

# Tips for Designing Sumps for Cooling Tower Applications

The design of remote sumps for cooling tower applications involves not only proper sizing, but consideration of flow patterns and operating levels within the sump. Improperly designed sumps often result in pumping problems, including low or inconsistent flow rates, air binding, noisy operation, and even excessive wear.

## Sizing

A properly sized sump provides:

1. Sufficient volume to accept, without overflowing, all suspended water that drains back during the pump “off” cycle.
2. Sufficient volume to fill the piping system and keep pump suction connections sufficiently flooded when the piping system is filled.

These two considerations require careful estimation of the volume of the water in the piping system served by the sump, including the “in transit” volume of the cooling tower. In addition, the sump size should allow sufficient surrounding space for performing maintenance procedures.

## Flow Patterns and Operating Levels

Because cooling towers bring air and water into intimate contact, the water reaching the sump is highly aerated. In addition, the process of pumping water from open sumps can result in vortexing, a process which itself mixes air with the water. If the sump design does not properly address the issues of highly aerated water and vortexing, excessive air finds its way to the pumps, resulting in any or all of the following:

- Reduced or erratic pump performance
- Excessive pump vibration with possible eventual seal or bearing damage
- Noise and vibration in suction and discharge piping
- Excessive corrosion

Each situation presents a number of unique variables, including:

- Flow rate
- Size of the sump in relation to flow rate
- Geometry of the sump
- Flow patterns within the sump, caused by relative location of inlet(s) to outlet(s)
- The number of pumps served by the sump, and how many operate at any time
- The pump style chosen (vertical in-line vs. end suction, etc.)

Each of these factors influences whether air reaches the pumps in sufficient quantity to cause the problems listed above.

In this article, we attempt to present certain guidelines from well-respected sources, which is, in turn, supported by our field experience. Hopefully, you will find the information useful. We realize that some of you may have additional experience with this subject. We welcome all feedback including stories regarding problem applications.

## Overall Design Considerations

In approaching sump design, the designer should:

- Arrange the inlet piping to the sump to avoid further entraining air.
- Design the sump so that the maximum amount of air can be released.
- Consider flow patterns, suction pipe intake velocity, and submergence depth to avoid vortexing.
- Design suction header piping to avoid air binding.
- For multiple pump applications, arrange the suction connections so that operation of any pump does not detract from the operation of other pumps.
- Consider mechanical means, such as inlet channels, anti-vortex baffles, specially designed suction distribution pipes, and stand pipes when the ability to meet other recommendations is compromised.

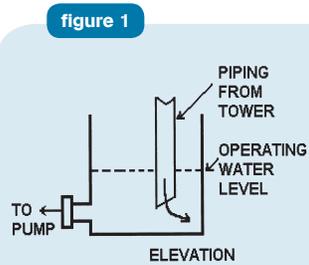
Let’s look at each of these considerations in detail:

## Avoid Entraining Air at the Water Inlet

We have found that one of two inlet patterns generally works well:

1. Extend the down comer piping from the tower to below the minimum operating level of the sump and cut the down comer at a 45 degree angle,

with the discharge directed at the wall opposite the pump connections as shown in Figure 1. Discharging below the water level avoids entraining air, which might occur with an above-surface discharge.



2. As an alternative, return the water through a pipe connection located below the minimum operating level. The best location for this connection is the wall of the sump opposite the pump connections. We have used both methods successfully. The first method, however, may disperse the inlet water more evenly.

## Design the Sump for Air Release

Bringing the entering water in near the wall opposite the pump connections:

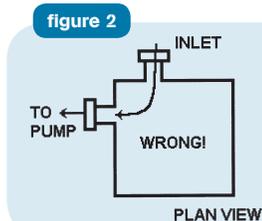
1. Ensures that air separation, which occurs with the turbulent discharge, takes place well away from the pump inlets.
2. Ensures a relatively long retention (or transit) time as the water works its way across the tank. During this time, additional air escapes. The sump should provide a minimum of one-minute retention time. This is achieved when the useable tank volume in gallons = 1.0 X GPM, where the usable volume is that amount contained in the difference between the maximum and minimum operating levels.
3. If the sump is a closed design (not having an open top), provide a top air release opening equal with double the area of the incoming water piping. For example of the inlet pipe is 8", provide either two 8" openings in the top or one opening with an equal area to two 8" pipes.

