Pump*Clinic*...Issue 33

Suction System Design

The design of a piping system can have an important effect on the successful operation of a centrifugal pump.

Selection of the discharge pipe size is primarily a matter of economics. The cost of the various pipe sizes must be compared to the pump size and power cost required to overcome the resulting friction head.

The suction system design is far more important. Many centrifugal pump troubles are caused by poor suction conditions. Such items as sump design, suction piping design, suction and discharge pipe size, and pipe supports must all be carefully considered.

The information detailed below is to be taken as guidelines only and all readers should have specific designs undertaken for individual applications.

Suction Piping Design

The function of suction piping is to supply an evenly distributed flow of liquid to the pump suction, with sufficient pressure to the pump to avoid excessive turbulence in the pump impeller.

The suction pipe should never be smaller than the suction connection of the pump and in most cases should be at least one size larger. Suction pipes should be as short and as straight as possible. Suction pipe velocities should be in 1.5 to 2.5 metres per second range unless suction conditions are unusually good.

Higher velocities will increase the friction loss and can result in troublesome air or vapour separation. This is further complicated when elbows or tees are located adjacent to the pump suction nozzle, in that uneven flow patterns or vapour separation keeps the liquid from evenly filling the impeller. This upsets hydraulic balance leading to vibration, possible cavitation and excessive shaft deflection, especially on high and very high suction energy pumps. Shaft breakage or premature bearing failure may result.

Ideally, a straight length of pipe of an equivalent length of five times the pump inlet size (5D) should be installed before any fitting or valve. Please refer to individual pump instruction books for individual manufacturer's recommendations.

On pump installations involving suction lift, air pockets in the suction line can be a source of trouble. The suction pipe should be exactly horizontal, or with a uniform slope upward from the sump to the pump as shown in Fig. 1. There should be no high spots where air can collect and cause the pump to lose its prime. If high spots are unavoidable, automatic vent valves should be installed at the high points on the piping.

Eccentric rather than concentric reducers should always be used, on horizontal installations, with the flat side located on top.

If an elbow is required at the suction of a double suction pump, it should be in a vertical position if at all possible. Where it is necessary for some reason to use a horizontal elbow, it should be a long radius elbow and there should be a minimum of five diameters of straight pipe between the elbow and the pump as shown in Fig 2.

Fig 3 shows the effect of an elbow directly on the suction. The liquid will flow toward the outside of the elbow and result in an uneven flow distribution into the two inlets of the double suction impeller. Noise and excessive axial thrust will result.

