INSTALLATION, OPERATION & MAINTENANCE INSTRUCTIONS

DISCONTINUED MODELS

HD172A HD372A HD373A HD612A HD613A

HDL372A HDL373A HDL612A HDL613A

WARNING

THIS PRODUCT MUST ONLY BE INSTALLED IN SYSTEMS WHICH HAVE BEEN DESIGNED BY THOSE QUALIFIED TO ENGINEER SUCH SYSTEMS. THE SYSTEM MUST BE IN ACCORDANCE WITH ALL APPLICABLE REGULATIONS AND SAFETY CODES AND WARN OF ANY HAZARDS UNIQUE TO THE PARTICULAR SYSTEM.

WARNING DANGER

DO NOT ATTEMPT TO OPEN THE COMPRESSOR UNTIL YOU HAVE BLED OFF ALL PRESSURE. THE COMPRESSOR VALVES MAY HOLD PRESSURE INDEFINITELY IN THE DISCHARGE PIPING

CAUTION:
IF SYSTEM IS TO BE HYDROSTATICALLY TESTED, COMPRESSOR MUST BE ISOLATED. WATER ENTERING THE UNIT CAN CAUSE CORROSION AND DAMAGE.

NOTE NAMEPLATE DATA HERE

MODEL: HD_____

ID#:_____

SERIAL NUMBER:_____

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GENERAL INFORMATION

COMPRESSOR DATA

Double-Seal Mode Triple-Seal Mode	Air Cooled **HD172A**	Air Cooled **HD372A** **HD373A**	Water Cooled **HDL372A** **HDL373A**	Air Cooled **HD612A** **HD613A**	Water Cooled **HDL612A** **HDL613A**
Displacement @ 350 rpm - CFM (m^3/hr) @ 825 rpm - CFM (m^3/hr)	3.57 (6.070 8.42 (14.3)	10.2 (17.3) 26.1 (40.8)		22.9 (38.9) 53.7 (91.2)	
Max. BHP (kw)	10 (7.5)	15 (11)		40 (30)	
MAWP - psia (kPa)	615 (4,241)	615 (4,241)		415 (2,862)	
Max. Discharge Temp.	350°F (176°C)				

NOTE: Reduce maximum speeds by 9% for continuous duty operation.

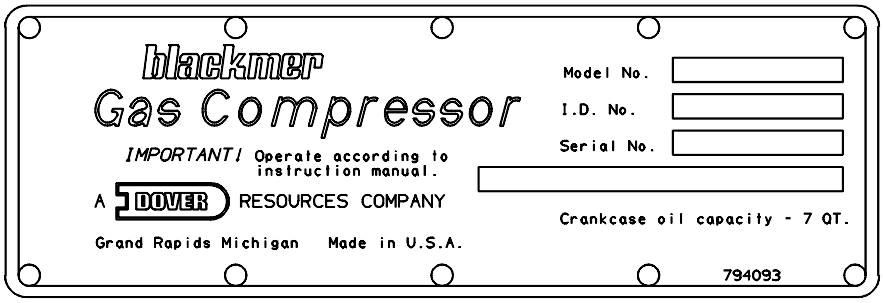
The models listed above are two-stage, vertical, air-cooled or water-cooled reciprocating style compressors with single acting cylinders. Three basic sizes are offered. Double or triple seal arrangements are available.

Before proceeding, you should:

1. Note the nameplate data in the space provided above.
2. Obtain the appropriate parts lists for the model in question.
3. These compressors are used on a wide variety of gasses. **Before doing any work on the compressor, be certain of the identification of the gas and the precautions to be followed when around that gas.**

NAMEPLATE DATA

A nameplate is attached to the side of all Blackmer compressors showing the Model No., I.D. No., and Serial No. These numbers should be available when information or parts are needed for a particular unit.



Model No. Indicates the basic size and type of the compressor. A suffix letter is used on most models to indicate the version.

I.D. No. An 11 character code identifies the construction of the compressor. A key to the I.D. Number is found on the next page.

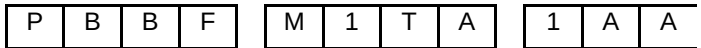
Serial No. 6 digits and a suffix letter indicating the year of manufacture.

Suffix	L	M	N	P	Q	R	S
Year	1991	1992	1993	1994	1995	1996	1997

GENERAL INFORMATION

HD TWO-STAGE COMPRESSORS

ID NUMBER KEY



VALVES	Code	Fields
TNT-12 steel	BE	1 & 2
TNT-12 steel w/ Unloaders	BF	
Ductile Iron / PEEK	PB	
DI/PEEK w/ Unloaders	PC	
TNT-12 DI/PEEK	PE	
TNT-12 DI/PEEK w/ Unloaders	PF	
Stainless Steel	SB	
SS w/ Unloaders	SC	
O-RINGS		Field 3
Buna-N	B	
Neoprene	N	
PTFE	T	
FKM	V	
Ethylene-Propylene	E	
GASKETS		Field 4
Aluminum	A	
Iron	F	
Copper	C	
PISTON RINGS		Field 5
Glass & Moly Filled	M	
Poly Filled PTFE	A	
SEAL (PACKING) ORIENTATION		Field 6
All Lips up	1	
Top Lips Down, Bottom Up Tube to Stage 1 outlet	2	
Top Lips Up, Bottom Down	3	
Top Lips Down, Bottom Up Tube to Stage 2 outlet	4	
Up, Down, Up	5	
Down, Down, Up	6	
Down, Up, Up	7	
SEAL MATERIAL		Field 7
PTFE	T	
CYLINDER & HEAD		Field 8
Ductile Iron	A	
TNT-12 DI Cylinder	B	
TNT-12 DI Cyl. & Head	C	
PISTON RODS		Field 9
Chrome Plated Steel	1	
CrO_2 Coated Steel	3	
Black Surface Steel	4	
CRANKSHAFT & OIL FILTER		Field 10
Standard	A	
Spin-on Oil Filter	C	
OTHER	A	Field 11

Notes: A 'Z' in any field indicates a non-standard option.
No model is available with all shown options.

GENERAL INFORMATION

MAXIMIZING COMPRESSOR LIFE

Life of critical compressor components such as piston rings, valves and packing will vary considerably with each application, installation, and operating procedures. Premature failure of wear parts can often be attributed to one the following causes:

1. **Excessive Temperatures**

   Primary causes are:

   Operating at pressures other than those originally specified.
   Handling a different gas than originally specified.
   Clogged strainer or filter elements.
   Line sizes too small, or other flow restrictions.
   Excessive ambient temperature or suction gas temperature.
   Cooling water temperature too high, or coolant flow too low.
   Valve problems (see Foreign Material below).
   Badly worn piston rings (see Foreign Material below).

   Lower operating temperatures will significantly increase valve and piston ring life.

2. **Foreign Material**

   Solid particles in the gas stream will:

   Rapidly wear the piston rings and score the cylinder wall.
   Destroy the rod packing causing excessive leakage and score the piston rods.
   Lodge in the valves causing loss of capacity and broken valve plates and springs.

   Liquid in the gas stream will:

   Cause broken valve plates and springs.
   Destroy the compressor if present in sufficient quantity.

On new installations, it is suggested that the valves and piston rings be inspected after the first few hundred hours of operation. This will give an early indication of any abnormal problems and allow for corrective action to be taken before a costly failure results. Although piston ring life will vary from application to application, wear will be fairly consistent on subsequent sets of rings.

SUCTION VALVE UNLOADERS

Compressors may be fitted with suction valve unloaders to provide loadless start or capacity control functions. Blackmer unloaders are basically a piston and a plunger atop the suction valve. When pressure is applied to the top of the unloader piston, it and the plunger move downward, pushing the suction valve off its seat and unloading the compressor. When the pressure signal is removed, the unloader spring pushes the piston and plunger back up and the suction valve will resume normal operation.

In order for the unloaders to function, the unloader pressure must be at least 30 psi (207 kpa) above suction pressure.

WATER-COOLED COMPRESSORS

DO NOT OPERATE WATER-COOLED UNITS WITHOUT WATER FLOW!

