

Reciprocating Compressors for industrial refrigeration GEA Grasso 12

Service Instruction Manual

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SAFETY INSTRUCTIONS



Hint!

This manual must be carefully read and understood prior to installing and servicing the compressor (package)

General Safety

All service operations described in this servicemanual are only to be carried out by well-trained/qualified personnel and even then only after this service manual has been read carefully and is fully understood.

Personal safety

Observe all (inter)national and/or local safety standards, measures and regulations during reinstalling, repairing and connecting the compressor (package).

Mechanical safety

If the compressor does not have to be removed from its base, it is advisable to put warning labels on vital parts of the compressor saying that the plant is out-of-operation and must not be started up.

If the compressor has to be opened for service, the refrigerant has to be pumped down and the electric supply has to be cut off.

After having run the initial 100 operating hours, it is essential (in both new and modified plants) to replace the red running-in discharge oil filter element with the permanent grey filter element. Also replace the running-in suction gas filter element.

Check the direction of rotation is correct before re-starting the compressor.

PREFACE

General

1. All documentation can be downloaded via our web site.
2. Grasso's technical manuals includes "generic paragraphs"; this means that ***it can occur*** that not all data as described is relevant for the current compressor series as mentioned in this manual. (For instance, not all compressor series are suitable for all mentioned refrigerants or not all compressor series includes two-stage compressors)

Directives

Equipment is based on Pressure Equipment Directive (PED 97/23/EG) regulations and according to Machine Directive (MD 2006/42/EG) regulations.

The applied standards are:

NEN-EN-IEC 60204, NEN-EN-ISO 12100, NEN-EN-ISO 13857, NEN-EN 378

GENERAL INFO SIM



Warning!

Never change positions of parts when re-assembling the compressor. E.g. cylinder liners, suction valves, discharge valves and relief valves have to be replaced always in the original position.

All bolts and nuts have to be mounted according to the torques as given in table "Survey of torques for bolts and nuts" as available in this manual. If you cannot find this information, consult Grasso.

General

This compressor service manual is intended to be used in the field by qualified personnel of refrigeration installers or contractors for proper(re)assembly, inspection, repair and part or total overhaul of Grasso single-stage and two-stage piston compressors.

Installation and maintenance instructions

The manual should also and always be used together with the corresponding "Installation and Maintenance Manual" (IMM) meant for the operator. The IMM is supplied with every compressor or compressor package.

Additional design details

Additional design details are available in the manual "Product Information"

How to read the pages of this manual

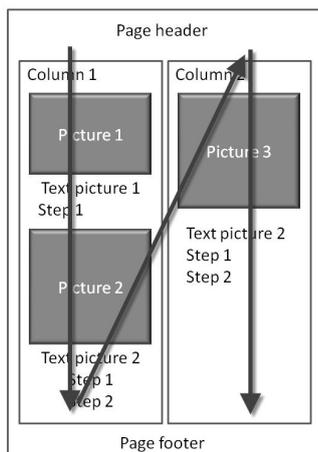


Fig.1



Hint!

When "[Tool set]" is mentioned in this manual, the tool as shown in the picture is part of the Grasso V tool set, which can be supplied by Grasso.

Important tables, refer to Chapter 5, Page 68!



Hint!

Tables like "Wear limits and tolerances" and "Torques for bolts and nuts" can be found at Chapter 5, Page 68

CYLINDER NUMBERING

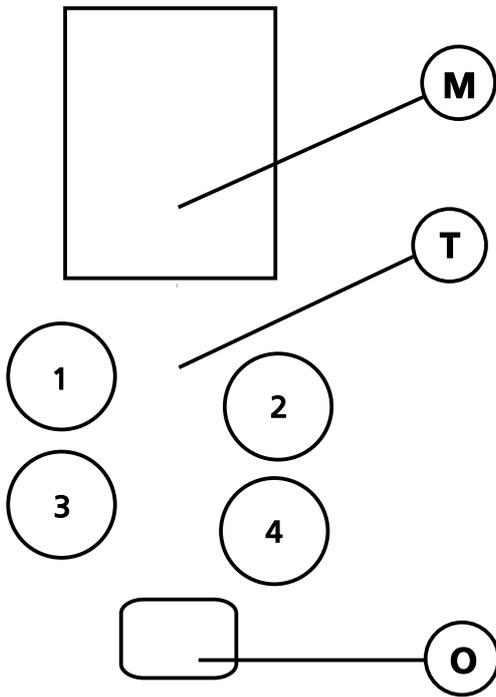


Fig.2: Cylinder numbering Grasso reciprocating compressors

Legend	
1, 2, 3, ...	Cylinder numbers
T	Top view of compressor
M	Motor/Drive end of compressor
O	Oil pump of compressor

GENERALINFO

Main setup data		
Description	Value	Remark
Start frequency	max. 6 starts per hour	
Time interval between stopping and re-starting	min. 2 minutes	
Time interval between starting and re-starting	min. 10 minutes	
Time interval between loading and unloading	min. 3 minutes	For continuous minimum part-load (i.e. more than 30 minutes) consult Grasso. Adjust the steps between up and down loading, in such a way that the system is running stable.
Oil level	25-75% crankcase sight glass	
Min. oil temperature	> 10 °C and > Pcrankcase + 15 K	
Max. oil temperature	Refer to oil selection table/ applied type of oil	Required oil viscosity; ≥ 10 cSt during operation at location of bearings
Control oil pressure	suction pressure + 8 bar	
Lubricating oil pressure difference	between 1.3 and 4.5 bar Setting approx. 2.0 bar	After a minimum of 15 minutes running time at an oil temperature of approx. 50 °C (122 °F)
Max. discharge temperature	170 °C	
Min. suction pressure	0.3 bar	
Max. intermediate pressure Max. suction pressure	NH3 - 7.0 bar R22 - 7.0 bar R134a - 6.2 bar R404A - 6.0 bar	
Pdischarge - Psuction	≤17.5 bar	
Superheat	>0 K for NH ₃ , >15K for R507/R404A/R134a	
Oil suction filter	Blue coloured filter element	

Main setup data		
Description	Value	Remark
Oil discharge - running in - filter	Red coloured filter element	 <p>Hint! Factory mounted; to be replaced after max. 100 running hours by permanent oil discharge filter element</p>
Oil discharge - permanent - filter	Grey filter element	 <p>Hint! Supplied loose; replacement for factory mounted running in filter</p>
Direction of rotation of compressor drive shaft	Counterclockwise when facing shaft end	

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1 REPAIR AND OVERHAUL

1.1 INTRODUCTION

Compressor and plant

All activities described can be carried out without taking the compressor off its base and without detaching it from the plant. In case of complete overhaul, it may, however, be useful to carry this out detached from the plant in a separate working area, whether or not in a workshop equipped for this purpose.

Accessories

This chapter only deals with the disassembly and assembly of a so-called "bare compressor" in standard design. This implies that, depending on the dismantling degree, it may be necessary to first completely or partially remove certain accessories.

It is recommended to distinctly mark the dismantled accessories or parts of them (for instance oil control lines and pressure gauge or safety switch lines, transducers, pressure and temperature sensors, V-belt pulleys and torsionally-stiff coupling) in order to avoid mistakes at reassembling.

Tools

For proper performance of the operations, at least the standard service tools and materials should be available.

Besides, for certain operations additional special GRASSO tools are required, which can be obtained as a complete standard service set.

Service Sets

Worn out parts are to be replaced by new parts which are available in sets with a brief service manual.

General

Although all the assembly and disassembly procedures shown relate to the two-stage compressor, they are basically applicable universally to all compressors. If not, it is explicitly stated in the text.

1.2 EVACUATION/DRYING THE REFRIGERATING SYSTEM

For evacuation of compressor only, refer to Section 1.3, Page 13

Procedure to evacuate and to dry a system:

- i. STATUS: System is filled with nitrogen and no oil has been added (oil prevents any trapped moisture from boiling off).
- ii. Verify that all valves in that part of the system to be evacuated are opened (refer also to the plant manual).
- iii. Connect vacuum pump to the evacuation/purging valve(s) of the compressor (for location of these valves refer to the "Product Information" or to a connection as mentioned in the plant manual and evacuate the system to approx. 6 mBar.
- iv. Break vacuum by charging dry nitrogen into the system.
- v. Repeat step iii, "Connect vacuum pump ...".
- vi. Wait approx. 24 hours.
- vii. If pressure has increased (system still contains moisture), repeat steps iv, and vi. Otherwise, continue with the "Initial oil charge" procedure.

1.3 EVACUATION, LEAK TESTING AND START-UP OF THE COMPRESSOR/PACKAGE

To evacuate the refrigeration system refer to Section 1.2, Page 13,

Always use a vacuum pump or pump-down unit to evacuate the refrigerant from the compressor.

1.3.1 EVACUATION OF REFRIGERANT BEFORE SERVICING

Procedure to evacuate the compressor:

1. Switch off main control panel
2. Remove main fuses
3. Close shut-off valves

4. Remove the refrigerant by means of a vacuum pump or pump-down unit, via the evacuation/purging valve(s) as prescribed by local safety regulations. For the location of these valves refer to the "Product Information".
5. Drain the oil from the compressor and oil separator, oil return /oil rectifier system if present.

1.3.2 LEAK-TIGHTNESS AFTER SERVICING

The necessary safety precautions should be taken before carrying out the leak-tightness test. To check leak-tightness use dry nitrogen at a positive pressure which is less than the admissible operating pressure of the low pressure stage.

1.3.3 EVACUATION AFTER SERVICING

After the pressure test has been completed, the compressor (package) must be evacuated and undergo a vacuum test. Evacuation is used to remove air and moisture from the compressor (package)

1.3.4 START-UP AFTER SERVICING

1. STATUS: Compressor (package) is dried and still evacuated.
2. Charge the oil separator, if present, with oil. See the appropriate Product Information for the correct quantity.
3. Charge the compressor crankcase with oil via the oil charge valve until the minimum level is seen at the sight glass at the level as indicated in IMM.
It is mandatory to pre-lubricate the oil circuit by adding the final quantity of oil via the charge valve mounted onto the oil pump by means of a separate oil filling pump. The required oil level is indicated in the IMM.
4. Re-install all accessories such as coupling, V-belt guard etc.
5. Open the shut-off valves.
6. Check the start-stop procedure.
7. Check all safeties and controls.

8. Re-install the main fuses.
9. Start up the compressor.
10. Check running condition.

Note:

The job isn't finished until the paper work is done! Complete the service report, e.g. Grasso report 00.89.062.

1.4 GENERAL RECOMMENDATIONS



Caution!

Always use new gaskets, O-rings and locking rings when reassembling after inspection or repair.

Use a torque wrench to tighten the threaded connections. (Survey of torques for bolts and nuts)

1. Do not disassemble more compressor parts than is necessary for the purpose (inspection, repair, overhaul).
2. Use clean and well-conditioned tools.
3. Make sure that there is a clean and neatly arranged working area well-equipped to provide temporary and adequately protected storage of dismantled components. Preferably use a table or working bench with a clean, moisture-free and non-scratching surface.
4. Immediately clean every dismantled part, check it for wear or damage and oil the machined surfaces of bright parts. The oiling is particularly important when the parts are not to be reassembled until after some time. Otherwise they will certainly become rusty.
5. The dismantled parts of every cylinder (cylinder liner, piston, connecting rod, valves) or of other main components should be kept together separately and marked if necessary. Thus they can later be replaced in their original place in the compressor.
6. All major parts that are not beyond repair have to be checked before reassembly for wear by measuring them and comparing the outcome with the wear limits and tolerances given in documentation.

7. Always replace damaged or worn compressor parts that are beyond repair by new GRASSO standard spare parts. These parts can always be fitted into the compressor without previous inspection or readjustments (if applicable, e.g. valves, connecting rods, etc.).
8. When fitting any moving parts, it is recommended to oil all running surfaces.

2 DISASSEMBLY

2.1 REMOVING FLYWHEEL

For many service and repair operations the flywheel or the V-belt pulley has to be removed.



Fig.3

1. Alternately unscrew the four M12-bolts five rotations (screwing anticlockwise).



Fig.4

2. Remove the locking plate.
3. Unscrew the centre M24-bolt five rotations (screwing anticlockwise).
4. Loosen the wheel by alternately tightening the four M12-bolts clockwise. Keep screwing until the wheel is entirely loose.



Fig.5

5. Remove the four M12 hexagon head bolts.
6. Fix a sling on the top of the wheel. Pull the sling in such a way that the wheel can still move freely on the shaft.

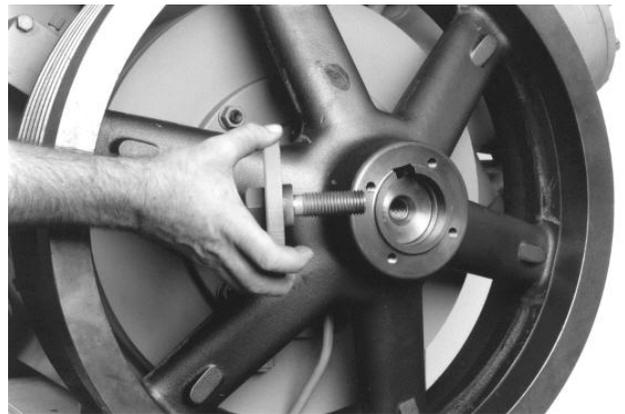


Fig.6

7. Remove the locking disc.



Fig.7

1. Now slide the wheel or V-belt pulley hanging in the sling off the compressor shaft.

2.2 DISMANTLING SUCTION GAS FILTER

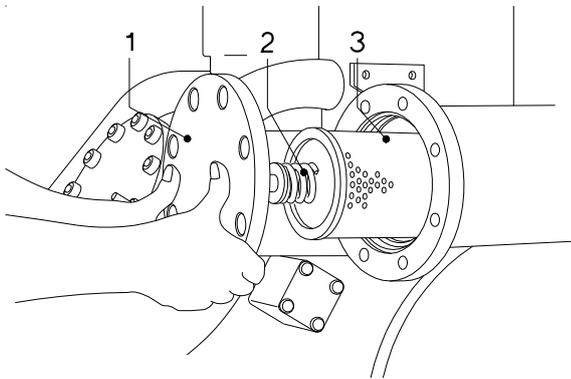


Fig.8

Legend	
1	Cover
2	Spring
3	Filter

1. Remove the bolts from the left cover of the suction gas filter housing.
2. Remove the cover with the pressure spring and filter mounted to it from the housing.
3. After the circlip ring has been removed from the centring pin, the filter can be easily removed.
4. Remove the O-ring from suction gas filter and replace a suction filter if it is dirty.
5. NOT FOR 21, 42, 63 and 84 compressors¹: Remove the cover on the right handed side of the suction gas filter housing in the same way and clean the inside of the housing.

2.3 DISMANTLING THE PRESSURE RELIEF VALVE HOUSING

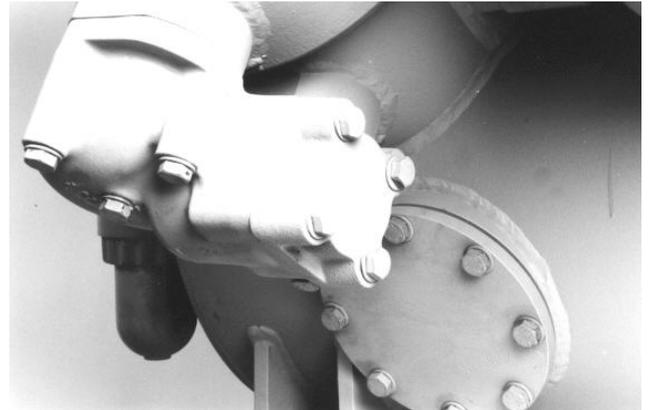


Fig.9: Back pressure dependent relief valve

The LP pressure relief valve housing is mounted against the cylinder block.

1. Unscrew four of the six M12 bolts out of the cylinder block and remove the bolts.
2. Unscrew the two remaining M12 bolts and remove the housing.



Warning!

If there is any doubt about the proper performance of a pressure relief valve, then the relief valve should be renewed immediately. When a pressure relief valve works improperly, discharge gas starts circulating through the cylinder head, which makes this cylinder head feel much warmer compared to other cylinder heads.

Never test the relief valve by closing the discharge valve of a running compressor. This will damage the seat of the relief valve.

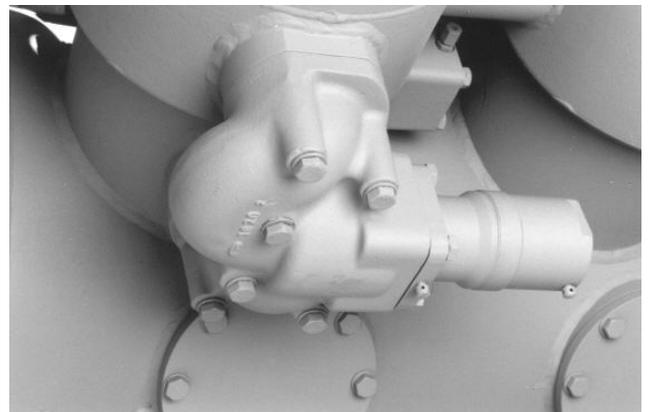


Fig.10: Back pressure independent relief valve

¹ Right side cover does not exist for 21, 42, 63 and 84 compressors



Hint!

For regular service it is not necessary to remove the pressure relief valve from its housing. However, if it has worked once, it can be dismantled/ serviced as described in this manual.

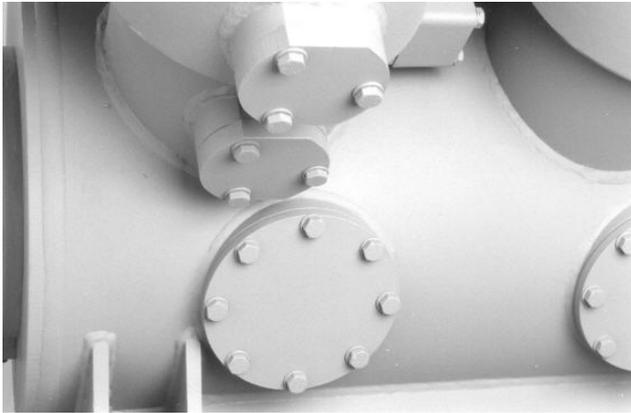


Fig.11: Blind flanges



Hint!

In some compressors blind flanges have been fitted at the connecting opening. There is no need to remove these blind flanges during normal servicing or repair.

2.4 REMOVING DISCHARGE VALVE ASSEMBLY

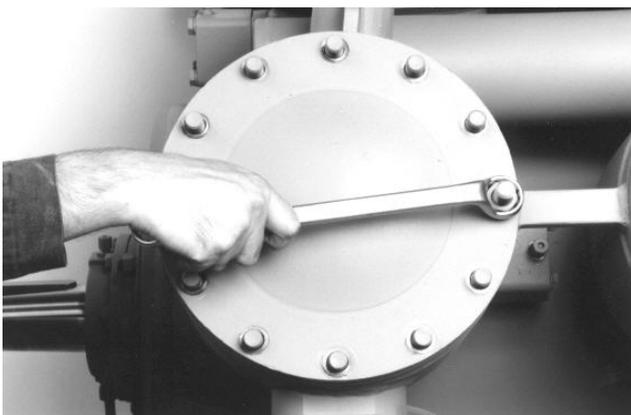


Fig.12

1. Remove dirt and paint particles from the cylinder head studs using a steel brush.
2. Oil all studs.
3. Remove all M16 bolts from the short studs.

4. Release the buffer spring tension by alternately unscrewing the two nuts on the longer studs.

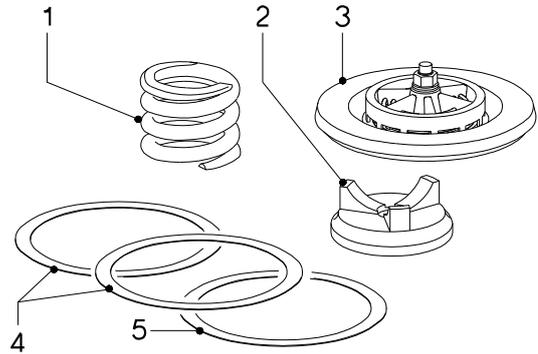


Fig.13: Discharge valve assy

Legend	
1	Buffer spring
2	Pressure spring cup
3	Discharge valve assembly
4	Sinusoidal springs
5	Suction valve ring

5. Remove the cylinder head cover, the buffer spring, the pressure spring cup, the discharge valve assembly with the two suction valve sinusoidal springs and the suction valve ring.

2.5 REMOVING THE PISTON/ CONNECTING ROD ASSEMBLY

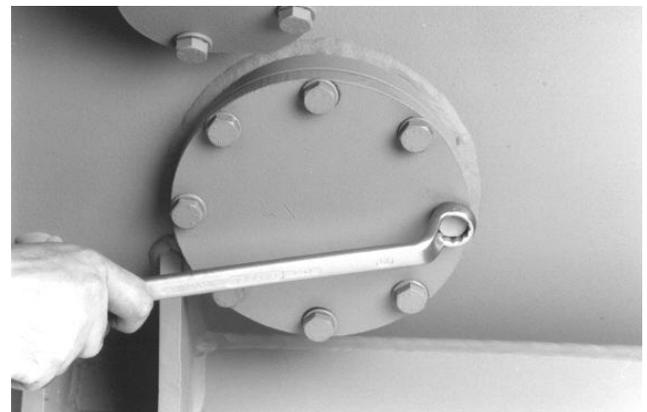


Fig.14

1. Place an oil drip tray under the service cover that is to be removed to collect the residual oil in the inclined crankcase openings.
2. Remove the service cover with O-ring opposite the cylinder under repair.
3. In the case of vertical cylinders, remove the opposing service covers.

