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Todo lo de parte 3

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Menu:

1. Components (part 3)
   Regular maintenance
2. ~~Schedule a el Hours of operation~~ Working Hours (manually)
   Maintenance Work

2. Working Hours /

List of component · Hours Done When 50 hrs before reminder that things has to be done

Filter

Confirmation that they did the maintenance
Add a checklist of maintenance to be done

Add export option
import

PDF / excel

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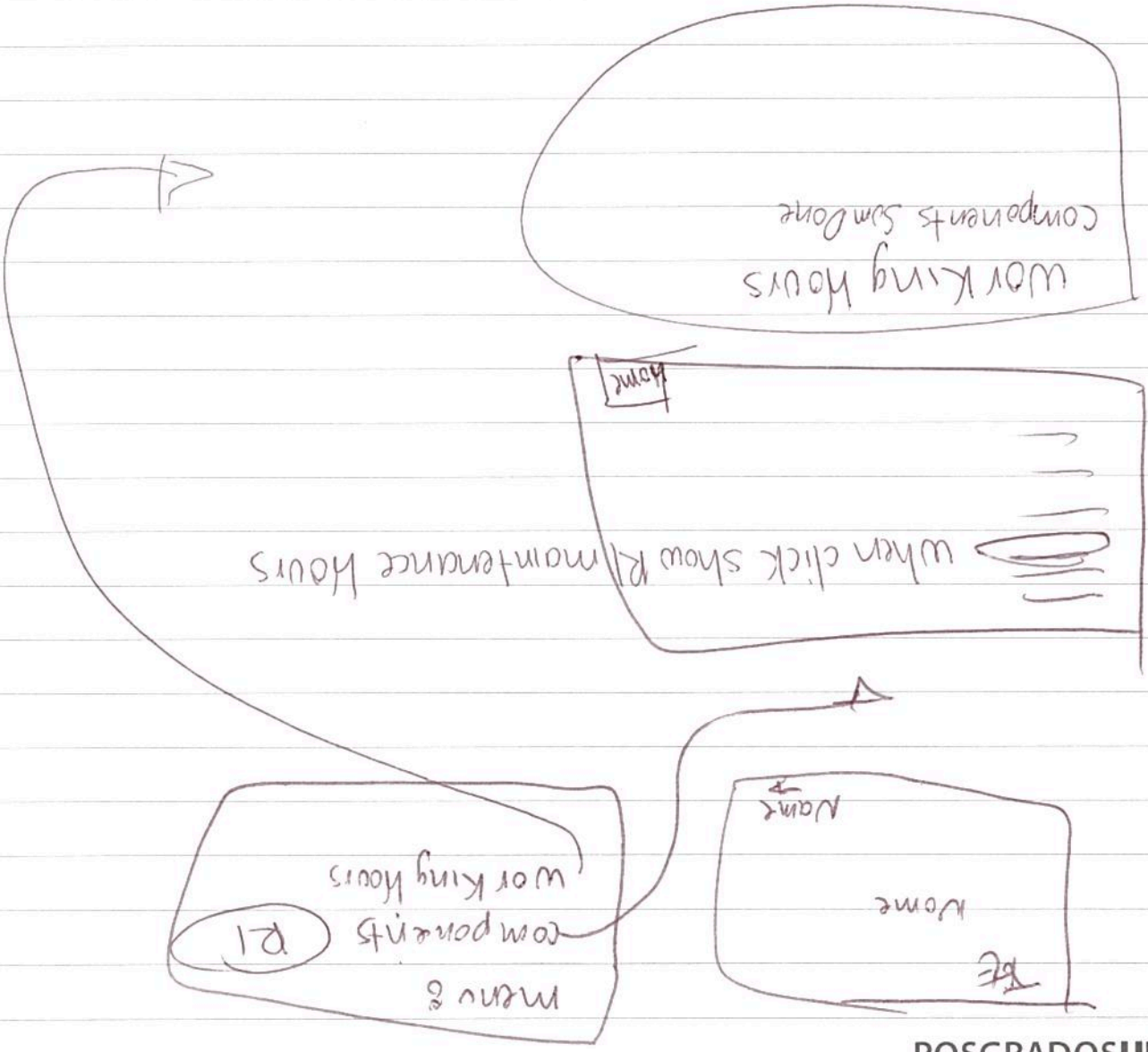


8.4.1 Plant

Maintenance Work	See section	Hours of operation						
		4000	8000	16000	24000	32000	40000	48000
Check set points of the safety devices; conduct function test.	8.6.7	x	x	x	x	x	x	x
Suction strainer(s): Check cleanliness of suction strainer and its components	8.6.4	x	x	x	x	x	x	x
Piping: Check bolted connections, flanges and pipe clamps for tightness	8.6.3	x	x		x		x	
Separator(s): Check proper condition of separator	3.3.6	x	x	x	x	x	x	x
Automatic condensate drain(s): Check drain valves, seat, cone, nozzles and position of switch	3.3.6	x	x	x	x	x	x	x
Damper(s): Check proper condition of damper	3.3.5		x	x	x	x	x	x
Gas cooler(s): Clean gas and cooling spaces, replace gaskets	8.6.5	Every 16000 hrs., depending on fouling factor and water treatment						
Safety valves: Check proper functioning of safety valves	8.6.7		x		x		x	
Relief valves: Check proper functioning of relief valves	8.6.7		x		x		x	
Non-return valve(s) for process gas: Check condition and function of non-return valve	9.4		x		x		x	

R1

8.4.2 Compressor

Maintenance Work	See Section	Hours of operation					
		8000	16000	24000	32000	40000	48000
Drain oil, clean oil strainer, crankgear and duplex oil filter (if applicable). First time after 200 hours of operation.	8.7.8	X	X	X	X	X	X
Check suction valves and discharge valves.	8.10	X	X	X	X	X	X
Check clearance between guide bearing and piston rod (with feeler gauge or dial gauge).	8.8.7	X	X	X	X	X	X
Check gland rings and replace if required.	8.9.2	In case of gas leaks to distance piece					
Dismantle piston and piston rod. Check oil scraper rings and piston rod surface.	8.9.1, 9.12, 9.16	In case of insufficient function of oil scrapers					
Check clearances of: crankshaft bearing, connecting rod bearing, crosshead pin bearing and crosshead without removing (by feeler gauge or dial gauge).	8.8		x		x		x
Check tightening of connecting rod bolts.	9.19		x		x		x
Check piston clearance by feeler gauge and the preload force/tightening of piston nut.	8.9.3, 8.9.4		x		x		x
Check pretension of piston crowns (piston with diameter 480 mm and larger).	8.9.3		x		x		x
Check alignment of flexible coupling.	5.7	At least every 16000 hours but each time after coupling of electric motor					
Remove some crankshaft bearings, connecting rod and crosshead pin bearings for inspection (spot check).	8.8			x			x
Clean the cooling chambers of the frame, cylinder. Check the corresponding gaskets.	8.6.5	According to fouling factor and water treatment					
Check the crankshaft seal (replace if necessary).	8.8.3	If shaft seal is leaking					

Operation Manual - List of Contents

12,000 m³ LEG-/LPG-/Ammonia-/VCM Carrier

HYUNDAI MIPO DOCKYARD, KOREA

Hull Nos.: 8163 - 8167

1	21.11.2014	First Issue	ew	JJ	woe
Rev.	Date	Subject of revision	Author	Checked	Validated

Part I

GAS PLANT AND OPERATIONS DESCRIPTION

Number of books: 1

Part II

LISTS / DIAGRAMS / PLANS

Number of books: 4

Part III

MANUFACTURERS DOCUMENTATION AND INSTRUCTIONS

Number of books: 15

Part IV

CERTIFICATES FOR GAS PLANT EQUIPMENT

Number of books: 2

Part I

Gas Plant & Operations Description

PART II

Lists, Diagrams & Plans

2. DIAGRAMS

2

2.1 Piping and Instrumentation Diagrams

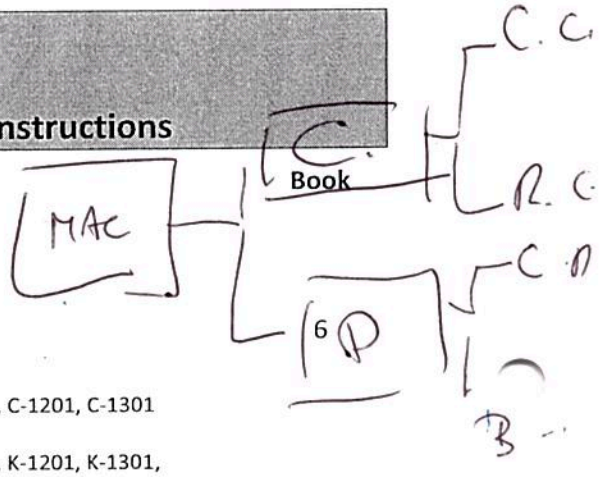
2.2 Process Flow Diagrams

3

PART III

Manufacturers Documentation and Instructions

List of components.



CONTENTS – PART IV –

CERTIFICATES FOR GAS PLANT EQUIPMENT

8.5 Plant in General

8.5.1 Tightening Torques and Method

For specific tightening methods for the *compressor* please see section 8.7.6 Tightening Methods and a comprehensive table with tightening torques can be found in chapter 13 Appendix.

Tightening Method I **Bolted Connections of Secondary Level**

- This category includes all bolts not being particularly stressed during operation.
- Tightening is usually done using a standard-sized wrench without extension.
- Tightening torques depend on bolt size and material.
- Torque values are listed in the following table.

Bolt quality class and bolt material are marked on the head of a bolt (see Fig. 8-16).

Should questions arise, please contact our Technical Service Support (address see section 1.4 Contact Address).

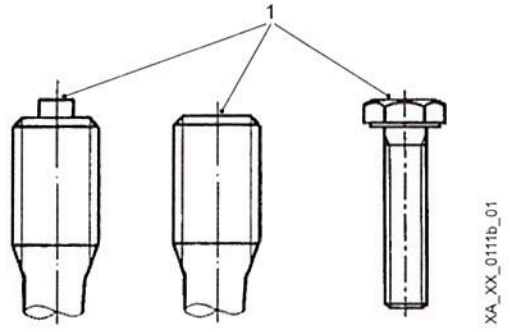


Fig. 8-16 Marking on bolts

1 Marking (quality class and material)

Data only applicable if no other tightening methods or torque values are specified.

CAUTION

If gaskets are used, attentively follow the specifications of the gasket manufacturer!

Tightening Method

- Clean areas of support (connecting parts) free of grease
- Apply lubricant to gliding surfaces of bolt (thread, head support and nut support)
- Tighten screw at least twice using torque wrench (tightening torque according to table)

Lubricant

- MOLYKOTE® G-N Plus
- Other suitable lubricants

Tightening Torques

Thread	Bolt quality standard 4.6-2, 5.6, G, YK			Bolt quality heat-treated 6.9, 8.8, VCN 35		
	Nm	mkp	ft-lbs	Nm	mkp	ft-lbs
M12	25	2.5	18.4	39	4	28.8
M14	39	4	28.8	64	6.5	47.2
M16	59	6	43.5	93	9.5	68.6
M18	83	8.5	61.2	132	13.5	97.4
M20	113	11.5	83.3	177	18	130.6
M22	147	15	108.4	245	25	180.7
M24	186	19	137.2	324	33	239
M27	265	27	195.5	461	47	340
M30	343	35	253	638	65.1	470.6
M33	422	43	311.3	834	85	615.2
M36	530	54	390.9	1080	110.1	796.6
M39	667	68	492	1373	140	1012.7
M42	–	–	–	1766	180.1	1302.6
M45	–	–	–	2256	230	1664

Data valid only using MOLYKOTE® G-N Plus!

8.6 Plant

8.6.1 Electric Motor and Coupling

Electric Motor

If electric motor has been removed for its overhaul and/or if the crankshaft deflection of the compressor crankshaft is larger than the permitted limit (see section 5.7.5 Check Crankshaft Deflection) the electric motor must be realigned.

Realignment is simplified if the position of the main motor had been marked with positioning pins during installation.

For realignment proceed according to section 5.7 Install Electric Motor and Coupling.

Coupling

Inspections are limited to a visual assessment of the condition of the coupling. Pay attention to damage or cracks in the rubber disc element, connecting bolt and any damage caused by force. The inspection of the coupling should always be carried out at the same time as the inspection of the entire system, or at least once a year.

8.6.2 Gas System

Cooler, Damper and Separator

Pressurized plant components, such as pressure vessels, coolers, dampers, etc. must be inspected periodically for deposits or corrosion according to local and/or work rules. If pressure test must be repeated periodically, see section 8.6.8 Hydrostatic Pressure Test.

Non-Return Valve

Check gaskets of non-return valve on a regular basis and use them only once.

WARNING

Unsuitable gaskets!

Damage of compressor or plant is possible.

⇨ Use only gaskets according to ANSI B 16.21.

8.6.3 Flange Connections and Pipe Fastenings

Gaskets/Seals

Check gaskets and seals on a regular basis and use them only once.

Flange Connections/Pipe Fastenings

Check all flange connections and pipe fastenings on a regular basis.

Retighten all flange connections and pipe fastenings according to specified tightening torques.

Pipe Supports

Defective or loose pipe supports can lead to vibrations and therefore interfere with the smooth running of the compressor.

To avoid damage to welds, check coolers, dampers etc. periodically for specified tightening torque.

Retighten bolted connections of their supports on a regular basis.

Check bolted connections for specified tightening torque on a regular basis.

Fit additional pipe supports if necessary.

Examples for pipe supports, see section 5.10.4 Recommendation for Pipe Support.

Information regarding admissible vibrations, see section .

Pipe System

To avoid damage to pipes, coolers, pulsation dampers etc. due to vibrations, the bolts of the pipe connections must be checked for specified tightening torque and if necessary re-tighten periodically. Loose pipe fastenings may lead to pipe damage and/or to fractures of weld seams. This may also lead to disturbances in the smooth running of the compressor.

Examples for pipe supports, see section 5.10.4 Recommendation for Pipe Support.

For information regarding vibrations, see section .

Gas leakage must be repaired immediately. Gaskets may become hard and brittle after a certain time; they must be replaced periodically. Gaskets should be used once only. Pipe connections must be accurately aligned to the design angle with regard to each other. Damaged surfaces of flanges must be re-machined. Flange connections must be checked periodically for specified tightening torque and re-tightened if necessary.

Process gas may be dangerous. Read the detailed gas description and warnings in section 2.9 Process Gas and Purge Gas.

8.6.4 Suction Strainer

Inspect suction strainer for cleanliness.

