The Wonderful World of Pumps
or
"What are they and what do they do?"

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Pumps, the second most used mechanical item in the world!

Definition of PUMP

1: a device that raises, transfers, delivers, or compresses fluids or that attenuates gases especially by suction or pressure or both

Commonly used pumps in the Water and Wastewater Fields

- ❑ Centrifugal
- ❑ Progressing Cavity
- ❑ Diaphragm
- ❑ Peristaltic

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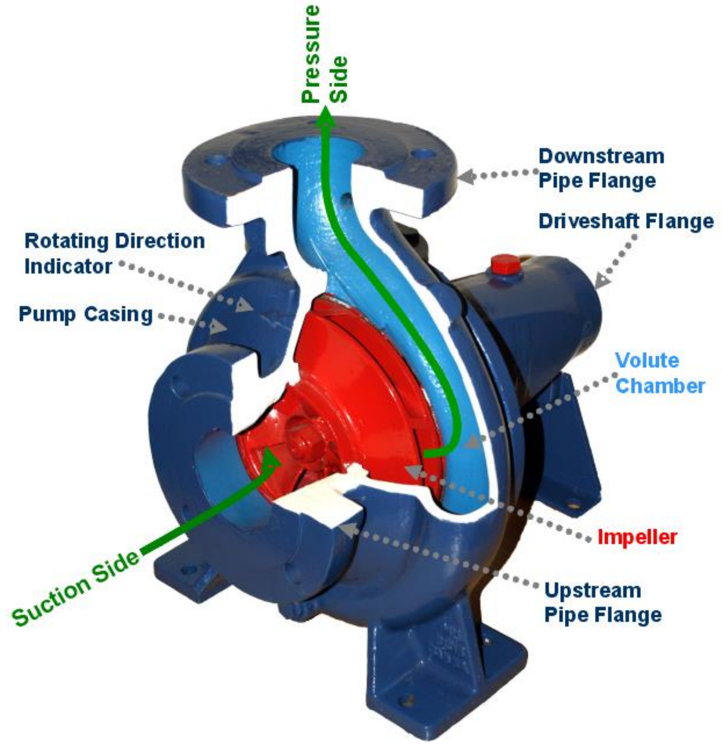
- Centrifugal pumps are a sub-class of dynamic axisymmetric work-absorbing turbomachinery.[1] Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits.
- Common uses include water, sewage, petroleum and petrochemical pumping; a centrifugal fan is commonly used to implement a vacuum cleaner. The reverse function of the centrifugal pump is a water turbine converting potential energy of water pressure into mechanical rotational energy.
- The first machine that could be characterized as a centrifugal pump was a mud lifting machine which appeared as early as 1475 in a treatise by the Italian Renaissance engineer Francesco di Giorgio Martini. True centrifugal pumps were not developed until the late 17th century, when Denis Papin built one using straight vanes. The curved vane was introduced by British inventor John Appold in 1851.



- A positive displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe.

- Some positive displacement pumps use an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant through each cycle of operation.

- Positive displacement pump behavior and safety
- Positive displacement pumps, unlike centrifugal or roto-dynamic pumps, theoretically can produce the same flow at a given speed (RPM) no matter what the discharge pressure. Thus, positive displacement pumps are constant flow machines. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

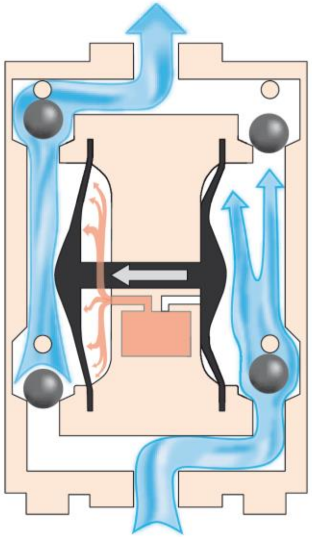
- A positive displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, or both.

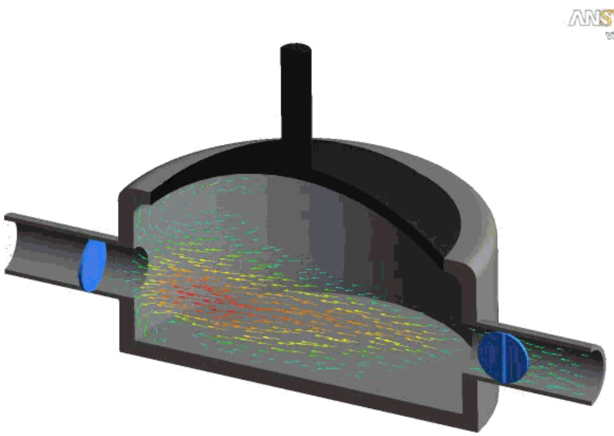
- A relief or safety valve on the discharge side of the positive displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually used only as a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank provides increased safety.

- A diaphragm pump (also known as a Membrane pump) is a positive displacement pump that uses a combination of the reciprocating action of a rubber, thermoplastic or teflon diaphragm and suitable valves on either side of the diaphragm (check valve, butterfly valves, flap valves, or any other form of shut-off valves) to pump a fluid.

- There are three main types of diaphragm pumps:

