SUCTION PIPING

According to the American National Standard for pump intake design

DECEMBER 19, 2019

ANSI/HI 9.8-1998

Contents

Abstract

Purpose of Standards:

Hydraulic institute Standards are adopted in the public interest and are designed to help eliminate misunderstandings between the manufactures and the purchaser and or the user and to assist in selection of proper product

ANSI/HI 9.8-1998

This Standard Provides Intake design recommendations for both suction pipes and all types of wet pits.

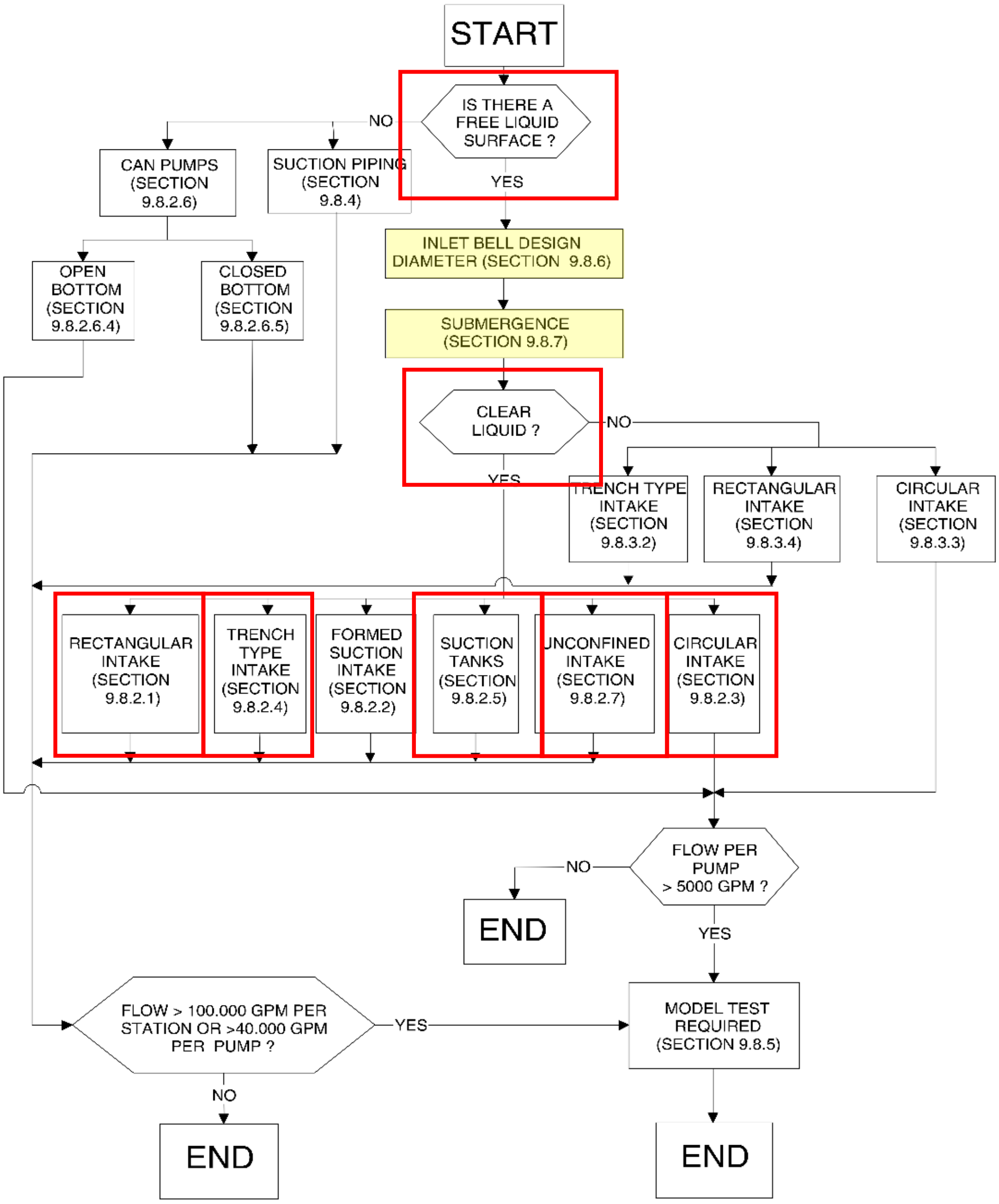


Figure 1 Flow Chart for use of Standard

Design objectives:

Specific hydraulic phenomena have been identified, that can adversely affect the performance of pumps, Such as:

1- Submerged vortices
2- Free Surface Vortices
3- Excessive pre swirl of flow entering pump
4- Non-Uniform distribution of velocity at impeller eye
5- Excessive variations on swirl with time
6- Entrained air or gas bubbles

The negative impact of each of these phenomena on pump performance depends on pump specific speed and size as well as other design features of the pump

Intake Structure:

1- Rectangular Intakes

Partitioned Structures: if multiple pumps are installed in a single intake structure dividing walls placed between pumps result in more favourable flow conditions than found in open sump, flows greater than 315 L/sec require dividing walls

Trash Racks and screens: Partially clogged trash racks or screens can create severely skewed flow patterns if the application is such that the trash racks are susceptible to clogging, the racks must be inspected frequently

Dimensioning Rectangular Intake Structures:

1- Adequate depth of flow to reduce the formation of vortices
2- Adequate pump bay width and depth to limit the maximum pump approach velocities to 0.5 m/sec , and keep the flow uniform as well
3- The minimum submergence (S) required to prevent string air core vortices based on the

Froude Number $F_D = V/(gD)^{0.5}$

Where:

F_D = Froude number (dimensionless)

V = Velocity at suction inlet = Flow/Area, based on D

D = Outside diameter of bell or pipe inlet

g = gravitational acceleration

Consistent units must be used for V, D and g so that F_D is dimensionless. The minimum submergence, S, shall be calculated from (Hecker, G.E., 1987),

$$S = D(1+2.3F_D)$$

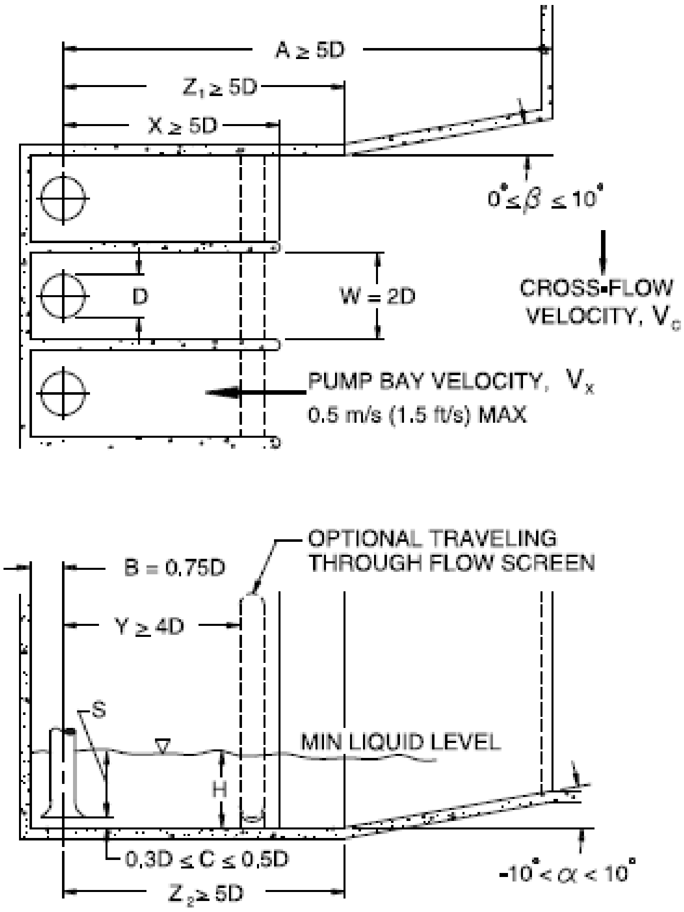


Figure 2 Recommended intake structure layout for rectangular intakes

It is appropriate to specify sump dimensions in multiples of pump bell diameters D as it ensures geometric similarity of hydraulic boundaries and dynamic similarity of flow patterns. Recommendations Shown in Fig.2

2- Circular Pump Stations

Stations with four or more pumps are not discussed in this standard due to resulting complex flow patterns that require a model study

Circular design is suitable for many types and sizes of pump stations. It can be used with most size of pumps and for most types of liquids a circular design may offer a more compact layout that often result in reduced construction costs.

