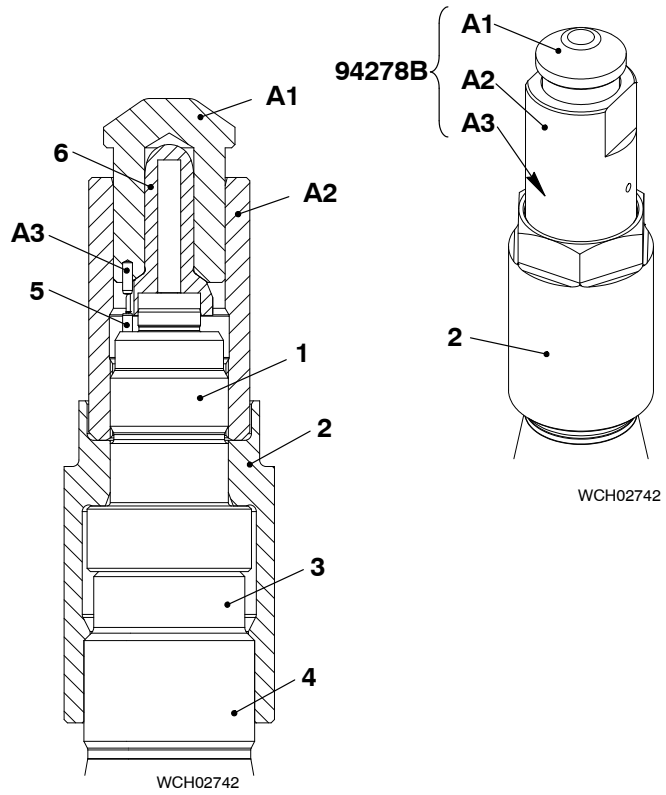


Fig. 5

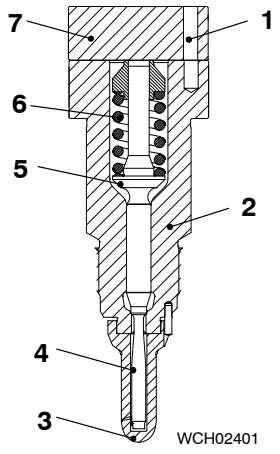


Fig. 6

5.2 Installation

1) Attach the nozzle body (1, Fig. 5) and coupling nut (2) with the injection valve (4) on the test bench.
2) Make sure that 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 in 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 a copper or rubber mallet to tap the cylinder (A1) fully down.
8) Turn the guide bush (A2) counterclockwise to remove the nozzle assembly tool (94278B).
9) Remove the coupling nut (2) and the nozzle body (1).
10) Use clean diesel oil, or clean kerosene to clean the needle, (5, Fig. 6), compression spring (6), and tappet (5).
11) Use a clean, low-pressure air supply to dry the needle, (5) compression spring (6), and tappet (5).
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 (6) into the nozzle body (2).
14) Attach the intermediate plate (7) to the nozzle body (2). Make sure that dowel pin (1) engages in the hole in the nozzle body.
15) Do the procedure in paragraph 6 to assemble the injection valve.

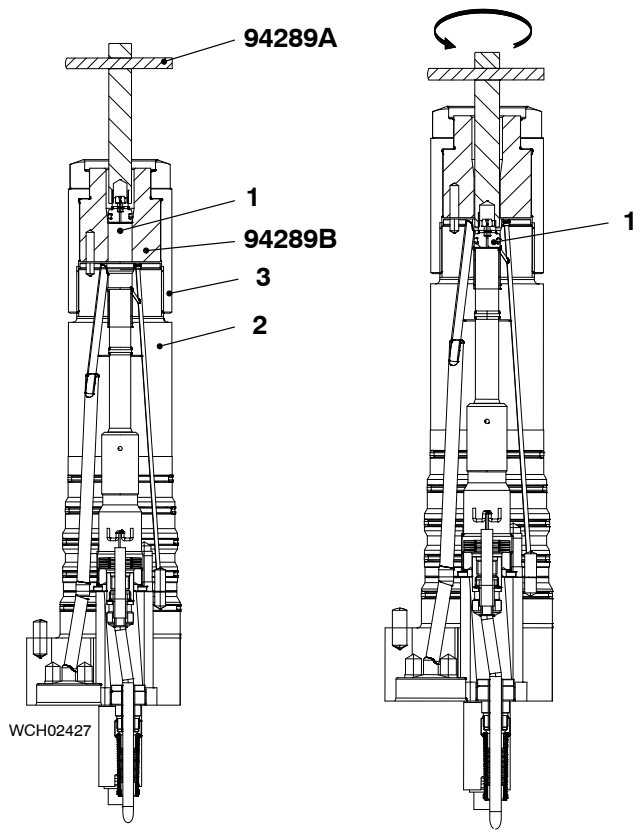


Fig. 7

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).

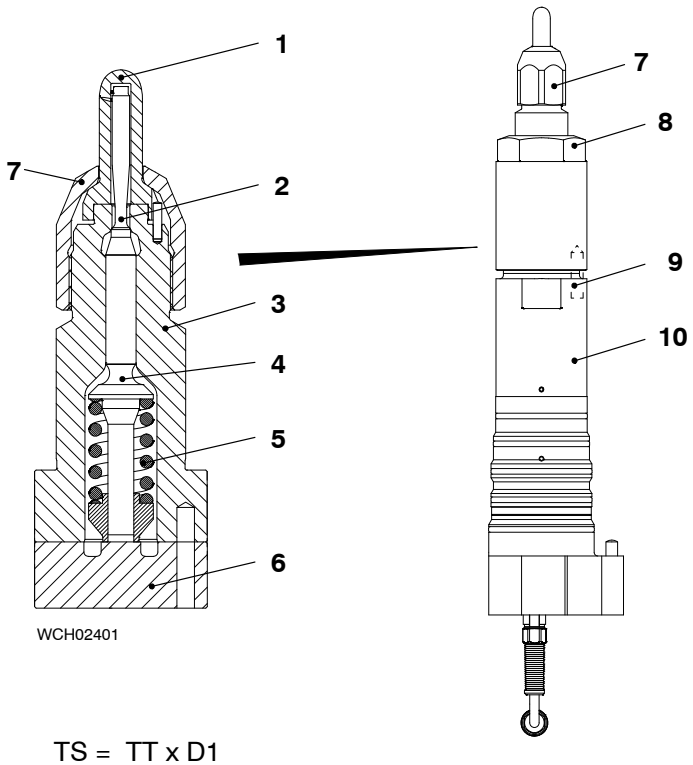
2) Attach the coupling nut (3) to the injection valve (2).

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 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 Nm

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

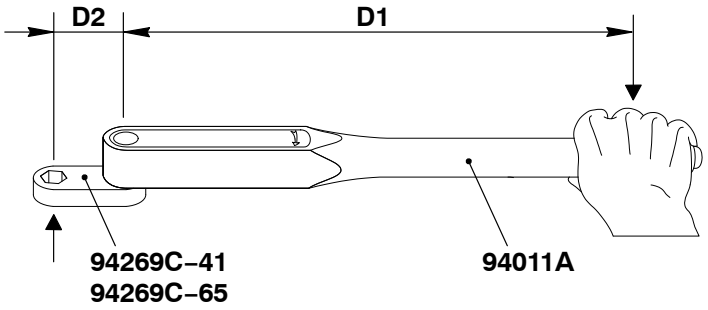


Fig. 8

6.2 Injection Valve – Assemble

WARNING

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

1) 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 NBST-8 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 formula 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 adapter (94269–65) to torque the coupling nut (8) to 88 Nm.

7) Use the wrench (94269A–65) and the cylinder on the test bench to add 35°– 40° to the position of the coupling nut (8).

8) Apply a thin layer of Never-Seez NBST 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 adapter (94269–41) to torque the locknut (7) to 169 Nm.

11) Do a check of the injection valve, refer to paragraphs 3.1 and 3.2.

Work Card
Starting Air Valve: Remove and Disassemble

Necessary Conditions

– Engine stopped
– No pressure in the starting air system
– Shut-off valves to starting air bottles closed
– Handwheel set to the position CLOSED
– Open the ball valves 30-8605_E0_6 and 30-8605_E0_7
– Control air pipe removed

Necessary Spare Parts (each cylinder)

O-ring	EX 27294	Qty 1
O-ring	EX 27301	Qty 1
O-ring	EX27295	Qty 1

Preparation

Not applicable

Tools and Consumables

Not applicable

Primary Task

Remove and disassemble the Starting Air Valve, refer to the Maintenance Manual 2728–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1
Crew	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card

Starting Air Valve: Check of the function of the solenoid valve

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

3/2-way solenoid valve	EX 27298	Qty 1

Preparation

Not applicable

Tools and Consumables

Not applicable

Primary Task

Do a check of the function of the solenoid valve

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Work Card
Starting Air Valve: Overhaul

Necessary Conditions

− Engine stopped
− No pressure in the starting air system
− Shut-off valves to starting air bottles closed
− Handwheel set to the position CLOSED
− Open the ball valves 30-8605_E0_6 and 30-8605_E0_7
− Control air pipe removed

Necessary Spare Parts (each cylinder)

Parts set − starting air valve	EX 27350	Qty 1

Preparation

Remove the Starting Air Valve, refer to 2728−1/A1

Tools and Consumables

Not applicable

Primary Task

Do an overhaul of the starting air valve

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Work Card WC2728−1.1
Remove and Install the Starting Air Valve, refer to the Maintenance Manual 2728−1/A1

Intentionally blank

Removal, Disassemble, Grinding, Assemble, Installation

1. General

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

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

Read the data in the Maintenance Manual 0380–1, Group 2728–1, for the applicable intervals to do checks on the starting air valve.

2. Preparation

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

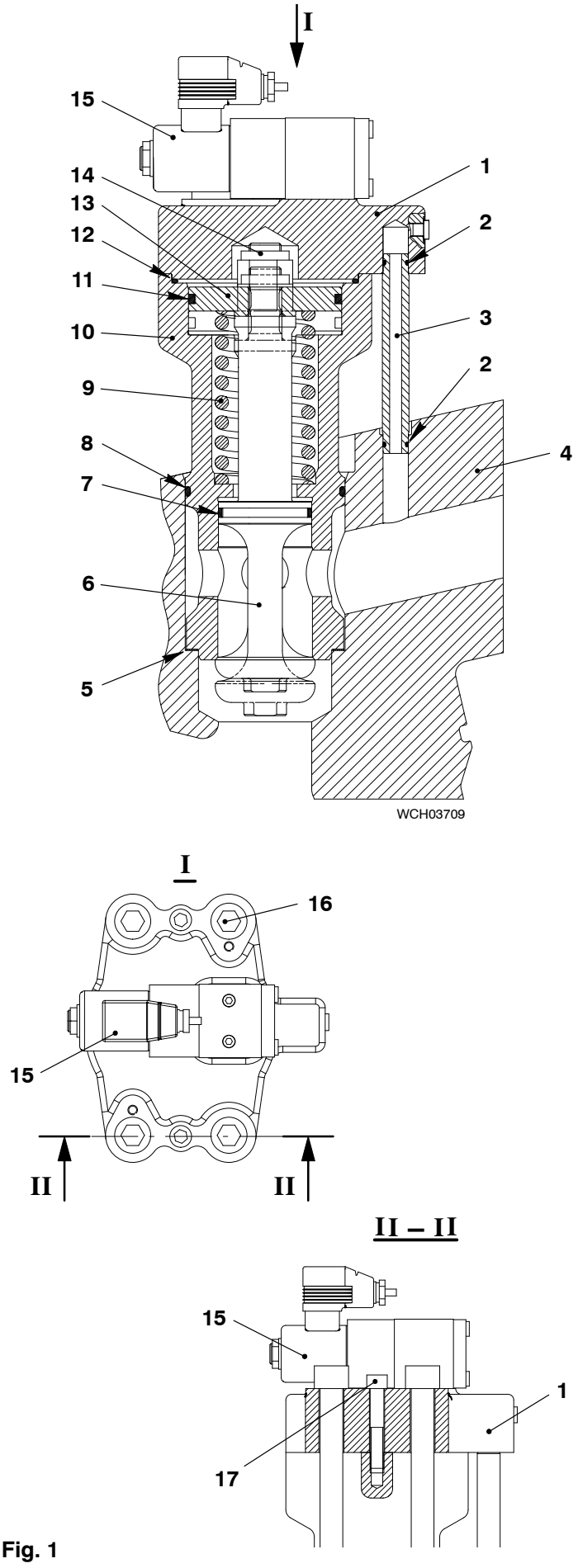


Fig. 1

3. Removal

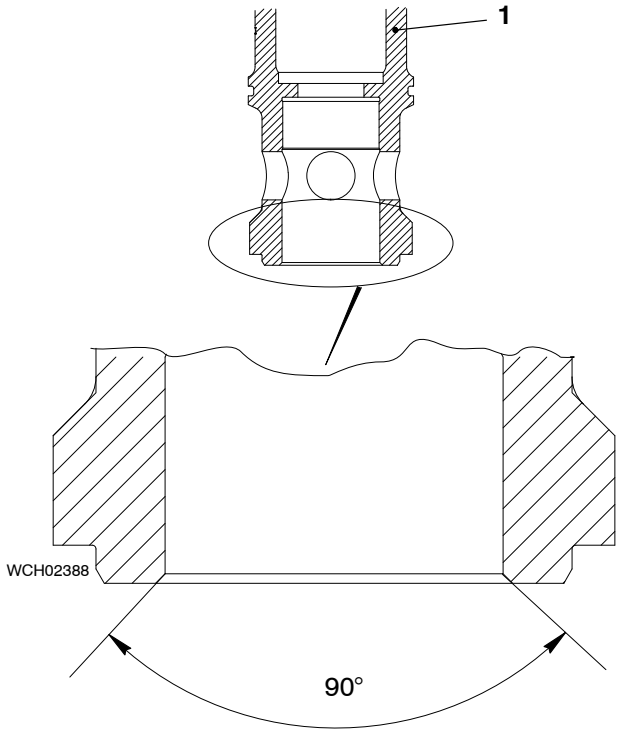
1) Disconnect the electrical connection from the 3/2-way solenoid valve (15, Fig. 1).
2) Remove the four screws (16).

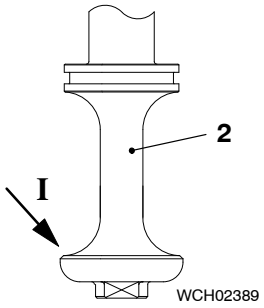
Note: When you do the step below, make sure that you do not damage the pipe (3).

3) Carefully remove the starting air valve (1) 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).





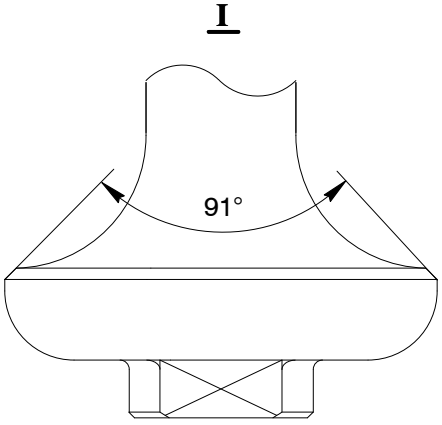


Fig. 2

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 given.
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.

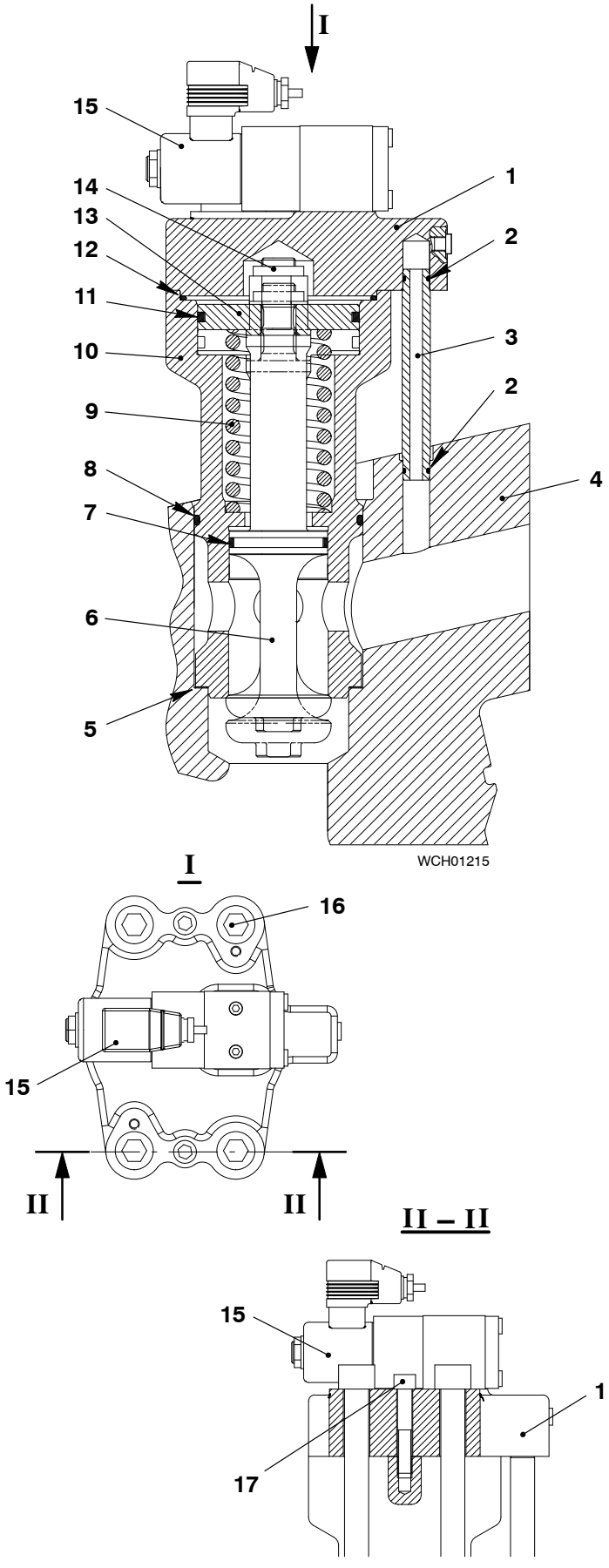


Fig. 3

6. Assemble

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

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

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

7. Installation

1) Put a new gasket (5) in the bore in the cylinder cover (4).
2) Apply a thin layer of oil 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 (16) in position in the cover (1).
6) Torque the four screws to 350 Nm.
7) Attach the control air pipe to the starting air valve.

Work Card
Exhaust Valve: General Inspection

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the exhaust valve, refer to 2751−1/A1, paragraphs 1 and 2

Tools and Consumables

Not applicable

Primary Task

Do a general inspection of the exhaust valve: valve housing, valve spindle and valve seat (exhaust valve is not disassembled)

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Work Card
Exhaust Valve Spindle

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the exhaust valve, refer to 2751−1/A1, paragraphs 1 and 2

Tools and Consumables

Not applicable

Primary Task

Do a check of the condition of the valve spindle (if necessary grind the valve seat)

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Valve Seat − Removal, Grind, Installation, refer to 2751−3/A1

Intentionally blank

Work Card
Exhaust Valve: Valve Drive Check

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the exhaust valve, refer to 2751−1/A1, paragraphs 1 and 2

Tools and Consumables

Not applicable

Primary Task

Valve Drive: do a check of the piston sealing ring / air spring and rod seal ring / guide bush

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Work Card

Exhaust Valve: Check the Condition of the Valve Seat

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the exhaust valve, refer to 2751−1/A1, paragraphs 1 and 2

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do a check of the condition of the valve seat	Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Work Card
Exhaust Valve: Random Checks

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the exhaust valve, refer to 2751−1/A1, paragraphs 1 and 2

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do a random check of the exhaust valve drive, outer and inner pistons, damper, thrust piece	Service Engineer	2.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Exhaust Valve

Exhaust Valve – Removal and Installation

Tools:

2 Sling 94049A

1. Preparation

1) Drain the cylinder cooling water from the related cylinder, refer to the Operation Manual 8017–1, paragraph 3.1 step 1).
2) Close the air inlet to the air spring at the control air supply.
3) Remove the hydraulic pipe (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 (6).
6) Disconnect the air supply pipe (5) from the air spring.
7) Close the valves from the pilot fuel supply. Make sure that there is no pressure in the pilot fuel pipes (4).
8) Remove the three HP pilot fuel pipes (4), refer to 8790–1.

2. Removal

1) Remove the two round nuts (3), refer to the procedure given in 9403–4, paragraph 1 and paragraph 2.
2) Disconnect the electrical connection (7) from the valve stroke sensor.

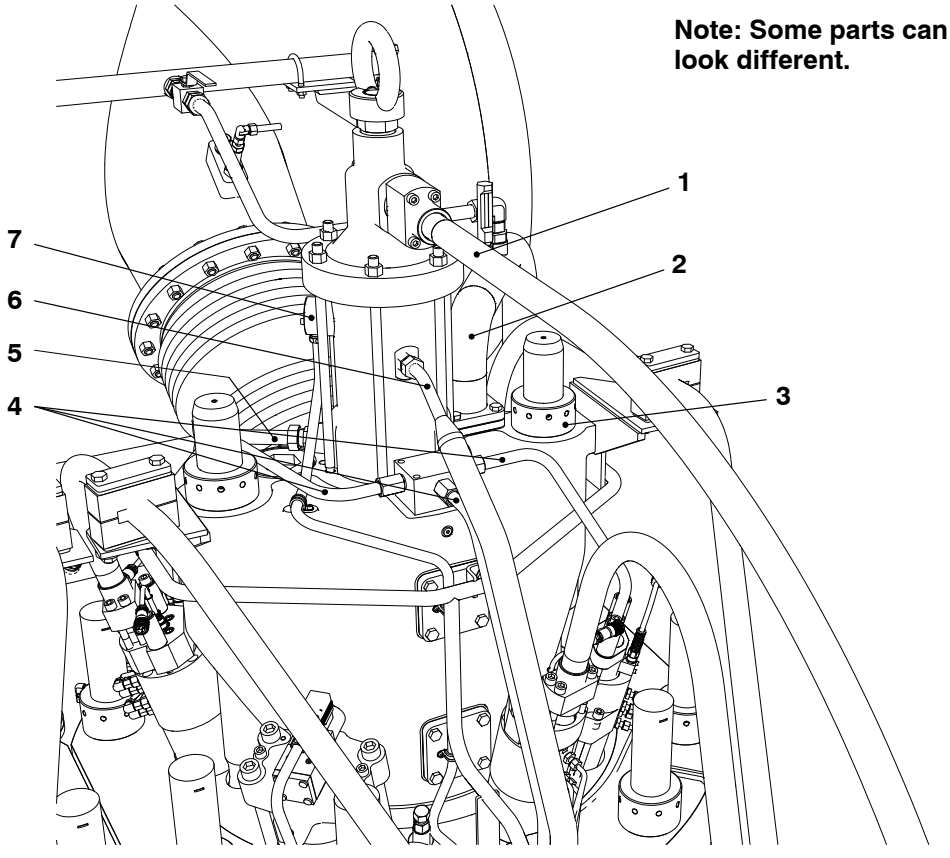
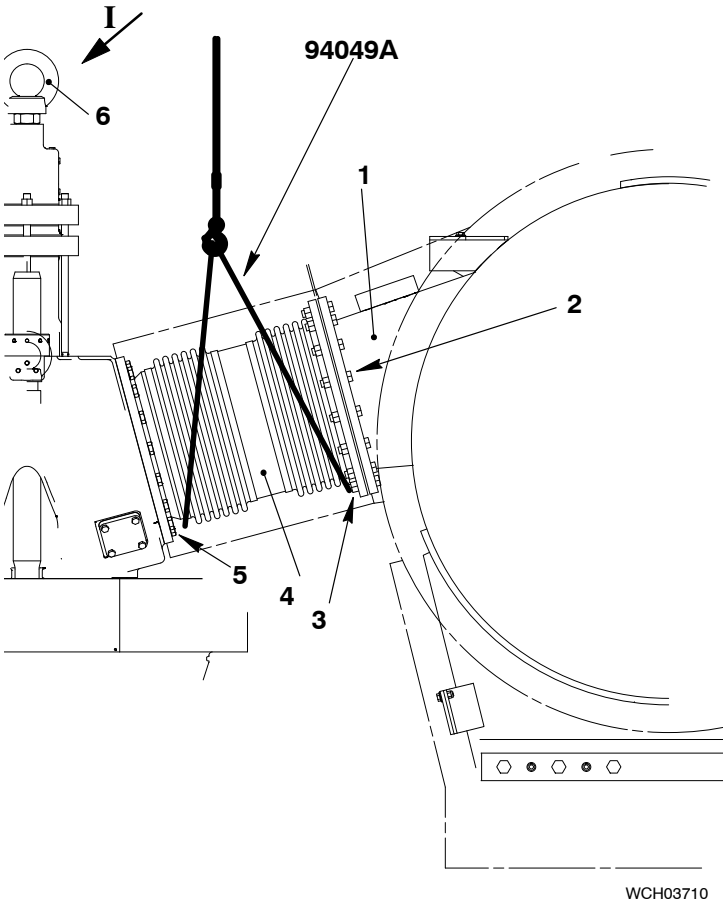


Fig. 1



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

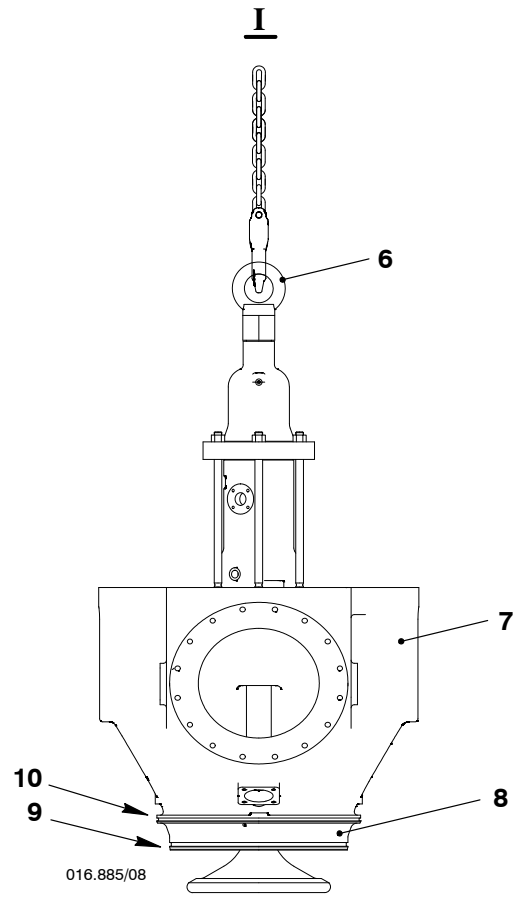


Fig. 2

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

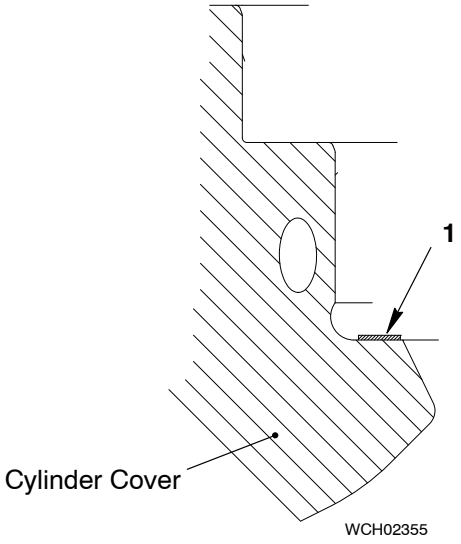


Fig. 3

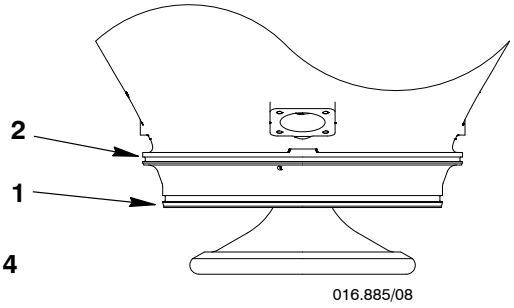


Fig. 4

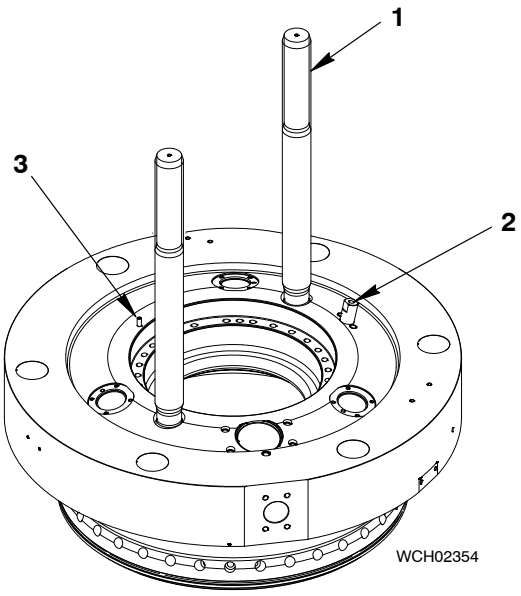


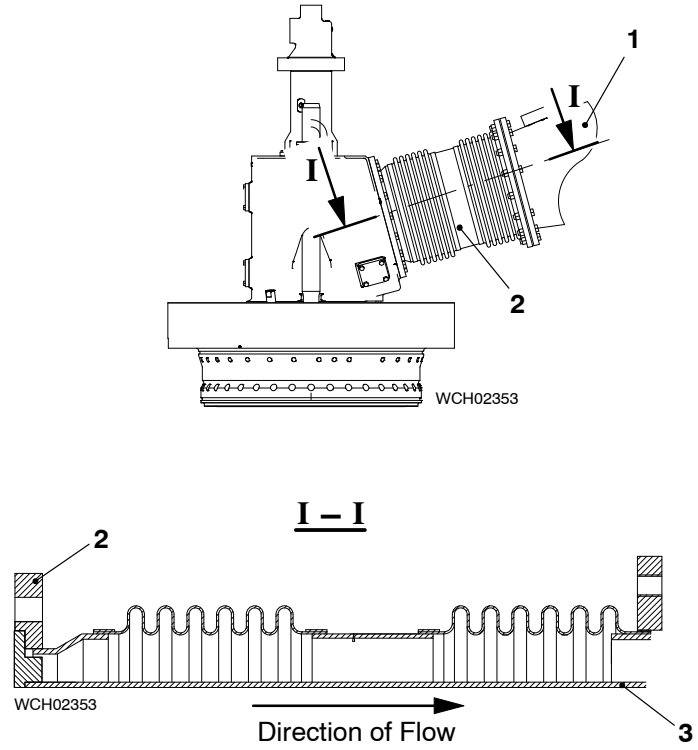
Fig. 5

3. Installation

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

Note: When you do 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.



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 the correct 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) Attach the expansion piece (2) with the 16 screws (5, 7) and the 16 nuts (4).
21) Remove the slings (94049A).

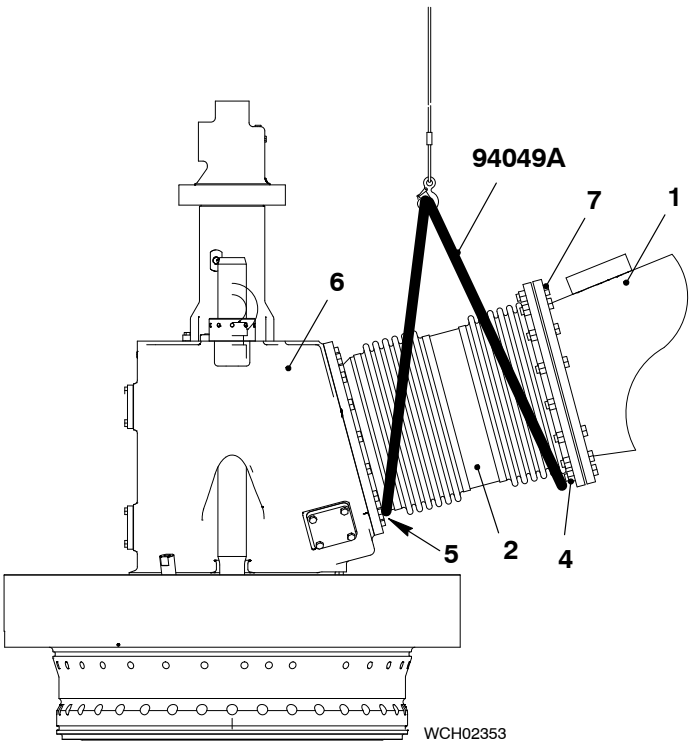


Fig. 6

4. Completion

1) Connect the electrical connector to the valve stroke sensor (7, 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 5.
4) Connect the air inlet pipe (5) to the air spring supply.
5) Install the three HP pilot fuel pipes (4), refer to 8790–1.
6) Connect the oil supply pipe (6) to the valve guide.
7) Connect the cooling water pipe (2).
8) On the applicable cylinder, fill the cylinder cooling water.
9) Open the valves you closed before (one valve each time) and do a check for leaks.

Note: Some parts can look different.

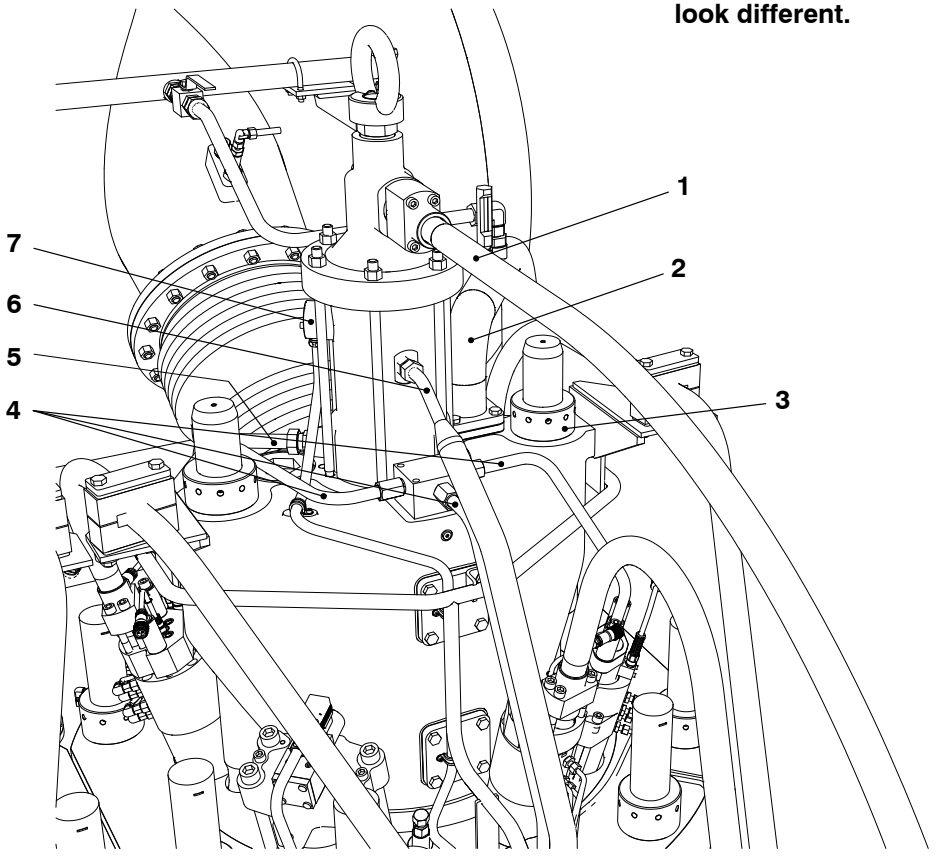


Fig. 7

Intentionally blank

Disassemble and Assemble

Tools:

1	Thrust pin	94259	1	Depth gauge	94126
2	Jack screws	94263	2	Eye bolts	94045–M20

1. General

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

Only qualified personnel, or a WinGD authorized repair workshop can repair defective exhaust valves.

For the inspection and overhaul intervals, refer to 0380–1, Exhaust valve.

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

WARNING

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

CAUTION

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

Note: Make sure that the work area is clean.

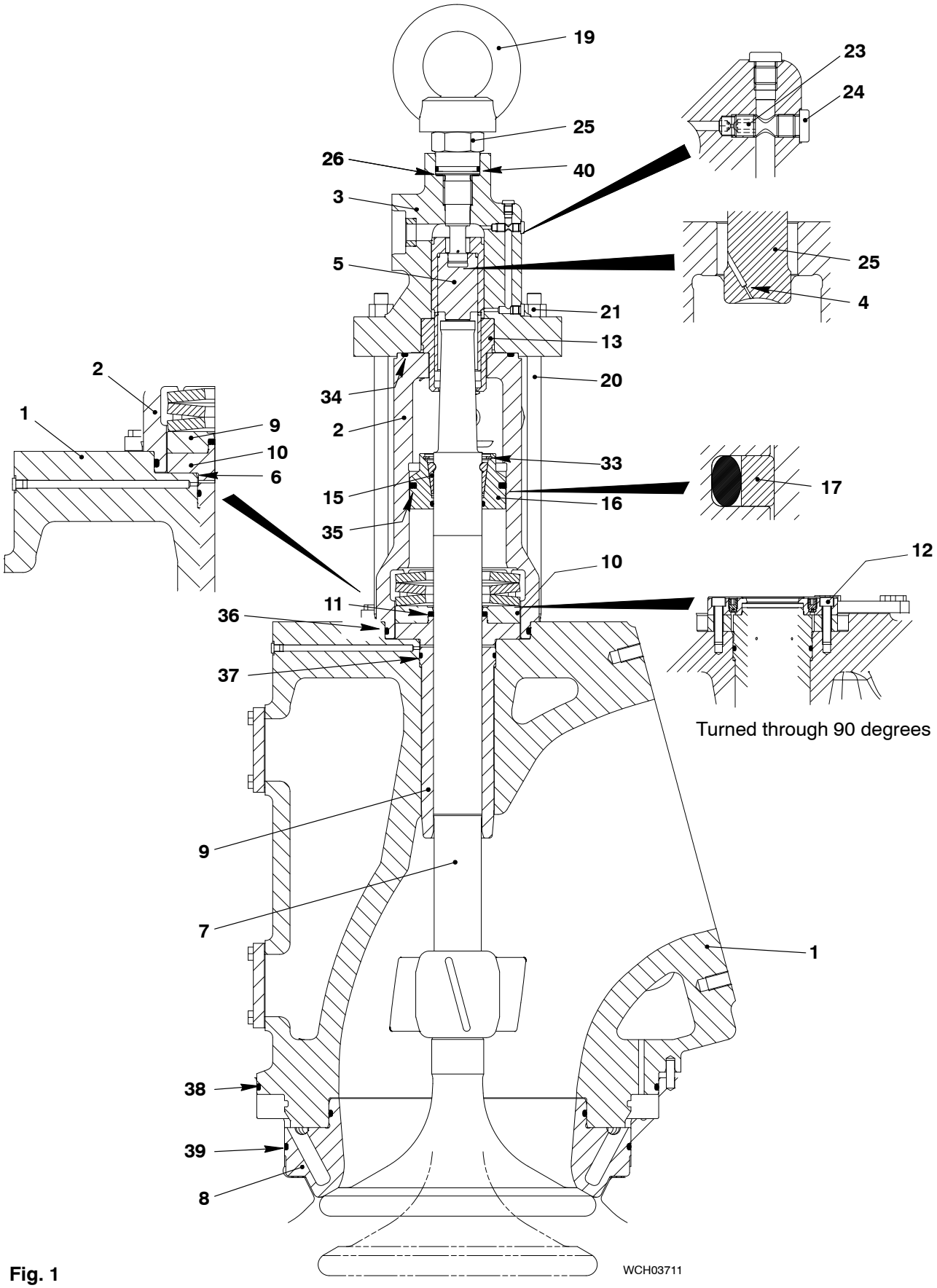

19
25
26
40
3
5
21
13
20
34
2
33
15
16
35
10
11
36
37
9
7
38
39
8
1
2
9
10
6
23
24
25
4
17
12
Turned through 90 degrees
WCH03711

Fig. 1

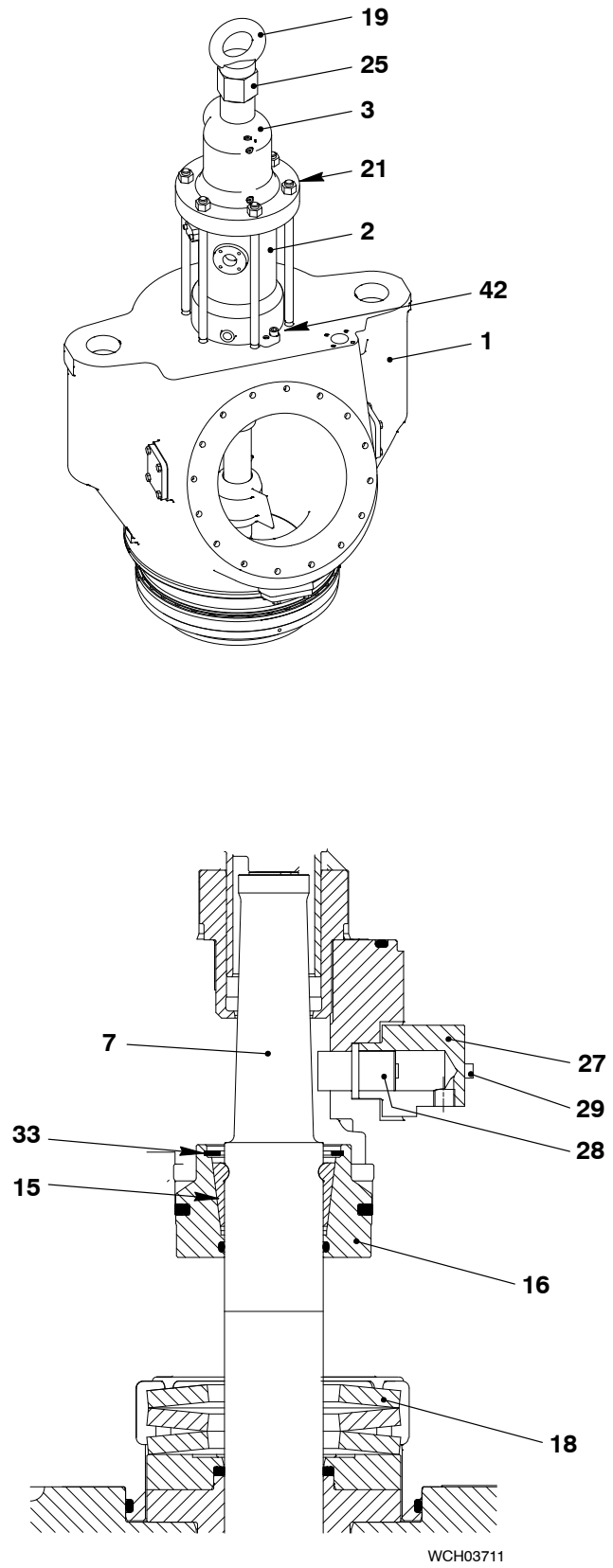


Fig. 2

2. Exhaust Valve – Disassemble

2.1 Valve Drive – Disassemble

1) Attach the lifting tool (94209) to the crane and the eye bolt (19, Fig. 2).
2) Remove the six nuts (21).
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 six cap screws (42).
9) Remove the bottom housing (2).

2.2 Valve Spindle – Remove

1) Remove the circlip (33).
2) Push the piston (16) up, then remove the valve cotters (15).
3) Remove the piston (16) from the valve spindle (7).
4) Remove the cup springs (18).
5) Use the lifting tool (94209) and the crane to lift the valve cage (1) 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.

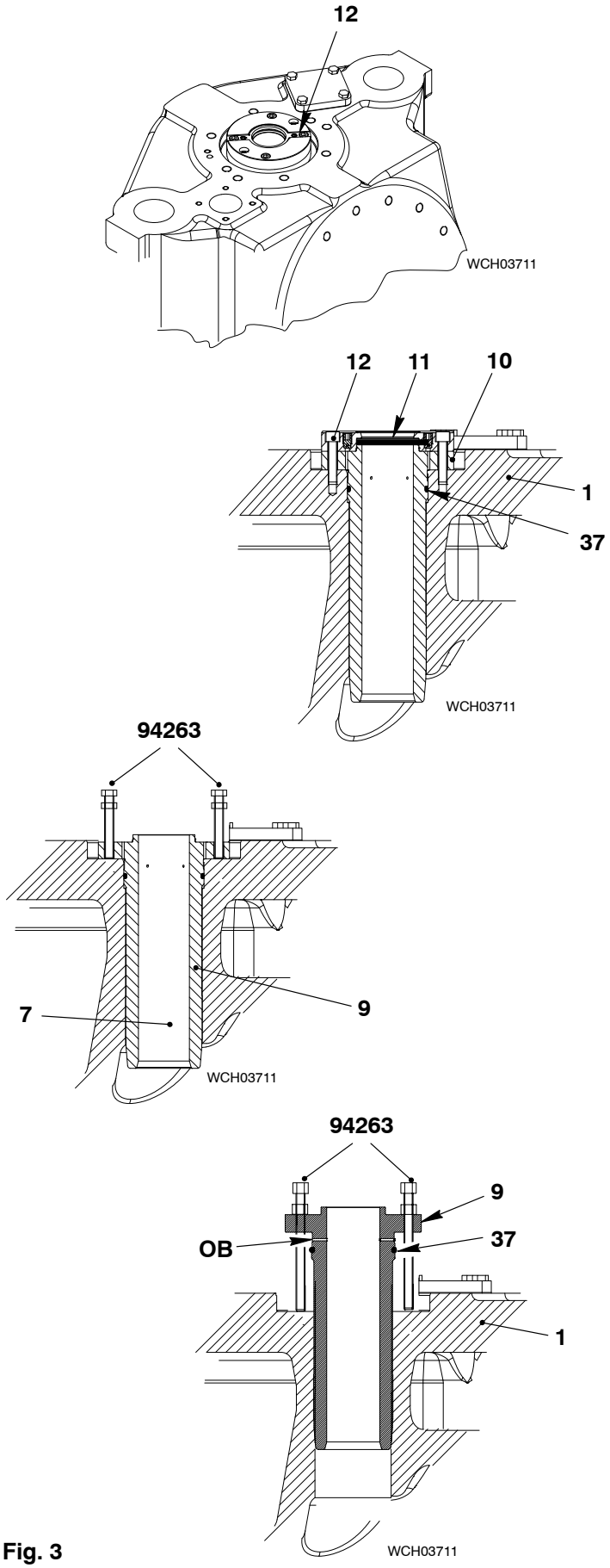


Fig. 3

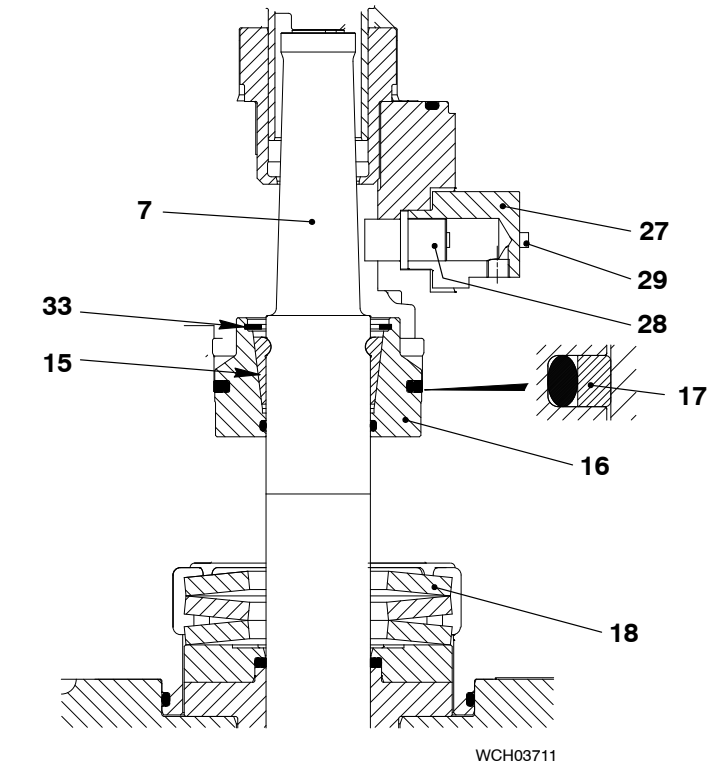
2.3 Guide Bush – Removal

1) Remove the four screws (12, Fig. 3).
2) Remove the spacer (10).
3) Remove and discard the rod seal (11).
4) Put the jack screws (94263) into the flange of the guide bush (9).
5) Turn the jack screws (94263) 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 dimension with the values given in 0330–1, Exhaust Valve.

3. Exhaust Valve – Assemble

3.1 Guide Bush – Installation

1) Clean the bore in the valve cage (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).



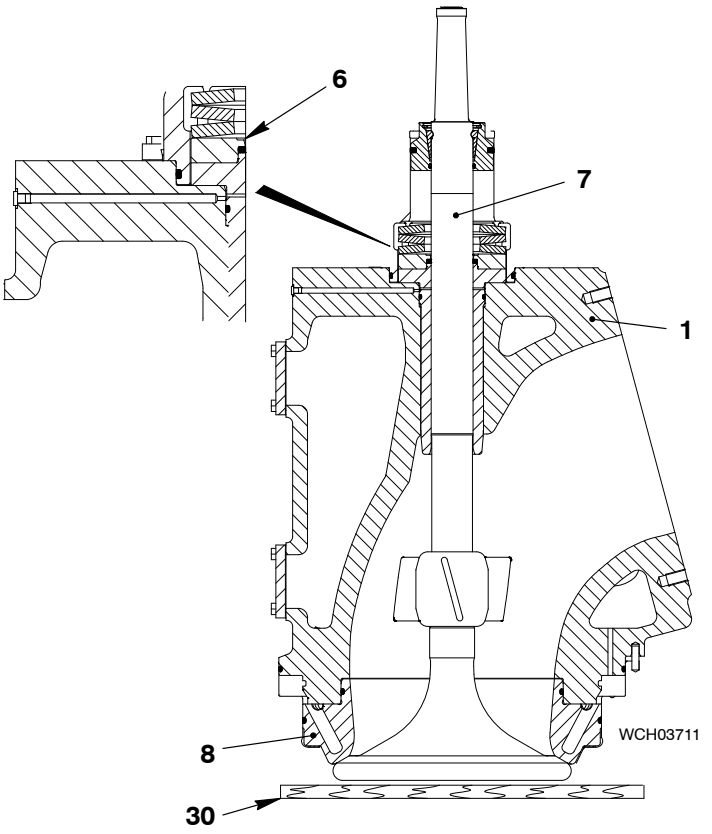


Fig. 4

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.
3) Do a check of the piston seal ring (17) for damage. If you find damage, replace the piston seal ring.
4) Replace all O-rings.
5) Put oil on the valve spindle (7).
6) Use the two M20 eye bolts and two ropes or the lifting tool (94209) to 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 the new rod seal (11).
9) Put the new rod seal (11) in position on the valve spindle (7, Fig. 3).
10) Before you install a new piston seal ring (17, Fig. 4), do as follows:
    a) Put the new piston seal ring in very hot water for some minutes.
    b) Carefully put the piston seal ring in the correct position on the piston (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 cotters (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) on to 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.

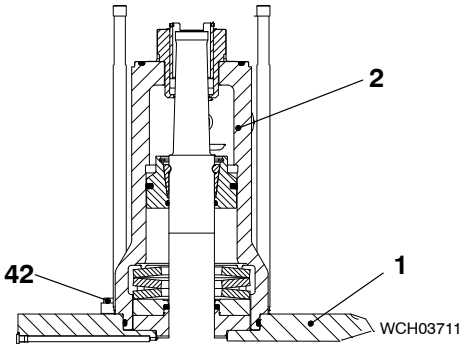
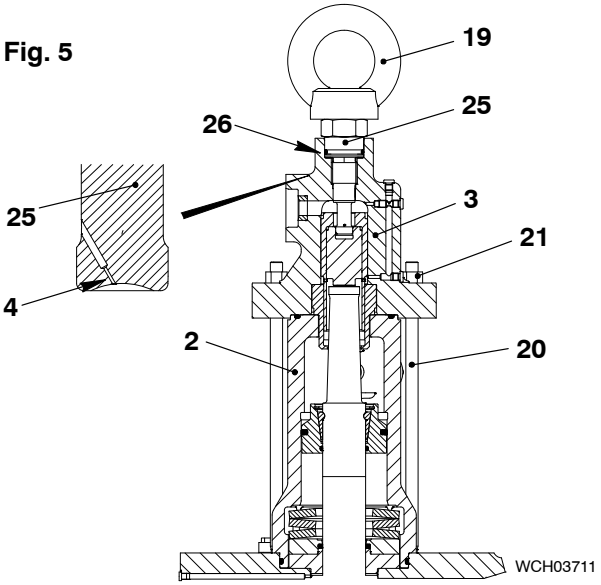


Fig. 5



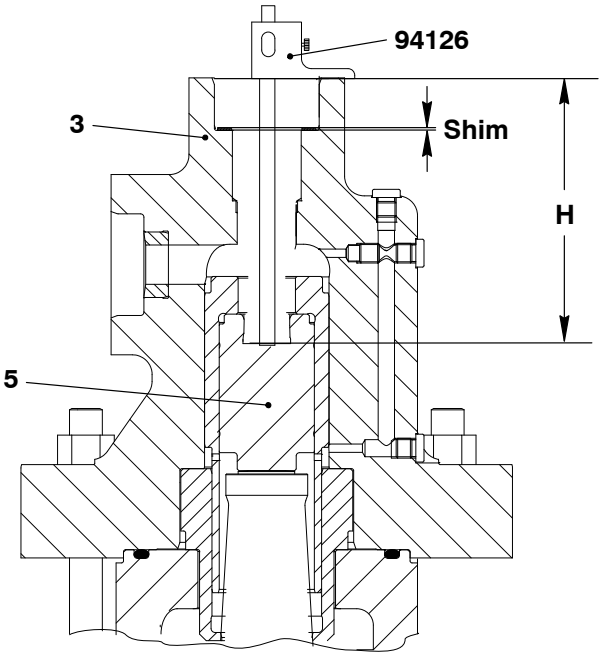


Fig. 6

10) Attach the lifting tool (94209) to the housing (2, Fig. 5) and the crane.
11) Lift, then lower the bottom housing (2) on to the valve cage (1).
12) Install the six screws (42).
13) Attach the lifting tool 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 290 Nm.

3.4 Damper Setting

You set the damper (25) only after you replace a valve spindle or valve seat, or after 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 that there is no clearance between the valve plate and valve seat.
5) Use the depth gauge (94126) to measure the height H from the edge of the top housing (3) to the bottom of the damper bore.
6) Install the damper (25) and the applicable shims (26) to get the total thickness.

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

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

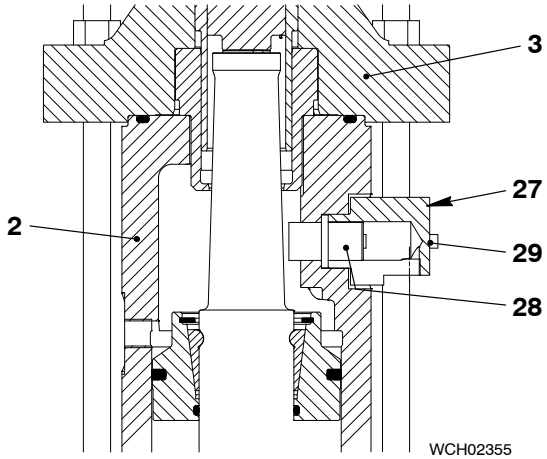


Fig. 7

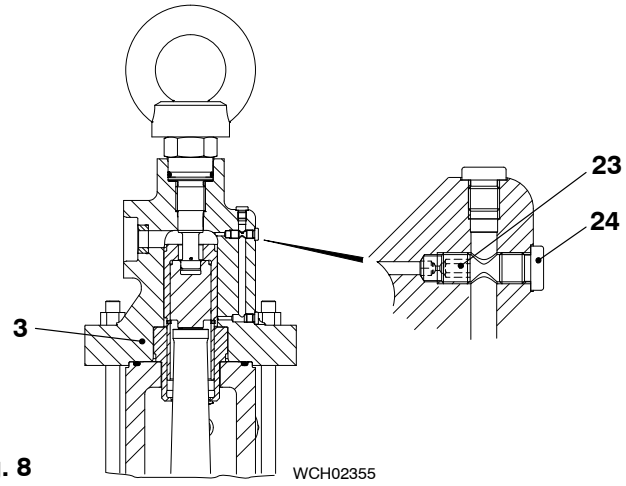


Fig. 8

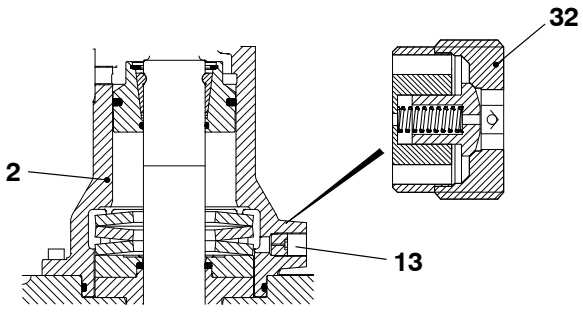


Fig. 9

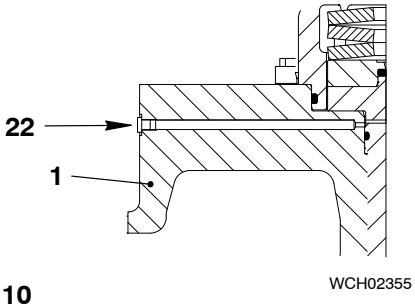


Fig. 10

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) Attach the transmitter housing (27) to the bottom housing (2)with the two screws (29).
3) 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 4.0 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 Oil Supply to Valve Guide

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

Intentionally blank

Exhaust Valve

Valve Seat – Removal, Grind and Installation

Tools:

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

1. General

You must replace the valve seat when:

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

2. Preparation

1) Disassemble the exhaust valve and remove the valve spindle, refer to 2751–2, paragraphs 2.1 and 2.2.

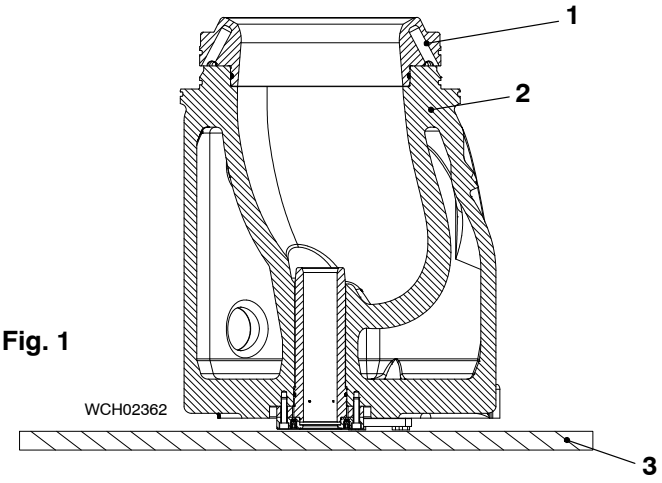
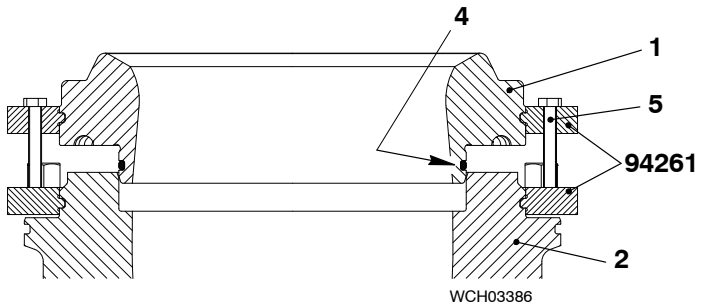
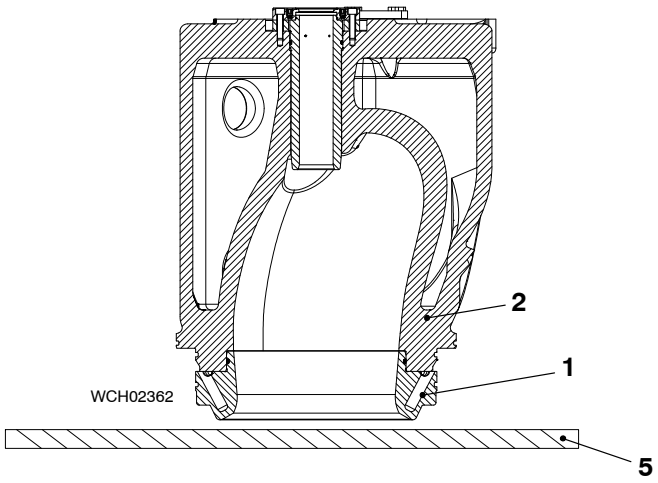


Fig. 1





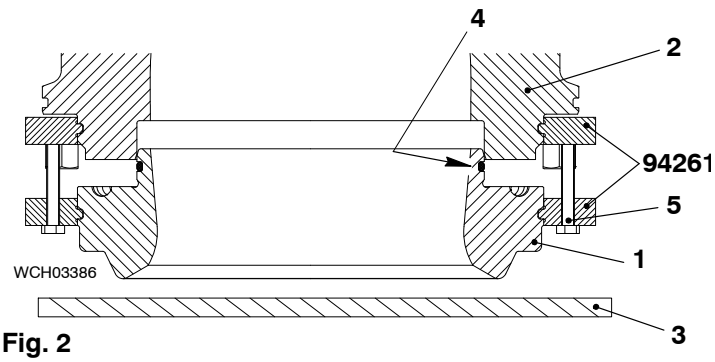


Fig. 2

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 device (94261) into the groove of the valve seat (1).
4) Install the bottom two halves of the device (94261) into the groove of the valve cage (2).
5) Turn the three jack-screws (5) equally to push out the valve seat (1) from the valve cage (2).
6) Remove and discard the O-ring (4).
7) Remove the device (94261).

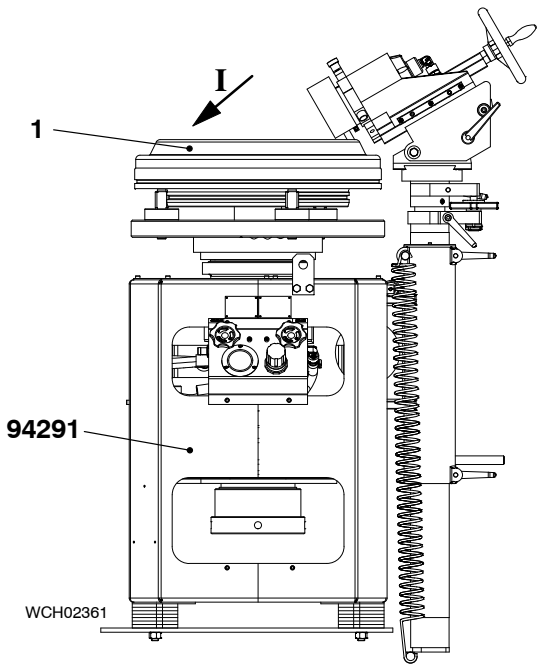
3.2 Alternative Procedure

If it is necessary to remove the valve seat when the valve cage must stay in the usual position (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).



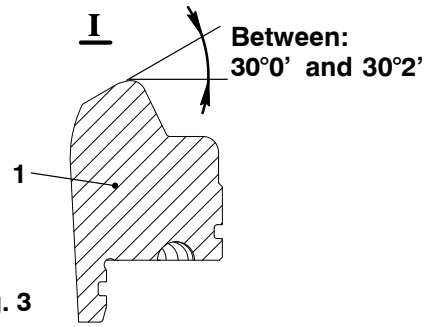


Fig. 3

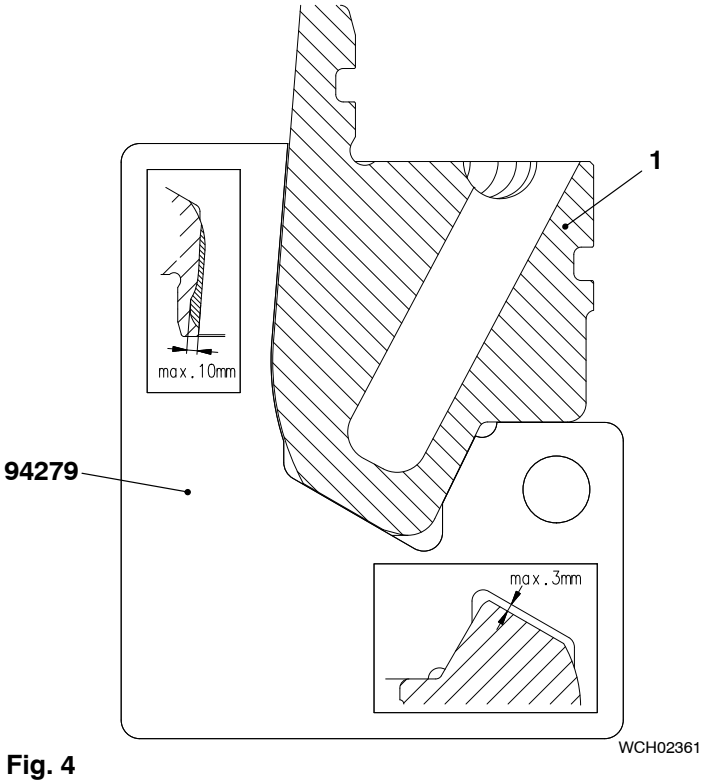


Fig. 4

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

8) Remove the tool (94261).

4. Valve Seat – Grind

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

1) Read the data in the manufacturer’s manual for the tool (94291).

2) Put the valve seat (1) in the correct position on the tool (94291).

3) Put the template (94279, Fig 4) on the valve seat.

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

4) Use the feeler gauge (94122) to measure the values.

5) If the measured values are more than the limits given on the gauge (94122), you must replace the valve seat (1).

6) If the values are less than the limits given, do the procedure that follows:

   a) Operate the tool (94291) to grind the sealing face of the valve seat (1). Make sure that you get a smooth and flat surface.

   b) Keep the valve seat angle to between 30°0’ and 30° 2’.

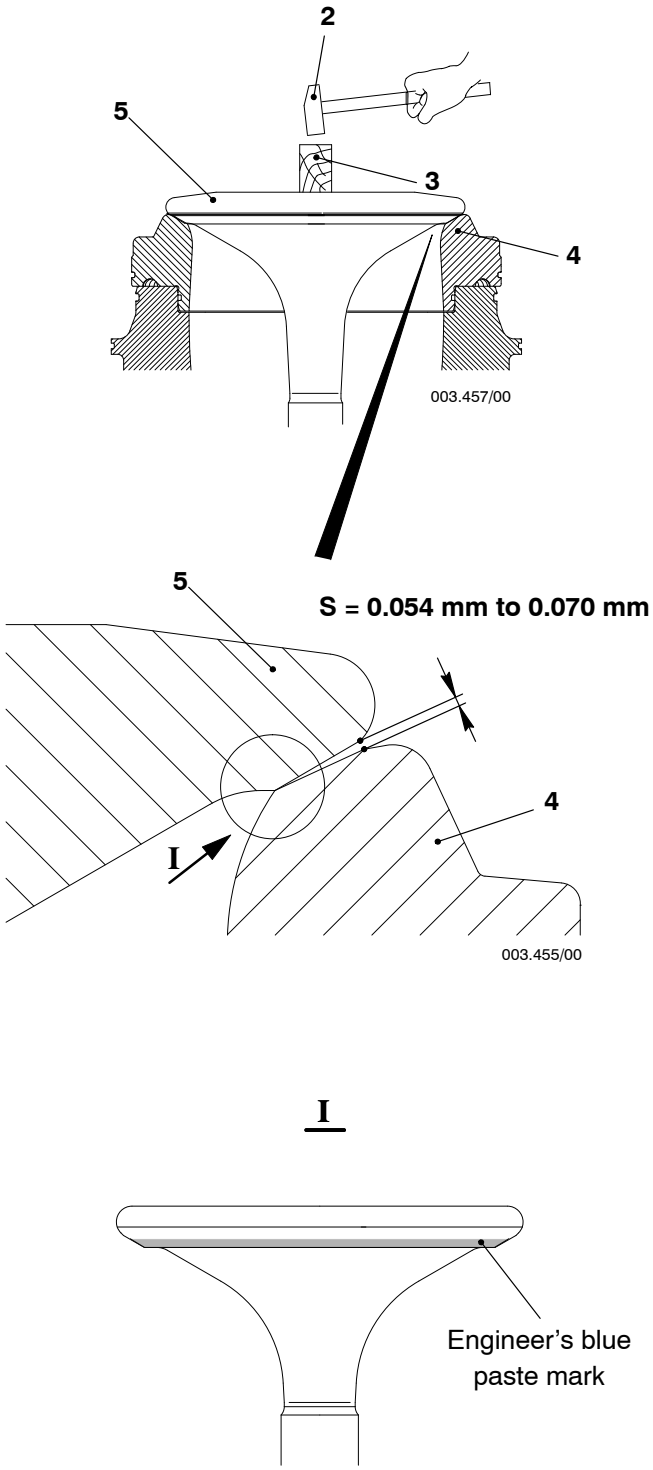


Fig. 5

5. Valve Seat – Check

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

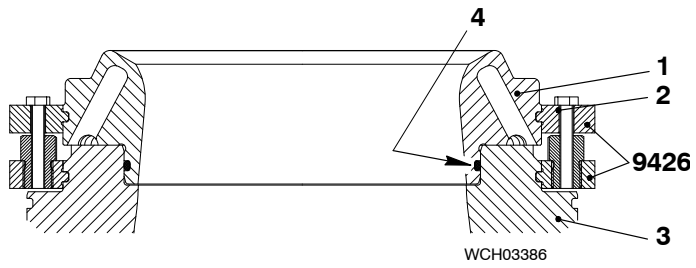
1) Put a thin layer of engineer's blue paste on the sealing face of the valve spindle (5), see Fig. 5.
2) Put the valve spindle (5) in position in the valve guide bush.
3) Put the wooden block (3) on the valve spindle (5).

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

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

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

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



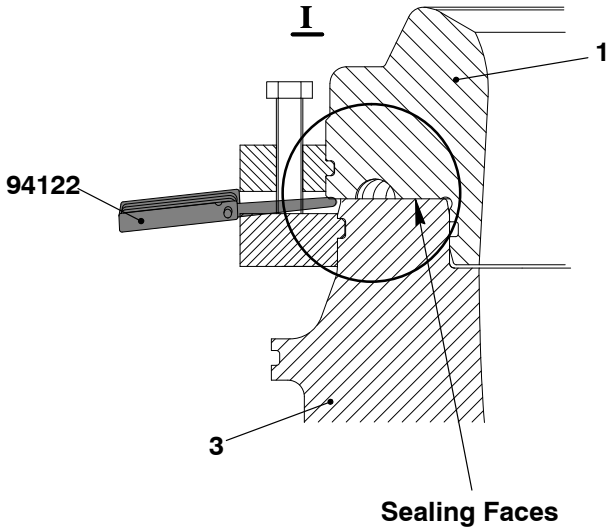


Fig. 6

6. Valve Seat – Installation

1) Clean the bores and the sealing faces of the valve cage (2, Fig. 6) and the valve seat (1).
2) Apply oil (or lubricants 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).

7. Completion

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

Intentionally blank

Valve Head: Seating Surface – Grind

Tools:

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

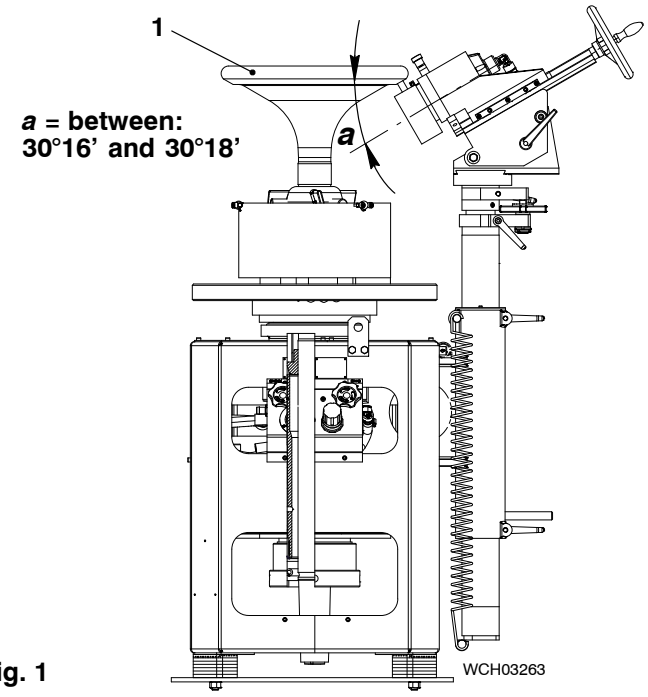


Fig. 1

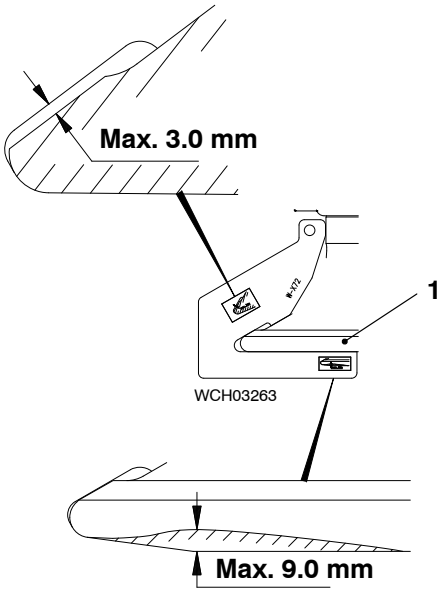


Fig. 2

1. General

Use only the tool (94291, Fig. 1) to grind the valve head.

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

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

2. Valve Head – Grind

1) Read the data in the manufacturer's manual for the grinding tool (94291).

2) Put the grinding tool (94291) in an area where there is no vibration.

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

3) Put the valve spindle in position in the tool (94291).

4) Put the gauge (94292) on the valve head (1, Fig. 2).

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

5) Use the feeler gauge (94122) to measure the values.

6) If the values are less than the limits given, do step a) to step c):

   a) Use the tool (94291) to grind the surface of the valve head (1). Remove only the minimum material necessary to get a smooth, flat surface.

   b) Use an applicable coolant to keep the valve head (1) cool.

   c) Keep the angle of the valve head (1) to between 30°16' and 30°18'.

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

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

8) If the measured values are more than the limits given on the gauge (94122), you can repair the valve spindle (refer to the data below).

9) If more than 3.0 mm is ground off, do step a) and step b) below:

   a) Use a build-up welding procedure to repair the surface of the valve seat.

   b) Grind the seating surface of the valve spindle again (refer to paragraph 2).

3. Corrosion

Corrosion can occur at the bottom of the valve plate when engines operate for a long period (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 WinGD authorized repair workshop.

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

Work Card

Pilot Injection Valve: Replace the Nozzle Spare Parts Set

Necessary Conditions

– Engine stopped
– Pilot injection valve removed

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the pilot injection valve, refer to 2790–1/A1

Tools and Consumables

Wrench	94269A-55	Qty 1
Socket wrench insert	94269C–55	Qty 1
Obel test bench	94272	Qty 1
Hydraulic cylinder	94269B	Qty 1

Molykote paste G–n

Primary Task

Replace the nozzle spare parts set

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Work Card
Pilot Injection Valve: Replace

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient
– Fuel supply and pilot fuel supply valves closed
– Fuel supply set to off
– Lube oil supply set to off
– Applicable pilot fuel pipe removed

Preparation

Pilot Valve, Removal and Installation, refer to 2790–1/A1

Primary Task

Replace the pilot injection valve

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Replace the nozzle body, refer to WC2790–1/A1
Replace the pre-chamber, refer to WC2790–1.2/A1

Necessary Spare Parts (each cylinder)

Pilot injection valve with seals (without the tension washer cage)	EX 27915	Qty 2

Tools and Consumables

Socket wrench insert	94269C–55	Qty 1
Obel test bench	94272	Qty 1
Support plate	94270F	Qty 1
Screw for support plate	94270G	Qty 2
Stud bolts	94270E	Qty 2
Eye bolts	94045–M12	Qty 2

Molykote paste G–n
White spirit
Brass wire brush
Never Seez NSBT

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1

Intentionally blank

Work Card
Pilot Injection Valve: Replace the Pre-chamber

Necessary Conditions

- Engine stopped
- Pilot injection valve removed
- All pipes and connectors removed from the holder

Necessary Spare Parts (each cylinder)

Conical seal	EX 27905	Qty 2
O-ring	EX 27909	Qty 2
Pre-chamber	EX 27903	Qty 2
Pilot injector valve with seals	EX 96235	Qty 2

Preparation

Remove the pilot injection valve, refer to 2790−1/A1

Tools and Consumables

M12 eye bolts	94045−M12	Qty 2
Never Seez NSBT		

Primary Task

Replace the pre-chamber

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	5.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Replace the nozzle body, refer to WC2790−1/A1
Replace the pilot injection valve WC2790−1.1/A1

Intentionally blank

Removal and Installation

Tools:

1	Obel test bench	94272	1	Socket wrench insert	94269C–55
1	Support plate	94270F	2	Stud bolts	94270E
2	Screw for support plate	94270G	2	Eye bolts	94045–M12

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:

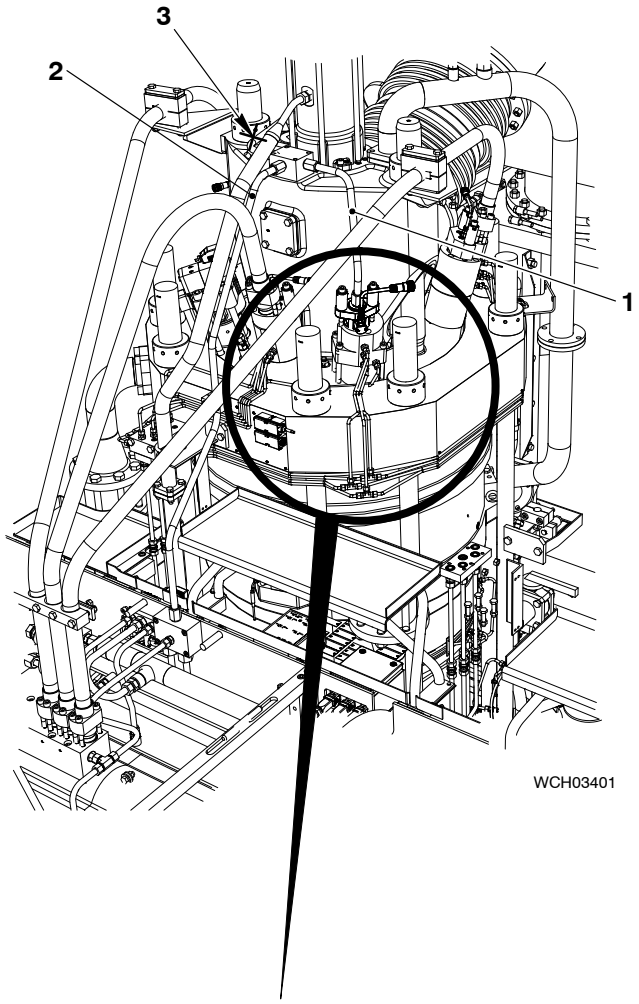
- The density at 15° C is 827 kg/m3 (ISO 12185)
- The kinematic viscosity at 40_C is 2.6 mm2/s (ASTM D445)
- The pour point is –27° C (ISO 3016).

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 pilot 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, refer to the Operation Manual 0320, paragraph 2 System Oil).



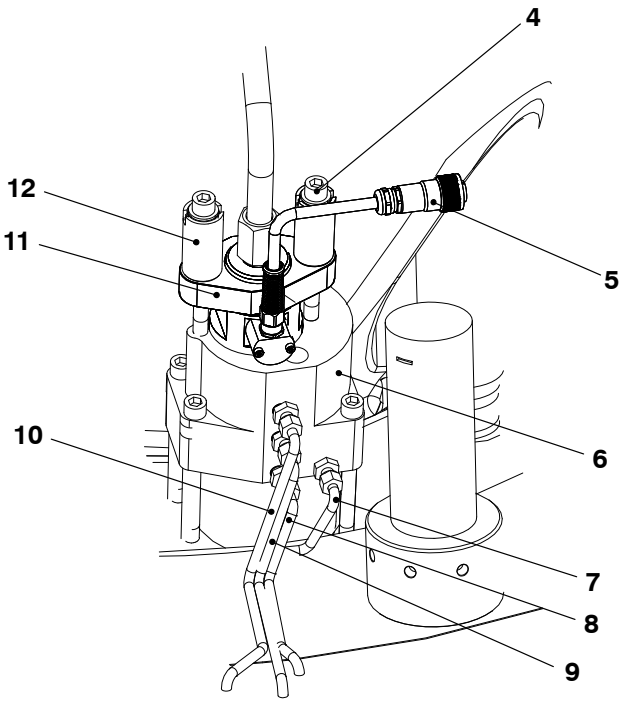


Fig.1

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 (1, 2 or 3, Fig. 1).
4) Set to off the fuel supply.
5) Set to off the lube oil supply.
6) Make sure that the drain from the pilot injection valve to the sludge tank is open.
7) Remove the applicable pilot fuel pipe (1, 2 or (2), refer to 8790 paragraph 1 and paragraph 2.
8) Make sure that the pipes attached to the holder (6) of the pilot injection valve have no pressure:
   a) Lube oil return (10)
   b) Lube oil inlet (8)
   c) Leakage fuel/lube oil (10)
   d) Control fuel return (9).
9) Disconnect the connection (5)

3. Removal

1) Remove the two bolts (4) together with the spring cages (12) and flange (11).

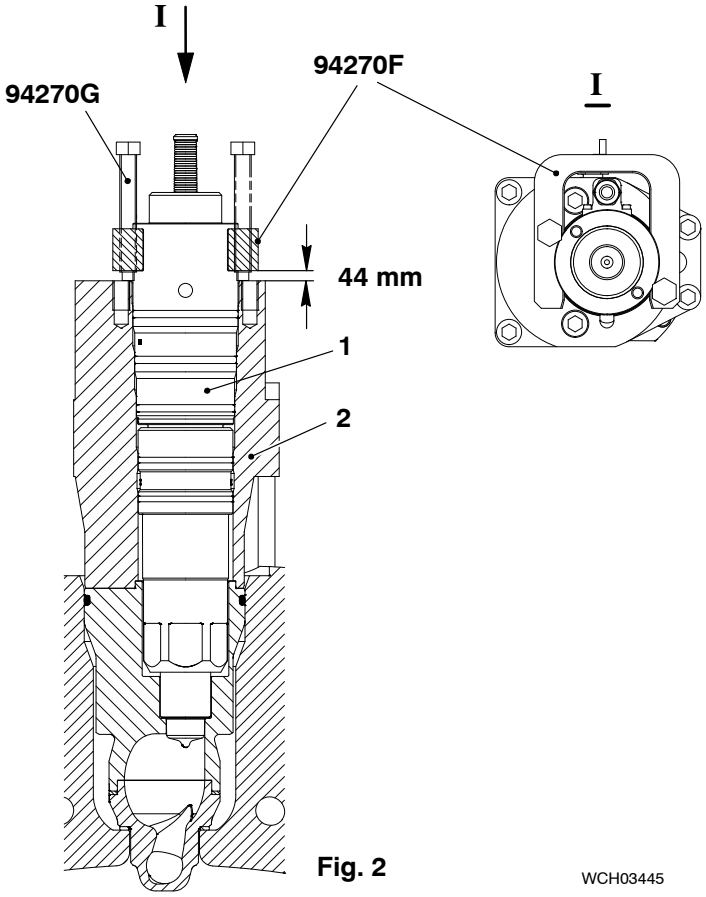


Fig. 2

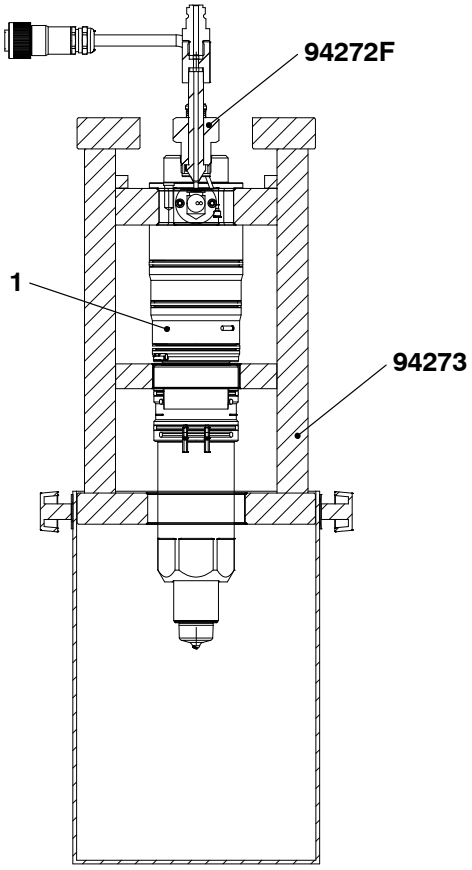


Fig. 3

2) Attach the support plate (94270F) with the screws (94270G) to the pilot injection valve (1, Fig. 2).
3) Turn equally the two screws (94270G) clockwise to lift the pilot injection valve 44 mm.
4) Remove the pilot injection valve from the holder (2).
5) Do a check of the pilot injection valve, refer to paragraph 4.

CAUTION

Injury Hazard: Always put on gloves and safety goggles that have a closed side frame when you do work with white spirit. White spirit can cause damage to your skin and eyes.

6) To clean the injection valve, use white spirit, e.g. Shellsol TD, Shellsol T or Solvent FP68.
7) If necessary, keep the pilot injection valve in a clean and dry storage area. The storage area must not have air that can cause corrosion.

4. Check

1) Read the data in the instruction manual of the test bench manufacturer.
2) Make sure that the work station is clean.
3) Put the injection valve (1, Fig. 3) in position in the valve holder (94273). Make sure that the injection valve points down.
4) Make sure the surfaces that touch on connection piece (94272F) and the pilot injector (1) are clean.
5) Attach the connection piece (94272F) to the pilot injector (1).
6) Use a brass wire brush to remove combustion particles from the external parts of the nozzle.

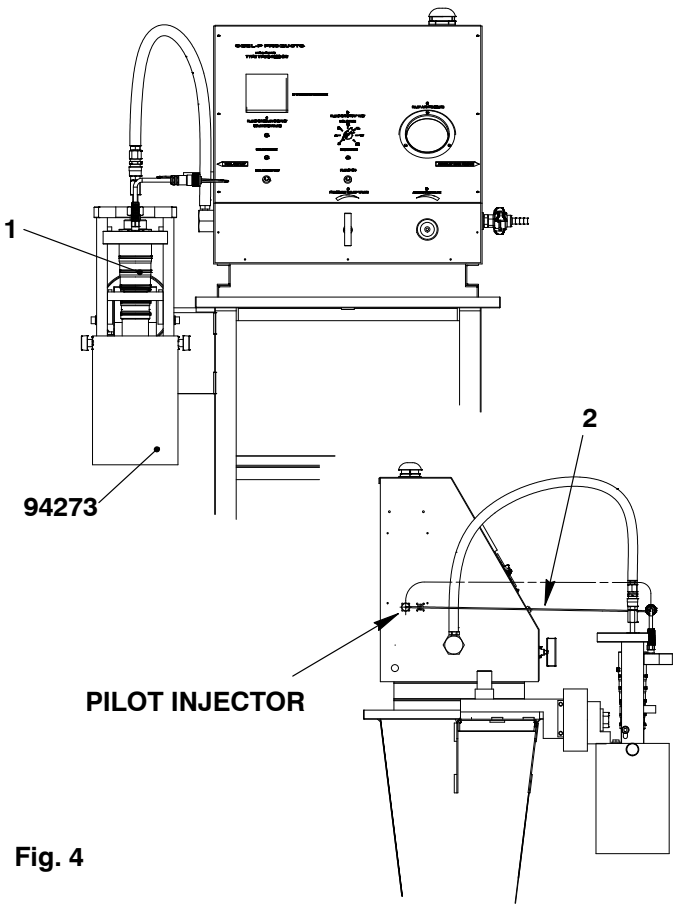


Fig. 4

7) Attach the HP hose to the connecting piece (94272F, Fig. 3).

8) Connect the injector cable (2, Fig. 4) to the socket for the 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.

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.

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.

3) Read the data in the manufacturer's instruction.

4) Set the pressure of the test bench to 600 bar.

5) Push the inject button. The injection valve must operate correctly.

6) 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.

7) 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.

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 bar 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 minimum opening pressure of 250 bar and a maximum 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 bodies that operates unsatisfactorily.

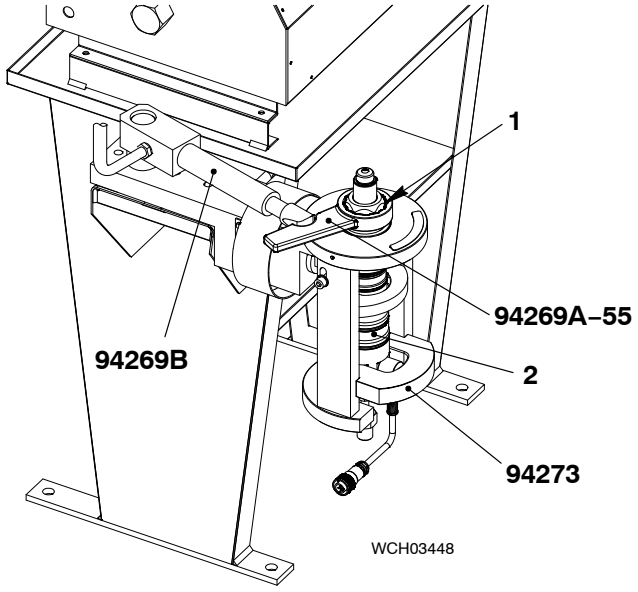
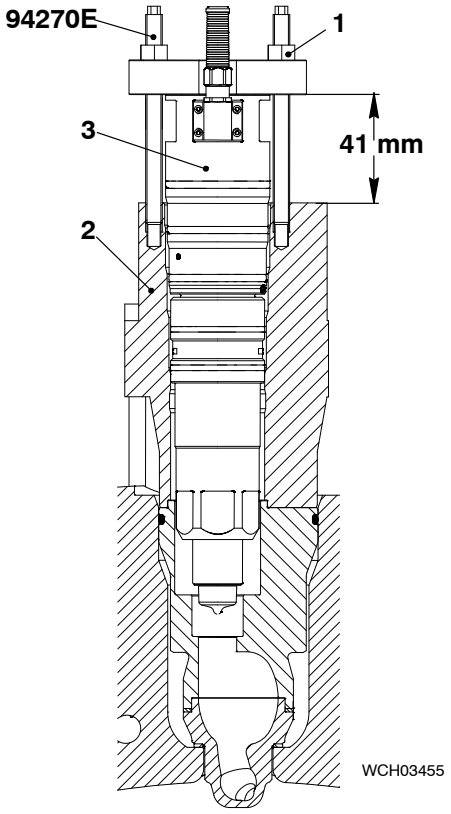


Fig. 5

5. Replace Nozzle Body

1) Attach the injection valve (1) to the valve holder (94273) as shown in Fig. 5.
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 (1) of the pilot injection valve (2).
4) Remove the coupling nut (1) and replace nozzle body if necessary (Spare Parts Code FX96236).
5) Apply Molykote paste G–n to the contact surfaces and thread of the coupling nut (1).
6) Use the torque wrench and socket wrench insert (94269C–55) to torque the coupling nut (1) to between 800 Nm and 830 Nm. Refer to 2722–2 , paragraph 6.2.
7) Replace the O–rings on the pilot injector (Spare Parts Code FX96237).



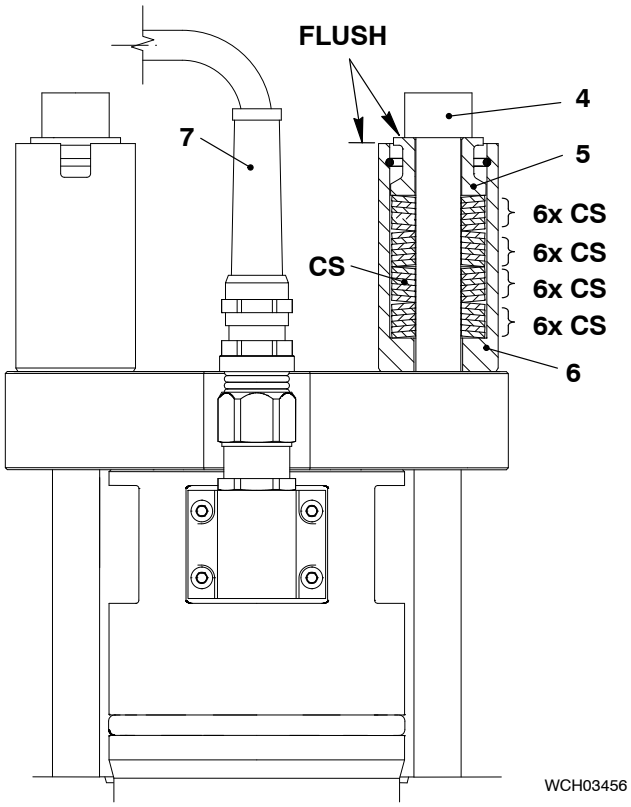
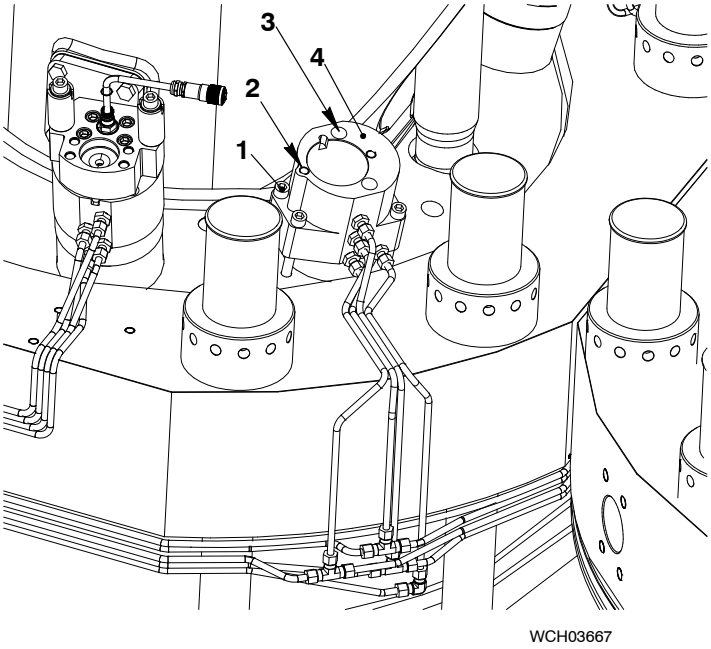


Fig. 6

6. Installation

1) Apply oil to the O−rings of the pilot injection valve (3, Fig. 6).
2) Put the injection valve (3) into the holder (2).
3) Put the stud bolts (94270E) into the holder (2) as shown.
4) Turn equally the two nuts (1) equally down until there is a distance of 41 mm as shown.
5) Remove the stud bolts (94270E).
6) If the spring cage (5) was disassembled, make sure the cup springs (CS) are installed correctly, (four packs with six cup springs each.
7) Apply Never Seez NSBT to the threads and surfaces that touch of the bolts (4).
8) Install the bolts (4) together with the spring cage (5) as shown.
9) Tighten equally the bolts (4) until the top of the spring guide is flush with the top of the spring cage (5).
10) Install the applicable pilot fuel pipe (1 or 2, Fig. 1), refer to 8790−1, paragraph 3.
11) Connect the injector cable (7) to terminal box E95.4.
12) Set to on the fuel supply.
13) Set to on the lube oil supply.



7. Pre-chamber – Removal

1) Remove the pilot injection valve, refer to paragraph 1 , paragraph 2 and paragraph 3.
2) Remove all pipes and connectors from the holder (4, Fig. 7)
3) Loosen the two bolts (3) one turn.
4) Remove the four bolts (1).
5) Attach two M12 eye bolts to the threads (3).

CAUTION

Injury Hazard: The weight of the pre-chamber is approximately 20 kg. Use the correct equipment, or two persons to lift and move the pre-chamber. This will prevent injury to personnel.

6) Carefully lift the holder (4) together with the pre-chamber from the cylinder cover.
7) Remove the two bolts (2) and the pre-chamber (5).

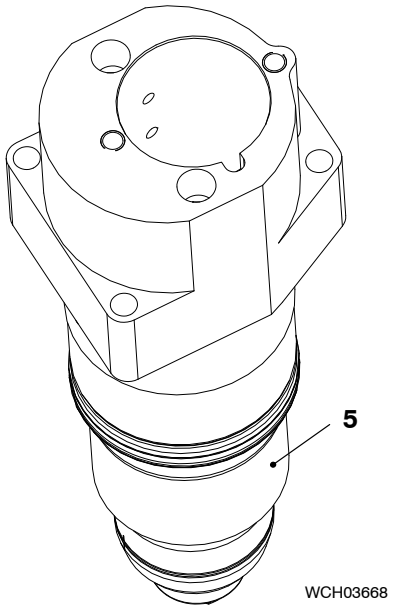


Fig. 7

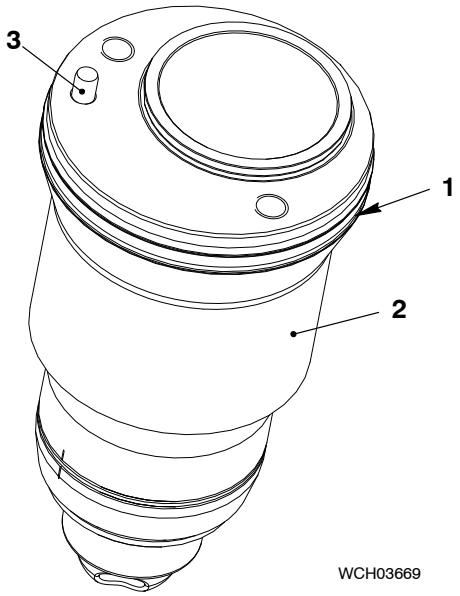


Fig. 8

8. Install Pre Chamber

1) Make sure that the pre-chamber (2, Fig. 8) is internally and externally clean.
2) Install the 8x20 dowel pin (3).
3) Attach a new O-ring (1) to the pre-chamber (2).

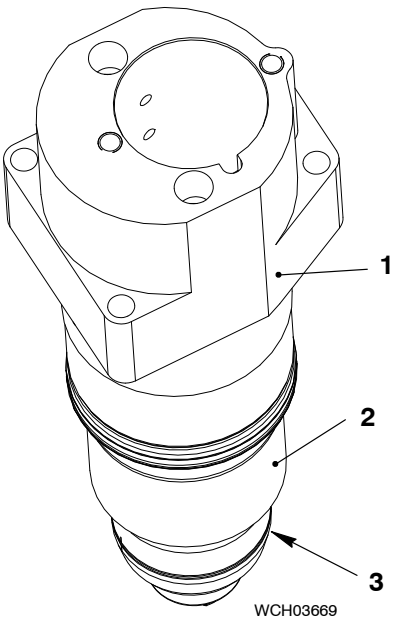


Fig. 9

4) Attach the new seal (3, Fig. 9) to the pre-chamber (2).
5) Put the pre-chamber (2) in the correct position on the holder (1) with the two M12x200 bolts.
6) Torque the two M12x200 bolts to the value given in 0352–2, paragraph 1.

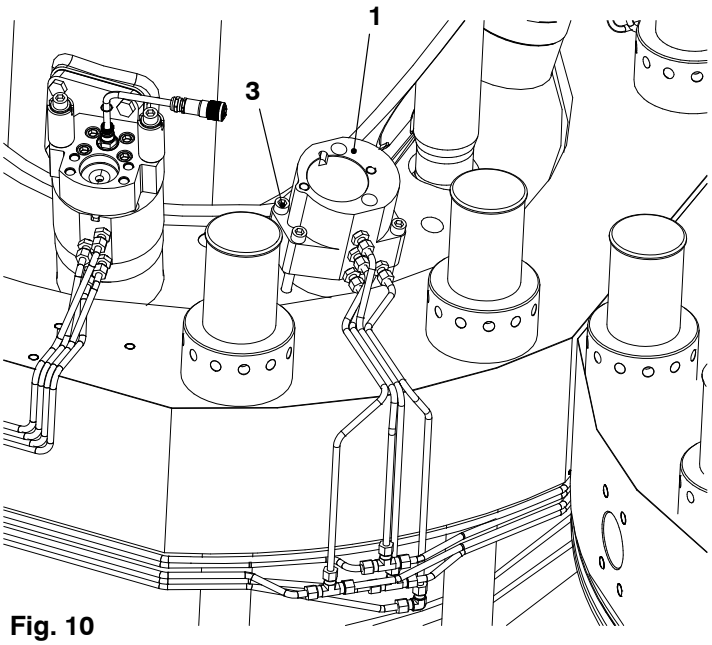


Fig. 10

1) Put the holder (1) together with the pre-chamber (2) into the cylinder cover.
2) Apply Never Seez NSBT to the four bolts (3).
3) Torque the four bolts (3) to 60 Nm.
4) Connect all pipes to the holder (1).
5) Install the pilot injection valve, refer to paragraph 6.

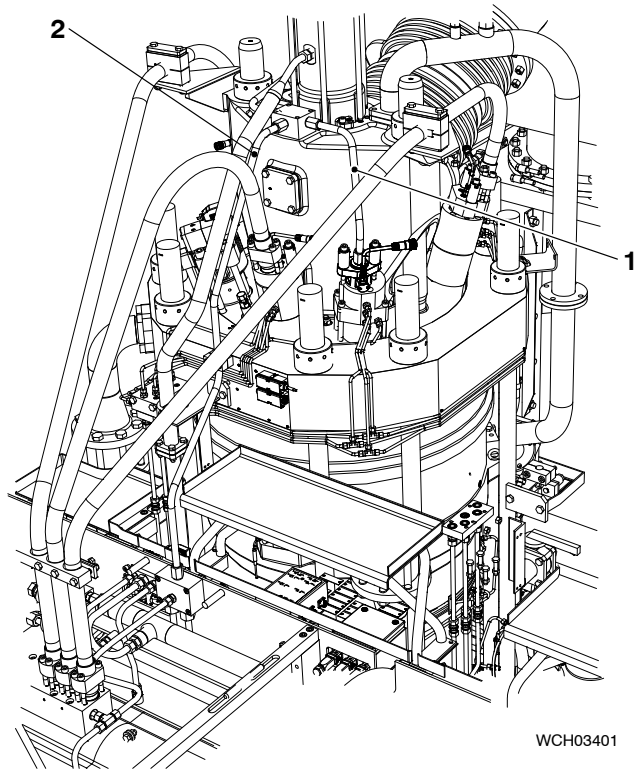


Fig. 11

9. Completion

1) Install the applicable pilot fuel pipe (1 or 2, Fig. 11), refer to 8790 paragraph 3.
2) Open the valves from the fuel supply and pilot fuel supply.
3) Set to on the lube oil supply.
4) Set to on the fuel supply.

Intentionally blank

Crankshaft, Connecting Rod and Piston — Group 3

Intentionally blank

Work Card
Crankshaft

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

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

Tools and Consumables

Crankshaft equipment (dial gauge)	94305	Qty 1

Primary Task

Measure the crank deflection, refer to 3103–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	0.5 hours	Qty 1
Service Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Not applicable

Intentionally blank

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 WinGD for support.

2. Preparation

Make sure that:

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

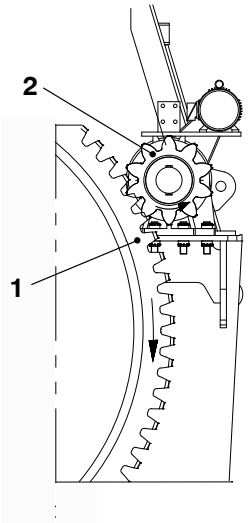


Fig. 1

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

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

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

3. 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.)

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.

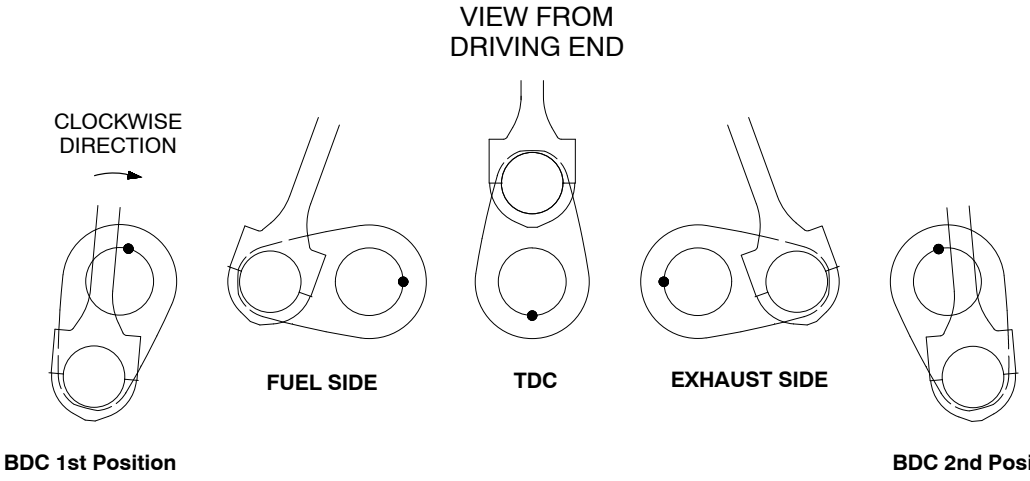
4) Turn the rod of the dial gauge to apply tension.

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.



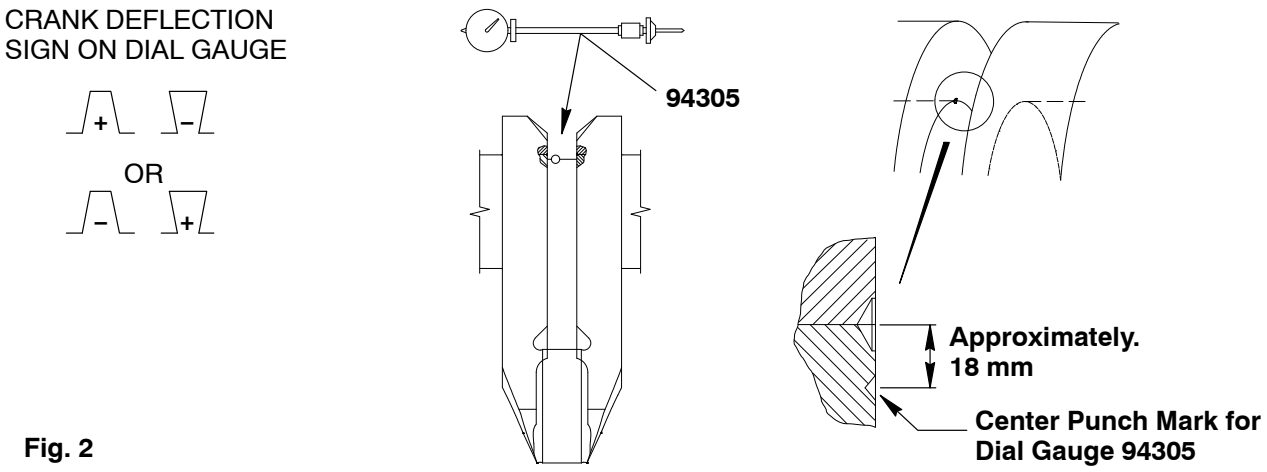


Fig. 2

4. Data Analysis

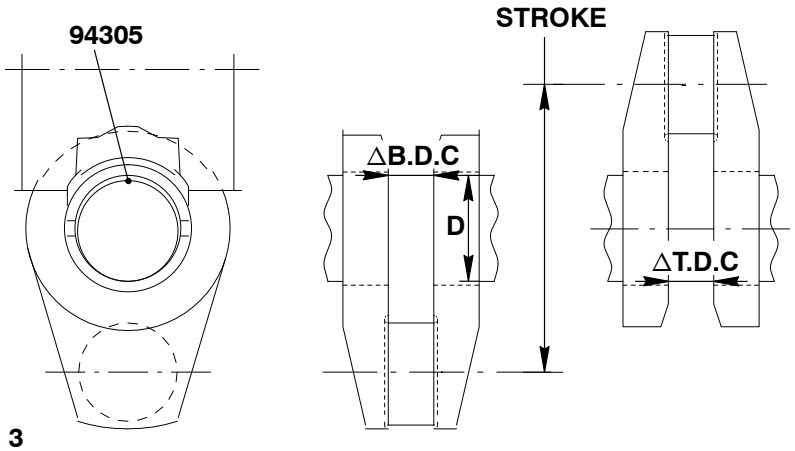


Fig. 3

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

Where values are measured, which are above the maximum permitted limits, you must find the cause (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 WinGD, if the last data is more than the limits given in the table above.

Intentionally blank

Silicone Fluid Sample

1. General

Viscous vibration dampers that Hasse & Wrede, Metaldyne International UK, STE Schwingungstechnik and Geislinger manufacture can be 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.

The effect of the vibration damper can decrease when changes to the properties of the silicone oil occur, and when the internal parts become worn.

Initially, the silicone oil must be examined between approximately 15000 operation hours and 18000 operation hours. Regular examinations of the silicone oil will show the manufacturers the condition of the vibration damper. Subsequent examinations are related to the results of the initial examinations.

Special sample containers are available from the vibration damper manufacturer.

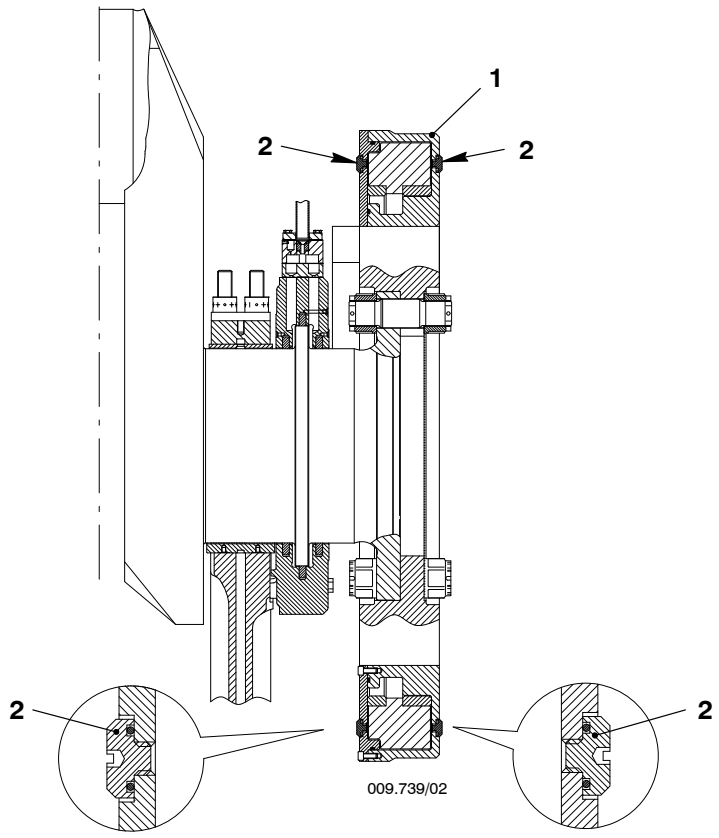


Fig. 1

2. Silicone Oil Sample – Preparation

WARNING

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

Note: Read the instructions in the manufacturer's documentation before you do the procedure that follows.

1) Remove the casing from the vibration damper (1, Fig. 1)
2) Operate the turning gear to move the crankshaft (1) until a screw plug (2) is horizontally opposite the other screw plug. If this is not possible, a vertically opposite position is satisfactory.
3) Carefully clean the area around the screw plugs (2).
4) Leave the vibration damper (1) in position for a minimum of two hours.

Note: The same conditions apply for a vibration damper that is removed from the engine.

5) Use applicable tools to remove the sealing material from the screw plugs (2).

Note: When you do step 6), make sure that the screw plug (2) still makes a seal.

6) Carefully loosen the screw plug (2).

3. Silicone Oil Samples

3.1 Metaldyne and STE

Note: Two different threads are used for the sample bores of the Metaldyne International and STE vibration dampers.

Note: The sample container lets you get a specified quantity of silicone oil from the damper. The total number of samples must not be more than 10.

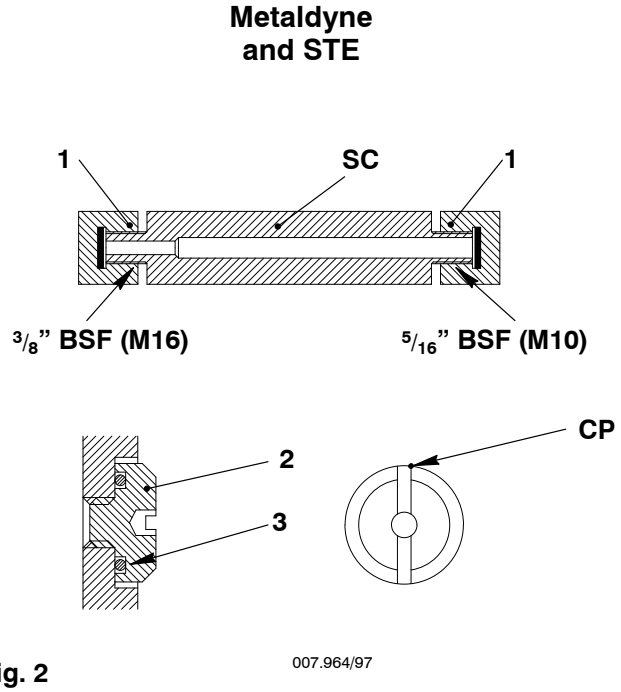


Fig. 2

1) Remove the two cap nuts (1, Fig. 2).
2) Examine the bore in the sample container (SC). Make sure that the bore is clean.
3) Remove the screw plug (2) loosened before.
4) Remove and discard the O-ring (3).
5) Put a new O-ring (3) in the screw plug (2).
6) Put the the sample container (SC) fully into the vibration damper housing, then turn the sample container back one turn. This will make sure that the sample container does not touch the flywheel.
7) When you see silicone oil in the sample container (SC), attach the cap nut (1) to the open end.
8) Remove the sample container (SC) from the vibration damper housing. Immediately attach the screw plug (2) to the vibration damper housing.
9) Attach the other cap nut (1) to the sample container (SC).
10) Torque the screw plug as follows:
    a) Metaldyne: Torque the screw plug to 25 Nm.
    b) STE: Torque the screw plug (3) to 15 Nm (M10) or 45 Nm (M16).
11) Use a center punch to lock the screw plug (3) in position.
12) Attach a label to the sample container. The label must have the data that follows:
    - Engine type and engine number
    - Number of operation hours of the vibration damper
    - Name of vessel
    - Shipyard and hull number
    - Manufacturer's serial number (data plate or stamped marks)
    - Damper location (crankshaft or camshaft).

13) Send the sample to:

Metaldyne International UK Ltd
131 Parkinson Lane
Halifax HX1 3RD
United Kingdom
Tel: +44 1422 357 234
Fax: +44 1422 354 432

Note: For STE Schwingungstechnik manufactured vibration dampers, send the samples to Hasse & Wrede (see paragraph 3.2, step 13)).

SAMPLE CONTAINERS

Hasse & Wrede

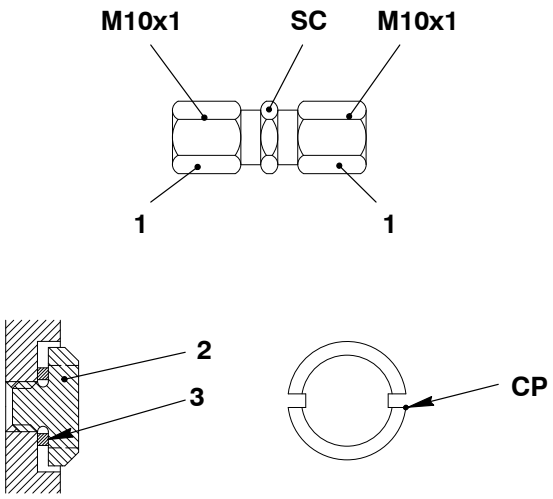


Fig. 3

3.2 Hasse and Wrede

Note: The sample container lets you get a specified quantity of silicone oil from the damper. The total number of samples must not be more than 10.

1) Remove the two cap nuts (1, Fig. 3).
2) Examine the bore in the sample container (SC). Make sure that the bore is clean.
3) Remove the screw plug (2) loosened before.
4) Remove and discard the sealing ring (3).
5) Put a new sealing ring (3) in the screw plug (2).
6) Put the the sample container (SC) fully into the vibration damper housing, then turn the sample container back one turn. This will make sure that the sample container does not touch the flywheel.
7) When you see silicone oil flow out of the sample container (SC), attach the cap nut (1) to the open end.
8) Remove the sample container (SC) from the vibration damper housing. Immediately attach the screw plug (2) to the vibration damper housing.
9) Attach the other cap nut (1) to the sample container (SC).
10) Torque the screw plug (2) to 20 Nm.
11) Use a center punch to lock the screw plug (3) in position.
12) Attach a label to the sample container. The label must have the data that follows:
    - Engine type and engine number
    - Number of operation hours of the vibration damper
    - Name of vessel
    - Shipyard and hull number
    - Manufacturer’s serial number of damper (data plate or stamped marks)
    - Damper location (crankshaft or camshaft).

13) Send the sample to:

Hasse & Wrede
Georg-Knorr-Strasse 4
D-12681 Berlin
Germany
Tel: +49 30 93 92 3135
Fax: +49 30 70 09 0835

If you cannot get a sample as given in paragraphs 3.1 and 3.2, do the procedure that follows:

1) Leave sample container (SC) in position.

1) Remove the opposite screw plug.

Note: Before you do step 2), make sure that the connections are clean.

2) Connect a clean, dry compressed air supply of approximately 3.5 bar to the screw plug.

3) When silicone oil flows to the open end of the sample container, stop the compressed air supply.

4) Attach a cap nut to the sample container.

5) Disconnect the compressed air supply.

6) Remove the sample container and attach the other cap nut.

7) Attach the related screw plugs to all withdrawal openings.

8) Torque the screw plugs as given in step a) and step b):

   a) For Metaldyne and STE vibration dampers, paragraph 3.1 step 10).

   b) For Hasse and Wrede vibration dampers, paragraph 3.2, step 10).

9) Use a center punch to lock the screw plugs (3) in position.

Note: The sample container lets you get a specified quantity of silicone oil from the damper. The total number of samples must not be more than 10.

For vibration dampers manufactured at Geislinger, send to samples to:

Geislinger GmbH
Hallwanger Landesstrasse 3
A-5300 Hallwang / Salzburg
Austria
Tel: +43 662 66 999 0
Fax: +43 662 66 999 40

The label must contain the following information:

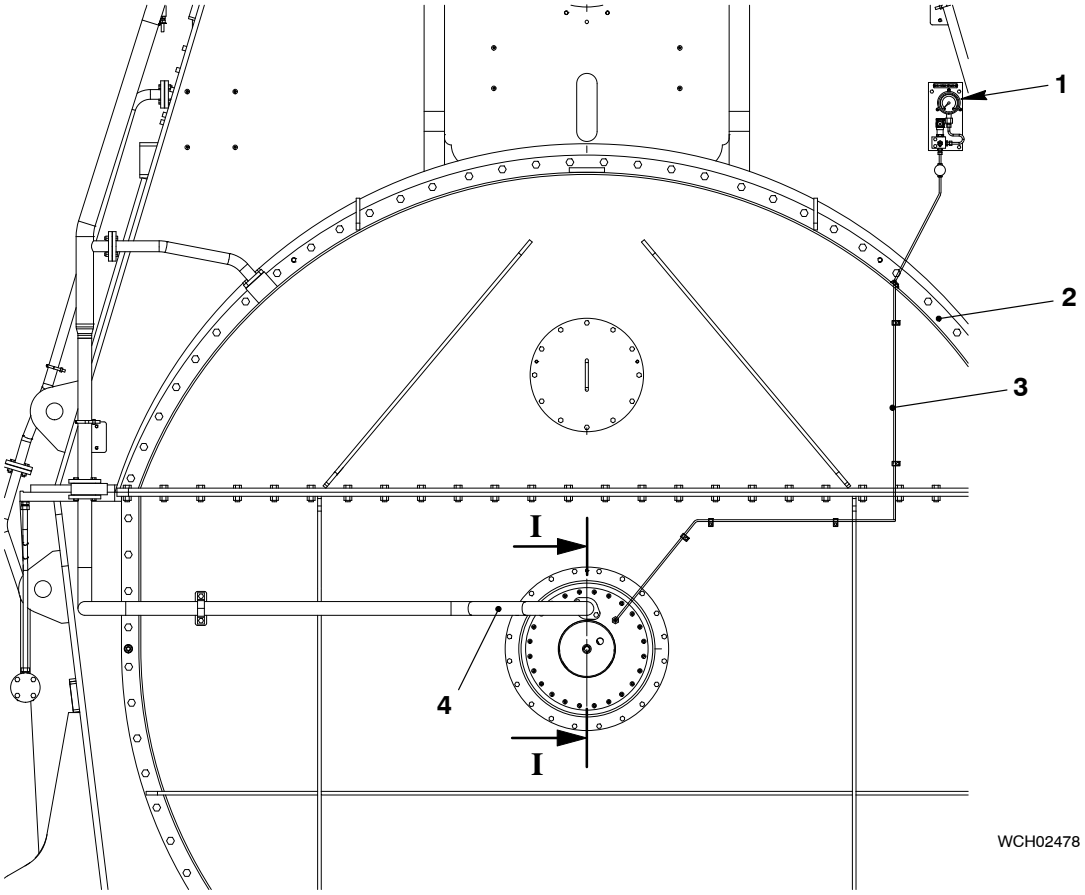
- Engine type and engine number
- Number of operating hours of the vibration damper
- Ship name
- Shipyard and hull number
- Manufacturer’s serial number of damper (data plate or stamped marks)
- Damper location (crankshaft or camshaft).

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
2 Damper casing
3 Monitor pipe
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.

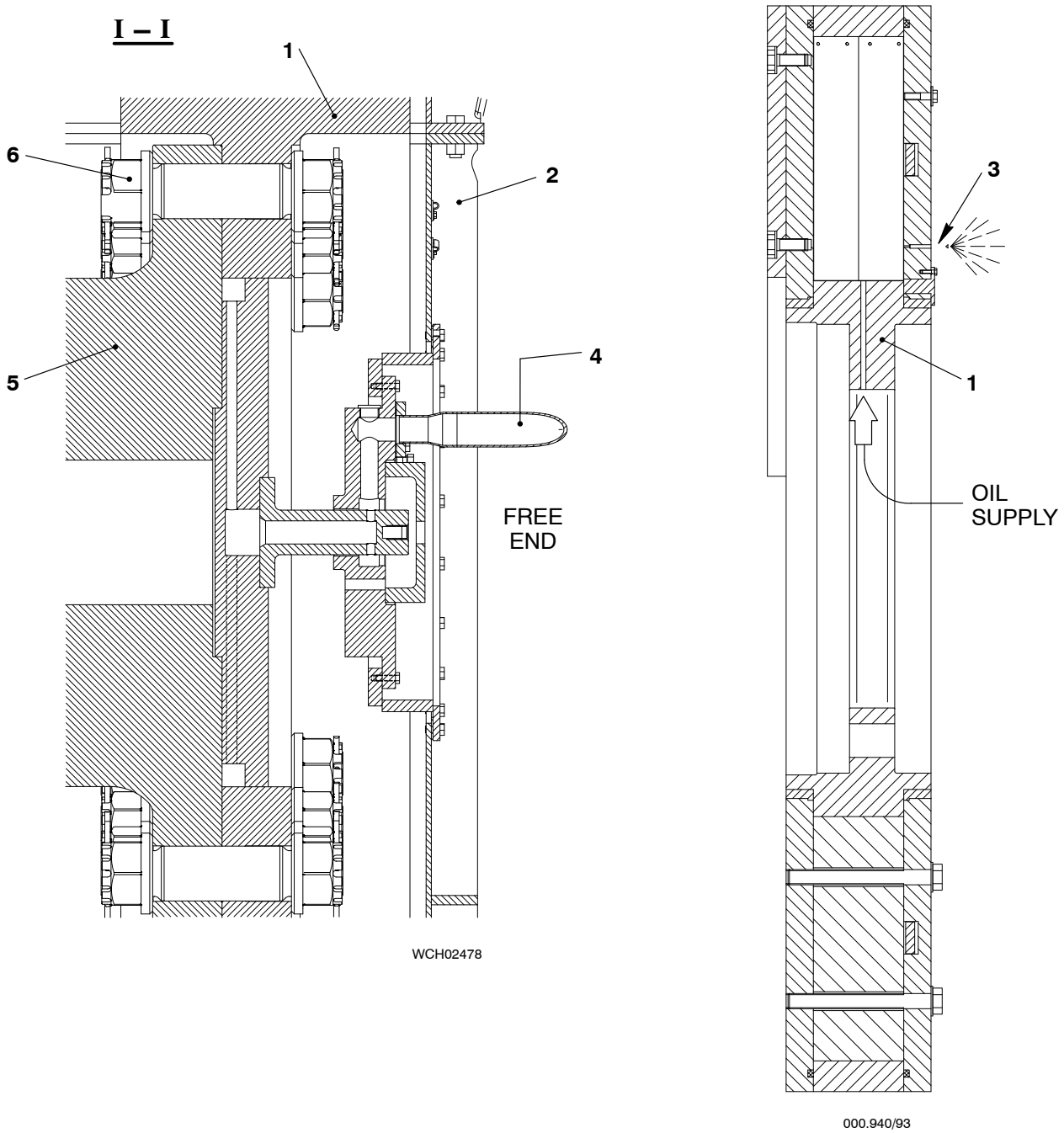
Before you remove a vibration damper and balance weight, record their positions with reference to the crankshaft position.

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

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

The address for GEISLINGER vibration dampers is given below:

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



Note: Some parts can look different.

Fig. 2: Vibration Damper (section view)

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

Intentionally blank

Removal and Installation

Tools:

2	Spur-geared chain block	94017-006	2	Eye bolt	94045-M36
2	Shackle	94018A	1	Lifting plate / link	94321
1	Chain	94019C			

1. Removal

When the 2-part gasket (9 or 10, Fig. 1) must be removed from the axial damper, do the procedure that follows:

1) Read the data in 0012–1 General Guidelines for Lifting Tools.
2) Remove the pipes (7, 8).
3) Remove the top housing (1).
4) Remove the oil supply pipe (6).
5) Remove the six bolts (5) and the four screws (4) from the top housing (1).
6) Remove the 2-part gaskets (9, 10).

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

7) Examine the 2-part gaskets (9, 10) for damage and contamination. If necessary, replace the 2-part gaskets.

For more data about the Axial Damper, refer to the Operation Manual 3140–1.

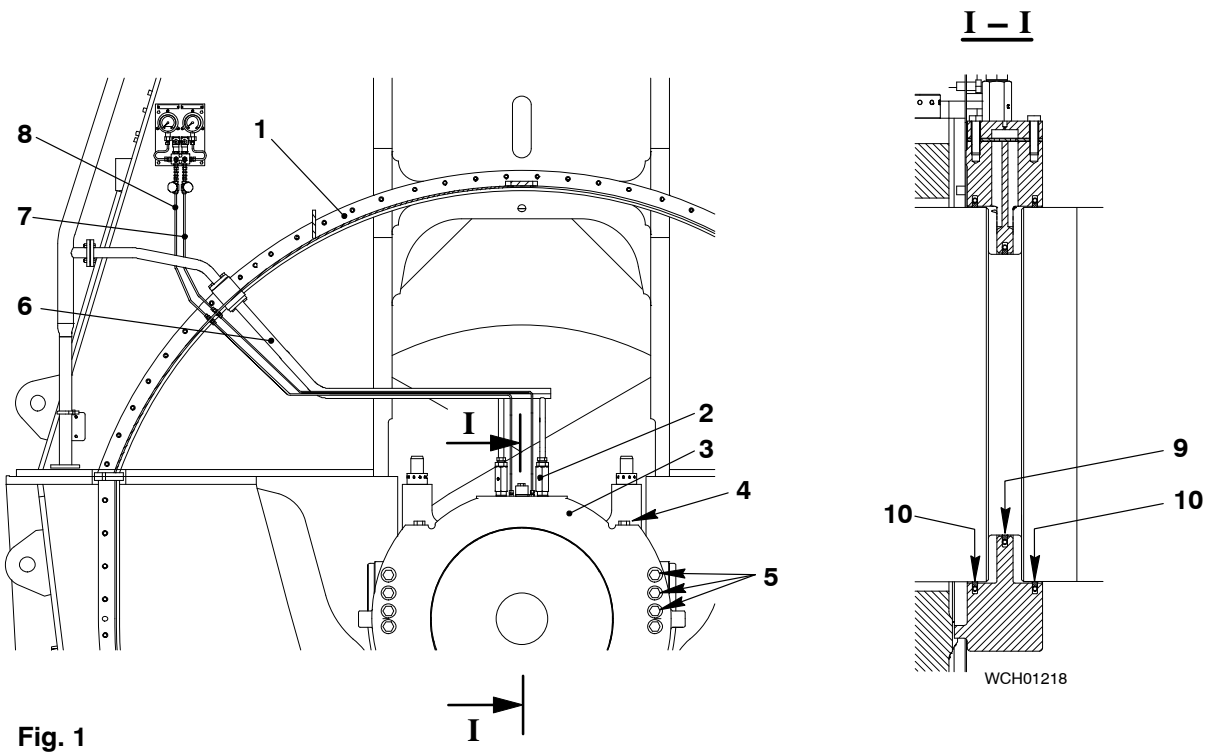


Fig. 1

8) Attach the two eye bolts (94045-M36, Fig. 2) to the axial detuner.
9) Attach the chain (94019C) to the eye bolts (94045-M36).
10) Attach the plate (94321) to the chain (94019C).
11) Install the two shackles (94018A, Fig. 3) to the column.
12) Attach the spur-geared chain blocks (94017-006) to the shackles in the column.
13) Operate the spur-geared chain blocks (94017–006) to lift and move the axial detuner to a position below the engine room crane.
14) Attach the hook of the engine room crane to the plate (94321).
15) Remove the spur-geared chain blocks (94017–006) from the plate (94321).
16) Operate the engine room crane to lower the axial detuner on to an applicable surface.

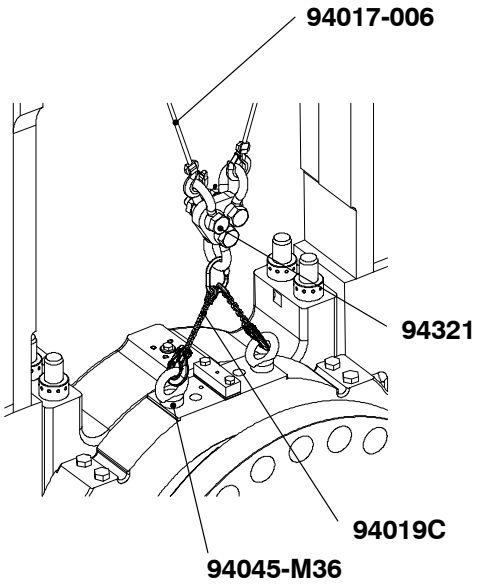


Fig. 2

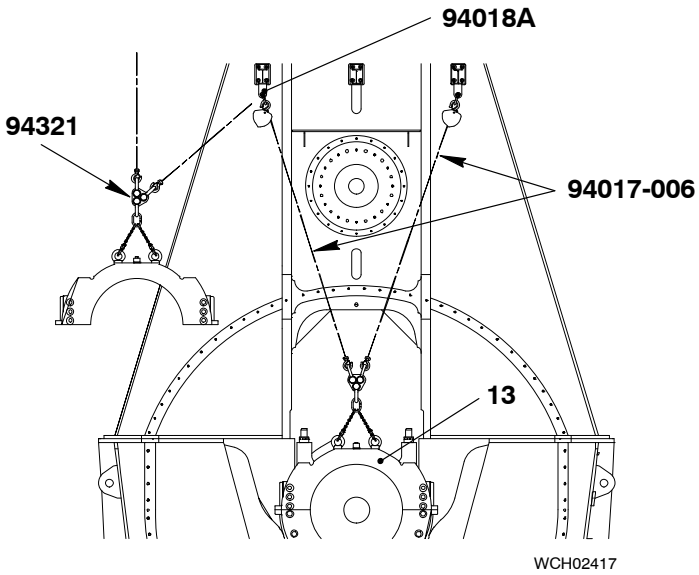


Fig. 3

2. Installation

1) Apply clean engine oil to the 2-part gaskets (9, 10, Fig. 1).
2) Install the 2-part gaskets (9, 10). Make sure that the 2-part gaskets can move freely.
3) Attach the plate (94321, Fig. 3) to the axial damper.
4) Attach a spur-geared chain block (94017–006) and the engine room crane to the plate (94321).
5) Operate the engine room crane and spur-geared chain block (94017–006) to lift and move the axial damper into position.
6) Attach the other spur-geared chain block (94017–006) to the axial damper.
7) Remove the hook of the engine room crane from the plate (94321).
8) Operate the two spur-geared chain blocks to carefully lower the axial damper on to the bottom housing. Make sure that you do not cause damage to the 2-part gaskets.
9) Apply Molykote paste G–n to the threads of the six bolts (5, Fig. 1).
10) Torque the six bolts (5) to 900 Nm (refer to 0352–1.
11) Install the four screws (4).
12) Install the pipes (7, 8) and the oil supply pipe (6).
13) Remove all tools and equipment from the work area.

Intentionally blank

Teeth and Screwed Connections – Check

Tools:

1 Pre-tensioning jack 94320

1. General

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

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

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

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

You must do a check of the tension of the elastic bolts (4). The intervals for the checks are given in the 0380.1, Maintenance Schedule, Inspection and Overhaul Intervals Turning Gear. The procedure to do a check of the tension is given in paragraph 3.

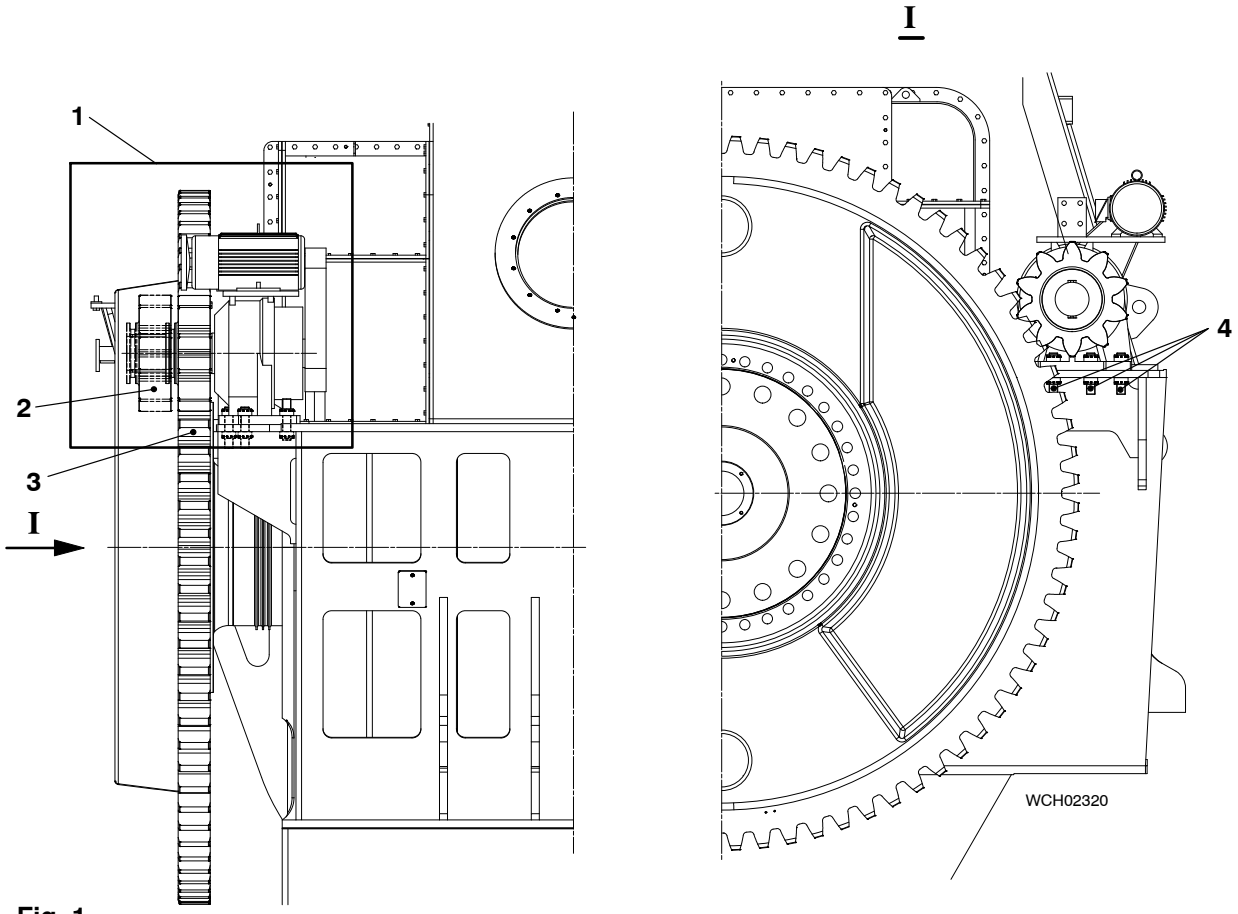


Fig. 1

2. Pinion and Flywheel Teeth

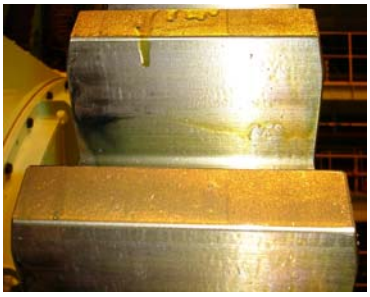
2.1 Procedure

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

Table 1: Instructions – Pyroshield

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

Table 2: Instructions – Klüberfluid

	Manufacturer	Location	Instruction
	Klüberfluid C–F 3 Ultra		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 approximately 35°C. Apply the Klüberfluid as shown in the photograph.