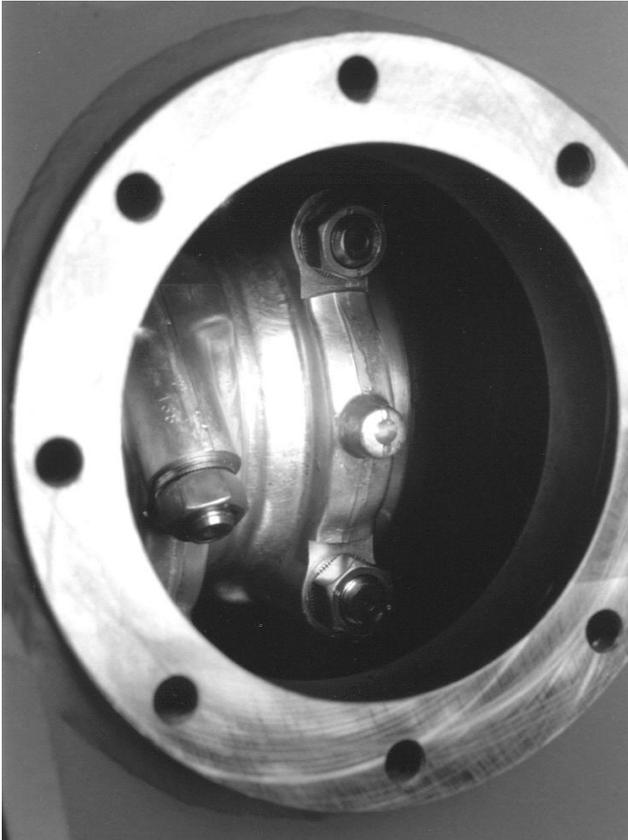


Fig.15

4. Rotate the crankshaft in such a way that the big end of the connecting rod becomes easily accessible.

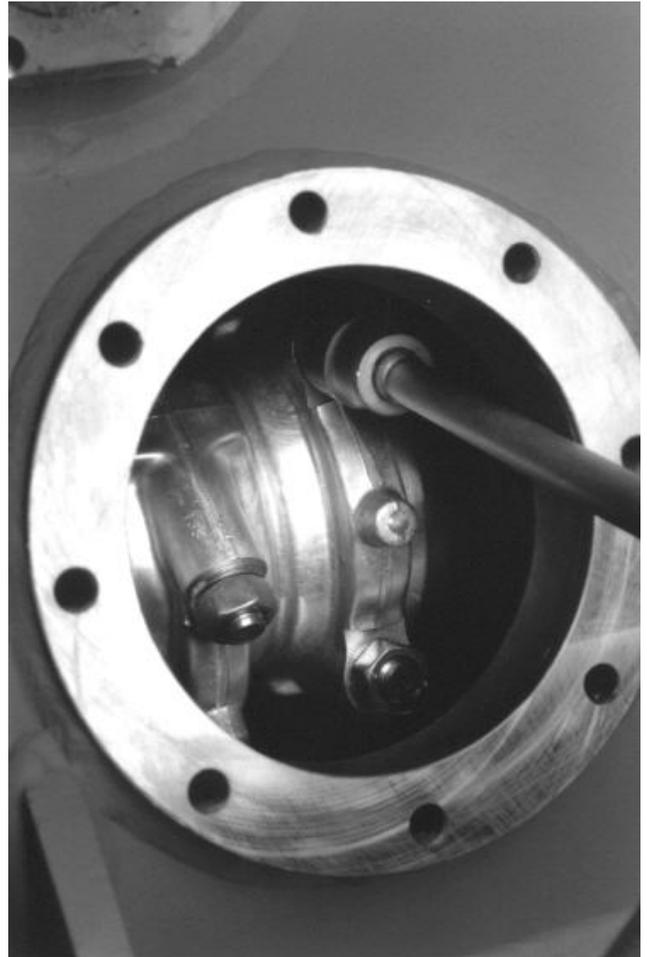


Fig.16

5. Unscrew the two M16 nuts from the connecting rod bolts and remove the (double) locking rings.

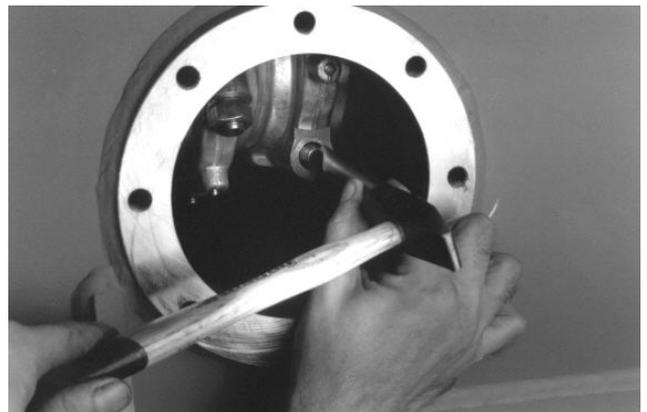


Fig.17

6. Tap up both connecting rod bolts a small amount of force so that the connecting rod cap can be removed easily.
7. Pull both connecting rod bolts back to their original places in the connecting rod.

8. Move the piston that is to be removed to top position by rotating the crankshaft by hand.

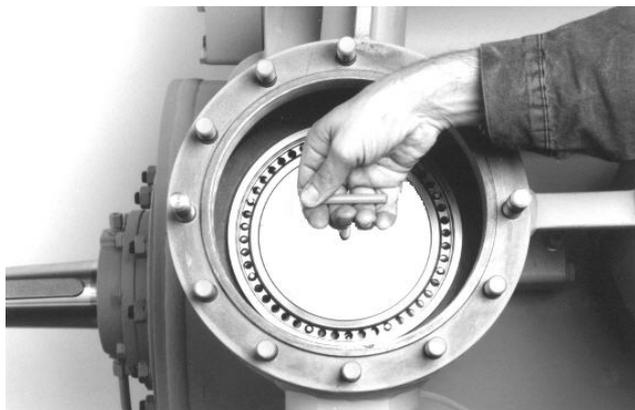


Fig.18

9. Insert the T-handle (from auxiliary tool kit) into the threaded hole at the top of the piston and carefully pull the piston and the connecting rod out of the cylinder liner, making sure that the big end of the connecting rod does not damage the cylinder liner.

10.  **Hint!**
The connecting rod cap is marked and belongs to a specific connecting rod. There is only one way to refit it onto the connecting rod. Therefore conrod numbers should always be situated on one side. Keep the corresponding connecting rod parts together!

11. Inspect the cylinder liner bore

-  **Hint!**
Measure the bore in three places of the empty and cleaned cylinder liner, being at the top, in the middle and at the bottom, and replace if the bore is larger than is given, or if the honing marks have (partly) disappeared.

2.6 REMOVING THE VALVE-LIFTING HOUSING AND CYLINDER LINER

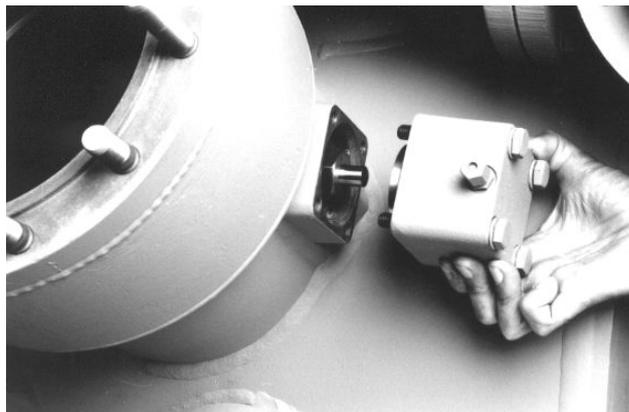


Fig.19

1. Disconnect the oil line on the valve-lifting housing.
2. Mark the position of (each) valve-lifting housing on the corresponding mounting flange.
3. Remove the entire housing, including the control piston in it, by unscrewing the M10 bolts off the cylinder jacket.



Hint!

REMARK: The valve-lifting housing can remain mounted to each cylinder wall if: - the control mechanism does not need to be inspected; - the cylinder liner does not have to be removed.



Fig.20

4. Remove the pressure pin from the plug and clean both the pressure pin and the bore in the end plug with respect to the measuring inspection described hereafter.
5. Inspecting the (hexagon) plug and pressure pin:

6. 6.a. Check the bore or the still mounted plug and replace it with a new pressure pin if the bore is over 14.07 mm.
- 6.b. Check the pressure pin for irreparable damage. For dismantling and/or inspection of the pressure pin, refer Section 4.8, Page 61.

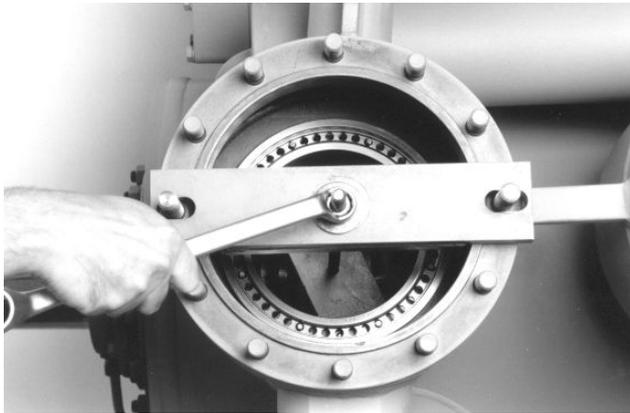


Fig.21

7. Place the longer green bar² over two studs of the cylinder head.
8. Insert the threaded rod with nut and washer into this bar.
9. Place the short green bar centrally across the bottom of the cylinder liner.
 - 9.a. Screw the threaded rod into this short bar until the assembly is fully closed.
 - 9.b. Now tighten the nut until the cylinder liner is loose.

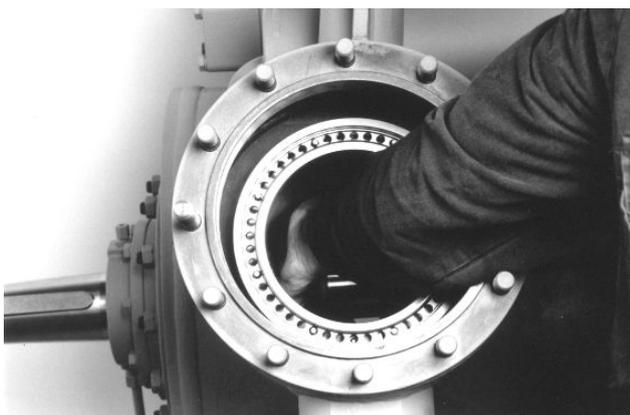


Fig.22

- 9.c. Remove the auxiliary tools and take out the cylinder liner by hand.

² All these parts are included in the auxiliary tool kit ETA.



Fig.23

- 9.d. Remove the gasket of the cylinder liner collar, determine the original thickness of the gasket (1.0, 1.25 or 1.50 mm) and write down this value on the corresponding cylinder wall.
- 9.e. Check the still mounted semi circular lever and supporting ring with dowel pin (= $\varnothing 6$ mm) for irreparable damage.

2.7 DISMANTLING THE ROTARY SHAFT SEAL



Fig.24

1. Dismantle and remove the leakage drain from the bottom of the shaft seal housing.



Fig.25

2. Remove the drive key from the crankshaft driving end.



Fig.26

3. Place the oil drip tray under the shaft seal housing and remove the M12 bolts from the shaft seal housing.



Fig.27

4. Slide the shaft seal housing over the shaft journal out of the bearing cover.

5. Take the counter slip ring from the shaft seal housing, remove the O-rings from the counter slip ring and from the rear side of the housing.

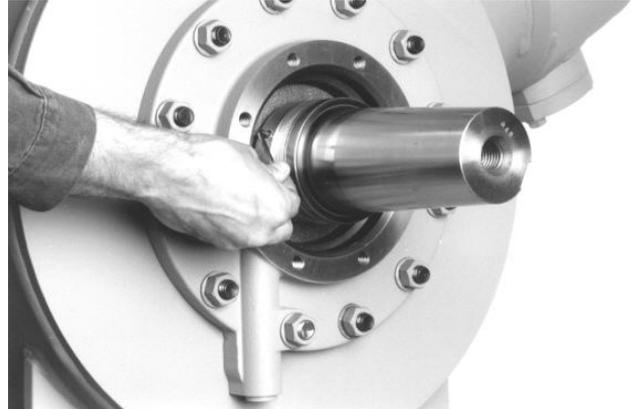


Fig.28

6. Unscrew the three locking screws at the circumference of the slip ring shaft seal using the M4 allen key from the auxiliary tool kit .

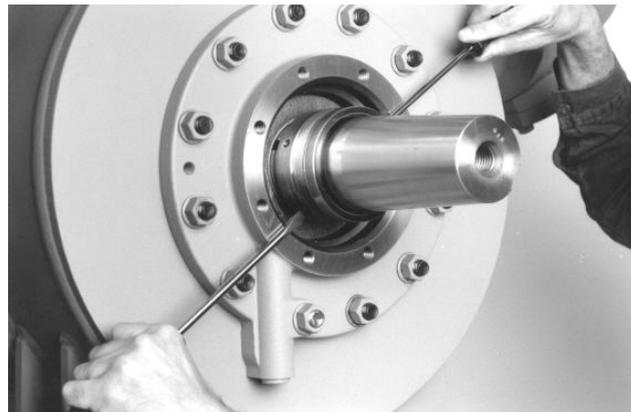


Fig.29

7. Place two similar screwdrivers behind the slip ring and carefully push the grips into the direction of the crankcase until the slip ring is loose.

- 7.a. Do not scratch the crankshaft!



Warning!

Avoid touching the (black) carbon ring (if necessary wear gloves or rub your hands with oil) and the lapped counter surface of the ring.

- 8.



Fig.30

9. Slide the slip ring from the shaft .

2.8 REMOVING OIL SUCTION AND OIL DISCHARGE FILTERS



Hint!

Pictures of oil pump are without the normally fitted oil charge valve.



Hint!

It is also possible to remove the oil pump and the filters mounted to it as a whole. If the filter elements only have to be inspected or replaced, it suffices to unscrew the grooved filter nut and the filter housing that has to be supported by hand, after an oil drip tray has been placed under it.



Hint!

Use the special tool key for removing oil filters.

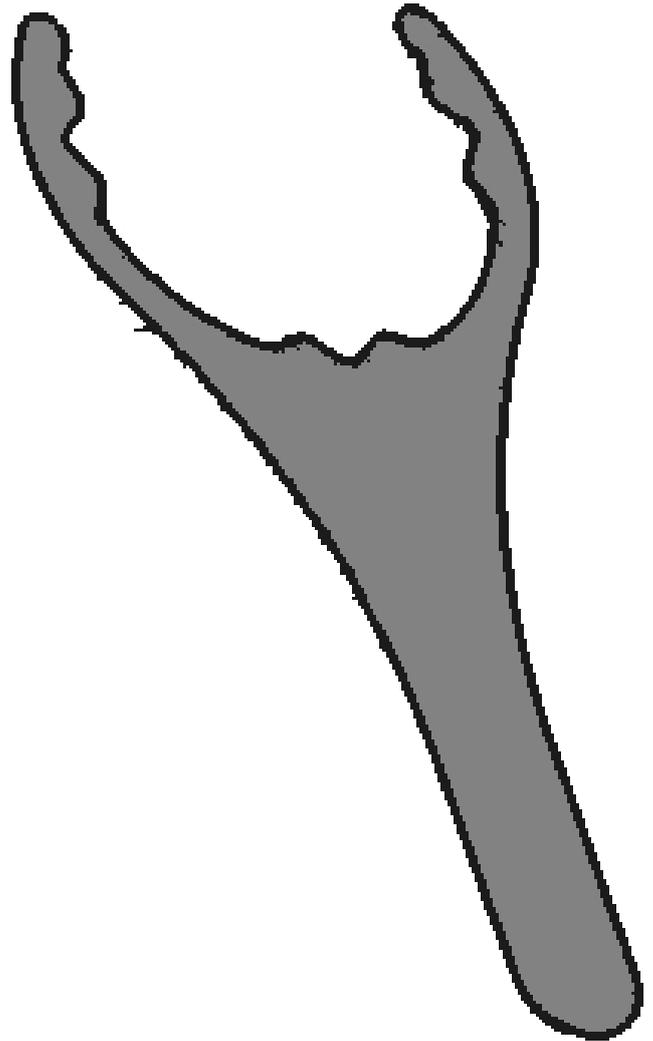


Fig.31: Special tool for removing oil filters

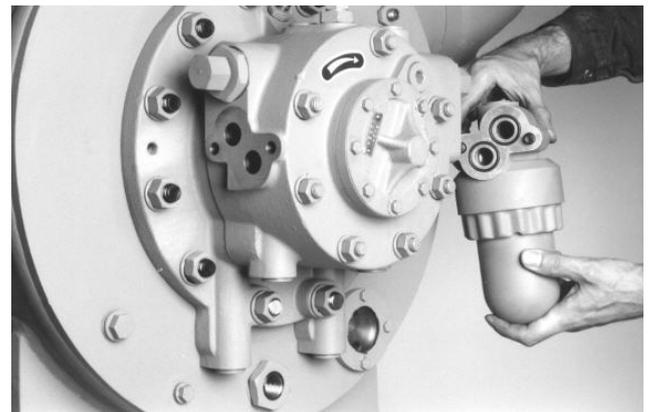


Fig.32: Oil pump and filter



Fig.33

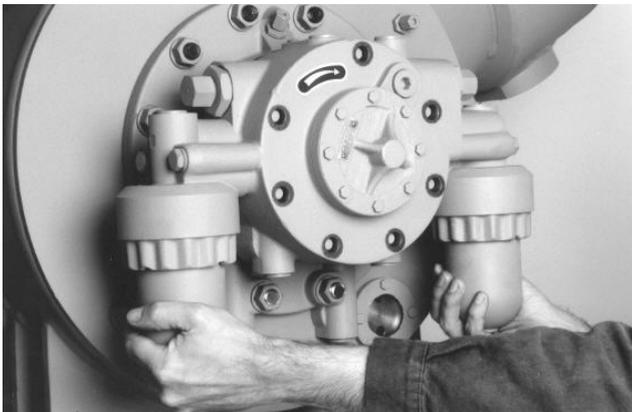


Fig.34

1. In order to remove the entire oil suction filter (left) and/or the oil discharge filter (right), only the two M10 mounting bolts of each filter have to be removed.
2. Mark the filter housing to prevent interchange!

3.  **Hint!**

As both filter housings are identical and can possibly be interchanged, every filter element is marked with a colour: - Red for the running-in oil discharge filter which must be replaced within the first 100 hours with a grey coloured oil discharge filter. The oil suction filter is coloured blue.

2.9 REMOVING OIL PUMP ASSEMBLY

1. Put an oil drip tray under the pump to collect the residual oil.

- 1.a. Unscrew the M12 nuts from the studs and slide the pump as a whole over the studs.



Hint!

If required, the oil pump can also be removed with both oil filters still mounted to it.

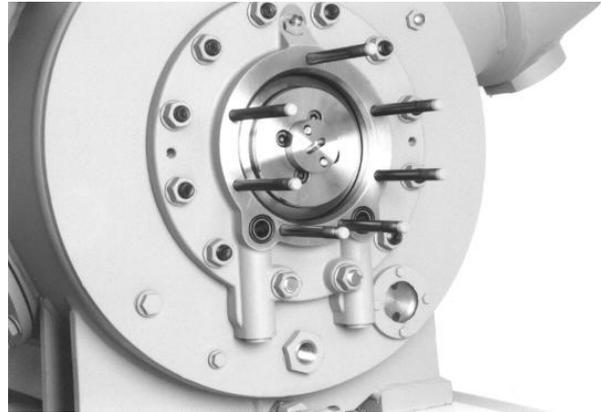


Fig.35

2. Remove the carrier disc which was left behind after removal of the oil pump.



Fig.36

1. Remove the now accessible four M10 socket bolts connecting the hold down disc with the crankshaft.
2. 2.a. Carefully remove the hold down disc with the fitted dowel pin from the crankshaft.



Warning!

On the crankshaft side this hold down disc is provided with a lapped surface. Damage to this surface as a result of rough use are very hard to repair and reuse of such a hold down disc can damage the compressor within a short time!

2.10 THRUST BEARING

Two types of thrust bearings have to be considered

1. Standard

- 1.a Bronze, mark 2, (latest version), refer Figure 37, Page 25
- 1.b Aluminium (old version), refer Figure 38, Page 25

2. Heavy duty

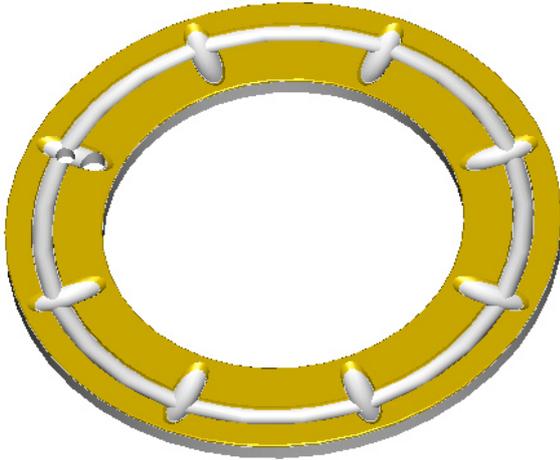


Fig.37: Standard bronze thrust bearing, "mark 2"



Fig.38: Old version of standard thrust bearing, aluminium.

2.10.1 DISMANTLING STANDARD THRUST BEARING

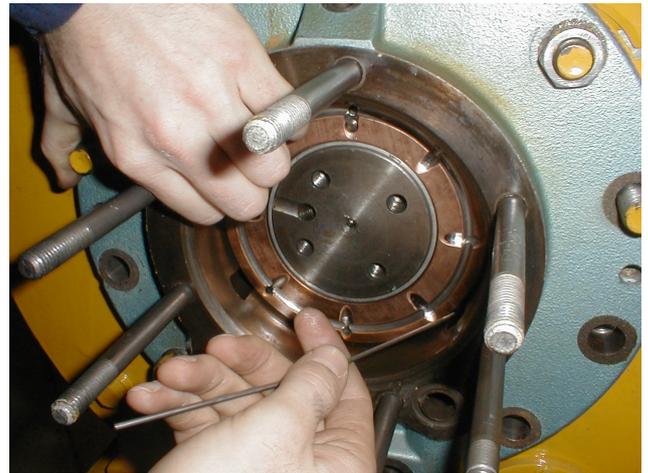


Fig.39

1. The released thrust bearing can now be carefully removed with an allen key (from the shaft seal kit or auxiliary tool set).



Hint!

As the adhesive power behind the thrust bearing has to be overcome, the ring can suddenly slip off.

2.10.2 HEAVY DUTY THRUST BEARING CONSTRUCTION

In addition to the standard design there is an alternative "heavy duty" roller thrust bearing available for certain applications and consists of a twin type roller assembly. One main bearing for the outward pull of the crankshaft and a second one for inward push of the crankshaft during vacuum operation. The total assembly is pre-loaded by means of springs to ensure proper running conditions are achieved.



Hint!

Compressors fitted with roller thrust bearings can be easily recognised by an external oil overflow line running from the oil pump to one of the crankcase covers and a marking on the top of the oil pump. (Compressors fitted with the standard thrust bearing arrangement have an internal overflow back to the crankcase and no marking)

2.10.2.1 DISMANTLING HEAVY DUTY THRUST BEARING

Remove external oil line, oil pump and carrier disk

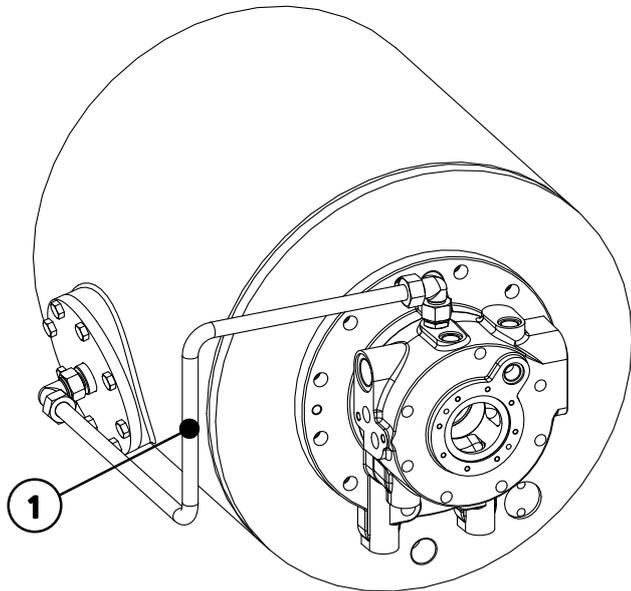


Fig.40: External oil line

1. Remove the external oil line (1) which is connected from the top of the oil pump to the service cover.
2. Remove the oil pump. Unscrew the M12 nuts, take off the washers and slide the oil pump of the M12 studs
 - 2.a. Pay attention not to lose the springs or the spring retainer.
3. Remove the carrier disc.

Remove heavy duty thrust bearing

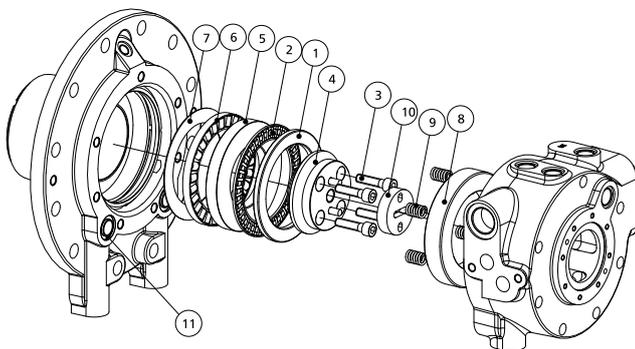


Fig.41: Heavy duty thrust bearing



Warning!

