After Backwash Part 2

# Controlling Turbidity Spike with Alum, Iron

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Because of its effectiveness in controlling or mitigating the initial turbidity spike at the start of a filter run after a backwashed filter's return to service, some water utilities add primary coagulant chemical or cationic polymer to the settled water entering the filter box as it refills following backwash termination. This may be done either in a slug dose following backwash or as a low continuous dosage.

**Resting a filter after backwash can help control the turbidity after startup.**

At the Lake Michigan Filtration Plant, operated by the city of Grand Rapids, Mich., undiluted liquid alum is added to influent settled water in a slug dose because it has proved effective in controlling turbidity spikes. The amount of coagulant added is approximately 1/3 gal (1.3 L) per 8,000 $ft^3$ (230 $m^3$) of water over the filter media. This calculation is based on the volume of water from the top of the media to the water surface, and ignores the volume the wash water troughs displace in the water. The dosage, calculated on the basis of commercial-grade powdered or granular alum [filter alum, $Al_2(SO_4)_3 \bullet 14\ H_2O$], is about 3.7 mg/L.

Peak turbidity normally does not exceed 0.1 ntu on startup after backwash at the Lake Michigan plant, and the typical alum dosage for coagulation is about 13 mg/L. The operator who backwashes the filter adds liquid alum manually, using a marked plastic jug so the alum can be easily measured. The alum is poured onto the surface of the inrushing settled water, and no mixing occurs other than that which happens naturally when water enters the filter box. The plant rests a filter after backwash, so both procedures may beneficially influence the initial water quality.

*Part 1 of this series, published in the October 2005* Opflow, *presented an overview of the study on which this article is based and four other techniques for controlling the initial turbidity spike when a filter is returned to service after backwash.*

## Comparison Tests

By adding liquid alum to the settled water as it fills the filter box after a filter backwash at the Witty Adkins Water Treatment Plant, the Greenville (S.C.) Water System is able to decrease the duration and magnitude of the initial turbidity spike. The Adkins plant also uses alum as its primary coagulant for treating their stable, high-quality (1–2 ntu) source water from Lake Keowee. To determine the most effective process for controlling the spike, GWS tested two filters, restarting them with and without addition of supplemental alum, so the performance comparison would not be influenced by changes in source water quality. During the evaluation, which lasted for several weeks, the filters were backwashed when needed, and not necessarily immediately one after the other. Raw water alum dosage was 8 to 9 mg/L, and the effective alum dosage added to the filter influent was about 3.2 mg/L, based on the volume of water in the filter box above the top of the media.

Twenty-eight filter runs were made without added alum, and GWS compared those results to 29 runs in which alum was added to influent settled water as a filter refilled. The median turbidity peak was 0.19 ntu for runs without added alum, but only 0.11 ntu for runs with added alum. The difference was statistically significant at the 0.05 level. Data on turbidity peaks are summarized in Table 1 on page 12. The upper quartile peak for starts with added alum was 0.l4 ntu, substantially better than the 0.27 ntu value for starts without any added alum.

Adding alum to the influent water greatly reduced the time needed to reach 0.10 ntu after filtration started. The median time for turbidity to return to 0.10 ntu after filter startup was 16.5 min for filters started without adding alum to the influent settled water and 1 min for filters started after alum was added (Table 2 on page 13). The median time reduced to 0.10 ntu is a major improvement in performance, as with the 1-min time to reach 0.10 ntu; the filter is practically at that value when operation begins.

Milwaukee Water Works compared backwash with no polymer addition, backwash with cationic polymer added, and cationic polymer added to the influent settled water for the last hour of a filter run and again during the first hour of the following run. Adding 0.4 mg/L polymer to the influent settled water before and after backwash controlled the initial spike better than adding polymer to backwash water, as determined by particle counting. This technique reduced the peak height and duration of the spike.

Full-scale practice at MWW was later modified to include a slug dose of undiluted cationic polymer in the filter box in front of the influent valve. The slug dose mixes with the settled water as it flows into the filter box after the influent valve is opened. The volume of polymer added in the slug dose is based on filter size and calculated to deliver a dosage of 0.4 mg/L, based on the amount of water needed to fill the filter. During the first hour of the filter run, polymer is fed at a rate of 0.4 mg/L. During the last hour of a filter run before backwash, polymer is no longer fed, because it is not beneficial.

