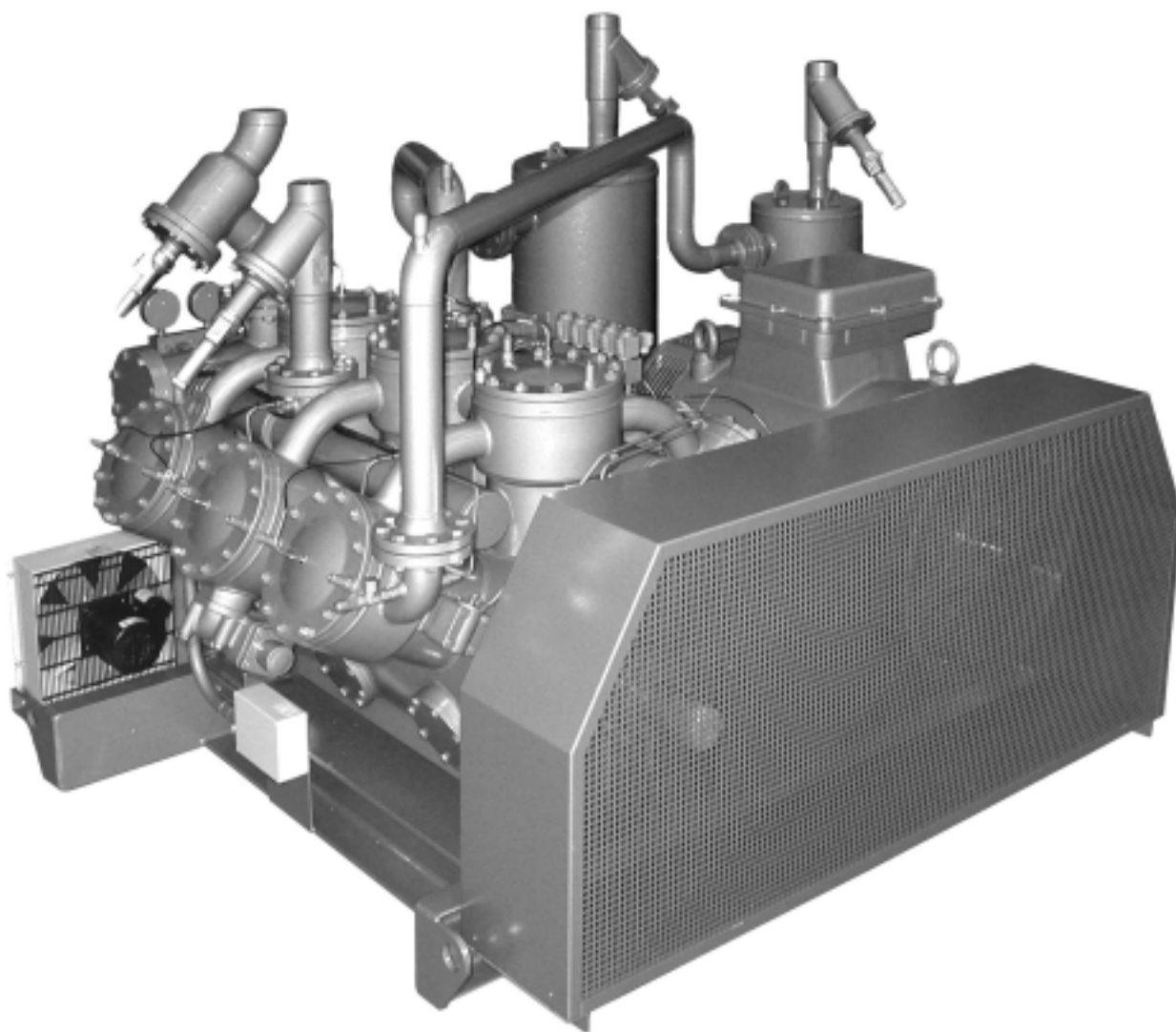


Reciprocating Compressors for industrial refrigeration Series Grasso 12E

Service Instruction Manual (SIM)

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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.

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Preface

This preface gives a survey of the types of documentation available for reciprocating Grasso compressor series.



All documentation and selection software is on-line available on www.grasso-global.com

1) Product Information (PI)

Contents

All product information (engineering data) for this series compressor and the corresponding recommended accessories. It is meant to be a guide to the selection of these components.

User group

Project engineers, application engineers, sales managers, product managers for both end-users and contractors.

Distribution

Your Grasso contact only.

2) Operating manual (OM)

Contents

General operation guide lines; safety instructions, periodical inspections, fault analysis, periodical maintenance.

User group

To be used in the field by the end-user.

Distribution

Supplied together with the compressor.

3) Safety instructions refrigerant ammonia

Contents

Strict safety provisions have been defined to protect human beings and facilities. Reference is made to the main guidelines and provisions to be observed in planning and operating refrigerating plants. With regard to their operation, the detailed operating manuals of the plant manufacturers shall be taken into account as well. Manual will be supplied with all compressors

User group

To be used in the field by qualified personnel for both end-user and contractor.

Distribution

(If applicable supplied together with the compressor)

4) Installation and maintenance manual (IMM)

Contents

This manual will provide information on how to transport, install, start-up and maintain the compressor (package). It also contains a number of "Product Information Sheets" and the current "Parts List"

User group

To be used in the field by qualified personnel for both end-user and contractor.

Distribution

Supplied together with the compressor.

5) Product Descriptions, Instructions for Accessories (PD)

Contents

All the relevant mounting and installation instructions and spare parts information for those accessories supplied with the compressor.

User group

To be used in the field by qualified personnel for both end-user and contractor.

Distribution

Supplied together with the compressor.

6) Parts list (PL)

Contents

All current parts of the compressor and accessories together with the design changes applicable to previous supplied components ("History").

User group

Service and parts department for both end-user and contractor.

Distribution

Your Grasso contact only.

7) Service & Maintenance Schedules (SMS)

Contents

Complete set of service and maintenance schedules for 100 operating hours up to 48000 operating hours (inspection, renewal, measuring, cleaning, ...) of the bare shaft compressor.

User group

Service and parts department and in the field by qualified personnel for both end-user and contractor.

Distribution

Your Grasso contact only.

8) Service Instruction Manual (SIM)

Contents

Description of (re)assembling, inspection, repair and part or total overhaul of the bare shaft compressor. This manual should be used together with the 'Installation and Maintenance Manual'.

User group

To be used in the field by qualified personnel of refrigeration installers or contractors.

Distribution

Your Grasso contact only.

9) Typographic signs



Indicates a WARNING. READ IT CAREFULLY!



Indicates an IMPORTANT note or procedure to which you should pay special attention.



Indicates a HINT.

Main setup data Grasso 12E

Table 1 Main setup data

Description	Value	Remark
Start frequency	max. 4 starts per hour	
Time interval between stopping and re-starting	min. 2 minutes	
Time interval between starting and re-starting	min. 15 minutes	
Time interval between capacity steps	min. 3 minutes	For continuous minimum part-load (i.e. more than 30 minutes) consult Grasso.
Oil level	25-75% crankcase sight glass	
Min. oil temperature	warmer than surroundings and , 20 °C for NH ₃ and , 30 °C for halocarbons	
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 3.0 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 (a)	
Max. intermediate pressure Max. suction pressure	NH ₃ - 7.0 bar (a) R22 - 7.0 bar (a) R134a - 6.2 bar (a) R404A - 6.0 bar (a)	
Pdischarge - Psuction	~19.0 bar	
Superheat	>0 K for NH ₃ , >15 K for R404A, R507 and R134a	
Oil suction filter	Blue coloured filter element	
Oil discharge - running in - filter	Red coloured filter element	 Factory mounted; to be replaced after max. 100 running hours by permanent oil discharge filter element
Oil discharge - permanent - filter	Grey filter element	 Supplied loose; replacement for factory mounted running in filter
Direction of rotation of compressor drive shaft	Counterclockwise when facing shaft end	

General info SIM

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.

Cylinder numbering

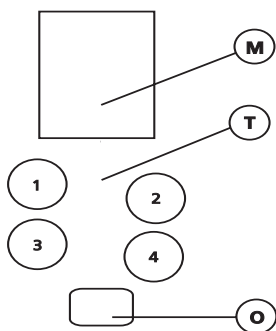


Fig. 1 Cylinder numbering Grasso reciprocating compressors

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

OUT OF PRODUCTION

2 AND 3 CYLINDER COMPRESSOR MODELS



Although this manual contains information on the 2, 3, 4, 6, 9 and 12 cylinder compressors, since the 1st October, 2003, the 2 and 3 cylinder compressors are no longer in production (single stage and two stage).

NEVER CHANGE POSITIONS!



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.

1. REPAIR AND OVERHAUL

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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

Procedure to evacuate and to dry a system:

- STATUS: System is filled with nitrogen and no oil has been added (oil prevents any trapped moisture from boiling off).
- Verify that all valves in that part of the system to be evacuated are opened (refer also to the plant manual).
- 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. 5 mm Hg (=6.6 mBar).
- Break vacuum by charging dry nitrogen into the system.
- Repeat step iii, 'Connect vacuum pump ...'.
- Wait approx. 24 hours.
- If pressure has increased (system still contains moisture), repeat steps iv, v and vi, otherwise, continue with the "Initial oil charge" procedure.

1.3 EVACUATION OF THE COMPRESSOR



Use always a vacuum pump to evacuate the compressor.

To evacuate the refrigeration system refer to Section 1.2, Procedure to evacuate the compressor:

- Switch off main control panel.
- Remove main fuses.
- Remove the refrigerant by means of a vacuum pump, via the evacuation/purging valve(s) as prescribed by local safety regulations. For the location of these valves refer to the "Product Information".

1.4 GENERAL RECOMMENDATIONS

- Do not disassemble more compressor parts than is necessary for the purpose (inspection, repair, overhaul).
- Use clean and well-conditioned tools.
- 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.
- 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.
9. Always use new gaskets, O-rings and locking rings when reassembling after inspection or repair.
10. Use a torque wrench to tighten the threaded connections. (Survey of torques for bolts and nuts refer to Chapter 5)

2. DISASSEMBLY

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2.1 REMOVING FLYWHEEL

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



Fig. 2.1-1

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



Fig. 2.1-2

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



Fig. 2.1-3

- ☐ Remove the four M12 hexagon head bolts.
- ☐ 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. 2.1-4

- ☐ Remove the locking disc.



Fig. 2.1-5

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

2.2 DISMANTLING SUCTION GAS FILTER

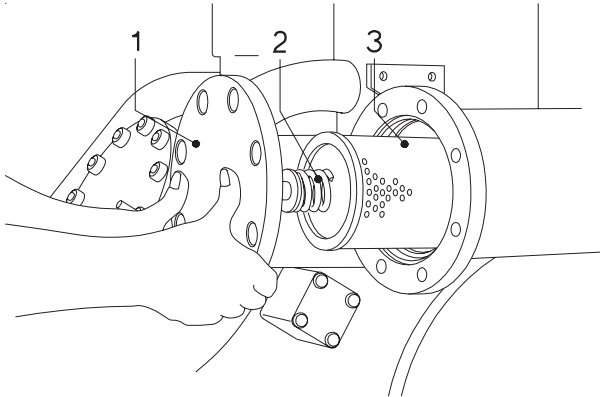


Fig. 2.2-1

Legend	
1	Cover
2	Spring
3	Filter

- ☐ Remove the bolts from the left cover of the suction gas filter housing.
- ☐ Remove the cover with the pressure spring and filter mounted to it from the housing.
- ☐ After the circlip ring has been removed from the centring pin, the filter can be easily removed.
- ☐ Remove the O-ring from suction gas filter and replace a suction filter if it is dirty.
- ☐ 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. 2.3-1 Back pressure dependent relief valve

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

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

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



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.

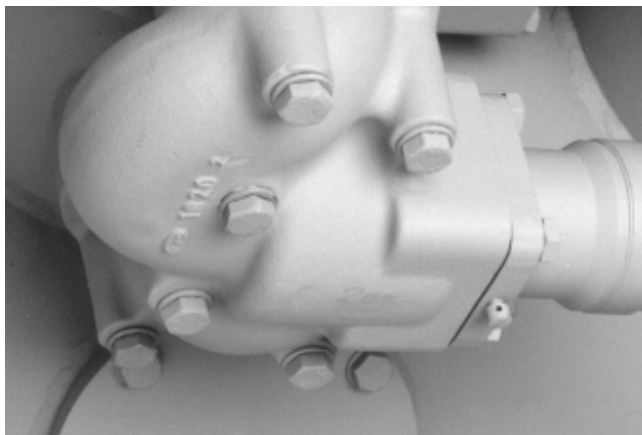


Fig. 2.3-2 Back pressure independent relief valve



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.

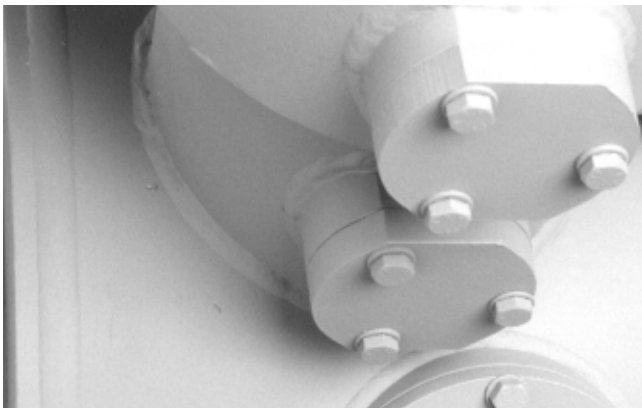


Fig. 2.3-3 Blind flanges



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. 2.4-1

- ☐ Remove dirt and paint particles from the cylinder head studs using a steel brush.
- ☐ Oil all studs.
- ☐ Remove all M16 bolts from the short studs.
- ☐ Release the buffer spring tension by alternately unscrewing the two nuts on the longer studs.

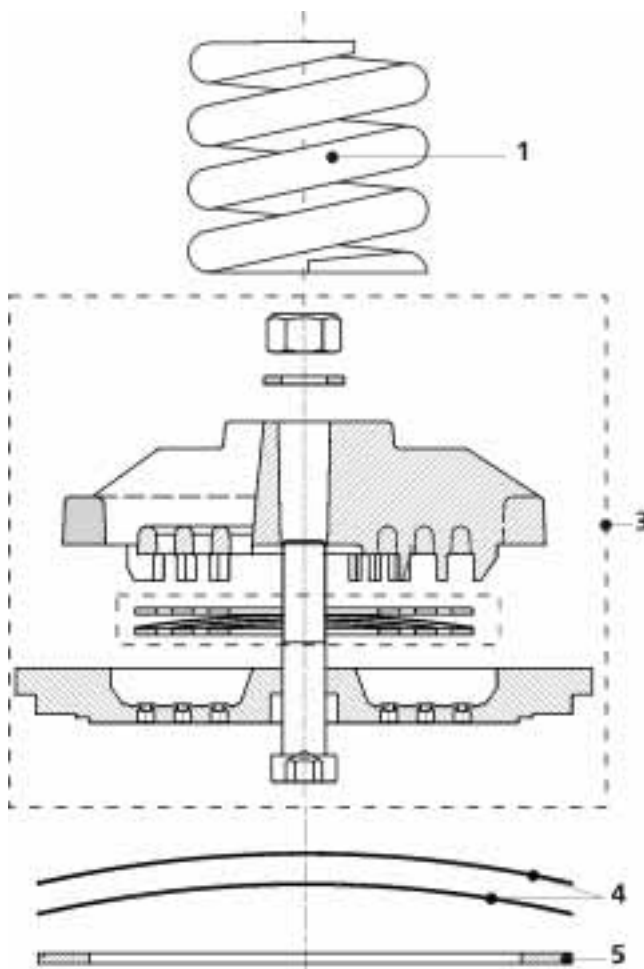


Fig. 2.4-2 Discharge valve assy (From serial number 00081502)

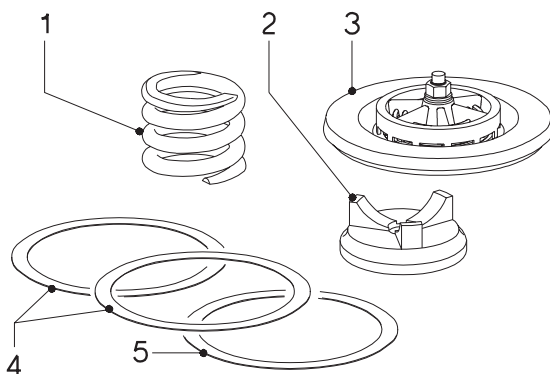


Fig. 2.4-3 Discharge valve assy (Up to serial number 00081502)

Legend	
1	Buffer spring
2	Pressure spring cup

Legend	
3	Discharge valve assembly
4	Sinusoidal springs ²
5	Suction valve ring

- ☐ Remove the cylinder head cover, the buffer spring, the pressure spring cup¹, the discharge valve assembly with the two or three² suction valve sinusoidal springs and the suction valve ring.

2.5 EXPLANATION CYLINDER LINER VERSIONS

Grasso 12E can have two different cylinder liner versions;

- 1 Latest version with suction sleeves; from approx August 2003
- 2 Olde version with suction holes; Before approx August 2003

For more details refer to Section 4.5.

2.5.1 REMOVING THE PISTON/CONNECTING ROD ASSEMBLY

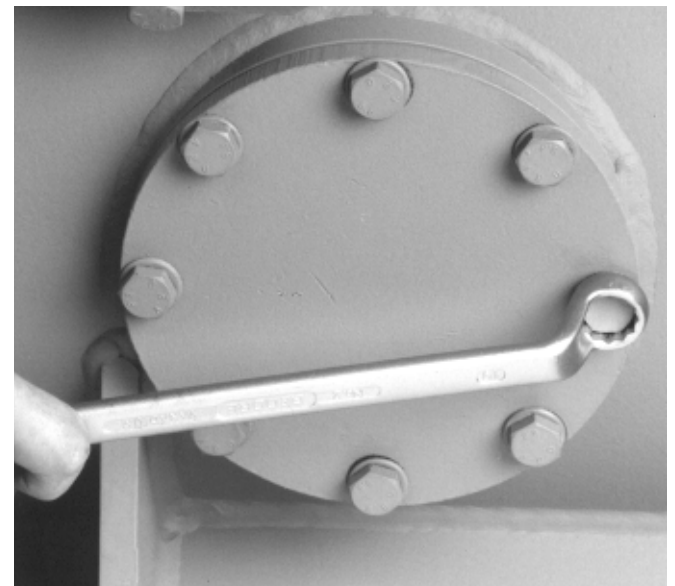


Fig. 2.5-1

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

1. Old version of discharge valve model only

2. The number of sinusoidal springs is dependent on refrigerant and/or operating conditions.

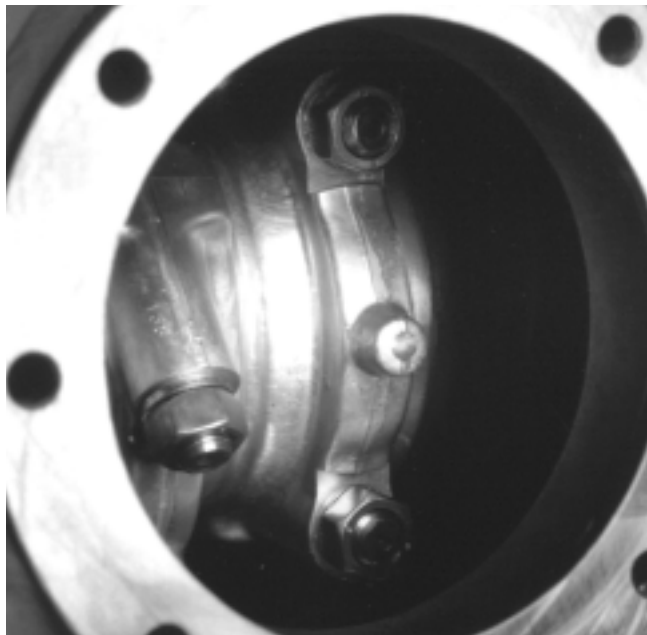


Fig. 2.5-2

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

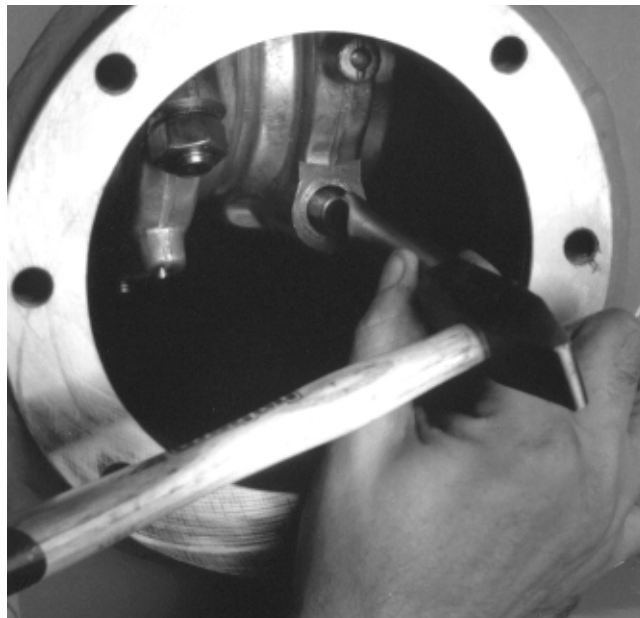


Fig. 2.5-4

- ☐ Tap up both connecting rod bolts a small amount of force so that the connecting rod cap can be removed easily.
- ☐ Pull both connecting rod bolts back to their original places in the connecting rod.
- ☐ Move the piston that is to be removed to top position by rotating the crankshaft by hand.

