Coagulation and Filtration Performance Optimized with Liquid Borne-Particle Counters

by Kent Horrell and Tony Sweazy

Louisville Water has increased its minimum coagulant dosage by using liquid borne-particle counters to measure water quality at particle levels, where turbidimeters are not as effective. Laboratory experiments have shown that particle counters are able to accurately measure filter and coagulant performance in the 0-70 particles per milliliter range, where the turbidimeters (in these same ranges) typically show constant readings. These more accurate measurements have made it possible to improve water quality adjusting filter run times and coagulant feed rates. The improvements have resulted in higher levels of performance than previously possible, by using turbidimeter measurements alone.

Louisville Water, owned by the City of Louisville, provides 225,000 connections and serves 700,000 people, including the entire city of Louisville and most of Jefferson County. The Ohio River is the company's sole water source. The company has two treatment plants: The Crescent Hill plant, which produces an average of 90 to 100 mgd, and the Payne plant, which produces 25 mgd. The company uses standard flocculation, coagulation and rapid sand filtration methods. Ferric chloride is used as the coagulant and a polymer is used as a coagulation aid. A closed-loop system is used to measure turbidity and adjust ferric feed rates. Source water varies greatly during the year, therefore, the influent turbidity to the coagulant ranges from 4 to 300 NTU. The plant's goal is to maintain a level of 1.5 to 2 NTU coming out of coagulation and then use filtration to further reduce this turbidity down to 0.1 NTU.

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Until recently, turbidimeters were the sole measurement method used to maintain these standards. Turbidimeters measure how much light is scattered by particulates in a large, illuminated sampling volume. The amount of scattered light depends on the shape, color, number, and size of the particles. These variables can combine in different ways to scatter the same amount of light for a large variety of particle-size combinations. Furthermore, water quality at this plant is high enough that measurements are near the minimum sensitivity of most turbidimeters. In these cases, a turbidimeter cannot sense the small changes in plant operation or be used to evaluate control strategies.

Sampling

Liquid-borne particle counters perform measurements either through light-blocking or light-scattering techniques. A laser illuminates only a small volume of liquid, so that only one particle is in the sampling volume at a time. This small sampling volume is called a view volume. The amount of blocked or scattered light is proportional to particle size. Individual particles can thus be sized and counted to determine both the concentration and the size distribution. Sensors are available in a wide variety of particle size categories ranging from 0.5 microns and higher with the most common being 1 to 300 and 2 to 400 microns.

At Louisville Water, particle counting has been proven to be an effective measurement technique at purity levels well below the range where turbidity measurements are effective. Louisville Water uses Model 215W on-line and Model ABS 2500 batch laser particle counters from Met One, Grants Pass, Oreg. These units were selected after evaluating a number of competitive units. The company has tested the accuracy and repeatability of these counters, and found them to be surprisingly high. The company's total investment in four on-line and one bench-top particle counters was about $62,000.

Performance

Tests at the Louisville laboratory have shown that turbidity can remain constant at 1.0 NTU, while particle count varies between 5 and 100 P/mL. Generally, 95 percent or more of the particles seen are in the two to seven micron size range. Turbidity measurements are not effective on this size particle until large numbers are reached. Louisville Water experiments have shown that turbidimeters provide good accuracy above 1.0 NTU. Particle counters are a more effective method of measuring changes in effluent quality below this level.

Louisville's Crescent Hill plant has four different sets of

filter banks. One particle counter has been installed on-line on a filter sample line. These lines normally provide a composite of the plant's 15 filters. Grab samples from each filter are analyzed by the bench-top unit to monitor individual filter performance. Being able to detect particle count changes below 1.0 NTU makes it possible to set filter run times and change coagulant feed programs with greater accuracy. In particular, the authors have witnessed dramatic increases in particle count, without any changes in turbidity near the end of a filter run. These increases might come at 100 hours for a particular set-up. The problem was the filter run was originally programmed to continue to 150 hours. This was the time when turbidity measurements detected an increase.

Another consideration was that these filters were all constructed at different times and some even have been renovated. Therefore, the performance of these filter banks can vary to a considerable degree. Toward the end of their run, the older filters typically rise to 200 P/mL, while the newer filters only go up to 40 P/mL. Yet, the turbidity readings on each filter are identical. The more sensitive particle count readings have made it possible to optimize run times for each individual filter. This was impossible with turbidity readings alone.

Chemists have also done experiments on variable rate filters to determine whether flow rate affects particle count. It was determined that high flow rates significantly reduced effective filter run times. The optimum filter run with high flow rate was reduced from 96 hours to 70 hours in one typical case, to avoid a breakthrough in particle count. Based on filter particle counts, the minimum coagulant feed rate has been increased from 10 to 20 pounds per million gallons.

Louisville Water closely monitors effluent quality on a continual basis. The quality lab runs daily testing on many parameters of process water as it goes through the treatment scheme. The use of on-line and batch particle counters is another effort by the company to improve its water treatment performance. Currently, the company is legally bound only to conduct turbidity and chlorine measurements. However, the company is proactively investigating and implementing particle counting technology because it recognizes the important advantages that it offers in optimizing treatment methods. Louisville Water is also performing research to determine what role particle counting might play in a closed-loop control scheme.

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