

Introduction

Centrifugal pumps must be primed (filled with liquid) before they can be operated. In many cases the pump can be placed in a location where the priming function can be accomplished by gravity feeding to the system. A typical example for such an installation would be locating the pump below the liquid level of a tank with a suction line design that eliminates the possibility for entrapping air.

If the configuration does not allow such a simple priming method and the pump is located above the liquid level or the chemical has to be drawn up thru a dip tube and out of a drum, then a vacuum can be used to prime the pump.

Concept

There are different possibilities to get the air out of pump head and suction line. The concept for every variant is basically the same: Since the suction capabilities of a centrifugal pump are very limited, a priming path has to be introduced. By aid of an additional construction the air is sucked out of the pump head and suction line and is replaced with liquid.

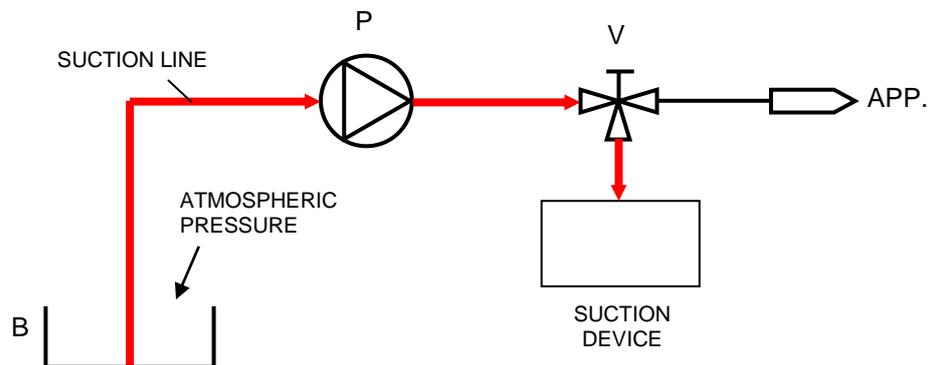


Figure 1: Priming Concept

*B: Bottle or drum with a dip tube
P: Main pump (BPS-1, BPS-3 or BPS-4)
V: 3-way valve*

Advantages

Considering a proper priming solution in hydraulic loop design helps avoiding issues caused by air in pump head respectively unprimed tubing.

Vacuum Priming

The vacuum method uses a vacuum to remove the air from both the suction line and the pump. Atmospheric pressure then fills the suction line with liquid through the submerged intake or dip tube.

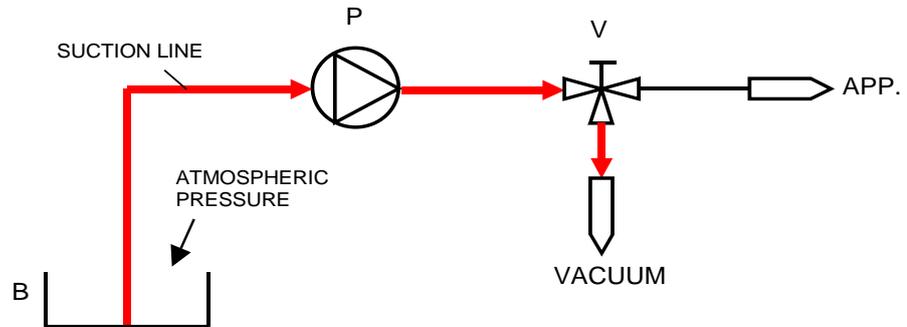


Figure 2: Vacuum Priming

B: Bottle or drum with a dip tube
P: Main pump (BPS-1, BPS-3 or BPS-4)
V: 3-way valve

Generating Vacuum

If a vacuum line is not available, a venturi valve (aspirator) or a small diaphragm pump can be used to draw a vacuum. For the selection of such a vacuum pump (or venturi) which not only meets the technical requirements of the application but also minimizes cost, the following aspects should be acknowledged:

- **Due to the minimal operating time of such a pump, wear, MTBF and operating costs are negligible.**
- **If the vacuum line is plumbed to drain, there will be no contamination or particle issues that can affect the product.**
- **Because of the advantages of the pump described above, the chemical resistance and purity of the wetted parts play a minor role. If there is a concern of a chemistry or slurry being left in the lines, the pump can also be flushed after the priming procedure.**
- **The pump performance (size) only has an influence on the duration of the priming process and not on the overall pump requirements of the application.**

In many cases these aspects result in a simple, small and inexpensive priming pump. There are several manufacturers of small electrically driven diaphragm liquid pumps. KNF Neuberger is such a supplier of these pumps. Venturi valves (aspirators) are available from companies such as Entegris or SMC. Either N₂, CDA or water can be used to produce the vacuum.