All running surfaces of the washers in contact with the cylindrical roller thrust bearing and the needle thrust bearing are hardened and smooth machined. Damages to these surfaces as a result of rough use are very hard to repair and reuse of such rings can damage the compressor within a short time

1. Remove the 7 mm. thick housing washer (1) from the hold down disc (4).
2. Remove the needle thrust bearing (2) from the hold down disc (4).
3. Remove the now accessible four M10 socket bolts (3) and the hold down disc (4) which is connected to the shaft washer (5).
4. Remove the shaft washer (5) from the crankshaft.
5. Remove the cylindrical roller thrust bearing (6) from the crankshaft.
6. The released 1 mm. thick thrust washer (7) can be carefully removed with a wire hook as shown Figure 42, Page 26.

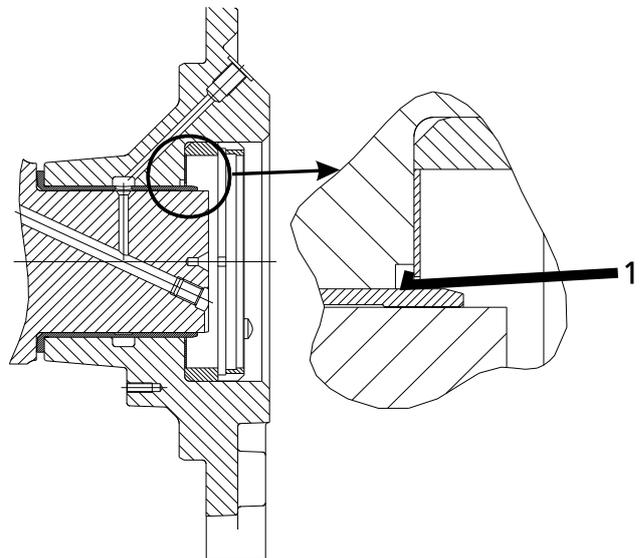


Fig.42: Remove thrust washer with hook (1)

- 6.a. The bearing cover has been equipped with three round shaped chambers to create space for a wire hook to grip behind the thrust washer for removal.



Warning!

As the adhesive power behind the 1 mm. thick thrust washer (7) has to be overcome, the ring can suddenly slip off.

7. Remove the spring retainer (8) from the oil pump housing.
8. Remove the springs (9) from the spring retainer(8)

2.11 REMOVING CRANKSHAFT, INTERMEDIATE BEARING AND MAIN BEARINGS

2.11.1 Introduction

1. Before starting, the following components must have been removed:
 - 1.a. All discharge valves
 - 1.b. All pistons and connecting rods
 - 1.c. Shaft seal and key
 - 1.d. Oil pump
 - 1.e. Thrust bearing



Hint!

In case of direct drive, preferably remove the crankshaft via the pump side.

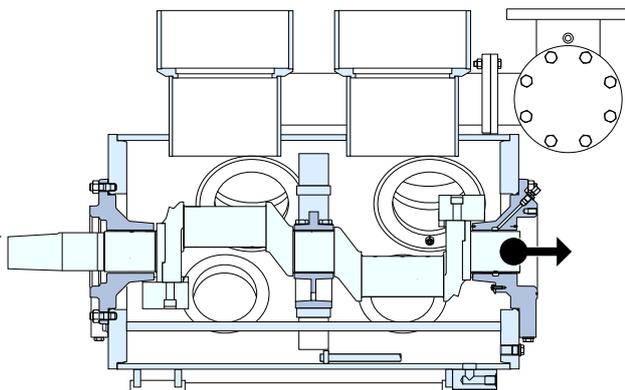


Fig.43

2.11.2 Intermediate bearings in 4, 6, 9 and 12 cylinder compressors



Fig.44

1. Mark both bearing block parts of each intermediate bearing so that they can later be refitted in the same position. For easy reference the crankshaft has been left out!
2. 2.a. Remove both M20 bolts with corresponding toothed spring washers from the intermediate bearing support(s) in the crankcase.

It is not necessary to remove the counter weights from the crankshaft, but on account of the crankshaft weight, the counter weights may preferably be dismantled.

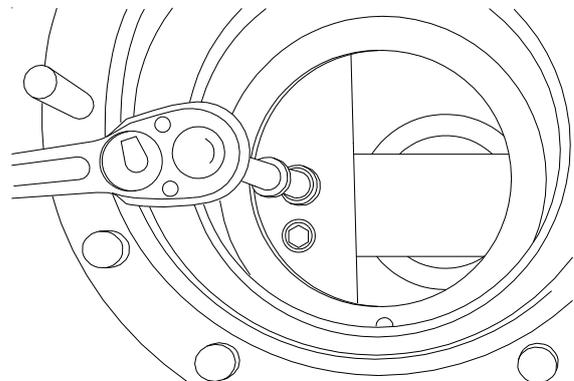


Fig.45

3. Write down the markings of the counterweights before they are taken off the crankshaft for faultless replacement later on.
4. 4.a. Unscrew both M16 bolts from each counterweight.
- 4.b. Remove the counterweights with the (double) locking rings.

2.11.3 2 and 3 cylinder compressors (i.e. without intermediate bearing)

1. Remove the swivel on top of the bearing cover on the pump side.
2. 2.a. Unscrew all M16 nuts from the studs of the bearing cover on the pump side.
- 2.b. Screw two M10 (jacking) bolts into the threaded holes on both sides of the bearing cover.
- 2.c. Tighten these two bolts evenly and alternately until the bearing cover is loose.

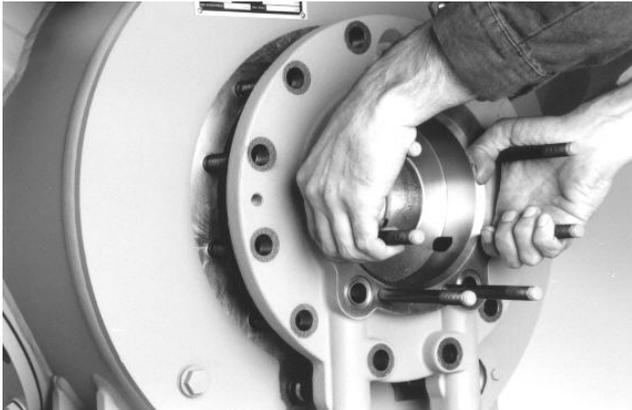


Fig.46

3. 3.a. Remove the bearing cover with the corresponding O-ring on the pump side. Now the crankshaft of the 2 and 3 cylinder compressor only rests in the bearing cover on the driving side.
- 3.b. Assisted by a second person, now carefully remove the crankshaft from the crankcase through the opening on the oil pump side.
- 3.c. Put the crankshaft down on a clean place. If the bearing is only to be inspected, there is no need to remove the parts mentioned.

2.11.4 4, 6, 9 and 12 cylinder compressors (with intermediate bearing)

1. Remove the swivel on top of the bearing cover on the pump side.
2. 2.a. Unscrew all M16 nuts from the studs of the bearing cover on the pump side.
- 2.b. Screw two M10 (jacking) bolts into the threaded holes on both sides of the bearing cover.
- 2.c. Tighten these two bolts evenly and alternately until the bearing cover is loose.

3. Remove the bearing cover (and the O-ring) and put it aside separately.



Hint!

As the 4 and 6 cylinder compressor has only one intermediate bearing, the crankshaft has to be supported.

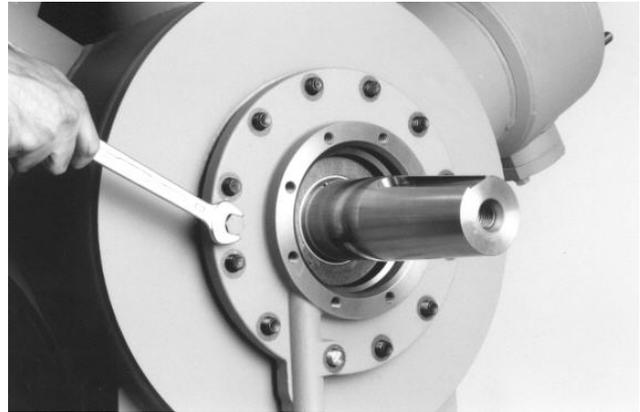


Fig.47

4. Unscrew all M16 nuts from the studs of the bearing cover on the driving side.
5. 5.a. Tighten the two jacking bolts further until the bearing cover is loose.
- 5.b. Remove the bearing cover (and the O-ring) and put it aside separately.

2.11.5 Removing the crankshaft, METHOD A (without auxiliary tools)

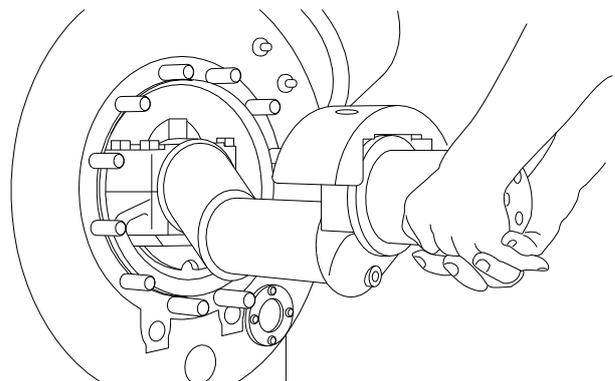


Fig.48

1. Remove the crankshaft of the 4, 6, 9, and 12 cylinder compressor in steps.

2. 2.a. Make use of the intermediate bearings and/or crank webs and the still mounted counter weights, for use as supports on the edges of the crankcase openings.
 - 2.b. With the 4, 6, 9 and 12 cylinder compressor, unscrew the four M16 intermediate bearing bolts.
 - 2.c. Remove both bearing block halves from the crankshaft and prepare them for inspection by reassembling them to each other leaving out the crankshaft.
3. The crankshaft can be removed more easily by making use of a simple tool. This method B (with auxiliary tool) is described below.

2.11.6 Removing the crankshaft method B (with auxiliary tools)

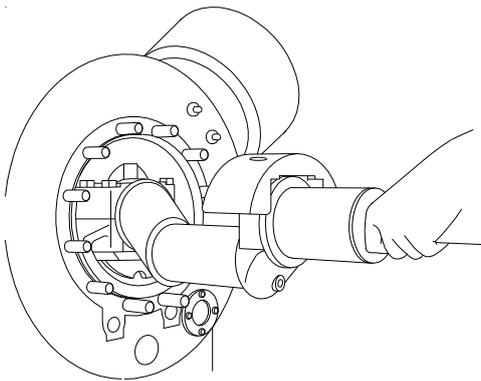


Fig.49

1. By sliding the long tool (not available from Grasso) over the shaft end on the pump side and the short tool over the shaft end on the driving side, the crankshaft can now be easily removed from the crankcase with assistance from a second person.
2. 2.a. With the 4, 6, 9 and 12 cylinder compressor unscrew the M16 intermediate bearing bolts.
- 2.b. Take both bearing block halves from the crankshaft and prepare them for inspection by reassembling them to each other leaving out the crankshaft.

2.11.7 Internal oil connection line

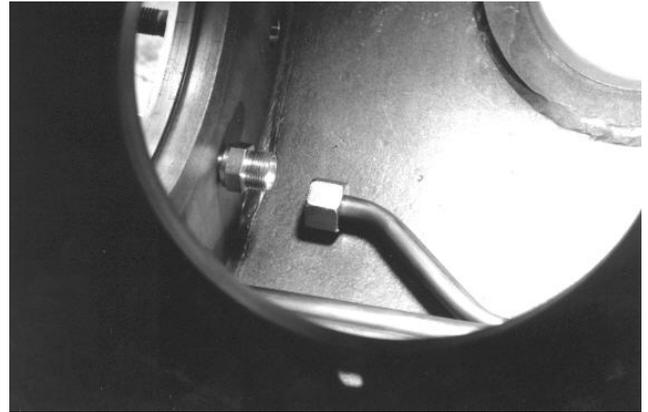


Fig.50

1. Uncouple and remove the internal oil connecting line and remove the oil line.

2.11.8 Line coupling pieces



Fig.51

1. Remove all line coupling pieces from both sides of the crankcase.

3 INSPECTION AND PREASSEMBLY



Warning!

All bolts and nuts have to be mounted according to the torques as given in table "Survey of torques for bolts and nuts" as available in this manual. If you cannot find this information, consult Grasso.

3.1 PRESSURE RELIEF VALVE ASSEMBLY

General

A defect or malfunctioning pressure relief valve can and may not be repaired. In these cases a new relief valve has to be ordered (safety regulation).

Two different types of relief valves can be applied:

1. Back pressure dependent
2. Back pressure independent

3.1.1 Back pressure dependent relief valve

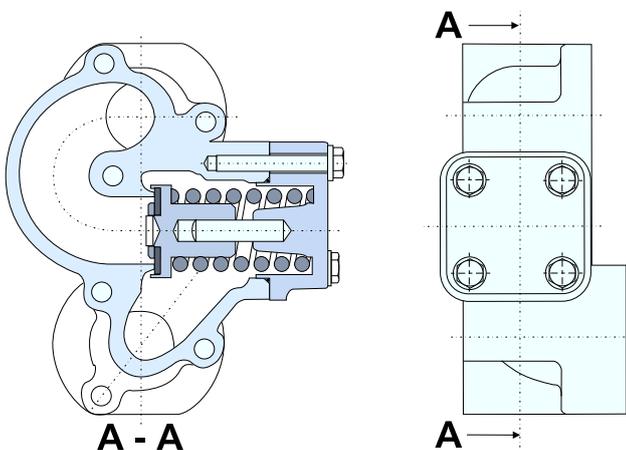


Fig.52: Back pressure dependent



Hint!

This type of relief valve can be supplied with different factory settings. Never change these relief valve(s) from compressor and/or position.

3.1.2 Back pressure independent relief valve

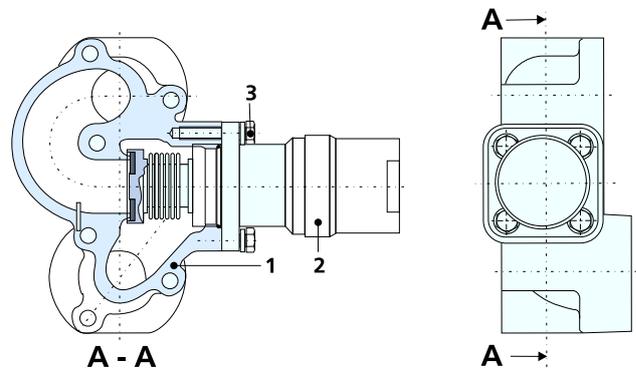


Fig.53: Back pressure independent

This back pressure dependent pressure relief valve consists of two major components, the pressure relief valve housing (1) and the pressure assembly (2). With this pressure relief valve it is permitted to replace only the pressure assembly (2) without the valve housing (1).

1. The cause of a malfunctioning pressure relief valve is usually a minor damage in the teflon seal of the pressure assembly (2).
2. Check the valve seat in the pressure relief valve housing (1).
3. In order to inspect this, only the four M12 bolts (3) have to be unscrewed from the pressure relief valve housing to remove the pressure assembly (2).
4. If damage or wear of the teflon ring of the pressure assembly (2) is detected, check whether this can be remedied by polishing.
5. Slight wear can be remedied with polishing paper.
6. Reassemble all parts into a whole after inspection/repair.

3.2 LUBRICATING OIL PRESSURE REGULATOR

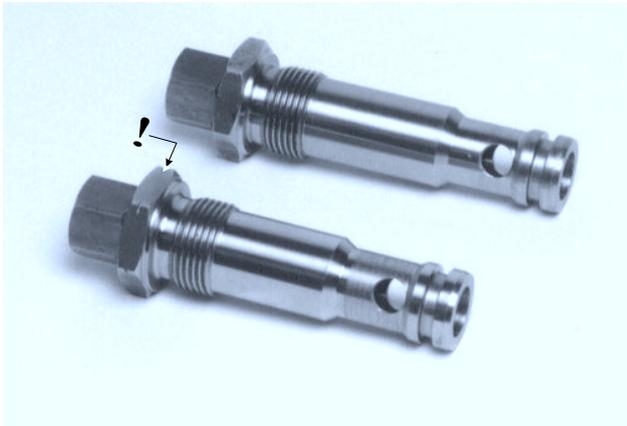


Fig.54: Oil pressure regulators

1. The lubricating oil pressure regulator (not equipped with a groove in the hexagon nut) (see Figure 54, Page 31) is fitted in the left-hand side of the pump and can be taken out with the help of a ring spanner or socket spanner 41, provided that the oil suction filter has been removed.

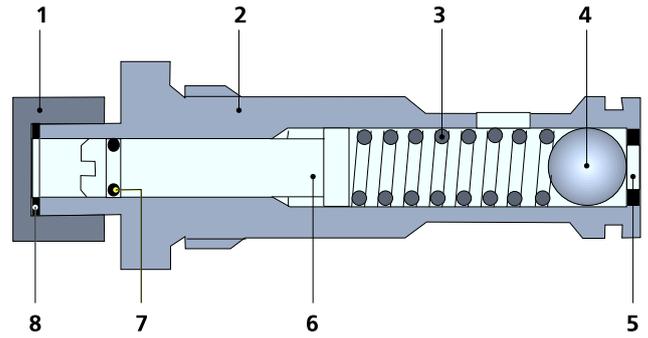


Fig.55

Legend	
1	Cap
2	Housing
3	Pressure spring
4	Ball
5	Circlip ring
6	Set bolt
7	O-ring
8	Alu-ring

2. Renew O-ring (7) and Alu-ring(8)
 All parts forming the regulator do not need wear inspection, but it is recommended to clean all (disassembled) regulator parts, to oil them with compressor oil and to reassemble.



Hint!

The pressure can be adjusted with a screwdriver only during operation.

3.3 CONTROL OIL PRESSURE REGULATOR

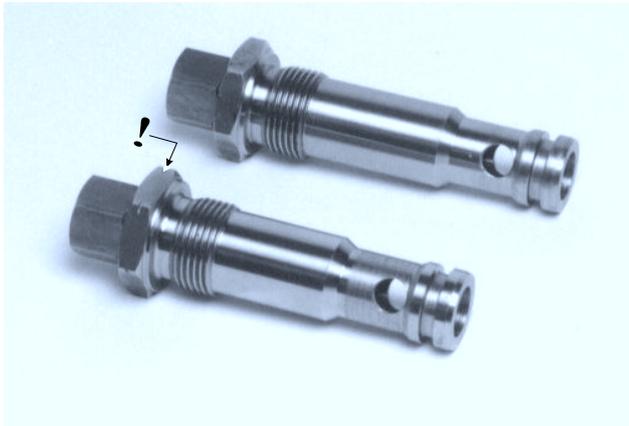


Fig.56: Oil pressure regulators

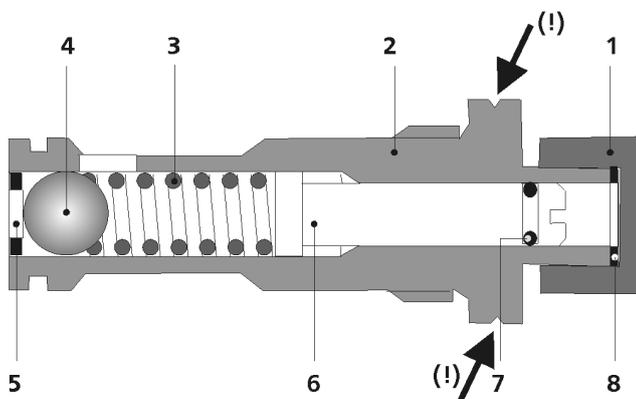


Fig.57: Control oil pressure regulator

1. The control pressure regulator (equipped with a groove in the hexagon nut, see lower regulator in Figure 56, Page 32) fitted in the right-hand side of the pump can be taken out with a ring spanner or socket spanner 41, provided that the oil discharge filter has been removed.
2. Disassemble, inspect and reassemble as described in relation to the lubrication oil pressure regulator.

3.4 VALVE-LIFTING CONTROL MECHANISM RC12

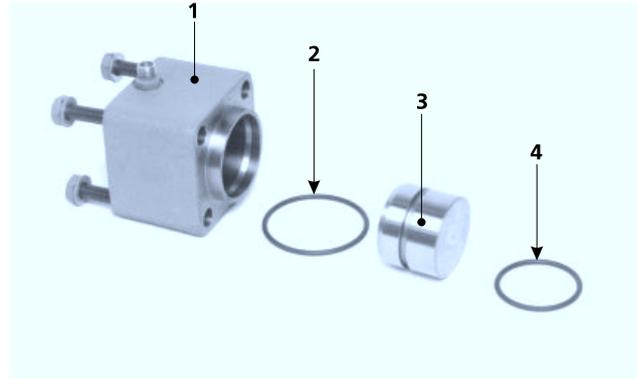


Fig.58

1. Remove the control piston (3) from the housing (1) with the T-handle (part of the auxiliary tool kit).
 - 1.a. Remove the O-ring (4) and clean the piston.
 - 1.b. Clean the control piston bore in the valve-lifting housing and check this for wear or slight damage (which may be remedied with polishing paper) and replace the housing if the bore is over 51.075 mm.
 - 1.c. Renew the O-ring (2), fit the lubricated piston with a new O-ring (4) into the housing and put it apart to be reassembled later.
1. If the pressure pin cannot easily move in and out of the (firmly tightened) plug (on the side of every cylinder head), due to slight wear or damage of the dowel pin and in the bore of the plug this may be remedied with polishing paper.
 - 1.a. In the case of irreparable damage or wear, both the plug and the dowel pin have to be replaced.

3.5 DISCHARGE VALVE ASSEMBLY

General

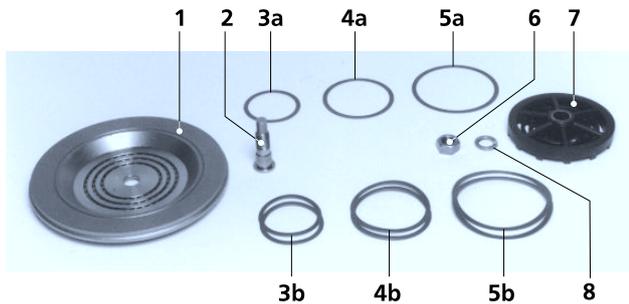


Fig.59: 8

1. Insert an 8 mm allen key into the bottom of the discharge valve assembly.
 - 1.a. Clamp the allen key in a vice and remove the M16 nut (6) from the central bolt (2), the double locking ring (8), the discharge valve stroke limiter (7), the sets of valve rings (3a, 4a and 5a) and sinusoidal springs (3b, 4b and 5b)
 - 1.b. Thoroughly clean all valve parts and the valve plate (1).

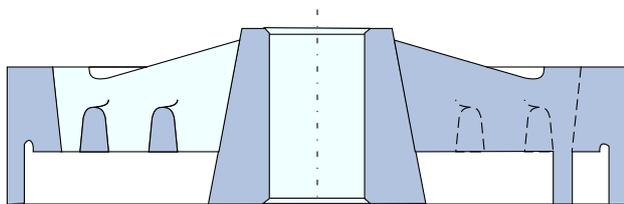


Fig.60: Stroke limiter

2. Inspect the discharge valve stroke limiter and the valve ring guide cams on the bottom side of the stroke limiter for wear.

In case of wear (shifting of valve rings and valve springs) or damage due to another cause, the discharge valve stroke limiter has to be renewed.

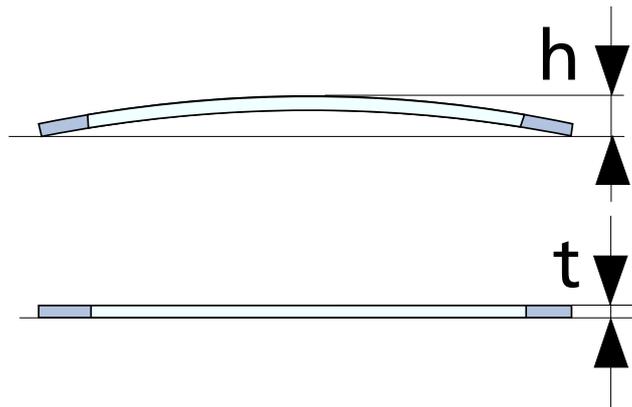


Fig.61: 10

1. Replace the discharge valve sinusoidal springs when they are damaged/discoloured and when the untensioned height "h" is less than:
 - 2.2 mm for the sinusoidal springs with the smallest diameter,
 - 3.5 mm for the sinusoidal springs with the medium diameter,
 - 5.5 mm for the sinusoidal springs with the largest diameter.
 - 1.a. Also replace the valve seat if due to wear the total scoring of the seat is over 0.2 mm.