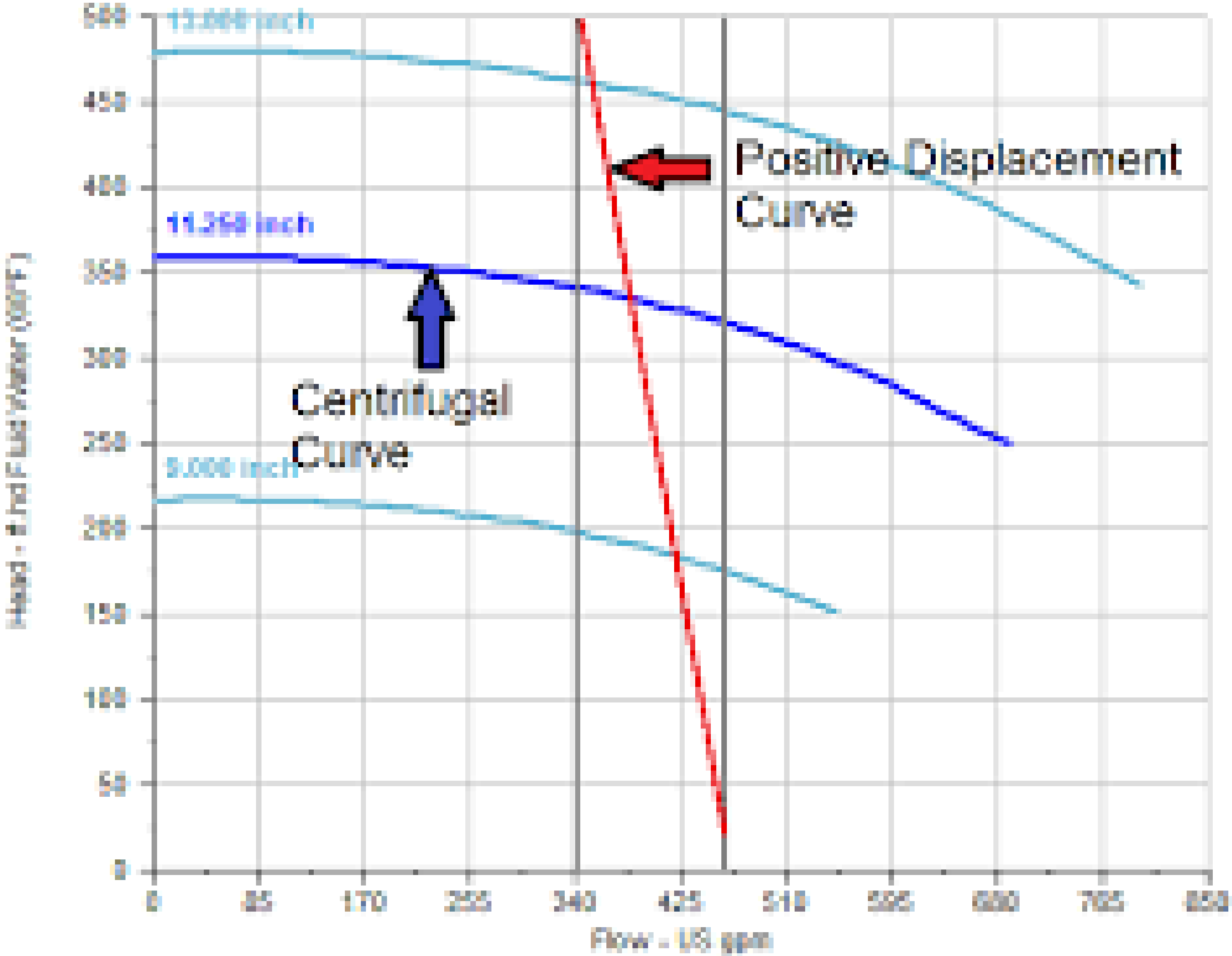
- Those in which the diaphragm is sealed with one side in the fluid to be pumped, and the other in air or hydraulic fluid. The diaphragm is flexed, causing the volume of the pump chamber to increase and decrease. A pair of non-return check valves prevent reverse flow of the fluid.[1]
- Those employing volumetric positive displacement where the prime mover of the diaphragm is electro-mechanical, working through a crank or geared motor drive, or purely mechanical, such as with a lever or handle. This method flexes the diaphragm through simple mechanical action, and one side of the diaphragm is open to air.[2]
- Those employing one or more unsealed diaphragms with the fluid to be pumped on both sides. The diaphragm(s) again are flexed, causing the volume to change.





- A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A rotor with a number of "rollers", "shoes", "wipers", or "lobes" attached to the external circumference of the rotor compresses the flexible tube. As the rotor turns, the part of the tube under compression is pinched closed (or "occludes") thus forcing the fluid to be pumped to move through the tube. Additionally, as the tube opens to its natural state after the passing of the cam ("restitution" or "resilience") fluid flow is induced to the pump. This process is called peristalsis and is used in many biological systems such as the gastrointestinal tract. Typically, there will be two or more rollers, or wipers, occluding the tube, trapping between them a body of fluid. The body of fluid is then transported, at ambient pressure, toward the pump outlet. Peristaltic pumps may run continuously, or they may be indexed through partial revolutions to deliver smaller amounts of fluid.

System Curves for Pumps



5 differences between centrifugal pumps and positive displacement pumps

1. Fluid Type

Centrifugal pumps are known for their versatility – they can handle both clean fluids and also those with a high solid content. However, they may have limitations when it comes to fluids with high viscosity, whereas positive displacement pumps may be better equipped to deal with such liquids, along with those containing entrained gases.

Fig 1: Centrifugal Pump

2. Efficiency

Centrifugal pumps generally have a narrow window for performing at best efficiency – this is due to frictional losses which occur when viscosity increases. Meanwhile, changes in viscosity and pressure tend not to affect positive displacement pumps.

3. Pressure head

Centrifugal pumps usually need to operate at high speeds in order to deliver high discharge pressure, but it's possible to achieve great differential pressures via positive displacement.

4. Flow rate

Centrifugal pumps tend to be used for handling high flowrates, whereas positive displacement pumps are better suited to applications with low flow rates.

5. Flow type

Centrifugal pumps are known for producing a smooth flow, while certain positive displacement pumps (namely reciprocating pumps) deliver a pulsating flow which requires a damper at the pump discharge.

Fig 2: Positive Displacement Pump

Classifications of Pumps

Overwhelming majority of all pumps are some type of Centrifugal Pump.

- Lower initial cost
- Reduced maintenance costs

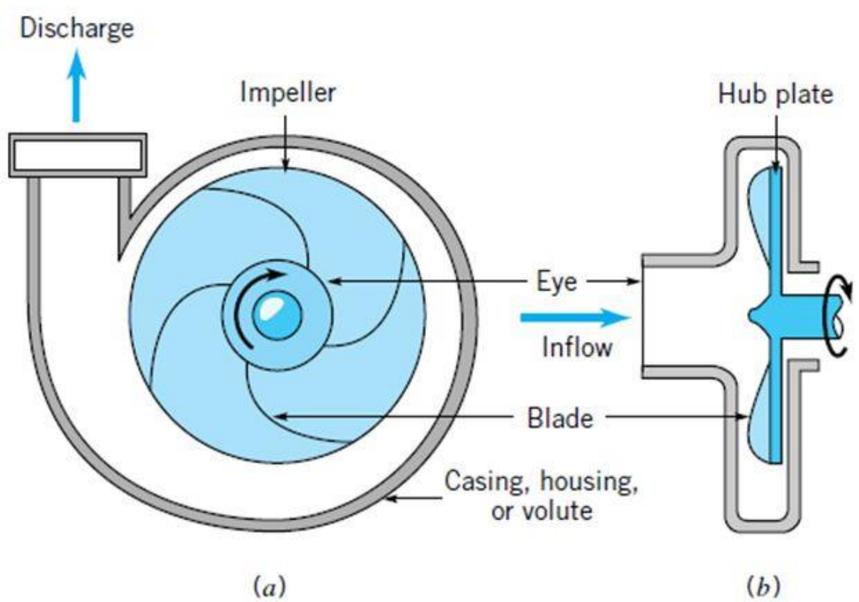
Positive Displacement Pumps are widely used but for specific applications.