### Adding Iron

Thames Water Utilities in Reading, UK, conducted a short-term trial of adding supplemental coagulant to filter influent water at a conventional treatment works where clarified water passed to six dual media filters operated at a nominal rate of 2 gpm/ft$^2$ (5 m/hr). The filter-to-waste ran for 22 min at approximately 0.8 gpm/ft$^2$ (2 m/hr). Three additional different nominal coagulant dosages of approximately 1.2, 2.9, and 4.8 mg/L as iron (Fe) were tested in parallel filters on one day. The additional coagulant dosages were calculated as nominal dosages based on the mass of Fe added into the volume of water in the side channel and above the filter media before the filter-to-waste process started.

Each of the three filters receiving extra iron reached 0.10 ntu more quickly than the three that were not dosed with extra coagulant (Figure 1 on page 14). The filter receiving a dosage of 4.8 mg/L of Fe reached 0.1 ntu the quickest, before the end of the 22-min filter-to-waste period. The turbidity peaks for filters receiving added iron dosages of 1.2 mg/L and 2.9 mg/L also were lower than the turbidity peaks of the filters that did not receive added iron.

### Lessons Learned

As with the addition of chemicals to backwash water, the type and dosage of coagulant or polymer were

*continued on page 12*

# Turbidity (from page 11)

determined by trial and error, and so was the dosing duration. A common mistake is the assumption that "if a little bit is good, a lot is much better." Overdosing either an inorganic coagulant or a polymer when settled water flows into the filter box after backwash can have detrimental consequences. For example, if excessive alum is added to the influent settled water, mudballs might develop in the filter. Excess polymer dosages can result in short filter runs and mudball formation.

Adding coagulant as the filter refills could help condition the media and destabilize any charges on the particles left in the filter or the supernatant after backwash. If coagulant is added when the filter box refills, it is less likely to pass into

| Peak Turbidity During Starts | Without added alum | With added alum |
|---|---|---|
| Number of starts | 28 | 29 |
| Smallest peak | 0.07 ntu | 0.07 ntu |
| Lower quartile | 0.145 ntu | 0.09 ntu |
| Median | 0.195 ntu | 0.11 ntu |
| Upper quartile | 0.27 ntu | 0.14 ntu |
| Largest peak | 0.64 ntu | 0.32 ntu |

**Table 1. Comparisons of turbidity peaks during filter starts with and without added alum.**

the filtered water as long as turbidity remains low. Also, filtered water can be analyzed for excess iron or aluminum coagulants to determine if coagulant chemical is passing through the filter. The effect of extra coagulant on pH should be checked, particularly when the alkalinity of coagulated water is low, a condition that could result in depressed pH and passage of undissolved coagulant into filtered water.

Slug dosing or a short-term continuous feed should be started with low doses of coagulant or polymer, and the dose gradually increased if the filter effluent quality does not improve. Alternate filter runs, both with and without added coagulant or polymer, should be performed to develop solid evidence that the lowered turbidity spike at the start of a run is a result of adding the chemical to the filter influent water and not a consequence of source water quality and treatability changes that occurred over time while the testing program was under way.

Some water utilities that use alum find that treating their source water effectively is difficult when the water is very cold. The chemical reaction time for alum is slower when

| Time to Reach 0.10 ntu During Starts | | |
|---|---|---|
| | Without added alum | With added alum |
| Number of starts | 28 | 29 |
| Shortest time | 0 min | 0 min |
| Lower quartile | 7.5 min | 0 min |
| Median time | 16.5 min | 1 min |
| Upper quartile | 27.5 min | 7 min |
| Longest time | 45 min | 26 min |

**Table 2. Comparisons of time for filtered water turbidity to decrease to 0.10 ntu during starts with and without alum.**

temperatures are around 3° to 5° C (37° to 41° F) or lower, and the floc that forms may be weaker and more easily disrupted in the filter bed. For very cold water, the time between adding alum to the filter box and starting the run may be too short for the alum to react, and dissolved aluminum could pass through the filter bed and into finished water. Where slow alum reaction time has been a problem in winter, adding alum at the start of the filter run may not help control the initial water quality.

When adding alum for the first time, monitor the filter effluent for dissolved aluminum for the first hour of the filter run, collecting samples at least every 10 min to determine the extent to which dissolved aluminum is passing through the filter. If dissolved aluminum concentrations are less than 0.2 mg/L, future aluminum monitoring may not be needed unless cold water conditions are encountered.

### Selecting Appropriate Procedures

The techniques used to control the turbidity spike at the start of a filter run have yielded mixed results. Some procedures described in this article and Part 1 may work well at one filtration plant but not at another. Finding an effective method for any plant is likely to include an element of trial and error until the best combination of techniques is discovered.