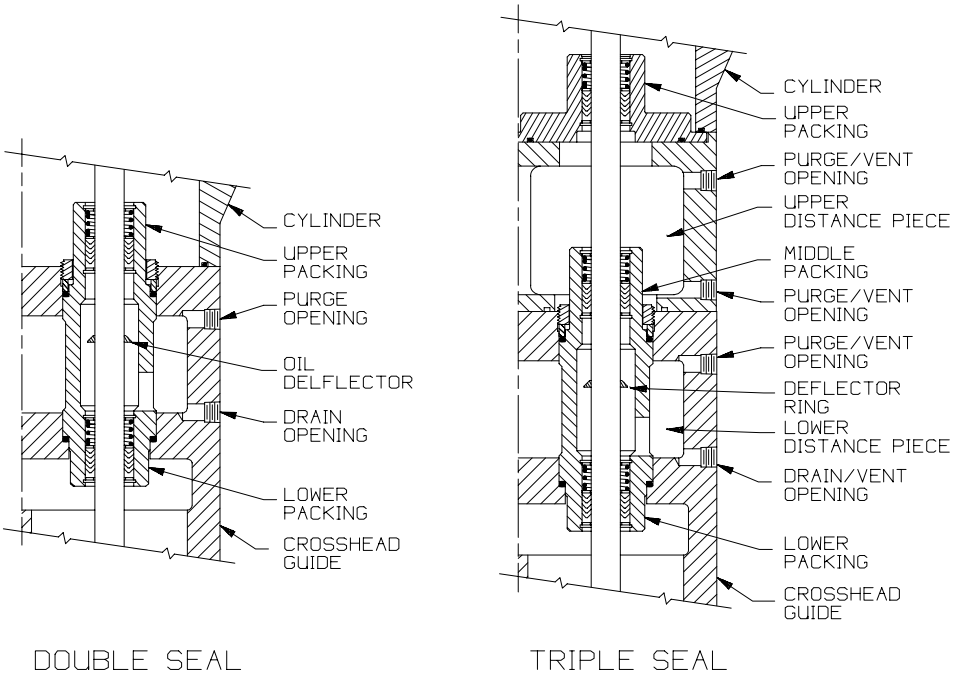
Cooling water should be clean and at not more than 100 psig (690 kpa-g). A flow of 1 gpm (4 lpm) is normally adequate. In general, cooler water temperatures are preferable. However, care must be taken as condensation may occur inside the compressor if the water is too cold. Such condensation can cause corrosion or even destroy the compressor.

NORMAL WATER FLOW PATH: →→→ Intercooler →→→ cylinder →→→ head →→→

SEAL (PACKING) ARRANGEMENTS

Double and Triple Seal models are available to provide a wide range of leakage control/containment options. Before starting work on the compressor, note the seal orientation indicated by the 6th digit of the Compressor ID # shown on the compressor's nameplate. Also note any tubing connections in the seal area. 1/4" NPT ports are provided between each pair of seals to allow proper venting or pressurization of the seal areas (double and triple seal models only).

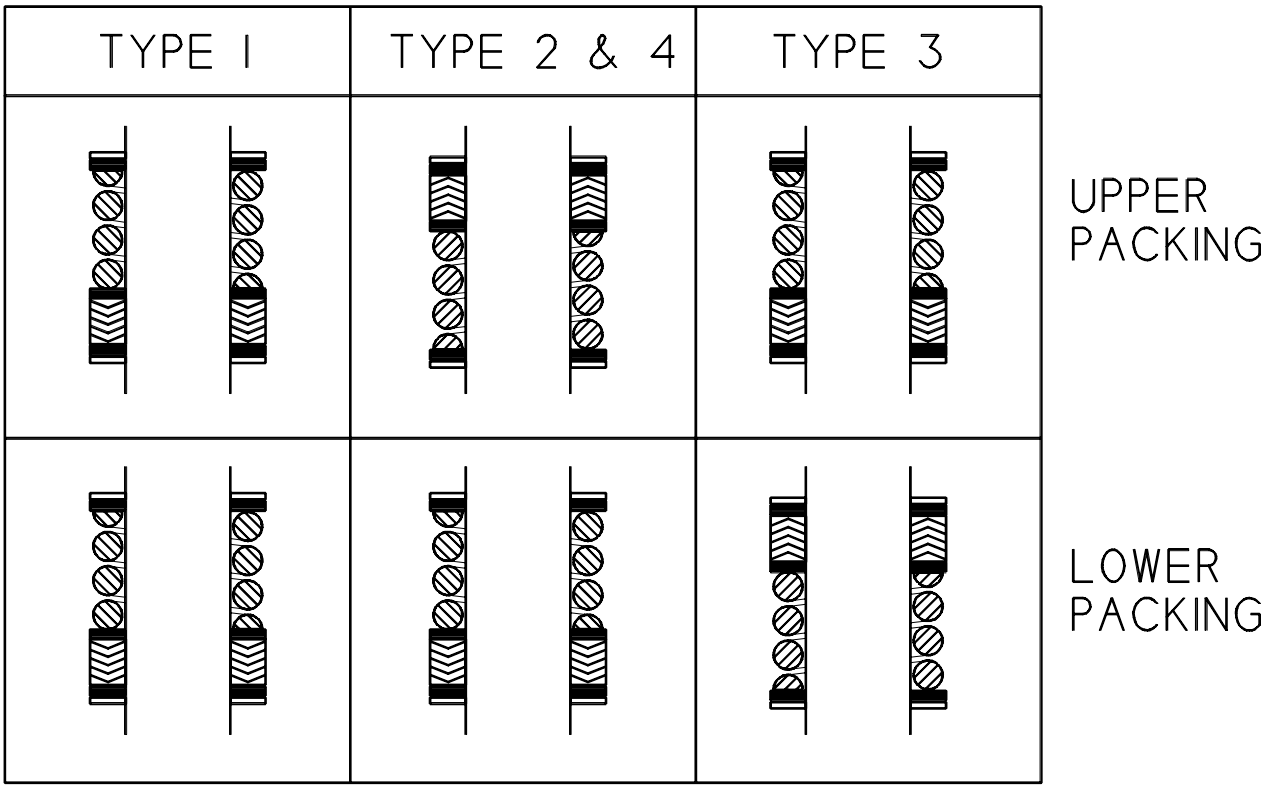
TYPICAL SEAL AREA CONSTRUCTION



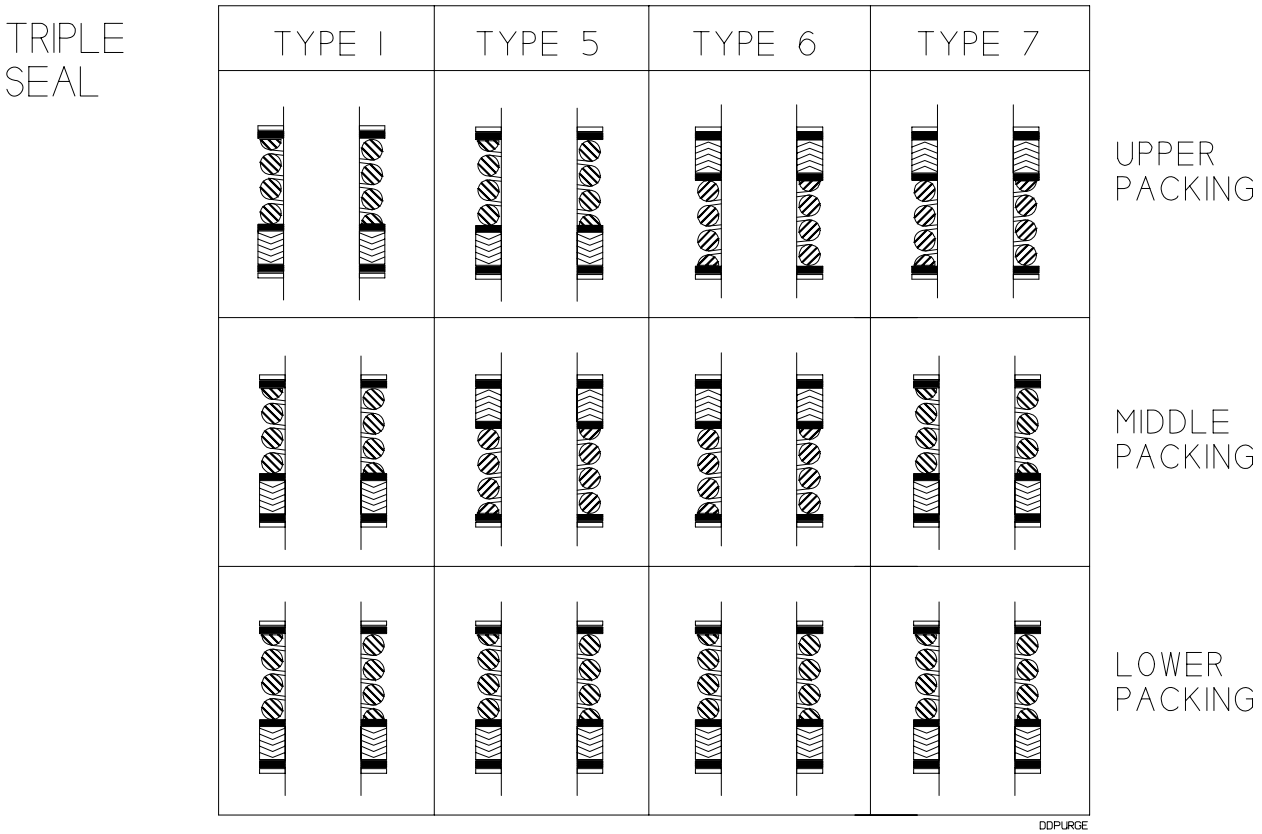
SEAL ARRANGEMENTS - ALL DOUBLE SEAL COMPRESSORS

Type	1	2		4	3
Inlet Pressure	Atmospheric Pressure or above	Vacuum to 25 psia		Under 5 psia	Special
Service	General Gas Transfer	Toxic, Flammable or otherwise Hazardous Gases		General Gas Transfer	
Upper Distance Piece Connections	Plugged	Purge with Inert gas below suction pressure and above atmospheric pressure, or Vent to a safe location	Pressurize or Purge with an Inert gas above suction pressure and above atmospheric pressure	Connect to: 1st-Stage Discharge	Tube to: 2nd-Stage Discharge
Lower	Install drain valve. Drain accumulated condensate or oil weekly.				
Ref. Notes:	a	b		A	c

NOTES:
a. Standard Configuration - use when no purge gas is available, or when mixing of the purge gas with the product stream is not desirable.
b. Use when no external product leakage is desirable.
Note: Mixing of inert pressurization gas and the product stream is likely to occur.
c. Consult Factory.



