

Opflow



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Applying Self-assessment to Filter Optimization

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Champlain Water District in Northwestern Vermont treats low-turbidity raw water and strives to produce consistent high-quality finished water. The district's Peter L. Jacob Filtration Facility provides multiple barriers to remove and inactivate protozoan and other microorganisms.

The facility obtains raw water from a depth of 75 ft (23 m) in Lake Champlain's Shelburne Bay. From 1980 to 1989, the facility consisted of two deep-bed, dual-media filters and one converted deep-bed, multimedia filter, preceded by flocculation basins operated in the direct filtration mode (Figure 1, page 4). At that time, the operational turbidity goal was from 0.15 to 0.2 ntu for the combined filter effluent.

In 1991, a phased three-year facility upgrade was completed. The existing flocculation basins were retrofitted with two adsorption clarifiers (AC) and two additional deep-bed, multimedia filters (DF) to strengthen the filtration barrier. A 1-mil gal contact time (CT) tank was built to strengthen the disinfection barrier (Figure 1). The Vermont Water Supply Division assigned the facility 2-log removal credit for *Giardia* with the possibility of demonstrating 2.5-log removal in the future. The operational goal after this upgrade was 0.1 ntu or less for the combined filter effluent.

Full-scale coagulant trials were conducted throughout an eight-month period in 1992. Cationic polymer and various coagulants were tested. The results indicated that a higher cationic polymer dose relative to the coagulant dosage was the predictor of treatment effectiveness. The facility's current dosages of 3.8 mg/L alum (dry) and 3.3 mg/L cationic polymer are based upon these results.

Third-Party Assessment

The district invited an independent third-party assessor to review the treatment facility in 1994 and continues to build upon the assessor's recommendations. The assessment was based on Pennsylvania's Filtration Plant Performance Evaluation approach (FPPE) to determine whether

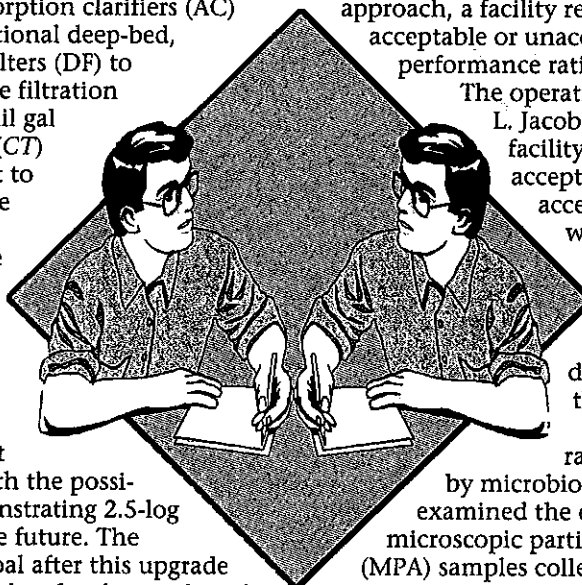
filtration facilities operate in an acceptable manner to protect against *Giardia*. Under this assessment approach, a facility receives either an acceptable or unacceptable performance rating.

The operation of the Peter L. Jacob filtration facility was rated acceptable. The acceptable rating was formed by combining information gained by the assessor during a walk-through assessment with ratings formed

by microbiologists who examined the entire pellet of microscopic particulate analysis (MPA) samples collected during the walk-through. The walk-through assessment included an extensive review of operating data and process control procedures.

At the time the facility was rated acceptable, the assessor and microbiologists involved had jointly applied this rating technique during more than 250 FPPEs throughout six years. Although this acceptable rating only applied to *Giardia* removal, the operational goal of 0.1 ntu used in the assessment is also widely accepted as necessary in *Cryptosporidium* removal.

The district believes that, because Pennsylvania's FPPE approach is conservatively based on the Composite Correction Program and has been used to assess more than 250 filtration plants, the acceptable facility rating should serve as a benchmark.



In This Issue

Applying Self-assessment to Filter Optimization	1
Certification Corner	2
Question of the Month: Fine-tuning Operations for Turbidity Problems	3
Putting the Squeeze on Flexible Pipe	6
Metering Method Changes But Memories Remain	8
Installing Relief Valves the Right Way	9
Gimmicks and Gadgets: Simple Device Supports Backflow Assembly	10
For More Information	10
From the Editor's Desk	11

continued on page 4

Applying Self-assessment to Filter Optimization *continued from page 1*

The recommendations in Table 1 are based on the assessor's observations, review of plant data, and discussions with plant staff. Other tools the district used during the assessment included particle counting; trend analysis of unit process turbidity, flow, and head loss; and filter media examination.

