Filter monitoring parameters, such as on-line turbidity and filter water levels, become ever more important as operators try to optimize effluent turbidity levels. Continuously collected information from filter operations is used to control filter flow rates and determine when a filter should be removed from service and backwashed.
Regulations

Treatment options for meeting LT2ESWTR’s more stringent turbidity limits range from expensive to less costly. Optimizing filter performance offers an economical solution. **BY MARK BISHOP AND WILLIAM BECKER**

FILTER PERFORMANCE: A KEY COMPONENT FOR LT2ESWTR COMPLIANCE

Compliance with Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) treatment requirements begins this year for large utilities (water purveyors of all types, private or public). For smaller utilities, the requirements take effect during the next 2.5 years.

The US Environmental Protection Agency (USEPA) established the rule to provide increased protection from *Cryptosporidium* oocysts and requires water purveyors to monitor raw source water for *Cryptosporidium* and/or *E. coli*. Utilities were assigned Bins, or water quality categories, based on the monitoring level of *Cryptosporidium* or *E. coli* detected. The regulation requires higher treatment levels based on the assigned Bin. Corresponding treatment options to achieve required log removals are listed in the regulations.

For utilities that achieve Bin 1, no additional treatment is required, but they must still meet filtered water turbidity regulations (i.e., ≤ 0.3 ntu at least 95 percent of the time). However, for utilities that are assigned Bins 2–4, additional treatment levels are needed to meet higher log-removal requirements. Options range from more expensive treatment processes (such as membranes or ozone) to less costly solutions (such as optimizing filtration performance to meet more stringent turbidity limits). The LT2ESWTR Toolbox Guidance Manual (www.epa.gov/safewater/disinfection/lt2/pdfs/guide_lt2_toolboxguidancemanual.pdf) discusses combined filter effluent (CFE) and individual filter effluent (IFE) removal credits.

In practice, filtration performance options include turbidity monitoring to meet CFE or IFE. The table on page 10 explains the criteria for qualifying for credit of 0.5-log for CFE and 0.5-log for IFE.

CFE turbidity measurements must be taken at 4-hour intervals, or more frequently. IFE turbidity measurements must be taken every 15 minutes. (Some state regulators may have more stringent requirements.) Systems that meet CFE and IFE requirements in the same month can claim a 1.0-log *Cryptosporidium* treatment credit for that month.
Regulations

For good filter performance, upstream treatment considerations—such as chemical feed and mixing, flocculation, clarification performance, and sludge removal—can also influence filter turbidity. Proper hydraulic control, with properly functioning monitors and valves, is also important.

OBTAINING CREDITS

Filter performance has long been a critical factor in drinking water treatment. Granular media filters are excellent at removing particles to low levels and improving turbidity. However, achieving more restrictive water quality goals, such as lower turbidity, can significantly affect filter functions and operations, such as

- Shorter filter runs resulting from lower ntu criteria and earlier breakthrough
- Longer filter-to-waste (rewash) time
- Increased volume of waste washwater to treat or recycle
- Limiting abrupt filter rate changes that may increase turbidity
- Modifying filter backwash procedures
- Tighter controls and monitoring to detect turbidity excursions as they occur
- New standard operating procedures for filter operations to ensure turbidity criteria are always met
- Optimizing coagulation and clarifier performance

FILTER RUN AND PRODUCTION

Traditionally, filter runs are based on a specific turbidity goal, maximum head loss (typically < 6 ft), or maximum run time. Establishing a maximum lower turbidity limit (< 0.10 ntu) can shorten run times for many plants. It's relatively easy to assess the possible effects of a lower turbidity goal on filter run length (FRL) by examining the effluent from a single filter during periods of historical poor water quality. Figure 1 shows a typical filter run.

The FRL is the length of time in which the maximum filter turbidity ($C_{\text{lim}}$) is acceptable. Filter-to-waste time is $t_R$, and filter run is halted at $t_C$. Run time decreases as the maximum allowable filtrate water quality decreases (measured as ntu). In some plants, this may imply that lowering the effluent turbidity limit from 0.2 ntu to 0.10 ntu could significantly affect run time and wash frequency. Typically, a minimum 24-hour filter run is desired for routine operations. Shorter runs result in generating more washwater, higher recycle rates (if practiced), and loss of production when a filter is out of service.

For example, assume that a normal filter run is 48 hours under current plant operations. Based on an assessment of turbidity data, filter run lengths will be reduced to 24 hours to meet a turbidity of 0.10 ntu for the combined filter effluent. The net filtered-water production (volume) for these two conditions will differ. With a shorter FRL, the filters will be in service for a shorter time, produce less water, and generate more backwash wastewater.