Factor	Centrifugal	Positive Displacement
Mechanics	Impellers pass on velocity from the motor to the liquid which helps move the fluid to the discharge port (produces flow by creating pressure).	Traps confined amounts of liquid and forces it from the suction to the discharge port (produces pressure by creating flow).
Performance	Flow rate varies with a change in pressure.	Flow rate remains constant with a change in pressure.
Viscosity	Flow rate rapidly decreases with increasing viscosity, even any moderate thickness, due to frictional losses inside the pump.	Due to the internal clearances high viscosities are handled easily and flow rate increases with increasing viscosity.
Efficiency	Efficiency peaks at a specific pressure; any variations decrease efficiency dramatically. Does not operate well when run off the middle of the curve; can cause damage and cavitation.	Efficiency is less affected by pressure, but if anything tends to increase as pressure increases. Can be run at any point on their curve without damage or efficiency loss.
Suction Lift	Standard models cannot create suction lift, although self-priming designs are available and manometric suction lift is possible through a non return valve on the suction line.	Create a vacuum on the inlet side, making them capable of creating suction lift.
Shearing	High speed motor leads to shearing of liquids. Not good for shear sensitive mediums.	Low internal velocity means little shear is applied to the pumped medium. Ideal for shear sensitive fluids.

Let’s explore each type of these pumps a few of their applications

The Centrifugal Pump

(Radial-flow turbomachines)



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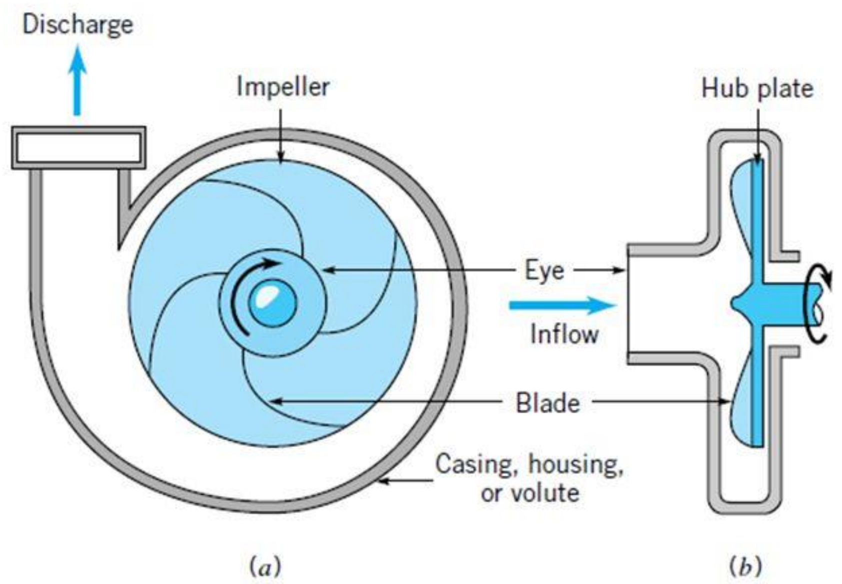
- Like most pumps, a centrifugal pump converts rotational energy, often from a motor, to energy in a moving fluid. A portion of the energy goes into kinetic energy of the fluid. Fluid enters axially through eye of the casing, is caught up in the impeller blades, and is whirled tangentially and radially outward until it leaves through all circumferential parts of the impeller into the diffuser part of the casing. The fluid gains both velocity and pressure while passing through the impeller. The doughnut-shaped diffuser, or scroll, section of the casing decelerates the flow and further increases the pressure.

Centrifugal pumps are most commonly used in water and wastewater pump application where a “flooded” suction condition can be met. The required inlet pressure assist in the pump being able to develop the required pressure to deliver the fluids to their intended destination.

The Centrifugal Pump

(Radial-flow turbomachines)



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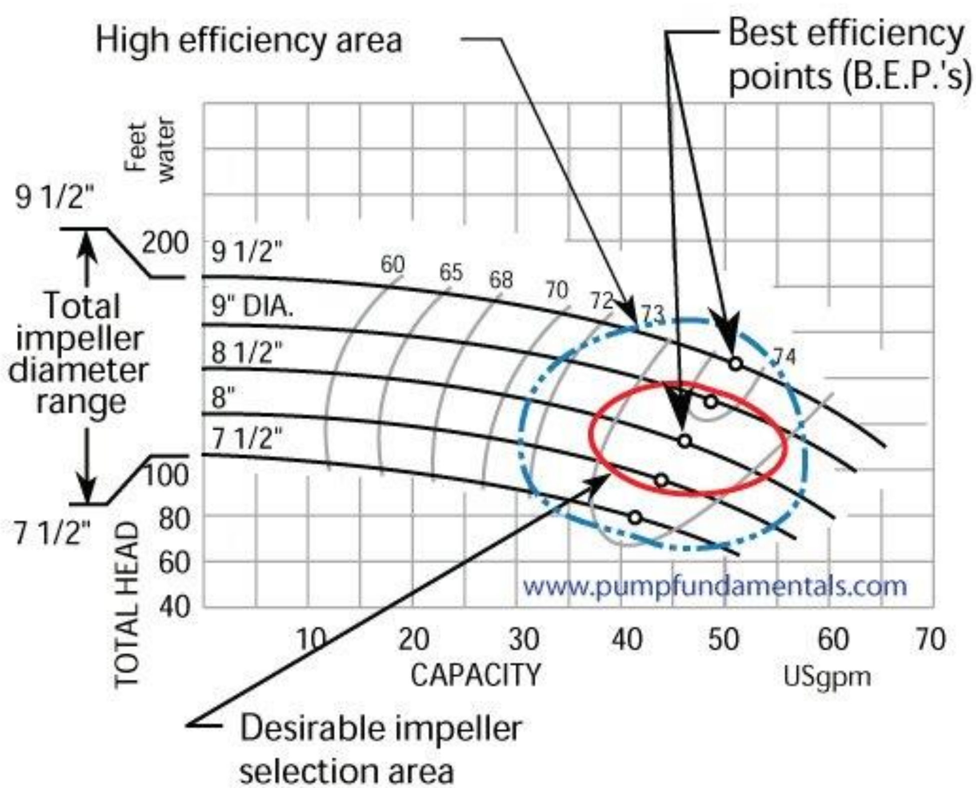
Pump with Shredder Capability

Centrifugal pumps and their respective curves allow us to pick a pump for a specific duty point that is based on the conditions in which the pump is expected to operate. The closer we pick the pump to operate in the "sweet spot" of it's curve the more efficient and effective the pump will operate. This also increased the useful life of the pump and its components.



