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Bacterial Control With Ozone

Testing of the CTS Treatment System Proves Reliable for Cooling Tower Water

The Center for Environmental Technology (TCET) at Pierce College, Woodland Hills, Calif., is engaged in the development and testing of new environmental technologies. In the April 2001 issue of *Water Quality Products*,[1,2] associates of TCET presented a new method using ozone to treat cooling tower water. Cooling Treatment Systems, Inc. (CTS) of Englewood, Colo., has adapted this method to produce a water treatment system it now is marketing for cooling towers. CTS submitted this new technology to TCET for testing. The results of these tests are presented here.

How the CTS System Works

The CTS system consists of two sidestream components. The first treats water with ozone while the second removes particles from system water.

The ozone generator consists of a pair of 33-inch ultraviolet (UV) (185 nm) lamps, each centered in a 2-inch-diameter stainless steel tube cooled by a water jacket. Oxygen from an AirSep AS12 is passed through the tubes at a rate of 15 scfh per tube. Measured on a BMT model 964 UV spectrophotometer, each tube produced ozone at the rate of 2.5 grams/hour for a total ozone output of 5 grams/hour for both tubes.

This is considerably less ozone than is produced by other systems now on the market. According to CTS, this small amount is effective because its High Shear Mixer (patent pending) is efficient. All water treatment is accomplished within the confines of the mixer thus eliminating the need to develop and sustain an ozone residual in the sump as required by other systems.

Water flows through the treatment loop at a rate of 43 gpm with ozone added to the water via a venturi injector located immediately upstream of the mixer. Treated water exiting the mixer is returned to the top of the tower where the ozone is removed by air stripping as the water cascades over fill elements. Since ozone has been removed from the sump water before it is delivered to the chiller, there is no concern that ozone will corrode the chiller or other components of the cooling loop.

Particle removal is accomplished by a second sidestream loop with a centrifugal separator designed by CTS. This separator is modeled after designs used in the paper and pulp industry. It is a common assumption that a centrifugal separator is not appropriate for treatment of cooling tower waters since good water quality requires removal of particles to micron size or less.[3] Manufacturer claims for common centrifugal separators report minimum size limits of 40 to 74 µ for particles that can be removed unless they are composed of particularly dense materials not commonly found in cooling towers.[5]† Therefore, it is interesting that the CTS system uses a centrifugal separator rather than a sand filter for particle removal.

Testing the System

The CTS treatment system was tested on a 100-ton BAC cooling tower with a York TurboPak Liquid Chilling Unit serving the performing arts building at Pierce College. The mild California climate and the hot lighting of the theater require that this building be air conditioned throughout the year. From its installation in the 1970s until three years ago, a commercial chemical treatment company maintained this tower. In 2000, it was dedicated to ozone research by TCET and has been treated only with ozone since. Within two months after ozone treatment began, both the tower and chiller had shed considerable scale, the ΔT dropped and the condenser amp draw was reduced by 35 percent. The following summer, the chiller did not suffer shutdown due to thermal overload, a problem that was common in previous years. This period of stable operation provides a baseline against which to evaluate any changes in operating parameters that may occur after installation of the CTS system.

In January 2003, the tower sump was drained, cleaned and refilled with city water and the CTS system was then installed. As of publication of this article, it has been in operation for six months. For the first three days after installation, the CTS ozone system was run continuously and from 10:00 a.m. to 4:00 p.m. (six hrs/day) thereafter. The particle removal system (centrifugal separator) has been operating continuously since startup. Water chemistry and chiller performance (ΔT and condenser amps) were monitored three times weekly during this period. After six months of operation, there has been no detectable effect on chiller performance when compared to the equivalent period before installation of the CTS unit. (See Table 1.)

Table 1: Machine Performance Comparison

Date	Average Condenser Amps	Average ΔT (°F)
April–May 2002	45	5
April – May 2003*	43	4