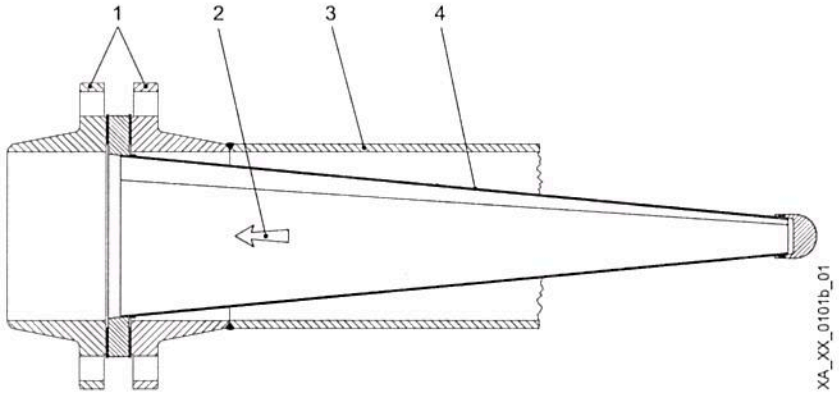


Fig. 8-17 Suction strainer

1 Flange
2 Flow direction
3 Intermediate piece
4 Conical suction strainer

8.6.5 Cooling System

Periods of Standstill

Avoid stationary coolant.

A minimal flow of coolant must always be maintained. During longer periods of standstill (exceeding a month), the system must be purged and the coolant spaces be dried with compressed air.

Contamination of the coolant leads to deposits in the piping (reduction of pipe diameter) and to deposits in the cooling chambers. This prevents proper heat transfer and results in insufficient cooling.

Increasing discharge gas temperatures, increasing lubricating oil temperatures and decreasing coolant temperatures are a clear sign of deposits in the cooling chambers.

To avoid overheating of critical points, cooling chambers must be inspected regularly; the length of the inspection intervals depends on the quality of the coolant.

CAUTION

The quality of the cooling water must be checked at regular intervals.

Do not use aggressive cooling water which easily builds up deposits.

Bubbles in the cooling water indicate that either ambient air or process gas enter the cooling water.

Oil in the cooling water indicates leaky oil coolers (if any).

WARNING

If the ambient temperature and/or process gas temperature drop below 0 °C the cooling water can freeze. If the wrong antifreeze solution is used the cooling water can, nonetheless, freeze.

⇨ Add antifreeze solution.

Coolant Treatment

The coolant in a closed cooling system must be treated (adding chemicals) in order to:

- prevent fouling,
- prevent deposits,
- prevent encrustation,
- protect the walls of the cooling chambers against corrosion.

CAUTION

Chemicals in the coolant of closed cooling circuits must not attack materials like copper, zinc and aluminium (gaskets).

Subcontract a specialized company for coolant treatment.

Check the concentration of the chemicals added to the coolant periodically. The mixture must be corrected according to the results obtained.

The coolant is a mixture of ethylene glycol and fresh water. The mixing ratio (concerning congealing temperature) must cover all possible operating conditions.

WARNING

Health hazard!

Pure ethylene glycol is noxious. Harmful or fatal if swallowed. Harmful if inhaled or absorbed through skin.

⇨ Avoid contact with ethylene glycol.

Inspecting Cooling Chambers

CAUTION

Loose Raschig rings!

⇨ Do not open frame cover (1) because Raschig rings would tumble out (see following figure).

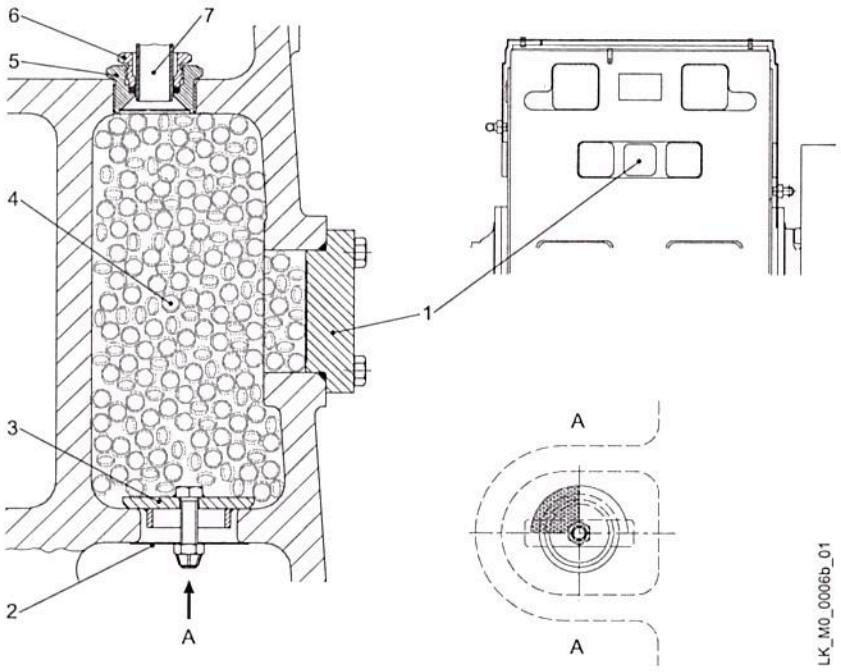


Fig. 8-18 Raschig filter

1	Frame cover	5	Nipple with perforated plate
2	Perforated plate	6	Nipple
3	Fastening clamp	7	Pressure equalizing and oil return pipe
4	Raschig rings		

Drain the cooling system and open the covers on each front side of the frame leading to the cooling chambers.

Also inspect the cooling chambers of the cylinders.

If there are deposits of sand, chalk or algae in the cooling chambers, we recommend to subcontract a specialized company to remove them and to clean the cooling chambers, as they have the necessary know-how and the required materials and equipment.

Cleaning of cooling chambers and removal of deposits can be carried out by the maintenance personnel as well (this is, however, not recommended). Cleaning is described in the following sections "Removing Deposits of Calcium Carbonate", "Removing of Algae" and "Removing Deposits of Sand".

Proceed according to following section "Leak Test".

Removing Deposits of Calcium Carbonate

Circulate the cleaning agent by means of a pump in order to ensure a reliable decomposition of the deposit.

WARNING

Consult manufacturer's instructions.

Remove calcium carbonate deposits with (for example):

Diluted formic acid (HCOOH)

or

Diluted sulphamic acid (NH_2SO_3H) with inhibitor.

CAUTION

Cast iron, steel, nonferrous heavy metals and aluminium must not be corroded by these chemicals.

Proceed according to following section "Leak Test".

Removing of Algae

If the coolant is not properly treated with chemicals, the growth of algae may result. This is particularly the case in open coolant circuits and in cooling towers.

WARNING

Consult manufacturer's instructions.

Remove algae with (for example):

- BIOSPERSE 250, DREW AMEROID
- NALFLOC 7330, NALFLOC
- VARICID AC, SCHILLING CHEMICAL

The treatment time depends on the extent of algae growth. After removal of algae, the coolant must be carefully filtered and properly treated by a specialized company.

Proceed according to following section "Leak Test".

Removing Deposits of Sand

Remove solidified crusts of sand manually and flush out the cooling chambers afterwards.

CAUTION

Chemicals for dissolving deposits of sand are too aggressive for the metallic components of compressors.

Leak Test

After each cleaning operation, a leak test must be performed. Special attention must be given to the internal cooling pipes and connections.

CAUTION

Water in the lubricating oil!

Do not exceed the maximum permitted coolant pressure!

For set pressure of the relief valve in the coolant line (if installed) see corresponding P&I Diagram in chapter 13 Appendix.

8.6.6 Lubricating System

Instrumentation

For detailed description of the instrumentation refer to the documentation of the manufacturer (see Technical Documentation).

8.6.7 Safety Devices

Functional Check of Safety Monitoring Systems

For technical information about safety devices, e.g. temperature sensors, level switches, vibration switches, etc. please see the respective sections in chapter 13 Appendix.

Safety monitoring systems must be checked for their switching points and their indicating values according to the safety requirements (for set points see section "Instrumentation" in chapter 13 Appendix).

By means of a suitable electrical circuit, the monitoring devices which switch off the motor can be overridden for checking the individual or collective functional ability of the devices.

The safety and monitoring devices must be switched on again after functional checks.

Safety Valves/Relief Valves

Safety valves and relief valves are the last inline safety devices for vessels and piping. Establish inspection intervals with regard to ambient and/or plant operating conditions as well as regulations and work rules.

Control and Shut-Off Valves

Maintenance for control and shut-off valves should be carried out regularly according to manufacturer´s instructions.

CAUTION

Observe instructions of the manufacturer (see Technical Documentation).

8.6.8 Hydrostatic Pressure Test

Hydrostatic pressure tests of the pipe system must be carried out by trained specialists only. Parts to be pressure tested must be air vented. Please ask for our technical assistance (address see section 1.4 Contact Address) for permitted design pressure on the gas side. Use approved pressure gauges only. For the gas and oil pipes only treated water must be used.

WARNING

Pressurized plant components.

Incorrect pressure testing may result in bursting plant components!

⇨ Do not exceed the maximum permitted pressure!

⇨ Observe the correct measuring unit on the pressure gauge.

Cleaning After the hydrostatic pressure test, clean all parts and surfaces of the plant components exposed to process gas according to chapter 10 Clean and Degrease Plant and Compressor Components.

8.7 Compressor in General

8.7.1 Dimensions, Weights, Space Requirements

Please see section 5.3 Dimensions, Weights, Space Requirement for details.

8.7.2 Marking of Compressor Components

Compressor parts which must always be fitted in the same position are numbered.

On the assembled compressor, these markings must lie on the right hand side when looking from the non-drive end towards the drive end.

The numbering of the individual parts starts with a V1 from the non-drive end and ascends to V2, V3 etc. towards the drive end. Furthermore, the serial no. is marked on important compressor components.

Some parts are only marked with a matching number, like the following:

- Connecting rod – connecting rod bearing shells
- Crankshaft main bearing – bearing cover
- Connecting rod – connecting rod bolts

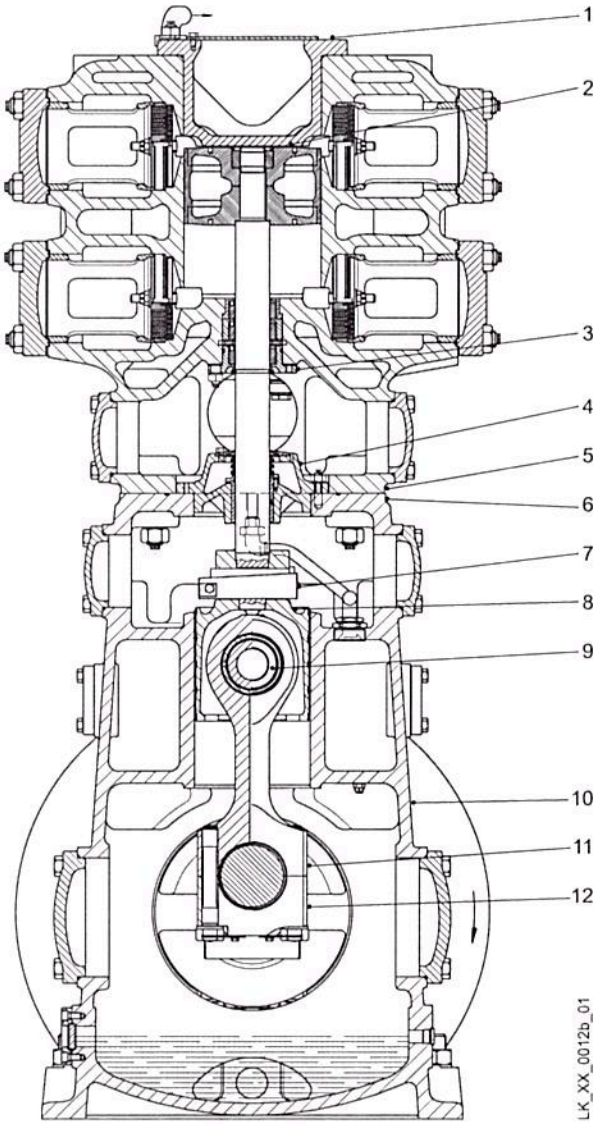


Fig. 8-19 Important markings on a Laby® compressor type K

1	Cylinder cover	7	Wedge (V1/V2 etc. only)
2	Upper piston crown	8	Crosshead
3	Gland flange	9	Crosshead pin
4	Guide bearing	10	Name plate
5	Cylinder (serial no. only)	11	Connecting rod
6	Frame (serial no. only)	12	Connecting rod cover

8.7.3 Piston Clearance Measurement

Measure Piston Clearance

Prior to measuring, clean all measuring tools, according to chapter 10 Clean and Degrease Plant and Compressor Components.

1. The piston clearance of each individual stage must be measured in the Top Dead Center (TDC) as well as in the Bottom Dead Center (BDC) position.

   Always measure simultaneously with two opposite feeler gauges (see Fig. 8-43).

   Record measured values in the compressor check list of section 8.7.5 Clearance Measurement Log Sheet.

   The clearance measured at the same place in the BDC and TDC must be practically the same. Should doubts arise concerning measurement, please contact our Technical Service Support.

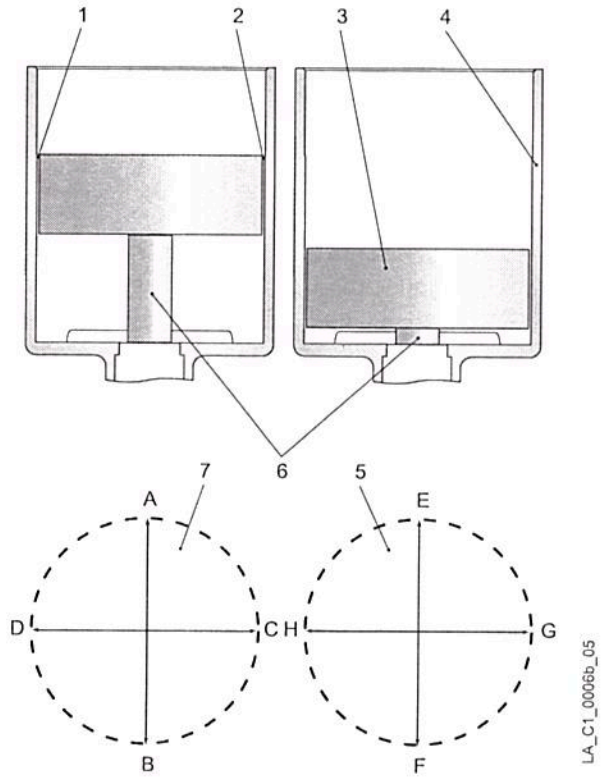


Fig. 8-20 Measure piston clearance

1	Feeler gauge no. 1	5	Measuring points BDC (E with F, G with H)
2	Feeler gauge no. 2	6	Piston rod
3	Piston	7	Measuring points TDC (A with B, C with D)
4	Cylinder		

8.7.4 Cylinder Clearance Measurement

General Remarks

The *top cylinder clearance* is the gap between the piston and the cylinder cover, if the piston is positioned in the top dead center (TDC).

