Water Quality

Reducing Chlorine Demand with Chemical Cleaning

by William W. Harjo, Charles Selvidge, and Ulrich Reimann-Philipp

Providing drinking water to Dustin, a small community in rural Oklahoma, has always been a challenge. Red-water complaints, elevated turbidity, and low chlorine residuals had occurred occasionally over the years, but in 2001, these events became more frequent and led to repeated Total Coliform Rule violations and boil-water orders. While it hasn't solved all the system's problems, chemically cleaning much of the infrastructure has helped eliminate excess chlorine demand and reduce the red-water and turbidity complaints.

The cleaning solution produces an acidic reaction that works on all surfaces.

The Dustin water system numbers less than 200 connections and supplies water to about 400 customers from a small artificial lake. The lake, the town's sole source, is susceptible to drought and subject to runoff from the surrounding farms and ranchland, and the raw water quality can fluctuate considerably.

The water treatment facility consists of a 20-yr-old micro-floc package plant, which operates for about 13 hr/day, producing 45,000 gpd. The finished water is disinfected with sodium hypochlorite before being pumped to a 60,000-gal steel clearwell and a 50,000-gal elevated storage tank, which are connected by a 1.6-mi polyvinyl chloride (PVC) pipeline. A pumping station at the treatment plant and the elevated tank provide the water pressure. In 2001, the distribution grid consisted of aging cast-iron pipes of various diameters.

A Clean Solution

With technical assistance from the Oklahoma Rural Water Association, the treatment procedures and chlorine-feeding equipment were repaired and upgraded in 1999 to ensure stable chlorine residuals. Other measures included frequent line flushing and washing the clearwell. However, the problem of maintaining the chlorine residual throughout the system persisted.

ORWA's Randy Caskey suggested chemical cleaning to control the chlorine demand problem. Cleaning chemicals are sprayed on and rinsed off the surface to be cleaned, removing biomass and corrosion buildup on smooth and porous surfaces and reducing chlorine demand.

Chemical cleaning of water treatment and storage facilities had been pioneered in Germany to prevent contamination of treated water during storage and distribution. Germany has a limit of 0.3 mg/L chlorine in drinking water, which is too low to provide an adequate chlorine residual in US distribution systems.

The town of Dustin decided to evaluate the effect of chemical cleaning on its water quality. Before any part of the system was cleaned, initial water quality data were collected at several locations. Collected data included total chlorine concentration, turbidity, total trihalomethane (TTHM) concentration, and the clearwell's chlorine demand.

The elevated tank was slated to be the first facility to be chemically cleaned in late November and early December 2001. However, the tank had neither an access ladder nor a usable bottom drain. This, and bad weather conditions at the time of cleaning, allowed for only a conventional washout and removal of the bottom sediment. The sediment was as deep as 18 in. in some places and had accumulated to the top of the riser pipe. The washing resulted

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Cleaning (from page 21)

in a reduction of turbidity at the town hall tap from 1.0 ntu to below 0.5 ntu, but had little effect on chlorine residuals.

Chemical cleaning of the package treatment plant, the clearwell, and the first 1.2 mi of pipeline that served the town was completed within one day; during this time, the town's water supply came from the elevated tank. The first cleaning step was to drain and clean the plant. The cleaning solution was prepared by mixing the cleaner and activator components. The chemicals used are NSF-60 certified; the cleaner and activator combined produce an acidic reaction that works on all surfaces. The mixture is applied as a low-pressure mist using either an electrical pump and extendable spraying wand or hand-held sprayers.

Heavy surface deposits, built up over 15 years, covered the treatment unit. Some brushing was needed to support the chemical cleaning reaction. The treatment exposed the unit's epoxy coating and revealed paint that was generally in good condition, except for some small spots where the primer was exposed. After cleaning, the biodegradable solution was flushed out of the facility (the solution can also be recycled to the head of the treatment process at 1:500 dilution).

The clearwell contained minimal sediment — mainly filter sand. However, a black layer that was completely resistant to firehose flushing covered the basin walls. Chemical cleaning, without pressure washing or brushing, removed these deposits. After cleaning the clearwell, the treatment unit was started so it would produce enough water to fill the section of pipeline to be treated. In the clearwell, the line treatment solution containing 0.5 percent of the activator component was prepared and pumped into the isolated line section, where it was allowed to react for 3 hr. During this time, the plant produced enough water to partially refill the clearwell and supply the water for flushing.

The clearwell's basin walls were covered with a black layer that was completely resistant to flushing with a fire hose (inset top). Chemical cleaning removed these deposits, without pressure washing or brushing (inset bottom).

Residual Testing

After cleaning, the tank was filled and isolated overnight; chlorine measurements were then taken, which showed the clearwell's chlorine demand had been eliminated. Free chlorine residuals were ascertained at the beginning and end of the off-line period. As a comparison, a control sample collected from the tank at the beginning of the off-line period was kept in a clean glass jar for the same period. Before cleaning, the chlorine residual dropped by more than 90 percent while the water was in the clearwell overnight. After cleaning, only 16 percent of the chlorine residual was lost, the same amount lost in the control jar. With the clearwell chlorine demand eliminated, chlorine-feeding at the plant could be reduced from 4.3 mg/L to 3.6 mg/L.

The cleaning program also dramatically affected chlorine residuals throughout the distribution system. Samples from the treatment plant effluent, the clearwell sampling tap, the elevated tank riser-pipe tap, the town hall and school kitchen taps all showed higher chlorine residuals, despite reduced chlorine feeding at the plant. At the town hall tap, the chlorine residual had increased from 0.5 mg/L before cleaning to 1.2 mg/L after cleaning. At the school, the effect was even greater, with an increase in residual from 0.8 to 2.5 mg/L. The elevated tank supplies water to the town hall, while the school receives water primarily from the clearwell. Sampling showed that the elevated tank, which had been cleaned only by flushing, still had a significant chlorine demand.

In May 2002, the elevated tank was chemically cleaned. This resulted in further stabilization of the chlorine residuals throughout the system.

The raw water quality of Dustin's sole water source, a small artificial lake, fluctuates dramatically with drought conditions and runoff from surrounding farms and ranchland.

Operators have been able to reduce chlorination to 2.0–2.2 mg/L free chlorine. There have been no TCR violations or boil-water orders since.

One persisting problem is the high disinfection by-product (DBP) concentration. The chemical cleaning program has reduced the TTHM concentrations by 40 µg/L throughout the system, but that is not sufficient for Dustin to comply with Stage 2 Disinfectants–Disinfection Byproducts Rule limits. In 2004, the distribution lines were replaced with PVC pipes, which also did not significantly improve the situation. Operators currently use powdered activated carbon (PAC) to reduce DBPs; yet, PAC has a limited effect on DBPs, so Dustin is considering converting to chloramine disinfection.

The Dustin water system continues to strive to meet all the regulations, which could not be done through water treatment alone. Chemical cleaning did eliminate chlorine demand in the distribution system, preserving reliable chlorine residuals while lowering the amount of added sodium hypochlorite necessary for disinfection and eliminating TCR violations. Customers are happy because they no longer are served red water nor need to heed boil-water orders.