

# BEST PRACTICES IN SELECTING AND APPLYING POSITIVE DISPLACEMENT PUMPS

by

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## ABSTRACT

Selecting a positive displacement pump is many times a confusing process. Unlike centrifugal pumps where pumping technology is familiar, positive displacement pumps operate differently than centrifugals and there is a wide diversity in product capability. Pump design, system parameters, and characteristics of the liquid pumped are all key factors in determining which pump is most suited for a given application. This paper covers design elements of nine different positive displacement pumps, their respective operating limits, performance characteristics, and a number of factors to consider when choosing a pump. Typical application areas are also discussed.

## INTRODUCTION

It has been said that pumps are the second most common piece of industrial equipment next to electric motors. Pumps are classified into two major groups: centrifugal and positive displacement. United States Department of Commerce figures state that about 80 percent of pumps sold in the US are centrifugal with the remaining 20 percent being positive displacement. Whether centrifugal or positive displacement, correct application of a pump is critical to the success of the installation. There is considerable resident knowledge on the design and application of centrifugal pumps both in educational institutions and in industry. There is not that level of knowledge for positive displacement pumps. This problem is further complicated by the large number of different types of positive displacement pumping principles available. This paper covers some of the design features of a number of the more common positive displacement pumps and typical application areas of each.

Figure 1 shows classifications of positive displacement pumps as broken out by the Hydraulic Institute. All these designs have technical merit and are used for a variety of applications. Some are used for very specific purposes and may be the only design that will work for a specific application. Space does not permit an in-depth discussion on each principle so only those most popular will be covered. Design and application of internal gear, external gear, vane, lobe, screw, and diaphragm pumps are discussed.

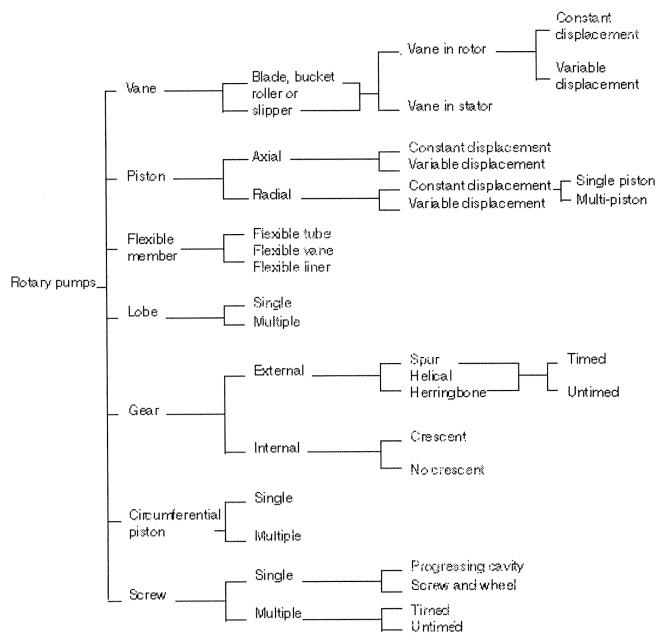


Figure 1. Classification of Positive Displacement Pumps. (Courtesy of Hydraulic Institute)

## THEORY OF OPERATION— POSITIVE DISPLACEMENT PUMPS

Unlike centrifugal pumps, positive displacement pumps rely on pumping element geometry to move a definite amount of liquid with each revolution or stroke. In each pumping revolution, a volume is opened within the pump that allows suction pressure to push liquid in the suction port of the pump. When the volume is filled, it is carried to the discharge side of the pump where the fluid is discharged, forcing it out the discharge port. This cycle is repeated for each revolution or stroke and results in relatively continuous flow. Because a controlled volume of liquid is transferred, output of positive displacement pumps is always a direct function of pump speed.

With the exception of the diaphragm pump, positive displacement pumps are characterized by close fitting parts. This is necessary to prevent liquid from going from the high pressure side of the pump to the low pressure side. Even though clearances are tight, there is some liquid that does escape the high pressure side. This is called slip. Slip is a function of pump internal clearances, liquid viscosity, and differential pressure. Slip is greater in a pump handling a thin liquid at higher pressure than would be a pump with a thicker liquid under the same operating conditions.

Positive displacement pumps will always try to pump the same amount of liquid with each revolution or stroke of the pumping elements. Because of this, flow is nearly constant even though pressure generated by changes in the system may vary. This is not the case with centrifugal type pumps. Here, flow varies considerably with pressure. Figure 2 shows flow versus pressure characteristics for positive displacement and centrifugal pumps.

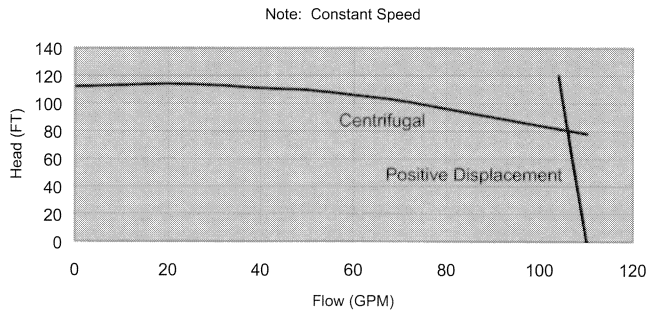


Figure 2. Flow Versus Pressure Characteristics for Centrifugal Versus Positive Displacement Pumps.

When the flow stream is blocked on a centrifugal pump, pressure will only go as high as the shutoff pressure. In positive displacement pumps, this is not true. Pressure will continue to climb until the prime mover stalls out, internal slip equals the pump displacement, or something breaks. Whenever a positive displacement pump is applied, overpressure protection needs to be considered. If there is any possibility of discharge flow being blocked, adequate overpressure protection must be provided in the system. This applies to both normal rotation of the pump and reverse rotation. Many positive displacement pumps can operate in both directions of rotation. If rotation of the pump can be reversed either intentionally or accidentally, overpressure protection must be provided on both sides of the pump. Many manufacturers provide a pressure relief on the pump and this is often an economical way to accomplish overpressure protection. Inline pressure relief valves, rupture disks, and torque limiting devices can also be used to accomplish the same purpose.

**PUMP DESIGN**

Most of the pumps discussed in this paper have a broad range of applications. Some designs will work better than others in a given application but some may not work well at all on a specific application. Understanding the basic design of a particular positive displacement pump helps in making this determination. Design features for the most common pumping principles are discussed below.

**GEAR TYPE PUMPS**

Gear pumps are divided into internal and external types. Principle of operation is very close for each; gear teeth coming out of mesh and into mesh open and close volumes to move the liquid through the pump.

*Internal Gear Pumps*

In an internal gear pump, the outer gear (rotor) drives an inner gear called an idler. An illustration of this pumping principle is shown in Figure 3. The rotor is affixed to a rotating shaft that is used to drive the pump. This shaft is supported by one or two bearings located behind the rotor. Pumps designed for higher pressure have two bearings. Since the bearings are located behind the rotor, the shaft has an overhung load. This can limit the maximum operating pressure of internal gear pumps. The idler gear normally has a sleeve bearing that rotates on a stationary pin. This combination runs in the liquid. Figure 4 shows a cutaway of a typical internal gear pump. Advantages and disadvantages of this pumping principle are listed in Table 1.