The *bottom cylinder clearance* is the gap between the piston and the cylinder bottom, if the piston is positioned in the bottom dead center (BDC).

Measure Cylinder Clearance

Prior to measuring, clean all measuring tools, according to chapter 10 Clean and Degrease Plant and Compressor Components.

Check cylinder clearances. Record measured values in the compressor check list of section 8.7.5 Clearance Measurement Log Sheet.

CAUTION

Use of wrong lead wire

Wrongly measured or adjusted cylinder clearances can cause major compressor failure.

- ⇨ Use lead wire of appropriate thickness or use a feeler gauge.
- ⇨ Using too thick lead wire can lead to wrong measurement of cylinder clearance.

1. Check the Bottom Dead Center (BDC) cylinder clearance with a feeler gauge through the valve openings (see Fig. 8-44).
   Repeat this procedure in the Top Dead Center (TDC).

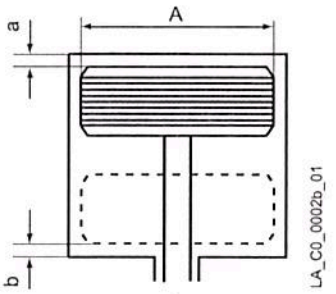


Fig. 8-21 Measure cylinder clearance

A Piston diameter
a Top Dead Center (TDC) cylinder clearance
b Bottom Dead Center (BDC) cylinder clearance

2. Compare the cylinder clearances, you have measured with the set values in section "Compressor" in chapter 13 Appendix.

   ⇨ *You have installed the piston correctly, if the measured values of the cylinder clearance correspond with the set values.*

3. If necessary, adjust the cylinder clearance.

Admissible Tolerances not Achieved?

If the values are not within the given tolerances, there might be a mix-up of parts (e.g. wedges, piston rods or crosshead).

If there is no mix-up with the assembly, the cylinder clearance must be adjusted with distance washers of 0.5 mm thickness between the lower piston crown and piston rod (Fig. 8-45).

In case the piston must be removed, mark skirt, upper and lower crown.

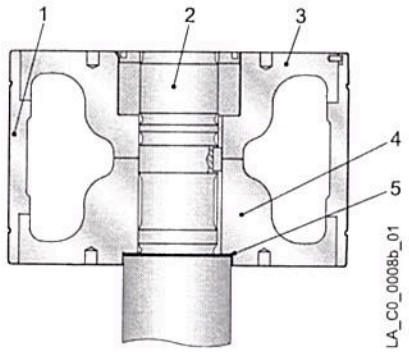


Fig. 8-22 3-piece piston

1 Piston skirt
2 Piston rod
3 Upper piston crown
4 Lower piston crown
5 Washer 0.5 mm

8.7.5 Clearance Measurement Log Sheet

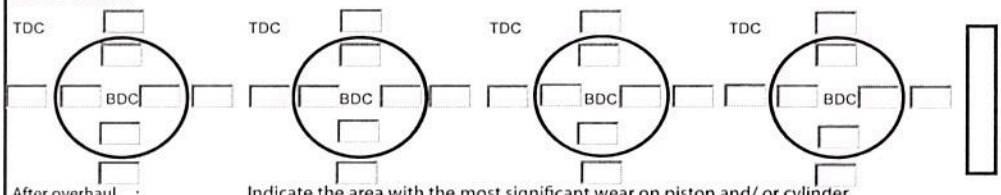
Burckhardt Compression	PL1 Clearance Measurement	TDO_2005513_E01_01.docx

Comp ressor S/N:	Comp ressor type:	Order / Job No.:

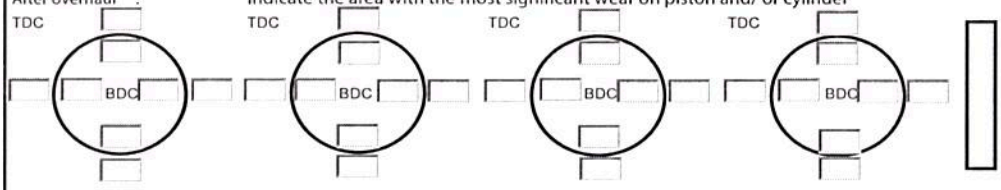
Piston radial clearances: in 1/100 mm, measured with the piston in bottom and top dead centre.

Piston: V 1 mm	V 2 mm	V __ mm	V __ mm

Before overhaul



After overhaul : Indicate the area with the most significant wear on piston and/ or cylinder



		V1	V2	V __	V __
Spacer ring installed		yes ○ no ○	yes ○ no ○	yes ○ no ○	yes ○ no ○
Spacer ring width		mm	mm	mm	mm
Dead space	TDC	mm	mm	mm	mm
	BDC	mm	mm	mm	mm
Piston Pre-Tension		mm	mm	mm	mm

Dead space checked by: Lead wire ☐ Feeler gauge ☐

Piston rod packing: The clearances of the rings are to be checked with a gauge tool or on the cylindrical part of the piston rod

Top ring clearances in mm	V1				V2				V __				V __			
	Before overhaul		After overhaul		Before overhaul		After overhaul		Before overhaul		After overhaul		Before overhaul		After overhaul	
	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type	Clear-ance	Type
Ring 1																
Ring 2																
Ring 3																
Ring 4																
Ring 5																
Ring 6																
Ring 7																

Mark the ring 4116 with a * to the ring No. and note the total segment joint clearances of these rings..

Marking of the Type box :	One (1) piece rings	A	Quality 9001	1		
	Three (3) segment rings	B	Quality 9003	3	Quality Peek	4

Number of springs installed per spring holder ring; V 1 ___ V 2 ___ V __ ___ V __ ___

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Freigabe / Approval DVS		14.12.2011	ASCH_T	vom / date	06.01.2012

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Fig. 8-23 Example sheet for clearance measurement (first page)

Burckhardt Compression	PL1 Clearance Measurement	TDO_2005513_E01_01.docx

Bearing clearances, in mm

	Measured values Radial				Required values according instruction manual
Crank No.	V 1	V 2	V __	V __	Radial
Guide bearing					
Crosshead					
Crosshead pin bearing					
Con-rod big end bearing					
	Pump side	Centre	Flywheel side	Motor DE	Motor NDE
Main bearing					
Axial clearances D comp.					
Axial clearances K comp.			0.0		

Oil scrapers

Replaced:	V 1		V 2		V __		V __	
	yes ○	no ○	yes ○	no ○	yes ○	no ○	yes ○	no ○

Checks made:	YES	NO		YES	NO
Piston nut tighten, SUPERBOLT	○	○	Internal water piping tight	○	○
Piston nut tighten, Standard nut	○	○	Internal oil piping tight	○	○
Crosshead <wedges > tight	○	○	Oil filter cleaned & checked	○	○
Crosshead <wedges > safety device	○	○			
Crosshead <nut> connection tight	○	○	Connecting rod tight	○	○
Crosshead <nut> safety device	○	○	Con rod safety device checked	○	○
Shaft seal material Bronze	○	Cast-iron ○	Leakage; Drops per min. approx.:		
Lube oil foam level during operation approx: cm			Oil level at the sight glass; ¼ □ ½ □ ¾ □		

Setting of safety instruments:			Checked by:		
Suction pressure switch	min.		Temp. Switch 1. Stage	max.	
Discharge pressure switch	max.		Temp. Switch 2. Stage	max.	
Oil pressure switch	min.		Temp. Switch 3. Stage	max.	
Cooling water pres. Switch	min.		Temp. Switch 4. Stage	max.	
Cooling water flow switch	min.	m3/min	Vibraswitch type:	1 G =	divisions

Remarks in the final report.

Place :

Name / Signature BCA:

Date :

Name / Signature Client:

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Überprüft / Reviewed		23.11.2011	OFFERMANN_P	Revision	gedruckt / printed:
Freigabe / Approval DVS		14.12.2011	ASCH_T	vom / date	06.01.2012

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Fig. 8-24 Example sheet for clearance measurement (second page)

Table of clearances see section “Compressor” in chapter 13 Appendix.

8.7.6 Tightening Methods

Please note that just a few methods mentioned here are used on your compressor.

Tightening torques for nuts, screws and bolts that are not specified in the "List of Tightening Torques" in chapter 13 Appendix are to be handled according to section 8.5.1 Tightening Torques and Method.

Preparation

- Clean areas of support (connecting parts) free of grease
- Apply lubricant to gliding surfaces of bolt (thread, head support and nut support)

Lubricant

- Lubricate the bolts at the cylinder with Burckhardt Lubrication Grease BLG05.
- Lubricate the bolts at the frame, and at the base plate (if applicable), with Molykote® G-N PLUS.

Tightening Method II **Bolted Connections with Specified Torque Values**

- Tightening is done using a torque wrench.
- If required, use a multiplier with the torque wrench.
- Torque wrenches are to be calibrated periodically.

Tightening Method III **Bolted Connections with Specified Torsion Angle**

- Without using force, manually tighten nut several times until the connection is well set.
- To be able to tighten nut up to specified angle, use wrench extension. For higher values, use extension or multiplier.

Tightening Method IV **Bolted Connections with Specified Bolt Elongation**

- Check length of bolt before tightening.
- Tighten nut until the bolt elongation is as specified.

Tightening Method V **SUPERBOLT®**

- For tightening of piston nut SUPERBOLT® see section 8.9.4 Piston Nut SUPERBOLT®.

Tightening Method VI **Bolted Connections with Specified Hydraulic Pressure**

- Tighten nut according to specified hydraulic pressure.

Tightening Method VII **Bolted Connection with Flogging Spanner**

- Tighten nut with flogging spanner.

For mandatory tightening torques, appropriate tightening methods and applicable lubricants: see section "Compressor" in chapter 13 Appendix.

8.7.7 NORD-LOCK® Securing System

The NORD-LOCK® securing system consists of a pair of washers with a wedge-locking action meeting DIN 25201. This method uses tension instead of friction.

NORD-LOCK® washer pairs positively lock fasteners in a joint which are subjected to vibrations or dynamic loads. Therefore a NORD-LOCK® washer pair may be used only once!

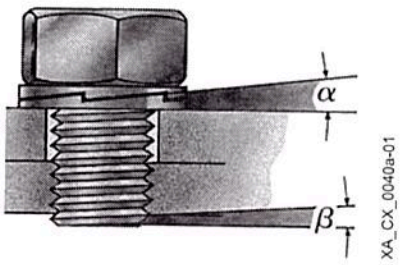
CAUTION

Wrong installation/reuse of NORD-LOCK® washer pair

Cap nut or nut for valve rotates loose. Damage to valves and loss of capacity possible.

- ⇨ Use NORD-LOCK® washer pairs only once!
- ⇨ Install new, unused NORD-LOCK® washer pair every time a cap nut or nut for valves is loosened.
- ⇨ Follow the instructions in this Instruction Manual.

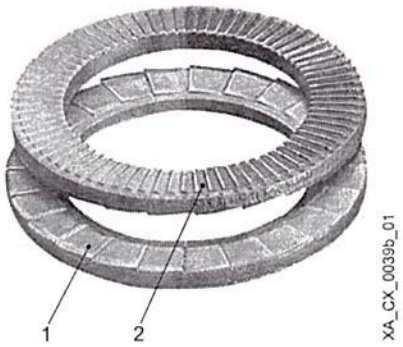
If correctly installed (see Fig. 8-25, Fig. 8-26 and Fig. 8-27), the NORD-LOCK® washer is locked in place, only allowing movement across the face of the cams. Any attempt from the bolt/nut to rotate loose is blocked by the wedge effect of the cams.



The rise of the cams between the NORD-LOCK® washers (α) is greater than the pitch of the bolt (β). In addition, there are radial teeth on the opposite side. The washers are installed in pairs, cam face to cam face.

$\alpha > \beta$ = locking effect

Fig. 8-25 NORD-LOCK® locking principle



1 Cams
2 Radial teeth

Fig. 8-26 NORD-LOCK® washer pair

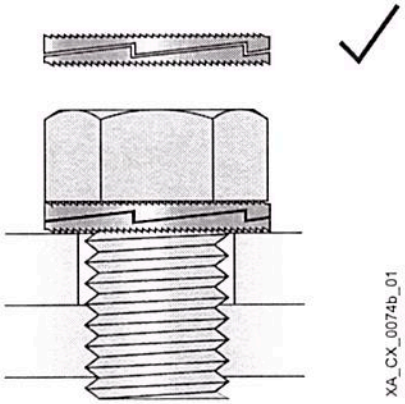


Fig. 8-27 Correct assembly of NORD-LOCK® washer pairs

For lubrication of bolts, please refer to section 8.7.6 Tightening Methods.

8.7.8 Oil Change

For lubricating oil specifications see section "Lubricating System" in chapter 13 Appendix.

For oil change interval see section 8.4 Maintenance Schedule. Analyze the oil periodically to check if the oil still fulfils the qualitative requirements.

Burckhardt Compression AG recommends to regularly obtain oil analysis from an appropriate lubricant laboratory.

In any case the oil must be changed if:

- coolant has penetrated into the oil (oily emulsion).
- the oil has been diluted by condensation.
- bearings have been replaced (due to material of damaged bearings inside the oil).

Permissible Values

- Water content: max. 0.3% (for mineral oil)
- Neutralisation value: max. 0.2mg KOH/g
- Metallic traces of wear: max. 150ppm
- Viscosity (kinematical, at 40 °C): not less than 80% of the new oil.

Oil Quantity The required lubricating oil quantity for the compressor crankgear is about 52 liters.

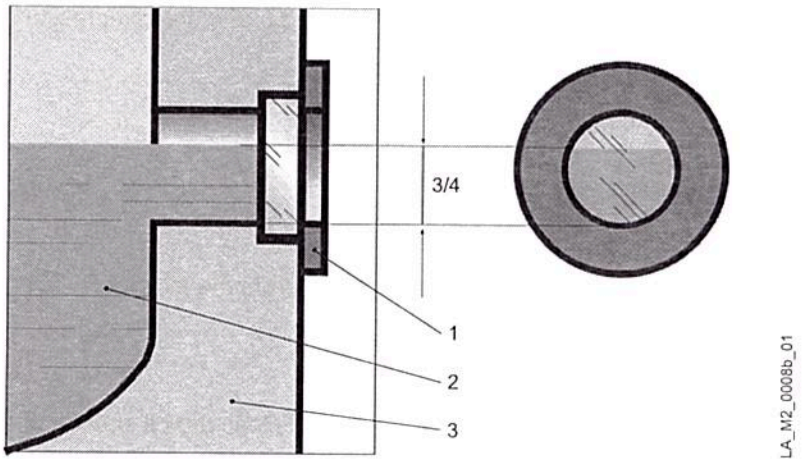


Fig. 8-28 Check oil level

1 Oil sight glass
2 Lubricating oil
3 Crankgear

The oil filling of the compressor is contained in the crankgear. The level may be checked at the oil sight glass. When the compressor is at standstill, 3/4 of the oil sight glass must be covered.