Floor clearances C_f

The floor clearance should not be greater than the necessary because excessive floor clearance increase the occurrence stagnant zones as well as sump depth at given submergence the condition that determines the minimum floor clearance are the risk of increasing inlet head loss and flow separation at the bell submerged vortices are also sensitive to floor clearance recommended floor clear is between 0.3D and 0.5 D

Wall clearance C_w

The minimum clearance between an inlet bell or a pump volute and a sump wall I 0.5 D or at least 100mm

Inlet bell clearance C_b

The minimum clearance between adjacent inlet bells or volutes in 0.5 D or at least 100 mm

Sump diameter D_s

Minimum sump diameter shall be as indicated for each type of pump sump as shown in figure

Inlet bell or volute diameterD_b

This parameter is given by proposed pump type or model

- For submersible and other pumps with a volute in the wet pit use the volute dimeter
- For pumps without a volute in the wet pit use the inlet bell diameter

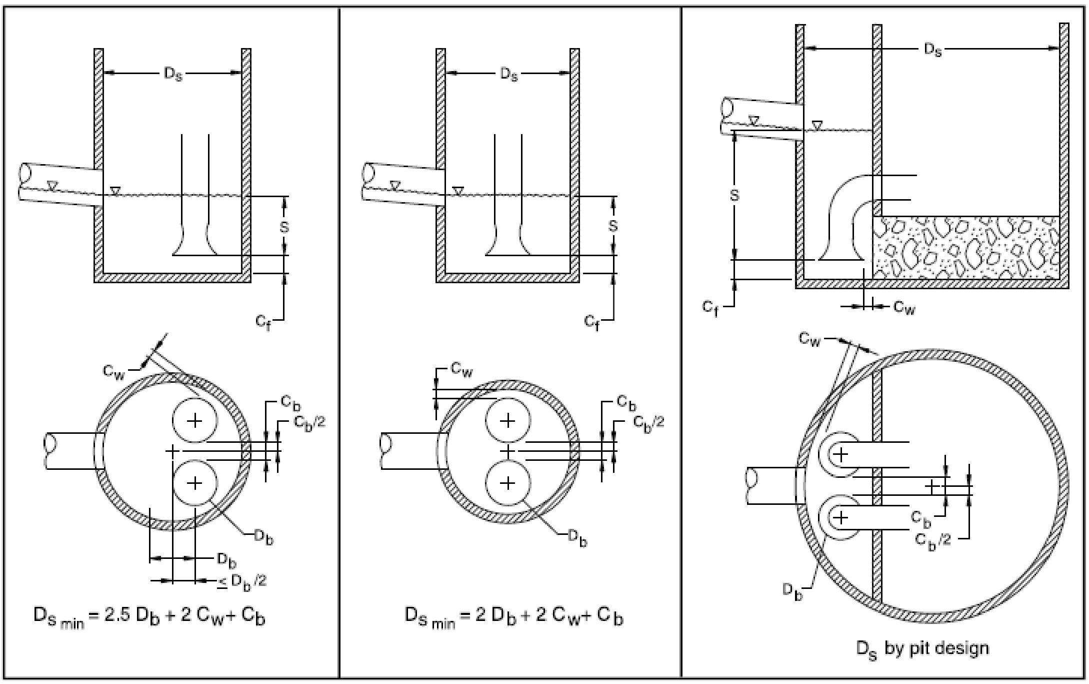


Figure 3 Examples of duplex sumps with referenced dimensioning

Inflow pipe

The inflow pipe shall not be placed at an elevation higher than shown in the figures this placement minimizes the air entrainment for liquid cascading down into the sump from an elevated inflow pipe it is important to position the inflow pipes radially and normal to the pumps as shown in the figures to minimise rotational flow patterns for the last five pipe diameter before entering the sump the inflow pipes shall be straight and have no valves or fitting