*External Gear Pumps*

External gear pumps consist of two identical gears rotating together. As in the internal gear pump, one gear drives the other one. The external gear pump principle is shown in Figure 5. There are a number of variations in this type of pump as the gears may be spur, helical, or herringbone, and the gears may also be externally timed. External timing prevents the pumping gears from contacting

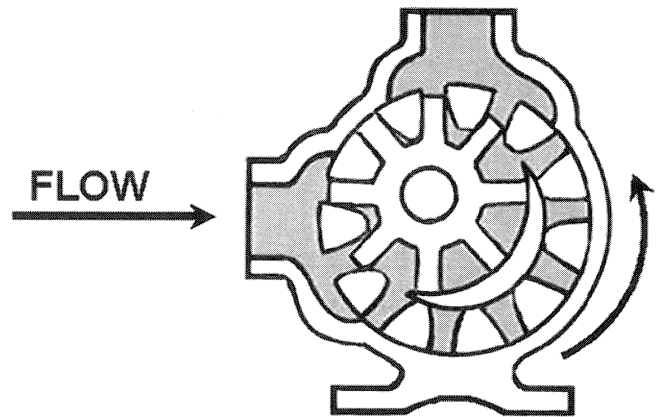


Figure 3. Internal Gear Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

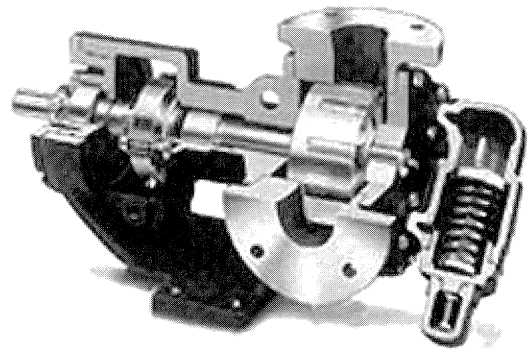


Figure 4. Internal Gear Pump Cutaway. (Courtesy of Viking Pump, Inc.)

Table 1. Internal Gear Pump Advantages and Disadvantages.

INTERNAL GEAR PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Only two moving parts</li> <li>• Only one shaft to seal</li> <li>• Non-Pulsating flow</li> <li>• Bi-Directional</li> <li>• Low NPSHr</li> <li>• Easy to maintain</li> <li>• Adjustable end clearance</li> <li>• Flexible design offers application customization.</li> </ul>	<ul style="list-style-type: none"> <li>• Larger pumps usually requires reduced speeds</li> <li>• At least one bearing runs in the product pumped</li> <li>• Overhung load on the rotor shaft</li> </ul>

one another as the timing gears now drive both pumping elements. This may be an advantage when the liquid pumped is not lubricating and rapid pump gear wear could result.

External gear pumps have the pumping elements (gears) supported by bearings on either side. This creates a very good bearing support situation that allows these pumps to go to high pressures. Hydraulic pumps for example, can attain pressures in excess of 3000 psi. Support bearings normally run in the liquid pumped but some designs seal them off. This requires four mechanical seals to accomplish and also lessens the ability of the pump to run at higher pressures since the bearing span is greater. An illustration of a typical transfer type external gear pump is shown in Figure 6. Advantages and disadvantages of this pumping principle are listed in Table 2.

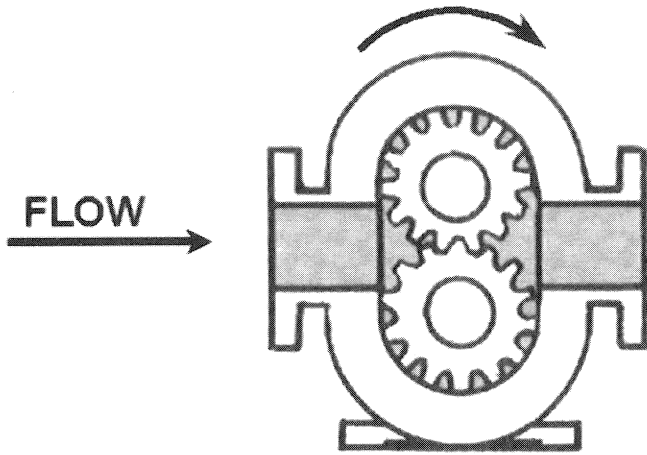


Figure 5. External Gear Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

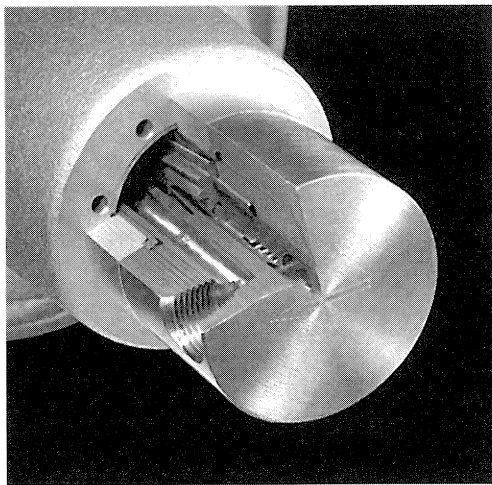


Figure 6. External Gear Pump Cutaway. (Courtesy of Micropump, Inc.)

Table 2. External Gear Pump Advantages and Disadvantages.

EXTERNAL GEAR PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• High speed.</li> <li>• High pressure capability.</li> <li>• No overhung bearing loads</li> <li>• Design accommodates wide variety of materials.</li> <li>• Sections can be stacked for multiple inlets and outlets</li> <li>• Bi-Directional</li> </ul>	<ul style="list-style-type: none"> <li>• Four bushings in liquid area</li> <li>• No solids allowed</li> <li>• Fixed End Clearances</li> </ul>

**LOBE PUMPS**

Lobe pumps are somewhat similar in design to external gear pumps. Two pumping elements (lobes) rotate counter to one another to expand and contract volumes. The main difference is the pumping elements are always externally timed resulting in no metal-to-metal contact within the pumping chamber. Each lobe is affixed to a shaft that is supported by antifriction bearings. Bearings are not in the liquid, which means two stuffing boxes are

required to isolate them. Since there are no bearings in the liquid, the lobes do provide a cantilevered load on the shaft. This principle is shown in Figure 7. A cutaway illustration of a typical lobe type pump is shown in Figure 8. Advantages and disadvantages of this pumping principle are listed in Table 3.

