



Suction Design
Guide for
**Reciprocating
Plunger Pumps**

Suction Design Guide for Reciprocating Plunger Pumps

Suction head is the energy of an incompressible fluid causing pressure within the piping of a pump. Suction head is generally expressed in terms of feet of water or pounds per square inch. Head is the weight of fluid being expelled from the opening of a feeding source to the suction side of the reciprocating pump.

To calculate the head of a particular fluid, use the following calculation:

$$h = p/SG$$

Where

h = Head, feet

p = Pressure, psi

SG = Specific gravity of the liquid



There are two suction head calculations particularly significant to plunger pump systems — Net Positive Suction Head available (NPSHa) and Net Positive Suction Head required (NPSHr).

Net Positive Suction Head required (NPSHr) is generally calculated by the original pump manufacturer through experimentation. The manufacturer calculates the NPSHr required for the pump to run safely and with optimal efficiency without the occurrence of cavitation.

NPSHr equation:

$$NPSHr = P_s - P_{vap}$$

P_s = Stagnation suction pressure at the pump inlet, with the pump running

P_{vap} = Vapor pressure of the amount raised by pumping at inlet temperature

$$NPSHr = P_s - P_{vap} = PSI$$

$$NPSHr = p/SG = \text{Feet}$$

Net Positive Suction Head available (NPSHa) is calculated on the suction side of the pump. Generally, the NPSHa of a pump is calculated during the design and construction of the pumping system and is used to test the pumping system upon design completion.



$$NPSHa = P_{sg} + P_z + P_{atm} + P_{vel} - P_{vap}$$

Where

NPSHa = NPSH
available to the pump, psi

P_{sg} = Gauge pressure measured at suction nozzle, psig

P_z = Elevation of gauge above pump centerline, converted to pressure units, psi

P_{atm} = Atmospheric pressure, psia

P_{vel} = Velocity head, converted to pressure units, psi

P_{vap} = Vapor pressure of the amount raised by pumping, at the pump suction nozzle, psia

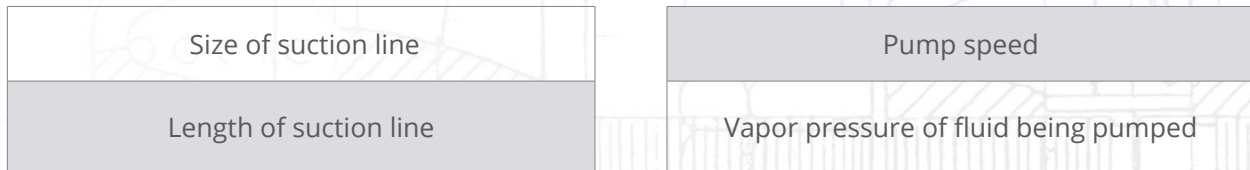
Suction head keeps the valve chamber on the suction side of the plunger pump full throughout the pumping cycle. Suction head is essential to the pumping system.

ADEQUATE SUCTION HEAD IS REQUIRED IN ORDER TO:

1. Sustain pressure above the fluid vapor pressure (fluid must remain in its liquid state during the pumping process).
2. Avoid fluid resistance throughout the piping system (fluid friction).
3. Defeat spring tension on the suction valve.
4. Overcome the weight of the valve.
5. Reduce fluid resistance as it moves through the suction valve.
6. Meet the acceleration requirements of the pump.
7. Meet velocity head in suction line.

If adequate suction head is not achieved in the pumping system, vapor cavities will form within the fluid being pumped (also known as cavitation). If cavitation occurs in the pump system or piping, it can impair the pump, causing damage and operational issues. Every pump system is different, as is the suction head required to optimally operate a pump.