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Operating a centrifugal pump outside the manufacturer’s recommended areas often creates conditions in the field that cause engineers, operators and maintenance staff to scratch their heads

“We were just as surprised by the test results as you. We're still scratching our heads over it.”

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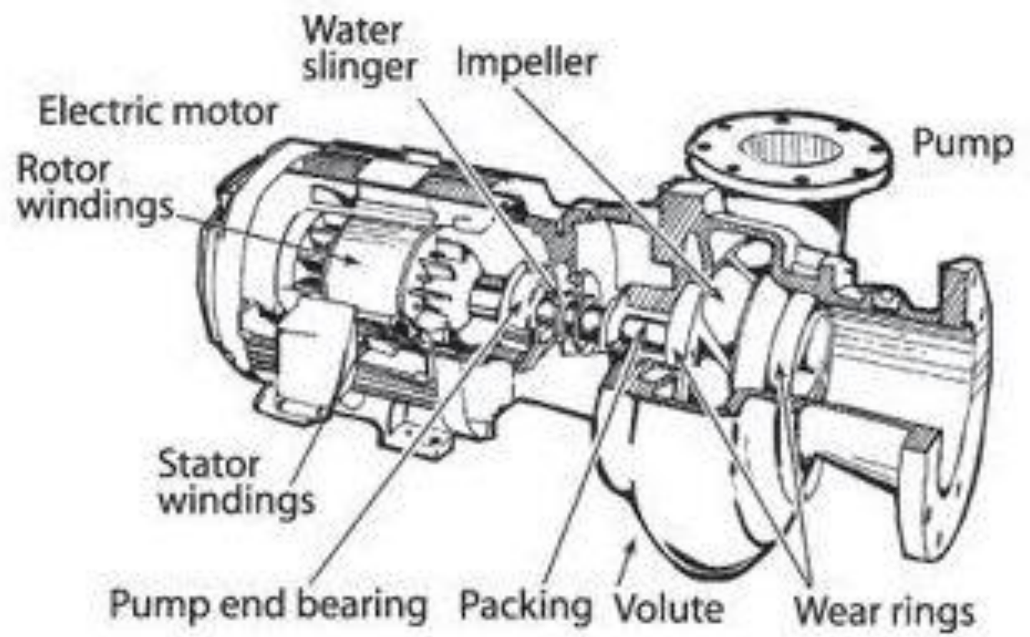
The design condition selected can be affected by several items: Pipe size, pipe and fitting restrictions, valve flow characteristics, atmospheric conditions, water temperature, and most importantly pump wear!! What started as a perfectly operating pump will not continue to be a perfectly operating pump as the components wear down.



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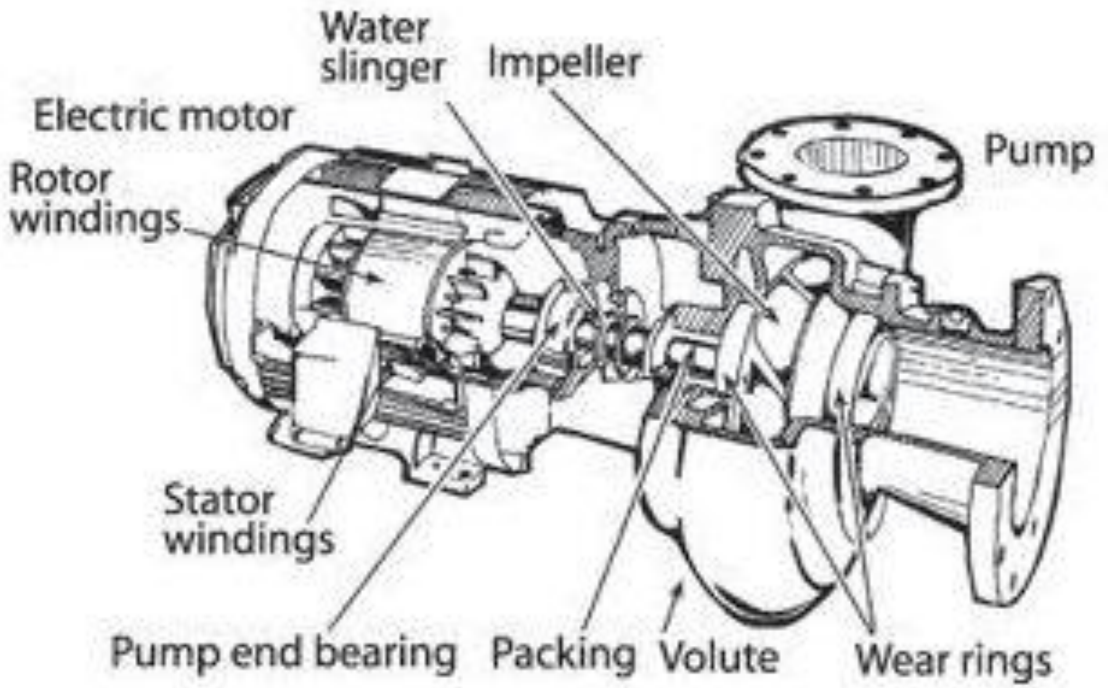
Inspection, testing and maintenance of these parts on a regular basis will allow your pump to have a long and useful life!