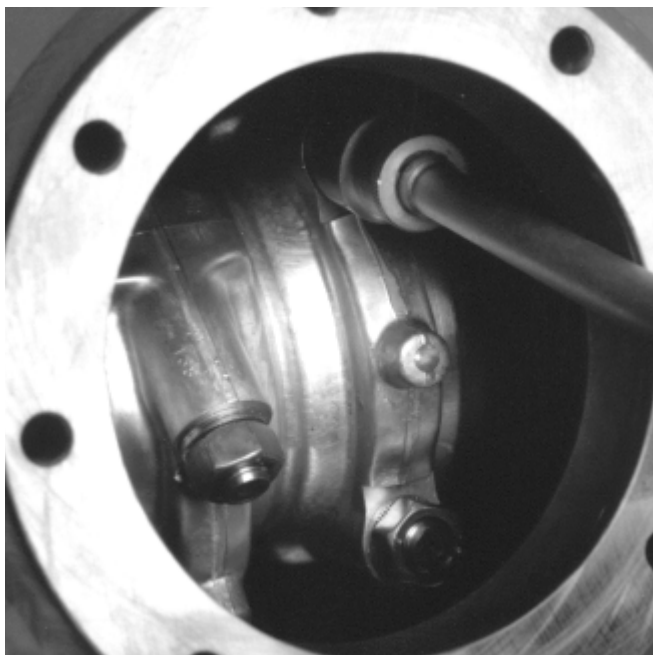


Fig. 2.5-3

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

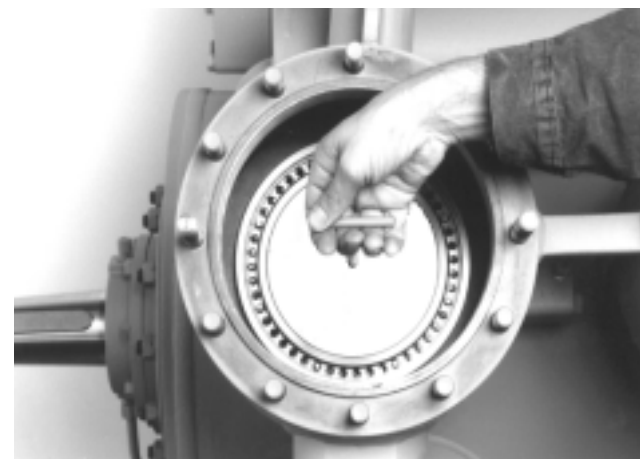


Fig. 2.5-5

- ☐ 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.



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!

- ☐ Inspect the cylinder liner bore



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 THE CYLINDER LINER

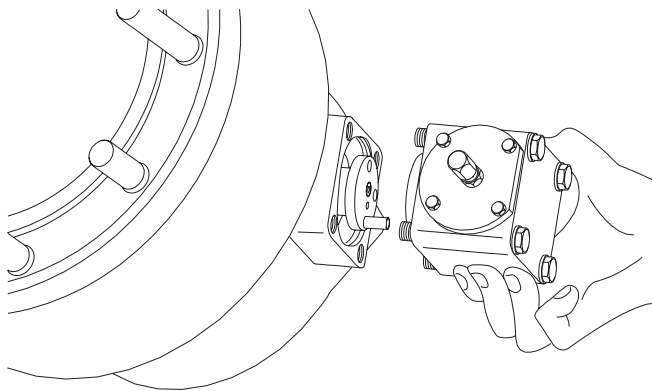


Fig. 2.6-1

- ☐ Disconnect the oil line on the valve-lifting housing.
- ☐ Mark the position of (each) valve-lifting housing on the corresponding mounting flange.
- ☐ Remove the entire housing, including the control piston in it, by unscrewing the M10 bolts from the cylinder jacket.
- ☐ Check the still mounted lever and carrier disc with dowel pin (= $\varnothing 8$ mm) for irreparable damage.



In order to be able to dismantle the cylinder liner, it is not necessary to remove the valve-lifting housing.



Fig. 2.6-2

- ☐ Place the longer bar¹ over two studs of the cylinder head.
- ☐ Insert the threaded rod with nut and washer into this bar.
- ☐ Place the short bar centrally across the bottom of the cylinder liner.
 - ✓ Screw the threaded rod into this short bar until the assembly is fully closed.
 - ✓ Now tighten the nut until the cylinder liner is loose.



Fig. 2.6-3

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

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

- ☐ For cylinder liners with suction holes only (old version):
 - ✓ 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.

2.7 DISMANTLING THE ROTARY SHAFT SEAL

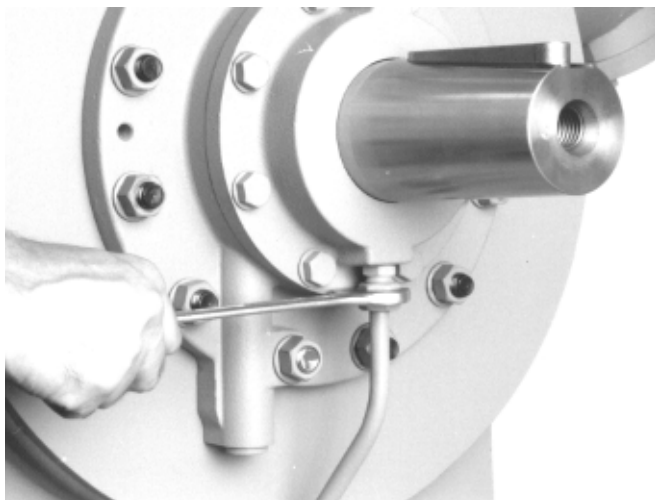


Fig. 2.7-1

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

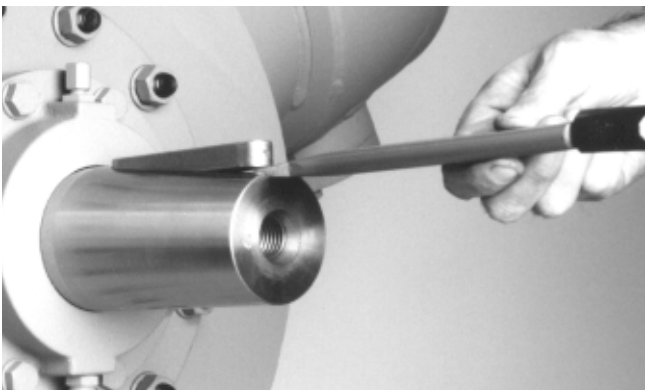


Fig. 2.7-2

- ☐ Remove the drive key from the crankshaft driving end.



Fig. 2.7-3

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

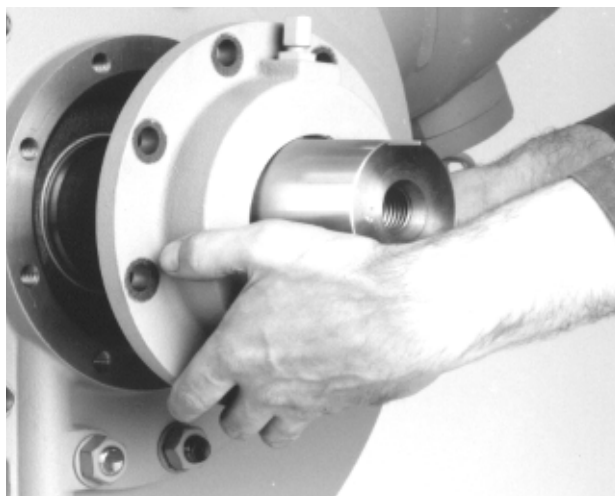


Fig. 2.7-4

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

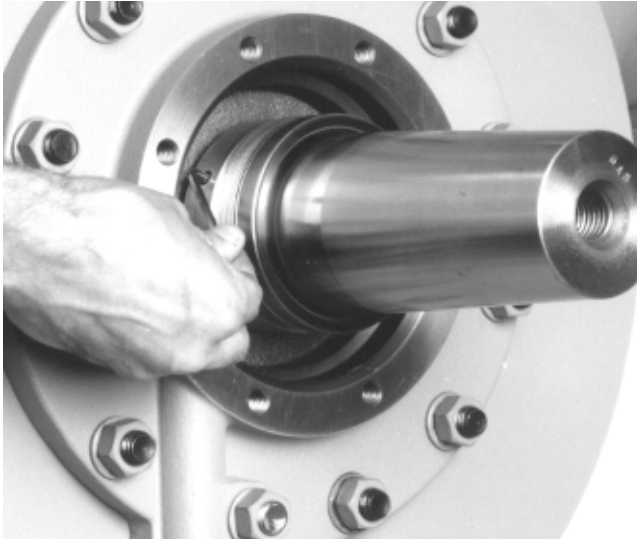


Fig. 2.7-5

- ☐ 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. 2.7-6

- ☐ 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.
- ✓ Do not scratch the crankshaft!



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



Fig. 2.7-7

- ☐ Slide the slip ring from the shaft .

2.8 REMOVING OIL SUCTION AND OIL DISCHARGE FILTERS



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



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.



Use the special tool key for removing oil filters.



Fig. 2.8-1 Special tool for removing oil filters

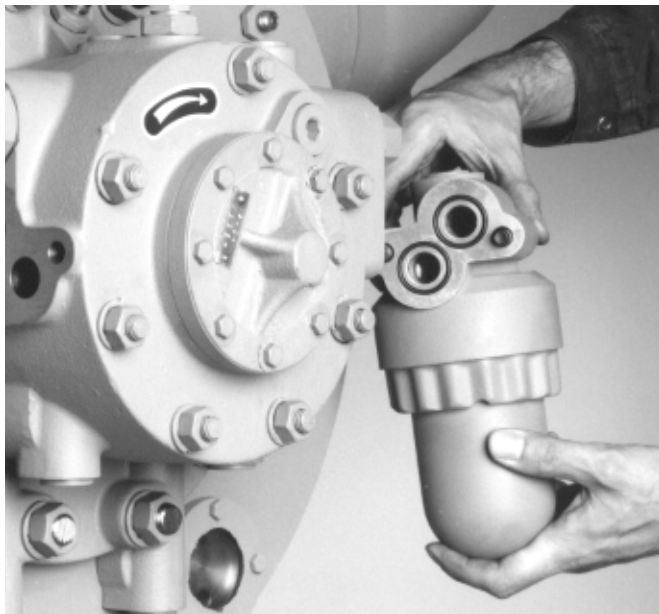


Fig. 2.8-2 Oil pump and filter

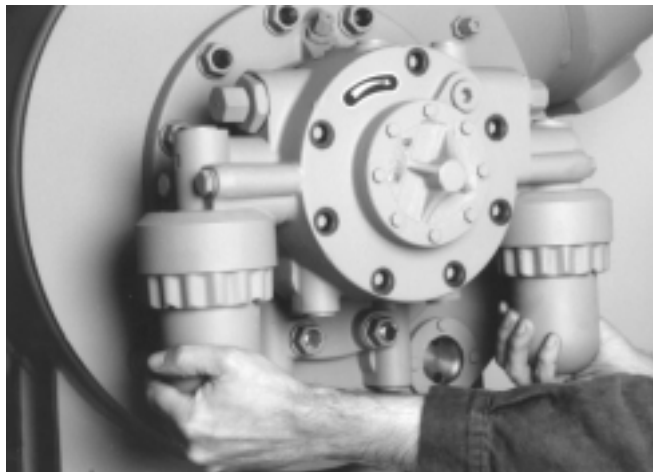


Fig. 2.8-4

- ☐ 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.
- ☐ Mark the filter housing to prevent interchange!



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

- ☐ Put an oil drip tray under the pump to collect the residual oil.
 - ✓ Unscrew the M12 nuts from the studs and slide the pump as a whole over the studs.



Fig. 2.8-3



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

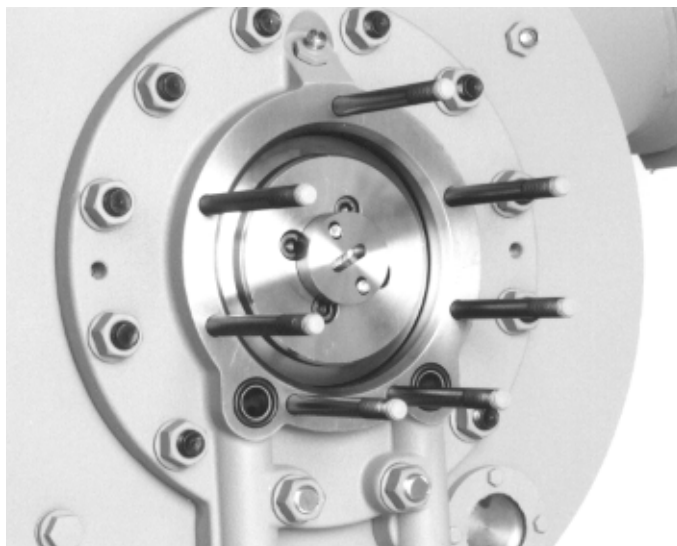


Fig. 2.9-1

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



Fig. 2.9-2

- ☐ Remove the now accessible four M10 socket bolts connecting the hold down disc with the crankshaft.
 - ✓ Carefully remove the hold down disc with the fitted dowel pin from the crankshaft.



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
 - a Bronze, mark 2, (latest version), refer Fig. 2.10-1
 - b Aluminium (old version), refer Fig. 2.10-2
2. Heavy duty



Fig. 2.10-1 Standard bronze thrust bearing, "mark 2"



Fig. 2.10-2 Old version of standard thrust bearing, aluminium.

2.10.1 DISMANTLING STANDARD THRUST BEARING



Fig. 2.10-3

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



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.



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

A) Remove external oil line, oil pump and carrier disk

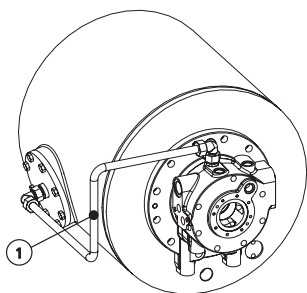


Fig. 2.10-4 External oil line

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

B) Remove heavy duty thrust bearing

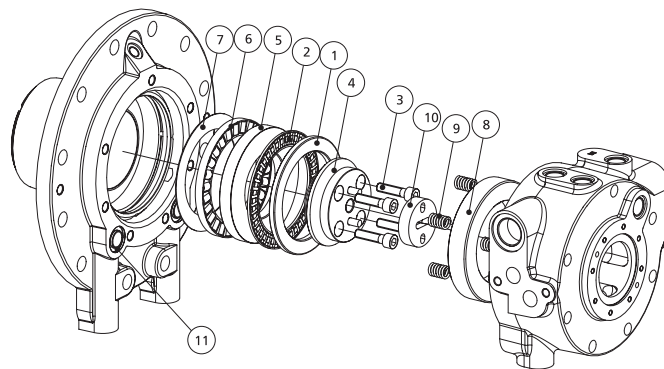


Fig. 2.10-5 Heavy duty thrust bearing



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

- ☐ Remove the 7 mm. thick housing washer (1) from the hold down disc (4).
- ☐ Remove the needle thrust bearing (2) from the hold down disc (4).
- ☐ Remove the now accessible four M10 socket bolts (3) and the hold down disc (4) which is connected to the shaft washer (5).
- ☐ Remove the shaft washer (5) from the crankshaft.
- ☐ Remove the cylindrical roller thrust bearing (6) from the crankshaft.
- ☐ The released 1 mm. thick thrust washer (7) can be carefully removed with a wire hook as shown Fig. 2.10-6.

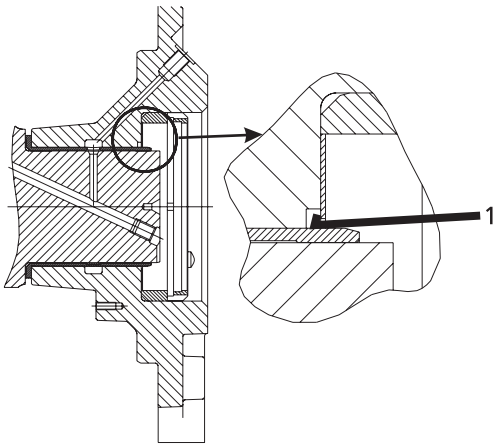


Fig. 2.10-6 Remove thrust washer with hook (1)

- ✓ 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.



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

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

2.11 REMOVING CRANKSHAFT, INTERMEDIATE BEARING AND MAIN BEARINGS

2.11.1 INTRODUCTION

- ☐ Before starting, the following components must have been removed:
 - ✓ All discharge valves
 - ✓ All pistons and connecting rods
 - ✓ Shaft seal and key
 - ✓ Oil pump
 - ✓ Thrust bearing



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

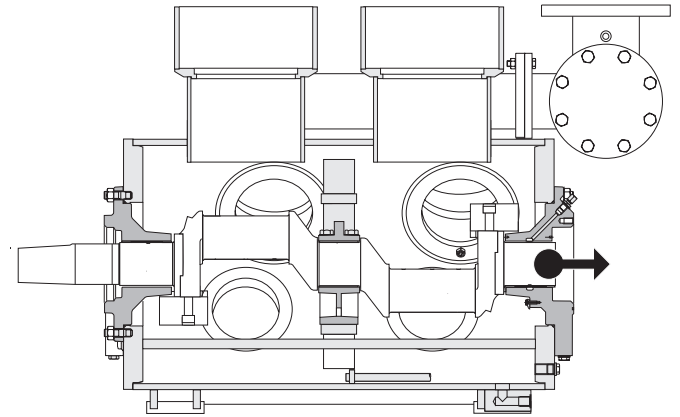


Fig. 2.11-1

2.11.2 INTERMEDIATE BEARINGS IN 4, 6, 9 AND 12 CYLINDER COMPRESSORS

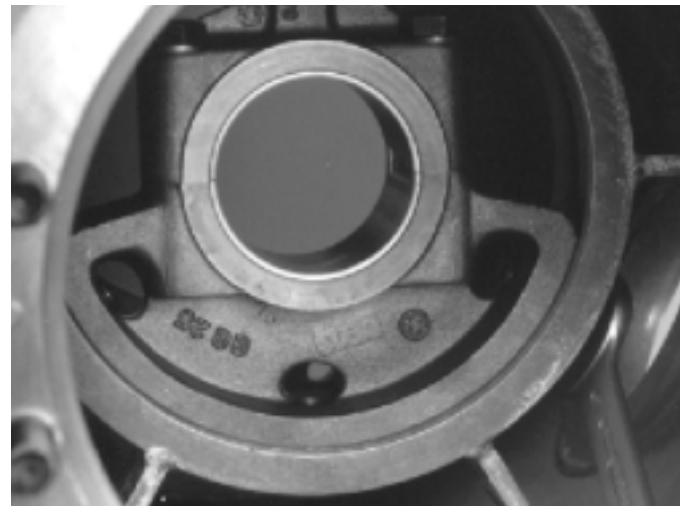


Fig. 2.11-2

- ☐ 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!
 - ✓ 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.