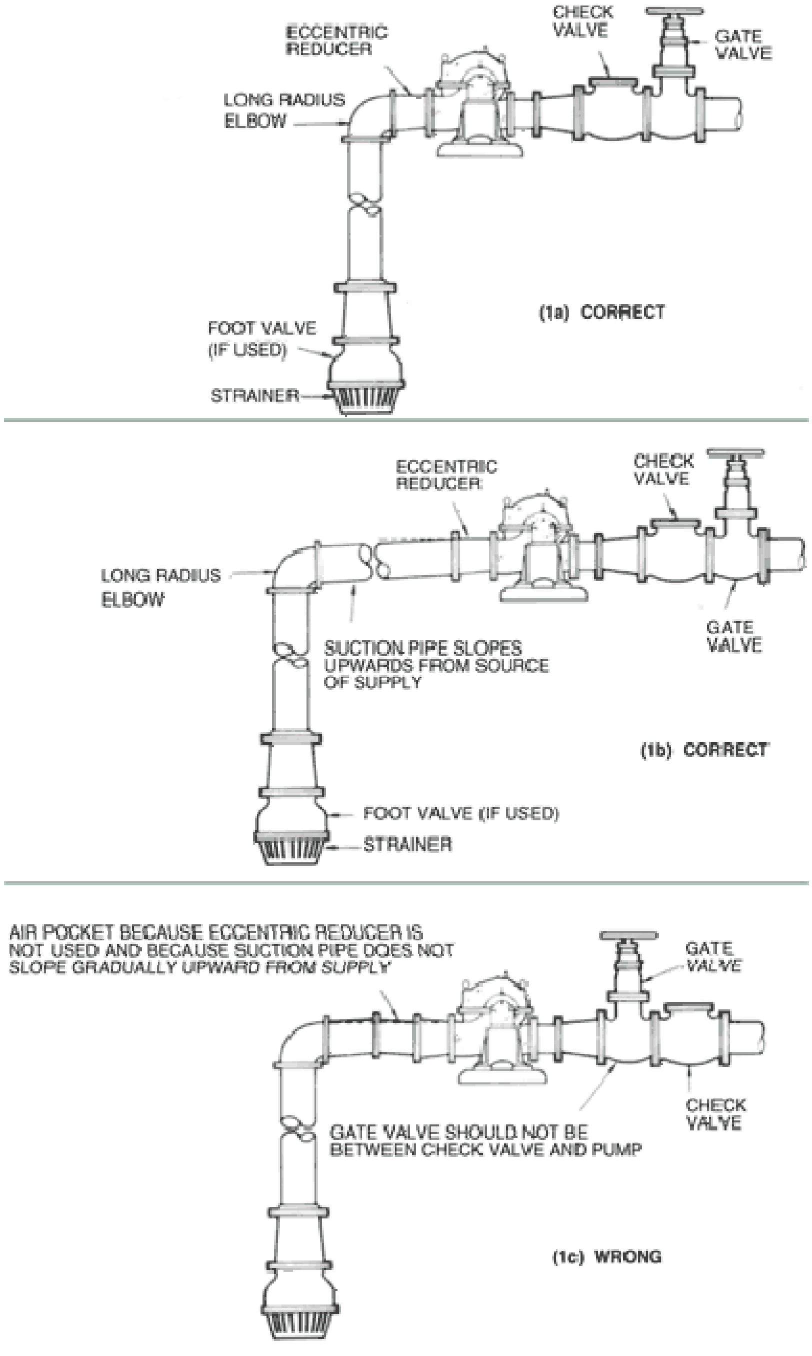


Fig 1 Air pockets in suction piping

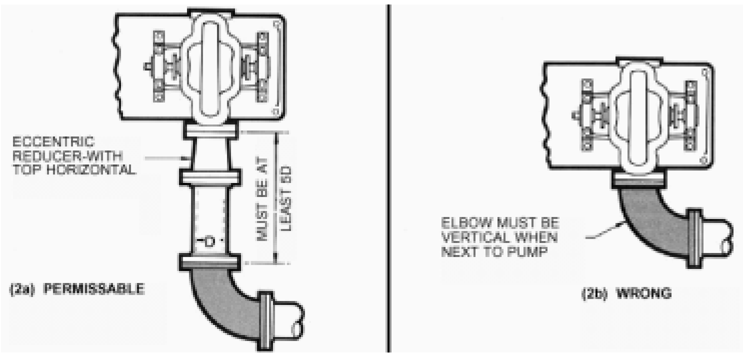


Fig. 2 Elbows at pump suction

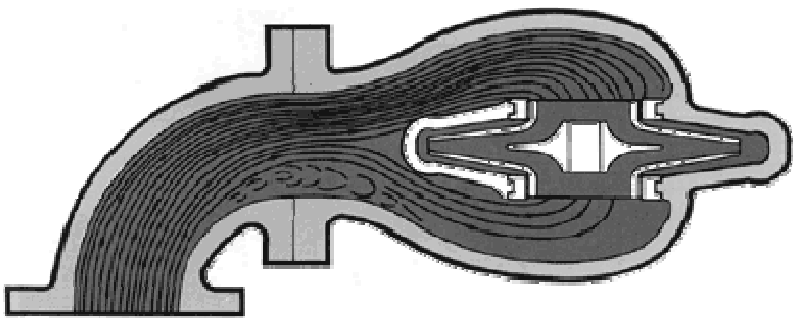


Fig. 3 Effect of elbow directly on suction

<u>Supply Tank and Sump Design</u>

There are several important considerations in the design of a suction supply tank or sump. These are:

Turbulence

It is imperative that the amount of turbulence and entrained air be kept to a minimum. Entrained air will cause reduced capacity and efficiency as well as vibration, noise, shaft breakage, loss of prime, and/or accelerated corrosion.

The free discharge of liquid above the surface of the supply tank at or near the pump suction can cause entrained air to enter the pump. All lines should be submerged in the tank, and baffles should be used in extreme cases as shown in Fig. 4.

