Characteristics of a Good Pumping System

Guide to Minimizing Start-up Headaches

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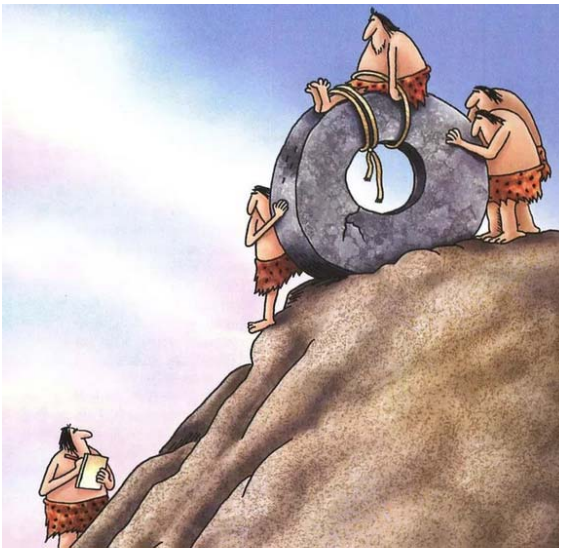


There is nothing quite like that anticipation prior to starting-up a newly installed pump system, hoping that everything will go as planned. The following article highlights installation recommendations and pump accessories that will contribute to a reliable pump system.

This is not an in-depth catch-all article covering all types of pumps, rather the following information summarizes recommendations by Wanner Engineering, manufacturer of sealless positive displacement pumps for general industrial and precision metering applications. As such, these guidelines are especially relevant for all positive displacement pump designs.

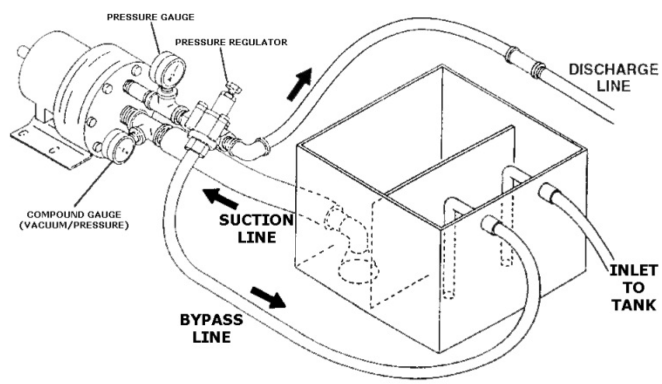
What are Positive Displacement Pumps?
They are pumps that discharge a fixed volume of fluid at a given pump shaft RPM regardless of the inlet or outlet pressure. Centrifugal pumps use centrifugal force to add to the inlet pressure and having a flow rate that changes (decreases) in relation to the discharge pressure.

Inlet Condition
Surmising there is adequate flow to the pump is easier when pumps are fed by a pressurized source, such as a water main or pressurized tank.

Pump Reservoirs
Pumps fed by a supply tank need sufficient volume to enable entrained air to escape. This is particularly important when the supply tank is frequently filled or fluid is bypassed back to it, such as the bypassed flow from a pressure-regulating valve. It is always a good idea to route such feed lines into the tank as far away from the tank outlet as possible and to introduce the fluid below the low level area to prevent extra air entrainment. Using oversized inlet plumbing reduces the inlet velocity and resulting agitation that contributes to entrained air and in some cases foaming.

Entrained Air Creates Problems
Positive displacement pumps displace a fixed volume of fluid per pump shaft revolution, ASSUMING a non-aerated fluid is being pumped. Entrained air or other gasses make the fluid somewhat compressible and that coincides with variation in fluid displacement.

Protecting the Pump System
If you require filtration to protect your pump or equipment downstream, it is a good idea to filter on the inlet side of the supply tank. When strainers or filters clog, they reduce the flow at a given pressure. Restrictions on the inlet side of a pump system contribute to cavitation; a potentially violent imploding of entrained air bubbles resulting in powerful shock waves harmful to both centrifugal and positive displacement pumps.



Inlet cavitation is a common pump problem and often associated with clogged filtration or plumbing components restricting flow rate to the pump. Interestingly, most versions of Wanner's Hydra-Cell pumps are impervious to inlet cavitation thanks to the Kel-Cell design.

Another cause of inlet cavitation is inadequate Net Positive Suction Head (NPSH). Even pumps that are able to lift fluids have limitations as to how much lift they can provide, so calculations are made to determine if the NPSHa (available) is ≥ the NPSHr (required).

NPSHa = Pt + Hz - Hf - Ha – Pvp

- Pt: Atmospheric pressure
- Hz: Vertical distance from surface liquid to pump
- centerline (if liquid is below pump centerline, then Hz is negative)
- Hf: Friction loss in suction pumping
- Ha: Acceleration head at pump suction
- Pvp: Absolute vapor pressure of liquid at pumping temperature.