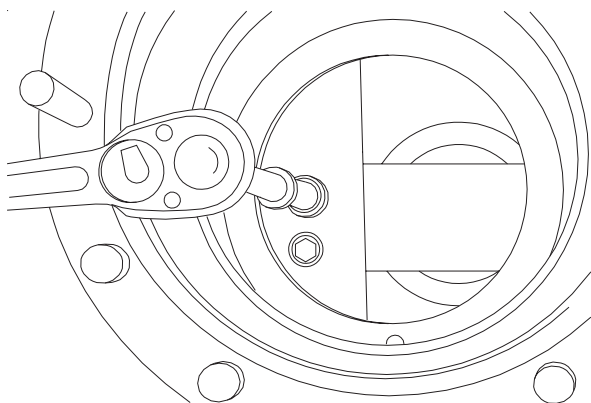


Fig. 2.11-3

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

2.11.3 2 AND 3 CYLINDER COMPRESSORS (I.E. WITHOUT INTERMEDIATE BEARING)

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

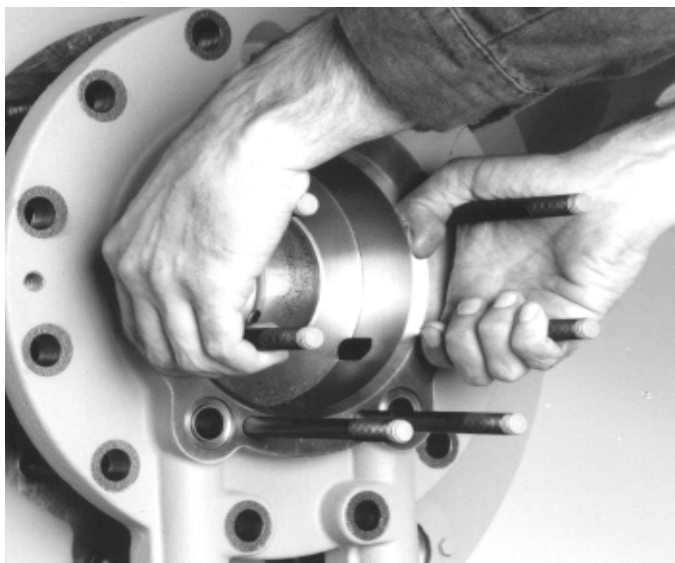


Fig. 2.11-4

- ✓ 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.
 - ✓ Assisted by a second person, now carefully remove the crankshaft from the crankcase through the opening on the oil pump side.
 - ✓ 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)

- ☐ Remove the swivel on top of the bearing cover on the pump side.
 - ✓ Unscrew all M16 nuts from the studs of the bearing cover on the pump side.
 - ✓ Screw two M10 (jacking) bolts into the threaded holes on both sides of the bearing cover.
 - ✓ Tighten these two bolts evenly and alternately until the bearing cover is loose.
- ☐ Remove the bearing cover (and the O-ring) and put it aside separately.

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



Fig. 2.11-5

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

2.11.5 REMOVING THE CRANKSHAFT, METHOD A (WITHOUT AUXILIARY TOOLS)

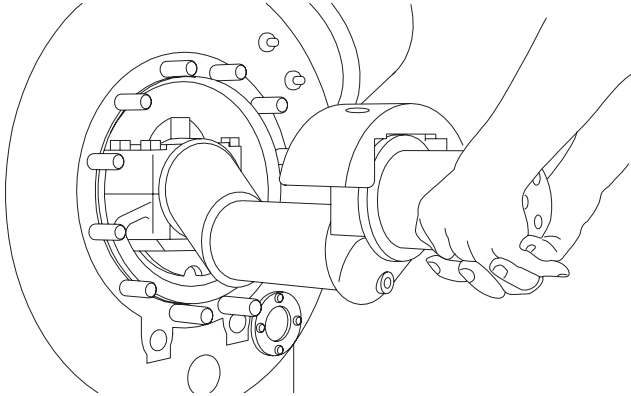


Fig. 2.11-6

- ☐ Remove the crankshaft of the 4, 6, 9, and 12 cylinder compressor in steps.
 - ✓ 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.
 - ✓ With the 4, 6, 9 and 12 cylinder compressor, unscrew the four M16 intermediate bearing bolts.
 - ✓ Remove both bearing block halves from the crankshaft and prepare them for inspection by reassembling them to each other leaving out the crankshaft.
- ☐ The crankshaft can be removed more easy 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)

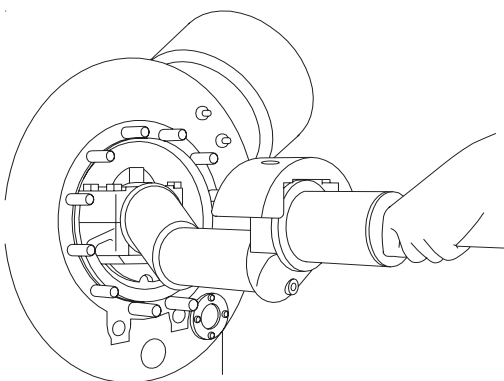


Fig. 2.11-7

- ☐ 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.

- ✓ With the 4, 6, 9 and 12 cylinder compressor unscrew the M16 intermediate bearing bolts.
- ✓ 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

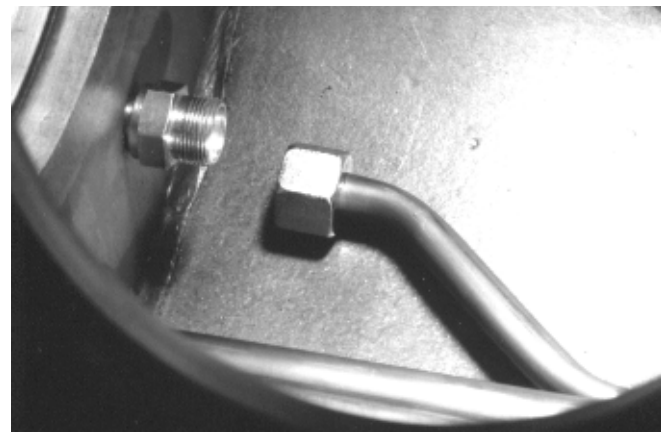


Fig. 2.11-8

- ☐ Uncouple and remove the internal oil connecting line and remove the oil line.

2.11.8 LINE COUPLING PIECES

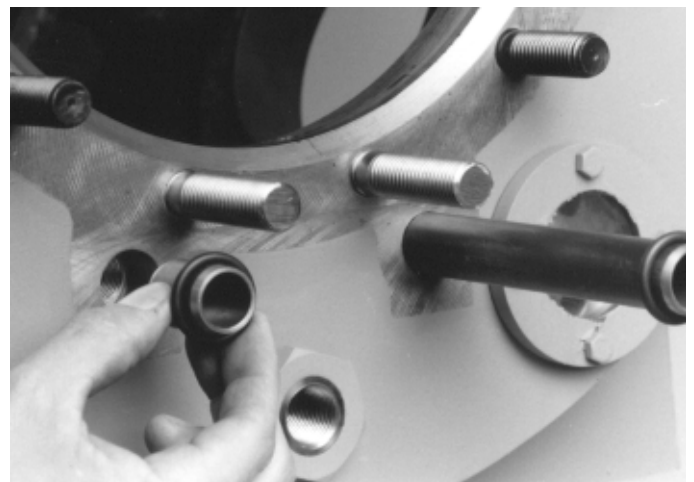


Fig. 2.11-9

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

3. INSPECTION AND PREASSEMBLY

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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

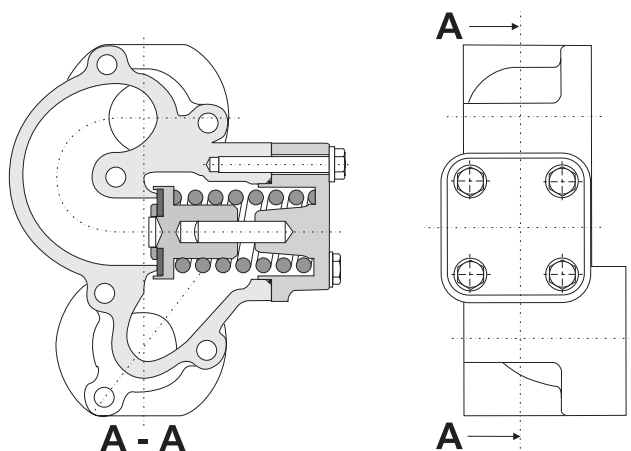


Fig. 3.1-1 Back pressure dependent

REMARK: 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

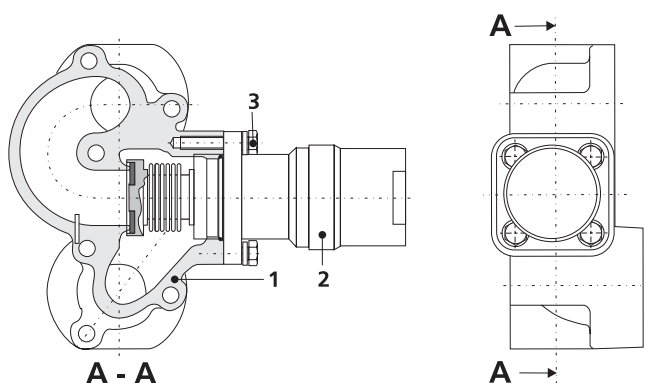


Fig. 3.1-2 Back pressure independent

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. 3.2-1 Oil pressure regulators

- ☐ The lubricating oil pressure regulator (not equipped with a groove in the hexagon nut) (see Fig. 3.2-1) 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.

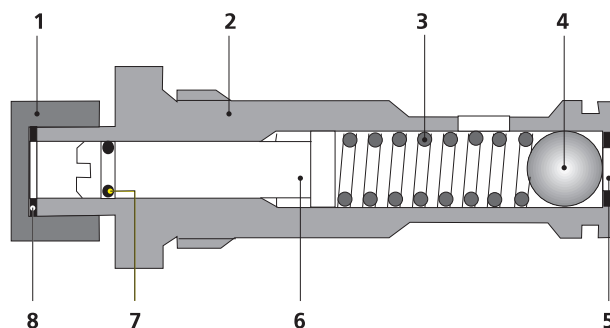


Fig. 3.2-2

Table 3.2-1

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

- ☐ 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.



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

3.3 CONTROL OIL PRESSURE REGULATOR



Fig. 3.3-1 Oil pressure regulators

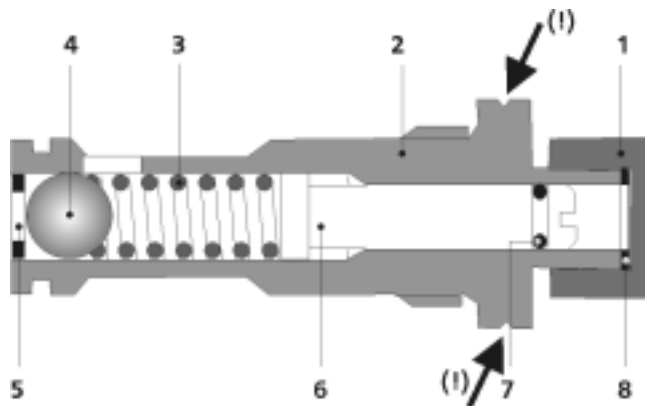


Fig. 3.3-2 Control oil pressure regulator

- ☐ The control pressure regulator (equipped with a groove in the hexagon nut, see lower regulator in Fig. 3.3-1) 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.
- ☐ Disassemble, inspect and reassemble as described in relation to the lubrication oil pressure regulator.

3.4 VALVE-LIFTING CONTROL MECHANISM RC12E

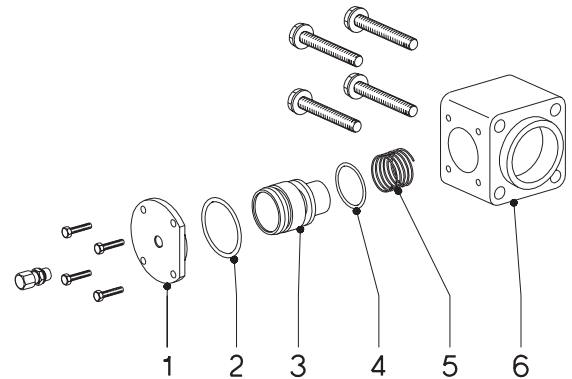


Fig. 3.4-1

A) Parts of the valve-lifting housing

- ☐ Remove the cover (1) from the housing (6) and remove the control piston (3) from the housing.
 - ✓ Remove pressure spring (5) with O-ring (4) and clean the piston.
 - ✓ 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 40.070 mm.
 - ✓ Check the pressure spring and replace it if the untensioned length is less than 51 mm.
 - ✓ Place the pressure spring and the lubricated piston with a new O-ring (4) into the housing, mount the cover with a new O-ring (2) and put it aside to be reassembled later.

B) Parts valve lifting mechanism

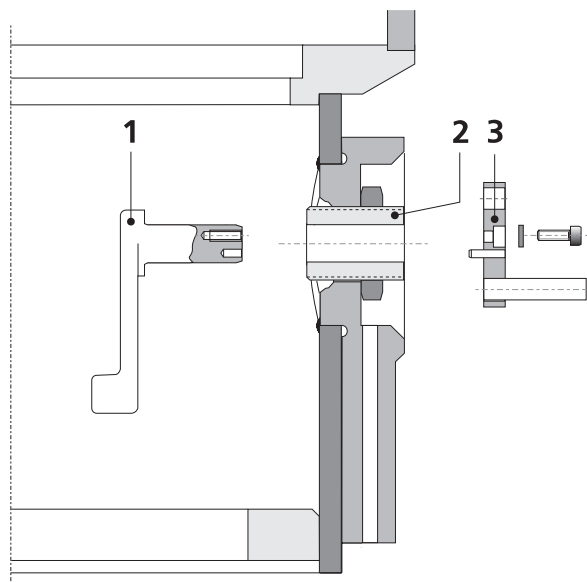


Fig. 3.4-2

- ☐ If the lever (1) does not easily fit inside the (firmly tightened) set screw (2) (on the side of every cylinder head), slight wear or damage of the lever shaft and in the bore of the still fitted set screw may be remedied with polishing paper after dismantling the disc (3) and lever (1).
- ✓ In the case of irreparable damage or wear, both the set screw and lever have to be replaced.

3.5 DISCHARGE VALVE ASSEMBLY AND SUCTION VALVE

3.5.1 DISCHARGE VALVE ASSEMBLIES

3.5.1.1 DIFFERENT TYPE OF DISCHARGE VALVE ASSEMBLIES

Following different types of discharge valve assemblies are possible;

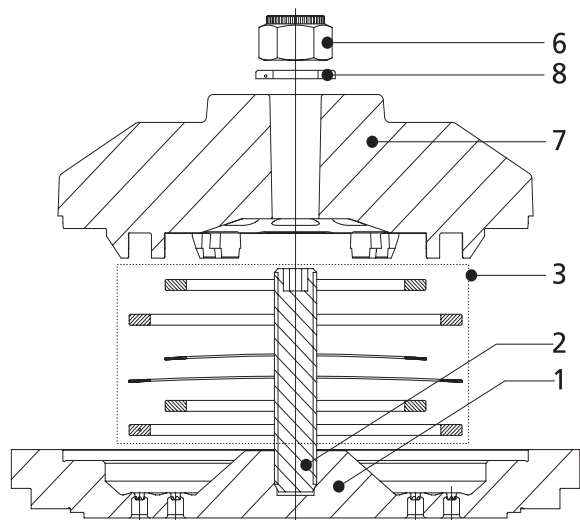


Fig. 3.5-1 OPTION 1; E3-2; Discharge valve assembly NH3 (From serial number 04010001)

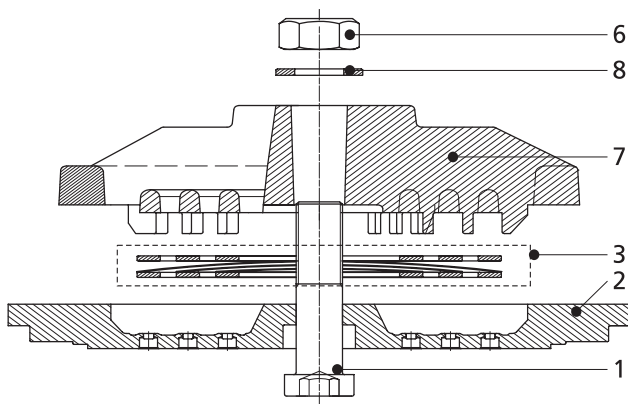


Fig. 3.5-2 OPTION 2; E3-3 Discharge valve assembly for halocarbons, type E (From serial number 00081502)

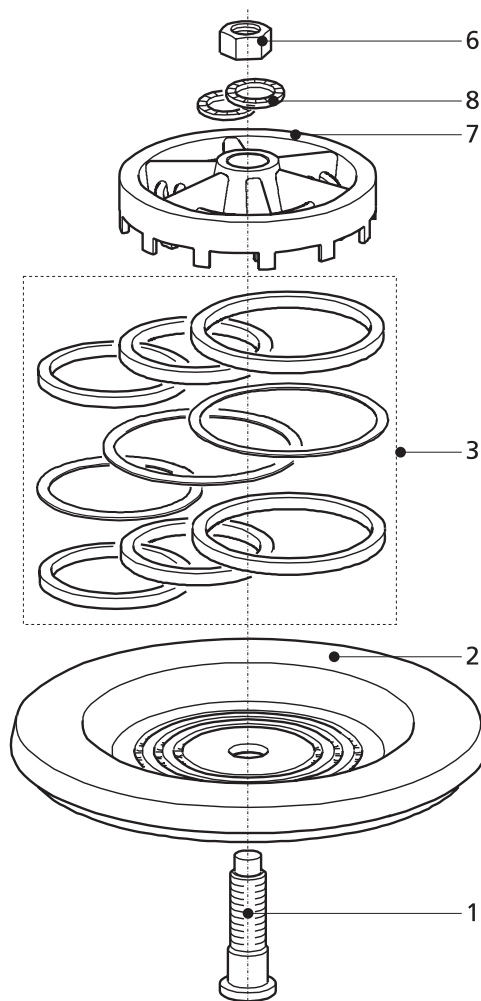


Fig. 3.5-3 OPTION 3; M2.2; Discharge valve assembly (Up to serial number 00081502)

Table 3.5-1 Legend discharge valve assemblies

Legend			
1	Valve seat	6	Nut
2	Central bolt	7	Stroke limiter
3	Damper rings, valve rings and springs	8	Double locking ring

3.5.1.2 DISMANTLING AND INSPECTION DISCHARGE VALVE ASSEMBLY

- ☐ Insert an allen key into center bolt (1).
 - ☐ Remove the M16 nut (6) from the central bolt (1), the double locking ring (8), the discharge valve stroke limiter (7), the sets of damper rings, sinusoidal springs and valve rings (3).
 - ☐ Thoroughly clean all valve parts and the valve seat (2).
 - ☐ Inspect the valve plate (2) for damage, wear or scoring. Replace the valve plate if one of the seats is damaged or when the seat is wider than 1.2 mm. If during this inspection the stroke limiter appears to have made contact with the piston, the connecting rod bearings have to be checked as well; the clearance should then be determined.
 - ☐ Inspect the PEEK valve and damper rings for discoloured, cracks or other signs of damage. Always replace the rings when they are close to the maximum allowed running hours.
 - ☐ Inspect the discharge valve stroke limiter (7) 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.

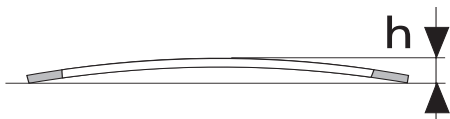


Fig. 3.5-4 Discharge valve, sinusoidal spring

- ☐ Replace the discharge valve sinusoidal springs when they are damaged/discoloured and when the unextended height 'h' is less than as given (Table 3.5-2)

Table 3.5-2 Minimum unextended heights

DISCHARGE VALVE ASSY	Sinusoidal spring	
	diameter	h min (mm) ^a
1 NH3 E3-2	smallest	5.5
	largest	8.5
2 Halocarbons from serial no. 00081502 E3-3	smallest	2.8
	medium	5.5
	largest	8.5
3 Up to serial no. 00081502 M2.2	smallest	2.5
	medium	3.5
	largest	5.5

a. Refer Fig. 3.5-4

3.5.1.3 PREASSEMBLING DISCHARGE VALVES

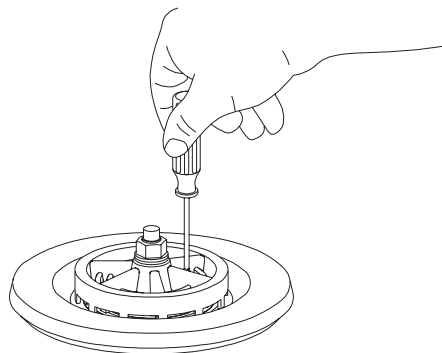


Fig. 3.5-5 Preassembling discharge valves

- ☐ Place each damper ring in their respective grooves of the discharge valve stroke limiter, then the sinusoidal springs (with the convex side facing the stroke limiter) and finally the discharge valve rings into the stroke limiter.
- ☐ Place the combined valve plate (2) over the stroke limiter.
- ☐ If necessary, adjust the clamped valve rings and valve springs with a screwdriver until all cams of the stroke limiter touch the valve seat.
- ☐ Fit the (M16) central bolt with a nut and a new double locking ring.
- ☐ Tighten this bolt/nut joint to the torque as given (Section 5.1).



