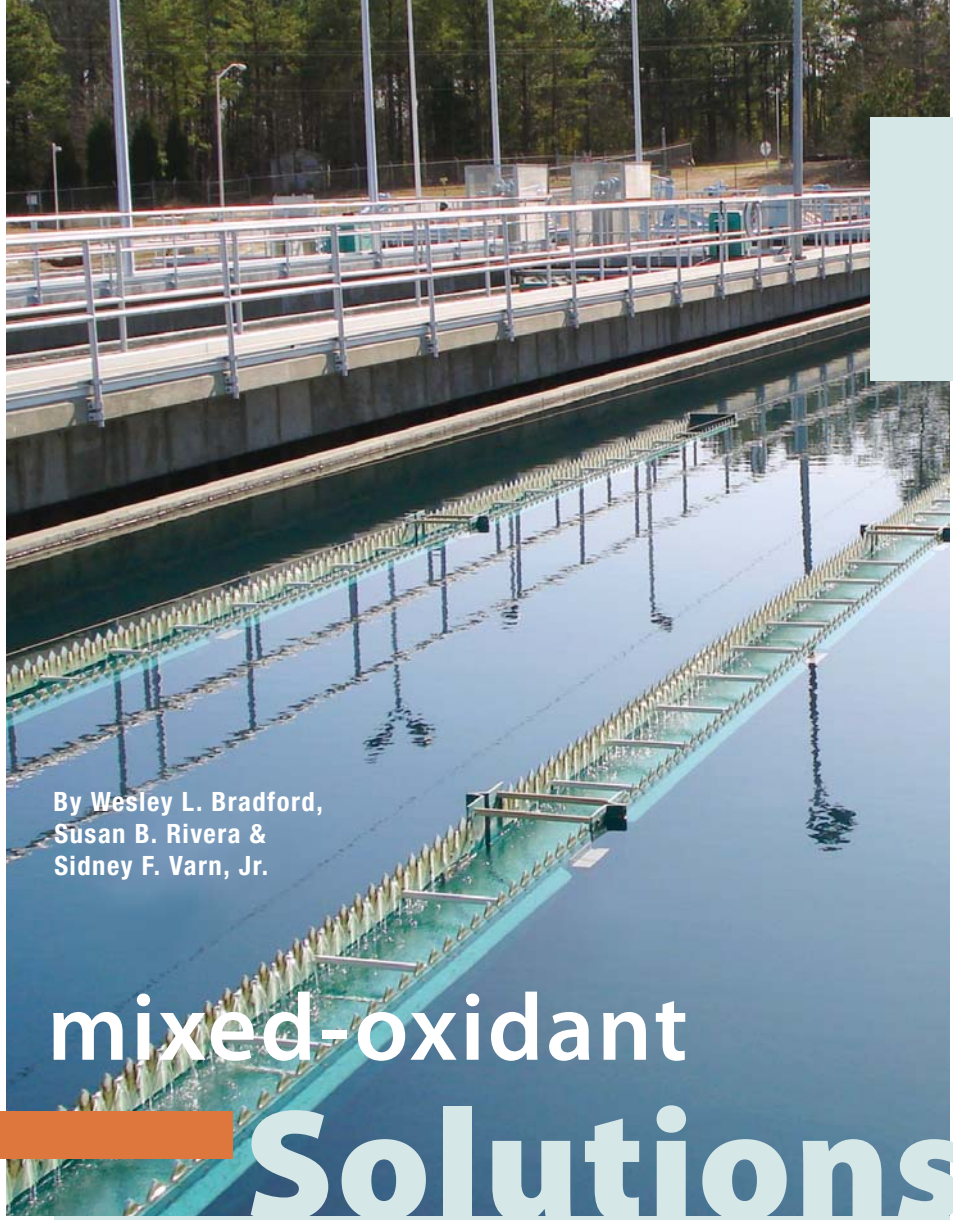

mixed-oxidant Solutions

By Wesley L. Bradford, Susan B. Rivera & Sidney F. Varn, Jr.

Moving away from chloramines while maintaining water quality

Managers at the Lake Murray Water Treatment Plant (LMWTP) in West Columbia, S.C., decided to convert to an on-site generation (OSG) system after nearly 20 years of using chloramines. A three-phased transition to MIOX mixed oxidant solution (MOS) began on February 2, 2007, with complete conversion on April 24. By October of 2007, samples collected showed DBP concentrations well under the MCLs, even without use of ammonia.

The Lake Murray Water Treatment Plant (LMWTP) in West Columbia, S.C., was dedicated in 1991 with a capacity of 6 million gal per day (mgd). With upgrades completed in 2007, the plant has a current capacity of 22.5 mgd. Most of the water from LMWTP is sold; 19% of the water is distributed to the system for which the LMWTP management and staff is responsible.