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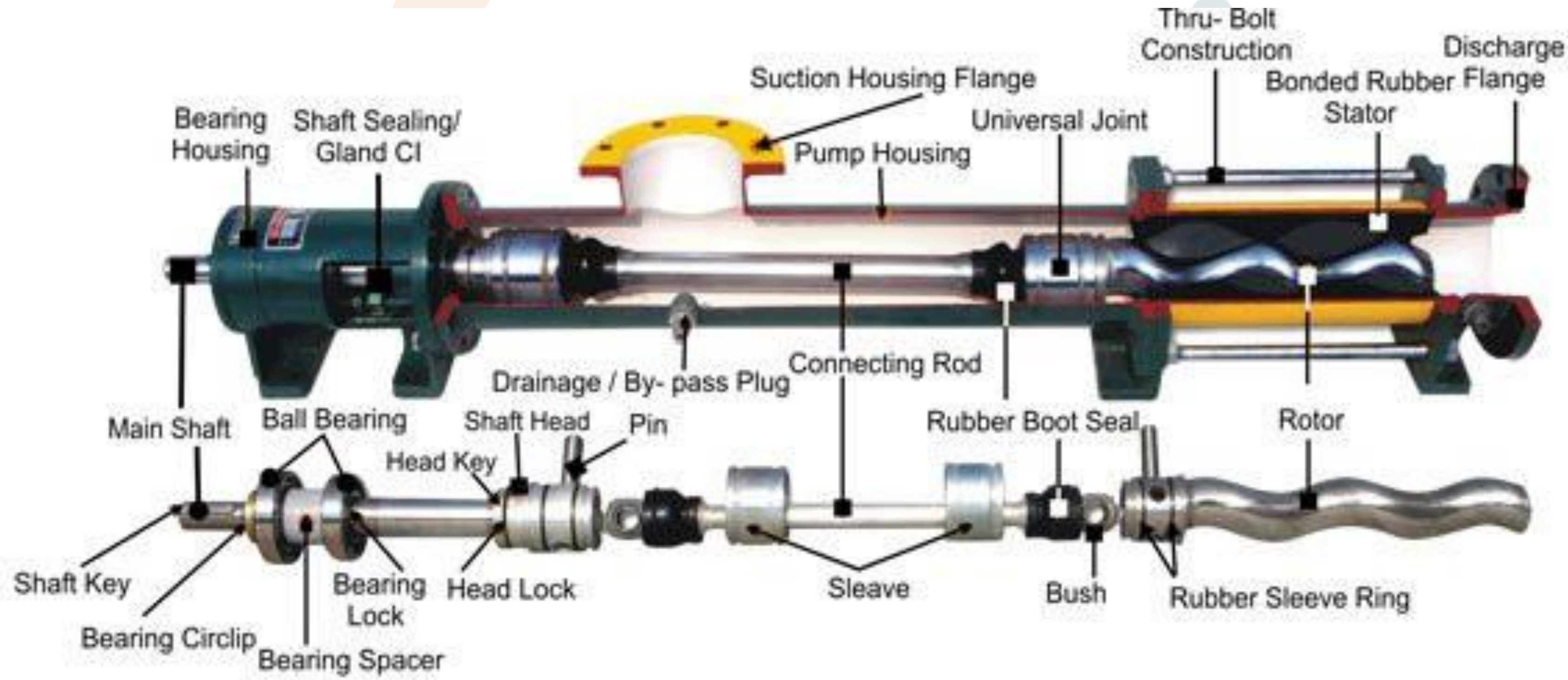
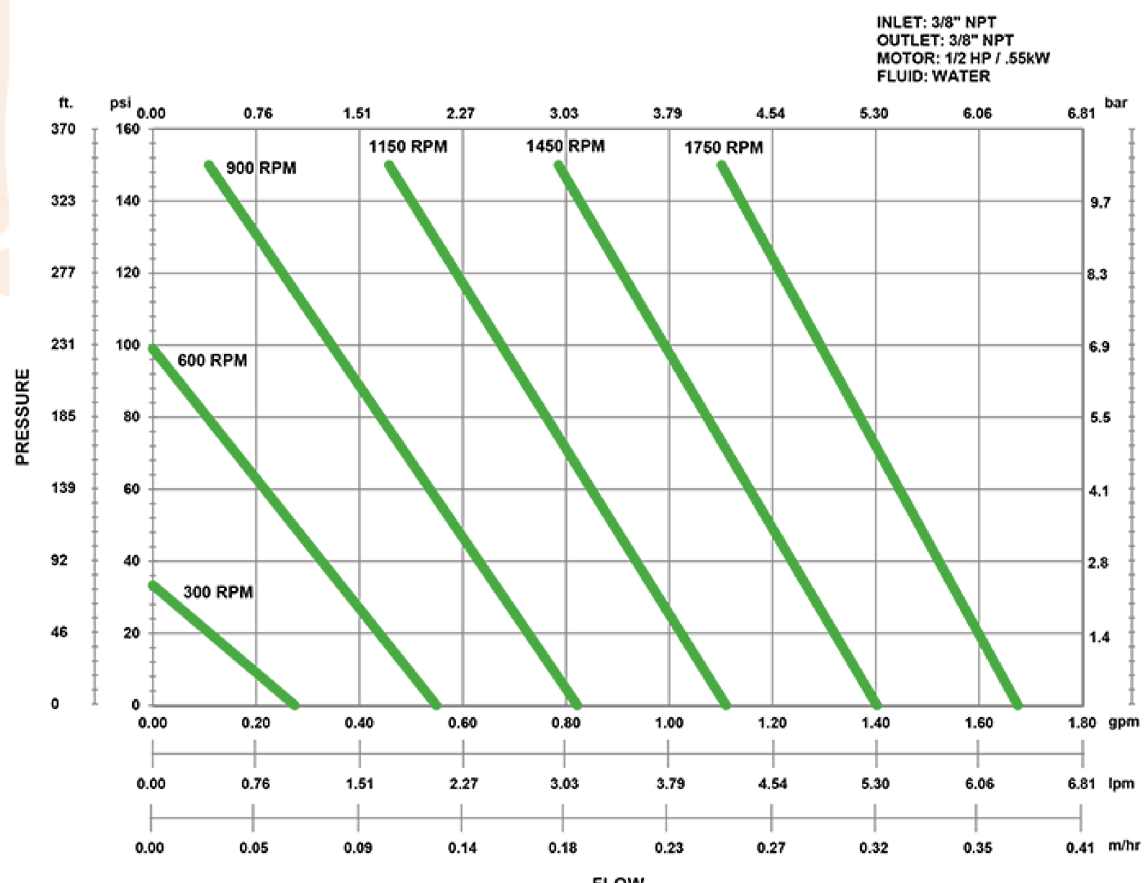
Progressing Cavity pumps are most often used when a viscous fluid is required to be pumped or when an exacting flow over a wide range of pump conditions is expected.



Syno Progressive Cavity Pump Cross-Section showing Internal Spare Parts (Pin-Bush Type)

Progressing Cavity pumps and their respective operating curves often are selected for pump effectiveness over efficiency due to the nature of their applications. Duty specific selections that afford the process they are connected to to perform correctly. RPM of the pump is very important in the design of the system.

