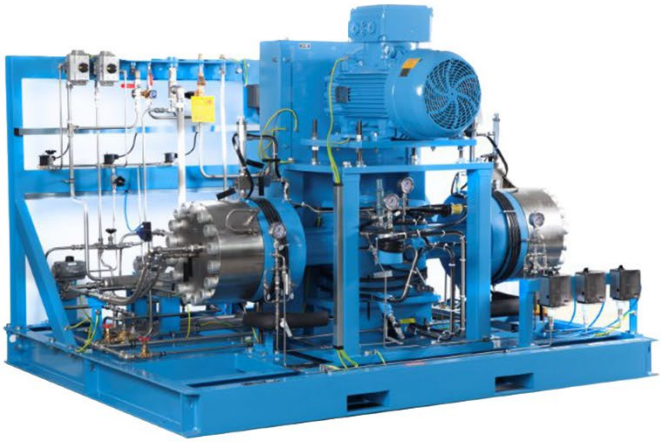

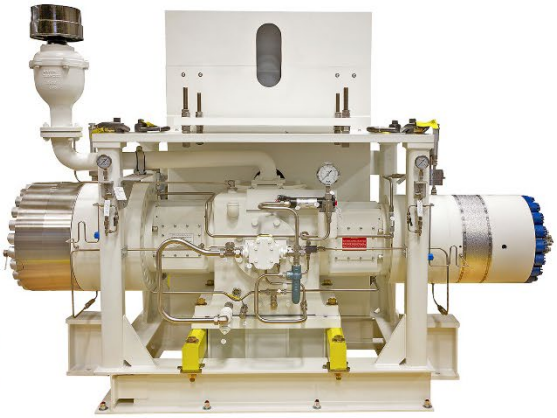

Manufactured with pride in the USA by:

An ISO 9001:2015 certified company.
Certification No. 1112232.01

We perform under pressure.

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Table of Contents

Notes

This manual is written to cover all Metallic Diaphragm Compressor models manufactured at PDC. Please direct all questions regarding this manual or compressor systems manufactured by PDC to the plant located in Souderton, PA USA. Please provide the following information with all inquiries, including spare part orders.

- PDC Job Number and Model Number which can be found in this manual or on the compressor nameplate.
- Your purchase order number and shipping information.

A recommended spare parts list is typically included in the Bill of Material titled “SP”.

PDC spare parts are provided specifically for diaphragm gas compressor systems engineered and fabricated by PDC. These parts are manufactured to their original tolerances and are designed to provide optimum dependability, performance, and reliability. Our rigorous quality assurance programs ensure high quality and consistency from part to part. All components are fabricated from carefully selected materials, whose characteristics are precisely controlled by our QC procedures.

PDC can also provide the following services:

- Fully trained and qualified field service technicians can be dispatched worldwide to provide compressor repair, troubleshooting, general maintenance, etc.
- Evaluation and analysis of existing compressor systems for fitness, function, or new applications.
- Start-up, commissioning, and training activities.

PDC remains dedicated to providing fast, professional service for our equipment providing our customers with reliable gas compression systems for many years after their installation.

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Foreword

Metallic Diaphragm Compressors fabricated by PDC, are the direct result of state of the art engineering and manufacturing practices. They are designed to provide reliable, dependable service for many years. However, to maximize performance, the user must exercise care in its operation and maintenance. This manual recommends regular preventive maintenance procedures, proper operational procedures, etc., which must be carefully adhered to for reliable, economic performance with minimal downtime. This document refers to PDC compressor models 2 through 13 for customer support, however PDC 3, 4, and 13 are currently only available.

Introduction

PDC Metallic Diaphragm Compressors are designed to pump gases in a contamination free or pure state. Since the pulsing media (hydraulic oil) and the process fluid being pumped are separated by a set of three metal diaphragms, contamination of the process fluid is avoided.

Contoured cavities are used to restrain diaphragm deflections and limit membrane stress as a result of being stretched into the contours. The cavity and diaphragm designs focus on high reliability and extended diaphragm life. The contoured cavity design is optimized using state of the art computer software and Finite Element Stress Analysis (FEA) techniques to provide uniform stress distribution within the established design limits.

The inherent design, i.e., the large surface area of the heads in contact with the process, allows diaphragm compressors to achieve high compression ratios. Clearance volumes are minimal and fixed, as opposed to adjustable, providing high efficiency without the need for sophisticated clearance volume adjustment mechanisms found in piston compressors. Thus, compression ratios as high as 100:1 can be achieved, if necessary. In certain cases, compression is remarkably close to isothermal, as opposed to adiabatic, when compared to a standard piston compressor.

PDC supplies Metallic Diaphragm Compressors in stand-alone configurations, or as completely integrated, skid mounted compressor systems, manufactured in accordance with the end user requirements and specifications.

Process wetted portions of Metallic Diaphragm Compressors can be manufactured from any machinable metal or alloy, which provides compatibility with the end users process fluid. Standard materials of construction are 304/316 SS, or, in other materials such as Inconel, Monel, Hastelloy, etc. Diaphragm material selection is limited to the commercial availability of material with the proper physical requirements necessary for acceptable diaphragm performance.

Principles of Operation

Please refer to our drawing A0020002, which includes the basic components of a diaphragm compressor. This example illustrates a single stage unit, but the same principles can be applied to each stage of compression in a compressor system. Drawing A0020001 also shows a typical hydraulic oil pressure versus crank angle curve.

Please note that the diaphragm set follows the hydraulic piston, or column of hydraulic oil, as it sweeps the cavity machined in the compressor heads. The relationship between the piston displacement and cavity volume is extremely critical and carefully designed and controlled.

The sequence of compressor operation is as follows:

- During the inlet stroke, the hydraulic piston moves towards the bottom dead center (BDC) position causing the pressure in the cavity to decrease as the diaphragm moves toward the bottom of the cavity.
- When the pressure in the cavity is below the inlet pressure to the compressor, the inlet check valve opens and permits gas to flow into the cavity. This is represented by the dip in the pressure versus crank angle curve at about 45°.
- Gas will continue to flow into the cavity until the piston reaches BDC.
- As the piston reverses direction and begins to move upward, the inlet check valve closes and the compression cycle starts.
- As the pressure in the cavity exceeds the compressor outlet pressure, the outlet check valve opens and gas flows at discharge pressure out of the compressor. The outlet check valve opening is represented by the pressure peak on the pressure versus crank angle curve at about 225°.
- The outlet flow will continue until the piston reaches the Top Dead Center (TDC) position at which point the piston reverses and the cycle repeats.

PDC utilizes a phased injection pump, which is driven by the crankshaft. This pump injects hydraulic oil into the cavity during the inlet stroke of the compressor.

The injection pump makes up for the oil loss in the system such as leakage past the piston, plus the amount of oil displaced over the oil relief valve during normal operation. The hydraulic relief valve setting is slightly higher than the outlet pressure of the compressor. This allows the diaphragms to contact the top of the cavity firmly, thus, assuring a complete sweep of the entire cavity volume. When the diaphragms contact the top of the cavity, the hydraulic piston still has a few degrees of crank angle left before it reaches TDC. During this period, the oil pressure rises above the compressor outlet pressure until it reaches the setting of the oil relief valve. At this point, the relief valve opens and oil, in the amount of the injection pump displacement less the losses in the system, is displaced over the relief valve. This oil flow is what is known as over pump. The relief valve opening is represented by the highest pressure peak on the pressure versus crank angle curve right before 360°.

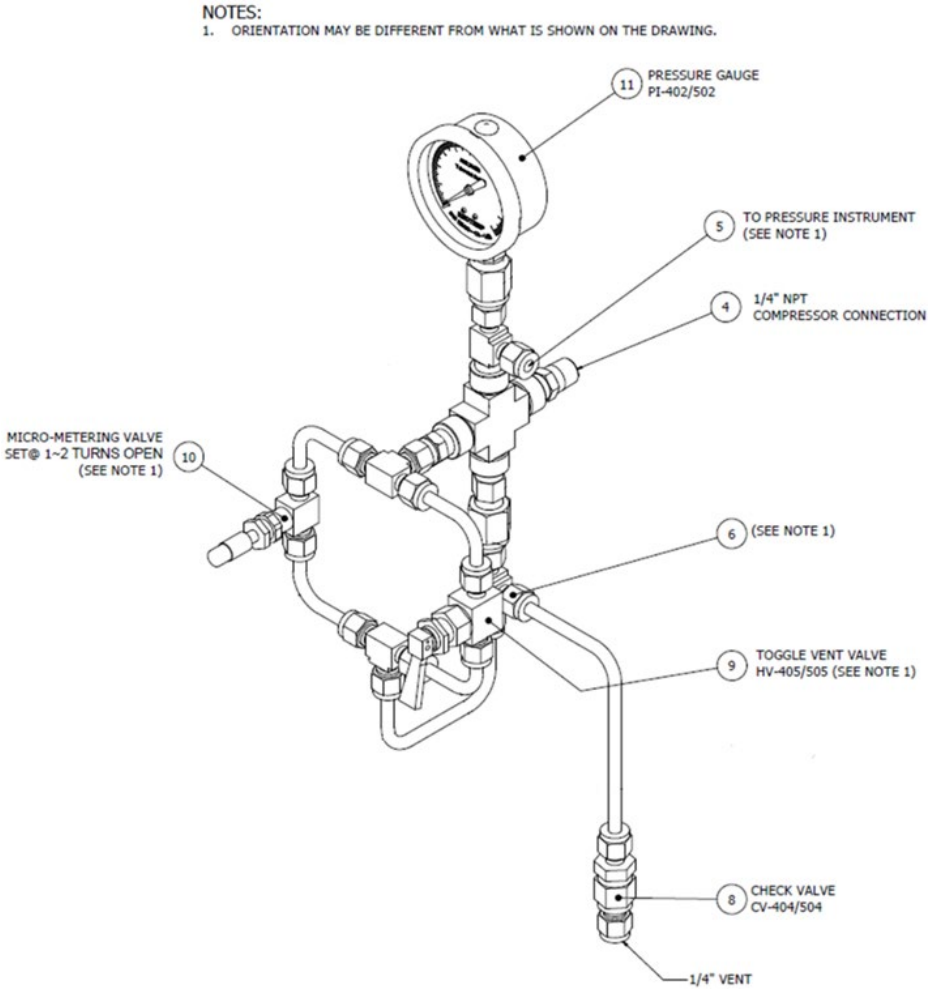
Triple Diaphragm Leak Detection

Drawing A0020002 shows a graphical and schematic representation of the Triple Diagram Leak Detection Concept.

A leak detection system is standard equipment on every stage of compression for PDC Metallic Diaphragm Compressors. This system detects diaphragm failure, (cracked diaphragm), gas and/or oil seal failure. Diaphragm failures are normally attributed to particles or contamination in the gas or oil systems of the compressor, moisture condensation inside the cavity, or improper tightening of the compressor head bolts.

The leak detection system concept utilizes a set of three (3) diaphragms, a closed chamber into which leaked media (gas or oil) accumulates, a leak detection, process and oil “O”-ring seal, a relief valve, a pressure gauge, pressure switch, and a normally closed manual blow down valve.

The middle diaphragm is manufactured with leak grooves to allow media to pass into the leak chamber. If the diaphragm is cracked, the gas or oil will penetrate through the crack, pass through the leak grooves in the middle diaphragm and then enter the closed leak chamber. As the gas or oil accumulates, the pressure increases. The pressure switch is set at 15 psig on increasing pressure and is typically used for interlock shut down of the compressor via the motor control system. The pressure gauge is used for visual indication of a leak, the relief valve protects the system from excessive pressure and the manual valve allows the operator to vent off the leak for maintenance and verification purposes. Care should be utilized to assure that hazardous process media vents, including leak detection vents, are properly routed to safe vent areas.



In some compressor systems the entire leak detection system is assembled and mounted directly to the compressor head assembly.

Leak Detection System Features

On the left side of the Leak Detection system is a toggle valve. This is to release built up pressure that may cause false readings due to recent service or maintenance. For example, if new diaphragms are installed, air trapped in between will get forced into the leak detection system when the compressor is restarted.

On the right is a metering valve. This is a factory set valve that allows a very small amount of gas out that is a result of hydrogen permeation through the O-Ring seals. The orifice on this valve is 0.0002 CV allowing very little gas to escape while still detecting actual failures of the diaphragms or O-rings.

Safety Precautions

Safety is everyone's concern and is based on the use of practical common sense and adherence to applicable safety codes and standards. Because a Metallic Diaphragm Compressor is a large, high-speed reciprocating piece of machinery, common sense precautions for this type of machinery should be observed, as carelessness in operation or maintenance is hazardous to personnel.

In addition to the several obvious safety rules that should be followed with this type of machinery, we suggest the following:

Cautions and Warnings

Failure to observe the various warnings in this manual could result in injury to or death of personnel, and or damage to compressor equipment.

- Do not operate the compressor unit without reading and understanding the Installation/Operational and Maintenance Instruction Manual. Contact PDC for any questions or clarifications regarding the manual.
- Keep fingers and clothing away from revolving or reciprocating parts.
- Do not loosen or remove any parts in the compressor process, lube oil or cooling systems until the compressor has been safely shut down and properly isolated from supporting equipment.
- Electrical shock can and may be fatal.
- The compressor electrical control systems and sub systems must be installed in accordance with the appropriate International, National or Local Code requirements and rated for the applicable electrically classified environment. Refer to the Compressor Data for compressor system ratings.
- The compressor should be properly grounded.
- Disconnect, tag and lockout the compressor power source prior to working on the unit.
- Properly shut down the compressor prior to making repairs or adjustments on or around the compressor.
- Do not exceed the rated maximum operating conditions specified in the Compressor Specifications or Data Sheets. This warning applies to the compressor and all its support equipment.
- Do not operate the compressors without the proper guards in place.

Cautions and Warnings (continued)

- Do not operate the compressor without installing the compressor as defined in this manual and other supporting documents, as well as in accordance to any International, National or Local Occupational Safety and Health Codes. Minimum recommended fail safe controls for a compressor system should include motor overload protection, leak detection system, cooling water flow switch, compressor base oil pressure switch (except for splash lubricated compressor bases) and appropriate process system interlocks. PDC can supply completely integrated compressor systems with all the above fail safe controls, however, if these controls are not provided by PDC, the end user is responsible for their installation.
- Generally, do not start compressors under load as this will result in oil priming difficulties, cavitation, and excessive vibration. There are many ways to design and provide unloading systems for compressors depending on the process fluid being handled. In most cases, PDC-2, 3 and 4 series compressors can be started under load, without the use of an unloading system. Refer to the Compressor Specification Sheet to determine if your compressor requires an unloading system. Consult the factory for recommendations if you have any questions regarding unloading requirements.
- Check torque on all bolts prior to operation of your compressor. Torque for individual fasteners can be found in the assembly drawings found in this manual or marked on the compressor itself. Use proper tools when applying torque to bolts. Do not over torque bolts.
- Pressure test all process lines with an inert gas such as N2 prior to introducing process gas into the compressor. Your compressor has been fully tested at the factory, however, during transportation; it is not uncommon for joints to loosen.
- Do not operate the compressor without the proper inlet filtration installed. Minimum filtration requirements are 5-10 micron nominal particle filtration, and the filter should be sized such that the pressure drop does not exceed 2% of the suction line pressure. Separation or filtration prior to the compressor inlet must remove any particulate or moisture present in the process media.
- Do not operate the compressor without adequate cooling water flow to the compressor heads and associated coolers.
- Do not operate the compressor with Suction pressure higher than the Discharge. First equalize the suction and discharge then start the compressor.
- Never operate the compressor, or any other equipment, without the proper safety protection devices and fail safe controls installed and functioning correctly. Safety and fail safe devices should be periodically checked for proper operation and general fitness and function. Never bypass safety or fail safe devices.
- Never tighten bolts or fittings while under load due to pressure.

Cautions and Warnings (continued)

- Observe all facility-implemented procedures during maintenance such as lockout, tag-out procedures, work permits, protective clothing, and gear, etc.
- Provide the proper freeze protection if the compressor will operate in cold environments. PDC can provide crankcase heaters and heat tracing upon request. Use additives in the cooling water to prevent freezing in the compressor heads and cooling lines during periods of inactivity. Freezing media in the compressor heads and cooling lines will cause failures.
- Do not use a compressor for any process fluid media other than those specified in the "Compressor Specifications Sheets". Consult the factory for information regarding different process media.
- Only use factory approved lubricants for your compressor.

Receiving and Storage

All Metallic Diaphragm Compressors are thoroughly inspected, carefully packaged on a wood skid, and wrapped in plastic prior to shipment from PDC. Inspect the skid carefully as soon as it is received at your facility. Any damage to the skid and or the compressor itself should be reported to the shipping service immediately.

Store the compressor in its original skid in a dry and clean location where it is protected from rain, snow, and extreme environments. The temperature of the storage area should be between 50 and 100°F.

If storage is required for an extended period, the following precautions should be observed:

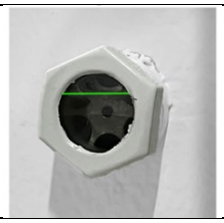
- Oil and elastomeric seals have a shelf life of approximately one year due. This is due to the installation and state of compression that the seals are in. Replace these, if necessary, before startup.
- Moisture condensation can take place when temperature drops excessively. Moisture condensation can cause corrosion damage to the various precision parts of the compressor. Take the necessary precautions and perform routine checks to avoid such damage. Replace oil as required to maintain adequate lubricant levels.
- Due to relative motion caused by vibration from the surrounding environment, fretting corrosion can occur when a compressor sits in one place for an extended period, especially in the bearing areas. Rotate the flywheel every 20 to 30 days so that the oil film is restored between the bearing rollers and races to prevent fretting corrosion of the bearings and other surfaces.
- Units shipped from the factory have all openings temporarily sealed for protection. Do not remove these seals until the compressor is ready to be installed.

Shelf Life

Elastomer Family	ASTM	Shelf Life
Aflas®		Unlimited
Butyl Rubber, Isobutylene Isoprene	IIR	Unlimited
Chloroprene (Neoprene®)	CR	15 Years
Epichlorohydrin (Hydrin®)	ECO	NA
Ethylene Acrylic (Vamac®)	AEM	15 Years
Ethylene Propylene, EPDM or EP	EP	Unlimited
Fluorocarbon (Viton®)	FKM	Unlimited
Fluorosilicone	FVMQ	Unlimited
Hydrogenated Nitrile, HNBR or HSN	HNBR	15 Years
Nitrile (Buna-N or NBR)	NBR	15 Years
Perfluorelastomer	FFKM	Unlimited
Polytetrafluoroethylene (Teflon®)	PTFE	N/A
Polyacrylate	ACM	15 Years
Polyurethane (Polyester or Polyether)	AU / EU	5 Years
Silicone	VMQ	Unlimited
Styrene Butadiene (Buna-S)	SBR	3 Years

*** Note AS5316 deals only with the storage of elastomeric parts and carries no justification for components post application/assembly.**

20 to 30 day flywheel rotation guide

Ensure that there is oil in the crank case buy verifying through the sight glass.	
Open the oil bypass valves on all the hydraulic oil heads.	
Manually rotate the fly wheel, counterclockwise. It should rotate freely once momentum is built. Note: Take extra caution to avoid injury around moving parts.	
Continue rotating flywheel unit hydraulic oil can be seen flowing through all sight glasses.	
Close oil bypass valves to ensure that the hydraulic oil is held in the hydraulic oil heads.	
Check oil level to ensure the compressor still has the required amount of oil.	

Installation

Inspection

Receive or remove from storage the compressor per Section 2 of this manual. Unpack the compressor and carefully inspect the compressor for damage corrosion or other adverse effects from shipping or storage. Remove any temporary connection covers, seals, or shipping support mechanisms, which should be clearly marked as temporary.

Location

The compressor should be located in an area of sufficient size to permit cleaning, maintenance, and disassembly of the compressor. The compressor installation site should be located in an area that is accessible to the process fluid media being pumped, cooling water service, electrical service, compressed air service and fluid drain system. The mounting surface should be level, hard and dry, such as a concrete floor or foundation.

Avoid mounting compressors on upper levels of mezzanines unless the mezzanine has been designed to accommodate reciprocating machinery.

General Arrangement and Foundation Drawings

General arrangement and foundation drawings for your compressor can be found in this manual in the "Engineering Drawing Section". The general arrangement drawing provides overall size information, weights, unbalanced forces, etc. In the case of smaller compressors, the foundation information will also be on the general arrangement drawing. For larger compressors, a foundation drawing will be provided. These drawings provide information from the floor up only.

Reciprocating compressors cannot be designed and fabricated to be completely counterbalanced. The foundation must be designed to support the weight of the compressor and to absorb unbalanced forces. An inadequately designed foundation will result in excessive vibration and or movement of the compressor during operation.

NOTICE **The responsibility for an adequate foundation lies with the end user or installation contractor. The foundation is a poor place to economize. The extra cost for an adequate foundation is generally small and is always well justified.**

Installation (continued)

Foundation and Anchoring for PDC 2, 3 and 4 Series Compressors

These compressors are relatively small and can be mounted securely to a level concrete foundation or floor (approximately 6" thick) using concrete anchors and the mounting holes provided on the bottom of the structural steel frame weldment of the compressor. For models PDC-4-100 and lower (i.e. PDC-4-50), reference PDC-5 through 13 foundation instructions due to the large size of the head and piston assemblies. Make sure the floor and bottom of the compressor are clean prior to mounting. Due to the inherent inconsistencies of both the concrete floor and the structural steel beams, there will be gaps between the floor and steel beams. Leveling shims must be inserted in these gaps so that the steel beams sit solidly on the concrete floor. When the compressor is correctly secured to the floor and leveled using shims, vibrations will be minimal. If vibration levels are excessive, recheck the shims and the mating surfaces between the compressor frame and the floor.

Foundation and Anchoring for PDC 5 through 13 Series Compressors

Foundation requirements for these compressors are significantly more involved due to their size and larger unbalanced forces. In these compressor series, PDC uses Gardner Denver/Joy reciprocating power frames fitted with PDC diaphragm head assemblies, and oil injection pump.

The following foundation information is typical information found in the Gardner Denver/Joy Installation manual for reciprocating compressors and should be adhered to:

Foundation and Installation

Foundation for reciprocating machines differs from foundation for buildings or similar structures since dynamic rather than static loads are involved. The foundation area should provide soil bearing pressure of approximately 500 PSF or less. Low soil bearing pressures keep the natural frequency of the foundation high, prevent resonance, and reduce the possibility of transmitted vibrations.

Where hard limestone or other equally hard stone formations come to the surface, it will be sufficient to clean off Alluvial soils, unconfined sand or gravel, soft clay, silt or filled ground do not furnish satisfactory support for foundations of reciprocating compressors. When these soils are encountered, the foundation below the floor line must be made larger than normal or pilings may be necessary to provide vertical support.

The foundations must always contain sufficient reinforcing steel, must be extended below the frost line, and should be completed in a single pour.

To help avoid transmission of vibration to the floors and walls of the compressor room, it must be isolated from the compressor foundation. The perimeter of the foundation below the floor should be surrounded with eighteen (18) inches of coarse dry gravel or by a narrow gap filled with asphalt or other suitable material.

