Foam Filtration Design

Point-Of-Use Foam Filtration Unit Design

Materials and Construction Components

At the moment, our design consists of the following parts:

- two five-gallon buckets to hold the unfiltered and filtered water
- 12 inch foam column, made of PVC pipe
- polyurethane foam, enough to produce 10 inch depth of foam media at 1" diameter circular cross section
- PVC tubing
- pipe cap
- valve
- two flow accumulators to act as alum and chlorine dosers (optional)
- float valve to control flow (optional)

General Description

Influent water from a stock tank first mixes with alum that is stored in an alum doser. It then enters the filtration column, where the water is filtered through the depth of foam media. The effluent water is then chlorinated and sent through a series of spiral tubing which serves as a rapid mix system. The filtered water is stored in the same bucket that holds the components of the filter. This acts as the distribution system for providing water to the community.

Fabrication of the filtration unit will utilize parts that are relatively inexpensive. The parts will also be locally available so that the operator can find and purchase newer parts for the filter when needed. Additionally, over-designing is better than under-designing: it is better to meet and exceed the needs of the users than to fail to meet the design requirements.

Design of Alum-Doser

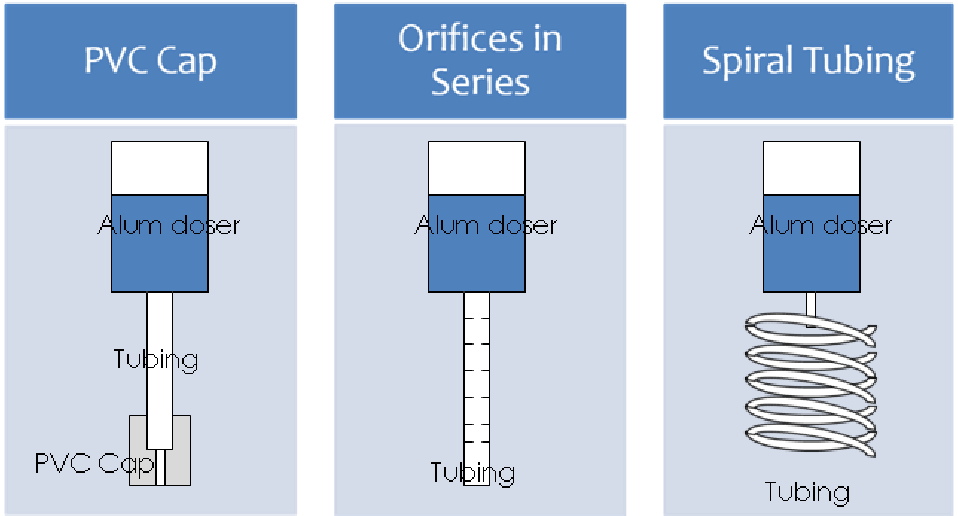
Much of the focus of our design work has been on the alum doser. Originally, we planned to use the alum doser to dose untreated water at an appropriate level using a mere "hole-in-the-bucket" situation with a float valve to maintain a constant water level and thus maintain constant head. Yet we discovered that this design required a bottom orifice with a diameter of less than 3 mm. These calculations can be seen in the original Alum Doser MathCAD file. The problem with small orifices (with diameters below 3 mm) is that clogging occurs very easily. Thus, we needed designs that incorporated large amounts of head loss in the system to allow for the use of a larger orifice size.

Hence, we proposed three alternative designs for incorporating this alum doser into our system:

(1) Spiral Tubing Design

(2) Series of Orifices Design

(3) PVC Cap as Orifice Design



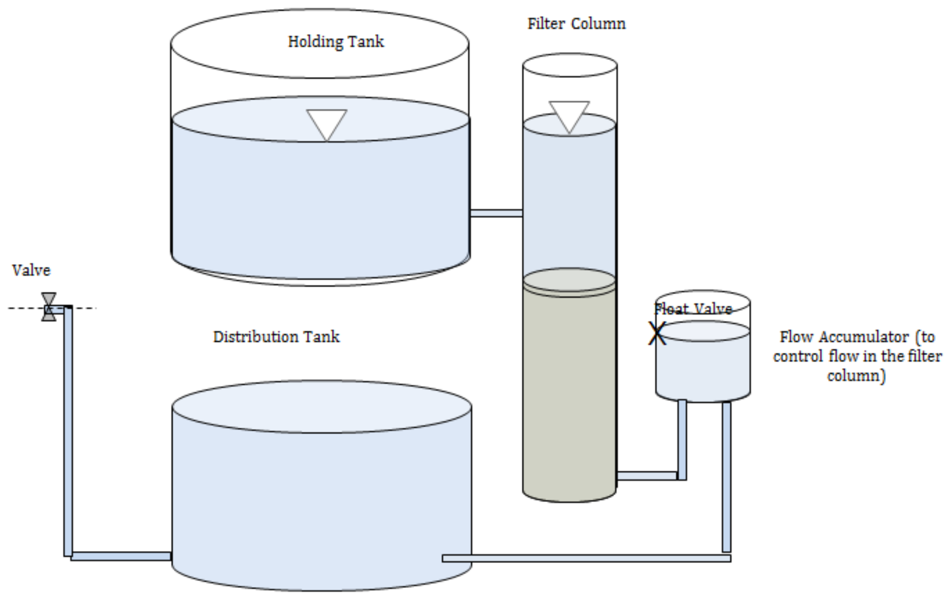
Unfortunately, we realized that both the "Series of Orifices" and "PVC Cap as Orifice" designs do not generate enough head loss to dose with small amounts. Also, in order for the the "Spiral Tubing" design to successfully work, a extra tubing length of around 3.5 meters is needed; this is not feasible considering our desire to have a small overall filtration unit. Therefore, we needed to look into other viable options for the design of the alum doser (which will be a model for the required chlorine doser as well).