When the compressor is running, 1/2 of the oil sight glass should be covered.

Procedure

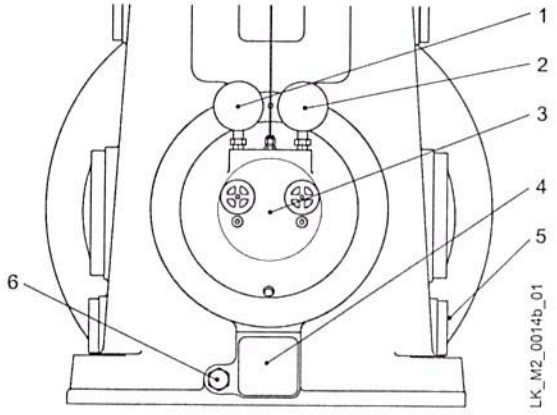


Fig. 8-29 Gear oil pump

1 Pressure gauge for crankgear
2 Pressure gauge for lubricating oil
3 Gear oil pump
4 Oil strainer
5 Oil sight glass
6 Oil drain

Proceed as follows when changing oil:

1. Shut down the compressor.

2. Protect main motor, etc. against unintended start-up.

Depressurize and purge the compressor plant (see section 8.2.1 Depressurize and Purge Plant).

3. Remove frame covers.

Drain

4. Drain the oil from the oil sump.

Clean

5. Remove and clean the oil strainer of the compressor.
6. Clean the crankgear with a new, unused sponge (do not use fibrous textile).
7. The Raschig filter must be cleaned if polymerization or damages with abrasion of cast iron occurs.

Refill

Check for proper lubricating oil quality and quantity see Fig. 8-28 and sections 8.7.8 Oil Change and 8.7.9 Lubricating Oil Specifications.

8. Shut oil outlets, refit oil strainer, etc. and fill the compressor with fresh oil.

8.7.9 Lubricating Oil Specifications

The lubricating oil must be compatible with the process gas because it is in direct contact in the crankgear.

Oil Quality Reference is made to the list of recommended lubricating oils in section "Lubricating System", chapter 13 Appendix.

8.8 Crankgear

8.8.1 Check Crankshaft Deflection

1. Measure crankshaft deflection on the drive end crank in 5 positions according to following figures. Record all measured values as well as the measuring position (i.e. offset from crankweb) of the dial indicator.

⇨ *For maximum permissible deflection on the dial indicator for a complete turn of crankshaft see Tab. 8-1.*

Compressor type	Flexible coupling max. permissible deflection in [mm]	
2K80	0.05	Measure the deflection at the outer most point.
2K90	0.06	
2K105	0.06	
2K120, 3K120	0.06	
2K140, 3K140	0.08	
2K158	0.08	
2K160, 3K160	0.08	
4K165	0.08	
2K250	0.08	

Tab. 8-1 Maximum permissible crankshaft deflection

2. If the deflection exceeds this limit, consult our Technical Service Support; address see section 5.1.1 Technical Support.

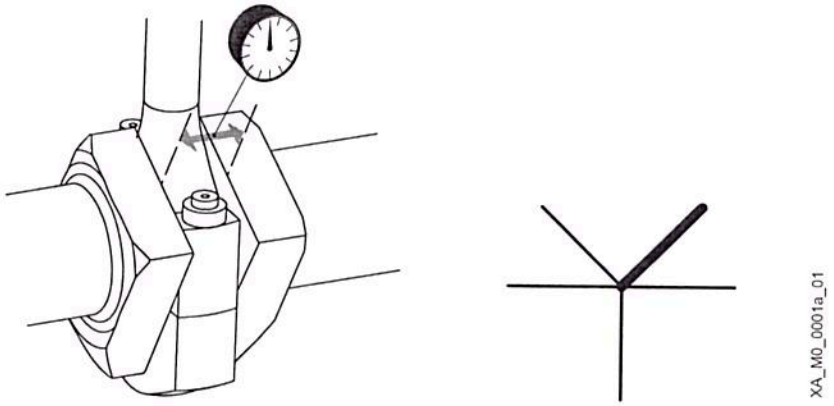


Fig. 8-30 First measurement

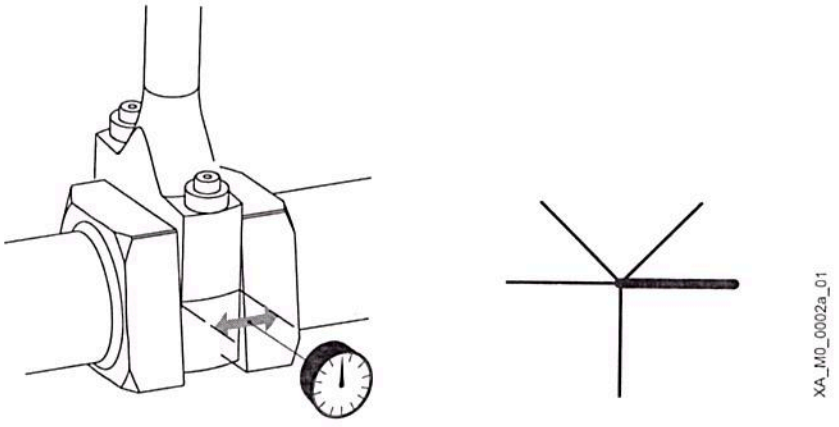


Fig. 8-31 Second measurement

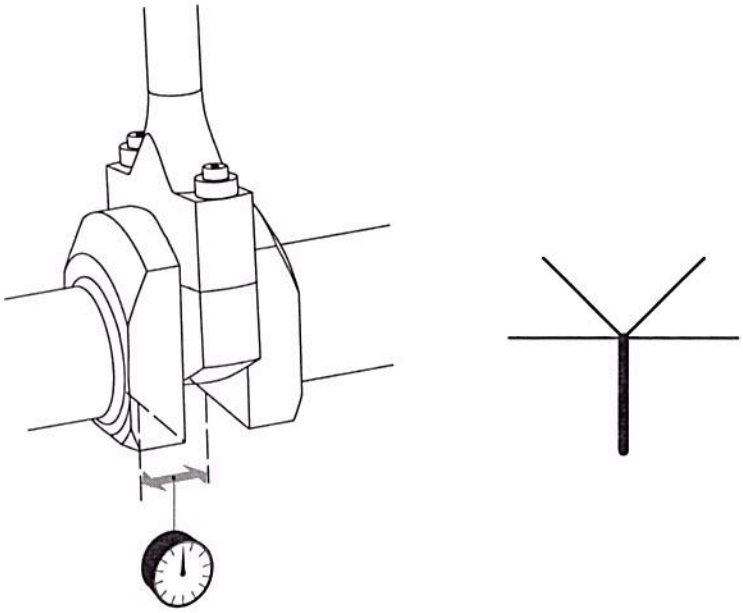


Fig. 8-32 Third measurement

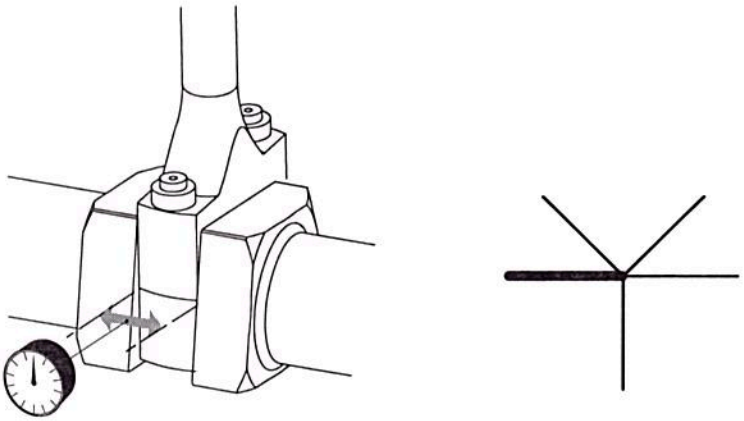


Fig. 8-33 Fourth measurement

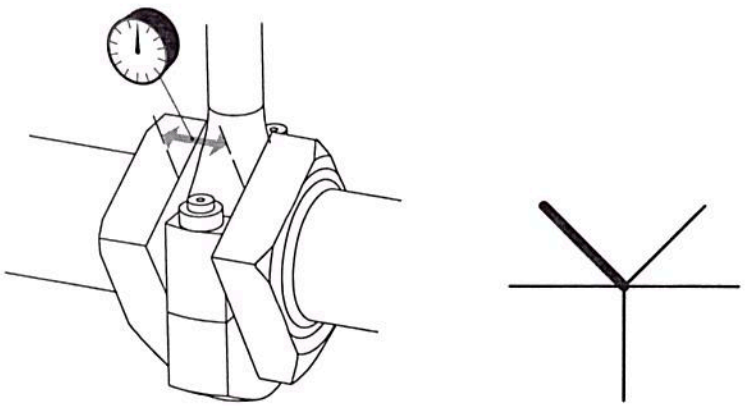


Fig. 8-34 Fifth measurement

8.8.2 Main Bearing and Connecting Rod Bearing

The bearings do not normally call for any maintenance. With regular oil changes they sustain only slight wear.

We recommend that the bearings are not checked too often by dismantling. Reliable inspection is possible without removal:

- measure the clearance between the bearing and crankshaft journal,
- check oil sump, oil strainer and/or duplex oil filter for deposits of white metal.

For applicable clearances see section "Compressor" in chapter 13 Appendix.

If abrasive components of the process gas get in the distance piece/crankgear, they may cause excessive wear of bearings. Consult our Technical Service Support, address see section 1.4 Contact Address.

8.8.3 Crankshaft Seal

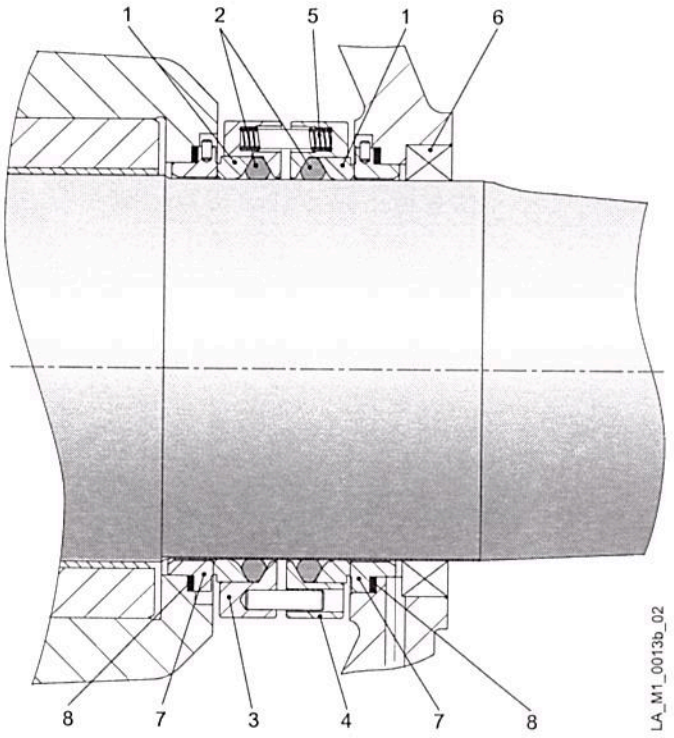


Fig. 8-35 Components of gastight crankshaft seal

1	Running ring	5	Spring
2	O-ring	6	Lip-seal
3	Spring guide ring with cylindrical pin	7	Sealing ring
4	Spring guide ring	8	Flat gasket (rubber)

The lip-seal (6) fitted to the cover prevents contaminants from entering the shaft seal, respectively the compressor. Oil leaking through the shaft seal is led to the outside of the compressor through a small bore drilled into the cover. With the shaft seal working properly, the oil leakage should not exceed 3–5 drops per minute.

8.8.4 Connecting Rod Bearing

Apart from the maintenance work specified in the maintenance schedule, no special maintenance of the connecting rod is required. The connecting rod bolts must be tightened to a certain elongation (Fig. 8-36). For applicable tightening torque (elongation) see section "Compressor" in chapter 13 Appendix.

We recommend, checking the correct tightening of the connecting rod bolts periodically, every 16000 operating hours. For safety reasons, the locking plate of the connecting rod bolts (if applicable) should be checked at each oil change.

WARNING

Loose connecting rod bolts!

After a liquid knock, the connecting rod bolts must be checked immediately for mandatory tightening torque!

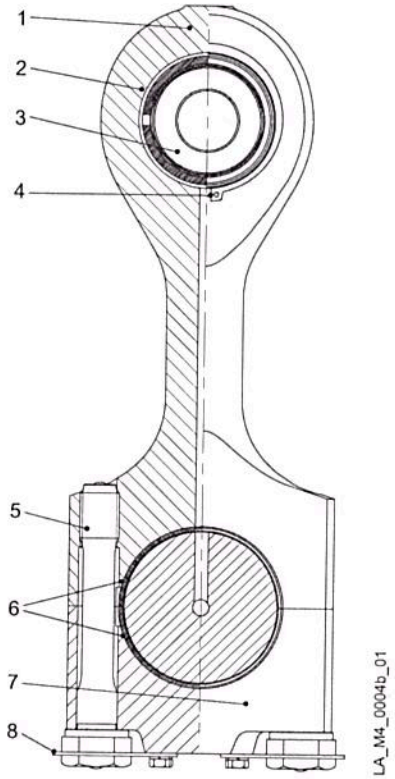


Fig. 8-36 Connecting rod bearing

1	Connecting rod	5	Connecting rod bolt
2	Crosshead pin bearing	6	Connecting rod bearing
3	Crosshead pin	7	Connecting rod cover
4	Circlip	8	Locking plate

Clearance Check of "Crankshaft Journal – Connecting Rod Bearing"

Turn crank to Bottom Dead Center (BDC) and measure clearance between crankshaft journal and connecting rod lower bearing shell with a feeler gauge.

For applicable clearances: see section "Compressor" in chapter 13 Appendix.

