Tech-Bulletin

Diaphragm Compressors

Designed and
Constructed for
High Reliablilty and
Low Maintenance

www.pdcmachines.com

Why Diaphragm Compressors?

Pdc's metallic diaphragm compressors are ideal for compressing all types of gases without incurring any contamination of the process media or leakage of gas to ambient air that results from reciprocating and other types of compressors. Traditional reciprocating compressors are subject to leakage past the piston rings which can result in contamination of the process gas with the hydraulic oil.

This is accomplished by isolating the process media from the piston and related components with a set of metal diaphragms. The piston moves a column of hydraulic fluid, which in turn moves the diaphragm-set, and displaces the process media. The process side of these units is constructed of corrosion-resistant materials to prevent further contamination.

Diaphragm compressors are well-suited for applications ranging from vacuum to **pressure as high as 60,000 psig.** Because of the large surface areas of the heads and diaphragms, the presence of pulsing oil and cooling of the upper heads (process side) Pdc compressors typically **run considerably cooler than conventional piston-type reciprocating compressors.**

Our compressors are more isentropic than adiabatic. The exponent runs between isothermal and adiabatic. This makes it possible for **higher compression ratios** to be achieved that would be difficult or impossible to achieve with conventional units. In some cases, compression ratios as high as one hundred to one is possible.

Cavity And Its Design –

The deflection and inherent stresses of the metal diaphragms are controlled by a carefully designed cavity contour.

We use state-of-the-art design and analysis with the assistance of sophisticated computers to create these cavity contours. Optimum displacements are obtained **while assuring maximum fatigue life for the diaphragms**. Finite element analysis is used to calculate the deflections of the compressor heads that house these cavities. The effects of head deflection on diaphragm stress are superimposed to determine their effect on fatigue life.

Oil Relief Valve -

This relief valve will accomplish the following:

A. Limits maximum oil and gas pressure generated by the diaphragm unit.

B. Assures that diaphragms completely sweep the cavity and contact the upper cavity contour, thus maximizing displacement. This is achieved by creating oil pressure that is slightly higher than the process discharge pressure. Additional plunger movement accomplishes this after the diaphragms contact the upper cavity contour and the relief valve setting. Once the relief valve pressure setting is achieved, the excess oil is discharged through the relief valve and returned to the crankcase. This oil flow is referred to as "over pump".

Priming Pump -

We provide an **automatic positive gear pump** on all motor-driven compressors. This pump eliminates priming problems that are typically associated with gravity-fed pumps. Depending on the size of the unit, the priming process can take up to a few minutes. This pump is driven by the main crankshaft.

Injection Pump -

Pdc provides an **automatic plunger type injection pump** on all motor-driven diaphragm units. The pump's function is to inject a specific volume of oil during the suction stroke of the machine. This volume of oil compensates for the following losses:

1. Normal leakage of oil across the hydraulic piston.
2. Compressibility of oil under pressure.
3. Over pump as defined above.

Boot Strap-

As the design pressure approaches 10,000 psig, very high loads are generated between the upper and lower heads. On lower pressure design, this load is offset by a series of bolts torqued to a specific value. Attempting to accomplish this on high-pressure designs results in impractical bolt sizes and torques. **The best solution is a boot strap design.**

With a boot strap configuration, there is an annular area greater than the cavity seal area that is subjected to the same hydraulic oil pressure providing a higher load than the load developed on the cavity seal area.

This offsetting load **will keep the heads clamped together without the need for large bolts and high torques.** We perform detailed, finite element analysis to study the stresses and deflections that could adversely affect normal operation under these high-pressure conditions.

Unique Design features of Pdc Compressors

1. To achieve maximum fatigue life for the diaphragm set, we **carefully design the cavity contours** in the head assembly (process and oil side). Different philosophies are used for suction like vacuum, atmospheric and high pressures. Unique cavity configurations are used for pressures above 3000 psi.
2. Critical consideration are inherent in sizing cavity volume and piston displacement at various pressure levels to **assure uniform movement of diaphragms, equalization of gas and oil pressures, and smooth start-ups,** and subsequent starts.
3. **Special processing of diaphragms.** Customers are reporting diaphragm lives of 10,000, 25,000 and 42,000 hours or operation.
4. **Unique hydraulic oil distribution** enables the compressor to run smoothly and quietly without soundproofing enclosure.

Process Head –

At Pdc, we machine process heads from a **wide variety of materials,** such as stainless steel, Hastelloy®, Inconel®, and Monel®, to best suit the process gas you require.