In the early 1990s, the water treatment plants in West Columbia began using chloramines as the primary disinfectant to control disinfection byproduct (DBP) concentrations in distribution. Chlorine gas was the source for the chlorine. In 2006, management at LMWTP was asked by the state regulatory agency to maintain a 30-day supply of chlorine on site. As a result, management decided to convert to a MIOX mixed-oxidant solution (MOS) onsite generation (OSG) system. The OSG system uses only salt and power to generate a dilute chlorine-based solution, eliminating the storage and handling of hazardous disinfection chemicals.

Making the Switch

The LMWTP management and staff began a three-phase transition to the new system in February 2007 by first replacing chlorine gas with MOS in pretreatment. In March, chlorine gas was replaced with MOS in the chloramination process. The third and final phase of the MOS transition was completed in April, when the anhydrous ammonia gas feed was discontinued.

ARTICLE SUMMARY

Challenge: State regulations required a South Carolina water treatment plant to maintain a 30-day supply of chlorine on site.

Solution: Management implemented a three-phase conversion to a mixed-oxidant solution onsite generation system which operates off salt and power.

Conclusion: Data collected by the state DHEC meets MCL standards and shows TTHM and HAA5 concentrations lower than those of a neighboring plant which uses chloramines.

Immediately after the switch, management was prepared to receive a significant increase in taste and odor complaints from customers in both the wholesaler and direct customer systems. Often, free available chlorine-containing water mixed with chloramines-containing water residing in the distribution system produces chlorinous taste and odor. Management planned for an aggressive flushing program to diminish the level of complaints. Instead, they were able to significantly reduce their flushing program planned for the switch due to the small number of complaints.

DBP Evaluation

The U.S. Environmental Protection Agency maximum contaminant levels (MCLs) are 80 ppb for total trihalomethanes (TTHMs) and 60 ppb for five haloacetic acids (HAA5s). Quarterly monitoring is performed by the South Carolina Department of Health and Environmental Control (DHEC). In order to supplement the quarterly testing, MIOX Corp. asked plant managers for their assistance in collecting samples monthly.

Initially after the switch, DBP concentrations rose in distribution to levels that exceeded the MCLs. However, in August, MOS dosing was strategically changed, reversing the DBP trend. Samples collected after the process changes (Sept. 11 and Oct. 2) showed DBP concentrations well under the MCLs. Comparisons of the data from November 2006 with November 2007 demonstrate that MOS is capable of reaching HAA5 values similar to chloramines at the same water temperature.

Even more striking are the reductions in TTHMs and HAA5s recorded from samples taken by the DHEC in August and October of 2007. The most dramatic reductions (greater than 50%) were in the HAA5 results. Because the raw water temperature had declined by only 3.9˚C and the water was still quite warm, the decrease in DBP concentrations likely is not due to a temperature decrease.

Samples collected that November showed even lower DBP concentrations than the previous month. It is likely that cooler raw water contributed to the decrease. However, further decreases in TTHMs from the December samples likely are due to loss of biofilms from distribution, not reduced temperature.

As the water warms, increases in the DBP concentrations are expected. The MIOX-supported samples collected in June 2008 show an increase in the TTHM concentrations, although they are substantially lower than those seen in the samples collected in October 2007, when the raw water temperature was last close to that of the June sampling. Moreover, the HAA5 concentrations have decreased since the special sampling in December.

Table 1: Table of Process Changes Associated with DBP Valves

DATE	PROCESS CHANGE
February 2, 2007	MOS replaced chlorine gas at pre-treatment
March 6, 2007	MOS replaced chlorine gas at post filtration
April 24, 2007	Ammonia discontinued
August 7, 2007	MOS dose in pre-treatment decreased from ~2.0 mg/L to ~1.5 mg/L
August 7, 2007	MOS dose in finished water decreased from ~2.1 mg/L to ~1.6 mg/L
October 3, 2007	MOS dose in pre-treatment decreased from ~1.5 mg/L to ~1.0 mg/L

Four 500 lb per day modular MOS systems are currently in service at the plant for a total production capacity of up to 2000 lb FAC per day.