8.8.5 Crosshead

The crosshead often rubs slightly against the upper part. This is often caused by starting in winter with a warm crosshead and a very cold coolant directly after stopping the compressor (oil acts as an insulator). After a shut-down we recommend waiting at least half an hour before restarting the compressor with a cold coolant.

Clearance Check

1. Move connecting rod/crosshead in Top Dead Center (TDC) by turning the crankshaft.
2. Press the crosshead in the crosshead bore of the frame to one side and measure the clearance with the feeler gauge at various points.
3. Check clearance between crosshead and crosshead bore with the feeler gauge.
4. Keep a record of measured clearances in a log sheet.
   ⇨ *The crosshead does not need to be replaced as long as the crosshead clearance in the lower half is tolerable.*

For applicable clearances see section "Compressor" in chapter 13 Appendix.

Should doubts arise about the admissibility of the measured clearance, consult our Technical Service Support, address see section 1.4 Contact Address.

Connection between Crosshead and Piston Rod

Connection between crosshead and piston rod, please see section 9.12 Piston and Piston Rod.

8.8.6 Crosshead Pin Bearing

The crosshead pin is fitted to the crosshead and secured by circlips. The crosshead pin bearing is fitted to the connecting rod´s small end with a tight fit. It is secured by circlips. A pin prevents its rotation in the connecting rod.

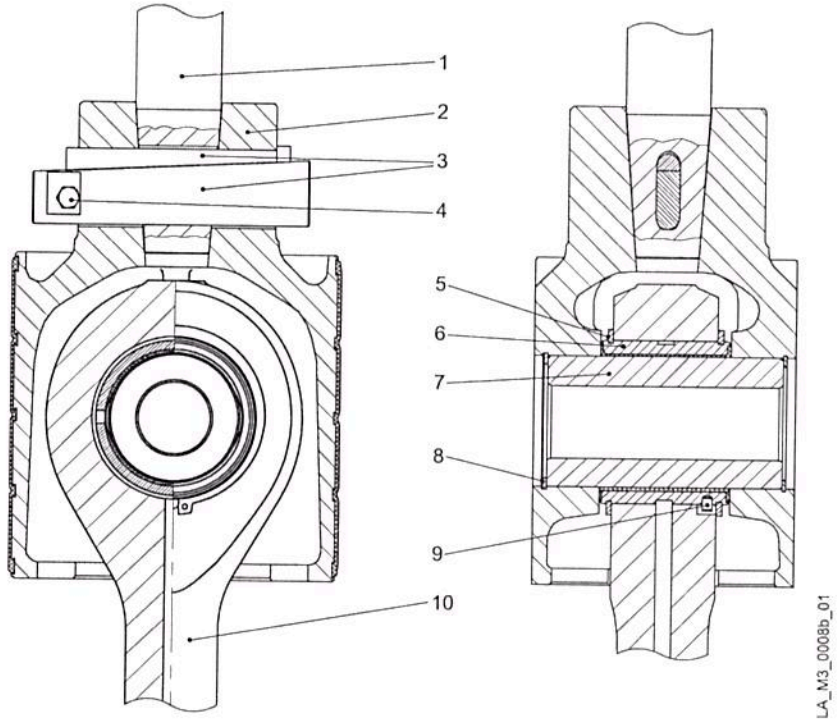


Fig. 8-37 Crosshead pin bearing

1	Piston rod	6	Crosshead pin bearing
2	Crosshead	7	Crosshead pin
3	Wedges	8	Circlip
4	Locking screw	9	Pin
5	Circlip	10	Connecting rod

Bring crank to Top Dead Center (TDC) and measure clearance with a dial gauge by lifting the crosshead. Pay attention to measure only the crosshead pin bearing clearance! If in doubt, eliminate the connecting rod bearing clearance and the crankshaft bearing clearance by lifting and blocking the connecting rod from the bottom side.

For applicable clearances: see section "Compressor" in chapter 13 Appendix.

8.8.7 Guide Bearing

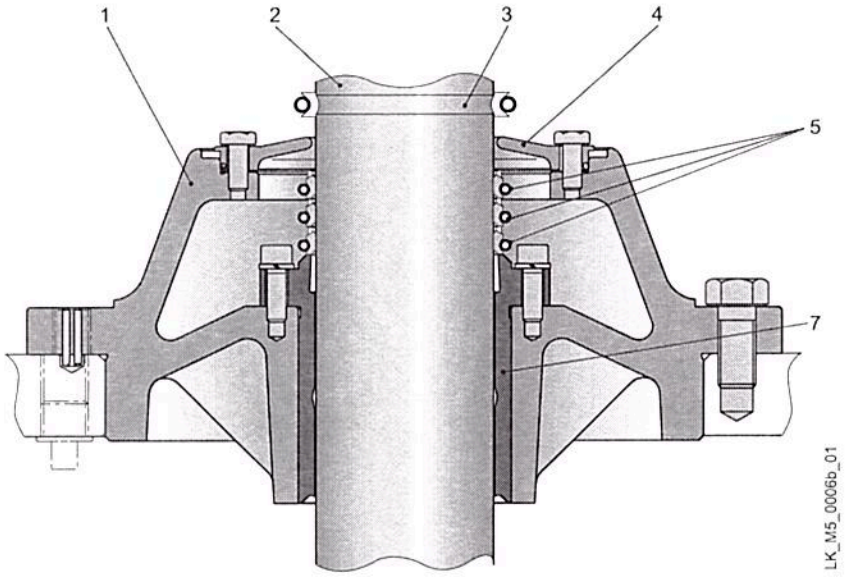


Fig. 8-38 Typical view of a guide bearing without cooling and with open design

1	Bearing housing	5	Oil scraper rings (according to application: 2 or 3 rings)
2	Piston rod		
3	Oil shield	6	–
4	Guide bearing cover	7	Bearing bush

Guide Bearing Clearance Check

Before dismantling the piston rod, the clearance between guide bearing and piston rod must be checked with a feeler gauge. If the clearance between bush and piston rod exceeds the value given in the table of clearances, the bush must be replaced.

Should doubts arise about the admissibility of the measured clearance, consult our Technical Service Support, address see section 1.4 Contact Address.

For applicable clearances see section "Compressor" in chapter 13 Appendix.

For guide bearing replacement, please see section 9.18 Guide Bearing.

Checks after Liquid Knock

Check tightness of connection between crosshead and piston rod immediately after a liquid knock (tightness of crosshead wedges).

Removal of Piston Rod and Oil Scraper Rings

For removal of piston rod and oil scrapers please see section 9.12 Piston and Piston Rod and 9.16 Oil Scraper.

8.9 Cylinder

8.9.1 Piston Rod

- Check piston rod for any surface defects.

Sometimes it is possible to overhaul replaced piston rods. To assure operational safety of an overhauled piston rod, only perform overhauls after consultation with our Technical Service Support.

8.9.2 Piston Rod Gland

The gland rings must be inspected every year or two by dismantling the piston and piston rod. Inspections at shorter intervals are recommended in case there are the following indications that the rings are badly worn:

- leakage of process gas into the distance piece below the glands,
- reduced discharge rate,
- changes in the intermediate pressure,
- increase of gland temperature, etc.

The piston rod gland is equipped with 1-piece gland rings.

The gland rings are to be handled with great care. In particular the labyrinth combs and the faces are to be free of damage. The same applies to the surface quality of the piston rod in the area where it enters the gland.

To prevent contamination of the rings when fitting them in their chambers, the area of the piston rod which enters the gland must be clean and completely free of oil.

Take care that the diametrical clearance (see section 9.14 Piston Rod Gland) between the gland rings and the piston rod is not too small.

WARNING

Wrongly modified or non-genuine spare parts.

Operational safety may be impaired!

- ⇨ Do neither modify parts nor spare parts.
- ⇨ Do not use unsuitable material.
- ⇨ Do not influence clearances on compressor.
- ⇨ Eliminate troubles immediately.
- ⇨ Exchange worn parts.

8.9.3 Piston

Check the Pretension of Piston Crowns

1. The pretension of the piston crowns to the piston skirt is measured when a piston part is replaced or after the interval indicated on the maintenance schedule. This applies also, if a piston nut came loose.
   Pretension is the value by which the piston crowns are bent inwards when the piston nut is tightened, thereby clamping the piston skirt. Measure distance "A" as shown in Fig. 8-39 with the piston crowns clamped together without the piston skirt.
   Pretension = Dimension B - Dimension A

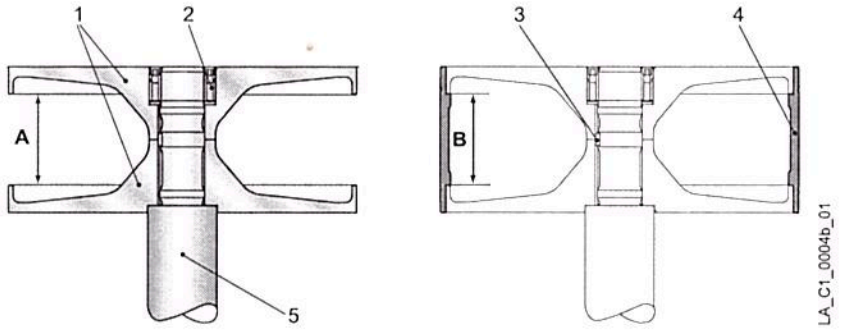


Fig. 8-39 Check pretension of piston crowns

1 Piston crown
2 Piston nut
3 Key
4 Piston skirt
5 Piston rod

2K140-2A_1	Diameter	Pretension
Piston 1st stage	405mm	0.34mm to 0.40mm
Piston 2nd stage	260mm	0.14mm to 0.20mm

Tab. 8-2 Pretension of piston crowns

WARNING

Risk of piston seizure or loose piston skirt!

⇨ The measured values must be within the tolerances given above.

⇨ Tighten piston nut in accordance with section 8.7.6 Tightening Methods and section "Compressor" in chapter 13 Appendix.

2. When installing a new piston skirt, it must be match-marked with the top piston crown. It is important to define the position of the piston parts by reference marking during assembly. This also applies to inspections,

whether parts are replaced or not (i.e. when checking the piston pretension). During reassembly of the parts, these markings will help to recover the correct position of the piston skirt in relation to the cylinder.

The marking should be stamped or engraved only. When assembled and installed the piston markings should always be on the "V"-side (name plate side) of the compressor (see Fig. 8-40).

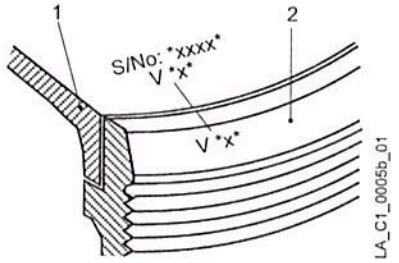


Fig. 8-40 Marking of piston crown and skirt

1 Upper piston crown
2 Piston skirt

3. Measure piston clearance (see section 8.7.3 Piston Clearance Measurement).

Re-machining of Piston Crowns

Piston crowns which have to be re-machined because of pretension loss must not be reduced more than 1.5 mm in height. Face runout must not exceed 0.02 mm.

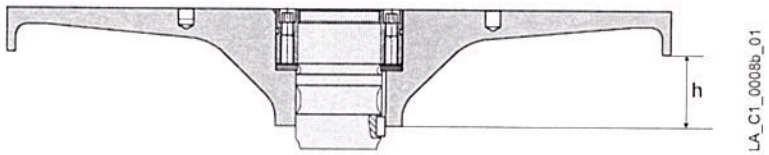


Fig. 8-41 Overview

$h_{min} = h - 1.5$ mm

After facing the outer contact surface (1) and the inner contact surface (2) of the upper and lower piston crown proceed as follows:

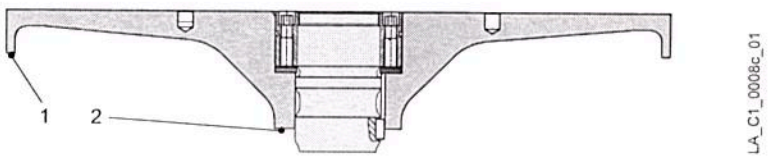


Fig. 8-42 Contact surfaces to be faced

1 Outer contact surface
2 Inner contact surface

1. Clamp the piston crowns together without the piston skirt, see Fig. 8-39.
2. Compare the measured pretension with the values in Tab. 8-2.
3. Re-machine the pretension by facing the outer contact surface (1) and the inner contact surface (2).

Measure Piston Clearance

Prior to measuring, clean all measuring tools, according to chapter 10 Clean and Degrease Plant and Compressor Components.

1. The piston clearance of each individual stage must be measured in the Top Dead Center (TDC) as well as in the Bottom Dead Center (BDC) position.

   Always measure simultaneously with two opposite feeler gauges (see Fig. 8-43).

   Record measured values in the compressor check list of section 8.7.5 Clearance Measurement Log Sheet.

   The clearance measured at the same place in the BDC and TDC must be practically the same. Should doubts arise concerning measurement, please contact our Technical Service Support.

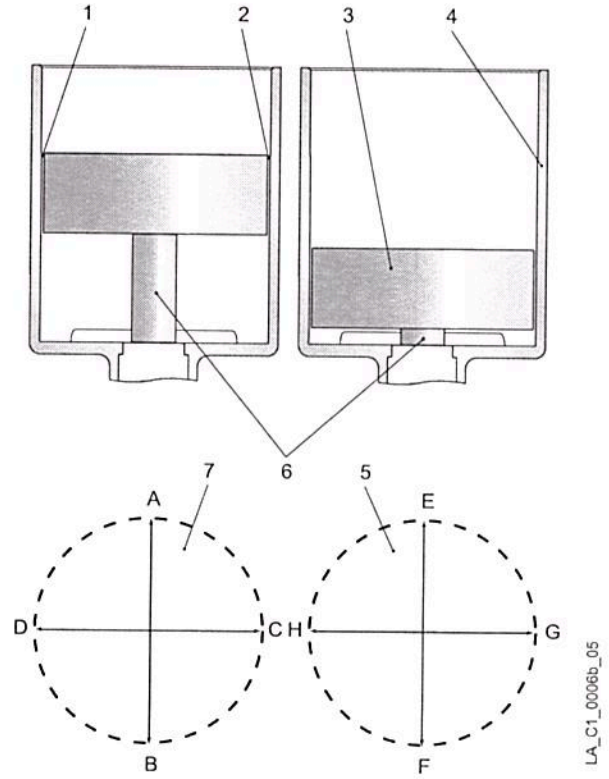


Fig. 8-43 Measure piston clearance

1	Feeler gauge no. 1	5	Measuring points BDC (E with F, G with H)
2	Feeler gauge no. 2	6	Piston rod
3	Piston	7	Measuring points TDC (A with B, C with D)
4	Cylinder		

Measure Cylinder Clearance

Check cylinder clearances. Record measured values in the compressor check list of section 8.7.5 Clearance Measurement Log Sheet.