See figures 3 and 4

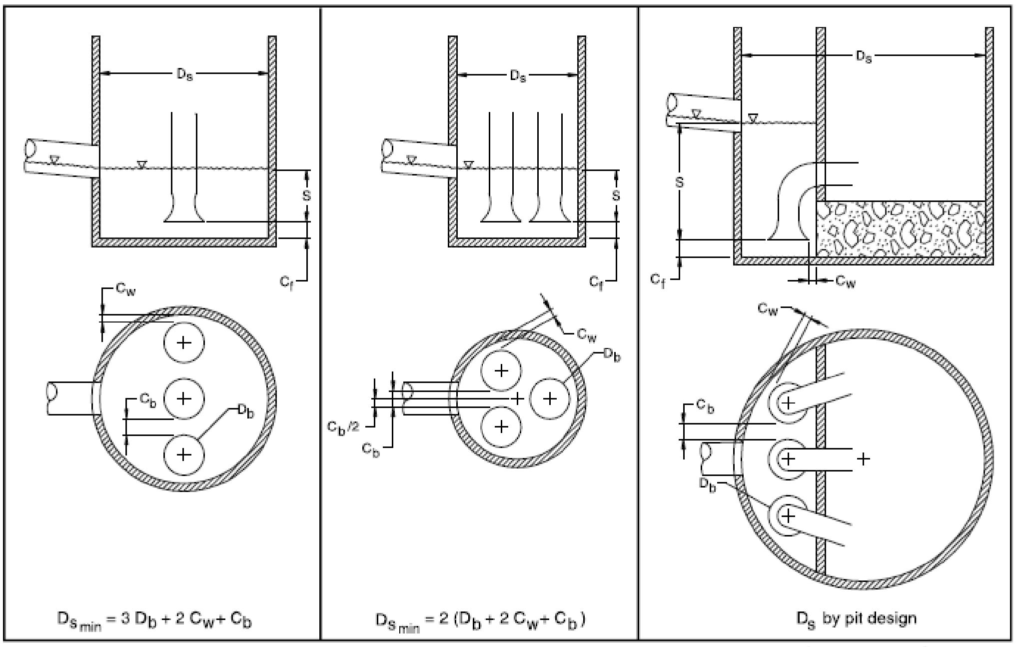


Figure 9.8.5A — Wet pit triplex sump, pumps in line

Figure 9.8.5B — Wet pit triplex sump, compact

Figure 9.8.5C — Dry pit/wet pit triplex sump

Figure 4 Examples of triples sumps with referenced dimensioning

3- Trench type intakes

Trench type wet wells differ from rectangular intake structures by the geometry used to form the transition between the dimensions of the influent conduit or channel and the wet well itself as shown in figures 5 and 6

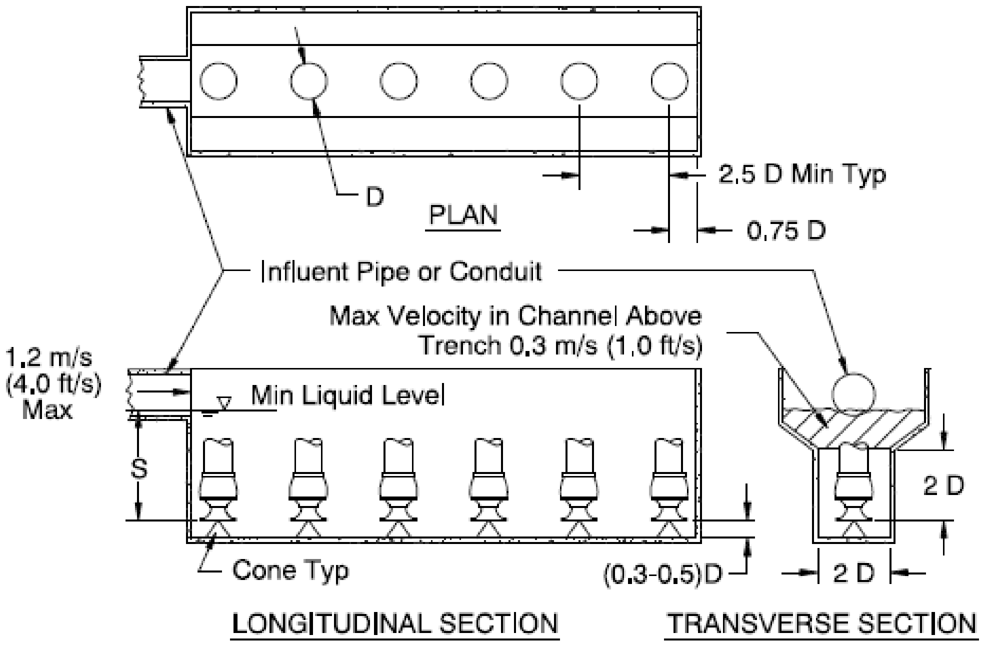


Figure 5 Trench Type Wet-well

Objectives

The purpose is the shield the pump intakes from the influence of the concentrated inflow

Orientation

It is preferable to align the long axis of the wet well with the centerline of the upstream channel

Approach velocity

The velocity in the approach channel upstream from the wet well shall be no greater than 1.2 m/s with the axis of the channel coaxial with the axis of the wet well, if it is normal a speed of 0.6 m/s is recommended

Width

The recommended width of the bottom of the trench is twice the diameter of the pump intake bell.