Installation (continued)

Sleeves are placed around foundation bolts to permit flexibility when lining up and leveling the compressor prior to grouting. These must not be filled with concrete when pouring the foundation but must be filled with grout when grouting the compressor. Sleeves around foundation bolts are considered necessary because they function as reinforcement and eliminate foundation cracking when the bolt is pulled tight.

All concrete surfaces to receive grout MUST BE LEFT ROUGH and NOT trawled smoothly. If an extra deep foundation is required, or the compressor is set higher above the floor level than shown on the foundation drawing, the area of the base of the foundation must be increased. This is especially important since both conditions will promote rocking of the foundation.

The foundation should be allowed to cure for at least one week before the compressor unit is placed on it.

The conduit leads; water and air piping and drain facilities should be provided for in the design of the foundation.

When conditions are at all doubtful, or if the foundation is located where transmitted vibration might be objectionable, a foundation specialist should be consulted.

FOUNDATION BOLTS AND SLEEVES (FIGURE 1-3)

Foundation bolts must be accurately located and held while concrete for the foundation is being poured. This can be accomplished by using a rigid template to hold the bolts in the proper position and wiring them to the bottom, so they remain plumb.

A sleeve, at least one inch larger than the bolt size, must be used to permit flexibility when lining up and leveling the compressor unit prior to grouting.

BOLTS AND SLEEVES MUST BE CLEAN AND FREE OF OIL.

SETTING AND LEVELING THE UNIT – Thoroughly clean the top of the foundation and the bottom of the compressor. Remove washers and nuts from foundation bolts. Make sure threads are not damaged. Remove plugs from the top of the foundation bolt sleeves.

Package, Skid or Base-Mounted Units – Package, skid or base-mounted units cannot be bolted to an ordinary existing floor. It is necessary to grout their bases to an adequate foundation.

1. Support the skid or base on metal wedges leaving a one-inch minimum space for grouting. Place wedges near each foundation bolt.
2. Place a level on top of the crankcase cover.
3. Drive wedges in small increments, in rotation, until the unit is at the correct height and level in both directions.
4. Securely tighten skid or base foundation bolts in rotation, checking the level to ensure the skid or base has not been distorted or moved on the wedges.

Installation (continued)

Grouting

1. Build a wood form around the foundation above the crankcase feet, cylinder support subbase, motor sole plates or base or bottom flanges of steel base or skids as shown in FIGURE 1-1 & FIGURE 1-2, page 2. This will form a temporary dam for the grout.
2. Wet down the top of the foundation thoroughly, remove any puddles of water, and blow water out of the sleeves around the foundation bolts. A grout mixture of one part cement to two parts sand with enough water to allow grout to be poured is satisfactory. Too rich or "soupy" condition causes grout to crack or to have too much shrinkage. Commercial non-shrinking grout mixtures are available. These mixtures can be used if the grout manufacturer's recommendations are followed.
3. Fill sleeves around the foundation bolts with grout first and pack tightly, then work grout under crankcase, cylinder support subbase, motor sole plates, or base, or steel base, or skid and around foundation bolts.

⚠ CAUTION **Use care when working grout under the cylinder support subbase and motor sole plates or base so that grout does not go above their inner edges.**

4. When the grout has started to set, remove the forms and with a trowel, smooth and trim the grout to the foundation. Normally, it will take one or two days for the grout to thoroughly set. Metal wedges should be removed, and openings should be patched.
5. The finished concrete surfaces should be sealed with good water and oil-proof cement paint to prevent deterioration of the concrete.

Final Shimming of the Unit

Package, Skid or Base-Mounted Units

1. Remove shims from between the crankcase and base, cylinder support and base, and motor and base.
2. Recheck tightness of all foundation bolts.
3. Place a dial indicator on the crankcase feet near the bolt being tightened, like FIGURE 1-4, page 4. If deflection is greater than .003" shim accordingly.
4. Replace shims between the cylinder support and base so the dial indicator shows that the cylinder support has been raised approximately .005" to .010".
5. Securely tighten the cylinder support to the base. If the proper number of shims were used, the dial indicator should return to within + .003" of zero. If not, repeat the procedure changing the number of shims used.
6. Use the same procedure for shimming between the motor and base.

Installation (continued)

Fastener and Fittings Torque Verification

Check all bolts, nuts, screwed fasteners and fittings for the proper torque or tightness, prior to operating the compressor. Although the compressor has been fully tested at the factory, vibration during transportation can cause things to become loose. Bolt and fastener torques can be found on the assembly drawings found in this manual or in some cases, marked on the compressor itself.

Piping – General Information

Provide appropriate materials of construction for the process fluid and other service media. The compressor materials of construction can be found on the Compressor Specification Sheets and Bills of Materials found in this manual. The Specification Sheets also contain information about service requirements.

Thoroughly clean all service lines to the appropriate level prior to installation. Remove all foreign particles from fabrication and assembly.

Adequate support must be provided for all connecting piping to avoid excessive nozzle loads and to isolate the compressor from any vibration generated by equipment up and down stream of the compressor. Piping systems should be designed to accommodate movement, which may occur as a result of vibration, temperature gradients, etc.

Provide isolation valves as required, to allow equipment isolation and safe conditions during maintenance activities.

Over pressure protection must be provided on the outlet side of the compressor and in all other service lines where over pressurization is a concern. Relief devices must be appropriately sized to meet the applicable codes and standards.

Pressure test all service and compressor piping prior to operation to assure fitness and functionality of piping systems. This can be done using inert gases such as helium, nitrogen, or clean air. Take all necessary safety precautions during pressure testing. Never over pressurize any part of the compressor system as this could damage equipment and cause injury or death to personnel. Repair any leaks prior to operation.

Never tighten fittings or bolts while under a load due to pressure.

Installation (continued)

Process Piping Connections

The process piping schematic, or P and ID, can be found in the drawing section of this manual. This schematic represents the extent of the process system supplied with the compressor. Typically, process piping consists of the compressor inlet, outlet, and vent connections. The size and type of connections provided on the compressor are listed on the drawing and tagged on the unit itself.

The line size servicing the compressor inlet and outlet should be the same size provided on the compressor, or preferably, one nominal size larger. The line sizes provided on the compressor have been carefully sized for the process conditions and the reciprocating nature of the flow. Do not use average velocity calculations to determine lines sizes, as the instantaneous velocities during the compression cycle are considerably higher. If the compressor line sizes are too small, the compressor will not perform in accordance with specifications.

If the volume of the piping system is insufficient to prevent pressure fluctuations during operation, volume tanks or pulsation suppressors must be installed. If the compressor is a packaged unit, these devices may already be included.

Adequate inlet filtration must be used to protect the compressor. Do not operate the compressor without the proper inlet filtration installed. Minimum filtration requirements are 5-10 micron nominal particle filtration, and the filter should be sized such that the pressure drop does not exceed 2% of the suction line pressure. Separation or filtration prior to the compressor inlet must remove any particulate or moisture present in the process media.

Unloading Systems

Refer to the Compressor Specification Sheet to determine if your compressor requires an unloading system. Generally, do not start compressors under load as this will result in oil priming difficulties, cavitation, and excessive vibration. There are many ways to design and provide unloading systems for compressors depending on the process fluid being handled. In most cases, PDC-2 and 3 series compressors can be started under load, without the use of an unloading system. Consult the factory for recommendations if you have any questions regarding unloading requirements.

Instrument Air

Refer to the Pneumatic System Schematic drawing and Compressor Specification Sheets found in this manual, for information on the Instrument Air system supplied with the compressor. Typically, instrument air is used to actuate automated valves, control valves, etc. Pressure, flow capacities, line size requirements are defined in the drawings and specification sheets. Instrument air should be of high quality and free of contamination. Dirty instrument air can interfere with proper valve function.

Installation (continued)

Cooling Water Piping

Refer to the Cooling Water Schematic drawing and Compressor Specification Sheets found in this manual, for information on the cooling system supplied with the compressor. Connection sizes, flow, pressure, and temperature requirements, etc., are referenced in these documents. Cooling water service lines should be constructed from materials compatible with the cooling water media.

The compressor should be interlocked via a flow detection device, such that if there is a cooling water failure, the compressor can be shut down.

Provide the proper freeze protection if the compressor will operate in cold environments. PDC recommends using 50/50 glycol mixture with DISTILLED water. Crankcase heaters and heat tracing can be provided by PDC upon request. Use additives in the cooling water to prevent freezing in the compressor heads and cooling lines during periods of inactivity. Freezing cooling media in the compressor heads and cooling lines will cause failures.

Over pressure protection must be considered if the cooling water system is isolated and allowed to heat up from exposure to sunlight or other heat sources.

Electrical Service Requirements

Refer to the Electrical Control Schematic drawing and Compressor Specification Sheets found in this manual, for information on the electrical control system supplied with the compressor. Voltage, power, environmental and other service requirements can be found in these documents.

Switchgear or other power distribution networks should be installed in accordance with the applicable electrical codes and rated appropriately.

Packaged systems are typically fully integrated. However, the user is responsible for assuring that the compressor is safely installed in accordance with all applicable Codes and Standards. As a minimum, the following interlocks are necessary to protect the compressor:

- High Discharge Pressure
- Low Cooling Water Flow
- Motor Overload
- Diaphragm Leak Detection (one for each stage of compression)
- Low Lube Oil Pressure (pressure lubricated frames)

Depending on the mode and style of operation, attended or unattended, etc., additional interlocks may be required for necessary for safe operation. Consult the factory for recommendations based on your specific installations.

When selecting the control system for automatic operation, it is important to note that the compressor should not start and stop any more than once every 15 minutes. It is not good practice to allow the compressor to cycle more frequently. The compressor capacity should be selected so that is not too large or small. Volume bottles, storage vessels, etc. can also be added.

Installation (continued)

As a standard, PDC compressors are designed for general-purpose industrial areas. Diaphragm compressors can be designed and fabricated for hazardous electrical areas. Refer to the Compressor Specification sheets for information regarding the electrical classification of your compressor.

⚠WARNING **Never install a compressor into a hazardous electrical area for which it is not rated.**

Operation

Basic Safety Rules

- Operators must familiarize themselves with the compressor, controls, safety systems and starting equipment, prior to operating the compressor. Carefully read and understand the manuals, drawings and other technical information provided with the compressor.
- Before starting, be sure all protective guards are in place and clear of moving parts.
- Never leave the compressor unattended until you are sure all controls and safety devices are operating properly.
- Observe all safety precautions and rules. Follow the procedures established for operating the compressor.

The compressor system has been carefully designed, fabricated, inspected, and fully tested under the appropriate factory conditions. Proper installation, operation and maintenance procedures must be followed in order to provide satisfactory service throughout the life of the compressor.

Preparation for Initial Startup

- Clean up the area in which the compressor is installed. Remove any oil, dirt, and grease from the floor, which may have accumulated during installation. Discard empty containers or other foreign matter from the area.
- Manually rotate the compressor flywheel a few turns, in the proper direction, to assure that movement is free. For larger compressors, this may require a barring device, which will be supplied by PDC. Make sure the compressor is unloaded both on the process side, as well as the hydraulic oil side. The compressor flywheel will not rotate freely if either the process or oil side is loaded. If the movement is not free, determine the cause and take the appropriate corrective action.
- Fill the crankcase to the proper level with the appropriate lubricant. Lubricant type and approximate capacity can be found in the Compressor Specification Sheets or the Lubrication Schedule if included. The compressor design, environmental climate and the process fluid being compressed, define the type of oil to be used.

⚠WARNING **Failure to use the proper lubricant, or the proper amount of lubricant, can result in damage to the compressor equipment and risks injury to the operating personnel.**

Operation (continued)

- Typically, oil is added through the air breather assembly located in the top of the crankcase. An oil level indication device is provided in the crankcase to determine proper fill levels. PDC 2 Series compressors have an oil dipstick for level determination. The dipstick hole is also used for oil filling.
- Replace the air breather assembly. Check to make sure the air breather assembly is free from obstructions and sources of contamination. Only clean air should be drawn through the breather assembly.
- Conduct a final inspection of the compressor, support equipment, service connections and safety devices.
- Check V—drive belts for proper tension and adjust if necessary. Observe sheaves for proper alignment. On smaller compressors, the belt guard may have to be removed to do this. On larger compressors a removable access plate is typically provided on the belt guard.
- Open isolation valves for the compressor cooling water service connections. Verify cooling water flow and check to be sure all cooling water interlocks (flow, temperature for cold environments, etc.) are working properly.
- Apply instrument air to the compressor system if required. Verify pressure level and capacity of the air service connected to the compressor.
- Review the unloading requirements for the compressor system and verify the necessary components are installed and operating. Unloading systems are not required for PDC 2 and most PDC 4 series compressors. Consult the Compressor Specifications Sheets for unloading system requirements.
- Open the relief valve bypass valves on the hydraulic oil system or systems depending on the number of compression stages. There will be one bypass valve per head assembly or stage of compression. This valve will be clearly tagged from the factory. There are (2) basic oil systems in a diaphragm compressor. One system is responsible for generating diaphragm displacement in the head, while the other is responsible for lubricating the compressor frame. Each stage of compression, or each head assembly, will have its own, dedicated, diaphragm displacement oil system, which includes the bypass valve. Each compressor frame, which may have one or more heads or compression stages, will have its own lubrication system. Review the “Hydraulic System Schematic” found in the drawing section of this manual for additional information.

Operation (continued)

- Regardless of normal startup requirements, initial startup for oil side priming must be done with a reduced process pressure load. This is necessary because the hydraulic oil relief valve, or pressure control, is manually bypassed during priming which allows free oil flow and air removal. During oil priming, any process pressure load experienced by the compressor must be overcome by the oil system. Since the pressure control system is bypassed during priming, it is difficult for the oil system to overcome this load, therefore, making priming difficult. For oil priming, the compressor inlet and outlet can be opened to atmosphere, allowed to recycle from outlet to inlet or can have the inlet pressure regulated to a low pressure which will be pumped through the compressor at minimal boost conditions. Never block (or dead end) the inlet or outlet of the compressor.

⚠WARNING **The oil priming procedure is extremely critical to establishing proper compressor operation, as an improperly primed compressor will cause hydraulic system cavitation, shock loading and excessive vibration.**

- When you are sure the compressor is properly configured for startup and oil priming mode, open the process fluid isolation valves.

⚠WARNING **Be sure all shutoff valves on the inlet and outlet side of the compressor are open prior to starting. Failure to do so may result in severe cavitation on the inlet and excessive pressure at the outlet, which may cause damage to the equipment and/or personal injury.**

- Jog the compressor motor for a brief period. Check and verify the direction of rotation, reverse motor direction if required. A rotation direction arrow is located on the belt guard assembly. Typically, PDC Diaphragm compressors rotate clockwise facing the compressor from the flywheel side. Check to make sure all moving compressor components are moving freely without obstruction.

⚠WARNING **When starting the compressor, operate for only a few seconds and shut down prior to reaching full speed. Do this to ensure that everything moves freely without obstruction and allows the operator to check the direction of rotation. Operating the compressor in the wrong rotational direction will result in hydraulic system failure and cause damage to the compressor.**

⚠WARNING **Never run the compressor with a suction pressure higher than the discharge. ALWAYS equalize the suction and discharge before starting the compressor. Failure to follow these procedures will result in extremely high gas velocities, high gas temperatures and damage to gas Check Valves.**

Operation (continued)

Initial Start-up and Priming

- Start the compressor and allow it to accelerate to full speed. Listen carefully for any unusual noises, vibration, or other abnormalities. Shut down the compressor immediately if you have any concerns. Allow the compressor to run and begin to circulate oil through the hydraulic systems. PDC 2, 3 and 4 Series compressors are splash-lubricated frames. PDC 5 through 13 Series compressors are pressure-lubricated frames via a hydraulic gear pump. All PDC compressors utilize a hydraulic gear pump to prime the inlet port of the injection pump. Please review the "Principles of Operation" section of this manual for additional information regarding the injection pump and other operational characteristics.
- For pressure lubricated frames, a pressure gauge and switch are provided to monitor and interlock the frame lubrication system. During startup, observe the pressure gauge to verify oil pressure is being generated. The pressure setting of the frame lubrication relief valve is found on the hydraulic system schematic. If pressure does not build in a timely manner (less than a minute) check the rotation direction of the compressor, oil level, or oil system for leaks or blockage. It is normal for this pressure level to decrease slightly as the oil warms up. This is due to the change in viscosity at higher temperatures. The compressor control circuit must incorporate a time delay of approximately 20 seconds to allow base oil pressure to build up during starting.
- For PDC 2, 3 and 4 series compressors (splash lubricated frames) an oil interlock system can be provided if the compressor is to be operated completely unattended for extended periods of time. This will protect the compressor in the unlikely event of a ruptured oil line or oil leak that results in a serious loss of oil in the crankcase. Consult the factory for information regarding this option if you intend to operate completely unattended for extended periods of time.

⚠WARNING **Failure to properly protect the compressor frame from inadequate lubrication will result in damage to the compressor.**

- During initial startup procedures, constantly check and maintain the crankcase oil level. As the compressor runs, oil is pumped to the head assemblies until they are filled. For larger compressors, the head filling procedure can take up to an hour of starting, stopping and filling before the oil level is stable. It is possible to observe a difference in oil levels between the stopped and running conditions. Typically, the stopped condition will result in higher oil levels. Ultimately, the minimum correct oil level is a half-filled indicator while the compressor is running properly.

Operation (continued)

- When the compressor heads are filled, oil will begin to flow in the sight flow indicator (sight glass) located downstream of the bypassed hydraulic relief valve. Typically, the sight glass flow is returned to the crankcase through the injection pump body assembly. This oil flow helps lubricate the cam found in the injection pump assembly. Depending on how the system is piped, (mainly based on how the trapped air in the tube lines is venting back to the crankcase) etc., the sight glass can run completely full, or the oil can run down the side of the glass. If the glass is full, it is difficult to observe oil flow in the glass. Shinning a small light through the glass from the opposite side you are viewing, allows you to observe oil flow in a full sight glass. Initially, this oil flow will be foamy as it is mixed with air that is being displaced from the compressor heads. Over a period of time, the larger the head the longer the time period, this oil flow will clear up as the air is completely displaced and the heads are filled with oil. Once the heads are filled, a clear oil flow should be established in each sight glass.
- Once clear oil flow has been established in the sight glass for each head, close the oil relief valve bypass valve for each head. At this point, oil which was bypassing around the relief valve will be diverted to the relief valve inlet port. For a brief period, oil flow in the sight glass will stop. The injection pump will add oil during each revolution of the crankshaft. The pressure will begin to rise in the hydraulic system and the noise level of the compressor will increase as a result of the load on the compressor system. As the pressure in the hydraulic system reaches the relief valve setting, oil will once again begin to flow in the sight glass. Small amounts of residual air that was trapped in the oil system will cause foamy oil characteristics for a brief period of time, however, a clear oil flow should be reestablished in a few minutes. Once the compressor has established clear oil flow in the sight glasses for several minutes with the relief valve bypass valves closed (indicating the compressor is fully primed), the compressor is ready to be loaded from the process side.

The hydraulic relief valve pressure setting has been factory set. Do not adjust, or tamper with the relief valve setting unless you have a thorough understanding of dynamically setting hydraulic relief valves. Information regarding the dynamic setting of relief valves can be found in the "Maintenance" section of this manual. The improper setting of the hydraulic relief may result in damage to equipment and/or injury to personnel.

Failure to assure the compressor is fully primed, prior to pumping process fluid, will result in poor compressor performance and may cause damage to the equipment.

Operation (continued)

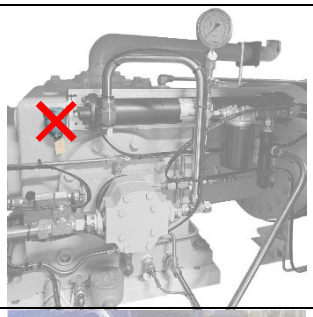
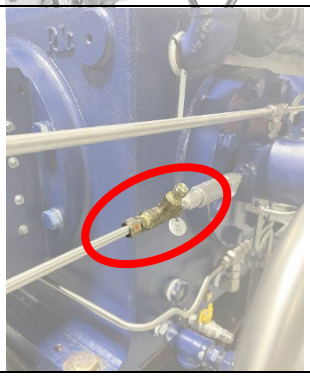
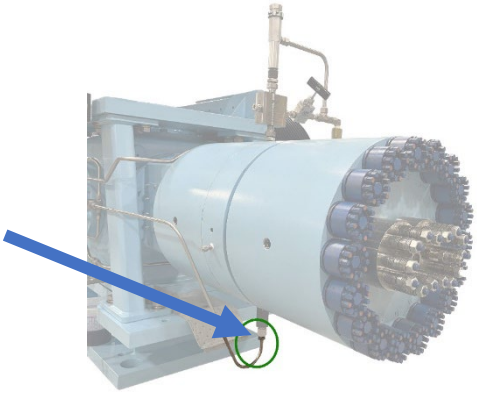
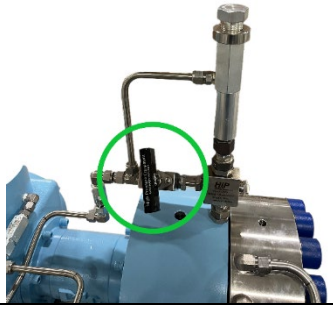
- Place the unloading system of the compressor in the loaded position, which will result in process fluid media being introduced to the compressor inlet and outlet. For compressors not using an unloading system and were primed with a reduced process load as discussed above, return the process load to normal conditions. Provided the compressor outlet is connected to a restricted source or some pressure control device, the pressure at the compressor outlet will initially balance with the inlet pressure and then begin to increase as the compressor pumps gas. Outlet pressure will continue to increase until the pressure control system either shuts the compressor off at the desired pressure or the pressure control system diverts flow back to the inlet or to another area of need.
- While the compressor is running, verify that all control, support, and safety systems are functioning correctly, and that the compressor is operating within its specified parameters. Monitor inter-stage temperatures and pressures to verify fitness and function of the compressor system. Check the current being drawn by the motor. Check and verify lubricant levels. Check V-drive belt tension. Observe all piping systems for leakage. Allow the compressor to run for a few hours while operation is carefully monitored. Recheck all systems for fitness and function prior to placing the compressor into final operation.

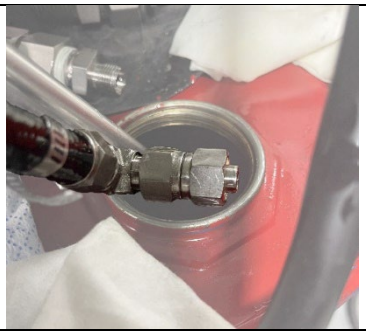
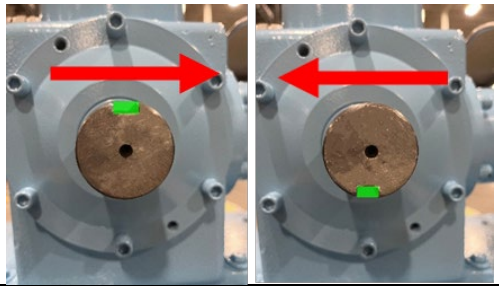
Shutting Down the Compressor

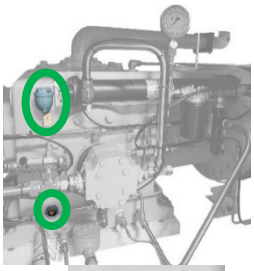
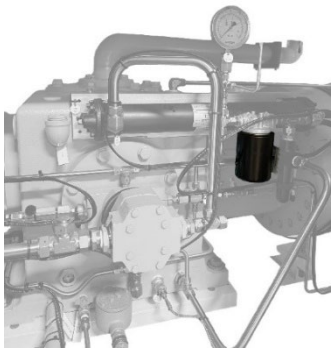
- Unload the compressor and then shut the compressor motor off. If you are not using an unloading system, shut the motor off.
- Cooling water should be run through the compressor for approximately 15 minutes after the compressor is shut down.

