In-Tank Aeration Predicts and Reduces THMs

Although using aeration to reduce THMs has produced encouraging but inconsistent findings in the past, a Texas utility is using an in-tank sprayer system with good results.

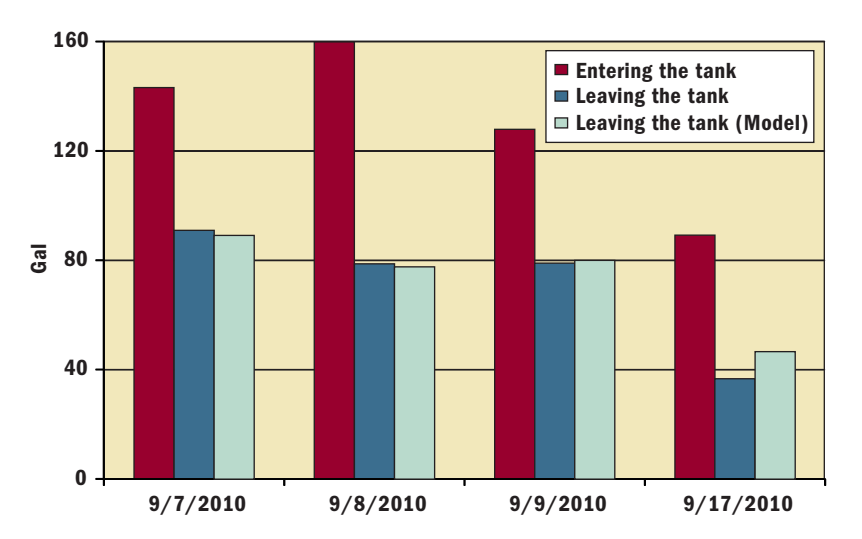
BY PETER S. FISKE, JASON OPPENHEIMER, RANDALL MOORE, AND RANDY EVERETT

THE STAGE 2 Disinfectants/Disinfection Byproducts Rule (D/DBPR) is presenting tough choices for many water system managers. Upstream treatment processes for reducing natural organic matter are expensive and constrained by existing infrastructure. In addition, changing disinfectants can be expensive and difficult to sell to a wary board and community. Some state health departments have already mandated major changes to upstream processes to promote Stage 2 D/DBPR compliance. Even process intensification, which doesn't require major physical upgrades, substantially increases operational costs.

However, distribution systems provide opportunities to reduce disinfection by-product (DBP) levels downstream of treatment plants. For the last 10 years, a handful of individual municipalities have experimented with aeration systems to remove volatile trihalomethanes (THMs) from finished water. Published results so far have been encouraging but inconsistent. Some utilities report major THM reductions; others, which appear to operate under similar conditions, report more modest results. Some aeration approaches have resulted in substantial chlorine residual loss; other approaches report no such losses.