** CTS system operational.*

Table 2: Coupon Corrosion Rates

Copper	0.439 mpy*
Mild Steel	0.0069 mpy
Galvanized Steel	0.5101 mpy

** mils per year*

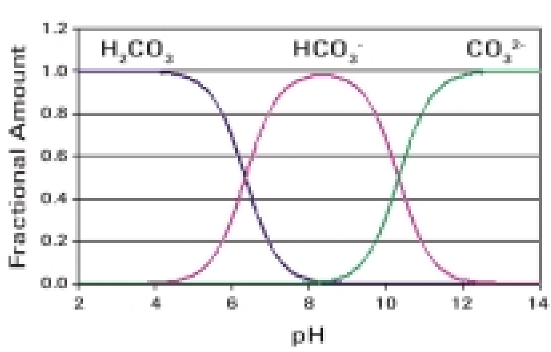

Figure 1.
The pH determines the carbonate species that forms. At pH = 8.4 bicarbonate is maximized and carbonate is at its minimum. Calcium bicarbonate is orders of magnitude more soluble than calcium carbonate, and as long as the pH does not get higher than 9 on a regular basis, scale does not form unless the TDS get unreasonably high.

Source: S. Bialkowski, Utah State University

Scaling and Corrosion

Ozone is incompatible with the chemicals commonly used for water treatment and generally is used without additional chemicals. This has led to concerns that the benefits provided by ozone for microbial control may, in the absence of additional chemical treatment, be countered by increased potential for corrosion or scaling. Though there are companies selling ozone-compatible chemicals for water treatment, the ozone studies at TCET have used only ozone without any other chemical additives.

The findings show that if the sump water is maintained at a pH of about 8.4, neither corrosion nor scaling occurs. At this pH, conditions are out of the corrosion range for the metals commonly

† *See product literature or websites for Process Efficiency Products, Lakos or other manufacturers of centrifugal separators. Most claim to be able to remove particles smaller than 40 microns only if the particles are of very high density.*

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used in cooling systems and favors the formation of bicarbonate (HCO_3^-) over carbonate (CO_3^{-2}) ion (Figure 1). Calcium bicarbonate is orders of magnitude more soluble than calcium carbonate; therefore, no scale forms under normal operating conditions. The pH of the makeup water at the site varies from 7.8 to 8.1. To maintain the desired pH of 8.4, the system is set to blow down at the conductivity value obtained when sump water reaches the desired pH. Depending on seasonal water quality, this usually results in 2.0 to 3.5 cycles of concentration.

Corrosion is minimized by a combination of two factors. First, by maintaining a pH of 8.4, the water is out of the corrosion range indicated by the Langalier Saturation Index, Ryznor's Index and others used to detect corrosive conditions. Second, since the ozone is stripped out of the water before it is returned to the sump and chiller, there is no contact between ozone and potential corrosive sites in the system. Corrosion coupons installed in May 2002 have been in place throughout the six-month period of CTS system operation. As Table 2 illustrates, corrosion rates were minimal.

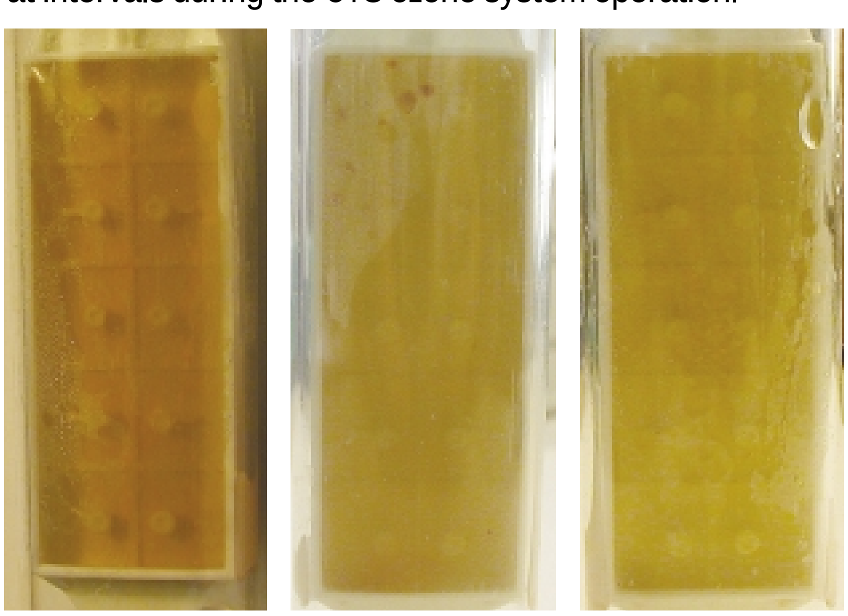
Disinfection

The small amount of ozone generated by the CTS system produced excellent bacterial control. On day three (Jan. 4, 2003) of operation, qualitative bacteria tests using a Hach paddle test were unable to detect bacteria (Figure 2). Regular testing revealed bacterial levels have remained low or undetectable since. On occasion, since there is no ozone residual in the sump, slight growths of algae occurred on submerged surfaces receiving sunlight. This is effectively eliminated by the addition of a single 3-inch chlorine tablet to the sump every several months as needed. This is consistent with the practice of rotating biocides to prevent development of bacterial resistance.[3] To date, no algal growth has occurred on fill elements. It seems likely that as the ozonated water is air-stripped in the fill cascade, algal growth is inhibited.

