Foam Filtration Head Loss Calculations

Head Loss Calculations

Head Loss through Foam

In order to calculate the head loss through the foam with clean water running through it, we needed to slightly modify our experimental apparatus. Usually, a pressure sensor would be used to monitor head loss, however the head loss through foam with clean water it so small that noise in a pressure sensor reading is significant to the reading itself. Therefore, we decided to visually measure the headloss through the foam. To conduct this experiment, two free surfaces were used, one on top of the foam and another at the water exit. The initial height of water was marked with a piece of tape. Water was then pumped through the foam at a flow rate corresponding to a 4 mm/s velocity. The water height rose, and equilibrium point was recorded. The difference between the two water heights corresponds to the head loss through the foam itself and the filter column. We then ran the same test with the filter column but without the foam to determine the head loss through the filter column. These two values were subtracted to obtain the head loss through the foam itself. This experiment was run using a 10 inch foam depth with both 60 and 90 ppi foam.

	60 ppi	90 ppi
Head Loss in Apparatus	7.7 cm	8.4 cm
Head Loss through Filter Column	5.7 cm	5.7 cm
Head Loss through Foam	2.0 cm	2.7 cm

Table 1. Head loss through 10 inches of foam at 4 mm/s

Head Loss through foam as over an Experimental Run and at Failure

In addition to knowing the head loss through the foam with clean water running through it, it is also important to know the head loss through the foam over time and when the foam eventually fails due to collapse. For this experiment, the head loss will be greater than the first experiment and it will be changing, so we used a pressure sensor to monitor head loss over time. The experiment was run using a 10 inch foam column with 60 ppi foam and a 1.5 mg/L alum dose. The influent turbidity was 5 NTU, and the experiment was run until the foam collapsed.