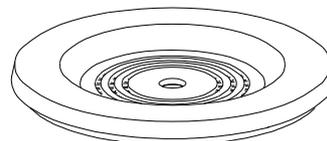


Fig.62: Valve plate

2. Check the discharge valve seat for damage, wear or scoring. If during this inspection the valve plate appears to have made contact with the piston, the connecting rod bearings have to be checked as well; the clearance should then be determined.

Preassembling the discharge valves

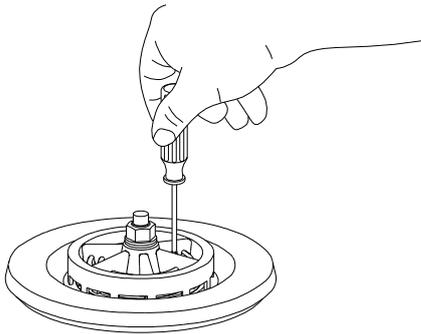


Fig.63: 12

1. Place the 3 discharge valve rings in their respective locations on the valve seat then cover each with the corresponding pair of sinusoidal springs (with convex side facing away from the valve plate).

Carefully position the discharge stroke limiter over the valve plate without dislodging the ring and springs.

- 1.a. Adjust the clamped valve rings and valve springs with a screwdriver until all cams of the stroke limiter touch the valve seat.
- 1.b. Fit the (M16) central bolt with a nut and a new double locking ring.
- 1.c. Tighten this bolt/nut joint to the torque as given in Section 5.1, Page 68.

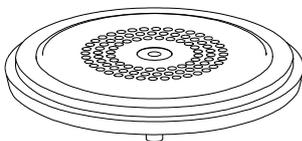
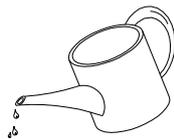


Fig.64

2. Place the discharge valve with the nut in the vice.
 - 2.a. Fill the openings with, for instance, kerosene or paraffin. After 2-3 minutes no leakage should be visible.

Suction valve

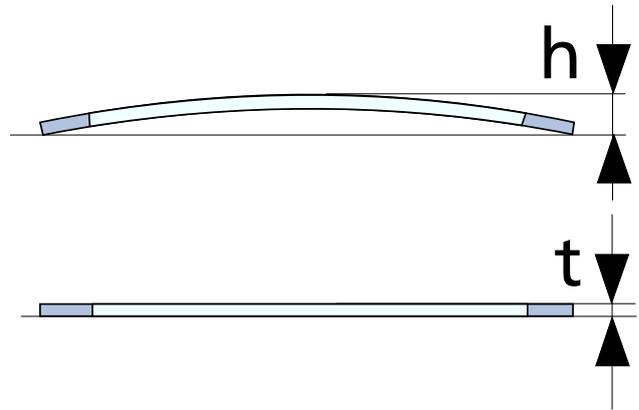


Fig.65: 10

1. Replace the suction valve sinusoidal springs when they are damaged or discoloured and when the unextended height "h" is less than 9.6 mm.
 - 1.a. Also replace the valve seat if due to wear the total scoring of the valve seat is over 0.2 mm.
 - 1.b. Also check the suction valve rings and replace them if the thickness "t" is less than 0.8mm in various places.

3.6 PISTON/CONNECTING ROD GRASSO 12

Since spring 2015, a new type of piston configuration has been introduced as replacement for the original configuration item no. 2417011.

This new piston assy DN160 with item no. 2417160, shows deviating features in comparison with the first type of piston:

1. 1. Piston body geometry.
2. 2. Piston ring arrangement and types.
3. 3. Gudgeon pin dimensions and fixation method in the piston body: bolt connection for 2417011, locked by circlip rings for 2417160.



Hint!

The parts, of which the both types of piston units are assembled of, are not mutually exchangeable!

Even when old and new piston assemblies can be used in one compressor, due to the same weight and main dimension, we recommend keeping one type of

configuration in the machine. In case not all pistons or piston assemblies can be replaced in one compressor during a repair or maintenance, we strongly recommend registering the assy part no. (old or new) per cylinder to avoid ordering non suitable piston ring sets or gudgeon pins in future. Until further notice, the old sub parts/part no's remain available.

3.6.1 Pistons 2417011 (before mid 2015)

3.6.1.1 General



Fig.66

1. Place the assembly upside down on the working bench and straighten the locking plate under the locking bolt.
 - 1.a. Unscrew the M12 locking bolt and remove the locking plate.



Fig.67

2. Heat the piston to approximately 80 °C
3. NEVER HEAT WITH OPEN FLAME! Pouring a little spirit into the piston and lighting it works just as well.
 - 3.a. Push the gudgeon pin out of the piston.
 - 3.b. Check the (cooled) gudgeon pin for wear and measure the outer diameter using an outside micrometer and replace the pin if the diameter is smaller as the value given.

3.6.1.2 Connecting rod



Fig.68

1. Assemble the bearing shells and the connecting rod cap into a whole.
 - 1.a. Tighten the nuts on the connecting rod bolts to the torque given.

- 1.b. Measure the bore of the clamped bearing with an inside micrometer and replace if it is larger as the value given.
- 1.c. Check the bronze bearing bush (for the LP cylinders) in the small end of the connecting rod for wear or damage.
- 1.d. With an inside micrometer measure the bore of the still fitted bronze bearing bush and replace if it is larger as the value given.
- 1.e. Insert a new bearing bush by lowering the non-heated bearing bush into the small end of the connecting rod which has been heated to approx 80 °C.
- 1.f. Check the condition of the double-row needle bearing (for the HP cylinders) and replace if necessary.
- 1.g. Insert the needle bearing as described for the bearing bush.



Fig.70

2. Roll each piston ring and oil scraper ring in the corresponding groove around the piston to trace parts that have become wedged. This can be remedied, for example, by using a smooth file.
 - 2.a. Also check the rest of the piston for wear or damage.

3.6.1.3 Piston



Fig.69

1. Remove the three piston rings and the two oil scraper ring using the appropriate piston ring pliers.
 - 1.a. Check the piston grooves for burrs, notch effects and cracked or broken grooved edges.



Fig.71

3. Check the gap in each piston ring by placing it in an unworn part of the cylinder liner. These unworn parts can be found at about 10 mm from the bottom of the cylinder liner. The max. gap may not exceed 2.1 mm.

3.6.1.4 Preassembling the piston/ connecting rod

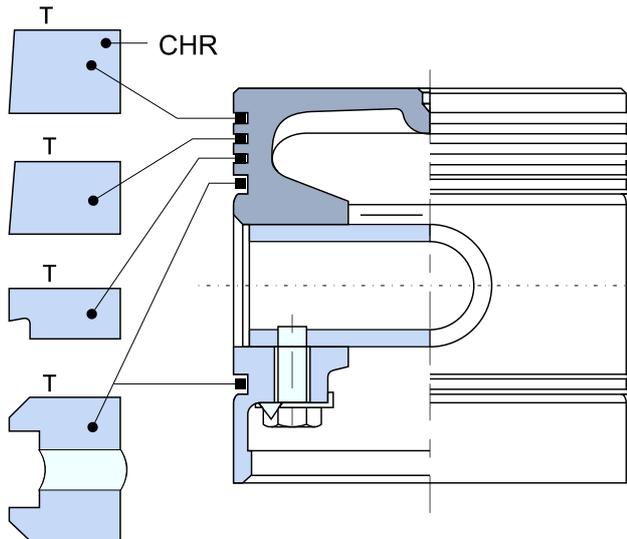


Fig.72: Piston

Legend	
T	Top
CHR	Chromium-plated

1. If the piston rings and oil scraper ring are no longer on the piston, fit them in the sequence as shown. Never mix old and new rings together. When placing the rings, pay attention to the word "TOP" on each ring.



Fig.73

2. Clean the connecting rod and blow out the oil passageway in the connecting rod.
 - 2.a. When replacing the bearing bushes or needle bearings, heat the small end of the connecting rod to approximately 80 °C.

- 2.b. Insert the bronze bearing bush (for LP cylinders) or respectively the needle bearing, distance ring and needle bearing (for HP cylinders) into the small end of the connecting rod.
- 2.c. Check whether the needle bearings project equally on both connecting rod ends.
- 2.d. Let the connecting rod cool off in ambient air.
- 2.e. Fit the bearing shells in both connecting rod parts. Due to the raised fixing cams only one building-in position is possible.



Fig.74

3. Heat the piston to approximately 80 °C, **DEFINITELY NOT IN OPEN FIRE!** Pouring a little spirit into the piston and lighting it works just as well.
4. 4.a. Degrease the gudgeon pin and oil it.
- 4.b. Check that the gudgeon pin fits properly into the connecting rod.

4.c.



Hint!

With the HP connecting rod it may be necessary to heat the small end of the connecting rod as well. Place the connecting rod into the piston and slide the oiled gudgeon pin through the piston into the connecting rod.



Warning!

The hole in the gudgeon pin has to coincide with the locking bolt hole in the piston.



Fig.75

5. For locking, position the flat face of the head of the hexagon bolt parallel with the piston wall. Lock the locking bolt with the locking plate: tap one face against the bolt head and the other faces against the piston cam.

3.6.2 PISTON



Fig.76: Remove the piston rings and the oil scraper ring (tool not in tool set)

1. Check the piston grooves for burrs, notch effects and cracked or broken edges



Fig.77: Replace the NEW piston rings; Roll each piston ring and oil scraper ring in the corresponding groove around the piston to trace parts that have become wedged.

2. Check the rest of the piston for wear or damage



Fig.78: Check the gap in each piston ring by placing it in an unworn part of the cylinder liner. These unworn parts can be found at about 10 mm from the bottom of the cylinder liner. The maximum gap as given ()



Warning!

Never use new piston rings in combination with a worn out cylinder liner.



Hint!

Never mix old and new rings together.

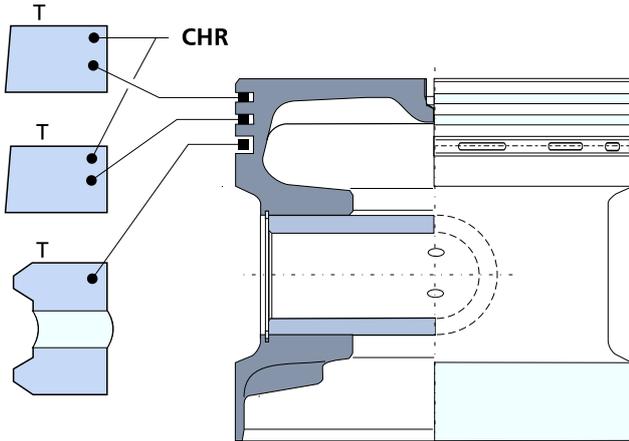


Fig.79: Piston Grasso 12 Series; T=Top, CHR=Chromium-plated



Fig.82: When placing the rings, pay attention to the word "CTOPZ" and "C" on the oil scraper ring

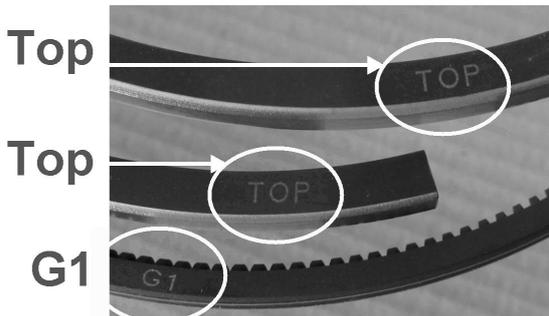
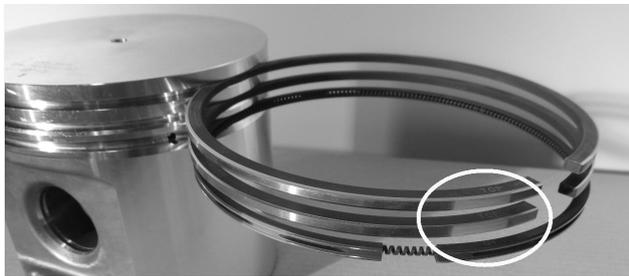


Fig.80: Fit the piston rings and oil scraper in the orientation as shown. When placing the 2 rings, pay attention to the word "TOP" and "G1" on the oil scraper ring

Old situation before mid 2015; 2471012

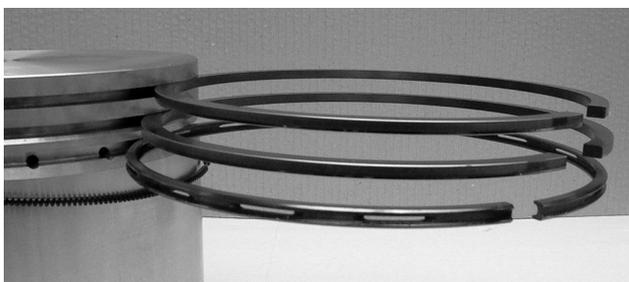


Fig.81: Fit the piston rings and oil scraper in the orientation as shown

3.7 CYLINDER LINER AND VALVE-LIFTING MECHANISM RC12

General

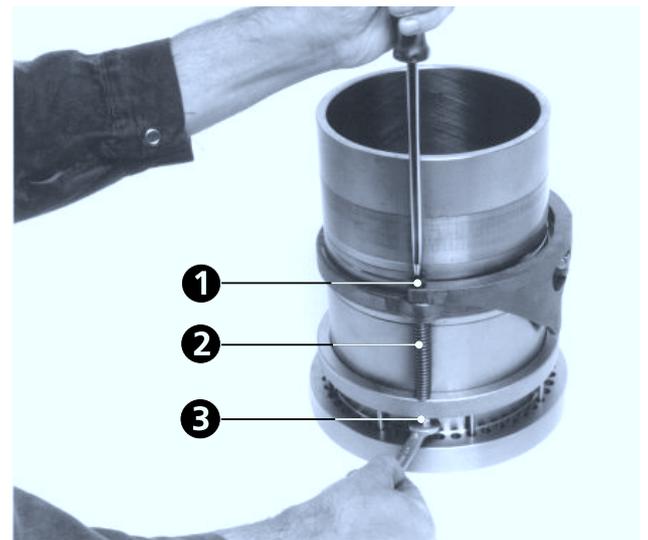


Fig.83

1. Unscrew the locking nuts (3) from both M6 tie bolts (1). Remove both tie bolts, the nuts (3) and the springs (2).



Fig.84

2. Place the cylinder liner upside down on the working bench.
 - 2.a. Remove the split pin (2) from the dowel pin (1) and slide the dowel pin out of the valve-lifting lever (3).
 - 2.b. Remove the lever.



Fig.85

3. Carefully tap with a hammer against the supporting ring (1), turning it clockwise, until the wire spring (2) is loosened from the supporting ring.
4. 4.a. Remove the wire spring.
5. Slide the supporting ring (1) and the pressure ring (3) off the cylinder liner.



Fig.86

6. Clean all parts.



Fig.87

7. Check the suction valve ring seat in the cylinder liner collar for damage or locally worn away honing tracks.

It is not necessary to check the cylinder liner diameter if the honing tracks in the cylinder liner bore are still complete. Irregularities can be carefully eliminated with abrasive paper.

 - 7.a. Check the outer surface of the cylinder liner for damage and eliminate slight damages with abrasive paper.
 - 7.b. Check the pressure ring on the inside. After truing up the inner and/or outer surfaces, check whether the pressure ring moves smoothly around the cylinder liner.

Preassembling the valve-lifting mechanism



Fig.88

1. Before starting, oil all parts with compressor lubricating oil. Place the cylinder liner with the collar on the working bench. Slide the pressure ring over the cylinder liner.



Fig.89

- 1.a. Slide the pressure ring with the hinging holes facing upward over the cylinder liner as far as the (wire spring) groove indicated with arrow "P".



Fig.90

2. Insert the wire spring, which should be 10 mm longer than the groove circumference of the cylinder liner, between the cams of the supporting ring into the groove; this groove is accessible through the insert hole in the left cam. Slide the wire spring into the groove as far as possible. With a soft hammer tap the supporting ring around the cylinder liner (constantly turning counter-clockwise), which makes the wire spring slide further into the groove.

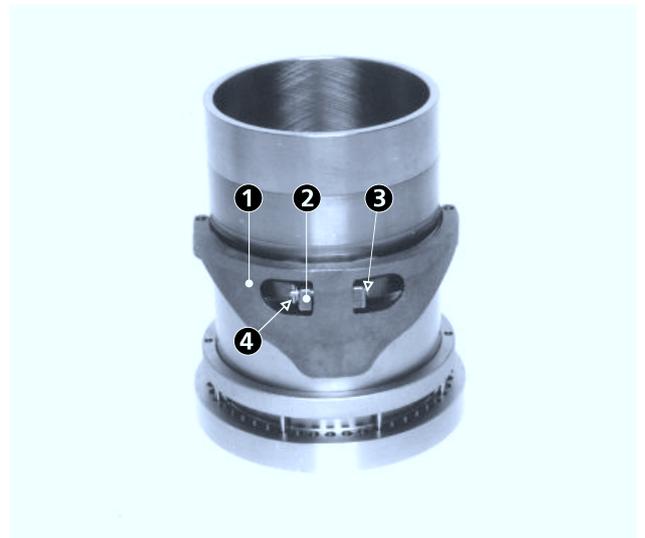


Fig.91

3. Place the semi circular lever (1) between the cams of the supporting ring (2) and slide the dowel pin (3) into the (hinging) holes. Insert a new split pin (4) into the hole at the end of the dowel pin.



Fig.92

4. Insert the two M6 tie bolts (1) through the holes into the lever (2), the supporting ring (3) into the springs (4) and finally into the pressure ring (5). Screw the tie bolts into the nuts (6).

ADJUSTING THE VALVE LIFT

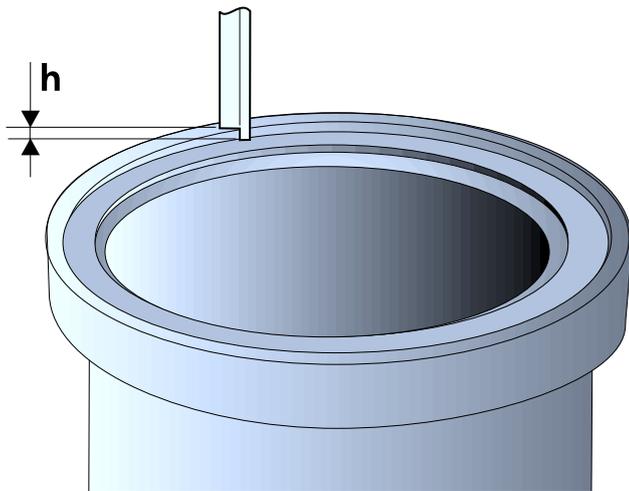


Fig.93

1. Place the suction valve ring on the push pins.
 - 1.a. Tighten the nuts on the tie bolts in such a way that the top of the suction valve ring (in situ of the tie bolts!) is positioned 5.0 mm below the cylinder liner collar.



Fig.94

When the adjustment in situ of both tie bolts has been done, provide both tie bolts with the lock nuts. When locking, always use two spanners to guarantee the adjustment.



Hint!

It is recommended to use a small amount of loctite in order to maintain adequate locking.

1. Check again whether the valve lift (5.0 mm) has remained unchanged.

3.8 OIL PUMP AND OIL FILTERS

General

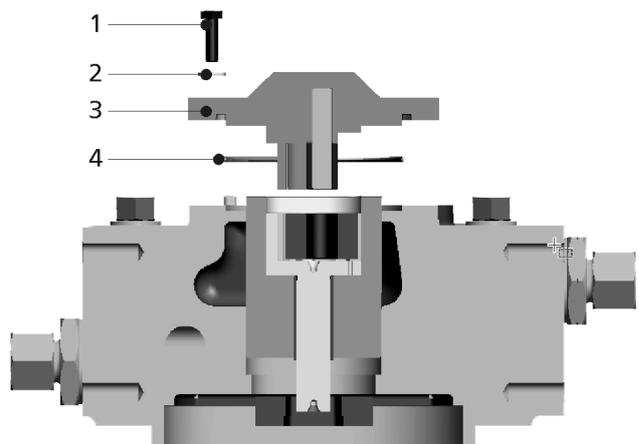


Fig.95

- Place the pump on the working bench and unscrew the eight M6 fixing bolts (1) in the pump cover out of the housing and remove the washers (2) and the pump cover (3) with the integrated pump element.

- Remove the O-ring (4).

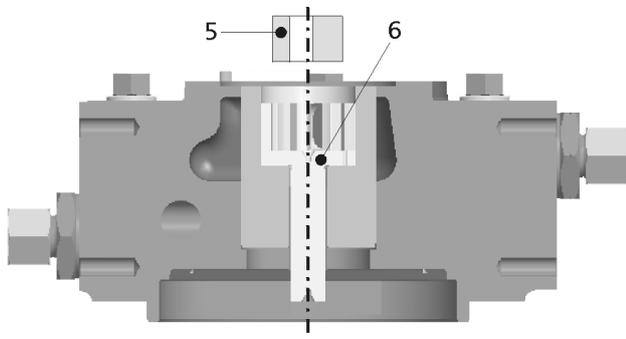


Fig.96

- Remove the pump gear (5) from the crown wheel (6) of the pump element/bearing assembly.
- Clean the pump housing and the pump cover with a non-fibrous cloth

Removing the pump element/bearing assembly

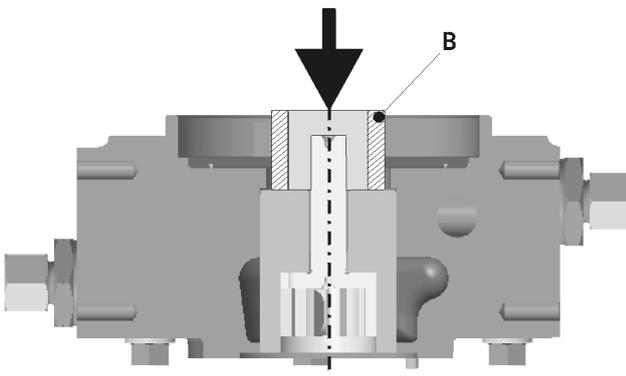


Fig.97

- Place the pump housing with the pump cover fixing face in central position and pointing downwards under a press (take precautionary measures that the fixing pin, indicated with arrow! does not break).
 - Place an auxiliary bush (B) with an outer diameter $\varnothing D < 60\text{mm}$ and an inner bore $\varnothing d > 45\text{ mm}$ over the crown wheel shaft. In this position the pump element/bearing assembly can easily be pressed out with a hydraulic press.

Inserting a new pump element

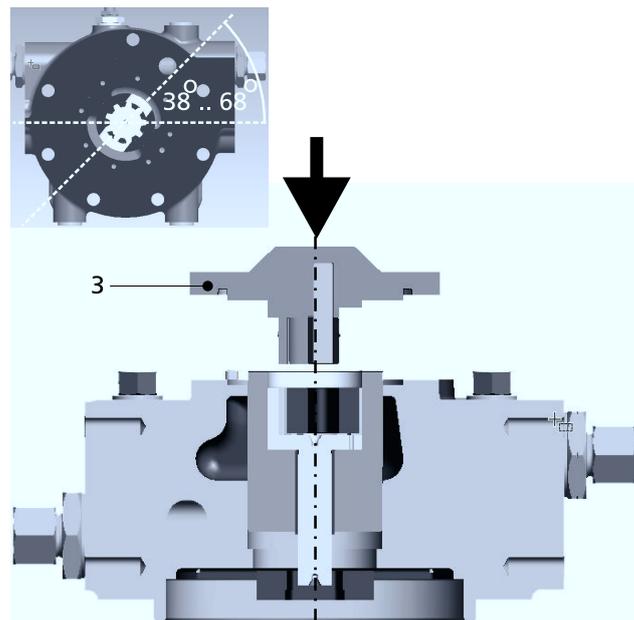


Fig.98

- Ensure that the bore and the contact face in the pump housing are clean and oiled.
- Place the pump housing with the bearing cover fixing face in central position and pointing downwards, using the pump cover(3)(!), under a press.