Compressor Priming Requirements

Compressors require priming whenever circumstances related to the most recent shut down allowed for oil loss in the heads or it is being started for the first time. Oil loss can occur from leaks, maintenance procedures, thermal contraction of the oil in the heads, opening of the oil relief valve bypass valve by the operator, sitting for periods of in excess of one week, etc. For any of the above reasons, the priming sequence must be repeated prior to placing a process load on the compressor. Compressors shipped from the factory are fully primed, however, may require re-priming during initial startup.

1. Do not fill crank case.	
2. Remove plug cap on fill port.	
3. If there is no fill port connection, disconnect the fitting behind the check valve under the head and connect there.	
4. Open oil bypass valve.	

5. Connect the oil pump hose to fill port.	
6. Manually turn the flywheel so the keyway is facing the head that is being filled. a. Ensure that the flywheel is locked in place. b. If you don't do this the heads can over fill with oil and cause severe damage during start up. PDC 3's must have the keyway facing up for the piston to be at top dead center on the right side and the keyway facing down for the piston to be at top dead center on the left.	PDC 4 & 13  PDC 3 
7. Turn on the pump and start filling with the appropriate oil recommended for the compressor. a. There is a pressure control valve to regulate the oil pressure going into the heads to ensure the seals and O-Rings don't get blown out. b. These seals and O-Rings are rated up to 100 psi and the pressure control valve should be set to approximately 80 psi.	

8. Stop filling when oil can be seen flowing through the sight glass with minimal air bubbles. a. Oil through the sight glass ensures that the head is full and purges out most of the trapped air.	
9. Manually turn fly wheel 2 full revolutions. a. This will lubricate the piston and sleeve to prevent seizing. b. This also prevents the possibility of hydro locking the heads if they become over filled with oil.	
10. Repeat steps 1 thru 8 on other head.	
11. Fill crank case with oil. a. Using the fill port add oil until the sight glass on the crank case is ¾ of the way filled.	 
12. Remove the oil filter and fill with oil before starting. a. This will reduce the amount of air in the system and reduce risk of damaging compressor.	

Operation (continued)

Restarting the Compressor

For starts **not requiring** priming:

- Re-establish cooling water flow.
- Verify the compressor is unloaded and start the motor. Allow the compressor to accelerate to operating speed. For compressors not using an unloading system, start the motor. After 20 seconds, set the process system to the loaded position. Observe compressor operation for abnormal conditions. Once the compressor has been successfully started and stopped several times, subsequent starting and stopping can be done unattended.

For starts requiring priming, follow the above procedure for “Initial Start-up and Priming”.

⚠WARNING **Starting the compressor when it is not fully primed will result in poor compressor performance, cavitations and may result in damage to the equipment.**

Normal Compressor Operation

Once the compressor has been successfully started, the compressor should continue to operate normally until it is shut down. The type of process being run and the piping/control system, which has been provided, typically defines normal compressor operation requirements. Refer to the “Process Schematic” or P and ID for information about the systems and components provided.

⚠WARNING **Never operate the compressor outside the design parameters specified in the “Compressor Specification Sheets” found in this manual.**

Back-up Compressor Operation

Many compressor systems utilize (2) compressors to achieve zero downtime attributed to maintenance, unexpected shutdown, etc. If the on-line compressor shuts down, the back-up compressor starts and takes over.

In order for the back-up compressor to start and take over, it must be properly primed and ready to start. It is necessary to run the back-up unit on a regular basis to assure it is fit and primed. For continuous operation, it is recommended the back-up unit be run at least once a day (either unloaded or with a reduced process pressure load as mentioned above) in order to assure its readiness. The duration of this run should be long enough to assure the compressor is fully primed as defined above, typically about (10) minutes.

Operation (continued)

Standard Operating Procedures

It is the user's responsibility to develop a sight specific "Standard Operating Procedure", or SOP, for each compressor installation. This procedure should cover compressor operation, maintenance and any sight specific requirements that apply to the compressor installation. Start-up, shut down, service interlocks, equipment isolation, lock out/tag out procedures, all should be included in this procedure. This procedure is necessary to ensure the compressors' safe and proper operation by all personnel using it. If requested, PDC will review and comment on your SOP with respect to compressor considerations.

Maintenance

Safety Precautions

Before and during any maintenance work being performed on the compressor or any of its support equipment, be absolutely sure the following precautions and safety rules are observed:

- Properly shut down the compressor. Allow hot components to cool prior to proceeding with maintenance.
- Isolate the compressor from all main service connections such as electrical, process, cooling water, instrument air, etc. Lock-out/tag-out procedures should be used to prevent the services from being accidentally restored.
- Vent residual pressure from all piping, compressor heads, etc.
- Always use the proper tools and other equipment to perform maintenance.
- Never place your hand or arm inside the crankcase without realizing the crankshaft can rotate unless it has been mechanically secured.
- After any maintenance, carefully observe the compressor for a period of time necessary to assure the compressor is operating normally.

Cleaning and Lubricating

It is important during maintenance activities that all parts be thoroughly cleaned, particularly oil passages, seal surfaces, etc. Where permitted generously lubricate parts as they are reassembled.

NOTICE **When replacing any parts in the compressor system, use only high quality replacement parts supplied by PDC Machines, The use of any other replacement parts will void the warranty.**

Maintenance (continued)

Daily Maintenance Check List

- Lubricant oil level. Add as required.
- Base frame lube pressure for PDC Series 5 through 13 compressors.
- Cooling water flow, temperature and pressure.
- Operation of control systems.
- Inlet filter pressure drop.
- Drain separator tanks.
- Verify inlet, inter-stage and outlet pressures are in order.
- Check for abnormal noise or vibration.
- Check the leak detection systems on all heads.

The above items should be checked at least once a day. It is not good practice to leave reciprocating machinery run unattended over prolonged periods of time. For units operating 24 hours a day, the above items should be checked every 8 hours. A logbook should be maintained to record equipment inspections and maintenance activities as they are performed.

Inlet Filter

The inlet filter should be disassembled and inspected every 300 hours of operation. Replace or clean the element as required. If the compressor system is equipped with an external filter-monitoring device such as a differential pressure gauge or transmitter, disassembly and inspection may not be necessary. If regular inspections at 300 hour intervals reveal excessively dirty elements, inspection frequency should be increased.

Some systems are equipped with dual filter systems for servicing one filter while the other remains on-line. This option is supplied with the appropriate isolation and venting valves. Isolate and vent pressure on the filter that requires maintenance. Always make sure to verify the alternate filter is in line prior to isolating the other filter. Process P and ID show the process system and its components. Sizing of the inlet filter is discussed in Section 3, Installation, Process Piping Connections.

⚠WARNING **Never isolate both filters of a dual element system. This will dead end the compressor and result in damage to the equipment and possible injury to personnel. The SOP should carefully detail this procedure. Lock and tag valves as required.**

Maintenance (continued)

Lubrication Systems

PDC 2, 3 and 4 Series compressors are splash-lubricated power frames. A slinger mechanism is attached to the crankshaft and splashes oil throughout the crankcase as it rotates. The oil level in this style power frame is critical and must be carefully maintained. A sight glass on the side of the crankcase is provided to monitor oil level. Do not over or under fill the crankcase. Oil level in the sight glass MUST be at least ½ to ¾ full when the compressor is running normally.

⚠ WARNING **Never overfill the crankcase. This will result in aeration of the oil, resulting in cavitations and potential damage to the compressor.**

PDC 5 through 13 Series compressors are pressure-lubricated power frames. The crankshaft drives a hydraulic gear pump, which provides pressurized oil to points requiring lubrication throughout the power frame. A relief valve in the circuit controls oil pressure. The oil pressure settings for your compressor can be found in the "Hydraulic Schematic" found in this manual. Typically, the crankshaft, connecting rods, wrist pin, crosshead and bearing housings have drilled passages to allow oil flow in these areas.

In either style power frame, splash or pressure lubricated, a hydraulic gear pump is used to prime the inlet port of the injection pump. The crankshaft drives the gear pump. In the case of the pressure lube power frame, the gear pump is sized to prime the injection pump as well as lubricate the frame. Oil is drawn up from the crankcase lubricant sump, through a lubricant strainer to the inlet of the hydraulic oil pump. Oil from the outlet of the pump is then forced through a filter, and then diverted to the injection pump inlets and other lubrication points in the power frame if it is pressure lubricated. The relief valve setting controls pump outlet pressure. Oil displaced by the relief valve is returned to the crankcase sump.

The following items need to be addressed during maintenance of the lubrication system:

- Crankcase Sump Oil – Drain and replace. Wipe the sump clean of any foreign particles. Inspect any foreign particles removed as they may indicate wear in other areas of the compressor. Replacement oil information can be found in the "Compressor Specification or Data Sheets" found in this manual. Typically, hydraulic oils used have the recommended viscosity, are of high quality, refined by a reputable oil company, contain anti-oxidation, anti-foam additives, have high chemical stability and adequate film strength. Oil is added through the breather port with the breather removed.
- Strainer – Remove screen element. Clean or replace as required.
- Filter Element – Remove element and replace. Fill element and/or housing with oil during reassembly. This will reduce the time components do not receive lubricant during the subsequent start-up. Inspect gaskets and seal rings in the filter housings, replace as required.
- Crankcase Breathers – Remove and inspect, replace as required.

Maintenance (continued)

Frequency of Lubrication System Maintenance

- Change oil and oil filter elements after 50 hours of initial operation. Clean or replace strainer element as required.
- Change oil and oil filter elements after every 2000 hours of subsequent operation. Clean and replace strainer element.
- Change oil and oil filters elements immediately if the oil viewed in the sight glass is abnormally discolored.

Maintain a logbook for all maintenance activities.

⚠WARNING **The use of oils other than those supplied by PDC, must be approved by PDC. Fax the data sheet from the oil you propose to use to PDC for review and approval.**

⚠WARNING **Failure to maintain the lubrication systems on a regular basis will result in premature component failure and poor compressor performance.**

⚠WARNING **Highly explosive or unstable process fluid media may require fire resistant oil. Consult the factory for recommendations.**

Diaphragm and O-Ring Seal Replacement

- Isolate the compressor from all main service connections such as electrical, process, cooling water, instrument air, etc. Lock-out/tag-out procedures should be used to prevent the services from being accidentally restored.
- Vent residual pressure from all piping, compressor heads, etc.

⚠WARNING **Failure to properly isolate and vent the compressor will result in serious injury to personnel.**

Review the “Head Assembly” drawing and associated “Bill of Material” found in the appropriate section of this manual. The “Head Assembly” drawing shows a cross sectional view of the head assembly and calls out the various items. Assembly notes, bolt torques, etc. are given on the drawing. The “Bill of Material” lists the individual items along with each items respective part number, description, material of construction and size.

Note: Never replace diaphragms without replacing O-Ring seals at the same time or vice versa.

Remove cooling water and process piping that will interfere with head removal. Process check valves and their retainers can be left in place if desired; however, since the head is apart, it is recommended they be inspected.

Depending on the design of the head assembly, it may be desirable to drain the oil from the heads, especially for larger head assemblies. For smaller compressors, the volume of oil in the head does not

Maintenance (continued)

warrant a draining system and can be handled with rags and small trays. The head assembly drawing shows the location and size of plugged drain ports. Typically, there will be one port at the bottom and some means for venting air at the top. Place a container under the bottom drain port. Remove the plugs and allow the oil to drain. Replace all plugs and remove containers once the oil has drained.

Arrange for the proper lifting mechanism to lift the process head. Mark the head assembly accordingly to shown orientation during reassembly. Secure the process head with the lifting device. The compressor heads are provided with tapped holes for lifting purposes. The user supplies lift eyes, bolts, chains, straps, etc. Loosen head bolts. Adjust the lifting mechanism so that it is taking the weight of the head prior to removing bolts. Remove bolts. Lift and move the head away from the compressor to an area where it can be cleaned and prepared for reassembly.

The diaphragm set is sandwiched between the process head (just removed) and the lower head. There are (3) diaphragms in the set and they are held in place by a series of cap screws around the perimeter. Remove the cap screws. Carefully hold the diaphragms around the edges and remove the used diaphragm set.

⚠ WARNING **Diaphragms are made from thin sheet metal and have very sharp edges. Exercise caution when handling diaphragms to prevent cutting your hands and fingers.**

There are (3) O-Ring seals, (1) in the face of the process head and (2) in the face of the lower head. Carefully remove the used O-Rings.

Using clean solvent and rags, wipe the face of both heads clean. Carefully wipe the O-Rings grooves clean. Deposits that will not wipe off can be polished with 600 grit sandpaper until removed. Score marks can be polished until they are flush or below the cavity surface. Final cleaning of the process head should be done with a cleaner that will not contaminate the process fluid media.

Remove the replacement Oil O-Ring from the plastic bag in which it is packed. Wipe a very thin coating of lubricant (usually vacuum grease) on the O-Ring. Place it in the Oil groove, which is the smaller (innermost) of the (2) grooves in the lower head. It may be necessary to stretch the O-Ring in order to make it fit in the groove. The lubricant will help hold it in place.

Verify the diaphragm material, as marked on the package, is consistent with the compressor's material of construction and the "Bill of Materials". Remove the replacement diaphragm set from its packaging. Replacement diaphragm sets from PDC are cleaned and ready for installation, however, check to make sure the diaphragm set has remained clean during shipping and is suitable for your application. Diaphragms sets have two stainless steel (or other materials) disks at the top and bottom separated by a brass disk in the middle.

Maintenance (continued)

Place the diaphragm set over top of the Oil O-Ring onto the face of the lower head. Secure the set in place with the screws previously removed. Check to be sure that the diaphragm set fits between the body of the attachment screws with a small amount of clearance and is held in place with the heads portion of the screws. Attachment screws do not have to be torqued, as they simply hold the diaphragm set in place during assembly. Over tightening these screws will damage the diaphragms.

Remove the replacement Leak Detection O-Ring from the plastic bag in which it is packed. Wipe a very thin coating of lubricant (usually vacuum grease) on the O-Ring. Place it in the Leak Detection groove, which is the larger (outermost) of the (2) grooves in the lower head. It may be necessary to stretch the O-Ring in order to make it fit in the groove. The lubricant will help hold it in place.

Remove the replacement Process O-Ring from the plastic bag in which it is packed. Wipe a very thin coating of lubricant (usually vacuum grease) on the O-Ring. Place it in the Process groove, which is in the process head. It may be necessary to stretch the O-Ring in order to make it fit in the groove. The lubricant will help hold it in place.

Position the process head in front of the lower head in the same position it was in prior to being removed. Note the markings from earlier in the procedure. Line up the bolt holes. Replace the bolts in the head assembly. Snug bolts by hand. Look between the process and lower heads to make sure that all the O-Rings and diaphragms have remained properly positioned. Tighten the bolts in increments of 25% of the final torque value specified on the drawing. The tightening sequence is stamped on the head. Verify that the final torque value has been obtained on all the head bolts. Do not apply 100% of the specified torque in one step.

Failure to tighten bolts properly will result in damage to the equipment and personnel injury.

Replace check valves and retainers if removed, torque retainers as specified on the drawing. Replace the cooling water and process piping which was previously removed.

Follow procedures for “Initial Startup and Priming” found in the “Operation” section of this manual.

Maintenance (continued)

Process Check Valves

Each head assembly has inlet and outlet check valves for the process stream. These valves are extremely critical to proper compressor operation. Faulty valves will seriously degrade the compressor performance. Process check valves, o-rings and bellevile washers should be inspected after every 4,000 hours of operation.

There are (2) basic types of process check valves used in PDC diaphragm compressors. The smaller valves are cartridge style valves whereas the larger valves are flat disc poppet style type. Refer to the “Illustration” section for typical exploded views of these valves.

Review the “Check Valve Assembly” drawing and associated “Bill of Material” found in the appropriate section of this manual. The “Check Valve Assembly” drawing shows a cross sectional view of the valve assembly and calls out the various items. Assembly notes, instructions, etc. are given on the drawing. The “Bill of Material” lists the individual items along with each item’s respective part number, description, material of construction and size.

Check valves are held in place by retainer plates or nuts, which are itemized on the associated “Head Assembly” drawing. Details for retainer assembly, valve orientation, retainer torque, etc, are also found on the “Head Assembly” drawing.

Cartridge style check valves use a press fit spring retainer in the outlet side of the check valve to hold the poppet and spring in place for assembly. This retainer has a radial slot so it can be spread open to achieve an appropriate press fit into the cage. Only enough interference to hold the retainer in place is necessary. To disassemble a cartridge check valve, push on the face of the poppet from the inlet side of the valve (through the flow orifice). Use caution and an appropriate pushing device, so as not to damage the poppet face. Lightly tap the poppet until the retainer is dislodged from the other side of the valve. Be sure to not to loosen the retainer and spring as the valve is disassembled.

At the user’s discretion, worn valves can be replaced completely, or rebuilt with new poppets, seals, and springs.

Make sure all replacement valves are thoroughly cleaned in an appropriate manner prior to putting them in service. Verify that all seals and gaskets have been reassembled.

Oil Inlet Check Valves

The oil inlet check valve should be disassembled and checked every 4,000 hours. Inspect the O-ring seal and mating seal surface for signs of wear. Replace if worn.

Maintenance (continued)

Hydraulic Oil Relief Valve

The hydraulic oil relief valve is extremely critical to proper compressor operation. This valve limits the oil pressure in the compressor system and opens at top dead center of every crankshaft revolution. The seat area of the oil relief valve is subjected to very high fluid velocities and as a result erosion and wear are concerns. The seat area design and materials of construction have been carefully selected to withstand this environment. The relief valve seat should be inspected at least once every 4,000 hours of operation.

Two styles of oil relief valves are used. For pressures below 1,000 psig, an internally adjustable, cartridge style relief valve is used. For pressures in excess of 1,000 psig, a custom fabricated, externally adjustable valve is used. An assembly drawing and bill of material is provided for the custom fabricated valves.

Disassemble the valves, inspect the seat and repair as required, or replace them entirely. Reassemble the valve. Install the valve on the compressor. Follow the dynamic setting procedure below.

Statically bench set relief valves will run at significantly higher pressures in the dynamic compressor environment.

Relief valves should be ordered set from the factory. Be sure to specify the set pressure when an order is placed with PDC. The set pressure can be found in this manual, or on the tag attached to the relief valve. Factory set relief valves are always marked as such. Never assume a valve is set if it is not marked.

Never operate a compressor with a hydraulic oil relief valve set dynamically above its design pressure. Damage to equipment and/or injury to personnel are likely to occur.

Hydraulic oil relief valves must be set dynamically on the compressor while it is running. Before the compressor is shipped, hydraulic oil relief valves are set at the specified pressure and marked accordingly. Spare part relief valves are not factory set and must be set in the field.

PDC uses two styles of relief valves. For pressures up to and including 600 psig, an internally adjusted, soft-seated relief valve is used. For pressures over 600 psig, a metal-seated valve, manufactured by PDC is used. The low-pressure valve is listed on the hydraulic system bill of material and is typically replaced in its entirety when necessary. For the high-pressure valve, a drawing and bill of material can be found in the manual for use in assembly/disassembly and maintenance purposes.

Maintenance (continued)

Setting the Hydraulic Oil Relief Valve

Install the valve on the compressor. Back off the adjustment nut (turn counterclockwise facing the nut) until you can feel the load or force from the internal spring release from the nut. In this position, the valve will hold no pressure. From this point, turn the nut clockwise 2 turns. This will keep the internal parts in position during setting.

Install the “Piping required to set relief valve dynamically” as shown in drawing A0020004 found in Section 7 of this manual. This piping consists of a gauge, check valve and vent valve. The check valve isolates the gauge and vent valve from pressures lower than what has already been trapped or in other words the gauge only reads the peaks or relief valve setting. The vent valve allows the operator to vent pressure and recheck the setting.

Start the compressor using the start-up procedures found in this manual.

Turn the valve adjustment nut clockwise to increase pressure setting, which should be followed by an increase in pressure as shown on the gauge. Do not turn the nut more than ½ turn per adjustment. Continue to adjust the nut until the specified setting is reached. For the low-pressure series of valves, the top section of the valve must be removed to make setting adjustments.

Check the setting several times after the valve has been set to assure setting. As the compressor warms up, the oil viscosity changes and the setting will change. The final valve setting should be determined with the compressor running warm at the actual process conditions.

Once the valve has been properly set, tag the valve accordingly and set the locking collar for the high-pressure valve.

Compressor Base or Crankcase, Injection Pump and Head Assembly

For each of these items, an assembly drawing and associated bill of material has been provided. The assembly drawings show a cross sectional view of the appropriate assembly and calls out the various items. Assembly notes, instructions, fastener torque, etc. are given on the drawing. The “Bill of Material” lists the individual items along with each items respective part number, description, material of construction and size.

⚠WARNING **After every disassembly of any component thoroughly clean all the items. Before assembly lubricate all threads with acceptable anti-seize lubricant. For any threads coming in contact with process gases ONLY use compatible lubricants for the applicable gases.**

Maintenance (continued)

Compressor Base Oil Reservoir Volumes

Following are the volumes of all the typical compressor frames used by PDC. These are volumes for just the crankcase. Keep additional oil on hand to accommodate volumes in the head assemblies.