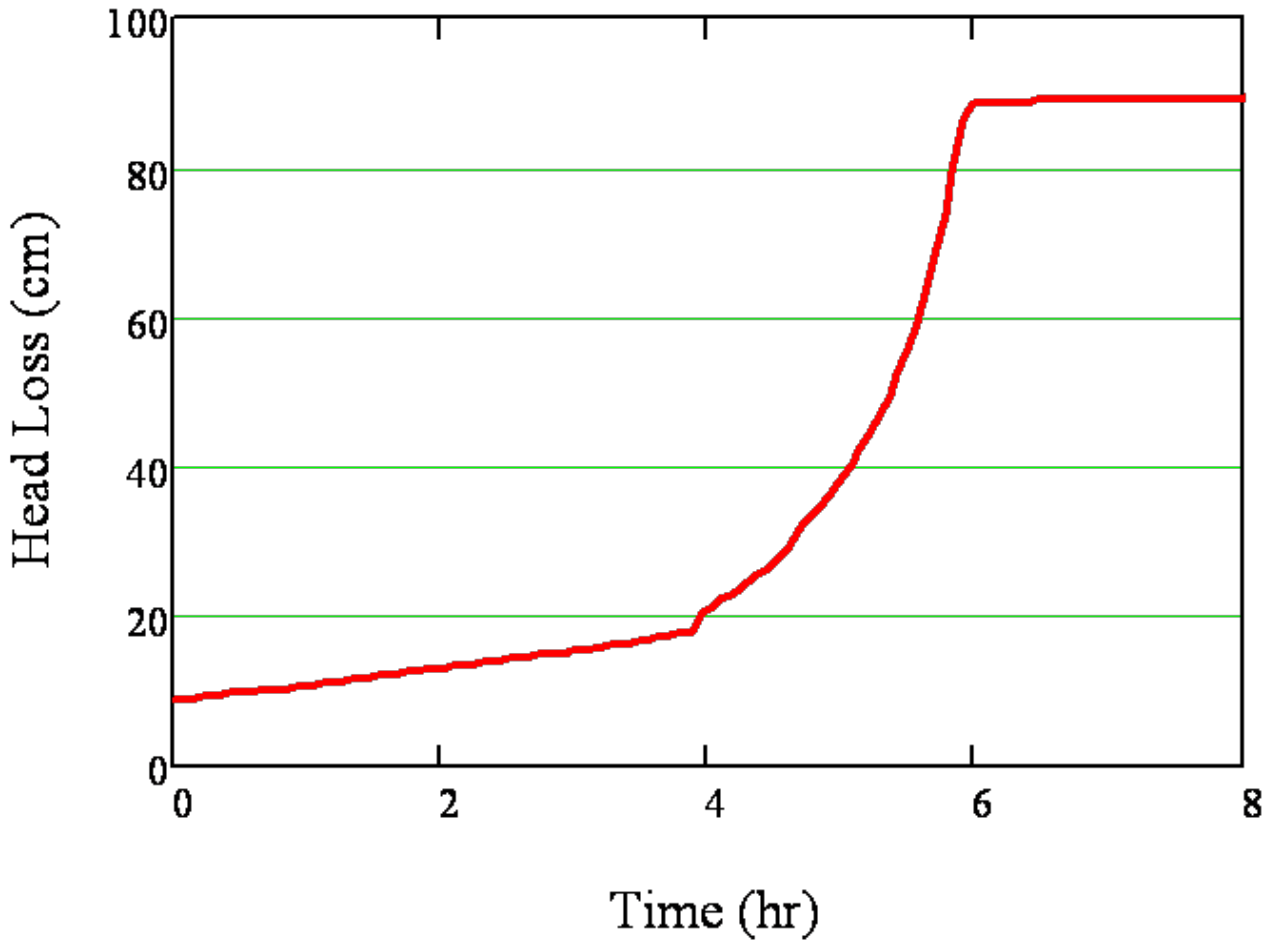

*Figure 1: Head Loss vs. Time, 90 ppi foam, 10 inch depth, alum dose, 50 NTU influent*These results show linear head loss followed by an exponential increase in head loss and constant head loss. We believe the linearly increasing head loss corresponds to the buildup of particles within the foam. The exponential increase corresponds to foam collapse. After particle buildup reaches certain levels, the foam experiences a compression force greater than its compressive strength. The beginning of the exponential increase in head loss corresponds to turbidity breakthrough, which can be seen in figure 2 below.

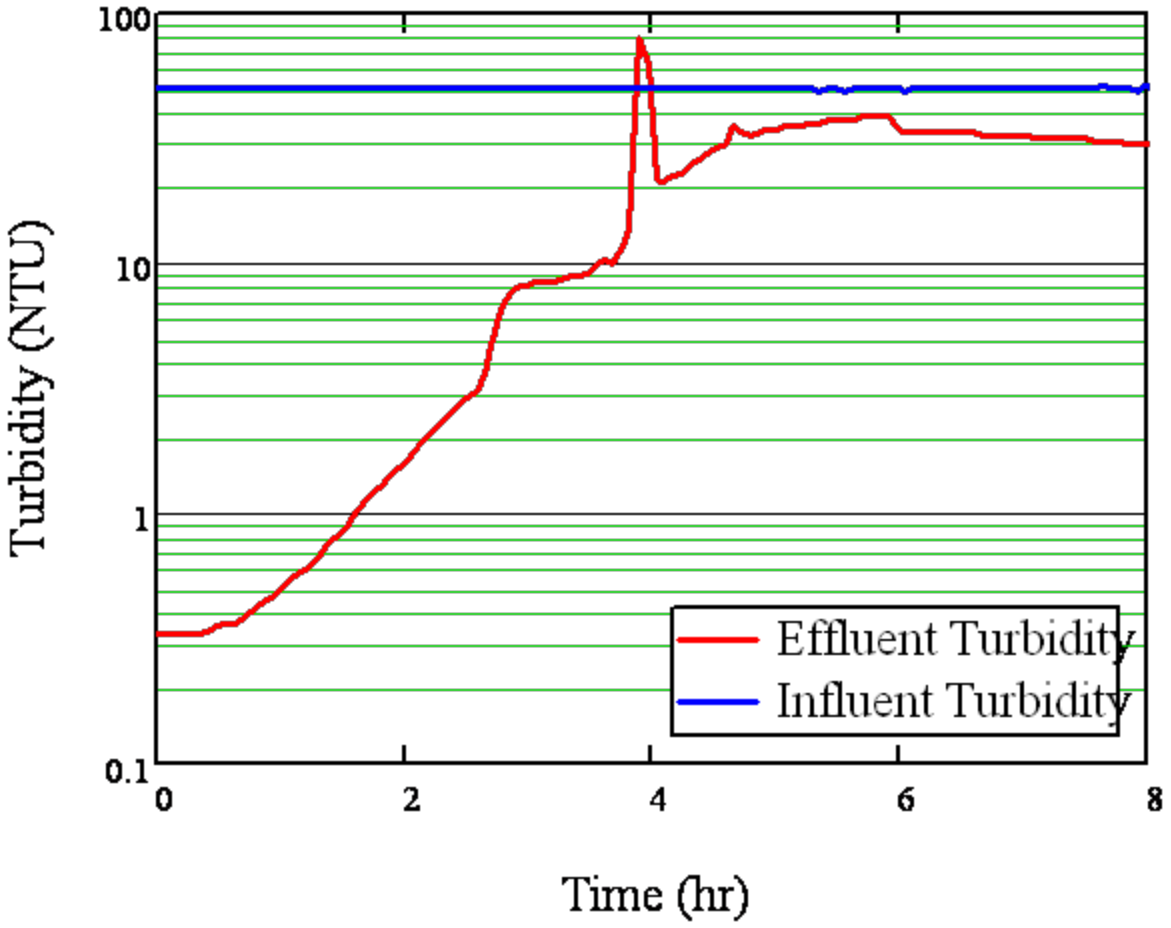

*Figure 2: Influent and Effluent Turbidity vs. Time, 90 ppi foam, 10 inch depth, alum dose, 50 NTU influent*If aligned correctly one can see that breakthrough occurs at the exact time that the exponential increase in head loss starts. This is considered the failure point of the filter run. In designing a point-of-use filtration unit, clear instructions will be provided so that the user does not experience this failure mode and produce high effluent turbidities.