2.2 Lubrication Intervals

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

2.3 Recommended Suppliers

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

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

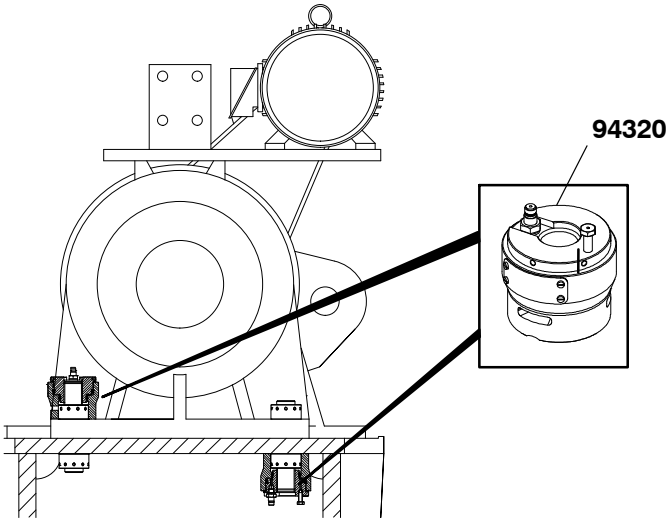
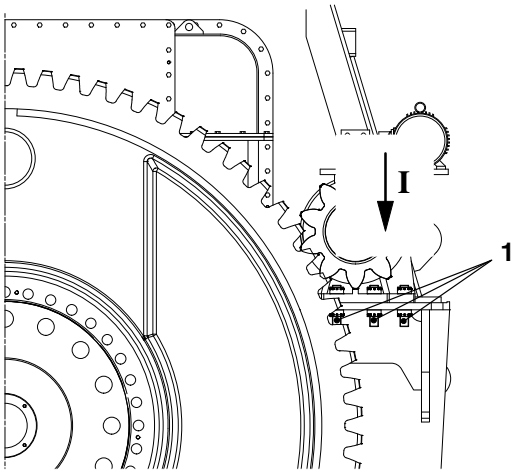


Fig. 2

3. Elastic Bolts – Apply Tension

1) Clean the round nuts, the threads of the elastic bolts and the seating surfaces.
2) Read the data in 9403–4.
3) Put the pre-tensioning jack (94320, Fig. 2) in position on the applicable elastic bolt (1, Fig. 3).
4) Apply tension to the elastic bolts (1) in the specified sequence shown and in accordance with the values given in 9403–4, Turning Gear..
5) Apply a protection agent e.g. Valvoline Tectyl 132 to the bolt threads, round nuts and the seating surfaces to give protection against corrosion



SEQUENCE

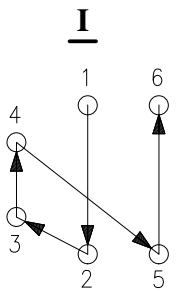


Fig. 3

Intentionally blank

Work Platform

Tools:

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

1. General

WARNING

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

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

You install the platform (94142) on the longitudinal beam (2) and the crank (1).

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

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

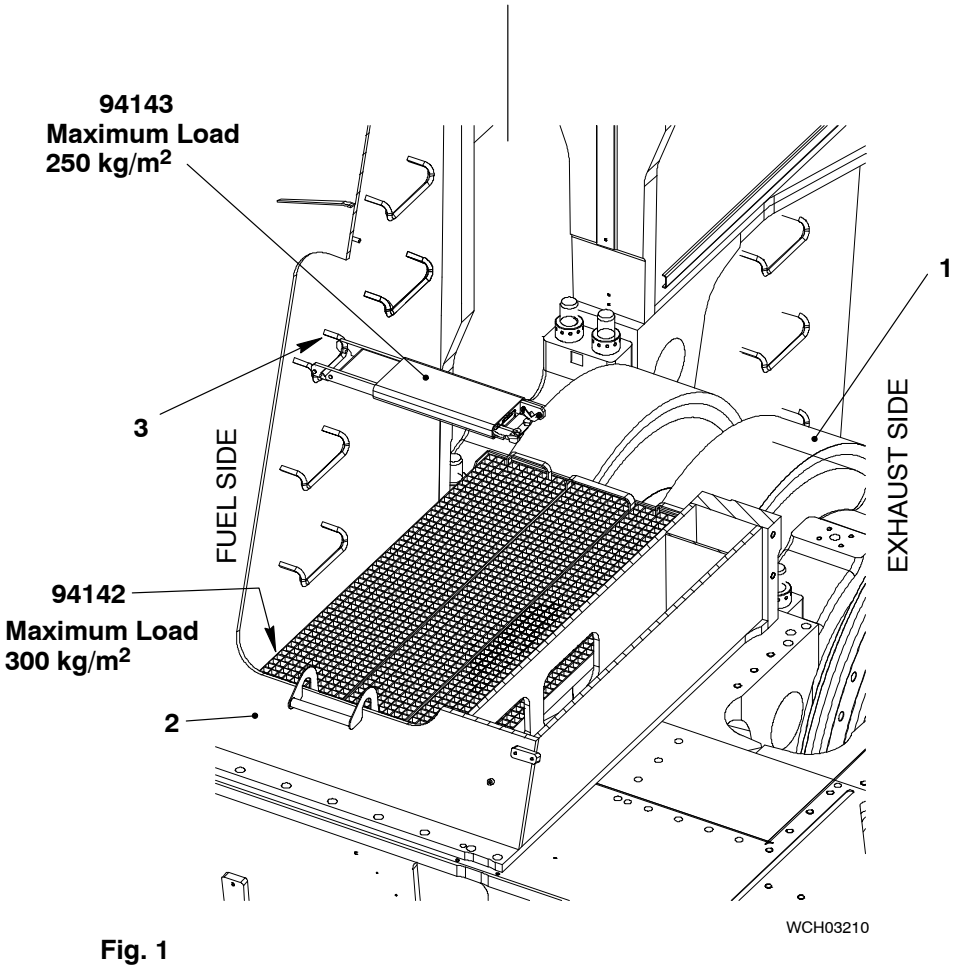


Fig. 1

Intentionally blank

Work Card
Connecting Rod: Check the Bearing Clearances

Necessary Conditions

– Engine stopped
– Crankshaft at TDC

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Tools and Consumables

Feeler gauge	94122	Qty 1

Primary Task

Do a check of the bearing clearances, refer to 0330–1, Group 3303

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Bottom End Bearing – Removal, Inspection and Installation

Tools:

2	Manual ratchet H1/H5 1000 kg	94016-009
2	Manual ratchet H2/H3, 1000 kg	94016-011
1	Manual ratchet H4, 1500 kg	94016-017
4	Shackle, 4750 kg	94018B
2	Shackle, 8500 kg	94018C
1	Chain, 5300kg	94019B
4	Eye bolt M8	94045-M8
1	Deviation pipe	94117B
1	Pre-tensioning jack	94252
1	Chain	94327
1	Console Frame	94326
1	Support	94322
1	Support (for iELBA)	94322A

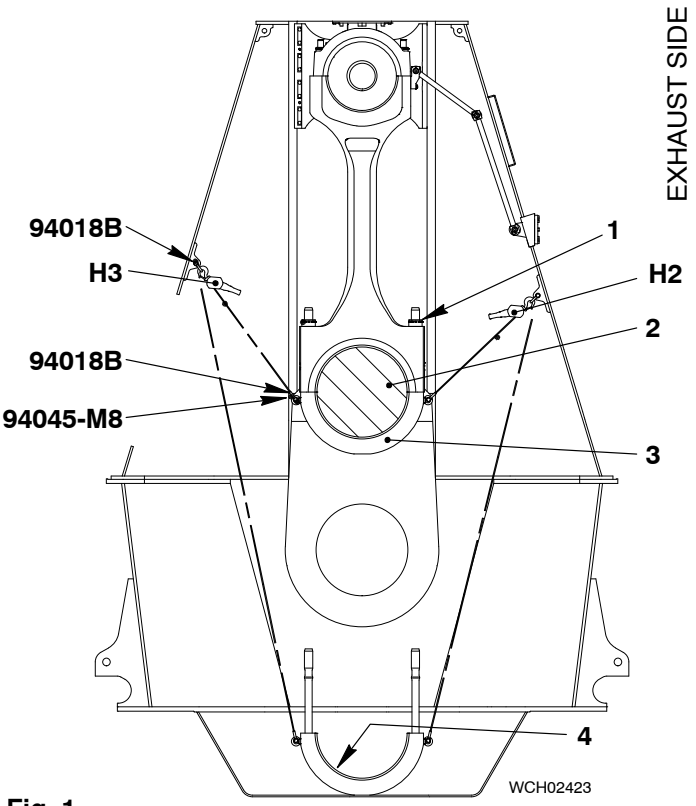


Fig. 1

1. Preparation

WARNING

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

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

2. Bearing Cover – Removal

1) Loosen the round nuts (1), refer to 9304–4 paragraph 2.
2) Remove the round nuts (1).
3) Carefully lower the bearing cover (3).
4) Examine the bearing shell (4).

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

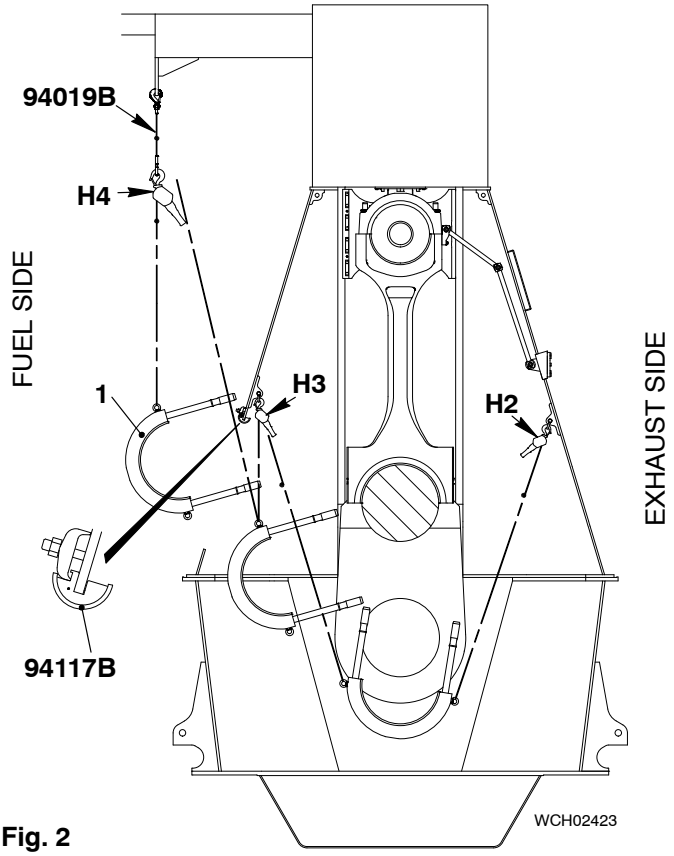


Fig. 2

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

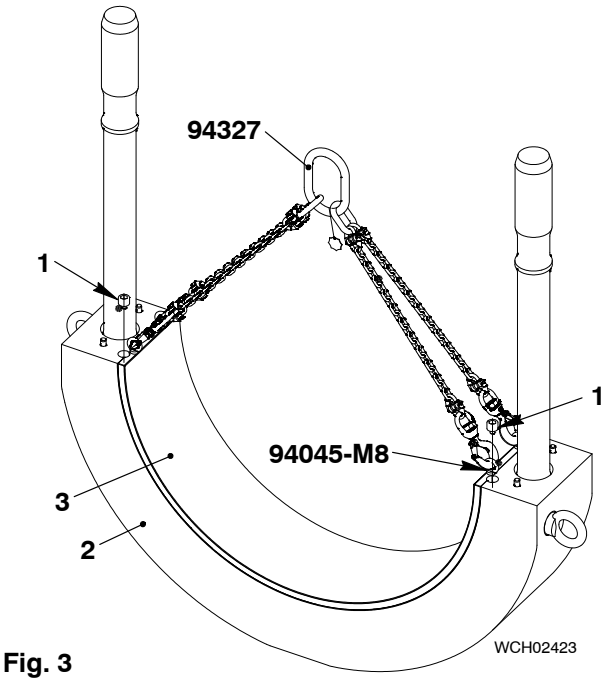


Fig. 3

3. Bearing Shell – Removal

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

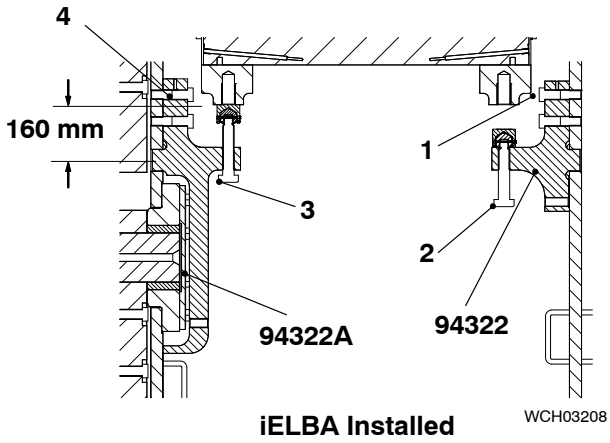


Fig. 4

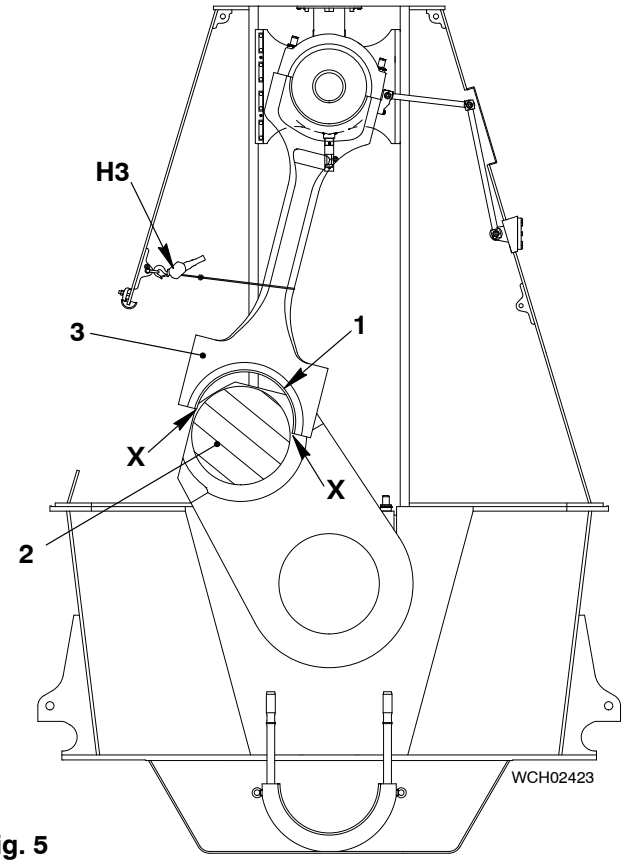


Fig. 5

4. Top Bearing Shell – Check

WARNING

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

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

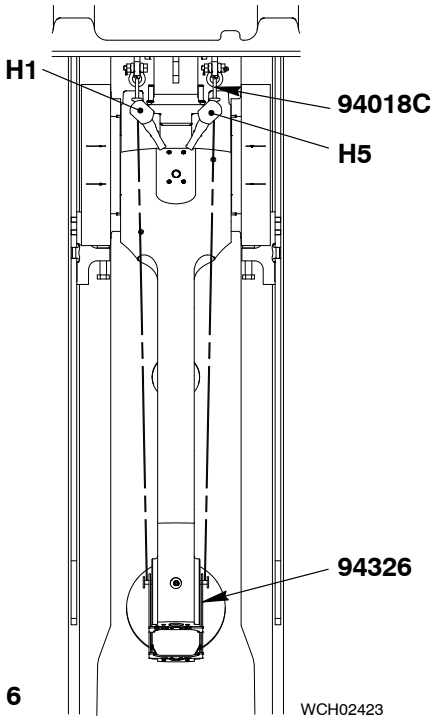


Fig. 6

5. Top Bearing Shell – Removal

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

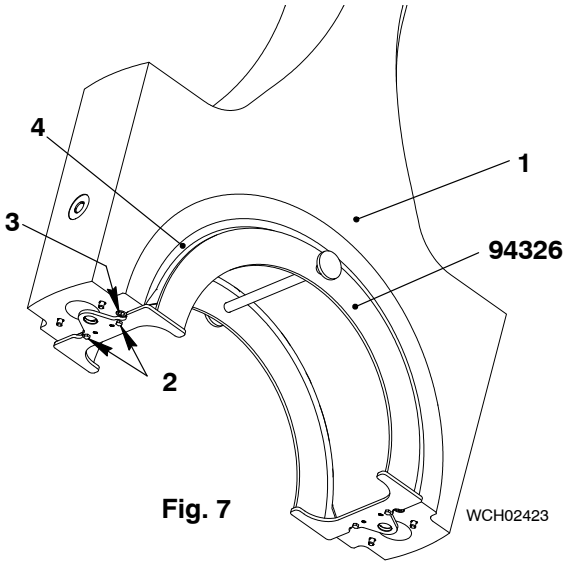


Fig. 7

7) Operate the manual ratchets (H5, H1) to lower the console frame (94326, Fig. 8) together with the bearing shell.
8) Attach the manual ratchet (H4) to the eyelet in the console frame (94326).
9) Operate the manual ratchets (H4, H1, H5) to move the console frame (94326) and bearing shell out of the column.
10) Remove the manual ratchets (H1, H5).

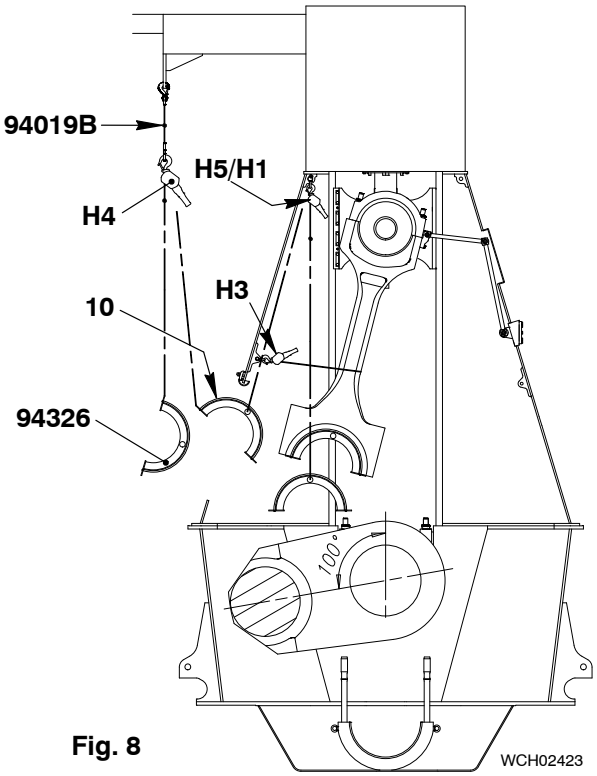


Fig. 8

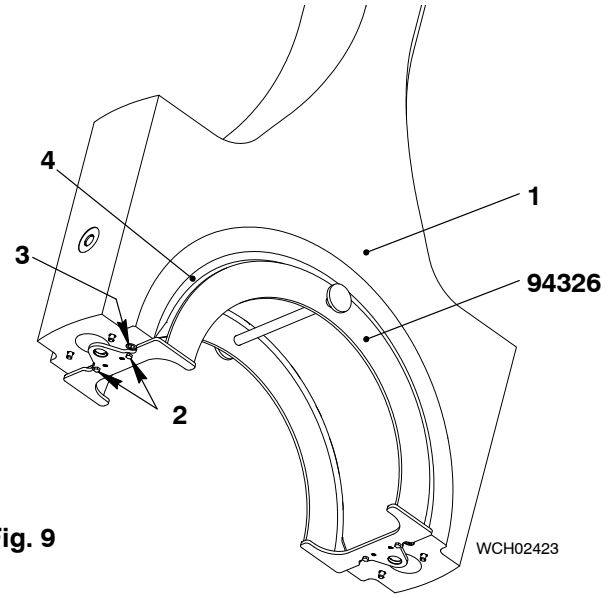


Fig. 9

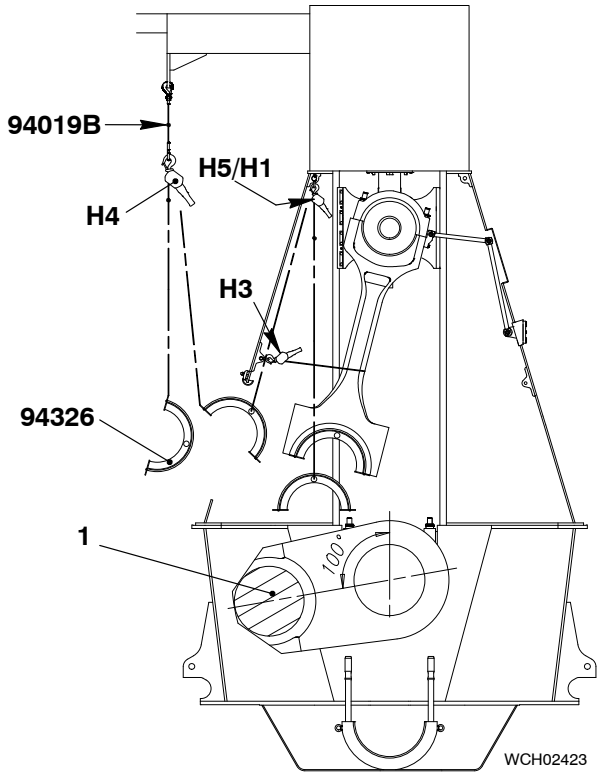


Fig. 10

6. Top Bearing Shell – Installation

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

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

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

WARNING

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

15) Operate the turning gear to move the crank to TDC. Make sure that there is no load at the points (X, Fig. 5).
16) Remove the supports (94322, 94322A).

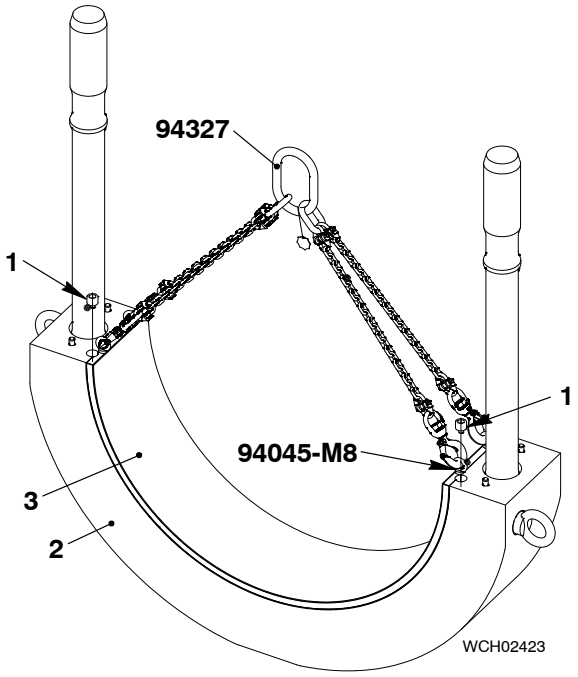


Fig. 11

7. Bottom Bearing Shell – Installation

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

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

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

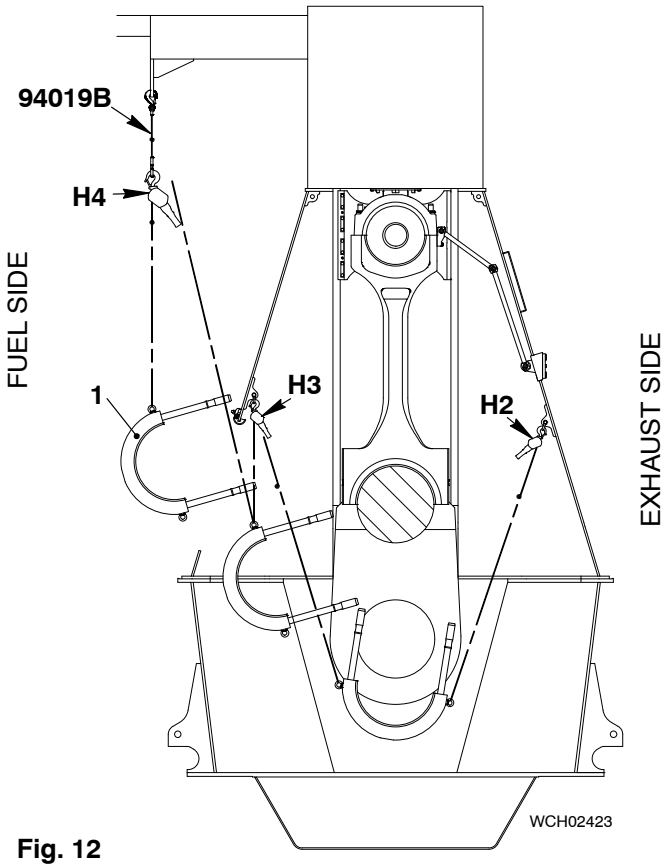


Fig. 12

8. Bearing Cover – Installation

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

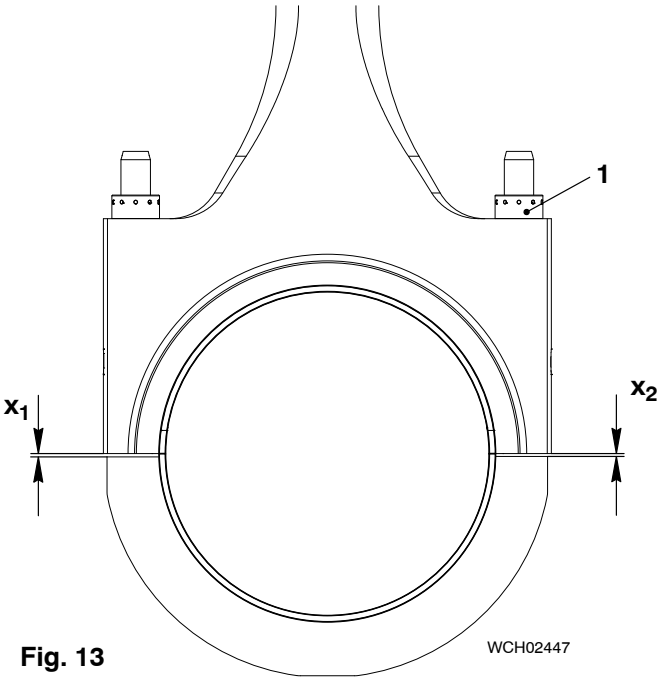


Fig. 13

8) Make sure that the bearing shell is clean.

9) Put oil on the bearing shell as follows:

   a) If you start the engine immediately after completion of this procedure, use only bearing oil.

   b) If the engine has stopped for some days, use a mixture of high-viscosity oil (steam engine cylinder oil, ISO VG 1000/1500) and bearing oil. The ratio is two thirds ISO VG 1000/1500 to one third bearing oil.

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

10) Put the round nuts (1, Fig. 13) on the elastic studs.

11) Tighten the round nuts (1) equally with a round bar.

12) Measure the distance (X1, X2) between the edges of the bearing shells and the bearing cover.

13) For new bearing shells, the dimensions X1 plus X2 must be between 1.18 mm and 1.34 mm.

14) Apply tension to the elastic studs, refer to 9403–4, paragraph 3.

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

Table 1: ISO G 1000/1500 Suppliers

Supplier	Type	Viscosity at 40° C mm^2/s	Viscosity at 100° C mm^2/s	Weight at 15° C g/ml
BP	ENERGOL DC 1000	980	49.0	0.913
BP	ENERGOL DCW 1000	920	40.0	0.913
CHEVRON	CYLINDER OIL 1000	1000	43.1	0.937
EXXON/ESSO	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

Intentionally blank

Work Card
Connecting Rod

Necessary Conditions

– Engine stopped

Necessary Spare Parts (each cylinder)

Bearing shell (bottom end bearing, top half)	EX 33100	Qty 1
Bearing shell, (bottom end bearing, bottom half)	EX 33101	Qty 1
Bearing shell (top end bearing)	EX 33150	Qty 1

Preparation

Attach applicable equipment, refer to 3303–2/A1 and 3303–3/A1

Tools and Consumables

Manual ratchet	94016-009	Qty 2
Manual ratchet	94016-011	Qty 2
Manual ratchet	94016-017	Qty 1
Manual ratchet	94016-031	Qty 2
Shackle	94018B	Qty 4
Shackle	94018C	Qty 2
Chain	94019B	Qty 1
Chain	94019A	Qty 1
Chain, 4-Sling	94327	Qty 1
Eye bolt	94045-M8	Qty 4
Eye bolt	94045-M24	Qty 2
Eye bolt	94045-M48	Qty 1
Deviation pipe	94117B	Qty 1
Pre-tensioning jack	94252	Qty 1
Pre-tensioning jack	94315	Qty 2
Pre-tensioning jack	94340	Qty 2
Chain	94327	Qty 1
Console Frame	94326	Qty 1
Support	94322	Qty 1
Support (for iELBA)	94322A	Qty 1
Platform	94143	Qty 1
Lifting tool	94324	Qty 1
Stop plate	94335	Qty 1
Steam engine cylinder oil, ISO VG 1000/1500		
Bearing oil		

Primary Task

Replace the connecting rod bearings, refer to 3303–2/A1 and 3303–3/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Superintendent	10.0 hours	Qty 1
Service Engineer	10.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Top End Bearing – Removal, Inspection and Installation

Tools:

2	Manual ratchet, 1000kg, H1,H2	94016-011	1	Deviation pipe	94117B
1	Manual ratchet, 1500kg, H3	94016-017	1	Platform	94143
2	Manual ratchet, 3000kg, H6,H7	94016-031	1	Support	94322
1	Chain block, 500kg, H5	94017-006	1	Support (for iELBA)	94322A
1	Chain block, 2000kg, H4	94017-021	1	Lifting tool	94324
4	Eye bolt	94045-M8	1	Chain, 4-Sling, 1120kg	94327
2	Eye bolt	94045-M24	1	Stop plate	94335
1	Eye bolt	94045-M48	1	Lifting tool	94337
2	Shackle, 4750	94018B	2	Pre-tensioning jack	94315
2	Shackle, 8500kg	94018C	2	Pre-tensioning jack	94340
1	Chain symmetrical	94019A			
1	Chain asymmetrical	94019B			

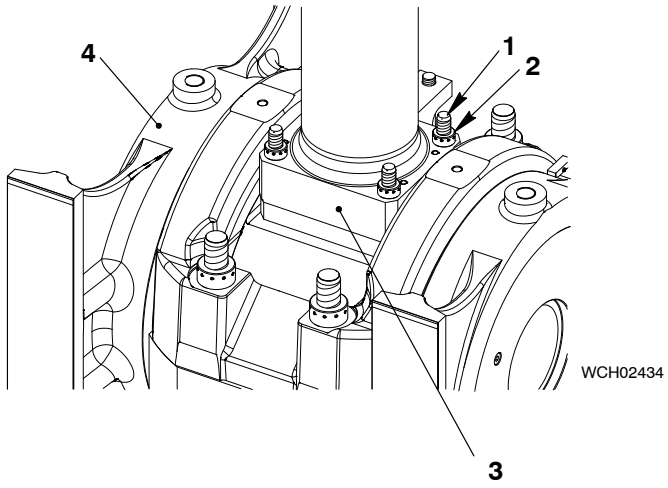


Fig. 1

1. Piston – Hold

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 to BDC.

3) Apply tension to the elastic studs (1, Fig. 1) of the piston rod foot (3), refer to 9403–4.

4) Remove the round nuts (2).

5) Operate the turning gear to turn the crank to TDC.

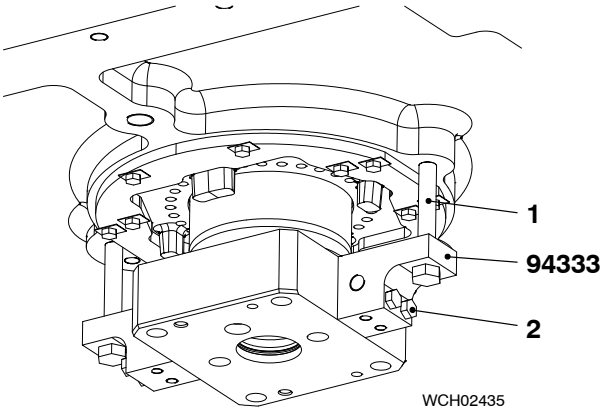


Fig. 2

6) If necessary, put oil on the two bolts (1, Fig. 2)
7) Install the two holders (94333) with the four bolts (2) to the piston rod foot.
8) Torque the four bolts (2) to 200 Nm.
9) Tighten the two bolts (2).
10) Operate the turning gear to move 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.

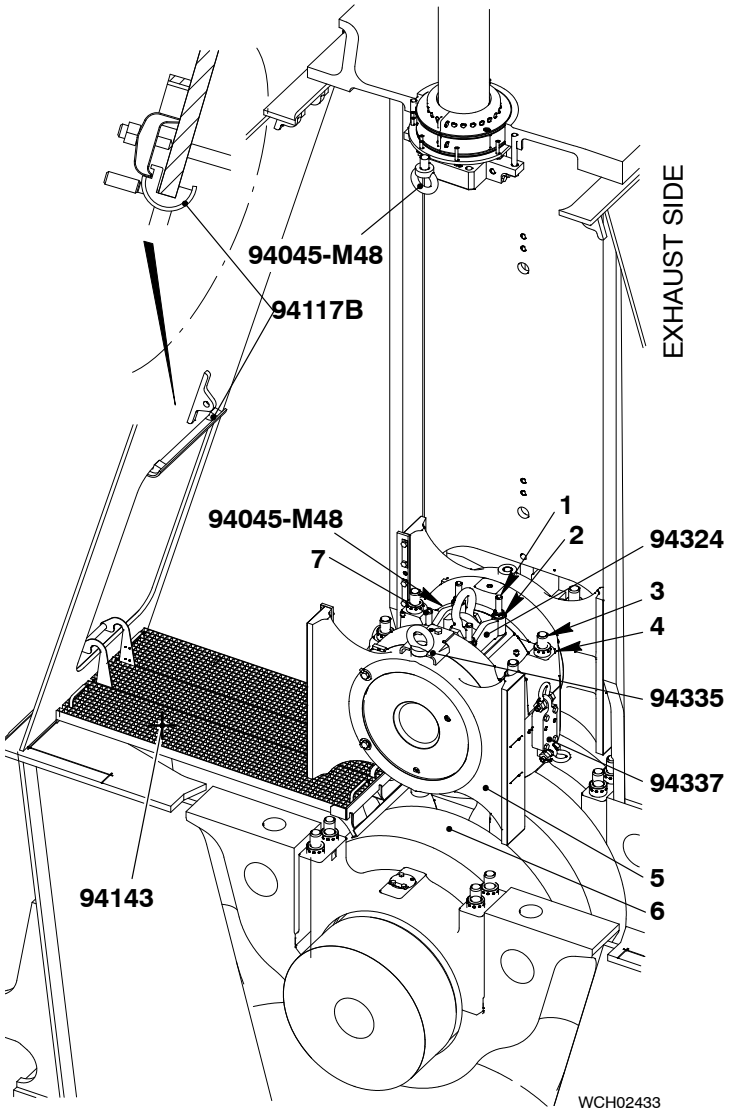


Fig. 3

2. Preparation

1) Install the platform (94143, Fig. 3).
2) Install one eye bolt (94045-M48) near the gland box.
3) Install one eye bolt (94045-M48) on the guide shoe below the eye bolt near the gland box.
4) Install the deviation pipe (94117B) to the column opening.
5) Use the pre-tensioning jack (94315) to apply tension to the elastic stud (3), refer to 9403–4.
6) Remove the four round nuts (4).
7) Attach the lifting tool (94324) to the elastic studs (3) with the round nuts (4)
8) Tighten the round nuts (4) with the round bar (94005).
9) Install the stop plate (94335) to the bearing cover (7).
10) Install the lifting tool (94337) to each side of the connecting rod.
11) Torque the four bolts of the lifting tool (94337) to 150 Nm.
12) Disconnect the toggle lever (1, Fig. 4) from the connecting rod.

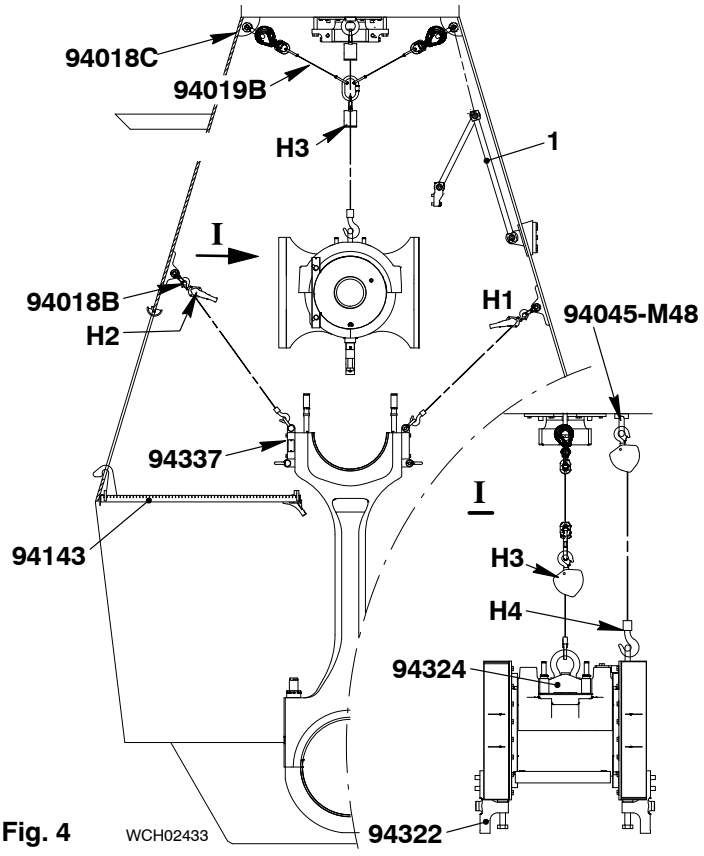
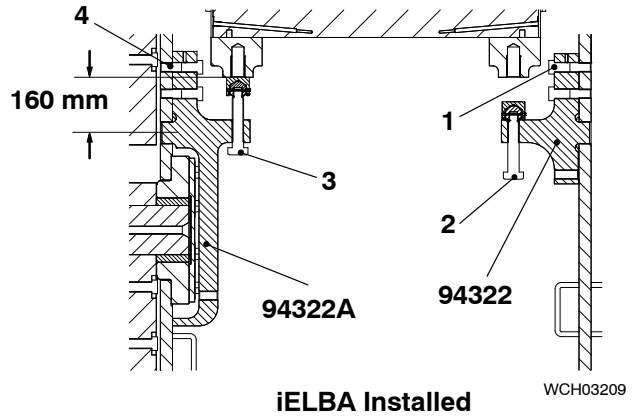


Fig. 4



iELBA Installed

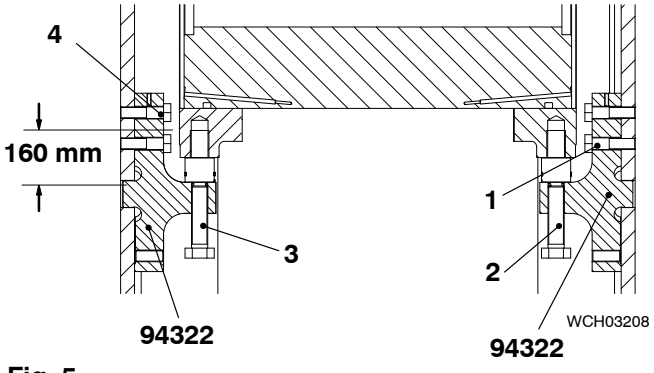


Fig. 5

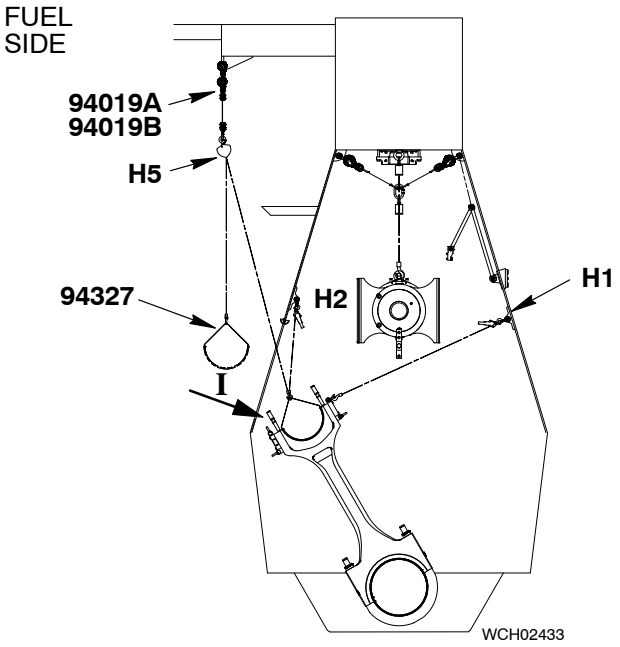
iELBA Not Installed

3. Crosshead – Lift

1) Attach the shackles (94018B, Fig. 4) to each side of the column.
2) Attach a manual ratchet (H1, H2) to the shackles (94018B) and the the two lifting tools (94337).
3) Apply a light tension to the manual ratchets (H1, H2).

Note: If the cylinder cover and piston are removed you can use the engine room crane and chain block (H4) to lift the crosshead.

4) Attach the chain (94019B) to the two shackles (94018C).
5) Attach the manual ratchet (94016-017, H3) to the chain (94019B).
6) Attach the manual ratchet (94017-21, (H4) to the eye bolt (94045-M48) at the top of the column and the eye bolt on the bearing cover, see View I.
7) Operate the manual ratchet (H3) to lift the crosshead approximately 300 mm above the plug bore center (Fig. 5) in the column.
8) Keep the tension on the chain block (H4).
9) Apply a small quantity of clean oil to the four bolts(1, 4).
10) Attach the supports as follows:
    a) For an engine with an iELBA installed, attach one support (94322A) and one support (94322) with the four bolts (1, 4).
    b) For an engine with no iELBA installed, attach two supports (94322) with the four bolts (1, 4).
11) Torque the four bolts (1, 4) to 300 Nm.
12) Operate the turning gear to lower crosshead to 160 mm above plug bore center.
13) Tighten the special screws (2, 3) on each support.
14) Examine the bearing shell.
15) If it is necessary to replace the bearing shell, refer to paragraph 4, step 1) to step 11).
16) Remove the platform (94143, Fig. 4).



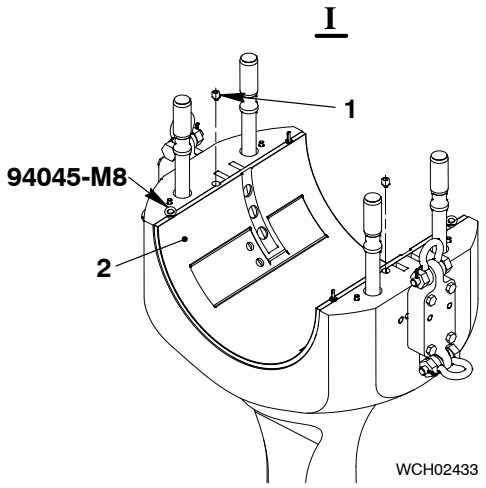


Fig. 6

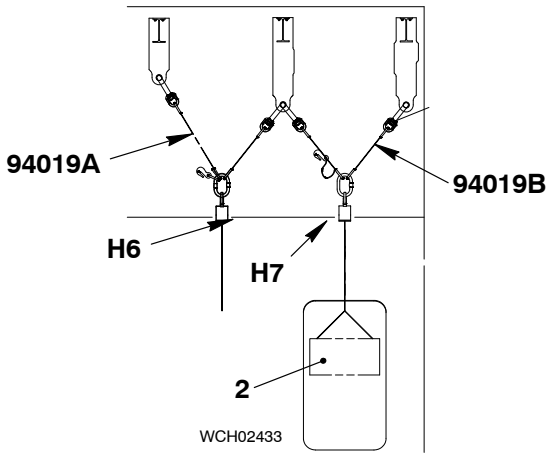


Fig. 7

4. Bearing Shell – Removal

1) Attach the chain (94019A, Fig. 6) to the gallery.
2) Attach the chain block (94017-006, H5) to the chain (94019A).
3) Operate the manual ratchets (H1, H2) to move the connecting rod to the fuel side.
4) Install the four eye bolts (94045-M8) into the bearing shell (2).
5) Attach the chain (94327) to the manual ratchet (H5) and the four eye bolts in the bearing shell (2).
6) Remove manual ratchet (H2) from the connecting rod.
7) Attach the manual ratchet (H2) to the chain (94327).
8) Remove the two screws (1).
9) Operate carefully the manual ratchet (H2) and the chain block (H5) to lift the bearing shell (2) from the connecting rod.
10) Continue to operate the manual ratchet (H2) and the chain block (H5) to remove the bearing shell (2) from the engine.
11) Lower the bearing shell (2) on to an applicable surface.
12) Remove the chain (94327), the manual ratchets (H2) and the chain block (H5).
13) Use the chains (94019A and 94019B, Fig. 7) and the two chain blocks (H6, H7) to move the bearing cover (1) to an applicable area.
14) Remove the four eye bolts (94045–M8) from the bearing cover (2).

5. Bearing Shell – Installation

1) Clean the seating surface of the bearing shell (2, Fig. 6).
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) to the bearing shell (2).
6) Attach the chain block (H5) to the chain (94327).
7) Attach the chain block (H5) to the eye bolts (9405–M8).
8) Carefully operate the the chain block (H5) to lift then lower the bearing shell (2) on to the connecting rod.
9) Install the two screws (1) to the bearing shell (2).

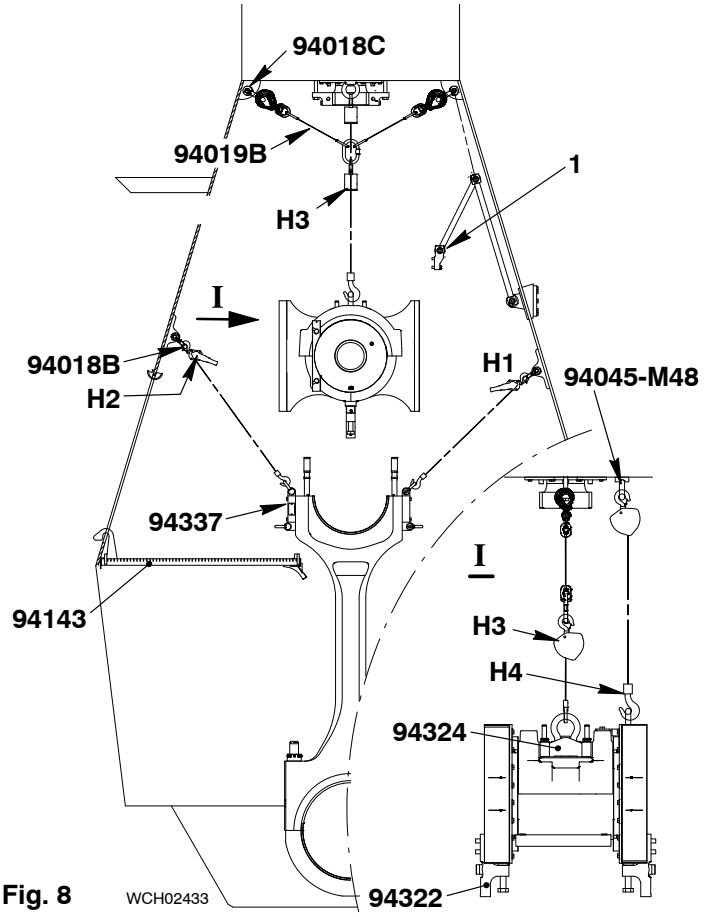


Fig. 8

10) Remove the chain block (H5).
11) Remove the four eye bolts (940545–M8).
12) Attach the manual ratchet (H2, Fig. 8) to the lifting tool (94337).
13) Operate the manual ratchets (H1, H2) to move the connecting rod to the center position below the crosshead.
14) Install the platform (94143).
15) Make sure that there is tension on the chain blocks (H3, H4).
16) Remove the two supports (94322, 94322A).
17) Operate carefully the chain blocks (H3, H4) to lower the crosshead into the connecting rod.
18) Remove the tools (94337).
19) Connect the toggle lever (1) to the connection piece.

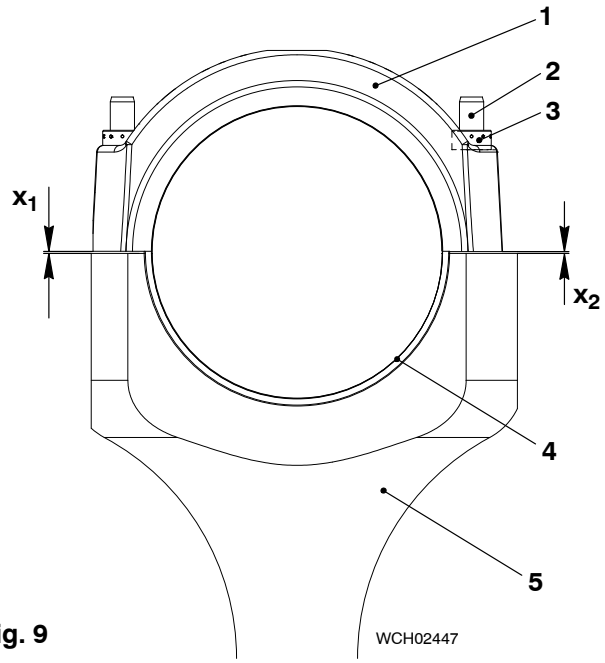


Fig. 9

20) Put the round nuts (3, Fig. 9) on the elastic studs (2).

21) Use the round bar (94005) to tighten equally the round nuts (3).

22) Measure the distances (X1, X2) between the edges of the bearing shells and the connecting rod (5).

23) For new bearing shells, the dimensions X1 plus X2 must be between 0.41 mm and 0.49 mm.

24) Apply tension to the elastic studs, refer to 9403–4, paragraph 3.

Note: During step 24), do not remove the holders (94333).

25) Remove all tools and equipment from the work area.

Table 1: ISO G 1000/1500 Suppliers

Supplier	Type	Viscosity at 40° C mm²/s	Viscosity at 100° C mm²/s	Weight at 15° C g/ml
BP	ENERGOL DC 1000	980	49.0	0.913
BP	ENERGOL DCW 1000	920	40.0	0.913
CHEVRON	CYLINDER OIL 1000	1000	43.1	0.937
EXXON/ESSO	CYLESSO 1000	950	44.0	
EXXON/ESSO	CYLESSO TK 1000	925	46.7	
MOBIL	EXTRA HECLA SUPER Cylinder Oil	680	39.0	0.905
SHELL	FIONA Oil 1500	1500	37.0	0.958
SHELL	VALVATA OIL 1000	1000	45.4	0.924
TEXACO	650T MINERAL Cylinder Oil	985	44.0	0.919

6. Bearing Lubrication

To decrease the risk of dry-running on 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. 10).
2) Attach the flange (94336) to the support (1).
3) Connect the hose (3) to the flange (94336).
4) Fill the lubricating pump (4) with steam-engine cylinder oil (refer to Table 1).
5) Operate the lubricating pump (4) until oil flows from the sides of the bearing.

Note: Do step 1) to step 5) weekly if the engine does not operate for some weeks.

6) Before you operate the engine do step a) to step d):
   a) Make sure that the hose (3) has no pressure.
   b) Disconnect the hose (3) from the flange (94336).
   c) Remove the flange (94336).
   d) Install the oil inlet pipe (2) to the support (1).

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

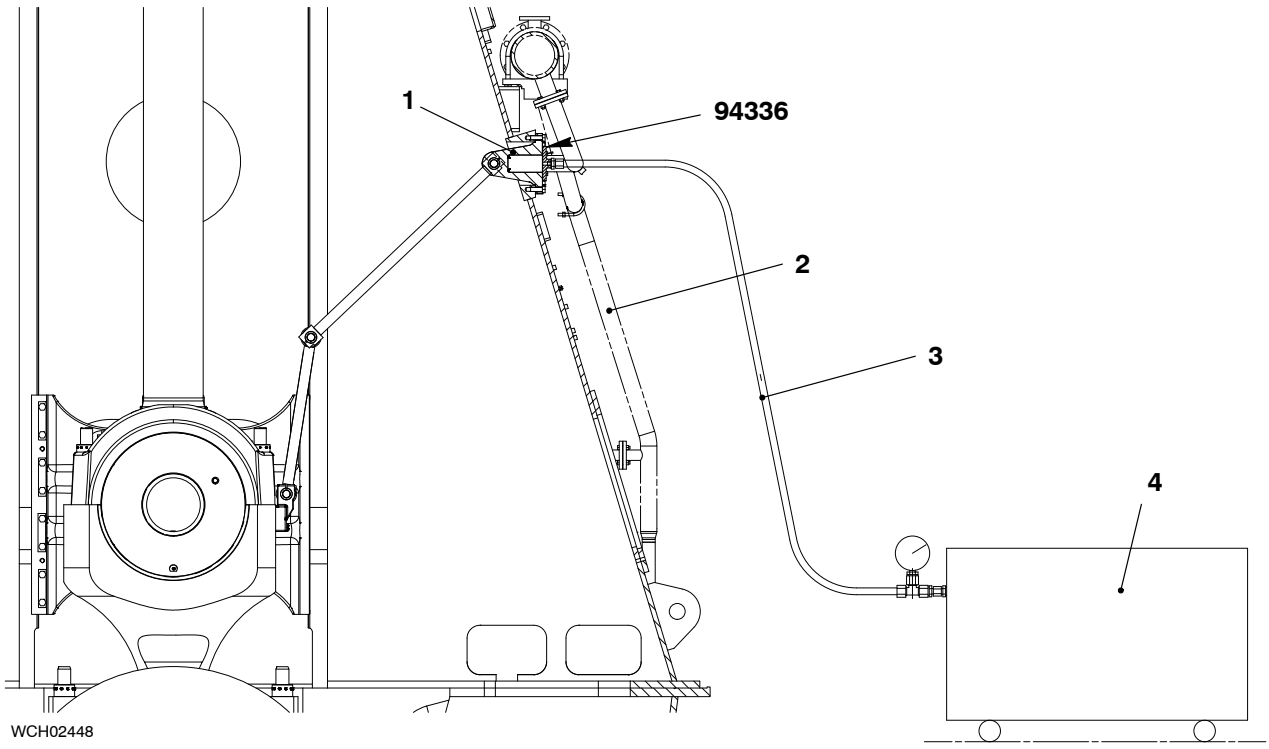


Fig. 10

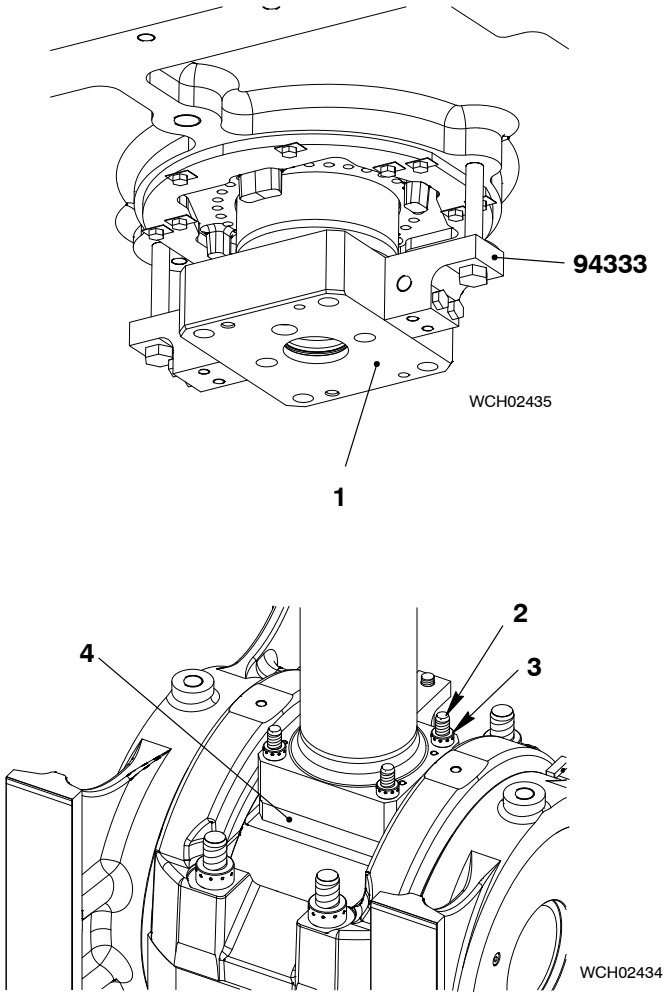


Fig. 11

7. Completion

WARNING

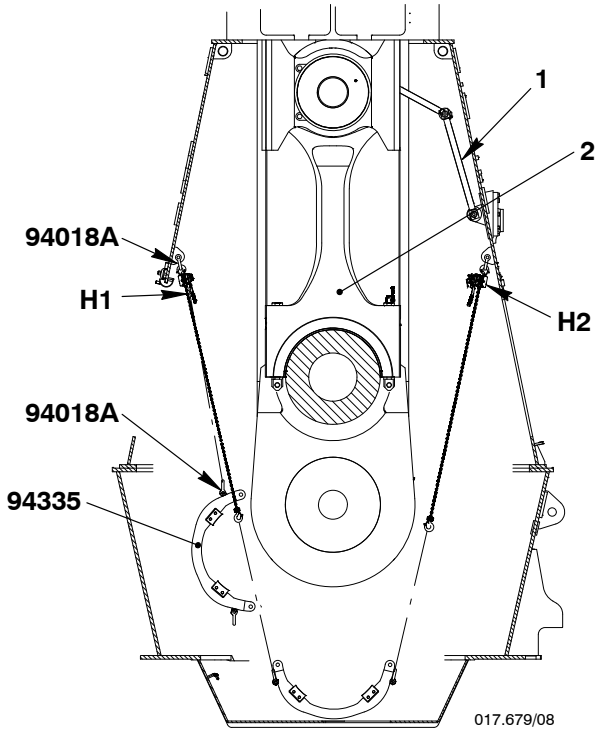
Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, the propeller shaft or inside the engine.

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

Removal and Installation

Tools:

4	Manual ratchet, 1000kg, H1, H2	94016-009	1	Chain asymmetrical	94019B
2	Chain block, 2000kg, H3,H4	94017-021	1	Bracket	94334
1	Shackle, 8500kg	94018C	1	Connecting element	94334A
1	Chain symmetrical	94019A	1	Shackle 3250 kg	94018A
2	Manual ratchet, 3000kg, H5, H6	94016–031			



Note: Some parts can look different.

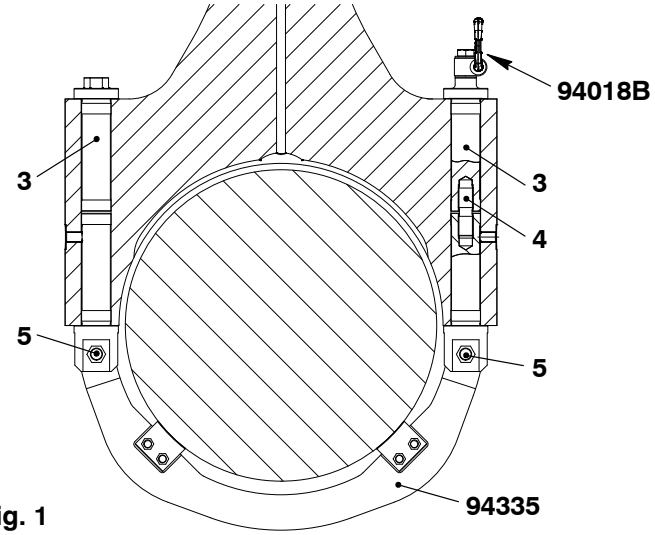


Fig. 1

1. Preparation

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

Note: During step 2), do not move the crosshead to BDC.

2) Prepare the piston, refer to 3303–3, paragraph 1.

3) Remove or lower the bottom end bearing cover of the connecting rod, refer to 3303–2, paragraph 2.

4) Attach the two shackles (94018B, Fig. 1) and the two manual ratchets (H1, H2) to the column.

5) Attach the two shackles (94018B) to the bracket (94335).

6) Attach the manual ratchets (H1, H2) to to the shackles on the bracket (94335).

7) Apply copper paste to the thread of the pin screw (4).

8) Put the rods (3) into the connecting rod.

9) Operate the manual ratchets (H1, H2) to lift the bracket (94335) into position on the the rods (3).

10) Tighten the nuts and bolts (5).

11) Torque the rods (3) to 90 Nm.

12) Lift the crosshead, refer to 3303–3, paragraph 2 and 3.

13) Remove the the manual ratchets (H1, H2) from the plate (94335).

14) Remove the toggle lever (1) from the connecting rod (2).

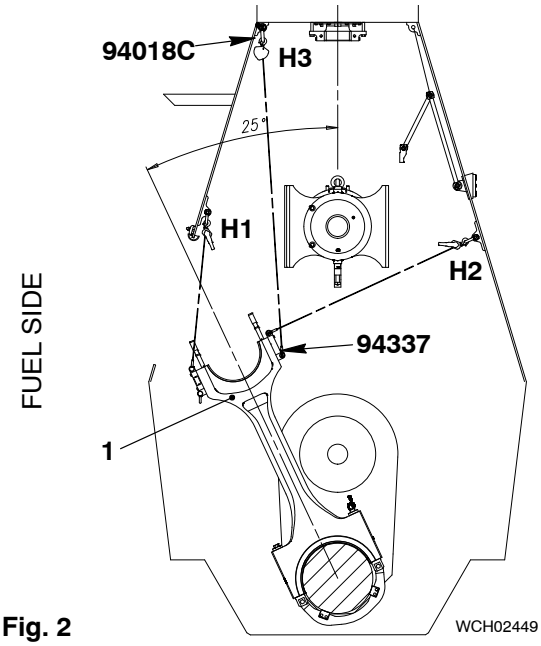


Fig. 2

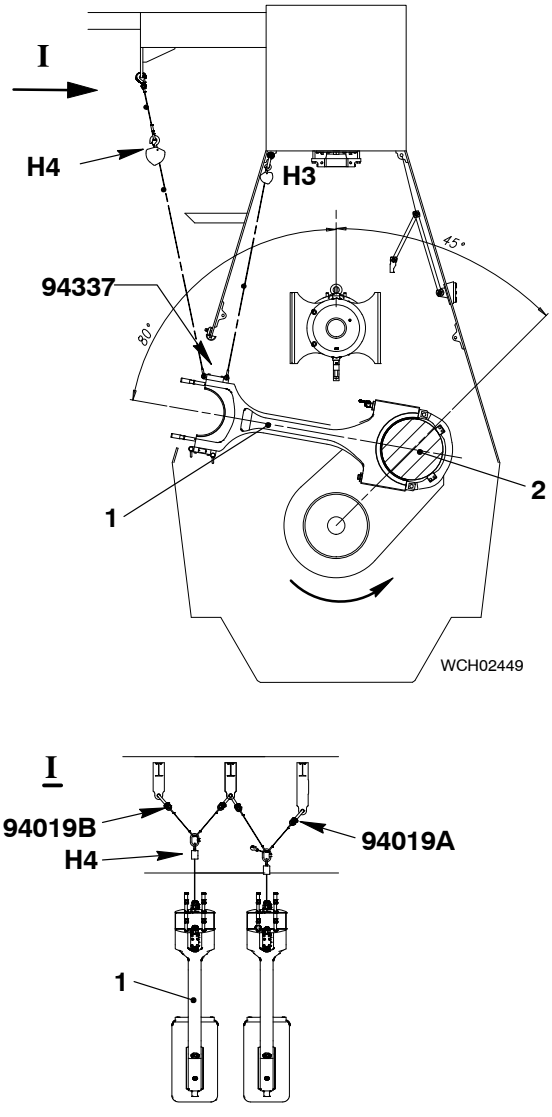


Fig. 3

2. Removal

WARNING

Injury Hazard: The connecting rod weighs approximately 3900 kg. To prevent injury, be careful when you move the connecting rod.

WARNING

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

1) Use the manual ratchets (H1, H2, Fig. 2) to move the connecting rod (1) to the fuel side.
2) Attach the shackle (94018C) and the chain block (H3) to the top of the column.
3) Attach the chain block (H3) to the bottom shackle of the lifting tool (94337).
4) Apply a light tension to the chain of the chain block (H3).
5) Attach the chain block (H4, Fig. 3) to the gallery.
6) Remove the manual ratchet (H2) from the top shackle of the lifting tool (94337).
7) Operate the turning gear and the chain block (H3) to move the connecting rod (1) counterclockwise to the position shown.
8) Attach the applicable chain (94019A or 94019B) to the gallery.
9) Attach the manual ratchet (H4) to the applicable chain (94019A or 94019B).
10) Attach the manual ratchet (H4) to the top shackle of the lifting tool (94337).
11) Apply tension to the manual ratchet (H4).
12) Remove the manual ratchets (H1, H2)
13) Remove the chain block (H3) from the bottom shackle of the lifting tool (94337).

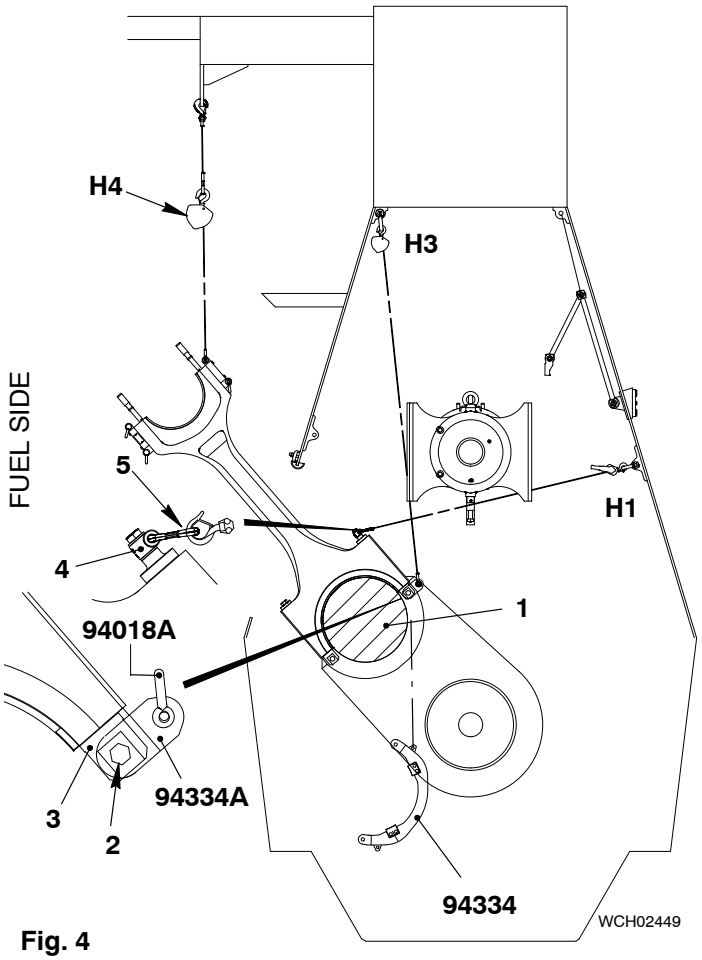


Fig. 4

14) Operate the turning gear and chain block (H4, Fig. 4) to move the crank anticlockwise to the position shown.
15) Attach the manual ratchet (H1) to the lug (5) on top of the rod (4)
16) Apply a light tension to the chain of the manual ratchet (H1).
17) Connect the chain block (H3) to the bracket (94334).
18) Apply a light tension to the chain block (H3).

Note: When you do step 19), hold the bracket (94334) in position.

19) Carefully remove the bottom nut and bolt (2) from the bracket (94334).
20) Lower the bracket (94334) to the floor.
21) Remove the chain block (H3) and the shackle from the bracket (94334).
22) Attach the connecting element (94334A) to the bottom of the rod (3) with the nut and bolt (2).
23) Attach the shackle (94018A) and the chain block (H3) to the connecting element (94334A).
24) Remove the manual ratchet (H1) from the lug (3) on top of the rod (2).

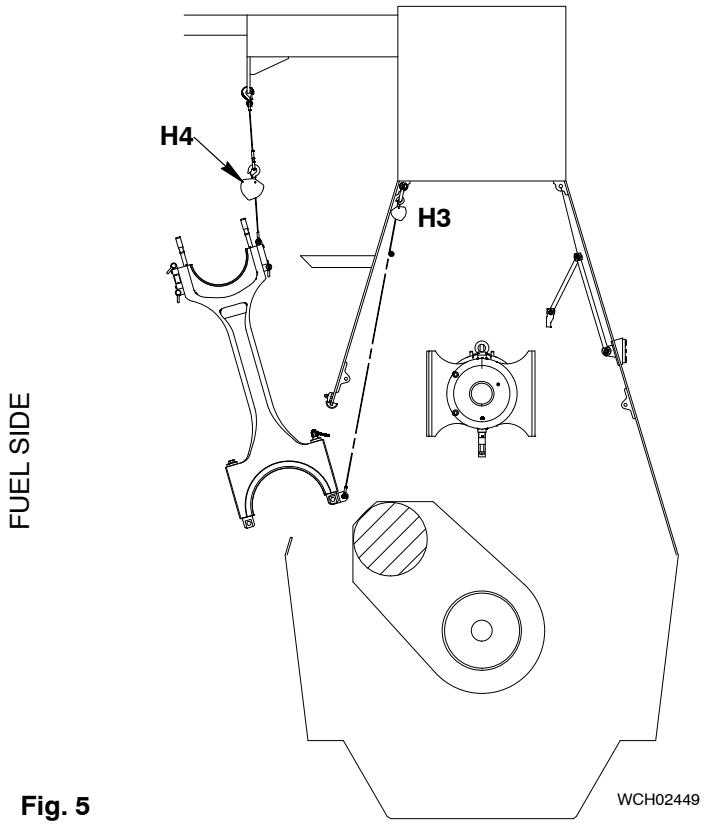


Fig. 5

25) Operate the turning gear and the chain block (H3 and H4, Fig. 5) to carefully move the connecting rod out of the column.
26) Remove the chain block (H3) from the shackle (94018A) on the connecting element (94334A).

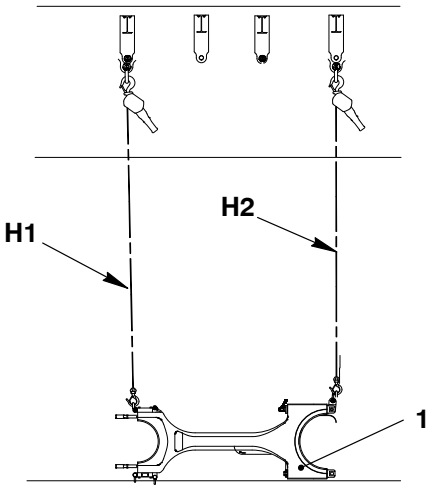
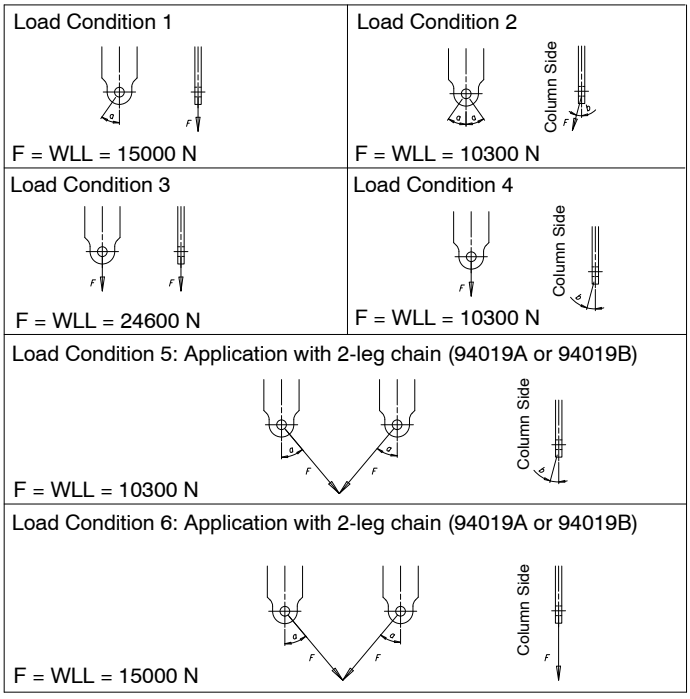


Fig. 6

3. Connecting Rod – Move

If it is necessary to move the connecting rod (1, Fig. 6) 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 (1) to the floor.
4) Remove the chain (94019 or 94019B).
5) Attach the two manual ratchets (94016-009,) to the connecting rod and the eyelets in the gallery as shown.
6) Read and obey the data given in Fig. 7.



Permitted Load on Gallery Eyelets

a = maximum 35°

b = maximum 20°

Note: only one load is permitted on each eyelet.

Fig. 7: Load Condition Data

7) Lift the connecting rod (5, Fig. 8) a small distance.
8) Attach the manual ratchets (H5, H6) 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.

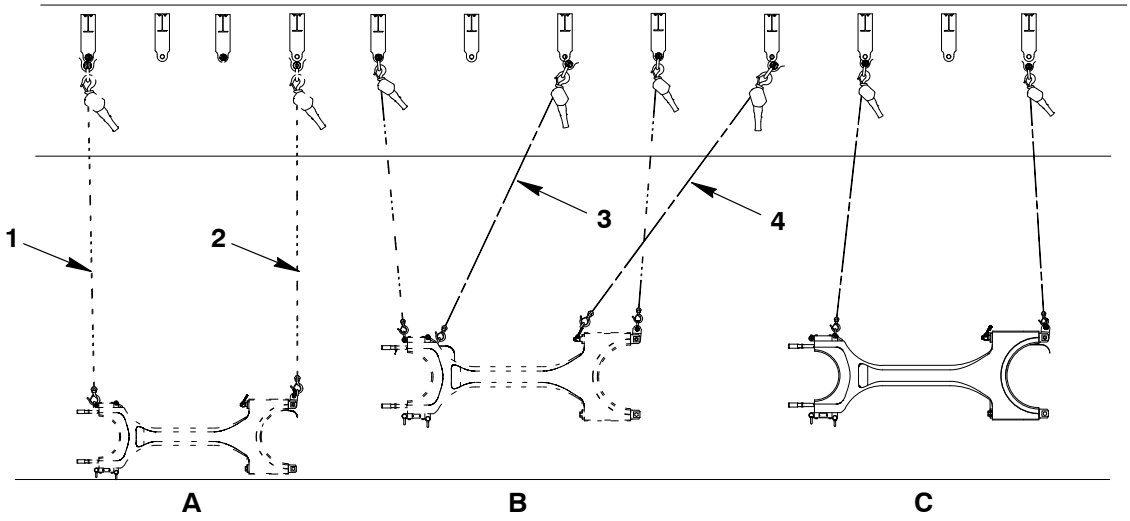


Fig. 8

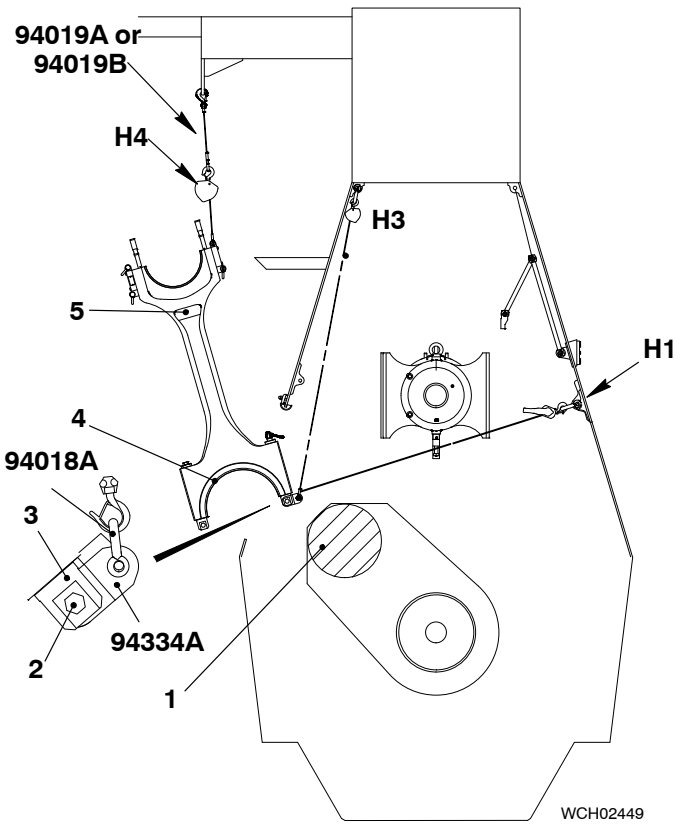


Fig. 9

4. Installation

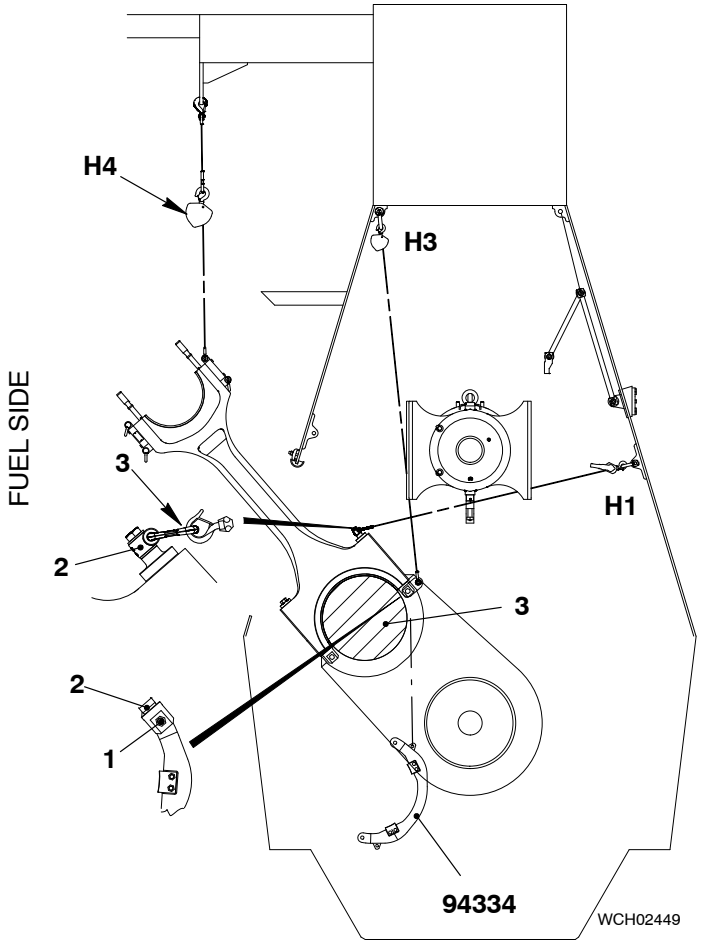
WARNING

Injury Hazard: The connecting rod weighs 3900 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. 9) and the crank pin (1).
2) Put oil on the bearing shell (4) and the crank pin (1).
3) Attach the chain block (H3) to the shackle (94018A) on the connecting element (94334A).
4) Attach the manual ratchet (H1) to the shackle (94018A) on the top rod (3).



5) Operate the turning gear, the chain blocks (H4, H3) and manual ratchet (H1), Fig. 10) to move the connecting rod and the crankshaft as shown.

6) Remove the chain block (H3) from the shackle (94018A).

7) Remove the shackle (94018A) and the connecting piece (94334A).

8) Attach the chain block (H3) to the top eyelet on the plate (94334).

9) Operate the chain block (H3) to lift the plate (94334) into position on the crank pin.

10) Attach the plate (94334) to the bottom of the rod (2) with the nut and bolt (1).

11) Remove the chain block (H3) from the top eyelet of the plate (94334).

12) Attach the chain block (H3) to the bottom eyelet on the plate (94334).

13) Operate the chain block (H3) to lift the plate (94334).

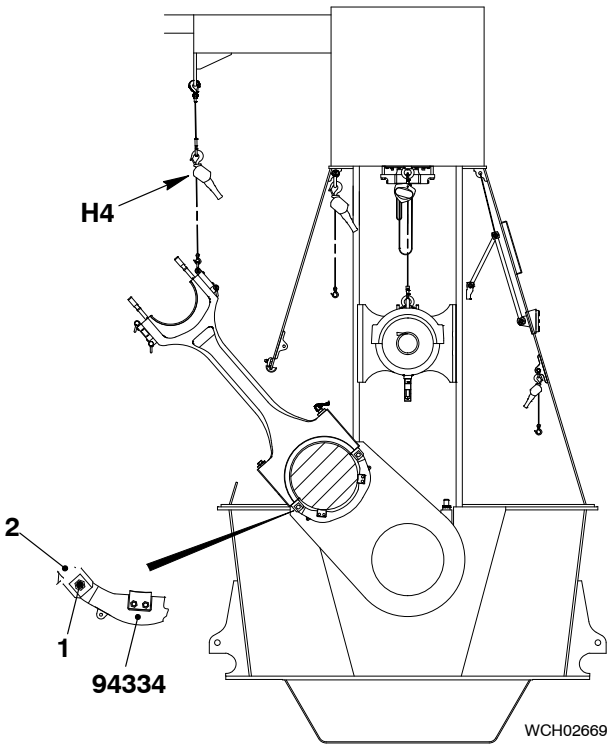


Fig. 10

14) Attach the bottom end of the plate (94334) to the bottom rod (2) with the nut and bolt (1).

15) Remove the chain block (H3) from the bottom eyelet of the plate (94334).

16) Remove the manual ratchet (H1) from the lug on the top rod.

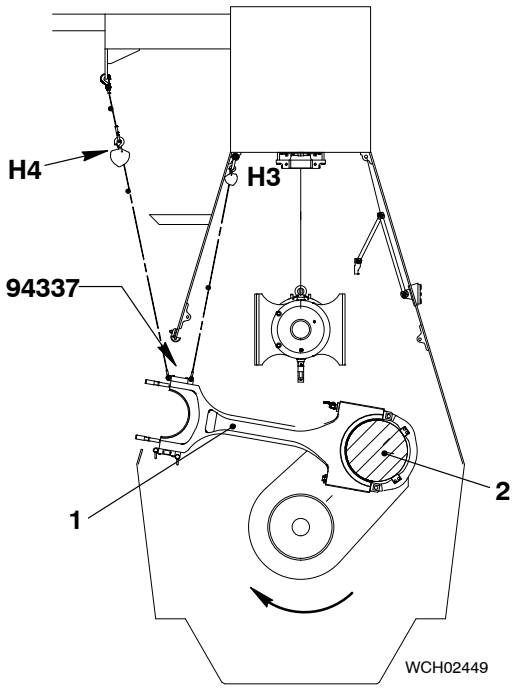


Fig. 11

17) Operate the turning gear and the chain block (H4, Fig. 11) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.
18) Attach the chain block (H3) to the bottom shackle on the lifting tool (94337).
19) Remove the chain block (H4) and the chain (94019A or 94019B).

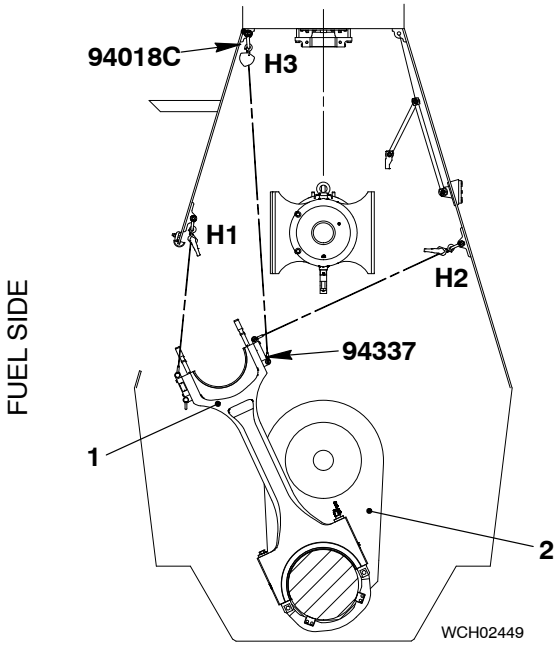


Fig. 12

20) Operate the turning gear and the chain block (H3, Fig. 12) to move the connecting rod (1) and crankshaft (2) clockwise into the position shown.
21) Attach the manual ratchet (H1) to the top shackle of the lifting tool (94337).
22) Remove the chain block (H3) from the bottom shackle of the lifting tool (94337) and the top of the column.
23) Use the turning gear and the chain block (H3) to move the connecting rod (1) and crankshaft clockwise into the position shown.

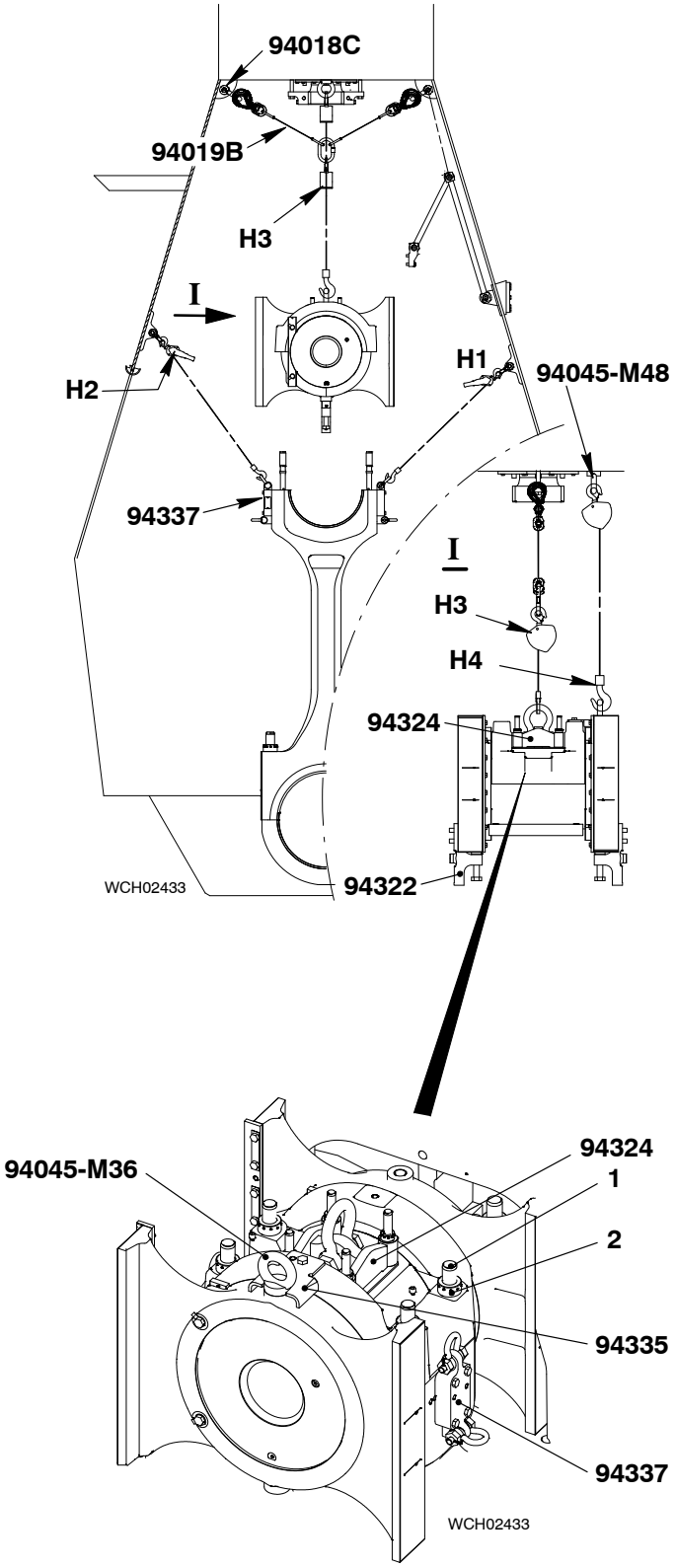


Fig. 13

24) Operate the turning gear and the manual ratchets (H1 and H2, Fig. 13) to move the connecting rod and crankshaft clockwise into the position shown.

25) Make sure that there is tension on the chain block (H4).

26) Remove the two supports (94332).

CAUTION

Damage Hazard: During step 27), make sure that the elastic studs are aligned with the related holes in the crosshead. This will prevent damage to equipment.

Note: During step 27), keep the tension on the chain block (H4).

27) Operate the chain blocks (H3, H4) to lower the crosshead on to the connecting rod.

28) Attach the four round nuts (2) to the elastic studs (1).

29) Remove the chain blocks (H3, H4).

30) Remove the tool (94324).

31) Remove the manual ratchets (H1, H2) from the lifting tool (94337).

32) Remove the lifting tool (94324).

33) Remove the eye bolt (94045–M36).

34) Remove the stop plate (94355).

35) Remove the manual ratchets (H1, H2) from the lifting tools (94337).

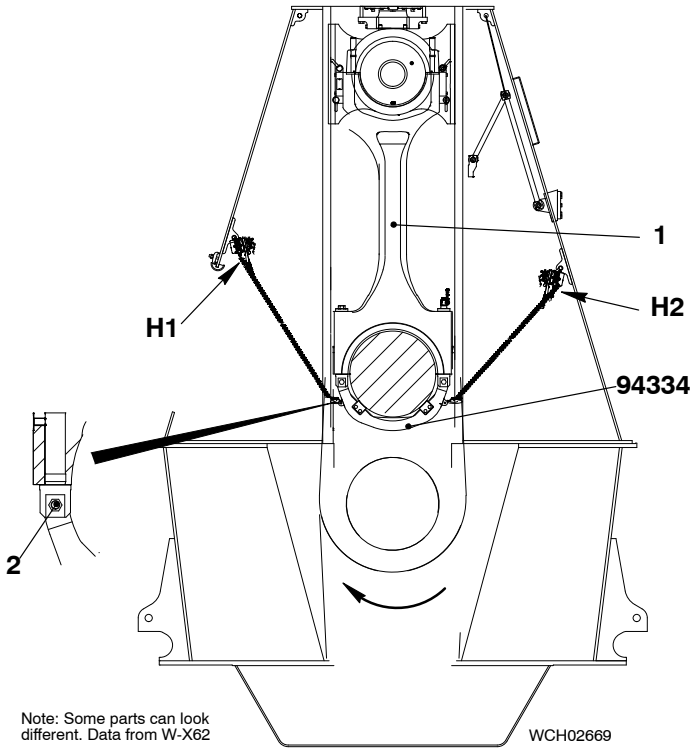


Fig. 14

36) Operate the turning gear to move the connecting rod (1, Fig. 14) clockwise to TDC.

37) Attach the manual ratchets (H1, H2) to the eyelets on the the bracket (94334).

38) Apply a light tension to the chains of the manual ratchets (H1, H2).

39) Remove the two nuts and bolts (2) from the plate (94334).

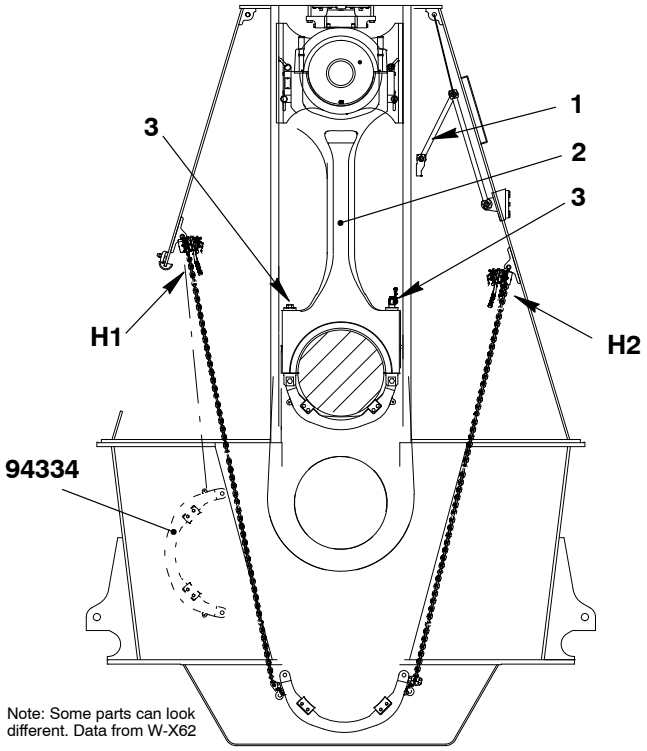


Fig. 15

40) Operate the manual ratchets (H1 and H2, Fig. 15) to lower the plate (94334).

41) Remove the manual ratchet (H2) from the eyelet on the plate (94334).

42) Use the manual ratchet (H1) to remove the plate (94334) from the crankcase.

43) Connect the toggle lever (1) to the connection piece on the connecting rod (2).

44) Remove the rods (3) from the connecting rod (2).

5. Completion

1) Install the bearing cover, refer to 3302, paragraph 8.

2) Install the platform (94334).

3) Attach the crosshead to the piston rod foot, refer to 3303, paragraph 7.

4) Make sure that all tools and equipment are removed from the area.

Intentionally blank

Top End Bearing Cover – Removal, Inspection and Installation

Tools:

2	Manual ratchet 1000 kg (H1, H2)	94016-009	1	Chain 5300 kg	94019A
1	Manual ratchet 1500kg H3	94016-017	1	Chain 5300 kg	94019B
2	Eye bolt	94045-M20	1	Deviation pipe	94117B
2	Shackle, 4750 kg	94018B	1	Platform	94143
2	Shackle, 8500 kg	94018C	2	Pre-tensioning jack	94315

1. Preparation

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

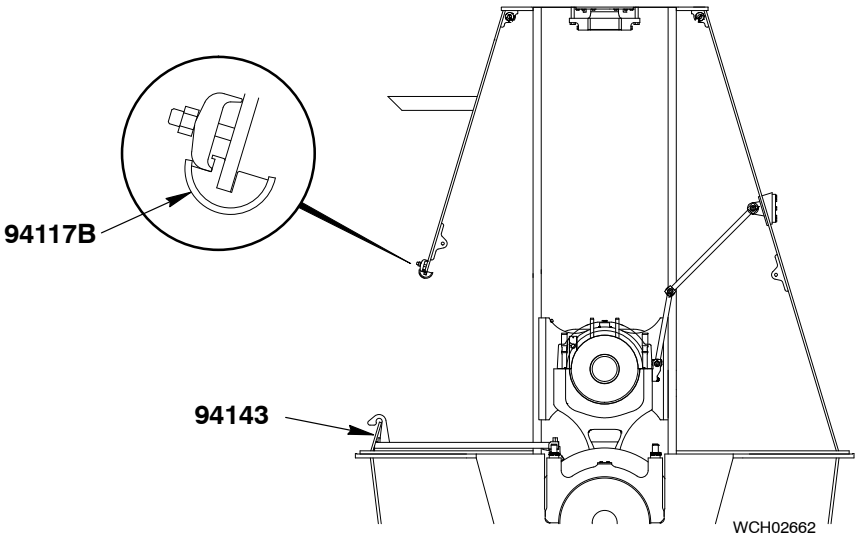


Fig. 1

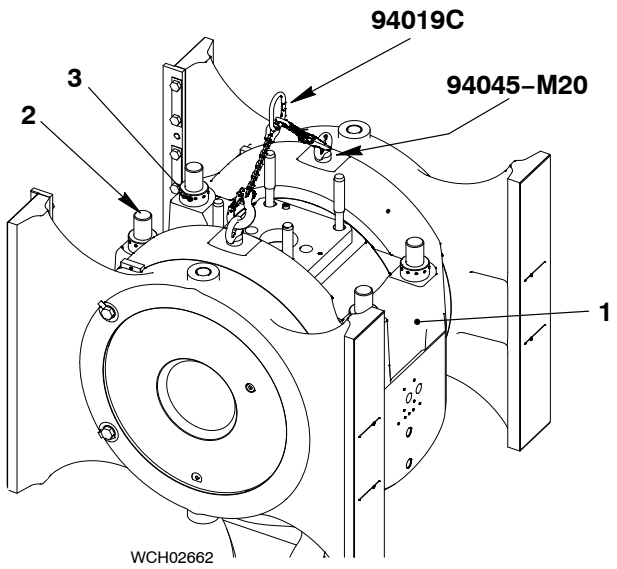


Fig. 2

2. Removal

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

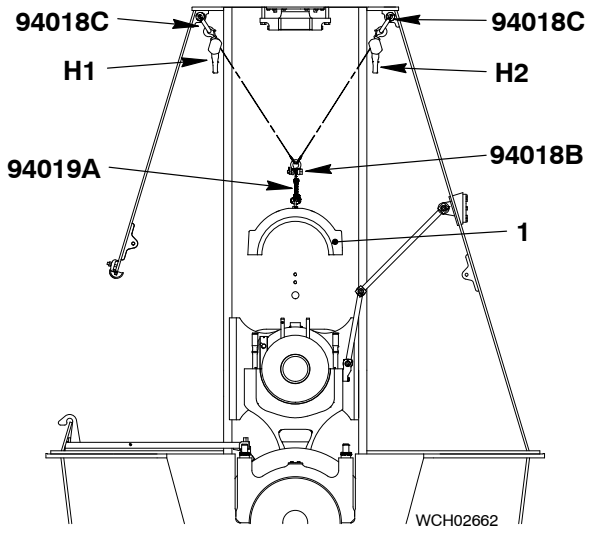


Fig. 3

5) Attach the two shackles (94018C, Fig. 3) to the attachment points on the frame.
6) Attach the two manual ratchets (H1, H2) to the shackles (94018C).
7) Attach the two manual ratchets (H1, H2) to the shackle (94018B). Make sure that the chain lengths of the manual ratchets are equal.
8) Attach the chain (94019A) to the shackle (94018B).

CAUTION

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

9) Operate carefully the two manual ratchets (H1, H2) to lift the bearing cover (1).

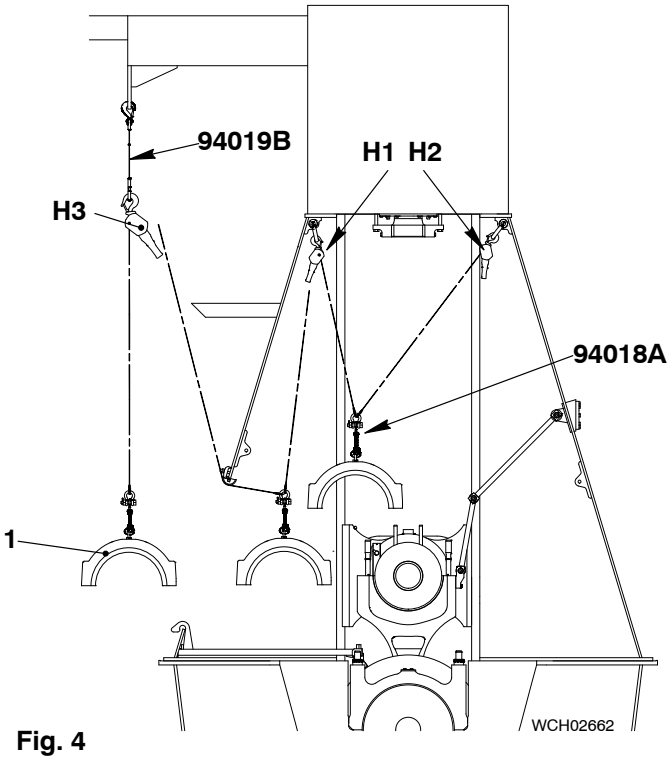


Fig. 4

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

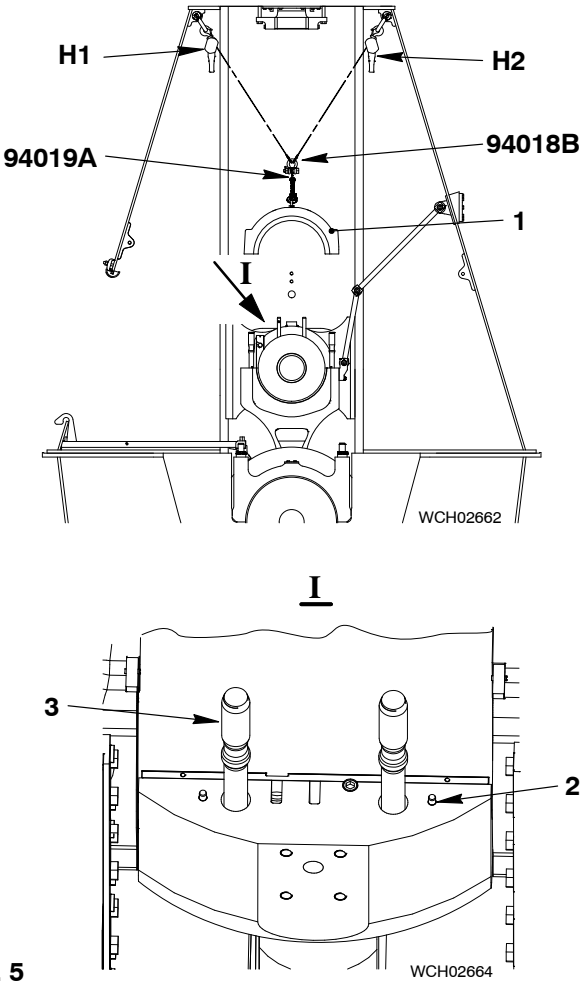


Fig. 5

3. Installation

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

Note: During step 8), make sure that you do not cause damage to the elastic bolts (2).

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

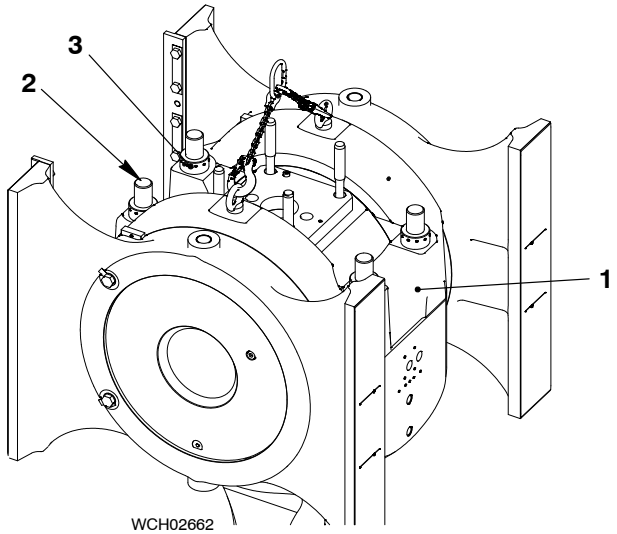


Fig. 6

10) Attach the round nuts (3, Fig. 6) to the elastic bolts (2).

11) Use the pre-tensioning jack (94315) to tighten the four round nuts (3) refer to 9403–4.

4. Completion

1) Attach the piston to the crosshead, refer to 3303–3, paragraph 7.

2) Remove all tools and equipment from the area.

Work Card
Crosshead and Guide Shoe: Check

Necessary Conditions

– Engine stopped
– During overhaul or installation of the crosshead

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

None

Tools and Consumables

Feeler gauge	94238	Qty 1
Hardwood wedge (or an item that is almost the same)		Qty 2

Primary Task

Do a check of the guide shoe and crosshead pin clearances, refer to 3326–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Clearance checks, 0330–1, Group 3326

Intentionally blank

Clearance Checks

Tools:

1 Feeler gauge 94238

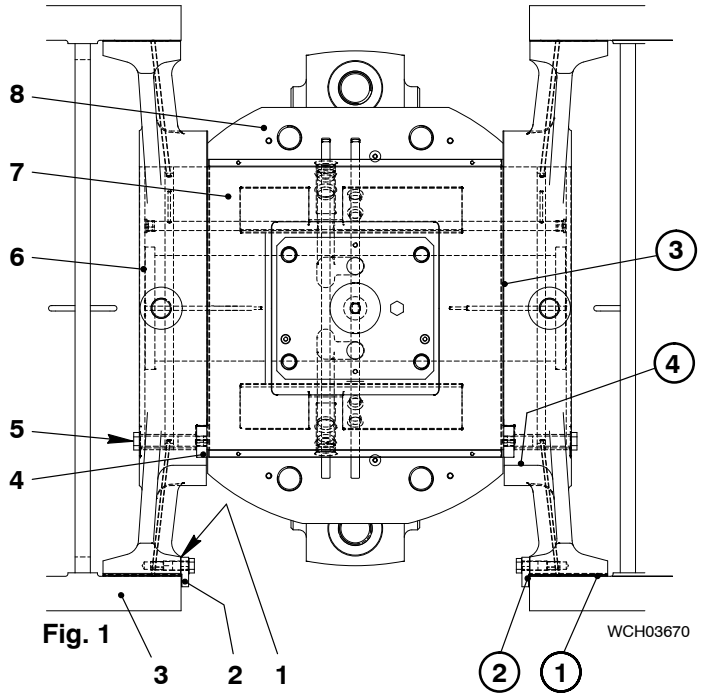


Fig. 1

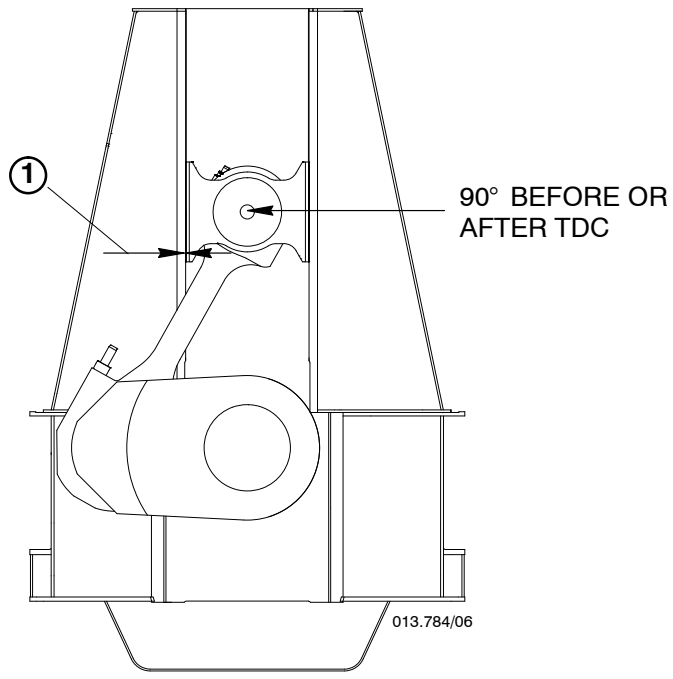


Fig. 2

1. General

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

- Measure and record the clearances shown in Fig. 1 and Fig. 2.
- Compare the clearances with those given in 0330–1, Group 3326.

2. Clearance Checks

2.1 Guide Shoe and Guide Way

1) Make sure that the related crank pin is in a position so that the guide shoes (6) touch the guide ways (3) on the fuel side (or exhaust side).

2) Measure the clearance ① between the guide shoe (6) and the guide way (3).

Note: The clearance ① 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 ② 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 ③ between the top end bearing (8) and the the guide shoes (6).

2.4 Radial Clearance

1) Measure the radial clearance ④ between the guide shoe (6) and crosshead pin at all positions of the crosshead.

Intentionally blank

Crosshead Pin – Removal and Installation

Tools:

1	Deviation pipe	94117B	2	Eye bolt M20	94045–M20
1	Platform	94142	2	Eye bolt M30	94045–M30
1	Lifting tool	94324	4	Eye bolt M48	94045–M48
2	Chain block 2000 kg (H1, H2)	94017–021	1	Chain	94325
2	Manual ratchet 1500 kg (H6, H7)	94016–017	1	Chain	94019B
2	Manual ratchet 1000 kg (H4, H5)	94016–011	1	Link	94321
1	Manual ratchet 1000 kg (H8)	94016–009	2	Lifting tools	94337
2	Manual ratchet 3000 kg (H3, H9)	94016–031	2	Supports	94322
4	Shackle 4750 kg	94018B	1	Feeler gauge	
4	Shackle 8500 kg	94018C			

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 (94142), refer to 3301–1.
5) Disconnect the toggle lever (9, 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, paragraph 2.
8) Put protection on the oil inlets of the crosshead pin to prevent damage and contamination.

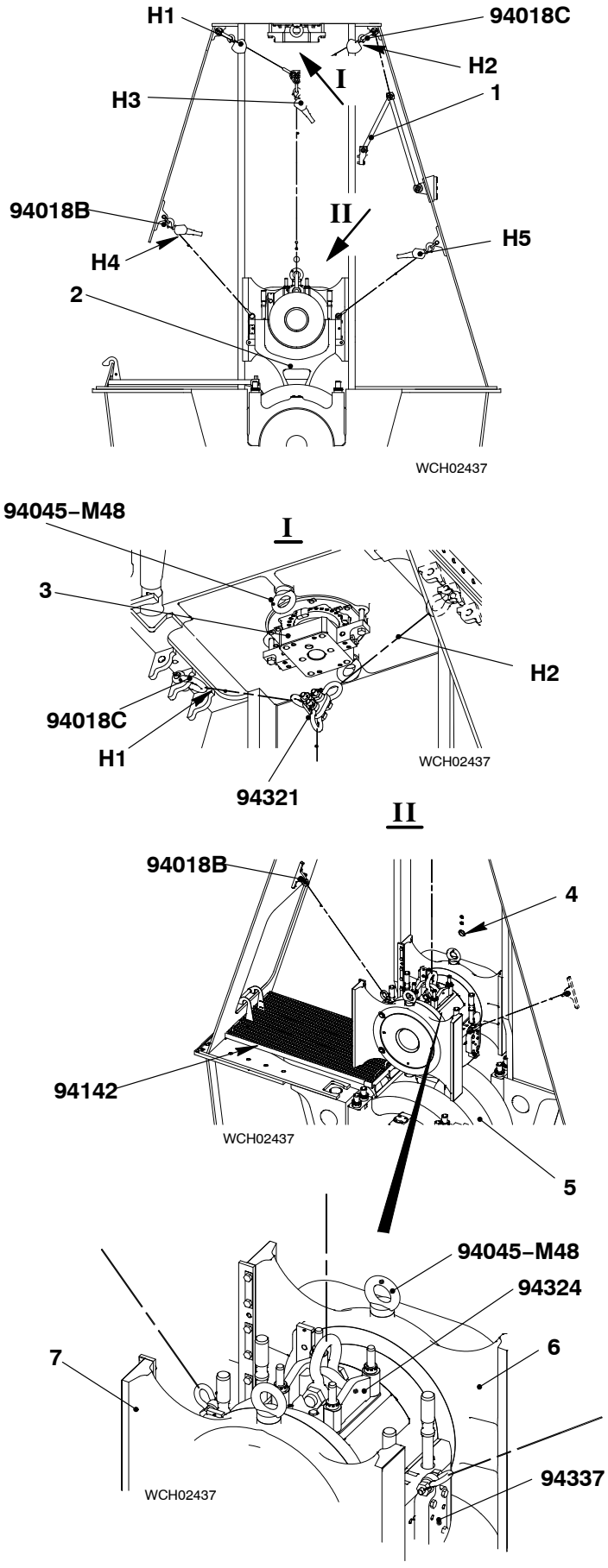


Fig. 1

2. Crosshead Pin – Removal

1) Attach the lifting tool (94324, Fig. 1) to the crosshead.
2) Attach the two eye bolts (94045–M48) to the bottom of the cylinder jacket.
3) Attach the two shackles (94018C) to the top of the column.
4) Attach the two chain blocks (H1, H2) to the shackles (94018C).
5) Attach the link (94321) to the chain blocks (H1, H2).
6) Attach the manual ratchet (H3) to the link (94321) and the eye bolt (94045–M48) on the lifting tool.
7) Attach the two eye bolts (94045–M48) to the guide shoes (6, 7).
8) Attach the two lifting tools (94337) to the connecting rod (2).
9) Attach the two manual ratchets (H4, H5) to the shackles (94018B). Operate the manual ratchets to apply a light tension to the chains.
10) Operate the manual ratchet (H3) to lift the crosshead approximately 160 mm above the center of the pin hole (4).

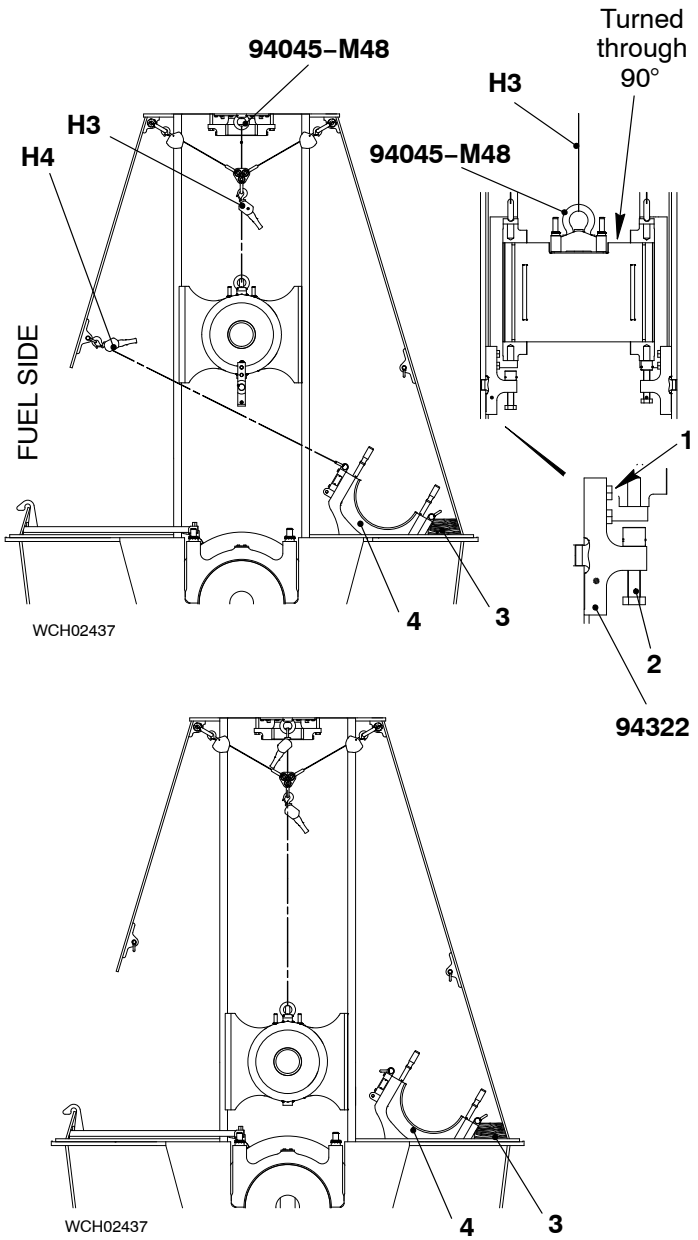


Fig. 2

Note: The two supports (94322, Fig 2) hold the weight of the crosshead while you move the connecting rod (4).

11) Attach the two supports (94322) to the guide way with the four bolts (1) as shown.

12) Torque the bolts (1) to 300 Nm.

13) Tighten the two set screws (2).

14) Put a wooden block (3) in position as shown.

Note: During the step 15), slowly move the connecting rod to the exhaust side.

15) On the fuel side, gradually loosen the manual ratchet (H4). At the same time, keep tension on the chain of the manual ratchet (H5).

16) Continue with step 15) until the connecting rod (4) touches the wooden block (3).

17) Loosen the two set screws (2).

18) Lift the crosshead a small distance.

19) Remove the two supports (94322).

20) Remove the manual ratchets (H4, H5).

21) Lower the crosshead to the same height as the column door frame.

22) Attach the manual ratchets (H6, H7) to the eye bolts (94045–M48) on the guide shoes (5) and (6).

23) Apply a light tension to the chains of the manual ratchets (H6, H7). Make sure that the primary load stays on the chain of the manual ratchet (H3).

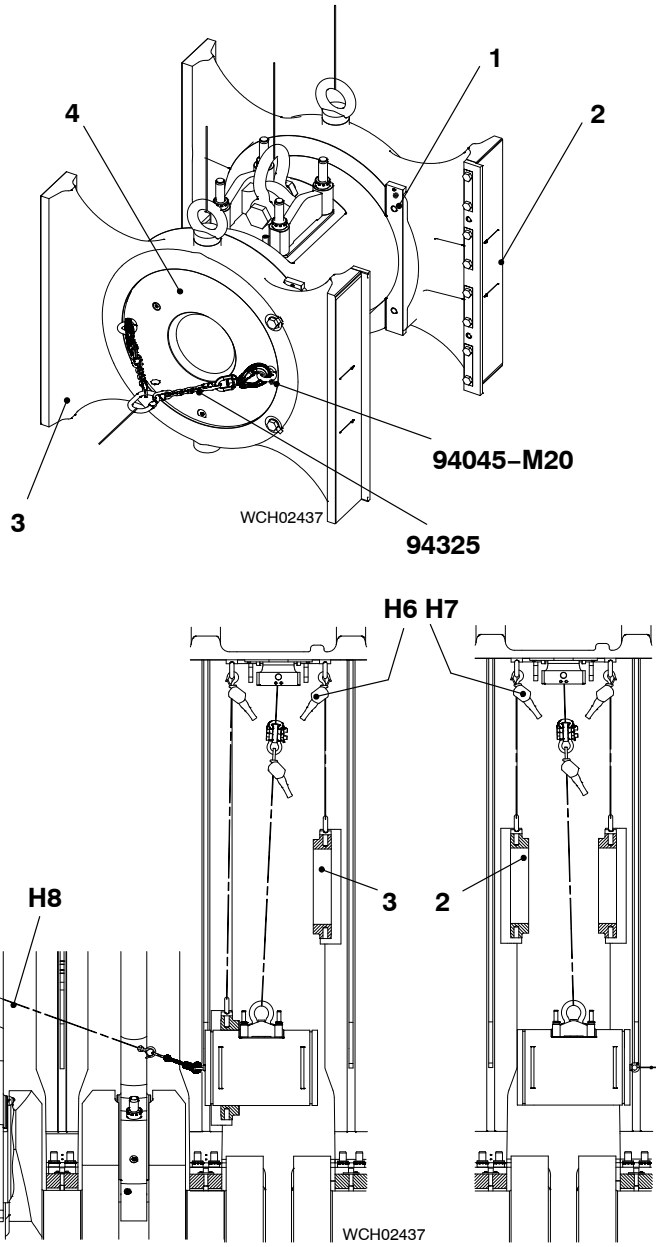


Fig. 3

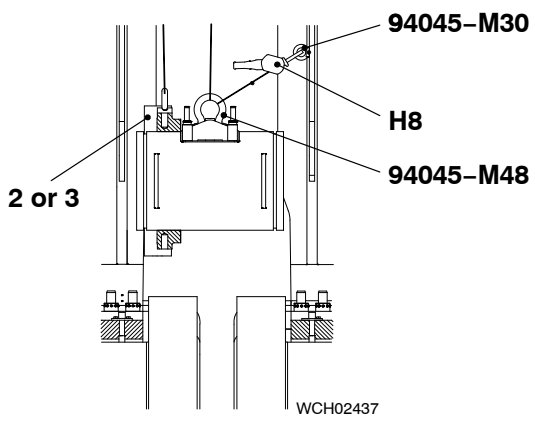
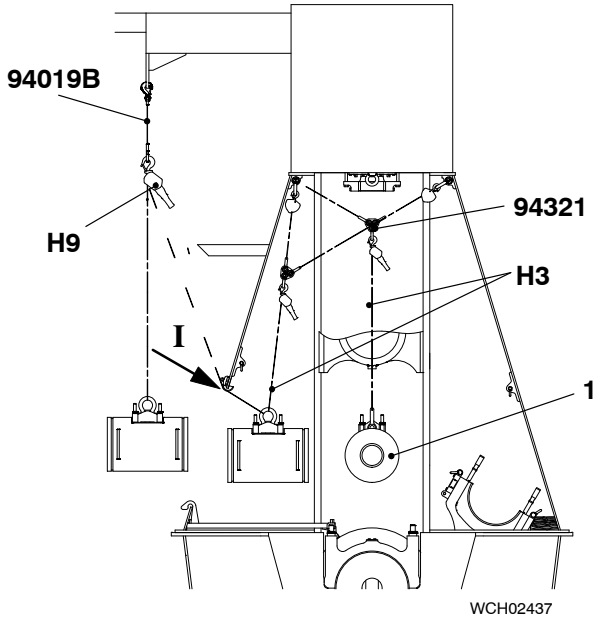
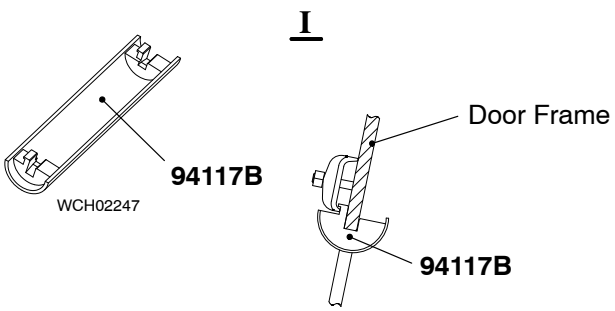


Fig. 4

24) Remove the two bolts, tab washers and holding plates (1, Fig. 3) from the guide shoe (4).
25) Attach the two eye bolts (94045–M20) and the chain (94325) to the crosshead pin (4).
26) Attach the shackle (94018B) to an applicable position on the column.
27) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).
28) Operate the manual ratchet (H8) to pull the crosshead pin (4) until the guide shoe (3) is clear.
29) Operate the manual ratchet (H6) to lift the guide shoe (3).
30) Remove the chain (94325), manual ratchet (H8), shackle (94018B) and eye bolts.
31) Attach the shackle (94018B) to an applicable position on the column.
32) Attach the eye bolts and chain (94325) and manual ratchet (H8) to the other side of the crosshead pin.
33) Operate the manual ratchet (H8) to pull the crosshead pin (4) until the guide shoe (2) is clear.
34) Operate the manual ratchet (H7) to lift the guide shoe (2).
35) When the crosshead (4) is in the first or last cylinder position,do step 36) to step 43)
36) Attach the eye bolt (94045–M30, Fig. 4) to the hole in the column.
37) Attach the manual ratchet (H8) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
38) Operate the manual ratchet to pull the crosshead (4) from the guide shoe (2, or 3).
39) Operate the manual ratchet (H6 or H7) to lift the guide shoe (2, or 3).
40) Remove the manual ratchet (H8) and the eye bolt (94045–M30).
41) Attach the eye bolt (94045–M30) to the other side of the column.
42) Attach the manual ratchet (H8) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
43) Operate the manual ratchet H6 or H7) to pull the crosshead (4) from the guide shoe (2 or 3).





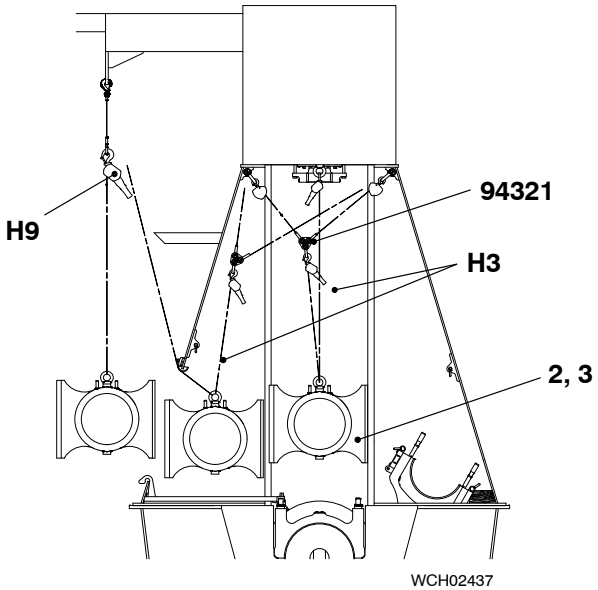


Fig. 5

44) Operate the manual ratchet (94016–009, Fig. 4) to lift the guide shoe (2 or 3).

45) Remove the manual ratchet (H8) and the eye bolt (94045–M30).

46) Attach the protection tool (94117B, Fig. 5) to the door frame.

47) Attach the manual ratchet (H9) to the attachment point on the gallery.

48) Attach the chain (94019B) to the manual ratchet (H9) and the eye bolt on the crosshead pin (2).

49) Turn the crosshead pin (2) 90°.

Note: When you step 50), keep the tension on the two manual ratchets (H3, H9).

50) Move the crosshead pin (1) through the door frame as follows:

   a) Tighten the manual ratchet (H9). At the same time, carefully loosen the manual ratchet (H3).

   b) Lower the crosshead on to an applicable wooden underlay.

   c) Remove the manual ratchets (H3, H9) from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

1) Record the positions of the guide shoes (2, 3). The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.

2) Operate the manual ratchet (H6, Fig 3) to lower the guide shoe (3) to the level of the door frame.

3) Attach the two manual ratchets (H3, H9) to the eye bolt on the guide shoe (3, Fig. 5).

4) Apply a light tension to the chains of the manual ratchets (H3, H9).

5) Remove the manual ratchet (H6) from the guide shoe (3).

Note: When you do step 6) and step 7), keep the tension on the two manual ratchets (H3, H9).

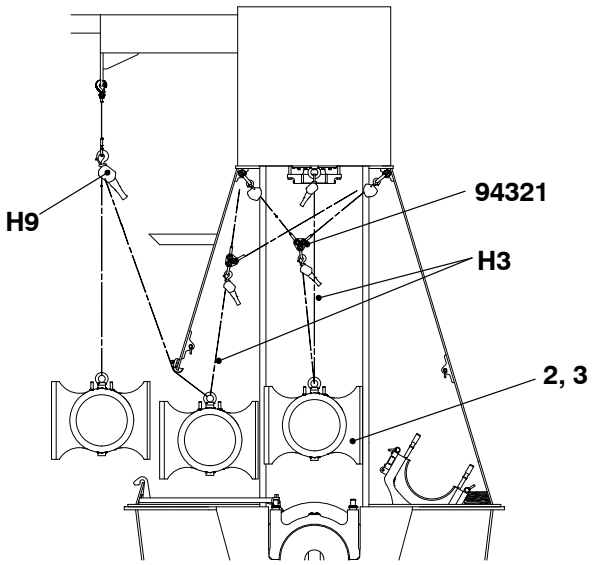


Fig. 6

6) Tighten the manual ratchet (H9). At the same time, carefully loosen the manual ratchet (H3, Fig. 6).

7) Lower the guide shoe (2) on to an applicable wooden underlay.

8) Do the procedure in this paragraph (step 1) to step 7)) to remove the guide shoe (3).

4. Guide Shoes – Installation

Note: When you do step 1) to step 8) below, make sure that you install the guide shoes in their original positions.

1) Attach the two manual ratchets (H3, H9) to the eye bolt on the guide shoe (2).

2) Apply a light tension to the chains of the manual ratchets (H3, H9).

Note: When you do step 3) and step 4) below, keep the tension on the two manual ratchets (H3, H9).

3) Move the guide shoe (2) through the door frame as follows:

4) Tighten the manual ratchet (H3). At the same time, carefully loosen the manual ratchet (H9).

5) Attach the applicable manual ratchet (H6 or H7, Fig. 3) to the applicable guide shoe (2, 3).

6) Remove the two manual ratchets (H3, H9) from the guide shoe (2 or 3).

7) Operate the applicable manual ratchet (H6 or H7) to lift the guide shoe (2 or 3).

8) Do step 1) to step 7) in this paragraph to install the other guide shoe.

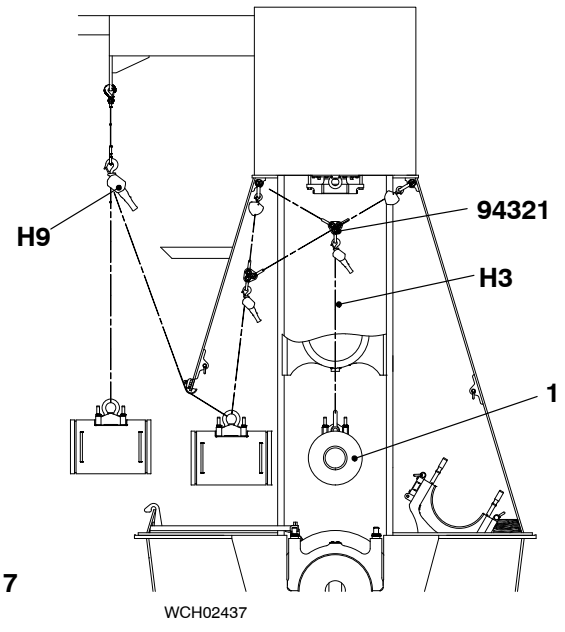


Fig. 7

5. Crosshead Pin – Installation

1) Clean the crosshead pin, 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 and all guide and bearing surfaces.

4) Attach the two manual ratchets (H3, H9, Fig. 7) to the eye bolt on the crosshead (1).

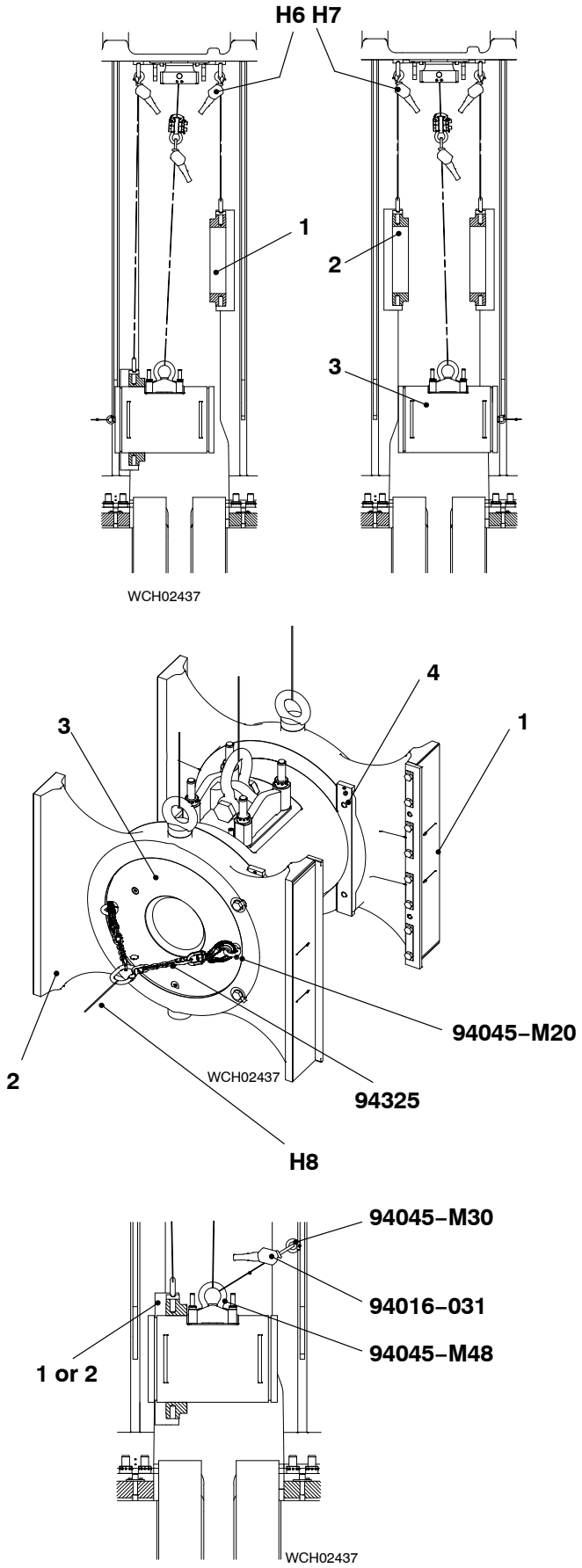


Fig. 8

Note: When you do step 5) and step 6) below, keep the tension on the two manual ratchets .

5) Tighten the manual ratchet (H3, Fig. 7). At the same time, carefully loosen the manual ratchet (H9) to move the crosshead pin (1) into the engine.

6) Remove carefully the manual ratchet (H9).

7) Turn the crosshead pin (3, Fig. 8) 90° .

8) Operate the manual ratchet (H7) to lower and align the guide shoe (2) with the crosshead pin (3).

9) Attach the two eye bolts (94045–M20) and the chain (94325) to the crosshead pin (3).

10) Attach the shackle (94018B) to an applicable position on the column.

11) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).

12) Operate the manual ratchet (H8) to pull the crosshead pin (3) into the guide shoe (2).

13) Remove the chain (94325), eye bolts, shackle (94018B) and manual ratchet (H8).

14) Attach the eye bolts and chain (94325), to the other side of the crosshead pin (3).

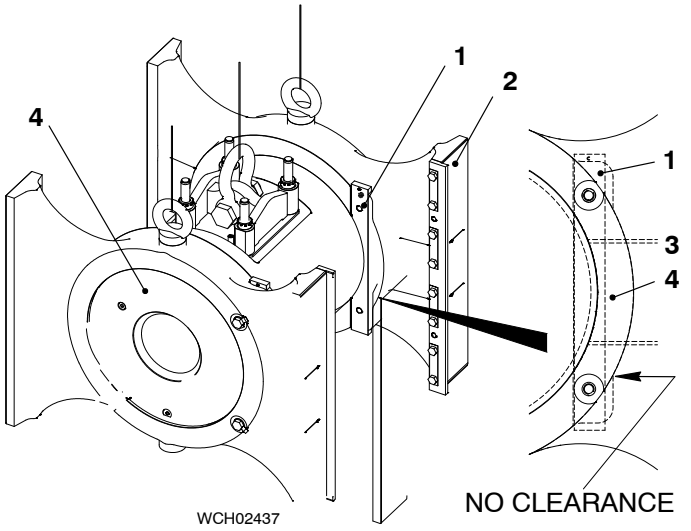
15) Attach the shackle (94018B) to an applicable position on the column.

16) Operate the manual ratchet (H6) to lower and align the guide shoe (1) with the crosshead pin (3).

17) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).

18) Operate the manual ratchet (H8) to pull the crosshead pin (3) into the guide shoe (1).

19) Remove the chain (94325), eye bolts, shackle (94018B) and manual ratchet (H8).



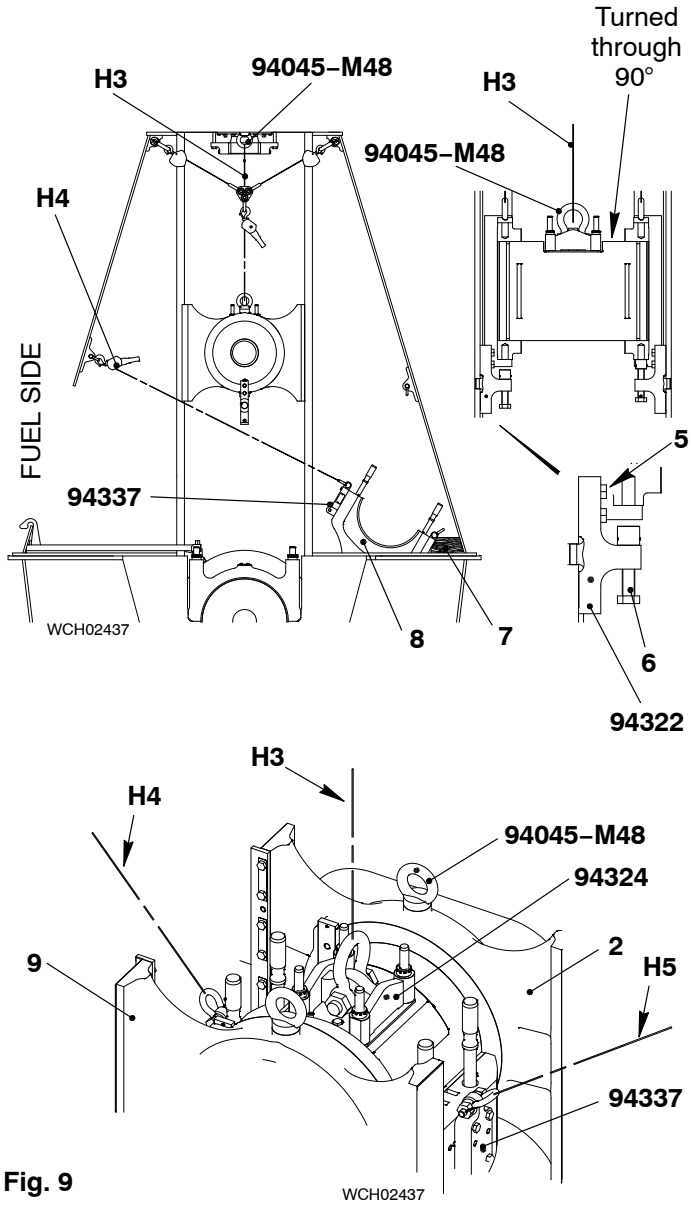


Fig. 9

20) When the crosshead pin is in the first or last cylinder position, do step 21) to step 29).
21) Attach the eye bolt (94045–M30, Fig. 8) to the hole in the column.
22) Attach the manual ratchet (H8) to the eye bolts (94045–M30, 94045–M48).
23) Operate the manual ratchet (H8) to pull the crosshead into the guide shoe (1 or 2).
24) Operate the manual ratchet (H6 or H7) to lower the guide shoe (1 or 2).
25) Remove the manual ratchet (H6 or H7) and eye bolt (94045–M30).
26) Attach the eye bolt (94045–M30) to the other side of the column.
27) Attach the manual ratchet (H6 or H7) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
28) Operate the manual ratchet (H8) to pull the crosshead into the guide shoe (1 or 2).
29) Remove the manual ratchet (H6 or H7) and the eye bolt (94045–M30).
30) Attach the two holding plates (1, Fig. 9) to the guide shoe (2) with the tab washers and bolts.
31) Make sure that there is no clearance between the holding plates (1) and crosshead pin (4).
32) Operate the manual ratchet (H3) to lift the crosshead approximately 160 mm above the center of the pin hole (3).
33) Attach the two supports (94322) to the guide way.
34) Torque the four bolts (5) to 300 Nm.
35) Tighten the two set screws (6).
36) Attach the two manual ratchets (H4, H5) to the shackles (94018B) and tools (94337) on the connecting rod (8). Apply a light tension to the chains.
37) Gradually tighten the manual ratchet (H4) to slowly move the connecting rod. At the same time, keep tension on the manual ratchet (H5).
38) Continue with step 37) above until the connecting rod (8) aligns with the crosshead.
39) Remove the wooden block (7).
40) If necessary, lift the crosshead a small distance.
41) Loosen the two set screws (6).

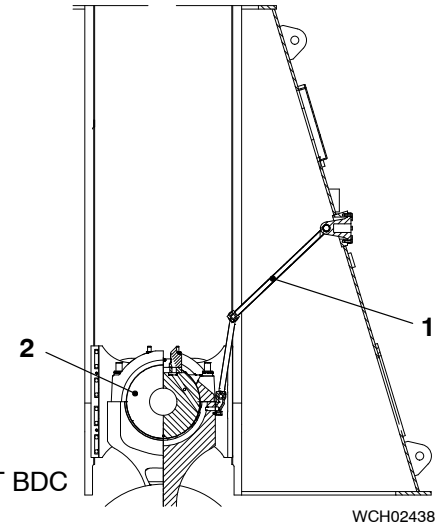


Fig. 10

42) Remove the two supports (94322, Fig. 9).

Note: During step 43), make sure that the elastic bolts on the connecting rod (8) align with the holes in the crosshead pin (4).

43) Lower carefully the crosshead on to the connecting rod (8).

44) Remove the lifting tools (94337).

45) Remove all manual ratchets, eye bolts and chain blocks.

46) Remove the deviation pipe (94117B).

47) Remove the protection from the crosshead pin (4).

CAUTION

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

48) Connect the toggle lever (1, Fig. 10) to the crosshead pin (2). make sure that the toggle lever is in the position shown.

6. Clearance Checks

1) Do the clearance checks given in 3326–1.

2) Compare the clearances with those given in 0330–1 Clearance Table, Crosshead Guide.

7. Completion

1) Install the round nuts to the elastic studs on the connecting rod, refer to 9403–4.

2) Install the top bearing cover, refer to 3303–5.

3) Make sure that all tools and equipment are removed from the work area.

4) Disengage the turning gear.

5) Set the lubricating oil pump to on.

6) Make sure that the crosshead and the bottom end bearings of the connecting rod have sufficient lubrication.

Intentionally blank

Crosshead Pin – Removal and Installation

Tools:

1	Deviation pipe	94117B	2	Eye bolt M20	94045–M20
1	Platform	94142	2	Eye bolt M30	94045–M30
1	Lifting tool	94324	4	Eye bolt M48	94045–M48
2	Chain block 2000 kg (H1, H2)	94017–021	1	Chain	94325
2	Manual ratchet 1500 kg (H6, H7)	94016–017	1	Chain	94019B
2	Manual ratchet 1000 kg (H4, H5)	94016–011	1	Link	94321
1	Manual ratchet 1000 kg (H8)	94016–009	2	Lifting tools	94337
2	Manual ratchet 3000 kg (H3, H9)	94016–031	1	Support	94322
4	Shackle 4750 kg	94018B	1	Support	94322A
4	Shackle 8500 kg	94018C	1	Feeler gauge	

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 (94142), refer to 3301–1.
5) Disconnect the toggle lever (9, 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, paragraph 2.
8) Put protection on the oil inlets of the crosshead pin to prevent damage and contamination.