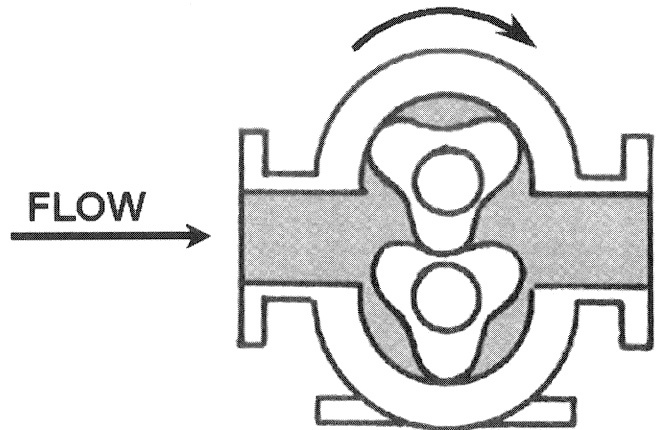


Figure 7. Lobe Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

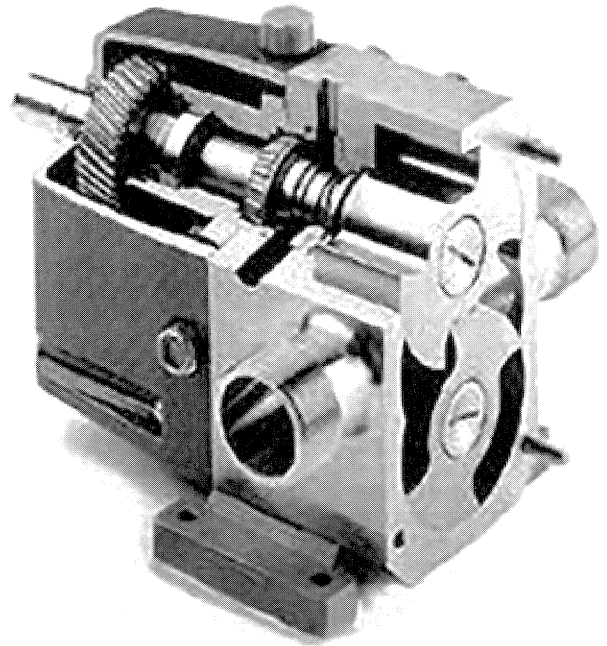


Figure 8. Lobe Pump Cutaway. (Courtesy of Viking Pump, Inc.)

Table 3. Lobe Pump Advantages and Disadvantages.

LOBE PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Pass medium solids</li> <li>• No metal-to-metal contact</li> <li>• Superior Clean-in-place and steam-in-place capabilities</li> <li>• Positive suction, nonpulsing discharge</li> <li>• Bi-directional</li> </ul>	<ul style="list-style-type: none"> <li>• Requires timing gears</li> <li>• Requires two seals</li> <li>• Overhung load on shafts</li> <li>• Reduced suction capability with thin liquids</li> </ul>

VANE PUMPS

Vane pumps use a rotating cylinder with slots (rotor) that house a series of vanes in the slots. The rotor is offset in a casing bore so that when rotated, the vanes slide in and out. This creates expanding and contracting volumes that move liquid through the pump. The principle of operation is shown in Figure 9. Note the area underneath the vanes also acts as pumps as the vanes go in and out of the slots in the rotor. This area is vented to suction and discharge areas either by passageways in the vanes or the rotor.

Most generally, the rotor is affixed to a shaft and is supported on either side by sleeve or antifriction bearings. The sleeve bearings run in the liquid but if antifriction bearings are used, they are isolated by mechanical seals. Vanes are normally constructed of a composite material that makes close running clearances possible. They are actuated or made to slide in and out of the slots by both centrifugal force and also push rods that go through the center of the rotor. A cutaway of a vane type pump is shown in Figure 10. Advantages and disadvantages of vane pumps are listed in Table 4.

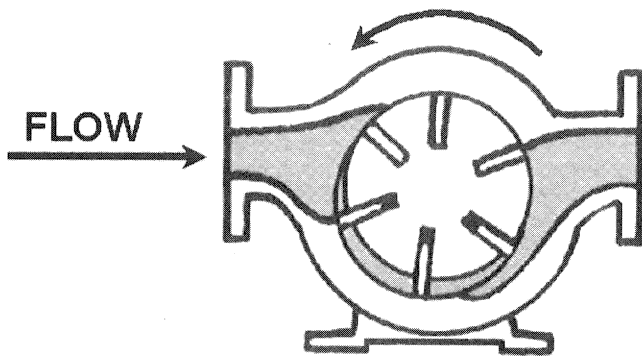


Figure 9. Vane Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

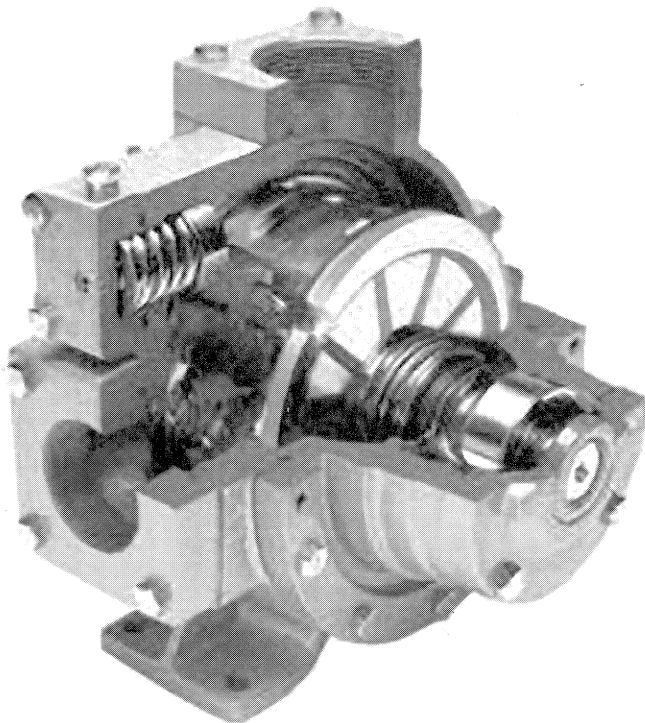


Figure 10. Vane Pump Cutaway. (Courtesy of Corken, Inc.)

Table 4. Vane Pump Advantages and Disadvantages.

VANE PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>Sliding contact of vanes make this pump good for thin liquids</li> <li>Can run dry for short periods</li> <li>Pump normally has one seal chamber</li> </ul>	<ul style="list-style-type: none"> <li>Can have two seal chambers</li> <li>Not suitable for high pressures</li> <li>Not suitable for high viscosity</li> <li>Not good with abrasives</li> <li>Failure mode is catastrophic when vanes fail (Unless metal vanes are used)</li> </ul>

SCREW PUMPS

Screw pumps are divided into single and multiple categories. While the principle of operation is similar for all varieties of screw pumps, the designs are quite different.

Single Screw or Progressing Cavity Pumps

Single screw pumps are called progressing cavity pumps and consist of a single center screw with a single thread helix and an outer stator that has a double thread helix. This design creates pockets or cavities of liquid that move through the pump and hence the name progressing cavity. The rotating screw is most often made from steel or stainless steel and the stator is made from a variety of elastomeric materials. The rotor and stator normally have a very slight interference fit to provide a good seal between cavities. Because of this, the pump cannot run dry. Frictional heat generated by the interference fit can destroy the stator in a short time. Most manufacturers provide options for protecting against a run dry condition.