It should also be noted that the head loss in the beginning of the run does not equal the values for head loss calculated in table 1. This is because all filtration trials include an equilibrium period to allow for filtering ripening time. When this equilibrium phase is considered, the head loss starts at values approximately equal to those shown in table 1 and increases linearly as shown in the first part of the head loss figure.

While the time to collapse for this experiment was approximately 5 hours, we expect that the time to collapse will vary with different influent turbidities, alum doses and foam porosity layering. We will not further investigate the time it takes for a filter to reach collapse since this failure mechanism should be avoided with POU filter use. In addition to causing effluent turbidity breakthrough, after collapse, the characteristics of the foam appear to be permanently altered, and because of this filtration performance is not as good. Trials conducted using foam that had previously been collapsed yielded much lower pC* readings than foam that had not been previously collapsed as seen in figure 3 below.

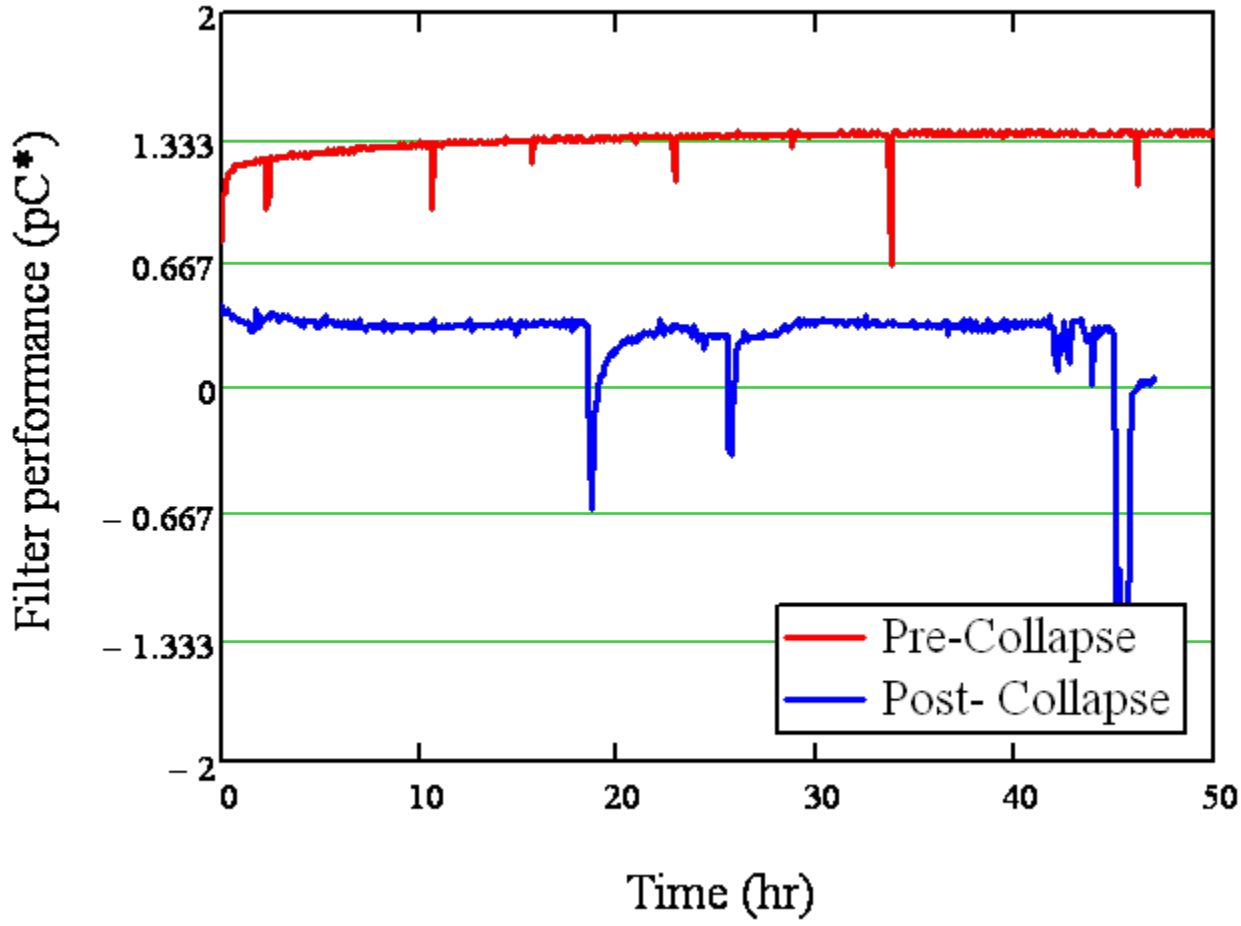

Figure 3: 60 ppi, 5 NTU influent, 1.5 mg/L alum dose