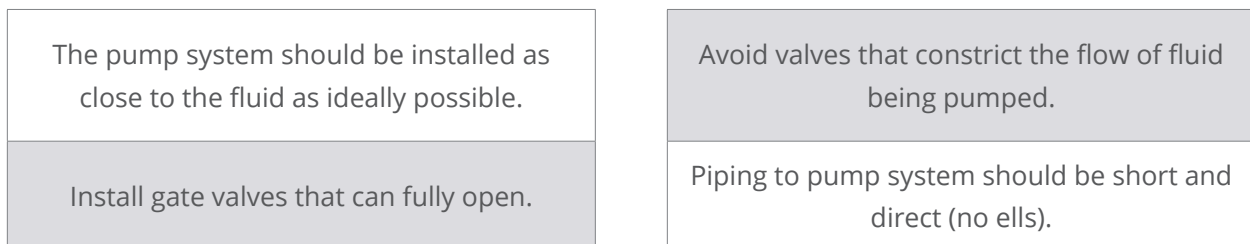
FACTORS THAT AFFECT THE SUCTION HEAD REQUIRED ARE AS FOLLOWS:



There are several types of pump system installations in which a loss of pressure or “head” in the pipes occurs; this is known as friction loss. The more viscous the liquid, the more resistance to flow, and, therefore, the higher the rate of friction loss. In most cases, friction loss is harmless. However, it’s still important to keep an eye on these situations. Once the pump system has been installed and NPSHa has been calculated, a proper pump valve may then be selected. The valve disc and the spring tension of the valve must be properly calibrated to provide optimal flow throughout the pump system.

In most cases, adequate suction head can be achieved by requiring the fluid being pumped to remain in a liquid state at least 15 feet above the vapor pressure of a fluid at the suction side of the pump system (where the pump and piping connect). Some companies allow pump systems to be installed without adhering to this recommendation, but lower than minimum vapor pressure in the pump system or pipes can result in less than ideal pumping conditions.

WHEN INSTALLING A PLUNGER PUMP SYSTEM, THE FOLLOWING RECOMMENDATIONS SHOULD BE CONSIDERED:



*Should an ell be necessary, it is best not to exceed a 45-degree angle. Pressure surges occur when ells are used in a pump system installation and are caused by obstructions and fluid having to curve around an angle in the piping system.

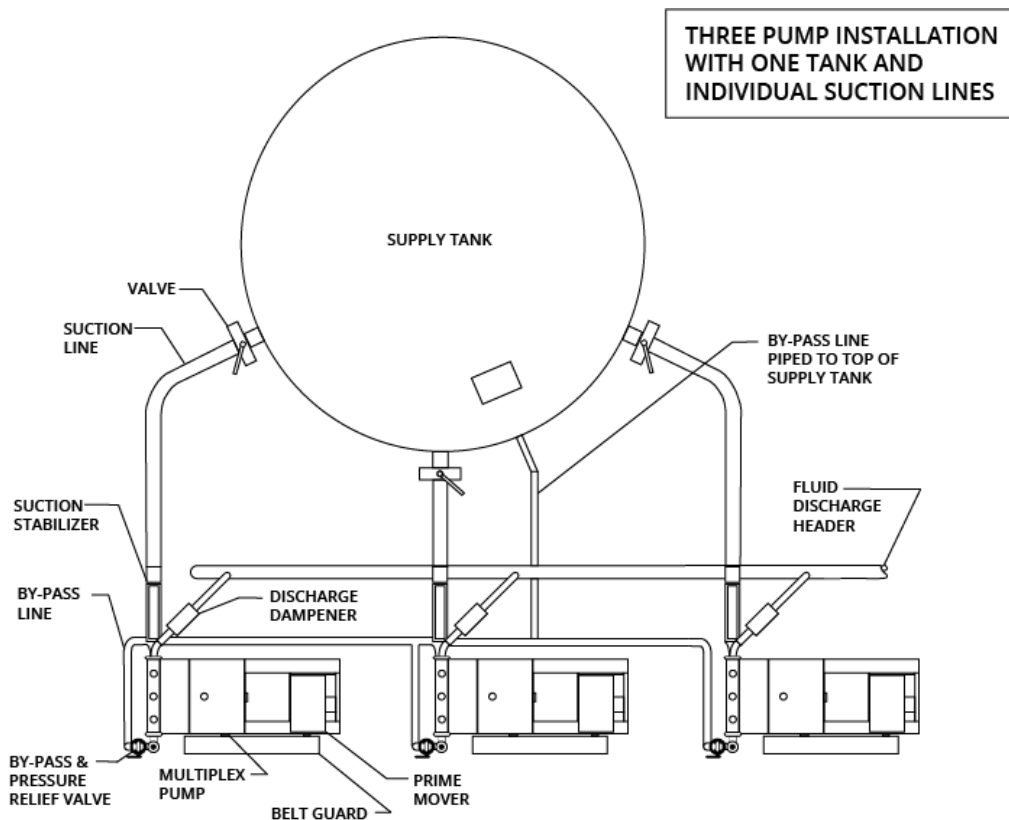
Should a reducer become necessary between the main suction line and the pump, use an eccentric reducer. Eccentric reducers can transition a pipe from a larger diameter to a smaller diameter and help improve low flow velocity and moderate fluid loss situations.