Make sure the oil canals in the oil pump assembly are aligned with the oil canals in the oil pump housing.

The oil pump direction is determined by the position of the cover.
- Carefully press the pump element into the housing with the cover until the contact face has been clearly reached.

Take care the positioning pin is aligned with the oil pump cover.

- 

Hint!
Check that pump element can be rotated by hand!

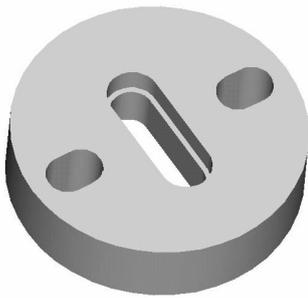


Fig.99: Carrier disc

5. Remove the carrier disc from the crankshaft journal and check the condition of the slot and the holes of the carrier disc.

Reassembling the oil pump

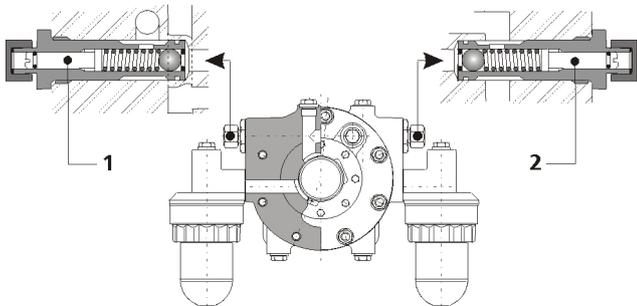


Fig.100

1. Lightly oil all parts mentioned below before reassembly!
 - 1.a. Insert into the housing: new O-rings in the internal oil passageways, the plugs provided with new alu-washers, the lubricating oil pressure regulator (1) in the left-hand part of the housing and the control pressure regulator (2) in the right-hand part of the housing.



Hint!

The shorter control pressure regulator has a groove on the hexagon nut. The longer lubricating oil pressure regulator does not have a groove.

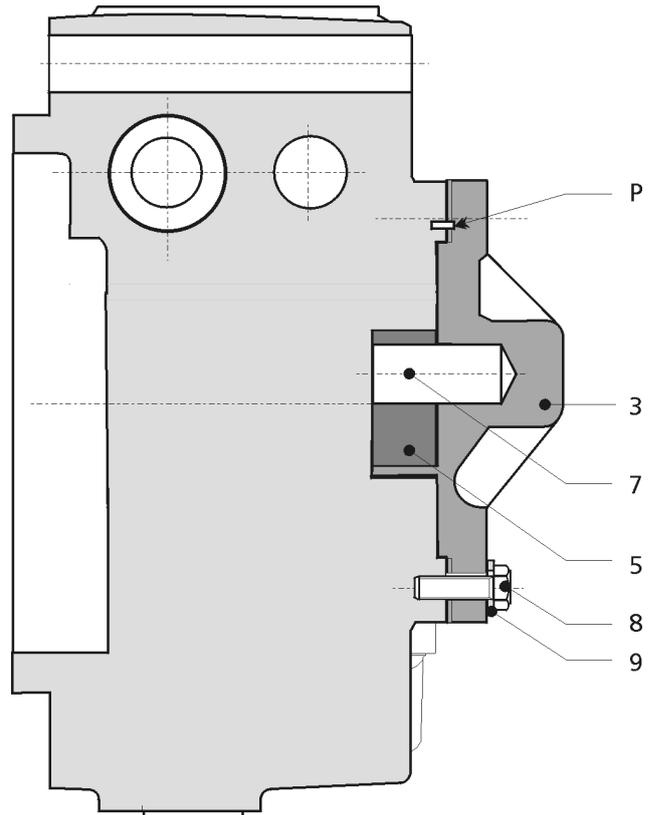


Fig.101: Pump detail

2. Slide the pump gear (5) onto the shaft (7) of the pump cover (3).
 - 2.a. Place the pump housing on its side and insert the preassembled pump cover element provided with a new O-ring in such a way that the fixing pin (P) fits into the corresponding hole.
3. Tighten the eight M6 bolts (8) provided with washers (9) in the pump housing to the torque given in table "Survey of torques for bolts and nuts"(Chapter 5, Page 68).
 - 3.a. Check that the pump rotates smoothly; if this is not the case, the pump element is not pressed far enough inside the oil pump housing.
 - 3.b. Place the preassembled pump in a separate clean area to be mounted onto the bearing cover later.

Filter elements



Hint!

Filter elements can also be replaced when the filter housings are still mounted to the compressor.

Use special tool to remove oil filters

1. In order to reach the oil suction filter or oil discharge filter element, only the lower housing half has to be removed by supporting the housing and unscrewing the grooved nut.

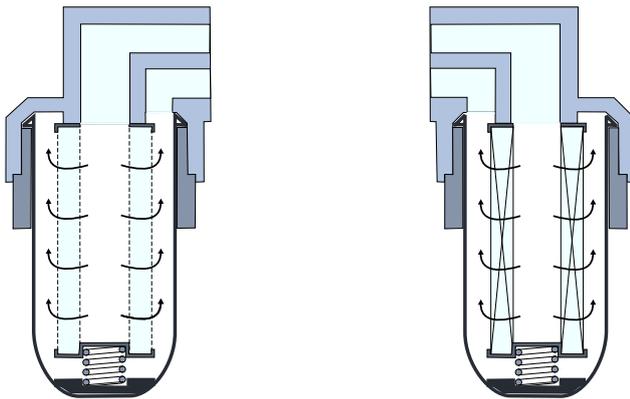


Fig.102: Oil suction and oil discharge filter

- 1.a. Pay attention to the residual oil in this filter bottom
- 1.b. For a total inspection both the upper filter housings can be removed from the pump housing by unscrewing both M10 bolts.
- 1.c. Remove the filters as described
- 1.d. Whilst the the oil suction filter element is cleanable, it should be replaced in case of damage or serious pollution.
- 1.e. The red "running-in" oil discharge filter element is to be replaced by a grey one after 100 running hours.
- 1.f. Renew a polluted grey-marked oil discharge filter element.

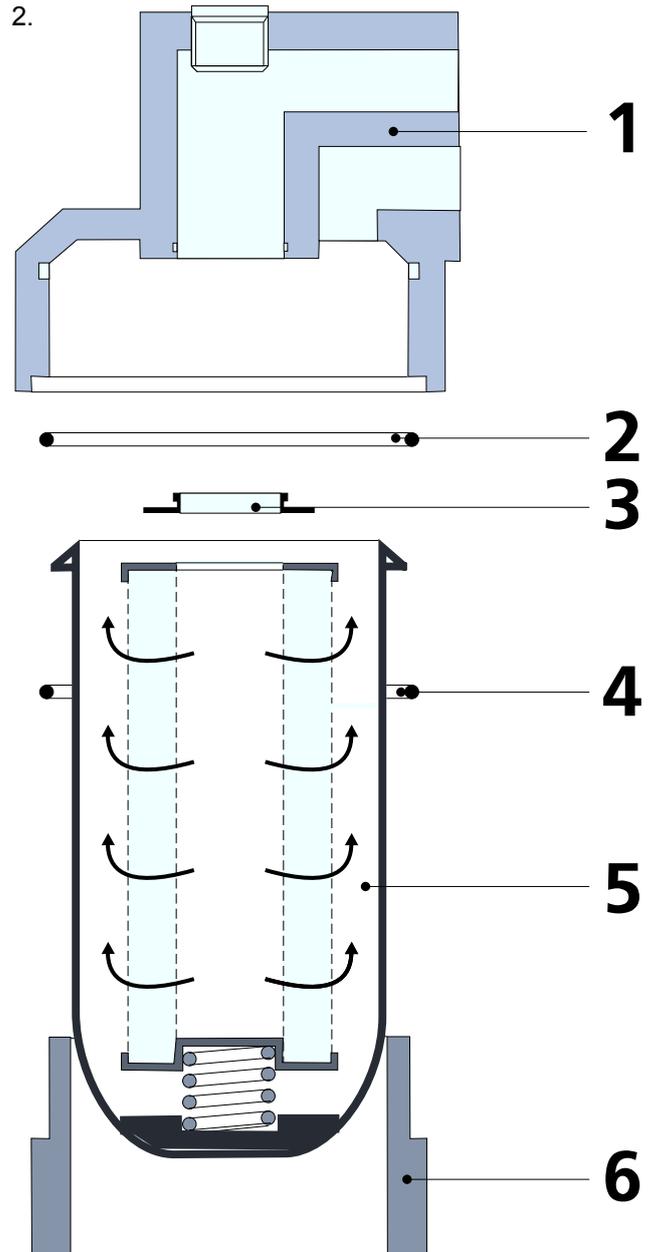


Fig.103

Remove the O-rings (2 and 4) and the seal (3).

- 2.a. Clean both filter housings (1 and 5) and the internal (connecting) passageways.
- 2.b. Insert each filter in the corresponding filter housing and reassemble them with a new set of seals³, a washer (3) and new O-rings (2 and 4).

3 Only available as set under Ref. No. 09.90.030.



Hint!

In order to avoid damaging the seals, the filter housing (5) should not revolve together with the grooved nut (6).



Hint!

After having dis-assembled the discharge filter element, check this for contamination, in particular for the presence of aluminium and/or white metal slide-bearing particles which would require further investigation in other parts of the compressor. In this case, regularly check the oil quality by means of an oil analysis.

Verwijderd nav wijzing oliepomp, KK, 8 mei 2008

3.9 MAIN BEARINGS

General

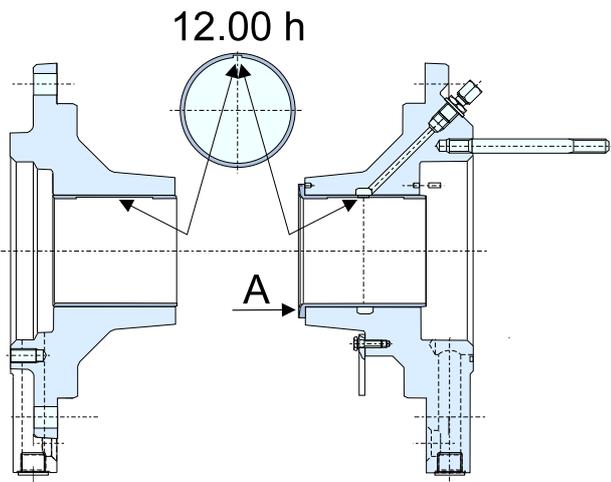


Fig.104: 41

1. Check both main bearing bushes, while they are in their respective bearing covers, for worn out white metal inner lining.
 - 1.a. Replace the bush(es) if the inner lining shows abnormal wear and also if the bore is over 90.16 mm.

- 1.b. Especially check those crankshaft parts rotating in the bearing covers. Eliminate slight damage using fine polishing paper.
- 1.c. Check the thrust face (see arrow "A") on the collar of the bearing bush on oil pump side for wear and replace it if one of the oil grooves has virtually disappeared.

Preassembling the bearing covers

1. Bearing cover on driving side:



Fig.105: 42

2. When replacing a bearing bush, proceed as follows:
3. Push or press (using a hydraulic press) the old bearing bush out of the bearing cover.
 - 3.a. Draw, for instance with a felt pen, a longitudinally line and over the full length on the outside of the new bearing bush above the centre of the oil chamber.



Fig.106: 43

4. Oil the bearing bush and place it with the internal chamfer facing upward and above the bore in the bearing cover in such a way that the oil passageway is in the centre of the locking pin.
 - 4.a. Slowly press the bearing bush (using a hydraulic press) into the bearing cover, making sure that the bearing bush is not displaced.

1. **Bearing cover on pump side;**

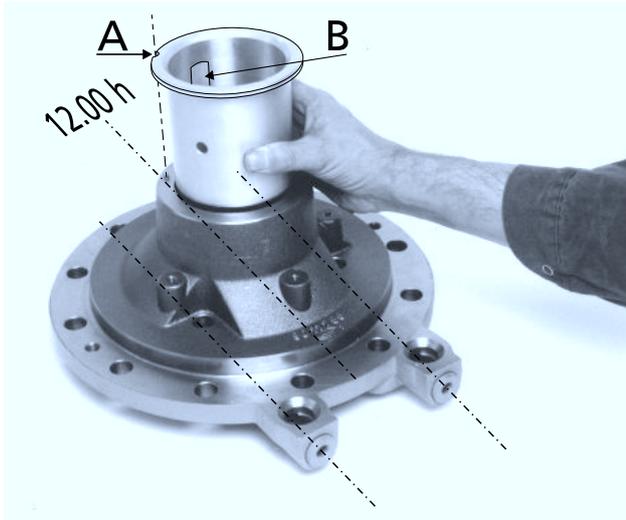


Fig.107: 44

When the bearing bush requires replacement, proceed as follows:

2. Push or press (using a hydraulic press) the old bearing bush out of the bearing cover.
 - 2.a. Draw a longitudinal line, for instance with a felt pen, on the outside of the new bearing bush from the centre of recess "A" (to the left of oil chamber "B") as far as the collarless end.



Fig.108: Bearing cover with mounted splash guard

3. Oil the bearing bush and position it above the bore in the bearing cover, so that the line drawn with the (felt) pen is in the centre of the locking pin.
 - 3.a. Slowly press the bearing bush (using a hydraulic press) into the bearing cover, making sure that the drawn line is not displaced, in order for the locking pin on the left-hand side (projecting 3 mm above the bearing cover) to be pressed entirely into recess "A".



Fig.109: 46

4. Inspect the intermediate bearing(s) for visual wear and for possible scoring of the white metal inner lining and collar bearings.
 - 4.a. Assemble the intermediate bearing(s) with the stamped-in numbers on one side and tighten the intermediate bearing bolts.
 - 4.b. Measure the inside diameter and replace it when it is over 90.14 mm.

3.10 ROTARY SHAFT SEAL



Hint!

**Avoid touching the carbon part!
 Preferably rub your hands with oil or wear gloves.**

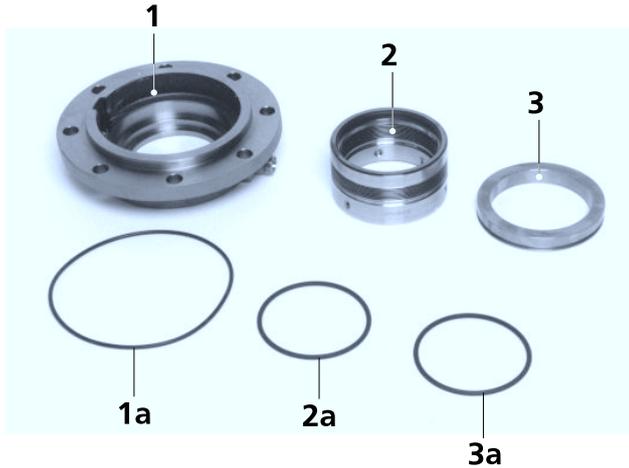


Fig.110

1. Remove the O-ring (3a) from the counter slip ring (3) and the O-ring (2a) in the rotating ring (2).
 - 1.a. Check the sliding surfaces of the counter slip ring (3) and the rotating ring (2) for wear or damage.
 - 1.b. Clean the housing (1) and all other parts.
 - 1.c. When one of the sliding surfaces is affected, replacement of both parts is required.
 - 1.d. Renew all O-rings (1a, 2a and 3a).



Fig.111

2. Renew the entire shaft seal in the case of damage or wear of the slip ring.

3.11 CRANKSHAFT

General

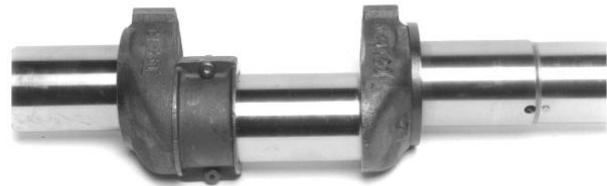


Fig.112: 49

1. Only with 2 cylinder compressors, remove the spacer (compensating mass) from the crankshaft and reassemble both halves into a whole, separately from the crankshaft.

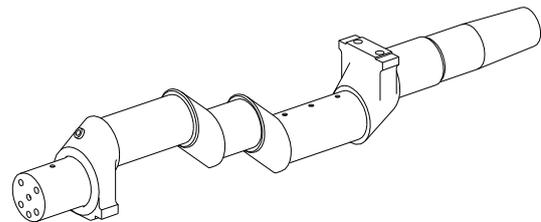


Fig.113: 50

2. Thoroughly clean the entire crankshaft:
 - 2.a. Check whether the axially fitted oil passageways in the crankshaft are unobstructed by cleaning them with compressed air or a brush.
 - 2.b. In order to be sure that the passage of lubricating oil within the crankshaft is unobstructed, unscrew the socket head screws (locked with centre punches) out of the crankshaft webs.
 - 2.c. Remove the dirt accumulated in the oil passageway (in the case of damage to bearings white metal particles) with a 6 mm bar.
 - 2.d. Brush and blow out the crankshaft again until all oil passageways are unobstructed.
 - 2.e. After cleaning, reassemble all oil passageway sealing bolts (socket head screws) and lock them with centre punches.

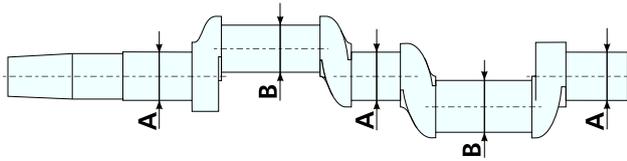


Fig.114: 51

3. Check the diameters of the shaft journals and shaft ends with an outside micrometer in at least 2 directions and dead square to the measuring surface.
 - 3.a. Here measure "A" should be at least 89.933 mm and measure "B" 89.945 mm.
 - 3.b. Should these measurements show that the shaft diameter(s) is (are) beyond the tolerance limits and there is any doubt about the serviceability of this crankshaft, then the shaft should be replaced.

Preassembling the crankshaft

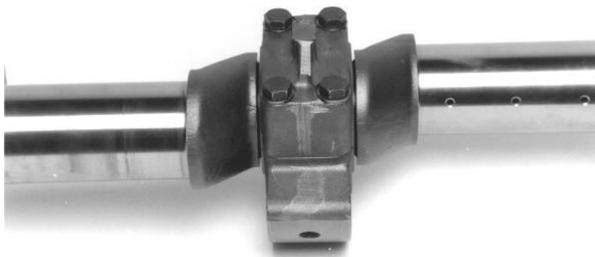


Fig.115: 52

1. In the case of 4, 6, 9 and 12 cylinder compressors, place the shells of the intermediate bearings into the bearing block(s).
 - 1.a. Oil both bearing shells well and fit the intermediate bearing(s) on the crankshaft (intermediate bearing halves with stamped-in numbers on one side).
 - 1.b. Tighten the four M16 bolts to the torque given.(refer Chapter 5, Page 68)
 - 1.c. Check that the intermediate bearing(s) freely revolve(s) around the crankshaft.



Fig.116: 53

2. In the case of a 2 cylinder compressor, fit the spacer onto the crank web on the driving side using two M8 bolt/nut joints and tighten these to the torque as given.(refer Chapter 5, Page 68)

3.12 THRUST BEARINGS

Besides a standard mounted thrust bearing, a heavy duty thrust bearing can be mounted (optional)

3.12.1 STANDARD BRONZE THRUST BEARING, MARK 2



Hint!

Refer Section 2.10, Page 25

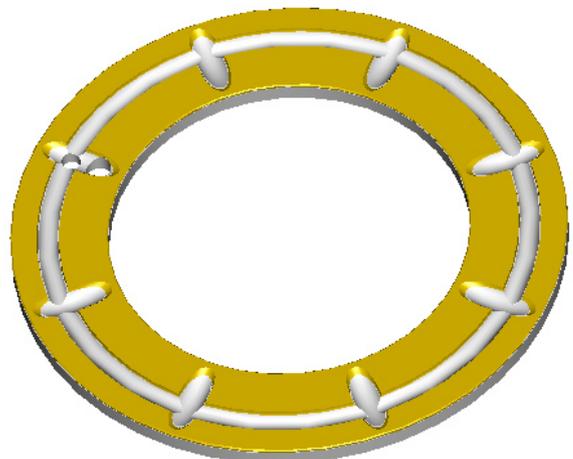


Fig.117: Standard bronze thrust bearing; refer also Figure 38, Page 25

1. Clean the thrust bearing and check the lapped running surface on the bronze side for (ir)regularly worn oil grooves and for material deposits.
 - 1.a. Replace this thrust ring if it shows signs of wear and when the thickness is less than 5.50mm.

3.12.2 HEAVY DUTY THRUST BEARING

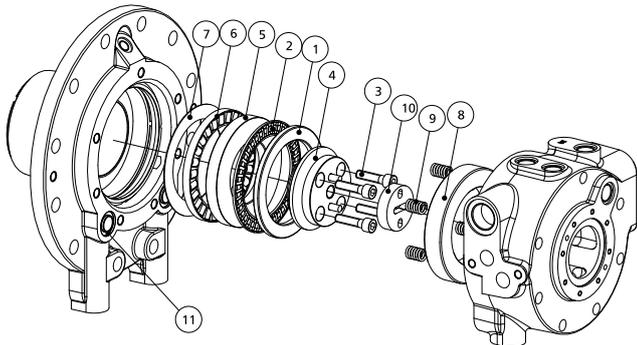


Fig.118: Heavy duty thrust bearing

1. Clean all thrust bearing parts. Check all running surfaces which are in contact with the cylindrical roller thrust bearing and the needle thrust bearing for (ir)regular wear and other damage such as pits, marks or scratches.
 - 1.a. Replace the complete heavy duty thrust bearing set when the rollers, needles or running surfaces show signs of wear.

3.13 CRANKCASE

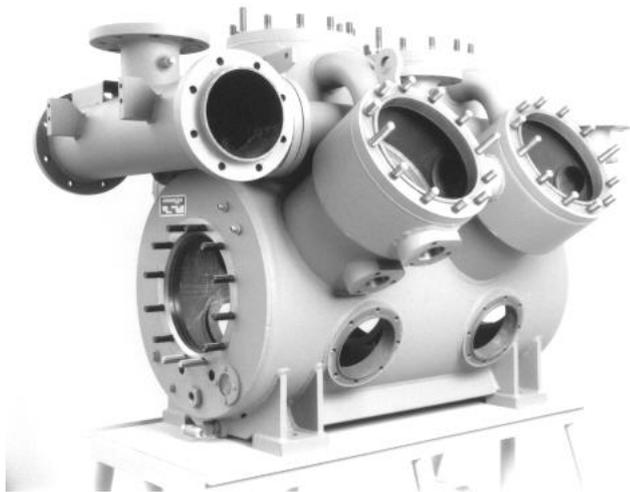


Fig.119

1. Thoroughly clean the crankcase interior and dry it with a non-fibrous cloth.
 - 1.a. Inspect all exterior packing faces and remove possible residual packing particles.
 - 1.b. Thoroughly blow through all connections on the inside and on the outside.
 - 1.c. Clean the sight glass.

- 1.d. Do not forget to remove the packing remains from the flanges of the main connections of the compressor!



Fig.120

1. Remove the oil return plug from the lowest landing of the cylinder jackets for the LP cylinders {see left plug in Fig.}
 - 1.a. Inspect the return plugs, clean them and tighten them after refitting.
 - 1.b. The plug for the HP cylinders {see right plug in fig.} does not need inspection and can therefore remain fitted.

4 REASSEMBLING



Warning!

All bolts and nuts have to be mounted according to the torques as given in table "Survey of torques for bolts and nuts" as available in this manual. If you cannot find this information, consult Grasso.



Hint!

All O-rings have to be oiled before assembling. Refer Section 5.8, Page 78.