SEAL ORIENTATION - DOUBLE SEAL COMPRESSORS



SEAL ORIENTATION - ALL TRIPLE SEAL COMPRESSORS

OPTIONAL COMPONENTS

RELIEF VALVES

If a relief valve is not installed by the factory or the purchaser, **one must be installed prior to compressor startup**. The relief valve should be installed in the discharge line between the compressor head and the first block valve.

The type of relief valve should be appropriate to the application. Blackmer offers three relief valves for gas compatibility: brass for LP-Gas service; aluminum for anhydrous ammonia; A.S.M.E. steel for both services, and other applications.

The relief valve must be of a type, material and pressure rating suitable to the installation.

LIQUID TRAPS

Compressors handling gasses that contain condensates or other liquids must be protected from entry of the liquid. LIQUID IN A COMPRESSOR CYLINDER CAN CAUSE DESTRUCTION OF THE COMPRESSOR.

A liquid trap may be required at the 2nd stage inlet as well as at the compressor suction. If used, a 2nd stage inlet liquid trap would be located after the intercooler.

Blackmer offers a variety of liquid traps. The most common variations include:

1. A non-code vessel fitted with a stainless steel float which will shut off the intake line to the compressor in the event of an excessive liquid level. A vacuum breaking valve is provided on the liquid trap head in case the trap closes and a vacuum develops between the compressor and the trap. A 1/4" manual drain valve is provided.
2. The above trap is fitted with an additional port allowing for the use of an optional electric float switch which provides protection to the compressor by stopping the compressor when a high liquid level is present in the liquid trap. The electric float switch may be used with or without the mechanical float described above.
3. For additional protection, a larger ASME code stamped vessel is available. This liquid trap is typically fitted with two electric float switches for both a high liquid level alarm and shut down signal, a relief valve, and a 1" manual drain valve. Level gauges and automatic drain systems are available options.

TEMPERATURE SWITCHES

Temperature switches are highly recommended as high discharge temperature is a leading cause of premature component failure and is often an early warning sign of impending problems.

Temperature switches should be installed with a thermowell as close to the compressor discharge as possible. They should be set to actuate at a temperature just above the normal maximum operating temperature of the compressor.

LOW OIL PRESSURE SWITCHES

Loss of crankcase oil pressure is a rare occurrence, but can result in costly damage. A low oil pressure switch set at about 15 psig (1 bar-g) may be installed to stop the compressor in the event of a lubrication failure. A 10 second delay timer should be used to lock the low oil pressure switch out during compressor startup.

PRESSURE SWITCHES

Pressure switches may be installed in the suction, interstage or discharge gas stream as protective devices or for compressor control. They may be used to stop or start the compressor, or to control the suction valve unloaders. Their use will vary with each application.

INSTALLATION

LOCATION AND PIPING

Compressor life and performance can be significantly reduced when installed in an improperly designed system. Before starting layout and installation of the piping system, consider the following suggestions:

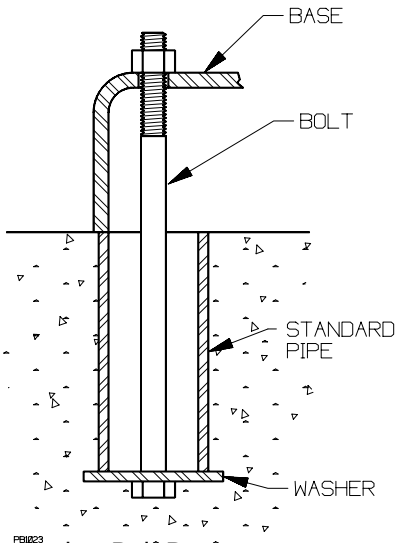
1. A strainer should be installed in the inlet line to protect the compressor from foreign matter. A #30 mesh screen or finer is recommended. Strainers must be cleaned regularly-once every 180 days, or more frequently if the system requires.
2. All piping must be leak free to a pressure of 1.5 times the maximum system pressure.
3. Expansion joints, placed within 36" (0.9 m) of the compressor, will compensate for expansion and contraction of the pipes.
4. Piping must be well supported so that it does not spring away or drop down when flanges or union joints are disconnected.
5. Both suction and discharge piping should slope down from the compressor. The compressor should not be placed at a low point in the piping system.

MOUNTING THE COMPRESSOR UNIT

A solid foundation reduces noise and vibration, and will improve compressor performance. On permanent installations it is recommended the compressor be secured by anchor bolts as shown. This arrangement allows for slight shifting of position to accommodate alignment with the mounting holes in the base plate.

For new foundations, it is suggested that the anchor bolts be set in concrete. When compressors are to be located on existing concrete floors, holes should be drilled into the concrete to hold the anchor bolts.

NOTE: To keep vibration at a minimum, in addition to a solid concrete foundation it is important that the concrete be located on a stable soil foundation. The base should have complete contact along its entire length with the foundation. Visible separations can result in vibrations which are magnified in the upper part of the unit.



Pipe Type Anchor Bolt-Box

OPERATION

PRE-STARTUP CHECK LIST

1. After the compressor is installed in the system, a complete leak test should be performed on both the compressor and the piping.
2. Check the alignment of the pipes to the compressor. Pipes should be supported so that they do not spring away or drop down when flanges or union joints are disconnected.
3. If V-belt driven, check the alignment of the motor and the compressor sheaves. The faces of the sheaves must be parallel.
4. It is recommended that pressure gauges be installed in the discharge and inlet lines. These can be used to check actual suction and discharge conditions after startup.
5. Check the electrical connections for proper wiring, grounding, etc.
6. Blackmer compressors are shipped from the factory without oil in the crankcase. Fill with a high quality oil of the proper viscosity (see "Lubrication").
7. Disconnect the power and remove the nameplate. Squirt oil onto the crosshead guide bores and rotate the compressor by hand to verify smooth operation.
8. Ensure that all guards in properly in place.

OPERATION

STARTUP PROCEDURE

1. Start the compressor for a couple of second to verify proper rotation direction. See the section "Rotation".
2. Start the compressor and check for oil pressure within 30 seconds. The pressure should register 25 psig (172 kPa). Adjust if necessary (see "Lubrication"). **If proper oil pressure is not present, stop the compressor and correct the problem.** Operating the compressor with low oil pressure will cause severe damage to the unit.
3. Verify the suction and discharge pressures and ensure that all readings are within the expected ranges. Operating limits listed in the "Compressor Data" section must not be exceeded
4. Check for leakage from the piping and equipment.
5. If the seals (packing) have just been replaced, the lower seal must be manually lubricated during the first 60 minutes of operation. See "Packing Lubrication" section. New compressors have had the packing broken in at the factory.
6. On newly rebuilt units, the valve holddown screws, valve cover plate bolts and cylinder head bolts should all be retightened after 60 minutes running time. Also retighten all holddown bolts, flywheel bolts, etc. after 60 minutes running time.

MAINTENANCE

MAINTENANCE AND TROUBLESHOOTING MUST BE DONE BY AN INDIVIDUAL EXPERIENCED WITH COMPRESSOR MAINTENANCE AND THE TYPE OF SYSTEM INVOLVED.

CAUTION: Before work is started on the compressor make sure all pressure is bled off on both the suction and discharge.

NOTE: When servicing the compressor, refer to the appropriate Parts Lists for detailed exploded views of the compressor parts.

ROUTINE SERVICE SCHEDULE

	Daily	Weekly	Monthly	6 Months	Yearly
Overall Visual Check	X				
Check Crankcase Oil Pressure	X				
Check Suction Pressure	X				
Check Discharge Pressure	X				
Drain Distance Piece		X			
Drain Liquid From Accumulation Points		X			
Clean Compressor Cooling Fins		X			
Clean Compressor Intercooler Fins		X			
Check Crankcase Oil Level *			X*		
Check V-Belt Tension			X		
Change Oil * (and Optional External Oil Filter)				X*	
Check Inlet Filter/Strainer Element				X	
Inspect Valves				X	
Lubricate Motor Bearings per Manufacturers Suggestions				X	
Inspect Motor Starter Contact Points					X

* Change oil every 1,000 hours of operation (2,000 hours with optional external oil filter), or every 6 months which ever occurs first. If the oil becomes unusually dirty, change oil and external filter as often as needed to maintain clean oil.