End wall clearance

End wall clearance should be 0.75 D

Floor clearance

Floor clearance 0.3D to 0.5D and floor cones are recommended under each intake as shown in figure 7

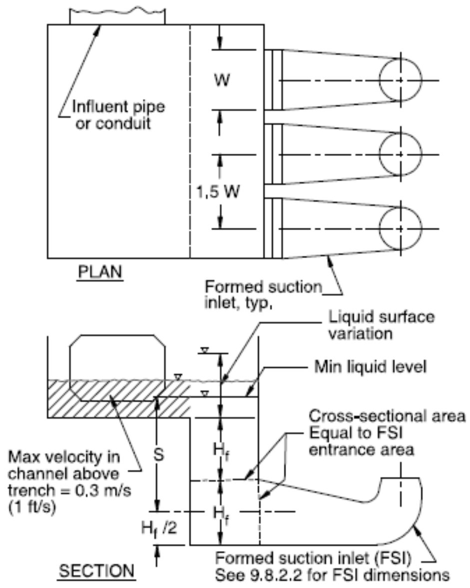


Figure 6 Trench type well with formed suction inlet

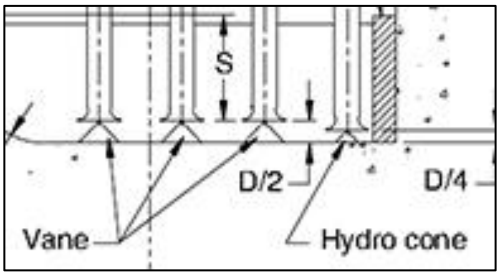


Figure 7 usage of hydro cones

4- Suction Tanks

This standard applies to partly filled tanks pressurized tanks handling non solids solids bearing liquid where the outflow occurs with or without inflow at the same time

Due to formation of vortices inside the tank air or gas entrainment can occur is pump suction tanks even when the air outlet is totally sumbmerged. The following should be considered:

- Tank Geometery
- Outlet orientation and location
- Outlet configuration
- Outlet fitting

NPSH considerations

All the head losses incurred from the free surface to th pump inlet must be considered