These pumps normally have a long footprint because of the length of sealing surfaces on the rotor and stator. Because of the long sealing surface, this pump can operate at higher pressures and can also be staged for additional pressure. In that the rotating screw rotates off center, a universal type joint is required to rotate the shaft. Figure 11 shows the operating principle for a progressing cavity pump and Figure 12 shows a cutaway of a typical pump. Advantages and disadvantages for this pumping principle are listed in Table 5.

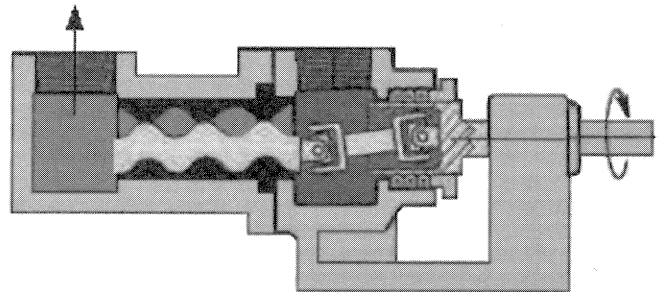


Figure 11. Progressing Cavity Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

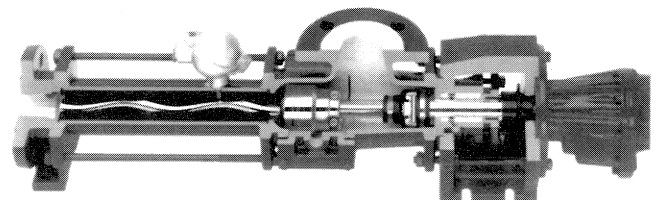


Figure 12. Progressing Cavity Pump Cutaway. (Courtesy of Seepex, Inc.)



Table 5. Progressing Cavity Pump Advantages and Disadvantages.

PROGRESSING CAVITY PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Very good on liquids with solids</li> <li>• Can handle dry material</li> <li>• Does not require modification for change in viscosity</li> <li>• Can be staged for high pressure</li> </ul>	<ul style="list-style-type: none"> <li>• Cannot run dry</li> <li>• Temperature limited to 350 ° F</li> <li>• Requires sealed universal joint</li> <li>• Large footprint</li> </ul>

Multiple Screw Pumps

Multiple screw pumps are normally either two screw or three screw designs. They are characterized by long threaded pumping elements rotating together that open and close volumes. Figure 13 shows the operating principle for a three screw pump. Two screw and three screw pumps transfer liquid in the same way but there are design differences. Two screw designs are externally timed as in lobe type pumps and use timing gears to accomplish this. Because of this, the screws do not come in contact, which allows this pump to be used for thin liquids and abrasive liquids. Screws are supported by bearings on each end. Depending on the application, bearings may run in the liquid or be separated by a seal. When all bearings are outside of the liquid, four shaft seals are required.

In three screw designs, the center element drives the other two. For this reason, they cannot be used on thin liquids. Three screw pumps are by far the most common as two screw pumps are very expensive to manufacture. Because they are hydraulically balanced, three screw pumps can go to pressures of 4500 psi. Examples of two and three screw pumps are shown in Figures 14 and 15. Advantages and disadvantages of these designs are listed in Tables 6 and 7.

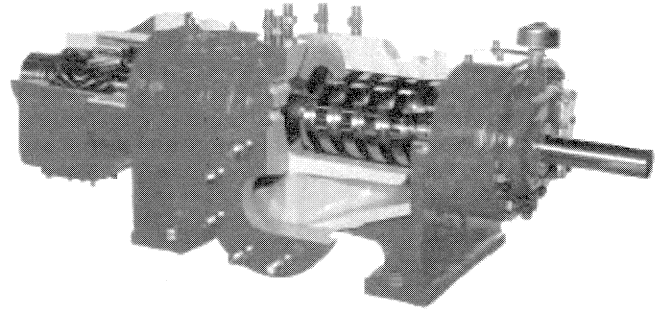


Figure 14. Two Screw Pump. (Courtesy of IMO Pump)

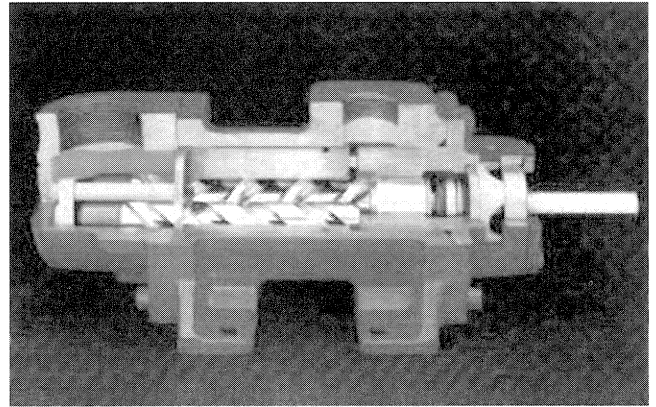


Figure 15. Three Screw Pump. (Courtesy of IMO Pump)

Table 6. Two Screw Pump Advantages and Disadvantages.

TWO SCREW PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Runs at motor speed</li> <li>• High pressure capability</li> <li>• Broad flow range</li> </ul>	<ul style="list-style-type: none"> <li>• Requires timing gears</li> <li>• Two to four shaft seals required</li> <li>• Will not tolerate solids</li> <li>• Expensive</li> </ul>

Table 7. Three Screw Pump Advantages and Disadvantages.

THREE SCREW PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Runs at motor speed</li> <li>• High pressure capability</li> <li>• Broad flow range</li> </ul>	<ul style="list-style-type: none"> <li>• Not well suited for thin liquids</li> <li>• Not well suited for non lubricating liquids</li> <li>• Not well suited for abrasives</li> </ul>

by check valves in the inlet and outlet ports. Diaphragms are actuated hydraulically, mechanically, or by air. Both hydraulically and mechanically actuated diaphragm pumps are normally considered metering pumps. It is not the intent of this paper to cover metering pumps.

Hydraulically Actuated Diaphragm Pumps

Hydraulically actuated diaphragm pumps are sometimes used in transfer applications because of their ability to handle high pressure and abrasives and for this reason will be included. In this design, uniform hydraulic pressure is applied to the back of a diaphragm to move it back and forth. Hydraulic pressure is

**FLOW**

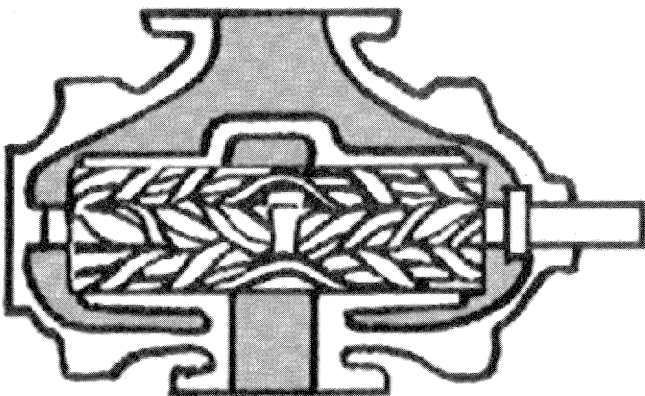


Figure 13. Screw Pump Operating Principle. (Courtesy of Viking Pump, Inc.)