MAINTENANCE

TOOL LIST

Description	Used For:
Blackmer Packing Installation Tool 790536 for 170, & 370 series 790538 for 600 series compressors	Rod-packing protection during installation.
Blackmer Wrench 790535	Valve Hold-down screw
3" Adjustable Spanner with 1/4" pins (like Blackmer PN 790316)	Piston Nut, Piston, Packing Box Hold-down Ring
9/16, 5/8 or 3/4" End Wrench	Cylinder and Crosshead Guide
1-1/16" Wrench or Socket	Valve Caps
3/16" Allen Wrench	
7/16", 1/2", 9/16", 3/4", 5/8", 3/4", 7/8" & 1-3/8" Sockets	Various
Internal Snap Ring Pliers	Seal Replacement
Feeler gauges or Depth Micrometer	Piston Clearance
Screwdriver, Flat Blade	Nameplate screws, Packing Installation
Pliers	
Rubber Mallet	
Arbor Press	Wrist Pin Removal
Bearing Puller	Crankshaft Bearings
Torque Wrench, 0 to 45 ft-lb range	Various
Hoist (useful)	Cylinder and Crosshead Guide

BOLT TORQUES

Proper bolt torques to use when reassembling the compressor.

BOLT TORQUE FOR BLACKMER COMPRESSORS FT-LBS (Nm)

Size	Con. Rod Bolt	Bearing Carrier	Bearing Cover Plate	Crank Case Inspec. Plate	Cross Head Guide	Cylinder	Head	Valve Assy. Nut	Valve Cover Plate	Valve Hold Down Screw	Valve Cap	Packing Box Hold Down Ring
170	30 (40.7)	30 (40.7)	30 (40.7)	7 (9.5)	25 (33.9)	25 (33.9)	20 (27.1)			120 (163)	80 (108)	75 (102)
370	35 (47.5)	30 (40.7)	35 (47.5)	7 (9.5)	35 (47.5)	35 (47.5)	40 (54.2)	10 (13.6)	35 (47.5)	120 (163)	80 (108)	75 (102)
610	45 (61.0)	30 (40.7)	40 (54.2)	7 (9.5)	40 (54.2)	40 (54.2)	40 (54.2)	10 (13.6)	35 (47.5)	120 (163)	80 (108)	--

MAINTENANCE

CRANKCASE LUBRICATION

Non-detergent motor oils are recommended. However, detergent oils can be used providing the gas being handled does not react with the detergent in the oil. If using a detergent oil, be sure there is not a compatibility problem. The following gasses are known to react with detergents in oil:

Ammonia - Monoethylamine - Monomethylamine - Dimethylamine - Trimethylamine

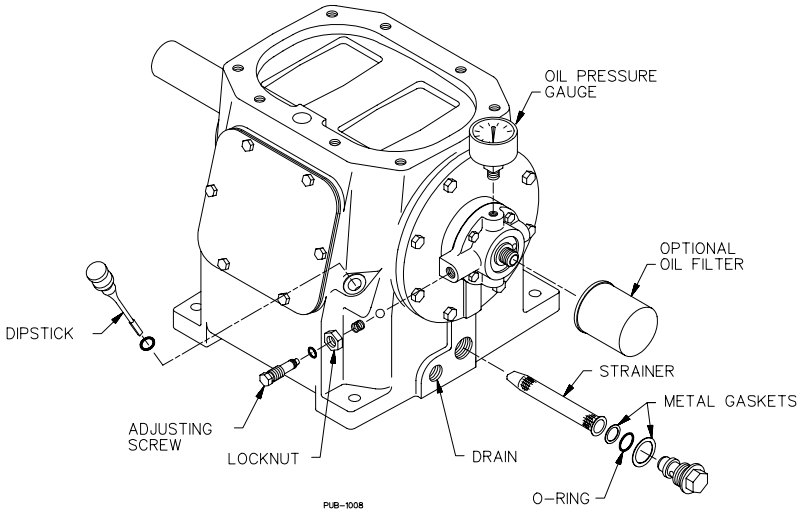
The oil used, detergent or non-detergent, should be of high quality such as API grade SF, SG, SH or similar. API grade SA, SB, SC or similar oils should never be used. Recycled oils should never be used.

The oil in the crankcase should be changed every 1,000 hours or 180 days, whichever is shorter. Under severe dusty or sandy operating conditions, the oil should be changed every 500 hours or every 90 days. NOTE: When equipped with a spin-on oil filter, intervals between oil changes may double (not to exceed 180 days).

Air Temperature	Oil Viscosity
Below 0°F (-18°C)	SAE 5W
0 to 32°F (-18 to 0°C)	SAE 10W
32 to 80°F (0 to 27°C)	SAE 20W
80°F (27°C) and above	SAE 30W

OIL CAPACITY	
Series	# Quarts
170A	2
370A	3
610A	6

To change the oil, drain the crankcase then clean the oil pickup screen in a suitable solvent. When reinstalling the pickup screen, inspect the metal gasket and the O-ring for damage. Replace if necessary. If supplied, the external oil filter should also be replaced. Refill the crankcase via the dipstick opening.



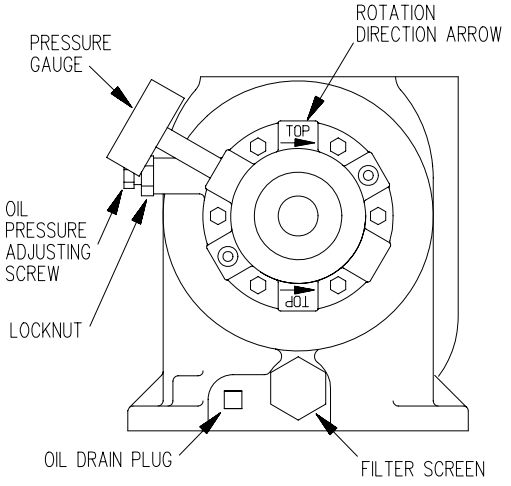
SETTING THE OIL PRESSURE: The oil pressure should be about 25 psig.

1. Loosen the locknut.
2. Turn the adjusting screw inward (clockwise) to increase the pressure setting or outward (counterclockwise) to decrease the pressure setting.
3. Retighten the locknut.

ROTATION

The compressor rotation direction is indicated by the upper arrow (12 o'clock position) located on the face of the oil pump cover.

To reverse the rotation of the compressor, remove the capscrews in the oil pump cover and rotate the cover 180 degrees. In this position, the upper arrow on the oil pump cover will indicate rotation in the opposite direction. **NOTE:** The oil pump pressure gauge must also be removed and reinstalled in the upper gauge port.



MAINTENANCE

COMPRESSOR DISASSEMBLY

CAUTION: Before work is started on the compressor make sure all pressure is bled off on both the suction and discharge.

1. Remove the flange bolts connecting the intercooler to the cylinder head.
2. Disconnect the return tube and fitting. Disconnect water tubing on water-cooled models.
3. Remove the center head capscrews from the cylinder head. Remove the outer cylinder head capscrews.
4. The cylinder head assembly and cylinder head O-rings can now be removed from the cylinder. The suction and discharge valve assemblies will come off with the cylinder head. For valve disassembly instructions refer to "Valve Replacement."
5. Removal of the piston requires a 3" adjustable spanner wrench with 1/4" pins (such as Blackmer PN 790316)
   a. Rotate the flywheel by hand to bring a piston to top dead center of the cylinder.
   b. Remove the piston nut by rotating the nut counterclockwise. (Note the nylon locking insert in the piston nut. This insert must be replaced during reassembly.)
   c. To remove the piston from the cylinder, rotate it counterclockwise with the use of the adjustable spanner wrench. For removal and replacement of the piston rings, refer to "Piston Ring Replacement."
   d. Remove the thrust washer and any shims. (Keep shims and piston together.)
   e. Repeat these steps for the other piston.
6. Remove the cylinder capscrews.
7. The cylinder and cylinder O-rings can then be lifted from the crosshead guide (or distance piece).
8. (Triple-seal models only) Lift the upper packing box assemblies and O-rings off the piston rods.
9. (Triple-seal models only) Remove the upper distance piece capscrews and lift the upper distance piece and O-rings off the crosshead guide.
10. Using an adjustable spanner wrench, loosen and remove the packing box retaining rings and spacer rings. The packing boxes can then be removed from the piston rods. The upper packing box O-rings will slide off with the packing boxes. For disassembly of the packing boxes, refer to "Packing Replacement."
11. After removing the packing boxes, remove the lower packing box O-rings from the crosshead guide.
12. Remove the crosshead guide capscrews, and lift the crosshead guide and gasket from the crankcase.
13. To remove the connecting rod assemblies (with the crossheads attached) it may be necessary to drain the oil from the crankcase. **NOTE:** The piston rod is permanently attached to the crosshead to form a single assembly. Do not attempt disassembly.
    a. Remove the inspection plate from the crankcase.
    b. Remove the locknuts from the connecting rod bolts. This will release the connecting rod cap (the lower half of the connecting rod) and the two halves of the bearing insert. **NOTE:** The connecting rod and the connecting rod cap are marked with a dot on one side so that they can be matched properly when reassembling.
    c. Lift the crosshead assembly and connecting rod off the top of the crankcase.
       NOTE: The connecting rod parts are not interchangeable and must be reassembled with the same upper and lower halves. To avoid confusion, it is advisable to work on one connecting rod at a time, or to mark the individual halves with corresponding numbers.
14. Remove the opposite connecting rod and crosshead assembly in the same manner as outlined in step 13.
15. Rest the crosshead assembly on a bench. Carefully drive the wrist pin and wrist pin plugs out of the crosshead and connecting rod using a suitable pin driver or an arbor press. Removal of the pin releases the crosshead assembly from the connecting rod.
16. If necessary, the wrist pin bushings can be replaced after the crossheads are removed. Connecting Rods with new brass bushings must be honed to the proper size after installation.
    Inner Dimensions: 0.8753" to 0.8756" (22.233 mm to 22.240 mm).
17. To replace the crankshaft bearings, the crankcase must be disassembled, and the crankshaft removed. Refer to "Bearing Replacement" for disassembly instructions.