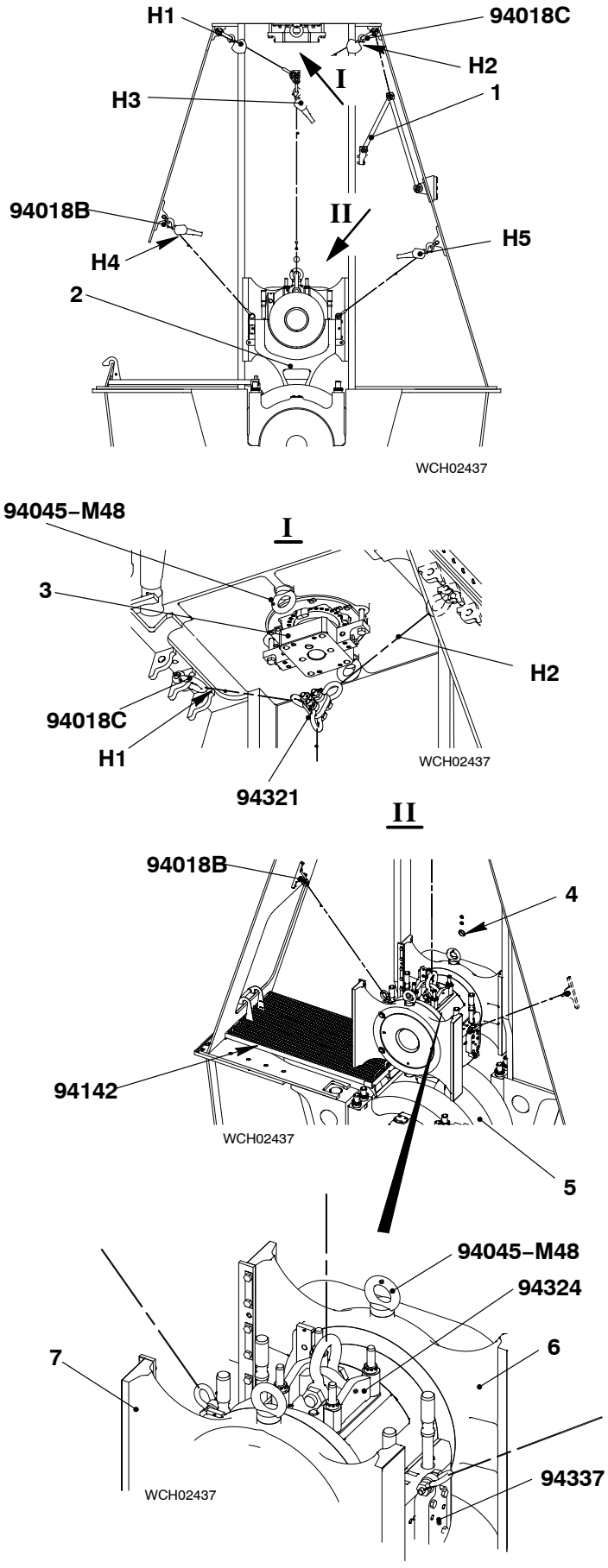
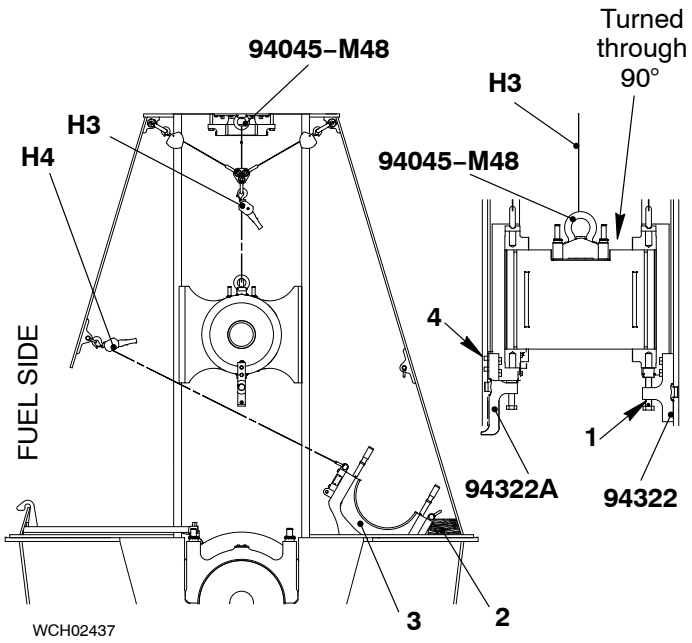
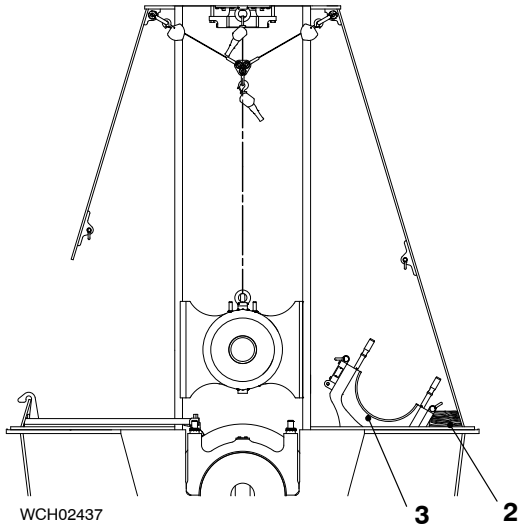


Fig. 1

2. Crosshead Pin – Removal

1) Attach the lifting tool (94324, Fig. 1) to the crosshead.
2) Attach the two eye bolts (94045–M48) to the bottom of the cylinder jacket.
3) Attach the two shackles (94018C) to the top of the column.
4) Attach the two chain blocks (H1, H2) to the shackles (94018C).
5) Attach the link (94321) to the chain blocks (H1, H2).
6) Attach the manual ratchet (H3) to the link (94321) and the eye bolt (94045–M48) on the lifting tool.
7) Attach the two eye bolts (94045–M48) to the guide shoes (6, 7).
8) Attach the two lifting tools (94337) to the connecting rod (2).
9) Attach the two manual ratchets (H4, H5) to the shackles (94018B). Operate the manual ratchets to apply a light tension to the chains.
10) Operate the manual ratchet (H3) to lift the crosshead approximately 160 mm above the center of the pin hole (4).





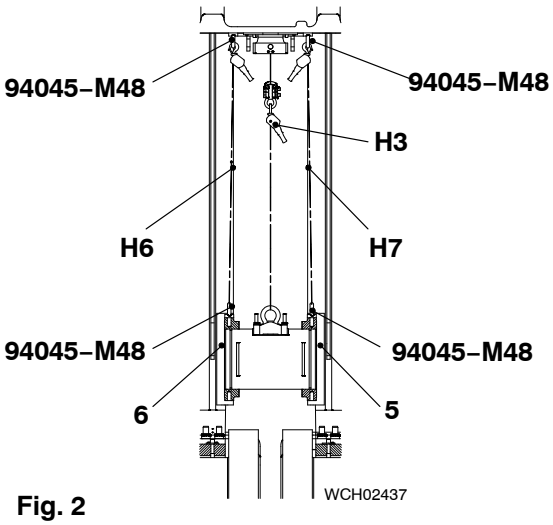


Fig. 2

Note: The two supports (94322, Fig 2) hold the weight of the crosshead while you move the connecting rod (4).

11) Attach the two supports (94322, 94332A) to the guide way with the four bolts (4) as shown.

12) Torque the bolts (4) to 300 Nm.

13) Tighten the two set screws (1).

14) Put a wooden block (2) in position as shown.

Note: During the step 15), slowly move the connecting rod to the exhaust side.

15) On the fuel side, gradually loosen the manual ratchet (H4). At the same time, keep tension on the chain of the manual ratchet (H5).

16) Continue with step 15) until the connecting rod (3) touches the wooden block (2).

17) Loosen the two set screws (1).

18) Lift the crosshead a small distance.

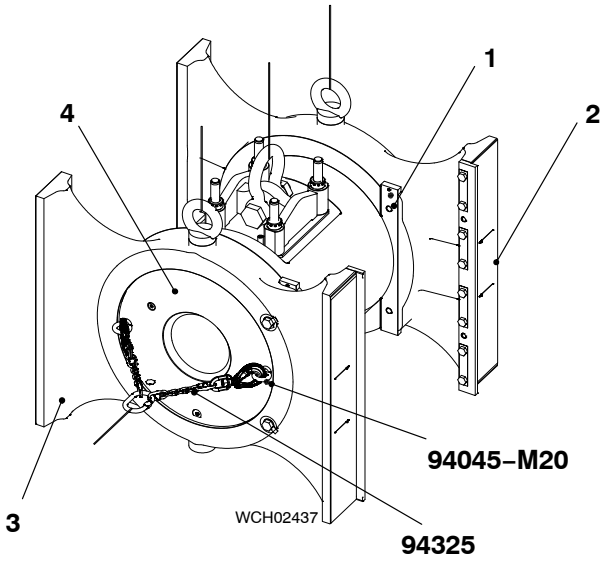
19) Remove the two supports (94322, 94322A).

20) Remove the manual ratchets (H4, H5).

21) Lower the crosshead to the same height as the column door frame.

22) Attach the manual ratchets (H6, H7) to the eye bolts (94045–M48) on the guide shoes (5) and (6).

23) Apply a light tension to the chains of the manual ratchets (H6, H7). Make sure that the primary load stays on the chain of the manual ratchet (H3).



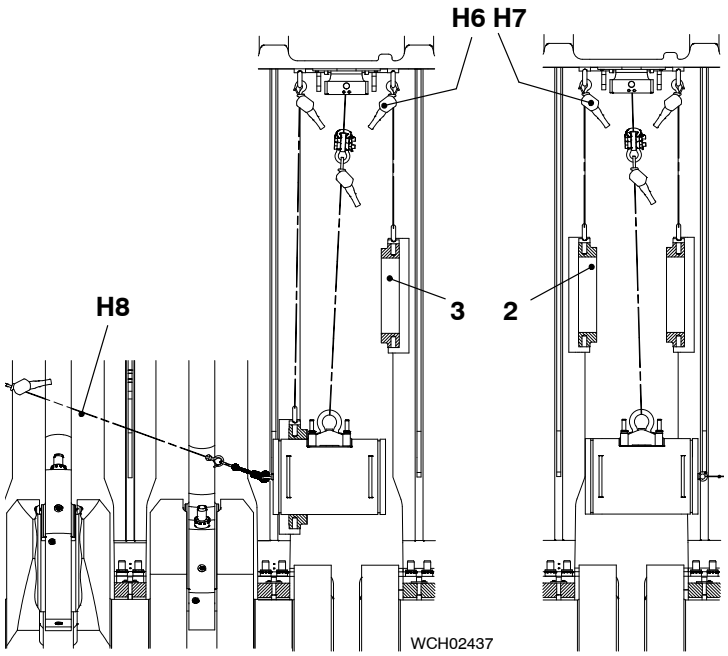


Fig. 3

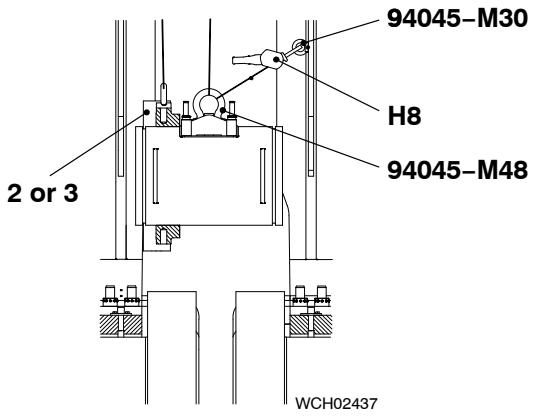
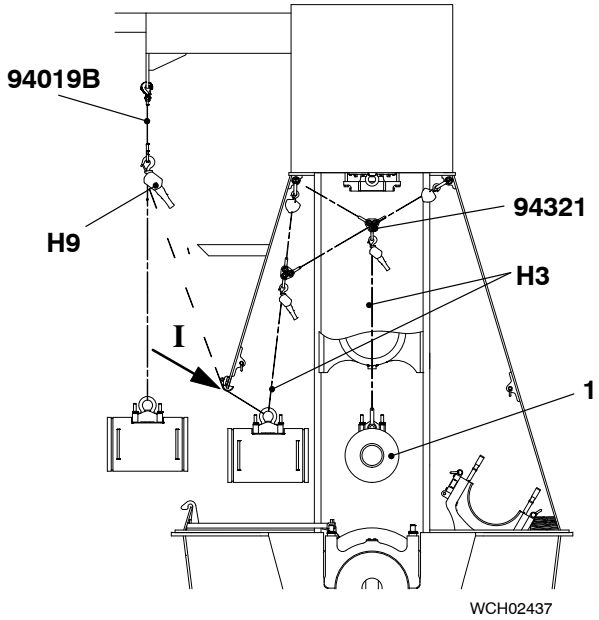
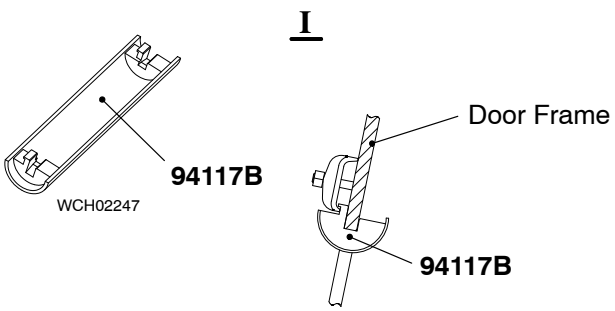


Fig. 4

24) Remove the two bolts, tab washers and holding plates (1, Fig. 3) from the guide shoe (4).
25) Attach the two eye bolts (94045–M20) and the chain (94325) to the crosshead pin (4).
26) Attach the shackle (94018B) to an applicable position on the column.
27) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).
28) Operate the manual ratchet (H8) to pull the crosshead pin (4) until the guide shoe (3) is clear.
29) Operate the manual ratchet (H6) to lift the guide shoe (3).
30) Remove the chain (94325), manual ratchet (H8), shackle (94018B) and eye bolts.
31) Attach the shackle (94018B) to an applicable position on the column.
32) Attach the eye bolts and chain (94325) and manual ratchet (H8) to the other side of the crosshead pin.
33) Operate the manual ratchet (H8) to pull the crosshead pin (4) until the guide shoe (2) is clear.
34) Operate the manual ratchet (H7) to lift the guide shoe (2).
35) When the crosshead (4) is in the first or last cylinder position,do step 36) to step 43)
36) Attach the eye bolt (94045–M30, Fig. 4) to the hole in the column.
37) Attach the manual ratchet (H8) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
38) Operate the manual ratchet to pull the crosshead (4) from the guide shoe (2, or 3).
39) Operate the manual ratchet (H6 or H7) to lift the guide shoe (2, or 3).
40) Remove the manual ratchet (H8) and the eye bolt (94045–M30).
41) Attach the eye bolt (94045–M30) to the other side of the column.
42) Attach the manual ratchet (H8) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
43) Operate the manual ratchet H6 or H7) to pull the crosshead (4) from the guide shoe (2 or 3).





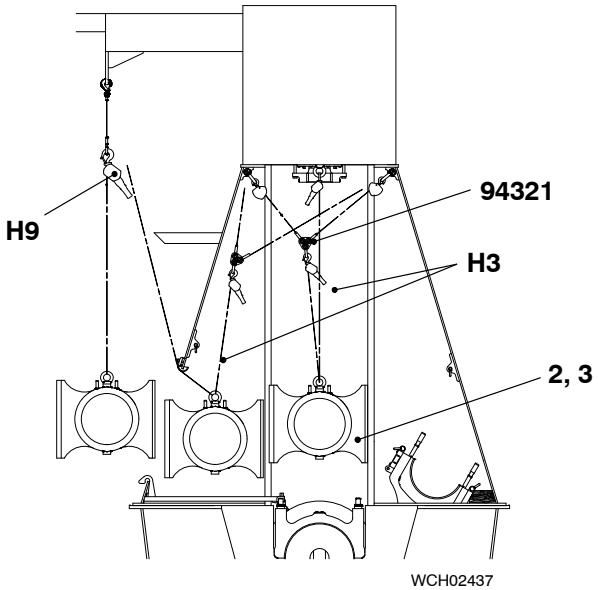


Fig. 5

44) Operate the manual ratchet (94016–009, Fig. 4) to lift the guide shoe (2 or 3).

45) Remove the manual ratchet (H8) and the eye bolt (94045–M30).

46) Attach the protection tool (94117B, Fig. 5) to the door frame.

47) Attach the manual ratchet (H9) to the attachment point on the gallery.

48) Attach the chain (94019B) to the manual ratchet (H9) and the eye bolt on the crosshead pin (2).

49) Turn the crosshead pin (2) 90°.

Note: When you step 50), keep the tension on the two manual ratchets (H3, H9).

50) Move the crosshead pin (1) through the door frame as follows:

   a) Tighten the manual ratchet (H9). At the same time, carefully loosen the manual ratchet (H3).

   b) Lower the crosshead on to an applicable wooden underlay.

   c) Remove the manual ratchets (H3, H9) from the eye bolt on the crosshead pin (1).

3. Guide Shoes – Removal

1) Record the positions of the guide shoes (2, 3). The shims of the guide shoes can have different dimensions. This will help you during the installation procedure.

2) Operate the manual ratchet (H6, Fig 3) to lower the guide shoe (3) to the level of the door frame.

3) Attach the two manual ratchets (H3, H9) to the eye bolt on the guide shoe (3, Fig. 5).

4) Apply a light tension to the chains of the manual ratchets (H3, H9).

5) Remove the manual ratchet (H6) from the guide shoe (3).

Note: When you do step 6) and step 7), keep the tension on the two manual ratchets (H3, H9).

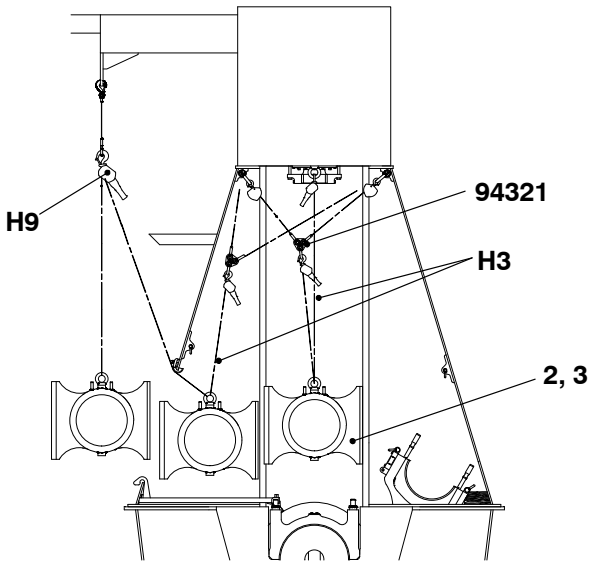


Fig. 6

6) Tighten the manual ratchet (H9). At the same time, carefully loosen the manual ratchet (H3, Fig. 6).

7) Lower the guide shoe (2) on to an applicable wooden underlay.

8) Do the procedure in this paragraph (step 1) to step 7)) to remove the guide shoe (3).

4. Guide Shoes – Installation

Note: When you do step 1) to step 8) below, make sure that you install the guide shoes in their original positions.

1) Attach the two manual ratchets (H3, H9) to the eye bolt on the guide shoe (2).

2) Apply a light tension to the chains of the manual ratchets (H3, H9).

Note: When you do step 3) and step 4) below, keep the tension on the two manual ratchets (H3, H9).

3) Move the guide shoe (2) through the door frame as follows:

4) Tighten the manual ratchet (H3). At the same time, carefully loosen the manual ratchet (H9).

5) Attach the applicable manual ratchet (H6 or H7, Fig. 3) to the applicable guide shoe (2, 3).

6) Remove the two manual ratchets (H3, H9) from the guide shoe (2 or 3).

7) Operate the applicable manual ratchet (H6 or H7) to lift the guide shoe (2 or 3).

8) Do step 1) to step 7) in this paragraph to install the other guide shoe.

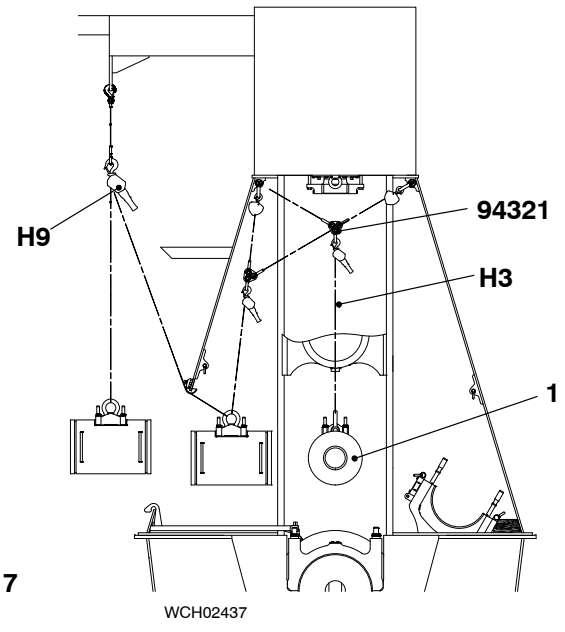


Fig. 7

5. Crosshead Pin – Installation

1) Clean the crosshead pin, 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 and all guide and bearing surfaces.

4) Attach the two manual ratchets (H3, H9, Fig. 7) to the eye bolt on the crosshead (1).

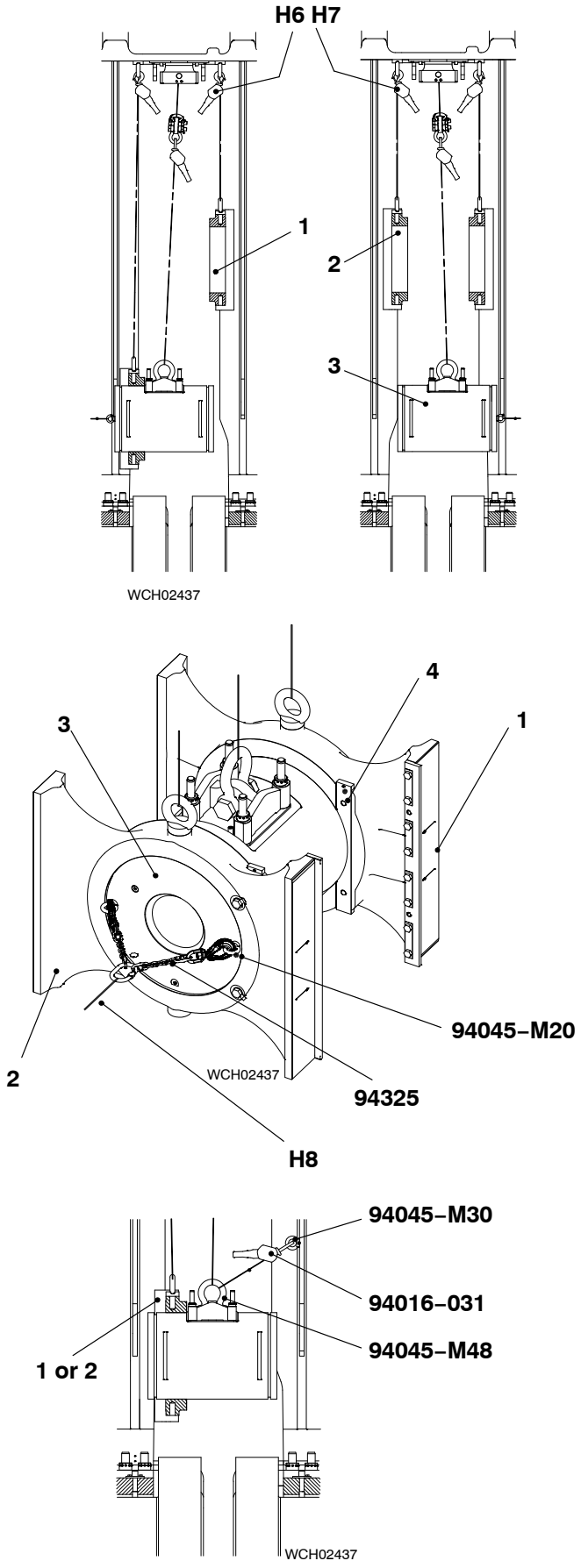


Fig. 8

Note: When you do step 5) and step 6) below, keep the tension on the two manual ratchets .

5) Tighten the manual ratchet (H3, Fig. 7). At the same time, carefully loosen the manual ratchet (H9) to move the crosshead pin (1) into the engine.

6) Remove carefully the manual ratchet (H9).

7) Turn the crosshead pin (3, Fig. 8) 90° .

8) Operate the manual ratchet (H7) to lower and align the guide shoe (2) with the crosshead pin (3).

9) Attach the two eye bolts (94045–M20) and the chain (94325) to the crosshead pin (3).

10) Attach the shackle (94018B) to an applicable position on the column.

11) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).

12) Operate the manual ratchet (H8) to pull the crosshead pin (3) into the guide shoe (2).

13) Remove the chain (94325), eye bolts, shackle (94018B) and manual ratchet (H8).

14) Attach the eye bolts and chain (94325), to the other side of the crosshead pin (3).

15) Attach the shackle (94018B) to an applicable position on the column.

16) Operate the manual ratchet (H6) to lower and align the guide shoe (1) with the crosshead pin (3).

17) Attach the manual ratchet (H8) to the eye bolts and the shackle (94018B).

18) Operate the manual ratchet (H8) to pull the crosshead pin (3) into the guide shoe (1).

19) Remove the chain (94325), eye bolts, shackle (94018B) and manual ratchet (H8).

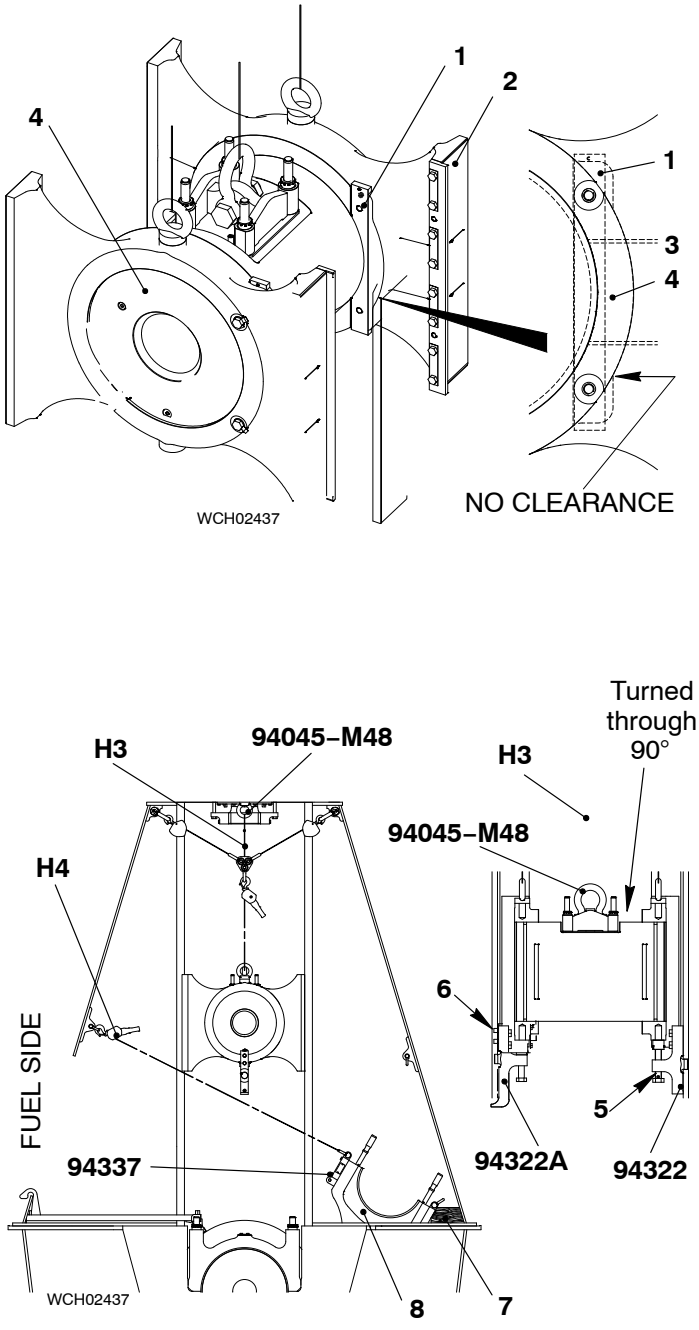


Fig. 9

20) When the crosshead pin is in the first or last cylinder position, do step 21) to step 29).
21) Attach the eye bolt (94045–M30, Fig. 8) to the hole in the column.
22) Attach the manual ratchet (H8) to the eye bolts (94045–M30, 94045–M48).
23) Operate the manual ratchet (H8) to pull the crosshead into the guide shoe (1 or 2).
24) Operate the manual ratchet (H6 or H7) to lower the guide shoe (1 or 2).
25) Remove the manual ratchet (H6 or H7) and eye bolt (94045–M30).
26) Attach the eye bolt (94045–M30) to the other side of the column.
27) Attach the manual ratchet (H6 or H7) to the eye bolt (94045–M30) and the eye bolt (94045–M48).
28) Operate the manual ratchet (H8) to pull the crosshead into the guide shoe (1 or 2).
29) Remove the manual ratchet (H6 or H7) and the eye bolt (94045–M30).
30) Attach the two holding plates (1, Fig. 9) to the guide shoe (2) with the tab washers and bolts.
31) Make sure that there is no clearance between the holding plates (1) and crosshead pin (4).
32) Operate the manual ratchet (H3) to lift the crosshead approximately 160 mm above the center of the pin hole (3).
33) Attach the two supports (94322, 94322A) to the guide way.
34) Torque the four bolts (6) to 300 Nm.
35) Tighten the two set screws (5).
36) Attach the two manual ratchets (H4, H5) to the shackles (94018B) and tools (94337) on the connecting rod (8). Apply a light tension to the chains.
37) Gradually tighten the manual ratchet (H4) to slowly move the connecting rod. At the same time, keep tension on the manual ratchet (H5).
38) Continue with step 37) above until the connecting rod (8) aligns with the crosshead.
39) Remove the wooden block (7).
40) If necessary, lift the crosshead a small distance.
41) Loosen the two set screws (5).

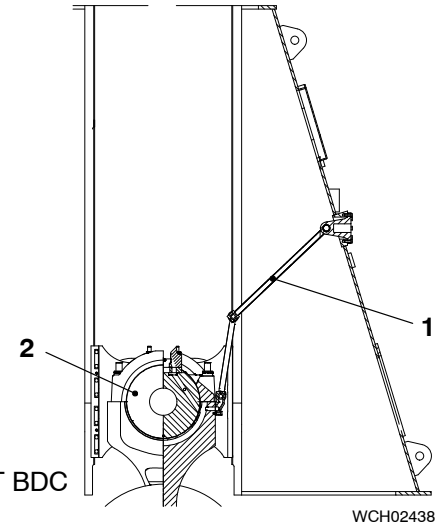


Fig. 10

42) Remove the two supports (94322 and 94322A Fig. 9).

Note: During step 43), make sure that the elastic bolts on the connecting rod (8) align with the holes in the crosshead pin (4).

43) Lower carefully the crosshead on to the connecting rod (8).

44) Remove the lifting tools (94337).

45) Remove all manual ratchets, eye bolts and chain blocks.

46) Remove the deviation pipe (94117B).

47) Remove the protection from the crosshead pin (4).

CAUTION

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

48) Connect the toggle lever (1, Fig. 10) to the crosshead pin (2). make sure that the toggle lever is in the position shown.

6. Clearance Checks

1) Do the clearance checks given in 3326–1.

2) Compare the clearances with those given in 0330–1 Clearance Table, Crosshead Guide.

7. Completion

1) Install the round nuts to the elastic studs on the connecting rod, refer to 9403–4.

2) Install the top bearing cover, refer to 3303–5.

3) Make sure that all tools and equipment are removed from the work area.

4) Disengage the turning gear.

5) Set the lubricating oil pump to on.

6) Make sure that the crosshead and the bottom end bearings of the connecting rod have sufficient lubrication.

Intentionally blank

Work Card
Piston: Remove and Clean

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Remove the cylinder cover, refer to 2708–1
Remove the piston, refer to 3403–1/A1
If the piston ring stroke has unwanted material, refer to 2124–3
Clean the top part of the cylinder liner
Attach the applicable equipment
Remove the antipolishing ring

Tools and Consumables

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

Oil
Drip trays

Primary Task

Remove and clean the piston

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Superintendent	2.0 hours	Qty 1
Service Engineer	2.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Install the piston, refer to 3403–1/A1.
Do a tightness check of the piston in the installed position. Do a visual check through the scavenge ports.
Do a check of the condition of the piston top surface.

Intentionally blank

Piston

Removal and Installation

Tools:

1	4-leg sling	94209	1	Disassembly/assembly tool	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–M42			

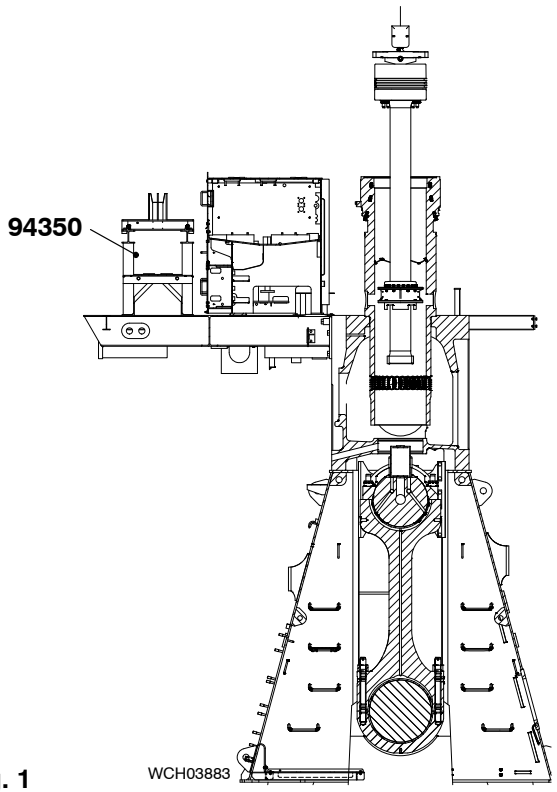


Fig. 1

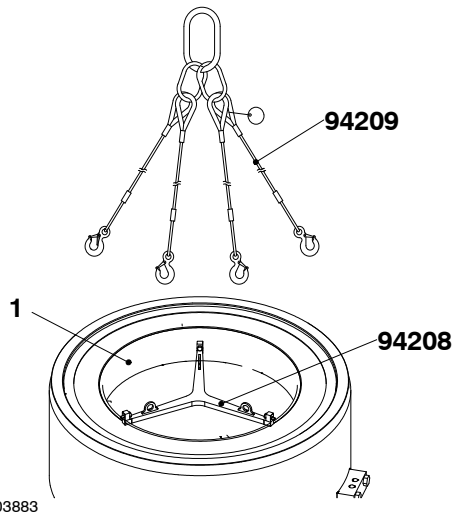


Fig. 2

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) 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) Attach the tool (94208, Fig. 2) to the antipolishing ring (1) with the three screws.
10) Attach the sling (94209) to the tool (94208) and the engine room crane.
11) Operate the engine room crane to remove the antipolishing ring (1).

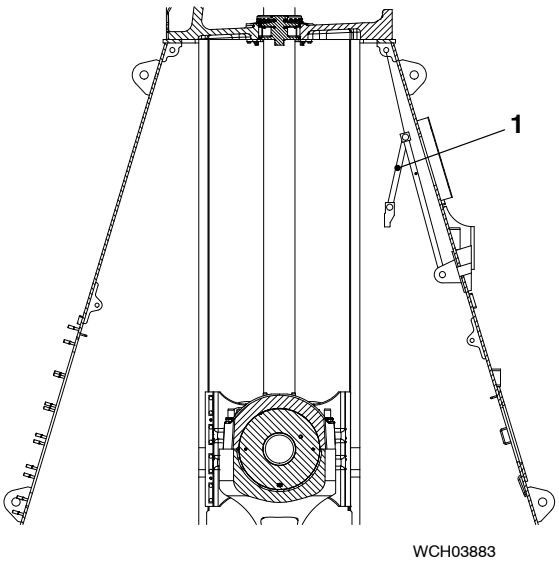


Fig. 3

12) Remove the knee lever (1, Fig. 3) from the crosshead connection.

13) Let the knee lever (1) hang as shown.

2. Removal

1) Operate the turning gear to turn the crank (1, Fig. 4) approximately 90° to the exhaust side.

2) Remove the four round nuts (2) from the piston rod foot, refer to the procedure in 9403–4.

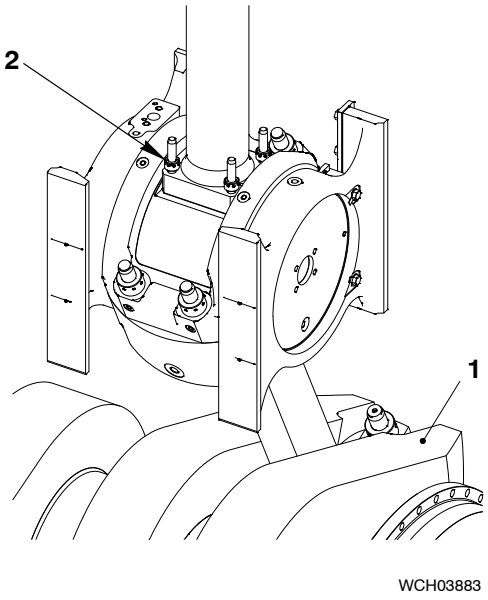


Fig. 4

Note: Some parts can look different.

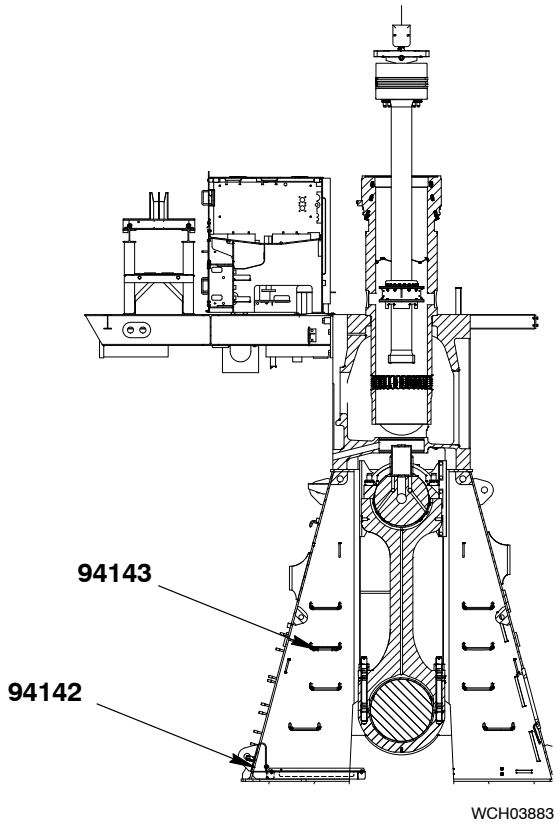


Fig. 5

3) Install the work platform (94142, Fig. 5) and the support (94143).

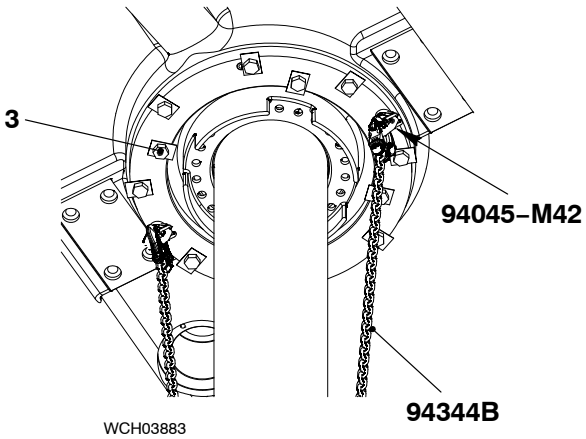


Fig. 6

4) Remove the four inner bolts (3, Fig. 6) from the support (4).

5) Attach the two eye bolts (94045–M42) to the support (4).

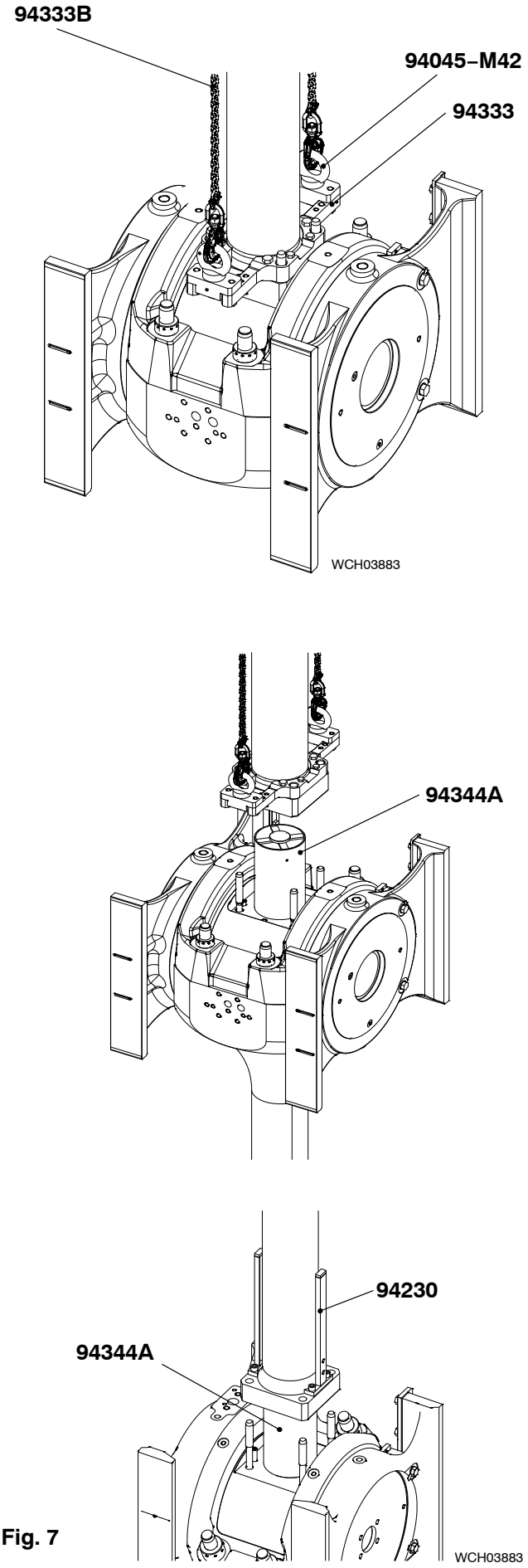


Fig. 7

6) Attach the lifting tool (94333, Fig. 7) to the piston rod foot.

7) Attach the two eye bolts (94045−M42) to the lifting tool (94333).

8) Attach the two chains (94333B) to the four eye bolts (94045−M42).

9) Remove the work platform (94142, Fig. 5).

Note: When you do step 10), 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.

11) Operate the turning gear to move the crosshead down sufficiently to put the spacer (94344A) in position.

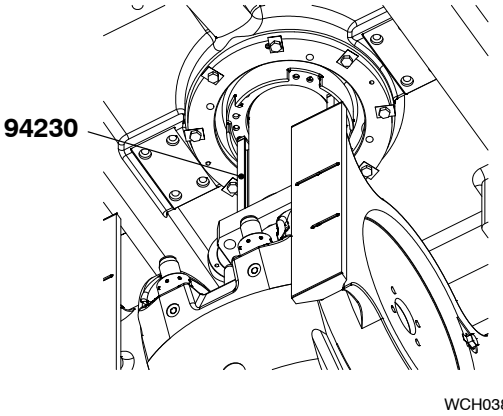
12) Put the spacer (94344A, Fig. 7) on the crosshead pin.

13) Operate the turning gear to move the crosshead pin up sufficiently so there is no tension on the chains (94333B).

14) Remove the chains (94333B) and the four eye bolts (94045−M42). Keep the spacer (94344A) in position on the crosshead pin.

15) Attach the two distance pieces (94230) to the piston rod foot as shown.

16) Make sure that the distance pieces (94230) are in line with the gland box.



Note: When you do step 17), the piston moves up and the distance pieces (94230) move the gland box up.

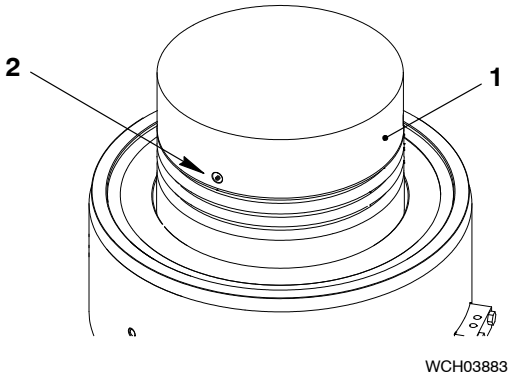
17) Operate the turning gear to move the piston (1, Fig. 8) to TDC.

18) Clean the three holes (2) and the top part of the piston crown (1).

19) Make sure that the tool (94341) is clean.

20) Remove the six bolts (3). and the three brackets (4).

21) Apply Molykote past G–n to the threads of the six bolts (1).



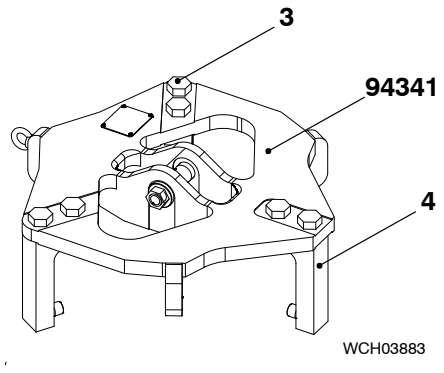
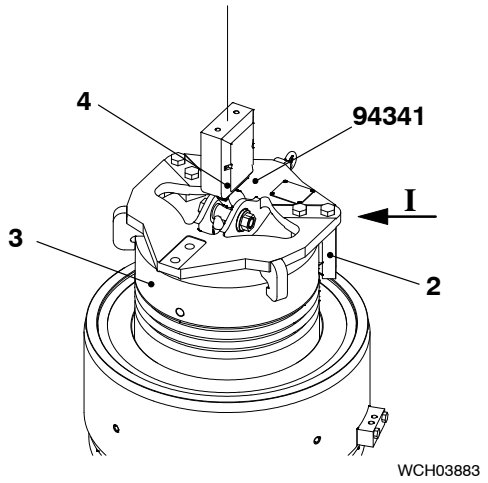


Fig. 8



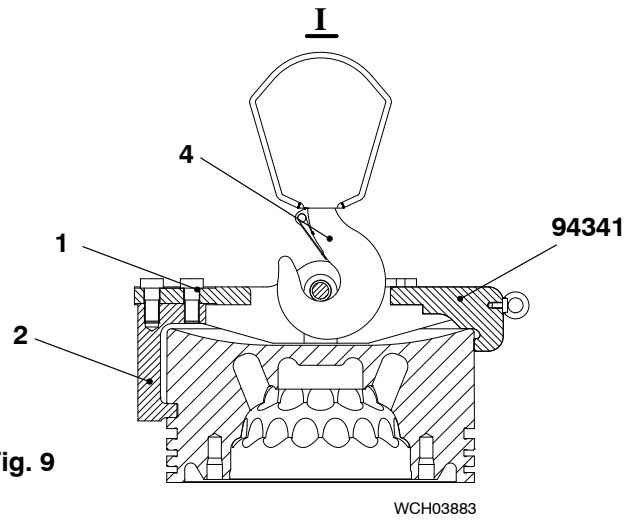


Fig. 9

22) 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).

23) 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).

24) Torque the six bolts (1) to 170 Nm.

25) Attach the crane hook (4) to the tool (94341).

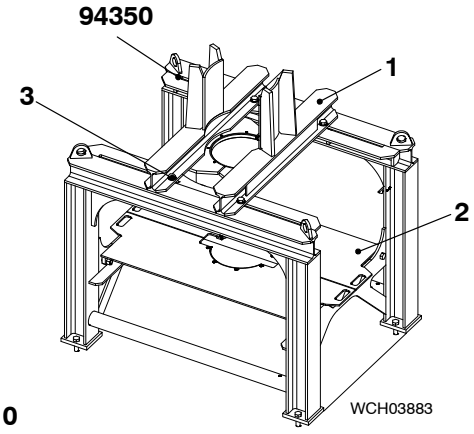


Fig. 10

26) Make sure that the piston support tool (94350, Fig. 10) is in the correct position on the top platform.

27) Loosen the four screws (3).

28) Move fully out the two supports (1).

29) Lift and lock the plates (2) in the vertical position.

Note: When you do step 30), make sure that the piston rod foot does not touch the support of the piston rod gland box.

30) Operate the engine room crane to lift the piston fully out of the cylinder liner.

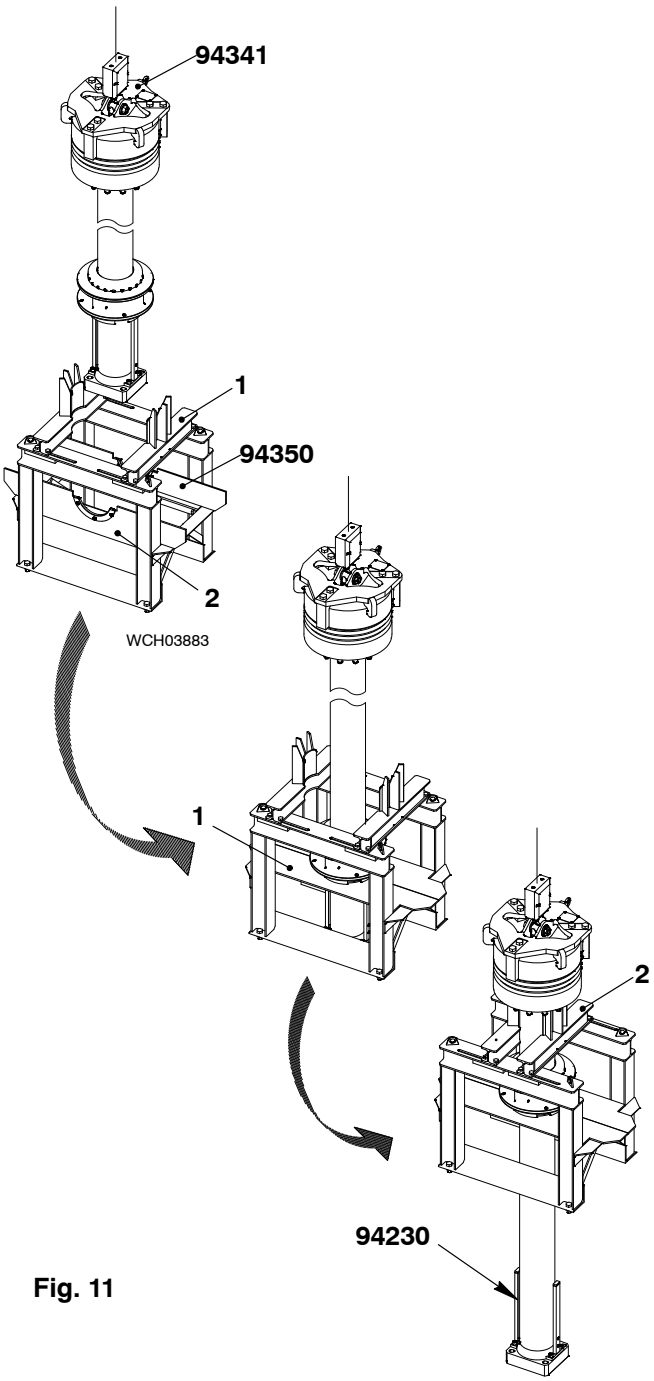


Fig. 11

31) Lower and align the piston between the supports (1, Fig. 11) until the piston rod foot is below the plates (2).
32) Close the plates (2).
33) Push fully in the two supports (1).
34) Tighten the four screws (3).
35) Lower the piston on to the supports (1).
36) Remove the crane hook from the tool (94341).
37) Remove the distance holders (94230) from the piston rod foot.
38) Remove the tool (94341).
39) To disassemble the piston, refer to 3043–3 paragraph 1 and paragraph 2.
40) Do a check of the top surface of the piston, refer to 3403–4.
41) Do a check of the piston rings and grooves, refer to 3425–1.
42) Refer to the Maintenance Schedule for other work on each piston 0380–1. Select the related data.

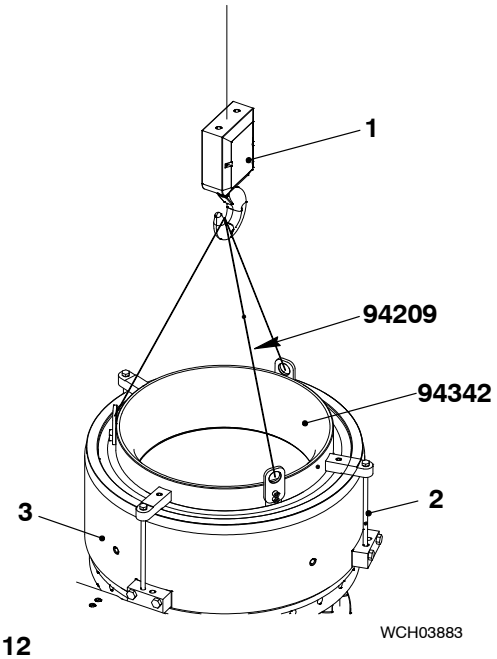


Fig. 12

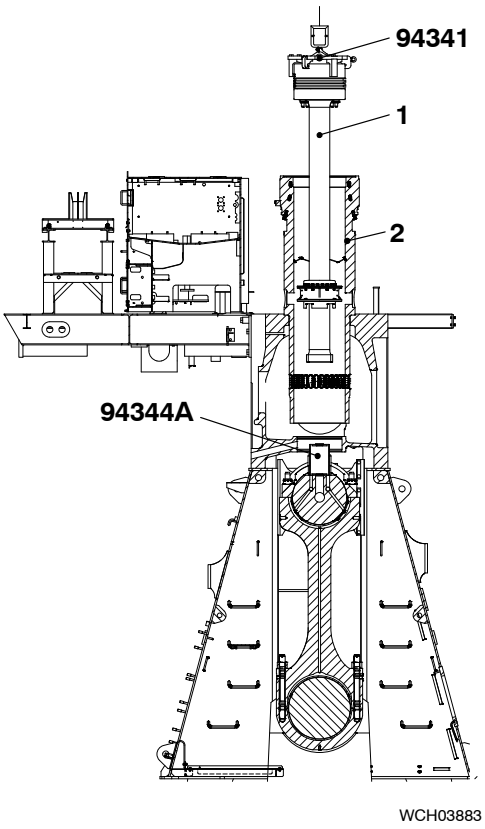
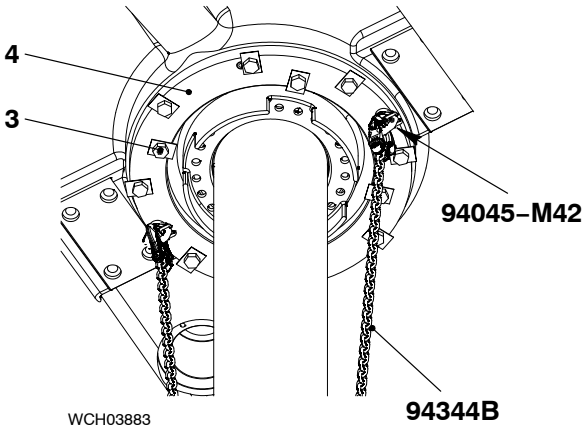
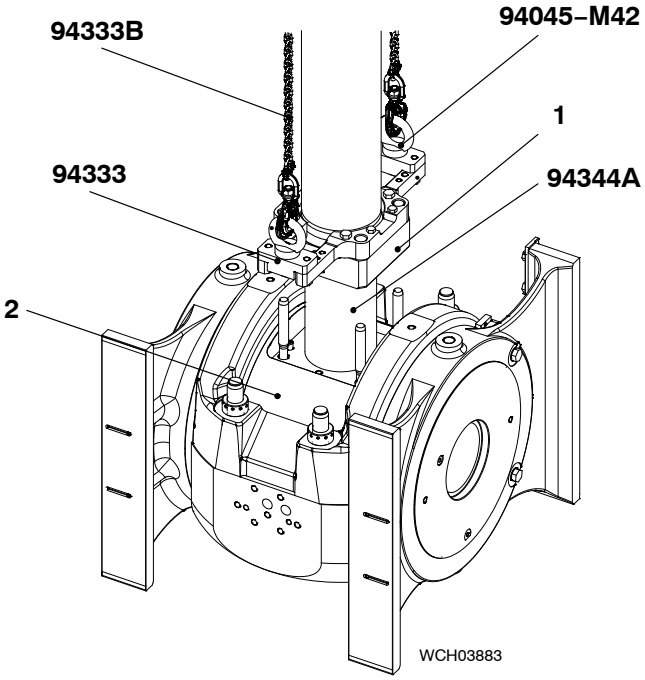


Fig. 13

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 paragraph 2, step 19) to 24).
13) Attach the engine room crane to the tool (94341).
14) Attach the 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) Operate the engine room crane to Lift the piston together with the piston rod gland box from the support (94350).





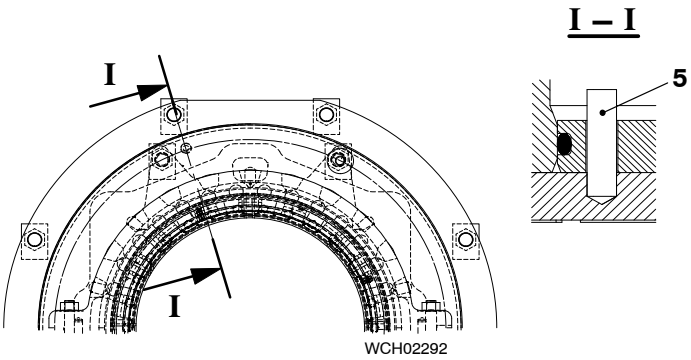


Fig. 14

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–M42) to the support ring (3).
26) Attach the two eye bolts (94045–M42) 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–M42).
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).

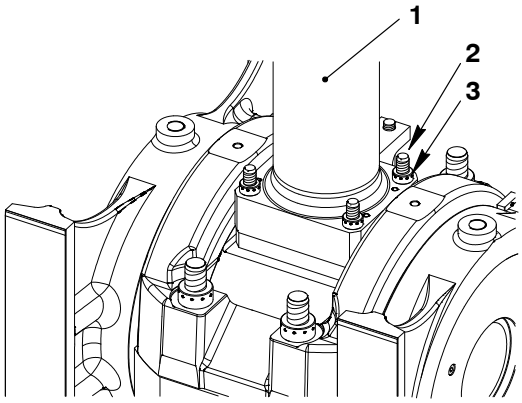


Fig. 15

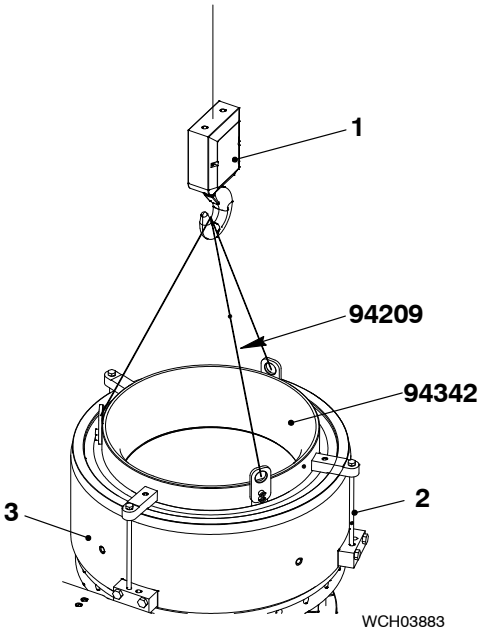


Fig. 16

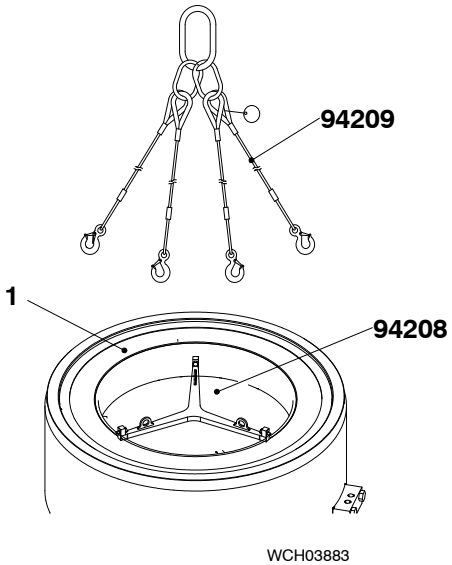


Fig. 17

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).

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).

4. Completion

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) 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.

Work Card
Piston: Disassemble and Assemble

Necessary Conditions

– Engine stopped
– Piston removed

Necessary Spare Parts (each cylinder)

O-ring for spray plate	EX 34016
O-ring for piston rod	EX 34018
O-rings – set	EX 34260

Preparation

Remove the piston, refer to 3403–1/A1
Attach the applicable equipment

Tools and Consumables

Pre-tensioner	94340	Qty 3
Lifting tool	94341	Qty 1
Jacking screws (see Note)	94364A	Qty 3
Jacking screws (see Note)	94364B	Qty 2
Jacking screws (see Note)	94364C	Qty 3

Note: Use the available screws from the piston assembly

Loctite No. 0270

Primary Task

Disassemble and assemble the piston, refer to 3403–3/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Superintendent	4.0 hours	Qty 1
Service Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Do a check of the piston top surface, refer to 3403–4/A1.
Install the piston, refer to 3403–1/A1.

Intentionally blank

Piston

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 nine round nuts, refer to 9403–4.

4) Remove the nine round nuts.

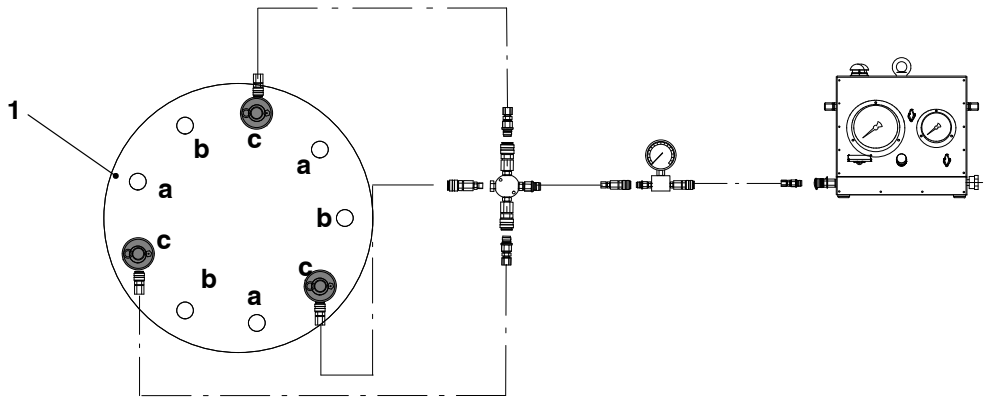


Fig. 1: Sequence to Apply Tension to the Elastic Bolts

Note: Some parts can look different.

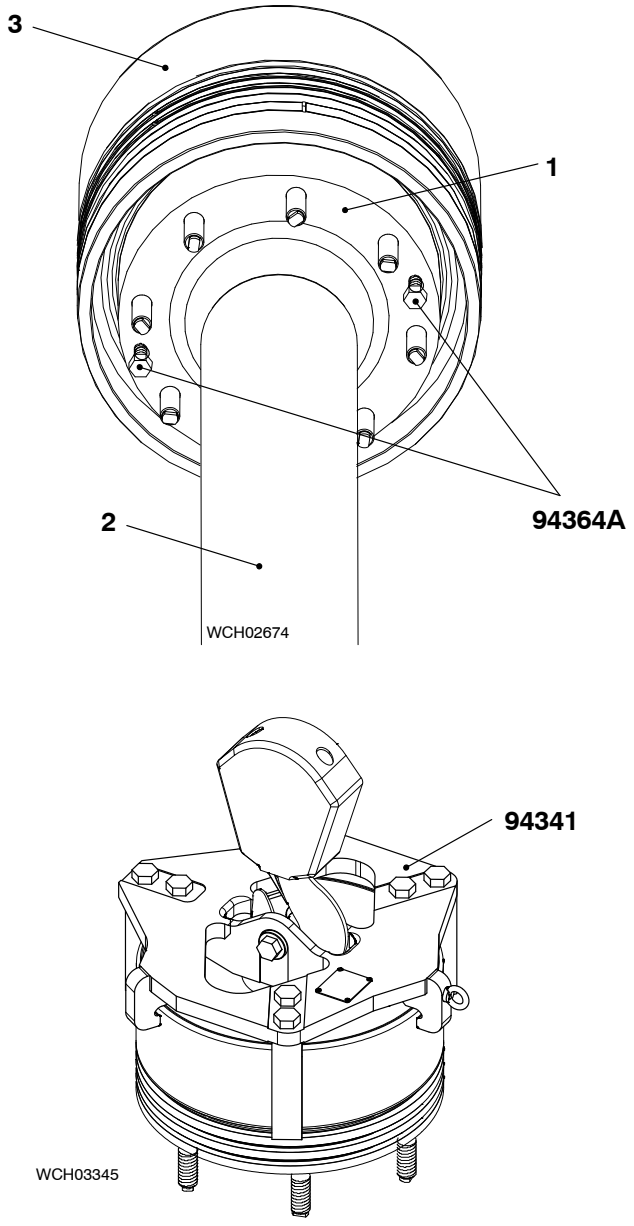


Fig. 2

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).
4) Install the lifting tool, refer to 3403–1, paragraph 2, step 17) to step 24).
5) Operate the engine room crane to lift the piston head.
6) Move the piston head to an applicable area.
7) Remove the jacking screws (94364A) from the top of the piston rod (2).

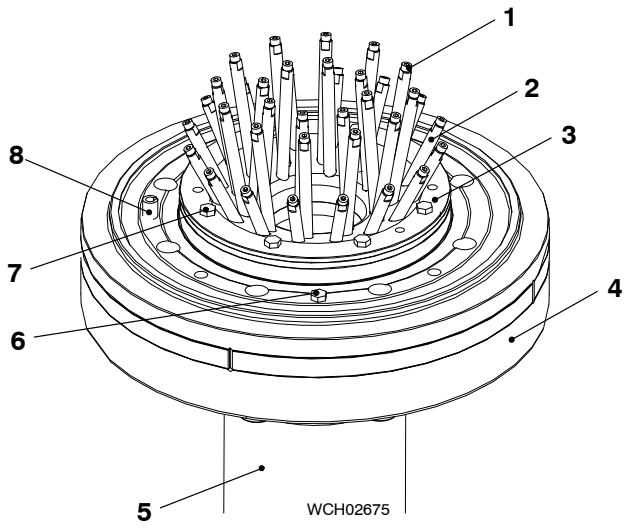


Fig. 3 7

CAUTION

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

8) Remove the piston skirt (4, Fig. 3) from the piston rod (5) as given in step a) to step c):

   a) Remove the two bolts (6).

   b) Use the jacking screws (94364C) to remove the piston skirt (4) from the piston rod (5).

   Note: When you lift the piston skirt (4), make sure that the spring dowel pin (8) does not catch.

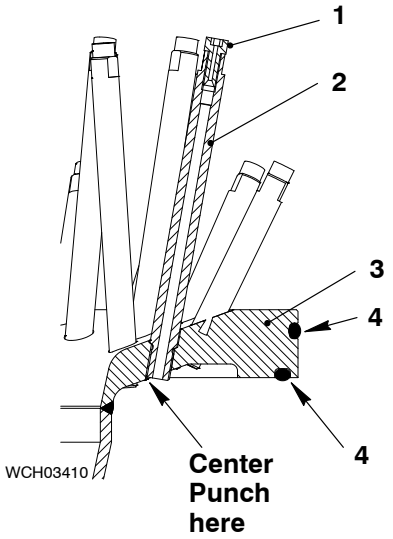
   c) Lift the piston skirt (4) away from the piston rod (5).

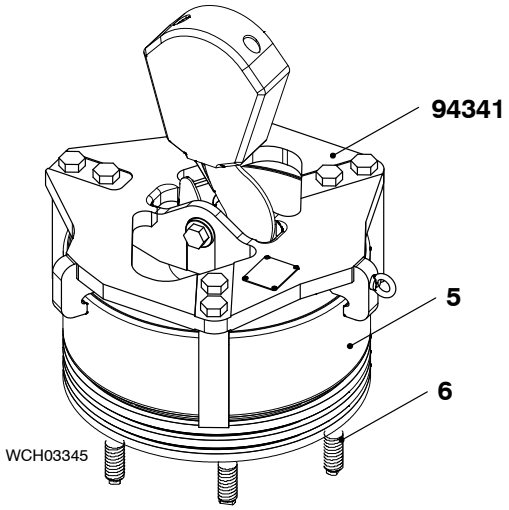
9) Remove the ten nuts (7).

10) Use the two jacking screws (94364B) to remove the spray plate (3) from the piston rod (5).

11) If necessary, remove the pipes (2) and nozzles (1).

12) Do a check of the top surface of the piston head, refer to 3403–4.





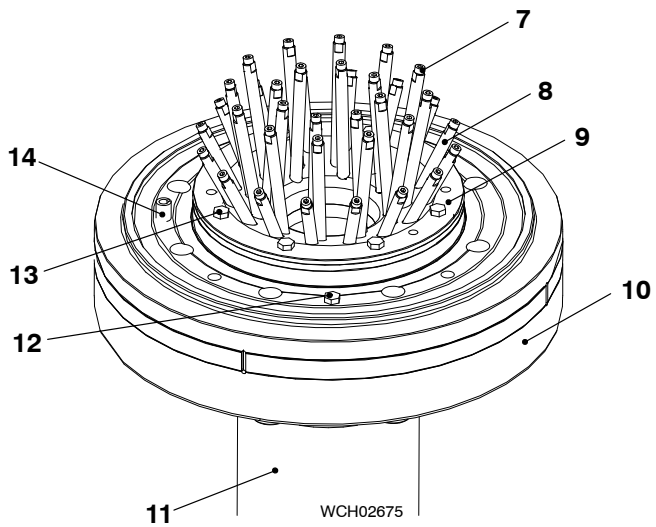


Fig. 4

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 (9) to the piston rod (11) with the ten nuts (13).
10) Torque the ten nuts (13) as follows:
    a) Symmetrically torque the ten nuts to 20 Nm.
    b) Symmetrically torque the eight screws to 75 Nm.

Note: When you do step 11), make sure that the dowel pin (13) engages in the related hole in the piston skirt (10).

11) Attach the piston skirt (10) to the piston rod (11) with the two screws (12).
12) Operate the engine room crane to lower the piston head (5) on the piston skirt (10). Make sure that the dowel pin (14) engages with the hole in the piston head.
13) Attach the nine round nuts to the elastic bolts.
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.
16) Install the piston, refer to 3403–1, paragraph 3.

Work Card
Piston: Check the Top Surface

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

If necessary, remove the piston, refer to 3403–1/A1

Tools and Consumables

Feeler gauge	94122	Qty 1
Template	94366	Qty 1
Template	94366A	Qty 1

Emery paper
Applicable grinding tool

Primary Task

Do a check of the top surface of the piston, refer to 3403–4/A1.

Note: This task can be done when the piston is installed, or removed.

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1
Crew	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Visual check of the piston and piston rings through the scavenge ports, refer to WC3403–4.1/A1

Intentionally blank

Work Card
Piston: Visual Check

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

None

Tools and Consumables

Not applicable

Primary Task

Do a visual check through the scavenge ports of the piston, piston rings and cylinder liner.

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Do a check of the piston top surface, refer to 3403–4/A1.

Intentionally blank

Work Card

Piston: Fully Re-manufacture the Piston Head Surface

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Piston head	EX 34060	Qty 1

Preparation

Remove the piston, refer to 3403–1/A1
Remove the piston head, refer to 3403–3/A1

Tools and Consumables

Applicable surface welding equipment

Emery paper

Primary Task

Fully re-manufacture the piston head surface

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Top surface check of the piston, 3403–4/A1

Intentionally blank

Work Card
Piston Underside: Check

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

None

Tools and Consumables

Not applicable

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Do a check of the condition of the piston underside. Clean as necessary Make sure that the drains and holes are not blocked	Crew	1.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

None

Intentionally blank

Piston

Top Surface – Check

Tools:

1	Feeler gauge	94122
1	Template	94366
1	Template	94366A

1. General

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

The causes of burn scars are as follows:

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

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

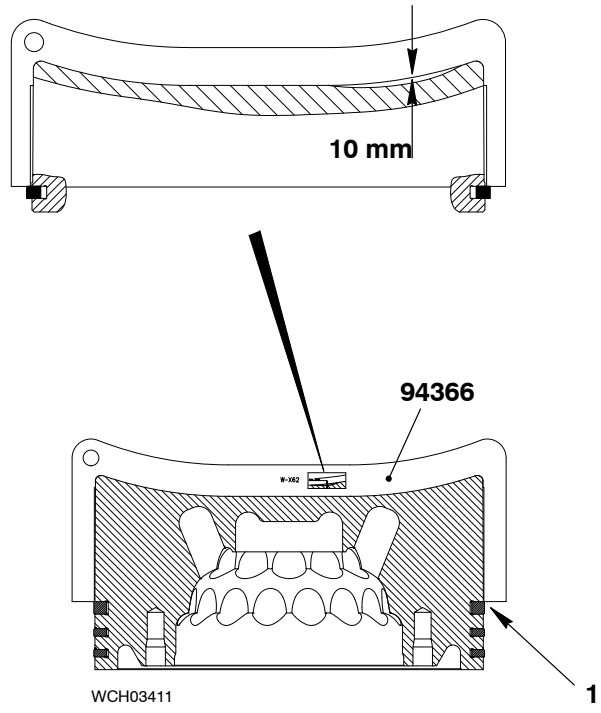


Fig. 1

2. Procedure – Piston Removed

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

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

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

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

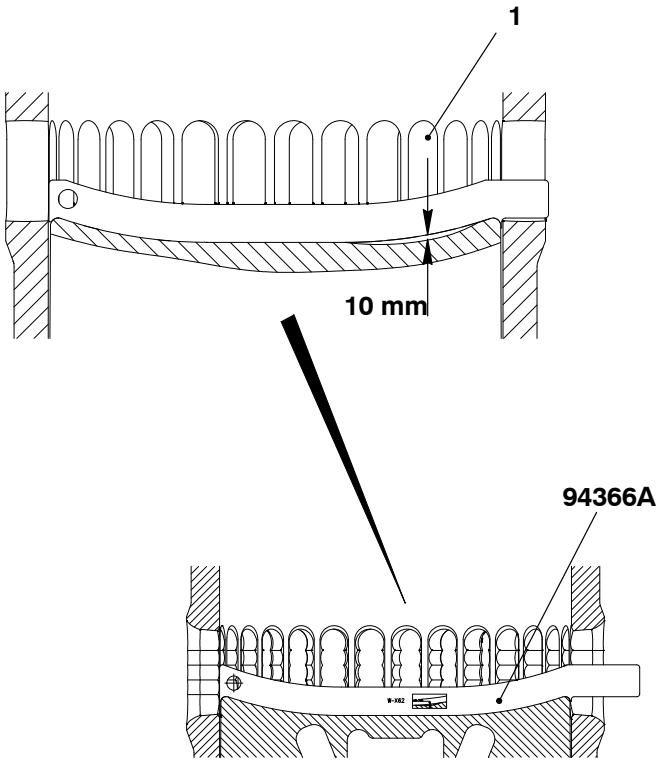


Fig. 2

3. Procedure – Piston Installed

WARNING

Injury Hazard: Before you operate the turning gear, make sure that no personnel are near the flywheel, or 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 3) and 4) again.
7) If the burn scars are less than 10 mm, do step a) and step b):
   a) Use an applicable tool to grind the burn scars.
   b) Use emery paper to make sharp edges smooth.
8) If the burn scars are more than 10 mm, do step a) to step d).
   a) Remove the piston, refer to 3403–1, paragraph 1 and paragraph 2.
   b) Remove the piston head, refer to 3403–3, paragraph 1 and paragraph 2.
   c) Use surface welding to repair the piston head to its original thickness.
   d) Assemble the piston, refer to 3403–3, paragraph 3.

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

Work Card
Piston Rings: Measure

Necessary Conditions

- Engine stopped
- Engine temperature must be at ambient
- Applicable piston at BDC

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Calibrate the Permascope MP0

Tools and Consumables

Inside micrometer	94101	Qty 1
Feeler gauge	94122	Qty 1
Permascope MP0 (with instruments to measure chrome-ceramic layers)	94356	Qty 1
Calliper gauge		
Piston ring piece (for alternative procedure to measure the thickness of the chrome-ceramic layer)		

Primary Task

Measure the thickness of the chrome-ceramic layer, refer to 3425−1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	0.5 hours	Qty 1
Ship Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Operation Manual 0750−1 Lubricating Oils.

Related Procedures

Compare the measured data with the limits given in 0330−1, Clearance Table, Piston and Piston Rings

Intentionally blank

Work Card
Piston Rings: Replace

Necessary Conditions

– Engine stopped
– Engine temperature must be at ambient

Necessary Spare Parts (each cylinder)

Piston ring GTP1CC22	EX 34250	Qty 1
Piston ring GTP1CC13	EX 34251	Qty 1

Preparation

Remove the piston, refer to 3403–1/A1

Tools and Consumables

Piston ring tool	94338	Qty 1
Piston ring tool	94338A	Qty 1

Primary Task

Replace the piston rings, refer to 3425–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	6.0 hours	Qty 1
Ship Engineer	6.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Install the piston, refer to 3403–1/A1

Intentionally blank

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	Piston ring tool	94338A	1	Calliper gauge	

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.

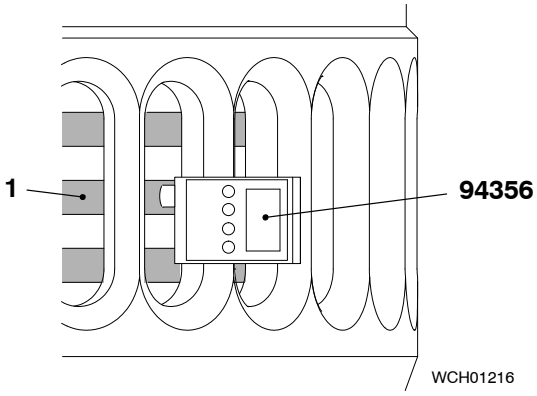
2. Piston Ring – Rate of Wear

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 suppler 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.



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

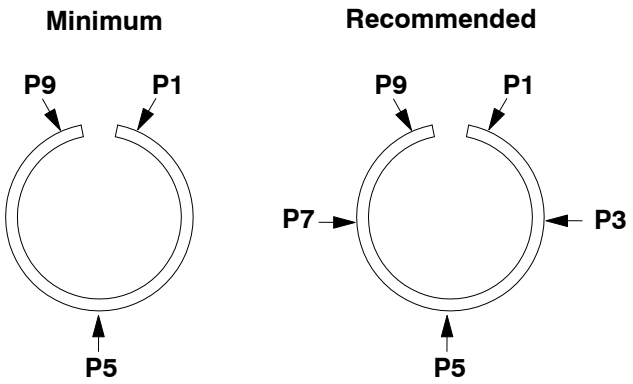


Fig. 1

2.2 Rate of Wear

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

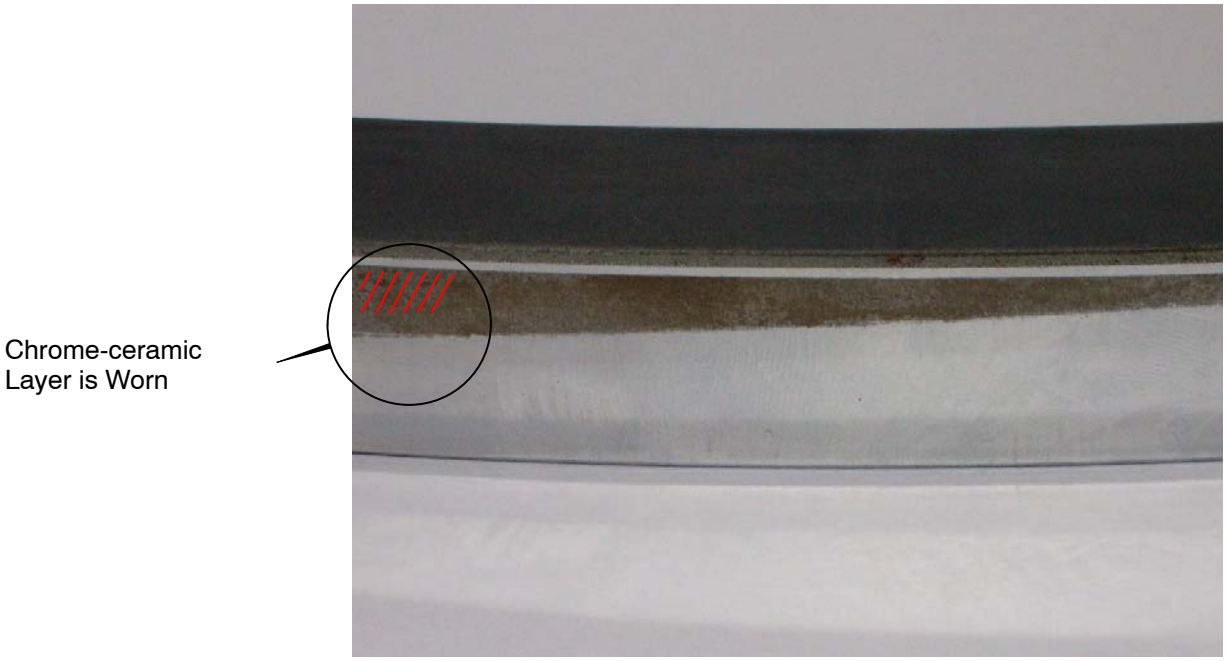


Fig. 2 Chrome-ceramic Layer

With regular procedures to measure the chrome-ceramic layer, you can calculate the 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 (refer to 0330–1 Pistons and Piston Rings). These records are important for an analysis of the running gear and must include the data that follow:

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

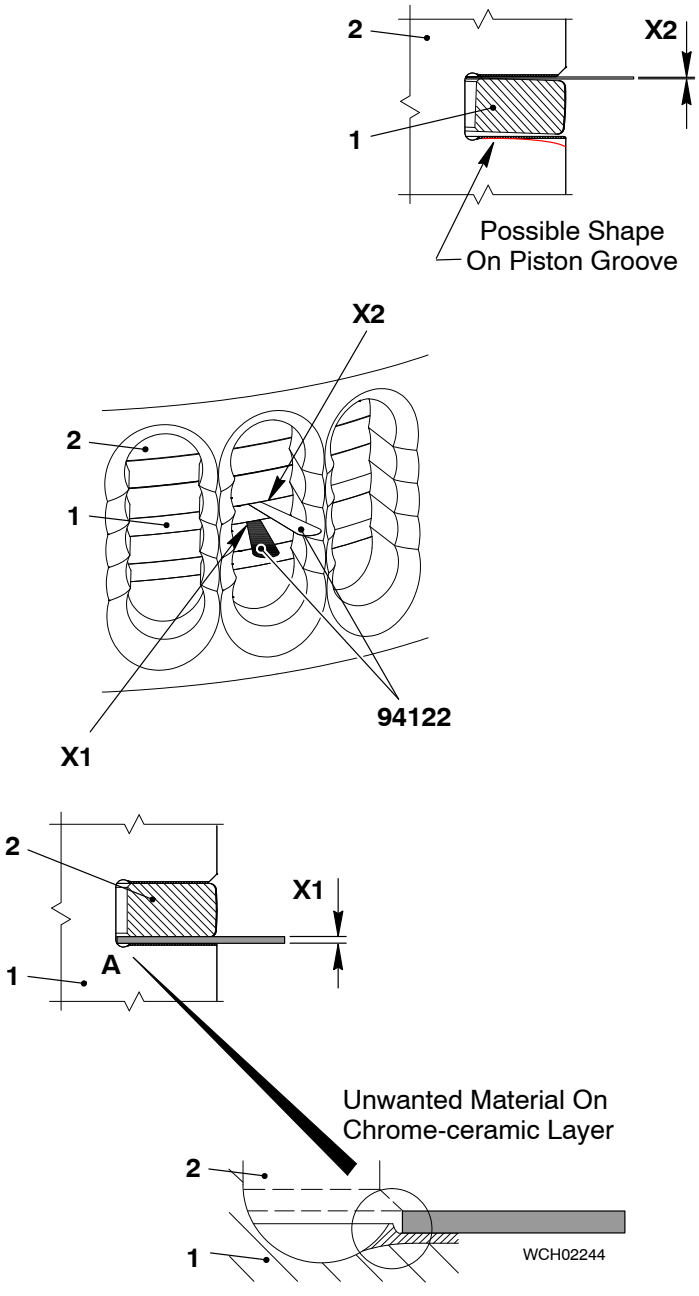


Fig. 3

3.1 Piston Ring Clearance (Piston Installed)

WARNING

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. Make sure that the feeler gauge touches 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 X1and X2 will give the total piston ring clearance.

The maximum clearance is at point A. For the maximum wear data, refer to 0330–1, Pistons and Piston Rings.

5) If the clearance at point A is more than the permitted value, do step a) and step b)

   a) Replace the piston rings.

   b) Repair the piston head.

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

3.2 Piston Rings – Removal

CAUTION

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

Note: If the same piston rings must be installed again, record their positions.

1) Use the tool (94338, Fig. 4) to remove the top piston ring. Make sure that you do not cause damage to the chrome-ceramic surface.
2) Use the tool (94338A) to remove the middle and bottom piston rings. Make sure that you do not cause damage to the chrome-ceramic surface.
3) Clean the grooves in the piston head.

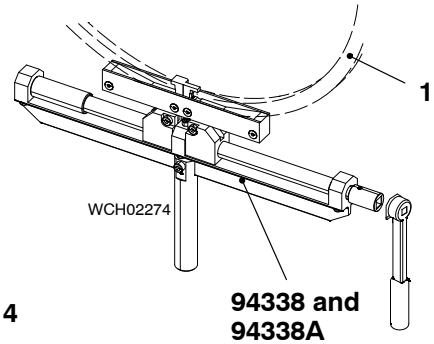


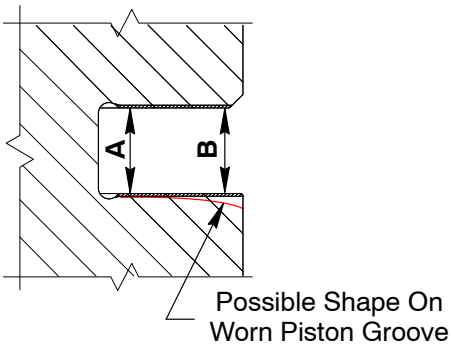
Fig. 4 **94338 and 94338A**

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.



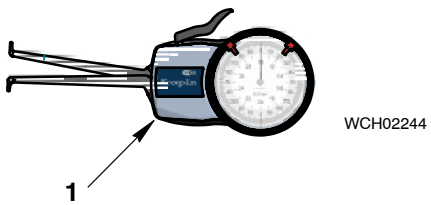


Fig. 5

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).

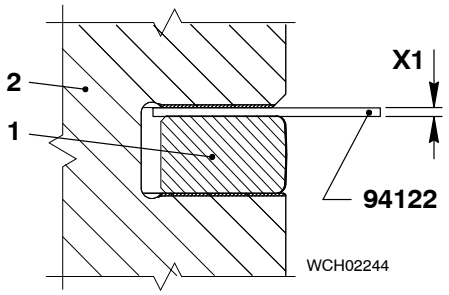


Fig. 6

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 WinGD Service Center.

Do not install a piston head that has clearances near the maximum value, 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) to install the piston rings.

1) Use the tool (94338A) to install the bottom piston ring (4, Fig. 7) to the piston head.
2) Use the tool (94338A) 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).

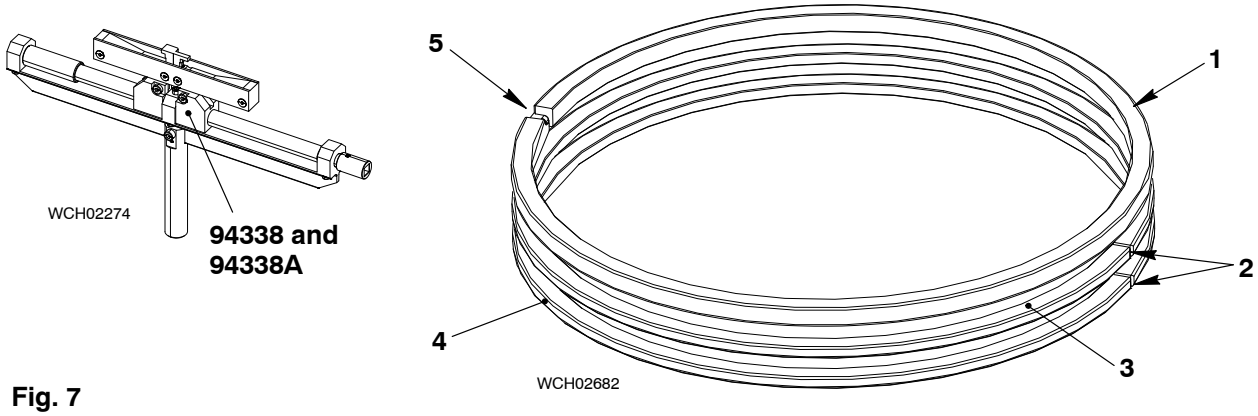


Fig. 7

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 (94338A, Fig. 8) to install the bottom piston ring (4) to the piston head.

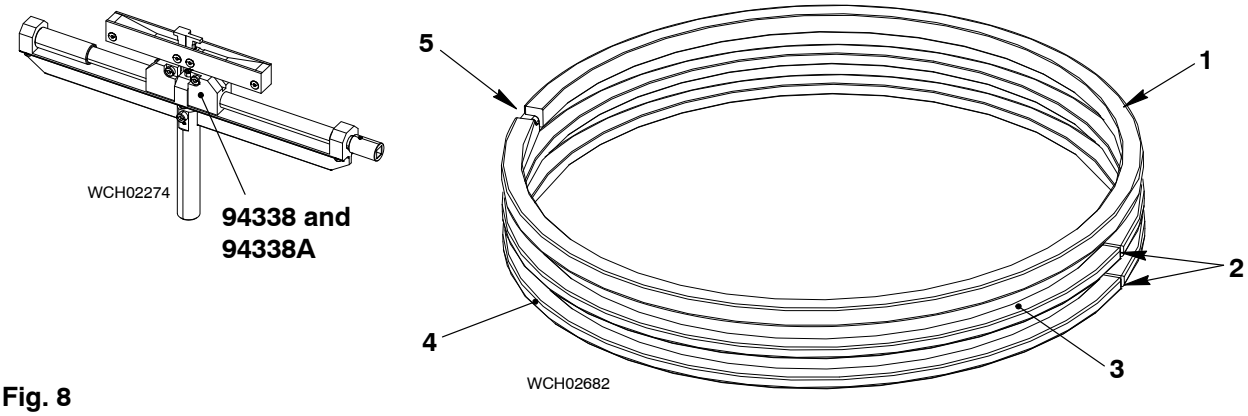


Fig. 8

3) Use the tool (94338A) 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.

Intentionally blank

Driving Wheels and Shut-off Valve for Starting Air — Group 4

Intentionally blank

Work Card
Start Interlock

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Not applicable

Preparation

None

Tools and Consumables

Magnet tester
Screwdriver

Primary Task

Do a check of the electric and pneumatic interlocks (refer to the Operation Manual 4003−1, paragraph 4.10).

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

None

Intentionally blank

Running and Backlash Clearances and Tooth Condition

Tools:

1	Feeler gauge 94122	1	Dial gauge
1	Micrometer	1	Lead wire 1.5 mm diameter

1. General

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

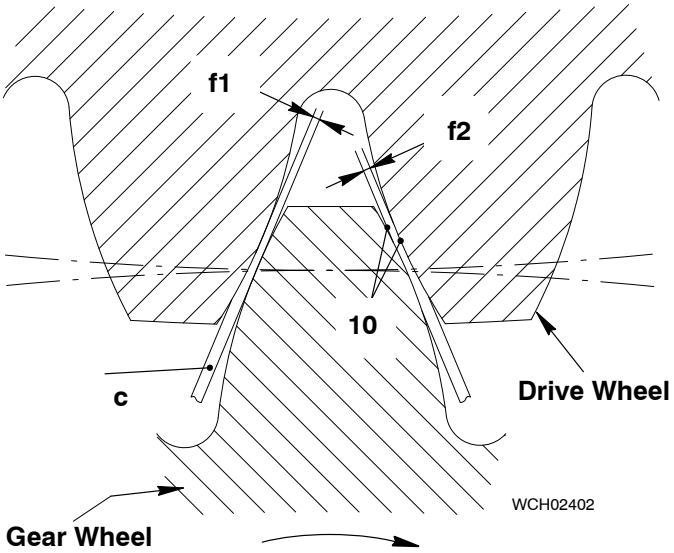
2. Checks

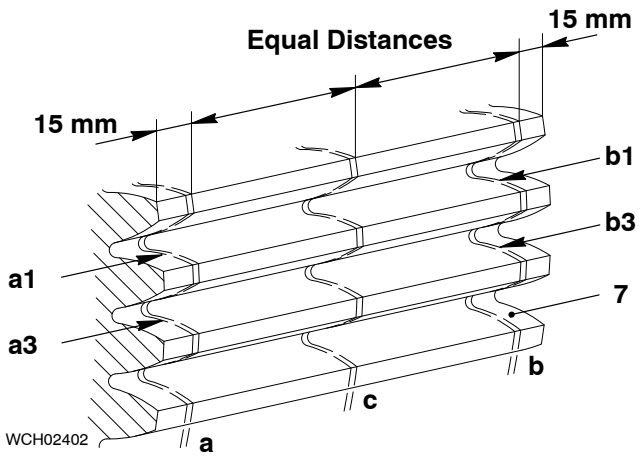
WARNING

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

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

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





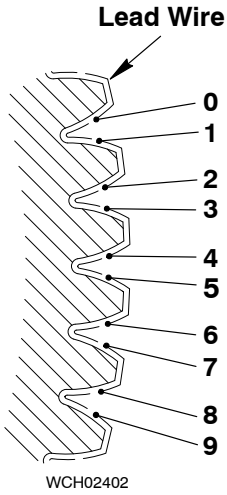


Fig. 1

3. Gear Tooth Backlash Checks

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

There are three procedures to measure the backlash.

3.1 Feeler Gauge (94122)

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

3.2 Dial Gauge

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

3.3 Lead Wire

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

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

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

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

4) Remove the lead wire.

5) Use the micrometer to measure the lead wire.

6) Calculate as follows:

- The full tooth backlash: f = f1 + f2
- The parallelity: Δf = a1 – b1 or a3 – b3.

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

4. Performance

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

1) Apply a thin layer of oil resistant engineer's blue ink to three of the teeth on each of the gear wheels.

2) Operate the turning gear to turn the engine.

3) Do a check of the marks on the gear wheel teeth and driving wheel teeth. This is make sure that the teeth engage correctly and are parallel.

Intentionally blank

Crankshaft Gear Wheel – Replace

Tools:

1	Ring slugging wrench	94002–60
1	Feeler gauge	94122

1. General

Usually, the crankshaft gear wheel is installed as one part on the crankshaft. If it becomes necessary to replace a damaged crankshaft gear wheel, it must be divided into two parts and disassembled. To prevent damage, speak to the engine supplier or to WinGD to get the applicable instructions to disassemble the crankshaft gear wheel.

The spare crankshaft gear wheel is a two-part assembly.

When you disassemble and assemble the crankshaft gear wheel, you must disengage the intermediate wheel of the supply unit.

When you order a new two-part crankshaft gear wheel, give the data that follows:

- Engine type
- Engine number
- Engine supplier.

This data is necessary because the two-part crankshaft gear wheel is manufactured to the specifications and dimensions of the crankshaft related to the engine.

2. Preparation

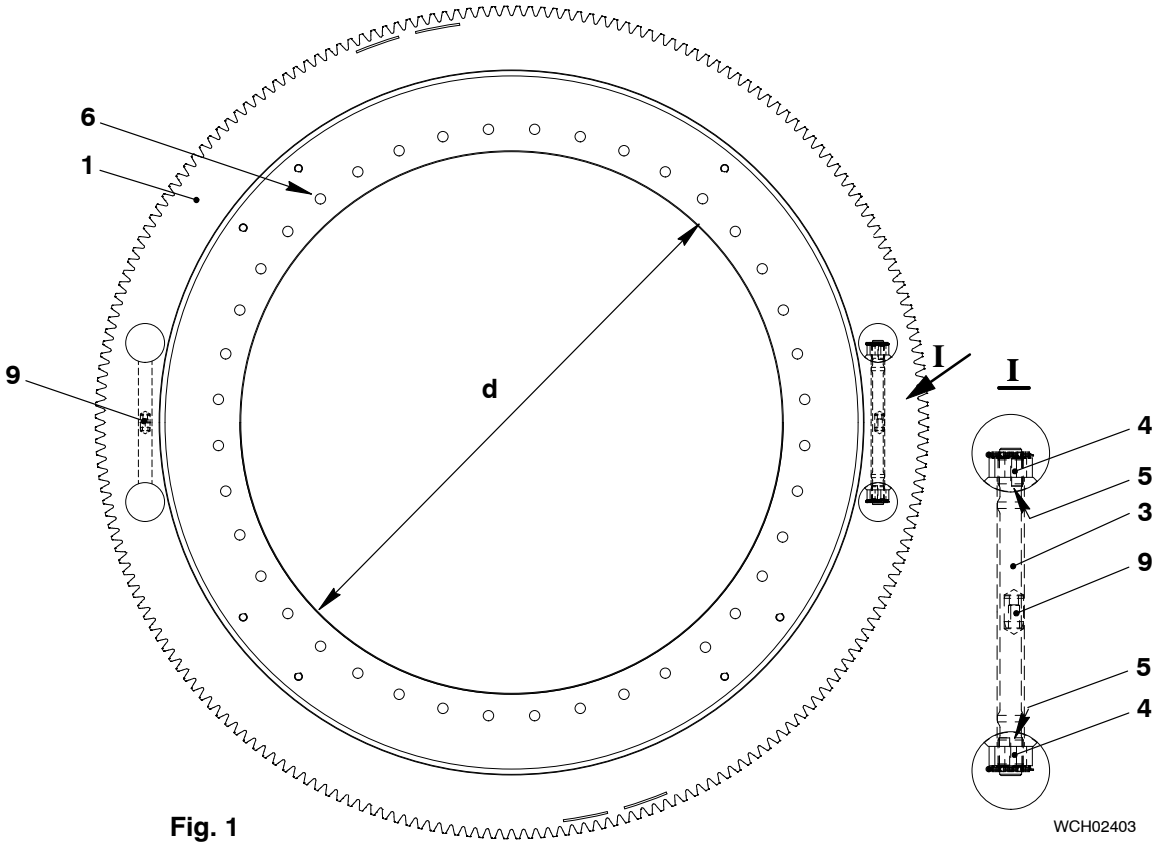


Fig. 1

1) Make sure that the temperature of the crankshaft, the gear wheel and the tool to measure the dimensions is the same.
2) Measure and record the inner diameter (d, Fig. 1) of the two-part gear wheel (1).
3) Measure and record the outer diameter of the crankshaft.
4) The inner diameter of the crankshaft gear wheel must be between 0.05 mm and 0.14 mm less than the outer diameter of the crankshaft.

Note: The nominal diameter of the crankshaft flange is 1670 mm.

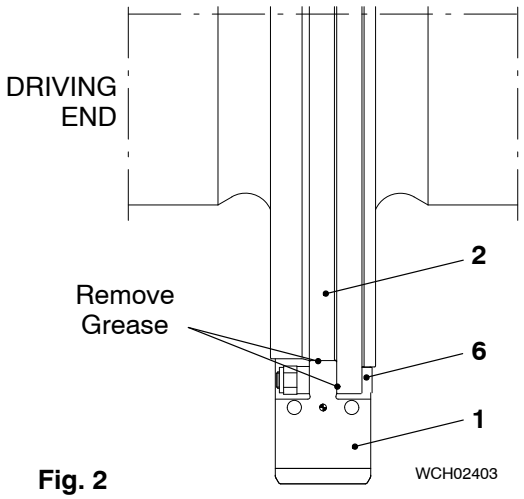


Fig. 2

5) If the value is not as given in step 4), do as follows before you assemble the gear wheel:
   a) Use the applicable equipment and processes (e.g. mill, or ream the bore etc) to get the inner diameter to the correct dimension.
   b) Make sure that there is a mark on the crankshaft flange (2, Fig. 2). During the assembly procedure, the partition of the crankshaft gear wheel must align with this mark.

Note: When you step 6) and step 7), do not use Molykote or oil.

6) Remove all grease from the applicable area on the crankshaft flange (2, Fig. 2). Make sure that the area is clean and in satisfactory condition.

7) Remove grease from the bore of the crankshaft gear wheel. Make sure that the crankshaft gear wheel is clean and in satisfactory condition.

3. Assemble

WARNING

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

Note: Carefully assemble the crankshaft gear wheel. Small faults can have an unsatisfactory effect on the operation of all gear wheels.

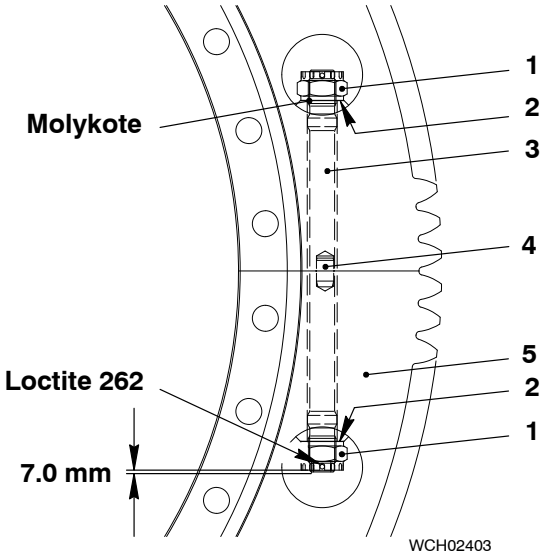


Fig. 3

1) Measure and record the length of the four elastic studs (3,Fig. 3).

2) Remove grease from the thread of the castle nuts (1).

3) Apply Loctite 262 to the thread of the castle nuts (1).

4) Put one elastic stud (3) in opposite positions in each half of the crankshaft gear wheel.

5) Put a base (2) and castle nut (1) in position on each end of the two elastic studs (3). Make sure that there is a distance of 7.0 mm between the top of the elastic stud and the castle nut.

6) Put a split pin in position in the elastic stud (3) to hold the castle nut (1) in position.

Note: The cure time for Loctite 262 is between one day and two days.

3.1 Procedure

1) Operate the turning gear to move the crankshaft. Get the mark on the crankshaft flange approximately horizontal to the crankshaft centerline.

Note: When you do step 2) make sure that the joint face of the crankshaft gear wheel aligns with the mark on the crankshaft flange.

2) Put one half of the crankshaft gear wheel (with two assembled elastic studs (3)) in position on the crankshaft flange.

3) Make sure that the mark DRIVING END, on the front of the crankshaft gear wheel, points to the flywheel.

4) Remove the grease from all flange screws (6, Fig. 4) and their locknuts.

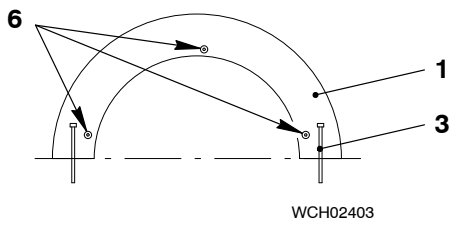


Fig. 4

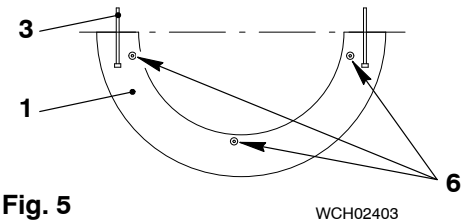


Fig. 5

WCH02403

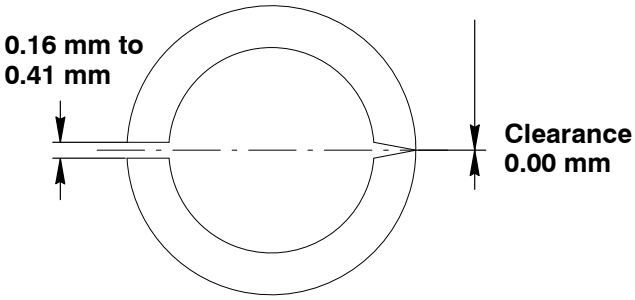


Fig. 6

WCH02403

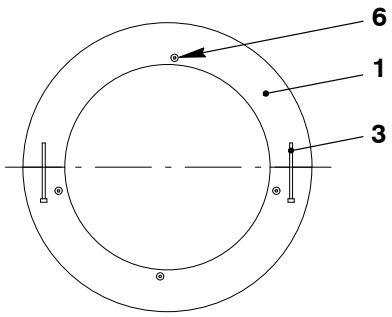


Fig. 7

WCH02403

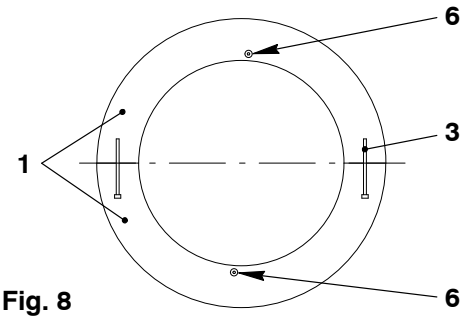


Fig. 8

WCH02403

5) Put three flange screws (6, Fig. 4) in position as shown in the wheel half (1). Tighten the screws temporarily.

6) Turn the turn the crankshaft to move the gear wheel half (1, Fig. 5) to the bottom position.

7) Put the other half of the crankshaft gear wheel (1, Fig. 6) (with the other two assembled elastic studs) in position on the crankshaft flange. Make sure that at one side, there is no clearance.

8) Measure the clearance between the two halves of the crankshaft gear wheel. The clearance must be between 0.16 mm to 041 mm.

Note: If the clearance is not between 0.16 mm and 0.41 mm do not assemble the gear wheel. Refer to paragraph 2, step 5.

9) Adjust the top half of the crankshaft gear wheel (1) to get an equal clearance on each side.

10) Lightly tighten the castle nuts on the elastic studs (3, Fig. 7).

11) Put a flange screw (6) in the center position in the top half of the crankshaft gear wheel (1). Temporarily tighten the flange screw.

12) Remove the two outer flange screws from the bottom half of the crankshaft gear wheel (1). Make sure that only the top and bottom flange screws (6, Fig. 8) stay in position.

13) Make sure that there is no clearance on the seating surfaces between the crankshaft gear wheel and the crankshaft flange.

14) Apply Molykote paste the threads of the four remaining castle nuts (1, Fig. 3)

15) Install the four remaining castle nuts (1) to the elastic studs (3).

Note: In step 16), tighten only the castle nuts that have Molykote paste on the threads.

16) Use the slugging wrench (94002–60) to symmetrically tighten the castle nuts. Use a wrench to hold the opposite castle nuts (that have a split pin and Loctite 262 on the threads).

17) Measure the length of the elastic studs (3, Fig. 3)

Note: The elastic studs have the correct tension if they are extended to 1.3 ± 0.06 mm more than the length measured in paragraph 3, step 1).

18) Make sure that there is no clearance between the two halves of the crankshaft gear wheel.

19) If you cannot install the split pin to lock the castle nut (1) do as follows:

    a) Turn the castle nut the minimum sufficient distance to align the slots with the hole in the elastic stud.

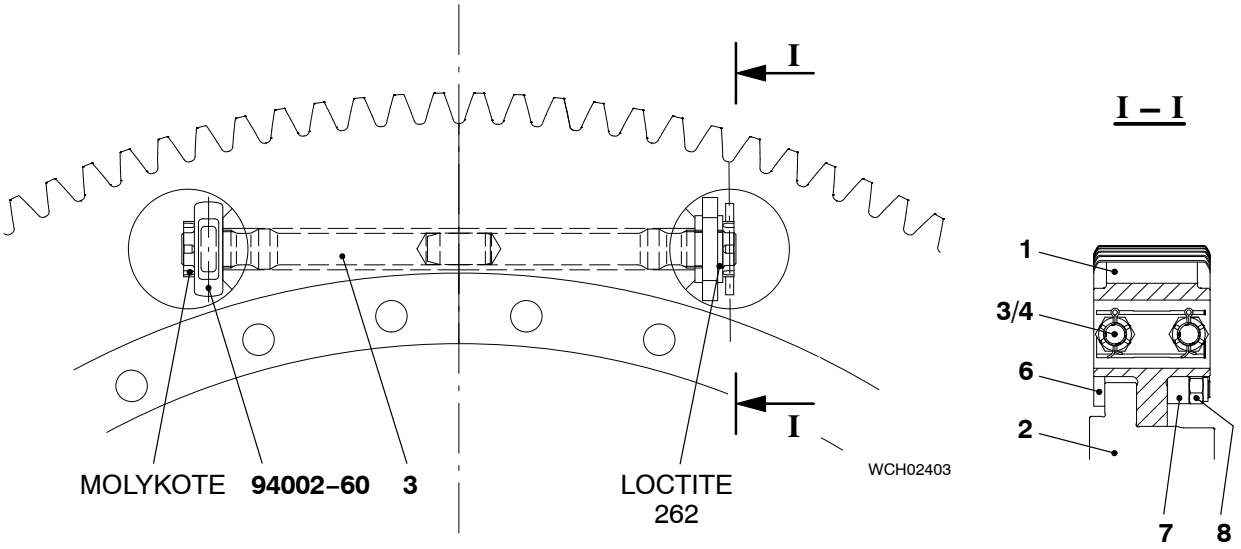
    b) Install the split pin.

20) Apply Loctite 262 to the threads of the flange screws

21) Install all the flange screws (6, Fig. 9), distance sleeves (7) and self-locking nuts (8) to the crankshaft gear wheel (1).

22) Symmetrically torque the flange screws (6) to 2700 Nm.

23) Do a check of the backlash and running clearances, refer to 4103–1.



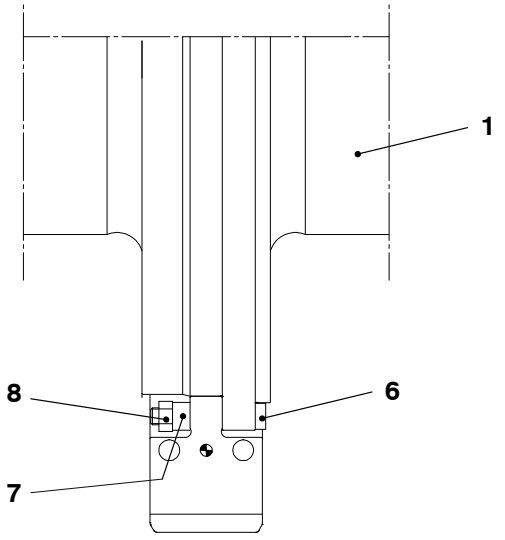


Fig. 9

Work Card
Starting Air Shut-off Valve: Remove and Disassemble

Necessary Conditions

− Engine stopped
− Stop valves closed on starting air bottles 930−V03−V04.

Necessary Spare Parts

Joint ring (for screw plug)	EX 43268	Qty 1
O-ring (for the housing)	EX 43270	Qty 1
O-ring	EX 43273	Qty 6
Joint ring (for the silencer)	EX 43274	Qty 1
O-ring (for the housing)	EX 43276	Qty 1
Joint ring	EX 43277	Qty 1
Gasket	EX 43281	Qty 1
O-ring (for the valve guide)	EX 43289	Qty 2
O-ring (for the cover)	EX 43290	Qty 1
Piston joint ring (for the valve)	EX. 43291	Qty 1
Gasket	EX 43293	Qty 1
Gasket	EX 43294	Qty 3
DU bush	EX 43303	Qty 1
Scraper ring	EX 43305	Qty 1
Rod joint ring	EX 43316	Qty 1
Spare parts for double non return valve	EX 43322	Qty 1

Preparation

Remove and disassemble the starting air shut-off valve, refer to 4325−1/A1

Tools and Consumables

AF 60 swan neck spanner

No consumables are necessary

Primary Task

Clean and do a check of the starting air shut-off valve

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	5.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Assemble and install the starting air shut-off valve, refer to 4325−1/A1

Intentionally blank

Work Card

Starting Air Shut-off Valve: Remove the Common Start Valve

Necessary Conditions

− Engine stopped
− Stop valves closed on starting air bottles 930−V03−V04.
− Turning gear engaged

Necessary Spare Parts

Not applicable

Preparation

Remove the common start valve, refer to 4325−1/A1

Tools and Consumables

No special tools are necessary
No consumables are necessary

Primary Task

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Do an overhaul of the common start valve	Service Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Assemble and install the starting air shut-off valve, refer to 4325−1/A1

Intentionally blank

Starting Air Shut-off Valve
Cleaning and Function Check

1. General

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

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

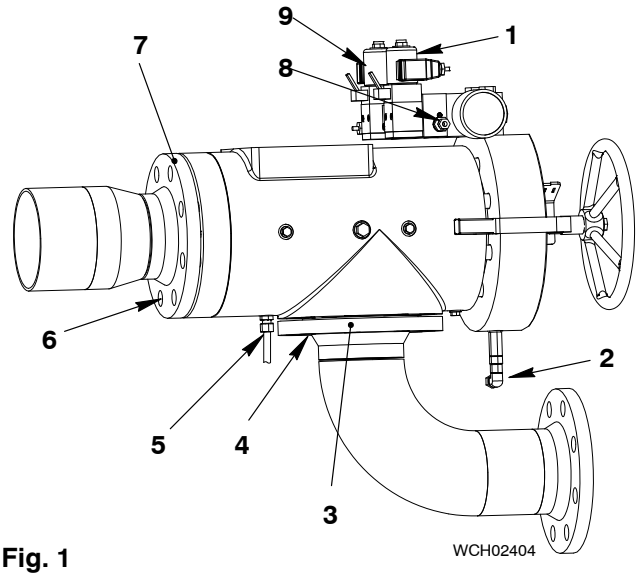


Fig. 1

2. Preparation

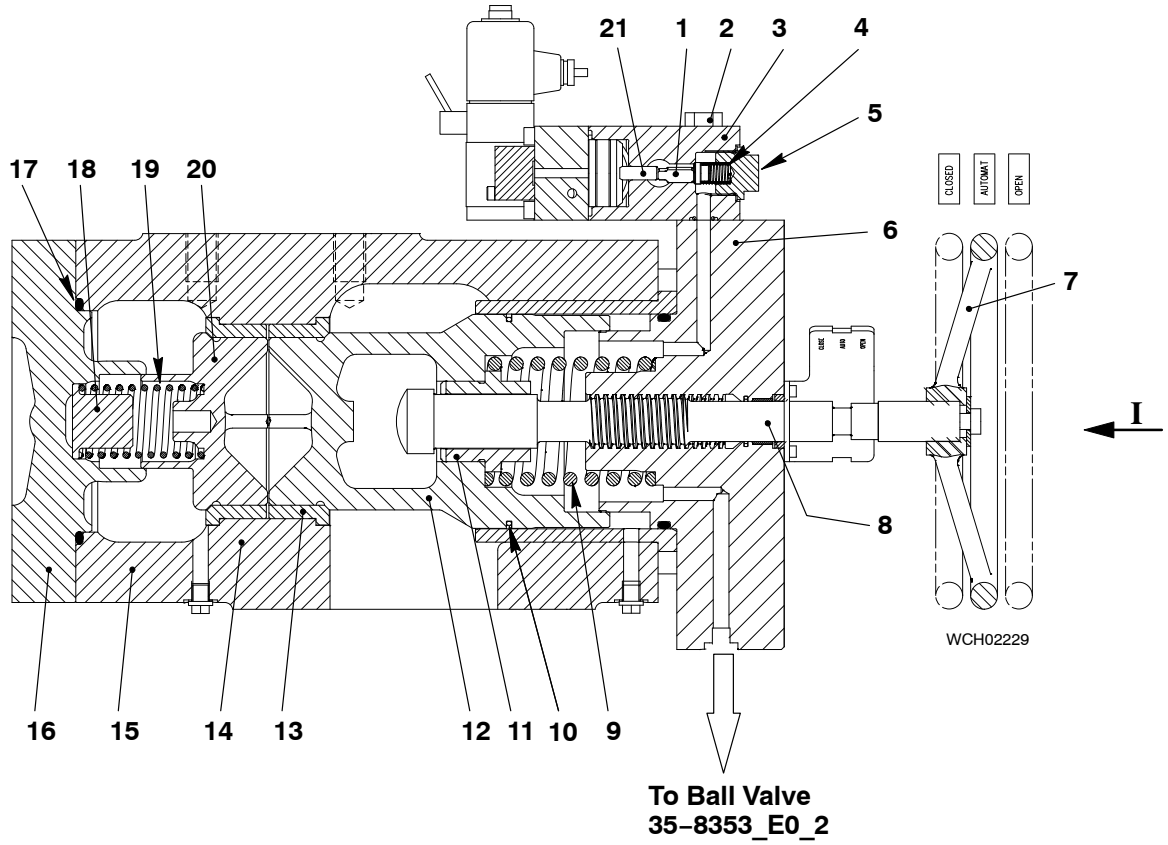
1) On the starting air bottles, close the stop valves 930–V03 and 930–V04.
2) Engage the turning gear.
3) Open the ball valves 30–8605_E0_6 and 30–8605_E0_7 to release air in the system.
4) Disconnect the electrical connections from the pressure transmitter (8, Fig. 1) and the solenoid valves (1, 9).
5) Remove the pipe (5).
6) Remove the pipe (2).
7) Remove the eight screws (6) from the flange (7).
8) Remove the eight screws (4) from the flange (3).
9) Remove the shut-off valve from the engine.
10) Do a check of the two gaskets that are installed on the flanges (3) and (7). If the gaskets are unserviceable, replace them.

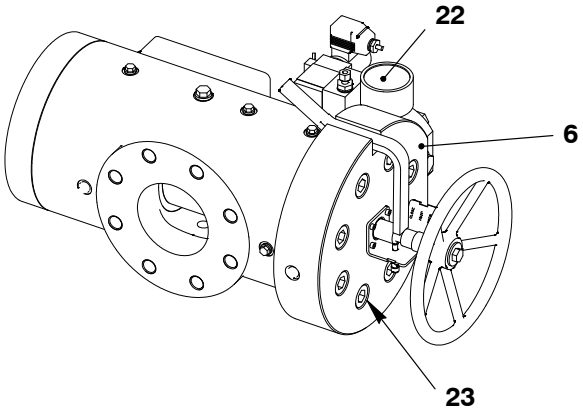
3. Disassemble

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

4. Servicing

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


21
1
2
3
4
5
17
18
19
20
6
7
CLOSED
AUTOMAT
OPEN
I
8
WCH02229
16
15
14
13
12
11
10
9
To Ball Valve
35–8353_E0_2


22
6
23

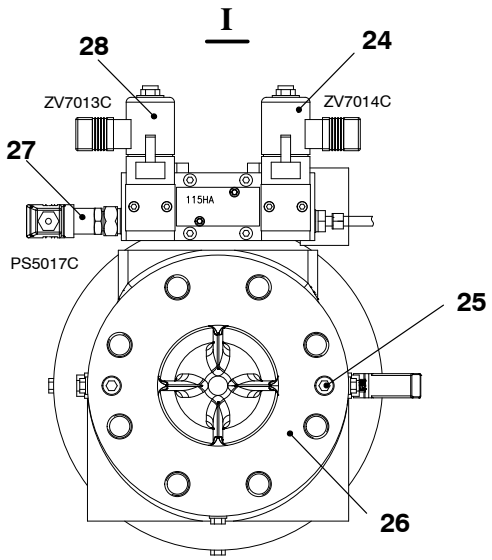

I
28
24
ZV7013C
ZV7014C
27
115HA
PS5017C
25
26

Fig. 2

5. Assemble

1) Make sure that all bores are clear.
2) Remove grease from the surfaces of the spindle (8, Fig. 2) and the threads of the spindle nut (11).
3) Apply a thin layer of Molykote paste to the stopper (18), the spring (19) and the valve body (20).
4) Put the O-ring (17) and valve body (20) into the housing (15).
5) Put the stopper (18) and spring (19) into the valve guide (16), then attach the valve guide to the housing (15) with the two screws (25).
6) Torque the two screws (25) to the value given in 0352–1, paragraph 1.
7) Apply Molykote paste to the bore of spindle nut (11). Put the spindle nut on the spindle (8).
8) Apply Loctite 0243 to the threads of the spindle nut (11).
9) Put the spindle (8) and spindle nut (11) into valve (12).
10) Attach the valve (12) together with spindle (8) and piston joint ring (10) to the housing (15).
11) Apply Molykote paste to the inner cylinder of the cover (6).
12) Put the spring (9) on to the spindle (8) in the cover (6).
13) Attach the cover (6), spring (9) and spindle (8) to the housing (5) with the eight screws (23).
14) Torque the eight screws (23) to value given in 0352–1, paragraph 1.
15) Install the handwheel (7).
16) Attach the control valve (3) to the cover (6) with the two bolts (2).
17) Torque the two bolts (2) to the value given in 0352–1, paragraph 1.
18) Put the piston (21), valve (1), spring (4) and screw plug (5) in position in the control valve (3), see Fig. 3.

Note: When you do step 19), look through the hole in the control valve (3).

19) Make sure that the clearance between the valve (1) and the piston (21) is 1.0 ±0.2 mm.

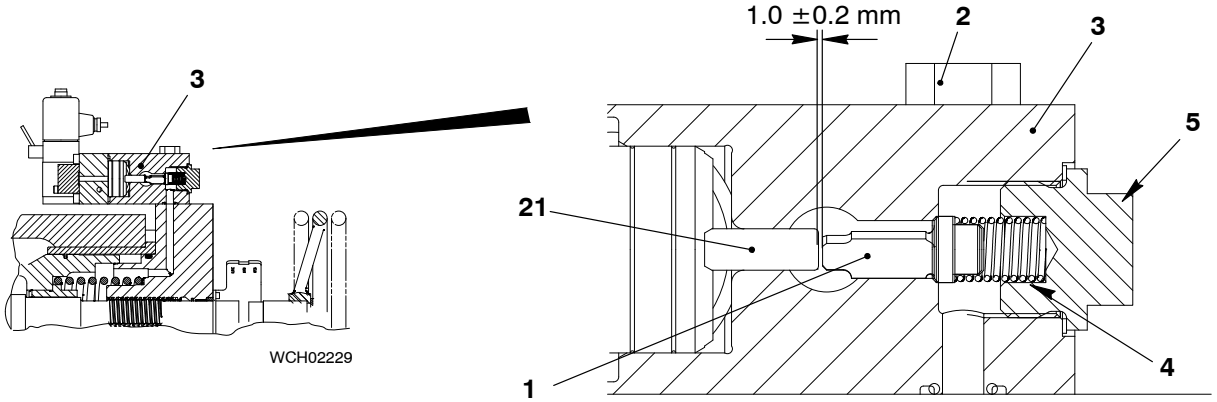


Fig. 3

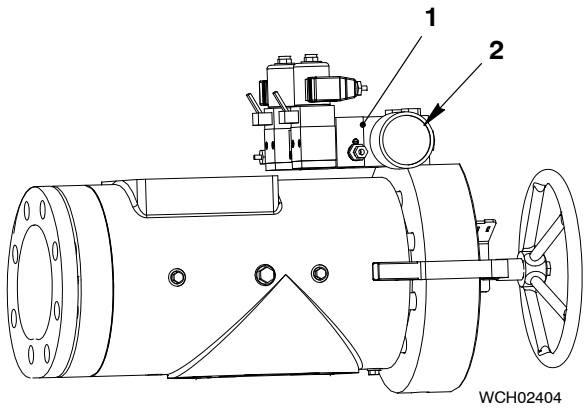


Fig. 4

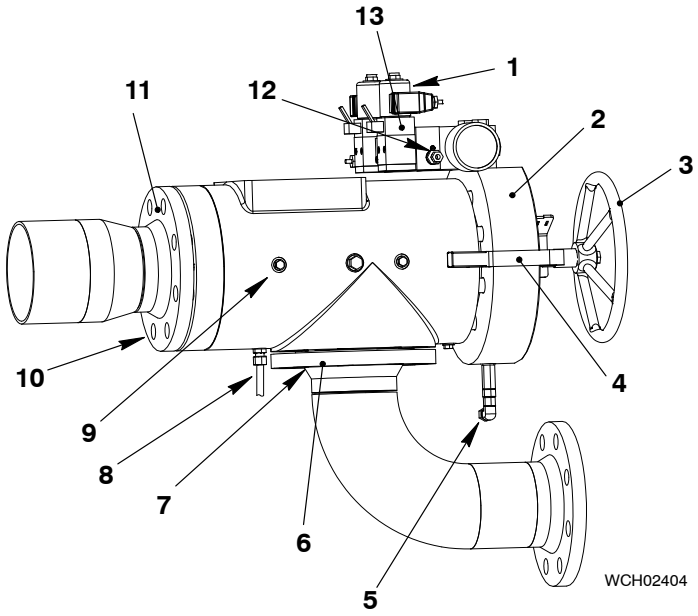


Fig. 5

20) Attach the silencer (2, Fig. 4) to the control valve (1).

21) Put the assembled shut-off valve in position as shown in Fig. 5.

22) Attach the flange (11) to the valve guide with the eight screws (10).

23) Torque the eight screws (10) to the value given in 0352–1, paragraph 1.

24) Attach the flange (6) to the shut-off valve with the eight screws (7).

25) Torque the eight screws (7) to the value given in 0352–1, paragraph 1.

26) Connect the check-pipe (8) to the pipe connection on the valve body.

27) Connect the control air pipe to the pipe connection (12).

6. Shut-off Valve – Test

6.1 Initial Position

Note: You must only do this test on a fully assembled engine that is ready to start.

1) Make sure that the stop valves 930–V03 and 930–V04 are closed.

2) Use the handwheel (3) to move the shut-off valve in the position CLOSED.

3) Disengage the turning gear.

6.2 Test Procedure

WARNING

Injury hazard. During this test, do not select START. Injury to personnel can occur.

1) Close the ball valve 30–8605_E0_6.

2) Slowly open the stop valves 930–V03 and 930–V04.

3) Slowly loosen the screw plug (9). Make sure that no air flows out.

Note: If air flows out, tighten the screw plug (9). The shut off valve is not airtight.

4) Remove the screw pug (9).

5) Slowly turn the handwheel (3) to move the shut-off valve to the position OPEN.

6) Make sure that air flows from the bore of the screw plug (9). When air flows, the manual function of the shut-off valve operates correctly.

7) Use the handwheel (3, Fig. 5) to move the shut-off valve to the position AUTOMAT. Make sure that the lever (4) engages with the groove in the spindle.

8) Make sure that no air flows from the bore of the screw plug (9). When no air flows, the automatic function of the shut-off valves operates correctly.

6.3 Automatic Mode

1) Make sure that the shut-off valve is in the position AUTOMAT.

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

2) Open the ball valve 35–8353_E0_2 to activate the control valve (13). The shut-off valve opens automatically.

3) Make sure that air flows from the bore of the screw plug (9).

4) Close the ball valve 35–8353_E0_2.

5) Make sure that no air flows from the bore of the screw plug (9).

7. Completion

1) Use the handwheel to move the shut-off valve to the position CLOSED.

2) Install the screw plug (9).

Supply Unit and Rail Unit — Group 5

Intentionally blank

Work Card
Servo Oil Pumps

Necessary Conditions

– Engine stopped
– Main bearing oil pump set to off
– Applicable electrical connections disconnected

Necessary Spare Parts

Servo oil pump	EX 55400	Qty 1

Preparation

Remove the HP servo oil pipes, refer to 8447-1
Remove the HP fuel pipes, refer to 8752–1/A1
Remove the applicable drain pipes, oil pipe and inlet pipes

Tools and Consumables

Sling	94650	Qty 2
Engine room crane		

Primary Task

Replace the servo oil pump, refer to 5591–1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1
Ship Engineer	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Remove and install the servo oil pump, refer to 5591–1/A1
Do a check for leaks

Intentionally blank

Work Card

Servo Oil Pump Drive: Remove the Cover Supply Unit Casing

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Remove the cover from the supply unit casing

Tools and Consumables

Not applicable

Primary Task

Do a check of the bearing bushes to the pinion

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Attach the cover to the supply unit casing

Intentionally blank

Work Card

Servo Oil Pump Drive: Remove the servo oil pumps

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Bearing bush	EX 55532	Qty 2

Preparation

Remove the servo oil pumps, refer to 5591−1/A1

Tools and Consumables

Oil
Drip tray

Primary Task

Replace the bearing bushes

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	2.0 hours	Qty 2

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Install the servo oil pumps, refer to 5591−1/A1

Intentionally blank

Work Card
Fuel Pump Drive: Camshaft Check

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Remove the covers from the supply unit housing, refer to 5581–1/A1

Tools and Consumables

Sealing compound

Primary Task

Camshaft: Do a check of the running surface of cams, rollers and roller guides (first time after 500 Operation hours)

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Attach the covers to the supply unit housing, refer to 5581–1/A1

Intentionally blank

Work Card
Fuel Pump Drive: Check Bearing Clearance

Necessary Conditions

– Engine stopped

Necessary Spare Parts

Top bearing shell half	EX 55462	Qty 4
Bottom bearing shell half	EX 55463	Qty 4

Preparation

Remove the covers from the supply unit housing, refer to 5581–1/A1

Tools and Consumables

Sealing compound

Primary Task

Camshaft: Do a check of the bearing clearances at random positions

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Attach the covers to the supply unit housing, refer to 5581–1/A1

Intentionally blank

Work Card
Fuel Pump Drive: Check Thrust Bearing Clearances

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Remove the covers from the supply unit housing, refer to 5581−1/A1

Tools and Consumables

Sealing compound

Primary Task

Camshaft: Do a check of the thrust bearing clearances

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Attach the covers to the supply unit housing, refer to 5581−1/A1

Intentionally blank

Work Card
Fuel Pump Drive: Replace the Camshaft Bearing

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Thrust bearing ring half	EX 55461	Qty 2
Top bearing shell half	EX 55462	Qty 5
Bottom bearing shell half	EX 55463	Qty 5

Preparation

Remove the covers from the supply unit housing, refer to 5581−1/A1

Tools and Consumables

Pre-tensioning jack	94557
Screwjack	94567B
Assembly template	94567
Assembly template	94567A
Holder	94566A
Holder	94566B

Sealing compound

Primary Task

Replace the camshaft bearings, refer to 5581−1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1
Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Loosen the round nuts, refer to 9403−4
Tighten the round nuts, refer to 9403−4
Camshaft installation 5581−1/A1

Intentionally blank

Work Card
Pilot Fuel Supply Unit

Necessary Conditions

- Engine stopped
- Service cover removed

Necessary Spare Parts

Not applicable

Preparation

None

Tools and Consumables

Lubricating oil

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Lubricate the flexible coupling of the pilot fuel pump, refer to 5555−1/A1	Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Attach the service cover

Intentionally blank

Work Card
Pilot Fuel Supply Unit − Pilot Fuel Pump

Necessary Conditions

− Engine stopped

Necessary Spare Parts

High pressure piston pump	EX 55382	Qty 1

Preparation

Refer to 5551−1/A1

Tools and Consumables

No special tools necessary

Primary Task

Replace the pilot fuel pump

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

None

Intentionally blank

Lubrication of Supply Unit during Maintenance

Tools:

1	Lubricating tool	94844	1	Adapter	
1	Adapter				

1. General

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

Clean system oil is used for the lubrication.

2. Procedure

1) Clean the surface of the supply unit casing.
2) Remove the blind flange from the lubricating tool (94884).
3) Attach a flange with a G1/2” thread to the lubricating tool (94884).
4) Remove the applicable pipe from the supply unit (7).
5) Make sure that the ball valve (9) is closed.
6) Attach the adapter (1) to the flange (6) on the lubricating tool (94844).
7) Attach the flexible hose (2) to the adaptor (1) with the hose clip (5).
8) Attach the lubricating tool (94844) to an applicable position approximately 2.0 m above the supply unit as shown.
9) Attach the flexible hose (2) to the adaptor (3) with the hose clip (4).
10) Remove the inspection covers from the supply unit (7).
11) Fill the lubricating tool (94844) with system oil.
12) Open the ball valve (9).
13) Make sure that the system oil flows on to the bearings and camshaft (8).

WARNING

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

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

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

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

Lubrication of Supply Unit during Maintenance

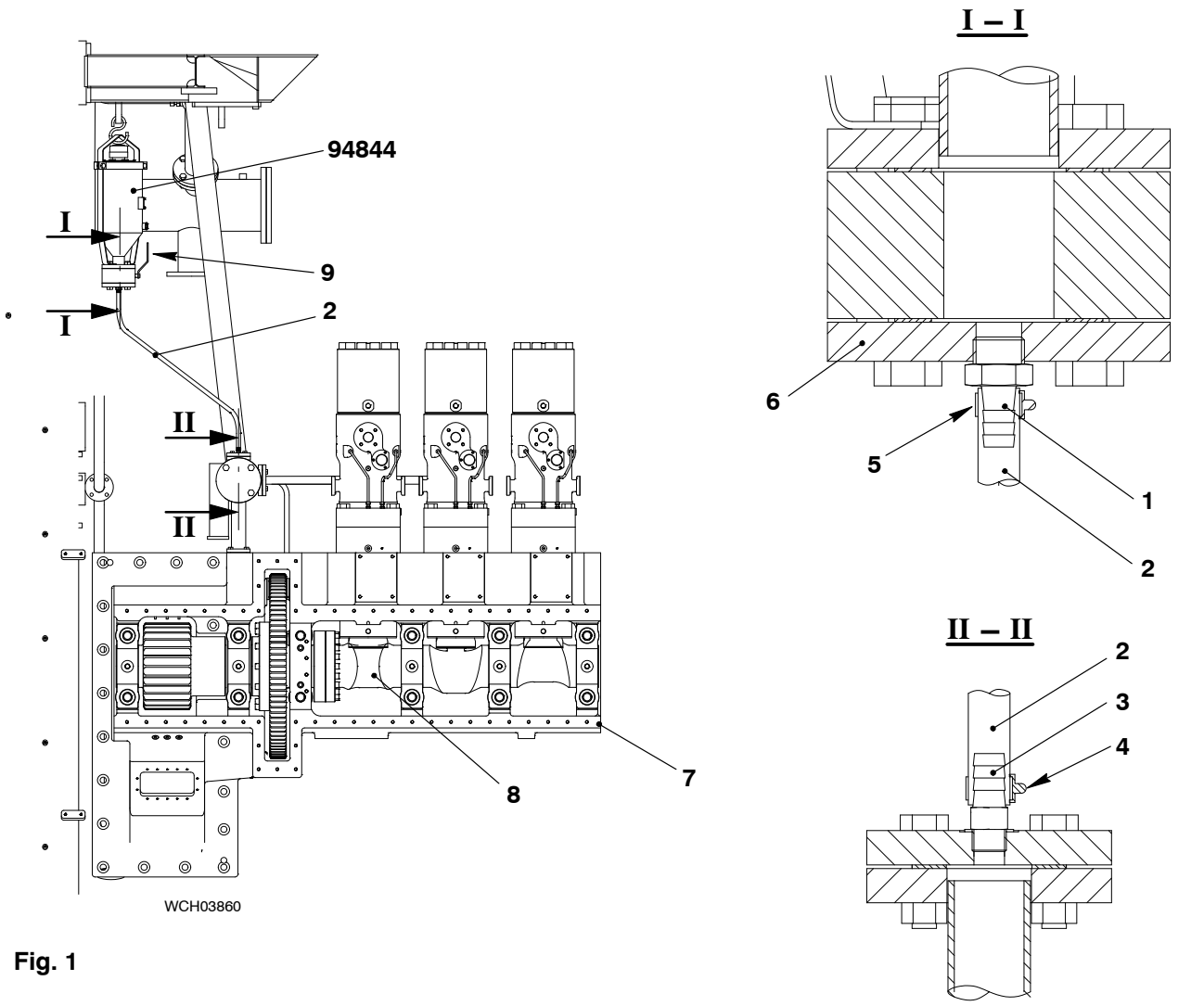


Fig. 1

Pilot Fuel Supply Unit

1. General

If you operate the engine in gas mode continuously, it is recommended that you have one more pilot fuel supply unit as a replacement.

The supply unit is an electric motor that has a flexible coupling to the pump and a duplex filter.

2. Maintenance

Lubricate the flexible coupling in accordance with the maintenance schedule.

1) Remove the service cover (4).
2) Turn the flange until you see the grease nipple.
3) Lubricate the flexible coupling.
4) Install the service cover (4).

CAUTION

Injury Hazard: The weight of the pilot fuel supply unit is approximately 367 kg. Use the correct equipment to lift and move the pilot fuel supply unit. This will prevent injury to personnel.

Note: To get access to duplex filter (2), you must remove the cover on the pilot fuel pump (3).

After the period given in the Maintenance Schedule, replace the pilot fuel supply unit.