DIAPHRAGM PUMPS

There are several types of diaphragm pumps but all use a flexible diaphragm that is actuated by external means to expand and contract volumes. Liquid flow through these pumps is controlled

generated by a separate hydraulic circuit within the pump. Because hydraulic oil is incompressible, diaphragm movement is very predictable and maximum pump discharge pressure is determined by maximum hydraulic capability. Most hydraulically actuated diaphragm pumps are single acting meaning there is one pumping cycle per stroke. Figure 16 illustrates the mechanics of a hydraulically actuated diaphragm pump. Figure 17 is a pictorial of a typical pump. Advantages and disadvantages of this pumping principle are listed in Table 8.

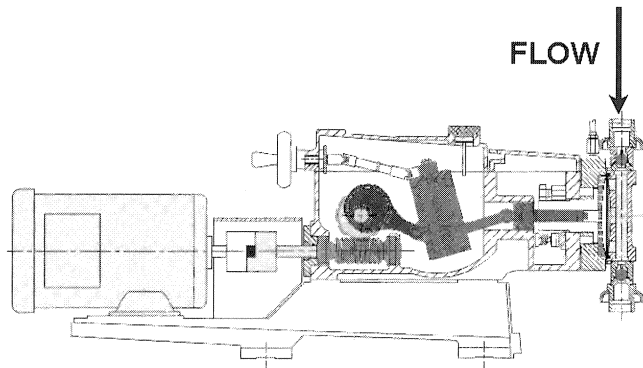


Figure 16. Hydraulically Actuated Diaphragm Pump Operating Principle. (Courtesy of Pulsafeeder, Inc.)

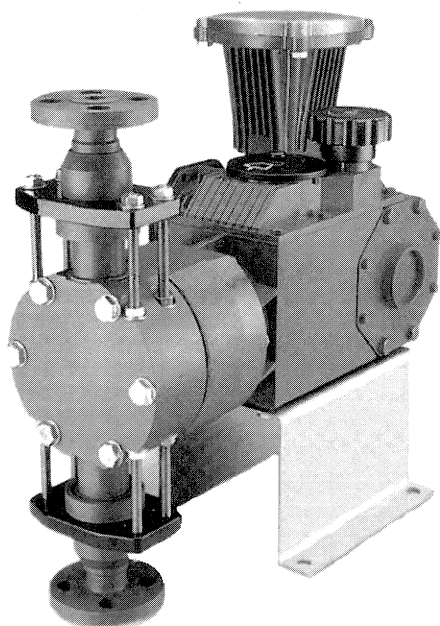


Figure 17. Hydraulically Actuated Diaphragm Pump. (Courtesy of Pulsafeeder, Inc.)

Table 8. Hydraulically Actuated Diaphragm Pump Advantages and Disadvantages.

HYDRAULICALLY ACTUATED DIAPHRAGM PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>No shaft seal required</li> <li>High pressure capability</li> <li>Excellent metering capability</li> <li>High temperature capability</li> </ul>	<ul style="list-style-type: none"> <li>Pulsing Flow</li> <li>Internal hydraulic system to maintain</li> </ul>

*Air Operated Double Diaphragm Pump*

Air operated diaphragm pumps use a connecting rod attached to the back of the diaphragm to move it back and forth. The rod is moved by an air operated piston device. Most air operated diaphragm pumps are double acting meaning each stroke of the connecting rod produces two pumping cycles. The correct name for these pumps is actually air operated double diaphragm pumps. Inlet and outlet ports for each diaphragm are connected together so there is a common suction and discharge for the pump. Since air pressure is used to actuate the diaphragms, maximum pressure is controlled by available air pressure. Figure 18 shows this operating principle and Figure 19 illustrates a typical pump. Advantages and disadvantages of this pump principle are listed in Table 9.

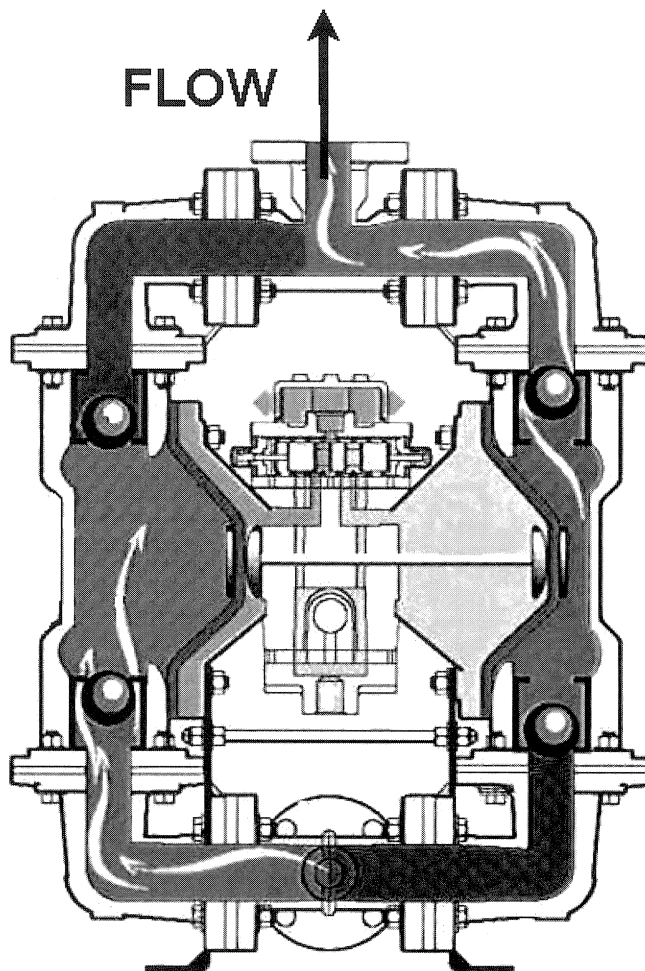


Figure 18. Air Operated Double Diaphragm Pump Operating Principle. (Courtesy of Warren Rupp, Inc.)

APPLICATION AREAS OF POSITIVE DISPLACEMENT PUMPS

There are three main reasons for selecting a positive displacement pump over a centrifugal pump.

- Liquid viscosity is too high for a centrifugal.
- Constant flow is needed over varying discharge pressure.
- There is a suction lift or high vapor pressure condition on the inlet side of the pump.