MAINTENANCE

COMPRESSOR ASSEMBLY

Compressor assembly is generally the opposite of compressor disassembly. Before reassembling, clean each part thoroughly. Check all machined surfaces for burrs or roughness, and file lightly if necessary.

NOTE: If any of the O-rings or gaskets are removed or disturbed during service, it is recommended they be replaced with new.

1. **CRANKCASE ASSEMBLY**
   After replacing the crankshaft, bearing carrier, and bearing cover plate (see "Bearing Replacement"), the connecting rod and crosshead can be installed.
   a. To attach the connecting rod to the crosshead assembly, first coat the wrist pin, the wrist pin bore in the crosshead assembly, and the wrist pin bushing in the connecting rod with grease.
   b. Start the wrist pin in the bore of the crosshead assembly and tap lightly until the pin begins to project through to the inside of the crosshead assembly.
   c. Slide the connecting rod up inside of the crosshead assembly and align the bushing with the wrist pin.
   d. Lightly tap the wrist pin through the connecting rod until it is centered in the crosshead assembly. NOTE: The wrist pin should be snug in the crosshead assembly. The connecting rod should rotate freely on the wrist pin, but should not be loose.
   e. Dip the wrist pin plugs in grease and press them in place.
   f. Place the bearing halves into each half of the connecting rod, aligning the bearing tangs with the slots in the connecting rod. Coat the bearing with grease.
   g. Set the top of the connecting rod over the crankshaft journal. Replace the connecting rod cap, remembering that the dots on the connecting rod and cap must be on the same side.
   h. Start the nuts on the connecting rod bolts and torque per the Bolt Torque Table.
   i. Follow this same procedure for the opposite connecting rod.

2. **CROSSHEAD GUIDE**
   a. Place the crosshead guide gasket on top of the crankcase.
   b. Lubricate the inside bore of the crosshead guide with light oil.
   c. Set the crosshead guide over the piston rods and the crossheads, and slowly lower it against the crankcase. Make certain that the crosshead assemblies are started straight in the bores of the crosshead guide to prevent binding when lowering the crosshead guide into position.
   d. Install the crosshead guide capscrews **loosely**.

3. Fill the crankcase with oil. See "Lubrication" for proper amount. Squirt oil into the crankshaft, roller bearings, crankshaft journals, and crosshead assemblies so they will have lubrication at start up.

4. Attach the inspection plate and the inspection plate gasket to the crankcase.

5. **PACKING BOX ASSEMBLIES**
   Before installing the packing boxes into the crosshead guide, inspect the piston rods for scoring or roughness. Remove any burrs or sharp edges. Lubricate the piston rods and packing box O-rings with light oil. **Do not damage the packing when starting it over the rod. Use of a Blackmer packing installation tool is recommended.**

   a. Place the packing installation cone (if available) on the top of the piston rod.
   a. Insert the lower packing box O-ring into the crosshead guide.
   b. Start the packing box assembly, short end down, over the piston rod.
   c. After the lower set of packing is started over the piston rod, make sure the oil deflector ring is properly aligned (with the flat side down) over the piston rod. Use the hole in the side of the packing box to center the deflector ring. Once the deflector ring is over the rod, the packing box can be fully inserted.
   d. Install the upper packing box O-ring on the end of the packing box.
   e. Place the packing box spacer ring over the O-ring.
   f. Install the packing box retainer ring with new nylon locking inserts, and tighten.
   g. Remove the packing installation cone, if used.
   h. Repeat the above steps for the remaining packing box.

   The following applies to Triple-Seal Models only.
   i. Install new O-rings in the bottom of the upper distance piece. A small amount of grease may be used to hold the O-rings in place during assembly.

j. Set the upper distance piece over the piston rods and against the crosshead guide, **loosely** install upper distance piece capscrews.
k. Install each upper packing box O-ring over the piston rods.
l. Install each upper packing box over the piston rods. (Use the packing installation cone if available.)

6. Rotate the crankshaft by hand a few times, then uniformly tighten the crosshead guide capscrews (and upper distance piece capscrews on triple-seal models) per the Bolt Torque Table.

7. **New packing must be broken in.** Refer to the end of "Seal Replacement".

8. **CYLINDER ASSEMBLY**
   a. Install new O-rings in the bottom of the cylinder. A small amount of grease may be used to hold the O-rings in place during assembly.
   b. Set the cylinder over the piston rods and against the crosshead guide.
   c. **Loosely** install the cylinder capscrews.

9. Rotate the flywheel by hand to ensure the compressor turns freely.

10. **PISTONS**
    a. If necessary, replace the piston rings and piston ring expanders (see "Piston Ring Replacement").
    b. Rotate the flywheel by hand to bring one piston rod to top dead center of the cylinder assembly.
    c. Set one thrust washer and one shim down against the shoulder of the piston rod.
    d. Squeeze the piston rings inward, with light pressure, while threading the piston clockwise onto the rod. Tighten with the 3" adjustable spanner wrench.
    e. Follow this same procedure for the second piston.
    f. Rotate the compressor by hand a number of times to verify that the pistons are centered in the cylinder bores. The pistons must not touch the cylinder walls. If necessary, adjust the cylinder.
    g. Tighten the cylinder capscrews per the Bolt Torque Table in an alternating pattern.
    h. It is important that the proper number of shims be installed under the piston. To check, rotate the flywheel by hand to bring one piston to the top.
       1. Measure the distance from the top of the piston to the top of the cylinder.

HD172	.015" to .010" (.381 to 762 mm)		
HD372 HDL372	.025" to .040" (.635 to 1.016 mm)	HD612 HDL612	.030" to .045" (.762 to 1.143 mm)
HD373 HDL373	.050" to .065" (1.270 to 1.651 mm)	HD613 HDL613	.060" to .075" (1.524 to 1.905 mm)

       2. If necessary, remove the piston and add or subtract shims accordingly.
       3. Follow this same procedure for the second piston.
    i. Replace the nylon locking inserts in the piston retainer nuts.
    j. Thread the piston nuts onto the piston rods and tighten with the spanner wrench.

11. **CYLINDER HEAD ASSEMBLY**
    If the valve assemblies have been removed from the cylinder head, it is easiest to reinstall them before attaching the cylinder head to the cylinder assembly. Refer to "Valve Replacement" for instructions.
    a. Place the cylinder head O-rings in the grooves located on top of the cylinder.
    b. Place the cylinder head assembly on top of the cylinder.
    c. Hand tighten the outer capscrews and center capscrews into the cylinder head.
    d. Uniformly torque the cylinder head capscrews according to the Bolt Torque Table.

12. Rotate the compressor by hand to verify that it turns freely. Make sure the pistons are not hitting against the bottom of the cylinder head assembly.

13. Install the intercooler and shroud or water tubing assemblies. Torque the intercooler flange capscrews to 20 FT-LBS (27 Nm).

14. Attach the return tube and fittings to the cylinder and cylinder head. (Reconnect water tubing.)

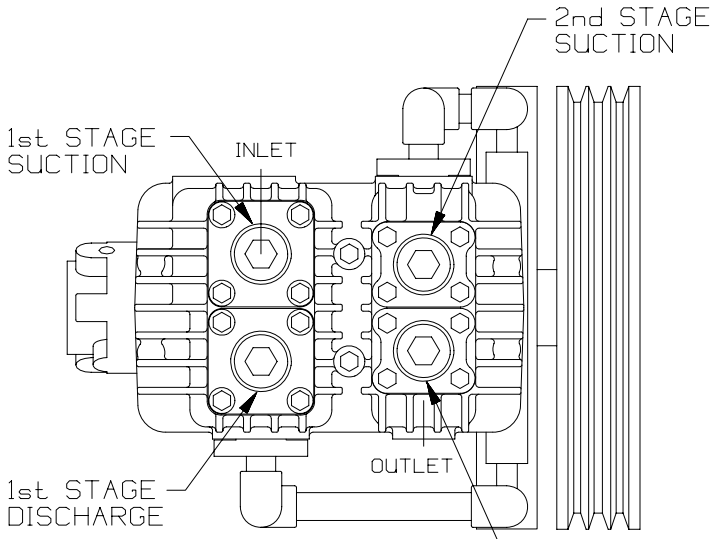
15. Refer to the "Pre-Startup Check List", and "Startup Procedure".