PDC Crankcase	Oil Volume, US Quarts / Gallons	Oil Volume, Liters
PDC-3	3 Quarts / 0.75 Gal	2.84 L
PDC-4	7.5 Quarts / 1.85 Gal	7.0 L
PDC-5	4 Gal	15.14 L
PDC-8	4 Gal	15.14 L
PDC-13	9 Gal	34.07 L

Maintenance (continued)

Crankcase Oil Cross Reference List

1. Royal Purple Limited – Standard Oil supplied by PDC
    a. Poly-Guard ® FDA Synthetic hydraulic fluid
    b. ISO Grade 68 AW***
2. Castrol Oil Company (formerly Drydene Oil Co.)
    a. Paradene AW series hydraulic fluid
    b. ISO Grade 68 AW***
3. Arco Oil Company
    a. DU20 AW series hydraulic fluid
    b. ISO Grade 68 AW***
4. Exxon Oil Company
    a. NUTO H series hydraulic fluid
    b. ISO Grade 68 AW***
5. Mobil Oil Company
    a. DTE 20 series hydraulic fluid or DTE 10 Excel Series
    b. ISO Grade 68 AW***
6. Shell Oil Company
    a. Tellus series hydraulic fluid
    b. ISO Grade 68 AW***
7. General Oil Description
    a. Premium quality, thermally stable, anti-wear hydraulic fluid with rust / oxidation inhibitors and anti-foam additives. ISO Grade 68 AW. ***
8. American Chemical Technologies / Shell
    a. SafetyFluid FR series fluids / Eco Safe S3
    b. FR-68 and FR-100. ***

IMPORTANT **PDC uses Mobil® DTE 10 Excel Series (68AW) Oil in the crankcase. If any of the above recommended oils need to be used, flush the oil from crankcase and the heads with the above oils before using any of the recommended Oils.**

IMPORTANT **ISO Grade 68 AW is used in all PDC-3 and PDC-4 compressors. ISO Grade 100 AW shall be used in all PDC-8 and PDC-13 compressors which utilize a lap-fit plunger, typically on compressors with discharge pressures greater than 3500 psig. Consult the compressor specification sheet for which oil is specific to your machine.**

Lubricants for Assembly

Process O-rings

Gas Type	Type	Make	Name
Hydrogen	Lubricant	Loctite	No. 2970 Krytox or DuPont MolyKote HP-870
Oxygen	Lubricant	Loctite	No. 2970 Krytox
Other Gases	Lubricant	Dow Corning	High Vacuum Grease DC-150

Pipe Thread

Gas / Application	Type	Make	Name
Hydrogen	Lubricant	Dow Corning	High Vacuum Grease
Oxygen	Lubricant	Loctite	No. 2970 Krytox
Other Gases	Lubricant	Dow Corning	High Vacuum Grease
Air/Coolant, Line	Lubricant	Loctite	No. 567
MP and HP Fitting	Lubricant	Loctite, Swagelok	LB 771, LB8150 or Silver Goop(MS-TL-SGT)
Other NPT Threads	Lubricant	Loctite, Swagelok	LB 771, LB8150 or Silver Goop(MS-TL-SGT)
All Lines-NPT and Swagelok	Tape	Loctite	PTFE Pipe Thread Tape*

Bolt Lubricant

Application	Type	Make	Name
Superbolts	Lubricant	SUPERBOLT	Type JLG
Other Fasteners	Lubricant	Loctite, Swagelok	LB 771, LB8150 or Silver Goop(MS-TL-SGT)

Maintenance Schedule Matrix

Medium Pressure Systems Under 12,000 PSI (825 BAR)

Maintenance Function	Daily	*First* 50 hours	*First* 300 hours	Every 2,000 hours	Every 4,000 hours	2 years 8,000 hours
Lube Oil Levels	*					
Lube Oil Pressure	*					
Cooling Water Flow, Temperature and Pressure	*					
Abnormal Noise or Vibration	*					
Motor Load	*					
Control System Functionality	*					
Instrumentation Functionality	*					
Heaters and Heat Trace Functionality	*					
Leak Detection System Status	*					
Initial Oil and Oil Filter Change, Inspect Oil Strainer		*				
Initial Process Inlet Filter			*			
Regular Oil and Oil Filter Change, Inspect Oil Strainer, Verify Oil Regulating Valve Set Points				*		
Diaphragms and Diaphragm O-Ring Seals (Replace)					*	
Process Check Valves in all Stages (Replace)					*	
Process Gas Filters and Coolant Filter (Replace)					*	
Inspect Crankcase Assembly (External)					*	
Inspect Compressor Lower Head (External)					*	
Inspect Injection Pump Assembly (External)					*	
Fuses					*	
Control System Functionality					*	
Instrumentation Functionality					*	
Drive Belts						*
Oil Inlet Check Valve (Replace)						*
Oil Relief Valve (Replace)						*
Injection Pump Plunger, Sleeve, And Foot Assembly						*

Maintenance Schedule Matrix

High Pressure Systems Over 12,000 PSI (825 BAR)

Maintenance Function	Daily	*First* 50 hours	*First* 300 hours	Every 2,000 hours	Every 4,000 hours	2 years 8,000 hours
Lube Oil Levels	*					
Lube Oil Pressure	*					
Cooling Water Flow, Temperature and Pressure	*					
Abnormal Noise or Vibration	*					
Motor Load	*					
Control System Functionality	*					
Instrumentation Functionality	*					
Heaters and Heat Trace Functionality	*					
Leak Detection System Status	*					
Initial Oil and Oil Filter Change, Inspect Oil Strainer		*				
Initial Process Inlet Filter			*			
Regular Oil and Oil Filter Change, Inspect Oil Strainer, Verify Oil Regulating Valve Set Points				*		
Diaphragms and Diaphragm O-Ring Seals (Replace)				*		
Process Check Valves in all Stages (Replace)				*		
Process Gas Filters and Coolant Filter (Replace)					*	
Inspect Crankcase Assembly (External)					*	
Inspect Compressor Lower Head (External)					*	
Inspect Injection Pump Assembly (External)					*	
Fuses					*	
Control System Functionality					*	
Instrumentation Functionality					*	
Drive Belts						*
Oil Inlet Check Valve (Replace)						*
Oil Relief Valve (Replace)						*
Injection Pump Plunger, Sleeve, And Foot Assembly						*

This maintenance matrix timeframe is the maximum recommended hours PDC allows before replacing. These components may need to be replaced earlier depending on how well the compressor is maintained, quality of the gas, climate, and other variables. Maintain a logbook for all maintenance activities.

- Keeping documents and pictures of worn parts is a great practice for referencing issues over time especially with diaphragms.

Before addressing any compressor issue, please follow all applicable safety procedures. If there are any uncertainties about the disassembly, reassembly, or functionality of the compressor and/or components please contact PDC Machines for assistance.

- Properly shut down the compressor. Allow hot components to cool prior to proceeding with maintenance.
- Ensure that the work area is clean and free of obstacles/hazards.
- Observe LOCK OUT/ TAG OUT REQUIREMENT OF THE SIGHT.
- Isolate the compressor from all main service connections such as electrical, process, cooling water, instrument air, etc. Lock-out/tag-out procedures should be used to prevent the services from being accidentally restored.
- Vent residual pressure from all piping, compressor heads, etc. in a safe manner in accordance with SOP's.
- **Always use the proper tools and other equipment to perform maintenance.**
- Never place your hand or arm inside the crankcase without ensuring the crankshaft cannot rotate and has been mechanically prevented from doing so.
- After any maintenance, carefully observe the compressor for a period of time necessary to assure the compressor is operating normally.
- **Recheck the integrity of the diaphragm leak detection system after EVER MAINTENANCE EVENT.**

Hydraulic oil viscosity is greatly affected by temperature. In colder climates, the oil may need time to warm up before checking any hydraulic oil pressure gauges.

Lube Oil Levels

Check Daily

While the compressor is running make sure the oil level is 75% filled. This is visible through the sight glass located on the front of the crank case. Fill if needed through fill port or breather tube.

Oil Sight Glass

*Make sure compressor is off while adding oil
*Ensure the same oil (Brand and Weight) are used for filling and/or replacing
-Never mix oil. This can cause foaming and impact the performance of the compressor
*Never over fill
*Oil level should never exceed full on the sight glass while compressor is in operation. This will result in aeration of the oil, resulting in cavitations and potential damage to the compressor.
*Change oil and oil filters elements immediately if the oil viewed in the sight glass is abnormally discolored. Black colored oil is always reason for immediate shut down and inspection.

Lube Oil Levels

Check Daily

PDC 3 & 4	Oil pressure gauge located on the front right of the crank case should read 15 psi that feeds oil into the bearing housing and injectors.	
PDC 4-150%	Oil pressure gauge located on the front right of the crank case should read 15 psi that feeds oil into the injectors. Oil pressure gauge on the left ensures 40 psi is going into the bearing housing. If the gauge is not at 40 psi, the pressure control valve (PCV) can be adjusted to achieve this reading. This is only on PDC 4-150%	
PDC 13	Oil pressure gauge located on the front of the crank case should read 80 psi that feeds oil into the bearing housing. If the gauge is not at 80 psi, the pressure control valve (PCV) can be adjusted to achieve this reading.	

Cooling Water Flow, Temperature and Pressure

Check Daily

Flow indicator can show that the coolant is circulating through each component and give a general rate of flow by seeing how fast or slow the indicator spins. They cannot give you an accurate flow rate measurement.	
Flow switches will tell the PLC controls that coolant is flowing through the system. If little or no coolant is flowing this will set off an alarm and shut down the machine.	
Sight glass on the coolant reservoir tank will show you the coolant level. Be sure to maintain a safe level.	
Coolant pump circulates coolant through the entire coolant system and should read 40 psi on the gauge attached to it.	

Abnormal Noise or Vibration

Check Daily

Abnormal Noise	
Compressor Knocking	Cavitation (can cause vibration too)
Hissing	Leak
Chirping	Check valve, belts, ORV

Vibration	
Pad, grouting and anchors	Make sure pad and grouting are to PDC standards and anchor bolts are torqued
Head support	Make sure the head support is secure and correctly installed
Shipping bar	Ensure the shipping bar is either detached from the frame or pedestal. The shipping bar does not need to be removed as long as it is not connected.

Motor Load

Check Daily

An In-Line AMP Meter can be installed on the customer's scope if it is installed by a licensed electrician and follows all codes and standards.

* If the motor is drawing higher amperage during normal operating conditions, a restriction in gas flow, running over designed pressure, too much Hydraulic pressure or other factors can be occurring requiring the motor to work harder.

Instrumentation Functionality

Check Daily

Ensure that the screen and all buttons function properly	

Control System Functionality

Check Daily

Inspect all gauges, sensors, transmitters, temperature elements and any applicable instrumentation for correct reading, damage, and performance.

This is an example of a gauge with no pressure on it however the dial is no longer set at zero. Replace or recalibrate through certified source.

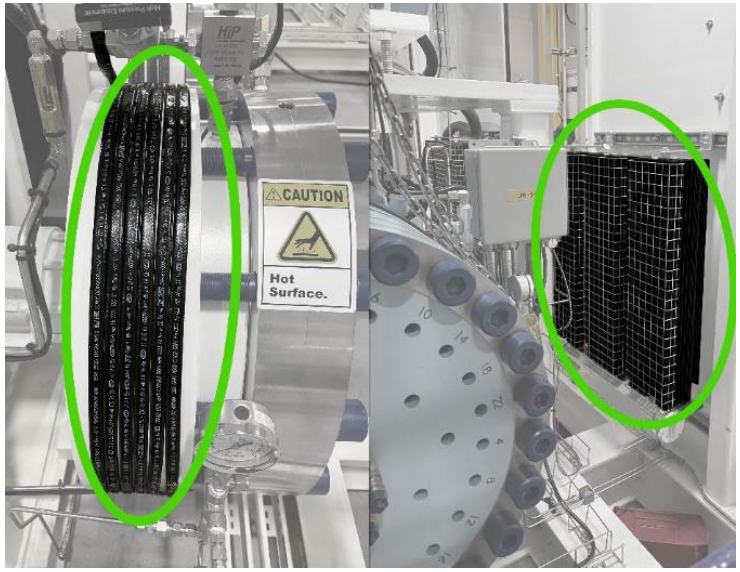
Heater and Heat Trace Functionality

Check Daily

Heat trace is wrapped around Hydraulic head and oil lines to maintain better viscosity in colder climates. Check for both damage and functionality.

Heaters may also be installed based on the climate. Check for both damage and functionality.

* Running the compressor in cold climates without heaters or heat trace will damage the compressor.



Leak Detection System Status

Check Daily

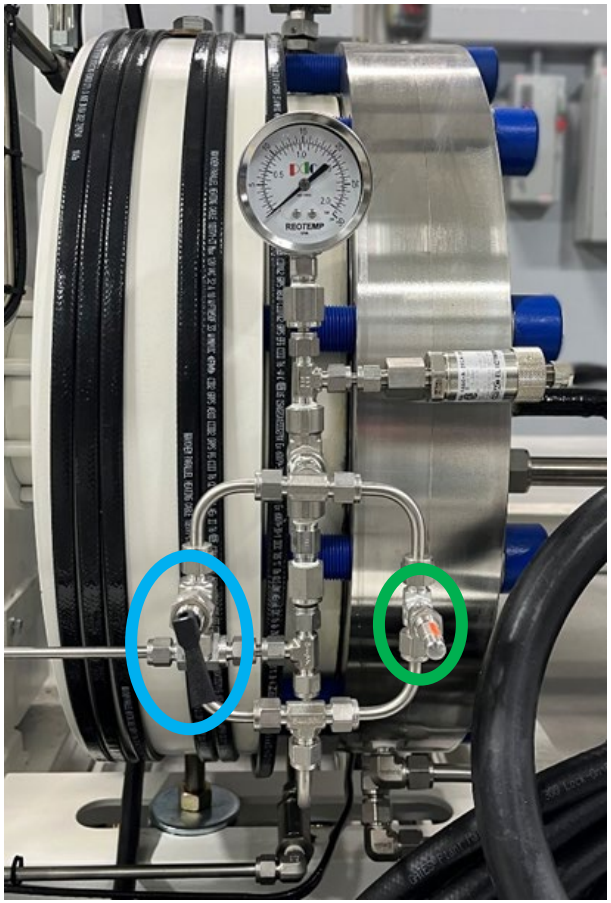
The leak detection gauge on each head should read zero. If the gauge shows any pressure reading this could indicate a diaphragm and/or O-ring failure.

Notify the proper personnel and check this issue.

The metering valve (circled in green) allows a very small amount of gas to be released from the permeation of hydrogen through materials. This is a factory set and should not be adjusted.

The toggle valve (circled in blue) can be used to release any built-up pressure that would cause a false leak detection reading, for example air that was trapped in between diaphragms after they have been changed. If pressure is released, then builds back up other issues may be occurring.

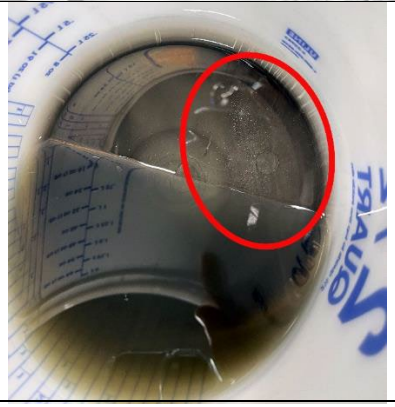
*Leak Detection must have its own separate vent line does not combine with Safety Relief Valves AOV's or anything else.



Initial Oil and Oil Filter Change, Inspect Oil Strainer

First 50 Hours

Place a pan or bucket under the drain valve. Remove end cap (ensure the yellow valve is closed first) Open valve and drain oil. Remove and replace oil filter. * Fill element and/or housing with oil during reassembly. This will reduce the time components do not receive lubricant during the subsequent start-up. *Inspect gaskets and seal rings in the filter housings, replace as required.		
Place a pan or bucket under the fitting located under each oil head of the compressor. Remove the fitting from the port and drain the oil from the head Open the oil bypass valve next to the Oil Relief Valve (ORV) on the top of the head.		

Remove the magnet filter plug (blue) and clean. Remove large front bolt (green) on the “Y” Body strainer and remove and clean strainer. Reassemble and ensure it does not leak	
When changing the oil, inspect old oil for metal flakes	

Initial Process Inlet Filter

First 300 Hours

This filter is on the customer side of installed components before the supplied gas enters the compressor. Depending on the quality of the gas, this filter may need to be checked/replaced more frequently.

PDC Machines recommends a 5-10 micron filter that is appropriately sized for the pressure, flow and gas being used.

*If the Gas molecule is large, having a low micron filter can restrict flow and suffocate the compressor causing damage.

Regular Oil and Oil Filter Change
Inspect Oil Strainer
Verify Oil Regulating Valve (Blue) Set Points

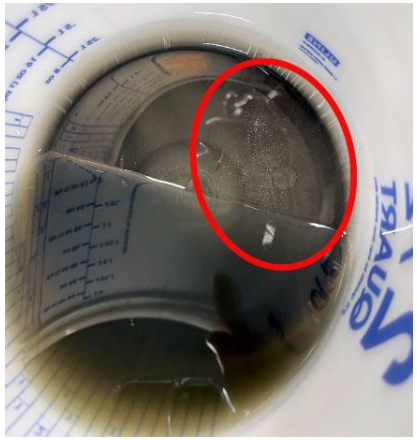
Every 2,000 hours

Place a pan or bucket under the drain valve.
Remove end cap (ensure the yellow valve is closed first).
Open valve and drain oil.
Remove and replace oil filter.
*Fill element and/or housing with oil during reassembly. This will reduce the time components do not receive lubricant during the subsequent start-up.
*Inspect gaskets and seal rings in the filter housings, replace as required.

Place a pan or bucket under the fitting located under each oil head of the compressor.

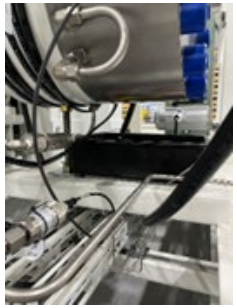
Remove the fitting from the port and drain the oil from the head.

Open the oil bypass valve next to the Oil Relief Valve (ORV) on the top of the head.

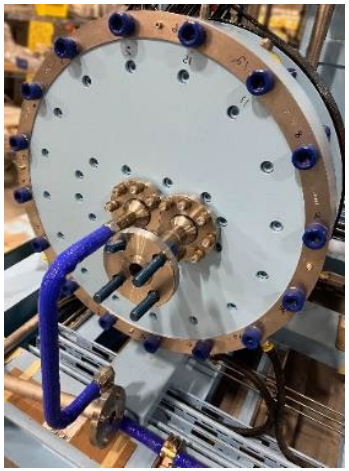
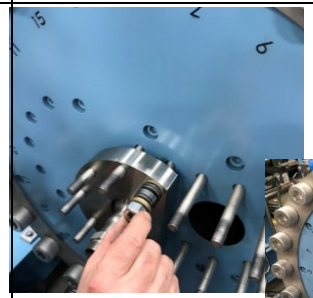
Remove the magnet filter plug (blue) and clean. Remove large front bolt (green) on the “Y” Body strainer and remove and clean strainer. Reassemble and ensure it does not leak.	
When changing the oil, inspect old oil for metal flakes	

Diaphragms and Diaphragm O-Ring Seals

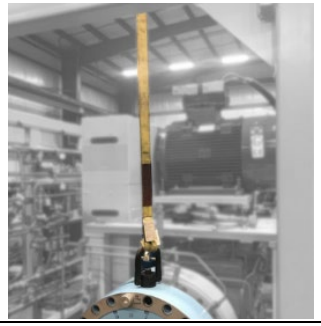
Every 2,000 hours

STEP 1	Isolate the compressor from all main service connections such as electrical, process, cooling water, instrument air, etc.	
STEP 2	Lock-out/tag-out procedures are to be used to prevent the services from being accidentally restored.	
STEP 3	Vent residual pressure from all process chambers. Purge compressor to ensure a safe working environment and that no hazardous gases are present when opening the compressor.	
WARNING	**Failure to properly isolate and vent the compressor will result in serious injury to personnel.**	
STEP 4	Review the Head Assembly drawing and associated Bill of Material (BOM). The Head Assembly drawings detail all assembled components in the head, as well as critical fastener torques, and assembly procedures if applicable. The Bill of Material lists the individual items along with each item's respective part number, description, material of construction, and size. The appropriate bill of material and correct assembly drawing are to be USED TOGETHER.	
IMPORTANT	Never replace diaphragms without replacing O-Ring seals at the same time or vice versa.	
STEP 5	Place a drip pan underneath the compressor head. Be sure it is large enough to contain the fluid of the head during disassembly. If the head is equipped with a drain valve, drain the head of oil. If not, drain head per instructions on page 14. Disassembly of the head will allow remaining oil to drip into the drip pan. Replace all plugs and remove containers once the oil has drained.	

Diaphragms and Diaphragm O-Ring Seals Continued

STEP 6	Remove cooling water connect (if they exist) and drain coolant out of head	
STEP 7	Remove process tubing going to the heads. • Tape off ends of process tubing to ensure no debris enters system.	
STEP 8	Remove check valve retainers and check valves. • Ensure the orientation of the Belleville washers is recorded for correct reinstallation. • Remove check valves. An extraction may be needed. 15,000 psi heads have check valves attached to check valve retainer via check valve retaining clip. *Replace all Belleville washers after 2 uses	 

Diaphragms and Diaphragm O-Ring Seals Continued

STEP 9	Securely attach the hoist ring to the lifting point on the top of the gas process head. Attach lifting strap/chain to hoist and hoist ring ensuring hoist is directly over top of hoist ring. Apply tension to the strap to support the head. *Ensure that all lifting equipment is rated to support the weight of the head.	
STEP 10	Loosen head bolts half turn at a time in the same pattern in which you would re-torque them until torque pressure is minimal. This torque pattern will either be stamped on the head or represented on a plate fastened to the head. Leave 2 bolts, one on top and bottom, slightly loosened but not allowing the heads to separate to prevent debris from entering the diaphragm area. This also prevents the head from swinging and searing off the heads of the cap screws and causing other damage. Adjust the lifting hoist as needed to remove weight on the bolts. Remove last 2 bolts.	
STEP 11	Lift and move the head away from the compressor to a safe secure area where it can be cleaned and prepared for reassembly. Take caution to ensure that the process head does not collide with the lower head to prevent damage to cavity surfaces and O-ring grooves.	

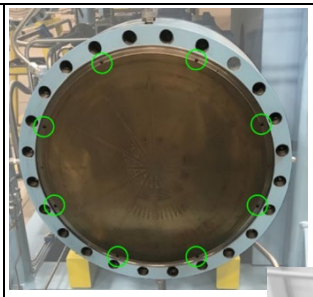
Diaphragms and Diaphragm O-Ring Seals Continued

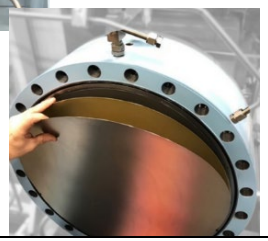
STEP 12

The diaphragm set is sandwiched between the process head (just removed) and the lower head.
There are (3) diaphragms in the set and they are held in place by a series of cap screws around the perimeter.

Remove the cap screws (the amount may vary).

Carefully hold the diaphragms around the edges and remove the used diaphragm set.



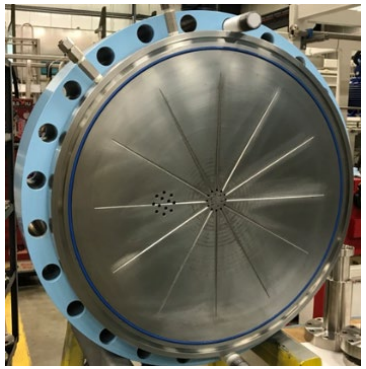


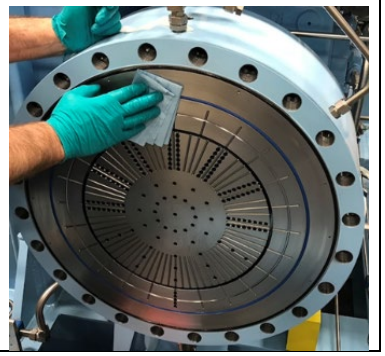
WARNING

Diaphragms are made from thin sheet metal and have very sharp edges. Exercise caution when handling diaphragms to prevent cutting your hands and fingers.