Evaluate more than one procedure and various combinations of procedures for controlling the initial turbidity spike on-site, as the efficacy of the various techniques was not consistent at all plants participating in the AwwaRF project. The Modesto (Calif.) Irrigation District compiled a list of data to collect, record, and evaluate when studying the addition of conditioning chemicals to backwash water, which includes

- Filter identification, i.e., filter number

*continued on page 14*

## Turbidity (from page 13)

- Time of day when the filtered water turbidity exceeds the plant's operational goal
- Time when filtered water turbidity meets the plant's goal
- Duration of time filtered-water turbidity exceeds plant's operational goal
- Maximum turbidity after startup
- Length of time that particle counts in filtered water exceed the plant's operational goal, if particle counters are employed
- Time to reach full rate of filtration, if a gradual or slow filter start is used
- Duration of backwash (min) and volume of water used
- Chemicals added to backwash water or to pretreated water flowing into a filter after conclusion of backwash, if applicable
- Primary coagulant dosage
- Filter aid and dosage, if applicable
- Raw water turbidity
- Settled water turbidity
- Settled water pH
- Raw water temperature
- Streaming current detector reading
- Raw water TOC concentration

For startup studies using other techniques to control the initial

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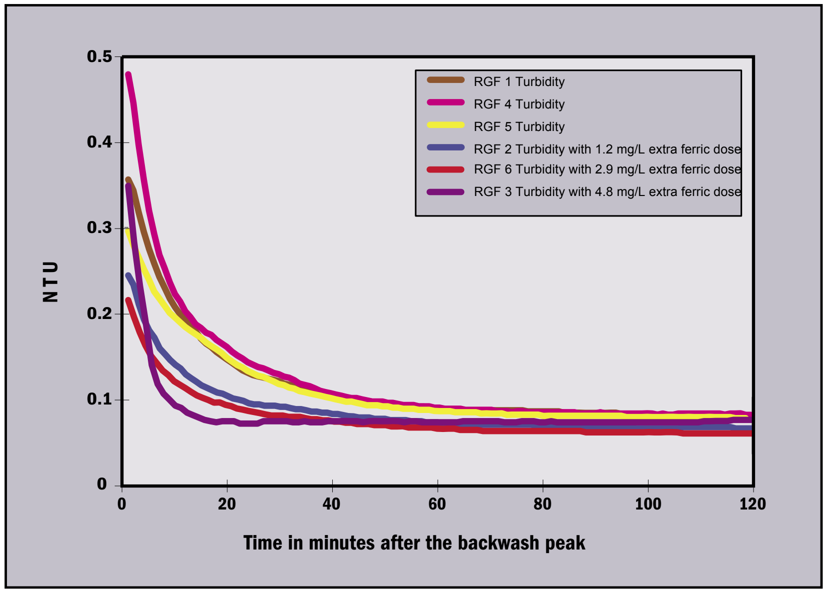


**Figure 1. Filter ripening curves with and without additional ferric dose — all backwashed over an 8-hr period.** *(RGF is rapid gravity filter)*

turbidity spike, collect most of the data from Modesto's list, as appropriate for the filter, source water quality, and startup technique being evaluated. If startup studies involve filter resting, the length of time between backwashing and return to service is important to record. For studies of gradual filter starts, collect data on the initial filtration rate; the timing, magnitude, and duration of each rate increase; the length of time the filter operates at the increased rate before another increase is imposed; and the maximum filtration rate attained. If coagulant or polymer are added to influent water when the filter box is filled, also record the volume and strength of chemical added, the time when added, and the duration of time when the addition occurred.

### Summary

A sharp rise in turbidity typically is associated with starting a rapid rate granular media filter after it has been backwashed. A variety of techniques may decrease the magnitude of the initial turbidity spike, and some of these techniques also can result in a shorter ripening period.

Water utilities are advised to use more than one technique to control turbidity when starting filters. Among the filtration plants that provided information to the AwwaRF project, multiple procedures were used to control the initial turbidity spike at the majority of plants that generally controlled turbidity to 0.3 ntu or lower. On-site evaluation of filter-starting techniques is recommended, as results may vary from plant to plant, and procedures can be evaluated most effectively using a trial and error approach. During filter-starting trials, carefully document procedures used and results attained.

### For More Information

These publications are available from AwwaRF.

- *Maintenance and Operation of Granular Media Filtration Plants,* AwwaRF report
- *Guidelines for Optimization of the High-Rate Filtration Process: Plant Demonstration Studies,* AwwaRF report
- *Filter Maintenance and Operations Guidance Manual,* AwwaRF report

Click on the following link for a more complete bibliography for both this article and Part 1, which is available in *Opflow Online* October 2005.