Once the need for a positive displacement pump is established, it then becomes a matter of which pumping principle to use. As mentioned previously, many positive displacement pumps have a fairly broad application area. Some principles do better than others and

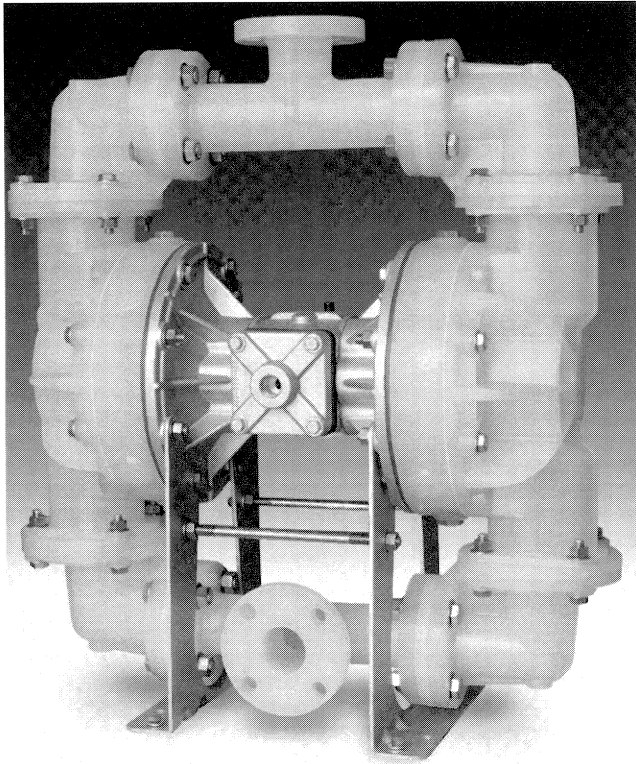


Figure 19. Air Operated Double Diaphragm Pump. (Courtesy of Warren Rupp, Inc.)

Table 9. Air Operated Diaphragm Pump Advantages and Disadvantages.

AIR OPERATED DOUBLE DIAPHRAGM PUMP	
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>No shaft seal required</li> <li>Portable</li> <li>Inexpensive</li> <li>Handles solids and abrasives</li> </ul>	<ul style="list-style-type: none"> <li>Pulsing flow</li> <li>May be expensive to operate</li> <li>Diaphragm failure may cause immediate leakage</li> <li>Limited diaphragm life due to constant flexing</li> <li>Discharge pressure is limited to maximum air supply pressure</li> </ul>

some may have limitations that prevent its use for a given application. A successful application results when one knows and understands characteristics of the liquid pumped, the pumping system, and the pump design. Most unsuccessful applications result from insufficient understanding of one or more of these key areas.

Flow, viscosity, pressure, and temperature are often the limiting factors when applying positive displacement pumps. These limits can be used to narrow the selection of pumps. Listed in Tables 10 and 11 are the normal operational envelopes for all the principles discussed. Note that these are nominal limits and some manufacturers may be able to adapt their pumps to exceed these limits. It is also important to remember that as viscosity increases, maximum capacity usually decreases. It is very normal to decrease operational speed as viscosity increases and this is done by nearly all positive displacement pump manufacturers. This is done to allow more time for the pump cavities to fill, to reduce frictional drag, and to account for the higher resistance to flow of thicker liquids.

Table 10. Flow and Pressure Limits of Positive Displacement Pumps.

Pumping Principle	Flow (GPM)		Pressure (PSI)
	Minimum	Maximum	Maximum
Internal Gear	.5	1500	400
External Gear	.001	1500	3000
Lobe	4	3000	225
Vane	5	2000	150
Three Screw	1	3400	4500
Timed Two Screw	20	5000	1500
Progressing Cavity	2	2400	1500
Hydraulic Diaphragm	.001	70	6000
Air Operated Diaphragm	.5	300	125

Table 11. Temperature and Viscosity Limits of Positive Displacement Pumps.

Pumping Principle	Temperature (° F)	Viscosity (cps)	
	Maximum	Minimum	Maximum
Internal Gear	800	.1	1,000,000
External Gear	500	.1	1,000,000
Lobe	350	.1	100,000
Vane	225	.1	25,000
Three Screw	500	1	100,000
Timed Two Screw	650	.1	250,000
Progressing Cavity	350	.1	1,000,000
Hydraulic Diaphragm	800	.1	10,000
Air Operated Diaphragm	212	.1	17,500

Once this step has been completed, one must look to liquid characteristics to further narrow the choices. Common liquid characteristics that can affect what pumping principle is used are listed in Table 12 and each principle's ability to deal with the condition. Note that abrasives are considered to be liquids with hard particles less than .010 inch and solids are considered to be particles above that. Shear sensitive liquids are polymers and emulsions where shear may change the liquid properties.

Next, consider system parameters where the pump may be required to run dry or deal with two phase flow. Two phase flow is simply a mixture of liquid and gas. Table 13 shows each pump's ability to deal with these conditions. Note that most positive displacement pumps can deal with short periods of running dry (such as the priming cycle for example). This table is intended to

Table 12. Abrasion, Solids, and Shear Sensitive Liquid Handling Capability for Positive Displacement Pumps.

	Ability to Handle:		
	Abrasives Liquids	Liquids with Solids	Shear Sensitive Liquids
Pumping Principle			
Internal Gear	X		X
External Gear			
Lobe		X	X
Vane			
Three Screw			
Timed Two Screw	X	X	X
Progressing Cavity	X	X	X
Hydraulic Diaphragm	X	X	X
Air Operated Diaphragm	X	X	X

show pumps' capabilities for extended periods of time. If a mechanical seal is involved, some liquid must be provided at the seal faces for lubrication.

Table 13. Ability of Positive Displacement Pumps to Handle Dry Running and Two Phase Flow.

	Ability to Handle:	
	Dry Running	Two Phase Flow
Pumping Principle		
Internal Gear		
External Gear		
Lobe	X	X
Vane		
Three Screw		
Timed Two Screw	X	X
Progressing Cavity		X
Hydraulic Diaphragm	X	X
Air Operated Diaphragm	X	X

There are a couple of other considerations that deal with design characteristics of positive displacement pumps. Some designs produce pulsating flow because of the method used to move liquid through the pump. This may be objectionable in some applications and others it may not. A summary of these is listed in Table 14. Some designs are also more cleanable than others. Because of this, certain pumping principles are used more often in sanitary situations or in places where liquid contamination cannot be tolerated. Pumps normally used for sanitary service are also listed in the table.

Even after going through the above tables, there still may be a number of pumping principles that could work for a given service. Other factors must then be considered to arrive at a good solution. One very important consideration is life-cycle cost. This in essence is the cost of ownership for a pump. It includes the first cost of the

Table 14. Flow Output Characteristics and Sanitary Capability of Positive Displacement Pumps.

	Flow Output	Suitable for Sanitary
Pumping Principle		
Internal Gear	Steady	
External Gear	Steady	
Lobe	Some Pulsing	X
Vane	Steady	
Three Screw	Steady	
Timed Two Screw	Steady	
Progressing Cavity	Steady	X
Hydraulic Diaphragm	Pulsed	
Air Operated Diaphragm	Pulsed	

pump, installation costs, repair and maintenance costs, energy cost to operate the pump, among other things. Figure 20 shows maximum efficiencies for a number of positive displacement pumps. Hydraulically actuated diaphragm pumps have the highest attainable efficiencies and air operated diaphragm pumps have the lowest attainable. Note that air operated diaphragm efficiencies are further reduced when a 60 percent efficient air compressor is used. There is a new document prepared jointly by Europump and the Hydraulic Institute that does a very good job of assisting in analyzing life-cycle costs. It guides the user through all the necessary calculations and provides good information on system information.