To check leakage of the discharge valves, a leak test after 4 running hours of the compressor is strongly recommended. (Refer Section 4.14)

3.5.2 SUCTION VALVE

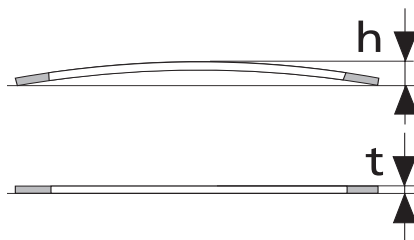


Fig. 3.5-6 Suction valve, sinusoidal spring

- ☐ Replace the suction valve sinusoidal springs when they are damaged or discoloured and when the unextended height 'h' is less than 9.6 mm.
- ☐ Inspect the cylinder liner for wear of the seats. Replace the cylinder liner if one of the seats is damaged or when the seat is wider than 2.2 mm.

3.6 PISTON/CONNECTING ROD

3.6.1 GENERAL



Fig. 3.6-1

- ☐ Place the assembly upside down on the working bench and remove one circlip ring from the gudgeon pin bore.

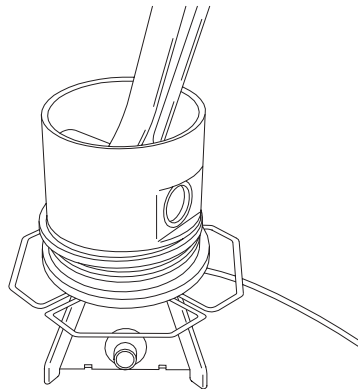


Fig. 3.6-2

- ☐ Heat the piston to approximately 80 °C
- ☐ NEVER HEAT WITH OPEN FLAME! Pouring a little spirit into the piston and lighting it works just as well.
 - ✓ Push the gudgeon pin out of the piston.
 - ✓ 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 than the value given (Table 5.2-1).

3.6.2 CONNECTING ROD

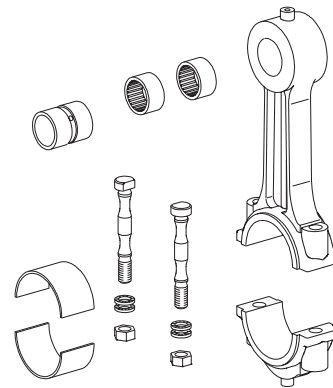


Fig. 3.6-3

- ☐ Assemble the bearing shells and the connecting rod cap into a whole.
 - ✓ Tighten the nuts on the connecting rod bolts to the torque given (Section 5.1).
 - ✓ Measure the bore of the clamped bearing with an inside micrometer and replace if it is larger as the value given (Table 5.2-1).
 - ✓ Check the bearing bush (for the LP cylinders) in the small end of the connecting rod for wear or damage.
 - ✓ With an inside micrometer measure the bore of the still fitted bearing bush and replace if it is larger as the value given (Table 5.2-1).
 - ✓ 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.
 - ✓ Check the condition of the double-row needle bearing (for the HP cylinders) and replace if necessary.
 - ✓ Insert the needle bearing as described for the bearing bush.

3.6.3 PISTON

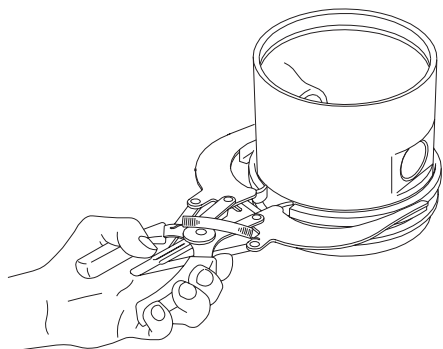


Fig. 3.6-4

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

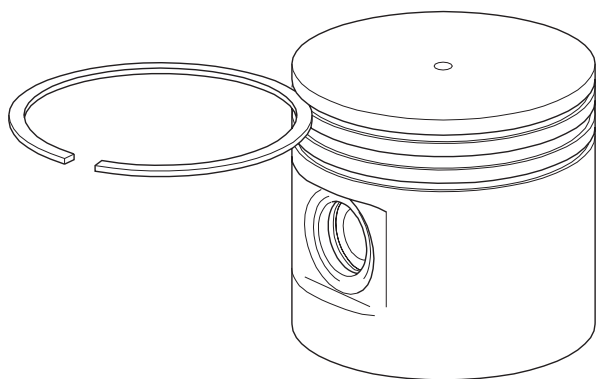


Fig. 3.6-5

- ☐ 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.
- ✓ Also check the rest of the piston for wear or damage.



Fig. 3.6-6

- ☐ 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 may not exceed 2.1 mm.

3.6.4 PREASSEMBLING THE PISTON/CONNECTING ROD



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

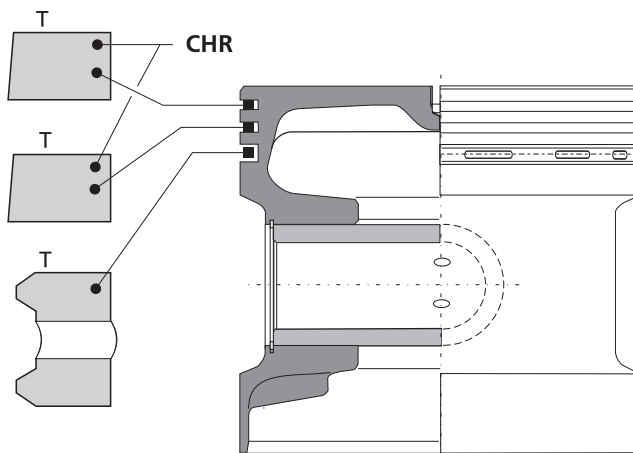


Fig. 3.6-7 Piston

Legend	
T	Top
CHR	Chromium-plated

- ☐ 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.

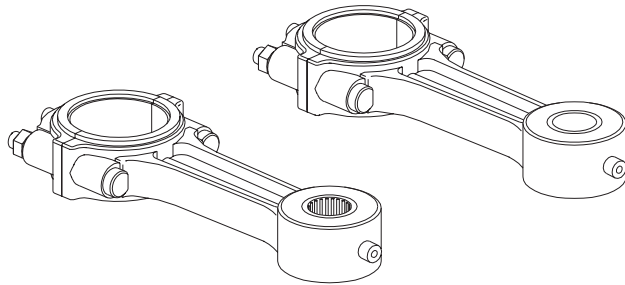


Fig. 3.6-8

- ☐ Clean the connecting rod and blow out the oil passageway in the connecting rod.
 - ✓ When replacing the bearing bushes or needle bearings, heat the small end of the connecting rod to approximately 80 °C.
 - ✓ Insert the 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.
 - ✓ Check whether the needle bearings project equally on both connecting rod ends.
 - ✓ Let the connecting rod cool off in ambient air.
 - ✓ Fit the bearing shells in both connecting rod parts. Due to the raised fixing cams only one building-in position is possible.

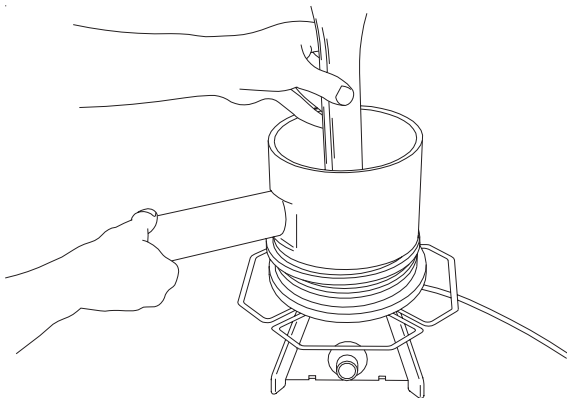


Fig. 3.6-9

- ☐ 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.
 - ✓ Degrease the gudgeon pin and oil it.
 - ✓ Check that the gudgeon pin fits properly into the connecting rod.

- ✓ Place the connecting rod into the piston and slide the oiled gudgeon pin through the piston into the connecting rod onto the still fitted circlip ring.

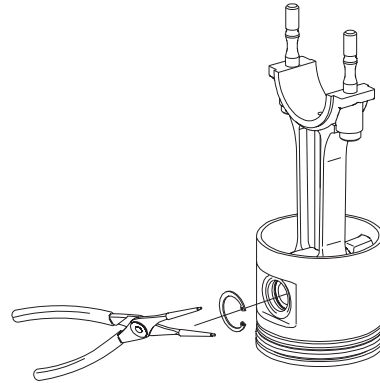


Fig. 3.6-10

- ☐ Lock the gudgeon pin with the other circlip ring.

3.7 CYLINDER LINER AND VALVE-LIFTING MECHANISM

General

Compressors older than approx. August 2003 can be applied with cylinder liners having suction HOLES. These cylinder liners can be re-newed for cylinder liners having suction SLEEVES, however in combination with the proper suction and discharge valves(Consult Grasso). The latest version of cylinder liners are those with suction sleeves, however the re-assembling procedure is described below for both types.

3.7.1 CYLINDER LINER WITH SLEEVES AND VALVE-LIFTING MECHANISM

3.7.1.1 GENERAL

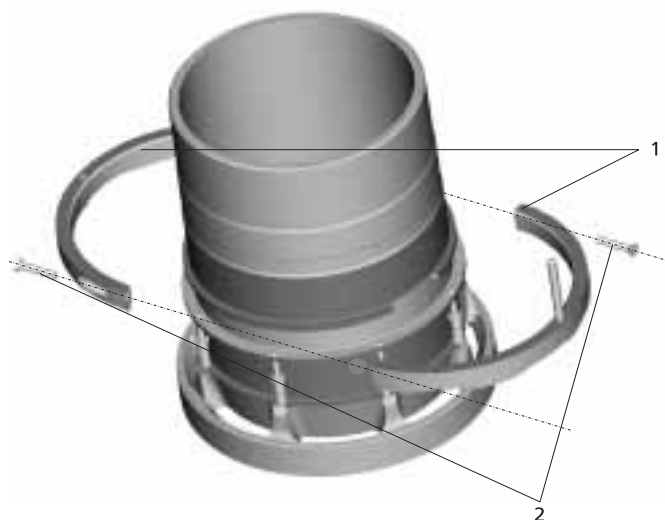


Fig. 3.7-1 Cam ring

- ☐ Place the cylinder liner upside down on the working bench, remove the 2 hexagon bolts (2) from the cam ring (1). Now the cam ring can be removed from the cylinder liner.



Fig. 3.7-2

- ☐ If necessary, remove the locking rings (1) of the 8 push pins (2) and the washers (3) and springs (4)
- ☐ Clean all parts
 - ✓ Check the suction valve ring seat in the cylinder liner collar for damage or locally worn honing tracks.
 - ✓ It is not necessary to check the cylinder liner diameter if the honing tracks in the cylinder liner bore are still intact. Irregularities can be carefully eliminated with abrasive paper.
 - ✓ Check the outer surface of the cylinder liner for damage and eliminate slight damages with abrasive paper.

- ✓ Also check the cam ring on the inside.
- ✓ After truing up the inner and/or outer surfaces, check that the cam ring moves smoothly around the cylinder liner.

3.7.1.2 PREASSEMBLING THE VALVE-LIFTING MECHANISM

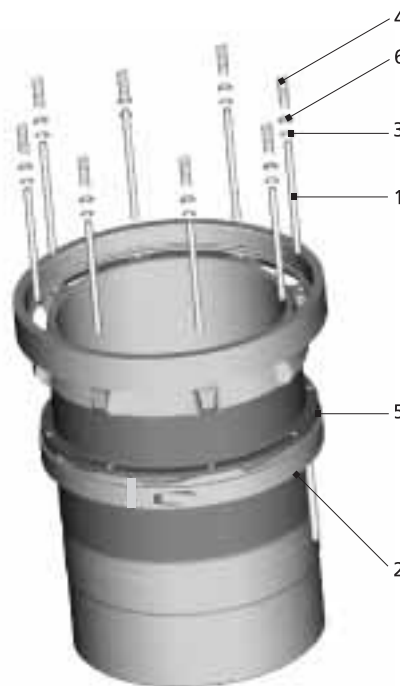


Fig. 3.7-3

- ☐ Before starting, oil all parts with compressor lubricating oil.
 - ✓ Place the cylinder liner with the collar on the working bench.
 - ✓ Mount the 8 push pins (sphere side must face to the cam ring!) (1) through the holes of the lowest guide ring (2) of the cylinder liner, fit the washers (3) and springs (4) and subsequently insert the push pins through the holes of the upper guide ring (5) and the holes of the cylinder liner collar.
 - ✓ Place the locking rings (6) on the push pins so the washer will be between the spring and locking ring.
 - ✓ Build the cam ring with the cams facing the suction sleeves onto the cylinder liner (refer Fig. 3.7-1). Mount 2 hexagon bolts with the spacers into the cam ring.
 - ✓ Check the cam ring manually for proper operating.

3.7.2 CYLINDER LINER (WITH HOLES, OLD VERSION) AND VALVE-LIFTING MECHANISM

A) General

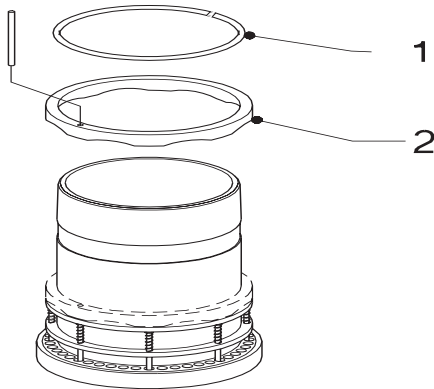


Fig. 3.7-4

- ☐ Place the cylinder liner upside down on the working bench, remove the locking spring (1) and subsequently slide the cam ring (2) from the cylinder liner.

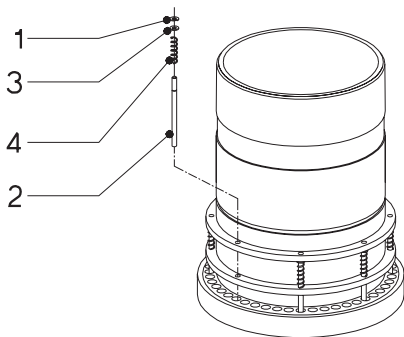


Fig. 3.7-5

- ☐ If necessary, remove the locking rings (1) of the 8 push pins (2) and the washers (3) and springs (4).



Fig. 3.7-6

- ☐ Clean all parts
 - ✓ Check the suction valve ring seat in the cylinder liner collar for damage or locally worn honing tracks.
 - ✓ It is not necessary to check the cylinder liner diameter if the honing tracks in the cylinder liner bore are still intact. Irregularities can be carefully eliminated with abrasive paper.
 - ✓ Check the outer surface of the cylinder liner for damage and eliminate slight damages with abrasive paper.
 - ✓ Also check the cam ring on the inside.
 - ✓ After truing up the inner and/or outer surfaces, check that the cam ring moves smoothly around the cylinder liner.

B) Preassembling the valve-lifting mechanism

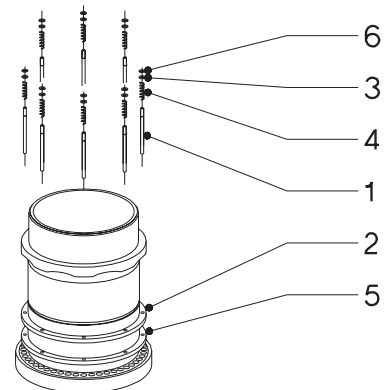


Fig. 3.7-7

- ☐ Before starting, oil all parts with compressor lubricating oil.
 - ✓ Place the cylinder liner with the collar on the working bench.

- ✓ Mount the 8 push pins (1) through the holes of the lowest guide ring (2) of the cylinder liner, fit the washers (3) and springs (4) and subsequently insert the push pins through the holes of the upper guide ring (5) and the holes of the cylinder liner collar.
- ✓ Place the locking rings (6) on the push pins so the washer will be between the spring and locking ring.
- ✓ Slide the cam ring with the cams facing downwards onto the cylinder liner.

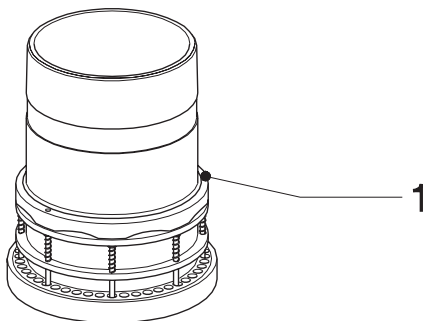


Fig. 3.7-8

- Insert the locking spring in the groove of the cylinder liner. During mounting align the gap in the locking spring with the guide pin of the cam ring then rotate the spring approx. 1/4 turn around the liner.
- ✓ Check that the push pins drop just beneath the suction valve ring when resting on the lower part of the cam ring.

3.8 OIL PUMP AND OIL FILTERS

A) General

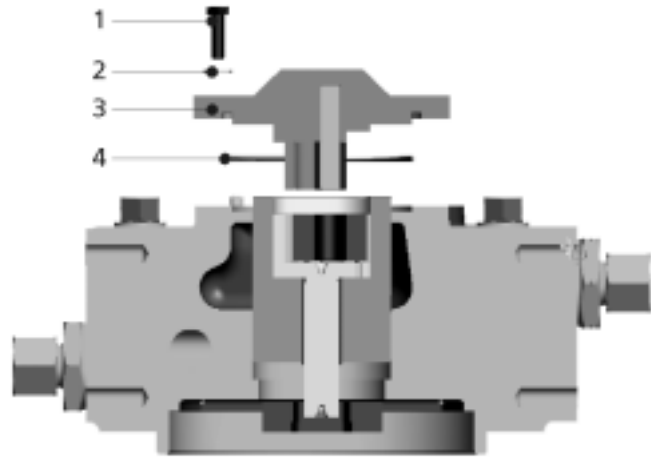


Fig. 3.8-1

- 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).

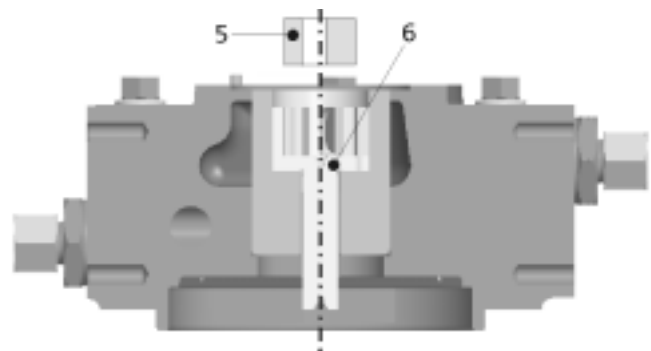


Fig. 3.8-2

- Remove the pump gear (5) from the crown wheel (6) of the pump element/bearing assembly.
- Remove all plugs with alu-washers from the pump housing as well as the O-rings which seal the internal oil passageways.
- ✓ Clean the packing face of the pump housing and the pump cover and if still present: Remove the lubricating oil and control pressure regulators.
- ✓ Clean the pump housing with a non-fibrous cloth and the internal oil passageways of the pump housing with compressed air.

- ✓ Renew the pump element/bearing assembly in case of irreparable damage or malfunctioning of the oil pump.