Actions Resulting From the Assessment

The actions taken as a result of the walk-through assessment have increased the ability of the facility to produce a consistent, high-quality drinking water. The assessor made specific recommendations, as well as recommendations for further evaluation.

Resulting changes have been made in flow control, process control, turbidimeter calibration, CT tank optimization, media addition, in-line mixing, and alum-polymer dose optimization.

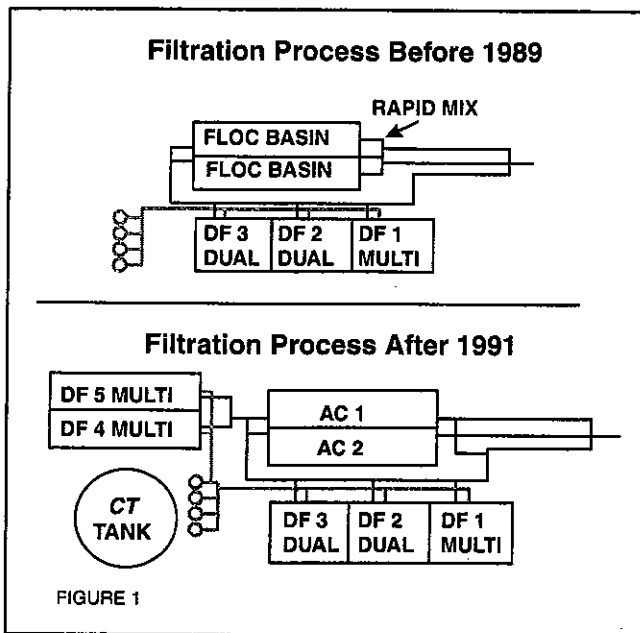
Flow Control

Trending process turbidity with process flow or head loss illustrated the importance of changes in flow rate upon unit process efficiency. This trending technique identified improper clarifier automatic valve operation known as "hunting" and led to the correction of this improper valve performance. The importance of steady process flow rates to protect against *Cryptosporidium* breakthrough and to optimize filter efficiency has been included in at least one water industry checklist.

The district has instituted gradual unit flow-rate increases in meeting system demand and has implemented a slow ramp of the filter effluent valve following filter backwash. The filter flow control valve is now ramped from zero to set point flow over 18 min. The resulting typical post-backwash peak reaches 50 counts/mL in the 2.75- μ m to 13- μ m range lasting up to 40 min and reaches a maximum of 0.15 ntu, lasting 5 to 10 min.

Process Control

The district adopted the values indicated in Figure 2 for making



process decisions for individual filters. A maximum level of 10 counts/mL in the 2.75- μ m to 13- μ m range is used as the primary control and the total counts/mL greater than 2 μ serve as a secondary control. Particle counts are trended for three filters, including the historically "weakest" filter. The maximum allowable turbidity level from each filter is now 0.1 ntu.

Real-time turbidity of each filter effluent is continually trended on the district's supervisory control and data acquisition (SCADA) system (Figure 3). The facility operators use these trends to ensure that individual filters do not exceed 0.1 ntu. The operators became experienced at reading the trends and at understanding the nuances of each filter and refined the operational goal to backwashing at the first sign of filter instability, as indicated in Figure 3.

The operators' use of individual filter turbidity trending was beneficial during the "great thaw" of January 1996. Figure 4 shows corresponding raw and finished water turbidity for 60 h during this event. The combined filter effluent peaked at 0.16 ntu when the raw water peaked at 21 ntu.

In addition, the finished water was at or below 0.1 ntu for eight of the 11 h that the raw water turbidity exceeded 12 ntu. Turbidity trending information enabled the operators to see the difficulty the two remaining dual-media filters were having meeting 0.1 ntu. The operators

reduced the flow of these filters and made up for that reduced flow in other, more efficient multimedia filters.

The performance of the filtration facility during the thaw illustrates the importance of striving for 0.1 ntu from each filter. At the time, the district was striving to produce finished water below 0.1 ntu from each filter 100 percent of the time. The January 1996, 15-year, worst-case condition challenged the district's optimized process.

To the facility staff, the self-assessment means learning to overcome complacency with a "stable" raw water source. The impact of the thaw would have been more severe had the district not conducted the third-party assessment.

Turbidimeter Calibration

The district upgraded its turbidimeters. The laboratory turbidimeter and the online turbidimeters are now calibrated at least quarterly and a quality control chart was implemented for the lab turbidimeter.