## Avoid Situations that Lead to Vortexing

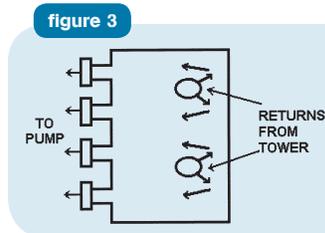
Vortexing results from rotational flow. You witness it when you pull the stopper from a bathtub. Severe vortexing entrains air, which in turn, results in pumping problems. In sump applications, vortexing occurs at the water surface directly above pump suction connections. The keys to vortex avoidance are:

- **Proper flow pattern within the tank:**

1. Avoid patterns that tend to induce vortices. Figure 2 shows a side sump inlet with a pump suction connection located nearby at a 90-degree angle. Not only does this arrangement result in short



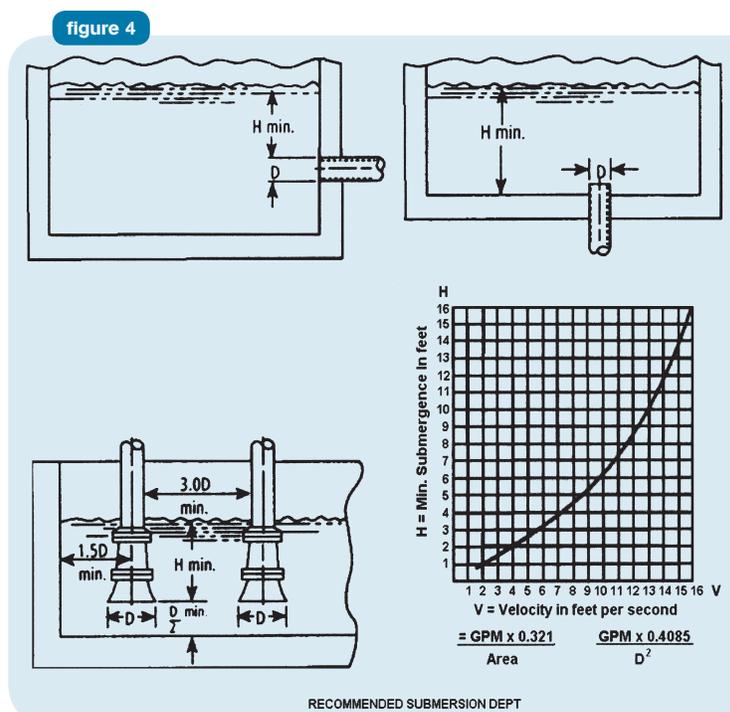
circuiting (thus reducing actual retention time), it tends to induce rotational flow due to the sharp turn. Bringing the inlet water into the tank at the side opposite the suction connection results in a relatively straight flow profile, a better situation.



2. If the sump has multiple suction connections, the flow pattern should provide a similar path from the inlet to each connection as practical. In Figure 3, the inlet flow has been divided into two down comers in order to provide a reasonably similar flow path to each of the 4 suction connections.

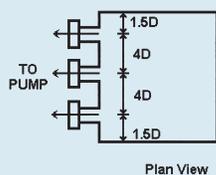
- **Proper flow pattern entering the suction connections:** The water should be free to approach the suction connection from all directions. Therefore, any suction connections should be located away from corners or obstructed sections of the sump.

- **Submergence depth (the height of the water surface above the top of the suction connection):** This is probably the most important factor in vortex avoidance. Various references provided widely differing opinions on what the submergence should be. We believe that the following graph from Goulds (Figure 4) provides a realistic, economically viable solution to determining minimum submergence. Note that the velocity is simply the flow rate in cubic feet per second divided by the cross sectional area of the suction connection. The minimum submergence depth from Figure 4 determines the minimum operating level of the sump. Therefore, the make up water valve should be set to maintain this level.



- In the case of multiple suction connections, design the sump so that operation of one has negligible effect upon the operation of others. Generally the connections should be

figure 5



in-line with each other with the centerlines at least four pipe diameters apart, and with 1.5 diameters between any connection centerline and sump wall as depicted in Figure 5. (Note that this figure shows 3 diameters between pipe walls, which essentially the same as 4 diameters between centerlines).

## Design Suction Piping to Avoid Air Binding

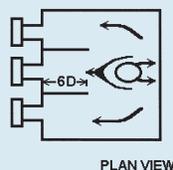
Achieving reasonable submergence depths often requires oversizing sump suction connections to reduce the connection velocity (see Figure 4). Therefore a reducer will often be required at the pump. All reducers should be eccentric, with the flat portion of the pipe at the top. This will prevent air from collecting at the top of the piping in pockets formed by concentric reducers. The suction piping may also be pitched slightly up toward the pump to encourage air movement. In some applications, a single sump connection serves multiple pumps through a single suction header. If the pumps are staged, sizing of the header can be tricky. While the pipe should be sized generously enough to result in minimal pressure drop between adjacent pumps, water velocities of at least 1.75-2.0 FPS are required to carry entrained air. At lower velocities, air bubbles tend to separate from the water. With only one pump operating, the header velocity may drop to the point that air disentrains and collects at the top of the suction header in a large bubble. The resulting air bubble will not move due to the low velocity, so the problem is not apparent. However, when the second pump starts, the velocity increases. The higher velocity water now entrains the bubble and moves it to the pumps, which results in various problems as outlined earlier. In some applications, no header size satisfies all conditions. **A standpipe may be required to vent air from the header (see the next section of this article and Figure 9 for details).**