B) Removing the pump element/bearing assembly

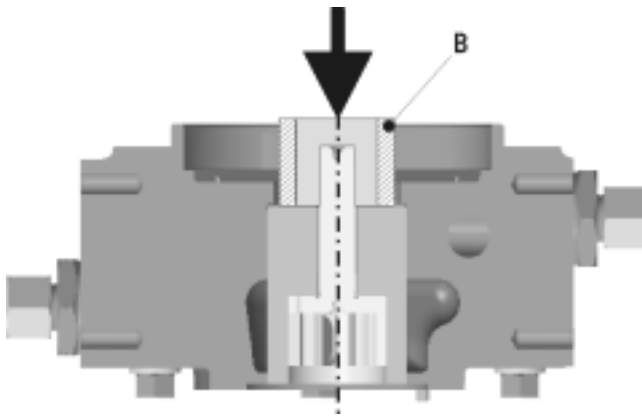


Fig. 3.8-3

- ☐ 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.
- ☐ Clean all pump parts and remove possible sharp edges and/or burrs.
 - ✓ Check the carrier lug for wear.
 - ✓ Check the teeth of both pump elements for broken or worn teeth.
 - ✓ Replace the entire pump element if at least one of the pump elements shows irreparable wear.
 - ✓ Minor damage may be eliminated.

C) Inserting a new pump element

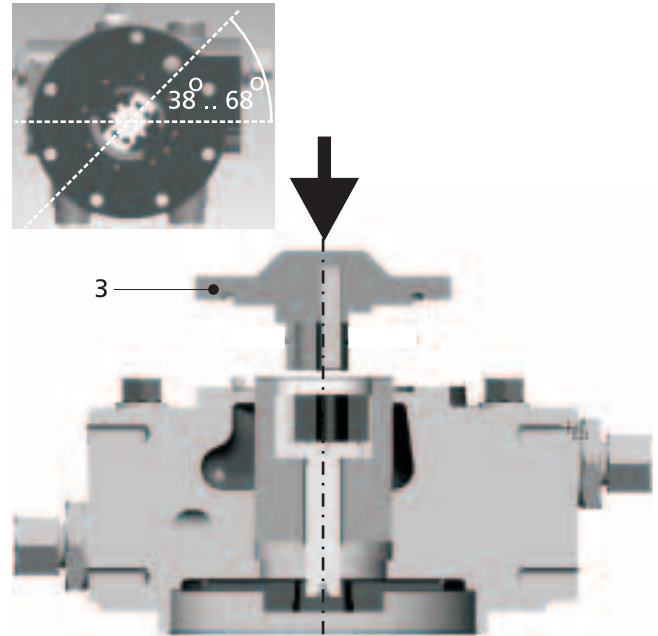


Fig. 3.8-4

- ☐ 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.
- ☐ Position the pump element/bearing assembly with the oil passageway (= notched groove in the running surface) at 12.00 h (visible via the small bores inside crown wheel surface).
- ☐ Carefully press the pump element into the housing with the cover until the contact face has been clearly reached.



Check that pump element can be rotated by hand!



Fig. 3.8-5 Carrier disc

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

D) Reassembling the oil pump

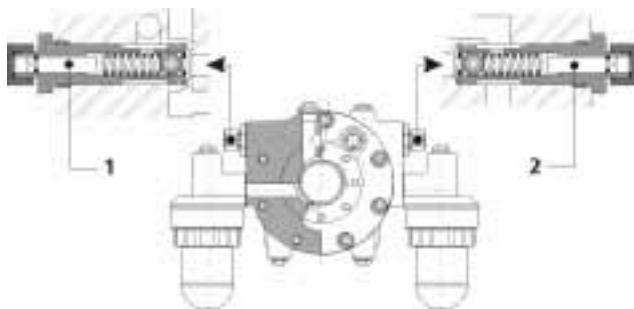


Fig. 3.8-6

- ☐ Lightly oil all parts mentioned below before reassembly!
 - ✓ 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.



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

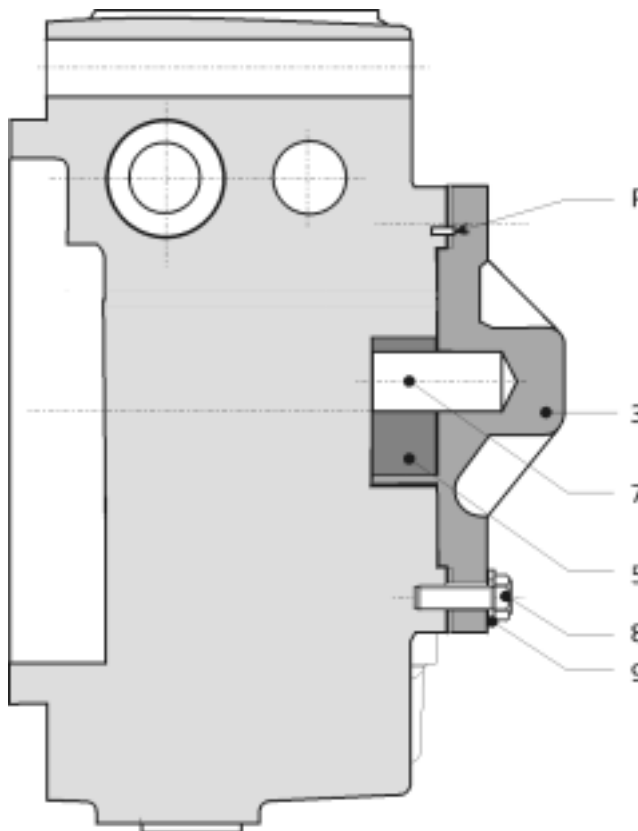


Fig. 3.8-7 Pump detail

- ☐ Slide the pump gear (5) onto the shaft (7) of the pump cover (3).
 - ✓ 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.
- ☐ 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).
 - ✓ 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.
 - ✓ Place the preassembled pump in a separate clean area to be mounted onto the bearing cover later.

E) Filter elements



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



Use special tool to remove oil filters (refer)Section 2.8

- ☐ 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.

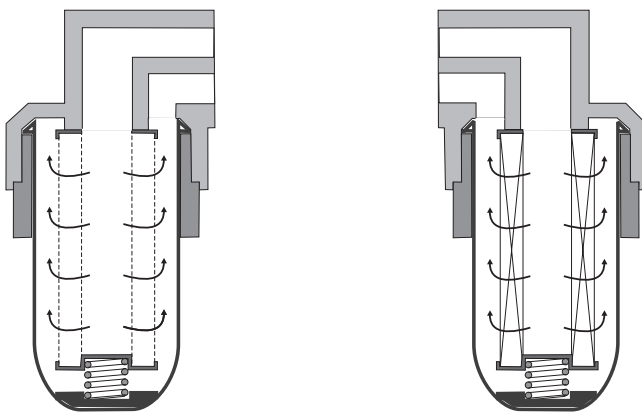


Fig. 3.8-8 Oil suction and oil discharge filter

- ✓ Pay attention to the residual oil in this filter bottom
- ✓ For a total inspection both the upper filter housings can be removed from the pump housing by unscrewing both M10 bolts.
- ✓ Remove the filters as described (Section 2.8)
- ✓ Whilst the the oil suction filter element is cleanable, it should be replaced in case of damage or serious pollution.
- ✓ The red 'running-in' oil discharge filter element is to be replaced by a grey one after 100 running hours.
- ✓ Renew a polluted grey-marked oil discharge filter element.

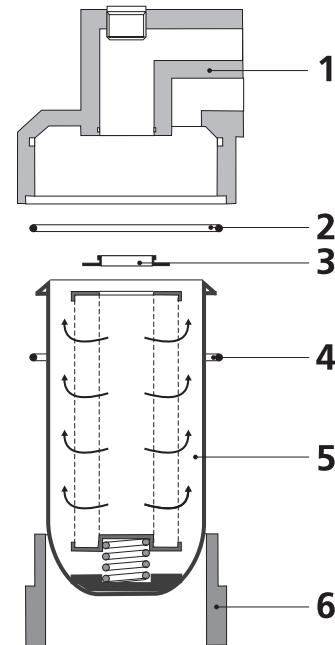


Fig. 3.8-9

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

- ✓ Clean both filter housings (1 and 5) and the internal (connecting) passageways.
- ✓ Insert each filter in the corresponding filter housing and reassemble them with a new set of seals¹, a washer (3) and new O-rings (2 and 4).



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

REMARK: 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.

3.9 MAIN BEARINGS

A) General

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

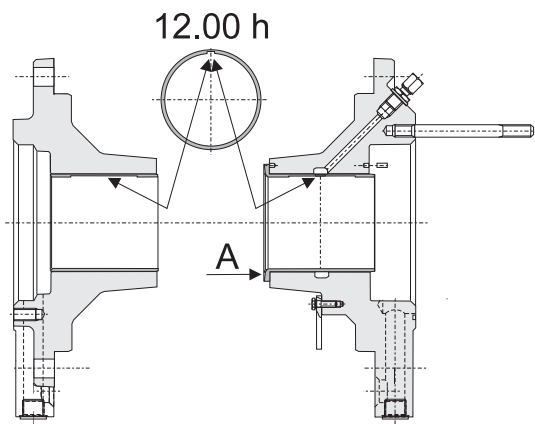


Fig. 3.9-1 41

- ☐ Check both main bearing bushes, while they are in their respective bearing covers, for worn out white metal inner lining.
- ✓ Replace the bush(es) if the inner lining shows abnormal wear and also if the bore is over 90.16 mm.
- ✓ Especially check those crankshaft parts rotating in the bearing covers. Eliminate slight damage using fine polishing paper.
- ✓ 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.

B) Preassembling the bearing covers

Bearing cover on driving side:

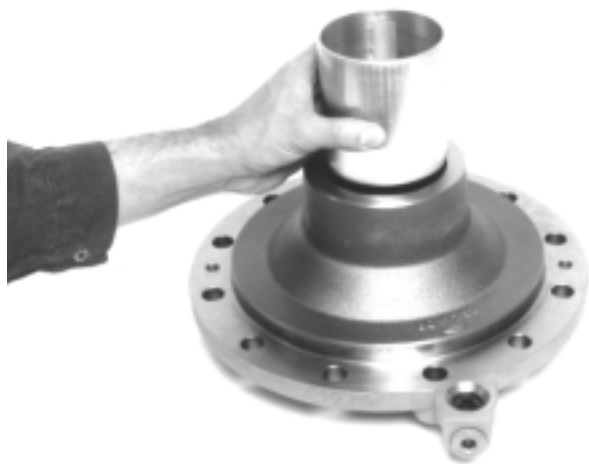


Fig. 3.9-2 42

- ☐ When replacing a bearing bush, proceed as follows:
- ☐ Push or press (using a hydraulic press) the old bearing

bush out of the bearing cover.

- ✓ 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. 3.9-3 43

- ☐ 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.
- ✓ Slowly press the bearing bush (using a hydraulic press) into the bearing cover, making sure that the bearing bush is not displaced.

Bearing cover on pump side;

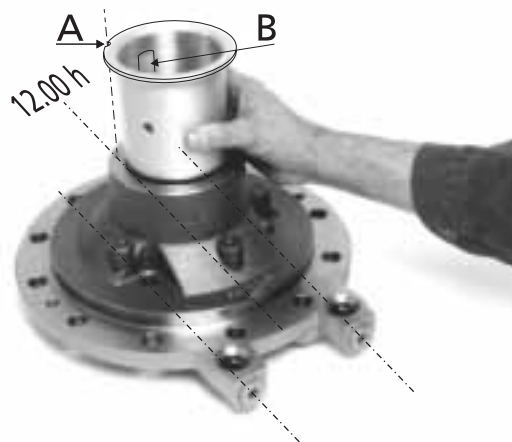


Fig. 3.9-4 44

When the bearing bush requires replacement, proceed as follows:

- ☐ Push or press (using a hydraulic press) the old bearing bush out of the bearing cover.

- ✓ 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. 3.9-5 Bearing cover with mounted splash guard

- ☐ 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.
- ✓ 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. 3.9-6 46

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

3.10 ROTARY SHAFT SEAL



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

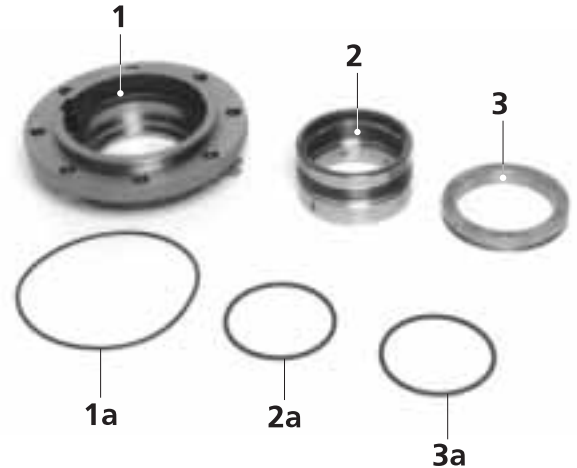


Fig. 3.10-1

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



Fig. 3.10-2

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

3.11 CRANKSHAFT

A) General

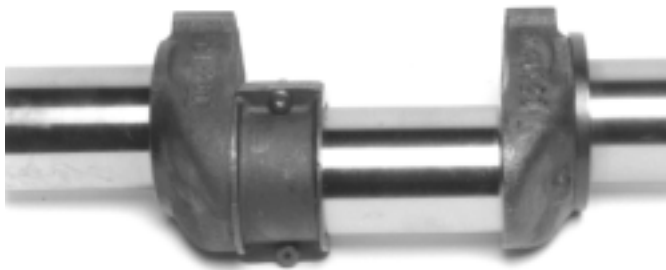


Fig. 3.11-1 49

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

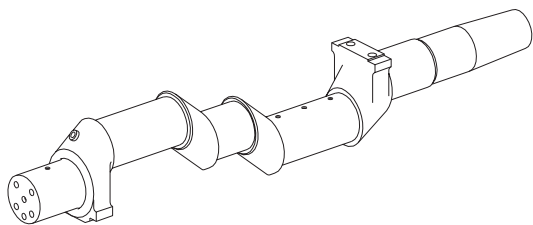


Fig. 3.11-2 50

- ❑ Thoroughly clean the entire crankshaft:
 - ✓ Check whether the axially fitted oil passageways in the crankshaft are unobstructed by cleaning them with compressed air or a brush.
 - ✓ 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.
 - ✓ Remove the dirt accumulated in the oil passageway (in the case of damage to bearings white metal particles) with a 6 mm bar.
 - ✓ Brush and blow out the crankshaft again until all oil passageways are unobstructed.
 - ✓ After cleaning, reassemble all oil passageway sealing bolts (socket head screws) and lock them with centre punches.

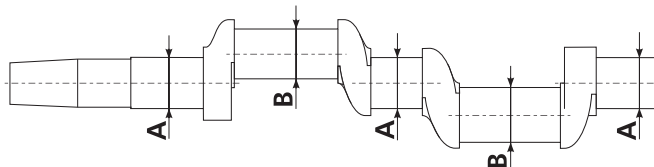


Fig. 3.11-3 51

- ❑ 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.
 - ✓ Here measure 'A' should be at least 89.933 mm and measure 'B' 89.945 mm.
 - ✓ 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.

B) Preassembling the crankshaft



Fig. 3.11-4 52

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

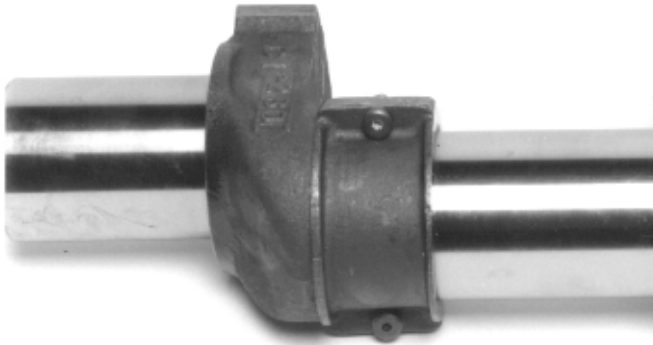


Fig. 3.11-5 53

- ❑ 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)

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



Refer Section 2.10



Fig. 3.12-1 Standard bronze thrust bearing; refer also Fig. 2.10-2

- ❑ Clean the thrust bearing and check the lapped running surface on the bronze side for (ir)regularly worn oil grooves and for material deposits.
 - ✓ 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

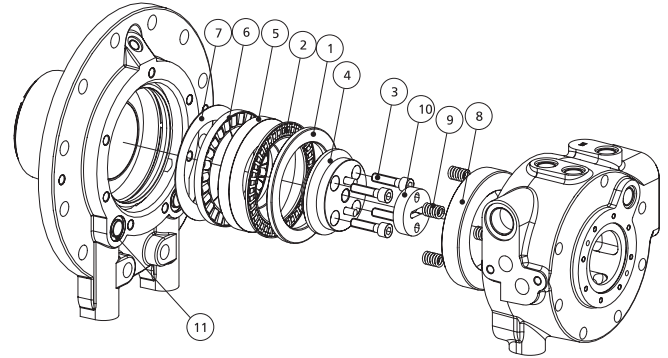


Fig. 3.12-2 Heavy duty thrust bearing

- ❑ 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.
 - ✓ Replace the complete heavy duty thrust bearing set when the rollers, needles or running surfaces show signs of wear.

3.13 CRANKCASE

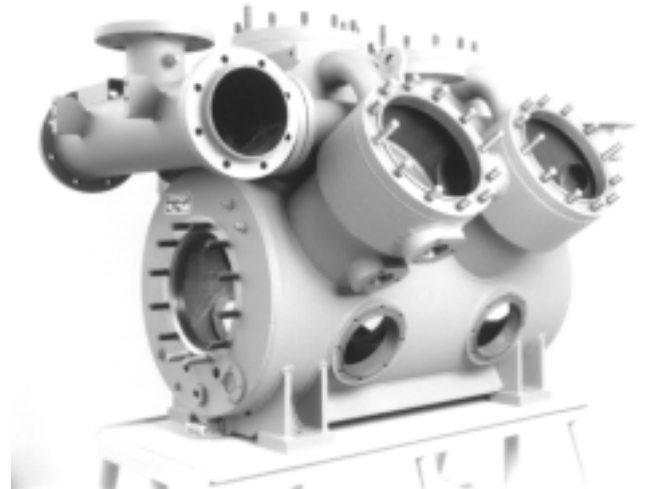


Fig. 3.13-1

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

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



Fig. 3.13-2

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

4. REASSEMBLING

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4.1 CRANKSHAFT, MAIN BEARINGS AND INTERMEDIATE BEARING

4.1.1 BEARING COVER DRIVING SIDE

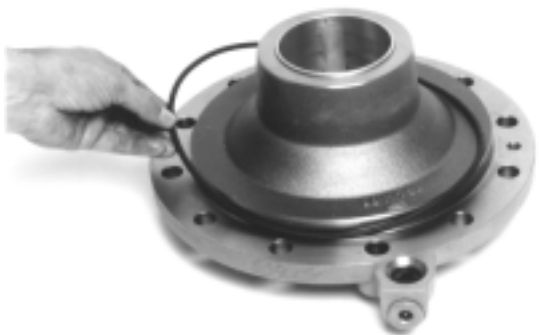


Fig. 4.1-1

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



Fig. 4.1-2

- ☐ 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.
- ✓ Then slide the bearing cover over the crankcase studs.
- ✓ Screw all M16 nuts provided with washers on the studs and tighten them alternately and crosswise to the torque given in (Chapter 5).

4.1.2 ASSEMBLY PROCEDURE OF 2 AND 3 CYLINDER COMPRESSORS

- ☐ 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

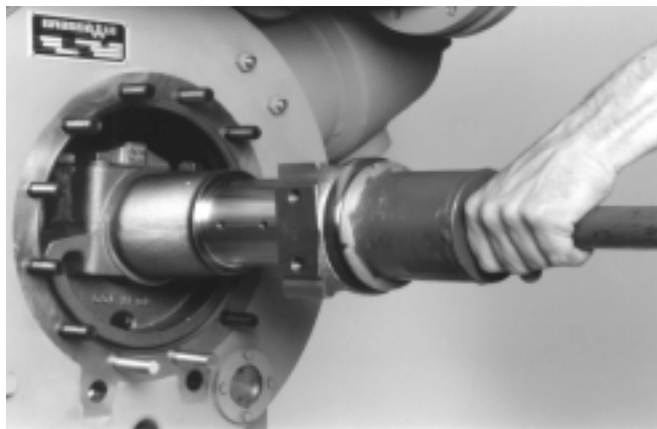


Fig. 4.1-3

- ☐ With assistance and using auxiliary tools, insert the crankshaft (with/without counterweights¹) through the crankcase opening on the pump side into the crankcase. The crankshaft now rests on the intermediate bearing block(s).
- ✓ Remove the auxiliary tools, clean the shaft journals and oil them.