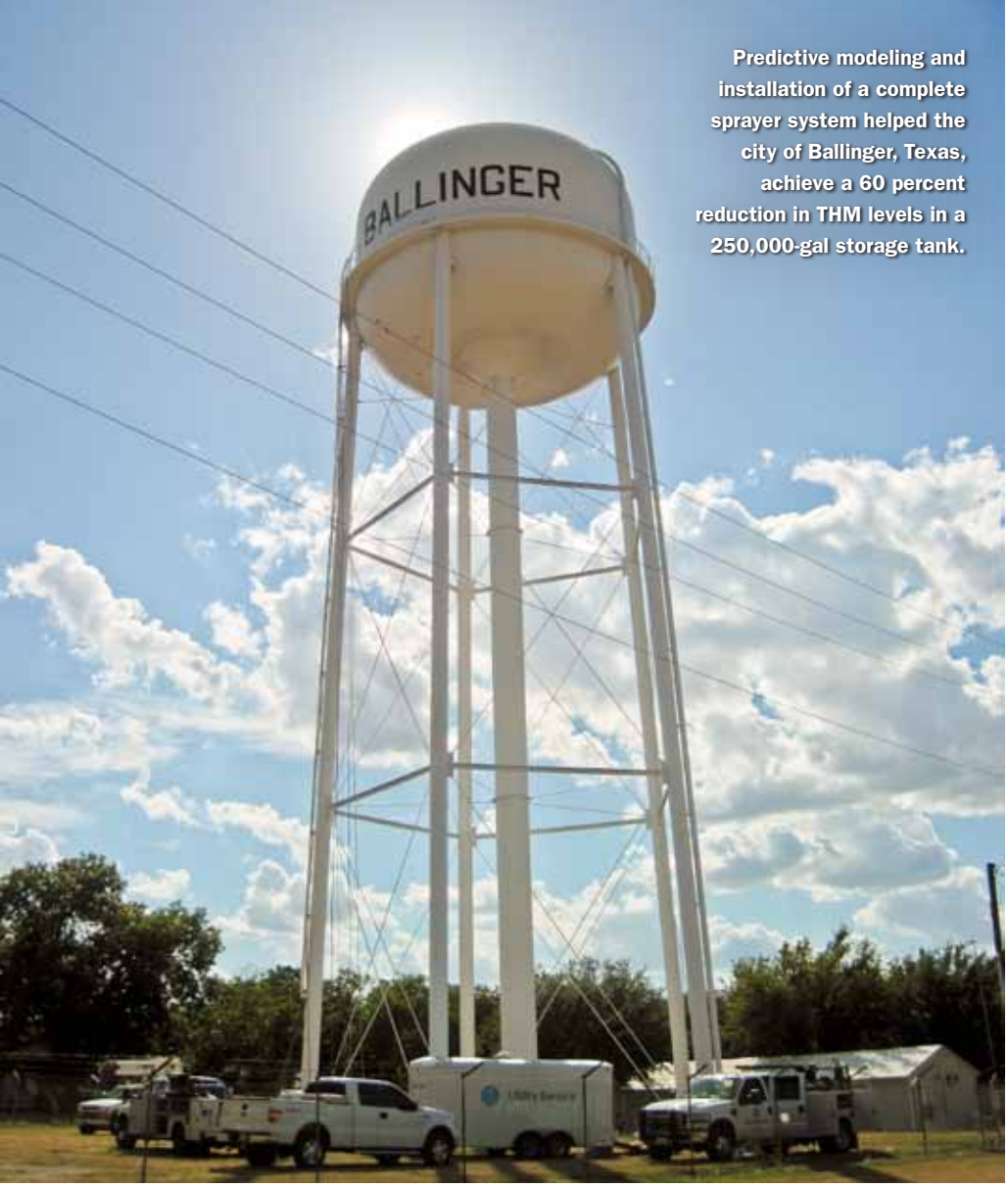
Figure 1. THM Levels

THM levels in water entering and exiting Ballinger's 250,000-gal tank were compared with levels predicted by the model.



CHALLENGING QUESTIONS

Which aeration technologies are suitable for which kinds of tanks? How do tank operations affect aeration hardware effectiveness and reliability? How can municipalities evaluate in-tank aeration options and choose a system that produces desired results with the least amount of energy? And which aeration technologies work best with various THM species? The



Predictive modeling and installation of a complete sprayer system helped the city of Ballinger, Texas, achieve a 60 percent reduction in THM levels in a 250,000-gal storage tank.

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city of Ballinger, Texas, was looking for answers to all of these questions.

The city owns and operates a 2.5-mgd water treatment plant commissioned in 2005 and two storage facilities. Despite converting to chloramine residual disinfection and implementing a major plant upgrade, the city had been unable to reduce DBP precursors to acceptable levels. THM levels in water leaving the plant had equaled or exceeded the maximum contaminant level (MCL) of 80 µg/L. At a compliance test location in the distribution system, THMs had exceeded MCL every quarter for 6 consecutive years. Ballinger's THM problem was particularly challenging because most of the THMs were brominated compounds, which are more difficult to liberate through aeration. Measurements of bromine concentrations in nearby source waters confirmed that bromine levels had increased during the last few years.

WEIGHING THE OPTIONS

Ballinger's utility managers determined a THM reduction of at least 60 percent would be sufficient to achieve compliance. Launching an investigation to determine how to achieve the 60 percent reduction, the city and its contractor analyzed three technologies—bubbler aerators, surface aerators, and spray aerators—to be used in a single 250,000-gal elevated storage tank. Because the tank was small and had rapid turnover, an aeration system would need to quickly and efficiently remove a large amount of brominated THM species. The analysis considered equipment and installation costs, as well as energy consumption and maintenance life-cycle costs.

PREDICTIVE MODELING

The contractor's physicochemical computer model of THM transport processes inside potable water storage tanks and reservoirs uses experimentally verified mass transfer coefficients for various mass-transport mechanisms and the aeration technologies being analyzed. The model factors in relevant distribution system operating conditions and predicts the performance of any aeration system configuration and its effect on THM levels in the tank. Energy-optimizing tools allow utilities to compare THM reduction and energy required for a wide range of aeration technologies and equipment configurations. Using these tools and models together, utilities can determine the best aeration system for specific tank and operating conditions.

Before the aeration system was installed, the city established a baseline by measuring THM levels up-range and downrange of the tank. These levels were compared with THM levels predicted by the model (Figure 1).

ANALYSIS

Although bubble aeration is commonly used, analysis showed that, for conditions in the Ballinger system, it was more energy intensive than alternative technologies. Bubble aeration favors removal of chloroform over other THM species. In the case of bromoform, a large amount of air must be cycled through the bubbler system to achieve 60 percent THM reduction. Compared with other technologies, the model suggested that 7–10 times the amount of electricity would be required for bubble aeration.

Surface aeration and spray aeration used comparable levels of energy. However, installing a surface aeration system in the Ballinger tank would have been significantly more expensive. In addition, the city would risk having to take the tank out of service if the system malfunctioned.

Analysis revealed that an energy-optimized sprayer system was the best all-around choice when considering capital and operating costs, performance, and reliability. A complete sprayer system

was designed and installed in less than 2 months.