Suction Line Design Rules

To be able to prime the system, an appropriate implementation of the suction line is needed. In general, the number of components that add a potential risk of entrapped air in the suction line (i.e. fittings, step junctions, valves etc.) should be minimized. Apexes, or high spots, in the suction line also increase the risk of air entrapments. After the priming process, this entrapped air could reach the pump with the liquid flow and result in a loss of prime. A minimum amount of air normally doesn't affect the pump, however if the suction line is of a large diameter, the remaining air volume in the suction line might be too high causing the pump to lose its prime. If a smaller diameter suction line is used, the risk of unsuccessful priming goes down. Since the cross-section area of the line is smaller, the liquid velocity during the priming process is high enough to flush out the air in the apex. Even if there should be some residual air left in the suction line, the air volume is small due to the small suction line diameter and the pump won't lose prime. In some applications an apex in the suction line can't be avoided. In a situation where liquid is drawn out of a drum through a dip tube and the pump is placed below the tank, the suction line has at least one apex. Vacuum priming is still possible even with a larger line diameter suction line. (see Figure 8). In many cases residual air left in the system is not a problem. These air bubbles will normally be swept along with the liquid flow and thus eliminated. In low flow applications, however, these air bubbles are not removed and careful design of the suction line must be considered.

- **A minimum number of components (i.e. valves, fittings, step junctions, etc.) in the suction line minimizes the risk of air entrapments.**
- **Apexes in the suction line should be avoided, especially if the suction line is of a larger diameter.**
- **Low flow applications require a careful design of the suction line because entrapped air is not always eliminated with the liquid flow.**

Pump Orientation

Pump orientation also has an influence on the priming function. Entrapped air in the pump could also result in insufficient priming and has to be considered in the initial design. If the pump is evacuated through the outlet during the priming process the optimum orientation is a forward incline of about 10 degrees (Figure 3 left). An additional improvement can be achieved by turning the pump till the outlet of the pump housing is exactly plumb (Figure 3 right). The outlet hole in the pump housing is then positioned directly above the inlet.

If the pump is evacuated through the inlet, the optimum orientation is upright (Figure 4).

- **Forward inclined and turned orientation if the pump is evacuated through the outlet**
- **Upright position if the pump is evacuated through the inlet**

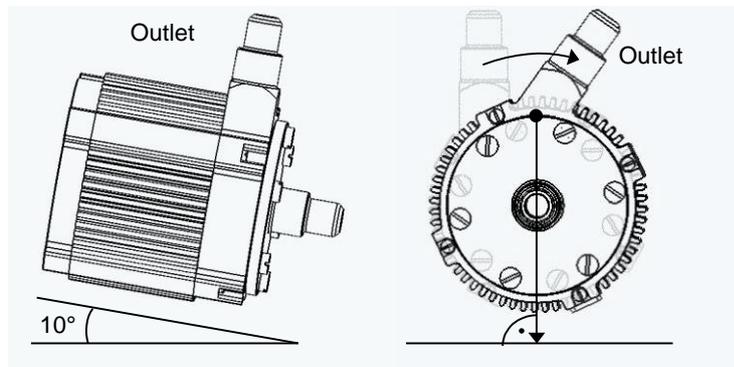


Figure 3: Forward Incline (left) / Turned Pump (right)

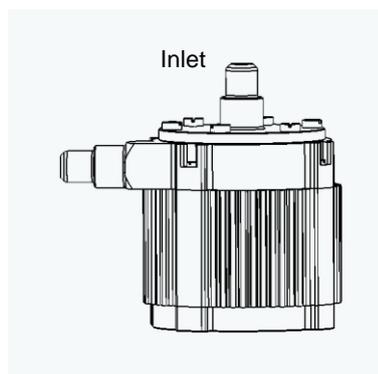


Figure 4: Upright Pump

Vacuum Priming Method 1

Vacuum Priming Through A 3-Way Valve

Figure 5 shows the priming configuration with a 3-way valve which is positioned down-stream from the main pump.