4.1.4 PUMP SIDE



Fig. 4.1-4

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

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



Fig. 4.1-5

4.1.5 BEARING COVER OIL PUMP SIDE (WITH TWO LUGS):

- ☐ Place a new O-ring on the inner side of the bearing cover.
- ✓ Place a new O-ring on both pipes of the internal oil passageway Fig. 4.1-4.



Fig. 4.1-6

- ☐ 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.

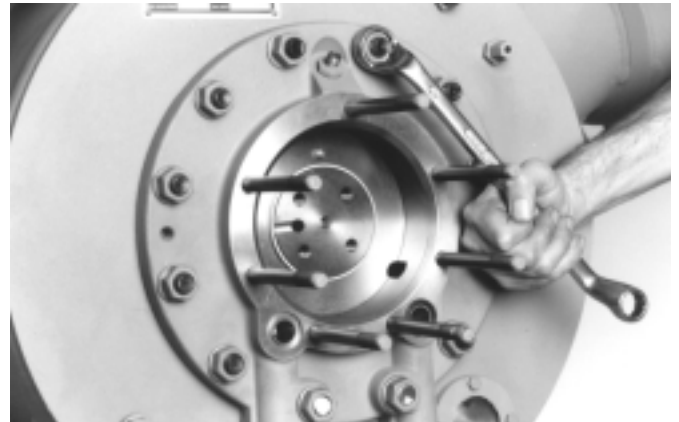


Fig. 4.1-7

- ☐ Screw all M16 nuts provided with washers on the studs.
- ☐ Finally tighten the nuts alternately and crosswise to the torque given (Chapter 5).
- ✓ Check that the crankshaft rotates freely.

4.1.6 STANDARD THRUST BEARING



Fig. 4.1-8 Standard thrust bearing; refer also Fig. 2.10-2

- ☐ 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.

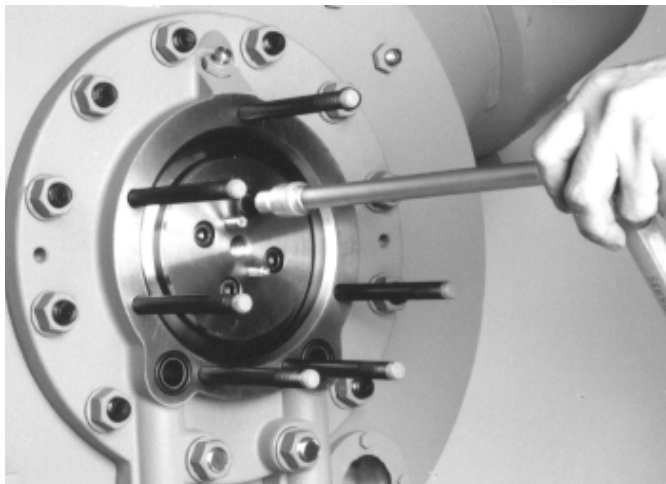


Fig. 4.1-9

- ☐ Check that the crankshaft boss is still clean and oiled.
 - ✓ Fit the hold down disc onto the crankshaft boss, using the four M10 socket head screws with the torque given(Chapter 5).
 - ✓ 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.

1st step; Heavy duty thrust bearing

- ☐ Check whether all components are clean, including the inside of the bearing cover and crankshaft on oil pump side.



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

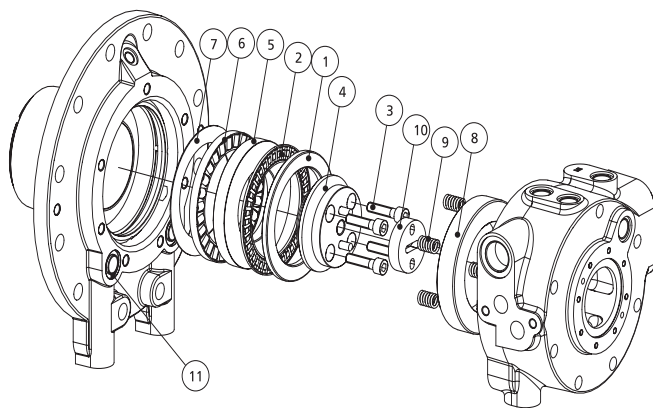


Fig. 4.1-10 Heavy duty thrust bearing



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

- ☐ Fit the oiled 1 mm. thick thrust washer (7) on the crankshaft on oil pump side.
 - ✓ The thrust washer (7) can be used on both sides.
- ☐ Fit the oiled cylindrical roller thrust bearing (6) on the crankshaft on oil pump side.
 - ✓ The cylindrical roller thrust bearing (6) can be used on both sides.
- ☐ Fit the oiled shaft washer (5) on the crankshaft on oil pump side. The shaft washer is recessed to **fit exactly** around the crankshaft.
- ☐ 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).
 - ✓ Check that the crankshaft rotates freely.
- ☐ Fit the oiled needle thrust bearing (2) on the hold down disc (4).
 - ✓ The needle thrust bearing (2) can be used on both sides.
- ☐ Mate the oiled 7 mm. thick housing washer (1) against the needle thrust bearing (2).
 - ✓ 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.

2nd step; oil pump for heavy duty thrust bearing

- ☐ Place the carrier disc (10) on the hold down disc (4).
 - ✓ The chamber of the slot of the carrier disc (10) must face the crankshaft.



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

- ☐ Place 2 new O-rings around the oil inlet- and outlet holes at the bearing cover (11).
- ☐ Check that the oil pump is clean.
- ☐ Place the oiled spring retainer (8) in the pump housing counter bore.
 - ✓ The opening of the holes should be pointed to the outside of the oil pump housing.
- ☐ Insert the oiled springs (9) in the holes of the spring retainer (8).
- ☐ Place a new O-ring on the inner side of the fully pre-assembled oil pump.
- ☐ Slide the oil pump over the studs of the bearing cover.
- ☐ Position the carrier lug of the pump element with the slot in the carrier disc.

- ✓ Pay at all times attention not to dislodge the springs (9) or the spring retainer (8).
- ❑ Push the oil pump as far as possible towards the bearing cover and screw the M12 nuts with washers on the studs.
 - ✓ 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
 - ✓ Check all springs to be present and in place.
- ❑ 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. 4.1-11

- ❑ For this measurement a magnet (clock) gauge with an extended gauge can be set up on the bearing cover.
 - ✓ Remove a stud and screw in the M12 eye bolt.
 - ✓ Screw another eye bolt into the threaded hole on the crankshaft.
 - ✓ Pull out the crankshaft and set the gauge on 0.00 (zero).
 - ✓ 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.

4.1.9 PROCEDURE FOR 4, 6, 9 AND 12 CYLINDER COMPRESSORS

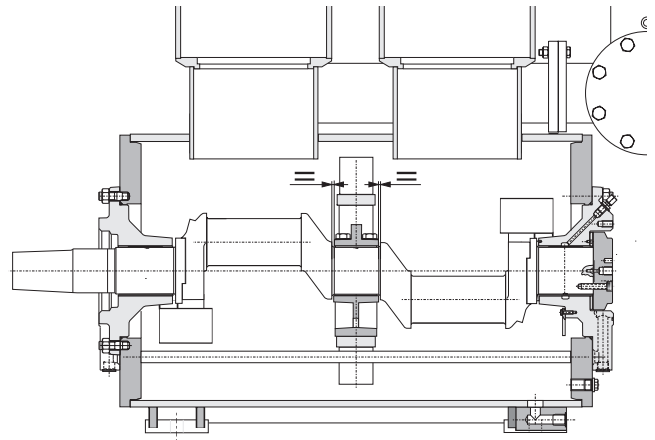


Fig. 4.1-12

- ❑ Measure the axial play proceeding in the same way as for the 2 and 3 cylinder compressors.
 - ✓ Position the intermediate bearing block(s) and fit handtight the 2 sets of toothed spring washers and the M20 bolts in the cross frame.
 - ✓ Check that the crankshaft rotates freely.
 - ✓ 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)(Fig. 4.1-12).
 - ✓ Further tighten the intermediate bearing bolts to the torque given(Chapter 5).



Fig. 4.1-13

- ❑ 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

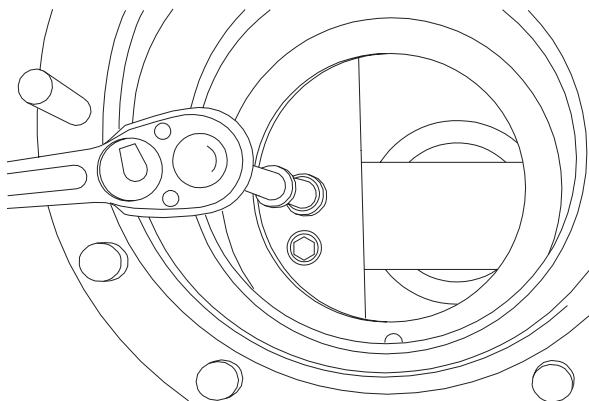


Fig. 4.1-14

- ☐ Fit the counterweights with new locking rings and bolts onto the crankshaft if dismantled.



Pay attention to numbers and marks!



Counterweights are not interchangeable!

- ☐ Fit the double locking rings in the proper position!
- ☐ Tighten the bolts with a torque wrench to the torque given(Chapter 5).

4.2 OIL PUMP

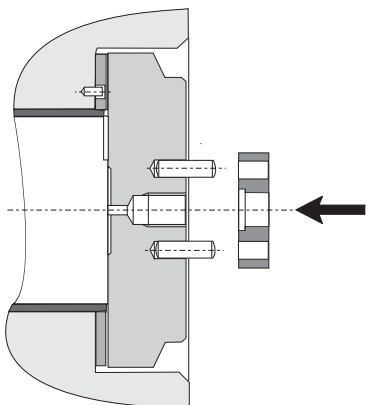


Fig. 4.2-1

- ☐ Place the carrier disc on the hold down disc.



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



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

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

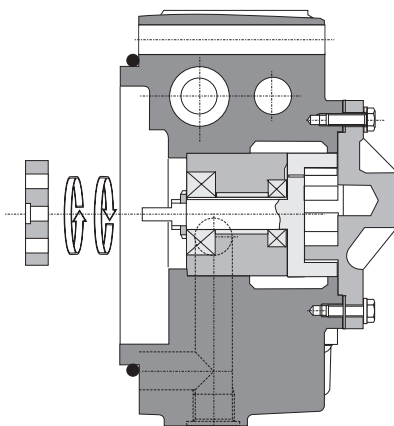


Fig. 4.2-2

- ✓ Position the carrier lug of the pump element with the slot in the carrier disc.
- ✓ Push the oil pump fully against the bearing cover and screw the M12 nuts with washers on the studs.
- ✓ 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. 4.3-1



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

- ☐ Fit the preassembled (red¹/grey) marked discharge filter using the two M10 bolts with washers on the right-hand side of the pump.
- ✓ Tighten the bolts to the torque given(Section 5.1).

4.3.2 OIL SUCTION FILTER

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

4.3.3 LUBRICATING OIL PRESSURE REGULATOR (WITHOUT GROOVE)

If not built in yet;

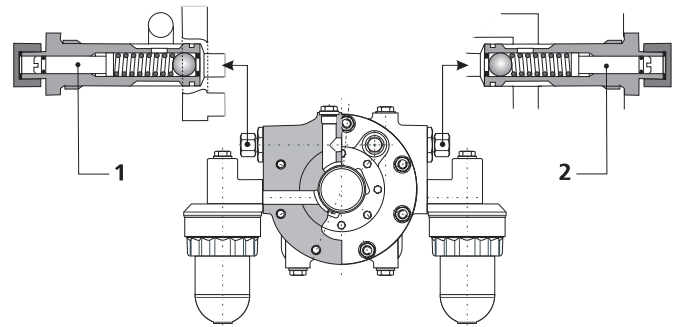


Fig. 4.3-2

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

REMARK: 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)

- ☐ Install the control pressure regulator with a new aluminium ring on the right-hand side of the pump. Fig. 4.3-2
- ✓ Finally fit the cap nut handtight on the regulator using a new alu-ring.

REMARK: 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.

4.4 VALVE-LIFTING CONTROL MECHANISM

Assembling dowel pin in carrier disc

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

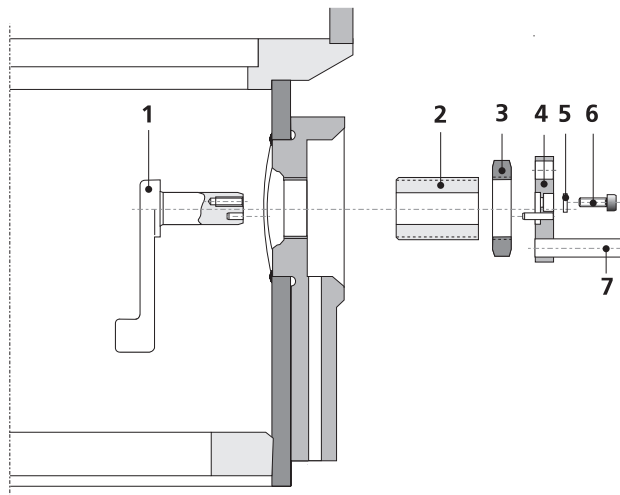


Fig. 4.4-1

- ☐ Press the dowel pin (7) perpendicular into the carrier disc (4).

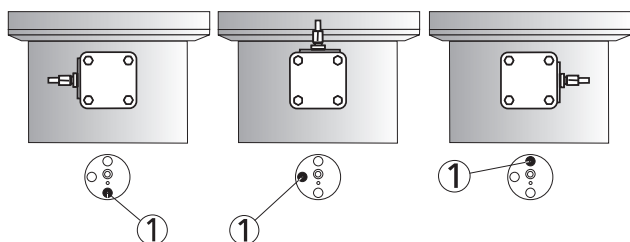


Fig. 4.4-2

- ✓ Pin location in the carrier disc depends on the position of the valve lifting housing on to the cylinder wall.

Assembling set screw and lever (in case the set screw has been removed/replaced):

- ☐ Screw the set screw (2) in to the threaded bore of the mounting flange and subsequently the nut (3) handtight on the set screw (2).
- ✓ Place the shaft of the lever (1) into the bore of the set screw.

Lever adjustment:

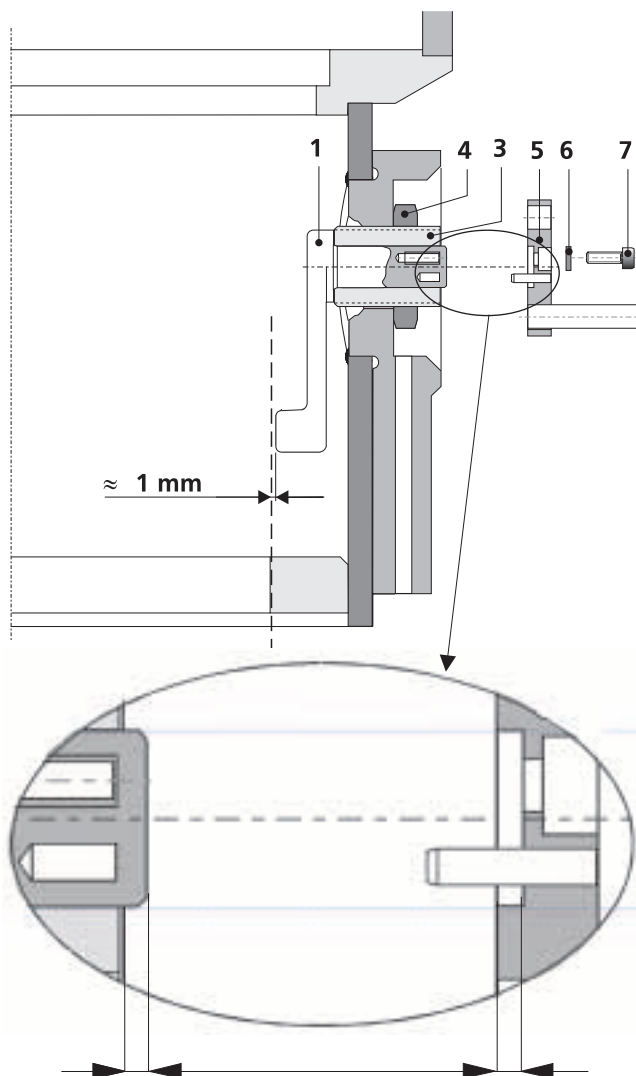


Fig. 4.4-3

- ☐ Prior to mounting the carrier disc the free space between cylinder liner and lever must be set to between 0,5-1,5 mm. This is the distance between the lever front side and inner side of the lowest supporting ring in the cylinder jacket which can be adjusted by turning the set screw.
- ✓ After adjustment screw down the nut (4), subsequently carrier disc (5) and mount socket screw (7, screw tight to the torque setting as given (Section 5.1) with locking ring (6).

Assembling valve-lifting housing:

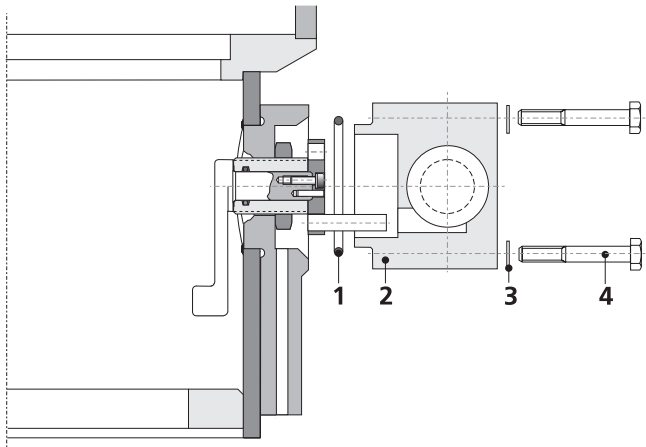


Fig. 4.4-4

- ❑ Place O-ring (1) and mount the valve lifting housing (2) with built-in piston in its original position to the flange of the cylinder jacket and fit the four M10-bolts (4) with washers (3).
- ✓ Tighten the bolts to the torque given (Section 5.1).
- ✓ Connect the control pressure oil line to the housing.

REMARK: After assembling the valve lifting housing, the lever is in part load situation.

4.5 CYLINDER LINER

General

Compressors older than approx. August 2003 had cylinder liners with holes to allow suction gas to pass through. These liners can be exchanged for the later execution having slots but only in combination with the corresponding suction and discharge valves (consult Grasso for advice). The re-assembly procedure for both types is given below.

4.5.1 CYLINDER LINER (LATEST VERSION, WITH SLOTS)

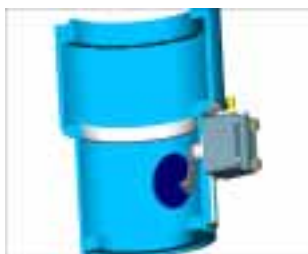


Fig. 4.5-1 Cylinder housing with hydraulic actuated lever mounted



Fig. 4.5-2 Use compressor oil to oil the O-ring location



Fig. 4.5-3 Fit the O-ring

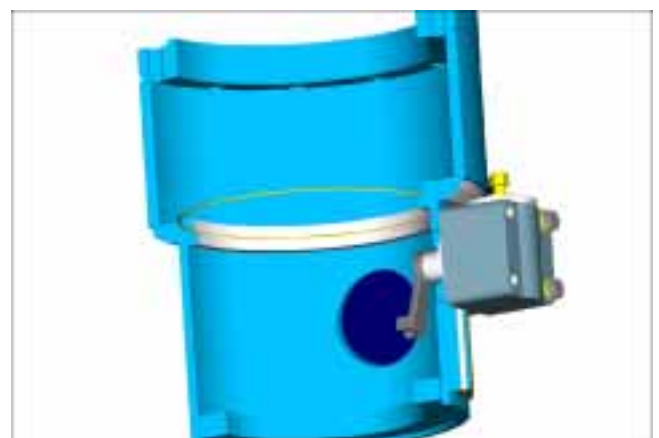


Fig. 4.5-4 O-ring fitted

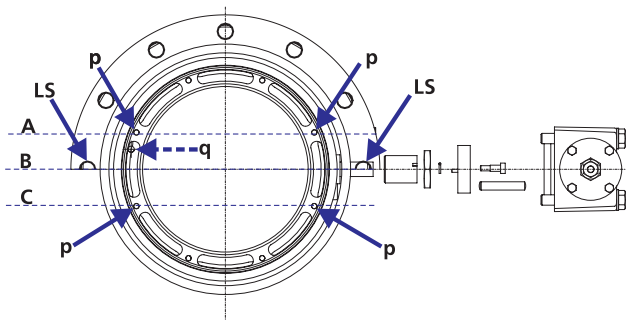


Fig. 4.5-5 Positioning cylinder liner (refer also Fig. 4.5-6)

Table 4.5-1 Legend

Top view cylinder liner		
A, B, C	Parallel lines	
p	valve lifting pin	
q	location pin, refer to Fig. 4.5-6	
LS	Long stud	



Fig. 4.5-7 Fit the cylinder liner



Check whether 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!