CAUTION

Use of wrong lead wire

Wrongly measured or adjusted cylinder clearances can cause major compressor failure.

⇨ Use lead wire of appropriate thickness or use a feeler gauge.

⇨ Using too thick lead wire can lead to wrong measurement of cylinder clearance.

1. Check the Bottom Dead Center (BDC) cylinder clearance with a feeler gauge through the valve openings (see Fig. 8-44).
   Repeat this procedure in the Top Dead Center (TDC).

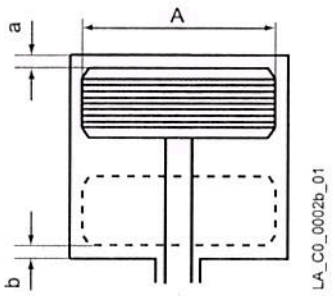


Fig. 8-44 Measure cylinder clearance

- a min. = 1.50 mm
- a max. = 2.00 mm

- b min. = 1.00 mm
- b max. = 1.50 mm

a + b shall not exceed 3.50 mm

A Piston diameter
a Top Dead Center (TDC)
b Bottom Dead Center (BDC)

Admissible Tolerances not Achieved?

If the values are not within the given tolerances, there might be a mix-up of parts (e.g. wedges, piston rods or crosshead).

If there is no mix-up with the assembly, the cylinder clearance must be adjusted with distance washers of 0.5 mm thickness between the lower piston crown and piston rod (Fig. 8-45).

In case the piston must be removed, mark skirt, upper and lower crown.

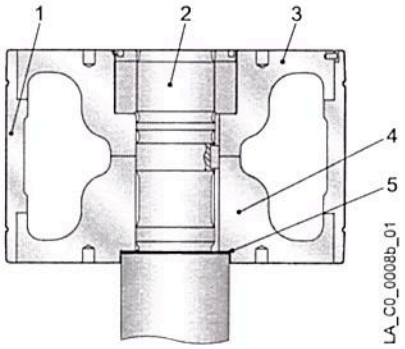


Fig. 8-45 3-piece piston

1 Piston skirt
2 Piston rod
3 Upper piston crown
4 Lower piston crown
5 Washer 0.5 mm

Failures and Repairs on Cylinder and Piston

Gas loss between cylinder and piston influences the intermediate pressures as well as the outlet temperatures on the corresponding cylinders (suction and final pressures maintained).

"Inadequate pistons" are defined as follows:

Piston with Excessive Diameter Clearance (possibly Labyrinth OK)

Possible causes:

- excessive vibrations at the foundation/compressor,
- piston rod gland in bad condition,
- excessive clearance between piston rod and guide bearing,
- excessive crosshead clearance,
- pretension of piston too small, i.e. piston or piston skirt rotates, respectively.

Piston Seizure, i.e. Piston Entirely or Partially with "Flattened" Labyrinth

Piston seizure often leaves piston residues in the cylinder. They are visible as smooth spots on the labyrinth.

Possible causes:

- rapid temperature increase, e.g. due to:
  - valve defect,
  - failure of cylinder cooling.
- Impurities inside gas piping and/or plant accessories getting into the cylinder.
- Broken valve parts getting into the cylinder.
- Liquid knock, e.g. leaky cooler during commissioning/condensate.

Following maintenance and/or repair work:

- rapid pressure raise during running-in of a new piston,
- insufficient clearance between guide bearing and piston rod,
- inadequate concentricity of guide bearing/guide bearing bush,
- insufficient clearance between piston rod and gland ring,
- excessive pretension of piston.

Insufficient Pretension of Piston

Insufficient pretension of piston leads to a loose piston skirt noticeable by a clear knocking of the compressor. Piston parts may be re-machined.

Should questions arise, please get in touch with our Technical Service Support (see 1.4 Contact Address).

Failed Piston

Failed pistons and/or pistons with excessive clearance must be replaced. If the clearance is still excessive, the cylinder must be rebored and oversized pistons have to be installed.

For further instructions, contact our Technical Service Support.

8.9.4 Piston Nut SUPERBOLT®

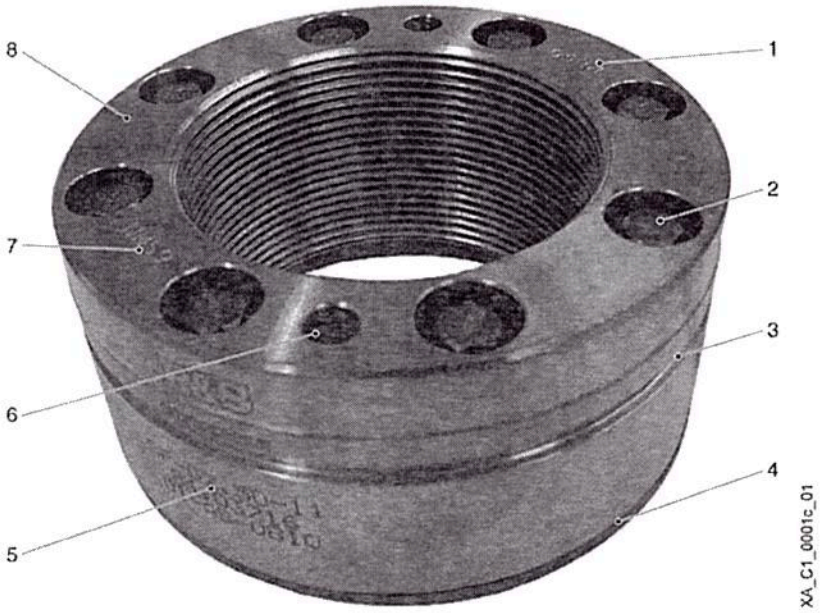


Fig. 8-46 Piston nut SUPERBOLT®

1	Admitted lubricant	5	Size
2	Pressure screw	6	Bore for piston nut wrench
3	Groove for O-ring (used with contaminated gas)	7	Tightening torque with Burckhardt Lubrication Grease BLG05
4	Hardened washer	8	Piston nut SUPERBOLT®

Piston nuts SUPERBOLT® do not loose their preload force even after several years in service providing that they are correctly tightened. Nevertheless, we recommend to check the preload force during each revision. Use a torque wrench adjusted to 100 % of the permitted tightening torque.

Should some pressure screws unexpectedly have lost some of the preload force the following procedure is recommended:

1. Relieve tension of the piston nut slightly by loosening the pressure screws (1/4 turn only) according to following subsection "Loosening Procedure". Thus, the nut remains tensioned.
2. Now tighten according to following subsection "Tightening Procedure", i.e. tighten in circular sequence with full tightening torque, until all pressure screws are tightened.

Preventive Maintenance i.e. removal for maintenance purposes:

1. Relieve according to following section "Loosening Procedure".
2. Treat thread and end of pressure screws with admitted lubricant.
3. A hardened washer may be re-used only once!
   Before re-installing a used hardened washer by turning it over,

- thoroughly deburr the previously used side with a grinding stone
- check the hardened washer for indentations. Eliminate identations by dressing washer with a grinding stone.

4. Tighten again according to following section "Tightening Procedure".

Loosening Procedure

Loosening requires an exact procedure. The pressure screws must be relieved stepwise!

Under no circumstances relieve single screws completely. The remaining screws would have to carry the entire load, which would make it difficult to loosen them. In extreme cases, the pressure screws could jolt and make loosening impossible!

1. Starting with No. 1, loosen every pressure screw in circular sequence maximal 1/4 turn. Do not loosen beyond break loose point. After the first round, pressure screw No. 1 will again be tightened, however, on a lower level of loading.

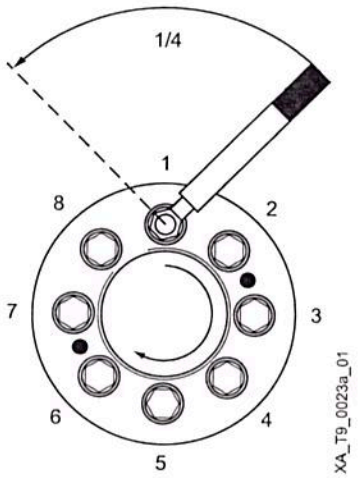


Fig. 8-47 Loosening of pressure screws

2. In a 2nd round, repeat step 1.
3. In a 3rd round, repeat step 1.
4. Relieve pressure screws completely. Now the piston nut can be removed by hand or with the piston nut wrench.

Due to dirt or a pretensioned piston the piston nut can still not be loosened. Use the piston nut wrench carefully to loose the nut.

Follow subsection "Trouble Shooting" in this section before reusing the pressure screws!

Tightening Procedure

Required Tools

- Piston nut wrench
- Torque wrench
- Hexagonal socket
- Extension for sockets
- Square insert for socket
- Lubricant "Burckhardt Lubrication Grease BLG05"

The marked tightening torque is the maximum permitted value. For applicable tightening torques: see section "Compressor" in chapter 13 Appendix.

Preparation

Make sure that:

- pressure screws do not protrude from the bottom of the nut,
- pressure screws are well lubricated.

Procedure

1. Clean main thread and contact areas.
2. Lubricate main thread and contact areas with admitted lubricant.

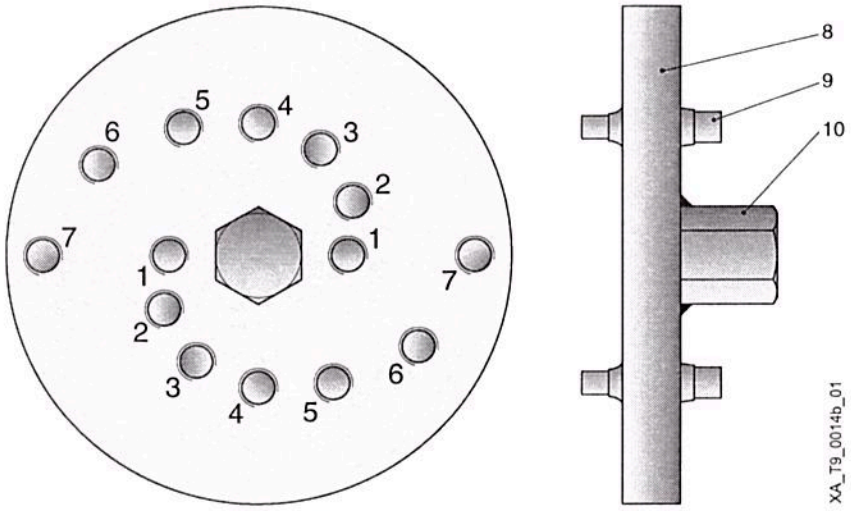


Fig. 8-48 Piston nut wrench for piston nut SUPERBOLT® (position 1–7 = SUPERBOLT® size)

1	G 1"	6	G 2 1/2"
2	G 1 1/4"	7	G 3"
3	G 1 1/2"	8	Piston nut wrench
4	G 1 3/4"	9	Pin (dia. 6 mm/dia. 8 mm)
5	G 2"	10	Hexagon 22 mm

3. If the piston is multi-part, tighten the nut to eliminate the pretension of the piston halves:
4. Screw the pins (9) into the piston nut wrench (8) at the position which corresponds with the SUPERBOLT® size.
   – Pin with diameter 6 mm, up to SUPERBOLT® size G 2"
   – Pin with diameter 8 mm, from SUPERBOLT® size G 2 1/2"
5. Attach piston nut wrench.

6. Tighten the piston nut with the piston nut wrench to a perceptible increasing resistance.

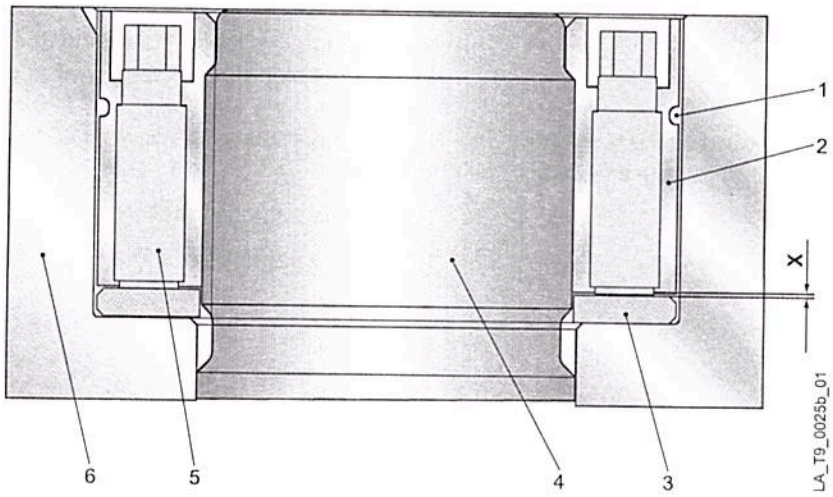


Fig. 8-49 X = Gap approx. 1 mm

1	Groove for O-ring (with contaminated gas)	4	Piston rod
2	Piston nut SUPERBOLT®	5	Pressure screw
3	Hardened washer	6	Piston

7. Afterwards *turn back approx. 1/4 turn*. Depending on the piston size the gap "X" will be approx. 1 mm. If a small piston is used, the 1/4 turn backwards may eliminate the pretension partially or entirely (this does not affect the tightening procedure).

Tightening of Piston Nuts Having 8 Pressure Screws

The tightening must take place gradually:

1. Tighten 4 pressure screws crosswise with 25 % of the recommended tightening torque.
2. Tighten the same 4 pressure screws crosswise with 50 %.
3. Tighten the same 4 pressure screws crosswise with 100 %.

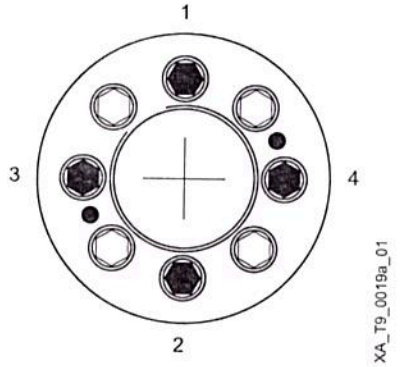


Fig. 8-50 Tighten 4 pressure screws

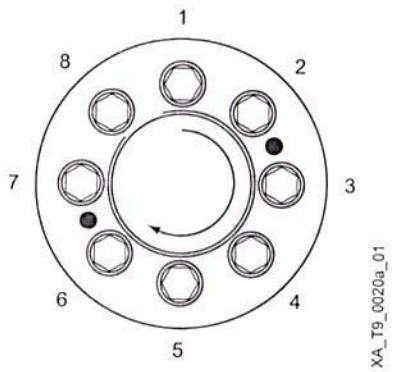


Fig. 8-51 Tighten all pressure screws

4. Tighten the remaining pressure screws crosswise with 50 % of the recommended tightening torque.
5. Repeat step 4 with 100 %.
6. Now change to circular tightening and tighten all pressure screws with 100 % until all pressure screws are equally tightened.