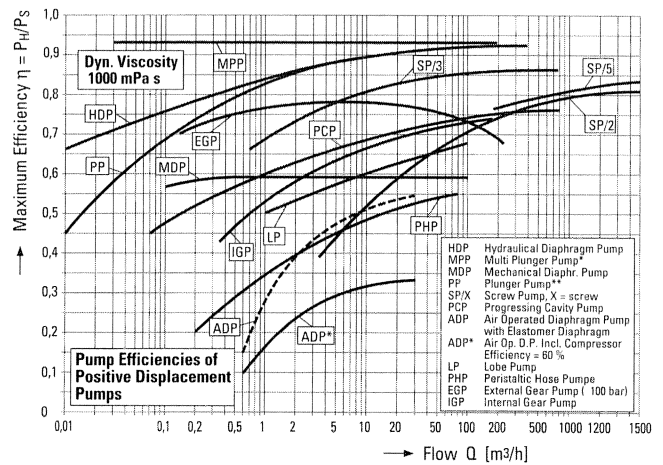


Figure 20. Maximum Efficiencies for Positive Displacement Pumps. (Courtesy of Professor E. Schlucker, University of Erlangen)

Available materials of construction are also very critical in selecting a pump. Most common materials are available with all the pumping principles discussed in this paper but individual manufacturers may vary. The user should discuss this with the vendor to make sure the proper materials are available and are suitable for the application and pumping principle.

Availability of shaft sealing options is another important consideration. Sealing problems can present more problems than a misapplied pump. Pumps with rotating shafts use either packing, mechanical seals, or sealless designs (magnetic drive) to control shaft leakage with mechanical seals being the most popular. Some



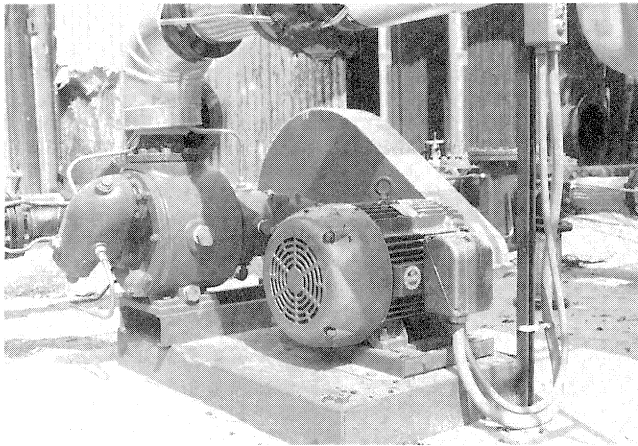
users have a preference for a particular type and brand of mechanical seal. Many seal manufacturers can accommodate a given seal design in a pump but the seal and/or pump may need extensive modifications. The preferable scenario is that no modifications are required since modified parts often are more difficult to obtain.

Another factor to consider is ease of maintenance. This is somewhat subjective in that all manufacturers portray their product as easy to maintain. Individual manufacturers should be able to demonstrate this and give reasonable assurances of what is involved in this process.

Lastly, although it is not possible to box in application areas for all positive displacement pumps, examples of typical applications for all the pumping principles discussed are shown below. Brief descriptions of the application are given along with the reasons for choosing the particular pumping principle.

#### *Internal Gear Pumps*

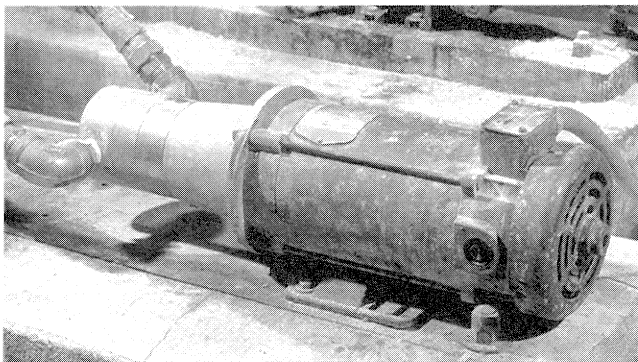
Figure 21 is an internal gear pump installed to handle asphalt. A number of pumping principles could have handled this application but availability of an integral heating jacket, ability to handle the temperature required, and ease of maintenance made this the pump of choice.



*Figure 21. Internal Gear Pump Asphalt Application. (Courtesy of Viking Pump, Inc.)*

#### *External Gear Pumps*

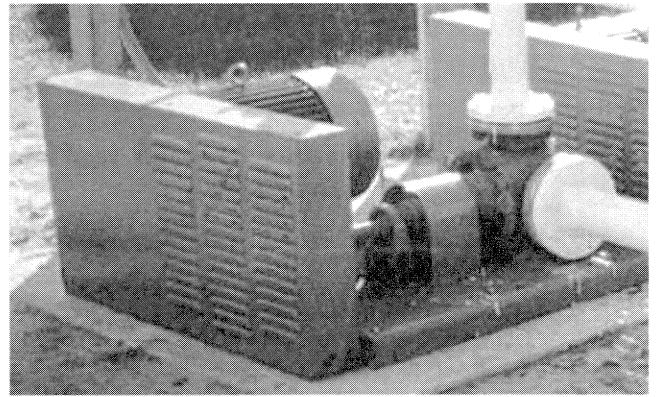
Figure 22 is an external gear pump used to meter dye in a paper mill application. Again, several pumping principles could have been chosen but metering ability, steady flow output, and availability of a sealless design were the reasons this pump was chosen.



*Figure 22. External Gear Pump Dye Application. (Courtesy of Micropump, Inc.)*

#### *Vane Pumps*

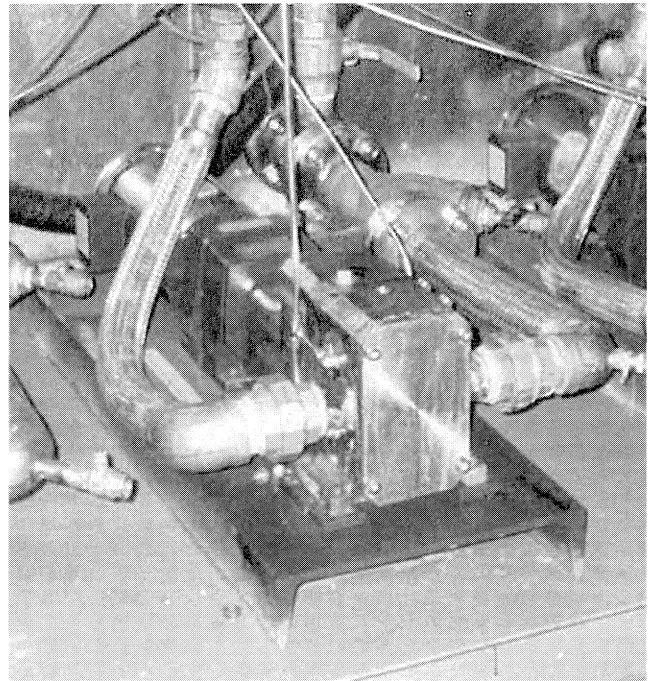
This sliding vane pump (Figure 23) is being used to pump liquid propane gas. The vane pump is the best choice because of its ability to handle thin, nonlubricating liquids. Other pumping principles could have been used but the vane pump would have the lowest initial investment.