After the rejection of the three options listed above, we re-considered the use of a float value to monitor the surface level of the alum solution. This should make dosing less variable and may help find a better solution to the orifice problem. Originally, we eliminated this design because we did not want to include small, hard-to-fabricate components into the design. Yet, this seemed like the only potentially successful option at the time, and still currently. Also, we are looking into the addition of a flocculation component; yet, this can be thoroughly researched and considered more next semester.

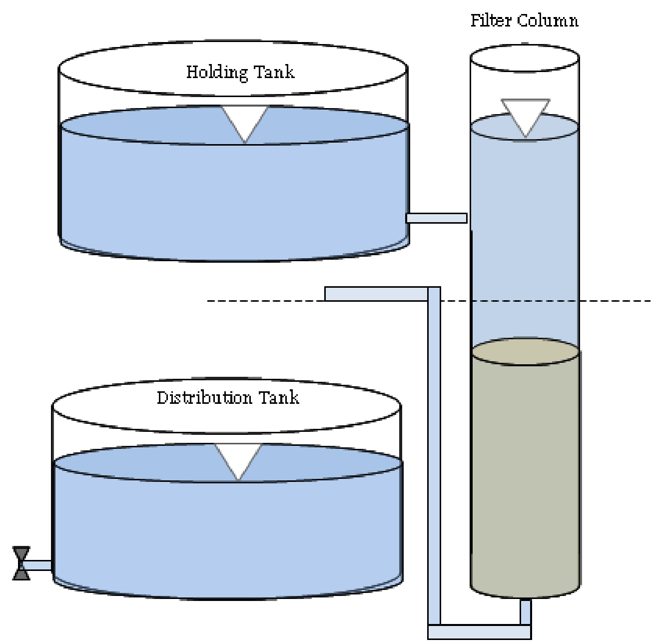
Our current design eliminates the alum and chlorine doser components, as we decided to utilize a "batch" system instead. More information about this dosing system can be found below under the section entitled "Final Design Schematic." In the Point-of-Use Design Calculations for this new design, the head loss through the system is calculated. The float valve should help maintain constant flow through the unit during its run-time. However, if no float valve is included, the as the entrance tank empties, the water level in the foam column should vary. Originally, the water level in the foam column would be equivalent to the water level in the entrance tank. But as the entrance tank empties, the water level in the foam column slowly decreases until it is level with the float valve. This variable water level difference determines the flow through the unit.

It was determined earlier that the maximum allowable velocity through the column was 6 mm/s. Using this and a column diameter of 4 inches, the maximum allowable flow through the column can be determined as .049 L/s. The variable water level difference in the foam column can not be large enough that this maximum flow is surpassed. Therefore, if (as we decided originally) we want a minimum of 2-inches above the foam column maintained at all times, we merely need to determine the maximum water level height above this 2 inches that results in a flow equivalent to the maximum allowable flow. Based on the diameter orifice, the resulting max. height is variable; but generally, it remains in the range of 3 to 5 inches. Therefore, the entrance tank should be positioned such that this maximum water height is never surpassed.

Final Design Schematic (as of currently)



Because there were many problems with the alum/chlorine doser designs, a "batch" dosing system was used instead of a continuous system. In this system, the user will manually add alum into the holding tank and chlorine into the distribution tank, while stirring the mixtures together. Influent water dosed with alum from the holding tank flows into the filter column and is filtered through the depth of foam in the column. The height of the foam in the column will be ten inches; this was chosen empirically based on previous experimental results from Summer 2010, which indicated that a ten inch height would result in the least effluent turbidity. Heights greater than 10 inches generally performed about the same, providing diminishing returns. The diameter of the column will be four inches to give the operator easy access to the contents inside for the purposes of cleaning and maintenance. After the water is filtered through the column, it enters a flow accumulator designed to maintain constant flow through the unit. A float valve can be utilized to monitor the level of water in the flow accumulator and, thus, control flow through the system (see picture above). If we decide to forgo these parts, the unit may be cheaper to construct, and the variable flow would then be determined by the height difference from the water surface in the foam column to the highest location of the exit tubing through which filtered water travels to the distribution tank (see picture below). From the flow accumulator, the water flows into the distribution tank where it is manually dosed with chlorine to deactivate any residual pathogens. The water is then ready for distribution.


Filter Column
Holding Tank
Distribution Tank