Submergence

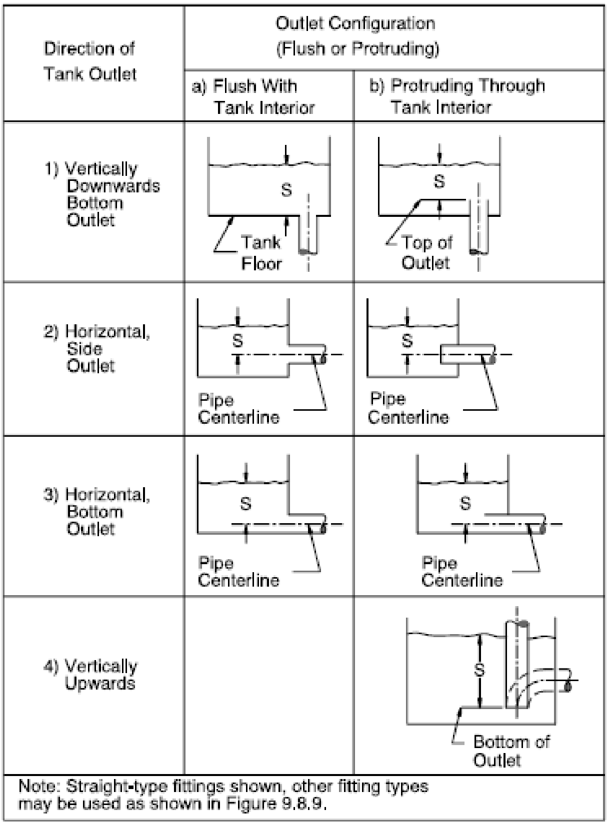


Figure 9.8.8 — Datum for calculation of submergence

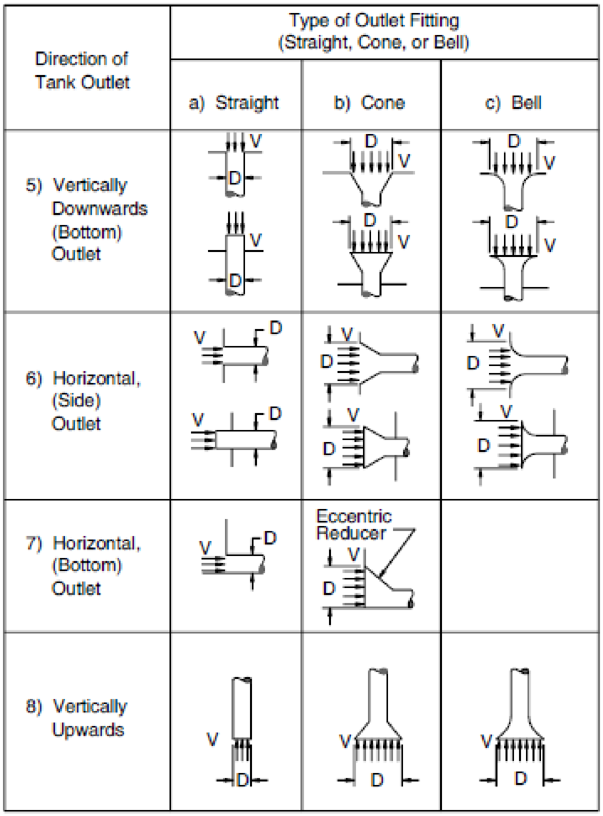


Figure 9.8.9 — Definitions of V and D for calculation of submergence

Simultaneous inflow and out flow

In general, tanks should not have the inlet pipe close to the outlet but suitable baffling may be required to isolate the outlet and reduce inlet effects on flow pattern

Unconfined Intakes

Unconfined intakes include pumps installed on platforms or other structures where the intake lacks guide walls, walls of a sump or other flow guidng structures. Like rivers canals lakes and seawater sytems.

Cross flow velocity and pump location

The minimum recommended distance from an obstruction to the pump suction in the direction of any current that could cause wake effects is five times the maximum cross sectional dimention of the obstruction

- Cross flow velocities shall be less than 25% of the bell velocity

Floor clearence

If debris or sediments are not a proplem the inlet bel shall be located 0.3 to 0.5D above the bottom to minimize sumberged vorticies.

PUMP SUTION PIPING

The ideal flow entering the pump inlet should be of a uniform velocity distribution without rotation and stable overtime this ideal flow is often referred to as undisturbed flow and it can be achieved by controlling pipe lengths and the type and location of fittings in the suction piping system, It should be designed such that it is simple with gentle transitions.

The effect of disturbed flow conditions at the inlet bell tend to diminish with distance, Short Suction piping is less effective in moderating disturbances before the flow reaches the pump. Good inflow conditions at the inlet exists if the intake is designed following the recommendation in this standard. See fig 8

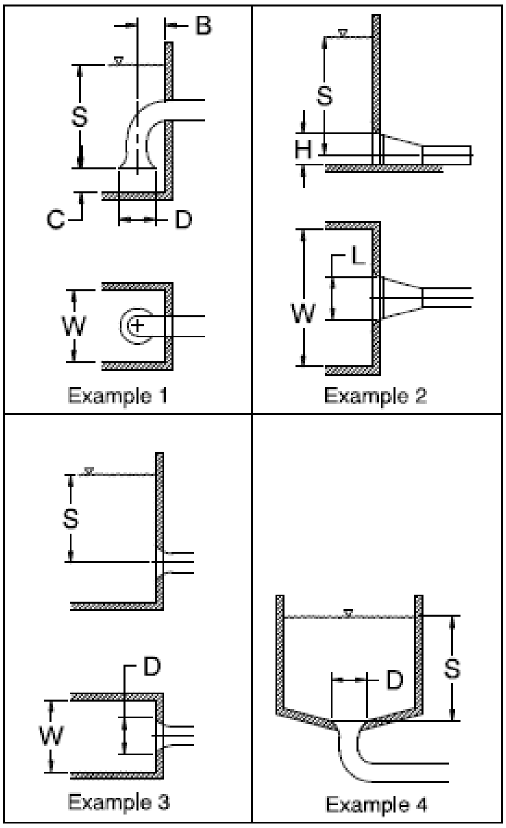


Figure 8 common suction piping near pump

Recommended Velocities

- Maximum recommended velocity 2.4 m/s
- Higher velocities are acceptable providing the design provides a smooth inlet flow
- For many common solids-bearing liquids a velocity of about 1.0 m/s is required to prevent sedimentation