Triple Diaphragm Construction –

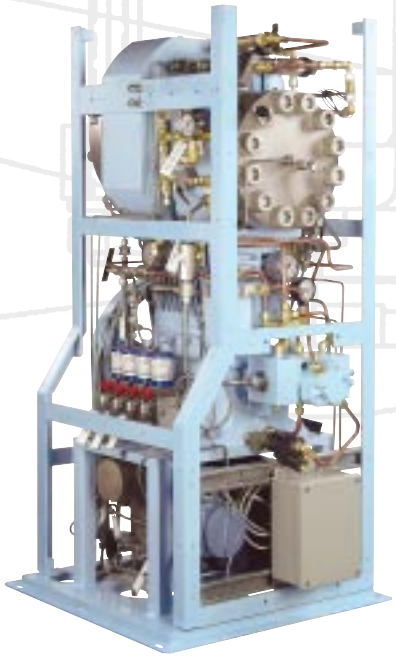
This is comprised of a stack of three metal diaphragms. The top diaphragm (process side) is made of a material compatible with the process media (stainless steel, Monel, etc.). The bottom diaphragm (oil side) is made of the same material as the upper and the middle diaphragm is made of brass. Without the brass-bearing surface of the middle diaphragm, the similar materials of the upper and lower diaphragms would exhibit a tendency to gall-sticking together.

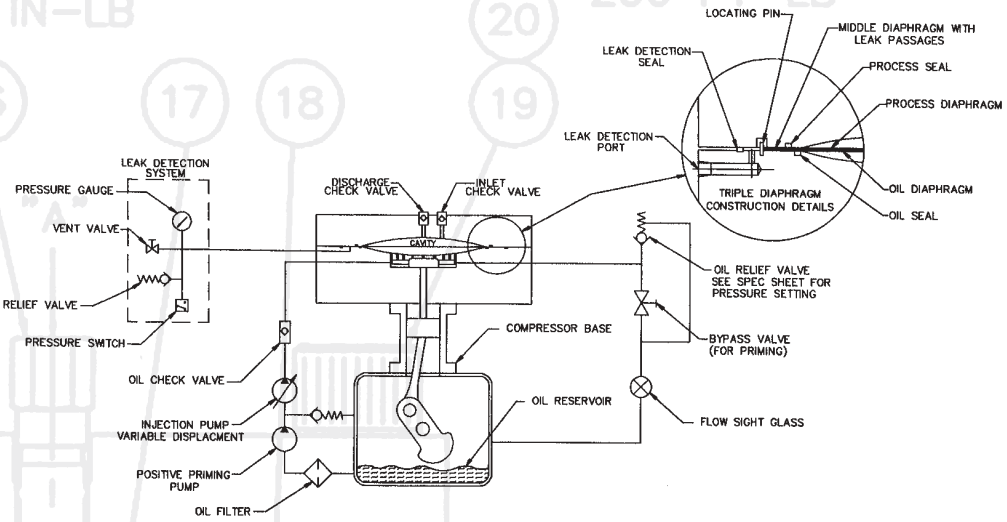
Process Contacting Seals –

We offer an **extensive variety of static elastomeric O-ring seals,** such as Viton®, Buna, Vespel®, Teflon, Peak, and Kalrez®, to suit the process gas you specify.

Leak Detection System –

We make a **leak-detection system** standard on every stage of compression for Pdc diaphragm compressors. This system detects diaphragm failure, (cracked diaphragm), gas and/or 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.





Our leak detection system utilizes a set of three diaphragms, a closed chamber into which leaked media (gas or oil) accumulates, a relief valve, pressure gauge, pressure switch, and manual blown-down valve which is normally closed.

We use triple diaphragm construction to detect diaphragm and main seal (gas or oil) failure. The middle brass diaphragm has radially scribed lines on both sides of the diaphragm. These serve as leak paths for moving any media that have leaked through a crack in either the upper or lower diaphragm to the leak collection area. Any failure of either the main oil or gas seal (O-ring) would also be detected in the leak collection area.

The leak detection system is attached to the access port and used to monitor the status of the diaphragms and seals. In addition, the pressure switch can be used to provide automatic shut-down when the pressure in the collection area exceeds the switch setting (set at 20 psig). The pressure gauge (0-30 psig) 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.

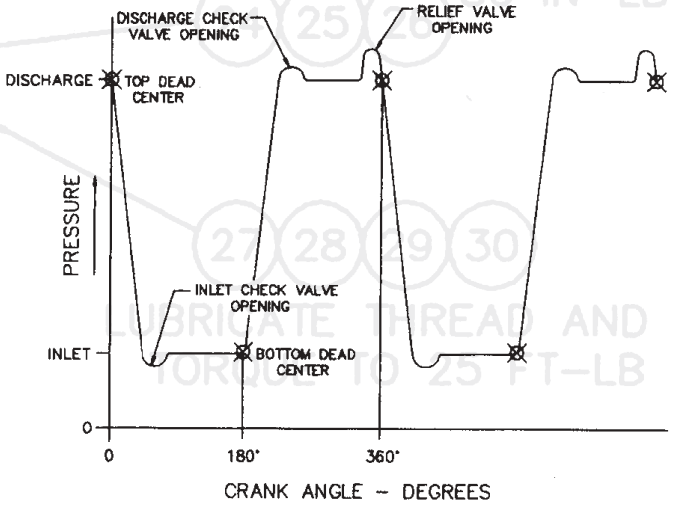
Process Inlet & Outlet Check Valves –

Pdc uses either cartridge or flat disc valves manufactured from Vespel®, Peek, or Monel®. We select the size and type of valves that will **best suit the specific operating conditions** and process gas. Incompatible materials of construction and or improperly sized valves can seriously degrade compressor performance. We have also designed our valves to be easily removable for maintenance without the need to dismantle the head assembly.