FLOW AND PRESSURE RATING



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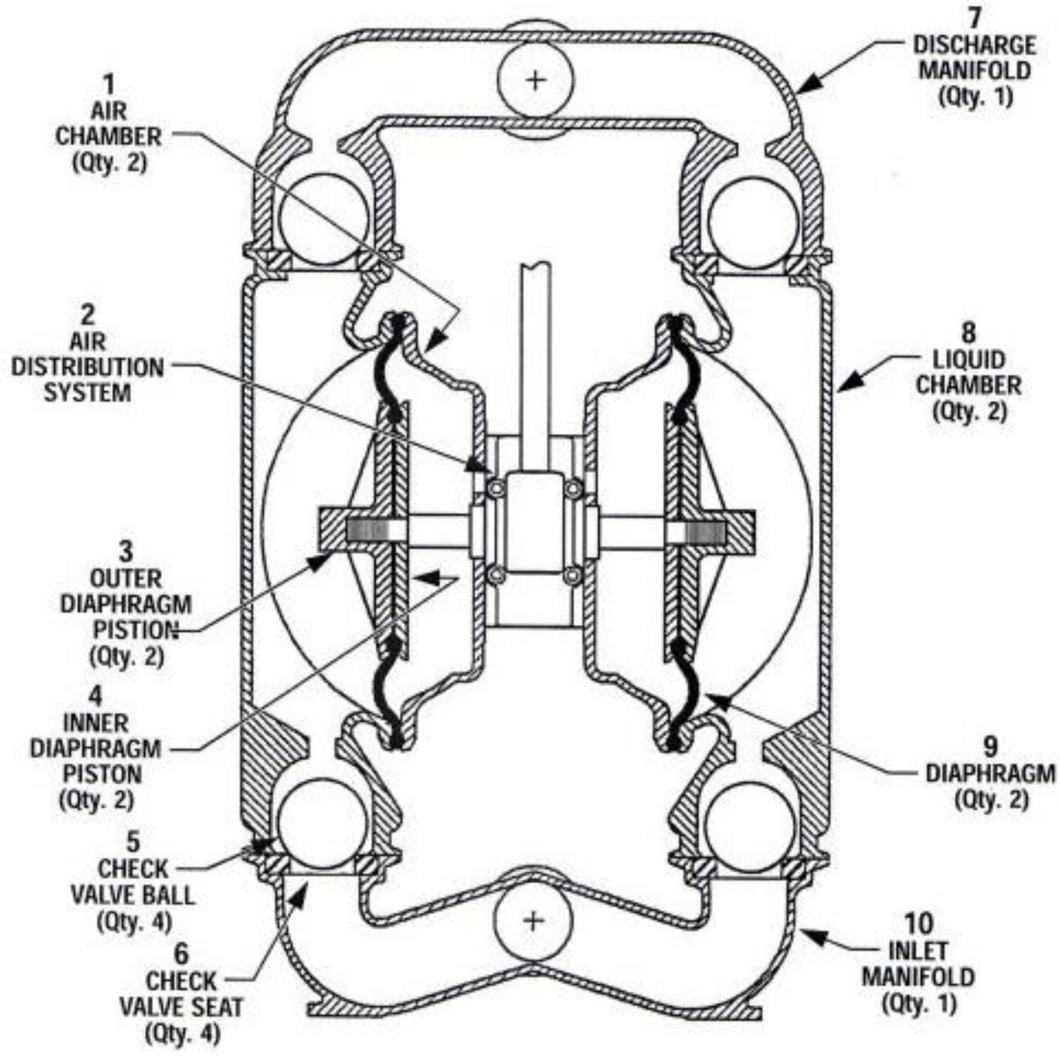
Diaphragm pumps are most often used when a thickened fluid is required to be pumped and conventional pumps cannot typically handle this type of duty



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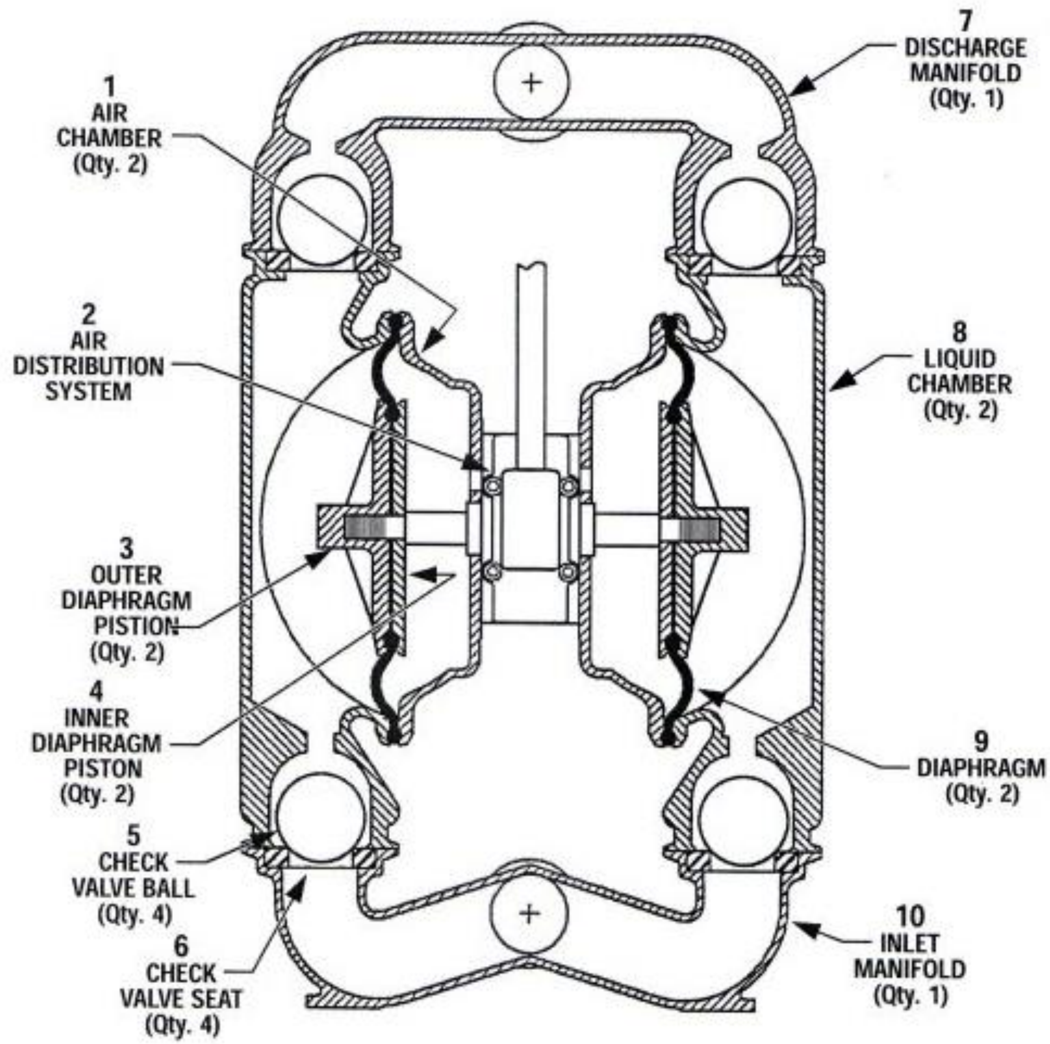
Diaphragm pumps require the addition of high pressure air to operate the pump chambers which means these pumps are not driven by electric motors. Most often seen in the world of water and wastewater in RAS/WAS and slurry applications.