When using the formula above it should reflect the specific gravity of the fluid and the units should be in "feet or meters absolute".

The formula above seems "simple" but the formula for acceleration head is **Ha = (L x V x N x C) ÷ (K x G)** where:

- L = Actual length of suction line (ft) — not equivalent length
- V = Velocity of liquid in suction line (ft/sec) [V = GPM x (0.408 ÷ pipe ID2)]
- N = RPM of crank shaft
- C = Constant determined by type of pump
- K = Constant to compensate for compressibility of the fluid — use: 1.4 for de-aerated or hot water; 1.5 for most liquids; 2.5 for hydrocarbons with high compressibility
- G = Gravitational constant (32.2 ft/sec2)

So you can see that the math gets complicated quickly, which is why we use special spreadsheets to assist us these calculations.

Minimization of acceleration head and friction losses is achieved by shortening the pump inlet line length (preferably ≤ 3 feet), using an inlet line having an ID larger than the ID of the pump inlet and minimizing the number of fittings used. An inlet velocity of 1-3 FPS (0.3 – 0.9 MPS) is ideal.

It is a good idea to cover feed tanks to prevent foreign material from being introduced. It is also important to install a vortex breaker by the outlet to prevent introduction of air into the pump inlet.

The ID of the bulkhead fittings should match the ID of the discharge line and their location on the tank should be above the bottom to reduce chances of settled materials from being drawn into the pumps inlet port.

If your feed tank is used for more than one pump, it is advisable that there are individual tank fittings for each pump system otherwise pumps operating from a shared line simultaneously might “fight” each other for the available flow.

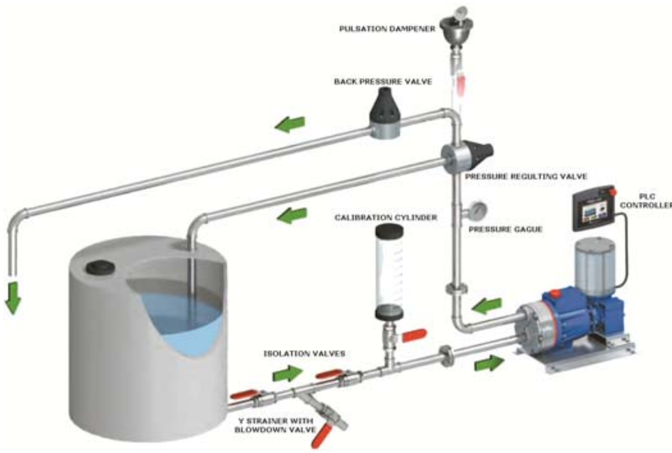
Non-air tight connections are another insidious way air enters your system. This can be difficult to troubleshoot unless you are using clear tubing. I recall one such application for a low flow rate metering pump that would start-up fine, then after a short time would lose pumping volume. Luckily, they were using clear tubing and we observed some air bubbles entering into the line from a barbed elbow connection. The issue was solved once we tightened the hose clamp.

Air was accumulating within a simplex pump chamber and preventing it from fully filling with liquid, reducing the discharge rate. Always make sure your connections are tight and realize that you might not observe leakage on the inlet side of your plumbing but could still be sucking-in air.

Helpful Accessories

Minimizing the number of fittings and accessories contributes to reliability, although there are certainly a few items that may enhance performance or provide helpful information.

A pulsation dampener installed on the inlet side of your pump system can reduce acceleration head (Ha) losses and smooth-out a turbulent flow, which you might expect from branches off a main or situations where one pump feeds another pump.



A compound pressure gauge to indicate vacuum and pressure on the inlet side of the pump is an inexpensive way to confirm the suction condition. If you are using filtration, a differential pressure gauge will provide a visual indication of the pressure drop. These can be made with reed switches to provide feedback to a control system or alarm. It is time to service your filter once the NPSHa approaches the NPSHr or when the differential pressure increases 5 PSI above the “clean” differential pressure.

Isolation valves keep fluid within the piping when the pump requires servicing, so locating those to minimize product loss is a good idea. Plumbing the pump with consideration of future maintenance or removal from the system is a good idea also.

A pressure gauge located prior to a backpressure or pressure-regulating valve enables accurate setting of those valves and reflects directly on the pumps performance.

If you have a batch style process that involves evacuating air from your system for each start-up, using an automatic priming valve located near the pump discharge port helps the pump prime quicker as there’s no need to move that air downstream nor physical attendance by plant personnel, such as the case when using a manually operated needle valve.

Well thought-out pump installations enhance performance and serviceability; it’s an aspect we discuss with customers with each new application based upon decades of in-field experience.

Chris Pasquali has been trained by Wanner Engineering, having provided sales and engineering support since 1991.