Diaphragm Life & Maintenance –

Pdc is continuously striving to extend diaphragm life. **Our goal is to minimize down time, spare parts, and maintenance costs for our customers.** We are committed to extensive R&D to develop new techniques to further reduce diaphragm stresses and extend fatigue life through advances in engineering design and manufacturing processes. Increasing diaphragm life reduces down-time and the cost of spares.

CRANK ANGLE – PRESSURE CURVE



Quality control is our top priority. Incoming, in process, and final inspection ensure very high quality levels. The majority of our low-quantity, custom-designed and machined parts are one hundred percent inspected.

We have developed **highly efficient methodology to reduce inspection time,** without sacrificing accuracy. Compressor cavities are measured on CNC machines and a computer printout provides documentation. Computerized coordinate measuring machines and digital optical comparators are used for part inspection.

Thorough testing of all custom-designed products is another way we assure the quality and reliability of our products. Units are assembled, tested and then disassembled for visual inspection prior to reassembly and shipment.

Other Quality Products from Pdc:

- *Reactors*
- *Magnetic Mixers*
- *Syringe Pumps*
- *Lab Scale Reaction Systems*
- *Pilot Plants*

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Advantages

- All process-wetted components are constructed from **corrosion resistant materials.** Proper oil and suitable construction materials insure safe handling of compressors serving explosive gases.
- Design pressures from **atmospheric to 65,000 psig.** Self-clamping boot strap designs for pressures over 10,000 psig.
- **Fast-acting leak detection system** to indicate diaphragm and seal failure.
- **Superior diaphragm life** due to proprietary cavity contour designs and manufacturing process. This reduces diaphragm stress and extends diaphragm life to potentially exceed 40,000 hours of operation.
- All of our models are equipped with **automatic positive priming and injection pumps** to minimize knocks, cavitation, and vibration for smooth start-up, operation, and re-priming during subsequent start-ups.
- **Self energizing seals** (O-rings).
- Ductile metal seals to meet **low leak rate** specifications (10^{-8} SCCS Helium).
- Off-loading to local storage is possible without the need for a regulator and reduced suction. This conserves energy and lowers costs.
- Reliable, **state-of-the-art** components are procured from industry-respected suppliers who are recognized for the performance, quality, and durability of their products.
- **High compression ratios per stage.** An application that would require two stages on a reciprocating compressor can be handled with one stage by a diaphragm compressor. This reduces capital costs and maintenance.
- **Cutting-edge technology** in design, manufacturing, and testing results in competitive pricing and lower maintenance costs when compared with standard piston compressors with clean-up systems and non-lube compressors.
- Pdc offers the **fastest turnaround** in the industry. We can typically deliver popular models in as little as 6 to 8 weeks.

Horizontally Opposed Designs for High-Efficiency Operation:

- Simplex, duplex, and multi-stage compression.
- **Easy** to install and maintain.
- **Reduced rod load** lowers torque and horse power.
- Only compression loading is on the rod.
- Duplex unit provides **twice the flow and 1/3 Hp consumption.**
- Field convertible from simplex to duplex or two-stage operation to provide twice the flow.
- **Capable of compressing** different gases simultaneously.

Purity of Inlet Gas

Diaphragm compressors, by design, cannot tolerate any free liquids in the gas stream. So it is important for the source gas to be clean and dry, i.e. it does not contain water mist, droplets, oil mist, water vapor, or other gases that could condense during any phase of compressor operation through final discharge. **To help maintain gas purity,** we install single or dual 10-micron inlet filter systems.

Electrical/Systems Integration

- Can meet American, Japanese and European Codes and Standards.

Design Codes

ASME, PED [Europe], NEC, CE marking, KHK [Japan], API, etc...

Highly Reactive Gases Service

For compression of oxygen, fluorine, and other highly reactive gases, Pdc performs rigorous cleaning procedures in a clean, dust-free environment. We use fire-resistant Halocarbon oil for the hydraulic system. We construct the process-side diaphragm, as well as the inner and outer check valve components, from Monel®, and or Inconel 718.

Stainless Steel Versus Carbon Steel Fabrication Materials

Pdc's standard material for all wetted-process components is stainless steel. **Carbon** steel heads and piping, though seemingly cost-effective, **can result in rust formation and migration of gas in the cavity,** leading to premature failure of diaphragms–increasing the cost of spares, maintenance frequency, and causing more down-time.