## Mechanical Additions Relieve Problems

A number of mechanical methods can be employed to solve specific problems. They may be applied:

1. During the design process to overcome other design deficiencies.
2. To improve existing conditions.

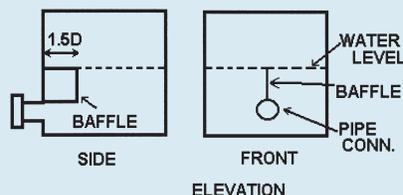
figure 6



## Suction Channels

When the available space precludes proper spacing between multiple suction connections, consider building suction channels into the sump, as shown in Figure 6. Construct the channels with vertical plates extending to the bottom of the sump. The plate should extend vertically to the minimum water level and have a length equal to 6 connection diameters. The approach velocity in the channels should be less than 2 FPS.

figure 7

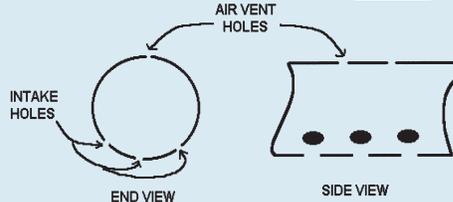


## Anti-Vortexing Baffles

Anti-vortexing baffles are effective as well. They consist of simple vertical plates installed above the suction connections and extending into the tank

at least 1.5 pipe diameters. Figure 7 shows a one-pump sump with an anti-vortex baffle. These simple baffles discourage rotational flow. The baffle should extend from the top of the connection to the minimum water level and should extend into the tank at least 1.5 connection diameters.

figure 8



## Anti-Vortexing Suction Pipe

Our own Rick Bienz devised this device. It consists of an intake pipe extending into the sump as shown in Figure 8. This pipe has intake holes

or slots located at 4, 6 and 8 o'clock. The total intake area of the holes or slots is three times the area of the cross-section of the pipe. In addition, air vent holes are drilled in the top of the pipe. The pipe may be steel or PVC. By increasing the total inlet area and by

distributing the inlet water into many passages, the pipe helps prevent vortexing. Two advantages of the “Bienz Suction Pipe” over vortex baffles or suction channels are that:

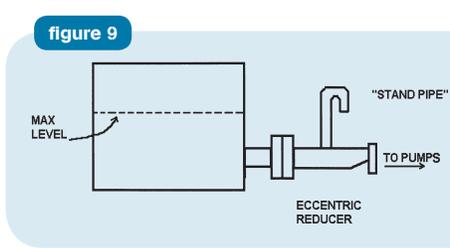
- a) It can be easily used with prefabricated, polyethylene tanks.
- b) It is sometimes easier to retrofit into an existing steel tank (where adding baffles might involve destroying part of any corrosion-resistant linings).

## Air Venting Stand Pipe

The standpipe serves as an air vent when a suction header serves multiple staged pumps. As outlined before, the very low pipe velocity that results from having only one pump in operation tends to result in pockets of air at the top of horizontal pipes. A goose-necked standpipe can be added from the top of the header, with a height somewhat greater than the maximum water level in the tank, as shown in Figure 9. This pipe vents air that collects in the header.

## Other Additions

Other anti-vortexing methods exist, but many of these apply to very large systems, as might be found in power stations. These include floating rafts and floating plastic balls above suction intakes, inlet channels with roofs, trash screens in front of suction intakes, and others. If you encounter a very large project that might make use of such devices, we will be pleased to share our resources. However, having had no direct experience with them, we hesitate to expound upon them.



## A Note on Pump Selection

Many styles of centrifugal pumps work well in remote sump applications. However, self-venting pumps prove to be the most trouble free in the event that design shortcomings exist. End suction pumps are self-venting if they have top centerline discharge (note that Taco end suction pumps do have top centerline discharge, B & G pumps do not). Vertical turbine pumps are also self-venting. While it is possible to air bind any type of pump, these styles tend to handle air better than other types and arrangements.

**Summary** – The design of remote sumps for cooling towers presents a number of challenges. Highly aerated water and vortexing can cause poor performance, noise, vibration, pump problems, and corrosion. Proper sump design eliminates many problems before they occur.

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