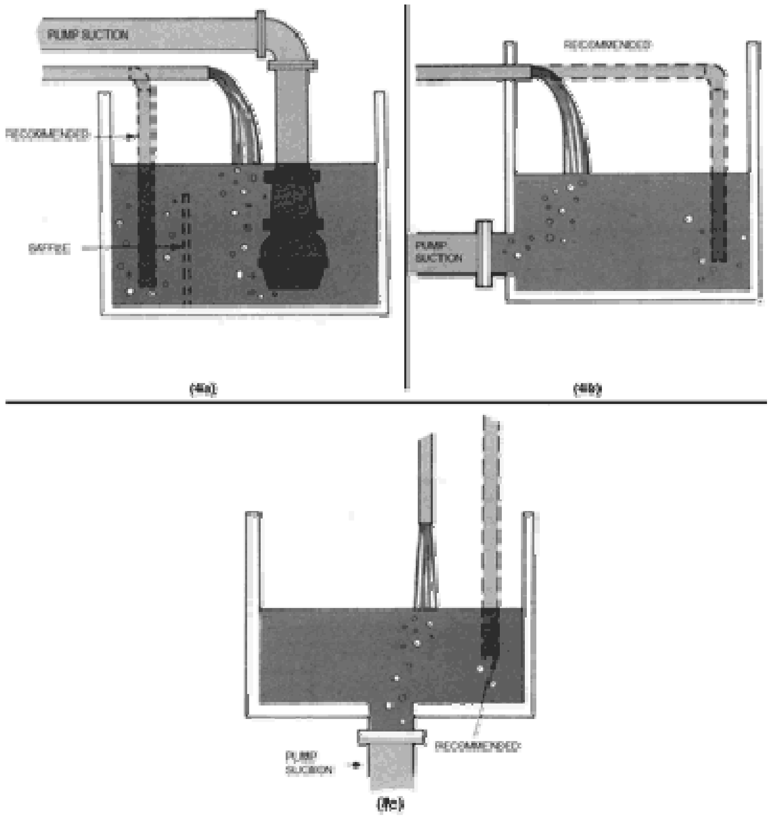


Fig. 4 Keeping Air out of pump

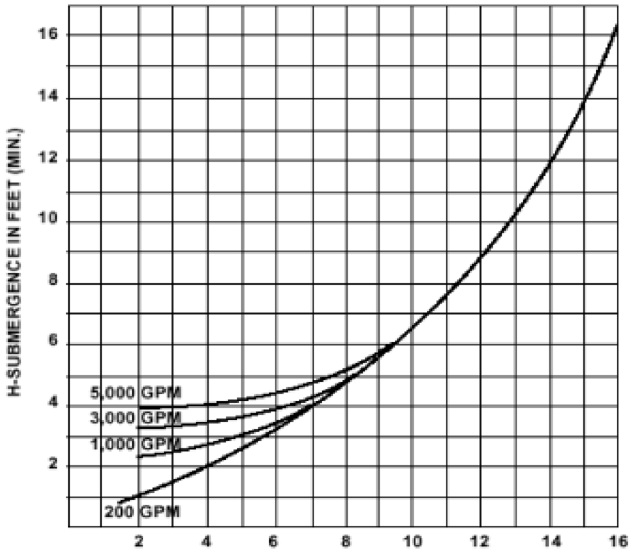
Submergence

Improper submergence of the pump suction line can cause a vortex, which is a swirling funnel of air from the surface directly into the pump suction pipe. In addition to submergence, the location of the pipe in the sump and the actual dimensions of the sump are also important in preventing vortexing and/or excess turbulence.

The amount of submergence required depends upon the size and capacity of the individual pumps as well as on the sump design. Past experience is the best guide for determining the submergence. The pump manufacturer should be consulted for recommendations in the absence of other reliable data.

1. Pump Flowrates below 315 lites/sec

For horizontal pumps, Fig. 5 can be used as a guide for minimum submergence and sump dimensions for flows up to approximately 5000 US gallons/min (315 litres/sec). For larger flowrates , refer to item 2 below.



$$\text{VELOCITY IN FEET PER SEC.} = \frac{\text{QUAN. (G.P.M.)} \times .321}{\text{AREA (inches)}^2} \text{ OR } \frac{\text{G.P.M.} \times .4085}{D^2}$$

