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TECHNICAL TIPS

Ten Things You Need to Know About Your Pumps

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ABSTRACT

This paper highlights 10 critical aspects that a brewer should consider when purchasing a pump. Brewers will gain an understanding of the differences and uses of centrifugal pumps versus positive displacement pumps and how to size the pump to produce pressure. Critical components, from impellers to seal kits and elastomers, are identified to understand pump performance and to assist in maintenance and repair. Finally, aftermarket support and optional upgrades are identified including variable frequency drive controllers and pump carts.

A pump is simply defined as a device that raises, transfers, delivers, or compresses fluids or that attenuates gases especially by suction or pressure or both. Pressure, friction, and flow are three important characteristics of a pump system. Pressure is the driving force responsible for the movement of the fluid. Friction is the force that slows down fluid particles. Flow rate is the amount of volume that is displaced per unit time.

#1: Which Type of Pump Do I Need?

Pumps are typically classified by the way they move fluids. Common pump types include centrifugal, positive displacement, progressive cavity, auger, and twin screw. For the sanitary industry, we will only focus on positive displacement pumps and centrifugal (or rotodynamic) pumps. Positive displacement pumps include single and double rotary lobe pumps and diaphragm pumps. Table 1 outlines a few of the basic differences between these pumps.

A centrifugal pump is a rotodynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid. Centrifugal pumps are the most common type of pump used to move liquids through a piping system.

#2: What Are the Basic Components of a Centrifugal Pump?

A typical centrifugal pump has five basic parts:

1. Casing—Also known as the volute, the casing is the outside visible part of the pump (Fig. 1). For sanitary processing, the casing is typically a heavy-walled 316L stainless configured in a spiral design to even out flow and minimize turbulence. The end cover is clamped on and can be easily removed for access to the impeller.
2. Impeller—The impeller is the main rotating part that provides the centrifugal acceleration of the product (Fig. 2). The impeller can have an open or closed vane. Generally, closed vane impellers develop higher pressures but have a lower capacity. Open vane impellers develop lower pressure but have a higher capacity. The impeller is attached to the shaft and rotates inside the casing at the speed of the shaft. The design is balanced to prevent vibration.

Table 1. Basic differences between pumps

Characteristic	Centrifugal	Positive Displacement
Flow rate and pressure	Has varying flow rate depending on the system pressure or head	Has nearly constant flow regardless of the system pressure or head
Viscosity	Flow is reduced when the viscosity is increased	Flow is increased when the viscosity is increased
Efficiency	Changing the system pressure or head dramatically affects the flow rate	Changing the system pressure or head has little to no effect on flow rate
Net positive suction head (NPSH)	NPSH varies as a function of flow determined by pressure	NPSH varies as a function of flow determined by speed. Reducing the speed reduces the NPSH.

Figure 1. 200 Series centrifugal pump. Image courtesy of SPX Flow, Inc.

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3. Shaft—The shaft (Fig. 3) rotates inside the casing at the speed of the motor and transfers the torque from the motor to the impeller. The shaft is typically made of 316L stainless.

Figure 2. Impeller. Image courtesy of SPX Flow, Inc.

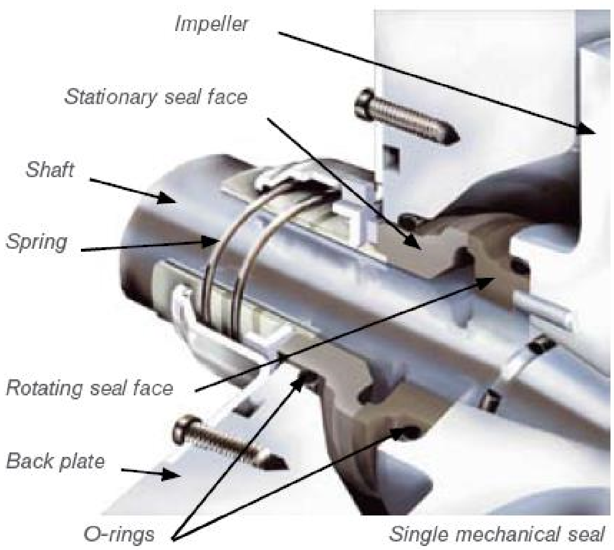

Figure 3. Shaft and seal. Image courtesy of SPX Flow, Inc.