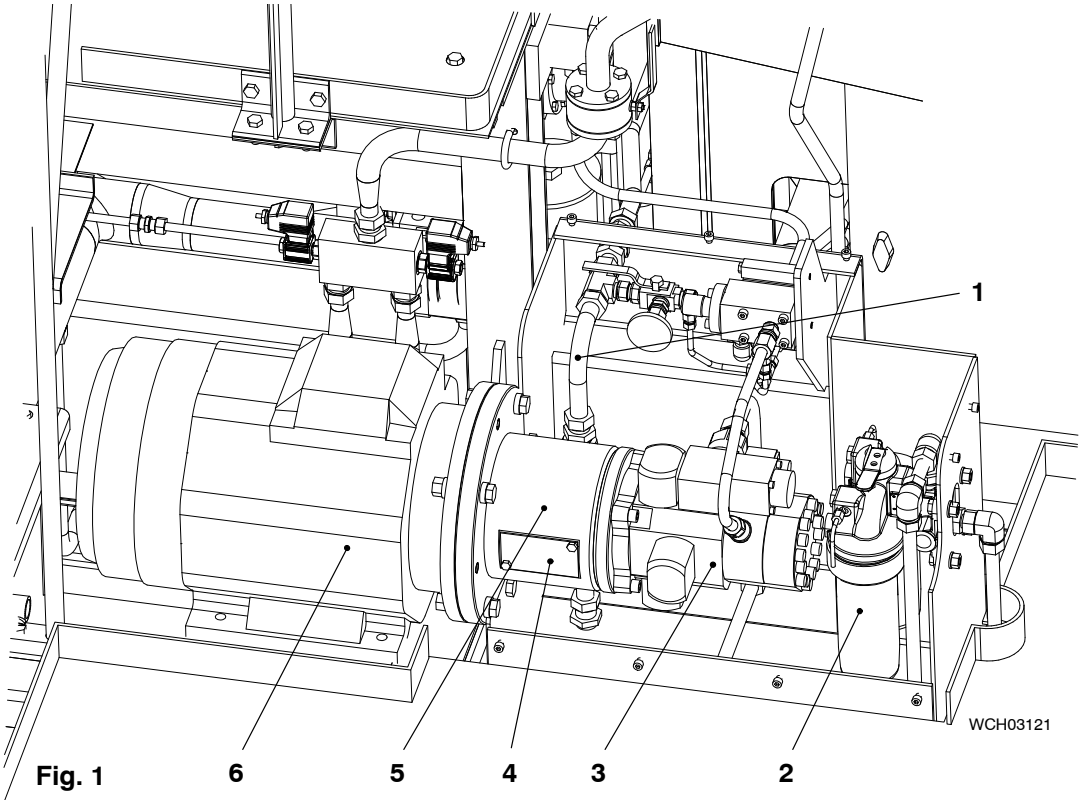


Fig. 1

Key to Fig. 1

1 High pressure fuel pipe
2 Filter unit
3 Pilot fuel pump
4 Service cover for flexible coupling
5 Flexible coupling
6 Electric motor

Intentionally blank

Pilot Fuel Pump
Removal and Installation

Tools:

1	HP oil pump	94931	1	HP hose	94935
1	Pressure gauge	94934A	1	Assembly tool	94573

1. Removal

1) Stop the engine.
2) Make sure that the pilot fuel pump (5, Fig. 1) has stopped.
3) Disconnect the electrical connection from the electric motor (1).
4) Close the stop valve (3).
5) Remove the pilot fuel pressure pipe (4).
6) Remove the pilot fuel return pipe (2).
7) Remove the fuel inlet pipe (9).
8) Hold the weight of the pilot fuel pump (7).
9) Remove the four Allen screws (6).
10) Remove the pilot fuel pump (5) from the electric motor (1).

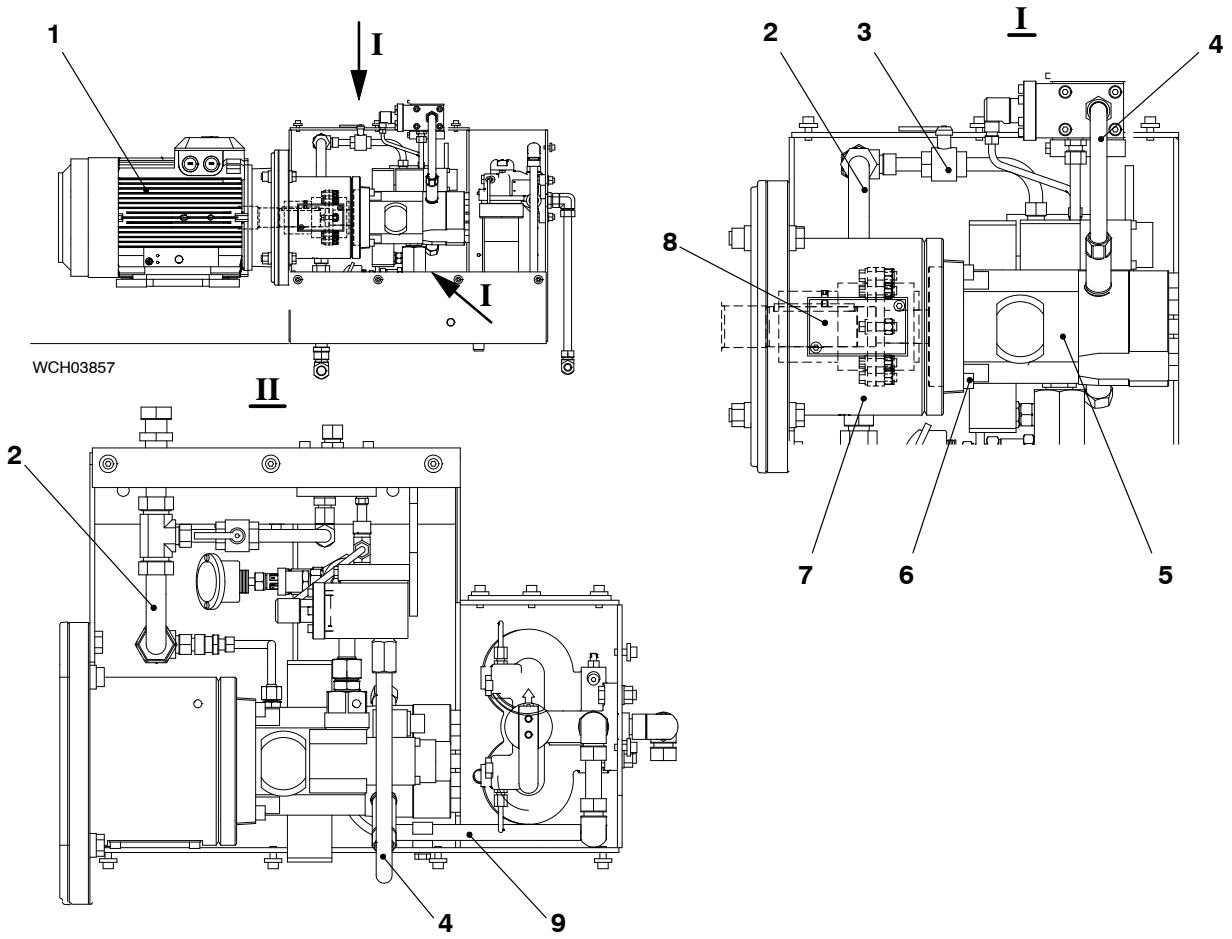
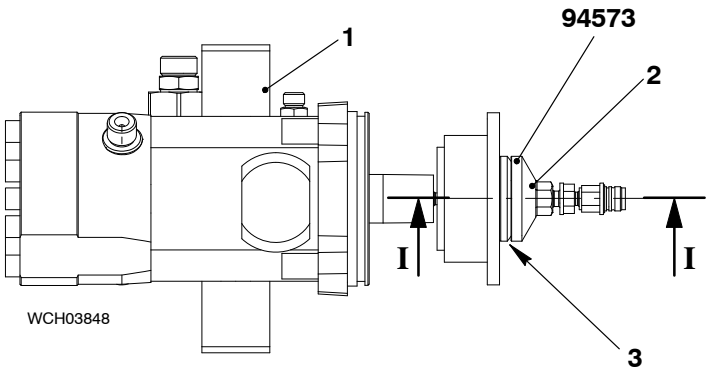


Fig. 1

11) On the assembly tool (94573, Fig. 2), turn fully back the special nut (2).
12) Apply Molykote G–Rapid Plus to the surfaces (4).
13) Attach the adapter piece (6) to the shaft of the pilot fuel pump (1).
14) Torque the adapter piece (6) to 45 Nm.
15) Turn the special nut (2) until touches the spherical disc (3). Do not tighten the special nut.
16) Connect the HP oil pump and hose to the assembly tool (94573).
17) Operate the HP oil pump tp increase the pressure to between 1600 bar and 1800 bar. Make sure that the coupling half floats on the oil film.
18) Operate the HP oil pump to keep the pressure constant.
19) Turn back 5.0 mm the special nut (2). Make sure that the hydraulic force pushes the coupling half against the spherical disc (3).
20) Make sure that the coupling half is loose.
21) Release the pressure from the HP oil pump.
22) Remove the gear coupling.



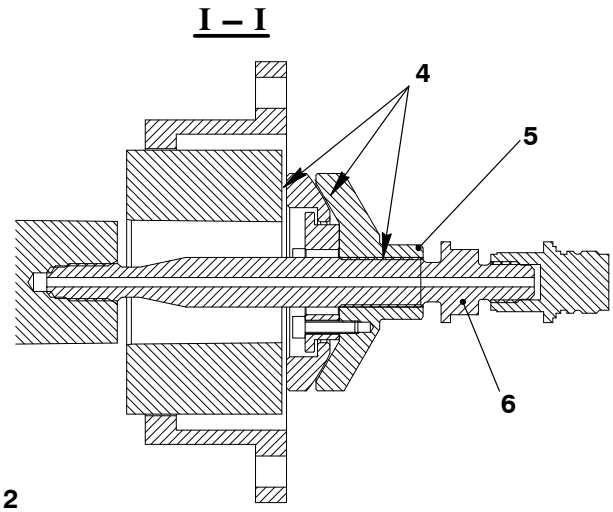


Fig. 2

2. Installation

1) Push as far as possible the special nut (2, Fig. 3) on the shaft of the pilot fuel valve (1). Make sure that the couping is at 90° to the shaft of the pilot fuel valve.
2) Measure the distance from the special nut (2) to the end face of the pump (1). Make sure that the distance is approximately 107.5 mm.
3) On the assembly tool (94573) turn fully back the special nut (2).
4) Apply Molykote G–Rapid Plus to the surfaces (3).
5) Attach the adapter piece (4) to the shaft of the pilot fuel pump (1).
6) Torque the adapter piece (4) to 45 Nm.
7) Turn the special nut (2) until it touches the spherical disc (7).
8) Attach the HP hose (9) to the HP oil pump (8)
9) Attach the hose (9) to the closing valve (5).
10) Operate the HP oil pump to get a pressure of between 1600 bar and 1800 bar.
11) Make sure that the coupling floats on the oil film.

12) Push the special nut (2) forward until the distance from the end face of the pilot fuel pump is 61.5 mm.
13) Release the pressure in the HP oil pump (8).
14) Remove the hose (9) from the closing valve (5).
15) Remove the assembly tool (94573) from the pilot fuel pump (1).

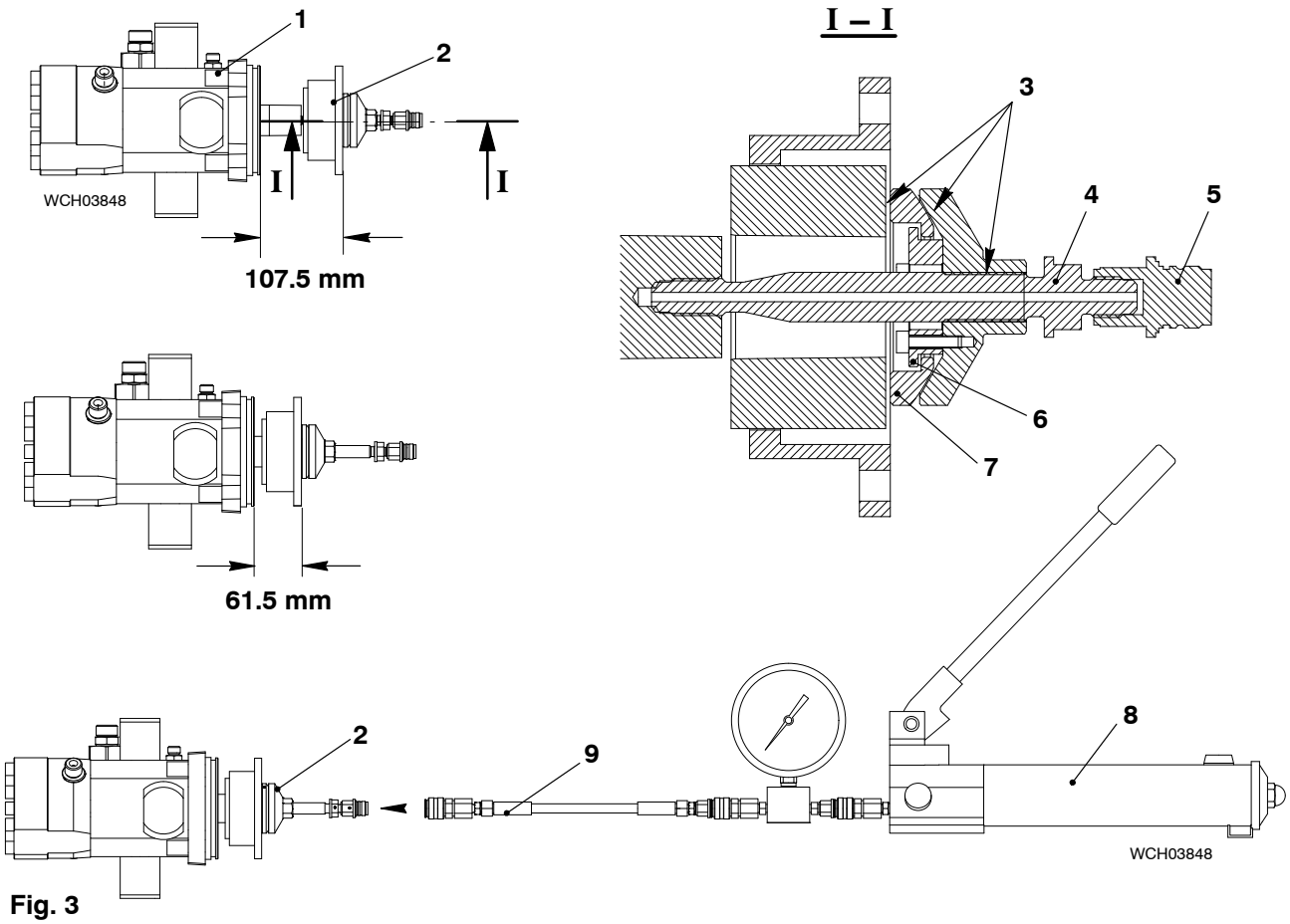


Fig. 3

16) Attach the pilot fuel pump to the electric motor temporarily with the four bolts and nuts (8, Fig. 1).
17) Measure the distance X through the opening in the connection piece (1, Fig. 4).
18) Remove the electric motor (6) from the connection piece (1).
19) Push the flange on the motor shaft until you get a distance of X–3.0 mm.
20) Lock the hubs with an M8 screw (5).
21) Fill the coupling with grease.
22) Attach the electric motor (6) to the connection piece (1) with the bolts/nuts (7).
23) Make sure that the distance between the hubs is 3.0 mm.

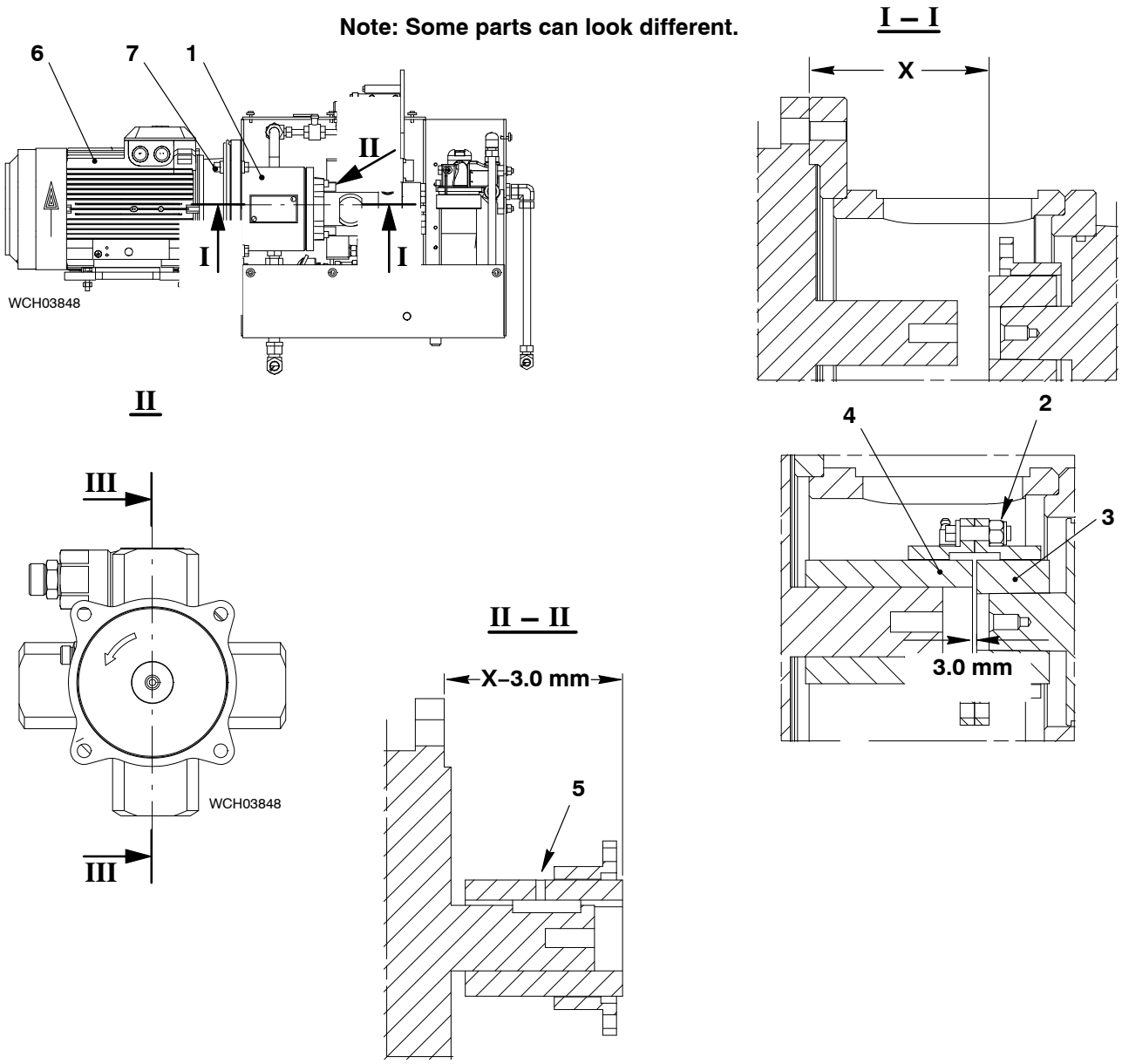


Fig. 4

24) Attach the sleeves together with the screws and nuts (2) (Fig. 4).

25) Torque the screws (3) and nuts (2) to 36 Nm.

26) Make sure that the sleeves (1) turn freely an axial distance of ±1.5 mm.

3. Completion

1) Apply NeverSeez NSBT8 to the threads and surfaces that touch of the pilot fuel pressure pipe (4, Fig. 5).

2) Attach the pilot fuel pressure pipe (4) as shown.

3) Torque the two coupling nuts (5) to 30 Nm.

4) Install the pilot fuel return pipe (2).

5) Install the fuel inlet pipe (10).

6) Connect the electrical connection to the electric motor (1).

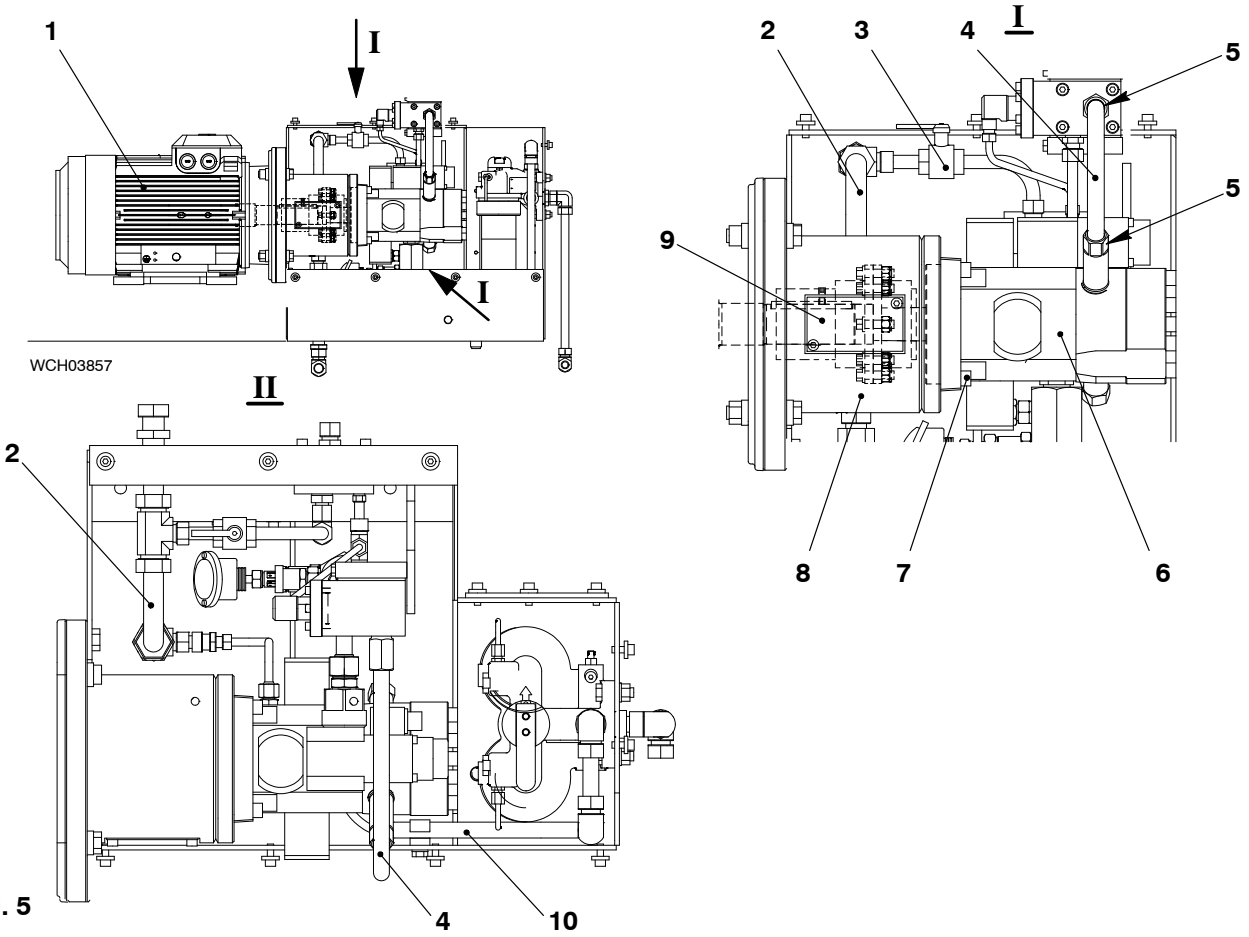


Fig. 5

Work Card
Fuel Pump: Check

Necessary Conditions

− Engine stopped

Necessary Spare Parts

Not applicable

Preparation

Operate the turning gear to get the roller of the related fuel pump to its highest position.
Remove the oil drain pipe from the fuel pump, refer to 5556−1/A1.
Set to on the servo oil service pump.

Tools and Consumables

Heat gun
Nylon brush
Drill bit (small)

WD−40

Primary Task

Do a random flow check of the lubricating oil, refer to 5556−1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Technical Bulletin RT−180
Attach the oil pipe to the fuel pump.

Intentionally blank

Work Card
Fuel Pump: Replace

Necessary Conditions

- Engine stopped
- Fuel temperature must be at ambient
- Fuel supply must be set to off
- Main oil supply must be set to off
- Fuel return valve must be open
- Fuel inlet valve must be closed
- Supply unit pressure must be zero
- Work area must be clean (no dust particles)

Necessary Spare Parts

O-rings and rod seal ring (set)	EX 55670	Qty 1
Fuel pump (includes the fuel pump plunger)	EX 55600	Qty 1

Preparation

Set to off the power supply to the actuators.
Make sure that the valves to the fuel pumps are closed.
Remove the applicable HP fuel pipes, refer to 8752−1
If necessary, attach the fuel pump rack to the top primary platform

Tools and Consumables

Lifting tool	94552	Qty 1
Manual ratchet	94016−017	Qty 1
Fuel pump rack	94592	Qty 1
Oil tray	94592A	Qty 1
Impact wrench	94958	Qty 1
Extension	94958A	Qty 1
Socket wrench insert	94958B	

Oil

Primary Task

Replace the fuel pump, refer to 5556−1/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	4.0 hours	Qty 2
Ship Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Flow check of the lubricating oil, refer to 5556−1/A1
Technical Bulletin RT−180

Intentionally blank

Fuel Pump

Removal, Disassemble, Assemble, Installation

Tools:

1	Circlip pliers	94007–A41
1	Handle	94009–M10
1	Manual ratchet	94016–017
1	2-part clamping ring	94550
1	Spindle press	94551
1	Lifting tool	94552
1	Rod	94553
1	Distance piece	94555
1	Fuel pump rack	94592
	Which includes:	
1	Oil tray	94592A
2	Limiters	94592B
2	Screws	94592C
4	Screws	94592D
2	Screws	94592E
1	Guide bracket	94593
	Which includes:	
1	Ring	94593A
2	Ring (2-part)	94593B
2	Guide rods	94593C
4	Screws M12x130	94593D
	With special nuts	
2	Screws M30x110	94593E
1	Mandrel (∅ 70 mm)	94597
1	Pneumatic impact wrench	94598
2	Extensions	94598A
1	Socket spanner insert	94598B

1. Preparation

WARNING

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

WARNING

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

CAUTION

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

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

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

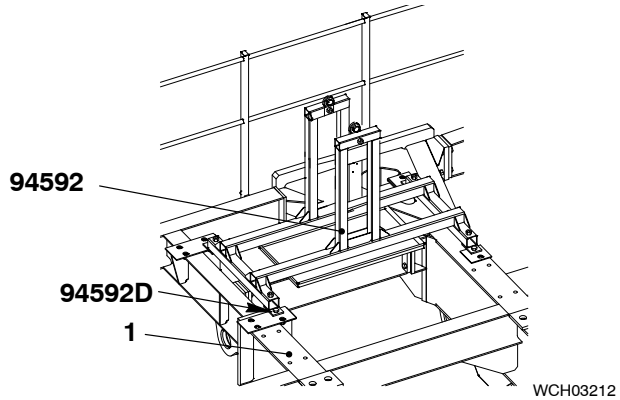


Fig. 1

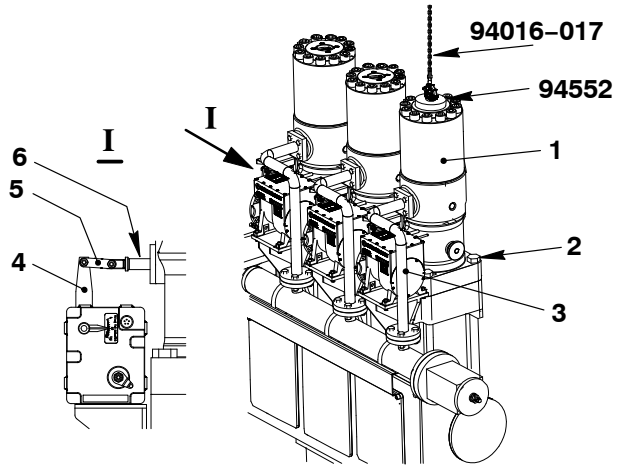


Fig. 2

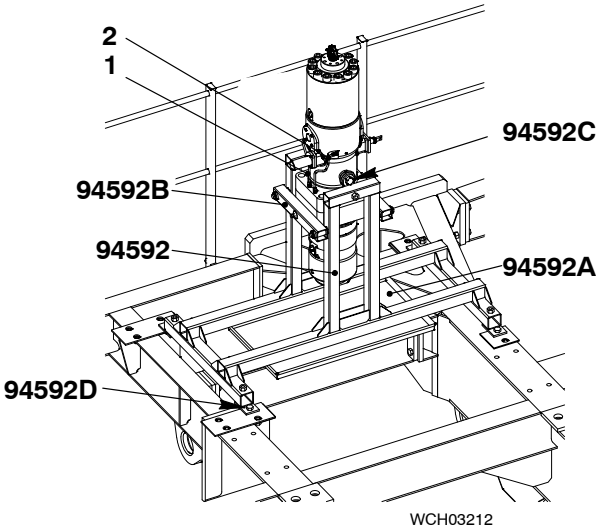


Fig. 3

2. Fuel Pump – Removal

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

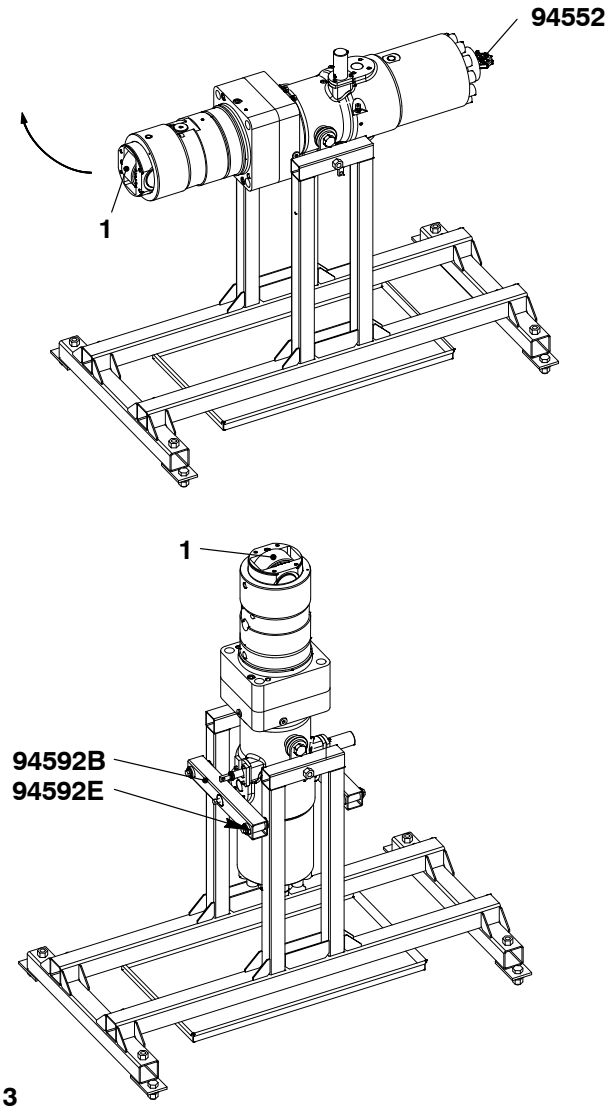


Fig. 3

3. Disassemble

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

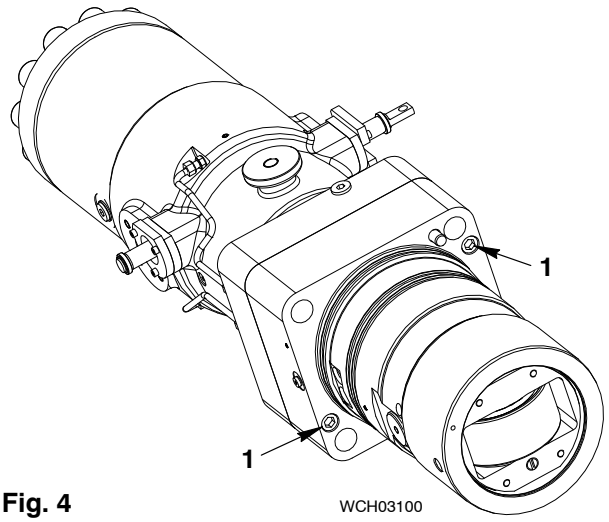


Fig. 4

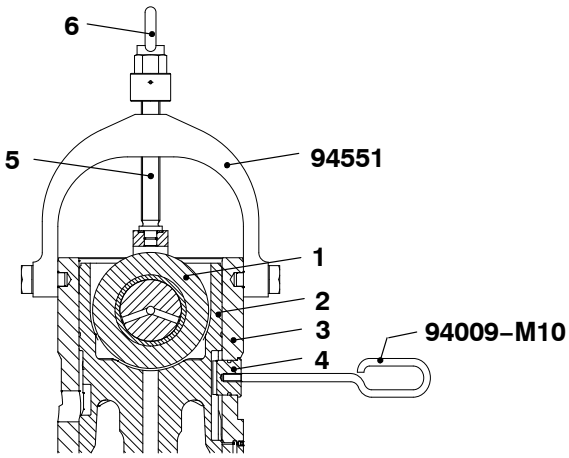


Fig. 5

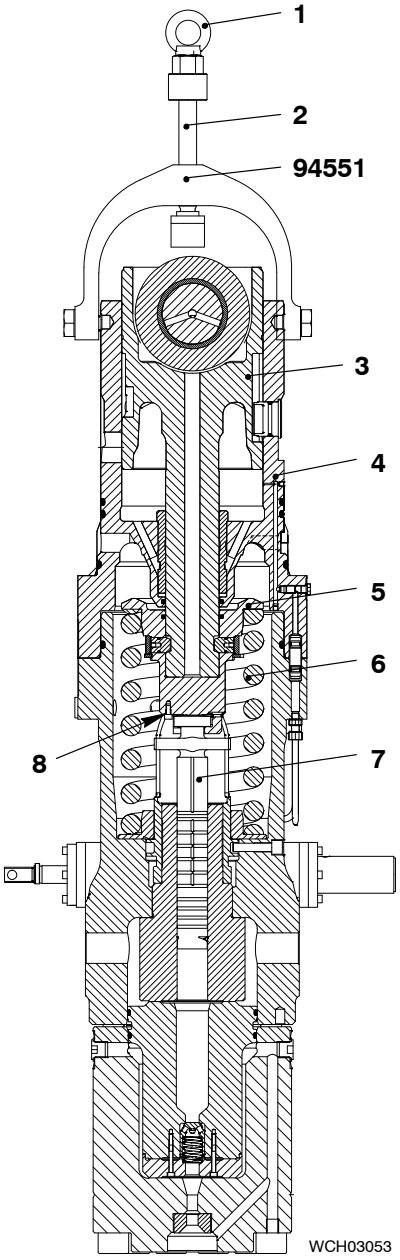
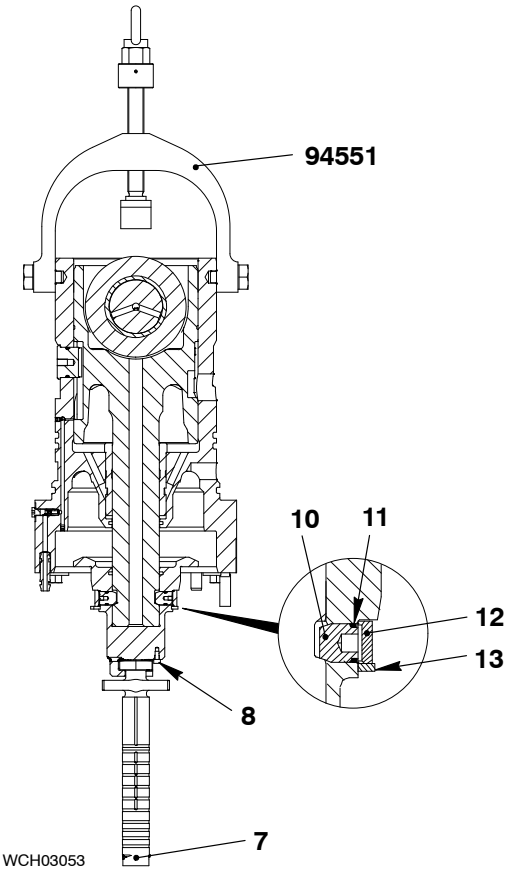


Fig. 6

11) Turn the eye bolt (1, Fig. 6) counterclockwise to move the spindle (2) up.
12) Carefully lift the bottom housing (4) together with the guide piston (3), the bottom spring carrier (5) and pump plunger (7).
13) Remove the compression spring (6).
14) Remove the screw (8).
15) Remove the pump plunger (7) from the bottom spring carrier (5).

Note: If you cannot remove the pump plunger (7), refer to 5556–2.

16) Remove the circlip (13) and push the retaining ring (12) down.
17) Hold the bottom spring carrier (5) while you remove the two connection pins (10).
18) Put the bottom housing (4) on an applicable underlay.
19) Put the pump plunger (7) into a safe storage area.
20) Remove the tool (94551).



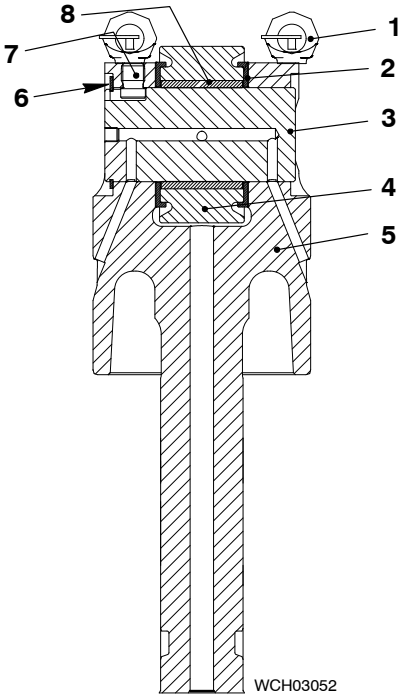


Fig. 7

3.1 Guide Piston – Disassemble

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

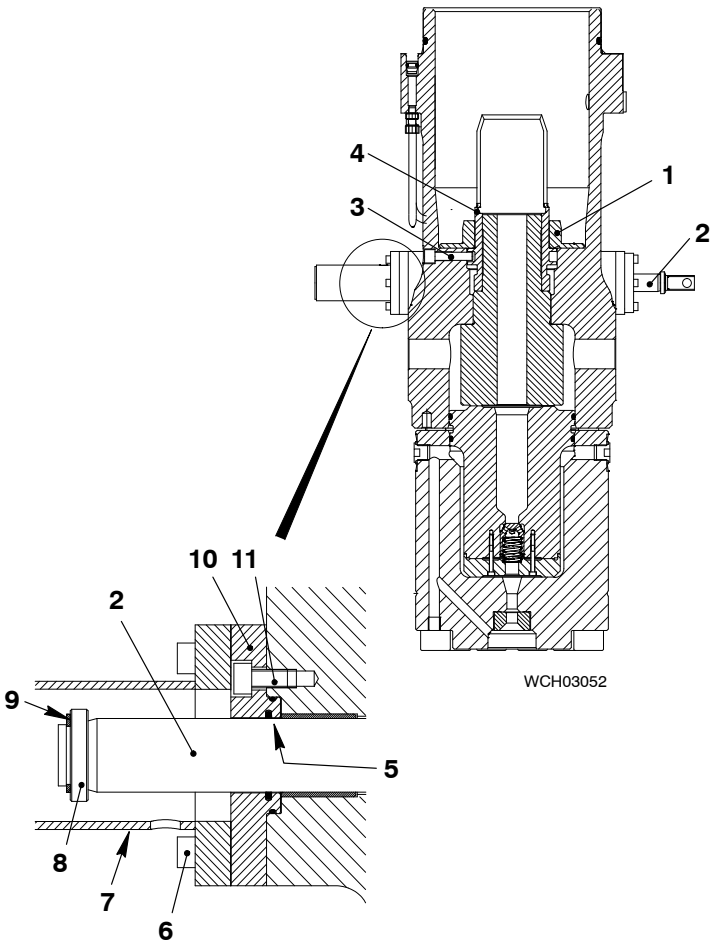


Fig. 8

3.2 Toothed Rack - Removal

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

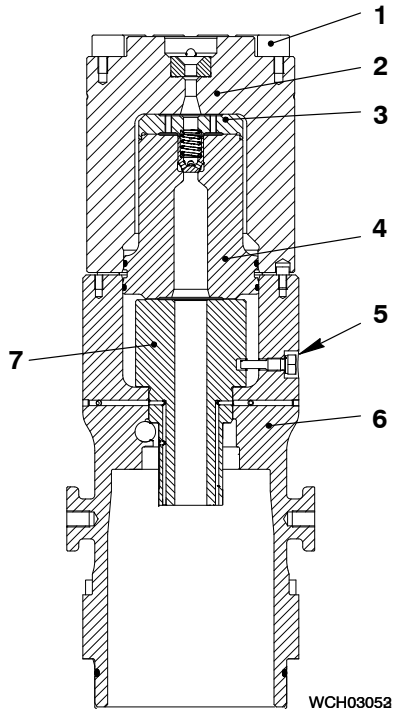


Fig. 9

3.3 Pump Cylinder – Removal

Note: The pump cylinder (7, Fig. 9) and pump plunger are not interchangeable and must stay together as a unit.

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

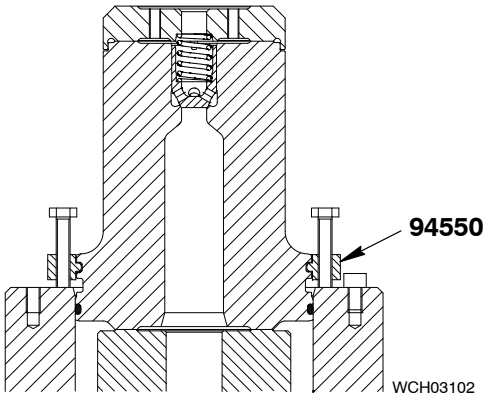


Fig. 10

5) Attach the clamp ring (94550, Fig. 10) to the valve block.
6) Use the clamp ring (94550 to remove the valve block (4).
7) Remove the retaining screw (5) and fluted seal ring.
8) Carefully remove the pump cylinder (7) from the housing (6).
9) Put all parts in a safe, clean storage area.

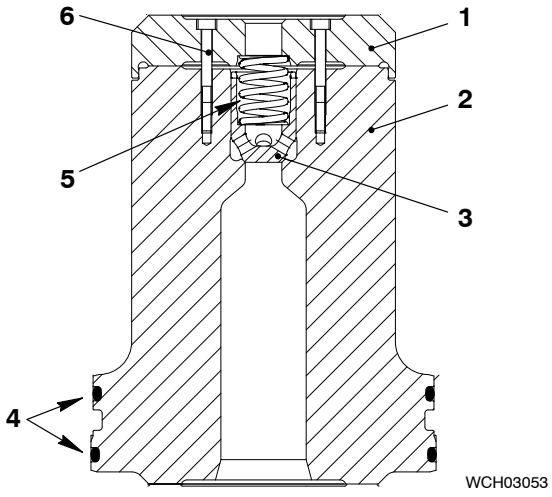


Fig. 11

3.4 Non-return Valve – Removal

1) Remove the two screws (6, Fig. 11).
2) Remove the intermediate piece (1) and the spring (5).
3) Remove the valve body (3) from the valve block (2).
4) Remove the two O-rings (4)

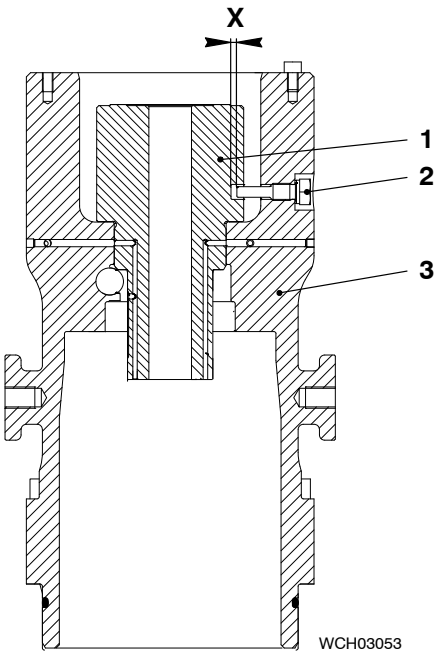


Fig. 12

4. Fuel Pump – Assemble

1) Clean all parts of the fuel pump and check their condition.
2) Examine all parts of the fuel pump for damage. Replace damaged parts with new items.
3) Replace all O-rings and rod seal rings.
4) Use a low-pressure air supply to make sure that the bores in the housings and the pump cylinder (1, Fig. 12) are clear.
5) Make sure that the top housing (3) points up.

4.1 Pump Cylinder – Assemble

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

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

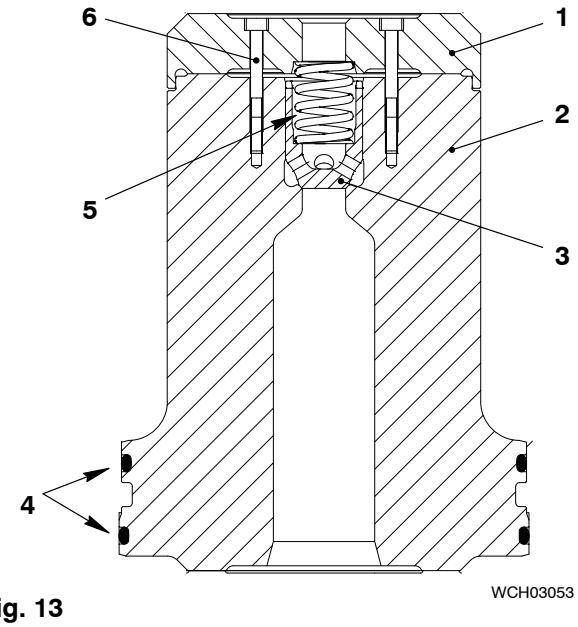


Fig. 13

4.2 Non-return Valve – Assemble

1) Make sure that the sealing surfaces of the valve block (2, Fig. 13) are clean and have no damage.
2) Put oil on the new O-rings (4).
3) Put the new O-rings (4) on the valve block (2).
4) Put the spring (5) in position in the valve body (3).
5) Attach the intermediate disc (1) to the valve body (2) with the two bolts (6).
6) Torque the two bolts (6) to 4.0 Nm.

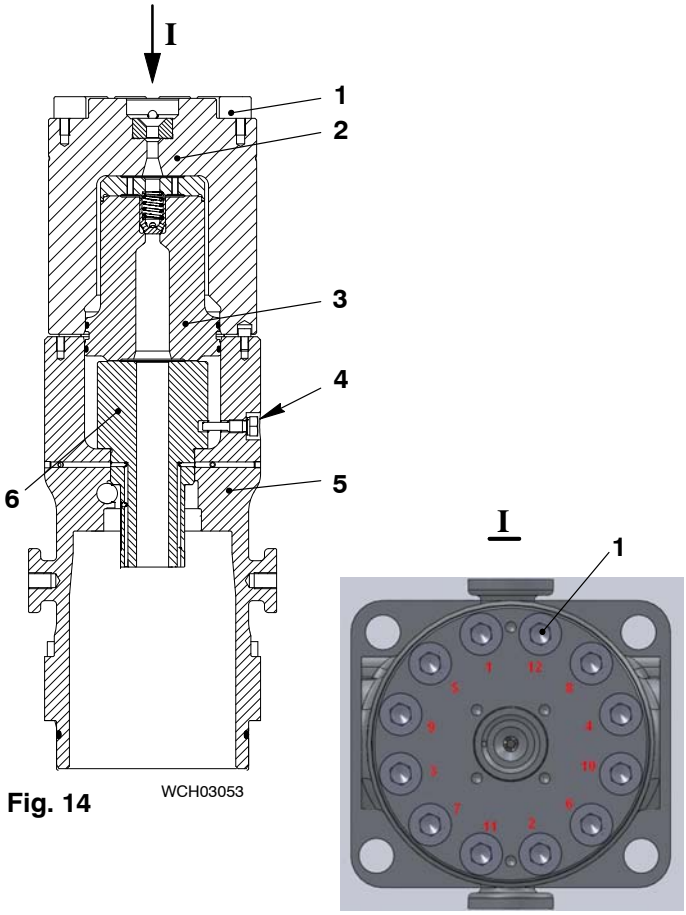


Fig. 14

4.3 Pump Cover – Assemble

1) Put oil on the bottom part of the non-return valve (3, Fig. 14.
2) Carefully put the assembled non-return valve (3) into the top housing (5).
3) Put the pump cover (2) in position on the top housing (5).
4) Apply NeverSeez NSBT to the threads and the bottom faces of the 12 bolts (1).
5) Put the 12 bolts (1) in position in the pump cover (2).
6) Torque the 12 bolts as follows:
   a) Torque the 12 bolts in the sequence shown to 100 Nm.
   b) Torque the 12 bolts in the sequence shown to 300 Nm.
   c) Torque the 12 bolts in the sequence shown to 480 Nm.

4.4 Guide Piston – Assemble

1) Clean all parts of the guide piston (5, Fig. 15).
2) Put oil on all parts of the guide piston.

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

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

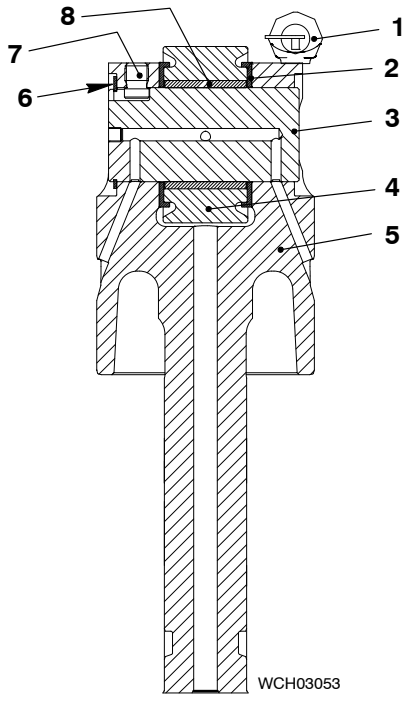


Fig. 15

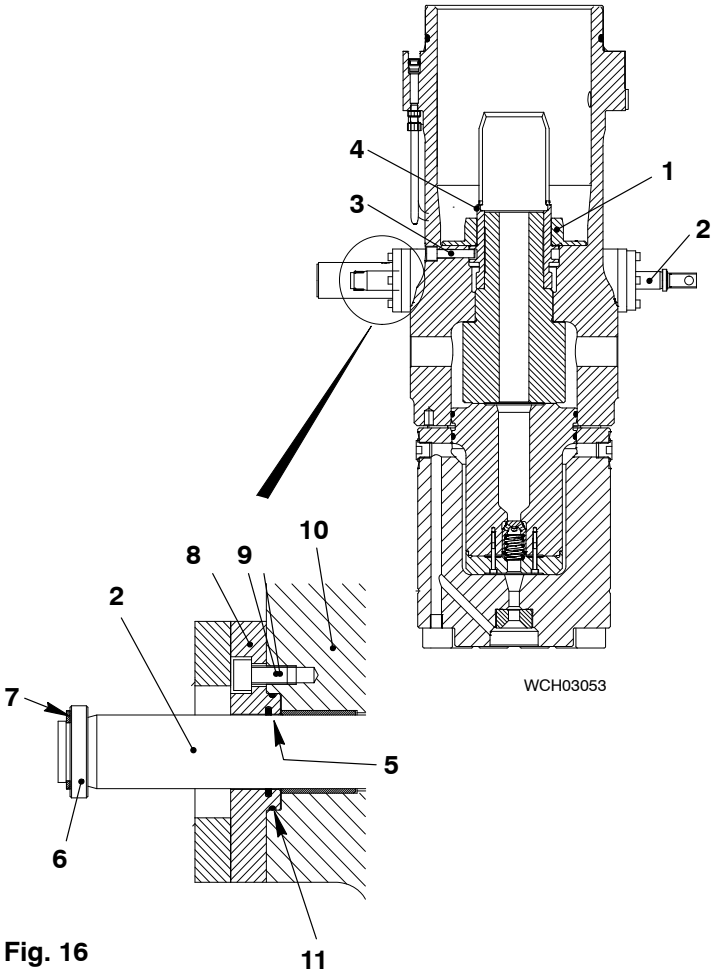


Fig. 16

4.5 Top Housing – Assemble

1) Turn the fuel pump into the position shown in Fig. 16.
2) Put the toothed rack (2) in position.

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

3) Put oil on the rod seal ring (5).
4) Put the rod seal ring (5) into the intermediate flange (8).
5) Put the intermediate flange (8) together with the O-ring (11) into the top housing (10).
6) Install the three screws (9).
7) Attach the rings (6) and the circlips (7).

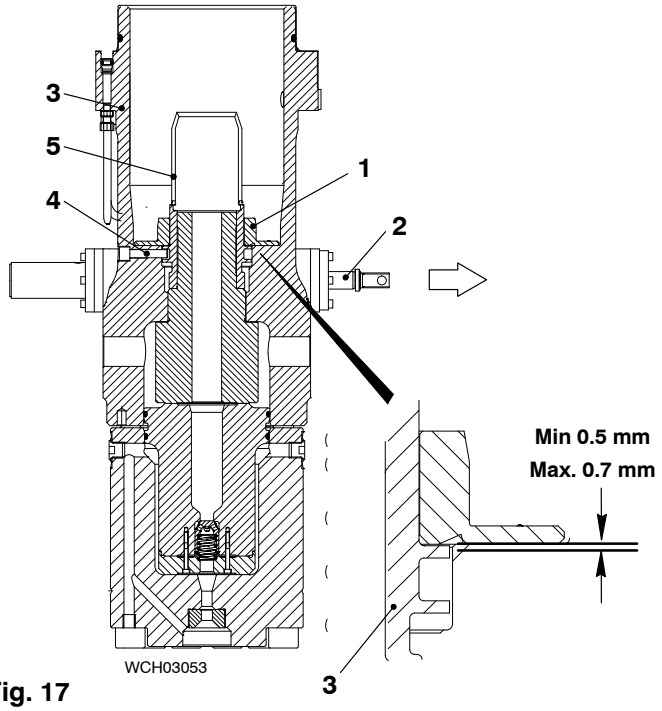


Fig. 17

8) Move the toothed rack (2, Fig. 17) fully out.
9) Put the regulating sleeve (5) in position in the top housing (3).
10) Turn the regulating sleeve (5) until the guide pin (4) is in line with the cut-out.
11) Move the toothed rack through the full range of movement.
12) Put the top spring carrier (1) in position in the top housing.
13) Push the top spring carrier (1) against the top housing, then move the regulating sleeve (5) up and down.
14) Use a dial gauge to measure the axial clearance between the regulating sleeve (5) and the top spring carrier (1).
15) Make sure that the axial clearance is between 0.5 mm and 0.7 mm.

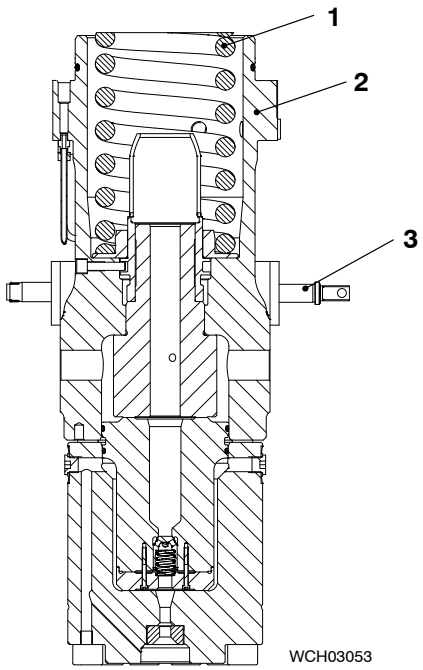


Fig. 18

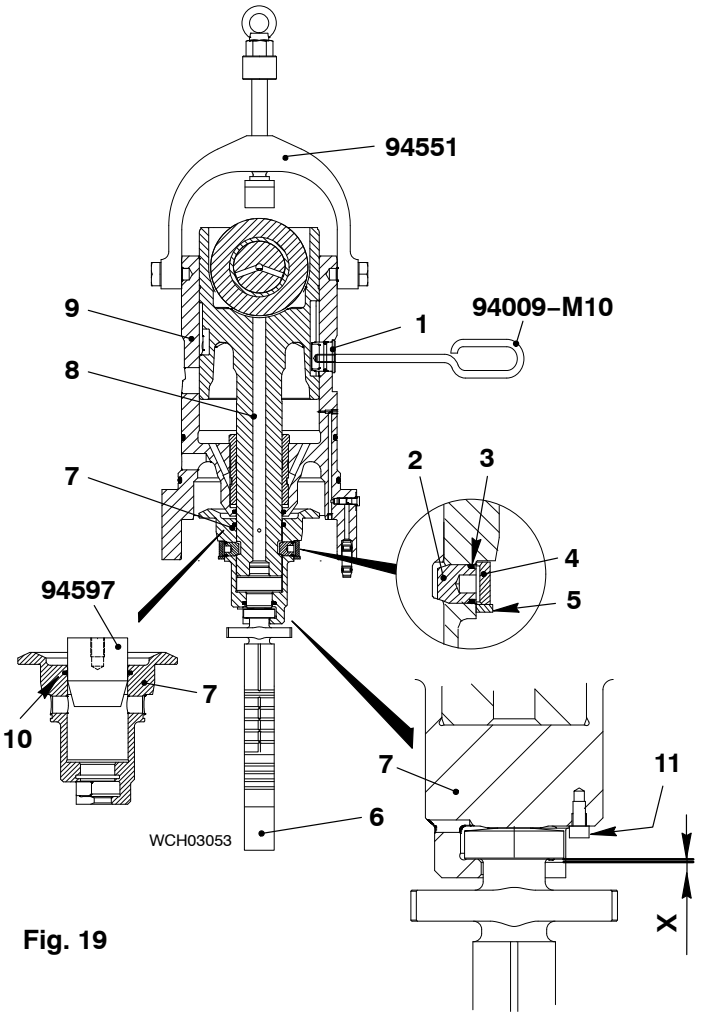


Fig. 19

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

4.6 Bottom Housing – Assemble

1) Attach the spindle press (94551) to the lower housing (9, Fig 19).
2) Put a new O-ring on the guide pin (1).
3) Put the assembled guide piston (8) in the bottom housing (9). Make sure that the groove in the guide piston aligns with the bore in the bottom housing.
4) Use the handle (94009–M10) to install the guide pin (1).
5) Use the mandrel (94597) to install a new seal (10) to the bottom spring carrier (7).
6) Put the bottom spring carrier (7) in position on the guide piston (8).
7) Put new O-rings (3) on the connection pins (2).
8) Put the two connection pins (2) through the bores in the top spring carrier. Make sure that the connection pins engage with the groove in the guide piston (8).
9) Attach the retaining rings (4) to the connection pins (2).
10) Attach the circlips (5) to hold the connection pins (2) and the retaining rings (4) in position.
11) Lift the assembly into position above the top housing.
12) Attach the pump plunger (6) to the bottom spring carrier (7).
13) Make sure that there is a clearance (X) of between 0.12 mm and 0.24 mm.
14) Apply Loctite 243 the thread of the screw (11).
15) Torque the screw (11) to 9 Nm.

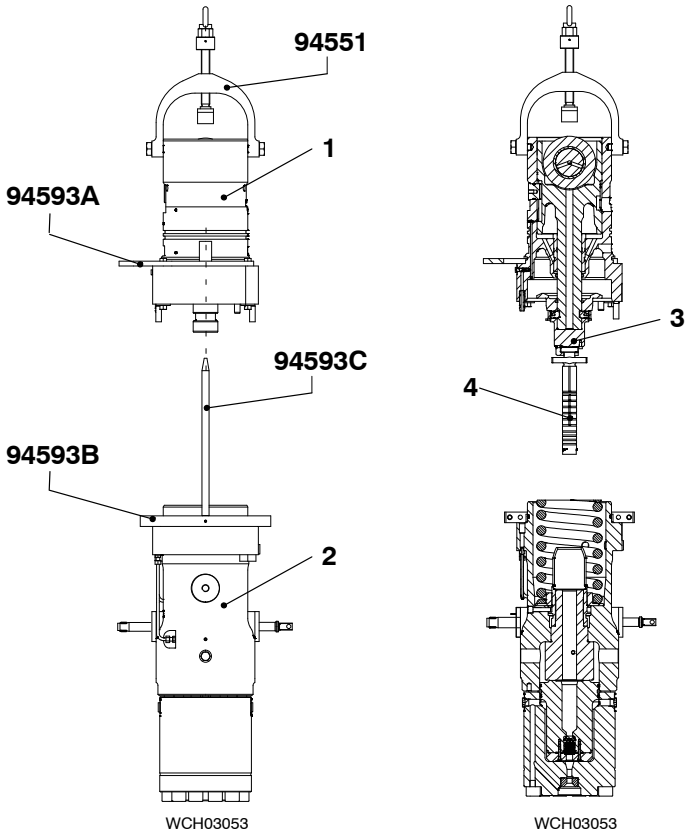


Fig. 20

4.7 Fuel Pump Assembly

1) Attach the ring (94593A, Fig. 20) to the bottom housing (1).
2) Attach the two-part ring (94593B) to the top housing (2). Make sure that the guide rods (94593C) align with the holes in the ring (94593A).
3) Attach the crane hook to the spindle press (94551).

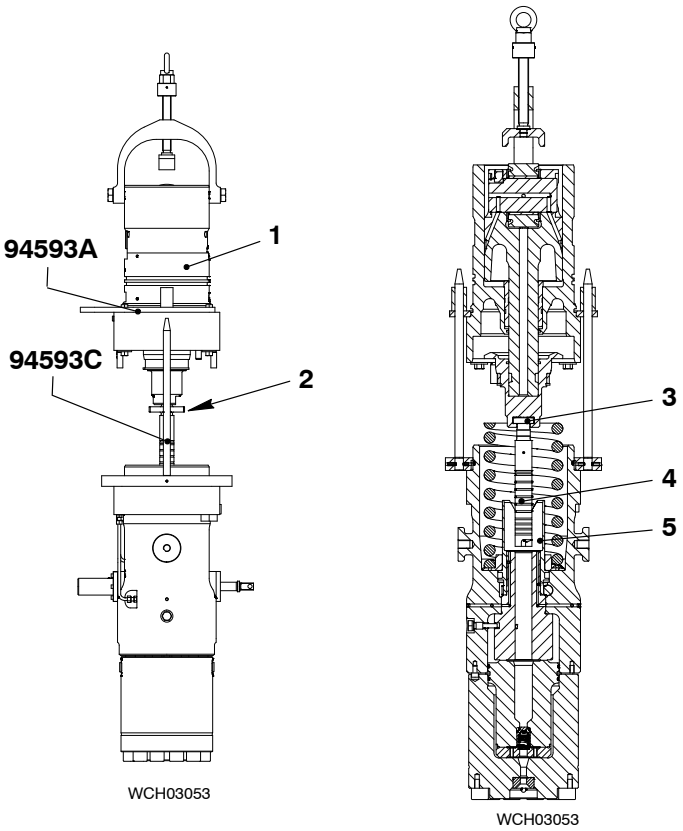


Fig. 21

4) Carefully lower the lower housing (1, Fig. 21) sufficiently to engage the rods (94593C) with the holes in the ring (94593A).
5) Continue to lower the bottom housing (1) until the pump plunger (4) is a small distance from the regulating sleeve (5).

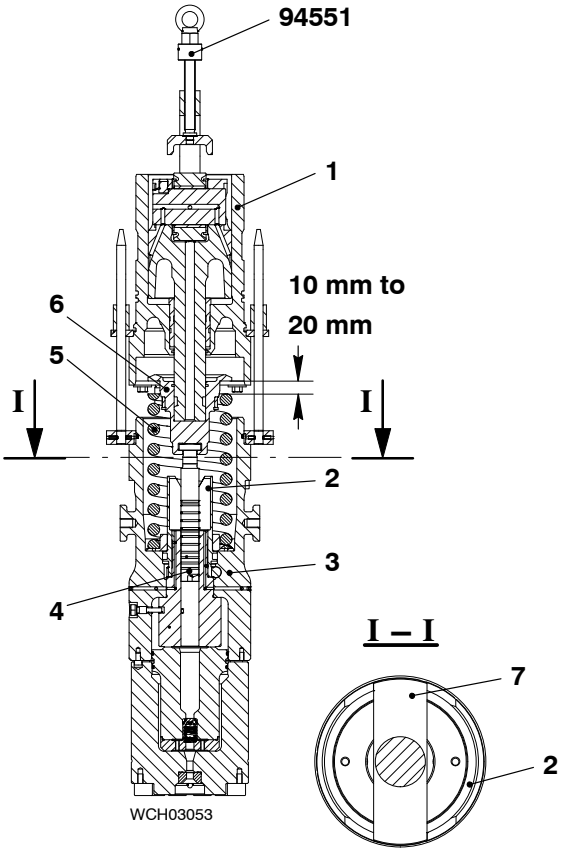


Fig. 22

6) Lower the bottom housing (1, Fig. 22) on to the top housing (3) until the spring carrier (6) is approximately 10 mm to 20 mm above the spring (5).

7) Align the tabs(7) on the pump plunger (4) with the holes in the regulating sleeve (2).

8) Continue to lower the bottom housing (1) until the spring carrier (6) touches the spring (5).

9) Remove the crane hook from the spindle press (94551).

10) Remove the ring (94593A) and the two-part ring (94593B).

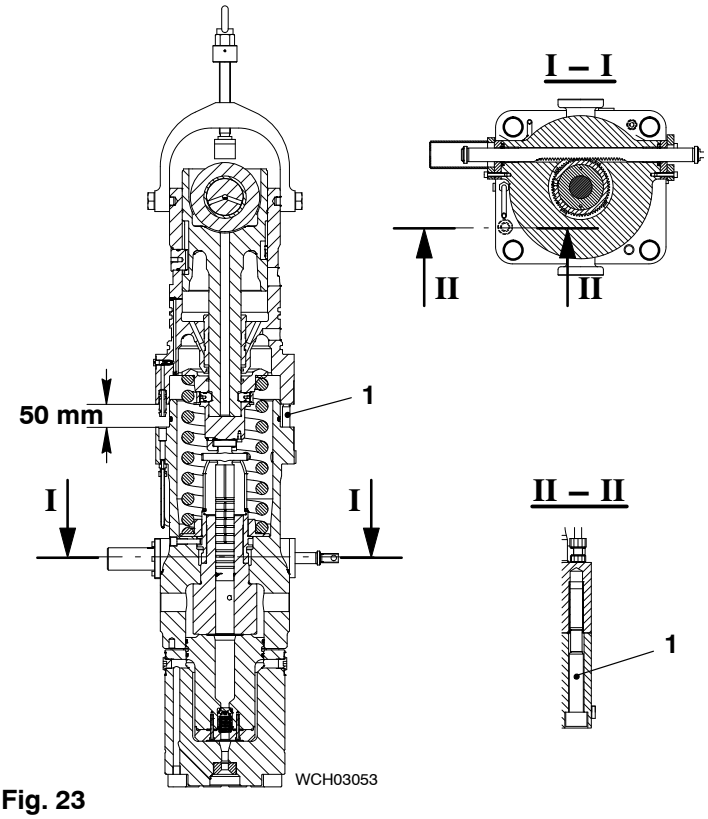


Fig. 23

11) Make sure that there is a clearance of 50 mm between the top housing and the bottom housing (see Fig. 23).

12) Put the two Allen screws (1) in position as shown.

13) Tighten equally with your hand the two Allen screws (1).

14) At the same time, torque the two Allen screws to 140 Nm.

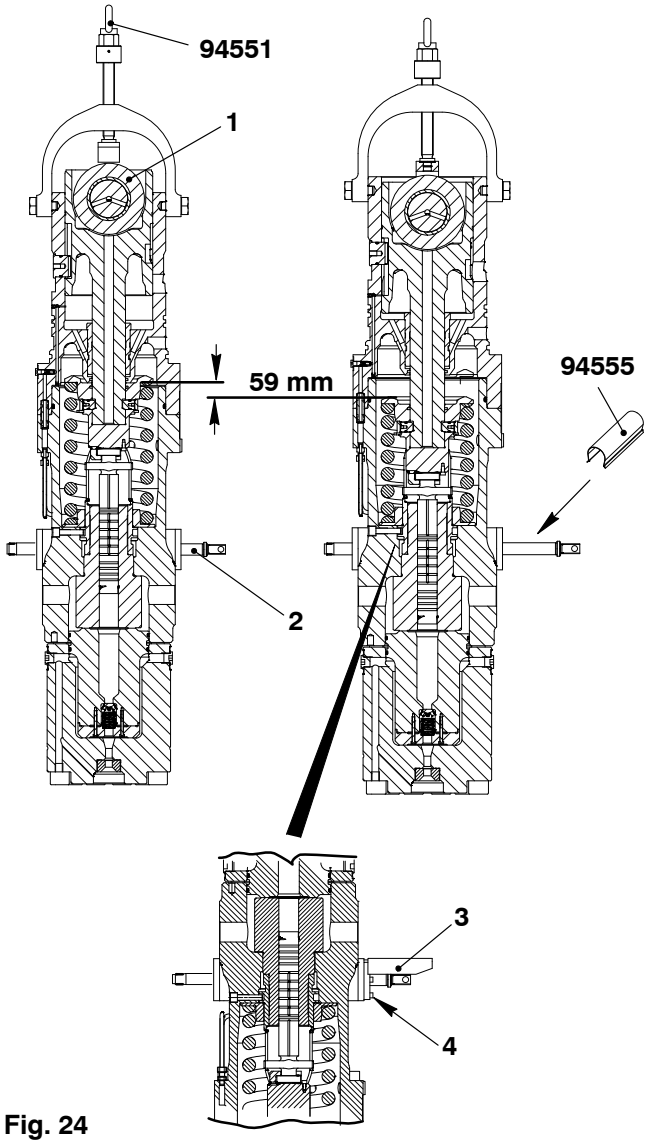


Fig. 24

4.8 Function Check

1) Turn the eye bolt on the spindle press (94551, Fig. 24) to move the roller (1) down 59 mm.

Note: The distance of 59 mm is equal to a hub stroke of 55 mm.

2) Turn the eye bolt on the spindle press (94551) back to the initial position.

3) Attach a spring balance to the toothed rack (2).

Note: During step 4), do a check of the spring balance. If the force to move the toothed rack is more than 30 Nm, disassemble the fuel pump and do a check of all important dimensions.

4) Use the spring balance to pull the toothed rack (2) fully out. Make sure that the toothed rack (2) moves freely.

5) Make sure that you can install the distance piece (94555).

6) Remove the the spindle press (94551).

7) Attach the cover (3) to the fuel pump with the six screws (4).

8) Torque the six screws to 20 Nm.

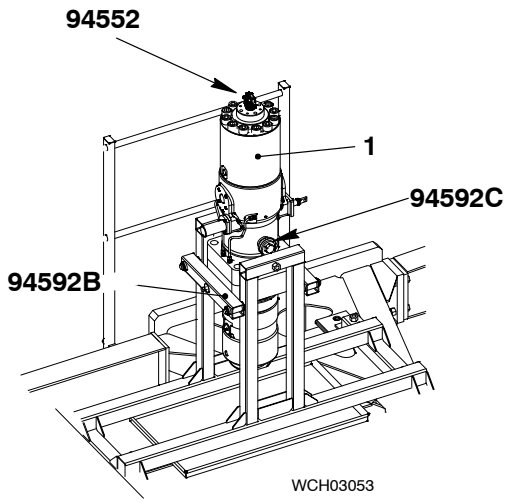
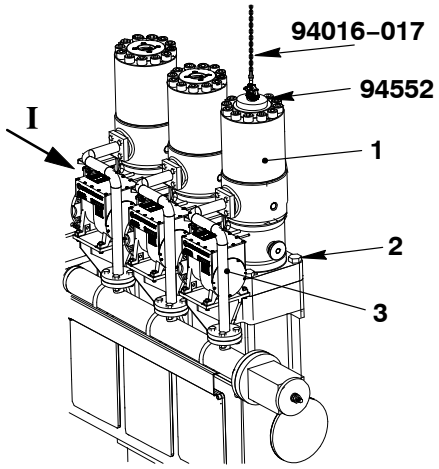


Fig. 25

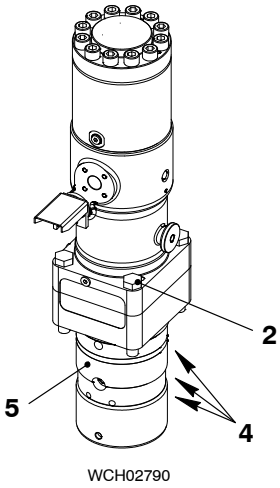
9) Remove the limiters (94592B and 94592C).

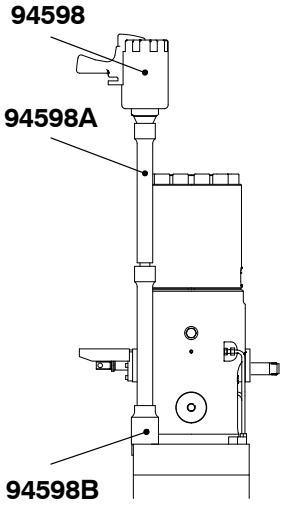
10) Turn the fuel pump (1, Fig. 25) until the pump cover points up.

11) Attach the lifting tool (94552) to the fuel pump pump (1).



For View I, see Fig 27





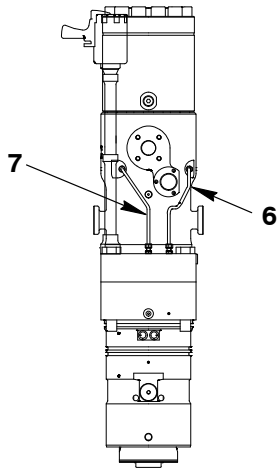


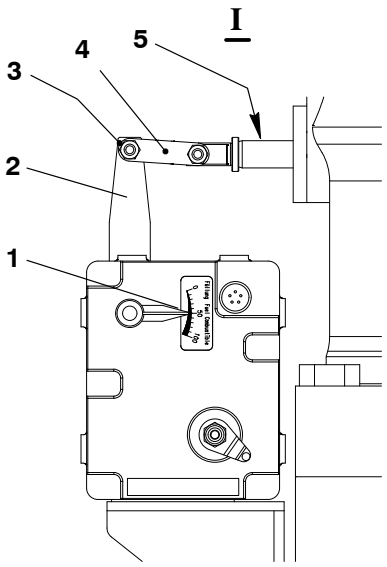
Fig. 26

5. Fuel Pump – Install

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 turn the camshaft until the applicable cam is at BDC.
2) Do a check of all parts of the fuel pump.
3) Make sure that the seating surfaces of the fuel pump are clean and have no damage.
4) Put new O-rings (4, Fig. 26) on the bottom housing (5).
5) Put oil on the threads and seating surfaces of the four bolts (2).
6) Attach the manual ratchet (94016–017) to the lifting tool (94552) and the engine room crane.
7) Lift the fuel pump.
8) Put the fuel pump directly above the applicable position of the supply unit.
9) Carefully lower the fuel pump into position.
10) Torque the four M30x220 bolts (2) to 1250 Nm (i.e. the value given in 0352–1). Use the socket wrench insert (94598B), the extensions (94598A) and the pneumatic impact wrench (94598).
11) Install the applicable HP fuel pipe(s), refer to 8752–1 paragraph 4.
12) Connect the oil drain pipe (6) and the oil inlet pipe (7).
13) Make sure that the fuel return valve and the fuel inlet valve are open. Refer to the Operation Manual, 4003–2 and 4003–11.
14) Operate the pump and do a leakage check.



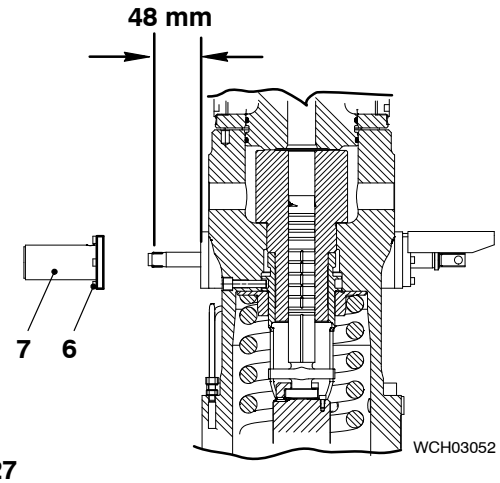
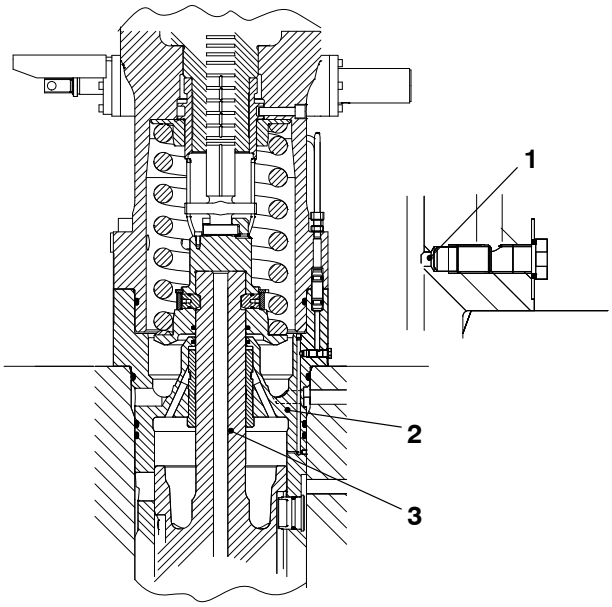
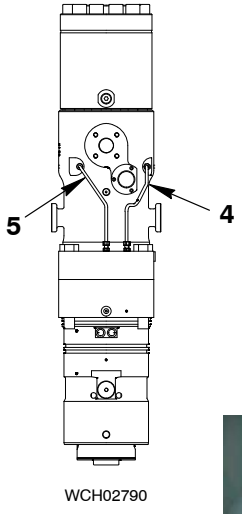


Fig. 27

15) Make sure that the connecting element (4, Fig. 27) moves freely.
16) Apply Molykote paste G to the connecting element(4).
17) Connect the connecting element (4) to the actuator lever (2) with the screw and new self-locking nut (3).
18) Move the the toothed rack (5) to the middle position as shown. Make sure that there is 48 mm at each end of the the toothed rack.
19) Make sure that the indicator (1) on the actuator shows 50% fuel.
20) Attach the cover (7) to the fuel pump with the six screws (6).
21) Torque the six screws (1) to 20 Nm.





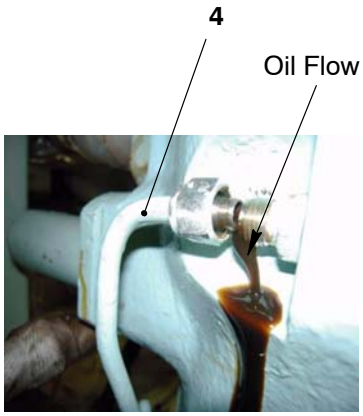


Fig. 27

6. Oil Flow Check

WARNING

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

WARNING

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

Note: The oil flows through the throttle (1, Fig. 27) to the bottom housing (2) and the guide piston (3).

1) The engine must be stopped.
2) Operate the turning gear to move the roller of the related fuel pump to its highest position (TDC).
3) Remove the oil drain pipe (4) from the fuel pump.
4) Set to on the servo oil service pump.
5) After one minute, make sure that you can see the oil flow as shown.
6) If the oil does not flow as shown, read the data in Technical Bulletin RT–180.
7) Make sure that the oil flows in the inlet pipe (5).

Note: If the oil in the inlet pipe (5) does not flow freely, it is possible that there are unwanted particles in the oil supply system. If you find particles, remove them.

8) If there is incorrect oil flow or no flow from the drain hole, do step a) to step d):
   a) If the oil cannot flow freely, flush the holes with e.g WD–40.
   b) If there is no oil flow, use a heat gun to apply heat to the clogged drain hole.
   c) Use a small drill bit to open the hole.
   d) Remove the particles with a nylon brush.
9) Install all unions and plugs.
10) Attach the oil drain pipe (4) and oil inlet pipe (5) to the fuel pump.

7. Storage

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

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

Fuel Pump

Seized Pump Plunger – Removal

Tools:

1	Piston reset tool	94595D	2	Screws	94595E
1	Hydraulic ram	94595	1	HP oil pump	94931
1	Short push rod	94595B	1	Pressure gauge	94934A
1	Long push rod	94595C	1	HP hose	94935

1. Fuel Pump – Preparation

1) Remove the fuel pump, refer to 5556–1 paragraph 1 and paragraph 2.

2) Disassemble the fuel pump (5556–1 paragraph 3) until the condition is as shown in Fig. 1.

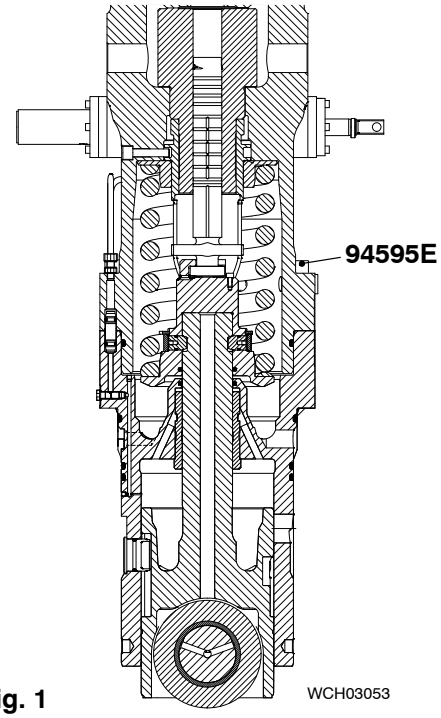


Fig. 1

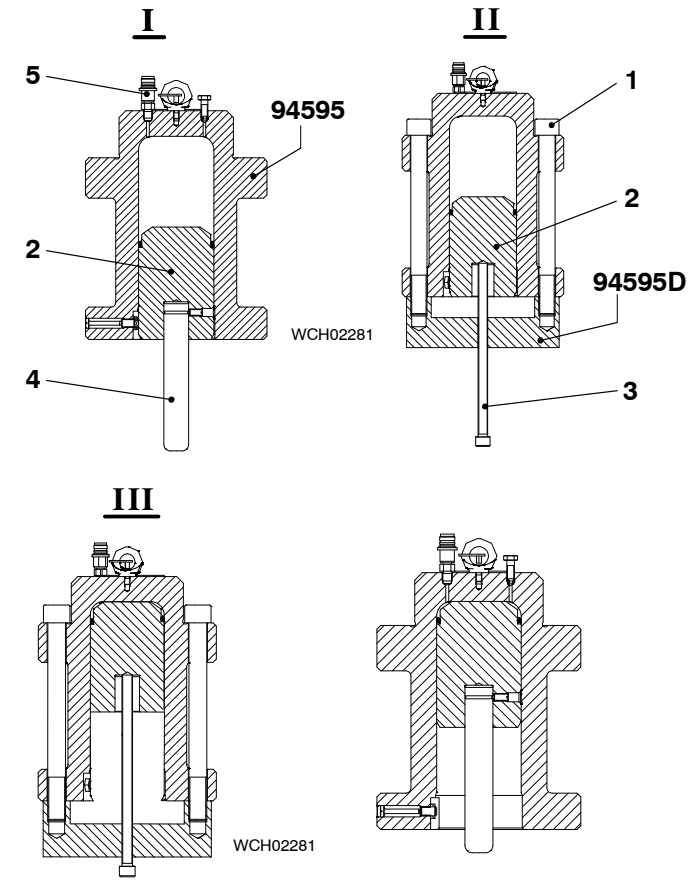


Fig. 2

2. Hydraulic Ram – Preparation

1) Open the vent screw (5, Fig. 2) and push the piston (2) to the top of the cylinder of the hydraulic ram (94595).

2) If you cannot move the piston (2) with your hand, do step a) to step c):

   a) Remove the push rod (4) (94595B or 94595C) from the piston (5).

   b) Attach the piston reset tool (94595D) to the hydraulic ram (94595) with two of the screws (1).

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

   c) Use the spindle (3) to push the piston (2) to the top of the cylinder.

3) Remove the piston reset tool (94595D).

4) Put the short push rod (4) (94595B) into the piston (5).

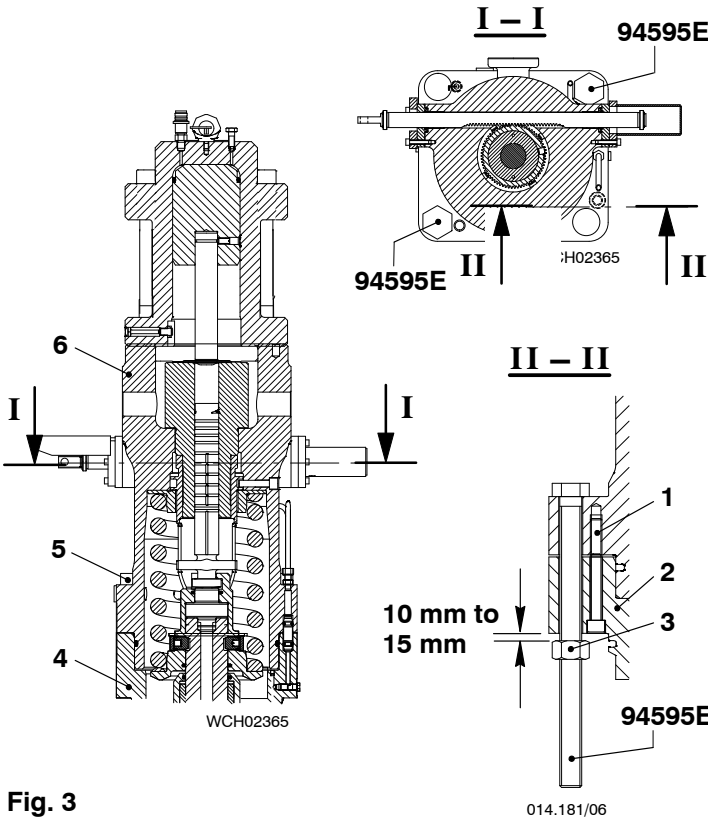


Fig. 3

3. Hydraulic Ram – Installation

CAUTION

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

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

2) Hold the bottom housing (4, Fig. 3) in position, then remove the four bolts (5) from the top housing (6).

3) Put the two screws (94595E) through the bores of the flange in the top and bottom housings (6, 4) in the positions shown (view I–I).

4) Put the nuts (3) on the screws (94595E).

5) Adjust the nuts (3) to get a minimum clearance of between 10 mm to 15 mm (view II–II).

6) Remove the two screws (1).

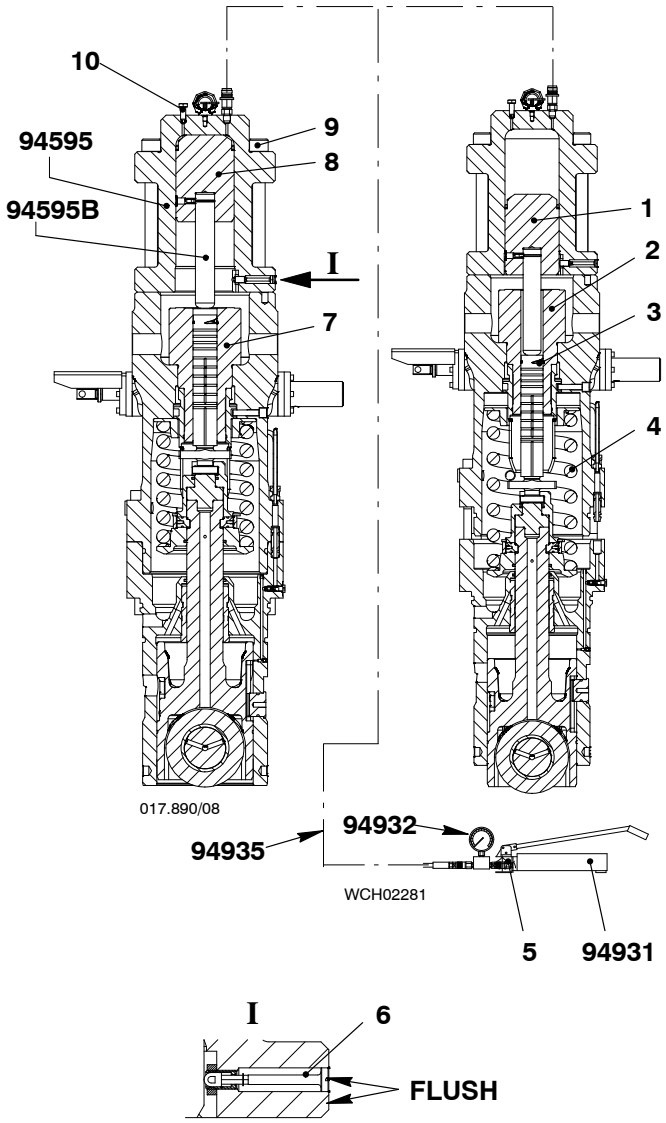


Fig. 4

4. Removal with Tool 94595B

1) Connect the hydraulic ram (94595, Fig. 4 to the HP oil pump (94931).
2) Close the relief valve (5).
3) Make sure that the vent screw (10) is open.
4) Operate the HP oil pump until oil that has no air flows from the vent screw (10).
5) Close the vent screw (10).

Note: During the step below, make sure that you keep a clearance of between 10 mm and 15 mm between the nuts (3, Fig. 3 II–II) and the bottom housing (4).

6) Operate slowly the HP oil pump (94931, Fig. 4) until:
   - The compression spring (4) pushes the plunger (2) out of the cylinder (7), or
   - The indicator (6) is flush with the housing. (This shows that the piston is at the end of its stroke.)
7) Open the relief valve (5) to release the pressure in the HP oil pipe (94935).
8) Disconnect the HP oil pump from the hydraulic ram (94595).
9) Remove the screws (9).
10) Remove the hydraulic ram (94595).
11) Remove the plunger (3).
12) Move the piston (8) to the initial position, refer to paragraph 2.
13) Continue to disassemble the fuel pump, refer to 5556–1 paragraph 3.
14) If you cannot remove the plunger (2), do the procedure given in paragraph 5.

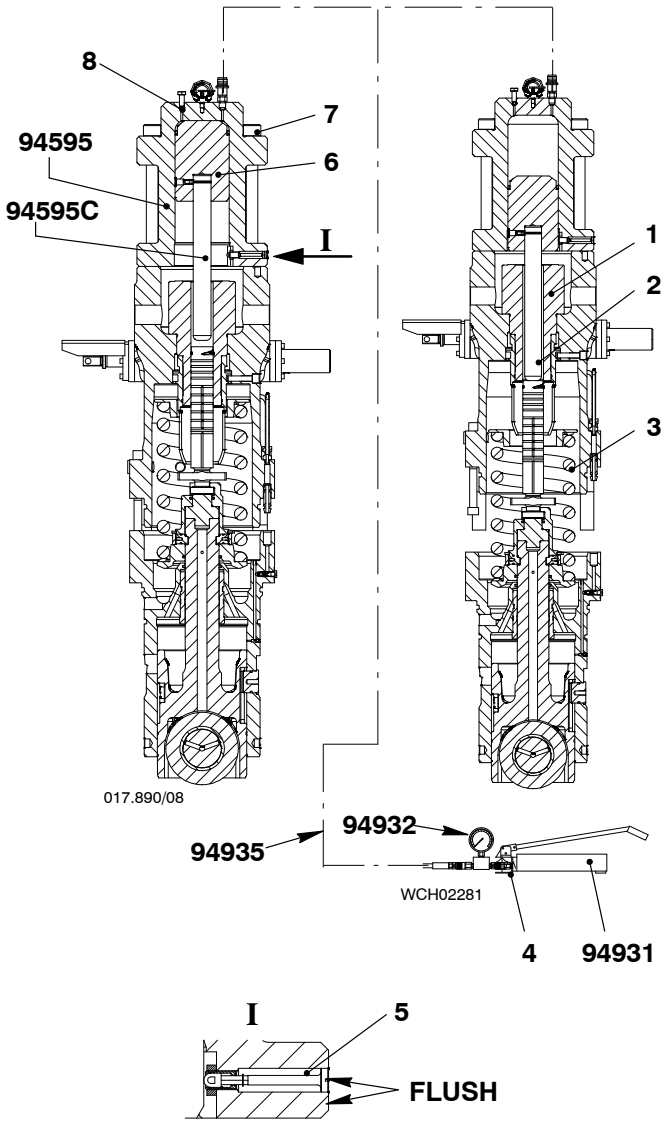


Fig. 5

5. Removal with Tool 94595C

1) Remove the short push rod (94595B) from the hydraulic ram (94595).
2) Put the long push rod (94595C, Fig. 5) into the hydraulic ram (94595).
3) Install the hydraulic ram (94595) to the fuel pump (refer to paragraph 3).
4) Connect the hydraulic ram (94595) to the HP oil pump.
5) Close the relief valve (4).
6) Open the vent screw (8).
7) Operate the HP oil pump until oil that has no air flows from the vent screw (8).
8) Close the vent screw (8).

Note: During the step below, make sure that you keep a clearance of between 10 mm and 15 mm between the nuts (3, Fig. 3 view II–II) and the bottom housing (4).

9) Operate slowly the HP oil pump until:
   - The compression spring (3, Fig. 5) pushes the plunger (2) out of the cylinder (1), or
   - The indicator (5) is flush with the housing. (This shows that the piston is at the end of its stroke.)
10) Remove the screws (7).
11) Remove the hydraulic ram.
12) Remove the plunger (2).
13) Continue to disassemble the fuel pump, refer to 5556–1 paragraph 3.

Fuel Pressure Control Valve
Removal, Check, Installation

Tools:

1	HP oil pump	94931	1	HP hose	94935
1	Pressure gauge	94934A	1	PCV test block with tube	94556

1. General

To prevent failure of the pressure control valve (PCV), WinGD recommends that you only do the procedures that follow:

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

For the maintenance intervals of the PCV, refer to the Maintenance Schedule 0380–1, PCV.

To do a check the fuel overpressure safety valve (6, Fig. 1), refer to 5562–2.

2. Preparation

WARNING

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

WARNING

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

1) Stop the engine, refer to the Operation Manual, 0310–1.
2) Release the pressure in the fuel rail. Do the procedure given in the Operation Manual 0515, paragraph 5.3.
3) Make sure that the work area is clean.

3. Removal

1) Make sure that the fuel rail (4, Fig. 1) has no pressure.
2) Disconnect the electrical connection from the solenoid valve (2).
3) Loosen the angle union (7), then remove the fuel return pipe (5) from the PCV (1).
4) Remove the four screws (8).
5) Remove the PCV (1) from the valve block (3).
6) Put protection on the valve block (3) to prevent contamination.

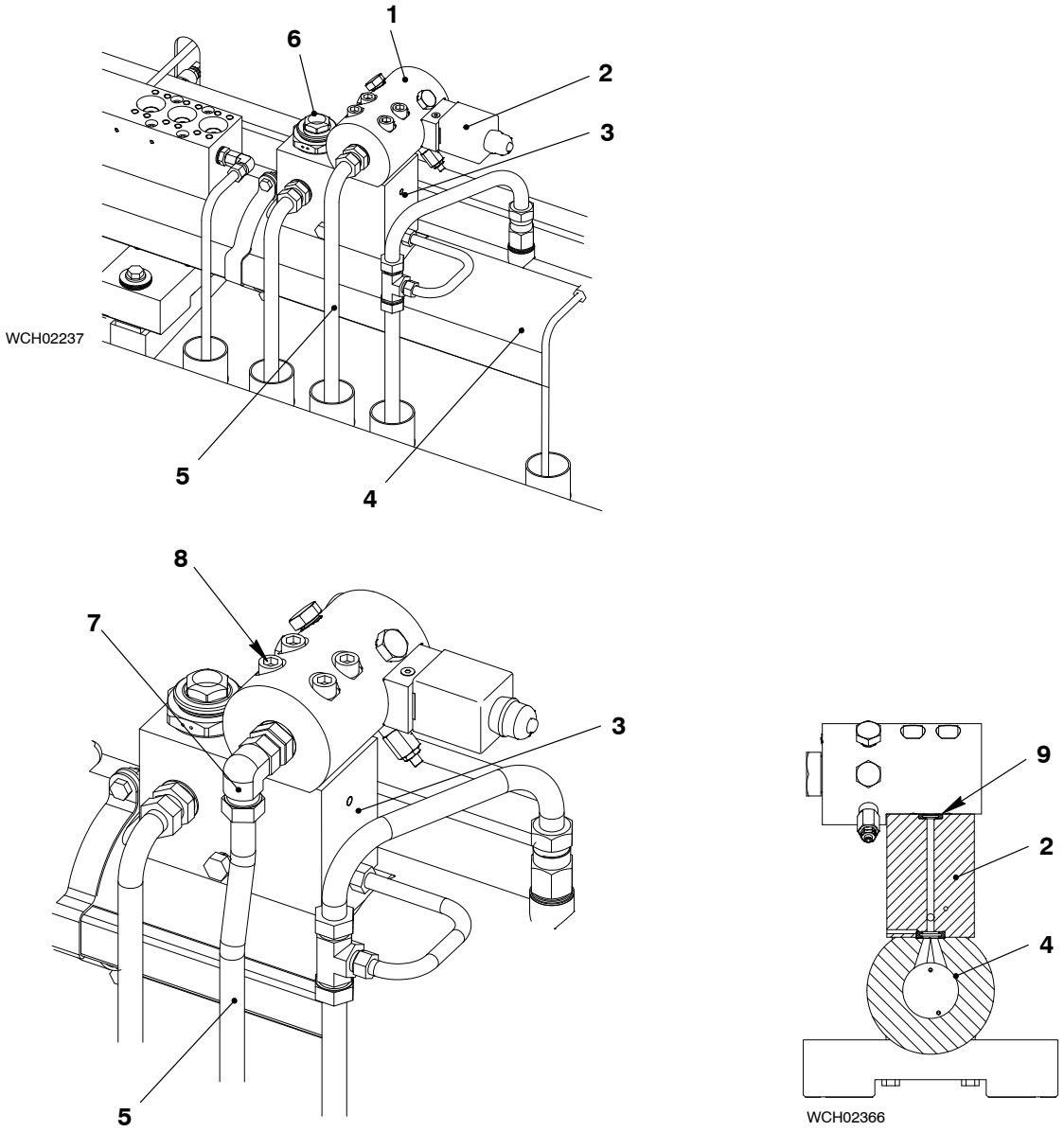


Fig. 1

4. PCV Check

4.1 Preparation

1) Put protection (6, Fig. 2) around the PCV test block (94556).
2) Put the test block (94556) in a bench vice.
3) Make sure that the sealing surfaces of the PCV and the test block (94556) are clean and have no damage.
4) Put the PCV in position on the test block (94556).
5) Put oil on the threads of the four screws (1).
6) Put the four screws (1) in position in the PCV.
7) Tighten the screws in the sequence given in view I as follows:
   a) Tighten the screws with your hand.
   b) Torque the screws to 80 Nm.
   c) Torque the screws to 190 Nm.
8) Attach the flexible tube (a part of the test block 94556) to the PCV outlet (2). Put the other end of the flexible tube into an applicable container (3).
9) Connect the HP oil pump (94931), pressure gauge (94932) and HP hose (94935) to the test block (94556).
10) Identify each of the two pressure control set screws.
11) On the setpoint adjustment valve (SAV) (7), loosen the locknut.
12) Fully loosen the SAV (7).

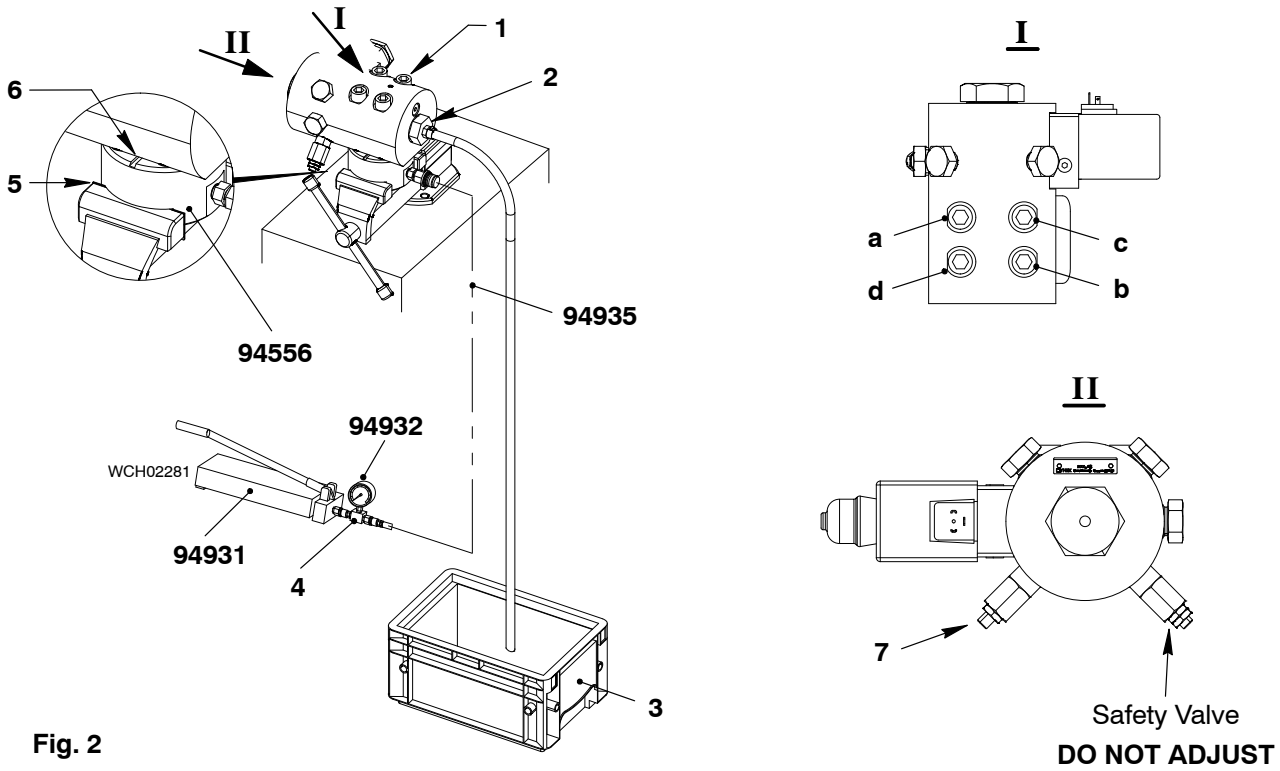


Fig. 2

4.2 Adjustment Procedure

CAUTION

Damage Hazard. Do not connect the solenoid valve. Damage to the PCV can occur.

1) Operate the HP oil pump (4, Fig. 2).
2) Tighten the SAV (7) to get a value of 100 bar.
3) Do a check for leaks.

Note: If oil flows into the groove (5) the PCV has a leak, or the O-ring in the tool (94556) has damage.

4) Continue to tighten the SAV (7) and do checks for leaks at the same time.
5) Adjust the SAV (7) until the PCV opens at 1050 bar.
6) On the SAV (7), tighten the locknut.
7) On the HP oil pump (94931), open the relief valve (4) to decrease the pressure to zero.

4.3 Setpoint Check

1) On the HP oil pump (94931), close the relief valve (4).
2) Operate the HP oil pump (94931).
3) Make sure that the PCV opens at 1050 ± 30 bar.
4) If the PCV opens at less than 1020 bar or more than 1080 bar, do the procedure in paragraph 4.2 again.

Note: If the PCV does not open at less than 1300 bar or opens at less than 1020 bar (when the SAV (7) is fully closed), the PCV has a malfunction. You must find and repair the malfunction before you install the PCV.

5) On the HP oil pump, open the relief valve (4) to decrease the pressure to zero.
6) Disconnect the flexible tube from the PCV outlet (2).
7) Disconnect the HP hose (94935) from the tool (94556).
8) Remove the four screws (1) from the PCV.
9) Remove the PCV from the bench vice.

5. Installation

1) Do a check of the lip seal (9, Fig. 1). Replace the lip seal if necessary.
2) Remove the protection from the valve block (3).
3) Make sure that the sealing surfaces of the PCV and the valve block (3) are clean and have no damage.
4) Put the PCV in position on valve block (3).
5) Put oil on the threads of the four screws (1).
6) Put the four screws (1) in position in the PCV.
7) Tighten the screws in the sequence given in Fig. 2, view I as follows:
   a) Tighten the screws with your hand.
   b) Torque the screws to 80 Nm.
   c) Torque the screws to 190 Nm.
8) Attach the fuel return pipe (5, Fig. 1) to the PCV (1).
9) Tighten the angle union (7).
10) Connect the electrical connection to the solenoid valve (2).

Intentionally blank

Fuel Pressure Control Valve: Manual Release Valve – Clean

1. General

If the pressure control valve does not close correctly, do the procedure given in paragraph 2.

2. Procedure

2.1 Disassemble

Note: It is not necessary to remove the PCV (1, Fig. 1) from the fuel rail (2) to do this procedure.

Note: For the full PCV overhaul instructions, speak to or send a message to WinGD.

1) Stop the engine

2) Make sure that the PCV (1) is open.

Note: If HFO is used, the drain port will be hot when the PCV is open.

3) Operate the pressure release button more than two times to release pressure.

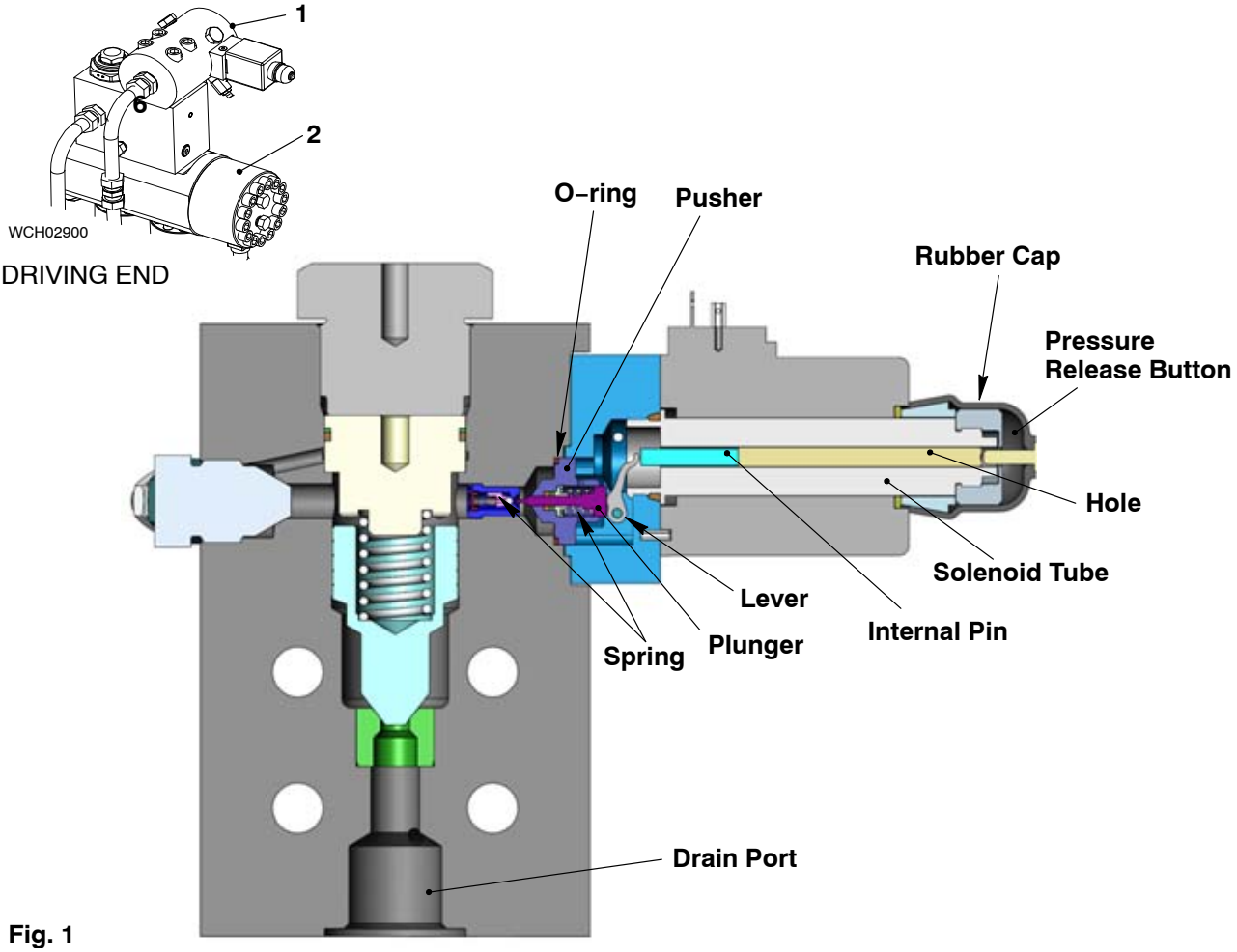


Fig. 1

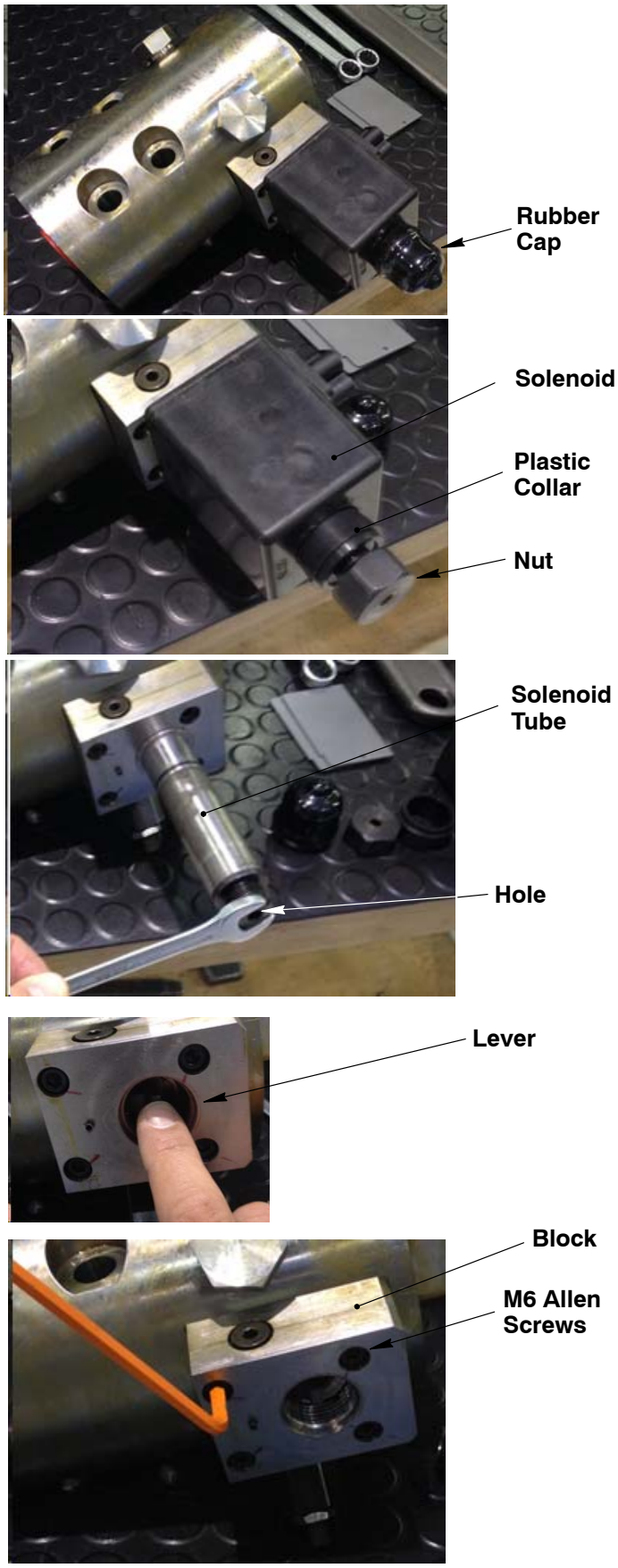


Fig. 2

4) Carefully remove the rubber cap (Fig. 2).

5) Record the installed position of the plastic collar.

6) Remove the nut, plastic collar and solenoid.

7) Remove the solenoid tube.

8) Use your finger to push the lever. Make sure that you can feel two different spring tensions.

Note: If the valve closes and you can get rail pressure, it is not necessary to continue the procedure. Refer to paragraph 2.3, step 5) to step 9) to assemble the PCV.

CAUTION

Injury Hazard: Make sure that there is no pressure in the fuel rail or the drain side of the system. High pressure fuel can cause injury to personnel.

9) Remove the four Allen screws from the block.

10) Remove the block.

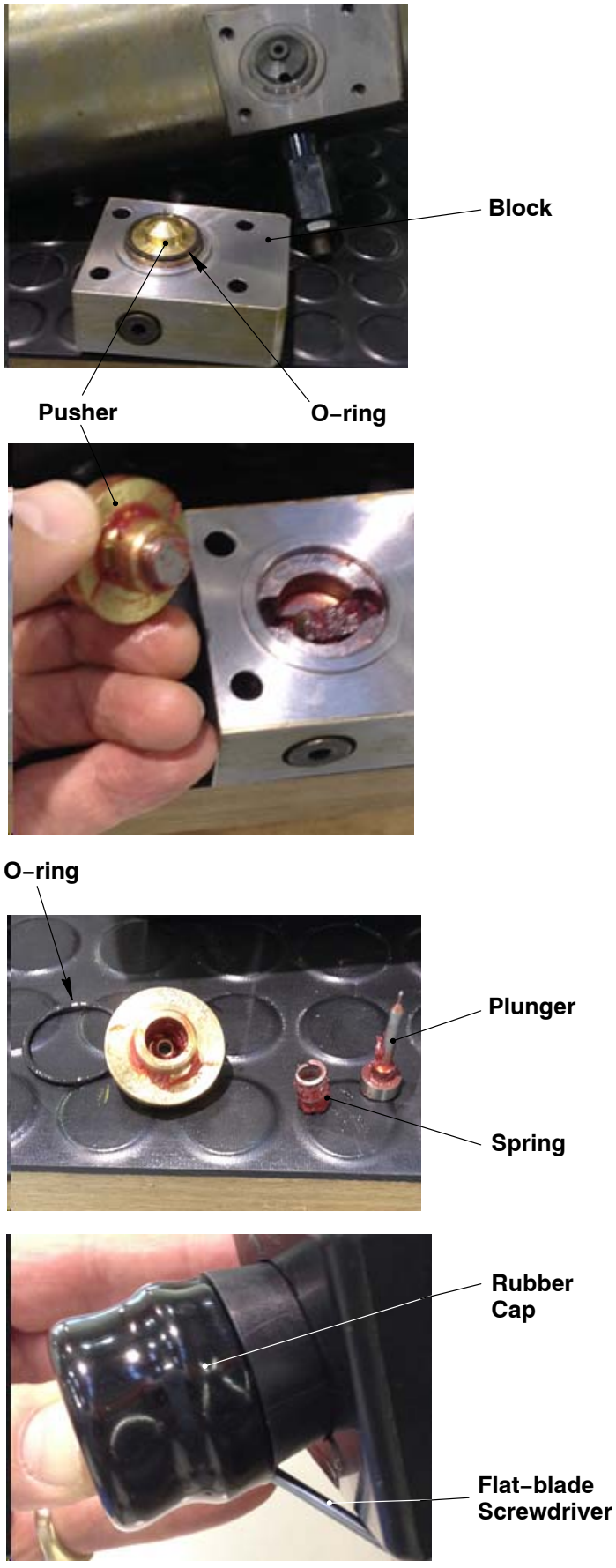


Fig. 3

11) Carefully remove the pusher (Fig. 3).

Note: It is possible that the pusher will stay on the PCV body.

12) Remove the plunger and spring from the PCV.

2.2 Clean and Apply NeverSeez

1) Remove the grease from all components (pusher, plunger, spring and O–ring).
2) Apply a thin layer of NeverSeez to all components (plunger, spring and pusher.
3) Put NeverSeez into the hole in the solenoid tube (see Fig. 1 and Fig. 2).
4) Push the internal pin in and out with your hand to apply the NeverSeez.

2.3 Assemble

1) Put the plunger and spring into the pusher assembly.
2) Put the O–ring and pusher in position in the block.
3) Attach the valve block to the PCV with the four M6 Allen screws.
4) Torque the for M6 Allen screws to 15 Nm.
5) Attach the solenoid tube to the valve block.
6) Put the solenoid in position on the valve block.
7) Put the thick part of the collar against the solenoid.
8) Attach the nut to the solenoid. Tighten the nut.

Note: During step 9), hold in the pusher with your hand to help you attach the rubber cap (Fig. 3).

9) Use a small flat–blade screwdriver to attach the rubber cap over the plastic collar.

Intentionally blank

Work Card
Fuel Overpressure Safety Valve

Necessary Conditions

– Engine stopped
– The fuel rail must have no pressure

Necessary Spare Parts

Not applicable

Preparation

Read the data in the instructions from the manufacturer about the specifications of the test bench.
Attach / connect the applicable equipment to the fuel overpressure safety valve

Tools and Consumables

HP oil pump	94931	Qty 1
Valve holder	94272A	Qty 1
Hydraulic unit	94942	Qty 1
Adapter piece	94234F	Qty 1
Adapter piece	94234A	Qty 1
Pressure gauge	94934A	Qty 2
HP hoses	94935	Qty 2

AF80 spanner
Calibration fluid S.9365

Primary Task

Do a check of the function on the test bench, refer to 5562–2/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

None

Intentionally blank

Fuel Overpressure Safety Valve
Removal, Check, Installation

Tools:

1	HP oil pump	94931	2	Pressure gauge	94934A
1	Adapter piece	94234F	2	HP hoses	94935
1	Adapter piece	94272A	1	Valve holder	94273
1	Hydraulic unit (optional)	94942			

1. General

Maintenance of the relief valve (1, Fig. 1) is not usually necessary, but you must do a function check at regular intervals. Refer to the Maintenance Schedule 0380–1 Relief Valve for the frequency to do the function test. Unserviceable relief valves must be sent to the manufacturer, or to a WinGD authorized repair workshop for inspection and repair.

The International Association of Classification Societies (IACS) approval is given for:

- The type of test
- The type of certificate
- The frequency of the test.

The results of the test must be recorded on the Inspection Report.

Note: The two bores (2) identify the relief valve (1) as a new item.

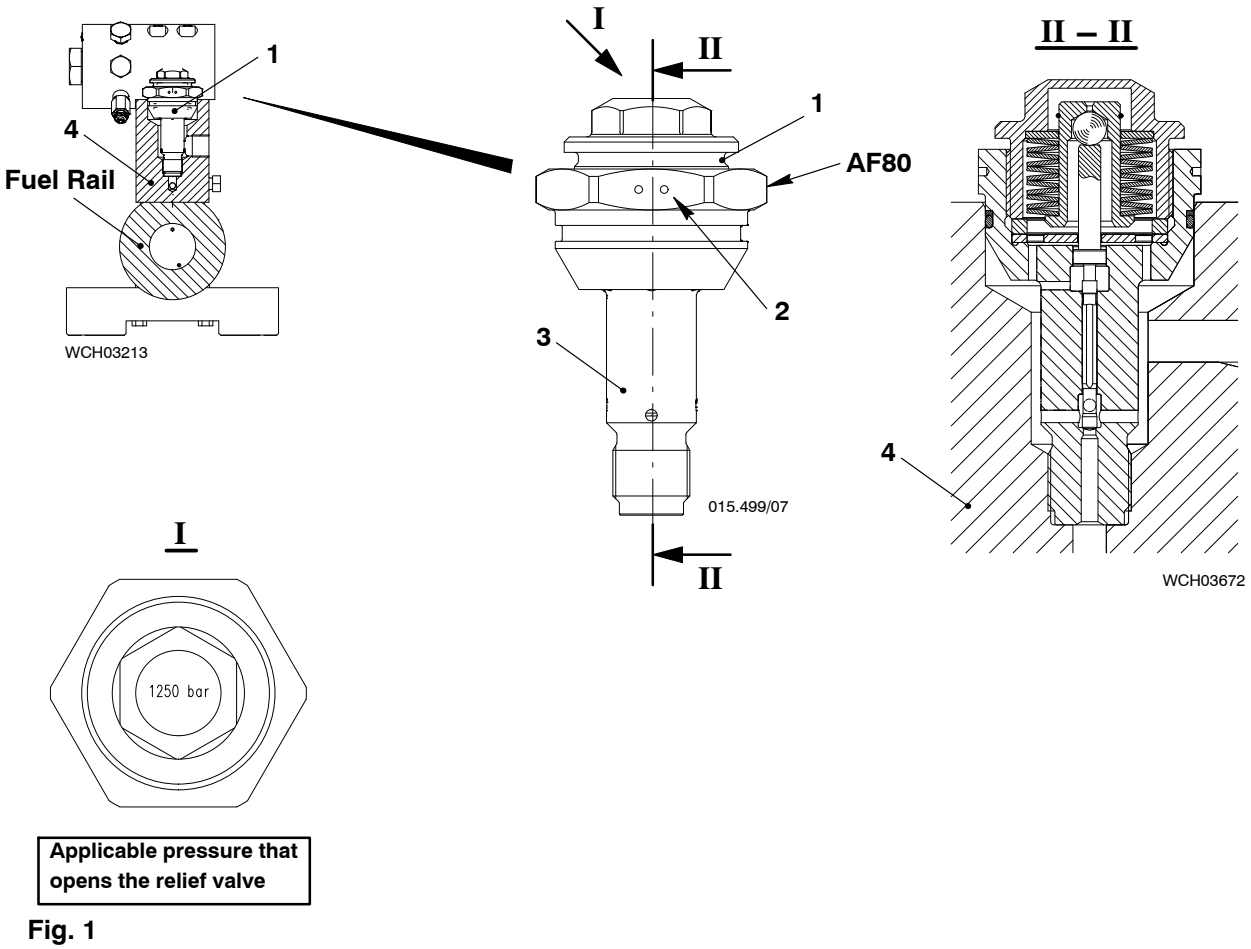


Fig. 1

2. Removal

1) Stop the engine (refer to the Operation Manual 0310–1).
2) Make sure that the fuel rail has no pressure.
3) Use a spanner (AF80, Fig. 1) to remove the relief valve (1) from the connecting piece (4).

3. Relief Valve Test

3.1 Test and Calibration Fluid – Physical Conditions

You use the test bench (94272) and the test and calibration fluid (e.g. Shell Calibration Fluid S.9365) to do a test of the relief valve. Table 1 gives the mandatory data for the test and calibration fluid.

Table 1

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

3.2 Preparation

Note: Read the data in the instructions from the manufacturer about the specifications of the test bench.

1) Put the relief valve (1, Fig. 2) in the valve holder (94272A).
2) Tighten the relief valve (1).
3) Connect the valve holder (94272A) to the HP oil pump (94931) or the hydraulic unit (94942).
4) Close the valve (3).

3.3 Sealing Pressure Check

1) Operate the HP oil pump (94931) to increase the pressure to 1150 bar.
2) Keep the pressure constant for one minute.
3) Make sure that there are no leaks.

3.4 Operation Pressure Check

1) Operate the HP oil pump to increase the pressure until the relief valve (1) opens.
2) Make sure that the relief valve opens at between 1200 bar and 1350 bar (1250 bar +100, –50 bar).
3) Operate the valve (3) to release the pressure in the HP hoses (94935).
4) Remove the relief valve (1) from the valve holder (94272A).

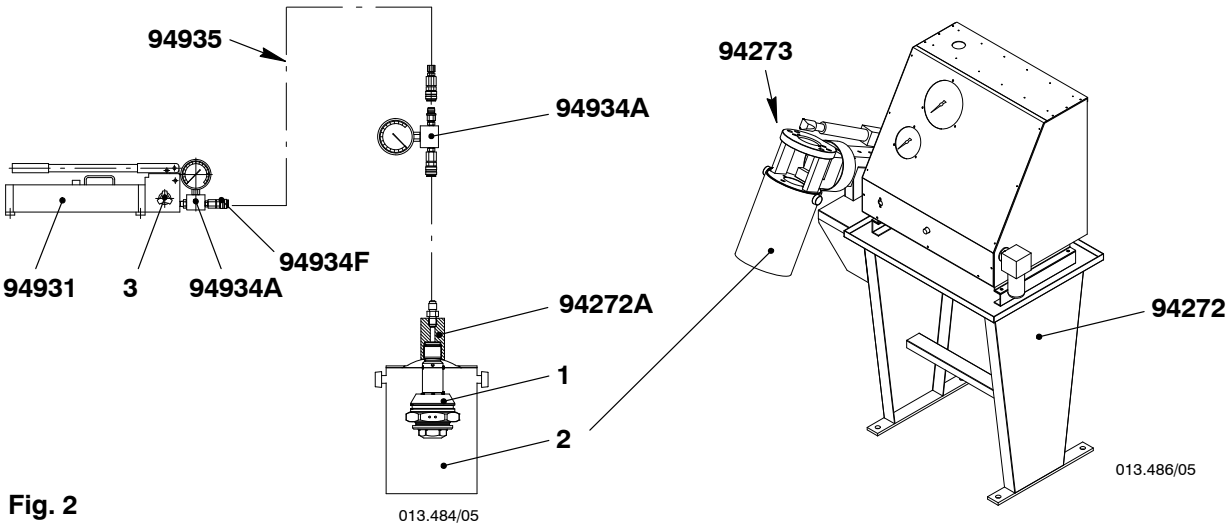


Fig. 2

4. Installation

1) Apply Never-Seez NSBT to the thread of valve housing (2, Fig. 3).
2) Install the relief valve (1) in the connecting piece (3).
3) Torque the relief valve (1) to 300 Nm.

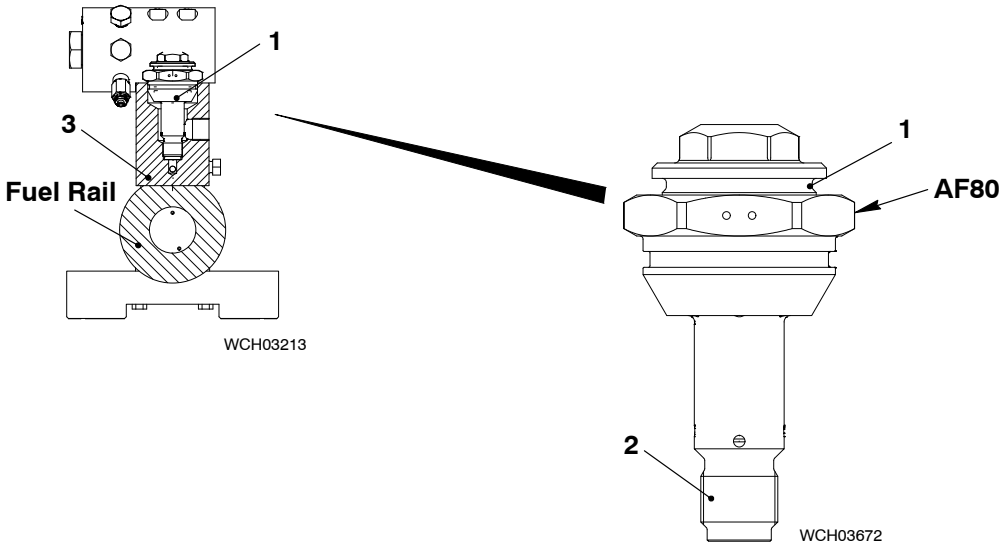


Fig. 3

Intentionally blank

Flow Limiting Valve
Removal and Installation

Tools:

No special tools
are necessary

1. General

It is possible to do the maintenance on a flow limiting valve (FLV) on board. Speak to, or send a message to WinGD to get a repair kit and instructions.

Approved personnel only are permitted to do maintenance on an FLV. If there are no approved personnel, send the FLV to a WinGD service station for overhaul.

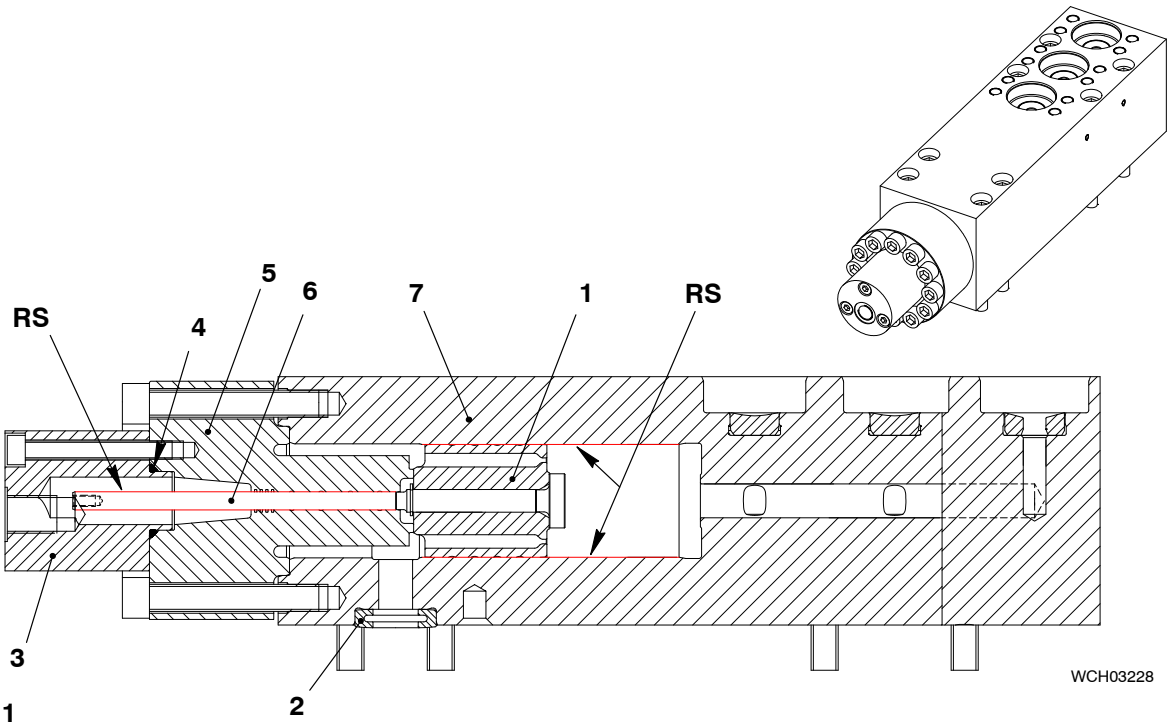


Fig. 1

Fig. 3: Flow Limiting Valve

1 Piston
2 Lip seal
3 Cover
4 O-ring
5 Flange
6 Piston rod
7 Valve block
RS Running surface

2. Preparation

WARNING

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

WARNING

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

WARNING

Injury Hazard: Do not operate the turning gear. Fuel can come out of the opening in the fuel rail and cause injury.

1) Stop the engine, refer to the Operation Manual, 0310–1.
2) Cut out the injection, refer to the Operation Manual, 0510–1.
3) Let the engine temperature decrease.
4) Let the pressure in the fuel rail decrease to zero.
5) Make sure that the fuel injection system has no pressure.
6) Make sure that all tools and equipment are clean and in good condition.

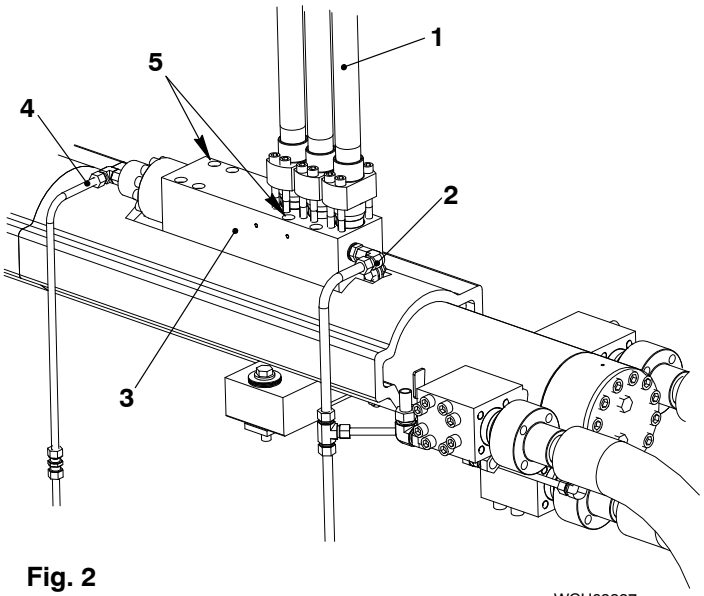


Fig. 2

7) Clean the work area adjacent to the FLV (3, Fig. 2).
8) Remove the HP fuel pipes (1), refer to 8733–1, paragraph 1 and paragraph 2.
9) Remove the leakage pipes (2, 4) from the flow limiting valve (3).
10) Apply protection to the openings on the FLV.
11) Apply protection to the open ends of the pipes (1, 2 and 4).

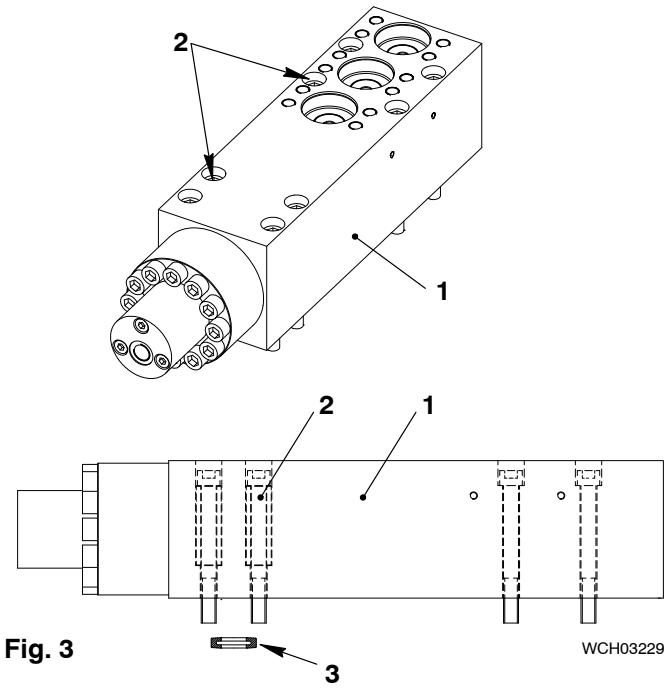


Fig. 3

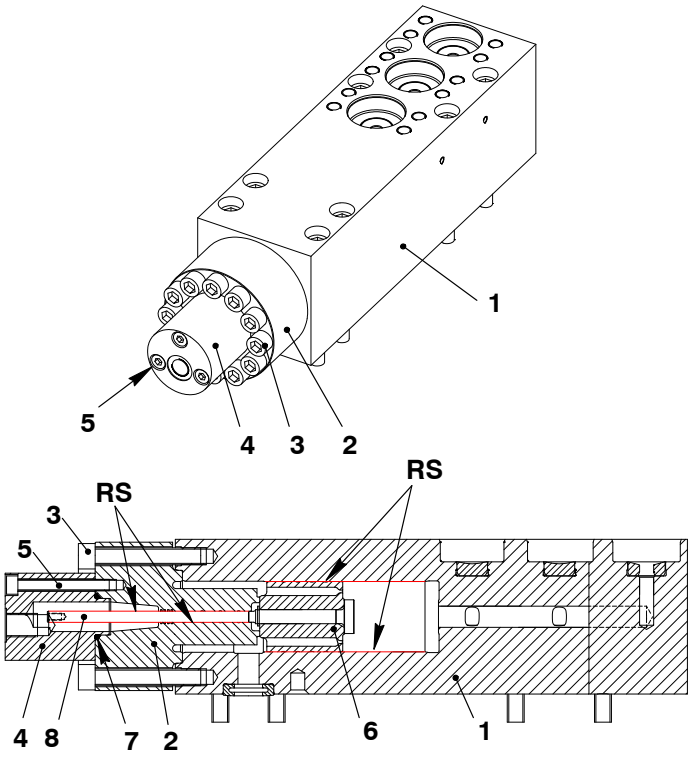


Fig. 4

3. Removal

CAUTION

Injury Hazard: The weight of the FLV is approximately 39 kg. Use the correct equipment, or two persons, to lift and move the FLV. This will prevent injury to personnel.

1) Remove the eight bolts (2, Fig. 3) from the FLV (1).
2) Lift the FLV.
3) Remove the lip seal (3). Make sure that you do not damage the lip seal.
4) Put the lip seal (3) in a safe area.
5) Make sure that the dowel pins stay in the fuel rail.
6) Lower the FLV (1) on to an applicable clean surface.

4. Disassemble

1) Remove the three bolts (5, Fig. 4) and the cover (4).
2) Remove the twelve bolts (3).
3) Carefully remove the flange (2) together with the piston rod (8) and the piston (6).
4) Remove the piston (6) together with piston rod (8) from the flange (2).
5) Use ScotchBrite™ and a cleaning solvent e.g, Neoval®, WD40® etc to clean the piston rod (8) and piston (6).
6) Put the piston rod (8) and piston (6) in the flange (2). If the piston rod does not freely move, clean the piston and piston rod again.
7) Examine the running surfaces (RS) of piston rod (8), flange (2), piston (6) and valve block (1).
8) Speak to, or send a message to WinGD for replacement parts and instruction. If necessary, send the FLV to a WinGD Service Station for an overhaul.

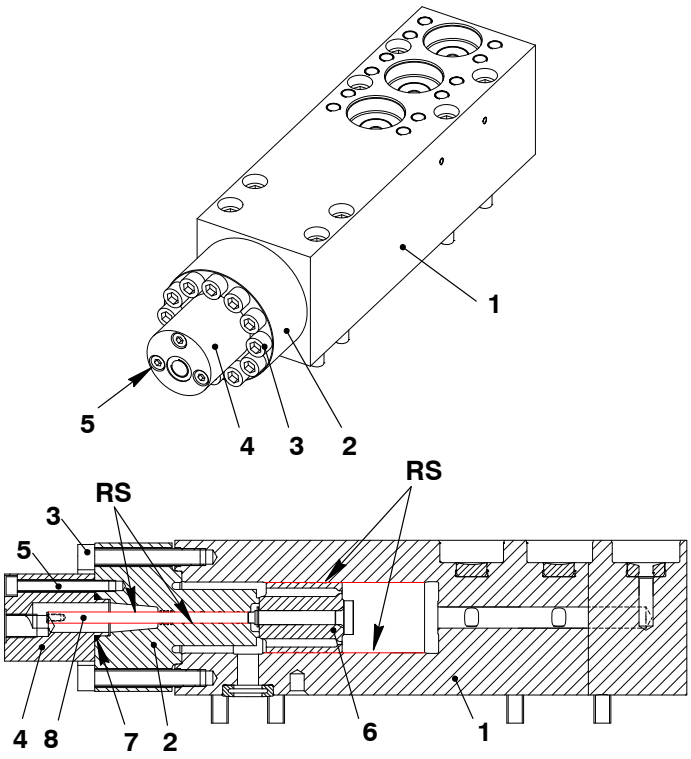


Fig. 5

5. Assemble

1) Clean all parts and running surfaces (RS, Fig. 5).
2) Apply lubricating oil to all running surfaces (RS).
3) Put the piston rod (8) together with the piston (6) into to flange (2). Make sure that the piston rod moves easily.
4) Put the piston (6) together with the flange (2) into the valve block (1).
5) Apply Never Seez NSBT to the threads and surfaces of the twelve bolts (3).
6) Tighten equally the twelve bolts (3) with your hand. Make sure that the twelve bolts turn easily.
7) Torque symmetrically the twelve bolts (3) to 60 Nm.
8) Put a new O-ring (7) on the cover (4).
9) Attach the cover (4) to the flange (2) with the three bolts (5).

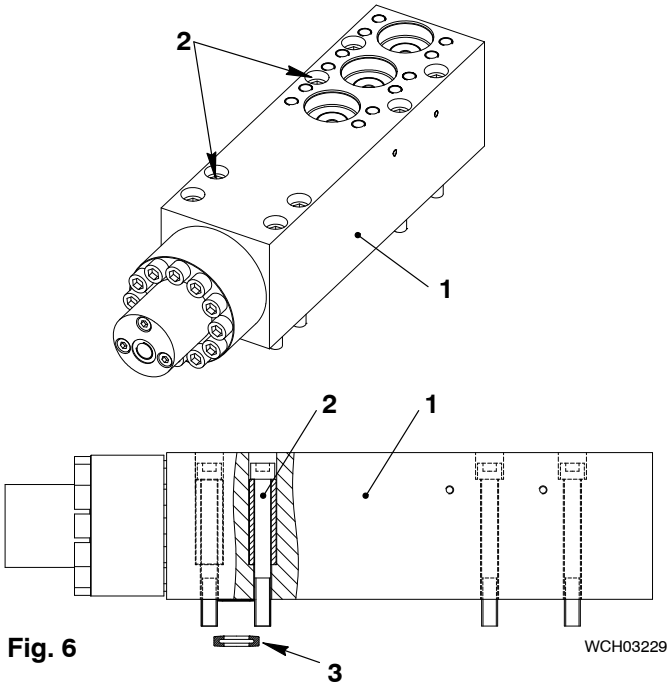


Fig. 6

6. Installation

1) Make sure that the dowel pins are in the fuel rail.
2) Clean the sealing surface in the valve block (1, Fig. 6) and the lip seal (3). It is recommended that you install a new lip seal.
3) Install the lip seal (3).
4) Clean the related surfaces on the fuel rail and the valve block (1).
5) Carefully put the FLV in the correct position on the fuel rail.
6) Apply Never Seez NSBT to the threads and surfaces of the eight bolts (2).
7) Put in the eight bolts (2) together with distance sleeves into the valve block
8) Tighten equally the bolts (2) with your hand.
9) Torque symmetrically the eight bolts (2) to 60Nm.