RESULTS

THM concentrations measured during the first three days of operation showed substantial and progressively lower levels of THMs in water leaving the tank. Because untreated water enters and treated water leaves the tank through the same system of pipes, fill water from the distribution system also showed progressively lower THM levels. The rate of decline of total THMs (TTHMs) in the tank was also in line with model predictions. Disinfectant residual levels weren't adversely affected by aeration system operation. Measurements of residual levels at various points near the tank showed no discernible residual reductions relative to other parts of the distribution system.

After 10 days of the aeration system's continuous operation, a peak reduction in THM levels was recorded (58.9 percent) throughout the tank. Levels dropped from 89.2 µg/L in the fill water to 36.7 µg/L in the effluent at the end of the drain cycle (Figure 1). Levels measured at the Stage 2 compliance point were within compliance (Figure 2).

THE NEXT STEP

With the initial performance of the aeration system having been established, the city and its contractor continued to test and optimize the reliability of various components. Because of typical delays in THM sampling and analysis, evaluating each change to system design required about 2 months. The schedule was delayed further when the tank was taken offline for maintenance and repainting. After the aeration system was reinstalled in late June 2011, THM reductions matched levels observed earlier, showing consistent system performance (Figure 3).

Lowering THM levels in storage tanks and reservoirs through aeration is a viable solution for Stage 2 compliance. The analysis conducted by the city of Ballinger illustrates that predictable, lasting THM reductions—especially as treatment plant and distribution operations change over time—can't be assured by equipment alone. By combining optimized hardware, software, modeling, maintenance, and monitoring, the city discovered a viable economical tool for Stage 2 D/DBPR compliance in its distribution system.

Figure 2. Compliance Levels

After 10 days of the aeration system's continuous operation, THM levels measured at the Stage 2 compliance point were within compliance.

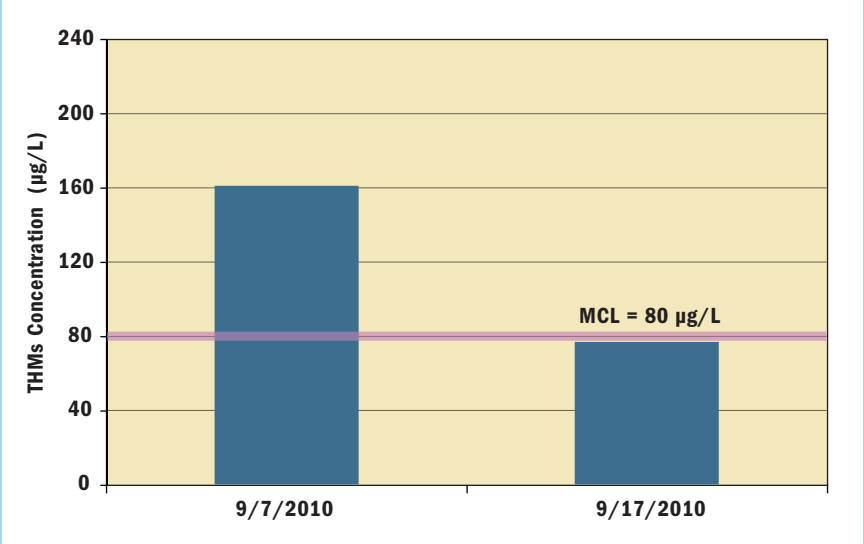
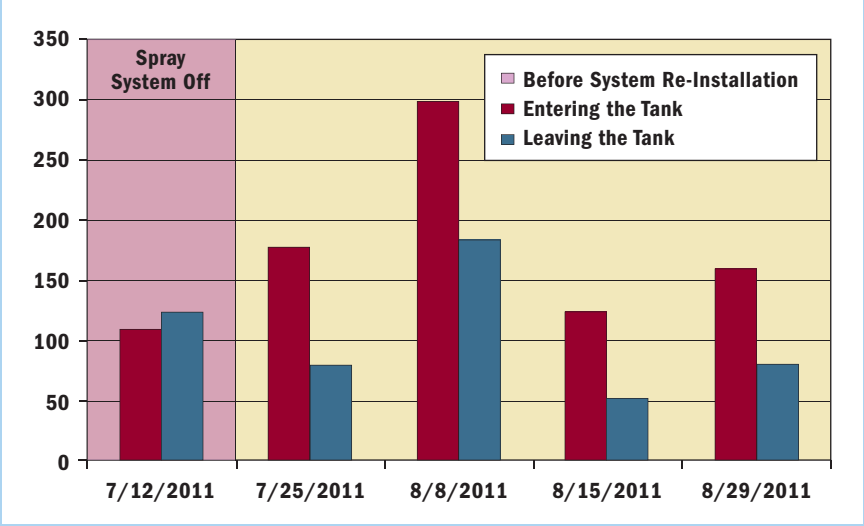


Figure 3. THM Levels Before and After System Re-installation

A dramatic increase in THMs around Aug. 8, 2011, was caused by a systemwide chlorine burn.