Table 2: Summary of DBP Analyses in the Distribution System

Sampling Date	Raw Water Temp	MIOX Sampling Locations						South Carolina DHEC Compliance Sampling Locations							
		Clearwell		Midpoint		Farthest Point		Location 1		Location 2		Location 3		Location 4	
		TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5	TTHM	HAA5
	°C	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
2006															
23-Feb	~14.0							26.2	32.9	30.0	34.9	30.3	37.4	33.0	36.5
25-May	~22.4							38.1	36.5	36.1	35.9	32.2	32.2	35.8	33.8
27-Jul	~26.6							34.9	36.5	37.5	30.7	33.5	26.3	n/a	n/a
28-Nov	~20.0							18.7	28.2	13.3	28.0	13.5	24.6	n/a	n/a
2007															
22-Feb	14.0							12.3	17.6	13.0	20.2	15.8	23.6	n/a	n/a
24-May	23.3							53.7	70.9	57.6	67.8	55.4	77.6	40.3	34.8
28-Jun	25.1	49.6	37.0	75.9	61.7	85.0	66.4	On 7 Aug. the LMWTP: 1) decreased MOS dose in pre-treatment from ~2.0 mg/L to ~1.5 mg/L and 2) decreased FAC in finished water from ~2.1 mg/L to ~1.6 mg/L							
18-Jul	26.6	60.9	52.0	85.5	54.0	96.8	63.4								
15-Aug	27.9	55.9	53.3	69.1	69.0	80.2	86.0								
28-Aug	28.2							71.4	63.5	83.4	66.8	75.3	74.6	n/a	n/a
12-Sep	27.0	40.8	29.0	57.6	34.0	72.1	50.6								
3-Oct	25.1	39.3	25.1	61.0	31.0	71.3	25.4	On 3 Oct., MOS dose in pre-treatment reduced to ~1.0 mg/L (from ~1.5)							
18-Oct	24.3							48.8	37.7	55.2	11.9	53.2	36.6	n/a	n/a
9-Nov	20.4	25.4	18.8	35.4	29.0	55.6	26.5								
19-Dec	17.4	25.9	22.1	30.0	39.0	37.9	34.0								
2008															
24-Jan	14.8							29.0	35.8	37.1	37.1	37.7	40.5	n/a	n/a
24-Apr	18.9							23.4	19.5	45.3	51.5	33.4	33.0	n/a	n/a
4-Jun	24.1	32.0	19.6	50.2	31.0	58.1	27.0								

Samples were collected and analyzed at the same laboratory by both the State in their quarterly monitoring and by plant staff at the request of MIOX Corporation.
* MOS phase-in began on February 2, 2007
Note: The rise in HAA5 concentrations coupled with decreases in the TTHM concentrations in the Dec. 18, 2007 samples from the Nov. 8, 2007 samples suggests a reduction in biofilm in the distribution system—biofilm reacts with FAC to form TTHMs but tends to degrade haloacetic acids.

Table 3: Comparison of DBP Data Taken by DHEC on Oct. 17, 2007								
	TTHM µG/L	HAA µG/L	TTHM µG/L	HAA µG/L	TTHM µG/L	HAA µG/L	TTHM µG/L	HAA µG/L
MOS treated distribution system – 17 Oct. (taken from Table 2)	48.8	37.7	55.2	11.9	53.2	36.6	NA	NA
Chloramines treated distribution system – 17 Oct. samples from the second system	69.8	42.1	55.8	45.0	54.8	54.8	46.1	47.5

All data taken by DHEC are now well below the MCLs, and these concentrations are even lower than those in the distribution system served by the other plant operating in West Columbia, which still uses chloramines.

MOS Chemistry Benefits

MOS dosing changes in pretreatment improved the coagulation and sedimentation operations significantly. Evidence indicates that the bulk of the DBPs were formed in-plant and mostly in the clearwells, suggesting they were contaminated with biofilms which are now gradually being removed by MOS. The pretreatment dose has been reduced by 50% from 2 to 1 mg/L.

The residuals in distribution have remained greater than 0.4 mg/L at all the testing locations. This type of residual maintenance is consistent with MOS chemistry observations. The final treatment dose is now down to approximately 1.6 mg/L, a reduction of 24%. The reduction in final dosing is consistent with prior MIOX MOS experience.

Studies are currently underway at the plant to gather detailed data on how unit operations impact DBP formation. Other operational changes to optimize plant performance, including coagulation and sedimentation processes, are underway.

Conclusions

- Conversion from chloramines to MOS was successfully implemented without major chlorinous odor complaints or problems.
- DBP compliance was reached by September 2007.
- By year's end, average DBP values were very near those of one year earlier when chloramines were used.
- MOS-treated distribution system DBP values were lower than those in the second system still using chloramines.
- Distribution system residual stability allowed lower MOS dosing at the plant.
- Increased TOC removal in treatment is possibly due to a microflocculation effect in pretreatment by MOS.
- TTHM, HAA5 and residual maintenance data suggest a gradual reduction in biofilms, in the clearwells and in distribution. WWD

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