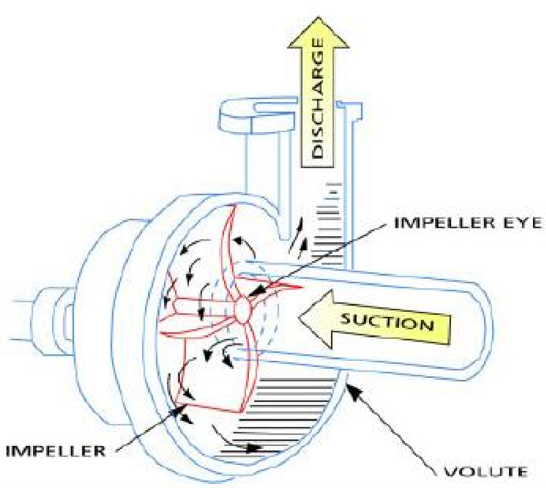

Figure 4. Fluid flow through volute (casing).

4. Bearings—The bearings support the shaft and keep it in alignment so that it does not wobble inside the casing and prevent it from touching the casing.
5. Seals and/or Packing—The seals are the essential area in terms of hygiene, because they prevent the product from leaking back inside the pump or outside of the pump when it is under pressure. Pumps can have either single-seal or double-seal arrangements.

#3: How Does It Produce Pressure?

The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller (Fig. 4), flowing radially outward or axially into a diffuser or volute chamber, from where it exits into the downstream piping system.

The velocity of the fluid is also partly converted into pressure by the pump casing before it leaves the pump through the outlet. Pressure is produced by the rotational speed of the impeller vanes. The speed is constant. The pump will produce a certain discharge pressure corresponding to the particular conditions of the system (for example, fluid viscosity, pipe size, elevation difference, etc.).

If changing something in the system causes the flow to decrease (for example, closing a discharge valve), there will be an increase in pressure at the pump discharge because there is no corresponding reduction in the impeller speed. The pump produces excess velocity energy because it operates at constant speed. The excess velocity energy is transformed into pressure energy, and the pressure goes up.

Centrifugal pumps are typically used for large discharge through smaller heads. Centrifugal pumps are most often associated with the radial-flow type. However, the term “centrifugal pump” can be used to describe all impeller-type rotodynamic pumps.

#4: What Are My Process Parameters?

The main factors that affect the flow rate of a centrifugal pump are as follows:

- Friction, which depends on the length of pipe and the diameter
- Static head, which depends on the difference of the pipe end discharge height versus the suction tank fluid surface height
- Fluid viscosity, if the fluid is different than water

Table 2 shows typical selection criteria for centrifugal pumps.

#5: What Size Do I Need?

When selecting a centrifugal pump, one should match the performance of the pump to that needed by the system. To do that, an engineer would refer to a pump’s composite curve. A typical composite curve includes the pump performance curves, horsepower curves, and net positive suction head (NPSH) required.

A pump performance curve indicates how a pump will perform in regard to pressure head and flow. A curve is defined for a specific operating speed (rpm) and a specific inlet/outlet diameter. In Figure 5, these curves show the performance at 1,450 rpm for a 3 in. inlet and 2 in. outlet.

Several curves on one chart indicate the performance for various impeller diameters. In the example in Figure 5, the impeller size ranges from 6.3 to 8.7 in. These curves also tell you the possible conditions that the pump could be modified to meet in the future by installing a different impeller size.

Flow is indicated on the *x* axis, and pressure head is indicated on the *y* axis. In this example, if pumping against a head of 40 ft using an impeller size of 7.9 in., you could pump at a rate of 140 gal/min. Typical centrifugal pumps will show an increased flow rate as pressure head decreases.

The curve also shows the shut-off head or the head that the pump would generate if operating against a closed valve. In our same example, the shut-off for the 7.9 in. impeller is 45 ft of head.

The pump performance curve also provides efficiency curves. These efficiency curves intersect with the head-flow curves and are labeled with percentages. The efficiency varies throughout

Table 2. Typical selection criteria for centrifugal pumps

Criterion	Reason
Low viscosity products (<1,000 cP)	As product viscosity increases, the amount of work needed to push the product increases. If impeller speed remains constant, then the flow will decrease.
Low temperature products	A rise in temperature can induce vaporization in a centrifugal pump, which can increase the likelihood of cavitation and even cause the pump to stop pumping.
High capacity flows (including clean in place [CIP] solutions)	Centrifugal pumps can handle high volumes with a smooth, nonpulsating flow. Ideal to pump CIP solutions at high velocity to ensure adequate cleaning.
Low maintenance	Wear due to operation is minimal because there are few moving parts. Pumps can be disassembled easily for quick service.