4.1 CRANKSHAFT, MAIN BEARINGS AND INTERMEDIATE BEARING

4.1.1 Bearing cover driving side

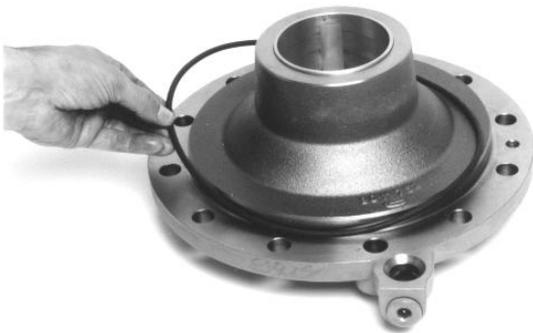


Fig.121

1. Place a new O-ring on the inner side of the bearing cover.

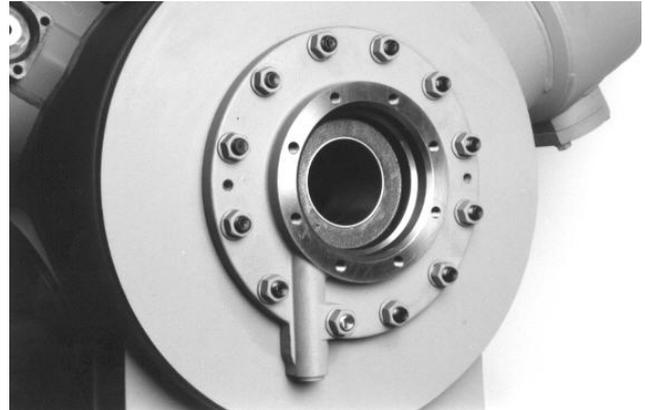


Fig.122

2. Place the bearing cover on the driving side in such a way that the hole in the lug of the bearing cover is opposite the internal oil passageway pipe.
 - 2.a. Then slide the bearing cover over the crankcase studs.
 - 2.b. Screw all M16 nuts provided with washers on the studs and tighten them alternately and crosswise to the torque given in (Chapter 5, Page 68).

4.1.2 Assembly procedure of 2 and 3 cylinder compressors

1. Insert the crankshaft (with/without counterweights) through the crankcase opening on the oil pump side into the bearing cover.

4.1.3 ASSEMBLY PROCEDURE 4, 6, 9 AND 12 CYLINDER COMPRESSORS

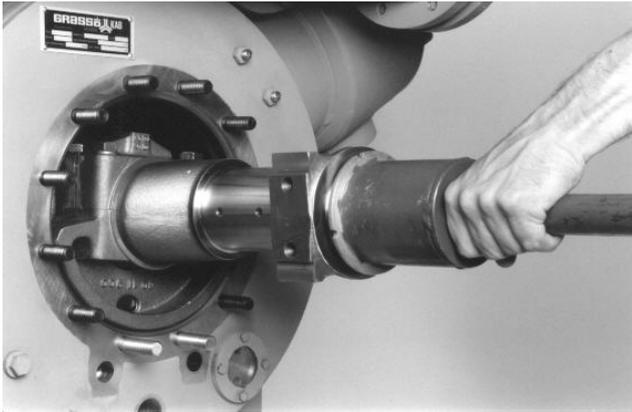


Fig.123

1. With assistance and using auxiliary tools, insert the crankshaft (with/without counterweights⁴) through the crankcase opening on the pump side into the crankcase. The crankshaft now rests on the intermediate bearing block(s).
 - 1.a. Remove the auxiliary tools, clean the shaft journals and oil them.

4.1.4 Pump side



Fig.124

1. Place a new O-ring on the pipe of the internal oil passageway.



Fig.125

4.1.5 Bearing cover oil pump side (with two lugs):

1. Place a new O-ring on the inner side of the bearing cover.
 - 1.a. Place a new O-ring on both pipes of the internal oil passageway Figure 124, Page 52.

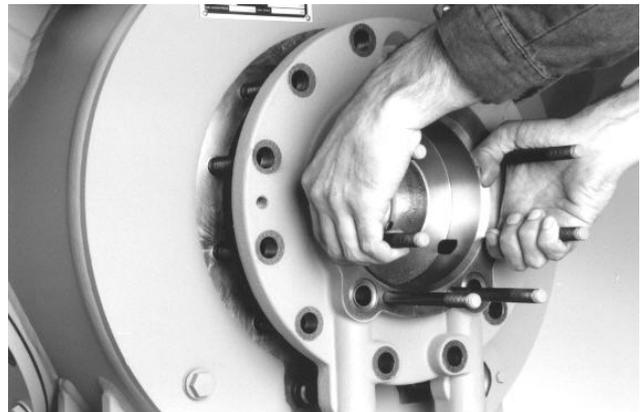


Fig.126

2. Place the cover in such a way that the holes in each lug of the bearing cover are opposite the pipes of the internal oil passageways and slide the bearing cover over the crankcase studs.

4 For mounting the counter weights see further on in this chapter "Assembling counter weights".

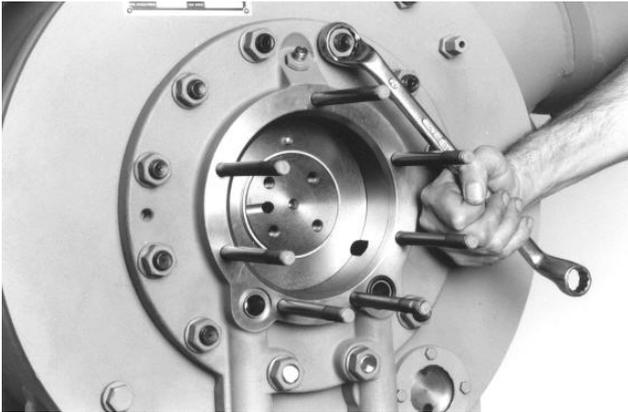


Fig.127

3. Screw all M16 nuts provided with washers on the studs.
4. Finally tighten the nuts alternately and crosswise to the torque given(Chapter 5, Page 68).
 - 4.a. Check that the crankshaft rotates freely.

4.1.6 Standard thrust bearing

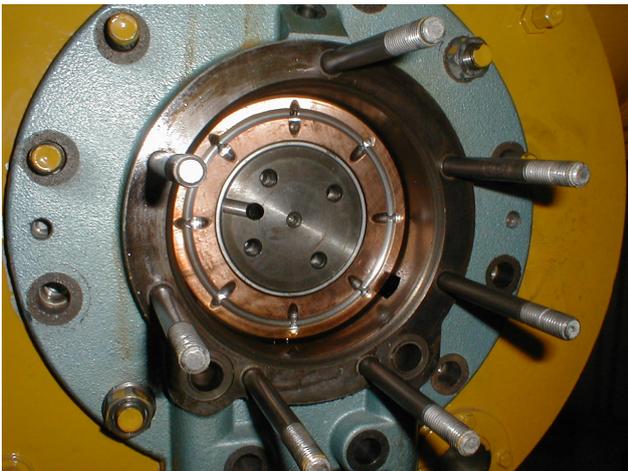


Fig.128: Standard thrust bearing; refer also Figure 38, Page 25

1. Fit the oiled thrust ring with the oil grooves directing outwards on the crankshaft on oil pump side in such a way that the locking pin in the bearing cover fits into the hole in this thrust ring surface.



Fig.129

2. Check that the crankshaft boss is still clean and oiled.
 - 2.a. Fit the hold down disc onto the crankshaft boss, using the four M10 socket head screws with the torque given(Chapter 5, Page 68).
 - 2.b. Check that the crankshaft rotates freely.

4.1.7 Heavy duty thrust bearing

The reassembling of the heavy duty thrust bearing is split into two parts, the heavy duty thrust bearing itself and the oil pump.

1. **1st step; Heavy duty thrust bearing**
2. Check whether all components are clean, including the inside of the bearing cover and crankshaft on oil pump side.



Warning!

Check the crankshafts top surface on oil pump side for having installed the closed M12 plug, *without* orifice.

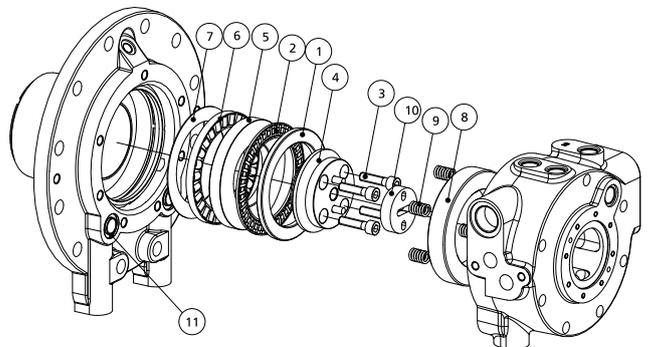


Fig.130: Heavy duty thrust bearing



Hint!

Pos. 1, 2, 4, 5, 6 and 7 can be mounted together in any crankshaft angle

3. Fit the oiled 1 mm. thick thrust washer (7) on the crankshaft on oil pump side.
 - 3.a. The thrust washer (7) can be used on both sides.
4. Fit the oiled cylindrical roller thrust bearing (6) on the crankshaft on oil pump side.
 - 4.a. The cylindrical roller thrust bearing (6) can be used on both sides.
5. Fit the oiled shaft washer (5) on the crankshaft on oil pump side. The shaft washer if recessed to **fit exactly** around the crankshaft.
6. Fit the oiled hold down disc (4) into the shaft washer (5), using the four M10 socket head screws (3) with the torque given(Chapter 5, Page 68).
 - 6.a. Check that the crankshaft rotates freely.
7. Fit the oiled needle thrust bearing (2) on the hold down disc (4).
 - 7.a. The needle thrust bearing (2) can be used on both sides.
8. Mate the oiled 7 mm. thick housing washer (1) against the needle thrust bearing (2).
 - 8.a. The housing washer (1) must be mated with its running surface against the needle thrust bearing (2), it can not be used on both sides.
9. **2nd step; oil pump for heavy duty thrust bearing**
10. Place the carrier disc (10) on the hold down disk (4).
 - 10.a. The chamber of the slot of the carrier disc (10) must face the crankshaft.



Hint!

Position the slot of the carrier disc (10) in vertical or horizontal position by rotating the crankshaft

11. Place 2 new O-rings around the oil inlet- and outlet holes at the bearing cover (11).
12. Check that the oil pump is clean.
13. Place the oiled spring retainer (8) in the pump housing counter bore.

- 13.a. The opening of the holes should be pointed to the outside of the oil pump housing.
14. Insert the oiled springs (9) in the holes of the spring retainer (8).
15. Place a new O-ring on the inner side of the fully pre-assembled oil pump.
16. Slide the oil pump over the studs of the bearing cover.
17. Position the carrier lug of the pump element with the slot in the carrier disc.
 - 17.a. Pay at all times attention not to dislodge the springs (9) or the spring retainer (8).
18. Push the oil pump as far as possible towards the bearing cover and screw the M12 nuts with washers on the studs.
 - 18.a. The oil pump cannot be pushed fully against the bearing cover, because of the springs and will only seat correctly when the nuts are tightened
 - 18.b. Check all springs to be present and in place.
19. Reinstall the external oil line. It is connected from the top of the oil pump to the service cover.

4.1.8 Measuring the axial crankshaft play

Procedure for 2 and 3 cylinder compressors

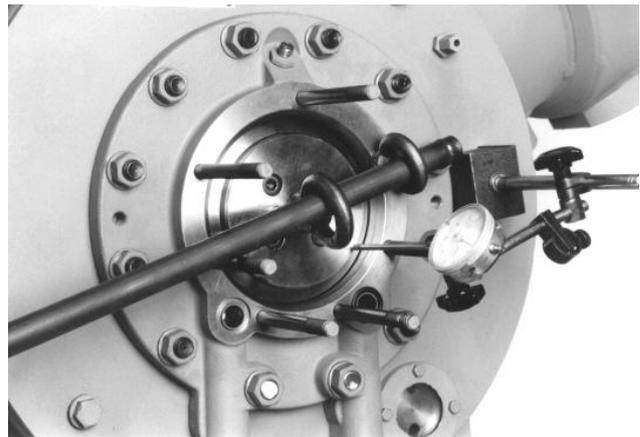


Fig.131

1. For this measurement a magnet (clock) gauge with an extended gauge can be set up on the bearing cover.

- 1.a. Remove a stud and screw in the M12 eye bolt.
- 1.b. Screw another eye bolt into the threaded hole on the crankshaft.
- 1.c. Pull out the crankshaft and set the gauge on 0.00 (zero).
- 1.d. Push the crankshaft inwards and check/ write down the axial play on the gauge.

For every compressor the play is determined between 0.05 and 0.85 mm.

Contact the service department of Grasso if the axial play is not within the tolerance limits.

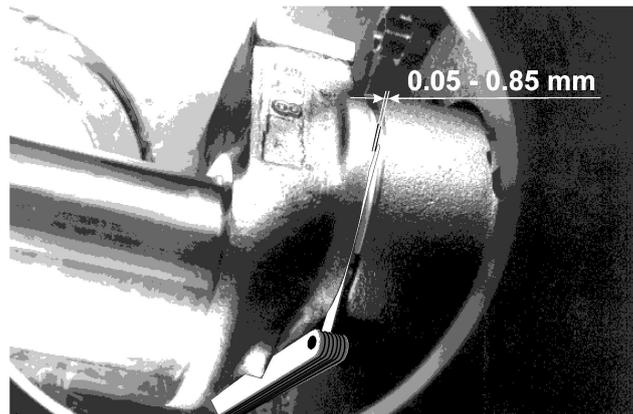


Fig.133

4.1.9 Procedure for 4, 6, 9 and 12 cylinder compressors

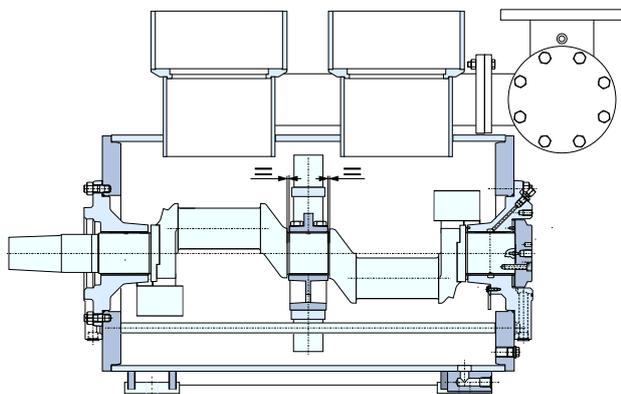


Fig.132

1. Measure the axial play proceeding in the same way as for the 2 and 3 cylinder compressors.
 - 1.a. Position the intermediate bearing block(s) and fit handtight the 2 sets of toothed spring washers and the M20 bolts in the cross frame.
 - 1.b. Check that the crankshaft rotates freely.
 - 1.c. Subsequently, firmly tighten the bearing block(s) after the intermediate bearing(s) has(ve) been adjusted in accordance with the drawing (measure "=" + 0.5 mm) (Figure 132, Page 55).
 - 1.d. Further tighten the intermediate bearing bolts to the torque given(Chapter 5, Page 68).

2. If there is no clock gauge available, the axial play in situ of the collar bearing can also be measured with the help of feeler gauges. Here again the axial play is measured by the difference between the pulled out and pushed in crankshaft (see also measuring procedure with clock gauge).

4.1.10 Assembling counter weights

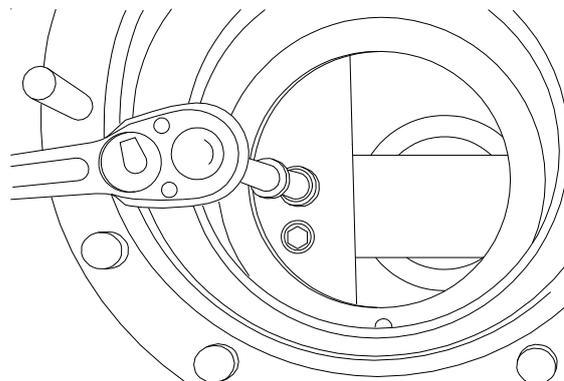


Fig.134

1. Fit the counterweights with new locking rings and bolts onto the crankshaft if dismantled.
2.

Hint!
Pay attention to numbers and marks!
Counterweights are not interchangeable!
- 3.
4. Fit the double locking rings in the proper position!

5. Tighten the bolts with a torque wrench to the torque given(Chapter 5, Page 68).

4.2 OIL PUMP

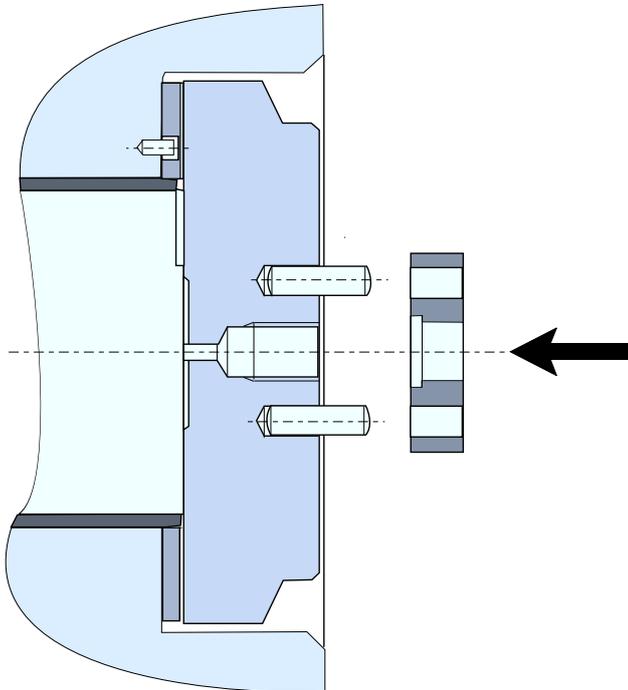


Fig.135

1. Place the carrier disc on the hold down disc.



Hint!

The chamber of the slot of the carrier disc must face the crankshaft.



Hint!

Position the slot of the carrier disc in vertical or horizontal position by rotating the crankshaft.

2. Place a new O-ring on the inner side of the fully pre-assembled oil pump.
 - 2.a. Slide the oil pump over the studs of the bearing cover.

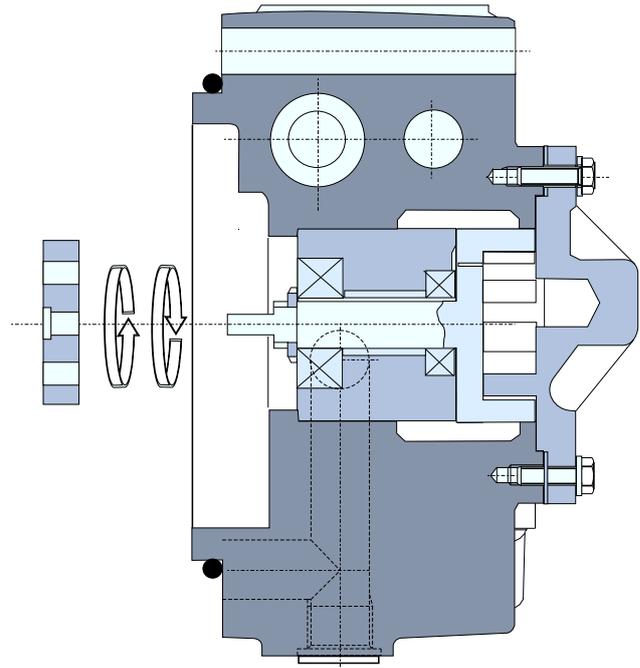


Fig.136

- 2.b. Position the carrier lug of the pump element with the slot in the carrier disc.
- 2.c. Push the oil pump fully against the bearing cover and screw the M12 nuts with washers on the studs.
- 2.d. Tighten all nuts evenly and crosswise to the torque given.

4.3 OIL SUCTION FILTER, OIL DISCHARGE FILTER, LUBRICATING OIL PRESSURE REGULATOR AND CONTROL OIL PRESSURE REGULATOR

4.3.1 Oil discharge filter



Fig.137



Hint!

After the first 100 operating hours the red-marked discharge filter has to be replaced by a grey-marked filter element!

1. Fit the preassembled (red⁵/grey) marked discharge filter using the two M10 bolts with washers on the right-hand side of the pump.
 - 1.a. Tighten the bolts to the torque given(Section 5.1, Page 68).

4.3.2 Oil suction filter

1. Fit the preassembled (marked blue) suction filter using the two M10 bolts with washers on the left-hand side of the pump.
 - 1.a. Tighten the bolts to the torque given(Section 5.1, Page 68).

4.3.3 Lubricating oil pressure regulator (without groove)

If not built in yet;

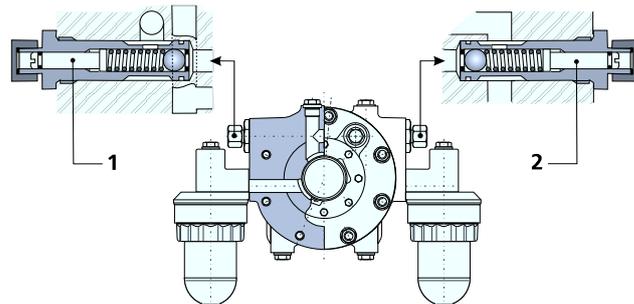


Fig.138

1. Install the lubricating oil pressure regulator with a new aluminium ring on the left-hand side of the pump.
2. 2.a. Finally fit the cap nut handtight on the regulator using a new alu-ring.



Hint!

Final adjustment of a reassembled lubricating oil pressure regulator can be done during compressor operation. This adjustment procedure is described in the Installation and Maintenance Manual.

4.3.4 Control oil pressure regulator (with groove)

1. Install the control pressure regulator with a new aluminium ring on the right-hand side of the pump. Figure 138, Page 57
 - 1.a. Finally fit the cap nut handtight on the regulator using a new alu-ring.



Hint!

Final adjustment of a re-assembled control oil pressure regulator can be done during compressor operation. This adjustment procedure is described in the Installation and Maintenance Manual.

5 Always fit a new red-marked oil discharge filter element into a modified plant.

4.4 Replacement piston rings and cylinder liners



Hint!

Recommendation/warning!

For major overhauls or every repair where piston rings are being replaced it is strongly recommended to replace the cylinder liners as well. This is very important for the next reasons:

For the best sealing between piston rings and cylinder liners, piston rings have to run in on the cylinder liner's inner surface. Therefore a new cylinder liner with a honing profile (crosshatching) in the best condition is absolutely required. Piston rings cannot run in properly on worn out or partly worn out cylinder liners. Without a decent honing profile no proper sealing between liners and rings can be achieved which may result in- or contribute to a bad performance of the compressor. Further on, this honing profile with the right crosshatching is demanded for a good lubrication between piston rings and liners and for the right oil distribution on the liner's inner surface.



Fig.139: New honing profile and crosshatching with the right angle

After being in operation for many running hours cylinder liners and piston rings will wear out and most cylinder liners will become unworn ridges (bumper rims or edges) due to the displacement of the piston rings inside the liner. The upper unworn ridge occurs at the upper death end and upper side of the upper piston ring and the lower ridge occurs at the death end of the lower side of the lower (oil scraper) ring. In many cases intermediate and oil scraper rings cause their own bumper ridges. (*Bumper steps*) Also, both upper and lower edge are set by the worn shape of the piston rings. This clearly explains why new piston rings can break when used in old/worn cylinder liners due to hitting the unworn bumper ridges at high speed. (*See also picture below*)

Therefore: Never install new pistons with new piston rings in old cylinder liners. It is strongly recommended to replace the cylinder liners too.