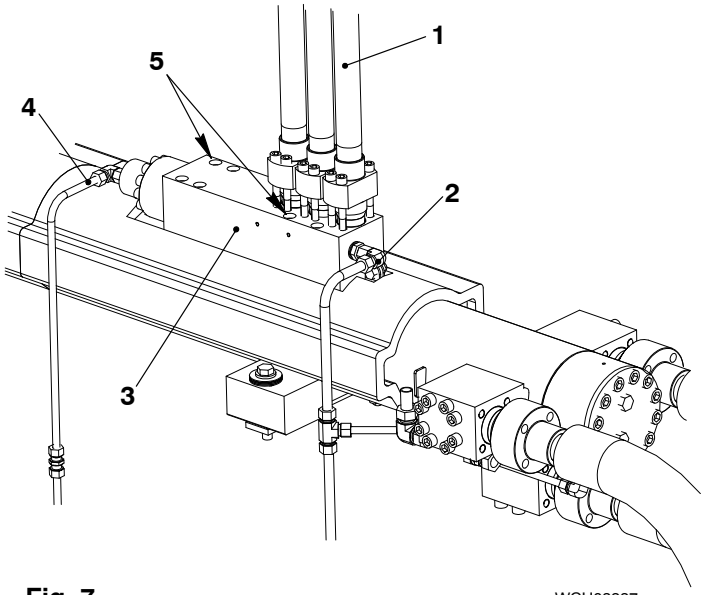


Fig. 7 WCH03227

7. Completion

1) Install the leakage pipes (2 and 4, Fig. 7) to the FLV (3).
2) Install the HP fuel pipes (1), refer to 8733–1, paragraph 4.
3) Cut in the injection, refer to the Operation Manual, 0510–1.
4) Operate the engine for a minimum of one hour with marine diesel oil. For more data, refer to the Operation Manual 0510–1.

8. Storage

Before you put an FLV into storage, do the procedure that follows:

1) Use a vacuum cleaner to remove dirt from all openings.
2) Clean the FLV.
3) Lubricate correctly the FLV.
4) Put the FLV in a plastic bag.
5) Remove as much air as possible from the plastic bag.
6) Seal the plastic bag.

Intentionally blank

Work Card
Flow Limiting Valve (FLV): Inspection

Necessary Conditions

– Engine stopped
– engine temperature must be at ambient
– Fuel rail pressure must be zero
– Fuel injection system pressure must be zero
– All tools and equipment must be clean
– The work area must be clean

Necessary Spare Parts

Not applicable

Preparation

Cut out the injection, refer to Operation Manual, refer to 0310–1.
Remove the applicable HP fuel pipes, refer to 8733–1
Remove the leakage pipes from the FLV
Remove the FLV, refer to 5562–3/A1

Tools and Consumables

No special tools are necessary

ScotchBrite™
Cleaning solvent
O-ring
Never Seez NSBT
Lubricating oil

Primary Task

Do an inspection, clean the piston rod and piston running surface

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Install the FLV,

Intentionally blank

Work Card
Flow Limiting Valve (FLV): Replace

Necessary Conditions

– Engine stopped
– engine temperature must be at ambient
– Fuel rail pressure must be zero
– Fuel injection system pressure must be zero
– All tools and equipment must be clean
– The work area must be clean

Necessary Spare Parts

Flow limiting valve	EX 55720	Qty 1

Preparation

Cut out the injection, refer to Operation Manual, refer to 0310–1.
Remove the applicable HP fuel pipes, refer to 8733–1
Remove the leakage pipes from the FLV
Remove the FLV, refer to 5562–3/A1

Tools and Consumables

No special tools are necessary

ScotchBrite™
Cleaning solvent
Never Seez NSBT
Lubricating oil

Primary Task

Replace the FLV, refer to 5562–3/A1

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	4.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

None

Intentionally blank

Work Card
Exhaust Valve Control Unit (VCU): Check

Necessary Conditions

– Engine stopped
– Servo oil rail pressure must be zero

Necessary Spare Parts

Not applicable

Preparation

Remove the applicable hydraulic pipe, refer to 8460–1
Disassemble the VCU, refer to 5612–1/A1

Tools and Consumables

Not applicable

Primary Task

Do a check of the piston and slide rod

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Service Engineer	3.0 hours	Qty 1
Ship Engineer	3.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Assemble and install the VCU, refer to 5612–1/A1

Intentionally blank

Work Card

Exhaust Valve Control Unit (VCU): Replace the solenoid valve

Necessary Conditions

– Engine stopped

Necessary Spare Parts (each cylinder)

Spare kit O-rings	EX 96191	Qty 1
Spare kit solenoid	EX 96192	Qty 1
Spare kit solenoid connector	EX 96193	Qty 1

Preparation

None

Tools and Consumables

Not applicable

Primary Task

Replace the 4/2-way solenoid valve on the exhaust valve control unit

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

None

Intentionally blank

Supply Unit

Camshaft and Bearing Shells – Removal and Installation

Tools:

2	Pre-tensioning jacks	94557	1	Screwjack	94567B
2	Support	94566	1	Connection block	94934
1 or 2	Holders	94566B	1	Pressure gauges	94934A
1	Holder	94566C	3	HP hoses	94935
1	Assembly template	94567	1	Hydraulic unit	94942
1	Assembly template	94567A			

1. Preparation

1) Remove the covers (3, 4, 5 and 6, Fig. 1) from the housing (2).

2) Remove the fuel pumps (1) refer to 5556–1, paragraph 1 and paragraph 2. As an alternative, lift the rollers (refer to step 3) and step 4).

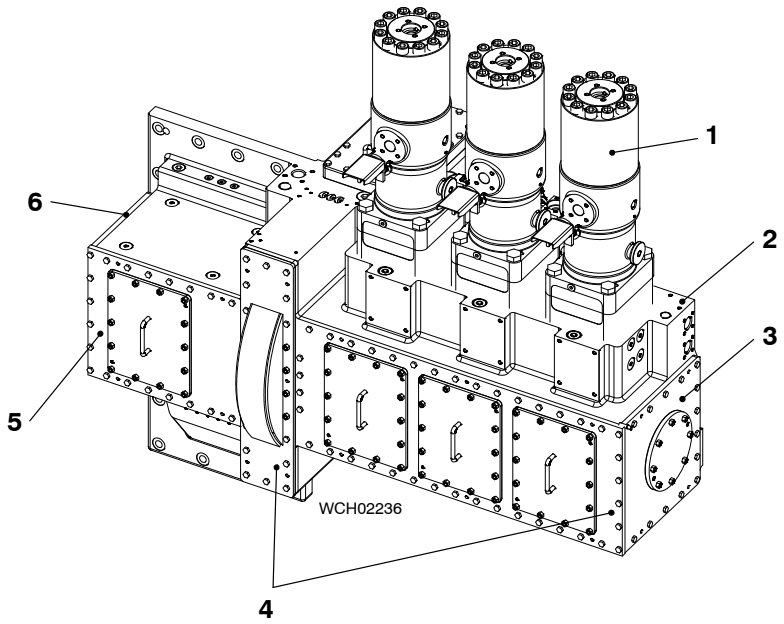


Fig. 1

3) Make sure that the bearing covers at positions No. 3, No 4 and No. 5 Fig. 2 and the housing (1), have marks to identify them as a set.

Note: The bearing at position No. 2 has the two thrust bearing ring halves (3).

4) Install the holders (94566B, 94566C) to lift the rollers and guide pistons of the fuel pumps.

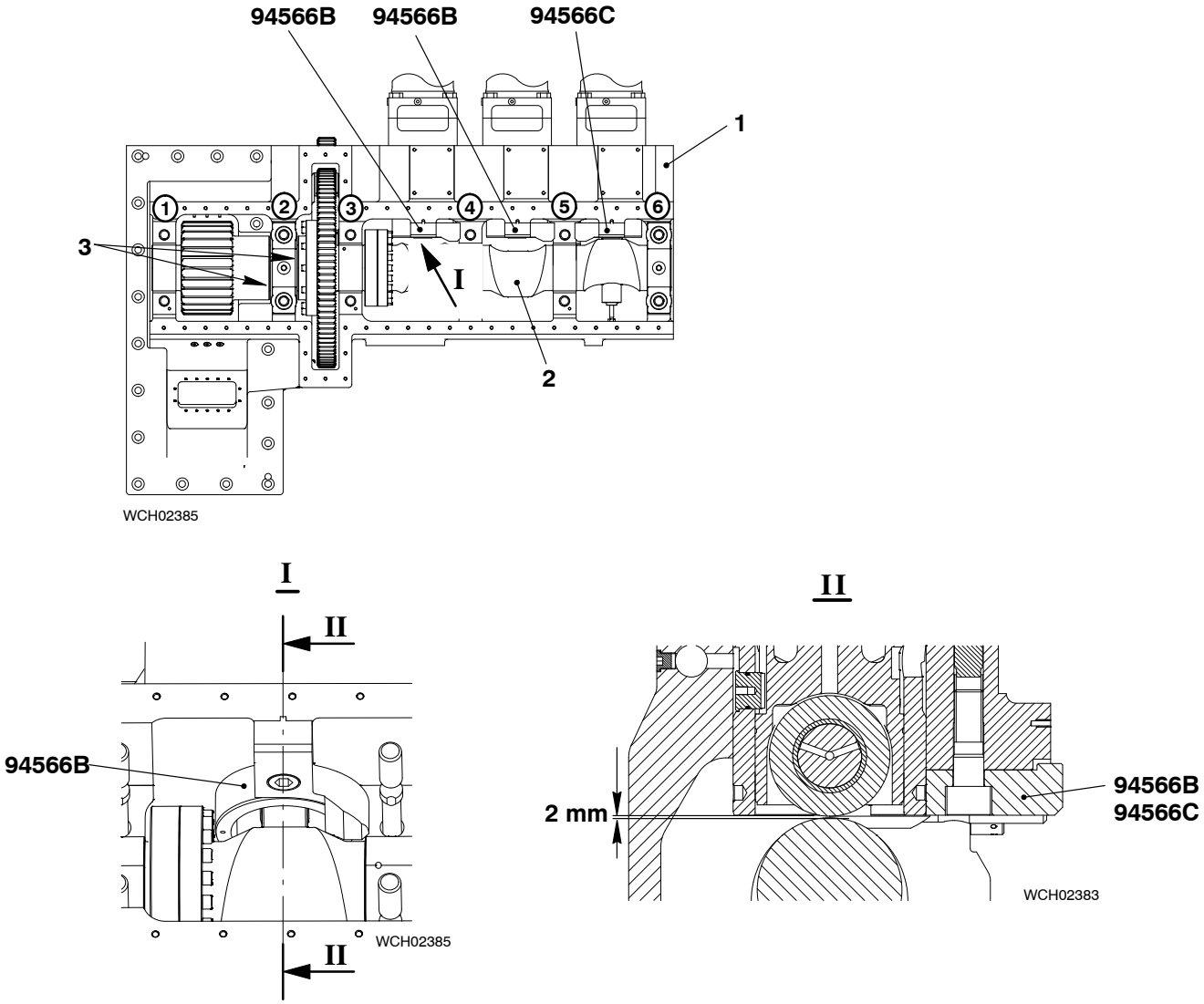


Fig. 2

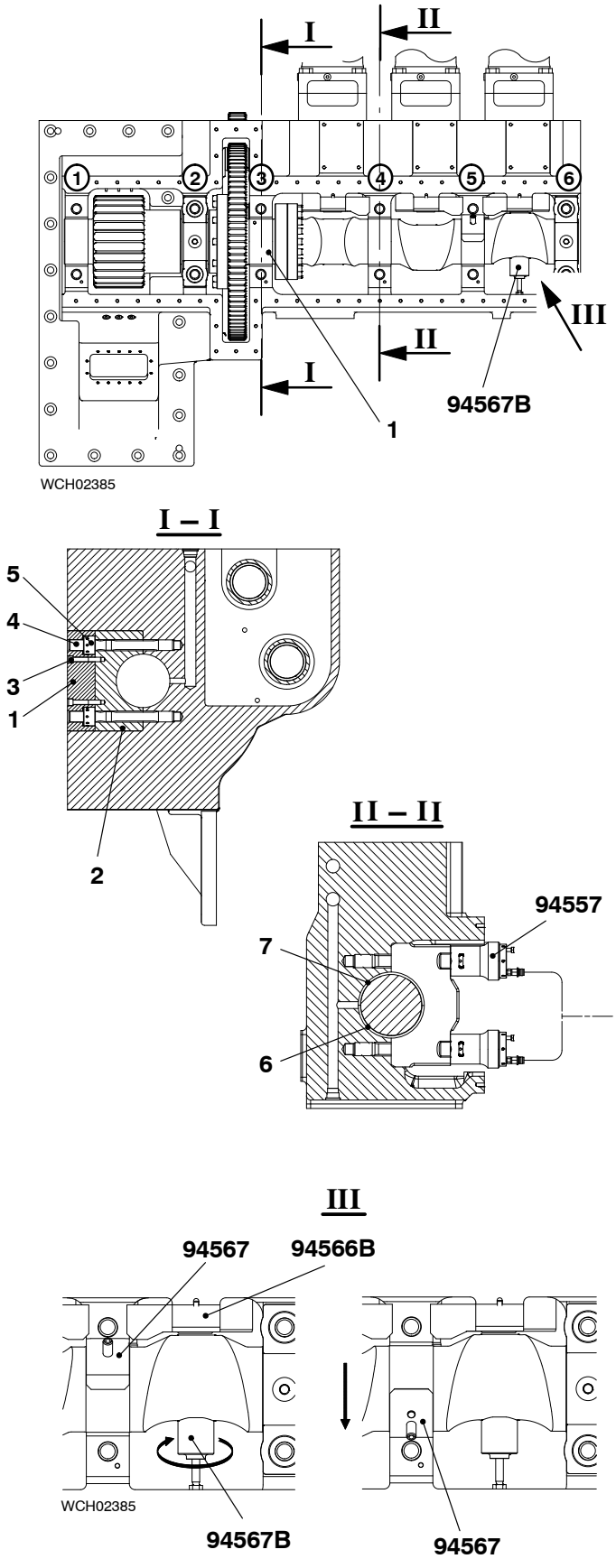


Fig. 3

2. Bearing Shells – Removal

1) Loosen the two Allen screws (3, Fig. 3) and remove the filling piece (1) from bearing cover No.3.
2) Use the pre-tensioner (94557) to loosen the round nuts (5) of the bearing covers No.1, No.3, No.4 and No.5, refer to 9403–4.
3) Remove the round nuts (5) and the bearing covers No.1, No.3, No.4 and No.5.
4) Put the screwjack (94567B) in position under the last cam.
5) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm and 0.15 mm.
6) Put the assembly template (94567) in position on the top bearing shell (7) of bearing No.5 (see View III).
7) Use the assembly template (94567) to turn the top and bottom bearing shells (6, 7) 90° (see View III).

Note: If you cannot turn the bearing shells, adjust the screwjack (94567B) again.

8) Hold the top bearing shell (7), then remove the assembly template (94567).
9) Put marks on the top bearing shells to identify their positions. This will help you when you install the bearing shells.
10) Remove the top bearing shell (7).
11) Do step 3) to step 10) to remove the remaining top bearing shells at positions No.3 and No.5.

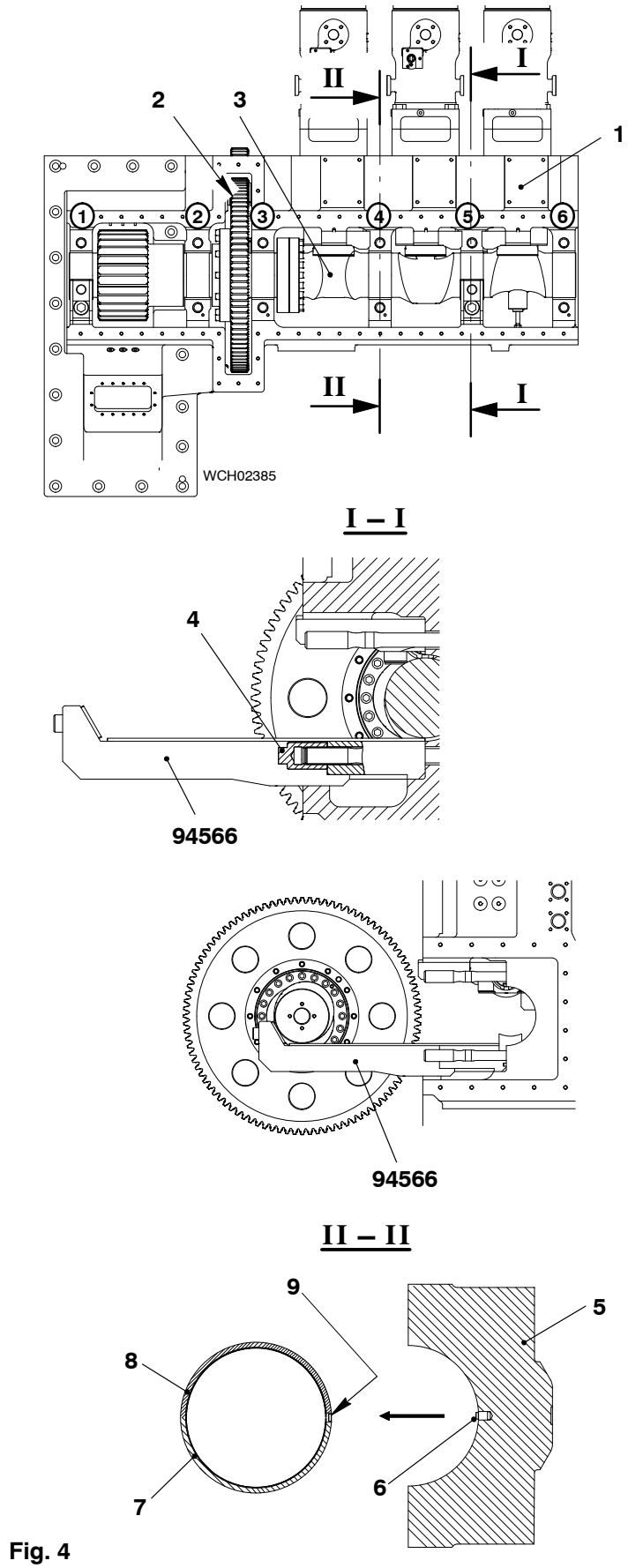


Fig. 4

3. Camshaft – Removal

1) Put the two supports (94566) in the positions at No.1 and No.5 (Fig. 4).
2) On the two supports (94566), tighten the nuts (4).
3) Make sure that the camshaft stays in position before you remove the last bearing cover.
4) Remove the remaining bearing covers and top bearing shells at positions No.2 and No.6 (see the procedure in paragraph 2, step 2) to step 11)).
5) Remove the screwjack (94567B, Fig. 3).
6) Carefully move the camshaft (3, Fig. 4) and the gear wheel (2) on to the two supports (94566).
7) Make sure that the camshaft (3) and gear wheel (2) do not move.
8) Make a mark on the remaining bottom bearing shells to identify their positions. This will help you when you install the bearing shells.
9) Remove the remaining bearing shells.

4. Camshaft and Bearing Shells – Installation

1) Make sure that all items are clean and do not have damage.
2) Apply oil to the bearing shells and the camshaft (3).
3) Put all bottom bearing shells into the casing in their correct positions. Refer to the marks you made before.
4) Put the camshaft (3) and gear wheel (2) in position on the two supports (94566).
5) Carefully move the camshaft (3) and the gear wheel (2) into the housing (1). Make sure that the bearing shells stay in position and do not fall.
6) Make sure the camshaft does not move.

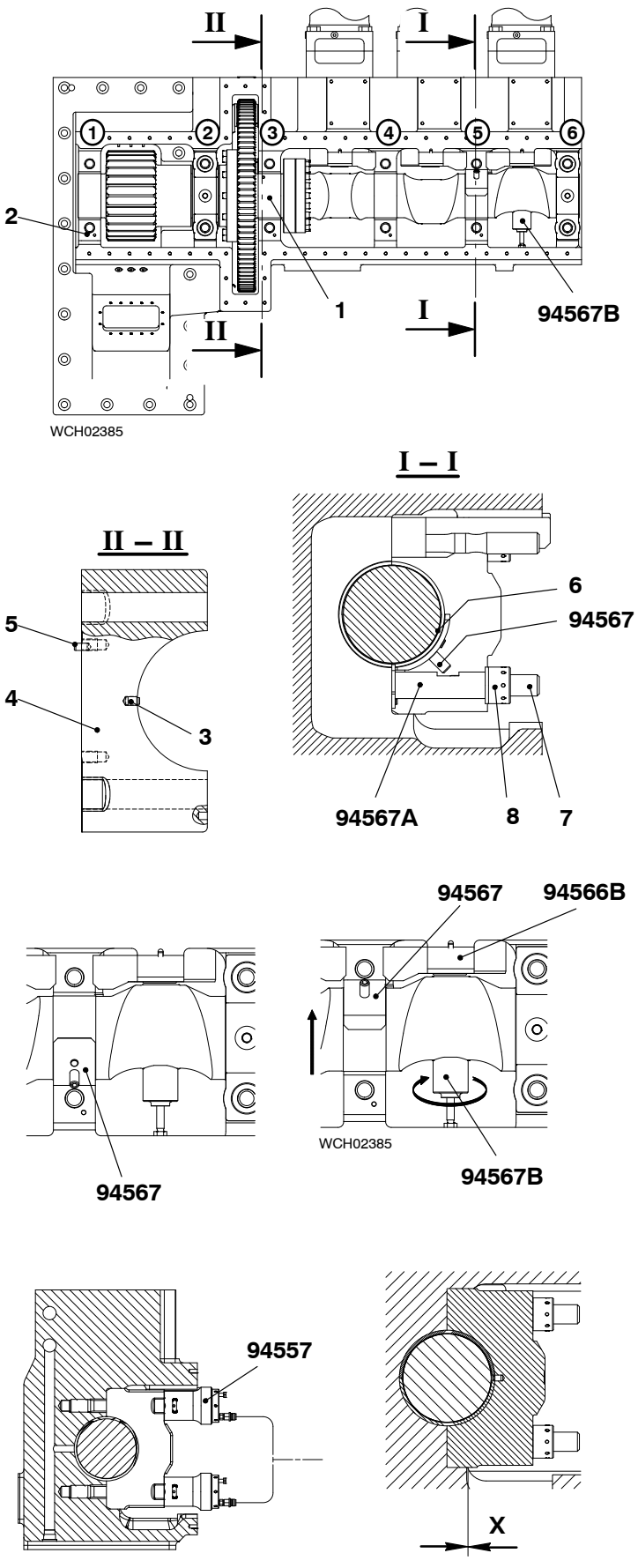


Fig. 5

7) Put the screwjack (94567B, Fig. 5) in position.
8) Turn the screwjack (94567B) to lift the camshaft between 0.05 mm and 0.15 mm.
9) Put the assembly template (94567A) on the bottom elastic bolt (7).
10) Put the round nut (8) on the elastic bolt (7). Tighten the round nut with your hand.
11) Put the top bearing shell (6) in position on the camshaft.
12) Put the assembly template (94567) in position on the bottom half of the top bearing shell. Use the assembly template (94567A) to help you get the bearing shell in the center.
13) Use the assembly template (94567) to turn the bearing shells (7, 8 Fig. 4) 90°upwards .
14) Make sure that the semicircular slots of the two bearing shells (7, 8) are in a horizontal position.
15) Remove the assembly templates (94567, 94567A).
16) Remove the holder (94566A or 94566B).
17) Make sure that the pin (3, Fig. 5 is in the bearing cover (4).
18) Attach the bearing cover (4).
19) Put the round nuts (8) on the elastic bolts (7). Tighten the round nuts with your hand.
20) Do step 1) to step 19) for the remaining bearing shells.
21) Remove the two supports (94566).
22) Put the bearing cover (4) that has the dowel pin (5) on to position No. 3.
23) Install the tool (94557) on to the elastic bolts (7) (refer to 9403–4).
24) Tighten the round nuts (8) to the value specified in 9403–4.
25) Make sure that there is no clearance at (X).

5. Completion

1) Refer to 0330−1 Clearance Table, Group 5552 for the axial clearances.
2) If the axial clearances are not in the specified range, loosen the round nuts on one of the bearing covers (refer to paragraph 2, step 2)).
3) Put the bearing cover in position again, refer to paragraph 4, step 17) to step 19) and step 22) to step 25).
4) Attach the filling piece (1, Fig. 3) to the bearing cover (5) with the two Allen screws (9).
5) If the fuel pumps (1, Fig. 6) were not removed, do step a). If the fuel pumps were removed, do step b).
   a) Remove the holders (94566B and 94566C).
   b) Install the fuel pumps, refer to paragraph 5.
6) Apply sealing compound to the sealing surfaces of the covers (3, 4 and 6).
7) Install the covers (3, 4, 5 and 6) to the housing (2).
8) Set to on the oil pump.

WARNING

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

9) Operate the turning gear to turn the engine.
10) Make sure that lubricating oil flows to all lubricating points and bearings.

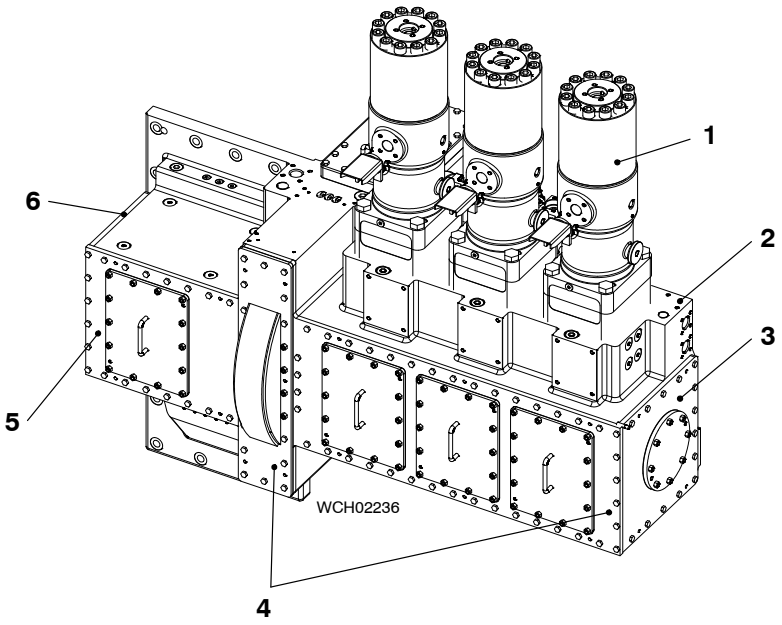


Fig. 6

Fuel Pump Actuator
Connection to Fuel Pump

1. General

Maintenance of the connection between the fuel pump and the actuator is not necessary.

1) Do a check of the connecting element (1, Fig. 1) as follows:
   a) Make sure that the connecting element is lubricated with Molykote paste G.
   b) Make sure that the connecting element can move freely.

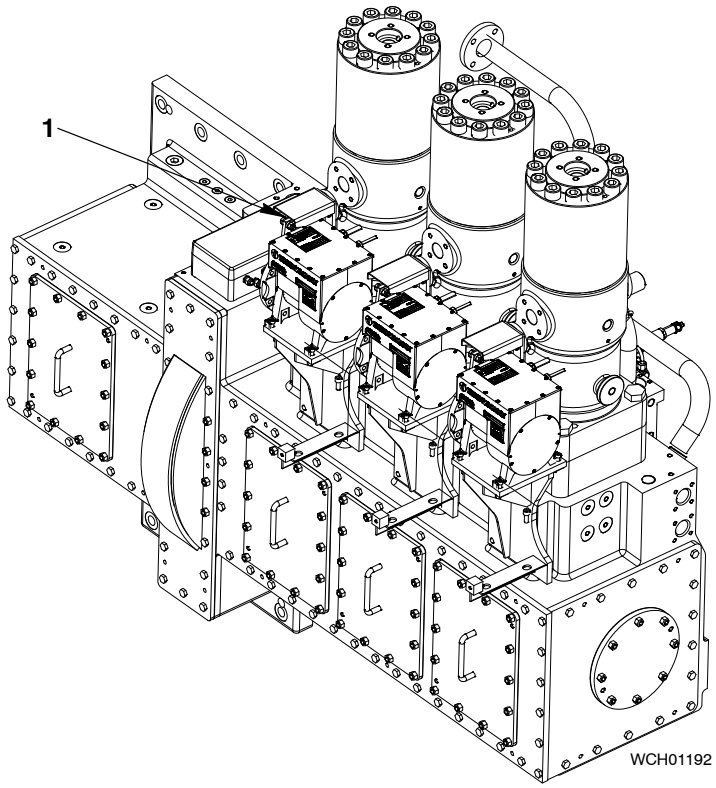


Fig. 1

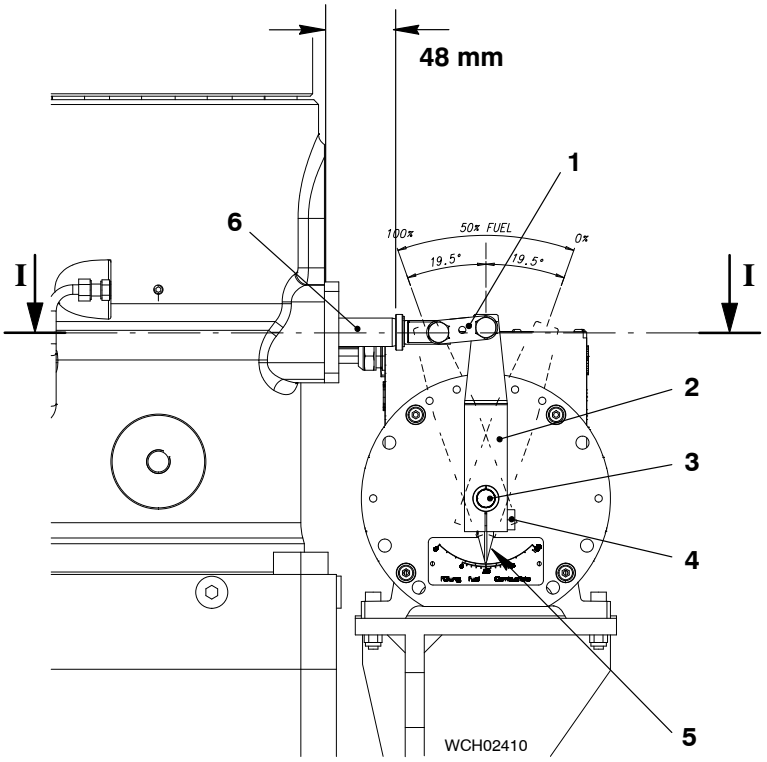
2. Actuator and Fuel Pump – Align

If there was an overhaul on the actuator, or the actuator was replaced do step 1) to step 9):

1) Make sure that the actuator is electrically disconnected.
2) Make sure that the connecting element (1, Fig 2) is disconnected from the lever (2).
3) Move the shaft (3) to get the indicator (5) to the 50% fuel position.
4) Remove the six screws (9), then remove the cover (10).
5) Move the toothed rack (6) to get a distance of 48 mm at each end.
6) Attach the cover (10) to the actuator (11) with the six screws (9).
7) Put the lever (2) in position on the shaft (3). Make sure that the center-line of the lever aligns with the 50% fuel indication on the actuator (11).
8) Attach the lever (2) to the connecting element (1) with the screw (8) and the self-locking nut (7).
9) Tighten the screw (4) on the shaft (3).

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

Fuel Pump Actuator: Connection to Fuel Pump



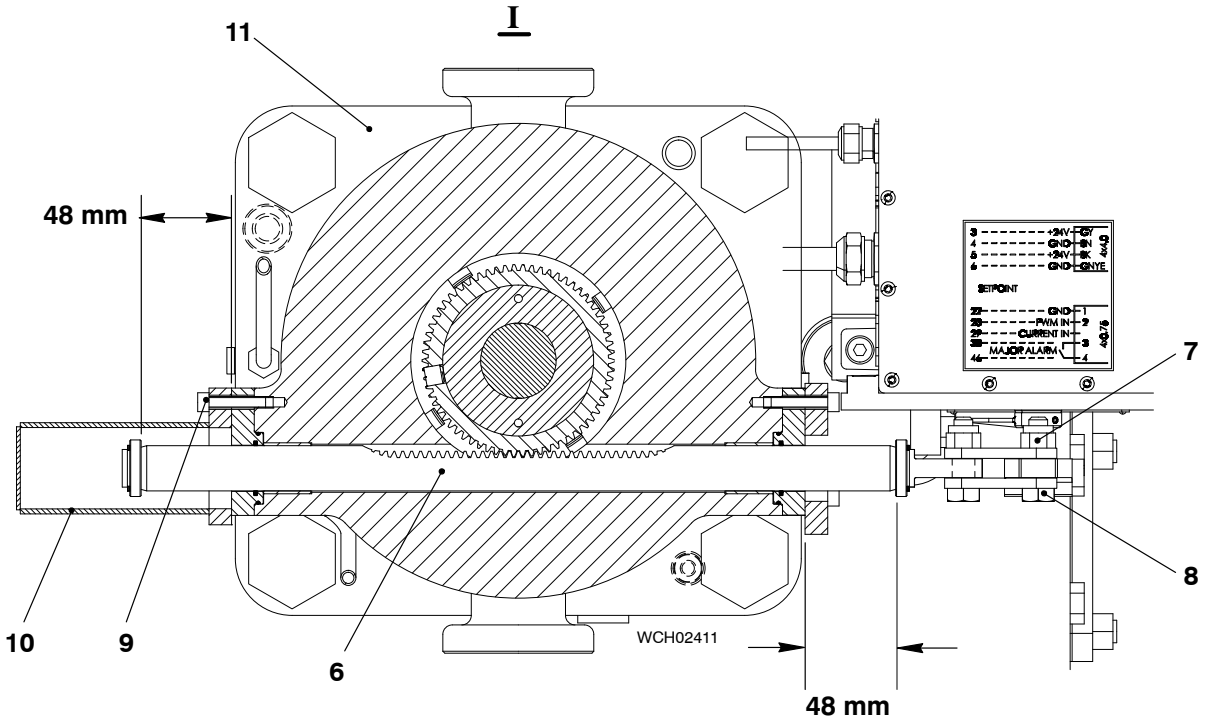


Fig. 2

Intentionally blank

Servo Oil Rail

Exhaust Valve Control Unit: Removal, Disassemble, Assemble, Installation

1. General

For more data, see the Operation Manual 8016–1.

2. Preparation

WARNING

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

1) Stop the engine, refer to 0310–1.
2) Release the pressure in the servo oil rail, refer the Operation Manual 0520–1 paragraph 2.3.
3) Remove the applicable hydraulic pipe, refer to 8460–1, paragraph 1 and paragraph 2.

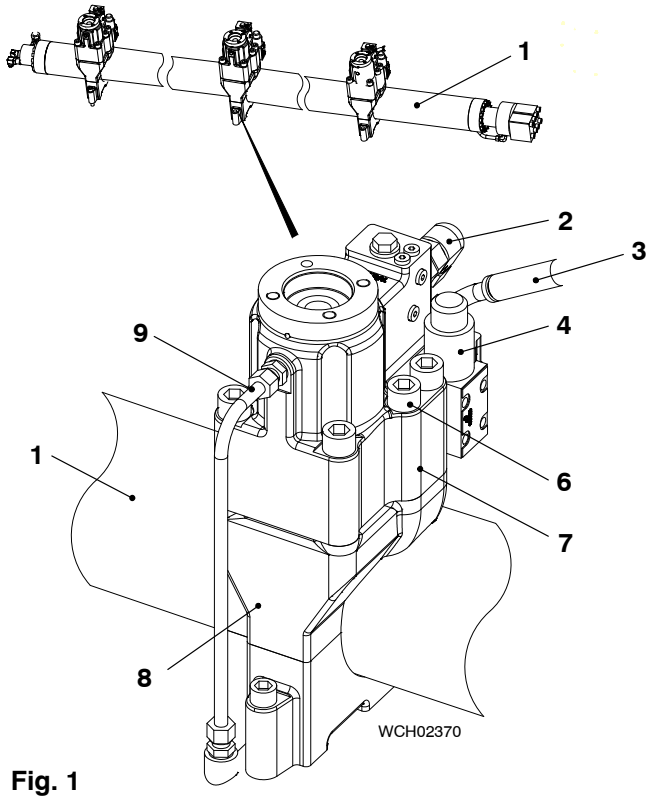


Fig. 1

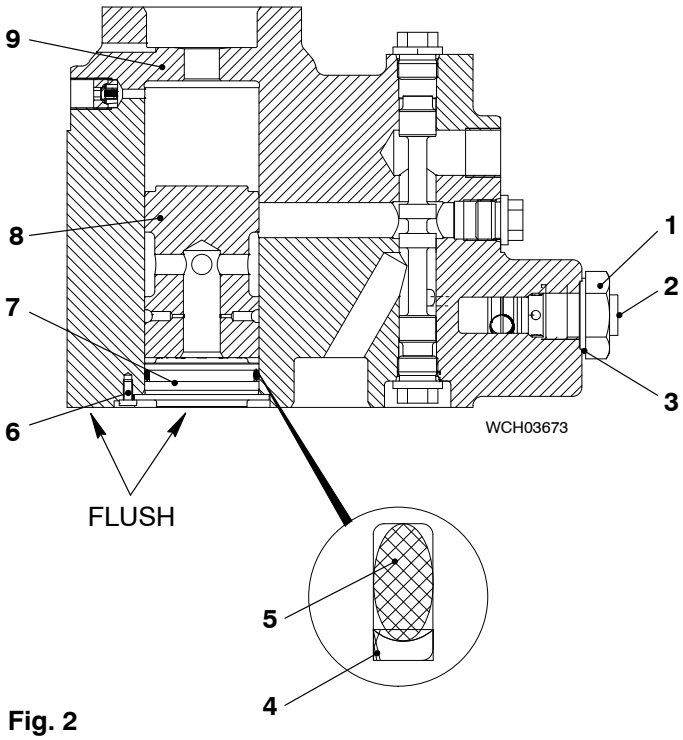


Fig. 2

3. Removal

1) Make sure that the servo oil rail (1, Fig. 1) has no pressure.
2) If the valve control unit (VCU) to be removed is nearest the driving end of the servo oil rail, do step a):
   a) Remove the HP hose (3) from the VCU (7).
3) Disconnect the electrical connection from the 4/2-way solenoid valve (4).
4) Remove the return pipe (2) from the VCU (7).
5) Remove the supply pipe (9) from the VCU (7).
6) Remove the six screws (6) from the VCU (7).
7) Carefully remove the VCU (7).
8) Put protection over the bore in the holder (8) and the servo oil rail (1).
9) Install blanks to the ports on the VCU (7).

4. Disassemble

1) Remove the pan head screw (6, Fig. 2).
2) Remove the plug (7).
3) Remove and discard the O-ring (5) and the back-up ring (4).
4) Make sure that the piston (8) moves freely.
5) Remove the oil filter (1) and the screw plug (2) from the valve control block (9).
6) Make sure that the oil filter (1) is clean and has no damage. If necessary, replace the oil filter.
7) Make sure that the seal (3) has no damage. If necessary, replace the seal.

5. Assemble

1) Apply oil to the thread of the oil filter (1).
2) Put the oil filter (2) and the screw plug (1) into the valve control block (9).
3) Torque the oil filter (1) to 225 Nm.
4) Put a new O-ring (5) and back-up ring (4) on the plug (7).
5) Push the plug (7) into the valve control block (9).
6) Install the pan head screw (6).
7) Make sure that the plug (7) is flush with the bottom of the valve control block (9).

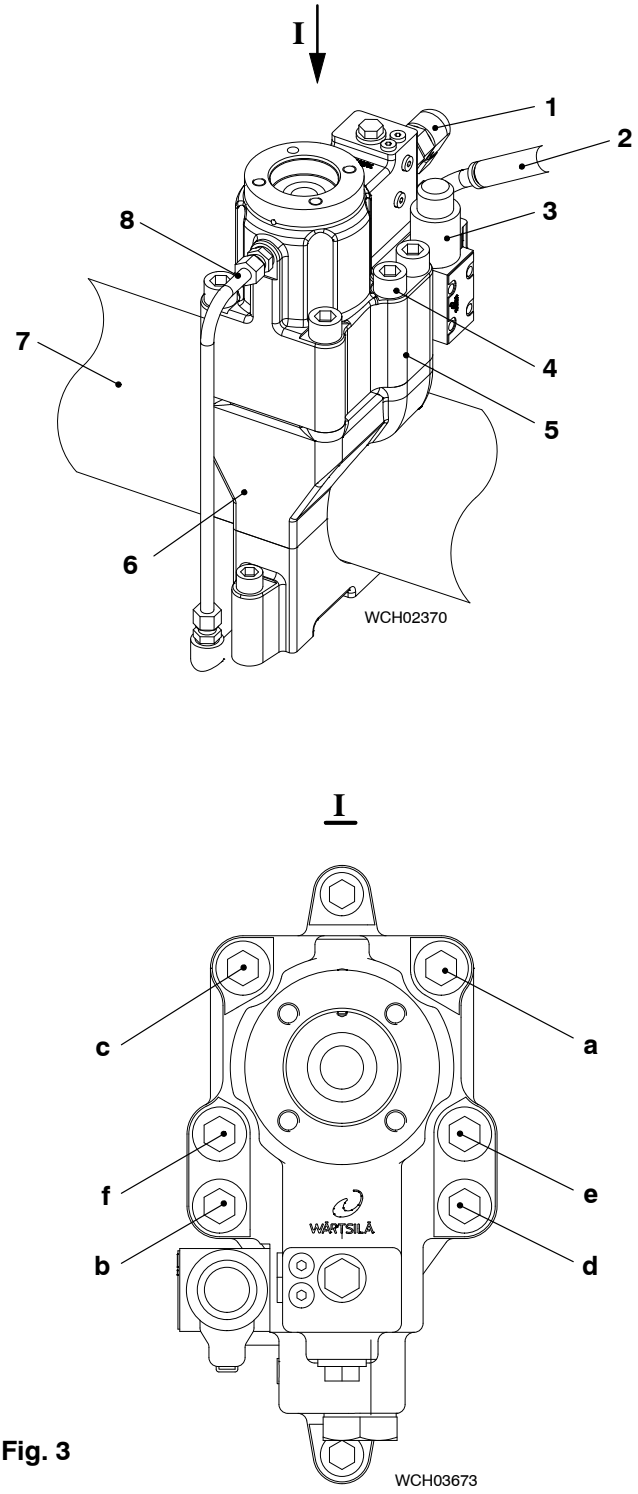


Fig. 3

6. Installation

WARNING

Injury Hazard: You must put on gloves and eye protection when you use white spirit. White spirit can cause damage to the skin and eyes.

1) If the VCU (1) is a new item, carefully remove it from its package.
2) Use white spirit, e.g. Shellsol TD, Shellsol T or Solvent FP68 to clean the VCU.
3) Remove the blanks from the ports in the VCU (5, Fig. 3).
4) Remove the protection from the holder (6) and the servo oil rail (7).
5) Clean the seating surfaces of the VCU (5) and the holder (6).
6) Make sure that the seating surfaces of the holder (6) and the VCU (5) have no damage.
7) Carefully put the VCU (5) in position on the holder (6).
8) Apply oil to the threads of the six screws (4).
9) Tighten with your hand the six screws (4).
10) In the sequence given, torque the six screws to 350 Nm.
11) Install the supply pipe (8) to the VCU (5).
12) Install the return pipe (1) to the VCU (5).
13) If the VCU (5) installed is nearest the driving end of the servo oil rail (7), do step a):
    a) Install the HP hose (2) to the VCU (5).
14) Connect the electrical connection to the 4/2-way solenoid valve (3).

7. Completion

1) Install the hydraulic pipe, refer to 8460–1, paragraph 4 and paragraph 5.
2) Put the replaced VCU in its original package.
3) Put the replaced VCU in an applicable dry storage area. The storage area must not be contaminated (e.g. with exhaust gases or air that has corrosion).

8. Relief Valve

Maintenance of the relief valve (1, Fig. 4) is not necessary.

The relief valve has a factory-set opening pressure of 350 bar.

1) At each primary engine overhaul, do a check of the relief valve.

Note: A relief valve that has damage or has a leak, must be replaced with a new item. A relief valve that has an incorrect setpoint can be adjusted.

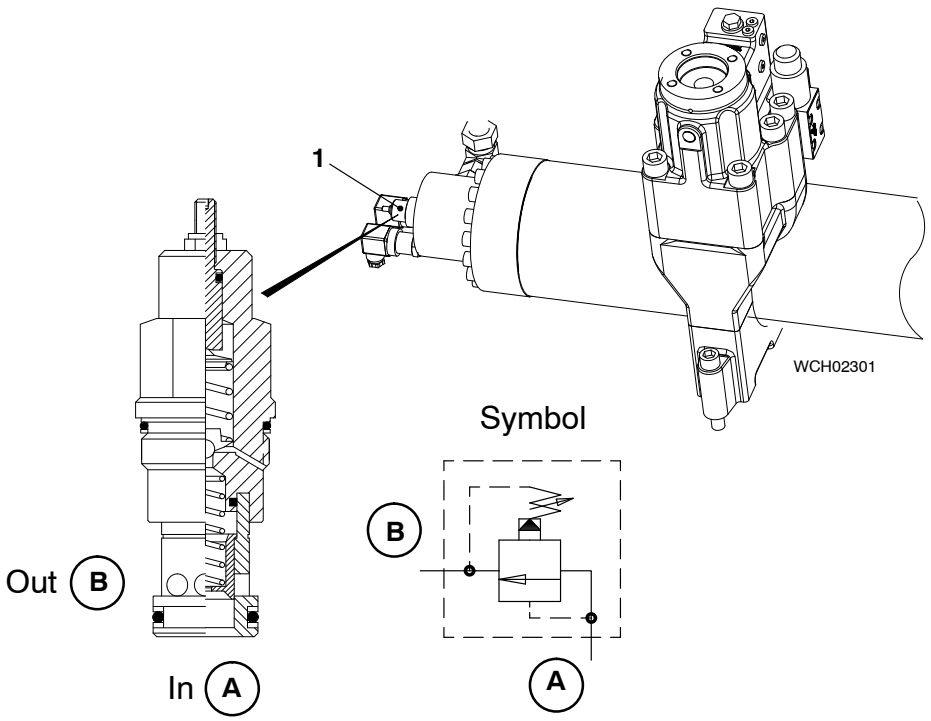


Fig. 4

Servo Pump Unit

Servo Oil Pump – Removal and Installation

Tools:

2 Sling 94650

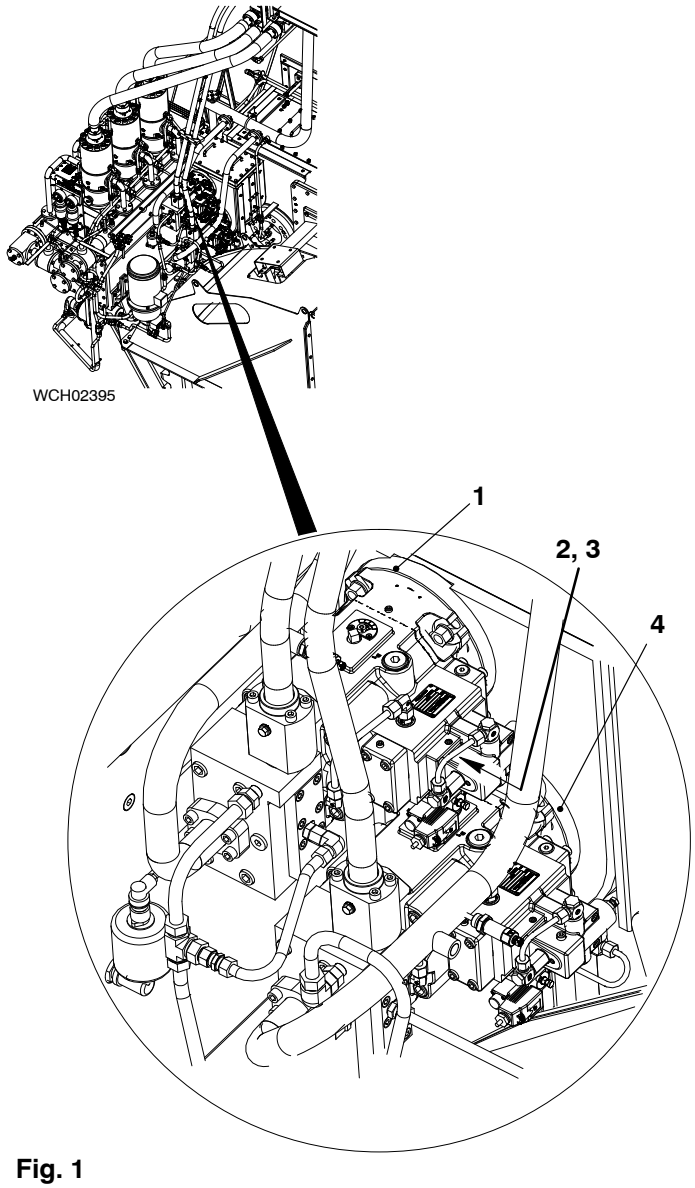


Fig. 1

1. General

Data about operation, maintenance and servicing of the servo oil pumps are given in the related documentation of the servo oil pump manufacturer.

Do the related maintenance in 0380–1 Maintenance Schedule, Servo Oil Pump and Servo Oil Pump Drive.

For more data, refer to the Operation Manual 5551-1 Servo Oil Pump.

2. Checks

2.1 Servo Oil Pump

1) While the servo oil pumps (1 and 4, Fig. 1) operate, listen for unusual noises. If you hear unusual noises, you must find the cause and correct the malfunction immediately.
2) Compare the temperatures of the two servo oil pumps (1, 4). If there is a temperature difference, you must find the cause and correct the malfunction immediately.

Note: The filter (3) is installed in the pipe (2).

3) Each time the ship is in port, do a check of the filter as follows:
   a) Make sure that the servo oil pumps do not operate.
   b) Remove the pipe (2).
   c) Do a check of the filter (3) for dirt or particles.
   d) If necessary, clean the filter (3).
   e) Install the pipe (2)

2.2 Pinions and Camshaft Gear Wheel

1) Remove the 20 screws (2, Fig. 2).
2) Remove the cover (1) from the supply unit casing (3).

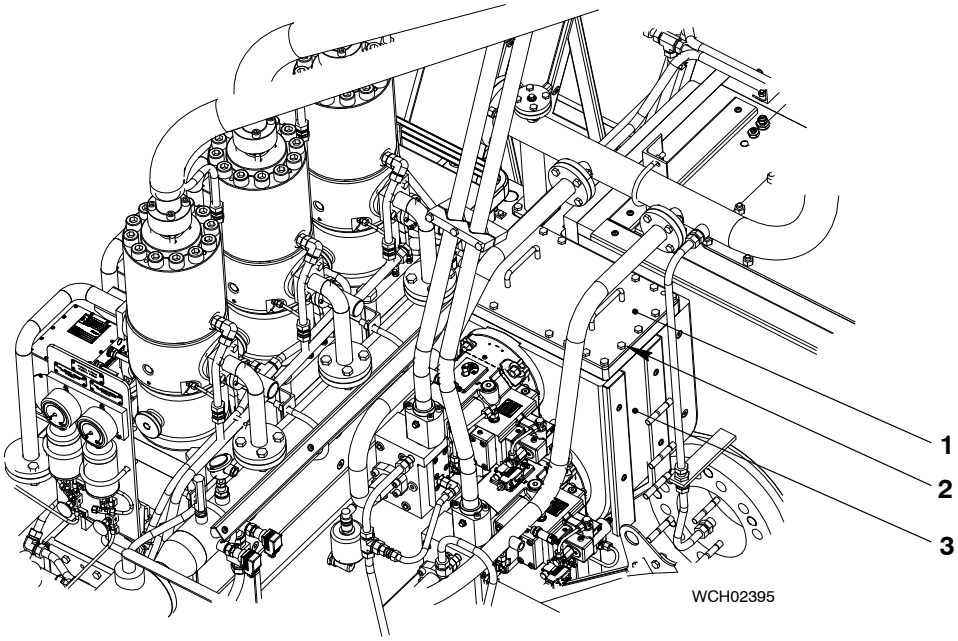


Fig. 2

3) Do a check of the pinions (1, and 2 Fig. 3) and the camshaft gear wheel (3) for wear and damage (refer to 0330−1, Clearance Table, Fuel and Servo Pump Units).
4) If there is too much wear and / or damage, you must replace the pinions (1, 2) and the camshaft gear wheel (3).
5) Attach the cover (1, Fig. 2) to the supply unit casing (3)with the 20 screws (2).

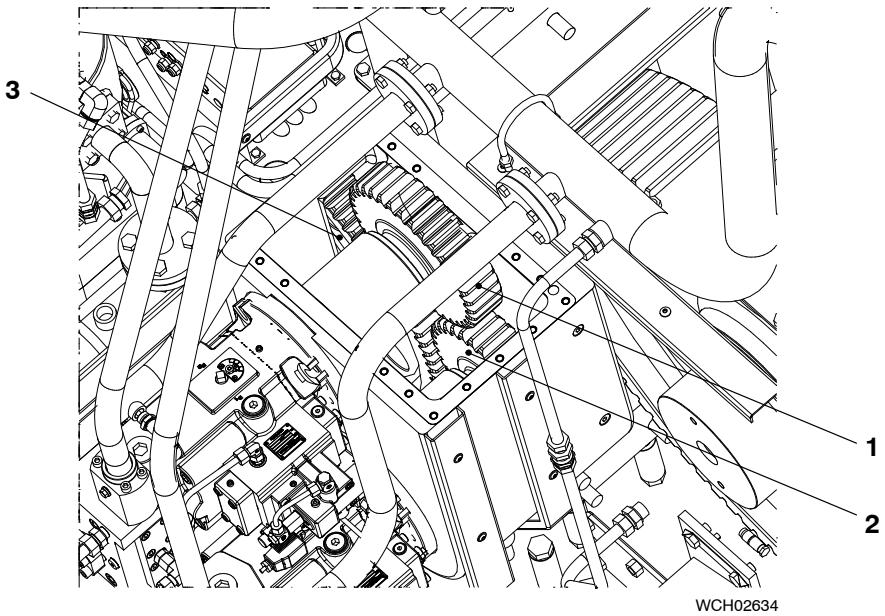


Fig. 3

3. Servo Oil Pump – Removal

3.1 Preparation

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Set to off the main bearing oil pump.
3) Remove the HP servo oil pipes (12, Fig. 4) (refer to 8447-1).
4) Remove the two HP fuel pipes from the fuel pumps, refer to 8752–1 paragraph 1 and paragraph 2.
5) Disconnect the electrical connections (7).

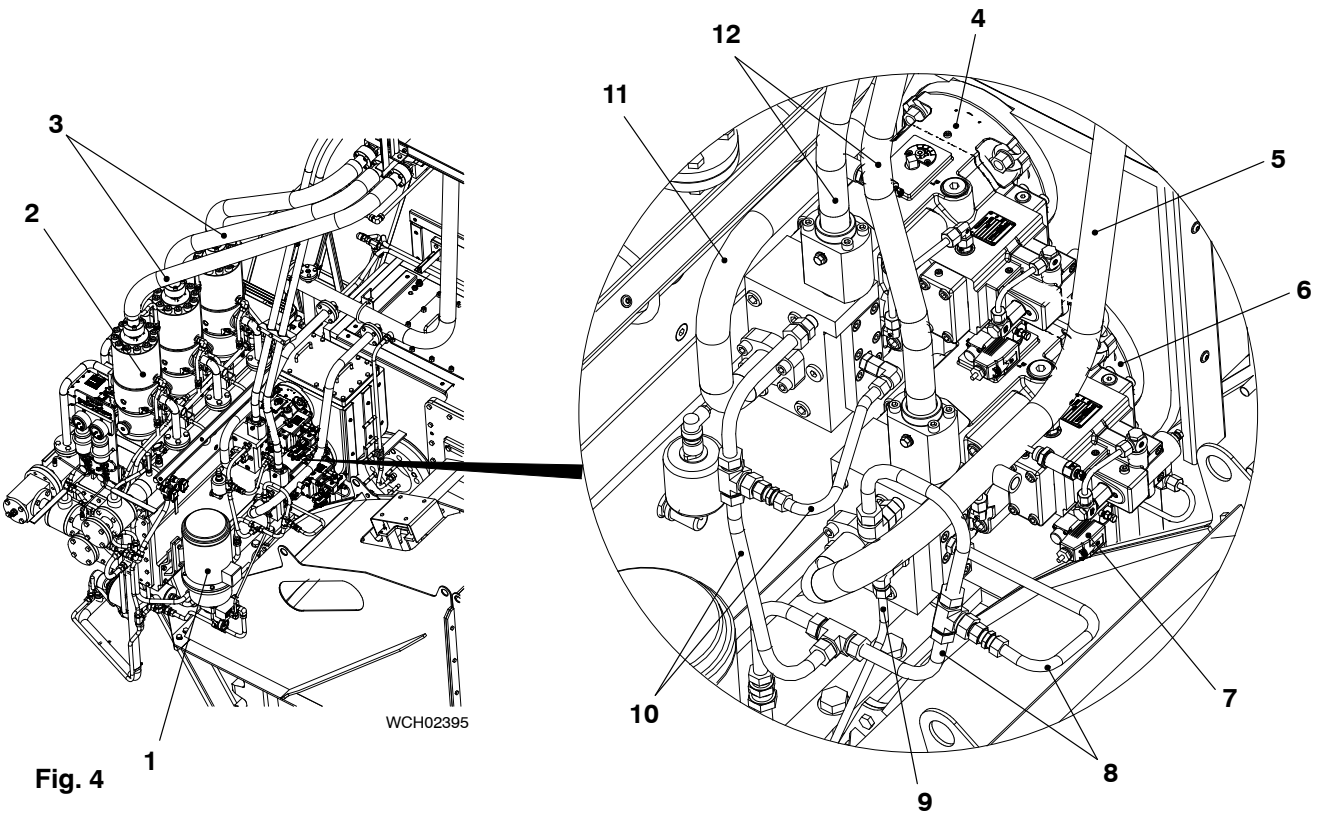


Fig. 4

6) Remove the drain pipes (8, 10).
7) Remove the inlet pipes (5, 11).

Note: Step 8) is applicable only for the servo oil pump (6). The pipe (9) connects the servo oil service pump (1) to the servo oil pump (6).

8) Remove the oil pipe (9) from the servo oil pump (6).

3.2 Removal

CAUTION

Injury Hazard: The weight of the servo oil pump is 116 kg. Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

1) Put the sling (94650, Fig. 5) around the servo oil pump (1) two times.

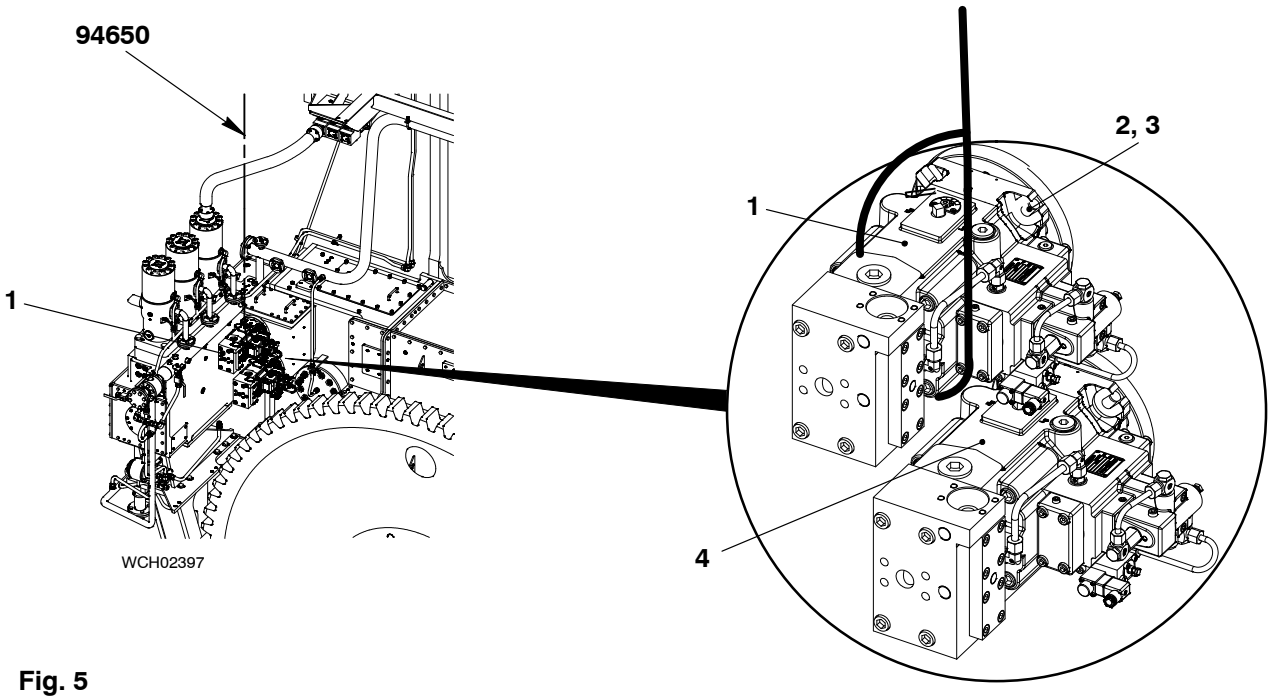
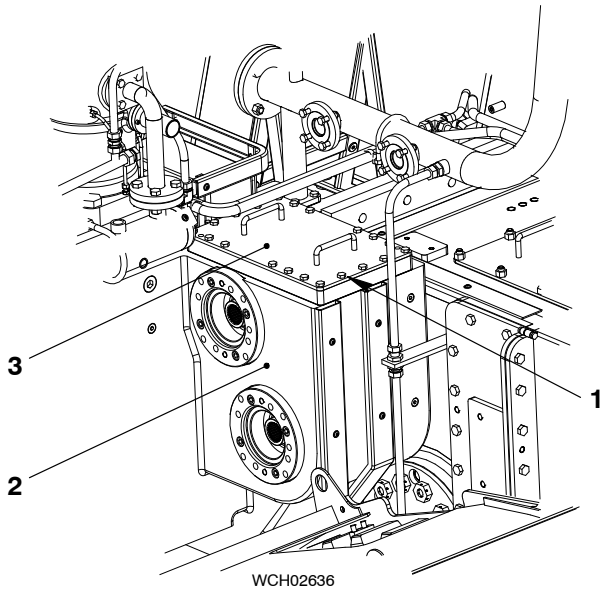
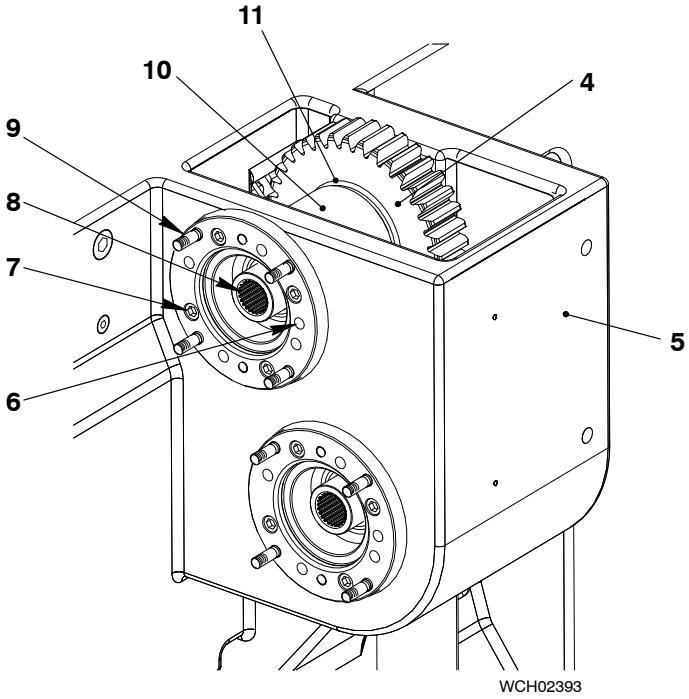


Fig. 5

2) Attach the sling (94650) to the engine room crane.
3) Operate the engine room crane and put sufficient tension on the sling (94650) to hold the weight of the servo oil pump (1).
4) Remove the four nuts (2) and washers (3).
5) Remove the servo oil pump (1) and the O-ring (not shown).
6) Move the servo oil pump (1) to an applicable area.
7) Lower the servo oil pump (1) to the floor.
8) Remove the sling (94650) from the servo oil pump.
9) Do step 1) to step 8) above to remove the servo oil pump (4).
10) If it is necessary to remove the bearing bushes, refer to paragraph 3.3.





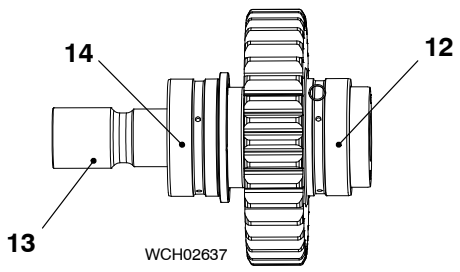


Fig. 6

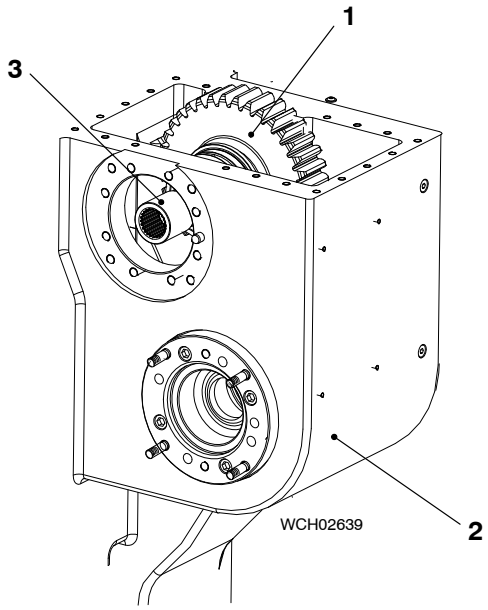
3.3 Bearing Bushes

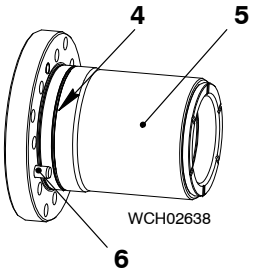
CAUTION

Injury Hazard: The weight of the pinion and shaft is approximately 50 kg. Use the correct equipment to lift and move the pinion and shaft. This will prevent injury to personnel.

Note: You do this procedure only if it is necessary to do a check of the bearing bushes.

1) Remove the 20 screws (1, Fig. 6) from the cover (3).
2) Remove the cover (3) from the casing (2).
3) Remove the four screws (7).
4) Move the pump support (10) a small distance away from the casing (5).
5) Put the sling (94650) around the shaft (11) two times.
6) Attach the sling (94650) to the engine room crane.
7) Put sufficient tension on the sling (94650) to hold the the shaft (11) and pinion (4) in position.
8) Remove the pump support (10) and the O–ring.
9) Carefully move the pinion (4) and shaft (11), in the direction of the driving end, approximately 30 mm out of the casing (5).
10) Put one more sling (94650) around the pinion (4) and shaft (11).
11) Attach the sling (94650) to the engine room crane.
12) Make sure that the two slings (94650) have equal tension.
13) Carefully tilt the pinion (4) and shaft (11).
14) Carefully lift the pinion (4) and shaft (11) fully out of the casing (5).
15) Lower the pinion (4) and shaft (11) to an applicable area.
16) Examine the two bearing bushes (12, 14) for wear and damage.
17) If necessary, replace the bearing bushes (12, 14).





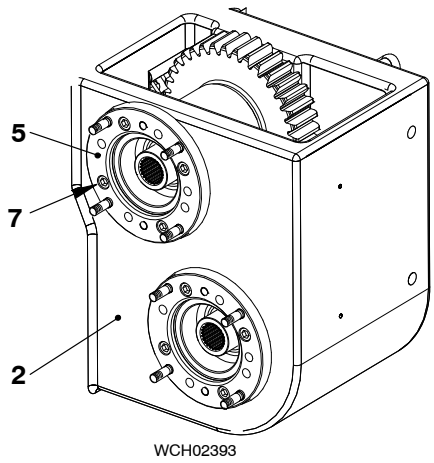


Fig. 7

18) Put oil on the two bearing bushes (12 and 14, Fig. 6) and the shaft (13) of the pinion.

19) Use the engine room crane and the two slings (94650) to lift the pinion (1, Fig. 7) and shaft (5) into position above the casing (2).

20) Carefully tilt the pinion (1) and shaft (5), then lower the pinion and shaft into the casing (2).

21) Put a small quantity of oil on the O-ring (4).

22) Remove one of the two slings (94650) from the pinion (1) and shaft (5).

23) Put the pump support (5) in position. Make sure that the dowel pin (6) in the pump support engages with the related hole in the casing (2).

24) Torque the four M16 screws (7) to the value given in 0352−2, paragraph 1.

25) Remove the other sling (94650) from the pinion (1) and shaft (5).

26) Do the procedures given in step 3) to step 25) for the bearing bushes of the other servo oil pump.

27) Attach the cover (3, Fig. 6) to the casing (2) with the 20 screws (1).

4. Servo Oil Pump – Installation

CAUTION

Injury Hazard: The weight of the servo oil pump is 116 kg. Make sure that you use the correct equipment to lift and move the servo oil pump. This will prevent injury to personnel.

1) Put a new O-ring (1, Fig. 8) in the pump support.
2) Apply a small quantity of oil to the the O-ring (1).

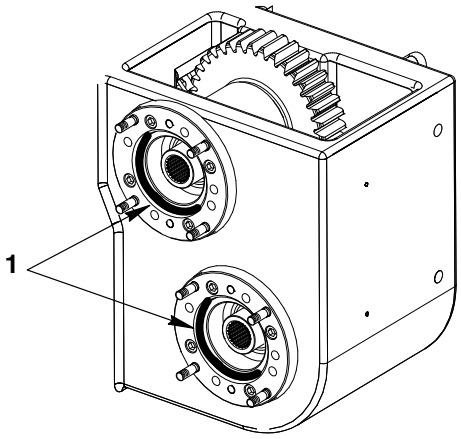


Fig. 8

3) Put the sling (94650, Fig 9) around the servo oil pump (1) two times.
4) Attach the sling (94650) to the engine room crane.
5) Use the engine room crane to put the servo oil pump (4) in position.
6) Attach the servo oil pump (4) to the casing with the four washers (3) and nuts(2).

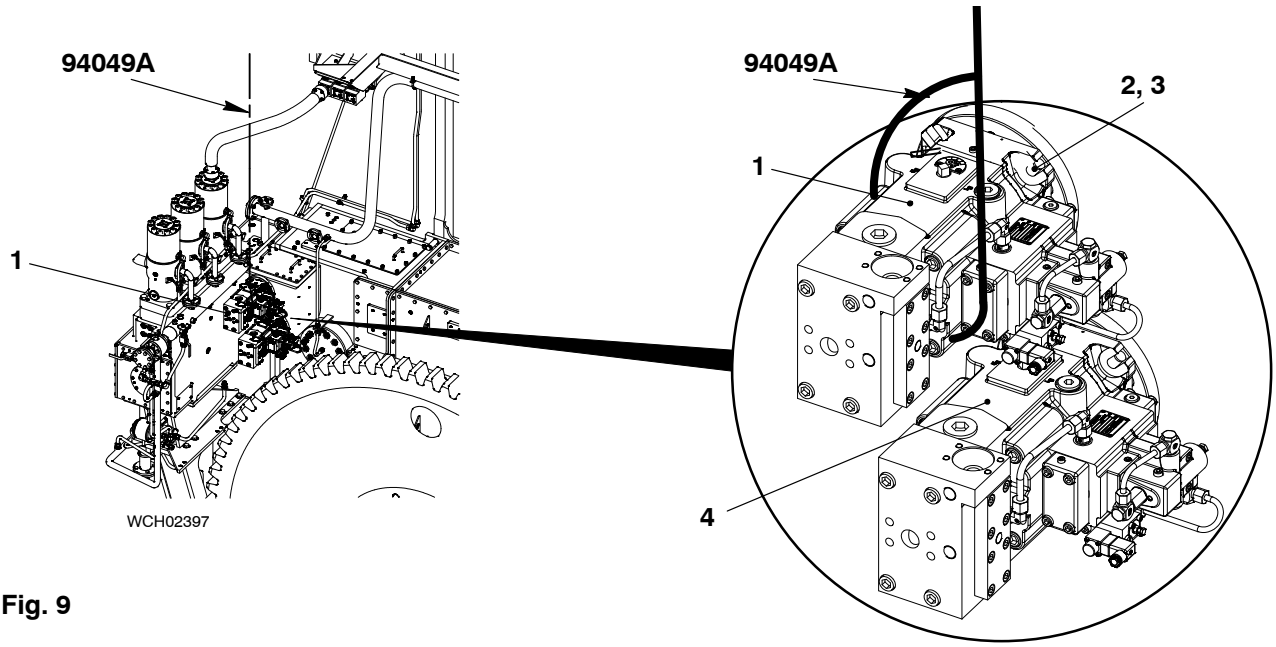


Fig. 9

7) Remove the sling (94650) from the servo oil pump (4).
8) Do step 1) to step 7) to install the servo oil pump (1).

5. Completion

1) Attach the oil inlet pipes (11, Fig. 10) to the servo oil pumps (4, 6).

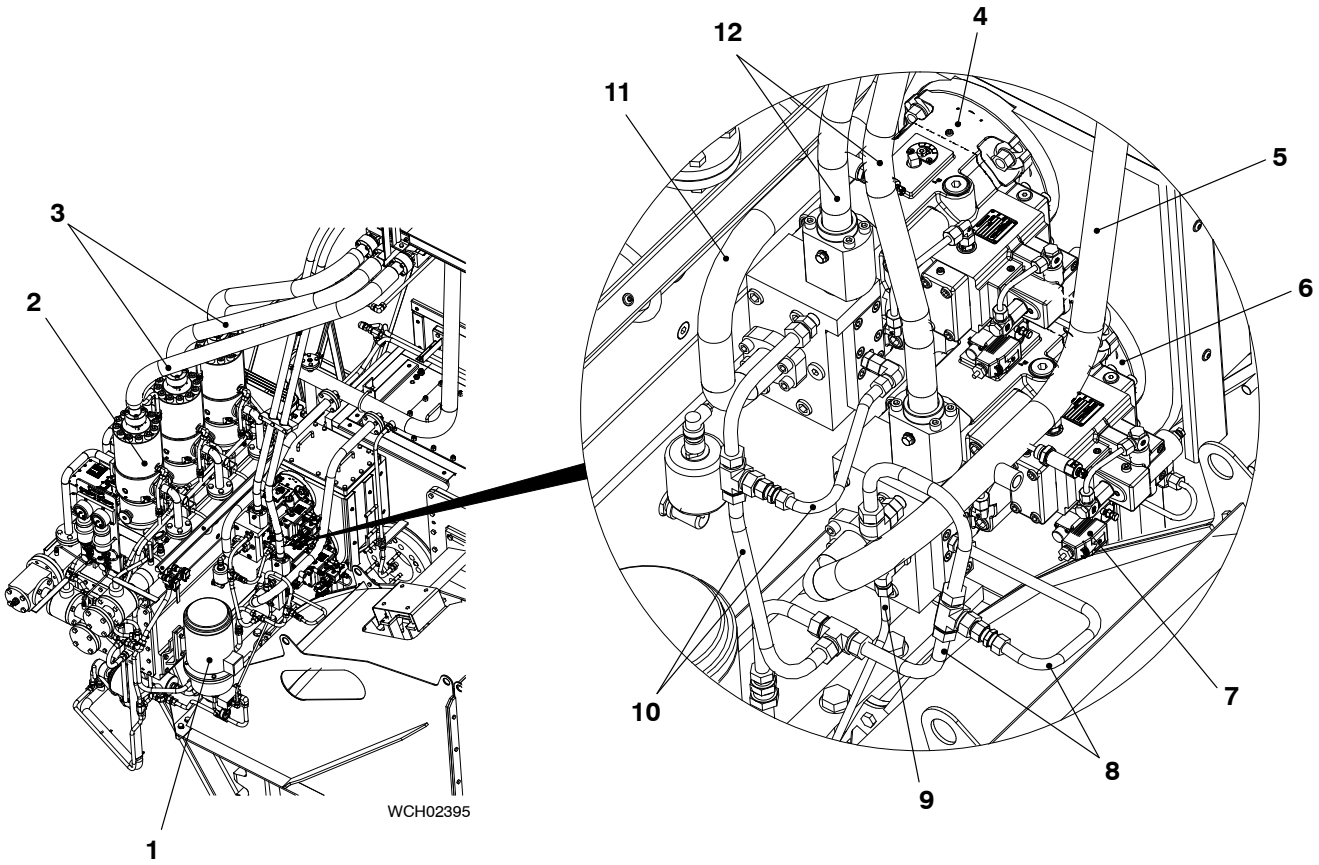


Fig. 10

2) Attach the drain pipes (8, 10) to the servo oil pumps (4, 6).
3) Attach the oil pipe (9) to the servo oil pump (6).
4) Install the HP servo oil pipes (12) to the servo oil pumps (4, 6) (refer to 8447−1, paragraph 5).
5) Attach the two rear HP fuel pipes (3) to the fuel pumps (2) (refer to 8752−1, paragraph 4)
6) Connect the electrical connections (7).
7) Set to on the main bearing oil pump.
8) Set to on the servo oil service pump (1).
9) Do a check for leaks.
10) Set to off the servo oil service pump (1).

Work Card

Exhaust Valve Control Unit (VCU): Oil Filter Check

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Oil filter	EX 56145	Qty 1

Preparation

None

Tools and Consumables

Not applicable

Primary Task

Do a check of the oil filter on the exhaust valve control unit

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	1.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

None

Intentionally blank

Work Card
Fuel Pump Actuator: Regulating Linkage Check

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

None

Tools and Consumables

Lubricating oil

Primary Task	Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation		
Make sure that the regulating linkage moves freely. Lubricate movable parts	Ship Engineer	0.5 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Connection to fuel pump, 5583−1/A1

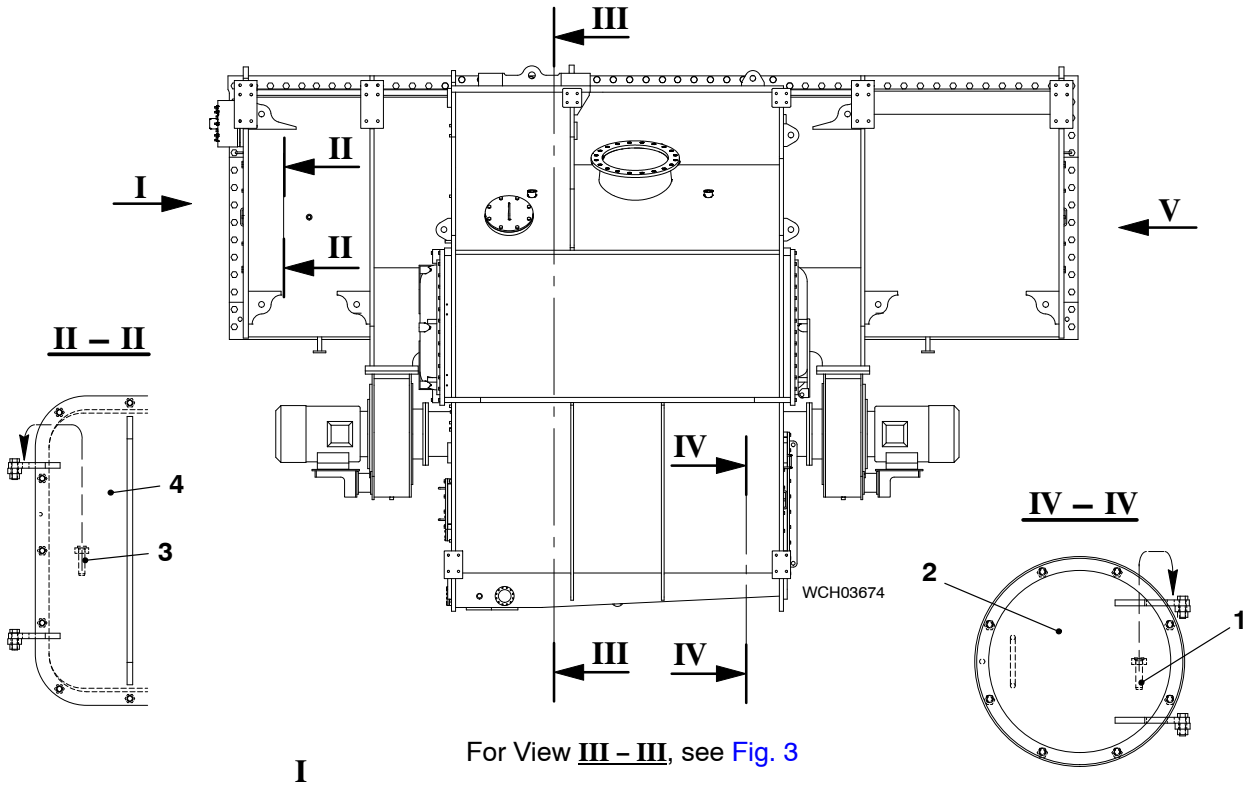
Intentionally blank

Scavenge Air Receiver and Auxiliary Blower — Group 6

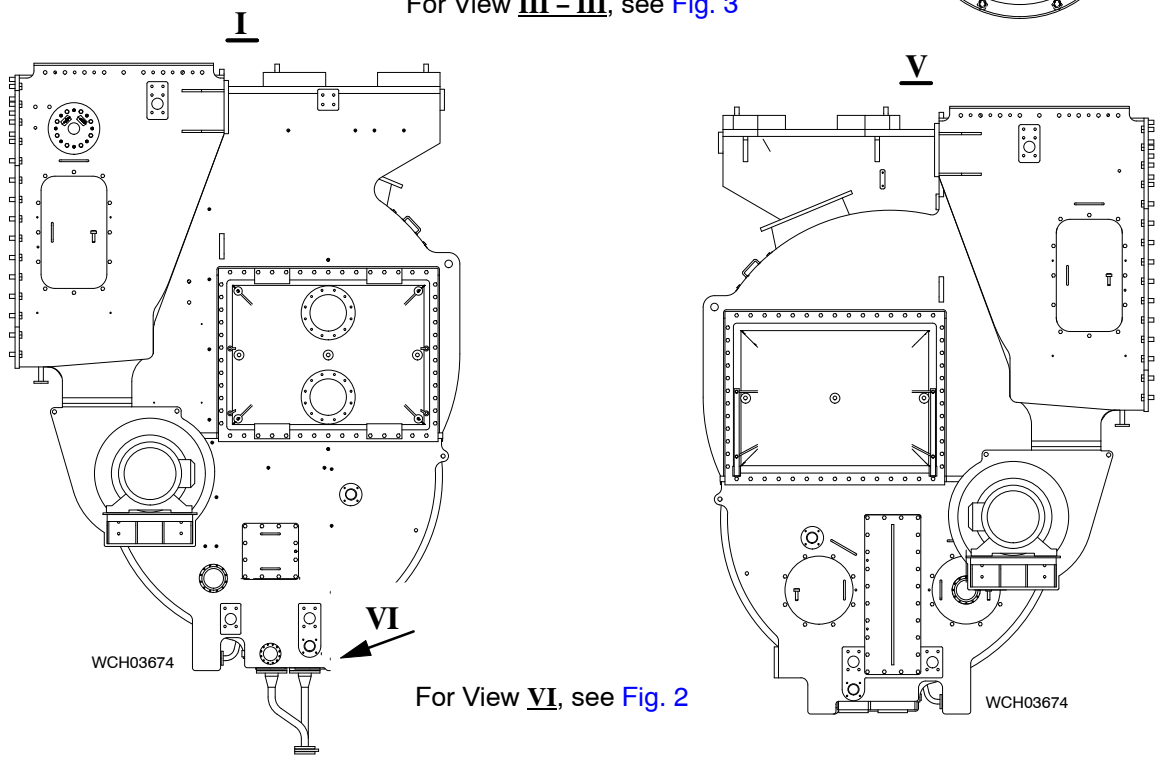
Intentionally blank

Scavenge Air Receiver

Clean and do Checks



For View III – III, see Fig. 3



For View VI, see Fig. 2

Fig. 1: Scavenge Air Receiver

1. Scavenge Air Receiver – Clean and do Checks

Read the data in 0380–1, Scavenge Air Receiver for the applicable Inspection and Overhaul Intervals to clean the scavenge air receiver. You must also clean and do a check of the scavenge air receiver after each piston overhaul.

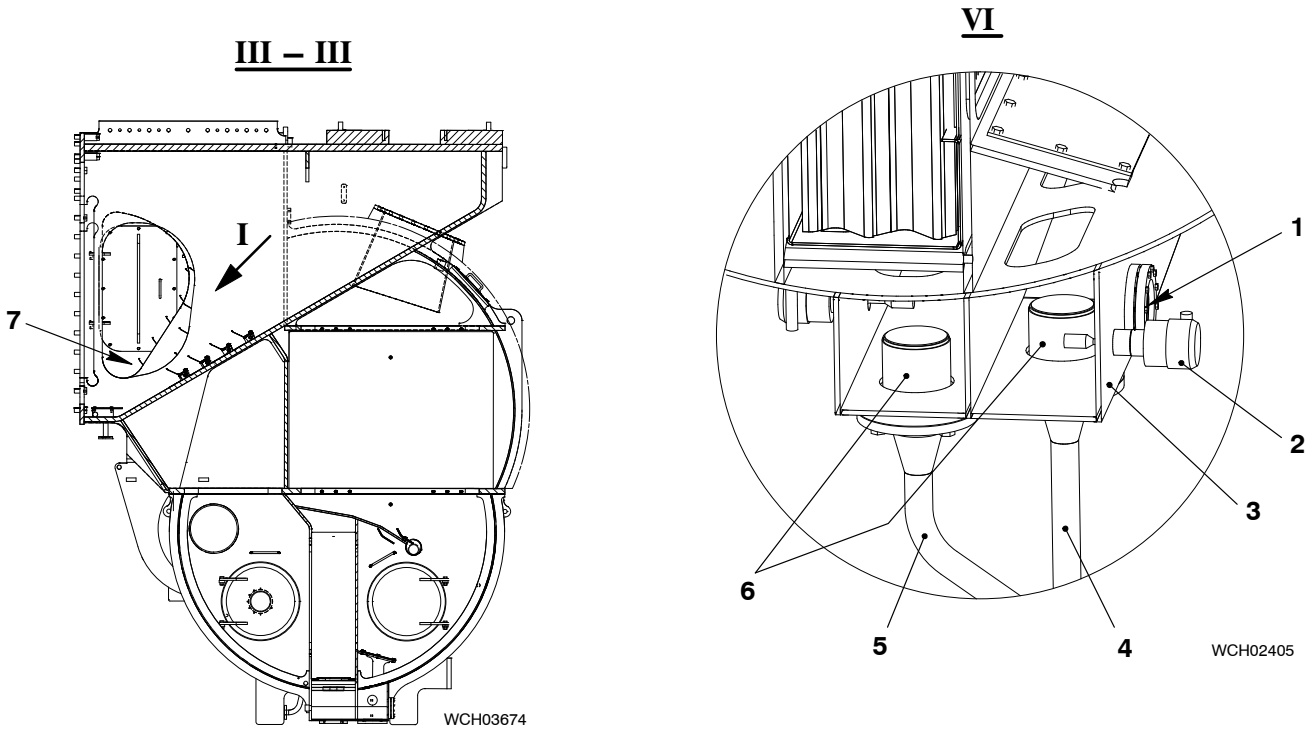
1) Open the covers (2 and 4, Fig. 1).
2) Lock the covers (2, 4) in the open position with the pins (1, 3) to prevent unwanted movement.
3) Clean the scavenge air receiver.
4) Do the checks that follow:

Note: The level switches LS4071A and LS4075A (2, Fig. 2) monitor the water level in the condensate collectors (3). For engines with two turbochargers, there are two more level switches (LS4072A and LS4076A) installed. For more data, refer to the Operation Manual 4003-4 Pipe Diagram – Water Systems.

a) At regular intervals, look at the sight glasses (1) of the condensate collector (3) to make sure that water flows.

b) If necessary clean the filters (6) and the drain pipes (4, 5). For more data, refer to the Operation Manual 8345-1.

c) Do a check of the flaps (7) for damage, free movement and dirt. If necessary, clean or replace the flaps (see paragraph 2).



For View I, (flaps) see Fig. 3.

Fig. 2: Condensate Collectors

2. Flaps

2.1 Removal

1) Remove the three screws (7, Fig. 3) and the tab washers (4).
2) Remove the two flat bars (9, 10) and the stop plate (6).
3) Remove the screw (3) and the tab washer (4).
4) Remove the guide (2), spacer (8), flap (5) and axle (1).

2.2 Installation

1) Put the axle (1), spacer (8), guide (2) and flap (5) in position.
2) Put the the flat bar (9), stop plate (6), flat bar (10) new locking plates (4), and screws (7) in position. Do not tighten the screws at this step.
3) Put the screw (3) and new locking plates (4) in position. Do not tighten the screws at this step.
4) Make sure that the axle (1) and the flap (5) can move freely.
5) Tighten the screws (3, 7).
6) Bend the tab washers (4) to lock the screws (3, 7).

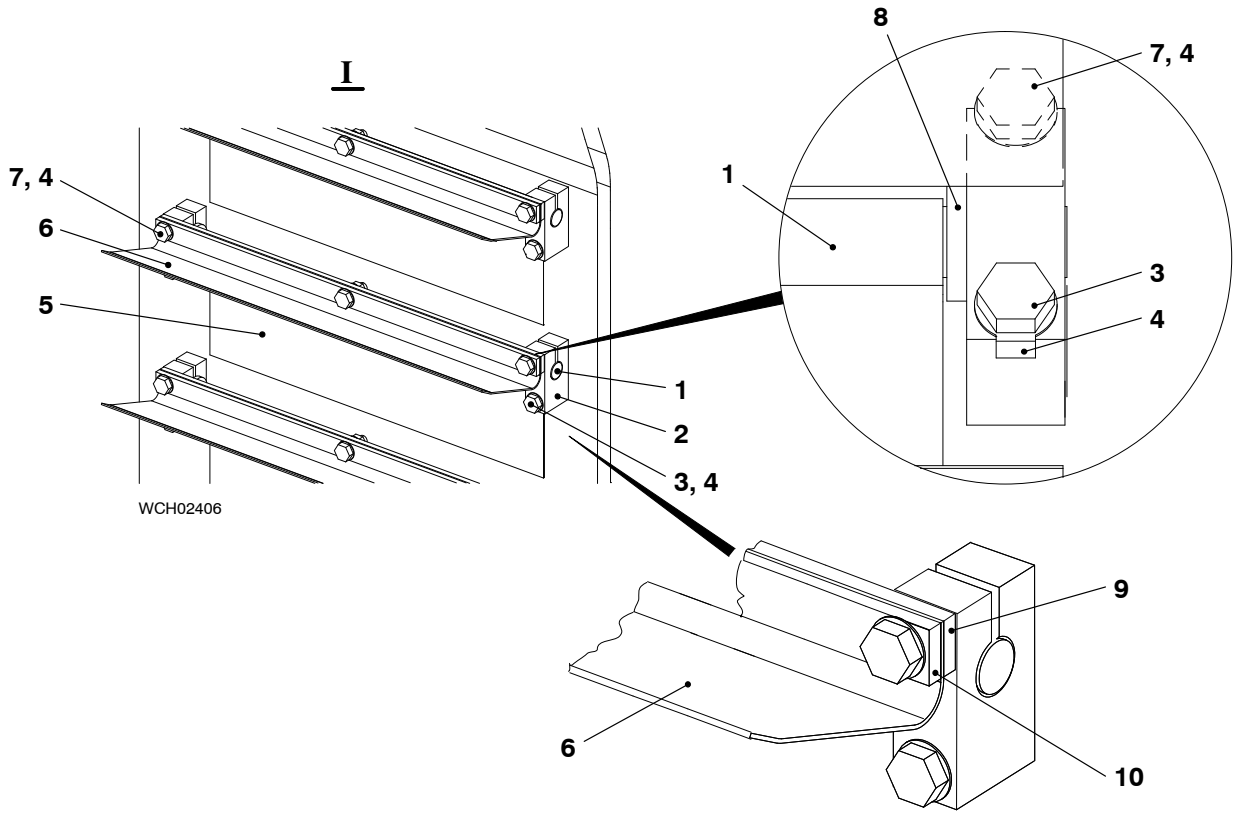


Fig. 3: Flaps

7) Remove the pins (2, Fig. 1).
8) Close the covers (1).
9) Install the pin (2) in the stowage position.

3. Relief Valve – Check

WARNING

Injury Hazard! Do not disassemble the relief valve. Parts can eject at high speed and cause injury. If there is damage or a malfunction, speak to the manufacturer of the relief valve or to WinGD.

1) Do a check of the relief valve during each engine overhaul as follows:
   a) Do a visual check for damage and corrosion. If necessary, replace the relief valve (1, Fig. 4).
   b) Do a check of the wire seal (3) and the lead seal (2). If the wire seal and lead seal are broken, you must replace the relief valve.

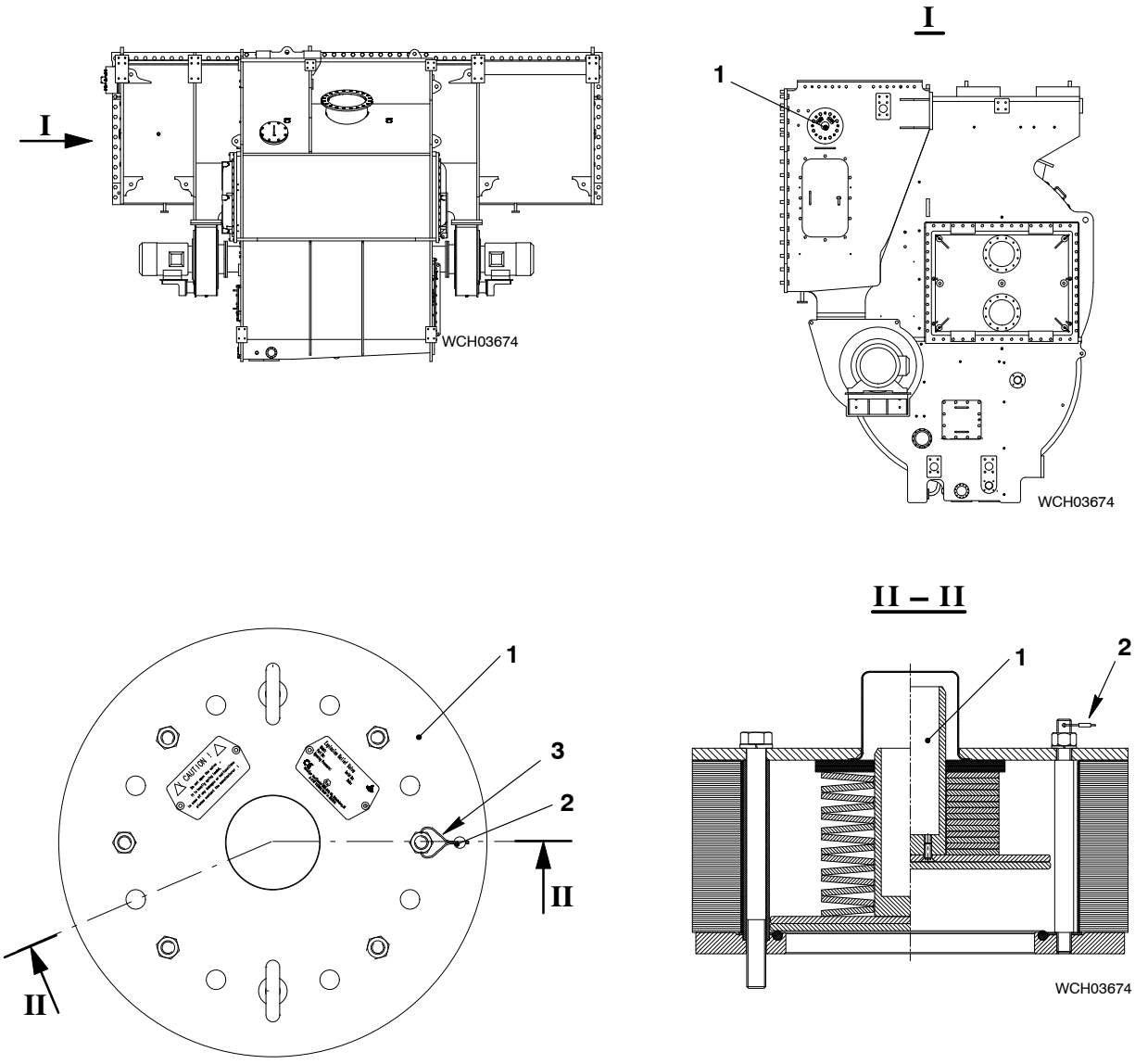


Fig. 4: Relief Valve

Work Card
Scavenge Air Receiver: Clean Flaps and Check

Necessary Conditions

– Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Open the covers to get access to the flaps, refer to 6420-1/A1

Tools and Consumables

Applicable tools and equipment

Primary Task

Do a check of the flaps. Clean the flaps.

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer 1.0 hours Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Clean and do Checks, 6420-1/A1

Intentionally blank

Maintenance

Tools:

2	Manual ratchets 1500 kg (H1, H2)	94016-017	1	Chain (asymmetric)	94019A
2	Spur gear chain block 2000 kg (H3, H4)	94017-021	1	Trolley	94021
4	Shackle	94018C	2	Sling	94650

1. General

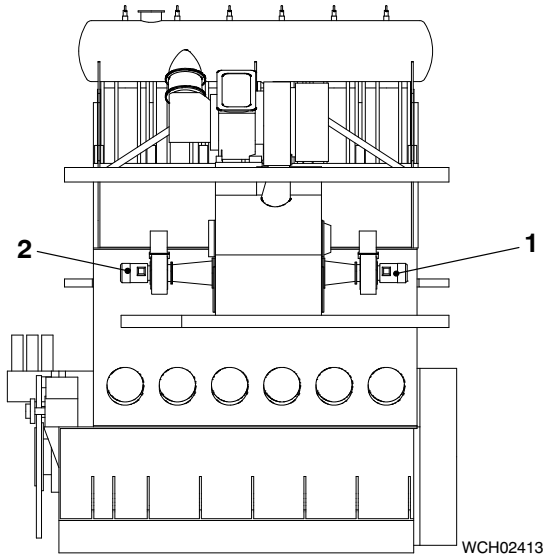
Two auxiliary blowers (2, Fig. 1) are attached to the scavenge air receiver (1). For more data about the auxiliary blower, see the Operation Manual 6545-1 Auxiliary Blower and Switch Box.

There are two procedures to remove and install an electric motor:

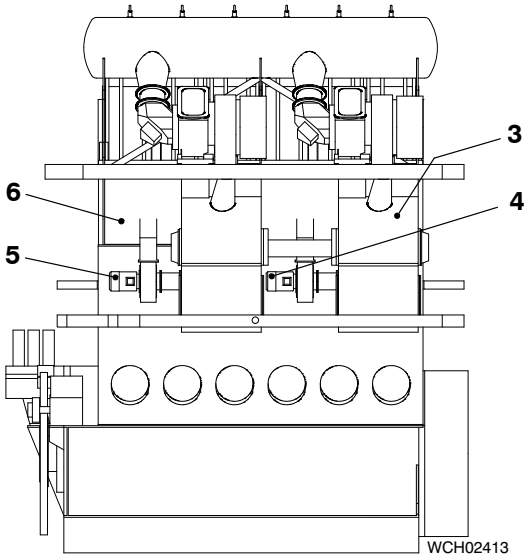
- Procedure One: For engines with one turbocharger, refer to the procedure given in paragraph 2.
- Procedure Two: One of the electric motors (4) is installed between the two scavenge air receivers (3, 6). The procedure to remove and install this electric motor is given in paragraph 3).

Note: Also use Procedure One to remove and install the outer electric motor (5) on an engine with two turbochargers.

For data about the procedure to clean the impeller and to replace the ball bearing, refer to the documentation of the auxiliary blower manufacturer.



Engine with One Turbocharger



Engine with Two Turbochargers

Fig. 1

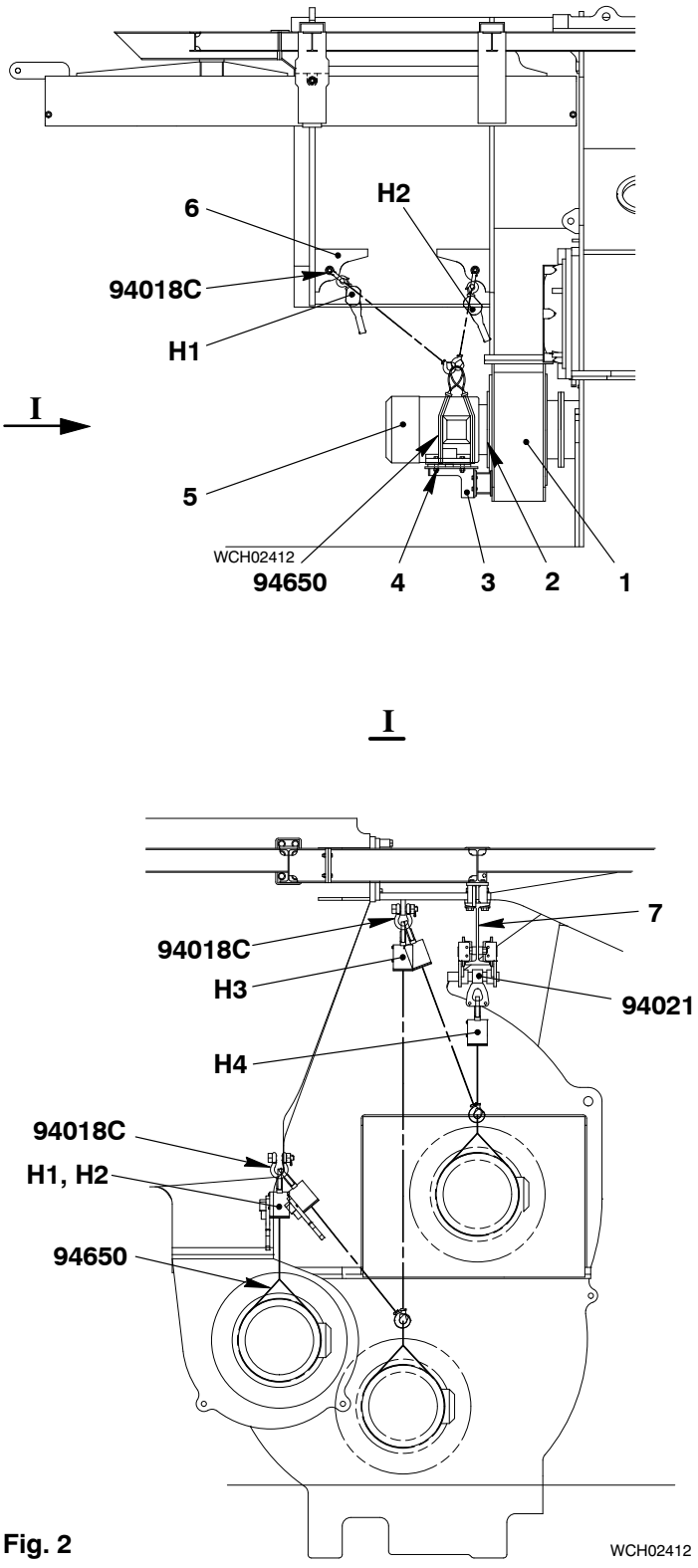


Fig. 2

2. Procedure One

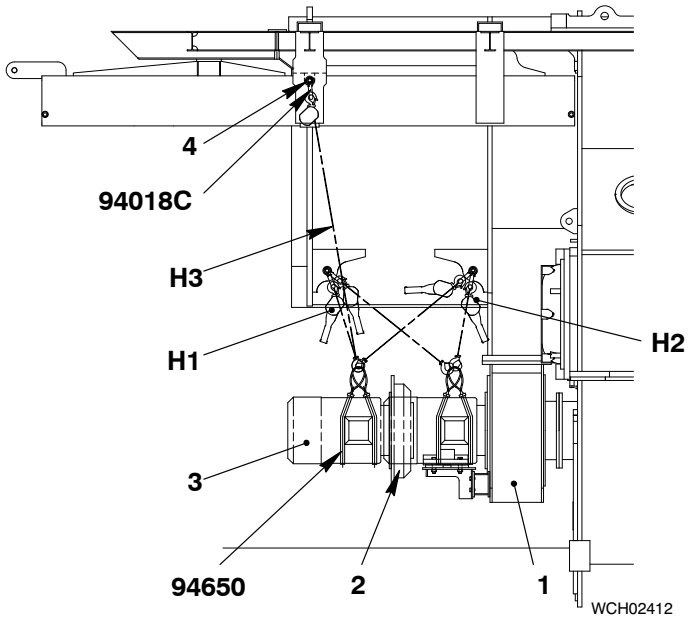
2.1 Preparation

Note: Read and obey the data given in 0012-1 General Guidelines for Lifting Tools.

1) Stop the engine.
2) Set to off the power supply.
3) Disconnect the electrical connection from the electric motor (5, Fig. 2).
4) Attach the shackles (94018C) and the manual ratchets (H1, H2) to the lifting lugs (6).
5) Attach the trolley (94021) to the beam (7).
6) Attach the chain block (H3) to the shackle (94018C).
7) Attach the chain block (H4) to the trolley (94021).

2.2 Removal

1) Attach the slings (94650) to the electric motor (5).
2) Attach the manual ratchets (H1, H2) to the slings (94650) as shown.
3) Put sufficient tension on the slings (94650) to hold the electric motor (5) in position.
4) Remove the screws (4) from the support (3).
5) Remove the screws (2) from the casing (1).



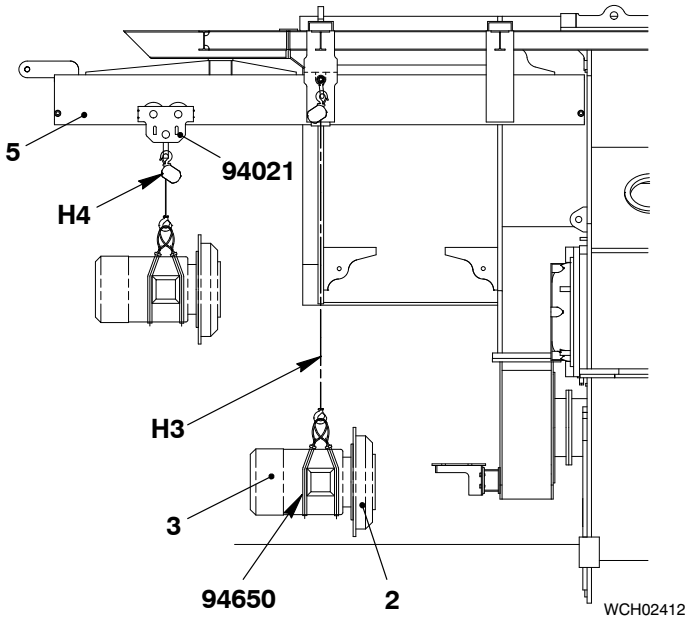


Fig. 3

CAUTION

Damage Hazard: Do not put the electric motor on the floor without an applicable support or damage to the impeller can occur.

6) Operate carefully the manual ratchets (H1, H2, Fig. 3) to move the electric motor (3) and impeller (2) out of the casing (1).
7) Lower the electric motor (3) and impeller (2) to almost the same height as the platform.
8) Attach the chain block (H3) to the lug (4).
9) Attach the chain block (H3) to the two slings (94650).
10) Carefully release the tension on the manual ratchets (H1, H2) until the electric motor (3) and impeller (2) are below the chain block (H3).
11) Remove the manual ratchets (H1, H2).
12) Attach the chain block (H4) to the two slings (94650).
13) Carefully release the tension on the chain block (H3) until the electric motor (3) and impeller (2) are below the chain block (H4).
14) Remove carefully the chain block (H3).
15) Move the electric motor (3) and impeller (2) out of the area.
16) Put the electric motor (3) and impeller (2) on an applicable surface.
17) Remove the two slings (94650) and chain block (H4).

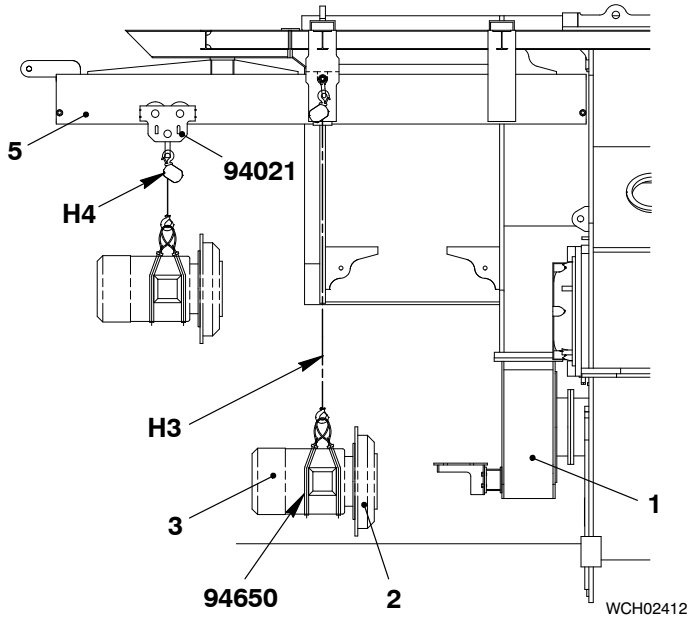


Fig. 4

2.3 Installation

1) Attach the two slings (94650, Fig. 4) to the electric motor (3) and impeller (2).
2) Attach the chain block (H4) to the trolley (94021).
3) Attach the chain block (H4) to the slings (94650).
4) Lift the electric motor (3) and impeller(2).
5) Move the electric motor (3) and impeller (2) into position.

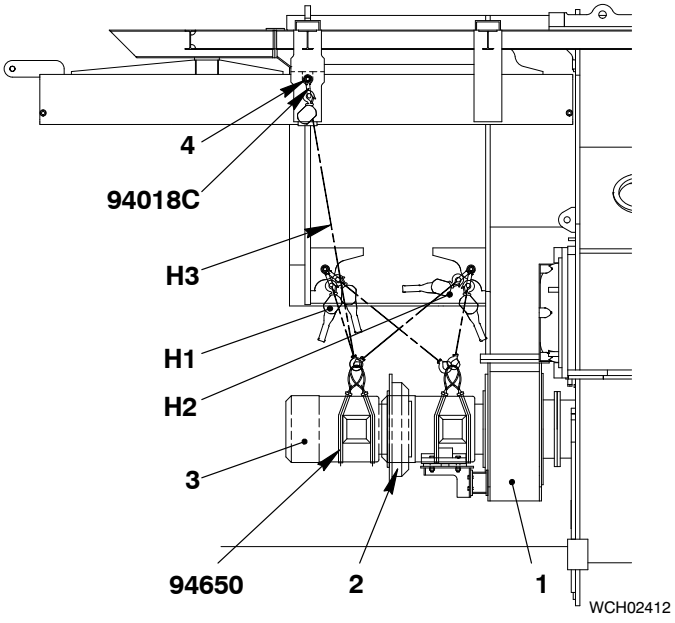


Fig. 5

6) Attach the chain block (H3, Fig. 5) to the slings (94650).
7) Put sufficient tension on the chain block (H3) to hold the electric motor (3) and impeller (2).
8) Remove the chain block (H4) from the slings (94560).
9) Attach the the manual ratchets (H1, H2) to the slings (94560).

Note: When you do step 10), make sure that the electric motor (3) and impeller (2) stay horizontal.

10) Operate the manual ratchets (H1, H2) and the chain block (H3) to move the electric motor (3) and impeller (2) into the casing (1).

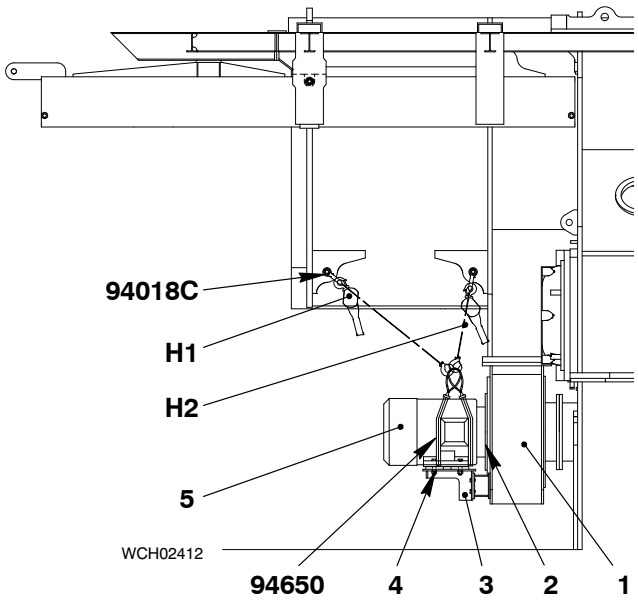


Fig. 6

11) Install the screws (4, Fig. 6) to the support (3).
12) Install the screws (2) to the casing (1).
13) Connect the electrical connections to the electric motor (5).
14) Remove all tools and equipment from the area.
15) Set the auxiliary blower to on.
16) Make sure that the impeller turns in the correct direction.

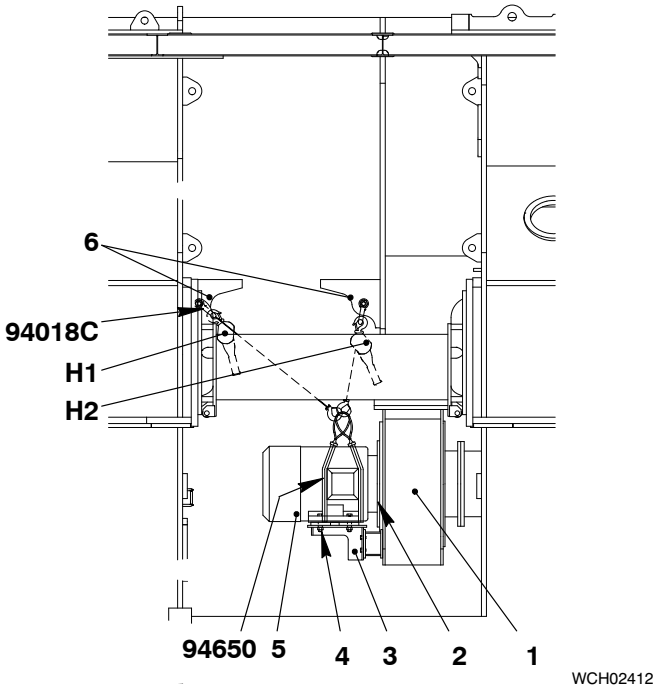


Fig. 7

3. Procedure Two

3.1 Preparation

1) Stop the engine.
2) Set to off the power supply.
3) Disconnect the electrical connection from the electric motor (5, Fig. 8).
4) Attach the shackles (94018C) and the manual ratchets (H1, H2) to the lugs (6).

3.2 Removal

1) Attach the shackles (94018C) and the manual ratchets (H1, H2) to the lugs (6).
2) Attach the two slings (94650) to the electric motor (5).
3) Connect the manual ratchets (H1, H2) to the slings (94650) as shown.
4) Put sufficient tension on the slings (94650) to hold the electric motor (5) in position.
5) Remove the screws (4) from the support (3).
6) Remove the screws (2) from the casing (1).

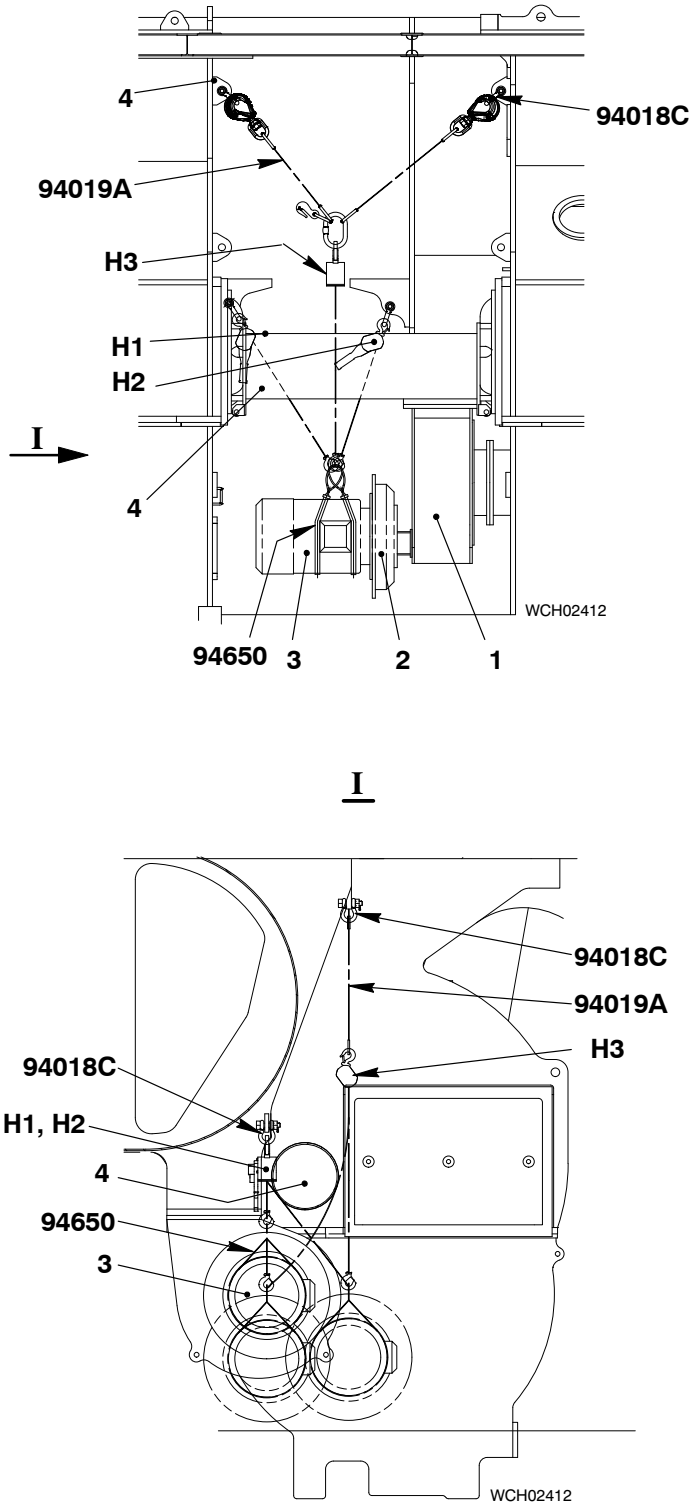


Fig. 8

CAUTION

Damage Hazard: Do not put the electric motor on the floor without an applicable support or damage to the impeller can occur.

7) Put protection on the pipe (4,Fig. 8) where the chain block (H3) and the manual ratchets (H1, H2) can touch.

8) Operate the manual ratchets (H1, H2),) to carefully remove the electric motor (3) and impeller (2) from the casing (1).

9) Lower the electric motor (3) and impeller (2) almost to the platform level.

10) Attach the shackles (94018C) and the chain (94019A) to the lugs (7).

11) Attach the chain block (H3) to the chain (94019A) and the slings (94650).

12) Carefully release the tension on the manual ratchets (H1, H2). At the same time increase the tension on the chain block (H3). Continue until the the electric motor (3) and impeller (2) are below the chain block (H3).

13) Carefully move the electric motor (3) and impeller (2) under the pipe (4).

14) Remove the chain block (H3) from the slings (94065).

15) Move the electric motor (3) and the impeller (2) away from the area.

16) Lower the electric motor (3) and impeller (2) on to an applicable surface.

17) Remove the manual ratchets (H1, H2) and the slings (94560) from the electric motor (3) and impeller (2).

3.3 Installation

1) Attach the manual ratchets (H1, H2) and the slings (94560) to the electric motor (3) and impeller (2).

2) Attach the chain block (H3) to the slings (94065).

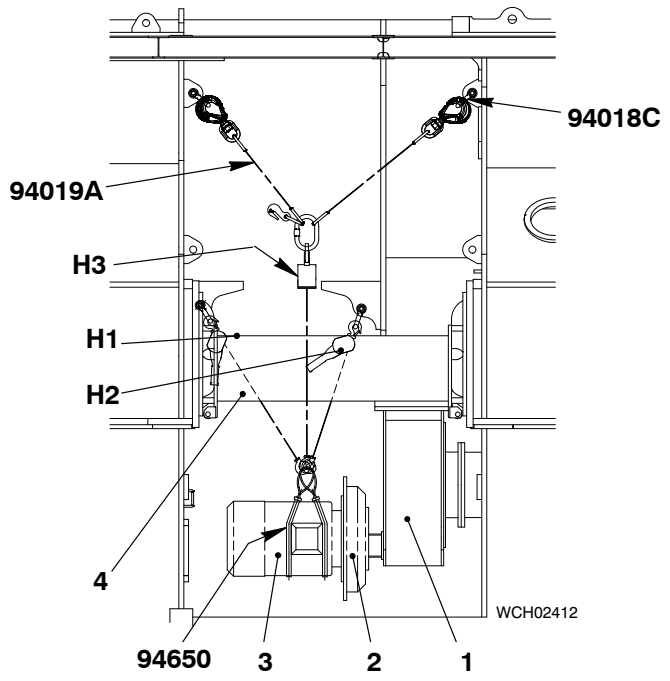


Fig. 9

3) Operate carefully the chain block (H3) and the manual ratchets (H1, H2) to move the electric motor (3, Fig. 10) and impeller (2) under the pipe (4).

4) Continue to operate the chain block (H3) and the manual ratchets (H1, H2). Make sure that the electric motor (3) and impeller (2) are below the chain block (H3).

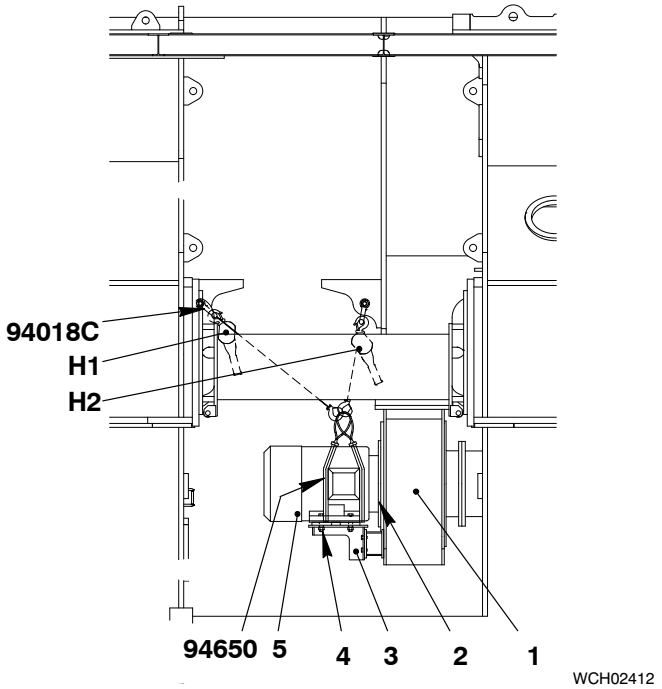


Fig. 10

5) Carefully lift the electric motor (5, Fig. 10) and impeller until they are in position in the casing (1).

6) Install the screws (4) to the support (3).

7) Install the screws (2) to the casing (1).

8) Connect the electrical connections to the electric motor (5).

9) Remove all tools and equipment from the area.

10) Set the auxiliary blower to on.

11) Make sure that the impeller turns in the correct direction.

Intentionally blank

Removal and Installation

Tools:

1	Manual ratchet H3 (1600 kg)	94016-017	2	Safety lugs	94663C
2	Spur-gear chain block H1, H2 (2000 kg)	94017-021	2	Safety chains	94663D
2	Trolleys (WLL 5000 kg)	94021	2	Double-chain sling	94666
6	Swivel lugs	94048–M30	1	Support	94663I
1	Support – left	94663A	2	Bracket	94664
1	Support – right	94663B	1	Dismantling pipe	94664A

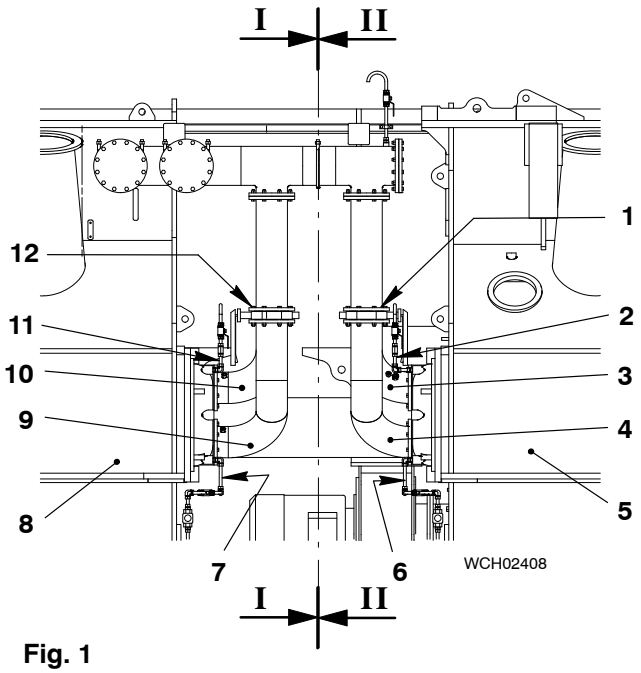


Fig. 1

1. Preparation

1) Read the data in 0012–1 General Guidelines for Lifting Tools.
2) Stop the engine.
3) Stop the cooling water pump.
4) Close the butterfly valves (1 and 12, Fig. 1) of each scavenge air cooler (SAC) (5, 8).
5) Drain the water from each SAC (5, 8).
6) Remove the drain pipes (6 and 7).
7) Remove the vent pipes (2 and 11).
8) Remove the outlet pipes (4 and 9).
9) Remove the inlet pipes (3 and 10).

Note: For Views I–I and II–II, see Fig. 2.

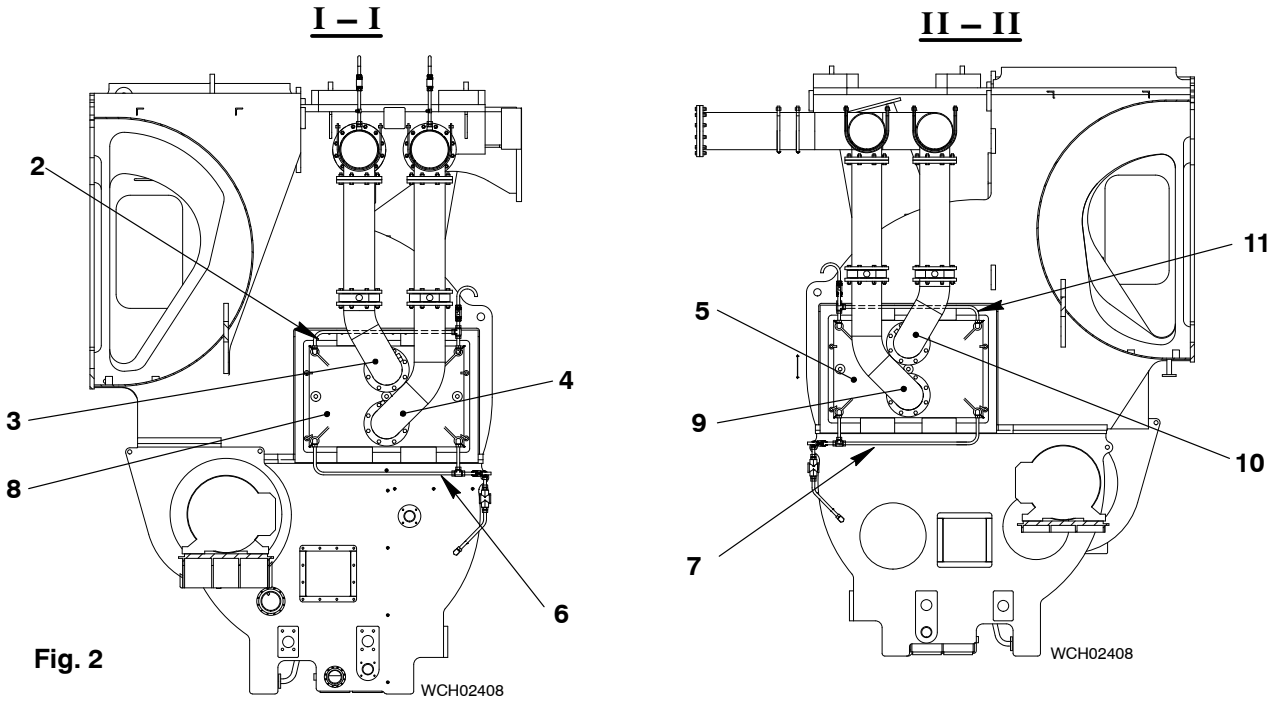


Fig. 2

2. Removal

2.1 Removal Procedure – Front SAC

Note: If the front SAC (3, Fig. 3) only is to be removed, do only paragraph 2.1.

If the rear SAC (2) only, or the two SAC are to be removed, you must first remove the front SAC (3).

1) Attach the two trolleys (94021) to the rail (1).
2) Attach the two spur-geared chain blocks (H1, H2) to the trolleys (94021).
3) Install the dismantling pipe (94664A) to the attachment points on the rail (1) and the platform.

Note: For View A and View I, see Fig. 4.

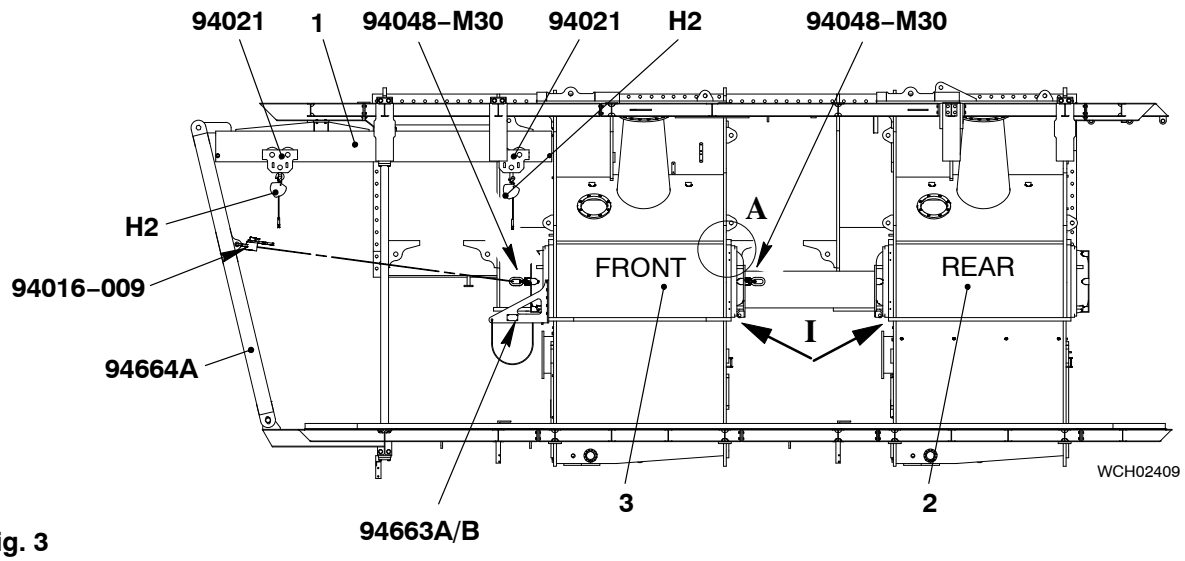


Fig. 3

4) Remove the four holders (18, Fig. 4) from each end of the SAC (5).
5) Remove the flanges (16), O-rings (19) and the inserts (15). Discard the O–rings.
6) Attach the two safety lugs (94663C) to the SAC (5).
7) Attach the supports (94663A, 94663B) to the positions shown with the screws (20).
8) Torque the screws (20) to 136 Nm.
9) Attach the two safety chains (94663D) to the supports (94663A, 94663B) and the safety lugs (94663C). Make sure that the length of the safety chains is sufficient for the full range of travel.
10) Attach three swivel lugs (94048–M30) to the front and rear of the SAC (5).
11) Torque the swivel lugs to the value given in 0352–1.
12) Attach the double-chain slings (94666) to the swivel lugs (94048–M30) on the front and rear of the SAC (5).

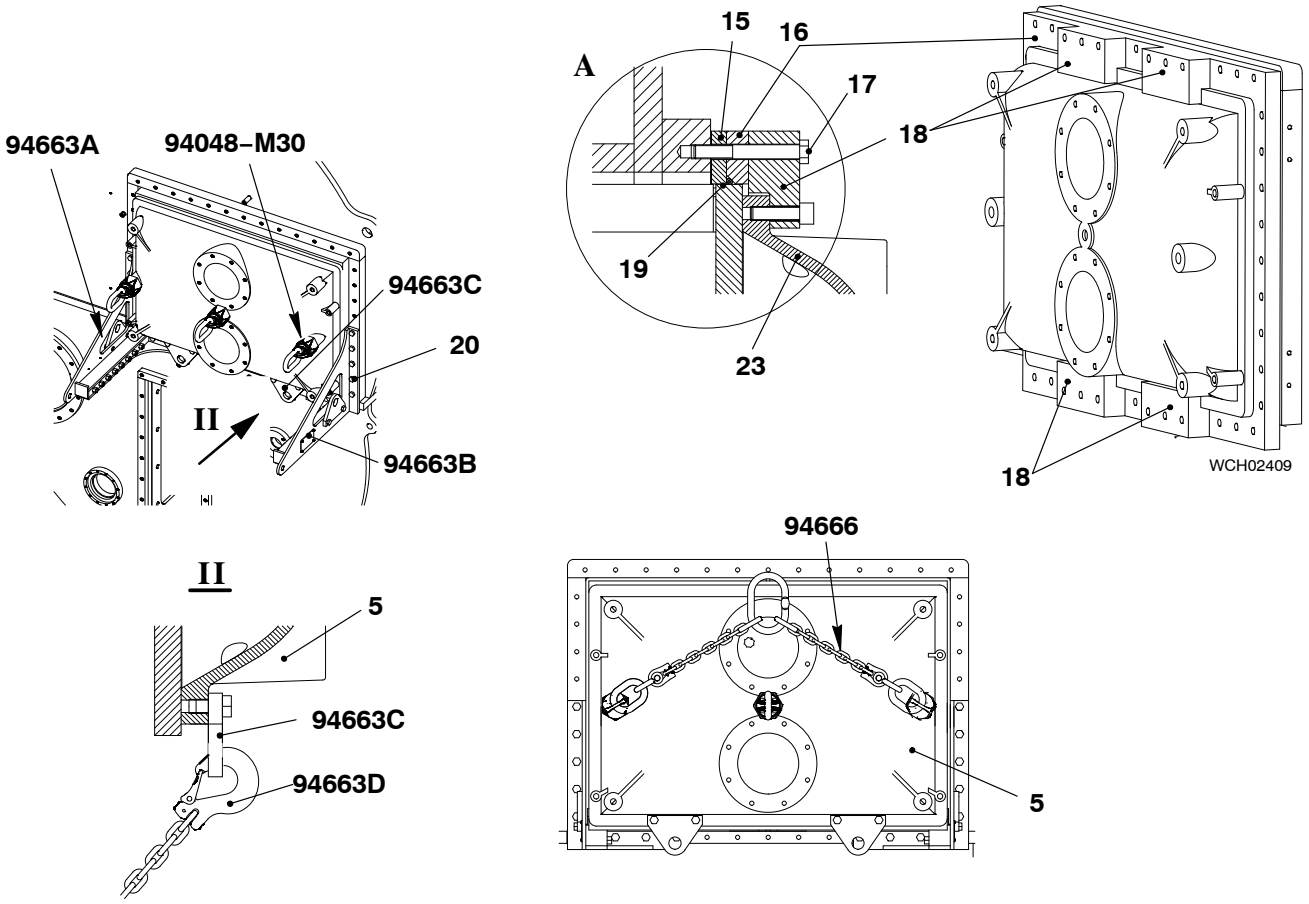


Fig. 4

13) Attach the manual ratchet (H3, Fig. 5) to the dismantling pipe (94664A) and to the center swivel lug on the front of the SAC (5).

14) Attach the chain block (H1) to the double-chain sling (94666).

15) Apply a light tension to the chain block (H1).

WARNING

Injury Hazard: The SAC weighs 3400 kg. When you do the step below, make sure that you do not move the SAC too far. This will prevent injury to personnel.

16) Operate the manual ratchet (H3) until the rear of the SAC (5) is on the two supports (94663A and 94663B).

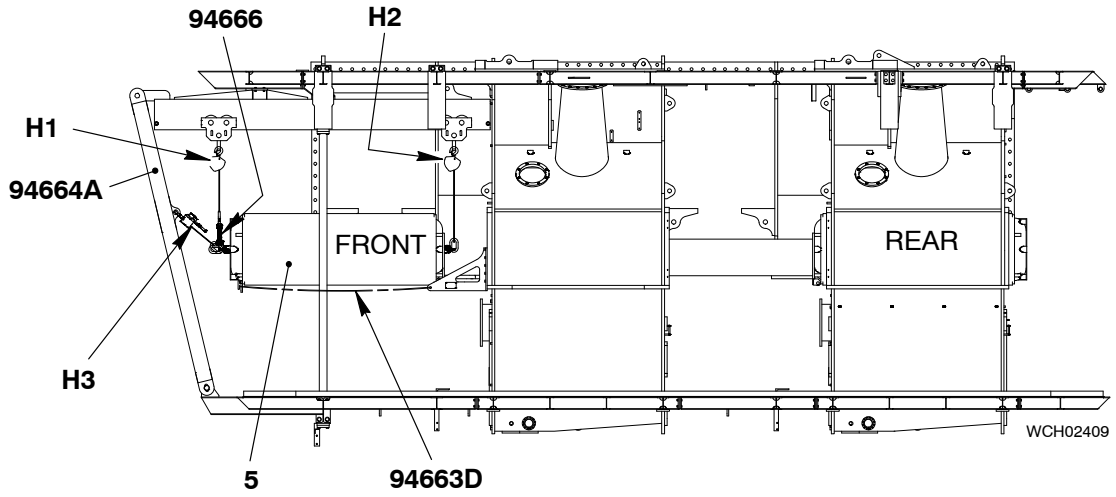


Fig. 5

17) Attach the chain block (H2) to the double-chain sling (94666) on the rear of the SAC (5).

18) Apply a light tension to the chain block (H2).

19) Remove the two safety chains 94663D (see Fig. 6).

