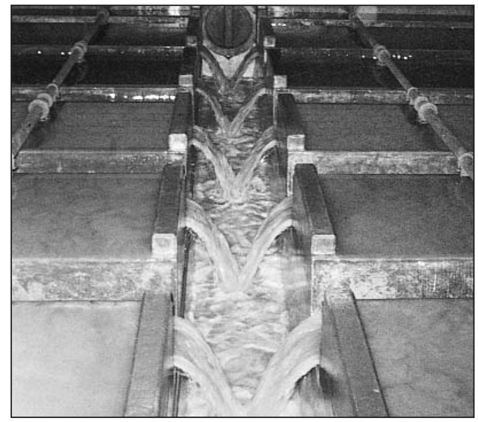
Treatment

Optimizing Your Plant's Filter Performance

by Nick Pizzi



With all the talk about water plant optimization, we would do well to review a few of the operational techniques for filters. The normal cycle for a rapid sand filter begins with the placement of a cleaned filter into service and follows through the steps of filter ripening, effluent production, and subsequent head loss increase. It finally results in particle and turbidity breakthrough, bringing the need for the backwash sequence. During those stages, flow rates through the filter can increase or decrease, and different-quality pretreated water can be introduced. What is done with these steps can greatly affect finished water quality.

Filter Ripening

A conceptual model suggested by some authors can be used to help understand the attachment process. Figure 1 (page 38) shows the relationship of forces involved in the process as a floc particle approaches a grain of sand or anthracite (collector). These forces, F_x (where x is London–van der Waals or F_L, electric double layer or F_{EDL}, gravity or F_G, and fluid drag or F_D), can determine the ability of the particle to attach itself (be filtered). In general, F_L and F_G can help bring the particle closer to the collector, and F_{EDL} can serve to keep the particle from getting close enough to attach. F_G may or may not help—it depends on whether the pull of gravity will bring the particle into contact with the filter media. The operator now has information he or she can use to manipulate the filtering process.

The coagulation and flocculation processes are designed to minimize the effects of electric double-layer repulsion. Poorly coagulated water will have many similarly charged particles suspended in it that will not attach themselves under normal flow conditions found in the conventional water treatment plant.

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Negate these charges through proper chemical treatment, and the other forces will tend to work in favor of the filter process. Of course, fluid drag is a physical process governed by velocities and viscosities and can be minimized by running the filters at or under rated capacity. Exceeding that capacity can increase fluid drag, which will sheer the attached floc particles from the collectors.

Filter ripening is important because the bulk of the particles that pass through a filter do so during the initial ripening period. Running filter to waste, which is a good way to ripen a filter, is a luxury that some of us don't have. However, another way to maximize the filter ripening process is to increase the time from backwashing to placing the filter in service.

If your plant has four or more filters, determine whether you can keep one out of service for at least four hours after washing. Some studies have shown that a filter that has been left out of service a few hours will produce better effluent water sooner than a filter that has been washed and placed into service immediately.

A filter study performed at the Lake County (Ohio) Aquarius Filtration Plant compared filter ripening times for two identical mixed-media filters—one washed and put into

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service immediately and one washed and left to sit for four hours before being put into service.

The turbidity characteristically increased at the beginning of the filter runs. However, the filters that had a four-hour delay did not increase in turbidity as much as the others, and they ripened in an average of 34 min, as opposed to the other filters, which ripened in an average of more than 60 min.

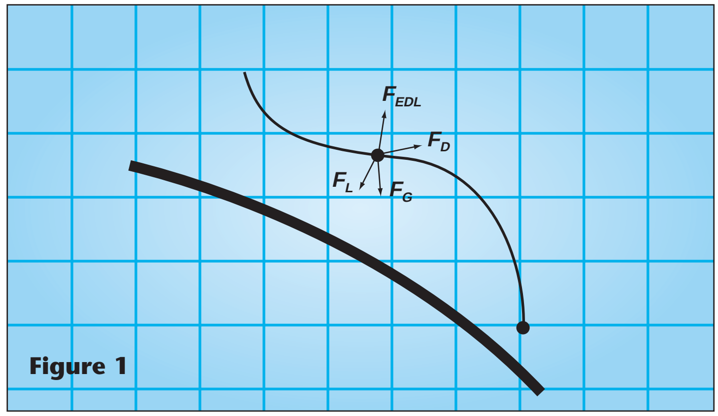

Figure 1

Backwash Considerations

Of course, the backwash sequence itself can have an adverse effect on water quality. Poorly washed filters and bad techniques are leading causes of early filter degradation. Therefore, operators should be properly trained in the technique. Some tips to remember at filter wash time are