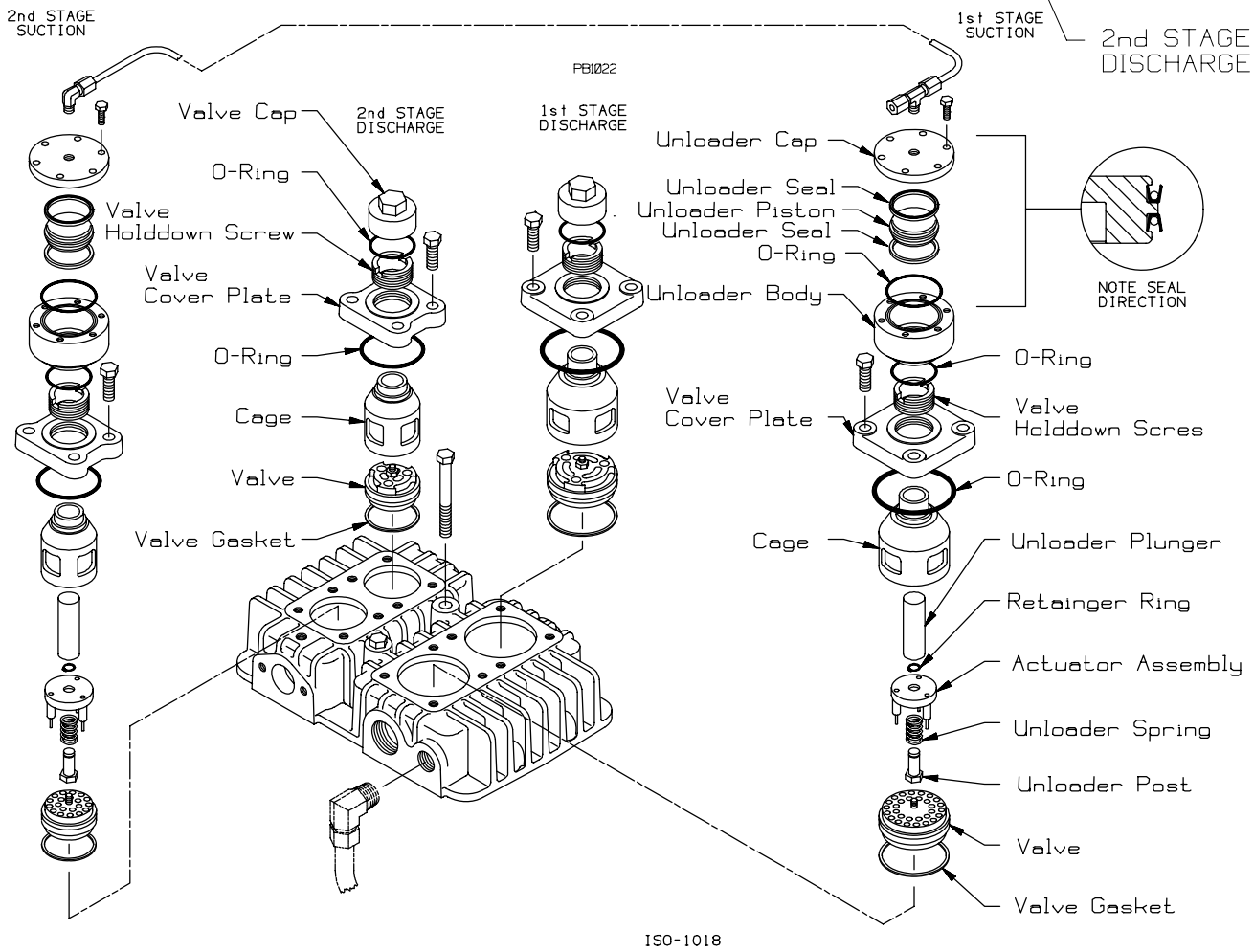
16. After the compressor has been run for a sufficient enough time to reach operating temperature, allow to cool and retighten the valve hold down screws.

MAINTENANCE

VALVE REPLACEMENT

When replacing the valves, it is important to install the suction and discharge valves in the correct location in the cylinder head.
NOTE: The valves may be removed without removing the cylinder head from the cylinder. Be sure to remove and replace the valve gaskets.



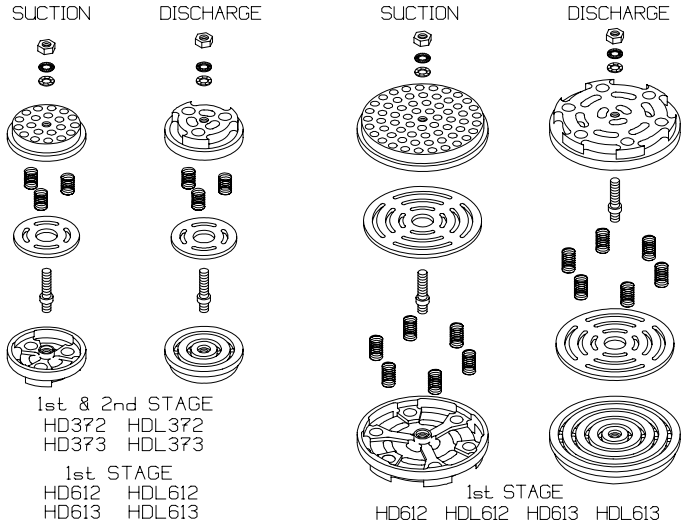


Typical Head Assembly (with Suction Valve Unloaders).

MAINTENANCE

VALVE REPLACEMENT (sizes 372, 373, 612 and 613)

1. Remove the valve cap (or unloader assembly) and O-ring from each valve.
2. **Remove** the valve hold down screw with a spanner wrench (such as Blackmer PN 790535).
3. Valve Removal and Disassembly
   a. Remove the valve cover plate capscrews then lift off the cover plate and O-ring.
   b. Remove the valve cage (and unloader plunger).
   c. Remove the valve assembly and the valve gasket.
   d. Inspect the valve for wear or breakage.
   e. Valve Repair
      1 Remove hex nut from valve (after removing the unloader actuator retaining ring, the actuator, spring, and post.)
      2 Separate the valve halves and remove springs and plate.
      3 Inspect and replace worn components.
      4 Reassemble valves as shown in the drawing and tighten the valve assembly nut according to the Bolt Torque Table.
      5 (Reassemble the unloader post, spring, actuator and retainer ring.)



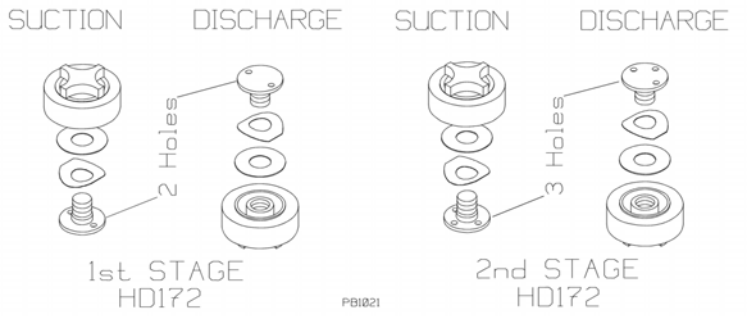
Typical Valve Assemblies

4. To reinstall valves:
   a. Install a new valve gasket into the cylinder head (remove any old gaskets).
   b. Install the valve assembly in the cylinder head. Make sure the valve's orientation and location are correct.
   c. Center the valve cage on the valve assembly.
   d. Applies only to suction valves with unloaders.
      Install the unloader plunger in the cage.
   e. Make sure the valve hold down screw is removed from the cover plate, then install the valve cover plate with a new O-ring. Tighten the cover plate capscrews according to the Bolt Torque Table.
   f. Install the hold down screw and tighten according to the Bolt Torque Table.
   g. Install the valve cap (or unloader assembly) and O-ring. (A little oil or grease on the O-ring will help hold it in place during installation.)
5. After replacing the valves, rotate the flywheel by hand to check for interference between the pistons and the valves.
6. After 60 minutes of running time, remove the valve cap (or unloader assembly) and retorque the hold down screw. Replace the valve cap and O-ring.

MAINTENANCE

VALVE REPLACEMENT (size 172)

1. Remove the valve cap (or unloader assembly) and O-ring from each valve.
2. **Remove** the valve hold down screw with a spanner wrench (such as Blackmer PN 790535).
3. Valve Removal and Disassembly
   a. Remove the valve cage (and unloader plunger, actuator, and spring).
   b. Remove the valve assembly and the valve gasket.
      NOTE: Although visually similar, the first and second stage valves are different. Valves for use in the first stage have two (2) holes in the bumper while second stage valves have three (3) holes. See drawing below.
   c. Inspect the valve for wear or breakage. If needed, the valve may be repaired:
      1 Unscrew the valve halves and remove the spring and plate.
      2 Inspect and replace worn components.
      3 Reassemble valves as shown below and tighten the valve halves together.
4. To reinstall valves:
   a. Install a new valve gasket into the cylinder head (remove any old gaskets).
   b. Install the valve assembly in the cylinder head. Make sure the valve's orientation and location are correct. **Note:** the HD170 series first stage valves have two holes in the bumper while the second stage valves have three holes.
   c. Center the valve cage on the valve assembly.
   d. Applies only to suction valves with unloaders.
      Install the unloader spring, actuator and plunger in the cage.
   e. Install the hold down screw and tighten according to the Bolt Torque Table.
   f. Install the valve cap (or unloader assembly) and O-ring. (A little oil or grease on the O-ring will help hold it in place during installation.)