In May 2003, a disinfection rate experiment was conducted to obtain a quantitative measure of bacterial control and determine the minimum daily time period required to accomplish it. For this determination, the ozone system was shut down for a week to allow a bacteria population to develop. When qualitative paddle tests indicated an elevated bacterial count in the sump water, the ozone system was turned on and water samples were collected for microbiological analysis at two-hour intervals for 12 hours with a final sample collected at 24 hours. These samples were submitted to Silliker Laboratories, Carson, Calif., for heterotrophic plate counts (HPC) to provide a quantitative measure of bacterial levels at each sampling interval.

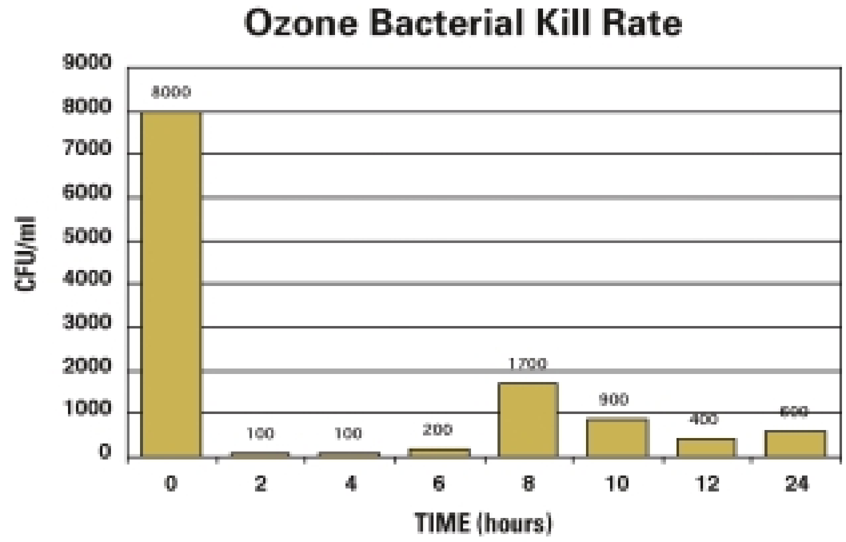
As indicated in Figure 3, the microbial population had reached 8,000 cfu/ml at the start of the test. Within the first two hours the population was reduced to 100 cfu/ml and remained low throughout the test. At 4:30 p.m., the chiller was activated to cool theater activities, and the untreated water in the chiller loop was circulated to the sump. This could account for the slight spike (1,700 cfu/ml) seen in the 5:00 p.m. sample. Based on the results of this experiment, it is planned to test the effect of lowering the operational period to four hours per day during the summer months when bacterial growth is at a maximum and there are no students on campus.

Figure 2. Qualitative HACH paddle bacterial tests taken at intervals during the CTS ozone system operation.



January 4, 2003 **March 1, 2003** **March 30, 2003**

Figure 3. Heterotrophic plate counts of water samples taken at two-hour intervals after starting ozone treatment.



Particle Removal

When the CTS system was installed, the sand filter that was previously used to remove particulates was replaced with a centrifugal separator. This has not resulted in any visible reduction of water clarity. When a panel of students was shown samples of tap water and tower water, a majority was unable to distinguish between the two.

Table 3: Effectiveness of Sand Filtration

Reported by the manufacturer in particle counts per 100 ml of water.*

Particle Size	Before Filtration	After Filtration
1–5 µ	44,879,400	346,760
5–10 µ	5,588,600	36,920
10–25 µ	1,420,600	24,060
>25 µ	126,800	8,760

** Process Efficiency Products*

To provide a quantitative evaluation of the effectiveness of the CTS centrifugal separator, a comparison between it and a sand filter was conducted. A sand filter manufactured by Process Efficiency Products (24-inch, 0.85 mm media) was plumbed into the sidestream line feeding the separator. This was done in a fashion that allows the flow (43 gpm) to be switched between the sand filter and centrifugal separator. Sump water samples were collected daily for five days while the separator was operating. The particle removal system was turned off for two days then the flow was routed through the sand filter. Daily sump water samples again were collected for five days. Both sets of samples were submitted to Particle Analysis Laboratories to determine particle counts in various size ranges using a laser particle counter.