See table 1

Table 1 Recommended velocity ranges

Pump Flow Range Q, l/s	Recommended Inlet Bell Design Velocity, m/s	Acceptable Velocity Range, m/s
< 315	V = 1.7	0.6 ≤ V ≤ 2.7
≥ 315 < 1260	V = 1.7	0.9 ≤ V ≤ 2.4
≥ 1260	V = 1.7	1.2 ≤ V ≤ 2.1

Fittings:

- There shall be no flow disturbing fittings such as partially opened valves tees or short radius elbows closer than five Suction pipe diameters from the pump. See fig.9
- If a fitting is necessary as fig 10 The approval of pump manufacturer is required

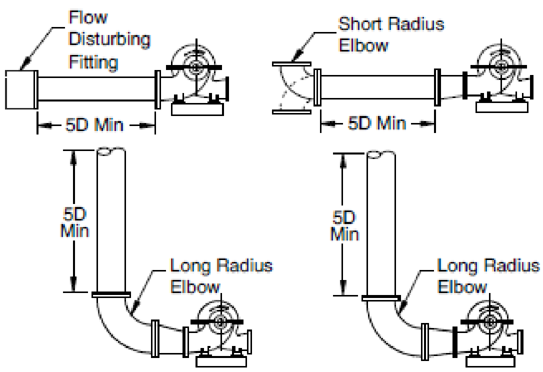


Figure 9 Recommended suction piping near pump

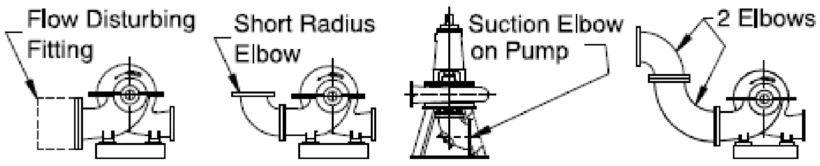
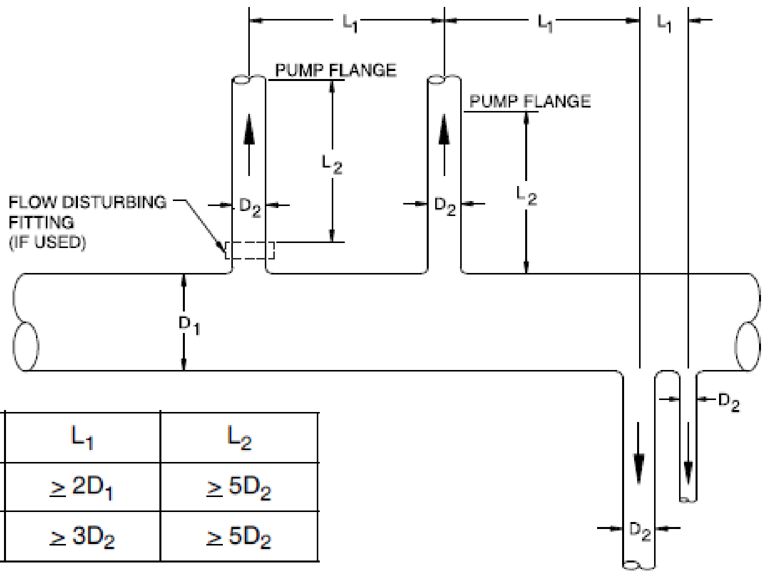


Figure 10 Suction pipe fittings that require manufacturer's approval

Suction Headers

- It is required when two or more pumps are fed from one common suction intake
- Opposite take-offs are not allowed
- The maximum velocity is 2.4 m/s
- If the ratio of take-off diameter to header diameter is greater than 0.3 then the minimum spacing is 2 Header diameters
- If the ratio of take-off diameter to header diameter is less than 0.3 then the minimum spacing is 3 Header diameters

See fig 11



D_2/D_1	L_1	L_2
≥ 0.3	$\geq 2D_1$	$\geq 5D_2$
< 0.3	$\geq 3D_2$	$\geq 5D_2$

Figure 11 Suction Header Design options

References

Hydraulic Institute. (1998). Pump Intake Design. *ANSI-HI_9.8*.