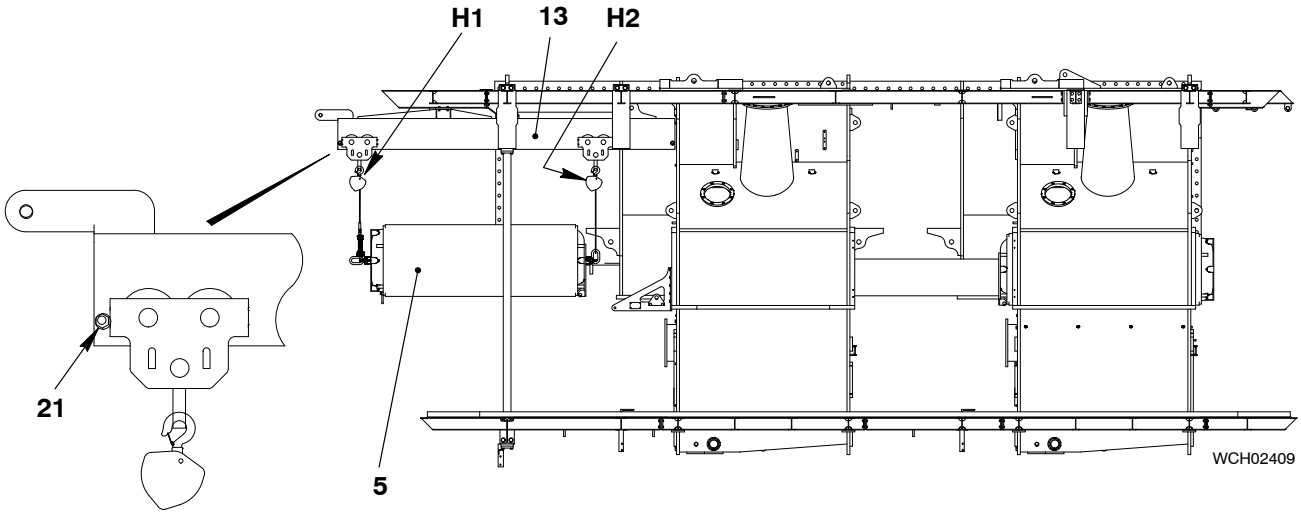


Fig. 6

20) Remove the manual ratchet (H3).

21) Remove the dismantling pipe (94664A).

22) Carefully move the chain blocks (H1, H2) together with the SAC (5) along the rail (13) until H1 touches the end stop (21).

23) Carefully operate the chain block (H1, Fig. 7) to lower the front of the SAC (5). At the same time, carefully move the chain block (H2).

24) Continue with step 23) above until the SAC (5) is in a vertical position.

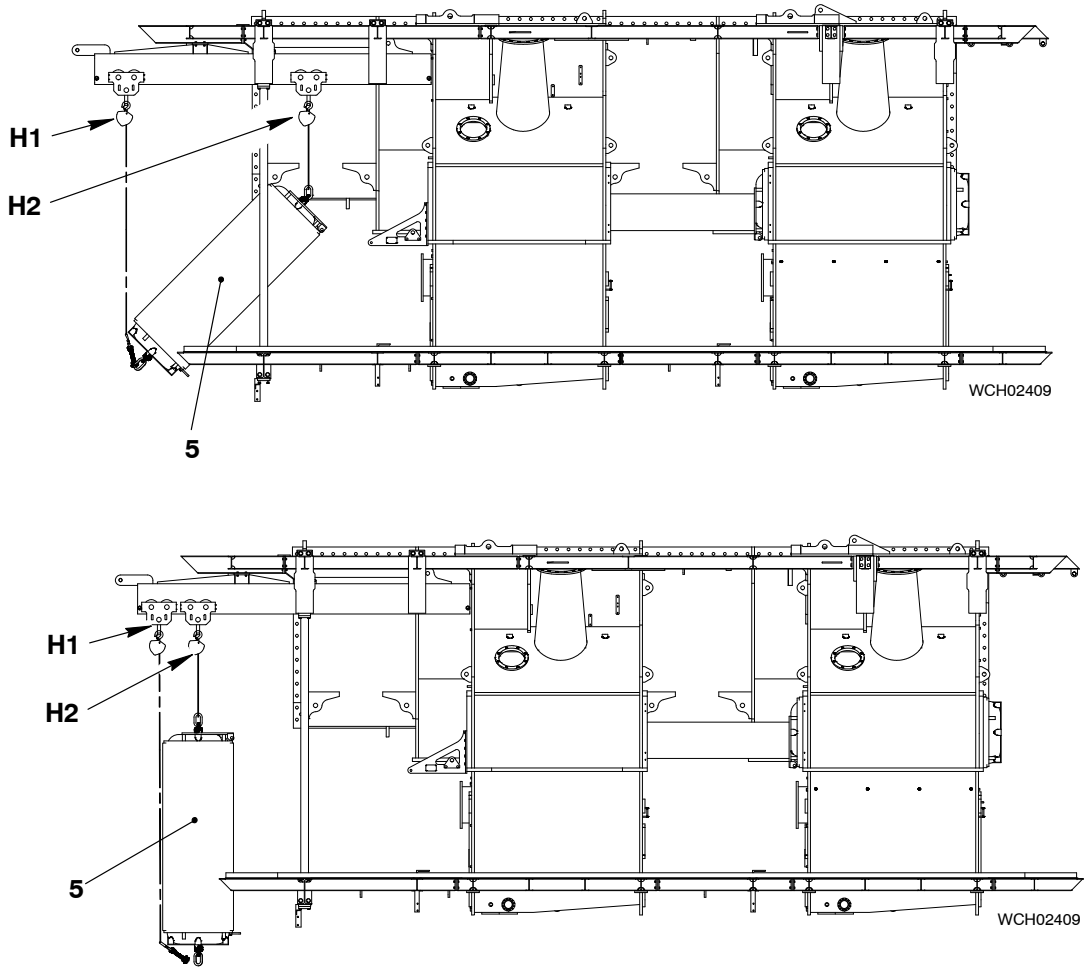


Fig. 7

25) Carefully operate the chain blocks (H1, H2) to lower the SAC (5) on to an applicable surface.

26) Remove the spur-geared chain blocks (H1, H2) from the SAC (5).

27) Remove the swivel lugs (94048–M30) from the SAC (5).

2.2 Removal Procedure – Rear SAC

1) Remove the front SAC, refer to paragraph 2.1.
2) Remove the screws (17, Fig. 8), then remove the four holders(18) from the rear SAC (12).
3) Remove the flanges (16), O-rings (19) and the inserts (15). Discard the O-rings.
4) Put the bracket (94664) in position between the two scavenge air receivers.
5) Torque the screws (22) to 136 Nm.

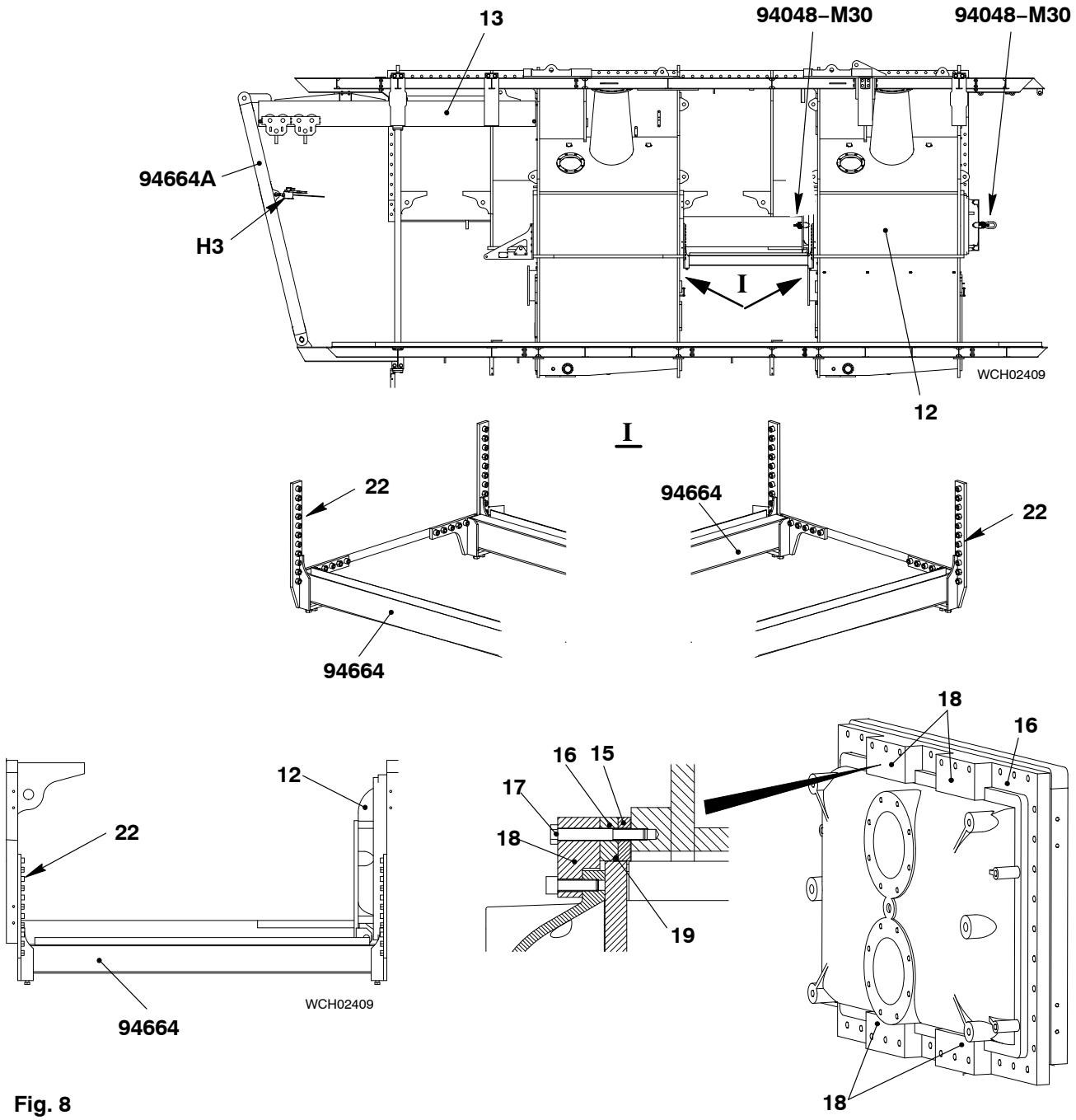


Fig. 8

6) Attach three swivel lugs (94048–M30) on both side of to the SAC (12).
7) Torque the swivel lugs to the value given in 0352–1.
8) Attach the dismantling pipe (94664A) to the attachment points on the rail (13) and the platform.

9) Attach the manual ratchet (H3, Fig. 9) to the dismantling pipe (94664A).

10) Attach the manual ratchet (H3) to the dismantling pipe (94664A) and the center swivel lug on the SAC (12).

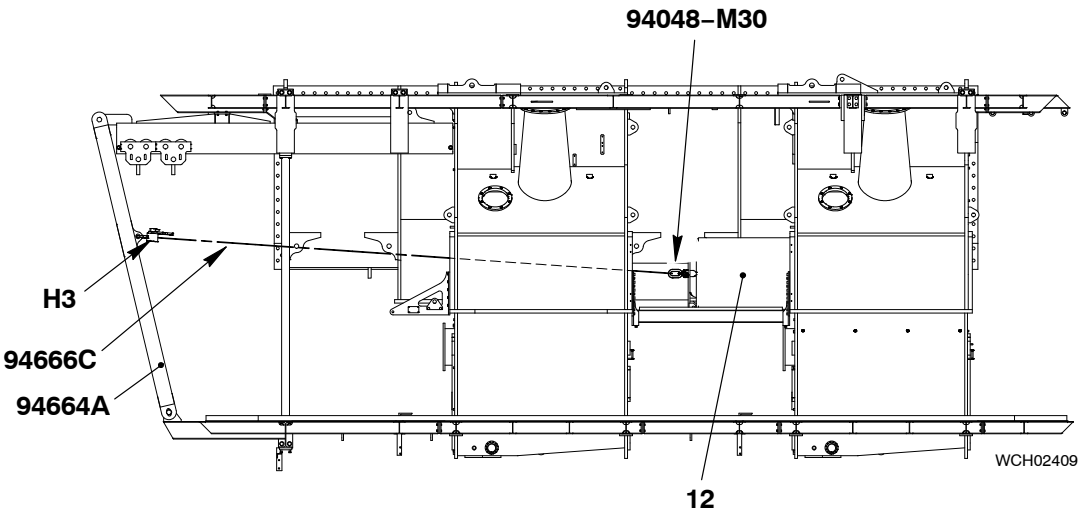
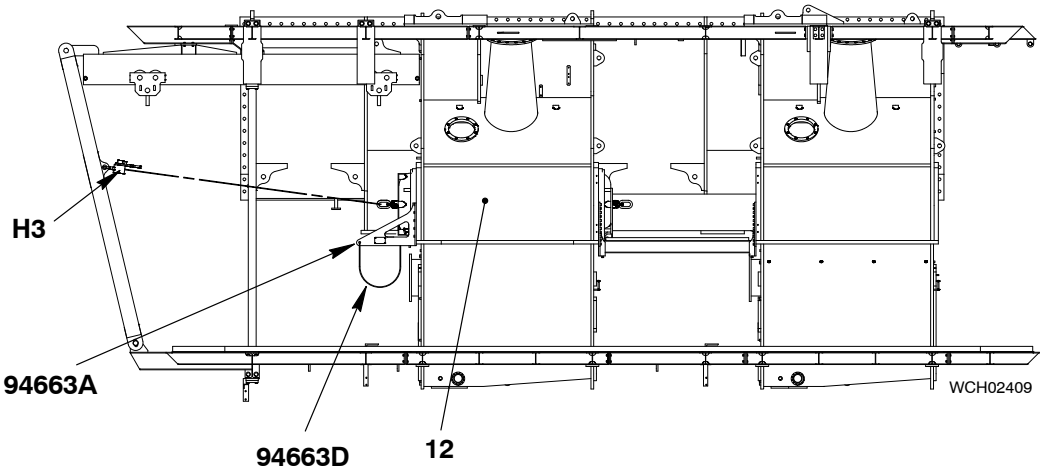


Fig. 9

11) Operate the manual ratchet (H3, Fig. 10). Move the SAC (12) until it is in the front position.

12) Attach the two safety lugs (94663C) to the SAC (12).



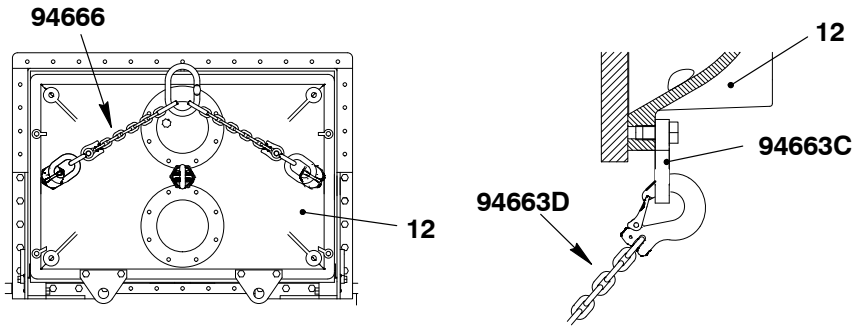


Fig. 10

13) Attach the two safety chains (94663D, Fig. 10) to the supports (94663A, 94663B) and the safety lugs (94663C). Make sure that the length of the safety chains is sufficient for the full range of travel.

14) Attach the double-chain slings (94666) to the swivel lugs (94666) on the front and rear of the SAC (12).

15) Attach the front chain block (H1, Fig. 11) to the double-chain sling (94666).

16) Apply a light tension to the chain block (H1).

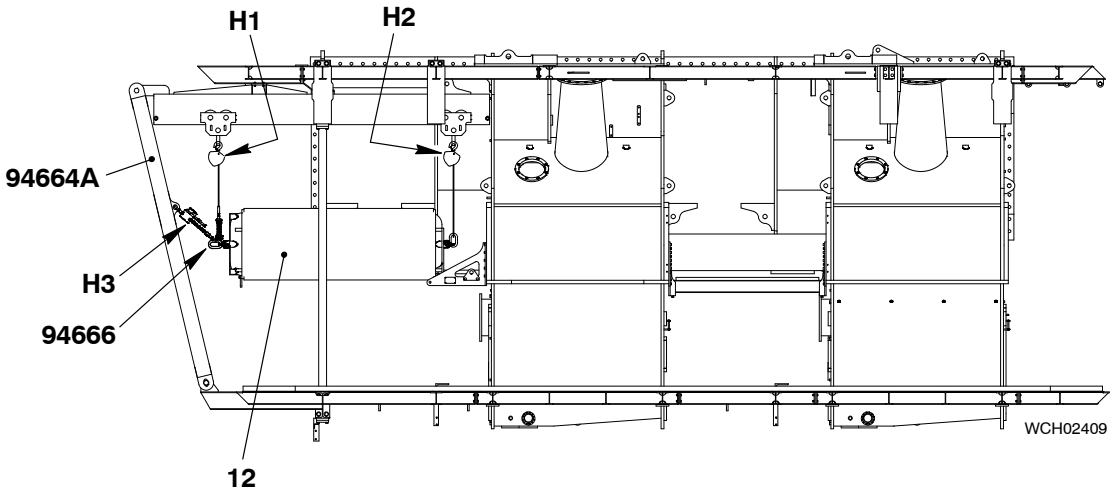


Fig. 11

WARNING

Injury Hazard: The SAC weighs 3400 kg. When you do the step below, make sure that you do not move the SAC too far. This will prevent injury to personnel.

17) Operate carefully the manual ratchet (H3) to move the SAC (12) until the rear of the SAC is on the two supports (94663A, 94663B).

18) Attach the chain block (H2) to the double-chain sling (94666) on the rear of the SAC (12).

19) Apply a light tension to the spur-geared chain block (H2).

20) Remove the two safety chains (94663D).

21) Remove the manual ratchet (H3).

22) Remove the dismantling pipe 94664A.

23) Carefully move the chain blocks (H1 and H2, Fig. 12) together with the SAC (12) along the rail (13) until the chain block (H1) touches the end stop (21).

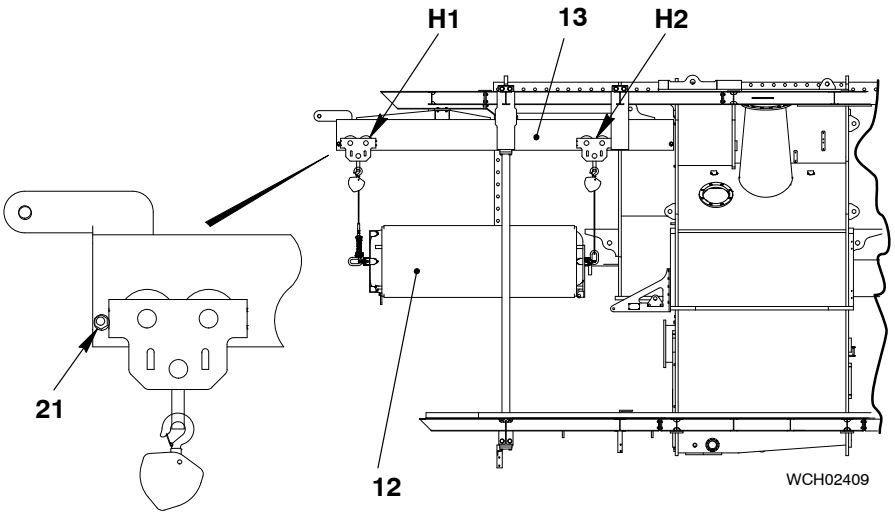


Fig. 12

24) Carefully operate the chain block (H1, Fig. 13) to lower the front of the SAC (12). At the same time, carefully move the chain block (H2).

25) Continue with step 24) above until the SAC (12) is in a vertical position.

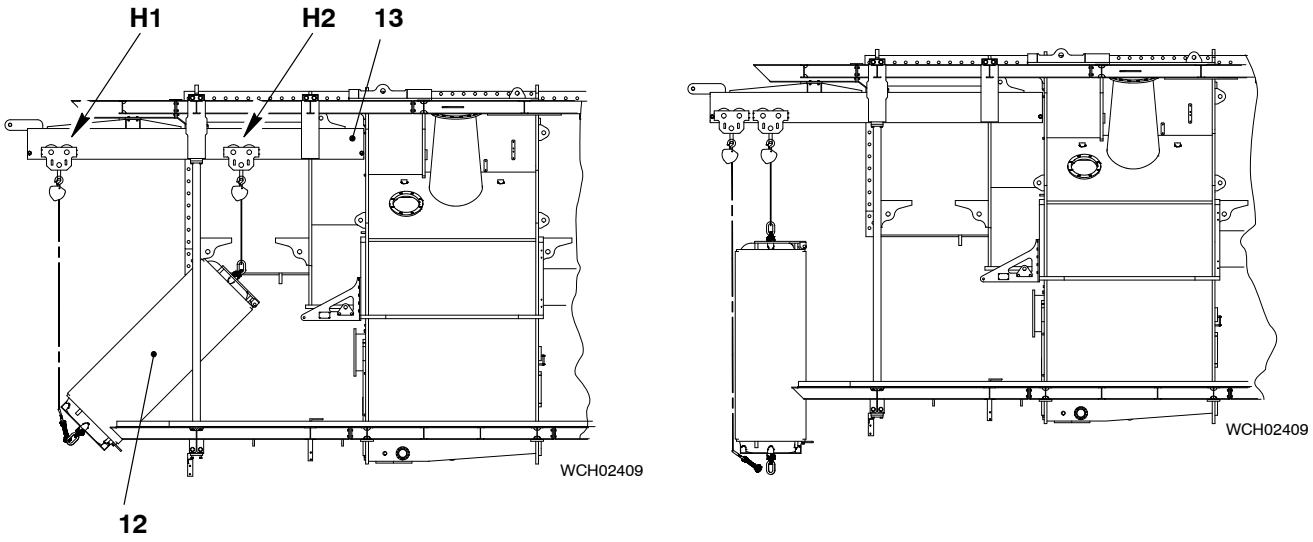


Fig. 13

26) Carefully lower the SAC (12) on to an applicable surface.

27) Remove the chain blocks (H1, H2) from the SAC (12).

28) Remove the swivel lugs (94048–M30) from the SAC (12).

3. Installation

3.1 Installation Procedure – Rear SAC

1) Make sure that all surfaces of the SAC (12) and the related surfaces in the scavenge air receiver are clean and have no damage.

2) Attach the support (94663I, Fig. 14) to the rear of the SAC housing.

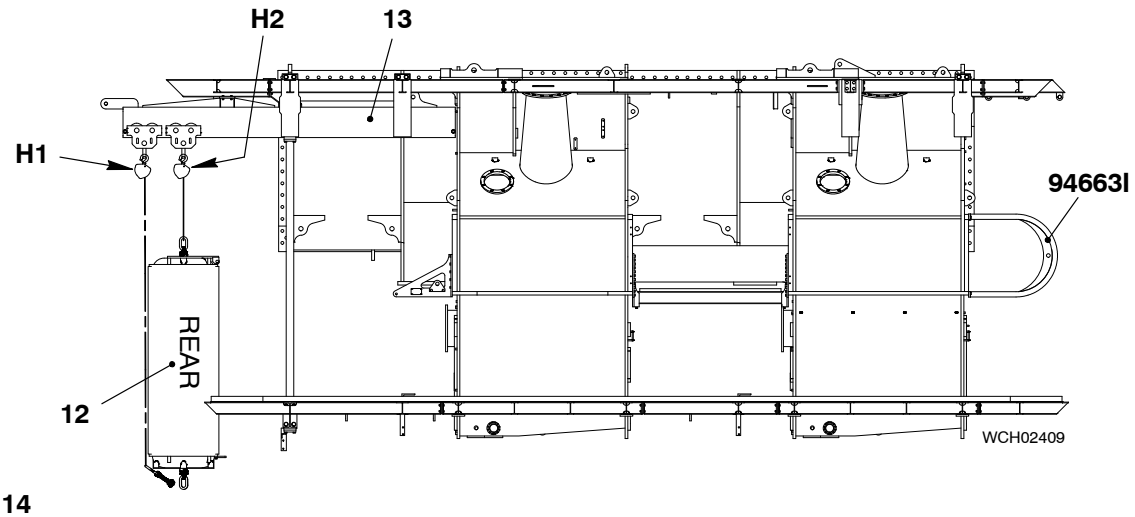


Fig. 14

3) Attach the chain blocks (H1, H2) to the trolleys on the rail (13).

4) Attach the six swivel lugs (94048–M30) to the front and rear of the SAC (12).

5) Torque the six swivel lugs (94048–M30) to the value given in 0352–1.

6) Attach the chain blocks (H1, H2) to the SAC (12).

7) Put the SAC (12) in position.

8) Operate the chain block (H1) to lift the front of the SAC (12). At the same time, move the chain block (H2) rearward (see Fig. 15).

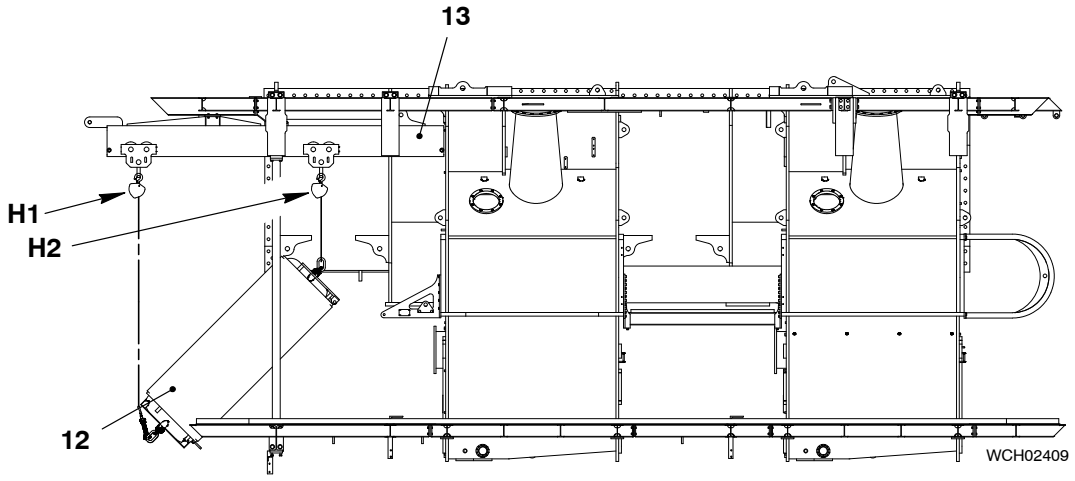


Fig. 15

9) Continue with step 10) above until the SAC (12, Fig. 16) is in a horizontal position. Make sure that the rear of the SAC is on the supports (94663A/B).

10) Attach the manual ratchet (H3) to the support (94663I) and the center rear swivel lug on the SAC (12).

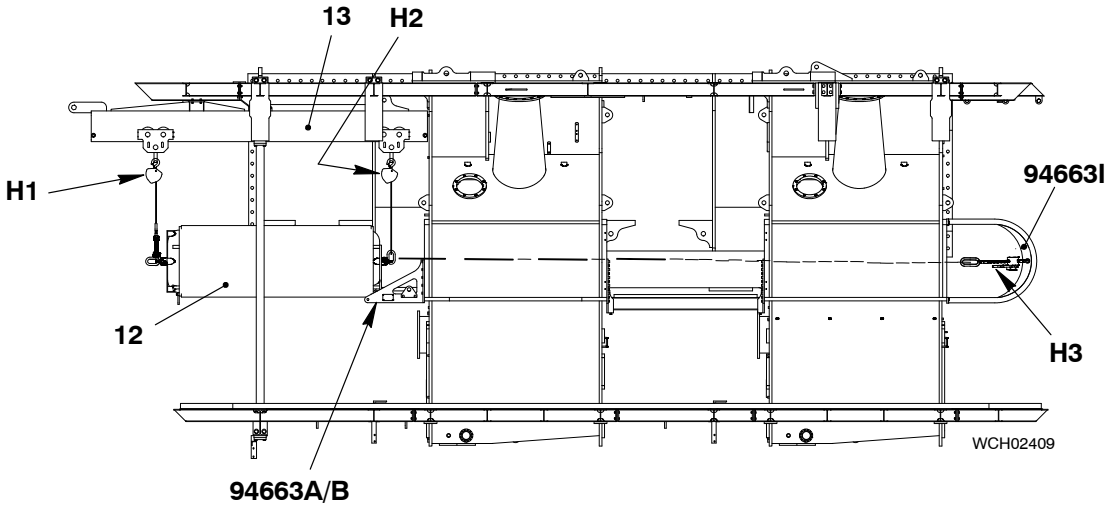


Fig. 16

11) Operate the manual ratchet (H3) to apply a light tension to the wire rope.

12) Remove the chain block (H2) from the double-chain sling (94666).

13) Operate the manual ratchet (H3) to move the SAC (12) rearward. At the same time, move the chain block (H1) rearward until the SAC is in the position shown in Fig. 17.

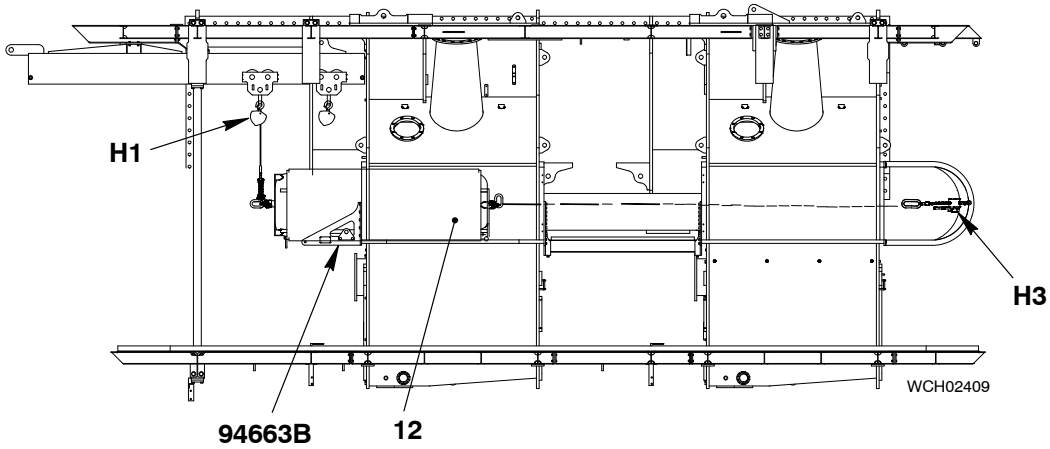


Fig. 17

14) Remove the chain block (H1) from the double-chain sling on the SAC (12).

15) Continue to operate the manual ratchet (H3) until the wheel of the SAC (12, Fig. 18) is on the lip of the opening.
16) Open the inspection cover (20) to get access into the under−slung part.
17) Apply a layer of high−temperature silicon sealing compound (ABT.250) to each side of the SAC (12) and the related surfaces in the housing in the scavenge air receiver.
18) Apply a layer of high−temperature silicon sealing compound (ABT.250) to the sealing surfaces of the SAC (12).
19) Close the inspection cover (19).
20) Operate the manual ratchet (H3) until the SAC is fully in.
21) Remove the wire rope from the manual ratchet (H3) and the rear double-chain sling (94666).

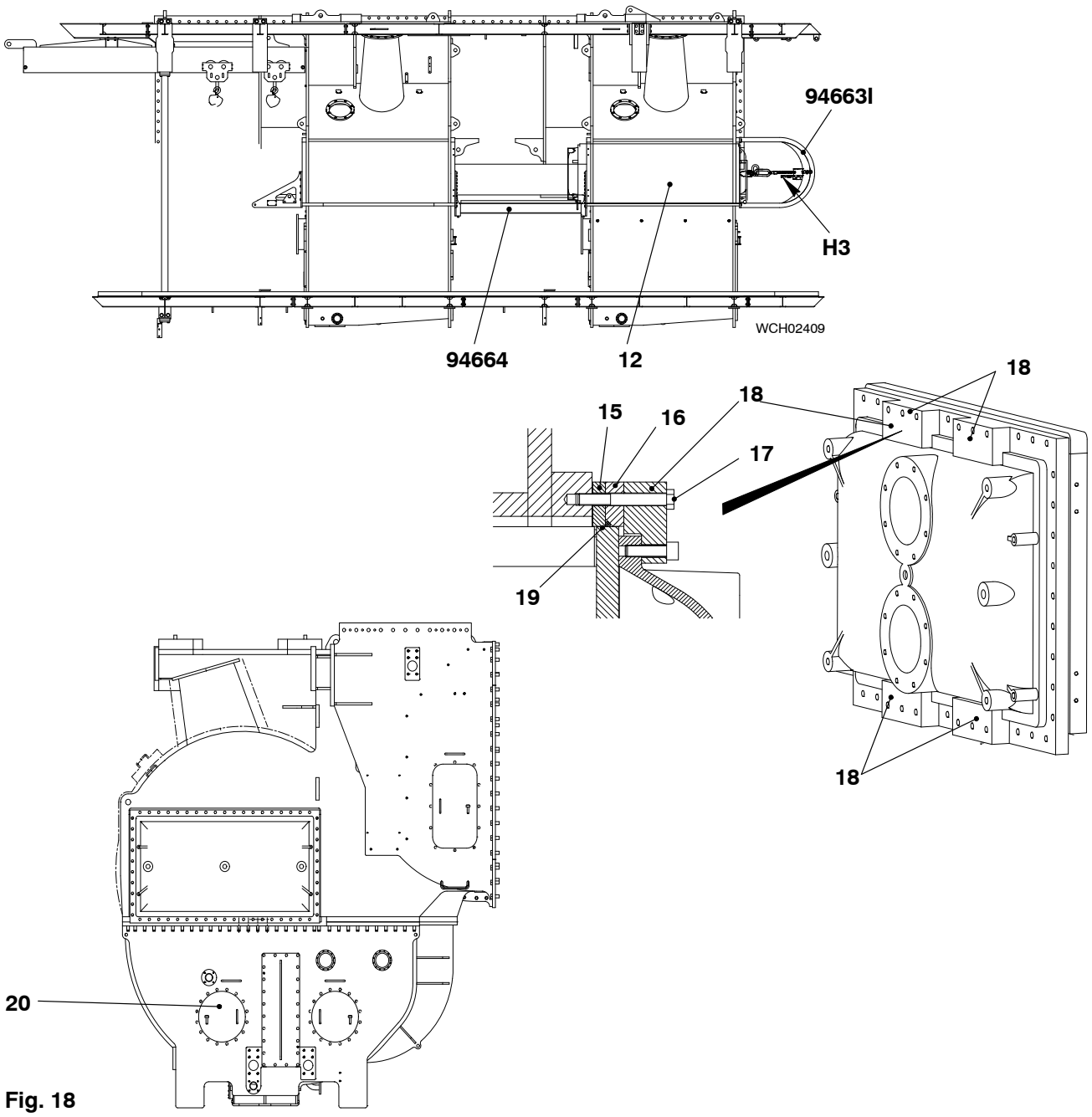


Fig. 18

22) Remove the two double-chain slings from the SAC (12).
23) Remove the six swivel lugs from the SAC (12).
24) Remove the manual ratchet (H3).
25) Remove the support (94663l).
26) Remove the bracket (94664).
27) Put the insert (15) in position on the SAC(12).
28) Put a new O–ring (19) in position on the flange (16).
29) Attach the holders (18) to the SAC 12 with the screws (17).
30) Torque the screws (17) to the value given in 0352–1.

3.2 Installation Procedure – Front SAC

1) Make sure that all the surfaces of the SAC (5, Fig. 19) and the related surfaces in the scavenge air receiver are clean and have no damage.
2) Apply a layer of silicon compound to each side of the SAC (5) and the related surfaces in the housing in the scavenge air receiver.
3) Apply a layer of silicon compound to the sealing surfaces of the SAC (5).
4) Attach the support (94663l) to the rear of the SAC housing.

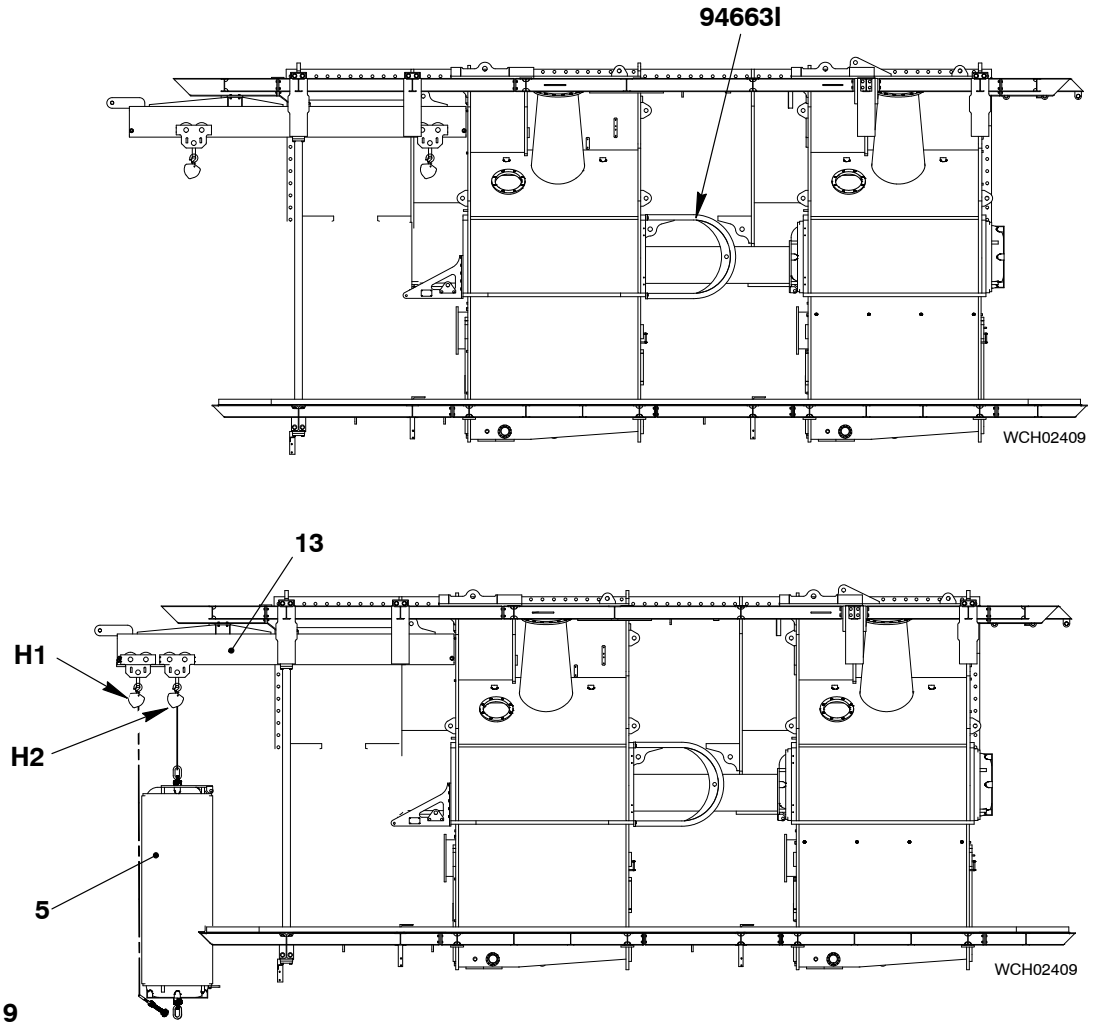


Fig. 19

5) Attach the chain blocks (H1, H2) to the trolleys on the rail (13).
6) Attach the six swivel lugs to the front and rear of the SAC (5).
7) Attach the chain blocks (H1, H2) to the SAC (5).
8) Put the SAC (5) in position as shown.
9) Operate the chain block (H1, Fig. 20) to lift the front of the SAC (5). At the same time, move the chain block (H2) rearward.
10) Continue with step 9) above until the SAC (5) is in a horizontal position. Make sure that the rear of the SAC is on the supports (94663B).

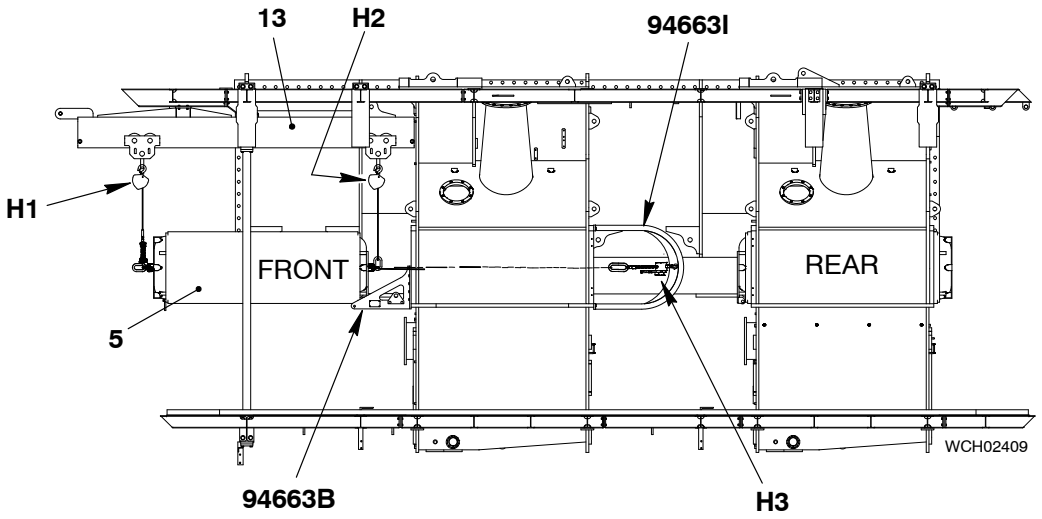


Fig. 20

11) Attach the manual ratchet (H3) to the support (94663I) and the center rear swivel lug on the SAC (5).
12) Apply a light tension to the manual ratchet (H3).
13) Remove the chain block (H2) from the double-chain sling (94666).
14) Operate the manual ratchet (H3, Fig. 21) to move the SAC (5) into the scavenge air receiver. At the same time, move the chain block (H1) until the SAC is in the position shown.
15) Remove the chain block (H1) from the double-chain sling on the SAC (5).

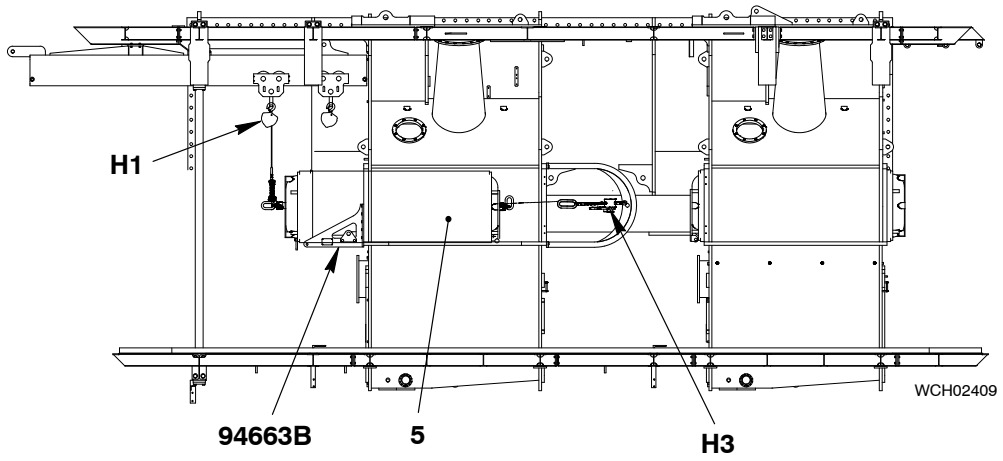


Fig. 21

16) Open the inspection cover (20, Fig. 22) to get access into the under−slung part.

17) Apply a layer of high−temperature silicon sealing compound (ABT.250) to each side of the SAC (12) and the related surfaces in the housing in the scavenge air receiver.

18) Apply a layer of high−temperature silicon sealing compound (ABT.250) to the sealing surfaces of the SAC (12).

19) Close the inspection cover (19).

20) Continue to operate the manual ratchet (H3) until the the SAC (5) is fully in.

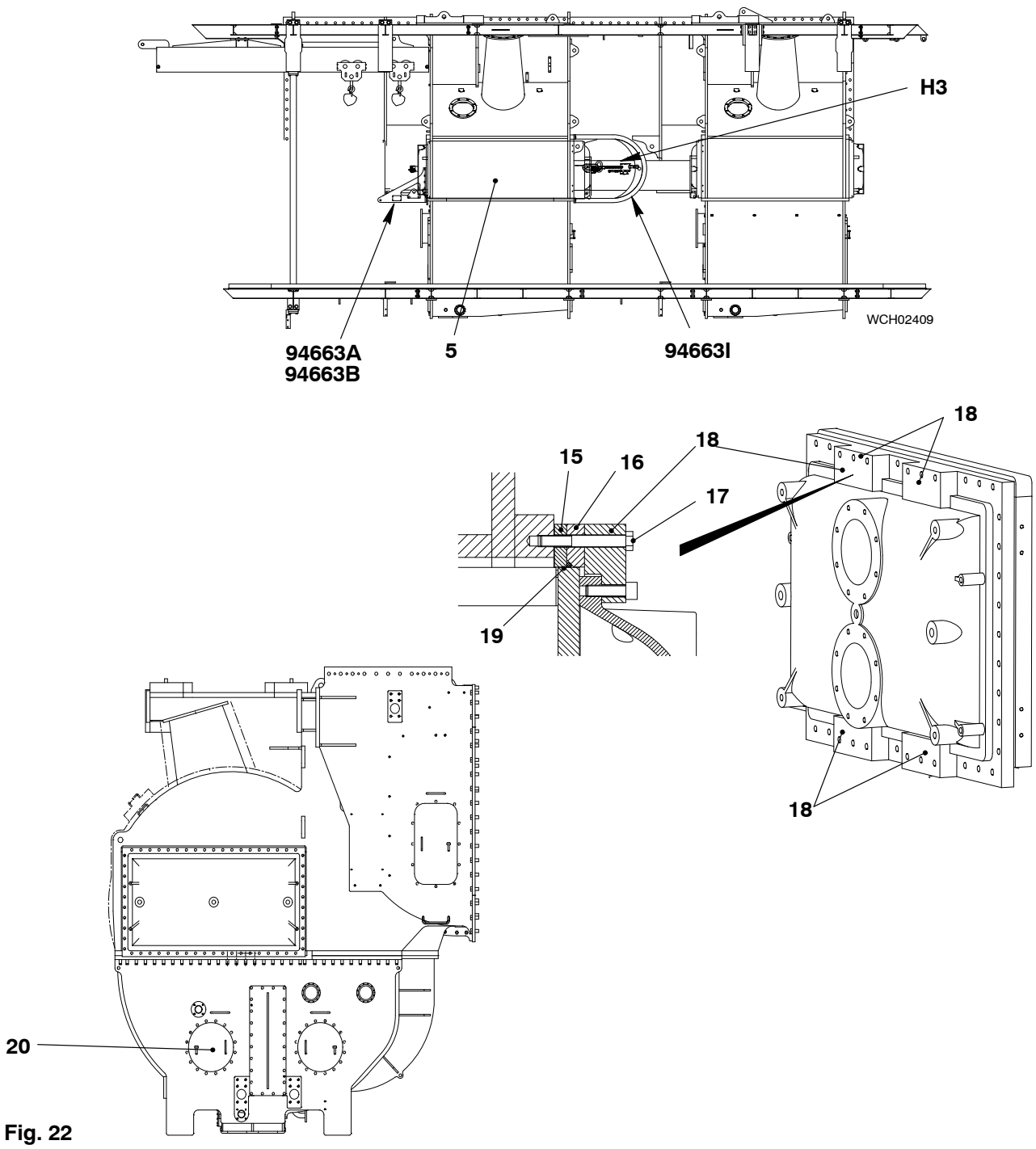


Fig. 22

21) Remove the two double-chain slings (94666) from the SAC (5).
22) Remove the six swivel lugs (94048–M30) from the SAC (5).
23) Remove the manual ratchet (H3).
24) Remove the tool (94663I).
25) Remove the supports (94663A and 94663B).
26) Remove the chain blocks (H1, H2) and the trolleys (94021).
27) Put the insert (15) in position on the SAC (5).
28) Put a new O-ring (19) in position on the flange (16).
29) Attach the holders (18) to the SAC (5) with the screws (17).
30) Torque the screws (17) to the value given in 0352–1.

4. Completion

1) Install the drain pipes (4 and 10, Fig. 23).
2) Install the vent pipes (7, 8).
3) Install the outlet pipes (6 and 9, Fig. 23).
4) Install the inlet pipes (3 and 11).
5) Open the butterfly valves (1 and 12, Fig. 1) of each SAC (5, 12).
6) Release the air in each SAC (5, 12).
7) Start the cooling water pump.
8) Make sure that there are no water leaks.
9) Make sure that no scavenge air flows between the SAC (5, 12) and the SAC housings.
10) Stop the cooling water pump.

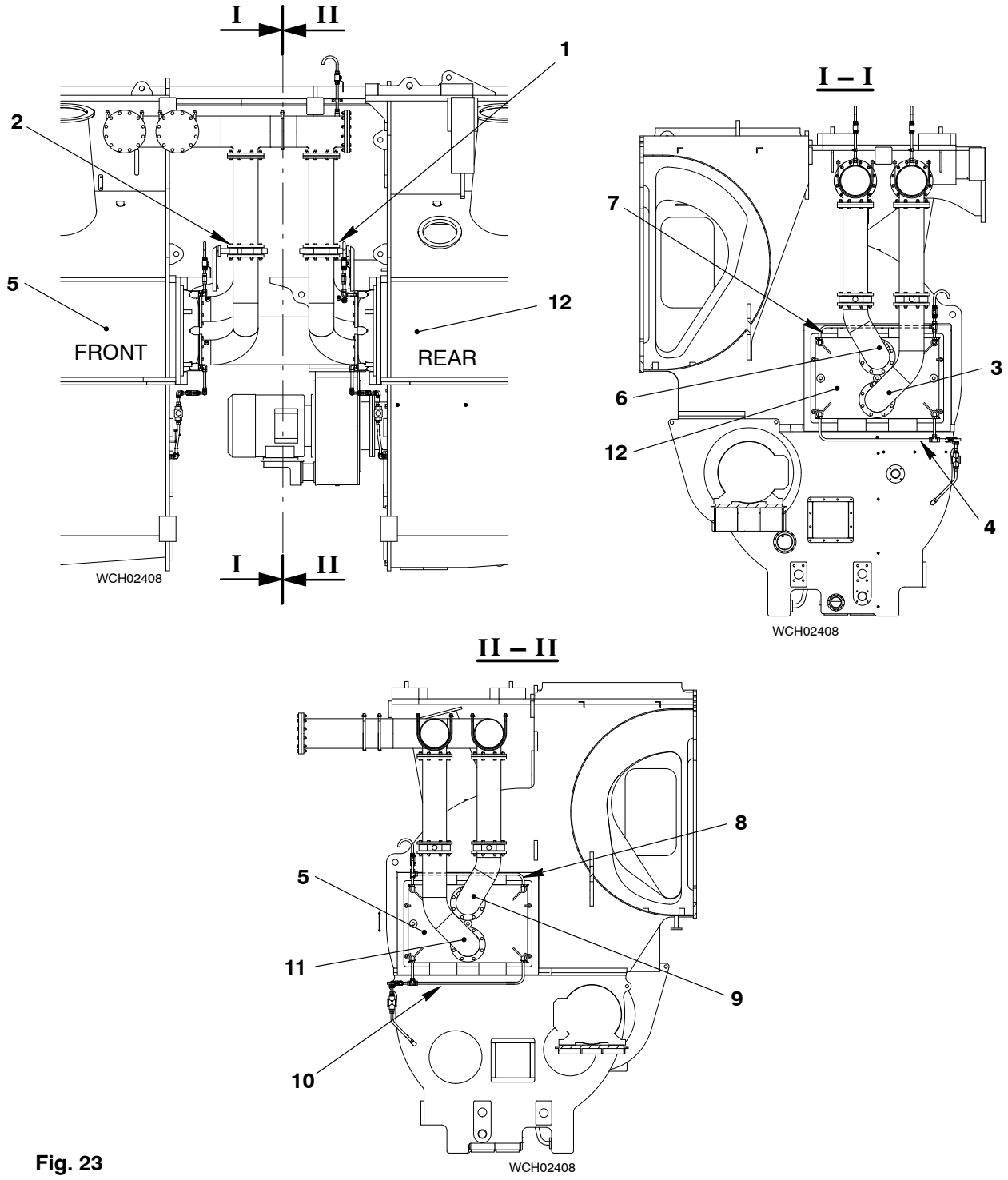

I
II
1
2
5
12
FRONT
REAR
WCH02408
I – I
7
6
12
3
4
WCH02408
II – II
8
5
11
9
10
WCH02408

Fig. 23

Intentionally blank

Removal and Installation

Tools:

2	Manual ratchet, WLL 1600 kg H1/H2	94016–017	2	Shackle, WLL 3250 kg	94018A
2	Manual ratchet, WLL 3000 kg H3/H4	94016–031	3	Lifting tool	94667
1	Holder	94667H	1	Holder	94667G

1. Preparation

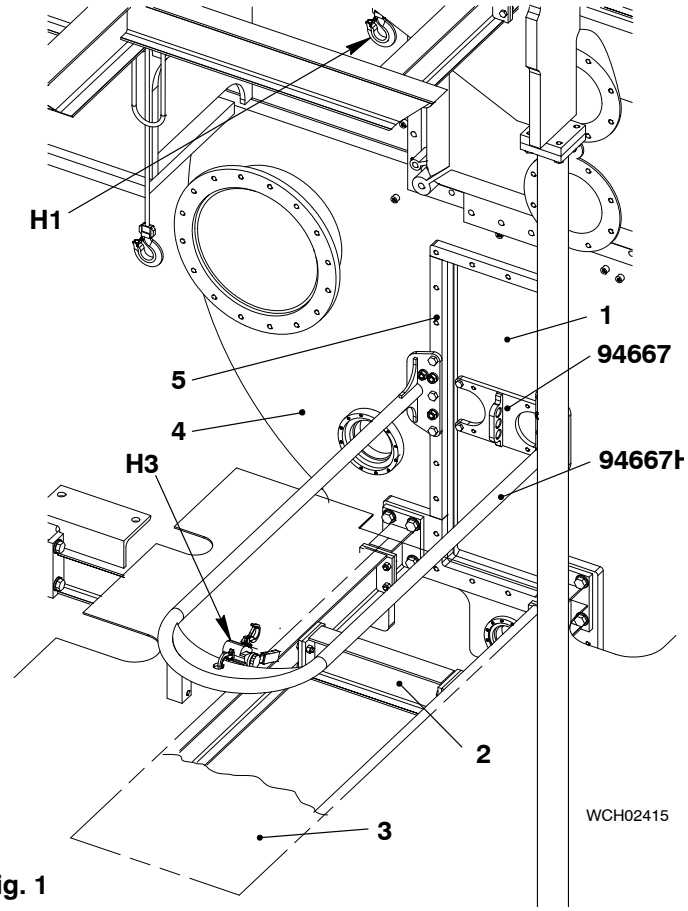


Fig. 1

1) Read the data in 0012–1. General Guidelines for Lifting Tools
2) Remove the front and rear cover from the housing of the water separator (1, see Fig. 1 and Fig. 2).
3) Install the tools (94667) to the front and rear of the water separator (1).
4) Install the holder (94667H) to the front frame (5) as shown.
5) Install the holder (94667G) to the rear frame (6) as shown.
6) Remove the bottom plate (3) and the beam (2).
7) Attach the manual ratchet (H3) to the holder (94667H) and the tool (94667).
8) Attach the manual ratchet (H4) to the holder (94667G) and the tool (94667).
9) Attach the manual ratchet (H1) to the shackle (94018A) on the gallery above water separator.

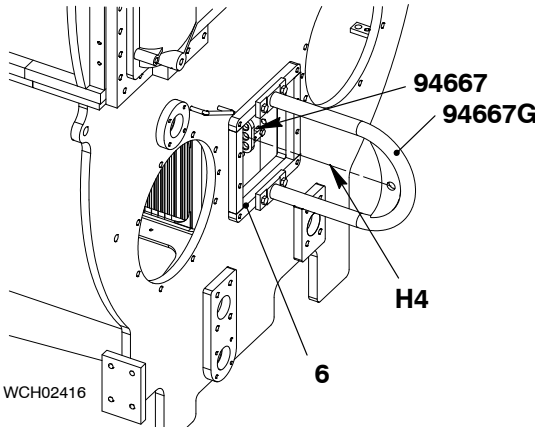


Fig. 2

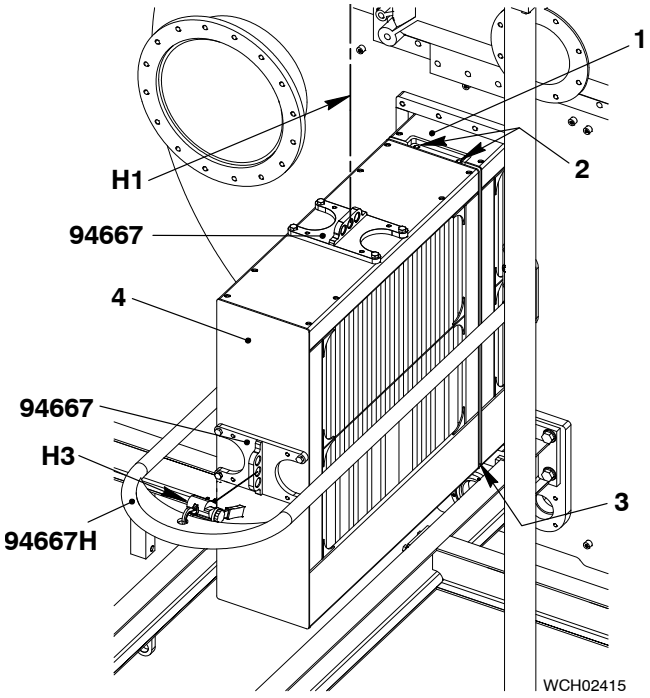


Fig. 3

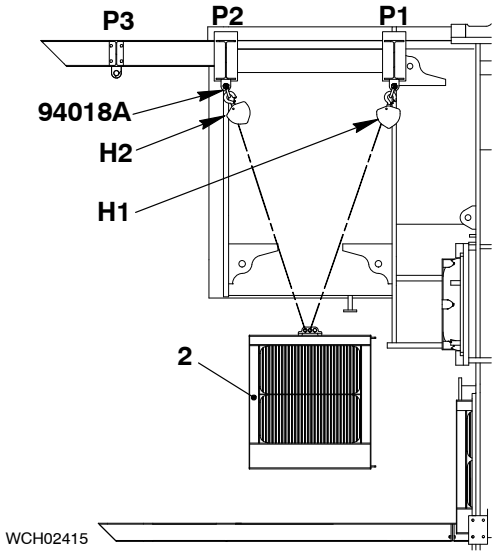


Fig. 4

2. Removal Procedure

2.1 Front Water Separator

1) Operate the manual ratchet (H2, Fig. 3) to pull the water separator (4) sufficiently so you can attach the tool (94667) to the water separator.
2) Attach the tool (94667) to the top of the water separator (4).
3) Attach the manual ratchet (H1) to the tool (94667).
4) Apply a light tension to the manual ratchet (H1).
5) Operate the manual ratchet (H3) to pull the water separator (4) from the receiver until you can get access to the four screws (2, 3). At the same time, operate the manual ratchet (H1) to hold the mass of the water separator.
6) Remove the the two top screws (2) and the two bottom screws (3) between the front and rear water separators.
7) Operate the manual ratchet (H3) to pull the water separator (4) a small distance to disconnect the water separator.
8) Remove the manual ratchet (H3) and the holder (94667H).
9) Remove the tool (94667) from the front of the water separator (4).
10) Attach the shackle (94018A, Fig. 4) to the gallery.
11) Attach the manual ratchet (H2) to the shackle (94018A).
12) Attach the manual ratchet (H2) to the lifting tool (94667) on the water separator (1).
13) Operate the manual ratchet (H1) to increase the tension. At the same time, operate the manual ratchet (H2) to decrease tension and keep the water separator level.
14) Remove the manual ratchet (H1) and the shackle (94018A) from the point (P1).

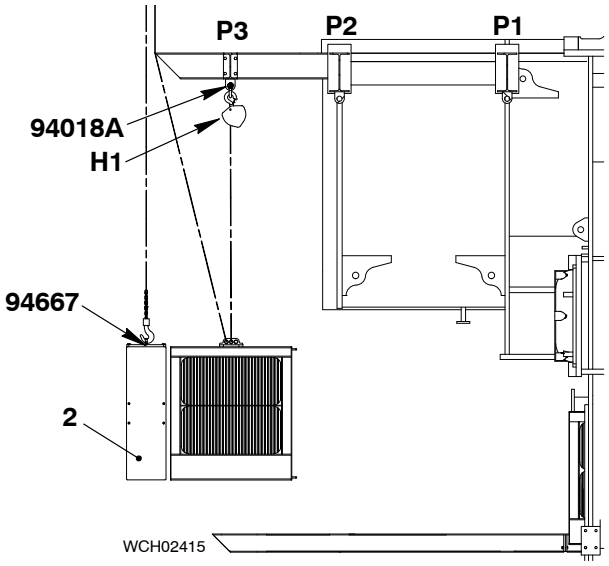


Fig. 5

15) Attach the manual ratchet (H1, Fig. 5) and the shackle (94018A) to the point (P3).
16) Attach the manual ratchet (H1) to the lifting tool (94667) of water separator.
17) Operate the manual ratchet (H1) to increase the tension. At the same time, operate the manual ratchet (H2) to decrease tension and keep the water separator level.
18) Attach the engine room crane to the lifting tool (94667).
19) Lower the water separator on to an applicable surface.
20) Remove the engine room crane from the water separator.
21) Remove the tool (94667) from the water separator.

2.2 Rear Water Separator

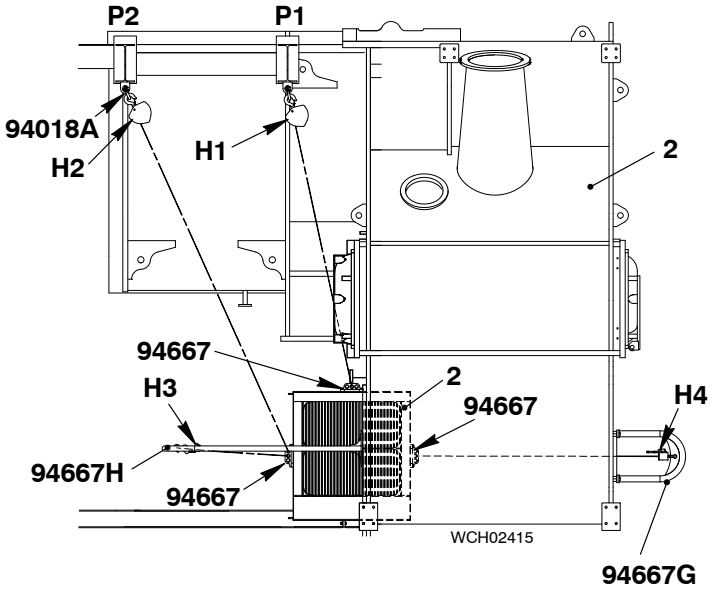


Fig. 6

1) Attach the tool (94667, Fig. 6) to the front of the water separator (2).
2) Attach the holder (94667H) to the housing on the receiver.
3) Attach the manual ratchet (H3) to the holder (94667H) and the tool (94667).
4) Attach the shackle (94018A) to the point (P2).
5) Attach the manual ratchet (H2) to the shackle (94018A) and the tool (94667).
6) Apply a light tension to the manual ratchet (H2).
7) Operate the manual ratchet (H3) to pull the water separator (2) sufficiently so that you can attach the tool (94667). At the same time, operate the manual ratchet (H2) to hold the mass of the water separator.
8) Attach the tool (94667) to the top of the water separator.
9) Apply a light tension to the manual ratchet (H1).
10) Operate the manual ratchet (H3) to pull the water separator fully from the receiver. Keep the tension on the manual ratchets (H1, H2) to hold the mass of the water separator (2).
11) Remove the holder (94667H) and the manual ratchet (H3).
12) Remove the tool (94667) from the front of the water separator (2)

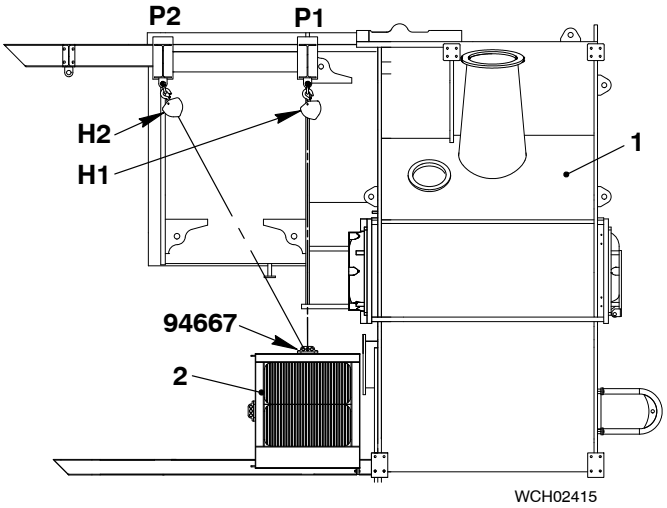


Fig. 7

13) Attach the manual ratchet (H2, Fig. 7) to the tool (94667) on the water separator (2).

14) Remove the manual ratchet (H4) from the rear of the water separator (2).

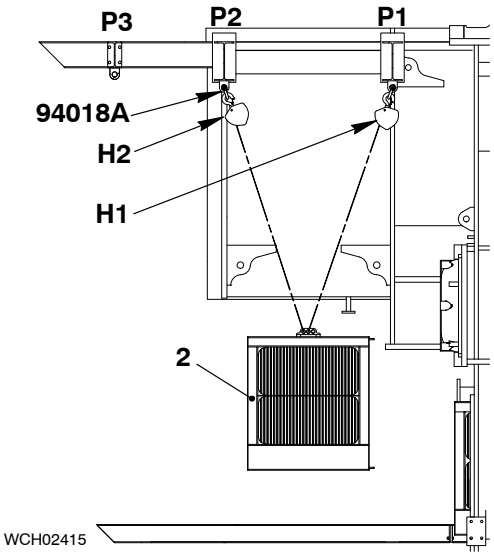


Fig. 8

15) Attach the shackle (94018A, Fig. 8) to the gallery.

16) Attach the manual ratchet (H2) to the shackle (94018A).

17) Attach the manual ratchet (H2) to the lifting tool (94667) on the water separator (2).

18) Operate the manual ratchet (H1) to increase the tension. At the same time, operate the manual ratchet (H2) to decrease tension and keep the water separator level (2).

19) Remove the manual ratchet (H1) and the shackle (94018A) from the point (P1).

20) Attach the manual ratchet (H1) and the shackle (94018A) to the point (P3).

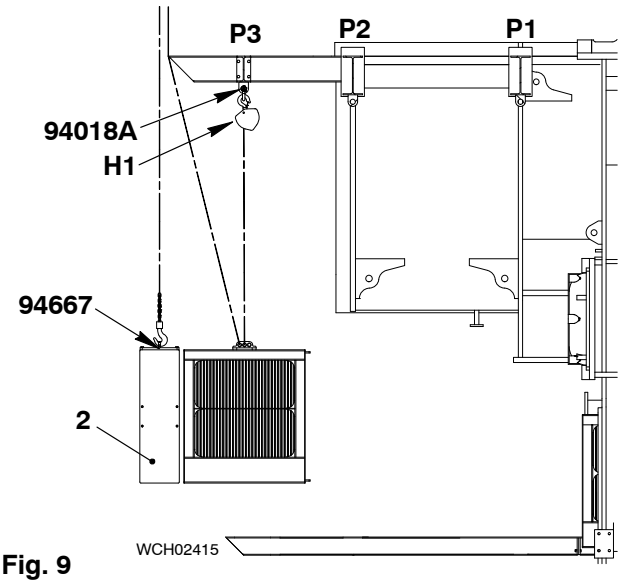


Fig. 9

21) Attach the manual ratchet (H1) to the lifting tool 94667 of water separator (2).

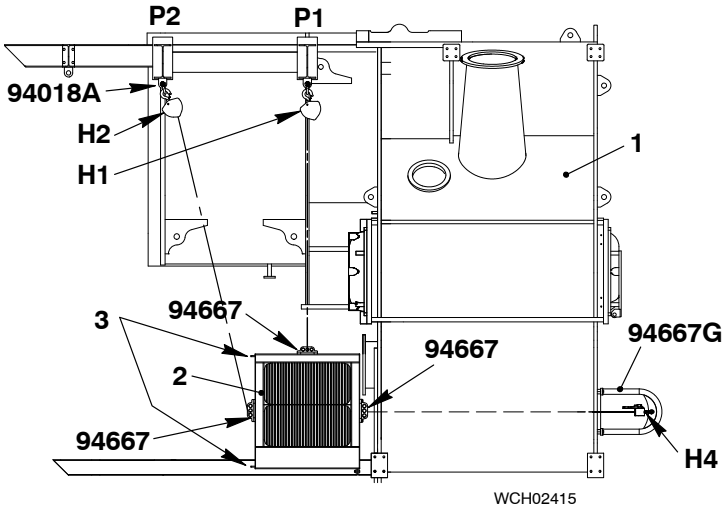
22) Operate the manual ratchet (H1, Fig. 9) to increase the tension. At the same time, operate the manual ratchet (H2) to decrease tension and keep the water separator level (2).

23) Attach the engine room crane to the lifting tool (94667).

24) Lower the water separator (2) on to an applicable surface.

25) Remove the engine room crane from the water separator (2).

26) Remove the tool (94667) from the water separator (2).



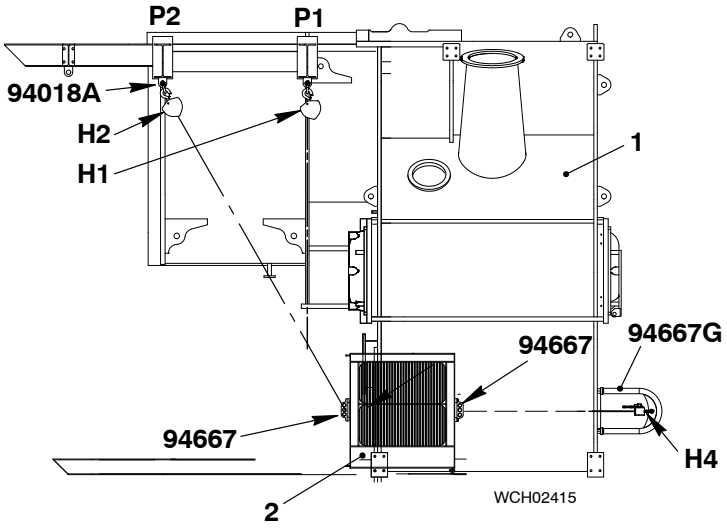


Fig. 10

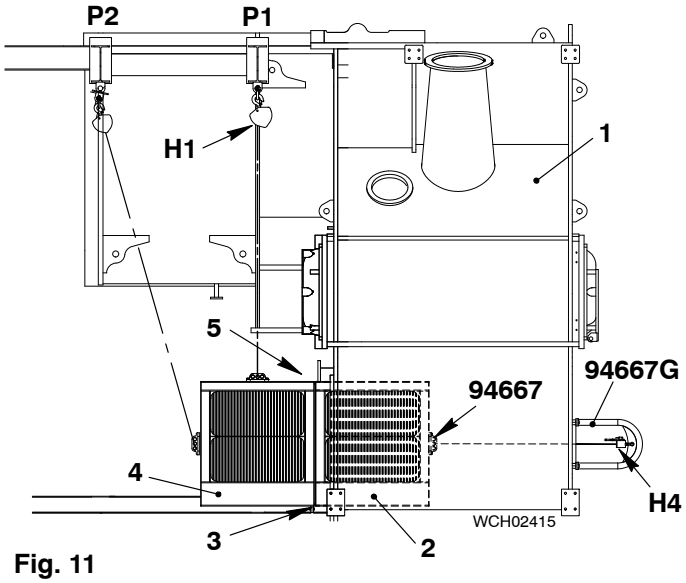


Fig. 11

3. Installation

3.1 Rear Water Separator

1) Attach the tools (94667, Fig. 10) to the applicable positions on the water separator (2).

Note: When you do step 2), make sure that the lugs (3) are at the front.

2) Use the manual ratchets and shackles used before to get the water separator (2) to the position shown.

3) Connect the manual ratchet (H4) to the tool (94667) on the rear of the water separator (2).

4) Operate the manual ratchet (H4) to move the water separator (2) into the receiver (1) a small distance.

Note: When you do step 5) keep the tension on the manual ratchet (H2) to hold the mass of the water separator (2).

5) Remove the manual ratchet (H1) and the tool (94667) from the top of the water separator (2).

6) Operate the manual ratchet (H4) to move the water separator (2) almost fully into the receiver (1). At the same time, operate the manual ratchet (H2) to hold the mass of the water separator.

7) Remove the manual ratchet (H2) and the tool (94667) from the front of the water separator (2).

3.2 Front Water Separator

1) In paragraph 3.1, do step 1) to step 7), then continue with step 2) below.

2) Align the the front and rear water separators (2 and 4, Fig. 11).

3) Attach the water separators (2, 4) together with the two top screws (5) and the two bottom screws (3).

4) Remove the manual ratchet (H1) and the tool (94667) from the top of the water separator (4).

5) Operate the manual ratchet (H4) to pull the water separators (2, 3) fully into the receiver (1).

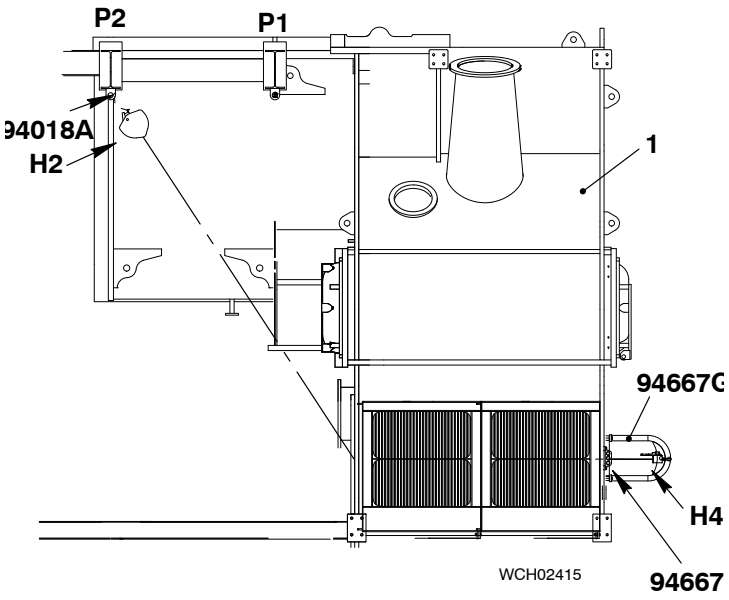


Fig. 12

6) Remove the manual ratchets (H1, H2, H3 and H4, Fig. 12).
7) Remove the holder (94667G).
8) Remove the tool (94667) from the rear water separator.
9) Remove the shackles from the points (P1, P2).

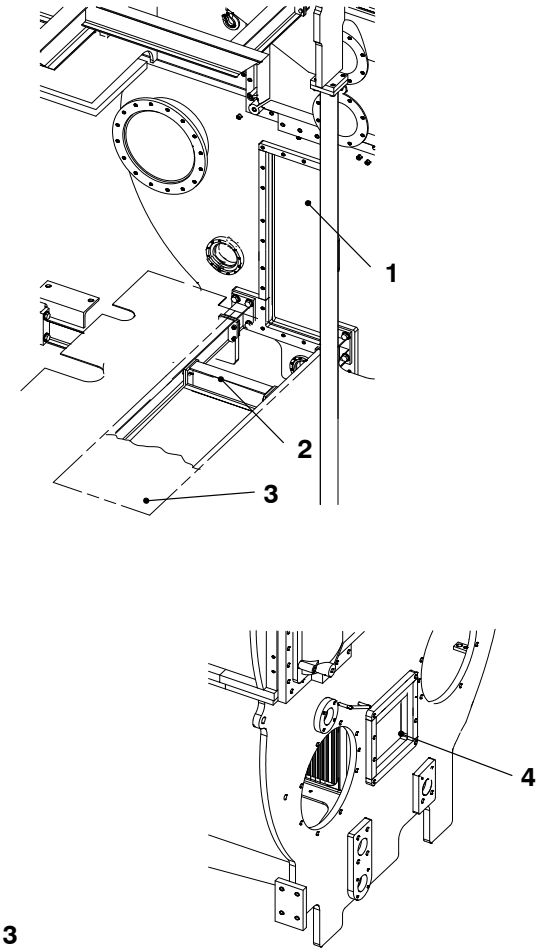


Fig. 13

10) Install the cover (1, Fig. 13) to the receiver.
11) Install the bottom plate (2).
12) Install the beam (2).
13) Install the cover (4) to the receiver.
14) Remove all tools and equipment from the work area.

Cylinder Lubrication and Balancer — Group 7

Intentionally blank

Cylinder Lubrication System

1. Cylinder Lubricating System

For more data about the cylinder lubricating system, refer to the Operation Manual, 7218-1.

1.1 Cylinder Lubricating System – Operate

For more data, refer to the Operation Manual, 4002–2, paragraph 3.2 and paragraph 3.21.

1) In the LDU-20, get the MAIN page.
2) In the navigation menu, select Cylinder Lubrication.
3) In the CYL. LUBRICATION page, field Manual lub. to Cyl. #, select the applicable cylinder number.
4) If necessary, change the number of lube pulses (in the range 0 to 200) in the field # of Manual Lub. Pulses.

Note: You can operate the 4/2-way solenoid valve (4, Fig. 1) to release manually one lube pulse.

Note: Some parts can look different.

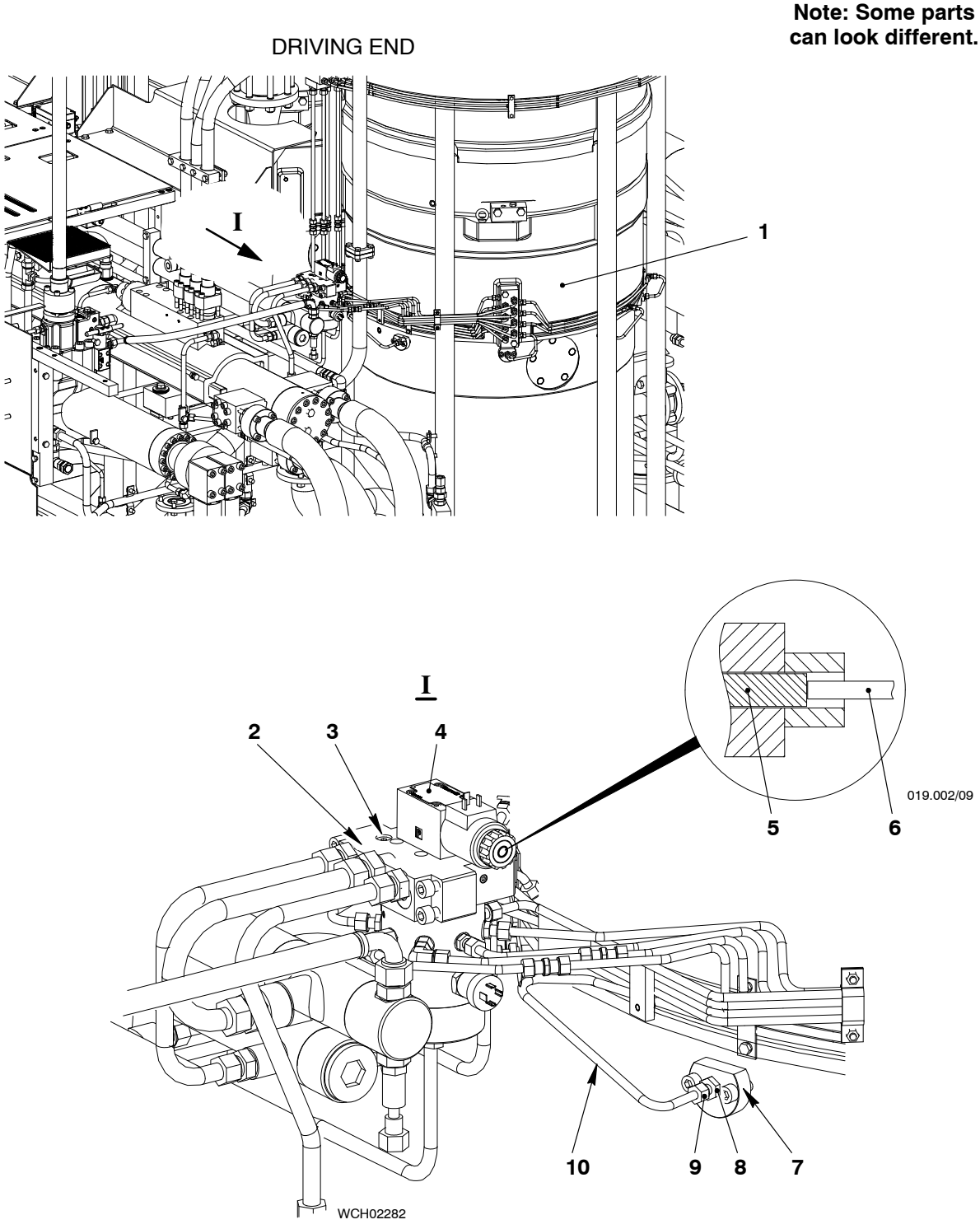


Fig. 1: Cylinder Lubrication Pump – Location

1.2 Function Check

WARNING

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

1) If necessary, bleed the cylinder lubricating system (refer to paragraph 3).
2) Make sure that the applicable piston is in the TDC position. If the piston is not in the TDC position, do step a) to step c):
   a) Engage the turning gear.
   b) Operate the turning gear to move the applicable piston to the TDC position.
   c) Disengage the turning gear.
3) Set to on the cylinder lubricating system for the related cylinder (refer to paragraph 1.1).

Note: During usual operation, the ECS controls the cylinder lubrication.

4) Operate manually one lube pulse from the cylinder lubrication system:
   a) Use a pin or a screwdriver (6, Fig. 1) to push in the plunger (5) of the 4/2-way valve (4).
5) Look through the scavenge air ports in the cylinder liner while the lubricating system operates.
6) Make sure that the lubricating oil flows on to the cylinder liner wall (refer to the Operation Manual 7218-1, paragraph 8.2 and paragraph 8.3).
7) Make sure that the oil that flows has no air. If necessary, bleed the cylinder lubricating pump (2) and the oil pipes (10) (refer to paragraph 3).
8) Set to off the cylinder lubricating system for the related cylinder.

2. Cylinder Lubrication Pump

For data about the cylinder lubricating pump (2), refer to the Operation Manual 7218-1, paragraph 5.

2.1 Checks

1) Examine the cylinder lubricating pump (2) for damage and leaks.
2) Do a function check of the cylinder lubricating system (refer to paragraph 1.2).

3. Cylinder Lubricating System – Bleed

Bleed the cylinder lubrication pump and oil pipes each time you do maintenance on the cylinder lubricating system.

3.1 Cylinder Lubrication Pump

To bleed the cylinder lubrication pump (2, Fig. 1), do the steps that follow:

Note: When you bleed the cylinder lubricating system, always start at the first cylinder at the free end. The hydrostatic pressure in the cylinder lubricating system helps you bleed the cylinder lubrication pump (2).

1) Make sure that the cylinder lubrication pump (2) is set to off.
2) Loosen the vent screw (3).
3) Keep the vent screw (3) open until oil that flows has no air.
4) Tighten the vent screw (3).
5) Clean the external surface of the cylinder lubrication pump (2).
6) If necessary, bleed the oil pipes (10), (refer to paragraph 3.2).
7) Do a function check of the cylinder lubricating system, (refer to paragraph 1.2).

3.2 Oil Pipes

To bleed the oil pipes (10), do the steps that follow:

1) Set to on the cylinder lubricating system, (refer to paragraph 1.1).
2) Use an open-ended spanner to hold the screw-in union (9) in position.
3) Loosen the nut (8) of the screw-in union (9) a maximum of two turns.
4) Keep the nut (8) of the screw-in union (9) open until oil that flows has no air.
5) Tighten the nut (8) of the screw-in union (9).
6) Clean the external surface (7) of the lubricating quill.
7) If necessary, bleed the cylinder lubrication pump (2) (refer to paragraph 3.1).
8) Do a function check of the cylinder lubricating system (refer to paragraph 1.2).

4. Duplex Filter

For data about the duplex filter (1, Fig. 2), see the Operation Manual 7218-1.

4.1 Clogged Filter Element – Replace

1) Close the ball valve (2).
2) Remove the cover from the rail unit.
3) Move the lever (3) to select the clean filter element.
4) Remove the three nuts (6) on the applicable filter chamber (5), then remove the cover (4).
5) Replace the clogged filter element.

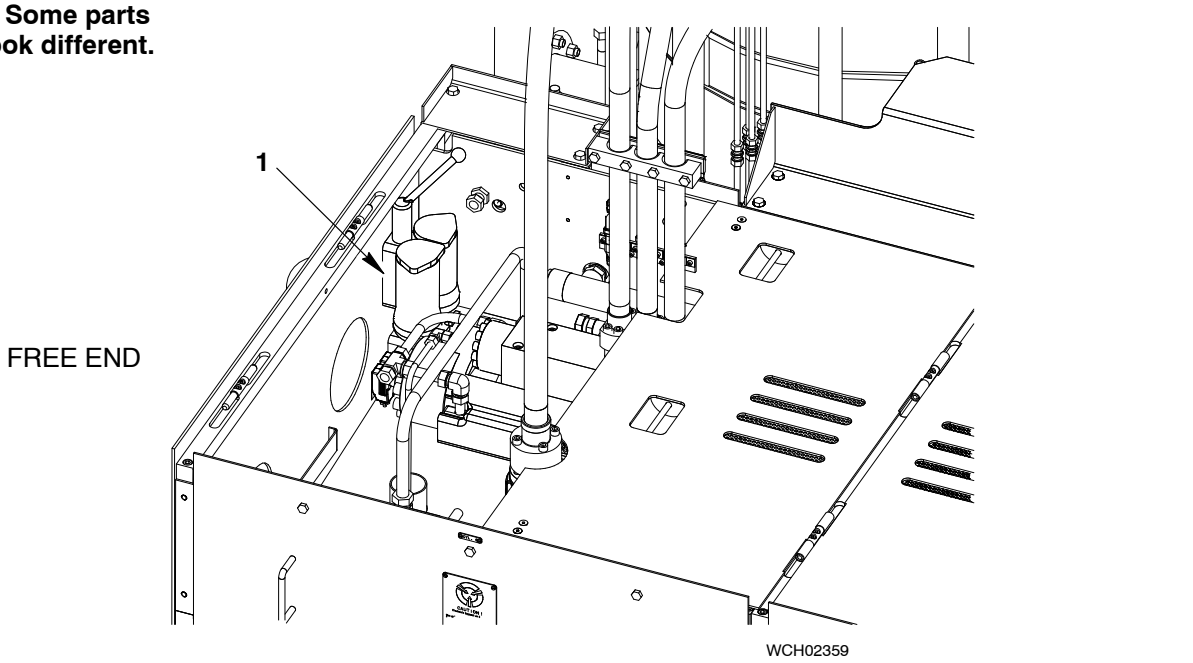
Note: As an alternative, you can clean the clogged filter element (refer to paragraph 4.2).

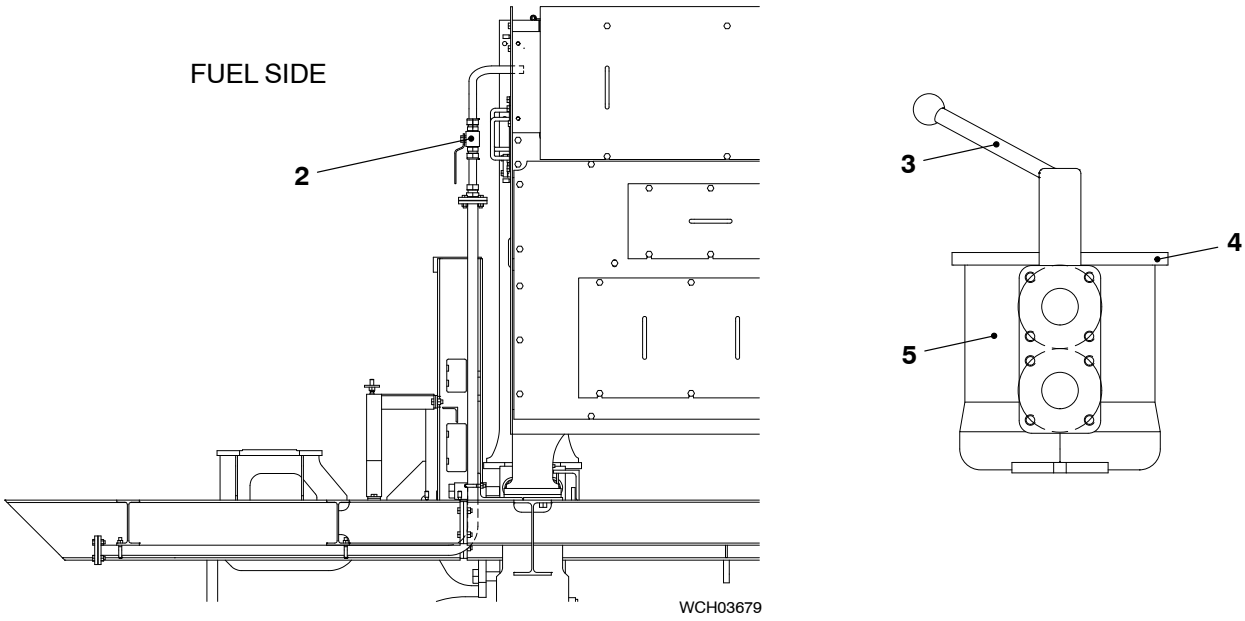
6) Attach the cover (4) to the filter chamber (5) with the three nuts (6).
7) Clean the external surface of the duplex filter (1).
8) Install the cover you removed before to the rail unit.
9) Open the ball valve (2).

4.2 Filter Element – Clean

For data about the procedure to clean the filter element, refer to the documentation of the filter element manufacturer.

Note: Some parts can look different.





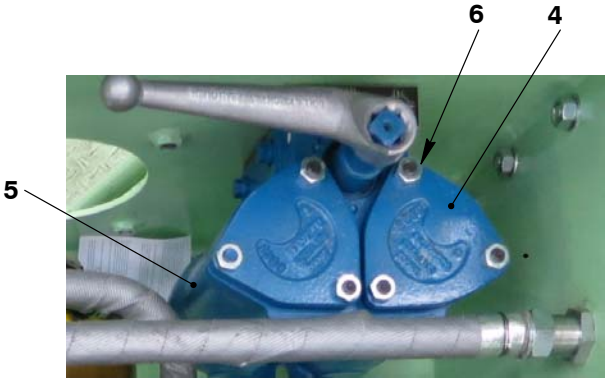


Fig. 2: Duplex Filter

Work Card
Cylinder Lubrication Pump: Replace

Necessary Conditions

– Engine stopped
– No pressure in the cylinder lubrication system

Necessary Spare Parts (each cylinder)

Cylinder lubricating pump	EX 72060	Qty 1

Preparation

Remove the pipes from the applicable pump.

Tools and Consumables

Applicable tools

Primary Task

Replace the lubricating pump with new item, or a pump that had a overhaul in a WinGD workshop. Refer to the supplier documentation.

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Bleed the cylinder lubrication system, 7218–1/A1
Operate the cylinder lubricating system, refer to the Operation Manual 4002–2, paragraph 3.2 and paragraph 3.21.

Intentionally blank

Integrated Electric Balancer, Bearing Replacement and Adjustment

Tools:

1	Adjusting tool	94701	1	Lifting tool	94704
1	Transportation tool	94702	2	Alignment tools	94705
1	Turning device	94703		Magnetic drill	
				Reamer for taper pin	

1. General

The Integrated Electric Balancer (iELBA) can be installed as follows:

- One ELBA installed at the driving end, or
- One ELBA installed at the free end, or
- Two ELBA installed (one at the driving end and one at the free end).

It is only necessary to replace the bearings. You must always replace the bearings as a pair.

For the first bearing replacement, speak to or send a message to WinGD to get data from approved personnel.

For more data about the Integrated Electric Balancer, refer to the Operation Manual, chapter 7752–1.

For the maintenance schedule, refer to 0380–1.

For the clearances, refer to the Clearance Table 0330–1, Group 7758.

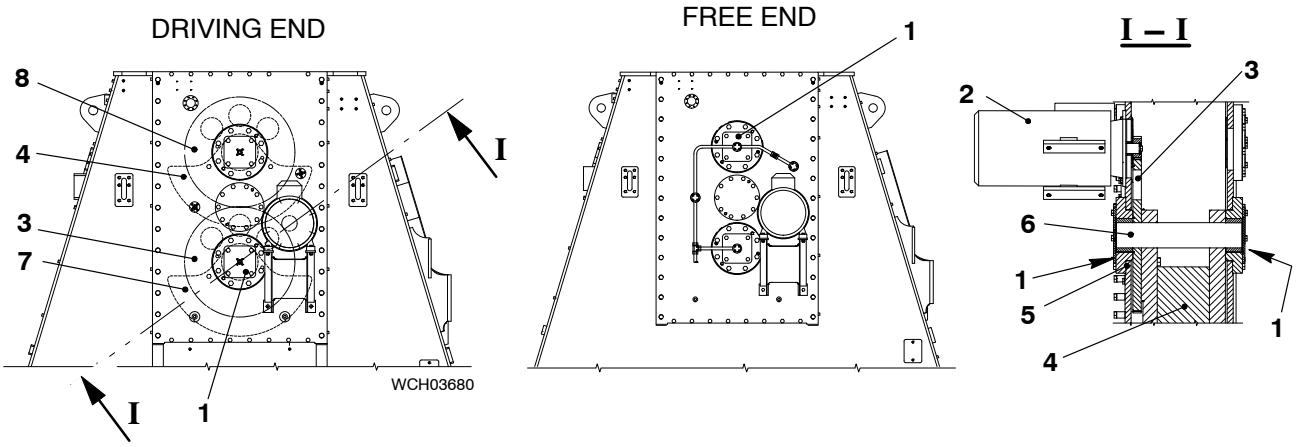


Fig. 1

Fig. 1: Location of ELBA

1 Bearing cover
2 Electric motor
3 Bottom gear wheel
4 Top counterweight
5 Bearing
6 Bearing pin
7 Bottom counterweight
8 Top gear wheel

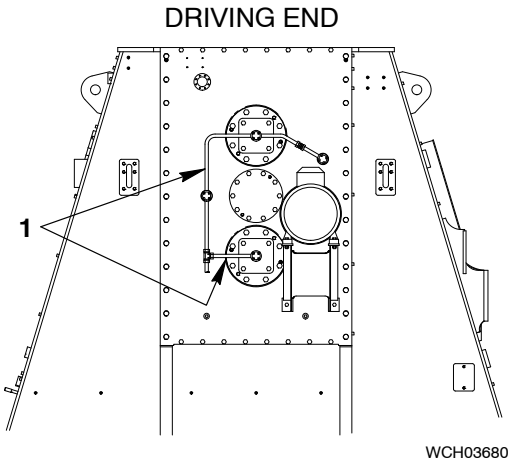


Fig. 2

2. Preparation

1) Stop the engine, refer to Operation Manual, 0310–1.
2) Make sure that the electric motor (2, Fig. 1) has stopped.
3) Stop the lubricating oil supply and close the oil inlet.
4) At driving end, put an oil tray under applicable oil pipe (1, Fig.2).
5) Remove the applicable oil pipes (1) to get access to the balancer shafts.

3. Counterweights – Lock

3.1 Top Counterweight

1) Apply lubricating oil to the thread and bottom of the head of the clamping screw (4, Fig. 3) and the nut (6).
2) Remove the two screws (2) from the main cover (1).
3) Put the two clamping screws (4) and the nuts (6) in position on the upper counterweight (10).
4) Torque the clamping screws (4) to 60 Nm.
5) Torque the nut (6) to 60 Nm.
6) Put the the M12 bolt (5) in position through the clamping screw (4).
7) Torque the M12 bolt (5) to 60 Nm.

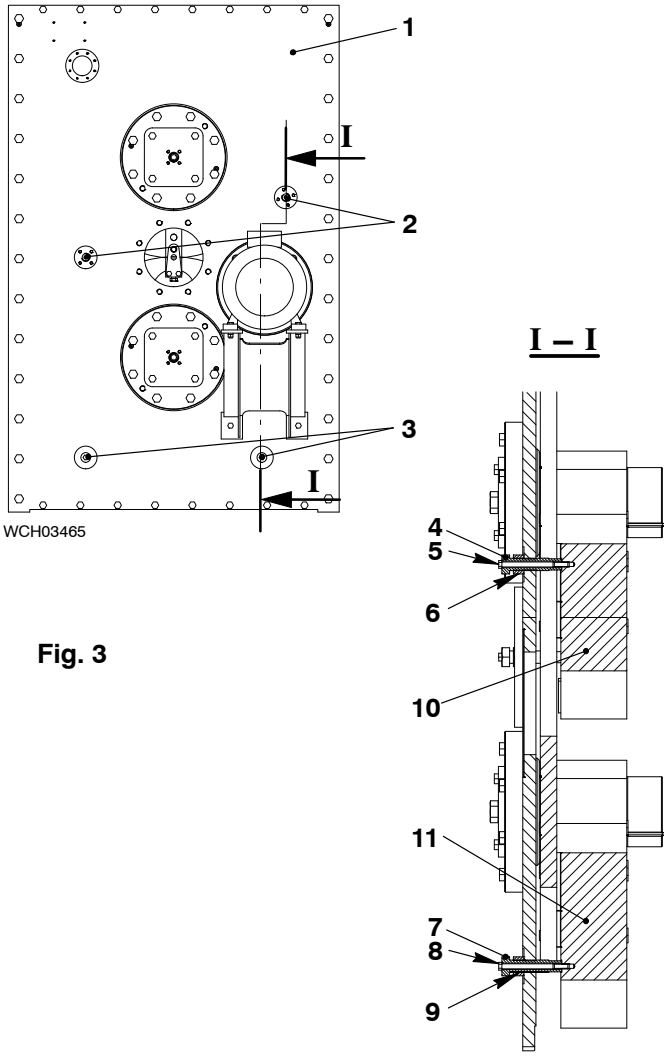


Fig. 3

3.2 Bottom Counterweight

1) Apply lubricating oil to the thread and bottom of the clamping screw (7) and the nut (9).
2) Remove the two screws (3) from the cover (1).
3) Put the two clamping screws (7) and the nuts (9) in position on the lower counterweight (11).
4) Torque the clamping screws (7) to 60 Nm.
5) Torque the nut (9) to 60 Nm.
6) Put the M12 bolt (8) in position through the clamping screw (7).
7) Torque the M12 bolt (8) to 60 Nm.

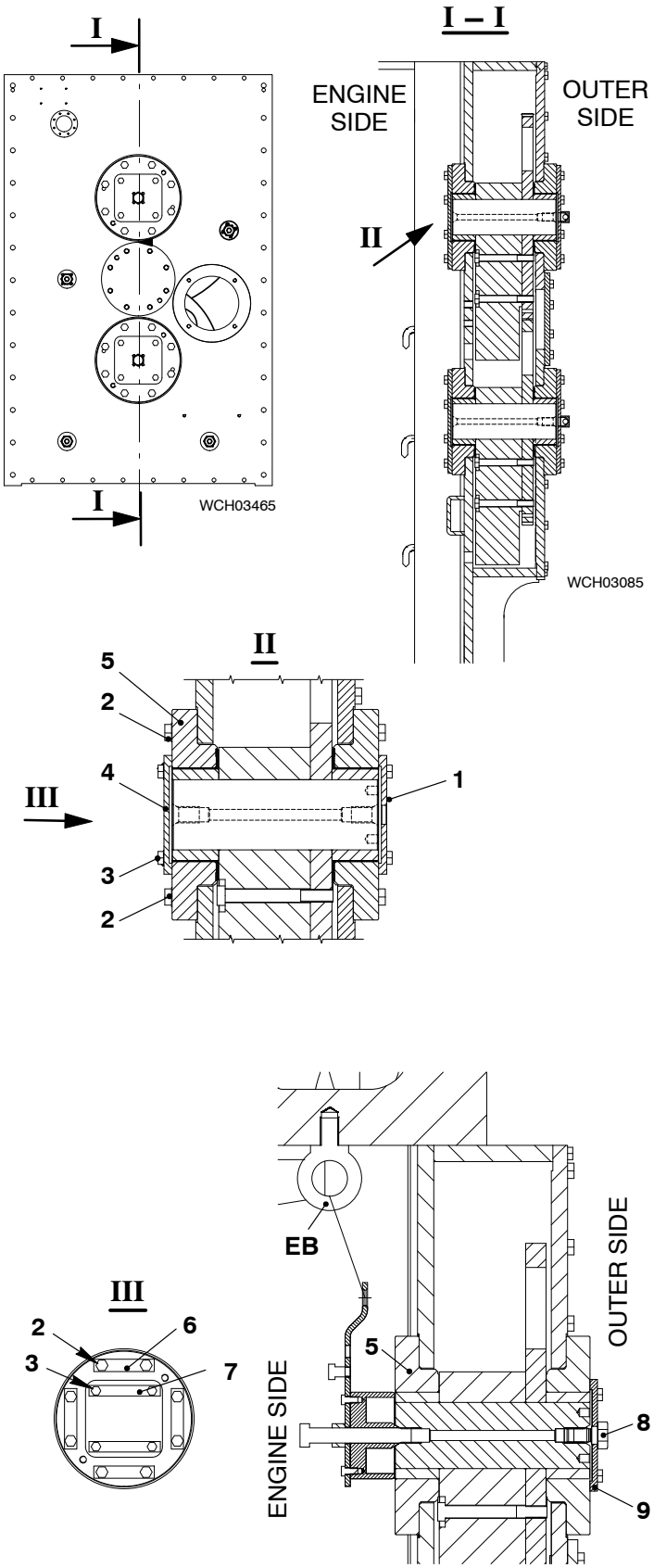


Fig. 4

4. Bearings – Replace

CAUTION

Injury Hazard: The weight of the bearing is 70 kg. Use the correct equipment to lift and move the bearing. This will prevent injury to personnel and damage to equipment.

CAUTION

Damage Hazard: To prevent damage to equipment, do not remove two bearings at the same time.

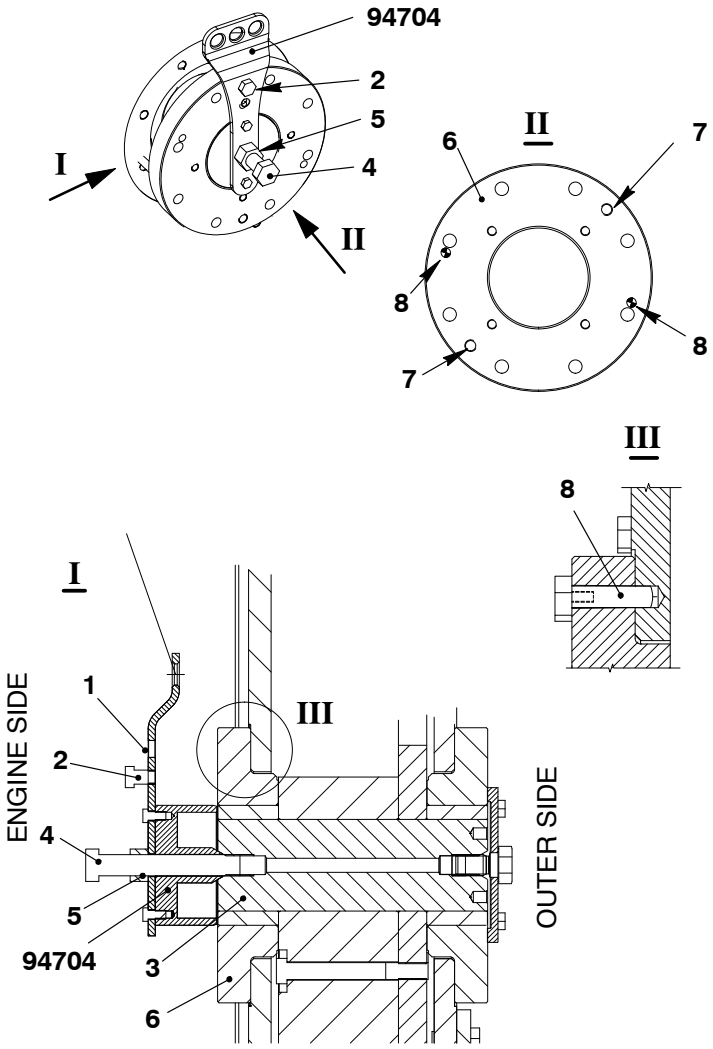
Note: On the outer side, use the crane and an applicable manual ratchet to lift and move the bearing.

Note: On the engine side, use an applicable manual ratchet and an eye bolt to lift and move the bearing.

4.1 Bearing – Engine Side

4.1.1 Removal

1) Attach an eye bolt to the applicable position in the gallery above the the bearing (5, Fig. 4). Attach an applicable manual ratchet to the eye bolt.
2) Apply lubricating oil to the thread and bottom of the head of the special screw (8, part of tool 94702).
3) Put the special screw (8) through the bearing cover (9) on the outer side.
4) Torque the special screw (8) to 150 Nm.
5) Remove the four screws (3) and the locking plates (7) on the bearing cover at the engine side.
6) Remove the bearing cover (4).
7) Remove the eight screws (2) and the locking plates (6) from the bearing (5).



8) Attach the lifting tool (94704) to the manual ratchet. Move the lifting tool in front of the bearing (6, Fig. 5).

9) Tighten the screw (4) with your hand.

10) Turn the nut (5) against the bearing (6) to push the lifting tool (94704) against the pin (3).

11) Put two M20 x 140 mm bolts into the two threads (7) in the bearing (6).

12) Tighten equally the two M20 x 140 mm bolts to push out the bearing (6).

Note: The bearing (6) will move on to the lifting tool (94704), see Step A.

13) Tighten the screw (2) to hold the bearing (6).

14) Loosen the nut (5). Operate the manual ratchet to hold the weight of the bearing (6), see Step B.

15) Carefully remove the screw (4).

16) Operate the manual ratchet to move the bearing (6) to an applicable area.

17) Remove the two taper pins (8).

18) Lower the bearing (6).

19) Remove the lifting tool (94704).

20) Remove the two bolts (7).

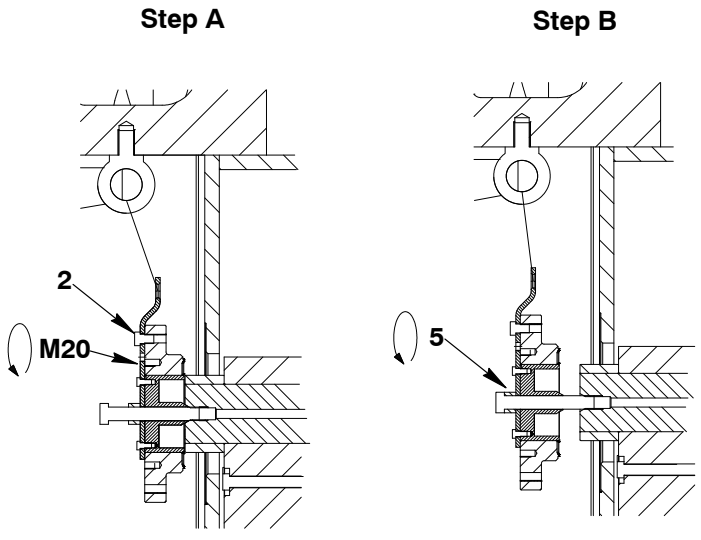


Fig. 5

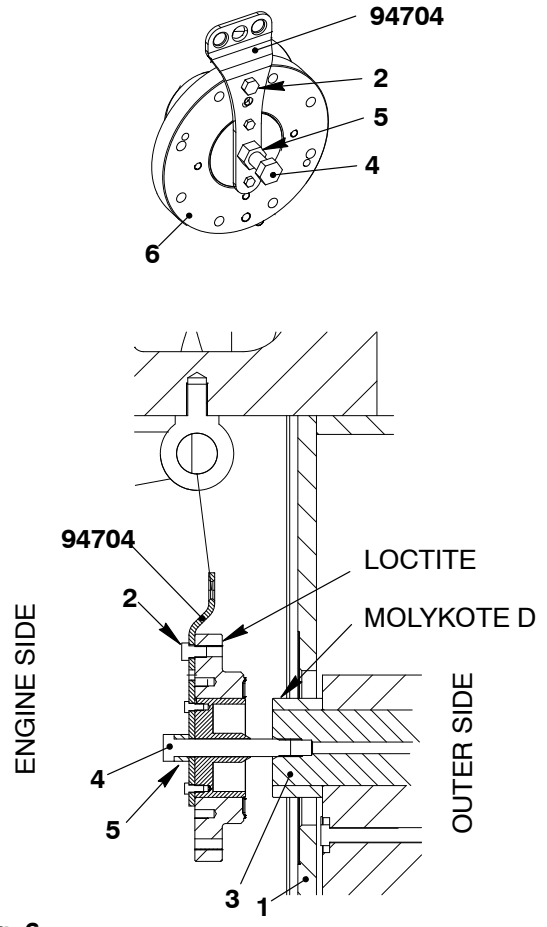


Fig. 6

4.1.2 Installation

1) Make sure that the new bearing is clean, dry and in good condition. Apply Molykote D to the bearing surface.

Note: Do not install the two taper pins (8, Fig. 5).

2) Attach the lifting tool (94704) to the bearing (6, Fig. 6).

3) Attach the manual ratchet to the lifting tool (94704).

4) Tighten the screw (2).

5) Operate the manual ratchet to move the bearing (6) in front of the pin (3).

6) Apply Loctite No. 640 to the surface of the bearing (6).

7) Apply Molykote D to the surface of the pin (3).

8) Install the screw (4) together with the nut (5) through the bearing (6) into the pin (3).

9) Remove the screw (2).

10) Align the taper pin bores with the column (1).

11) Turn the bearing (6) until the pin bores in the bearing are at 90° to the bores in the column (1).

12) Tighten the nut (5) and move the bearing (6) into the correct position on the column (1).

Note: Operate the manual ratchet if the pin (3) is too low.

13) Remove the lifting tool (94704).

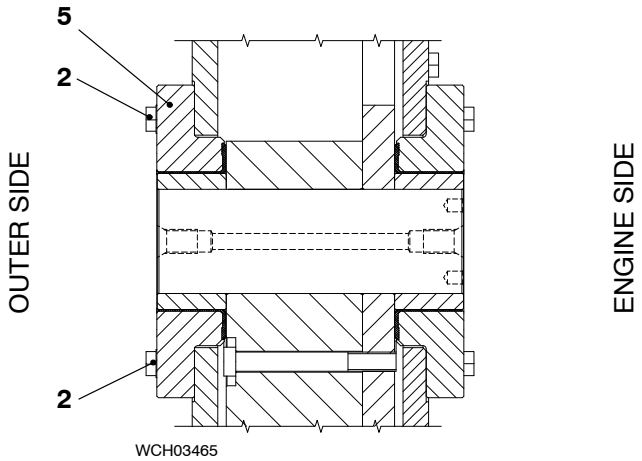


Fig. 7

14) Put four (of the eight) bolts M20x70 (2, Fig. 7) in position. Do not tighten the four bolts at this step.

15) Adjust the backlash and the parallelism of the gear wheels, refer to paragraph 5.2.

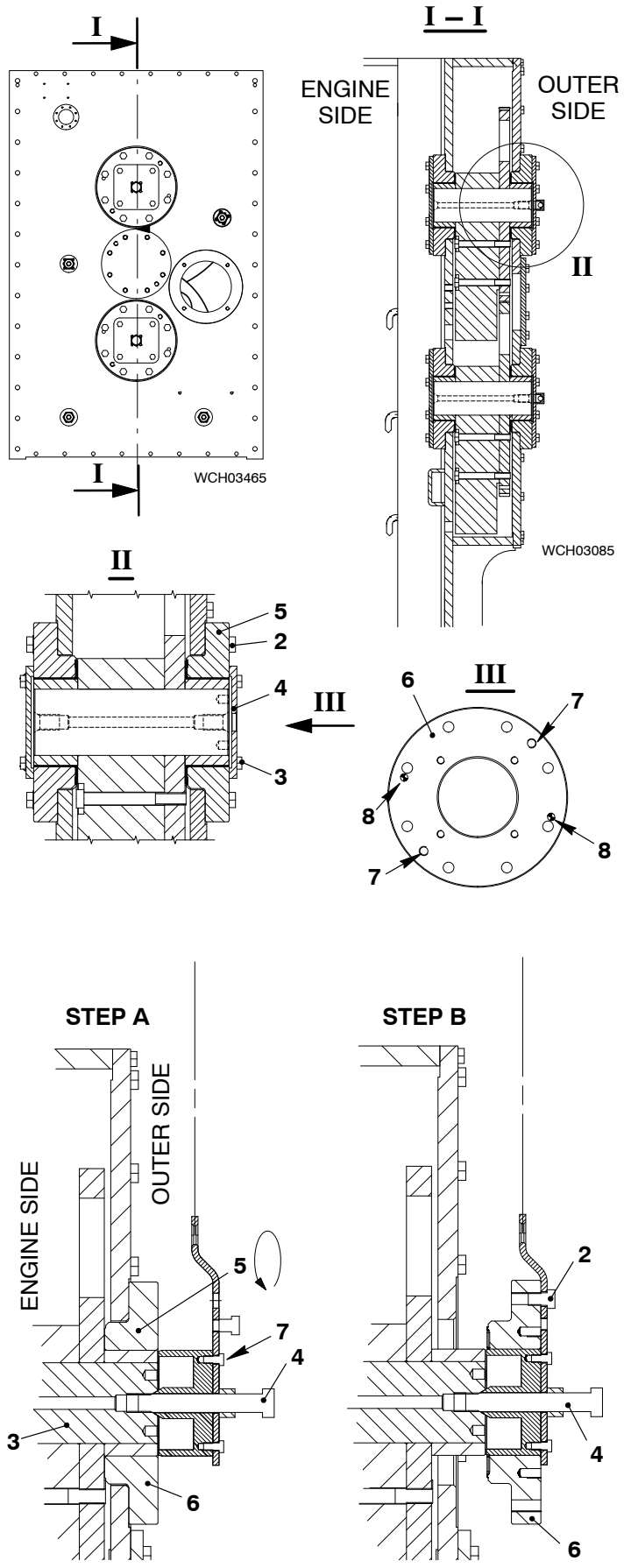


Fig. 8

4.2 Bearing – Outer Side

4.2.1 Removal

1) Remove the four screws (3, Fig. 8) from the bearing cover (4) at the outer side.
2) Remove the bearing cover (4).
3) Remove the eight screws (2) from the bearing (5).
4) Attach the lifting tool 94704 to the crane and move it in front of the bearing (6) (STEP A).
5) Turn the screw (4) into the pin (3) and tighten slightly.
6) Tighten the nut (5) to push the lifting tool 94704 against the pin (3).
7) Put two M20 x 140 mm screws into the two threads (7, view III) in bearing (6).
8) Tighten equally the two M20 screws to push out the bearing (6).

- The bearing (6) will move on to the lifting tool 94704 (STEP 2).

9) Tighten screw (2) to hold the bearing (6).
10) Operate the crane to hold the weight of the bearing (6).
11) Carefully remove screw (4) and put the bearing in an applicable area.
12) Remove the two taper pins (8).
13) Remove the lifting tool 94704.
14) Remove the two bolts (7).

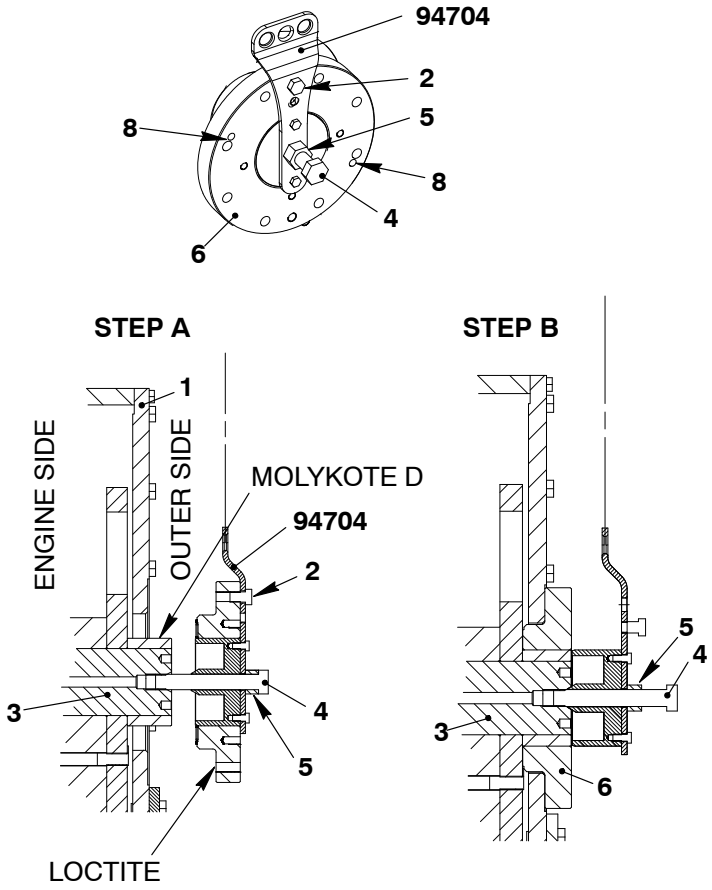


Fig. 9

4.2.2 Installation

1) Make sure that the bearing (6, Fig. 9) is clean, dry and in good condition. Apply Molykote D to the surface of the bearing.

Note: Do not install the two taper pins (8).

2) Attach the lifting tool (94704) to the bearing (6).

3) Attach the crane to the tool (94704).

4) Tighten the screw (2).

5) Operate the crane to move the bearing (6) in front of the pin (3).

6) Apply Loctite No. 640 to the surface of the bearing (6).

7) Apply Molykote D to the surface of the pin (3).

8) Install the screw (4) together with the nut (5) through the bearing (6) into the pin (3).

9) Remove screw (2).

10) Align the taper pin bores with the cover (1).

11) Turn the bearing (6) until the pin bores in the bearing are at 90° to the bores in the column (1).

12) Tighten the nut (5) and move the bearing (6) in the correct position on the column (1) (STEP B).

Note: Operate the crane if the pin (3) is too low.

13) Remove lifting tool (94704).

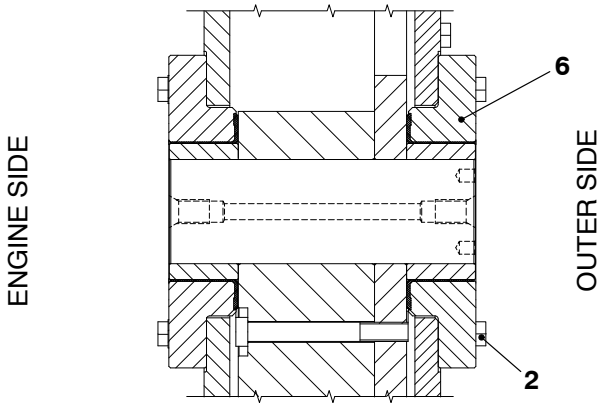


Fig. 10 WCH03465

14) Install four (of the eight) bolts M20x70 (2, Fig. 10) in position. Do not tighten the four bolts at this step.

15) Adjust the backlash and the parallelism of the gear wheels, refer to paragraph 5.2.

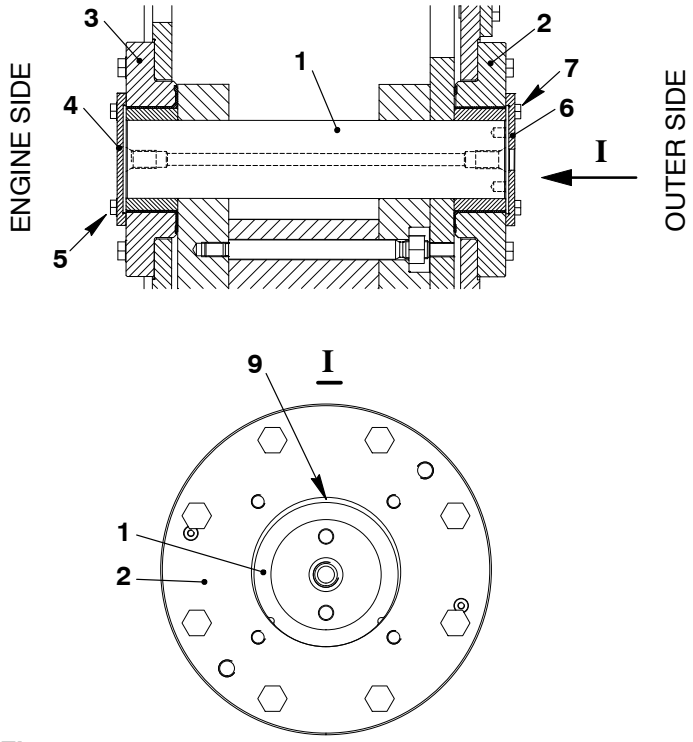


Fig. 11

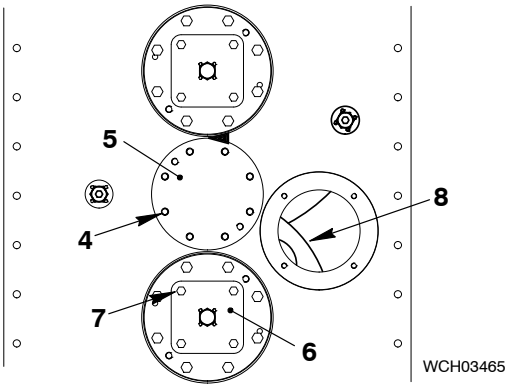


Fig. 12

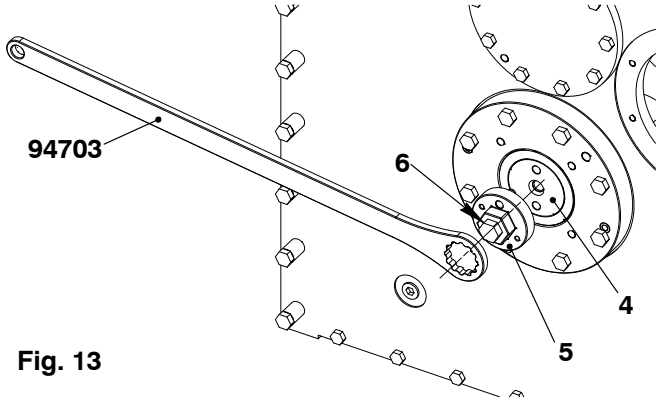


Fig. 13

5. Check

5.1 Bearing Clearance

Note: For the first bearing replacement, speak to or send a message to WinGD to get data from approved personnel.

1) On the engine side, remove the four screws (5, Fig. 11) and the locking plates from the bearing cover (4).
2) Remove the bearing cover (4).
3) On the outer side, remove the four screws (7) from the bearing cover (6).
4) Remove the bearing cover (6).
5) Use a feeler gauge to measure the clearance between the pin (1), the bearings (2, 3) at the top position (9).
6) Compare clearance with the data given in 0330–1, Group 7758.
7) If the clearance is more than the permitted maximum, replace the bearing.

5.2 Backlash – Measure

1) Remove the eight screws (4, Fig. 12) and the cover (5).
2) Make sure the screws (4, Fig. 3) are removed.

Note: You can get access to the service hole (8, Fig. 12) in the engine.

3) Measure the backlash between the motor pinion and the bottom gear wheel.
4) Remove the four screws (7) on the bottom bearing cover (6) at the outer side.
5) Attach the device (94703) as follows:
   a) Install the socket insert (5, Fig 13) with the screw (6) on the pin (4) of the bottom bearing.
   b) Torque the screw (6) to 100 Nm.

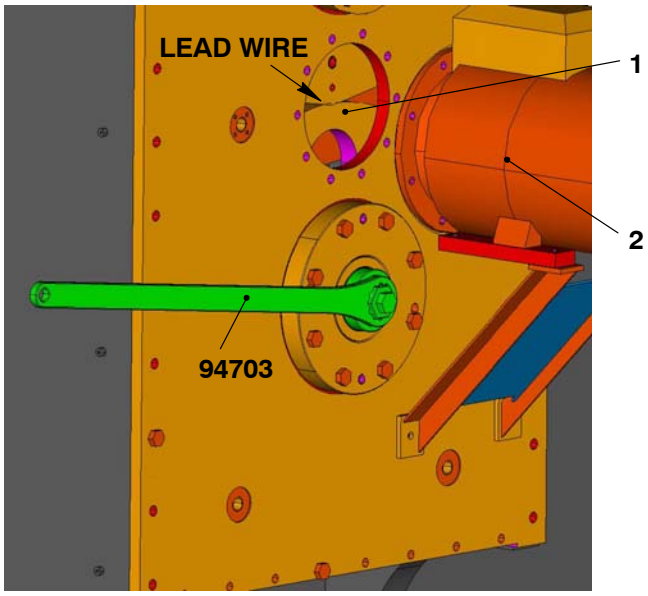


Fig. 14

CAUTION

Injury Hazard: Do not put your hands between the gears that move. This can prevent injury to personnel.

Note: You can get access to the pinion and bottom gear wheel (1, Fig. 14) through a hole at the inner area behind the column.

Note: When you do step 6), use pliers to attach the lead wire.

6) Attach lead wire of Pb99.9 fine and a diameter of 1.00 mm between the electric motor pinion (2) and the bottom gear wheel (1).

7) Refer to 0330–1 Group 7758 to get backlash data.

8) Operate the device (94703) to turn the gears. The lead wire moves between the electric motor pinion (2) and the bottom gear wheel (1).

9) Measure the backlash.

10) If the backlash of the bottom gear wheel (1) and the electric motor pinion (2) is in the permitted tolerance, do as follows:

    a) Loosen the bearings of the top gear wheel.

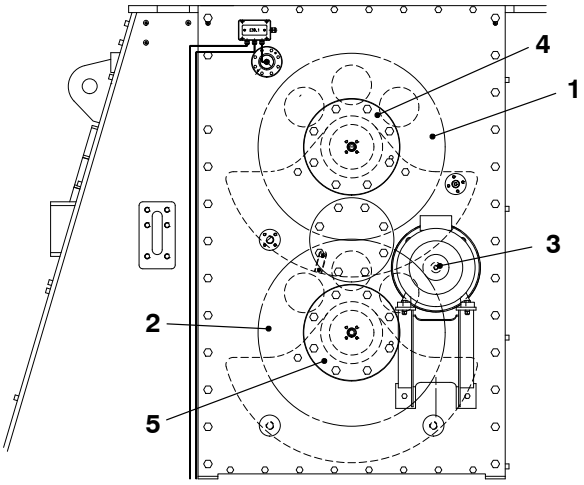


Fig. 15

5.3 Bearings – Adjust

Note: Before you do this task for the first time, speak to, or send a message to an applicable Service Partner (e.g. WinGD) to get data.

1) Loosen all bearings.
2) Remove the taper pins from all bearings.
3) Lift the top bearing.
4) Lift the bottom bearings until the backlash between the pinion and the bottom gear wheel is in the permitted tolerance.
5) Lower the bottom bearing until the backlash in the permitted tolerance.
6) Turn the bearings 90° .
7) Use a drill to make new holes for the taper pins.
8) Measure the backlash.
9) If the backlash of the bottom gear wheel (2, Fig. 15) and the electric motor pinion (3) is in the permitted tolerance, do as follows:
   a) Loosen the bearings of the top gear wheel.

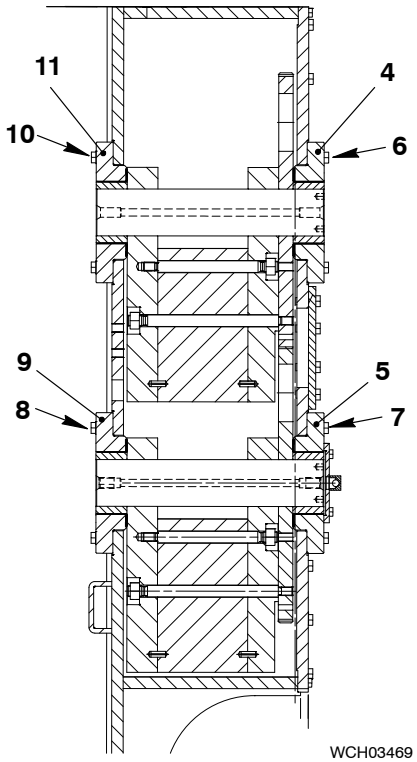
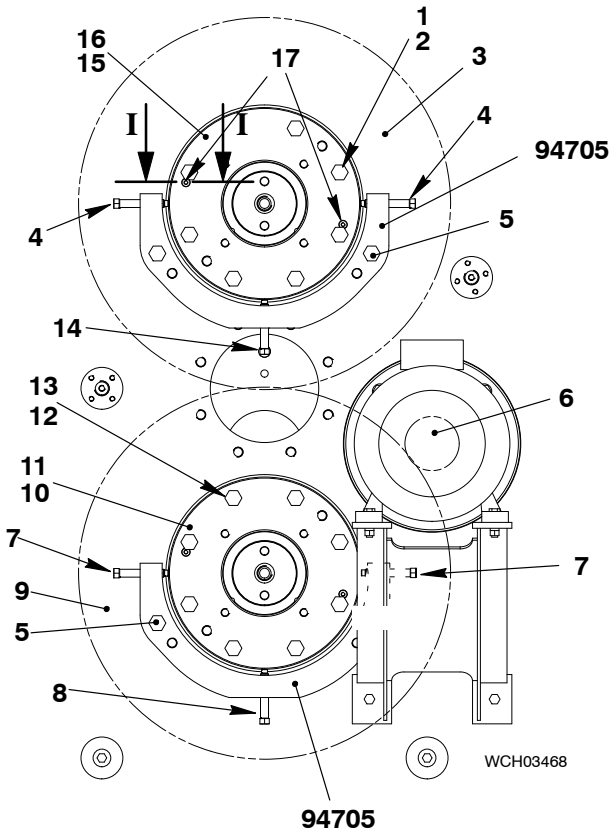


Fig. 16

10) Make sure all the screws (6, 10, 7, and 8, Fig. 16) are loose or removed. One screw for each bearing must stay in position to hold the bearing.
11) If you have installed new bearings (4, 11, 5, 9) turn the bearings 90° .
12) Use a drill to make new holes for the taper pins after the adjustment procedure.



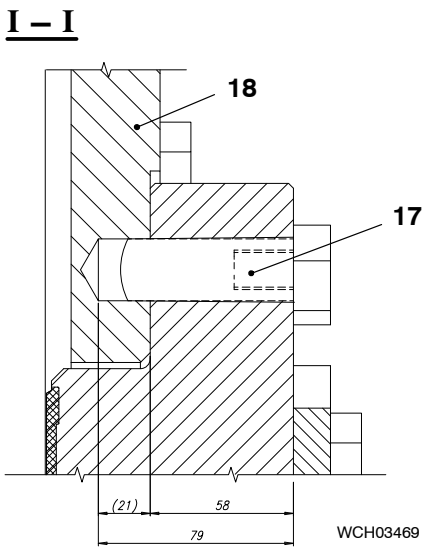


Fig. 17

13) Apply oil to the eight screws (5, Fig. 17).

14) Attach the four alignment tools (94705) with the eight screws (5) (two tools for the front and rear each bearing).

15) Torque the eight screws (5) to 490 Nm.

16) Turn the two screws (14) to lift the front and rear top bearings (15, 16), which removes the load from the bottom gear wheel (9).

17) Adjust the backlash between the electric motor pinion (6) and the bottom gear wheel (9).

18) Measure the backlash, refer to paragraph 5.2.

Note: During step 19) and step 20), make sure that the top and bottom bearings are parallel.

19) Adjust the bottom bearings (10, 11) as follows:

   a) Turn the two screws (8) to adjust the height of the bottom bearings.

   b) Turn the four screws (7) to adjust the horizontal position of the bottom bearings.

20) Adjust the top bearings (15, 16) as follows:

   a) Turn the two screws (14) to adjust the height of the top bearings.

   b) Turn the four screws (4) to adjust the horizontal position of the top bearings.

21) Make sure that the adjusted bearings are turned 90°.

22) Measure the backlash again, refer to paragraph 5.2.

23) Use a magnetic drill and a reamer to make holes of depth 21 mm in the covers (18) for the 25x70 mm taper pins (two holes for each of the four covers).

24) Put two taper pins (17) for each bearing in the new holes.

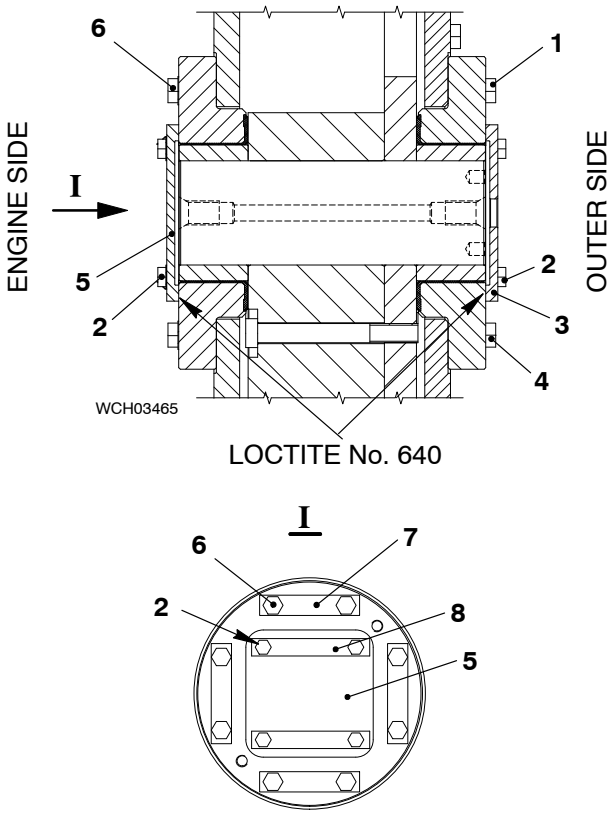


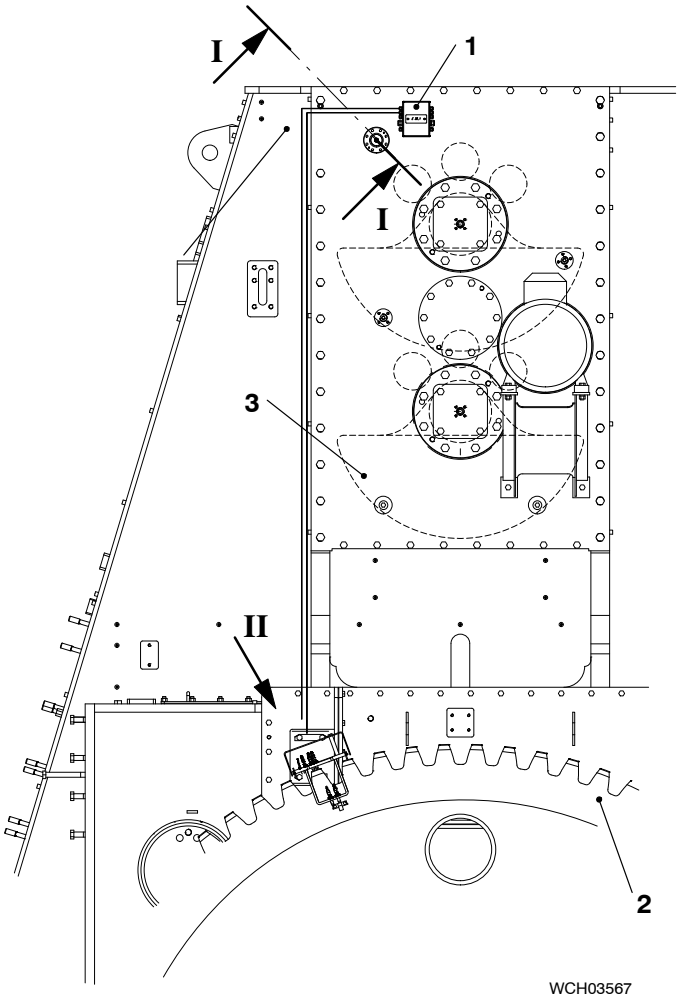
Fig. 18

6. Completion

1) Attach the eight M20x70 bolts (1, Fig. 18) to the outer side of each bearing.
2) Torque the eight M20x70 bolts (1) to the value given in 0352–2, paragraph 1.
3) Apply Loctite No. 640 to the surfaces that touch on the bearing cover (3).
4) Attach the bearing cover (3) to the bearing with the four M16x35 screws (3).
5) Torque the four M16x35 (3) to the value given in 0352–2, paragraph 1.
6) Attach the locking plates (7) to the engine side of each bearing with the eight M20x70 bolts (6).
7) Torque the eight M20x70 bolts (6) to the value given in 0352–2, paragraph 1.
8) Remove the four alignment tools 94705.
9) Apply Loctite No. 640 to the surfaces that touch on the bearing cover (2).
10) Attach the bearing cover (5) to the bearing on the engine side with the four M16x35 screws (2).
11) Torque the four M16x35 screws (2) to the value given in 0352–2, paragraph 1.
12) Install the oil pipes (1, Fig.2) that you removed before.
13) Open the oil inlet.
14) Set to on the lubricating oil supply.

Intentionally blank

Proximity Sensor – Replacement



1. General

One proximity sensor is installed on each end of the engine. The proximity sensors give the position and speed of the balance weights (3, Fig. 1).

The proximity sensors are installed in the positions that follow:

- ZS5401C on the Driving End
- ZS5405C on the Free End

The proximity sensors are connected to the terminal box (1).

Two more proximity sensors (ZS5141C and ZS5142C) for engine speed and crank position are installed above the flywheel (2) near the crank angle sensors (view II).