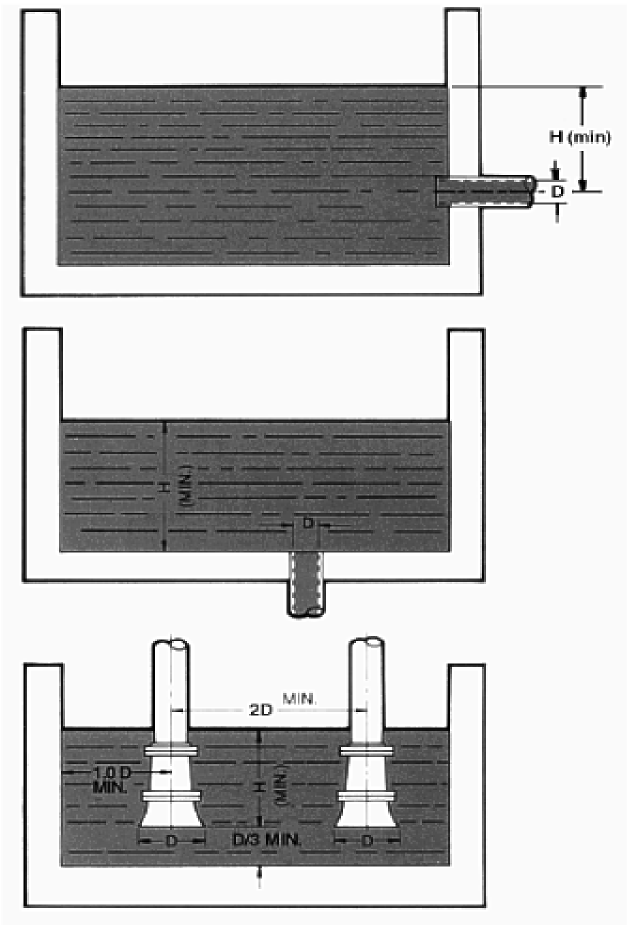


Fig. 5 Minimum suction pipe submergence and sump dimensions

Baffles can be used to help prevent vortexing in cases where it is impractical or impossible to maintain the required submergence. Fig. 6 below shows three such baffling arrangements.

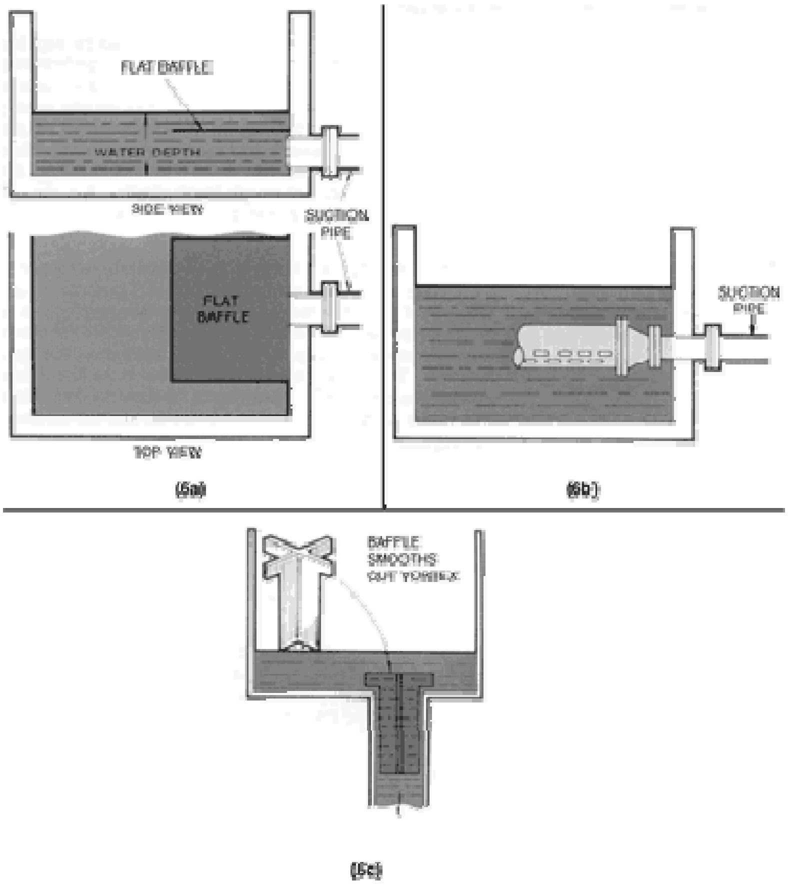


Fig. 6 Baffle arrangements for vortex prevention

On horizontal pumps, a bell should be used on the end of the suction pipe to limit the entrance velocity to 1 - 2.5 metres per second. Also, a reducer at the pump suction flange to smoothly accelerate and stabilize the flow into the pump is desirable.

2. Pump Flowrates above 315 litres/sec

For larger units (over 315 litres/sec) taking their suction supply for an intake sump (especially vertically submerged pumps), requires special attention.