WHEN DESIGNING AND INSTALLING THE SUCTION SYSTEM OF A RECIPROCATING PUMP, THE FOLLOWING RECOMMENDATIONS SHOULD BE CONSIDERED:

Avoid air pockets by sloping suction lines at a downward angle, as this will provide a more efficient flow.

If the pumping system has a bypass design, it should lead fluid back to its original source.

Anchor or bury the pump system's suction and discharge line(s); this will lessen the strain on the pump. If a pump system's pipelines are not anchored or buried, pressure surges and the pump system's suction process can cause harmful vibrations, which will negatively affect the reciprocating pump.



When possible, the suction line should be greater than the pump inlet. Avoid using a suction line smaller than the pump inlet whenever possible. If two or more pumps share a common header, the fluid traveling from the head through the suction line(s) should not exceed more than 2 ½ feet per second at the combined pumps' capacities. Therefore, the suction line(s) needs to be large enough that it will not exceed the recommended flow speed. A header is a piece of the pipe connected to two or more pumps allowing for multiple discharge piping connections.

If fluid in the pump pipeline accelerates or decelerates, pressure surges may occur. The acceleration or deceleration of fluid within the pump system starts on the suction side of the pump.

PRESSURE SURGES CAN CAUSE:

Vibration in the suction pipeline.

Restriction and impedance of fluid flow through the pipe system.

Failure of the valve chamber to fill completely.

The degree of pressure surges and the effects they can have on a pump system are impossible to foresee. Due to the unforeseen behavior of pressure surges, the cause of the surges needs to be eliminated as close to the source as possible. A pulsation dampener, properly installed, will greatly decrease the magnitude of pressure surges by reducing the vibrations traveling through the system. The pulsation dampener feeds fluid back to the low part of the cycle after absorbing the "peak" of the pressure surge. Install the pulsation dampener as close to the pump's suction line as possible. If installation close to the suction line is not possible, attach the dampener to the blind flange side of the pump suction.

A reciprocating plunger pump is a pumping mechanism used to move fluid from the suction side to the discharge side. The pump will not operate efficiently if fluid does not move through the pumping system properly and evenly. This will also cause problems on the discharge side of the pumping system. If the suction side does not have efficient fluid flow throughout the piping system, it can cause severe discharge problems.

When the pump itself requires repair, most often the blame is put on the pump manufacturer, or it is assumed that parts or materials were defective. However, reciprocating plunger pumps require routine inspection and maintenance, and in most cases, the pump is not the problem; rather, it is the damage caused by insufficient suction and/or discharge applications.





About Triangle Pump

For almost 100 years, Triangle Pump Components Inc. has been an industry leader in durable, dependable pump components. From our patented World War II-era **Durabla**® style valve to our plate valves, **Resista**™ abrasion resistant valves, plungers, packing, and **DynaRod**™ extension rods, our entire product line is equipped to mitigate suction system failures for your pump.

We manufacture and sell reciprocal pump valves, plungers, packing, and a full line of stuffing box components. Our dependable products and dedicated staff are here to help resolve any suction system problems you may be experiencing.

To learn more about our diverse line of pump products, [contact us](#) today to speak with a Triangle Pump representative.



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