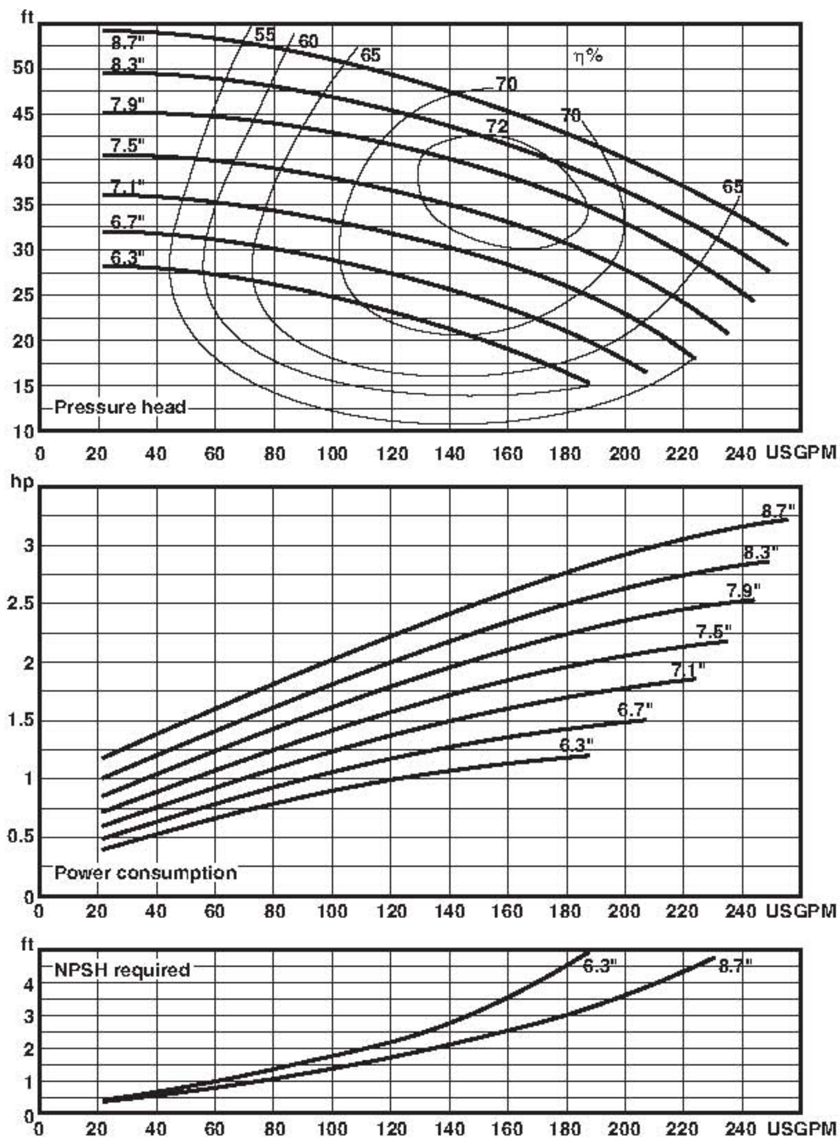

Figure 5. Pump performance curves for a centrifugal pump. Performance curve example courtesy of SPX Flow, Inc.

the operating range. In our same example with the 7.9 in. impeller, we can see that at 140 gal/min, the pump is operating at 72% efficiency.

Some curves will also mark the best efficiency point (BEP). This is the point on a pump's performance curve that corresponds to the highest efficiency and is usually between 80 and 85% of the shut-off head. At this point, the impeller is subjected to minimum radial force, promoting a smooth operation with low vibration and noise. Pumps run best at or near BEP. Operating the pump outside of the recommended range will most likely shorten the pump life.

#6: What Type of Seals and Elastomer Should I Use?

As previously mentioned, the seals are the essential area in terms of hygiene, because they prevent the product from leaking back inside the pump or outside of the pump when it is under pressure. Pumps can have either single-seal or double-seal arrangements. Single mechanical seals are the most common configuration. They use a carbon, carbon composite, or ceramic-based rotating seal on a stainless steel back plate or other stationary seal component. The single seal is vulnerable to cavitation and will degrade faster when using abrasive or "sticky" products.

A double-seal design minimizes the possibility of seal failure. It consists of two independent seals mounted within a seal chamber. By adding a second seal, it provides insurance against seal leakage. The seals must be flushed with an independent water supply at a low flow rate (2–4 gal/min) and low pressure. When the first seal begins to leak, the operator would see discoloration of the seal water. This early indicator prevents damage to the pump or components in the chamber.