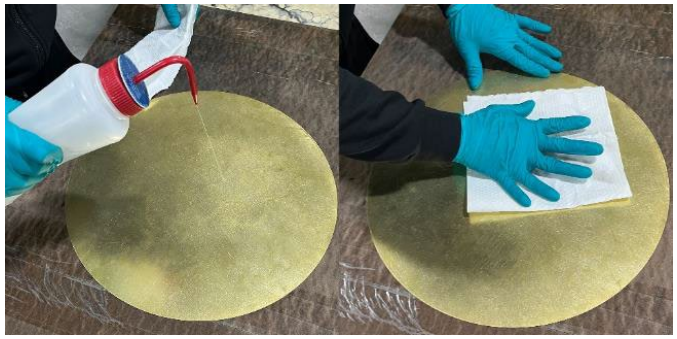
STEP 13

There are (3) O-Ring seals, (1) in the face of the process head and (2) in the face of the lower head. Carefully remove the used O-Rings, taking care not to damage the sealing areas.

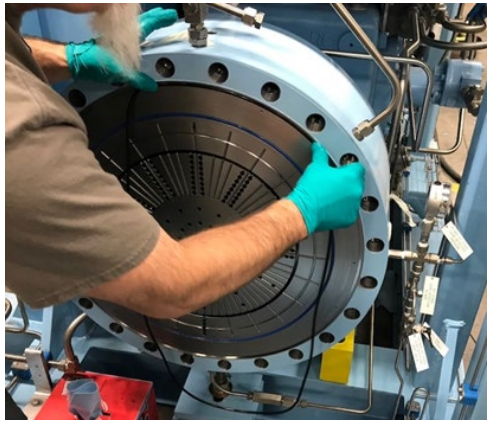




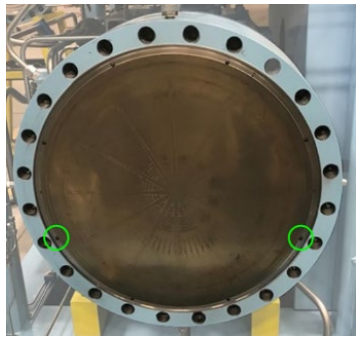
Diaphragms and Diaphragm O-Ring Seals Continued

STEP 14	Using clean solvent (Naptha, Acetone, or similar) and rags, wipe the face of both heads clean and new diaphragms. Clean again with Denatured Alcohol to remove any remanence of cleaning solvent.	
STEP 15 (Gas Head)	Carefully wipe the O-Ring grooves clean and clean them with cotton swabs. Deposits that will not wipe off can be polished with 600 grit sandpaper or scotch brite until removed. Score marks can be polished until they are flush or below the cavity surface. Check Valve holes are to be cleaned with cotton swabs. Ensure ALL surfaces of the diaphragms, gas process head and oil head clean and free of debris	 

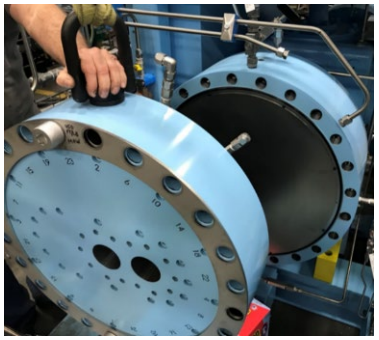
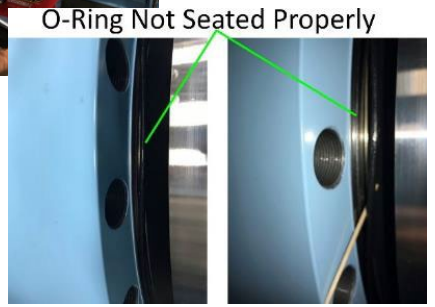
Diaphragms and Diaphragm O-Ring Seals Continued

STEP 16 (Oil Head)	Wipe a coating of High Vacuum Grease on the OIL O-Ring and LEAK DETECTION O-Ring ONLY. High Vacuum Grease helps hold the O-Rings in place during assembly. While applying grease ensure not to stretch out O-Rings.	 
STEP 17 (Oil Head)	Install Leak Detection O-Ring in outer most groove and the Oil O-Ring on the inner most groove. Wipe off excess vacuum grease.	

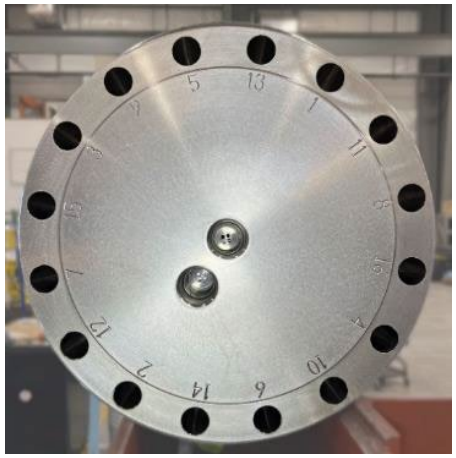
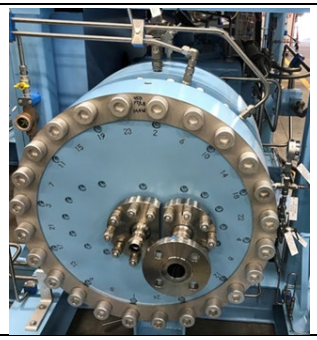
Diaphragms and Diaphragm O-Ring Seals Continued

STEP 18 (Oil Head)	Install 2 (cleaned) cap head screws near the bottom of the oil head. These will loosely hold the 3 new diaphragms in place while installing the rest of the (cleaned) cap head screws. DO NOT TORQUE DIAPHRAGM RETENTION SCREWS DOWN.	 
WARNING	**DO NOT TORQUE THE CAP SCREWS DOWN. They only hold the diaphgrams in palce until gas process head is installed.**	
STEP 19 (Gas Head)	Ensure the Gas Process Head has been thoroughly cleaned. Place a thin coat of Krytox Grease on the Gas process O-Ring. Install Gas process O-Ring carefully and wipe off excess Krytox.	 
IMPORTANT	**Krytox is use on the Gas Process Head only to prevent build up of foreign material on the diaphgram that will lead to premature failure. Gloves should be worn while using Krytox.**	

Diaphragms and Diaphragm O-Ring Seals Continued

STEP 20	Carefully position the Gas Head inline with the oil head, lining up the bolt holes. Use caution during this step, do not allow the heads to collide or swing freely. Ensure that the Leak Detection O-ring is properly in place and did not pop out of the groove	
STEP 21	Hand tighten top and bottom bolts and adjust hoist of needed. Inspect the area between the head to ensure the O-Rings are still seated properly. Install all bolts and hand tighten. Inspect the area between the head again to ensure the O-Rings are still seated properly. A flashlight may be needed.	 
WARNING	**If an O-ring comes loose during this step, continuing to torque the bolts without correcting will result in damage to the heads.**	

Diaphragms and Diaphragm O-Ring Seals Continued

STEP 22	Tighten the bolts in increments of 25% of the final torque value specified on the drawing and in sequance specified on the Gas Process Head. **EXAMPLE:** **If final torque spec is 400 ft lb** **Step 1 at 100 ft lb all bolts in sequance** **Step 2 at 200 ft lb all bolts in sequance** **Step 3 at 300 ft lb all bolts in sequance** **Step 4 at 400 ft il all bolts in sequance** **Final step is varifing all bolts at 400 ft lb**	
WARNING	**Improper installation and torque can crack heads and cause other issues.**	
IMPORTANT	**If Super Bolts are used, refrence the Super Bolt Torque Procedure for installation**	
STEP 23	Replace check valves and retainers, torque retainers as specified on the drawing. Refer to 7 bolt document	
STEP 24	Replace the cooling water and process piping which was previously removed. Follow procedures for “Initial Startup and Priming” found in the “Operation” in Opreating Manual	

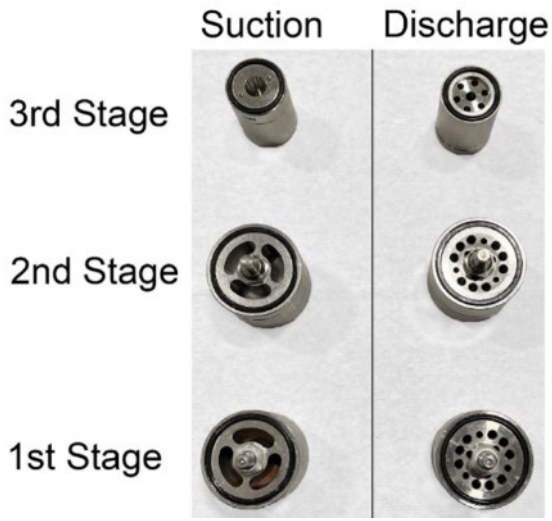
Process Check Valves (Replace ALL)

Every 2,000 hours

All suction, discharge, and inline gas check valves need to be replaced. Do not replace springs, poppets or any components but rather replace the WHOLE Check Valve.

Inline Process Check Valve

Suction and Discharge Check Valves



Process Gas Filter and Coolant Filter

Every 4,000 hours

Replace all process Gas Filters. Ensure the filters are being replaced with matching micron filtration size. • Supply gas filter • Interstage filter	
Replace Coolant Filter	

Inspect Crankcase Assembly (External)

Every 4,000 hours

Check all areas of the crankcase for loose bolts.

Breather plate bolts

PDC 13	PDC 4	PDC 3
200 Ft Lbs.	25 Ft Lbs.	25 Ft Lbs.

Cylinder bolts

PDC 13	PDC 4	PDC 3
200 Ft Lbs.	25 Ft Lbs.	25 Ft Lbs.

Pump End plate bolts

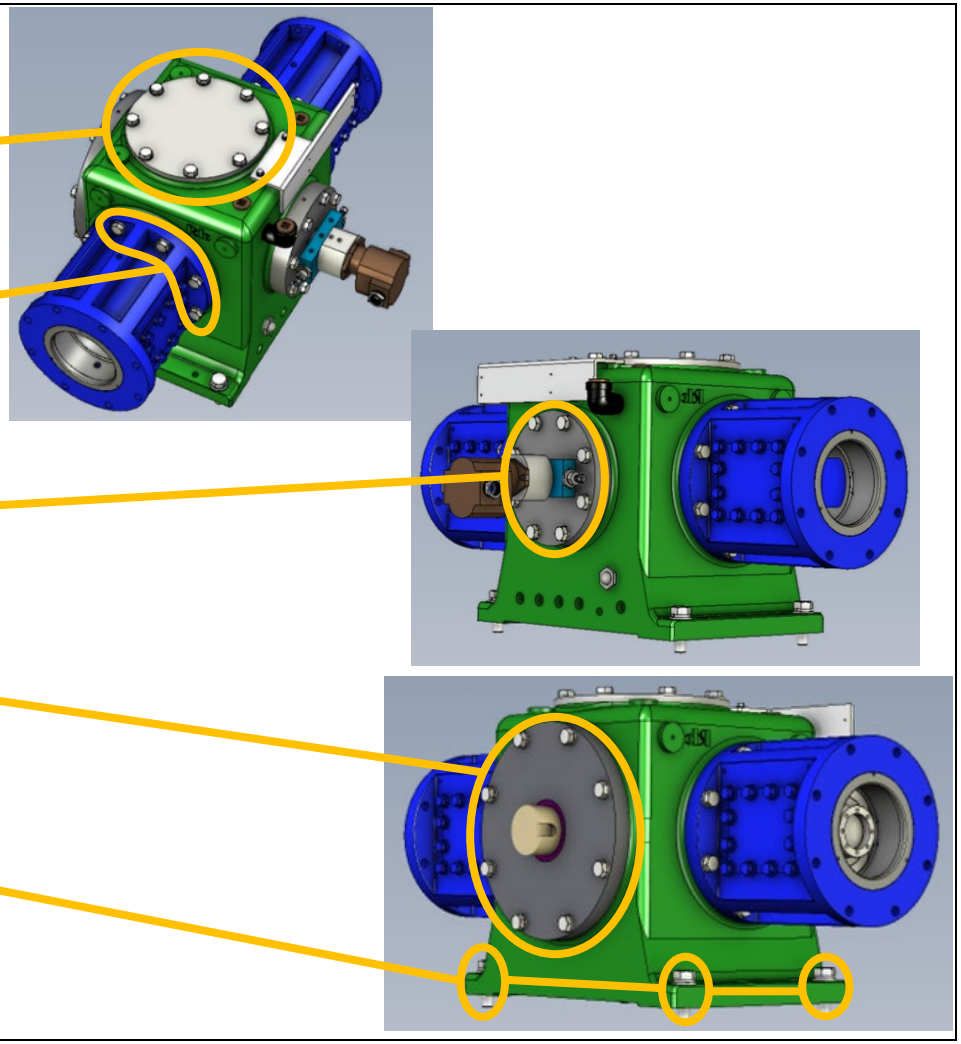
PDC 13	PDC 4	PDC 3
200 Ft Lbs.	50 Ft Lbs.	25 Ft Lbs.

Fly wheel End plate bolts

PDC 13	PDC 4	PDC 3
200 Ft Lbs.	50 Ft Lbs.	25 Ft Lbs.

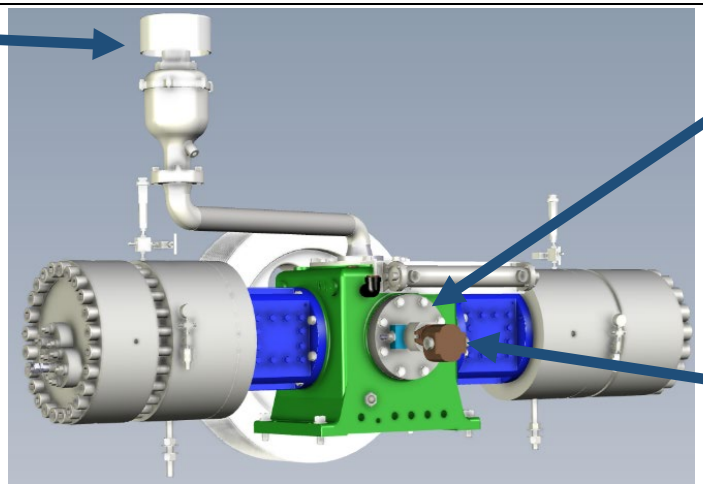
Pedestal bolts

PDC 13	PDC 4	PDC 3
250 Ft Lbs.	50 Ft Lbs.	25 Ft Lbs.



<u>Oil Breather Filter</u>
-ensure breather filter is not saturated with oil. Replace filter if saturated.

<u>Fitting leaks</u>
-inspect oil process tubing and fitting for leaks.

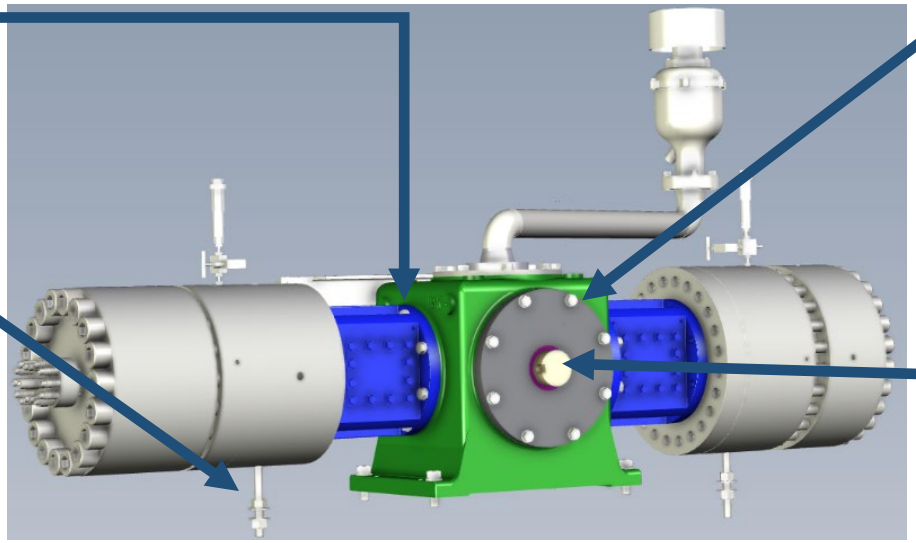


<u>Pump End Plate Seal</u>
-check around plate for leaks.

<u>Injection Pump Area</u>
-Check area for leaks

<u>Cylinder Seals</u>
-Check around area for leaks.

<u>Head Support</u>
-ensure all bolts are secure and installed properly. Improper installation can create excuse vibration.



<u>Fly Wheel End Plate Seal</u>
-Check around plate for leaks.

<u>Crank Shaft Seal</u>
-Check around seal for leaks

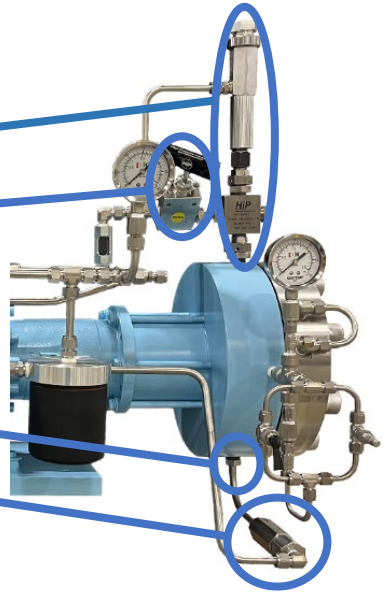
Inspect Compressor Lower/Oil Head (External)

Every 4,000 hours

Check all areas of the Oil Head for leaks.

- All Oil relief valve fittings
- Bypass valve fittings
- Oil inlet
- Oil check valve

Tighten fitting if needed. Use Swagelok gap checker to ensure all fitting are properly tightened.



Inspect Injection Pump Assembly (External)

Every 4,000 hours

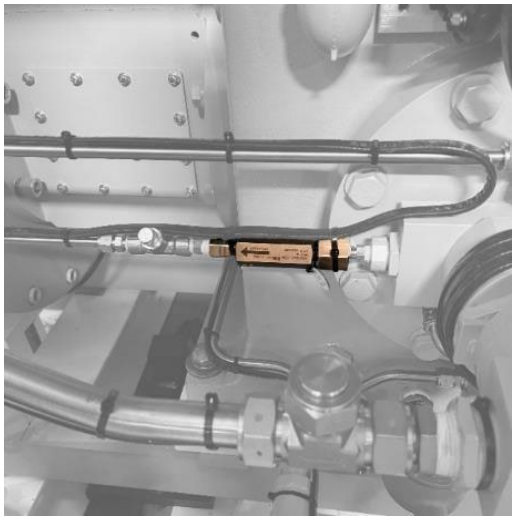
Check all areas of the Injection Pump and oil filter for leaks and loose fittings.

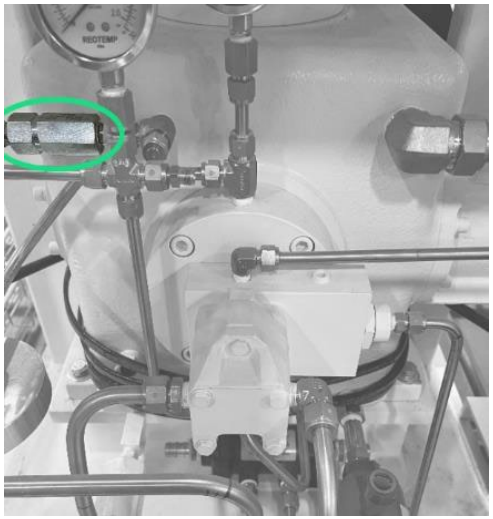
Use Swagelok gap checker to ensure all fitting are properly tightened.

Oil Inlet Check Valve (Replace)

Every 2 Years/8,000 Hours

All hydraulic check valves need to be replaced. Check valves are located under each process head. Depending on the compressor model hydraulic check valves can also be located after the injectors and overflows into the crankcase.





When reinstalling new hydraulic check valves, ensure the flow arrow is facing the direction of the flow of the hydraulic oil.

Oil Relief Valve (Replace)

Every 2 Years/8,000 Hours

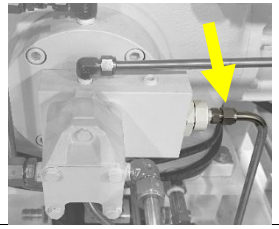
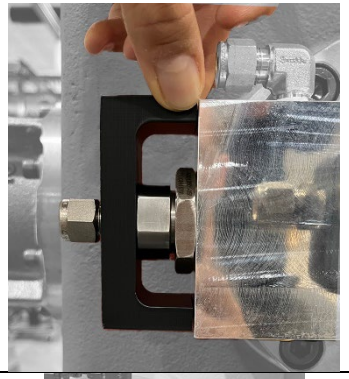
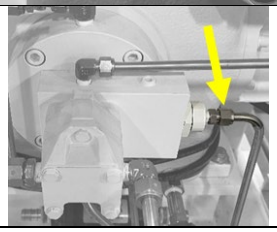
Ensure the compressor is off and bypass valve is open	
Remove Swagelok fitting connecting the oil line to the side of the ORV	
• Loosen set screws on the Thrust Nut (Blue circle) • Loosen Thrust Nut (Blue circle) • Remove Gland Nut and remove ORV (Green circle) *Only hand tighten set screws	

When reinstalling, torque the Gland Nut to 50 FT/LB into the ORV body.

ORV has internal components that will ware over time and the ORV will need to be replaced. For proper installation refer to the Oil Relief Valve instructions. Once a new ORV is installed it must be dynamically set with a gauge tree to ensure it is set to the proper pressure. Failure to set the ORV with a gauge tree can led to sever damage of the compressor.