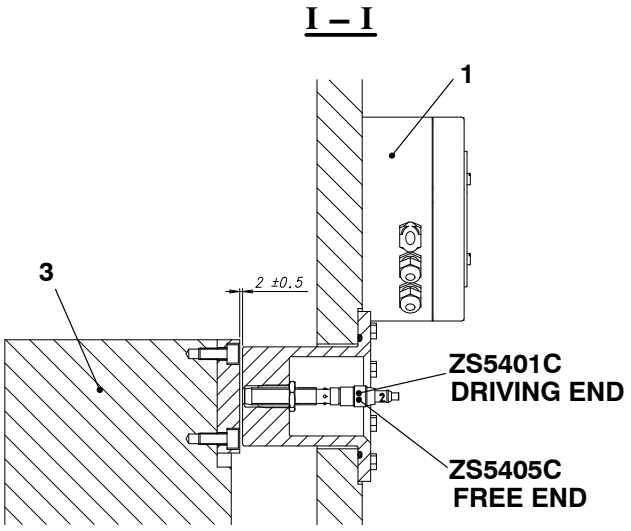
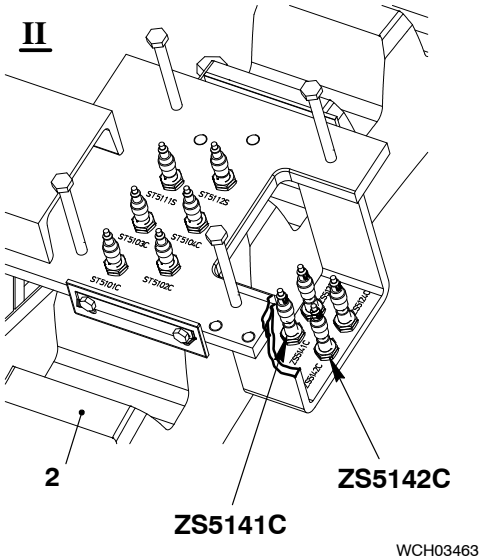


Fig. 1



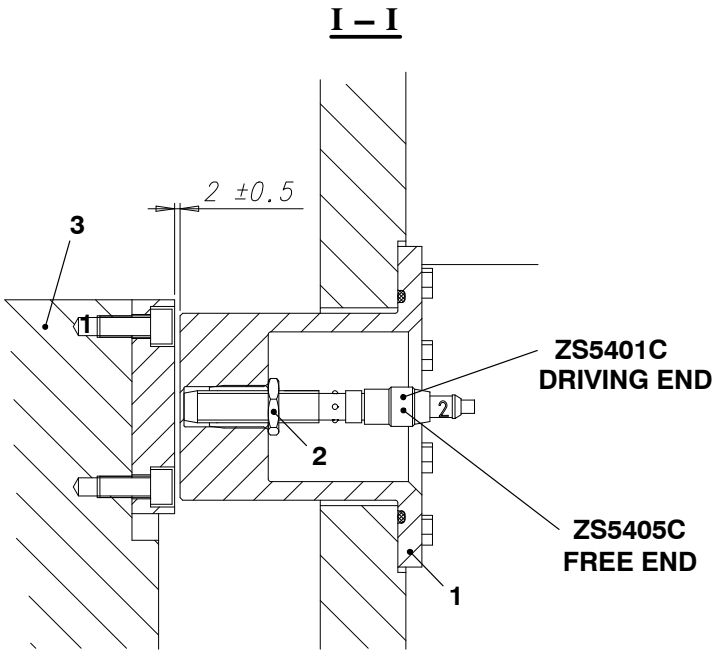


Fig. 2

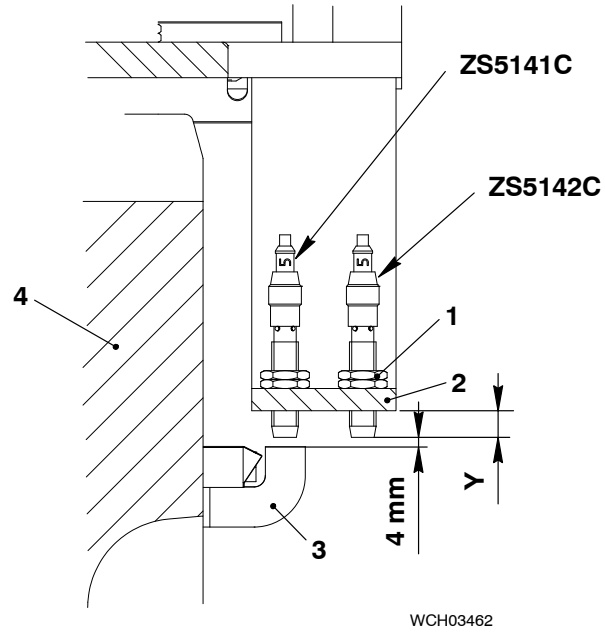


Fig. 3

2. Procedures

2.1 Balance Weights Proximity Sensors – Replace

1) Disconnect the electrical connection from the applicable proximity sensor (ZS5401C or ZS5405C, Fig. 2).
2) Loosen the nut (2).
3) Remove the applicable proximity sensor (ZS5401C or ZS5405C).
4) Attach the new sensor fully into the sensor adapter (1).
5) Tighten the lock nut (2).
6) Connect the electrical connection the proximity sensor.
7) Do a check of the Alarm System in the LDU for Signal Failure (refer also to the Operation Manual, Chapter 4002–2).

Note: Some designs do not have a connection to the Alarm System. These designs have a control box (Lenze Drive), which shows a signal failure. This control box is installed in the control cabinet.

2.2 Flywheel Proximity Sensors – Replace

Note: Refer to Fig. 1, view II for the location of the proximity sensors.

1) Disconnect the electrical connection from the applicable proximity sensor (ZS5141C or ZS5142C, Fig. 3).
2) Measure the distance (Y). Use this distance when you install the new proximity sensor.
3) On the applicable proximity sensor, loosen the nut and lock nut (1).
4) Remove the applicable proximity sensor.
5) Put the new proximity sensor in the holder (2) to the measured distance (Y).

Note: If the proximity sensor (ZS5141C) is directly above the crank angle mark, do step 6) and step 7, then continue from step 8).

6) Put the new proximity sensor (ZS5141C) in the holder (2, Fig. 3) until the sensor touches the crank angle mark (3).
7) Turn the proximity sensor (ZS5141C) back four turns (4mm).
8) Tighten the nut and lock nut (1).
9) Connect the electrical connection to the applicable proximity sensor.
10) Do a check of the Alarm System in the LDU for Signal Failure (refer also to the Operation Manual, Chapter 4002–2).

Intentionally blank

Piping

Group 8

Intentionally blank

Exhaust Waste Gate (Low-load Tuning)

1. General

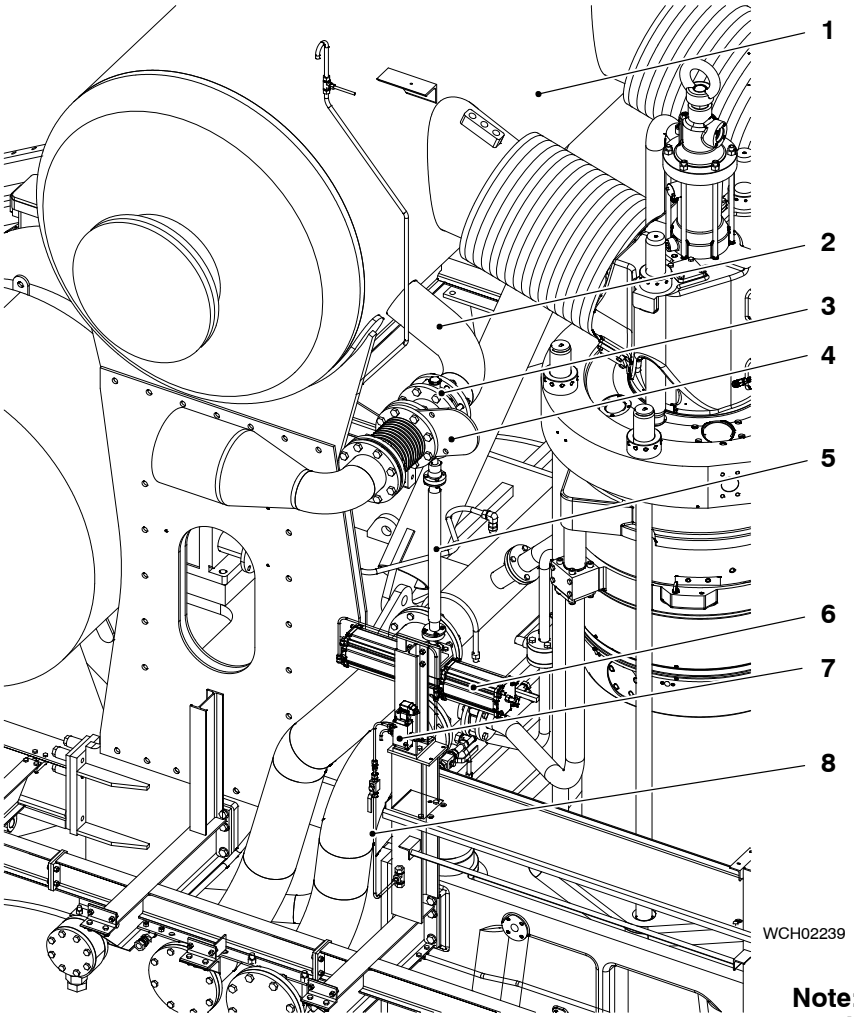
The Low-load Tuning (LLT) uses a specially designed turbocharger system and specified engine parameters. These parameters are related to fuel injection and exhaust valve control and get the best decreased part-load BSFC in LLT.

For more data about the exhaust waste gate and LLT, refer to the Operation Manual 8135–1.

2. Maintenance

Special maintenance of the butterfly valve (3, Fig. 1) is not necessary. For a general inspection, refer to the instructions in the documentation of the manufacturer.

To do a function check, refer to 8135–1 in the Operation Manual and the Maintenance Schedule 0380–1, Exhaust Waste Gate (LLT).



Note: Some parts can look different.

Fig. 1: Exhaust Waste Gate

1 Exhaust manifold
2 Exhaust by-pass line
3 Butterfly valve
4 Orifice
5 Cardan rod
6 Control actuator
7 Solenoid valve
8 Air spring air pipe

Intentionally blank

HP Servo Oil Pipe

Removal, Grind Sealing Faces and Installation

Tools:

1	Grinding tool	94841		Emery cloth (as necessary)
1	Stencil	94841A	1	Hand drill

1. Preparation

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Make sure that the servo oil service pump is set to off.
3) Put an oil tray under the applicable servo oil pump (1, Fig. 1).

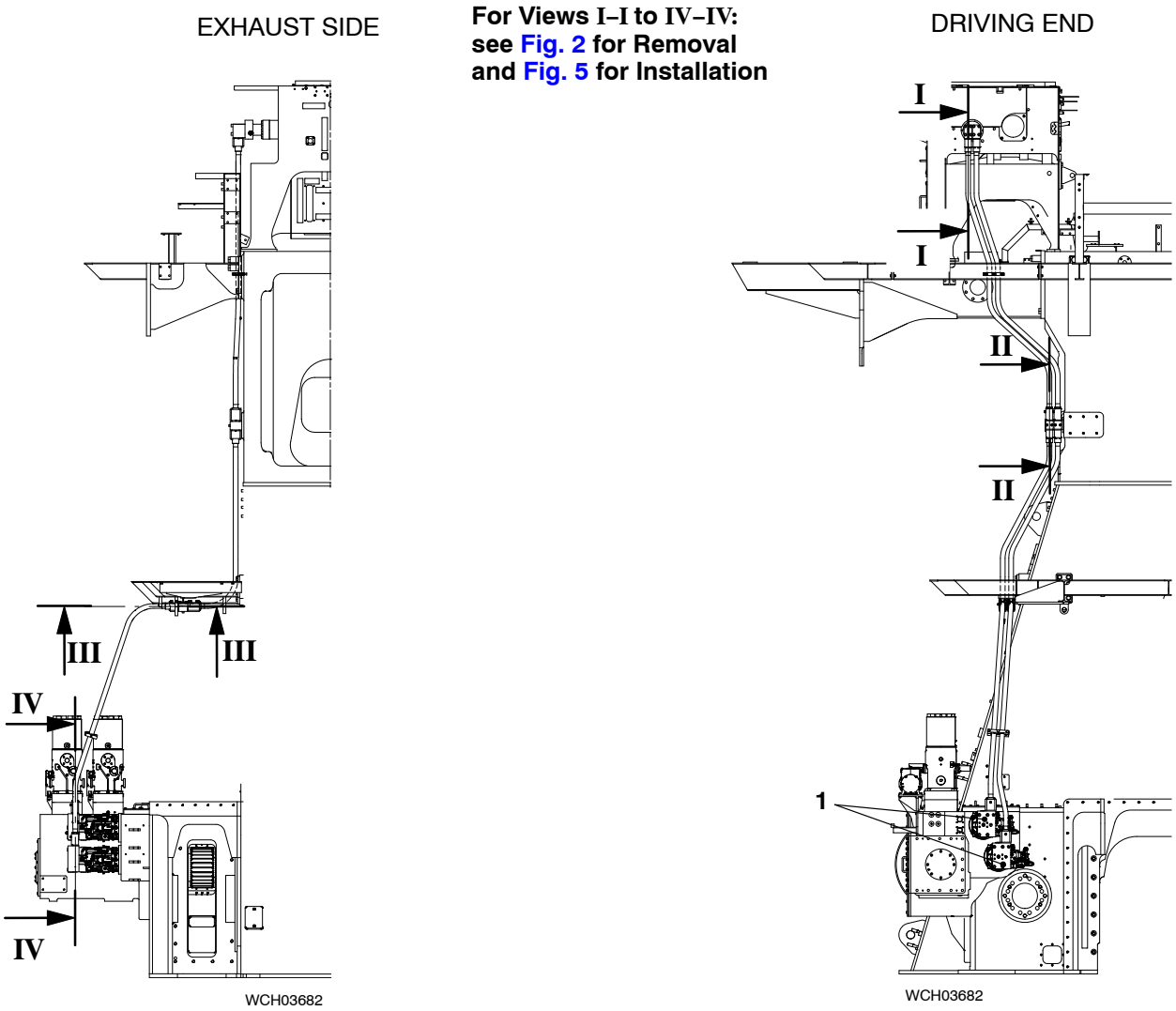


Fig. 1: Servo Oil Pipes

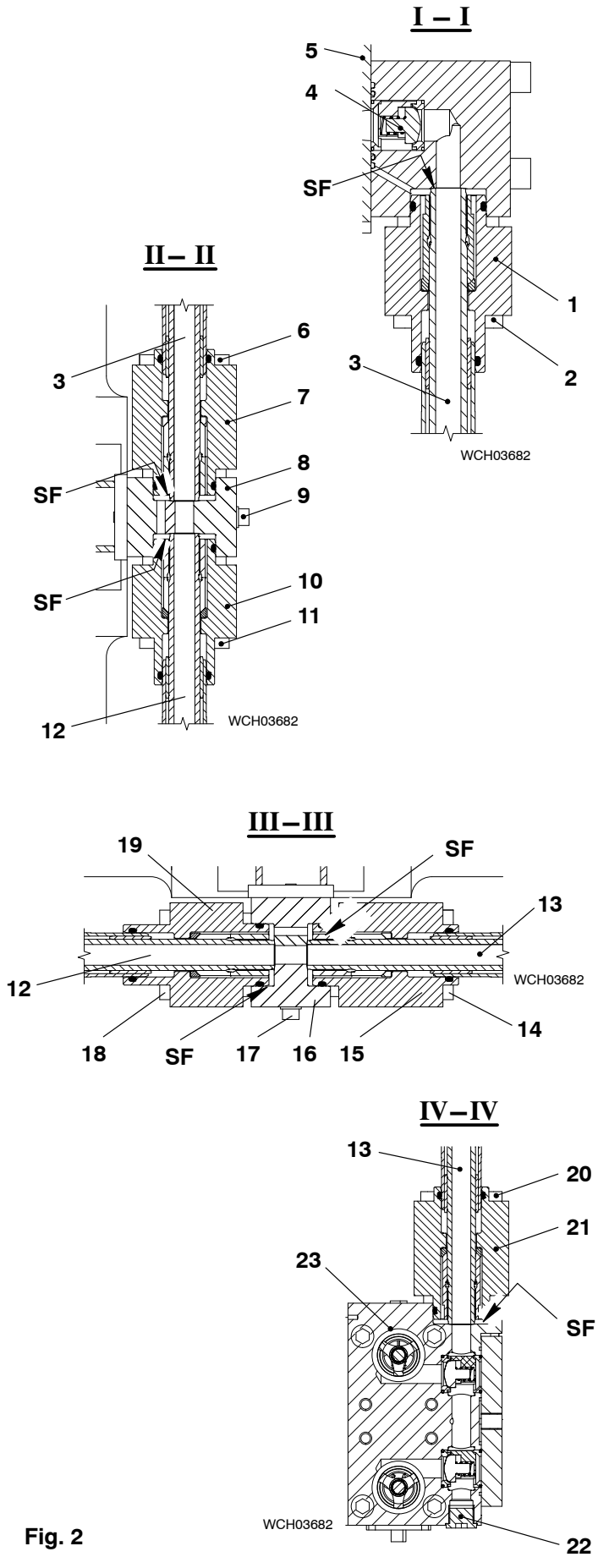


Fig. 2

4) Loosen the screw plug (22, Fig. 2) to drain the HP servo oil pipes (3, 12 and 13).
5) On the flange (1), loosen the four screws (2).
6) Push down the flange (1) to get air into the HP servo oil pipe (3).

After approximately one minute, the oil will drain from the servo oil pipes.

2. Removal

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP servo oil pipes.

1) Remove the four screws (20) from the flange (21).
2) Move the flange (21) up.
3) Remove the four screws (14) from the flange (15).
4) Move the flange (15) away from the the intermediate piece (16).
5) Remove the two screws and washers (17) from the intermediate piece (16).
6) Carefully remove the HP servo oil pipe (13).
7) Apply protection to the sealing faces (SF) to prevent damage.
8) Remove the four screws (18) from the flange (19).
9) Move the flange (19) away from the intermediate piece (16).
10) Remove the intermediate piece (16).
11) Remove the four screws (11) from the flange (10).
12) Move the flange (10) down.
13) Carefully remove the HP servo oil pipe (12).
14) Apply protection to the sealing faces (SF) to prevent damage.

15) Loosen the two screws (9, Fig. 2) on the intermediate piece (8).
16) Remove the four screws (6) from the flange (7).
17) Move the flange (7) up.
18) Remove the four screws (2) from the flange (1).
19) Carefully remove the HP servo oil pipe (3) from the valve housing (5).
20) Apply protection to the sealing faces (SF) to prevent damage.

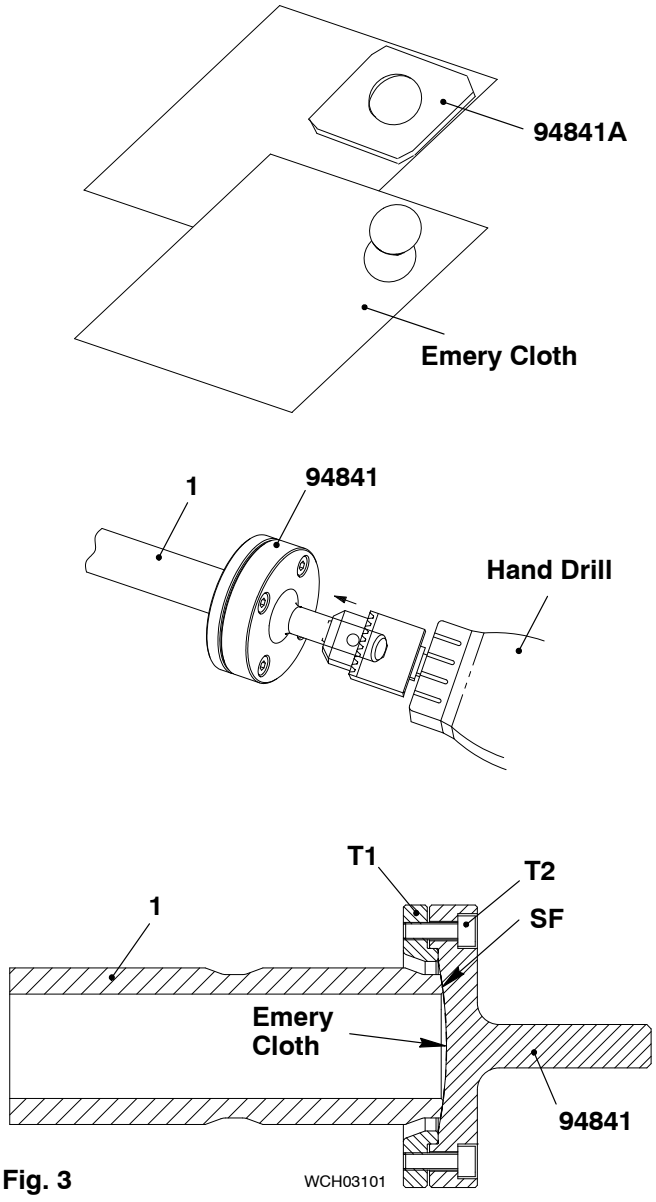


Fig. 3

3. Sealing Faces – Grind

To get a clean and smooth finish on the hydraulic pipe, do step 1) to step 20):

1) Put the stencil (94841A, Fig. 3) on the back of the emery cloth.
2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
3) Use a pencil or a ball pen to make the inner shape.
4) Cut out accurately the shape.
5) Remove the four screws (T2) and the grinding tool (94841).
6) Apply Molyslip Copaslip paste to the threads and faces of the four screws (T2).
7) Remove the cover (T1).
8) Put the emery cloth you cut out into the grinding tool (94841).
9) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the hydraulic pipe (1).
10) Torque symmetrically the the four screws (T2) to 2.0 Nm.
11) Put the hydraulic pipe (1) in a vice, as vertically as possible.
12) Adjust the speed of the hand drill to between 200 rpm and 500 rpm.
13) Align the hand drill and the grinding tool (94841) accurately with the hydraulic pipe (1) as shown.

14) Use light pressure and start grinding.
15) Regularly remove the unwanted material from the grinding tool (94841).
16) Make sure that the circular marks around the sealing face of the pipe are concentric.
17) Change the emery cloth for a smoother grade, then do step 1) to step 16) again until you get a smooth finish.
18) Replace the emery cloth with a polishing cloth as a last step to polish the HP servo oil pipe.
19) Clean the HP servo oil pipe (1).
20) If necessary, do step 1) to step 19) for the other servo oil pipes.

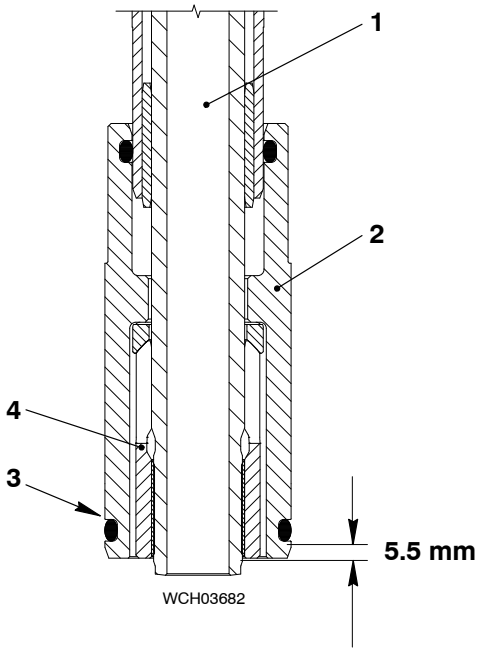


Fig. 4

4. Adjustment

1) Make sure that the claw (4, Fig. 4) is correctly attached to the HP servo oil pipe (1).
2) Do a check of the O-ring (3). If the O-ring is unserviceable, remove and discard it.
3) Make sure that there is a distance of 5.5 mm between the end of the HP servo oil pipe (1) and the claw (4).

Note: You can adjust the claw (4) with an open-ended wrench.

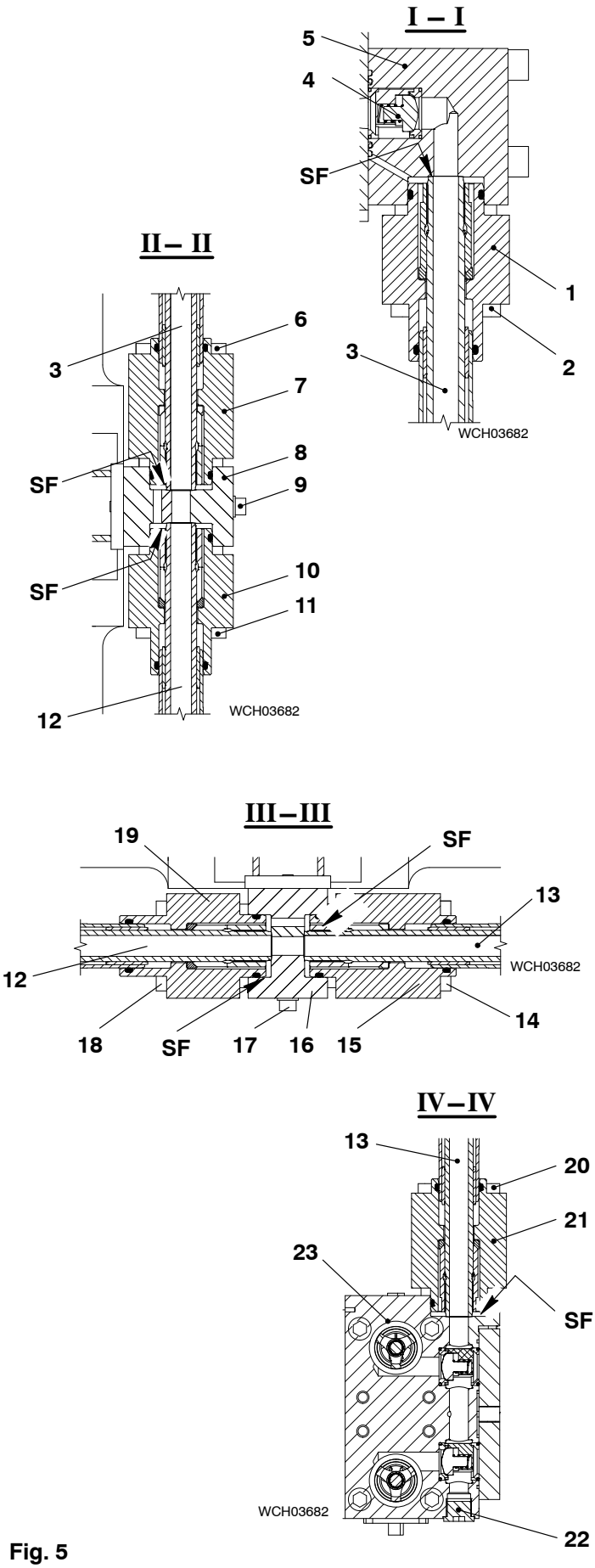


Fig. 5

5. Installation

1) Remove all of the protection from the sealing faces (SF) in the valve housing (5, Fig. 5), the intermediate pieces (8, 16) and the servo oil pump (23).
2) Apply oil to the the threads of all the screws (2, 6, 11, 14, 18, and 20)
3) Carefully put the HP servo oil pipe (3) in position in the valve housing (5) and the intermediate piece (8).
4) Torque symmetrically the four screws (2) to 20 Nm.
5) Torque symmetrically the four screws (6) to 20 Nm.
6) Attach the intermediate piece (16) to the plate (20). Do not torque the screws (17) at this step.
7) Carefully put the HP servo oil pipe (12) in position in the intermediate piece (8) and the intermediate piece (16).
8) Torque symmetrically the four screws (11) to 20 Nm.
9) Torque symmetrically the four screws (18) to 20 Nm.
10) Carefully put the HP servo oil pipe (13) in position in the intermediate piece (16 and the servo oil pump (23).
11) Torque symmetrically the four screws (14) to 20 Nm.
12) Torque symmetrically the four screws (20) to 20 Nm.
13) Torque the screws (9) on the intermediate piece (8) to 20 Nm.
14) Torque the two screws (17) on the intermediate piece (16) to 20 Nm.

Intentionally blank

Hydraulic Pipe – Exhaust Valve Drive

Removal, Grind Sealing Faces and Installation

Tools:

1	Grinding tool	94841
1	Stencil	94841A

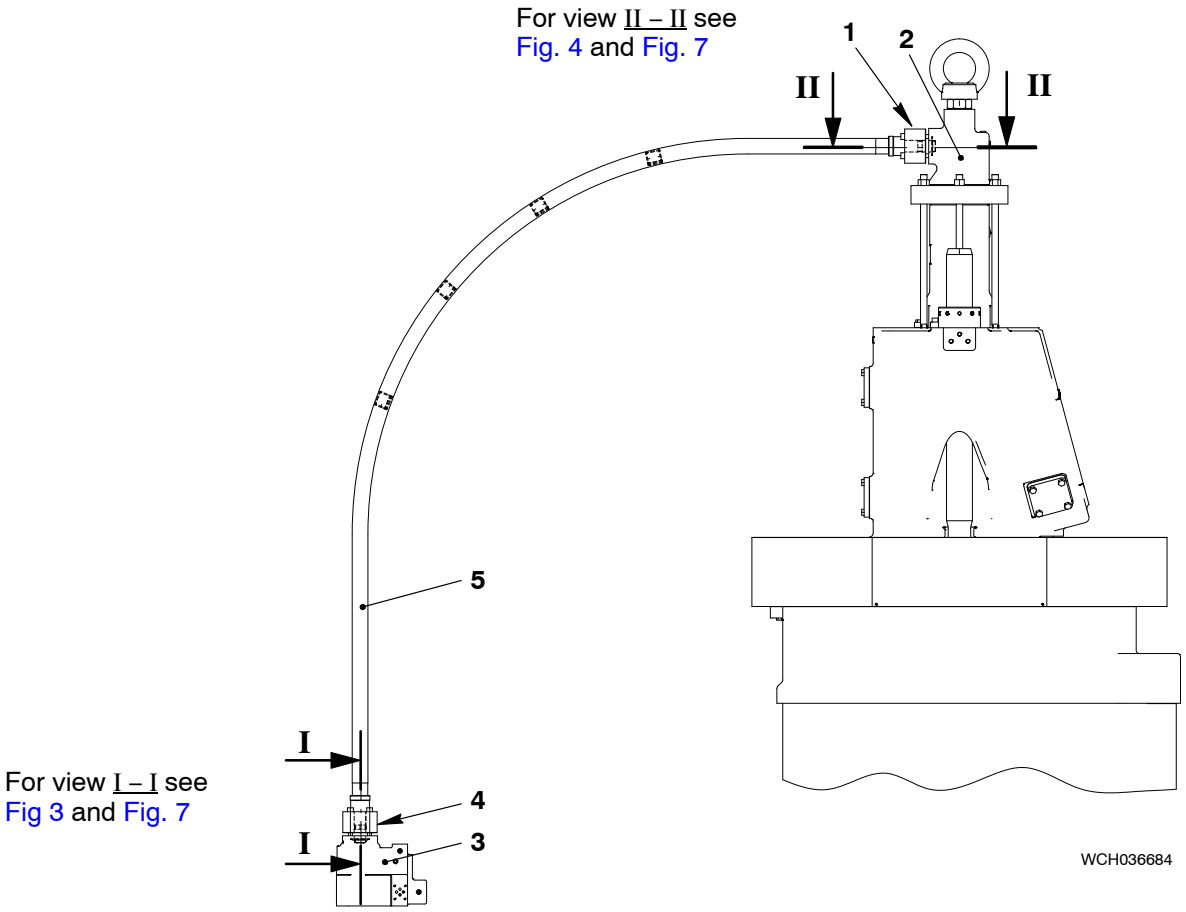


Fig. 1 Exhaust Valve Control Unit

1 Flange
2 Top housing
3 Exhaust valve control unit (VCU)
4 Flange
5 Hydraulic pipe

1. Preparation

WARNING

Injury Hazard: The servo oil system has high pressure. Replace a defective hydraulic pipe only when the engine has stopped.

WARNING

Injury Hazard: You must put on gloves and safety goggles when you do work on hot components. When drain screws and plugs are opened, servo oil can come out as a spray and cause injury.

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Set to off the servo oil service pump.
3) Make sure that there is no pressure in the servo oil system refer to the Operation Manual 0520-1, paragraph 2.3.
4) Set to off the main bearing oil supply.

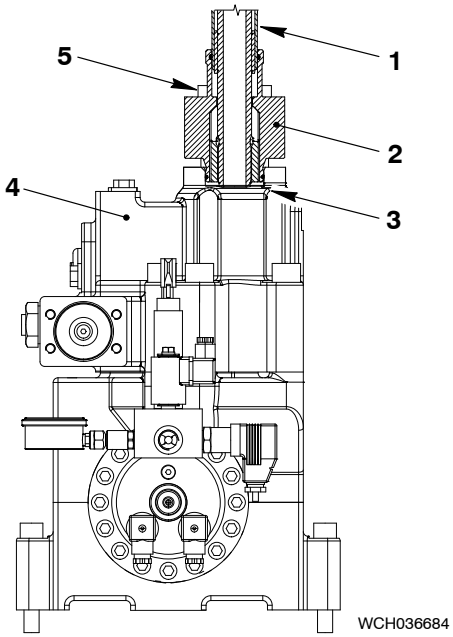


Fig. 2

5) Put an oil tray under the applicable hydraulic pipe (1, Fig. 2).
6) Loosen the screws (5) on the flange (2) to drain the applicable hydraulic pipe (1) through the check bore (3) in the housing of the VCU (4).

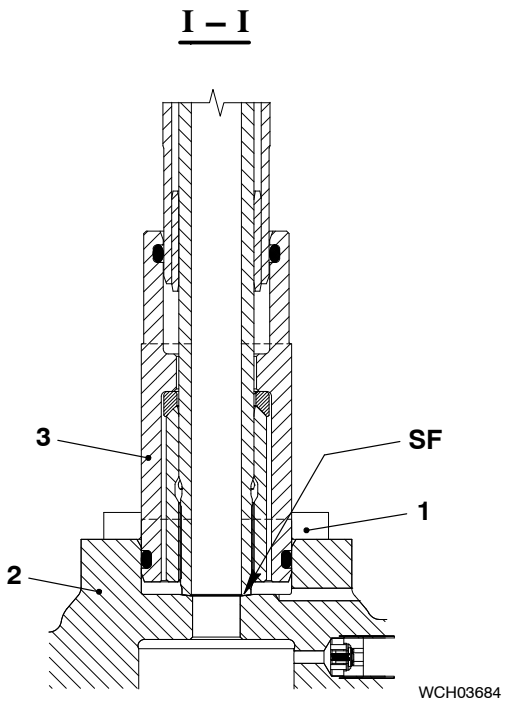


Fig. 3

2. Removal

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the hydraulic pipes.

1) Remove the four screws (1, Fig. 3) from the flange (3).
2) Carefully move the flange (3) away from the VCU (2).
3) Apply protection to the sealing faces (SF) to prevent damage and contamination.

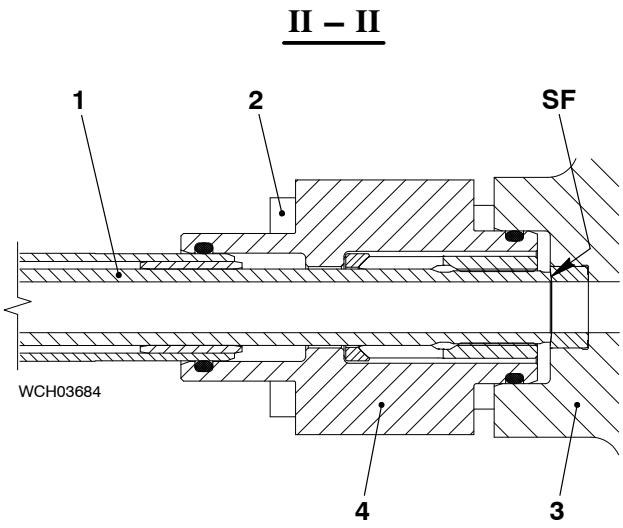


Fig. 4

4) Remove the four screws (2, Fig. 4) from the flange (4).
5) Carefully move the flange (4) away from the top housing (3).

CAUTION

Injury Hazard: The weight of the hydraulic pipe is approximately 37 kg. Use approved equipment or sufficient personnel to lift and move the hydraulic pipe.

6) Carefully remove the hydraulic pipe (1).
7) Apply protection to the sealing faces (SF) to prevent damage and contamination.

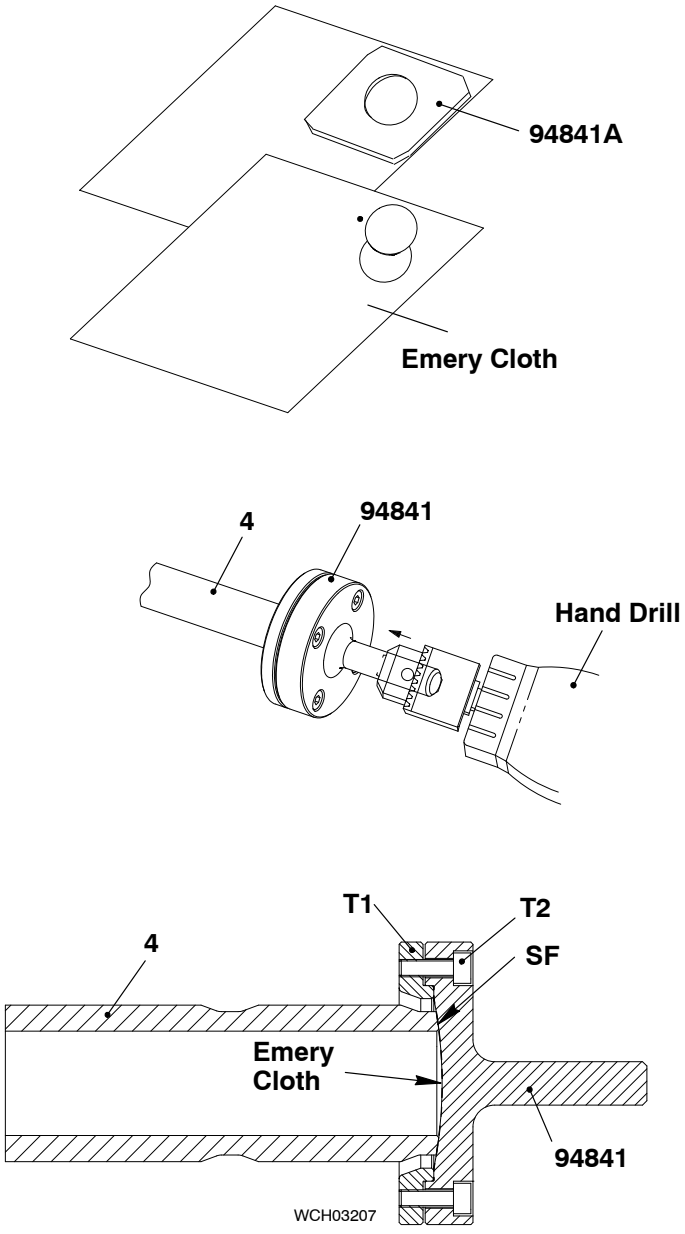


Fig. 5

3. Sealing Faces – Grind

To get a clean and smooth finish on the hydraulic pipe (1, Fig. 5) , do step 1) to step 20):

1) Put the template (94841A) on the back of the emery cloth.
2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
3) Use a pencil or a ball pen to make the inner shape.
4) Cut out accurately the shape.
5) Remove the four screws (T2) and the grinding tool (94841).
6) Apply Molyslip Copaslip paste to the threads and faces of the four screws (T2).
7) Remove the cover (T1).
8) Put the emery cloth you cut out into the grinding tool (94841).
9) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the hydraulic pipe (1).
10) Torque symmetrically the the four screws (T2) to 2.0 Nm.
11) Put the hydraulic pipe (1) in a vice, as horizontally as possible.
12) Adjust the speed of the hand drill to between 200 rpm and 500 rpm.
13) Align the hand drill and the grinding tool (94841) accurately with the hydraulic pipe (1) as shown.
14) Use light pressure and start grinding.
15) Regularly remove the unwanted material from the grinding tool (94841).
16) Make sure that the circular marks around the sealing face of the hydraulic pipe (1) are concentric.
17) Change the emery cloth for a smoother grade, then do step 1) to step 16) again until you get a smooth finish.
18) Replace the emery cloth with a polishing cloth as a last step to polish the hydraulic pipe (1).
19) Clean the hydraulic pipe (1).
20) If necessary, do step 1) to step 19) for the other hydraulic pipes.

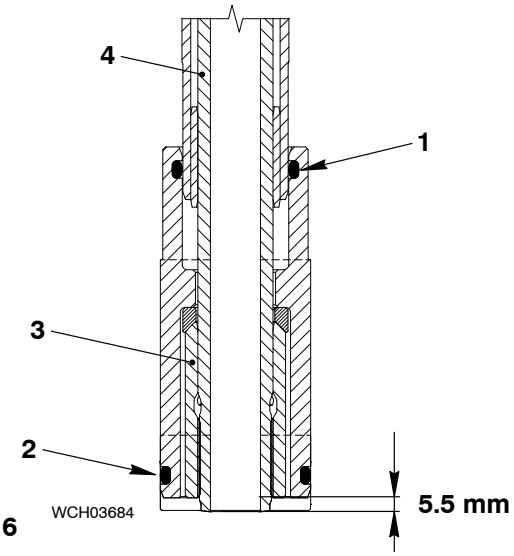
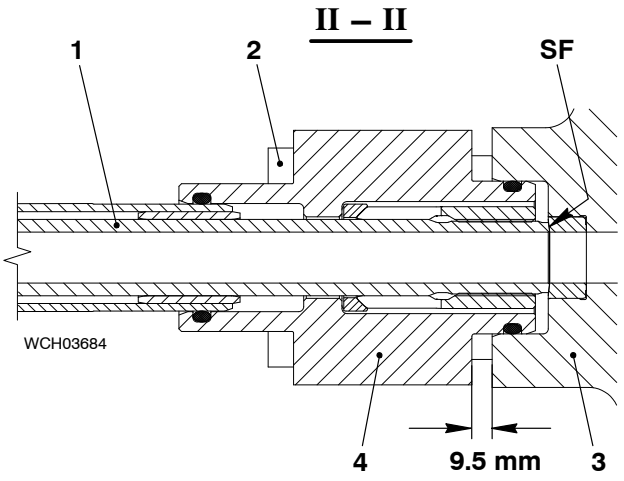


Fig. 6



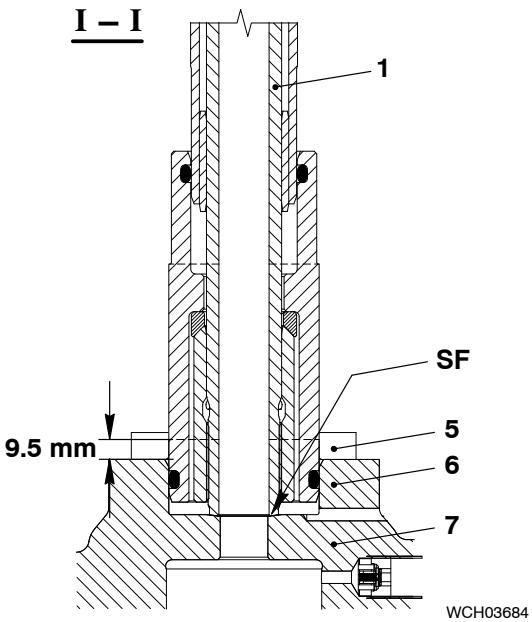


Fig. 7

4. Adjustment

1) Remove the protection from the hydraulic pipe (4)
2) Make sure that the claw (3, Fig. 6) is correctly attached to the hydraulic pipe (4).
3) Do a check of the O-rings (1, 2). If the O-rings are unserviceable, replace them.
4) Make sure that there is a distance of 5.5 mm between the end of the hydraulic pipe (4) and the claw (3).

Note: You can adjust the claw (3) with an open-ended wrench.

5. Installation

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces (SF) or the hydraulic pipes. Do not apply lateral force to the hydraulic pipe and the flanges.

1) Remove all of the protection from the sealing faces (SF, Fig. 7) in the top housing (3, Fig. 9) and the VCU (6).
2) Apply oil to the threads of the screws (2, 5).
3) Carefully put the hydraulic pipe (1) in position in the top housing (3) and the VCU (7).
4) Torque symmetrically the four screws (2) to 40 Nm.
5) Make sure that there is a distance of 8.0 mm between the flange (4) and the top housing (3).
6) Torque symmetrically the four screws (5) to 40 Nm.
7) Make sure that there is a distance of 8.0 mm between the flange (6) and the VCU (7).

Note: After 1000 operation hours, do step 4) to step 7) again.

8) Set to on the main bearing oil supply.

Intentionally blank

HP Fuel Pipe (Injection Valve)
Removal, Grinding and Installation

Tools:

1	Grinding tool	94871
1	Stencil	94871A

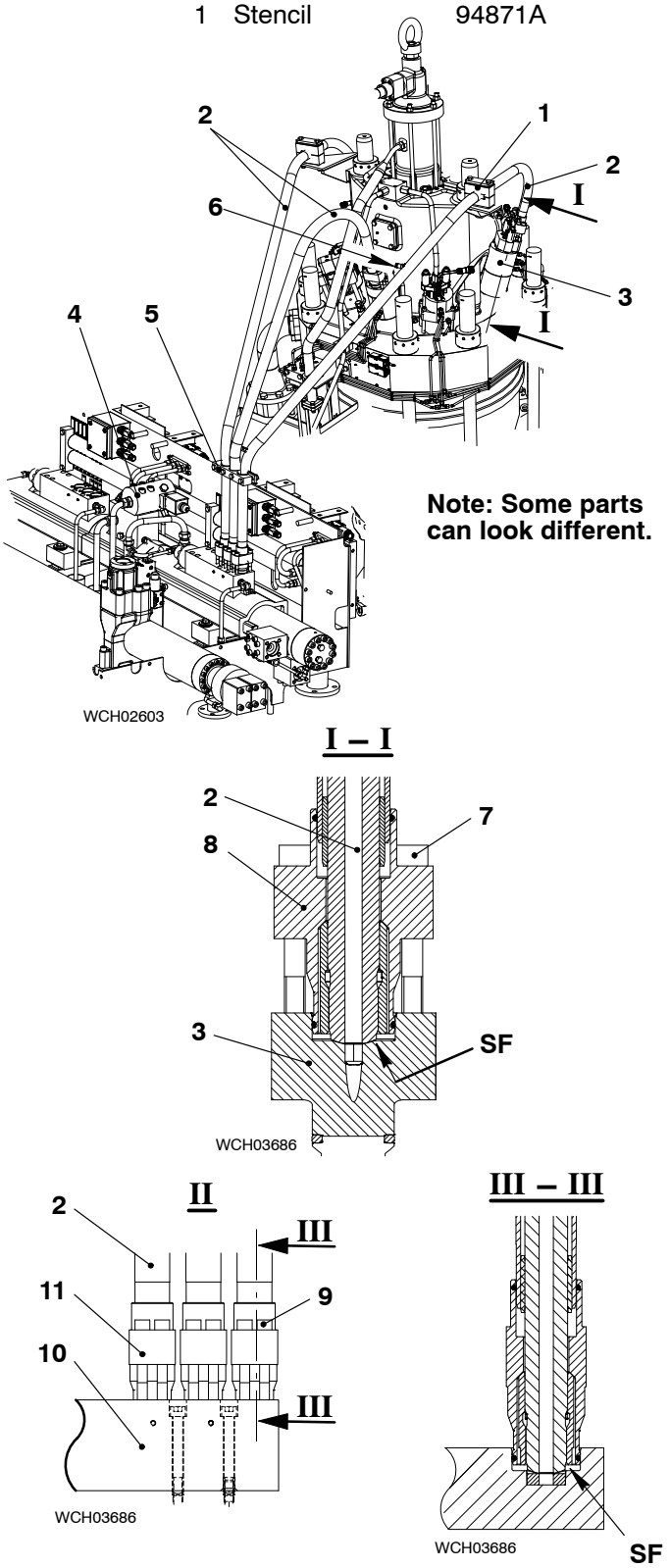


Fig. 1

1. Preparation

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Make sure that there is no pressure in the fuel rail as follows:
   a) Set to off the fuel booster pump (plant).
   b) Close the shut-off valves to the fuel inlet and return pipes.
   c) Operate the button on the pressure control valve (4, Fig. 1) to release the pressure in the fuel rail.
   d) On the Local Display Unit (LDU), make sure that the pressure shows zero.
3) Set to off the electrical trace heating system.

2. Removal

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP injection pipes.

1) On the applicable HP injection pipe (2), disconnect the electrical connection (6).
2) Remove the applicable pipe bracket (1).
3) Remove the pipe bracket (5).
4) On the injection valve (3) remove the four screws (7) from the flange (8).
5) On the flange (11), remove the four screws (9).
6) Carefully remove the applicable HP injection pipe (2) from the injection valve (3) and the flow limiter valve (10).
7) Apply protection to the sealing faces (SF) and the open ends of the HP injection pipe (2).

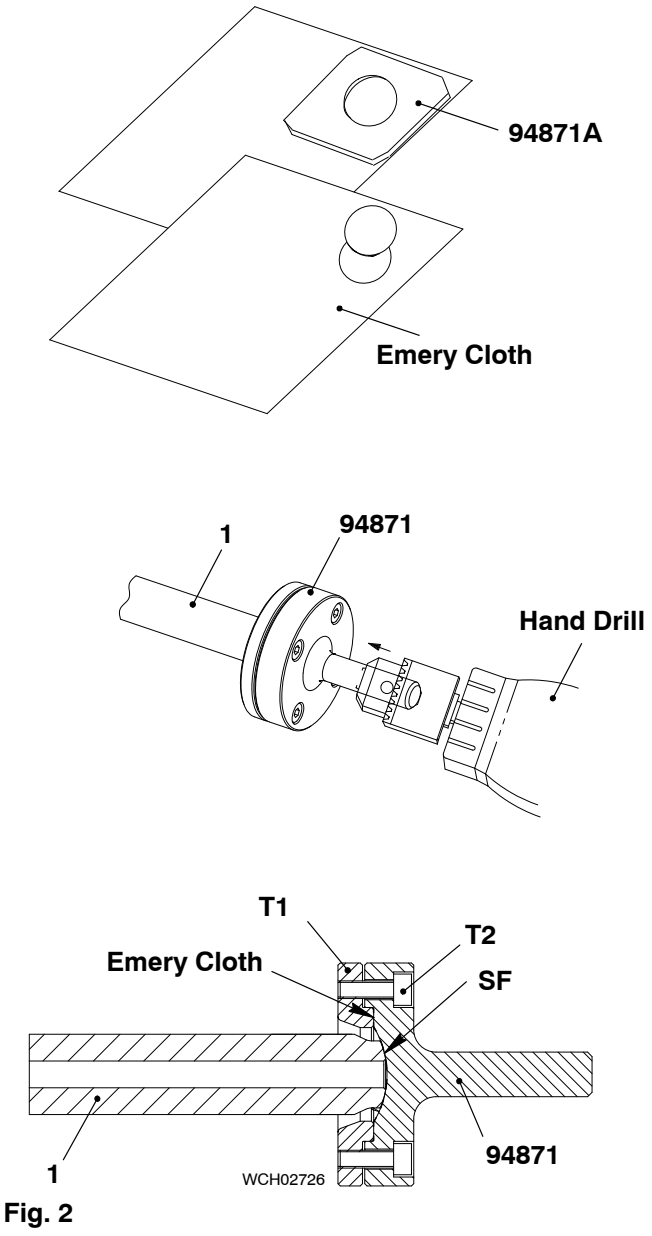
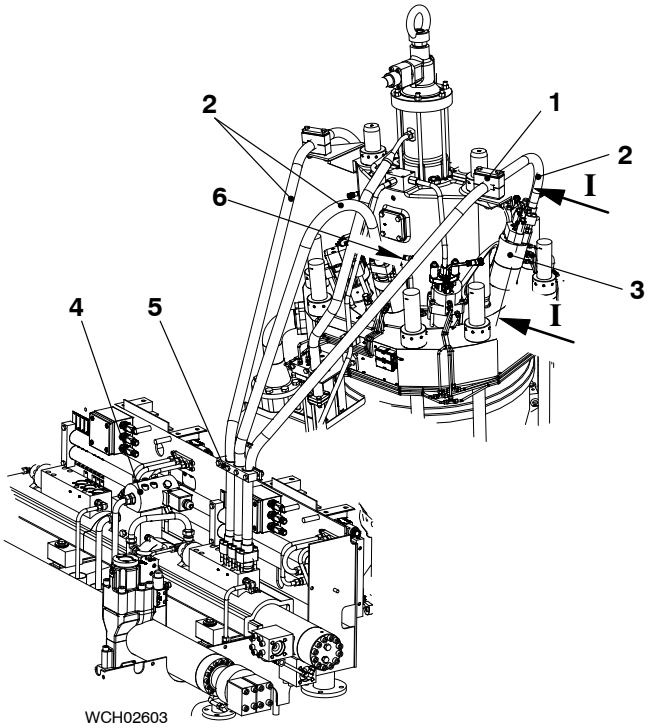


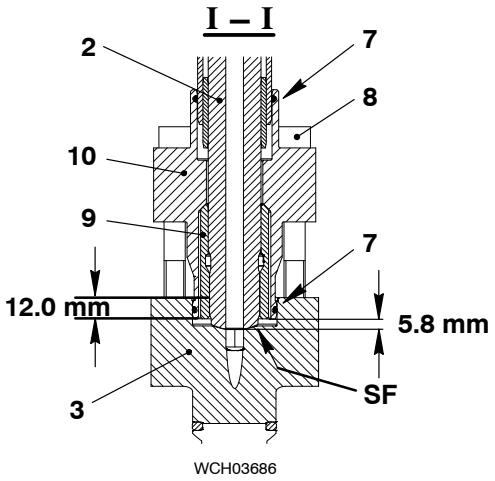
Fig. 2

3. Sealing Faces – Grind

To get a clean and smooth finish on the HP injection pipe, do the procedure that follows:

1) Put the template (94871A, Fig. 2) on the back of emery cloth.
2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
3) Use a pencil or a ball pen to make the the inner shape.
4) Cut out accurately the shape.
5) Remove the four screws (T2) and the grinding tool (94871).
6) Apply Molyslip Copaslip paste to the threads and faces of the four screws (T2).
7) Remove the cover (T1).
8) Put the emery cloth you cut out into the grinding tool (94841).
9) Put the grinding tool (94841), emery cloth and the cover (T1) in position on the HP injection pipe (1).
10) Torque symmetrically the four screws (T2) to 2.0 Nm.
11) Put the HP injection pipe (1) in a vice, as vertically as possible.
12) Adjust the speed of the hand drill between 200 rpm and 500 rpm.
13) Align the hand drill and the grinding tool (94841) accurately with the HP injection pipe (1) as shown.
14) Use light pressure and start grinding.
15) Regularly remove unwanted material from the grinding tool (94871).
16) Make sure that the circular marks around the sealing face of the pipe are concentric.
17) Change the emery cloth for a smoother grade, then do step 1) to step 16) again until you get a smooth finish.
18) Replace the emery cloth with a polishing cloth as a last step to polish the HP injection pipe.
19) Clean the HP injection pipe (1).
20) If necessary, do step 1) to 19) for the other HP injection pipes.





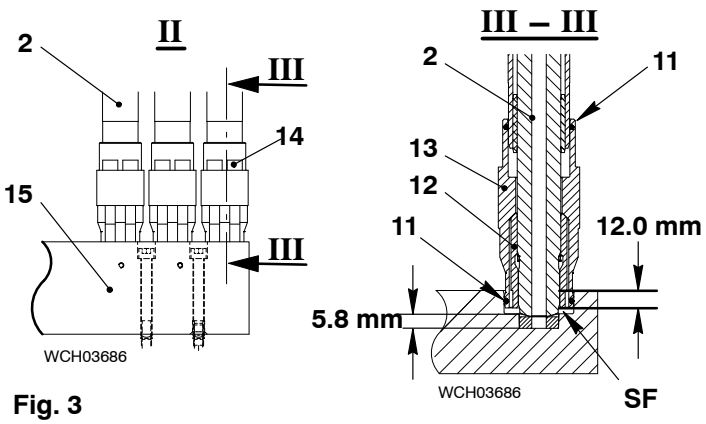


Fig. 3

4. Installation

CAUTION

Damage Hazard: Make sure that you do not damage the sealing faces or the HP injection pipes.

1) If necessary, replace the O-rings (7and 11, Fig. 3).
2) Make sure that the claws (9, 12) are correctly attached to the HP injection pipe (2).

Note: You can adjust the claws (9, 12) with an open-ended wrench.

3) Remove all of the protection from the sealing faces in the injection valve (3) and the flow limiter valve (15).
4) Make sure that there is distance of 5.8 mm between the ends of the HP injection pipe (2) and the claws (9, 12).
5) Apply Never-Seez NSBT to threads of the screws (8, 14).
6) Carefully put the HP injection pipe (2) in position in the injection valve (3) and the flow limiter valve (15).
7) Torque symmetrically the four screws (8) to 60 Nm.
8) Make sure that there is a distance of 12.0 mm between the flange (10) and the injection valve (3).
9) Torque symmetrically the four screws (14) to 60 Nm.
10) Make sure that there is a distance of 12 mm between the flange (13) and the flow limiter valve (15).
11) If necessary, install the insulation to the HP injection pipe (2).
12) Install the pipe clamps (1, 5).

Intentionally blank

HP Fuel Pipe
Removal, Grinding and Installation

1	Grinding tool	94870	Grinding tool		94870F
1	Screw-on sleeve	94870E	Locknut		94870G
			Template		94870H

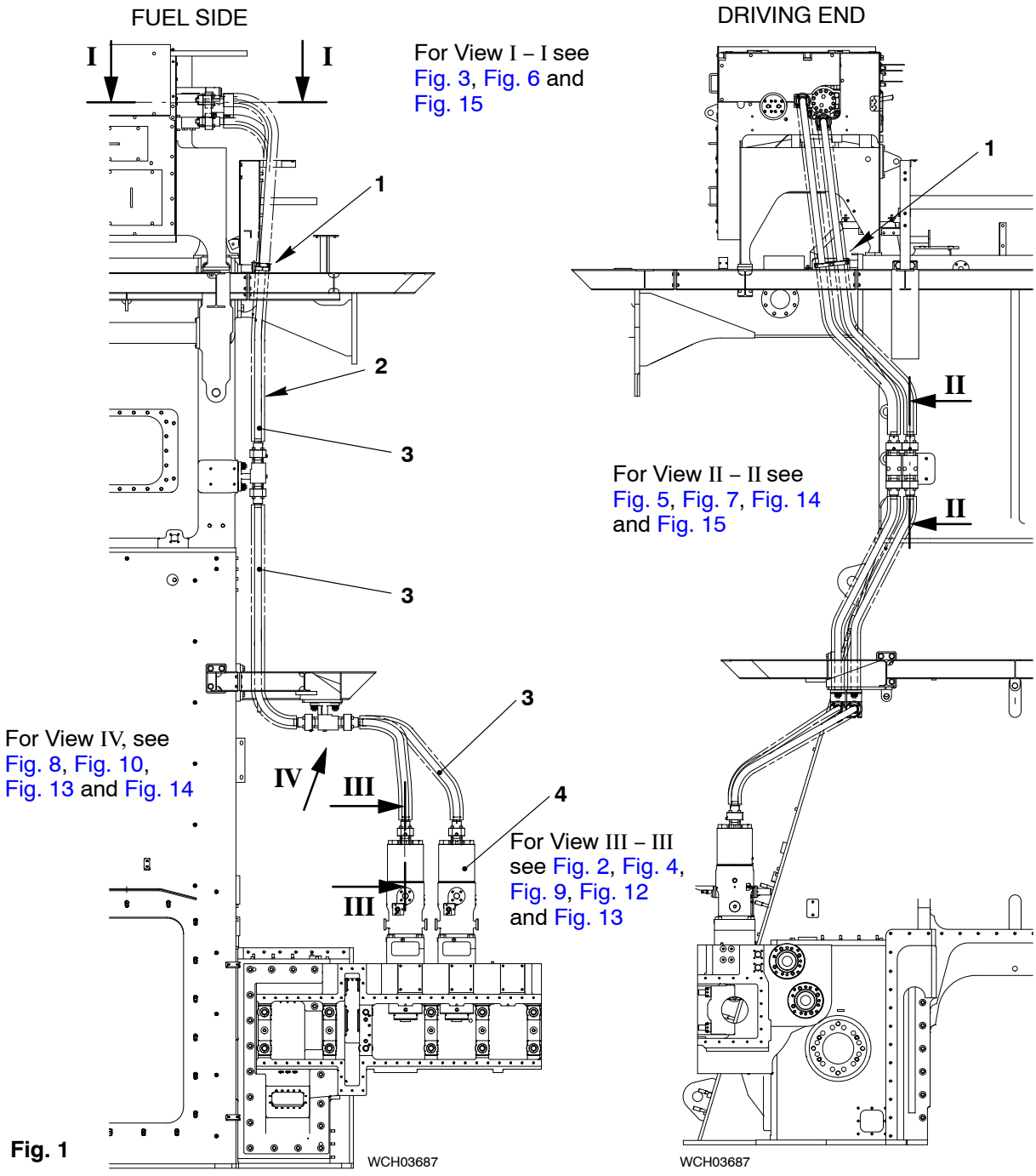


Fig. 1

1. Preparation

WARNING

Injury Hazard: The fuel system has high pressure. Replace a defective HP fuel pipe only when the engine has stopped. You must obey the data given in the Operation Manual 0520-1.

WARNING

Injury Hazard: Always put on gloves and safety goggles when you do work on hot components. When screws and plugs are opened, steam or fuel can come out and cause injury.

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP fuel pipes. Do not apply lateral force to the HP fuel pipes and the flanges.

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Set to off the fuel supply pump.
3) Set to off the trace heating.
4) If the HP fuel pipes must be replaced, remove the insulation (2, Fig. 1) from the HP fuel pipes (3).
5) If necessary, disconnect the trace heating pipes.
6) Remove the clamps (1).
7) Put an oil tray under the applicable fuel pump.

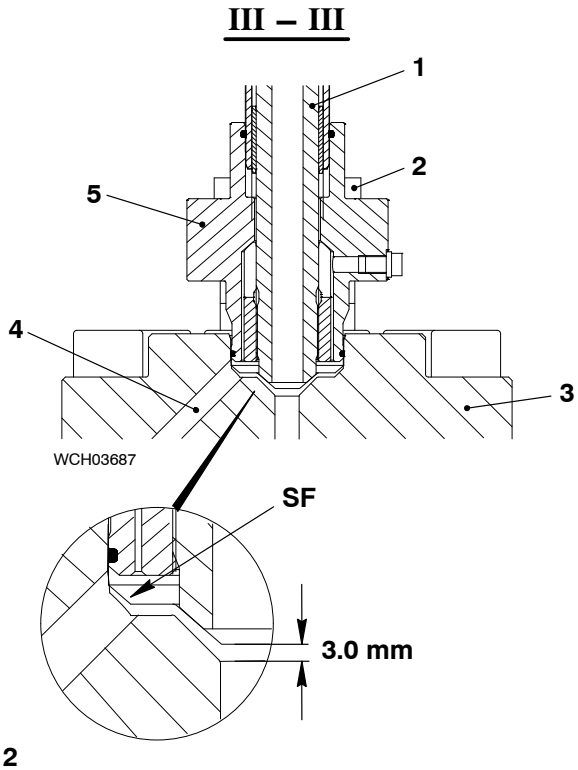


Fig. 2

8) Loosen the four screws (2, Fig. 2) on the flange (5) a maximum of three turns.

Note: The fuel will drain through the drain bore (4) into the fuel leakage pipe.

9) Move the HP fuel pipe (1) up. Make sure that there is a distance of approximately 3.0 mm between the fuel pump cover (3) and the HP fuel pipe (1).

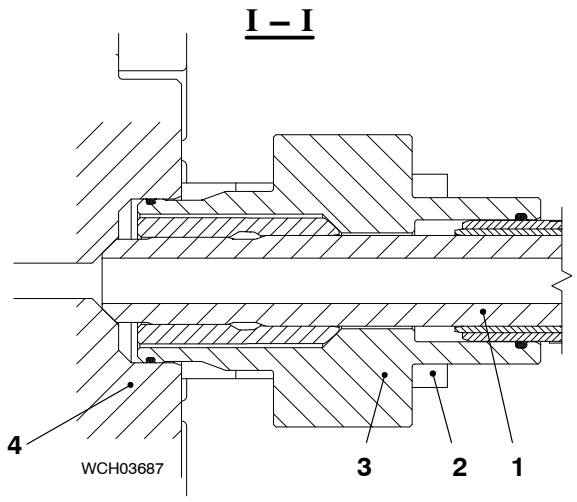


Fig. 3

10) Loosen the four screws (2, Fig. 3) on the flange (3) a maximum of three turns.
11) Move the flange (3) away from the valve housing (4) and make sure that air goes into the HP fuel pipe (1).

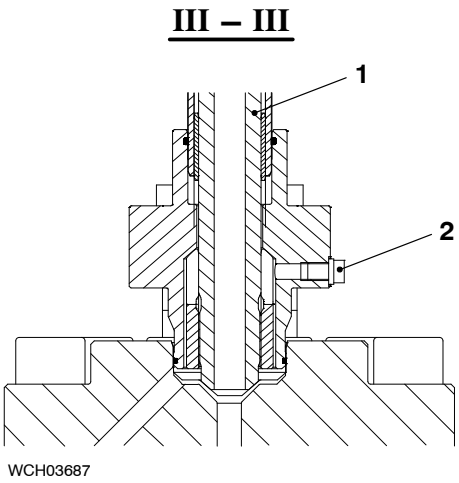


Fig. 4

12) Open the screw plug (2, Fig. 4). If there is no fuel, the HP fuel pipe (1) is fully drained.
13) Tighten the screw plug (2).

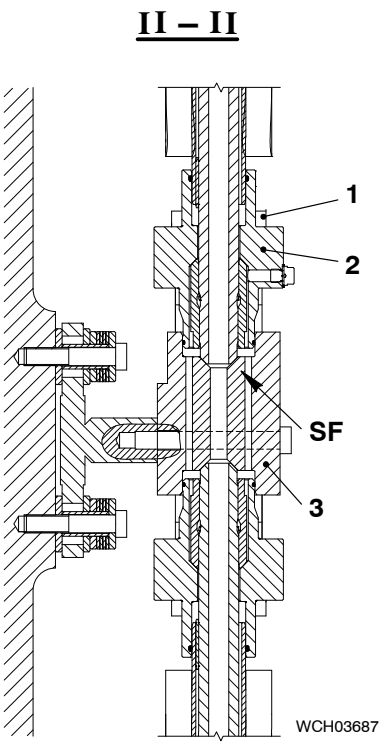


Fig. 5

2. Removal

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP fuel pipes.

1) Remove the four screws (1, Fig. 5) from the flange (2).
2) Carefully move the flange (2) away from the intermediate piece (3).

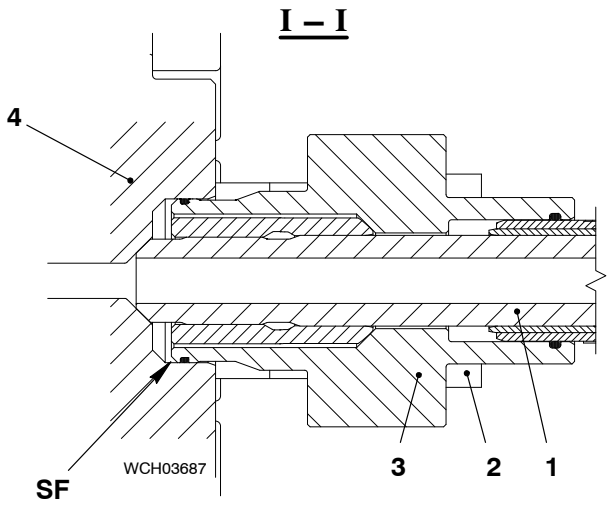


Fig. 6

3) Remove the four screws (2, Fig. 6) from the flange (3).
4) Carefully move the flange (3) away from the valve housing (4).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 41 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

5) Carefully remove the HP fuel pipe (1).
6) Apply protection to the sealing faces (SF) to prevent damage and contamination.

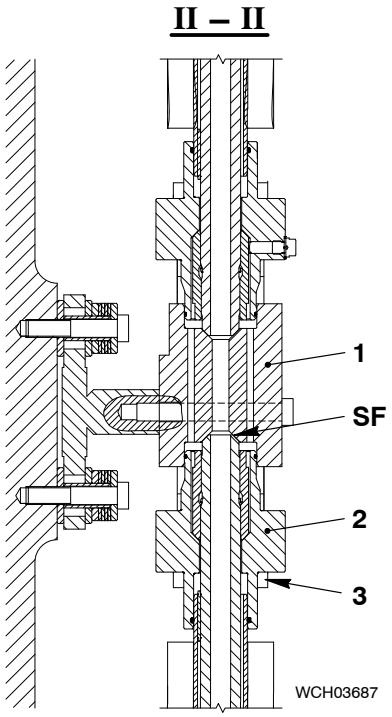


Fig. 7

7) Remove the four screws (3, Fig 7) from the flange (2).

8) Carefully move the flange (2) away from the intermediate piece (1).

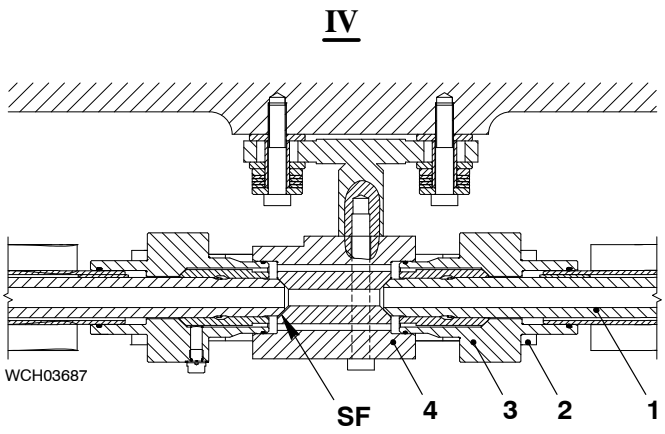


Fig. 8

9) Remove the four screws (2, Fig 8) from the flange (3).

10) Carefully move the flange (3) away from the intermediate piece (4).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 32 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

11) Carefully remove the HP fuel pipe (1).

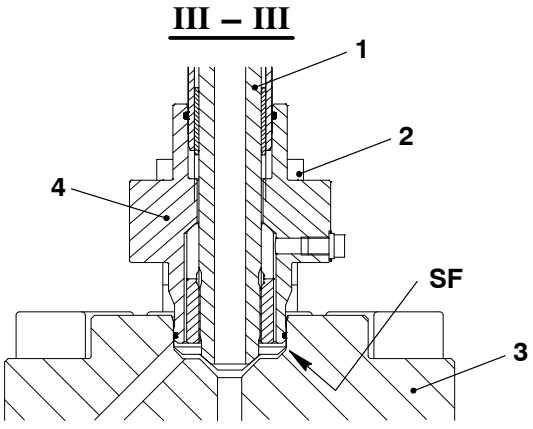


Fig. 9

12) Apply protection to the sealing faces (SF) to prevent damage and contamination.

13) Remove the four screws (2, Fig. 9) from the flange (4).

14) Carefully move the flange (4) away from the fuel pump cover (3).

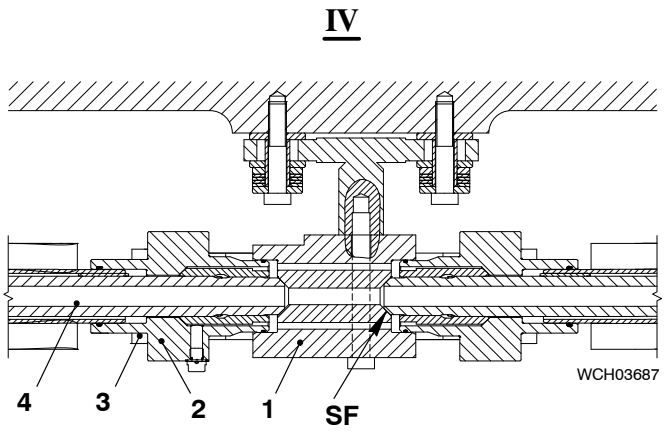


Fig. 10

15) Remove the four screws (3, Fig. 10) from the flange (2).

16) Carefully move the flange (2) away from the intermediate piece (1).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 28 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

17) Carefully remove the HP fuel pipe (4).

18) Do a check of the sealing faces (SF). If you find damage, do the procedure given in paragraph 3.

19) Apply protection to the sealing faces (SF) to prevent damage and contamination.

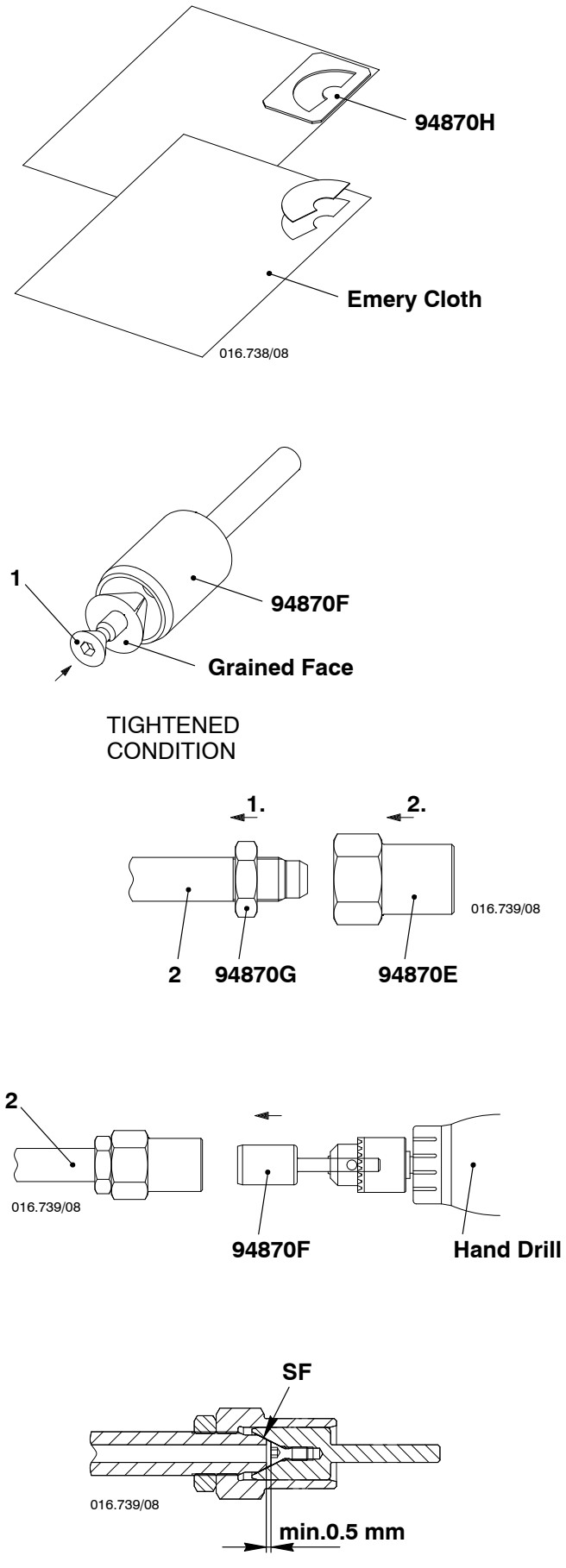


Fig. 11

3. Sealing Faces – Grind

To remove deep notches of more than 0.1 mm, use emery cloth of medium to coarse grain (30 to 80 CAMI). For finish grinding, use emery cloth with fine or ultra-fine grains (100 to 600 CAMI).

To get a clean and smooth finish on the pipe, do the procedure that follows:

1) Put the template 94870H on the back of the emery cloth, see Fig. 11.
2) Use the applicable grade of the emery cloth related to the quantity of metal you want to remove.
3) Use a pencil or a ball pen to make the the inner shape.
4) Cut out accurately the shape.
5) Put the cut shape into the cone of the grinding tool 94870F as shown.
6) Tighten the countersunk screw (1).
7) Remove the pipe claw.
8) Put the HP fuel pipe in position in a vice.
9) Attach the nut (94870G) on to the thread of the HP fuel pipe (2).
10) Attach the sleeve (94870E) to the nut (94870G).
11) Attach the grinding tool (94870F) to the hand drill.
12) Move the grinding tool (94870F) into the sleeve (94870E) until the grinding tool lightly touches the HP fuel pipe (2).
13) Adjust the hand drill speed to a maximum of 1500 rpm.
14) Operate the hand drill for between 3 seconds and 5 seconds.
15) Remove the grinding tool (94870F) from the sleeve (94870E).
16) Use a low-pressure air supply to clean the HP fuel pipe.
17) Do a check of the sealing face. If necessary, use a new piece of emery cloth and do step 3) to step 16) again.

Note: If the notches are large, you must decrease the length of the HP fuel pipe. Make sure that there is a distance of 0.5 mm between the countersunk screw (1) and the end face of the HP fuel pipe.

18) Remove the nut (94870G) and sleeve (94870E).

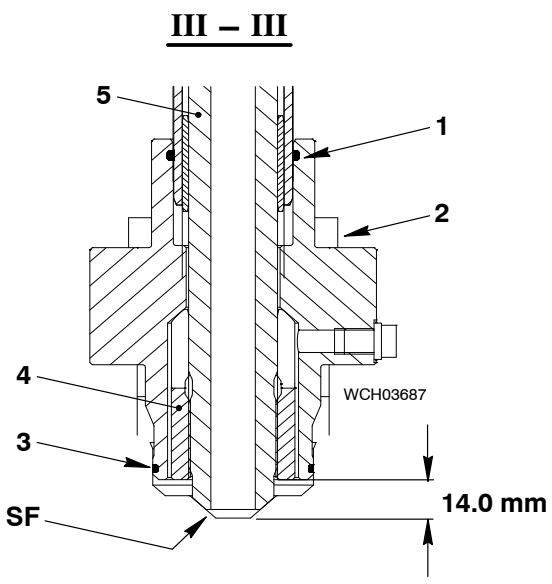


Fig. 12

4. Installation

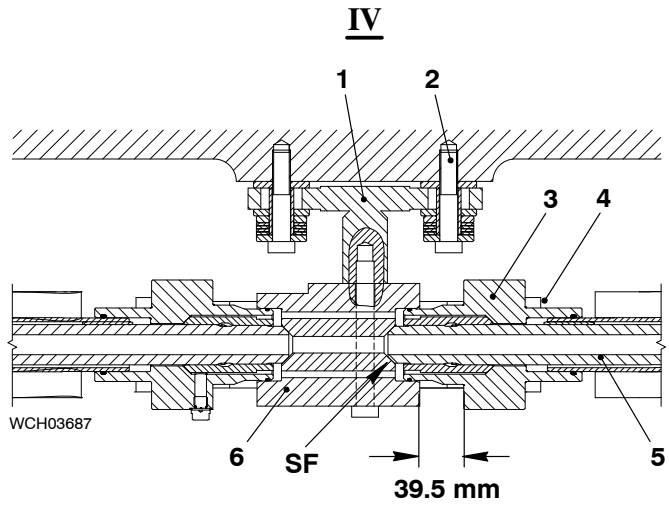
CAUTION

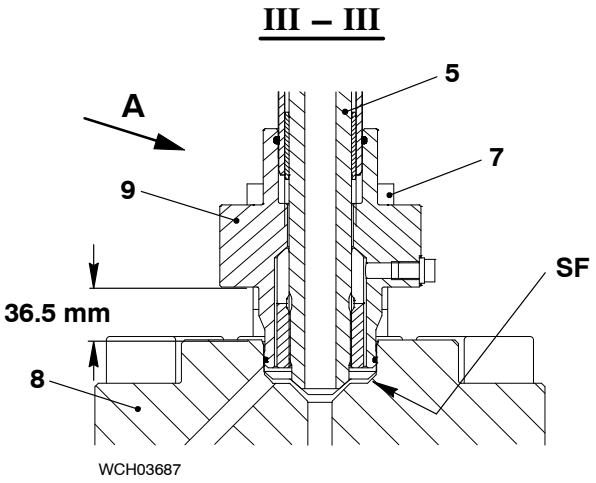
Injury Hazard: The weight of the HP fuel pipe is approximately 28 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

1) Do a check for damage of the O-rings (1 and 3, Fig. 12). If necessary, replace the O-rings.
2) Remove all of the protection from the sealing faces (SF).
3) Make sure that the claw (4) is correctly attached to the HP fuel pipe (5).

Note: You can adjust the claw (4) with an open-ended wrench.

4) Make sure that there is a distance of 14.0 mm between the end of the HP fuel pipe (5) and the claw (4).
5) Make sure that the O-rings (1, 3) are in position.
6) Apply Never-Seez NSBT to the threads of all the screws (2).





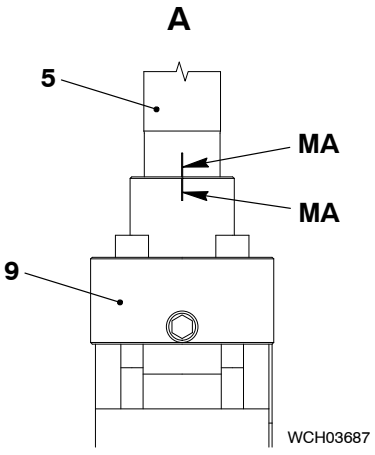


Fig. 13

CAUTION

Damage Hazard: Do not apply lateral force to the HP fuel pipe and the flanges. Damage the sealing faces (SF) and the HP fuel pipe can occur.

7) Loosen the screws (2, Fig. 16) on the support (1) of the intermediate piece (6).

8) Carefully put the HP fuel pipe (5) in position in the fuel pump cover (8) and the intermediate piece (6).

9) Make sure that the HP fuel pipe (5) is in the correct position. Align the marks (MA) on the HP fuel pipe (5) and the flange (9).

10) Torque the screws (4, 7) as follows:

   a) Torque symmetrically the four screws (4, 7) to 30 Nm.

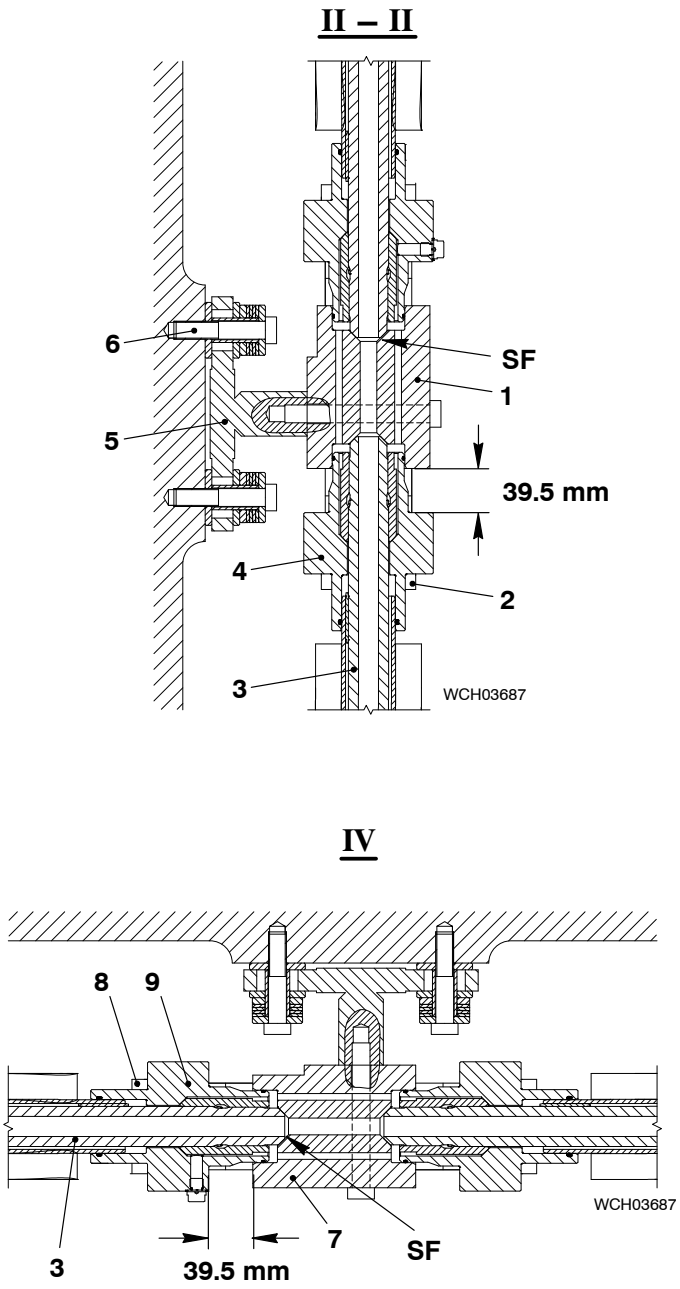
   b) Make sure that the flanges (3, 9) are in the correct position and not tilted.

   c) Torque symmetrically the four screws (4, 7) to 55 Nm.

   d) Torque symmetrically the four screws (4, 7) to 80 Nm.

11) Make sure that there is a distance of 36.5 mm between the flange (9) and the fuel pump cover (8).

12) Make sure that there is a distance of 39.5 mm between the flange (3) and the intermediate piece (6).



13) Loosen the screws (6, Fig. 14) on the support (5) of the intermediate piece (1).

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 32 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

14) Carefully put the HP fuel pipe (3) in position in the intermediate piece (1) and the intermediate piece (7).

15) Make sure that the HP fuel pipe (3) is in the correct position.

16) Torque the screws (2, 8) as follows:

a) Torque symmetrically the four screws (2, 8) to 30 Nm.

b) Make sure that the flanges (4, 9) are in the correct position and not tilted.

c) Torque symmetrically the four screws (2, 8) to 55 Nm.

d) Torque symmetrically the four screws (2, 8) to 80 Nm.

17) Make sure that there is a distance of 39.5 mm between the flange (4) and the intermediate piece (1).

18) Make sure that there is a distance of 39.5 mm between the flange (9) and the intermediate piece (7).

Fig. 14

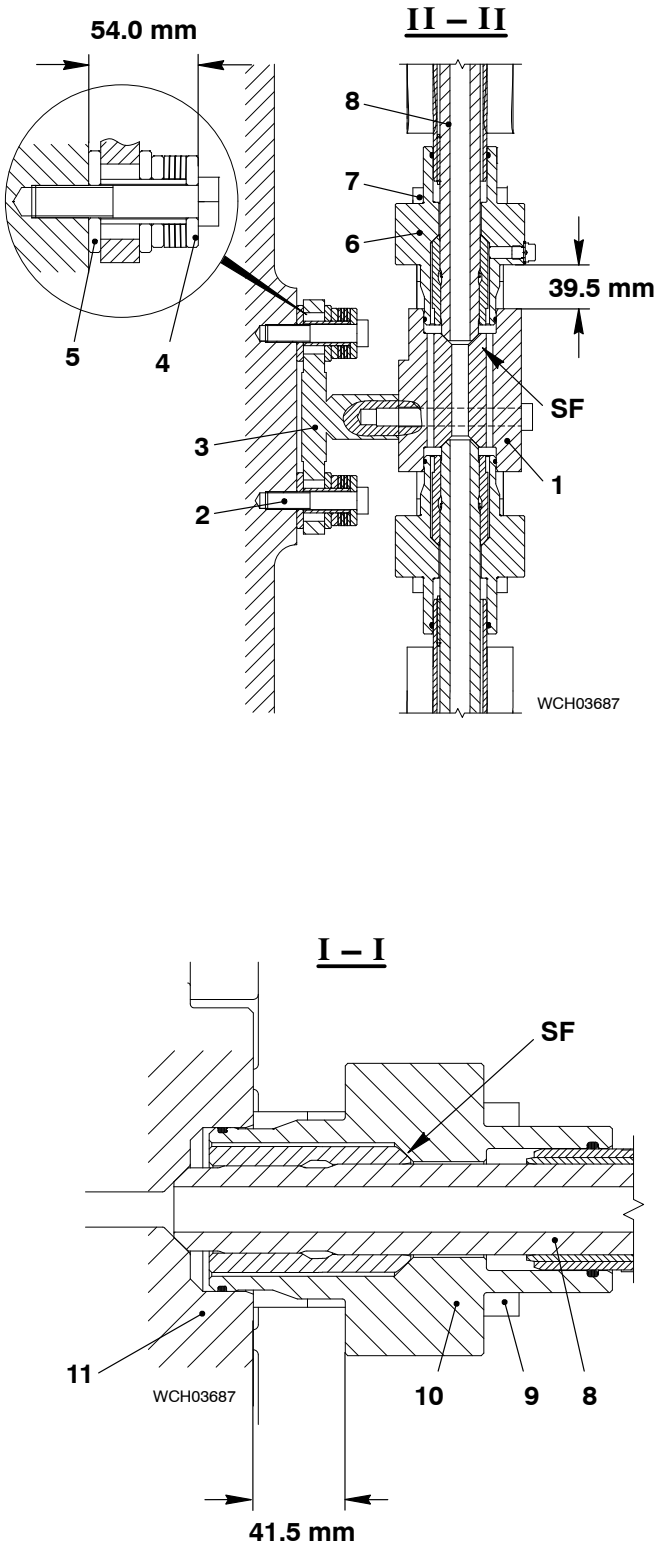


Fig. 15

CAUTION

Injury Hazard: The weight of the HP fuel pipe is approximately 43 kg. Use approved equipment or sufficient personnel to lift and move the HP fuel pipe.

19) Carefully put the HP fuel pipe (1, Fig. 15) in position in the intermediate piece (5) and the valve housing (4).

20) Make sure that the HP fuel pipe (1) is in the correct position.

21) Torque the screws (7, 9) as follows:

   a) Torque symmetrically the four screws (7, 9) to 30 Nm.

   b) Make sure that the flanges (6, 3) are not tilted and in the correct position.

   c) Torque symmetrically the four screws (7, 9) to 55 Nm.

   d) Torque symmetrically the four screws (7, 9) to 80 Nm.

22) Make sure that there is a distance of 39.5 mm between the flange (6) and the intermediate piece (1).

23) Make sure that there is a distance of 41.5 mm between the flange (10) and the valve housing (11).

24) Tighten the screws (2) on the support (3).

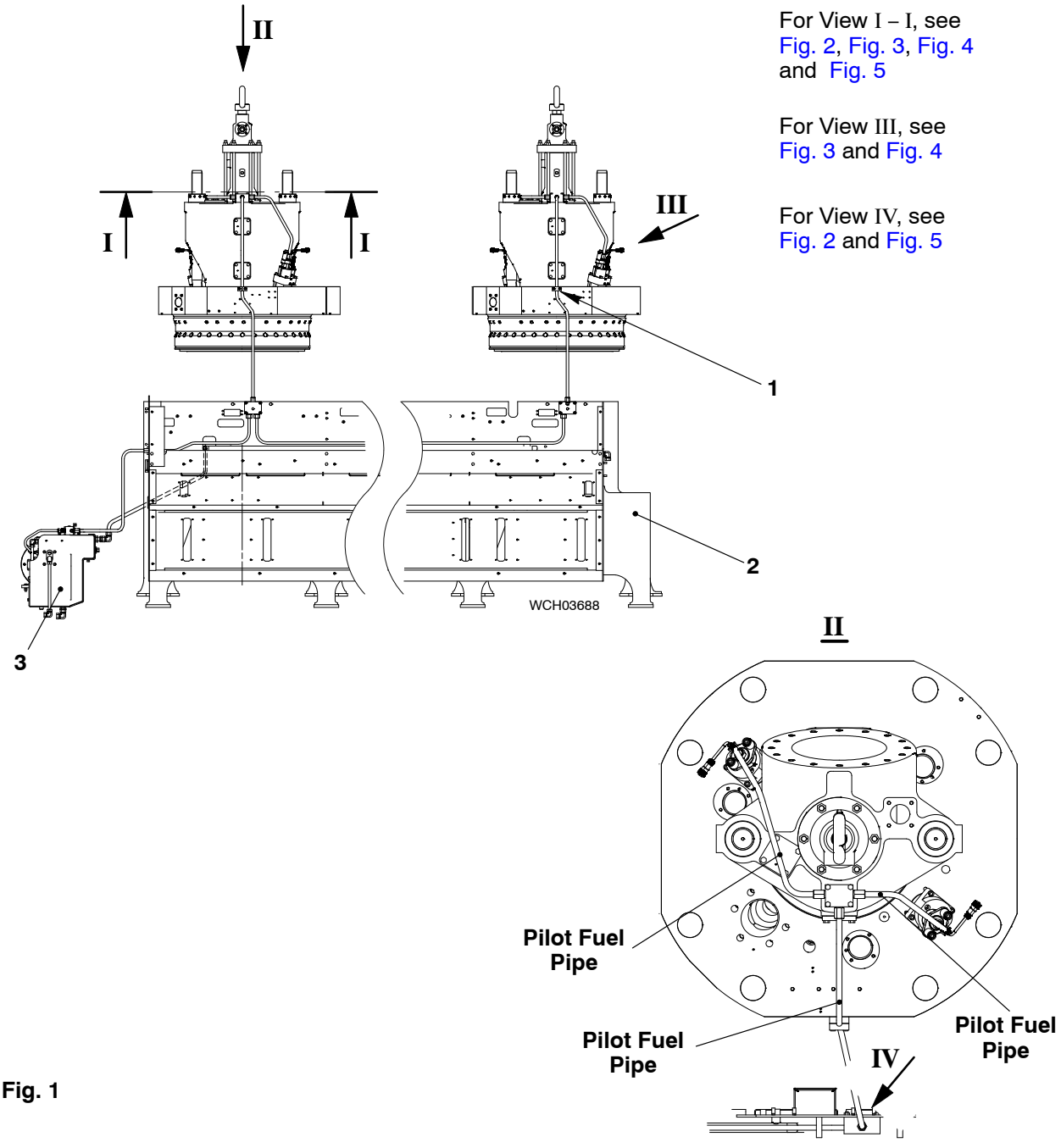
25) Make sure that there is a distance of 54.0 mm between the steel ring (4) and the slide ring (5).

5. Completion

1) If applicable, install the insulation (2, Fig. 1) to the HP fuel pipes (3).
2) Install the clamps (1).
3) If necessary, connect the trace heating pipes.
4) Set to on the trace heating.
5) Set to on the fuel supply pump.

HP Pipe – Pilot Fuel

Removal and Installation



For View I – I, see Fig. 2, Fig. 3, Fig. 4 and Fig. 5

For View III, see Fig. 3 and Fig. 4

For View IV, see Fig. 2 and Fig. 5

Fig. 1

1 Clamp
2 Rail unit
3 Pilot fuel supply unit

1. Preparation

WARNING

Injury Hazard: The pilot fuel system has high pressure. Replace a defective HP pilot fuel pipe only when the engine has stopped. You must obey the data given in the Operation Manual 0520-1.

WARNING

Injury Hazard: Always put on gloves and safety goggles when you do work on hot components. When screws and plugs are opened, steam or fuel can come out and cause injury.

CAUTION

Damage Hazard: Make sure that you do not cause damage the sealing faces or the HP pilot fuel pipes. Do not apply lateral force to the HP pilot fuel pipes and the flanges.

1) Stop the engine, refer to the Operation Manual 0310–1.
2) Set to off the fuel supply pump.
3) Make sure that the pilot fuel supply unit (3, Fig. 1) is set to off.

2. Removal

2.1 Pilot Fuel Pipe

1) Remove the pipe clip (1).
2) Put an oil tray under the applicable pilot fuel pipe (2, Fig. 2).
3) Loosen the coupling nut (1) a maximum of two turns.
4) Loosen the coupling nut (5) a maximum of three turns.

Note: Make sure that the fuel drains into the oil tray.

5) Fully loosen the coupling nuts (1, 5).
6) Carefully remove the HP pilot fuel pipe (3) from the distributor blocks (4, 6).
7) Remove and discard the O-rings (3, 7).
8) Attach protection to all openings and sealing faces to prevent contamination.
9) To remove the remaining pilot fuel pipes, refer to paragraph 2.2.

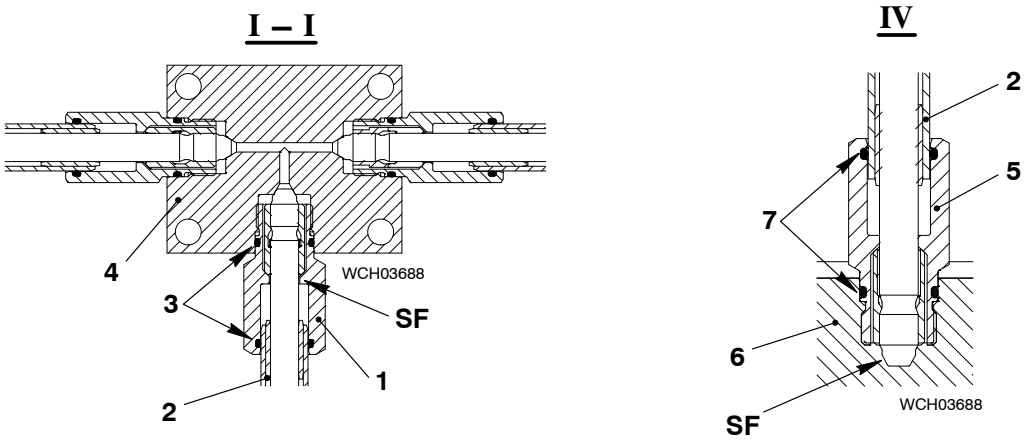


Fig. 2

2.2 Pilot Fuel Pipes

1) Put an oil tray under the applicable pilot fuel pipe (2, 5).
2) Loosen the coupling nut (1) a maximum of two turns.
3) Loosen the coupling nut (6) a maximum of three turns.

Note: Make sure that the fuel drains into the oil tray.

4) Fully loosen the coupling nuts (1, 6).
5) Carefully remove the HP pilot fuel pipe (2, 5) from the distributor block (3) and the pilot injection valve.
6) Remove and discard the O-rings (4, 7)
7) Attach protection to all openings and sealing faces to prevent contamination.

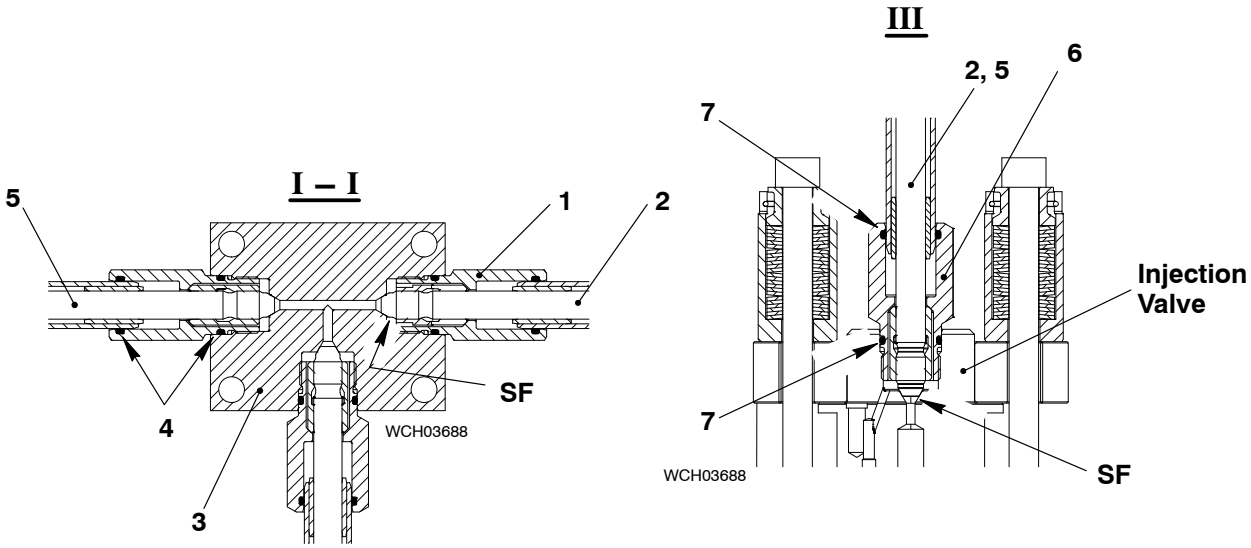


Fig. 3

3. Installation

3.1 Pilot Fuel Pipes

1) Remove all protection from the openings and sealing faces.
2) Do a check for damage of the sealing faces.
3) Put new O-rings (4, 7, Fig. 4) in position on the applicable pilot fuel pipe (2, 5).
4) Put the applicable pilot fuel pipe (2, 5) in position in the injection valve and the distributor block (3).
5) Make sure that the claws (8, 10) are correctly attached to the applicable pilot fuel pipe (2, 5).

Note: You can adjust the claws (8, 10) with an open-ended wrench.

6) Apply Never-Seez NSBT8 to the threads of the coupling nuts (1).
7) Make sure that there is a distance of 6.5 mm between the end of the pilot fuel pipe (2, 5) and the claws (8, 10).
8) Torque the coupling nuts (1, 9) to 30 Nm.

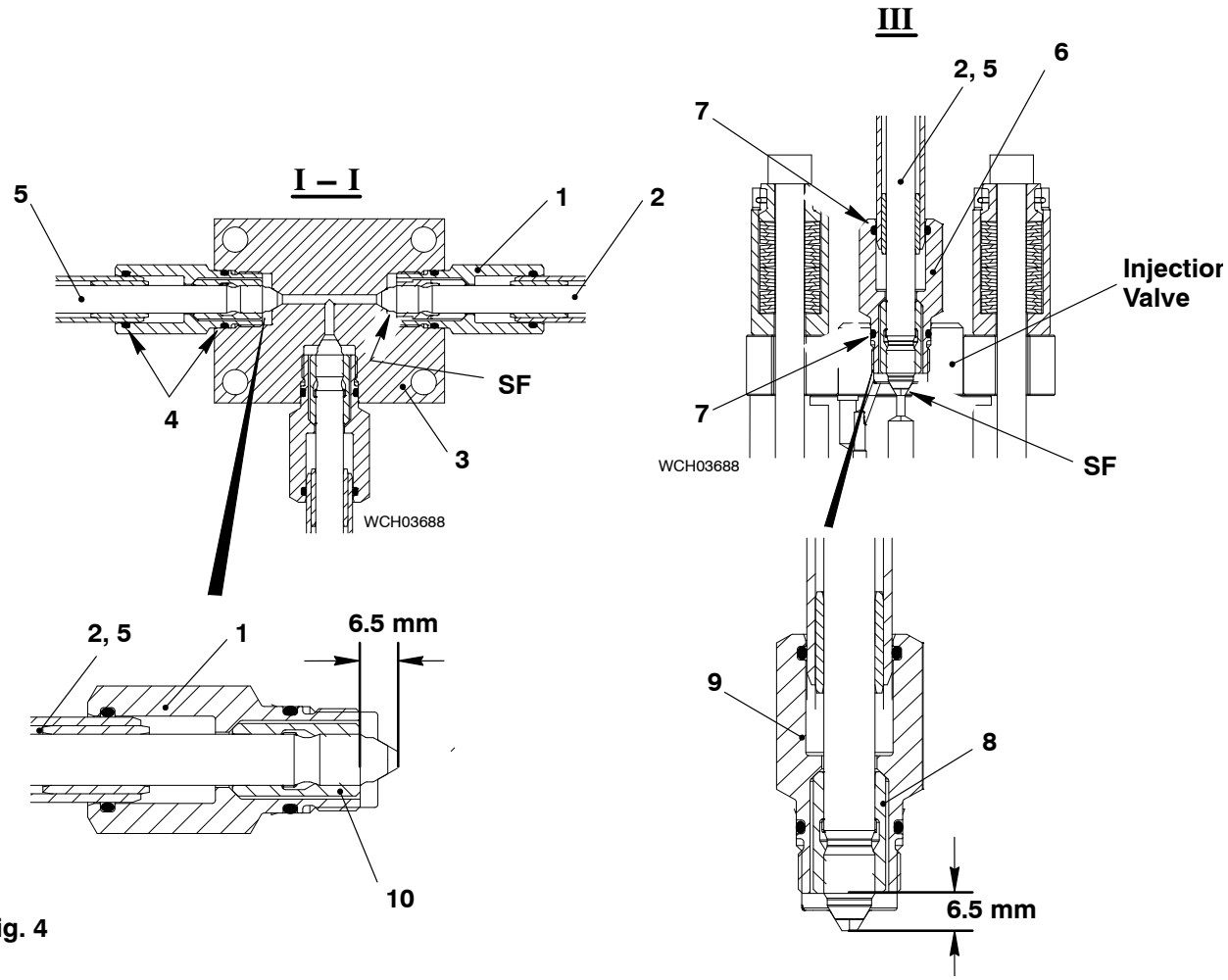


Fig. 4

3.2 Pilot Fuel Pipe

1) Remove all protection from the openings and sealing faces.
2) Do a check for damage of the sealing faces.
3) Put new O-rings (3 and 8, Fig. 5) in position on the pilot fuel pipe (2).
4) Put the pilot fuel pipe (2) in position in the injection valve and the distributor blocks (4, 7).
5) Make sure that the claws (5, 9) are correctly attached to the pilot fuel pipe (2).

Note: You can adjust the claws (5, 9) with an open-ended wrench.

6) Apply Never-Seez NSBT8 to the threads of the coupling nuts (1, 6).
7) Make sure that there is a distance of 6.5 mm between the end of the pilot fuel pipe (2) and the claws (5, 9).
8) Torque the coupling nuts (1, 6) to 30 Nm.
9) Attach the pipe clip (1, Fig. 1).

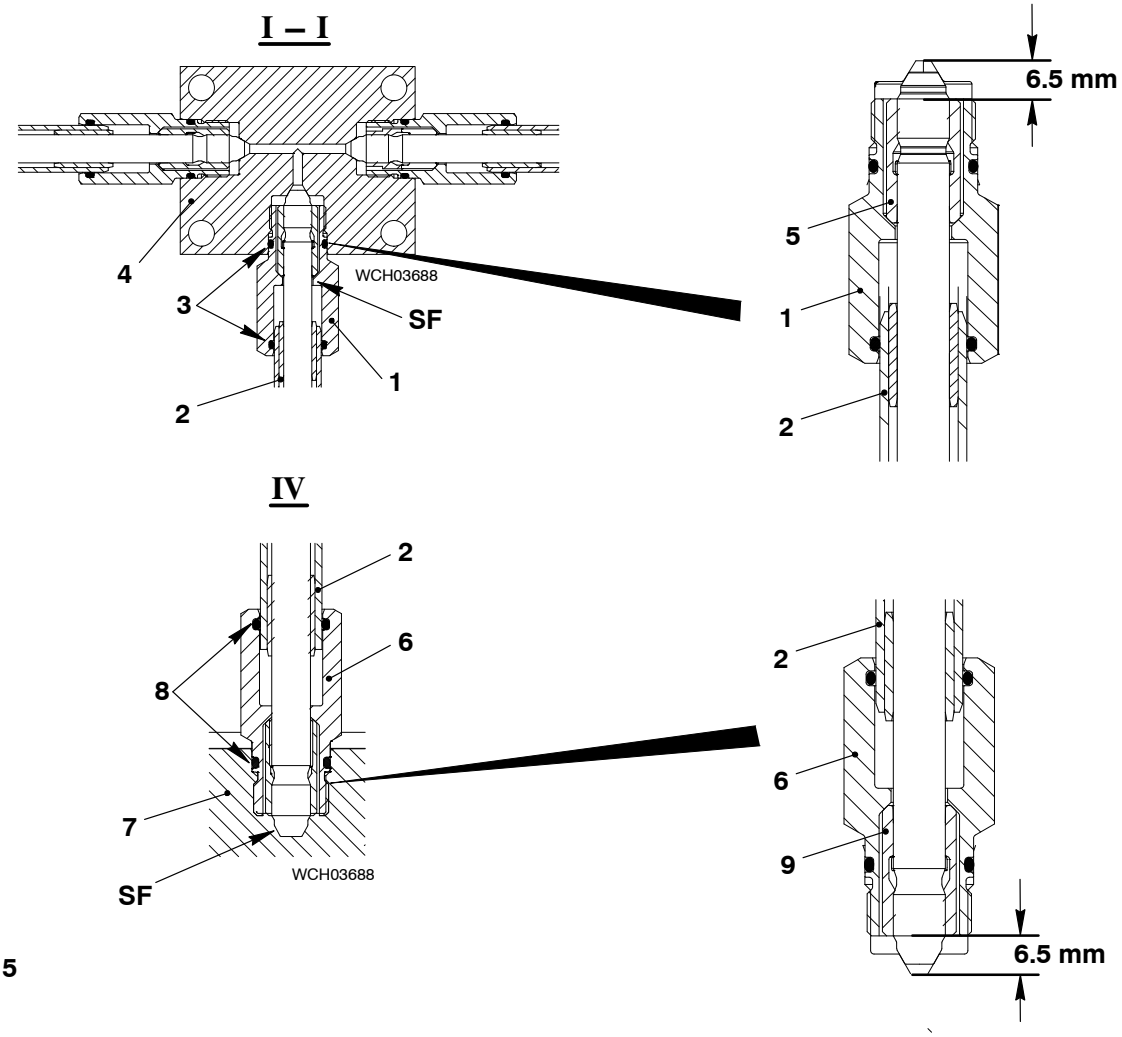


Fig. 5

4. Completion

1) Set to on the pilot fuel supply unit (3, Fig. 1).
2) Set to on the fuel supply pump.

Intentionally blank

Work Card
Gas Supply Pipe: Shut-off and Vent Valves

Necessary Conditions

– Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Tools and Consumables

Applicable tools

Primary Task

Do a check of the tightness of ball valves. Do a check of the shaft sealing

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Crew	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330–1/A1
Overhaul intervals	0380–1/A1
Component weights	0360–1/A1

Related Procedures

Intentionally blank

Crank Angle Sensor Unit, Tools — Group 9

Intentionally blank

Proximity Sensor – Replace

1. General

The crank angle sensor (CAS) unit (Fig. 1) is installed on the supply unit drive at the driving end. The CAS has four proximity sensors (ST5131–34C). There are two crank angle systems (for redundancy) that monitor the teeth on the intermediate wheel (1). The holder (2) is installed with screws to the cover (3) on the drive column.

Two more proximity sensors (ZS5123–34C) are used to find the crank angle marks on the flywheel (4) for TDC and BDC.

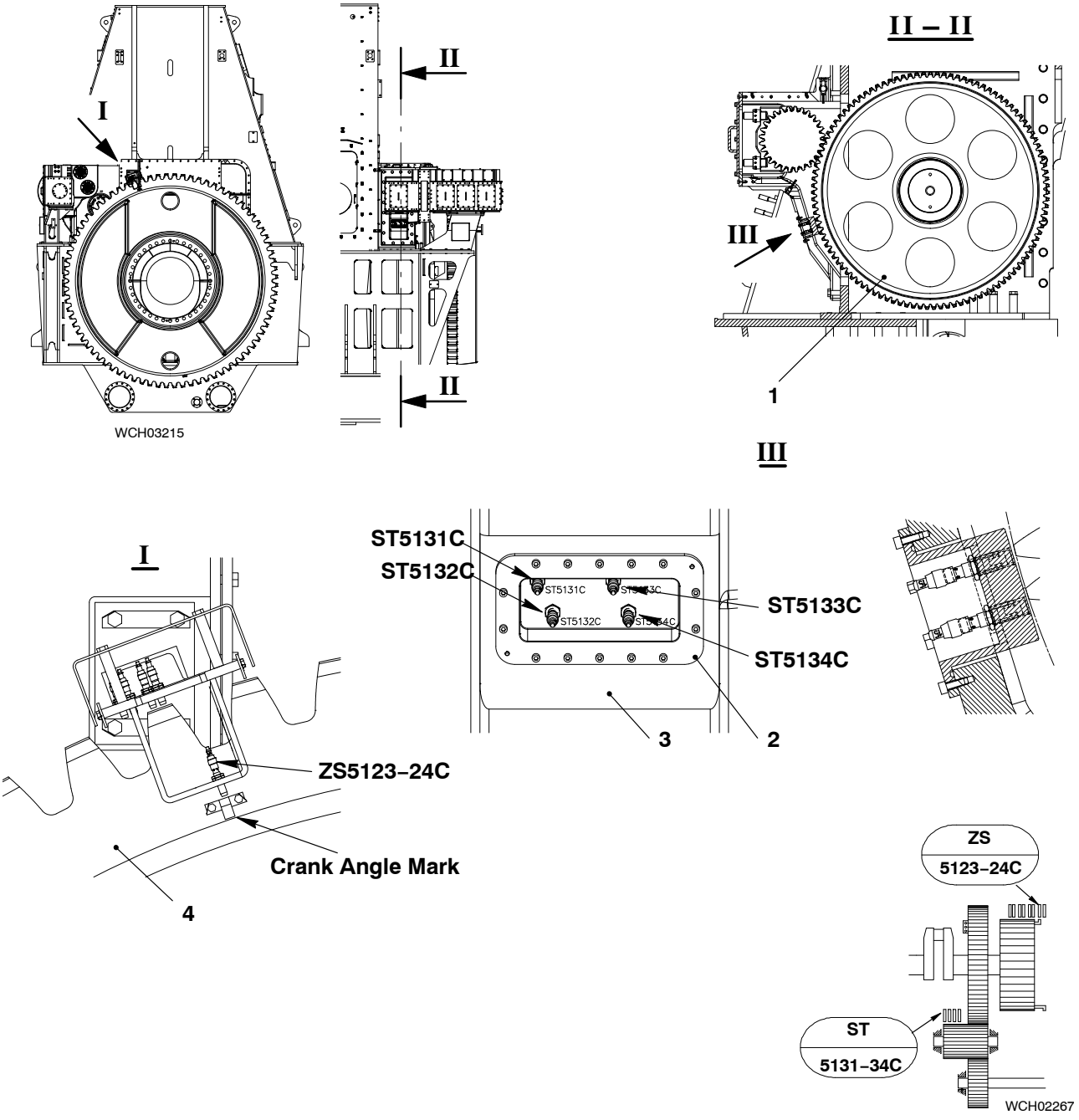


Fig. 1: Crank Angle Sensor Unit

2. Procedures

2.1 Proximity Sensors (ST5131–34C) – Replace

WARNING

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

1) Stop the engine.
2) Operate the turning gear to get a tooth (1, Fig. 2) of the intermediate wheel opposite the applicable proximity sensor (2).
3) Put a mark on the applicable cable to identify its position.
4) Disconnect the applicable electrical connection from the proximity sensor (2).
5) Loosen the locknut (4).
6) Remove the proximity sensor (2) from the holder (3).
7) Attach the new proximity sensor to the holder (3).
8) Turn the proximity sensor (2) fully down until the tip of the proximity sensor (2) touches the holder (3).

Note: During installation/commissioning the clearance between the flywheel tooth (1) and the holder (3) is set to 2.0 mm.

Note: The wall thickness of the holder (3) is 1.5 mm.

9) Loosen the proximity sensor (2) a half turn to get a clearance of 4.0 mm between the flywheel tooth (1) and the bottom face of the proximity sensor (2).
10) Carefully tighten the locknut (4) with your fingers.
11) Connect the electrical connection to the proximity sensor (2). Refer to the mark made before to identify the correct cable.

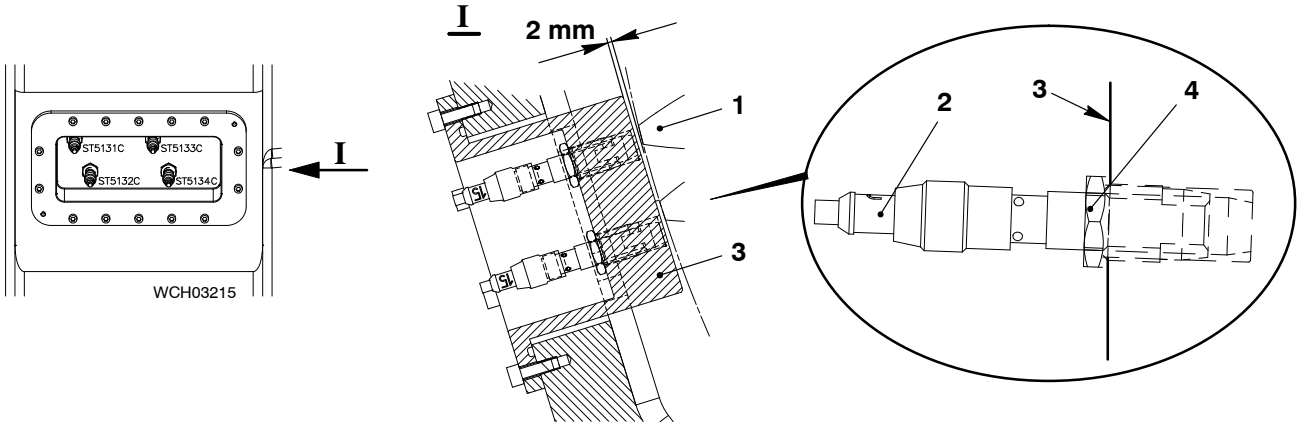


Fig. 2

2.2 Proximity Sensors (ZS5123C–24C) – Replace

WARNING

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

1) Stop the engine.
2) Operate the turning gear to get the applicable crank angle mark (2, Fig. 3) on the flywheel wheel opposite the unserviceable proximity sensor.
3) Put a mark on the applicable cable to identify its position.
4) Loosen the locknut (1).
5) Remove the proximity sensor (4) from the holder (3).
6) Attach the new proximity sensor to the holder (3).
7) Make sure that the proximity sensor (4) touches the applicable crank angle mark (2).
8) Loosen the proximity sensor (4) until you get a clearance of 4.0 mm between the crank angle mark and the bottom face of the proximity sensor.
9) Carefully tighten the locknut (1) with your fingers.
10) Connect the electrical connection to the proximity sensor (4). Refer to the mark made before to identify the correct connection.

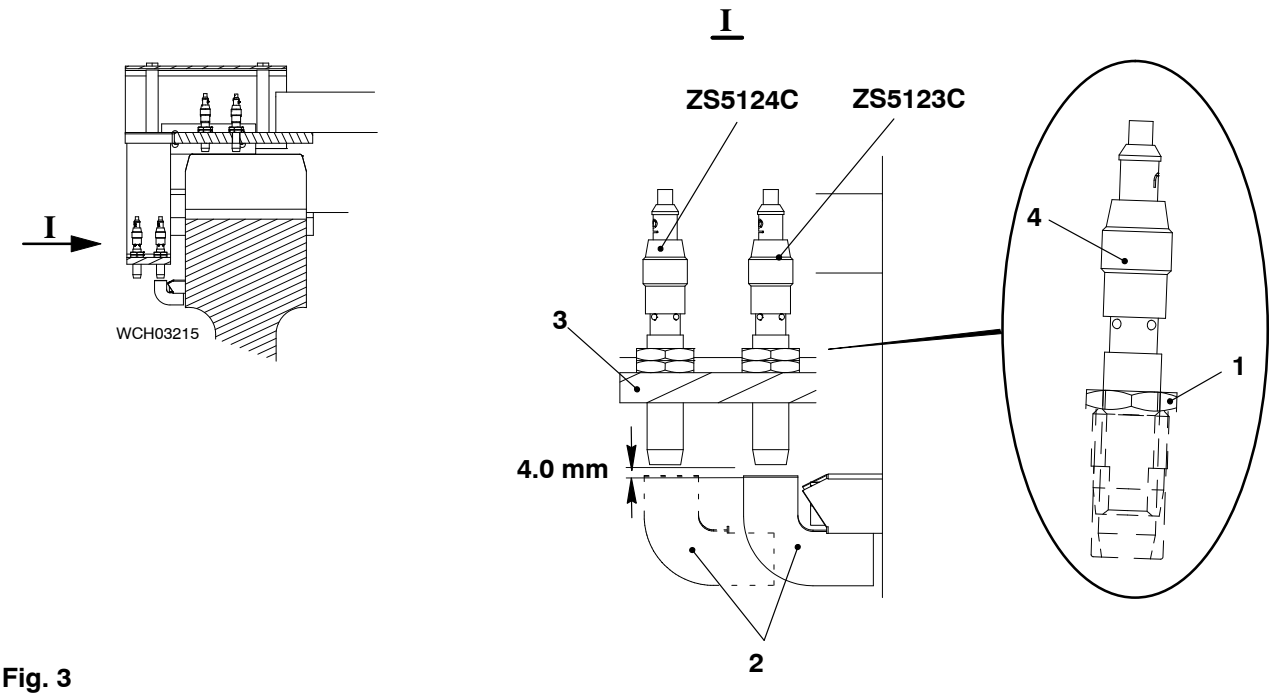


Fig. 3

For the function of the Crank Angle Sensor Unit, read the data in the Operation Manual, 4002–1 paragraph 4.6.

For the Inspection and Overhaul Intervals refer to Maintenance Schedule 0380–1, Crank Angle Sensor Unit.

Intentionally blank

Cylinder Pressure Sensor

Replacement of Cylinder Pressure Sensor

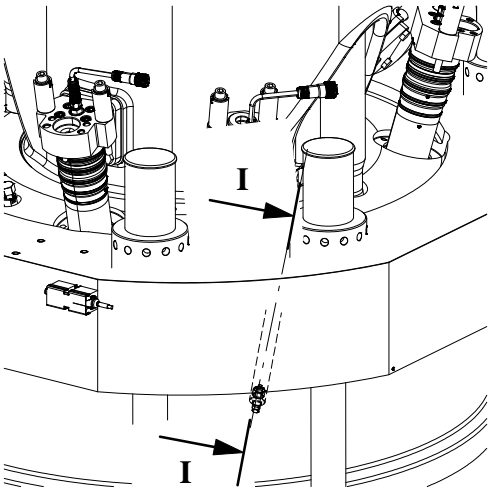
Tools:

1 Disassembly and assembly tool 94022H

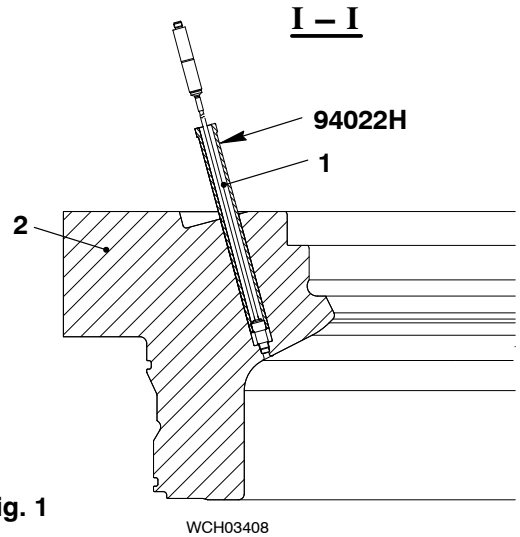
1. General

For data about cylinder pressure balancing control, refer to the Operation Manual 4002-1, paragraph 3.10.

For the signal failure list, refer to the Operation Manual, 4002-2, chapter 3.25.



WCH03692



WCH03408

Fig. 1

2. Replace

1) Make sure that there is no pressure in cylinder cover (2).
2) Disconnect the electrical cable from the pressure sensor (1) PT3601.
3) Attach the tool (94022H) to the casing of the pressure sensor (1).
4) Carefully remove the pressure sensor (1).
5) Put the pressure sensor in a clean dry area.
6) Apply a thin layer of oil to the thread of the pressure sensor (1).
7) Attach the tool (94022H) to the pressure sensor (1).
8) Install fully the new pressure sensor (1).
9) Torque the pressure sensor (1) to 25± 5Nm.
10) Lock the sensor with the locknut.
11) Connect the electrical connector to the pressure sensor (1).
12) Do a check of the pressure sensor as follows:
    a) On the Local Control Panel, get the signal failure list.
    b) Make sure that the pressure sensor PT3601–0n appears.

Note: n = cylinder number (e.g. PT3601–08 is cylinder number eight).

Intentionally blank

Work Card
Engine Control System: Replace the Modules

Necessary Conditions

− Engine stopped

Necessary Spare Parts (each cylinder)

Not applicable

Preparation

Set to off the control system
Disconnect the applicable power supplies to defective items

Tools and Consumables

Applicable tools

Primary Task

Replace the modules: CCM−20, MCM−11 and LDU−20, refer to the Operation Manual 4002−4.

Time and Personnel necessary for Primary Task (estimate), without Necessary Conditions and Preparation

Ship Engineer	2.0 hours	Qty 1
Service Engineer	2.0 hours	Qty 1

Related Data

Tolerances and Clearances	0330−1/A1
Overhaul intervals	0380−1/A1
Component weights	0360−1/A1

Related Procedures

Intentionally blank

Description of Tool Categories

1. General

The tools necessary for the maintenance of the engine are divided into three groups:

- Standard Tools
- Recommended Special Tools
- Special tools available on loan.

When it becomes necessary to order more tools or replacements, the tool number and the tool description, which must include the engine type, must be shown (refer to 9403–5).

The instructions on the configuration and application, overview, storage, servicing and maintenance of the hydraulic pre-tensioning jacks are given in 9403–2, 9403–3 and 9403–4.

A set of tools is supplied for important components from sub-suppliers, which must be isolated from the engine tools.

Note: Some tools have special screws and/or devices that must be kept together. Thus, tapped holes are bored into these tools. The screws and/or devices must always be kept at the correct storage positions on the tools when they are not in use.

2. Standard Tools

These tools and devices are necessary for usual maintenance on the engine.

Some of these tools and devices given in the references above are not necessary for some engine designs. Thus, are not part of the engine tools supply.

3. Recommended Special Tools

These tools and devices let you do specified maintenance more easily, and in a shorter time, than with the standard tools.

You can make an order for these tools with the engine, or after the engine is supplied.

4. Special Tools Available On Loan

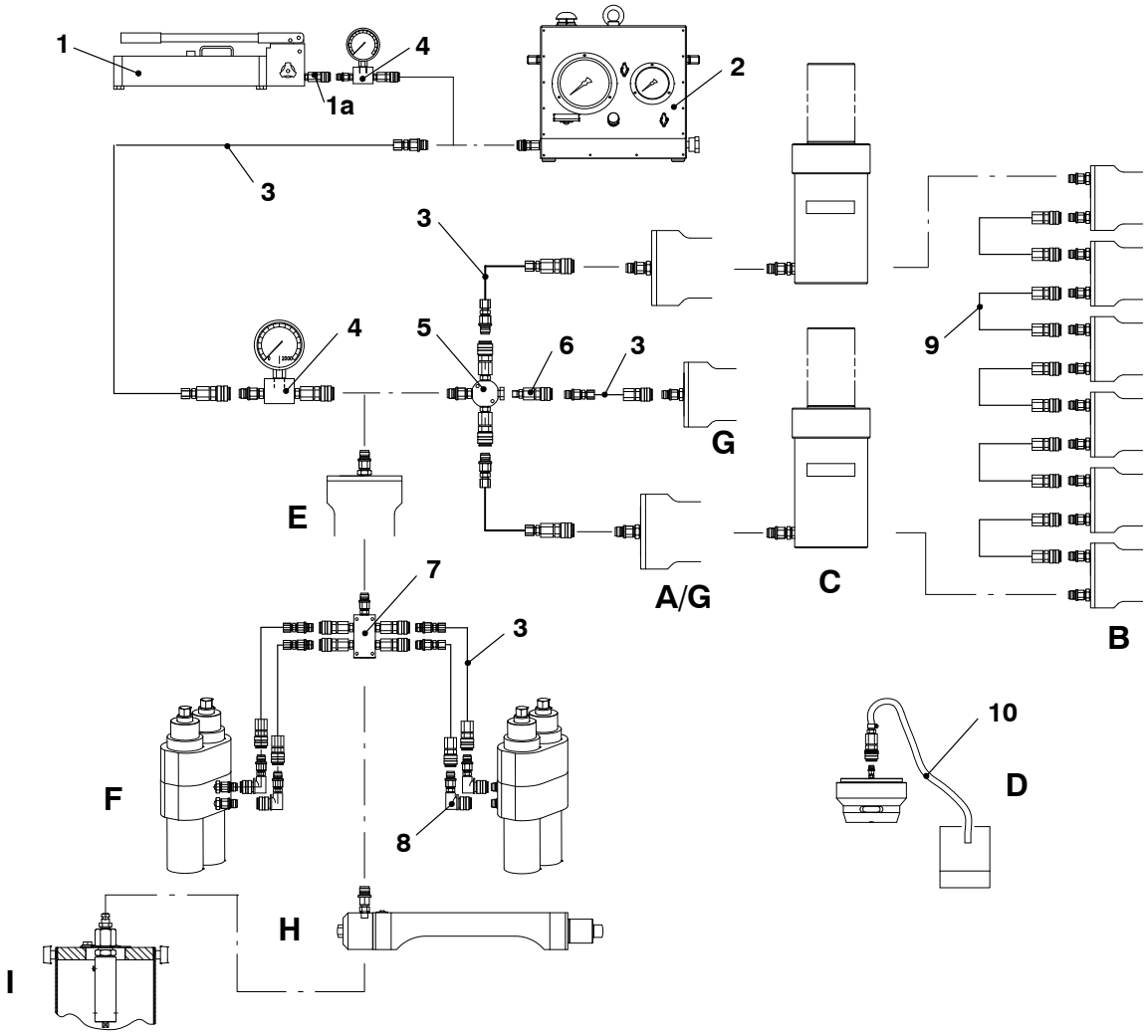
These are tools and devices that are loaned for the movement and for assembly of the engine. The tools are to be given back to the engine manufacturer after the engine assembly is completed.

Intentionally blank

Configuration and Application

Tools:

1	HP oil Pump, 2800 bar	94931	6	Adapter piece	94934F
1a	Adapter piece	94934F	7	Distributing piece	94934C
2	Hydraulic unit, 2000 bar	94942	8	Coupling element	94934G
3	HP hose	94935	9	Flexible hose	94935A
4	Pressure gauge	94934A	10	Oil pipe drain	94935C
5	Connection block	94934			



A For tie rods (jack: 94180), elastic studs to exhaust valve cages and bottom connection rod bolts (94252), top connection rod bolts (94315) and elastic studs on supply unit (94557)

B For elastic studs to cylinder cover (94215A)

C To lift the crankshaft for removal and installation of main bearing shells (94936)

D Oil drain after use of pre-tensioning jacks

E For foundation bolts (94145), turning gear (94320) and for supply unit lifting tool (94430A)

F For elastic studs to main bearing (94114)

G For elastic studs to piston, piston rod and crosshead (94340)

H Thrust device for main bearing cover (94110)

I For checks and setting of fuel overpressure safety valve

Intentionally blank

Storage, Servicing and Maintenance

1. General

The hydraulic pre-tensioning jacks must be kept in their tool boxes when not in use. After you use the pre-tensioning jacks, close the connections with plugs and apply grease. We recommend that, for each jack, you keep a sealing kit (KJ–) in stock.

Always make sure that new back-up rings and O-rings are installed in their correct positions, as shown in the data that follows.

Note: Carefully install new back-up rings and O-rings to prevent damage. Do not use tools that have sharp edges.

Back-up rings that are not cut, must be put into hot water before you install them.