The function of the intake structure, whether it is an open channel, a fully wetted tunnel, a sump or a tank, is to supply an evenly distributed flow to the pump suction. An uneven distribution of flow, characterised by strong local currents, can result in formation of surface or submerged vortices and with certain low values of submergence, may introduce air into the pump causing a reduction of capacity, an increase in vibration and additional noise. Uneven flow distribution can also increase or decrease the power consumption with a change in total developed head.

The ideal approach is a straight channel coming directly to the pump or suction pipe. Turns and obstructions are detrimental, since they may cause eddy currents and tend to initiate deep-cored vortices.

The amount of submergence available is only one factor affecting vortex-free operation. It is possible to have adequate submergence and still have submerged vortices that may have an adverse effect on pump operation. Successful, vortex-free operation will depend greatly on the approach upstream of the sump.

Complete analysis of intake structures can only be accurately accomplished by scale model tests. Model testing is especially recommended for larger pumping units.

Subject to the qualifications of the foregoing statements, Figures 7 through 10 have been constructed for single and multiple intake arrangements to provide guidelines for basic sump dimensions.

$D = (760 \times Q)^{0.5}$	$S = D + (29560 \times Q) / D^{1.5}$
$W = 2D$	Where
$Y \geq 4D$	S – in mm
$A \geq 5D$	D – in mm
$C = .3D$ to $.5D$	Q – flow in litres/sec

Fig. 7 Sump dimensions calculations

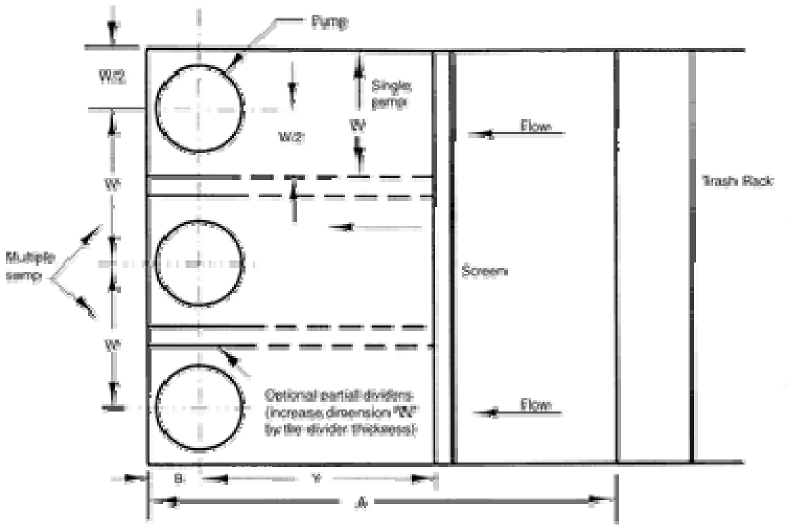


Fig. 8 Sump dimensions, Plain view, wet pit type pumps

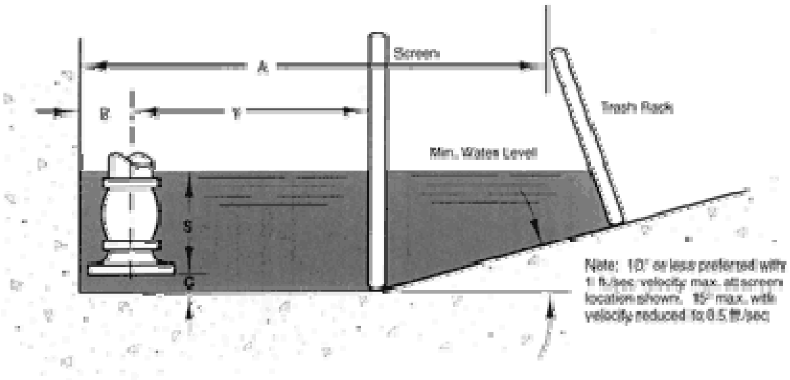


Fig. 9 Sump dimensions, elevation view, wet pit type pumps

Optimum Sump Volume

During start-up of an electric motor, motors encounter high starting currents. These effects put a constraint on the maximum number of starts in a given time and hence there is an optimum sump volume to minimise the possibility exceeding the maximum allowable starts for motors.

Pumps start most frequently when the flowrate into the sump is exactly half the pumping rate (Q litres/sec) and the cycle time (t secs) is determined by the following formula:

$t = 240 \times V / Q$

where V= volume in litres

Therefore for a maximum allowable start frequency of 10 starts/hour (i.e. t =360 secs), V =1.5 x the pumping rate (Q litres/sec) or 6 minutes