Injection Pump Plunger, Sleeve, And Foot Assembly

Every 2 Years/8,000 Hours

Remove fitting from injector *excess oil will come out	
Remove injector	
Install new injector and set to proper depth with Injector Setting Block	
Reinstall fitting	

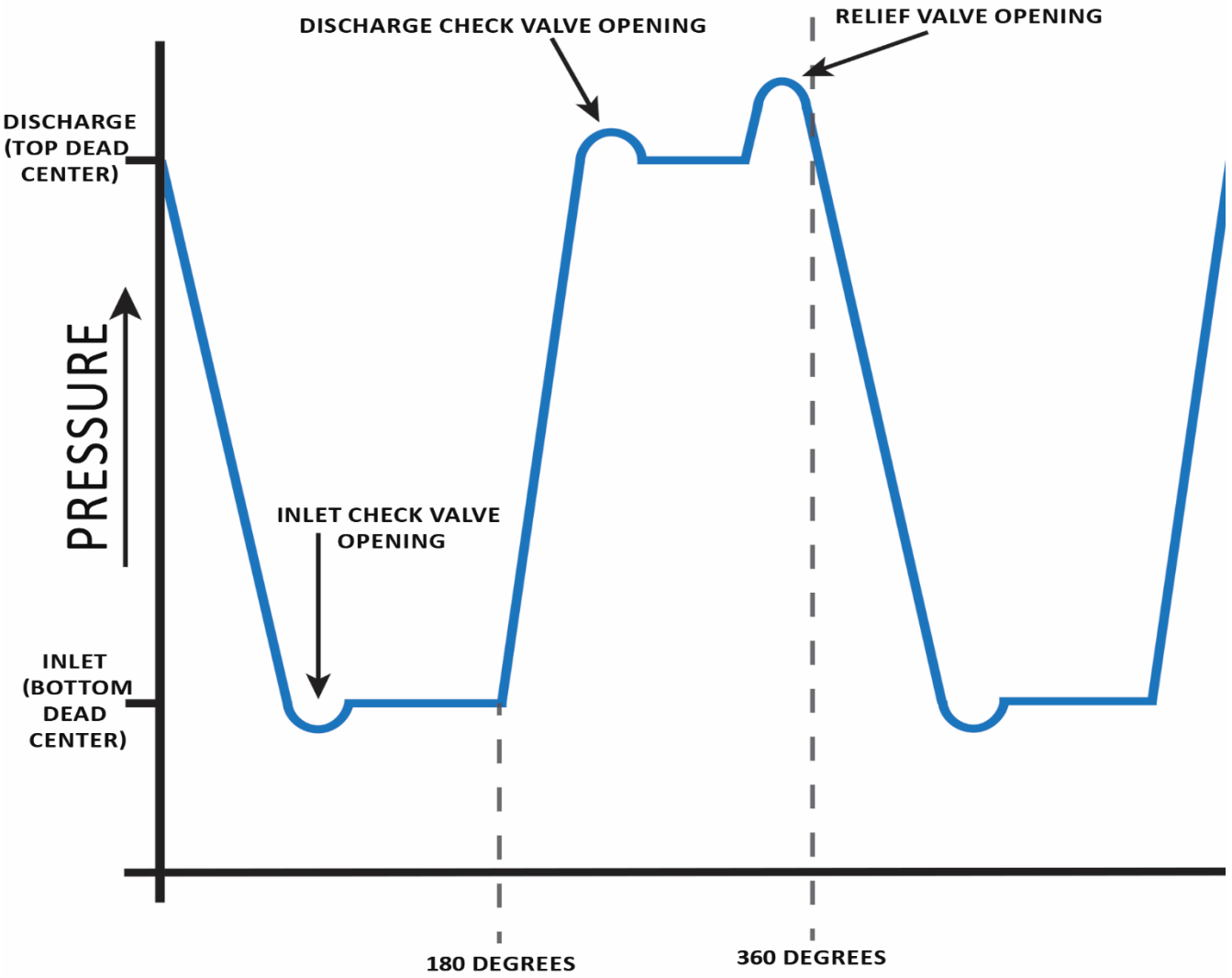
Troubleshooting

Below is a list of potential problems, causes and corrective actions to be taken:

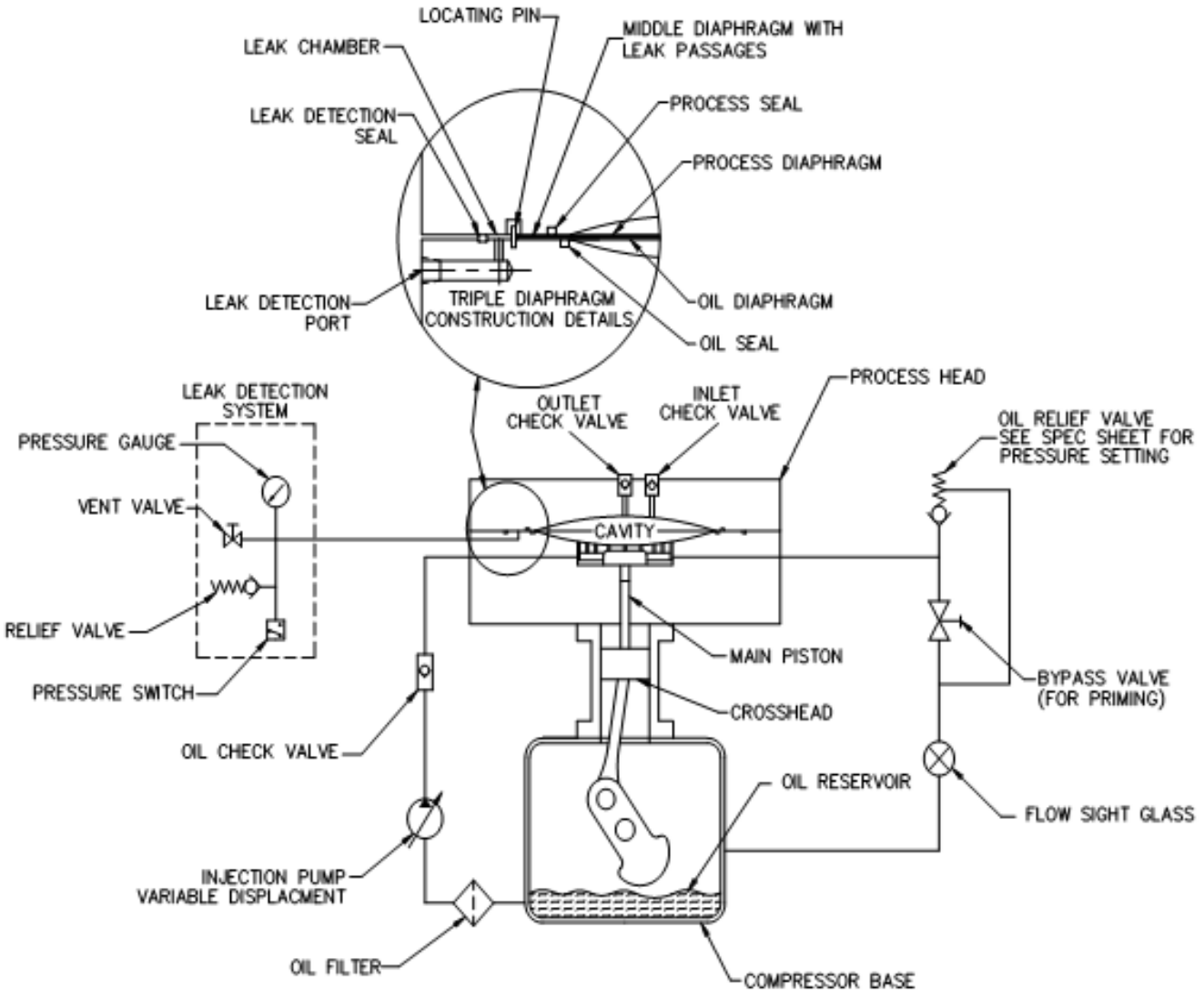
Problem	Cause	Corrective Action
Loss of prime, cavitation, excessive noise or vibration	Check oil level and pressure	Add oil to reservoir sump
	Oil relief valve bypass valve open under process load	Close valve and prime
	Worn, leaky oil relief valve	Replace and reset
	Leakage past main plunger, plunger seal rings, etc.	Disassemble and inspect Replace and repair as required
	Poor over-pump or injection pump flow	Adjust injection pump sleeve for max flow. Disassemble and inspect, repair, or replace as required
	Oil relief valve set too low.	Check setting and adjust as required
	Clogged or blocked line from reservoir to injection pump	Inspect line, strainer, filter, fittings, etc.
Decrease in flow or pressure	Loss of prime	See above
	Process check valves leaking	Inspect process check valves. repair or replace as required
	Excessive pressure drop	Lines and or piping components to small. Replace with properly sized equipment
	Piping leaks	Vent down pressure and repair any leaks
Inlet line gets hot	Inlet check valve leaking back	Vent down pressure and repair
Leak detection system	Diaphragm or head seal failure	Disassemble heads, replace
Motor overload	Suction pressure to high	Reduce suction pressure

Drawings

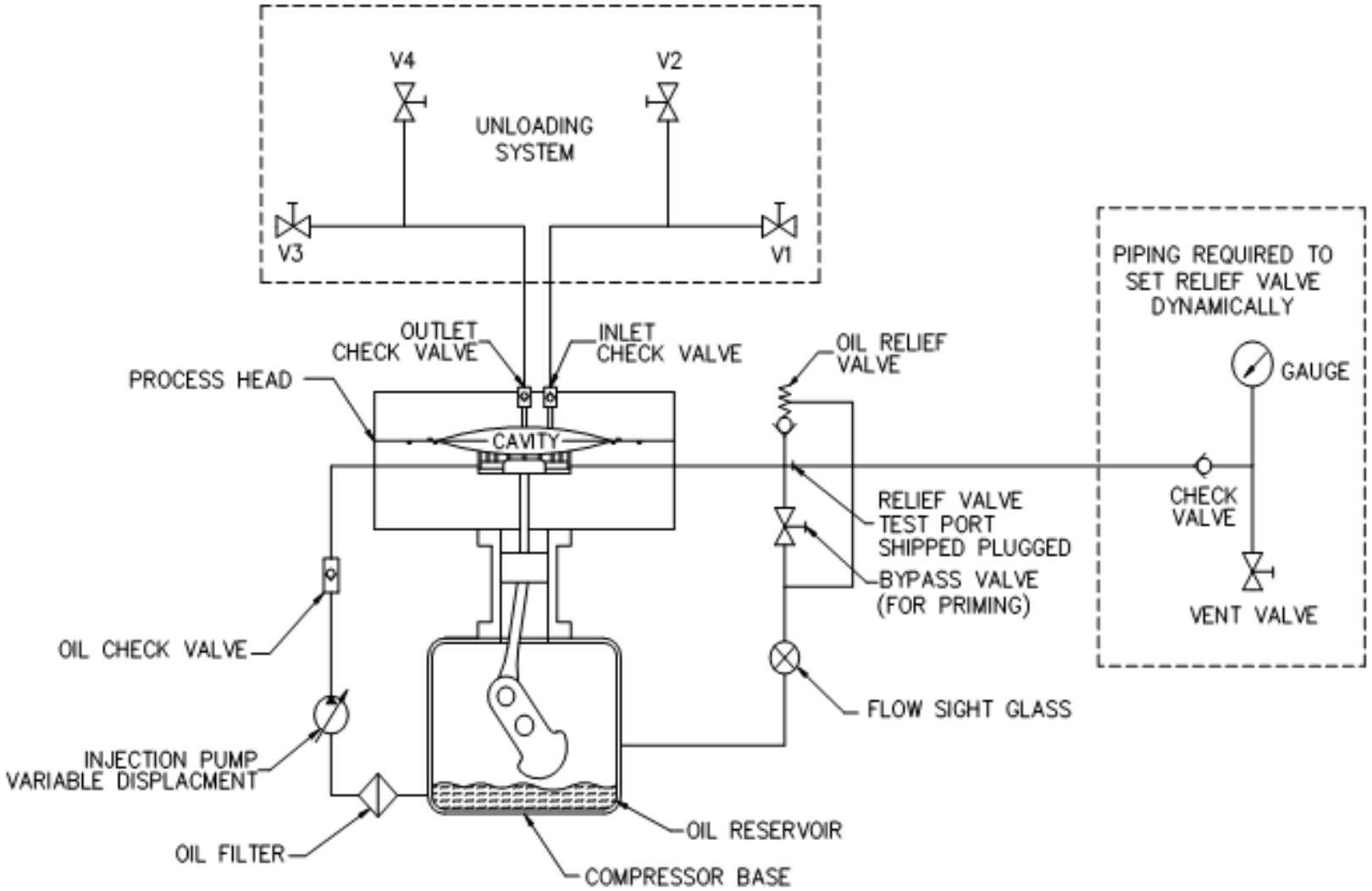
Drawing A0020001 – Hydraulic Pressure versus Crank Angle Curve



Drawing A0020002 – Basic Compressor Components



Drawing A0020004 – Compressor Accessories



Foundation Figures

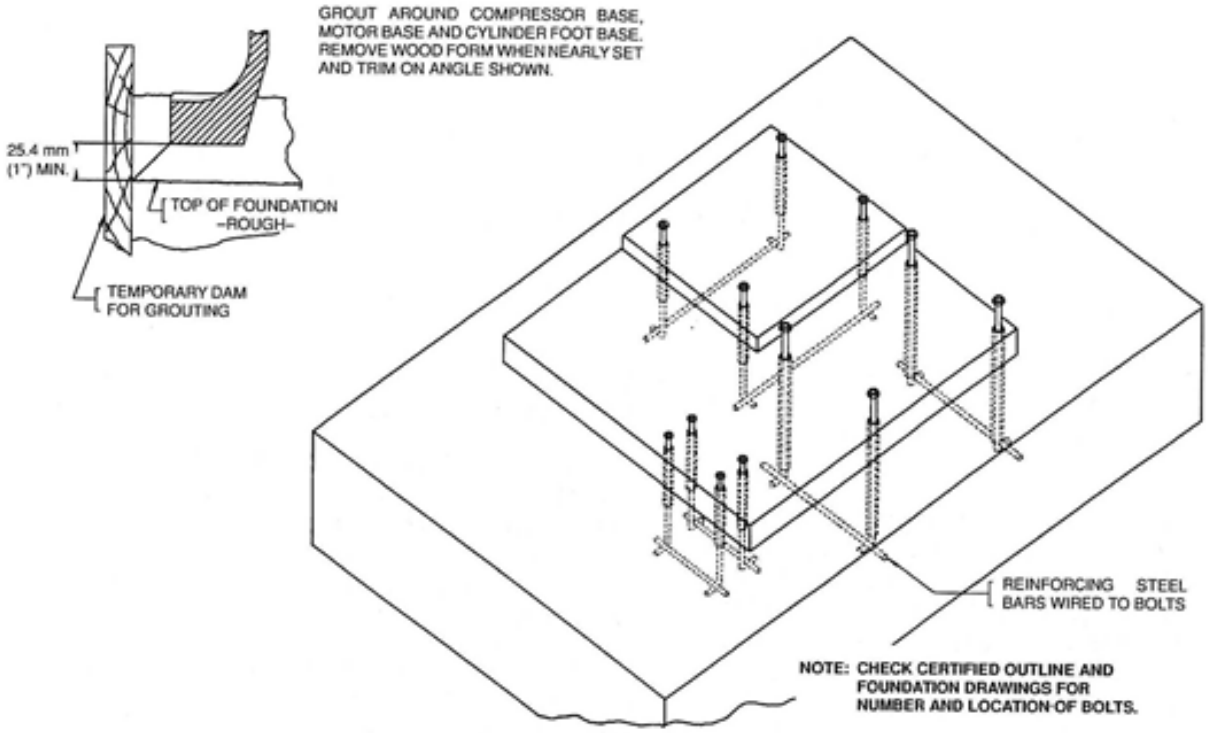


FIGURE 1–1 – TYPICAL FOUNDATION WHEN COMPRESSOR IS MOUNTED DIRECTLY ON FOUNDATION

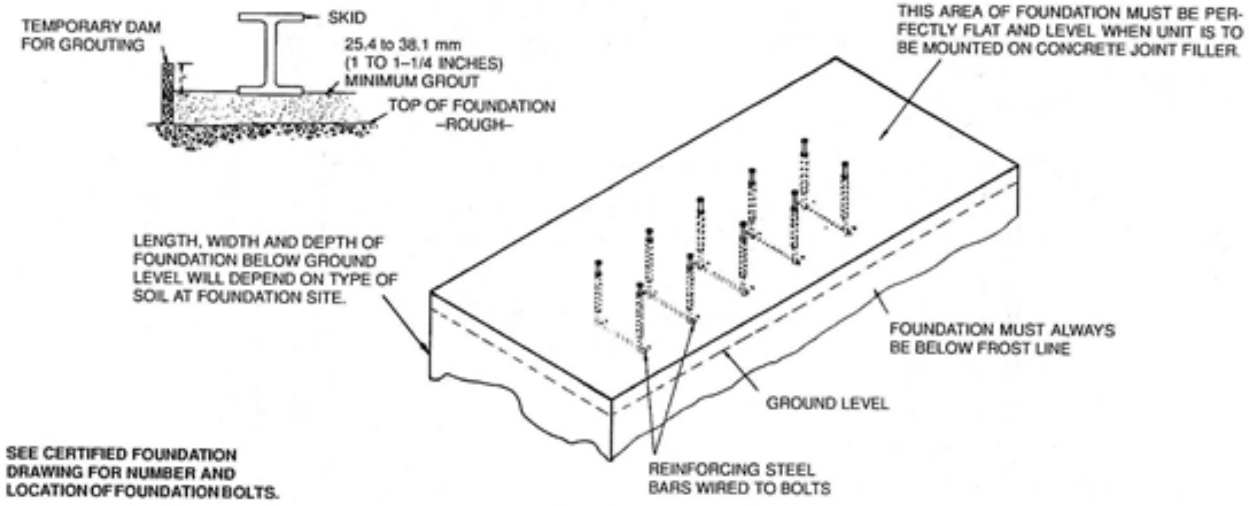


FIGURE 1–2 – TYPICAL FOUNDATION WHEN COMPRESSOR IS MOUNTED ON A STEEL BASE OR SKID

Foundation Figures- (Continued)

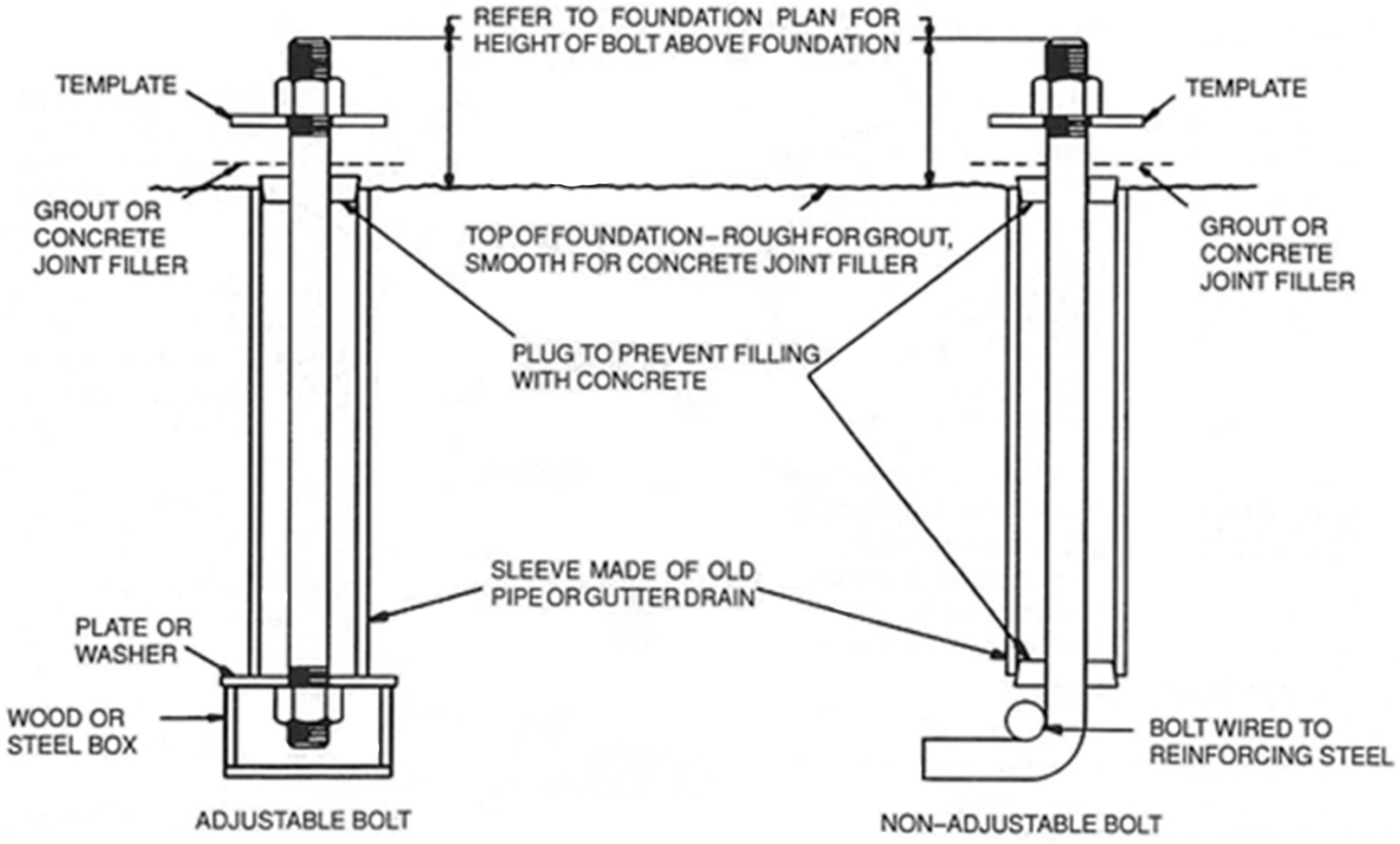
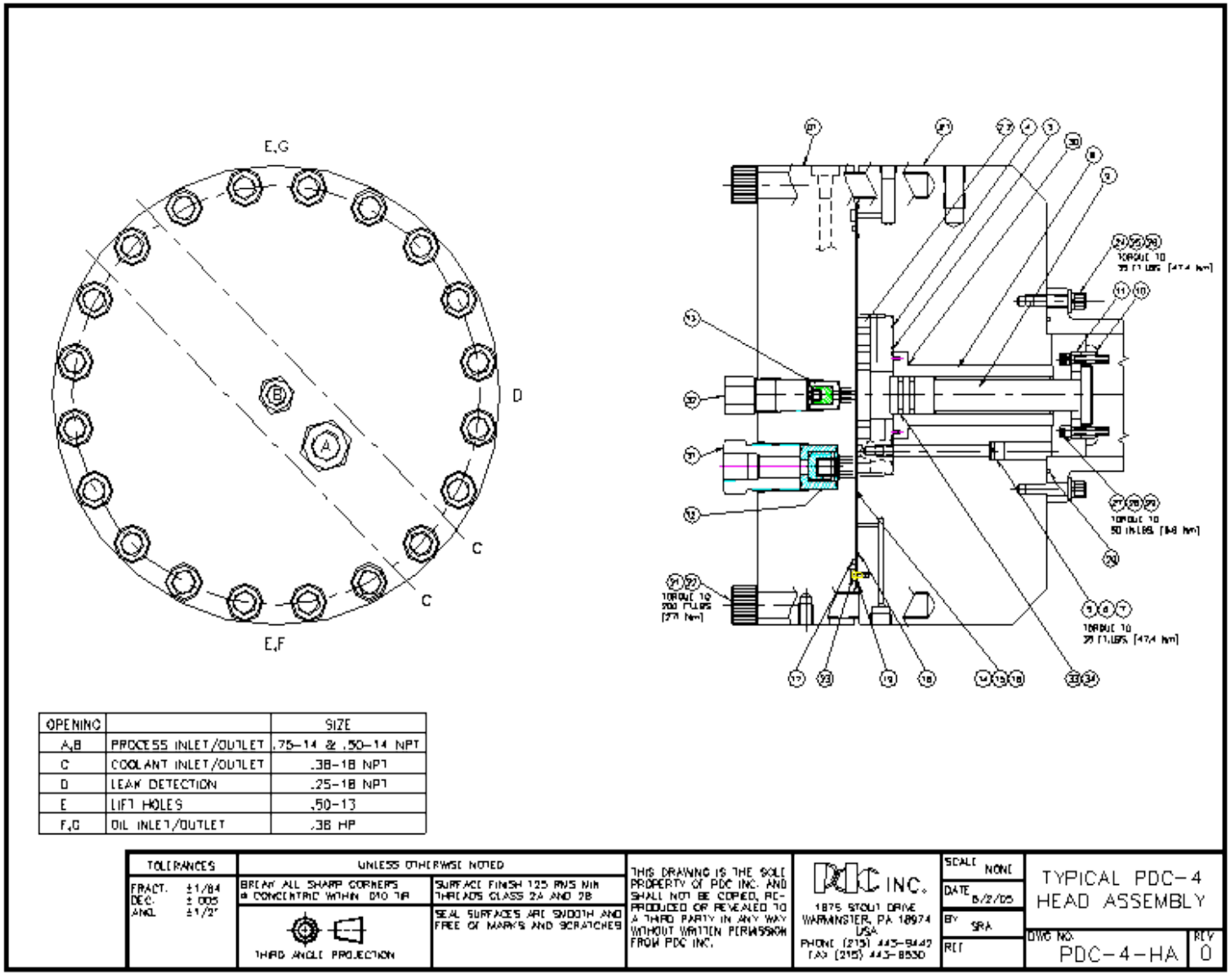