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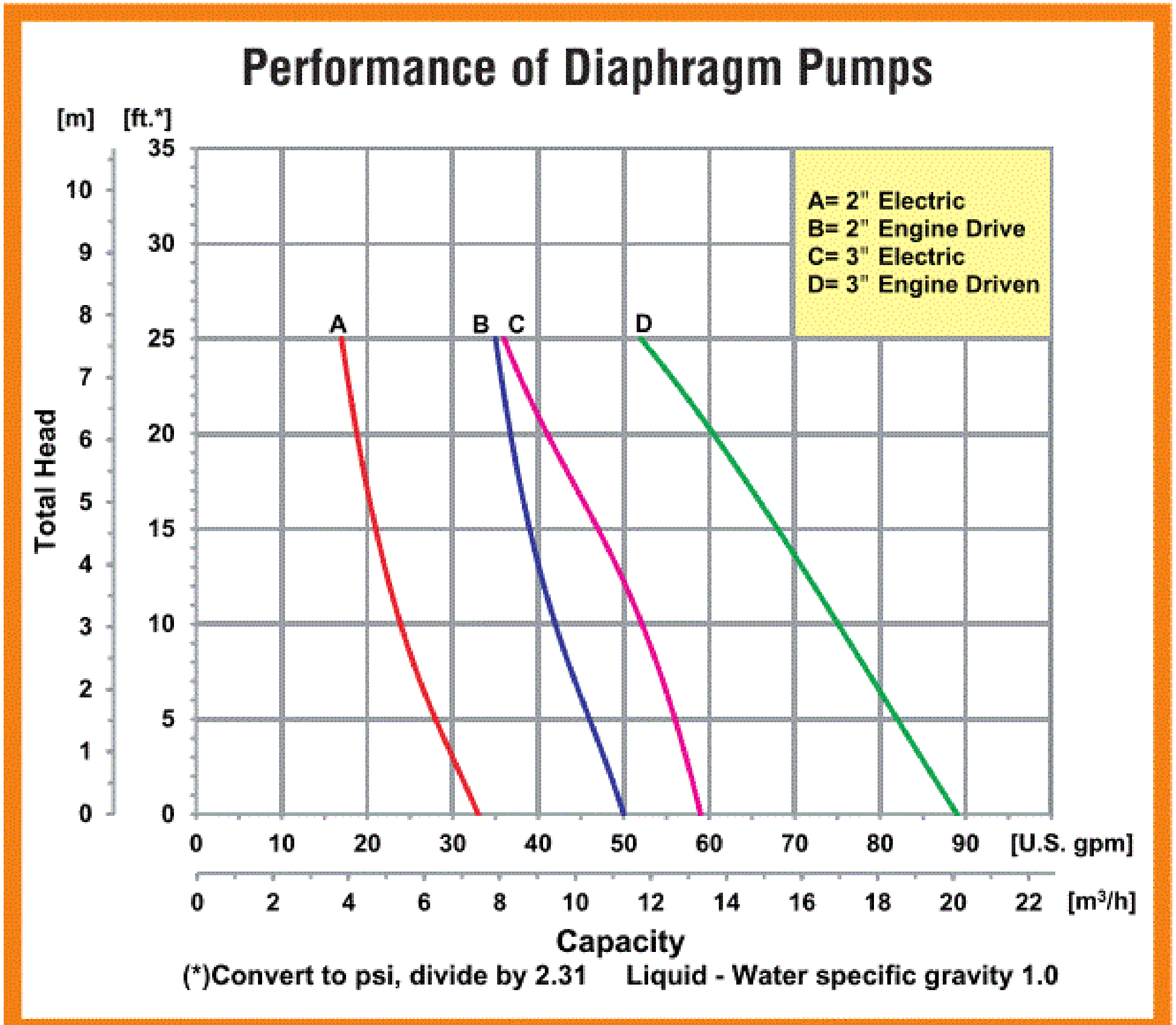
Diaphragm pumps selection curves are very specific in the flow and head and must be applied correctly to be effective.



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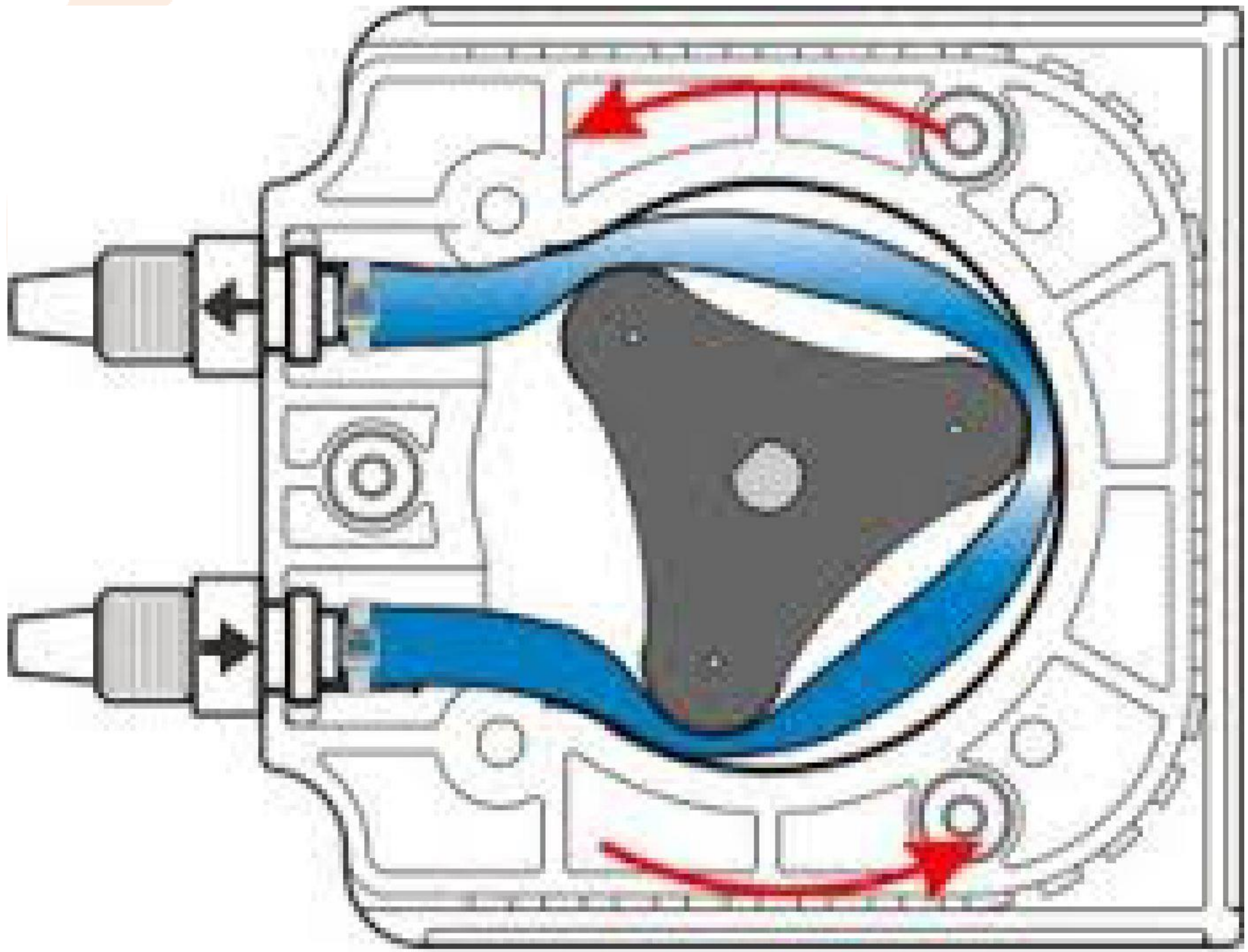
Peristaltic pumps are most often used when a small amount of fluid is required to be pumped and an exacting amount of flow is required. Most often in a “metering” type application. This style pump is also referred to as a positive displacement pump