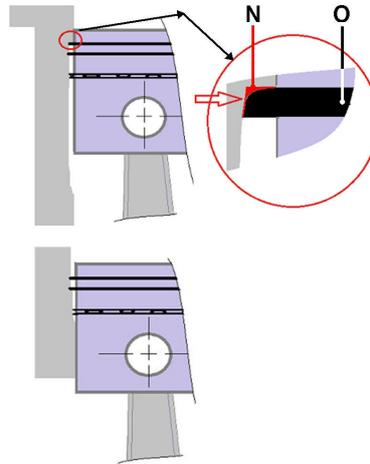


Fig.140: Don't use new piston rings on old cylinder liner

N	Shape of new piston ring (sharp)
O	Shape of old piston ring (rounded)

4.5 CYLINDER LINER

1. Examine the thickness of the gasket which was originally placed on the lower landing of the cylinder jacket and under the cylinder liner collar.
 - 1.a. Select a new gasket of the same thickness, being 1, 1.25 or 1.5 mm.
 - 1.b. Check that the gasket face of the cylinder jacket is still clean and place the greased gasket into the landing.
 - 1.c. Write down the thickness of the gasket on the outside of the cylinder jacket.
2. Draw a line from the centre of the valve-lifting lever up to the cylinder liner collar.
 - 2.a. Place the cylinder liner above the cylinder jacket.
 - 2.b. Position the line drawn on the cylinder liner with the flange centre (mounting face of valve-lifting housing) on the outside of the cylinder jacket.
3. 3.a. Lower the cylinder liner as far as possible into the cylinder jacket.

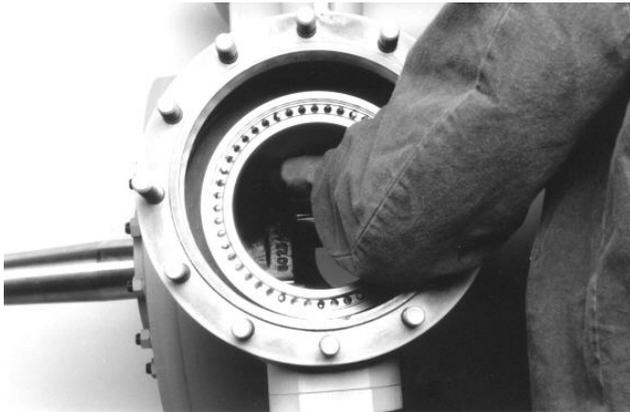


Fig. 141

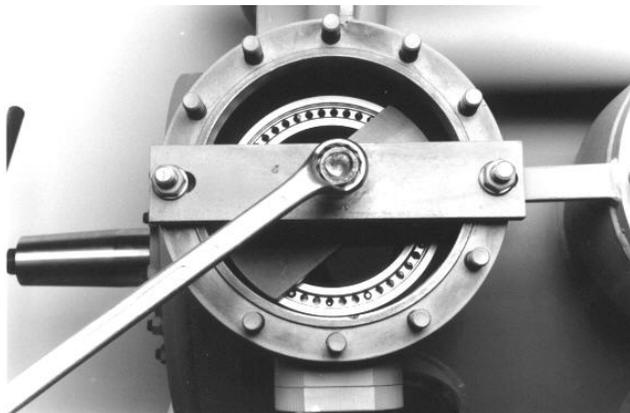


Fig. 142

- 3.b. Place the short green bar⁶ on the upper cylinder liner collar and the long green bar over 2 cylinder head studs.
- 3.c. Fix the long bar with two M16 nuts and place a steel disc on the threaded hole in the lower bar to protect the threaded hole from damaging.
- 3.d. Screw the long M24 bolt into the long bar and tighten it turning clockwise until the cylinder liner is fully seated in the inner landing of the cylinder jacket.
- 3.e. Remove the auxiliary tools.



Hint!

Check that the inserted cylinder liner is positioned properly by comparing it with the other cylinder liners that were assembled earlier. Check the valve lifting action with compressed air. Make sure that the cylinder liner does not rotate!

6 Parts of the auxiliary tool kit.

4.6 PISTON/CONNECTING ROD ASSEMBLY



Fig. 143

- 1. Slide the connecting rod bolts into the big end of the connecting rod (make sure that the flat side is positioned correctly!).
 - 1.a. Place the bearing shells into the connecting rod cap.
 - 1.b. Oil bearing shells, piston and piston rings.
 - 1.c. Slide the ring compression bush⁷ with the chamfered end pointing downwards over the connecting rod, the piston and the first oil scraper ring in such a way that this oil scraper ring is only just visible.
 - 1.d. Oil and set the relevant crankshaft journal in the uppermost position of the cylinder centre.
 - 1.e. Screw the T-handle (from the auxiliary tool kit) into the threaded hole of the piston.

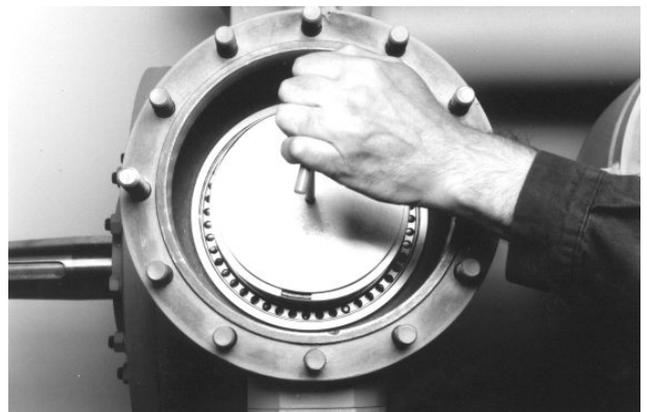


Fig. 144

7 Parts of the auxiliary tool kit.

2. Insert the piston/connecting rod assembly into the cylinder liner.
 - 2.a. Lower it very carefully until the ring compression bush strikes the cylinder liner and after that slowly push on until the piston is almost entirely located inside the cylinder liner.
 - 2.b. Check that the connecting rod properly embraces the crankshaft journal. If so, push through to the crankshaft journal and check that the bearing shell in the connecting rod has not been displaced.

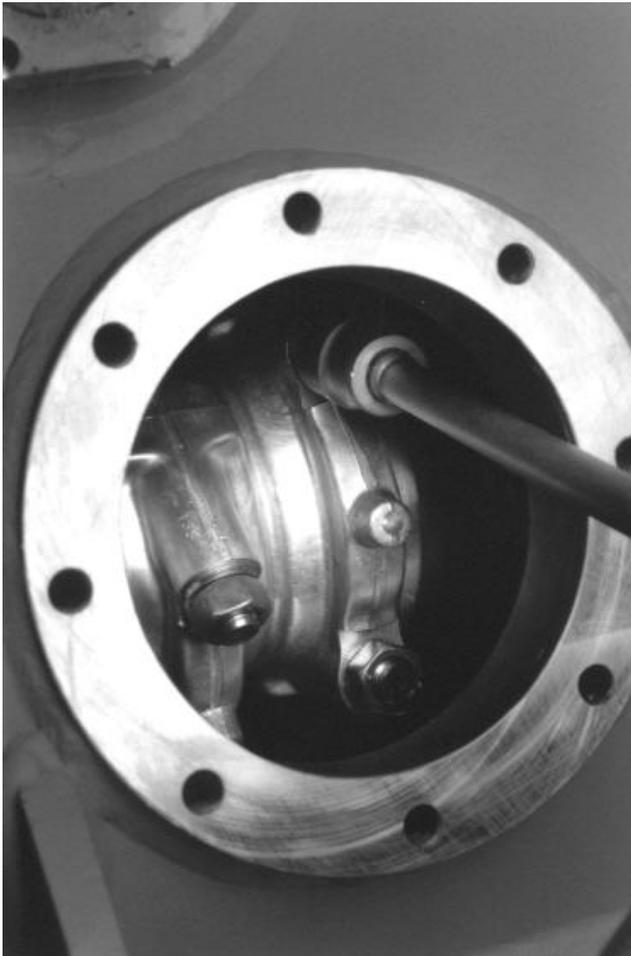


Fig. 145

3. Slide the corresponding connecting rod cap over the connecting rod bolts.



Hint!

Fit the connecting rod parts with the machine codes on one side.

- 3.a. Fit both MF16 nuts with new (double) locking rings on the connecting rod bolts and tighten to the torque given.

4.7 DETERMINING THE PISTON CLEARANCE

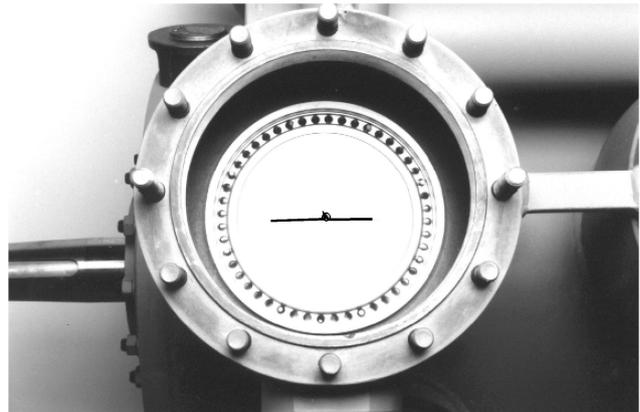


Fig. 146

1. Place a solid 2 mm thick lead or tin soldering wire which has been shaped to fit into the threaded hole of the piston and laid parallel with the crankshaft or gudgeon pin.

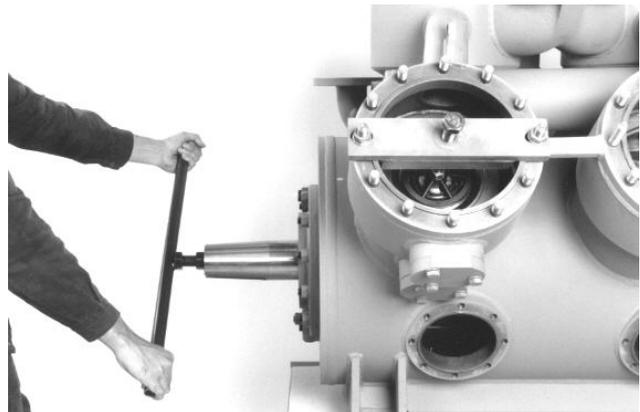


Fig. 147

2. Oil the discharge valve assembly and place it on the cylinder liner.
 - 2.a. Place the bar from the auxiliary tool kit on the studs as well as on the discharge valve centre.
 - 2.b. Screw two M16 nuts on the studs .
 - 2.c. Screw the M24 push bolt into the long bar and after that revolve the crankshaft two or three times.

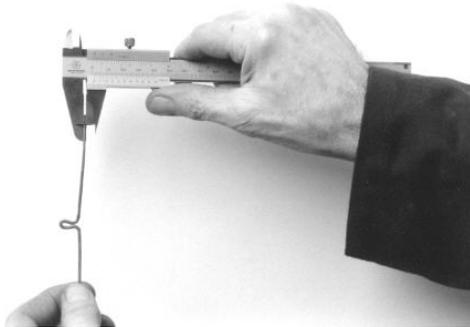


Fig.148

- Remove all measuring aids and measure the thickness of the flattened wire. This thickness, which is equal to the clearance, should be at least 1.05 mm and at most 1.45 mm. If the measuring result is beyond these limits, it is necessary to remove the piston/connecting rod again and replace the sealing ring under the cylinder liner collar by a thicker or thinner one, according to whether the clearance was too small or too large.

4.8 VALVE-LIFTING CONTROL MECHANISM



Fig.149

- Place the pressure pin into the bore of the plug screwed into the cylinder jacket.

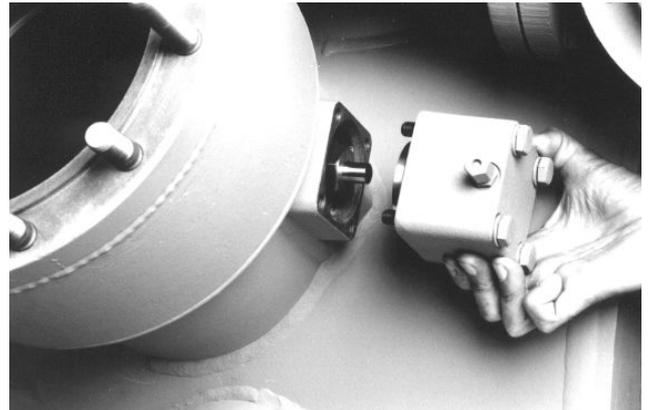


Fig.150

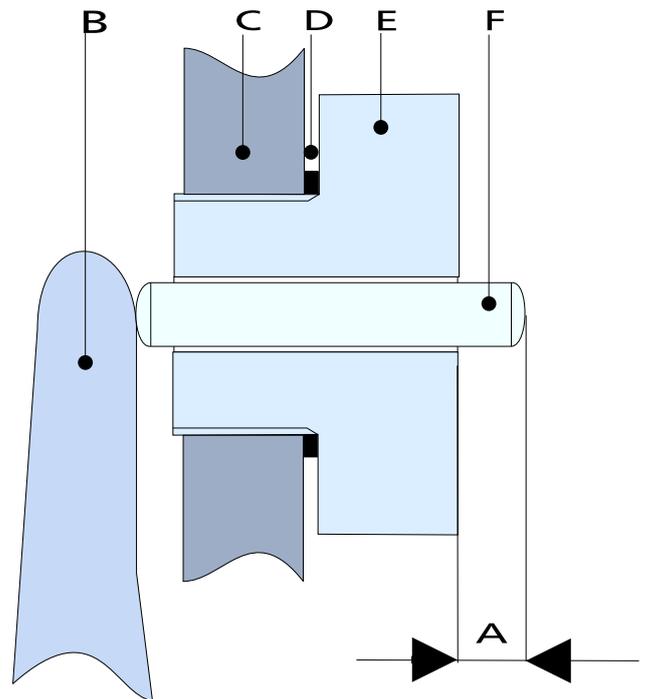


Fig.151

Legend	
A	Distance when assembled 4 to 5 mm
B	Semi circular lever
C	Cylinder jacket
D	Alu ring
E	Plug
F	Pressure pin

- When assembled, distance A must be 4 to 5 mm.

3. Put the valve-lifting housing with in-built piston back into its original position on the flange of the cylinder jacket.
 - 3.a. Tighten the four M10 bolts in the cylinder jacket to the torque given(Section 5.1, Page 68).
 - 3.b. Connect the 8 mm control pressure oil line to the housing.

4.9 SUCTION/DISCHARGE VALVE ASSEMBLY

1. Place the suction valve ring on its seat in the cylinder liner collar.

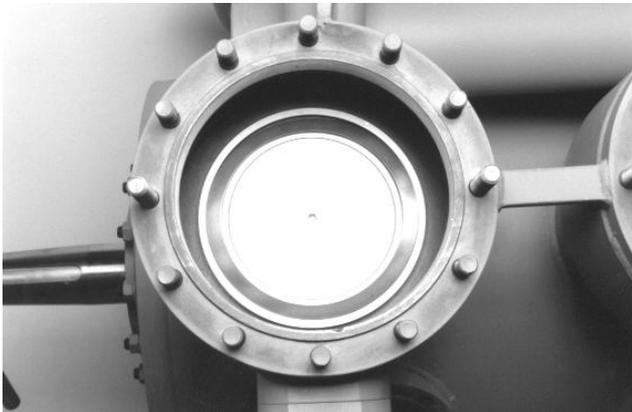


Fig.152: Top view piston

2. Place the sinusoidal springs with the convex side pointing upwards on the suction valve ring.



Hint!

During the assembly the sinusoidal springs in inclined cylinders can fall out of the cylinder liner. This can be prevented by placing the sinusoidal springs in such a way on the valve ring that the springs touch the valve ring at the highest and the lowest point in the inclined cylinder liner.



Fig.153: Top view of discharge valve assy

3. Place the preassembled discharge valve assembly on the sinusoidal springs of the suction valve.
 - 3.a. Clean the sealing edge of the cylinder head cover and also the edge on the cylinder head itself.
 - 3.b. Rub both packing faces and the studs with grease.

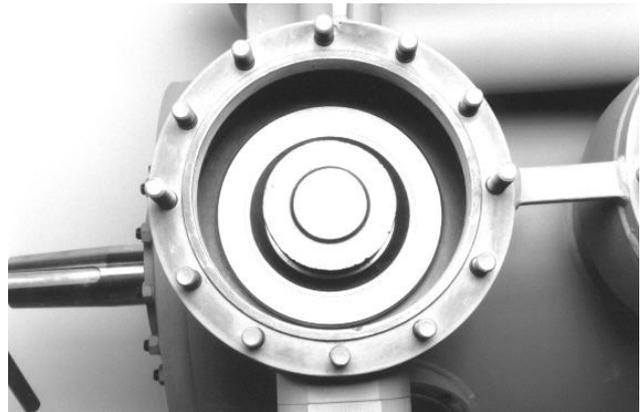


Fig.154: Top view of discharge valve assy

4. Place the oiled pressure spring cup on the discharge valve assembly.

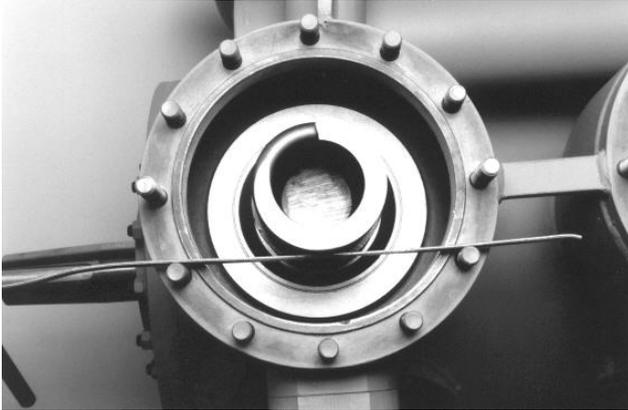


Fig.155: Top view buffer spring

5. Subsequently, fit the buffer spring which has to be prevented from tipping by a steel strip placed against the two studs.
6. Insert a new gasket into the cylinder cover groove and slide the cylinder head cover over the studs on the buffer spring.

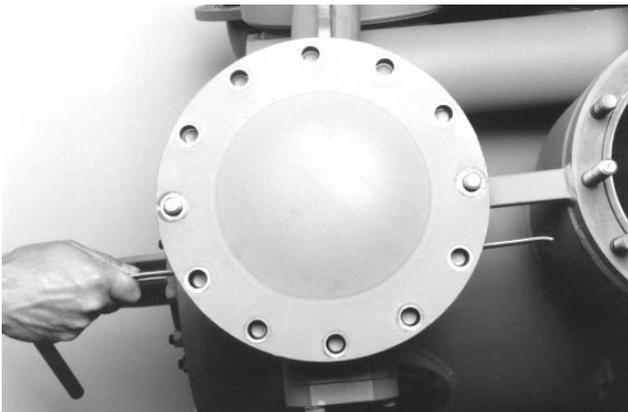


Fig.156: Top view cylinder cover

- 6.a. Remove the strip.
- 6.b. Screw two M16 nuts on the two long and oiled studs.

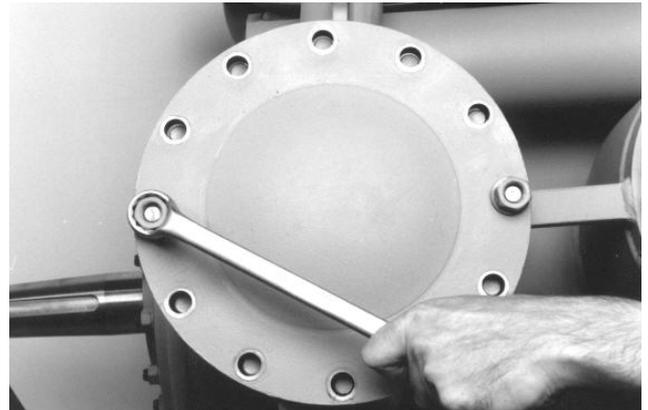


Fig.157: Top view cylinder cover

- 6.c. Tighten these two nuts alternately to the torque given(Section 5.1, Page 68).
- 6.d. After that, fit the other nuts in the same way.

4.10 ROTARY (SLIP RING) SHAFT SEAL



Fig.158: 40

1. In the case of new parts, check that the protective foil has been removed.
 - 1.a. Avoid touching the contact faces of these parts; slightly rub your hands with oil or wear gloves.
 - 1.b. Especially inspect the crankshaft part where the O-ring moves.
 - 1.c. Remove all (rubber) deposit by sanding or polishing.
 - 1.d. Oil all parts with compressor lubricating oil, as well as the crankshaft part in situ of the shaft seal.

- 1.e. Slide the slip ring part over the crankshaft and push through until the rear side is positioned against the crankshaft boss.

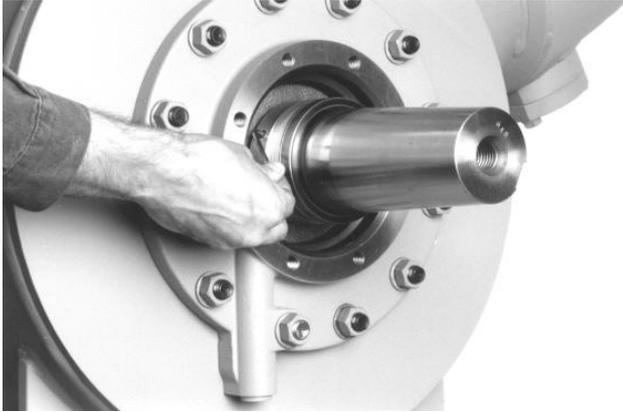


Fig.159: 41

2. Lock the slip ring on the crankshaft by tightening the three grub screws with an allen key⁸. (Torque refer Section 5.1, Page 68)

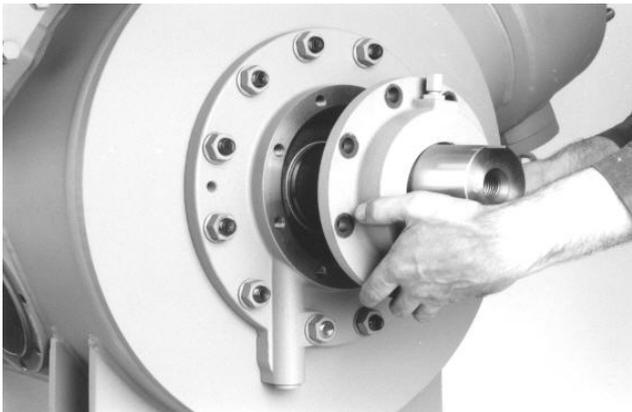


Fig.160: 42

3. Insert the counter slip ring with the O-ring into the shaft seal housing.
 - 3.a. Place a new O-ring into the groove of the cleaned shaft seal housing.
 - 3.b. Mount the shaft seal housing (only one mounting position is possible) onto the crankcase.



Fig.161: 43

4. Place the M12 nuts and tighten them alternately crosswise to the torque given.
 - 4.a. Screw the nipple coupling for the oil leakage drain line into the bottom of the shaft seal housing and then the drain line.

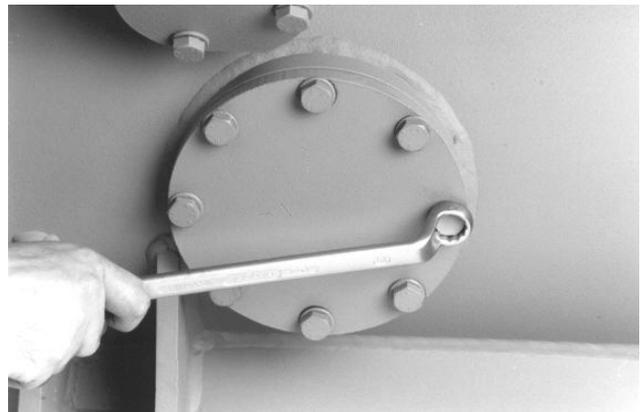


Fig.162

5. Check that the crankcase is clean and dry and, subsequently, fit all crankcase covers with new O-rings.

⁸ Part of the auxiliary tool kit.