5. After replacing the valves, rotate the flywheel by hand to check for interference between the pistons and the valves.
7. After 60 minutes of running time, remove the valve cap (or unloader assembly) and retorque the hold down screw. Replace the valve cap and O-ring.

UNLOADER SEAL REPLACEMENT

   a. Remove the unloader cap and O-ring.
   b. Remove the unloader body from the cylinder head (a strap wrench is helpful).
   c. Push the unloader piston out the top of the unloader body.
   d. Inspect and replace the seals as needed - note the seal orientation!
   e. Inspect the unloader body bore - it must be clean and smooth.
   f. Reassemble in the reverse order.

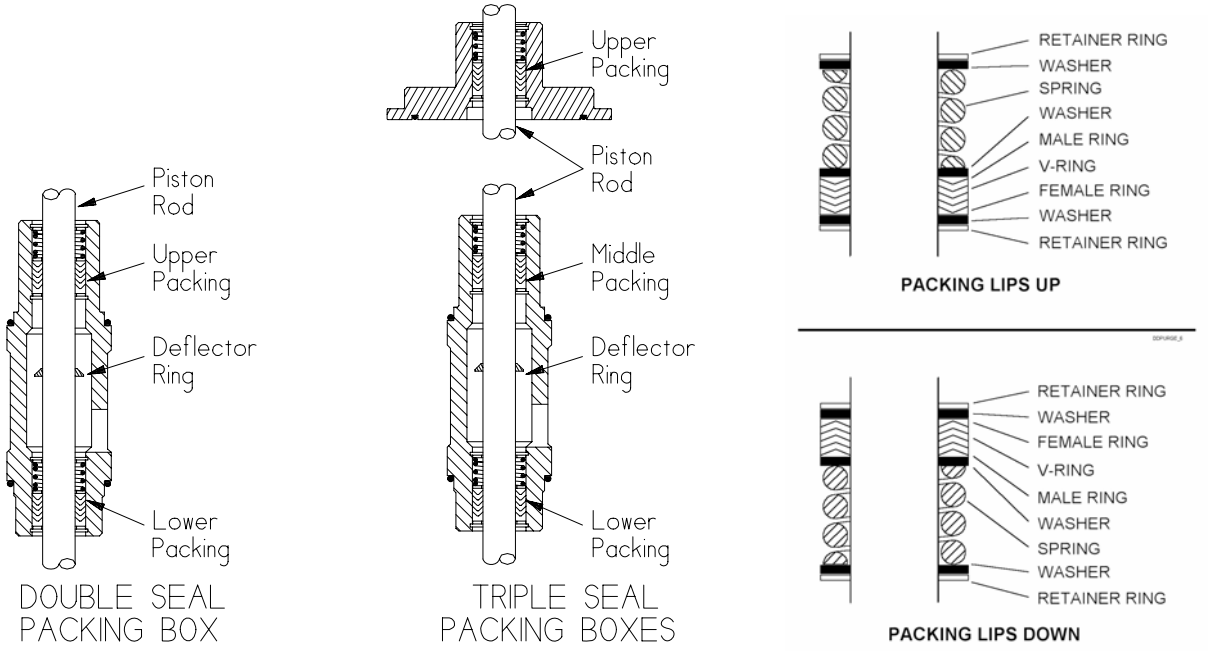
PISTON RING REPLACEMENT

1. Refer to the "Compressor Disassembly" section to remove the pistons.
2. Remove the piston rings and the piston ring expanders from the pistons.
3. To replace the piston rings:
   a. Place an expander in the top groove of the piston. Place an expander in the second groove with the break in this expander 180 degrees from the break of the top expander. Place the third expander in the bottom groove with its break in the same position as the top expander.
   b. Place piston rings in all three grooves of the piston. Make sure the breaks in the piston rings are directly opposite the breaks in the corresponding expanders.
4. Reassemble the compressor per the "Compressor Assembly" section.

MAINTENANCE

SEAL (PACKING) REPLACEMENT

1. Refer to the "Compressor Disassembly" section to remove the packing boxes.
2. Remove the upper and lower retainer ring from the packing box being serviced. Disassemble the packing box and discard the old packing sets and packing springs.



NOTE: Before reassembling the packing boxes, refer back to "Seal Arrangements". The 6th digit of the Compressor ID# identifies the packing orientation.

3. Packing boxes may contain either one or two sets of packing, depending on the compressor being serviced. To reassemble a packing box:

   a. Clean the packing box in a suitable solvent. Inspect the bore for wear, roughness, or corrosion.

   b. Install the first retainer ring (start with the inner ring on two seal packing boxes). See "Seal Arrangements" for the proper location and orientation of the packing components, then install the packing rings, spring, washers, and the second retainer ring. Note: To ease installation on the second retainer ring, use a screwdriver handle and press on the last washer to compress the seal spring slightly.

   c. Two seal packing boxes only

   Insert the oil deflector ring through the top of the packing box, flat side down, into the cavity between the upper and lower packing. NOTE: The oil deflector ring will be positioned between the two sets of packing. Install the second set of packing per step b.

4. The lower packing must be manually lubricated with oil several times during the first 60 minutes of compressor operation. This will prevent overheating of the piston rods and potential damage to the packing material.

WARNING!
DO NOT INSERT OBJECTS OR FINGERS INTO INSPECTION CAVITY WHILE COMPRESSOR IS OPERATING.

To lubricate the packing:

Remove the inspection plate from the crosshead guide.

Stop the compressor frequently (approximately every 5 minutes) to allow adequate cooling of the piston rods.

Lubricate the piston rods each time the compressor is **stopped**. A small oil can should be used for lubrication.

5. Reassemble the compressor per the "Compressor Assembly" section.

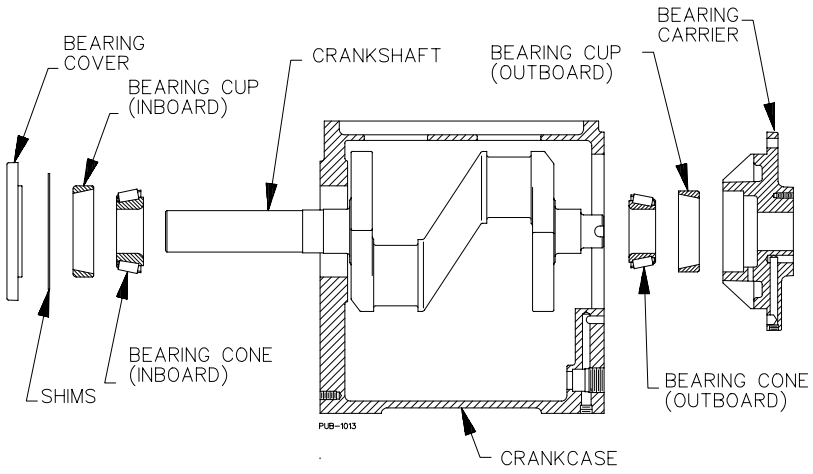
MAINTENANCE

BEARING REPLACEMENT

NOTE: When replacing the bearings, the entire bearing assembly, including the bearing cup and the bearing cone, must be replaced.

1. Follow all steps in "Compressor Disassembly."
2. Remove the Oil Pump per the section on "Oil Pump Replacement".
3. Remove the flywheel.
4. Remove the bearing carrier and gasket from the outboard end of the crankcase. The outboard bearing cup will come off with the bearing carrier and will need to be removed with a bearing removal tool.
5. Remove the key from the crankshaft and slide the crankshaft through the outboard end of the crankcase. Once the crankshaft is removed from the crankcase, the bearing cones can be removed with a bearing puller.
6. Remove the bearing cover plate from the inboard end of the crankcase. The inboard bearing cup is pressed into the crankcase and can be removed with the use of a bearing removal tool.

7. To install the bearings:
   a. Grease the outer edges of the bearing cups.
   b. Refer to the drawing for the proper orientation, and carefully press the inboard bearing cup into the crankcase until it is flush with the outer surface of the crankcase.
   c. Carefully press the outboard bearing cup into the bearing carrier assembly, noting the proper orientation.
   d. Press a bearing cone onto each end of the crankshaft with the tapered end outward. The bearing race should rest against the shoulder on the crankshaft.



   e. Lubricate the bearings with grease.
8. Install the crankshaft through the outboard end of the crankcase.
9. With the oil pump assembly removed, install the bearing carrier and gasket (the bolt holes are positioned to ensure proper orientation). Tighten the bolts evenly per the Bolt Torque Table.
10. Reinstall the inboard bearing cover plate and a trial set of shims. If the bearings have not been replaced, use the previous shim set. If the bearings have been replaced, use a **thicker** trial set of shims.
11. Rotate the crankshaft by hand to verify free movement of the shaft.