- Always begin with and use surface washers, if available, for 1–2 min before washing.
- Continue to use surface wash as you begin the wash sequence. Cut off surface wash when the high wash rate is achieved.
- Ramp the filter wash rates in increments—both up to a maximum and back down. In general, remember to use a higher rate in summer than in winter for waters that are subject to temperature swings (surface supplies). In addition to temperature, the backwash rate is determined by specific gravity and size of the media.
- Do not wash the filter too much. Leave some turbidity (4–5 ntu) in the backwash stream at cutoff. This will preserve the bed ripening and allow the filter to more quickly produce quality effluent when placed into service.
- Think about how your filter wash event will affect the rest of plant operations—pumping rates, dosages, washwater return storage and capability. If another clean filter is waiting in standby, put it into service as you take the filter to be cleaned off-line.

Run Length and Hydraulic Shock

Filter run length can have an adverse effect on the number of particles that pass through a filter, and so can the magnitude of the shocks we place on filters through pump changes and operating habits.

Most operators wash filters at a preset run length, loss of head, or effluent turbidity limit. At some point in the filter run, a filter will begin to pass turbidity (if allowed to continue). Before that time, the effluent particle output will increase. Particles the size of *Giardia* cysts and *Cryptosporidium* oocysts may pass without any discernible increase in effluent turbidity.

During a typical filter run of 57 hours, expect the filter to begin passing an increased number of particles at the end of the run—six hours before the turbidity increases.

Shocks to filters also cause particle breakthrough long before the run comes to an end. Any change in loading rate will cause a temporary breakthrough as filters resettle themselves. This breakthrough is proportional to the magnitude—not the length—of the shock. For example, if all of a plant's eight filters are operating, and the raw water flow is increased, all the filters must absorb one eighth of the shock (ignoring differences in flow rate due to age of the run). For this reason, all changes in flow should be anticipated when possible so that minimization techniques can be employed. Some operating techniques plants have employed are

- operating the clearwell at higher or lower levels to minimize the number of pump changes;
- reducing the number of washwater return pumps that are used to recycle washwater;
- keeping one filter out of service, so that it can be placed on line as another is taken out for washing;
- not operating at negative head, which can form air bubbles that can dislodge and cause small, localized hydraulic shocks in the filter; and
- minimizing the span on rate controllers that "hunt."

Perhaps you can think of other ways, particular to your own plant, that can be eliminated or minimized.

Note: Many small water plants start and stop frequently because they operate for only a portion of the day. This is a major shock that may be minimized only by filtering to waste, if possible.

Effect of Backwash Return

In addition to the hydraulic shock problems that backwash return can cause, we should examine associated concerns. The purpose of the filter is to collect and concentrate the suspended floc particles during the filter run so that they may be wasted at a convenient time.

If the plant recycles this waste, however, it also recycles the concentrated organic carbon and possibly pathogens such as *Giardia* cysts and *Cryptosporidium* oocysts, and it does so in a relatively short burst.

Think of this: a plant does a good job of capturing bacteria and cysts for 50–80 hours, and then returns them to the treatment process in 20–30 min. This loading can represent a treatment challenge that exceeds the plant's capacity to cope. Operators must be especially diligent during this time of loading.

Additionally, some plants combine other smaller streams to this large washwater stream. Supernatant from thickeners and basin sludge units is an example of the kind of sidestreams that needs attention. In many plants, operators do not react to this treatment change, but it is exactly the time to make changes. More coagulant may be needed, and because the flow increases, more filters may be needed to compensate. Activated carbon is a good choice here, also. It is believed to be better to waste this washwater if possible, but if you must treat it, treat it carefully.

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