4.11 SUCTION GAS FILTER

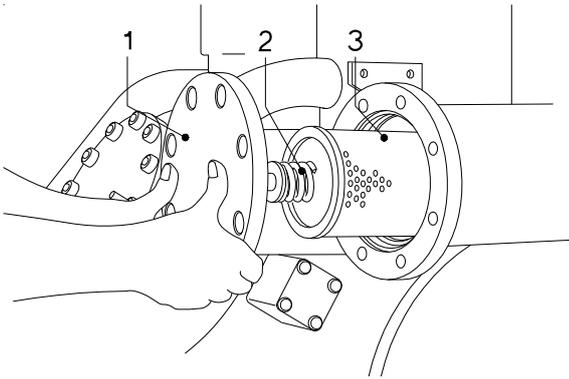


Fig.163

1. Place a new gasket into the groove of the suction gas filter cover.
1. 1.a. Slide the preassembled cover of the suction gas filter assembly into the housing in such a way that the centring profile around the filter fits into the fixed centring edge.
1. Screw the eight bolts into the housing and tighten them to the torque given(Section 5.1, Page 68).

4.12 PRESSURE RELIEF VALVE ASSEMBLY

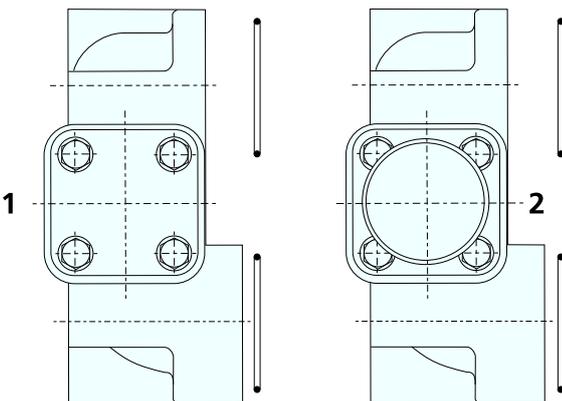


Fig.164: Relief valves

Legend	
1	Back pressure dependent
2	Back pressure independent



Hint!

Refer to the valve position table (Section 5.7, Page 74) for the location of pressure relief valves.

1. Place a new O-ring in (each) pressure relief valve housing.
 - 1.a. Put the pressure relief valve housing into the proper mounting position (only one mounting position is possible!) against the cylinder jacket.
 - 1.b. Screw the six M12 bolts into the cylinder jacket and tighten them evenly and crosswise to the torque given(Section 5.1, Page 68).

4.13 Running-in oil filter has to be installed after an overhaul or big repair



Hint!

This is why and when the running in oil filters are required:



Warning!

A running in oil filter has always to be installed after an overhaul or big repair for the 1st 100 hours of operation!

The oil and oil filters have to be replaced by new oil and filters.

Due to running-in wear of liners and piston rings, it's normal that the oil becomes grey during the 1st 100 operating hours.

After 100 operating hours, the oil could slightly become clear again.

4.14 OIL FILLING



Hint!

Use clean or fresh original oil only!

1. The following components have to be filled with oil before starting up via the oil charge valve, mounted on the oil pump, refer Figure 166, Page 66:

- 1.a. Crankcase
- 1.b. Shaft seal housing(Figure 165, Page 66)
- 1.c. Oil pump
- 1.d. Oil discharge filter
- 1.e. Oil lubrication circuit
2. Oil suction filter(Figure 166, Page 66 ,left filter): Charge through the filling openings or prelubricating valves (if present) on the top of the filter housing.

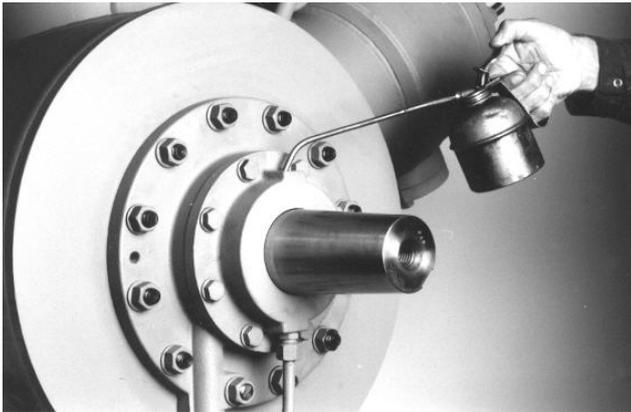


Fig.165: Shaft seal housing

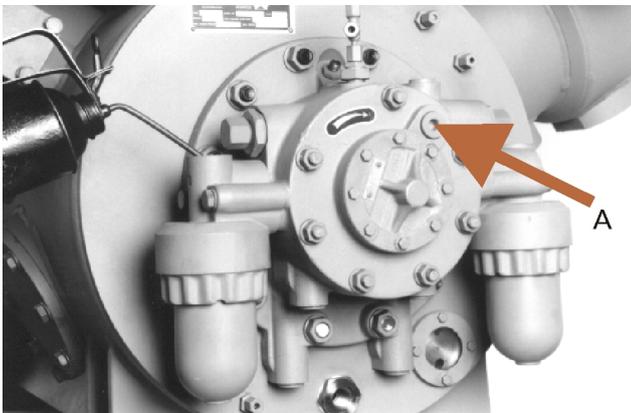


Fig.166: Oil filters and location oil charge valve (A); not shown!

3. Oil discharge filter:

Remove all oil filling plugs and fill the corresponding components with the amount of oil given(Page 66).

- 3.a. Fit the oil filling plugs with new aluminium rings.
- 3.b. Fit the other nipples and couplings and tap the key into the crankshaft key way.

Quantity of oil				
QUANTITY OF OIL TO BE FILLED (IN dm ³)				
Number of cylinders	Shaft seal housing incl. internal circuit of crankshaft	Oil filters	Oil pump	Crankcase
2	0.63	1.5 each	0.5	7.8
3				
4	0.72			13.6
6	0.73			14.7
9	0.83			21.7
12	0.93			28.7

4.15 MOUNTING FLYWHEEL



Fig.167

1. Place the flywheel on the crankshaft using a suspension gear with sling.

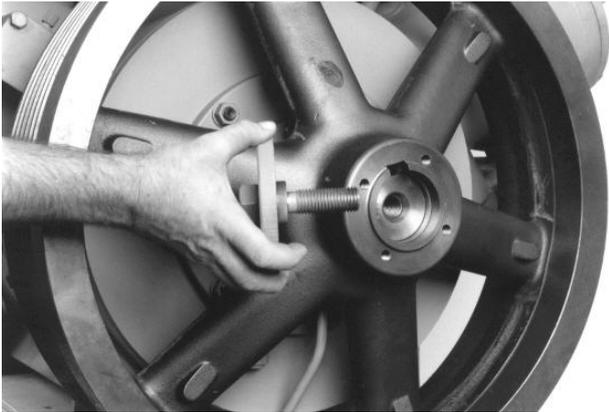


Fig.168

2. Place the locking disc and screw the centre bolt as far as possible into the crankshaft.



Fig.169

3. Screw three (3) M12-bolts fully into the flywheel hub.



Fig.170

4. Tighten the central M24-bolt with a torque wrench to the torque given(Section 5.1, Page 68).



Fig.171

5. Lock the central bolt with locking plate, together with the fourth M12 bolt.

4.16 DISCHARGE VALVES, LEAKAGE TEST PROCEDURE

A leak test after 4 running hours of the compressor is strongly recommended;

1. Stop compressor
2. Immediately close the discharge stop valve and record the discharge pressure (must be at least 6 bar)
3. Measure the time it take for the discharge pressure to fall to 3 bar. (decrease from 6 to 3 bar)



Warning!

If equalizing time is less than 60 seconds, all the discharge valves have to be checked.

5 MISCELLANEOUS

5.1 SURVEY OF TORQUES FOR BOLTS AND NUTS

Item	Threaded connection	Thread size	Torque in N.m.	Remarks
1	Bearing cover nuts (both sides)	M16	120	
2	Coupling bearing cover on pump side	G1/4"	tightened	
3	Shaft seal housing nuts	M12	40	
4.1	Oil pump housing bolts	M12	40	
4.2	Pump element bolts	M6	7	
5	Connecting rod bolts	MF16x1.5	100	
6	Gudgeon pin locking bolt	M12	40	
7	Valve-lifting housing bolts	M10	35	
8	Coupling of the control line valve-lifting housing	G1/8"	tightened	

Item	Threaded connection	Thread size	Torque in N.m.	Remarks
9	Discharge valve (centre bolt)	M16	120	
10	Cylinder head nuts	M16	120	
11	Cylinder liner tie bolt - nut	M6	---	
12	Sight glass flange bolts	M6	7	
13	Crankcase side cover bolts	M12	80	
14	Pressure relief valve cover bolts	M12	80	
15	Pressure relief valve assembly mounting bolts	M12	80	
16	Oil discharge filter bolts	M10	35	
16	Oil suction filter bolts	M10	35	
18	Suction filter housing bolts 2, 3 and 4 cyl. compressor	M12	40	
19	Suction filter housing bolts 6, 9 and 12 cyl. compressor	M16	120	
20	Bearing block bolts	M16	120	

9 1 N.m = 0,102 kgf.m = 0,738 lbf.ft

Item	Threaded connection	Thread size	Torque in N.m. 9	Remarks
21	Intermediate bearing block bolts	M20	tightened	
22	Counterweight bolts	M16	120	
23	Crankshaft spacer ring bolts	M8	17.5	
24	Standard and heavy duty thrust bearing (pressure piece) socket head screws	M10	35	
25	Shaft seal (locking) screws	M4	handtight	
26	Socket head screw of disc/lever	M5	5.5	
27	Coupling leakage drain shaft seal	G1/8"	tightened	
28	Oil splash plate bolts	M6	7	
29	Sealing plug	G1/4"	tightened	

Item	Threaded connection	Thread size	Torque in N.m.	Remarks
30	Sealing plug	G1/2"	tightened	
31	Hand nut suction/discharge filter	M90x3	handtight	
32	Threaded rod auxiliary tool	M12	---	
33	Lubricating oil pressure regulator - hexagon	M27	tightened	
34	Control oil pressure regulator - hexagon	M27	tightened	
35	Crankshaft sealing plugs	M8	centre punch	
36	Non-return valve in cylinder liner collar	M22	tightened	
37	Tapered plug in cylinder liner collar	G1/4"	tightened	
38	Push bolt from auxiliary tools	M24	---	

9 1 N.m = 0,102 kgf.m = 0,738 lbf.ft

Item	Threaded connection	Thread size	Torque in N.m.	Remarks
39	Pulley puller for shaft seal	M8	---	
40	Foundation bolts	M20	tightened	
41	Drive coupling bolts			refer to service instruction on 00.87.537
42	Hub securing bolts (4x)	M12	tightened	
43	Hub securing (centre) bolt	M24	400	
44	Shaft seal - Crankshaft	M6	15 - 18.3	

5.2 WEAR LIMITS AND TOLERANCES



Hint!

Not only the wear limits determine whether a part is to be replaced, but moreover the condition of the part; have the honing or grinding tracks of precision machined butting or running faces been worn off irregularly, are there any visible discolouring of material, has the roundness remained correct and are there any signs of glazing. All these wear factors make a part virtually unserviceable, even if this part remains within its wear limits.

Wear limits and tolerances				
Item	Description of part	Ref.	Limits (mm)	Remarks
1	Main bearing bush pump side	20.38.110	max. inside diam. 90+0,16	When fitted
2	Main bearing bush driving side	20.38.102	max. inside diam. 90+0,16	When fitted
3	Bearing bush small end of the connecting rod	11.46.652	max. inside diam. 50+0,14	When fitted
4	Bearing shell big end of the connecting rod	20.38.140	max. inside diam. 90+0,14	When fitted
5	Crankshaft (main bearing and crankshaft journal)	22.39....	min. outside diam. 90-0.07	
6	Crankshaft (intermediate bearing)	22.39....	min. outside diam. 90-0.05	

9 1 N.m = 0,102 kgf.m = 0,738 lbf.ft

Wear limits and tolerances				
Item	Description of part	Ref.	Limits (mm)	Remarks
7	Crankshaft (axial play)	22.39.	min. 0.05 / max. 0.85	When fitted
8	Cylinder liner	23.18.010	max. inside diam. 160+0.12	When fitted
9	Gudgeon pin	24.18.320	min. outside diam. 50-0.00	
10	Piston rings	09.74.160	max. gap 2+0.1	Measured in non-scored part of cylinder liner
11	Suction valve ring	11.34.171	min. thickness 0.8	In situ of scoring of seat
12	Discharge valve ring	11.34.	min. thickness 0.8	In situ of scoring of seat
13	Control pressure piston for valve lifting	20.38.134	min. outside diam. 51-0.08	
14	Control pressure piston housing	27.38.650	max. inside diam. 51+0.07	
15	Intermediate bearing	11.44.890	max. inside diam. 90+0.14	When fitted

Wear limits and tolerances				
Item	Description of part	Ref.	Limits (mm)	Remarks
16	Thrust ring	11.42.012	min. thickness 5.50	
17	Bore in plug control mechanism	03.04.514	max. inside diam. 14.07	When fitted
18	Buffer spring	11.31.181	max. 115, min. 110	

5.3 REQUIRED SERVICE TOOLS AND MATERIALS

In order to properly carry out the disassembly, inspection and assembly procedures described in this manual, the service engineer should possess the following tools, measuring equipment and aids.

Description		
-Spanners:	Ring spanners and socket spanners (metric):	8-10 (2x) -13-14-17-19-24-27-30-32-36 -41
	Hexagon socket head spanners (metric):	8-13-10-17
	Torque spanners (metric)	19-24-30-36
	Pin-face wrench (metric) for shaft seal	M4
-Measuring equipment:	Inside micrometer of 0-50 mm	
	Inside micrometer of 50-100 mm	
	Outside micrometer of 0-50 mm	
	Outside micrometer of 50-112 mm	
	Depth micrometer of 0-50 mm	
	Vernier gauge of 10"	
	Feeling gauges of 0.05-1.00 mm	
	Magnetic gauge with extended plunger	
Misc:	Grasso special tool kit TA	various service activities
	Vacuum pump	
	Centre punch	

Description	
Circlip pliers	
Hammer (steel)	
Hammer (soft)	
Pair of pliers	Remove split pin valve-lifting mechanism
Loctite	243
Lead or tin soldering wire 2 mm	for measuring piston clearance
Polishing paper	
Polishing (compound) paste	
(two) Screwdrivers (small)	e.g. for removing shaft seal
Screwdriver (large)	removing key
Abrasive linen	
Silicon grease	
Wire brush	
Piston ring pliers	
Grease	
Self-made (crankshaft) auxiliary tool	removing and inserting crankshaft
Auxiliary tools for shaft seal	
Steel strip	support buffer spring
Oil drip tray	
Tube brush ø10 mm	cleaning crankshaft oil passageways
Bar ø6 mm	cleaning crankshaft oil passageways
Compressed air device	cleaning e.g. crankshaft oil passageways

Description		
	Hydraulic press	
	Heater approx. 80 °C	removing and inserting connecting rod bearings

5.4 GRASSO SPECIAL TOOLS AND AIDS

Certain operations which requires fitting and removing pistons and cylinder liners can be substantially be simplified by using special tools and aids which are obtainable as standard auxiliary tool kit, ref. no. 20.38.010 and instruction 00.87.121.

5.5 FITTING INSTRUCTIONS FOR PIPE COUPLINGS AND DOUBLE LOCKING RING

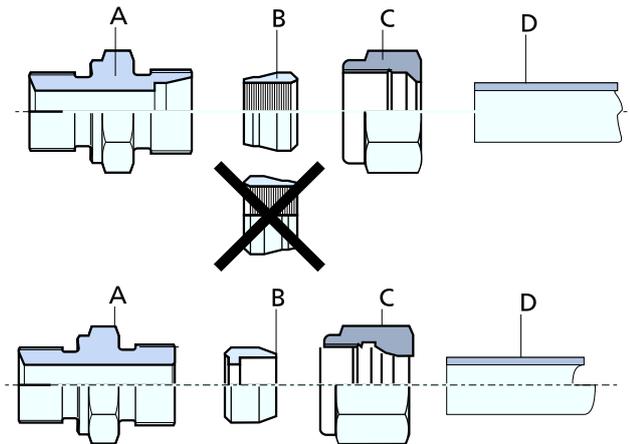


Fig.172: Pipe couplings

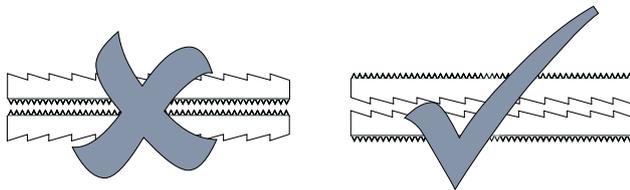


Fig.173: Double locking ring

5.6 MASS OF SEPARATE COMPONENTS AND COMPRESSORS

Description		Mass (kg)	Remarks
Bearing cover drive end (assembly)		22.2	
Bearing cover oil pump end		22.5	
Oil pump housing, complete with filters		28.2	Mind the remaining oil still present when removing the oil pump housing!
Cylinder liner assy		11.7	
Intermediate bearing assy		10.2	
Crankshaft	number of cylinders	-	With the assistance of a second person and using auxiliary tools the crankshaft can be removed or fitted.
	2	54.0	
	3	57.5	
	4	66.5	
	6	81.0	
	9	124.0	
	12	145.0	

Description		Mass (kg)	Remarks
Relief valve assy		13.0	Careful when removing! The full weight is released all at once.
For weights of bare shaft compressor and flywheel, refer to Product Information (ED).			

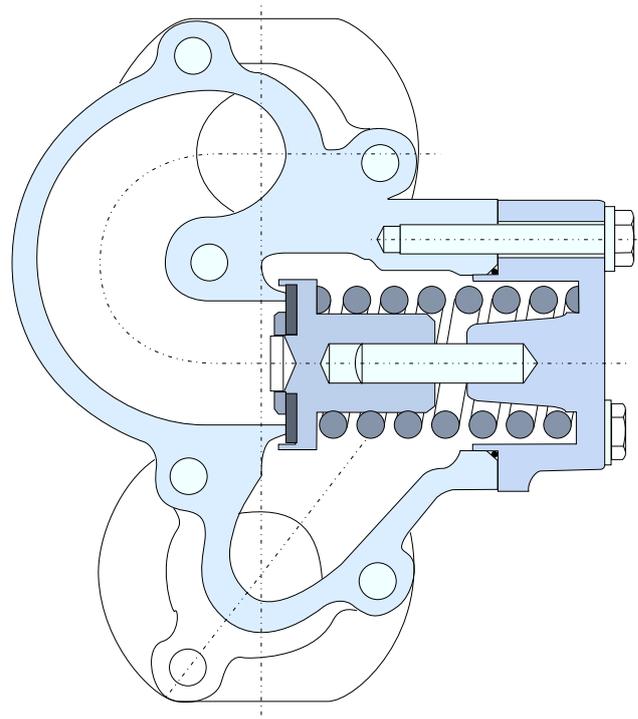


Fig.175: Relief valve; Back pressure dependent

5.7 RELIEF VALVE POSITIONS

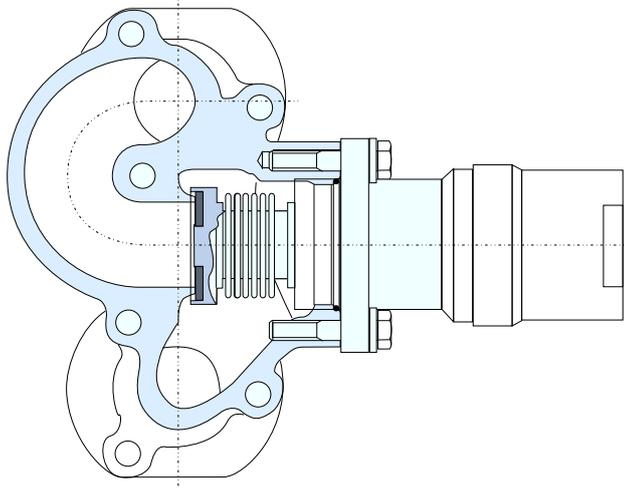


Fig.174: Relief valve; back pressure independent

Relief valves NH3												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange): NH ₃											
	1	2	3	4	5	6	7	8	9	10	11	12
2	LP											
3	LP											
4	LP											
6	LP											
9			B		LP							
12					LP	B						
21	LP		HP									
31	LP	HP										
42	LP				HP							
51	LP		HP									
63			LP		HP							
72			LP		HP							
84	LP				HP	B						B

Relief valves NH3												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange): NH ₃											
	1	2	3	4	5	6	7	8	9	10	11	12
93	LP					HP	B					
102						HP	B					LP

Relief valves R134a												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange): R134a											
	1	2	3	4	5	6	7	8	9	10	11	12
2	LP											
3	LP											
4	LP											
6	LP											
9				B		LP						
12						LP	LP					
21	LP		HP									

Relief valves R134a												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange):											
	R134a											
	1	2	3	4	5	6	7	8	9	10	11	12
31	L P	H P										
42	L P					H P						
51	L P		H P									
63				L P		H P						
72				L P		H P						
84	L P					H P	B					H P
93	L P					H P	B					
102						H P	L P					L P

Relief valves R404A												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange):											
	R404A											
	1	2	3	4	5	6	7	8	9	10	11	12
2	L P											
3	L P											
4	L P											
6	L P											
9				L P		L P						
12						L P	L P					
21	L P		H P									
31	L P	H P										
42	L P					H P						
51	L P		H P									
63				L P		H P						
72				L P		H P						
84	L P					H P	L P					H P

Relief valves R404A												
Type of compr.	Relief valve positions per cylinder number (LP = Low Pressure, HP = High Pressure, B = Blind flange): R404A											
	1	2	3	4	5	6	7	8	9	10	11	12
93	LP					HP	LP					
102						HP	LP					LP

5.8 MOUNTING O-RINGS



Warning!

In order to avoid damaging O-rings during re-assembling the compressor, carefully read the following instruction!



Fig.176: Clean the groove carefully with a clean, non fibrous cloth

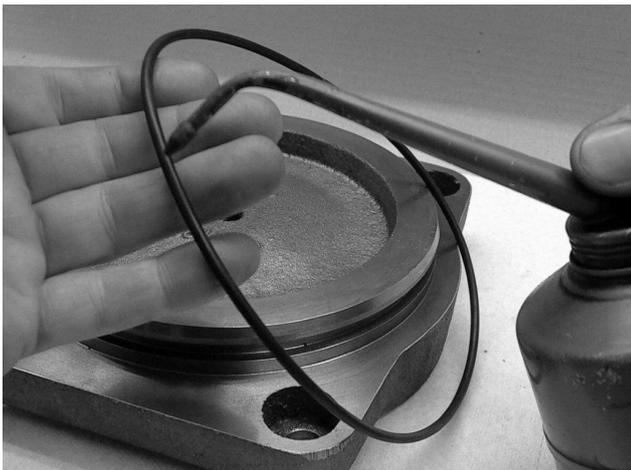


Fig.177: Oil the O-ring with compressor oil

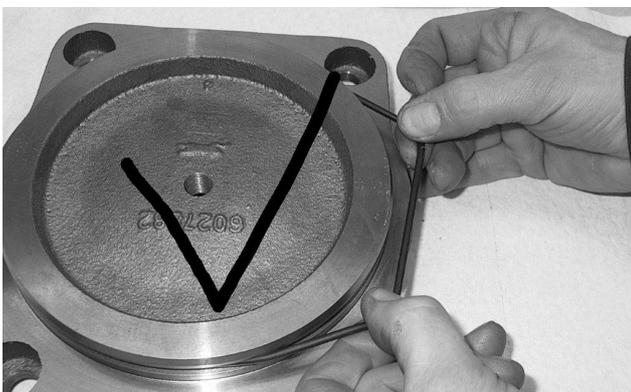


Fig.178: Proper way of mounting



Hint!

Pull the O-ring slightly and release it in the groove, be sure that the O-ring IS NOT twisted (Figure 178, Page 78)



Warning!

Never roll the O-ring in the groove (Figure 179, Page 78) because the O-ring will twist. This results into leakage!



Fig.179: WRONG WAY OF MOUNTING



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