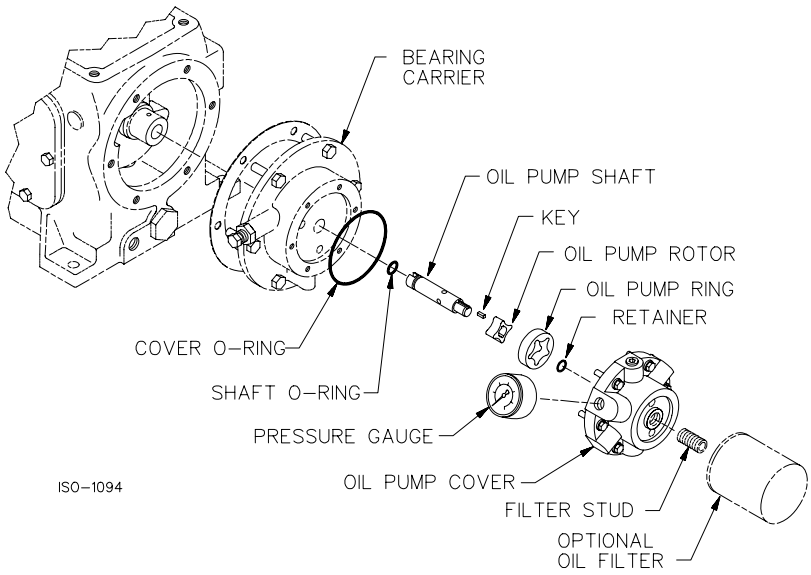
    NOTE: If the crankshaft is loose, with an excessive amount of end play, too many shims have been used. Lateral crankshaft movement (end play) between the bearings should be 0.0015" to 0.0030" (0.038 to 0.076 mm). If necessary, remove shims until the end play is within tolerance.

    If the crankshaft binds, or will not turn, not enough shims have been used pushing the bearing cup too tight against the bearing cone. In this case, the crankshaft must be removed from the crankcase and the inboard bearing cup must be driven out toward the inboard side of the crankcase. Reinstall the crankshaft and the bearing cover plate using additional shims as required.
12. Install the oil pump per the "Oil Pump Replacement" section.
13. Reassemble the compressor according to "Compressor Assembly."

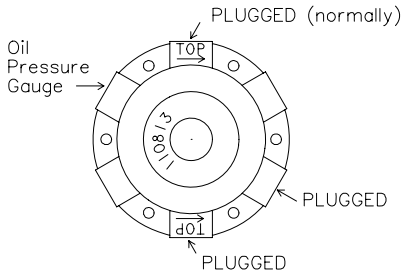
MAINTENANCE

OIL PUMP REPLACEMENT

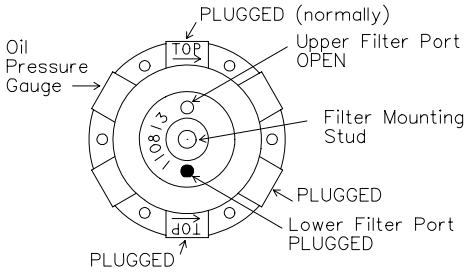
1. Remove the oil pump cover bolts and the oil pump cover.
2. Remove the cover O-ring, oil pump ring and shaft assembly.
3. Clean, inspect and replace parts as necessary.
4. Place the oil pump shaft assembly (complete with oil pump rotor, key, retainer ring and new shaft O-ring) into the bearing housing. If the bearing housing is bolted to the crankcase, the slot in the end of the oil pump shaft must align with the pin in the end of the crankshaft.
5. Place the oil pump ring over the rotor. Place the cover O-ring into the bearing carrier (do **not** place it on the oil pump cover).



6. Orient the oil pump cover with the upper direction arrow (the one labeled 'TOP') for the proper crankshaft rotation direction.
7. Tighten the oil pump cover bolts <u>by hand</u>. **NOTE: If the pump cover cannot be drawn flush with the bearing carrier by hand, either the oil pump shaft or other parts are not properly aligned. DO NOT USE A WRENCH AT THIS POINT AS THE OIL PUMP WILL BE DAMAGED IF INSTALLED INCORRECTLY.**
8. Once the oil pump cover is secured by hand, the bolts may be evenly tightened per the Bolt Torque Table.



WITHOUT FILTER



WITH FILTER

9. Verify that the proper plugs are installed in the oil pump cover per the above sketches.

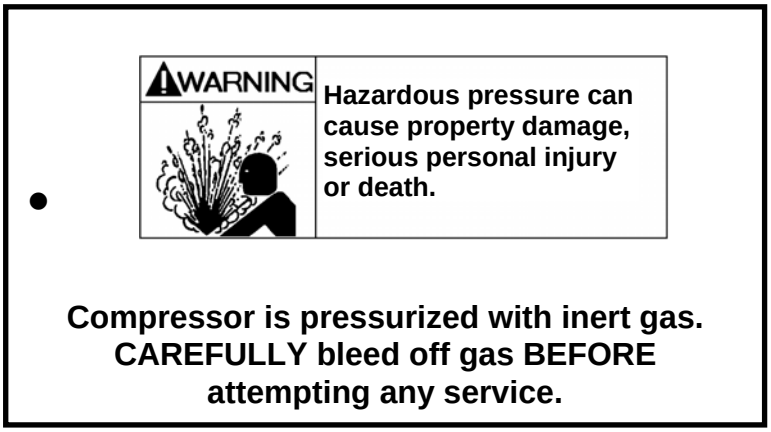
EXTENDED STORAGE PROCEDURES

If a compressor is not to be put into service for some time, or if a compressor is to be taken out of service for an extended period, the following procedures should be taken.

1. Fill the crankcase with rust inhibiting oil. (New compressors are shipped from the factory without oil.) Squirt oil on the piston rods and crossheads through the nameplate opening. Loosen the V-belts to relieve the load on the bearings. Rotate the compressor by hand a few times to distribute the oil.

2. Plug all openings and purge the compressor with an inert gas such as nitrogen or **dry** air at about 50 psig (3.5 bar-g). This may be done at the factory if requested. Leave the compressor pressurized to prevent air or moisture from entering the unit.

   NOTICE: Tag the unit with a warning that it is pressurized.



3. If a purge gas is not available, fog oil into the compressor suction while rotating the unit. Then plug all openings to keep out moisture, insects, etc.

4. Turn the flywheel by hand a few revolutions once a month to distribute the oil.

5. Store the unit under a plastic wrap on its wooden shipping base up off the ground. If the unit was boxed for export shipment, leave it in its box. An indoor or covered storage area is preferable.

6. When the compressor is to be put in service, vent the remaining purge gas and change the crankcase oil. See the 'Pre-Startup Checklist' and 'Startup Procedure' sections in this manual.

TROUBLESHOOTING

PROBLEM	STEP	PROBABLE CAUSE	WHAT TO CHECK	IF PROBLEM STILL EXISTS GO TO STEP ...
Low Transfer Rate	1	Worn or Broken Piston Rings	Check condition of rings by restricting discharge line. If pressure increases slowly, rings are probably faulty.	2
	2	Compressor Valve Faulty	Remove and inspect for broken or worn springs, discs, or bodies.	3
	3	Compressor Drive Slipping	Tighten belts, check for sheared keys, loose couplings or flywheel.	4
	4	Piping Improperly Designed or Installed	Use proper pipe sizes.	
Knocks or Other Noises	5	Loose Valves	Tighten valve hold-down screws.	6
	6	Worn Internal Parts	Inspect through inspection plates and repair as necessary.	2
No Oil Pressure	7	Oil Pump Relief Valve Not Properly Set.	Set oil pump relief valve.	8
	8	Oil Pump Not Working	Check the Oil Pump drive tab or stop pin for damage.	9
	9	Low Oil Level	Check and fill as necessary	10
	10	Dirty Inlet Strainer	Clean Inlet Strainer	
Gas Leaking From Crankcase Breather	11	Faulty/Worn Packing	Replace Packing.	12
	12	Piston Rod Scored	Replace crosshead assemblies and packing.	13
	13	Improper Seal Arrangement	See "Seal Arrangements".	
Shake or Vibration	14	Improper Mounting	Ensure base rails are supported full length (see "Mounting the Compressor Unit").	15
	15	Nonfunctioning Valves	Replace or repair valves.	16
	16	Unbalanced Load	Consult Factory-See Notes Below	

ADDITIONAL NOTES FOR INTERSTAGE PRESSURE:

Interstage pressure is an important indicator of the proper operation or condition of a two-stage compressor.

* Low interstage pressure may indicate problems with the first stage valve or piston rings.
* High interstage pressure may indicate problems with the second stage valves or piston rings.

Low compression ratios can cause high interstage pressures. Two-stage compressors are not normally recommended for operation below 5 compression ratios.

Consult factory for further information.

NOTES

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