Tightening of Piston Nuts Having 6 Pressure Screws

1. Tighten 3 pressure screws with 25 % of the recommended tightening torque.
2. Tighten the same 3 pressure screws with 50 %.
3. Tighten the same 3 pressure screws crosswise with 100 %.

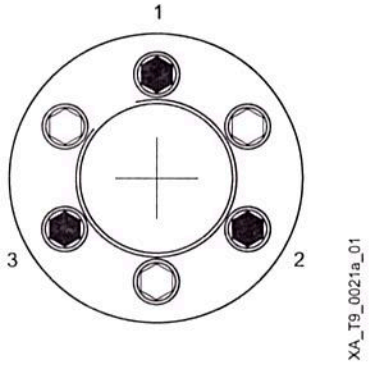


Fig. 8-52 Tighten 3 pressure screws

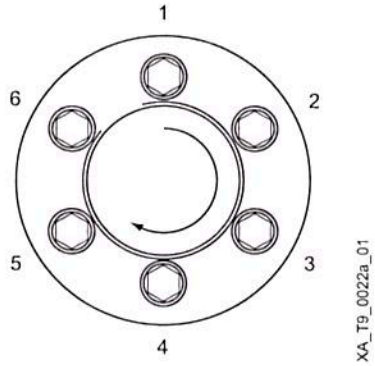


Fig. 8-53 Tighten all pressure screws

4. Tighten the remaining pressure screws with 50 % of the recommended tightening torque.
5. Repeat step 4 with 100 %.
6. Now change to circular tightening and tighten all pressure screws with 100 % until all pressure screws are equally tightened.

Trouble Shooting

Pressure Screws Cannot Be Loosened

1. Remove possible existing dirt from the piston and SUPERBOLT® piston nut.
2. In case of heavy contamination, apply anti seizing or anti corrosion spray to the SUPERBOLT® piston nut and wait approx. 12 hours until this agent has penetrated into the dirt.
3. Try to loosen at least one pressure screw.
4. Turn the loosened pressure screw back as far as possible and apply a lubrication penetrating agent/spray.
5. Tighten this pressure screw with 110 % of the nominal torque
6. The two neighboring pressure screws should loosen.
7. Turn these two pressure screws back as far as possible and apply a lubrication penetrating agent/spray.
8. Retighten these two pressure screws with 110 % of the nominal torque.

9. The next neighboring screws should now loosen.
10. For loosening the rest of the pressure screws proceed in the same manner as mentioned above (paragraphs 4 to 8).
11. For final loosening of all pressure screws proceed according to section "Loosening Procedure".

Hardened Washers Damaged After Multiple Assembly /Disassembly

Exchange against original (OEM) hardened washers SUPERBOLT®.

Pressure Screws Are Damaged or Missing

Exchange against original (OEM) pressure screws SUPERBOLT®.

CAUTION

Do not use commercial screws because they are not suitable for such high loads!

Piston Nut Cannot Be Loosened Manually

Residue caused by dirty process gases can obstruct the nut despite the pressure screws are loosen. Thus, use the piston nut wrench to loose the piston nut carefully.

Other Problems?

Please contact our Technical Service Support (address see section 1.4 Contact Address).

8.10 Suction Valves and Discharge Valves

8.10.1 Valve Maintenance

Since the compressor valves are among the most delicate components of the compressor, they should be inspected every 6000–8000 hours of service at normal conditions i.e. continuous operation.

If the compressor is not running continuously and/or with different gases, the valves must be inspected at shorter intervals.

The intervals must be adjusted according operating experience and/or in cooperation with our specialists.

Some process gases (propylene etc.) tend to polymerize. This may lead to blocked valves.

Valve Service

CAUTION

We strongly recommend having valve overhauls carried out by our specialists on site or in one of our Burckhardt Compression AG licensed Service Centers. We assume no liability for damage caused by inexpert valve overhauls. We also reject liability for wrongly assembled valves, or when non-genuine spare parts are used.

WARNING

Wrongly modified or non-genuine spare parts.

Operational safety may be impaired!

- ⇨ Do neither modify parts nor spare parts.
- ⇨ Do not use unsuitable material.
- ⇨ Do not influence clearances on compressor.
- ⇨ Eliminate troubles immediately.
- ⇨ Exchange worn parts.

Valves can be sent to the nearest Burckhardt Compression AG Service Center to be reconditioned at a competitive price.

Contact Address

Burckhardt Compression AG
Service Center
Sulzer Allee 23
Wareneingang Geb. 501G
CH-8404 Winterthur
Switzerland
www.burckhardtcompression.com
Find your country-specific contact person on the homepage via Contact\Spare Parts and Components

For the address of your nearest Service Center see www.burckhardtcompression.com, “Your Contacts Worldwide”, “Service Centers Worldwide”.

For dismantling and assembling of valves see section 9.7 Suction Valves and Discharge Valves.

8.10.2 Valve Failures (Malfunction)

If uniform service conditions are accompanied by pronounced fluctuations of the interstage pressure, this may indicate broken or clogged valve plates. The temperature fluctuations which follow a broken valve plate may lead to dangerous failures (malfunction) on the compressor. Therefore, defective valve components should be replaced as soon as they occur.

If repeated valve failure (malfunction) occurs, the lift of the valves can be reduced or stronger springs be fitted. Such modifications are only to be carried out with Burckhardt Compression´s consent. Since computer programs can simulate valve behavior at a specific operating point within the operating range, therefore a set of actual readings (temperatures and pressures) is needed in order to determine the necessary modification.

Possible Causes of Valve Failures (Malfunction)

- Dirt in the process gas lines
- Broken valve springs
- Gas pulsations
- Significant change of process conditons

Incorrect valve assembly:

- Loose pressure screws → loose valve lantern (broken valve guard)
- Loose nut of center bolt
- Valve seat of Burckhardt Poppet Valve™ or Burckhardt Plate Valve™ has been re-machined too much → pinhole has not sufficient depth (see section 9.7 Suction Valves and Discharge Valves).
- Valve springs for Burckhardt Plate Valve™ not fitted correctly (see section 9.7 Suction Valves and Discharge Valves).
- Center cuts of metallic valve plate and damper plate for Burckhardt Plate Valve™ plate do not coincide (see section 9.7 Suction Valves and Discharge Valves).

8.10.3 Maintenance of Controlled Suction Valves

To assemble the control mechanism of the controlled suction valves, see section 9.6 Controlled Suction Valve and 9.7 Suction Valves and Discharge Valves.

The clearance "X" (see following illustration) between the tips of the finger unloader and the sealing element must be checked every time before fitting a valve. The fingers of the finger unloader should be adjusted to move freely through the gaps of the valve seat.

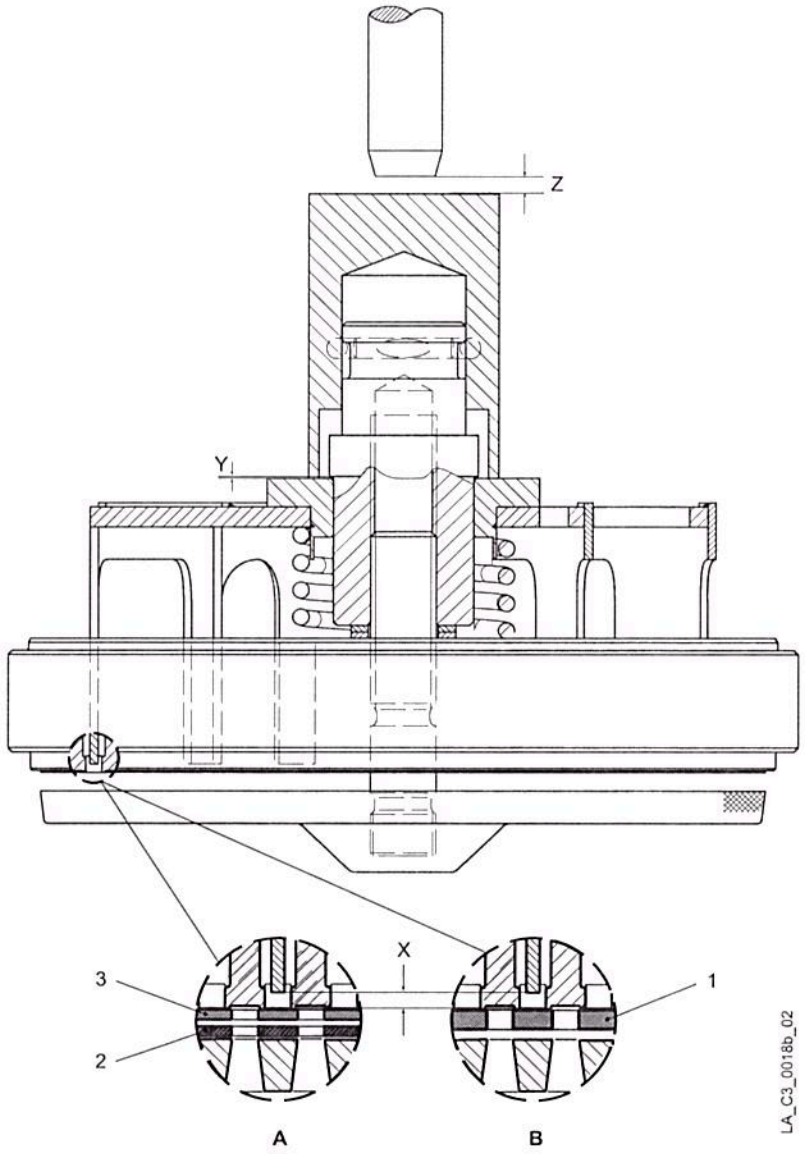


Fig. 8-54 Tolerances and clearances of controlled Burckhardt Plate Valve™ (typical view)

A	Valve with metallic valve plates	X	Clearance
B	Valve with non-metallic valve plates	Y	Clearance
1	Non-metallic valve plate	Z	Clearance
2	Damper plate		
3	Metallic valve plate		

Instructions Regarding Failures (Malfunction) on Controlled Suction Valves

Blocked suction valves on multi-stage compressors are bound to lead to changes in the interstage pressure and hence to dangerous temperature increases and overloading of the properly working stage. All moving valve components are to be given a light application of a process gas compatible grease.

8 Preventive Maintenance

8.1 Importance of Preventive Maintenance

By doing preventive maintenance at regular intervals, these improvements arise:

- increased life time
- prevention of breakdowns and damages
- increased safety for man and machine

We strongly recommend to do all maintenance work under the supervision of a specialist from Burckhardt Compression AG. For damage caused by nonprofessional maintenance, Burckhardt Compression will not assume any liability.

If you have any questions concerning maintenance procedures, please contact your local Burckhardt Compression Office or Burckhardt Compression Agent.

For details visit our website www.burckhardtcompression.com.

Find your nearest Agent or Service Center on www.burckhardtcompression.com/Contact and choose “Service Centers Worldwide” or “Agents Worldwide”.

Contact in Switzerland:

Burckhardt Compression AG
Technical Service Support
Im Link 5
P.O. Box 65
CH-8404 Winterthur
Switzerland
Tel. +41 (0)52 262 55 00 Fax +41 (0)52 262 00 53
www.burckhardtcompression.com

8.2 Prerequisites for Maintenance

Safety Precaution

Process gas may be dangerous. Read the detailed gas description and warnings in section 2.9 Process Gas and Purge Gas.

Condensate of process gas may be aggressive or toxic. Read the detailed gas description and warnings in section 2.9 Process Gas and Purge Gas.

CAUTION

Contamination of process gas!

All components coming in contact with process gas must be checked for cleanliness prior to their installation.

⇨ When performing overhauls or exchanging spare parts, make sure that all significant surfaces have been cleaned according to the cleaning specification prior to assembly or installation.

⇨ If in doubt about cleanliness, repeat cleaning procedure.

Maintenance Guidelines

- Carry out adjustments, preventive and corrective maintenance in due time.
- Regularly check plant components like pressure vessels, coolers, dampers, separators etc. for deposits and corrosion.
- Recondition loose contacts and damaged cables immediately.
- Protect all plant components such as main motor, oil and cooling system pumps, pneumatic or hydraulic control systems etc. against unintended start-up.
- Before beginning any inspection or repair, switch off the power at the switch box and padlock the switch in the OFF position.
- Always comply to local and company safety regulations (e.g. warning sign "Machine under maintenance or overhaul", put up safe work platforms, setting spectacle flange etc.).
- Depressurize and purge the compressor plant (see section 8.2.1 Depressurize and Purge Plant).

Lockout and Tagging of Electric Circuits

DANGER

Unintended start-up of compressor is possible!

⇨ Before beginning any inspection or repair, switch off the power at the switch box and padlock the switch in the OFF position.

The first step before beginning any inspection or repair job, switch off the power at the switch box and padlock the switch in the "OFF" position. This applies even on so-called low-voltage circuits. Securely tagging the switch or controls of the compressor or equipment being locked out of service clarifies to everyone in the area which equipment or circuits are being inspected or repaired. Only qualified electricians who have been trained in safe lockout procedures should maintain electrical equipment.

No two of the locks used should match, and each key should fit just one lock. In addition, one individual lock and key should be issued to each maintenance worker authorized to lock out and tag the equipment. All employees who repair a given piece of equipment should lock out its switch with an individual lock. Only authorized workers should be permitted to remove it.

Do not start work prior to a written confirmation that safety measures have been taken.

Transport and Lifting of Heavy Components

For transport and lifting of heavy components, take care to avoid any damage; please see section 5.2.1 Safety of Transport, for weights see section 5.3 Dimensions, Weights, Space Requirement.

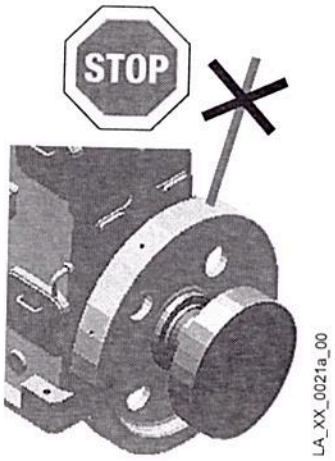
Lubricants, Tightening Torques and Methods

For applicable lubricants, mandatory tightening torques as well as appropriate tightening methods: see sections “Lubricating System” and “Compressor” in chapter 13 Appendix.

Restart Compressor

Perform functional test on protective devices after maintenance.

Turn flywheel of compressor several times by hand – with the bar – in running direction and verify that everything is in proper mechanical condition.



WARNING

Rotating components, drawing in and crush hazard!