CT Tank Optimization

To provide more disinfectant contact time, the minimum operational level for the 38-ft (12-m) CT tank is now 25 ft (8 m) for water below 10° C. In addition, a spreadsheet was developed to compare different CT tank levels and chlorine residual options. The spreadsheet calculates delta CT as the difference between the required CT and the actual CT. The district strives to continually maintain a positive delta CT.

Media Addition

During the assessment, the district also collected particle counting data and submitted MPA samples to two other laboratories. One result of this MPA sampling was the better removal performance of the multimedia filter (*Giardia* size = 2.7 log), as compared to the dual-media filter (*Giardia* size = 1.6 log).

SCADA turbidity trending showed that the two remaining dual-media filters were less efficient than the

multimedia filters, with shorter run times and more unstable turbidity baselines. Ilmenite was added to the two dual-media filters in April 1996. The district now operates five deep-bed, multimedia filters—30 in. (760 mm) anthracite, 9.5 in. (240 mm) sand, and 4.5 in. (115 mm) ilmenite.

In-line Mixing

The facility's mixing process had relied upon solution tube injection of the polymer and alum into turbulent flow prior to the clarifiers. The assessor suggested increasing this in-line mixing due to the brief contact time between chemical addition and the clarifier inlet. The mixing jet shown in Figure 5 on page 6 resulted from this in-house investigation. The relatively high-pressure water jet creates turbulence that further disperses the treatment chemicals.

Alum-Polymer Dose Optimization

Turbidity trending showed minor increases in filtered water turbidity during clarifier backwashes, as shown in Figure 3. The increased turbidity was eliminated by enhancing the alum and polymer pacing systems to accommodate the 30 percent increase in total raw water flow during a clarifier backwash.

Particle Size Removal Assessment

The district participated as a sample location for the AWWA Research Foundation's "A National Assessment of Particle Removals by Filtration" project. The 90th percentile data greater than 2 μ during this counting period ranged from 8 to 10 counts/mL, and the 50th percentile particle removals were over 2.5 log. Additional MPAs were conducted during a 10-month period in 1995.

Under typical operating conditions, the average removal for algae and diatoms was 3.7 log. The average removal in the *Giardia* size range was 3 log and in the *Cryptosporidium* size range was 4.2 log.

Particle removal indicated by the 1995 daily combined-filter effluent data submitted to the Partnership for Safe Drinking Water program shows that the

values did not exceed 0.1 ntu and were less than 0.1 ntu 99 percent of the time in 1995. These three forms of particle size removal assessment—particle counting, MPA, and turbidity—and the district's actions due to the third-party assessment process, made the case for increased removal credit in the *Giardia* size range.

The Vermont Water Supply Division credited the district filtration facility with a minimum removal credit for *Giardia* of 2.5 log in an amended operating permit in July 1996. In addition, the stage was set for at least 3-log removal credit for *Cryptosporidium* when this organism is regulated.

Partnership for Safe Drinking Water

The assessment produced a report detailing the data and findings that was made available to the public upon request. The FPPE conducted at the district is most closely related to the operational aspect of the Partnership for Safe Drinking Water Self-assessment Procedures. CWD served as a field contact and reviewer for these procedures. The district

joined the Partnership in November 1995 and requested that its FPPE report be placed in CWD's Partnership files. Our organization strongly supports the positive, voluntary nature of the Partnership program and welcomes the third-party assessment aspect of the Partnership. We are now formatting the previous FPPE work into the Partnership format.

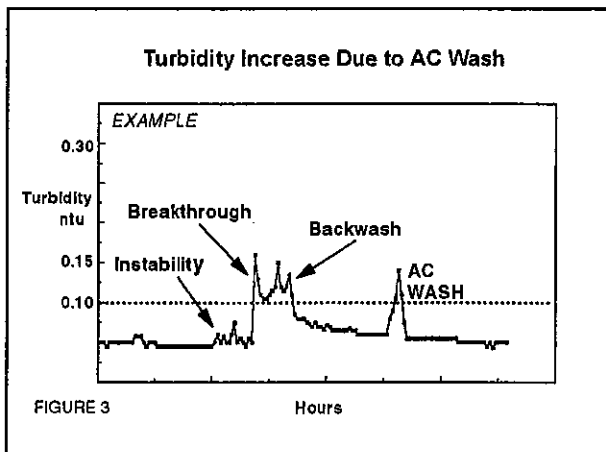
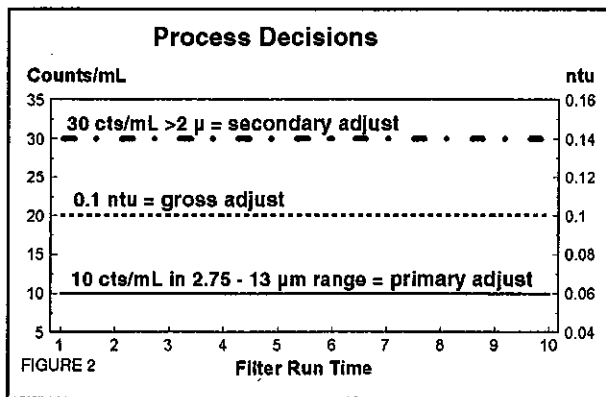
Tenacity to Protect Public Health