1.1 Dimensions of Back-up Rings and O-rings

Tool No.	Position of application of pre-tensioning jack	Part	Back-up Ring (uncut)	O-ring
			Dimension (mm)	
			o∅ x i∅ x t	i∅ x s
94110	Thrust device for main bearing cover	piston cylinder	94 x 84.6 x 1.7 60.2 x 54 x 1.4	81.92 x 5.33 53.57 x 3.53
94114	Elastic bolts to main bearing	piston cylinder	136 x 123.8 x 2.5 99.4 x 90 x 1.7	123.19 x 6.99 91.44 x 5.33
94145	Foundation bolts and engine stays	piston cylinder	123 x 113.6 x 1.7 102 x 93 x 1.7	113.67 x 5.33 91.44 x 5.33
94180	Tie rods	piston cylinder	230 x 217.8 x 2.5 158.2 x 146 x 2.5	215.27 x 6.99 145.42 x 6.99
94215A	Elastic bolts to cylinder cover	piston cylinder	196 x 183.8 x 2.5 126.4 x 117 x 1.7	183.52 x 6.99 116.84 x 5.33
94252	Elastic bolts to exhaust valve cage and bottom connecting rod studs	piston cylinder	175 x 162.8 x 2.5 121.4 x 112 x 1.7	158.12 x 6.99 110.49 x 5.33
94315	Elastic bolts to top connecting rod bearing	piston cylinder	113 x 103.6 x 1.7 81.2 x 75 x 1.4	100.97 x 5.33 75.79 x 3.53
94320	Turning gear	piston cylinder	104.5 x 95.1 x 1.7 74.2 x 68 x 1.4	97.79 x 5.33 72.62 x 3.53
94340	Piston, piston rod and crosshead	piston cylinder	62 x 55.8 x 1.4 50.2 x 44 x 1.4	53.57 x 3.53 44.04 x 3.53
94430A	Roller lifting tool – supply unit	piston cylinder	87 x 77.6 x 1.7 60.2 x 54 x 1.4	75.57 x 5.33 53.57 x 3.53
94557	Elastic studs on supply unit	piston cylinder	86 x 76.6 x 1.7 66.2 x 60 x 1.4	75.57 x 5.33 59.92 x 3.53

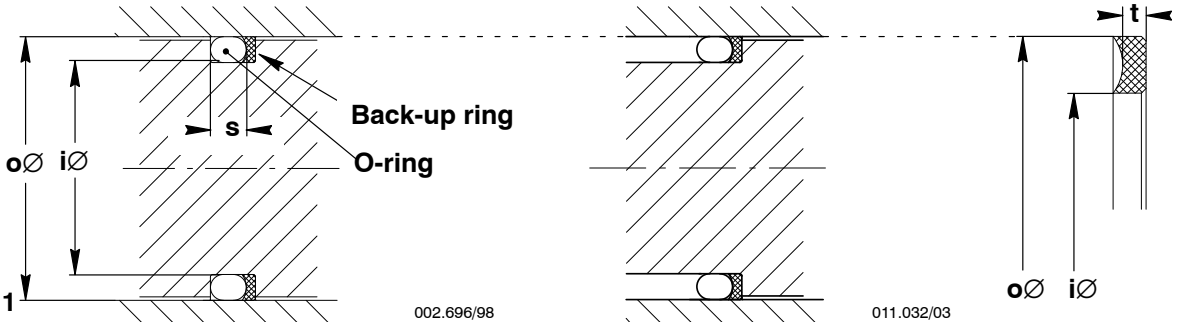


Fig. 1

2. Pre-tensioning Jacks

Tool 94110 Thrust Device for Main Bearing Cover

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

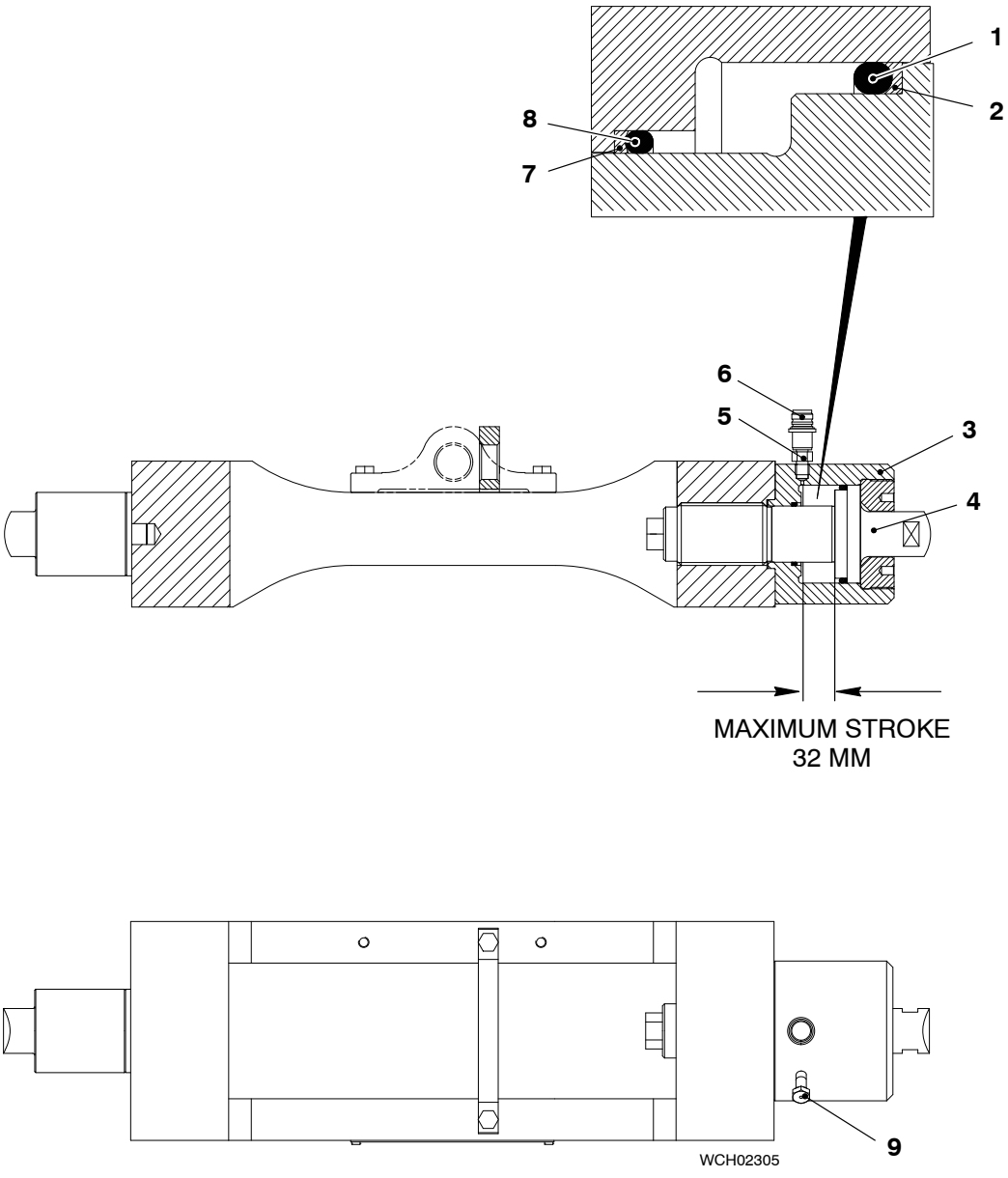


Fig. 2

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

1 Double cylinder
2 Adapter piece
3 Closing valve
4 Vent screw
5 O-ring
6 Back-up ring
7 O-ring
8 Back-up ring
9 Backing bush
10 Tension sleeve
11 Piston
12 Round nut

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

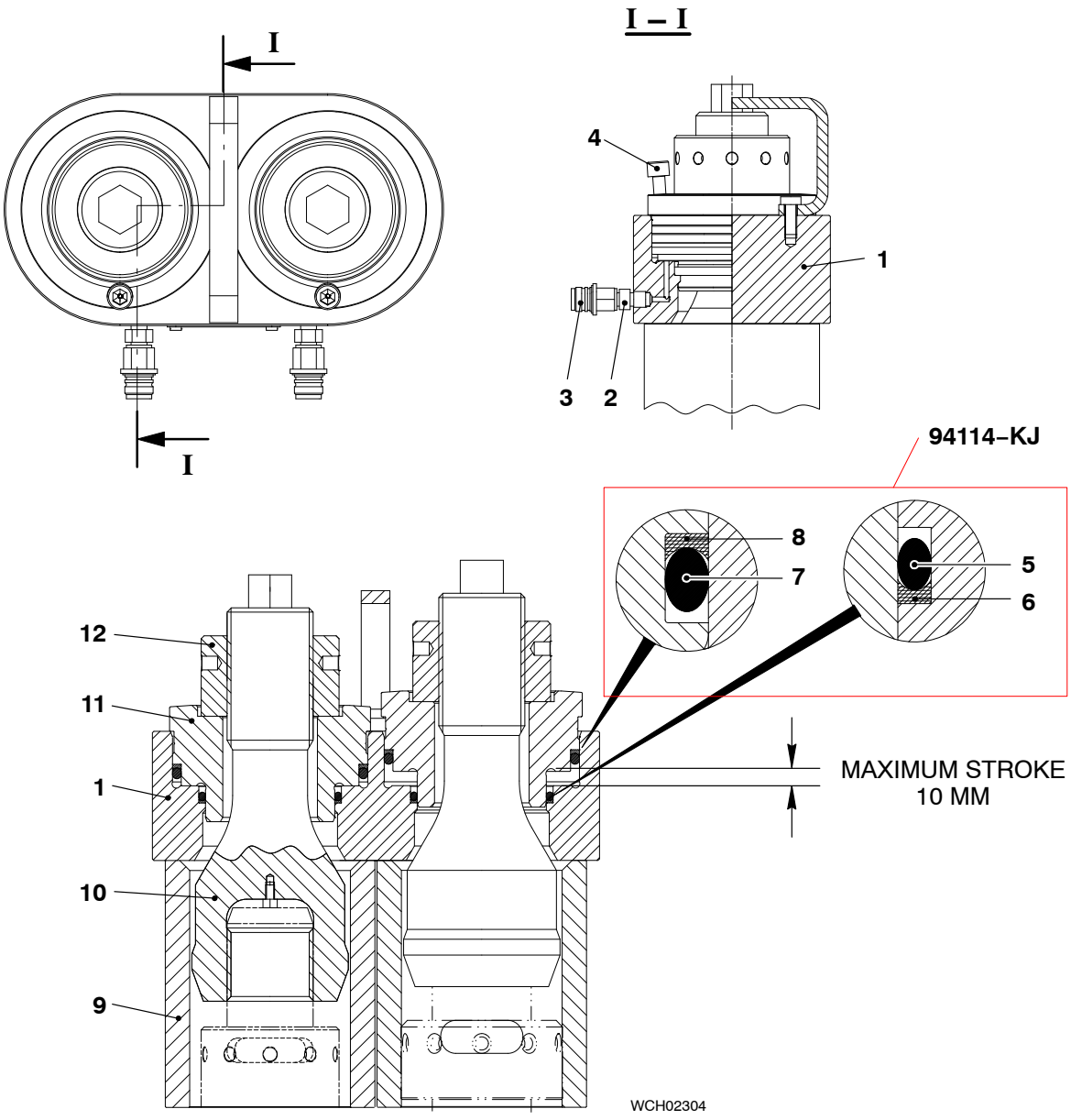


Fig. 3

Tool 94145 **Pre-tensioning jack for foundation bolts and engine stays**

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

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

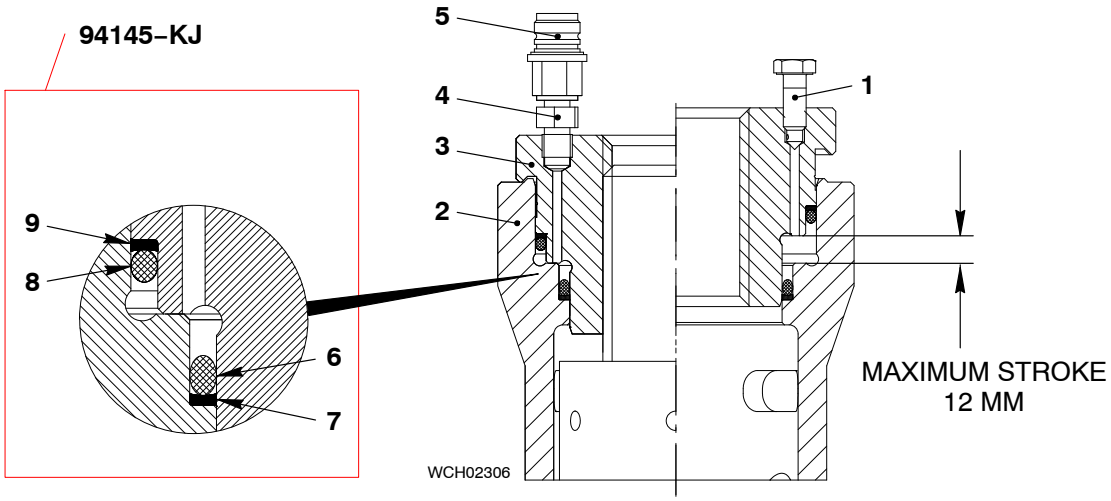


Fig. 4

Tool 94180 Pre-tensioning jack for tie rods

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

94180–KJ Kit with back-up rings and O-rings for double pre-tensioning jack

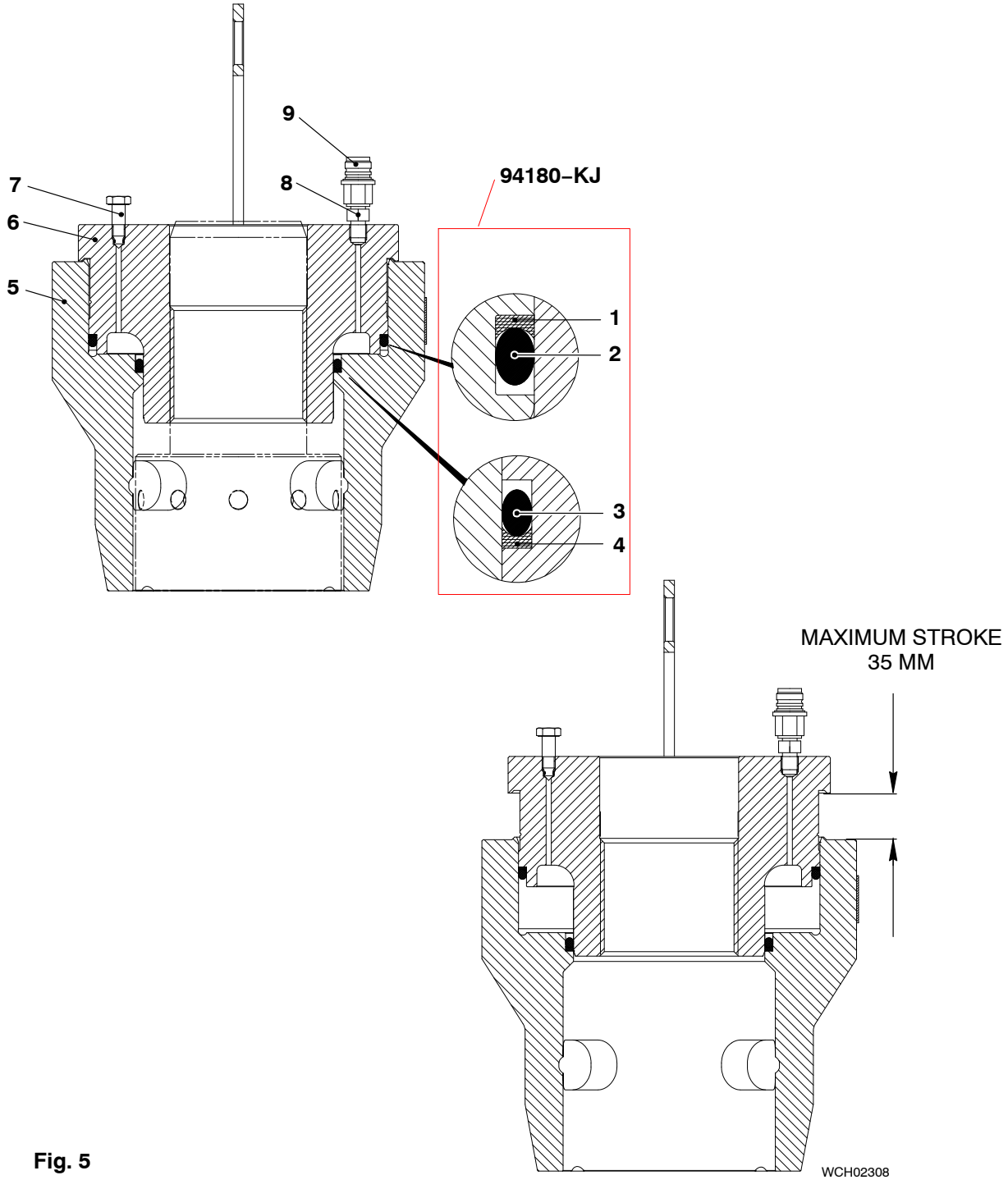
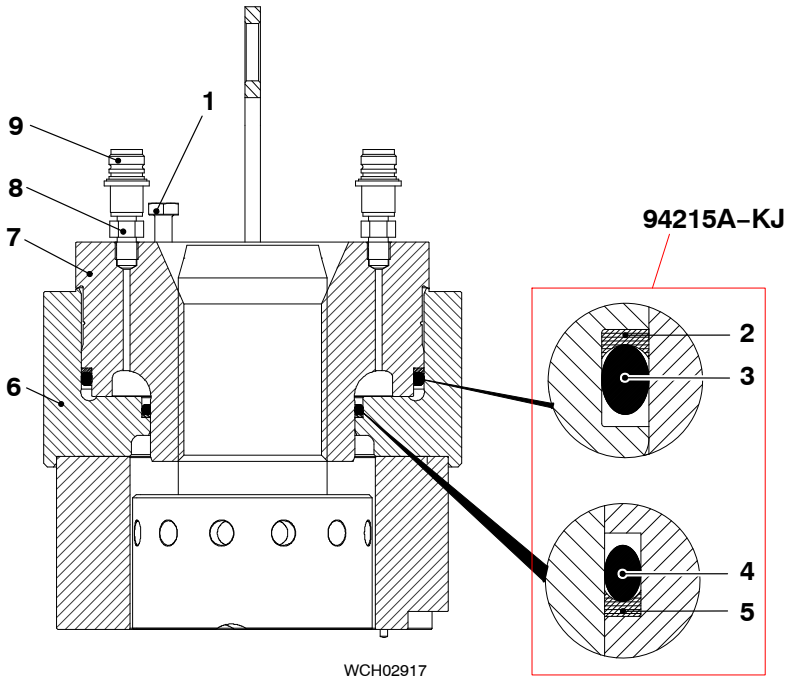


Fig. 5

Tool 94215A Pre-tensioning jack for elastic bolts to cylinder cover

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

94215A–KJ Kit with back-up rings and O-rings for pre-tensioning jack



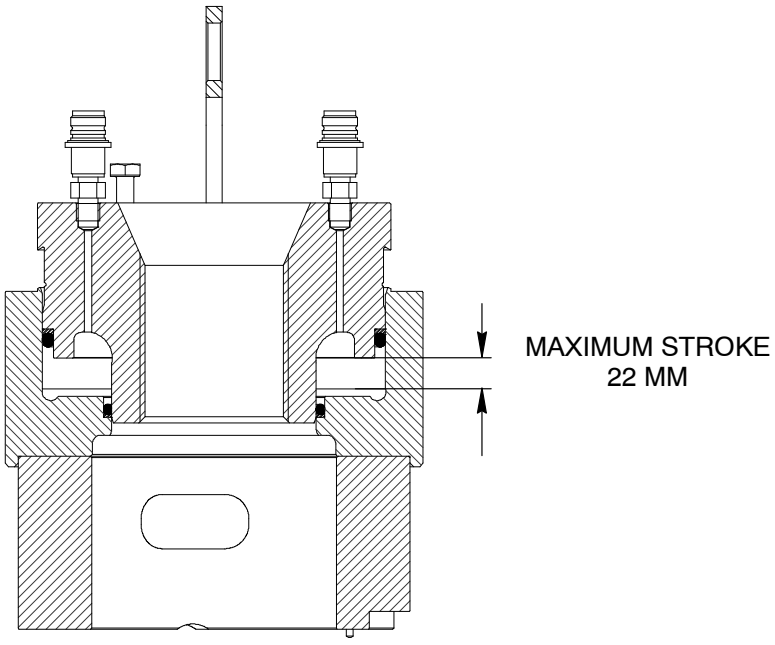


Fig. 6

Tool 94252 **Pre-tensioning jack for elastic bolts to exhaust valve cage and bottom connecting rod studs**

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

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

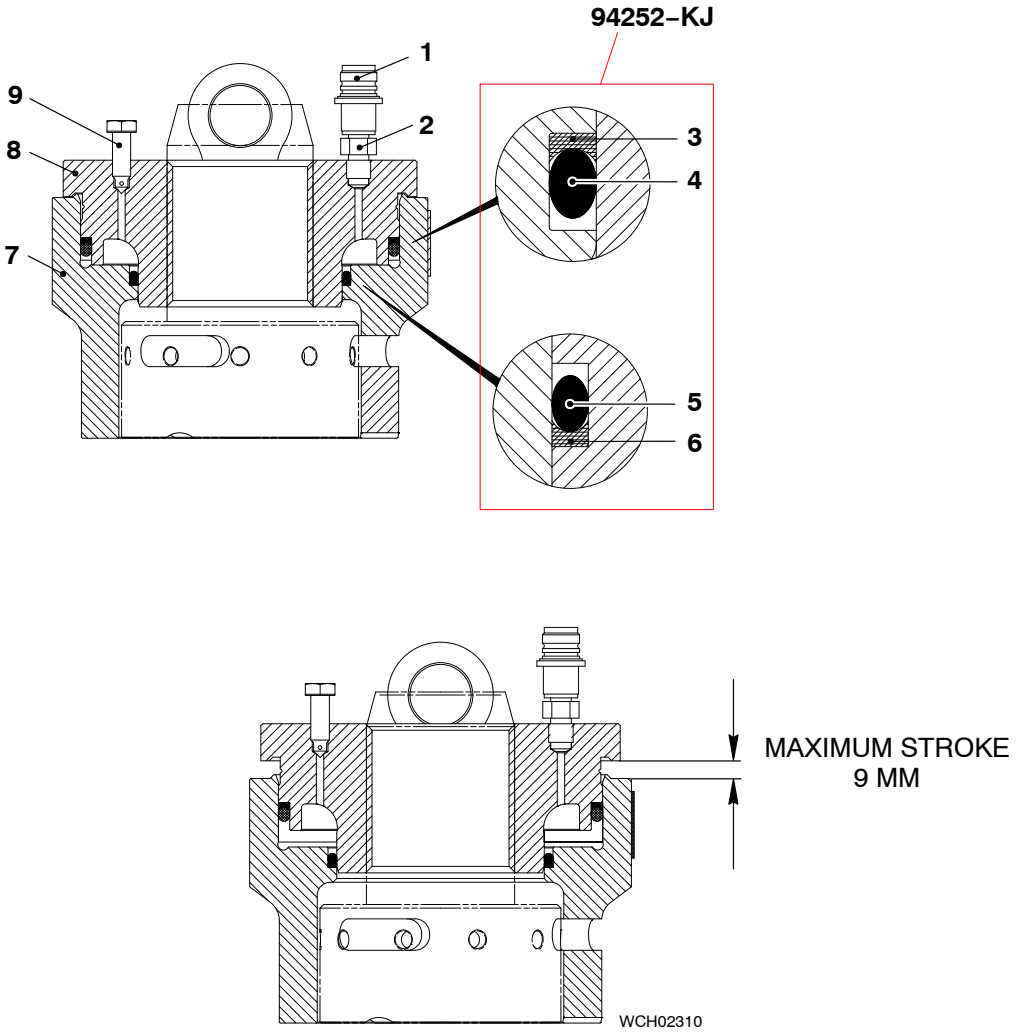


Fig. 7

Tool 94315 **Pre-tensioning jacks for elastic bolts to top connecting rod bearing**

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

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

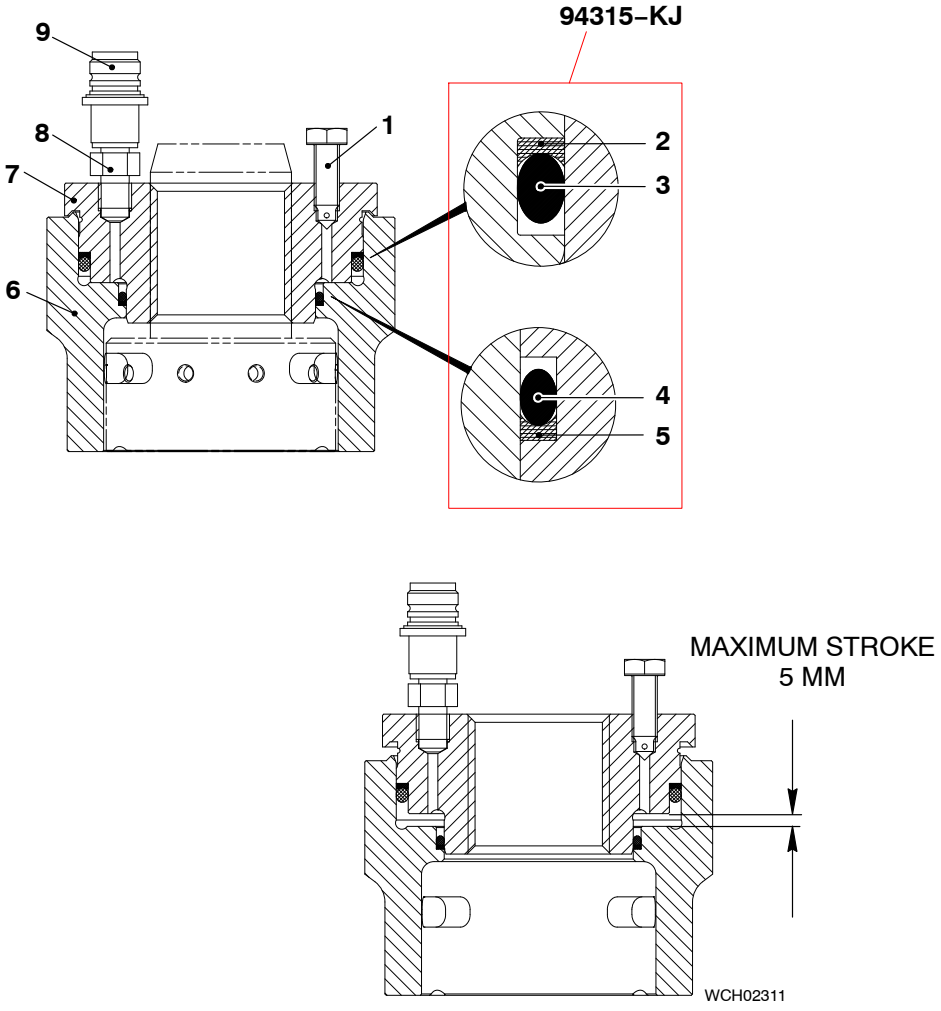


Fig. 8

Tool 94320 Pre-tensioning jacks for elastic bolts to turning gear

1 Closing valve
2 Gasket
3 Back-up ring
4 O-ring
5 O-ring
6 Back-up ring
7 Cylinder
8 Piston
9 Vent screw

94320–KJ Kit with back-up rings and O-rings for pre-tensioning jack

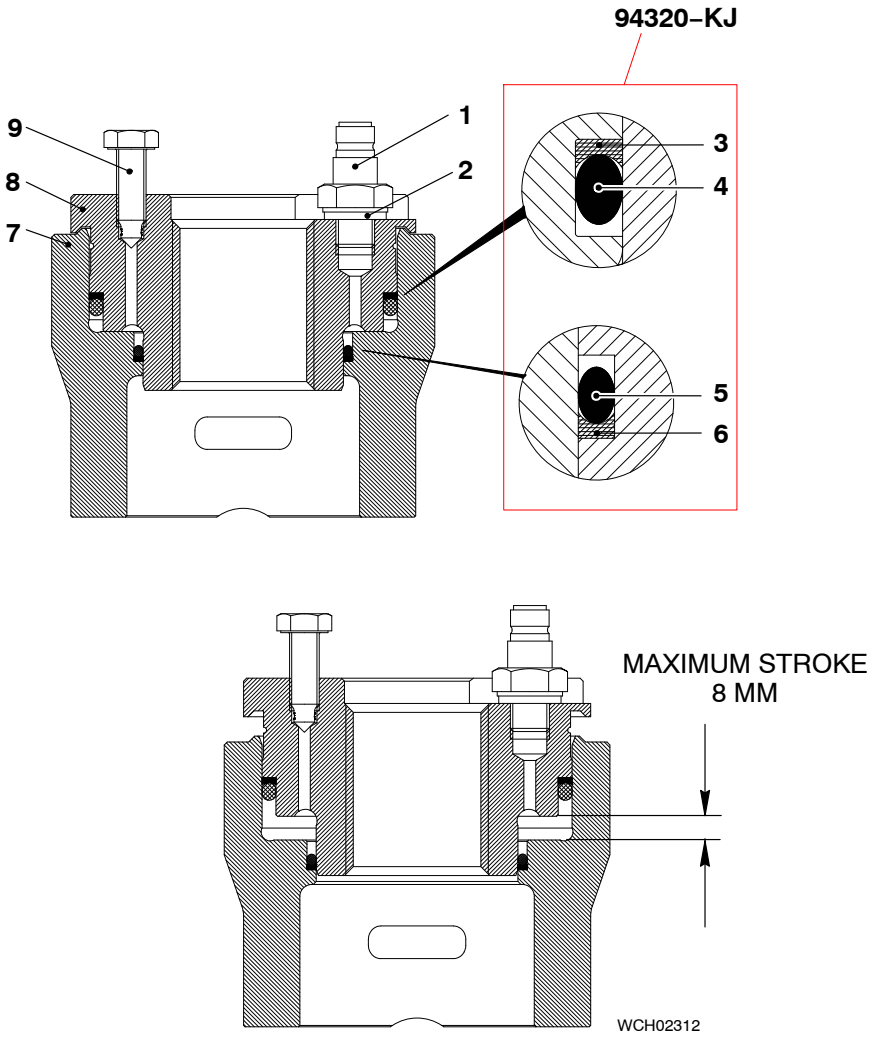


Fig. 9

Tool 94340 **Pre-tensioning jack for piston and piston rod foot to crosshead**

1 Closing valve
2 Adapter Piece
3 Back-up ring
4 O-ring
5 O-ring
6 Back-up ring
7 Cylinder
8 Piston
9 Vent screw

94340–KJ Kit with back-up rings and O-rings for pre-tensioning jack

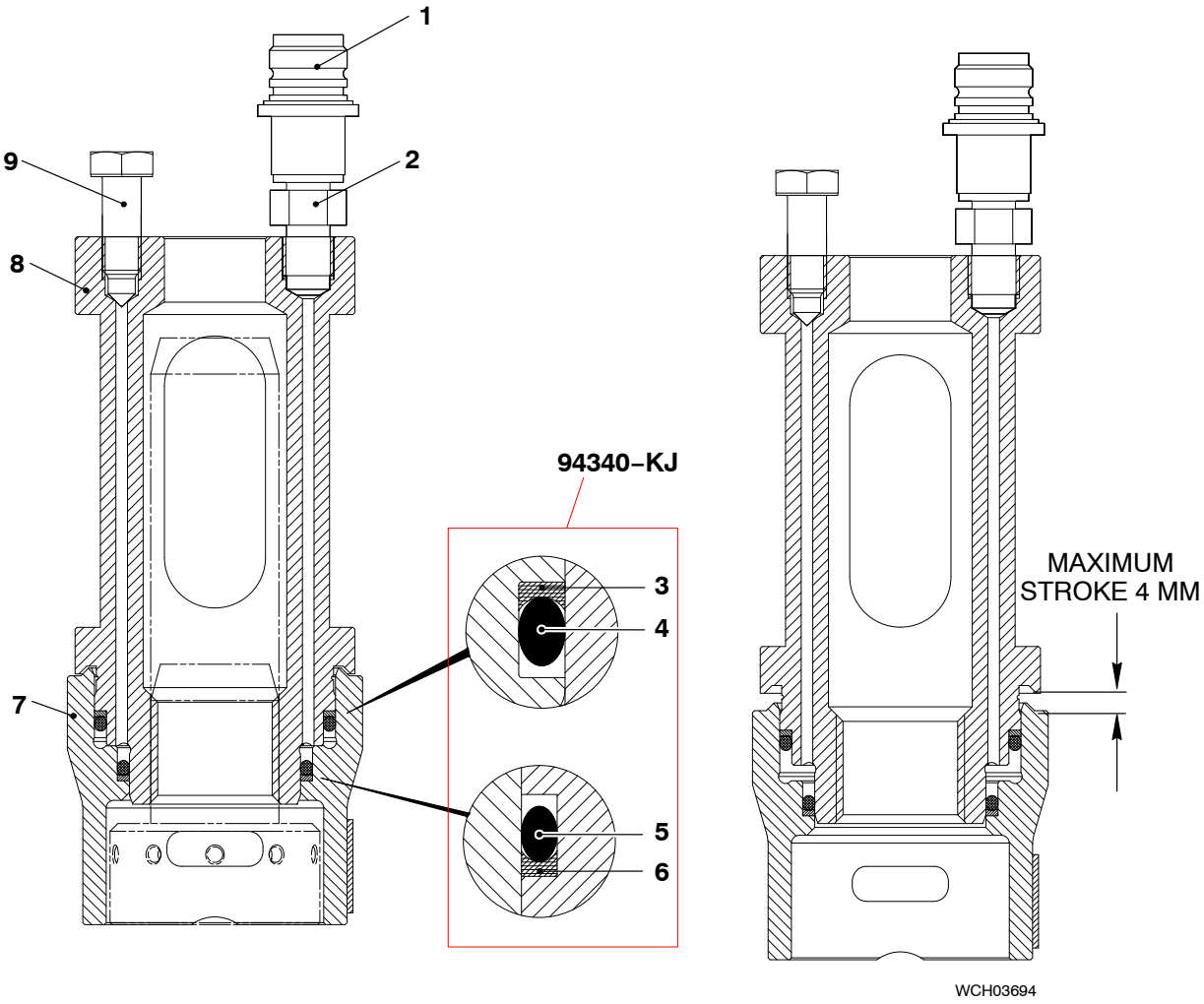


Fig. 10

Tool 94430A Pre-tensioning jack for roller lifting tool (supply unit)

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

94430A–KJ Kit with back-up rings and O-rings for pre-tensioning jack

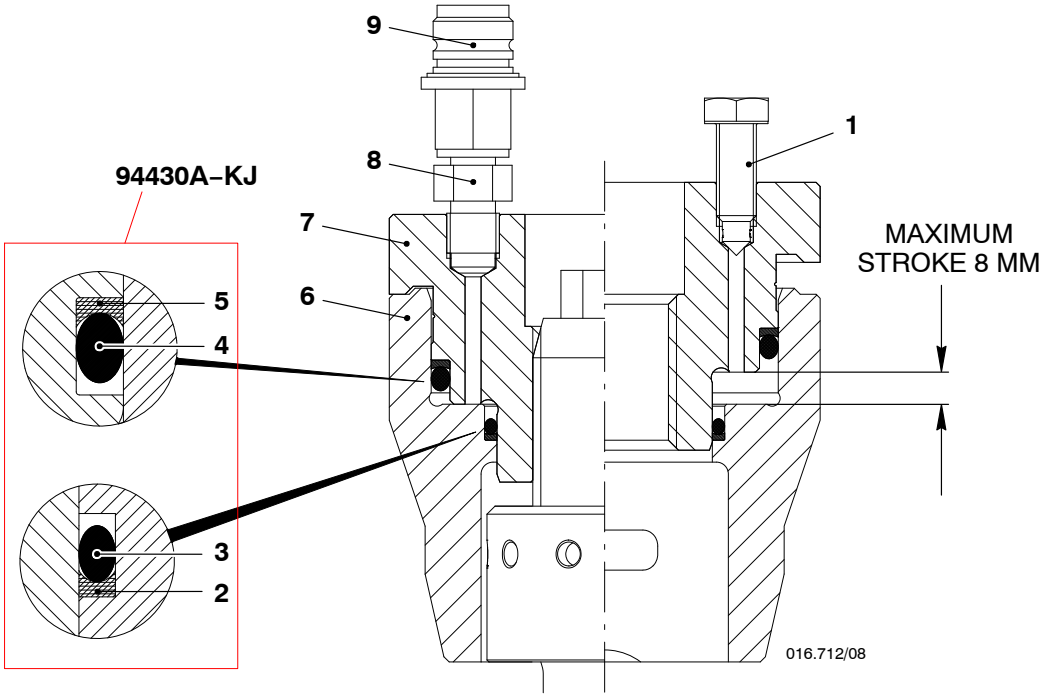


Fig. 11

Tool 94557 **Pre-tensioning jacks for elastic bolts to top end bearing (supply unit)**

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

94557–KJ Kit with back-up rings and O-rings for pre-tensioning jack

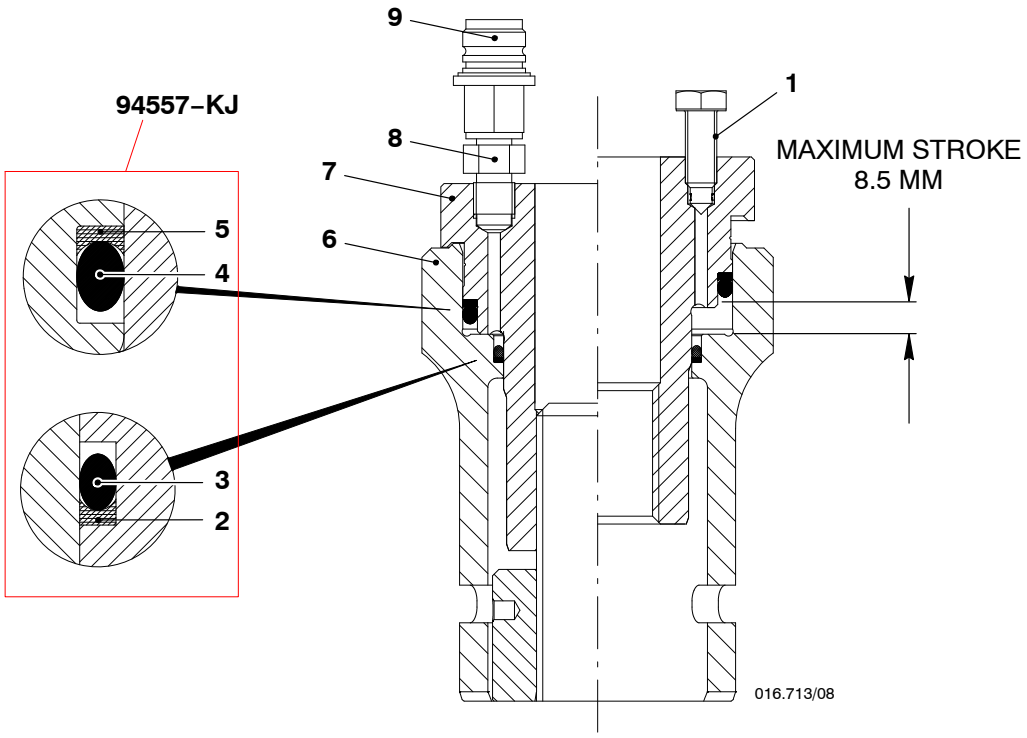


Fig. 12

General Instructions

Hydraulic pre-tensioning jacks for:

Version 1:		**Version 2:**	
Foundation bolt and engine stay	94145	Main bearing	94114
Tie rod	94180		
Cylinder cover	94215A		
Exhaust valve cage and bottom connecting rod studs	94252		
Top end bearing	94315		
Turning gear	94320		
Piston, piston rod foot	94340		
Roller lifting tool (fuel pump)	94430A		
Supply unit (fuel pump unit)	94557		

1. General

WARNING

Injury Hazard: Hydraulic tools can cause injury to personnel. Always put on gloves, a face shield and safety goggles when you do work with hydraulic tools.

There are two versions of hydraulic jack preparation:

- Version 1 – the piston (2) is attached directly on to the elastic bolt / elastic stud (5, Fig. 1).
- Version 2 – the nut (3, Fig. 2) is used to apply tension to the elastic bolt / elastic stud.

1) Make sure that the threads of elastic bolts and hydraulic jacks are smooth and clean.

2) Make sure that you add lubricant to the elastic bolts and hydraulic jacks, refer to 0352-1.

3) Connect the hydraulic components to the hydraulic jacks, refer to 9403–2.

4) Fully tighten the high pressure (HP) hoses to make sure that the built-in non-return valves can operate.

5) Do a check of the oil in the HP oil pump or hydraulic unit.

6) When you must add oil, read the specification of the pump manufacturer.

7) Use an engine lubricating oil that has a viscosity of SAE 30 to SAE 40.

Note: In unusual conditions, you can also use cylinder lubricating oil.

8) For data about the sealing rings on the hydraulic jacks, see 9403–3.

9) To install elastic studs, see 0352–2.

Version 1

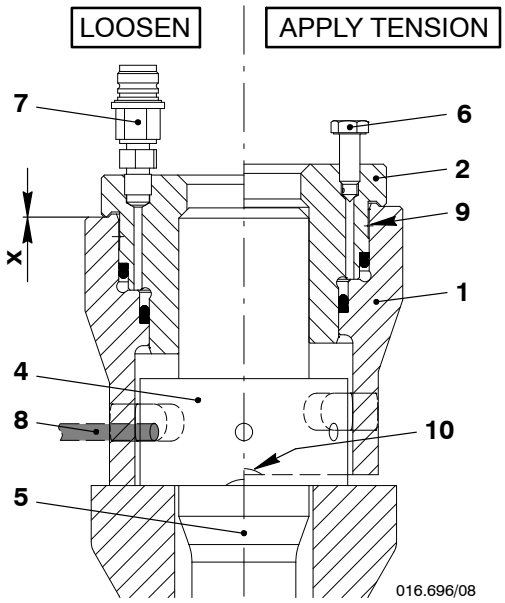


Fig. 1

Version 2

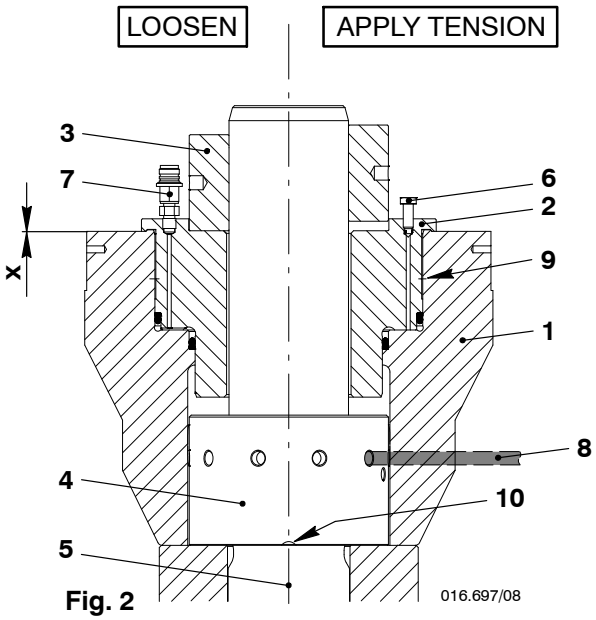


Fig. 2

2. Loosen

2.1 Version 1 – Preparation

1) Make sure that the vent screw (6, Fig. 1) is open.
2) Put the hydraulic jack on to the elastic stud (5).
3) Turn the hydraulic jack until it is tight. Make sure that there is no clearance at X.

2.2 Version 2 – Preparation

1) Make sure that the vent screw (6, Fig. 2) is open.
2) Put the hydraulic jack over the elastic stud (5).
3) Use the round bar to lightly tighten the round nut (4).

2.3 Procedure

1) Turn back the round nut (4), or the hydraulic jack (refer to Table 1 below).
2) On the HP oil pump, close the relief valve.
3) Connect the hydraulic jack to the HP oil pump or the hydraulic unit.
4) Put a hose on the vent screw (6) and a container below the hose to drain the oil.
5) Operate the HP oil pump.
6) Close the vent screw (6) when oil that has no air flows out.

Note: Do not move the piston (2) above the limit of the red groove (9).

7) Operate the HP oil pump to slowly increase the pressure to approximately 20 bar to 30 bar more than the value give in Table 1.
8) Keep the pressure constant and use the round bar to loosen the round nut (refer to Table 1 below).
9) On the HP oil pump,or hydraulic unit, decrease the pressure to zero.
10) Remove the hydraulic jack.

3. Apply Tension

1) Turn the round nut (4) fully down (Fig. 1 and Fig. 2). Make sure that there is no clearance at the slot (10).
2) Put one reference mark (Y) on the nut and one on the part below (X) (see Fig. 3 and Fig. 4).

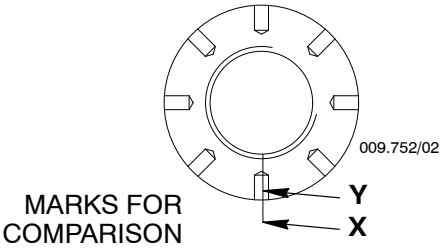


Fig. 3

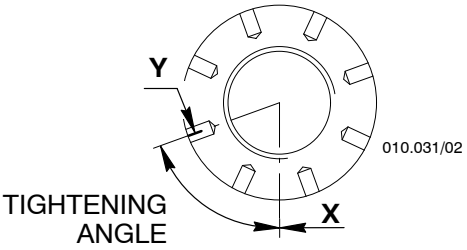


Fig. 4

3.1 Version 1 – Preparation

1) Make sure that the vent screw (6, Fig 1) is open.
2) Put the hydraulic jack on the elastic stud (5).
3) Turn the hydraulic jack until it is tight. Make sure that there is no clearance at X.

3.2 Version 2 – Preparation

1) Put the hydraulic jack over the elastic stud (5, Fig. 2).
2) Use the round bar to lightly tighten the round nut (4).

Note: If necessary, turn back the hydraulic jack a small distance to get access to the hole in the round nut (4).

3.3 Procedure

1) On the HP oil pump, close the relief valve.
2) Connect the hydraulic jack to the HP oil pump or the hydraulic unit.
3) Operate the HP oil pump.
4) Close the vent screw (6) when oil that has no air flows out.
5) Slowly increase the pressure to the nominal value, then keep the pressure constant (see the Table for the pressure values)
6) Make sure that there are no leaks.
7) Operate the HP oil pump to slowly increase the pressure to approximately 20 bar to 30 bar more than the value give in Table 1.

Note: Do not move the piston (2) above the limit of the red groove (9).

8) Use the round bar (8) to tighten the round nut (4) nut.
9) Put the feeler gauge through the slot (10) to make sure that there is no clearance between the round nut (4) and the seating.
10) Compare the angle between the reference marks (X and Y) on the round nut (4) and the Comparison value in the Table. If there is a large difference, you must investigate the cause and do the procedure again.
11) On the HP oil pump,or hydraulic unit, decrease the pressure to zero.
12) Remove the hydraulic jack.

Table 1 – Hydraulic Jacks – Values and Comparison

Application	**Group**	**Jack**	**Tightening Value [bar]**	**Comparison [°⦟ mm]**	**Reset Jack / Round Nut [turns]**	**Lubricating Agent 2)**
Foundation bolts	1112–1	94145	(1st step 1000) 1500	–	¼	MOLYKOTE paste G
Main bearing	1132–1	94114	1500	–	1¼	Oil
Engine stays	1715–1	94145	170	–	¼	MOLYKOTE paste G
Tie rods	1903–1	94180	1500	from 100 to 1500 bar 13.5 to 15.5 mm	3½	MOLYKOTE paste G
Cylinder cover	2708–2	94215A	1500	495°	2½	Oil
Exhaust valve cage	2751–1	94252	1500	165°	1	Oil
Turning gear	3206–1	94320	(1st step 600) 1500	–	½	Oil
Top con rod	3303–1	94315	(1st step 1100) 1500	1st to 2nd step 15°	½	Oil
Bottom con rod	3303–1	94252	(1st step 700) 1500	1st to 2nd step 65°	1	Oil
Piston rod foot	3403–1	94340	(1st step 1000) 1500	1st to 2nd step 20°	½	Oil
Piston head	3403–3	94340	1500	75°	½	Oil
Bearing, supply unit	5581–1	94557	1500	–	½	Oil
Roller lifting tool, supply unit	5556–2[1)]	94430A	1500	84°	½	No lubricant

1) For cutting out and cutting in a fuel pump, refer to the Operation Manual 5556–2.

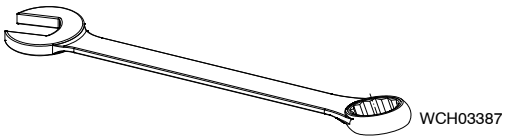
2) For lubrication on threads and contact surfaces.

Standard Tools

94000 **Combination wrenches, set complete**

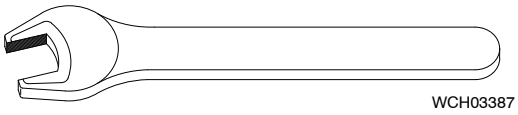
Includes:
34 wrenches AF6 to AF60
To send an order for single wrenches state AF
Example: **94000–6**
94000–60

94000–6
94000–60



94001 **Open end wrenches**

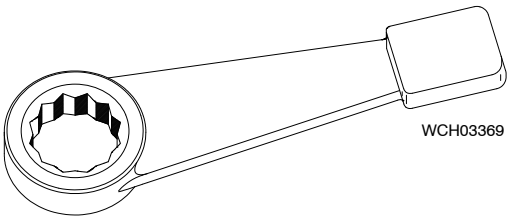
94001–85 1 Piece AF85
94001–110 1 Piece AF110



94002 **Ring slugging wrenches, set complete**

Includes:
13 wrenches AF27 to AF110
To send an order for single wrenches state AF
Example: **94002–27**
94002–110

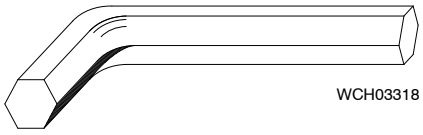
94002–27
94002–110



94003 **Allen keys, set complete**

Includes:
9 Allen keys AF3 to AF17
To send an order for single wrenches state AF
Example: **94003–3**
94003–17

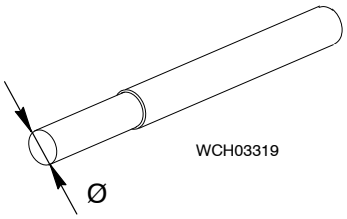
94003–3
94003–17



94005 **Round bars**

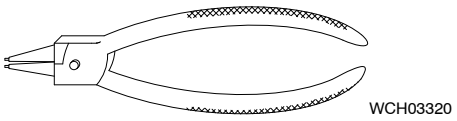
for round nuts

94005–4 1 Pieces . . . . Ø 4 mm (M27 – M33)
94005–6 1 Pieces . . . . Ø 6 mm (M36 – M56)
94005–9.5 1 Pieces . . . . Ø 9.5 mm (M60 – M80)
94005–14 1 Pieces . . . . Ø 14 mm (M85 – M100)



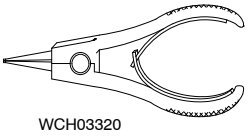
94007 **Circlip pliers**

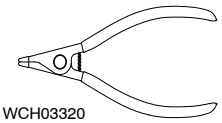
94007–C8 1 Piece . . . . . Type C 8
94007–C19 1 Piece . . . . . Type C 19
94007–C40 1 Piece . . . . . Type C 40
94007–C85 1 Piece . . . . . Type C 85



94007–A10 1 Piece . . . . . Type A 10
94007–A19 1 Piece . . . . . Type A 19
94007–A40 1 Piece . . . . . Type A 40
94007–A85 1 Piece . . . . . Type A 85

94007–A41 1 Piece . . . . . Type A 41

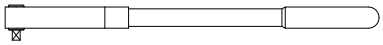


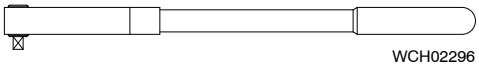


94009		**Handle**
94009–M5	1	Pieces M5x150
94009–M8	1	Pieces M8x100
94009–M10	1	Pieces M10x100

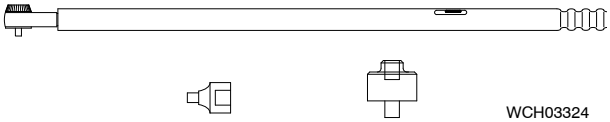

WCH03370

94011	1	**Torque spanner ½ inch** No ratchet mechanism (Range 12 Nm to 68 Nm)
94011A	1	**Torque spanner ½ inch** No ratchet mechanism (Range 50 Nm to 225 Nm)

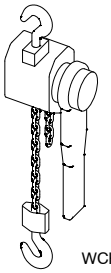

WCH02296


WCH02296

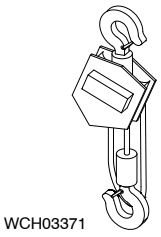
94012	1	**Torque spanner ¾ inch** (Range 150 Nm to 50 Nm)
94012A		adapter piece ¾ inch to ½ inch,
94012B		shell type ratchet ½ inch to ½ inch


WCH03324

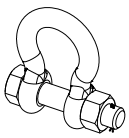
94016–009	2	**Manual ratchets** WLL 1000 kg, stroke 4 m
94016–011	2	**Manual ratchets** WLL 1000 kg, stroke 6 m
94016–017	2	**Manual ratchets** WLL 1500 kg, stroke 6 m
94016–031	2	**Manual ratchets** WLL 3000 kg, stroke 2 m


WCH03371

94017–006	2	**Spur-geared chain block** WLL 500 kg, stroke 7 m
94017–021	2	**Spur-geared chain block** WLL 2000 kg, stroke 4 m


WCH03371

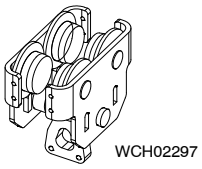
		Shackle
94018A	4	WLL 3250 kg
94018B	4	WLL 4750 kg
94018C	4	WLL 8500 kg


WCH02297

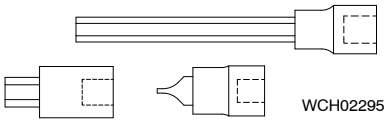
		Chain
94019A	1	1089x1323 mm, WLL 5300 kg
94019B	1	1089x1089 mm, WLL 5300 kg


WCH02297

94021	**2**	**Trolley** WLL 5000 kg


WCH02297

		Socket wrench inserts
94022A–10		AF10
94022A–SC		Screwdriver

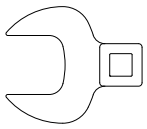

WCH02295

		Socket wrench inserts ¾”
94022B–19		AF19
94022B–36		AF36
94022B–41		AF41
94022B–46		AF46
94022B–50		AF50
94022B–60		AF60
94022F		**Adapter piece ½ inch to ¾ inch**
94022G		**Adapter piece ½ inch to ⅜ inch**

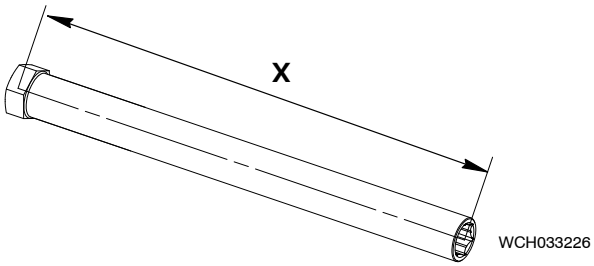


WCH02295

		Crowfoot Wrench
94022C–22		AF22
94022C–24		AF24
94022C–42		AF42

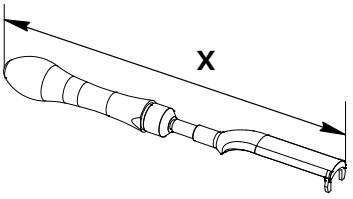

WCH02295

		Socket wrench inserts ⅜ inch
94022D–06		AF06
94022H	**1**	**Disassembly and assembly tool** AF19 X = 313



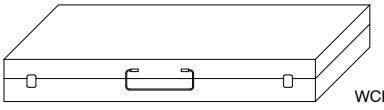
WCH033226

94023A	**1**	**Assembly tool** AF13 X = 225

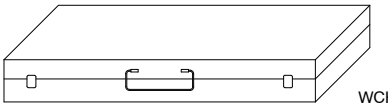


WCH03326

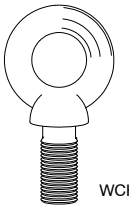
94025	**1**	**Tool box with socket wrench set** ½ inch (AF10–24, 26, 27, 28, 30,32, 33, 34, 36)


WCH03326

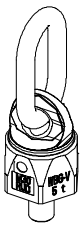
94026	**1**	**Tool box with hex. head drivers** ½ inch (AF5–10, 12, 14, 17)


WCH03326

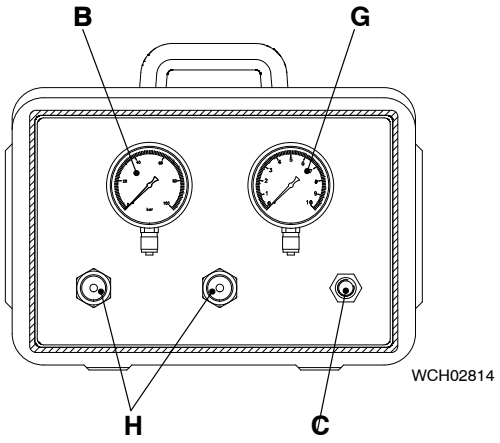
94045	**Eye bolt**
94045–M8	6 Pieces M8
94045–M10	4 Pieces M10
94045–M12	3 Pieces M12
94045–M16	4 Pieces M16
94045–M20	2 Pieces M20
94045–M24	4 Pieces M24
94045–M30	3 Pieces M30
94045–M36	4 Pieces M36
94045–M48	6 Pieces M48


WCH03370

94048	**Swivel lug**
94048–M30	6 Pieces M30

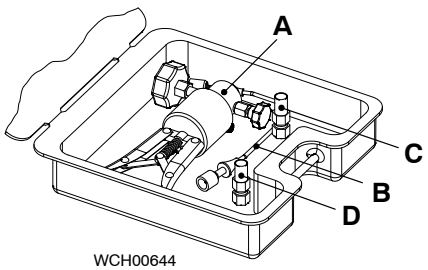

WCH00113

94050	**Tool for pressure measurement**
	for pneumatic elements
94050B	1 Pressure gauge 0–100 bar
94050C	1 Adapter
94050G	1 Pressure gauge 0–10 bar
94050H	2 Stop valve



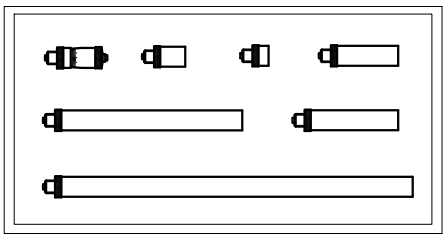
WCH02814

94051	**Tool for pressure measurement**
	for pneumatic elements
94051A	1 Pressure generator 700 bar
94051B	1 HP hose
94051C	1 1/4 inch connector
94051D	1 1/4 inch NPT connector

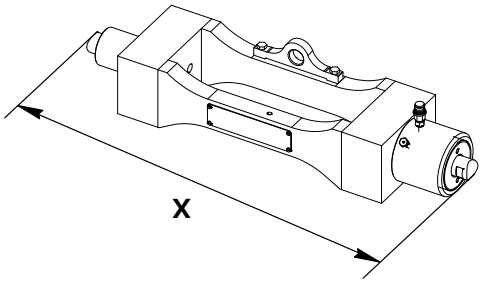


WCH00644

94101 1 Inside micrometer Set
(7 pieces with a measuring range 50 mm to 1010 mm), with case

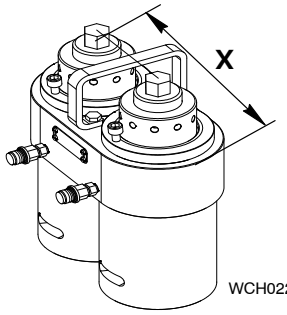

WCH02258

94110 1 Thrust device
To remove and install the main bearing cover
X = 880 mm
Mass approx. 84 kg



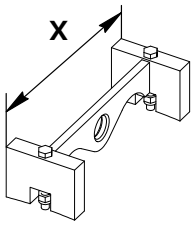
WCH02251

94114 2 Double pre-tensioner
for elastic studs to main bearing, including a metal box
X = 311 mm
Mass approx. 68 kg



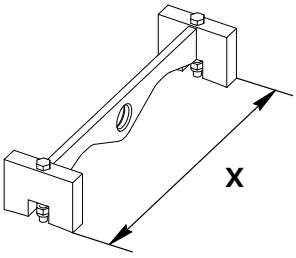
WCH02251

94116A 1 Lifting tool
To remove and install the main bearing shell
X = 224 mm
(WLL 60 kg)



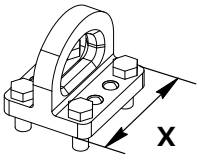
WCH02247

94116B 1 Lifting tool
To remove and install the main bearing shell
X = 319 mm
(WLL 90 kg)



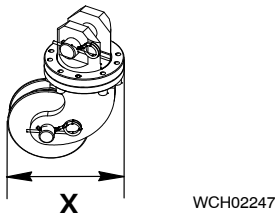
WCH02247

94116C 1 Lifting lug
To remove and install the main bearing cover
X = 120 mm
(WLL 900 kg)

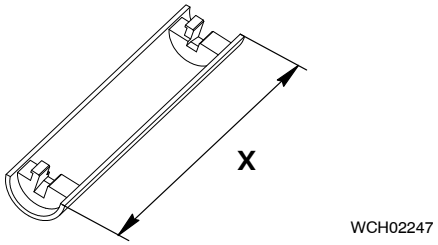


WCH02247

94117 1 Roller support
To remove and install the main bearing cover
X = 232 mm
(WLL 1200 kg)

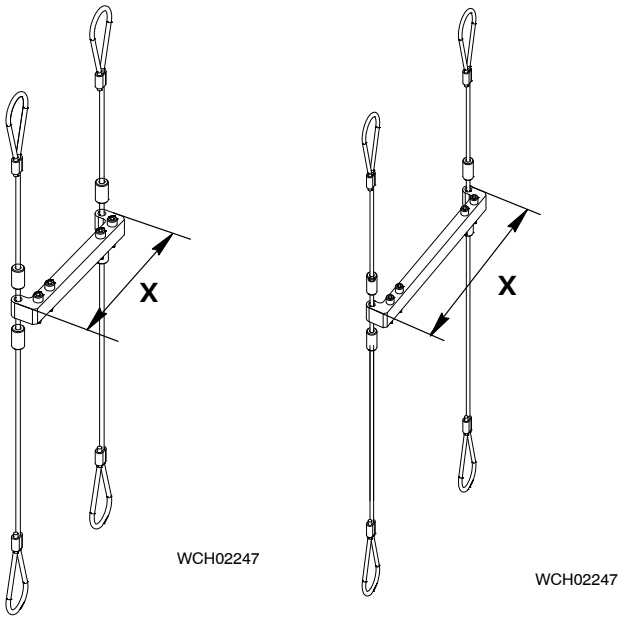


94117B 1 Deviation pipe
To remove and install the:
– main bearing, cover, shell
– connecting rod, cover, shell
– etc.
X =700 mm

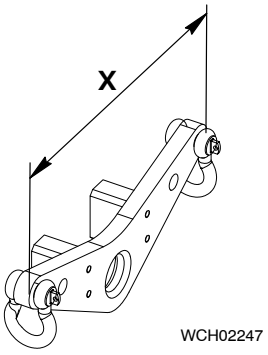


94118A 1 Turning-out device
To remove and install the main bearing shell at the driving end
X = 234mm
(WLL 800 kg)

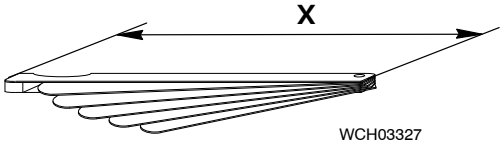
94118B 1 Turning-out device
To remove and install the main bearing shell
X= 330 mm
(WLL 800 kg)



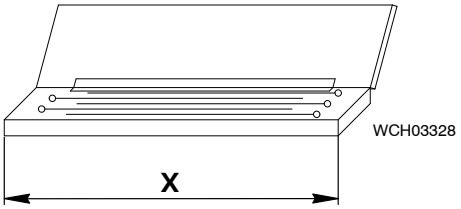
94119 1 Lifting plate
To remove and install the main bearing shell
X = 347 mm
(WLL 800 kg)



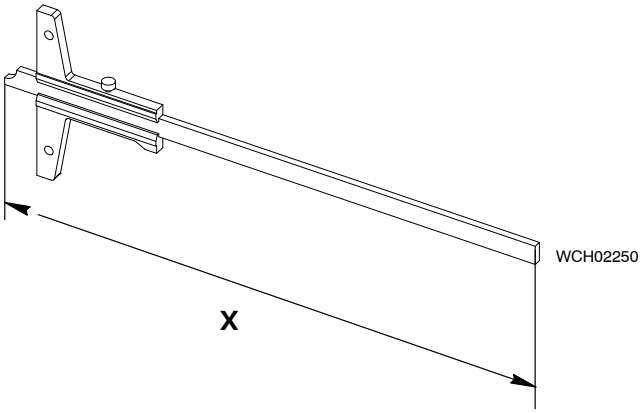
94122 1 Feeler gauge
X = 100 mm
Blade thickness 0.05 mm to 1.00 mm
(13-part)



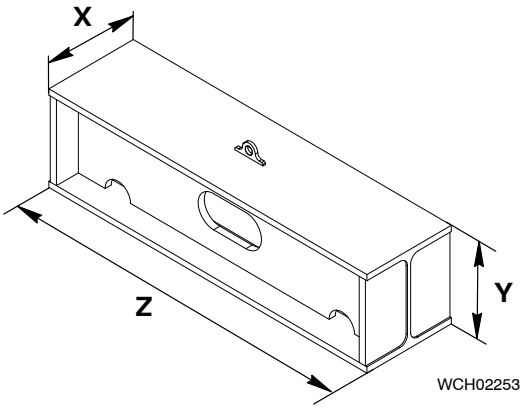
94123 1 Bearing feeler gauge
for main bearing
X = 620 mm
Blade thickness 0.1 mm to 1.1 mm
(11-part)



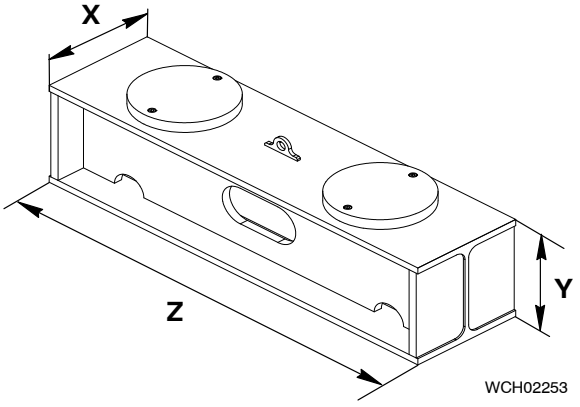
94126 1 Depth gauge
with case
X = 310 mm



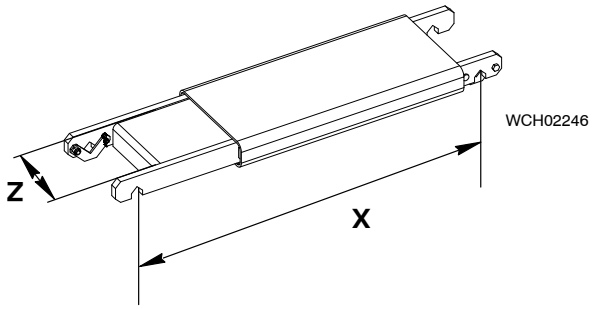
94141A 1 Bracket
To remove and install the
main bearing shells
X = 300 mm
Y = 345 mm
Z = 1130 mm
Mass approx. 245 kg



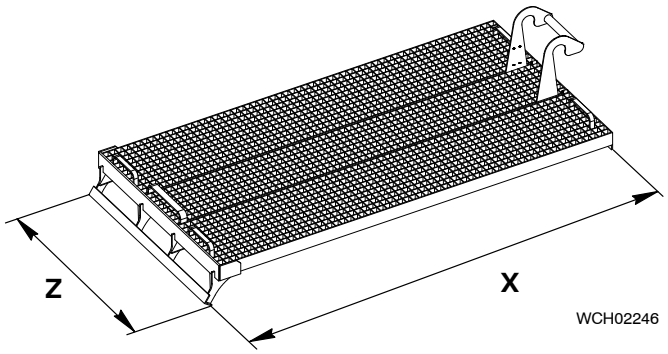
94141B 1 Bracket
To remove and install the
main bearing shells (FCV3 Crank only)
X = 300 mm
Y = 345 mm
Z = 1130 mm
Mass approx. 245 kg



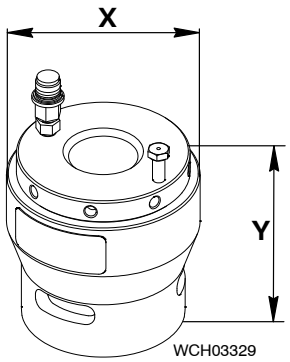
94142 1 Work platforms
X =770 mm
Z = 240 mm
Mass approx. 10.4 kg
(max. loading 200 kg/m^2)



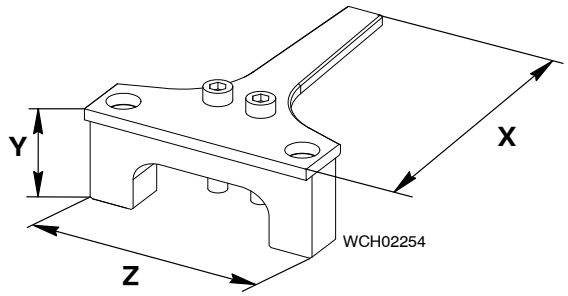
94143 1 Work supports
Includes: 3 grids each
X =1969 mm
Z = 947 mm
Mass approx. 136 kg
(Mass of 1 grid approx. 45 kg)
(max. loading 200 kg/m^2)



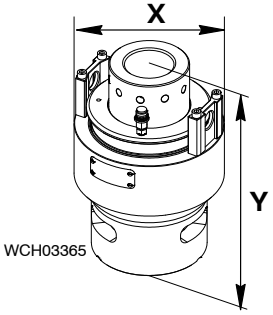
94145 1 Pre-tensioner
for foundation bolts and engine stays
X = ∅ 156 mm
Y = 151 mm



94155 1 Carrier
To remove the thrust pads
X = 397 mm
Y = 169.5mm
Z = 310 mm



94180 2 Pre–Tensioner
for tie rods
X = 308 mm
Y = 375 mm
Mass approx 93.9 kg



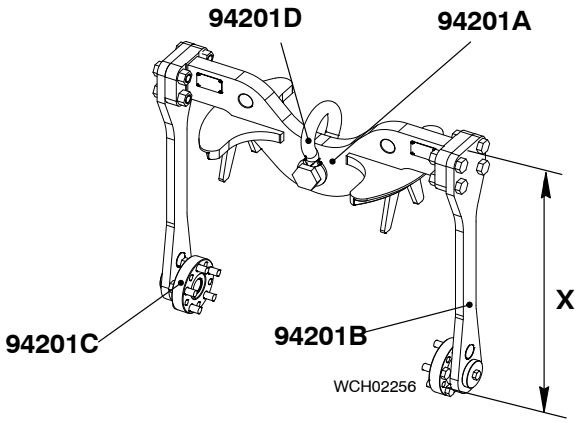
94201 **1 Lifting device**
To remove and install the cylinder Liner
X = 1195 mm
Mass approx. 265 kg
(WLL 6900 kg)
consisting of:
94201A, B, C, D

94201A **1 Lifting tool**
X = 1116 mm
Mass approx. 168 kg

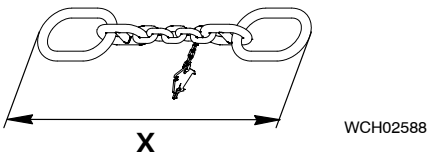
94201B **2 Holder**
X = 1182 mm
Mass approx.36.4 kg

94201C **2 Flange coupling**
X = Ø164 mm

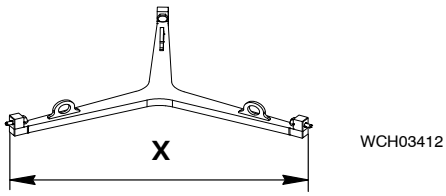
94201D **1 Shackle**



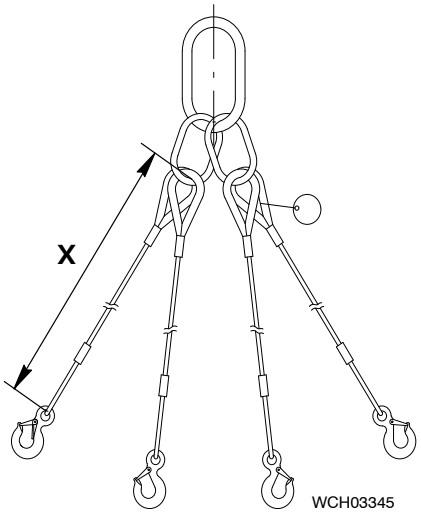
94202L **1 Chain**
X = 1060mm
WLL 8000 kg



94208 **1 Disassembly tool**
To remove and install the antipolishing ring
X = 638.5 mm

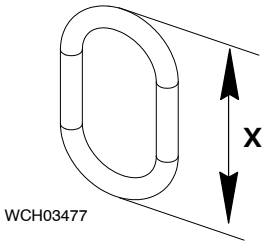


94209 **1 Hook set**
To remove and install the antipolishing ring
X = 1000 mm
WLL 750 kg

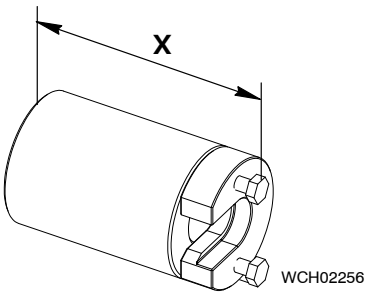


Standard Tools

94210–005 **1** **Ring**
For SAC A74–SD
X = 224 mm
WLL 5500 kg

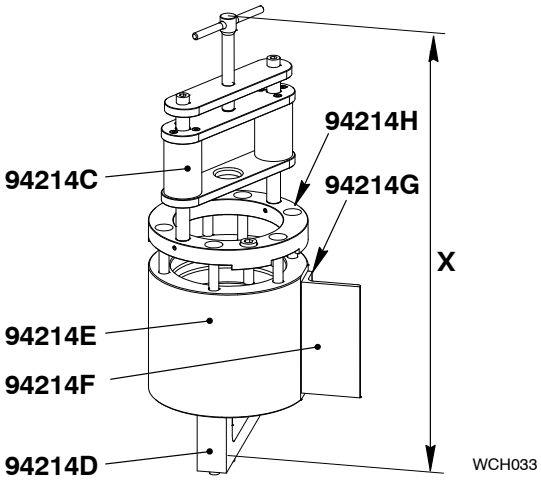


94213 **1** **Disassembly tool**
X = 104 mm

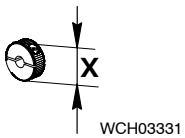


94214 **1 Disassembly and assembly tool**
for gas admission valve
X = 473 mm
Includes:

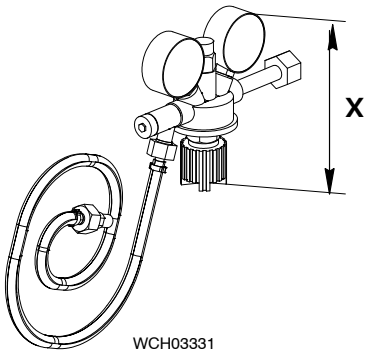
94214C	**1**	**Disassembly and assembly tool** for gas admission valve
94214D	**1**	**Disassembly and assembly tool** for gas admission valve
94214E	**1**	**Bush**
94214F	**1**	**Angle steel**
94214G	**5**	**Hexagon head screw** M6x16
94214H	**6**	**Hexagon socket head cap screw M10x45**
94214I	**1**	**Gasket** Sealing between bush and for gas admission valve
94214K	**3**	**O–Ring** for gas admission valve



94214A **1 Handle**
X = 37.5 mm

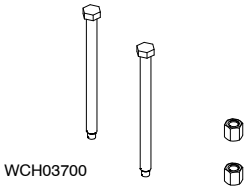


94214B **1 Pressure reducing valve**
X = 172 mm

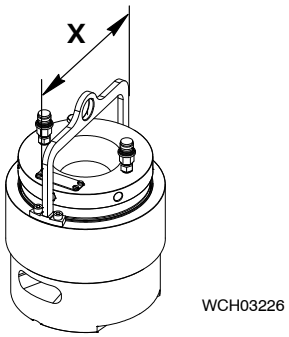


94214L **2 Screw M10**
X = 140 mm

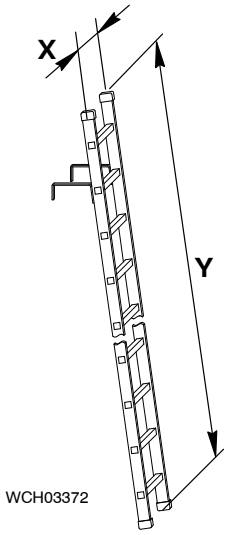
94214M **2 Hexagon nut M10**
SW 15



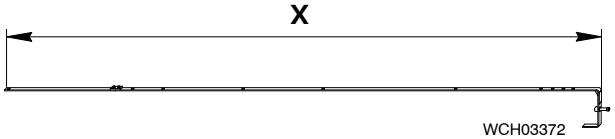
94215A 8 Pre-tensioner
for cylinder cover studs
X = 224 mm
Mass approx. 41.6 kg



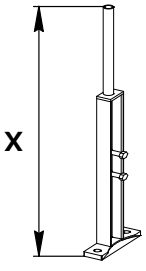
94224 1 Ladder
For the cylinder liner bore
X = 350 mm
Y = 3550 mm



94225 1 Gauge
To measure the cylinder liner bore
(includes:
inside micrometer tool 94101)
X = 3423 mm



94230 2 Distance holders
for removal and fitting of piston rod gland and piston,
including 2 screws M16x50
X = 1100 mm

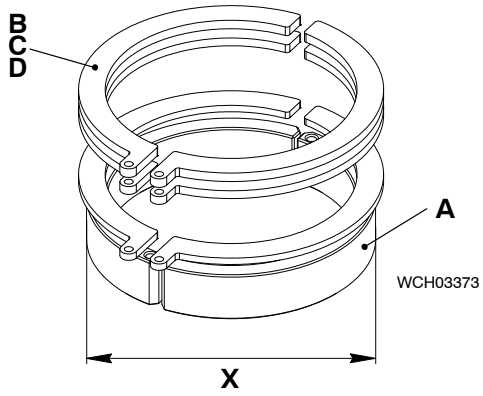


94231A 2 Clamping rings
Thick 62
X = 326mm

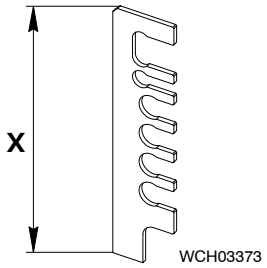
94231B 2 Distance pieces
Thick 12
X = 344 mm

94231C 2 Distance pieces
Thick 11
X = 344 mm

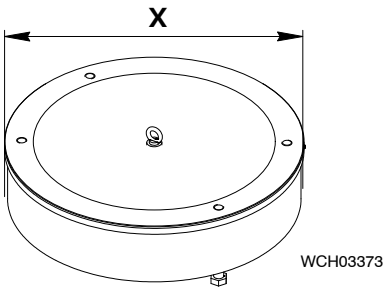
94231D 2 Distance pieces
Thick 9
X = 344 mm



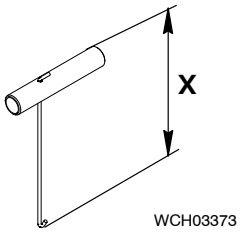
94231E 1 Template
for fitting scraper rings
X = 262 mm



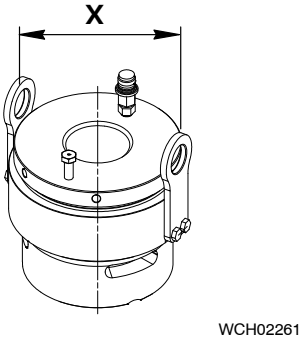
94232 1 Covering
To cover the bore of the piston rod gland in the cylinder jacket (when piston and gland are removed)
X = ∅ 516 mm
Mass approx. 40 kg



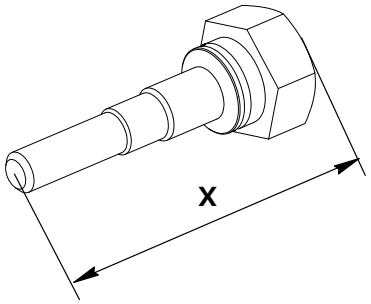
94233 1 Assembly tool
To apply tension to the springs
In the piston rod gland and insulation bandage
X = 150 mm



94252 2 Pre-tensioner
for exhaust valve cage / Bottom connecting rod
X = ∅ 229.6 mm
Mass approx. 21.9 kg

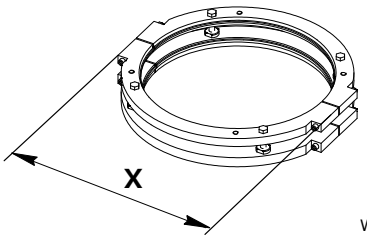


94259 **2** **Pressure element**
For the exhaust valve
X = 243 mm



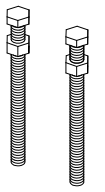
WCH03377

94261 **1** **Valve seat disassembly and assembly device**
X = 616 mm
Mass approx. 43 kg

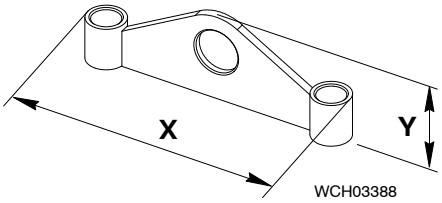


WCH03376

94263 **2** **Jack screws M12x110**
To assemble the guide bush to the exhaust valve,
includes:
2 hexagon nuts M12


WCH03388

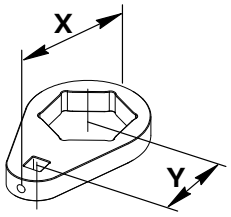
94265 **1** **Suspension**
for the cylinder cover
(WLL 2900 kg)
X = 696 mm
Y = 243 mm
Mass approx. 46 kg



WCH03388

94269C–41 **1** **Torque wrench extension**
To loosen and tighten the clamp nut (AF41) on the injection valve with FAST
X = 106 mm
Y = 55 mm

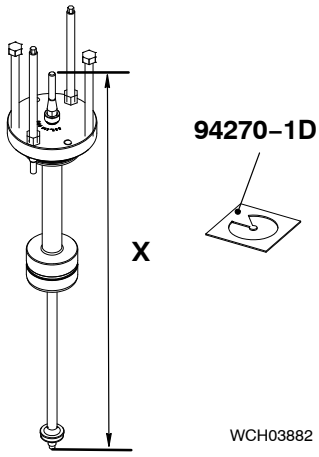
94269C–55 **1** **Socket wrench insert**
To loosen and tighten the clamp nut (AF55) on the injection valve with FAST
X = 155 mm
Y = 55 mm



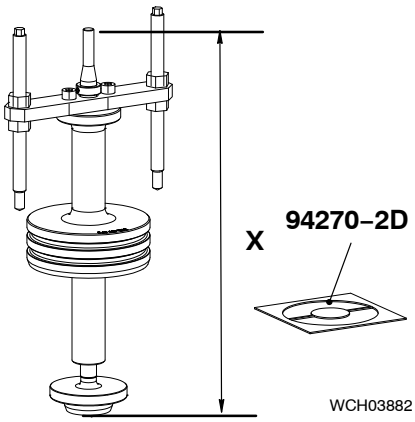
WCH01208

94269C–65 **1** **Torque wrench extension**
To tighten the coupling nut (AF65) on injection valve with FAST
X = 144.5 mm
Y = 75 mm

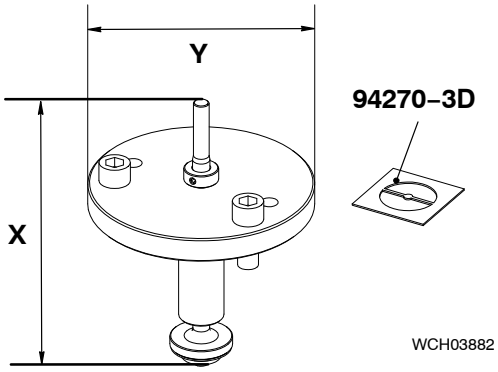
94270–01 **1** **Grinding device**
To grind the fuel injection valve bore bore.
X = 523 mm



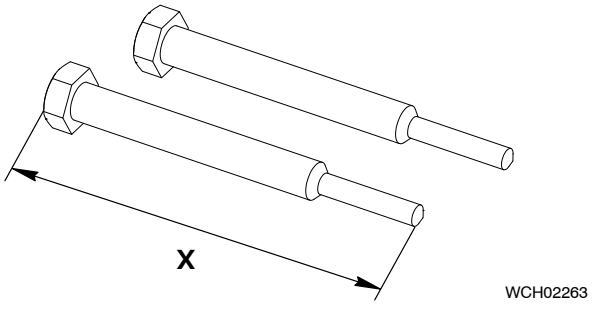
94270–02 **Grinding device**
To grind the pilot injection valve bore bore.
X = 374 mm



94270–03 **Grinding device**
To grind the prechamber bore.
X = 172 mm
Y = 130 mm

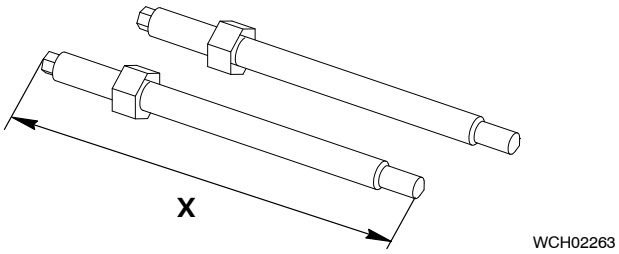


94270C **2** **Hexagon head bolt**
For the injection valve
X = 170 mm

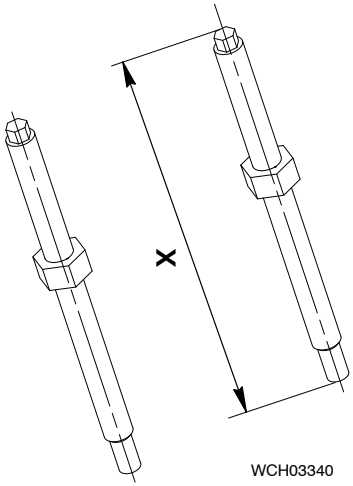


Standard Tools

94270D **2** **Stud bolt**
For the injection valve
X = 176 mm

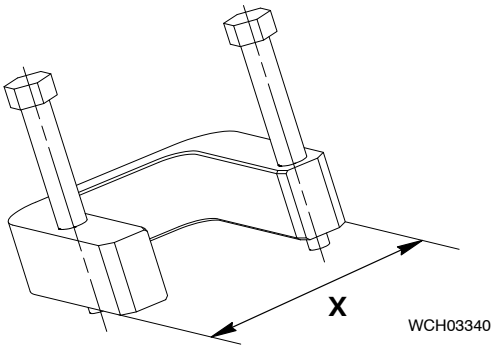


94270E **2** **Stud bolt**
For the injection valve
X = 176 mm
without nut



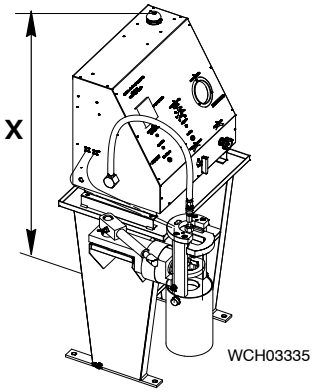
94270F **1** **Support plate**
X = 104 mm

94270G **2** **Hexagon head screw with dog point**
M12x90
X = 176 mm



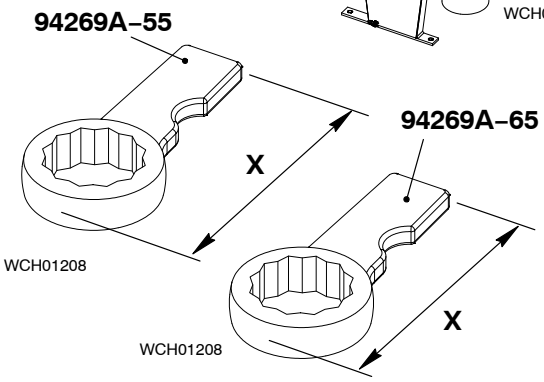
94272 **1 Tool injector test bench**
To set and do a test of of the:
- injection valve
- safety valve
- relief valve

X = 1458 mm
includes:

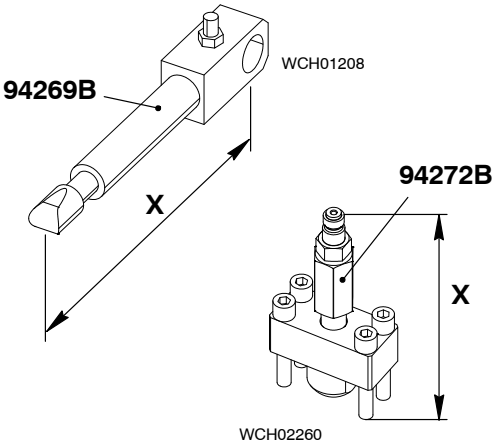


94269A–55 **1 Slugging wrench**
To loosen the Coupling nut (AF55 to pilot injection valve)
X= 219 mm

94269A–65 **1 Slugging wrench**
To loosen the Coupling nut (AF65)
X= 232 mm

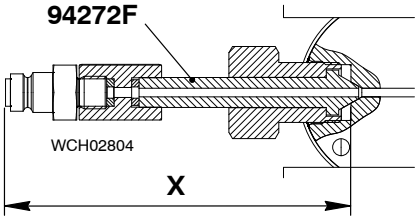


94269B **1 Hydraulic cylinder**
To loosen and tighten the coupling nut on the injection valve
X = 395 mm



94272B **1 Connecting piece**
To adjust the injection valve
X = 133 mm

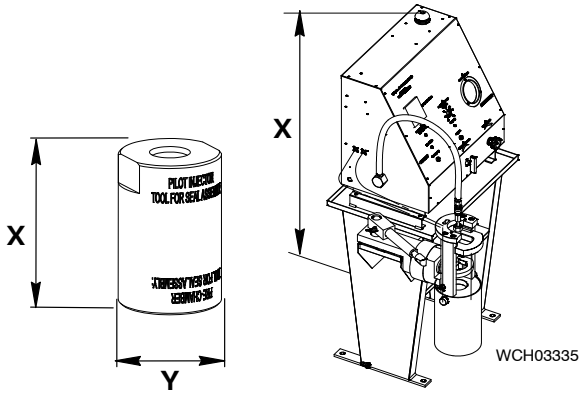
94272F **1 Adapter**
For the pilot injection valve
X = 134.5 mm



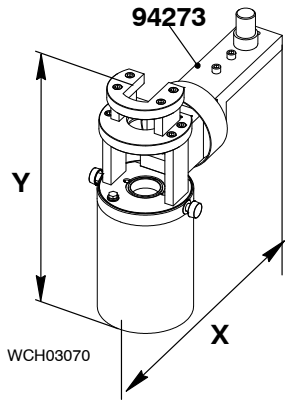
See next page

94272 Continued

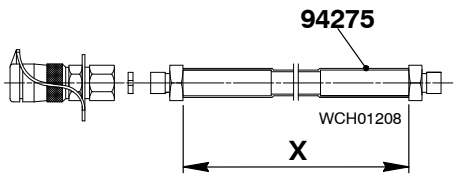
9427X **1 Assembly tool**
X = 150 mm
Y = 100 mm



94273 **1 Valve holder**
For the OBEL test bench
To attach the injection valve
X = 576 mm
Y =468 mm



94275 **1 HP hose**
For the OBEL test bench
To do tests and loosen / tighten the coupling nut on the injection valve
X = ca. 1000 mm
Max. working pressure 1800 bar

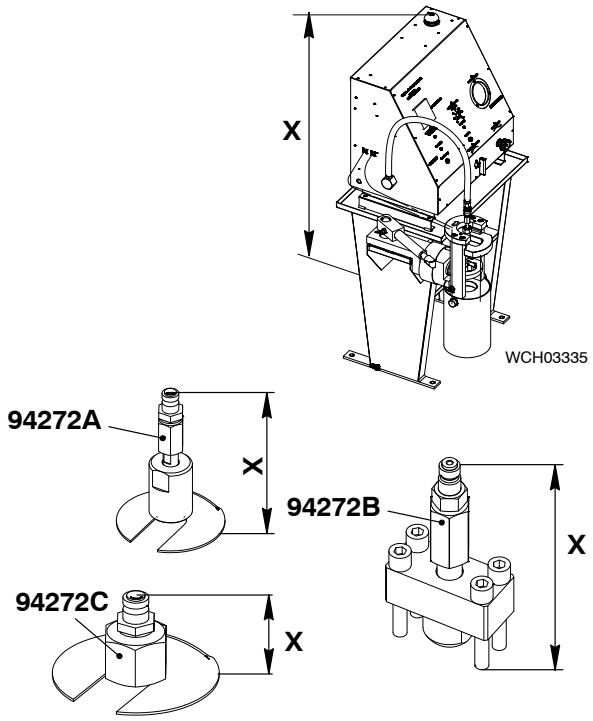


94272 Continued

94272A **1 Valve holder**
To do checks of the fuel overpressure safety valve
X =170 mm

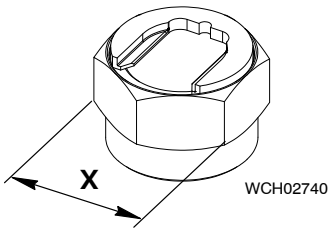
94272B **1 Connecting piece**
To adjust the injection valve
X = 130 mm

94272C **1 Valve holder**
To do checks and Adjust the relief valve on the cylinder Cover
X = 68 mm

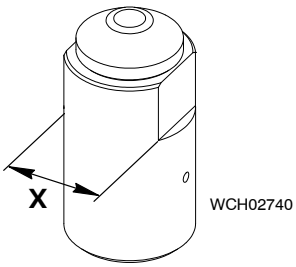


Standard Tools

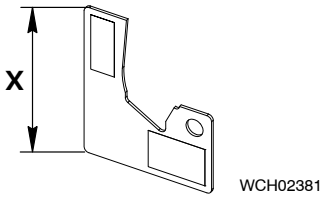
94278A 1 Nozzle disassembly tool
for injection nozzle disassembly
X = AF 46 mm



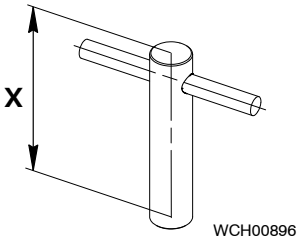
94278B 1 Nozzle assembly tool
for injection nozzle assembly
X = AF 41 mm



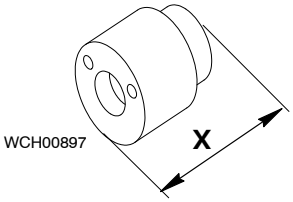
94279 1 Template
To do checks of the wear rate on the exhaust valve seat
X = 160 mm



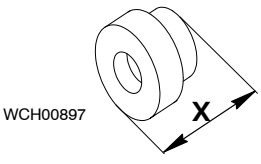
94289 1 Assembly tool (bush with dowel pin)
for dismantling and assembling injection valve
X = 120 mm



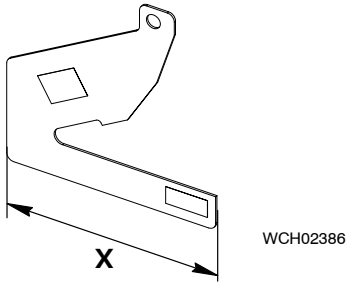
94289A 1 Bush
for dismantling and assembling injection valve
X = 70 mm



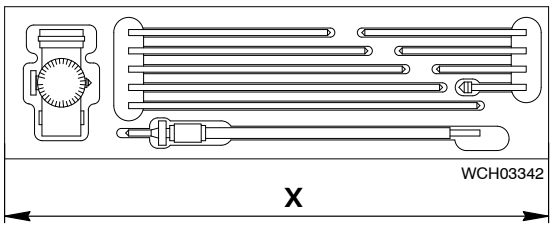
94289B 1 Bush
for dismantling and assembling injection valve
X = 42 mm



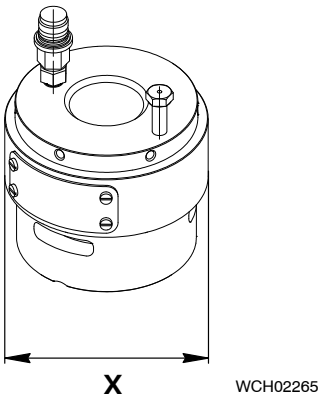
94292 1 Template
To do checks of the wear rate of the exhaust valve spindle
X = 300 mm



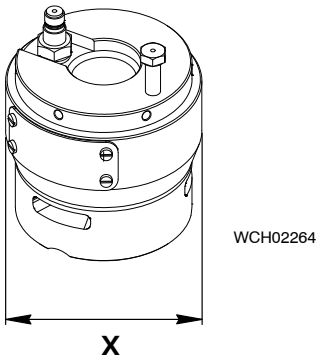
94305 1 Crankshaft equipment
To measure the crank deflection (in wooden box)
X = 364 mm



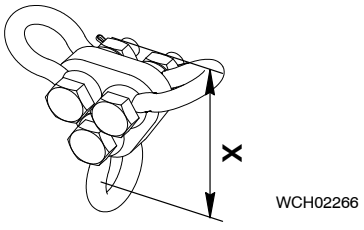
94315 2 Pre-tensioner
for the connecting rod studs on the top end bearing
X = 138 mm



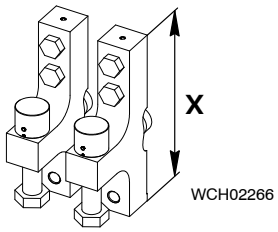
94320 1 Pre-tensioner
For the turning gear pre-tensioning,
X = 130 mm



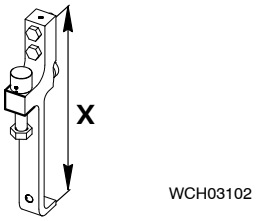
94321 1 Link
For the connecting rod assembly
X = 268 mm



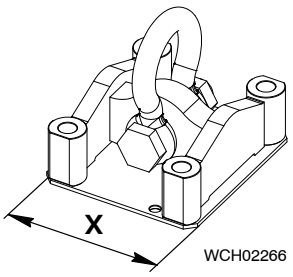
94322 2 Support
For the crosshead
X = 460 mm



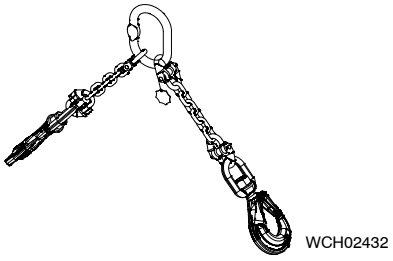
94322A 1 Support (Engines with ELBA)
For the crosshead
X = 800 mm



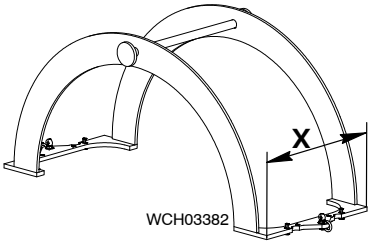
94324 1 Lifting tool
For the connecting rod assembly
X = 336 mm
Mass approx. 56.9 kg
(WLL 8200 kg)



94325 1 Chain
To remove the crosshead pin
2 slings of 424 mm
Mass approx. 4 kg
(WLL 1500 kg)



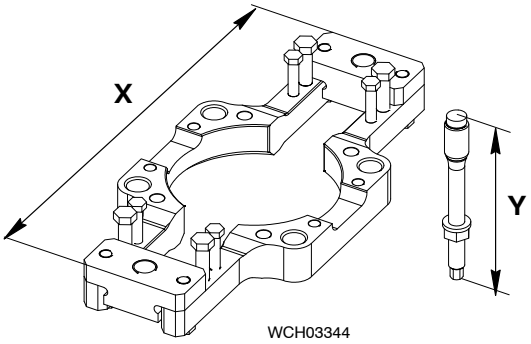
94326 1 Console Frame
To remove and install the bottom end bearing shell
X = 340 mm
Mass approx. 21 kg
(WLL 60 kg)



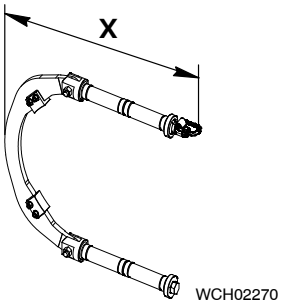
94327 1 Chain
To remove and install the bottom connecting rod bearing shell
4 slings of 654 mm
Mass approx. 5.76 kg
(WLL 1120 kg)

94333 1 Lifting tool
For the connecting rod bearing assembly
X =710 mm
Includes:

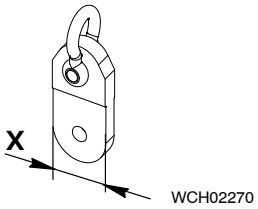
94333A 2 Bolts
Y = 299 mm



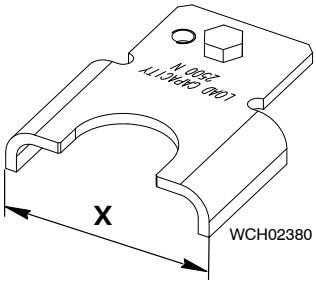
94334 1 Bracket
To remove and install the connecting rod (∅ 880 mm), includes:
X = 1448 mm
Mass approx. 134 kg



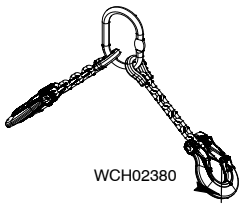
94334A 1 Connecting element with shackle
X = 116 mm
(WLL 4500 kg)



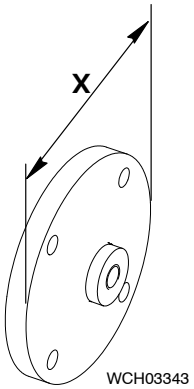
94335 1 Stop plate
with screw M24x45
To do an inspection of the top end bearing
X = 226 mm



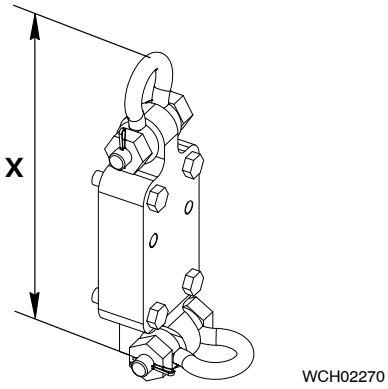
94335A 1 Chain
To lift / lower top bearing cover
2 slings of 314 mm



94336 1 Connecting flange
for the lubrication of the top and bottom end bearings
X = ∅ 140 mm

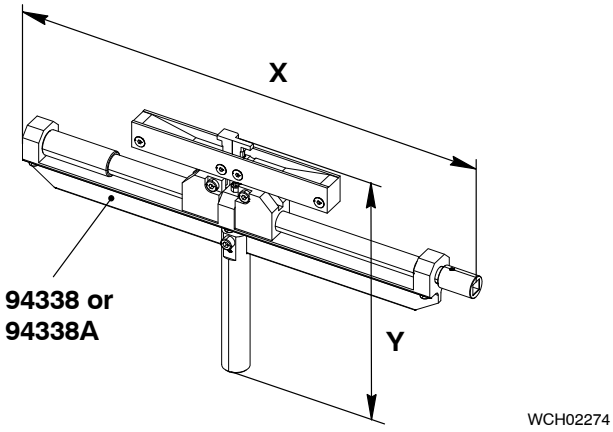


94337 2 Lifting tools
with 4 screws M20x90
for the connecting rod
X = 478 mm
WLL:
– vertical 4000 kg
– horizontal 2600 kg

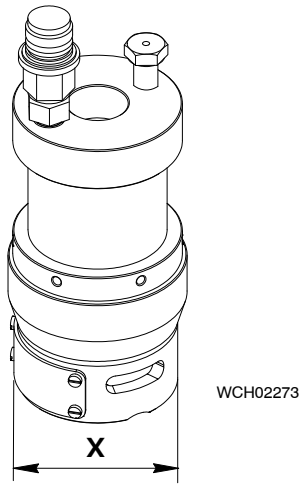


94338 1 Piston ring tensioning device
X = 550 mm
Y = 296.1 mm
Ring type SCP2CC13 = 13 mm

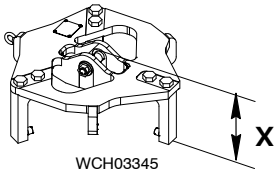
94338A 1 Piston ring tensioning device
X = 550 mm
Y = 296.1 mm
Ring type GTP1CC22 = 22 mm



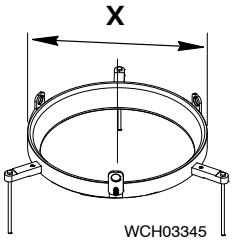
94340 3 Pre-tensioner
For piston rod foot fastening and piston head.
includes a metal box
X = ∅ 76 mm



94341 1 Lifting tool
For the removal and installation of the piston
X = 345 mm



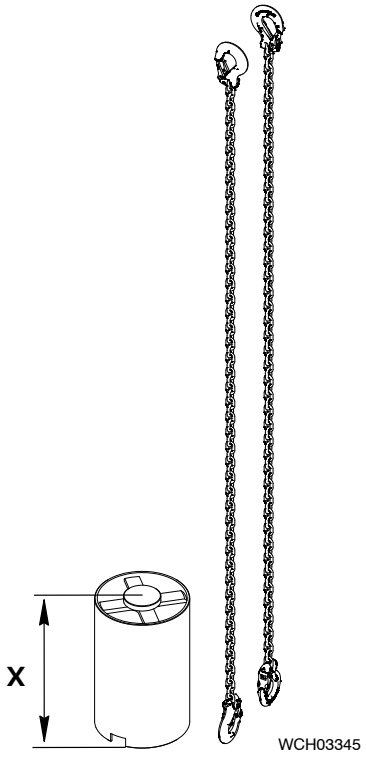
94342 1 Assembly tool
To install a piston
X = ∅ 818 mm



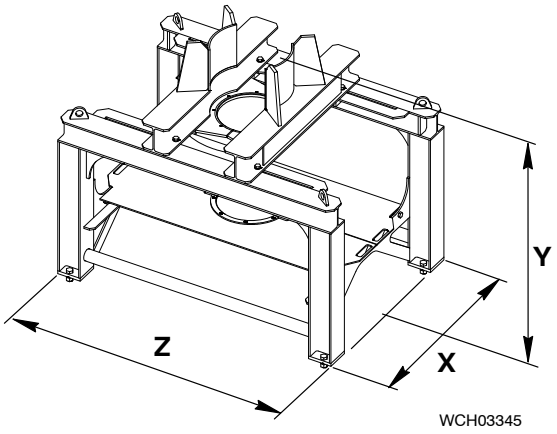
94344 1 Disassembly and assembly tool
for the removal and installation of piston and rod gland and piston
includes:

94344A 1 Distance piece
X = 405 mm

94344B 2 Chains



94350 1 Device
To hold the piston and piston rod gland
X = 1030 mm
Y = 1351 mm
Z = 1342 mm
Mass approx. 420 kg

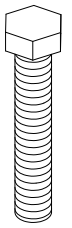


WCH03345

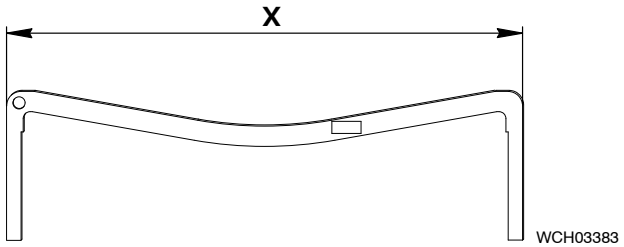
94364A 3 Jacking screws
To remove the piston head
M20x220

94364B 2 Jacking screws
To remove the spray plate
M12x70

94364C 3 Jacking screws
To remove the piston skirt
M20x70

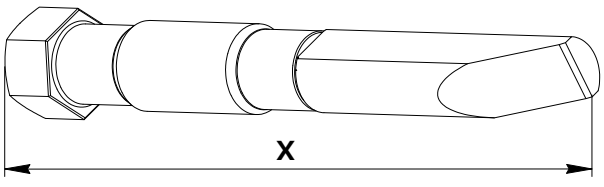

WCH03383

94366 1 Template
To do a check of the piston crown contour
X = 788.1 mm



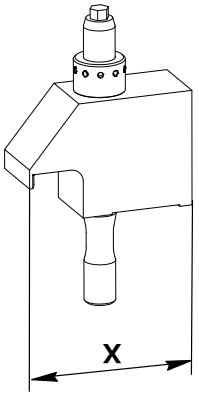
WCH03383

94410 1 Adjustment devices
To align the intermediate wheel
X = 248 mm



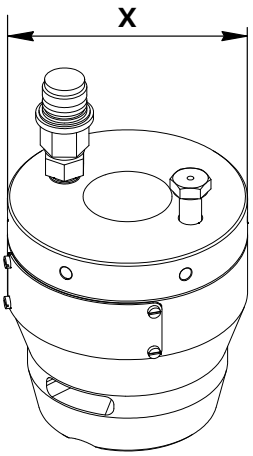
WCH02276

94430 1 Roller lifting tools
for cutting out and cutting in the fuel pump,
includes: elastic bolts and round nut
X = 197 mm



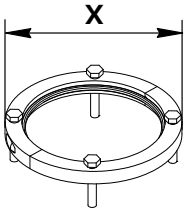
WCH02278

94430A 1 Pre-tensioner
for roller lifting tool
X = ∅ 108 mm



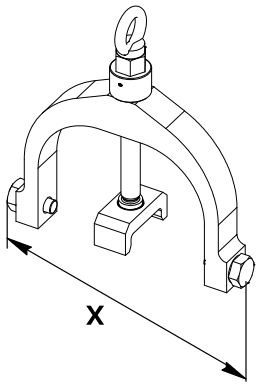
WCH02278

94550 1 Clamping ring 2-parts
X = ∅ 210 mm



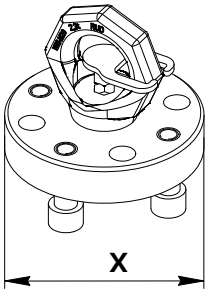
WCH02281

94551 1 Fitting and dismantling device
To remove and install the guide pin on the fuel pump
X = 334 mm



WCH02281

94552 1 Lifting tool
with hexagon head screws M14x40
To remove and install the fuel pump
X = ∅ 120 mm
(WLL 600 kg)



WCH02281

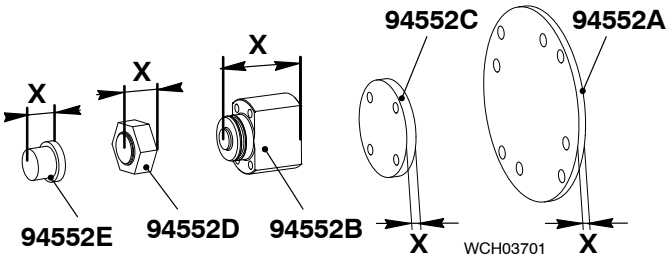
94552A 1 Cover
X = ∅ 290 mm

94552B 1 Blind flange
X = ∅ 130 mm

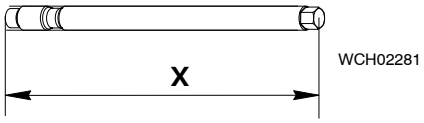
94552C 1 Blind flange
X = ∅ 100 mm

94552D 1 Screw plug
X = 15 mm

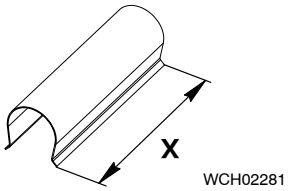
94552E 1 Plug
X = 19 mm



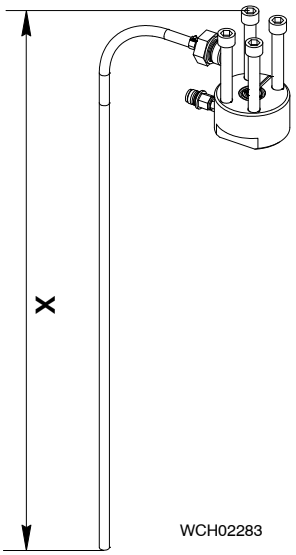
94553 2 Rod
Guide rod for the fuel pump
X = 470 mm



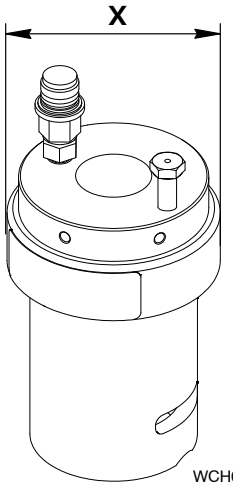
94555 2 Distance piece
For teh fuel pump
X = 95 mm



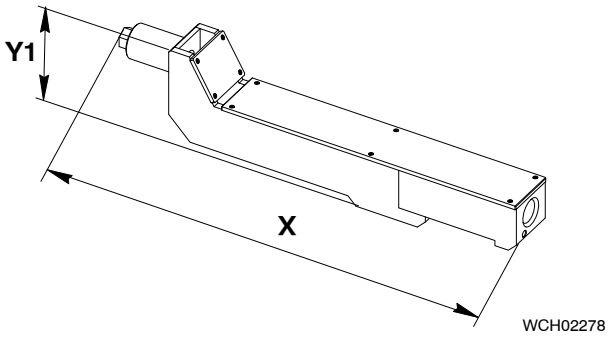
94556 1 PCV test block with tube
To do a pressure check of the pressure control valve
X = 954 mm



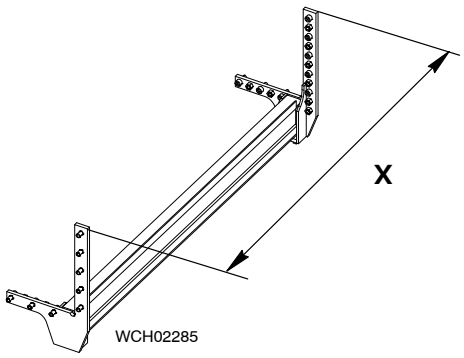
94557 2 Pre-tensioning jacks
For the elastic bolts on the camshaft bearing
X = ∅ 112 mm



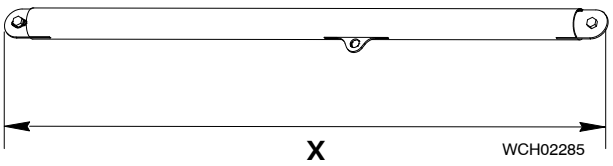
94566 2 Support
For the camshaft assembly,
Includes the clamp nut
X = 925 mm
Y1 = 180 mm
Mass approx. 69.1 kg



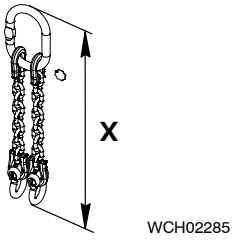
94664 2 Bracket
To replace the scavenge air cooler
X = 1796 mm



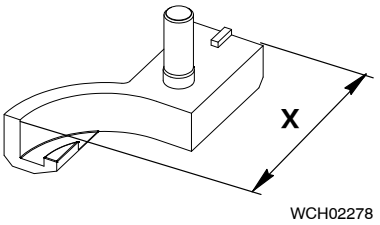
94664A 1 Dismantling pipe
X = 3599 mm



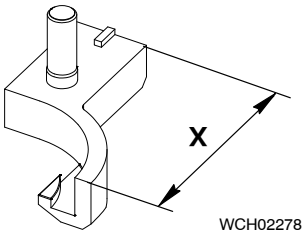
94666 1 Chains (double sling)
To remove and install the scavenge air cooler
X = 625 mm



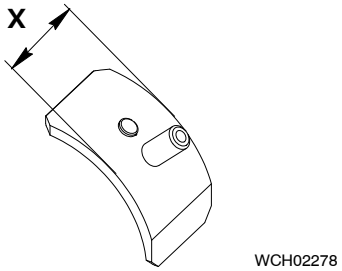
94566B 1 Holder
for camshaft assembly,
Includes the hexagon socket screw
X = 290 mm



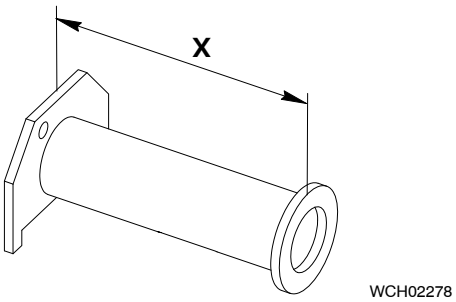
94566C 1 Holder
for the camshaft assembly,
includes hexagon socket screw
X = 290 mm



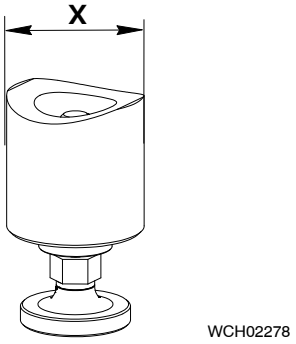
94567 1 Assembly template
To remove and install the bearing shells of the fuel pump unit
X = 90 mm



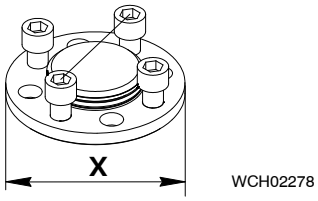
94567A 1 Assembly template
To install the bearing shells to the fuel pump unit
X = 177 mm



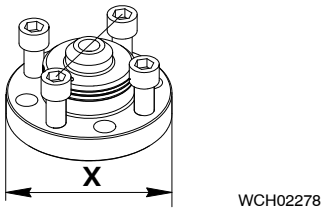
94567B 1 Jacking screw
To assemble the camshaft
X = ∅ 75 mm



94569 1 Blank flange
For the fuel pump,
includes screws M14x25
X = ∅ 120 mm

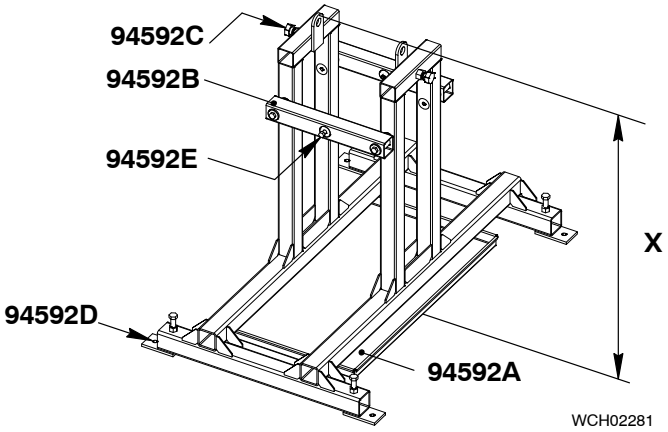


94569A 1 Blank flange
For the intermediate piece,
includes screws M14x50
X = ∅ 116 mm

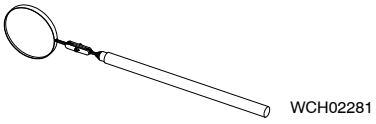


94592 1 Fuel pump rack
For the fuel pump
X = 1039 mm
Mass approx. 86.6 kg
includes:

- **94592A 1 Oil trough**
- **94592B 2 Limiter**
  with 4 screws M16x50
  and washers
- **94592C 2 Screws M20**
- **94592D 4 Screws (M12x100)**
- **94592E 2 Screws (M12x90)**

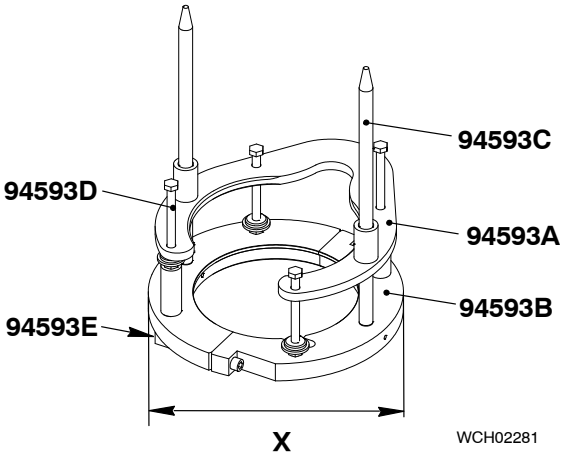


94592M 1 Mirror



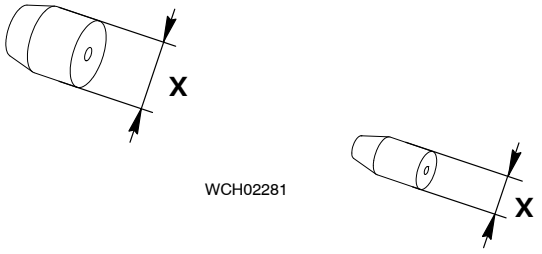
94593 1 Guide bracket
for pre-tensioning device
X = ∅ 370 mm
Mass approx. 23.5 kg

- **94593A 1 Ring**
- **94593B 1 Ring (2-part)**
- **94593C 2 Guide rods**
- **94593D 4 Screws M12x130**
  With special nuts
- **94593E 2 Screws M30x110**



94597 1 Mandrel
To install the seal into the bottom spring carrier and the bottom housing of the fuel pump
X = ∅ 70 mm

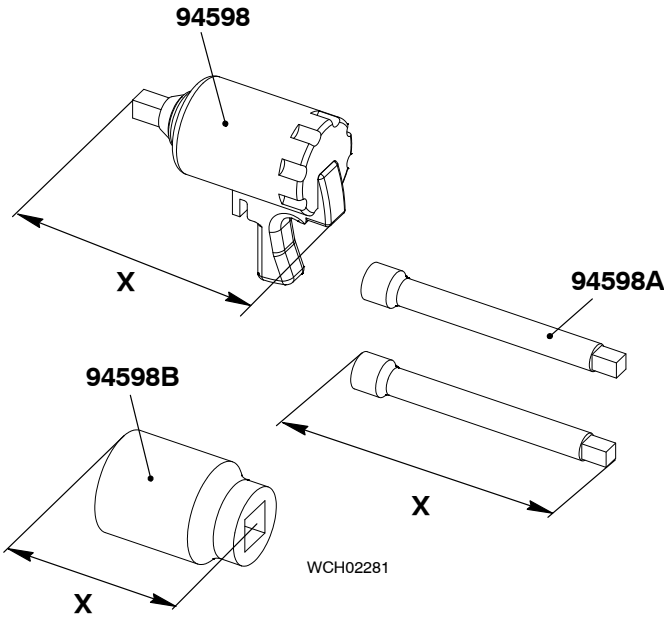
94597A 1
Mandrel
To install the seal into the bottom spring carrier
X = ∅ 40 mm



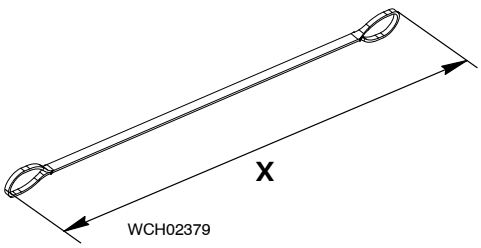
94598 1 Pneumatic impact wrench
To loosen and tighten the fuel pump on the fuel pump unit
X = 271 mm

94598A 2 Extensions
X = 400 mm

94598B 1 Socket wrench insert
X = 100 mm



94650 2 Sling
X = 1750 mm



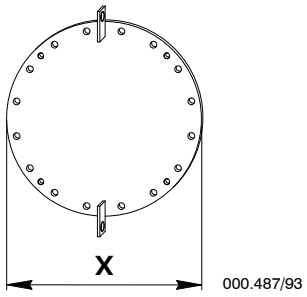
In case of a turbocharger breakdown

Cover to exhaust manifold outlet:

94653A–M60	for MET 60 MB, X = 680 mm, 12 holes
94653A–A175	for ABB 175, X = 948 mm, 16 holes
94653A–A265	for ABB 265, X = 680 mm, 12 holes
94653A–A270	for ABB 270, X = 763 mm, 16 holes
94653A–A275	for ABB 275, X = 890 mm, 16 holes

Cover to turbocharger inlet:

94653B–M60	for MET 60 MB, X = 680 mm, 16 holes
94653B–A175	for ABB 175, X = 726 mm, 16 holes
94653B–A265	for ABB 265, X = 680 mm, 12 holes
n/a	for ABB 270, use 94653A–A270
n/a	for ABB 275, use 94653A–A275



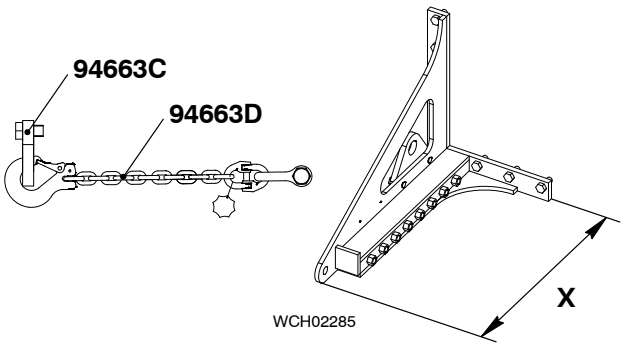
Cover to scavenge air receiver:

94653C–M60	for MET 60 MB, X = 640 mm, 16 holes
94653C–A175	for ABB 175, X = 680 mm, 16 holes
94653C–A265	for ABB 265, X = 555 mm, 16 holes
94653C–A270	for ABB 270, X = 668 mm, 16 holes
94653C–A275	for ABB 275, X = 736 mm, 20 holes

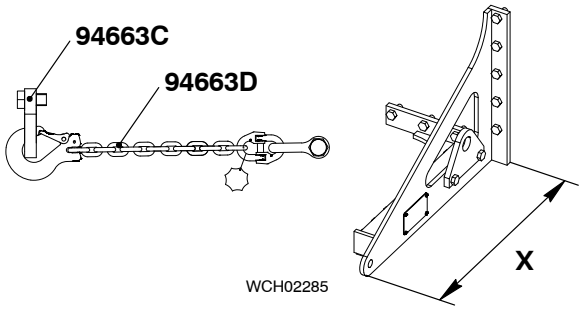
Cover to turbocharger outlet:

94653D–M60	for MET 60 MB, X = 600 mm, 16 holes
94653D–A175	for ABB 175, X = 900 mm, 16 holes
n/a	for ABB 265, use 94653C–A265
94653D–A270	for ABB 270, X = 633 mm, 16 holes
94653D–A275	for ABB 275, X = 686 mm, 20 holes

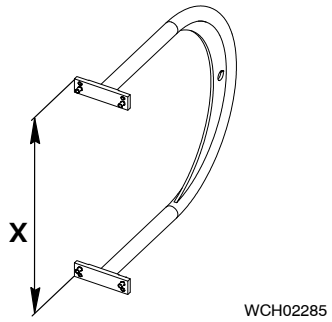
94663A 1 Support left
Includes a safety chain 94663D and safety lug
To remove and install the scavenge air cooler
X = 681 mm
(WLL 3800 kg)
Mass approx. 39.5 kg



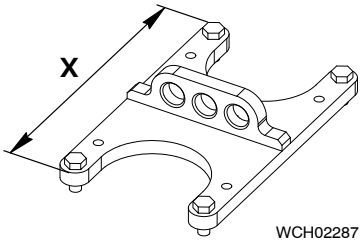
94663B 1 Support – right
Includes a safety chain 94663D and safety lug 94663C
To remove and install the scavenge air cooler
X = 681 mm
(WLL 3800 kg)
Mass approx. 39.5 kg



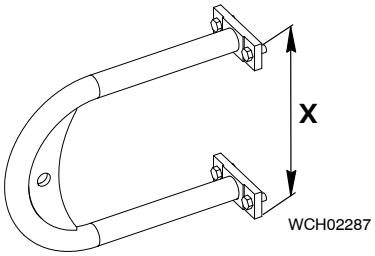
94663I 1 Support
To install the scavenge air cooler
X = 960 mm



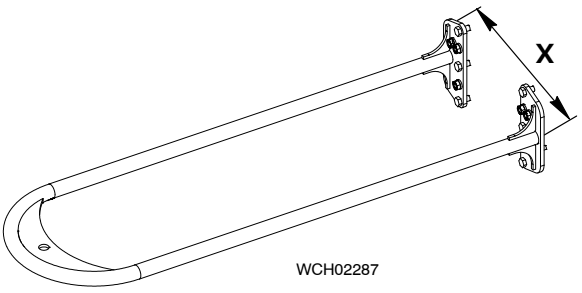
94667 3 Lifting tool
To remove the water separator,
includes:
4 Hexagon head screw M12x30
X = 300 mm
(WLL = 240 kg



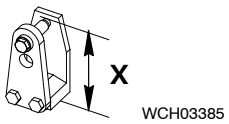
94667G 1 Holder
To remove the water separator
X = 420 mm



94667H 1 Holder
To install the water separator
X = 540 mm

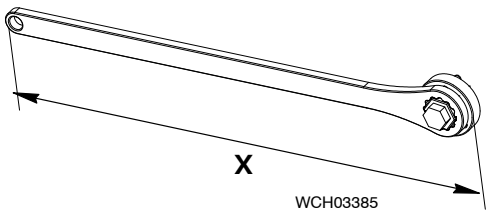


94701 1 Adjusting tool
For the ELBA assembly
X = 139 mm

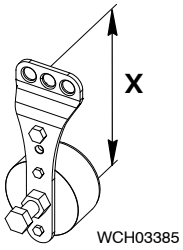


94702 1 Transportation tool
For the ELBA assembly
X = 200 mm

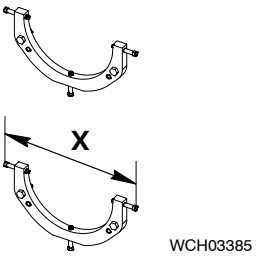
94703 1 Turning device
For the ELBA assembly
X = 1089 mm



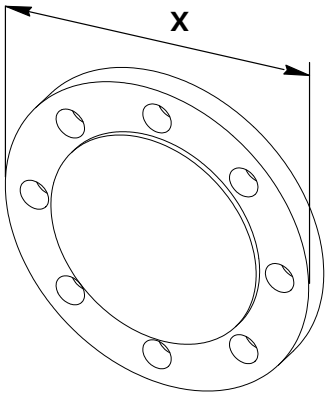
94704 1 Lifting tool
For the ELBA assembly
X = 368 mm



94705 2 Alignment tools
For the ELBA assembly
X = 326 mm



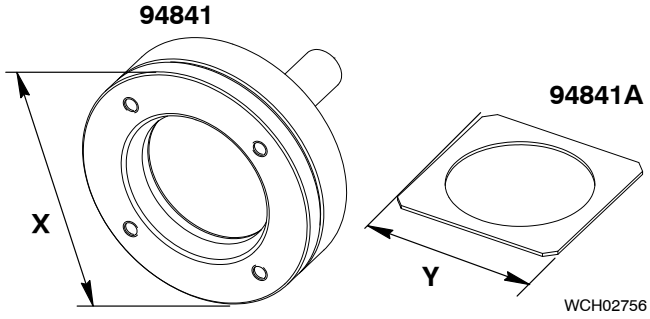
94831 1 **Blind flange**
To blank off the starting air pipe during emergency operation
X = ∅ 235 mm



WCH02289

94841 1 **Grinding tool**
For the hydraulic pipe
X = ∅ 65 mm, R100

94841A 1 **Stencil**
Y = 65 mm



WCH02756

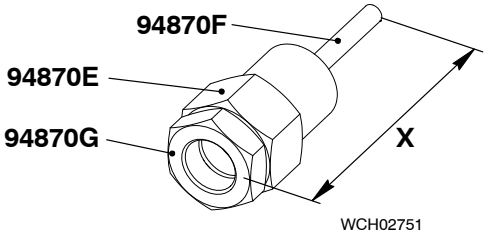
94870 1 **Grinding device**
For the HP fuel pipe
X = 166 mm
includes:

94870E 1 **Screw-on sleeve**
AF60

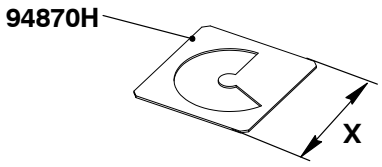
94870F 1 **Grinding tool**
with countersunk screw
M8

94870G 1 **Lock nut**
M36x2, AF46

94870H 1 **Template**
X = 70 mm



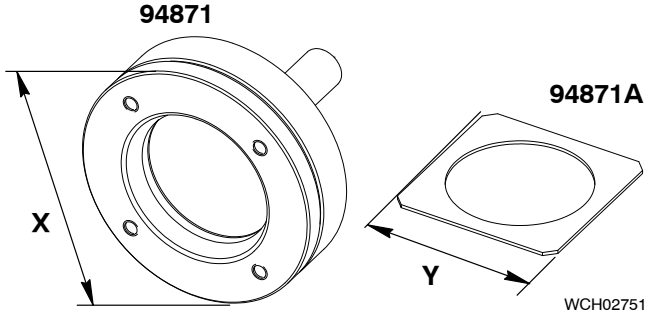
WCH02751



WCH02751

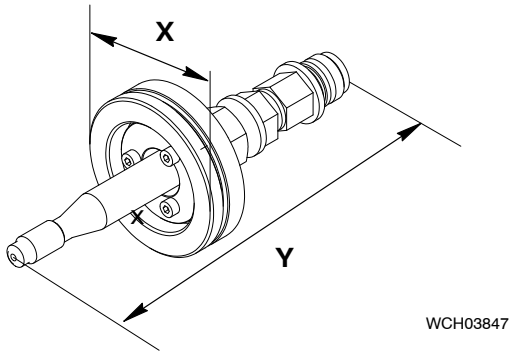
94871 1 **Grinding tool**
for the injection pipe
X = ∅ 60 mm, R30.5

94871A 1 **Stencil**
Y = 50 mm

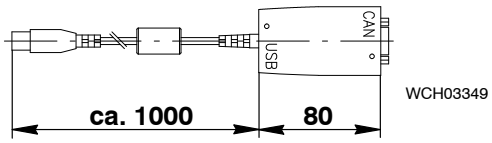


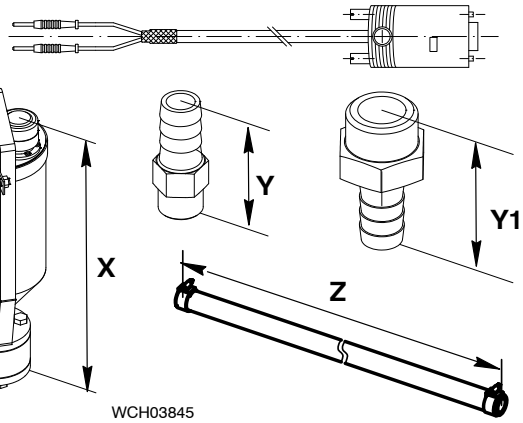
WCH02751

94573 **Assembly Tool**
for gear coupling on pilot fuel pump
X = 70 mm
Y = 181 mm



94930 1 **SW-download package**
ECS for uni-tool
includes:
94930A 1 UBS to CAN adapter
94930B 1 CAN cable (approx. 2.5 m)
94930C 1 Ethernet adapter cable
(software tool)

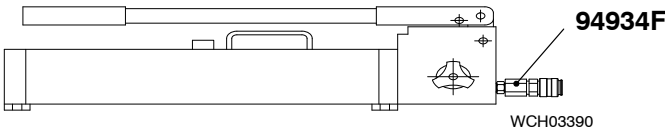




94844 1 **Lubrication device**
for supply unit lubrication during maintenance
X = 600 mm
Adaptors:
Y = 40 mm
Y1 =45 mm
Flexible hose:
Z = 3500 mm

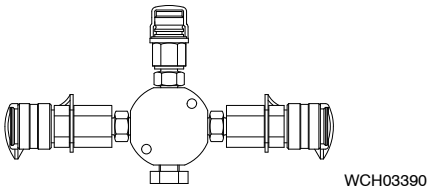
Hydraulic parts and pump

94931 1 HP oil pump
Operation pressure. Maximum permitted pressure is 2800 bar

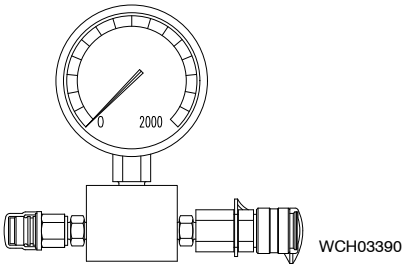


94934F 1 Adapter piece

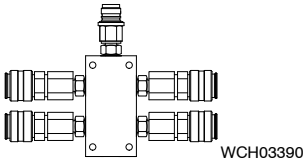
94934 2 Connection block



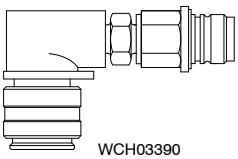
94934A 2 Pressure gauges



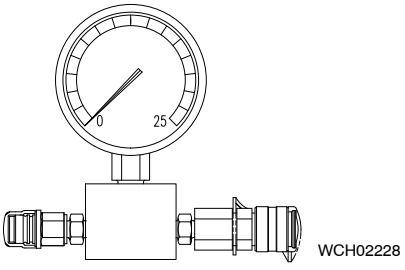
94934C 1 Distributing piece



94934G 4 Coupling elements

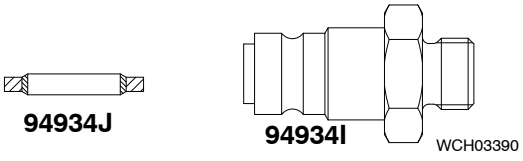


94934H 1 Pressure gauge
0–25 bar

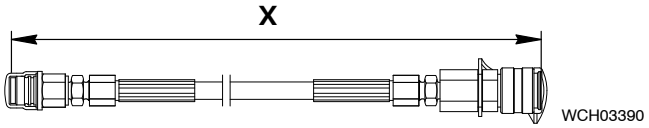


94934I 1 Connection nipple
To do a test of the lubrication quill

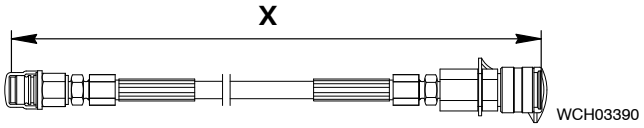
94934J 1 Tredo joint
To connect the nipple 94934I



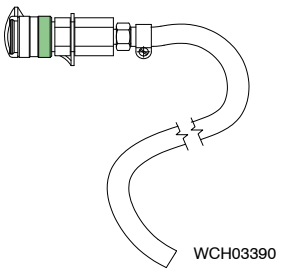
94935 5 HP hoses
with closing valves and coupling sockets
X = 2130 mm
Operation pressure max. 2000 bar



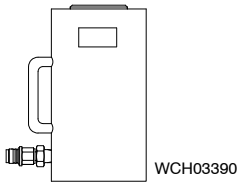
94935A 5 Flexible hoses
with closing valves and coupling sockets
X = 1210 mm
Operation pressure max. 2500 bar



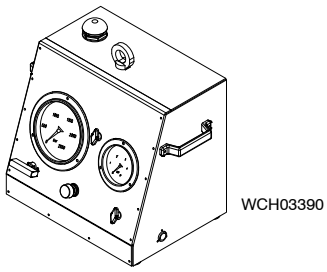
94935C 1 Hose
To drain oil from pre-tensioning jacks



94936 2 Hydraulic ram
with closing valves
Operation range 933 kN to 1002 kN
(95 t to 100 t)



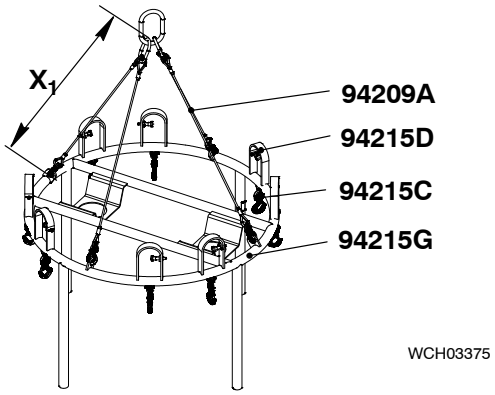
94942 1 Hydraulic unit
Operation pressure max. 2000 bar



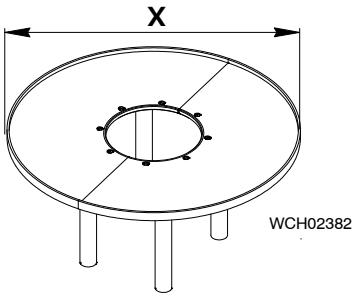
Recommended Special Tools

94215 1 Lifting tool
for cylinder cover pre-tensioners
Mass approx. 75.8 kg
Includes:

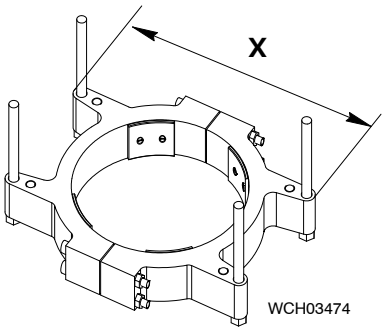
94209A	**1**	**Wire rope sling with hook**
94215C	**8**	**Shackle**
94215D	**8**	**Hooks** X_1 = 1000 mm
94215G	**1**	**Lifting tool**



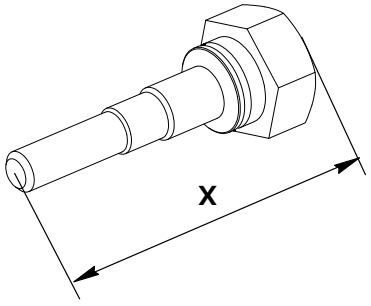
94234 1 Platform
for piston rod gland removal inside the engine
X = ∅ 850 mm
Mass approx. 33.2 kg



94235 1 Lifting tool
For the piston rod gland removal in the engine
X = 453 mm



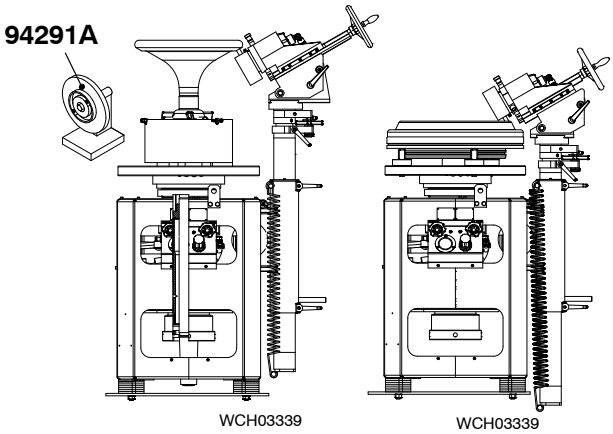
94259 2 Pressure element
For the exhaust valve
X = 243 mm



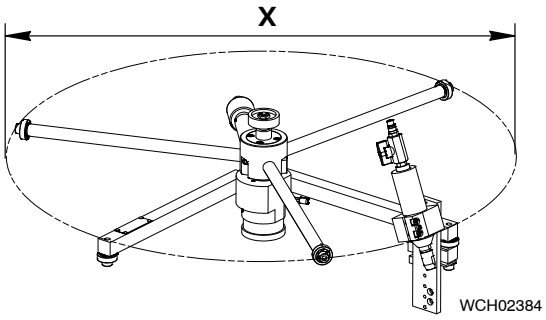
Recommended Special Tools

94291 **1** **Valve grinding device complete**
For the valve spindle and valve seat

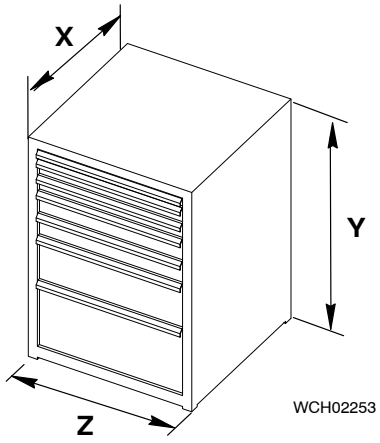
94291A **2** **Grinding discs**
(C-M No. 11373-01-01)



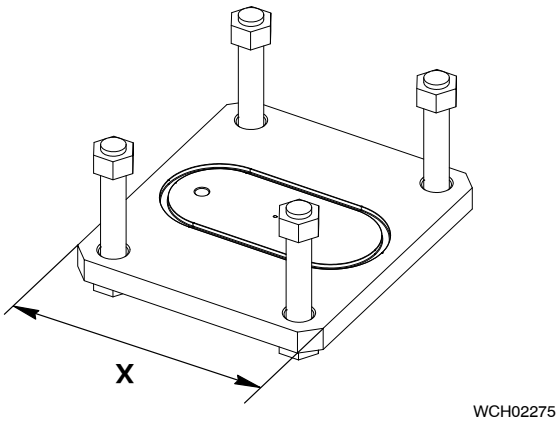
94299 **1** **Grinding device**
X = ∅ 834 mm



94300 **1** **Tool Cupboard**
X = 725 mm
Y = 1000 mm
Z = 717 mm
Mass approx. 133 kg

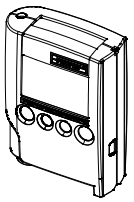


94349 **1** **Plate**
For the piston pressure tests
X = 336 mm
Mass approx. 34.5 kg

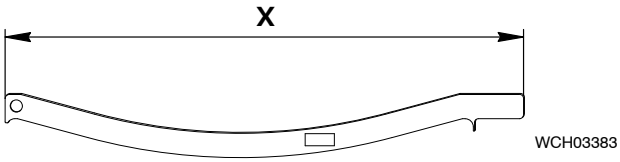


Recommended Special Tools

94356 1 Equipment case
with instruments
To measure the thickness of chrome-ceramic-layer on the piston rings

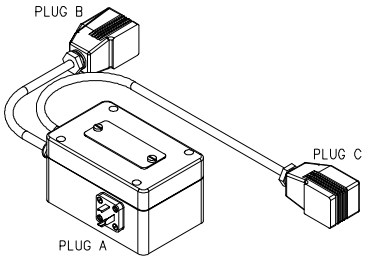

WCH01216

94366A 1 Template
To do a check of the piston crown contour
(when the piston is installed)
X = 849.7 mm



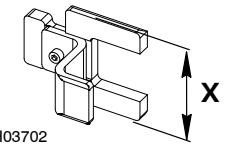
WCH03383

94929 2 Connecting cables with plugs
for emergency cylinder lubrication
Connector (plug C)
Plug B with cable: length = 0.5 m
Plug C with cable: length = 2.5 m



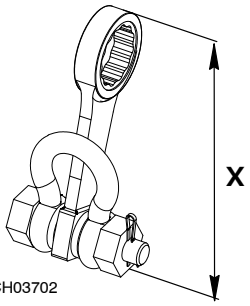
WCH01087

94412E Fork Wrench
X = 110 mm



WCH03702

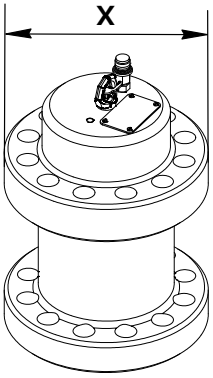
94412F Tightening device
X = 277 mm



WCH03702

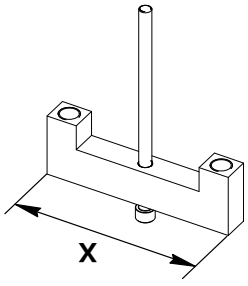
Recommended Special Tools

94595 1 Hydraulic ram
for assembling fuel pump
X = ∅ 270 mm
Mass approx. 79.4 kg
consisting of:



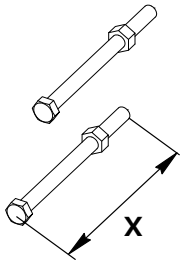
WCH02281

94595D 1 Piston reset device with short push rod
X = 255 mm



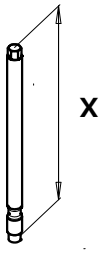
WCH02281

94595E 2 Screw M30x400
X = 418.7 mm



WCH02281

94595C 2 Long push rod
X = 470 mm



WCH02281

Intentionally blank