*Figure 23. Vane Pump Propane Application. (Courtesy of Corken, Inc.)*

#### *Lobe Pumps*

These lobe pumps (Figure 24) are being used to handle paint. They were chosen because of their ability to clean in place. Paint color can be easily changed by cleaning the pump in place; there is no resultant color cross-contamination.



*Figure 24. Lobe Pump Paint Application. (Courtesy of Viking Pump, Inc.)*

#### *Progressing Cavity Pumps*

Progressing cavity pumps are often used in the waste water industry. Here (Figure 25), the pump is being used to handle a combination of dewatered sludge and lime. Ability of the pump to handle solids and abrasives was the main reason this pump was chosen.



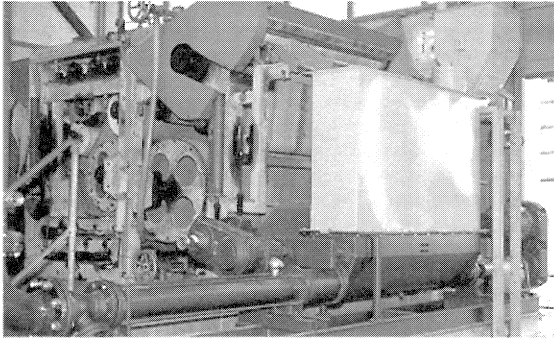


Figure 25. Progressing Cavity Pump Handling Dewatered Sludge. (Courtesy of Seepex, Inc.)

#### Screw Pumps

This three screw pump (Figure 26) is delivering 410 gpm of crude oil at 1540 psi. The three screw pump was chosen because it is one of the few pumping principles available to handle the flow and pressure. A two screw pump could have been used but it is more costly than a three screw pump.

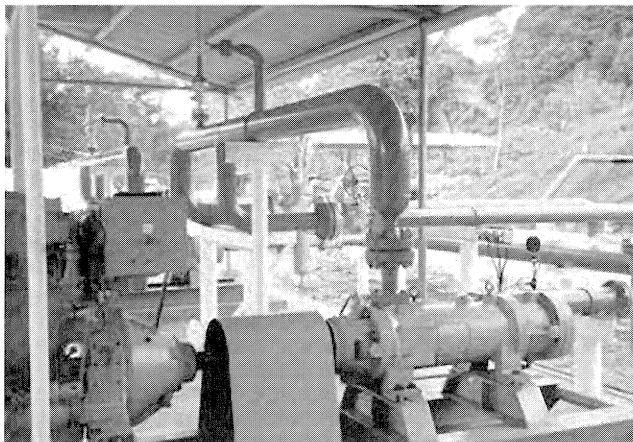


Figure 26. Two Screw Pump Crude Oil Application. (Courtesy of IMO Pump)

#### Hydraulically Actuated Diaphragm Pumps

The hydraulically actuated diaphragm pump used here (Figure 27) is dispensing a polymer used in a wastewater treatment facility. This pump was chosen for its metering ability and also because the polymer is a shear sensitive liquid.

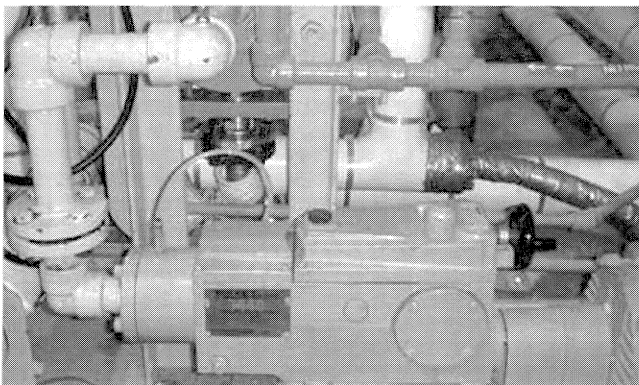


Figure 27. Hydraulically Actuated Diaphragm Pump Metering Polymer. (Courtesy of Pulsafeeder, Inc.)

#### Air Operated Diaphragm Pumps

Not many positive displacement pumps do very well on water due to their basic design. Air operated double diaphragm pumps are an exception to this and were selected here (Figure 28) because they provided an economic solution to this liquid transfer problem. Also note that a suction lift is involved and industrial wastewater may contain some solids.

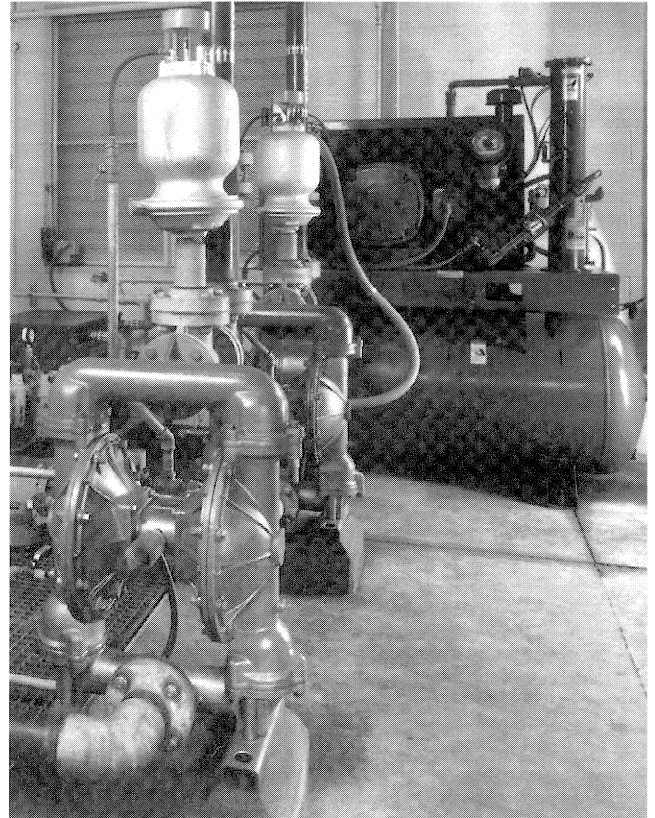


Figure 28. Air Operated Diaphragm Pump Handling Industrial Wastewater. (Courtesy of Warren Rupp, Inc.)

#### CONCLUSION

Positive displacement pumps are generally simple in design but differ greatly from centrifugal pumps in their design, operation, and application. There are numerous positive displacement pumping principles and each has unique design and operational characteristics. In order to arrive at a successful installation, a thorough understanding of the pump, the pumping system, and the liquid pumped is required.

#### ACKNOWLEDGEMENTS

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