A major author of the Partnership for Safe Drinking Water Self-assessment Procedures and the Composite Correction Program Handbook has stressed the need for a utility's operational personnel to develop the "tenacity" to protect public health. The CWD facility operators have been able to develop this tenacity due to the assessment's support for their existing interest in optimization. The operators enhanced this tenacity through intensive training using the 1994 AWWA teleconference videos about preventing waterborne disease titled *Is Your System at Risk?*

Prior to this training, the concept that filter performance should be measured from each individual filter was not completely accepted. Following the training session, the operators were making their own process control decisions based on the first indication that a filter had become potentially unstable. The training infused them with the "tenacity" discussed above. The district operations staff now subscribes to the motto that "your finished water is only as good as your worst filter's performance."

The assessment encouraged the CWD organization to embrace the multiple barrier concept. The district employees, board members, and external stakeholders met and created 10 guiding principles for the future. The multiple barrier concept's importance to the entire organization was at the top of the list throughout this strategic planning process. The principle reads, in part:

"... The district's approach to producing and delivering a



Your Main Squeeze

Putting the Squeeze on Flexible Pipe

by Russ Glaser

Clark Public Utilities in Vancouver, Wash., uses polyethylene (PE) pipe to provide water from the main water lines to the water meter at each customer location. During the process of installing water distribution mains and providing service for new construction, it sometimes is necessary to shut off the water service line connected to the meter. It also is necessary to shut off the flow of water when repairs, pipe maintenance, or pipe damage are encountered at an existing site.

We have found it more practical to squeeze off the flow in the polyethylene pipe just ahead of the leak or hookup, rather than shut down the entire main. Shutdowns inconvenience other customers connected to the main line and create potential backflow contamination of the water supply by exposing the main to migration of bacteria and microor-

ganisms from the rupture area after water pressure is removed.

Choosing the Right Clamp

We use a clamp similar to one originally developed to squeeze off natural gas flow quickly in polyethylene pipes, so we are confident about its ability to stop the flow. Some of the features our operators consider in choosing a squeeze-off clamp include:

- must not damage the PE pipe
- small size and weight
- durable and nonrusting
- convenient to store and operate
- adjustability to various pipe diameters
- use from the top of the pipe (reducing excavation)
- operation from ground level (eliminating need to enter the excavation hole)

The final point above is an especially important consideration for us, in view of the Occupational Safety and Health Administration's recently revised "confined area" regulations. With a properly chosen squeeze-off tool, our service personnel save valuable time when repairing leaks, restore service to the customer faster, and prevent backflow of contamination into potable service lines.

Squeeze-off Procedure

The clamp we primarily use has built-in jaw spacing so that it cannot be overtightened on the pipe after the proper pipe size is selected, and its self-locking feature prevents premature release. This makes the squeeze-off almost too fast and easy! The most important point for our operators to remember is that they could damage the pipe if they close or release the clamp too quickly. To be on the safe

continued on page 7

Applying Self-assessment to Filter Optimization *continued from page 5*

high-quality product to consumers' homes and businesses will follow the multiple barrier approach. The treatment barriers under this approach are

- 1) source protection ...
- 2) optimization of water filtration processes ...
- 3) optimization of water disinfection processes ..., and
- 4) best management practices ... within the distribution, transmission, and storage facilities ... "

The statement of principles was mailed as part of a consumer information brochure in May 1996 to all of the district's 60,000 customers.

The third-party assessment conducted at Champlain Water District beginning in July 1994 was a logical step following facility upgrades and full-scale coagulant testing. The process stimulated many followup actions and acted as a catalyst by stressing the multiple barrier concept and continuous

process optimization. The district plans to continue building upon the assessment's findings and actively participate in the Partnership for Safe Drinking Water assessment programs.

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