FIGURE 1–3 – FOUNDATION BOLTS

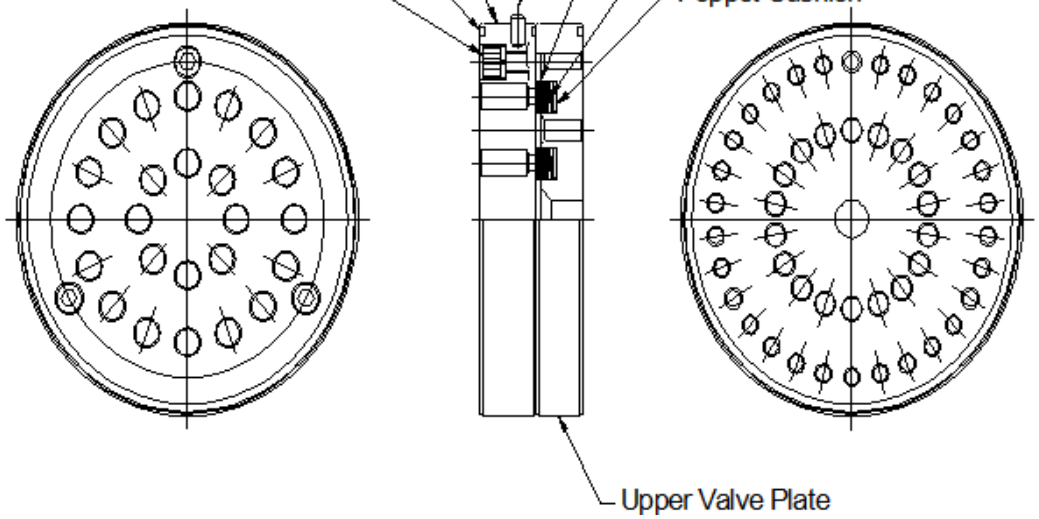
Typical Head Assembly Drawing

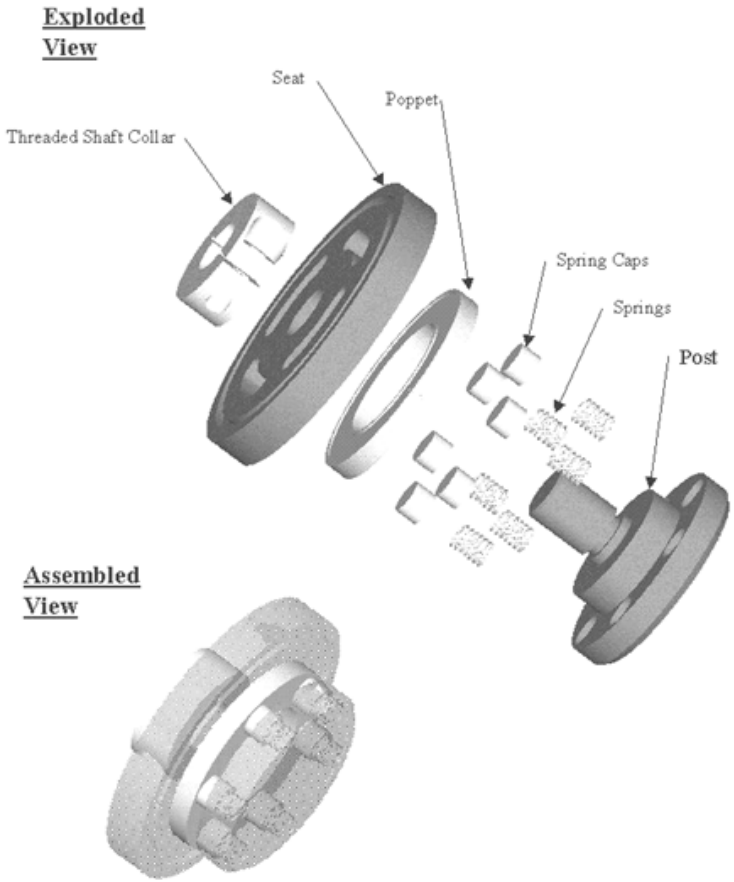


OPENING		SIZE
A,B	PROCESS INLET/OUTLET	.75-14 & .50-14 NPT
C	COOLANT INLET/OUTLET	.38-18 NPT
D	LEAK DETECTION	.25-18 NPT
E	LIFT HOLES	.50-13
F,G	OIL INLET/OUTLET	.38 HP

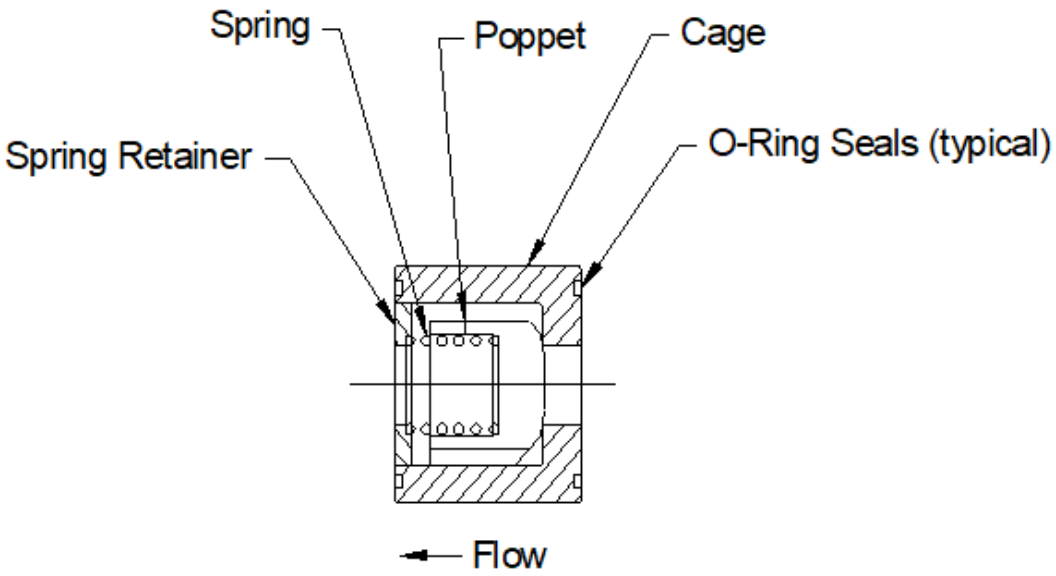
TOLERANCES	UNLESS OTHERWISE NOTED				
FRACT. ±1/64 DEC. ±.005 ANGL ±1/2°	BREAK ALL SHARP CORNERS ⌀ CONCENTRIC WITHIN .010 TIR THIRD ANGLE PROJECTION	SURFACE FINISH 125 RMS MIN THREADS CLASS 2A AND 2B SEAL SURFACES ARE SMOOTH AND FREE OF MARKS AND SCRATCHES	THIS DRAWING IS THE SOLE PROPERTY OF PDC INC. AND SHALL NOT BE COPIED, RE-PRODUCED OR REVEALED TO A THIRD PARTY IN ANY WAY WITHOUT WRITTEN PERMISSION FROM PDC INC.	PDC INC. 1875 STOUT DRIVE WARMINSTER, PA 18974 USA PHONE (215) 443-9442 FAX (215) 443-8530	SCALE NONE DATE 6/2/05 BY SRA REF	TYPICAL PDC-4 HEAD ASSEMBLY DWG NO. PDC-4-HA REV 0

Flat Disc Check Valves

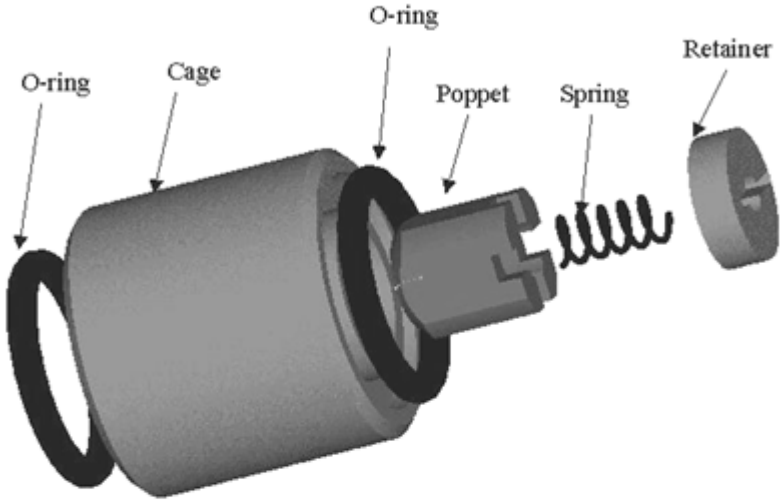




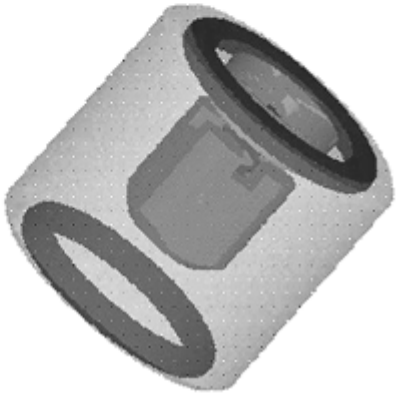
Cartridge Check Valves



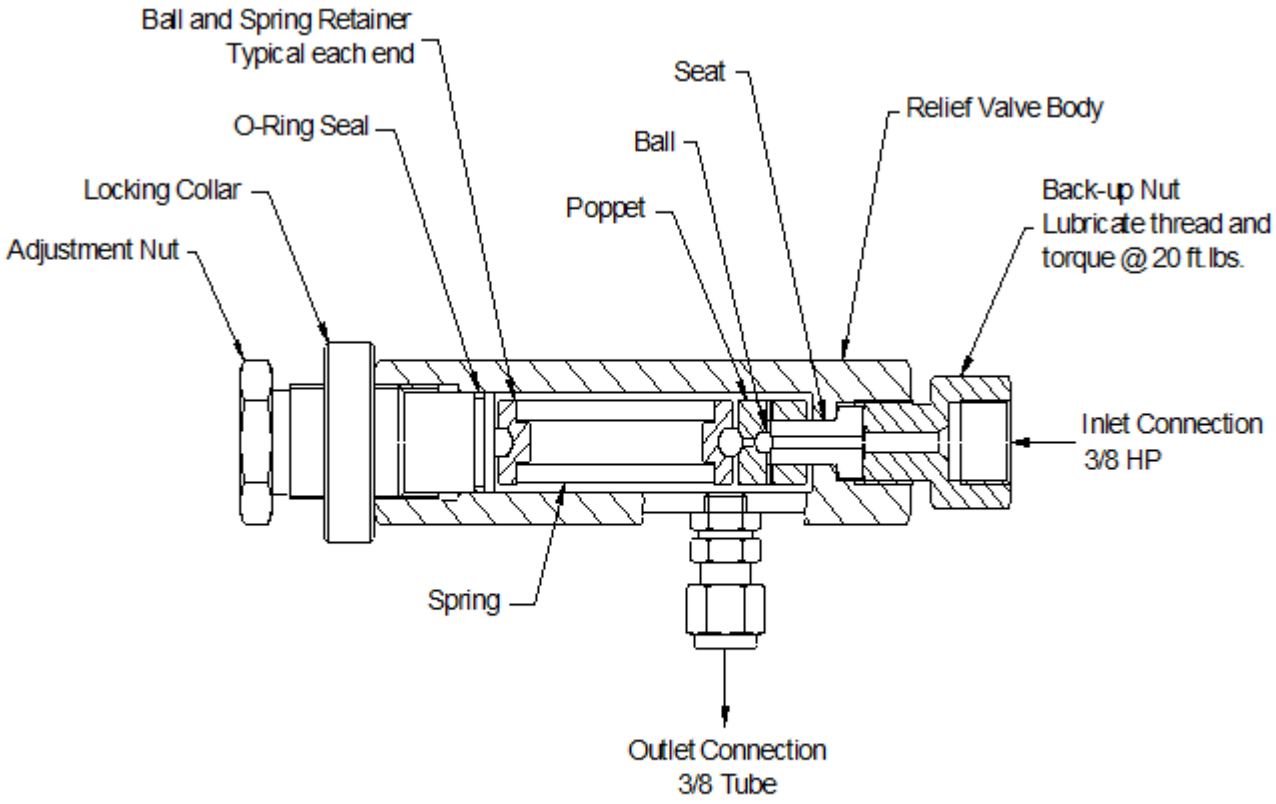
Exploded View



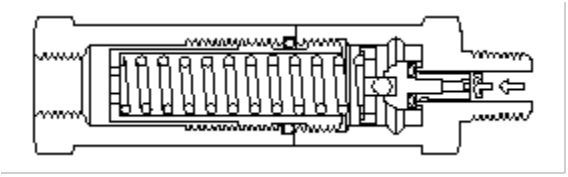
Assembled View



High Pressure Relief Valve

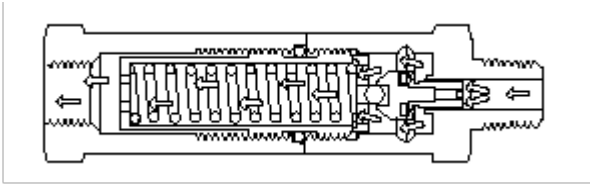


Low Pressure Relief Valve



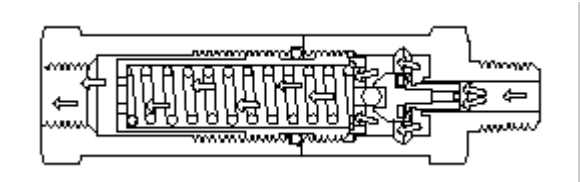
CLOSED

The spring load is carried by a metal-to-metal seat. The O-ring provides a dead tight seal. Sealing efficiency increases as the pressure increases up to the cracking pressure.



CRACKING

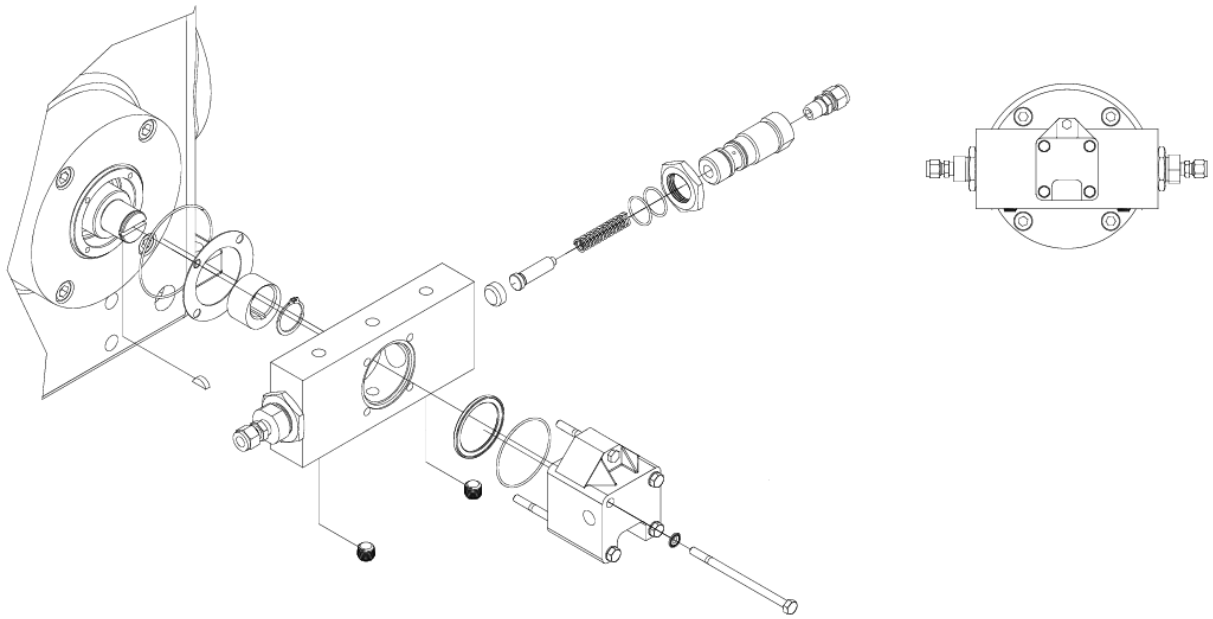
The ports in poppet open fully and eliminate rapid increase in the pressure. The flow is throttled between the poppet shoulder and the seat, which provides regularly increasing flow area with increasing flow rates.



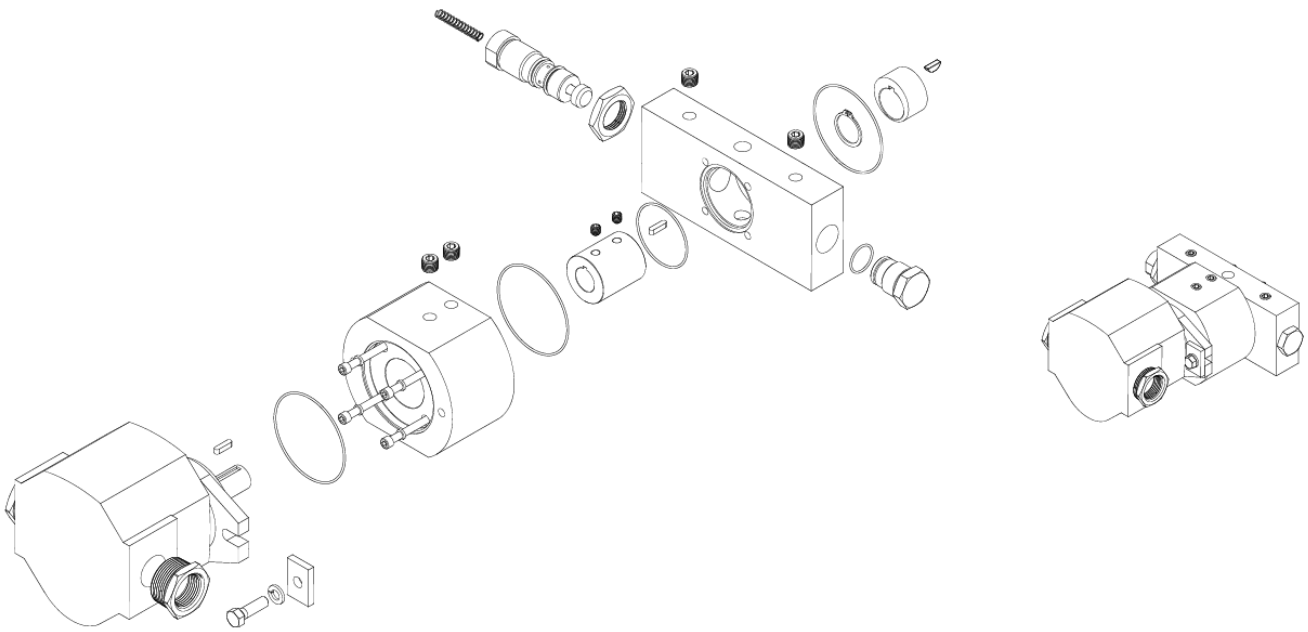
OPEN

The inline construction and full flow ports permit maximum flow with minimum increase in the system pressure.

Injection Pump (typical)



PDC 13



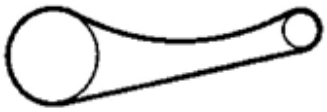
Belt Tightening Procedures

Installing A Drive

Here are a few suggestions to keep in mind when installing the drive:

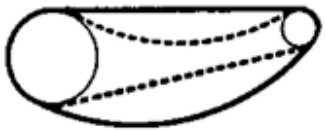
1. Use a matched set of belts.
2. Clean oil and grease from the sheaves; remove any rust or burrs from the sheave grooves.
3. Shorten the center distance of the drive until the belts can be put on the sheaves without forcing.
4. Make sure that the sheaves are correctly aligned, that the shafts are parallel, that there is clearance for the drive to run and that the bearings have oil.
5. Work belts around in the groove by hand, so that the slack of **all** belts is on the top, or slack of **all** belts is on the bottom.

LIKE THIS:
(all slack at top)



OR LIKE THIS:
(all slack at bottom)

DO NOT APPLY THIS WAY:
(with slack at top and bottom)



Do not apply with the slack of some belts on the bottom (see solid line) and the slack of others on the top (see dotted line). Since V-belts will not slide in the groove, belts thus applied will be injured when tightened for operation.

Now tension the drive until only a slight bow appears on the slack side of the belts when they are operating.

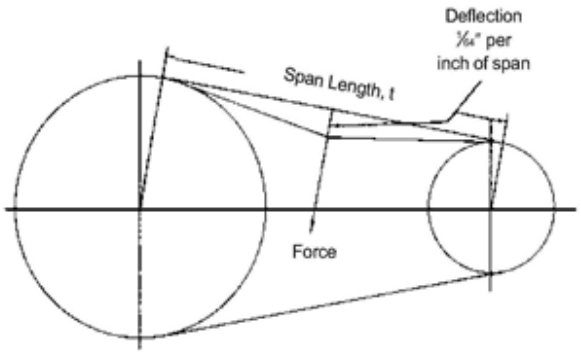
6. In a day or so, when the belts have had time to seat in the grooves, re-tension the belts.

All V-belt drives should be guarded in such a manner as to comply with the Williams-Steiger Occupational Safety and Health Act and with all state and local laws and the American National Standard Institute (ANSI) safety code.

Tensioning The Drive

General Rules of Tensioning:

1. Ideal tension is the lowest tension at which the belt will not slip under peak load conditions.
2. Check tension frequently during the first 24-48 hours of run-in operation.
3. Overtensioning shortens belt and bearing life.
4. Keep belts free from foreign material which may cause slip.
5. Make V-drive inspection on a periodic basis. Tension when slipping.



Test The Tension

If you want to check the tension in a conventional V-belt drive, use the procedure below:

1. Measure the span length, t.
2. At the center of the span (t) apply a force (perpendicular to the span) large enough to deflect the belt 1/64" for every inch of span length. For example, the deflection of a 100 inch span would be 100/64 or 1 36/64 inches.
3. Compare the force you have applied with the values given in Table 12. If the force is between the values for normal tension, and 1½ times normal tension, the drive tension should be satisfactory. A force below the value for normal tension indicates an under-tensioned drive. If the force exceeds the value for 1½ times normal tension, the drive is tighter than it needs to be. A new drive can be tightened initially to two times normal tension to allow for the normal drop in tension during run in.