Taking this example a step further, for a 400 ft² filter operated at 4 gpm/ft², the difference in performance for 48- and 24-hour FRLs is calculated as follows:

$$\text{Total production per run at a 24-hour run time} = 400 \text{ ft}^2 \times 4 \text{ gpm/ft}^2 \times 60 \text{ minutes/hour} \times 24 \text{ hours/day} = 2.30 \text{ mgd}$$

Assuming that a combined filter wash and filter-to-waste period consumes 100,000 gal of water and the filter is out of service for 1 hour during washing, which affects its efficiency, net production can be estimated as follows:

$$\text{Net production} = 2.3 \text{ mgd} \times (23 \text{ hours}/24 \text{ hours}) - 100,000 \text{ gal/day (wash)} = 2.11 \text{ mgd}$$

In terms of efficiency, the plant would be delivering 91.7 percent (2.11 mil gal/2.30 mil gal) of its rated 4-gpm/ft² capacity.

Comparing this scenario to a 48-hour filter run, which would have a total production of 4.60 mil gal (twice that of the 24-hour run), the filter would deliver 2.3 mil gal on day 1, plus 2.11 mil gal on wash day, or 4.41 mil gal total. Therefore, efficiency would be 4.41 mil gal/4.60 mil gal, or 96 percent efficient. The water production difference between the two filter-run scenarios is, therefore, about 4.3 percent.

Further shortening the filter runs would have an even greater effect on production and washwater generation. As shown in the example, FRL reduction would result in less treated water delivered. Increased recycle rates would have to be managed appropriately.

Figure 2 shows net filter production for various filter rates and run lengths. The graph can be used to estimate net water production based on changes in filter runs resulting from shorter operating periods before washing.

TIGHTER OPERATIONAL CONTROL

As frontline employees, plant operators must continuously monitor and maintain filtered-water quality. Current state-of-the-art automated systems and data acquisition permit a higher level of water quality to be attained. The technology also enables continuous turbidity monitoring and turbidity triggers for taking poorly performing filters out of service immediately.
Achieving more restrictive water quality goals, such as lower turbidity, can significantly affect filter functions and operations.

Achieving an IFE of 0.15 ntu at least 95 percent of the time requires a strict monitoring period (every 15 minutes) and, if a turbidity spike occurs, a filter’s immediate shutdown. Such tight operating processes require well-written operating procedures. With a CFE or IFE goal, plant personnel may have to revise their operating procedures and shutdown logic. Filter startup and wash procedures may also need to be modified to maintain reasonable filter-to-waste times. Experimentation with filter operations—such as resting filters or starting filters at low filter rates while filtering to waste—could help decrease wasted water at startup. The use of polymer filter aids can also help performance.

Also, to achieve tighter turbidity limits, consider the number of filters out of service at any time. In other words, if a filter is taken off-line, should the resulting filter rate bump be handled in the remaining filters in service, or should a spare filter always be held in reserve to compensate for the lost filter?

COSTS OF CFE OR IFE CREDITS

There may be additional costs associated with applying a CFE/IFE performance strategy, including

- modified or new chemical additions, such as filter aid or backwash coagulant, coagulant feed improvements, etc.
- filter improvements, such as media addition, filter-to-waste improvements, etc.
- increased plant staffing and training.

Consider using pilot or full-scale tests to evaluate alternatives for reducing filtered water turbidity, as well as new instrumentation or increased instrument calibration frequency, depending on the condition of current on-line monitoring or lab equipment.

IMPLEMENTING CREDITS FOR COMPLIANCE

Implementing CFE or IFE criteria for credit as an enhanced barrier for microbes can be a cost-effective strategy for water utilities that need additional log-removal credit. The viability of such a strategy should be based on an objective assessment of plant performance and possible changes to plant filter operations. This assessment should include the following:

- Discussions with your state regulators regarding criteria for credit.
- Review of viability based on analysis of historical seasonal filter performance, considering a CFE or IFE limit of 0.10 ntu.
- Pilot testing a full- or pilot-scale filter to assess run lengths with lower turbidity goals.

- Consideration of lower net water production from shorter filter runs and more washing and recycling, if practiced.
- Changing current standard operating procedures to ensure turbidity violations don't occur, establishing turbidity triggers for taking a filter off-line, and having a standby filter to resume capacity.
- Additional operator training for all aspects of maintaining good settled and filtered water turbidity.
- A frequent and vigilant instrument calibration program.

Figure 1. Filter Run and Production Considerations

By examining filter effluent, you can assess the effects of a lower turbidity goal on filter run length.

Figure 2. Net Filter Production

Net water production can be estimated based on changes in filter runs resulting from shorter operating periods before washing.