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Peristaltic pump selections include flow, head, material being pumped, and temperature of material being pumped. Very precise calculations are required for these selections.

CHARACTERISTIC CURVE OF A PERISTALTIC PUMP

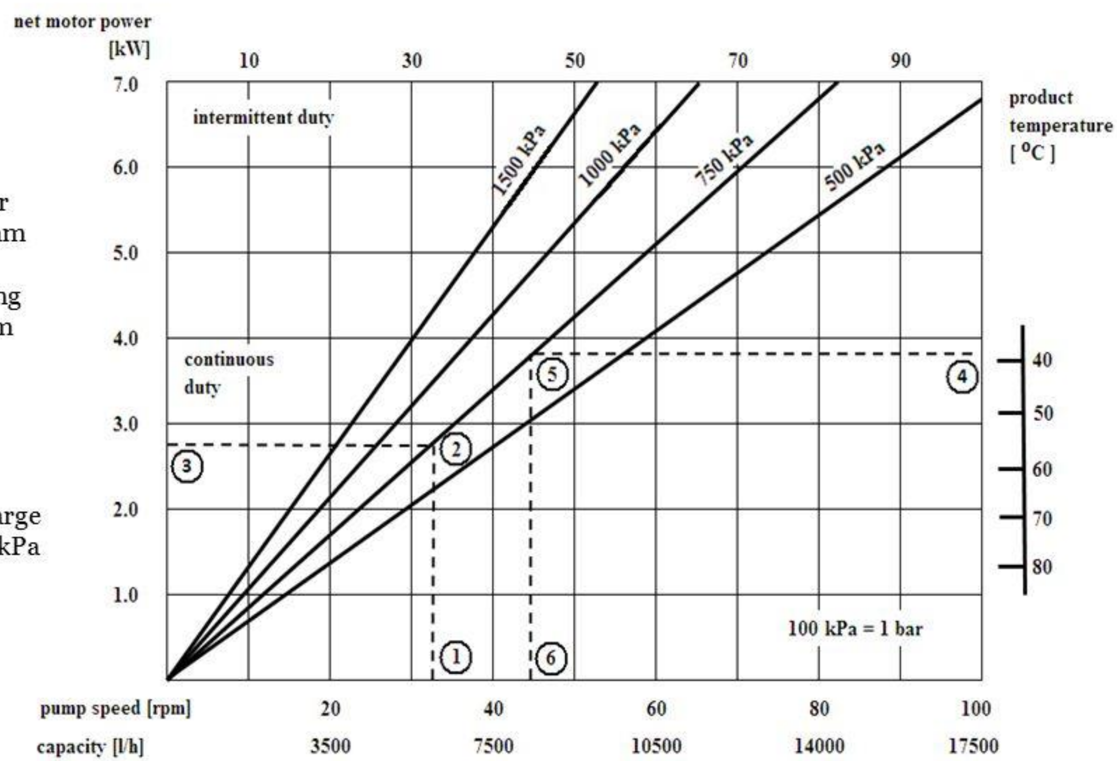
Type SP/50

Pump Hose Inner Diameter - 50 mm

Minimum Starting Torque – 620 Nm

Capacity per revolution 2.9 L

Maximum discharge pressure – 1500 kPa (15 bar/220 psi)



Pump Maintenance!!

It's no mystery, it's mechanical, electrical and runs a lot! It needs maintenance and an occasional repair.

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So, we have seen a few examples of the most commonly used pumps in our business. Let's explore the maintenance aspect of pumps in general.
A few common items on all pumps that should be checked are as follow:

1. Suction pressure
2. Discharge pressure
3. Flow
4. Pump speed
5. Pump efficiency
6. Power Supply

How do you find this information???????

First start with the original pump information data

Second, check the gauges…..Gauges you say!!!!!!!!!

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YES!!!!! Gauges, they can tell you everything you need to know about your pump, regardless of the type or style or application. Pressure readings can lead you to the promised land of pump maintenance and repair!

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So before you begin to tear that pump down, check the gauge readings. If you don't have a gauge to read, install one! Time saved for the future and also it will allow you to keep track of the pump performance and trend its wear patterns.

GAUGE

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Common maintenance functions such as, grease, oil, lubrication, tighten, loosen, adjust, align, clean, balance are all important and are all functions that each individual pump manufacturer has determined for their specific pump. For that reason, any pump you have in your system should include the original O&M manual and required maintenance intervals in those manuals that should be followed.

The guidelines established for your maintenance intervals will also be driven by the duty conditions the pump is put in. Dirty & hot atmosphere in a WWTP will be different than a nice clean booster station. So you as the professional must make note of those conditions and add that to the thought process of your maintenance schedules.

Q&A

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Covalen – Mark Bombardier
3981 Walnut Street
Loris, SC 29569
877-770-8277
www.covalen.com

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