Installation and Take-up Allowances

After calculating a center distance from a standard pitch length, make provision for adjusting the center distance as in Table 13, to allow for installation of the belts without injury, for tensioning, and for maintenance of proper tension throughout the life of the belt.

Table 12 — Belt Deflection Force

V-Belt Cross Section	Smallest Sheave Diameter Range	RPM Range	Belt Deflection Force			
			A, B, C, D		AX, BX, CX	
			Normal	1⅛ × Normal	Normal	1⅛ × Normal
A	3.0-3.6	1000-2500 2501-4000	3.7 2.8	5.5 4.2	4.1 3.4	6.1 5.0
	3.8-4.8	1000-2500 2501-4000	4.5 3.8	6.8 5.7	5.0 4.3	7.4 6.4
	5.0-7.0	1000-2500 2501-4000	5.4 4.7	8.0 7.0	5.7 5.1	9.4 7.6
B	3.4-4.2	860-2500 2501-4000			4.9 4.2	7.2 6.2
	4.4-5.6	860-2500 2501-4000	5.3 4.5	7.9 6.7	7.1 7.1	10.5 9.1
	5.8-8.6	860-2500 2501-4000	6.3 6.0	9.4 8.9	8.5 7.3	12.6 10.9
C	7.0-9.0	500-1740 1741-3000	11.5 9.4	17.0 13.8	14.7 11.9	21.8 17.5
	9.5-16.0	500-1740 1741-3000	14.1 12.5	21.0 18.5	15.9 14.6	23.5 21.6
D	12.0-16.0	200-850 851-1500	24.9 21.2	37.0 31.3		
	18.0-20.0	200-850 851-1500	30.4 25.6	45.2 38.0		

V-Belt Cross Section	Smallest Sheave Diameter Range	RPM Range	Belt Deflection Force			
			3V, 5V, 8V		3VX, 5VX	
			Normal	1⅛ × Normal	Normal	1⅛ × Normal
3V	2.2-2.4	1000-2500 2501-4000			3.3 2.9	4.9 4.3
	2.65-3.65	1000-2500 2501-4000	3.6 3.0	5.1 4.4	4.2 3.8	6.2 5.6
	4.12-6.90	1000-2500 2501-4000	4.9 4.4	7.3 6.6	5.3 4.9	7.9 7.3
5V	4.4-6.7	500-1749 1750-3000 3001-4000			10.2 8.8 5.6	15.2 13.2 8.5
	7.1-10.9	500-1740 1741-3000	12.7 11.2	18.9 16.7	14.8 13.7	22.1 20.1
	11.8-16.0	500-1740 1741-3000	15.5 14.6	23.4 21.8	17.1 16.8	25.5 25.0
8V	12.5-17.0	200-850 851-1500	33.0 26.8	49.3 39.9		
	18.0-22.4	200-850 851-1500	39.6 35.3	59.2 52.7		

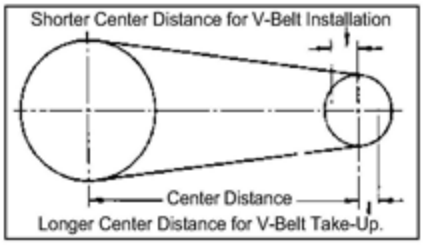


Table 13 — Center distance allowance for installation and take-up

Standard Length Designation	Minimum Allowance Below Standard Center Distance for Installation of Belts (Inches)								Minimum Allowance Above Standard Center Distance for Maintaining Tension (Inches) All Sections
	A, AX	A, AX Joined	B, BX	B, BX Joined	C, CX	C, CX Joined	D	D Joined	
26 to 37	0.75	1.20	1.00	1.50					1.00
38 to 59	0.75	1.20	1.00	1.50	1.50	2.00			1.50
60 to 89	0.75	1.30	1.25	1.60	1.50	2.00			2.00
90 to 119	1.00	1.30	1.25	1.60	1.50	2.00			2.50
120 to 157	1.00	1.50	1.25	1.80	1.50	2.10	2.00	2.90	3.00
158 to 194			1.25	1.80	2.00	2.20	2.00	3.00	3.50
195 to 239			1.50	1.90	2.00	2.30	2.00	3.20	4.00
240 to 269			1.50	2.00	2.00	2.50	2.50	3.20	4.50
270 to 329			1.50	2.20	2.00	2.50	2.50	3.50	5.00
330 to 419					2.00	2.70	2.50	3.60	6.00
420 and over					2.50	2.90	3.00	4.10	1.5% of belt length

Standard Length Designation	Minimum Allowance Below Standard Center Distance for Installation of Belts (Inches)						Minimum Allowance Above Standard Center Distance for Maintaining Tension (Inches) All Cross Sections
	3V, 3VX	3V, 3VX Joined	5V, 5VX	5V, 5VX Joined	8V	8V Joined	
Up to and incl. 475	0.5	1.2					1.0
Over 475 to and incl. 710	0.8	1.4	1.0	2.1			1.2
Over 710 to and incl. 1060	0.8	1.4	1.0	2.1	1.5	3.4	1.5
Over 1060 to and incl. 1250	0.8	1.4	1.0	2.1	1.5	3.4	1.8
Over 1250 to and incl. 1700	0.8	1.4	1.0	2.1	1.5	3.4	2.2
Over 1700 to and incl. 2000			1.0	2.1	1.8	3.6	2.5
Over 2000 to and incl. 2360			1.2	2.4	1.8	3.6	3.0
Over 2360 to and incl. 2650			1.2	2.4	1.8	3.6	3.2
Over 2650 to and incl. 3000			1.2	2.4	1.8	3.6	3.5
Over 3000 to and incl. 3550			1.2	2.4	2.0	4.0	4.0
Over 3550 to and incl. 3750					2.0	4.0	4.5
Over 3750 to and incl. 5000					2.0	4.0	5.5

Super Bolt

The following procedure should be followed to torque the Superbolt® on the PDC-13 compressors.
Helpful Hints:

- ❑ Prior to Tightening:
  1. Check threads of main stud: If possible, verify that the tensioners spin on prior to the installation date. If a tensioner is tight or will not thread on, try using lapping compound on the main thread and work the tensioner in a back and forth motion making small advances when the thread loosens up. If necessary, chase the studs with a die.
  2. Use of spacers: Tensioners should be positioned at the ends of the studs to minimize exposed threads and facilitate easy access to the jackbolts. A spacer (or stacked washers) can be used beneath the special hardened washer to accomplish this. A spacer will also "step over" a damaged area on a stud where years of bolting have deformed the first few threads.
  3. Back the tensioner off before tightening to provide 1/16" to 1/8" gap [1.6 – 3.2mm]. The additional jackbolt extension provides easy access for oiling the jackbolt tips prior to removal. This is especially beneficial for oiling when the tensioners are inverted.
     Note: There may be insufficient jackbolt stroke to allow this step when tensioning exceptionally long bolts or tie rods, or when closing a gap between flanges.
  4. For spinning the tensioner on and off the stud: Custom "sockets" which grip the tensioner are available. Also, two deep well sockets inserted over two jackbolt hex's at 180º apart can serve as "handles" for spinning the tensioners on and off the studs.
- ❑ For Tightening
  5. To improve efficiency when using Pulseless tools: Don't wait for the socket to stall completely on a specific jackbolt before advancing to the next jackbolt. It is faster, overall, to move quickly between jackbolts.
  6. Overshooting the target torque: You may want to use 110 - 120% of the target Torque for Step 3, Step 4, and for 1-2 rounds of Step 5. This may eliminate a tightening round. Be careful not to stabilize all of the jackbolts at this torque however. For long bolts or tie rods, you may want to experiment using even higher torque values. Call Superbolt before using more than 120% target torque.
  7. For gasketed joints: During gasket compression, the load is transferred to the jackbolts (i.e. stud) being tightened. Don't be concerned if some jackbolts (or tensioners) become loose during the procedure.

Super Bolt Torque Procedure For PDC-13 High Pressure Heads Continued

- ❑ For Removal
  8. 1/4 turn or less: Removing the jackbolts more than a 1/4 turn will increase the removal torque of the remaining jackbolts and you may get stuck. If this happens, you will have to retighten and start again.
  9. Stuck jackbolt removal: If a jackbolt will not turn, remove, re-lube, and retighten a neighboring jackbolt and then try to turn it.

IMPORTANT GUIDELINES

- ❑ Any brand Anti-Seize compound can be used ONLY on the main threads of the Superbolt®
  - To avoid mix-up/ error use only Type-JLG lubricant on threads.
- ❑ ONLY USE Superbolt® Lubricant Type-JLG on the jacking bolts.
  - **USE OF ANY OTHER LUBRICANT WILL AFFECT THE FRICTION COEFFICIENT AND MAY LEAD TO OVER/ UNDER TORQUE CONDITION.**

Installation Preparation:

Superbolt® Product: Confirm jackbolts are lubricated with correct Superbolt® lubricant (JL-G or JL-M). New product is lubricated at the factory. Make sure the jackbolt tips are flush (or recessed) with the bottom of the nut body.

Torque Wrenches: Select appropriate hand tools, depending on your target torque.

Sockets: High hex stresses require the use of quality six-point impact sockets. Have several spares handy for each job and replace them at the first sign of wear. Special Superbolt® sockets may be required when using a 3/4" impact or torque wrench and jackbolt spacing is close.

Installation Sheet *(shipped with product)*. Determine the target jackbolt torque. NOTE: The jackbolt torque stamped on the tensioner is a standard value for that part and may not be correct for your application. If you are unsure, contact Superbolt®.

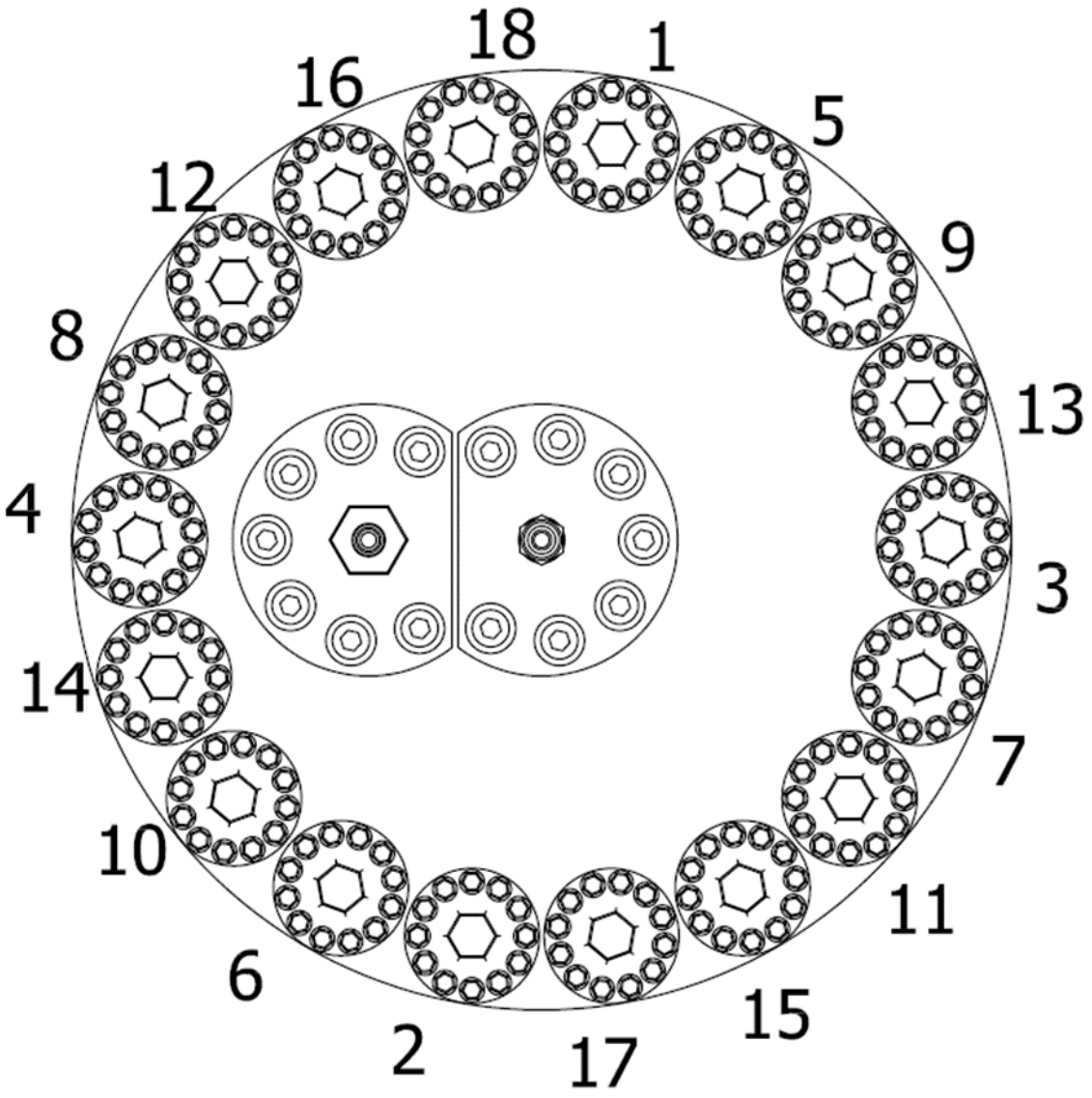
Lubricants: Jackbolts are pre-lubricated from the factory with either JL-G or JL-M lubricant. For the main stud any standard anti-seize lubricant can be used. For reuse after temperature service, remove, clean, and re-lubricate the jackbolts with the correct Superbolt® lubricant.

Washers: Apply the correct Superbolt® lubricant to the washer face or to the jackbolt tips.

Further Preparation Steps:
1) Lubricate the thread of the main stud. 2) Slide the hardened washer onto the stud. 3) Lubricate the washer face or jackbolt tips with the correct Superbolt lubricant (JL-G or JL-M).

For flanges: To speed up installation, use two workers at 180° apart, following OEM pattern for tightening.

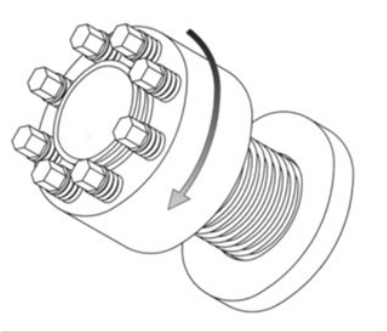
SUPERBOLT TORQUE PATTERN FROM PDC-13-15000 HEAD ASSEMBLY

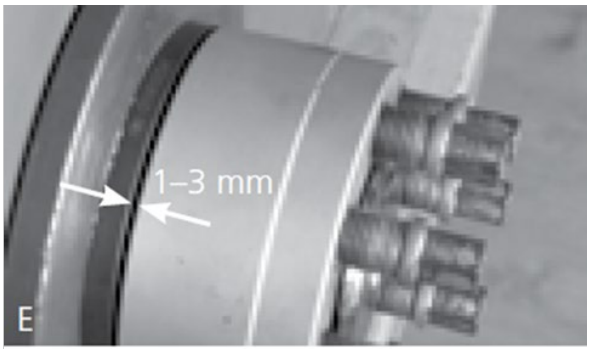


Note: Follow the above pattern to uniformly torque all the bolts.

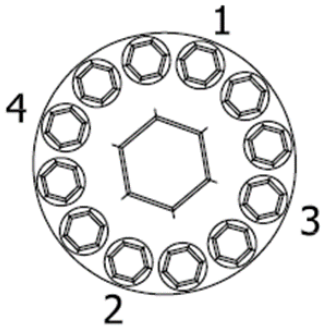
1. Lift the head assembly with an appropriate size hoist
2. Lubricate the tip of the jacking bolts OR the face of the hardened washer facing the jacking bolts, prior to installing the Superbolt® in the head.
   - **NOTE: ONLY USE SUPERBOLT LUBRICANT JLG ON THE JACKING BOLTS.**
   - **USE OF ANY OTHER LUBRICANT WILL AFFECT THE FRICTION COEFFICIENT AND MAY LEAD TO OVER/ UNDER TORQUE CONDITION.**

3. Spin ALL the Superbolts® into the Lower head until it seats flush against the washer.
    - Back off the Superbolt slightly as mentioned in Helpful Tip #3 above. 1/16” to 1/8” gap [1.6 – 3.2mm]

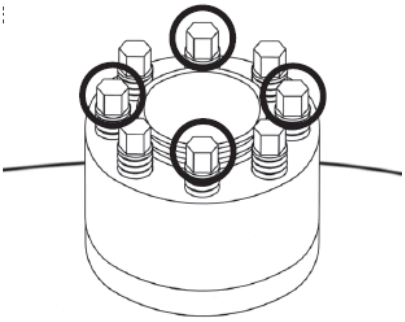




4. Mark the initial bolt pattern (shown below) on the jacking bolts of ALL the Superbolts®. Alternatively the 4 bolt heads shown can be marked/ colored for identification.



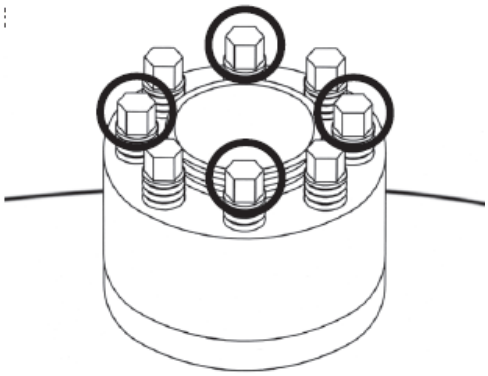
5. Starting at Superbolt #1:
    - Tighten (4) jackbolts at 90º apart (1, 2, 3, and 4) with a partial torque (16 Ft.Lbs [22Nm]). This serves to seat the flange.
        - ❑ If using a Pulse air torque wrench, use a reduced setting or lightly pulse the trigger at the full setting.



16 Ft,Lbs [22 Nm] - PRESET

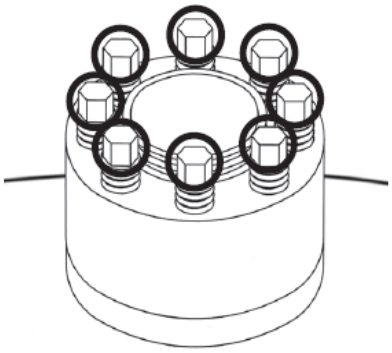
Few jackbolts shown for Clarity

6. Repeat Step# 5 on ALL the Superbolts® following the Head Assembly pattern shown on Page-123
7. Starting at Superbolt #1: Torque the initial 4 jackbolts (from Step-3) to 32 Ft.Lbs [44Nm], UNTIL THERE IS NO MOVEMENT IN THE JACKING BOLTS.



32 Ft,Lbs [44 Nm] - FINAL

8. Repeat Step# 7 on ALL the Superbolts® following the Head Assembly bolt pattern shown above
9. Remove Hoist from the head
10. Starting at Superbolt #1: At 32 Ft.Lbs [44Nm] target torque, tighten all jackbolts in a clockwise circular pattern. Do this for all jackbolts on Superbolt #1 (1 round only). See Helpful Tip #6 about using up to 120% torque.



@ 32 Ft.Lbs [44Nm] for ALL jackbolts. ONLY ONCE

11. Repeat Step# 10 on ALL the Superbolts® following the Head Assembly bolt pattern shown above.
12. Starting at Superbolt #1: Repeat Step #11, following the Head Assembly bolt pattern shown above, UNTIL THERE IS NO MOVEMENT IN THE JACKING BOLTS.
13. Repeat Step# 12 until all jackbolts are stabilized (NO rotation of Jackbolts). The number of passes is determined by the initial start point. Repeat till there is no rotation of the jackbolts.
    - ❑ During this Step air tools are not recommended, switch to a manual torque wrench. Use the torque wrench to stabilize ALL the Superbolts at the target torque.

Warranty Terms and Conditions

PDC, (hereafter referred to as “Company), guarantees its products to be free from defect in material and workmanship under normal use and service for a period of one and one-half years from the date of shipment or one year from the date of installation, whichever comes first, being subject to the following limitations:

1) Company makes no warranties regarding equipment manufactured by it or others (including without limitation warranties as to merchantability and fitness for a purpose), either expressed or implied, except as provided hereunder. The foregoing shall constitute the exclusive remedies of purchaser for any breach by company or its warranties hereunder, and seller further expressly waives and disclaims any liability for incidental or consequential damages.

2) Where equipment sold hereunder is used with attachments and/or modifications, which have not been recommended or approved by Company in writing, such use shall not be considered normal use and service under this guarantee and this guarantee shall not apply.

3) This guarantee does not extend to, and Company assumes no liability for, consequential and/or secondary damages, or losses of any kind sustained directly or indirectly as a result of a defect in any equipment, material or installation. Company shall, in no event, be liable in any amount exceeding the purchase price of the equipment and transportation charges thereon.

4) This guarantee extends only to the repair of any or all defective material, part, or assemblies which may be returned, prepaid by the buyer, to Company’s factory for repair and returned thereof at Company’s expense, to the buyer; or, at the Company’s option and at Company’s expense, Company will supply replacement parts to the buyer upon receipt by Company of the defective material or assemblies. Company shall not be liable for the cost and expense of any repair or installation of replacement parts hereunder unless the same is accompanied under the direct supervision of Company or pursuant to its written authority.

5) All equipment sold is guaranteed to function in accordance with the current Company equipment specification, if installed and operated in strict accordance with accompanying installation manuals, but the buyer shall be solely responsible for determining suitability for use and the Company shall in no event be liable in this respect. Company reserves the right to determine if any equipment has been subject to misuse or misapplication beyond Company’s specifications.

6) Company makes no guarantee whatsoever with respect to equipment, material, or parts supplied or manufactured by others, and such equipment, materials or parts will be repaired or replaced only to the extent of the original supplier’s or manufacturer’s guarantee.

7) This guarantee does not extend to, and the Company assumes no liability for, any damage or destruction of the equipment sold hereunder as a result of improper or unauthorized service. The buyer is cautioned that appropriate and effective service may be essential for proper working of the products sold hereby. The Company reserves the right in its sole discretion to determine whether service to the equipment has been proper or whether such service has voided the warranties herein discussed.

History of Revisions			
Revision Number	**Revision Date**	**Revised By**	**Reason for Revision**
4			Revised from original Manual
4b 4b	2/5/19 2/5/19	JE AA	Added Oil Note on Page 41 Added Document Number
5	1/4/22	Bree McQuillan	Updated Warranty Terms and Conditions and Logo
6	3/9/23	Tom P	Changed all 3000 hour reference to 4000 hours
7	3/20/23	Tom P	Added lubricant list & FR series oil
8	9/6/23	Tom P	Added Belleville Washers to maintenance
9	10/18/23	Tom P	Added new maintenance matrix from AM team
10	1/4/24	Tom P, Dave K	Reformat document, Added full maintenance matrix, Added step by step guides, Added shelf life information
10.1		Dave K.	Add SuperBolt info, undated oil prime for PDC 3,