Exposed rotating components can cause severe injury or death.

- ⇨ Always remove bar from flywheel after use.
- ⇨ Do not operate the compressor with flywheel guard removed.
- ⇨ Follow lockout procedure before maintenance.

8.2.1 Depressurize and Purge Plant

It is the superior authority's responsibility to ensure safe working conditions.

WARNING

Compressor/plant still pressurized

Severe injuries and damage to equipment can occur if maintenance is started before the compressor and plant are completely depressurized.

⇨ Completely depressurize compressor/plant before starting maintenance work!

⇨ Check relevant pressure indicators for atmospheric pressure on compressor and pipe system.

The corresponding parts of the plant must be completely purged with dry inert gas or nitrogen.

To evacuate the process gas trapped in the compressor, proceed as follows:

1. Close the shut-off valves in the suction and discharge line.
2. Depressurize plant by *slowly* venting gas in the crankgear first, then venting gas in the process gas lines.
   A sudden pressure release in the compressor crankgear would result in excessive oil foaming and thus oil contamination of the compressor distance piece and cylinder spaces.
3. Close vent valves.
4. Close bypass valves (if not already done)
5. Connect an inert gas supply line to the suction side of compressor.
6. Pressurize the plant section between suction and discharge shut-off valves with dry inert gas up to the lowest safeguarded pressure limit within this section, however, not higher than 8 bar g.
7. Stop inert gas supply and *slowly* vent the gas trapped in the crankgear first, then vent gas in the process gas lines.
8. Repeat steps 6 to 8 until the analysis of the vented gas shows that the content of process gas is below the limits set by work rules.

8.2.2 Clean Compressor Plant

Assure cleanliness and tidiness of compressor and surrounding area. Use appropriate cleansing agents and materials. For safe use of cleansing agents see section 10.3 Select Cleansing Agent.

Please take care of the environment!

When using leach, solvents and cleansing agents, observe manufacturer's instructions for use. When working on the compressor, make sure there is sufficient circulation of fresh air.

8.3 Tools

CAUTION

Increased risk!

Damage to the equipment or risk of injury can occur.

- ⇨ Only use original (OEM recommended) tools.
- ⇨ Only use special tools delivered with compressor.
- ⇨ Clean tools after use and store them in a closed and corrosion-resistant cabinet nearby the compressor.

8.3.1 Standard Tools

Txxxxx = code no. for ordering special tools and standard tools.

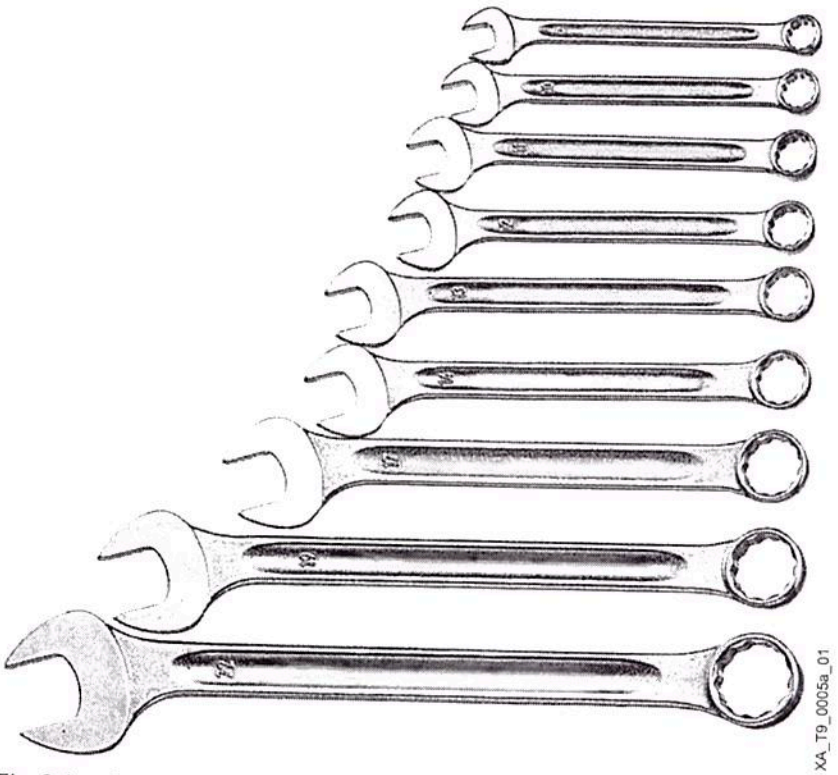


Fig. 8-1 Combination spanners

T96100: Set of combination spanners 17–46 mm

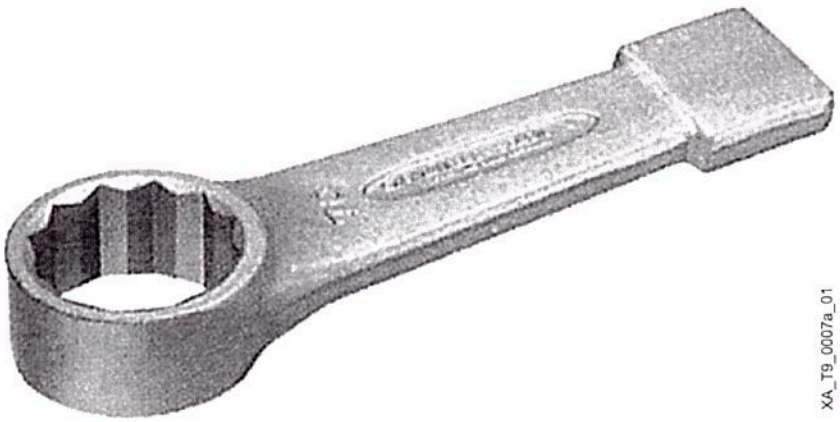


Fig. 8-2 Flogging spanner

T96111: 46 mm
T96112: 55 mm

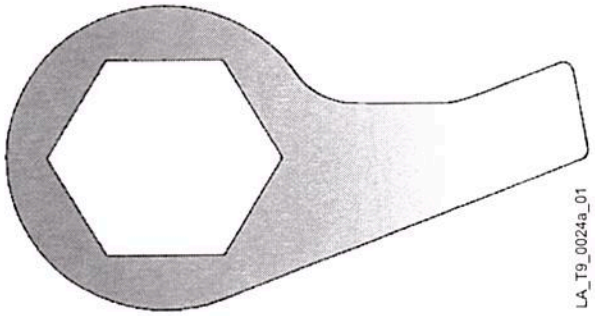


Fig. 8-3 Flogging spanner for crankshaft nut

T97040: 105 mm

Fig. 8-4 Eye bolt

T96061: 2 eye bolts M12
T96062: 2 eye bolts M16
T96063: 2 eye bolts M20
T96064: 2 eye bolts M24

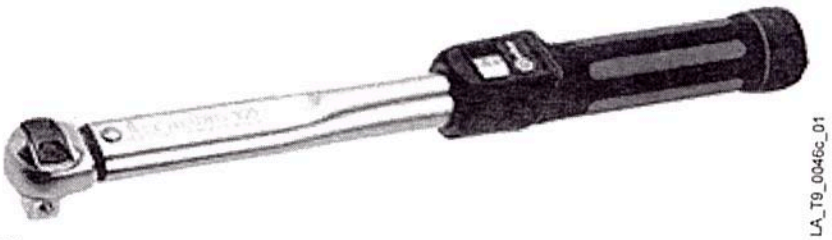


Fig. 8-5 Torque wrench

T96010: 3/8" x 20–100 Nm

Fig. 8-6 Extension for sockets

T96031: 3/8" x 240mm

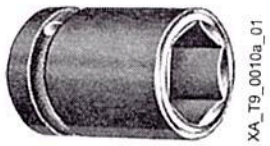


Fig. 8-7 Hexagonal socket

T96021: 1/4" x 7mm
T96022: 3/8" x 13 mm

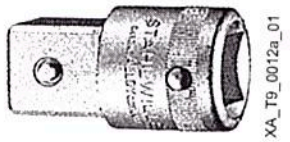


Fig. 8-8 Square insert for socket

T96041: 3/8"–1/4"

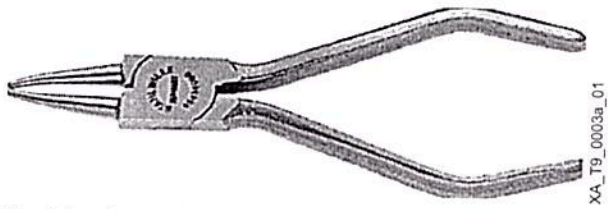


Fig. 8-9 Inner circlip pliers

T96070

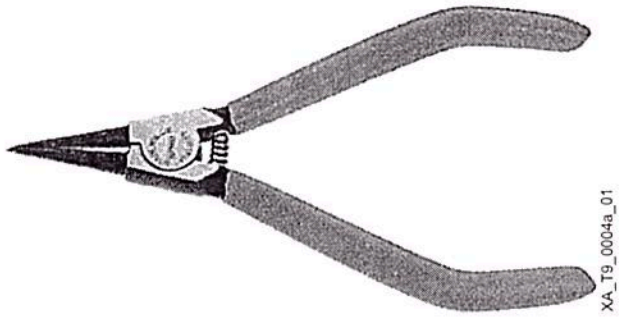


Fig. 8-10 Outer circlip pliers

T96080

8.3.2 Special Tools

Txxxxx = code no. for ordering special tools and standard tools.

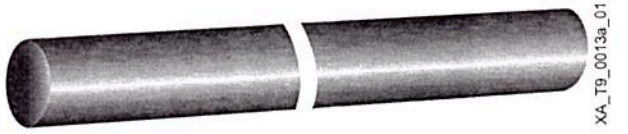


Fig. 8-11 Round bar for turning of flywheel

T97230: Dia. 32 mm x 1050 mm

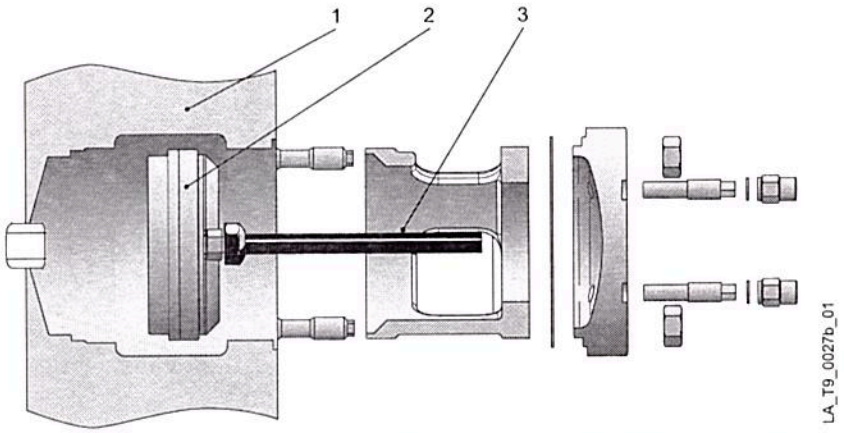


Fig. 8-12 Valve dismantling and assembling device for lightweight valves with pressure screws

1 Cylinder
2 Valve
3 Dismantling and assembling device

T97061: M16

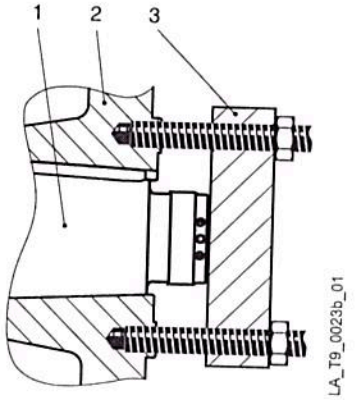


Fig. 8-13 Pull-off device for dismantling of flywheel (complete with threaded rod and nut)

1 Crankshaft
2 Flywheel
3 Pull-off device

T97030

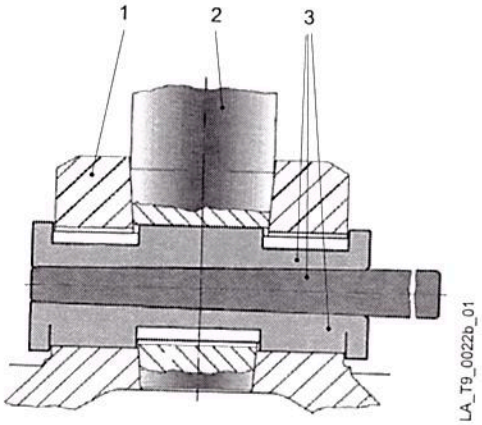


Fig. 8-14 Cotter key in 3 pieces

1 Crosshead
2 Piston rod
3 Cotter key

T97010

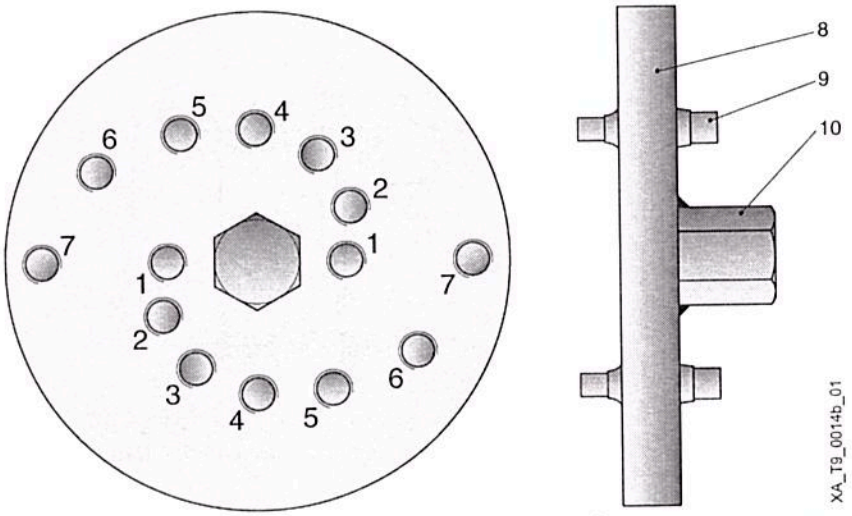


Fig. 8-15 Piston nut wrench for piston nut SUPERBOLT® (position 1–7 = SUPERBOLT® size)

1	G 1"	6	G 2 1/2"
2	G 1 1/4"	7	G 3"
3	G 1 1/2"	8	Piston nut wrench
4	G 1 3/4"	9	Pin (dia. 6 mm/dia. 8 mm)
5	G 2"	10	Hexagon 22 mm

T97364

8.4 Maintenance Schedule

The indications on the following tables serve as general guideline only. The final schedule should be worked out together with our Technical Service Support. We refer to the specific maintenance requirements in this Instruction Manual.