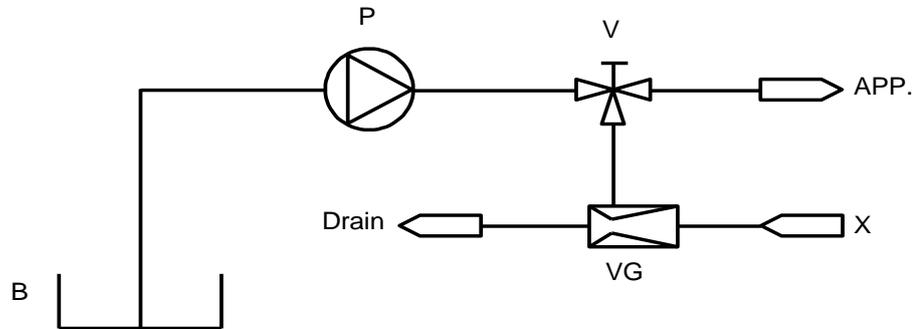


Figure 5: Priming with venturi (aspirator) down-stream from the main pump

B: Bottle or drum with a dip tube

P: Main pump (BPS-1, BPS-3 or BPS-4)

V: 3-way valve

VG: Vacuum generator (venturi aspirator)

X: Either gas (N₂, CDA) or liquid (DI water)

How the method works

During the priming process the 3-way valve links the suction line and the Levitronix pump to the venturi (aspirator). When the suction line and pump are filled with liquid, the venturi can be separated by switching the 3-way valve which then directs the flow to the process. To avoid the loss of prime, the Levitronix pump should be running before the 3-way valve switches to the process line. To prevent the formation of airlocks in the pump, the pump should run at low speed (1000-2000 RPM) during the priming process. An even more effective method is to pulsate from 0RPM to speeds between 1000RPM and 2000RPM.

Alternative use of diaphragm pump

In Figure 5 the outlet of the venturi is sent to drain. Depending on the liquid that is pumped and the medium used to generate the vacuum, the output could also be directed back into tank (B). Since a diaphragm pump does not add any other liquid or gas to the chemistry, it is the preferred priming pump whenever it is not possible or desired to go to drain (see Figure 6).

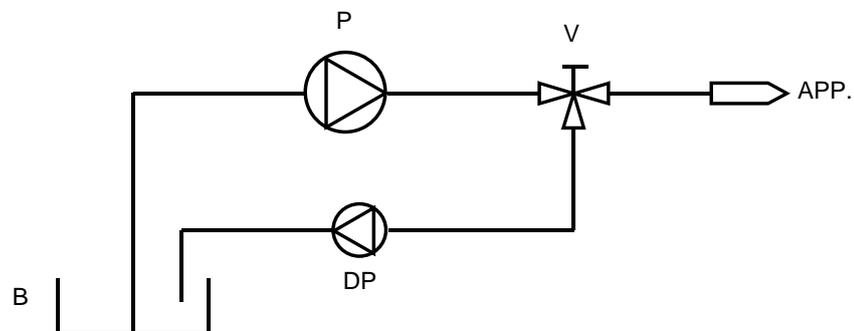


Figure 6 Priming with diaphragm pump down-stream the main pump

DP: Diaphragm pump

Vacuum Priming Method 2

Vacuum Priming Through A Filter Bleed Port

Many filters are equipped with a bleed port.

Figure 7 shows how to use this bleed port to prime the main pump. The arrangement does not require any additional valve, since the two 2-way valve already exists. Valve V1 is needed to bleed the filter and V2 is needed to simplify the filter replacement.

How the method works

During the priming process, V2 is closed and V1 is opened and the vacuum pump evacuates the suction line, pump and filter. In this situation, a pulsating pump speed helps to prevent entrapped air in the pump. When the system is primed, V1 can be closed. Before V2 can be reopened it is advisable to run the pump at least at the speed where no backflow occurs (backpressure has to be taken into consideration) to protect the main pump from loss of prime.