In addition to the seals themselves, there are typically also elastomers. The most common are as follows:

- Nitrile rubber (also known as NBR or Buna-N), a copolymer of butadiene and acrylonitrile
- Ethylene propylene diene rubber (EPDM), a terpolymer of ethylene, propylene, and a diene component
- Fluorinated propylene monomer (FPM), commonly sold under the trade name Viton
- Polytetrafluoroethylene elastomer (PTFE), commonly sold under the trade name Teflon
- Silicone

Each elastomer offers protection at different temperature ranges and pressures and against different products. It is recommended that you contact your pump or seal manufacturer to determine the compatibility of your elastomer with the products that are being pumped and your process conditions.

#7: What Maintenance Is Required?

All pumps need routine maintenance to extend the life of the pump and to prevent long downtimes in processing. By design, centrifugal pumps are easier to maintain in-house with some basic guidelines. A proper maintenance procedure should begin with a file for each pump. The file should contain complete pump identification: size, type, operating speed, manufacturer, serial number, and material of construction should be noted. Instruction sheets, maintenance booklets, and parts lists provided with the unit should also be assembled in a file for each specific pump. All pertinent data relative to the pump process conditions and fluid handled should also be included. Complete records of maintenance and repair costs along with a log of the unit's operating hours should be kept. Relevant comments and/or photos of specific problems can also be of interest.

During installation and start-up, operating personnel should acquaint themselves with the pump. Suction and discharge pressure readings, indicated flow, and if possible seal leakage loss rate, bearing temperature, and noise and vibration levels all provide input to a pump's performance in the system. Additionally, operating personnel must be aware that any change in the system, including the fluid being pumped, could affect the pump's performance. Any changes in noise, seal leakage, or pressure/flow changes should be examined immediately.

Depending on the amount of use, a typical inspection should occur every six months. The operator should check the seals and lubrication and look for signs of wear. All maintenance should be noted in the file. Most pump manufacturers will also offer pump maintenance programs.

Pump maintenance should be considered a critical decision point during the selection of the pump manufacturer. Although centrifugal pumps in theory operate by the same principles, each manufacturer's design can vary significantly. Items such as mechanical seal design vary from simple to extremely complicated and cumbersome.

#8: What Aftermarket Support Is Available?

Pump manufacturers and their distributors can provide all of the spare parts that may be needed during maintenance of your pump. This includes seal kits, impellers, shafts, gear casings, and motors. For faster service, identify the part that needs replacing as well as the pump. Include the serial number and other information located on the pump nameplate. The operating manual for the pump can be used to identify the part in question and the part number.

Many of these companies have service technicians that can come into your facility to perform routine maintenance and inspections of the equipment. Manufacturers also offer training classes and support by phone and email. Instruction manuals and parts lists can be found on their websites. Videos can also be found online on YouTube or on the manufacturer's website that will offer step-by-step instructions for common maintenance issues.

A final consideration for aftermarket support needs to be the availability of components and technical support including the origination of components and support. Keep in mind that items that must be shipped from overseas not only will have longer shipping and lead times but also must clear customs each time they are shipped across borders.

#9: What Critical Spares Are Needed?

The first question to ask yourself is, "Where am I going to be if this pump is down due to failure for one day or more?" Many spare parts, when ordered from a manufacturer, may have a lead time of several days, or you may incur expedited shipping charges to overnight a part to your facility. Depending on the extent to which you can risk a shutdown, an adequate supply of repair and maintenance parts should be kept on hand. The economics of maintaining replacement parts must be balanced against the cost of your downtime.

Figure 6. Portable pump cart with variable frequency drive.

A minimum requirement for pump maintenance should include seal kits and elastomers. A wet-end assembly is also recommended. If the pump is the primary piece of equipment in your process, then you should also consider investing in a motor and a complete pump assembly. If you have a number of identical units in service, the replacement inventory may be reduced.

#10: What Portability and Controls Are Needed?

Depending on the usages of each pump, you may find that a portable pump cart (Fig. 6) is a better option than a pump hard piped into your process. Pump carts allow you to maneuver the pump throughout your facility for use at multiple locations. The same pump can be used for transfer between various tanks and clean in place systems of those tanks. Pump carts can be further customized to include remote or mounted controls as well as designs to meet NEMA-4 (water-tight) and/or explosion proof conditions. Onboard controls can include a variable frequency drive to control the revolutions per minute of the motor and thus the flow rate, or a simple motor starter for easy on/off control.