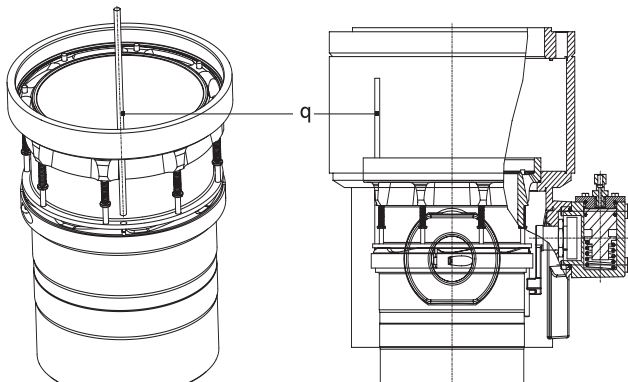


Fig. 4.5-6 Positioning cylinder liner (refer also Fig. 4.5-5)

- ☐ Fix the cam ring through the slots of the cylinder liner with location pin of the auxiliary toolkit (refer to Fig. 4.5-5 and Fig. 4.5-6).

- ☐ Position the pressure pins of the cylinder liner in line with the centre of the long cylinder head studs (refer to Fig. 4.5-5 and Fig. 4.5-6)

- ☐ Insert the cylinder liner carefully as far as possible into the cylinder jacket.

The guide pin must locate in the fork of the lever of the valve lifting mechanism.

- ☐ Check this by rotating the carrier disc of the valve lifting mechanism.

There must be only a very limited play on this mechanism.



Fig. 4.5-8 Fit the cylinder liner

- ☐ Place the short bar¹ on the upper cylinder liner collar and the long bar over 2 cylinder head studs.
- ☐ 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.
- ☐ 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.
- ☐ Remove the auxiliary tools.

1. Parts of the auxiliary tool kit.



Fig. 4.5-9 Top view, suction valve with slots

4.5.2 CYLINDER LINER (OLD VERSION, WITH HOLES)

REMARK: Prior to mounting the cylinder liner, first position the valve lifting-control mechanism.

- ☐ Examine the thickness of the gasket which was originally placed on the lower landing of the cylinder jacket and under the cylinder liner collar.
 - ✓ Select a new gasket of the same thickness, being 1, 1.25 or 1.5 mm.
 - ✓ Check that the gasket face of the cylinder jacket is still clean and place the greased gasket into the landing.
 - ✓ Write down the thickness of the gasket on the outside of the cylinder jacket.

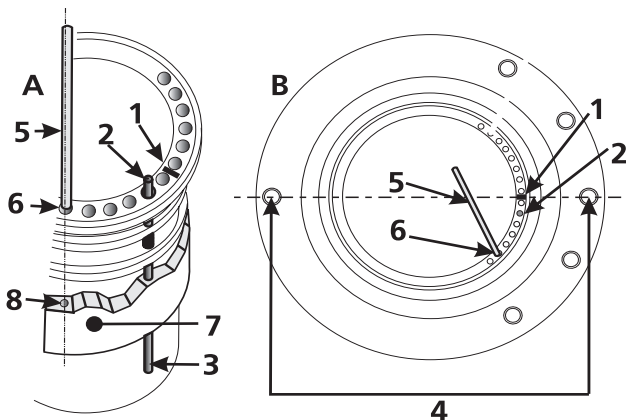


Fig. 4.5-10

- ☐ To ensure that the guide pin (3) of the cam ring (Pos. 7) locates in the fork of the lever, proceed as follows:
 - ✓ Turn the cam ring (Pos. 7) to part load position (pressure pins up)

- ✓ A pressure pin (Pos. 2) is now in line with the guide pin of the cam ring (Pos 3)
- ☐ Mark (Pos 1) the second bridge between the suction gas opening and the pressure pin (Pos 2)
- ✓ Insert the cylinder liner push bolt (Pos. 5, part of the auxiliary tool kit) through hole (Pos. 6; 6th hole) of the suction gas openings in the cylinder liner. Ensure that it locates in the corresponding recess (Pos. 8) in the cam ring (Pos. 7)

REMARK: The cylinder liner push bolt (Pos. 5) has to be inserted through the 6th suction gas opening, counted from the mark (Pos. 1)

- ✓ Position the marking (Pos 1) in line with the centre of the long cylinder head stud (Pos. 4, sketch B).



Fig. 4.5-11

- ✓ Press the cylinder liner as far as possible into the cylinder jacket.



Fig. 4.5-12

- ✓ Place the short green bar¹ on the upper cylinder liner collar and the long green bar over 2 cylinder head studs.
- ✓ 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.
- ✓ 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.
- ✓ Remove the auxiliary tools.

REMARK: 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!

4.6 PISTON/CONNECTING ROD ASSEMBLY



Fig. 4.6-1

- ❑ Slide the connecting rod bolts into the big end of the connecting rod (make sure that the flat side is positioned correctly!).
 - ✓ Place the bearing shells into the connecting rod cap.
 - ✓ Oil bearing shells, piston and piston rings.
 - ✓ Slide the ring compression bush² with the chamfered end pointing downwards over the connecting rod, the piston and the oil scraper ring and piston rings.
 - ✓ Oil and set the relevant crankshaft journal in the uppermost position of the cylinder centre.
 - ✓ Screw the T-handle (from the auxiliary tool kit) into the threaded hole of the piston.

1. Parts of the auxiliary tool kit.

2. Parts of the auxiliary tool kit.



Fig. 4.6-2

- ❑ Insert the piston/connecting rod assembly into the cylinder liner.
 - ✓ 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.
 - ✓ 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.

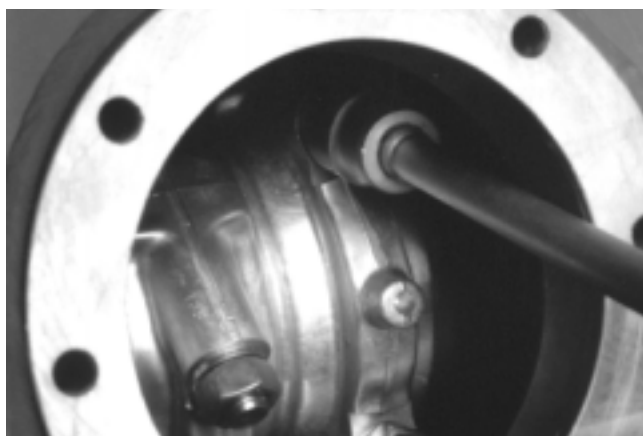


Fig. 4.6-3

- ❑ Slide the corresponding connecting rod cap over the connecting rod bolts.
 - ✓ Fit both MF16 nuts with new (double) locking rings on the connecting rod bolts and tighten to the torque given.



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



Determining the piston clearance according to Section 4.7, is required for cylinder liners with holes (old version) only.

4.7 DETERMINING THE PISTON CLEARANCE

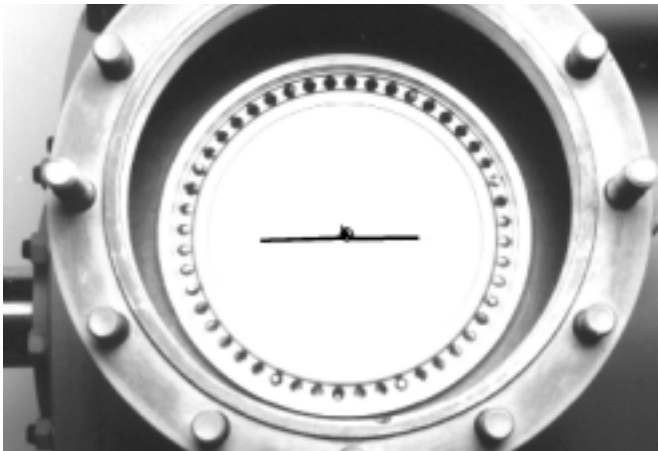


Fig. 4.7-1

- ☐ 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.

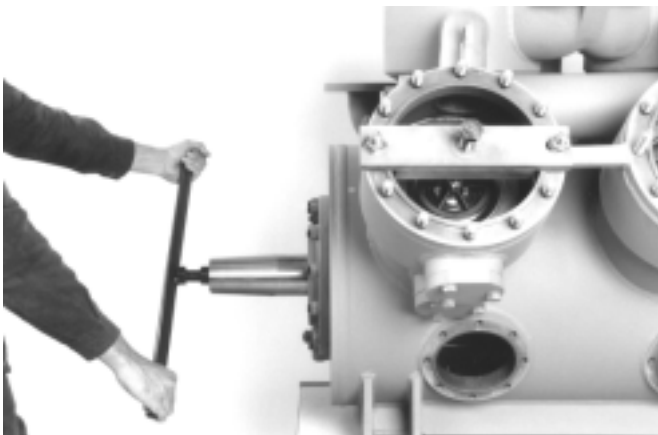


Fig. 4.7-2

- ☐ Oil the discharge valve assembly and place it on the cylinder liner.
 - ✓ Place the bar from the auxiliary tool kit on the studs as well as on the discharge valve centre.
 - ✓ Screw two M16 nuts on the studs.

- ✓ Screw the M24 push bolt into the long bar and after that revolve the crankshaft two or three times.

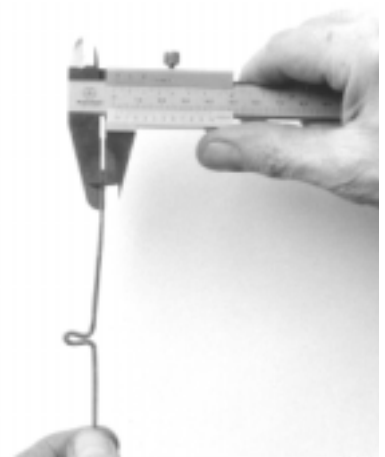


Fig. 4.7-3

- ☐ 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 SUCTION/DISCHARGE VALVE ASSEMBLY

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

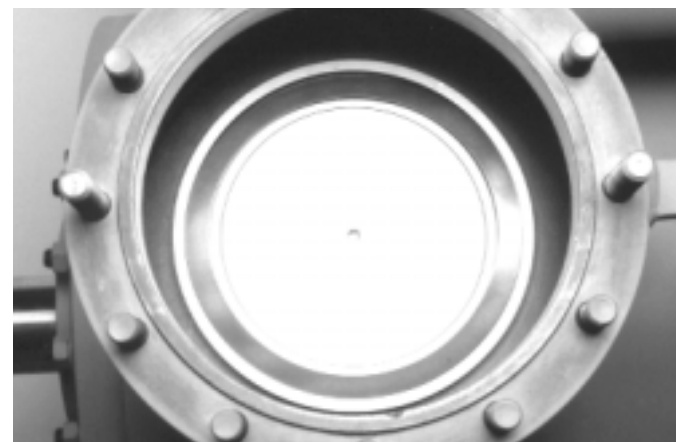


Fig. 4.8-1 Top view piston

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

REMARK: 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. 4.8-2 Top view of discharge valve assy (new version)



Fig. 4.8-4 Top view of discharge valve assy (new version)



Fig. 4.8-3 Top view of discharge valve assy (old version)

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



Fig. 4.8-5 Top view of discharge valve assy (old version)

- ☐ For old version only; Place the oiled pressure spring cup on the discharge valve assembly.

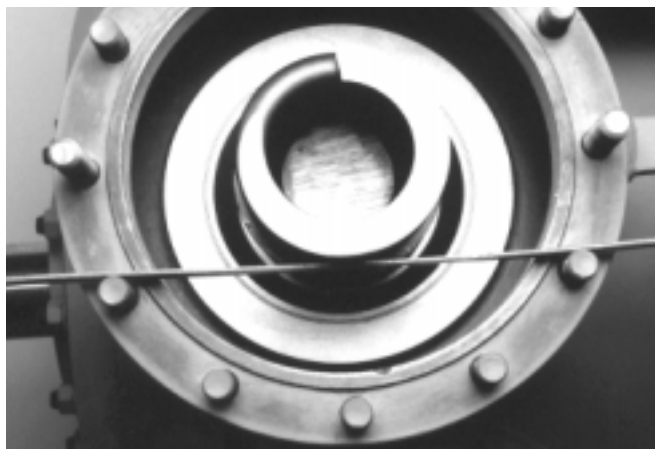


Fig. 4.8-6 Top view buffer spring (old version)

- ☐ For old version only; Subsequently, fit the buffer

spring which has to be prevented from tipping by a steel strip placed against the two studs.

- ☐ Insert a new gasket into the cylinder cover groove and slide the cylinder head cover over the studs on the buffer spring.

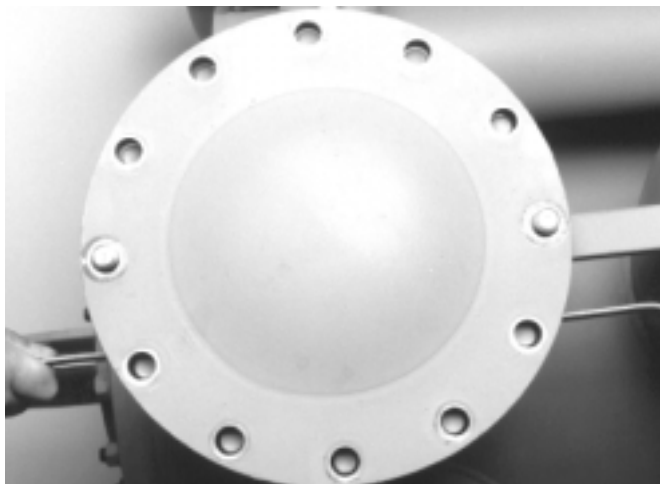


Fig. 4.8-7 Top view cylinder cover

- ✓ Remove the strip.
- ✓ Screw two M16 nuts on the two long and oiled studs.

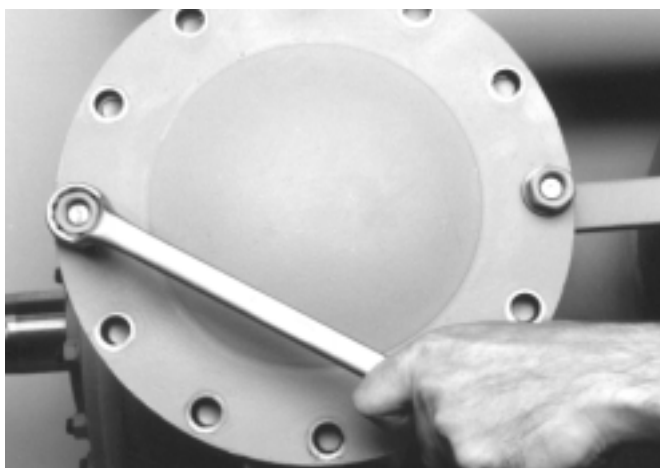


Fig. 4.8-8 Top view cylinder cover

- ✓ Tighten these two nuts alternately to the torque given (Section 5.1).
- ✓ After that, fit the other nuts in the same way.

4.9 ROTARY (SLIP RING) SHAFT SEAL



Fig. 4.9-1 40

- ☐ In the case of new parts, check that the protective foil has been removed.
 - ✓ Avoid touching the contact faces of these parts; slightly rub your hands with oil or wear gloves.
 - ✓ Especially inspect the crankshaft part where the O-ring moves.
 - ✓ Remove all (rubber) deposit by sanding or polishing.
 - ✓ Oil all parts with compressor lubricating oil, as well as the crankshaft part in situ of the shaft seal.
 - ✓ Slide the slip ring part over the crankshaft and push through until the rear side is positioned against the crankshaft boss.

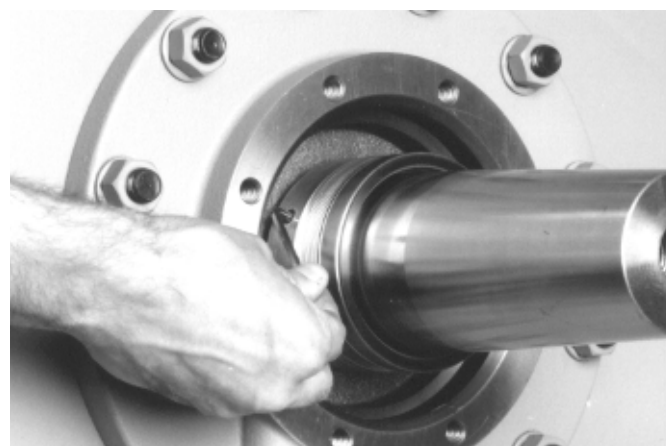


Fig. 4.9-2 41

- ☐ Lock the slip ring on the crankshaft by tightening the three grub screws with an allen key¹. (Torque refer Section 5.1)

1. Part of the auxiliary tool kit.



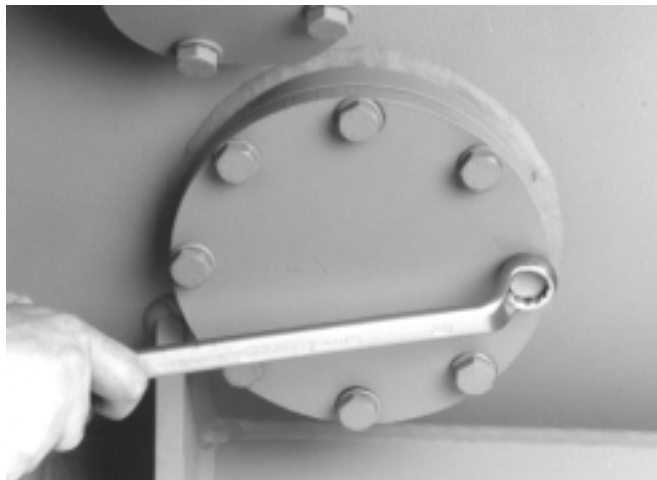
Fig. 4.9-3 42

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



Fig. 4.9-4 43

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



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

4.10 SUCTION GAS FILTER

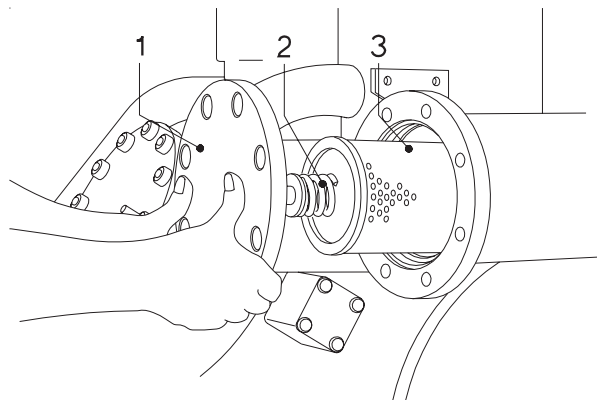


Fig. 4.10-1

- ☐ Place a new gasket into the groove of the suction gas filter cover.
 - ✓ 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.
- ☐ Screw the eight bolts into the housing and tighten them to the torque given (Section 5.1).

4.11 PRESSURE RELIEF VALVE ASSEMBLY

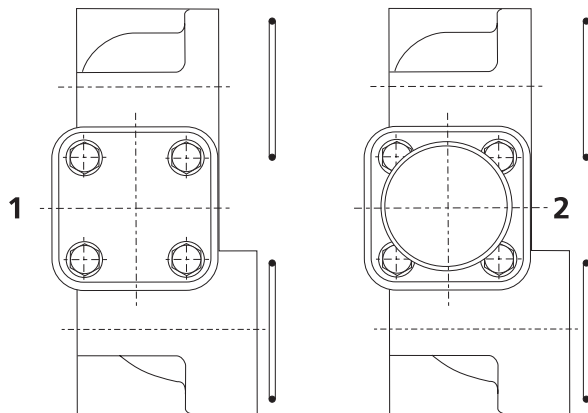


Fig. 4.11-1 Relief valves

Legend	
1	Back pressure dependent
2	Back pressure independent



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

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

4.12 OIL FILLING



Use clean or fresh original oil only!

- ☐ The following components have to be filled with oil before starting up via the oil charge valve, mounted on the oil pump, refer Fig. 4.12-2:
 - ✓ Crankcase
 - ✓ Shaft seal housing(Fig. 4.12-1)
 - ✓ Oil pump
 - ✓ Oil discharge filter
 - ✓ Oil lubrication circuit
- ☐ Oil suction filter(Fig. 4.12-2 ,left filter): Charge through the filling openings or prelubricating valves (if present) on the top of the filter housing.