Both particle removal systems proved quite effective. For comparison, Table 3 shows before and after filtration results reported by Process Efficiency Products. Both the sand filter and separator produced results comparable to those presented in Table 3, and results were even better for the larger size ranges. (See Figure 4.) As indicated in Figure 4, the sand filter was slightly more effective at removing particles in all size ranges. An unexpected result was the CTS separator's particle counts in the 0.5–5 µ range, which were comparable to those obtained by the sand filter. Removal of these smallest particles is especially important since they produce a significant part of the deleterious particle effects and must be removed to provide best protection. Surprisingly, the differences were most pronounced for larger particle sizes.

The CTS system performed as claimed by the manufacturer. Though no chemical treatment was used, continuous monitoring of machine parameters revealed no evidence of abnormal corrosion or scaling.

The low levels of ozone used for water treatment, when coupled with their mixer technology, produced excellent bacterial control with HPCs in the hundreds of cfu/ml (Figures 2 and 3). For comparison, EPA standards allow a maximum HPC of 500 cfu/ml for drinking water. Chemically treated towers often have HPCs in the tens of thousands, and people in the chemical treatment industry have claimed that an HPC of one million may be acceptable in cooling towers.

The CTS centrifugal separator performed better than the reputation for this technology would suggest. Though slightly less effective than the sand filter in comparative tests, the CTS system performed well using the separator, indicating that, in this application, the separator generally is comparable to sand filtration in effectiveness.

The results of this test indicate that the CTS cooling tower treatment system is an effective option for treatment of cooling tower water in smaller volume systems where oxygen demands will not exceed its limited ozone generation capacity (CTS has a similar system using corona discharge for larger cooling systems). Though no cost data were supplied, the simplicity of the CTS system and its low energy demand when compared to units using corona discharge for ozone generation suggest this system should be obtainable at reasonable cost. The simplicity of the system also leaves few areas for problems to occur. The simple UV lamp used to generate ozone depends on a ballast for power and should run as dependably as a fluorescent light system. Throughout the course of this test, none of the system's components failed to operate as designed. WQP

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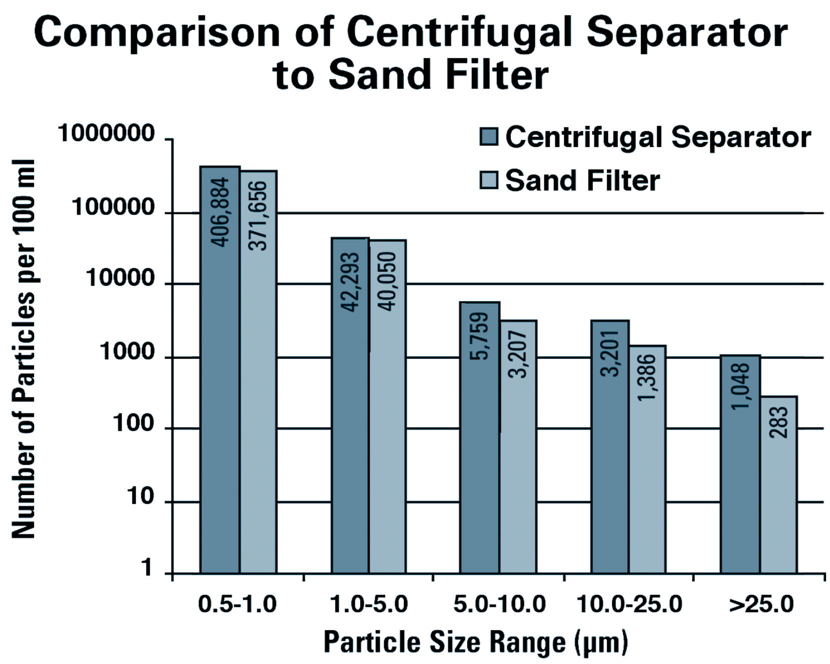
Figure 4. Particle counts and size distribution of water treated by the CTS centrifugal separator and PEP sand filter.



Acknowledgements

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