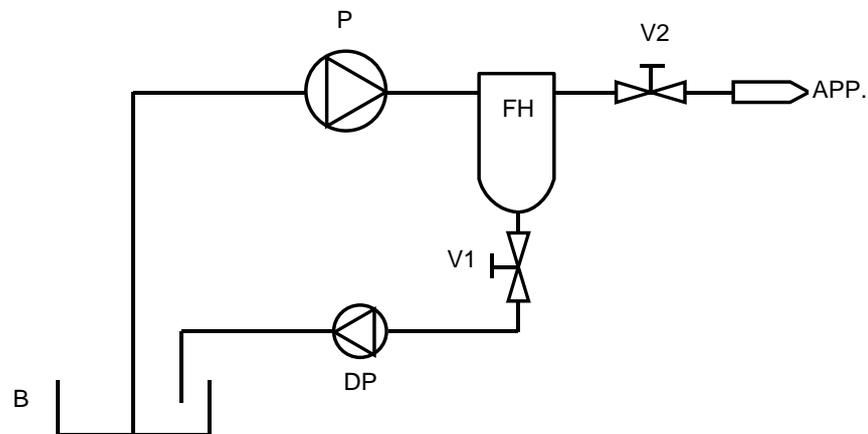


Figure 7 Priming the system through the filter bleeding port

*B: Bottle or drum with dip tube
P: Main pump (BPS-1, BPS-3 or BPS-4)
V1, V2: 2-way valve
DP: Diaphragm pump
FH: Filter housing*

Vacuum Priming Method 3

Vacuum Priming At The Apex Of The Suction Line

In some applications (i.e. chemical delivery where chemicals are drawn through a dip tube and out of a drum) the suction line contains an apex (see Figure 8, the apex is at the end of the dip tube and/or top of the riser R1) where gas or air can accumulate. When the BPS-3 or BPS-4 larger model pumps are used in this type of an application, the diameter of the supply lines are often larger in size. This makes it difficult for a small priming pump to flush the air out of the system. Under these circumstances the suction line can be evacuated through a bleeding port at the highest point. Since every apex needs its own bleeding port, it is advantageous to have only one apex in the whole suction line.

How the method works

To prime the system V1 has to be open and V2 has to be closed (Figure 8). The diaphragm pump (or venturi) evacuates the suction line of air and liquid starts to go up the dip tube and the R1 riser. When the level reaches the point AP, the liquid will flow and prime the pump and the suction line. Since the pump is evacuated through the inlet, the optimum orientation to prevent airlocks is upright (Figure 4).

During the replacement of the chemical drum, only the riser R1 will be filled with air. The suction line behind the apex will not lose prime as long as the main pump has been stopped before the drum empties. Since the volume that has to be evacuated could be much smaller (depending on the suction line configuration) this priming procedure could take significantly less time than the initial priming. Before V2 can be reopened it is advisable to run the pump at least at the speed where no backflow occurs (backpressure has to be taken into consideration) to protect the main pump from loss of prime.

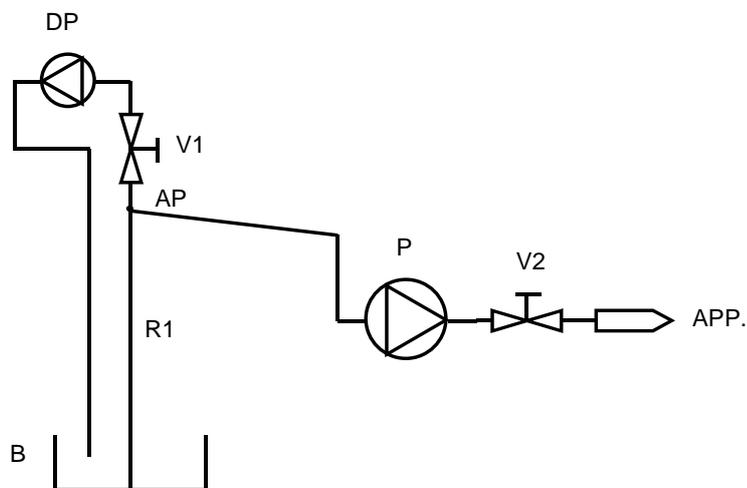


Figure 8 Priming at the apex of the suction line

*B: Bottle or drum with dip tube
P: Main pump (BPS-1, BPS-3 or BPS-4)
V1, V2: 2-way valve
DP: Diaphragm pump
R1: Riser
AP: Highest point of suction line (apex)*

Automated Priming

Levitronix pump controllers are provided with programmable digital and analog in- and outputs that can be used for automated priming. Components like valves or the priming pump can be operated directly by the pump controller. It is also possible to incorporate sensor signals (e.g. from a level sensor) into the priming procedure. For more details please contact Levitronix.

Technical Support

For troubleshooting, support and detailed technical information contact Levitronix® Technical Service Department:

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