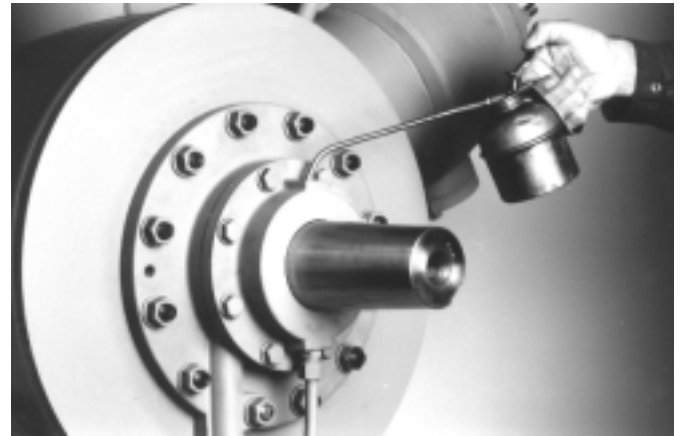


Fig. 4.12-1 Shaft seal housing



Fig. 4.12-2 Oil filters and location oil charge valve (A); not shown!

Oil discharge filter:

Remove all oil filling plugs and fill the corresponding components with the amount of oil given(Table 4.12-1).

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

Table 4.12-1 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

4.13 MOUNTING FLYWHEEL



Fig. 4.13-1

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

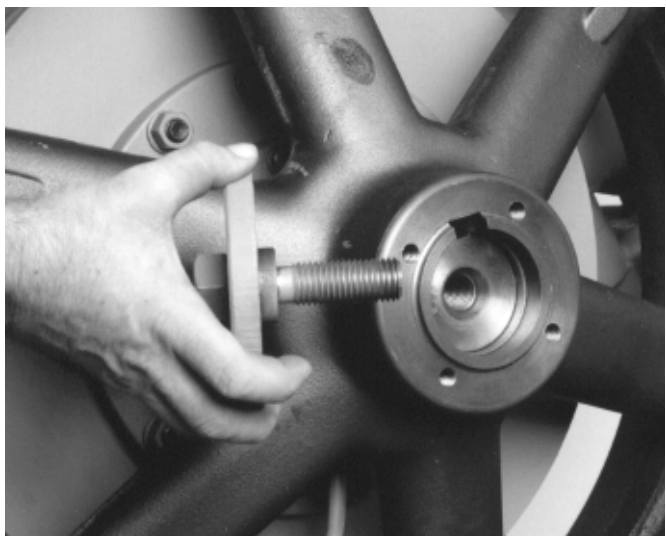


Fig. 4.13-2

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



Fig. 4.13-3

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



Fig. 4.13-4

- ☐ Tighten the central M24-bolt with a torque wrench to the torque given (Section 5.1).



Fig. 4.13-5

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

4.14 DISCHARGE VALVES, LEAKAGE TEST PROCEDURE

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

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



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

5. MISCELLANEOUS

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5.1 SURVEY OF TORQUES FOR BOLTS AND NUTS

Table 5.1-1

Item	Threaded connection	Thread size	Torque in N.m. ^a	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	
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	
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	

Item	Threaded connection	Thread size	Torque in N.m. ^a	Remarks
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	
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	---	
39	Pulley puller for shaft seal	M8	---	
40	Foundation bolts	M20	tightened	
41	Drive coupling bolts			refer to service instruction 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	

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

5.2 WEAR LIMITS AND TOLERANCES



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 not 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.

Table 5.2-1 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	11.46.640	max. inside diam. 40+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	
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	24.70.040	min. outside diam. 40-0.00	
10	Piston rings	09.74.163	max. gap 2+0.1	Measured in non-scored part of cylinder liner
11	Control pressure piston for valve lifting	27.70.670 / 20.70.134	min. outside diam. 40-0.08	
12	Control pressure piston housing	27.70.012	max. inside diam. 40+0.07	
13	Spring valve lifting housing	11.31.332	min. 51	Length
14	Lever	27.70.112	min. outside diam. 14-0.25	
15	Set screw	11.16.112 / 20.70.136	max. inside diam. 14+0.05	When fitted
16	Intermediate bearing	11.44.890	max. inside diam. 90+0.14	When fitted
17	Pivot disc	----- / 20.38.106	min. thickness 5.50	
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.

Table 5.3-1

	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 50-100 mm	
	Depth micrometer of 0-50 mm	
	Vernier gauge of 10"	
	Feeling gauges of 0.05-1.00 mm	
	Magnetic gauge with extended plunger	

	Description	
Misc:	Grasso special tool kit TA	various service activities
	Vacuum pump	
	Centre punch	
	Circlip pliers	
	Hammer (steel)	
	Hammer (soft)	
	Pair of pliers	Remove split pin valve-lifting mechanism
	Loctite	
	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
	Hydraulic press	
	Heater approx. 80 °C	removing and inserting connecting rod bearings

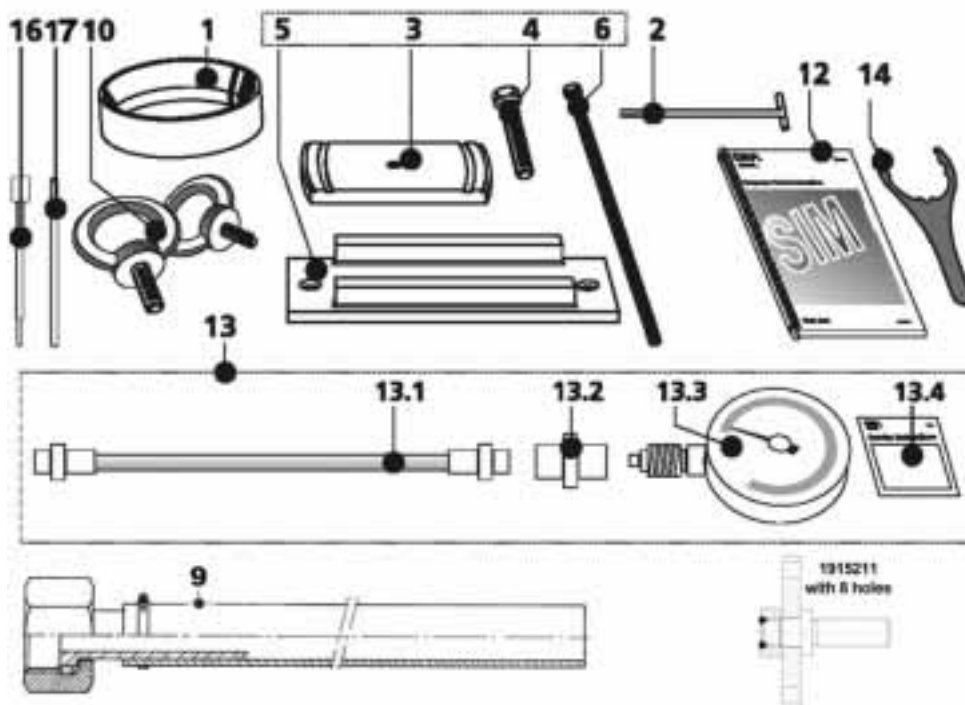
5.4 GRASSO SPECIAL TOOLS AND AIDS GRASSO 12E

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 under ref. no. 20.70.010. A list of the content of this standard kit is given below.

This table below describes the instructions for use to (dis)assemble the RC12E-Compressor or compressor components with Grasso special tools and should be carried out in conjunction with the RC12E- Documents as mentioned below. This special tool set ETA contains the following items:

Item list of Set ETA, Reference number 20.70.010:

Item	Qty	Description	To be used for	Ref. No.:
1	1	Ring compression bush 160	Fitting piston rings and springs	73.43.160
2	1	Piston spanner (T-handle) M8	Removing&fitting piston/con rod, removing control piston	7340009
3	1	Short auxiliary bar	Removing&fitting piston/con rod	70.50.627
4	1	Cylinder liner push bolt M20	Fitting and clearance determination	70.50.627
5	1	Long auxiliary bar	Ditto as item 4 and for removing	70.50.627
6	1	Threaded rod with nut M12	Removing and fitting cylinder liner	70.50.627
9	1	Oil charging line	Filling crankcase	15.25.113
10	1 + 1	1x Eye bolt M12 + 1x Eye bolt M16	Measuring crankshaft end play	01.18.606/812
12	1	Service Instruction Manual RC12	Maintenance, inspection, repair and overhaul	00.87.127
13	1	Control oil pressure measuring set	Control oil pressure during operation	20.38.121
14	1	Key	To remove oil filter	73.40.100
15	1	Service instruction ETA	Service jobs	00.87.153
16	1	Push pin (cylinder liner – holes)	Position cam ring valve lifting mechanism	70.11.370
17	1	Push pin (cylinder liner – slots)	Position cam ring valve lifting mechanism	70.11.370
18	1	Service instruction CFF	Control oil pressure measurement	00.87.126
-	1	Pully M24x108	Disassembly tool coupling hub. Use the hub locking disc 1915211 you already have.	



5.5 FITTING INSTRUCTIONS FOR PIPE COUPLINGS AND DOUBLE LOCKING RING

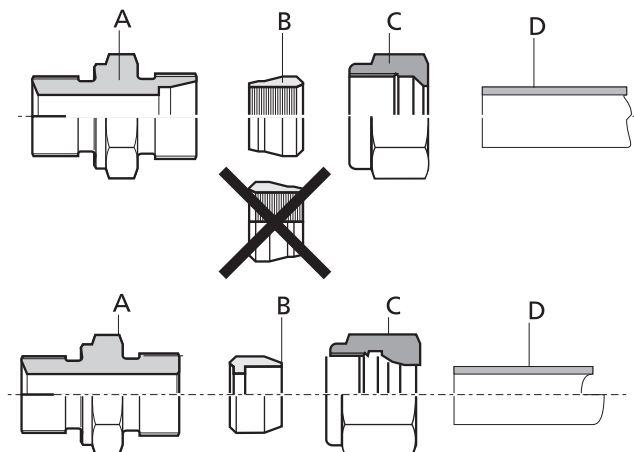


Fig. 5.5-1 Pipe couplings

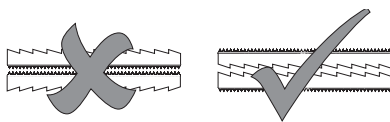


Fig. 5.5-2 Double locking ring

A) Preparation

- ☐ Saw off the pipe at right angles.
- ☐ Deburr and clean the pipe end.
- ☐ Oil thread, taper and clamping sleeve (facilitates fitting).
- ☐ In bends, the minimum length of the straight pipe end must be twice the height of the union nut.
 - ✓ A = Coupling threaded piece
 - ✓ B = clamping sleeve
 - ✓ C = Union nut
 - ✓ D = Pipe

B) Fitting

- ☐ Slide union nut and clamping sleeve on the pipe (mind the assembling sequence).
- ☐ Press pipe against stop and tighten union nut by hand.
- ☐ Tighten a further half a turn (clamping sleeve is about to grip).
- ☐ Slack the union nut and retract pipe from stop by 2 - 3 mm.
- ☐ Tighten 3/4 - 1 turn (ridges now penetrate into pipe).
- ☐ On reassembly, only tighten up the union nut.

5.6 MASS OF SEPARATE COMPONENTS AND COMPRESSORS

Table 5.6-1

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	
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).			

5.7 RELIEF VALVE POSITIONS

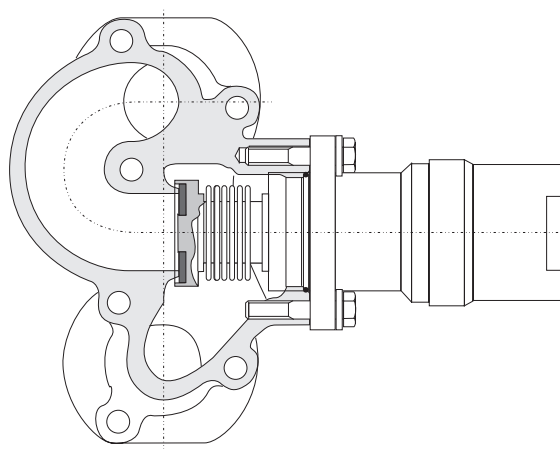


Fig. 5.7-1 Relief valve; back pressure independent

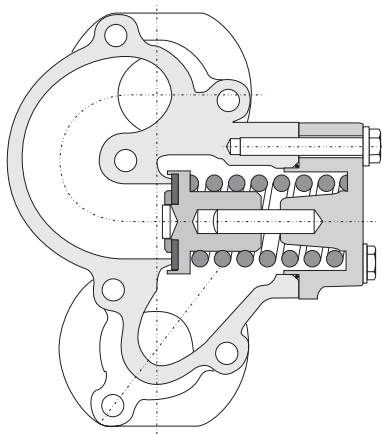


Fig. 5.7-2 Relief valve; Back pressure dependent

Table 5.7-1 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
93	LP					HP	B					
102						HP	B					LP

Table 5.7-3 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	LP											
3	LP											
4	LP											
6	LP											
9				LP		LP						
12						LP	LP					
21	LP		HP									
31	LP	HP										
42	LP					HP						
51	LP		HP									
63				LP		HP						
72				LP		HP						
84	LP					HP	LP					HP
93	LP					HP	LP					
102						HP	LP					LP

Table 5.7-2 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									
31	LP	HP										
42	LP					HP						
51	LP		HP									
63				LP		HP						
72				LP		HP						
84	LP					HP	B					HP
93	LP					HP	B					
102						HP	LP					LP

6. APPENDIX; Product Information (PI)

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6.1 MAIN DIMENSIONS AND SPACE REQUIREMENTS

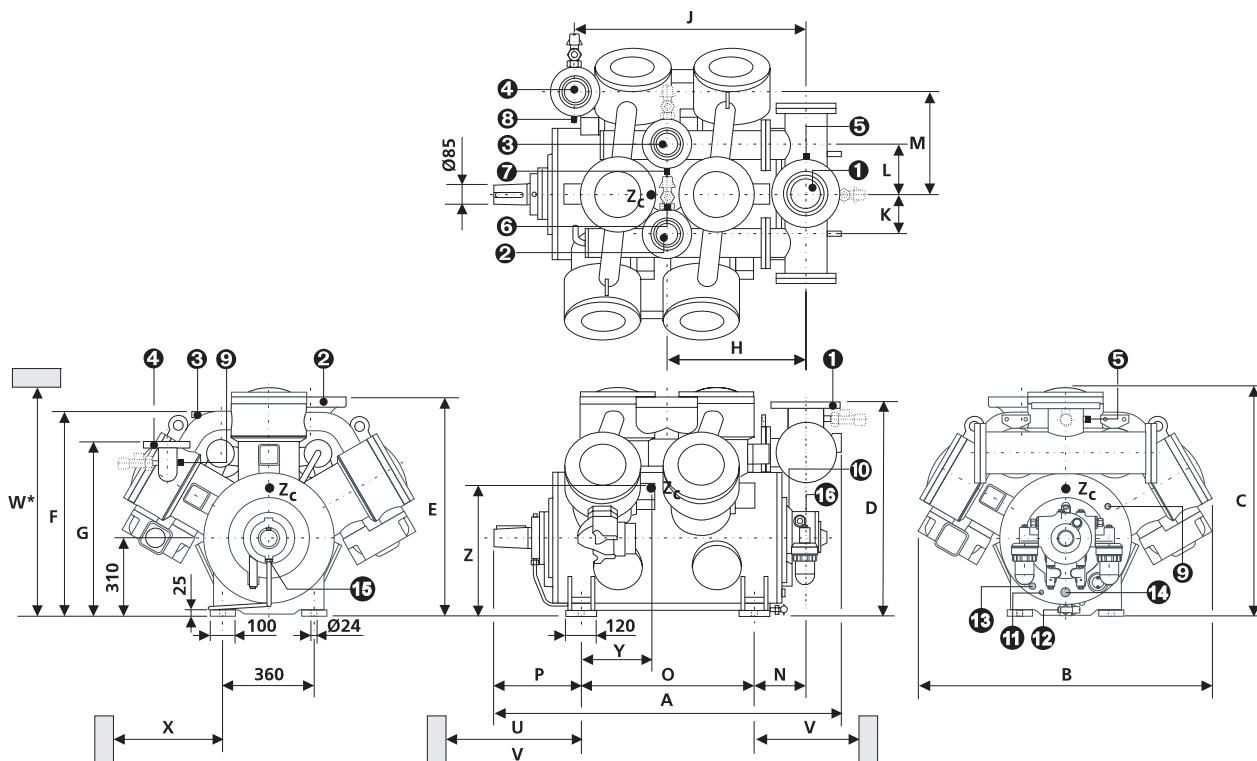


Table 6.1-1

COMPRESSOR TYPE		212	312	412	612	912	1212	2112	3112	4212	5112	6312	7212	8412	9312	10212
Length	A	977	987	1307	1377	1792	2182	987	1307	1377	1377	1792	1792	2182	2182	2182
Width	B	1077	1171	1077	1171	1171	1171	1171	1110	1171	1171	1171	1171	1171	1171	1171
Height	C	881	931	884	931	931	931	931	876	931	931	931	931	931	931	931
	D	876	848	876	848	848	848	848	876	848	848	848	848	848	848	848
	E	881	688	884	871	871	871	871	864	871	871	871	871	871	871	871
	F	316	522	316	548	560	950	786	790	795	795	795	795	795	795	795
	G	0	406	0	189	189	189	648	745	688	688	688	688	688	688	688
	H							530	541	548	548	560	560	950	950	950
	J							509	903	913	913	1315	1315	1705	1705	1705
	K							149	224	163	163	163	163	163	163	163
	L							195	108.5	195	195	195	195	195	195	195
	M							406	331	406	406	406	406	406	406	406
	N	205	205	205	205	217	217	205	205	205	205	217	217	217	217	217
	O	295	295	625	685	1075	2x732.5	295	625	685	685	1075	1075	2x732.5	2x732.5	2x732.5
	P	345	345	345	345	369	369	345	345	345	345	369	369	369	369	369

COMPRESSOR TYPE		212	312	412	612	912	1212	2112	3112	4212	5112	6312	7212	8412	9312	10212
MINIMUM REQUIRED FREE SPACE for removal of:																
flywheel	U	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
crankshaft	V	875	875	1205	1265	1655	2045	875	1205	1265	1265	1655	1655	2045	2045	2045
piston and cylinder liner	W ^a	1010	1160	1010	1160	1160	1160	1160	1010	1160	1160	1160	1160	1160	1160	1160
	X	460	595	460	595	595	595	595	460	595	595	595	595	595	595	595
LOCATION OF CENTRE OF GRAVITY																
length	Y	197	197	280	405	600	795	197	280	405	405	600	600	795	795	795
width	Z	405	423	423	435	440	445	423	423	435	435	440	440	445	445	445
MAIN CONNECTIONS DN (mm)																
(LP) suction	1	80	80	100	125	125	125	65	65	100	125	100	100	100	100	100
LP discharge/ HP suction	2/3							50	50	80	80	80	80	80	80	80
(HP) discharge	4	65	65	80	100	100	100	40	40	65	65	65	65	65	65	65
AUXILIARY CONNECTIONS																
suction ^b pressure	5	1/4" BSP (plugged off)														
LP discharge pressure ^b	6															
HP suction pressure	7															
discharge pressure ^b	8															
Crankcase pressure	9															
lubricating oil pressure	10															
Oil temperature	11															
Oil charge and drain valve	12	1/2" BSP (plugged off; separate stop valve, type TAH8, supplied loose with the compressor)														
Return from oil separator or rectifier	13	1/2" BSP (plugged off; separate swivel coupling, supplied loose with the compressor)														
Crankcase heater	14	1/2" BSP (plugged off) to suit thread of heating element														
Oil leakage drain of rotary shaft seal	15	clamp coupling provided with ø12x1.5 mm steel precision tube														
Control oil pressure	16	T-coupling														

a. Minimum required free space for interstage cooling system A or B.

b. When a microprocessor is applied (see also the relevant Data Sheet), these auxiliary connections are provided with a swivel coupling with two connections. The straight-through and side connection of this swivel coupling are provided with a clamp coupling for ø6x1 mm steel precision tube, in order to accommodate the temperature sensor element and the steel precision tube for the pressure transducer respectively.

7. NOTES

[illegible]

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